



Facility for Rare Isotope Beams

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Nuclear Science Advisory Committee Meeting
17 November 2014

MICHIGAN STATE

UNIVERSITY

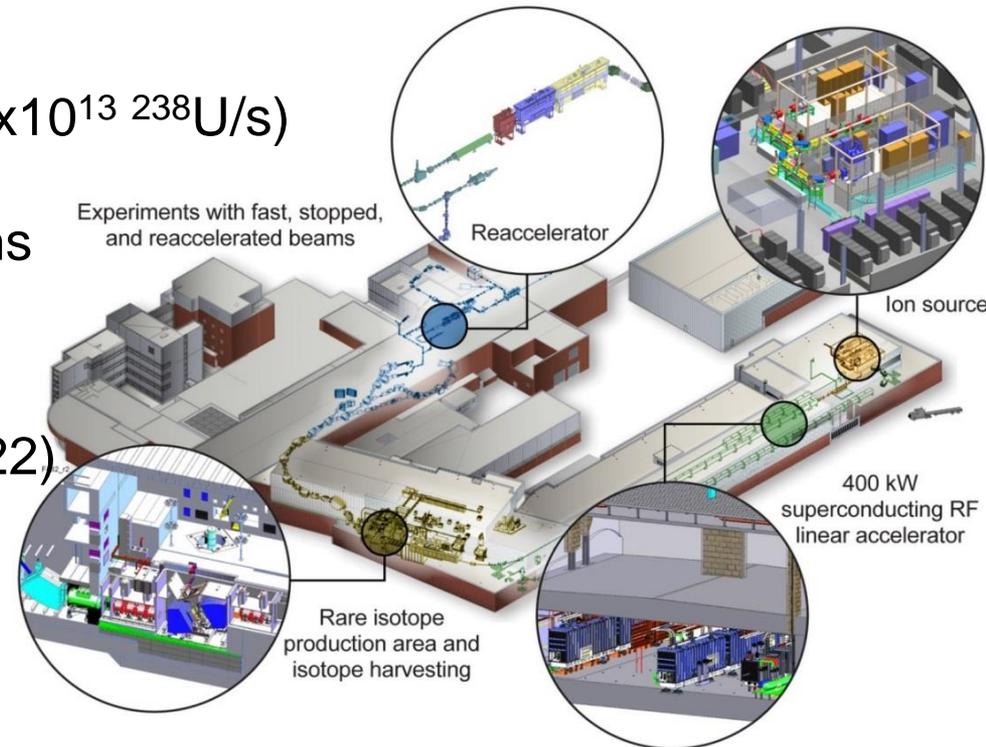


U.S. DEPARTMENT OF
ENERGY

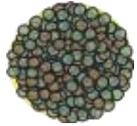
Office of
Science

Facility for Rare Isotope Beams (FRIB): A Future DOE-SC Scientific User Facility

- Funded with financial assistance from DOE Office of Science (DOE-SC) with cost share and contributions and from Michigan State University (MSU) and State of Michigan
- Supporting mission of Office of Nuclear Physics (SC-26) in DOE-SC
- Key features
 - 400 kW beam power for all ions (5×10^{13} $^{238}\text{U/s}$)
 - Separation of isotopes in-flight
 - Fast, stopped, reaccelerated beams
- On schedule and within budget
 - Managing to early completion in December 2020 (CD-4 June 2022)
 - » Construction started in March 2014
 - » Tunnel and first surface buildings (ECR and frontend) in 2015
 - » First beam from ECR in 2016
- Users engaged and ready for science

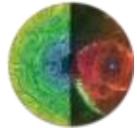


FRIB's Scientific Promise: Enabling Scientists to Make Discoveries



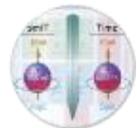
Properties of atomic nuclei

- Develop a predictive model of nuclei and their interactions
- Profound connections between nuclear many-body problem and physics of complex systems: transition from microscopic to mesoscopic and to macroscopic



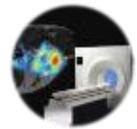
Astrophysics: Nuclear Processes in the Cosmos

- Origin of the elements, chemical history
- Stellar evolution, stellar explosions and the resulting compact objects



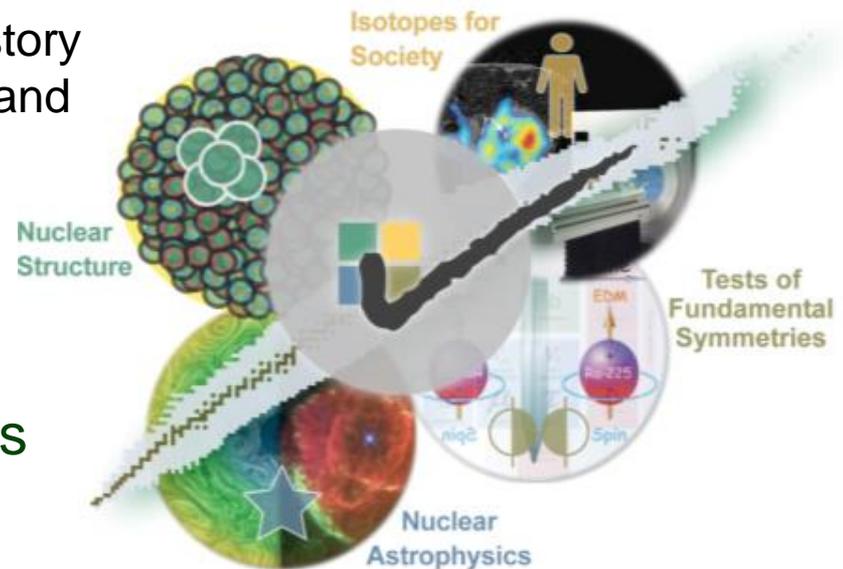
Tests of laws of nature

- Effects of symmetry violations are amplified in certain nuclei



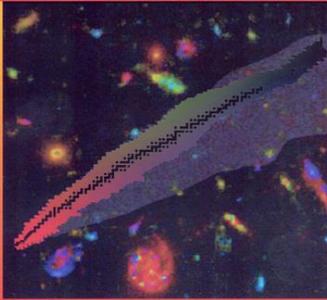
Societal applications and benefits

- Medicine, energy, material sciences, national security



FRIB Science Endorsed by National Research Council of the National Academies

Scientific Opportunities with a
RARE-ISOTOPE FACILITY
in the United States



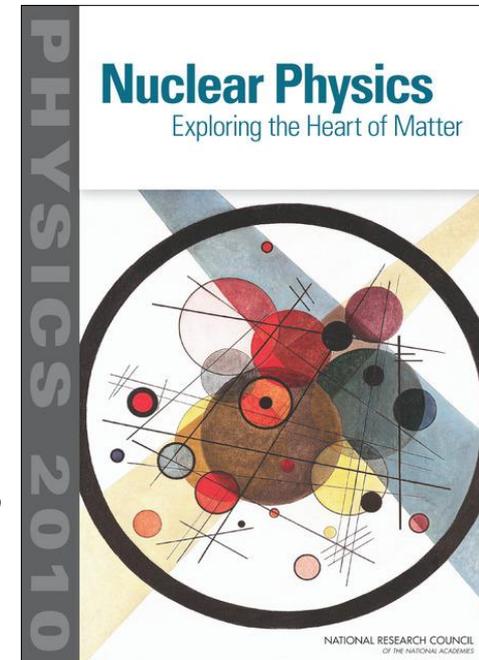
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

- National Academies Rare Isotope Science Assessment Committee Report (RISAC). Scientific Opportunities with a Rare-Isotope Facility in the United States (2007)

“The committee concludes that nuclear structure and nuclear astrophysics constitute a vital component of the nuclear science portfolio in the United States.”

“The committee concludes that a next generation, radioactive beam facility, of the type embodied in the U.S. FRIB concept represents a unique opportunity to explore the nature of nuclei under conditions that previously only existed in supernovae and to challenge our knowledge of nuclear structure by exploring new forms of nuclear matter.”

- National Research Council Decadal Study on Nuclear Physics Report. Nuclear Physics: Exploring the Heart of Matter (2013)
“Recommendation: The Department of Energy’s Office of Science, in conjunction with the State of Michigan and Michigan State University, should work toward the timely completion of the Facility for Rare Isotope Beams and the initiation of its physics program.”



NATIONAL RESEARCH COUNCIL
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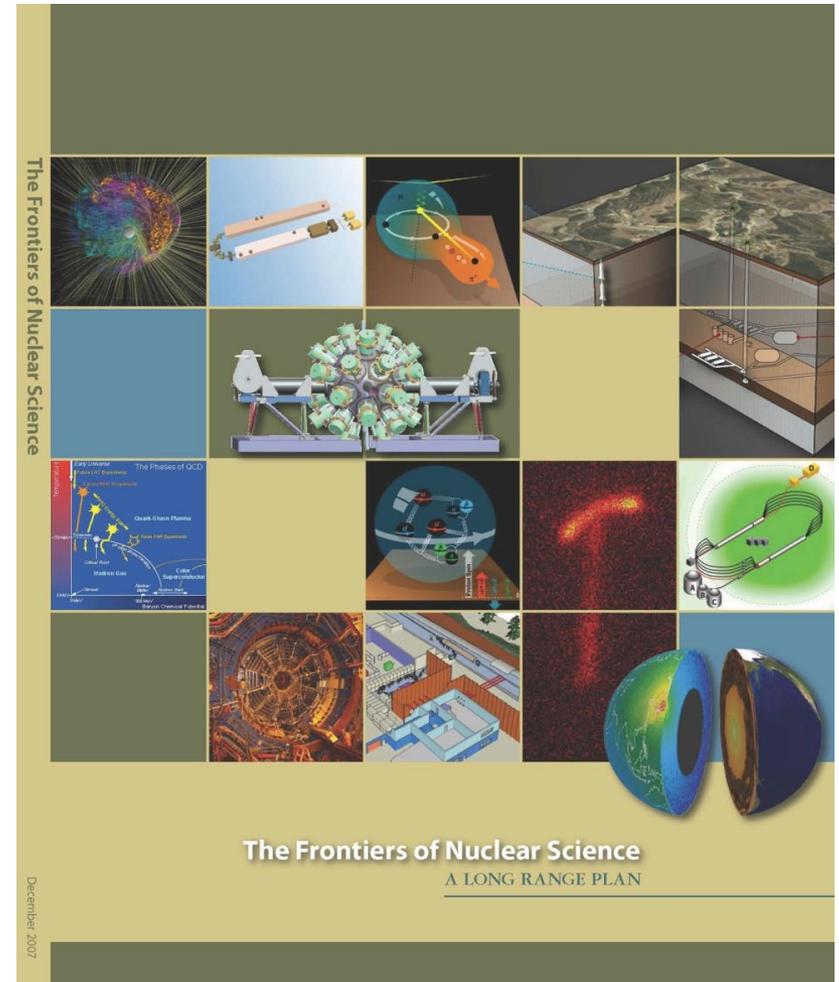
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NSAC Long Range Plan Recommended FRIB Construction in 2007

Recommendation II

- ***“We recommend construction of the Facility for Rare Isotope Beams (FRIB), a world-leading facility for the study of nuclear structure, reactions, and astrophysics. Experiments with the new isotopes produced at FRIB will lead to a comprehensive description of nuclei, elucidate the origin of the elements in the cosmos, provide an understanding of matter in the crust of neutron stars, and establish the scientific foundation for innovative applications of nuclear science to society.”***

Priority for FRIB construction
reaffirmed by NSAC in 2012



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FRIB Construction Update: Civil Construction Nine Weeks Ahead of Baseline Schedule



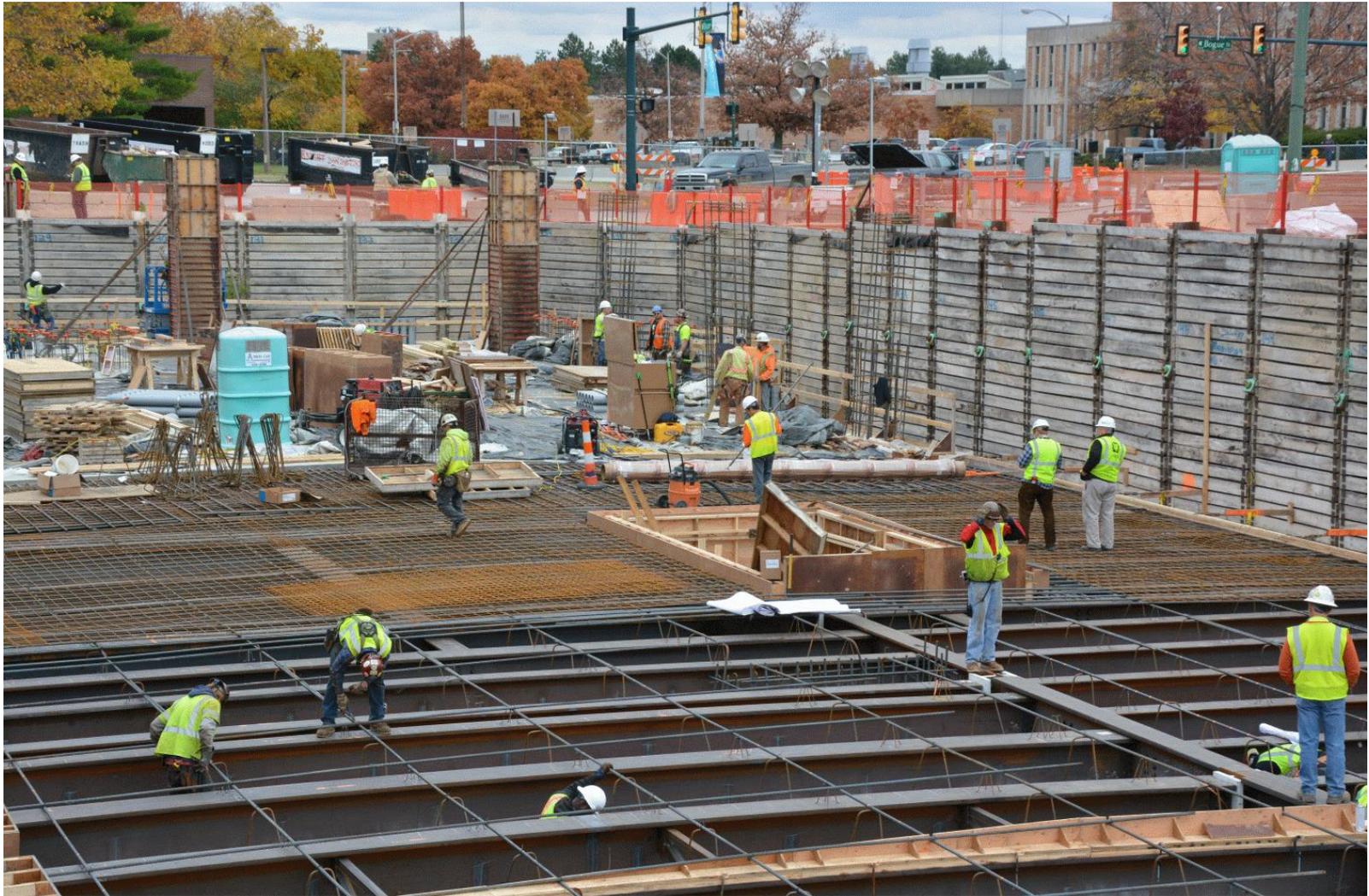
FRIB construction site on 12 November 2014 - web cameras at www.frib.msu.edu



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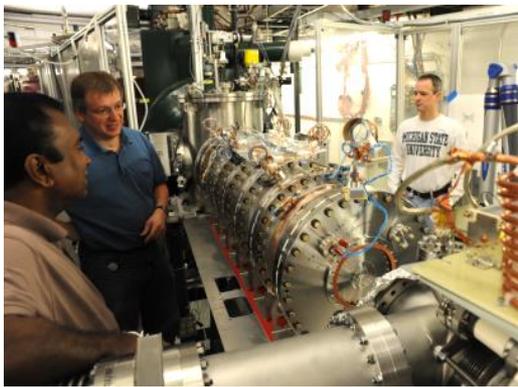
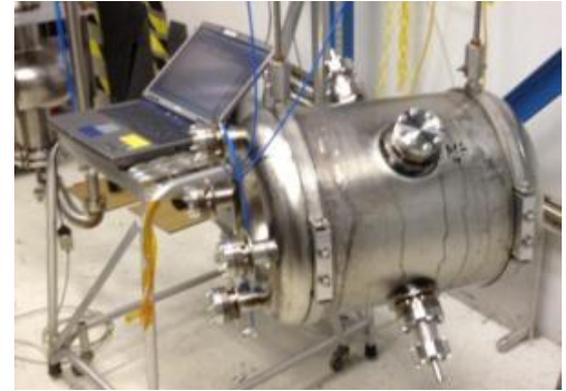
T. Glasmacher, 17 November 2014, Slide 6

Steel-work Prior to Second Section Tunnel Lid Placement



Technical Design Substantially Complete

- R&D and preliminary technical design are complete
 - Several prototypes successfully tested, exceeding FRIB requirements
- Technical construction started in October 2014



FRIB is Becoming Real: Working with the Best in the Nation and World

- Argonne National Laboratory
 - Liquid lithium charge stripper; Stopping of ions in gas; Fragment separator design; Beam dynamics; SRF
- Brookhaven National Laboratory
 - Radiation resistant magnets; Plasma charge stripper
- Fermilab
 - Diagnostics
- Jefferson Laboratory
 - Cryogenics; SRF
- Lawrence Berkeley National Laboratory
 - ECR ion source; Beam dynamics
- Oak Ridge National Laboratory
 - Target facility; Beam Dump R&D; Cryogenic Controls
- Stanford National Accelerator Lab
 - Cryogenics
- Sandia
 - Production target



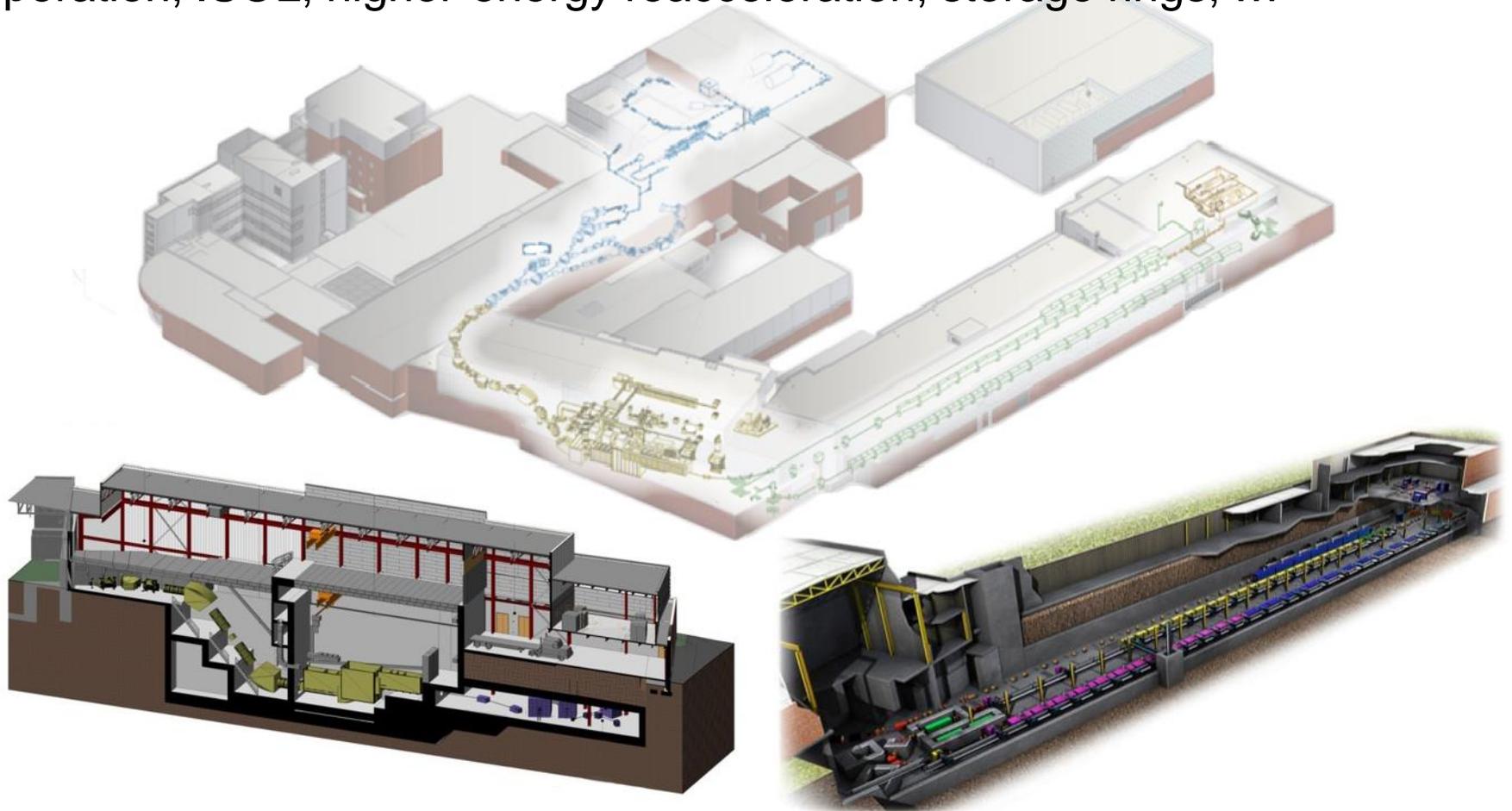
- Budker Inst. of Nuclear Physics (Russia)
 - Production target
- GANIL (France)
 - Production target
- GSI (Germany)
 - Production target
- INFN Legnaro (Italy)
 - SRF
- KEK (Japan)
 - SRF technology, SC solenoid magnets
- RIKEN (Japan)
 - Charge strippers
- Soreq (Israel)
 - Production target
- Tsinghua University & CAS (China)
 - RFQ
- TRIUMF (Canada)
 - SRF, beam dynamics



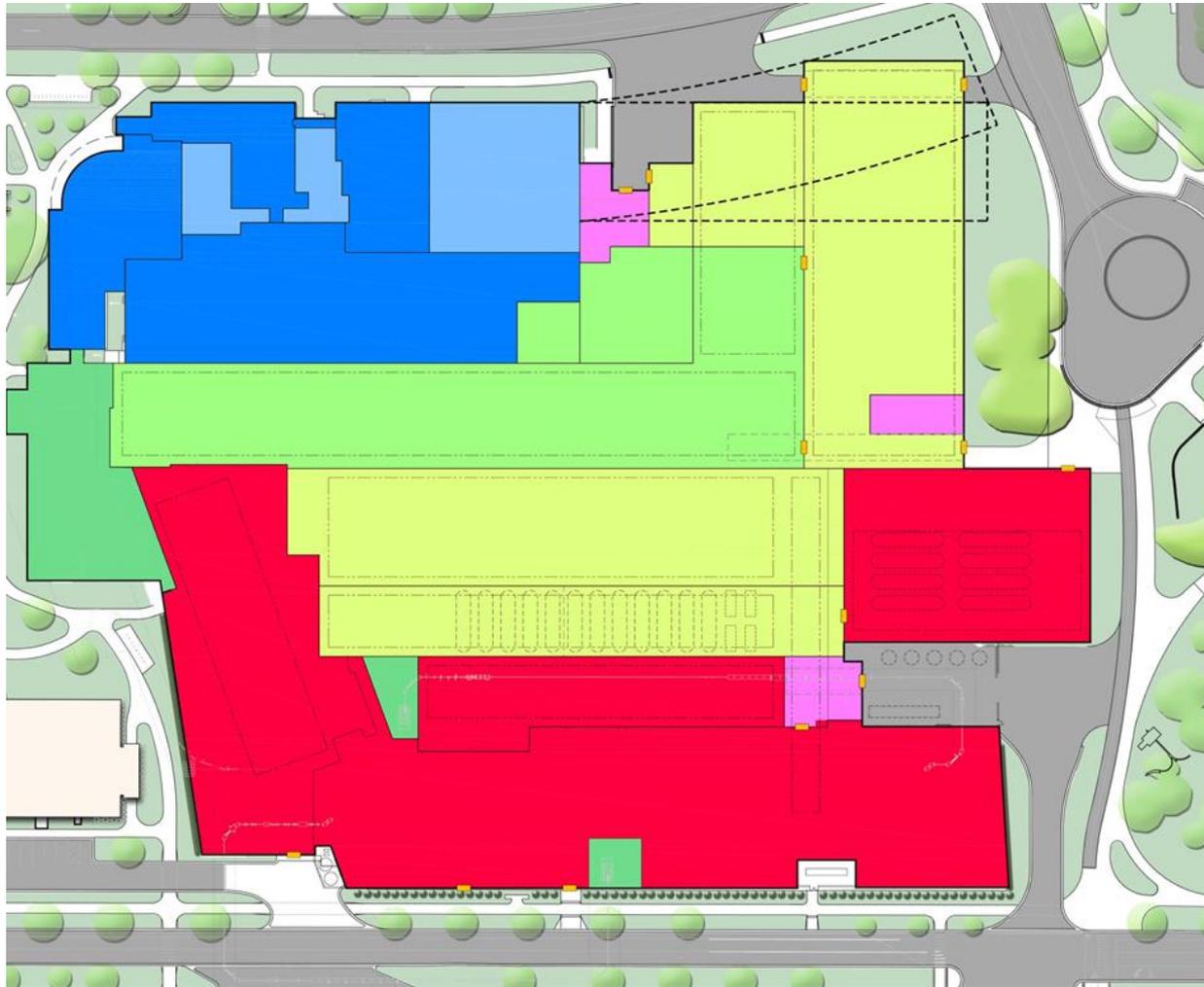
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Integrated Design Includes Options for Science-Driven Upgrades

Possibilities include higher beam energy, isotope harvesting, multi-user operation, ISOL, higher-energy reacceleration, storage rings, ...



Site Master Plan Includes Space for Equipment and Science-Driven Upgrades



- Higher beam energy
- Isotope harvesting
- Multi-user operation,
- ISOL
- Higher-energy reacceleration
- Storage rings, ...

Legend

- Blue: existing offices
- Light green: Existing NSCL high bays
- Red: FRIB
- Yellow: Upgrade space

Delivering FRIB Project on Schedule and on Budget

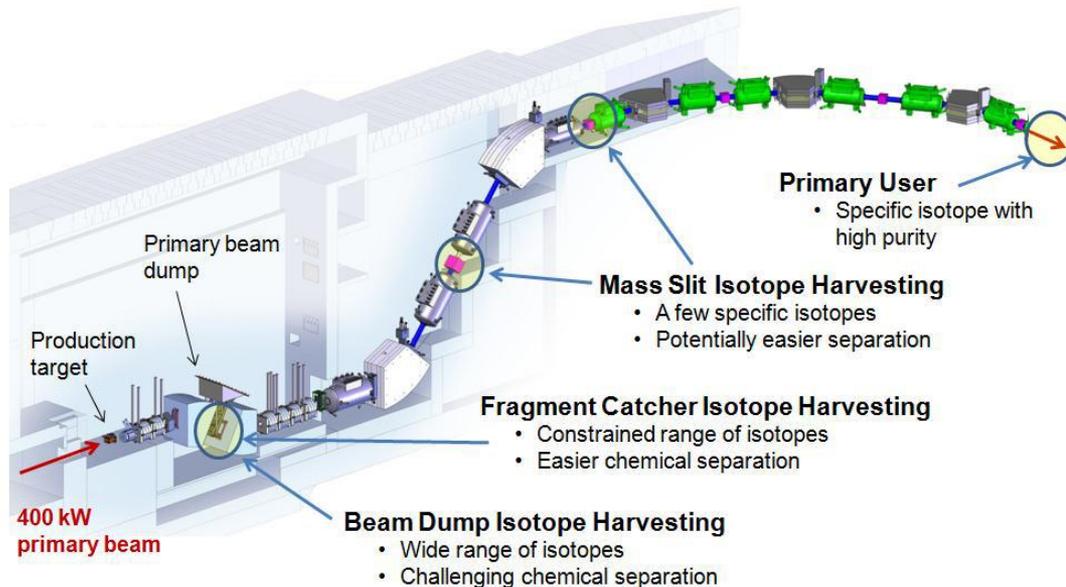
- Project started in June 2009: Cooperative Agreement between DOE-SC and MSU
 - Project delivery per DOE Order 413.3B: Acquisition Executive SC-2 Dr. Patricia Dehmer, DOE-SC Office of Project Assessment reviews, Federal Project Director from SC-Chicago; MSU shares \$94.5M in cost and contributes \$212M (actual \$306M), D&D is MSU responsibility
 - CD-1 approved in September 2010: Conceptual design complete
 - CD-2 (Performance Baseline) and CD-3a (Start of Civil Construction) approved in August 2013, pending notice to proceed for civil construction upon FY14 appropriation
 - Civil construction began March 3, 2014
 - CD-3b (Start of Technical Construction) approved in September 2014
 - Technical construction began October 2014
-
- Managing to early completion in December 2020, CD-4 is June 2022
 - Tunnel and first surface buildings (ECR and frontend) complete in 2015
 - First beam from ECR in 2016
 - Funding from DOE-SC is \$635.5M
 - Total project cost of \$730M includes \$94.5M MSU cost share with additional MSU contributions exceeding \$212M



Applied Isotope Science

Isotope Harvesting Opportunity at FRIB

- Produce a rare isotope beam for a primary user, for example ^{200}W from a ^{238}U primary beam
- At the same time up to 1000 other isotopes are produced that could be harvested and used for other experiments or applications in a commensal mode of operation



FINAL REPORT

Second of Two 2008 NSAC Charges on the Isotope Development and Production for Research and Applications Program

Isotopes for the Nation's Future

A long range plan

NSAC Isotopes Subcommittee

science.energy.gov/~media/np/nsac/pdf/docs/nsaci_ii_report.pdf

FRIB is the only fragmentation facility worldwide with provisions for isotope harvesting fully incorporated in the design

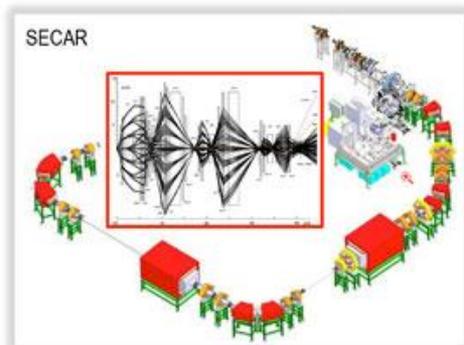


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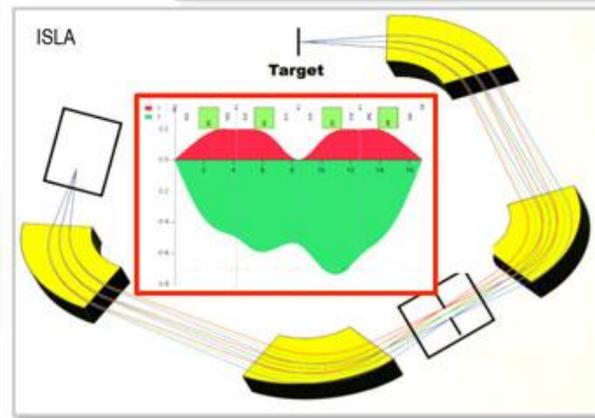
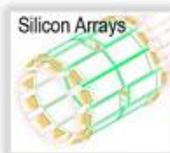
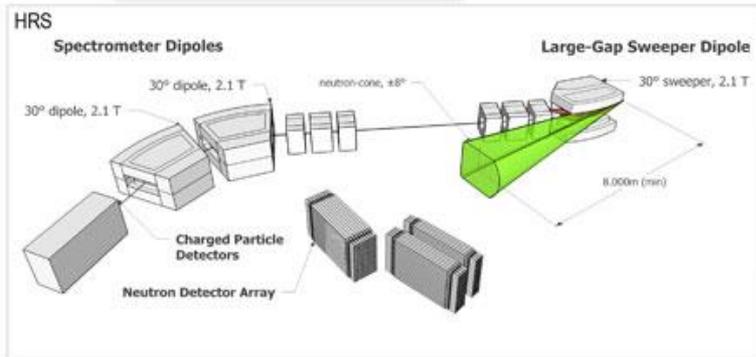
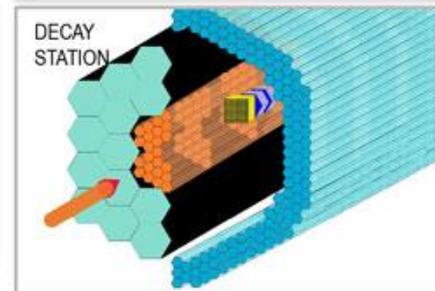
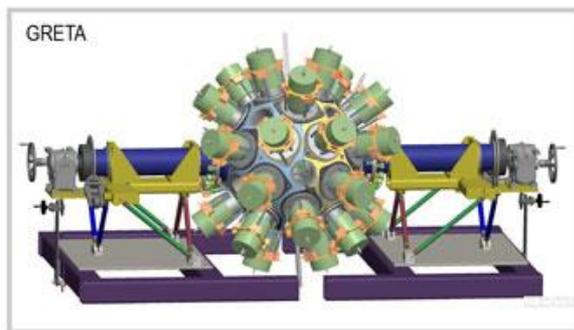
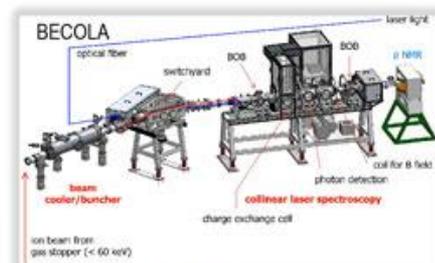
Engaged Users Planning for Instruments Summary Presented by Michael Smith

"To realize the full scientific discovery potential of FRIB and existing facilities it is essential that major experimental systems are available."

Joint DNP Town Meetings on Nuclear Structure and Astrophysics, 2014



Michael Smith
FRIB Users Organization
ORNL Physics Division



Theory and FRIB

- Theory plays a key role in the scientific program for FRIB and delivering on FRIB's discovery potential
- The community recommends creation of a national FRIB Theory Center
 - The JLab and BNL/RIKEN theory centers are internationally recognized as critical contributors to the success of the associated experimental facility.
- The proposed FRIB theory center will
 - continuously update the intellectual framework;
 - optimize the coupling between theory and experiment;
 - rejuvenate the field by creating permanent positions across the country;
 - attract young talent through the national FRIB theory fellow program;
 - foster interdisciplinary collaborations and shepherd international initiatives.

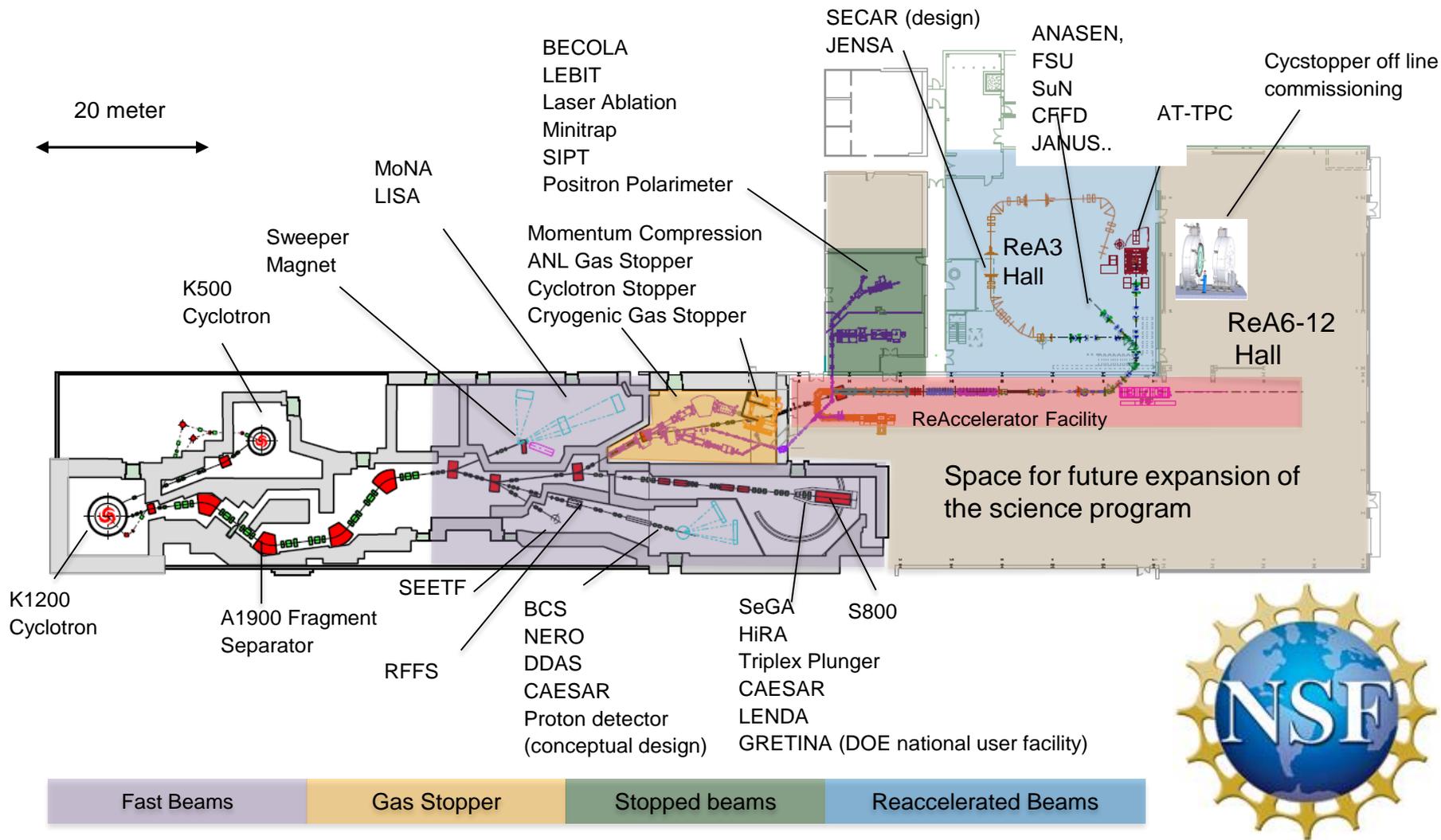
“We recommend that enhanced support for nuclear theory be provided to address key questions in nuclear physics and astrophysics and to realize the full potential of the experimental program at FRIB. We recommend the creation of a national FRIB theory center to drive this exciting science and the computational nuclear physics initiative to take maximum advantage of high performance computing critical to this effort.”

www.lecmeeting.org/preambleAndResolutionsTAMU2014.pdf



Pre-FRIB Science Opportunities at NSCL

Important NSF Stewardship Role



Summary and Outlook

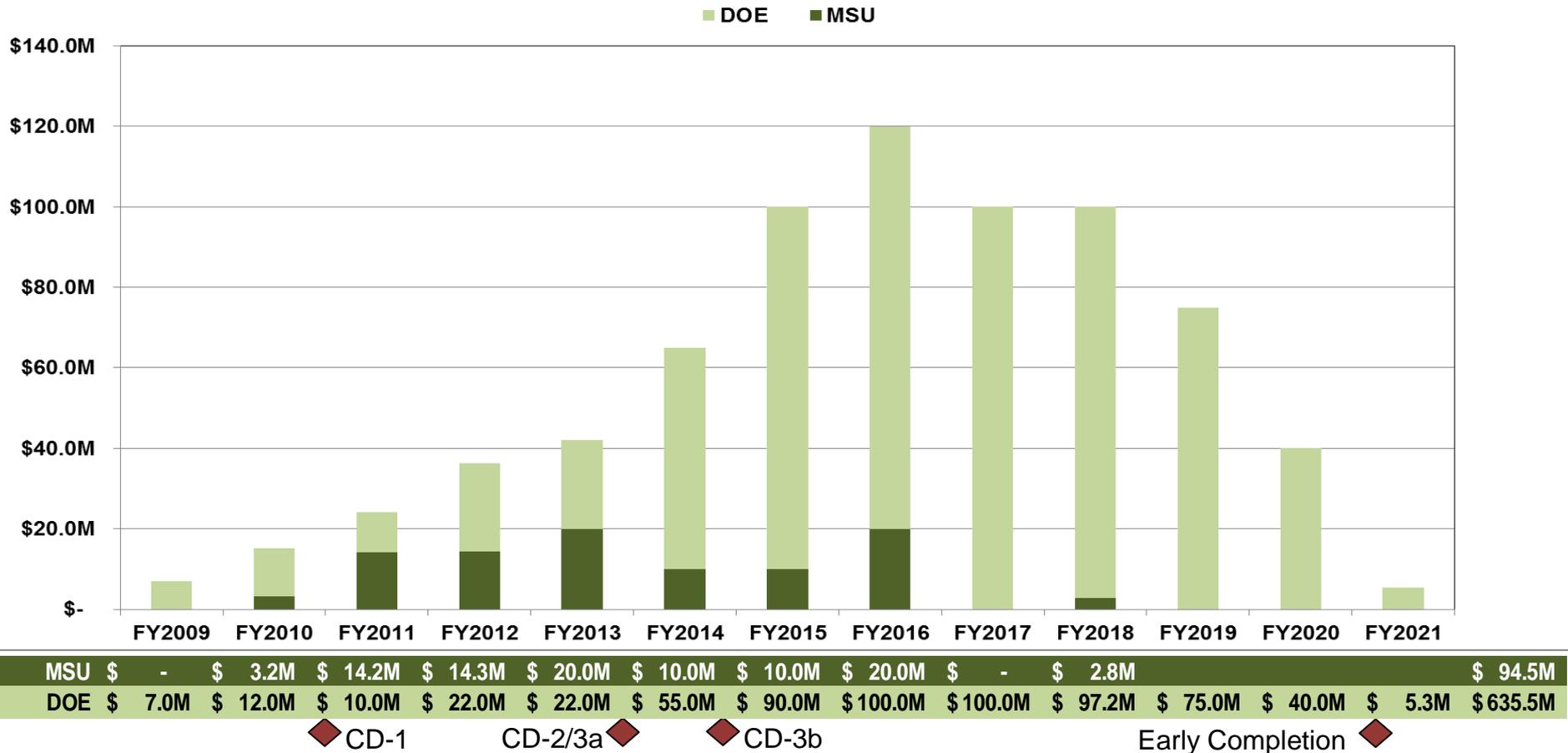
- FRIB civil construction started in March 2014, technical construction started in October 2013
- Managing to early completion in December 2020, CD-4 in June 2022
- Excellent working relationships with DOE-SC Nuclear Physics, Acquisition Executive, Federal Project Director, DOE-SC ISC Chicago and within MSU
- On schedule and within budget
- Significant involvement in project by ANL, JLab, LBNL, BNL and ORNL; in science by universities and national laboratories
- FRIB users (experiment and theory) engaged, ready for science, planning for instruments and reiterate importance of FRIB:

“The highest priority in low energy nuclear physics and nuclear astrophysics is the timely completion of the Facility for Rare Isotope Beams and the initiation of its full science program”

www.lecmeeting.org/preambleAndResolutionsTAMU2014.pdf



Project Execution Plan Funding Profile Supports Performance Measurement Baseline



- One TPC, two funding sources: DOE and MSU
- After construction start, MSU allowed FRIB to advance remaining cost share to benefit project

