LABORATORY UPDATE for USERS

FRIB

July 2018

FRIB Project marks major commissioning milestone, momentum building to project completion

by Thomas Glasmacher, FRIB Laboratory Director and FRIB Project Director

Earlier this month, FRIB achieved a major project milestone by accelerating its first beams in three of forty-six superconducting cryomodules. This demonstrates 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. Read the full story below. We are delighted about this great success and the momentum it provides to move the project further toward completion so FRIB science can commence.

In addition to the significant beam-commissioning milestone, we continue making progress with cryomodule production. All cryomodules are now in production. As of the end of June, 22 of 46 cryomodules have been installed in the linear accelerator tunnel, and the rest will be finished and installed by the end of 2019. FRIB is on the leading edge of cryomodule manufacturing with its highly trained staff and advanced production facility, and FRIB trains cryogenic students in its state-of-the-art facilities to give them a unique experience and prepare them for jobs in the industry. Read more about two parallel programs we've put into place in the past year to address workforce development: the MSU Cryogenic Initiative and Accelerator Science and Engineering Traineeship program.

We are excited about hosting the upcoming Nuclear Structure conference at NSCL and FRIB, followed by the Low Energy Community Meeting in August, and look forward to the discussions and continued collaboration with the community. We look forward to seeing many of you there. In the meantime, we hope you enjoy this latest issue of the Update for Users.

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

On 11-12 July, the Facility for Rare Isotope Beams accelerated first primary 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.

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.

About 35 accelerator physicists and engineers worked together on 11-12 July to achieve first primary 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.

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 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.

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.

FRIB Science Advisory Committee meeting held 6 July

by Brad Sherrill, FRIB

The FRIB Science Advisory Committee (SAC) met on 6 July 2018 to review preparations for Day-one science at FRIB and consider the reasons for an upgrade of the FRIB production energy to 400 MeV/u. The meeting was primarily an interim update in preparation for a full meeting to review the status of FRIB experimental equipment planning to be held late this year or early next calendar year. SAC members joined the meeting by video conference and all agreed the format worked well.

The SAC was charged with four items:

• Is the engagement of FRIB users adequate to realize the Day-one scientific goals of FRIB?
• Are the activities of the FRIB Theory Alliance appropriate to guide and support the early science program?
• Are the plans for the FRIB Program Advisory Committee appropriate for a DOE Office of Science user facility?
• Should the FRIB Laboratory pursue with high priority an upgrade of the LINAC energy to 400 MeV/u?

The SAC heard presentations related to each of the charge items and an overview of the status of the FRIB Project. At the end of the meeting the SAC gave closeout comments and a full report will be submitted in a few weeks.

During the closeout, the SAC endorsed FRIB plans toward developing a 400 MeV/u beam-energy upgrade path for FRIB. The interpretation of the recent observation of gravitational waves and subsequent optical follow-up of the merger of two stars provides a strong motivation for the upgrade. The SAC also had comments regarding the planned FRIB Program Advisory Committee process. Based on this feedback, updated plans for the FRIB PAC and first PAC meeting will be presented at the 2018 Low Energy Community Meeting (LECM). A workshop on the science of the FRIB 400 MeV/u upgrade will be held on the evening of 9 August, in connection with the LECM. Talks are scheduled on the upgrade and aspects of the significant benefits of a higher production energy.

News from the FRIB Users Executive Committee

by Heather Crawford, FRIB Users Organization Chair

Immediately following the Nuclear Structure 2018 conference, the annual 2018 Low Energy Community Meeting (LECM) will be held at the same venue as the conference. The meeting will begin in the afternoon of 10 August and will conclude on 11 August. Please note that while there is no registration fee associated with the LECM, a separate registration is required.

The LECM meeting will include overview talks from the major user facilities, Argonne Tandem Linac Accelerator System (ATLAS), NSCL and FRIB, as well as an Association for Research at University Nuclear Accelerators (ARUNA) overview and focused talk highlighting Triangle Universities Nuclear Laboratory (TUNL). There will also be working group sessions including 15 FRIB working groups and the FRIB Theory Alliance annual meeting. In addition, there will be satellite workshops, including the ATLAS Long Range Planning Meeting during the evening of 10 August.

The overall focus of the meeting is the future of FRIB, including Day-one science, and the science case for the 400 MeV/u beam-energy upgrade will be discussed.

Last year's LECM included more than 200 participants — we in the FRIB Users Executive Committee hope to see you all there, and carry on the successful tradition of this important meeting for our community.

Nuclear Structure 2018 conference to be held 5-10 August

FRIB and NSCL will host the Nuclear Structure 2018 (NS2018) conference from 5-10 August at MSU. The focus of the conference will be nuclear structure physics at the extremes of isospin, spin and excitation energy. The conference will consist of invited talks, contributed talks, and a poster session.

FRIB beam-energy upgrade would double beam energy, produce higher intensities, variety of rare isotope beams

by Peter Ostroumov, FRIB

Figure 1: Two prototype superconducting cavities for FRIB energy upgrade.

The FRIB Project is progressing on schedule and delivery of the first rare isotope beams is expected in 2021. Meanwhile, Michigan State University launched research and development (R&D) and prototyping activities to support an FRIB beam-energy upgrade that would double the beam energy and produce higher intensities of rare isotope beams.

The resulting technical report, "Elliptical superconducting RF cavities for FRIB energy upgrade," explored three different frequencies for superconducting elliptical cavities: 644, 805, and 1288 MHz.

The preferred option with 644 MHz 5-cell elliptical cavities at β_{OPT}=0.65 can provide 400 MeV/u uranium beam in eleven cryomodules containing five cavities each installed in an 80-meter-long available space in

The energies of selected ion species resulting from the beam-energy upgrade are listed in Table 1. Two prototype cavities have been built (see Figure 1), and we are demonstrating their performance of 12.4 MV accelerating voltage per cavity.

This primary-beam-energy upgrade will result in substantially higher secondary-beam intensities (typically more than a factor of 2 and more than an order of magnitude in some cases) of rare isotope beams while providing the same primary-beam power of 400 kW. The higher energy also enables the use of higher-energy nuclear reactions that allow rare isotopes to be probed more deeply and allows the study of compressed neutron-matter to twice normal nuclear density. The latter is particularly important given the recent observation of gravitational waves from neutron-star mergers. A workshop to discuss the science of the upgrade will be held in connection with the 2018 Low Energy Community Meeting.

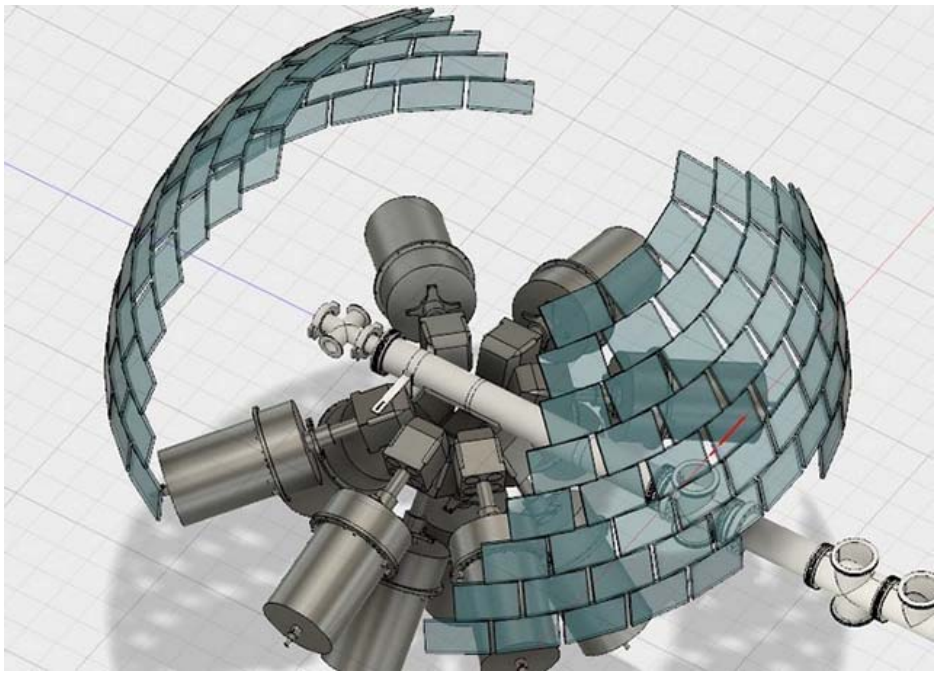
Ion Species	Charge state	Energy (MeV/u), FRIB	Energy (MeV/u), FRIB-Upgrade
^{40}Ar	18	320	540
^{48}Ca	20	264	508
^{86}Kr	35	257	497
^{124}Sn	47	235	464
^{198}Au	68	210	421
^{238}U	78	200	403

the tunnel. A large beam aperture of elliptical cavities (83 mm) facilitates minimization of beam losses in the upgraded high-energy section of FRIB.

Table 1: Selected ion primary-beam energies available in an upgraded FRIB.

Beta Decay Station Workshop summary

by Robert Grzywacz, University of Tennessee Knoxville



The second FRIB Decay Station workshop was held in January 2018. The station will be a modular and flexible multi-detector system for study of nuclear decays.

Researchers participated in the second FRIB Decay Station Workshop hosted at Michigan State University 25-26 January 2018 to discuss the FRIB Decay Station.

The FRIB Decay Station will be a flexible and modular multi-detector system with the ability to measure all possible nuclear decay paths of rare isotopes produced at FRIB including charged particles, photons, and neutrons. University and national laboratory researchers presented a broad experimental program well aligned with the FRIB scientific mission in areas of nuclear structure, the origin of the elements, fundamental symmetries, and the application of the resulting science to the benefit of society.

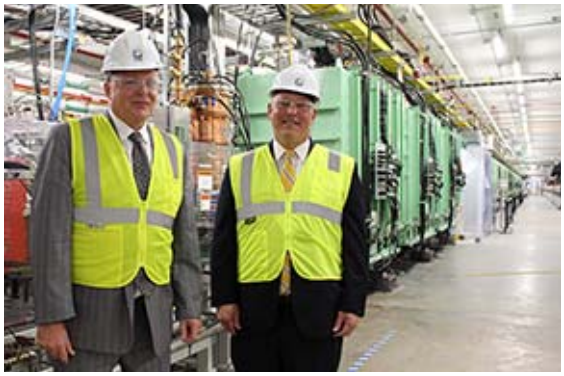
The flexibility of the instruments will enable researchers to tailor the experimental system to their specific scientific requirements.

The full program of the workshop is online.

In addition to the science program of the Decay Station participants talked about staging the Decay Station and the locations in the facility available to perform decay spectroscopy. Three stages are currently envisioned with increased scientific opportunities at each stage.

The 2018 Decay Station Workshop follows the last successful Decay Station workshop hosted in Oak Ridge in January 2016. A white paper for the FRIB Decay Station is currently being written.

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) .

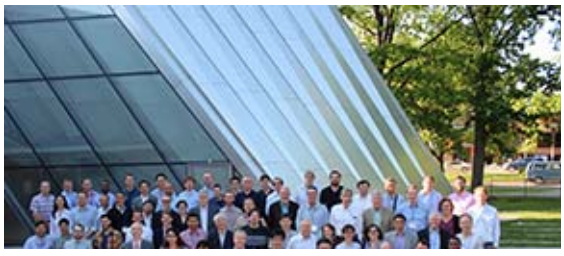
Dr. Fall spent the day at Michigan State University (MSU) where he met with Interim President John Engler, Provost June Youatt, and several MSU faculty members. While at FRIB, Dr. Fall met with FRIB Laboratory Director Thomas Glasmacher and other members of the laboratory staff. His visit included presentations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

by Jorge Piekarewicz, Florida State University

The summer has been a very busy time for the FRIB Theory Alliance (FRIB-TA). The first direct detection of gravitational waves from a binary neutron star merger by the LIGO-Virgo collaboration is providing fundamental new insights into the nature of dense matter and the astrophysical site for the r-process — topics at the core of FRIB's science mission.



Along these lines and in support of the FRIB-TA mission to train the next generation, an exciting and enormously successful three-day summer school titled "Neutron star merger for non-experts: GW170817 in the multi-messenger astronomy and FRIB eras" was hosted by the alliance and had more than 80 students in attendance.

The alliance also supports a visiting program that brings together researchers to focus on a problem of relevance to the FRIB mission. This summer, a topical program titled "Connecting bound state calculations with the scattering and reaction theory" successfully ran from 11-22 June. A second topical program titled "Implications of the neutron star merger GW170817 and its associated Kilonova for r-process nucleosynthesis" ran from 16-17 July.

As reported in the previous issue, we are delighted to have the first two bridge faculty hires, Saori Pastore and Maria Piarulli, join our nuclear colleagues at Washington University, St. Louis. Further, a call is now out for applications from institutions that would like to host the next bridge position (deadline: 1 August).

A call is also out to universities and national laboratories to partner with the FRIB Theory Fellow Program (deadline: 31 August). This initiative provides a unique opportunity to participating institutions to attract and help develop the next generation of scientists. Stay tuned for the next announcement for applications from potential FRIB theory fellows.

This summer, the FRIB Theory Alliance hosted a topical program titled "Connecting bound state calculations with the scattering and reaction theory" from 11-22 June.

Recently, we welcomed to the executive board three new members: Alexandra Gade, Dean Lee, and Thomas Pappenbrock. At the same time, we owe a huge debt of gratitude to David Dean and Witek Nazarewicz for their service and commitment to the alliance.

Finally, our FRIB-TA annual meeting will take place concurrently with the Low Energy Community Meeting (LECM) on 10 August, in East Lansing. The alliance will participate in the morning plenary session, which is joint with the Nuclear Structure 2018 conference, and we will break out in the afternoon with our own annual FRIB-TA meeting. We look forward to having an engaging representation of our membership at the LECM.

As you see, this is an exciting time for FRIB science. If you are a theorist interested in contributing to the FRIB science mission, please join the alliance by signing up at fribtheoryalliance.org — and have your students sign up, too.

FRIB users Zach Meisel and Jaideep Singh awarded U.S. Department of Energy Office of Science Early Career awards

Two scientists who perform research at the National Superconducting Cyclotron Laboratory and will perform research at FRIB have received U.S. Department of Energy Office of Science (DOE-SC) Early Career Research Program awards.

The program, in its ninth year, awards financial support to scientists from universities and DOE national labs to help advance their research. Research proposals are peer-reviewed and selected by one of the following six offices: Advanced Scientific Computing, Biological and Environmental Research, Basic Energy Sciences, Fusion Energy Sciences, High Energy Physics, and Nuclear Physics. This year, eighty-four scientists from across the United States were selected for the honor.

Zach Meisel

Zach Meisel, assistant professor of physics and astronomy at Ohio University, was selected by the Office of Nuclear Physics to receive funding for his proposal, “Constraining Neutron Star Structure with Indirect Nuclear Reaction Studies.” Meisel has an active experimental program at NSCL and will continue it at FRIB.

Meisel’s research involves the origin of the elements and the behavior of matter at extreme densities and low temperatures. He also investigates the structural evolution of nuclei, nuclear reactions for intermediate mass nuclides, and the development of nuclear instrumentation and analysis techniques.

"How matter behaves at the highest densities achieved by nature is an open question," said Meisel. “My research supported by the DOE Early Career Award will shed light on this by constraining processes occurring in the outer layers of neutron stars, ultradense remnants of stellar explosions, by removing some of the most important nuclear physics uncertainties involved. I’m looking forward to carrying out part of this research using the world-class capabilities of NSCL and related work at FRIB in the near future.”

Meisel earned his bachelor’s degree in astrophysics and his PhD in physics from MSU. He is a member of the Institute of Nuclear and Particle Physics and is affiliated with the Joint Institute for Nuclear Astrophysics. Meisel also conducts nuclear astrophysics research at Ohio University’s Edwards Accelerator Laboratory.

Jaideep Singh

Jaideep Singh, Michigan State University assistant professor of physics at FRIB, was selected by the Office of Nuclear Physics to receive funding for his proposal, “Towards a Next Generation Search for Time-Reversal Violation Using Optically Addressable Nuclei in Cryogenic Solids.” Singh has a joint appointment in the Department of Physics and Astronomy.

Singh’s research examines how certain rare atoms with a pear-shaped core (nucleus) have unmatched sensitivity to new kinds of forces between subatomic particles that are not the same when the arrow of time is reversed. Such forces are believed to be responsible for all of the visible matter in the observable universe. These rare atoms, some for the first time, will be produced in large numbers at FRIB. In anticipation, he is developing a very sensitive laser-based clock using more common atoms implanted inside of a transparent sheet of frozen neon at very cold temperatures (-452 degrees F). Implantation into a solid is potentially an effective way to both efficiently capture and repeatedly probe the small number of rare atoms, such as radium and protactinium. The potential sensitivity of this new approach could be at least a few hundred times greater than the current leading experiment.

“I was speechless when I was informed by my DOE Program Officer that I was to receive an Early Career Award,” said Singh. “It will accelerate my research program by about fifteen years. The award is a recognition of both the world-class scientific support at the laboratory as well as the unique scientific opportunities of FRIB.”

Singh earned his bachelor’s degree in physics from the California Institute of Technology, and earned his PhD in physics from the University of Virginia. He was a postdoctoral fellow at Argonne National Laboratory and a postdoctoral research scientist at the Technical University of Munich in Germany. In 2014, he joined

MSU as an assistant professor in experimental nuclear science and began his research at NSCL.

Nuclear engineering partnership with UC Berkeley and MSU

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 Michigan State University. 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 Czerwinksi (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 Michigan State University. 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.

DOE-SC Office of Project Assessment review held 15-17 May

The DOE-SC Office of Project Assessment's (OPA) review of FRIB was held 15-17 May. Reviewers are pictured above.

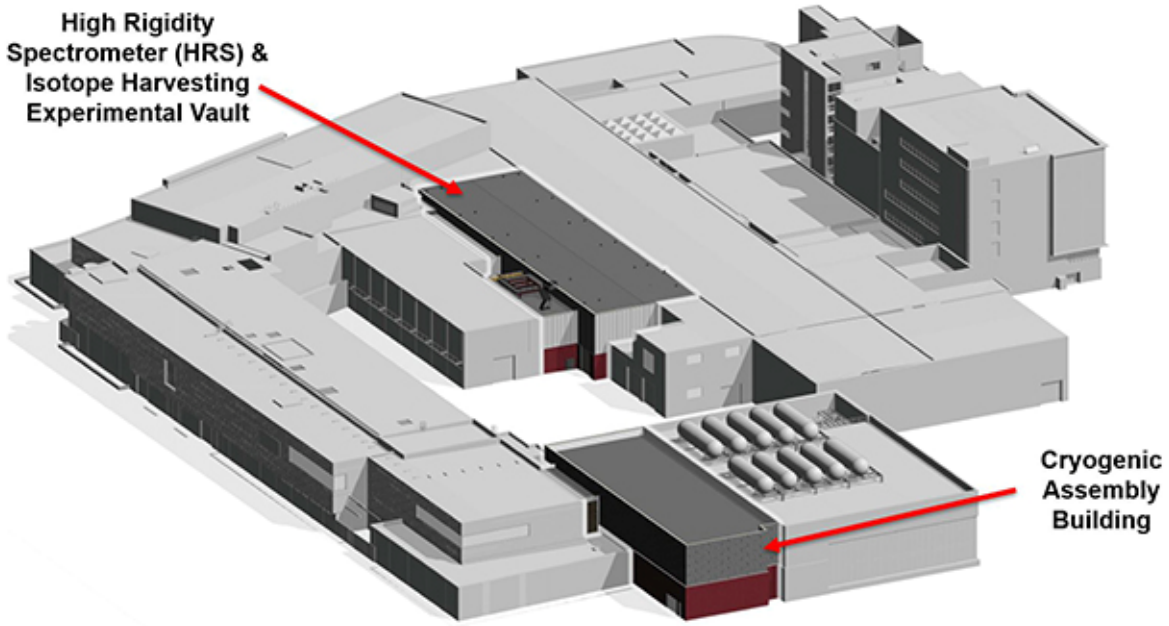
The DOE-SC Office of Project Assessment's (OPA) review of FRIB was held 15-17 May. The main focus of the review was to assess overall FRIB Project progress since the last review in December 2017, with a focus on technical progress.

The review committee was organized into four subcommittees, and FRIB staff gave 50 presentations.

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

DOE has tentatively scheduled the next FRIB Project progress review for 6-8 November 2018.

Construction underway on two FRIB additions



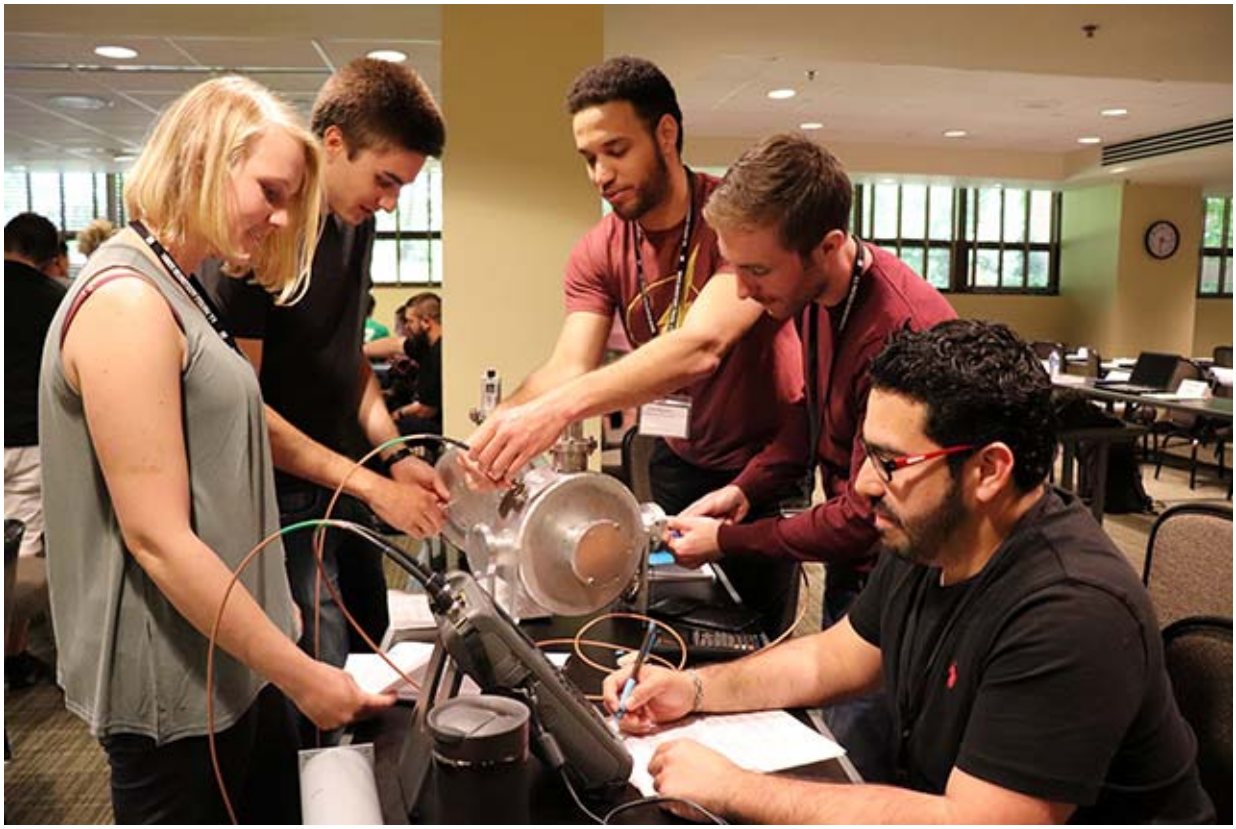
In February, the MSU Board of Trustees authorized FRIB to proceed with two new additions to the facility, and construction of the additions is currently underway.

On 16 February, the MSU Board of Trustees authorized FRIB to proceed with two new MSU-funded additions to the laboratory that will expand FRIB's discovery potential and enable isotope harvesting, and construction is now underway.

The 31,000-square-foot High Rigidity Spectrometer (HRS) and Isotope Harvesting Vault will house research equipment for isotope harvesting and to 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 at the site has been demolished, including foundations and the abandoned steam tunnel which was under the old building footprint. Earth retention is being installed, which will accommodate the installation of the shallow and deep foundations for the new HRS building. The deep foundations will start in late July or early August. The addition is scheduled to be completed in August 2019.

The 14,000-square-foot Cryogenic Assembly Building (CAB) adjacent to the existing Superconducting Radio Frequency Highbay will be for the maintenance of cryomodules and to perform research pertaining to cryogenic engineering. FRIB's current cryomodule assembly space will become research space for the reaccelerated beam program when the FRIB cryomodule production completes in 2019. Excavation for the footings and foundations has begun, with CAB's first concrete pour happening in late July. After concrete footings are complete, the duct bank work will begin, followed by concrete slabs. Structural steel for the building will be erected starting in September. Like the HRS addition, CAB is also scheduled to be completed in August 2019.

MSU hosts U.S. Particle Accelerator School



Students in the 2018 U.S. Particle Accelerator School (USPAS) held at Michigan State University work together on a project. One-hundred thirty-three students from around the world attended the intensive two-week session at MSU. Photo credit: Irina Novitski, USPAS

MSU hosted the summer 2018 session of the U.S. Particle Accelerator School (USPAS), a national graduate-level training and workforce development program in accelerator science and engineering funded by the Office of High Energy Physics in the U.S. Department of Energy Office of Science (DOE-SC).

Particle accelerators are used in discovery science, medicine, and high-tech industry. USPAS trains graduate students as well as scientists and engineers in rigorous courses that are designed to support the needs of the field.

This intensive two-week session of USPAS was held at the Kellogg Center and Conference Center on MSU's campus. Nine courses were offered at the MSU session and 133 students from all over the world were in attendance. This is the third time that MSU has hosted the USPAS. Of the twenty-two instructors who taught at this summer's school, nine were from MSU. The MSU instructors are experts in accelerator physics, ion source physics, and cryogenic engineering. They are affiliated with FRIB, the National Superconducting Cyclotron Laboratory, the MSU Department of Physics and Astronomy, and the MSU Department of Mechanical Engineering.

USPAS has offered graduate-level accelerator science and engineering courses in an intensive-school format since 1981. USPAS courses and documentation have been recognized for excellence and the school has had a positive impact on the field. The school is intended not only to meet the needs of national laboratories, but to educate people to develop particle accelerators for use in other fields, including industrial and medical applications. The USPAS offers a continually updated curriculum of courses ranging from fundamentals of accelerator science to advanced physics and engineering concepts.

Having available and training a workforce in accelerator science and engineering is an important part of FRIB.

FRIB provides hands-on opportunity to train the next-generation accelerator science and engineering workers on a world-class accelerator. In collaboration with the College of Natural Science and the College of Engineering, FRIB

attracts the best and brightest students into accelerator science and engineering.

FRIB Professor of Physics Steve Lund is the director of the USPAS. “MSU has been a superb host of USPAS. Courses are being held in unique facilities on campus and the departments have sent many talented students and have provided a high level of instructor and grader support,” Lund said.

USPAS sessions are held every year in June and January. USPAS students come from all a broad range of educational and practical experience. The courses are aimed toward upper-level undergraduates and graduate students. The students are highly selected and motivated. They are from laboratories, private companies, government, or the military. Some come from abroad. Some of the students have been working in the accelerator field and are expanding their skills to support and extend the latest technology as the field evolves.

The USPAS collaboration includes Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, SLAC National Accelerator Laboratory and Thomas Jefferson National Accelerator Facility, all U.S. DOE Office of Science labs; Los Alamos National Laboratory, a U.S. DOE National Nuclear Security Agency lab; Cornell University and Michigan State University.

FRIB hosts summer school on neutron-star mergers

Lecturer Luke Roberts (right) talks to attendees of the summer school.

FRIB hosted a summer school focused on the scientific discoveries resulting from the recent observation of a neutron-star merger.

The school, held from 16-18 May, was titled “Neutron star mergers for non-experts: GW170817 in the multi-messenger astronomy and FRIB eras.” It brought together graduate students, postdoctoral researchers, and senior scientific experts working in nuclear physics, astrophysics, astronomy, and related areas to discuss the impact of the merger on nuclear science

Students attending the summer school engage in a discussion.

More than 80 attendees from around the world came to the summer school, plus over 20 Zoom connections. Attendance was more than twice the originally expected number.

and nuclear astrophysics.

“This is a unique and unprecedented opportunity to bring all these subfields of physics together,” said the lead organizer, Professor Charles Horowitz of Indiana University.

Hosted by the FRIB Theory Alliance, a coalition of scientists from universities and national laboratories, this summer school had more than 80 attendees from around the world as well as over 20 Zoom connections. Attendance was more than twice the originally expected number.

The observation of this merger provides additional information for nuclear astrophysics, and it signals a new era in multi-messenger astronomy. This summer school was designed to allow a broader audience to better appreciate the developments resulting from the observation of the merger. Lecturers at the summer school were from Columbia University, Indiana University, Princeton University, the Canadian Institute for Theoretical Astrophysics, Joint Institute for Nuclear Astrophysics – Center for the Evolution of the Elements (JINA-CEE), and Michigan State University.

“This is a crash course covering the wide range of physics relevant to understanding neutron star mergers, and gravitational wave event GW170817 in particular. This will help to give the students the tools they need to connect the science of FRIB to gravitational wave observations and in the future contribute to our understanding of the properties of neutron stars and the origin of the heavy elements in our galaxy,” said Luke Roberts, a lecturer at the school.

FRIB Theory Alliance Managing Director Filomena Nunes said that “there was a tremendous and worldwide response when we sent out the announcement of the school, from truly passionate people who are now here learning more and sharing their excitement.”

JINA-CEE, a multi-institutional Physics Frontiers Center funded by the National Science Foundation (NSF), hosted livestream discussion on 1 December 2017 to discuss the nuclear science impacts of the merger.

MSU Cryogenic Initiative marks one year with growing interest

Participants in the cryogenic engineering course held during the U.S. Particle Accelerator School (USPAS) at MSU earlier this summer. This course was filled to capacity and more courses are being developed for MSU students interested in pursuing cryogenic engineering through the MSU Cryogenic Initiative.

In 2017, FRIB established the MSU Cryogenic Initiative with the MSU College of Engineering. The initiative combines classroom education with training on cutting-edge technologies and advancements in the cryogenic field that exist and are being implemented at FRIB. A concentration in cryogenic engineering has been recently added to the mechanical engineering undergraduate curriculum.

After its first year, the program is growing and garnering more interest. This fall there will be four graduate and two undergraduates enrolled in the program, and twelve students enrolled in the fall course, Mechanical Engineering 414, Mechanical Design of Cryogenic Systems. Additionally, the cryogenic engineering course held during the U.S. Particle Accelerator School (USPAS) at MSU earlier this summer was filled to capacity with 20 students from across the nation, and internationally, including students from government laboratories.

The program is led by Rao Ganni and Peter Knudsen, whose collective cryogenic engineering experience spans more than six decades. Ganni is the Director of the MSU Cryogenic Initiative and Knudsen is a senior cryogenic process engineer at FRIB. In addition, Nusair Hasan, who works with Ganni and Knudsen, has recently joined the Initiative. All organize and teach courses in the program.

Duncan Kroll, is a first-year graduate student 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.”

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.

The Initiative plans include continued collaboration with MSU’s mechanical engineering department to recruit students by exposing them to the unique opportunities that FRIB has to offer, and to develop curriculum and courses for both graduate and undergraduate students. Ganni, Knudsen, and Hasan plan to also continue mentoring and training students already involved in the program by serving as their dissertation/thesis advisors and co-advisors, and with the help of the Cryogenics Department staff, expose them to FRIB’s systems and equipment, and have them actively participate in the development of FRIB’s new cryogenic facilities.

“I have spent a year working as an intern for the cryogenics department and I can confirm that I have learned an enormous amount in that time,” said first-year PhD candidate Kyle Dinger. “In my experience it has been the most rewarding position I have held yet in my career.”

Dinger is pursuing a degree in mechanical engineering, and, like Kroll, would recommend the Cryogenic Initiative to others. “From the student perspective, there is no opportunity more attractive than to learn from the leaders of a field that is in demand.”

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

Accelerator Science and Engineering Traineeship program gaining momentum after first year

Chris Richard (left) talks with his advisor Steven Lidia as they inspect the controls for a system used to select ion-beam charge states at FRIB. Richard is a student in the Accelerator Science and Engineering Traineeship program. Photo credit Greg Kohuth, Michigan State University

In 2017, Michigan State University established an Accelerator Science and Engineering Traineeship (ASET) program to address a national shortage in accelerator scientists and engineers. ASET 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. Students who complete the curriculum will be certified, well-trained, and ready for productive ASET careers in DOE laboratory facilities and industry in discovery science and technology. Fulfilling these needs is critical to maintaining U.S. leadership in accelerator

technology and enhancing economic growth.

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 ten students are enrolled in the program, and five are enrolled for the fall 2018 semester. Current students say they were draw to the program for the opportunities it presents.

Elliot Lu, is pursuing a PhD in physics, with computational and theoretical accelerator physics his research topic. “The ASET program will sponsor me for internships at national labs, giving me research experience I could not otherwise gain at MSU. Such experience will both aid my PhD candidacy and be esteemed by future employers, whether in academia or industry.”

ASET student Chris Richard is pursuing a PhD in accelerator physics, studying non-relativistic beam instrumentation and diagnostics. “Participating in the ASET program has given me the opportunity to perform research at Fermilab working with the Proton Improvement Plan II Injector Test (PIP2IT) beamline. This has given me hands-on experience with beam instrumentation and machine operation at PIP2IT,” he said.

The Accelerator Traineeship Advisory Panel (ATAP) is a national advisory committee established to help guide the ASET program and its outcomes. Members are Alexander Chao (SLAC National Accelerator Laboratory – retired), Michael Harrison (Brookhaven National Laboratory), and Sergei Nagaitsev (Fermi National Accelerator Laboratory). ATAP held a meeting at FRIB in May to assess the effectiveness and efficiency of the ASET program at MSU, its relevance to the Department of Energy – Office of Science (DOE-OS) mission, and to provide recommendations to the FRIB Laboratory director.

ATAP found that ASET is performing well and is attracting students in all four areas of interest (physics and engineering of large accelerators, superconducting radio-frequency technology, radio-frequency power engineering, and large-scale cryogenic systems). The program is already exceeding its proposed enrollment count of students. Additionally, ATAP was pleased that there are accelerator science and technology students at MSU, not related to the ASET program, creating added value to the program and leveraging available resources. ATAP also was pleased with recruitment efforts, the new website, the connection to the U.S. Particle Accelerator School and to the Lee Teng Undergraduate Fellowship in Accelerator Science and Engineering program at Argonne National Laboratory and Fermi National Accelerator Laboratory. Finally, ATAP was impressed by the support from the physics-astronomy, electrical and computer-engineering, and mechanical-engineering graduate programs at MSU, and also supports the Accelerator Science and Engineering certification.

Looking ahead to year two of ASET, there are several second year goals that have been established to help enhance the program and provide additional benefits to students. One to two students will be recruited from the admitted pool of NSCL/FRIB students. In addition, courses will be added to the program including a new Physics 862 course (accelerator systems) in fall 2018 and a new electrical and computer engineering course (power engineering) in spring 2019. New cryogenics courses in mechanical engineering will be added as well.

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

NS3 Nuclear Science Summer School held 13-19 May at MSU

The National Superconducting Cyclotron Laboratory hosted the 2018 Nuclear Science Summer School (NS3) from 13-19 May. This is the third year for the annual educational event.

NSCL hosted the 2018 Nuclear Science Summer School (NS3) from 13-19 May. This is the third year for the annual educational event. Involvement in NS3 is funded by the National Science Foundation CAREER grant, NSCL, and the Joint Institute for Nuclear Astrophysics – Center for the Evolution of the Elements, and all of the students were fully supported for their participation.

At NS3, fifteen undergraduate students from eleven universities spent a full week at NSCL learning about nuclear science. Participants interacted with twenty lecturers and ten graduate students. The students had the opportunity to attend lectures from experts in the field, participate in hands-on activities, interact with graduate students, postdocs and faculty, and take a tour of NSCL and FRIB.

“The best thing about the school is to see the students’ transformation from curious but uncertain to excited and confident within a week,” said Associate Professor of Physics and NSCL Associate Director for Education and Outreach Artemis Spyrou. “Most students come from small physics departments around the country and it’s their first time interacting with such a large group of other interested students and researchers. And for us it is simply a joy to share our favorite nuclear physics topics with a group of enthusiastic young physicists.”

FRIB and NSCL open house set for 18 August

FRIB and NSCL are inviting the public to go behind the scenes during an open house scheduled for Saturday, 18 August. The event will run from 11 a.m. to 5 p.m., with last tours starting at 4 p.m. At the open house, attendees will have the opportunity to learn more about FRIB and NSCL, rare isotope research, and view FRIB project progress.

The open house is free and open to all ages, and no appointment is necessary to participate. Attendees will be able to view progress made in the establishment of FRIB, tour some currently operational experimental areas in NSCL that will

be used in FRIB experiments, explore the fields of FRIB and NSCL research with several hands-on activities and demonstrations, and meet nuclear scientists as they talk about their work on the frontiers of rare-isotope research.

Visit frib.msu.edu/openhouse2018 for the most up-to-date information as the event date approaches.

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LOOKING AHEAD

5-10 August	Nuclear Structure 2018 Conference in East Lansing, Michigan
10-11 August	Low Energy Community Meeting at FRIB/NSCL in East Lansing, Michigan
18 August	FRIB/NSCL Open House
2-4 October	Accelerator System Advisory Committee Review of FRIB
16-18 October	Experimental System Advisory Committee Review of FRIB
6-8 November	DOE Office of Project Assessment Review of FRIB

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Please email questions, comments, and contributions to communications@frib.msu.edu.

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Michigan State University is establishing FRIB as a scientific user facility for the Office of Nuclear Physics in the U.S. Department of Energy Office of Science.