NHMFL User Committee Report 2023

Chair: Nicholas Butch (NIST & University of Maryland)

DC/Pulsed/High B/T Vice-Chair: Brad Ramshaw (Cornell University)

NMR/MRI/ICR/EMR Vice-Chair: Franklin Leach (University of Georgia)

DC/High B/T Committee: Nathanael Fortune (Executive Committee Member, Smith College), Jia (Leo) Li (Brown University), Johannes Pollanen (Michigan State University), Sufei Shi (Rensselaer Polytechnic Institute), Raivo Stern (Executive Committee Member, National Institute of Chemical Physics and Biophysics, Estonia), Fazel Tafti (Boston College), Sergei Zvyagin (Dresden High Magnetic Field Laboratory, Germany), Sanfeng Wu (Princeton University), Daniel Rhodes (University of Wisconsin – Madison)

PFF Committee: Nicholas Butch (Executive Committee Member, NIST & University of Maryland), Joseph Checkelsky (Massachusetts Institute of Technology), Paul Goddard (University of Warwick, UK), Michihiro Hirata (Los Alamos National Laboratory), Rongyin Jin (University of South Carolina), Minhyea Lee (University of Colorado Boulder), Lu Li (University of Michigan), Brad Ramshaw (Executive Committee Member, Cornell University), Sheng Ran (Washington University in St. Louis)

NMR/MRI Committee: Vipin Agarwal (Tata Institute of Fundamental Research), Claudia Avalos (New York University), Galia Debelouchina (Executive Committee Member, University of California San Diego), Shella Keilholz (Executive Committee Member, Emory University/Georgia Tech), Danielle Laurencin (Institut Charles Gerhardt de Montpellier), Lothar Schad (Medical Faculty Mannheim), Sonia Waiczies (Max Delbrück Center for Molecular Medicine in the Helmholtz Association), Tuo Wang (Louisiana State University), Jun Xu (National Center for Magnetic Resonance in Wuhan)

EMR Committee: Alina Bienko (University of Wroclaw), Selvan Demir (Executive Committee Member, Michigan State University), Carole Duboc (Universite Grenoble Alpes, France), Sandrine Heutz (Imperial College, UK), Effie Kisgeropoulos (National Renewable Energy Laboratory), Muralee Murugesu (University of Ottawa), Troy Stich (Wake Forest University), Joshua Telser (Roosevelt University)

ICR Committee: Nathalie Agar (Executive Committee Member, Harvard University), Caroline DeHard (Frederick National Laboratory for Cancer Research), Facundo Fernández (Georgia Institute of Technology), Ryan Julian (University of California Riverside), Franklin Leach (Executive Committee Member, University of Georgia), Patricia Medeiros (University of Georgia), Mike Senko (Thermo Fisher Scientific), Caitlin Tressler (Johns Hopkins University School of Medicine), Robert Young (New Mexico State University)

(1) Executive summary and general comments

The User Committee (UC) is pleased overall with the National High Magnetic Field Laboratory (MagLab)'s performance and return to pre-pandemic levels of operation. The MagLab maintains its leading position as the provider of high magnetic fields to a broad research community that impacts a broad swath of scientific disciplines. We thank the NSF and institutional partners for their continued support and commitment to

maintaining the excellence of the MagLab. Here we provide a summary of important points that affect the whole MagLab. Facility-specific discussions are in the following sections.

Director Search: The UC thanks Dr. Gregory Boebinger for his many years of leadership and vision, and for guiding the MagLab to its current leading position. We look forward to similar strong levels of engagement and interaction with the new MagLab director when one is appointed. We look forward to discussing user priorities with each director candidate during the ongoing search.

Looking forward, we anticipate that there will be additional changes in facility leadership in the near future. We encourage more discussion of leadership succession plans at various MagLab facilities, hope for continued transparency in future selections, and hope to remain engaged in relevant discussions.

Condition Assessment: The UC appreciates the tremendous financial support that has been provided over the years for aging infrastructure and the work that the MagLab has put into repairing infrastructure. At the same time, we realize that much more support is badly needed for the MagLab to perform its national mission. We appreciate that the National Science Foundation (NSF) recognizes the great need for repair and replacement of large-ticket items. The NSF is at the forefront of advancing world-leading research capabilities and it would be a shame if US national high magnetic field science were to languish.

We are looking forward to the upcoming condition assessment scheduled for later this calendar year. The need is laboratory-wide, where old equipment approaches or is already at end of life. We recommend that future condition assessments be performed more frequently so that upkeep can be performed on a more routine basis. We also emphasize that only identifying problems is not enough; the financial support needs to follow. Failure to identify funding for current and future needs threatens the viability of the MagLab.

We also recognize a need for sustained funding for the development of new magnet technologies and magnet design. These activities are central to the upkeep of measurement capability and development of new technologies, but are typically supported by varying funding streams. Areas of concern include the development and procurement of conducting and superconducting materials for magnet production, and other bespoke components of the MagLab's unique equipment. Further, we encourage the extension of development efforts to magnet technologies needed by the resonance facilities.

Staffing: The UC is grateful to its university partners for offering cost of living adjustments to staff, but we remain concerned about staff retention. Across different facilities, there is still a need to recruit new talent to maintain current user support and development efforts.

Helium: The UC is pleased with and encourages the MagLab to continue their efforts at helium recovery.

We note that there is a great need for a new liquefier in Tallahassee.

Data: The UC is pleased that the MagLab is a leader in developing an open data framework. The UC is eager to know what the NSF's eventual requirements are and we encourage continued engagement between the NSF and the MagLab FAIR data team.

Housing: Limited and expensive housing availability in the vicinity of the MagLab sites continues to be a concern for many users, and the situation has only worsened recently. It is a particular financial strain for users with limited funding. The UC suggests that the best way to support democratization of magnet access is for the NSF to support travel to and housing during MagLab experiments, the costs of which continue to

increase to the point that it is now difficult to cover the costs of multiple experimental trips with a typical single-PI grant. This situation contrasts starkly with high-field experiments in Europe, where travel reimbursement is provided by the EMFL, and many user facilities have onsite lodging available. We note that guest houses are also available onsite at several US user facilities.

Future 30 T Magnets: The possibility of nationally-distributed 30T magnet facilities was raised again, and again we urge caution. The user committee supports expanding access to underserved scientific communities, also known as democratizing access. We insist that such a program cannot occur at the expense of existing MagLab funding.

It is not clear how the magnets would be used, how they would be supported, who the user base would be, or how these plans would achieve the goal of expanding access to high magnetic fields to underserved scientific communities. The user committee identified several concerns, such as whether lower field magnets in the range of 20T, which are an order of magnitude less expensive, would be more appropriate for a satellite facility, whether there would be sufficient funding for continued technical staffing and long-term maintenance, and how any satellite facilities would be related to the MagLab. A possible benefit of a lower-field laboratory would be to perform preliminary measurements before the typical higher-field work performed at the MagLab. We also discussed approaches to expanding magnet access through targeted outreach programs, which could help develop technical expertise where there currently is no user base.

Outreach and Access: The MagLab has several excellent and popular outreach programs including an RF coil building workshop, several winter/summer schools, and community outreach days. The committee recognizes those efforts and encourages the MagLab to consider additional funding avenues for training new PI and young scientist users. We discussed multiple approaches, some of which already exist and might be expanded upon: travel assistance or fellowships at the MagLab specifically for underserved scientific communities; summer-long internships for graduate students focused on building and developing instrumentation; and a MagLab small training grant for learning new techniques.

(2) Report of the DC Field and High B/T Facility User Advisory Committee

Overview: We thank the NSF and the representatives of three supporting institutions — Florida State University, University of Florida, and Los Alamos National Laboratories — for their continued support of the laboratory and its users. This support is essential to the success of our research.

Staffing: Experiments are more than magnets: specialized staff make the experiments using these high field magnets possible. They are the key step to expanding scientific capabilities and quality of data, user base, and democratization of access through expansion and training of the user base. We echo support for recent staff pay raises as a first step in restoring competitiveness of salaries and benefits.

Urgent needs (1 year horizon): We recommend repair of the 32 T SCM-4. There is overwhelming demand for this system's unique capabilities.

A second liquefier is needed to sustain operations of (most) systems and maintain non-interruptible He recover during necessary regular shutdowns of large primary liquefier for routine maintenance at DC. The

alternative is a significant loss of magnet time for experiments in cryogenic systems and/or an impairment in the lab He recovery rates at a time when an expansion in recovery rates is necessary.

We recommend replacement of the now-defunct clean power/standby power system for the B/T lab. The B/T lab's international leadership has depended upon its ability to provide a unique combination of exceptionally low electron temperatures and high magnetic fields; regaining that ability requires the use of new and functional clean power systems.

We recommend the expedited completion of projects for which funding has been allocated but which have encountered a variety of multi-year delays in implementation. We encourage a focus on timely coordination of vendor selection, contractor schedules, and magnet maintenance shutdowns at every stage, including ongoing updates to purchasing processes.

Important needs (5 year horizon): We recommend the deployment of a second high field superconducting magnet (40 T). This is a nationally identified priority. High demand for the existing 32 T demonstrates already that there is a need for a second magnet of this class.

We recommend replacement of the 30+ year old SCM-1 workhorse 18 T dil fridge with a 22 T dil fridge and field modulation coil. This remains the most heavily used magnet at the lab, demonstrating its continued value and importance.

We recommend a large bore 23 T magnet suitable for testing of cable and conductors for magnet lab users (especially growing number of industrial users) and critical in-house R&D needed to produce future high field magnets (pulsed field, resistive, and superconducting). For want of a nail, a kingdom can be lost.

Further comments: We encourage appropriate use of DRY systems and applaud creative plans for integration of compact demagnetization stages with these DRY fridge magnet systems. We encourage partnership with BlueFors should opportunities exist.

We encourage succession planning: B/T (and in fact all divisions) should develop plans, including identification of possible interim directors. There is concern that new, young hires should not end up with administrative responsibilities; may require a senior hire for this purpose.

Users prize improvements in reliability of all systems and building in plans for continuous improvement of systems once built. We encourage collaborations between B/T, DC, and pulsed for thermalization, improvements in RF screening and filtering, and data acquisition methods.

(3) Report of the Pulsed Field Facility User Advisory Committee

Overview: The UC acknowledges the hard work of the MagLab staff that has kept the PFF world-leading in terms of available fields and measurement techniques, experimental throughput, and scientific output over the last year.

We note that other institutes, including those with significantly higher funding levels than the NHMFL, are currently working on magnets with specifications that match or surpass those currently at NHMFL. Attention is needed from the NSF and the MagLab if the NHMFL-PFF is to remain the world-leader in the future. We consider the 1.4 GW LANL generator is a key part of the present and future position of the PFF

in the world standings and that every effort should be made to prioritize its return to service and future-proof the ancillary equipment and associated magnet design and development.

The UC appreciates efforts made to balance funding from NSF and other sources to maintain sufficient technical and scientific staff on the user program, but are very unhappy that shortfalls in the core NSF budget have led to a 20% reduction in magnet time.

Maintaining world-leading position: The UC is pleased to hear that the replacement process of the rotor for the LANL generator is on track. We appreciate that this is a complex, multifaceted project. We are actively looking forward to user operations in fields up to 100 T scheduled for 2025. We ask the PFF to contact the user community in advance of this to allow time for high-quality 100 T magnet time proposals to be developed.

The UC is very happy with the 75 T duplex and the 60 T mid-pulse magnets put in place to fill the gap left while generator-driven magnets are down. Also appreciated is the imminent addition of the 85 T duplex magnet and the new magnet cell to accommodate it.

We remain significantly concerned about the replacement of the aging magnet-power delivery controllers (known as PSRs). The UC sees this as an existential issue for the PFF user program. This issue is intimately tied to the NSF Conditional Assessment, which is a process the UC welcomes in order to identify and replace critical equipment, including the PSRs. However, we remain confused about exactly how the process is expected to evolve after the assessment has taken place and are worried that the timescale of this process will endanger the prompt and safe return of the generator-driven magnets to the user program.

Another major concern of the UC is the future availability of Cu:Nb high-strength conductor, which is currently a vital component of the PFF's highest field magnets. At present, the sole source of Cu:Nb is located in the Russian Federation. This situation provides a direct risk to NHMFL users' access to the world's highest fields. Moreover, several of the MagLab's competitor institutes retain access to this conductor, which endangers the MagLab's position as a world-leader in pulsed-field delivery. We appreciate that the PFF are aware of this situation and are taking steps to prioritize the remaining stock. However, the UC strongly believes that NSF should work with the MagLab and take urgent action to address this issue.

Additional matters: The UC encourages continued development of boundary-pushing experimental techniques and sample environments, including spectroscopy, current-controlled electronic transport and applied pressures across both low and high-pressure regimes. We are also pleased about the refurbishment and standardization of the 65 T short-pulse magnet cells.

We are happy that the FAIR data guiding principles are taken seriously by the PFF and their implementation is on the right track.

We appreciate that some of the LANL badging issues identified by users have been mitigated with the introduction of a badge office in Los Alamos town center, but would like to see greater transparency and for users to have the ability to check on the status of their badge application. We emphasize that it needs to be clearer whether students from particular countries will have their badges eventually approved.

The UC are happy that users can now access video conferencing on site at the PFF, which was requested at the last UC meeting. We believe that this will improve PI presence at LANL.

Finally we note once again that availability and cost of lodging in the Los Alamos area remains a concern for a great many users. By comparison, pulsed-field facilities in Europe and China frequently reimburse users for travel costs.

(4) Report of the NMR/MRI User Advisory Committee

Overview: We commend the ongoing and outstanding efforts of NMR/MRI staff for running a world-class users program and also pushing the boundaries of magnetic resonance technologies. Research and development in magnetic resonance technology is critical for the continued development of NMR and MRI as tools for fundamental science, and the MagLab leads the way. The instruments that the MagLab supports provide capabilities beyond those obtainable in a single PI's lab, and some are not available anywhere else in the world. Just as critically, they provide the infrastructure, support, expertise, and development that allow these instruments to be used in innovative and transformative ways. As one example of the synergy of the research approaches, the NMR/MRI program is in the rare position of having the capability to perform studies ranging from protein structure analysis to in vivo human research to spectroscopic imaging, facilitating novel biological insights. In addition, every year, the

NMR/MRI and AMRIS facilities organize a workshop on the design of RF probes, which is an important national training mechanism for the next generation of researchers. The NMR/MRI program will be offering its first Spring NMR School in May 2024, which is aimed at undergraduates from HBCUs, HSIs, and PUIs and junior graduate students – it is hoped that this will have a lasting impact on the dissemination of NMR/MRI knowledge to students throughout the country.

The NMR and MRI facilities continue to be in high demand and constitute an important resource for the nation, with all operating systems at or near their maximum capacity. The committee is impressed that some critical instrumentation issues were skillfully and promptly addressed over the past year, including the replacement of the 600 MHz DNP gyrotron tube and console, the system upgrade for the 750 MHz NMR/MRI/microimaging system, and the acquisition of an 850 MHz spectrometer to replace the quenched 830 MHz magnet, which has been a "workhorse" instrument for materials research. The 36 T Series Connected Hybrid (SCH) continues to be the highest field NMR magnet in the world, and the committee is excited about the improved stability and homogeneity, as well as the new probes, which will significantly expand the type of systems that can be analyzed on this system. The committee is also excited about the new low temperature DNP probes and the HTS probes for MRI, which have enabled new applications. The productivity of the user program remains excellent as demonstrated by the number and impact of publications. For example, the MagLab's 600 MHz DNP system alone currently accounts for 40% of all global publications on DNP platforms of 600 MHz or greater. Given the high utilization and strong outcomes from the NMR/MRI programs, it should be recognized that the U.S. is falling behind international competitors in the installation of high field NMR and MRI systems, and resources are needed if the MagLab is to maintain leadership in this area.

Funding: The NMR/MRI user committee is extremely concerned about the effects of the budget cuts imposed by NSF on the NMR/MRI and AMRIS user programs. These budget cuts are especially alarming since the U.S. is falling further behind European institutions, and will soon be outpaced by Asian institutions,

in the installation of high-field 28.2 T NMR platforms and high-field 18 T MRI systems. The MagLab continues to be an important resource for the nation and is at the leading edge of magnet technology; however, it is clear that without a strong commitment to invest in high-field NMR and MRI, the U.S. will no longer lead the world in NMR/MRI and magnet technologies.

We commend the NMR/MRI staff who have been extremely creative and diligent in identifying alternative sources of funding. Most recently, they have submitted two major RI-I proposals, one for an 800 MHz DNP NMR spectrometer, and a second one for a 28 T 1.2 GHz system for NMR (and potentially some MRI) applications, both of which are absolutely necessary for the US to remain competitive in high field NMR spectroscopy. The program receives funding from the NSF, NIH, as well as industrial sources and local users. However, there are limits to how much outside funding can be obtained without impacting the availability of the magnets for the user community. At the higher administrative levels in the NSF and NIH, and even among different directorates, there seems to be a lack of consensus about the funding 'home' for NMR and MRI technological development. This lack of clarity is a serious problem for the nation, given the accelerating international competition that threatens MagLab's position as the acknowledged leader in this area. Partly as a result of the combination of funding mechanisms and lack of a single source of support, some AMRIS facility magnets that were previously available to MagLab users on a part time basis are no longer available through the user facility and instead are operated entirely under a fee-for-service schedule.

The committee supports NSF's goal of democratizing access to high field NMR and MRI equipment but cautions that the success of such efforts requires building substantial local expertise and support, which is currently available at only a few sites in the US. To take maximal advantage of the cutting-edge probe technology and specialized institutional support available at the MagLab, the NMR/MRI user committee feels that this goal would be best reached by providing support for travel and lodging at the MagLab facilities. Such funding could be organized as travel grants provided to universities throughout the nation.

Condition Assessment: The NMR/MRI user committee is pleased that there will be a condition assessment soon. We support the replacement of the control room for the 21 T ultra-widebore MRI/NMR platform, which is currently the highest field MRI spectrometer in the world. One particular point of concern is the aging 11 T wide bore MRI system at AMRIS, which is unshielded and creates a fringe field that encompasses most of its wing. While MagLab has a vision for their pathway to NMR and MRI at higher fields, the market is dominated by a single manufacturer (Bruker) that limits choice of field and bore size. The magnet development team could play a valuable role in providing more flexible design if resources allow.

(5) Report of the EMR Facility User Advisory Committee

Overview: The user committee (UC) recognizes the continued productivity, sourcing of critical replacement equipment, and pursuit of excellent science by the EMR group. We note that the number of users has returned to 2019/pre-pandemic levels with a major increase in first-time users over the last few years.

The UC is excited by the addition of new and replacement staff and post-docs to the group over the last year. However, to assure the continued success of the EMR group, serve the growing biological user base, and replace the recently-retired Dr. Song, we encourage the addition of a staff member with expertise in biophysical/biomedical EPR. The UC also strongly suggests that the EMR group be proactive in identifying

and hiring personnel to be trained by any outgoing staff prior to their retirement. This is especially important as many of the NHMFL-constructed spectrometers are unique in the world.

It was fortunate that end-of-cycle funds could be used to replace aging superconducting magnets on two vital instruments, which alone contributed to 75% of the EMR group's publications last year. Similarly, the UC would like to congratulate EMR director Stephen Hill in obtaining funding (NSF MRI) for a new X-/Q-band commercial pulse EPR system that (i) helps lower pressures on demand; (ii) contributes to democratization of access to research by providing on-site rapid screening of samples and a means for underserved research programs to gain proof-of-principle data for proposals; (iii) provides a long-requested platform for integration with optical excitation for transient EPR.

The EMR UC is excited to learn the results of the conditional assessment. However, we are concerned that assets with replacement costs below $500k are not to be included, as multiple components critical to the continued function of EMR instruments fall within this price range. The UC encourages the NSF and the NHMFL to conceive of a mechanism for modestly expensive, but critical components to be replaced as needed to allow usage to proceed with minimal interruption.

Personnel: The UC continues to be highly impressed by the expertise and the dedication of the EMR staff and its director. They are critical for the success of the EMR program. The hiring last year of Thierry Dubroca and Tomas Orlando has helped to stabilize the DNP program, providing expertise that should persist for many years to come. The UC acknowledges and appreciates FSU, UF, and LANL for providing raises for faculty and staff. This will help the NHMFL recruit and retain personnel.

With Dr. Song's unexpected retirement, the UC recognized last year that a replacement would be needed in the near-term. The hiring of core-grant funded post-doctoral scholar Kavipriya Thangavel will help to stabilize the user support on the high-power pulsed W-band spectrometer (HiPER) instrument. However, a long-term staff position should be made available to support the burgeoning biological EPR user group. Ideally, this person would also be responsible for maintenance and operation of the pulse X-/Q-band EPR spectrometer to be acquired via NSF MRI funding (see above). The UC remains concerned that some administrative aspects of operation are being delegated to FSU graduate students. The UC recommends that the NHMFL hire administrative support for grant submission, rapid onboarding of new hires, and management for PIs in the EMR division. Further, Andrew Sapronetti's expanding duties within the NHMFL has spread him rather thin and presents complications for operation of the EMR program.

User Program: The UC is overall impressed by the ability of the EMR Facility to pursue impactful science (28 publications in 2022, 17 so far in 2023). These results are featured in the best possible journals (e.g., Nature, Science, J. Am. Chem. Soc., etc.). User survey results point to a sweeping majority of users being satisfied or extremely satisfied with their interactions with NHMFL staff. The UC is pleased to see expansion of the EMR group user base, as evidenced by the aforementioned increase in first-time users (35% of total in 2023), and that this has coincided with an increase in external users being on-site rather than sending their samples for analysis by NHMFL support staff and resources.

To continue growing the user base, the UC recommends the group to again host an EMR School. In-person is preferred, but a virtual or hybrid symposium may be a useful option. The UC commends EMR for hosting the Southeastern Magnetic Resonance Conference (SEMRC) in Tallahassee in November 2022. If the EMR

school in Tallahassee is not an option, the UC suggests possible integration with the EPR school operated through the Rocky Mountain Magnetic Resonance Conference, or other conferences where EMR spectroscopy is applicable, e.g. those related to bioinorganic chemistry, or the SEMRC.

Capabilities: The UC is relieved to hear about replacement of two vital superconducting magnets, one servicing the heterodyne transmission spectrometer and one for HiPER. The UC is also excited by the procurement of funds for the pulse X-/Q-band EPR spectrometer which includes a tunable OPO laser that has been requested by the UC for 5+ years. This new ability for optical excitation can be integrated with existing W-band and high-field instrumentation, further expanding the NHMFL capabilities.

The UC is very concerned about the inevitable upcoming failure of crucial, lower-cost (<$500k) components, for example, the investment in replacing the magnet of the workhorse homodyne transmission system would be lost if the front-end frequency multiplier chain were to fail and not be replaced/repaired. We recognize this requires planning and highly recommend consideration of central funding or funding mechanism for de-risking total instrument failure due to failure of these components.

(6) Report of the ICR User Advisory Committee

Overview: Overall, the ICR program continues to be a world leader in instrumental capabilities across a range of applications including biological and environmental analyses. The program maintains a diverse user portfolio, which is a testament to their outstanding outreach. In addition, the number of users and publications is consistent with years prior to the pandemic. Like the broader NHMFL User Committee, the ICR User Advisory Committee (ICR-UAC) thanks Greg Boebinger for his dedicated service as NHMFL director, and sincerely appreciates the institutional efforts made with respect to employee retention and recruitment through the first salary increases in 5 years. The ICR program will not maintain its world-leading status without talented leadership and staff. The ICR-UAC looks forward to the

NHMFL-wide Condition Assessment. The success of the program is very dependent on the continued operation of the instrumentation, with some components approaching 30 years of usage. The ICR-UAC also supports and values the idea of continuous R&D to keep the NHMFL at the leading edge of magnet science and technology, including with respect to the development of higher field resonance magnets. The ICR-UAC also appreciates the NSF Division of Chemistry's continued support of the ICR program.

Core operations: A major instrumentation initiative for the upgrade of both the 21 T and 15 T system front ends has commenced under a collaborative agreement with Thermo Fisher Scientific. This effort will modernize and enhance the overall performance of these two platforms in key performance metrics such as acquisition speed and sensitivity. Concurrently, the advanced software architecture of this platform will enable the progression towards a more user-friendly GUI for data acquisition. The replication of the front end across the two systems will enable overflow experiments to be conducted with similar methods on the 15 T and enable it to serve as a technology development platform for future implementation on the 21 T system.

The ICR biological applications program continues to make significant contributions to the field of top-down proteomics. These achievements include core participation in mapping the KRAS proteoform landscape in

colorectal cancer in collaboration with the National Cancer Institute and Northwestern University, resulting in 39 completely characterized proteoforms across 14 colorectal cancer cell lines and 34 primary colorectal tumor samples. The 21 T also provided the first identification of novel truncated KRAS4B proteoforms later observed in over half of the tumor samples and all mutation contexts analyzed, emphasizing the ability of this platform and the ICR User Program to accelerate key discoveries in cancer biology and therapeutic development.

The ICR program also continues to be a leader in the analyses of complex organic mixtures in environmental samples, including the detection of molecular formulae containing additional elements other than C, H, O, N, and S, such as organically bound copper and halogens. In addition, substantial advances have been achieved in the analyses of soil organic matter after prescribed fires and wildfires, the latter a current environmental problem. Unraveling changes in the composition of chemicals of societal concern after severe disasters contributes to the implementation of science-based management practices. The unique capabilities and expertise of the ICR program developing methods for the analysis of low concentrated carbon samples are allowing for a wider range of studies, such as those focused on ice and aerosols. The online LC system is already improving sample throughput and providing more molecular information to users.

Priority Recommendations: The program initiated in 2022 to replace the aging Velos Pro front ends for the 15T and 21T with more modern Eclipses will dramatically expand the performance and flexibility of the instruments. Phase 1, demonstrating feasibility is complete, and phase 2, which provides more complete functionality with unified computer control is underway using the 15T. Until phase 2 is complete, facility operations are limited to the Velos based 21T. Associated with the Eclipse upgrades, the MALDI imaging capabilities previously available on the Velos must be preserved. The ICR-UAC supports the conversion of the Spectroglyph source for compatibility with the Eclipse front ends. The ICR-UAC also supports the allocation of ICR funding to purchase an upgraded liquid chromatography system to complement the Eclipse front ends, as this will further enhance the overall performance of both instrument platforms and allow higher experimental throughput by providing new high-flow rapid separation modes.

To further expand capacity, and unburden the facility staff, the initial efforts to automate data acquisition, particularly for the environmental/complex mixture program, should be completed in a timely fashion. This will free up the valuable time of the staff to further improve the methods and capabilities of the facility. The award of a UCGP grant to fund PyC2MC has enabled the development of this open-source analysis package that will benefit the complex mixture community worldwide. PyC2MC will replace the petroleum-centric PetroOrg software that has been used for data analysis for over 10 years. New capabilities will improve usability, including chromatography support and new algorithms to help automate challenging analysis steps which previously required significant user experience. Critical to the success of this program is the identification of funding to continue the work past the UCGP 2-year period. It would also be beneficial to support the development of new tools to make FT-ICR MS data that is already accessible to the public more usable through user-friendly interfaces and APIs, particularly if their value could be demonstrated through a UCGP or other short-term grant. Users have expressed concern over the application of FAIR data principles to data from their experiments, so it would be beneficial to develop additional documentation to explain how these principles apply when magnet time is granted.

For the first 25 years of operation at the NHMFL, there was a fully capable electronics shop available on site to support the various scientific programs. This shop provided numerous benefits for the ICR program, given that the control of gas phase ions inherently requires sophisticated electronics to generate necessary electric fields. The electronics shop is now fully engaged in MagLab engineering projects that include support for new magnet systems and electrical infrastructure upgrades. The instrumentation development capabilities of the ICR program would improve if the electronics shop's support of the ICR program could be reestablished.

Finally, the ICR-UAC and the users that it represents would like to express their most sincere gratitude to Professor Alan Marshall for the establishment of the ICR program at the NHMFL 30 years ago, and his overall contributions to the ICR community for a half century. With his imminent retirement, we support the FSU chemistry department's search for a faculty member that can continue diverse investigations that further develop and exploit the capabilities of ICR. Having an academic group co-located with the user facility will allow a deeper understanding and appreciation of the technology for future leaders in the field of ICR. This academic group, including postdoctoral fellows and graduate students, would also help to unburden the facility staff, who are working diligently to upgrade the 15T and 21T front ends, but are also responsible for keeping the Velos based 21T available for user experiments, and for maintaining and repairing the 9.4T FT-ICR MS, which will continue to be used for direct infusion complex mixture analysis. If this search is delayed, then a postdoc hire at the user facility to focus on instrumentation would help to advance these competing goals.