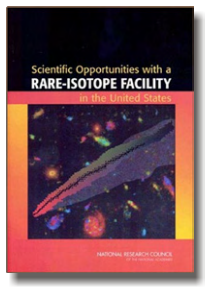
FRIB Project History

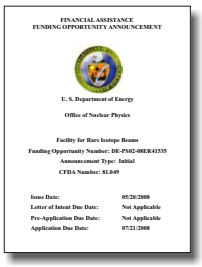
Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)

Last decade: The U.S. Department of Energy's (DOE) Office of Science determines that the Facility for Rare Isotope Beams (FRIB) is a high priority for the future of U.S. nuclear science research as documented in several reports, including:

- *Facilities for the Future of Science, A Twenty-Year Outlook,* Department of Energy, Office of Science, December 2003
- *Four Years Later: An Interim Report on Facilities for the Future of Science, A Twenty-Year Outlook,* Department of Energy, Office of Science, August 2007
- *The Frontiers of Nuclear Science, A Long Range Plan,* Department of Energy/National Science Foundation Nuclear Science Advisory Committee, December 2007



December 2006: National Research Council of the National Academies publishes *Scientific Opportunities with Rare-Isotope Facility in the United States*, concluding the science addressed by a rare-isotope facility should be a high priority for the United States.



May 20, 2008: DOE conducts a competition through a Funding Opportunity Announcement for the establishment of a rare isotope beam facility for nuclear structure and astrophysics research.

December 11, 2008: DOE concludes after performing an environmental critique that the physical environmental impacts identified could be successfully managed to avoid or minimize impact. DOE selects Michigan State University (MSU) at completion of a Merit Review Panel process.

June 8, 2009: DOE and MSU sign a Cooperative Agreement for establishment of the FRIB.

October 27, 2009: The National Environmental Policy Act process begins, a required step prior to final design and construction of the FRIB.

U.S. DEPARTMENT OF ENERGY | Office of Science

FRIB

MICHIGAN STATE UNIVERSITY

Facility for Rare Isotope Beams

Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)

Mission

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, located on the Michigan State University (MSU) campus in East Lansing, establishes a highly sophisticated research laboratory that would produce intense beams of rare isotopes.

Design

The FRIB would provide a safe and secure facility enabling 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 would be designed to limit its environmental impact.**

Environmental Impact Limits for FRIB

Target Receptor	Limit	
Radiation Dose - Worker	Standard[1]: 5,000 mrem/yr MSU ALARA Goal[3]: <500 mrem/year	
Radiation Dose - Public	Standard[1]: 100 mrem/yr and ≤2 mrem/(any one hour) MSU ALARA Goal[3]: < 10 mrem/year and ≤2 mrem/(any one hour)	
Air - maximum exposure to nearest receptor	Standard[1]: 10 mrem/yr MSU ALARA Goal[3]: < 1 mrem/year	
Groundwater[4] *(in situ, no decay reduction factor)*	H-3 Drinking Water Standard[2]: 20 pCi/ml	Na-22 Drinking Water Standard[2]: 0.4 pCi/ml
Sump Water[5]	H-3 Standard[2]: 10,000 pCi/ml	Na-22 Standard[1]: 60 pCi/ml

Notes:

[1] Standard refers to 10 CFR 20 (U.S. Nuclear Regulatory Commission).

[2] Standard refers to 40 CFR 141 (U.S. Environmental Protection Agency).

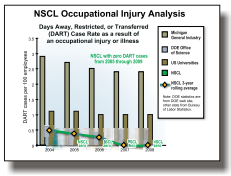
[3] Note: Some conservative self imposed limits are used to provide flexibility in the design, commissioning, and operation of the FRIB and accommodate future upgrades or changes in mission. The as low as reasonably achievable (ALARA) goals represent action levels for the FRIB and MSU where actions are taken to reduce the exposures to maintain operations within the ALARA goal. The radiation ALARA goal for workers and the public is based on using 10 percent of the regulatory limit and is applicable for any MSU facility. The effluent limits for air releases are applicable to the integrated release from all MSU effluent generators. Therefore, the limit and ALARA goal must account for all releases from MSU. The FRIB limit is an integral part of the overall MSU release limits and not a stand-alone value.

[4] Groundwater is being evaluated using drinking water limits to assure that there are no negative impacts for water that may migrate to the underground aquifer.

[5] Sump water is being evaluated using limits for release to the sanitary sewer.

Safety and Regulatory Compliance

MSU holds the necessary licenses, permits and registrations required for the construction and operation of the FRIB and has managed these responsibly in the operation of the National Superconducting Cyclotron Laboratory (NSCL). NSCL maintains, as would the FRIB, the highest level of standards for health and safety management systems, environmental management systems, and quality management systems as also evident by its recognition as a Clean Corporate Citizen.



Existing MSU Applicable Licenses, Permits, and Registrations

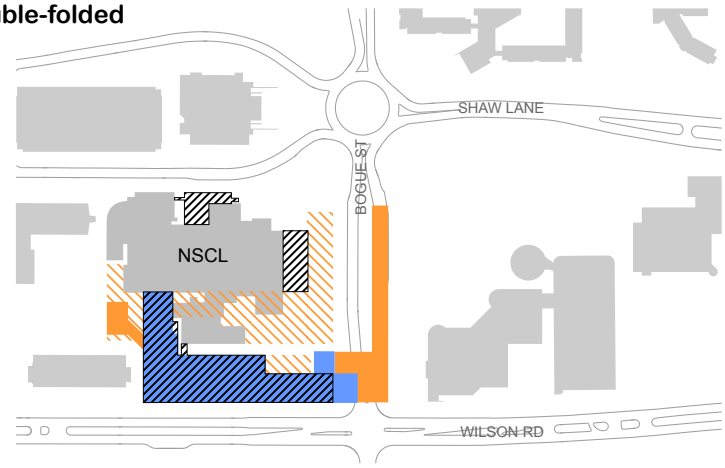
License, Permit, or Registration	Regulatory Agency/Standard
Resource Conservation and Recovery Act (RCRA) - Chemical Waste Treatment, Storage, and Disposal (TSD) Permit	State of Michigan, Department of Environmental Quality, Waste Management Division — MDEQ Rule 299.9501-299.9713
Clean Air Act - National Emission Standards for Hazardous Air Pollutants (NESHAPS - Renewable Operation Permit [ROP])	State of Michigan, Department of Environmental Quality, Waste Management Division — MDEQ Rule 336.1211
Clean Water Act - National Pollutant Discharge Elimination System (NPDES) Storm Water Permits	State of Michigan, Department of Environmental Quality, Water Division — MDEQ Rule 323.2161 *et seq*
Radiation Producing Machines Registration	State of Michigan, Department of Community Health, Radiation Safety Section Michigan Ionizing Radiation Rules for Radiation Producing Machines
NRC Broad Scope License for Radioactive Materials	NRC 10 CFR 1 - 199 as applicable and NUREG 1556
Local Requirements	MSU Board of Trustees
Community Right to Know Act - Notifications and Plans	State of Michigan, Department of Environmental Quality / U.S. EPA Michigan Executive Order — 40 CFR 350 - 372
Sanitary Hookup	City of East Lansing
Drinking Water Dispensing Permit	State of Michigan, Department of Environmental Quality Water Bureau — MDEQ Rule 325.1001-325.1023

The State of Michigan, the U.S. Environmental Protection Agency (EPA), U.S. Department of Transportation (DOT), the U.S. Department of Labor (DOL), and U.S. Nuclear Regulatory Commission (NRC) would have regulatory authority for the FRIB construction and operation. Required permits have been obtained. Permits requiring amendment are noted by the blue shade.

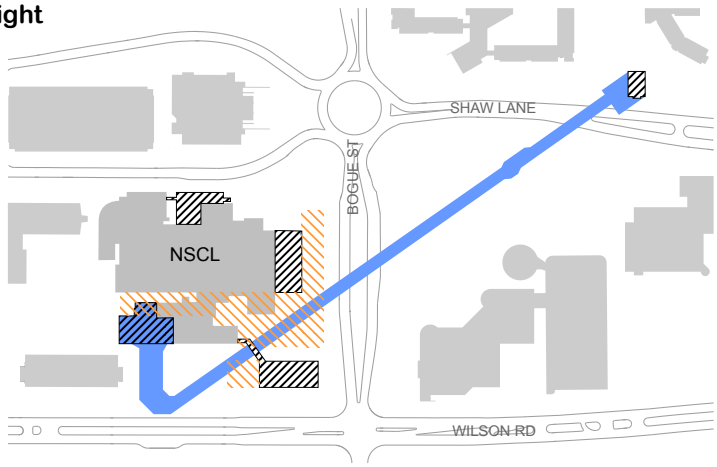
Proposed FRIB Site and Design

Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)

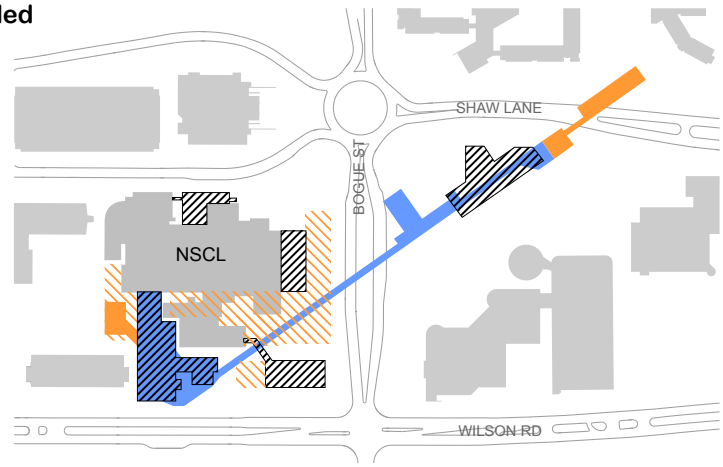
Double-folded



Straight



Folded



200 FT
50 M

Existing | New Underground | New Surface | Upgrade Underground | Upgrade Surface

U.S. DEPARTMENT OF ENERGY | Office of Science

FRIB

MICHIGAN STATE UNIVERSITY

From NSCL to FRIB

Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)

1958 Michigan State University (MSU) hires first accelerator expert

1961 National Science Foundation (NSF) approves sector foscused K50 cyclotron

1965 Research with K50; single turn extration

1975 NSF approves superconducting cyclotron magnet prototype

1977 NSF approves K500 cyclotron

1978 Nuclear Science Advisory Committee (NSAC) recommends national user facility at MSU

1982 Research with stable beams from K500

1989 Research with stable beams from K1200

1990 Research with fast rare isotope beams from A1200

1996 NSF approves coupled cyclotron facility (CCF)

2001 Research with fast rare isotope beams from CCF

2002 Infrastructure for Superconducting Radio-Frequency (SRF) linear accelerator research and development

2005 Research with trapped rare isotope beams

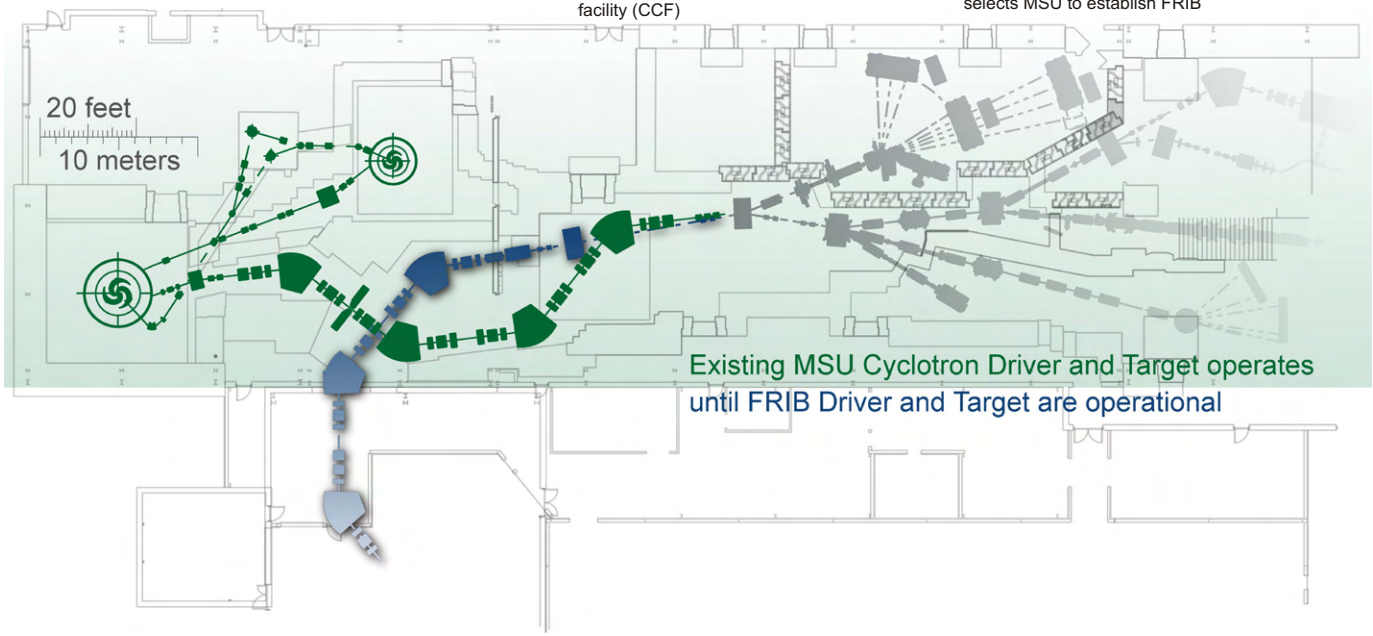
2006 MSU funds ReA3 reaccelerator project

2008 U.S. Department of Energy (DOE) selects MSU to establish FRIB

2010 Research with reaccelerated rare isotope beams from ReA3

2017 FRIB operational

National Superconducting Cyclotron Laboratory (NSCL) → **FRIB**



U.S. DEPARTMENT OF ENERGY | Office of Science

FRIB

MICHIGAN STATE UNIVERSITY

Establishment of FRIB

Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)

National Superconducting Cyclotron Laboratory (NSCL)

(today – approximately 2017):

- ✓ National user facility operated by Michigan State University (MSU) and funded by the U.S. National Science Foundation (NFS) through a Cooperative Agreement
- ✓ 700 users from around the world
- ✓ 300 employees
- ✓ Approximately $20 million annually in NSF funding
- ✓ Coupled superconducting cyclotrons accelerate and smash atomic nuclei in basic nuclear science experiments
- ✓ Rare isotope beams made from primary beams with 0.5 kW – 1 kW power
- ✓ Regulated by State of Michigan, the U.S. Environmental Protection Agency (EPA), U.S. Department of Transportation (DOT), U. S. Department of Labor (DOL), and U.S. Nuclear Regulatory Commission (NRC)
- ✓ International Organization for Standardization (ISO) 9001-registered Quality Management System
- ✓ ISO 14001-registered Environmental Management System
- ✓ Occupational Health and Safety Assessment Series (OHSAS) 18001-registered Integrated Safety Management System
- ✓ Best-in-class safety record

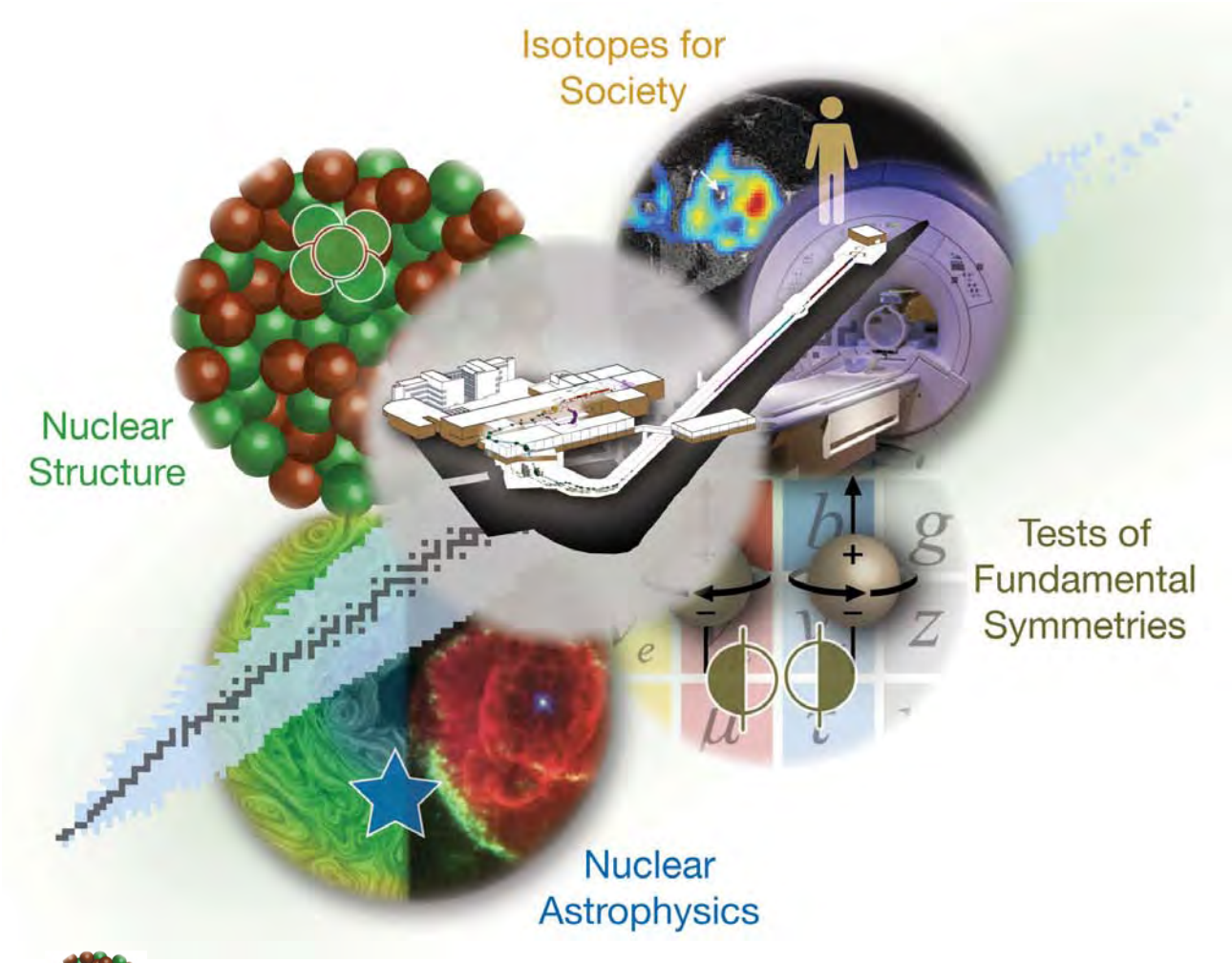
Facility for Rare Isotope Beams (FRIB)

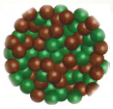
(anticipated 2017):

- ✓ National user facility operated by MSU and funded by the U.S. Department of Energy (DOE) through a Cooperative Agreement
- ✓ Up to 1,000 users from around the world
- ✓ Approximately 400 employees
- ✓ Approximately $50 million annually in DOE funding
- ✓ Superconducting linear accelerator accelerates and smashes atomic nuclei in basic nuclear science experiments
- ✓ Rare isotope beams made from primary beams with 0.5 kW – 400 kW power
- ✓ Regulated by State of Michigan, EPA, DOT, DOL, and NRC
- ✓ Same ISO and OHSAS registrations as for NSCL

Facility for Rare Isotope Beams Research Goals

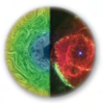
Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)





Properties of nucleonic matter

- Classical domain of nuclear science
- Many-body quantum problem: intellectual overlap to mesoscopic science - how to understand the world from simple building blocks

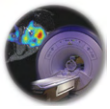


Nuclear processes in the universe

- Energy generation in stars, (explosive) nucleo-synthesis
- Properties of neutron stars, Equation-of-State (EOS) of asymmetric nuclear matter

Test of fundamental symmetries

- Effects of symmetry violations are amplified in certain nuclei



Societal applications and benefits

- Bio-medicine, energy, material sciences, and national security

U.S. DEPARTMENT OF ENERGY | Office of Science

FRIB

MICHIGAN STATE UNIVERSITY

Periodic Table of the Elements and Chart of Nuclides

Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)

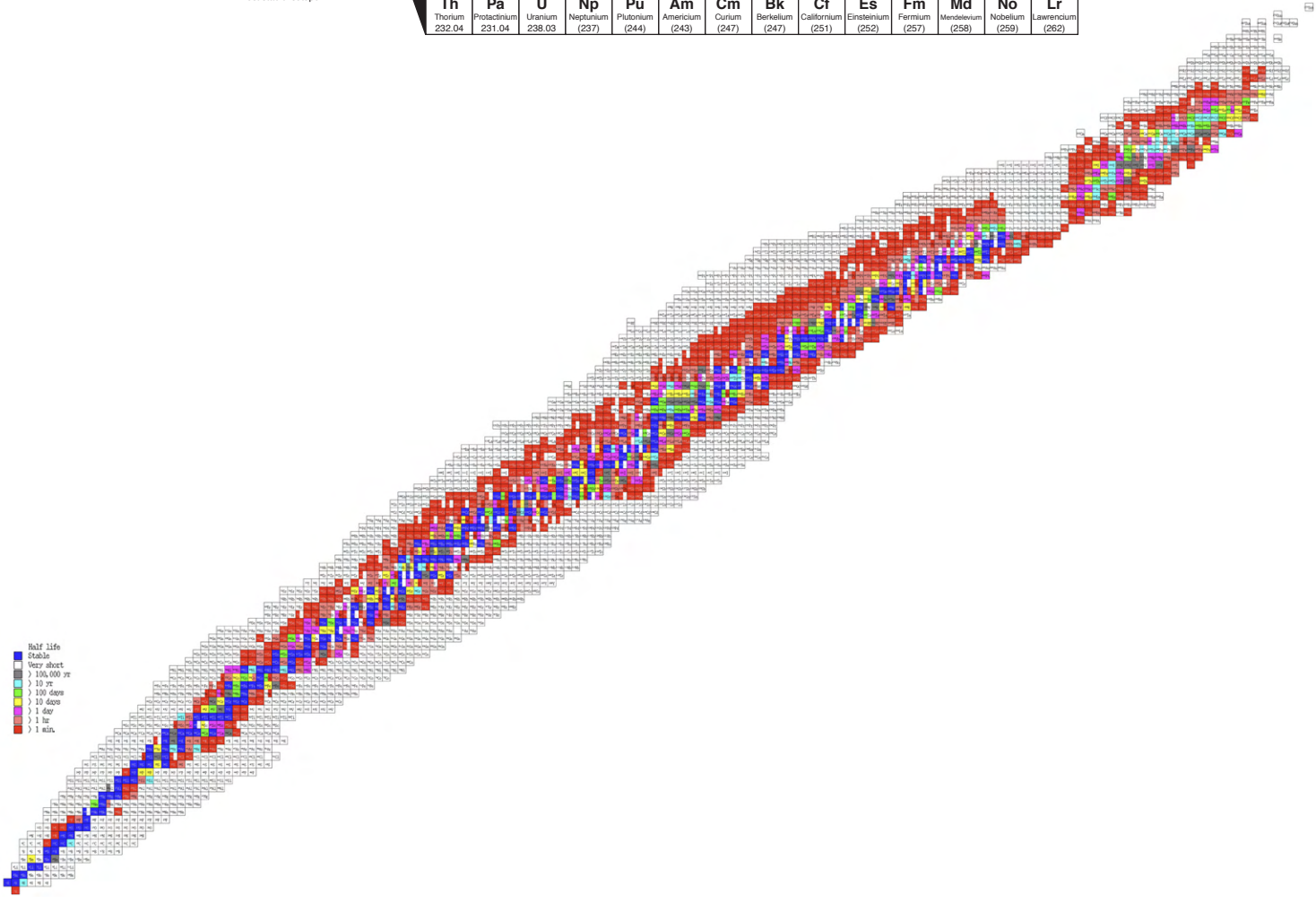
	1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 H Hydrogen 1.01	2 2A																2 He Helium 4.00
2	3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
3	11 Na Sodium 22.99	12 Mg Magnesium 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)									

Key

11 — Atomic number
Na — Element symbol
Sodium — Element name
22.99 — Average atomic mass*

* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.

58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)



U.S. DEPARTMENT OF ENERGY | Office of Science

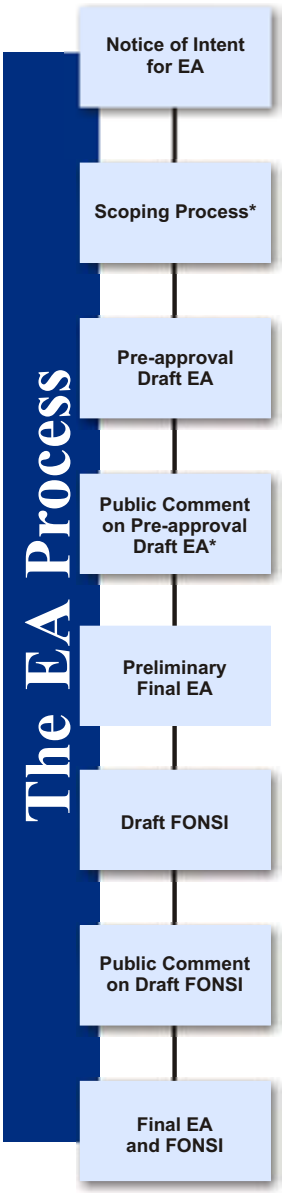
FRIB

MICHIGAN STATE UNIVERSITY

What is an Environmental Assessment?

Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)

An environmental assessment (EA) is a National Environmental Policy Act (NEPA) document describing the environmental impacts that would result from implementation of a proposed action and alternatives.



* Opportunities for public participation, including public meetings

Why Is an EA Being Prepared?

NEPA requires Federal agencies to prepare NEPA documents for major Federal actions that could have significant impacts on the human environment. Major Federal actions refers to actions that the Federal government has some level of control or responsibility for. Under NEPA, human environment includes the natural and physical environment (such as air, water, and biological resources) and the relationship of people with that environment (such as health, safety, and jobs). NEPA documents look at both short-term and long-term effects and consider possible mitigation measures, if applicable.

Depending on the potential to impact the environment, an environmental impact statement (EIS) or an EA is prepared or a categorical exclusion determination is made. The U.S. Department of Energy (DOE) believes significant impacts associated with construction and operation of the Facility for Rare Isotope Beams (FRIB) are unlikely and thus determined it should prepare an EA. The EA will either corroborate DOE's belief or conclude that significant impacts are likely and that it should therefore prepare an EIS.

The EA Process

An EA is prepared in a series of steps, normally: gathering government and public comments to define the issues that should be analyzed in the EA (known as "scoping"); preparing the pre-approval draft EA; receiving and addressing public comments on the draft EA; preparing a final EA, and preparing a finding of no significant impact (FONSI), if warranted, or preparing an EIS.

DOE tailored the FRIB EA process to include enhanced opportunities for public involvement.

Scoping (Public Input)

Scoping during the EA process is usually an internal Federal agency planning process used to establish the alternatives and type of analysis to be performed.

DOE tailored the FRIB EA process to include publication of a Notice of Intent (NOI) in the *Federal Register* to let the public know that it is considering an action and will prepare an EA. NOIs describe the proposed action and may provide background information on issues and potential impacts. During the scoping period, the public can provide comments on the proposed action, alternatives, issues, and environmental impacts to be analyzed in the EA. Scoping may involve public meetings and other means to obtain public comments on the EA.

The NOI for the FRIB EA was published on October 27, 2009, and announced a 45-day comment period and a public meeting on November 11, 2009.

Pre-approval Draft EA (Public Input)

The draft EA presents, analyzes, and compares the potential environmental impacts for the proposed action and alternatives, taking into account the scoping comments received. It also provides information on possible mitigation actions to avoid or reduce adverse impacts. The draft EA is made available for public review and comment.

The pre-approval draft FRIB EA was published on March 16, 2010, which began a 30-day comment period, including today's public meeting.

Preliminary Final EA

Upon completion of the public comment period and analysis of the input received on the pre-approval draft EA, it is revised accordingly and reviewed internally by DOE.

Draft FONSI (Public Input)

After preparation of the preliminary final EA, the Federal agency normally prepares a FONSI, assuming that the EA justifies a conclusion that there are no significant environmental impacts associated with the proposed action. The FONSI explains the agency's basis for this determination and describes any commitments for mitigating potential environmental impacts.

DOE tailored the FRIB EA process to include preparation of a draft FONSI. The draft FONSI is distributed for public comment, currently scheduled for summer 2010, with a 30-day comment period.

Final EA and FONSI

Based on public input, and if a determination of no significant impacts can be supported, the EA and FONSI are finalized and published. Approval of the FONSI concludes the EA process.

The final EA and FONSI are scheduled for fall 2010.

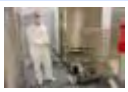
U.S. DEPARTMENT OF ENERGY | Office of Science
FRIB
MICHIGAN STATE UNIVERSITY

Summary of Key Effects

Facility for Rare Isotope Beams Environmental Assessment (FRIB EA)

The results of the analyses indicate minor adverse effects to environmental resources would be expected from construction and operation of the Facility for Rare Isotope Beams (FRIB).

Standard safety protocols would minimize the likelihood of accidents and personal injury at the FRIB, and operations pose no threat to the surrounding communities.

	Construction	Operation
Land Use and Visual	 • The proposed FRIB would be built on a previously disturbed site directly adjacent to the existing NSCL. • An existing nearby soils disposal area would be used for storage and disposal of soils. • Use of Bogue Street, Shaw Lane, and Wilson Road would be impaired. • Shaw Lane between Bogue Street and Hagedorn Road would be closed to through-traffic for approximately 2 months if the linear option is selected. • Wharton Center surface parking area would be closed, demolished, and used as a laydown area.	• No land use impacts from FRIB operations are anticipated. • No adverse visual impacts were identified.
Geology and Soils	 • Approximately 325,000 cubic yards of soil would be excavated during construction of the linear accelerator tunnel. • Affected soils are stable and acceptable for standard construction requirements. • Erosion prevention and sedimentation control measures would minimize the potential for adverse impacts.	• No impacts on geology and soils from FRIB operations are anticipated.
Water Resources	 • Erosion and sedimentation controls would limit potential impacts on surface water. • Moderate to heavy volumes of groundwater would likely be encountered where excavations extend below the water table. A dewatering system could be used to temporarily lower the water table below the level of the tunnels and the resulting groundwater would be filtered and discharged into the existing stormwater drainage system. • No impacts on wetlands or floodplains would occur.	• Normal facility operations would not have adverse impacts on any surface water. • Groundwater levels would be expected to return to normal with no long-term impacts or changes in groundwater flow or levels. • Potential low-level activation of immediately adjacent to the FRIB tunnels would be managed according to U.S. Nuclear Regulatory Commission (NRC) license requirements. The design goal for the proposed FRIB is more than a factor of 10 times better than the NRC requirements. • No impacts on wetlands or floodplains would occur.
Air Quality	 • Construction emissions would be short-term, sporadic, localized, and no change in attainment area designation is expected. • Fugitive dust would be controlled to minimize emissions.	• No continuous emissions of criteria air pollutants are expected. • Limited hazardous air pollutant emissions.
Biological Resources	 • No threatened or endangered species nor critical habitats exist at the project site or soil disposal area so no impacts are expected.	• No threatened or endangered species nor critical habitats exist at the project site or soil disposal area so no impacts are expected.
Noise	 • Temporary and short-term noise would be generated during and construction near sensitive receptors, including dormitories to the north of Shaw Lane, Wharton Center for Performing Arts, plant biology laboratories, and the Biochemistry Building, as well as pedestrians. • Construction noise could be mitigated by employing standard construction noise mitigation, including use of quieted equipment, shielding of noisy equipment and activities, careful location of noisy equipment, proper maintenance of equipment, and administrative controls such as scheduling to avoid interfering with noise-sensitive activities. • MSU would control impacts on noise- and vibration-sensitive activities.	• Noise sources would be relatively minor and similar to ongoing National Superconducting Cyclotron Laboratory (NSCL) activities. • MSU would control impacts on noise- and vibration-sensitive activities.
Utilities	 • Existing utilities have adequate capacity to support FRIB construction.	• Average rate of electric power use is 18 megawatts. • Existing non-power utilities have adequate capacity to support FRIB operations so no impacts are expected. • Estimated power requirements for FRIB operations would be supplied by offsite commercial power, which would require a new duct bank to deliver power to the FRIB.
Cultural and Historical Resources	 • No cultural or historical resources are known to exist in potentially affected areas so no impacts are expected.	• No cultural or historical resources are known to exist in potentially affected areas.
Health and Safety	 • Construction workers would be subject to typical hazards and occupational exposures faced at other industrial construction sites but would be expected to comply with existing health and safety requirements to minimize adverse impacts.	• Exposure to radiation limited to 10% of standards.
Waste Management	 • Waste would be characterized, stored, and disposed of in accordance with applicable regulations in existing facilities so no adverse impacts are expected.	• Hazardous and radioactive waste streams would be similar to existing NSCL wastes and would be handled and disposed of using existing MSU waste management program; therefore, no adverse impacts would occur even though the quantities would be moderately greater.
Transportation	 • No adverse impacts associated with the transport of construction materials and workers are expected given the approximate 400 additional vehicles per day. • Road closures would disrupt and divert traffic for periods of up to 2 years. Temporary closures of Bogue Street, Shaw Lane, and Wilson Road would also impact pedestrian and bicycle traffic. • Temporary walkways would be established, with sufficient safety features such as fencing to direct pedestrian and bicycle traffic around the construction site.	• 160 additional commutes per day.
Socioeconomics and Environmental Justices	 • Total peak year earnings from both direct and indirect employment are estimated to be $20.2 million. • Total spending to build the proposed FRIB is estimated to be $548 million, of which $348 million is assumed to be spent locally. • Indirect economic output generated by that spending is estimated to be $279 million, for a total economic impact of $627 million. • No high and adverse human health or environmental impacts are anticipated during construction; consequently, there would be no disproportionately high and adverse effects on minority or low-income populations. • Peak employment: 175 direct, 145 indirect jobs.	• It is anticipated that the FRIB would result in approximately 160 additional professional and technical service jobs plus 214 indirect jobs. • No high and adverse human health or environmental impacts are anticipated FRIB operations; consequently, there would be no disproportionately high and adverse effects on minority or low-income populations.

U.S. DEPARTMENT OF ENERGY | Office of Science

FRIB

MICHIGAN STATE UNIVERSITY