FRIB

FRIB Project Status and Plans for Initial Operation

2016 Low Energy Community Meeting

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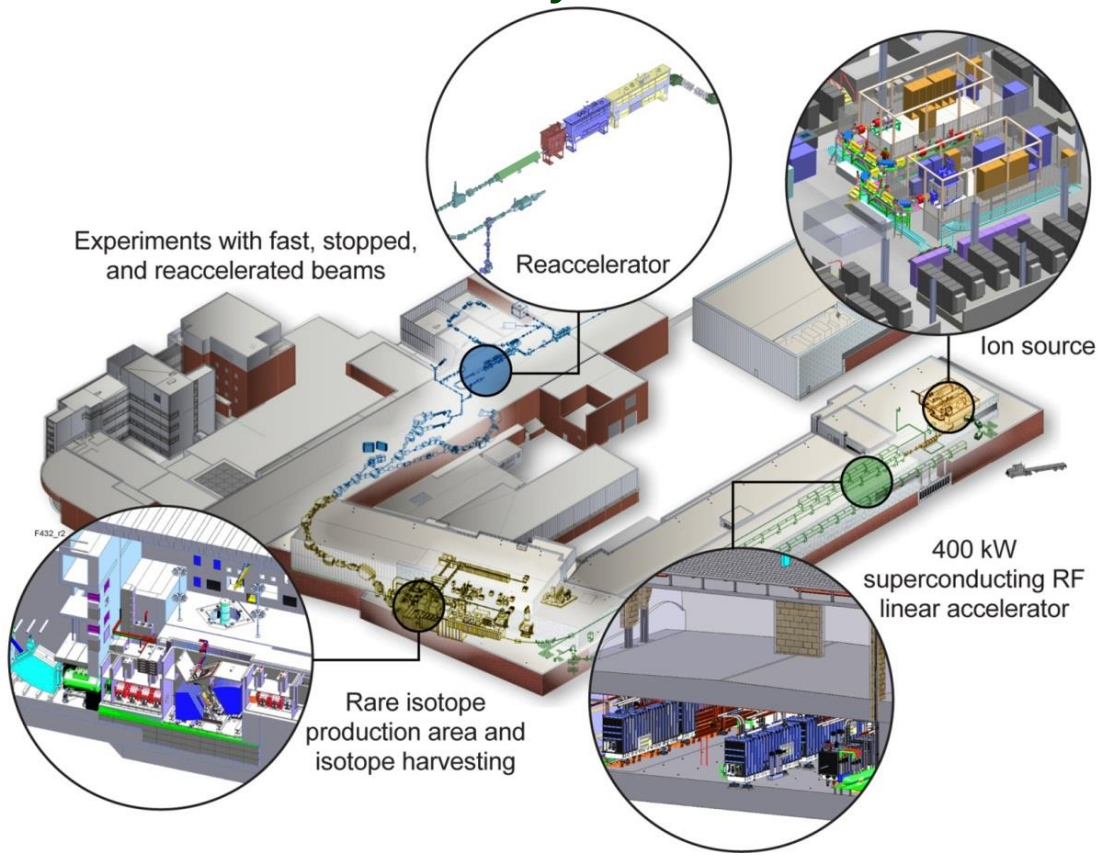
MICHIGAN STATE UNIVERSITY

U.S. DEPARTMENT OF ENERGY | Office of Science

This material is based upon work supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661, the State of Michigan and Michigan State University. Michigan State University designs and establishes FRIB as a DOE Office of Science National User Facility in support of the mission of the Office of Nuclear Physics.

Facility for Rare Isotope Beams
A Future DOE-SC Scientific User Facility for Nuclear Physics

- Funded by U.S. Department of Energy Office of Science (DOE-SC) supporting the mission of the Office of Nuclear Physics in DOE-SC
- Serving over 1,400 users
- Key feature is 400 kW beam power for all ions ($5x10^{13}$ $^{238}U/s$)
- Separation of isotopes in-flight
  - Fast development time for any isotope
  - Suited for all elements and short half-lives
  - Fast, stopped, and reaccelerated beams



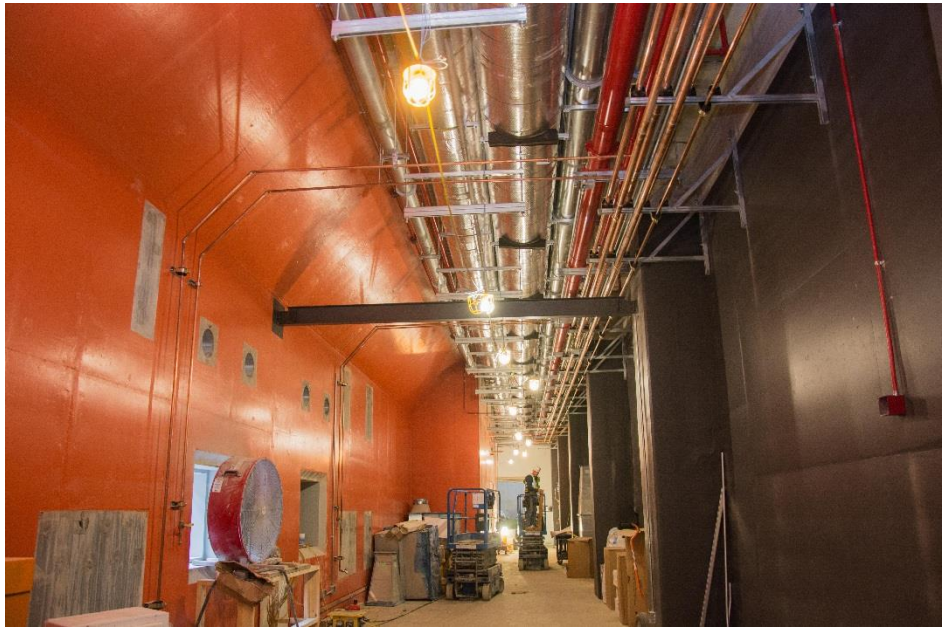
Facility for Rare Isotope Beams in 2021

Civil Construction Progressing Well
Ten Weeks Ahead of Baseline Schedule

FRIB construction site on August 12, 2016
Web cameras at www.frib.msu.edu

Civil Construction Progressing Well
Ten Weeks Ahead of Baseline Schedule

Mechanical piping in lower second floor



Remote handling gallery painted (looking north)

Civil Construction Progress
Allows Technical Construction to Advance Ahead of Beneficial Occupancy

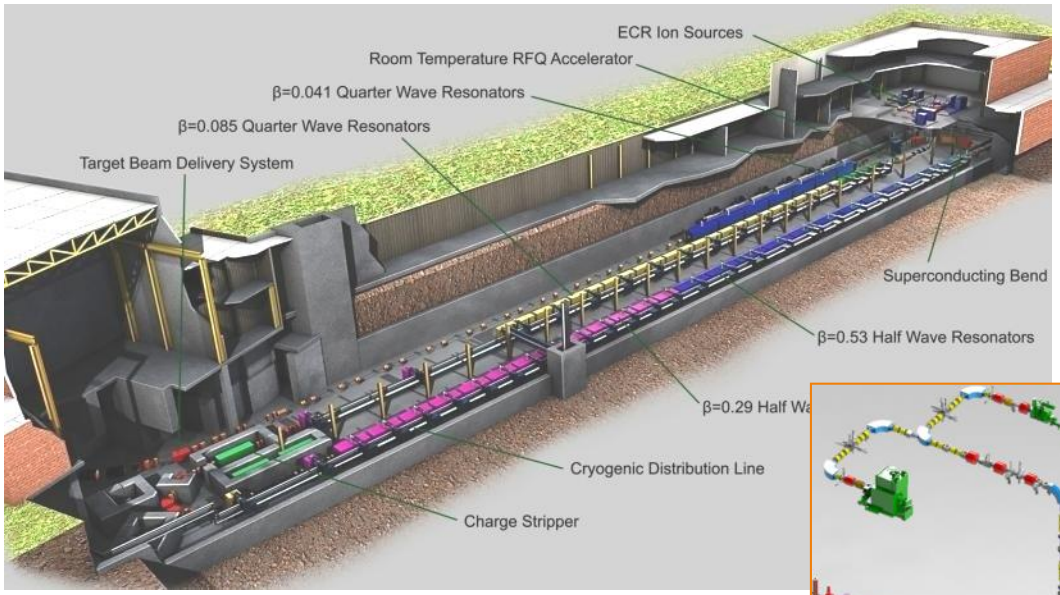
Cryogenic transfer lines being installed in the linac tunnel for linac segment 1

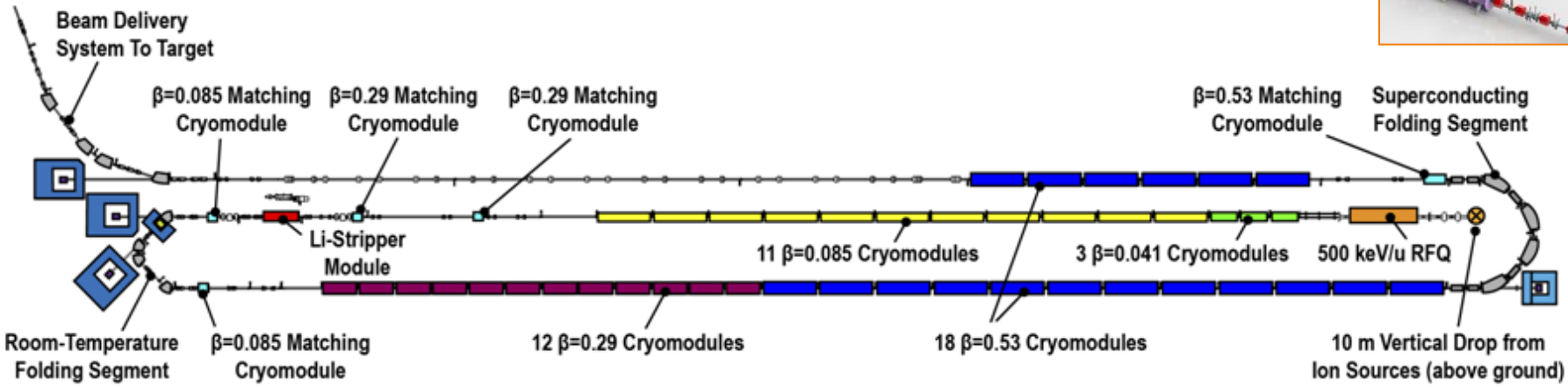
DC cables being installed for folding segment 1

4K Upper Cold Box Lifted Off 150ft Trailer and Placed in Cryogenic Plant

FRIB Accelerator Systems
Superconducting RF Driver Linac

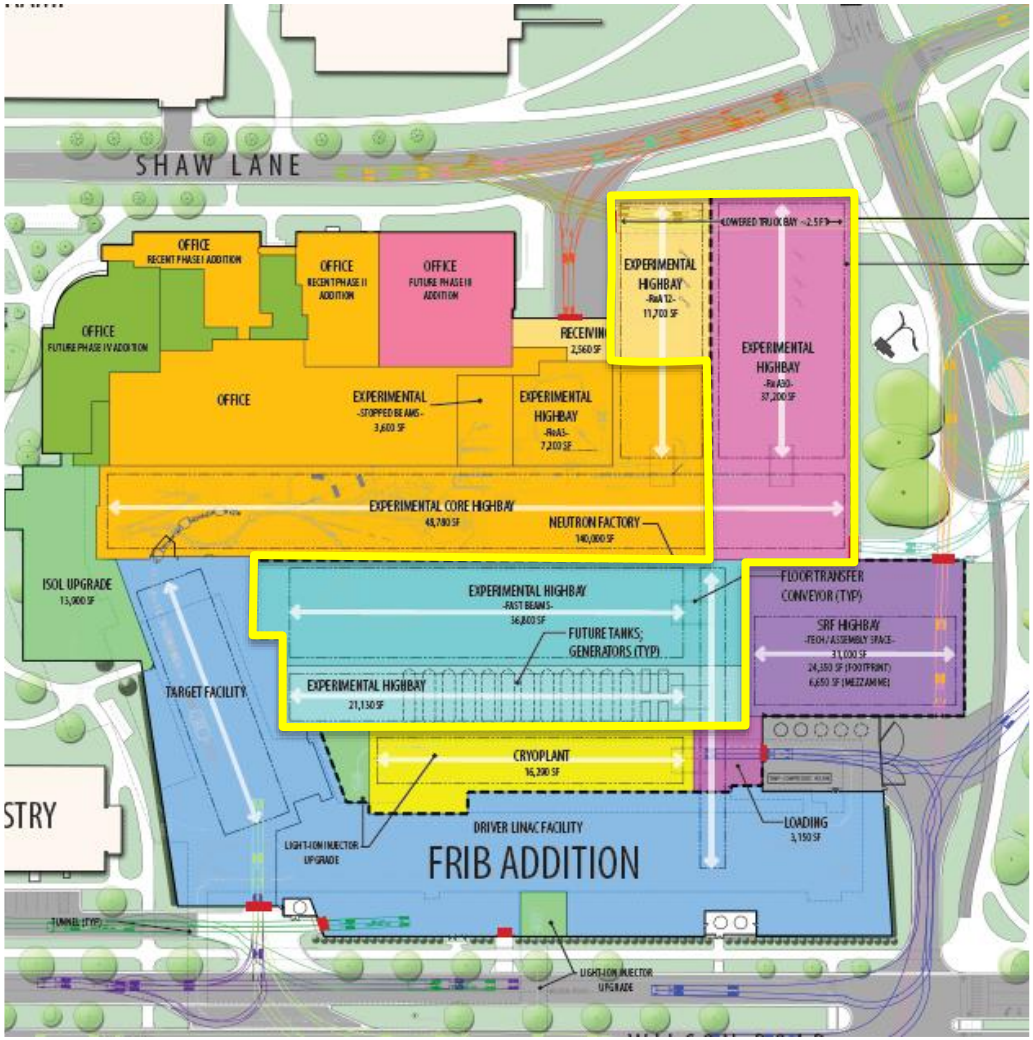
- Accelerate ion species up to ^{238}U with energies of no less than 200 MeV/u
- Provide beam power up to 400kW
- Energy upgrade to 400 MeV/u for ^{238}U by filling vacant slots with 12 SRF cryomodules
- Provisions for ISOL upgrade





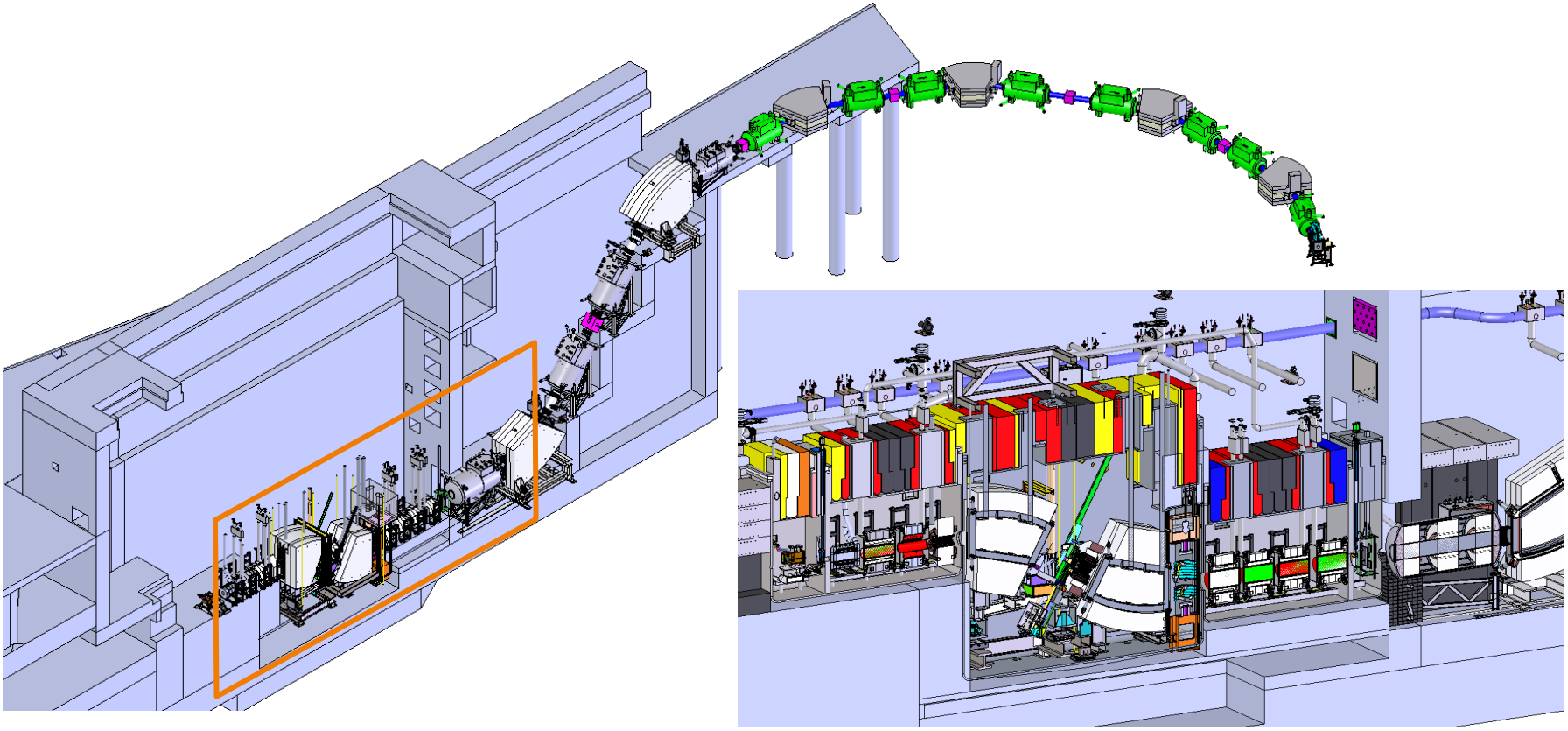
Experimental Area Expansion and New Scientific Instruments

- 47,000 sq ft operational when FRIB starts, upgrade space of more than 60,000 sq ft
- Experimental Equipment
  - Equipment at NSCL (existing or under development): S800, SeGA, MoNA, MoNA-LISA, LENDA, NSCL-BCS, LEBIT, BECOLA, AT-TPC, CAESAR, SUN, ...
  - Equipment available in the community and movable (existing, under development, or planned): GRETINA, ANASEN, CHICO, Nanoball, ORRUBA, JANUS, …
  - Science-driven new equipment developed by FRIB user community: SECAR, GRETA, HRS, Decay Station, ISLA, …



Fragment Separator

- Three-stage fragment separator for production and delivery of rare isotope with high rates and high purities to maximize FRIB science reach
- Primary beam power of 400 kW and beam energies of ≥ 200 MeV/u



Vacuum Vessel Fabrication Progressing Well

- Fabrication is making good progress
  - Target: Final assembly 93% complete
  - Beam dump: Upper half 7% complete; Lower half 24% complete
  - Wedge: Wedge vessel shipped to machine shop in Cincinnati, OH, final machining underway; machining to be completed by end of August
- Preparing for vacuum tests at Cincinnati machine shop


Wedge Vessel Seal Retainer


Wedge vessel arrival in Cincinnati, OH


Wedge Vessel loaded on Truck in Camden, NJ

2nd β=0.085 Cryomodule Being Tested; 1st β=0.041 Cryomodule Being Assembled

Four Cryomodules Being Assembled in Parallel

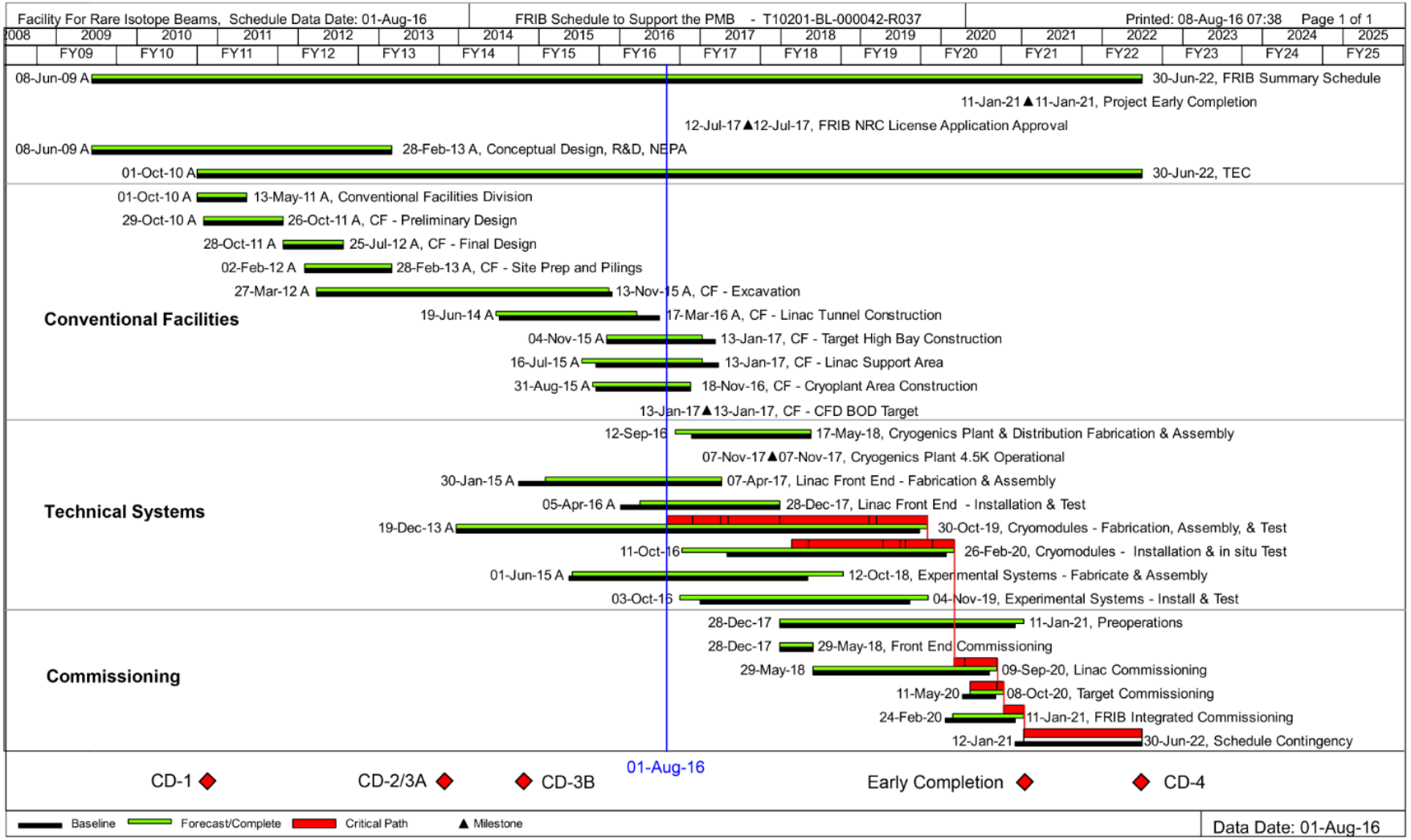
RFQ Segments Assembled and Tested

In Transit to FRIB - Arriving Early September

RFQ assembly at supplier

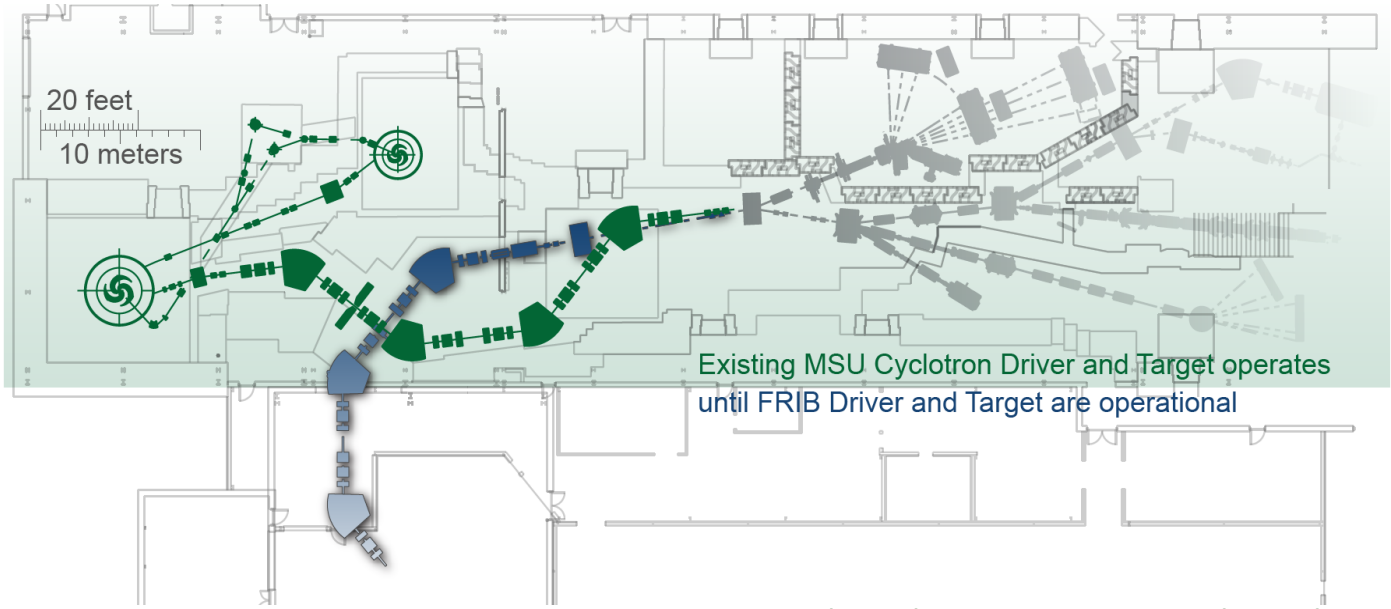
RFQ amplifier assembly at FRIB

FRIB Project is on Schedule for Completion in FY2021 and on Budget



NSCL-FRIB Integration Plan in Place and Being Executed by all Parties

- FRIB project managing towards early completion in FY21
- NSF National Science Board approved cooperative agreement for NSCL operation FY17 - FY21
  - NSCL operations completes in FY2021
- DOE-SC NP reviewed FRIB operations cost in January 2016
- Transition to FRIB operations is planned for less than a year
  - Plan optimizes continuity of nation's world-class science endeavor in low-energy nuclear science



T. Glasmacher, Low Energy Community Meeting, August 2016, Slide 16

1400 Users Engaged and Ready for Science

www.fribusers.org

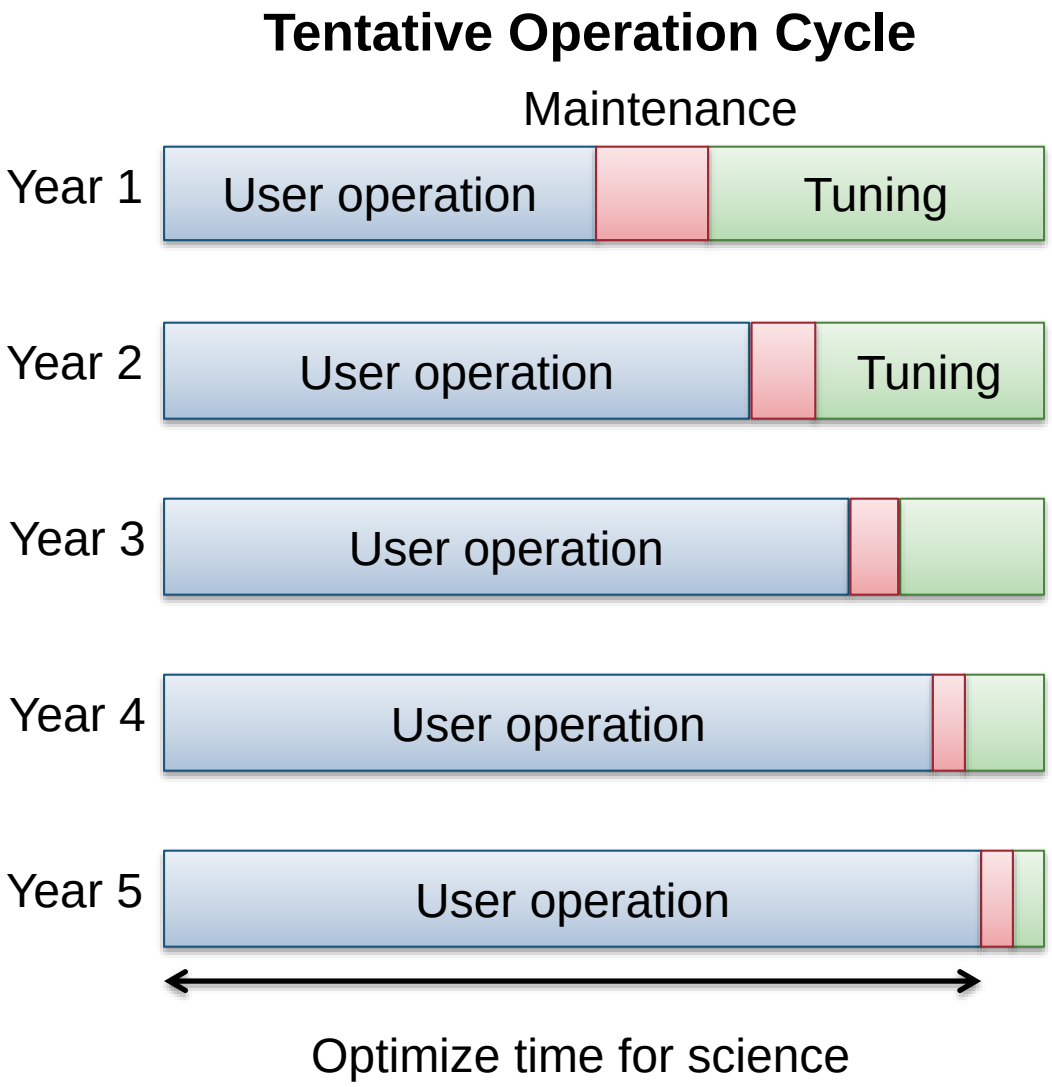
- Users are organized as part of the independent FRIB Users Organization (FRIBUO)
  - Chartered organization with an elected executive committee
  - 1,400 members (107 U.S. colleges and universities, 12 national laboratories, 51 countries) as of August 2016
  - 19 working groups on instruments
- Science Advisory Committee
  - Review of equipment initiatives (February 2011)
  - Review of FRIB integrated design (March 2012)
  - Review of equipment working group progress (October 2013)
  - Review of experimental equipment plans (March 2015)
  - Next meeting December 2016

FRIB Theory Alliance Inaugural Meeting Held

- A meeting marking the creation of the FRIB Theory Alliance was held on March 31 and April 1 at Michigan State University. It was very well attended (around 100 participants), with many FRIB-TA members present and others observing by videocast.
- The first day contained talks by MSU, DOE, and NSF representatives, and presentations from past and present FRIB Theory Fellows. An overview summary of the FRIB-TA goals and initiatives led into a general open discussion and the ratification of the FRIB-TA Charter.
- The second day was devoted to an excellent series of talks covering the full depth and breadth of FRIB-related science. Slides for the talks are available at: http://fribtheoryalliance.org/content/meetings/TA_Inaugural_talks.php.
- The FRIB-TA Managing Director (Filomena Nunes) has been appointed by the FRIB Laboratory Director in coordination with DOE.
- The first elections for the two open seats held: Rebecca Surman and Chuck Horowitz joined the FRIB-TA Executive Board.

Balance Between Science and Machine Advancement to Enhance Discovery Potential

- After CD-4, adequate time allocated for maintenance and tuning to assure machine integrity and path towards mission goal while enabling world-class science
- Time allocation optimized for efficient integration assuming more extensive maintenance/tuning to reach 400 kW for early years
- Detailed operation cycle is under discussion, trade-offs will be discussed with *Accelerator Systems Advisory Committee* (*Machine Advisory Committee* once FRIB in operation) and *Science Advisory Committee* (*Program Advisory Committee* once FRIB in operation)



Accelerator Operations on Day-one

- Primary beams
  - See tables to right
- Beam power
  - Year One – 10 kW
  - Year Two – 50 kW
- Secondary beams
  - See reference to scientific benchmarks
  - Initial studies for all benchmarks enabled by year two
- Experimental end stations
  - Existing NSCL instruments
  - GRETA
  - SECAR
- Early operations funding ensures that key staff are available to deliver primary and secondary beams for science

Year One

Beam	Notional Weeks/ Year	RISAC Bench-marks
^{238}U	12	7,10,12,15
^{48}Ca	6.34	2,14
^{78}Kr	2.21	3,8,9,16,17
^{124}Xe	1.3	1,11,17
^{18}O	0.86	2,8
^{86}Kr (CD-4)	0.63	1,3,4,6, 14,15
^{16}O	0.44	2,8
^{36}Ar (CD-4)	-	8
Total	23.8	

^{86}Kr and ^{36}Ar used to demonstrate FRIB Project's Key Performance Parameters

Year Two

Beam	Notional Weeks/ Year	RISAC Bench-marks
^{82}Se	5.25	1,3,4,5,6, 13,14,15
^{92}Mo	2.45	1,3,9,11,16, 17
^{58}Ni	1.64	1,3
^{22}Ne	0.54	2
^{64}Ni	0.5	1,13,14
Total	10.4	

FRIB Project is on Track

- 8 June 2009 – DOE-SC and MSU sign Cooperative Agreement
- September 2010 – CD-1 approved, DOE issues NEPA FONSI
- April 2012 – Lehman review, baseline and start of civil construction
- August 2013 – CD-2 approved (baseline), CD-3a approved (start civil construction pending FY2014 federal appropriation)
- March 2014 – Start civil construction
- August 2014 – CD-3b approved (technical construction)
- Jan 2016 DOE NP operations cost review
- June 2022 – CD-4, managing to early completion in FY21
  - First beam from ECR in 2016
  - Liquid helium in 2017

Summary

- FRIB project is making good progress
- Plan to ensure nation's leadership in low-energy nuclear science in place, on track and supported by all parties
  - NSF National Science Board has approved NSCL Cooperative Agreement to operate NSCL FY17-21
  - DOE-SC Office of Nuclear Physics has held FRIB operations cost review
  - MSU ensures FRIB on track for completion in FY2021 with DOE funding and MSU funding
- Users engaged and planning for day-one scientific program
- Instruments under construction and more planned
- Theory Alliance inaugural meeting held
- Will need to balance science experiments (realization of discovery potential afforded by FRIB) with machine development (which increases discovery potential)