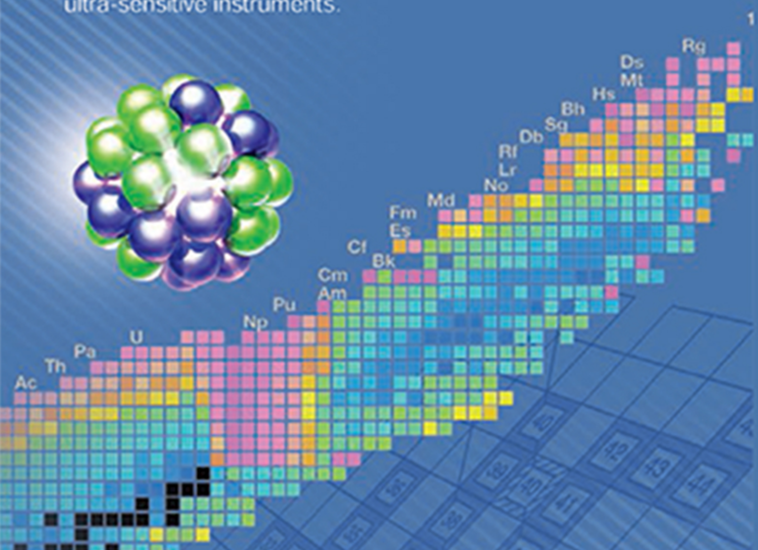
The Cornerstone for Discovery, for Innovation, for Solutions

Rare Isotope Science

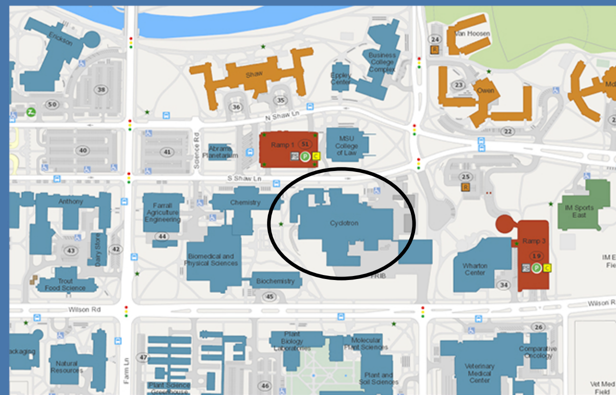
Atoms are the basic building blocks of nature, composing everything from stars and planets to people. At the center of every atom is a nucleus that is 10,000 times smaller than the atom itself, but contains more than 99.9% of its mass. Though much too small to see directly, scientists at NSCL study the nucleus by using sophisticated and ultra-sensitive instruments.



Every element is determined by the specific number of protons in its nucleus. Meanwhile, the number of its neutrons determines the isotope of the element.

The number of isotopes one can find naturally on earth is rather limited, but thousands can be made in the laboratory and even more are continually produced in the cosmos. Only about 300 isotopes are stable, all others decay into stable ones by emitting radiation. Short-lived "rare" isotopes can decay as fast as 1/100th of a second; other isotopes can live billions of years. NSCL is a world-leading rare isotope factory where nuclei are accelerated up to half the speed of light so that they can be fragmented to produce rare isotopes. Scientists investigate those isotopes to better understand the universe that we live in, how the elements on earth were made in the cosmos, and to determine which ones could be used to benefit society.

NSCL is located on the Michigan State University campus on the southwest corner of the intersection of South Shaw Lane and Bogue Street. Visitor parking is available at meters in the underground levels of the parking ramp to the north of the laboratory.



Operation of NSCL as a national user facility is supported by the U.S. National Science Foundation.

Each year, thousands of people visit NSCL, which offers tours, camps and education for students of all ages. For more information on these programs or to schedule a free 90 minute tour, phone (517) 355-9671 or email visits@nscl.msu.edu

Michigan State University

NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY

A world leader in rare isotope research and education.

640 South Shaw Lane
Michigan State University
East Lansing, Michigan 48824-1321
t: 517.355.9671
f: 517.353.5967

www.nscl.msu.edu

MSU is an affirmative-action, equal-opportunity institution.

Michigan State University

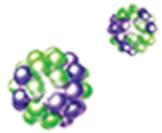
NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY

A world leader in rare isotope research and education

MICHIGAN STATE UNIVERSITY

NSCL

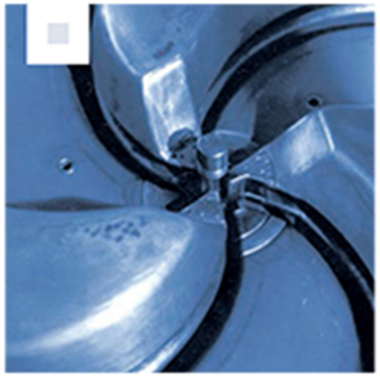
How NSCL Works



Acceleration

To study rare isotopes, we must first produce them. The Superconducting Source for Ions (SuSI) strips away some electrons from atoms in the source (metal vapors or gasses) to produce positive ions that can be manipulated with electric and magnetic fields.

The positive ions are injected into the K500 cyclotron, where a magnetic field up to 100,000 times stronger than the Earth's field bends their path into circular orbits. Each revolution, the ions receive three 140,000-volt electric jolts, which add energy and widen the orbit. The ions are then passed to the larger K1200 cyclotron, where they are stripped of more electrons and accelerated to speeds up to 93,000 miles per second, having travelled almost three miles in 0.00006 seconds.



Fragmentation

The speeding ions are fragmented on a thin foil. Most of them pass right through (it's hard to hit one nucleus with another), but some break apart to form various isotopes. Of those, a select few will be the exact isotope wanted for study.

Separation

Scientists separate the desired rare isotopes from other nuclear debris by a combination of magnetic lenses and prisms, analogous to filtering light of a desired color (wavelength) by means of a prism spectrograph. The A1900 Fragment Separator (designed and built at NSCL, as is much of the lab's equipment) can filter one particular isotope from a million billion nuclei in less than one millionth of a second.

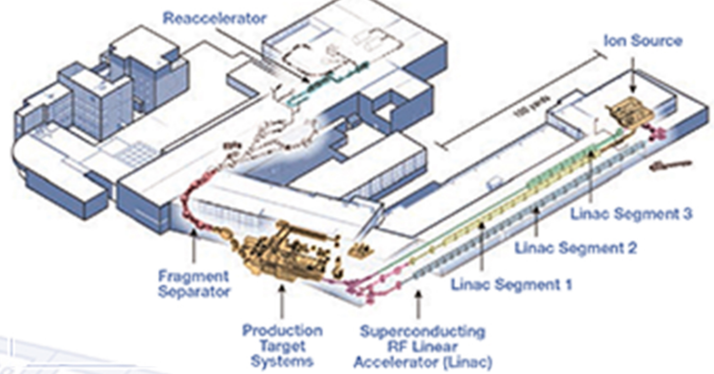
Exploration

The selected isotopes can be studied using sophisticated instruments designed for a wide variety of experiments. For example:

- The Low Energy Beam Ion Trap (LEBIT) uses a high-field magnet to weigh an isotope to one part in 100 million before it undergoes radioactive decay. This is equivalent to weighing a truck to determine whether the driver left a one-dollar bill in it or not – all within a fraction of a second before the truck might blow up.
- At three stories tall and 300 tons, the S800 Spectrograph can measure an isotope's velocity within 0.005 percent, which is like determining the speed of a 50 mile per hour car to within 0.04 inches per second.
- Slowed isotope beams from gas stoppers also can be sent to the BEam COoler and LAser (BECOLA) spectroscopy end station, where lasers are used to measure nuclear properties.
- The Reaccelerator (ReA) accelerates rare isotope ion beams from the thermal beam area to energies that closely resemble the temperatures found in stellar environments. It will be a prime instrument for nuclear astrophysics.

Facility for Rare Isotope Beams

FRIB



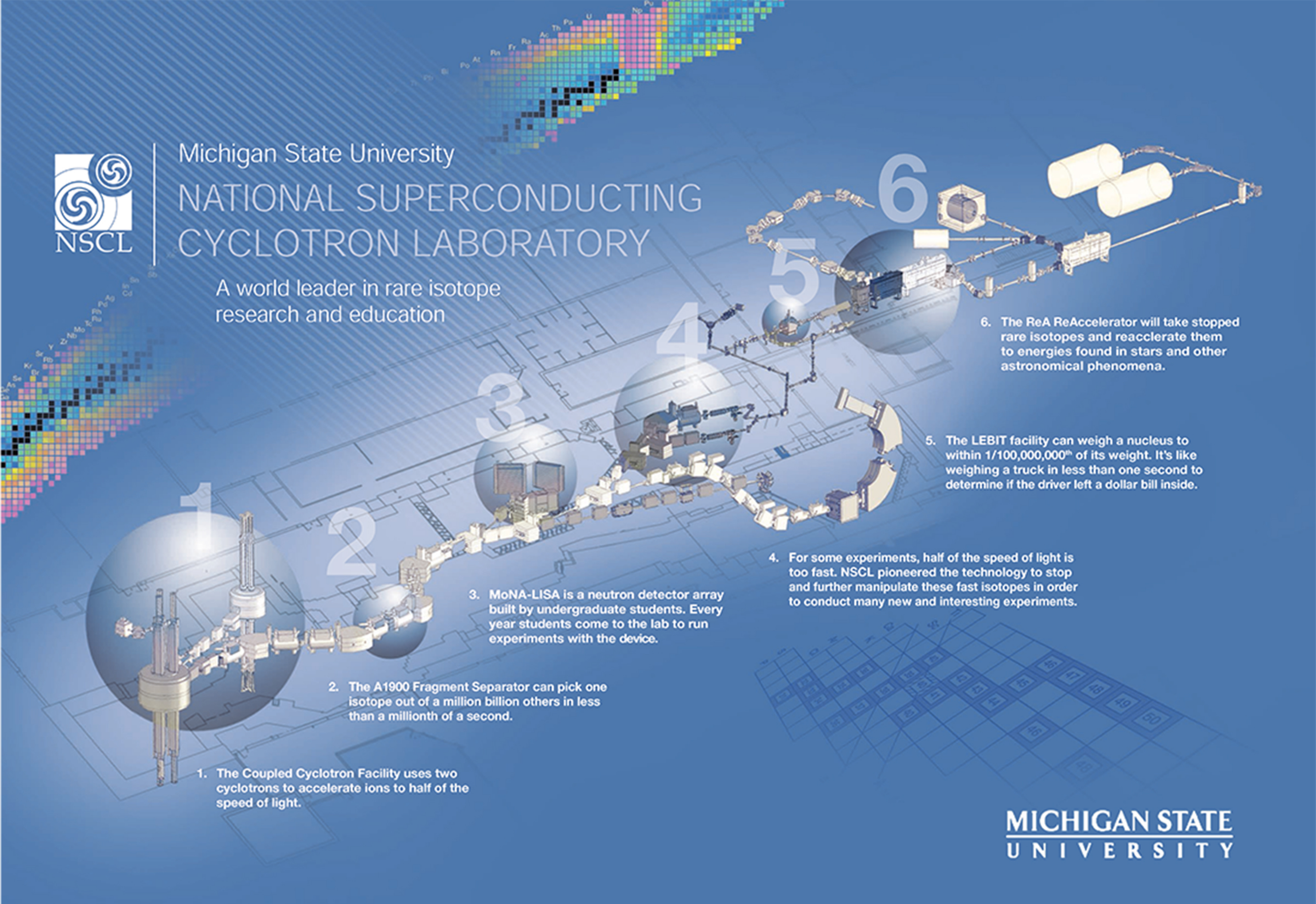
Nuclear Research at MSU

The National Science Foundation (NSF) currently provides more than $20 million each year to operate NSCL and support nuclear science research at MSU. NSF support for nuclear physics on campus dates back to 1961, when NSF approved construction of the K50 cyclotron.

Today, NSCL is the nation's flagship rare isotope user facility, serving over 700 researchers from more than 20 countries. It is also the nation's largest university-campus-based nuclear science laboratory, producing approximately 10% of the nation's Ph.D.s in nuclear physics and ranked the #1 nuclear physics graduate program by U.S. News & World Report. The laboratory employs more than 100 students and provides them with access to top-level research and educational experience.

The Future of NSCL

A rare isotope laboratory is only as good as the number and types of rare isotopes it can make available for research. On December 11, 2008, the Department of Energy announced that Michigan State University would be the site of a $680 million project called the Facility for Rare Isotope Beams (FRIB). FRIB will use a high-power superconducting linear accelerator to produce more rare isotopes and at much higher rates than possible anywhere else in the world. When FRIB turns on, NSCL's aging cyclotrons will be retired, while the detectors and research stations will remian in place. FRIB will fragment 400 billion nuclei every second at up to 57 percent of the speed of light, allowing it to complete experiments in hours that would take NSCL years. Scheduled for completion in 2021, FRIB will open the door to new, unexplored frontiers in nuclear science and many other fields of research.


Michigan State University
NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY
NSCL
A world leader in rare isotope research and education
1
2
3
4
5
6
1. The Coupled Cyclotron Facility uses two cyclotrons to accelerate ions to half of the speed of light.
2. The A1900 Fragment Separator can pick one isotope out of a million billion others in less than a millionth of a second.
3. MoNA-LISA is a neutron detector array built by undergraduate students. Every year students come to the lab to run experiments with the device.
4. For some experiments, half of the speed of light is too fast. NSCL pioneered the technology to stop and further manipulate these fast isotopes in order to conduct many new and interesting experiments.
5. The LEBIT facility can weigh a nucleus to within 1/100,000,000th of its weight. It's like weighing a truck in less than one second to determine if the driver left a dollar bill inside.
6. The ReA ReAccelerator will take stopped rare isotopes and reacclerate them to energies found in stars and other astronomical phenomena.
MICHIGAN STATE UNIVERSITY