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Director’s Executive Summary
2016 Year in Review

The National High Magnetic Field Laboratory had another record number of users with 1,778 researchers, students and technicians conducting experiments in 2016. More than 650 users were principal investigators – a 33% increase from last year. Around 24% of the MagLab’s users who chose to identify were females and 7% identified as a minority.

The MagLab’s research community continued evolving with 24 percent of the lab’s users performing experiments at our lab for the first time in 2016 and nearly half of the user community comprised of students and postdocs.

When asked to rate their experience with the lab, MagLab users are exceptionally positive. A user survey was conducted between June 6, 2016 and July 12, 2016 and continues to show overwhelming satisfaction:

- 95% satisfied with the performance of the facilities and equipment
- 96% satisfied with the assistance provided by MagLab technical staff
- 90% satisfied with the proposal process
- 95% satisfied with the availability of the equipment and facilities

After conducting research at the MagLab, users submit brief summaries of their experimental results. In 2016, users generated 474 reports across 17 categories representing condensed matter physics, magnet science and technology, chemistry, and life sciences. All research reports are available on our website at https://nationalmaglab.org/research/publications-all/research-reports and the highlights will be released in the coming months.


New Magnets

The year could also be summarized with the exciting magnet developments made across the lab.

After a decade of planning, designing and building, the Series Connected Hybrid magnet reached full field – 36 tesla - in November 2016. Operating on only 14 MW of power, the SCH is more than 40 percent stronger than the previous world-record NMR magnet. This power boost, coupled with the high homogeneity of 0.1 ppm, means that this magnet will revolutionize nuclear and electron magnetic resonance in condensed matter physics, chemistry and biology research.

Engineers at the National MagLab also broke two world records with a 5 cm magnet coil made of high-temperature superconducting REBCO tape. This mini-magnet is designed without insulation, allowing engineers to pack far more conductor into a small area. The coil reached 11.3 tesla inside a 31.2 tesla resistive magnet, breaking the record for an HTS magnet operating within a background field and achieving a world record for the highest field in which a superconducting magnet has ever operated: 42.5 tesla.

Assembly of the 32 tesla all-superconducting magnet was also completed in 2016 and construction began on a 1600 square foot building expansion, which will be permanent location for this magnet. The building features two magnet pits to allow for a future HTS magnet to be installed as well as separate star grounds located under each pit to provide clean grounding for user instrumentation. The walls and ceiling include a layer of copper to reduce the ambient RF levels from external sources. This magnet will be the first ultra-high field magnet using high-temperature superconducting (HTS) materials to be put into routine service to the scientific community in 2017.

User Facility Enhancements

Throughout the National MagLab’s seven user facilities, enhancements and upgrades were made in 2016 that improve the user experience and experimental environment. These enhancements included:

- A new vacuum pumping system was installed in the DC Field Facility with a modern control system that interfaces to the MagLab’s digital control system (DCS) allowing for integration with the rest of the hybrid cryogenic cooling systems, giving the cryogenic operators better control over the cool down and operation processes.
- Three new high power circuit breakers were installed at the Pulsed Field Facility for the 1.43 GW generator, improving the reliability of power distribution for the user program.
• A new 4-way isolation switch was installed at the Pulsed Field Facility that allows utility workers access to perform breaker maintenance and repairs without disturbing users.
• A user cell for the upcoming Duplex magnet was installed at the Pulsed Field Facility. The Duplex magnet will be commissioned in 2017.
• High B/T has been developing low-temperature ultra-low noise radio-frequency capabilities in the form of contactless techniques to measure RF conductivities and the real and imaginary components of RF magnetic susceptibilities in new materials. Tunnel diode oscillators are being tested for their high sensitivity and low power dissipation. These devices can also, in principle, be used for NMR and EMR studies at very high frequencies.
• A new power supply was purchased for the EMR Facility’s 15/17 T superconducting magnet associated with the Broadband Transmission Spectrometer which is able to deliver a current of up to 180 A.
• EMR also received a new data acquisition program for controlling magnet power supply, microwave source, temperature controller and lock-in EPR detection devices.
• A new transmission-type probe was designed and implemented to serve EMR Facility users on the 35 T magnet that allows for both single-crystal measurements in a fixed orientation (no goniometer), or powder/frozen solution samples.
• The high-pressure single-crystal EPR capability also underwent an extensive re-design during 2016.
• DNP efforts at 395 GHz (600 MHz) were also greatly expanded in 2016, thanks to the acquisition of an NIH-funded 14.1 T sweepable magnet and state-of-the-art magic angle spinning (MAS) NMR spectrometer. This new instrument, coupled with the existing gyrotron source, is now part of the user program.
• The NMR Facility designed and built first generation probes for MAS and Oriented Sample NMR for the Sch magnet system.

• The AMRIS Facility added a second DNP polarizer to the growing DNP-focused user program.
• Upgrades were made to the AMRIS Facility’s 11.1 T system including a new, state-of-the-art console and phased array coils.
• The ICR Facility advanced the user efforts on their new 21 T magnet system.

Acclades Abound
In 2016, both MagLab faculty and users were recipients of prestigious awards:
• Greg Boebinger, Director of the National High Magnetic Field Laboratory, was awarded the Francis G. Slack Award by the Southeastern Section of the American Physical Society for his work to advance physics across the region and nation.
• Education, outreach, and diversity director Roxanne Hughes was invited to serve on the American Physical Society (APS) Committee on the Status of Women in Physics.
• Giti Khodaparast, a Virginia Tech physicist who has conducted experiments at the National MagLab using magneto-optics measurement techniques, was recognized by the American Physical Society as its Woman Physicist of the Month for March 2016.
• Luis Balicas, Scott Crooker and Kun Yang have been named fellows of the American Association for the Advancement of Science (AAAS) for their contributions to innovation, education and scientific leadership.
• Chemist Yan-Yan Hu won a prestigious award from the American Association for the Advancement of Science that recognizes promising female scientists in the early stages of their career.
• Alan Marshall was named a fellow of the National Academy of Inventors and was a 2016 inductee into the Florida Inventors Hall of Fame.

Dedication to Education, Diversity & Safety
In 2016, the MagLab continued to reach thousands of K-12 students through classroom outreach. More than 100 students participated in a 2016 MagLab summer camp and nearly 60 in an intern-
ship or REU program. In the summer of 2016, the MagLab piloted a SciGirls Coding Camp with eight middle and high school girls getting an introduction to Raspberry Pi and coding/computer science role models. After the camp, the participants indicated that the camp improved their understanding and perception of computer science careers. Another SciGirls Coding Camp is planned for 2017. The MagLab also hosted its largest Open House ever with more than 8,200 visitors coming to learn about the harmony of science and music. A weeklong workshop for users on the design, construction and testing of RF coils for MRI applications was also launched in 2016 with plans to become an annual event. The lab continued hosting the annual User Summer School and, this year, added video tutorials, which received more than 730 views in 2016 alone.

In 2016, MagLab staff gave more than 360 lectures, talks and presentations across 20 foreign countries. The Diversity Committee funded five recruitment trips, including visits to HBCUs (Grambling State University and Tuskegee University), the National Organization for the Professional Advancement of Black Chemists & Chemical Engineers (NOBCChE) Conference and the National Postdoctoral Association Meeting. The lab also sponsored and participated in the 2016 Expanding Your Horizons New Mexico Technical Career Workshop held in Santa Fe for more than 260 middle-school aged girls. Close to 87% of the students attending the conference said that they feel more motivated to take STEM classes and over 75% had a more positive attitude towards STEM scientists and engineers after the workshop. In 2016, the lab also launched a diversemag.com reporting system to provide an anonymous way for MagLab staff to report diversity or inclusion issues or suggest improvements.

Florida State University’s Environmental Health and Safety Department (EH&S) is providing additional leadership for safety at the MagLab. Laymon Gray, Assistant Director of FSU EH&S, became the MagLab Safety Director in 2016, providing additional support to the lab’s existing safety programs and allowing the MagLab safety team the chance to focus on supporting researchers, staff, and users on a day-to-day basis. The lab also hired an engineer into our Facilities Department as well as a safety engineer into our Safety Department to enhance the focus on safety of both of these departments.

The Bright Future Ahead...

Commissioning of the SCH will continue as the magnet prepares to provide users with the strongest field in which to perform NMR and EMR experiments in mid to late 2017.

A 75 T Duplex magnet is also nearing completion with a capacitor bank upgrade scheduled for early 2017 to enable operation of the magnet with the current 4 MJ system. Work is also continuing on a 40 Tesla-class resistive magnet that will use the full capacity of our DC magnet power supplies.

The transformational 32 T all-superconducting magnet is expected to reach full field in early 2017. Engineers are currently testing the protection system and high-current testing is scheduled to begin shortly. When completed, this magnet will provide users with a nearly 50% increase in fields available from superconducting magnets and will be the first in the world to capitalize on the work that began decades ago on high-temperature superconductors (HTS).

All MagLab user facilities and in-house research groups continue to advance their instrumentation developments and make meaningful upgrades to serve our growing user community. Please explore the detailed information available in the individual chapters that follow and across our website at https://nationalmaglab.org/.
Chapter 1

Year at a Glance
In 2016, the MagLab’s 1,778 users represented 174 universities, government labs and private companies in the United States and a total of 321 worldwide.
The MagLab’s interdisciplinary research environment brings scientists from a variety of disciplines to explore materials, energy and life.

### What Our Users Say

- **95%** of users were satisfied with performance of the facilities and equipment.
- **96%** of users were satisfied with the assistance provided by MagLab technical staff.
- **90%** satisfied with the proposal process.

Data reflects external users only. All users were surveyed anonymously.

### 2016 Users by Discipline

The MagLab's interdisciplinary research environment brings scientists from a variety of disciplines to explore materials, energy and life.

### User Diversity

- **Senior Personnel:** 52%
- **Post Docs:** 12%
- **Technicians:** 3%
- **Students:** 33%

### Users by Career Level

- **DC Field:** 578
- **NMR:** 269
- **AMRIS:** 252
- **Pulsed Field:** 148
- **High B/T:** 20
- **EMR:** 198
- **ICR:** 313

32% of students and 26% of postdocs are female.
**FINANCIAL REPORT**

**TOTAL BUDGET: $54,636,228**

- **NATIONAL SCIENCE FOUNDATION** (MagLab Core Grant only): 64% $34,660,000
- **STATE OF FLORIDA**: 24% $13,184,776
- **INDIVIDUAL INVESTIGATOR AWARDS***: 12% $6,791,452

*These are new 2016 awards from funding other than the NSF core grant and State of Florida that benefit the MagLab user program.

**RESEARCH INVESTMENTS**

- **INDIVIDUAL INVESTIGATOR AWARDS**: 12%
  - $6,791,452
- **STATE OF FLORIDA**: 24%
  - $13,184,776
- **NATIONAL SCIENCE FOUNDATION**: (MagLab Core Grant only) 64%
  - $34,660,000

**PARTNERSHIPS**

- **15 UNIVERSITIES**
- **4 SPINOFFS**
- **20 LABS & INSTITUTES**
- **56 INDUSTRY**
- **108 Cross-Sector Partners**
- **13 COMMUNITY & EDUCATIONAL GROUPS**

**NEW WORLD RECORD MAGNET**

**Introducing the Series Connected Hybrid:**
Coupling field strength and stability, this powerful new instrument promises big advances in peak field for physics, chemistry & biology research.

- **36 T**
- **1.5 GHz**
- **1 parts per million**
- **40 mm bore**
- **14 MW Power to Operate**

**ECONOMIC IMPACT**

**THE MAGLAB ANNUALLY GENERATES**

- **$182 million** in economic output
- **more than 1,560 jobs**

**OVER THE NEXT 20 YEARS, PROJECTED TO GENERATE**

- **$3.6 billion** in economic output
- **more than 31,000 jobs**

**RETURN ON INVESTMENT**

**$1 INVESTED BY THE STATE = $6.57 ECONOMIC ACTIVITY IN FLORIDA**

MagLab 2016 Annual Report
**ENGAGING THE COMMUNITY**

8,200 visitors and 6 FSU Music Department performances at 2016 Open House.

84 scientists engaged in community outreach to 4,700+ people.

1 MILLION page views to newly launched website.

---

**ENGAGING STUDENTS & TEACHERS**

More than 9,000 K-12 students participated in outreach, received a tour, or learned about the lab through a presentation.

20 students in Research Experiences for Undergraduates program across all 3 sites. 88% from underrepresented groups.

113 students in long-term mentorship, internship or camp programs. 68% from underrepresented groups.

---

**ENGAGING EARLY CAREER SCIENTISTS**

360+ lectures, talks or presentations given by MagLab staff across 20 countries.

26 participants in User Summer School and more than 730 views of the online Summer School video tutorials.

803 of the MagLab’s users were postdocs or students.

---

**MAGLAB STAFFING**

Personnel at FSU, UF & LANL includes employees funded by the NSF Core Grant or State of Florida.

Total MagLab Staff: 738

- Senior Personnel: 225
- Other Professional: 96
- Postdoc: 61
- Graduate Student: 165
- Undergraduate Student: 76
- Support Staff - Technical/Managerial: 85
- Support Staff - Secretarial/Clerical: 30

Postdocs, graduate students and undergraduate students make up 40% of the staff.

50% OF UNDERGRADS

39% OF GRAD STUDENTS

23% OF POSTDOCS

803 of the MagLab’s users were postdocs or students.

**ARE FEMALE**
Chapter 2
Laboratory Management
The Florida State University (FSU), the University of Florida (UF), and Los Alamos National Laboratory (LANL) jointly operate the National High Magnetic Field Laboratory (NHMFL or MagLab) for the National Science Foundation (NSF) under a cooperative agreement that establishes the lab’s goals and objectives. FSU, as the signatory of the agreement, is responsible for establishing and maintaining administrative and financial oversight of the lab and ensuring that the operations are in line with the objectives outlined in the cooperative agreement.

The structure of the MagLab is shown in the three figures below. Figure 1 illustrates the external oversight and advisory committees, as well as the three internal committees that provide guidance to NHMFL leadership.

Greg Boebinger is the Director of the MagLab and PI of the cooperative agreement. Together, the Director, Deputy Laboratory Director, Eric Palm, and Chief Scientist, Laura Greene, function as a team to provide management oversight for the laboratory. The Management Committee — consisting of the Associate Lab Directors, Director of CIRL, PA, EH&S Director and the Assistant Director for Business Administra-
Chapter 2 - Laboratory Management

tion — meets on a weekly basis to discuss issues of importance across the MagLab. The **Executive Committee** meets on a monthly basis to discuss lab wide issues as well as program – specific issues.

The lab’s scientific direction is overseen by the **Science Council**, a multidisciplinary “think-tank” group of distinguished faculty from all three sites. Members are: Vivien Zapf (co-chair), Theo Siegrist (co-chair), Gail Fanucci (co-chair), Luis Balicas, Zhehong Gan, Lev Gor’kov, Neil Harrison, Stephen Hill, Kevin Ingersent, Jurek Krzystek, Joanna Long (ex officio), Ross McDonald, Amy McKenna, Mark Meisel, Albert Migliori (ex officio), Dragana Popovic, Ryan Rodgers, John Singleton, Stanley Tozer, Glenn Walter, and Huub Weijers including the four chief scientists Laura Greene (Chief Scientist), Lucio Frydman (Chief Scientist for Chemistry & Biology), David Larbalestier (Chief Materials Scientist), and Alan Marshall (Chief Scientist for ICR).

Two external committees meet regularly to provide critical advice on important issues. The **External Advisory Committee**, made up of representatives from academia, government, and industry, offers advice on matters critical to the successful management of the lab. The **Users Committee**, which reflects the broad range of scientists who conduct research at the lab, provides guidance on the development and use of facilities and services in support of the work of those scientists. These committees and their 2016 meetings are further described below.

**Figure 2** shows the structure of the user program with its seven user facilities – DC Magnet Field Facility, Pulsed Magnetic Field Facility, High B/T Facility, Electron Magnetic Resonance Facility, Nuclear Magnetic Resonance and Magnetic Resonance Imaging at Florida State University and at University of Florida and Ion Cyclotron Resonance.

**Figure 2**: NHMFL User Program (as of September 28, 2016).
Figure 3 displays the internal, operational organization of the laboratory. It includes the seven user facilities, all Associate Lab Directors as well as the Office of the Director structure.

Figure 3: MagLab Organizational Chart (as of September 28, 2016).
Chapter 2 - Laboratory Management

External Advisory Committee

The External Advisory Committee met July 28-29, 2016 in Tallahassee, FL. Their report called out the success of the MagLab and provided advice in the form of recommended actions and priorities of the MagLab. This advice spanned challenges faced by budgetary constraints and the lab’s renewal in coming years. The list below shows External Advisory Committee members at the date of their 2016 meeting.

External Advisory Committee Members & Affiliations

Meigan Aronson
External Advisory Committee Chair
Texas A&M University

Chris Wiebe
User Committee Chair (ex officio member of EAC)
University of Winnipeg

Lora Hine
Director of Educational Programs for the Cornell High Energy Synchrotron Source

Magnet Technology and Materials Subcommittee

Luca Bottura
Magnets, Superconductors and Cryostats

Jeff Parrell
Oxford Superconducting Technology

Bruce P. Strauss
US Department of Energy

Biology and Chemistry Subcommittee

R. David Britt
UC-Davis

Jack Freed
Cornell University

Jean Futrell
Battelle

Gillian R. Goward
McMaster University

Robert Griffin
MIT

Condensed Matter Subcommittee

Stuart Brown
University of California, Los Angeles

Moses Chan
Penn State University

Barbara A. Jones
IBM Almaden Research Center

Stephen Julian
University of Toronto

Philip Kim
Columbia University

Junichiro Kono
Rice University

Songi Han
University of California, Santa Barbara

Carol Nilsson
University of Texas Medical Branch

Stanley Opella
UC-San Diego

Ravinder Reddy
University of Pennsylvania

Dean Sherry
UT Southwestern

Peter Littlewood
Argonne National Laboratory

Art Ramirez
University of California, Santa Cruz

Susan Seestrom
Los Alamos National Laboratory

Mansour Shayegan
Princeton University

Nai-Chang Yeh
California Institute of Technology
Chapter 2 - Laboratory Management

User Committee

The Magnet Lab’s Users Committee represents the MagLab’s broad, multidisciplinary user community and advises the lab’s leadership on all issues affecting users of our facilities. The Users Committee is elected from the user base of the NHMFL. Each facility has a subcommittee elected by its users to represent their interests to the NHMFL. DC Field and High B/T facilities have a single, combined subcommittee representing the two user facilities. Likewise, the NMR facilities at UF and FSU have a single, combined subcommittee. Pulsed Field, ICR, and EMR facilities have their individual subcommittees. Each subcommittee then elects members to represent it on the Users Executive Committee. This Users Executive Committee elects a chair and two vice chairs. The DC Field/High B/T Advisory Committee, the Pulsed Field Advisory Subcommittee, the EMR Advisory Subcommittee, the NMR/MRI Advisory Committee, and the representative from the ICR Advisory Committee met August 1-3 in Tallahassee, FL to discuss the state of the laboratory and provide feedback to the NSF and MagLab management.

User Advisory Committee Members & Affiliations

**DC Field/ High B/T Advisory Committee**

Jason Cooley, Los Alamos National Laboratory  
Nathanael Fortune*, Smith College  
Madalina Fuiris*, University of Vermont  
Malte Grosche, Cambridge University  
Zhigang Jiang, Georgia institute of Technology  

Lu Li, University of Michigan  
Philip Moll, Max Planck Institute  
Chris Wiebe*, University of Winnipeg  
James Williams, University of Maryland

**Pulsed Field Advisory Committee**

Charles Agosta, Clark University  
Kristen Alberi, National Renewable Energy Lab  
James Analytics, University of California, Berkeley  

Jamie Manson, Eastern Washington University  
Wei Pan, Sandia National Laboratory  
Filip Ronning, Los Alamos National Laboratory

**EMR Advisory Committee**

Erik Cizmar, P. J. Safaik University  
Chris Key, University College London  
Christos Lampropoulos, University of North Florida  

Dane McCamey, The University of New South Wales  
Stefan Stoll, Department of Chemistry  
Kurt Warncke*, Emory University

**ICR Advisory Committee**

Jonathan Amster*, University of Georgia  
Michael Chalmers, Eli Lilly and Company  
Michael Freitas, Ohio University Medical Center  
Elizabeth Kujawinski, Woods Hole Oceanographic Institution  

John Shaw, University of Alberta  
Forest White, Massachusetts Institute of Technology

**NMR/MRIs Advisory Committee**

Ed Chekmenev, Vanderbilt University  
O C Hee Han, Korea Basic Science Institute  
Brian Hansen, University of Aarhus  
Michael Harrington, Huntington Medical Research Institute  
Doug Kojetin, Scripps Institute  
Len Mueller, University of California, Riverside  

Marek Pruski, Ames Laboratory, Iowa State University  
Rob Schurko*, University of Windsor  
Fang Tian, Penn State University

*Members of User Executive Committee

MagLab 2016 Annual Report
Chapter 2 - Laboratory Management

Personnel

Key Faculty and Staff

As of January 3, 2017, seven hundred thirty eight people (738) worked for or were affiliated with the MagLab at FSU, UF, and LANL in 2016 compared to 716 in 2015. A list of MagLab key faculty and staff is presented below. All information in the Personnel section is as of January 3, 2017.

Principle Investigators

**Greg Boebinger**  
Director/Professor, Professor of Physics  

**Joanna Long**  
MagLab Chemistry & Biology Director and Associate Professor, Biochemistry & Molecular Biology (UF)  

**Alan Marshall**  
Ion Cyclotron Resonance (FSU)

**Charles Mielke**  
Director, Pulsed Field Facility at LANL and Deputy Group Leader

**Neil Sullivan**  
High B/T Facility (UF)

User Facility Directors

**Timothy Cross**  
Nuclear Magnetic Resonance (FSU)  

**Chris Hendrickson**  
Ion Cyclotron Resonance  

**Stephen Hill**  
Electron Magnetic Resonance  

**Joanna Long**, Nuclear Magnetic Resonance (UF)

**Chuck Mielke**  
Pulsed Field  

**Tim Murphy**  
DC Field  

**Neil Sullivan**  
High B/T

Key Personnel

Director’s Office

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
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<tbody>
<tr>
<td>Boebinger, Gregory</td>
<td>Director/Professor of Physics</td>
</tr>
<tr>
<td>Gray, Laymon</td>
<td>Director Safety &amp; Security</td>
</tr>
<tr>
<td>Hughes, Roxanne</td>
<td>Research Faculty II, Director, Center for Integrating Research and Learning</td>
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<tr>
<td>Jacobson, Thomas</td>
<td>Director, EH&amp;S FSU</td>
</tr>
<tr>
<td>Palm, Eric</td>
<td>Deputy Lab Director</td>
</tr>
<tr>
<td>Roberson, Bettina</td>
<td>Assistant Director, Administrative Services, Human Resources</td>
</tr>
<tr>
<td>Roberts, Kristin</td>
<td>Director of Public Affairs</td>
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Management and Administration

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<th>Name</th>
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<tbody>
<tr>
<td>Cordi, Thomas</td>
<td>Assistant Lab Director, Business Administration</td>
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<tr>
<td>Coyne, Sean</td>
<td>Facilities Engineer</td>
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<tr>
<td>Greene, Laura</td>
<td>Chief Scientist</td>
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<td>Hunter, Tra</td>
<td>Plant Engineer</td>
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<td>Kynoch, John</td>
<td>Assistant Director</td>
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<td>McEachern, Judy</td>
<td>Assistant Director, Business Systems</td>
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<tr>
<td>Rea, Clyde</td>
<td>Assistant Director, Business &amp; Financial / Auxiliary Services</td>
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<tr>
<td>Wood, Marshall</td>
<td>Facilities Electrical Supervisor</td>
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DC Instrumentation

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<tbody>
<tr>
<td>Dalton, Bryon</td>
<td>Scientific Research Specialist</td>
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MagLab 2016 Annual Report
### Chapter 2 - Laboratory Management

- **Hannahs, Scott**
  - Research Faculty III
- **Jensen, Peter**
  - Network Administrator
- **Powell, James**
  - Research Engineer
- **Vanderlaan, Mark**
  - Research Engineer, Cryogenic Operations
- **Williams, Vaughan**
  - Research Engineer

### Magnet Science and Technology

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<td>Adkins, Todd</td>
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<td>Bird, Mark</td>
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<td>Cantrell, Kurtis</td>
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<td>Dixon, Iain</td>
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<td>Gavrilin, Andrey</td>
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<td>Goddard, Robert</td>
<td>Scientific Research Specialist</td>
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<td>Han, Ke</td>
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<td>Lu, Jun</td>
<td>Research Faculty II</td>
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<td>Markiewicz, William</td>
<td>Research Assistant</td>
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<td>Marks, Emsley</td>
<td>Research Engineer</td>
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<td>Marshall, William</td>
<td>Sr Research Associate</td>
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<td>Miller, George</td>
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<td>Noyes, Patrick</td>
<td>Sr Research Associate</td>
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<td>O’Reilly, James</td>
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<td>Sr Research Associate</td>
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<td>Toth, Jack</td>
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<td>Van Sciver, Steven</td>
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<td>Research Faculty II</td>
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<td>Zavion, Sheryl</td>
<td>Sr Research Associate (MS&amp;T Operations Manager)</td>
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### Condensed Matter Science

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**UF**

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MagLab 2016 Annual Report
**Chapter 2 - Laboratory Management**

### Staffing and Demographics

The MagLab comprises 738 people at its three sites, who are paid by NSF use grant, State of Florida funding, individual investigator awards, as well as home institutions and other sources. Of that number, senior personnel represent the largest group at 31%, followed by graduate students at 22% and other professionals at 13%. The total distribution by NSF classification appears in **Figure 1**.

**MagLab Staffing**  
**Personnel at FSU, UF, and LANL** includes NHMFL employees paid by the NSF Core Grant or State of Florida funding, plus all Affiliated Professors, Post-doctoral Researchers and Graduate Students.

**Figure 1: MagLab Staffing - Distribution by NSF Classification as of January 3, 2017, Total Personnel: 738**

The NHMFL is committed to expanding and maintaining a diverse and inclusive organization to ensure a broad pool of highly qualified applicants for open positions to enhance our diversity efforts. Search committees are strongly encouraged to recruit minorities from underrepresented groups. Positions are advertised in venues that target women and minorities, e.g., Association for Women in Science (AWIS), National Society of Black Physicists (NSBP), etc. Additional contact is made through special subgroups of professional organizations, focused conferences and workshops. The Director's letter to each search committee chair for Senior Personnel provides guidelines for best practices to increase the recruitment of members of underrepresented groups. In addition, chairs of search committees for scientific staff meet with the Diversity Committee both before and after the search. This allows the Diversity Committee to help the search committee conduct a search that is as diverse as possible and then collects lessons learned from each committee to pass on to future search committees.
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New permanent hires in 2016: Eleven scientific senior personnel were hired (5 white males, 1 Asian male, 1 Asian female, 4 white females). Four of the senior personnel were hired as visiting faculty. Two changed from visiting faculty to permanent faculty. One is a Professor in the Physics Department. The MagLab permanent faculty are hired after an extensive recruitment. Eight Postdoctoral Research Associates were hired (1 white male, 2 white females, 5 Asian males). Additionally, we hired three STEM related employees (2 white males, 1 white female).

Overall distribution of diversity for all three sites of the MagLab includes 47.20% white males, 22.4% Asian males and females, 16.6% white females, 6.5% black or African American, 6.4% Hispanic and <1% American Indian. The total distribution by diversity appears in Figure 2.

MagLab Demographics

Personnel at FSU, UF, and LANL includes NHMFL employees paid by the NSF Core Grant or State of Florida funding, plus all Affiliated Professors, Postdoctoral Researchers and Graduate Students.

![Figure 2: MagLab Demographics - Distribution by Diversity as of January 3, 2017, Total Personnel: 738](image-url)
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Diversity and Inclusion

The National High Magnetic Field Laboratory (NHMFL) is committed to diversity and inclusion in the STEM workforce at the Magnet Lab and throughout the nation through outreach, education, and mentoring programs. To accomplish this goal, our efforts are focused on: outreach to underrepresented and underserved populations in STEM from K-early career scientists; utilizing best practices in our recruitment and hiring strategies to improve the representation of underrepresented minority groups (URGs refers to the following demographics: women and African American/Black, Hispanic/Latino/a, and Native American personnel) at the lab and in the STEM workforce; and the NHMFL is committed to creating a climate where all personnel feel that they have equal opportunities to career development and mentoring leading them to want to remain at the lab/within the STEM workforce (retention). As part of this strategic plan, the diversity committee structures its budget and subcommittees to align with these efforts.

The MagLab Diversity Committee meets every other month to discuss and review reports and issues facing the lab.

The members of the NHMFL Diversity Committee in 2016 were (new members are in bold):

- Chair: Roxanne Hughes, FSU
- Shelby Anderson, FSU
- Ryan Baumbach, FSU
- Shermane Benjamin, FSU-Graduate Student
- Gregory Boebinger, NHMFL Director
- Marcelo Febo, UF
- David Graf, FSU
- Laura Greene, NHMFL Chief Scientist
- Audrey Grockowiak, FSU Postdoc
- Felicia Hancock, FSU Diversity Staff
- Eric Hellstrom, FSU
- Steve Hill, FSU
- Jason Kitchen, FSU
- Amy McKenna, FSU
- Doan Ngyuen, LANL
- Dragana Popovic, FSU
- Bettina Roberson, FSU
- Kari Roberts, FSU
- Kristin Roberts, FSU
- Andreas Stier, LANL Postdoc
- Yasu Takano, UF
- Anke Toth, FSU
- Elizabeth Webb, UF
- Laurel Winter, LANL Postdoc
- Yan Xin, FSU

All of these members work diligently to reach our diversity mission in one and/or all three of the main areas of focus: outreach, recruitment, and retention.

---

1 30% of the MagLab staff includes students and postdocs, who will most likely not be hired at the lab but will move on to work in STEM in the US or potentially their home country. Therefore, we do have a nationwide impact.
Diversity and inclusion Outreach highlights from 2016 include:

1. The Expanding Your Horizons New Mexico Technical Career Workshop held in Santa Fe, NM in March 2016. This workshop targets middle school girls. The MagLab sponsored this event in 2016 and scientists from the Pulsed Field Facility at LANL participated. The 2016 NNM-EYH workshop boasted 264 participants from cities and pueblos all over northern New Mexico. For 81% of these participants, this was their first EYH experience. Over 80% of those polled say their attitude toward STEM fields was positively affected by their experience at the conference. Even more impressive is that close to 87% of the students attending the conference expressed that they feel more motivated to take STEM classes and over 75% have a more positive attitude towards STEM scientists and engineers. EYH 2016 reached out to underrepresented areas and demographics with an impressive (66%) participation by minorities. The workshop is also a great opportunity for female scientists/engineers at the MagLab to serve as role models.

2. The Women in Science and Engineering (WiSE) Girlz Spring Break Camp was held in March at University of Florida (UF). This camp is a graduate student run organization designed to foster STEM interest among low income middle school girls. For the third year in a row, UF hosted a spring break camp for middle school girls from Alachua County. MagLab affiliated graduate students participated in this program. It is a bare bones operation, organized and run by graduate students who donate their time.

3. For the first time, the MagLab in Tallahassee hosted a SciGirls Coding Camp in July, 2016. Computer science is one of the only STEM fields to show a decline in women’s representation since the 1980s. Best practices to change this trend advise schools and other informal education programs to make computing relevant to girls at an early age. The SciGirls coding camp invited middle and high school girls to participate in a one week camp that introduced them to Raspberry Pi, coding and computer science role models. The girls indicated that the camp improved their understanding and perception of computer science careers.
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4. The MagLab provided financial support to host Dr. Jedidah Isler (http://www.jedidahislerphd.com/) at FSU. Dr. Isler is an astrophysicist who is passionate about mentoring students, particularly women of color in STEM careers. She spoke to various student, faculty (including the FSU physics faculty), and members of the general public (including some of the MagLab’s SciGirls) during her visit in October. More information on the MagLab’s outreach can be found in Chapter 4.

Recruitment and Hiring

In 2016 the MagLab Diversity Committee compiled and reviewed the historical hiring data of STEM positions at the lab. This report highlighted that hiring committees who followed best practices – open searches and inviting more than one diverse candidate had a higher likelihood of hiring diverse candidates. The report compared hiring demographics from the years before the MagLab required members of hiring committees to participate in an implicit bias training to the years where hiring committee members did participate in an implicit bias training.

This comparison indicates that the MagLab improved its hiring of diverse candidates in the years where implicit bias training was required (We cannot report a direct causal link, only correlational.) The recommendations that came from the analysis of this data were:

1. All hiring committee members should take the Implicit Bias training.
2. Hiring committee chairs should bring in multiple candidates for interviews.
   a. The lab has many recruitment sources including membership to various organizations that reach URGs. In addition, bringing in one candidate does not help to improve the MagLab’s expertise and the quality of science. To remain competitive all hires should include multiple interviewees.
3. Hiring committee chairs should expend extra effort to recruit at least one qualified diverse candidate for these interviews.
   a. The lab belongs to multiple organizations that reach URGs and will pay for advertisements in these. These resources should be utilized by all hiring committees.

4. Hiring committee chairs should notify the Director of Public Affairs and the Diversity Committee chair of all job searches so that we can utilize our networks to advertise.
   a. Both of these individuals are aware of the best practices and venues to share advertisements.

The summary of this report was presented to the entire MagLab during the winter Director’s Quarterly Meeting as well as at an Associate Lab Director’s Meeting and an Executive Committee Meeting.

It is important for us to review hires over a period of time because the numbers of hires are so low it is difficult to determine trends year to year. Over the past two years, 2015 and 2016, we hired into eight Research Faculty positions with two of the hires being from underrepresented groups (URGs) (including females). In 2016, we hired four faculty members, and despite having applicants from URGs for three of the four positions, all of hires were white males. However, in addition to the Research Scientist faculty positions, the MagLab hired into five Visiting Scientist faculty positions. These positions include 3 hires from URGs. Depending upon future funding, MagLab management is hopeful to turn a majority of these positions into permanent positions in the future, with the expectation that the current hires will be very strong candidates for the permanent positions.

The Diversity Committee has two subcommittees that are responsible for overseeing recruitment and hiring procedures. The first of these is the Compliance Subcommittee, chaired by Jason Kitchen. Members of this subcommittee ensure that hiring committees for STEM positions follow the proper procedures outlined in the hiring committee checklist. Members review each hiring committee’s initial advertisement for new positions to ensure that the advertisements are sent to networks that reach URGs and that the descriptions follow the best practices informed by the latest research. Before hiring committees make a formal offer to a candidate, they meet (in person or via email) with the compliance subcommittee for their final review of the process. For each search committee this year, the compliance subcommittee followed these guidelines.

The second subcommittee is the Recruitment Subcommittee, chaired by Kristin Roberts, that re-
views the lab’s current recruiting practices and provides suggestions for improvement. Part of the Diversity Budget is allocated for recruitment (e.g. travel to conferences or Minority Serving Institutions). In 2016, five recruitment trips were funding by the Diversity Committee. Dr. Amy McKenna visited Grambling State University and Tuskegee University to discuss MagLab research opportunities for students and faculty there. Dr. McKenna’s previous visits to HBCUs have resulted in ongoing partnership with Morgan State University. In addition Dr. McKenna conducted a presentation about the MagLab and research opportunities at the 2016 National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE) Conference. Dr. Huan Chen also received recruitment funds as part of the visit to Grambling State University. Dr. Thierry Dubroca received recruitment travel funds to recruit potential postdocs and scientists at the National Postdoctoral Association Meeting in 2016.

Throughout the year, the Recruitment Subcommittee played a strong role in promoting specific MagLab positions on the lab’s social media sites. All positions were posted to the MagLab website and shared across Facebook, Twitter, and LinkedIn multiple times while they were active, garnering thousands of additional views and engagements from potential candidates. One post about open positions at the MagLab in July received over 100 clicks alone.

In 2016, members of the Diversity Committee (Dr. Roxanne Hughes, Dr. Amy McKenna, and Kristin Roberts) wrote and submitted a conference proposal to the National Science Foundation to host a conference for faculty and students from Minority Serving Institutions at the MagLab in Tallahassee. If funded the conference would be held in 2017. The purpose of this conference would be to bring MSI faculty and students to the lab to initiate research partnerships, improve their chances of submitting successful research proposals, and to expose students to graduate school and career opportunities at the MagLab and the participating universities: Florida Agricultural and Mechanical University, Florida State University, and University of Florida.

Retention, Advancement, and Mentoring

To fully understand the MagLab’s current climate as it applies to retention, advancement, and mentoring, the MagLab Diversity Committee compiled a historical report promotion and salary comparisons at the lab. The Promotion and Salary reports indicated that there were no inequities in the promotion process or salaries for men and women in STEM positions at the lab. In addition to these reports, the MagLab conducted its first internal Climate Survey in 2016. The results indicated that people at the lab perceive inequities in promotion and salaries for women and men. As a response to this perception, the MagLab Director discussed the Diversity Reports with the entire MagLab at his summer quarterly meeting. In addition, summaries of these reports were discussed at the Associate Lab Directors weekly meeting and an Executive Committee Meeting. The 2016 climate survey indicated that faculty at the MagLab did feel completely informed on promotion procedures. As a result, the MagLab Director held a faculty meeting in March to inform faculty of promotion procedures and create an open forum for the discussion of other issues. One issue that faculty asked for more clarification on was the User Collaboration Grants Program. As a result, the Diversity Committee compiled a report analyzing the diversity demographics and equitable distribution of UCGP funds and compared it to the diversity demographics of MagLab staff and users in the spring of 2016. The report indicated that fewer MagLab female scientists were applying for UCGP. In June, members of the Diversity Committee (Dr. Hughes, Dr. Dragana Popovic, Dr. Steve Hill, Dr. Ryan Baumbach, and Dr. Amy McKenna) met with the Director of the UCGP program (Dr. Lloyd Engel) to discuss changes that could improve the UCGP process and diversity. This meeting resulted in the following recommendations for the UCGP:

1. To eliminate misunderstandings regarding who are eligible to apply, we recommend that the website be updated with wording to make all potential applicants aware of the “plus-ups” and the variety of eligible foci for grants.
2. We recommend that new faculty be made aware early on about the program and that the website encourage applicants to contact members of the Review committee with questions that could help to make their grants more competitive.
3. We recommend that members of the Review committee review the one-page implicit bias description to help inform their choices.
4. We recommend that representatives from the UCGP review committee work with early career
applicants to help them improve their submission in the following cycle, thereby providing mentoring and professional development to improve our faculty members' and users' research. Dr. Engel is planning to institute these changes in 2017.

In an effort to improve diversity and inclusion at the lab, the Diversity Committee increased the number of sessions it held in 2016. In addition to the annual Implicit Bias training held in April, the Diversity committee also scheduled and facilitated the following:

1. In April, representatives from FSU’s Center for Leadership and Social Change came to the lab to conduct a presentation on Cross Cultural Mentoring.
2. In May, the FSU Title IX Director conducted a presentation Title IX [http://titleix.fsu.edu/Title-IX](http://titleix.fsu.edu/Title-IX)
3. In June and October, representatives from FSU conducted a Seminoles Safe Zone training – which focuses on LGBTQ+ communities [http://sga.fsu.edu/safe_zone-program-info.shtml](http://sga.fsu.edu/safe_zone-program-info.shtml)
4. In October, representatives from FSU’s Center for Leadership and Social Change came to the lab to conduct a presentation on Microaggressions

We plan to hold some of these sessions again in 2017. The Climate survey also asks for recommendations for sessions. In 2016 we also started the diversemag.com reporting system. This is an anonymous reporting system for MagLab staff to report issues or suggest improvements. One issue that was presented in 2016 came from some of our international students who suggested workshops on dealing with cultural conflicts. Dr. Hughes met with representatives from FSU’s Center for Global Engagement to discuss options. As a result of this meeting, the 2016 Climate survey included specific questions for international staff, faculty, and students to determine what specialized support they need. The FSU Center for Global Engagement is using this data to prepare training sessions for international personnel and another session for leadership and staff. In addition we included separate questions for MagLab staff who are members of the LGBTQ+ population to determine ways that we can be more inclusive to these groups.

In addition to this work, the Diversity Retention, Advancement, and Mentoring Subcommittee votes on all budget requests for retention/advancement, which include professional development travel grants and bridge funding. In 2016, six MagLab staff members were awarded professional development travel grants. Elizabeth Webb utilized these funds to attend the American Physical Society March meeting to learn more about opportunities for the MagLab to become involved in Physics outreach. The remaining awardees utilized the funds to increase the breadth of their networking through travel to discipline conferences or to collect data. These recipients included: You Lai (a graduate student), Emily Estry (an undergraduate), Daniel Suarez (an undergraduate), Huan Chen (a postdoc), and Xiaoling Wang (a postdoc).

The Bridge funding program provides support for students and postdocs as a bridge between funding sources. The requirement for all diversity funding including the bridge funding is that the funds are used to support individuals or trips that support the diversity mission in any capacity. Recipients of bridge funding in 2016 included: four undergraduate students under the supervision of Drs. Amy McKenna (FSU), Steve Hill (FSU), Dr. Jun Lu (FSU), and Dr. Yuri Corilo (FSU); and three graduate students under the supervision of Dr. Gail Fanucci (UF), Dr. Irinel Chiorescu (FSU), and Dr. Christiane Beekman (FSU).

### Diversity and Inclusion Professional Development and Advice

In addition to the internal Climate survey and other metrics (hiring, salary, user, and promotion reports), members of the MagLab Diversity Committee serve on committees that allow them to benefit from other’s expertise and share the MagLab’s successes. Dr. Dragana Popovic and Dr. Roxanne Hughes serve on the FSU Diversity and Inclusion Committee. In 2016, Dr. Popovic served on the Faculty Recruitment and Retention Working Group and Dr. Hughes served on the Student Recruitment and Retention Working Group. Both of these groups developed policies for the FSU administration to improve diversity and inclusion at FSU. These included but are not limited to: holding deans and chairs accountable for diversity demographics of their faculty and students; providing financial support for faculty mentoring, particularly for faculty of color. Dr. Hughes was selected by FSU to represent the MagLab on the FSU National Coalition Building Insti-
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tute (NCBI) Leadership team which participated in a two-day training in September. NCBI is an international non-profit leadership development network dedicated to the elimination of racism and other forms of oppression. The program is rooted in an understanding of individual, community, and systemic change. NCBI leaders work with public and private organizations to further cultural competence, collaboration and partnerships, and effective relationships within and across group identities (http://ncbi.org/). The leadership team at FSU will begin training faculty, staff, and students in 2017 in effective techniques for improved communication and coalition building that can result in more inclusive and diverse climates. In addition to this program, Dr. Hughes attended the ADVANCE Conference held at the University of Delaware which focused on best practices for the recruitment and retention of women of color as STEM faculty.

The MagLab also utilizes an External Advisory Committee who reviews our policies and procedures. In 2016, this committee reviewed our strategic plan for the next grant cycle and provided feedback that we utilized for the final strategic plan which was presented to the NSF Renewal Site Visit team. The members of our External Advisory Committee in 2016 were:

- C.J. Bacino, LANL Diversity Director
- Susan Blessing, FSU Physics Professor, Women in Math, Science, and Engineering Living and Learning (WIMSE) Director
- Alberto Camargo, Diversity Program Manager, Argonne National Laboratory
- Chamane Caldwell, Diversity and Inclusion Coordinator for Florida Agricultural and Mechanical University-Florida State University College of Engineering
- Simon Capstick, FSU Physics Professor
- Donna Dean, Tulane University School of Science and Engineering retired, Research focuses on improving mentoring for women
- Ted Hodapp, American Physical Society Director of Education and Diversity
- Keisha John, Director of Diversity Programs, Graduate and Postdoctoral Affairs, University of Virginia
- Michelle Douglas, Florida State University Director of Equal Opportunity and Compliance
- Nancy Marcus, FSU Dean of Graduate School
- Karen Molek, University of West Florida, Chemistry Associate Professor
- Bob Parks, Director of University of Florida Training and Organizational Development

Plans for 2017

In 2017, the Diversity Committee plans to update the Implicit Bias training to make it more interactive. Dr. Hughes plans to meet with faculty at FSU who specialize in STEM student and faculty recruitment and retention best practices to develop this new training. Dr. Hughes will be working closely with FSU's NCBI team to conduct trainings for MagLab staff and faculty. Dr. Hughes is working closely with faculty at FSU and FAMU to submit an NSF ADVANCE grant in 2017 to improve the recruitment and retention of women faculty in STEM departments.
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Safety

A central focus of all National High Magnetic Field Laboratory (MagLab) is to ensure employees, users, and visitors are provided with a safe and educational environment. The MagLab’s Environmental, Health, and Safety team works collaboratively with management, researchers, staff and users, as well as with other public and private entities, to proactively mitigate hazards in our industrial, laboratory and office settings.

Safety Team Transition

During 2016 a strategic transition occurred with the MagLab Safety team. The Florida State University’s Central Environmental Health and Safety Department (EH&S) located on the main campus assumed responsibility for safety at the MagLab. This change provides substantial new support to existing safety programs at the MagLab. The MagLab Safety Team now has additional program support in areas of Chemical Safety and Environmental Compliance, Laboratory Safety, Biological Safety, Radiation Safety and Industrial Hygiene. This transition allows the Safety Team at the MagLab to provide greater focus and support to researchers, staff, and users on a day-to-day real-time basis. Enhanced areas of program support are highlighted below. These activities are coordinated with the MagLab Safety Team.

Chemical Safety

The Chemical Safety Office performs chemical and hazardous waste pick-ups and hazardous waste management support. Waste pick-ups are now scheduled by phone or through an online system. Additionally, hazardous waste that is picked up is now stored in the Southwest Campus 90 day storage facility until shipped. The Chemical Safety Office also provides chemical safety support to the MagLab.

During 2016 the Chemical Safety Office provided assistance with the removal of an acid neutralization tank associated with the MilliKelvin Building Construction project and the recharge of a second. The Chemical Safety Office provided specific training on the use and disposal of Nital and Hydrofluoric acid to researchers.

Biological Safety

The Biological Safety Office works closely with researchers and users to ensure work with Biosafety Level 2 (BSL-2) materials is in accordance with the regulation and safety guidelines set forth by the Centers for Disease Control and Prevention and the National Institutes of Health. This support includes reviewing research proposals related to biohazardous materials, establishment and setup of BSL-2 facilities, biohazardous-waste disposal, and biosafety training.

The Biological Safety Office assisted with the review and update of the MagLab’s Automatic External Defibrillator and Sharps Programs, and provided guidance for stocking first aid kits.

The Biological Safety Office conducted equipment inspections and vertebrate animal medical monitoring for researchers and users. Safety equipment inspections include annual inspections of fume hoods, eyewashes, safety showers, and biosafety cabinets, as well as any additional inspections requested by researchers and users or following maintenance or repairs of laboratory equipment. The Biological Safety Office also provides guidance on new installation and renovation projects as they pertain to safety equipment.

Laboratory Safety

The Laboratory Safety Office inspects all laboratory spaces at the MagLab biannually. Inspection findings are provided to each laboratory including positive feedback for safe practices observed. The Laboratory Safety Office provides real-time guidance to researchers during the inspections concerning needed corrective actions.

The Laboratory Safety Office also provides guidance to researchers and users who require the use of controlled substances in their research and consultations concerning occupational exposures risk in the laboratory.

Radiation Safety

The Radiation Safety Office manages the Laser Safety Program at the MagLab. This includes the registration and inspection of laser producing devices and assisting with new equipment setup. The Radiation Safety Office oversees the Laser Safety Committee and is responsible for biennial meeting coordination, management of inventory and procedure audits.

The Radiation Safety Office serve as subject matter experts for any experiment or procedure involving radiation, x-rays, or laser beams. This includes
regulatory support related to the use of radioisotopes including radioactive materials permitting, monthly use area surveys, maintenance and calibration of radiation detection equipment, personnel dosimetry, and support of research involving the use of radioactive materials.

**Investments**

Our investments in safety equipment and materials along with management support and employee involvement illustrate our commitment to sensibly utilize resources in a manner that protects all MagLab personnel, property, and the environment.

In 2016 the MagLab strategically invested over $50,000 for safety related equipment, supplies, training, and processes along with $150,000 for additional equipment in all active magnet cells that allow a double block and bleed Lock/Tag/Verification of the magnet cooling water system during maintenance activities. The project installed pin devices on existing valves in all 16 magnet cells, and additional valves on all active magnet cells. The pin devices were installed on maintenance Mondays utilizing existing facilities and operations employees. The majority of the secondary valves were installed during the fall resistive magnet operational shutdown.

**Safety Survey 2016**

In order to gauge the continued effectiveness of the Safety program and the overall attitude toward safety, the MagLab conducted its Annual Safety Survey. The data from over 200 respondents provided reliable and measurable feedback. The results of the 2016 Safety Survey indicate a favorable climate for the Integrated Safety Management (ISM) process and our EH&S program.

The MagLab continues to foster a sustainable and strong Safety Culture. Some examples of the activities that contribute to a favorable safety climate and commitment to a strong Safety Culture are listed below.

- Safety is viewed as an investment not a cost.
- Management drives and is actively involved with promoting our Safety Culture.
  - Quarterly Safety Meetings are conducted by the Director of the MagLab to address lab wide safety issues and initiatives.
  - The Director of the MagLab and Director of Safety conduct weekly walkthroughs of lab areas to engage researchers, staff, and users, and to observe ongoing work.
- New Employee Orientation is provided to all incoming employees with specific emphasis on our Integrated Safety Management System. New employees are taught that safety is the top priority at the MagLab, to have a questioning attitude about their safety, our Stop Work Policy, and no fault self-reporting near miss and accident Policy.

**Committees**

**Safety Committee**

The MagLab Safety Committee met monthly to discuss updates to safety programs and procedures, safety concerns and actions taken or proposed to mitigate hazards associated with those concerns and planning. During 2016 several committees were formed to address specific safety issues.
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Lock/Tag/Verification Committee
The Committee was established to review and update the MagLab’s Lock/Tag/Verification Program. This Program covers all personnel as well as contractors who may come in contact with ANY form of hazardous energy. The following improvements were made to the Program.

- Established a more robust process for the identification, isolation and control of all hazardous energy sources.
- Established Site Superintendent and Controlled Access requirements. The Site Superintendent is used for complex jobs with multiple workgroups to ensure safe coordination of all activities. The Controlled Access procedure is used to control a work area when only one group is involved.

Integrated Safety Management Committee
The Committee was established to review and update the ISM system and establish a more robust work control over all hazardous work activities. A Task Hazard Analysis Worksheet was developed that is used to plan work tasks. The THA provides a matrix that considers the complexity and worker’s experience when determining the potential consequences.

New Employee Safety Committee
The Committee was established to review and update new employee orientation. The new employee orientation process will now include a Safety mentor. The Safety Mentor will work with the new employee to review hazards specific to their work area. The Safety Mentor will be available to assist with training and will introduce the new employee to the entire lab. The formal mentorship will end when the new employee demonstrates an understanding of safe work practices, has completed training on procedures specific to their work and demonstrated the ability to complete work tasks safely. This commitment to the new employee will also ensure the continued growth and support of the MagLab’s Safety Culture.

Safety Highlights

Equipment Upgrades to Magnet Cells
An engineering design review of the energy isolation system in Cell 14 was performed to determine if adequate controls were in place to mitigate hazardous energy concerns.

Based on the results of the review, engineering upgrades were installed in Cell 14 to allow for safe construction and maintenance activities to be performed while the master cooling water (MCW) system is energized.

The upgrades included installation of the following:

- Pin locking valve control device (allows the existing control valve to be locked).
- Secondary lockable high performance butterfly valve.
- Vents, drains, and pressure/temperature gauges on all supply and return piping.

Upgrades to the isolation system allow workers to secure the isolation valves between the MCW system and the magnet, and verify no hazardous energy is present. Cells 14 and 5 were retrofitted in early 2016. All other active cells were retrofitted during the winter shutdown period. These modifications ensure that an effective LTV is achieved.

Emergency Action Preparedness for Hurricane Hermine

Hurricane Hermine (a Category 1 hurricane) made landfall in Florida’s Big Bend area early Friday September 2, 2016. This was the first hurricane to make landfall in Florida in more than 10 years. Seven days prior to landfall, the MagLab activated its Natural Disaster Preparedness Emergency Action Plan (EAP).

As part of the EAP, key personnel from each department met daily. Departments reviewed their specific preparedness plans for shut down and began taking actions to secure areas and equipment.
Current and scheduled users were notified of the impending storm. Possible travel disruption issues were addressed along with information concerning sheltering in place, rescheduling of magnet time, evacuation plans and local emergency services.

Critical areas of concern such as cryogens, fuel for backup generators, computer support and overall security and safety at the MagLab were addressed.

The effective implementation of the EAP was key to ensuring safety of personnel and users, and in reducing overall impacts to operations. As a result of careful preparation, no significant damage occurred to MagLab facilities and magnet operations were suspended for only two and a half days.

**Annual Maintenance Shutdown**

The MagLab’s Integrated Safety Management (ISM) process was utilized to carefully plan and coordinate work assignments among MagLab workgroups and external contractors for the MagLab’s annual maintenance shutdown.

Servicing the MagLab’s Uninterruptible Power Supply involved work on high-voltage (>400V) battery banks, which required the development of specific procedures to account for both electrical and chemical hazards. Due to the hazards that needed to be effectively mitigated, an energized work permit was required that included prior approval from both the MagLab Safety Department and Director’s Office.

To enhance safety of the high pressure magnet cooling water (MCW) system, the MagLab completed installation of double block and bleed valves in all active user cells. Installation of these valves allows each user magnet to be safely and individually isolated from the MCW system as part of the Lock/Tag/Verify (L/T/V) process now required for individual DC magnet repair or maintenance.

Employees replaced several hundred pneumatic disconnect/reversing switch hoses during the shutdown, many of which were over 15 years old. Replacement of the hoses will ensure greater reliability of electrical switching systems that distribute power to magnet cells.

Although there were numerous inter-dependent work processes involved with the shutdown, the MagLab’s ISM process provided the careful planning and coordination that ensured that all employees and contractors safely completed their assigned work activities without incident.
Budget

Table 1: Summary Proposal Budget January - December 2016

<table>
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<th>NSF - Funded</th>
<th>Funds Requested by</th>
<th>Person-months</th>
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<td><strong>A.</strong> (60) TOTAL SENIOR PERSONNEL</td>
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<td>6. (0) OTHER Temporary</td>
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<td><strong>C.</strong> FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)</td>
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<td><strong>D.</strong> EQUIPMENT</td>
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<td><strong>I.</strong> INDIRECT COSTS</td>
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</table>

The primary funding source for operation of the seven user programs of the National High Magnetic Field Laboratory (NHMFL) remains the National Science Foundation (NSF) and funds provided through the participating institutions: the Florida State University, the University of Florida, and the Los Alamos National Laboratory.

According to the NHMFL Program Officer, funding for FY 2016 will be dispersed in multiple increments. If the funding increments can be held to two increments, the NHMFL will be able to better maintain uninterrupted user program operations and efficient use of finite resources and staffing. Optimal use and timing of expenditures...
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will require careful planning for personnel, equipment, materials and supplies, travel, sub-awards, and electricity. Specific rationale for the 2016 budget follows:

A. Personnel

The current level of staffing is required for the Lab to maintain user support, technology development, and science (NHMFL User Collaboration Grant Program) activities. Actual salary rates, plus a 3% increase, of existing NHMFL Staff have been used in the cost calculations. Florida State University’s fringe benefit rates for permanent staff fluctuate depending on the benefit package chosen by the staff member. Therefore, an average fringe benefit rate of 34.85% is used to calculate the cost of fringe benefits for permanent staff. This rate includes social security, Medicare, health insurance, retirement, workers comp, and terminal leave payout. FSU’s fringe benefit rate for postdocs and non-students is 1.95% plus the cost of health insurance. The fringe rate for Graduate and Undergraduate Students is 0.50% plus the subsidy for health insurance for Graduate Students of either $850 or $1,500 per FSU policy. In accordance with state law, Florida State University is providing health insurance coverage to OPS employees working 30 hours or more per week. The annual rate for family insurance is $15,169 per employee while individual coverage is $7,098 per year.

Since the NHMFL is a large, complex, multidisciplinary user facility, there is a requirement for a larger than normal level of research and non-research support staff. The faculty included in the budget are twelve (12) month specialized research faculty (not tenured or tenure track nine (9) month teaching and research faculty). Therefore, the effort of these research faculty and the effort of other research and administrative staff identified in this proposed budget exceed the NSF two month limitation associated with regular tenure/tenure track nine (9) month teaching faculty.

Due to the mission of the NHMFL, a higher level of administrative support is required to insure successful operation of the facility. The primary responsibility of the NHMFL’s administration is to ensure compliance with the terms and conditions of our sponsored project while facilitating the day-to-day work for our users and scientific staff. The NHMFL is an extension of Florida State University.

Because of the requirements of the NSF Cooperative Agreement, the administrative staff exceeds the level of staff routinely provided by the university. To insure performance, the staff offers direct, on-site services to the user and research community. The administrative staff is responsible for a core set of activities including budget and finance; accounting; purchasing, shipping, and receiving; human resources; facilities management and engineering as well as safety, security, and environmental protection. In addition to central departments and activities, the user divisions have a Program Associate to support and facilitate the non-science related tasks required to ensure that the user program’s operational needs are met. The services being provided by administrative staff are accrued solely for the benefit of the NHMFL core mission and exclusively support the NSF Cooperative Agreement. The total FTE required for administrative, secretarial, and clerical services to directly support this NSF project is 9.16. The total administrative staff is comprised of 3.46 FTE in Secretarial/Clerical staff and 5.70 FTE in administrative staff classified as Other Professionals.

B. Equipment

Equipment funds will be devoted to mitigating equipment failures, purchasing new and updated equipment for the User Programs, and new Magnet technology. Within the five years of this grant, the overwhelming majority of equipment funds represent essential expenditures to maintain and enhance User Support.

Anticipated major equipment purchases are listed below by MagLab division. Note the total for the equipment listed below is more than our budget for equipment purchases.

A portion of the equipment funds will be allocated to needs that arise throughout the project that cannot be specifically determined at this date. This need is based on historical experience in having to address unanticipated needs throughout the project period. We believe this to be a conservative estimate to cover those needs that will arise.

Throughout the year, equipment purchases will be approved based upon users’ scientific needs and the progress of major projects. Our highest priority is to continue to maintain the highest quality of User Science.
## Table 2: NHMFL Specifically Budget Equipment

### Magnet Science and Technology

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Split Magnet Rotation</td>
<td>350,000</td>
</tr>
<tr>
<td>Pulsed 100T Wire Conductor</td>
<td>150,000</td>
</tr>
<tr>
<td>Large Bore Resistive Magnet</td>
<td>55,000</td>
</tr>
<tr>
<td>28MW Magnet</td>
<td>1,050,000</td>
</tr>
<tr>
<td>32T Coil and System Integration</td>
<td>21,000</td>
</tr>
<tr>
<td>YBCO Tape for 40T Magnet</td>
<td>500,000</td>
</tr>
</tbody>
</table>

### Applied Superconductivity Center

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Gravimetric Analysis/Differential Thermal Analysis System</td>
<td>60,000</td>
</tr>
<tr>
<td>Vibrating Polisher</td>
<td>7,000</td>
</tr>
<tr>
<td>Diamond Saw</td>
<td>9,000</td>
</tr>
<tr>
<td>Keithley 2182 and 2440 Source Meter</td>
<td>8,000</td>
</tr>
<tr>
<td>Leak Detector</td>
<td>25,000</td>
</tr>
</tbody>
</table>

### DC Field Facility

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keithley 2450 Source Meters</td>
<td>15,000</td>
</tr>
<tr>
<td>Lockin Amplifiers SR124</td>
<td>14,000</td>
</tr>
<tr>
<td>LakeShore 372 AC Resistance Bridge</td>
<td>19,000</td>
</tr>
<tr>
<td>Current and Voltage Preamps</td>
<td>20,000</td>
</tr>
<tr>
<td>Voltmeters/Electrometers</td>
<td>20,000</td>
</tr>
<tr>
<td>Lockin Amplifiers SR 865</td>
<td>24,000</td>
</tr>
<tr>
<td>Microscopes</td>
<td>24,000</td>
</tr>
<tr>
<td>Power Conditioners</td>
<td>20,000</td>
</tr>
</tbody>
</table>

### Nuclear Magnetic Resonance

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 GHz Digital Oscilloscope</td>
<td>25,000</td>
</tr>
<tr>
<td>Gyrotron Chiller</td>
<td>15,000</td>
</tr>
<tr>
<td>500-1000 MHz 500W Amplifier</td>
<td>38,000</td>
</tr>
<tr>
<td>FTS Unit</td>
<td>20,000</td>
</tr>
</tbody>
</table>

### Ion Cyclotron Resonance

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pumping Speed Turbo-Molecular Pumps (2)</td>
<td>70,000</td>
</tr>
<tr>
<td>Atmospheric Pressure Ion Mobility Source</td>
<td>80,000</td>
</tr>
<tr>
<td>RF Drivers for Multipoles</td>
<td>50,000</td>
</tr>
</tbody>
</table>

### Electron Magnetic Resonance

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>340 GHz High Power Source for Pulsed Spectrometer</td>
<td>50,000</td>
</tr>
<tr>
<td>400 GHz Microwave Source for the Homodyne Spectrometer</td>
<td>65,000</td>
</tr>
<tr>
<td>Microwave Source Replacement for the Bruker Machine</td>
<td>14,000</td>
</tr>
<tr>
<td>115 GHz Multiplied Source</td>
<td>25,000</td>
</tr>
<tr>
<td>170-260 GHz Frequency Doubler</td>
<td>7,000</td>
</tr>
<tr>
<td>Nd-YAG Laser Flashlamp Replacement</td>
<td>5,000</td>
</tr>
<tr>
<td>Laser Head with Power Supply (Innolas)</td>
<td>28,000</td>
</tr>
<tr>
<td>Mossbauer Gamma Source</td>
<td>8,000</td>
</tr>
<tr>
<td>100L Liquid Helium Dewar</td>
<td>5,000</td>
</tr>
</tbody>
</table>
C. Travel

Travel budget levels are required to maintain a basic level of user support, technology development and science activities. Total dollars of $236,511 are requested for domestic travel while $38,261 is requested for foreign travel. Based on conference attendance and research performed in the past, the following expenditures are anticipated for travel to the following countries in 2016:

Scientific Conferences held in the United States, United Kingdom, China, Netherlands, France, Greece, Japan, India, Turkey and Spain.

Workshops held in in the United States, United Kingdom, Netherlands, and France.

Research held in the United States, United Kingdom, France, and Spain.

D. Participant Support – Stipends

Research for Undergraduates:

This item is an estimate of the budget required to support the Research Experience for Undergraduates (REU) Program. Although students are recruited from across the United States, the requested funding is an estimate. If participants include students from FAMU or FSU (local students), housing and travel expenses are not incurred. This creates the flexibility to support more students than originally anticipated.

This summer internship program matches qualified undergraduate students with scientists and researchers at the NHMFL’s three sites. The eight-week research experience offers unique opportunities to explore science at the extremes of magnetic field, pressure and temperature. Students explore contemporary science and engineering issues, working alongside some of the finest scientists, magnet designers and engineers in the world. Each student accepted by the program receives a stipend, and, if necessary, travel support and housing.

The NHMFL offers a wide range of science, math, engineering, and interdisciplinary experiences in physics, chemistry, biological sciences, geochemistry, materials science, and magnet science and engineering. Summer interns, working closely with their faculty mentors, are thoroughly integrated into these research and development activities. Students broaden their knowledge of the diverse research that takes place here by attending weekly seminars and colloquia.

In 2015, there were 26 students, 10 males and 16 females. Of the 26 participants, 14 were minorities. Examples of student projects may be seen on the NHMFL website at https://nationalmaglab.org/education. In 2016, the goal is to continue our efforts to increase the number of students from underrepresented groups including women, African Americans, and Hispanic students. A special effort will be made to recruit students from HBCU, colleges and universities that serve a large percentage of African Americans, Hispanic, and other underrepresented students.

Costs: Approximately $5,200 per student – includes $3,600 stipend; $1,000 housing; $600 non-local travel; and a program total of $2,158 for mentors to purchase various supplies required for scientific experiments. Excess travel allowance not paid to local participants enables the lab to utilize these funds to increase the number of participants. The total amount of funds requested to support the REU program is $106,158 based on twenty participants.

Research for Teachers:

The Research Experience for Teachers (RET) Program is a six week summer residential program that gives K-12 teachers the chance to participate in the real-world science of cutting-edge magnetic field research. Through various program activities, the teachers develop strategies and resources to translate the experience into material for their classrooms. In 2015 there were 10 teachers, 6 males and 4 females. Of the 10 participants, 6 were minorities.

The cost of the program is approximately $5,200 per teacher which includes a stipend, housing, and non-local travel. The funding for the RET Program will be split between the NSF budget and other university funding. NSF funds will be used for stipends, while all other expenses will be covered by funds from other sources.

E. Other Direct Costs: Materials and Supplies

Approximately 1,442 scientists annually request ‘magnet time’ for performing research and subsequently publishing the results of their research in premier scientific journals. Other Direct expenses are necessary due to the complexity of operating and maintaining a large, international user facility while supporting the development of new magnet technology for the science communi-
Chapter 2 - Laboratory Management

ty. In many cases these items may be charged to another source; however, since the NHMFL is a NSF funded user facility, these charges are directly related to the scope set forth in the Cooperative Agreement.

The FY 2016 budget for direct expenses remains the same as the total for direct expense for FY 2015.

Specific purchases in this category include but are not limited to:

- Helium and nitrogen are required components for the operation of the assorted magnets located within the lab. These commodities represent a significant amount of the materials and supplies budget.
- Computer hardware and software which are dedicated to or support scientific instrumentation in the user facility or are required for experiment control, data acquisition, or scientific analysis. As a user facility, the NHMFL supports a variety of computing systems and services for international, academic, and government researchers which require computing hardware and specialized software. These costs are necessary to support the operations of a user facility and can be identified readily with the NSF Cooperative Agreement.
- Instrumentation and lab equipment such as voltmeters, current sources, thermometers, pumps, glassware, tape, etc. are required for various labs used by researchers and users.
- Chemicals and raw materials such as acids and bases, reagents, metal, plastics, etc. are required for researchers to conduct their research.
- Safety equipment such as safety glasses, gloves, fall protection, harnesses, electrical safety gear, etc. These items are required to insure the safety of the staff.
- Postage expense is used for activities required by the NSF Cooperative Agreement such as: MagLab Reports and other research reports to national and international users and prospective users and other documents deemed necessary to meet the needs of our users and to further our commitment to education, research, and learning. In order to support education at all levels, K-12, technical, undergraduate, graduate and postdoctoral, the dissemination of educational materials through the mail becomes greater than customary in an academic department. These mailings are readily identifiable and significantly exceed the level of postage normally associated with other sponsored projects.

F. Sub-Awards

The proposed level of funding is required to maintain the level of operations for the AMRIS, High B/T and Pulsed Magnet User Programs that promote magnet-related research for the scientific user community. Detailed budgets and budget justifications for each individual division reflect their specific spending plan.

A sub award to Steven Beu, Consultant, will be funded from the Ion Cyclotron Resonance (ICR) User Program fund. As in the past five years, Dr. Beu will continue to consult with the ICR Program on the development of new ion transfer optics and techniques for improved ion transmission and decreased time-of-flight mass discrimination in FT-ICR mass spectra.

G. Other Direct Cost

Electricity – Funds to cover part of the electrical costs for magnet use is requested. This cost is an extraordinary cost for electrical power and represents unlike circumstances since the magnets require large amounts of electricity to operate. The electrical costs attributed to the magnet operation, which has been direct charged to the NSF Core since NSF first began funding the lab, is not included in FSU’s indirect cost but has been treated as other direct costs charged to grants and included in our research base when preparing our F&A rate proposal. These costs represent unlike circumstances because the electrical power does not support the general power needs required of all buildings and labs, i.e. overhead lights, small office and lab equipment, room heating and cooling, etc. The electrical power usage for the magnet operation is separately metered from other normal electrical demands. Because the magnet operations require such a huge amount of power, this is a cost directly required in order to support a user facility. The amount of available user time will be impacted without these funds to assist in covering the costs of magnet operations. The total electricity budget for FY 2016 is $2,645,323 of which $1,800,000 is a part of the NSF budget. The budget was based on the average cost of electricity over the last few years. Funds received from FSU in
the amount of $845,323 will be used to subsidize the cost of electricity. At this time we do not expect an increase in the rates for electrical power from the City of Tallahassee.

Florida State University receives two power bills each month. One is the Electric Contract (Interruptible) and the other is the Electric Large Demand (Firm). These bills are generated from two different sets of meters. The electrical system is segregated into (1) the power required to run the high power DC Field magnets (Interruptible) and (2) all power that is for general building operations (lighting, heating and cooling, computers and any scientific equipment (Firm). For the magnets (Interruptible) the NHMFL has a special rate, since the City of Tallahassee can contact the lab and interrupt the power for magnets if the need occurs. Florida State University pays for the Electric Large Demand (Firm) from university funds, while the Electric Contract (Interruptible) is paid with NSF funds since that electricity is directly used for magnet operations.

Tuition - Florida State University policy requires that In-State tuition waivers be paid and tuition rates do not include student related fees. For FSU FY 2016-2017, the tuition rate per hour is $466.30. Graduate students are required to be enrolled for nine hours each semester. The cost of tuition for nine hours per semester is $4,197. These costs, which are the standard tuition rates for FSU, were used to calculate the tuition for each Graduate Student based on the length of their appointment. The total cost of tuition for Graduate Students for FY 2016 is $62,950. Tuition rates and annual increases are set annually by the Florida Legislature and the Florida State University Board of Trustees. The current approved rate of increase is 7.5% per year.

User Collaboration Grant Program (UCGP) – The National Science Foundation has charged (through the Cooperative Agreement) the NHMFL with developing an in-house research program that utilizes the NHMFL facilities to carry out high quality high field research at the forefront of science and engineering; and advances the NHMFL facilities and their scientific and technical capabilities. To this end, the NHMFL’s Users Collaboration Grants Program seeks to achieve these objectives through funded research projects of normally 2 years duration in the following categories:

- Collaborations between internal and/or external investigators that utilize their complementary expertise;
- Bold but risky efforts which hold significant potential to extend the range and type of experiments;
- Initial seed support for new faculty and research staff, targeted to magnet laboratory enhancements.

The UCGP strongly encourages collaboration between NHMFL scientists and external users of the NHMFL facilities.

Funds in the amount of $650,000 have been designated to support UCGP funding for FY2016.

H. Indirect Cost

Per the Florida State University’s Indirect Cost Rate Agreement, the approved indirect cost rate for NHMFL awards is 70% modified total direct costs (MTDC).

UF High B/T Facility

A. Personnel

Neil S. Sullivan (0.5 summer months) is the Director of the High B/T Facility and is responsible for the overall operation of the Ultra-Low Temperature program of the NHMFL. He is a full-time professor of physics at the University of Florida and also directs the University of Florida Microkelvin Laboratory in which the High B/T facility is located.

Chao Huan (12 calendar months) is a research scientist who operates Bay 2 of the Microkelvin Laboratory for external users. He is directly responsible for coordination with new users and the planning of experimental cells for installation on the nuclear demagnetization refrigerators.

Alessandro Serafin (12 cal) is a postdoctoral fellow who leads the development of new instrumentation for users and who also assists the UF-NHMFL staff in the design and setup of experiments for users.

A graduate student will be appointed part-time to develop specialized radio-frequency detectors using tunnel diodes as detectors that can operate in a high magnetic field at very low temperatures. The new instrument will be used for magnetic susceptibilities at very low temperatures.
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B. Equipment
We have budgeted $35,000 for the purchase of new equipment in the High B/T facility to support advanced instrumentation for the NHMFL external user program. This includes a new high circulation pump for helium-four (estimated $21,000) and a new radio-frequency power amplifier (estimated $14,000).

C. Travel
We have budgeted $3,000 for domestic travel. This includes partial support to assist 2 people to attend the March Meeting of the American Physical Society to be held in Maryland, USA in 2016. Also budgeted is $3,000 for international travel to partially support attendance at the International Quantum Fluids and Solids Symposium to be held in Prague, Czech Republic in August 2016.

D. Materials & Supplies
We have budgeted $82,871 in materials and supplies. The principal cost is that for liquid helium which is provided at a cost of $2.50 per liquid liter and we are budgeting for 25,000 liters for operation of Bay 2, Bay 3 and the fast turn-around facility for at least 300 days of the twelve month period for a total cost of $62,500. In addition we have budgeted $20,371 for small items such as tools, small electronic components, vacuum and gas plumbing, and miscellaneous supply items.

E. Indirect Costs
The University of Florida charges 50% indirect costs on the total of direct charges minus equipment costs.

F. Fringe Benefits.
The fringe benefits at the University of Florida are 25.7% for faculty (professorial faculty and research scientists) and 14.9% for postdoctoral and graduate student appointments.

FY 2016 BUDGET JUSTIFICATION
UF AMRIS Facility

A. Personnel
Joanna Long (3.0 cal) is AMRIS Director and Co-PI of the subcontract and is responsible for the overall operation of the AMRIS user program, distributing the NHMFL supply money to pay for AMRIS fees, and annual reporting. She also directs the dynamic nuclear polarization technology program to enhance the NHMFL external user program. She has 3 months total effort, divided into 1.8 months for AMRIS and 1.2 months for the DNP initiative. Thomas H. Mareci (1.2 cal) is the AMRIS Associate Director and directs the high field structural MRI program and MRI technology development to enhance the NHMFL external user program. Matthew E. Merritt (1.2 cal) directs the high sensitivity NMR technology program to enhance the NHMFL external user program. Glenn Walter (1.2 cal) leads the molecular imaging technology program to enhance the NHMFL external user program and serves on the Science Advisory board. Gail Fanucci (1.2 cal) is a member of the Science Advisory board and develops technology in the DNP program; she is also the UF liaison between the EMR and NMR groups of the NHMFL. Steve Blackband (0.6 cal) leads the microimaging technology program to enhance the NHMFL external user program. Marcelo Febo (0.6 cal) leads the functional MRI program to enhance the NHMFL external user program and serves on the diversity committee. Denise Mesa (3.6 cal) is responsible for the reporting and secretarial activities necessary to run the NHMFL external user program. Malathy Elumalai (12 cal) is the RF engineer responsible for designing, constructing, testing, and maintaining unique RF coils for the horizontal animal imaging systems and the WB 750 system within the AMRIS facility as well as coordinating with new RF projects pursued by the NMR probe development group in Tallahassee. Funds for this position are requested under “materials and supplies” due to this position falling under the AMRIS auxiliary.

B. Equipment
We have budgeted $100,000 each year for the purchase of new equipment in the AMRIS facility to support the NHMFL external user program. This includes equipment for 8 spectrometers, an RF engineering laboratory, and staff scientists. Typical items include new RF or gradient amplifiers, new NMR probes, RF frequency generators, computer workstations, network analyzers, and animal monitoring equipment. In FY 2016 we plan to direct these funds to upgrading the digital and RF electronics on our world unique 11 T / 40 cm MRI/S system.
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C. Travel

1. The travel budget in the NHMFL subcontract includes funds for the NHMFL investigators affiliated with the AMRIS facility to travel to the requisite annual meetings for the NHMFL. NSF site visit, the Users Committee meeting, an internal strategic planning meeting, and the External Advisory Committee meeting. Each of these is estimated at $400 per person to cover two nights hotel, the meeting registrations, and travel to Tallahassee from Gainesville. Two people, four meetings total $3,200.

2. We cover the costs of three of the members of the Users Committee (non-NHMFL investigators) to travel to the annual Users Committee meeting. Each of these is estimated at $1,000 to cover airfare, two-three nights hotel, and meeting registration. This totals $3,000.

3. Drs. Long, Mareci, and Febo also make about four trips per year to the NSF, labs the NHMFL is collaborating with, HBCUs for outreach activities, and vendors to discuss designs and specifications. Each of these trips is estimated at $750 per person to cover airfare, one night hotel, and meals. Four trips total $3,000.

4. Drs. Long, Mareci, Merritt, Blackband, Walter, Febo and Fanucci travel to Tallahassee for face-to-face meetings as needed with NHMFL colleagues. Most communication is through email and skype, but approximately 10 trips per year total are made. Each of these trips is estimated at $250 for one person to cover hotel, meals, and transit to Tallahassee. This is a total of $2,500.

5. Both Dr. Long and Dr. Merritt will attend the Experimental NMR Conference to publicize technical developments at the NHMFL and our user program. The AMRIS RF engineer, Malathy Elumalai, will also attend this year to present new capabilities developed for high field animal imaging. This is the premier conference of the NMR community in the U.S. This year the conference is in April in Pittsburgh, PA. Each person is estimated to cost $2,000 for airfare, registration, hotel and meals. This is a total of $6,000.

6. Drs. Mareci and Walter will attend the 24th Annual Meeting of the International Society for Magnetic Resonance in Medicine to publicize technical developments at the NHMFL and our user program. This is the premier international conference of the MRI community. This year the conference is in May in Singapore. The cost for this conference is estimated at $3,500 per person for airfare, registration, hotel and meals. This is a total of $7,000.

7. Dr. Long and Dr. Fanucci will be attending the XXVIth International Conference on Magnetic Resonance in Biological Systems (IC-MRBS) in Kyoto, Japan, August 21-26, 2016. This is the premier international conference on magnetic resonance in biological systems for 2016. They will be presenting new technology developments at the NHMFL in DNP and MRI/S and plans for expansion of the user program into EMR. The cost for this conference is estimated at $3,500 per person for airfare, registration, hotel and meals. This is a total of $7,000.

The total of all travel listed above is $31,700. A contingency fund of $1,188 to cover cost overruns is also budgeted, since all trips listed above were conservatively estimated. This brings the total travel budget to $32,888.

D. Materials and Supplies

The AMRIS Facility is a core facility at the University of Florida which operates under federal cost accounting standards (Federal Circular OMB A-21). It currently has an annual operating budget of just over $1.13 M. This includes ~$780k to support 9.45 FTE staff and ~$350k to support eight instruments---the seven high field NMR and animal MRI systems which are part of the NHMFL user facility, and a 3T/90 cm clinical MRI scanner used in human and large animal research, which does not receive staff or equipment support from the NHMFL grant. Instead, external users can request access to the clinical MRI scanner on a case by case basis. Of the AMRIS operating budget, $100,000 earmarked for equipment and $343,000 for operations, listed under “materials and supplies”, comes from the NHMFL subcontract. The funds under “material and supplies” are specifically allocated to pay for (a) external user projects ($200,000), which come through the NHMFL user portal, and (b) development projects ($143,000), as identified by the renewal proposal and approved UCGP projects; this includes funding for
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the RF engineer listed under personnel who is dedicated to developing new coils and keeping existing coils operational. Users at UF pay for instrument and staff costs out of other federally funded grants, including NIH, NSF, DOE, and VA funded projects. These fees cover most of the remaining ~$690k of our annual budget.

AMRIS is administered in full compliance with federal cost accounting standards and the rates for instrument time and AMRIS staff consulting is calculated in a manner that is straightforward and fair: real costs divided by use set the rates for each individual instrument and all expenses are assigned to individual instruments. This includes the daily operation costs of the instrument, service contracts, and staff FTEs dedicated to the instrument management and repairs. Our accounts and billing are independently reviewed every year with rate adjustments based on three-year averages of operating costs. The NHMFL subcontract funds external user fees (i.e. for investigators outside of UF, FSU, or LANL) and development projects to pay for staff and instrument time, which allows AMRIS to run the NHMFL user program within the CAS structure.

FY 2016 BUDGET JUSTIFICATION

Los Alamos National Laboratory

We intend to operate the Pulsed Field Facility (NHMFL-PFF) at Los Alamos National Laboratory to continue to provide NHMFL users with access to pulsed magnetic fields for reviewed and approved research. We will continue to develop state-of-the-art pulsed magnet systems and operate them for qualified users. The total FY16 budget of $7,300,000 will be used for operation of the user program, which includes salaries, materials and supplies, and consumables such as liquid cryogens and a travel budget. Fringe benefit costs are included in the salary amounts.

A. Personnel

Charles H. Mielke (0.0 cal) is the Director of the Pulsed Field Facility and is responsible for the overall operation of the Los Alamos National Laboratory based NHMFL-PFF. He is a full time Research and Development manager at LANL based at the NHMFL-PFF in Los Alamos, NM, his salary is fully paid for by LANL for the purpose of directing the facility and managing the personnel.

Scientific User Support Staff (85.2 cal) will be assigned to directly working with qualified NHMFL-PFF users to conduct experiments in high magnetic fields. The expert scientific staff possesses demonstrated competencies in magneto-transport, magnetic susceptibility, magneto-optical spectroscopy, thermal transport, radio frequency contactless transport, specialized non-metallic cryogenic systems and pulsed field diagnostic and analysis specializations. This skill set from this group of 9 individuals is first rate in the world for state-of-the-art pulsed magnetic field experimentation. Working to enable users to return home with a complete set of data that is analyzed and interpreted is an essential function of the NHMFL-PFF.

Engineering Staff (24.0 cal) consist of two individuals who are responsible for the development of pulsed magnet systems and the engineering support/operation of the 1.43 billion watt generator system located at LANL. The world class 100 tesla Multi-Shot Magnet has set the World record for highest non-destructive pulsed magnetic field and more importantly delivered nearly 1,000 high field pulses for users. This system requires expert attention and monitoring to safely operate and maintain it for future experiments. The insert magnet system requires highly specialized design and optimization and monitoring. The NHMFL-PFF team of two scientist/engineers delivers for users and is fully committed to the smooth operation of this world-class system. Their participation and dedication is essential.

Technician Support (82.92 cal) at the NHMFL covers direct interfacing with users to provide needed technical resources for a successful user experience, infrastructure support to maintain our user "magnet cells" and ancillary equipment, two technicians provide support here. All of the 65 tesla user magnets (our current workhorse magnets) are manufactured fully in house because these are highly specialized units under tremendous stresses each shot. The workhorse magnets are fired approximately 6,000 times each year for users and we need to replace these magnets about every 1000-1,200 shots. Two technicians are dedicated to this effort currently. The operation and maintenance of the 1.43 billion watt generator system is used for the 100 tesla multi-shot magnet and the 60 tesla long pulse magnet. This generator system can safely deliver up to 600 million Joules of energy in its
current configuration and is arguably the best and safest way to deliver the very large electrical energy pulse to our largest magnet systems. Three technicians are dedicated to operation of this system and the maintenance of the generator. The NHMFL-PFF has achieved first ever status on several magnet systems in part due to this LANL resource made fully available to the NHMFL-PFF program and our technicians are highly trained professionals needed to safely operate this system to deliver magnet pulses of immense electrical energy magnitudes. A total of seven technicians are required to operate the NHMFL-PFF as described above.

Postdocs and Students (36 cal) are an important aspect of the NHMFL-PFF. A total of ten postdocs and students are currently active at the NHMFL-PFF while the core funding is currently providing only a fraction of their financial support. Often a postdoc or student will be attached to a science staff member and funded through another research channel such as LANL sponsored LDRD grants or DOE-BES channels. Students that are funded through core NSF program support are of strategic design. The funded students are engaged in strategic scientific areas or targeted diversity development opportunities.

Contractor (7.2 cal) support is highly focused and relatively temporary in nature at the NHMFL-PFF. Contracts are annually renewed and may be task specific. An effort of 6.0 cal is directed towards magnet design and 3-D modeling, working very closely with the design engineers responsible for bringing our unique and world leading pulsed magnet designs forward into the future and ahead of the competition. The generator system requires the precise development and updating of its extensive control system and an effort of 6.6 cal is directed toward that project and the maintenance of the generator control system. That effort is essential as control components age beyond useful repair life cycles and must be repaired or replaced with safety certified components. A total of more than 5,000 diagnostic signals are actively monitored and controlled continuously for every pulse of our 1.43 billion watt generator system and the controls engineer contractor is essential for completing the systems upgrades and maintenance to the level we need for sustained operations.

B. Equipment

A total of $0.00 is currently budgeted for equipment as we will leverage LANL investments for institutional capability developments and needed equipment. Specific program equipment may be requested as supplemental budgetary requests should the need arise.

C. Materials & Supplies

A total of $529,059 is needed for materials and supplies. This figure is determined by considering historical rates of consumption of products like liquid cryogens and magnet winding materials and allocating a flexible amount of remaining funds from our budget positioning projections so that low cost consumables may be purchased to enable the scientific staff, technicians and postdocs and students to have the flexibility to develop new pulsed field probes and measurement techniques based on general materials and consumables. Fiberglass rods, thermometer chips, fiber optical cable, and machined specialized parts are broadly used for these developments. The staff spends a significant portion of their time using these materials for developing new research probes for pulsed field diagnostic developments.

D. Travel

A total of $35,000 has been budgeted for travel that includes experimental user support efforts at the NHMFL-DC Field Facility (a total of 6 trips to the DC Field facility are budgeted for FY16 at $2,000 each), the APS March meetings (12 people attending at $1,700 each) and two domestic scientific conferences (three people attending at $867 each). LANL institutional funds will be used for scientific outreach efforts both domestically and internationally, allowing the NHMFL to leverage LANL commitment to the accomplishments of the NHMFL as a partner in success.

FY 2016 BUDGET JUSTIFICATION

Sub-Award to S.C. Beu Consulting

Dr. Steven Beu will perform objective scientific analysis in support of new development in Fourier Transform Ion Cyclotron Resonance (FT-ICR) mass spectrometry, including but not limited to:
Chapter 2 - Laboratory Management

- Development of new methods of ion injection into high magnetic fields by use of rf multipole ion guides,
- Simultaneous excitation and detection for enhanced mass resolving power and quantitation,
- Combined electron capture and infrared multiphoton dissociation (ECD/IRMPD) in narrow bore (<110 mm) magnets,
- Minimization of m/z discrimination due to time-of-flight dispersion during ion injection into the ICR cell, and
- Development and testing of new ICR cell geometries.
- Integration of all developed technologies into a 21 T FT-ICR mass spectrometer.

Dr. Beu will conceive new methods, develop models and experiments to test the methods, collect and interpret data, prepare manuscripts, present his findings at national meetings, and recommend future directions.

Services will be billed quarterly at a rate of $100 per hour.

Total time billed for the 2016 calendar year will not exceed 550 hours for a total amount payable not to exceed $55,000.

<table>
<thead>
<tr>
<th>Table 3: Statement of Residual Funds – FY 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$132,580,000</strong> NSF Budget Allocation for FY 2013-2016</td>
</tr>
<tr>
<td><strong>($134,038,893)</strong> Total Expenses and Encumbrances (including related Indirect Cost)</td>
</tr>
<tr>
<td>Reconciliations</td>
</tr>
<tr>
<td><strong>$2,590,000</strong> LANL operating cost expensed in FY 2016 but budgeted and paid from FY 2017 funds.</td>
</tr>
<tr>
<td>Obligations</td>
</tr>
<tr>
<td><strong>($981,450)</strong> User Collaboration Grants Program awards obligated to the PI’s. Funds are to be expensed over next two years.</td>
</tr>
<tr>
<td><strong>($1,000,000)</strong> Electricity for magnets</td>
</tr>
<tr>
<td><strong>($150,000)</strong> FSEC Laser Equipment</td>
</tr>
<tr>
<td><strong>($1,172,062)</strong> Additional personnel costs projected for FY 2017 for Magnet, Science and Technology Department.</td>
</tr>
<tr>
<td><strong>($253,875)</strong> Construction of the 28 MW/41T Magnet.</td>
</tr>
<tr>
<td><strong>($1,000,000)</strong> Magnet Coils, CuAG, Sheet Metal for the Resistive Magnet, 18 MW/41T Magnet, and SCH Magnet.</td>
</tr>
<tr>
<td><strong>($2,120,182)</strong> Reserve funds for new and on-going projects, deferred annual magnet replacement parts, magnet upgrades, and applicable indirect cost.</td>
</tr>
<tr>
<td>Residual Funds</td>
</tr>
<tr>
<td><strong>$910,157</strong></td>
</tr>
</tbody>
</table>

Encumbrances are included to reflect the budget amount reserved for future purchases.

Advanced funding for FY 2017 was received in September 2016. These funds were encumbered in FY 2016 for personnel cost and the related indirect cost for the period of January 1, 2017 through April 30, 2017.

LANL’s first increment of 2017 was paid in December 2016 and must be included in the total expenses of 2016. This payment is budgeted and paid from 2017 funds that are not included in total budget above.

Lines 5-11: Funds obligated for specific purposes but not yet expended.
### Table 4: Statement of Expenses and Encumbrances (January 2013 through December 2016)

<table>
<thead>
<tr>
<th></th>
<th>2013-2016</th>
<th>As of 12/31/16</th>
<th>TOTAL COSTS 2013-2016</th>
<th>2016</th>
<th>As of 12/31/16</th>
<th>TOTAL COSTS 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-C. TOTAL SALARIES, WAGES AND FRINGE BENEFITS</td>
<td>32,801,761</td>
<td>3,798,011</td>
<td>36,599,772</td>
<td>9,588,819</td>
<td>3,798,011</td>
<td>13,386,830</td>
</tr>
<tr>
<td>D. TOTAL EQUIPMENT</td>
<td>5,689,148</td>
<td>1,436,442</td>
<td>7,125,589</td>
<td>1,609,118</td>
<td>1,436,442</td>
<td>3,045,560</td>
</tr>
<tr>
<td>E. TRAVEL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. DOMESTIC</td>
<td>869,889</td>
<td>4,719</td>
<td>874,608</td>
<td>238,966</td>
<td>4,719</td>
<td>243,685</td>
</tr>
<tr>
<td>2. FOREIGN</td>
<td>285,856</td>
<td>2,756</td>
<td>288,612</td>
<td>86,836</td>
<td>2,756</td>
<td>89,592</td>
</tr>
<tr>
<td>F. PARTICIPANT SUPPORT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. STIPENDS</td>
<td>506,596</td>
<td></td>
<td>140,166</td>
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<tr>
<td>2. TRAVEL</td>
<td>16,943</td>
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<td></td>
</tr>
<tr>
<td>3. SUBSISTENCE</td>
<td>58,492</td>
<td></td>
<td>2,287</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL PARTICIPANT COSTS</td>
<td>582,032</td>
<td></td>
<td>582,032</td>
<td>142,453</td>
<td></td>
<td>142,453</td>
</tr>
<tr>
<td>G. OTHER DIRECT COSTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. MATERIALS AND SUPPLIES</td>
<td>9,217,658</td>
<td>1,192,196</td>
<td>10,409,855</td>
<td>2,617,191</td>
<td>1,192,196</td>
<td>3,809,387</td>
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<tr>
<td>2. PUBLICATION/DOCUMENTATION/</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>DISSEMINATION</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. CONSULTANT SERVICES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. COMPUTER SERVICES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. SUBAWARDS</td>
<td>37,154,522</td>
<td>836,063</td>
<td>37,990,585</td>
<td>9,232,228</td>
<td>836,063</td>
<td>10,068,292</td>
</tr>
<tr>
<td>6. OTHER</td>
<td>6,396,627</td>
<td></td>
<td>6,396,627</td>
<td>1,222,526</td>
<td></td>
<td>1,222,526</td>
</tr>
<tr>
<td>TOTAL OTHER DIRECT COSTS</td>
<td>52,768,807</td>
<td>2,028,260</td>
<td>54,797,067</td>
<td>13,071,945</td>
<td>2,028,260</td>
<td>15,100,205</td>
</tr>
<tr>
<td>H. TOTAL DIRECT COSTS (A THROUGH G)</td>
<td>92,997,492</td>
<td>7,270,188</td>
<td>100,267,680</td>
<td>24,738,138</td>
<td>7,270,188</td>
<td>32,008,326</td>
</tr>
<tr>
<td>I. INDIRECT COSTS (F&amp;A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base</td>
<td>43,175,164</td>
<td>4,997,682</td>
<td>48,172,846</td>
<td>12,531,812</td>
<td>4,997,682</td>
<td>17,529,494</td>
</tr>
<tr>
<td>Rate: %</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>TOTAL INDIRECT COSTS (F&amp;A) - see note</td>
<td>30,272,836</td>
<td>3,498,378</td>
<td>33,771,214</td>
<td>8,772,453</td>
<td>3,498,378</td>
<td>12,270,831</td>
</tr>
<tr>
<td>J. TOTAL DIRECT AND INDIRECT COSTS (H + I)</td>
<td>123,270,328</td>
<td>10,768,566</td>
<td>134,038,993</td>
<td>33,510,592</td>
<td>10,768,566</td>
<td>44,279,157</td>
</tr>
</tbody>
</table>

Note: Rebudgeting to increase IDC to 70% occurred in FY 2015.
Cost Recovery Report

Seldom does the NHMFL incur costs due to resources used or sacrificed for companies doing proprietary research. On occasion, companies will need access to the unique equipment at the NHMFL, and they will contract for the use of said equipment. The NHMFL has established procedures to accumulate and report costs continuously, routinely, and consistently for all such contracts based upon an agreed-upon schedule of fees and costs to cover the use of such equipment that involves proprietary research.

If the MagLab receives program income defined as “gross income earned by the non-Federal entity that is directly generated by a supported activity or earned as a result of the Federal award during the period of performance”, this income must be reported in a cost recovery report. (200.80). According to 200.307 (f), there are no Federal requirements governing the disposition of income earned after the end of the period of performance of the Federal award, unless the Federal awarding agency regulations or terms and conditions specify otherwise.

During 2016, the MagLab recovered a total of $21,289.50 from private industry for the use of NSF-funded equipment/software during the period of performance of our Federal award.

Equipment usage remuneration from OMICS on behalf of work done for the following companies: BP, GE, NALCO, Cobalt, BakerPetrolite, Maersk, Polyglass, CCQTA, Thermo, and Waters.

We intend to reinvest these funds in the Core Program by the end of the semester.
Chapter 2 - Laboratory Management

Industrial Partners and Collaborators

Industry

89 North, Burlington, VT
Scientists at the MagLab are working with applications specialists at 89 North to develop light-emitting diode technology for fluorescence microscopy. This collaboration involves testing the power output and usability of new high power LED technology in the emission region between 490 and 590 nanometers, a spectral region that is central to microscopy investigations.
(MagLab contact: Eric Clark, Optical Microscopy)

Advanced Conductor Technologies, Boulder, CO
The Applied Superconductivity Center and the Magnet Science and Technology division of the MagLab are collaborating with Advanced Conductor Technologies on the development and testing of Coated Conductor Stranded Cable (CCSC), using multi-layer spiraling tapes around a core, for magnet applications. Danko van der Laan, director of the company and associated with NIST/University of Colorado Boulder, is developing compact cables based on REBCO coated conductors, a high temperature superconductor. The ongoing collaboration is transitioning from measurements of HTS cables at low temperature and high magnetic fields, that set new benchmarks for peak current, current density, bend radius and ramp rates, to detailed characterization of strands post-cabling and full-current testing of joints.
(MagLab contact: Huub Weijers, MS&T)

Agilent Technologies, Santa Clara, CA
Agilent Technologies is entering the imaging arena with a new “Monolithic” laser combiner featuring acousto-optic-tunable filter (AOTF) control. The MagLab is collaborating with Agilent to prototype the laser system for use in super-resolution imaging.
(MagLab contact: Eric Clark, Optical Microscopy)

Allele Biotech, San Diego, CA
Allele is a manufacturer and distributor of fluorescent protein constructs made by Robert Campbell and Nathan Shaner. The MagLab is collaborating with Allele to develop fusion vectors of selected fluorescent proteins.
(MagLab contact: Eric Clark, Optical Microscopy)

Andor-Tech, Belfast, Northern Ireland
Andor-Tech is an imaging specialist involved with development of CCD camera systems designed to produce images at extremely low light levels. The MagLab is collaborating with Andor-Tech to produce interactive tutorials describing electron multiplying CCD (EMCCD) technology and will work with the company to test new camera products in live-cell imaging.
(MagLab contact: Eric Clark, Optical Microscopy)

B&B Microscopes, Pittsburgh, PA
Scientists in the Optical Microscopy facility at the MagLab are working with B&B engineers to develop new live-cell imaging techniques using the wide array of products offered by the company. Eventually, an educational website is planned.
(MagLab contact: Eric Clark, Optical Microscopy)

Bioptechs, Butler, PA
The MagLab is involved with Bioptechs of Pennsylvania to develop live-cell imaging techniques using the company’s advanced culture chambers. The collaboration involves timelapse imaging of living cells over periods of 36-72 hours using techniques such as differential interference contrast, fluorescence, and phase contrast.
(MagLab contact: Eric Clark, Optical Microscopy)

Bruker EAS GmbH, Hanau, Germany
Bruker EAS is manufacturing accelerator quality Nb3Sn strands based on the powder-in-tube process that have the potential to provide the performance necessary for higher magnetic field upgrades to the Large Hadron Collider at CERN and the Applied Superconductivity Center is collaborating with Bruker and CERN to optimize the performance of the wire utilizing the electromagnetic testing and advanced microstructural and microchemical analysis facilities at the MagLab.
(MagLab contacts: Chiara Tarantini, Peter J. Lee and David C Larbalestier, ASC)

Bruker Biospin Corp, USA
The EMR and NMR groups have entered into a collaborative effort with Bruker Biospin regarding the
Dynamic Nuclear Polarization (DNP) program. In particular, the effort aims at improving Bruker's recently acquired products (395 GHz gyrotron, 600 MHz/14.1 T DNP probe) beyond their normal commercial uses by making technical modifications. The modifications allow the DNP instruments to be more user program friendly without voiding the warranty.

(MagLab contact: Stephen Hill, EMR)

**Bruker Biospin Corp., Billerica, MA**

The MagLab's NMR instrumentation program and Bruker Biospin collaborate on the development of Low-E probes for solid-state NMR in heat sensitive biological samples, such as proteins. Bruker Biospin manufactures a line of Efree probes based on the Low-E design developed at our lab.

(MagLab contact: Peter Gor'kov, NMR)

**Bruker Biospin, Faellanden, Switzerland**

Scientists in the MagLab NMR Program are working with Bruker Biospin and with Prof. Art Edison at the University of Georgia to improve the sensitivity of high field solution NMR probes by utilizing high temperature superconducting resonators.

(MagLab contact: William Brey, NMR)

**Callaghan Innovations, Lower Hutt, New Zealand**

The Applied Superconductivity Center and the Magnet Science and Technology division of the MagLab are collaborating with researchers at New Zealand's Industrial Research Limited on the testing of Roebel-style cables based on REBCO coated conductors, a high temperature superconductor. Testing of a 15-strand cable with transposed 5 mm wide strands is in preparation. Roebel-style cables represent one of three viable concepts for REBCO coated conductor cables suitable for high field magnets.

(MagLab contact: Bob Walsh, MS&T)

**Chroma, Rockingham, VT**

A major supplier of Interference filters for fluorescence microscopy and spectroscopy applications, Chroma is collaborating with the MagLab to build educational tutorials targeted at fluorescence microscopy. Working in conjunction with Nikon, engineers from Chroma and scientists from the MagLab are examining the characteristics of a variety of filter combinations.

(MagLab contact: Eric Clark, Optical Microscopy)

**The Cooke Corp., Romulus, MI**

Scientists at the MagLab are working with applications specialists at Cooke to field test the company's cooled and electron-multiplied scientific CCD camera systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.

(MagLab contact: Eric Clark, Optical Microscopy)

**CoolLed Ltd., Andover, Hampshire, UK**

Scientists at the MagLab are working with applications specialists at CoolLed to develop light-emitting diode technology for fluorescence microscopy. This collaboration involves testing the power output and usability of new LED technology in the emission region between 490 and 590 nanometers, a spectral region that is central to microscopy investigations.

(MagLab contact: Eric Clark, Optical Microscopy)

**Covance Research Products, Berkeley, CA**

Covance is a biopharmaceutical company involved with research and diagnostic antibody production. MagLab scientists are working with Covance researchers to examine immunofluorescence staining patterns in rat and mouse brain thin and thick sections using a wide spectrum of antibodies.

(MagLab contact: Eric Clark, Optical Microscopy)

**Criotec Impianti, Piedmont, Italy; ENEA, Rome, Italy**

The MagLab is collaborating with Criotec Impianti, an Italian cryogenic systems manufacturing company, and ENEA, an Italian Fusion Energy Research Organization, to jacket the cable-in-conduit superconductor for the outset coils of the series-connected hybrid magnets. This work includes the welding and inspection of the stainless steel conduit, insertion of the cabled superconductor strands into the conduit, and compaction of the assembled conductor to a rectangular cross-section.

(MagLab contact: Iain Dixon, MS&T)

**Danfoss Turbocor Inc, Tallahassee, FL**

Danfoss Turbocor Inc. is a company specializing in compressors, particularly the totally oil-free compressors. The compressors are specifically designed for the heating, ventilation, air conditioning, refrigeration (HVACR) industry and need high performance soft and hard magnet materials. The company
and the laboratory have a joint research project on selection, characterization, and development of permanent magnet materials and other materials for high performance and environmentally friendly compressors.

(MagLab contact: Lin Sun, MS&T)

Diagnostic Instruments, Sterling Heights, MI
Scientists at the MagLab are working with applications specialists at Diagnostics to field test the company’s new line of cooled scientific CCD systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.

(MagLab contact: Eric Clark, Optical Microscopy)

Evrogen, Moscow, Russia
Evrogen is a manufacturer and distributor of fluorescent protein constructs made by Dmitriy Chudakov and Vladislav Verkhusha. The MagLab is collaborating with Evrogen to develop fusion vectors of selected fluorescent proteins.

(MagLab contact: Eric Clark, Optical Microscopy)

EXFO, Mississauga, Ontario, Canada
The MagLab is collaborating with EXFO to examine the spectra and output power of various illumination sources for microscopy including metal halide lamps, light engines, LEDs, and the LiFi illumination system.

(MagLab contact: Eric Clark, Optical Microscopy)

FullScaleNANO, Inc., Tallahassee, FL
FullScaleNANO is an analytical consultancy and software development company established in 2012. The company is focused on creating full solutions for automatic characterization of nanomaterials called NanoMet. NanoMet converts images into useful data using powerful machine learning image processing algorithms combined with an intuitive, robust and fast user interface. The core technology of NanoMet is now commercially available to both academia and industry as the NanoMet WebApp and Histogram On Demand.

(MagLab contact: Jeffrey Whalen, CMS)

Hamamatsu Photonics, Bridgewater, NJ
Scientists at the MagLab are working with applications specialists at Hamamatsu to field test the company’s cooled and electron-multiplied scientific CCD camera systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.

(MagLab contact: Eric Clark, Optical Microscopy)

Hyper Tech Research Inc, Columbus, OH
Hyper Tech Research Inc. develops and manufactures MgB2 superconducting wires for MRI applications. In this collaboration, the Magnet Science and Technology division measures critical current of MgB2 wires developed by Hyper Tech Research. The critical current measurements are performed at 4.2 K and in 0 – 10 tesla magnetic fields.

(MagLab contact: Jun Lu, MS&T)

Leco Corporation, MI
The ICR Program collaborates with the instrumentation and application scientists at Leco to determine the utility of high resolution mass spectrometry in energy and fuel research. Current work focuses on pyrolysis gas chromatographic analysis performed with a high resolution time-of-flight mass spectrometer.

(MagLab contact: Ryan Rodgers, ICR)

Linkam, Surrey, UK
Scientists at the MagLab collaborate with Linkam engineers to design heating and cooling stages for observation of liquid-crystalline phase transitions in the optical microscope. In addition, microscopists are assisting Linkam in introducing a new heating stage for live-cell imaging in fluorescence microscopy.

(MagLab contact: Eric Clark, Optical Microscopy)

Lumencor Inc., Beaverton, OR
The MagLab is collaborating with Lumencor to examine the spectra and output power of various illumination sources for microscopy including metal halide lamps, light engines, LEDs, and the LiFi illumination system.

(MagLab contact: Eric Clark, Optical Microscopy)

Major Tool and Machine, Indianapolis, IN
The US-ITER organization has contracted MTM as one of two primary vendors to supply large forgings of a super austenitic steel for the massive CS pre-compression structure (Tie Plates). The tie plate alloys, and their welds, are being studied and characterized here to ensure their performance and relia-
Chapter 2 - Laboratory Management

bility. This is an example of industry relying on NHMFL’s expertise and infrastructure to perform cryogenic temperature characterization of an advance alloy.  
(MagLab contact: Bob Walsh, MS&T)

MBL International, Woburn, MA
Scientists at the MagLab are collaborating with MBL to develop new fluorescent proteins for live-cell imaging applications. These include both optical highlighters and fluorescence resonance energy transfer (FRET) biosensors.  
(MagLab contact: Eric Clark, Optical Microscopy)

Media Cybernetics, Silver Spring, MD
Programmers at the MagLab are collaborating with Media Cybernetics to develop imaging software for timelapse optical microscopy. In addition, the Optical Microscopy group is working to add new interactive tutorials dealing with fundamental aspects of image processing and analysis of data obtained with the microscope.  
(MagLab contact: Eric Clark, Optical Microscopy)

Mevion Medical Systems, Littleton, MA
Mevion is a pioneer in the development of proton radiation therapy systems for the non-invasive treatment of cancer. The center of the systems is the proton accelerator that utilizes low temperature superconductors. NHMFL provides engineering support to Mevion by assisting in qualification testing of full-scale high current superconductors in background fields at low temperatures. The tests require NHMFL’s unique test facility designed for tests of large conductors in a 12 tesla split solenoid superconducting magnet system.  
(MagLab contact: Bob Walsh, MS&T)

Molecular Probes/Invitrogen, Eugene, OR
A major supplier of fluorophores for confocal and wide-field microscopy, Molecular Probes is collaborating with the MagLab to develop educational tutorials on the use of fluorescent probes in optical microscopy.  
(MagLab contact: Eric Clark, Optical Microscopy)

Nanoelectro Ltd, Russia
and the National High Magnetic Field Laboratory have been developing new high strength conductors for next generation magnets. They published one joint paper in 2016.  
(MagLab contact: Ke Han, MS&T)

Nikon, Melville, NY
The MagLab maintains close ties with Nikon on the development of an educational and technical support microscopy website, including the latest innovations in digital-imaging technology. As part of the collaboration, the MagLab is field-testing new Nikon equipment and developing new methods of fluorescence microscopy.  
(MagLab contact: Eric Clark, Optical Microscopy)

Olympus America, Melville, NY
The MagLab is developing an education/technical website centered on Olympus products and will be collaborating with the firm on the development of a new tissue culture facility at the MagLab in Tallahassee. This activity will involve biologists at the MagLab and will feature Total Internal Reflection Fluorescence microscopy.  
(MagLab contact: Eric Clark, Optical Microscopy)

Olympus Corp., Tokyo, Japan
Investigators at the MagLab have been involved in collaboration with engineers at Olympus to develop and test new optical microscopy systems for education and research. In addition to pacing the microscope prototypes through basic protocols, the Optical Microscopy group is developing technical support and educational websites as part of the partnership.  
(MagLab contact: Eric Clark, Optical Microscopy)

Omega Optical, Brattleboro, VT
The MagLab is involved in collaboration with Omega to develop interactive tutorials targeted at education in fluorescence filter combinations for optical microscopy. Engineers at Omega work with MagLab microscopists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission.  
(MagLab contact: Eric Clark, Optical Microscopy)

Oxford Instruments Superconducting Technology, Carteret, NJ
Oxford Instruments Superconducting Technology (OST) is one of the major manufacturers of superconducting wires. In this collaboration, the Magnet
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Science and Technology division measures hysteresis loss of Nb$_3$Sn wires developed by OST. The hysteresis loss measurements are performed at 4.2 K and in 0 – 5 tesla magnetic fields by a vibrating sample magnetometer. (MagLab contact: Jun Lu, MS&T)

**nGiMat LLC, Lexington, KY**

nGiMat LLC is a small business specializing in manufacturing oxides nanopowders, and insulation of superconducting wires. MagLab collaborates with nGiMat LLC on a small business innovation research grant funded by US Department of Energy. The goal of this research is to improve the quality of ceramic insulation for Bi$_2$Sr$_2$CaCu$_2$O$_{8+x}$ superconducting wire. (MagLab contact: Jun Lu, MS&T)

**Qimaging, Burnaby, British Columbia, Canada**

High-resolution optical imaging is the focus of the MagLab collaboration with Qimaging, a Canadian corporation that specializes in CCD digital cameras for applications in quantitative image analysis and high-resolution images for publication. Target applications are interactive tutorials and image galleries that will be displayed on the Internet. (MagLab contact: Eric Clark, Optical Microscopy)

**Oxford Instruments, Abingdon, UK**

Oxford Instruments is under contract to deliver a 15 T large-bore low temperature superconductor magnet to the NHMFL, to be combined with 17 T YBCO-coated conductor coils under development at the NHMFL to create the first 32 T all-superconductor magnet. In case of a quench, the LTS and HTS coils interact in a complex manner. The quench protection systems for the individual coil sets are interdependent. This cannot be handled by routine specifications in a standard vendor relationship. Therefore, Oxford Instruments and NHMFL Magnet Science and Technology are collaborating on quench protection to ensure compatibility of the coil sets and are developing a numerical code to model quench in combined YBCO-LTS magnets. (MagLab contact: Huub Weijers, MS&T)

**Oxford Superconducting Technology, Carteret, NJ**

Extensive collaborations exist between ASC and OST on both Nb$_3$Sn and Bi-2212 conductor development, aided by direct support of R&D on these materials from DOE-High Energy Physics to ASC PIs and to OST through the Conductor Development Program managed out of Lawrence Berkeley National Laboratory. In this way OST has been able to develop the most advanced Nb$_3$Sn and Bi-2212 conductors made. (MagLab contacts: David Larbalestier, Eric Hellstrom, Peter Lee, Chiara Tarantini, Jianyi Jiang, ASC)

**Philips Medical Systems MR, Inc., Cleveland, OH**

The National High Magnetic Field Laboratory, Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) Facility in the McKnight Brain Institute of the University of Florida (UF) has a master research agreement with Siemens to develop applications on Siemens MR systems installed in the University of Florida. Several UF research groups are involved in this research agreement and are developing new MRI methods and applications. (MagLab contact: Joanna R Long, AMRIS Facility)

**Photometrics (Roper Scientific Inc.), Tucson, AZ**

The microscopy research team at the MagLab is exploring single molecule fluorescence microscopy using electron-multiplying CCD camera systems developed by Photometrics. In addition, the team is conducting routine fixed-cell imaging with multiple fluorophores to gauge camera performance. (MagLab contact: Eric Clark, Optical Microscopy)

**Prior Scientific Inc, Rockland, MA**

Prior is a major manufacturer of illumination sources and filter wheels for fluorescence microscopy. The MagLab team is collaborating with Prior to develop new illumination sources and mechanical stages for all forms of microscopy. (MagLab contact: Eric Clark, Optical Microscopy)

**Revolution NMR LLC, Fort Collins, CO**

Revolution NMR has licensed from FSU the Low-E probe technology developed at MagLab in order to fabricate static NMR probes for biological (protein) samples. Additionally, the MagLab’s NMR instrumentation program and Revolution NMR collaborate on the development of stators for magic angle spinning NMR. (MagLab contact: Peter Gor‘kov, NMR)

**Scot Forge, Spring Grove, IL**

The US-ITER organization has contracted Scot Forge as one of two primary vendors to supply large forgings of a super austenitic steel for the massive CS
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The pre-compression structure (Ti Plates). The tie plate alloys, and their welds, are being studied and characterized here to ensure their performance and reliability. This is an example of industry relying on NHMFL's expertise and infrastructure to perform cryogenic temperature characterization of an advance alloy.

(MagLab contact: Bob Walsh, MS&T)

Semrock, Rochester, NY
The MagLab Optical Microscopy group is collaborating with Semrock to develop interactive tutorials targeted at education in fluorescence filter combinations for optical microscopy. Engineers and support personnel at Semrock work with MagLab microscopists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission. In addition, MagLab scientists produce images of living cells with Semrock filter combinations.

(MagLab contact: Eric Clark, Optical Microscopy)

Siemens Medical Solutions USA, Inc., Malvern, PA
The National High Magnetic Field Laboratory, Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) Facility in the McKnight Brain Institute of the University of Florida (UF) has a master research agreement with Siemens to develop applications on Siemens MR systems installed in the University of Florida. Several UF research groups are involved in this research agreement and are developing new MRI methods and applications.

(MagLab contact: Joanna R Long, AMRIS Facility)

SuperPower Inc, Schenectady, NY
The Applied Superconductivity Center and the Magnet Science and Technology division of the MagLab are collaborating with SuperPower Inc. on the characterization of YBCO coated conductors. This material has the potential to transform the field of high-field superconducting magnet technology and is in an early stage of commercialization. We work to improve our understanding of this product in support of the NHMFL 32 T project as well as to provide guidance to SuperPower on enhancing the quality of their product. We have also taken the lead in encouraging a Coated Conductor Round Table of users of coated conductors at which much information about the long length performance of coated conduc-
tors has been shared.

SupraMagnetics Inc, Plantsville, CT
The Applied Superconductivity Center is participating in the development of a superconducting Nb3Sn wire that uses artificial flux-pinning centers to achieve high critical current densities. The MagLab provides microstructural and microchemical support for this work.

(MagLab contact: Peter J. Lee, ASC)

Sutter Instrument, Novato, CA
The MagLab is collaborating with Sutter to examine the spectra and output power of various illumination sources for microscopy including metal halide lamps and the LiFi illumination system.

(MagLab contact: Eric Clark, Optical Microscopy)

Thomas Keating Ltd, UK
The EMR group has entered into a partnership with Thomas Keating (TK) Ltd in the UK as part of its program aimed at developing a new characterization tool, Dynamic Nuclear Polarization Nuclear Magnetic Resonance (DNP - NMR) at high fields (14.1 T / 600 MHz). TK draws on tool-making skills to design and develop quasi-optical Terahertz systems and subsystems.

(MagLab contact: Stephen Hill, EMR)

Voltronics Corporation, Cazenovia, NY
Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) Facility in the McKnight Brain Institute of the University of Florida (UF) have collaborations with Voltronics in testing low temperature trimmer capacitors for cryogenic applications. The Dynamic Nuclear Polarization (DNP) probe that operates at 1K uses these capacitors to tune/match the coil resonance.

(MagLab contact: Malathy Elumalai, AMRIS Facility)

Waters Corporation, MA
The ICR and Future Fuels Institute are a Waters Corporation, Center of Innovation and collaborate on advances in instrumentation for biological and petroleum applications. Instrument and ion source advances are provided to both facilities before their commercial release and allow for applications devel-
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opment well before mainstream introduction.  
*(MagLab contact: Ryan Rodgers, ICR)*

Zeiss Micro Imaging, Thornwood, NY
The Optical Microscopy group at the MagLab is negotiating a contract with Zeiss on the development of an educational and technical support microscopy website, including the latest innovations in digital imaging technology. As part of the collaboration, microscopists are field-testing new Zeiss equipment and developing new methods of fluorescence microscopy.  
*(MagLab contact: Eric Clark, Optical Microscopy)*

National or International Labs/Institutes

CERN, Geneva, Switzerland
The Large Hadron Collider (LHC) at CERN uses a 27 km ring of superconducting magnets based on Nb-Ti to accelerate particles in the world’s largest and most powerful collider but plans to increase the energy capability of LHC will require higher magnetic fields. The Applied Superconductivity Center is collaborating with CERN to characterize and optimize a new generation of accelerator quality Nb₃Sn strands based on the powder-in-tube process that have the potential to provide the performance necessary for the next step in LHC upgrades.  
*(MagLab contacts: David Larbalestier, Chiara Tarantino and Peter Lee, ASC)*

Dana-Farber Cancer Institute, Boston, MA
Current collaboration between Dana-Farber Cancer Institute and the MagLab is aimed at determining the molecular details of HIV envelope protein gp41 using electron paramagnetic resonance methods. Other goals include characterization of antibody-induced structural changes of gp41, and developing optimized vaccine immunogens by structural approaches.  
*(MagLab contact: Likai Song, EMR)*

EUCARD2 (European Collaboration for Accelerator R&D)
EUCARD2 is a European Framework collaboration of about 10 European labs aimed at developing kiloamp high temperature superconductor cables for future application to a high energy LHC. The European emphasis is on Roebel cables of REBCO coated conductors but an equally attractive cable for accelerator purposes is a round wire cable made in the Rutherford style out of Bi-2212 (Bi₂Sr₂CaCu₂O₈₋ₓ). This conductor has been developed at the MagLab under DOE-HEP support in the context of the Bismuth Strand and Cable Collaboration (BSCCo) that unites the MagLab, BNL, FNAL, LBNL and OST in a team developing this material for accelerator use. The MagLab is now the US point of contact for collaborations between EUCARD2 and the US program.  
*(MagLab contacts: David Larbalestier, Eric Hellstrom and Jianyi Jiang, ASC)*

European MicroKelvin Platform (EMP)
The University of Florida MicroKelvin Laboratory and the National High Magnetic Field Laboratory’s High B/T Facility has entered into a co-operative agreement with the European Microkelvin Platform (EMP) to establish a program of collaborative research in areas of mutual interest at ultra-low temperatures, with a focus on promoting and facilitating, where feasible, exchange visits for scientists and students. The EMP is a consortium of 20 leading ultralow temperature physics and technology partners in Europe. The main aim of the consortium is the further integration of ultralow temperature research for the development of new ideas, knowledge, technology, applications and commercial exploitation to enhance further the innovation potential in this field. In addition to research activities, the parties to this agreement will cooperate in the training of ultra-low temperature physicists through course offerings to qualified candidates such as the European Advanced Cryogenics Course and the Cryogenics Course at the University of Florida.  
*(MagLab contact: Neil Sullivan, UF)*

Fermilab, Batavia, IL
The shaping of Nb sheet to produce superconducting RF cavities introduces microstructural defects that may impact cavity performance; in collaboration with Fermilab the Applied Superconductivity Center is studying the surface and bulk superconductivity in deformed niobium wires. Controlled deformation is introduced into the Nb samples wire drawing and the resulting defects are quantified and compared to the measured superconducting properties.  
*(MagLab contact: Peter J. Lee, ASC)*
Future Fuels Institute, FL
The Future Fuels Institute (FFI) was established to enhance the existing Ion Cyclotron Resonance (ICR) Program at the NHMFL to deal specifically with biological and fossil fuels, particularly for heavy oils and synthetic crudes. Supported by sponsoring companies and collaborative entities (instrument companies, universities and research institutes), the FFI works to develop and advance novel techniques for research applications and problem solving. FFI is actively seeking up to 6 industrial collaborators as corporate members to support core research programs. Each of these corporate members will be asked to provide $250,000/year for 4 years. The member may terminate the membership by giving the institute 30 days written notice prior to the membership renewal date.
Current corporate members include:
• Total
• Petrobras
• Reliance Industries
• Ecopetrol
The institute also serves as a training center for fuel-related science and technology.
(MagLab contact/Director: Ryan Rodgers)

Helmholtz Zentrum Berlin, Berlin, Germany
The MagLab has partnered with the Helmholtz Zentrum Berlin (HZB) to develop the highest field magnet worldwide for neutron scattering at HZB. In March 2007, HZB (formerly the Hahn-Meitner Institute) signed an agreement with Florida State University Magnet Research and Development Inc. in 2007. The magnet exceeded specification in October 2014 and has been serving users at 25 T since July 2015. The original design and construction agreement has ended, we now have an agreement to assist with operation and maintenance
(MagLab contact: Mark D. Bird, MS&T)

Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) of Chinese Academy of Sciences
The collaboration between the IVPP and the MagLab is related to the investigation of Late Cenozoic Vertebrate Paleontology and Paleoenvironments of the Tibetan Plateau (China). Samples collected in this project are analyzed in the Geochemistry Laboratories in the Maglab.
(MagLab contact: Yang Wang, Geochemistry Program)

International Thermonuclear Experimental Reactor (ITER) International Organization, Cadarache, France
US-ITER Project Office, Oak Ridge, TN
The Applied Superconductivity Center has for the last 5 years played a major role in helping ITER-Io understand the properties of the cables being wound into the Central Solenoid (CS) and the Tokamak Field (TF) coils. A central task has been the disassembly and metallographic analysis of the prototype Cable-in-Conduit-Conductors (CICC) needed for TF and CS coils after testing in the SULTAN facility in conditions designed to simulate ITER operations. Many of these conductors Toroidal Field (ITER Organization) and Central Solenoid (US-ITER) CICCs typically suffered significant performance degradation during cyclic loading and occasional warm-up and cool-down cycles. The tests performed at the MagLab were able to identify many of the causes for this degradation and were instrumental in developing new cable patterns that resolved the degradation. This work was collaborative with groups at CEA-Cadarache, the University of Twente in the Netherlands and US-ITER.
(MagLab contacts: Peter J. Lee and David C. Labalestier, ASC)

International Thermonuclear Experimental Reactor (ITER), US-ITER Project Office, Oak Ridge National Laboratory (ORNL), Oak Ridge, TN
The United States is part of an exciting international collaboration to demonstrate the feasibility of an experimental fusion reactor that is under construction in France. The MS&T’s Mechanical Properties Lab is the US-ITER primary materials research and qualification laboratory supporting the US effort. The Tokamak machine consists of three types of very large, complex superconducting magnets that all utilize Cable-in-Conduit Conductors (CICC) as the main structural components. Another important component for stress management of the Central Solenoid is a massive CS pre-compression structure (Tie Plates). The conduit and tie plate alloys, and their welds, are being studied and characterized here to ensure their performance and reliability. The funding for this research is provided by US-DOE, US-ITER Project Office at ORNL.
(MagLab contact: Bob Walsh, MS&T)

Jefferson Lab, Newport News, VA
Recently Nitrogen and Titanium doping have

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emerged as highly effective methods of improving the quality factor on Nb SRF cavities; the Applied Superconductivity Center is working with scientists at Jefferson Lab to evaluate the interaction between prior cold-work and doping treatment of Nb samples and their influence on the superconducting properties. Doping is carried out at Jefferson Lab and superconducting property measurements, including magneto optical imaging area carried out at the MagLab.

(MagLab contact: Peter J. Lee, ASC)

Key Laboratory of Electromagnetic Processing of Materials, Northeastern University, Shenyang, China
The collaboration between the Northeastern University and the MagLab is related to the magnetic field impact on fabrication of high strength conductors. A professor visited MagLab in 2015 and a MagLab faculty member visited Northeastern University in 2016. They published six joint papers in 2016.

(MagLab contact: Ke Han, MS&T)

Large Accelerator Project for the HiLumi upgrade of the CERN LHC, Brookhaven National Lab, Upton, NY
Accelerator magnets based on Nb$_3$Sn wires are required to provide the increased magnetic fields for the next LHC upgrade. The Applied Superconductivity Center is collaborating with Brookhaven National Lab to understand the design and heat treatment optimization of accelerator magnet quality strand fabricated by the internal Sn process with a view to driving high current density strands to smaller filament sizes. Close collaboration with the R&D billets being manufactured for LARP under the Conductor Development Program of DOE High Energy Physics is a key part of the work.

(MagLab contacts: Chiara Tarantini, Peter J. Lee and David C Larbalestier, ASC)

Lawrence Berkeley Laboratory, Accelerator and Fusion Research, Berkeley, CA
The Applied Superconductivity Center and the Magnet Science and Technology division of the MagLab are collaborating with researchers at the Berkeley National Laboratory on the testing of Roebel-style cables based on REBCO coated conductors, a high temperature superconductor. Testing of a 10-strand cable with transposed 2 mm wide strands is in preparation. Roebel-style cables represent one of three viable concepts for REBCO coated conductor cables suitable for high field magnets.

(MagLab contact: Huub Weijers, MS&T)

Los Alamos National Laboratory Community Programs Office, NM
CIRL works closely with our counterpart, the Los Alamos National Laboratory Community Programs Office. Over the last year we have developed a partnership wherein we share information and resources on our educational activities. The community programs office has a large staff that oversees more than 15 different educational/community outreach programs including the Bradbury Museum.

(MagLab contact: Roxanne Hughes, Carlos Villa, Educational Programs)

School of Mechanical Engineering and Automation, Fuzhou University, Fuzhou, China
The collaboration between the Fuzhou University and the MagLab is related to the characterization of high strength conductors. They published one joint paper in 2016.

(MagLab contact: Ke Han, MS&T)

Scripps Research Institute, FL
We continue to collaborate with Dr. Thomas Kodadek (Scripps Florida), for structural characterization of transfer RNA synthetases functioning in roles other than protein synthesis. Those functions result from complexation of a given synthetase with one or more other proteins. Synthetase mutations lead to various diseases. Scripps provides the mutants, and we use hydrogen/deuterium exchange monitored by FT-ICR mass spectrometry to map the protein:protein contact surfaces in the complexes to establish structure function relationships.

Southeast Center for Integrated Metabolomics, University of Florida, FL
With a new $9 million grant from National Institutes for Health, the University of Florida created a Southeast Center for Integrated Metabolomics which joins a consortium of five other regional resource centers and a national coordinating center to spur metabolomics research in the United States by funding training, technology development, standards synthesis and data-sharing initiatives. Metabolomics draws
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from many scientific disciplines, including chemistry, physiology, statistics, genetics, computer science and systems design and, as such, has many partners: the National High Magnetic Field Laboratory at Florida State University, Sanford-Burnham Medical Research Institute, Ohio State University, the University of Georgia, Imperial College London, the University of Geneva and industry partners IROA Technologies and Thermo Fisher Scientific.

(MagLab contact: Matt Merritt, AMRIS)

Thomas Jefferson National Accelerator Facility, Newport News, VA
Large-grain Nb has become a viable alternative to fine-grain Nb for the fabrication of superconducting radio-frequency cavities. NHMFL collaborated with engineers at Jefferson Lab to evaluate the effect of thermal processing and grain size on the mechanical properties of Nb. The mechanical properties evaluation was carried out at MS&T’s Mechanical Properties Lab.

(MagLab contact: Bob Walsh, MS&T)

Woods Hole Oceanographic Institute, FL
As part of FSU’s Gulf Research Initiative Consortium, NHMFL collaborates with Christopher Reddy and Robert Nelson at WHOI in characterization of petroleum oil spills at the molecular level, by gas chromatography x gas chromatography and FT-ICR mass analysis. Characterization of the 2010 Macondo wellhead oil has been completed, and current research focuses on subsequent physical, chemical, and biological changes as the spill propagates into the environment.

(MagLab contact: Ryan Rodgers, ICR)

Universities

Florida State University, College of Education, Tallahassee, FL
The Center for Integrating Research & Learning works closely with faculty from the FSU College of Education to network and strengthen programs on campus and at the lab. Currently, we utilize the expertise of FSU faculty for research projects. We also recruit graduate students from FSU departments to conduct research on CIRL programs.

(MagLab contact: Roxanne Hughes, Educational Programs)

Korea Advanced Institute of Science and Technology (KAIST)
Professor Hyoungsoo Choi’s group at the Korea Institute of Science and Technology (KAIST) has developed a cooperative agreement with Professor Yoonseok Lee and the National High Magnetic Field Laboratory’s High B/T Facility for the study and development of the design of coolant materials used in nuclear demagnetization refrigerators. The collaboration focuses on the techniques and expertise required to produce high residual resistant ratios for the metallic materials used for the coolants and the associated components. KAIST is a leading center for ultra-low temperature research in Korea.

(MagLab contact: Yoonseok Lee, UF)

Michigan State University, Lansing, MI
The Applied Superconductivity Center is collaborating Michigan State University on a US-DOE funded project to study the impact of grain boundaries and associated microstructural defects on the performance of superconducting cavities using the advance microstructural, microchemical, and electromagnetic characterization techniques and expertise available in the MagLab.

(MagLab contact: Peter J. Lee, ASC)

Nagoya University, Nagoya, Japan

Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Leibniz Institute for Solid State and Materials Research (IFW), Dresden, Germany

The Applied Superconductivity Center is collaborating with Nagoya University, the Karlsruhe Institute of Technology, and the Leibniz Institute in the investigation of iron-based superconductors in order to establish their intrinsic properties and determine their potential for applications using electromagnetic characterization techniques with the high field and expertise available at the MagLab.

(MagLab contact: Chiara Tarantini, ASC)

Osaka City University, Japan

The EMR group received joint funding with the University of Modena in Italy and Osaka City University in Japan through an International Program sponsored by the Air Force’s Asian Office of Aerospace Research and Development (AOARD). This joint program focuses on quantum properties of molecular magnets. A cooperative agreement between Osaka
City University and Florida State University have been established in order to formalize this collaboration. *(MagLab contact: Stephen Hill, EMR)*

**The Pennsylvania State University, State College, PA**  
Scientist from the NMR User Program at the MagLab are working with Prof. Jeffrey Schiano in the PSU Dept. of Electrical Engineering to improve field regulation in powered magnets to enable high resolution NMR measurements at previously inaccessible fields. *(MagLab contact: William Brey, NMR)*

**Radboud University, Nijmegen, The Netherlands**  
The MagLab has partnered with the High Magnetic Field Lab in The Netherlands to develop a 45 T hybrid magnet using only 24 MW of power. The project was funded by the Dutch government in 2006 and in 2012 an agreement was signed for the MagLab to play a leading role in the development of the Nb3Sn cable-in-conduit superconducting coil for this magnet system. This will be the 4th hybrid outsert to be developed at the MagLab (MagLab 45 T, HZB, FSU SCH, Nijmegen) and the Dutch lab will benefit from our extensive experience. When complete it is expected to be one of the three 45 T systems worldwide. Cable-in-conduit conductors have arrived and have been wound into the coil. Fabrication of the joints between pieces of conductor is now underway. This will be followed by reaction, impregnating, final assembly, and shipping.  
*(MagLab contact: Mark D. Bird, MS&T)*

**Shanghai University, Shanghai, China**  
The collaboration between the Shanghai University and the MagLab is related to the solidification of metallic materials. A scientist from Shanghai University was in the MagLab as a visiting scientist for one year to do the research on microstructure of high strength materials. They have published two joint papers.  
*(MagLab contact: Ke Han, MS&T)*

**St. Andrews University, UK**  
The EMR group has an ongoing partnership with St. Andrews University in the UK, involving the development of a high-power (1 kW) high-frequency (94 GHz) pulsed EPR spectrometer (HiPER) for its user program.  
*(MagLab contact: Stephen Hill, EMR)*

**Texas A&M University, College Station, TX**  
Texas A&M University is fabricating Nb sheet and tubes with ultra-fine grain size and controlled textures for superconducting RF cavities by using the Equal Channel Angular Extrusion (ECAE) process; the Applied Superconductivity Center is providing microstructural characterization of the Nb primarily using the new fast-cameral crystallographic orientation mapping system at the MagLab.  
*(MagLab contact: Peter J. Lee, ASC)*

**University of Colorado Boulder, Boulder, CO**  
Nb3Sn is the primary superconductor for providing magnetic fields in the 11-22 T range but is brittle and there is the potential for filament fracture when subjected to the high Lorentz forces produced when the superconducting magnets are energized. The University of Colorado Boulder, (using the NIST-Boulder electromechanical testing facilities) has determined the strain sensitivity of a wide range of commercial Nb3Sn wires and has found a large variation in irreversibility strains (the limit in strain that the wire can be subjected to before unrecoverable degradation in performance), and the Applied Superconductivity Center has been working with UC-Boulder to try and the understand reasons for these variations so that future strands will be able to withstand the forces generated at high magnetic fields.  
*(MagLab contact: Peter J. Lee, ASC)*

**University of Illinois, Chicago, IL**  
The National High Magnetic Field Laboratory, Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) Facility in the McKnight Brain Institute of the University of Florida is collaborating with the research group of Professor Richard Magin in the Department of Bioengineering of the University of Illinois, Chicago to measure anomalous translational diffusion in porous materials. These measurements provide unique information about the microstructure of porous materials and require the high sensitivity of, and high strength gradients systems available on, the 17.6 T magnetic system in the AMRIS Facility.

**University of Illinois, Chicago, IL**  
The National High Magnetic Field Laboratory, Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) Facility in the McKnight Brain Institute
of the University of Florida is collaborating with the research group of Professor Dieter Klatt in the Department of Bioengineering of the University of Illinois, Chicago to measure properties of elastic materials using magnetic resonance imaging. These measurements provide unique, detailed information about the propagation of motion though elastic materials and require the high sensitivity available on the 11.1 T magnetic system in the AMRIS Facility.  
(MagLab contact: Thomas H. Mareci, AMRIS Facility)

University of Modena, Italy
The EMR group received joint funding with the University of Modena in Italy and Osaka City University in Japan through an International Program sponsored by the Air Force’s Asian Office of Aerospace Research and Development (AOARD). This joint program focuses on quantum properties of molecular magnets.  
(MagLab contact: Stephen Hill, EMR)

University of Texas Medical Branch at Galveston
(MagLab contact: Alan Marshall, ICR)

Community Groups/ Educational Groups

Alachua County Public Schools, Gainesville, FL
The UF-NHMFL site has a close working relationship with the Alachua County Public Schools through our in-classroom presentations, participation in evening programs and special events, and bi-monthly science club.  
(MagLab contact: Elizabeth Webb, UF)

CAISE - Center for the Advancement of Informal Science Education, D.C.
The Center for the Advancement of Informal Science Education (CAISE) works in collaboration with the National Science Foundation (NSF) Advancing Informal STEM Learning (AISL) Program to strengthen and advance the field of professional informal science education and its infrastructure by providing resources for practitioners, researchers, evaluators, and STEM-based professionals. CAISE also facilitates conversation, connection, and collaboration across the ISE field — including in media (TV, radio, and film); science centers and museums; zoos and aquariums; botanical gardens and nature centers; cyber-learning and gaming; and youth, community, and out of school time programs. The Center for Integrating Research & Learning (CIRL) has worked with CAISE to provide advice for reaching Principal Investigators and improving the evaluation of broader impacts.  
(MagLab contact: Roxanne Hughes, Educational Programs)

Community Classroom Consortium, Tallahassee, FL
The Community Classroom Consortium (CCC) is a coalition of more than thirty cultural, scientific, natural history, and civic organizations in north Florida and South Georgia that provide educational experiences and resources to the public, especially K-12 teachers and students. Representatives from CIRL and Public Affairs represent the Lab on the board of this organization and as general members.  
(MagLab contact: Kristen Coyne, Public Affairs)

Florida Afterschool Network, Tallahassee, FL
The Florida Afterschool Network (FAN) is an organization that is working toward creating and sustaining a statewide infrastructure to establish collaborative public and private partnerships that connect local, state, and national resources supporting after-school programs that are school-based or school-linked; develop quality afterschool standards that are endorsed and promoted by statewide stakeholders and through Florida Afterschool Network; and promote public awareness and advocate for policy that expands funding, quality improvement initiatives, and accessibility of afterschool programs. The Center for Integrating Research & Learning is a member of the advisory council for this organization.  
(MagLab contact: Roxanne Hughes, Educational Programs)

Future Physicists of Florida
Future Physicists of Florida is an organization dedicated to recognizing talented middle school math and science students and providing educational guidance to these students to prepare them for careers in physics and engineering. CIRL is a partner in the organization.  
(MagLab contact: Roxanne Hughes, Educational Programs)
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Leon County and City of Tallahassee Commission on the Status of Women and Girls, FL
The Commission on the Status of Women and Girls was formed in April of 2011 by the Leon County Board of County Commissioners. The CSWG was established as a citizens advisory committee. In March of 2013, the City of Tallahassee proudly joined Leon County and created the new Tallahassee/Leon County Commission on the Status of Women and Girls (CSWG). By establishing and supporting this Commission, the City of Tallahassee and Leon County have taken a strong stand in support of women and girls in our community. Roxanne Hughes was selected to serve a two-year term by county commissioner Kristin Dozer.  
(MagLab contact: Roxanne Hughes, Educational Programs)

Leon County Schools, FL
CIRL works closely with Leon County Schools (LCS) through their K-12 outreach and our middle school mentorship program. In 2014, CIRL staff worked with Title I elementary school teachers from LCS to develop and facilitate a year-long teacher professional development that culminated in a STEM challenge for students.  
(MagLab contact: Roxanne Hughes or Carlos Villa, Educational Programs)

Los Angeles County Museum of Natural History, CA
The collaboration between the IVPP and the MagLab is related to the investigation of Late Cenozoic Vertebrate Paleontology and Paleoenvironments of the Tibetan Plateau (China). Stable isotopic compositions of the samples collected in this project are analyzed in the Geochemistry Laboratories in the MagLab.  
(MagLab contact: Yang Wang, Geochemistry Program)

Oasis Center for Women and Girls, FL
The Oasis Center is a nonprofit organization in Tallahassee whose mission is to "improve the lives of women and girls through celebration and support". They are focused on personal, professional, and economic concerns facing women, girls and their families. CIRL has worked closely with this center through outreach including providing mentors and/or tours for their science summer camps.  
(MagLab contact: Roxanne Hughes, Educational Programs)

Palmer Munroe Teen Center, FL
The Palmer Munroe Teen Center is a community center that focuses on teens from low income neighborhoods in Tallahassee. The center is run by the City of Tallahassee. CIRL works closely with students and staff at the center through outreach.  
(MagLab contact: Roxanne Hughes, Educational Programs)

Panhandle Area Educational Consortium (PAEC), FL
The Panhandle Area Educational Consortium serves 13 school districts in the panhandle of Florida. PAEC provides leadership and support services to these districts, increases networking among members, and maximizes resources. Over the years, CIRL has provided teacher workshops and high school summer information sessions to students and teachers from these districts with PAEC’s facilitation.  
(MagLab contact: Roxanne Hughes, Educational Programs)

South Florida Water Management District (SFWMD)
The collaboration between the SFWMD and the MagLab is related to the investigation of land-use and change on food web structure and mercury cycling in the Everglades. Isotopic compositions of the samples collected in this project were analyzed in the Geochemistry Laboratories in the MagLab.

WFSU-TV, Tallahassee, FL
The Center for Integrating Research & Learning partners with WFSU-TV, the area’s public television station, to administer SciGirls. The program is a 2-week camp for middle and high school girls with an interest in science. The collaboration between the MagLab and WFSU-TV has resulted in a successful 6-year camp that has engaged the larger community. In addition, WFSU-TV and the Center partner to provide summer physics experiences for students entering high school.  
(MagLab contact: Roxanne Hughes, Educational Programs)
Spin Offs

**High Performance Magnetics (HPM), FL**
High Performance Magnetics was founded in 2008 by Thomas Painter, an engineer at the National High Magnetic Field Laboratory. High Performance Magnetics established a nearly half-mile long superconducting cable jacketing facility located at the Tallahassee Regional Airport. High Performance Magnetics jacketed Toroidal Field Nb₃Sn cable-in-conduit conductors for Oak Ridge National Laboratory as part of the United States contribution to an international clean energy experiment, ITER, being built in France. These high-current, high-field superconducting cables were jacketed according to the strictest quality standards required by the nuclear industry.
*(MagLab contact: Tom Painter)*

**MAXIKAT, Inc., FL**
is a spinoff company that performs data analysis for petroleum industry. It was formed in 2015.
*(MagLab contact: Vladislav Lobodin)*

**Omics LLC, FL**
Omics LLC is a spinoff company that serves the data analysis and interpretation needs of the high resolution mass spectrometry market. It was formed 8 years ago and has grown over the years to address a wider analytical community.
*(MagLab contact: Ryan Rodgers)*

**Specialized Crystal Processing, Inc., FL**
Specialized Crystal Processing, Inc. (SCPI) is an advanced materials processing, manufacturing and consultation spin-off of the National High Magnetic Field Laboratory. The SCPI home base facility is located off-campus in Tallahassee, FL and has the infrastructure for both R&D and manufacturing of highly specialized single crystal products. These crystals can be used for a variety of applications, including but not limited to high tech devices and sensors, advanced materials basic science research and crystalline additives for composite materials.
*(MagLab contact: Jeffrey Whalen, Theo Siegrist)*
Chapter 2 - Laboratory Management

Data Management Plan

The National High Magnetic Field Laboratory (MagLab) provides seven high magnetic field user facilities across the three campuses of the MagLab at Florida State University, the University of Florida, and Los Alamos National Laboratory. These user facilities are the DC Field Facility; Pulsed Field Facility; High B/T Facility; and the Nuclear Magnetic Resonance (NMR), Electron Magnetic Resonance (EMR), Ion Cyclotron Resonance (ICR), and Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) Facilities. Each user facility is built around unique magnetic field facilities and world leading scientific expertise serving a multi- and interdisciplinary scientific research community. Though each facility has a unique environment and tradition of data management, this policy is applied in a consistent way across sites. Our data management practices are driven by our user community and the standards of the associated funding agencies. The policy is reviewed annually to stay current with user demands and changes in technology.

Data Types

Our user facilities data consists primarily of electronic records of measurements taken during a scheduled experiment. Data from a facility can be generated on either a facility computer system, visiting user’s computer, or special data acquisition systems provided by a user. These electronic records may or may not exist on a facility computer during the course of an experiment.

The MagLab scientific staff develops, maintains, and updates many software routines for analysis of data tailored to the different needs of the user facilities.

Data Standards

The standards for data vary across user facilities as required by the experimental methods and equipment used. The most open standard for the DC Magnet facility is for ASCII text files in column format. High data rate experiments such as the Pulsed Field Facility necessitate the use of open binary formats or custom file formats developed by MagLab personnel. The ICR facility also stores data in a MagLab-developed format. For NMR experiments, data formats are dictated by the research equipment used, such as the vendor-specific format for NMR data collected by Bruker spectrometers. Magnetic Resonance Imaging data from our AMRIS facility is in DICOM images for OSIRIX viewer. Data is made available to researchers through the use of the current picture archiving and communication systems (PACS) with dedicated computers on a local high speed network.

All MagLab-developed formats are open. Specifications and software to read and analyze data in these formats is available to the scientific community for free or at nominal reproduction costs. These software tools are provided on laboratory web sites and software storage areas.

Meta-data can be recorded with the raw data files at the option of the researchers. Other meta-data is recorded in the users written notebooks, computer files, or other media at the option of the principal investigator. Management of the meta-data associated with standard data files is exclusively the purview of the principal investigator.

Data Access Policies

The principal investigator in charge of a user experiment has exclusive rights to all data related to that experiment, including raw data and meta-data. Access to experiment data is granted only to individuals designated by the principal investigator. The principal investigator retains full control of the use of the data, including its publication in refereed literature. The principal investigator is responsible for adhering to the policies and procedures of their funding agency.

The MagLab’s data management and sharing practices align with the policy applied to NSF and NIH single investigator grants, as the MagLab user community consists primarily of researchers supported by these types of awards.

Data Re-use Policies

Data is not reused nor are any data-mining operations performed by the MagLab on historical user data. Once data is collected and provided to the user, it is solely the property of that particular user. Any reuse within their own program (external to MagLab) is strictly at their discretion. Users are encouraged to make their research findings and final data readily available for research purposes to qualified individuals within the scientific community by publishing the results in peer-reviewed journals and by presenting the findings at conferences. In addition, the MagLab requires all users to submit a one-
Chapter 2 - Laboratory Management

Page annual research report on each project for inclusion in the MagLab Annual Report. These reports are available on the MagLab web site and serve to illustrate the quantity, quality, and breadth of research activities at the lab. Each year, a subset of these reports are chosen as highlights to be published in a Special Issue of MagLab Reports, the MagLab’s quarterly magazine that is widely distributed to scientists, students, and granting agencies.

Users are reminded to follow all regulations of the NSF and NIH data sharing policies by posting of this policy (http://grants.nih.gov/grants/policy/data_sharing) on the AMRIS webpage (http://amris.mbi.ufl.edu) as well as via periodic emails to the user group. (see NIH Grants Policy Statement: http://grants.nih.gov/policy/nihgps/index.htm and NSF Award and Administration Guide http://www.nsf.gov/pubs/policydocs/pappguide/nsf11001/aag_6.jsp). When appropriate, users are encouraged to deposit standard data formats in existing repositories, such as the “Protein Data Bank” and “Biological Magnetic Resonance Data Bank.”

Data Archiving

Data collected and stored on a MagLab facility computer system are backed-up to local hard drives, tape storage or other common backup media. Data archiving is primarily the responsibility of the PI at their home institutions, but archived user data are retained at the MagLab facility for a period ranging from six months to two years after collection at the MagLab. This retention policy is reviewed annually and may be revised at the request of our user community, or in response to the continually evolving capabilities and reduction in costs of data storage. Archived data will only be made available to individuals at the request of the principal investigator of the project.

Users may transfer their data to portable storage devices or other computers, both local and remote, in accordance with local facility administration policies. Upon request user data will be archived on optical or other similarly permanent media and provided to the user.
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User Program

The MagLab is one user program with seven user facilities. DC Field, Pulsed Field, High B/T, NMR-MRI@FSU, NMR-MRI@UF (AMRIS), EMR, and ICR, each with exceptional instrumentation and highly qualified staff scientists and staff, comprise the MagLab’s User Program. In this chapter of the annual report, information is presented about the proposal review process, user safety training, special user funding opportunities, and user committee report.

Proposal Review Process

Across all seven facilities, proposals for magnet time are submitted online (https://users.magnet.fsu.edu/) and reviewed in accordance with the NHMFL User Proposal Policy (https://users.magnet.fsu.edu/Documents/UserProposalPolicy.pdf). In brief, each user facility has a User Proposal Review Committee (UPRC) comprising at least seven members, with more external members than internal. UPRC memberships are treated confidentially by the laboratory but are available for review by NSF and NHMFL advisory committees. Proposal reviews are conducted in strict confidence and are based on two criteria: (1) the scientific and/or technological merit of the proposed research, and (2) the “broader impacts” of the proposed work. They are graded online according to a scale, ranging from ‘A’ - Proposal is high quality and magnet time must be given a high priority; to “C” - Proposal is acceptable and magnet time should be granted at NHMFL discretion; to “F” - Proposal has little/no merit and magnet time should not be granted. The Facility Directors dovetail the UPRC recommendations with availability and scheduling of specific magnets, experimental instrumentation, and user support scientists and make recommendations for magnet time assignments to the NHMFL Director. The NHMFL Director is responsible for final decisions on scheduling of magnet time based on these recommendations.

Research Reports

At the end of each year, MagLab users and faculty at FSU, UF and LANL submit brief abstracts of their experiments, research and scholarly endeavors. All reports are available online at https://nationalmaglab.org/research/publications-all/research-reports. Users generated 474 research reports in 2016 (Table 1).

Table 1: 2016 Research Reports by Facility

<table>
<thead>
<tr>
<th>FACILITIES</th>
<th>NUMBER OF REPORTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Field Facility</td>
<td>135</td>
</tr>
<tr>
<td>Pulsed Field Facility</td>
<td>69</td>
</tr>
<tr>
<td>High B/T Facility</td>
<td>7</td>
</tr>
<tr>
<td>NMR-MRI@FSU</td>
<td>62</td>
</tr>
<tr>
<td>NMR-MRI@UF (AMRIS)</td>
<td>54</td>
</tr>
<tr>
<td>EMR Facility</td>
<td>52</td>
</tr>
<tr>
<td>ICR Facility</td>
<td>29</td>
</tr>
<tr>
<td><strong>MAGLAB DEPARTMENTS &amp; RELATED GROUPS</strong></td>
<td></td>
</tr>
<tr>
<td>Applied Superconductivity Center</td>
<td>18</td>
</tr>
<tr>
<td>Condensed Matter Theory/ Experiment (FSU)</td>
<td>13</td>
</tr>
<tr>
<td>Magnet Science &amp; Technology</td>
<td>10</td>
</tr>
<tr>
<td>UF Physics</td>
<td>5</td>
</tr>
<tr>
<td>Geochemistry</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL REPORTS</strong></td>
<td><strong>474</strong></td>
</tr>
</tbody>
</table>
Chapter 3 – User Facilities

User Safety Training by Facilities
Safety training, across all facilities, is an important component of the Lab’s Integrated Safety Management.

**DC Field Facility**

**Users of the DC Field Facility must complete the appropriate online safety training prior to being issued a badge and receiving access to the DC Magnet Building.** Users are assigned training modules that are appropriate to the experiment they are conducting and the part of the facility they will be working in. When magnet time is awarded, the safety training status of the researchers who are traveling to the MagLab is checked by the DC Field User Program Coordinator several weeks prior to their arrival. Any users who either have not taken the required training or whose training has expired are directed to the training website: [https://training.magnet.fsu.edu/Login/Default.aspx](https://training.magnet.fsu.edu/Login/Default.aspx) to take the appropriate training. Users who arrive at the lab without having completed the training are set up in one of our user offices so that they can complete the training before they are granted access to the magnet cells.

During the user’s magnet time they are assigned an in-house scientist as well as a technician in order to provide scientific and technical support. This also ensures that the user performs their experiment in a safe manner. In addition, the control room operators monitor the magnet cells via cameras located in each cell. User operations on the 45 T hybrid magnet are also monitored directly by a hybrid operator who is present on the user platform while the hybrid magnet is in use.

**Pulsed Field Facility**

Users of the Pulsed Field Facility (PFF) are treated equally as full time employees at Los Alamos National Laboratory (LANL) with respect to hazardous work activities and authorization. New for 2016 was the development and implementation of a “Competent worker pilot program for cryogenic transfers.” The notion was to allow first line managers the ability to develop criteria for evaluating a person’s experience and ability and then to verify the person’s competencies in the field. This is needed because LANL used multiple live training courses that are scheduled too infrequently to be effective for NHMFL users. A documented process was designed and tested and two NHMFL users were the subjects of the pilot program. So far the concept has demonstrated that LANL can be “agile” in meeting the needs of users while applying a graded approach towards risk and worker safety.

All LANL workers are educated on a comprehensive approach towards safe work practices within the context of Integrated Safety Management at LANL before being authorized to perform hazardous work activities. The approach that LANL takes is based on “Human Performance Improvement” or HPI (available at: [http://energy.gov/sites/prod/files/2013/06/f1/doe-hdbk-1028-2009_volume1.pdf](http://energy.gov/sites/prod/files/2013/06/f1/doe-hdbk-1028-2009_volume1.pdf)) The use of engineering controls are preferred to keep workers safe and reduce the risk of a human based error whenever possible (example: door interlocks and “Kirk Keys” used to ensure safe equipment configuration in pulsed capacitor bank operations at the PFF). The knowledge of HPI practices and the approach to safety management is central to the safety aware work culture at the PFF and throughout LANL. All safety management is governed by LANL policies and procedures. All work performed at the PFF is categorized into one of three hazard classes (Low, Medium, or High). By default no Medium or High hazard work activities are permitted at the PFF unless needed and authorized.

All hazardous work that is categorized as Medium or High Hazard work activities (based on the LANL hazard categorization matrix found in the LANL Integrated Work Management policy P300 Hazard Grading Table Attachment B) require a written and approved work control process (called an Integrated Work Document or IWD) and documented work authorization by the Safety Responsible Line Manager (SRLM). All LANL workers (staff and users performing hazardous work) use an online system (called U-Train) to assign and track training and work authorization. All users are assigned one or two PFF Scientists to assist and support scheduled experiments. When users arrive they first complete a briefing by the assigned Scientist and the program specialist. The program specialist, based on the nature of the visit, then assigns any additional training to the user. Live training or on-line content is then completed by the user and tracked in U-Train. If hazardous work is to be performed by the user (e.g. operate the PFF User Capacitor Bank) the IWD is read, training is verified by the SRLM, and
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based on need and agreement with the Person In Charge of the IWD, the work authorization is grant-
ed by the SRLM (tracked in U-Train). At this time, PFF users may be authorized on work that is catego-
rized as low or medium hazard work. All of the in-
frastucture and management support of the above
work control process at LANL is provided by institu-
tional support of programs.

High B/T Facility

All members of a user group carrying out exper-
iments at the High B/T Facility must observe all the
safety precautions required by the National High
Magnetic Field Laboratory and the University of
Florida. New Users are asked to review the NHMFL
Integrated Safety Management plan and to familiar-
ize themselves with the High B/T User’s manual.
Prior to carrying out an experiment, all members of
the user group must pass the safety training provid-
ed by the National High Magnetic Field Laboratory.
On the first day of their visit, users are introduced to
the facility and its layout and the safety precautions
for working in the designated area: use of O2 sen-
sors, covering of all pits, location of safety goggles
and tools, and exits in case of a magnet quench etc.
Access to the Microkelvin Laboratory is limited to
authorized personnel who will be provided with an
access key. All users must comply with the following
rules that are specific to the High B/T facility:
1. No user may transfer cryogenic fluids.
2. No user may charge or discharge any magnets in
the facility.
3. All undergraduate students must be accompa-
nied by a supervising faculty or staff member at all
times.
4. Users may not be present in the lower floor area
when the dewars or electromagnetic shields
(socks”) are being raised or lowered and when the
pit covers are temporarily open.
5. All personnel including users who need to enter
the pit(s) must have completed “confined space
training” and” fall protection training” with the
University of Florida Environmental Health and
Safety Department.

Access to the High B/T facility is limited to au-
thorized personnel who will be provided with a UF
key for entry. Users will receive a key on notification
they have passed the safety training.

Detailed information regarding safety proce-
dures is available on the facility web page at:

NMR Facility

External Users

Each external user prior to carrying out an exper-
iment at the NMR Facility is required to pass the
online safety training course(s) provided by the
NHMFL (https://nationalmaglab.org/user-facili-
ties/). This is currently enforced by the NMR Admin-
istrative Assistant and/or CIMAR Coordinator, who
will not issue a laboratory access card or any keys
without all trainings being completed and passed.

Prior to an experiment, potential safety issues are
discussed individually with each new user. During
the actual experiments, users are accompanied/ su-
ervised by one of the NMR science staff. All non-
routine or increased-risk operations, such as refill-
ing the magnets with liquid helium, are performed
by NMR staff rather than by the user.

Internal Users

All of the NMR group members have become fa-
miliar with the ISM (Integrated Safety Management)
principles. All of them attend the quarterly NHMFL
Safety Meetings. A representative of the NMR group
attends the monthly NHMFL Safety Committee
meetings and reports on pertinent issues to the
NMR group during its meetings.

NMR staff and faculty group meetings are con-
ducted weekly. Every 6 weeks a meeting is dedicat-
ed to safety, safety issues, and/ or safety training. All
members of the NMR group are required to com-
plete and pass the NHMFL online safety training
courses, and they are required to keep those train-
ings current.

AMRIS Facility

All internal and external users that will assist in
data acquisition (i.e. anyone who will enter the facili-
ty without direct supervision of AMRIS personnel)
are required to attend a one hour safety class as a
first step to getting keyed access. In this class, safe
operation in high magnetic fields, working with RF
cables, and the principles of ISM are presented and
discussed. Anyone working with animals is required
to carry documentation of their IUCAC approved
protocol when working with animals in the AMRIS
facility. The UF IUCAC office oversees all animal re-
lated safety training and authorization of work with
animals at UF, including for external users. Users
wanting to work independently in the 11 T room
(i.e. without an AMRIS staff person present) are re-
cquired to demonstrate instrument proficiency to
Chapter 3 – User Facilities

AMRIS personnel and to attend an additional hour of safety training specific to the 11 T system.

AMRIS personnel have weekly staff meetings and at each of these meetings we review whether there are any safety issues or training needing discussion. If so, time is dedicated to discussing any incidents or changes in training/operation and ensuring all AMRIS personnel are apprised of them. We also regularly update our web pages to reflect current safety policies. All AMRIS personnel are required to keep both the NHMFL and UF safety training current. Regular inspections of AMRIS facilities are performed by the UF office of Environmental Health & Safety as well as by the IUCAC. AMRIS personnel directly accompany all new users in the facility and regularly interact with experienced users to discuss any issues which might arise during their facility use. All non-routine, increased-risk operations, such as refilling the magnets with cryogens, are performed by trained AMRIS personnel. Any use of cryogens during experiments to cool samples requires additional training in safe handling of cryogens.

All access to the AMRIS facility is via RFID keys; these keys are monitored and regulated through the UF Police Department so we have a record of their use and can revoke access to an individual user at any point in time if needed.

EMR Facility

External Users

Each external user prior to carrying out an experiment at the EMR Facility is required to pass the on-line safety training course(s) provided by the NHMFL (https://nationalmaglab.org/user-resources/safety). This is currently enforced by the EMR Administrative Assistant, who will not issue a laboratory entrance card or any keys without proof of completion of the required course(s). Prior to an experiment, potential safety issues are discussed individually with each new user. During the actual experiments, each user is accompanied/supervised by one of the EMR science staff. All non-routine or increased-risk operations such as refilling the magnets with liquid helium or sample changes are performed by the staff rather than the user.

Internal Users

All of the EMR group members have become familiar with the ISM (Integrated Safety Management) principles. All of them also attend the quarterly NHMFL Safety Meetings. A representative of the EMR group attends the monthly NHMFL Safety Committee meetings and reports on pertinent issues to the EMR group during its meetings.

ICR Facility

All internal ICR personnel and external users that will assist in data acquisition are required to select the labs that they will be working in prior to assignment of safety training. Safety training is assigned based on the working hazards that are within each lab space. For example, each person who will work in the ICR high bay is required to take the following safety training courses: cryogen safety, high magnetic field, general safety, laser safety and electrical safety. Additionally, no one is allowed to perform any cryogen fills or operate any instrument systems without extensive, supervised, hands-on safety training by an ICR staff member.

All users that will be entering all ICR lab spaces are required to complete online safety training, but are assisted by an internal ICR group member for all sample preparation, instrument start up and shutdown, and data acquisition. All ICR magnet system usage is limited to trained ICR personnel. No external users are allowed to start up or shut down ICR magnet systems. In addition, access to the ICR 21 T high bay is limited to only personnel that have been approved for access to the high bay area. All visitors are required to have an escort at all times, and everyone who enters any ICR lab space (C330, B239, B240, NM 113 and NM 117) is required to wear safety glasses with no exceptions. No food and drink is allowed in any ICR lab space except in designated areas that are marked with appropriate signs. Safety glasses are mandatory at all times in all ICR laboratory and high bay spaces.
User Collaboration Grants Program

The National Science Foundation charged the National High Magnetic Field Laboratory with developing an internal grants program that utilizes the NHMFL facilities to carry out high quality research at the forefront of science and engineering and advances the facilities and their scientific and technical capabilities. User Collaboration Grants Program (UCGP), established in 1996, stimulates magnet and facilities development and provides intellectual leadership for research in magnetic materials and phenomena.

The UCGP seeks to achieve these objectives by funding research projects of normally one- to two-year duration in the following categories:

- small, seeded collaborations between internal and/or external investigators that utilize their complementary expertise;
- bold but risky efforts that hold significant potential to extend the range and type of experiments; and
- Initial seed support for new faculty and research staff, targeted to magnet laboratory enhancements.

The Program strongly encourages collaboration between NHMFL scientists and external users of NHMFL facilities. Projects are also encouraged to drive new or unique research, i.e., serve as seed money to develop initial data leading to external funding of a larger program. In accord with NSF policies, the NHMFL cannot fund clinical studies.

Nineteen (19) UCGP solicitations have now been completed with a total of 538 pre-proposals being submitted for review. Of the 538 proposals, 279 were selected to advance to the second phase of review, and 122 were funded (23% of the total number of submitted proposals).

2015 Solicitation and Awards

The NHMFL UCGP has been highly successful as a mechanism for supporting outstanding projects in the various areas of research pursued at the laboratory. The proposal submission and two-stage proposal review process has been handled by means of a web-based system. The most recent solicitation, was announced in January, 2015 and already summarized in the 2015 Annual report, but is repeated here because awards were issued during 2016. To better manage funds as the NHMFL core grant is renewed, there was no solicitation announced during 2016.

Of the 26 pre-proposals received, the committee recommended that 12 pre-proposals be moved to the full proposal state. Of the 12 full proposals, 5 were awarded. A breakdown of the review results is presented in *Tables 1 and 2.*

<table>
<thead>
<tr>
<th>Research Area</th>
<th>Pre-Proposals Submitted</th>
<th>Pre-Proposals Proceeding to Full Proposal</th>
<th>Projects Funded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensed Matter Science</td>
<td>12</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Biological &amp; Chemical Sciences</td>
<td>10</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Magnet &amp; Magnet Materials Technology</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>26</strong></td>
<td><strong>12</strong></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>
Chapter 3 – User Facilities

Table 2. UCGP Funded Projects from 2015 Solicitation.

<table>
<thead>
<tr>
<th>PI</th>
<th>NHMFL Institution</th>
<th>Project Title</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seungyong Hahn</td>
<td>NHMFL-FSU</td>
<td>Partial No-Insulation and Metallic Cladding Insulation Techniques for Compact, Self-Protecting, and Low-Cost REBCO Magnets</td>
<td>$240,000</td>
</tr>
<tr>
<td>Yan-Yan Hu</td>
<td>NHMFL-FSU</td>
<td>Innovative In Situ And Operando Characterization Capabilities for Energy Materials Research</td>
<td>$199,904</td>
</tr>
<tr>
<td>David Graf</td>
<td>NHMFL-FSU</td>
<td>High Pressure Measurements of Magnetization by Field Modulation</td>
<td>$223,397</td>
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<tr>
<td>Johan Van Tol</td>
<td>NHMFL-FSU</td>
<td>High Field Integrated EPR And NMR for DNP Applications</td>
<td>$200,000</td>
</tr>
<tr>
<td>Scott Crooker</td>
<td>NHMFL-LANL</td>
<td>Free-Space Ultrafast Optics and Time-Domain Terahertz Spectroscopy In Pulsed Magnetic Fields</td>
<td>$240,463</td>
</tr>
</tbody>
</table>

2017 Solicitation

The 2017 Solicitation announcements should be released around March, 2017. Awards will be announced by the end of the year, and, depending upon the core grant renewal, made in early 2018.

Results Reporting

To assess the success of the UCGP, reports were requested in January 2017, on grants issued from the solicitations held in the years 2010 through 2016, which had start dates respectively near the beginnings of years 2010 through 2016. At the time of the reporting, some of these grants were in progress, and some had been completed. For this “retrospective” reporting, PIs were asked to include external grants, NHMFL facilities enhancements, and publications that were generated by the UCGP. Since UCGP grants are intended to seed new research through high risk initial study or facility enhancements, principal investigators (PIs) were allowed and encouraged to report results that their UCGP grant had made possible, even if these were obtained after the term of the UCGP grant was complete.

The PIs reported:
- Lab enhancements which were used by 114 different external user groups.
- At least partial support for 11 undergraduate researchers, 54 grad students, and 33 postdocs.
- 15 funded external grants which were seeded by results from UCGP awards. The total dollar value of the external grants was $11.4 M.
- 154 publications, many in high profile journals, as summarized in Table 3.

Table 3. Publications Reported, UCGP awards beginning 2011-2015

<table>
<thead>
<tr>
<th>Journal Name</th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Materials Research</td>
<td>1</td>
</tr>
<tr>
<td>Acta Metallurgica Sinica</td>
<td>1</td>
</tr>
<tr>
<td>Appl. Supercond.</td>
<td>4</td>
</tr>
<tr>
<td>ACS Catal.</td>
<td>1</td>
</tr>
<tr>
<td>Applied Materials &amp; Interface</td>
<td>1</td>
</tr>
<tr>
<td>App. Phy. Lett</td>
<td>1</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>Chem. Science</td>
<td>3</td>
</tr>
<tr>
<td>Chem. Materials</td>
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</tr>
<tr>
<td>Crystals</td>
<td>1</td>
</tr>
<tr>
<td>ECS Electrochem. Lett</td>
<td>1</td>
</tr>
<tr>
<td>Emerging Materials Research</td>
<td>1</td>
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</tbody>
</table>
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<table>
<thead>
<tr>
<th>Journal Name</th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Society for Magnetic Resonance in Medicine</td>
<td>4</td>
</tr>
<tr>
<td>J. of Alloy Compound</td>
<td>2</td>
</tr>
<tr>
<td>Journal of Applied Physics</td>
<td>3</td>
</tr>
<tr>
<td>Journal of Chemical Physics</td>
<td>1</td>
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<tr>
<td>J. of Solid State Chemistry</td>
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<tr>
<td>J. of Magnetic Resonance</td>
<td>4</td>
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<td>J. of Membrane Science</td>
<td>2</td>
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<tr>
<td>Journal of Molecular Biology</td>
<td>3</td>
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<tr>
<td>J. Non-Crystalline Solids</td>
<td>3</td>
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<tr>
<td>J. Physical Chemistry</td>
<td>5</td>
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<tr>
<td>J. Phys. Condens. Mat.</td>
<td>7</td>
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<td>Magnetic Reson</td>
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<tr>
<td>Magnetic Reson. Med</td>
<td>2</td>
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<tr>
<td>Materials Science Forum</td>
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<tr>
<td>Materials Science &amp; Engineering</td>
<td>2</td>
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<tr>
<td>Nano Letters</td>
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<tr>
<td>Nature</td>
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<tr>
<td>Nature Communications</td>
<td>6</td>
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<tr>
<td>Nature Physics</td>
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<tr>
<td>Nature Struct. Mol. Biol</td>
<td>1</td>
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<tr>
<td>NeuroImage</td>
<td>2</td>
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<td>Neuroscience</td>
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<td>Optics Express</td>
<td>2</td>
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<td>Phy. Rev. B</td>
<td>39</td>
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<td>Phy. Rev. Rapid Communication</td>
<td>3</td>
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<td>Phys. Che., Chem. Phys.</td>
<td>3</td>
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<tr>
<td>Phys. Rev. Lett</td>
<td>8</td>
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<td>Proceeding</td>
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<td>PLoS One</td>
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<td>Polyhedron</td>
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<td>RSC Advances</td>
<td>1</td>
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<td>Sci. Report</td>
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<td>Scripta Mater</td>
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<td>Spintronic</td>
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Publications (including accepted for publication) as of January 2017, reported from UCGP grants.

### Table 4. Facility Enhancements Reported from UCGP awards beginning 2011-2015

<table>
<thead>
<tr>
<th>Enhancement and available date</th>
<th>users *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified 1800 C tube furnace for molten metal flux growth of uranium compounds (1/15)</td>
<td>7</td>
</tr>
<tr>
<td>Development of capabilities for hazardous substance handling (1/15)</td>
<td>4</td>
</tr>
<tr>
<td>microsurface coils at 14.1 and 17.6 Tesla+ strong planar gradient coils (7/11)</td>
<td>5</td>
</tr>
<tr>
<td>Arduino-controlled, NMR spectrometer-synchronized near-infrared high power laser tuning system (8/15)</td>
<td>3</td>
</tr>
<tr>
<td>Three (3) cryogenic NMR probes, all with through-space optical access (9/12-8/15)</td>
<td>10</td>
</tr>
<tr>
<td>Ac susceptometers (12/13)</td>
<td>8</td>
</tr>
<tr>
<td>variable temperature (VT) magic-angle spinning (MAS) probe for the 900 MHz NMR</td>
<td>2</td>
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</tbody>
</table>
## Chapter 3 – User Facilities

<table>
<thead>
<tr>
<th>Enhancement and available date</th>
<th>users *</th>
</tr>
</thead>
<tbody>
<tr>
<td>(6/14) 3.2mm double resonance MAS NMR probe for ultra-narrow bore 830 MHz magnet (11/13)</td>
<td>6</td>
</tr>
<tr>
<td>Relaxation-enhanced magnetic resonance spectroscopy set-up</td>
<td>4</td>
</tr>
<tr>
<td>dielectric-based cylindrical waveguide structure for the 900 UWB magnet. (12/11)</td>
<td>2</td>
</tr>
<tr>
<td>Improved EMR high pressure facility (11/16)</td>
<td>2</td>
</tr>
<tr>
<td>Fiber Bragg Grating based magnetostriction pulsed field and dc magnets (3/12)</td>
<td>21</td>
</tr>
<tr>
<td>Reel-to-reel magnetometer for 4.2 K conductor characterization (7/13)</td>
<td>2</td>
</tr>
<tr>
<td>VSM with rotator modified for high torque (4/16)</td>
<td>1</td>
</tr>
<tr>
<td>Imaging and measurement of photocurrent and photoluminescence in high magnetic field (9/12)</td>
<td>1</td>
</tr>
<tr>
<td>Probes for Split Helix, free space Raman measurement, Photoluminescence excitation, fluorescence line narrowing, magnetic circular dichroism (12/14)</td>
<td>7</td>
</tr>
<tr>
<td>Lithographically defined induction coil for pulse field measurement (4/15)</td>
<td>1</td>
</tr>
<tr>
<td>Apparatus allowing measurement in pulsed field in He exchange gas (3/16)</td>
<td>2</td>
</tr>
<tr>
<td>mK (³He and dilution fridge) NMR probes (8/15)</td>
<td>9</td>
</tr>
<tr>
<td>1 kW, 1GHz NMR power amplifier (10/16)</td>
<td>3</td>
</tr>
<tr>
<td>direct-optics setup for PL, reflectance, Raman magneto-spectroscopy at B&lt;14.5T and T=4-300K (6/15)</td>
<td>4</td>
</tr>
<tr>
<td>Facility to process samples before biological and chemical EPR measurements (6/13)</td>
<td>12</td>
</tr>
<tr>
<td>force magnetometers for unprecedented low T, high B (11/12)</td>
<td>2</td>
</tr>
<tr>
<td>Faraday magnetometer for the 20 T (6/13)</td>
<td>1</td>
</tr>
<tr>
<td>Expanded range of magnetic field sweep rates in the 60 T shaped-pulse magnet (8/12)</td>
<td>5</td>
</tr>
</tbody>
</table>

*Number of external users (PI’s only) reported to have used the enhancement.
Dependent Care Travel Grant Program

Eligible recipients are early career scientists, including undergraduate and graduate students, postdocs, and scientists with fewer than 10 years of active professional work since receiving a Ph.D. To be eligible, a scientist must be: An early career user traveling to a Magnet Lab facility in Tallahassee, Gainesville, or Los Alamos to conduct an experiment as part of a user program (not including employees of Florida State University, the University of Florida or Los Alamos National Laboratory) or a Magnet Lab early career scientist employed by any of the three Magnet Lab partner institutions who is selected to present results at scientific meetings, conferences, or workshops. A dependent is defined as 1) a child, newborn through 12 years of age (or any physically or mentally disabled child under the age of 18 who is unable to care for himself or herself), who resides with the applicant and for whom the applicant provides primary support, or 2) a disabled adult/elder (spouse, parent, parent-in-law, or grandparent) who spends at least eight hours per day in the applicant’s home and for whom the applicant has responsibility. The Dependent Care Travel Grant Program (DCTGP) is described in detail at https://nationalmaglab.org/user-resources/funding-opportunities/1126.

In 2016, three scientists benefited from this funding. One external user Dr. Amal B. al-Wahish (F) who is a postdoctoral researcher at the University of Tennessee, Knoxville applied and received $800 to pay for child care support for her child while she came to the lab to analyze samples from February 29, 2016 to March 6, 2016. Two MagLab postdoctoral researchers applied and received funds during 2016. Dr. Bimala Lama (F) is a postdoc at UF who received $800 in child care support while she traveled a conference in July of 2016. Dr. Bernhard Mayer (M), a postdoc at the lab, received $800 for child care support while he attended a conference in March of 2016.

First-Time User Support

The NHMFL is charged by the National Science Foundation with developing and maintaining facilities for magnet-related research that are open to all qualified scientists and engineers through a peer-reviewed proposal process. Facilities are generally available to users without cost. In an effort to encourage new research activities, first-time users are provided financial support for travel expenses. International users are provided $1,000 of support and domestic users are provided $500 of support for their travel costs. Support for this funding is provided by the State of Florida and is available for Tallahassee facilities only.

Visiting Scientist Program

The National High Magnetic Field Laboratory provides researchers from academia, industry, and national laboratories the opportunity to utilize the unique, world-class facilities of the laboratory to conduct magnet-related research. In 2016, the Visiting Scientist Program provided a total of $77,560 financial support for 8 research projects on a competitive basis. The primary intent of this program is to provide greater access to the unique facilities at the MagLab and to seed research programs that help advance the laboratory. State funding is being used and principally intended to partially support travel and local expenses. Requests for stipends are considered but given a lower priority. The amount of support generally ranges from a few thousand to $20,000. Beyond conducting the research as approved and maintaining fiscal integrity, the researcher has one additional responsibility, which is to provide the MagLab with a progress report on request and a final report on their research to be included in the online version of the NHMFL Annual Report. Participants in the NHMFL Visitors Program are expected to acknowledge support provided by the NHMFL in any publications coming from work during their visit or collaboration with the NHMFL. To apply for support from the Visiting Scientist Program, interested researchers are required to submit an application and a proposal that will be reviewed by appropriate facility directors and scientists at the NHMFL. All requests for support must be submitted online at https://vsp.magnet.fsu.edu/ at any time throughout the year.
Chapter 3 – User Facilities

User Advisory Committee Report

Chair: Chris Wiebe, Department of Chemistry, University of Winnipeg/University of Manitoba (adjunct, Department of Physics and Astronomy, McMaster University)

DC/Pulsed/High B/T Vice-Chair: Madalina Furis, Department of Physics, University of Vermont

NMR/MRI/ICR/EMR Vice-Chair: Robert Schurko, Department of Chemistry and Biochemistry, University of Windsor

User committee members:
DC/High B/T committee: Jason Cooley (Los Alamos National Laboratory), Nathanael Fortune (Smith College, Executive Committee Member), Madalina Furis (Chair for DC/ Pulsed Field /High B/T, University of Vermont), Malte Grosche (Cambridge University), Zhigang Jiang (Georgia Institute of Technology), Lu Li (University of Michigan), Philip Moll (Max Planck Institute for Chemical Physics of Solids), Chris Wiebe (University of Winnipeg, User Committee Chair), James Williams (University of Maryland)

Pulsed Field committee: Chuck Agnosta (Clark University), Kristin Alberi (National Renewable Energy Lab), James Analytis (University of California, Berkeley), Jamie Manson (Newly elected Chair, Eastern Washington University), Wei Pan (Sandia National Laboratory), Filip Ronning (Los Alamos National Lab)

NMR/MRI committee: R.W. Schurko (Chair, University of Windsor), Marek Pruski (Ames Lab, Iowa), Michael Harrington (Huntington Medical Research Institute), Brian Hansen (University of Aarhus), Eduard Chekmenev (Vanderbilt University), Oc Hee Han (Korea Basic Science Institute), Doug Kojetin (Scripps Research Institute), Len Mueller (UC Riverside), Fang Tian (Penn State University), Scott Prosser (University of Toronto)

EMR committee: Kurt Warncke (Chair, Emory University, U.S.), Chris Kay (University College, U.K.), Dane McCamey (University of New South Wales, Australia), Christos Lampropoulos (University of North Florida, U.S.), Stefan Stoll (University of Washington, U.S.), Erik Cizmar (P. J. Safarik University)

ICR User Advisory Committee: Jonathan Amster (Chair, Franklin College), Michael Chalmers (Eli Lilly and Company DCR&T Analytical), Michael Freitas (Ohio University Medical Center), Elizabeth Kujawinski (Woods Hole Oceanographic Institution), John Shaw (University of Alberta), Forest White (MIT)

The User Community would like to extend their appreciation to Greg Boebinger and the NHMFL for hosting this meeting in Tallahassee. The timing is very important for addressing the NSF Renewal Grant Process. As a community, we are overall very impressed with the direction that the magnet lab is taking with the Science Drivers and Grand Challenges.

We are also thankful for the continued support of the host institutions (FSU, LANL, and UF) and the NSF in the funding of the NHMFL. The NHMFL is a world class facility that offers techniques for the exploration of matter that are unique in the world. We are confident that the NHMFL will continue to be an important facility for high impact, ground breaking science that serves a broad and diverse community well.

We would also like to thank the administrative and support staff for organizing the meeting, which was a great success and very productive.

One of the dominant themes of the meeting was addressing the concerns brought up about user satisfaction. Many metrics were presented at this meeting which showed that the great majority of the user community is very satisfied by their experiences at all three branches of the NHMFL. This is echoed in the high satisfaction rate that Director Boebinger quoted on Monday evening in his report (> 90 %!). If there are issues that arise with experiments, these tend to be addressed almost immediately. Safety is also a high priority for the user base and safety concerns are taken very seriously by the NHMFL staff. The large majority of users feel safe when working at the NHMFL.

Executive Summary:
This report is divided into (i) an executive summary, which touches on aspects of the user program which
Chapter 3 – User Facilities

affect all subcommittees, and (ii) individual subcommittee reports.

(1) **Renewal Proposal.** The general response that we have had from the UC about the renewal proposal is that it is very well written, and by and large echoes the needs of the community. As Chair I have always felt that there is good communication between the NHMFL and the UC. This is reflected in the prioritized needs and budget presented in the Renewal Proposal. We are excited and invigorated by the new initiatives and improvements in the future.

(2) **The Housing.** We were pleased to see the update on the housing situation in Tallahassee. The institutional support is important and we are very happy that FSU has stepped up to offer funding. A guest house next to the NHMFL in Tallahassee is a must for the user community and for the NHMFL to maintain its world class presence in the world. We have been stressing this point for years. This is one of the biggest complaints from users from their exit survey comments – having no guest house in Tallahassee. We are confident that this problem will be solved in the near future and that positive steps are being taken to construct a guest house near FSU.

(3) **Magnets time.** Significant portions of the Renewal Proposal budget were focused on increasing the capacity of the magnet lab. These requests were made based upon feedback from the community that users could use more magnet time for their experiments, with subscription rates of 150% - 400% for some instruments. We fully support these increases. Running magnets on weekends, for example, opens new possibilities for users. This would be a transformative way of doing research at the NHMFL which would have wide reaching positive results in terms of meeting the needs of the community.

(4) **Infrastructure updates.** There are many critical infrastructure updates that are needed for the magnet lab (at all three locations) to remain at the forefront. Aging technology from the 1980s needs to be replaced. This is important so that the NHMFL is not “run into the ground.” Innovative solutions are often found to bypass old technology that is present to conduct high quality research, but the old infrastructure must be replaced in the long term.

(5) **Balancing direct needs of the community with new frontiers.** We believe as a community that breaking world records for magnetic fields, B/T, imaging resolution, etc. is important. We support all of these efforts. However, we feel that it is equally important to continue work on improving the day-to-day aspects of the NHMFL that make experiments possible – improving signal to noise ratios, making experiments more efficient, designing new probes, etc. These should also be emphasized as part of the NHMFL mission even though they may not explicitly be mentioned with the same prominence in the renewal proposal.

(6) **New hires.** We are very pleased with the new hires made over the last year, and the efforts to fill gaps that appear in the NHMFL personnel as they appear. Different committees have comments on minor concerns for hires, but on the whole we feel like our requests are listened to and prioritized.

(7) **Diversity.** We are encouraged by recent efforts to continue to improve diversity at the NHMFL. It was noted by several members of the committee that every presentation made addressed this important metric and that the NHMFL is making very strong efforts to improve diversity.

(8) **Safety.** The NHMFL has gone through a period of introspection and change with respect to safety protocols. The User Community as a whole feels that the NHMFL is a safe place to work, and there have been great strides to further improve the safety of users. There is an overwhelming majority of users that feel safe working at the NHMFL, and if there are safety concerns that arise during an experiment, these are taken care of in a timely fashion.

(9) **Summer school and outreach.** The User Committee is very proud of the educational outreach at the NHMFL, which sets the gold standard for how national laboratories can make an impact in the community. Keep up the great work!

(10) **UC meeting format.** The UC is a very important meeting and strongly valued by the community. We would like to be able to make some small changes to the format in the future (perhaps holding workshops on the day before on Future Directions for the Magnet Lab). We were very happy with some of the changes made to the format of this meeting (and the DC BHT/PFF split breakout sessions).

(11) **New committee members:** We have some changes in the executive committee that were voted in during the meeting:

- Chair: Madelina Furis (effective Jan. 1, 2017)
- DC Field/HBT: Sara Haravifard (effective immediately)
- PFF: Jamie Manson (effective immediately)
- Vice Chair, Resonance (and EMR): Dane McCamey (effective immediately)
Chapter 3 – User Facilities

- MRI/NMR: Ed Chekmenev (effective immediately)

DC, HB/T Facility UC Report 2016

Contributors: Nathanael Fortune (Smith College, Executive Committee Member), Madalina Furis (Chair for DC/ Pulsed Field /High B/T, University of Vermont), Malte Grosche (Cambridge University), Zhigang Jiang (Georgia Institute of Technology), Lu Li (University of Michigan), Chris Wiebe (University of Winnipeg, User Committee Chair), James Williams (University of Maryland)

World-leading high magnetic field instrumentation and technology development

The DC user community applauds the progress made in the past year on the new magnet constructions, i.e. the series connected hybrid (SCH), the 32 T superconducting magnet and the 40T resistive magnet. The new extension to the mK facility in Tallahassee that will house the 32 T superconducting magnet will provide much better shielding and reduced noise in the measurements. The instrumentation development projects such as the vibrating sample magnetometer, the magnetic field calibrated thermometry and the improvements in the high B/T facility are essential for the future of the lab.

The entire user community is excited about the new magnet construction plans for the next five to ten years. We consider the 40 T superconducting magnet and the upcoming HTS technology as game changers for research requiring high magnetic fields. They will ensure that the Maglab keeps up the pace with user demands for implementation of the newest techniques in the high magnetic field environment. Maintaining world leadership in high magnetic field scientific discovery is accomplished not only through reaching higher fields but also with unique combinations of high magnetic fields and techniques that approach zero field signal/noise ratio, resolution etc. In this context the UCGP program remains critically important for new techniques development that take advantage of the new magnet capabilities. The weekend operations would help the Maglab better support the UCGP program as well and enables further technique development in general. The high B/T, sub-mK access for cutting-edge experiments is in high demand, causing long waiting times, which will be cut by the planned improvements. By continuing to invest in this facility, NHMFL leadership will be maintained in a region of parameter space that is vital for fundamental research in quantum matter.

Ensuring adequate staff and support

The committee would like to see the two vacated staff scientist positions filled as soon as possible. The users support the new staffing plans for the optics program and the high B/T facility as being critical for the success of the user program in the next funding cycle. They also identified the need for a condensed matter NMR junior staff scientist hire. The users recognize the efforts made in improving diversity among the new hires and encourage the lab to continue these hiring policies.

Maintaining key infrastructure

Replacing the obsolete and aging 1980s resistive magnets infrastructure must be an absolute priority for the lab if it is to maintain its leading position among similar facilities around the world. There is an increasing number of documented infrastructure breakdowns that cost users delays and result in cancelled or failed magnet runs. These replacements and upgrades will avoid a catastrophic operational failure that may shutdown the lab for a very long period of time. They will also provide faster troubleshooting of future problems and, most importantly, ensure more magnet time and scheduling flexibility.

User satisfaction and magnet time suggestions

Recent user polls demonstrate that the NHMFL staff scientist and technician performance is stellar. The users are very satisfied with their skills, competence, dedication and scientific vision. The two major recurrent concerns with exit reports remain the aging infrastructure mentioned earlier and the magnet time availability. With regards to the second concern, users in general need more magnet time or simply more flexibility in scheduling the available magnet time. This is due, in part, to the tremendous progress made at the lab in terms of developing new magnets and techniques that require longer sample swaps, more prep time, and a greater variety of operating patterns. These experiments keep the magnet lab competitive because cutting edge science often comes with cutting edge experimental techniques. The staff realize that the scientific diversity that generates great science and enables interdisciplinary research. The proposed weekend runs would free up the magnet time and resources currently oc-
cupied with in-house materials testing. It would introduce flexibility in scheduling shorter resistive magnet runs in conjunction with superconducting magnet runs. This is a good start for accommodating a greater experiments variety that is required for the ambitious and transformative scientific drivers in the next five to ten years.

The oversubscription on the most popular magnets can lead to delays of half a year or more for time-critical experiments and significant delays to research progress of graduate students and untenured faculty. The lab needs to address both oversubscription and flexibility of scheduling in the next five to ten years.

**Future scientific directions**

The users continue to support the idea of a spectroscopy cluster serving condensed matter, electronic materials, chemistry and biochemistry users with enhanced inter-operability among complementary techniques. We are very happy to see that components of this cluster are already present in the proposed five-year effort: scheduling flexibility, new optical spectroscopy hire, the Faraday insert of the Helix, new magnets, the proposed upgrades at the EMR, and condensed matter NMR facilities and the integrated magnetic resonance science driver. We encourage the lab to continue exploring how this interoperability may be accomplished. A workshop preceding the users’ committee meeting next year might solidify these ideas.

**Lab Safety and Housing Accommodations**

The user community is very pleased with the efforts and measures taken to make the lab a safer environment for staff and users alike. We want to stress that, from the users perspective, the NHMFL is one of the safest user facilities in the nation. The lab not only encourages users to raise any concerns they might have, but also addresses such concerns in a timely and efficient manner.

The DC users continue to emphasize the need for guest housing that not only provides convenient on-site accommodations but also ensures personal safety, specifically in case of evening shifts. In comparison to other high field facilities, the lack of affordable on-site housing at NHMFL is imposing a financial burden on the users, making it harder and harder to bring new student users to participate in experiments. This ultimately represents a limiting factor for scheduling experiments (especially for early career and junior investigators).

**Pulsed Field Facility Report 2016**

**Contributors:** Chuck Agosta (Clark University), Jason Cooley (LANL), Jamie Manson (Eastern Washington University) and Kirstin Alberi (National Renewable Energy Lab)

The pulsed field facility (PFF) user committee was updated on the status of the existing pulsed magnetic field capabilities as well as future plans for advancing magnet technology and associated measurement techniques. It is clear that the PFF remains the world leader in generating the highest peak fields at millisecond time scales, offering a diverse array of experimental techniques and consistently providing outstanding user support. None of this would be possible without the expertise and involvement of exceptional staff, and the users recognize and appreciate the support they continually receive at the PFF. The user committee would also like to commend the PFF for maintaining a focus on safety as a top priority.

It is clear to the committee that the considerable efforts devoted to strategic planning have resulted in a very coherent plan for the future development of the PFF. When implemented, this development will help the PFF to preserve its status as the world leader in pulsed field science and capability. In particular, the user committee believes that reaching a new world record of 120 T at the PFF is a highly desirable and attainable goal. The present 101 T magnetic field system has produced spectacular science, and the careful engineering plan described to increase this world record magnetic field by developing a Tri-Plex Magnet will allow the NHMFL to retain its leadership status in magnet technology as well as remain at the forefront in high-field science and technology publications. We believe this project should be one of the highest priorities outlined in the renewal proposal. The PFF committee also strongly supports the 225 T Experiment Development project. This project, too, will leverage a unique facility and promises to advance the range of measurements available at both the 225 T facility and 120 T facilities.

The user committee also enthusiastically supports several other current and planned activities at the PFF. The committee concurs with the plan to repair the 60 T Long Pulse magnet and was impressed with the ongoing failure analysis of that system. The time currently estimated to complete repairs (24
months) is still quite long, so we encourage the PFF to explore avenues to accelerate this timeline if possible.

The committee was pleased to learn of the development of a prototype 75 T duplex magnet and believes engineering expertise gained from this activity will result in improvements to workhorse magnets in the 55 - 75 T range that form the backbone of the pulsed field user program. Magnet development, in addition to the continued maintenance of the existing 65 T Short Pulse magnet capabilities, requires increased production of short pulse magnets wound at Los Alamos. The PFF has highlighted the need to expand its technical support in this area, and the committee fully endorses and supports this plan.

While the User Advisory Committee is extremely pleased with the techniques offered by the PFF, we wish to highlight future opportunities where we feel the development of new capabilities will lead to significant scientific advances:

1. **High-pressure measurement capabilities.** As outlined in the renewal proposal, scientific breakthroughs increasingly require the ability to perform experiments across a wide range of parameter space. The potential to incorporate high pressure measurements with high magnetic fields presents an important opportunity in this regard. A limited but growing high-pressure capability currently exists at the DC and PFF facilities, proof-of-principle experiments on metals and insulators have been done in the 60 T long pulse and short pulse magnets. The committee would like to encourage a long-term emphasis on high pressure transport and magnetic susceptibility at the PFF. We realize this may eventually require a new hire and other investments in staff and infrastructure and encourage planning in this direction. Some of these efforts to reach high pressure are currently being developed by Scholar Scientists such as Stan Tozer. We encourage these in house programs as the initial steps towards increased high pressure research.

2. **Mid-pulse magnet.** A mid-pulse magnet would be a valuable platform to complement the 60 T Long Pulse high-pressure effort. The larger bore-size, relative to the workhorse 55 – 75 T short pulse systems, of a 50 T Mid-Pulse magnet could more easily accommodate a range of pressure cell designs. In addition, a mid-pulse capability could allow some experiments development time prior to deployment in the 60 T Long Pulse magnet and increase sample throughput. Such a magnet existed in the past, and we encourage the PFF to reinstate such a system if feasible. We applaud the diligent efforts of the PFF scientific and technical staff in recognizing and supporting the specialized needs and requirements of the pulsed-field user community.

**NMR/MRI UC Report 2016**

**Contributors:** Robert Schurko (Chair, University of Windsor), Ed Chekmenev (Vanderbilt University), Michael Harrington (Harrington Medical Research Institutes)

**Overview:**

The NMR/MRI subcommittee is pleased about the continued progress being made at the NHMFL and with AMRIS. This is reflected in a large, wide and diverse user base that is growing. The publications per year have an increasing trend over time, and users often have the support of external sources such as the NSF and NIH (as well as international sources). It is exciting that the P41 grant application is going forward. One of the most consistent bits of feedback from outgoing users is the appreciation of the strong amount of support from the NHMFL for their experiments.

The subcommittee would also like to applaud the recent outreach and educational activities by the NMR/MRI staff at the NHMFL. The RF coil development workshop in particular is excellent and innovative. We are hoping that more of these efforts will be undertaken in the near future.

It is worth noting that the three grand challenges outlined in the Renewal Proposal ("Why superconductivity?", "Unlocking the Periodic Table", and "Molecules of Life") are all related to magnetic resonance activities. The themes of the Renewal Proposal are all tied to new efforts by the NMR/MRI staff to further increase the sensitivity to NMR, the development of new methods (especially NMR/EMR collaborations), and the exploration of new applications.

**Positions and personnel:**

The subcommittee is very pleased that NMR/MRI staff was added in 2009 and 2013. However, there are several recommendations for future hires that are essential: (i) Another staff scientist is needed like Peter Gor'kov. Peter is a very talented scientist that is stretched too thin for probe develop-
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The need for a key hire to relieve the bottleneck for experiments, (iii) An MRI RF engineer is needed. This is crucial for building new coils for the 900 MHz and to extend MRI to the Series Connected Hybrid magnet.

**Equipment/Instrumentation:**

There have been numerous upgrades and innovations in NMR/MRI equipment and instrumentation at all three NHMFL sites. The 600 MHz DNP NMR is in the final stages of development at Tallahassee and will be very important for future users. There was a discussion in the subcommittee about a fast broadband probe unit that had interested users at UF, FSU, and external to the NHMFL. At AMRIS this fall, there will be a second dissolution DNP polarizer which will also be available. The high temperature superconducting material development for higher field magnets is also very innovative and exciting.

The subcommittee and user base are both extremely excited to see the 36 T SCH come online. Three probes are nearly ready for this system. In addition, the subcommittee heard in the presentation about three probes that are ready or almost ready for this system. The testing of shims on the 25 T Keck is also promising, and will be essential for the "unlocking of the periodic table" science driver. The building of a resistive insert with a wider bore for imaging on the SCH would also be desirable (ie. Na MRI).

**MRI Specific Concerns:**

(i) **MRI RF Engineer:** This personnel request in the renewal is fairly critical as we continue to build new coils for the 900 MHz and extend MRI to the Series Connected Hybrid. With simultaneous RF fabrication for SS-NMR and DNP, our capacity for MRI/S coil construction is limited and needs to be expanded, particularly to cover RF build initiatives at both the Tallahassee and Gainesville facilities.

(ii) **High field gradient coils:** Users and staff have worked well with RRI in the past to build micro-imaging gradient coils. We intend to continue this collaborative effort to build (1) an enhanced integrated micro imaging gradient/shim set with enhanced peak gradients and homogeneity correction for in vivo MRS (part of the renewal) and (2) to pursue in vivo MRI/S at > 28 T on a modified Series Connected Hybrid (we will need imaging gradients and RT shims with field drift correction). In addition, as commercial vendors do not have a strong interest in high power planar gradient coils, we too are pursuing in house and collaborative fabrication of microimaging coils for MR microscopy applications at > 14.1 T.

(iii) **SCH modification for mouse imaging at >28 T**

Using the console and associated hardware under development for the Series Connected Hybrid, we plan to propose an NSF MRI to remove and reconfigure the inner two coils of the SCH to provide an 89-mm bore for small rodent imaging. To match exiting amplifiers and filters, the minimum target field would be 28 T. A prototype design for the reconfigured inner coil has been discussed.

**Concluding Remarks:**

There is simply no NMR/MRI centre like the NHMFL in the world - the new SCH system, the DNP600 and future long-term plans are keeping the centre ahead of the curve. The NHMFL should continue to increase their user base.

Science will be done at the NMR/MRI facilities that can simply not be done anywhere else. The promise of new high temperature superconducting materials in particular to develop NMR at 30 T is particularly noteworthy. The combination of equipment and personnel, with access to new magnet technologies will ensure that the NMR/MRI capabilities will remain at the forefront of high field research.

2016 User Advisory Committee Report - ICR Users’ Facility

**Contributors:** Jon Amster (Chair: in person), Michael Chalmers (on phone), Michael A. Freitas (on phone), Elizabeth Kujawinski (in person); John Shaw (on phone). Not present - Forest White.

**Overview**

The ICR Users’ Advisory Committee (UAC) is extremely impressed with the progress of the ICR group over the past year. The ICR group has made important advances in the development of state-of-the-art ICR technology and have shown great progress in its application to several key areas, including proteomics, petroleomics, environmental chemistry, and materials research. They have maintained and grown their presence within the user community, with their best year yet in terms of the number of user projects, and have established a strong record
in outreach. Overall, they have been successful in every aspect of activity expected for a user facility.

Chris Hendrickson assumed the role of Director of the ICR User Program last year, and he has successfully made the transition into this leadership role. Alan Marshall continues to contribute key scientific themes as Chief Scientist of the ICR Facility. Lissa Anderson was recruited as the Director of Biological Applications. Since her hire, Lissa has focused on top-down proteomics, and has brought the ICR facility up to speed in this area, and is in fact pushing the edge of the envelope in whole proteome analyses. The collaboration with Neil Kelleher at Northwestern is working well, and is providing the user community with access to state-of-the-art tools in this hot area of proteomics research.

The newest instrument in the facility’s inventory is the 21 T FTICR, which was brought on-line one year ago. The ICR group has obtained outstanding data that demonstrates the advantage of the 21 T magnet, and which establishes benchmarks in performance that greatly exceed competing technology, specifically, the Orbitrap. The ICR group presented petrolemic analysis data having 125,000 resolved peaks, with 28,500 assigned compositions, at 52 ppb RMS error. These specs make this the world’s leading instrument in terms of mass resolving power, mass accuracy, and dynamic range.

Petrolemics research remains one of the strengths of the user facility. Guided by Ryan Rodgers, the petrolemics group has established itself as a world leader in this area. The group has added chromatographic separations to the sample analysis pipeline, and this has tripled the number of compounds that can be identified in highly complex mixtures. These methodology developments translate directly to environmental research, specifically for the analysis of dissolved organic matter. The petrolemics group has also developed a sophisticated software package for the analysis of extraordinarily dense data sets, PetroOrg, and a complementary package for environmental analysis, EnviroOrg. These provide great benefit to the user community. The UAC fully supports the request in the NSF renewal for 0.5 FTE for a scientist position with expertise in environmental analysis. This will be essential to support users in environmental chemistry, which represents the largest user (and growth) area for the ICR Users’ Facility.

Petrolemics

The ICR group leads the world in petroleum compositional analysis. The advent of the 21-T instrument brings unprecedented power to the deconvolution of isobaric species in Earth’s most complex mixture. The ICR group achieved a number of compositional milestones this year: (a) the highest number of peaks detected at one nominal mass (~600) and (b) the largest number of peaks with assigned elemental formulas in one mass spectrum (125,000). These achievements highlight the unique power of high-field FT-ICR MS, relative to Orbitrap and other lower-field instruments.

- The UAC was excited to see the continued application of pre-separation protocols for petroleum analysis. The breadth of molecules now observed with FT-ICR MS approximates a chemical continuum, supporting novel insights into petroleum chemistry and fate in natural environments. The combination of separation technology with the benefits of 21-T will open up new and exciting venues of research.

- The UAC notes the continued excellence of the ICR group, even in the face of continuing economic pressures associated with variable oil prices, and commend the group for ongoing method developments and research collaborations that will push this field forward.

Natural Organic Matter

- The ICR group is applying its expertise in petrolemics to the study of natural organic matter in a variety of aquatic and terrestrial environments. The ICR group is well-positioned to develop new methods and capabilities in this exciting growth area. In particular, the separation technologies and high-field applications developed in petrolemics are expanding our understanding of NOM reactions in the environment.

- EnviroOrg was released in February 2016 and will greatly enhance data analysis and visualization tools for the NOM user community. The UAC applauds the ICR group’s decision to provide this software to all users, as this will propel applications with a significant impact on the field of biogeochemistry.

- User requests for NOM analysis have expanded dramatically over the past year, both in terms of principal investigators and magnet time requests. Rapid growth in this area is a testament to the broad expertise of the existing ICR group, but highlights the need for additional staff to work with these users. The UAC strongly supports the ICR budget re-
Chapter 3 – User Facilities

quest for a FTE to fill this niche and recommends that funding be sought for a full FTE, rather than the 0.5 FTE in the current renewal request.

Proteomics

- The advisory committee was extremely impressed with the progress of the ICR group in the area of proteomics over the last year.
- The ICR group responded to the AC’s recommendation to recruit a Director of Biological Applications, with the hire of Lissa Anderson. Lissa has made a strong start, specifically in her achievements in implementing top-down proteomics.
- LC/MS and LC-MS/MS of protein mixtures has been achieved. IgG1 light chain (24 kDa) and IgG1 heavy chain (50 kDa) have been analyzed by online LC-MS/MS, with a resolving power of 125,000 and RMS errors of 1.3 ppm for the light chain product ions and 2 ppm for the heavy chain product ions. The precursor ions show baseline resolution of the isotope peaks, with excellent matching to the statistically predicted patterns.
- The collaboration with Neil Kelleher at Northwestern has been fruitful for getting the lab up to speed on whole proteome top-down analysis.
- The analysis of GelFree fractions is going well, with success on fractions up to 55 kDa in MW. Eight of twelve GelFree fractions have been analyzed by LC-MS/MS for a human cancer cell proteome, with 580 proteins identified, and 1820 proteoforms represented. Almost half the proteoforms have C-scores >=40. This is outstanding performance. The remaining fractions have proteins in the 60-150 kDa range, and will be challenging targets for future efforts.
- The 21 T instrument clearly shows superior performance compared to the Orbitrap, which is unable to cope with top-down analysis on proteins larger than 35 kDa in molecular weight.
- LC-MS/MS is working well with collision induced dissociation and front end electron transfer dissociation, as shown by the 85% coverage attained for the 24kDa IgG1 light chain. The efforts to implement ETD in the analyzer cell will benefit future proteomics work.
- UVPD has been successfully implemented on the 21 T instrument, and will be particularly useful for the analysis of intact proteins in targeted proteomics approaches.

Other Biological Mixtures

- The ICR group continues to apply their expertise in complex mixture analysis to other fields, including metabolomics and lipidomics and imaging of tissues. This expertise is highlighted in the renewal proposal under the grand challenge “Molecules of Life”.
- The UAC was pleased to see the continued collaboration with NMR researchers for metabolite identification and quantification. This collaboration is explicitly discussed in the renewal proposal and could be a growth area for the ICR facility. The UAC recommends a continued expansion of research efforts into the higher molecular weight fractions of these mixtures, where high-field mass spectrometry is uniquely appropriate.
- Good progress has been made over the past year for small molecule tissue imaging of drugs, metabolites and peptides. Method developments are planned for the coming year and the UAC is excited to see the results of this progress in 2017.

Carbon Clusters

- The ICR group has made significant progress in nanomaterials research through the analysis of metallo- and cluster-fullerenes. The high-field capabilities enable precise measurements of the masses of these molecules which are not possible on lower-resolution instruments (including the Orbitrap).
- These tools are being applied increasingly to questions of nanomaterials growth during synthesis and to compositional analysis of astronomical dust. The ICR group is now working with ~15 outside collaborators, approximately double the 2015 number!
- The UAC was very impressed at the nascent program in Carbon Clusters and recommends the continued support of Paul Dunk and his team.

Instrumentation

- The user facility is equipped with four FTICR mass spectrometers to support user projects as well as research and development activities. The advisory committee feels that there is a good distribution of instrumentation to support the various missions of the ICR group.
- The 21 T instrument provides world-leading capabilities for attacking extremely challenging chemical and biological topics. Many important instrumentation developments that have been implemented on
Chapter 3 – User Facilities

this mass spectrometer, including a dynamically harmonized analyzer cell and novel ion optics, provide world-class performance in terms of mass resolution, mass accuracy, sensitivity and dynamic range.

- One of the two 9.4 T instruments is equipped with a specialized cluster source, and is devoted to the carbon cluster research program. This instrument has been very productive resulting in several publications in high impact journals.
- The second 9.4 T instrument, equipped with an electrospray ionization source, is the workhorse instrument for many of the user projects, particularly for biological mixtures (DOM, in particular), which have become one of the most requested types analysis requested by users.
- The 14.5 T instrument will undergo a total renovation of its vacuum cart and ion optics, duplicating most of the developments that were made for the 21 T system. With these upgrades, it is anticipated that this will become the workhorse system for user projects in the future.
- The advisory committee was impressed by the progress with third harmonic detection. Once the issues with distributed capacitance and sensitivity have been solved, this detection scheme will speed up data acquisition time by a factor of three, extend the mass-to-charge range of the instrument, and provide higher ultimate mass resolving power.

ICR Users’ Program and Outreach

- The ICR Users’ Program has been growing tremendously over the past two years, with a record number of users in 2015. At the current pace, this record will be exceeded during 2016.
- The largest growth area in user requests is Natural Organic Matter analysis. The number of user requests is approaching the current capacity of the magnets and personnel of the ICR group, highlighting the need for additional experienced staff in this area (such as the requested FTE in the renewal proposal).
- The new capabilities in top-down proteomics are likely to attract additional users over the coming months.
- Outreach programs for K-12 students remain strong and successful. Undergraduate opportunities are plentiful and alumni are attending top graduate schools.

EMR UC Report 2016

Contributors: Kurt Warncke (Emory University, U.S.; Chair), Erik Cizmar (P. J. Safarik University, Slovakia), Christopher Kay (University College London, U.K.), Dane McCamey (University of New South Wales, Australia), Christos Lampropoulos (University of North Florida, U.S.), Stefan Stoll (University of Washington, U.S.).

Program

- The UC is extremely enthusiastic about the contributions of the EMR group to the development of unique high-field EMR capabilities, which continues to enable new science by the diverse user base.
- The renewal proposal captures the recommendations of the UC in prior years. There is an excellent alignment of the proposed science and capabilities in the renewal proposal with the needs of the user community.
- Feedback from users is, across the board, extremely positive. No issues were brought forward regarding the operations of the EMR user program.
- EMR users expressed satisfaction with safety at the MagLab.

Personnel

- The UC particularly values the extraordinary scientific contributions of the EMR staff. Both the quality and quantity of users’ scientific output is enhanced because of the staff’s world-leading expertise across instrumentation development, experimental design, and applications.
- Steve Hill is a highly effective leader, who brings in-depth experience in instrumentation, science and organization that maintains the MagLab EMR program as the international leader in high-field EMR. We appreciate his broad purview and engagement with users across disciplines.
- We are pleased to see that the renewal proposal includes a request for an additional EMR staff member and instrumentation for the development of the specialized quasi-optical microwave instrumentation for the 36 T series connected hybrid (SCH) magnet system. In addition to enabling new, exciting science, this will provide robustness in the ability to support all quasi-optical instrumentation in the EMR program. This addresses the prior recommendation of the EMR UC.
Chapter 3 – User Facilities

Capabilities

• We are particularly pleased with the significant progress in implementing the capabilities of the HiPER W-band spectrometer, which now allows integrated magnetic resonance techniques, such as high-resolution probing of electron-nuclear interactions, and its integration into the DNP program. The process was accelerated by the recent hire of postdoc Johannes McKay.

• The proposed purchase of a 2 W continuous-wave amplifier for HiPER will significantly increase the sensitivity, and have a major impact on data quality and sample throughput. This will increase user access to HiPER.

• We are enthusiastic about the planned implementation of tunable optical excitation, as outlined in the renewal proposal. This capability is critical for addressing the breadth of user systems and needs, especially for quantum materials.

• The UC is pleased with the continued advances in DNP. The proposed EMR group request for a DNP staff specialist with microwave engineering experience will bring vital EMR expertise directly to DNP development. This will lead to delivery of new DNP capabilities, for which there is much user demand.

• The UC is enthusiastic about the plans, as mentioned in the renewal proposal, to extend the frequency range and coverage of the microwave source for the 17 T continuous-wave transmission spectrometer, which will enable research on a wider range of quantum materials than previously possible.

• The UC supports the comprehensive upgrades to the high-frequency pulsed quasioptical EMR spectrometer (sources >220 GHz, acquisition, detection). These will improve sensitivity for applications involving dilute samples, and increase the range of timescales for studying coherent spin dynamics and control. Coherent spin effects are an important and growing field, in-demand by users from physics, chemistry and biology.

• The UC is excited about the plans to provide high-resolution EMR up to 1 THz for the high-homogeneity 36 T SCH magnet system. This will enable science for users who study carbon-based paramagnets in biological materials and quantum devices.

Other

• The UC encourages the MagLab to organize a hands-on EMR workshop. This will enhance the ability of the user base to propose, design and undertake new and effective experiments.
Annual User Program Survey

The National High Magnetic Field Laboratory conducted its sixth annual user survey between June 6, 2016 and July 12, 2016. User input assisted all seven facilities to respond to user needs, improve facilities and services, and guided the MagLab in setting priorities and planning for the future. This request was sent to all MagLab User Principal Investigators (PI) and to their collaborators who received magnet time between June 1, 2015 and May 31, 2016, including PIs who sent samples, where the experiment was performed by laboratory staff scientists.

All user responses were treated anonymously. All presented figures exclude internal responders.

**How satisfied were you with the proposal process (e.g., submission and review)?**

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Satisfied</td>
<td>57%</td>
</tr>
<tr>
<td>Satisfied</td>
<td>33%</td>
</tr>
<tr>
<td>Neutral</td>
<td>9%</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>0%</td>
</tr>
<tr>
<td>Very Dissatisfied</td>
<td>0%</td>
</tr>
</tbody>
</table>

**How satisfied were you with the availability of the facilities and equipment?**

<table>
<thead>
<tr>
<th>Satisfaction Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Satisfied</td>
<td>75.74%</td>
</tr>
<tr>
<td>Satisfied</td>
<td>20.00%</td>
</tr>
<tr>
<td>Neutral</td>
<td>2.98%</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>0.85%</td>
</tr>
<tr>
<td>Very Dissatisfied</td>
<td>0.43%</td>
</tr>
</tbody>
</table>
Chapter 3 – User Facilities

How appropriate and user friendly were the training and safety procedures?

- Very Satisfied: 56%
- Satisfied: 34%
- Neutral: 9%
- Dissatisfied: 1%
- Very Dissatisfied: 0%

How satisfied were you with the performance of facilities and equipment (e.g., were they maintained to specifications for your intended use, ready when scheduled, etc.)?

- Very Satisfied: 69.66%
- Satisfied: 25.21%
- Neutral: 3.42%
- Dissatisfied: 1.28%
- Very Dissatisfied: 0.43%

How satisfied were you with the assistance provided by MagLab facilities technical staff?

- Very Satisfied: 86.02%
- Satisfied: 10.17%
- Neutral: 2.54%
- Dissatisfied: 0.42%
- Very Dissatisfied: 0.85%
Chapter 3 – User Facilities

How satisfied were you with the assistance provided by MagLab facilities administrative staff?

- Very Satisfied: 81.06%
- Satisfied: 15.86%
- Neutral: 2.20%
- Dissatisfied: 0.00%
- Very Dissatisfied: 0.88%

As a result of your use of MagLab facilities, do you expect to ...

- Publish your results in peer-reviewed open literature: 89%
- Disseminate results via presentations at professional society meeting: 75%
- Pursue future experiments stimulated by this visit: 78%
- Train young scientists (undergraduate, graduate, postdoc associate): 51%
- Use data for Thesis or Dissertation: 50%
- Acquire a patent: 3%
- Establish a new collaboration: 34%
- Other: 3%
User Facilities

**DC FIELD FACILITY**

The DC Field Facility in Tallahassee serves its large and diverse user community by providing continuously variable magnetic fields in a range and quality unmatched anywhere in the world. The DC Field user community is made up of undergraduate students, graduate students, post docs and senior investigators from around the country and the world. State-of-the-art instrumentation is developed and coupled to these magnets through the efforts of our expert scientific and technical staff. The users of the DC Field Facility are supported throughout their visit by the scientific, technical and administrative staff to ensure that their visit is as productive as possible. The interaction between the NHMFL scientific and technical staff and the students, post docs, and senior investigators who come to the DC Field Facility to perform their research results in a continuous mix of scientific ideas and advanced techniques that are passed both to and from users.

1. **Unique Aspects of Instrumentation Capability**

### FLORIDA-BITTER and HYBRID MAGNETS

<table>
<thead>
<tr>
<th>Field, Bore, (Homogeneity)</th>
<th>Power (MW)</th>
<th>Supported Research</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>45 T</strong>, 32 mm, (25 ppm/mm)</td>
<td>30.4</td>
<td>Magneto-optics – ultra-violet through far infrared; Magnetization; Specific heat; Transport – DC to microwaves; Magnetostriction; High Pressure; Temperatures from 30 mK to 1500 K; Dependence of optical and transport properties on field, orientation, etc.; Materials processing; Wire, cable, and coil testing. Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.</td>
</tr>
<tr>
<td><strong>35 T</strong>, 32 mm, (x2)</td>
<td>19.2</td>
<td></td>
</tr>
<tr>
<td><strong>31 T</strong>, 32 mm to 50 mm(^1), (x2)</td>
<td>18.4</td>
<td></td>
</tr>
<tr>
<td><strong>30.5 T</strong>, 32 mm, (~50 ppm/mm)(^2)</td>
<td>18.3</td>
<td></td>
</tr>
<tr>
<td><strong>17 T</strong>, 195 mm</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td><strong>25 T</strong>, 52 mm, (10 ppm/mm)(^2)</td>
<td>18.6</td>
<td></td>
</tr>
<tr>
<td><strong>25 T</strong>, 32 mm bore, (with optical access ports)(^3)</td>
<td>27</td>
<td></td>
</tr>
</tbody>
</table>

### SUPERCONDUCTING MAGNETS

<table>
<thead>
<tr>
<th>Field (T), Bore (mm)</th>
<th>Sample Temperature</th>
<th>Supported Research</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>18/20 T</strong>, 52 mm</td>
<td>20 mK – 1 K</td>
<td>Magneto-optics – ultra-violet through far infrared, Magnetization, Specific heat, Transport – DC to microwaves, Magnetostriction; High pressure, Temperatures from 20 mK to 300 K, Dependence of optical and transport properties on field, orientation, etc. Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.</td>
</tr>
<tr>
<td><strong>18/20 T</strong>, 52 mm</td>
<td>0.3 K – 300 K</td>
<td></td>
</tr>
<tr>
<td><strong>17.5 T</strong>, 47 mm</td>
<td>4 K – 300 K</td>
<td></td>
</tr>
<tr>
<td><strong>10 T</strong>, 34 mm(^3)</td>
<td>0.3 K – 300 K</td>
<td></td>
</tr>
</tbody>
</table>

1. A coil for modulating the magnetic field and a coil for superimposing a gradient on the center portion of the main field are wound on 32 mm bore tubes.
2. Higher homogeneity magnet for magnetic resonance measurements.
3. Optical ports at field center with 4 ports each 11.4° vertical x 45° horizontal taken off of a 5mm sample space.

The table above lists the magnets in the DC Field Facility. The NHMFL leads the world in available continuous magnetic field strength, number of high field DC magnets available to users and accessibility for scientific research. The 45 T hybrid magnet is the highest field DC magnet in the world, which is
Chapter 3 – User Facilities

2. Facility Developments and Enhancements

45 T Hybrid Vacuum Pump Replacement

The superconducting outsert magnet for the 45 T hybrid magnet operates at 1.8 K in superfluid 4He and is cooled via two Joule-Thompson (J-T) refrigerators located in the supply cryostat that are pumped by two 1,000 CFM pumps (Fig. 1). The existing pumps were 23 years old and, while still functional, they had exceeded their design lifetime and were requiring increasing amounts of maintenance. A new vacuum pumping system was installed with a modern control system that interfaces to the MagLab’s digital control system (DCS) allowing for integration with the rest of the hybrid cryogenic cooling systems, giving the cryogenic operators better control over the cooldown and operation processes. The pumps feature variable speed drives on the roots blowers that allow the pumping speed to be accurately matched to the requirements of the J-T refrigerators. The two independent pumping systems provide redundancy against mechanical failure and allow for continued operation of the 45 T during maintenance.

Expansion of the mK Facility

Construction began in 2016 on a 1600 ft² expansion to the mK facility in order to provide a permanent location for the 32 T all superconducting magnet. The building features two magnet pits to allow for a future HTS magnet to be installed as well as separate star grounds located under each pit to provide clean grounding for user instrumentation. The walls and ceiling include a layer of copper to reduce the ambient RF levels from external sources. The expected completion date is the latter part of April 2017 and installation of the 32 T magnet is anticipated to take place over the summer.

Fig. 1 New vacuum pumps for the 1.8 K cooling loop of the 45T hybrid.

Fig. 2 Fiberglass reinforcing bar is laid out in preparation for pouring the concrete slab.
Platform for Sample Diagnostics

A collaborative effort between Ju-Hyun Park and the NHMFL electronics shop has produced an easy-to-use platform (Fig. 3) for testing samples that are attached to either 8 or 16 pin DIP headers prior to mounting on a probe. The box allows for the electrical contacts to be selectively grounded via switches and the full range of instrumentation to be connected to the sample, replicating the sample-probe-breakout box interface used at the MagLab. The low-force mounting socket is contained within an ESD-safe enclosure that protects the user’s device during testing and with the protective cover opened it allows for unobstructed access to the device for work.

Fig. 3 One of the sample diagnostic boxes designed and built at the MagLab.

36 T Series Connected Hybrid Reaches Full Field

On November 8th the series connected hybrid achieved its most important milestone to date, full field, 36 T, at 20 kA. An NMR map revealed that the native homogeneity of the magnet was 20 ppm, which was consistent with design parameters. In early 2017 work will begin on testing the ferrosims as well as testing of the active shims and stabilization. The design goal is 1 ppm over a 10 mm DSV. The NMR probes and console are ready to commence experiments once the desired field uniformity has been achieved. The cryostat for condensed matter experiments in the SCH has been delivered, tested at zero field and will be ready for use by the time the magnet is available for users.

Fig. 4 Testing of the SCH moments prior to achieving 36 T.

Sample-In-Vacuum Probe for Thermal Measurements

An innovative approach to creating a sample-in-vacuum environment at low temperatures and high magnetic fields in Cell 9 (31 T) was developed and implemented by Hongwoo Baek. This novel design allows users who wish to perform heat capacity, thermal conductivity, Nernst effect measurements, etc. to do so without the need to mount an additional vacuum can on the probe (Fig. 5). This allows users to take advantage of the full sample space of the top loading 3He system. The probe design also removes the possibility of forming a gas bubble in the liquid 3He at field center when the magnetic field is above 18 T. The base temperature of the probe is 0.37 K with a hold time of 10 hours. Thermal conductivity experiments were successfully conducted up to 31 T using a platform designed by Eun Sang Choi.

Fig. 5 Cell 9 sample-in-vacuum probe.
Chapter 3 – User Facilities

3. Major Research Activities and Discoveries

A number of user groups produced impactful results on materials and research areas that cut across a broad range of physics and chemistry. A Penn State research group led by Kin Fai Mak working in the Cell 9, 31 T magnet, identified Ising pairing in superconducting NbSe2. Cory Dean’s group from Columbia University discovered a new series of quantum Hall states in graphene that appear at fractional Bloch filling indices while working in the 45 T hybrid magnet. Professor Jim Gleeson’s group from Kent State University explored a molecular liquid crystal in the 25 T Split-Helix magnet and discovered that high magnetic fields are able to subtly change the shape of the molecules, greatly affecting the transition temperature of the material as it changes state from isotropic to nematic.

4. Facility Plans and Directions

In 2017, three major projects are projected to be completed which will substantially affect users of the DC Field Facility. Two new magnet systems will be brought online (SCH & 32 T) for users and completion of construction on the mK expansion. Commissioning tests and user operations will begin in the Series Connected Hybrid (SCH). Work is underway to optimize the active and passive shim systems to achieve a field homogeneity of 1 ppm. The user probes and spectrometer for chemical-biological NMR experiments have been fabricated and tested at lower fields in superconducting magnets. The top loading cryostat for condensed matter research in the SCH arrived in the fall of 2016 and passed zero field acceptance tests. Work on the probes and sample holders are currently underway.

The 32 T all superconducting magnet will be tested and commissioned in 2017 with user operations projected to begin shortly after completion and commissioning tests. The room temperature electronics for the HTS quench protection system are being completed, and testing into a room temperature resistive load will take place in the first quarter of 2017. The variable temperature insert (VTI) with a temperature range of 1.5 K – 300 K has been received and awaits the completion of magnet testing.

Modernization of the resistive magnet protection system (RMPS) has begun and a test system utilizing a compactRIO has been assembled with initial versions of the code being tested. The RMPS system continuously monitors key operational parameters of the resistive magnets and quickly shuts the system down should they exceed their predetermined operation envelope. This upgrade will modernize both the hardware and the software and will incorporate the experience and knowledge gained from the many years of using the current system.

5. Outreach to Generate New Proposals: Progress on STEM and Building User Community

The DC Field Facility continued to see heavy user demand in 2016 as shown by the usage tables in Appendix A. In spite of this oversubscription, however, the DC Field Facility has continued to make bringing new primary investigators (PIs) into the NHMFL a priority. We continue our efforts to reach out wherever possible in order to expand our user program and enable PIs from backgrounds underrepresented in the scientific community. In particular, the NHMFL sponsored a booth at the 2016 APS March Meeting in Baltimore to advertise the capabilities and opportunities offered by the MagLab. The booth is staffed by NHMFL scientists & staff who explain the spectrum of research possibilities and support available at the NHMFL. In addition our DC Field Facility user support scientists regularly travel to conferences to present their results that showcase the capabilities of the laboratory and to recruit new users.

In 2016, the DC Field Facility continued to attract a significant number of new researchers. Appendix A, Table 8, shows we attracted 24 new PIs in 2016. This is in addition to the 18 new PIs which we reported last year (2015) and 16 in 2014. These new PIs came from institutions as varied as Harvard University; University of Akron; Colorado State University; and the Institute of Physics, Chinese Academy of Sciences. Three of the new PIs in 2016 are female.

The DC Field Facility also hosted the 2016 NHMFL User Summer School that attracted 26 graduate students and post doc attendees (Fig. 6). It is a 5-day series of lectures and practical exercises in experimental condensed matter physics techniques developed and taught by members of the MagLab scientific staff from the 3 sites. It has
proven to be an excellent vehicle for communicating valuable experimental knowledge to the next generation of scientists from the enormous trove of experience encompassed by the MagLab scientific staff. The summer school is an annual event and will be presented again in 2017. Feedback from participants and their advisors continues to be very positive.

Fig. 6 2016 User Summer School participants.

6. Facility Operations Schedule

At the heart of the DC Field Facility are the four 14 MW, low noise, DC power supplies. Each 20 MW resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies. Thus the DC Field Facility operates in the following manner; in a given week there can be four resistive magnets + three superconducting magnets operating or the 45 T hybrid, two resistive magnets and three superconducting magnets. The powered DC resistive and hybrid magnets operated for 46 weeks out of the year in 2016 with a 4 week shutdown for infrastructure maintenance from November 18 to December 11 and a 1 week shutdown period for the university mandated holiday break from December 24, 2016 to January 3, 2017. The three superconducting magnets operated for 48 weeks out of the year with staggered maintenance periods as required. The hourly operation schedule for the resistive and hybrid magnets is as follows: 16 hours/day on Monday and 21 hours/day Tuesday-Friday. The superconducting magnets operate 24 hours/day 7 days/week.
Ising pairing in superconducting NbSe$_2$ atomic layers

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1. Penn State University; 2. National High Magnetic Field Laboratory; 3. Hong Kong University of Science and Technology; 4. Ecole Polytechnique Fédérale de Lausanne

Funding Grants: G.S. Boebinger (NSF DMR-1157490); K.F. Mak (DOE DESC0013883); J. Shan (DOE DESC0012635, NSF DMR-1410407); K. T. Law (HKUST3/CRF/13G, CIG); L. Forro (Swiss NSF); Z. Wang (NSF DMR-1420451)

Effects of spin-orbit interactions (SOIs) on superconductivity (SC), which can lead to unconventional pairing symmetries and topological SC, have attracted tremendous recent interest. Most of the recent studies have focused on inducing SC in non-superconducting materials with strong SOIs. Here, we examine the effects of SOIs on SC in NbSe$_2$, a superconducting material with strong SOIs, down to the monolayer limit.

The maximum magnetic field to which conventional SC can survive is known as the Pauli paramagnetic limit. Monolayers of NbSe$_2$, however, have upper critical fields that extrapolate to $\sim$35T, a six-fold violation of the Pauli paramagnetic limit (dashed line in the phase diagram). Probing such high upper critical fields calls for state-of-the-art low-temperature, high magnetic field electrical transport measurement facilities in the MagLab. The observed ultrahigh upper critical fields can be understood as a result of the very strong SOIs in inversion asymmetric NbSe$_2$ monolayers, which lock the electron spins to the out-of-plane direction and produce Cooper pairs with effective Ising spins. The applied in-plane magnetic field, therefore, has little effect in its attempt to polarize the Ising-like out-of-plane spins in the in-plane direction.

These effects are stronger as the sample is thinned from bulk, to trilayer, to bilayer, and ultimately to the monolayer limit. As such, this study is important in the search for unconventional SC in the exact two-dimensional limit.

Facilities: DC field, 31T, Cell 9 top loading cryostat

Recently we showed that magnetotransport in moiré-patterned graphene enables measurement of the fractal spectrum known as the Hofstadter butterfly. Here we report measurement of the butterfly spectrum in very high mobility devices. We observe that the Hofstadter spectrum supports conventional fractional quantum Hall Effect (QHE) states. More surprisingly, we find evidence of a new kind of fractional QHE, emerging at the highest achievable magnetic fields\textsuperscript{1}.

Hints of an unexplainable Hall plateau were first observed in the cell 9, 31T magnet. Further measurements in the cell 15, 45T hybrid magnet enabled high resolution maps of the Butterfly minigaps over sufficient field range to unambiguously confirm that the new QHE states project to a fractional Bloch Band filling index.

For the first time we report the coexistence of conventional fractional quantum Hall effect together with integer gap states associated with the fractal Hofstadter spectrum. Above 30T, a new series of states appear at fractional Bloch filing index. \textit{These fractional Bloch band QHE states are not anticipated by existing theoretical pictures and point towards a new type of many-body state.} Our findings demonstrate the Hofstadter spectrum to be a rich new system in which to study emergent behavior.

\textbf{Facilities:} NHMFL, 31 T magnet (cell 9), 45 T magnet (cell 15).

**Chapter 3 – User Facilities**

**PFF Facility**

The National High Magnetic Field Laboratory - Pulsed Field Facility (NHMFL-PFF) is located in Los Alamos, New Mexico, at the Los Alamos National Laboratory (LANL). The NHMFL-PFF utilizes LANL and US Department of Energy (DOE) owned equipment and resources to provide world record pulsed magnetic fields to users from the scientific and engineering community worldwide. The pulsed field users program is engineered to provide researchers with a balance of the highest research magnetic fields and robust scientific diagnostics specifically designed to operate in pulsed magnets. The connection with the DC Field Facility is strong and complementary in expertise. Although achieving the highest research magnetic fields possible is a fundamental competency at the NHMFL-PFF, we also strive to create the very best high-field research environment and to provide users with support from the world’s leading experts in pulsed magnet science. All of the user support scientists are active researchers and collaborate with multiple users per year. A fully multiplexed (6-output) and computer controlled, 4.0 mega-Joule (32 mF @ 16 kV) capacitor bank system is at the heart of the short pulse magnet activities. Many thousands of shots are fired for the User Program, which accommodates approximately 150 different users each year and fires more than 7,000 high magnetic field pulses each year for users. Beyond the workhorse shortpulse magnets, we provide users with the highest non-destructive magnetic fields available worldwide. The 100’s of mega-Joules necessary are provided by a 1.4 GW AC generator that is a truly unique pulsed power supply that dwarfs the pulsed power systems of all other magnet labs. The AC rectification allows for a greatly flexible pulsed power waveform to be delivered and customized to optimize performance of the associated magnet system (enabling technology for both the 100 T multishot and 60 T controlled waveform magnets). Pulsed field users have access to magnetic fields exceeding 100 T using the semidestructive Single Turn magnet system which produces 6 microsecond duration magnetic field pulsed approaching 300 tesla.

1. **Unique Aspects of Instrumentation Capability**

<table>
<thead>
<tr>
<th>Capacitor Driven Pulsed Magnets</th>
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<tr>
<td>Magnet, Field (T), Bore (mm)</td>
</tr>
<tr>
<td>Cell 1, 65 T, 15.5 mm</td>
</tr>
<tr>
<td>Cell 2, 72 T, 7.0 mm</td>
</tr>
<tr>
<td>Cell 3, 65 T, 15.5 mm</td>
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<td>Cell 4, 65 T, 15.5 mm</td>
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<tr>
<td>Cell 294 Pulsed Power Test cell</td>
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<td>Bldg 125 Single Turn, 300 T, 10mm</td>
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<table>
<thead>
<tr>
<th>Generator Driven Magnets</th>
</tr>
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<tbody>
<tr>
<td>Magnet, Field (T), Bore (mm)</td>
</tr>
<tr>
<td>100 T Multi-Shot, 101 T, 10 mm</td>
</tr>
<tr>
<td>60 T Controlled Waveform, 60 T, 32 mm</td>
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</tbody>
</table>
Chapter 3 – User Facilities

The table above lists the pulsed magnets available to users of the NHMFL-PFF. The short pulse magnets serve the majority of users with maximum fields currently in the 65-72 T range. The 100 T multi-shot magnet is the first and only magnet in the world to successfully perform a magnetic field pulse to 100 tesla in a non-destructive manner. The NHMFL pulsed magnets are arguably the best and most capable pulsed magnets in the world that are available to any qualified user through the NSF-DMR supported user program. The expertise in pulsed power engineering and access to world-class materials scientists at both LANL and FSU focus attention on development and characterization of the best materials for magnets. The PFF at LANL is also home to the 60 T Controlled Waveform (A.K.A. “Long Pulse”) magnet which has the ability to customize pulse waveforms for optimal user research. The 300 tesla single turn magnet at the PFF (development and installation was funded by LANL) provides users with access fields in excess of 100 T – routine pulses are to 170 tesla with a pulse duration of 6 microseconds. This research platform is mainly suitable to optical studies, but is being expanded with highly specialized sample preparation techniques. An inductive contactless method was developed in 2016 that enables thin (~micron thickness conductors) to be studied at extremes of high magnetic fields.

2. Facility Developments and Enhancements

In 2016 the most significant facility enhancement was the installation of the three new ABB high power circuit breakers for the 1.43 GW generator facility. The new breakers were funded by LANL to improve reliability of the power distribution to the NHMFL for the user program. The project cost about $0.5M in equipment and installation. Not only were new circuit breakers installed as can be seen in figure 1 but a new 4-way isolation switch was installed that allows the utility workers to disconnect 13.8kV utility power for the generator facility feeders without disturbing the NHMFL user program that relies on the 4 MJ capacitor bank. This is a major improvement as compared to the past when annual breaker maintenance and repairs would cause outages for the short pulse magnets and add additional power cycles on the sensitive waveform rectification and control system for the 100 T and 60 T Long Pulse magnet systems.

Figure 1. A new 27kV and 2000A circuit breaker is lowered into position at the PFF’s 20 MW power substation at TA-35 at LANL in 2016.

Also in 2016 the user cell for the Duplex magnet was installed in building 294. The new user cell will house a magnet that is to be powered by the 4 MJ user capacitor bank. The duplex magnet will be commissioned in 2017.

Figure 2. The new Duplex magnet cell is housed in building 294 and will allow routine pulses up to 75 T for users in 2017.

3. Major Research Activities and Discoveries

The PFF is at the forefront of pulsed field compatible instrumentation: For example, contactless conductivity methods that were highly developed at the PFF are now giving users the ability to measure sub-
tle changes in conductivity in magnetic fields well above 100 tesla.

In 2016 the helium recovery system at the MagLab Pulsed Field facility provided the user program with 19,025 liters of liquid helium. This is the first time that the PFF user program has been liquid helium self-sufficient for 12 consecutive months. An active monitoring system of all the cryostats and the high pressure storage provides valuable information regarding the helium usage and system leaks.

During 2016 the development of a new high resolution pulsed echo ultrasound technique was fielded on the 100 tesla Multi-shot magnet system. The new method provided unprecedented level of sensitivity to this method at magnetic fields extending to 95 tesla. The technique will be available to users in 2017 with close support from PFF scientists. Also in 2016 a new optical flow cryostat with sample in vacuum was designed built and tested for the Single Turn Magnet System. Summer intern student, Emily Follansbee with support from NHMFL scientists Jon Betts, Dwight Rickel, and Andreas Stier, designed the new cryostat. The new system is available to users now and is ideal for ~4K to room temperature experiments in the Single Turn Magnet (to fields of 185 tesla). Experiments like cyclotron resonance probed by 10.6 micron light or visible wavelength reflectance or transmission spectroscopy is also very well suited to the new system.

4. Facility Plans and Directions

The Pulsed Field Facility is gearing up for operation of the Duplex magnet system in 2017 (see figure 2). In Early 2017 a capacitor bank shutdown is scheduled to allow for updating of the operational software to allow for independent control of sections of the bank. Testing of the new magnet will commence in the second quarter of FY17. Another major institutional investment from LANL (over $1M) is
aimed at the 1.43 GW generator facility. The 450 MW power supply regulator system (PSR) will be replaced and a new design is needed to allow for the upgrade. Procurement processes are underway at LANL that will include upgrades of the generator drive system as well as the exciter system. These major improvements will allow for greater reliability and safety of this massive pulsed power system.

5. Outreach to Generate New Proposals—Progress on STEM and Building User Community

During 2016 the PFF hosted and participated in numerous outreach events. PFF scientists participated in the Expanding Your Horizons event in Santa Fe, NM. The event was specifically designed for middle school girls with interest in STEM and it attracted approximately 700 students.

The IEEE student group from New Mexico Tech toured the facility as well as the McDermott scholars from Dallas, Texas. The local PFF user support scientists visited area schools and gave presentations on the physics of magnetism and pulsed magnets. PFF Director Chuck Mielke and PFF Scientist Scott Crooker participated in the “Scientist Ambassador” program sponsored by the Bradbury science museum in Los Alamos. LANL was pleased to sponsor the visit of NSF Director France Cordova in April 2016 in which she toured multiple LANL facilities, gave a presentation and then took a detailed tour of the PFF. In Figure 6, Dr. Cordova discusses pathways of funding of major projects with LANL Associate Director Mary Hockaday and PFF Director Chuck Mielke.

Figure 6: LANL employee Adam Dioguarti joined NHMFL-PFF scientists to demonstrate magnetism to a group of students at the Expanding Your Horizons outreach event in Santa Fe, NM in March 2016.

Figure 7: NSF Director France Cordova touring the NHMFL-PFF with PFF Director Chuck Mielke and LANL Associate Director Mary Hockaday.

6. Facility Operations Schedule

The PFF has operated for three years now with a quarterly scheduling model and has solicited the quarterly call in concert with the DC facility. The reason for the change is to better serve users by fixing the schedules of the PFF user support scientists. This new approach is better for planning of the user support scientist schedule. Hours of operation are from 8:00am – 5:00pm. A16KV 4MJ User accessible capacitor bank is used to drive the 65 T short pulse magnets, 4 cells are equipped with these magnets and typically 3 are in use Monday – Friday 7:30am to 10:30pm. Preventative maintenance is scheduled each week (Monday 8:00am-10:00am) or performed on an as needed basis.
Upper Critical Magnetic Field and Kondo Effect in FeTe$_{0.9}$Se$_{0.1}$ Thin Films by Pulsed Magnetic Field Measurements

M.B. Salamon ¹, N. Cornell², M. Jaime³, F. Balakirev³, A. Zakhidov¹, J. Huang⁴, H. Wang⁴


Funding Grants: G.S. Boebinger (NSF DMR-1157490)

The superconducting transition temperatures of epitaxial films of FeTe$_{0.9}$Se$_{0.1}$ are remarkably insensitive to applied magnetic field, leading to predictions of upper critical magnetic fields, Hc2(T=0), in excess of 100T.

Using pulsed magnetic fields, we find Hc2(0) to be on the order of 45T, similar to the value found in bulk FeTe$_{0.9}$Se$_{0.1}$ yet still in excess of the paramagnetic limit, the magnetic field which would be expected to destroy superconductivity by polarizing the electron spins.

The same films show strong magnetoresistance in fields above Hc2(T), consistent with the observed Kondo minimum seen for T>Tc. Fits to the temperature dependence of Hc2(T) in the context of the standard (WHH) model, using the experimental value of the Maki parameter, require an effective spin orbit relaxation parameter of order unity. A Kondo scaling is successfully implemented by a simple temperature renormalization of the magnetic field B → B/(1-T/T_K). We suggest that Kondo localization plays a similar role to spin orbit pair breaking in making WHH fits to the data. [1]

Instrument: 60T short pulsed magnet at MagLab/LANL
Citation: Myron B. Salamon et al., Upper Critical Field and Kondo Effects in Fe(Te0.9Se0.1) Thin Films by Pulsed Field Measurements, Sci. Rep. 6, 21469 (2016).
Optical Spectroscopy of New Atomically-Thin Semiconductors to 65 Tesla

Andreas V. Stier¹, Kathleen M. McCreary², Berend T. Jonker², Junichiro Kono³, Scott A. Crooker¹,

1. NHMFL-Los Alamos National Laboratory; 2. Naval Research Laboratory; 3. Rice University

Funding: G.S. Boebinger, A.V. Stier, S. A. Crooker (NSF DMR-1157490); B.T. Jonker (NRL Nanoscience Institute; AFOSR AOARD 1410A018-134141); J. Kono (AFOSR FA9550-14-1-0268)

A new family of atomically-thin semiconductors known as the “monolayer transition-metal dichalcogenides” (e.g., MoS₂ or WSe₂), discovered in 2010, has the potential to advance many applications in optoelectronics, including light harvesting (solar cells) and light generation (LED lighting and lasers). As such, studies of their fundamental optical and electronic properties represent very active areas of present-day research.

Historically, magneto-optical measurements have played an essential role in determining the key parameters of electronic excitations in both bulk semiconductors and quantum-confined semiconductors (quantum wells and quantum dots). These excitations include excitons, an excited electron orbiting around the positively charged hole that was left behind by the exciting of the electron. Key parameters to characterize excitons include the exciton binding energy, size, spin, and dimensionality.

MagLab users have recently performed magneto-reflection spectroscopy on atomically-thin films of MoS₂ and WS₂ in pulsed magnetic fields to 65T. These measurements reveal the magnetic moment of the excitons in these 2D semiconductors, and also - for the first time - their physical size. Importantly, these parameters can then be used to constrain estimates of the exciton binding energy itself -- a parameter of significant interest in this new material class that is promising for future technological applications in solar energy and lighting.

Facilities: NHMFL Pulsed Field Facility, Los Alamos National Laboratory; 65 tesla capacitor-driven magnet.


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HIGH B/T FACILITY

The High B/T facility provides users with a unique combination of high magnetic fields (up to 16T) and ultra-low temperatures down to 1 mK for long durations (~ a few weeks). It is possible to cool to much lower temperatures ~0.4 mK for short times depending on the nature of the sample and the method of thermal linkage to the nuclear refrigerators. (Users should consult with staff on the best approaches to use.) A suite of specialized instrumentation is available for users conducting studies of magnetic or electric susceptibilities, nuclear magnetic and nuclear quadrupole resonance, transport, ultrasound, and thermal properties of modern materials in an ultra-quiet environment designed for high sensitivity studies. All users are required to take the NHMFL on-line safety training before conducting experiments at the facility.

1. Unique Aspects of Instrumentation Capability

A) High Sensitivity NMR Spectrometer for very Low Temperatures

Chao Huan and Naoto Masuhara have completed the construction and testing of a new pulsed spectrometer to provide users with high frequency (50-1000 MHz) NMR/NQR capabilities at moderate low temperatures (to 25 mK) or low frequency (1-50 MHz) NMR at ultra-low temperatures (to 1 mK) with sample volumes up to 1 cm³. High sensitivity high frequency NMR cells at ultra-low temperatures are challenging and need very special design considerations, but have been carried out using re-entrant RF cavities at 14.5 T with sample temperature at 1.7 mK [Akimoto et al. Phys. Rev. Lett. 90, 105301 (2003)]. The new system includes sections of high quality superconducting cables in low field regions above the nuclear refrigerator bundle and low loss Ag plated copper cables along the bundles. A unique double tuning capability is provided by a fixed preset tuning and a well-matched circuit at low temperatures followed by a fine tuning at room temperature to offset the changes as the system is cooled.

A hybrid tee bridge is used for the NMR detection. The system was tested using 10⁻³ moles of ³He adsorbed on MCM nanotubes. Signal/noise ratios greater than 100 were observed for a bandwidth of 1 kHz at lattice temperatures of 100 mK. Studies at lower temperatures can be carried out by thermally isolating the RF excitation coil from the sample system. [Ref: C. Huan et al. J. Low Temp. Phys. 75, 133-139 (2014)].

The new spectrometer is particularly useful for exploring the dynamics of new materials at low temperatures and high magnetic fields. Figure 2 shows data obtained for ³He adsorbed on MCM nanotube structures. The low temperature behavior is characteristic of quantum fluids at low temperatures in reduced dimensions.

Figure 1. View of low temperature NMR cell attached to a silver post extending from the tail of a nuclear refrigerator. The sample was 10⁻³ moles of ³He adsorbed in silica nanotubes.

Figure 2. Temperature dependence of the nuclear spin-spin relaxation time T₂ of thick films of ³He constrained to nanotubes at low temperatures.
B) High Pressure cell for low temperature high field measurements.

A simple clamped cell (Figure 3) for high pressure studies has been developed by Jiang-sheng Xia for susceptibility measurements at low temperatures in high magnetic fields. The cell is a gold plated BeCu cylinder using Daphne oil for pressure transmission and a small-diameter annealed magnanin wire for pressure measurements. The top of the cell is clamped to a sold silver extension from a nuclear refrigerator or a dilution refrigerator.

Figure 3 (left). BeCu high pressure cell for low temperature applications. The cell can accommodate samples up to 3x3x4 mm for ac magnetic susceptibility studies, and up to mm in thickness, and 4 mm in diameter for dielectric susceptibility measurements.

C) Other specialized instrumentation includes a sample tilt-platform for transport studies that uses sintered Ag heat exchangers in the probe leads that are immersed in superfluid $^3$He to ensure reliable thermal contact, ultrasound cells and $^3$He melting curve thermometry.

2. Facility Developments and Enhancements

We are developing low temperature ultra-low noise radio-frequency capabilities in the form of contactless techniques to measure RF conductivities and the real and imaginary components of RF magnetic susceptibilities in new materials. Tunnel diode oscillators are being tested for their high sensitivity and low power dissipation. These devices can also, in principle, be used for NMR and EMR studies at very high frequencies. The performance of these systems in high magnetic fields is not well understood.

3. Major Research Activities and Accomplishments


The investigators studied high mobility ($\mu = 3 \times 10^6$ cm$^2$/Vs) dilute (4 $\times$ 10$^{10}$ cm$^{-2}$) two-dimensional hole systems in 20-nm GaAs/AlGaAs quantum wells down to 10 mK. With a quenched kinetic energy in a perpendicular magnetic field $B$, a prominent reentrant insulating phase (RIP) is observed in a strongly correlated regime around 4.5 Tesla [Fig. 4 (a)]. Centering at the RIP peak, Huang et al. observed a striking DC-IV threshold below $T_{c1}$=30mK, confirming a pinned Wigner Crystal (WC) exhibiting $G\rho$ resistivity ($\rho$) within a very narrow range of excitation ($I_c=\pm 5$pA) [Fig.4(b)].

Figure 4. (a) Quantum Hall oscillations as a function of a B-field showing a new re-entrant insulating phase. (b) Non-linear DC-IV characteristics, evolving from a rigorous threshold to a linear relationship as a function of $T$, measured at the center of the RIP peak.
Chapter 3 – User Facilities

The WC is depinned beyond $I_c$ with $\rho$ plummeting by over three orders of magnitude. An intermediate/mixed phase appears beyond $T_{c1}$ and it becomes a liquid, absent from pinning, upon reaching $T_{c2}=120$ mK as indicated by only linear IV. This piecewise $T$-dependence [Fig.5] is consistent with a second order melting transition. With $T_{c2}$ being only 1/3 of the classical estimate, the investigators conclude that this solid-liquid transition possesses much more pronounced quantum mechanical contributions than what is expected theoretically. Centering at the RIP peak, Huang et al. observed a striking DC-IV threshold below $T_{c1} =30$ mK, confirming a pinned Wigner Crystal (WC) exhibiting GΩ resistivity ($\rho$) within a very narrow range of excitation ($I_c=\pm 5$pA) [Fig.4(b)]. The WC is depinned beyond $I_c$ with $\rho$ plummeting by over three orders of magnitude. An intermediate/mixed phase appears beyond $T_{c1}$ and it becomes a liquid, absent from pinning, upon reaching $T_{c2}=120$ mK as indicated by only linear IV. This piecewise $T$-dependence [Fig.5] is consistent with a second order melting transition. With $T_{c2}$ being only 1/3 of the classical estimate, the investigators conclude that this solid-liquid transition possesses much more pronounced quantum mechanical contributions than what is expected theoretically.

**Figure 5.** Inferred phase diagram for the high mobility 2DES (square well GaAs/AlGaAs) with high mobility ($\mu = 3.0\times10^6$ cm$^2$/Vs).

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B) Ostwald Ripening and Quantum Phase Separation

High sensitivity NMR capabilities at the NHMFL High B/T Facility have enabled researchers (Don Candela et al.) to follow the phase separation of solid $^3$He-$^4$He mixtures for the first time at very low $^3$He concentrations. At high temperatures the $^3$He is dissolved in the solid $^4$He matrix but at low temperatures the $^3$He separates out as small degenerate Fermi droplets. This phase separation is a first order transition with a conserved order parameter and represents a particularly clean and accessible example because the time constants are accessible on laboratory time-scales as a result of the fast quantum mechanical particle exchange in the solid state. Initially the $^3$He droplets grow exponentially due to the diffusion of dissolved $^3$He through the $^4$He background, but after the droplets grow to a critical size and the $^4$He matrix is largely devoid of $^3$He the growth is limited by the diffusion of subcritical droplets to the larger droplets which now grow at the expense of small droplets. In this time of coarsening of the droplets the time dependence is determined by the rate of capture at the surface of the droplets – a characteristic $t^{1/3}$ dependence. These experiments were made possible by the high sensitivity techniques developed by Chao Huan using field effect transistors operating in magnetic field at low temperatures near the NMR cell. A compact crossed coil design enabled the users to allow the RF excitation coil to operate at much higher temperatures than the RF receiving coil and the sample. (These results were presented at the 2015 International Symposium on Quantum Fluids and Solids, Grenoble, 2015.)

**Figure 6.** Comparison of the short term homogeneous nucleation of $^3$He Fermi droplets in solid $^3$He-$^4$He solutions with the late term Ostwald ripening which has a $t^{1/3}$ time dependence.
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C) UF Theory Program Achievements on DC and Pulsed Field Experiments

(I) Orbitally Selective Spin Fluctuation Pairing in FeSe Crystals

P.J. Hirschfeld (U. Florida), B.M. Andersen and A. Kreisel (Niels Bohr Inst.)

Introduction

Iron selenide is at once the simplest of the Fe-based superconductors, and one of the most mysterious. Its Tc is only 8K, but this increases under pressure or intercalation to 40K, and to 70K or above when deposited as a single layer on strontium titanate. It is not magnetic, unlike most of the Fe-based superconducting parent compounds, but displays a very strong electronic nematic order below a transition to an orthorhombic structure at 90K, possibly due to magnetic correlations frustrated by ordering tendencies at several competing wavevectors [1].

Figure 7: Clockwise from upper left: A) schematic gap function on tiny hole (α) and electron (ε) pockets measured by Cornell group on FeSe; B) measured gap functions vs. angle on the respective Fermi surfaces shown in 1-Fe Brillouin zone; C) theoretical spin fluctuation prediction using ansatz that pairing occurs only in yz orbitals; D) anti-symmetric part of differential conductance ρ vs. bias, with predictions for s-, and s+, from calculations in Ref. 3, indicating that gap in FeSe changes sign on Fermi surface.

Results and Discussion

In Ref. 2, quasiparticle interference (QPI) measurements determined the FeSe band and superconducting gap structure, indicating strong near-nodal anisotropy consistent with other experiments. However the gap minima were in different positions from those anticipated by spin fluctuation theory, oriented along the tips of the electron and hole ellipses. A special single-impurity QPI measurement allowed for a definitive conclusion that the gap in FeSe changes sign, using the method proposed in Ref. 3.

Conclusions

It appears that strongly orbitally selective quasiparticle weights, as indicated by recent angle-resolved photoemission, are necessary to explain the gap structure in FeSe. Recent theoretical analysis indicates that an ansatz with suppressed quasiparticle weights explains the gap structures in several Fe-based systems that had been poorly understood [4].

Acknowledgements

Supported by DOE DE-FG02-05ER46236

References


(II) Probing the semiconductor to semimetal transition in InAs/GaSb double quantum wells by magneto-infrared spectroscopy

Y. Jiang, Z. Jiang (Georgia Institute of Technology), S. Thapa, G. D. Sanders, C. J. Stanton (University of Florida), Q. Zhang, J. Kono, Rice University), W. K. Lou, K. Chang (Chinese Academy of Sciences), S. D. Hawkins, J. F. Klem, W. Pan (Sandia National Laboratory), D. Smirnov (National High Magnetic Field Laboratory).

Introduction

Magneto-infrared spectroscopy studies of the semiconductor to semimetal transition of InAs/GaSb double quantum wells have been carried out to explore the evolution from the normal to the inverted state. Because of the low carrier density of the samples (approaching the intrinsic limit), the magneto-absorption spectra evolve from a single cyclotron resonance peak in the normal state to multiple absorption peaks in the inverted state with distinct magnetic field dependence. Using an eight-band Pidgeon-Brown model.
Results

This theoretical contribution is able to explain all the major absorption peaks observed in the experiment (figure 8). It is shown that the semiconductor to semimetal transition can be realized by manipulating the quantum confinement, the strain, and the magnetic field. This work paves the way for band engineering of optimal InAs/GaSb structures for realizing novel topological states as well as for device applications in the terahertz regime.

Figure 8. Comparison of the observed magnetic field dependence of the major IR absorption peaks with theory for (a) 10 nm, (b) 11 nm, and (c) 15 nm double quantum well samples. The blue (red) solid lines represent the manifold-resolved inter-band (intra-band) transitions. The dashed red lines indicate the diminishing absorption peaks that are blocked when the corresponding level crosses above the Fermi energy.

Conclusion

The theoretical results confirm the interpretation of the experimental results for the magneto-IR spectroscopy of InAs/GaSb double quantum wells in terms of a band inversion that modifies the magneto-absorption leading to multiple absorption peaks with distinct non-linear field dependencies.

(III) Resistivity Minimum in Highly Frustrated Itinerant Magnets Zhentao Wang (Rice University), Kipton Barros (University of Tennessee), Gia-Wei Chern (University of Virginia), Dmitrii L. Maslov (University of Florida), Cristian D. Batista (Los Alamos National Laboratory)

Introduction

The group has studied the transport properties of frustrated itinerant magnets comprising localized classical moments, which interact via exchange with the conduction electrons. Strong frustration stabilizes a liquidlike spin state, which extends down to temperatures well below the effective Ruderman-Kittel-Kasuya-Yosida interaction scale. The crossover into this state is characterized by spin structure factor enhancement at wave vectors smaller than twice the Fermi wave vector magnitude. The corresponding enhancement of electron scattering generates a resistivity upturn at decreasing temperatures.

Results

The results obtained show unambiguously that frustrated itinerant magnets can exhibit a low temperature liquid-like spin state with enhanced resistivity under quite general conditions. Fig. 9 summarizes the results.

Figure 9. Comparison of the theoretical fits (solid lines) to various resistivity data (circles). The data points are taken from (a) KPM-LD results for a triangular KLM with J/t = 0.2 at 0.009 filling; (b) SmCuAs2 [Ref 1], (c-d) GdIn1-xCdxCu4 [Ref 2].

References


4. Facility Plans and Directions

With the recent success of the high temperature superconducting (HTS) insert coils that have been able to reach above 40 T when inserted into a conventional low temperature superconducting (LTS) magnet. We have proposed developing a special HTS magnet facility that has available both high circula-
tion rate dilution refrigerators for low temperature users, and high temperature inserts for experiments up to ~ 2000K) for materials science and engineering studies. This new facility has been proposed as part of a UF legislative request and would use the UF Physics High bay space that could accommodate up to three HTS magnet systems that would also include a magnet dedicated to AMRIS.

5. Outreach to Broader Communities and Building participation in STEM Careers

In 2016, the NHMFL coordinator at the University of Florida, Elizabeth Webb, and graduate students and post-doctoral fellows working with her visited 100 classrooms in 18 schools, reaching 2,225 students as part of the NHMFL classroom outreach program in Gainesville. An additional 19 presentations were made at 8 schools reaching 342 students as part of the afterschool science program Elizabeth started this year, after school science clubs at local libraries and schools, and summer programs. This year faculty and students also participated in a Family Science Night at a local middle school, reaching nearly 100 students. Also new this year, the High B/T Facility participated in the WiSE Girlz spring break camp (a camp for middle school girls organized by the Women and Science and Engineering group at UF), showing the girls the facility and introducing them to fun demonstrations and hands-on activities with liquid nitrogen. Leading tours for teachers and school groups is an annual practice at High B/T, and this year, Facility leadership and staff lead 4 tours, reaching 70 college, high school, and middle school students and teachers. NHMFL faculty from the Facility also visited local after school programs for low income students, bringing with them physics demonstrations and hands-on activities, and served as judges at Middle School Science Fairs as well as the Alachua County Science Fair.

6. Facility Operations Schedule

The majority of the experiments conducted at the High B/T Facility need a dedicated study of the experimental cell in order to be certain that the sample can reach ultra-low temperatures in the course of the measurements being proposed by users. This study is necessary because of the high Kapitza thermal resistance at ultra-low temperatures. Users work closely with High B/T staff in the design, construction and testing of the cells. The experiments can take one to nine months to complete and for this reason the facility operated 24/7 for 330 days in 2016. Shutdowns are planned to occur whenever possible at the same time as major scientific meetings in the fields, notably for the March APS meetings and the International Low Temperature Physics Conferences.

7. Performance Goals – Present and Future

We plan to reduce the current waiting time for users who have approved proposals for magnet time from about nine months by a factor of two by opening another nuclear demagnetization refrigerator (0.1 mK, 8 T) for user operations. The timing for this improvement is dependent on available funding as it is dependent on obtaining additional staff. The primary equipment is already on hand but does need to be revitalized.
Chapter 3 – User Facilities

Phase Separation of Very Dilute Concentrations of $^3$He in Solid $^4$He

D. Candela$^1$, B. P. Cowan$^2$, C. Huan$^3$, S. S. Kim$^3$, L. Yin$^3$, J. S. Xia$^3$ and N.S. Sullivan$^3$


Funding Grants: G.S. Boebinger (NSF DMR-1157490); N. Sullivan (NSF-DMR-1303599)

Studies of the phase separation in solid $^3$He-$^4$He mixtures is of fundamental interest to physicists because it is a first order phase transition with a conserved order parameter. The order parameter is the concentration of $^3$He, which does not change through the phase transition. The samples can be substantially supercooled and have very few defects, which makes them an excellent model system for studying this unusual class of phase transition that is in many ways analogous to phase separation in classical metal alloys. Unlike classical metal alloys, however, the relevant time scales are short, due to the effects of quantum diffusion. As such, the transitions can be studied on accessible laboratory time scales.

Samples were studied with a specific balance of $^3$He versus $^4$He such that they formed solid solutions in which the $^3$He rich phase – when separated – would form nanoscale $^3$He droplets. At the transition temperatures well below 1K, $^3$He is a degenerate Fermi liquid. As such, the reduced NMR magnetic susceptibility allows one to easily determine the onset of the phase separation transition using the MagLab’s ultralow-temperature NMR techniques.

The observed phase transition temperatures $T_{ps}$ shown in Figure 1 are well described by $\Delta_{ps}$ is the $^3$He-$^4$He binding energy and $A_3$ is an asymmetry factor due to the different crystal structures. Future work seeks to measure critical fluctuations that accompany this unusual phase transition.

$T_{ps} = \frac{A_3 (1 - 2x_3) + A_3}{k_B} \left[ \ln \frac{1}{x_3} - 1 \right]$  

**Figure:** Experimentally observed phase separation temperatures in solid $^3$He-$^4$He mixtures for dilute $^3$He concentrations. The solid lines are theoretical predictions using regular solution theory, modified to account for differences in free energies of hexagonal-close-packed $^4$He and body-center-cubic $^3$He.

References:

Facilities: Bay 3 MicroKelvin Laboratory, High B/T Facility
Citation: D. Candela et al., J. Phys. Conf. Ser. 568 (1), 012017 (2014)
Presented at 2015 Symposium on Quantum Fluids and Solids, Buffalo, NY.
Mott Transition and Multiferroic Behavior in PbCrO₃

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Funding Grants: G.S. Boebinger (NSF DMR-1157490);

PbCrO₃ is an especially interesting highly-correlated electron system, as it is believed to provide the only experimental example of a Mott transition [1] generated by a strong screening of the Coulomb potential that is associated with a lattice contraction.

At low pressures, this material is a cubic paramagnet with an anomalously large unit cell that transitions to an antiferromagnet at TN ~ 190 K. Increasing the pressure above 1.6 GPa results in an isostructural transition with a reduced cell volume and, therefore, an increased screening of the Coulomb potential, which in turn leads to a Mott transition.

A ferroelectric transition occurs at TC ~ 65-80 K, below which the low temperature state exhibits magnetic frustration of the magnetic moments on the Cr atoms. This drives spatial variations of the local magnetization and eventually results in ferroelectricity. The dielectric susceptibility of the low temperature phase was measured at the MagLab’s High B/T facility using a specialized high-sensitivity dielectric cell. The electric susceptibility observed down to 50 mK depends strongly on the applied DC field (up to 6T) and on the frequency, suggesting strong magneto-electric effects.

References

Facilities: The Williamson Hall Annex of the high B/T Facility
Citation: Unusual Mott transition in multiferroic PbCrO₃, S. Wang et al., Proceedings of the National Academy of Sciences 112 (50), 15320 (2015)

Figure: Temperature dependence of the dielectric susceptibility for PbCrO₃ at different frequencies, showing both the Neel transition (TN) and the ferroelectric transition (TC). Note the temperature scale has been reversed, with zero at the right.
Chapter 3 – User Facilities

NMR FACILITY

The NMR and MRI User Program in Tallahassee is a partner with the AMRIS facility of the NHMFL at the Univ. of Florida in Gainesville. The Tallahassee facility offers scientists access to high magnetic fields with the world’s highest sensitivity NMR and MRI probe technology. Our flagship 900 MHz ultra-wide bore spectrometer is the world’s highest field instrument for in vivo MRI/S and also offers high sensitivity probes for materials and biological solid state NMR. We also offer Dynamic Nuclear Polarization spectroscopy at 600 MHz as a user facility. This instrument provides much higher sensitivity for biological solids and for materials research than is available from NMR. Lower field instruments offer users additional unique capabilities in solution and solid state NMR. Our technology efforts continue to be focused on the development of innovative probes for triple resonance solid state NMR for both oriented sample and magic angle sample spinning, high field in vivo imaging and spectroscopy as well as high sensitivity solution NMR probes. This past November the Series Connected Hybrid magnet, a combination of a 14T superconducting coil and 22T resistive insert reached full field. The homogeneity and stability of the field is currently being enhanced on our way to achieve 1 ppm homogeneity and stability over a 1 cm ds. Data from the last three years (2013-2015) for which we have data analyzed show how successful the MagLab NMR/MRI Facility has been: 386 Users crediting 245 Grants (60 NSF grants from 19 different NSF programs; 65 NIH grants from 12 institutes; and 120 other grants), 149 publications acknowledging 161 Institutions from around the world.

1. Unique Aspects of Instrumentation Capability

A unique user facility has been launched in the United States at the NHMFL – a 600 MHz Dynamic Nuclear Polarization (DNP) Facility that takes advantage of NIH funding for a sweepable 14.1±0.13T magnet that was installed this past year and an NSF MRI grant for a gyrotron, plus NSF and State of Florida NHMFL support to assemble this instrument that provides ultra high sensitivity NMR spectroscopy of materials and biological solid state NMR to our national and international user community.

Two new technologies are being installed for NMR at the NHMFL. The first is a pair of 0.75mm 110kHz MAS spinners for solid state NMR. Fast MAS spinners are ushering in a new era for NMR, one in which proton detection is possible with ultra high spectral resolution and sensitivity. This is similar to the revolution that occurred in the 1980’s when solution NMR spectroscopy gained proton detection capabilities. That opened a flood-gate for protein structural characterization of water soluble proteins. Now for solid state NMR a similar flood-gate can be opened for proteins that are not water soluble such as membrane proteins and proteins that form fibrils, such as amloid fibers. We hope to have these MAS probes available for the community in mid to late 2017.

The second revolution is occurring with magnet technology. The future of NMR is going to be at field strengths far above those that can be generated with Low-Temperature Superconductors (LTS). High Temperature Superconducting (HTS) materials development is progressing apace with the potential to more than double current NMR field strengths and the magnet lab is at the forefront of this technology thanks to support from NSF, NIH, and DOE. While it will still be a while before such high field superconducting magnets become a reality, the NHMFL currently has a 36T magnet designed for NMR that has reached field. This magnet has the latest generation Bruker Console a 5-channel Avance IV. The 36T hybrid is not a persistent magnet and can therefore be operated at any field strength between 0-36T. The Bruker console comes with proton amplifiers for 1.0, 1.2 and 1.5 GHz so that field dependence studies can be performed. Through October 2017 this spectrometer will be in a commissioning phase in which we will optimize a variety of probes and spectroscopic experiments before opening this instrument as a user facility for the broad community.

This magnet will allow us to peer into the future when we will have persistent superconducting magnets operating at such fields. Sensitivity for many nuclei increases with \( B_0^{3/2} \) and signal averaging time decreases as the square of this factor. For quadrupolar nuclei the sensitivity factor can be \( B_0^{7/2} \) or even \( B_0^{7/2} \). One of the most exciting prospects in the biological and material sciences is the study of \(^{17}O\). It is at the oxygen atoms where much of biological and materials chemistry takes place and yet it has not been possible to routinely observe these nuclei because of the poor sensitivity and severe resonance overlap. Fortunately, high fields dramatically en-
hance the prospects for doing this spectroscopy routinely on biological macromolecules and in materials.

2. Facility Developments and Enhancements

Despite years of development effort to get DNP to be a commercial product there is a great deal of work left to be done to have this technology be a routine tool. Robust infrastructure needs to be installed, more robust probes than what is available commercially needs to be developed. Sample preparation techniques need to be developed to gain the highest benefit from this technology. Additional temperature range is needed for many studies. Plans have been made and resources are being sought for such probe developments.

For the SCH magnet a first generation of probes for MAS and Oriented Sample NMR have been designed and built. These probes are currently being tested, but this 50% jump in magnetic field is a dramatic jump in frequency and there will certainly be multiple generations of probes that enhance NMR performance over the years to come. Indeed, this is very exciting, because there is an opportunity to do this prior to the development of very high field and very expensive LTS/HTS all superconducting magnets.

3. Major Research Activities and Discoveries

NMR has long been known as a structural biology tool, a technology for obtaining the molecular structure of proteins and nucleic acids. Yet there are other technologies such as X-ray diffraction and now CryoEM that can also generate structures. So what is unique about NMR data? First, it is able to characterize these molecular structures in a more native like environment. This is important since the amino acid sequence or the nucleotide sequence alone does not determine the molecular structure. Instead, it is a combination of the molecular interactions within the molecule and between the molecule and its environment. More importantly, NMR can uniquely determine the dynamics or molecular motions that occur within the molecular structure. In addition, it is now possible to characterize details of the functional mechanism of these molecular machines as was recently achieved by Fu and coworkers (PSU & MagLab) for the M2 protein that functions as a proton channel in the Influenza A viral coat. Importantly, this is just an example of the significant science that can be uniquely achieved through the use of NMR spectroscopy.

Along similar lines of thought, the science community would like to understand how proteins function within the cellular environment. This is not possible if one has to purify the protein conducting the chemistry first. This past year Frederick (UTSouthwestern) obtained detailed conformational insights for a protein in its native cellular environment using the MagLab’s new 600 MHz DNP User Facility.

4. Facility Plans and Directions

From its very beginning the NMR/MRI program has been supporting and grant writing for the design and then for the construction of the Series Connected Hybrid Magnet. Peering into the future of NMR long before the NHMFL’s UWB 900 MHz had been completed and brought to field, the description of a scientific vision for field strengths nearly twice the field strength of our highest field NMR magnets required a major effort and many of those goals identified 15 years ago are ready to be achieved in forthcoming months.

Now a new frontier is being worked on with additional goals. Europe has placed orders for nine 1.2 GHz all superconducting magnets, while there is not a single 1GHz NMR instrument in the Americas despite their availability for the past 5 years. Graduate students and postdocs are choosing European labs to work at the frontier of NMR because there has been no federal dollars to support high field NMR instrumentation with the exception of the SCH magnet supported by the National Science Foundation. Now, investments must be made in high temperature superconducting magnet development. In November 2014 a workshop on Ultra-High Field NMR was held in DC sponsored by the NSF, NIH, and DOE. A report was written and a now a Strategic Plan has been written by many members of the NMR community including MagLab personnel identifying a design for facilities that would make Ultra-High Field NMR spectrometers available to a broad scientific community and would equip them with novel probe technology and maintain the instruments at state of the art performance.

Despite its age the 900 UWB is producing many significant publications each year. However, the console is old, the instrument’s sensitivity is now less than a recently refurbished midbore 800 MHz mag-
net with an Avance III Bruker console and a new MAS triple resonance probe from our RF group. Our 900 UWB needs new probes and a new RF console, the latter is in the MagLab renewal budget along with an RF engineer for the 900. Our RF instrumentation group now with 5 full time engineers and technicians and a machinist is overwhelmed with important and challenging projects. However, with three probes ready for the SCH, the DNP and potentially the 900 will now be on the priority list.

The NMR science on the SCH is going to be very challenging. We are hoping to perform high resolution solid state NMR spectroscopy on a DC Powered magnet – this has not been done before (unless one counts some of the early NMR spectroscopy from the middle of the last century). In collaborating with Prof. Jeffrey Schiano at Penn State, the NHMFL has developed technology to stabilize powered magnets. This technology is now ready to be tested on the SCH and our plan is that we will be able to perform high resolution solid state NMR spectroscopy with this instrument.

5. Outreach to Generate New Proposals - Progress on STEM and Building User Community
   Our primary mechanism for recruiting new users involves one on one contact with potential users at national and international meetings with follow up to bring those users here. Our staff scientists go to important national and international meetings annually and one of their tasks at these meetings is identify new users and to follow up with them when they return to the MagLab. A greater challenge that we are beginning to work on, is to recruit users who are not NMR spectroscopists, but scientists that could use NMR data for the science they do. This opens the NHMFL facility to a much broader and more diverse community of biological and chemical scientists.

6. Facility Operations Schedule
   The NMR/MRI facilities are open 24/7 and for 365 days of the year. The only down time is when there is a need for instrument maintenance.
Site-specific structure changes of the Rous Sarcoma virus capsid proteins upon assembly revealed by solid state NMR

Jaekyun Jeon¹, Xin Qiao¹, Ivan Hung², Peter L. Gor'kov², Zhehong Gan² and Bo Chen¹

1. University of Central Florida; 2. National High Magnetic Field Laboratory, Florida State University;

Funding Grants: G.S. Boebinger (NSF DMR-1157490); Bo Chen (AFOSR FA9550-13-1-0150)

The Rous Sarcoma virus (RSV) is the archetype of the retrovirus family that includes many formidable pathogens such as HIV that causes AIDS. The viral genome is housed within and protected by a protein “capsid” shell. The capsid is formed by ~1500 copies of a single retrovirus capsid protein. All capsid proteins share a common tertiary structure (Fig.B), yet assemble into distinctly-shaped capsids. The in vitro retroviral capsid assemblies (Fig.A) provide a convenient avenue to study the in vivo capsids that are found in living systems. The high resolution structural knowledge of these assemblies will aid the design of antiviral drugs to disrupt this protective capsid. However, the intrinsic polymorphism of the retroviral capsid assemblies defies conventional structural characterization techniques.

High-magnetic-field solid state NMR (ssNMR) is the ideal technique to characterize the structure and dynamics of disordered systems at atomic resolution. The high magnetic fields plus the MagLab’s low-electric-field probe¹ enable the acquisition of high resolution spectra (Fig.C) to study large and disordered assemblies formed by RSV capsid proteins.

Recent user results reveal detailed structural rearrangements of the capsid proteins upon capsid assembly. This provides critical insights for understanding retroviral capsid formation. The study more broadly advances sequential assignment strategies for ssNMR studies of large protein assemblies.

Facilities: MagLab solid state NMR systems, including low-E probe.

Detection of “Free” Oxide Ions in Silicate Glasses by Double-Resonance Solid-State NMR

Ivan Hung¹, Zhehong Gan¹, Peter L. Gor’kov¹, Derrick C. Kaseman², Sabyasachi Sen², Michelle LaComb³, Jonathan F. Stebbins³,*

1. NHMFL; 2. University of California, Davis; 3. Stanford University

Funding Grants: J.F. Stebbins (NSF EAR-1521055); S. Sen (NSF DMR-1505185)

Knowledge of the molecular-scale structure of oxide glasses and glass-forming liquids is of key importance in understanding, predicting, and optimizing their physical and chemical properties for applications to both advanced technological materials and to basic research in the Earth sciences. Of particular importance is the role of the oxygen anion, which is numerically and volumetrically predominant in all oxide glasses, and connects the Si cations to define the glass ‘network’.

In conventional models of most glass-forming compositions, all oxide ions should be bonded to one or two network cations such as Si⁴⁺, but recent studies by NMR and other methods have suggested this view may need revision and that “free” oxide ions may play an important role. This controversy has proven difficult to resolve.

We present a technically-challenging double-resonance NMR experiment involving ¹⁷O and ²⁹Si that quantifies ‘free’ oxide O²⁻ species in CaMgSiO₄ glasses. The technique, called CP-HETCOR, measures the transfer of nuclear spin polarization between oxygen and silicon atoms. Isotopic enrichment, special methods to form low-silica glasses, NMR pulse sequence development, testing with crystalline model compounds of known structure, and high magnetic fields are all required to make this measurement possible.¹

Facilities: NMR facility at NHMFL, 800 Mhz MB
Chapter 3 – User Facilities

ADVANCED MAGNETIC RESONANCE IMAGING AND SPECTROSCOPY (AMRIS)

The AMRIS facility at the University of Florida supports nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI) studies of chemical compounds, biomolecular systems, tissues, small animals, large animals, and humans. We currently offer eleven systems with different magnetic fields and configurations to users for magnetic resonance experiments. AMRIS has twelve professional staff members to assist users, maintain instrumentation, build new coils and probes, and help with administration.

1. Unique Aspects of Instrument Capability

Several of the AMRIS instruments offer users unique capabilities: the 750 MHz wide bore provides outstanding high-field imaging for excised tissues and small animals as well as diffusion measurements with gradient strengths up to 30 T/m; the 11.1 T horizontal MRI has the highest field strength MRI magnet in the world with a 400 mm bore and gradient strengths up to 1.5 T/m; the 600 MHz 1.5-mm HTS cryoprobe is the most mass-sensitive NMR probe in the world for $^{13}\text{C}$ detection and is ideal for natural products research; the 5 T DNP polarizer enables both fundamental studies of DNP mechanisms down to 1.2 K as well as in vivo metabolism measurements when coupled to either the 4.7 or 11.1 T systems. These systems support a broad range of science, from natural product identification to solid-state membrane protein structure determination to cardiac studies in animals and humans to correlating neural structures at high resolution with brain function and chemistry.

2. Facility Developments and Enhancements

Support from the University of Florida for recruiting NHMFL-affiliated faculty enabled us to: 1) add a second DNP polarizer to the user program; 2) upgrade the 11.1 T system with a state of the art console and phased array coils; and 3) expand the human imaging program to a second 3T MRI scanner. NHMFL funds were used to develop a week-long annual workshop for users on the design, construction, and testing of RF coils for MRI applications. A $^{13}\text{C}$-optimized 10 mm cryoprobe was also purchased with UF funds and will be installed early in 2017. We also added two radiological technologists to our staff. An 18.8 T magnet was recently donated to our program and expansion of the NMR program with this magnet is underway.

3. Major Research Activities and Discoveries

This year we saw continued research growth in three new user areas developed during this funding cycle. The first area is in fundamental DNP studies and their application to in vivo metabolic studies. We also saw increased research in the area of metabolomics through support of the NIH-funded SEClM grant which provides comprehensive and complementary resources for clinical and basic science metabolomics studies and has enabled us to expand our user program. A third area of growth was in the use of in vivo MRI and MRS to study rodent models up to 17.6 T. Research in these areas led to and will leverage the enhancements described in section 2. AMRIS facility users reported 81 peer-reviewed publications and 9 theses and dissertations for 2016.

4. Facility Plans and Directions

In spite of the continued challenging budgetary climate, our users have consistently successfully pursued federal funding to support their research programs and assisted the AMRIS facility in writing proposals to upgrade instrumentation. The successful partnership of the NHMFL user program with individual investigator research grants also provides constant scientific motivation for our technology development. Developing an NMR program on the recently donat-ed 18.8 T magnet will enable the 17.6 T system to be dedicated to MRI/S studies enabling us to support increased demands in both biomolecular NMR and neuroscience studies combining high field imaging with in vivo spectroscopy. An NSF MRI proposal was submitted in January 2017 to enable the development of unique HTS/DNP capabilities at 18.8 T.

5. Progress on STEM and Building the User Community

The addition of an NHMFL outreach and education coordinator, Elizabeth Webb, at UF in 2015 has enabled us to increase our efforts substantially in these areas. In 2016, Ms. Webb organized visits of UF scientists to 100 classrooms in 18 schools, reaching 2,225 students. She made an additional 19 presentations at 8 schools reaching 342 students as part of an afterschool science program started this
year, visiting school science clubs at local libraries and schools and summer programs. The NHMFL at UF is now a major contributor to the WiSE Girlz spring break camp (a camp for middle school girls organized by the Women and Science and Engineering group at UF).

This year we held the first annual RF Coil building workshop in the AMRIS Facility. Five participants came for a week to learn the physics behind MRI, RF coil theory, and how to build RF coils. As part of this workshop, a half-day training workshop on CST software was given to 20 students and postdocs, including the workshop participants.

Faculty associated with the AMRIS Facility mentored three NHMFL REU students over the summer and gave periodic tours of the AMRIS Facility. These faculty consistently have ~20 undergraduate and high school students working on projects at any given time.

6. Facility Operations Schedule

The AMRIS facility operates year round, except during the last week of December when the University of Florida is shut down. Vertical instruments for ex vivo samples are scheduled 24/7, including holidays and weekends. Horizontals operate primarily 8 hr/day, 5 days/week due to the difficulty in running animal or human studies overnight. The AMRIS facility operates as an auxiliary under federal cost accounting standards. Local and NHMFL-affiliated users pay for magnet time from federally funded projects (primarily individual investigator grants); the NHMFL funds magnet time for users from outside the UF system and development projects.

### NMR & MRI Systems in the AMRIS Facility at UF in Gainesville

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Death Acid Structure Determination by $^1$H and $^{13}$C NMR Spectroscopy

Shawn A. Christensen¹, Fatma Kaplan², James Sims³, Alisa Huffaker⁴, Eric A. Schmelz⁴,

1. USDA; 2. Kaplan Schiller Research; 3. ETH Zurich; 4. University of California at San Diego

Funding Grants: G.S. Boebinger (NSF DMR-1157490); G. Jander, E. Schmelz, A. Huffaker (NSF IOS-1139329)

Plant oxylipins (oxygenated fatty acids) modulate development, reproduction, and innate immune responses against pathogens and pests. Researchers recently identified in fungal-inoculated maize leaves a series of oxylipins that are produced in dying necrotic tissue, collectively termed “Death Acids.” Death Acids appear in abundance within infected tissues, display direct antibiotic activity against pathogens, mediate defense gene expression, and can even promote programmed cell death.

One-dimensional and two-dimensional $^1$H and $^{13}$C NMR spectra of purified oxylipins were acquired at the McKnight Brain Institute, home of the MagLab's Advanced Magnetic Resonance Imaging and Spectroscopy facility, from which the molecular structures were determined. Relative stereochemistry was determined by gas chromatography retention times based on an authentic standard of predominantly cis-10-OPEA (Larodan; Malmö, Sweden). Residual CHCl₃ was used to reference chemical shifts to δ(CHCl₃) = 7.26 ppm for 1H and δ C of 77.36.

In this study we describe a novel series of potent signaling compounds and elucidate previously unknown cell defense and cell death mechanisms. Understanding this biochemical pathway at the genetic level will predictably demonstrate essential roles in plant stress resilience and innate immune regulation.

Facility: Advanced Magnetic Resonance Imaging and Spectroscopy
Chapter 3 – User Facilities

A Hybrid Peptide in Nematodes That Promotes Larval Survival

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Funding Grants: R.A. Butcher (NSF, Career 1555050; NIH, GM118775; Ellison Medical Foundation, AG-NS-0963-12; Alfred P. Sloan Foundation, BR2014-071); G.S. Boebinger (NSF DMR-1157490)

Polyketides and nonribosomal peptides are structurally complex natural products that have been developed into many important therapeutics. Hybrid polyketide-nonribosomal peptides (that were named “nemamides”) were purified from the nematode Caenorhabditis elegans and structurally characterized. As microorganisms and plants are usually responsible for producing structurally complex natural products, it is quite remarkable to discover these types of natural products in an animal species.

The nemamides were identified by comparing the metabolomes of wild-type worms and pks-1 and nrps-1 mutant worms that lack the biosynthetic genes required for nemamide biosynthesis. Only very minute quantities of the nemamides could be purified from C. elegans (70 mg of nemamides from 50L of worms). Thus, the ultra-sensitive high-temperature superconducting NMR probe at the MagLab was required to structurally characterize the nemamides (see Fig. 1b).

Identification of the chemical structures of the nemamides will enable their biosynthesis in the worm to be studied (Fig. 1a). The nemamides promote larval survival during starvation by influencing insulin signaling in C. elegans. Future work will investigate the exact mechanism of action of the nemamides. Other nematode species, including parasitic ones, likely produce nemamide-like molecules, and these molecules may play an important role in larval survival in these other species as well.

Facilities: AMRIS, Agilent 600 MHz spectrometer with high-resolution 1.5mm high temperature superconducting probe
EMR Facility

Electron Magnetic Resonance (EMR) covers a variety of magnetic resonance techniques associated with the electron. The most widely employed is Electron Paramagnetic/Spin Resonance (EPR/ESR), which can be performed on anything that contains unpaired electron spins. EPR/ESR has thus proven to be an indispensable tool in a large range of applications in physics, materials science, chemistry, and biology, including studies of impurity states, molecular clusters, molecular magnets; antiferromagnetic/ferromagnetic compounds in bulk as well as thin films and nanoparticles; natural or induced radicals, optically excited paramagnetic states, electron spin-based quantum information devices; transition-metal based catalysts; and for structural and dynamical studies of metallo-proteins, spin-labeled proteins, and other complex bio-molecules and their synthetic models.

1. Unique Aspects of Instrumentation Capability

The EMR facility at the NHMFL offers users several home built high-field and multi-high-frequency instruments covering the continuous frequency range from 9 GHz to ~1 THz, with additional frequencies up to 2.5 THz using a molecular gas laser. Several transmission probes are available for continuous-wave (CW) measurements, which are compatible with a range of magnets at the lab, including the highest field 45 T hybrid. Some of the probes can be configured with resonant cavities, providing enhanced sensitivity as well as options for in-situ rotation of single-crystal samples in the magnetic field, and the simultaneous application of pressure (up to ~3 GPa). Quasi-optical (QO) reflection spectrometers are also available in combination with high-resolution 12 and 17 T superconducting magnet systems; a simple QO spectrometer has also been developed for use in the resistive and hybrid magnets (up to 45 T). EMR staff members can assist users in the DC field facility using broadband tunable homodyne and heterodyne spectrometers as well.

In addition to CW capabilities, the NHMFL EMR group boasts the highest frequency pulsed EPR spectrometer in the world, operating at 120, 240, and 336 GHz with <100 ns time resolution. A new quasi-optical 94 GHz spectrometer (HiPER) with 1 ns time resolution was recently upgraded for high power (1 kW) operation, becoming available to users at the end of 2015. A commercial Bruker Elexys 680 operating at 9/94 GHz (X-/W-band) is also available upon request. This unique combination of CW and pulsed instruments may be used for a large range of applications in addition to EPR, including the study of optical conductivity and electron cyclotron resonance.

2. Facility Developments and Enhancements

A number of upgrades and improvements to the workhorse EMR instruments were implemented during 2016. A new power supply was purchased (Oxford Instruments MercuryIPS) for the 15/17 T superconducting magnet associated with the Broadband Transmission Spectrometer, replacing an older one that was failing and therefore impacting user operations. The new supply consists of a master unit and two slaves which, together, are able to deliver a current of up to 180 A, sufficient to reach the maximum field of 17 T. A maximum voltage of 10 V is also sufficient to drive the magnet at the maximum allowed sweep rate of 8 mT/s. The new supply necessitated development of an entirely new data acquisition program for controlling the magnet power supply, microwave source, temperature controller, and lock-in EPR detection device. The Heterodyne Quasioptical Spectrometer also underwent some upgrades, including: acquisition of a new fundamental mixer for 120 GHz, allowing for higher sensitivity and full quadrature detection in CW mode and higher sensitivity for pulsed EPR and installation of a switch in the detection amplifier chain, decreasing the spectrometer deadtime for pulsed measurements to about 100 ns.

A new probe was designed and implemented by EMR Engineer Bianca Trociewitz to serve EMR users on the 35 T Cell 8 resistive magnet, which was made necessary by decommissioning of the Keck magnet in Cell 6. The probe is transmission-type and allows for both single-crystal measurements in a fixed orientation (no goniometer), or powder/frozen solution samples. Specifically, it has been designed to be broadband, and has been tested in the 100 to 800+ GHz frequency range. The first users to successfully employ it were Dr. Sergei Zvyagin (Dresden High Magnetic Field Laboratory, Germany) and Thomas Room (Estonian Academy of Sciences, Tallinn, Estonia).

The high-pressure single-crystal EPR capability also underwent an extensive re-design during 2016,
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with the first successful tests taking place at the time of writing of this report. The new design no longer employs a lossy plastic turnbuckle cell, thereby increasing the achievable pressure and greatly reducing losses in the microwave resonator, leading to marked improvements in sensitivity and extended frequency coverage. The elimination of the plastic cell also allows for much faster thermal cycling, thereby greatly improving sample throughput.

User activity on HiPER ramped up significantly during 2016, with its first publication appearing early in the year [J. Magn. Res. 265, 188-196 (2016)]. In fact, 2016 marks the first year for which statistics are being reported on this new instrument, which logged 295 days total usage. About 100 of these days were employed for further in-house developments described below, meaning that outside users accounted for almost 200 days. Users have reported tremendous satisfaction with this new instrument, and several exciting results demonstrating HiPER’s unique capabilities are reported in the scientific section of this year’s report.

HiPER is a 94 GHz quasi-optical pulsed EPR spectrometer, offering exceptional sensitivity and low deadtime. The spectrometer was developed at St. Andrews University and delivered to the MagLab in 2014. It is the only instrument of its kind that is part of a user program. In 2015, HiPER was upgraded to a high power mode through integration of a state-of-the-art Extended Interaction Klystron amplifier, enabling pulses with 1 kW instantaneous power and up to 1 GHz bandwidth. This capability makes possible π/2 pulses for spin $S = \frac{1}{2}$ of just a few ns (shorter for larger spin values). HiPER offers true nanosecond deadtime and the possibility to perform Fourier-transform-type HF EPR measurements, akin to what is routinely achieved in NMR.

During the past year, the possibility of Arbitrary Waveform Generation was tested on HiPER, thanks to the loan of a device from the group of Robert Griffin at MIT. Instrumental to these developments has been the new HiPER Postdoc, Johannes McKay. A demonstration of pulsed/chirped 94 GHz Dynamic Nuclear Polarization (DNP) using this new capability can be found in the scientific section of this report. These measurements also required integration of an NMR capability, which means that CW and pulsed Electron Nuclear Double Resonance (ENDOR) is also now possible at 94 GHz. HiPER represents the centerpiece of the EMR program’s growth into biophysical/biochemical EPR applications, whilst also bringing important new capabilities for users interested in spin quantum computing.

The DNP efforts at 395 GHz (600 MHz) were also greatly expanded in 2016, thanks to the acquisition of an NIH-funded 14.1 T sweepable magnet and state-of-the-art magic angle spinning (MAS) NMR spectrometer. This new instrument, coupled with the existing gyrotron source, is now part of the user program (see NMR section of this report). Meanwhile, several other developments associated with the solid-state MAS and solutions DNP programs at 395 GHz have been ongoing during 2016, thanks to the support of a User Collaboration Grants Program award to Hans van Tol. This includes development of an in situ 395 GHz EPR spectrometer, which will allow users to obtain an EPR spectrum of their as-prepared samples. This information is extremely important in order to best prepare samples optimized for DNP. The 395 GHz EPR spectrometer will also be easily transportable, so that it can be used elsewhere within the MagLab user programs. In particular, it will be employed extensively in the 600 MHz Overhauser DNP system, but may also be used within the DC facility, as well as enabling pulsed EPR in the 12 T heterodyne spectrometer.

3. Research Productivity and Achievements

A large number of research groups and projects were accommodated by the EMR program in 2016, resulting in the submission of 51 research reports. In addition, 36 peer-reviewed journal articles were reported by our users, as well as numerous presentations at conferences. Many publications appeared in high-impact journals including: Nature (1); Angewandte Chemie (1); Journal of the American Chemical Society (2); Chemical Science (3); Phys. Chem. Chem. Phys. (3); Inorganic Chemistry (8); Journal of Physical Chemistry (2); Dalton Transactions (1); Physical Review B (1); and Journal of Magnetic Resonance (1). The work published in Nature was reviewed in the American Physical Society magazine, Physics Today [69, 17 (2016)], as well as the April 4th Physics Update. Projects in the facility spanned a range of disciplines from applied materials research to studies of proteins; see also highlights below.
4. Facility Plans and Directions

The EMR program recently ordered a state-of-the-art AWG for integration with both HiPER and the commercial X/W-band Bruker E680 spectrometer. This device, which will be delivered by the middle of 2017, will serve as a permanent replacement for the loaned device discussed earlier in this report. Software has already been acquired for use with the Bruker instrument, while software development is under way for HiPER. This upgrade will enable a wide range of new experiments, impacting user activities in the areas of DNP and Quantum Information Processing (QIP).

A new 395 GHz CW/pulsed capability will become available on the 12 T heterodyne spectrometer later this year. This upgrade will extend the range of the instrument beyond the current world record for pulsed EPR of 336 GHz.

The group also recently acquired another commercial X-band spectrometer thanks to a donation from retiring FSU Professor, Betty Gaffney. This instrument will be integrated into the user program during 2017 in order to relieve some of the over-subscription on the E680 instrument. In particular, many CW measurements are currently performed on the E680 that could just as easily be performed on the newly acquired spectrometer.

5. Outreach to Generate New Proposals-Progress on STEM and Building User Community

The EMR user program continues to grow, as measured by the total number of 81 proposals that received magnet time during 2016, which is up from 71 in 2015 (and just 42 as recently as 2012). During 2016, we received 26 proposals from first time users, meaning that 32% of our users were new to the program. This growth may be attributed to several new experimental capabilities that came online in 2015, particularly HiPER. In addition, a new postdoc joined the group, which helped in providing the required increase in user support. The EMR program assisted 198 individual researchers in 2016 (up significantly from 143 in 2014 and 157 in 2015), of which nearly a quarter of those reporting were female (22%), and 10% minority. In an effort to attract new users, the EMR group continues to provide up to $500 in financial support to first time visitors to the lab ($1,000 for overseas users). The EMR group has also made tremendous progress in terms of the diversity of its own students and staff: 38% are female and 24% minority.

Members of the EMR group continue to make aggressive efforts to advertise the facility at regional, national, and international workshops and conferences, as well as via seminars at universities around the globe (the EMR Director gave 14 such presentations in 2016). These efforts included attending and presenting at conferences outside of their own immediate research areas. In 2016, the EMR Director Co-Chaired the 2nd Gordon Research Conference on Conductivity and Magnetism in Molecular Materials, together with Stuart Brown (also a MagLab user). This hugely successful conference was attended by many EMR users (see www.grc.org/programs.aspx?id=16768). The group also organized or participated in focused sessions/symposia at other major conferences and provided financial support in the form of student travel grants for the two main EPR conferences in the US – the Southeaster Magnetic Resonance Conference (SEMRC) and the Rocky Mountain Conference on Magnetic Resonance. In 2017, the group will organize the SEMRC in Tallahassee, including a hands-on pre-conference workshop for students and postdocs. Finally, the EMR group has participated in several outreach activities, including the mentorship of REU students and local high-school interns.

6. Facility Operations Schedule

The most heavily used instrument in the program is the 17 T homodyne transmission spectrometer. This instrument has reached a point where it is significantly over-subscribed; it continues to be booked many months out, with users running 7 days per week, 24 hours per day. The spectrometer was available for all of 2016, with the exception of a few days due to the installation of the new magnet power supply. The usage (including tests/calibration) during 2016 was 311 days, implying that it was in use on every single weekday, as well as on >60 weekend days and/or holidays.

The 12 T heterodyne/pulsed instrument was also available for all of 2016. This spectrometer is not straightforward to use, requiring constant oversight by the EMR staff member (van Tol) responsible for the instrument. Consequently, users are not usually scheduled when this staff member is traveling. 191 days of usage were reported in 2016, constituting
~75% of the available working days (not including weekends and holidays).

The two Mössbauer instruments were available throughout the year. When available, the high-field instrument was used practically constantly day and night due to the nature of the Mössbauer experiment. 473 total days were logged between the two instruments during 2016.

The Bruker E680 spectrometer was also oversubscribed in 2016, with total usage of 303 days (up from 267 in 2015). The instrument is shared between the FSU biology department and the EMR user program. Only 30% of the machine time was originally designated for the MagLab user program. In 2016, due to high demand from users, 83% of its usage (including holidays and weekends) was allocated for user operations.

Finally, as noted earlier in this report, HiPER formally became a part of the EMR user program in 2016. During this first year of operation, 295 days were logged. This means that it was operational on 40 weekend days and/or holidays. It should also be noted that ~200 days were employed for outside user projects. HiPER is already in very high demand. At the time of writing, it is booked out several months, complicating planned upgrades.
New Record Magnetic Anisotropy in a Molecular Nanomagnet

K. E. R. Marriott¹, C. Wilson¹, M. Medarde², S. T. Ochsenbein², L. Bhaskaran³, S. T. Ochsenbein², L. B. Bhaskaran3, S. Hill3, M. Murrie¹


Funding Grants: G.S. Boebinger (NSF DMR-1157490); M. Murrie (EPSRC Ref. EP/J018147/1); S.T. Ochsenbein (EC FP7/2007-2013 grant # 290605); S. Hill (NSF DMR-1309463)

Understanding and controlling magnetic anisotropy at the level of single atoms is vital for the miniaturization of data storage to continue to drive transformative technologies. Work on molecular nanomagnets is making rapid progress in this regard, with IBM recently demonstrating that information can be encoded in the magnetization of a single Co atom coordinated to a MgO surface at low temperatures. This result relies upon a strong uniaxial magnetic anisotropy which pins the magnetic moment of the Co ion in one of two preferred orientations.

Maximization of magnetic anisotropy requires both spin-orbit coupling and the stabilization of the orbital moment that couples strongly to the molecular ligand field. However, transition metal complexes tend to adopt structures that lower energy by reducing – or “quenching” – the orbital momentum, thereby significantly reducing anisotropy of the magnetization. In the present study, researchers employed rigid and bulky ligands to impose a trigonal bipyramidal coordination to a Ni ion, thus preventing orbital quenching. Electron paramagnetic resonance (EPR) measurements then required very high magnetic fields to measure the new record magnetic anisotropy of this molecule.

This work highlights an important strategy for designing highly anisotropic magnetic building blocks that could potentially be employed in a new generation molecular scale magnetic memory storage devices.

Facilities: EMR & DC Field (35 T, 32 mm bore resistive magnet)

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EPR Studies of Supramolecular Aggregates of Single-Molecule Magnets

T. N. Nguyen¹, W. Wernsdorfer², T. Ghosh¹, M. Shiddiq³, K. A. Abboud², S. Hill³ and G. Christou¹

1. University of Florida; 2. Louis Néel Lab, Grenoble; 3. NHMFL and Florida State University

Funding Grants: Boebinger (NSF DMR-1157490); Hill (NSF DMR-1309463); Christou (NSF DMR-1213030)

Single-molecule magnets (SMMs) are individual molecules that function as single-domain nanoscale magnetic particles. Recent studies suggest that they may potentially be employed as the elementary computational unit (qubit) of a quantum computer. In order to perform large scale quantum computations, the coupling of multiple SMMs to each other will be essential. However, the interaction should be relatively weak in order to maintain the intrinsic properties of each SMM.

Weak coherent coupling of pairs of SMMs has previously been demonstrated by high-field Electron Paramagnetic Resonance (EPR) [Science 302, 1015 (2003)], albeit only in cases where the coupling was crystallographically imposed. In the present investigation, high-field EPR studies have demonstrated coherent coupling within covalently linked dimers and tetramers (supramolecular aggregates) of Mn₃ SMMs. EPR spectra reveal features that are lacking in spectra of the isolated Mn₃ SMMs, which can be attributed to the coherent coupling within the aggregates. Importantly, powder and solution spectra are essentially identical, indicating that the supramolecular aggregates remain intact in solution, thus demonstrating for the first time that their unique properties survive outside of a crystal. This work opens up a new direction in the study of exchange-coupled SMM oligomers. Their robustness in solution offers a feasible means for their deposition on surfaces for device studies.

Facilities: EMR

Instrument/Magnet: 17 T and Broadband MVNA

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ICR FACILITY

During 2016, the Fourier Transform Ion Cyclotron Resonance (ICR) Mass Spectrometry program continued instrument and technique development as well as pursuing novel applications of FT-ICR mass spectrometry. These methods are made available to external users through the NSF National High-Field FT-ICR Mass Spectrometry Facility. The facility features seven staff scientists who support instrumentation, software, biological, petrochemical, and environmental applications, as well as a machinist, technician, and several rotating postdocs who are available to collaborate and/or assist with projects.

1. Unique Aspects of Instrumentation Capability

The Ion Cyclotron Resonance facility provides operations for sample analysis that requires the ultra-high resolution (m/Δm50% > 1,000,000 at m/z 500, where Δm50% is the full mass spectral peak width at half-maximum peak height) and sub-ppm mass accuracy only achievable by FT-ICR MS coupled to high magnetic fields. The facility’s four FT-ICR mass spectrometers feature high magnetic fields < 21 tesla, and are compatible with multiple ionization and fragmentation techniques.

<table>
<thead>
<tr>
<th>ICR Systems at the Magnet Lab in Tallahassee</th>
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<tr>
<td>Field (T), Bore (mm)</td>
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<td>21, 123</td>
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<td>14.5, 104</td>
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<td>9.4, 220</td>
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2. Facility Developments and Enhancements

In 2015, the ICR facility revealed the design and initial performance of the first actively-shielded 21 tesla Fourier transform ion cyclotron resonance mass spectrometer. The 21 tesla magnet is the highest field superconducting magnet ever used for FT-ICR and features high spatial homogeneity, high temporal stability, and negligible liquid helium consumption (J. Am. Soc. Mass Spectrom., 26, 1626-1632 (2015)).

Mass resolving power of 150,000 (m/Δm50%) is achieved for bovine serum albumin (66 kDa) for a 0.38 second detection period (see Figure 1), and greater than 2,000,000 resolving power is achieved for a 12 second detection period. Externally calibrated broadband mass measurement accuracy is typically less than 150 ppb rms, with resolving power greater than 300,000 at m/z 400 for a 0.76 second detection period. Combined analysis of electron transfer and collisional dissociation spectra results in 68% sequence coverage for carbonic anhydrase. The instrument is part of the NSF High-Field FT-ICR User Facility and is available free of charge to qualified users.

Figure 1. Schematic of the 21 tesla FT-ICR mass spectrometer. Approximately half of the magnet cross-section is shown. Differentially pumped vacuum chambers are shown in red, yellow, and blue (the blue chamber contains two differentially pumped regions, the second of which includes the ICR cell). The scale at the bottom shows the approximate distance from the external quadrupole trap to the ICR cell.
Figure 2. Single-scan electrospray FT-ICR mass spectrum of the isolated 48+ charge state of bovine serum albumin following a 12 s detection period. Mass resolving power is approximately 2,000,000, and the signal-to-noise ratio of the most abundant peak is greater than 500:1. The ion accumulation period was 250 ms and the ion target was 5,000,000.

The instrument includes a commercial dual linear quadrupole trap front end that features high sensitivity, precise control of trapped ion number, and collisional and electron transfer dissociation. A third linear quadrupole trap offers high ion capacity and ejection efficiency, and rf quadrupole ion injection optics deliver ions to a novel dynamically harmonized ICR cell.

An actively-shielded 14.5 T, 104 mm bore system offers the highest mass measurement accuracy (<300 parts-per-billion rms error) and highest combination of scan rate and mass resolving power available in the world. The spectrometer features electrospray, atmospheric pressure photoionization (APPI), atmospheric pressure chemical ionization sources (APCI); linear quadrupole trap for external ion storage, mass selection, and collisional dissociation (CAD); and automatic gain control (AGC) for accurate and precise control of charge delivered to the ICR cell. The combination of AGC and high magnetic field make sub-ppm mass accuracy routine without the need for an internal calibrant. Mass resolving power > 200,000 at m/z 400 is achieved at one scan per second, which is ideal for de novo sequencing (Rapid Commun. Mass Spectrom. 29, 659-666 (2015)) and facilitates automated data reduction for H/D exchange experiments (J. Biol. Chem., 291, 12467-12480 (2016)). Robotic sample handling allows unattended or remote operation. An additional pumping stage has been added to improve resolution of small molecules.

The 9.4 T, passively-shielded, 220 mm bore system offers a unique combination of mass resolving power (m/Δm = 8,000,000 at mass 9,000 Da) and dynamic range (>10,000:1), as well as high mass range, mass accuracy, dual-electrospray source for accurate internal mass calibration, efficient tandem mass spectrometry (as high as MS^3), and long ion storage period (J. Am. Soc. Mass Spectrom., 25, 943-949 (2014)). A redesign to the custom-built mass spectrometer coupled to the 9.4T, 200 mm bore superconducting magnet designed around custom vacuum chambers has improved ion optical alignment, minimized distance from the external ion trap to magnetic field center and facilitates high conductance for effective differential pumping. (J. Am. Soc. Mass Spectrom. 22, 1343-1351, (2011)) The length of the transfer optics is 30% shorter than the prior system, for reduced time-of-flight mass discrimination and increased ion transmission and trapping efficiency at the ICR cell. The ICR cell, electrical vacuum feed through, and cabling have been improved to reduce the detection circuit capacitance (and improve detection sensitivity) 2-fold (Rev. Sci. Instrum., 85, 066107 (2014)). When applied to compositionally complex organic mixtures such as dissolved organic matter (Water Research, 96, 225-235 (2016); Env. Sci. Technol., 50, 3391-3398 (2016)), biofuels (AIChE Journal, 62, 815-828 (2016) and petroleum fractions (Energy Fuels, 61, 666-668 (2016)), mass spectrometer performance improves significantly, because those mixtures are replete with mass “splits” that are readily separated and identified by FT-ICR MS (Energy Fuels, 30, 3962-3966 (2016)). The magnet is passively shielded to allow proper function of all equipment and safety for users. The system features external mass selection prior to ion injection for further increase in dynamic range and rapid (~100 ms time scale) MS/MS (Anal. Chem., 75, 3256-3262 (2003)). Available dissociation techniques include collision-induced (CID), infrared multiphoton-induced (IRMPD) (J. Am. Soc. Mass Spectrom., 23, 644-654 (2012)), and electron capture-induced (ECD) (J. Phys. Chem. A., 117, 1189-1196 (2013)).

The 9.4 T actively shielded FT-ICR instrument is available for analysis of complex nonpolar mixtures and instrumentation development. The 9.4 T magnet
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is currently used for field desorption (Anal. Chem., 80, 7379-7382 (2008)) and elemental cluster analysis, and reported the formation of the smallest fullerene by stabilization through cage encapsulation of a metal by use of a pulsed laser vaporization cluster source (Molecular Physics, 113, 15-16 (2015), which indicate that metallofullerenes should be constituents of stellar/circumstellar and interstellar space as well as fullerenes (Proc. Natl. Acad. Sci. U.S.A., 110(45), 18081-18086 (2013)).

3. Major Research Activities and Discoveries

Automated broadband phase correction of FT-ICR data can in principle produce an absorption-mode spectrum with mass resolving power as much as a factor of 2 higher than conventional magnitude-mode display, an improvement otherwise requiring a more expensive increase in magnetic field strength. We have developed and implemented a robust and rapid automated method to enable accurate broadband phase correction for all peaks in the mass spectrum and present experimental FT-ICR absorption-mode mass spectra with increased number of resolved peaks and higher mass accuracy relative to magnitude mode spectra, and produce more complete and more reliable elemental composition assignments for nickel and vanadyl porphyrins in natural petroleum seeps (Figure 3, Energy Fuels., 28, 2454-2462 (2014)).

Figure 3. Broadband positive-ion APPI FT-ICR mass spectrum for an Il Duomo asphalt volcano sample. The achieved resolving power \( m/\Delta m_{50\%} = 1,400,000 \) at \( m/z \ 515 \) enables resolution of 85,920 mass spectral peaks, each with magnitude greater than 6a of baseline rms noise (m/z 200-1100) with a mass distribution centered at m/z 400. The mass scale-expanded segment at \( m/z \ 515 \) shows ~171 peaks. The theoretical resolving power required to separate two equally abundant species that differ in mass by ~548 \( \mu \)Da at 9.4 tesla is 890,000. The presently achieved resolving power (m/\Delta m_{50\%} = 1,400,000 at m/z 515) enables separation of species that differ in mass by \( C_{3}N_{4}^{13}C_{1} \) versus \( H_{3}^{34}S_{1} \), both of nominal mass 39 Da, and differing in mass by 530 \( \mu \)Da—i.e., less than the mass of an electron (548 \( \mu \)Da).

To the best of our knowledge, this mass spectrum represents the most peaks resolved and identified in a single spectrum of any kind, and represents the highest broadband resolving power for any petroleum mass spectrum, and emphasizes the need for ultrahigh resolving power achievable only by FT-ICR MS sufficient to separate isobaric overlaps prevalent in complex seep samples.

Tertiary and quaternary structure can also be probed. Automated hydrogen/deuterium exchange improved by depletion of heavy isotopes (\( ^{13}C/^{15}N \)) for protein subunits of a complex can greatly simplify the mass spectrum, increase the signal-to-noise ratio of depleted fragment ions, and remove the ambiguity in assignment of m/z values to the correct isomeric species.

The detailed characterization of large protein assemblies in solution remains challenging to impossible. Nonetheless, these large complexes are common and often of exceptional importance. Hydrogen/Deuterium exchange (HDX) experiments reveal changes in deuterium over time to examine protein-protein contacts. Proteins are diluted into a D\(_{2}\)O solution to induce the exchange of hydrogen atoms with deuterium. The degree of protection from deuterium exchange is indicative of local structure as well as dynamics. (Figure 4). Extracellular domain 1 (EC1) has a lower deuterium uptake percentage than the EC2 region, consistent with the higher stability of the first domain. As seen in Fig.1, averaged relative difference in deuterium (ARDD) uptake for NCAD12 apo dimer and monomer are mapped onto PDB crystal structure (4NUM) of Ca\(^{2+}\) saturated NCAD12 because no crystal structure for the apo dimer exists. The ARDD map shows significant protection within EC2 upon dimer formation, defining this as an adhesive interface region not consistent with the current crystal structure. It is clear from this region in EC2 that the D_{sat} structure shown does not represent the structure of the kinetically trapped NCAD12 apo dimer, D^{*}_{apo}.
containing compounds increases relative to the hydrocarbon class (from top to bottom), and at the highest total sulfur value (bottom), the most abundant class shifts to the S1 class. Furthermore, the signal magnitude for the S2 and S3 classes (left) increases concurrently with sulfur concentration.

**Sulfur Prediction with Chemometrics.** The current paradigm shift to unconventional crude oils has led to the production of oils enriched in heteroatom-containing species (N, S, and O) that are problematic in refining operations. Bulk sulfur measurements provide little information about chemical composition (molecular distributions and speciation of heteroatoms). Figure 5 shows the power of molecular-level chemical characterization of sulfur compounds and aromatic hydrocarbons by APP FT-ICR MS may be combined with principal component analysis (PCA) and partial least-squares analysis to predict sulfur concentrations in crude oil. Thus, both molecular-level and bulk values for heteroatom-containing species are accessed simultaneously.

**Calcium naphthenate deposits** differ from other naphthenic acid salts. A family of tetraprotic carboxylic acids cross-link with divalent calcium cations and form a network of hard, polymerlike material that makes up the bulk of these deposits. Low concentrations of ARN acids and high concentrations of other carboxylic acid species (NAP acids) complicate the detection of ARN acids in crude oils. Current tech-

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**Figure 4.** Averaged relative difference in deuterium (ARDD) uptake between NCAD12 apo dimer and monomer mapped on PDB 4NUM crystal structure of mouse NCAD EC1-2 A78SI92M. The potential adhesive interface segments are defined as regions with overlapping peptides that have ARDD values more than -10%; meaning at least a 10% reduction of HDX upon dimerization.

The 9.4 T and 14.5 T instruments are primed for immediate impact in environmental and petrochemical analysis, where previously intractable complex mixtures are common. The field of “petroleomics” has been developed largely due to the unique ability of high-field FT-ICR mass spectrometry to resolve and identify all of the components in petroleum samples.

**Figure 5.** (Left) Zoom inset (Δm/z 0.5) of the broadband (+) APP FT-ICR mass spectra and (right) further zoom mass inset (Δm/z 0.02) for three selected crude oil samples with sulfur contents for (top) 0.095%, (middle) 1.48%, and (bottom) 3.79%. At the lowest sulfur concentration analyzed (top), the hydrocarbon class is clearly most abundant. However, with increased sulfur concentration, the signal magnitude of the S1-

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**Figure 6.** (Top) Schematic representation of the general polymerization procedure for preparation of MIPs and (bottom) flowchart diagram for a typical binding assay.

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Techniques for isolating ARN acids from crude oils often require a multi-step sample preparation to help in the detection, separation, and ionization of ARN acids. A combination of large sample size, multiple chromatographic separations, reprecipitation, and/or derivatization steps makes current screening for ARN a time-consuming process. Molecularly imprinted polymers (MIPs) achieve highly selective binding of target molecules. Figure 6 shows a schematic representation of ARN imprinted polymer synthesis, in which methacrylic acid (MAA) is the functional monomer and ethylene glycol dimethacrylate (EGDMA) is the cross-linking agent.


Of the estimated 5 million barrels of crude oil released into the Gulf of Mexico from the Deepwater Horizon oil spill, a fraction washed ashore onto sandy beaches from Louisiana to the Florida panhandle. **Targeted petroleomics** characterized petrogenic material isolated from the Pensacola Beach sand displays greater than 2-fold higher molecular complexity than the MWO constituents, most notably in oxygenated species absent in the parent crude oil. Surprisingly, the diverse oxygenated hydrocarbons in the Pensacola Beach sediment extracts were dominant in all ionization modes investigated, (±) ESI and (±) APCI. Thus, the molecular-level information highlighted oxygenated species for subsequent “targeted” analyses (Energy Fuels, 28, 4043-4050 (2014)). We identify persistent MWO transformation products and catalogue compositional changes that occur to parent MWO in Barataria Bay saltmarsh sediments up to 4 years after the Deepwater Horizon oil spill. Highly polar, acidic oxygenated transformation products derived from biodegradation of Macondo Well oil in coastal salt marshes span a wide range of chemical functionalities, and remain environmentally persistent (Figure 8). The increased abundance of highly polar compounds of low volatility is ideally suited for FT-ICR MS can address the complexity of these highly polar, multifunctional oxidized transformation products at the molecular level. Compositional images of

![Figure 7. Percentage of assigned molecular formulae determined by FT-ICR MS analysis for the different organic-soil horizons before and after incubation.](image)

![Figure 8. Heteroatom class distribution of major species (>1% relative abundance) derived from negative ESI FT-ICR mass spectra of parent MWO Macondo well oil and oil contaminants over 48 mos post-spill with a TMAH-modified solvent system.](image)
DBE versus carbon number indicate that degradation processes convert nonpolar, saturated compounds into highly polar, carboxylic acid compounds that appear over time, and subsequent oxidation converts lower order oxygen compounds (O₁-O₃) to higher order oxygen compounds (O₅-O₆) after 36 mos.

Hydrothermal liquefaction (HTL) of algae is a biomass conversion process that yields “biocrude” oil, water-soluble compounds, gases, and solids. FT-ICR MS analysis revealed that biocrudes from fast HTL contain several compounds with no N but 3–7 O atoms (Figure 9). These compounds are likely free fatty acids and/or oligomerized or polymerized fatty acids (AIChE Journal, 62 815-828 (2016)).

![Figure 9](image)

**Figure 9.** Heteroatom density graph for biocrude samples (positive ESI). Several compounds with no N atoms are present in the biocrudes from fast HTL, but all compounds in the biocrude from isothermal HTL contain at least 1 N atom (after analysis by positive ESI). It is possible that the compounds with no N and 3–7 O atoms identified in the biocrudes samples produced via fast HTL are polymerized fatty acids with varying levels of oxygenation. Since none of these compounds are present in the biocrude produced via isothermal HTL, it is likely that the extended reaction time facilitated reactions of fatty acids and/or polymerized fatty acids with amino acids, ammonia, or other N-containing compounds.

**Endohedral metallofullerenes**, which are metal-encapsulated nanoscale carbon cages, are of particular interest because of their unique properties that offer promise in biomedicine and photovoltaics. An understanding of chemical formation mechanisms is essential to achieve effective yields and targeted products. One of the most challenging endeavors is synthesis of molecular nanocarbon. Nevertheless, the mechanism of formation from metal-doped graphite has largely eluded experimental study, because harsh synthetic methods are required to obtain them (Nat. Commun. 5:5844, 1-8 (2014)). **Figure 10** (right) shows molecular cage behavior and reactivity of Pr@C₈₂ (I) under synthetic conditions that generate EMFs, namely at high temperature, in the presence of carbon evaporated from graphite, and at a low-pressure of He. Direct sampling of the chemical formation process is achieved by the use of a pulsed laser vaporization source analyzed by FT-ICR mass spectrometry. Pr@C₈₂ (shown in blue) is unambiguously observed to undergo C₂ insertion reactions to form large and giant metallofullerenes (shown in orange) in a bottom-up formation mechanism. All observed product EMFs display excellent agreement with calculated isotope distributions (figure 10, inset). Charge transfer from the encapsulated metal to the carbon cage is found to be a determinate factor in the bottom-up mechanism shown by (figure 10) study of metallofulleren formation with virtually all elements of the periodic table. These results could enable production strategies that overcome problems that hinder current and future applications of metallofullerenes.

![Figure 10](image)

**Figure 10.** Bottom-up formation of large and giant mono-EMFs from Pr@C2v-C82. (a) FT-ICR mass spectrum of cluster cations after reaction of Pr@C82 with carbon evaporated from graphite in a low-pressure He atmosphere and (b) reaction scheme, with possible structures of the larger EMFs. The starting material is shown in blue, whereas bottom-up formation products are shown in orange.
4. Facility Plans and Directions
The ICR facility will continue to expand its user facility to include user access to the world's first 21 tesla FT-ICR mass spectrometer.

5. Outreach to Generate New Proposals-Progress on STEM and Building User Community
The ICR program had 30 new principal investigators in 2016. The ICR program also enhanced its undergraduate research and outreach program for 4 undergraduate scientists (one female). The ICR program in 2016 supported the attendance of research faculty; postdoctoral associates; and graduate, undergraduate, and high school students at numerous national conferences to present current results.

6. Facility Operations Schedule
The ICR facility operates year-round, with weekend instrument scheduled. Two shifts (8 hours each) are scheduled for each instrument year-round, including holiday shut-downs, which are utilized for routine instrument maintenance.

7. The Future Fuel Institute
The Future Fuels Institute completed its fourth full year in 2016, with two full share members ($250K each / year for 4 years) to support research to address challenges associated with petroleum production, processing, and upgrading. The Future Fuels Institute currently supports 1 fulltime Technician and 2.5 fulltime Research Faculty to pursue analytical method development. For 2015/2016 the corporate members are: Reliance and Total. Additionally, the FFI partners with two instrument manufacturers (Leco Instruments, Waters Instrument Company) for state-of-the-art instrumentation prior to commercial release.
Binding Sites for DNA on a DNA-Unwinding Protein, Probed by Hydrogen/Deuterium Exchange and Ion Cyclotron Resonance Mass Spectrometry

Brian W. Graham¹, Yeqing Tao⁴, Katie L. Dodge³, Carly T. Thaxton³, Danae Olaso³, Nicolas L. Young⁴,⁵, Alan G. Marshall²,⁴, and Michael A. Trakselis³


Funding Grants: G.S. Boebinger (NSF DMR-1157490); M. A. Trakselis (American Cancer Society RSG-11-049-01-DMC)

For DNA to reproduce, its double-helix must be made to unwind so that new double-helices can be synthesized from each of the two strands. The archaeabacterial MCM A “helicase” protein from Sulfolobus solfataricus is a model for understanding this DNA unwinding. Although interactions of the DNA double-strand portion within the central channel of the helicase are well known, interactions with the excluded unwound single strand on the exterior surface of the helicase protein had remained largely unexplored.

By “spray-painting” the DNA:helicase complex (by exposing it to D₂O), researchers map the DNA:helicase contact regions as those regions that are protected against hydrogen/deuterium (H/D) exchange relative to the free protein. Each H replaced by D increases the protein mass by 1 mass unit.

To determine the location of the hydrogen-to-deuterium replacements, researchers enzymatically cut the protein into small segments and weigh them in the MagLab’s 14.5 tesla Fourier Transform Ion Cyclotron Resonance Mass Spectrometer. That instrument readily resolves and identifies dozens of segments to provide a detailed map of the contact surface(s). In this way, researchers find direct evidence for binding of the unwound single-strand portions of the DNA to specific regions of the helicase during the unwinding process.

Facilities: Ion Cyclotron Resonance Facility, On-Line Liquid Chromatography Electrospray Ionization 14.5 T FT-ICR Mass Spectrometer

Isolation of Interfacial Material from Athabasca Bitumen

Clingenpeel, A.C.; Robbins, W.K.; Corilo, Y.E.; Rodgers, R.P.

1. Department of Chemistry and Biochemistry, Florida State University
2. Consultant, Future Fuels Institute
3. Future Fuels Institute (FFI)
4. ICR User Facility, National High Magnetic Field Laboratory

Funding Grants: G.S. Boebinger (NSF DMR-1157490), R.P. Rodgers (FFI)

Water-in-oil emulsions are one issue commonly encountered during steam-aided petroleum production and refining. If left untreated, the water in these emulsions can cause severe corrosion issues and equipment failure. Therefore, a key objective in petroleum production is to understand what compounds are drawn to the oil/water interface in an effort to separate the water from the oil. Here, we report a novel method to isolate interfacial materials (IM) from bitumen, the residue from petroleum refining used for road surfacing.

Water was added to silica gel to generate four different silica gels (17.6, 33.3, 53.8, and 66.6% water per gram of silica gel). Immediately after IM isolation, silica gels 17.6% to 53.8% water per gram are "stained" (Figure 1). The staining is a mark of failure, i.e. the result of irreversible adsorption of non-interfacially active species to the silica gel surface.

However, once the silica gel is watersaturated (66.6% water per gram of silica gel), a sufficient number of water monolayers are present (~26) to prevent irreversible adsorption, and IM compounds are selectively isolated. Subsequent analysis by FT-ICR MS (Figure 2) reveals that interfacially active crude oil components are highly enriched in oxygen, and thus function as naturally occurring surfactants. Even though the surfactants comprise only ~1% of the crude oil mass, their removal achieves the desired result: prevention of stable emulsion formation in the 99% (by weight) of the material that remains. Emulsion tests with isolated interfacial material yield emulsions that are stable for days (inset in Figure 2).

Facilities: 9.4T Fourier Transform – Ion Cyclotron Resonance (FT-ICR) Mass Spectrometer (MS)
Chapter 4

Education and Outreach
### Education and Outreach

In 2016, the Center for Integrating Research and Learning worked closely with Public Affairs to continue our mission to expand scientific literacy and to encourage interest in and the pursuit of scientific studies among educators and students of all ages. CIRL continues to evaluate our educational programs so that we can ensure that our programs are meeting our goals to excite and educate students, teachers, and the general public about science, technology, and the world around them. Our expansion of K-12 outreach at Magnet Lab facilities at University of Florida and Los Alamos National Laboratory are progressing well. In 2016, UF representatives reached over 2,500 K-16 students and members of the general public through their outreach efforts. LANL staff reached over 500 students in their outreach efforts. Three highlights for our Education and Outreach programs this year were:

1. A record breaking attendance for Open House!
2. A new coding camp for girls. Through a partnership with a local organization in Tallahassee, CIRL was able to offer a one week coding camp for SciGirls in the summer of 2016.
3. Dr. Roxanne Hughes and Kari Roberts are co-PIs on an NSF AISE (Advancing Informal Science Education) grant with Twin Cities Public Television. Dr. Hughes and Ms. Roberts will be responsible for the research component of this grant which includes studying the impact of 16 different SciGirls programs on participating students’ STEM identity development. The research portion of the grant begins in 2017.

In addition to these highlights, Kari Roberts worked closely with Florida State University’s Postdoctoral Affairs office to facilitate their new requirement of annual evaluations for all Postdocs. She helped to communicate the process to postdocs at the MagLab and their mentors. The basis for this annual review was the Individual Development Plan (IDP) as developed by the American Association for the Advancement of Science (AAAS). has worked closely with postdoctoral associates (postdocs) at all three sites to ensure their professional development and mentoring needs are being met. This includes working with postdocs to discuss their annual evaluation with their respective mentors through the Individual Development Plan (IDP) process.

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A video from the MagLab website featuring Mr. Villa conducting an outreach lesson.
K-12 Students
On-Site and Classroom Outreach Conducted Through CIRL

CIRL staff and Magnet Lab scientists conduct outreach in local schools each year. We record this outreach during the school year as opposed to the calendar year. During the 2015-2016 school year CIRL’s Outreach Coordinator, Mr. Carlos Villa, provided outreach to over 4,000 students from school districts in Northern Florida and Southwest Georgia. Close to half (48%) of the schools reached through our outreach programs were Title I schools. Mr. Villa continued to offer 12 types of outreach activities. The two most popular activities were the Build an Electromagnet and the Magnet Exploration activities. (For more information on the activities, please visit https://nationalmaglab.org/education/teachers/classroom-outreach). The majority of these activities are conducted with elementary school students (43%) and middle school students (19%). The top three outlets from which teachers learned about our programs included colleague communication (29%), the MagLab website (21%), and MagLab Education Workshops (21%).

In 2016, Ms. Elizabeth Webb continued to lead outreach efforts for the MagLab at UF. Ms. Webb and fellow UF personnel reached 2,225 students through classroom outreach lessons – 71% of the students reached were from Title I schools. The most frequently requested lesson was the Build an Electromagnet lesson followed by Magnet Exploration. The majority of these outreach lessons were presented to elementary school students (88%) in the Alachua county area – the remaining lessons were given to middle school students. In addition, Ms. Webb coordinated activities to summer camps and afterschool programs reaching an additional 142 elementary and middle school students.

In 2016, LANL staff members conducted outreach lessons in three schools and took part in a district wide science expo for 4th-12th grade students, reaching more than 300 students. Dr. Laurel Winter Stritzinger was part of the organizing committee for the Expanding Your Horizons conference which took place in October. The goal of this conference is to encourage young women into STEM careers by providing female STEM role models and hands on activities. The conference was held in Santa Fe and had 168 girls, grades 5th-8th, participate.

Middle School Mentorship

The MagLab Middle School Mentorship Program continues to expand in terms of mentors volunteering and mentees applying. In 2016, 18 students from middle schools in Leon County participated with 10 Magnet Lab scientists serving as mentors: Ryan Baumbach, Gary Davis, Lloyd Engel, Amy McKenna, Jose Mendoza-Cortes, Rongmei Niu, Dmitry Smirnov, Vince Toplosky, Hans Van Tol, and Bob Walsh. The students worked with their mentors over an entire semester. The program culminates in a presentation by each group to an audience of their family, teachers, principals, and mentors. This year’s class was comprised of 61.1% underrepresented minorities in STEM (4 African American students, 4 Hispanic student, 9 female students, and 3 students from Title I schools).

2016 Middle School Mentorship Participants
### 2016 Middle School Mentorship Participants and Projects

<table>
<thead>
<tr>
<th>Participant</th>
<th>School</th>
<th>Research Area</th>
<th>Mentor</th>
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<tbody>
<tr>
<td>Aniketh Mukhirala</td>
<td>Fairview Middle School</td>
<td>Wave Pendulums</td>
<td>Dmitry Smirnov</td>
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<tr>
<td>David Yang</td>
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<tr>
<td>Shemuel Roberts</td>
<td>Florida A&amp;M DRS</td>
<td>Creating a Data Logger for Collecting Wind Direction</td>
<td>Gary Davis</td>
</tr>
<tr>
<td>Michael Sweeney</td>
<td>Home School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McKenna Parker</td>
<td>Swift Creek Middle School</td>
<td>Extraction of DOM in different tea varieties of different geographic origins</td>
<td>Amy McKenna</td>
</tr>
<tr>
<td>Dimitry Tarkalnova</td>
<td>Montford Middle School</td>
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<tr>
<td>Terryn Edwards</td>
<td>Florida A&amp;M DRS</td>
<td>Materials Research in Head Injury Prevention</td>
<td>Vince Toplosky &amp; Bob Walsh</td>
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<td>Evelyn Martinez-Angeles</td>
<td>R. Frank Nims Middle School</td>
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<td>Akash Bhat</td>
<td>Fairview Middle School</td>
<td>Ferrofluids to Fight Disease</td>
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<td>Matthew Carpenter</td>
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<tr>
<td>Asya Adderson</td>
<td>Florida A&amp;M DRS</td>
<td>Microscopic Metallography</td>
<td>Rongmei Niu</td>
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<td>Maggie Hulbert</td>
<td>Fort Braden School</td>
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<td>Spencer Gibbs</td>
<td>Maclay School</td>
<td>Optimization and Range Finding of The MagLab's Open House Radar</td>
<td>Lloyd Engel</td>
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<td>Alex Hu</td>
<td>Fairview Middle School</td>
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<tr>
<td>Gabi Bynum</td>
<td>Swift Creek Middle School</td>
<td>Analysis of Crystal Growth</td>
<td>Ryan Baumbach</td>
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<td>Catharine Tew</td>
<td>Cobb Middle School</td>
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<td>Caasi Lampkin</td>
<td>Florida State University School</td>
<td>Simulation of Structure and Function of Carbon Nanotubes</td>
<td>Jose L. Mendoza-Cortes</td>
</tr>
<tr>
<td>Rowan Ray</td>
<td>Swift Creek Middle School</td>
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</tr>
</tbody>
</table>

### Summer Programs

In 2016 CIRL housed five middle school summer camps (MagLab Summer Camp 1 and 2, SciGirls 1 and 2, and SciGirls Coding Camp) reaching over 100 students.

### MagLab Summer Camp

The MagLab Summer Camp was held for its sixth year. This camp runs for two one-week sessions. There were 48 students who participated in the program. This camp is run by Mr. Carlos Villa. In 2016, 37% of the campers were female, 21% of the campers were African American, and 10% were Hispanic. Highlights from the 2016 camp were building electromagnets, building their own speakers, and the science of Star Wars.

### SciGirls Summer Camp

The SciGirls Summer camp was held for its 11th year. This program is based on a partnership between the Magnet Lab and our local public television station, WFSU. The program is closely associated with the SciGirls Connect program, an NSF funded national SciGirls Program associated with Twin Cities Public Television. The camp includes two two-week camps for middle school girls. In 2016, 46 girls participated, 20% of whom were African American and 9% were Hispanic. The highlights of this year's camp included creating a virtual reality game with the Florida Center for Interactive Media, along with meeting women scientists throughout the camp who could serve as role models including some of our MagLab scientists, postdocs, and graduate students.

![2016 SciGirls 1 Summer Camp Participants](image-url)
Chapter 4 – Education and Outreach

SciGirls Coding Camp

In 2016 CIRL partnered with Creators Camp, a local program designed to engage youth from 8 years old to 18 years old in technology and entrepreneurship. The directors of Creators Camp held a special Coding camp for SciGirls alumni. Eight middle and high school girls participated in this one week program where they learned how to program a Raspberry Pi. They developed projects and plans that they presented on the final day of the camp. All of the participants mentioned how the camp helped them to realize their talents and connect those to computer programming.

K-12 Teacher
Leon County Schools Workshop

In 2016, the Leon County Schools district was awarded an AT&T grant to develop a STEAM Bowl Challenge in all of the districts’ elementary schools. CIRL staff members, Mr. Jose Sanchez and Mr. Carlos Villa, worked closely with the PI on the grant and the elementary teachers. The program began with a workshop in January 2016. CIRL staff facilitated a workshop that helped teachers understand how to incorporate engineering and art concepts and problem-solving activities in their classrooms and clubs. Then throughout the semester, CIRL staff visited each elementary school’s STEAM Bowl club to help the teachers and students develop, plan, and test their skills. The program culminated in a STEAM Bowl Challenge (the creation and testing of electrolytes to find the best possible conductor and maximize voltage strength) that involved over 23 schools, 115 students, and over 30 teachers. The teachers credited the success of the STEAM challenge to CIRL’s dedication to the project. This partnership is further evidence of CIRL and the Magnet Lab’s commitment to education in Leon County.

Research Experiences for Teachers (RET)

The Magnet Lab RET program has been in existence since 1998. In 2016, ten teachers (5 from elementary schools and 5 from secondary schools) from the United States participated in the program. The RET program is a 6-week program wherein teachers are paired with scientist mentors. In 2016, of the 10 teachers, 80% came from Title I schools, 20% were African American, 20% were Hispanic, and 10% were Native American. A full list of the RET participants, their mentors, and links to their posters can be found at https://nationalmaglab.org/education/teachers/professional-development/research-experiences-for-teachers/ret-archives/ret-2016.
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MagLab Educators Club
The MagLab Educators Club is an email list that CIRL utilizes to send information about Magnet Lab community events, outreach, programs, and other exciting opportunities at the lab. We have over 300 members, providing further evidence of the interest of educators in Magnet Lab programs.

Magnet Academy – For Teachers
The Magnet Academy is the outreach portion of the Magnet Lab’s website. This site has a page that focuses on teachers (https://nationalmaglab.org/education-magnet-academy/teachers). This page provides lesson plans, science demonstrations, and interactive activities for teachers of students of all ages. Pageviews to Magnet Academy were up 93% in 2016 compared to the previous year.

Public Affairs and CIRL
In collaboration with Public Affairs, the Magnet Lab also expanded its outreach efforts to the public in 2016. The Public Affairs team, under the direction of Kristin Roberts, uses a wide variety of communications tools to share scientific news with the Magnet Lab’s diverse audiences:

Website
The Magnet Lab’s website, overseen by Web Content Director Kristen Coyne and Webmaster Nihlon Tabtimtong, is a critical tool for communicating important information about the lab to a variety of audiences, including: scientists, teachers/students, and the general public.

In 2016, the website continued to grow with more than a million pageviews, an increase of 5% over the year before. The pageviews were divided throughout key content areas around the site.

Sections of the site, by percentage of all pageviews, Jan-Dec 2016
- Education: 33%
- Homepage: 16%
- User Facilities: 10%
- Personnel and Publication databases: 6%
- Research: 5%
- News/Events: 5%
- Staff: 5%
- About: 4%
- Magnet Development: 3%

In addition, the website saw growth in sessions, users and traffic:
- Number of sessions up 27%
- Number of users up 46%
- Percentage of new users up from 58% of all users to 66% of all users
- Percentage of users on a tablet or other mobile device: up from 17% of all users to 22% of all users
- Organic search traffic is up 74%, indicating better performance of site content in search engines
- Referral traffic is up 10%, indicating an increase in the number of websites that have links to our site
• Social traffic up 41%, indicating more engagement by users of Facebook, Twitter, and LinkedIn.
• Number of pageviews to Magnet Academy up 93%

**Social Media**

In 2016, the MagLab’s online presence continued to expand through the use of social media. Our Facebook page saw a 27% growth, with fans almost evenly split between male (51%) and female (48%). The page is most popular with people between the ages of 24 and 44, with 25-34 year old males making up the largest percentage of our audience (18%). Most of the lab’s Facebook fans are from the United States, but our followers also come from more than 40 other countries including these ten who have the most followers: India, Brazil, Pakistan, Canada, Egypt, Bangladesh, Mexico, Turkey, France, and the United Kingdom. When adjusted for people who are reached by our Facebook posts, women (52%) outperform men (46%).

*Facebook growth over 2016: From 1,800 on January 1, 2016 to 2,287 on December 31st.*

*Facebook Total Post Reach 2016: The number of people who were served any activity from the MagLab Facebook page including posts, mentions, and checkins.*

Our Twitter page earned 212 followers in 2016. But the impact of Twitter is best shown in our nearly 600 tweets in 2016 that earned over 327,000 impressions and close to 5,000 profile visits. The lab’s Twitter followers are mostly male (63%) and between age 25 and 34 (42%). About 40% of our Twitter audience identifies their occupation as professional/technical.

**Instagram** is continuing to grow as an impactful social media tool with about 270 total followers at the end of 2016.
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LinkedIn growth over 2016: From 397 in January to 637 in December – a growth of 60%.

The lab’s LinkedIn company page added 240 followers in 2016. Our LinkedIn followers are predominantly entry-level (47.9%) from the research and higher education sectors (combined to make up 59.7%). In 2016, more followers came from the biotechnology, mechanical and electrical engineering sectors.

Overall, the most clicked social media content of the year spanned across the MagLab, including:

- Director Greg Boebinger was recently presented with the Francis G. Slack Award by the Southeastern Section of APS: http://ow.ly/Xw5XB (1/26/16)
- When a student’s first publication lands in a journal like Nature, you can bet it’s not beginner’s luck: http://ow.ly/URtR300IHxn (5/30/17)
- After a decade of planning, designing & building, today we successfully tested our newest world-record magnet: http://ow.ly/eQhX305Z2b1 #SCH (11/8/17)
- We’re hiring! Take a look at these three open positions & apply to work at our one-of-a-kind facility: http://ow.ly/D05i301uYNQ (6/21/17)
- Read about this weekend’s big event in @TDOonline: http://ow.ly/YCEJc #OpenHouse2016 #MagLabOpenHouse #Science #Music (2/22/17)
- Watch our own Jose Sanchez on @abc27 promoting the Tallahassee Science festival & come see us there on Sep 10: http://ow.ly/TDmJ303JJMC (8/30/17)
- A physicist weighs in on Simone Biles’ signature move: http://ow.ly/bRx3036sJR #Olympics #Rio2016 (8/10/17)

Pinterest has continued to grow with over 778 average daily impressions and nearly 500 average daily viewers. The most popular board on Pinterest is Science and Literature where science-related books for people of all ages are featured. Other new boards were launched this year focusing on magnetic technology, science and style, world record magnets, and electricity and magnetism pioneers.
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The Magnet Lab has had an active YouTube page since 2008. This channel added 113 new subscriptions in 2016 with close to 10,000 minutes watched. Shares of our YouTube videos increased 148% and our audience in the age group of 25 to 44 grew nearly 7% in 2016.

New video content was added in 2016, including:

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<td>An Inventors Story: Dr. Alan Marshall</td>
<td>11/22/16</td>
<td>77</td>
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<td>#ISCSMD: Cooling Towers</td>
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<td>#ISCSMD: ASC Furnace</td>
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<td>#ISCSMD: 45T Hybrid Magnet</td>
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<td>#ISCSMD: Superconductivity</td>
<td>11/10/16</td>
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<td>SCH Full Field Reached</td>
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<td>MagLab User Summer School</td>
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<td>MagLab Science Café: Exploration and Discovery</td>
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<td>MagLab scientists uncover secrets of the highly radioactive element berkelium</td>
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<td>Science in a Sentence: Your Tax Dollars at Work for Science</td>
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<td>Guitar Pickups</td>
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<td>Open House: Mesmeric Music</td>
<td>3/2/16</td>
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<td>MagLab Science Café: High Temperature Superconductors</td>
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</table>
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**YouTube Key Metrics from Jan. 1, 2016 through Dec. 31, 2016**

**Watch time**
- 97,237 minutes

**Average view duration**
- 1:43 minutes

**Views**
- 56,534

**Your estimated revenue**
- $0.00

**Likens**
- 182

**Dislikes**
- 17

**Comments**
- 17

**Shares**
- 517

**Videos in playlists**
- 364

**Subscribers**
- 113

**Top 10 Videos**

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<td>81,754 15.4%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>The Amazing Quantum Shrinking Mat...</td>
<td>11,270 12.5%</td>
<td>3,627 6.2%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>How to Make an Electromagnet</td>
<td>11,097 11.4%</td>
<td>16,092 20.8%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>Seeing Magnetic Field Lines</td>
<td>5,996 6.2%</td>
<td>4,938 6.7%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>MagLab Science Cafe: High Trench...</td>
<td>4,416 4.5%</td>
<td>573 1.0%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>MagLab Science Cafe: Chemistry of...</td>
<td>3,922 4.1%</td>
<td>291 0.5%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>Making Resilient Magnets</td>
<td>3,828 3.7%</td>
<td>1,009 1.8%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>The Scientist and the Sample</td>
<td>3,436 2.5%</td>
<td>1,673 2.6%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>Bubble Wall: Surface Tension, Hydri...</td>
<td>2,364 2.4%</td>
<td>1,879 3.3%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
<tr>
<td>MagLab Tour: The World’s Strongest...</td>
<td>2,100 2.3%</td>
<td>1,837 2.2%</td>
<td>$0.00 0.0%</td>
<td>$0.00 0.0%</td>
</tr>
</tbody>
</table>

**Top geographies**

<table>
<thead>
<tr>
<th>Country</th>
<th>Watch time</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>58%</td>
</tr>
<tr>
<td>India</td>
<td>8.5%</td>
</tr>
<tr>
<td>Canada</td>
<td>4.4%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>3.5%</td>
</tr>
<tr>
<td>Germany</td>
<td>2.3%</td>
</tr>
</tbody>
</table>

**Gender**

- Male (79%)
- Female (21%)

**Traffic sources**

- External (45%)
- Suggested videos (15%)
- YouTube search (15%)
- Other (10%)

**Playback locations**

- YouTube watch page (70%)
- Embedded in external websites and apps (30%)
- YouTube channel page (0.4%)
- YouTube other (0.3%)
Chapter 4 – Education and Outreach

Science Café

The Magnet Lab’s Science Café series continued in 2016 with quarterly cafés. The Cafés were also video recorded, posted on the Magnet Lab’s YouTube channel, and shared via social media, allowing this local series to have a broader impact than just the Tallahassee geographic area.

Science Café Presentations in 2016

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Speaker</th>
<th>Number of attendees/views online</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 13, 2016</td>
<td>High-Temperature Superconductors: How Taming Serendipity Could Change Our World</td>
<td>Laura Greene</td>
<td>72 attendees 639 views</td>
</tr>
<tr>
<td>April 5, 2016</td>
<td>Mapping Chemical Properties of Arctic Waters</td>
<td>Pete Morton</td>
<td>75 attendees 87 views</td>
</tr>
<tr>
<td>July 27, 2016</td>
<td>Crowdsourcing Electrons</td>
<td>Ross McDonald</td>
<td>68 attendees 142 views</td>
</tr>
</tbody>
</table>

Open House

More than 8,200 visitors came to spend the day at the National MagLab’s world-class research laboratory and take part in the nearly 100 fun, hands-on science demonstrations during Open House on February 27, 2016. Open House visitors came from around the Southeast, including Panama City, Daytona, Valdosta, and Dothan. This year’s Open House focused on the *harmony of science and music* with featured performances by the FSU Student Opera Society and world-renowned pianist and FSU faculty Ian Hobson under the world’s strongest magnet.

Surveys show that visitors leave Open House with an overwhelmingly positive opinion:
- After Open House, 100% of respondents had a positive opinion of the Lab.
- 100% of survey respondents said they would attend another Open House.
- 97% said they would attend another MagLab event.

Open ended survey responses and social media feedback reinforce the impact of this one-day event on our target audience:
Chapter 4 – Education and Outreach

- I learned how science plays a major role in our everyday lives.
- The MagLab is awesome!
- I learned a lot about magnets and their role in our society.
- Scientists were so willing to answer questions.
- So much diversity in scientists.
- You guys are doing a wonderful job, thanks for sharing with the community.
- What a treasure for Tallahassee!
- We planned to go and stay for an hour or two, or until the kids lost interest, and ended up staying until it closed. We had a wonderful time!
- This was our first visit. It was awesome! So much to see and do. Can't wait until next year.
- This was our first time at the open house and I have to say it was one of the best things for kids in Tallahassee! So many interesting presentations and experiments for young and old. We will be back next year!

Freeze & Fright Night

The MagLab hosted a Halloween-themed science event on October 25, 2016. More than 500 people came to have some spine-chilling science fun, exploring about a dozen different hair-raising activities and eerie experiments conducted by our spooky scientists during the two-hour event!

Presentations in 2016

In addition to these many forms of outreach, CIRL staff also present at conferences for teachers and the general public to inform them about our programs and the research conducted at the NHMFL. The 2016 educational outreach presentations included:

- C. Villa (April 2016). Tesla Tales: Take a journey through the history of electromagnetic discovery. Presentation at the National Science Teacher Association Conference, Nashville, TN.
- R. Hughes (September, 2016). An Evolving Landscape of Opportunity: Informal education and STEM research working together. Presentation on MagLab Educational programs at the Annual Association of Science-Technology Centers, Tampa, FL.
- C. Villa (October 2016). Tesla Tales: Take a journey through the history of electromagnetic discovery. Presentation at the Florida Association of Science Teachers.
Undergraduate, Graduate, and Postdocs

Magnet Lab Internship Program (For students 17 years or older)

The MagLab Internship program is facilitated by Mr. Jose Sanchez. The program runs on a semester basis. During the fall and spring semester students volunteer for the program, however, during the summer, students are paid for their internship work. This program provides stellar high school students with an interest in research working with a scientist at the lab. It also provides undergraduates who may not have the research and course experience for acceptance into an REU program with the opportunity to gain that experience. In 2016, 39 high school and college students participated in this program, of these: 54% were female and 5% were African American. Mr. Sanchez plans to work towards increasing the diversity of the participating interns in 2017.

Undergraduate – Research Experiences for Undergraduates (REU)

The MagLab’s REU program has been facilitated by CIRL since 1999. Since then more than 300 students have participated. This program is one of CIRL’s finest in its historical quality and demonstration of the commitment of the MagLab to mentoring early career scientists. The director of the REU program is Mr. Jose Sanchez. In 2016, 20 undergraduates participated in the REU program at all three Magnet Lab sites, of these students: 30% were female, 10% were African American, 5% were Hispanic, 5% were Native Hawaiian/Pacific Islander, and 5% came from Minority Serving Institutions. A full list of the 2016 REU participants, their mentors, and a link to their posters can be found at https://nationalmaglab.org/education/college-students-early-career-scientists/reu/reu-archives/reu-2016.

Graduate Students and Postdocs

Kari Roberts continues to serve as our Postdoc Liaison and Evaluation Coordinator for the lab. She works closely with Postdocs to ensure that their mentoring and professional development needs are being met. The professional development opportunities that she organizes are also open to graduate students and any other Magnet Lab staff.
In 2016 these professional development opportunities included:

<table>
<thead>
<tr>
<th>Session Topic</th>
<th>Date</th>
<th>Presenter</th>
<th>Attendance (Postdocs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postdoc Seminar</td>
<td>January 2016</td>
<td>Vijaykumar Ramaswamy</td>
<td>5 (2)</td>
</tr>
<tr>
<td>Postdoc Seminar</td>
<td>February 2016</td>
<td>Nihar Pradhan</td>
<td>11 (5)</td>
</tr>
<tr>
<td>Practice Session for APS</td>
<td>March 2016</td>
<td>Audrey Grockiowski</td>
<td>6 (3)</td>
</tr>
<tr>
<td>Presentations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross Cultural Mentoring</td>
<td>April 2016</td>
<td>Carolyn Harris and Josh Kinchen</td>
<td></td>
</tr>
<tr>
<td>FSU Postdoc Symposium</td>
<td>September 2016</td>
<td>FSU Office of Postdoctoral Affairs</td>
<td>10 (10)</td>
</tr>
<tr>
<td>Pfeiffer Vacuum Techniques</td>
<td>October 2016</td>
<td>Joseph Rajan and Ron Lighthart</td>
<td>9 (4)</td>
</tr>
</tbody>
</table>

*No sessions were held during the summer based on previous feedback that many people travel during the summer.*

Postdoc Seminars are opportunities for postdocs to present their work. This seminar series is designed to give postdocs the chance to perfect their presentation skills to a wider audience who may not be familiar with their research and to network with colleagues at the lab. Postdocs will often use these seminars as a chance to practice for upcoming conference presentations and job talks. After each talk, attendees are given the opportunity to give feedback to the presenter. Attendance at these seminars ranges from 5-15, and the turnout for seminars is typically higher than for professional development sessions.

**Professional Development Resources at FSU, UF, and LANL**

Postdocs have access to professional development resources at all three sites. LANL offers postdoc specific awards and prizes, resources for work/life balance, as well as a matched mentoring program. The website for the LANL postdoc program can be found here: [http://www.lanl.gov/careers/career-options/postdoctoral-research/postdoc-program/](http://www.lanl.gov/careers/career-options/postdoctoral-research/postdoc-program/). UF has an office of postdoctoral affairs, which offers regular professional development workshops, new postdoc orientation, and sends out regular newsletters to postdocs on UF’s campus. Their website can be found here: [http://postdoc.aa.ufl.edu/](http://postdoc.aa.ufl.edu/). CIRL coordinates with FSU’s programs for postdocs because of the proximity and because our largest percentage of postdocs are at our Tallahassee location. There are three main sources of professional development for postdocs on FSU’s campus: FSU Libraries, The Graduate School, and The Office of Postdoctoral Affairs. The Office of Postdoctoral Affairs sends out a weekly email with all upcoming professional development sessions from these three sources. About 50 unique sessions presented by FSU faculty and staff as well as paid presenters from outside the university were offered on campus last year. These sessions also align with the professional competencies for postdocs outlined by the National Postdoctoral Association. Topics for these sessions included:

- Preparing for Academic Jobs
- Preparing for Non-Academic Jobs
- Job Application Materials and Process (Resume, CV, Cover Letter, Interviews, etc.)
- Teaching
- Mentoring (Both being a mentor and a mentee) and Supervising Employees
- Improving Conference Presentations
- Fellowship Opportunities
- Grant Writing
- Citation Management Software
- Copyright and Intellectual Property
- Lab/Scientific Management
Chapter 4 – Education and Outreach

Mentoring for MagLab Postdocs

Postdocs at the MagLab have opportunities to be both a mentor and a mentee. The lab has a large number of potential mentors for postdocs including MagLab research staff, professors at nearby universities, and users. Additionally, the lab has about 175 undergraduate and graduate students that postdocs could mentor.

Overall, postdocs report that their PI or supervisor acts as a mentor, and that they are satisfied with the mentoring they receive. To prepare for mandatory evaluations for postdocs in summer 2016, evaluations were strongly encouraged in fall of 2015 using the Individual Development Plan (IDP) format. As a result, several postdocs received evaluations for the first time in fall 2015. Kari Roberts supported and will continue to support any postdoc or supervisor who had questions about using IDP’s or the evaluation process. After this trial run of evaluations, we sought feedback from the Postdoctoral Advisory Committee on the use of IDPs for evaluations. Committee members reported that the IDP format was not a good fit for everyone. As a result, we have expanded the recommendation for postdoc evaluations to allow for customization based on the supervisor’s and postdoc’s goals. In 2016, FSU required mandatory evaluations which were conducted in the summer of 2016. Postdocs predominately used an IDP (33.3%), faculty evaluation (16.7%), or the custom FSU postdoc evaluation (33.3%) as the format of their evaluation. An additional 33.3% used a custom format to do their evaluations. Postdocs were able to combine multiple formats if they wished.

Annual Survey to Postdocs

In 2016 we added the annual postdoc survey questions to the annual climate survey. Overall, the responses of postdocs align with the responses of other staff categories in the climate survey, however there were times where the opinions of postdocs deviated from others at the lab. Similar to the results of the annual postdoc survey, the postdocs rated their supervisor highly, with 93.8% rating their supervisor positively and 6.2% rating them neutrally. 0% of postdocs rated their supervisor negatively. All of the postdocs who responded to the climate survey said that they felt they could ask their supervisor questions about their job assignments. This is especially important considering that a postdoctoral position is intended to be a traineeship. Additionally, when asked their agreement with the statement “my supervisor encourages me in my career goals, postdocs average response was a 4.57 on a scale of 1 to 5, 1 being strongly disagree and 5 being strongly agree. Even though most postdocs reviewed their supervisor favorably, only 43% of postdocs reported receiving an annual evaluation, which was significantly less than other job categories. While evaluations were technically “mandatory” this year, FSU did not provide an official mechanism for penalizing anyone who did not complete an evaluation. The demographics for our Postdocs are below.

<table>
<thead>
<tr>
<th>Race/Ethnicity- Excluding Affiliates</th>
<th>Number</th>
<th>Percentage (N= 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic or Latino/a</td>
<td>8</td>
<td>26.7%</td>
</tr>
<tr>
<td>Asian</td>
<td>12</td>
<td>40.9%</td>
</tr>
<tr>
<td>Black/African American</td>
<td>1</td>
<td>3.3%</td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Native Hawaiian or Pacific Islander</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>5</td>
<td>16.7%</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender- Excluding Affiliates</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>23</td>
<td>(76.6%)</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>(23.4%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Citizenship Status- Excluding Affiliates</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>US Citizen or Permanent Resident</td>
<td>11</td>
<td>(36.7%)</td>
</tr>
<tr>
<td>Visa Holder</td>
<td>19</td>
<td>(63.3%)</td>
</tr>
</tbody>
</table>

Future Plans

In 2017, Kari is working to pair postdocs with interested faculty to serve as additional mentors. This is part of our formal Postdoc Mentoring program.
NHMFL Scientists’ and Staffs’ Commitment to Outreach

**NHMFL Personnel Outreach**

CIRL is only one piece of the NHMFL’s outreach, without the scientists and staff at the lab, there would be no role models to motivate students to pursue STEM and to inform the community about the NHMFL’s commitment to materials, energy, and life. In 2016, 84 NHMFL scientists and staff members reported doing at least one type of outreach in the community. The outreach conducted by these scientists reached 4,734 people (this does not include the annual Open House). Outreach conducted by NHMFL staff reached a wide range of ages, from elementary school students to senior scientists.

The representation of these groups is:

- 31% General Public
- 29% Undergraduate and Graduate Students
- 21% Middle and High School Students
- 20% Elementary School Students
- 6% Scientists and Faculty
- 1% K-12 Teachers

In 2016, 51 scientists participated in long-term commitment outreach efforts, reaching a total of 100 individuals. As part of CIRL programs, these scientists mentored 18 middle school mentorship students, 39 interns, 10 RETs, and 20 REUs.
## Chapter 4 – Education and Outreach

### Short-Term Outreach

<table>
<thead>
<tr>
<th>Department</th>
<th>Tour of MagLab Facility</th>
<th>Presentation</th>
<th>Visit K-12 classroom</th>
<th>Worked With K-12 Group at the Lab</th>
<th>Judged a Science Fair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Scientists</td>
<td>Number of people reached</td>
<td>Number of Scientists</td>
<td>Number of people reached</td>
<td>Number of Scientists</td>
</tr>
<tr>
<td>ICR</td>
<td>6</td>
<td>128</td>
<td>3</td>
<td>525</td>
<td>3</td>
</tr>
<tr>
<td>CMS</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>1,284</td>
<td>5</td>
</tr>
<tr>
<td>ASC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMR</td>
<td></td>
<td>1</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>NMR</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>UF</td>
<td></td>
<td>8</td>
<td></td>
<td>351</td>
<td></td>
</tr>
<tr>
<td>PFF</td>
<td>1</td>
<td>45</td>
<td>1</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>MS&amp;T</td>
<td>2</td>
<td>23</td>
<td>1</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>DC</td>
<td>4</td>
<td>105</td>
<td>2</td>
<td>350</td>
<td>1</td>
</tr>
<tr>
<td>Geochem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directors Office*</td>
<td>2</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managem. &amp; Admin.</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td><strong>18</strong></td>
<td><strong>713</strong></td>
<td><strong>24</strong></td>
<td><strong>3,350</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

### Outreach Audience: Short- and Long-Term Outreach

<table>
<thead>
<tr>
<th>Department</th>
<th>Number of PeopleReached</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Scientists</td>
</tr>
<tr>
<td>ASC</td>
<td>5</td>
</tr>
<tr>
<td>NMR</td>
<td>5</td>
</tr>
<tr>
<td>EMR</td>
<td>3</td>
</tr>
<tr>
<td>ICR</td>
<td>9</td>
</tr>
<tr>
<td>CMS</td>
<td>14</td>
</tr>
<tr>
<td>UF</td>
<td>10</td>
</tr>
<tr>
<td>DC</td>
<td>10</td>
</tr>
<tr>
<td>Geochem</td>
<td>4</td>
</tr>
<tr>
<td>MS&amp;T</td>
<td>10</td>
</tr>
<tr>
<td>Managem.&amp; Admin.</td>
<td>5</td>
</tr>
<tr>
<td>Director's Office*</td>
<td>6</td>
</tr>
<tr>
<td>PFF</td>
<td>3</td>
</tr>
</tbody>
</table>

*Includes Public Affairs, Safety, and Microscopy

MagLab 2016 Annual Report
Research and Evaluation Evaluation

Ms. Kari Roberts conducts all evaluation for our programs. Her evaluation and research statistical expertise allow CIRL to maintain high quality programs. A list of our evaluation efforts can be found in the table below.

<table>
<thead>
<tr>
<th>Outreach</th>
<th>Form of Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom outreach</td>
<td>Post-survey to teachers after outreach conducted (formative assessment)</td>
</tr>
<tr>
<td>RET/REU/Summer Camps/Middle School Mentorship</td>
<td>Pre-/post-survey measuring attitudes toward STEM careers, perceptions of STEM careers, and self-efficacy in STEM (for teachers in teaching STEM) Annual tracking of past participants to determine persistence over time</td>
</tr>
<tr>
<td>Graduate Student/Postdoc Professional Development</td>
<td>Annual survey to current postdocs to determine professional development needs and assess mentoring, post-session surveys after each professional development event, annual tracking of graduate students and postdocs to determine career trajectories.</td>
</tr>
<tr>
<td>MagLab Users Summer School</td>
<td>Pre-/Post-survey assessing perceived value of program on their career trajectories.</td>
</tr>
</tbody>
</table>

Research

In 2016, Ms. Kari Roberts and Dr. Roxanne Hughes presented the results of research that they are conducting with scientist mentors who work with the MagLab educational programs. The study is part of an ongoing project that is trying to identify what motivates scientists to work with students and teachers on long term projects so that it can be replicated at other labs and organizations.

This research resulted in the following presentations in 2016:


The following are a list of CIRL staff research publications in 2016:

Peer-reviewed articles:


Grants Awarded in 2016

In 2016, Dr. Hughes was a co-PI on an NSF-AISEL grant, SciGirls CONNECT2: Investigating the Use of Gender Equitable Teaching Strategies in a National STEM Education Network. For this grant, Dr. Hughes and Ms. Roberts will be conducting research on STEM identity development for middle school girl participants in 16 national SciGirls programs. This research aligns with Dr. Hughes and Ms. Roberts’ current research on the middle school programs that the MagLab conducts. The results of this project can also improve the overall impact of the MagLab programs as well.

Grants Submitted in 2016

Dr. Hughes partnered with faculty from Florida State University and Florida Agricultural and Mechanical University to submit a grant to the NSF-IUSE program. This grant (A Comparative Case Study of Undergraduate Chemistry and Physics Programs within Two Diverse College Campuses) would allow the PIs to conduct a comparative case study of the climates within physics and chemistry departments at FSU and FAMU to determine how these respective climates impact underrepresented minority students’ persistence in and perceptions of these fields.
Diversity and Inclusion in Education and Outreach

Diversity and inclusion is a large part of all of the MagLab’s educational and outreach activities.

The following table highlights the demographics for our long term programs (e.g. one week or longer).

**Education Programs in Diversity Classification**

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>Total</th>
<th>% Women</th>
<th>% African American</th>
<th>% Hispanic</th>
<th>% Native American/Hawaiian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Experiences for Undergraduates (REU) summer</td>
<td>20 undergraduates</td>
<td></td>
<td>30%</td>
<td>10%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Research Experiences for Teachers (RET) summer</td>
<td>10 K-12 teachers</td>
<td></td>
<td>70%</td>
<td>20%</td>
<td>20%</td>
<td>NA</td>
</tr>
<tr>
<td>Middle school Mentorship (Fall)</td>
<td>18 middle school students</td>
<td></td>
<td>50%</td>
<td>22%</td>
<td>22%</td>
<td>NA</td>
</tr>
<tr>
<td>Internship</td>
<td>39 (high school and college)</td>
<td></td>
<td>54%</td>
<td>5%</td>
<td>0%</td>
<td>NA</td>
</tr>
<tr>
<td>MagLab Summer Camp (Two 1-week camps)</td>
<td></td>
<td></td>
<td>37%</td>
<td>21%</td>
<td>10%</td>
<td>4%</td>
</tr>
<tr>
<td>SciGirls Summer camp (Two 2-week camps)</td>
<td>46 (middle school students)</td>
<td></td>
<td>100%</td>
<td>20%</td>
<td>9%</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Plans for 2017**

MagLab scientists and staff continue to be an important part of the work that the Center for Integrating Research and Learning along with Public Affairs does to engage the public and educate students about scientific research occurring at the MagLab. In 2017 we plan to continue to maintain our high quality programs. CIRL staff plan to make a larger effort to improve diversity numbers particularly as they related to the engagement of African Americans and Hispanic students. Public Affairs plans to incorporate metrics in the Open House survey that will measure diversity demographics to determine who is coming to our event. We will continue to build on the strong educational and outreach partnership with UF and LANL MagLab facilities. We will also continue to pursue professional development opportunities that maintain current knowledge of best practices in broader impacts as they apply to K-16 students, teachers, faculty, and the general public.
Conferences and Workshops

Throughout the year, the National High Magnetic Field Laboratory hosts or sponsors a variety of workshops and conferences related to our science.

Physical Phenomena in High Magnetic Fields
January 6 – 9, 2016
Tallahassee, FL

This conference brings together experts from around the world to discuss recent advances in areas of science and technology in which high magnetic fields play or could play an important role. Talks explored the wide range of research and experimental techniques of interest to the high magnetic field community and sought to identify new opportunities in magnetic field research, including:

- superconductivity including pnictides, cuprates, heavy fermions, and organics
- semiconductors and the quantum Hall effect
- topological magnetism
- magnetoelectrics and multiferroics
- spintronics and quantum computing
- magnetic materials
- quantum fluids and solids
- application of high magnetic fields on soft matter

116 people attended.

Biological Solid State NMR Winter School
January 10-15, 2016
Stowe, VT

Similar to the three previous highly successful Winter Schools, this pedagogical meeting is aimed at students and postdocs in solid-state NMR as well as more senior scientists in related fields who are interested in entering this vibrant field. The event provides a focused week of teaching core concepts and practices in the increasingly multifaceted and complex field of biological solid-state NMR spectroscopy, and encourages information sharing among different laboratories. Topics covered in the 4th Winter School include:

- Basics of solid-state NMR: orientation-dependent NMR frequencies, MAS, rotations, density operator and its time evolution, dipolar recoupling, and average Hamiltonian theory.
- Multidimensional correlation spectroscopy, resonance assignment and protein structure determination
- Theory of dipolar decoupling and polarization transfer
- Pushing the sensitivity envelope: dynamic nuclear polarization and 1H detection
- Effective "sensitivity enhancement" by non-uniform sampling
- Solid-state NMR techniques for measuring molecular motion
- Solid-state NMR techniques for measuring membrane protein orientation
- Beyond spin 1/2: NMR of quadrupolar nuclei
- Beating the 800-pound gorilla: NMR of membrane proteins
- XPLOR-NIH for structure calculation

APS Reception
March 15, 2016
Baltimore, MD

The MagLab hosted a reception at the American Physical Society’s March Meeting. Sponsored by Florida State University, University of Florida, and the MagLab, about 200 researchers from around the world were in attendance.

Workshop on Mechanical and Electrical Properties of Composite Superconductors (MEM)
March 21-23, 2016
Tallahassee, FL

The 8th Workshop on Mechanical and Electromagnetic Properties of Composite Superconductors showcased the high quality, internationally competitive and cutting-edge work going on in this research area. Around 65 people attended.

User Summer School
May 16-20, 2016
Tallahassee, FL

The 6th annual User Summer School introduced 28 students, early-career scientists and potential
users to the MagLab’s infrastructure, experimental options, and support staff. Through a combination of tutorials, talks, and practical exercises, the User Summer School helped attendees develop skills for use in both their home laboratory and across user facilities worldwide. This weeklong event features tutorials on measurement techniques, practical exercises and plenary talks from experts in the field of condensed matter physics.

**Gordon Research Conference on “Two Dimensional Electronics beyond Graphene”**

June 5-10, 2016
Mount Holyoke College, South Hadley, MA

The 2016 Gordon Conference presented research addressing the fundamental properties and potential uses of ultrathin-layered systems with a fundamental band gap including transition metal dichalcogenides, group V systems including phosphorene, and related isoelectronic structures. Interdisciplinary research driven by experimentalists and theorists in the fields of Physics, Chemistry, Materials Science and Device Engineering contributes to the unprecedented growth in this area. Presentations and discussions focused on questions including:

- Which are the most promising aspects of 2D electronics in our 3D world?
- What is the state of the art in the synthesis, assembly and passivation of 2D materials and related heterostructures?
- What is our understanding of the unique behavior of 2D systems?
- What is the promise of 2D systems for spintronics and optoelectronics?
- Which are the fundamental advantages and disadvantages of 2D systems for electronics applications?
- Are 2D materials viable candidates for electronics that would out-perform current silicon-based devices?

**7th International Workshop on Materials Analysis and Processing in Magnetic Fields**

June 15-18, 2016
Brown University, Providence, RI

This workshop promoted discussions of recent advances in research on the use of magnetic fields for the study of materials properties, the manipulation of materials, and the processing of materials. The presentations touched on a wide range of materials from the very soft, like biomatter, to the very hard, like ceramics, and on a plethora of goals like creating more ordered structures or probing phase transitions. They included descriptions of novel modalities for industrial waste remediation and some of the most advanced magnetic field based techniques for elucidating the microscopic properties of matter. Other topics included:

- Magnetic field effects on chemical, physical, hydrodynamic, and biological phenomena.
- Magnetic processing of materials.
- Diamagnetic effects and Levitation.
- Magnetic field effects on phase transition, crystallization, and texturing.
- Medical application of magnetic fields.
- Development of technique, equipment, and high magnetic field generation.
- Environmental application and magnetic separation.
- Other phenomena related to magnetism or magnetic fields.

There were about 35 participants from 7 different nations in attendance.

**RF Coil Workshop**

June 20-24, 2016
UF-AMRIS, Gainesville, FL

This workshop trained graduate and post-doctoral students in building RF coils for magnetic resonance imaging and spectroscopy. The five-day workshop focused on the following goals:

1. Building an RF quadrature coil
2. Tuning/matching the coil and test performance
3. How to use software to 3D print probe support parts
4. How to use software for 3D Electro-magnetic coil simulation.

After the workshop, participants should be able to build their own coils and test them in their individual facilities. 5 external participants attended and an additional 15 UF graduate students and post docs also came to the computer simulation technology (CST) workshop as part of the larger, weeklong RF Coil workshop.
Rocky Mountain Conference Solid-State NMR Symposium and EPR Symposium
July 17-21, 2016
Breckinridge, CO

The MagLab supported the largest solid state NMR meeting in North America. Beginning in 2010, this symposium occurs biennially in alternation with the biennial Alpine NMR conference in Chamonix, France, to ensure broad international participation in both conferences. Around 350 people attended the symposium.

Applied Superconductivity Conference – No-Insulation Coils Special Session
September 4-9, 2016
Denver, CO

At the 2016 Applied Superconductivity Conference, a special session on no-insulation HTS coils was held. Professor Hahn organized this session and was the first to implement this technology on coils with HTS, a topic that is gaining interest in the community. The number of submitted abstracts to the conference on no-insulation coils has increased significantly over the past few years and this session included 7 talks from leaders in the field.

Coated Conductors for Application 2016
September 11-14, 2016
Aspen, CO

This international workshop explored recent developments of REBCO coated conductors and their applications, with a focus on new conductor development directions and the latest application milestones and technical challenges that coated conductors face. Attendance was around 81 participants.

Tech Topics
September 21, 2016
Tallahassee, FL

The Leon County Research and Development Authority (LCRDA) September TechTopics event featured dynamic research and commercialization from the MagLab’s Ion Cyclotron Resonance Facility. About 50 business leaders and community members attended.

The Southeast Magnetic Resonance Conference (SEMRC)
October 14-16, 2016
Emory University, Atlanta, GA

SEMRC is held every year and rotates among various locations in the southeastern United States. With a long history of bringing together leading scientists to discuss the latest developments in NMR, EPR, and MRI, the focus of the conference is the exchange of ideas and recent magnetic resonance research highlights, including new applications and technique development. Particular emphasis is placed on activities in the region. The SEMRC puts a special emphasis on the participation of young scientists (students and postdocs) and provides excellent opportunities to exchange new exciting results with their peers as well as with the leaders in the field. 96 people participated this year.

Symposium Celebration for Dr. Steven Van Sciver
October 22, 2016
Tallahassee, FL

This one-day symposium celebrated the career and research of Steven Van Sciver, a distinguished Professor at Florida State University and former Magnet Science and Technology Director. His colleagues and former students highlighted his achievements and advances in cryogenics research through short talks. More than 30 people were in attendance.

Weekly Seminar Series:
In addition to these special workshops and conferences hosted or sponsored by the MagLab, weekly seminars were held in departments across the lab:

January 14, 2016: Madeline Furis Physics Colloquium at UF: Organic Magnetic Semiconductors: Bridging Quantum Chemistry to Condensed Matter Physics

January 26, 2016: Seminar By Zhengcheng Gu, Perimeter Institute, CA: Emergence of topological superconductivity in 2D strongly correlated doped Dirac systems

January 29, 2016: Seminar by Wilfried Goldacker, Karlsruhe Institute of Technology, Institute for
Chapter 4 – Education and Outreach

Technical Physics: HTS magnet activities at KIT, a 5T system for space research and the Roebel HTS cable R&D for a dipole insert magnet at CERN

January 29, 2016: Seminar by Johnpierre Paglione, University of Maryland: Surface ferromagnetism and 1D edge state transport in SmB6

February 3, 2016: Seminar by Rachel Martin, UC Irvine: Probe development for NMR spectroscopy of liquid crystals and biological macromolecules

February 12, 2016: Seminar by J. Murray Gibson, Northeastern University, Boston: Coherent diffraction with electrons or x-rays – new routes to atomic structure in materials

February 19, 2016: Seminar by Seiji Miyashita, University of Tokyo: Competitions of elastic and short range interactions in spin-crossover materials

February 26, 2016: Seminar by David Parker, Oak Ridge National Laboratory: Recent Theoretical Work on Materials at ORNL: Magnetism, Thermoelectricity, and Superconductivity

March 4, 2016: Seminar by Nicolas Regnault, Princeton University: Matrix Product States and the Fractional Quantum Hall Effect

March 16, 2016: Seminar by Yukikazu Iwasa, Massachusetts Institute of Technology: HTS Magnet Technology: Current Activities at FBML and Options for >35-T Magnets

March 25, 2016: Seminar by Jian Wei, Peking University: Superconductivity at the point contact on the surface of Sr2RuO4 single crystal

March 25, 2016: Seminar by Amit Amal Ghosal, Indian Institute of Science Education and Research (IISER): Disorder induced inhomogeneities in cuprate superconductors

April 8, 2016: Seminar by Xiaoxing Xi, Temple University: Building Nanoscale Oxide Thin Films and Interfaces One Atomic Layer at a Time

April 13, 2016: Hot Topic Talk by Naveen Anand, University of Florida: Temperature dependent optical and magnetic field study of class IV-VI Chalcogenides

April 18, 2016: Colin Smith, Max Planck Institute for Chemistry: Population Shuffling and Concerted Protein Motion Mediate Allosteric Communication

April 22, 2016: Seminar by Diyar Talbayev. Tulane University: Spin-fluctuation dynamics in magnetic oxides studied by time-resolved optical and terahertz spectroscopies


April 29, 2016: Seminar by James Hone, Columbia University: 2D materials in the ultraclean limit: basic science and applications

May 13, 2016: Seminar by Dilpuneet Aidiy, Univ. of Wyoming: Microstructure design for fast ion conduction

June 3, 2016: Seminar by Li Chen, Washington University: Algebraic approach to the study of zero modes of pseudopotentials in quantum Hall effect

June 9, 2016: Celine Baligand, University of California San Francisco: Multimodal MRI/MRS Metabolic Biomarkers of Neuromuscular Disorders

June 17, 2016: Seminar by Wenlian Zhu, Johns Hopkins University: Breast MRI: Preclinical and Clinical Applications


July 8, 2016: Seminar by Alfonso Chaon Roldan, Technische Universität München: Uniaxial Pressure Dependence of Magnetic Order in MnSi

July 14, 2016: Seminar: Aaron Rossini, Iowa State University: DNP Enhanced Solid-State NMR for Surfaces, Materials and Pharmaceuticals
Chapter 4 – Education and Outreach

August 26, 2016: Seminar by Zhixian Zhou, Wayne State University: Contact Engineering of Two-Dimensional Layered Semiconductors beyond Graphene

September 16, 2016: Seminar by Nicholas P. Butch, University of Maryland, College Park: SmB6 – Obstinately Intermediate Valient, Plausibly Topologically Nontrivial

September 23, 2016: Seminar by Chandra Varma, Univ. of California, Riverside: Quantitative Determination of the the Fluctuations for the Strange Metal Phase and Superconductivity in Cuprates

September 28, 2016: Seminar by Wei Ku, Shanghai Jiao Tong University, China: Orbital/spin correlation and quantum fluctuation in Fe-based high-temperature superconductors

September 30, 2016: Seminar by Chi Zhang, Peking University, Beijing: Quantum capacitance anomaly of nonequilibrium electron states under microwave irradiation

October 7, 2016: Seminar by Gamini Sumanasekera, University of Louisville: In-situ Transport Study of Graphene-Gas Interaction and its Applications in Energy Storage

October 10, 2016: Seminar by Eric Gottwald, Karlsruhe Institute of Technology: Microcavity array-based microbioreactors: organotypic threedimensional tissue culture in an MRI-compatible setup

October 10, 2016: Seminar by Lothar Schad, University of Heidelberg: Spin >1/2 X-nuclei MRI: Physics, Methods and High Field Applications

October 10, 2016: Seminar by Kevin Freudenberg, US ITER, Oak Ridge National Laboratory: Helium Inlet Assessments for the US-ITER Central Solenoid

October 17, 2016: Seminar by Smita Mohanty, Oklahoma State University: Pheromone Perception: Structure and Function of Pheromone-Binding Proteins

October 17, 2016: Seminar by David Everitt, US ITER Central Solenoid Systems Manager: CS Module Manufacturing progress at GA

October 20, 2016: Seminar by Alexandros Lappas, Fulbright Fellow, Foundation for Research and Technology – Hellas: Frustration-induced Structural Complexity in Layered Rock-Salt Manganites

October 21, 2016: Seminar by Anatoli Polkovnikov, Boston University: Quantum chaos and eigenstate thermalization

November 4, 2016: Seminar by Andy Christianson, Oak Ridge National Lab: The Consequences of Spin-Orbit Coupling on the 5d3 Electronic Configuration

November 10, 2016: Seminar by Xiaoyu Wang, University of Minnesota: Superconductivity mediated by quantum critical antiferromagnetic fluctuations: the rise and fall of hot spots

November 18, 2016: Seminar by Jian Kang, University of Minnesota: Interplay between nematicity and superconductivity in iron-based superconductors

November 30, 2016: Seminar by Junji Iwahara, University of Texas Medical Branch: Dynamics in DNA Scanning and Recognition of Proteins

December 2, 2016: Seminar by Giuseppe Melacini, McMaster University: Tapping the Translation Potential of cAMP-Scaling and Amyloid Inhibition Using NMR

December 2, 2016: Seminar by David Tomanek, Michigan State University: Unexpected behavior of 2D semiconductors beyond graphene

December 14, 2016: Seminar by David Boehr, Penn State University Chemistry Department: Controlling enzyme structural dynamics and function

December 16, 2016: Seminar by Kate Ross, Colorado State University: Quantum phenomena in XY pyrochlores

MagLab 2016 Annual Report
Broadening Outreach

In addition to the Diversity and Education sections which speak to the MagLab’s work in broadening outreach through education and underrepresented groups, the lab’s staff are regularly presenting new research and sharing information about our user program at national and international conferences, workshops and seminars. Each presentation, poster or abstract opportunity offers the chance for scientists around the world the opportunity to learn more about the lab’s research capabilities and broaden our user program to appeal to new scientists from varying levels – from graduate students and postdoc to seasoned scientists.

In 2016, MagLab staff gave more than 360 lectures, talks and presentations across 20 foreign countries:

<table>
<thead>
<tr>
<th>Conference</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th International Workshop on Novel Magnetic and Multifunctional Materials, organized jointly with the French-Korean Meeting on Functional Materials for Organic Optics, Electronics and Devices, Université Pierre et Marie Curie</td>
<td>Paris, France</td>
</tr>
<tr>
<td>4th Awaji International Workshop on Electron Spin Science &amp; Technology: Biological and Materials Science Oriented Applications,</td>
<td>Awaji Island, Hyogo, Japan</td>
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<tr>
<td>5th Joint Meeting ASA/ASJ</td>
<td>Honolulu, HI</td>
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<tr>
<td>5th International Workshop on Numerical Modelling of High Temperature Superconductors</td>
<td>Bologna, Italy</td>
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<tr>
<td>6th International Workshop on Dual Nature of f-electrons</td>
<td>Idaho Falls, ID</td>
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<tr>
<td>6th Workshop on Current Trends in Molecular and Nanoscale Magnetism (CTNMN)</td>
<td>Pylos, Greece</td>
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<tr>
<td>10th INTECOL International Wetlands Conference</td>
<td>Changshu, China</td>
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<tr>
<td>12th European Fourier Transform Mass Spectrometry Workshop</td>
<td>Matera, Italy</td>
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<tr>
<td>13th International Conference on Quasicrystals (ICQ13)</td>
<td>Kathmandu, Nepal</td>
</tr>
<tr>
<td>15th Human Proteome Organization World Congress</td>
<td>Taipei, Taiwan</td>
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<tr>
<td>15th International Conference on Molecule-Based Magnets (ICMM)</td>
<td>Sendai, Japan</td>
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<tr>
<td>16th International Conference on Transport in Interacting Disordered Systems (TIDS16)</td>
<td>Granada, Spain</td>
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<tr>
<td>17th Petrophase Conference</td>
<td>Elsinore, Denmark</td>
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<tr>
<td>19th Conference on Quantum Information Processing (QIP2016)</td>
<td>Calgary, Canada</td>
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<tr>
<td>20th Osaka City University (OCU) International Conference on Molecular Spins and Quantum Technology</td>
<td>Osaka, Japan</td>
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<tr>
<td>21st International Mass Spectrometry Conference</td>
<td>West Toronto, ON, Canada</td>
</tr>
<tr>
<td>22nd Annual Meeting of the Organization for Human Brain Mapping</td>
<td>Geneva, Switzerland</td>
</tr>
<tr>
<td>22nd International High Magnetic Field Conference (HMF22)</td>
<td>Sapporo, Japan</td>
</tr>
<tr>
<td>28th ASMS Sanibel Conference on Mass Spectrometry: Characterization of Protein Therapeutics</td>
<td>Clearwater Beach, FL</td>
</tr>
<tr>
<td>29th International Symposium on Superconductivity (ISS 2016)</td>
<td>Tokyo, Japan</td>
</tr>
<tr>
<td>35th Annual Scientific Meeting of the American Pain Society</td>
<td>Austin, TX</td>
</tr>
<tr>
<td>41st International Conference on Infrared, Millimeter and Terahertz Waves</td>
<td>Copenhagen, Denmark</td>
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<tr>
<td>45th Southeastern Magnetic Resonance Conference (SEMRC)</td>
<td>Atlanta, GA</td>
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<tr>
<td>57th Experimental Nuclear Magnetic Resonance Conference (ENC)</td>
<td>Pittsburg, PA</td>
</tr>
<tr>
<td>59th Annual Meeting of Biophysical Society</td>
<td>Los Angeles, CA</td>
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<tr>
<td>60th Annual Biophysics Society Meeting</td>
<td>Long Beach, CA</td>
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</tbody>
</table>
## Chapter 4 – Education and Outreach

<table>
<thead>
<tr>
<th>Conference</th>
<th>Location</th>
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<tbody>
<tr>
<td>64th Amer. Soc. Mass Spectrometry Conference on Mass Spectrometry and Allied Topics</td>
<td>San Antonio, TX</td>
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<tr>
<td>64th American Society for Mass Spectrometry and Allied Topics</td>
<td>Sendai, Japan</td>
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<tr>
<td>71st Annual Meeting, Phys. Soc. Japan</td>
<td>San Diego, CA</td>
</tr>
<tr>
<td>251st American Chemical Society National Meeting &amp; Exposition</td>
<td>Philadelphia, PA</td>
</tr>
<tr>
<td>Advances in Strongly Correlated Electronic Systems (ASCES2016)</td>
<td>Minneapolis, MN</td>
</tr>
<tr>
<td>American Physical Society March Meeting 2016 (APS)</td>
<td>Baltimore, MD</td>
</tr>
<tr>
<td>An international symposium on recent advances in biomolecular NMR spectroscopy</td>
<td>Ann Arbor, MI</td>
</tr>
<tr>
<td>Anomalous Transport in Multipolar and Topological Materials Workshop</td>
<td>Baltimore, MD</td>
</tr>
<tr>
<td>Applied Superconductivity Conference 2016 (ASC)</td>
<td>Denver, CO</td>
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<tr>
<td>Association for the Sciences of Limnology and Oceanography (ASLO)</td>
<td>Pacific Grove, CA</td>
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<tr>
<td>Association of Science-Technology Centers (ASTC) Annual Conference</td>
<td>New Orleans, LA</td>
</tr>
<tr>
<td>Biomedical Engineering Society 2016 Annual Meeting (BMES)</td>
<td>Tampa, FL</td>
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<tr>
<td>Biomedical Sciences Seminar Series</td>
<td>Minneapolis, MN</td>
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<tr>
<td>Biophysical Society 60th Annual Meeting</td>
<td>Tallahassee, FL</td>
</tr>
<tr>
<td>Center for Computational Materials Sciences 2016 Fall Workshop</td>
<td>Los Angeles, CA</td>
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<tr>
<td>CIMTEC Congress 2016</td>
<td>Stony Brook, NY</td>
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<tr>
<td>Coated Conductors for Applications (CCA)</td>
<td>Perugia, Italy</td>
</tr>
<tr>
<td>Current status and Perspective of Super-High Field NMRs Operated Beyond GHz</td>
<td>Aspen, CO</td>
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<tr>
<td>Electronic Poster, The 24th Annual Meeting of the International Society for Magnetic Resonance in Medicine (ISMRM)</td>
<td>Kyoto, Japan</td>
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<tr>
<td>Electronic Poster, The 24th Annual Meeting of the International Society for Magnetic Resonance in Medicine (ISMRM)</td>
<td>Singapore</td>
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<tr>
<td>EMN meeting</td>
<td>Orlando, FL</td>
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<tr>
<td>European Conference on Molecular Spintronics (ECMoIS)</td>
<td>Bologna, Italy</td>
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<tr>
<td>FASEB Conf. on Virus Structure and Assembly</td>
<td>Steamboat Springs, CO</td>
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<tr>
<td>FFLO-Phase In Quantum Liquids, Quantum Gases, and Nuclear Matter (FFLO16)</td>
<td>Dresden, Germany</td>
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<tr>
<td>Florida ACS Meeting</td>
<td>Tampa, Florida</td>
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<tr>
<td>Florida chapter of the American vacuum society (AVS)</td>
<td>Orlando, FL</td>
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<tr>
<td>Geological Society of America Annual Meeting</td>
<td>San Diego, CA</td>
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<tr>
<td>George A. Olah Award in Hydrocarbon or Petroleum Chemistry: Symposium in Honor of Mieczyslaw M. Boduszynski, 251st Amer. Chem. Soc. National Meeting</td>
<td>Ventura, CA</td>
</tr>
<tr>
<td>Gordon Conference on Metals in Biology</td>
<td>Mount Holyoke, MA</td>
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<tr>
<td>Gordon Research Conference on Two-Dimensional Materials Beyond Graphene</td>
<td>Ventura, CA</td>
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<tr>
<td>Gordon Research Conference: Chemistry &amp; Biology of Peptides,</td>
<td>Berkeley, CA</td>
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<tr>
<td>Graduate Research Conference</td>
<td>Andover, NH</td>
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<tr>
<td>GRC ‘in vivo MR’</td>
<td>Heifei, China</td>
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<tr>
<td>Hefei International Conference on Novel Phenomena in High Magnetic Fields</td>
<td>Heifei, China</td>
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</tbody>
</table>
## Chapter 4 – Education and Outreach

<table>
<thead>
<tr>
<th>Conference</th>
<th>Location</th>
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<tbody>
<tr>
<td>High Temperature Superconductors in High Frequency Fields (HTSHFF)</td>
<td>Tiburon, CA</td>
</tr>
<tr>
<td>ICTP Conference on Interactions and Topology in Dirac Systems</td>
<td>Trieste, Italy</td>
</tr>
<tr>
<td>IEEE Low Temperature Superconductor Workshop (LTSW 2016)</td>
<td>Santa Fe, NM</td>
</tr>
<tr>
<td>International Conf. on Magnetic Resonance in Biological Systems</td>
<td>Kyoto, Japan</td>
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<tr>
<td>Intertwined Orders in Strongly Correlated Systems</td>
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<tr>
<td>ISMRM Scientific Workshop: Breaking the Barriers of Diffusion MRI</td>
<td>Lisbon, Portugal</td>
</tr>
<tr>
<td>LTSW 2015 Low Temperature Superconductivity Workshop</td>
<td>Santa Fe, NM</td>
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<tr>
<td>Lunar &amp; Planetary Science Conference XLVII</td>
<td>The Woodlands, TX</td>
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<tr>
<td>Mass Spectrometry and Proteomics Congress</td>
<td>London, UK</td>
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<tr>
<td>Mona Symposium 2016 (oral presentation)</td>
<td>Jamaica, W. I.</td>
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<tr>
<td>MRPM13 – International Bologna Conference on Magnetic Resonance in Porous Media</td>
<td>Bologna, Italy</td>
</tr>
<tr>
<td>MRS Fall meeting</td>
<td>Boston, MA</td>
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<tr>
<td>MRS-2016, Materials Research Society Spring Meeting</td>
<td>Phoenix, AZ</td>
</tr>
<tr>
<td>Multi-Component and Strongly-Correlated Superconductors</td>
<td>Stockholm, Sweden</td>
</tr>
<tr>
<td>Oral presentation, Physical Phenomena at High Magnetic Field (PPHM-8)</td>
<td>Tallahassee, FL</td>
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<tr>
<td>Organic Geochemistry Gordon Conference</td>
<td>Holderness, NH</td>
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<tr>
<td>PCSI-4</td>
<td>Palm Springs, CA</td>
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<tr>
<td>PQE-2016</td>
<td>Snowbird, UT</td>
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<tr>
<td>Quantum criticality and topology in itinerant electron systems</td>
<td>Albuquerque, NM</td>
</tr>
<tr>
<td>Rocky Mountain Conference on Magnetic Resonance, EPR Symposium</td>
<td>Breckenridge, CO</td>
</tr>
<tr>
<td>Second Int. Mtg. on Innovations in Mass Spectrometry Instrumentation and Methods</td>
<td>Moscow, Russia</td>
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<tr>
<td>September TechTopics</td>
<td>Tallahassee, FL</td>
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<tr>
<td>Soil Science Society of America</td>
<td>Phoenix, AZ</td>
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<tr>
<td>South Eastern Section American Physical Society (SESAPS)</td>
<td>Charlottesville, VA</td>
</tr>
<tr>
<td>Southern Section of AOAC Conference</td>
<td>Atlanta, GA</td>
</tr>
<tr>
<td>Strong Correlations and the Normal State of the High Temperature Superconductors</td>
<td>Dresden, Germany</td>
</tr>
<tr>
<td>Symposium on Condensed Matter Physics at ORNL and the National Magnetic Field Laboratory, at the 2016 Southeastern Section of the APS Conference (2016 SESAPS)</td>
<td>Charlottesville, VA</td>
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<tr>
<td>TB Summit</td>
<td>London, UK</td>
</tr>
<tr>
<td>TMS 2016 145th Annual Meeting &amp; Exhibition</td>
<td>Nashville, TN</td>
</tr>
<tr>
<td>Topological Phenomena in Novel Quantum Matter: Laboratory Realization of Relativistic Fermions and Spin Liquids</td>
<td>Dresden - Germany</td>
</tr>
<tr>
<td>Ultrahigh-Resolution Mass Spectrometry: A New Frontier Symp., PittCon 2016</td>
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### Conference

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<td>2016 Gulf of Mexico Oil Spill &amp; Ecosystem Science Conference</td>
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<td>2016 Workshop on Innovative Nanoscale Devices and Systems (WINDS2016)</td>
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<td>Department of Chemistry, Kansas State University</td>
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<td>FSU College of Medicine Life Science Symposium</td>
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<td>IGER International Symposium on Science of Molecular Assembly and Biomolecular Systems</td>
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<td>MS&amp;E faculty seminar, FSU</td>
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### Chapter 4 – Education and Outreach

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<td>National Postdoctoral Association annual meeting</td>
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<td>School on Current Frontiers in Condensed Matter Research</td>
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<td>XXI Ural International Winter School on the Physics of Semiconductors</td>
<td>Ekaterinburg-Samotsvet, Russia</td>
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<td>Young Researchers Meeting</td>
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Chapter 5

In-house Research
Condensed Matter Science

This section contains reports represent the widely varied activity of the NHMFL’s in-house condensed matter experimental scientists, and is not intended to be a complete summary of all in-house experimental work in that area.

1. Pressure Study of CeCu$_2$(Si$_{1-x}$P$_x$):

Lai, Y. (FSU, Physics); Saunders, S. (ISU, Physics); Gallagher, A. (FSU, Physics); Chen, K.-W. (FSU, Physics); Graf, D. (NHMFL) and Baubach, R.E. (NHMFL)

Introduction

Our earlier work studying Si → P chemical substitution in the heavy fermion superconductor CeCu$_2$Si$_2$ revealed a complex phase diagram that is similar to that seen for Si → Ge substitution. In the Si → Ge series, applied pressure suppresses the magnetism and produces two distinct superconducting domes, whose origins remain controversial. [1,2,3] Thus motivated, we studied the influence of applied pressure in our Si → P series, hoping to gain new insight into these materials’ unconventional superconductivity and other interesting behaviors.

Experimental

Electrical resistivity measurements were performed using a piston cylinder pressure cell with the pressure transmitting medium Daphne 7474 oil for pressures $P < 20$ kbar and temperatures $T < 300$ K. $P$ was determined from the shift in ruby fluorescence peaks below $T = 10$ K. These measurements were performed at the NHMFL DC Field Facility using He$^3$ cryostats and SCM1.

Results and Discussion

Measurements were performed for select concentrations ($x = 0.015, 0.043, 0.098$) spanning the $T$-$x$ phase diagram (Fig. 1). For $x = 0.015$ and 0.045, the magnetic ordering temperatures $T_N$ and $T_N$ are suppressed and are extrapolated to approach zero temperature near $P_c = 12 - 16$ and 18 - 22 kbar, respectively. Near $P = 15$ kbar for $x = 0.015$, superconductivity is recovered with an onset temperature $T_{SC} = 150$ mK. A departure from Fermi liquid behavior similar to what is seen for $x = 0$ is also observed. For both of these concentrations, the Kondo coherence temperature $T_{coh}$ increases with increasing $P$. For $x = 0.098$, the magnetic ordering temperatures $T_N$ and $T_C$ are suppressed by $P$, where the extrapolated critical pressures are above 20 GPa. $T_{coh}$ changes little with $P$.

Conclusions

Together with our earlier Si → P substitution study, this study demonstrates that the f-electron physics of CeCu$_2$Si$_2$ is controlled by at least two nearly independent parameters, electronic doping, and unit cell volume. [4] This insight will be useful to design novel behaviors such as superconductivity in the broader family of strongly correlated f-electron materials with the ThCr$_2$Si$_2$-type structure.

![Fig.1 Temperature $T$ - pressure $P$ phase diagram constructed from electrical resistivity measurements for CeCu$_2$(Si$_{1-x}$P$_x$)$_2$ at select concentrations $x = 0.015, 0.043,$ and 0.098.](image)

Acknowledgements

A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490 and the State of Florida. A portion of this work was supported by the NHMFL User Collaboration Grant Program (UCGP).

References

2. Carrier Compensation, Impurity Dependent Superconductivity, Anomalous Berry Phase and Bulk Fermi Surface of the Weyl Type-II Semi-Metal Candidate MoTe2

Rhodes, D.; Zhou, Q.; SchöNemann, R.; Zhang, Q.R. (NHMFL); Kampert, E.; Shimura, Y. (ISSP-Tokyo); McCandless, G.T.; Chan, J.Y. (UT-Dallas); Das, S. (NHMFL); Manousakis, E. (FSU Physics), M. D. Johann- nes (ONR) and Balicas, L. (NHMFL)

Introduction

Orthorhombic MoTe2 and its isometric compound WTe2 were recently claimed to belong to a new class (type II) of Weyl semi-metals [1-3] characterized by a linear touching between hole and electron Fermi surfaces in addition to nodal lines [3]. ARPES claims to confirm these predictions. To explore its electronic structure at the Fermi level, we synthesized high-quality MoTe2 single-crystals through a Te flux method.

Experimental

We performed detailed Hall-effect measurements as a function of temperature using a physical properties measurement system. We also performed magnetoresistance measurements in SCM1, at the pulsed field facility in Dresden, in addition to measurements in cell 12.

Results and Discussion

![Image](Fig1)

**Fig.1** Left panel: (a) Density of electrons and holes as a function of the temperature as extracted from a two-band model fitting of the raw Hall data. (b) Electron and hole Hall-mobilities as extracted from the two band model. Right panel: (a) Resistivity as a function of the temperature for several β-MoTe2 single crystals. Notice that these crystals display resistivity ratios ranging from hundreds to more than one thousand. (b) Low temperature cool-down curves, displaying superconducting transitions which are sample quality dependent. (c) Non-saturating magnetoresistivity of β-MoTe2 for fields along the c-axis. (d) Same as in c but for fields along the b-axis. (e) Oscillatory component superimposed onto the magnetoresistivity for several temperature. (f) Oscillatory signal superimposed onto the torque data of b-MoTe2. Red line is a fit to two Lifshitz-Kosevich oscillatory components which yield non-trivial Berry phases approaching π.

Conclusions

Two band analysis of the Hall-effect indicates that MoTe2 is a compensated semi-metal at low temperatures displaying high carrier mobilities which is consistent with its large and non-saturating magnetoresistance. De Haas van Alphen measurements reveal a Fermi surface geometry which is inconsistent with the band structure calculations and with ARPES, although it does indicate a non-trivial Berry phase close to π, as predicted for Weyl semi-metallic systems. The origin of this discrepancy remains unclear.

Acknowledgements

This work was supported by DOE-BES through award DE-SC0002613, and by the U.S. Army Research Office MURI Grant W911NF-11-1-0362. A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by NSF Cooperative Agreement No. DMR-1157490 and the State of Florida.

References

Chapter 5 – In-house Research

3. Electrical Transport on Superconductors I
Chan, M.K.; McDonald, R.D. and Harrison, N. (NHMFL, Los Alamos)

Introduction
The observation of a small reconstructed Fermi surface via quantum oscillations in hole doped cuprates opened a path towards identifying broken symmetry states in the pseudogap regime. However, such an identification has remained inconclusive due to the multi-frequency spectrum of quantum oscillations and complications in accounting for bilayer effects in most studies. We overcome these impediments with high resolution quantum oscillation measurements on the structurally simpler single layer cuprate HgBa$_2$CuO$_{4+\delta}$ (Hg1201).

Experimental
Experiments were performed with the 65T short pulse magnet as well as the 100T magnet at the NHMFL, Los Alamos. Contactless measurements were performed with a Proximity Detector Oscillator Circuit (PDO).

Results and Discussion
Figure 1 shows our successful measurements of Shubnikov de-Haas oscillations in Hg1201, Hg1201 exhibits only a single oscillatory component with no signatures of magnetic breakdown tunneling to additional orbits. Therefore, the reconstructed Fermi surface is comprised of only a single quasi-two-dimensional pocket. Quantitative modeling of these results indicate that biaxial charge-density-wave order within each CuO$_2$ plane is responsible for the reconstruction, and rules out ‘criss-crossed’ charge stripes between layers as a viable alternative in Hg1201. Lastly, we determine that the characteristic gap between reconstructed Fermi surface pockets is a significant fraction of the pseudogap energy.

Acknowledgements
This work, performed at Los Alamos National Lab, was supported by the US Department of Energy BES “Science at 100 T” grant no. LANL100. The National High Magnetic Field Laboratory is funded by the National Science Foundation and the State of Florida.

References

Fig.1 Shubnikov-de Haas oscillations in the cuprate high-Tc superconductor Hg1201 measured in maximum field of 90 T with a proximity-detector oscillator circuit

4. Collective Dynamics at the Structural and Charge-Density-Wave Transition in Stripe-Ordered La1.48Nd0.4Sr0.12CuO4
Baity, P.G.; Popović, D. (FSU, Physics and NHMFL) and Sasagawa, T. (Tokyo Inst. of Tech.)

Introduction
The role of various forms of charge and spin density wave orders (“stripes”) observed in underdoped cuprate high-Tc superconductors is one of the main open issues in the field [1]. In particular, the search for fluctuations of charge-density-wave (CDW) order has been the subject of intensive research with the goal to clarify their relationship to high-T$_c$ superconductivity [2]. While the stability of the CDW order and its short-range nature are usually believed to be due to the pinning by disorder [3], in general the existence of nanodomains, resulting from the interplay of various degrees of freedom [4], may be expected to give rise to an exponentially large number of metastable states, perhaps even in the absence of disorder [5]. Thus the key questions
that arise are whether the observed static domain structures correspond to a ground state or a long-lived metastable state, and the role of disorder. We address these issues by studying La$_{1.48}$Nd$_{0.52}$Sr$_{1.2}$CuO$_4$ (LNSCO), which exhibits a CDW order only below a first-order structural phase transition from the low-temperature orthorhombic (LTO) to the low-temperature-tetragonal (LTT) phase.

**Experimental**

Out-of-plane magnetoresistance (MR) has been measured on high quality LNSCO single crystals with $x=0.12$ near the LTO-LTT and CDW transitions ($T_{\text{LTT}}=70.8\pm0.5$ K, $T_{\text{CDW}} \leq T_{\text{LTT}}$) with $H \parallel c$ up to 12 T [6,7]. A standard four-probe dc reversal technique was used to measure resistance, and field sweep rates were low enough to avoid sample heating. Before each MR measurement, the sample system was prepared by warming to 90 K, cooling to 40 K, then finally warming to the measurement temperature without overshoot.

**Results and Discussion**

We find evidence for the existence of metastable states and collective dynamics in the form of avalanches and return-point memory. Avalanches are only observed during the initial sweep to higher fields (Fig. 1), and were only observed if temperature overshoot was avoided before measuring MR. After the initial sweep, the $H=0$ resistance is decreased, indicating that the system acquires a memory of its magnetic history. A detailed analysis of the avalanche statistics provides information about the collective dynamics of domains, which are strongly pinned by disorder [7].

**Conclusions**

We have measured MR in LNSCO single crystals and found evidence of long-lived metastable states in the CDW-ordered phase, but only when the transition is approached from the CDW-ordered side. By unveling the asymmetry of the transition, these results also point a way to detecting fluctuating CDWs in other cuprates.

**Acknowledgements**

This work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agree-

**References**


**5. Dielectric Measurements at Ultra-Low Temperatures and High Magnetic Fields**

Xia, J.-S. (High B/T Facility, NHMFL); Yin, L. (High B/T Facility, NHMFL); Zapf, V.S. (Los Alamos National Laboratory & NHMFL); Paduan-Filho, A. (University de Sao Paulo, Brazil) and Sullivan, N. (High B/T Facility, NHMFL)

**Introduction**

A new device has been developed to measure the magneto-electric effects and dielectric susceptibilities in organic quantum magnets and other materials down to mK temperatures.
Experimental

The unique feature of the device is the immersion of the sample in liquid $^3$He which is cooled with a large (25 m$^2$) surface area sintered silver heat exchanger connected to the nuclear stage of a demagnetization refrigerator. In addition to a DC applied magnetic field (up to 16 T) an AC magnetic field is provided by a Helmholtz coil located outside the sample. With this design the magnetic field dependent electric susceptibilities, and the DC and AC resistance can be measured simultaneously. The sample is held between the plates of a capacitance immersed in the liquid $^3$He and the variation of the capacitance compared to a nearby reference is measure using a standard bridge with an isolated ratio transformer.

Results and Discussion

The overall sensitivity for measurements of the electric susceptibility $\varepsilon=\varepsilon'+j\varepsilon''$, is 0.1 ppm for $\varepsilon'$ and 10 ppm for $\varepsilon''$. For Br-doped dichloro-tetrakis-thiourea Ni (NiCl$_2$-4SC(NH)$_2$ we have observed a quadratic magnetic field dependence of the electric polarization in the Bose-Einstein condensed state for $0.9 < B < 11.3$ T, consistent with the observations of Ref. [1], followed by a drop at the transition to the Bose Glass state for $11.3 < B < 12.4$ T.

Conclusions

A high sensitivity device has been realized for measurements of the dielectric susceptibility of materials down to mK temperatures with a precision of 0.1 ppm.

Acknowledgements

This work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490 and the State of Florida. This work was presented at the 2016 International Symposium on Quantum Fluids and Solids by Jian-sheng Xia (to be published).

References


MagLab 2016 Annual Report
Experimental

Variable temperature- and field-dependent PL-MCD measurements were carried out in Cell 3 of the NHMFL. A sample of the MPC Au_{25}(SC_8H_9)_{18} dispersed in a polystyrene film was loaded into a 17.5T magnet under vacuum and cooled to 4.5 K. Electronic excitation was achieved using a regeneratively amplified Ti:Sapphire laser system (Legend, Coherent). The resulting PL spectra and lifetimes were collected as a function of varying field <17.5 T and temperature <200K. Isolation of emission from fine-structure states was achieved using a polarization film mounted directly after the sample slide and control over the direction of applied field (figure 1).

Results and Discussion

The resulting field-dependent difference PL spectra taken at 4.5 K are shown in figure 2. The spectra were fit to multiple Gaussian curves corresponding to separate emissive fine-structure contributions to the total PL. The relative intensities of each component were plotted as a function of applied field at multiple sample temperatures allowing for the quantization of the state’s Lande g-factor (figure 3). The g-factor of 1.7 +/- 0.1 for the 1.78 eV curve suggests emission from a quartet P-state which agrees with theory and signifies the first experimental determination of the total angular momentum of an excited state in MPCs. Saturation behavior of the magnetization curves occurred only at 4.5K suggesting a thermal energy activation barrier to field-induced state mixing effects on the order of k_BT. To quantify this activation barrier, Arrhenius analysis of the field-dependent PL lifetimes was carried out to find an energy barrier of ~0.63 meV.

Conclusions

Through temperature- and field-dependent measurements, we were able to quantify the spin character of emissive states in the Au_{25}(SC_8H_9)_{18} MPC as well as calculate the energy barrier for field-dependent state-mixing. In order for these systems to progress further in becoming practical photonic and spintronic materials, these types of measurements are necessary on a structurally-varying series of clusters. This should allow us to obtain a structurally predictive model for understanding the optical properties of MPCs.

Acknowledgements

A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490 and the State of Florida. In addition, this work was supported by an award from the National Science Foundation to K.L.K., under Grant Number CHE-1150249.
Chapter 5 – In-house Research

References

7. Exciton Magnetic Polarons in (CdMn)Se Colloidal Nanocrystals

**Rice, W.D.; Crooker, S.A. (NHMFL-Los Alamos); Liu, W. and Klimov, V.I. (Chemistry Division, LANL)**

**Introduction**

Advances in the colloidal synthesis of magnetically-doped nanomaterials have sparked a renewed focus on low-dimensional magnetic semiconductors. The interesting magnetic properties of these materials originates in the strong sp-d exchange interactions that exist between carrier spins (i.e., band electrons and holes with s- and p-type wavefunctions) and the local 3d spins of embedded paramagnetic dopant atoms such as Mn, Co, or Fe. At the microscopic level, the strength of this interaction for a dopant located at position \( r \) scales with the probability density of the carrier envelope wavefunctions at that point: \( \mid \psi(r) \mid ^2 \). As such, local spin-spin interactions can be greatly enhanced by strong quantum confinement, which compresses carrier wavefunctions to nanometer-scale volumes and therefore increases \( \mid \psi(r) \mid ^2 \). The extent to which these exchange interactions can be enhanced and controlled via quantum confinement is an area of significant current interest.

A particularly striking consequence of sp-d interactions in II-VI semiconductors is the formation of exciton magnetic polarons (EMPs), wherein the effective magnetic exchange field from a single photogenerated exciton -- \( B_{ex} \) -- induces the collective and spontaneous ferromagnetic alignment of the magnetic dopants within its wavefunction envelope, generating a net local magnetization even in the absence of any applied field. In turn, these aligned local moments act back on the exciton’s spin, which lowers the exciton’s energy, further localizes the exciton, and further stabilizes the polaron.

**Experimental**

An especially powerful and incisive technique for directly revealing the presence and properties of magnetic polarons is the method of resonant PL. Here, a narrow-band excitation laser, tuned to the low-energy side of the exciton absorption peak, resonantly excites low-energy ‘cold’ excitons. Subsequently, the exciton’s exchange field \( B_{ex} \) aligns the Mn\(^{2+} \) spins, forming an EMP, which in turn lowers the exciton’s energy. When the exciton recombines, it therefore emits a lower-energy photon. Thus, the Stokes shift between the pump laser and the emitted PL directly reveals the polaron binding energy. Moreover, the resonant PL linewidth provides insight into Mn\(^{2+} \) spins fluctuations. To date, however, this powerful technique has never been applied to study EMPs in colloidal nanocrystals, despite the fact that they represent the strongest case of 0D quantum confinement, in which sp-d exchange interactions are expected to be most enhanced.

![Fig.1 Resonant PL spectra from CdMnSe nanocrystals at 1.8K, from B=0 to 7T. The narrowing and shift of the emitted PL are hallmarks of magnetic polaron formation.](image)

**Results and Discussion**

Despite small Mn\(^{2+} \) concentrations (\( x=0.4-1.6\% \)), large polaron binding energies from 8-30 meV are observed at low temperatures via the substantial Stokes shift between the pump laser and the resonant PL maximum, indicating the complete alignment of all Mn\(^{2+} \) spins by \( B_{ex} \). Temperature and magnetic field-dependent studies reveal that \( B_{ex} \sim 10T \) in these nanocrystals, in good agreement with theoretical estimates. Further, the emission linewidths provide direct insight into the statistical fluctuations of the Mn\(^{2+} \) spins. These resonant PL studies provide detailed insight into collective magnetic phenomena, especially in lightly-doped nanocrystals where con-
8. Theoretical Studies of Fractional Quantum Hall Liquids

Yang, K. (NHMFL) and Wan, X. (Zhejiang Univ.)

Introduction

Fractional Quantum Hall (FQH) liquids represent novel states of matter with non-trivial topological order. Consequences of such topological order include chiral edge excitations with predicted universal properties. Some of these states may support exotic bulk quasiparticle (qp) excitations with non-Abelian statistics, and the prime candidate is the 5/2 fractional quantum Hall state. However the qp statistics as well as edge properties of the 5/2 state remains puzzling. We proposed a new state that can potentially describe the 5/2 state and explain the experimental observations. In addition to topological aspects, it has become clear in recent years that there is also a geometrical aspect in FQH liquids. Quantum fluctuations of the geometric degree of freedom gives rise to long wavelength collective modes in them known as gravitons. We have found a way to excite and detect these gravitons.

Methods of Theoretical Studies and Results

Existing models for the 5/2 state includes the Moore-Read Pfaffian (Pf) state, and its particle-hole conjugate anti-Pfaffian (APf) state. In Ref. [1] we showed that a stripe state that is made of alternating regions of Pf and APf states is a viable candidate of the 5/2 state. We were able to show that this state is incompressible, and thus a fractional quantum Hall state. We also demonstrated that this new state has many exotic bulk and edge properties that are consistent with existing experiments.

In Ref. [2] we demonstrated that acoustic waves in crystals play a role very similar to gravitational waves in FQH liquids, as the strain it induces couple directly to the electron effective mass tensor whose role is very similar to the metric tensor. It can excite the gravitons, whose energy is revealed in a resonance peak of the acoustic wave absorption spectroscopy. Numerical study of the spectral function indeed reveals the graviton peak prominently.

Conclusions

We have performed comprehensive theoretical studies on FQH liquids. Our results have provided new methods to probe these novel states of matter.

References


Acknowledgements

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9. Pressure and high-Tc Superconductivity in Sulfur Hydrides

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Introduction

The search for high-Tc (“room”) superconductivity at high pressure was triggered by the suggestion that one can expect high values of Tc in systems comprised of light atoms, including the metallic hydrogen. It is based on the fact that according to the BCS theory, the transition temperature is proportional to the frequency of phonons mediating the pairing. Half a century later, superconductivity at 190 K was claimed in sulfur hydrides under pressure P>150GPa1. Recently, Tc=203K was confirmed in In H3S formed in the decomposition of H2S under pressure2.

Results and Discussion

The rapid increase of Tc with pressure in the vicinity of Pcr =120GPa is interpreted as the fingerprint of a first-order structural transition. Based on the cubic symmetry of the high-Tc phase, it is argued that the lower-Tc phase may have a different perio-
Magneticty, possibly related to an instability with a commensurate structural vector. In addition to the acoustic branches, the phonon spectrum of H$_3$S contains hydrogen modes with much higher frequency. Because of the complex spectrum, usual methods of calculating Tc are here inapplicable. A modified approach is formulated and shown to provide realistic values for Tc and to determine the relative contributions of optical and acoustic branches. The isotope effect (the change of Tc upon Deuterium for Hydrogen substitution) originates from high frequency phonons and differs in the two phases. The decrease of Tc following its maximum in the high-Tc phase is a sign of intermixing with pairing at hole-like pockets which arise in the energy spectrum of the cubic phase at the structural transformation. Pairing on the pocket leads to the appearance of a second gap and is remarkable for its non-adiabatic regime as hydrogen mode frequencies are comparable to the Fermi energy on a pocket.

Conclusions
The results are in the qualitative agreement with the experimental behavior of Tc as a function of pressure.$^3$

Acknowledgements
A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490 and the State of Florida.

References
Cryogenics Research Group

The Cryogenics Laboratory located at the National High Magnetic Field Laboratory is a fully developed facility for conducting low temperature experimental research and development. A number of specialized experimental equipment are available in the lab, which include the Cryogenic Helium Experimental Facility (CHEF) for horizontal single and two-phase heat transfer and flow research, the Liquid Helium Flow Visualization Facility (LHFVF) for high Reynolds number superfluid helium (He II) flow visualization research, the Laser Induced Fluorescence Imaging Facility (LIFIF) for high precision molecular tagging velocimetry measurement in both gaseous and liquid helium, and the Cryogenic Magnetic Levitation Facility (CMLF) for studying cryogenic fluid hydrodynamics in micro-gravity. The laboratory supports in-house development projects as well as contracted scientific work directed by two faculty members, Prof. Guo and emeritus Prof. Dr. Van Sciver, of the Mechanical Engineering department at Florida State University.

The major research focus of the cryogenics lab currently includes: 1) fundamental turbulence and heat transfer research in He II; 2) quantized vortex-line imaging in levitated helium drops; 3) catastrophic loss of vacuum accidents in liquid helium cooled systems; 4) multilayer insulation (MLI) material thermal property characterization. These research activities are supported by external funding agencies including the National Science Foundation (NSF), the Department of Energy (DoE), the National Aeronautics and Space Administration (NASA), and our industrial partners.

**Turbulence research with He II:** Many flows in nature have extremely high Reynolds (Re) or Rayleigh (Ra) numbers, such as those generated by flying aircraft and atmospheric convection. Better understanding of these flows can have profound positive impacts on everyday life, such as improving the design in energy efficient applications and our understanding of climate change. To achieve large Re values in laboratory, a common route is to increase the characteristic length of the flow, which normally requires the construction of expensive and energy consuming large-scale flow facilities and wind tunnels. An alternative method is to use a fluid material with very small kinematic viscosity. At the cryogenics lab, we adopt helium-4 as the working fluid. Helium-4 has extremely small kinematic viscosity (3 orders of magnitudes smaller than that for air) which enables the generation of highly turbulent flows in compact table-top equipment. Furthermore, when helium-4 is cooled below about 2.17 K, it undergoes a phase transition into a superfluid phase (He II) which consists of two intermiscible fluid components: a viscous normal component and an inviscid superfluid fluid component. Turbulence in He II is a cutting-edge research area that is important both in fundamental science and in practical applications of He II as a coolant. In order to make quantitative flow field measurements, we have developed two powerful flow visualization techniques. One is the so-called molecular-line tagging technique which is developed based on tracking thin lines of He2 excimer tracers created via femtosecond-laser field ionization of helium atoms (see Fig. 1). Besides this technique, a

**Figure 1:** (a) Schematic diagram of the experimental setup for flow visualization using He2 molecules. A high intensity femto-second laser (red beam) through the windows ionizes helium atoms and creates a tracer line of He2 excimer molecules. Then the imaging laser at 905 nm (yellow beam) drives the tracers to produce fluorescent light (640 nm) for the imaging. (b) Typical images of the tracer line in thermal counterflow generated by an applied heat flux in He II. The deformation of the tracer lines provides quantitative information about the velocity field in He II.
particle tracking velocimetry method in He II using seeded micron-sized frozen hydrogen particles has also been developed and implemented. The application of these techniques to the study of heat induced flow in He II has revealed a novel form of turbulence (counterflow turbulence). A systematic characterization of this turbulence will be indispensable for developing a theoretical understanding that will potentially benefit the design of He II based cooling systems.

**Vortex imaging in levitated helium drops:** The motion of quantized vortex lines is responsible for a wide range of phenomena, such as the decay of quantum turbulence and the initiation of dissipation in type-II superconductors, and it is also implicated in the appearance of glitches in neutron star rotation and the formation of cosmic strings in the early universe. A systematic study of vortex-line dynamics promises broad significance spanning multiple physical science disciplines. In He II, vortex lines can be directly visualized by imaging tracer particles trapped on the lines. However, producing tracers in helium at low temperatures and imaging the trapped tracers remains challenging, and the container walls can often affect the vortex-line motion. In the cryogenics lab, a magnetically levitated helium-4 drop is used as the working system, in which the vortices can be produced via fast evaporative cooling and controllable drop rotation (see Fig. 2). These vortices can be decorated with He₂ excimer tracers or fluorescence nano-particles which can be imaged via laser-induced fluorescence. This process can enable unprecedented insight into the behavior of a rotating superfluid drop and will untangle some key issues in quantum turbulence research.

**Loss-of-vacuum heat and mass transfer:** High performance superconducting magnets and superconducting radio frequency (SRF) cavities are essential components of almost all future high energy particle accelerators. These magnets and SRF cavities are normally cooled by liquid helium. The study of the heat and mass transfer processes that can occur during a sudden catastrophic loss of vacuum (SCLV) incident in a liquid-helium cooled system is therefore of great importance to the design and safe operation of the superconducting magnets and SRF cavities. A project has been launched in the cryogenics lab to study how a gas such as atmospheric air/nitrogen will condense inside a liquid-helium cooled vacuum tube while the gas simultaneously propagates down the vacuum space. Systematic study on the propagation of condensable gas (air or nitrogen) in a vacuum tube cooled by liquid helium at 4.2 K has been carried out. The variations of the temperatures at different locations along the tube following the vacuum break were studied at controlled inlet gas pressure. We

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**Figure 2:** Schematic of the experimental apparatus inside the optical cryostat for visualizing quantized vortex lines in a magnetically levitated helium drop.

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**Figure 3:** (left) Schematic of the helix tube and the top flange of the cryostat. (right) Schematic diagram of the vacuum break experiment in He II.
have observed exponential deceleration of the gas front velocity as the gas propagates along the vacuum tube. A phenomenological model has been developed by which explains the deceleration as a consequence of the gas condensation on the inner wall of the tube. Based on this model, we have calculated the decay time constant by examining the heat transfer into the helium. The result compares well with the decay time constant obtained directly from the measured gas front velocity. A new experimental rig that will incorporate a vacuum tube of helical geometry has been designed for He II immersion experiments (see Fig. 3). We expect to retrieve significantly more data per run of the experiment with the new rig/tube while being more efficient with the usage of helium.

**Multi-layer insulation thermal conductivity experiment (MIKE):** The Multi-layer Insulation thermal performance of multi-layer insulation (MLI) materials. This lightweight insulation is composed of alternating thin reflective layers with insulating layers and is used as a high performance insulation for spacecraft, cryogen storage tanks, MRI’s, and space-borne instruments. We have designed and fabricated a special facility for measuring MLI effective thermal conductivity (see Fig. 4). This facility consists of two concentric copper cylinders which are temperature controlled by cryocoolers and heaters. The MLI is attached in-between the cylinders by taping each layer to itself. The heat from the warm cylinder flows through the MLI to the cold cylinder and then through a calibrated rod to determine the heat load. The cylinder measures 191 mm in diameter and 1232 mm long. The warm cylinder measures 272 mm in diameter and 1524 mm long. This facility has allowed us to conduct systematic characterization of the thermal properties of MLI materials. This capability has attracted funds from funding agency such as NASA as well as space industrial partners. Our research projects have allowed us to support both undergraduate and graduate students. We have also been able to engage interns, visiting students and scholars. These students have obtained training and experiences in fluid dynamics, cryogenics, advanced laser technologies, electronics, and data analysis techniques. These skills are applicable to nearly all STEM related fields, giving these students the technical dexterity necessary to excel in today’s science and technology dominated market. All the students support by our project have also had the opportunity to develop teamwork and communication skills by working closely with facilities engineers, mechanics, electricians, machinists, safety engineers, and welders throughout the construction of the experimental facility. Our cryogenics lab is also involved in various outreach activities, such as contributing demonstration experiments for the annual open house event at the NHMFL. In April 2017, the cryogenics lab will host a three-day international workshop on quantum turbulence research, sponsored by the NHMFL, FSU, and the NSF. This event is expected to enhance FSU’s profile in quantum fluid research and will provide young researchers the opportunity to interact with eminent scientists in the quantum fluid field.

![Figure 4: Schematic of the facility built for MIKE research.](image)
Geochemistry

The facility primarily investigates natural processes, both recent and ancient, through the analysis of trace element contents and isotopic compositions.

Introduction

The Geochemistry Program funding is through grants from the Geoscience directorate at NSF, NASA, and the USGS. All tenure-track faculty have their appointments in FSU's College of Arts and Sciences. The facility has six mass spectrometers, which are available to outside users. Three instruments are single collector inductively coupled plasma mass spectrometers for elemental analysis, of which one is dedicated to in-situ trace element analyses on solid materials using laser ablation. The other two are dedicated to elemental analyses of solutions. The facility has three mass spectrometers dedicated to determination of isotopic compositions. One is a multi-collector inductively coupled plasma mass spectrometer (NEPTUNE) used for determination of isotopic abundances of metals. A second is a thermal ionization multi collector mass spectrometer, which is mainly used for Sr-isotopic compositions. The third mass spectrometer is designed for the measurement of the light stable isotope compositions (C, N, O). A fourth mass spectrometer dedicated to sulfur isotope analyses has arrived but is not installed.

Publications and Outreach

The group members have published 23 peer reviewed publications and a similar number of presentations at meetings and invited presentations at other institutions. The group involves a large number of undergraduate students in their research.

Science Highlights

The Macondo well oil spill introduced a large amount of organic matter into the Gulf of Mexico. The recovery of the ecosystem in response to this oil spill is an issue of debate. For example, remnants of the Exxon Valdez oil spill are still present in the sediment. The oil that is spilled in the Gulf was formed millions of years ago and has a different isotopic composition than present-day carbon and is “dead” with respect to radioactive carbon-14, which had a half-life of 5,730 years, and will yield old ages. Time series measurements of carbon-14 age and carbon isotopic composition of the sediment from traps in the Gulf near the Macondo well reveal how long this “old” carbon is still present in the bottom of the food web. Our isotope data indicates that it took up to 6 months after the oil spill ended before the phytoplankton at the bottom of the food web was devoid of spill carbon. The lingering of the spill carbon in the water column is much longer than the residence time of the oil at the sea-surface, which is only several weeks.

A new direction of research started this year is the use of metal stable isotopes to determine the paleoredox conditions. In particular, thallium isotopes are sensitive to redox conditions as adsorption to Mn-oxides is one of the two outputs from seawater. The oxygen concentration in the atmosphere increases from near-zero levels in the early Archean to present-day levels. Mn-oxides will form and precipitate during the early oxygenation of the oceans, but it is difficult to determine Mn-burial in ancient sediment. This past year we established an analytical technique for Tl-isotopes and show that Tl-isotopes in sediments faithfully record the seawater Tl composition and that there is an isotope effect associated with a change from anoxic to oxic conditions. This shows for the first time that Tl-isotopes can be used as a paleoproxy of redox conditions in the oceans.

Progress on Stem and Building the User Community

The facility is open to users of all disciplines, and we have a long-time collaboration with the USGS and the South Florida Water Management District. During the summer we hosted one undergraduate student from the REU program; nineteen undergraduate students are involved in research throughout the year. In the last year 65 users, of which 52% are female, used our analytical facilities. Graduate student users are 65% female. Within the area of Geosciences the faculty has collaborations with researchers throughout the US, Europe as well as Asia. The disciplines for which we do service analyses at a more local level range from magnet science to pharmacy. We also receive several requests per year from the public to identify rock samples that are found, often with the expectation that the sample is a meteorite. In addition, we have helped the Leon County school system with identifying whether there is a problem with the lead levels in drinking water at schools.
Magnets and Materials

Introduction

A central feature of the MagLab’s mission is the provision of unique, high-performance magnet systems that exploit the latest materials and magnet design developments for our users. As we move forward, maintaining a balance of development of new magnet systems with development of new technology is of critical importance to keep us at the forefront. Collaborations with other leading industrial, academic, and government groups that develop these new magnet technologies is built into many of these thrusts.

Executive Summary

During 2016 the MagLab made progress on many fronts. In particular:

1) The 36 T Series-Connected Hybrid magnet has reached 36.2 T, exceeding specification! The magnet includes current-density grading in the innermost resistive coils to cancel the z2 term. NMR mapping of the magnet has started and the homogeneity of the magnet is better than anticipated. Oxford NMR has developed resistive shim coils for the magnet and is developing ferromagnetic shims presently. After shimming to 1 ppm over a 1-cm diameter spherical volume, we will start testing of the stabilization system to reduce the field fluctuation from ~20 ppm to < 1 ppm. We expect the magnet to be ready for external users in 2Q2017, raising the field available for condensed-matter NMR 44%! This low-power resistive magnet, combined with probes developed in-house and a console from the commercial sector, will open a new era in ultra-high field (UHF) NMR which should build the case for UHF high-resolution NMR magnets (Fig. Summ 1).

2) In 2016 assembly of the 32 T superconducting magnet was completed (Fig. Summ 2). Presently the protection system is being tested and high-current testing of the magnet should start shortly. This magnet should be the first UHF magnet using High-Temperature Superconducting (HTS) materials to be put into routine service to the scientific community later this year.

3) The MagLab has been developing No-Insulation REBCO coils for a couple of years. By leaving out the insulation between turns, the current is able to flow around a quench (into adjacent turns) when one occurs. This means less Cu is required in the conductor for protection and the resulting coil is much more compact. In 2016 an NI-REBCO coil was installed in the bore of our 31 T, 50 mm bore resistive magnet and reached 9T of self-field for a total field of 40 T. In early 2017 a similar coil reached 42 T. This self-field of 9T constitutes a factor of 1.8 times the best that has been attained using any other HTS conductor or coil technology.

4) Work is also being conducted developing technology that might be suitable for NMR magnets based on HTS conductors. Specifically, Bi2223 and Bi2212 are multifilamentary which results in them having less screening current and less field inhomogeneity upon charging than REBCO does.

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**Fig. Summ 1.** Orange line shows inhomogeneity of SCH prior to shimming. Red line shows shimmed homogeneity, <1 ppm over 10 mm cylinder.

**Fig. Summ 2.** 32 T magnet being assembled.
Bi2223 is now available in a high-strength version that shows promise for ultra-high field (UHF) NMR magnets, and test coils are being made to verify viability. Round Wire Bi2212 is a Wind and React technology that most closely approximates the low temperature superconductor technology of Nb-Ti and Nb$_3$Sn but the price is that putting it into the superconducting state must be done by the user (as must Nb$_3$Sn in most cases too). Both the conductor and the coil technology advanced in significant ways in 2016, especially in scaling up into coil-sized overpressure (OP) reaction furnace technology. It has also now been made in a high-strength form and also shows great promise for NMR magnets due to its multi-filamentary nature and round, isotropic structure.

5) Great progress continues to be made on both HTS and LTS conductor technology. A major effort to understand length-wise variations of REBCO coated conductors has shown up many kinds of defects that appear in as-delivered and as-tested wires. A major effort, in collaboration with DOE-High Energy Physics and the industrial base has been put into assuring new Bi-2212 powder suppliers and into understanding the parameters that must be specified in order to specify “good” powder. Major successes in understand the highest current-density forms of Nb$_3$Sn, RRP and PIT, have shown the vital role played by ternary phase (Nausite, a Sn-Nb-Cu intermetallic) membranes in mediating Sn diffusion in the low temperature portion of the reaction of Nb$_3$Sn conductors.

6) Pulsed magnets had another good year in 2016. We continued to operate the new 74 T magnet with the bore size of 7 mm. The magnet operates stably and has delivered more than 100 shots above 70 T for users to perform successful experiments in that small bore and at temperatures as low as 500 mK. The 100T magnet system delivered more shots than any other year in its history by a significant margin (238 shots, of which 50 shots are above 90 T and 80 shots are above 80T). Magnet pulses to 95.4 tesla were delivered for user experiments.

LTS Magnets and Materials

FSU Series-Connected Hybrid

The Series-Connected Hybrid (SCH) magnet at FSU will provide 36 T in a warm bore of 48 mm for condensed-matter NMR. It is designed to have a uniformity and stability of 1 ppm over a 10 mm diameter spherical volume. It features state-of-the-art compact ferromagnetic and resistive shims developed by Oxford NMR. While the power supply has ~10 ppm of ripple and noise, an active feedback-control system developed in collaboration with Penn State University increases the field stability. This system employs both an inductive pickup coil and an NMR lock. The focus in 2016 was primarily on integration of the magnet system into the house utilities. These include a cryosystem to deliver 4.5 K supercritical helium to the outsert coil at 3 – 3.5 bar and a chilled water system to supply 25 bar at 1201/s to the resistive coils and a 20 kA, 700 V power supply. In addition, a major effort was directed at completion of the monitoring, control, and protection system as well as testing of the various subsystems and the final combined system.

Fig. SCH 1. The Series-Connected Hybrid (background) with Iron Shield Installed and Personnel Monitoring the System during Magnet Testing.

A significant accomplishment was achieved at the end of 2016 with the operation of the FSU Series-Connected Hybrid (SCH) to full current which produced a central field of 36.2 T. The hybrid magnet consists of a 23 T resistive Florida-Bitter insert coil set nested inside of a 13 T superconducting coil wound with high critical current density Nb$_3$Sn/Cu cable-in-conduit conductor. The resistive and superconducting coils are connected electrically in series and operate at 20 kA. To restrict the fringe field to less than 10 gauss in public spaces and to reduce field fluctuations in the SCH sample space from neighboring magnets, 16.4 tons of iron was installed around the SCH. A recent photograph
of the SCH, iron shield, and user platform is shown in Figure SCH 1.

In the summer of 2016, the SCH was cooled down to 4.5 K. The initial cool-down stage was achieved using a dedicated 80 K cold box which is a nitrogen heat exchanger that intercepts heat from the recirculated helium flow. Once the coil reached 80 K, further reduction in temperature was achieved with the MagLab’s helium refrigerator and cryogenic distribution box which has a 500 liter buffer dewar to subcool the refrigerator’s helium stream to 4.5 K.

Magnet testing was achieved over a number of stages. The first stage demonstrated full current of the resistive insert only; other stages included the combined resistive and superconducting magnets. The first phase of combined magnet testing was limited to 3 kA such that the protection system and safety interlocks could be fully debugged without endangering equipment or personnel. Magnet testing progressed in sequentially higher current steps while continuing to test the safety systems. On November 8 of 2016, the SCH was brought to full field for the first time.

Initial mapping results without shims show a uniformity of ~20 ppm over 1 cm DSV. This is much better than anticipated. A first set of ferroshims has been developed and installed reaching ~4ppm. Testing of resistive shims is starting. These results are better than what was obtained previously in the all-resistive Keck magnet and provide confidence that the target of 1 ppm will be achieved. Future work includes additional detailed mapping and implementation of the temporal field stability system.

### LTS Conductor Optimization

High critical current density, $J_c$, Nb$_3$Sn wire ($J_c \geq 2500$ A/mm$^2$, 12 T/4.2 K) can be manufactured by the internal Sn (IT) or powder in tube (PIT) processes. Our studies are aimed at improving the properties of both types primarily for applications in high energy physics (who support the work). The highest critical current density wires are those produced by the IT-based “RRP” process at Bruker-OST, but the PIT wires produced by Bruker-EAS offer potentially better magnet stability through their smaller effective filament diameters. Below we summarize our principal findings for both Bruker-OST RRP and Bruker-EAS PIT wires:

1. **RRP**: New Heat Treatments for Higher Critical Current Density

Throughout the development of Internal Tin Nb$_3$Sn superconducting wires, the initial heat treatment conditions have been empirically derived for each wire design. However, historically developed heat treatments do not necessarily apply to the new generation of High $J_c$ internal Sn strands that are becoming increasingly important for the next generation of high field accelerator magnets designed for the High Luminosity upgrade of the LHC. In particular our studies show that standard heat treatment schedules are not optimized for the small effective filament diameter ($D_{eff}$) designs that will be required for these magnets. Therefore we have performed the first in depth exploration and optimization of these heat treatments based on quantitative analysis of the microstructures. We find that the key process in developing a homogeneous and efficient microstructure is the formation and control of a Sn-Nb-Cu "Nausite" phase membrane separating the Sn-core components from the Cu-Nb filament pack. This new understanding has allowed us to develop heat treatments that have increased $J_c$ values by as much as 26% in small $D_{eff}$ wires.

For these studies we use partially reacted wires “quenched” at different stages of the heat treatment to study the microstructure at important stages during the heat treatment. We have developed digital image analysis algorithms to extract quantitative information from the reaction kinetics

![Fig. LTS.1. In this series of holds at 398°C , we observe a diffusion of Cu into the core of a sub-element of aNb$_3$Sn strand leaving voids between the filaments. The “Nausite” layer appears to play a beneficial role, controlling Cu and Sn diffusion.](image)
and these techniques have been made available [Figure 5.LTS.1] for use with the widely available open source ImageJ/Fiji software originally developed at NIH [Figure 5.LTS.2].

Using the knowledge acquired through the quench experiments and image analysis, we have designed a new heat treatment that takes advantage of the kinetic processes facilitated by the Nausite membrane and we have managed to increase the \( J_c \) of the wires significantly. Figure 5.LTS.1 shows the different \( J_c \) values at different fields for the same wire at different sizes, comparing the standard heat treatment to the new heat treatment proposed. When tested across several billets we found this heat treatment has the greatest beneficial impact on wires with small \( D_{eff} \), as is also the case of Figure 5.LTS.1 (as indicated by the green arrows). Thus we have developed a new approach to developing Nb3Sn heat treatments based on precise image analysis and we have significantly improved for the so called “mixing” dwells, producing a 13% increase in 15 T \( J_c \) across several wire billets at various sizes—while at the same time maintaining the high levels of Cu RRR required for good magnet stability. The \( J_c \) enhancement increases as the designed \( D_{eff} \) decreases and will therefore be of great benefit to future high field accelerator magnets.

![Fig. 5.LTS.2. Dependence of LG A15 formation as a function of temperature. In the left column, only SG A15 has formed of varying thickness, while in the right column more time has elapsed and LG A15 and Cu precipitates have appeared.](image)

2. PIT: Suppressed Formation of Large Grain Nb3Sn

The critical current density, \( J_c \), of PIT is less than comparable RRP® wires mostly because much of the superconducting Nb3Sn (25-30% of the total A15 area) that is present after heat treatment has a large grain (LG) morphology that does not contribute to transport current, thus it is important to understand how this layer forms so it can be minimized. During heat treatment (HT), the NbSn2-rich powder core undergoes a complex reaction with the Nb7.5wt%Ta tube (which is lined with a Cu sleeve) to form a ternary Sn-Nb-Cu phase (“Nausite” - Nb_{0.75}Cu_{0.25}Sn_{2}). Upon further heating, the Nausite decomposes into NbSn + Cu at \( \sim610°C \), which then rapidly forms Nb_{0.5}Sn at 630°C before finally transforming to Nb3Sn. We have made two critical new observations: 1.) The Nb_{0.5}Sn is Cu-containing while NbSn2 is not (nor is A15 but this is well known) and 2.) The initiation of the LG formation can be controlled over a wide range of temperatures relative to the formation of the small grain (SG) A15. The initial LG A15 can be uniquely identified as a decomposition product of the Nb_{0.5}Sn/Cu by the layer of rejected Cu around it. Thus the LG A15 is not only of low vortex pinning density, but it is also disconnected by the layers of rejected Cu. We have found for single step reactions limited to 630-690°C that the maximum SG A15 layer thickness is about 2.0 \( \mu \)m before LG A15 and Cu precipitates form. We have also found that multistage HT’s in the same temperature range can increase the SG A15 layer thickness while suppressing the undesired LG A15 morphology. Our goal is to use such HT’s to greatly suppress the LG A15 and drive \( J_c \) (12 T, 4.2 K) to exceed 3 kA/mm\(^2\).

Using the high resolution FESEM facility at NHMFL we are able to create high quality backscattered electron images of polished samples of samples obtained using a systematic heat treatment matrix. After imaging, we use the ImageJ/Fiji based software described above to quantify the average SG A15 layer thickness. We find that the SG A15 layer forms well before the LG A15 layer and has a maximum thickness (absent of LG A15) dependent on temperature (Figure 5.LTS.2).
Chapter 5 – In-house Research

At 630°C the layer thickness is about 0.5 μm after 10 hours while the SG A15 layer grows to 0.85 μm. The thickest SG layer we have so far managed to achieve without LG formation is 2.0 μm at 670°C. However it appears that higher temperatures will not produce a thicker SG A15 layer as after 2 hours at 690°C it is only 1.6 μm thick and LG A15 has begun to form. Based on these results, it was possible to design a multi-stage HT aimed at avoiding LG A15 formation. While these initial multi-stage HT's still formed some LG A15, we achieved an SG A15 layer thickness of about 3.0 μm (higher than any single step HT). Understanding the conditions surrounding the formation of LG A15 will be important to prevent or minimize it so that the Jc can be increased in these strands that are being developed to enable a Future Circular Collider at CERN. Here we demonstrate through microstructural observations that it is possible to control the LG/SG A15 ratio early on in the reaction. The next step is to further optimize the early stages of the reaction to grow the thickest SG A15 layer.

References

Structural Materials for LTS Magnets

Structural materials-research for high field LTS magnets is driven by the need to improve magnet reliability, efficiency, and costs. Austenitic steels have face-centered cubic (fcc) structure and are the material of choice for many cryogenic structural applications as they satisfy strength, ductility, and toughness requirements. For some contemporary magnet designs (i.e. the MagLab Series Connected Hybrid and the ITER Central Solenoid), the fatigue life expectations are considerable with >1 million cycles of fatigue testing required. Due to the limited availability of cryogenic fatigue data, we have conducted fatigue tests at 4 K to generate data on three high performance austenitic alloys (316LN, Nitronic 50, and JK2LB) designed for use in superconducting magnets. Characterizing the 4 K fatigue performance can be expensive because it requires multiple time-consuming tests to produce an S-n (stress vs number of cycles to failure) curve. Here, to enable economic testing, the test machine is equipped with a thermally efficient cryostat, which features automated liquid He refill, and He gas recovery features (in-house designed). Approximately 20 specimens were tested for each of the three alloys and the results for alloy JK2LB are shown in Figure Str Mat 1 above. Engineers use this data for safe reliable design of superconducting magnets. The findings from this research will be published in the 2017 Advances in Cryogenic Engineering.

Based on our experiences on fcc alloys, we have been developing a new fcc-matrix alloy with high strength, high modulus, and short age-hardening time for precipitation hardening[1]. This material was designed based on Ni-Mo-Cr alloys and may promise superior properties to austenitic steels for use in future superconducting magnets. Ni-Mo-Cr alloys have an fcc structure above ~1123 K with short-range-ordered (SRO) domains. Long-range-ordered (LRO) domains of A2B form below 1123 K after prolonged aging time. These alloys are strengthened by aging as LRO precipitation occurs. Our experimental results demonstrate that the addition of Re increases Young’s modulus and storage modulus by more than 10% and enhances the stability of the materials during aging. A higher Young’s modulus would result in lower strain in the Nb3Sn superconductor inside the conduit which would reduce the size and cost of the large magnet systems. At the same time, Re reduces precipitation hardening time by 36 times. Although we anticipated that Re could promote LRO precipitation, the magnitude of acceleration was surprising. The reduction in aging time resulting from the addition of Re means that new precipitate-hardened alloy can be produced with much greater energy efficiency than before.

References
HTS Magnets and Materials

32 T Magnet Project

The MagLab intends to commission the world’s first 32 T superconducting user-magnet during the first half of 2017. This will be the first user-magnet to emerge from the ultra-high-field (UHF) coil-development effort based on high-temperature superconductors (HTS) that began in 1991. The 32 T superconducting magnet has been constructed as a 15 T Low Temperature Superconductor (LTS) magnet mated with a pair of separately powered REBCO High Temperature Superconductor (HTS) insert coils generating 17 T. Featuring a 34-mm bore and a target ramp rate of 1 hour to full field, it is expected to be the first user magnet capable of > 25 T. For comparison, the strongest LTS user magnet is an NMR magnet operated since 2009 in Lyon, France, which is limited to 23.5 T. Unique features of the NHMFL 32 T magnet are its large HTS field contribution, active quench protection heaters in the HTS coils [1], and an extensive prototype testing phase [2] to validate the design and technology choices.

Figure 32Ta right: HTS coils (1) being loaded in the LTS coils (2), with a quench vent valve (3) visible on the LTS magnet’s top flange.
Chapter 5 – In-house Research

By the end of 2015, all 56 double pancake modules of the two REBCO coils were wound and impregnated with paraffin wax. Assembly with the quench heaters, pre-compression, installation of the crossover joints, terminals, over-banding, and securing the windings with band clamps took about 3 months per coil. Connecting all the wiring and nesting the HTS coils together, followed by nesting the HTS coils inside the LTS coils required another two months. Repeated high-voltage testing at 3 kV ensured the integrity of the electrical insulation of both the coil and quench heater circuits. After installing temporary instrumentation for the first magnet test and loading the coils into the cryostat (Figure 32Ta), the magnet itself was ready for cooldown (Figure 32Tb).

2. Magnet Testing

After slowly cooling down to liquid-nitrogen temperatures, the HTS coils were operated at low current. No abnormalities were observed in the coils. As expected, there is minor hysteresis in the central magnetic field on account of shielding currents. Both HTS and LTS coils are ready for continued testing at the intended operating temperature of 4.2 K.

3. Quench Protection

Quench simulations have clarified that the temperature margin in the 32 T HTS coils is larger than in the prototype coils, and that the 32 T quench protection heaters therefore need to operate at a higher power level than for the prototypes. Accordingly, a new, higher energy, battery bank was built to power the 32 T quench heaters. Testing of spare heaters in a realistic cryogenic mock-up demonstrated that the heaters as installed are capable of the required power levels. However, full-current testing of the new battery bank in a dummy load resistor led to component failure in the switchgear. The switchgear has been redesigned. Once the switchgear has been fully qualified, the 32 T magnet will be cooled to 4.2 K to complete its test protocol, culminating with the intended operation to 32 T.

References


Figure 32Tb left: The 32 T magnet in Cell 4. Recognizable are the two quench vent valves (1), the stepping-motor assembly to move a hall sensor along the magnet axis and the cryostat (3).
No-insulation REBCO coil-development

1. Background and significance

REBCO tapes have been regarded as promising candidates for high-field magnets for several applications, mainly owing to their superb mechanical strength (>700 MPa tension with 95% critical-current retention) and large in-field current-carrying capacities (e.g., >1,000 A/mm² at 4.2 K and a 5 T “c-axis parallel” field). Yet, conventional REBCO magnets with insulation between turns (e.g. the MagLab 32 T) have to be designed with a relatively low coil current-density, typically at ~ 200 A/mm² as in the 32 T magnet, at a nominal operating-temperature of 4.2 K, due to the need for sufficient copper for quench protection. First introduced in 2010, the no-insulation (NI) winding technique enables an NI-HTS magnet to be essentially self-protecting. The key idea is elimination of turn-to-turn insulation within the HTS pancake coils so that the coil current can automatically bypass normal zones in the superconducting turns by the turn-to-turn contacts. This shorting prevents overheating of the initial quench-spot and thus protects the magnet. Owing to this self-protecting feature, a minimal amount of stabilizer is required, just that required for ease of splicing and handling. Consequently an NI-HTS magnet is very compact and operates at a substantially higher engineering current-density than its insulated counterpart. The elimination of insulation and stabilizer layers, both mechanically “softer” than the REBCO tape itself, significantly enhances the mechanical robustness of an NI winding, which is another major benefit particularly relevant to ultra-high field (>30 T) magnets.

2. Progress in 2016

A two-fold approach has been taken this year to develop NI technology. The first is to continue to achieve the highest fields possible and the second is to determine how usable NI technology is for performing scientific measurements. Regarding the highest fields, a new world record of 9 T was produced by an NI superconducting magnet operating a 31.2 T background field for a total of 40.2 T magnetic field as shown in Fig. NI-REBCO1. The NI superconducting magnet had a total current density of 935 A/mm², a phenomenal leap in superconducting magnet technology solely attributable to the NI coil technology. Fig. NI-REBCO2 shows a picture of the NI test coil. Improvements in this technology and testing system have been identified and are being implemented for further studies.

The second achievement this year was to produce a 20 T user science magnet by building a 13 T NI coil installed inside an existing, refurbished 7 T low temperature superconducting coil. This coil was built in collaboration with colleagues at the University of Florida who are interested in using this technology for Axion detection magnets. Some advanced features of this NI coil are the multi-width tape used to allow higher current densities throughout the coil and a variable inner diameter design for greater magnetic field homogeneity. Much of the technology for this project has been based on the design and fabrication of the 32 T all superconducting magnet now being commissioned at the NHMFL in Tallahassee. The 13 T NI coil fabrication has been completed and the coil is undergoing final quality control measurements prior to final assembly. Fig. NI-REBCO3 shows a picture of the assembled 13 T NI coil.

\[\text{Fig. NI-REBCO1. Test results of the 9 T insert coil in the 31 T background field. Due to a helium bubble, the magnet temperature was 17.6 K. No coil damage was observed after the sudden discharge at } t = 6822 \text{ sec.}\]
REBCO conductor

For better understanding of REBCO Coated Conductors (CC) in real magnet and cable applications we have made many reel-to-reel critical current $I_c$ measurements. For CC tape characterization, we used the instrument initially designed, patented, and manufactured at Los Alamos National Laboratory by Y. Coulter. In its original version, the instrument measured $I_c$ in transport by the four-probe method. It is a unique instrument because of its capability to measure in field with two orthogonal direction magnets. After modifications at the NHMFL, it also can assess $I_c(x)$ lengthwise variations by means of magnetization measured by an array of Hall probes.

Examination of tapes unwound from magnet coils and or cables. The goal of that kind of testing is to find the reason for underperforming and to precisely localize defects for further examination with other methods. The third category is the study of the origin of critical current non-uniformity, attempting to answer the question of whether the tape geometry is responsible for it or rather the vortex pinning strength is varying along the tape.

Fig. REBCO4 shows $I_c(x)$ measured as a function of position in several (a) older (2010-2012) and (b) newer (2013-2014) CC tapes from SuperPower Inc. All the samples have nominally the same architecture and the same ‘advanced pinning’ (AP) formulation with 7.5%-Zr-doping. All the measurements were performed at $\mu_0H = 0.52$ T perpendicular to the tape surface at 77 K. It is clear that $I_c(x)$ variations are much stronger in older than in newer tapes. Quantitatively speaking, the standard deviation decreased from $\sim 7\%$ to 1-2% over these 4-5 years. It must be stressed that this refers to $I_c(x)$ variations along a particular tape, not spread of mean $I_c$ of different tapes. Fourier analysis revealed rich spectra of periodic and aperiodic $I_c(x)$ fluctuations. Their origin varies from trivial lengthwise width variations to apparent pinning homogeneity variations along the conductor. Whatever the reasons, our study shows that the uniformity of $I_c$ along the lengths of CC has substantially increased in recent years, but, also, that present tapes are far from perfectly uniform.

Figure REBCO5 shows a study that belongs to the second category, where tapes from deconstructed CORC cable were measured after cabling and compared with these before cabling. It is seen, that for all cabling angles, $I_c$ is actually enhanced by $\sim 10\%$ after fabrication. However, for low cabling angles, substantial $I_c$ dropouts are clearly seen. These observations are very important for cable technology.

References
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Fig. NI-REBCO3. The assembled 13 T NI coil is shown in the winding machine being prepared for soldering of the electrical joints on the outer diameter.

Figure REBCO4. Critical current as a function of position at 77 K in several (a) older (2010-2012) and (b) newer (2013-2014) CC tapes. The inset in (a) shows details of \( I_c(x) \) for sample SPD. The labels of the tapes are from our different internal projects.

Figure REBCO5. Critical current versus position in REBCO tapes before (black lines and symbols) and after use in the CORC cable made with different cabling angles: 23 deg (a) and 60 deg (b). Critical current as a function of position at 77 K in several (a) older (2010-2012) and (b)
Bi-2212 Coil Development

1. Winding of Bi-2212 Round Wire Coils

A technique was developed to allow for a circular and uniform winding pack of ortho cyclical coils, which is the case when winding Bi-2212 round wire into a layer-wound coil [1]. A good winding technique is essential to building superconducting magnets since it affects mechanical integrity as well as field quality of the resulting magnet. A practical magnet design is based on an assumption of uniform current density, and it is governed by tolerance of the wire's geometry and preciseness of the winding. Since one of our foci is developing a Bi-2212 insert coil technology for NMR applications, a precise winding technique is also required to obtain high homogeneous field at operation. We built several small size coils as well as two larger coils using Bi-2212 round wire and recorded surface maps of the finished coils to evaluate their circularity. One main factor of non-uniformity in the coils is the accumulation of cross-overs of two adjacent layers in one azimuthal location. We have developed a method to distribute the cross-overs azimuthally so that we can obtain a rather uniform and circular winding pack. Fig. Platy1 shows an early mock-up solenoid made with copper wire. Fig. Platy2 shows the circularity map of the mock-up copper coil. Radial variations ranged from -0.572 mm to 1.071 mm and the map clearly shows some periodic unevenness caused by the cross-overs. Ten small test coils and two larger coils were wound in this fashion. In the two larger coils it could be shown that it is possible to reduce these variations further down to ~1 mm.

Figs. Platy3a, b shows the two larger coils with their surface uniformity map. It also indicates that the addition of co-winding material and conductor braiding is smoothening out the periodic unevenness seen in the mock-up coil.

Fig. Platy1. Copper wire mock-up coil.

Fig. Platy2. Surface uniformity map of mock-up copper coil

Fig. Platy3. a) Larger coil #1 (left) surface map and b) larger coil #2
2. FEM Modeling of Strain Management of Bi-2212 Round Wire Coils

We fabricated a series of prototype coils designed to experimentally validate coil-level strain management. Finite element modeling (FEM) was performed in COMSOL Multiphysics to develop winding designs to be used and tested in these coils. Testing of these coils was limited to our Cryomagnetics 8.5 T LTS magnet, after the decommissioning of the NHMFL Cell-4 ultra-wide bore 20 T resistive magnet. In order to strain the individual conductors at such a reduced field, the prototype coils were designed with a larger diameter, but still within the constrictions of our overpressure furnace, which is required to transform the Bi-2212 into its superconducting state. FEM was used as a numerical test-bed to evaluate the efficacy of each coil’s strain management approach by comparing the FEM with experimental results. Models feature independent and complicated material properties and wire-by-wire detail for each of several constituents in the test coils (“Riky” coils) shown in Fig. Platypup. In principle, three coils were designed to have nearly identical geometry – i.e. inner diameter, individual wire diameter, number of turns and layers.

The FEM shows an axiomatic development of the coil-level reinforcement approach. The first coil was hardly reinforced (only epoxy impregnated), the second was fully reinforced, and the design of the third has limited reinforcement so as to more quantitatively validate the modeling efforts, within the performance limits of our testing equipment. Fig. Platypup reflects experimental results and coil-level reinforcement success. The strain-limited performance of Riky-1 matches the FEM predictions (see Fig. Platyp6) well. Riky-2 is shown to drastically out-perform Riky-1, and is not strain limited (there was some heat introduced through the external lead system). The 0.6% upper strain limit of Bi-2212 is shown as a cut-off in the Fig. Platyp6 plot, which is generated by numerically sweeping through operating currents for the Riky coils as well as the 8.5 T LTS outsert magnet. Illustrated in Fig. Platyp6 is the predicted performance of a tailored Riky-3 to see strain failure within the limits of our existing testing probe. Successive prototype tests have provided encouraging results. Following the Platypup test coils from last year, the Riky prototype coils are being designed to fit into available outsert magnets to achieve similar operating conditions and further investigate the mechanical performance limits of this conductor.

Fig. Platyp4. A “Riky” test coil mounted on the probe.

Fig. Platyp5. Experimental results of Riky-1 and Riky-2.

Fig. Platyp6. The computed operating envelope for Riky-1 (red) and the revised Riky-3 (blue).
3. Electrically Insulating Bi-2212 Round Wires with a Combination of TiO₂ Coating and Aluminosilicate Braid

One peculiarity of using Bi-2212 round wire for magnets is that in most cases it can only be used in the wind-and-react coil making method. Though it has the advantage that winding strains can be neglected during the design of a magnet, since the wire will be fully annealed after the reaction, it puts challenges on the magnet design regarding the choices of suitable materials. During the heat treatment, temperatures of up to 890°C have to be reached to achieve a proper superconducting crystallographic phase formation. All of the structural materials need to be able to withstand these high temperatures. While for structural materials, low Cr Ni-base alloys appear to be the material of choice, finding suitable electrical insulation of the Bi-2212 is more complex. Bi-2212 round wire is commonly offered by the manufacturer with an aluminosilicate braid as electrical insulation. Through a series of experiments, we realized that the aluminosilicate reacts with the silver of the conductor matrix, forming an AgAlO₂ delafossite. While the fibers saturate with silver they transform from a fiber with relatively high strength to a glassy and brittle compound with a large number of cracks as shown in Fig. Platy7. Based on these observations we originally abandoned the use of aluminosilicate braid and developed a TiO₂ based coating route. In this route a layer of polymer saturated with TiO₂ nano-particles is deposited onto the conductor by dip-coating. During the early stages of the heat treatment procedure, the polymer is burned off at a slow rate to prevent sudden combustion, which can cause delamination and loss of the coating. During the final stages of the heat treatment when the Bi-2212 phase formation begins to occur, the TiO₂ is sintered onto the silver matrix as a hard, abrasion resistant ceramic layer. In some instances, however, silver has been observed to penetrate the ceramic layer causing electric shorts in tightly wound coils as shown in Fig. Platy8. A combination of the two processes, coating with TiO₂ and braiding with the aluminosilicate, has been shown to alleviate the observed issues, Fig. Platy9. In several coils we were able to show that a combination of the coating and the aluminosilicate braid yields an electrical insulation layer that is reliable and provides some additional mechanical strength since the fibers stay intact without degradation from the silver matrix, which is now separated from the fibers by the ceramic layer. Another considerable advantage of the combination of coating and braid is the braid’s ability to encourage penetration into the winding pack during the vacuum pressure impregnation (VPI) step. In addition to the combination of coating and braid, a modification in the recipe of the coating components is currently being explored that shows promise to provide a thicker ceramic layer and a lower tendency of silver penetrating it. Parallel to this, efforts were made to minimize the thickness of the braid without sacrificing properties. A variation of this approach is currently being tested on Bi-2212 Rutherford type cables.

Fig. Platy7 (left). Alumino-silicate braid on Bi-2212 wire after reaction. Fig. Platy8 (center). Silver bridges between two Bi-2212 wires inside a coil winding pack after heat treatment. Fig. Platy9 (right). Coated and braided conductor in a coil winding pack.
4. Persistent Joints with Bi-2212

All HTS conductors are produced in limited piece lengths that are shorter than conductor lengths required to build high field magnet systems that usually require several kilometers of conductor. To apply these conductors in those systems requires use of multiple electrical joints between each piece length. In conventional soldered joints, Ohmic losses in the joints contribute to the total heat generation of the coil. Particularly for high field magnets where high field homogeneity and long term field stability are required, like nuclear magnetic resonance (NMR) magnets, persistent or semi-persistent electrical joints are highly desirable. To understand if it was possible to make practical persistent joints with Bi-2212 a series of experimental joints and a small coil with such a joint were made of the type as shown in Fig. Platy10. Bi-2212 has to be heat treated at temperatures of ~890°C to form a well-connected superconducting crystallographic phase. These conditions are also required for the superconducting joints made [2]. These joints were evaluated by direct transport measurements as shown in Fig. 11 and field decay measurements. Since the joint sections are exposed to different field orientations, transport measurements were carried out with straight short samples that were then exposed to the two prevailing field orientations, parallel and orthogonal to the conductor axis. It is clearly visible in Fig. 11 that the critical current vs. applied field \( I_c(B) \) trace of the whole joint falls right between the measurements of the two field orientations, which means that the coil performance (mostly \( B \) perpendicular to the conductor axis) is not limited by its joints. The microstructure in Fig. 12 shows well textured Bi-2212 crystal colonies in the contact area between the two wires. Long term magnetic field decay was measured on a small test coils having a persistent joint and it was shown to be consistent with logarithmic creep of short samples.

**Fig. Platy10 (left upper).** Experimental Bi-2212 superconducting electric joint.

**Fig. Platy11 (right).** Critical current of joint sections vs. applied field.
5. Bi-2212 Accelerator Magnet Collaboration with LBNL

The Lawrence Berkeley National Lab (LBNL) is running an advanced accelerator program using Bi-2212 under the lead of Dr. Tengming Shen. A two-layer racetrack coil that LBNL made using a 17-strand Bi-2212 Rutherford cable ("HTS-RC-1"), shown in Fig. Platy13, was heat-treated in our large overpressure furnace and then sent back to LBNL for transport characterization. The coil parameters were \( J_{\text{cable}} = 470 \, \text{A/mm}^2 \) and \( J_c = 640 \, \text{A/mm}^2 \) using about 140 m of Bi-2212 round wire conductor with a coil geometry of 370 mm x 120 mm x 31 mm shown in Fig. Platy14. The coil broke the 5 kA barrier and with this could carry a current that was higher by a factor of 2.6 compared with previously made racetrack coils at LBNL using 1 bar HT.

The OPHT demonstrated that it is suitable to develop high transport current densities in race track coils. It also shows the versatility of Bi-2212 coil technology.

References

Bi-2212 – Conductor Development

We investigated 2212 powders made by MetaMateria and nGimat, and did overpressure heat treatments (OPHT) on wires made from these powders by Oxford Superconducting Technologies (OST).

Nexans was the sole commercial source for 2212 powder until 2015 when they closed their powder production. MetaMateria and nGimat are developing commercial 2212 powder in the US with DOE-SBIR funding. Our OP-HT studies of wires made with new powders from these two companies are particularly relevant, because the primary bench mark for the powder is the critical current density \( J_c \) (and \( J_s \)) achievable in wires made with these powders. As shown in Fig. 2212-1, the \( J_c \) of 2212 round wires made by OST using MetaMateria and nGimat powders are both as good as, and in some cases better than, those in wires made with Nexans powder. This is good news as it shows that both companies can produce powder that can replace the dwindling supply of Nexans powder, and the powders improved during 2016 to the point that a new record \( J_c \) values were obtained with both MetaMateria and nGimat powders. We have begun studies using OP-HT wire processed on ITER barrels to investigate the \( I_c \)-strain behavior of the 2212 wire in magnetic fields using induced hoop strain. We have also started stress-strain studies and \( I_c \)-strain studies of rectangular 2212 wire that we received from Solid Materials Solutions who have reinforced the rectangular 2212 with a strip of high-strength alloy. The reinforced strips show promise for strengthening the 2212 conductor as shown in Fig. 2212-2.
We are studying the effects of twisting on hysteretic losses and $J_c$ of round wire. In general decreasing the twist pitch decreased the hysteretic losses. There was a greater decrease in hysteretic loss for wire with a sparse filament density (i.e., large spacing between the filaments) that have little bonding between the filaments after OP-HT, compared to a smaller decrease in hysteretic loss for wires with high filament density (i.e., many filaments that were closely spaced) that have extensive filament coupling between the filaments after OP-HT. Twisting the wire did not affect $J_c$ up to the tightest twist pitch of 12 mm used in this study for 0.8 mm wires with both sparse and dense filament geometries. A PhD student who graduated in 2016 completed a factorial Design of Experiment (DOE) study to investigate the details of the OP-HT process after eliminating the current limiting bubbles that were present in all earlier 1 atm processing. This study identified two factors that are particularly important during OP-HT, which are the time in the melt (i.e., the length of time between 2212 melting and when 2212 starts to reform on cooling) and the cooling rate during which the 2212 crystals reform from the melt. These two factors, which had been identified in earlier 1 atm heat treatment studies, were quantified in the DOE study. An important outcome of this study was being able to shorten the OP-HT time by as much as a factor of two while still retaining the same high $I_c$. We also did extensive studies of a large coil that we OP-HTed in 2015. We had the completely unexpected result that the 2212 wires had shorted together during the OP-HT as seen in Fig. 2212-3. In our post-mortem studies we determined that the shorting was caused by Ag in the outer Ag(Mg) sheath extruding through cracks in the TiO$_2$ insulation during the OP-HT. Although we have not yet determined the root materials-science cause, we have developed and successfully tested a method to prevent shorting in coils during OP-HT going forward. During OP-HT the wire shrinks ∼4%, which significantly increases $J_c$ but can cause problems with large coils because the coil may sag due to the shrinkage. We showed that we can do a pre-densification step before melting in which 80% of the total shrinkage occurs. This pre-densified wire can be handled, insulated, and wound into a coil just like the as-drawn wire. The fully OP-HTed pre-densified wire has the same $J_c$ as wire that is not pre-densified, it does not leak, and it has much less sag due to shrinkage than the un-densified wire. We continued to work actively with a variety of collaborators including powder production (MetaMateria and nGimat), fabricating wire (Oxford Superconductor Technology), developing methods to strengthen the 2212 wire (Solid Material Solutions), plus building and OP-HTing coils and...
cables (LBNL, CERN, and the University of Twente, The Netherlands). **Bi2223 Coil Development** Building on recent findings from our feasibility study of high-strength laminated Bi-2223 conductors for NMR insert coils [1], we initiated a program of coil fabrication and testing. We procured 3.2 km of laminated and insulated conductor, designated Type HT-NX, from Sumitomo Electric for the purpose of making a series of demonstration coils. Designs for five test coils were prepared to explore the design limits of critical current, peak field, field homogeneity, strain, and fatigue life for this conductor. Coil form hardware was then fabricated.

The first test coil was wound with particular attention given to accurate placement and support of each conductor turn in the windings (**Fig. 2223-1**). The windings are configured to minimize the bending strain. To place the turns and layer transitions, a detailed CAD model of a conductor layer was made. Parametric modeling was used to convert the model of a single conductor layer to models of every layer. Filler pieces used to support the conductor in the layer transition regions were modeled and made in a similar manner. A numerically controlled coil winding machine was programmed to place the conductor. The end fillers are formed by a numerically controlled cutter using the CAD data, and then placed in the windings. Procedures for forming each layer of the coil were worked out by iterative trial and the windings were then completed.

The first coil was tested at 77 K (**Fig. 2223-2**). Findings from this test indicate that the coil inductance is within 2% of the design value of 43 mH. The critical current measured was 48 A, which was better than expected, suggesting that the design model for critical current at 77 K is conservative.

**References**


*Figure 2223-1 (left). Winding of the first test coil, Figure 2223-2. 77 (right). K self-field test.*
Iron-based superconductors (FBS)

1. Thin films

The superconducting properties of Fe-based (FBS) compounds in the form of thin films have been investigated at the Applied Superconductivity Center and in the DC user facility up to high field in collaboration with Nagoya University, the Institute for Technical Physics at Karlsruhe Institute of Technology (KIT), Tokyo Institute of Technology and the Institute for Metallic Materials at IFW-Dresden and. We investigated both the intrinsic and the extrinsic properties of clean NdFeAs(O,F) (Nd1111) films, both of which are important [1]. Although Nd1111 belongs to the FBS family with the highest $T_c$ and the largest anisotropy, the effect of intrinsic pinning is quite surprising. Characterizing the $J_c(H,T,0)$ behavior, we observed a sudden decrease of the $n$-value when the applied field $H$ approaches the $ab$-planes, forming a dip in the angular dependence at intermediate temperatures. At lower temperatures, a peak forms inside the dip in the $n(0)$ curves. This unusual behavior was previously observed only in HTS cuprate materials, where it was shown to originate from the trapping and locking-in of the vortices parallel to the $ab$ planes. This is the first study on FBS showing that this behavior occurs over the full temperature, field, and angular range. The study demonstrates, despite the lower $T_c$ and anisotropy of Nd1111 with respect to Sm1111 and HTS, that this compound is substantially affected by intrinsic pinning, which generates a strong $ab$-peak in $J_c$. We also studied the electrical transport properties of epitaxial Ba(Fe$_{1-x}$Ni$_x$)$_2$As$_2$ thin films [2], showing that the pinning is in this case dominated by elastic pinning at two-dimensional nonmagnetic defects. Compared to the single-crystal data, we find a higher slope of the upper critical field for the thin film at a similar doping level and a small anisotropy. Also, an unusual small vortex liquid phase was observed at low temperatures, which is a striking difference to Co-doped BaFe$_2$As$_2$ thin films.

The investigation of in-field transport properties of P-doped BaFe$_2$As$_2$ (Ba-122) thin films grown on technical substrates revealed that a non-Ohmic linear differential signature exists at low field due to flux flow along the grain boundaries. However, grain boundaries can also work as flux pinning centers as demonstrated by the pinning force analysis[3].

2. Bulk samples

High intergrain $J_c$ (10$^5$ A cm$^{-2}$ at self-field and 10$^4$ A cm$^{-2}$ at 10 T) has been reported in randomly-oriented K-doped BaFe$_2$As$_2$ (K-doped Ba-122) bulks and round wires by our research group [4]. However to be of use in applications, $J_c$ must be raised to at least 10$^5$ A cm$^{-2}$ at high fields (10 T – 30 T) [5].

![Fig Bulk1. (a) $J_c$ as a function of magnetic field at 4.2 K and (b) normalized susceptibility as a function of temperature for a sample made with our standard synthesis process (1 h milling/ 10 h HIP)](image)

The high $J_c$ Weiss et al. [4] reported in K-doped Ba-122 bulks and wires is associated with it having a fine grain size (100-200 nm). We varied the synthesis process of optimally-doped (Ba$_{0.6}$K$_{0.4}$) Fe$_2$As$_2$ bulks to obtain materials with even finer grains than obtained by Weiss et al. [4], [6] in order to enhance the pinning of the vortices within the grains and to raise $J_c$. To change the grain size in these bulk, untextured samples, we milled the starting materials for times ranging from 1 to 50 h and then heat treated the samples for times ranging from 0.5 to 10 h in a HIP at 600°C at 193 MPa. Samples were characterized using X-ray diffraction, SEM imaging, and electromagnetic measurements to assess the best way to inhibit grain growth and to
learn how varying grain size impacts the superconducting properties. To evaluate the superconducting properties, we analyzed $T_c$ obtained from magnetic susceptibility measurements and calculated $J_c$ from magnetization measurements. Variations in the milling time had a more important effect on $J_c$ than variations in the HIPping time. Samples milled for 50 h exhibited the highest $J_c$ at 10 T for all the HIPping times. The results also indicate that shorter HIPping time produce samples with higher $J_c$. A 30 min HIP treatment was enough to fully densify Ba-122 and this short time also produced the highest $T_c$ in our study. In **Figure Bulk1**, we compare $J_c$ and $T_c$ in the K-doped Ba-122 bulk samples produced with our standard synthesis process and our optimized synthesis described.

**Figure Bulk1**(a) shows that we were able to increase $J_c$ by a factor of 2.2 (4.2 K, 10 T) in a sample that was milled for 50 h and then HIPped for 0.5 h compared with $J_c$ in a sample made using our standard synthesis (milled 1 h and HIPped for 10 h). **Figure Bulk1**(b) shows the susceptibility plots for the 50 h-milled sample is very sharp and that $T_c$ decreased slightly when compared to the standard sample. This small decrease in $T_c$ is not significant compared to the more than doubling of $J_c$ at 10 T.

**Figure Bulk2.** Comparison of grain diameter distribution between samples made with our standard synthesis process (1 h milling/ 10 h HIP) and our optimized synthesis processes (50 h milling/ 0.5 h HIP).

**Figure Bulk2** are the histograms of the grain diameter determined using the Feret estimation in ImageJ. The average grain diameter was 267 ± 114 nm for the K-doped Ba-122 sample milled for 1 h HIPped for 10 h whereas, it was 90 ± 40 nm for the sample milled for 50 h and HIPped for 30 minutes. These results confirm our hypothesis that $J_c$ can be raised in Ba-122 by decreasing the grain size. Samples with very fine grains can be achieved by applying long milling time, e.g. 50 h, which decreases the size of the starting powder, and using very short HIP heat treatments, e.g. 30 min, which densifies the sample but does not allow extensive grain growth. We attribute the increase of $J_c$ at 10 T to the reduction of the grain size, which favors vortex pinning at grain boundaries.

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Resistive Magnets and Materials

DC Magnets

In 2016 the Series Connected Hybrid magnet reached 36.2 T as indicated above! This magnet is intended to provide a field uniformity and stability of 1 ppm over a 1 cm diameter spherical volume. Typical resistive magnets have ~500 ppm over this volume. To reach this higher homogeneity, the innermost coil includes current-density grading (lower current density near its mid-plane) and the second coil includes a 22 mm gap at the midplane. These features together result in a negative z2 term that cancels the positive z2 term of the remaining two resistive and one superconducting coils. The first NMR map of the magnet was performed and the inner two resistive coils were shifted to reduce the z1 term. A subsequent NMR map is shown in Fig. ResMag1. We see that the homogeneity is dominated by a first-order transverse term (x1). Oxford NMR has developed ferromagnetic shims which reduce the inhomogeneity to ~5 ppm. Resistive shims are now being tested to reach the 1 ppm goal. In addition, fabrication of a complete set of spare coils was also completed in 2016.

To support smooth operation of the resistive magnet user program, the NHMFL has completed fabrication and assembly of seven resistive spare coils as part of the routine 2016 maintenance program. In addition 2 spare coils were delivered to the Helmholtz Zentrum Berlin.

Pulsed Magnets

1. The 65 T user pulsed magnets:

Figure PFF1 depicts the usage of these magnets for the last six years from 2011 to 2016. In 2016, the four user cells of these magnets operated near their full capacity to deliver a total of ~ 7900 shots, of which ~2500 shots are 60 T and above. The steady increase of number of shots over the years indicates an increased demand from users and significant improvement in the magnet-performance. In 2016 the NHMFL-PFF constructed 7 of the 65 tesla user magnets. Higher magnetic fields for users can be obtained simply by reducing the bore size of the magnets. In 2016, we ran a prototype 74 T magnet with the bore size of 7 mm. We delivered about 100 shots above 70 T for users at temperatures as low as 500 mK. The magnet demonstrated that we can successfully reduce the bore of user magnets to reduce stress, increase performance, and still deliver excellent data for users.

![Figure PFF1: 65 tesla user magnet performance since 2011. In 2016 nearly 8000 shots were fired for our users.]

2. 60 T controlled waveform (CW) magnet:

We are in the process of rebuilding coils #3, #4, and #7 of the 60 T Long Pulse Magnet System. Sectioning and inspection of the windings and microscopy of the conductor indicates that the material contained measurable imperfections that precipitated the failure. Figure PFF 2 shows the sectioned coil #7.
3. **100 T magnet system:**

In 2016, the 100T magnet system delivered more shots than any other year in its history by a significant margin (Figure PFF 3). The system delivered 238 shots, of which 50 shots are above 90 T and 80 shots are above 80T. In 2016 two 10 mm bore insert magnets were fabricated for users. New large cross section conductor was received from Nanoelectro which will be used in a future upgrade of the 100T magnet. Magnet pulses to 95.4 tesla were delivered for user experiments.

![Figure PFF 3. Number of pulses to various field provided to the user community per year.](image)

completed before the end of the first quarter of 2017. A capacitor bank upgrade is scheduled for Q1 of 2017 to enable operation of the magnet with the current 4 MJ user capacitor bank. The second stage of system upgrade is scheduled for completion by Q2 of 2017 which will include integration of a transient voltage suppression system to be installed to cope with a potential fault scenario of only one section firing and a back electro-motive induction on the secondary magnet section causing an over-
Chapter 5 – In-house Research

voltage condition across the thyristor switches. Figure PFF 4 shows the completed magnet containment structure and user access platform installed in TSL-294 at the NHMFL-PFF.

High-Strength Conductors

High-field magnets require conductors made of Cu matrix composites that have an exceptional combination of strength and electrical conductivity. In 2016, we continued our research to understand new Cu matrix conductors for use in both existing and next generation magnets. In collaboration with our partners, we have developed new fabrication methods for making Cu-Ag composites. The strength of these composites is the result of formation of a high-density of interface boundaries between Ag precipitates and the Cu matrix. Given that an increase in strength is generally accompanied by a decrease in electrical conductivity, our objective is to adjust manufacturing parameters to reach the optimum balance between the two. We studied the microstructure and properties of Cu-6wt% Ag alloy that had been directionally solidified under a magnetic field (MF) and thermos-mechanically processed. Applying MF during solidification widened the spacing between pro-eutectic Cu dendrites and increased the fraction of supersaturated Ag in pro-eutectic Cu. The additional supersaturated Ag raised both the electrical resistivity and the hardness of the alloy. Increased resistivity occurs because of increased impurity-scattering; increased hardness occurs because of solid solution strengthening. Differential scanning calorimetry (DSC) data showed that precipitation of Ag from Cu started at 300 °C ±25 °C (Fig. HSHC1(a)). Precipitation enhances precipitate-hardening and reduces impurity-scattering. The optimized precipitation temperature range was found for maximizing hardness and minimizing electrical resistivity in both solidified composites and rolled Cu-6wt% Ag composites solidified under MF (Fig. HSHC1(b)) [1].

In further studies, we categorized Ag precipitates according to whether they formed inside Cu grains (continuous precipitates) or at grain boundaries (discontinuous precipitates). In a Cu-8 wt%Ag composite, discontinuous and continuous precipitation phenomena were shown by DSC to correspond to two distinct exothermic reactions in the alloy. At higher temperatures (475-580 °C), we observed both continuous and discontinuous precipitation; at lower temperatures (410 °C), only discontinuous precipitation. Because of higher density and very fine continuous precipitation, the micro-hardness and tensile strength of a sample aged at 475 °C were up to 22% higher than samples aged at other temperatures.

![Image](image.png)

**Fig. HSHC1.** (a) DSC curves of directional solidified Cu-6wt.%Ag alloy with and without MF at a heating rate of 10°C/min; (b) Micro-hardness and electrical resistivity as a function of ageing temperature showing that at about 450 °C, hardness reaches maximum and resistivity reaches minimum in a Cu-6wt%Ag alloy after solution treated at 760 °C for 2 h.

Because the formation of precipitation reduces Ag dissolved in Cu matrix, the electrical resistivity of aged samples began to decrease above 410 °C. The size, volume fraction, and spacing of continuous Ag precipitates apparently play important roles in maximizing total strength and electrical resistivity [2].

Working with our collaborators, we continued our research on thermal stability of Cu-Nb composites. We studied the effect of microstructure evolution during annealing on the magneto-resistance (MR) and hardness of Cu-Nb composite wires [3]. Our results revealed that microstructure,
hardness and MR showed no changes until annealing temperatures reached 500 °C, indicating high thermal stability. Above 500 °C, stability gradually decreased. For samples annealed at 900 °C, the MR at -196 °C exhibited distinct changes, reaching 22% at 19 T. Thus, annealing below 500 °C can be used to preserve both hardness and MR, but elevated annealing temperature introduces softening in conductors. After being annealed at optimized temperatures, the conductors can be wound into coils with an inner diameter smaller than 15 mm. Within these wound wires, we observed changes not only in geometry but also in microstructure [4].

In addition to Cu-Ag and Cu-Nb composites, we also studied Cu-2wt% Fe composite, an inexpensive candidate for high strength conductors. The electrical conductivity of this composite is usually low and depends on the precipitation of Fe. During the ageing treatment of this alloy, we applied an external 12 T high magnetic field (HMF) in order to study the effect of the resulting γ-Fe precipitation on electrical conductivity. At 700 °C, HMF promoted a transformation from coherent to semi-coherent γ-Fe precipitates, which increased electrical conductivity [5].

The strength of Cu composite depends on the strengthening effect of not only the interface between Cu and precipitates, but also on the grain boundaries, like twin boundary, within the Cu component of the Cu matrix. Although the high density grain boundaries provide high strength, they may also introduce undesirable features, like thermal instability and low electrical conductivity. In Cu that was manufactured to include nanotwins (NT), we investigated the kinetics of recovery and recrystallization, using the isothermal Johnson-Mehl-Avrami-Kolmogorov (JMAK) model to estimate activation energy values and comparing the results to values derived using the non-isothermal Kissinger equation [6]. The JMAK model hinges on an exponent that expresses the growth mechanism of a crystal. The exponent for this nanotwinned Cu was close to 0.5, which indicates the kind of low-dimensional microstructure evolution that is usually associated with anisotropic twin coarsening, heterogeneous recrystallization, and high stability. Plasma peak shapes and L3 edge positions measured by electron energy loss spectroscopy in atomic columns both at twin boundaries (TBs) and in the interior showed similar pattern, which implies that values for conductivity and Fermi level are equal in both places and thus that TB have limited impact on conductivity.

References
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Accomplishments & Discoveries
Chapter 6 – Accomplishments and Discoveries

Products of MagLab Users and Faculty

The laboratory continued its strong record of publishing, with 420 articles appearing in peer-reviewed scientific and engineering journals in 2016. The full listing, along with citations for over 355 presentations, is available on the MagLab’s web site https://nationalmaglab.org/research/publications-all/publications-search. All information in the Accomplishments and Discoveries section is as of January 26, 2017.

This chapter lists publications by user facility, followed by publications attributed to Magnet Science & Technology, the NHMFL Applied Superconductivity Center, UF Physics, the Condensed Matter Theory/Experiment group, the Center for Integrating Research & Learning, Geochemistry, and Optical Microscopy. Please note that publications may be listed with more than one facility or group, as the research may have resulted from the use of multiple facilities, e.g., using both DC and Pulsed Field Facilities, or from a collaboration that involves both user/experimentalists and theorists.

Of the 420 publications, 213 (51%) appeared in significant journals. Presented on the remaining pages of this chapter are lists of one-time publications, internet disseminations, patents, awards, PhD dissertations, and Masters theses.

Table 1: Submitted Peer-Reviewed Publications from OPMS live database, the point-in-time snapshot was on January 26, 2017. A total number of publications per year should NOT be drawn from this report because a submitter may, as appropriate, link a publication to two facilities.

<table>
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<th>FACILITY/DEPARTMENT</th>
<th>2016 Peer Reviewed</th>
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<td>Pulsed Field Facility</td>
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<td>EMR Facility</td>
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<td>UF Physics</td>
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<td>Geochemistry Facility</td>
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<tr>
<td>Optical Microscopy</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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Baity, P.G.; Shi, X.; Shi, Z.; Benfatto, L. and Popovic, D., Effective two-dimensional thickness for the Berezinskii-Kosterlitz-Thouless-like transition in a highly underdoped $La_{2-x}Sr_xCuO_6$, Phys. Rev. B, 93, 024519 (2016)


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Drichko, I.L.; Smirnov, I.Y.; Suslov, A.V.; Galperin Pfeiffer, L.N. and West K.W., Melting of Wigner cry high-mobility n-GaAs/AlGaAs heterostructures at factors 0.18<v>0.125: Acoustic studies, https://arxiv.org/abs/1607.01918, (2016)


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Balicas, L., Fellow of the American Association for the Advancement of Science (2016-present)

Humayun, M. (Munir), 2015-2016 Undergraduate Teaching Award (2016)

Jaime, M., Tooru Atake Lecture Award at 2016 Calorimetry Conference, Oahu, Hawaii. (2016)

Lu, Z., Best Student Poster Award, 33rd International Conference on the Physics of Semiconductors (ICPS 2016, Beijing, China, 2016.7.31 - 2016.8.5) (2016-present)

Marshall, A.G., Florida Inventors Hall of Fame (2016-present)

Paulino, J., Travel stipend 57th Experimental Nuclear Magnetic Resonance Conference (2016-present)

Sanabria, C., Academic Leadership Award at the Florida State University (2016)

Sanabria, C., Best Student Paper, Materials 1st Place. Award presented at the Applied Superconductivity Conference (2016)

Sanabria, C.,

Ph.D. Dissertations (local) (26)


Victor Keilin Memorial Prize (Materials) Best Paper for “Development of Superconducting Materials for Large Scale Applications” Award presented at the Applied Superconductivity Conference (2016-present)

Segal, C., IEEE Best Student Paper in Materials - First Place. (2016)

Segal, C., Victor Keilin Memorial Prize (Materials) - Best Paper for Development of Superconducting Materials for Large Scale Applications (2016)

Singleton, J., Organizer and chair, Focus topic, APS March Meeting, DMR, Van der Waals Bonding in Advanced Materials: Methods (2016-2016)

Singleton, J., Outstanding Innovation Award, Los Alamos National Security and the DoE (2016)

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Brown, Daniel Ross, "Hard Magnetic Materials without rare Earth Elements", Florida State University, Program in Material Science and Engineering, advisors: Ke Han and Eric Hellstrom (2016)
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Clingenpeel, Amy, "Characterization of Interfacial Material Isolated from Petroleum Crude Oils by FT-ICR MS", Florida State University, Chemistry & Biochemistry Department, advisor: Alan Marshall (2016)


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Kang, Daesung, "Network Analysis of Neural Activity", University of Florida, Department of Biomedical Engineering, advisor: Mingzhou Ding (2016)

Kasinadhuni, Aditya Kumar, "Mapping Current Density Due To Electrical Stimulation Using Magnetic Resonance Electrical Impedance Tomography", University of Florida, Biomedical Engineering, advisor: Thomas Mareci (2016)

Kaur, Pavanjeet, "Lipid-protein interactions defined by multi-frequency EPR: examples from HIV-1 envelope and antimicrobial peptides", Florida State University, Physics, advisor: Song, Likai (2016)

Kirton, Joshua, "Regional White Matter Lesion Volume and Depressive Symptom Dimensions: Cerebrovascular Aging after 40 and in Late Life", University of Florida, Department of Clinical & Health Psychology, advisor: Vonetta Dotson (2016)


Lee, Minseong, "Magnetic Phase Diagram of Triangular Lattice Antiferromagnet Ba3MnNb2Co9 (M = Co, Mn) and its Multiferroicity", Florida State University, Dept. of Physics, advisor: Choi, E. S. (2016)

Ludwig, Jonathan, "Optical spectroscopy of novel semiconductors in high magnetic fields", Florida State University, Department of Physics, advisor: Smirnov, Dmitrii (2016)

Myers, Jennifer, "Investigation of Human Prostate Cancer through Experimental and Bioinformatics Study of Gene and Protein Expression", Florida State University, Molecular Biophysics, advisor: Amy Qing-Xiang Sang (2016)

Reeg, Christopher, "Superconducting Proximity Effect in Topological Materials", University of Florida, Department of Physics, advisor: Christopher J. Stanton (2016)


Tan, Xiaoyan, "Synthesis and Investigation of Ternary Intermetallics as Itinerant Magnets", Florida State University, Chemistry, advisor: Shatruk, M (2016)

Tang, Shao, "Impurities and Defects in Mott Systems", Florida State University, Physics, advisor: V. Dobrosavljevic (2016)

Tang, Yibing, "NMR Studies of 2D Quantum Systems: 3He Adsorbed ion Boron Nitride", University of Florida, Department of Physics, advisor: Neil Sullivan (2016)

Tao, Yeqing, "Probing Protein Conformation and Protein-Protein Interaction by Hydrogen Deuterium Exchange Coupled with FT-ICR MS", Florida State University, Chemistry & Biochemistry Department, advisor: Alan Marshall (2016)

Xu, Jia, "Controlling the interfacial structure surrounding single-walled carbon nanotubes", University of Florida, Department of Chemical Engineering, advisor: Kirk Ziegler (2016)

Zeng, Pan, "Study of Normal and Superfluid 3He Films with Micro-Electro-Mechanical Devices.", University
Chapter 6 – Accomplishments and Discoveries

of Florida, Department of Physics, advisor: Lee Yoon (2016)
Zech, Daniel, "Entangling Qubits by Heisenberg"

Ph.D. Dissertations (external) (33)
Ang, Aileen C., "Antioxidant and Toxicity Assay-Guided Isolation of Herniarin from Equisetum debile ("Sumbak")", Stanford University, Department of Physics, advisor: Not provided (2016)


Chang, Hui, "High Pressure Quantum Oscillation Study of the Mott Insulator NiS2", University of Cambridge, Cavendish Laboratory, advisor: Dr. F. Malte Grosse (2016)


Congcong, Zhao, "A study of Ag precipitation and properties of Cu-Ag Alloys", Northwestern University in China, advisors: Engang Wang and Ke Han (2016)

Du, Lingjie, "Transport Properties of Quantum Spin Hall Effect and Exciton Condensation in InAs/GaSb", Rice University, Department of Physics and Astronomy, advisor: Rui-Rui Du (2016)

Frampton, Miles, "The Magnetostructural Transition in Iron-based Superconductors and Their Parent Compounds", University of California, Davis; Physics, advisor: Rena Zieve (2016)

Gao, Shang, "Frustration in quantum spinels", University of Geneva, Department of Quantum Matter Physics, advisor: Christian Ruegg (2016)

Gueneli, Nur, "Late Mesoproterozoic Microbial Communities", Australian National University, Research School of Earth Sciences, advisor: Jochen J. Brooks (2016)


Hodgkins, Suzanne, "Changes in Organic Matter

Spin Exchange and Anyon Braiding", Florida State University, Department of Physics, advisor: Bonesteel, N.E. (2016)

 Chemistry and Methanogenesis due to Permafrost Thaw in a Subarctic Peatland", The Florida State University, Earth, Ocean & Atmospheric Science, advisor: Jeffrey P. Chanton (2016)

Jeon, Jaekyun, "Self-Assembly of Rous Sarcoma Virus CA, Probed by Solid-State NMR and TEM", University of Central Florida, Department of Physics, advisor: Chen, Bo (2016)


Kendrick, Agnieszka Anastazja, "The regulation of pancreatic cancer progression by CD147 and cyclophilin A and the study of interleukin-8 dynamics and interaction with CXCR1 receptor peptide", University of Colorado Denver, Anschutz Medical Campus, Structural Biology & Biochemistry, advisor: Kieft, Jeffrey S.; Eisenmesser, Elan Z. (2016)


Liang, Tian, "Transport and Magnetic Properties in Topological Materials", Princeton University, Department of Physics, advisor: Nai Phuan Ong (2016)

Ling, Shenglong, "Structure Characterization and Functional study of Membrane Protein by Electron
Chapter 6 – Accomplishments and Discoveries

Paramagnetic Resonance Based Hybrid Method”, University of Science and Technology of China, advisor: Changlin Tian (2016)

Mama, Rohaidah L., "Chlorophyll Related Compounds Isolated from the Hexane Extract of the Leaves of Sechium edule", Stanford University, advisor: Not provided (2016)

Matras, Maxime, "Optimization of Ag-sheathed multifilamentary 2212 superconducting round wire processed with overpressure for high field magnets", ASC, FSU, advisor: David Labalesteir (2016)

Mazoom, Reoee Ann Mae C., "Chlorophyll and its Degradants from the Leaves of Bambusa blumeana Schultes f. ("Kauyan-Tinik"), Stanford University, Department of Physics, advisor: Not provided (2016)


Paulino, Joana, "Dynamics of the M2 Proton Channel of Influenza A: Gating by VAL27 and TRP41", FSU, Institute Of Molecular Biophysics, advisor: Cross, Timothy (2016)


Master Theses (9)

Abad, Nastaren, "Quantitative Analysis of Sodium Fluxes and Metabolic Changes in Migraine Using 23Na MRI and 1H MRS At Ultra High Field", Chemical & Biomedical Engineering, Florida State University, advisor: Grant, Samuel (2016)

Chitsike, Lennox., "The role of c-Abl kinase in HCC development", Loyola University Chicago, Molecular and Cellular Biochemistry Program, advisor: Wei Qui (2016)

Imperial, Lorelie, "Non-thesis MS", University of Florida, Department of Medicinal Chemistry, advisor: Hendrik Luesch (2016)

Ould Ismail, Abdal Aziz, "DTI-Based Connectivity in Isolated Neural Ganglia: A Default Structural Graph in a Small World Framework", Florida State University, advisor: Dr. Samuel C. Grant (2016)

Qu, C., "Melt Memory of Crystallization Above the Equilibrium Melting Temperature in Model Long Chain Branched Polyethylenes", Florida State University, Chemical Engineering, advisor: Rufina G. Alamo (2016)


Sang, Y., "Self-Nucleation of Broad Ethylene 1-Alkene Random Copolymers", Florida State University, Chemical Engineering, advisor: Rufina
Chapter 6 – Accomplishments and Discoveries

G. Alamo (2016)  

Appendix I
User Facility Statistics
Appendix I – User Facility Statistics

User Facilities

Seven user facilities — DC Field, Pulsed Field, High B/T, NMR-MRI@FSU, NMR-MRI@UF (AMRIS), EMR, and ICR — each with exceptional instrumentation and highly qualified staff scientists and staff, comprise the magnet lab’s user program. In this appendix, each facility presents detailed information about its user demographics, operations statistics and requests for magnet time.

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be “on site” for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the magnet lab, are all considered users. All user numbers reflect distinct individuals, i.e. If a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once. All user data in the user facility statistic is as of February 13th, 2017.

DC Field Facility

Table 1 – User Demographic

<table>
<thead>
<tr>
<th>DC Field Facility</th>
<th>Users</th>
<th>Male</th>
<th>Female</th>
<th>Prefer Not to Respond to Gender</th>
<th>Minority¹</th>
<th>Non-Minority²</th>
<th>Prefer Not to Respond to Race</th>
<th>Users Present</th>
<th>Users Operating Remotely²</th>
<th>Users Sending Sample³</th>
<th>Off-Site Collaborators⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>171</td>
<td>136</td>
<td>19</td>
<td>16</td>
<td>5</td>
<td>144</td>
<td>22</td>
<td>106</td>
<td>0</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>Senior Personnel, non-U.S.</td>
<td>75</td>
<td>57</td>
<td>9</td>
<td>9</td>
<td>3</td>
<td>58</td>
<td>14</td>
<td>26</td>
<td>0</td>
<td>17</td>
<td>32</td>
</tr>
<tr>
<td>Postdocs, U.S.</td>
<td>57</td>
<td>48</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>50</td>
<td>4</td>
<td>46</td>
<td>0</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Postdocs, non-U.S.</td>
<td>17</td>
<td>10</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>10</td>
<td>7</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Students, U.S.</td>
<td>179</td>
<td>133</td>
<td>36</td>
<td>10</td>
<td>6</td>
<td>149</td>
<td>24</td>
<td>155</td>
<td>0</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>70</td>
<td>51</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>52</td>
<td>16</td>
<td>47</td>
<td>0</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Technician, U.S.</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>578</td>
<td>443</td>
<td>86</td>
<td>49</td>
<td>19</td>
<td>472</td>
<td>87</td>
<td>399</td>
<td>0</td>
<td>52</td>
<td>127</td>
</tr>
</tbody>
</table>

¹ NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin

² “Users Operating Remotely” refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.

³ “Users Sending Sample” refers to users who send the sample to the facility and/or research group and the experiment is conducted by other collaborators on the experiment. Users at UF, FSU, and LANL cannot be “sample senders” for facilities located on their campuses.

⁴ “Off-Site collaborators” are scientific or technical participants on the experiment; who will not be present, sending samples, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).

Note: Users using multiple facilities are counted in each facility listed.
### Table 2 – User Affiliation

<table>
<thead>
<tr>
<th>DC Field Facility</th>
<th>Users</th>
<th>NHMFL-Affiliated Users¹</th>
<th>Local Users²</th>
<th>University Users²,⁴</th>
<th>Industry Users⁴</th>
<th>National Lab Users³,⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>171</td>
<td>61</td>
<td>11</td>
<td>149</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Senior Personnel, non-U.S.</td>
<td>75</td>
<td>0</td>
<td>0</td>
<td>51</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Postdocs, U.S.</td>
<td>57</td>
<td>8</td>
<td>7</td>
<td>49</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Postdocs, non-U.S.</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Students, U.S.</td>
<td>179</td>
<td>17</td>
<td>18</td>
<td>175</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>70</td>
<td>0</td>
<td>0</td>
<td>63</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Technician, U.S.</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>578</td>
<td>94</td>
<td>36</td>
<td>511</td>
<td>0</td>
<td>67</td>
</tr>
</tbody>
</table>

¹NHMFL-Affiliated users are defined as anyone in the lab's personnel system (i.e. on our Web site/directory), even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.

²The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as “Internal Investigators.”
³In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
⁴The total of university, industry, and national lab users will equal the total number of users.

### Table 3 – Users by Discipline

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>171</td>
<td>125</td>
<td>8</td>
<td>16</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Senior Personnel, non-U.S.</td>
<td>75</td>
<td>61</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Postdocs, U.S.</td>
<td>57</td>
<td>50</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Postdocs, non-U.S.</td>
<td>17</td>
<td>14</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Students, U.S.</td>
<td>179</td>
<td>149</td>
<td>13</td>
<td>14</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>70</td>
<td>68</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Technician, U.S.</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>578</td>
<td>469</td>
<td>27</td>
<td>33</td>
<td>33</td>
<td>16</td>
</tr>
</tbody>
</table>

### Table 4 – User Facility Operations

<table>
<thead>
<tr>
<th>DC Field Facility</th>
<th>Resitive Magnets &amp; Hybrid</th>
<th>Superconducting Magnets</th>
<th>Total Days Used / User Affil.</th>
<th>Percentage Used / User Affil.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
<td>113</td>
<td>193</td>
<td>306</td>
<td>17%</td>
</tr>
<tr>
<td>Local</td>
<td>4</td>
<td>69</td>
<td>73</td>
<td>4%</td>
</tr>
<tr>
<td>U.S. University</td>
<td>362</td>
<td>613</td>
<td>975</td>
<td>55%</td>
</tr>
<tr>
<td>U.S. Govt. Lab.</td>
<td>6</td>
<td>22</td>
<td>28</td>
<td>2%</td>
</tr>
<tr>
<td>U.S. Industry</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Non-U.S.</td>
<td>210</td>
<td>122</td>
<td>332</td>
<td>19%</td>
</tr>
<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>21</td>
<td>25</td>
<td>46</td>
<td>3%</td>
</tr>
<tr>
<td>Total</td>
<td>716</td>
<td>1,044</td>
<td>1,760</td>
<td>100%</td>
</tr>
</tbody>
</table>

¹Note: Since each resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies, there can be four resistive magnets + three superconducting magnets or the 45 T hybrid, two resistive magnets + three superconducting magnets operated in a given week. User Units are defined as magnet days. Users of water-cooled resistive or hybrid magnets can typically expect to receive enough energy for 7 hours a day of magnet usage so a magnet day is defined as 7 hours. Superconducting magnets are scheduled typically 24 hours a day. There is an annual four week shutdown in fall of powered DC resistive and hybrid magnets for infrastructure maintenance and a two week shutdown period for the university mandated holiday break.
### Table 5 – Operations by Discipline

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NHMF-fl-Affiliated</td>
<td>306</td>
<td>237</td>
<td>0</td>
<td>2</td>
<td>67</td>
<td>0</td>
</tr>
<tr>
<td>Local</td>
<td>73</td>
<td>45</td>
<td>28</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>U.S. University</td>
<td>975</td>
<td>888</td>
<td>56</td>
<td>14</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>U.S. Govt. Lab.</td>
<td>28</td>
<td>28</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>U.S. Industry</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-U.S.</td>
<td>332</td>
<td>326</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>46</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>1,760</strong></td>
<td><strong>1,542</strong></td>
<td><strong>87</strong></td>
<td><strong>16</strong></td>
<td><strong>112</strong></td>
<td><strong>2</strong></td>
</tr>
</tbody>
</table>

¹ Note: Since each resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies, there can be four resistive magnets + three superconducting magnets or the 45 T hybrid, two resistive magnets + three superconducting magnets operated in a given week. User Units are defined as magnet days. Users of water-cooled resistive or hybrid magnets can typically expect to receive enough energy for 7 hours a day of magnet usage so a magnet day is defined as 7 hours. Superconducting magnets are scheduled typically 24 hours a day. There is an annual four week shutdown in fall of powered DC resistive and hybrid magnets for infrastructure maintenance and a two week shutdown period for the university mandated holiday break.

### Table 6 – User Program Experiment Pressure

<table>
<thead>
<tr>
<th>DC Field Facility</th>
<th>Experiment Requests Received</th>
<th>Experiment Requests Deferred from Prev. Year</th>
<th>Experiment Requests Granted</th>
<th>Experiment Requests Declined/Deferred</th>
<th>Experiment Requests Reviewed</th>
<th>Subscription Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>344</td>
<td>115</td>
<td>282 (61.44%)</td>
<td>177 (38.56%)</td>
<td>459</td>
<td>162.77%</td>
</tr>
</tbody>
</table>

### Table 7 – New User PIs¹

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blumberg, Girsh</td>
<td>Rutgers University</td>
</tr>
<tr>
<td>Chen, I-Wei</td>
<td>University of Pennsylvania</td>
</tr>
<tr>
<td>Chen, Zhiguo</td>
<td>Institute of Physics, Chinese Academy of Sciences</td>
</tr>
<tr>
<td>Daid Pengcheng</td>
<td>University of Tennessee Knoxville</td>
</tr>
<tr>
<td>de Vaulchier, Louis-Anne</td>
<td>Ecole Normale Supérieure</td>
</tr>
<tr>
<td>Deshpande, Vikram</td>
<td>University of Utah</td>
</tr>
<tr>
<td>Dordevic, Sasa</td>
<td>The University of Akron</td>
</tr>
<tr>
<td>Drichko, Natalia</td>
<td>Johns Hopkins University</td>
</tr>
<tr>
<td>Gedik, Nuh</td>
<td>MIT</td>
</tr>
<tr>
<td>Grockowiak, Audrey</td>
<td>NHMFFL</td>
</tr>
<tr>
<td>Hu, Jin</td>
<td>Tulane University</td>
</tr>
<tr>
<td>Jena, Debdeep</td>
<td>Cornell University</td>
</tr>
<tr>
<td>Jin, Rongying</td>
<td>Louisiana State University</td>
</tr>
<tr>
<td>Lee, Cheol Eui</td>
<td>Korea University</td>
</tr>
<tr>
<td>MA, Bin</td>
<td>University of Minnesota</td>
</tr>
<tr>
<td>Pasupathy, Abhay</td>
<td>Columbia University</td>
</tr>
<tr>
<td>Puig, Teresa</td>
<td>ICMAB-CSIC</td>
</tr>
<tr>
<td>Ross, Kate</td>
<td>Colorado State University</td>
</tr>
<tr>
<td>Rotkin, Slava V</td>
<td>Lehigh University</td>
</tr>
<tr>
<td>Suh, Dongseok</td>
<td>Sungkyunkwan University</td>
</tr>
<tr>
<td>Wei, Jiang</td>
<td>Tulane University</td>
</tr>
</tbody>
</table>

¹ Note: Since each resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies, there can be four resistive magnets + three superconducting magnets or the 45 T hybrid, two resistive magnets + three superconducting magnets operated in a given week. User Units are defined as magnet days. Users of water-cooled resistive or hybrid magnets can typically expect to receive enough energy for 7 hours a day of magnet usage so a magnet day is defined as 7 hours. Superconducting magnets are scheduled typically 24 hours a day. There is an annual four week shutdown in fall of powered DC resistive and hybrid magnets for infrastructure maintenance and a two week shutdown period for the university mandated holiday break.
### Appendix I – User Facility Statistics

#### Table 8 – Research Proposals Profile with Magnet Time

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1. A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2. The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3. The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

#### Table 9 – User Proposal

This report lists all proposals that were allocated magnet time from January-December 2016 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users. (S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

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## Appendix I – User Facility Statistics

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### Appendix I – User Facility Statistics

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MagLab 2016 Annual Report
### Appendix I – User Facility Statistics

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MagLab 2016 Annual Report
## Appendix I – User Facility Statistics

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MagLab 2016 Annual Report
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## Appendix I – User Facility Statistics

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MagLab 2016 Annual Report
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**Participants (6 items) (1 item)**

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**Participants (PI, Coll.):**

- **Dmitry Smirnov (S):**
  - Org.: NHMFL
  - Dep.: Instrumentation & Operations

- **Chun Ning (Jeanie) Lau (S):**
  - Org.: Univ of California, Riverside
  - Dep.: Dep. of Physics and Astronomy

- **Kevin Myhro (G):**
  - Org.: Univ of California, Riverside
  - Dep.: Physics

- **Yanmeng Shi (G):**
  - Org.: Univ of California, Riverside
  - Dep.: Physics

- **Yongjin Lee (G):**
  - Org.: Univ of California, Riverside
  - Dep.: Physics Dept

- **Nathaniel Giligren (G):**
  - Org.: Univ of California, Riverside
  - Dep.: Physics

- **Petr Stepanov (G):**
  - Org.: Univ of California, Riverside
  - Dep.: Physics

- **Shi Che (G):**
  - Org.: Univ of California, Riverside
  - Dep.: Physics

- **Son Tran (G):**
  - Org.: Univ of California, Riverside
  - Dep.: Physics

- **Jiawei Yang (G):**
  - Org.: Univ of California, Riverside
  - Dep.: Physics

**Name** | **Role** | **Org.** | **Dep.** | **Award #** | **Div** | **Funding Agency Title**
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| Pfeiffer (S) ton Un
| Engineering | | | | | | |
| Ken West (S) Princeton | Institute for | the Science | | | | |
| University | and Technology | and | | | | |
| Kirk Baldwin (S) Princeton | University | Electrical | Engineering | | | |
| Md Shafayat | Princeton | Electrical | Engineering | | | |
| Meng Ma (G) | | | | | | |

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Vortex structures in Hg1201 single crystals: competition with antiferromagnetism and the pseudo \( \Delta p \) 
P07171 CM Physics 1 9

Magnetic properties of quantum spin systems 
P07174 CM Physics 1 5
### Appendix I – User Facility Statistics

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| (7 items) | (1 item) | Magneto-spectroscopy of metamorphic InAsSb narrow band semiconductors | P07180 | CM Physics | 1 | 6 |

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Quantum oscillation measurement of a novel non-centrosymmetric superconductor P07190 CM Physics 1 8

Magneto-optical studies on complex fluids P07193 CM Physics 2 14

Magneto-optics of 2D semiconducting transition metal P07197 CM Physics 3 16
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- Cory Dean (S)
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**Funding Source(s)**

- NHMFL
- Condensed Matter Experiment
- SCU
- CMS
- NHMFL
- Physics
- City College of New York
- Washington Univ
- Georgia Institute of Technology
- NHMFL -FSU

**Prop. Title**

- No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)
- Resistively and inductively detected NMR as probe of 3D topological Kondo Insulators
- Evolution of the upper critical field, its anisotropy and Hall effects of iron-pnictide epitaxial films with a high critical current density
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### Upper critical fields, magneto-transport properties and thermally activated flux flow in Ba(Fe0.91Co0.09)2As2, Ba(Fe0.95Ni0.05)2As2, and Ba(Fe0.94Ni0.06)2As2 superconductors

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High Field Heat Capacity of High Tc Cuprate Superconductors | P08321 | CM Physics | 1 | 9 |
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MagLab 2016 Annual Report
## Appendix I – User Facility Statistics

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- Prop. ID: P08338
- Prop. Disc.: CM Physics
- Exp. Sched.: 1
- # of Days Used: 7

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- Prop. Title: Development of dilatometer with optical readout
- Prop. ID: P0839
- Prop. Disc.: Magnets, Materials, Testing, Instrumentation
- Exp. Sched.: 1
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- Prop. Disc.: CM Physics
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### Appendix I – User Facility Statistics

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- A search for topological surface states
- Studies of Novel Two Dimensional Material Phosphorene

MagLab 2016 Annual Report
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| Studying the electronic structure of WTe2 as a function of the number of atomic layers | P08406 | CM Physics | 1 | 10 |

| Magnetotransport in Underdoped Cuprates | P08411 | CM Physics | 5 | 23 |
## Appendix I – User Facility Statistics

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MagLab 2016 Annual Report
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## Appendix I – User Facility Statistics

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Study of metallic state of (TMTTF)2Br - Unified model for the quasi-one-dimensional conductors

Unconventional anisotropic magnetoresistance in a canted antiferromagnet
### Appendix I – User Facility Statistics

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- **Other**

**Prop. Title**

- Weyl Semimetallic state and Shubnikov-de-Haas effect in Pr2Ir2O7
- Field and Pressure Tuning of Anomalous Metallic State in the Mixed Valence Compound a-YbAlB4
- Quantum oscillations and magnetotransport properties of layered transition-metal chalcogenide...
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MagLab 2016 Annual Report
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MagLab 2016 Annual Report
## Appendix I – User Facility Statistics

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High field magnetotransport behavior and Fermi surface study by quantum oscillation for topological semimetals

High magnetic

Quest for novel high-magnetic-field superconducting phases in 2D organic superconductors

MagLab 2016 Annual Report
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High field magnetophotoluminescence studies of organic and hybrid organic/inorganic semiconductors with tunable spin-orbit coupling | P13618 | CM Physics | 3 | 12 |

SCH Magnet Testing | P13623 | Magnets, Materials, Testing, Instrumentation | 4 | 7 |
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Hongwoo Baek (S) Coll. NHMFL DC field

Jeong-hoon Ha (P) Coll. NHMFL CMS

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Arnei Reyes (S) Coll. NHMFL CMS

Philip Kuhns (S) Coll. NHMFL CMS

Rajib Sarkar (S) Coll. Technische Universität Dresden | Fachrichtung Physik |

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William Blackmore (G) Coll. Univ of Warwick | Physics |

Monica Ciomaga Hatnean (P) Coll. Univ of Warwick | Physics |
## Appendix I – User Facility Statistics

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Investigation of magnetic anisotropy in low dimensional systems | P13639 | CM Physics | 2 | 11 |

Charge Dynamics in Narrow-Gap Mott Insulators | P13641 | CM Physics | 1 | 7 |
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**Hall effect in high quality underdoped YBCO**

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MagLab 2016 Annual Report
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MagLab 2016 Annual Report
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Anisotropic and nonequilibrium transport in 2D systems

Chiral magnetic effect in transition-metal pentatellurides

Quantum Electronic Transport in Atomically Layered Semimetals and Superconductors

MagLab 2016 Annual Report
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Magnetic Characterization of a New Class of 2D Layered Materials

Thermal conductivity measurements on magnetic multiferroic materials

Sub-10 nm 1D/3D Disordered Electron Systems

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Title: dimensional holes in Ge/SiGe heterostructure field-effect transistors

Title: Magneto-optical characterization of systems with linear electronic dispersion

Title: Pinning properties of CSD YBCO nanocomposites at ultrahigh magnetic fields and very low temperatures

Title: Understanding Change of Permanent Magnetic Material Properties in High Magnetic Field Annealing

Title: Phase Transitions in Graphene's s=0 Landau Level

MagLab 2016 Annual Report
### Appendix I – User Facility Statistics

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<td>Physics</td>
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<td>Dept. of Physics</td>
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### Pressure-Induced

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<th>Title</th>
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<td>pi</td>
<td>Universität Leipzig</td>
<td>Superconductivity and Magnetism</td>
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<td>Search for high-field superconductivity at embedded interfaces in natural graphite crystals</td>
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<td>Luis Balicas (S)</td>
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<td>Condensed Matter Experiment</td>
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<td>Qimiao Si (S)</td>
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<td>Dept. of Physics</td>
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### Appendix I – User Facility Statistics

<table>
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<th>Participants (PI, Coll.)</th>
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<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<td></td>
<td>Bosonic States in the Spin Dimer System SrCu2(BO3)2 at Low Fields</td>
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<td>David Graf (S)</td>
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<td>Optical Spectroscopy of Novel Two-Dimensional Materials</td>
<td>P15996</td>
<td>CM Physics</td>
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<td>William Steinhardt (G)</td>
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<td>CM Physics</td>
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<td>Efstratios Manousakis (S)</td>
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<td>Joshua Holleman (G)</td>
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<td>Carlos Garcia (G)</td>
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<td>Nuh Gedik (S)</td>
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<td>Stephen McGill (S)</td>
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<td>Emre Ergecen (G)</td>
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<td>Yong Chen (S)</td>
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<td>Yang Xu (G)</td>
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## Appendix I – User Facility Statistics

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<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<td>Ireneusz Miotkowski [S]</td>
<td>Coll. Purdue Univ</td>
<td>Physics Dep.</td>
<td></td>
<td></td>
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<tr>
<td>(8 items)</td>
<td>(1 item)</td>
<td>Measurement of Quantum Oscillations near the Quantum Limit in Mn:Sn; a Candidate for a Magnetic Metallic Weyl Fermion system</td>
<td>P16028</td>
<td>CM Physics</td>
<td>1 5</td>
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<tr>
<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award #</td>
<td>Div Funding Agency Title</td>
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<td>Ross McDonald [S]</td>
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<td>Physics</td>
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<td>Neil Harrison [S]</td>
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<td>NMFL</td>
<td>Physics</td>
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<tr>
<td>Luis Balicas [S]</td>
<td>Coll.</td>
<td>NMFL</td>
<td>Condensed Matter Experiment</td>
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<tr>
<td>Jonathan Betts [S]</td>
<td>Coll.</td>
<td>NMFL</td>
<td>NMFL-PFF</td>
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</table>

282 1,760
## Appendix I – User Facility Statistics

### Table 1 – User Demographic

<table>
<thead>
<tr>
<th>PFF Facility</th>
<th>Users</th>
<th>Male</th>
<th>Female</th>
<th>Prefer Not to Respond to Gender</th>
<th>Minority¹</th>
<th>Non-Minority²</th>
<th>Prefer Not to Respond to Race</th>
<th>Users Present</th>
<th>Users Operating Remotely</th>
<th>Users Sending Sample³</th>
<th>Off-Site Collaborators⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>61</td>
<td>52</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>56</td>
<td>4</td>
<td>36</td>
<td>0</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Senior Personnel, non-U.S.</td>
<td>22</td>
<td>20</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>20</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>8</td>
<td>8</td>
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<tr>
<td>Postdocs, U.S.</td>
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<td>2</td>
<td>2</td>
<td>12</td>
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<td>0</td>
<td>4</td>
<td>2</td>
<td>3</td>
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<tr>
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<td>6</td>
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<td>1</td>
<td>6</td>
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<tr>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Total:</td>
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<td>118</td>
<td>19</td>
<td>11</td>
<td>127</td>
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<td>93</td>
<td>0</td>
<td>21</td>
<td>0</td>
<td>34</td>
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</tbody>
</table>

¹ NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin.

² “Users Operating Remotely” refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.

³ “Users Sending Sample” refers to users who send the sample to the facility and/or research group and the experiment is conducted by other collaborators on the experiment. Users at UF, FSU, and LANL cannot be “sample senders” for facilities located on their campuses.

⁴ “Off-Site collaborators” are scientific or technical Names (PI, Coll.) on the experiment; who will not be present, sending samples, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).

**Note:** Users using multiple facilities are counted in each facility listed.

### Table 2 – User Affiliation

<table>
<thead>
<tr>
<th>PFF Facility</th>
<th>Users</th>
<th>NHMFL-Affiliated Users¹</th>
<th>Local Users¹</th>
<th>University Users²,³</th>
<th>Industry Users⁴</th>
<th>National Lab Users²,³,⁴</th>
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<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
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<td>23</td>
<td>7</td>
<td>40</td>
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<td>6</td>
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<td>8</td>
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<td>9</td>
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<td>16</td>
<td>104</td>
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</table>

¹ NHMFL-Affiliated users are defined as anyone in the lab’s personnel system (i.e. on our Web site/directory), even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.

The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as “Internal Investigators.”

² In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.

³ In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.

⁴ The total of university, industry, and national lab users will equal the total number of users.
### Table 3 – Users by Discipline

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<td><strong>Total:</strong></td>
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<td><strong>136</strong></td>
<td><strong>7</strong></td>
<td><strong>1</strong></td>
<td><strong>2</strong></td>
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### Table 4 – User Facility Operations

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<tr>
<th>PFF Facility</th>
<th>Short Pulse</th>
<th>Mid Pulse</th>
<th>Long Pulse</th>
<th>100T</th>
<th>Single Turn</th>
<th>Total Days Used / User Affil.</th>
<th>Percentage Used / User Affil.</th>
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<td>NHMFL-Affiliated</td>
<td>190</td>
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<td>0</td>
<td>3</td>
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<td>193</td>
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<tr>
<td>Local</td>
<td>9</td>
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<td>0</td>
<td>3</td>
<td>0</td>
<td>12</td>
<td><strong>2%</strong></td>
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<tr>
<td>U.S. University</td>
<td>212</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>219</td>
<td><strong>35%</strong></td>
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<tr>
<td>U.S. Govt. Lab.</td>
<td>23</td>
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<td>5</td>
<td>0</td>
<td>28</td>
<td><strong>5%</strong></td>
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<td>U.S. Industry</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Non-U.S.</td>
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<td>0</td>
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<td><strong>22%</strong></td>
</tr>
<tr>
<td>Test, Calibration, Set-up,</td>
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<td>0</td>
<td>17</td>
<td>0</td>
<td>28</td>
<td><strong>5%</strong></td>
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<tr>
<td>Maintenance, Inst. Dev.</td>
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<td></td>
<td><strong>Total:</strong> 618</td>
<td><strong>100%</strong></td>
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</table>

1User Units are defined as magnet days. Magnets are scheduled typically 12 hours a day.

### Table 5 – Operations by Discipline

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</thead>
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<td>NHMFL-Affiliated</td>
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<td>188</td>
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<td>Local</td>
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<td>12</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>U.S. University</td>
<td>219</td>
<td>198</td>
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<td>0</td>
<td>16</td>
<td>0</td>
</tr>
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<td>U.S. Govt. Lab.</td>
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<td>28</td>
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<td>0</td>
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<tr>
<td>U.S. Industry</td>
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<tr>
<td>Test, Calibration, Set-up,</td>
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<td>5</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Maintenance, Inst. Dev.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>618</strong></td>
<td><strong>569</strong></td>
<td><strong>5</strong></td>
<td><strong>0</strong></td>
<td><strong>44</strong></td>
<td><strong>0</strong></td>
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</tbody>
</table>

1User Units are defined as magnet days. Magnets are scheduled typically 12 hours a day.

### Table 6 – User Program Experiment Pressure

<table>
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<tr>
<th>PFF Facility</th>
<th>Experiment Requests Received</th>
<th>Experiment Requests Deferred from Prev. Year</th>
<th>Experiment Requests Granted</th>
<th>Experiment Requests Declined/Deferred</th>
<th>Experiment Requests Reviewed</th>
<th>Subscription Rate</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>103</td>
<td>37</td>
<td>82 (59%)</td>
<td>58 (41%)</td>
<td>140</td>
<td>171%</td>
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</table>

### Table 7 – New User PIs

<table>
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<tr>
<th>Name</th>
<th>Organization</th>
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<tbody>
<tr>
<td>Batista, Cristian</td>
<td>LANL</td>
</tr>
</tbody>
</table>
Appendix I – User Facility Statistics

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lashley, Jason</td>
<td>LANL</td>
</tr>
<tr>
<td>Li, Yuan</td>
<td>Peking University</td>
</tr>
<tr>
<td>Marie, Xavier</td>
<td>INSA - Toulouse</td>
</tr>
<tr>
<td>Nakatsuji, Satoru</td>
<td>University of Tokyo</td>
</tr>
<tr>
<td>Ramshaw, Brad</td>
<td>NHMFL</td>
</tr>
<tr>
<td>Señaris-Rodriguez, Maria</td>
<td>University of A Coruña</td>
</tr>
<tr>
<td>Shehter, Arkady</td>
<td>NHMFL</td>
</tr>
<tr>
<td>Sun, Young</td>
<td>Chinese Academy of Sciences</td>
</tr>
<tr>
<td>Wehinger, Bjoern</td>
<td>University of Geneva</td>
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</table>

TOTAL: 10

1 PI who received magnet time for the first time across all facilities.

Table 8 – Research Proposals Profile with Magnet Time

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</thead>
<tbody>
<tr>
<td>Number of Proposals</td>
<td>57</td>
<td>0</td>
<td>7</td>
<td>50</td>
<td>2</td>
<td>0</td>
<td>5</td>
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</table>

1 A “proposal” may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

Table 9 – User Proposal

This report lists all proposals that were allocated magnet time from January-December 2016 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.
(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<tbody>
<tr>
<td>(2 items)</td>
<td>(1 item)</td>
<td>Magnitization studies of Ni(II)-based molecular and polymeric magnets</td>
<td>P01531</td>
<td>Chems-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award #</td>
<td></td>
<td></td>
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<tr>
<td>Jamie Manson (S)</td>
<td>pi</td>
<td>Eastern Washington Univ</td>
<td>Chemistry and Biochemistry</td>
<td>100582</td>
<td>NSF</td>
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<td>Vivien Zapf (S)</td>
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<td>Physics</td>
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<td>(9 items)</td>
<td>(1 item)</td>
<td>High Field Ultrasonic Studies and Torque Magnetometry in Heavy Electron Materials</td>
<td>P02054</td>
<td>CM Physics</td>
<td>2</td>
<td>10</td>
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<tr>
<td>Name</td>
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<td>Dep.</td>
<td>Award #</td>
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<tr>
<td>Bellave Shivaram (S)</td>
<td>pi</td>
<td>Univ of Virginia</td>
<td>Physics</td>
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</table>
## Appendix I – User Facility Statistics

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<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<td>Ryan Baumbach (S)</td>
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<td>Eric Bauer (S)</td>
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<tr>
<td>John Singleton (S)</td>
<td>Coll. NHMFL Physics</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Ross McDonald (S)</td>
<td>Coll. NHMFL Physics</td>
<td></td>
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<tr>
<td>Brian Maple (S)</td>
<td>Coll. Univ of California, San Diego Inst for Pure &amp; Applied Physical Sciences</td>
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<tr>
<td>Marcelo Jaime (S)</td>
<td>Coll. NHMFL Physics</td>
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<td>Dagmar Weickert (S)</td>
<td>Coll. LANL MPA-CMMS</td>
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(1 item) (1 item) Maintenance of 1.4GW Generator system P02322 Magnets, Materials, Testing, Instrumentation 1 5

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<th>Name</th>
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<th>Org.</th>
<th>Dep.</th>
<th>Award #</th>
<th>Div</th>
<th>Funding Agency Title</th>
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<td>Jonathan Betts (S)</td>
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<td>NHMFL-PFF</td>
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<td>No other support (i.e. this experiment is entirely supported by NHMFL user services via its core grant)</td>
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(21 items) (1 item) High field spectroscopy of materials P02415 Chemistry, Geochemistry 1 5

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<th>Dep.</th>
<th>Award #</th>
<th>Div</th>
<th>Funding Agency Title</th>
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<tr>
<td>Janice Musfeldt (S)</td>
<td>pi</td>
<td>Univ of Tennessee</td>
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<td>JLM</td>
<td>Other</td>
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<tr>
<td>Michael Yokosuk (G)</td>
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<td>Amal Al-Wahish (P)</td>
<td>Coll.</td>
<td>Univ of Tennessee</td>
<td>Chemistry</td>
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<td>Judy Cherian (G)</td>
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<td>Kendall Hughey (G)</td>
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<td>Ken O’Neal (G)</td>
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<td>Amanda Clune (G)</td>
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MagLab 2016 Annual Report
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<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<tbody>
<tr>
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<td>Coll. Univ of Tennessee</td>
<td>Physics</td>
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<td>David Mandrus (S)</td>
<td>Coll. Univ of Tennessee</td>
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<td>Bernd Lorenz (S)</td>
<td>Coll. Univ of Houston</td>
<td>Texas Center for Superconductivity</td>
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<td>Dmitry Smirnov (S)</td>
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<td>Instrumentation &amp; Operations</td>
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<td>Wei Tian (S)</td>
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<td>Brian Holsworth (G)</td>
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<td>Julia Mundy (P)</td>
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<td>R. Ramesh (S)</td>
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<td>Dep. of Materials Science and Engineering</td>
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<td>Randy Fishman (S)</td>
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(10 items) | (1 item) | Magneto-transport and Symmetry-broken Quantum Hall States in Few Layer Graphene | P02457 | CM Physics | 1 | 5
### Appendix I – User Facility Statistics

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<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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</thead>
<tbody>
<tr>
<td>Kevin Myhro (G)</td>
<td>Coll.</td>
<td>Univ of California, Riverside</td>
<td>Physics</td>
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<tr>
<td>Yanmeng Shi (G)</td>
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<td>Univ of California, Riverside</td>
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<tr>
<td>Yongjin Lee (G)</td>
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<td>Petr Stepanov (G)</td>
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<td>Award #</td>
<td>Div</td>
<td>Funding Agency Title</td>
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<tr>
<td>Brad Ramshaw (P)</td>
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<td>DOE-BES</td>
<td>DOE</td>
<td>Crossing the Dome: YBa2Cu3O6+43 delta Fermi Surface Measurements at 100 Tesla</td>
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<tr>
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<td>Doug Bonn (S)</td>
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<td>Walter Hardy (S)</td>
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<td>Mun Chan (P)</td>
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<td></td>
<td>Pulsed field transport measurements of nano-machined Ce-based compounds</td>
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<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award #</td>
<td>Div</td>
<td>Funding Agency Title</td>
</tr>
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<tr>
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<td>ETH</td>
<td>Zuerich</td>
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<tr>
<td>Fedor Balakirev (S)</td>
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<td>Filip Ronning (S)</td>
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MagLab 2016 Annual Report
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<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<tbody>
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<td>Marcelo Jaime (S)</td>
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### (10 items)

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<td>20140</td>
<td>177ER</td>
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<td>Inorganic, Isotope and Actinide Chemistry</td>
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<td>Rutgers Univ</td>
<td>Physics and Astronomy</td>
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<td>John Singleton (S)</td>
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<td>NHMFL</td>
<td>Physics</td>
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<td>Michael Hoch (S)</td>
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<td>CMP NMR</td>
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<td>Materials Science Div</td>
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<td>Shalinee Chikara (P)</td>
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<td>NHMFL-PFF</td>
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<th>Funding Agency Title</th>
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Field Induced density wave in CeRhIn5 and CeCoIn5

The ground-state of the cuprate high-temperature superconductor

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Comparative study of Ic(B) for (Re)BCO, Bi-2223 and Bi-2212 conductors from different manufacturers.

**Exp. Sched.**

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- Electronic structure of URu2Si2 and related strongly correlated materials in very strong magnetic fields
- High Field Studies of Actinide Antiferromagnets

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MagLab 2016 Annual Report
## Appendix I – User Facility Statistics

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<th>Participants (PI, Coll.)</th>
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### Optical studies of monolayer and bulk transition-metal dichalcogenides in high magnetic fields
- **Prop. ID**: P14846
- **Funding Agency**: CM Physics
- **Days Used**: 1/5

### Magnetoelectric coupling in Cu2+$\text{S}=1/2$ spin systems under high magnetic field.
- **Prop. ID**: P14865
- **Funding Agency**: CM Physics
- **Days Used**: 1/12

### Striction of Shape-Memory Alloys
- **Prop. ID**: P14882
- **Funding Agency**: CM Physics
- **Days Used**: 1/4

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(1 item)

| Name                     | Role              | Org.        | Dep.    | Award #     | Div         | Funding Agency Title |
| Philip Moll (S)          | pi                | ETH Zuerich | MPI Chemical Physics of Solids | Microstructured Quantum Matter | Other | High-field magnetotransport in microstructures of the frustrated antiferromagnet Yb$_2$Sn$_2$Pt$_2$Se$_6$ |

(10 items)

| Name                     | Role              | Org.        | Dep.    | Award #     | Div         | Funding Agency Title |
| Arkady Shehter (S)       | pi                | NHMFL       | NHMFL, DC Field Facility | | | NHMFL VSP - Visiting Scientist Program |
| Jose Galvis Echeverri (P)| Coll.             | NHMFL       | CMS | | | |
| Paula Giraldo Gallo (P)  | Coll.             | NHMFL       | Physics | | | |
| Greg Boebinger (S)       | Coll.             | NHMFL       | Directors Office | | | |
| Laurel Winter (P)        | Coll.             | NHMFL       | Physics | | | |
| Kimberly Modic (G)       | Coll.             | NHMFL       | PFF | | | |
| Philip Moll (S)          | Coll.             | ETH Zuerich | MPI Chemical Physics of Solids | | | |
| Fedor Balakirev (S)      | Coll.             | NHMFL       | PFF | | | |
| Jonathan Betts (S)       | Coll.             | NHMFL       | NHMFL-PFF | | | |
| xiujun lian (G)          | Coll.             | NHMFL       | NHMFL | | | |

(5 items)

| Name                     | Role              | Org.        | Dep.    | Award #     | Div         | Funding Agency Title |
| James Analytis           | pi                | Univ of California, Physics | | | No other support (i.e. this experiment) | |

(1 item)

| Name                     | Role              | Org.        | Dep.    | Award #     | Div         | Funding Agency Title |
| Philip Moll (S)          | Coll.             | ETH Zuerich | MPI Chemical Physics of Solids | | | |
| Fedor Balakirev (S)      | Coll.             | NHMFL       | PFF | | | |
| Jonathan Betts (S)       | Coll.             | NHMFL       | NHMFL-PFF | | | |
| xiujun lian (G)          | Coll.             | NHMFL       | NHMFL | | | |

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| Name                     | Role              | Org.        | Dep.    | Award #     | Div         | Funding Agency Title |
| James Analytis           | pi                | Univ of California, Physics | | | No other support (i.e. this experiment) | |

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| Philip Moll (S)          | Coll.             | ETH Zuerich | MPI Chemical Physics of Solids | | | |
| Fedor Balakirev (S)      | Coll.             | NHMFL       | PFF | | | |
| Jonathan Betts (S)       | Coll.             | NHMFL       | NHMFL-PFF | | | |
| xiujun lian (G)          | Coll.             | NHMFL       | NHMFL | | | |

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| James Analytis           | pi                | Univ of California, Physics | | | No other support (i.e. this experiment) | |

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MagLab 2016 Annual Report
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<td>NHMFL</td>
<td>NHMFL-PFF</td>
<td></td>
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<tr>
<td>John Singleton</td>
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<td>Physics</td>
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<tr>
<td>Marcelo Jaime</td>
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<td>NSF</td>
</tr>
<tr>
<td>Zhiqiang Mao</td>
<td>Coll.</td>
<td>Tulane Univ</td>
<td>Physics Dep.</td>
<td></td>
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<td>NSF</td>
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</table>

MagLab 2016 Annual Report
### Appendix I – User Facility Statistics

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
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<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<tbody>
<tr>
<td>Satoru Nakatsuji (S)</td>
<td>pi</td>
<td>Univ of Tokyo</td>
<td>Institute for Solid State Physics</td>
<td>JAP8q374 238953</td>
<td>Other</td>
<td>Magnetic Metallic Weyl Fermion system</td>
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<tr>
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<td>NHMFL</td>
<td>Physics</td>
<td></td>
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<tr>
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<td>Institute for Solid State Physics (ISSP)</td>
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<td>Luis Balicas (S)</td>
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<td>Condensed Matter Experiment</td>
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<tr>
<td>Rico Schoenemann (G)</td>
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<td>Helmholz-Zentrum Dresden-Rossendorf</td>
<td>Dresden High Magnetic Field Laboratory</td>
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<th>Div</th>
<th>Funding Agency Title</th>
<th>Project</th>
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<tr>
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<td>NHMFL</td>
<td>MPA-CMMS</td>
<td></td>
<td></td>
<td>Other</td>
<td>P16083</td>
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</tr>
<tr>
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<td>NHMFL</td>
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<td>Eric Bauer (S)</td>
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<td>LANL</td>
<td>MST-10</td>
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<tr>
<td>Filip Ronning (S)</td>
<td>Coll.</td>
<td>LANL</td>
<td>MPA-CMMS</td>
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<tr>
<td>Kimberly Modic (G)</td>
<td>Coll.</td>
<td>NHMFL</td>
<td>PFF</td>
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</table>
### High B/T Facility

#### Table 1 – User Demographic

<table>
<thead>
<tr>
<th>HBT Facility</th>
<th>Users</th>
<th>Male</th>
<th>Female</th>
<th>Prefer Not to Respond to Gender</th>
<th>Minority&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Non-Minority&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Prefer Not to Respond to Race</th>
<th>Users Present</th>
<th>Users Operating Remotely&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Users Sending Sample&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Off-Site Collaborators&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>12</td>
<td>10</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Senior Personnel, non-U.S.</td>
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<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
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</tr>
<tr>
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<td>1</td>
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<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, U.S.</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
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<td>15</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>16</td>
<td>4</td>
<td>12</td>
<td>0</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

<sup>1</sup> NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin.

<sup>2</sup> “Users Operating Remotely” refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.

<sup>3</sup> “Users Sending Sample” refers to users who send the sample to the facility and/or research group and the experiment is conducted by other collaborators on the experiment. Users at UF, FSU, and LANL cannot be “sample senders” for facilities located on their campuses.

<sup>4</sup> “Off-Site collaborators” are scientific or technical participants on the experiment, who will not be present, sending samples, or operating the magnet system remotely, and who are not located on the campus of that facility (i.e., they are off-site).

**Note:** Users using multiple facilities are counted in each facility listed.

### Table 2 – User Affiliation

<table>
<thead>
<tr>
<th>HBT Facility</th>
<th>Users</th>
<th>NHMFL-Affiliated Users&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Local Users&lt;sup&gt;2&lt;/sup&gt;</th>
<th>University Users&lt;sup&gt;3,4&lt;/sup&gt;</th>
<th>Industry Users&lt;sup&gt;4&lt;/sup&gt;</th>
<th>National Lab Users&lt;sup&gt;1,4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>12</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Senior Personnel, non-U.S.</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Postdocs, U.S.</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Postdocs, non-U.S.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Students, U.S.</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, U.S.</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
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<td>3</td>
<td>1</td>
<td>16</td>
<td>0</td>
<td>4</td>
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</tbody>
</table>

<sup>1</sup> NHMFL-Affiliated users are defined as anyone in the lab’s personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.

The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as “Internal Investigators.”

<sup>2</sup> In addition to external users, users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.

<sup>3</sup> In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.

<sup>4</sup> The total of university, industry, and national lab users will equal the total number of users.
## Appendix I – User Facility Statistics

### Table 3 – Users by Discipline

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>12</td>
<td>9</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Senior Personnel, non-S.</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Postdocs, U.S.</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Postdocs, non-U.S.</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Students, U.S.</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>1</td>
<td>1</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Technician, U.S.</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>20</strong></td>
<td><strong>17</strong></td>
<td><strong>0</strong></td>
<td><strong>2</strong></td>
<td><strong>0</strong></td>
<td><strong>1</strong></td>
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</table>

### Table 4 – User Facility Operations

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<tr>
<th>HBT Facility</th>
<th>16T Bay 3</th>
<th>8T Bay 2</th>
<th>10T Williamson Hall</th>
<th>4T Williamson Hall</th>
<th>Total Days Used / User Affil.</th>
<th>Percentage Used / User Affil.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Local</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>U.S. University</td>
<td>91</td>
<td>99</td>
<td>0</td>
<td>0</td>
<td>190</td>
<td>23%</td>
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<tr>
<td>U.S. Govt. Lab.</td>
<td>0</td>
<td>98</td>
<td>0</td>
<td>0</td>
<td>98</td>
<td>12%</td>
</tr>
<tr>
<td>U.S. Industry</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
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<tr>
<td>Non-U.S.</td>
<td>190</td>
<td>0</td>
<td>0</td>
<td>119</td>
<td>309</td>
<td>38%</td>
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<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>42</td>
<td>86</td>
<td>36</td>
<td>62</td>
<td>226</td>
<td>27%</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>323</strong></td>
<td><strong>185</strong></td>
<td><strong>134</strong></td>
<td><strong>181</strong></td>
<td><strong>823</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

1User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

### Table 5 – Operations by Discipline

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Local</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>U.S. University</td>
<td>190</td>
<td>190</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>U.S. Govt. Lab.</td>
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<td>98</td>
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<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>U.S. Industry</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-U.S.</td>
<td>309</td>
<td>309</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>226</td>
<td>226</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
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<td><strong>823</strong></td>
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<td><strong>0</strong></td>
<td><strong>0</strong></td>
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</table>

1User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

### Table 6 – User Program Experiment Pressure

<table>
<thead>
<tr>
<th>HBT Facility</th>
<th>Experiment Requests Received</th>
<th>Experiment Requests Deferred from Prev. Year</th>
<th>Experiment Requests Granted</th>
<th>Experiment Requests Declined/Deferred</th>
<th>Experiment Requests Reviewed</th>
<th>Subscription Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>4</td>
<td>10 (63%)</td>
<td>6 (38%)</td>
<td>16</td>
<td>160%</td>
</tr>
</tbody>
</table>

MagLab 2016 Annual Report
Appendix I – User Facility Statistics

Table 7 – New User PIs1

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hallock, Robert</td>
<td>University of Massachusetts</td>
</tr>
<tr>
<td>Obukhov, Sergey</td>
<td>The Ioffe Physical Technical Institute of the Russian Academy of Sciences</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2</strong></td>
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</tbody>
</table>

1PI who received magnet time for the first time across all facilities.

Table 8 – Research Proposals Profile with Magnet Time

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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Proposals</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

1A “Proposal” may have associated with it a single experiment or a group of closely related experiment. A PI may have more than one proposal.
2The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

Table 9 – User Proposal

This report lists all proposals that were allocated magnet time from January-December 2016 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users. (S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>(6 items)</td>
<td>(1 item)</td>
<td>Preliminary Exploration of Wigner Crystallization Effects in HIGFET Devices</td>
<td>P02007</td>
<td>Condensed Matter Physics</td>
<td>1</td>
<td>106</td>
</tr>
<tr>
<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award #</td>
<td>Div.</td>
<td>Funding Agency Title</td>
</tr>
<tr>
<td>Jian Huang (S)</td>
<td>pi</td>
<td>Wayne State Univ</td>
<td>Dep. of Physics and Astronomy</td>
<td>DOE</td>
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<td>Loren Pfeiffer (S)</td>
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<td>Electrical Engineering</td>
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<td>P07151</td>
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<td>Award #</td>
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<td>Funding Agency Title</td>
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<td>pi</td>
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<td>Semiconductor Devices and Science</td>
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<tr>
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### Appendix I – User Facility Statistics

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<th>Participants (PI, Coll.)</th>
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<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<td>Microkelvin Laboratory, Physics</td>
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<td>Nicholas Curro (S)</td>
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<td>Univ of California</td>
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<td>Blaine Bush (G) Coll. Univ of California, Davis</td>
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<td>Funding Agency Title</td>
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<tr>
<td>Geetha Balakrishnan (S)</td>
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<td>Other</td>
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<td>Monica Ciomaga Hatnean (P) Coll. Univ of Warwick</td>
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<td>Div.</td>
<td>Funding Agency Title</td>
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<td>McGill Univ</td>
<td>Physics Dep.</td>
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<td>Other</td>
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<td>Coll. McGill Univ</td>
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<td>Participants (PI, Coll.)</td>
<td>Funding Source(s)</td>
<td>Prop. Title</td>
<td>Prop. ID</td>
<td>Prop. Disc.</td>
<td>Exp. Sched.</td>
<td># of Days Used</td>
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<td>-------------</td>
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<tr>
<td>Bilodeau (G)</td>
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(2 items) (1 item)

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<th>Funding Agency Title</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<td>McGill Univ</td>
<td>Physics Dep.</td>
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<td>Semiconductor Materials and Device Dep.</td>
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(2 items) (1 item)

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<th>Div.</th>
<th>Funding Agency Title</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<td>Dep. of Physics</td>
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<td>NSF</td>
<td>Study of Solid 4He to Very Low Temperatures</td>
<td>P14962</td>
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10 823
### Table 1 – User Demographic

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<tr>
<th>NMR Facility</th>
<th>Users</th>
<th>Male</th>
<th>Female</th>
<th>Prefer Not to Respond to Gender</th>
<th>Minority¹</th>
<th>Non-Minority²</th>
<th>Prefer Not to Respond to Race</th>
<th>Users Present</th>
<th>Users Operating Remotely²</th>
<th>Users Sending Sample³</th>
<th>Off-Site Collaborators¹</th>
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<tr>
<td>Senior Personnel, U.S.</td>
<td>114</td>
<td>83</td>
<td>19</td>
<td>12</td>
<td>3</td>
<td>97</td>
<td>14</td>
<td>34</td>
<td>21</td>
<td>25</td>
<td>34</td>
</tr>
<tr>
<td>Senior Personnel, non-U.S.</td>
<td>36</td>
<td>20</td>
<td>3</td>
<td>13</td>
<td>1</td>
<td>21</td>
<td>14</td>
<td>3</td>
<td>4</td>
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<td>23</td>
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<td>3</td>
<td>4</td>
<td>27</td>
<td>4</td>
<td>17</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Postdocs, non-U.S.</td>
<td>3</td>
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<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
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<td>54</td>
<td>6</td>
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<td>7</td>
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<td>0</td>
<td>8</td>
<td>0</td>
<td>7</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Total:</td>
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<td>179</td>
<td>58</td>
<td>32</td>
<td>13</td>
<td>214</td>
<td>42</td>
<td>97</td>
<td>41</td>
<td>38</td>
<td>93</td>
</tr>
</tbody>
</table>

¹ NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin

²“Users Operating Remotely” refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.

³“Users Sending Sample” refers to users who send the sample to the facility and/or research group and the experiment is conducted by other Collaborators on the experiment. Users at UF, FSU, and LANL cannot be “sample senders” for facilities located on their campuses.

⁴“Off-Site Collaborators” are scientific or technical Names on the experiment; who will not be present, sending samples, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).

*Note:* Users using multiple facilities are counted in each facility listed.

### Table 2 – User Affiliation

<table>
<thead>
<tr>
<th>NMR Facility</th>
<th>Users</th>
<th>NMFAL-Affiliated Users¹</th>
<th>Local Users¹</th>
<th>University Users²,³</th>
<th>Industry Users⁴</th>
<th>National Lab Users²,³,⁴</th>
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<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>114</td>
<td>31</td>
<td>11</td>
<td>109</td>
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<tr>
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<tr>
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<tr>
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<td>41</td>
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</table>

¹NMFAL-Affiliated users are defined as anyone in the lab’s personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NMFAL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.

The sum of NMFAL-Affiliated and Local users equals what was formerly referred to as “Internal Investigators.”

²In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NMFAL associates.

³In addition to external users, users with primary affiliations at NMFAL/LANL are reported in this category.

⁴The total of university, industry, and national lab users will equal the total number of users.
### Table 3 – Users by Discipline

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<td><strong>10</strong></td>
<td><strong>64</strong></td>
<td><strong>46</strong></td>
<td><strong>21</strong></td>
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### Table 4 – User Facility Operations

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<th>830</th>
<th>800 NB</th>
<th>800 MB</th>
<th>720</th>
<th>600</th>
<th>600 WB</th>
<th>600 WB2</th>
<th>600 MAS</th>
<th>500</th>
<th>500 E</th>
<th>Total Days Used / User Affil.</th>
<th>Percentage Used / User Affil.</th>
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</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
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<td>60</td>
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<td>271</td>
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<td>25</td>
<td>37</td>
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<tr>
<td>Local</td>
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<td>161</td>
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<td>33</td>
<td>17</td>
<td>19</td>
<td>111</td>
<td>66</td>
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<td>16%</td>
</tr>
<tr>
<td>U.S. University</td>
<td>132</td>
<td>101</td>
<td>159</td>
<td>193</td>
<td>14</td>
<td>128</td>
<td>26</td>
<td>50</td>
<td>43</td>
<td>174</td>
<td>127</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>64</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
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<tr>
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<td>18</td>
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<td>136</td>
<td>17</td>
<td>11</td>
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<tr>
<td>Test, Cali., Set-up, Maint., Inst. Dev.</td>
<td>13</td>
<td>23</td>
<td>101</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>36</td>
<td>15</td>
<td>42</td>
<td>11</td>
<td>39</td>
<td>288</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>366</strong></td>
<td><strong>345</strong></td>
<td><strong>354</strong></td>
<td><strong>364</strong></td>
<td><strong>298</strong></td>
<td><strong>290</strong></td>
<td><strong>292</strong></td>
<td><strong>364</strong></td>
<td><strong>117</strong></td>
<td><strong>326</strong></td>
<td><strong>289</strong></td>
<td><strong>3,405</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

1User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

2600 MHz MAS DNP magnet system was made available for users on September 12, 2016.

### Table 5 – Operations by Discipline

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
<td>1,086</td>
<td>0</td>
<td>116</td>
<td>0</td>
<td>0</td>
<td>970</td>
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<td>Local</td>
<td>539</td>
<td>1</td>
<td>405</td>
<td>30</td>
<td>0</td>
<td>103</td>
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<tr>
<td>U.S. University</td>
<td>1,147</td>
<td>0</td>
<td>253</td>
<td>55</td>
<td>0</td>
<td>839</td>
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<td>U.S. Govt. Lab.</td>
<td>64</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>64</td>
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<tr>
<td>U.S. Industry</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>Non-U.S.</td>
<td>281</td>
<td>0</td>
<td>136</td>
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<td>5</td>
<td>140</td>
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<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>288</td>
<td>0</td>
<td>26</td>
<td>0</td>
<td>262</td>
<td>0</td>
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<tr>
<td><strong>Total:</strong></td>
<td><strong>3,405</strong></td>
<td>1</td>
<td><strong>936</strong></td>
<td><strong>85</strong></td>
<td><strong>267</strong></td>
<td><strong>2,116</strong></td>
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</table>

1User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

### Table 6 – User Program Experiment Pressure

<table>
<thead>
<tr>
<th>NMR Facility</th>
<th>Experiment Requests Received</th>
<th>Experiment Requests Deferred from Prev. Year</th>
<th>Experiment Requests Granted</th>
<th>Experiment Requests Declined/Deferred</th>
<th>Experiment Requests Reviewed</th>
<th>Subscription Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>439</td>
<td>49</td>
<td>421 (86%)</td>
<td>67 (14%)</td>
<td>488</td>
<td>116%</td>
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</tbody>
</table>
### Table 7 – New User PIs

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bai, Shi</td>
<td>University of Delaware</td>
</tr>
<tr>
<td>Blackband, Steve</td>
<td>UF</td>
</tr>
<tr>
<td>Corzilius, Björn</td>
<td>Goethe-Universität Frankfurt am Main</td>
</tr>
<tr>
<td>Forder, John</td>
<td>UF</td>
</tr>
<tr>
<td>Garcia, Carlos</td>
<td>Clemson University</td>
</tr>
<tr>
<td>Gottwald, Eric</td>
<td>Karlsruhe Institute of Technology</td>
</tr>
<tr>
<td>Gunaydin-Sen, Ozge</td>
<td>Lamar University</td>
</tr>
<tr>
<td>Hayes, Sophia</td>
<td>Washington University</td>
</tr>
<tr>
<td>Kim, Sung Joon</td>
<td>Baylor University</td>
</tr>
<tr>
<td>Sachdeva, Mandip</td>
<td>FAMU</td>
</tr>
<tr>
<td>Schad, Lothar</td>
<td>Heidelberg University</td>
</tr>
<tr>
<td>Shimizu, Linda</td>
<td>University of South Carolina</td>
</tr>
</tbody>
</table>

TOTAL 12

1 PI who received magnet time for the first time across all facilities.

### Table 8 – Research Proposals Profile with Magnet Time

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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Proposals</td>
<td>84</td>
<td>4</td>
<td>16</td>
<td>1</td>
<td>20</td>
<td>4</td>
<td>4</td>
<td>55</td>
</tr>
</tbody>
</table>

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

### Table 9 – User Proposal

This report lists all proposals that were allocated magnet time from January-December 2016 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.

(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Proposal Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
</tr>
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<tbody>
<tr>
<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award ID</td>
<td>Div.</td>
<td>Funding Agency Title</td>
</tr>
<tr>
<td>Sungsool Wi (S)</td>
<td>pi</td>
<td>NHMFL</td>
<td>NMR</td>
<td></td>
<td></td>
<td>No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)</td>
</tr>
<tr>
<td>Lucio Frydman (S)</td>
<td>Coll.</td>
<td>Weizmann Institute of Science</td>
<td>Dept. Chemical Physics</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Appendix I – User Facility Statistics

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Proposal Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<tbody>
<tr>
<td>Mandip Singh (S)</td>
<td>Coll. FAMU</td>
<td>College of Pharmacy and Pharmaceutical Sciences</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(4 items)</td>
<td>(1 item)</td>
<td>Membrane Interaction and Atomic-Level Structures of Membrane-Active Peptides by 15N and 2H Solid-State NMR</td>
<td>P02289</td>
<td>Biology, Biochemistry, Biophysics</td>
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<td>19</td>
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<td>Name</td>
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<tr>
<td>Myriam Cotten (S)</td>
<td>pi</td>
<td>College of William and Mary</td>
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<td>NSF</td>
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<tr>
<td>Riqiang Fu (S)</td>
<td>Coll. NHMFL</td>
<td>NMR</td>
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<tr>
<td>Akritee Shrestha (U)</td>
<td>Coll. Hamilton College</td>
<td>Chemistry</td>
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<tr>
<td>Lennox Chitsike (G)</td>
<td>Coll. Hamilton College</td>
<td>Chemistry</td>
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<tr>
<td>(11 items)</td>
<td>(2 items)</td>
<td>Structure and dynamics study of Rous Sarcoma Virus capsid assembly</td>
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<td>Biology, Biochemistry, Biophysics</td>
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<td>---</td>
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<tr>
<td>Bo Chen (S)</td>
<td>pi</td>
<td>UCF</td>
<td>Dep. of Physics</td>
<td>FA9550-13-0150</td>
<td>Air Force Office of Scientific Research</td>
<td>DOD</td>
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<td>Jaekyun Jeon (G)</td>
<td>Coll. UCF</td>
<td>Physics</td>
<td>In-house award</td>
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<td>Other</td>
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<td>Xin Qiao (G)</td>
<td>Coll. UCF</td>
<td>Physics</td>
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<td>Coll. UCF</td>
<td>Biomedical</td>
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<td>Suren Tatulian (S)</td>
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<td>Psychiatric</td>
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<td>Stephanie Bautista (U)</td>
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<td>Justin Castillo (U)</td>
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<tr>
<td>Daniel Huang (U)</td>
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<tr>
<td>Fangqiang Zhu (S)</td>
<td>Coll. Indiana University</td>
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<td>(4 items)</td>
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<td>Determining the Conformational Changes within Active Enzyme-Substrate</td>
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<tr>
<td>Fengli Zhang (S)</td>
<td>Coll. NHMFL</td>
<td>CIMAR</td>
<td>1R01GM096019-01A1</td>
<td>NIH</td>
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<tr>
<td>Elan Eisen-</td>
<td>pi</td>
<td>Univ of Colorado</td>
<td>Biochemistry &amp;</td>
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</table>
### Appendix I – User Facility Statistics

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Proposal Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
</tr>
</thead>
<tbody>
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<td>messer (S)</td>
<td>Molecular Genetics</td>
<td>Systems on both Sides of the Reactions.</td>
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<td>Agnieszka Kendrick (G)</td>
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<tr>
<td>Michael Holliday (G)</td>
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#### (1 item)

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<th>Div.</th>
<th>Funding Agency Title</th>
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<tbody>
<tr>
<td>Riqiang Fu (S)</td>
<td></td>
<td>NHMFL</td>
<td>NMR</td>
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#### (8 items)

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<th>Div.</th>
<th>Funding Agency Title</th>
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</thead>
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<td>Biochemistry and Molecular Biology, Penn State Medical School</td>
<td>R01 GM10596 30-02</td>
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<td>Richard Gill (G)</td>
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<td>Pennsylvania State Univ</td>
<td>College of Medicine</td>
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</tr>
<tr>
<td>Jie Xu (S)</td>
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<td>Pennsylvania State Univ</td>
<td>Biochemistry and Molecular Biology</td>
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<td>Nicole Briley (G)</td>
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<td>Medical Center</td>
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<tr>
<td>Xiaoyan Ding (P)</td>
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<td>Pennsylvania State Univ</td>
<td>College of Medicine</td>
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#### (6 items)

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<th>Award ID</th>
<th>Div.</th>
<th>Funding Agency Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Harrington (S)</td>
<td>pi</td>
<td>Huntington Medical Research Institutes</td>
<td>Molecular Neurology</td>
<td>R01NS07 2497</td>
<td>NINDS</td>
<td>NIH</td>
</tr>
<tr>
<td>Eduard Chekmenev (S)</td>
<td>Coll.</td>
<td>Vanderbilt Univ</td>
<td>Institute of Imaging Science</td>
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<tr>
<td>Victor Schepkin (S)</td>
<td>Coll.</td>
<td>NHMFL</td>
<td>CIMAR</td>
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#### (1 item)

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<th>Name</th>
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<th>Dep.</th>
<th>Award ID</th>
<th>Div.</th>
<th>Funding Agency Title</th>
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</thead>
<tbody>
<tr>
<td>Riqian Fu (S)</td>
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<th>Dep.</th>
<th>Award ID</th>
<th>Div.</th>
<th>Funding Agency Title</th>
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<tbody>
<tr>
<td>Eduard Chekmenev (S)</td>
<td>Coll.</td>
<td>Vanderbilt Univ</td>
<td>Institute of Imaging Science</td>
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<td>Molecular Neurology</td>
<td>R01NS07 2497</td>
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<td>Eduard Chekmenev (G)</td>
<td>Coll.</td>
<td>Vanderbilt Univ</td>
<td>Institute of Imaging Science</td>
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<tr>
<td>Victor Schepkin (S)</td>
<td>Coll.</td>
<td>NHMFL</td>
<td>CIMAR</td>
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<tr>
<td>Nastaren Abad (G)</td>
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<td>FSU</td>
<td>Chemical-Biomedical Engineering</td>
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<tr>
<td>Milton Truong (P)</td>
<td>Coll.</td>
<td>Vanderbilt Univ</td>
<td>Medical Center</td>
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</tbody>
</table>
## Appendix I – User Facility Statistics

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Proposal Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shannon Helsper (T)</td>
<td>Coll. NHMFLoratory NMR</td>
<td>Multinuclear SSNMR of Unreceptive Nuclides Using Adiabatic Pulses</td>
<td>P02490</td>
<td>Chemistry, Geochemistry</td>
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</table>

### Participants (PI, Coll.)

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Org.</th>
<th>Dep.</th>
<th>Award ID</th>
<th>Div.</th>
<th>Funding Agency Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robert Schurko (S)</td>
<td>pi</td>
<td>Univ of Windsor</td>
<td>Chemistry</td>
<td></td>
<td>Other</td>
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</tr>
<tr>
<td>Lucio Friedman (S)</td>
<td>Coll.</td>
<td>Weizmann Institute of Science</td>
<td>Dept. Chemical Physics</td>
<td></td>
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<tr>
<td>Zhehong Gan (S)</td>
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<td>NHMFL</td>
<td>NHMFL</td>
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<td>Ivan Hung (S)</td>
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<td>David Hirsch (G)</td>
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<td>Univ of Windsor</td>
<td>Chemistry and Biochemistry</td>
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## MagLab 2016 Annual Report
### Appendix I – User Facility Statistics

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## Appendix I – User Facility Statistics

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Comparison Of Potassium, Chlorine And Sodium Triple Quantum Signals From In Vivo Rat Head At 21.1 T

P07296

Biology, Biochemistry, Biophysics

5 23
# Appendix I – User Facility Statistics

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MagLab 2016 Annual Report
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**P08470** Chemistry, Geochemistry 8 62

**Structural Study of Fibrils Formed by the Low-Complexity Domains of mRNA Binding Proteins**  P08483 Biology, Biochemistry, Biophysics 5 41

**Dynamics of M2 full length: Understanding the dynamics of the proton conductance and the gating mechanism of the full length M2 proton channel of Influenza A.** P08486 Biology, Biochemistry, Biophysics 15 118

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- High-temperature Solid-state NMR Studies of Ionic Conduction Mechanisms in Low-cost and Rare-earth-free Superior Fast Oxide-ion Conductor Sr3-3xNa3xSi3O9-1.5x
- Hyperpolarization of Nano-Structured Materials
- In vivo tracking of exogenous and labeled

### Funding Agency Title:
- Chemistry, Geochemistry
- DOE - Dep. of Energy

### Proposal ID:
- P09504
- P11434
- P11442

### Additional Information:
- No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)
## Appendix I – User Facility Statistics

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MPIO Labeling of Cytogenically Preserved Neurroprogenitor Cells

P11457 Engineering 1 30
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**Appendix I – User Facility Statistics**

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MagLab 2016 Annual Report
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MagLab 2016 Annual Report
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Proposed Title: Structural Characterization of ChiZ membrane protein

Proposal ID: P14693

Funding Agency Title: Biology, Biochemistry, Biophysics

Proposed Disc. Ex. Sched.: 19 120

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NMR Participants (PI, Coll.)

Proposed Title: Protein conformation determined in native cellular environments

Proposal ID: P14735

Funding Agency Title: Biology, Biochemistry, Biophysics

Proposed Disc. Ex. Sched.: 3 21

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NMR Participants (PI, Coll.)

Proposed Title: NMR analysis of ligand binding to the nuclear receptor PPARG, a type 2 diabetes drug target

Proposal ID: P14736

Funding Agency Title: Biology, Biochemistry

Proposed Disc. Ex. Sched.: 1 3

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NMR Participants (PI, Coll.)

Proposed Title: Quadrupolar nuclei NMR using 36 T Series Connected Hybrid Magnet

Proposal ID: P14747

Funding Agency Title: Chemistry, Geochemistry

Proposed Disc. Ex. Sched.: 1 1
## Appendix I – User Facility Statistics

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*Telemisar-tan loaded Gd-liposome for enhanced MRI detection in lung tumors*
### Appendix I – User Facility Statistics

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- Magnetic resonance imaging of maternal glycemic state by glucose tolerance test during pregnancy in mice
- Evaluation of Sodium and Metabolic Dysfunction in a Rat Migraine Model
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<td>NMR</td>
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<td>Structure determination of β-amyloid oligomers and investigation of their formation pathways</td>
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<td>Anant Paravastu (S)</td>
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<td>Georgia Institute of Technology</td>
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<td>Monu Kaushik (G)</td>
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## Appendix I – User Facility Statistics

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<th>Prop. Disc.</th>
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<th># of Days Used</th>
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<td>Frederic Mentink (S)</td>
<td>NHMFL NMR Div.</td>
<td>No other support (i.e. this experiment is entirely supported by NHMFL user services via its core grant)</td>
<td>CIMAR</td>
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<td>Gael De Paepe (S)</td>
<td>CEA Institute for Nanoscience and Cryogenics</td>
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<td>Shimon Vega (S)</td>
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<td>Sabine Hediger (S)</td>
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<td>Tim Cross (S)</td>
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### Participants and Funding Source(s)

#### Name | Role | Org. | Dep. | Award ID | Div. | Funding Agency Title
---|---|---|---|---|---|---|
| Huan-Xiang Zhou (S) | pi | FSU Physics | 7.30025E+13 | NIH |        |
| Pieter Smith (P)    | Coll. | NHMFL-FSU Institute of Molecular Biophysics |         |       |        |
| Huan-Xiang Zhou (S) | Coll. | FSU Physics |         |       |        |
| Di Wu (P)           | Coll. | FSU IMB |         |       |        |
| (7 items) |                   |               |       |         |             |                |

#### Name | Role | Org. | Dep. | Award ID | Div. | Funding Agency Title
---|---|---|---|---|---|---|
| Samuel Grant (S)    | pi | NHMFL Chemical & Biomedical Engineering | 227000-520-030759 | NMR | NHMFL UGP |        |
| Ghoncheh Amouzandeheh (G) | Coll. | FSU Physics |         |       |        |
| Jens Ros-          | Coll. | NHMFL NMR |         |       |        |
| Abdul Aziz Ould Ismail (G) | Coll. | NHMFL Chemical and Biomedical Engineering |         |       |        |
| (1 item) |                   |               |       |         |             |                |

### Proposal Title

#### The binding mechanism of Cdc42 with its intrinsically disordered binding partner WASp GBD

#### Electrical Properties Derivation using Radiofrequen

### Award ID

#### Biology, Biochemistry, Biophysics

### Funding Agency Title

#### Biology, Biochemistry, Biophysics

### Exp. Sched.

#### Biology, Biochemistry, Biophysics

### # of Days Used

#### Biology, Biochemistry, Biophysics

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---|---|---|---|---|---|---|
| Samuel Grant (S)    | pi | NHMFL Chemical & Biomedical Engineering | 227000-520-030759 | NMR | NHMFL UGP |        |
| Ghoncheh Amouzandeheh (G) | Coll. | FSU Physics |         |       |        |
| Jens Ros-          | Coll. | NHMFL NMR |         |       |        |
| Abdul Aziz Ould Ismail (G) | Coll. | NHMFL Chemical and Biomedical Engineering |         |       |        |
| (1 item) |                   |               |       |         |             |                |
### Appendix I – User Facility Statistics

<table>
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<tr>
<th>Participants (PI, Coll.)</th>
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<th>Exp. Sched.</th>
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<td>Scott Boebinger (U) Coll. FSU</td>
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3,405
## Table 1 – User Demographic

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<thead>
<tr>
<th>AMRIS Facility</th>
<th>Users</th>
<th>Male</th>
<th>Female</th>
<th>Prefer Not to Respond Gender</th>
<th>Minority¹</th>
<th>Non-Minority¹</th>
<th>Prefer Not to Respond to Race</th>
<th>Users Present</th>
<th>Users Operating Remotely²</th>
<th>Users Sending Sample³</th>
<th>Off-Site Collaborators⁴</th>
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<td>Senior Personnel, U.S.</td>
<td>112</td>
<td>55</td>
<td>14</td>
<td>43</td>
<td>6</td>
<td>59</td>
<td>47</td>
<td>95</td>
<td>0</td>
<td>11</td>
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<tr>
<td>Senior Personnel, non-U.S.</td>
<td>6</td>
<td>2</td>
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<tr>
<td>Postdocs, U.S.</td>
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<td>14</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>21</td>
<td>10</td>
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<td>0</td>
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<td>Students, U.S.</td>
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<td>31</td>
<td>25</td>
<td>16</td>
<td>10</td>
<td>41</td>
<td>21</td>
<td>64</td>
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<td>11</td>
<td>8</td>
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<tr>
<td><strong>Total:</strong></td>
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<td>109</td>
<td>58</td>
<td>85</td>
<td>21</td>
<td>135</td>
<td>96</td>
<td>216</td>
<td>0</td>
<td>25</td>
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1. NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin.
2. “Users Operating Remotely” refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
3. “Users Sending Sample” refers to users who send the sample to the facility and/or research group and the experiment is conducted by other collaborators on the experiment. Users at UF, FSU, and LANL cannot be “sample senders” for facilities located on their campuses.
4. “Off-Site Collaborators” are scientific or technical participants on the experiment; who will not be present, sending samples, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).

**Note:** Users using multiple facilities are counted in each facility listed.

## Table 2 – User Affiliation

<table>
<thead>
<tr>
<th>AMRIS Facility</th>
<th>Users</th>
<th>NHMFL-Affiliated Users¹</th>
<th>Local Users¹</th>
<th>University Users²,³</th>
<th>Industry Users⁴</th>
<th>National Lab Users⁵,⁶</th>
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<tr>
<td>Senior Personnel, U.S.</td>
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<td>18</td>
<td>64</td>
<td>108</td>
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<td>168</td>
<td>246</td>
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1. NHMFL-Affiliated users are defined as anyone in the lab’s personnel system (i.e. on our Web site/directory), even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.

The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as “Internal Investigators.”

2. In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.

3. In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.

4. The total of university, industry, and national lab users will equal the total number of users.
## Appendix I – User Facility Statistics

### Table 3 – Users by Discipline

<table>
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<tr>
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<td>1</td>
<td>2</td>
<td>26</td>
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<tr>
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<tr>
<td>Students, non-U.S.</td>
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<td>24</td>
<td>27</td>
<td>24</td>
<td>173</td>
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</table>

### Table 4 – User Facility Operations

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<th>AMRIS Facility</th>
<th>500 MHz NMR</th>
<th>600 MHz NMR warm bore</th>
<th>600 MHz cryo</th>
<th>750 MHz whole body</th>
<th>4.7 T / 33 cm</th>
<th>11.1 T / 40 cm</th>
<th>3T whole body</th>
<th>Total Days Used/ User Affil.</th>
<th>Percentage Used / User Affil.</th>
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<td>NHMFL-Affiliated</td>
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<td>38</td>
<td>57</td>
<td>127</td>
<td>118</td>
<td>157</td>
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<td>684</td>
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<tr>
<td>Local</td>
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<td>131</td>
<td>22</td>
<td>35</td>
<td>71</td>
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<td>17</td>
<td>218</td>
<td>571</td>
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<tr>
<td>U.S. University</td>
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<td>3</td>
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<td>15</td>
<td>0</td>
<td>15</td>
<td>0</td>
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<tr>
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<td>20</td>
<td>20</td>
<td>20</td>
<td>23</td>
<td>20</td>
<td>41</td>
<td>39</td>
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<td>258</td>
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<tr>
<td>Total</td>
<td>110</td>
<td>293</td>
<td>106</td>
<td>125</td>
<td>316</td>
<td>233</td>
<td>233</td>
<td>363</td>
<td>1,779</td>
</tr>
</tbody>
</table>

1User Units are defined as magnet days; time utilized is recorded to the nearest 15 minutes. Magnet-day definitions for AMRIS instruments: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours. Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours. This accounts for the difficulty in running animal or human studies overnight. Magnet days were calculated by adding the total number of real used for each instrument and dividing by 24 (vertical) or 8 (horizontal). Note: Due to the nature of the 4.7 T, 11 T and 3 T studies, almost all studies with external users were collaborative with UF investigators. In 2014 the 3T system was funded entirely off of non-NHMFL funds but is reported for historical purposes.

### Table 5 – Operations by Discipline

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<td>NHMFL-Affiliated</td>
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<td>75</td>
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<td>496</td>
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<td>0</td>
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<td>U.S. Govt. Lab.</td>
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<td>0</td>
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<td>U.S. Industry</td>
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<tr>
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<td>10</td>
<td>0</td>
<td>0</td>
<td>24</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>258</td>
<td>0</td>
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<tr>
<td>Total</td>
<td>1,779</td>
<td>0</td>
<td>102</td>
<td>135</td>
<td>259</td>
<td>1,283</td>
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</table>

1User Units are defined as magnet days; time utilized is recorded to the nearest 15 minutes. Magnet-day definitions for AMRIS instruments: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours. Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours. This accounts for the difficulty in running animal or human studies overnight. Magnet days were calculated by adding the total number of real used for each instrument and dividing by 24 (vertical) or 8 (horizontal). Note: Due to the nature of the 4.7 T, 11 T and 3 T studies, almost all studies with external users were collaborative with UF investigators. In 2014 the 3T system was funded entirely off of non-NHMFL funds but is reported for historical purposes.
### Appendix I – User Facility Statistics

#### Table 6 – User Program Experiment Pressure

<table>
<thead>
<tr>
<th>AMRIS Facility</th>
<th>Experiment Requests Received</th>
<th>Experiment Requests Deferred from Prev. Year</th>
<th>Experiment Requests Granted</th>
<th>Experiment Requests Declined/Deferred</th>
<th>Experiment Requests Reviewed</th>
<th>Subscription Rate</th>
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<tbody>
<tr>
<td></td>
<td>2,365</td>
<td>34</td>
<td>2,238 (95%)</td>
<td>127 (5%)</td>
<td>2,365</td>
<td>103%</td>
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#### Table 7 – New User PIs

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<th>Organization</th>
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<td>UF</td>
</tr>
<tr>
<td>Corti, Manuela</td>
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</tr>
<tr>
<td>Dayton, Kristin</td>
<td>UF</td>
</tr>
<tr>
<td>Ding, Yousong</td>
<td>UF</td>
</tr>
<tr>
<td>Domenico, Lisa</td>
<td>UF</td>
</tr>
<tr>
<td>Forbes, Sean</td>
<td>UF</td>
</tr>
<tr>
<td>Huigens, Robert</td>
<td>UF</td>
</tr>
<tr>
<td>Kurland, Irwin</td>
<td>Albert Einstein College of Medicine</td>
</tr>
<tr>
<td>Landsman, Sarah</td>
<td>UF</td>
</tr>
<tr>
<td>Lighthall, Nichole</td>
<td>University of Central Florida</td>
</tr>
<tr>
<td>Maurer, Andrew</td>
<td>UF</td>
</tr>
<tr>
<td>Norton, Luke</td>
<td>University of Texas Health Science Center at San Antonio</td>
</tr>
<tr>
<td>Periasamy, Muthu</td>
<td>Sanford Burnham Prebys Medical Discovery Institute</td>
</tr>
<tr>
<td>Rahman, Maryan</td>
<td>UF</td>
</tr>
<tr>
<td>Roddy, Thomas</td>
<td>Agios Pharmaceuticals</td>
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<tr>
<td>Wang, Gary</td>
<td>UF</td>
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<td>Zubcevic, Jasenka</td>
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<td>TOTAL</td>
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1. PI who received magnet time for the first time across all facilities.

#### Table 8 – Research Proposals Profile with Magnet Time

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<tbody>
<tr>
<td>Number of Proposals</td>
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<td>6</td>
<td>21</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>92</td>
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</table>

1. A “proposal” may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
2. The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
3. The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.
**Appendix I – User Facility Statistics**

### Table 9 – User Proposal

This report lists all proposals that were allocated magnet time from January-December 2016 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.

(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Proposal Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th># of Days Used</th>
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<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award ID</td>
<td>Div</td>
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<tr>
<td>Matthew Erickson (S)</td>
<td>pi</td>
<td>UF</td>
<td>ER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thomas Marie (S)</td>
<td>Coll.</td>
<td>NHMFL</td>
<td>Biochemistry and Molecular Biology</td>
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<tr>
<td>Nicholas Simpson (S)</td>
<td>Coll.</td>
<td>UF</td>
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<tr>
<td>Malathy Elumalai (O)</td>
<td>Coll.</td>
<td>UF</td>
<td>Engineer</td>
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<td><strong>(4 items)</strong></td>
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<td>Name</td>
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<td>Award ID</td>
<td>Div</td>
</tr>
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<td>Rebecca Butcher (S)</td>
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<td>David Powell (S)</td>
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<tr>
<td>Qingyao Shou (P)</td>
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<td><strong>(6 items)</strong></td>
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<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award ID</td>
<td>Div</td>
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<td>Ben Turner (S)</td>
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<td>K. Ramesh Reddy (S)</td>
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<td>Soil &amp; Water Science</td>
<td>NSF GROW and GRIP travel awards</td>
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<tr>
<td>Anna Normand (G)</td>
<td>Coll.</td>
<td>UF</td>
<td>Soil and Water Science</td>
<td>NSF GROW and GRIP travel awards</td>
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### Appendix I – User Facility Statistics

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<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Proposal Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th># of Days Used</th>
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<td>ITN</td>
<td>Chemistry</td>
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<td>Medicine</td>
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<td><strong>Name</strong></td>
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<td><strong>Name</strong></td>
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<td><strong>Div</strong></td>
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# Appendix I – User Facility Statistics

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<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Proposal Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th># of Days Used</th>
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<tbody>
<tr>
<td><strong>Name</strong></td>
<td><strong>Role</strong></td>
<td><strong>Org.</strong></td>
<td><strong>Dep.</strong></td>
<td><strong>Award ID</strong></td>
<td><strong>Div</strong></td>
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<td>Fisk Univ</td>
<td>Chemistry</td>
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<td>Div</td>
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<td>Magdooom Mohamed Kulam Najmudeen (G)</td>
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<td>Mechanical and Aerospace Engineering</td>
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<td>Physics</td>
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## Appendix I – User Facility Statistics

### Participants (PI, Coll.)

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<th>Dep.</th>
<th>Award ID</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>#of Days Used</th>
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<td>Univ of Puerto Rico</td>
<td>Dep. of Physics</td>
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<tr>
<td>Daysi Diaz-Diestra (G)</td>
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<td>Molecular Science Research Center</td>
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<td>Lloyd Lumata (S)</td>
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<td>Physics</td>
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<td>Biochemistry &amp; Molecular Biology</td>
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<td>Biochemistry and Molecular Biology</td>
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<td>Andhika Kiswandhi (P)</td>
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<td>Dep. of Physics</td>
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<td>Jennifer Isaacs (S)</td>
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### Proposal Title

- The Effect of Glassing Matrix Deuteration on 13C Dynamic Nuclear Polarization at 5 T
- New equipment/upgrades/troubleshooting on verticals
- New equipment/upgrades/troubleshooting on horizontal
- New user training
### Appendix I – User Facility Statistics

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|-----------------------|------|--------------|-------------------------------------|----------------|-----|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------|-------------|----------------|----------------|
| Marcus Bäumer (S)     | pi   | Univ Bremen  | Institute of Applied and Physical Chemistry | CBET No. 0951812 | ENG | NSF                                                                                   | Identifying the role of nanoporous gold by high field NMR diffusometry           | P14812   |             |                |                 |
| Arne Wittstock (S)    | Coll.| Univ Bremen  | Chemistry                           |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Sergey Vasenkov (S)   | Coll.| UF           | Chemical Engineering                |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Evan Forman (G)       | Coll.| UF           | Chemical Engineering                |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Rebecca Butcher (S)   | pi   | UF           | Chemistry                           | 2015-2016      | AFRI| Other                                                                                  | Identification of pheromones from entomopathogenic nematodes                   | P14802   |             | 16             |                 |
| S. Patricia Stock (S) | Coll.| Univ. of Arizona | Entomology                             |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Fatma Kaplan (S)      | Coll.| Kaplan Schiller Research, LLC |                                |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Prashant Singh (G)    | Coll.| UF           | Chemistry                           |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Yuting Wang (G)       | Coll.| UF           | Chemistry                           |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Rachel Jones (P)      | Coll.| Univ. of Florida | Chemistry                              |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Alexandra Roder (G)   | Coll.| Univ. of Arizona | Entomology                             |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Russell Bauer (S)     | pi   | UF Dep. of Clinical & Health Psychology and VA BRRC | Clinical & Health Psychology              |                |     | Other                                                                                  | Characterizing in vivo BBB permeability changes in wildtype (WT)               | P14917   |             | 8              |                 |
| Aliyah Snyder (G)     | Coll.| Clinical and Health Psychology | Clinical and Health Psychology           |                |     |                                                                                       |                                                                              |          |             |                |                 |
| Richard Ferranti (U)  | Coll.| UF           | Clinical and Health Psychology       |                |     |                                                                                       |                                                                              |          |             |                |                 |
### Appendix I – User Facility Statistics

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## Appendix I – User Facility Statistics

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### Jae Woo Chung (G)
Coll. Laboratory for Rehabilitation Neuroscience
Applied Physiology and Kinesiology
6AZ07 Other

### Roxana Burciu (P)
Coll. UF Applied Physiology and Kinesiology
NS052 318 NINDS NIH

### Michael Okun (S)
Coll. UF Neurology
NS082 168 NINDS NIH

### Priyank Shukla (P)
Coll. UF Laboratory for Rehabilitation Neuroscience
NS093 695 NINDS NIH

### Marcelo Febo (S)
Coll. UF Psychiatry
NS094 946 NINDS NIH

### Luis Colon-perez (G)
Coll. UF Physics
R01 NS058 487 NIH

### Yuqing Li (S)
Coll. UF Neurology
R01 NS082 244 NIDS NIH

### Hong Li (S)
Coll. Medical Univ of South Carolina
Dep. of Public Health Sciences
R01 NS523 18 NINDS NIH

### Nikolaus McFarland (S)
Coll. UF Dep. of Neurology
R01NS 75012 NINDS NIH

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### Appendix I – User Facility Statistics

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<th>Prop. Disc.</th>
<th>#of Days Used</th>
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## Appendix I – User Facility Statistics

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1,779
**EMR Facility**

### Table 1 – User Demographic

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<th>Female</th>
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<th>Minority¹</th>
<th>Non-Minority²</th>
<th>Prefer Not to Respond to Race</th>
<th>Users Present</th>
<th>Users Operating Remotely ²</th>
<th>Users Sending Sample ³</th>
<th>Off-Site Collaborators ⁴</th>
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¹ NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin.

² “Users Operating Remotely” refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.

³“Users Sending Sample” refers to users who send the sample to the facility and/or research group and the experiment is conducted by other collaborators on the experiment. Users at UF, FSU, and LANL cannot be “sample senders” for facilities located on their campuses.

⁴“Off-Site Collaborators” are scientific or technical participants on the experiment; who will not be present, sending samples, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).

*Note: Users using multiple facilities are counted in each facility listed.*

### Table 2 – User Affiliation

<table>
<thead>
<tr>
<th>EMR Facility</th>
<th>Users</th>
<th>NHMFL-Affiliated Users¹</th>
<th>Local Users²</th>
<th>University Users²,³</th>
<th>Industry Users⁴</th>
<th>National Lab Users³,⁴</th>
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¹NHMFL-Affiliated users are defined as anyone in the lab’s personnel system (i.e. on our Web site/directory), even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.

The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as “Internal Investigators.”

²In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.

³In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.

⁴The total of university, industry, and national lab users will equal the total number of users.
**Table 3 – Users by Discipline**

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<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Postdocs, U.S.</td>
<td>17</td>
<td>5</td>
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<td>1</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Postdocs, non-U.S.</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Students, U.S.</td>
<td>47</td>
<td>10</td>
<td>28</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>10</td>
<td>3</td>
<td>7</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, U.S.</td>
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<td>0</td>
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<tr>
<td>Technician, non-U.S.</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>198</td>
<td>55</td>
<td>96</td>
<td>4</td>
<td>5</td>
<td>38</td>
</tr>
</tbody>
</table>

**Table 4 – User Facility Operations**

<table>
<thead>
<tr>
<th>EMR Facility</th>
<th>17T</th>
<th>12T</th>
<th>Mossbauer</th>
<th>Bruker</th>
<th>HiPER</th>
<th>Total Days Used / User Affil.</th>
<th>Percentage Used / User Affil.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
<td>21</td>
<td>23</td>
<td>14</td>
<td>106</td>
<td>80</td>
<td>244</td>
<td>16%</td>
</tr>
<tr>
<td>Local</td>
<td>12</td>
<td>15</td>
<td>38</td>
<td>9</td>
<td>10</td>
<td>84</td>
<td>5%</td>
</tr>
<tr>
<td>U.S. University</td>
<td>103</td>
<td>59</td>
<td>301</td>
<td>146</td>
<td>154</td>
<td>763</td>
<td>49%</td>
</tr>
<tr>
<td>U.S. Govt. Lab.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>0%</td>
</tr>
<tr>
<td>U.S. Industry</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Non-U.S.</td>
<td>135</td>
<td>65</td>
<td>56</td>
<td>37</td>
<td>34</td>
<td>327</td>
<td>21%</td>
</tr>
<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>40</td>
<td>29</td>
<td>64</td>
<td>5</td>
<td>12</td>
<td>150</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>311</td>
<td>191</td>
<td>473</td>
<td>303</td>
<td>295</td>
<td>1,573</td>
<td>100%</td>
</tr>
</tbody>
</table>

1User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

**Table 5 – Operations by Discipline**

<table>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
<td>244</td>
<td>5</td>
<td>71</td>
<td>0</td>
<td>31</td>
<td>137</td>
</tr>
<tr>
<td>Local</td>
<td>84</td>
<td>7</td>
<td>60</td>
<td>0</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>U.S. University</td>
<td>763</td>
<td>64</td>
<td>288</td>
<td>90</td>
<td>0</td>
<td>321</td>
</tr>
<tr>
<td>U.S. Govt. Lab.</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>U.S. Industry</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-U.S.</td>
<td>327</td>
<td>102</td>
<td>210</td>
<td>0</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>150</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>100</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>1,573</td>
<td>178</td>
<td>663</td>
<td>90</td>
<td>146</td>
<td>496</td>
</tr>
</tbody>
</table>

¹User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

**Table 6 – User Program Experiment Pressure**

<table>
<thead>
<tr>
<th>EMR Facility</th>
<th>Experiment Requests Received</th>
<th>Experiment Requests Deferred from Prev. Year</th>
<th>Experiment Requests Granted</th>
<th>Experiment Requests Declined/Deferred</th>
<th>Experiment Requests Reviewed</th>
<th>Subscription Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>178</td>
<td>25</td>
<td>191 (94%)</td>
<td>12 (6%)</td>
<td>203</td>
<td>106%</td>
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</tbody>
</table>
### Table 7 – New User PIs

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
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</thead>
<tbody>
<tr>
<td>Arion, Vladimir</td>
<td>University of Vienna</td>
</tr>
<tr>
<td>Baker, Robert</td>
<td>University of Dublin, Trinity College</td>
</tr>
<tr>
<td>Broholm, Collin</td>
<td>Johns Hopkins University</td>
</tr>
<tr>
<td>Clérac, Rodolphe</td>
<td>Centre de Recherche Paul Pascal</td>
</tr>
<tr>
<td>Columbus, Linda</td>
<td>University of Virginia</td>
</tr>
<tr>
<td>Coronado, Eugenio</td>
<td>Instituto de Ciencia Molecular (ICMol), Universidad de Valencia</td>
</tr>
<tr>
<td>DeGrado, William</td>
<td>University of California San Francisco</td>
</tr>
<tr>
<td>Doerrr, Linda</td>
<td>Boston University</td>
</tr>
<tr>
<td>Dorn, Harry</td>
<td>Virginia Tech</td>
</tr>
<tr>
<td>Goodwin, Douglas</td>
<td>Auburn University</td>
</tr>
<tr>
<td>Griffin, Robert</td>
<td>MIT</td>
</tr>
<tr>
<td>Joon Oh, Kyoung</td>
<td>Rosalind Franklin University</td>
</tr>
<tr>
<td>Li, Ping</td>
<td>Kansas State University</td>
</tr>
<tr>
<td>Mateeva, Nelly</td>
<td>FAMU</td>
</tr>
<tr>
<td>Myles, Dean</td>
<td>ORNL</td>
</tr>
<tr>
<td>Nehrkorn, Joscha</td>
<td>University of Hamburg</td>
</tr>
<tr>
<td>Pan, Jianjun</td>
<td>University of South Florida</td>
</tr>
<tr>
<td>Qin, Peter</td>
<td>University of Southern California</td>
</tr>
<tr>
<td>Room, Toomas</td>
<td>National Institute of Chemical Physics and Biophysics</td>
</tr>
<tr>
<td>Ross, Kate</td>
<td>Colorado State University</td>
</tr>
<tr>
<td>Salguero, Tina</td>
<td>The University of Georgia</td>
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<tr>
<td>Sarachik, Myriam</td>
<td>City College of New York</td>
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<td>Stroupe, Elizabeth</td>
<td>FSU</td>
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<tr>
<td>Takui, Takeji</td>
<td>Osaka City University</td>
</tr>
<tr>
<td>Vassilyeva, Olga</td>
<td>Taras Shevchenko National University of Kyiv</td>
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<tr>
<td>Yang, Fengyuan</td>
<td>The Ohio State University</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>26</strong></td>
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</table>

1 PI who received magnet time for the first time across all facilities.

### Table 8 – Research Proposals Profile with Magnet Time

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Proposals</td>
<td>81</td>
<td>2</td>
<td>15</td>
<td>19</td>
<td>37</td>
<td>1</td>
<td>6</td>
<td>18</td>
</tr>
</tbody>
</table>

1 A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.

2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.

3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.
## Table 9 – User Proposal

This report lists all proposals that were allocated magnet time from January-December 2016 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users. 

(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th>#of Days Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1 item)</td>
<td></td>
<td>High Frequency Pulsed EPR/ENDOR instrumentation testing</td>
<td>P00082</td>
<td>Magnets, Materials, Testing, Instrumentation</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award #</td>
<td>Div</td>
<td>Funding Agency Title</td>
</tr>
<tr>
<td>Johan van Tol (S)</td>
<td>pi</td>
<td>NHMFL</td>
<td>CIMAR</td>
<td></td>
<td></td>
<td>No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)</td>
</tr>
<tr>
<td>(5 items)</td>
<td></td>
<td>Study of Magnetic Ordering in AFe2-xMnxB2 by Mössbauer Spectroscopy</td>
<td>P02021</td>
<td>Chemistry, Geochemistry</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award #</td>
<td>Div</td>
<td>Funding Agency Title</td>
</tr>
<tr>
<td>Michael Shatruk (S)</td>
<td>pi</td>
<td>NHMFL</td>
<td>Dep. of Chemistry</td>
<td>955353</td>
<td></td>
<td>NSF</td>
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<tr>
<td>Ping Chai (P)</td>
<td>Coll.</td>
<td>FSU</td>
<td>Dep. of Chemistry and Biochemistry</td>
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<tr>
<td>Xiaoyan Tan (G)</td>
<td>Coll.</td>
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<td>Dep. of Chemistry and Biochemistry</td>
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<td>NHMFL</td>
<td>EMR</td>
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<tr>
<td>Sebastian Stoian (P)</td>
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<td>NHMFL</td>
<td>NHFML</td>
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<tr>
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<td>Magneto-transport and Magneto-optical Study of Topological Insulators</td>
<td>P02349</td>
<td>CM Phys</td>
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<td>4</td>
</tr>
<tr>
<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award #</td>
<td>Div</td>
<td>Funding Agency Title</td>
</tr>
<tr>
<td>Zhiqiang Li (S)</td>
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<td>SCU</td>
<td>Physics</td>
<td>DC field</td>
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<td>NHMFL UCGP</td>
</tr>
<tr>
<td>Zhiguo Chen (S)</td>
<td>Coll.</td>
<td>Institute of Physics, Chinese Academy of Sciences</td>
<td>Key Laboratory of Extreme Conditions Physics</td>
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</tr>
<tr>
<td>Sanfeng Wu (G)</td>
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<td>Xiang Yuan (G)</td>
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<td>Fudan Univ</td>
<td>Physics</td>
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</table>
## Appendix I – User Facility Statistics

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched.</th>
<th># of Days Used</th>
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<tbody>
<tr>
<td>Cheng Zhang (G) Coll.</td>
<td>Fudan Univ</td>
<td>Physics</td>
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<tr>
<td>Ying Wang (G) Coll.</td>
<td>NHMFL-FSU</td>
<td>Physics</td>
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(4 items) (1 item)

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<th>Award #</th>
<th>Div</th>
<th>Funding Agency Title</th>
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<tbody>
<tr>
<td>Albert Steigman</td>
<td>pi</td>
<td>FSU</td>
<td>Chemistry</td>
<td>911080</td>
<td></td>
<td>Chemistry, Geochemy</td>
</tr>
<tr>
<td>Jurek Krzystek (S) Coll. NHMFL CMS</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Adrian Lita (P) Coll. NHMFL Chemistry and Biochemistry</td>
<td></td>
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<tr>
<td>Nathan Peek (G) Coll. NHMFL Chemistry and Biochemistry</td>
<td>pi</td>
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(3 items) (1 item)

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<td>Ryan Baumbach (S) Coll. NHMFL CMS</td>
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<tr>
<td>Kwang Yong Choi (S) pi Chung Ang Univ Dep. of Physics</td>
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<tr>
<td>Su-Heon Lee (G) Coll. Chung Ang Univ Dep. of Physics</td>
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(10 items) (2 items)

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<th>Dep.</th>
<th>Award #</th>
<th>Div</th>
<th>Funding Agency Title</th>
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<td></td>
<td></td>
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<td>Wenlong Yu (P) Coll. Sandia National Laboratories Quantum Phenomena Dep.</td>
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<td></td>
<td></td>
<td>DMR-0820382</td>
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<td>NSF</td>
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<tr>
<td>Xunchi Chen (G) Coll. Georgia Institute of Technology Physics</td>
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<td></td>
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</tr>
<tr>
<td>Yuxuan Jiang (G) Coll. Georgia Institute of Technology School of Physics</td>
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<td></td>
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</tr>
<tr>
<td>Dmitry Smirnov (S) Coll. NHMFL Instrumentation Operations &amp;</td>
<td></td>
<td></td>
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<td>DOE</td>
<td></td>
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</tr>
<tr>
<td>Jean-Marie Poumirol (P) Coll. NHMFL CMS</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Zeyan Xu (U) Coll. Georgia Institute of Technology School of Physics</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Jeremy Yang (G) Coll. Georgia Institute of Technology Physics</td>
<td></td>
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</tr>
</tbody>
</table>

ESR Studies on Novel Quantum States of Matter

Quantum Transport and Infrared Spectroscopy of Graphene

MagLab 2016 Annual Report
## Appendix I – User Facility Statistics

### Participants (PI, Coll.)

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Org.</th>
<th>Dep.</th>
<th>Award #</th>
<th>Div</th>
<th>Funding Agency Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claire Berger (S)</td>
<td>Coll.</td>
<td>Georgia Institute of Technology</td>
<td>Physics</td>
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</tr>
<tr>
<td>Dogukan Deniz (G)</td>
<td>Coll.</td>
<td>Georgia Institute of Technology</td>
<td>Physics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5 items)</td>
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<td></td>
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</tr>
<tr>
<td>Name</td>
<td>Role</td>
<td>Org.</td>
<td>Dep.</td>
<td>Award #</td>
<td>Div</td>
<td>Funding Agency Title</td>
</tr>
<tr>
<td>Richard Oakley (S)</td>
<td>pi</td>
<td>Univ of Waterloo</td>
<td>Chemistry</td>
<td>11-12360</td>
<td>NSF</td>
<td>Magnetic Resonance in Anti-ferromagnetic Organic Radicals</td>
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<tr>
<td>Stephen Hill (S)</td>
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<td>EMR</td>
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<tr>
<td>Komalavalli Thirunavukkuarasu (S)</td>
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<td>EMR</td>
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</tr>
<tr>
<td>Samuel Greer (G)</td>
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<td>Chemistry</td>
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MagLab 2016 Annual Report
## Appendix I – User Facility Statistics

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## Appendix I – User Facility Statistics

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High Frequency EPR Studies of Coordinate Unsaturated Transition Metal Complexes with Possible SMM Behavior

High Frequency EPR studies of spin-spin interaction between pi-electronic edge-localized spin states and molecular oxygen in defective carbon onions

Single-ion magnets with giant axial magnetic anisotropy

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Pulsed electrically detected magnetic resonance experiments on organic light emitting diodes at high magnetic fields

Study of decoherence and relaxation in single-crystals of molecular nanomagnets

Using High-Field EPR to Explore Electronic Structures of Bis(aldimino)pyridine Nickel Complexes
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MagLab 2016 Annual Report
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| Firoz Khan (G)           | Coll. | Indian Institute of Technology Kanpur | Chemistry |         | Div | Other                |

| Kasturi Chaudhuri (G)    | Coll. | Indian Institute of Technology Kanpur | Chemistry |         | Div | Other                |

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### Appendix I – User Facility Statistics

| Name               | Role | Org.          | Dep.                        | Award # | Div | Funding Agency Title                  | Prop. Title                                                                 | Prop. ID | Prop. Disc. | Exp. Sched. | # of Days Used |
|--------------------|------|---------------|-----------------------------|---------|-----|---------------------------------------|--------------------------------------------------------------------------------|----------|-------------|-------------|----------------|----------------|
| Collin Broholm (S) | pi   | Johns Hopkins | Physics and Astronomy       |         |     | Other                                 | tions and their lifetime in 1D and 2D spin dimer systems                    |          |             |             |                |                |
|                    |      | Univ          |                             |         |     |                                       |                                                                               |          |             |             |                |                |
| (5 items)          | (1 item) |               |                             |         |     |                                       |                                                                               |          |             |             |                |                |
| Stephen Hill (S)   | pi   | NHMFL         | EMR                         |         |     | EMR                                   | No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) |          |             |             |                |                |
|                    |      |               |                             |         |     |                                       |                                                                               |          |             |             |                |                |
| Johannes McKay (P) | Coll. | NHMFL         | EMR                         |         |     |                                       |                                                                               |          |             |             |                |                |
| Likai Song (S)     | Coll. | NHMFL         | EMR                         |         |     |                                       |                                                                               |          |             |             |                |                |
| Paul Cruickshank (S) | Coll. | Univ of St Andrews | School of Physics & Astronomy |         |     |                                       |                                                                               |          |             |             |                |                |
| Nandita Abhyankar (G) | Coll. | FSU           | Chemistry                   |         |     |                                       |                                                                               |          |             |             |                |                |
| (5 items)          | (1 item) |               |                             |         |     |                                       |                                                                               |          |             |             |                |                |
| Le Li (P)          | Coll. | Oakridge national lab | BSMD                       |         |     |                                       |                                                                               |          |             |             |                |                |
| Stephen Hill (S)   | Coll. | NHMFL         | EMR                         |         |     |                                       |                                                                               |          |             |             |                |                |
| Thiago Szymanski (G) | Coll. | NHMFL         | CMS/EMR                     |         |     |                                       |                                                                               |          |             |             |                |                |
| Dean Myles (S)     | pi   | ORNL          | Biology and Soft Matter Div |         |     |                                       |                                                                               |          |             |             |                |                |
| (2 items)          | (1 item) |               |                             |         |     |                                       |                                                                               |          |             |             |                |                |
| Kyoung Joon Oh (S) | pi   | Rosalind Franklin Univ | Biochemistry and Biophysics |         |     | NIH                                   | Structural Analysis of the BAK Oligomeric Pore formed in the Membrane by EPR | P14923   | Biology, Biochemistry, Biophysics | 1   | 2             |
| Likai Song (S)     | Coll. | NHMFL         | EMR                         |         |     |                                       |                                                                               |          |             |             |                |                |
| (3 items)          | (1 item) |               |                             |         |     |                                       |                                                                               |          |             |             |                |                |
| William DeGrado (S) | pi   | Univ of Califor- | Dep. of Pharm                |         |     | NIH                                   | Multi-Frequency EPR Analysis of Catalytic Helix Bundles                      | P14935   | Biology, Biochemistry, Biophysics | 1   | 15            |

MagLab 2016 Annual Report
### Appendix I – User Facility Statistics

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**Participants (PI, Coll.)**
- Shao-Qing Zhang (P)
- Likai Song (S)

**Funding Source(s)**
- EMR

**Prop. Title**
- Interactions of Protein Aggregates with Lipid Membranes Defined by Multi-Frequency EPR
- Development of Pulsed Dynamic Nuclear Polarization at High Magnetic Field
- No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)
- Study of electron relaxation times of radicals under conditions relevant for hyperpolarization techniques
# Appendix I – User Facility Statistics

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### Appendix I – User Facility Statistics

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New Schiff base heterometallics towards magnetic materials and catalysts

High-Frequency and Field EPR Studies of Complexes of Groups 5 – 9 Ions with Unusual Ligands

Probing signatures of low-dimensional magnetism in layered honeycomb compound BaCo$_2$ (PO$_4$)$_2$ using high frequency electron paramagnetic resonance spectroscopy
## Appendix I – User Facility Statistics

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(3 items) (1 item)

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| Total                      | 191            | 1,573 |
Appendix I – User Facility Statistics

ICR Facility

Table 1 – User Demographic

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<th>Minority¹</th>
<th>Non-Minority²</th>
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<th>Users Operating Remotely</th>
<th>Users Sending Sample³</th>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Students, U.S.</td>
<td>79</td>
<td>28</td>
<td>39</td>
<td>12</td>
<td>4</td>
<td>59</td>
<td>16</td>
<td>52</td>
<td>0</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Technician, U.S.</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total:</td>
<td>313</td>
<td>166</td>
<td>85</td>
<td>62</td>
<td>21</td>
<td>213</td>
<td>79</td>
<td>145</td>
<td>0</td>
<td>43</td>
<td>125</td>
</tr>
</tbody>
</table>

¹ NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin.
² "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
³ "Users Sending Sample" refers to users who send the sample to the facility and/or research group and the experiment is conducted by other collaborators on the experiment. Users at UF, FSU, and LANL cannot be “sample senders” for facilities located on their campuses.
⁴ "Off-Site collaborators" are scientific or technical participants on the experiment; who will not be present, sending samples, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).

**Note:** Users using multiple facilities are counted in each facility listed.

Table 2 – User Affiliation

<table>
<thead>
<tr>
<th>ICR Facility</th>
<th>Users</th>
<th>NHMFL-Affiliated Users¹</th>
<th>Local Users²</th>
<th>University Users²³</th>
<th>Industry Users²⁴</th>
<th>National Lab Users²⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>152</td>
<td>16</td>
<td>22</td>
<td>127</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Senior Personnel, non-U.S.</td>
<td>44</td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Postdocs, U.S.</td>
<td>20</td>
<td>5</td>
<td>5</td>
<td>18</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Postdocs, non-U.S.</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Students, U.S.</td>
<td>79</td>
<td>10</td>
<td>18</td>
<td>78</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, U.S.</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total:</td>
<td>313</td>
<td>34</td>
<td>48</td>
<td>266</td>
<td>21</td>
<td>26</td>
</tr>
</tbody>
</table>

¹NHMFL-Affiliated users are defined as anyone in the lab’s personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.

The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as “Internal Investigators.”

² In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.

³ In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.

⁴ The total of university, industry, and national lab users will equal the total number of users.
### Appendix I – User Facility Statistics

#### Table 3 – Users by Discipline

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Personnel, U.S.</td>
<td>152</td>
<td>0</td>
<td>82</td>
<td>12</td>
<td>4</td>
<td>54</td>
</tr>
<tr>
<td>Senior Personnel, non-</td>
<td>44</td>
<td>1</td>
<td>31</td>
<td>2</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Postdocs, U.S.</td>
<td>20</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Postdocs, non-U.S.</td>
<td>7</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Students, U.S.</td>
<td>79</td>
<td>0</td>
<td>53</td>
<td>6</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Students, non-U.S.</td>
<td>5</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technician, U.S.</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Technician, non-U.S.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total:</td>
<td>313</td>
<td>1</td>
<td>193</td>
<td>21</td>
<td>9</td>
<td>89</td>
</tr>
</tbody>
</table>

#### Table 4 – User Facility Operations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
<td>121</td>
<td>10</td>
<td>72</td>
<td>0</td>
<td>203</td>
<td>17%</td>
</tr>
<tr>
<td>Local</td>
<td>39</td>
<td>8</td>
<td>22</td>
<td>0</td>
<td>69</td>
<td>6%</td>
</tr>
<tr>
<td>U.S. University</td>
<td>124</td>
<td>20</td>
<td>161</td>
<td>51</td>
<td>356</td>
<td>30%</td>
</tr>
<tr>
<td>U.S. Govt. Lab.</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>25</td>
<td>30</td>
<td>3%</td>
</tr>
<tr>
<td>U.S. Industry</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>18</td>
<td>2%</td>
</tr>
<tr>
<td>Non-U.S.</td>
<td>8</td>
<td>1</td>
<td>95</td>
<td>137</td>
<td>241</td>
<td>20%</td>
</tr>
<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>30</td>
<td>219</td>
<td>30</td>
<td>0</td>
<td>279</td>
<td>23%</td>
</tr>
<tr>
<td>Total:</td>
<td>322</td>
<td>258</td>
<td>403</td>
<td>213</td>
<td>1,196</td>
<td>100%</td>
</tr>
</tbody>
</table>

1User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets, but it is possible that more than one project is assigned to each magnet day, which can result in more than 365 days assigned per magnet per year.

#### Table 5 – Operations by Discipline

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NHMFL-Affiliated</td>
<td>203</td>
<td>0</td>
<td>74</td>
<td>1</td>
<td>59</td>
<td>69</td>
</tr>
<tr>
<td>Local</td>
<td>69</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>U.S. University</td>
<td>356</td>
<td>0</td>
<td>202</td>
<td>10</td>
<td>0</td>
<td>144</td>
</tr>
<tr>
<td>U.S. Govt. Lab.</td>
<td>30</td>
<td>0</td>
<td>28</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>U.S. Industry</td>
<td>18</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-U.S.</td>
<td>241</td>
<td>0</td>
<td>240</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Test, Calibration, Set-up, Maintenance, Inst. Dev.</td>
<td>279</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>271</td>
<td>7</td>
</tr>
<tr>
<td>Total:</td>
<td>1,196</td>
<td>0</td>
<td>593</td>
<td>13</td>
<td>331</td>
<td>259</td>
</tr>
</tbody>
</table>

1User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets, but it is possible that more than one project is assigned to each magnet day, which can result in more than 365 days assigned per magnet per year.

#### Table 6 – User Program Experiment Pressure

<table>
<thead>
<tr>
<th>ICR Facility</th>
<th>Experiment Requests Received</th>
<th>Experiment Requests Deferred from Prev. Year</th>
<th>Experiment Requests Granted</th>
<th>Experiment Requests Declined/Deferred</th>
<th>Experiment Requests Reviewed</th>
<th>Subscription Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125</td>
<td>52</td>
<td>170 (96%)</td>
<td>7 (4%)</td>
<td>177</td>
<td>104%</td>
</tr>
</tbody>
</table>

MagLab 2016 Annual Report
### Appendix I – User Facility Statistics

#### Table 7 – New User PIs

<table>
<thead>
<tr>
<th>Name</th>
<th>Org.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aiken, George</td>
<td>U.S. Geological Survey</td>
</tr>
<tr>
<td>Arnold, William</td>
<td>University of Minnesota</td>
</tr>
<tr>
<td>Baalousha, Mohammed</td>
<td>University of South Carolina</td>
</tr>
<tr>
<td>Bythell, Benjamin</td>
<td>University of Missouri</td>
</tr>
<tr>
<td>Chang, Ni-Bin</td>
<td>University of Central Florida</td>
</tr>
<tr>
<td>Chen, Huan</td>
<td>National High Magnetic Field Lab</td>
</tr>
<tr>
<td>Chen, Yongsheng</td>
<td>Georgia Institute of Technology</td>
</tr>
<tr>
<td>Combariza, Marianny</td>
<td>Universidad Industrial de Santander</td>
</tr>
<tr>
<td>del Giorgio, Paul</td>
<td>Université du Québec à Montréal</td>
</tr>
<tr>
<td>Edison, Art</td>
<td>University of Georgia</td>
</tr>
<tr>
<td>Emmett, Mark</td>
<td>University of Texas</td>
</tr>
<tr>
<td>Hemingway, Jordon</td>
<td>MIT/WHOI Joint Program in Oceanography</td>
</tr>
<tr>
<td>Horabin, Jamila</td>
<td>Florida State University</td>
</tr>
<tr>
<td>Kekalainen, Timo</td>
<td>University of Eastern Finland</td>
</tr>
<tr>
<td>Kocar, Benjamin</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>Li, Hong</td>
<td>Florida State University</td>
</tr>
<tr>
<td>Mackelprang, Rachel</td>
<td>California State Northridge</td>
</tr>
<tr>
<td>Maekawa, Toru</td>
<td>Toyo University</td>
</tr>
<tr>
<td>Marcé, Rafael</td>
<td>University of Girona</td>
</tr>
<tr>
<td>Martin, Jonathan</td>
<td>University of Florida</td>
</tr>
<tr>
<td>McDowell, William</td>
<td>University of New Hampshire Main Campus</td>
</tr>
<tr>
<td>Repeta, Daniel</td>
<td>Woods Hole Oceanographic Institution</td>
</tr>
<tr>
<td>Ryan, Joseph</td>
<td>University of Colorado</td>
</tr>
<tr>
<td>Shorina, Natalia</td>
<td>Ural Branch of the Russian Academy of Sciences</td>
</tr>
<tr>
<td>Sufita, Joseph</td>
<td>University of Oklahoma</td>
</tr>
<tr>
<td>Swarthouw, Bob</td>
<td>Appalachian State University</td>
</tr>
<tr>
<td>Walter Anthony, Katey</td>
<td>University of Alaska Fairbanks</td>
</tr>
<tr>
<td>Whitty, Adrian</td>
<td>Boston University</td>
</tr>
<tr>
<td>Xu, Yunping</td>
<td>Shanghai Ocean University</td>
</tr>
<tr>
<td>Young, Robert</td>
<td>Colorado State University</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

1 PI who received magnet time for the first time across all facilities.

#### Table 8 – Research Proposals Profile with Magnet Time

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Proposals</td>
<td>126</td>
<td>11</td>
<td>20</td>
<td>0</td>
<td>78</td>
<td>3</td>
<td>8</td>
<td>37</td>
</tr>
</tbody>
</table>

1 A “proposal” may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.

2 The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.

3 The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.
## Table 9 – User Proposal

This report lists all proposals that were allocated magnet time from January-December 2016 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users. (S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

<table>
<thead>
<tr>
<th>Participants (PI, Coll.)</th>
<th>Funding Source(s)</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched</th>
<th># of Days Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8 items)</td>
<td>(1 item)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Name</strong></td>
<td><strong>Role</strong></td>
<td><strong>Org.</strong></td>
<td><strong>Dep.</strong></td>
<td><strong>Award #</strong></td>
<td><strong>Funding Agency Title</strong></td>
<td><strong>Exp. Sched</strong></td>
</tr>
<tr>
<td>Henry Williams (S)</td>
<td>pi</td>
<td>FAMU</td>
<td>School of the Environment</td>
<td>No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)</td>
<td>P01964</td>
<td>Biology, Biochemistry, Biophysics</td>
</tr>
<tr>
<td>Despoina Lymeropoulo (P)</td>
<td>Coll.</td>
<td>FAMU</td>
<td>Environmental Science Institute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jackie Jarvis (S)</td>
<td>Coll.</td>
<td>New Mexico State Univ.</td>
<td>Chemical Analysis and Instrumentation Laboratory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huan Chen (S)</td>
<td>Coll.</td>
<td>NHMFL</td>
<td>ICR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamar Dickerson (P)</td>
<td>Coll.</td>
<td>FAMU</td>
<td>School of the Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edward Laws (S)</td>
<td>Coll.</td>
<td>Louisiana State Univ.</td>
<td>School of the Coast and Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ashvini Chauhan (S)</td>
<td>Coll.</td>
<td>FAMU</td>
<td>School of the Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denene Blackwood (O)</td>
<td>Coll.</td>
<td>UNC-CH</td>
<td>Institute of Marine Sciences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9 items)</td>
<td>(2 items)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Name</strong></td>
<td><strong>Role</strong></td>
<td><strong>Org.</strong></td>
<td><strong>Dep.</strong></td>
<td><strong>Award #</strong></td>
<td><strong>Funding Agency Title</strong></td>
<td><strong>Exp. Sched</strong></td>
</tr>
<tr>
<td>Michael Van Stipdonk (S)</td>
<td>pi</td>
<td>Lawrence Univ.</td>
<td>Chemistry</td>
<td>963450</td>
<td>NSF</td>
<td></td>
</tr>
<tr>
<td>Benjamin Bythell (S)</td>
<td>Coll.</td>
<td>Univ. of Missouri</td>
<td>Dep. of Chemistry &amp; Biochemistry</td>
<td>DE-AC02-05CH11231</td>
<td>DOE</td>
<td></td>
</tr>
<tr>
<td>John Gibson (S)</td>
<td>Coll.</td>
<td>Lawrence Berkeley National Laboratory</td>
<td>Chemical Sciences Div</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daniel Rios (P)</td>
<td>Coll.</td>
<td>Lawrence Berkeley National Laboratory</td>
<td>Chemical Sciences Div</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Michael Kullman (U)</td>
<td>Coll.</td>
<td>Wichita State Univ.</td>
<td>Chemistry</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix I – User Facility Statistics

<table>
<thead>
<tr>
<th>Participants (Pl, Coll.)</th>
<th>Funding Source(s)</th>
<th>Prop. Title</th>
<th>Prop. ID</th>
<th>Prop. Disc.</th>
<th>Exp. Sched</th>
<th># of Days Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theodore Corcovilos (S)</td>
<td>Duquesne Univ.</td>
<td>Physics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patricia Mihm (G)</td>
<td>Duquesne Univ.</td>
<td>Chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cassandra Hanley (G)</td>
<td>Duquesne Univ.</td>
<td>Chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jordan Pestok (U)</td>
<td>Duquesne Univ.</td>
<td>Chemistry and Biochemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
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Characterization of the BP petroleum residuals in the sediment of the Salt Marshes in the Northern Gulf of Mexico.
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**Characterizing histone modification dynamics of human pluripotent stem cells during cell cycle transitions**

**Investigating dissolved organic matter decomposition pathways with depth along a natural permafrost thaw gradient in Northern Sweden**

**Biology, Biochemistry, Biophysics**

**Chemistry, Geochemistry**

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**MagLab 2016 Annual Report**
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### Additional Notes

- No other support (i.e., this experiment is entirely supported by NHMFL users services via its core grant)

### Additional Funding

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### Additional Notes

- FT-ICR MS characterization of natural oil seep (Mega-plume) from Gulf of Mexico.

**MagLab 2016 Annual Report**
### Appendix I – User Facility Statistics

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MagLab 2016 Annual Report
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- Correlation of mass spectral data to petroleum bulk properties

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ICR Program Proposal Kristina Håkansson, Dep. of Chemistry, Univ. of Michigan

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MagLab 2016 Annual Report
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## Appendix I – User Facility Statistics

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**Identifications**

- Halogenated organics in fracking wastewaters
- Dynamics of DOM composition and microbial function in streams: Investigating the influence of land-cover and permafrost loss across a sub-arctic landscape gradient
- Adsorptive Fractionation
### Appendix I – User Facility Statistics

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**MagLab 2016 Annual Report**
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MagLab 2016 Annual Report
## Appendix I – User Facility Statistics

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- Study of Biological removal effects of dissolved organic nitrogen (DON) through biosorption activated media (BAM) P14856 Engineering 2 8
- Electron Capture & Infra-Red Multi-Photon Dissociation as Probes for Fe/Co Cyanometalate Square Stability & Structure P14858 Biology, Biochemistry, Biophysics 2 5
- Direct comparison of HTL oil composition P14896 Chemistry, Geochemistry 1 2

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Biodegradation of Photosolubilized Weathered Oil Components  P14927  Chemistry, Geochemistry  1 4

Longitudinal patterns of dissolved  P14928  Biology, Biochemistry  1 5
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## Appendix I – User Facility Statistics

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Research Experience for Undergraduates: Unveiling sulfur speciation by deconvolution of low resolution mass spectrometer data

Oil to Dissolved Organic Matter: The Composition and Structure of Biosolubilized Carbon Produced from Petroleum

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Deciphering coupled photochemical-microbiological controls on terrestrial carbon cycling | P16016 | Chemistry, Geochemistry | 1 | 3 |
# Appendix I – User Facility Statistics

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MagLab 2016 Annual Report
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<td>NSF</td>
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<td>Anne Kellerman (P)</td>
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Appendix I – User Facility Statistics

MagLab 2016 Annual Report
# Appendix I - User Facility Statistics

<table>
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<tr>
<th>Participants (PI, Coll.)</th>
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<th>Prop. Disc.</th>
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<td>Amazon Program</td>
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**ICR**

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<td></td>
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<tr>
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<th>Funding Agency Title</th>
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<td>Pharmacology and Toxicology</td>
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<td>EOAS</td>
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### Appendix I – User Facility Statistics

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<td>Gheorghe Bota [S]</td>
<td>pi</td>
<td>Institute for Corrosion and Multiphase Technology at Ohio Univ.</td>
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<td>Characterization of Residual Acids and Ketones Generated From Iron Corrosion of HVGO Acids</td>
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<td>Design of Chiral Reagents for Click Chemistry</td>
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Appendix II
User Facilities Overview
Overall Statistics across All NHMFL User Facilities

User Demographics

Table 1: MagLab User Profile (Demographics) for 2016

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<tr>
<th></th>
<th>Users</th>
<th>Male</th>
<th>Female</th>
<th>No Response to Gender</th>
<th>Minority 1</th>
<th>Non-Minority 1</th>
<th>No Respond to Race</th>
<th>Affil. Users 2</th>
<th>Local Users 2</th>
<th>Uni. Users 3,5</th>
<th>Indus. Users 5</th>
<th>Nation. Lab Users 4,5</th>
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<td>Senior Personnel, U.S.</td>
<td>693</td>
<td>480</td>
<td>97</td>
<td>116</td>
<td>27</td>
<td>526</td>
<td>140</td>
<td>172</td>
<td>120</td>
<td>610</td>
<td>11</td>
<td>72</td>
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<tr>
<td>Senior Personnel, non-U.S.</td>
<td>236</td>
<td>165</td>
<td>26</td>
<td>45</td>
<td>14</td>
<td>166</td>
<td>26</td>
<td>56</td>
<td>2</td>
<td>163</td>
<td>22</td>
<td>51</td>
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<tr>
<td>Postdocs, U.S.</td>
<td>180</td>
<td>118</td>
<td>42</td>
<td>20</td>
<td>14</td>
<td>140</td>
<td>26</td>
<td>36</td>
<td>57</td>
<td>159</td>
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<td>38</td>
<td>21</td>
<td>7</td>
<td>10</td>
<td>3</td>
<td>21</td>
<td>14</td>
<td>1</td>
<td>0</td>
<td>32</td>
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<tr>
<td>Students, U.S.</td>
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<td>279</td>
<td>145</td>
<td>50</td>
<td>33</td>
<td>357</td>
<td>84</td>
<td>54</td>
<td>133</td>
<td>466</td>
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<tr>
<td>Students, non-U.S.</td>
<td>111</td>
<td>76</td>
<td>19</td>
<td>16</td>
<td>3</td>
<td>76</td>
<td>32</td>
<td>0</td>
<td>0</td>
<td>98</td>
<td>0</td>
<td>13</td>
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<tr>
<td>Technician U.S.</td>
<td>45</td>
<td>21</td>
<td>16</td>
<td>8</td>
<td>3</td>
<td>33</td>
<td>9</td>
<td>19</td>
<td>20</td>
<td>42</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Technician non-U.S.</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>1,778</td>
<td>1,161</td>
<td>352</td>
<td>265</td>
<td>97</td>
<td>1,317</td>
<td>364</td>
<td>284</td>
<td>330</td>
<td>1,571</td>
<td>35</td>
<td>172</td>
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</table>

1. NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander (and if more than one has been selected). The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin.
2. NHMFL-Affiliated users are defined as anyone in the lab’s personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as “Internal Investigator”. “Users Sending Sample” refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be “sample senders” for facilities located on their campuses.
3. In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
4. In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
5. The total of university, industry, and national lab users will equal the total number of users.

New PI

In 2016, 1,778 users from around the world enjoyed access to magnet time at the lab’s seven user facilities at three sites. The MagLab was extremely pleased to welcome requests for magnet time from 122 new principal investigators in 2016: 25 in the DC Field Facility; 10 in the Pulsed Field; 2 in the High B/T; 12 in NMR-MRI@FSU; 17 in NMR-MRI@UF (AMRIS); 26 in EMR; and 30 in ICR. All 122 of these new PIs submitted a request and received magnet time or have been scheduled to receive magnet time during the year.
Appendix II – User Facilities Overview

User Affiliation

Table 2: MagLab Facility Usage Profile (Type of Affiliation) for 2016

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<tr>
<td>NHMFL-Affiliated</td>
<td>2,716</td>
<td>430</td>
<td>261</td>
<td>3</td>
<td>163</td>
<td>1,859</td>
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<tr>
<td>Local</td>
<td>1,348</td>
<td>65</td>
<td>598</td>
<td>30</td>
<td>-</td>
<td>-</td>
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<td>U.S. University</td>
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<td>1,340</td>
<td>821</td>
<td>304</td>
<td>30</td>
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<td>154</td>
<td>28</td>
<td>2</td>
<td>-</td>
<td>-</td>
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<tr>
<td>U.S. Industry</td>
<td>28</td>
<td>-</td>
<td>18</td>
<td>-</td>
<td>-</td>
<td>10</td>
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<tr>
<td>Non-U.S.</td>
<td>1,662</td>
<td>875</td>
<td>599</td>
<td>-</td>
<td>24</td>
<td>164</td>
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<td>Test, Calibration, Set-up, Maint, Inst. Dev.</td>
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<td>249</td>
<td>61</td>
<td>-</td>
<td>942</td>
<td>23</td>
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<tr>
<td><strong>Total:</strong></td>
<td><strong>11,154</strong></td>
<td><strong>3,113</strong></td>
<td><strong>2,387</strong></td>
<td><strong>339</strong></td>
<td><strong>1,160</strong></td>
<td><strong>4,156</strong></td>
</tr>
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</table>

* User Units are defined as magnet days for four types of magnets. One magnet day is 7 hours in a water cooled resistive or hybrid magnet in Tallahassee. One magnet day is 12 hours in any pulsed magnet in Los Alamos and 24 hours in superconducting magnets in Tallahassee and the High B/T system in Gainesville. Magnet days for AMRIS instruments in Gainesville: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours (7 days/week); Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours (5 days/week).

Instrumentation Operation

Table 3: MagLab Instrumentation Operation for 2016

<table>
<thead>
<tr>
<th>User Facility</th>
<th>Total # Instr. Operations#</th>
<th># days to outside users at facility#</th>
<th># days in-house (NHMFL Affiliated research)10</th>
<th># days instrument development and maintenance (Combined)11</th>
<th># days to awardee institution faculty (local)12</th>
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<tbody>
<tr>
<td>DC Field 1</td>
<td>1,760</td>
<td>1,335</td>
<td>306</td>
<td>46</td>
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<td>PF Field 2</td>
<td>618</td>
<td>385</td>
<td>193</td>
<td>28</td>
<td>12</td>
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<tr>
<td>HBT 3</td>
<td>823</td>
<td>597</td>
<td>0</td>
<td>226</td>
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<td>NMR 4</td>
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<td>1,492</td>
<td>1086</td>
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<td>AMRIS 5</td>
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<td>684</td>
<td>258</td>
<td>571</td>
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<tr>
<td>EMR 6</td>
<td>1,573</td>
<td>1,095</td>
<td>244</td>
<td>150</td>
<td>84</td>
</tr>
<tr>
<td>ICR 7</td>
<td>1,196</td>
<td>645</td>
<td>203</td>
<td>279</td>
<td>69</td>
</tr>
</tbody>
</table>

1 Note: Since each resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies, there can be four resistive magnets + three superconducting magnets or the 45 T hybrid, two resistive magnets + three superconducting magnets operated in a given week. User Units are defined as magnet days. Users of water-cooled resistive or hybrid magnets can typically expect to receive enough energy for 7 hours a day of magnet usage so a magnet day is defined as 7 hours. Superconducting magnets are scheduled typically 24 hours a day. There is an annual four weeks shutdown in fall of powered DC resistive and hybrid magnets for infrastructure maintenance and a two weeks shutdown period for the university mandated holiday break.

2 User Units are defined as magnet days. Magnets are scheduled typically 12 hours a day.

3, 4, 6, 7 User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

5 User Units are defined as magnet days; time utilized is recorded to the nearest 15 minutes. Magnet-day definitions for AMRIS instruments: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours. Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours. This accounts for the difficulty in running animal or human studies overnight. Magnet days were calculated by adding the total number of real used for each instrument and dividing by 24 (vertical) or 8 (horizontal). Note: Due to the nature of the 4.7 T, 11 T and 3 T studies, almost all studies with external users were collaborative with UF investigators. In 2014 the 3T system was funded entirely off of non-NHMFL funds but is reported for historical purposes

#Total # days Instr. Operations = > total days allocated

# days to outside users at facility => all U.S. University, U.S. Govt. Lab., U.S. Industry, Non-U.S. excluding NHMFL Affiliated and local and Test, Calibration, Set-up, Maintenance, Inst. Dev.

# days in-house (NHMFL Affiliated research) => NHMFL Affiliated only

# days instrument development and maintenance (Combined) => test, calibration, set-up, maintenance, Inst. Dev.

# days to awardee institution faculty (local) => local only

MagLab 2016 Annual Report
### Appendix II – User Facilities Overview

#### Table 4: User Program Proposal Pressure by User Facility

<table>
<thead>
<tr>
<th>User Facility</th>
<th># experiments received (requested and deferred)</th>
<th># experiments reviewed</th>
<th># days requested in reviewed experiments</th>
<th># days allocated to outside users</th>
<th># days allocated to awardee institution personnel (local)</th>
<th>Total # days used</th>
<th>% Subscription (# days requested / # days used)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Field</td>
<td>344</td>
<td>459</td>
<td>2,844</td>
<td>1,335</td>
<td>73</td>
<td>1,760</td>
<td>162%</td>
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<tr>
<td>PF Field</td>
<td>103</td>
<td>140</td>
<td>786</td>
<td>385</td>
<td>12</td>
<td>618</td>
<td>127%</td>
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<tr>
<td>HBT</td>
<td>12</td>
<td>16</td>
<td>860</td>
<td>597</td>
<td>0</td>
<td>823</td>
<td>104%</td>
</tr>
<tr>
<td>NMR</td>
<td>439</td>
<td>488</td>
<td>3,608</td>
<td>1,492</td>
<td>539</td>
<td>3,405</td>
<td>105%</td>
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<tr>
<td>AMRIS</td>
<td>2,365</td>
<td>2,365</td>
<td>1,964</td>
<td>266</td>
<td>571</td>
<td>1,779</td>
<td>110%</td>
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<tr>
<td>EMR</td>
<td>178</td>
<td>203</td>
<td>3,008</td>
<td>1,095</td>
<td>84</td>
<td>1,573</td>
<td>191%</td>
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<tr>
<td>ICR</td>
<td>125</td>
<td>177</td>
<td>1,587</td>
<td>645</td>
<td>69</td>
<td>1,196</td>
<td>133%</td>
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#### Table 5: Funding Source of User’s Research - Days allotted (counts)

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<th>DOD (NASA, U.S. Army, U.S. Navy, U.S. Airforce)</th>
<th>NHMFL VSP</th>
<th>FFI</th>
<th>UF McKnight Brain Institute</th>
<th>Other</th>
<th>Sum (# of days)</th>
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#### Table 6: Funding Source of User’s Research - Fraction of Days allotted (percentage)

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<th>UF McKnight Brain Institute</th>
<th>Other</th>
<th>Sum (# of days)</th>
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<td>0%</td>
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<tr>
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<td>36%</td>
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<tr>
<td>EMR</td>
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<td>2%</td>
<td>0%</td>
<td>14%</td>
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Appendix III
Geographic Distribution
### National Distribution

#### DC Field Facility

**Senior Personnel, U.S.**

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<td>Dmytro Abraimov (S/PI)</td>
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<td>Clark University</td>
<td>USA (MA)</td>
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<tr>
<td>Hongwoo Baek (S/PI)</td>
<td>NHMFL</td>
<td>USA (FL)</td>
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<tr>
<td>Fedor Balakirev (S/PI)</td>
<td>NHMFL</td>
<td>USA (NM)</td>
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<tr>
<td>Kirk Baldwin (S)</td>
<td>Princeton University</td>
<td>USA (NJ)</td>
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<tr>
<td>Luis Balicas (S/PI)</td>
<td>NHMFL</td>
<td>USA (FL)</td>
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<td>Cristian Batista (S/PI)</td>
<td>Los Alamos National Laboratory</td>
<td>USA (TN)</td>
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<tr>
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<td>Christianne Beekman (S/PI)</td>
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<tr>
<td>Gregory Belenky (S)</td>
<td>SUNY at Stony Brook</td>
<td>USA (NY)</td>
</tr>
<tr>
<td>Jonathan Betts (S/PI)</td>
<td>NHMFL</td>
<td>USA (NM)</td>
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<tr>
<td>Mark Bird (S/PI)</td>
<td>NHMFL</td>
<td>USA (FL)</td>
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<tr>
<td>Girsh Blumberg (S/PI)</td>
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<td>USA (NJ)</td>
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<tr>
<td>Greg Boebinger (S/PI)</td>
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<td>USA (FL)</td>
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<tr>
<td>Scott Bole (S)</td>
<td>NHMFL</td>
<td>USA (FL)</td>
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<tr>
<td>William Brey (S/PI)</td>
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<td>USA (FL)</td>
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<tr>
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<td>USA (FL)</td>
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<tr>
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<td>USA (KY)</td>
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<tr>
<td>I-Wei Chen (S/PI)</td>
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<td>USA (PA)</td>
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<td>Yong Chen (S/PI)</td>
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<td>USA (IN)</td>
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<td>Andrew Christianson (S)</td>
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<td>Jason Cooley (S/PI)</td>
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<tr>
<td>Timir Datta (S/PI)</td>
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<td>USA (SC)</td>
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<tr>
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<tr>
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<td>Nathanael Fortune (S/PI)</td>
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## Appendix III – Geographic Distribution

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### Appendix III – Geographic Distribution

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### Appendix III – Geographic Distribution

#### Name | Organization | Country
--- | --- | ---
Jun Zhu (S/PI) | Pennsylvania State University | USA (PA)
Michael Zudov (S/PI) | University of Minnesota | USA (MN)

#### Postdocs, U.S.

#### Name | Organization | Country
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Zhanybek Alpikeshev (P) | MIT | USA (MA)
Amal Al-Wahish (P) | University of Tennessee | USA (TN)
Christopher Beedle (P/PI) | NHMFL | USA (NM)
Xinghan Cai (P) | University of Washington | USA (WA)
Mun Chan (P/PI) | NHMFL | USA (NM)
Hang Chi (P/PI) | Brookhaven National Laboratory | USA (NY)
Shalinee Chikara (P/PI) | NHMFL | USA (NM)
Erik Cizmar (P) | UF | USA (FL)
Anca Constantinescu (P) | NHMFL | USA (FL)
Sergio de la Barrera (P) | Carnegie Mellon University | USA (PA)
Scott Dietrich (P) | Columbia University | USA (NY)
Paula Giraldo Gallo (P) | NHMFL | USA (FL)
Martin Gustafsson (P) | Columbia University | USA (NY)
Jeonghoon Ha (P) | NHMFL | USA (FL)
Anthony Hatke (P) | NHMFL | USA (FL)
Tetyana Ignatova (P) | Lehigh University | USA (PA)
Shengwei Jiang (P) | Penn State University | USA (PA)
Long Ju (P) | Cornell University | US (NY)
Hyunsoo Kim (P) | University of Maryland College Park | USA (MD)
Jae Wook Kim (P) | Rutgers University | USA (NJ)
Youngduck Kim (P) | Columbia University | USA (NY)
Alexey Kovalev (P) | NHMFL | USA (FL)
Jin Jung Kweon (P) | NHMFL | USA (FL)
Gil-Ho Lee (P) | Harvard University | USA (MA)
Sanghan Lee (P) | University of Wisconsin | USA (WI)
Jia Li (P) | Columbia University | USA (NY)
Cunming Liu (P) | University of South Florida | USA (FL)
Ruiyuan Liu (P) | Rice University | USA (TX)
Margherita Mäiuri (P) | Princeton University | USA (NJ)
Ludi Miao (P) | Pennsylvania State University | USA (PA)
Julia Mundy (P) | University of California at Berkeley | USA (CA)
Efren Navarro-Moratalla (P) | MIT | USA (MA)
Nihar Pradhan (P) | NHMFL | USA (FL)
Brad Ramshaw (P/PI) | NHMFL | USA (NM)
Sheng Ran (P) | University of California, San Diego | USA (CA)
Daniel Rhodes (P) | Columbia University | USA (NY)
Rebeca Ribeiro Palau (P) | Columbia university | USA (NY)
Zhenzhong Shi (P) | NHMFL | USA (FL)
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**Technician, U.S.**

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## Appendix III – Geographic Distribution

### Pulsed Field Facility

**Senior Personnel, U.S.**

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**Technician, U.S.**

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**High B/T Facility**

**Senior Personnel, U.S.**

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### Appendix III – Geographic Distribution

#### Name | Organization | Country
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Wei Pan (S/PI) | Sandia National Laboratories | USA (NM)
Loren Pfieffer (S) | Princeton University | USA (NJ)
John Reno (S) | Sandia National Laboratories | USA (NM)
James Sturm (S) | Princeton University | USA (NJ)
Neil Sullivan (S) | UF | USA (FL)
Daniel Tsui (S/PI) | Princeton University | USA (NJ)
Jian-sheng Xia (S) | UF | USA (FL)

#### Postdocs, U.S.

#### Name | Organization | Country
--- | --- | ---
Liang Yin (P/PI) | UF | USA (FL)

#### Students, U.S.

#### Name | Organization |
--- | ---
Blaine Bush (G) | University of California, Davis | USA (CA)

#### Technician, U.S.

#### NMR Facility Senior Personnel, U.S.

#### Name | Organization | Country
--- | --- | ---
Edward Agyare (S/PI) | Florida A&M University | USA (FL)
Rufina Alamo (S/PI) | Florida A&M University | USA (FL)
Rajendra Arora (S) | Florida A&M University | USA (FL)
Chulsung Bae (S/PI) | Rensselaer Polytechnic Institute | USA (NY)
Shi Bai (S/PI) | University of Delaware | USA (DE)
Steve Blackband (S/PI) | UF | USA (FL)
Clifford Bowers (S/PI) | UF | USA (FL)
Jeanine Brady (S) | UF | USA (FL)
William Brey (S/PI) | NHMFL | USA (FL)
Thomas Budinger (S/PI) | Lawrence Livermore National Laboratory | USA (CA)
Marc Caporini (S) | Bruker Biospin | USA (MA)
Leah Casabianca (S/PI) | Clemson University | USA (SC)
Eduard Chekmenev (S/PI) | Vanderbilt University | USA (TN)
Bo Chen (S/PI) | University of Central Florida | USA (FL)
Hailong Chen (S/PI) | Georgia Institute of Technology | USA (GA)
Bradley Chmelka (S/PI) | University of California, Santa Barbara | USA (CA)
Myriam Cotten (S/PI) | College of William and Mary | USA (VA)
Tim Cross (S/PI) | FSU | USA (FL)
Mark Davis (S/PI) | California Institute of Technology | USA (CA)
Rafaela de Negri (S) | University of Miami | USA (FL)
Harry Dorn (S/PI) | Virginia Tech | USA (VA)
Art Edison (S/PI) | University of Georgia | USA (GA)
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**MBI-UF AMRIS**

**Senior Personnel, U.S.**

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### Name Organization Country
Jacquelyn Walejko (G) UF USA (FL)
wei-en Wang (G) Department of Applied Physiology and Kinesiology, Laboratory for Rehabilitation Neuroscience USA (FL)
Yuting Wang (G) UF USA (FL)
Allen Ye (G) University of Illinois at Chicago USA (IL)
Siyang Yin (G) Biomedical engineering of UF USA (FL)
Evan Wenbo Zhao (G) UF USA (FL)

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**ICR Facility**

**Senior Personnel, U.S.**

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### Appendix III – Geographic Distribution

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### International Distribution

#### DC Field Facility

**Senior Personnel, non-U.S.**

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### Technician, non-U.S.

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### Pulsed Field Facility

#### Senior Personnel, non-U.S.

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#### Technician, non-U.S.

Zero
## Appendix III – Geographic Distribution

### High B/T Facility
#### Senior Personnel, non-U.S.

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<td>Stephen Julian (S/PI)</td>
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<tr>
<td>Alix McCollam (S)</td>
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### NMR Facility
#### Senior Personnel, non-U.S.

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<td>Joost Verhaagen (S)</td>
<td>Vrije University of Amsterdam/Netherlands Institute for Neuroscience</td>
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MagLab 2016 Annual Report
# Appendix III – Geographic Distribution

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**Postdocs, non-U.S.**

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**Students, non-U.S.**

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**Technician, non-U.S.**

**Zero**

**MBI-UF AMRIS**

**Senior Personnel, non-U.S.**
## Appendix III – Geographic Distribution

### Postdocs, non-U.S.

#### Zero

### Students, non-U.S.

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### EMR Facility

#### Senior Personnel, non-U.S.

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<td>Alina Dinca (P)</td>
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**Technician, non-U.S.**

**Zero**

**ICR Facility**

**Senior Personnel, non-U.S.**

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<td>Natalia Shorina (S/PI)</td>
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### Appendix III – Geographic Distribution

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#### Postdocs, non-U.S.

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<td>Mathilde Farenc (G)</td>
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<td>Sara Gutiérrez Sama (G)</td>
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<td>Alexander Zherebker (G)</td>
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#### Technician, non-U.S.

Zero
Appendix IV
Personnel
## Appendix IV – Personnel

Senior Personnel at FSU, UF, and LANL (225)

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### Appendix IV – Personnel

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### Appendix IV – Personnel

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**800 - UF**

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<td>Douglas, Elliot</td>
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## Appendix IV – Personnel

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<tr>
<td>Lai, Song</td>
<td>Professor of Radiation Oncology and Neurology, Director, CTSI Human Imaging Core McKnight Brain Institute, Director, CTSI Human Imaging Core McKnight Brain Institute</td>
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<td>Lee, Yoonseok</td>
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<td>Long, Joanna</td>
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<td>Mareci, Thomas</td>
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<tr>
<td>Masuhara, Naoto</td>
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<td>Stewart, Gregory</td>
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<tr>
<td>Sullivan, Neil</td>
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<tr>
<td>Takano, Yasumasa</td>
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<td>Vandenborne, Krista</td>
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<td>Vasenkov, Sergey</td>
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<tr>
<td>Xia, Jian-Sheng</td>
<td>Associate Scientist</td>
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<tr>
<td>Zeng, Huadong</td>
<td>Specialist, Animal MRI/S Applications</td>
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<td><strong>1100 - ASC</strong></td>
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<tr>
<td>Abramov, Dmytro</td>
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<tr>
<td>Cheggour, Najib</td>
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<td>Griffin, Van</td>
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<td>Kametani, Fumitake</td>
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<td>Kim, Youngjae</td>
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<td>Labbasteier, David</td>
<td>Chief Materials Scientist, Director, Applied Superconductivity Center</td>
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<tr>
<td>Lee, Peter</td>
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<tr>
<td>Pamidi, Sastry</td>
<td>Associate Professor, Electrical &amp; Computing Engineering; Associate Director, Center for Advanced Power Systems</td>
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<tr>
<td>So, Noguchi</td>
<td>Visiting Scientist/Researcher</td>
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<tr>
<td>Starch, William</td>
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# Appendix IV – Personnel

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<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Trociewitz, Ulf</td>
<td>Research Faculty III</td>
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<tr>
<td><strong>1200 - Director's Office</strong></td>
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<tr>
<td>Boebinger, Gregory</td>
<td>Director/Professor, Professor of Physics</td>
</tr>
<tr>
<td>Gray, Laymon</td>
<td>Asst Dir Safety &amp; Security</td>
</tr>
<tr>
<td>Hughes, Roxanne</td>
<td>Research Faculty II, Director, Center for Integrating Research and Learning</td>
</tr>
<tr>
<td>Palm, Eric</td>
<td>Deputy Lab Director</td>
</tr>
<tr>
<td>Roberts, Kristin</td>
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<tr>
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<td>Visiting Research Faculty I</td>
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<tr>
<td>Woods, Marvin</td>
<td>Assistant Director of Research Support</td>
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<tr>
<td><strong>1300 - Geochemistry</strong></td>
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<tr>
<td>Chanton, Jeff</td>
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<tr>
<td>Cooper, William</td>
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<td>Froelich, Philip</td>
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Postdoctoral Associates at FSU, UF, and LANL (61)

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<th>Name</th>
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<td><strong>400 - Magnet Science &amp; Technology</strong></td>
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<tr>
<td>Niu, Rongmei</td>
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<td>Winter, Laurel</td>
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**700 - CIMAR**

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### Other Professionals at FSU, UF, and LANL (96)

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<tr>
<td><strong>100 - Management and Administration</strong></td>
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<tr>
<td>Barron, John</td>
<td>Maintenance Mechanic</td>
</tr>
<tr>
<td>Clark, Eric</td>
<td>Application Developer/Designer</td>
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<tr>
<td>Cobb, Damaris</td>
<td>Program Coordinator, Purchasing</td>
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<td>Greenlee, Reshaye</td>
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### 300 - DC Instrumentation

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<td>Boenig, Heinrich</td>
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<td>Williams, Vaughan</td>
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### 400 - Magnet Science & Technology

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<tbody>
<tr>
<td>Adkins, Todd</td>
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<tr>
<td>Cantrell, Kurtis</td>
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<tr>
<td>Geohagan, Doris</td>
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<td>Goddard, Robert</td>
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<tr>
<td>Gundlach, Scott</td>
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<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Jarvis, Brent</td>
<td>Research Engineer</td>
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<td>Lucia, Joseph</td>
<td>Technical/Research Designer</td>
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<td>Marks, Emsley</td>
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<td>McRae, Dustin</td>
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<td>Mellow, Amy</td>
<td>Administrative Specialist</td>
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### 500 - Condensed Matter Science

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<tr>
<td>Javed, Arshad</td>
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<tr>
<td>Shehter, Arkady</td>
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### 700 - CIMAR

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<tr>
<td>Beu, Steven</td>
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<tr>
<td>Bickett, Karol</td>
<td>Senior Administrative Specialist</td>
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<td>Hodges, Kurt</td>
<td>Coordinator, Animal Welfare Compliance</td>
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<td>Kitchen, Jason</td>
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<tr>
<td>McIntosh, Daniel</td>
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<td>Schiano, Jeffrey</td>
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<td>Jenkins, Kelly</td>
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<tr>
<td>Nicholson, Tammy</td>
<td>Certified Radiology Technology Mgr. (3T Imaging Applications)</td>
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<td>Rocca, James</td>
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### 1100 - ASC

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<td>Linville, Connie</td>
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### 1200 - Director's Office

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<tr>
<td>Arline, Benjamin</td>
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<tr>
<td>Bilenky, Stephen</td>
<td>Industrial Safety &amp; Health Eng</td>
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<tr>
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### Appendix IV – Personnel

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<tr>
<td>Furrow, Lindsey</td>
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<tr>
<td>Gray, Ashley</td>
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#### 1300 - Geochemistry

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Graduate Students at FSU, UF, and LANL (165)

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## Appendix IV – Personnel

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## Appendix IV – Personnel

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**600 - LANL**

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### Appendix IV – Personnel

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<th>Position Title</th>
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<tr>
<td>Abad, Nastaren</td>
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## Appendix IV – Personnel

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Undergraduate Students at FSU, UF, and LANL (76)

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<tr>
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**500 - Condensed Matter Science**

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# Appendix IV – Personnel

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<td>Taylor, Joshua</td>
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MagLab 2016 Annual Report
## Appendix IV – Personnel

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<th>Position Title</th>
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<tbody>
<tr>
<td>Wang, Judith</td>
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<tr>
<td>Chambers, Austin</td>
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<td>Billings, Beau</td>
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### Support Staff – Technical/Managerial at FSU, UF, and LANL (85)

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<td>Allbaugh, Tony</td>
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## Appendix IV – Personnel

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### 300 - DC Instrumentation

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### 400 - Magnet Science & Technology

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### 500 - Condensed Matter Science

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# Appendix IV – Personnel

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<td>Swiers, Christi</td>
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<td>Webb, Elizabeth</td>
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<td>Maleszewski, Matthew</td>
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<td>Wilson, Lauren</td>
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Support Staff – Secretarial/ Clerical at FSU, UF, and LANL (30)

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<th>Position Title</th>
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# Appendix IV – Personnel

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<td>Patel, Nilay</td>
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## 400 - Magnet Science & Technology

- Maddox, James: Program Associate

## 500 - Condensed Matter Science

- Qureshi, Aisha: Administrative Assistant

## 600 - LANL

- Gallegos, Julie: Program Administrator

## 700 - CIMAR

- Davis, Cameron: SOAR Internship
- Desilets, Mary: Administrative Support Assistant
- Jemmott, Krista: Program Associate
- Mozolic, Kimberly: Program Associate

## 800 - UF

- Colson, Marcia Tessie: Program Assistant
- Fuhr, Angela: Office Manager
- Mesa, Denise: NHMFL Administrative Assistant

## 1100 - ASC

- Hall, Charlotte: Admin Support Assistant
- Pelletier, Tiffany: Office Assistant

## 1200 - Director’s Office

- Davis, Colleen: Safety Coordinator
- Fitch, Morgan: Program Associate
- McClure, Dylan: Intern
- Patel, Nilay: Volunteer

MagLab 2016 Annual Report
## Appendix IV – Personnel

<table>
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<tr>
<th>Parameter / Category</th>
<th>Senior Personnel</th>
<th>Postdoc</th>
<th>Other Professional</th>
<th>Graduate Student</th>
<th>Undergraduate Student</th>
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<td>11.5%</td>
<td>4.1%</td>
<td>100.0%</td>
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Appendix V
Postdoctoral Mentoring Plan
MagLab Postdoctoral Mentoring Plan

The goal of the Postdoctoral Mentoring Plan at the National High Magnetic Field Laboratory (MagLab) is to provide MagLab postdoctoral associates with a complete skill set that addresses the modern challenges of a career in science, technology, engineering and mathematics (STEM). A key component of the plan is full immersion in the interdisciplinary culture of the MagLab and in the surrounding communities of one of the MagLab’s three partner institutions - the Florida State University (FSU), the University of Florida (UF), and Los Alamos National Laboratory (LANL). The Center for Integrating Research and Learning (CIRL), housed within the MagLab, will facilitate this Postdoctoral Mentoring Plan.

Currently, MagLab postdoctoral researchers are required by their supervisors and research groups to participate in the preparation of publications, and to make presentations at group meetings and conferences. Postdoctoral researchers are also expected to play active roles in STEM-strengthening programs, such as the MagLab Diversity Plan, outreach efforts, and formal educational or mentoring programs (e.g. the Research Experiences for Undergraduates program, the Research Experiences for Teachers program, and other CIRL outreach programs, through which they can provide significant STEM mentorship to students, early career scientists and the teachers of the next generation of scientists). Finally, MagLab postdoctoral associates are expected to provide service to the laboratory through participation in the MagLab Annual Open House or other events designed specifically to translate and communicate research in the MagLab user community to members of the general public.

Key components of the Postdoctoral Mentoring Plan are:

- **Orientation.** Orientations where new employees meet with the MagLab Director and the Human Resources Director who address questions they may have related to their new position and the lab are held quarterly for all new employees including postdocs. Orientation materials, including a “Welcome to the MagLab” document are available online to augment the face-to-face orientation. The postdocs at the lab have developed an additional orientation booklet that speaks to the unique issues postdocs face. Orientation includes an overview of: the three sites of the MagLab, the breadth of scientific research in the MagLab user program, particularly interdisciplinary research, and practical institutional information (including but not limited to performance expectations, salary information, the ordering and delivery of materials, as well as information about local housing, schools, health care resources, and links to special interest groups at the local partner institution).

- **Professional Development.** Professional development classes, workshops, and online materials will cover grant writing, ethical conduct of research, organizing data, writing manuscripts, giving effective scientific presentations, mentoring other scientists and communicating scientific research to non-scientists. Workshops will be facilitated by CIRL and involve faculty from the MagLab sites, the FSU Career Center, National Postdoc Associates, and Industry partners.

- **Career Counseling.** Sometimes postdoctoral associates may have career questions that their assigned mentor cannot speak to (e.g. careers in industry, networking opportunities for underrepresented minority students). Therefore, the MagLab Postdoctoral Mentoring Plan includes a list of additional volunteer mentors who are willing to answer questions that postdoctoral associates may have. Postdoctoral associates may choose to contact volunteers from this list if they feel they need additional advice not exclusively from their direct supervisor. Possible forms of advice include: providing guidance, encouragement, and information on opportunities for networking, contributed and invited talks, and travel funds to attend conferences, including the MagLab’s Dependent Care Travel Grant Program [https://nationalmaglab.org/user-resources/funding-opportunities].

- **Assessment.** Assessment will be conducted by CIRL through the analysis of annual evaluation surveys to determine topics of interest to postdoctoral researchers and to ensure that postdoctoral researchers are being well mentored.