

NSCL is a center for world-class rare isotope research and education. Scientists here are dedicated to studying the nature of the nucleus and the rules that govern its behavior. Each new discovery helps shed light on how nuclei have shaped our universe and ourselves.



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

Each year several thousand people visit NSCL, which offers tours, camps and research programs for students of all ages.

For more information on these programs or to schedule a free 90-minute tour,

call: (517) 355-9671

write to: visits@nscl.msu.edu

go to: www.nscl.msu.edu

The nuclear physics graduate program at MSU is consistently ranked one of the best in the country

The proposed next step for NSCL – the Facility for Rare Isotope Beams (FRIB) – will allow experimenters to study previously unattainable nuclei. FRIB-produced beams will allow researchers and students to answer questions at the frontier of nuclear science. The Facility will also yield a host of cross-disciplinary benefits in fields as diverse as biomedicine, materials science, national and international security, and nuclear energy.

The scientists who will take advantage of FRIB's capability are being trained today at NSCL, which awards 10 percent of U.S. nuclear science Ph.D.s. The nuclear physics graduate program at MSU is consistently ranked one of the best in the country. NSCL is committed to attracting, teaching and mentoring the next generation of scientists – work that will continue far into the future with the construction of FRIB.



NSCL is located on the Michigan State University campus near the intersection of Shaw Lane and Bogue Street.

Visitor parking is available in the lot to the east of the laboratory, while the ramp to the north can be used as overflow.

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NSCL Welcome

National Superconducting Cyclotron
Laboratory at Michigan State University

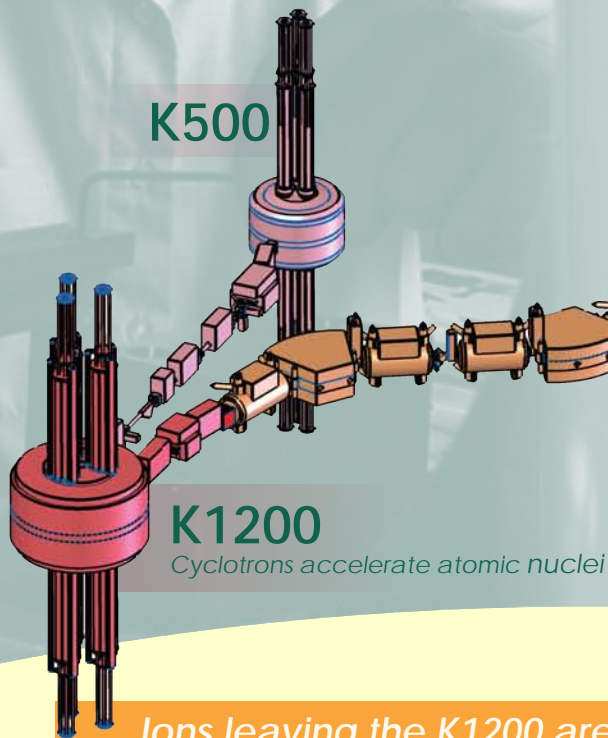


...a world-leading laboratory for rare isotope research and nuclear science education.

The Coupled Cyclotron Facility at NSCL

Ion sources feed partially-ionized atoms to the K500 cyclotron, which accelerates the ions up to 30,000 miles per second or 15 percent of the speed of light. The larger and more powerful K1200 cyclotron boosts the ions to half the speed of light.

The K500 is the world's first superconducting cyclotron



K500

K1200

Cyclotrons accelerate atomic nuclei

Ions leaving the K1200 are fast enough to circle the Earth four times every second

The A1900 can select one nucleus from a million billion others

The fast beam of ions then collides with a target, creating a wide variety of secondary isotopes. These isotopes are filtered with the A1900 fragment separator, which carefully selects certain nuclei from the fast beam that are rare and unstable isotopes.

A1900

A1900 fragment separator precisely selects rare isotopes for study

NSCL is the premier laboratory in North America for generating isotopes using the beam fragmentation method... The NSCL Coupled Cyclotron Facility serves as a focal point, both for the immediate generation of experiments, and for planning, design and possible construction of any future facility aimed at the succeeding generation of experiments using beams of unstable isotopes.

S800

Downstream detectors measure reaction products made when a beam of rare isotopes strikes a target

The S800 helped researchers discover the world's heaviest silicon, magnesium and aluminum isotopes

NSCL detectors measure properties of nuclei, which are far smaller than the tiniest thing that can be seen with a microscope. One example is the three-story, 300-ton S800 Spectrograph, located at one endpoint of a beamline. This device is used to determine properties of rare isotopes with high precision. Other detectors at NSCL can yield information about the structure of a nucleus, measure the mass of extremely short-lived isotopes, and explore the nuclear forces that govern how they interact.

- Arden L. Bement, Jr.
Director of the National Science Foundation

Outreach at NSCL

In keeping with our lab's commitment to education, NSCL offers many ways for classes, clubs and individuals to connect with our renowned researchers and facilities.

Laboratory Tours

Enjoy a free 90-minute tour behind the scenes of world-class rare isotope laboratory where nuclei are accelerated, smashed, filtered and studied. Tours are by appointment and can accommodate groups of 10-70 people from school age to retirees.

Physics of Atomic Nuclei (PAN)

PAN is a two-week residential nuclear science program for high school/middle school science teachers and high school students. Application to PAN is competitive, and is due by April 30 for the program to be held in July/August.

Catch a Cosmic Ray

High school physics classes can spend up to four hours at NSCL performing their own experiments on cosmic rays, with activities for the classroom before and afterward. Participating classes may be awarded funds to defray some travel costs.

NSCL outreach programs are co-sponsored by the Joint Institute for Nuclear Astrophysics (JINA) and Michigan State University, and funded by the National Science Foundation.

Learn Nuclear Science with Marbles

This downloadable hands-on lesson plan for grades 7-12 teaches nuclear astrophysics using models constructed from magnetic marbles. These lessons can also be used in conjunction with a field trip to NSCL.

NSCL Open House

Every 1-2 years NSCL offers an afternoon of free activities to show hundreds of visitors behind the scenes of our research facility. Learn more about plans for the next Open House at the website below.

Students in Research

High school and college students can get involved with experiments at NSCL through the HSHSP and REU programs. Working closely with a faculty member, students pursue cutting-edge research in a world-class laboratory.

Learn more about these programs online at www.nscl.msu.edu/outreach or contact visits@nscl.msu.



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Research at NSCL

To probe the mysteries of an atom's nucleus is to seek fundamental answers about how the elements were formed and what keeps nuclei together. Nuclear scientists pursue these big mysteries by smashing and examining the tiniest of particles. Collisions at half the speed of light create new isotopes in a billionth of a trillionth of one second. To do this, researchers need particle accelerators, state-of-the-art computers, and specially designed equipment.

Creating something new

Research at NSCL concentrates on the study of exotic nuclei, one of the current frontiers in nuclear science. Compared to the more familiar stable nuclei, these exotic nuclei have large excesses of either protons or neutrons and tend to decay quickly, sometimes within fractions of a second. Experimental groups use the world-leading capabilities of cyclotrons at NSCL to produce exotic nuclei through fragmentation of accelerated stable nuclei bombarding a solid target. In less than a microsecond, the exotic fragments are transported to experimental stations where a wide range of experiments can be carried out using state-of-the-art equipment.

Dissecting the nucleus

Some experiments are designed to discover a new nucleus, while others capture known nuclei to study their decay or measure their mass. Yet other experiments use the exotic nuclei to bombard another target and study the ensuing nuclear reactions. This can reveal information about the internal structure of the nucleus or the behavior of nuclear matter under the extreme temperatures and densities triggered in a nuclear collision.

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Constructing nuclear theory

Experiments have already revealed many surprising properties of exotic nuclei, such as the formation of a neutron halo around the dense central part of the nucleus. Many more remain to be discovered. NSCL theorists are working closely with experimentalists to interpret these results and to use exotic nuclei to uncover hidden aspects of the nuclear force that holds together all atomic nuclei. Understanding this force and building a theory that can predict the properties of nuclei is one of the ultimate goals in nuclear science.

Probing the stars

Exotic nuclei also play an important role in astrophysics. They are created in stellar explosions such as X-ray bursts and supernovae, and they may exist inside neutron stars. Often the decays of exotic nuclei are intermediate steps in the astrophysical processes that created the elements in nature. Many NSCL groups work at the intersection of nuclear physics and astrophysics to explain astronomical observations concerning the origin of the elements, the nature of stellar explosions, and the properties of neutron stars. This research is the result of combined NSCL experiments, nuclear theories, astrophysical models, and observations.

Learn more about these programs at www.nscl.msu.edu/science or contact visits@nscl.msu.edu



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NSCL considers safety and environmental stewardship to be top priorities. NSCL has established written Environmental and Occupational Safety management systems that are registered as compliant with International Standards Organization (ISO) 14001 and Occupation Health and Safety Assessment Series (OHSAS) 18001.

Safety at NSCL

NSCL's Environmental Management System (EMS) earned MSU the first Clean Corporate Citizen designation for a university from the State of Michigan. These registered management systems assure NSCL complies with applicable regulations, and requires continuous improvement of its operations to provide the safest possible workplace while providing the smallest environmental impact.

Things to know before your visit:

- No eating, drinking or smoking during the tour.
- High-heeled shoes are not permitted on the tour.
- Stay with your tour guide and follow instructions.
- Watch your head and step; don't lean on railings.
- Tour guides are trained to ensure your safety and will provide any required Personal Protective Equipment (PPE) during your visit along with direction when and how to use.
- If an evacuation alarm is sounded, immediately follow your guide or other yellow hat emergency team member to the nearest exit and assemble next to the parking ramp north of NSCL.
- If you become separated from your tour group, pick up the nearest facility telephone and dial "0". The operator will send assistance to your location.
- In an emergency, call 911 from any phone.



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If you have questions or require more information, do not hesitate to contact the following NSCL personnel:

Tours:

Dr. Zachary Constan
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Phone (517) 333-6363 • Office N107

General safety:

Terry Monahan, CSP
NSCL Environment, Safety & Health Manager
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Radiation safety:

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Phone (517) 333-6378 • Office N104

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NSCL Visitor Safety

National Superconducting Cyclotron
Laboratory at Michigan State University



*...a world-leading laboratory
for rare isotope research and
nuclear science education.*

Safety Guidelines for Visitors at NSCL

Security

The NSCL building is a “controlled area.” Within the building there are “restricted areas” established for occupational safety and radiation protection. In order to ensure your safety, immediately prior to your tour a radiation and hazard survey was performed of the planned tour route. You are authorized to traverse the controlled area as dictated by the needs of your visit. You may not enter restricted areas unless accompanied by an appropriately trained NSCL staff member.

Radiation Safety

Radiation consists of energy or small particles, such as gamma rays and beta and alpha particles, emitted from radioactive materials. Radiation can cause chemical or physical damage in living tissue. When the quantity of radiation energy deposited in living tissue is high enough, biological damage can occur from chemical bonds being broken and cells being damaged or killed. These effects can result in observable clinical symptoms.

Radiation Dose

Radiation dose is a measure of energy absorption in material such as tissue exposed to radiation. Biological risk, which depends on the type of radiation, its energy and duration, and the organs exposed, is assigned to the dose.

The rem is the unit of dose used to estimate biological risk. The unit millirem (mrem), equal to 1/1000 rem, is often used.

NSCL contains radiation-producing devices such as accelerators, ion sources, specialized equipment and test facilities. Some components were made radioactive by beams or fragments of beams. Commercial radioactive sources are used to test instruments.

Radiation doses to visitors and workers at NSCL are regulated by the US Nuclear Regulatory Commission and by the State of Michigan:

1. Visitors who enter restricted areas are subject to “public” dose limits if the purpose of their visit does not include exposure to radiation:
 - Less than 2 mrem in any one hour from external radiation sources
 - Less than 100 mrem in a calendar year from both external and internal sources of radiation.
2. Visitors to restricted areas whose assigned duties involve radiation exposure are subject to “occupational” dose limits.
 - Occupational exposures may not exceed 5,000 mrem per year.
 - Radiation safety training is required.
3. Your dose will be kept As Low As Reasonably Achievable (ALARA). NSCL and MSU commit to keeping doses to less than 10% of appropriate limits.

Your tour will encounter only very low levels of radiation. The following table shows sources of radiation that may be encountered by the average person, the doses from those sources, along with a comparison to the dose received during a visitor tour of NSCL.

Radiation source	Hourly dose (mrem/hr)	Annual dose (mrem/yr)
Tour of NSCL	less than 0.02 (avg)	0.02 (one tour)
Natural sources	0.034	300
Airline flight	0.5 (typical)	
Smoking	0.7	850 (pack/day)
Dental x-ray	1-2 (per set)	1-2 (once/yr)
Average public exposure		400 (300 natural + 100 artificial)

Other Restricted Area Hazards

- High magnetic fields - may affect medical implants. Warning signage indicates where these fields are present.
- Electrical hazards - NSCL has a written Electrical Safety Policy that provides hazard mitigation and guidance.
- Chemical hazards - NSCL follows MSU's written Chemical Hygiene Plan.
- Slip, trip or fall hazards - are mitigated through signage, training, and barriers.
- Eye hazards - Personal Protective Equipment (PPE) is provided where hazards may occur.
- Overhead hazards - employees and visitors are alerted by local warning signs and lights.
- Material handling hazards – only authorized personnel may operate fork lifts and cranes. Pinch points are identified and controls implemented wherever possible.
- High noise areas - NSCL complies with the MSU Hearing Conservation Program, and noise surveys have been conducted. Warning signage and PPE are in place.