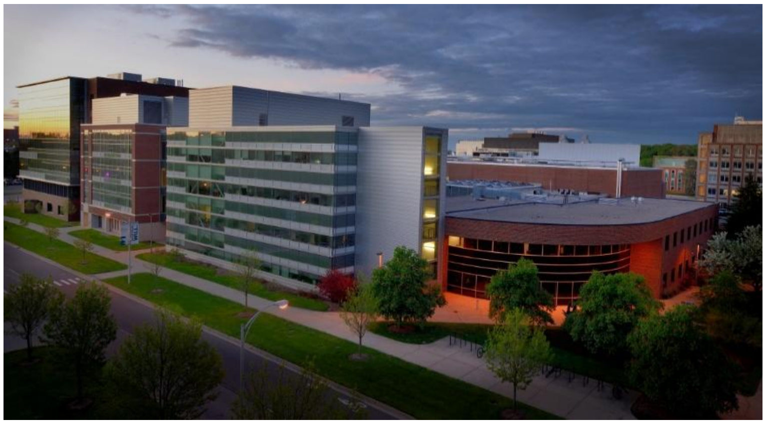
FACILITY FOR RARE ISOTOPE BEAMS

July 2026

Overview



U.S. Department of Energy Office of Science User Facility

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.

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.

FRIB's high-power superconducting linear accelerator (linac) accelerates all ions from hydrogen to uranium to at least 200 MeV/nucleon and produces rare isotopes by in-beam fragmentation. FRIB provides intense beams of rare isotopes (short-lived nuclei not normally found on Earth).

FRIB enables scientific research with fast, stopped, and reaccelerated rare isotope beams, supporting a community of 1,800 scientists.

Science

Particle accelerators, including the superconducting linear accelerator at the core of FRIB, enable the production and study of rare isotopes no longer found on Earth that have a host of basic and applied uses.

Each element has a specific number of protons, its atomic number. Most elements are stable and can be found on Earth, like oxygen (8 protons), carbon (6 protons), or calcium (20 protons). When neutrons are added to or removed from the stable nucleus of an element, it becomes more unstable and will decay.

While we are not sure exactly how many new isotopes remain to be discovered, it is pretty certain that a majority of isotopes have not been discovered. Many isotopes exist for only fractions of seconds before they decay towards stability.

Learn more at frib.msu.edu

How It Works

A beam of stable atomic nuclei is accelerated to half the speed of light and impinges on a thin target material. When the beam impacts the target, the resulting collision creates a number of reaction products, most with fewer protons and neutrons than the stable beam. (On occasion, a beam nucleus picks up a proton or neutron from the target material.)

Among those products are the rare isotopes requested by experimenters. This mixture continues to speed through the fragment separator, where a series of magnets selects the desired isotopes for study and sends them to the experimental area. Scientists use detectors to measure their unique properties or interaction with other nuclei.

Why It's Important

FRIB provides researchers with a vast unexplored terrain of more than 1,000 new rare isotopes never before produced on Earth—more than double what was previously possible. The same isotopes are needed to develop a predictive model of atomic nuclei and how they interact. Researchers using FRIB are able to improve our understanding of how atomic nuclei may be used to diagnose and cure diseases. Improved nuclear models and precision data allow optimization of the next generation of nuclear reactors and evaluation of techniques to destroy nuclear waste. They probe advanced materials to examine the processes involved on the nano- and micro-scale, providing insights into how materials are affected by radiation and other forces.

Modeling atomic nuclei and their interactions—a challenging problem in science—can also help lead to breakthroughs in energy, security, medicine, the environment, and more.

Approximately 1,800 scientists are organized in existing, independent FRIB Users Organization (fribusers.org).

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Rare isotopes are not normally found on Earth. Instead, they are forged in some of the most spectacular processes in the cosmos, including exploding stars known as supernovae.

FRIB Designed, Built, and Now Operates Highest-Energy, 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.

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 Operates 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, 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.

The facility consists of 536,000 gross square feet, which includes 229,800 gross square feet of new construction. The underground tunnel is 570 feet long, 70 feet wide, and 13 feet high; and the floor is 32 feet underground.

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.

Scaling Capability to Meet National Needs

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

Construction is underway on the High Transmission Beam Line (HTBL), to be completed in 2029. HTBL is one of two subprojects of the High Rigidity Spectrometer (HRS) (hrs.lbl.gov), a scientific instrument that will serve as the core of FRIB's fast-beam basic research program. With HRS, luminosity for experiments with the most neutron-rich nuclei will increase by up to a factor of 100.

The FRIB400 upgrade (frib.msu.edu/frib400) will double FRIB's beam energy to 400 MeV/nucleon and expand the laboratory's scientific impact by increasing the yield of many key rare isotopes tenfold. The community laid out the scientific case for the energy upgrade in the FRIB400 whitepaper.

These investments will significantly expand U.S. capacity for discovery, application, and scientific leadership.