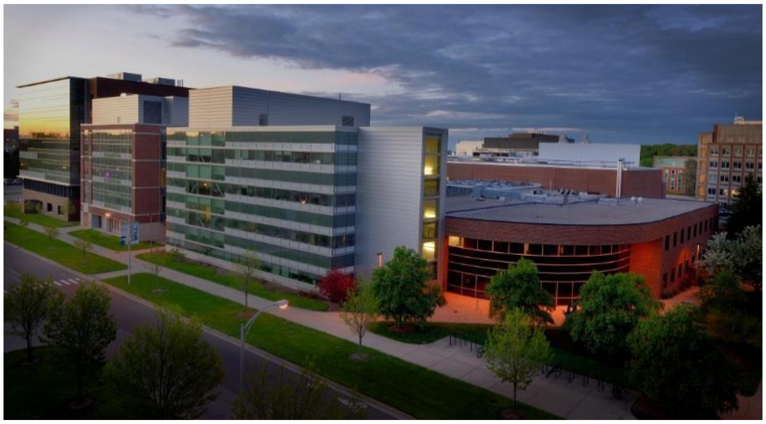
FACILITY FOR RARE ISOTOPE BEAMS

January 2025

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

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. Approximately 1,800 scientists from 134 U.S. colleges and universities, 13 national laboratories, and 51 countries are organized in existing, independent FRIB Users Organization (fribusers.org).

Learn more at frib.msu.edu