# Scoping Meeting Objectives and Agenda

## SCOPING MEETING OBJECTIVES

The objectives of the Facility for Rare Isotope Beams Environmental Assessment (FRIB EA) scoping meeting are to:

- inform stakeholders about the proposed action to build the FRIB on the campus of Michigan State University (MSU); and
- solicit relevant, focused input from stakeholders on the scope of the FRIB EA, including identification of a range of reasonable alternatives and environmental issues to be analyzed.

## SCOPING PROCESS

To encourage meaningful public involvement, the U.S. Department of Energy (DOE) is sponsoring a public meeting in the vicinity of the proposed action for the construction and operation of the FRIB. The purpose of this meeting is to provide participants the opportunity to meet officials from the DOE Office of Science (SC) and MSU, who are working cooperatively to prepare the EA, as well as design the FRIB to ensure it meets DOE's mission requirements and allows the United States to maintain its leadership in the fields of nuclear astrophysics, nuclear structure, and fundamental symmetries. The results of the scoping meeting will be a better understanding among members of the public of the proposed action, input on the scope of the FRIB EA, and a better understanding within DOE of public preferences and/or concerns.

A court reporter will transcribe the comments provided during the formal comment phase. Comments obtained at this scoping meeting, as well as oral and written comments obtained from other communication mechanisms, will be given equal consideration in defining the scope of the FRIB EA.

### Scoping Meeting Agenda

**Registration: 6:30 p.m.**
- Receive registration packet
- Sign-up to provide comments
- View exhibits, review information materials, and speak with subject matter experts

**Presentation: 7:00 p.m.**
- Welcome and introductions
- FRIB project
- Questions and answers

**Formal Comment Period: 8:00 p.m. – 10:00 p.m.**
- Participants provide comments
- Concluding remarks
- Comments captured by a court reporter

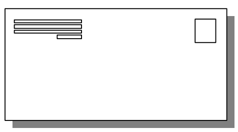
NOTE: Times are approximate and are subject to change based on meeting attendance levels.

OVER→

# Opportunities for Public Comment

The U.S. Department of Energy (DOE) and Michigan State University (MSU) are fully committed to providing the public access to information about its activities and opportunities for involvement in preparing the Facility for Rare Isotope Beams Environmental Assessment (FRIB EA). Accordingly, DOE is soliciting written and oral comments on the proposed scope and issues that should be addressed in the FRIB EA.

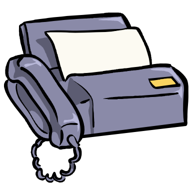
A variety of methods listed below are available for providing comment. All comments received by close of business December 11, 2009, both written and oral, will be equally considered when developing the draft FRIB EA. Late comments will be considered to the extent practicable.



FRIB Comments
U.S. Department of Energy (STS)
9800 South Cass Avenue
Argonne, IL 60439

Web site: http://www.frib.msu.edu/NEPA/

E-mail: frib.comments@ch.doe.gov



Written comments may be submitted by faxing to our 24-hour toll-free number: 1-888-676-3672

Participants in the public meetings will have access to the following tools to assist them in submitting written and oral comments:

*Project Staff*: To answer questions and discuss issues
*Comment Forms*: To prepare and submit written comments
*Court Reporter*: To record oral comments

# Facility for Rare Isotope Beams Environmental Assessment

## PURPOSE AND NEED

The U.S. Department of Energy (DOE) has a mission to advance our basic understanding of science. Scientific research at a Facility for Rare Isotope Beams (FRIB) holds the promise to vastly expand our understanding of nuclear astrophysics and nuclear structure. DOE determined that the establishment of the FRIB is a high priority for the future of U.S. nuclear science research. The FRIB establishes a highly sophisticated research laboratory that would produce intense beams of rare isotopes. These beams enable scientists to study the nuclear reactions that power stars and generate the elements found on earth; explore the structure of the nuclei of atoms, which form the core of all matter and the forces that bind them together; test current theories about the fundamental nature of matter; and play a role in developing new nuclear medicines and other societal applications of rare isotopes.

The FRIB concept has undergone numerous studies and assessments within DOE and by independent parties such as the National Research Council of the National Academy of Sciences. These studies—in addition to the joint DOE and National Science Foundation, Nuclear Science Advisory Committee 2007 Long Range Plan—concluded that such a facility is a vital part of the U.S. nuclear science portfolio, complements existing and planned international efforts, and will provide capabilities unmatched elsewhere.

## PROPOSED ACTION AND ALTERNATIVES

A Notice of Intent (NOI) was published in the *Federal Register* on October 27, 2009, announcing DOE's intention of preparing an environmental assessment (EA) to evaluate the potential environmental impacts of the proposal to construct and operate the FRIB on approximately 10 acres on the Michigan State University (MSU) campus in East Lansing. Its design is comprised of buildings and/or building additions for a heavy ion/proton accelerator and ancillary laboratories, support facilities such as a cryomodule, and offices. Construction would occur on campus, adjacent to the existing National Superconducting Cyclotron Laboratory (NSCL), which would ultimately be subsumed into FRIB. The function, scope, and licensing of operations of FRIB would be similar to NSCL, but FRIB would have substantially more power.

Most of the structures that would house the accelerator would be thick-walled, reinforced concrete structures. The heavy ion linear accelerator (linac) would be located in a tunnel below grade. A trench (varying between 30 and 75 feet below grade up to 1,800 feet long) would be excavated for the accelerator, necessitating that Bogue Street be closed between Wilson Road and East Shaw Lane two years and portions of East Shaw Lane possibly to be closed for a number of months. The high-energy end of the accelerator would join with the existing NSCL building.

The National Environmental Policy Act (NEPA) requires that Federal agencies consider a range of reasonable alternatives for implementing a proposed action. The FRIB EA will analyze the following preliminary alternatives; however, public input during the scoping period may result in the addition of other alternatives:

- No action alternative (i.e., maintain current research capability at NSCL and do not proceed with the proposed FRIB). NEPA requires agencies to consider a no action alternative.
- Build and operate the proposed FRIB at MSU. Two configurations are under consideration: a straight linac and a folded linac.

## PRELIMINARY IDENTIFICATION OF ENVIRONMENTAL ISSUES

In the EA, DOE will examine public health and safety effects and environmental impacts from the construction and operation of the proposed FRIB at MSU. DOE has tentatively identified a list of potential environmental issues for analysis. It is not intended to be comprehensive or to imply any predetermination of impacts but serves as a starting point for the public when considering their comments. These issues include:

- impacts from construction accidents;
- impacts to both workers and the public from potential exposure to radiation and other hazards under routine operations and credible accident scenarios including natural disasters (e.g., floods, hurricanes, tornadoes, and seismic events);
- transportation-related impacts;
- impacts on surface and groundwater and on water use and quality;
- impacts on air and soil;
- socioeconomic impacts;
- disproportionately high and adverse impacts on minority and low income populations;
- impacts on land-use plans, policies and controls, and visual resources;
- pollution prevention and waste management practices and activities;
- unavoidable adverse impacts, and irreversible and irretrievable commitments of resources;
- cumulative environmental effects of past, present, and reasonably foreseeable future actions;
- status of compliance with all applicable Federal, state and local statutes and regulations, international agreements, and required Federal and state environmental permits, consultations, and notifications; and
- impacts of intentional destructive acts, including sabotage and terrorism.

Because the proposed site is adjacent to a currently operating accelerator facility and would involve digging and construction in previously disturbed areas now occupied primarily by parking lots and roads, impacts in several areas are expected to be minor. These impact areas will therefore not be evaluated in detail:

- impacts on protected, threatened, endangered, or sensitive species of animals or plants, or their critical habitats;
- impacts on cultural or historic resources; and
- impacts on floodplains and wetlands.

## DECISIONS TO BE MADE

Environmental consequences are of great importance to DOE in this endeavor and will be an integral part of the decision-making process. If at any time during preparation of the EA DOE determines that potentially significant environmental impacts might occur with the implementation of the proposed action and that an environmental impact statement (EIS) would be needed, DOE will issue an NOI in the *Federal Register*.

No decisions will be made in the EA itself; however, the decision whether to build the FRIB will be made based on the analyses, as well as public comment. Should the analysis indicate no significant environmental impacts DOE will issue a finding of no significant impact (FONSI).

## PUBLIC INVOLVEMENT

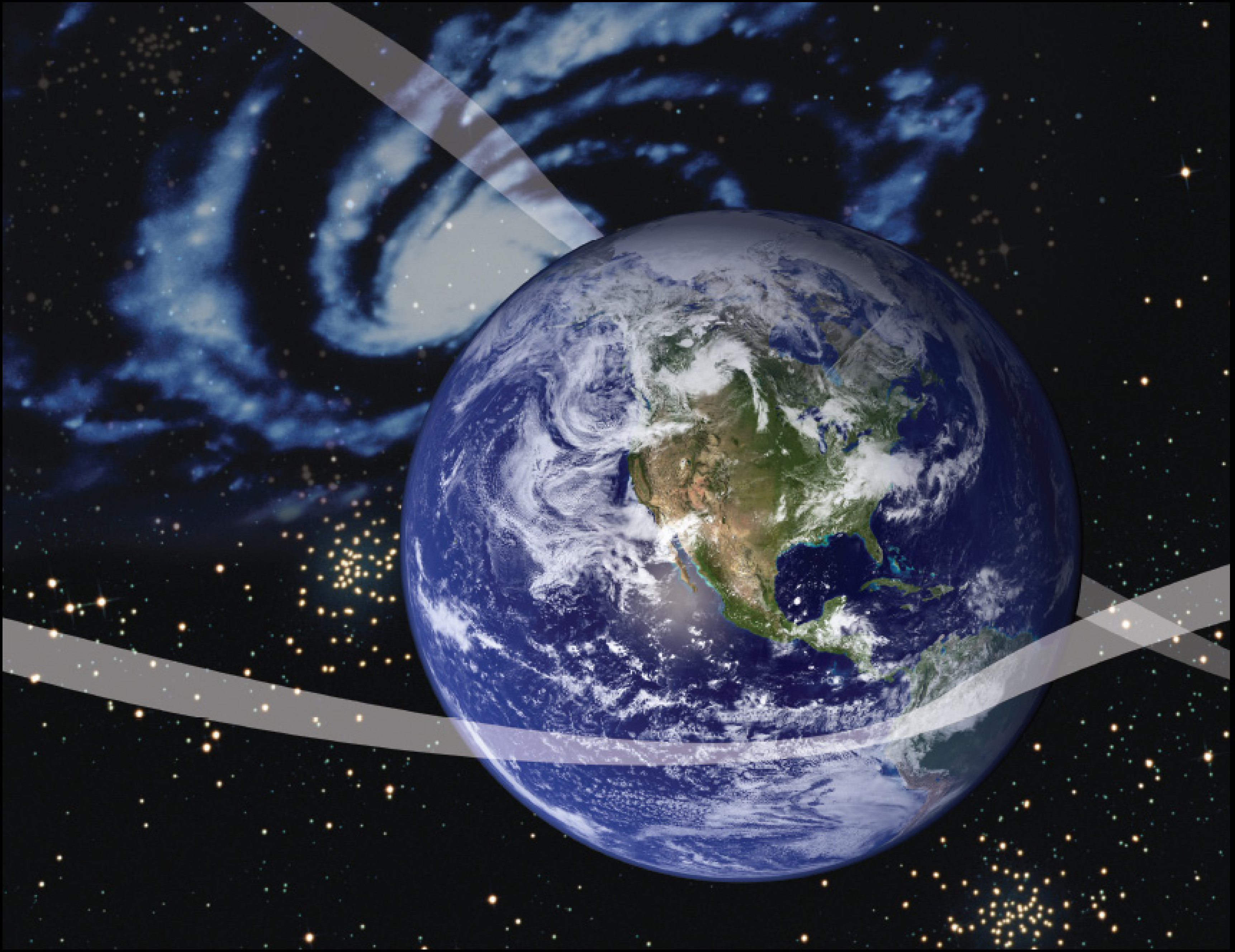
DOE is currently soliciting public input on the scope of the FRIB EA and holding a public meeting to facilitate public participation. In addition to providing oral comments or submitting written comments at the meeting, the following communication mechanisms are available. All comments, both oral and written, received during the scoping period (October 27 through December 11, 2009), will be given equal consideration.

**U.S. MAIL:** FRIB Comments
U.S. Department of Energy (STS)
9800 South Cass Avenue
Argonne, IL 60439

**E-MAIL:** frib.comments@ch.doe.gov
**ONLINE:** http://www.frib.msu.edu/NEPA
**TOLL-FREE FAX**: 1-888-676-3672

# Journey Into the Heart of Matter

The Department of Energy's Office of Science Office of Nuclear Physics



# Nuclear physics is a quest to understand the origin, evolution and structure of the matter of the universe that leads to stars, the Earth and us.

## Introduction

Through research, nuclear physicists are leading us on a journey of discovery into the nucleus of the atom – the very heart of matter. The goal is a roadmap of matter that will help unlock the secrets of how the universe is put together.

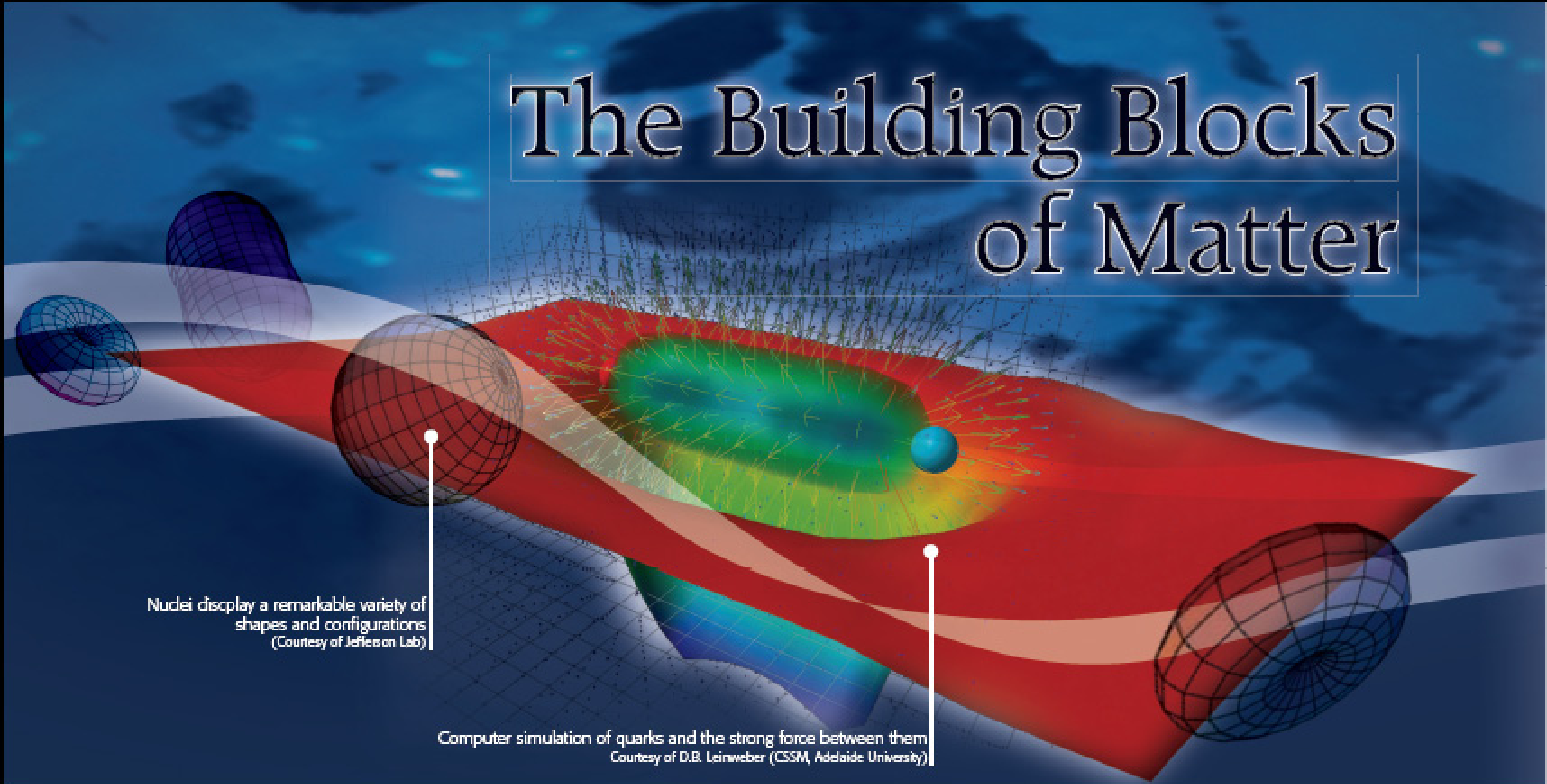
The Office of Nuclear Physics in the Department of Energy's (DOE's) Office of Science supports the experimental and theoretical research needed to create this roadmap. This quest requires a broad approach to different, but related, scientific frontiers: improving our understanding of the building blocks of matter; discovering the origins of nuclei; and identifying the forces that transform matter. Stewardship of the field is shared with the National Science Foundation's (NSF's) Nuclear Physics Program. DOE and NSF fund almost all basic research in nuclear physics.

Funding for nuclear physics provides leading-edge instrumentation, world-class facilities, and training and support for the people involved in these pursuits. The result is a vast array of information that is helping us understand the universe at ever-deeper levels.

Forefront nuclear physics research provides solid foundations for other fields: the accumulation of new results and the intellectual training of new generations of scientists foster important advances in medicine, chemistry and other sciences.

Join us on our journey into the heart of matter and learn how nuclear physicists are creating a roadmap of the evolution and structure matter that will benefit our nation for generations.

# The Building Blocks of Matter



Nuclei discplay a remarkable variety of shapes and configurations
(Courtesy of Jefferson Lab)

Computer simulation of quarks and the strong force between them
Courtesy of D.B. Leinweber (CSSM, Adelaide University)

## A Journey in Space

Nearly all of what we see in the universe, from people to stars, gets its mass from nuclei. As we zoom into smaller and smaller dimensions, from human hearts to cells, from molecules to atoms, we reach the nucleus at the center of an atom surrounded by a cloud of electrons. If an atom were the size of a football stadium, its nucleus would be about the size of a marble. Despite its tiny dimensions, the nucleus accounts for 99.9% of an atom's mass.

The microscopes that scientists use for peering into a nucleus are accelerators that bounce energetic particles or other nuclei from the nucleus, breaking pieces off of it or adding energy to it. The detectors used to look at these collisions reveal that nuclei are turbulent, active environments. Protons and neutrons swirl around each other at up to half the speed of light in a cosmic dance that gives rise to a remarkable range and diversity of shapes and configurations.

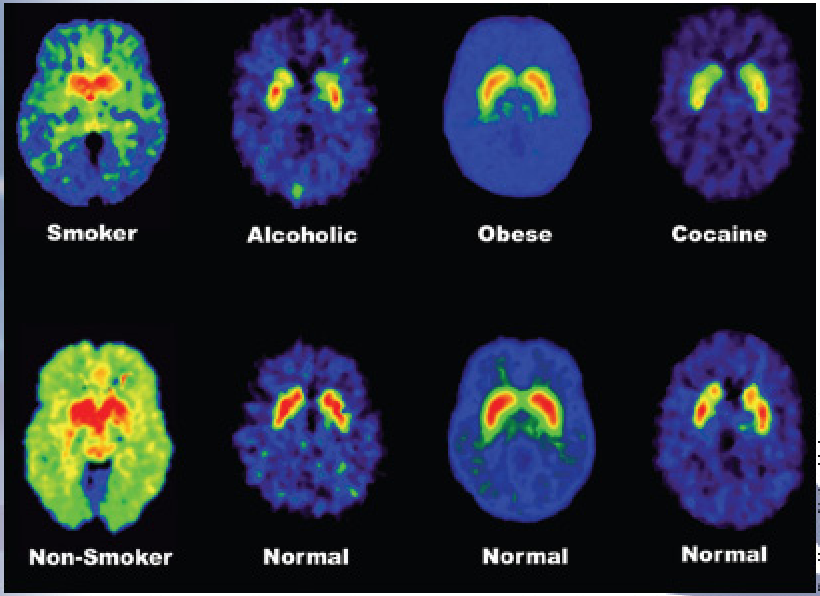
For example, nuclei containing up to some 100 protons and 150 neutrons have been found, but one extraordinary puzzle is that a nucleus with 250 constituents is about the same size as one special case containing just 11. To study such diverse behavior, nuclear physicists are using accelerators to create "designer nuclei." Finding simple, reproducible patterns among the many complex behaviors of both designer and ordinary nuclei will allow us to better understand how and why certain chemical elements are found on Earth and in stars.

Going one level deeper, nuclear physicists are looking at the building blocks of protons and neutrons: quarks and gluons. The theory of Quantum Chromodynamics, or QCD, describes how quarks exchange gluons, much the way children toss a ball back and forth. According to QCD, this exchange of gluons binds quarks together via the strong force. This force is so strong that when pried even a little

## Nuclear Physics Applications

The precise knowledge of nuclear materials and nuclear reactions gained through basic research in nuclear physics has yielded many benefits for society, including:

- radiation therapy for eradicating cancer while shielding healthy tissues from harm
- medical imaging technologies such as X-ray, MRI and PET
- the potential for abundant nuclear power and safer ways to dispose of nuclear waste
- radiation detectors for screening cargo and protecting our national security




Brookhaven National Laboratory

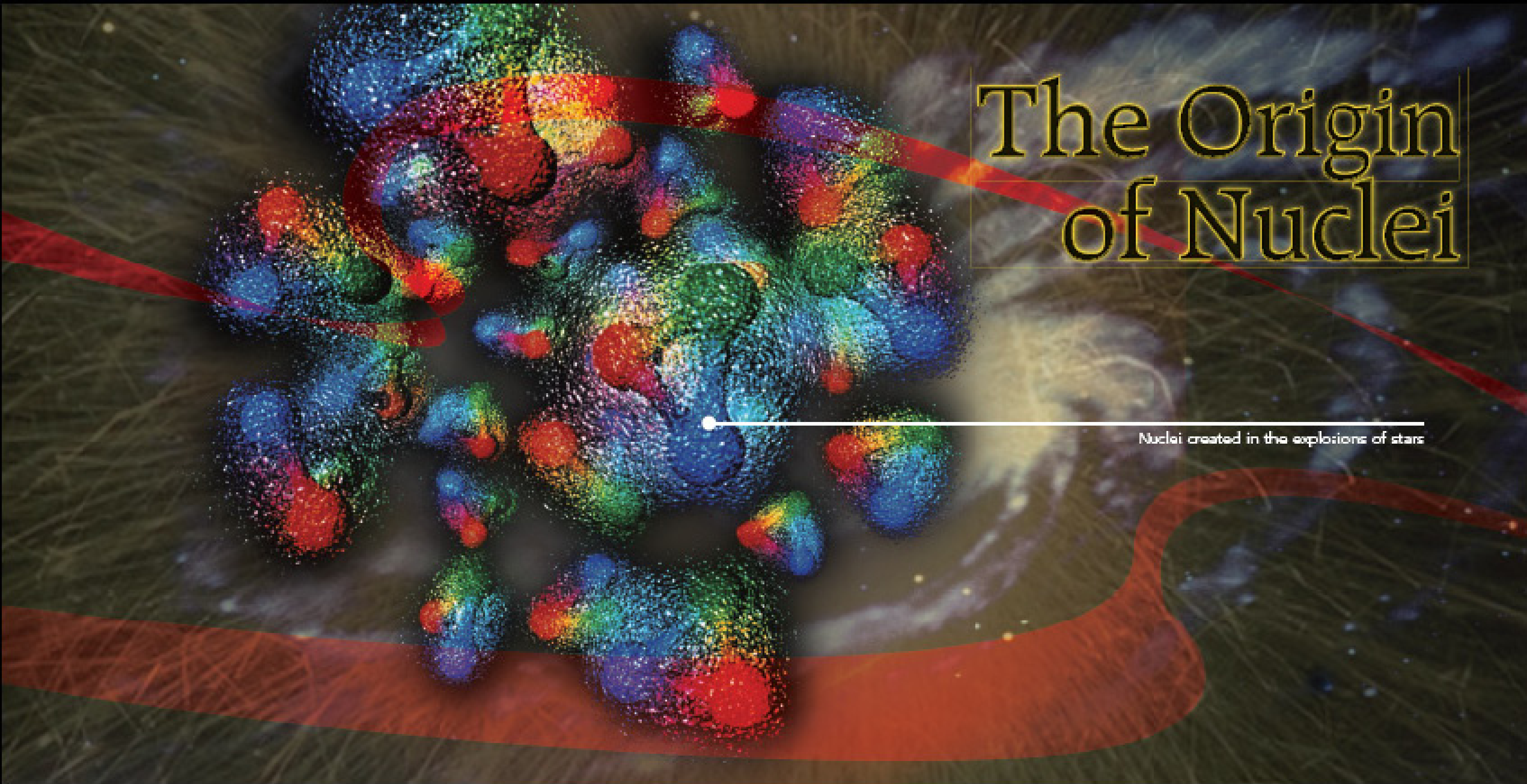
As a by-product of building and using accelerators, pioneering nuclear physicists have also developed new tools to peer inside the human body. Using radiotracers and positron emission tomography (PET) scanners developed by nuclear physicists, biochemical clues have been identified for a range of addictive behaviors including smoking, alcoholism, overeating, and drug abuse. The PET scans reveal that people with addictions have fewer receptors for one of the brain's "pleasure" chemicals and may be attempting to compensate for a blunted pleasure response by taking drugs.

apart, quarks experience many tons of force pulling them together again.

As a result, protons and neutrons are hot, bubbling cauldrons of activity. Quarks and gluons jiggle around inside at nearly light-speed, and extra gluons and quark/anti-quark pairs may even pop into existence one moment only to disappear the next. It is this flurry of activity, fueled by the energy of the gluons, that generates nearly all the mass of protons and neutrons and thus ultimately of all the matter we see. One of the most bewildering questions nuclear physicists are trying to answer is how the basic properties of protons and neutrons like mass, shape and spin come about from this flood of gluons, quark/anti-quark pairs and a few ever-present quarks.

Scientists are also investigating how the strong force that glues quarks and gluons together influences nuclear properties. A small fraction of that force leaks out beyond the edges of protons and neutrons and binds them together to form nuclei. Thus, the very same force that makes a proton or a neutron also generates nuclei. We are only beginning to understand how this "leakage" occurs and how it results in the impressive variety of nuclei found in nature.

*Nuclear physicists study the building blocks of nuclei that make up 99.9% of the mass of our everyday world.*




## A Journey Through Time

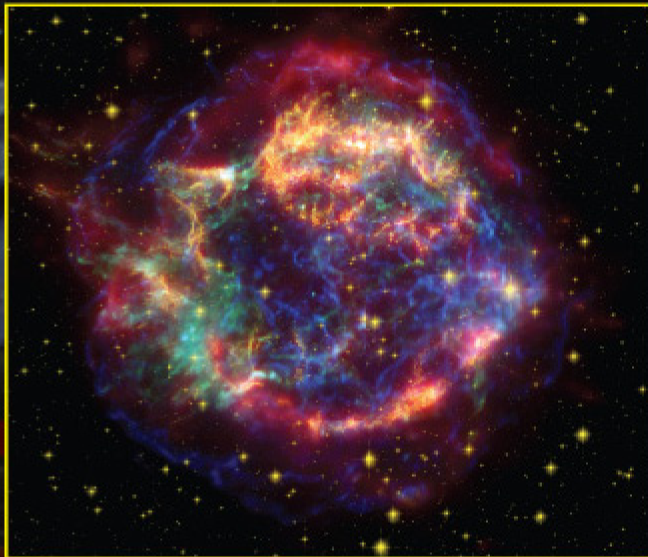
When you examine the matter surrounding us, you are seeing material distilled in the hearts of stars. Tracing the origin of the carbon in your blood or the calcium in your bones is a journey through time.

More than 15 billion years ago, the Big Bang produced a scorching-hot fireball of the most basic particles. A few millionths of a second later, just as hot water vapor condenses to liquid, some of the simplest components of the matter we see today — protons and neutrons — formed as the primordial fireball expanded and cooled. For the first time since this unique event, nuclear physicists are now recreating in the laboratory the matter that existed in that first fraction of a second of the universe's life to learn how it condensed into protons and neutrons.

One of the greatest mysteries scientists are exploring is why the pure energy of the Big Bang did not turn into equal amounts of matter and antimatter. Antimatter is extremely rare in nature. Experiments in nuclear physics are helping to reveal secrets of the forces that acted during the universe's earliest moments to find out why.

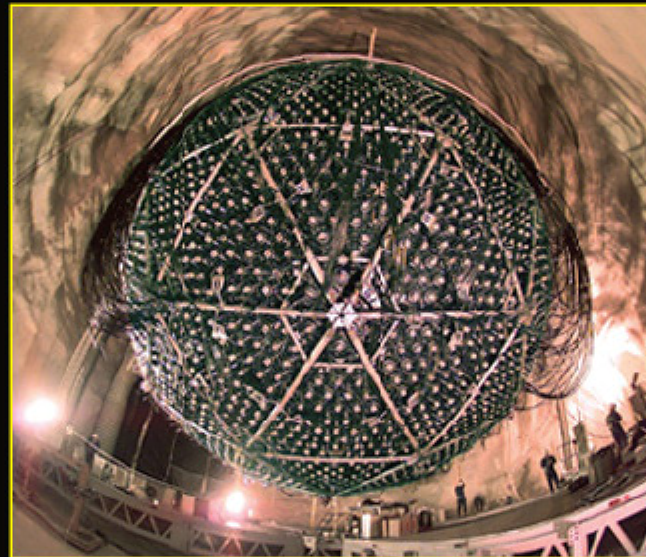
In the minutes following the Big Bang, the first, simplest nuclei formed. Gravity exerted its sway on the swirling gas of atoms and formed clumps of hydrogen atoms, which compressed, heated and started to fuse and glow. A new light shone in the formerly dark universe, powered by the energy of nuclear reactions. As the stars evolved, these nuclear reactions produced heavier and heavier nuclei.

Relatively small stars like our sun burn steadily for billions of years, creating the conditions needed for life. Nuclear physics experiments can detect not only the light from the surface of our sun but also ghost-



NASA/JPL-Caltech/O. Krause (Steward Observatory)

Using tools like the NSCL at Michigan State University, ATLAS at Argonne National Laboratory and HRIBF at Oak Ridge National Laboratory nuclear physicists are deciphering the processes by which supernova explosions create elements.



Ernest Orlando Lawrence Berkeley National Laboratory

Neutrinos are produced in vast numbers in some nuclear reactions, such as those that occur in the processes that light the stars and in the nuclear power plants that light our cities. But neutrinos rarely interact with other matter. They can pass through the entire Earth without interacting with a single atom. Neutrinos get even stranger: they can morph into one of three different types and back again. These properties make neutrinos notoriously difficult to study — and fascinating. The Sudbury Neutrino Detector, located over one mile underground (pictured above), provided the first direct evidence that neutrinos change as they travel from the core of the sun to the Earth.

like neutrinos that emerge from the fiery nuclear reactions at its core. These experiments are confirming our picture of the sun. They have also revealed that neutrinos change their nature during their 93-million-mile journey to Earth. This "oscillation" from one neutrino type to another demonstrates that neutrinos have mass. While that mass is tiny, there are so many neutrinos in the cosmos that their total mass may outweigh that of the visible stars.

Large stars burn up quickly and can end their lives in catastrophic explosions. Supernovas, which briefly shine brighter than an entire galaxy of stars, may be the source of over half the elements heavier than iron and may create additional short-lived nuclei, such as those containing extra neutrons. Fingerprints of these unusual nuclei can be seen in the chemical distribution of the elements on Earth.

However, this story can only be partly told: simulated supernovas in today's computer models fail to explode at all. What does nature know about the properties of neutrinos and nuclei that we do not? Through nuclear physics research, scientists are aiming to find out.

*Massive detectors enable nuclear physicists to study the processes that allowed matter to form after the Big Bang and learn about the origin of nuclei and the ultimate fate of stars.*

# Changing Matter

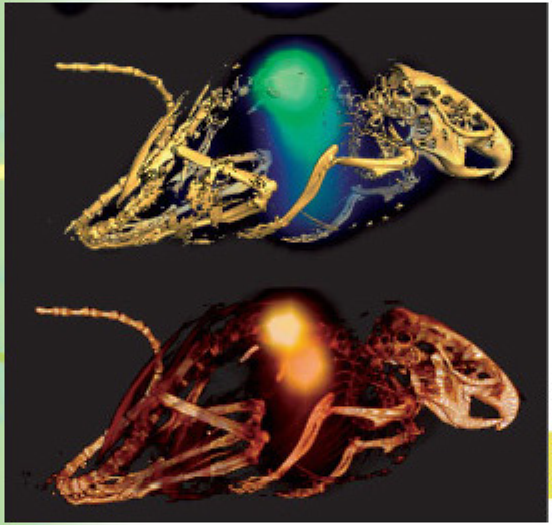
## A Journey to the Extremes

What happens when you boil water? Bend metal? Burn wood? Throughout human history, scientific thinkers have asked questions about what happens when you change matter. Even babies act as scientists, pushing and pulling on everything around them to learn how things work. Such experimentation is essential to our survival and often helps us gain control of our world.

In experiments using powerful particle accelerators, nuclear physicists poke and prod nuclei by colliding atoms or subatomic particles to discover what happens when these packets of particles are heated to extreme temperatures under extreme pressure. These experiments are allowing scientists to change things in a predictable way, so they can see what happens as conditions like temperature and density vary, observe at what point significant changes occur, and determine how to control the transitions. It's much like being able to watch the evolution of the universe on "videotape" — rewinding, fast-forwarding and freeze-framing to better understand what transpired.

Nuclear physicists are also probing matter at larger scales to see nuclei we have never seen before, how nuclei transform themselves from one type to another, how long they live, and how to detect such a change has taken place.

Future facilities will allow scientists to create the neutron-rich exotic nuclei that may be formed in supernovas to understand how elements are produced in the universe. They are also aiming to create nuclei with exotic species of quarks. Most nuclei in nature are primarily made of "up" and "down" quarks. Nuclear physicists are creating nuclei



Oak Ridge National Lab

The knowledge of unstable nuclei is allowing the collaboration of Oak Ridge National Lab, Jefferson Lab and Johns Hopkins University to develop a small-animal imager that collects metabolic and structural images of mice as they move freely within a very small space. Scientists are developing a similar system for medical imaging of children, eliminating the need for sedation.

with a third species of quark, "strange" quarks, to probe how the force that holds the nucleus together changes when different building blocks are used to make nuclei.

Today's experiments are only just beginning to allow nuclear physicists to examine the properties of these exotic nuclei, and tomorrow offers even more exciting possibilities. New advances in accelerator technology pioneered by this scientific community have made it possible to plan new facilities that can cook up fresh batches of star-stuff. This will help us understand, for example, why the sun burns as brightly as it does and how long it's likely to continue. It may also help us discover which nuclei might be used as tiny specialists to journey into our bodies to diagnose disease and vanish once their job is done.

*Accelerators allow nuclear physicists to study matter under different conditions to learn how its building blocks interact and combine to form more complex particles and materials, helping scientists search for new ways to benefit society.*

# Nuclear Science Education

## Profiles in Nuclear Physics

**Jennifer Thomas**, a Naval Officer with HSL-49, the Helicopter Anti-Submarine Squadron Light, served in 2005 aboard the USS Ingraham, deployed with Expeditionary Strike Group One in support of the Global War on Terrorism. She is an Aircraft Commander flying SH-60B Seahawk helicopters. Her leadership, reasoning skills and hands-on technical experience were developed while studying for her master's degree in instrumentation from the State University of New York at Stonybrook. That experience enabled her to build large detector systems for nuclear physics experiments at Brookhaven National Lab and prepared her for a successful career in the Navy.

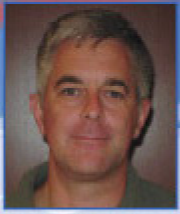
## Investing in Our Nation's Future

Nuclear science is a key component of the Nation's research capabilities. In addition to providing fundamental insights into the origin, evolution and structure of matter, nuclear scientists create knowledge and devices that are directly applicable to the nation's energy resources, security safeguards, health needs, environmental protection and economic vitality. Students with nuclear science training become the skilled workforce necessary for the many industries that apply nuclear science and related technologies.

Research and development for homeland security is an important application of nuclear science. Detection systems based on the very same technologies developed in nuclear physics experiments are providing important techniques for efficiently and unobtrusively screening transport containers at our nation's borders. These methods draw heavily on nuclear science expertise in detector development, experimental simulation, source design and analysis.

Declining oil reserves and mounting concerns about greenhouse gases and global warming are making nuclear power more attractive as a reliable source of energy for the future. Nuclear science faculty educate and train nuclear power engineers. Responsible stewardship of the Nation's nuclear power industry relies on a capably trained nuclear science workforce.

The growing field of nuclear medicine has its origin in nuclear science. Applications developed in the last 50 years include beams of ionizing radiation, magnetic resonance imaging, and radionuclides for medical imaging. These techniques, for example, enable the early detection of cancer and detailed studies of how the brain and heart function.



**David Fields** began his career in experimental nuclear physics, gaining experience in detection and sensor hardware and analysis of complex data. He has worked at Lawrence Livermore National Laboratory and the Defense Advanced Research Projects Agency (DARPA), managing research programs focusing on weapons, weapons physics, non-lethal systems, land mine detection, sensors, and communications. As an independent government contractor, he now supports defense, intelligence, and homeland security organizations. His undergraduate research in nuclear physics at Tennessee Technological University was supported by the DOE. Fields has a Ph.D. in physics from Michigan State University, and he credits his Ph.D. training with enhancing his ability to grasp complex physical concepts in diverse disciplines and to parse problems and projects.

**Roland Henry** is pioneering new MRI techniques to study brain structure and function at the Center for Molecular and Functional Imaging in the University of California, San Francisco Radiology Department. These studies include neurological disorders like brain tumors, Multiple Sclerosis, and Amyotrophic Lateral Sclerosis (ALS), as well as normal and abnormal development of the neonatal brain. As an associate professor, he is also teaching and training a new generation of biomedical engineers in the Graduate Program in Bioengineering at UC's Berkeley and San Francisco campuses. His skill at extracting signals from large backgrounds was developed by taking some of the first measurements of highly elongated heavy nuclei using efficient gamma-ray detectors at Argonne National Lab. He is the second person originally from Belize to received a Ph.D. in physics (1992).

**Ani Aprahamian** is the Chair of the Department of Physics at the University of Notre Dame and the Director of the Institute for Structure and Nuclear Astrophysics. She is investigating how the properties of nuclei can affect the distributions of the "star stuff" that we are all made of. She is presently measuring the half-lives of the most neutron-rich nuclei made in the laboratory. These measurements provide crucial historical information about our universe. At the same time, Aprahamian and her graduate students are investigating the role long-lived states (isomers) in nuclear reactions have on neutron stars. These studies lead to a wide range of potential applications – from medicine to energy storage to basic nuclear science. Aprahamian earned her Ph.D. from Clark University.

Diagnostic techniques with roots in nuclear science become even more important as our society ages.

Students in nuclear science gain a broad range of skills that are invaluable to the workforce, including problem solving, mining of data from large data sets, working in teams, advanced theoretical modeling and mathematical skills, and computer simulation of complex systems. Over two-thirds of nuclear science graduates find employment outside of academia, representing a significant transfer of knowledge to meet society's needs.

Advanced education in nuclear science has contributed to America's prosperity and technological advances for more than half a century. A robust educational system supporting and training the best U.S. scientists and engineers and attracting outstanding students and scientists from other nations is essential for producing a world-class workforce.

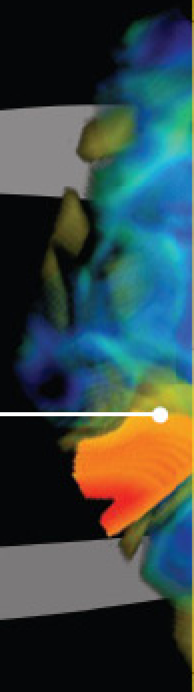
*Nuclear scientists fill a variety of roles in government and industry in careers ranging from finance to medical physics.*

The Department of Energy's Office of Nuclear Physics is the primary funding agency for the quest to understand the origin, evolution and structure of the matter in the universe leading to the stars, the Earth and us.

The Department of Energy's Office of Nuclear Physics supports national labs and university research groups and provides research tools utilized by the national and international research community. These trailblazers are adding to the knowledge base of humankind, developing new technologies, training the next generation of scientists, and improving the science literacy of the general public.

From the question of how it all began, to what the far future holds, from dissecting things we can observe in the universe, to searching for things unseen, nuclear physicists are testing the boundaries of our knowledge. The only way to find out where these experiments might lead is to keep moving forward with the endeavor to explore and understand the heart of matter.

For more information, visit: www.science.doe.gov/feature/NP.htm



Computer simulation of fluctuations in the strong force
Coutesy: Brookhaven National Lab

This brochure was collaboratively prepared by participants from Argonne National Lab, Brookhaven National Lab, Jefferson Lab, Lawrence Berkeley National Lab, Oak Ridge National Lab, Massachusetts Institute of Technology, Michigan State University, National Science Foundation and the University of Maryland using funds from the Office of Nuclear Physics.

# Glossary of Technical Terms

**absorber:** Any material that stops ionizing radiation. Lead, concrete, and steel attenuate gamma rays. A thin sheet of paper or metal will stop or absorb alpha particles and most beta particles.

**accelerator:** Device used to increase the energy of particles, which then collide with other particles. Major types are linear accelerators and circular accelerators. The name refers to the path taken by the accelerated particle.

**atom:** A particle of matter indivisible by chemical means. It is the fundamental building block of molecules. It consists of a positively charged nucleus and orbiting electrons. The number of electrons is the same as the number of protons in the nucleus.

**atomic number:** *Z*, the total number of protons found in a nucleus.

**beta particle (beta radiation, beta ray):** An electron of either positive charge ($e^+$ or b+) or negative charge (e, $e^-$ or b-) emitted by an atomic nucleus or neutron in the process of a transformation. Beta particles are more penetrating than alpha particles but less than gamma rays or x-rays. Electron capture is a form of beta decay.

**Big Bang:** Beginning of the universe; a transition from conditions of unimaginable density and temperature to conditions of lower density and temperature.

**cryogenic:** The branches of physics and engineering that involve the study of very low temperatures, how to produce them, and how materials behave at those temperatures. Cryogenic cooling of devices and material is usually achieved via the use of liquid nitrogen, liquid helium, or a cryocompressor (which uses high pressure helium lines).

**cyclotron:** Circular accelerator in which the particle is bent in traveling through a magnetic field, and an oscillating potential difference causes the particles to gain energy.

**decay (radioactive):** The change of one radioactive nuclide into a different nuclide by the spontaneous emission of radiation such as alpha, beta, or gamma rays, or by electron capture. The end product is a less energetic, more stable nucleus. Each decay process has a definite half-life.

**detector:** A device or series of devices to used to measure nuclear particles and radiations.

**dose:** A general term denoting the effect of absorption of a quantity of radiation or energy absorbed.

**electron:** An elementary particle with a unit electrical charge and a mass 1/1837 that of the proton. Electrons surround an atom’s positively charged nucleus and determine that atom’s chemical properties.

**electron capture:** A radioactive decay process in which an orbital electron is captured by and merges with the nucleus. The mass number is unchanged, but the atomic number is decreased by one.

**electronvolt (eV):** A unit of energy equal to the kinetic energy (or energy of motion) an electron gains when being accelerated through a potential difference on 1 volt. Another unit of energy is the joule and 1 joule equals 6.2415E18 eV. One joule is roughly the energy needed to lift 1 kg (2.2 pounds) on the surface of the earth by 0.1 meter (4 inches). **keV:** One thousand electronvolts. **MeV:** One million electronvolts.

**gamma ray:** A highly penetrating type of nuclear radiation, similar to x-radiation, except that it comes from within the nucleus of an atom, and, in general, has a shorter wavelength.

**half-life:** The time in which half the (large number of) atoms of a particular radioactive nuclide disintegrate. The half-life is a characteristic property of each radioactive isotope.

**ion:** An atomic particle that is electrically charged, either negatively or positively.

**isotope:** Isotopes of a given element have the same atomic number (same number of protons in their nuclei) but different mass numbers (different number of neutrons in their nuclei). $^{238}U$ and $^{235}U$ are isotopes of uranium.

**linac:** Another name for a linear accelerator.

**linear accelerator:** Particle accelerator laid out in a straight line. FRIB will have a linear accelerator. An alternative considered is a folded linear accelerator.

**mass number:** The total number of protons and neutrons in the nucleus**:** $A=Z+N$. This is also the total nucleon number of the

**nuclear reaction:** A reaction involving an atomic nucleus. It is usually initiated by bombarding a target nucleus with a radiation, called a projectile. The interaction of the radiation with the nucleus may cause the emission of other radiations, called ejectiles.

**neutron:** One of the basic particles that make up a nucleus. A neutron and a proton have about the same mass, but the neutron has no electrical charge.

**neutron number:** The total number of neutrons in the nucleus, N.

**nucleon:** A constituent of the nucleus; that is, a proton or a neutron.

**nucleus:** The core of the atom, where most of its mass and all of its positive charge is concentrated. Except for $^{1}H$, the nucleus consists of a combination of protons and neutrons.

**nuclide:** Any species of atom that exists for a measurable length of time. A nuclide can be distinguished by its atomic mass, atomic number, and energy state.

**proton:** One of the basic particles that makes up an atom. The proton is found in the nucleus and has a positive electrical charge equal to the negative charge of an electron and a mass similar to that of a neutron**:** a hydrogen nucleus.

**proton number:** The total number of protons in the nucleus, Z.

**radioactive waste:** Materials that are radioactive and for which there is no further use.

**radioactivity:** The spontaneous decay or disintegration of an unstable atomic nucleus accompanied by the emission of radiation.

**shielding:** A protective barrier, usually a dense material, that reduces the passage of radiation from radioactive materials to the surroundings by absorbing it.

**source:** A radioactive material that produces radiation for experimental or industrial use.

**stable:** Strictly speaking, a nuclide that is not radioactive. The definition is often relaxed to include very long-lived nuclides that are naturally occurring.

**superconductivity:** occurs in certain materials at very low temperatures. When superconductive, a material has an electrical resistance of exactly zero and no interior magnetic field.

**symmetry:** Invariance of equations of motion under changes in condition.

**target nuclide:** The initial nucleus in a nuclear reaction on which a projectile is incident. It is used in the context of a nuclear reaction where the projectile interacts with a target nucleus, producing a product nucleus and an ejectile.

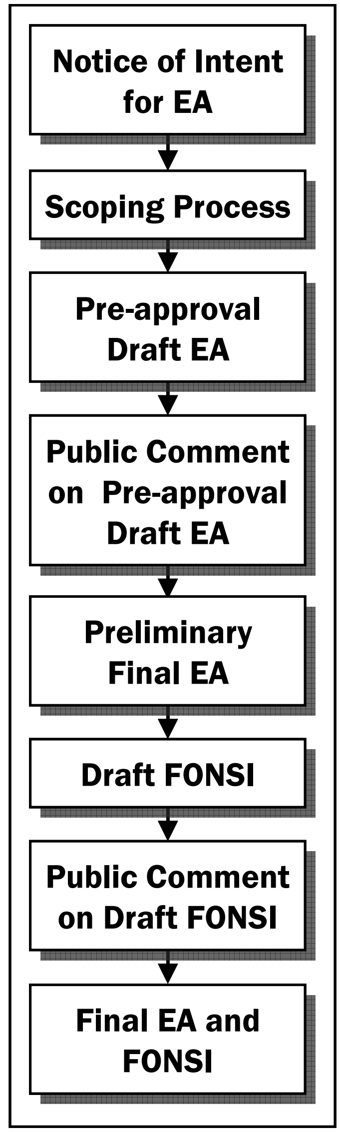
**x-ray:** Electromagnetic radiation with wavelengths between ultraviolet and gamma rays.

# FRIB, NEPA, and You

The U.S. Department of Energy (DOE) has prepared this fact sheet to encourage and help you to participate in the DOE National Environmental Policy Act (NEPA) process for the Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU). DOE has determined that it must prepare an environmental assessment (EA) to ascertain whether project construction or operation have the potential to significantly affect the environment. This fact sheet describes the planned NEPA activities, focusing on opportunities for your involvement.

### *HOW CAN I BE INVOLVED IN THE PREPARATION OF THE FRIB EA?*

DOE takes a graded approach in designing public participation processes. The following process was designed specifically with public interest in the FRIB in mind.




- ✓ **Notice of Intent (NOI)**. On October 27, 2009, DOE published an NOI to prepare an EA in the *Federal Register* and subsequently made announcements in the local media. The NOI states the need for action and provides preliminary information on the EA scope. The NOI serves as the beginning of the scoping process.

  **TIP:** The NOI explains how you can participate in the scoping process.

- ✓ **Scoping Process.** DOE requests your comments on the scope on the FRIB EA. What alternatives should be evaluated? What potential environmental impacts should be analyzed? The FRIB scoping process will last through December 11, 2009. A public meeting will be held on November 11, 2009.

  **TIP:** During the scoping process, tell DOE what EA information you would like.

- **Pre-approval Draft EA.** DOE will consider scoping comments in preparing a Draft EA. The Draft EA will analyze the potential environmental impacts of the FRIB, and will provide for a comparison with project alternatives, one of which is always a “no action” alternative. It will also discuss ways to avoid or reduce potential adverse impacts. It is expected to be completed in the spring of 2010.

- **Public Comment Period on the Draft EA.** DOE will send e-mails and letters to those on its mailing list and issue a public announcement opening a 30-day public comment period. DOE will also present details regarding how to comment on the Draft EA, either in writing or orally at a public meeting yet to be scheduled.

  **TIP:** If you did not sign up during scoping to receive a copy of the Draft EA, the public announcement will advise you about how to obtain one. http://www.frib.msu.edu/nepa can also keep you up-to-date.

- **Preliminary Final EA.** DOE will consider all timely public comments on the Draft EA in preparing the Final EA. The Final EA will address those comments. It is scheduled to be completed in the summer of 2010.

- **Draft Finding of No Significant Impact (FONSI).** Unless the Draft EA reveals the potential for significant environmental impacts, DOE will prepare a Draft FONSI, which will discuss the basis for such a finding and describe any commitments for mitigating potential environmental impacts. Such a determination will be made late in the summer of 2010. If a FONSI can not be supported, DOE would prepare an environmental impact statement.

- **Public Comment on Draft FONSI.** If a Draft FONSI is prepared, DOE will make the appropriate public announcements and open a 30-day public comment period.

- **Final EA and FONSI.** In the absence of new evidence of significant impacts during the public comment period, DOE will finalize the EA and FONSI. At this time, MSU will be authorized to proceed with FRIB.

U.S. DEPARTMENT OF ENERGY | Office of Science

MICHIGAN STATE UNIVERSITY

# NEPA Background

## WHAT IS NEPA?

The National Environmental Policy Act (NEPA) is a Federal law that serves as the Nation's basic charter for environmental protection. It requires that all Federal agencies consider the potential environmental impacts of proposed actions which are subject to their control and responsibility and which have the potential to significantly effect the environment. NEPA promotes better agency decision making by ensuring that high quality environmental information is available to agency officials and the public before the agency decides whether and how to undertake a major Federal action. Through the NEPA process, you have an opportunity to learn about government agencies' proposed actions and to provide timely information and comments.

To implement NEPA, all Federal agencies follow procedures issued by the President's Council on Environmental Quality in the Code of Federal Regulations (40 CFR Parts 1500-1508). DOE also follows its own supplementary procedures, found in 10 CFR Part 1021.

## HOW DOES NEPA WORK?

Early in its planning process for a proposed action, DOE considers how to comply with the NEPA. The appropriate level of review depends on the significance (i.e., the context and intensity) of the potential environmental impacts associated with the proposed action. There are three levels of NEPA review:

- **Environmental Impact Statement (EIS).** For major Federal actions that may significantly affect the quality of the human environment, NEPA requires preparation of an EIS. An EIS is a detailed analysis of the potential environmental impacts of a proposed action and the range of reasonable alternatives. Public participation is an important part of the EIS process.
- **Environmental Assessment (EA).** When the need for an EIS is unclear, an agency may prepare an EA to determine whether to prepare an EIS or to issue a Finding of No Significant Impact (FONSI). An EA is a brief analysis. DOE's procedures normally provide notification and comment opportunities for host states and tribes only. DOE also may provide notification and comment opportunities for other interested people. DOE considers any comments received, makes revisions as appropriate, and issues the EA and FONSI. If at any point during preparation of the EA DOE determines that significant impacts would be likely, an EIS is prepared
- **Categorical Exclusion.** DOE's NEPA regulations list classes of actions that normally do not require an EIS or an EA because, individually or cumulatively, they do not have the potential for significant environmental impacts. Examples are information gathering activities and property transfers when the use is unchanged.

## WHAT KINDS OF POTENTIAL ENVIRONMENTAL IMPACTS DO NEPA DOCUMENTS EXPLORE?

EAs and EISs present coordinated analyses of a broad range of potential environmental impacts, including those to: human health, air, water, soil, biological resources, and historical/cultural resources.

### DOE Encourages Public Participation

DOE is committed to open communication and providing public access to pertinent information and opportunities for involvement throughout the NEPA process. Accordingly, DOE encourages your participation because it helps shape the scope and issues addressed in the FRIB EA.

The scoping period ends Dec. 11, 2009. All comments, both oral and written, received during this period will be given equal consideration during the development of the EA. Comments may be submitted at the scoping meeting or by:

**U.S. MAIL:** FRIB Comments
U.S. Department of Energy (STS)
9800 South Cass Avenue
Argonne, IL 60439

**E-MAIL:** frib.comments@ch.doe.gov
**ONLINE:** http://www.frib.msu.edu/NEPA
**TOLL-FREE FAX**: 1-888-676-3672

For specific information on the FRIB EA visit http://www.frib.msu.edu/NEPA/ or contact the NEPA Compliance Officer, Peter Siebach at (630)-252-2007 or peter.siebach@ch.doe.gov. For further information on NEPA visit: http://www.eh.doe.gov/NEPA or http://ceq.hss.doe.gov/nepa/nepanet.htm