Celebrating Jim Brooks
His passion for physics impacted scientists around the world.
HOW TO MAKE A MENTOR

Jim Brooks was a mentor to practically everyone he met. His life was a primer for educators everywhere on how to groom better scientists – and better people.

LOOKING BACK, MOVING FORWARD

The National MagLab looks back on two decades and offers a glimpse into the future.
This past October marks 20 years since the dedication of the National High Magnetic Field Laboratory and the launch of our user program. That means two decades of cutting-edge user science, exciting in-house research, record-breaking magnet making and inspiring educational outreach.

We ate cake to celebrate this milestone birthday – maybe next year, we’ll break out the single-malts when we turn 21! We also marked the day with the release of a new visual identity for the lab and a yearlong campaign – Moving Science Forward – to showcase our impact on researchers, educators and students for our state, country and the world. Read more about this celebration in our cover feature article, “Looking Back, Moving Forward,” on page 8.

Much like in our personal lives, being a 20-year-old lab has some major advantages. We are still young and agile enough to change directions to respond to new scientific opportunities. But we no longer have to prove ourselves – our 1,300 users, 14 world records and 400 plus publications each year make a pretty strong case for our significance.

Two decades after dignitaries dedicated our lab, it continues to evolve in ways we could not have imagined at our inception. And we still have the youthful energy to pull daily all nighters (see “Science Never Sleeps” on page 16)!

People affiliated with the lab continue to be recognized for their exceptional work. For the second time in two years, a physicist associated with the MagLab has won the prestigious American Physical Society (APS) Buckley Prize. MagLab students, staff and users were all recognized at the Applied Superconductivity Conference in Charlotte, and two different MagLab leaders have been selected as fellows to the prestigious American Association for the Advancement of Science and APS.

This past fall, though, we lost one of our MagLab pioneers and my personal friend, Jim Brooks. He was one of the earliest experimental physicists to join the lab, and remained centrally involved in the MagLab throughout his career, most recently serving as chair of both FSU’s Physics Department and the MagLab’s Science Council. Many of you are fortunate enough to have your own personal memories of Brooks, but for those of you who didn’t know him, perhaps you can get a sense of his love of mentorship and teaching in “How to Make a Mentor” on page 4. I count myself lucky to have known Brooks for 32 years. The best way to honor his memory is to continue to do great science and to continue to have great fun doing it. So to keep Moving Science Forward, that’s just what we intend to do…

**HAPPY BIRTHDAY TO US!**

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**DIRECTOR’S DESK**

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We have a new and improved website. Visit NationalMagLab.org for more science content, a revamped education section and a modern, mobile-friendly look that better showcases the lab’s instruments, research and expertise.
How to Make E=mc² (energy equals mass multiplied by the speed of light squared – thanks, Einstein!).

So it’s not entirely kooky to think of Brooks himself as an equation. Given his offbeat sense of humor (he did, after all, pluck a frog from a pond and levitate it in a magnet back when such stunts raised more chuckles than eyebrows), the idea might have tickled his funny bone.

Brooks also devoted countless hours to mentoring students, post-docs and colleagues. By all accounts, he was as passionate and gifted at that job as he was as physics: Every moment was a teachable moment for Brooks.

“Jim had an unusually broad range of research interests, and he was also an exceptional human being,” said MagLab Director Greg Boebinger, whose friendship with Brooks spanned three decades. “He took great pride in applying his expertise to help younger researchers advance in their careers, which has made his impact on physics all the greater.”

Brooks’ sudden death prompted a flood of reminiscences that spoke as much to his legacy as a mentor as to his impact as a scientist. Below, we’ve distilled the stories of Brooks the Mentor — or Brooks-sensei, as he was fondly known among his Japanese students and colleagues — into a kind of equation. Add up all these traits and you’re bound to come out with a fine mentor for a long time to come.

A CHAMPION FOR OTHERS Those who knew Brooks best describe a man whose passion for science was unfettered by ego. “He never pretended to know what he didn’t know,” said Andhika Kiswandhi, a former Brooks post-doc now at the University of Texas at Dallas, “and he loved to learn from everyone, including his own students.”

When he advised on a successful project or paper, he scrupulously side-stepped the spotlight.

“He always cared about our careers,” said MagLab researcher Eden Steven, another of the half-dozen grad students and post-docs Brooks was supervising at the time of his death. "On every occasion when there was an opportunity for us to shine, he would always give us that chance.”

Brooks groomed his students for independence and success. He taught them how to focus their work, when to stop taking data and how to write well. Some mentors, said Steven, will write a paper based on a student’s work in order to get the research published more quickly. Not Brooks: He pushed students to author their own papers and to take the credit — even though it meant reviewing every draft along the way.

Brooks didn’t reserve encouragement for his students only. When physicist David Graf sought advice as a newbie to the lab in the late 1990s, the common refrain was, “Go see Brooks.”

“It didn’t matter if you were his student or post-doc: His door was open,” said Graf. “He would guide any willing student through the scientific process and then push them forward to take the credit for any success.”

The many young scientists who sought out Brooks’ office — a space Blanketed by papers, instruments, travel mementos and thank-you gifts — always found the door ajar. Brooks also opened many figurative doors for them through introductions and recommendation letters that could clinch a new job or award. When physicist Irinel Chiorescu first came to the MagLab and Florida State University, Brooks took him under his wing. After winning a prestigious National Science Foundation award for early-career scientists, Chiorescu placed a late-night call to Brooks so that he was the first to know.

“I remember he was quite thrilled about it,” said Chiorescu. “He was as happy as I was.”

SPACE FOR MISTAKES Of Brooks’ many philosophies about science, this was surely one: You can’t do it right without making a mess and a few mistakes along the way.

The younger the scientist, of course, the more frequent the mistakes. As a mentor, Brooks knew his students would sometimes stumble, and he always made room for that critical part of the scientific process.

“He didn’t watch your back all the time: He gave you an idea and let you work on your own schedule,” said Steven. “He always told us that creativity is something you cannot predict. It doesn’t work this way. You need to give them space.”

Brooks’ love for teaching even extended to school-age kids. He taught impromptu physics lessons to pint-size friends and kids-at-heart with demonstrations involving loud noises and smashed fruit. Brooks was never one to spoon-feed science: He threw down the ingredients like a gauntlet and then made room for sticky, smelly, blooper-filled science to happen.

Educational consultant Brenda Crouch, who worked many years with Brooks teaching kids and educators hands-on science
through the Panhandle Area Educational Consortium, was awed by his ability to point students in the right direction, step back and make way for learning. "After he explained how something worked, he really didn't give the students a lot of details, except to say, 'This is what it does; this is how it works. Let's see what you can do.'"

WORK HARD...

With his Hawaiian shirts, mop of gray hair and socks-and-sandals footwear, Brooks looked the part of a chill dude. That hippie-esque demeanor notwithstanding, few people worked harder.

"Nothing was asking too much. He just worked very, very hard," said Crouch. And he never shirked the grunt work. "He was not an assigner of tasks," she added. "He was, 'Let’s roll up our sleeves and get the work done.’"

That dedication inspired a similar work ethic in his students. "He never asked us to come in during the weekend, but we always came," said Steven. "I think what drives us is that we saw him work so hard for us, and that made us in turn want to repay that favor."

… PLAY HARD

Long hours in the lab and at the computer could well make for a bunch of dull (and ornery) scientists. Luckily, Brooks had a fun side. He was famous for the parties he hosted, attended or sponsored. But even a meeting could be a party, as physicist Graf discovered when he first met Brooks back in 1999.

"He was laughing, drinking beer, looking at data and having a great time discussing the results," recalled Graf. "It was the first time of many that he would show me that you could work and have a good time at the same time.

In Brooks' book, science was best done with a smile … the more devilish, the better.

Brooks taught MagLab Director Boebinger this lesson early in his career. An assistant professor at Boston University at the time, Brooks shared a magnet with then-grad student Boebinger. One day, Brooks and a visiting scientist were using it for a sensitive experiment on the fractional quantum Hall effect.

"He was precise, and all the words had a lot of weight," said Chio-

KNOW YOUR AUDIENCE

Although Brooks deployed fun to maximum pedagogical benefit, he was not a one-size-fits-all mentor. Thanks to a keen emotional intelligence, he could discern people’s needs, fears and strengths quite well.

"He taught every student differently," said Steven. "He really knew which buttons to push." Whether you were a kid or adult, physicist or layperson, teacher or student, he knew how to connect, Crouch said. "He had such a gift … for figuring out ways to make complex science content understandable."

Former student Arjun Narayanan said he still turns to his old professor when stumped by something: "Often … I have found the concept I have been struggling with best explained in some paragraph of an old paper of his.

For MagLab physicist Chiurescu, Brooks’ secret to science communication was being a caring listener. Whenever he came to Brooks with an issue, the senior scientist listened carefully, interrupting with a question only as needed.

"He was not a talker who spends minutes and minutes talking. He was precise, and all the words had a lot of weight," said Chi-

IN A WORD: BE A MENSCH

Of all the attributes that made Brooks a fine mentor, the one remembered most fondly may also be the one most difficult to duplicate: Kindness. He offered to help people move, loaned them his truck, fetched them from the airport with a favorite beverage at the ready. His memorial page chronicles thoughtful acts, large and small.

"Jim was a very caring person, and he had a very open heart for everybody who needed his help and support," wrote physicist Hans Schneider-Muntau.

"I hope someday to learn to treat others with grace, humility, and unearned affection from the first moment, as he did with me,” noted his one-time student Narayanan.

The laboratory where Brooks’ group worked was, like his office, cluttered with the tools and byproducts of science. Walking in, you felt like you’ve interrupted a dozen different experiments. Working there recently, the young scientists were excited to observe an interesting phenomenon. The thrill of discovery was quickly dampened, however, by the realization that their mentor was no longer there to share it with them.

"We can talk about it to someone," said Steven, "but nobody will appreciate it as much as Brooks." 

Mentorship is part of the MagLab experience. This article is part of our series Mentoring Moments, in which scientists, teachers and students share their stories of mentorship at the lab. Read more Mentoring Moments at NationalMagLab.org/education/about-us/mentoring-moments.
The National High Magnetic Field Laboratory was to be the most powerful and comprehensive collection of advanced research magnets in the world. Four years after the National Science Foundation’s decision to move the lab to Tallahassee, the renovation of an abandoned administrative building into a complex scientific laboratory was completed and users were welcomed for science.

A Moving Dedication

A veritable Who’s Who of state and national academics, scientists and politicians came to dedicate the facility, under blue skies and breezy weather. A large stage was set up near the front parking lot, and at one moment in the program an oversized sign hanging behind the podium succumbed to the windy weather. Master of Ceremonies and State Chancellor for Education Charlie Reed assured that the lab would operate more successfully than the event’s backdrop. And it has.

The new lab was a first-time partnership between multiple states and the federal government to run a science facility. Presidents of Florida State University (FSU) and the University of Florida (UF) joined the director of Los Alamos National Lab (LANL) to explain how the three-site lab would work. With unique magnets housed at each location, all three would come together to offer a comprehensive user program. Los Alamos National Lab’s Dr. Pete Miller described it as “a model for future state and federal collaborations to support education, science and economic competitiveness.”

Florida Governor Lawton Chiles and U.S. Senator Bob Graham welcomed the keynote speaker, Vice President Al Gore. Gore arrived on crutches due to a basketball injury, but spoke in stride about the lab’s “amazing story ... of how people working together can create the world’s preeminent magnetic laboratory where a few short years before there was nothing.” He predicted that the National MagLab would “lead America into the next frontier of technology” and provide the United States “with a significant global competitive edge in many areas of science and technology.”

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Advances in superconductivity and magnet design helped facilitate the construction of the lab’s first Nuclear Magnetic Resonance (NMR) magnet, the groundbreaking 900 MHz Ultra-Wide Bore, in 2004. This magnet enables scientists to look inside small living animals to study diseases like tuberculosis, Alzheimer’s, HIV/AIDS, influenza and Parkinson’s.

In 2012, the 100 T at Los Alamos’ Pulsed Field Facility broke records, providing scientists with 15 milliseconds of very high fields to better understand superconductivity, phase transitions and so-called quantum critical points.

The lab’s newest world record holder, the 21 tesla Fourier Transform Ion Cyclotron Resonance (FT-ICR) magnet, offers the highest resolution mass spectrometry available for the analysis of extremely complex mixtures, including petroleumomics, dissolved organic matter, metabolomics, top-down proteomics and matrix-assisted laser desorption/ ionization imaging.

Breaking Records

The lab’s first operational magnet in 1994—a 27 tesla (T) resistive magnet that beat the records of the time—was built in-house and set into motion magnet-making dominance at the MagLab. Fast forward 20 years, and now the National MagLab is home to 14 world-record magnet systems.

A new concept in bitter disk design developed a few months after the facility was dedicated changed the way resistive magnets are built. MagLab engineers discovered that modifications to the nearly 60-year-old disk design (such as elongating the cooling holes) could result in less stress on the magnet and better overall performance. Invented at the FSU headquarters, these patented “Florida bitter disks” continue to be used at most of the world’s high field magnet labs today.

These disks also became the foundation for the 45 T Guinness World Record magnet that came online in December 1999. The 45 T has produced important research on some of condensed matter physics’ most puzzling phenomena, including high-temperature superconductivity, the quantum Hall effect and Bose-Einstein condensation.

MEASURING UP

Thumbing through the program from the lab’s dedication written over 20 years ago is a remarkable measure of how far the National MagLab has come—the promises of

Brazil was the World Cup winner, a dozen eggs cost 86 cents and people everywhere were quoting Forrest Gump’s philosophy that “life is like a box of chocolates.”

1994 brought us the Lion King and the Sony Playstation, but in October, the scientific community turned to Tallahassee and the dedication of a new national science facility.
magnets that have been realized (and other magnet systems that couldn’t even be conceived of back then), of discoveries that have been made and of an interdisciplinary research community that has been built. The lab’s original 290,000-square-foot facility has expanded to nearly 600,000 square feet, and is now filled with not just world-record magnet systems, but research and office space for hundreds of highly experienced scientists and technicians.

Labs from around the world now call on the National High Magnetic Field Laboratory to construct one-of-a-kind magnet systems, like the 26 T series connected hybrid magnet used for neutron scattering at Helmholtz Zentrum Berlin in October 2014. MagLab engineers have also built magnets for labs in Japan, France, the Netherlands and Australia.

And perhaps the most important measure of progress is the growth from dozens of users in the lab’s first year, to thousands of users from around the world this past year. After traveling to one of the lab’s three sites to conduct research on materials, energy and life, MagLab users are publishing over 450 articles each year in peer-reviewed scientific and engineering journals.

**Forward Thinking**

This year, on the 20th anniversary of that original dedication, the MagLab is celebrating its impact on science and renewing its promise to continue operating as a hub of discovery. The lab has launched a new look and a yearlong campaign — “Moving Science Forward” — that showcases its impact on researchers, educators, students, our state, country and the world. The lab kicked off “Moving Science Forward” during the 2014 User Committee Meeting in early October, an especially fitting time considering the lab’s strong focus on users.

“The MagLab has been built around its user community from the very beginning,” said Greg Boebinger, the MagLab’s director since 2004. “These are our lab’s scientific pioneers, the people who make the trailblazing discoveries that shape the future.”

A commemorative video featuring footage of the original dedication event (now available on the lab’s YouTube channel – www.youtube.com/uuidml) was released during the User Committee Meeting along with student design boards from a unique partnership with FSU’s College of Fine Arts. Working with two classes – one led by Disney Imagineer and FSU Entrepreneur in Residence Mk Haley, and the other part of FSU’s Interior Design Department – fine arts students joined forces with scientists from the Maglab to craft a fun, educational space for all that teaches about electricity and magnetism. Their semester-long efforts proposed hands-on exhibits and its application to quantum computing.

- New states of matter have been discovered in graphene through the application of high magnetic fields, including room-temperature quantum Hall effect, fractional quantum Hall effect and fractal energy states.
- Breakthroughs in applied superconductivity, for example, the changes in Bi-2212 when pressurized enable the creation of new magnets.
- Imaging sodium to study cancer, stroke, migraines and traumatic brain injuries.
- Exciting electrons in magnetic resonance spin work and its application to quantum computing.
- Work on other 2D materials beyond graphene like topological insulators or oxide interfaces, that provide new environments or unusual collective electronic behaviors.

**REACHING OUT**

October 1994 was also the public’s first peek at the lab and the very beginning,” said Greg Boebinger, the MagLab’s director since 2004. “These are our lab’s scientific pioneers, the people who make the Trailblazing discoveries that shape the future.”

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Boebinger was pleased with the work. “The quality of this student work has been impressive and speaks to my strong personal interest in the interplay between art and science.”

**EXPANDING ONLINE**

Beyond this design partnership, a new website launched in January offers visitors more hands-on opportunities to engage with the lab, this time from the comfort of their mobile devices. The site features more science content, a revamped education section and a modern, mobile-friendly look that better showcases the lab’s instruments, research output and expertise, all at the tap of a finger.

“When we gave our User Committee an early look at the site in October, they were very excited about the new user support features,” Boebinger recalled. “Tools like comprehensive magnet and technique searches, links to published papers on existing techniques and information on various sample environments are very exciting for bringing in first-time users.”

But not all of the new website’s features are for scientists. A section dubbed “Magnet Academy” offers students, teachers and other curious adults the opportunity to explore electricity and magnetism. Demonstrations, videos, interactive tutorials and activities answer questions about magnetism. Visitors can select content catered to their specific learning style and teachers can search for lessons and other activities by topic, age or grade level.

“We know that teachers are asked to do so much in the classroom,” said Carlos Villa, the lab’s K-12 education coordinator. “This site gives teachers the tools they need to feature electricity and magnetism in their science classes in an engaging way that their students will enjoy.”

Coupled with this new website, the MagLab is also expanding its overall online presence further into the social sphere. The lab has long been active on Facebook, Twitter and YouTube, but new accounts on Pinterest, Flickr, Instagram and LinkedIn offer even more opportunities to engage with the lab and stay on top of new research, jobs and events.

**TIME FOR A FACELIFT**

At the center of the new website, campaign and design collaboration is an updated, modern look for the 20-year-old lab. A new logo – a vector arrow above the letter M – is the scientific symbol for magnetization, or what happens to a material inside a magnet. The image is rooted in high-level magnet science, but is also cool and accessible to the lab’s layperson fans.

“There were many early sketches of coils and field lines, but ultimately, this choice offered a unique and graphic visual symbol for our lab,” said Boebinger who was actively involved in the design process.

The color palate for the lab’s new brand is also inspired by science: the electromagnetic spectrum of light – from infrared to ultraviolet – grounded by a strong, metallic gray. Even the short animation that introduces online videos and tutorials is built using the real sound of the 100 T pulsed magnet.

In the coming months, the lab plans to release other pieces of this campaign, including an economic impact report showcasing the value of the lab.

But the lab isn’t merely celebrating the past; it is looking ahead to a strong future as well. What new discoveries will be made at the lab in the coming years?

**The future is the most difficult thing to predict,” Boebinger said, “and the frontiers for high field research are ever accelerating. We are developing new science drivers with our users and prioritizing the resulting research programs for new magnet systems and measurement techniques. All of this balanced with a need to maintain our world-leading facilities in service to the ever-expanding demands for magnet time from our user community.**

The lab is building a laundry list of new magnets to continue serving both the user program and in-house research efforts.

In 2015, the MagLab is slated to complete a 36 tesla series connected hybrid magnet that will break the record for field homogeneity. This new magnet will enable new science with a magnetic field that is both very high and very stable, offering much more cost effectively than comparable magnets.

- The following year, a 32 T all-superconducting magnet will become the world’s most powerful superconducting magnet.
- The cleverly named “Platyplus” will be a high-field, high-homogeneity magnet built from Bi-2212 round wire. It is known as “a first mammal in the age of NMR dinosaurs.”
- A forthcoming 28 megawatt magnet will also offer very high fields of around 40 T while using much less power.

Twenty years after opening, there is new terrain ahead and pioneers are always welcome. *by Kristin Roberts*
In October 1994, the National High Magnetic Field Laboratory was dedicated. Vice President Al Gore delivered the keynote speech and the lab held its first Open House, which has become a popular annual event. Here are 20 monumental moments that have occurred since:

- **FLORIDA BITTER**
  - The MagLab's first world record, which resulted from the invention of "Florida Bitter" magnet technology, becomes the foundation for future resistive magnets built both at the National MagLab and other magnet labs around the world.

- **MAGNETS IN SPACE**
  - MagLab engineers complete a resistive magnet for use on the International Space Station.

- **LANDMARK EMR RESEARCH**
  - Research shows the value of high magnetic fields in the study of single molecule magnets, which do not give a signal at low frequencies due to zero-field energy level splittings.

- **TEACHER TRAINING**
  - Research Experiences for Teachers program debuts, partnering educators with MagLab scientists.

- **WORLD'S STRONGEST MAGNET**
  - The world's strongest magnet – 60 t Controlled Waveform

- **MAY 2000**
  - A new approach for characterizing the three dimensional structures of membrane proteins was discovered. The approach is based on the unique pattern of signals displayed in nuclear magnetic resonance (NMR) spectra.

- **JUNE 2004**
  - World-unique magnet opens at Pulsed Field Facility offering users the chance to specify the magnetic field profile optimized for the investigation of physics in very high magnetic fields.

- **JULY 2004**
  - 900 MHz Ultra Wide Bore NMR Magnet comes online. This 21.1 tesla superconducting magnet is the strongest MRI scanner in the world.

- **DEC 1999**
  - The world's strongest magnet – 60 tesla hybrid – reaches full field and is commissioned for user service, earning a certification from the Guinness Book of World Records.

- **MAY 2005**
  - A microscopy technique pioneered with the help of the National MagLab leads to the development of a new microscope able to distinguish individual molecules. Eric Betzig was awarded the 2014 Nobel Prize in Chemistry for development of PALM.

- **AUG 2005**
  - The first observation of the quantum Hall effect, a quantum phenomenon, made clearly visible in graphene at room temperature using the 45 tesla hybrid.

- **NOV 2005**
  - MagLab tops 1,000 users for the year! They come from around the world to perform research at the lab.

- **SEPT 2006**
  - The MagLab and industry partner SuperPower collaborate to set a new world record for magnetic field created by a superconducting coil: 26.8 tesla. Built with YBCO, this triggers the launch of the 32 tesla all superconducting magnet project that will be completed in 2016.

- **SEP 2010**
  - MagLab researchers at the Pulsed Field Facility set a new world record of 100.75 tesla using a multi-shot magnet, the highest field ever achieved without destroying the magnet.

- **JUNE 2017**
  - MagLab tops 2,000 users for the year! They come from around the world to perform research at the lab.

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Florida State University (FSU) students collaborated with MagLab staff this fall and winter to reimagine the 20-year-old lab’s public spaces. The interior design students’ biggest challenge: Redo the lab’s lobby, reception area and café—a 5,600-square-foot space where visitors gather for tours and researchers collaborate over coffee.

For years, the lobby walls featured a dated timeline and a photo of the brilliant, quirky inventor Nikola Tesla. The lab wanted something more interactive and fun, but something that still maintained the gravitas befitting a renowned national lab. With the most admired interior design program in the country at FSU, why look anywhere else for a design project?

For two decades, Mk Haley has created top-of-the-line, museum-quality exhibits as an “Imagineer” at Disney. For this first-ever MagLab/design school collaboration, she joined the FSU faculty as an entrepreneur in residence and taught “Innovation and Advocacy for the National High Magnetic Field Laboratory”—better known as “the MagLab class”—to the 13-advanced art and design students enrolled in it.

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On the first day, after a brainstorming session, the students spread out with markers and tape and began to sketch ideas for the space. They had to serve sometimes competing goals: to represent the lab’s mission and the science behind the experiments. They had to make high-impact, hands-on educational exhibits. They had to create an engaging and interactive public experience. They had to sort through all the ideas we had, and figuring out which would be the most successful.

The students’ designs added creative features to the lab including pop-out meeting tables along the lobby’s main staircase, futuristic furniture, individual and group meeting areas, decorative geometric designs and vectors, beautiful wood paneling and outdoor seating.

The students worked incredibly hard,” said Haley. “I’m very impressed with them and what they’ve done. They’ve created the kind of exhibits that guests at the lab will want to interact with and entice them to learn more about what you can do with big, powerful magnets. That was our design goal: We wanted visitors to the MagLab to leave with a sense of wonder and a greater interest in science.”

“I was impressed with the students’ enthusiasm and excitement at the outset,” said MagLab Director Greg Boebinger, “as well as the ideas and the exhibits they produced.”

For the next few months, he added, the lab will continue to evaluate where to go next with the prototype exhibits and the three major lobby redesigns.

“Stay tuned!”

STUDENTs MAKE OVER LAB’S PUBLIC SPACE

Move over Project Runway – Project MagLab has arrived.

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She began by opening her young designers’ minds to a new world of possibilities. She took them to her home turf where some of the best interactive exhibits are produced: Walt Disney World in Orlando.

“We got some amazing behind-the-scenes advice on how to make high-impact, hands-on educational exhibits,” said FSU doctoral art-education student Samuel Rosenzweig, who helped create one of the prototype exhibits. “This has been the most incredible experience I’ve ever had.”

Charrette, anyone?

The first stage of Project MagLab was a large-scale design charrette: a design workshop that engaged students from the entire interior design department to create a reimagined look for the MagLab’s atrium lobby/reception/cafeteria space and main tour stops. Their designs had to serve sometimes competing goals: of encouraging scientific collaboration, while also providing an engaging and interactive public experience.

Working in teams of four or five the 114 students had less than a week to create their design and post it in the same area of the lobby where the timeline had hung. Some featured miniature three-dimensional models. All incorporated the MagLab’s new logo—a “M” with a vector above it—and many featured the MagLab’s main logo color: purple.

“One of the hardest things for these students was the teamwork,” said Steven Webber, an interior design assistant professor. “But they loved having the MagLab as their client.”

Tony Purvis, a visiting FSU assistant professor in the Department of Interior Design, agreed.

“I don’t think a single student who worked on this project really had any kind of hard science background,” he said, “but they really enjoyed the science aspect of it.”

Get Science!

For many of the young designers, Project MagLab was a mind-expanding experience.

“I never thought that there were magnets like this, on this kind of big scale,” 20-year-old Madison Campbell said.

“It was very overwhelming to just walk through here,” 19-year-old Madie Hogue agreed.

“Just the sheer scale of the building and how it’s separated into these different sections, that was hard to comprehend at first,” said Gabriel L’Heureux.

“We’ve never done anything on this kind of scale before,” said Sasha Pussey.

But after the students toured the lab several times and spoke with staff and scientists, they grew more accustomed to the space. They held brainstorming sessions on how to best communicate the lab’s mission and the science behind the experiments.

“We tried very hard to engage visitors and expose them to the scope of the work that’s being done here,” senior Jeremy Sackler said of his team’s redesign, Due North. “The hardest part was sorting through all the ideas we had, and figuring out which would be the most successful.”

The exhibit prototypes

After the charrette was over, MagLab staff, users and visitors voted on the designs. Awards were presented and most of the students moved on to other projects, but about 20 students continued with Project MagLab. Seven design graduate students culled the charrette redesigns to finalize three formal design proposals. Haley’s 13-advanced students worked to create six dynamic exhibits, drawing on some of the best ideas generated during the charrette.

The group working on building the prototypes started with 28 original ideas, instructor Haley said, and whittled them down to a top 10. Then the students focused on what was most feasible given their time frame and budget. Finally, they settled on six ideas.

In December, they came to the lab to unveil their work. Their prototype exhibits included:

- A tesla coil hooked up to a keyboard; the coil creates music through heat and pressure. During its demonstration, sounds boomed from the lab’s lobby, luring curious staff from their labs and offices.
- Jars of black, goopy ferrofluid (liquids that become magnetized in the presence of a magnetic field) demonstrate a magnet’s effect on materials. Visitors use magnets of varying strength to create temporary sculptures.
- A wind tunnel that uses air as a metaphor to demonstrate magnetic field strength.
- Compasses for a magnetic scavenger hunt around the lab.
- Window clings to help explain magnetic resonance machines.
- A blue, goopy ferrofluid that changes color as it is magnetized.
- An electric guitar that a visitor can play, with sound-activated lights that explain aspects of electric currents and magnetic fields. The guitar display was inspired by an animation on the MagLab’s website: https://nationalmaglab.org/education/magnet-academy/watch-play/interactive-guitar-pickup
The official business hours of the National High Magnetic Field Laboratory are 8 a.m. to 5 p.m., Monday through Friday.

But the official science hours are 24/7.

Every evening, administrators, technicians and other staff at the MagLab’s three sites head home after a long day in the office, workshop or lab. But because our unique facilities are in such high demand, our magnets are almost always open for business.

So no matter the day of the week, no matter the time of night, there are always scientists running experiments at the lab.

However, our DC Field Facility, home to the largest number of our magnets, sees the most foot traffic. The 75,000-square-foot area includes several superconducting magnets that operate continuously. Where the magnets work around the clock, so do the scientists. If you pass by one of those instruments in the early hours of the morning, says DC Field Facility Director Tim Murphy, “...there is a 98 percent chance you’ll see someone sitting in a chair taking data, trying desperately to stay awake.”

But it’s not unusual for them to spend twice that time in the magnet “cell” – the 750-square-foot space where the magnet and related electronics, cryogenics and sample prep tables are located – preparing or reviewing data.

The DC Field Facility is a cold, creaky, cavernous place, its pipes rushing with water and busbars buzzing with current. According to control room operator Joseph Petty, making rounds during the lonely late shift is like a mall cop patrolling at midnight. “You have this huge building and empty hallways,” says Petty. “You’re hoping you’re not going to find a surprise around the corner.”

For user Wei Pan, burning the midnight oil at the lab isn’t creepy – it’s peaceful and productive. He takes advantage of the solitude by talking to himself about his experiment, which he describes as “a once-a-year kind of thing for many of our users,” notes Dan Freeman, part of the team who operates the world-record 45 tesla, 45 tesla hybrid magnet. Users don’t want to blow it.

“The stakes can seem especially high for users of the 45 tesla, the lab’s most in-demand magnet. Operating this powerhouse, Dan Freeman, part of the team who operates the world-record 45 tesla hybrid magnet. Users don’t want to blow it.

“Running experiments in the hybrid is very tiring,” says Murphy. “Resistance in the jetlag is suffered by many far-flung scientists and the fatigue is even greater. “By the end of the week, the users are exhausted. We try to tell first-timers up front, but they usually have to learn the hard way.”

Every morning, a hybrid operator reports to work at 5 a.m. to ramp up the magnet – often to find users waiting to start the day’s experiment. Staffers have even had to rouse a scientist sacked out on the floor in a sleeping bag. Although the hybrid stops running at 6 p.m. every evening, researchers are often up late preparing for the next day of magnet time.

Elsewhere in the DC Field Facility, scientists using one of the powerful resistive magnets are also sometimes found slumbered over a desk in the dead of night like a student cramming for a final exam. Users closely monitor experiments from start to finish: Depending on their data, they may want to make on-the-fly adjustments to the temperature, pressure, magnetic field or the sample’s angle within that field.

After all, most DC Field Facility users have just a week to conduct their experiments. Then it’s time to pack up and make way for the next scientist. So they cram as much work as possible into those few days, laboring toward that holy grail of science, publishable data. Forgoing luxuries like sleep is a small price to pay for such a prize.

Wei Pan, a physicist from Sandia National Laboratory who uses the lab’s superconducting magnets to study the quantum Hall effect, feels the pressure during his visits. Mindful that his experiment was selected over competing proposals, he tries to use his limited time wisely so that he will have something to show for it.

“This is a very unique facility,” says Pan. “It’s only one week. You want to get as much data as you can.”

Getting “magnet time” at the MagLab is a big deal for scientists. They apply months in advance, describing the planned experiment and arguing why it’s more compelling than competing proposals. If their request is successful, they spend weeks before their arrival preparing their instrumentation and samples.

“It’s a once-in-a-year kind of thing for many of our users,” notes Dan Freeman, part of the team who operates the world-record 45 tesla hybrid magnet. Users don’t want to blow it.

Best, though, is when the hard work, long nights, jet lag and time away from family and job all pay off with exciting data that adds something new to science. That, says Pan, “is like winning the lottery.” — by Kristen Coyne
In his 1928 treatise on the origins of ferromagnetism, Werner Heisenberg concluded that the presence of atoms with principal quantum number (PQN) \( > 3 \) was a fundamental requirement for magnetic order. The discovery of ferromagnetism in “light atom” organic radicals (PQN \( = 2 \)) appeared to violate this axiom, prompting parallels with the comment of Dr. Johnson on seeing a dog walk on its hind legs: “it is not done well, but you are surprised to find it done at all.” Unfortunately, the ordering temperatures and coercivities (ability to withstand external demagnetizing influences) of these light atom materials are low. However, recent synthetic efforts have afforded “heavy atom” organic radicals, spin-\( \frac{3}{2} \) molecular species containing heavy elements (S, Se, PQN \( = 3, 4 \)), which display magnetic properties once considered exclusive to conventional metal-based magnets. In essence, Heisenberg was right: spin density on the heavy atoms (see figure) promotes increased isotropic and anisotropic exchange coupling between spins, mediated by spin-orbit interactions. These factors give rise to respectable ferromagnetic ordering temperatures and coercivities. MagLab users have employed a combination of ab-initio theory and a newly developed high-pressure, high-field ferromagnetic resonance (EMR) technique, which is uniquely sensitive to anisotropic magnetic interactions, to gain insights into the importance of spin-orbit coupling effects in a range of organic materials where this effect is usually considered to be small. The findings may be applicable to topics as diverse as spintronics, photovoltaics and topological spin phases.

Normal State Electronic Structure in Underdoped High-T\(_c\) Cuprates

One of the outstanding problems in high-temperature (high-T\(_c\)) superconductivity has been the identification of the normal state out of which superconductivity emerges in the mysterious underdoped regime, called the "pseudogap" state. Knowledge of this normal state is thought to be essential for finding the origin of superconducting pairing in momentum space and for identifying the ground state whose instability enhances the pairing. The authors address this longstanding problem by mapping out the electronic structure of \( \text{Yb}_2\text{Cu}_3\)O\(_{6.25}\) in very high magnetic fields. Strong magnetic fields enable the normal state to be accessed by suppressing

Diamonds are a scientist’s best friend. They are, at least, if the scientist needs to put a sample of a material she is studying under a lot of pressure. Pressure is one of the parameters scientists play with at the National MagLab. Researchers come to put various materials into the powerful magnets, and then watch what happens to them when they are subjected to lasers, different temperatures, electrical currents or high pressure.

One way scientists compress materials is to put them in a little contraption called a diamond anvil cell (DAC). “They’re nothing more glamorous than a nutcracker,” says MagLab physicist Stan Tozer, who specializes in high-pressure experiments. Make that a nutcracker on steroids.

Many materials behave differently in different environments. Niobium-tin, niobium-titanium, for example, become superconducting at very low temperatures, which is why they are used to build superconducting magnets. These magnets need to sit in a bath of liquid helium to stay cold enough to operate.

Tozer’s characterization notwithstanding, diamond anvil cells are not only gorgeous, but a scientific gem in the MagLab’s jewelry box: Tozer also uses sapphire anvils for experiments at lower pressures and crushed rubies to measure pressure in the cells. The compound cerium-indium \( 3 \) (CeIn \( 3 \)) can also become part of condensed, metallic hydrogen. Also, water subjected to varying pressures up to \( 100 \text{ GPa} \) creates \( 10 \) different kinds of ice crystals. High pressures could potentially make cars more efficient, as well: Methane forms dense structures that, when squeezed, could allow us to store more energy in our vehicles.

Scientists have discovered many interesting things by compressing materials. Hydrogen, for example, turns metallic under very high pressure; in fact, Jupiter is believed to be made up in part of condensed, metallic hydrogen. Also, water subjected to varying pressures up to \( 100 \text{ GPa} \) creates \( 10 \) different kinds of ice crystals. High pressures could potentially make cars more efficient, as well: Methane forms dense structures that, when squeezed, could allow us to store more energy in our vehicles.

Most of the MagLab’s DACs, crafted in our machine shop, use a turnbuckle design devised by Tozer. As shown in the illustration above, two diamonds, encased in the turnbuckle body, face each other pointy side first. In the very tiny space between the points (polished to provide a small, flat surface) sits a gasket into which scientists place an even tinier sample – no wider than a human hair. When the system is closed and the turnbuckle is turned, the endcaps force the two diamonds toward each other, squeezing the devil out of whatever is sandwiched between them. All of this happens in a package smaller than your pinky.

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superconductivity. Fields approaching 100 tesla, in particular, enable comprehensive angle-resolved measurements of the Fermi surface to be made by way of quantum oscillations. By accessing a very broad range of angles, the authors arrive at a much clearer image of the normal state that might be driven by electronic interactions in topological materials. The observation of a clean metallic surface state is a milestone in the search for novel correlated bulk material that is a clean two-dimensional metal.

The induced AC polarization is strongly frequency dependent (figure at upper right) and gives clear indications of the phase transitions from the BG state to the BEC and Mott insulator states (phase diagram at right).

Magnetic Field Induced Polarization in a Bose Glass State
Liang Yin¹, Jian-sheng Xia¹, Vivien Zapf¹, Armando Paduan-Filho¹
1. University of Florida; 2. Los Alamos National Laboratory; 3. Universidade de Sao Paulo, Brazil
Funding Grants: G.S. Boebinger (NSF DMR-1157490); Lu Li (DOE DE-SC0008110, NSF eCCS-1307744); Z. Fisk (NSF DMR-0801253); G. Li, Z. Xiang, F. Yu, T. Asaba, B. Lawson, P. Cai, C. Tinsman, A. Berkley, S. Wolgaist, Y. S. Eo

Today’s electronics are a triumph of decades of research and development of metals and semiconductors. These electronics are well-described by freely-moving electrons that carry electrical signals independent of other electrons. By contrast, in correlated electronic materials, strong interactions usually slow the movement of electrons, tending to stabilize insulating behavior. Surprisingly, recent experiments at the MagLab show that a correlated topological insulator exhibits a conductive surface, becoming a very clean metal even though the bulk of the sample is insulating due to electron correlations.

MagLab visitors used the 4.5 T Hybrid magnet and the 20 T superconducting magnets to demonstrate the existence of this new type of clean metallic surface state in the correlated insulator, samarium hexaboride, SmB₆. The magnetic signal of the surface state was evidenced by the angular dependence of the torque on the samples that results from the application of an intense magnetic field. By using a special rotation probe (Fig. 1), the magnetization signal (Fig.2) is found to exhibit quantum oscillations whose angular and magnetic field dependences are characteristic of a clean two-dimensional metal.

The observation of a clean metallic surface state on a strongly correlated bulk material is a milestone in the search for novel behaviors that might be driven by electronic interactions in topological materials.

Crystal structure of DTN: Ni spins blue, Cleavagise planes green.

Citation: Magnetic Bose Glass in Br-doped NiCl₂-4SC(NH₂)₂: Magneto-electric Effect. L. Yin, J. S. Xia, V. Zapf, A. Paduan-Filho (unpublished).

For more science highlights, visit NationalMagLab.org/research and search by research area, initiative or facility.
Spooky Science
Around 200 people came to the lab’s Spooky Science event on Tuesday, October 28, 2014. Students of all ages participated in microscopy activities, tested the tesla coil and had tours of the lab before the main attraction – the Spooky Science Show. Led by the MagLab’s Center for Integrating Research and Learning, the event gave students had the chance to conduct experiments and understand the science behind things like glow sticks and goo.

Dwight Rickel, a founding member of the MagLab's Pulsed Field Facility, is retiring in April. He will be missed.

Postdoctoral Fellowship
The MagLab is seeking applicants for the Jack E. Crow Postdoctoral Fellowship. Named after the founding director of the lab before the main attraction – the Spooky Science Show. Led by the MagLab’s Center for Integrating Research and Learning, the event gave students had the chance to conduct experiments and understand the science behind things like glow sticks and goo.

Lee Osheroff Richardson Science Prize
Oxford Instruments is delighted to announce the winner of the 2015 Lee Osheroff Richardson Science Prize for North America – Dr. Cory Dean, Assistant Professor, Department of Physics of Columbia University.

FSU Postdoc Scholars
The 2014 FSU Postdoctoral Scholars Award recipients were announced at a symposium in September. Huuan Chen, Yan Li, Peter Morton and Nihar Pradhan were recognized with Career Development Travel Awards. Two students were also recognized with Poster Awards: Peter Morton (Earth Ocean and Atmospheric Science, MagLab) and Nihar Pradhan (Physics, MagLab).

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Oxford Instruments is delighted to announce the winner of the 2015 Lee Osheroff Richardson Science Prize for North America – Dr. Cory Dean, Assistant Professor, Department of Physics of Columbia University.

Dean is recognized for his definitive measurement of the Hofstadter butterfly, a butterfly-shaped fractal energy spectrum that emerges when 2D electrons are subjected simultaneously to both a spatially periodic electric potential and a transverse magnetic field. By combining novel techniques in nanoscale fabrication of graphene-based devices with ultra high magnetic fields at the National MagLab, Dean’s research provides the first experimental verification of this nearly 40-year-old problem.

Dean was presented with the prize at the Oxford Instruments ‘Socialize with Science’ event at the 2015 APS March Meeting in San Antonio, Texas, USA.

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NAI Fellow Status
Election to NAI fellow status is a high professional distinction conferred on academic inventors who have demonstrated a prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development and the welfare of society.

For the second time in two years, a physicist associated with the MagLab has won the prestigious Oliver E. Buckley Condensed Matter Physics Prize. Arthur Hebard, MagLab-affiliated faculty at the University of Florida, was awarded for “discovery and pioneering investigations of the superconductor-insulator transition, a paradigm for quantum phase transitions.” Last year’s Buckley Prize winner, Philip Kim, is also a frequent National MagLab user in the DC Field Facility and a member of the lab’s External Advisory Committee. He was honored for his work discovering unconventional electronic properties of graphene.

Humboldt Award
Paul Canfield, a frequent user in the DC Field Facility, has won the prestigious Humboldt award. This award recognizes Canfield’s achievements over his career. Canfield will use the award to continue his research with collaborators in Germany.

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Global High Magnetic Field Forum

Director Greg Boebinger was selected as the first president of a new Global High Magnetic Field Forum (HiFF). The HiFF aims to bring together relevant world expertise on the operation of facilities dedicated to the generation of the highest magnetic fields for scientific research. This consortium of high magnetic field laboratories in China, France, Germany, Japan, Netherlands and the United States will work to stimulate worldwide activities promoting scientific research and technology development using the highest magnetic fields. A first meeting was held in November 2014, and future meetings are planned for 2015 to continue performing this important work.

EAS Award

Tim Cross, director of the MagLab’s NMR/MRI user facility, was recognized with the 2015 EAS Award for outstanding achievements in nuclear magnetic resonance.

HONORS & AWARDS

Applied Superconductivity Conference

Maxime Mantras, Chris Segal, and Charlie Sanabria were recognized for the Best Student Paper.

Peter J. Lee is the 2014 winner of the IEEE Dr. James Wong Award for Continuing and Significant Contributions to Applied Superconductor Materials Technology. This newly established award recognizes Lee’s achievements and outstanding technical contributions in the field, his novel and innovative concepts and theories, and the authorship or co-authorship of many publications of major significance to the field of applied superconductor materials technology.

The Roger W. Boom Award was presented to Dr. Danko van der Laan, president, Advanced Conductor Technologies and MagLab user. The award honors van der Laan for his work on Conductor-on-Round-Core (CORC) cable implantation of a coated conductor, which he then moved to an industrial scale at his own company, Advanced Conductor Technologies, developing cables for high-field magnets and high-density power transmission. Van der Laan has worked with the MagLab’s magnet science and technology department extensively over the years and was also a graduate student at the MagLab.

American Association for the Advancement of Science

Director Greg Boebinger is the chair-elect of the physics section of American Association for the Advancement of Science (AAAS). His term began in February 2015.

David C. Larbalestier has been elected fellow of the American Association for the Advancement of Science (AAAS) for “advancing our understanding of the materials science of high-field superconductors and for developing processing techniques that incorporate this knowledge.”

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