FACILITY FOR RARE ISOTOPE BEAMS

April 2024

Overview

A 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), supporting the mission of the DOE-SC Office of Nuclear Physics. FRIB is the only accelerator-based 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. 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 heart of FRIB is a high-power superconducting linear accelerator (linac) that accelerates all ions from hydrogen to uranium to at least 200 MeV/nucleon and produces rare isotopes by in-beam fragmentation. FRIB enables scientific research with fast, stopped, and reaccelerated rare isotope beams, supporting a community of 1,800 scientists from around the world.

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. Rare isotopes are not normally found on Earth. Instead, they are forged in some of

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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

With FRIB we, for the first time, have the capability to produce most of the same rare isotopes that are created in the cosmos, which then decay into the elements found on Earth. This helps us understand the origins of the elements. 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.

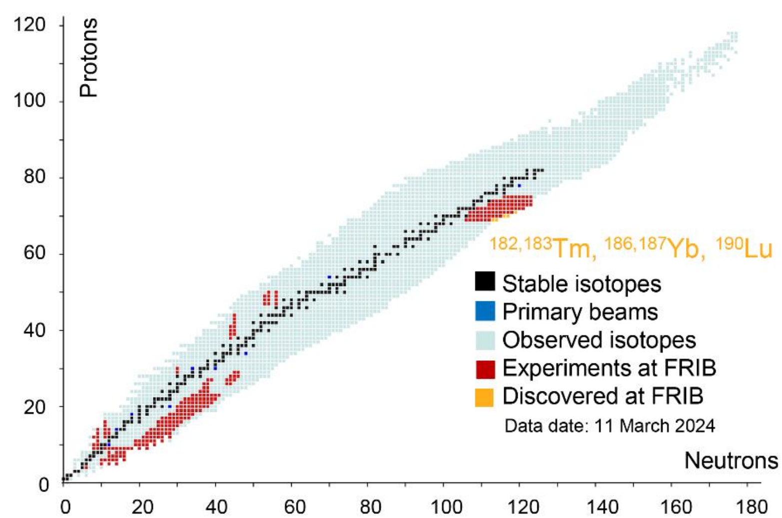
the most spectacular processes in the cosmos, including exploding stars known as supernovae.

FRIB Users Organization

Approximately 1,800 scientific users are engaged and ready for science at FRIB. They organized themselves in an independent FRIB Users Organization (fribusers.org), with 21 working groups specializing in instruments and scientific topics. Members are from 125 U.S. colleges and universities, 13 national laboratories, and 53 countries.

Since the start of user operation in May 2022, FRIB has delivered more than 260 rare isotope beams to experiments and supported 1,263 participants, including 340 students, across 89 experiments, 101 countries, and 354 institutions (including U.S. national laboratories, colleges, and universities: Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Lawrence Livermore National Laboratory, Argonne National Laboratory, Los Alamos National Laboratory, Mississippi State University, University of Tennessee Knoxville, Florida State University, Rutgers University, Ursinus College, and more; and the Institute for Basic Science (Korea), RIKEN (Japan), Gesellschaft für Schwerionenforschung (Germany); universities in the United Kingdom, Italy, France, Spain, Sweden, Canada, and many others).

Published results are available at frib.msu.edu/publications.



U.S. Department of Energy Office of Science

FRIB is supported by the Office of Science of the U.S. Department of Energy (science.energy.gov). The Office of Science is the single largest supporter of basic research in the physical sciences in the United States and is working to address some of the most pressing challenges of our time.

Workforce Development

Training the next generation of scientists at a world-unique campus-based DOE-SC user facility is a unique experience and top priority at FRIB.

MSU’s nuclear physics graduate program is a top-ranked program nationally, according to *U.S. News & World Report*.

The median time to a physics PhD at MSU is 5.4 years; the national median time is 6.2 years.

FRIB expands on MSU’s practice to involve undergraduate and graduate students in research. FRIB is the only accelerator-based 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.

For More Information

Visit frib.msu.edu

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