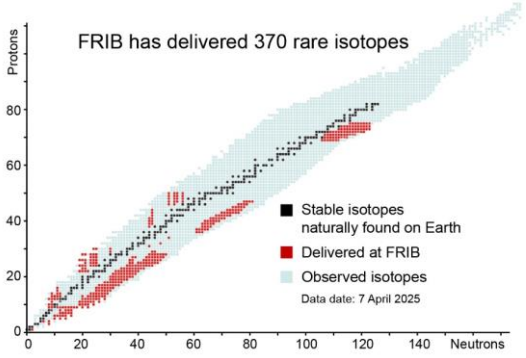
FACILITY FOR
RARE ISOTOPE BEAMS

April 2025

FRIB Quick Facts

Operating Most Powerful Heavy-Ion Accelerator

- Michigan State University operates the Facility for Rare Isotope Beams (FRIB) as a user facility for the U.S. Department of Energy Office of Science (DOE-SC), with financial support from and furthering the mission of the DOE-SC Office of Nuclear Physics.
- FRIB is the only accelerator-based DOE-SC user facility on a university campus. User facility operation is supported by the DOE-SC Office of Nuclear Physics as one of 28 DOE-SC user facilities.



Complex Systems Operating Reliably

- FRIB operates with 93% availability for scientific user experiments.
- FRIB's automation control system uses 22,000 input/output points to send and receive information for various machine functions.
- The controls network connects over 3,000 devices and tracks 1.3 million control values as fast as every few milliseconds, which are backed up every second for operators and experts to manage FRIB.
- FRIB uses artificial intelligence and machine learning's power to process immense data sets for experiments, theoretical studies, and the science and engineering to operate the instruments.

ISO Programs Keep Public Trust

- FRIB maintains management systems externally registered by NSF International Strategic Registrations (NSF-ISR) to the ISO 9001 (since 2008), ISO 14001 (since 2006), ISO 27001 (since 2018), and ISO 45001 (since 2007) standards. ISO registration ensures compliance and quality to external international standards.

Enabling Scientific Discoveries

- Since the start of user operation in May 2022, FRIB has:
  - delivered more than 370 rare isotope beams to experiments,
  - supported 840 participants, including 221 students, across 155 experiments, 22 countries, and 149 institutions.
- Published results available at frib.msu.edu/publications.
- FRIB is oversubscribed and can only accommodate a third of all requested time.
  - Since 2022, FRIB has received 251 proposals for beam time use.
- Currently, FRIB employs 556 employees, 152 graduate students, and 134 undergraduate students.

The Science

- Most elements are stable and naturally occurring on Earth.
- When neutrons are removed from or added to the nucleus of a stable atom it becomes more unstable, thus rare.
- Many rare isotopes exist only for fractions of seconds before they decay into a more stable form.
- Rare isotopes are not normally found in nature; most likely a majority of possible isotopes have not been discovered.
- Rare isotopes are forged in spectacular cosmic processes and in rare isotope accelerators.
- Operating the most powerful heavy-ion accelerator, FRIB enables scientists to make discoveries about the properties of rare isotopes, nuclear astrophysics, fundamental interactions, and applications for society, including in medicine, homeland security, and industry.

The Process

- At the beginning of the process, the ion sources heat the element to be studied, knock off electrons, and push the ionized atoms around with electric and magnetic fields to create beams that are injected into the linear accelerator.
- The 400 kW superconducting radio-frequency linear accelerator drives these charged particles down the track at ever-increasing speed, providing the highest intensity beams at half the speed of light.
- The beams arrive at the rare isotope production area where they strike a target and, when their nuclei collide, produce the rare isotopes.
- The isotopes advance to the experimental area where scientists conduct experiments with fast, stopped, and reaccelerated beams to measure the rare properties and give us unprecedented understanding of these rare isotopes.

Building

- Facility consists of 536,000 gross square feet, which includes 229,800 gross square feet of new construction
- Underground tunnel: 570 feet long, 70 feet wide, 13 feet high; floor: 32 feet underground

Learn more at frib.msu.edu

Michigan State University (MSU) operates the Facility for Rare Isotope Beams (FRIB) as a user facility for the U.S. Department of Energy Office of Science (DOE-SC), with financial support from and furthering the mission of the DOE-SC Office of Nuclear Physics.

- Approximately 1,800 scientists from 133 U.S. colleges and universities, 13 U.S. national laboratories, and 51 countries are organized in existing, independent FRIB Users Organization (fribusers.org).
- FRIB enhances capability based on scientific needs in a safe manner and consistent with available resources. Capabilities, including the beam list, are online at frib.msu.edu/beams.

FRIB Adds Value to Nation

FRIB Expertise Applied to National Need for Chip Testing

- The FRIB Single Event Effects (FSEE) Facility uses energetic and penetrating heavy-ion beams to measure the response of electronic components to such ions. This simulates in a few minutes the effect of cosmic rays on electronics over decades. Existing facilities are oversubscribed. The FSEE facility will provide up to 2,000 hours/year to users.
- The federal government awarded $14M to MSU to establish the K500 Chip Testing Facility at FRIB, which supports the refurbishment of the world's first superconducting cyclotron—built at MSU in the 1980s—into a heavy-ion chip testing facility. In June 2024, the MSU Board of Trustees authorized construction of a highbay addition to the K500 Chip Testing Facility.
- Student opportunities through the MSU Space Electronics Initiative started by FRIB and the MSU College of Engineering will position MSU as a national leader in chip design and testing and will develop the nation's workforce in these fields.

Isotope Harvesting Benefits Society

- Rare isotope harvesting provides additional discovery opportunity. During routine operation for its nuclear physics mission—without interfering with FRIB's primary users—extra, unused isotopes can be "harvested."
- Rare isotopes have a role in multiple fields of study, such as medicine, biochemistry, materials science, horticulture, and astrophysics.
- Isotope harvesting at FRIB is recommended by the Nuclear Science Advisory Committee Isotopes, a federally chartered advisory committee to DOE.
- The DOE Isotope Program (energy.gov/science/ip) awarded $13.2M for FRIB's isotope harvesting project to establish the capability and now supports operations and research.
- Project completed in December 2024.

Enhancements to Optimize FRIB Potential

"A New Era of Discovery: The 2023 Long Range Plan for Nuclear Science" (nuclearsciencefuture.org) recommends the following enhancements:

High Rigidity Spectrometer (HRS)

- HRS (hrs.lbl.gov) will have a significant benefit for FRIB's scientific program, extending the scientific reach to neutron-rich isotopes by a combined production-rate and luminosity increase of up to a factor of more than 100.The project is underway, and a user community of over 500 scientists supports HRS.

FRIB400 Energy Upgrade

- The FRIB400 energy upgrade (frib.msu.edu/frib400) will double its beam energy to 400 MeV/nucleon, expanding the scientific impact by increasing the yield of many rare isotopes tenfold. The science community laid out the opportunities in the FRIB400 whitepaper (frib.msu.edu/frib400paper).

Workforce Development

- Training of the next generation of scientists at a world-unique campus-based DOE-SC user facility is a unique experience and a top priority at FRIB.
- MSU's nuclear physics graduate program is a top-ranked program nationally, according to *U.S. News & World Report*.
- MSU awards 15 percent of nuclear physics doctorate degrees*.
- The median time to a physics PhD at MSU is 5.5 years; the national median time is 6.2 years.
- FRIB is the only accelerator-based DOE-SC user facility on a university campus for students studying accelerator science, cryogenic engineering and radiochemistry, all areas identified in federal advisory panel reports as in short supply for the nation, and critical to U.S. economic competitiveness, energy security, nuclear security, and nonproliferation efforts.
- FRIB collaborates with the MSU College of Natural Science and the MSU College of Engineering to attract the best and brightest students into accelerator science and engineering.

** Based on National Science Foundation National Center for Science and Engineering Statistics (NCSES) Survey of Earned Doctorates between 2018 and 2022*

Significant Dates

- December 2024 – Isotope harvesting project completed
- May 2022 – FRIB's first experiment commenced
- May 2022 – DOE officially opened FRIB with ribbon cutting
- January 2022 – FRIB completed on budget, ahead of schedule
- May 2009 – Project started
- December 2008 – DOE-SC selects MSU to establish FRIB

For More Information

- FRIB Laboratory: frib.msu.edu
- Tour information: (517) 355-9672
- FRIB Users Organization: fribusers.org

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