

LABORATORY UPDATE for ALUMNI



November
2018



FRIB Project marks technical progress, meaningful collaborations, successful public open house in last quarter

by Thomas Glasmacher, FRIB Laboratory Director and FRIB Project Director

In July, we celebrated a major project milestone when FRIB accelerated its [first beams in three of forty-six superconducting cryomodules](#). This demonstrated for the first time that FRIB's major systems (front end, liquid helium plant, superconducting cryomodules) which were commissioned individually, work well together and can successfully accelerate beams of atomic particles.

Since then, we've marked another significant accomplishment with the first circulation of liquid-lithium film in the FRIB charge stripper. This signifies a new era in stripper development as FRIB is the first in the world to use liquid lithium as a charge stripper. Following the successful first circulation in August, in September FRIB completed a successful 50-hour continuous attended operation of the stripper. [Read the story below](#). We also report on several other technical developments in [remote-handling](#), [beam-instrumentation](#), and [magnet installation](#).

We were pleased to host the Nuclear Structure conference at NSCL and FRIB in August, followed by the [Low Energy Community Meeting](#), and look forward to the continued discussions and collaboration with the community. A whitepaper is being developed to summarize the exciting scientific opportunities of the primary beam energy upgrade to at least 400 MeV/u for all ions. Read more about the proposed upgrade [in the story below](#).

Also in August, the laboratory hosted another [successful public open house](#). FRIB and NSCL provided 4,000 tours during the six-hour open house, and participants enjoyed demonstrations and presentations. We are privileged to work in a publically-funded one-of-a-kind research facility and we were delighted to convey our excitement to members of the public, who pay us.

Additionally, we successfully concluded three high-level reviews since our last issue, with the [Accelerator Systems Advisory Committee](#) and [Experimental Systems Advisory Committee](#) reviews in October, and the [DOE-SC Office of Project Assessment review](#) of FRIB in November. In addition, the National Science Foundation conducted its yearly [site visit of NSCL](#) to evaluate progress.

Our [Advanced Studies Gateway at FRIB initiative](#) continues to expand, with several more events slated before year's end. Read about the [upcoming events below](#).

We continue pushing to the finish line of the FRIB Project and are transitioning the project team again, this time from construction to operations, focusing on FRIB availability and users doing successful experiments at FRIB while we operate NSCL and enable forefront research now. Thank you for your continued support.

Over 4,000 tour FRIB and NSCL during public open house



FRIB and NSCL provided 4,000 tours to members of the public during the open house on 18 August. (Photo credit: Thomas Baumann, NSCL)

FRIB and NSCL provided 4,000 tours to members of the public during the open house on 18 August.

The event included activities, demonstrations, presentations, and tours that allowed attendees to learn more about a world-leading science facility in operation (NSCL) and one in the making (FRIB).

The six-hour open house, made possible by 150 volunteers, offered an array of experiences for all ages. Tours were held in the currently operational experimental areas in NSCL that will be used in FRIB experiments, and visitors could tour the FRIB linear accelerator currently under construction.

Several hands-on activities and demonstrations showed the fields of FRIB and NSCL research, including a 3D model of the FRIB facility under construction, the ["Isotopolis" video game](#), coloring pages and activity sheets related to nuclear astrophysics, safety equipment to wear, magnetic marbles to practice "smashing nuclei," and much more. Additionally, scientists were on-hand to talk about their work on the frontiers of rare-isotope research, and several educational videos were shown in the "FRIB Theater."

In the lecture hall, speakers gave presentations that gave a behind-the-scenes look at the FRIB Laboratory, the science being explored, and career opportunities for young people.

For photos of the event, visit the [photo gallery](#) on the FRIB website.

Additionally, the open house received attention from a number of media outlets:

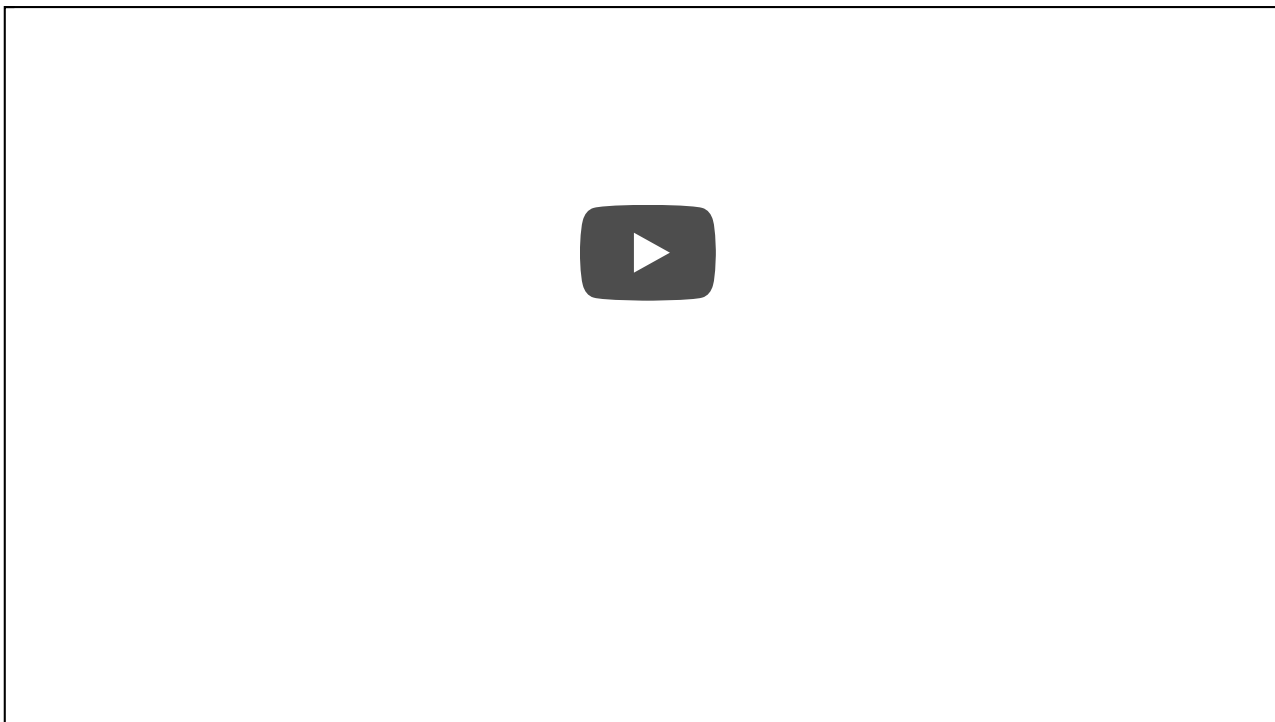
- WKAR: [Public tours at FRIB Saturday](#)
- East Lansing Info: [Facility for Rare Isotope Beams opens doors to the public this Saturday](#)
- 1929fm.com: [FRIB tours at MSU set for Saturday](#)
- Lansing State Journal: [MSU's FRIB holds open house](#)
- WILS 1320: [Interview with Artemis Spyrou](#)



The six-hour open house, made possible by 150 volunteers, offered an array of experiences. Several hands-on activities and demonstrations showed the fields of FRIB and NSCL research. Here, NSCL Student Research Assistant Gabriel Moreau is shown interacting with a visitor in the demonstration area. (Photo credit: Thomas Baumann, NSCL)

Special features from MSU highlight FRIB and NSCL

The Facility for Rare Isotope Beams (FRIB) at MSU



A new video (above) highlights FRIB from its conception to its future and features an animation showing how rare isotopes are created.

FRIB and NSCL are highlighted in several recent features from MSU.

[“Accelerating into the future”](#) features a video (shown above) that gives a high-level overview of FRIB, from its conception to its future.

[“Gaining ground”](#) is an article about how MSU’s growth brings new opportunities in research, education, and the arts. Included in the article is FRIB.

TECHNICAL INSTALLATIONS PROGRESS

Technical installation progress continues to advance at FRIB, with the project meeting new milestones on a regular basis. This article highlights significant progress since what was featured in our last issue in June.

FRIB accelerates first beams in three of forty-six superconducting cryomodules



As FRIB prepares for operation in 2021, several stages of commissioning (integrated testing of individual devices and beam commissioning of devices working together) are planned to demonstrate readiness of the different segments of the accelerator. Integrated testing examines the functionality of the system.

The Department of Energy Office of Science has established Key Performance Parameters (KPP) for project success, and this second stage of FRIB linear accelerator commissioning required acceleration of

On 11-12 July, the Facility for Rare Isotope Beams accelerated first beam in three of forty-six superconducting cryomodules (painted green). Beam in the warm radio-frequency quadrupole was previously accelerated in September 2017.

On 11-12 July, FRIB achieved a major project milestone by accelerating its first primary beams in three of forty-six superconducting cryomodules. This demonstrates that the major systems (front end, liquid helium plant, superconducting cryomodules) which were commissioned individually, work well together and can successfully accelerate beams of atomic particles.

Beams of argon and krypton were accelerated to the beam energy of 2 million electron-volts per nucleon (MeV/nucleon) required at project completion for the first three cryomodules.

The heart of FRIB is a high-power superconducting linear accelerator that will accelerate ion beams up to half the speed of light to strike a target, creating rare isotopes. The linear accelerator is made of cryomodules, which contain superconducting radio frequency (SRF) cavities that accelerate the beam while operating at temperatures a few degrees above absolute zero. Much like a heavy truck, heavy ion beams speed up slowly and the first three cryomodules accelerate the beam to 1 percent of 200 MeV/nucleon, the remaining 43 cryomodules will provide the other 99 percent of beam energy.



About 35 accelerator physicists and engineers worked together on 11-12 July to achieve first beam acceleration in the superconducting cryomodules. A temporary control room has been set up in a trailer, while the laboratory's main control room continues to operate the Coupled Cyclotron Facility at the National Superconducting Cyclotron Laboratory until FRIB is complete.

both argon and krypton beams up to 1.5 MeV/nucleon. While this commissioning period was scheduled for two weeks, about 35 physicists and engineers worked together and accelerated an argon beam to 2.01 MeV/nucleon in one day of commissioning. The next day, the krypton beam was accelerated to the same energy. The demonstrated beam energy is 30 percent higher than required by the KPPs and provides technical margin, which is important to ensure overall mission success in one-of-a-kind accelerators.

Each commissioning sequence is preceded by an extensive, several-day Accelerator Readiness Review (ARR) by experts external to FRIB and MSU to ensure technical readiness, team readiness, and safety system readiness. FRIB passed its first Accelerator Readiness Review (ARR01) in July 2017. Successful completion of ARR01 paved the way for ARR02 in May 2018, and the go-ahead to accelerate beam through the first three cryomodules. Following this successful demonstration of the KPPs, FRIB will spend an additional week characterizing the accelerator with beam, and then stop beam operation and continue technical installation activities for the remainder of the year.

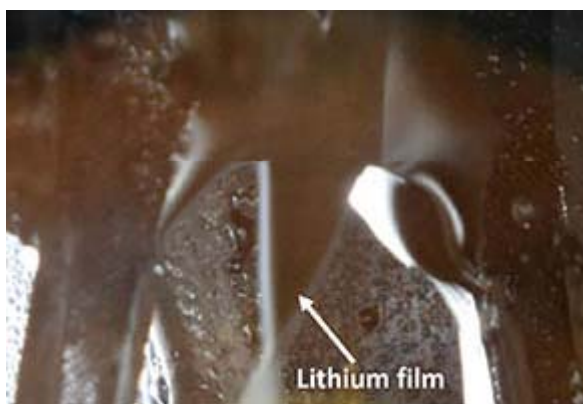
FRIB's next beam-commissioning milestone (ARR03) planned for spring 2019 will include the first 15 cryomodules and the first of two 180-degree bending sections of the accelerator.



The temporary control room is divided into multiple stations, each of which controls a set of devices. Each set of devices worked as designed and in proper coordination with each other to accelerate FRIB's first beams in three of forty-six superconducting cryomodules.

FRIB successfully circulates liquid lithium in charge stripper to establish lithium film; completes 50-hour continuous operations

This successful first circulation demonstrates that the system functions properly. It is a significant step toward future work on lithium stripper production.



Melted liquid lithium film as seen from a view port in the charge stripper.

On 3 August, FRIB successfully circulated liquid lithium and established a lithium film in its charge stripper. FRIB is the first in the world to use liquid lithium as a charge stripper, marking a new era in stripper development history.

The lithium charge stripper will play a critical role in the FRIB linear accelerator in order to achieve design-goal beam energies beyond 200 mega electron volt/nucleon (MeV/u) and beam power up to 400 kilowatts (kW).

New vision system augments remote-handling operations



A new vision system will allow remote-handling operators to view and record work taking place. The operator is sitting next to a control unit that allows for remote operating of a crane. The crane uses guides to direct the magnet in and out of the beam-accelerating cryomodule ([for more about the crane, read this article](#)).

During operation, the liquid lithium needs to be continuously circulated with a pump to produce the film. For this purpose, an electromagnetic pump was designed and fabricated based on original concepts developed by [Argonne National Laboratory](#).

All systems were properly designed and implemented to work concurrently. The circulation was successful due to the effort of mechanical and controls engineers.

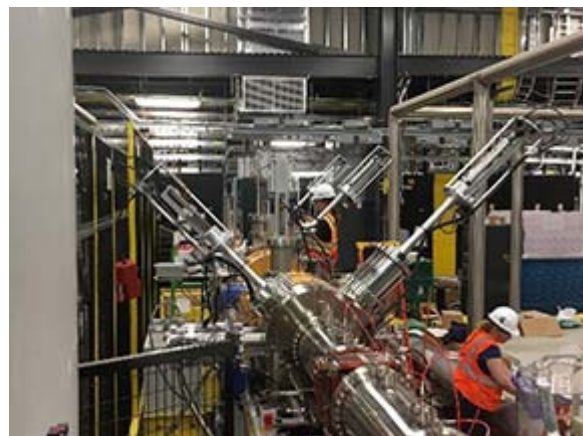
Following the first circulation in August, in September, the lithium charge stripper completed 50 hours of continuous attended operations with round-the-clock monitoring by trained operators. The stripper operated safely, reliably, and stably. The next step is to operate the system without direct supervision.

FRIB's remote-handling system allows maintenance on equipment difficult to handle in person. The remote-handling vision system permits FRIB staff to remotely conduct such maintenance.

The vision system is a collection of video cameras that can pan, tilt, and zoom as needed. The cameras can show multiple or single views and record the footage. The system lets the operator work from a separate room that contains the controls. The operator can remotely maneuver the crane to remove equipment from the beamline..

The design allows flexibility for alterations in the future. As operators train and the vision system is in use, FRIB can change it as needed.

FRIB successfully completes beam-instrumentation testing



As accelerator facilities like FRIB push the boundaries of energy and intensity, specialized and larger amounts of instrumentation aid in more rapidly understanding the behavior of particle beams.

A variety of devices and processes comprise beam instrumentation and each of the beam-instrumentation systems must work in concert with each other. FRIB's beam instrumentation is being commissioned in several stages. Final validation of the instrumentation

Engineers and technicians work to install beam instrumentation on the FRIB Lower Energy Beam Transport (LEBT) line.

Recently, FRIB successfully completed beam-instrumentation testing, which ensures the beam doesn't destroy the linear accelerator.

FRIB will deliver up to 400 kilowatts of high-intensity and high-quality beam power—the highest-power heavy-ion beam in the world.

FRIB completes repeatability testing for magnet installation



Using a remote-handling crane, a magnet is lowered into place during repeatability testing.

FRIB staff have successfully completed the repeatability testing for maintenance of the laboratory's magnets. Over 240 magnets of various types are used to focus and steer the beam as it is transported through the accelerator.

begins with beam commissioning. This began in early 2017 with the front end, and in summer 2018 with the linear accelerator. Only a few systems remain for beam testing, which will begin in 2019. As commissioning continues, each stage will enable improvements to measurement and detection capabilities as beam intensity is increased..

The magnets require careful handling and precise alignment, but they can't be handled in person once the linear accelerator is operational. To address this, FRIB has built a remote-handling system to access the magnets easily.

The repeatability testing proves that the magnets can be removed from and replaced back to the same spot each time. The magnet alignment ensures FRIB will be able to deliver rare isotopes. The system built for removal consists of a kinematic coupler to hold the magnet stationary. A crane uses guides to direct the magnet in and out of the fragment separator vacuum vessel. The system is able to place the magnets within 75 to 100 microns (ten times thinner than the width of a driver's license) of their location.

Former NSCL graduate student awarded 2019 Tom W. Bonner Prize in Nuclear Physics



Jacak received her PhD from MSU for her research at NSCL in 1984 working under the supervision of University Distinguished Professor of Physics Gary Westfall. Her thesis was entitled "Fragment Production in Intermediate Energy Heavy Ion Reactions." The experiments carried out included the measurement of light particle spectra with $1 \leq A \leq 14$ from Ar+Ca, Ar+Au, Ne+Au, and Ne+Al reactions at 43, 92, 137, and 156 AMeV. These results were compared with hydrodynamic and cascade model calculations as well as quantum statistical and coalescence models.

early career experimentalist in nuclear physics.

Barbara Jacak (Photo courtesy of Barbara Jacak via the American Physical Society) and innovative contributions to precision mass measurements, commitment to mentoring of young researchers, and leadership in the low energy nuclear physics community." [2019 Tom W. Bonner Prize in Nuclear Physics by the American Physical Society.](#)

The Bonner Prize is awarded annually to recognize and encourage outstanding experimental research in nuclear physics. Jacak received the Bonner Prize "for her leadership in the discovery and characterization of the quark-gluon plasma, in particular for her contributions to the PHENIX experiment and its explorations of jets as probes."

Jacak continued her career after MSU as a J.R. Oppenheimer Fellow at Los Alamos National Laboratory and later as a staff scientist there. In 1997, she joined Stony Brook University as a professor and led the Relativistic Heavy Ion Group working with the PHENIX Collaboration at RHIC. In 2006, Jacak was elected as the spokesperson of the PHENIX Collaboration at RHIC. She was elected to be a member of the National Academy of Science in 2009. Jacak became the director of the Nuclear Science Division at Lawrence Berkeley National Laboratory and joined the faculty of the Department of Physics at the University of California at Berkeley in 2015.

Former NSCL graduate student wins 2018 Stuart Jay Freedman Award in Experimental Nuclear Physics



Ania Kwiatkowski (Photo courtesy of Ania Kwiatkowski via the American Physical Society)

Former NSCL graduate student Ania Kwiatkowski has been awarded by the American Physical Society the [2018 Stuart Jay Freedman Award in Experimental Nuclear Physics](#). The award recognizes outstanding early career experimentalist in nuclear physics. Kwiatkowski received this award for "For outstanding and innovative contributions to precision mass measurements, commitment to mentoring of young researchers, and leadership in the low energy nuclear physics community."

Kwiatkowski received her PhD from MSU in 2011 for her research at the NSCL at the Penning trap mass spectrometry Low Energy Beam and Ion Trap (LEBIT) facility under supervision by Professor Georg Bollen, FRIB Experimental Systems Division director. Her thesis work included the high-precisions mass measurement of ^{32}P , which provided the most stringent test of the Isobaric Multiplet Mass Equation at the time and she added the new ion manipulation technique called Stored Waveform Inverse Fourier Transform ion excitation to the LEBIT portfolio. Already during her time as graduate student at MSU, Kwiatkowski demonstrated her interest and talent in bringing students together and engage them in extracurricular activities, for example in the Women and Minorities in the Physical Sciences program.

Kwiatkowski continued her successful career as postdoctoral researcher at TRIUMF, Canada's national particle accelerator center, at the TITAN ion trap facility under the supervision of Jens Dilling before accepting an assistant professorship position at Texas A&M. She returned to TRIUMF as a staff physicist and adjunct faculty at the University of British Columbia to take on the leadership of the TITAN program.



FRIB Laboratory research assistant earns Barry M. Goldwater Scholarship

by Stephanie Cepak, MSU Honors College



Gabriel Moreau (Photo credit: Stephanie Cepak, MSU Honors College)

Gabriel Moreau, an Honors College sophomore majoring in physics in Lyman Briggs College and music in the College of Music at Michigan State University, has been named a recipient of the Barry M. Goldwater Scholarship. He works as a research assistant for Professor Oscar Naviliat-Cuncic at NSCL and in the Department of Physics and Astronomy.

Moreau is the 44th Goldwater Scholar from MSU since Congress established the scholarship program in 1986.

The Goldwater Foundation seeks scholars committed to a career in science, mathematics or engineering who display intellectual intensity and who have the potential for significant future contribution in their chosen field, providing them with funding for undergraduate tuition and living expenses.

"I am grateful and honored to receive this prestigious research scholarship and would like to thank my research mentors and all the people at MSU who have helped me, supported me and believed in my potential," Moreau said. "I truly would not have been able to achieve this goal without them. I look forward to continuing my research here at MSU, finishing my degrees and going to graduate school. The Goldwater Scholarship is not only an incredible honor – it is an immense opportunity for me."

Moreau eventually plans to pursue a doctorate in nuclear or plasma physics, conducting research in either nuclear fusion energy or nuclear medicine.

"I can simply say that I never met somebody as extraordinary as Gabriel," said Naviliat-Cuncic. "He is perseverant when facing difficulties and remains focused and problem solving oriented. He has an outstanding level of academic preparation and computing skills and has made achievements to the research work of my group comparable to those made by a graduate student during a PhD thesis."

"On behalf of the students, staff and faculty of Michigan State University, I am happy to congratulate Gabriel for being named a recipient of this award and congratulate the three additional students for receiving honorable mentions," said Cynthia Jackson-Elmoore, dean of the Honors College. "Gabriel has been enthusiastic about engaging in research since he first came to the university and earning this award is a wonderful acknowledgement of the effort he has made thus far."



FRIB Laboratory undergraduate researcher nominated for Marshall Scholarship



Garrett King (Photo credit: Stephanie Cepak, MSU Honors College)

MSU nominated Garrett King, a student research assistant at NSCL, for the [Marshall Scholarship](#). It is a national scholarship that supports up to forty U.S. students to study at a graduate level at a United Kingdom institution in any field of study.

"I feel honored to be nominated, and I'm excited to have this opportunity," said King. "Being a Marshall Scholar would be a great experience, and I am glad that I have a chance to be considered."

King is an Honors College senior majoring in physics in the College of Natural Science. At NSCL, he is an undergraduate researcher under the supervision of FRIB Theory Alliance Managing Director and Professor of Physics Filomena Nunes. His work focuses on uncertainty quantification in reaction theory, which looks at how well constrained models are by data. This work is relevant to the interpretation of many experiment to take place at FRIB. His work also looks at how uncertainties in those models propagate when they are used to make predictions for other kinds of reactions. He is the lead author on one accepted publication.

"I am extremely happy for him," said Nunes. "Garrett is an exceptional student, and the university did well in recognizing this."

King plans to obtain a PhD in physics. Following that, he plans to continue nuclear physics research in graduate school and in his future career.



FRIB passes information security audit and receives ISO 27001 registration

FRIB has successfully passed its first annual Information Security Management System (ISMS) audit and is now registered to the external ISO 27001 information security standard.

The [ISO 27001](#) standard helps organizations manage the security of assets such as financial information, intellectual property, employee details, and information entrusted to the laboratory by third parties.

Following a two-year implementation period, internal audits, and a desk-audit earlier this year, three auditors from the certification organization [NSF International Strategic Registrations](#) (NSF-ISR) completed their four-day on-site audit after

visiting various departments within the FRIB Laboratory and interviewing staff members between October 22 and 25. The auditors assessed the FRIB ISMS against the ISO 27001 standard, which has been implemented to secure FRIB's information and information assets to support the laboratory's mission. The FRIB ISMS covers both information and information assets and employs a risk-based approach to manage information security needs against external requirements and expectations.

The audit resulted in no major and two minor corrective actions that have been rectified. Following FRIB's response, NSF-ISR recommended the FRIB Laboratory's ISMS for registration to the ISO 27001 standard. The external auditors will return for an annual ISMS surveillance audit in 2019.

FRIB operates under an ISO 9001-registered Quality Management System, an ISO-14001-registered Environmental Management System, and an OHSAS-18001-registered Occupational Health and Safety Management System.

[MSU Today published an article about FRIB receiving the ISO 27001 registration.](#)

REVIEW ROUNDUP

ASAC review completed 2-4 October



The ASAC Review Committee: (back row, from left) Yuke Tian, Bob Laxdal, Soren Prestemon, Kay Kasemir; (front row, from left) Sang-ho Kim, Stuart Henderson, Yatming Roberto Than, John Galambos. Not photographed: Thomas Roser.

The Accelerator Systems Advisory Committee (ASAC) held its eighteenth meeting 2-4 October.

ASAC focused on the progress of FRIB's Accelerator Systems Division (ASD) in the last six months. Progress included:

- effort toward delivery of the baseline,
- technical design verification,
- technical procurement progress,
- installation and commissioning planning,
- and operational planning.

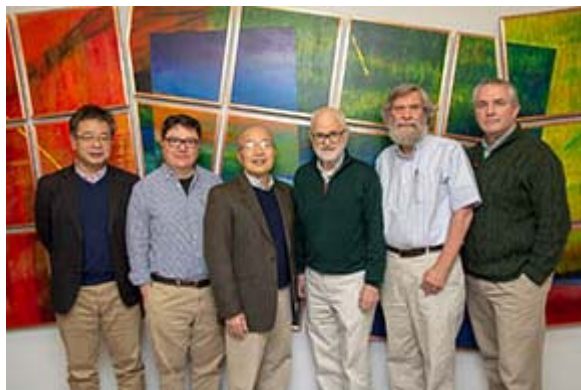
The committee answered all charge questions affirmatively, and recognized several achieved goals, including:

- keeping a completion rate of more than one cryomodule per month,
- liquid-helium production by the FRIB cryoplant,
- continuous circulation of liquid lithium and establishment of lithium film in the charge stripper,
- and demonstration of the machine-protection system.

The committee also supported the advancement of liquid-lithium beam commissioning.

The focus of the review was to assess whether experimental systems scope is being managed to deliver the baseline with a high likelihood of success, and whether technical design verification, technical, and environmental issues are being addressed appropriately.

ESAC review completed 16-18 October



In addition, the progress in the planning for the A1900 and transfer hall reconfiguration was reviewed. All charge questions were answered in the affirmative.

ESAC found that with the changes in technical management and the availability of an integrated schedule through the end, appropriate progress is being made. ESAC provided a number of recommendations and advice, including making effective use of the schedule now available and fully developing acceptance criteria and test plans for the remaining scope.

The ESAC Review Committee: (from left to right) Hiroki Okuno, Patrick Hurh, I-Yang Lee, Jerry Nolen, Dave Harding, James Kerby. Not pictured: John Post.

The Experimental Systems Advisory Committee (ESAC) held a review of FRIB experimental systems 16-18 October.

DOE-SC Office of Project Assessment review completed 6-8 November



The DOE-SC Office of Project Assessment's (OPA) review of FRIB was held 6-8 November. Reviewers are pictured above.

The Department of Energy Office of Science's (DOE-SC) Office of Project Assessment's (OPA) review of FRIB was held 6-8 November. The main focus of the review was to assess the overall progress of the FRIB Project since the last review in May 2018.

The review committee was organized into four subcommittees, and FRIB staff gave 48 presentations.

The OPA assessed all aspects of the FRIB Project — technical, cost, schedule, management, environmental safety and health, and quality assurance. The committee found that FRIB is making appropriate progress toward completion and is well-managed, and answered all charge questions affirmatively.

In closing the review, the committee commended the FRIB Project team on their progress. Jehanne Gillo, director of the DOE-SC Office of Nuclear Physics' Facilities and Project Management Division, said the FRIB Project team is the "gold standard in terms of how to execute a project. It's always a pleasure to come here to see the progress that's been realized and to see you remain on cost and schedule."

The committee also advised the project team to keep up the good work as the project enters the homestretch and transitions from construction to operations to user relations.

DOE has tentatively scheduled the next FRIB Project progress review for 14-16 May 2019.

National Science Foundation conducts NSCL site visit

The NSCL Cooperative Agreement between MSU and the National Science Foundation requires that there be a yearly site visit to evaluate progress.

This year's visit occurred on 7-8 August, during the Nuclear Structure 2018 Conference. The overlap of the visit and the conference allowed a number of NSCL users to meet with the site-visit committee. The committee also heard presentations on the NSCL scientific program and operations. This year's visit had a special focus of education, outreach, and diversity activities. NSCL has a new [code of conduct](#) and a diversity plan to increase participation of under-represented groups in the NSCL technical staff.

The committee was very positive regarding all these activities and the report overall gave NSCL high marks.

Included in the comments the committee complimented the outstanding science with ReA3. The panel pointed out the future science opportunities with reaccelerated beams and stated: "The panel encourages NSCL to begin discussions with the user community about the potential science impact and consider a ReA-only running period."



Construction continues on two FRIB building additions



Construction continues on the MSU-funded Cryogenic Assembly Building (CAB) at FRIB. The first CAB concrete slab was placed in October.

Construction continues on two new MSU-funded additions to the laboratory that will expand FRIB's discovery potential and enable isotope harvesting.

The 31,000-square-foot High Rigidity Spectrometer (HRS) and Isotope Harvesting Vault will house research equipment for isotope harvesting and provide experimental space for the FRIB science program. Existing utilities have been rerouted around the HRS construction site, including the temporary support system for the cryogenic lines which will remain in place. The existing building and utilities have been demolished. The deep foundations are underway and progressing on schedule. The addition is scheduled to be completed in October 2019.

The 14,000-square-foot Cryogenic Assembly Building (CAB) adjacent to the existing Superconducting Radio Frequency Highbay will enable cryomodule maintenance and cryogenic engineering research. FRIB's current cryomodule assembly space will become research space for the reaccelerated beam program when FRIB cryomodule production completes in 2019. Underground electrical and mechanical work is complete. The first CAB concrete slab was placed in October along the west side of the site. Steel installation began in early November. CAB is scheduled to be completed in August 2019.



FRIB hosts Dr. Chris Fall



On 16 July, Dr. Chris Fall (right), principal deputy director of the U.S. Department of Energy's Advanced Research Projects Agency-Energy, visited FRIB and FRIB Laboratory Director Thomas Glasmacher (left) provided a tour of the superconducting linear accelerator.

On 16 July, FRIB hosted Dr. Chris Fall, principal deputy director of the [U.S. Department of Energy's \(DOE\) Advanced Research Projects Agency-Energy \(ARPA-E\)](#).

Dr. Fall spent the day at Michigan State University (MSU) where he met with Interim President John Engler, Provost June Youatt, and several MSU faculty members. While at FRIB, Dr. Fall met with FRIB Laboratory Director Thomas Glasmacher and other members of the laboratory staff. His visit included presentations about FRIB science, enabling technology, and a tour of the laboratory.

In addition to FRIB, he toured the [MSU-DOE Plant Research Laboratory](#), and the [Great Lakes Bioenergy Research Center](#), which are also supported by the U.S. Department of Energy Office of Science. Additionally, Dr. Fall toured MSU's [Institute for Quantitative Health Science and Engineering](#).



FRIB hosts Professor Dr. Richard Baum



On 27 June, FRIB Deputy Laboratory Director Paul Mantica (left) met with Professor Dr. Richard Baum (right) and provided a tour of the FRIB Laboratory.

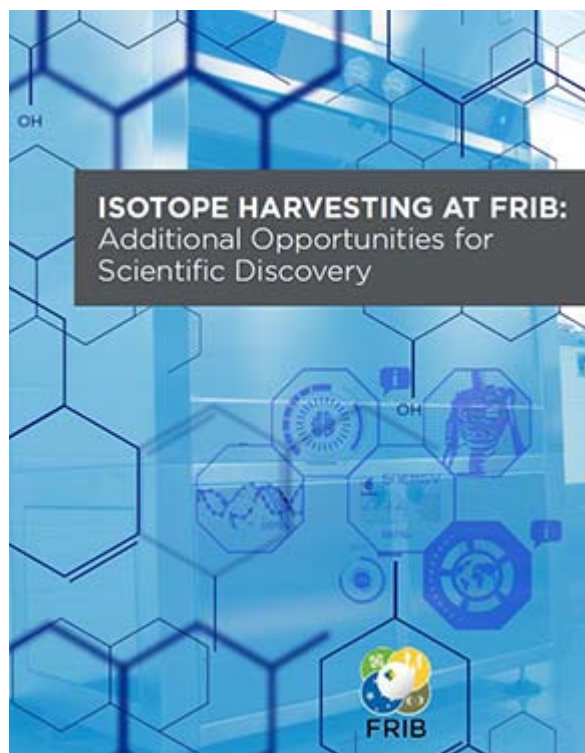
On 27 June, FRIB hosted Professor Dr. Richard Baum of the Theranostics Center for Molecular Radiotherapy and Molecular Imaging, Zentralklinik Bad Berka, in Germany.

Professor Dr. Baum spent the day at Michigan State University (MSU) meeting MSU faculty members and Michigan business leaders. FRIB Deputy Laboratory Director Paul Mantica met with Professor Dr. Baum and provided a tour of the FRIB Laboratory.

Professor Dr. Baum and his team specialize in [Peptide Receptor Radionuclide Therapy](#), an internal molecular therapy using radioactive material to treat neuroendocrine tumors in patients. He has been the chairman and clinical director of the Theranostics Center for Molecular Radiotherapy and Molecular Imaging since 1997 and professor of nuclear medicine at the [Goethe University of Frankfurt](#) since 1996.



Greg Severin awarded grant to harvest medical isotopes at FRIB



[The U.S. Department of Energy Office of Science's Office of Nuclear Physics](#) awarded the "Isotope Development and Production for Research and Applications" grant to a Michigan State University (MSU) chemistry professor. It is a two-year \$356,598 grant.

With the grant, MSU Assistant Professor of Chemistry Greg Severin will look into new methods of gathering rare isotopes. These isotopes have promise in medical research where they will allow scientists to evaluate new diagnostic and therapeutic techniques.

Severin is testing the new isotope collection system at NSCL. He is developing a similar system for the new and more powerful FRIB.

"Harvesting is one of the best ways to meet the growing research-isotope needs in the United States," said Severin. "We will collect isotopes from NSCL and use them to take on challenging problems in basic and applied science."

Once developed at NSCL, the system will later be used to harvest isotopes from FRIB. In addition to medical research, those isotopes can be used for studies in astrophysics, plant sciences, and biochemistry. One main goal is to harvest the isotopes necessary for targeted alpha therapy, a promising new treatment option for metastatic cancer.

A white paper titled "[Isotope Harvesting at FRIB: Additional opportunities for scientific discovery](#)" highlights many of the research projects that the wide selection of isotopes at FRIB can facilitate. Read more about the white paper in the [June 2018 issue of the Laboratory Update for Alumni](#).

The white paper is posted [online](#), and hard copies are available by emailing Severin at severin@frib.msu.edu. Read the MSU Today article about Severin's award: [MSU professor awarded grant to harvest medical isotopes at FRIB](#)

FRIB beam-energy upgrade would double beam energy and yield higher intensities of rare isotope beams



Two prototype superconducting cavities that could be used in an FRIB energy upgrade.

The science planned for FRIB requires a beam-energy upgrade in order to produce higher intensities of rare isotope beams. A beam-energy upgrade would double FRIB's primary beam energy from 200 million electron-volts per nucleon (MeV/u) to at least 400 MeV/u for all ions.

Recent news from the world of astronomy announced the [discovery of gravitational waves from the merger of two neutron stars](#). Subsequent observation of the merger site showed it to be a place where vast amounts of heavier elements were created and hint that this is the long-sought-for site of the r-process. The extremely neutron-rich environment is predicted to produce extremely rare isotopes. To make these isotopes, FRIB will benefit from an upgrade of the base production energy.

With the upgraded energy FRIB will be able to:

- Make and study more of the very rare isotopes important for modeling what elements are made in neutron-star mergers
- Compress neutron-rich nuclei to twice their normal density and study how they react. This will provide important information on the neutron-matter equation of state, also important for interpreting the multi-messenger data from the observed neutron-star merger
- Open a new toolbox of nuclear reactions to probe deeper and more cleaning into the structure of the most exotic isotopes

At its July meeting, the [FRIB Science Advisory Committee](#) considered the upgrade, was excited about the prospect, and stated that the [recent neutron-star merger observation](#) provides a compelling and timely rationale for the upgrade: "Thus, a very strong and exciting scientific justification has emerged recently for a timely energy upgrade of FRIB."

The science of the upgrade was further endorsed at the [2018 Low Energy Community Meeting](#) in August, where they stated: "We strongly support pursuit of the 400 MeV/u energy upgrade of FRIB. It will open new scientific opportunities and is timely given the recent neutron-star merger observation." The scientific community is now preparing a whitepaper on the opportunities.

Nuclear engineering partnership between UC Berkeley and MSU enters eighth year

by Jasmina Vujic, University of California at Berkeley, and Sean Liddick, FRIB



Pictured are members of the Nuclear Science and Security Consortium at a 2017 Workshop and Advisory Board Meeting at Lawrence Berkeley National Laboratory.

The [Nuclear Science and Security Consortium \(NSSC\)](#) is entering its eighth year. The NSSC is led by Jasmina Vujic at the University of California at Berkeley and is funded by the [National Nuclear Security Administration \(NNSA\)](#). The consortium is comprised of eight universities including University of California at Berkeley, Irvine, and Davis, University of Nevada at Las Vegas, Texas A&M University, University of Tennessee – Knoxville, George Washington University, and MSU. The consortium includes five national laboratory partners: Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, and Sandia National Laboratories.

The mission of the NSSC is to support the nation's nuclear security agenda, recruit and train students and postdoctoral researchers in relevant nuclear disciplines in preparation for research and leadership roles at the U.S. national laboratories. The research thrusts of the consortium include nuclear and particle physics led by Barbara Jacak (UCB), radiochemistry led by Ken Czerwinski (UNLV), nuclear engineering led by Max Fratoni (UCB), and nuclear instrumentation led by Kai Vetter (UCB). Within each of these research thrusts are cross-cutting focus areas in nuclear education, nuclear data, modeling and simulation, and nuclear security policy.

The local principal investigators at MSU include Sean Liddick, Alexandra Gade, Hiro Iwasaki, and Artemis Spyrou. Currently, eleven graduate students (John Ash, Dayah Chrisman, Alexander Dombos, Brandon Elman, Mara Grinder, Brenden Longfellow, Alicia Palmisano, Roy Ready, Thomas Redpath, Krystin Stiefel, and Daniel Votaw) and two postdoctoral researchers (Stephanie Lyons and Andrea Richard) are members of the NSSC at MSU. All graduate students have a mentor at the national laboratories and the students and mentors have wide-ranging discussions from the best analysis procedure of the student's thesis data to the direction of the student's career path. The members of the consortium also are provided an opportunity to travel to the national laboratories and work closely with one of the staff scientists on a research project and engage in current topics in nuclear security for a period around two to three months. Currently Brandon Elman, Mara Grinder, Brenden Longfellow, Alicia Palmisano, Thomas Redpath, and Daniel Votaw are working at Los Alamos National Laboratory or Lawrence Livermore National Laboratory for the summer. Former members of the MSU NSSC have gone on to a variety of positions in the national laboratories, industry, and academics.

MSU Cryogenic Initiative, Accelerator Science and Engineering Traineeship program gaining momentum after first year



The MSU Cryogenic Initiative leverages FRIB to attract talented students to the cryogenics field. Earlier this summer, students came to MSU from all over the world to participate in the U.S. Particle Accelerator School (USPAS)



Graduate student Chris Richard (left) talks with his advisor, Adjunct Professor Steven Lidia as they inspect FRIB controls. Richard is part of the Accelerator Science and Engineering Traineeship (ASET) program, which leverages FRIB to address a national shortage in accelerator scientists and engineers. Working with Lidia, Richard is learning about the physics and engineering of large accelerators, which is an ASET focus area because it is an area in the United States experiencing critical workforce needs. (Photo credit Greg Kohuth, Michigan State University)

at MSU. The cryogenics engineering course at USPAS was filled to capacity, and course participants toured FRIB, as shown above.

In 2017, FRIB established the MSU Cryogenic Initiative with the MSU College of Engineering, and MSU established an Accelerator Science and Engineering Traineeship (ASET) program, leveraging FRIB.

MSU Cryogenic Initiative

The MSU Cryogenic Initiative combines classroom education with training on cutting-edge technologies. It includes advancements in the cryogenic field that exist and are used at FRIB. A concentration in cryogenic engineering has been added to the mechanical engineering undergraduate curriculum.

After its first year, the program is growing and garnering increasing interest. This fall, there are three graduate and two undergraduates enrolled in the program. Thirteen students are enrolled in the fall course, Mechanical Engineering 414, Mechanical Design of Cryogenic Systems. The cryogenic engineering course held at the U.S. Particle Accelerator School (USPAS) at MSU earlier this summer was filled to capacity. Students came from across the nation and internationally, including students from government laboratories.

The program is led by Rao Ganni and Peter Knudsen. Their collective cryogenic engineering experience spans more than six decades. Ganni is the director of the MSU Cryogenic Initiative. Knudsen is a senior cryogenic process engineer at FRIB. Nusair Hasan is a cryogenics engineer who also recently joined the initiative. All organize and teach courses in the program.

The MSU Cryogenic Initiative:

- Educates and trains future cryogenic engineers and system innovators;
- Develops and maintains a cryogenic system knowledge base of cryogenic technology and skills;
- Investigates, proposes, and fosters efficient cryogenic process designs and research of advanced cryogenic technologies;
- Maintains a knowledge base to operate unsupported equipment.

Tasha L. Williams is a second-year PhD student at MSU from Melbourne, Florida. Her research topic is focused on improving the efficiency of rotary screw compressors. She was interested in the program due

Accelerator Science and Engineering Traineeship

ASET addresses a national shortage in accelerator scientists and engineers. It leverages unique campus-based equipment, systems, and experts at FRIB and NSCL, extensive ASET faculty and research support in the MSU Department of Physics and Astronomy and the College of Engineering, and resources at U.S. Department of Energy national laboratories.

The program addresses four major areas where there are critical workforce needs:

- Physics and engineering of large accelerators
- Superconducting radio frequency accelerator physics and engineering
- Radio frequency power engineering
- Large-scale cryogenic systems

The U.S. Department of Energy Office of Science (DOE-SC) Office of High Energy Physics (OHEP) awarded MSU a \$990,000 accelerator science and engineering traineeship grant to develop the program.

More than 20 faculty members from participating MSU academic programs and over 30 additional PhD accelerators scientists and engineers will mentor ASET program participants.

Currently eleven students are enrolled in the program, and six are enrolled in the fall 2018 semester. Current students say they were drawn to the program for the opportunities it presents.

Michael Balcewicz from Aliso Viejo, California, is pursuing a PhD in physics at MSU. His research involves square wells, which can be used to study and better understand what physical parameters create instabilities in a beam. He enrolled in ASET in part for its career benefits. "What interested most me about the ASET program was ability to work in a national laboratory and work on cutting-edge research there." He aims to work at Brookhaven National Laboratory, and is interested in Brookhaven's possible upgrade to its high energy electron-ion collider and light-source work at the National Synchrotron Light Source II.

Crispin Contreras, originally from San Francisco de la Cruz, Guanajuato México, and Reading, Pennsylvania, is pursuing a PhD in physics at MSU, studying the electromagnetic and mechanical properties of medium beta superconducting elliptical cavities as his research topic. Through ASET, he is continuing his research at Fermi National Accelerator Laboratory, which provides unique opportunities to

to the learning opportunities offered through hands-on training and being surrounded by so many other individuals excelling in the field. "I think it will help catapult and put me in connection with the right people, while also preparing me to fill the role," Williams said about how the program may impact her career.

Duncan Kroll is a first-year graduate student from Michigan pursuing engineering research and development or design. He joined the program for the training opportunities and career impacts. "It is an opportunity to work at a world-class facility, on important projects, with very knowledgeable people. As a resume builder, that's about as good as it gets," Kroll said. "I think the greatest benefit to my career will be the opportunity to work at such a cutting-edge facility as FRIB."

Cryogenic Initiative leaders will continue to collaborate with MSU's mechanical engineering department to recruit students by exposing them to the unique opportunities that FRIB has to offer. It will also develop curriculum and courses for graduate and undergraduate students. Ganni, Knudsen, and Hasan plan to also continue mentoring and training students already involved in the program. They will serve as dissertation/thesis advisors and co-advisors. With the help of the cryogenics department staff, they will expose students to FRIB's systems and equipment. Students will also participate in the development of FRIB's new cryogenic facilities.

Read more about the MSU Cryogenic Initiative at frib.msu.edu/cryoinitiative.



Alumni spotlight: Erich Ormand



advance his education and career. "Staying at Fermilab is essential for my thesis project since my collaborators have a lot of experience working with resonance control." With the research results obtained at Fermilab, he intends to present his work to scientists at several international conferences.

There are several second-year goals to help enhance the program and provide additional benefits to students. Courses will be added to the program including a new Physics 862 course (accelerator systems) and a new electrical and computer engineering course (power engineering). New cryogenics courses in mechanical engineering will be added as well. In addition, one or two students will be recruited from the admitted pool of NSCL/FRIB students.

Read more about ASET at frib.msu.edu/aset.

In 2016, Ormand was selected as the Deputy Division Leader for Science in Technology in the Nuclear and Chemical Sciences Division. Ormand has served on many review panels for the U.S. Department of Energy, the NSCL program advisory committee, and served a three-year term on the Nuclear Science Advisory Committee, where he contributed to the 2015 Nuclear Physics Long Range Plan.

At LLNL, Ormand's research focused on a fundamental understanding of nuclear physics as well as the application of cutting-edge nuclear science to address problems important to national security.

Erich Ormand (Photo courtesy of Lawrence Livermore National Laboratory)

Erich Ormand earned his PhD in theoretical nuclear physics from MSU in 1986 under the mentorship of Professor Alex Brown. Ormand started his research career at NSCL as an experimentalist working with Jerry Nolen, who is now senior scientist and adjunct professor of physics at Argonne National Laboratory, but eventually he concluded that theory and computing were better suited for him. For his PhD thesis, Ormand performed detailed studies of how isospin symmetry is violated in nuclei and its impact on superallowed Fermi beta decay and isospin-forbidden particle emission. With this experience, Ormand became an expert in the nuclear structure, especially the computational aspects of the nuclear shell model.

After earning his PhD, Ormand went abroad with post-doctoral research positions at the Niels Bohr Institute and later at the University of Milan. Ormand returned to the U.S. in 1990 as the first Lee A. DuBridge Research Fellow in Physics at the California Institute of Technology. Ormand then held research assistant professor positions at the University of Tennessee and Louisiana State University. In 1998, he became a staff scientist at Lawrence Livermore National Laboratory (LLNL) and was elected Fellow of the American Physical Society in 2003. In 2005, Ormand became group leader of the Nuclear Theory and Modeling Group, where he helped establish a premier nuclear theory effort focusing on high-performance computing.

Ormand built on the experience from his graduate student days to pursue a research effort based on a first-principles approach to describing the structure of light nuclei. Toward this end, he built a small research group at LLNL utilizing the high-performance computing capabilities at LLNL. Ormand was the lead author of the shell-model code REDSTICK, which then formed the basis of the improved code BIGSTICK, which he co-authored with fellow FRIB Theory Alliance member Calvin Johnson of San Diego State University. The LLNL theory team performed the first ab initio calculations within the No-core, Shell Model (NCSM) with induced three-body interactions, and then later with initial three-nucleon interactions. These first calculations demonstrated that initial three-nucleon interactions were essential to describe the low-lying structure of ^{10}B .

Many experiences during his period as a graduate student at the NSCL have followed Ormand throughout his life. This includes his wife, Silvana Angius (whom he met at NSCL), vegetable gardening, photography, and exploring the great outdoors. Ormand and his wife have a goal of visiting and camping in every national park. This dream started while they were graduate students when, on two occasions, they spent two weeks backpacking the wilderness of Isle Royale National Park, photographing moose and listening to wolves howl.

Advanced Studies Gateway at FRIB events



[Student piano recital: Friday, 30 November at 5:30 p.m.](#)

- Piano students from the MSU College of Music will perform a recital. Featured students are: James Schippers, Jingyu Xu, Elizabeth Clarke, Paige Harpring, and Hrant Bagrazyan.

[A public talk on canonical forms: Monday, 10 December at 8 p.m.](#)

- Professor Noam Elkies will give a public talk for a general audience titled Canonical Forms: A Mathematician's View of Musical Canons. The lecture will feature examples played from the piano keyboard.

Noam Elkies (Photo courtesy of Noam Elkies)

Advanced Studies Gateway at FRIB events continue at the laboratory. The Advanced Studies Gateway initiative features research workshops as well as public talks, concerts, and other events that are free and open to the public. The program brings together researchers, innovators, creative thinkers, artists and performers from all fields and strengthens ties between Michigan State University and the larger science community.

FRIB invites you to its next Advanced Studies Gateway events in November and December: A student recital in collaboration with the MSU College of Music, a public talk on canonical forms featuring Professor Noam Elkies from the Department of Mathematics at Harvard University, and a four-hands piano concert featuring Professor Elkies and Professor Young Hyun Cho from the MSU College of Music.

[Piano recital: Friday, 14 December at 5:30 p.m.](#)

- Professor Noam Elkies will perform a four-hands piano concert with Professor Young Hyun Cho from the MSU College of Music.

The events are free and open to the public, and will take place in Room 1300 FRIB Laboratory. [Parking](#) is available in the [Shaw Lane](#) and [Wharton Center](#) parking ramps.

For more information about the Advanced Studies Gateway at FRIB, visit frib.msu.edu/gateway.



FRIB science and scientists in the news

Physics Today published an article about a National Academies of Sciences, Engineering, and Medicine committee endorsing construction of an electron-ion collider: [National Academies endorse construction of electron-ion collider](#)

The paper led by the FRIB/NSCL theory group on "[Eigenvector Continuation with Subspace Learning](#)" was highlighted by Physics as a synopsis: [Making Quantum Computations Behave](#)

The paper "Bayesian approach to model-based extrapolation of nuclear observables" by a [new collaboration between nuclear theorists and statisticians](#) was highlighted as [an editors' suggestion in Physical Review C](#).

The Phys. Rev. Lett. paper on "[From Calcium to Cadmium: Testing the Pairing Functional through Charge Radii Measurements of 100–130Cd](#)" involving nuclear theorists from FRIB/NSCL was highlighted by [Technische Universität Darmstadt](#).

Professor Dean Lee was featured in several recent articles, including:

- MSU Today published an article about a recent MSU Board of Trustees meeting, including Lee's presentation about his group's research: [Board supports Engler's call for stronger state investment in higher education](#)
- MSU Today presented an interview with Lee as part of the "Faculty Voice" series: [Dean Lee: Answering philosophical questions \(Faculty Voice\)](#)
- WKAR published an article and audio interview about Lee's research: [MSU FRIB researcher Dean Lee works to understand the nature and origins of matter](#)



News media features FRIB

Several media outlets featured FRIB recently:

- WILX TV-10: [MSU's FRIB has potential to "make the world a better place"](#)
- Lansing State Journal: [A decade later, Facility for Rare Isotope Beams director can see the finish line](#)



Please update your information via the alumni directory form

The FRIB Laboratory has an [alumni directory form](#) to communicate with laboratory alumni and to track their career paths.

Please take a couple of minutes to fill out or update the form by answering a few simple questions. This will ensure our records are accurate. Visit the online [alumni directory form](#) to enter and update information.



We want to hear from you

Send us your story ideas! Let us know what you are up to!

We want to feature at least one story each issue about you—our FRIB/NSCL alumni, so please email us story tips about you and/or your fellow alumni to alumni@frib.msu.edu. Tell us about discoveries, business ventures, partnerships, awards, and other professional developments, and we may feature them in a future issue. Also let us know if there are other types of laboratory updates you'd like to see in future alumni issues.



Contributors this issue

- Stephanie Cepak
- Thomas Glasmacher
- Peter Knudsen
- Jessica Kolp
- Sean Liddick
- Erich Ormand
- Peter Ostroumov
- Brad Sherrill
- Jasmina Vujic

LOOKING AHEAD

- 30 November** Advanced Studies Gateway at FRIB event – Piano recital featuring students from the MSU College of Music
- 10 December** Advanced Studies Gateway at FRIB event – Public talk for a general audience titled Canonical Forms: A Mathematician's View of Musical Canons, featuring Professor Noam Elkies, Harvard University Department of Mathematics
- 14 December** Advanced Studies Gateway at FRIB event – Four-hands piano concert, featuring Professor Noam Elkies, Harvard University Department of Mathematics and Professor Young Hyun Cho from the MSU College of Music
- 23-25 January 2019** Accelerator Readiness Review 03 of FRIB
- 14-16 May** DOE Office of Project Assessment Review (tentative)
- 5-7 November** DOE Office of Project Assessment Review (tentative)

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Facility for Rare Isotope Beams | Michigan State University | 640 South Shaw Lane | East Lansing, MI 48824 | (517) 355-9672 | frib.msu.edu | nsl.msu.edu

Michigan State University is establishing FRIB as a national user facility for the [Office of Nuclear Physics](#) in the [U.S. Department of Energy Office of Science](#). Operation of NSCL as a national user facility is supported by the [Physics Division](#) of the [U.S. National Science Foundation](#).