FRIB Introduction and FRIB Controls

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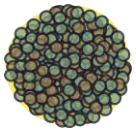
MICHIGAN STATE UNIVERSITY

U.S. DEPARTMENT OF ENERGY | Office of Science

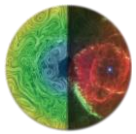
This material is based upon work supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661.
Michigan State University designs and establishes FRIB as a DOE Office of Science National User Facility in support of the mission of the Office of Nuclear Physics.

FRIB – a DOE-SC National User Facility Enabling Scientists to Make Discoveries



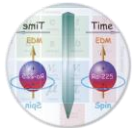
Properties of nucleonic matter

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



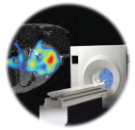
Nuclear processes in the universe

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



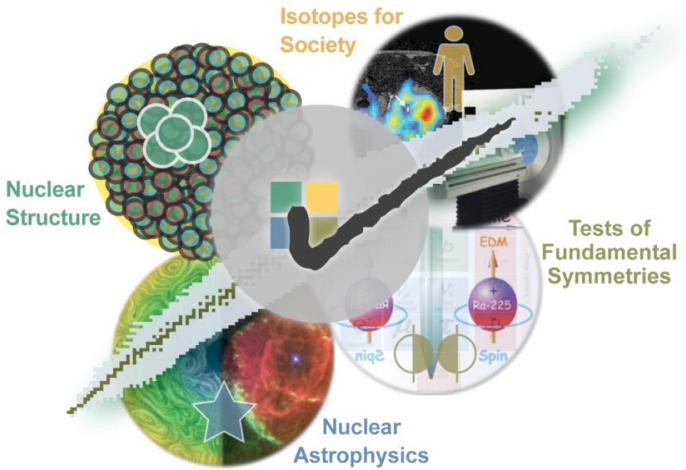
Tests of fundamental symmetries

- Effects of symmetry violations are amplified in certain nuclei



Societal applications and benefits

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



FRIB Users Organization
1333 Users Ready for Science

- Users are organized as part of the independent FRIB Users Organization
  - FRIBUO has 1350 members (92 U.S. colleges and universities, 10 national laboratories, 53 countries) as of April 2013
  - Chartered organization with an elected executive committee (Chair is Michael Smith, Oak Ridge National Laboratory (ORNL))
  - FRIBUO has 20 working groups on experimental equipment
  - Significant User participation and support for FRIB in the NSAC Long Range Plan Implementation subcommittee
- Science Advisory Committee
  - Review of equipment initiatives (February 2011)
  - Review of FRIB integrated design (March 2012)
  - Review of first steps to science (planned for Dec 2013)

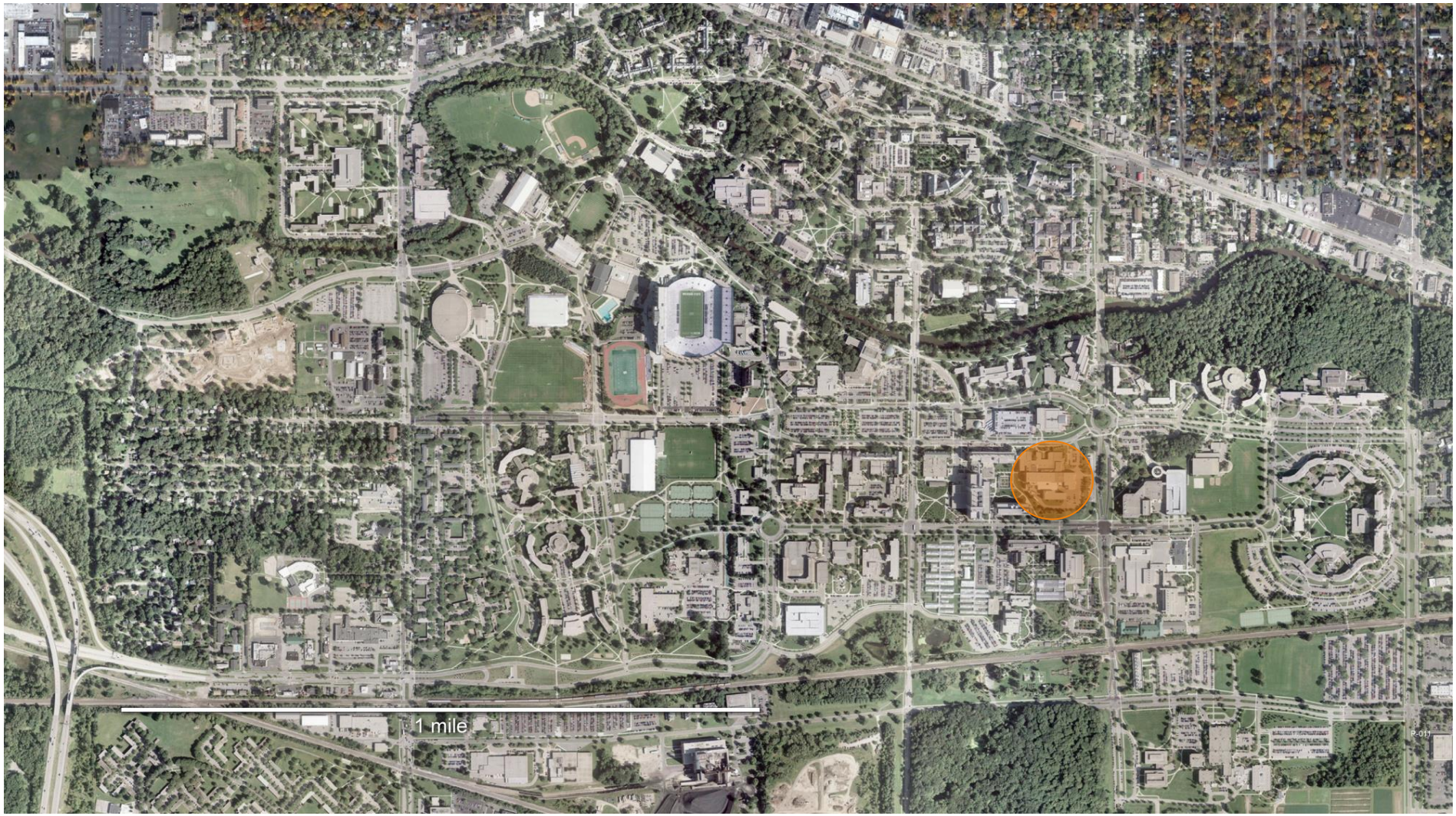
August 2012
Joint Users Meeting
306 participants

fribusers.org

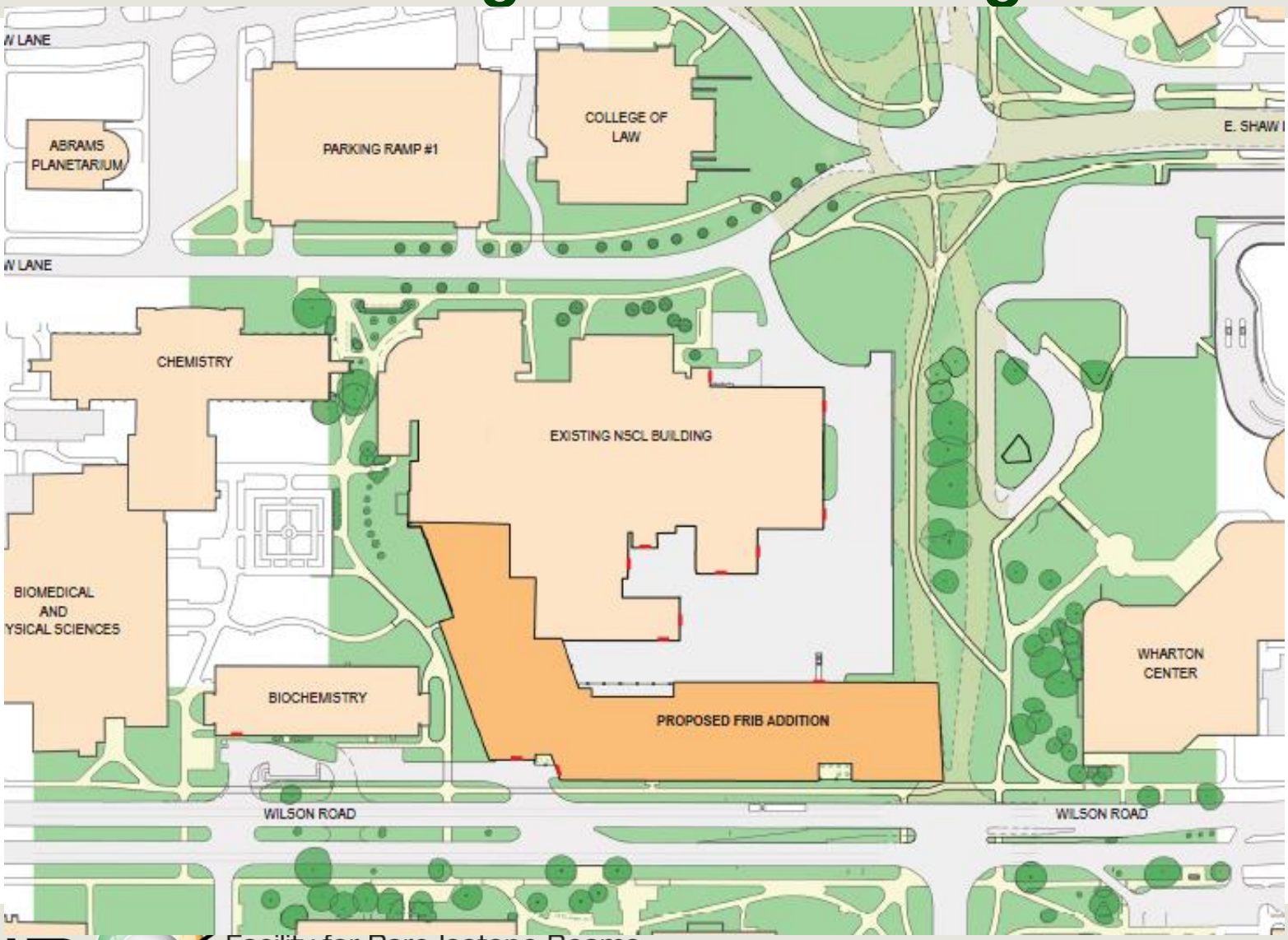
FRIB Project at MSU
Project of $700M ($94.5M MSU, the rest from DOE)

- Dec. 2008: DOE selects MSU to establish FRIB
- June 2009: DOE and MSU sign corresponding cooperative agreement
- Sept. 2010: CD-1 granted; conceptual design complete & preferred alternatives decided
- April 2012: Lehman Review, finds FRIB is ready for construction
- June 2013: Lehman Review, plan to get CD-2/3A approval 3rd Quarter 2013

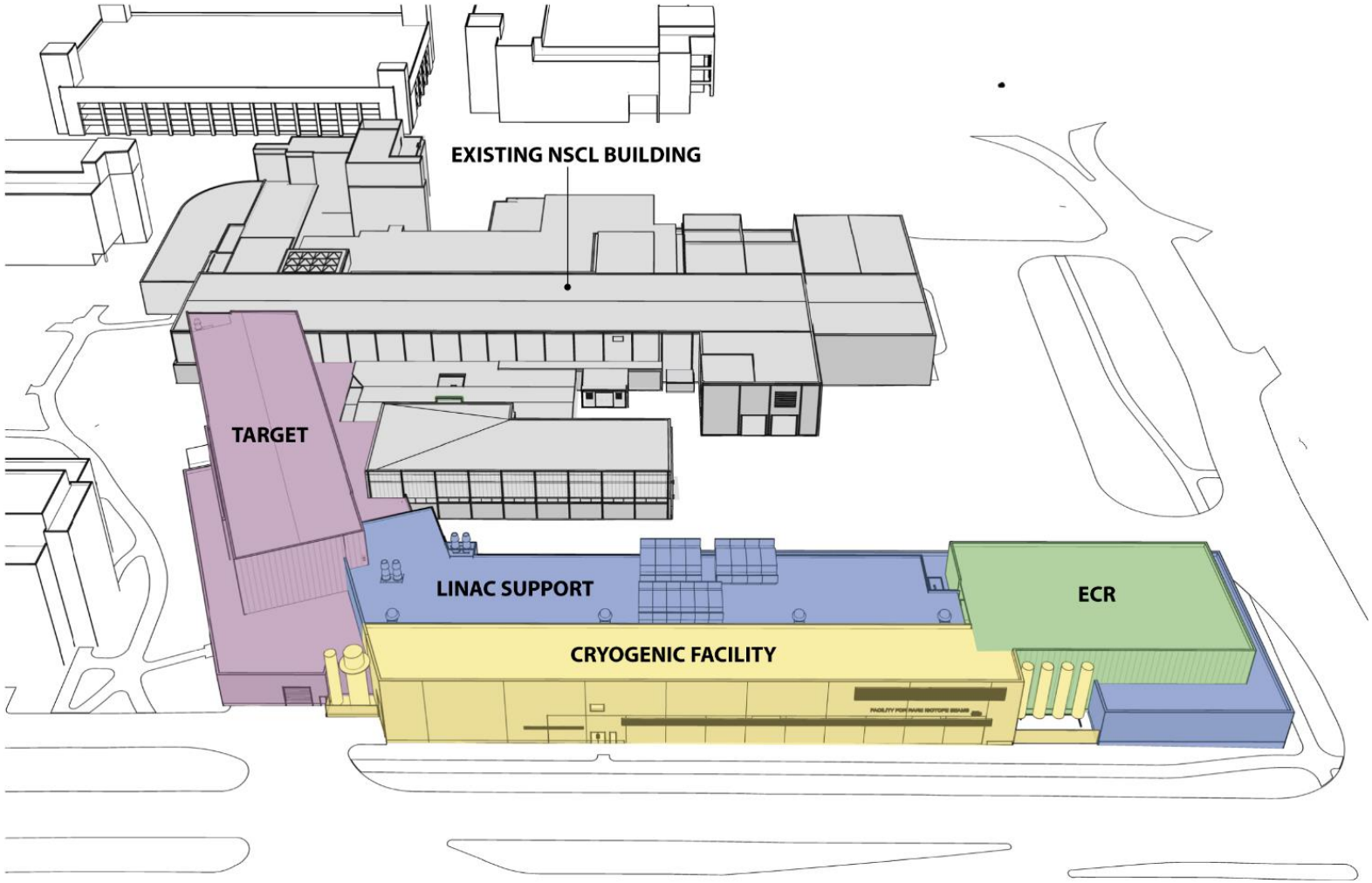
Michigan State University
57,000 people; 36 sq mi; $1.8B annual revenue; 552 buildings



Site Layout: FRIB addition connects to existing NSCL building



Building Configuration



Final Design of Conventional Facilities Complete

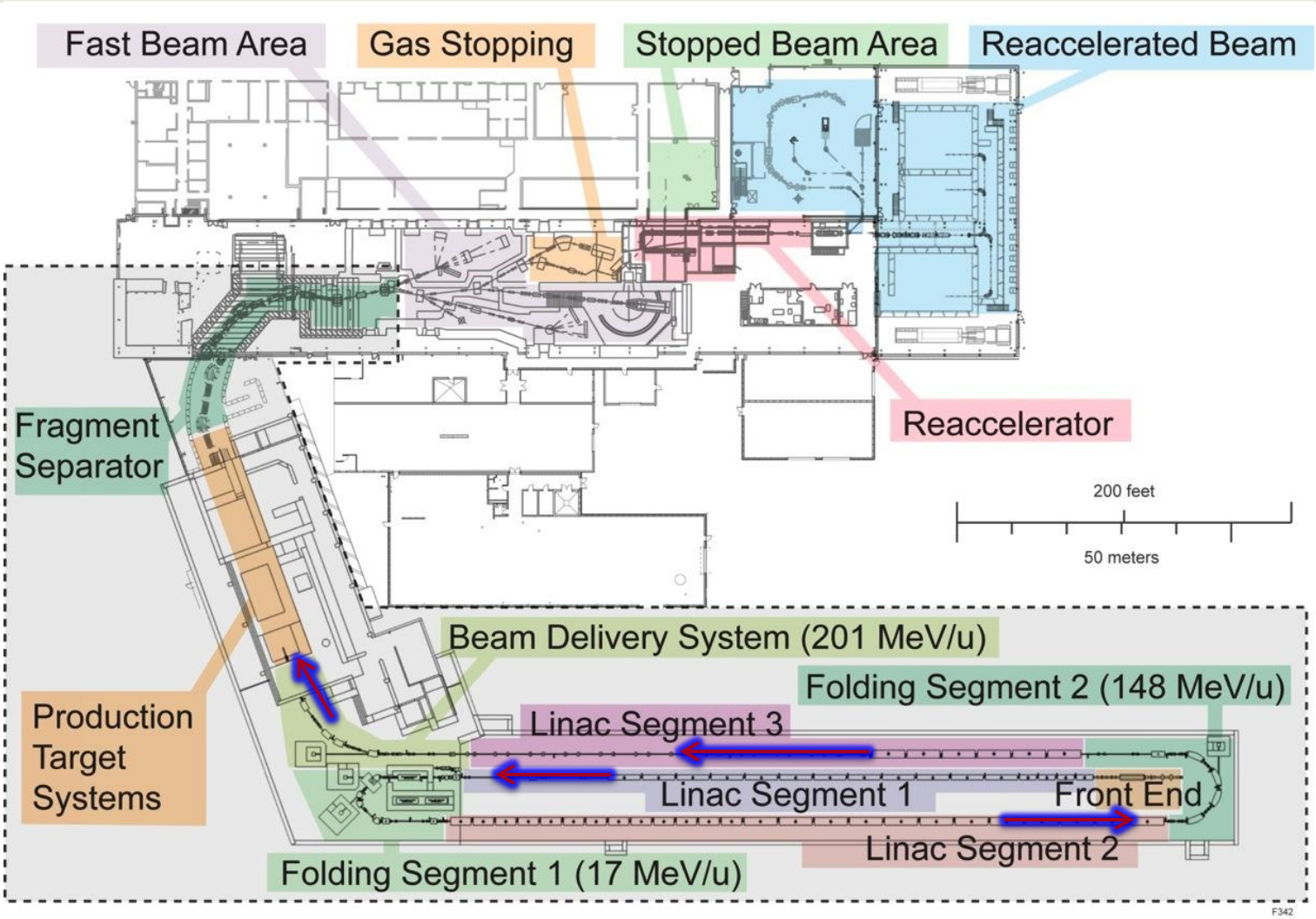
View from Southeast

Ready for Civil Construction to Begin

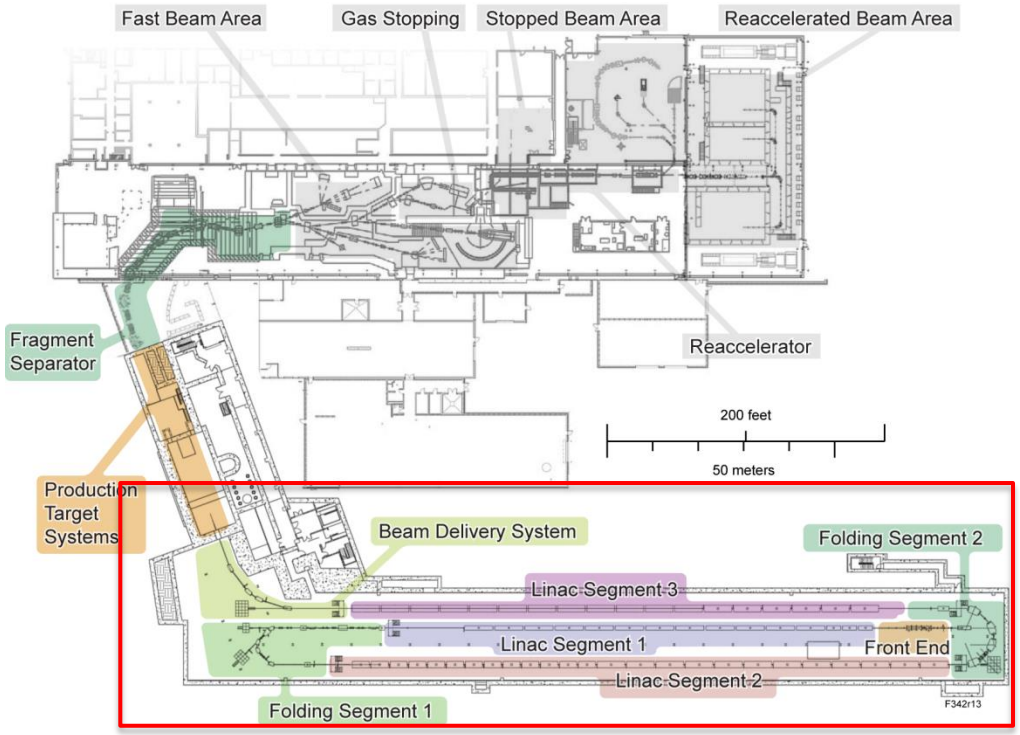
- Site preparation and placement of pilings for earth retention complete
- Ready for start of civil construction upon approval from DOE-SC

Photo from 25 February 2013; live and time lapse images at frib.msu.edu

Facility Layout



Accelerator Design & Requirements

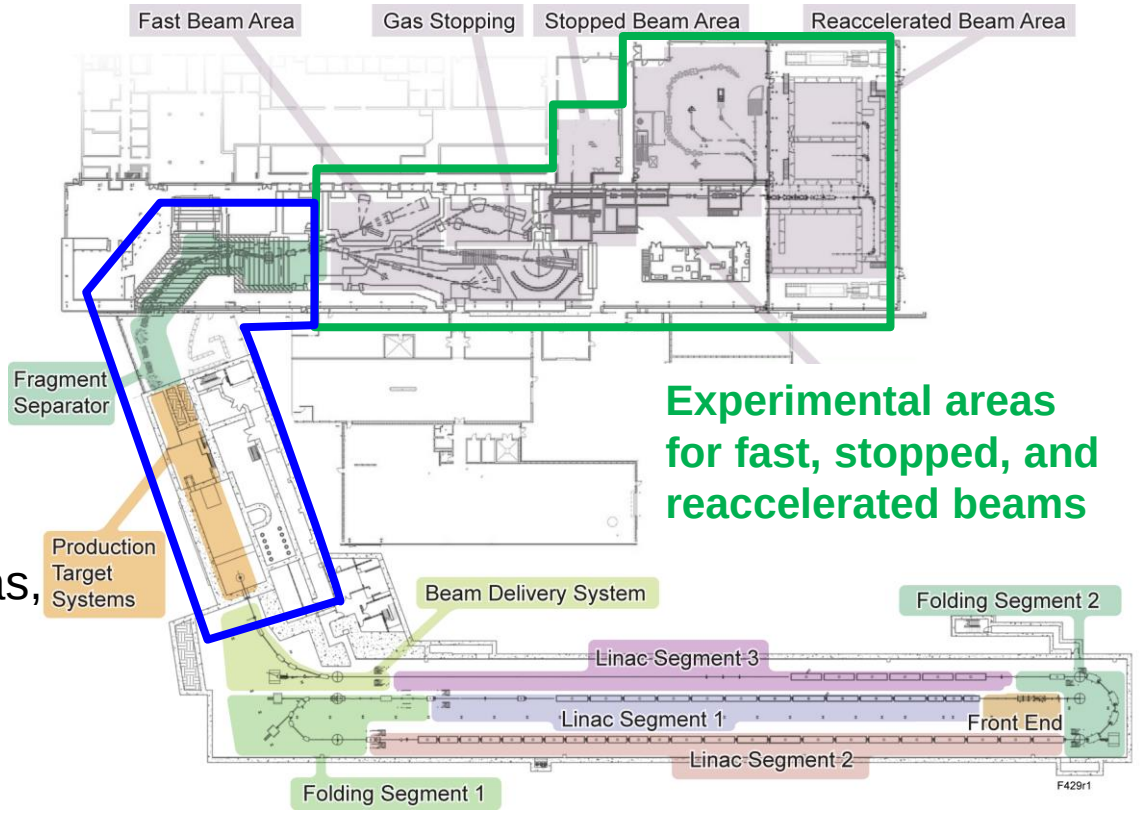


- Delivers FRIB accelerator as part of a DOE-SC national user facility with high reliability & availability
- Accelerate ion species up to ^{238}U with energies of no less than 200 MeV/u
- Provide beam power up to 400 kW
- Satisfy beam-on-target requirements

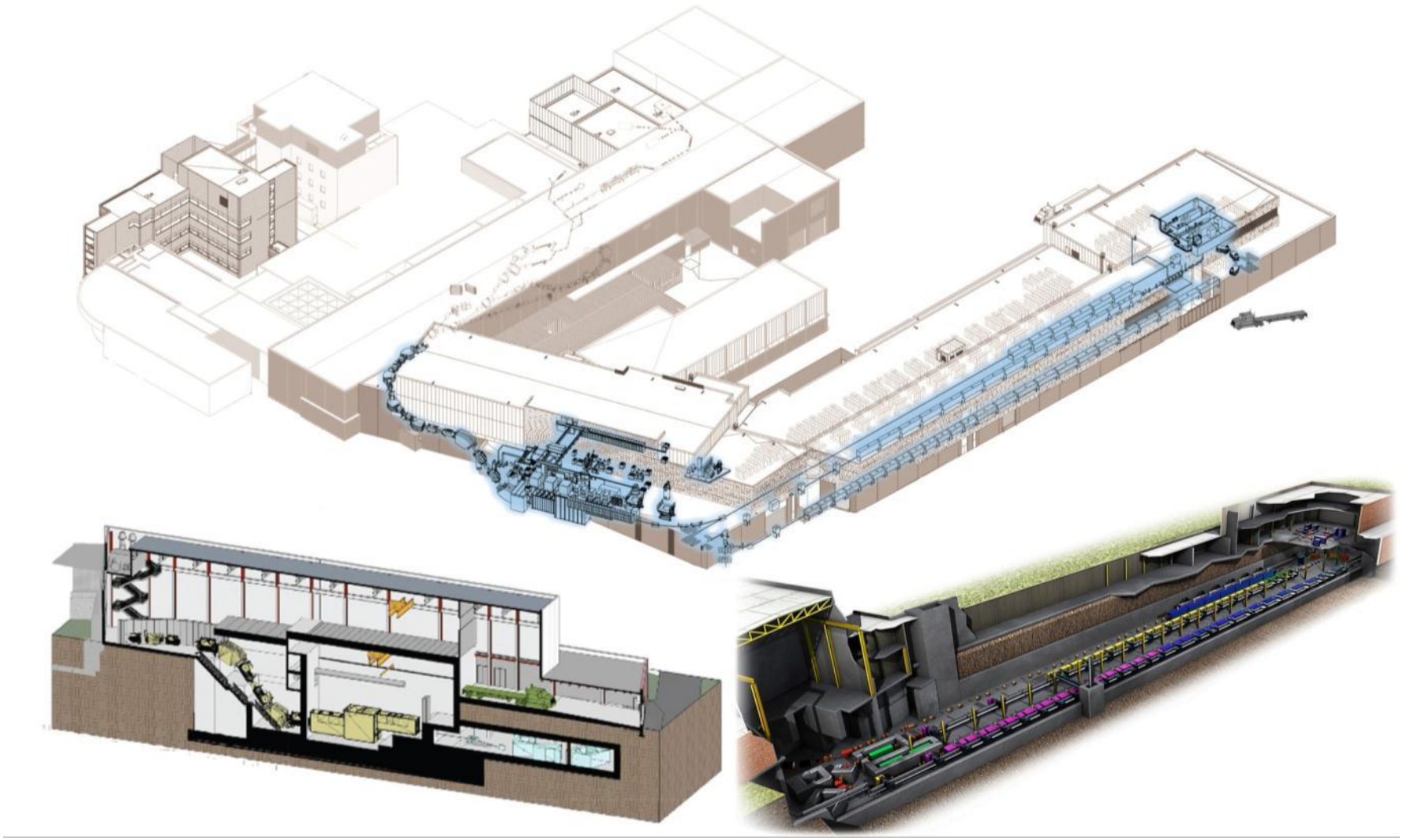
- Energy upgrade by filling vacant slots with 12 SRF cryomodules
- Maintain ISOL option
- Upgradable to multiuser simultaneous operation of light/heavy ions with addition of a light-ion injector

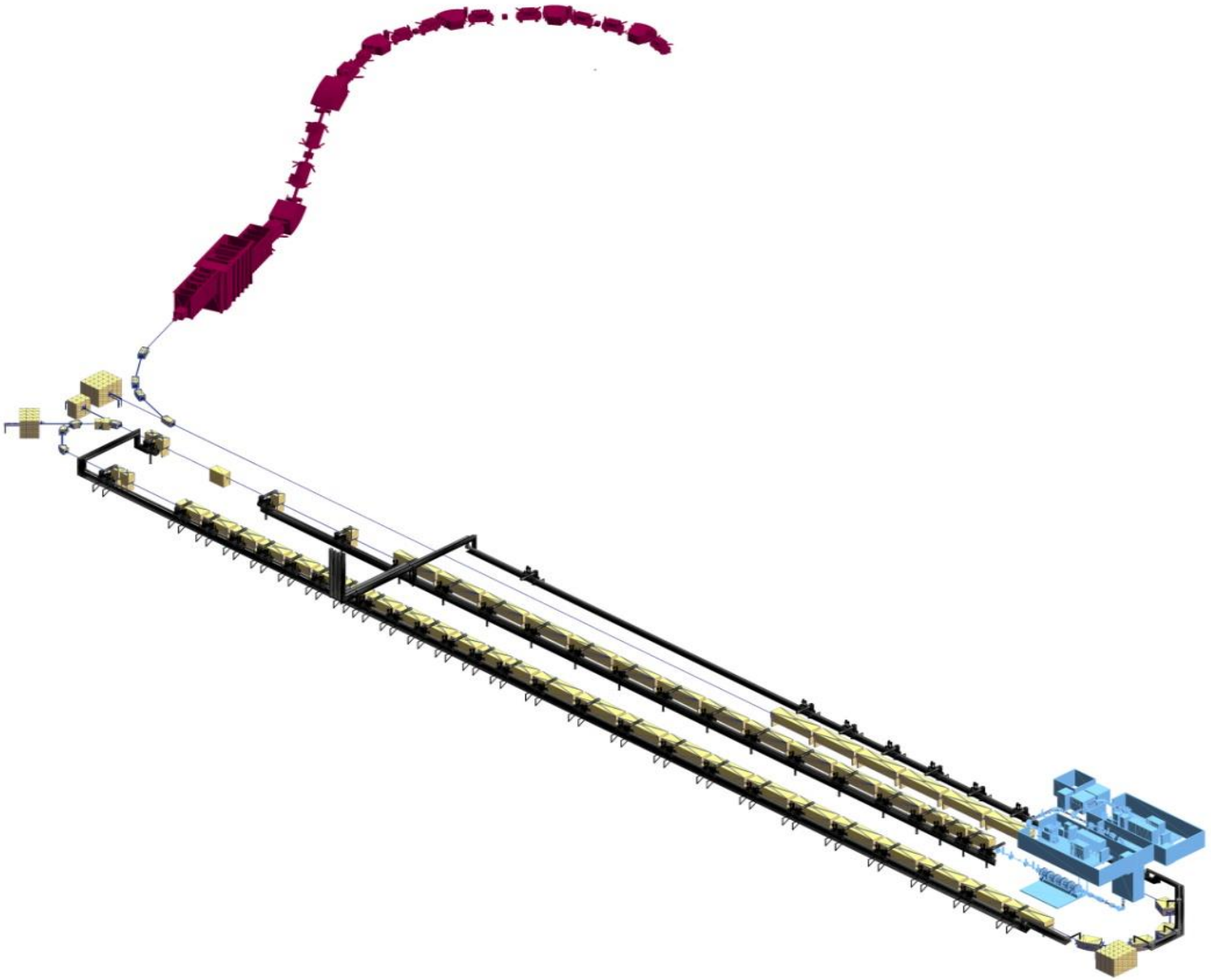
Experimental Systems Scope

- Facility performance expectations
  - Rare isotope production with primary beams up to 400 kW, 200 MeV/u uranium
  - Fast, stopped and reaccelerated beam capability
  - Experimental areas and scientific instrumentation for fast, stopped, and reaccelerated beams
  - World-class science on day one
- Experimental Systems project scope
  - Production target facility
  - Fragment separator
- Non-TPC contributions to Experimental Systems
  - Beam stopping systems, reaccelerator, experimental areas, experimental equipment

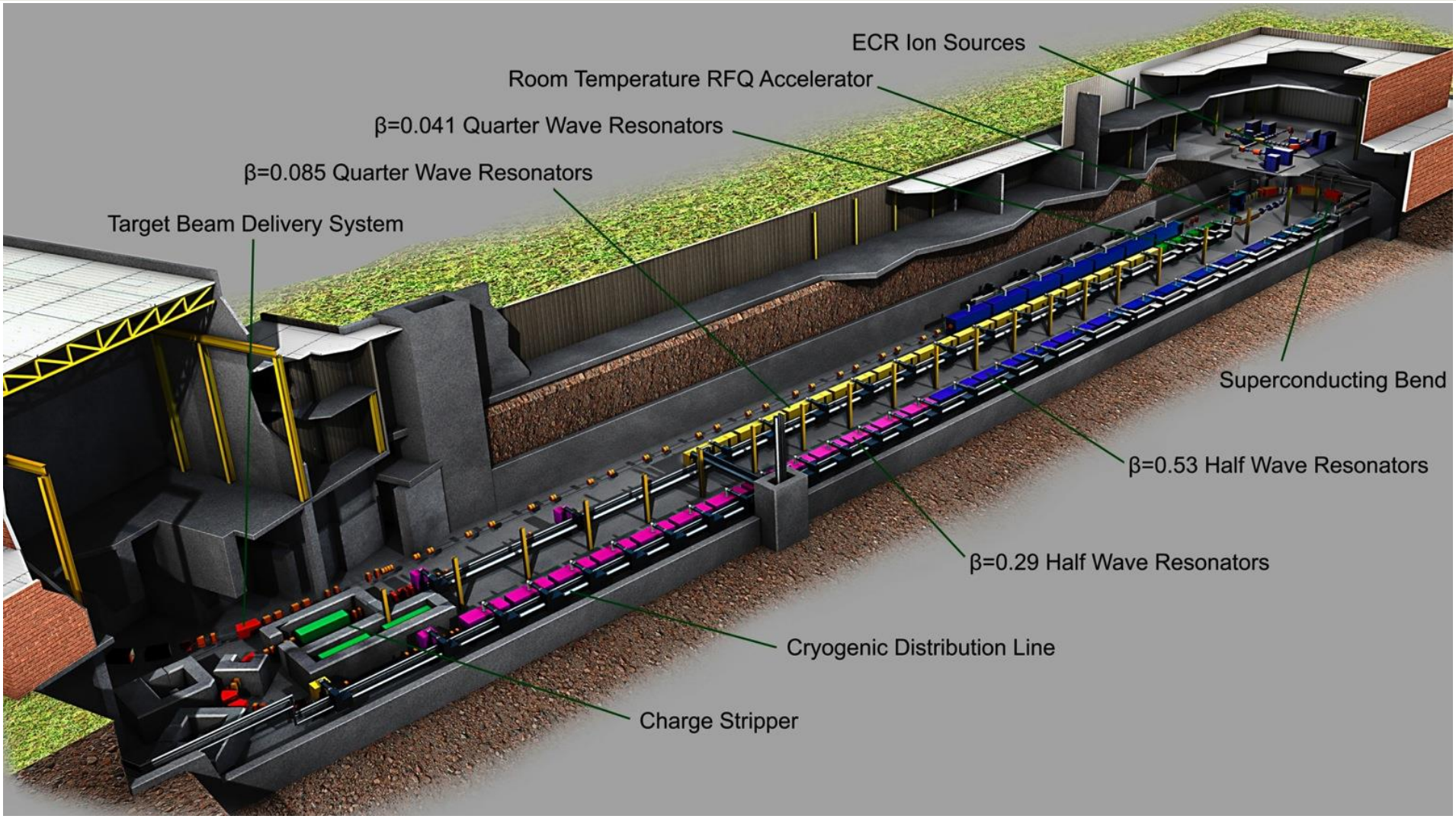


Facility Layout



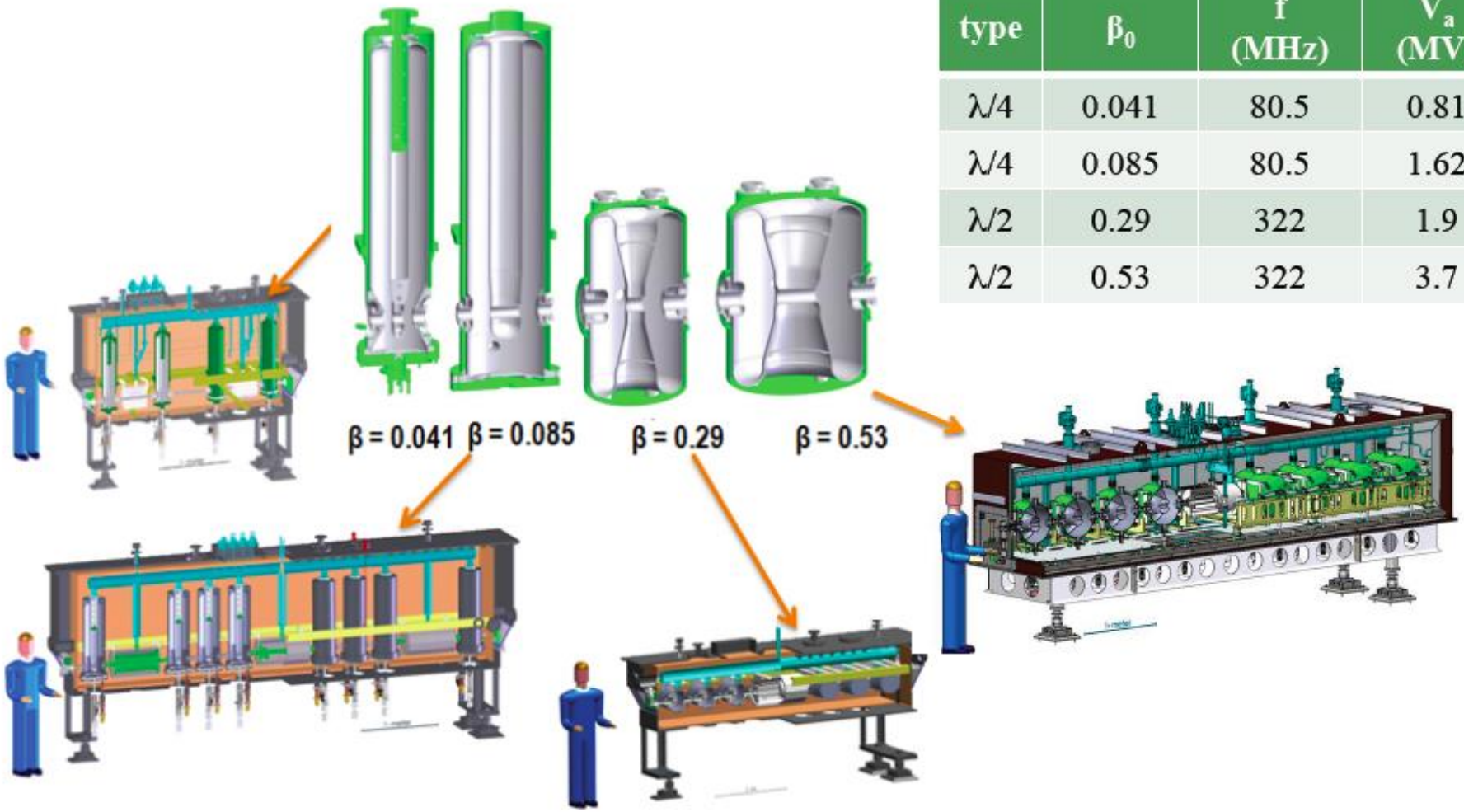


FRIB Driver Accelerator Layout



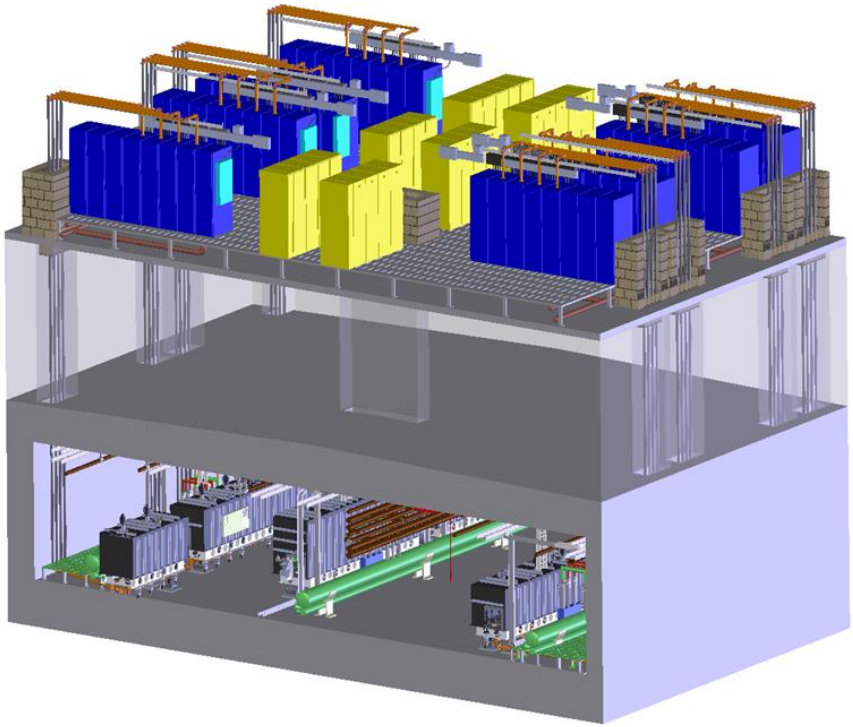
FRIB Resonators and Cryomodules: Beam Dynamics Specifications

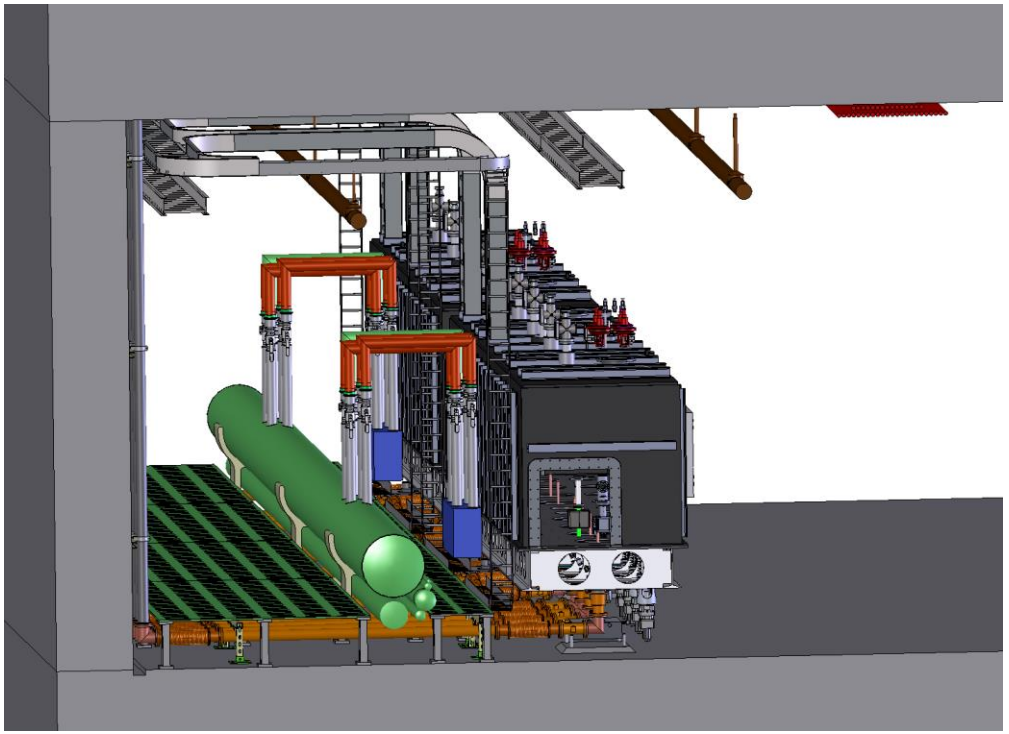
type	β_0	f (MHz)	V_a (MV)
λ/4	0.041	80.5	0.81
λ/4	0.085	80.5	1.62
λ/2	0.29	322	1.9
λ/2	0.53	322	3.7



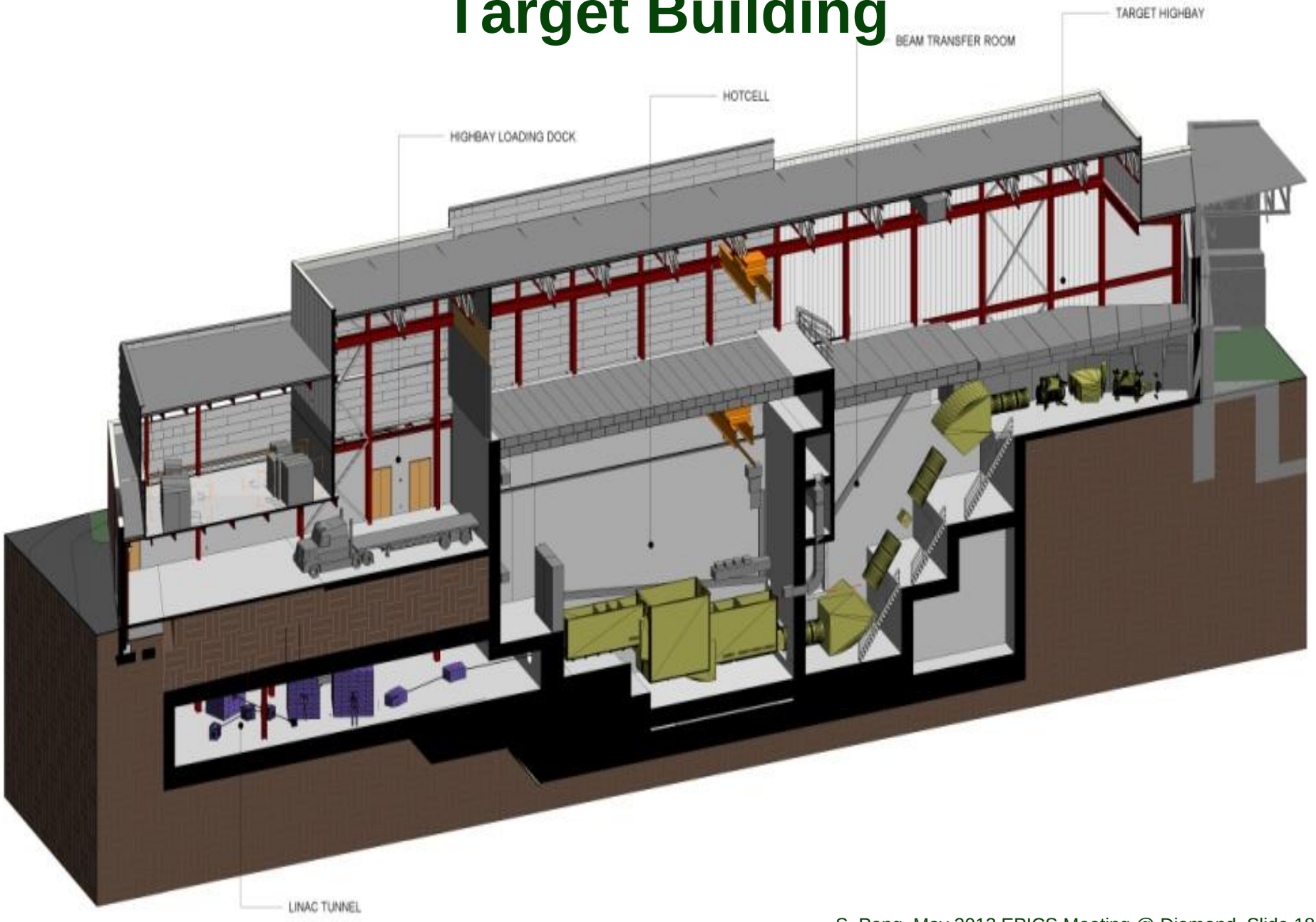
Conventional Facility

- Racks, cable tray, conduit arrangement
- How does tunnel look like





Target Building



Controls Technical Scope

- An integrated control system
  - Technically Integrated
  - No fence between accelerator and experiments
- A large distributed control system based on EPICS framework
- Global systems
  - Global timing system
  - Machine protection system
  - Network and computers
- High level applications
  - High level applications
    - » Control Room Application
    - » Operation Application
  - Physics applications
  - Database
- Low level controls
  - Vacuum/Power Supply/RF
  - Cryomodule & Cryoplant
  - Front End/Ion Source/RFQ
  - Stripper
- Personnel protection system
- Diagnostics support
- Conventional facility integration

Collaboration

- EPICS is an extremely successful story of collaboration
- Are we ready for another success
  - Database collaboration
  - EPICS V4 collaboration
  - Control System Studio
  - OpenXAL
  - MTCA.4
- Overall it is a full solution control system

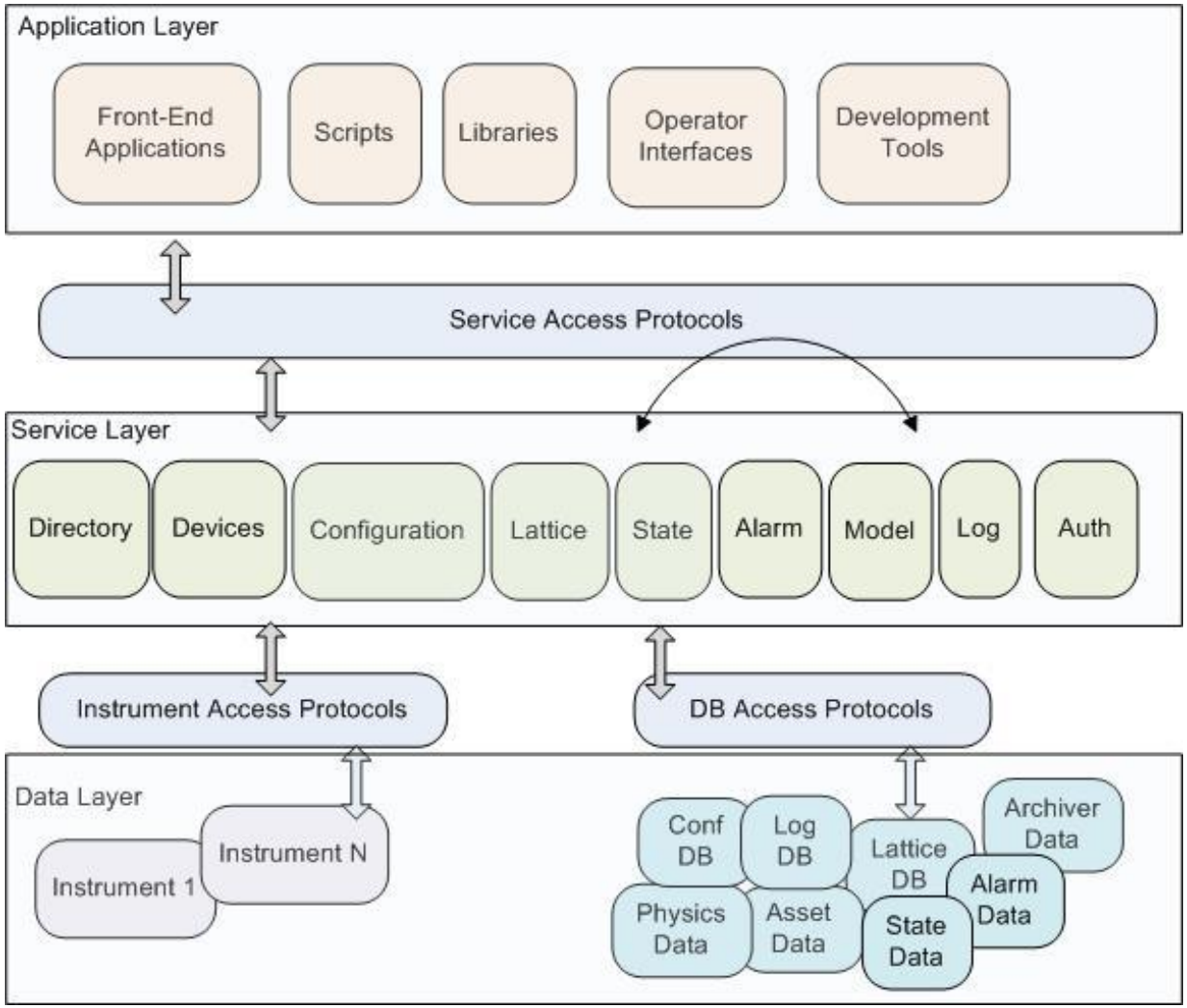
Database Scope

#	DB	Description
1	Logbook	Logbook entries
2	Traveler	Production, test, design data
3	Configuration	Physical and logical information about the facility and its configuration
4	Infrastructure	Cables, IOCs, Racks, Rooms etc
5	Lattice/ Model	Elements and online model
6	Inventory	Spare parts, stock items
7	State	Save/restore state of FRIB segments

#	Database	Description
8	Alarm	Set changes, set/read mismatches
9	Operations	Beam statistics, run hours, beam on target, shift summary, downtime, bypass records
10	FRIB Reqs	Parameter list, system and component requirements
11	MPS	Machine state dumps
12	Results	Results from physics experiments
13	Maintenance	Preventive maintenance data, failure analysis, lifetime analysis
14	Interlocks	Interlock hierarchy information [optional]

Application Architecture

- Application layer
  - Operator interfaces
  - High-level applications
  - Libraries
- Service layer
  - Access to data
  - Programming Interface
- Data layer
  - Managed data
  - Instrument data
  - No direct access



CDB Collaboration

- Partners
  - Brookhaven National Lab, New York, USA
  - European Spallation Source, Sweden
  - Facility for Rare Isotope Beam, Michigan, USA
  - Institute for High Energy Physics, Beijing, China
- Co-chairs:
  - Vasu Vuppala, FRIB
  - Bob Dalesio, BNL
- Goal: EPICS for Data Services
  - Easy to Install
  - Easy to Configure
  - Extensible
  - Well-Defined Interfaces
  - Documentation, Training
- Started in November 2011

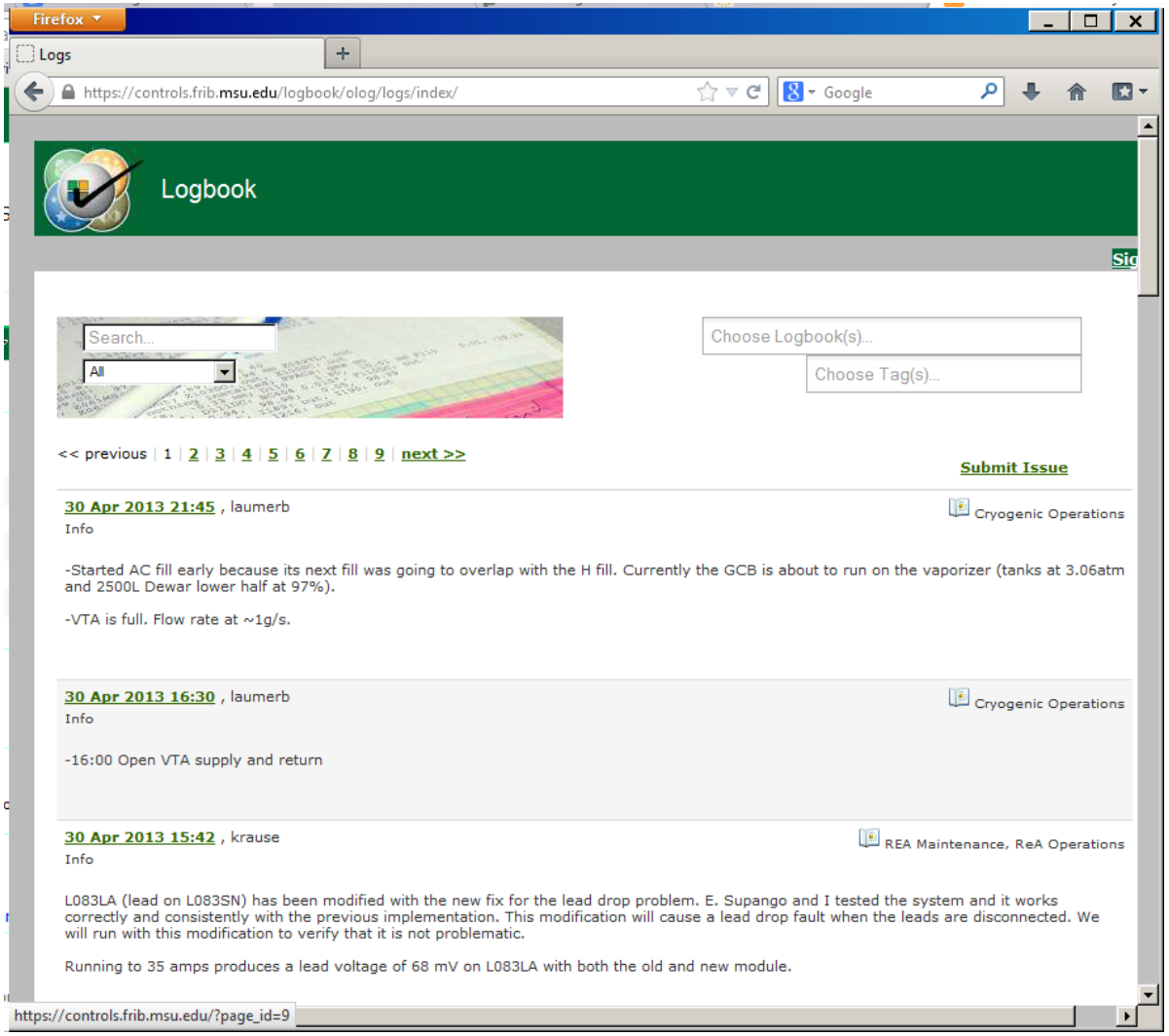
Collaboration Status

#	Module	Developed At	Status
1	Logbook	FRIB, BNL, SNS	Production: FRIB, BNL. Evaluation: ITER
2	Traveler	FRIB	Production: FRIB
3	Configuration	FRIB (BNL)	Production: FRIB
4	Save/Restore	BNL	Production: BNL Evaluation: FRIB
5	Lattice/Model	FRIB, IHEP	Test: FRIB, IHEP
6	Cables	BNL, FRIB	Test: BNL
7	Signals (PVmanager, ChannelFinder, DirectoryService)	BNL, HZB	Production: FRIB, BNL, HZB
8	Authentication	FRIB	Prototype: FRIB

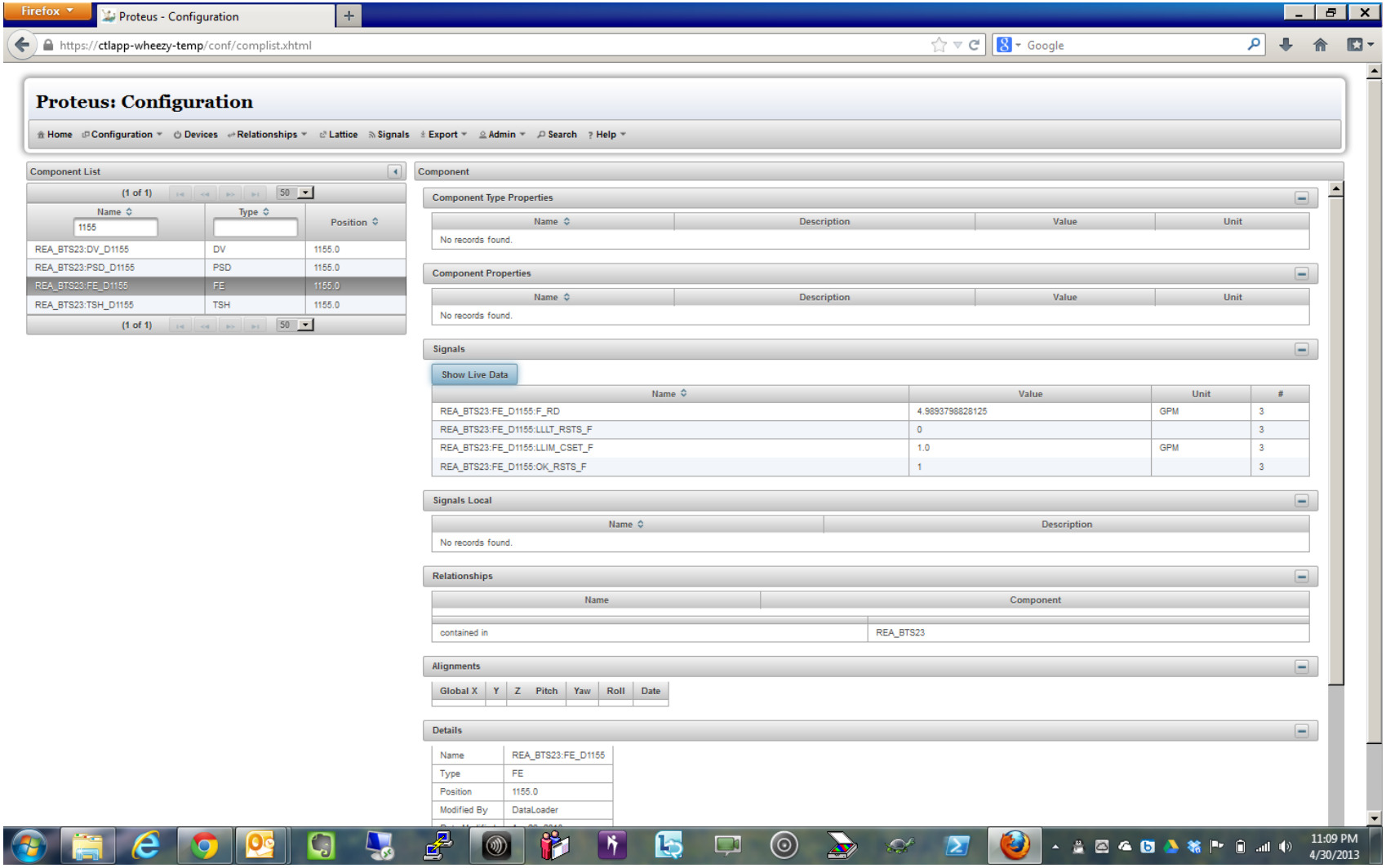
Operation Applications

- Logbook (olog) in Production
- eTraveler in Production
- Proteus: Configuration Manager in Production
- Proteus: Naming System in Production
- Actively working on cable management
- Actively working inventory and calibration

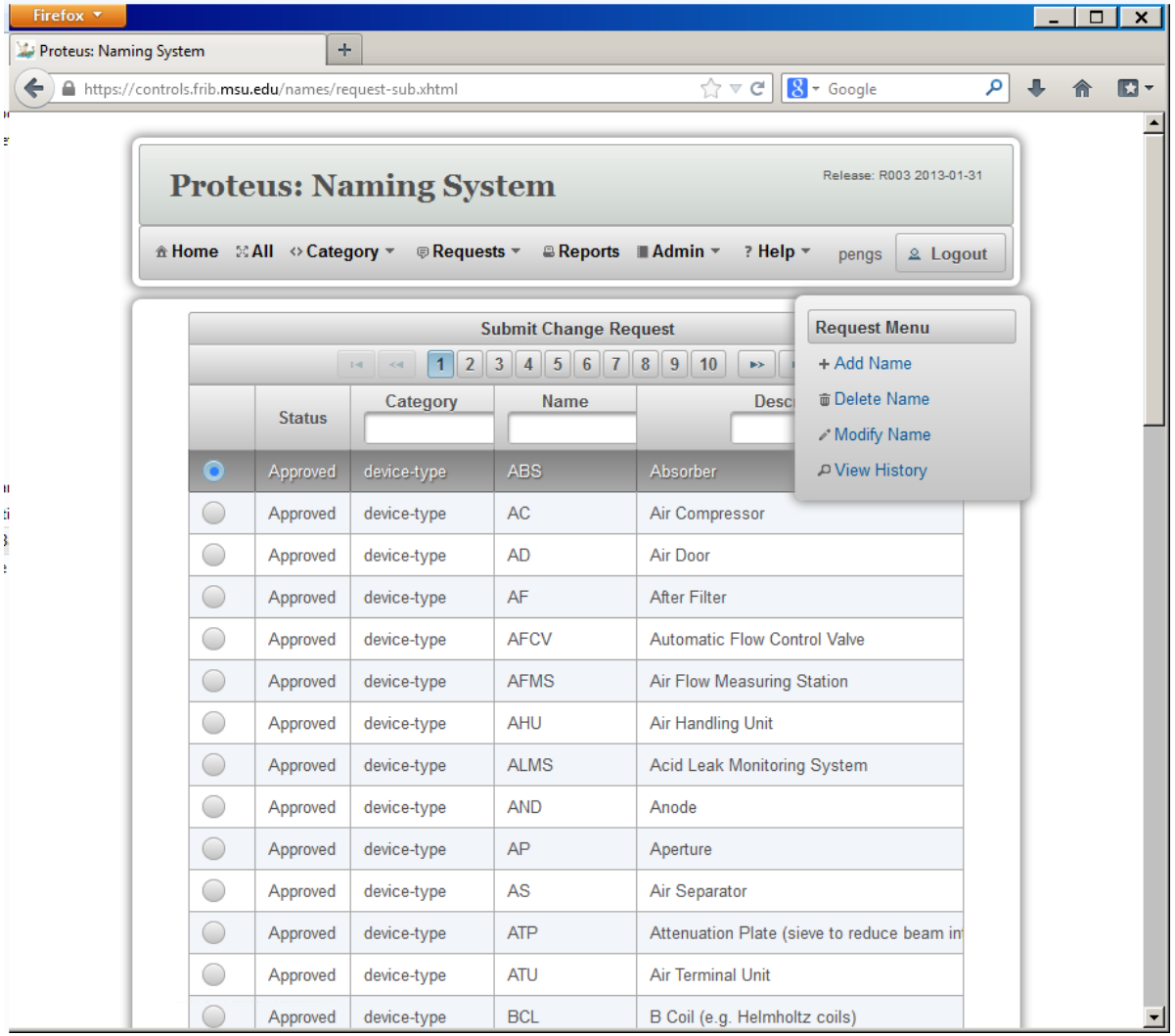
E-Logbook


Firefox
Logs
https://controls.frib.msu.edu/logbook/olog/logs/index/
Google
Logbook
Search...
All
Choose Logbook(s)...
Choose Tag(s)...
<< previous | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | next >>
Submit Issue
30 Apr 2013 21:45 , laumerb
Cryogenic Operations
Info
-Started AC fill early because its next fill was going to overlap with the H fill. Currently the GCB is about to run on the vaporizer (tanks at 3.06atm and 2500L Dewar lower half at 97%).
-VTA is full. Flow rate at ~1g/s.
30 Apr 2013 16:30 , laumerb
Cryogenic Operations
Info
-16:00 Open VTA supply and return
30 Apr 2013 15:42 , krause
REA Maintenance, ReA Operations
Info
L083LA (lead on L083SN) has been modified with the new fix for the lead drop problem. E. Supango and I tested the system and it works correctly and consistently with the previous implementation. This modification will cause a lead drop fault when the leads are disconnected. We will run with this modification to verify that it is not problematic.
Running to 35 amps produces a lead voltage of 68 mV on L083LA with both the old and new module.
https://controls.frib.msu.edu/?page_id=9

Integrated Configuration Manager with alive PV reading



Naming management

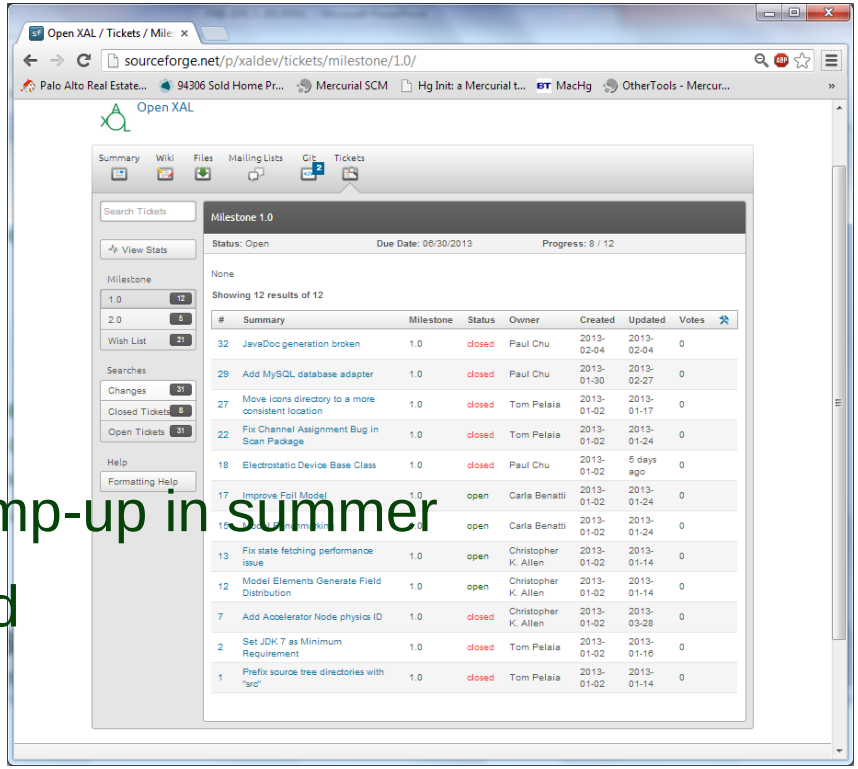


Control Room Applications (mostly CSS)

#	Client	Description	Owner	Status
1	Alarm Handler (BEAST)	Control System Studio (CSS) feature that allows user to acknowledge, and configure alarms	SNS	Installed Next: JMS PvManager Datasource
2	Save Set Restore (MASAR)	CSS feature to allow user to configure sets, save, and restore PVs	FRIB/BNL	Design
3	Operator Interface Builder (BOY)	CSS BOY is a WYSIWYG display builder and Operator Interface (OPI) runtime environment	SNS	Installed Next: User training
4	Knobs	CSS interface to hardware knobs	FRIB	Design
5	Scan Client	CSS feature that allows a user to define and run scans, view it's progress, and save results to file	FRIB	Installed (sscan based) Next: SNS Scan Client
6	Logbook	A web and CSS application to create operational log entries,	FRIB	Web: Installed Next: Drop CakePHP CSS: Installed Next: BNL Logviewer
7	Databrowser	CSS application to view both realtime and archived data from the control system	SNS	Installed
8	Directory Service Integration	Allows CSS and BOY to create screens from queries instead of static PV names	BNL	Installed

OpenXAL

- A collaboration of
  - FRIB
  - SNS
  - ESS
  - Triumf
  - CSNS
  - GANIL
- Still at early stage, looking for ramp-up in summer
- MySQL database interface added
- FRIB devices added
- Physics algorithm verification and design benchmark are going on



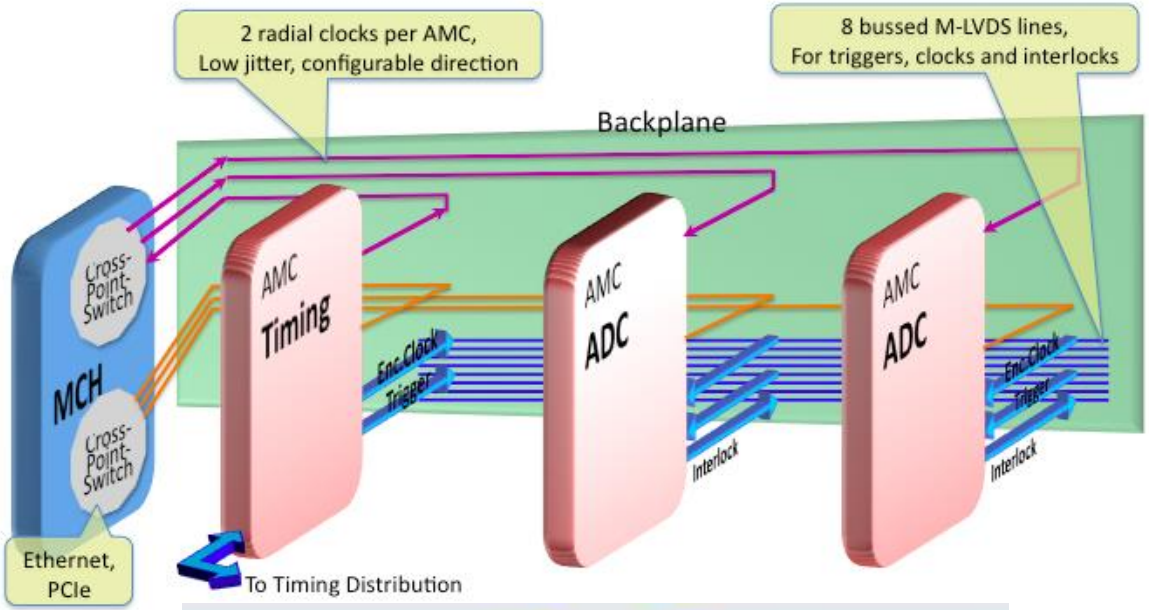
EPICS V4

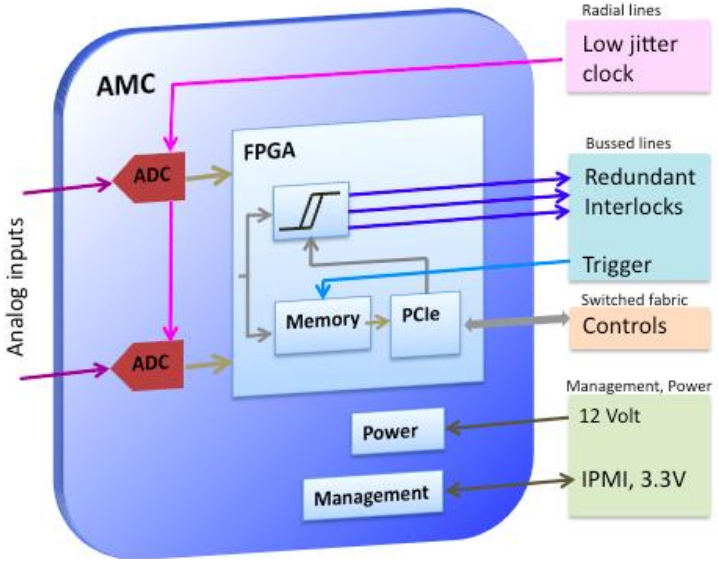
- Bob has a lot to say
- FRIB is supporting/utilizing EPICS V4 interface

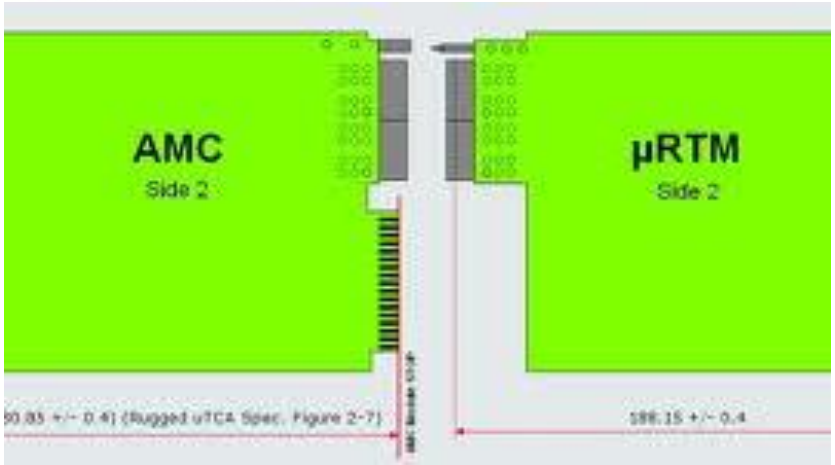
Low Level Control

- Allen Bradley PLC
  - Vacuum
  - Cryo
- Ethernet-serial terminal server
- UDP over Ethernet
  - LLRF
  - PS
- EPICS V3 IOC
  - Hot-swappable IOC
  - IPMI manageable
  - Virtualized IOC
- Do we need Real Time?
  - Redhat MRG-R
  - RT patch

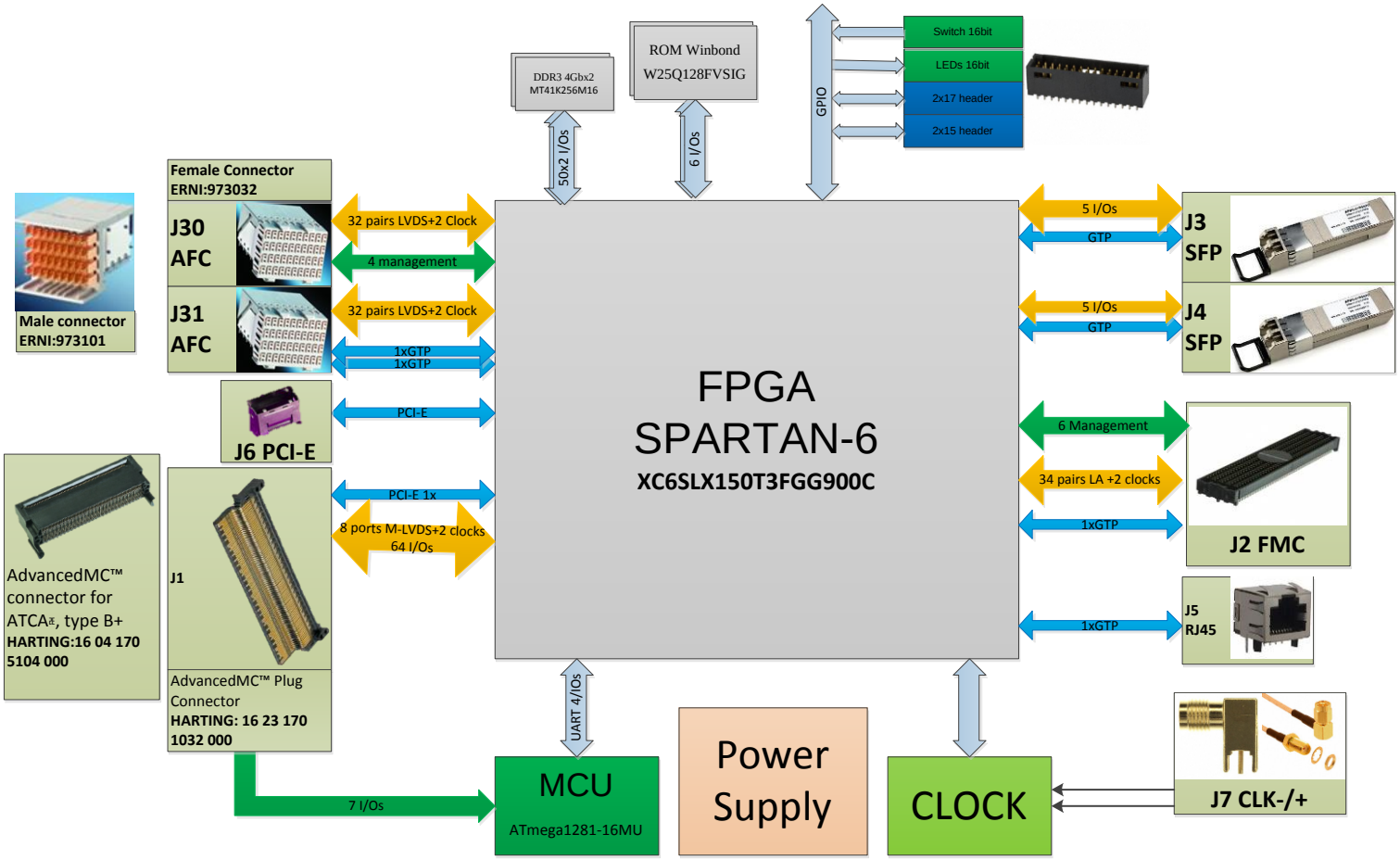
MTCA.4


2 radial clocks per AMC,
Low jitter, configurable direction
8 bussed M-LVDS lines,
For triggers, clocks and interlocks
Backplane
Cross-Point-Switch
MCH
Cross-Point-Switch
Ethernet, PCIe
AMC
Timing
AMC
ADC
AMC
ADC
Enc.Clock
Trigger
Interlock
To Timing Distribution


AMC
FPGA
ADC
ADC
Analog inputs
Memory
PCIe
Power
Management
Radial lines
Low jitter clock
Bussed lines
Redundant Interlocks
Trigger
Switched fabric
Controls
Management, Power
12 Volt
IPMI, 3.3V


AMC
Side 2
µRTM
Side 2

MTCA.4: FRIB General Purpose Digital Board



- MTCA.4
- Three SFPs
  - 1 Ethernet
- FMC(LPC)
- 4Gb DDR3
- GPIOs
- Update Online
- Support Tree & Multi-circle topology
- Help from DESY

FGPDB Detail

Spartan-6 FPGA
Up to 147K logic cell
Up to 540 IOs and 8 MGTs
Low-cost

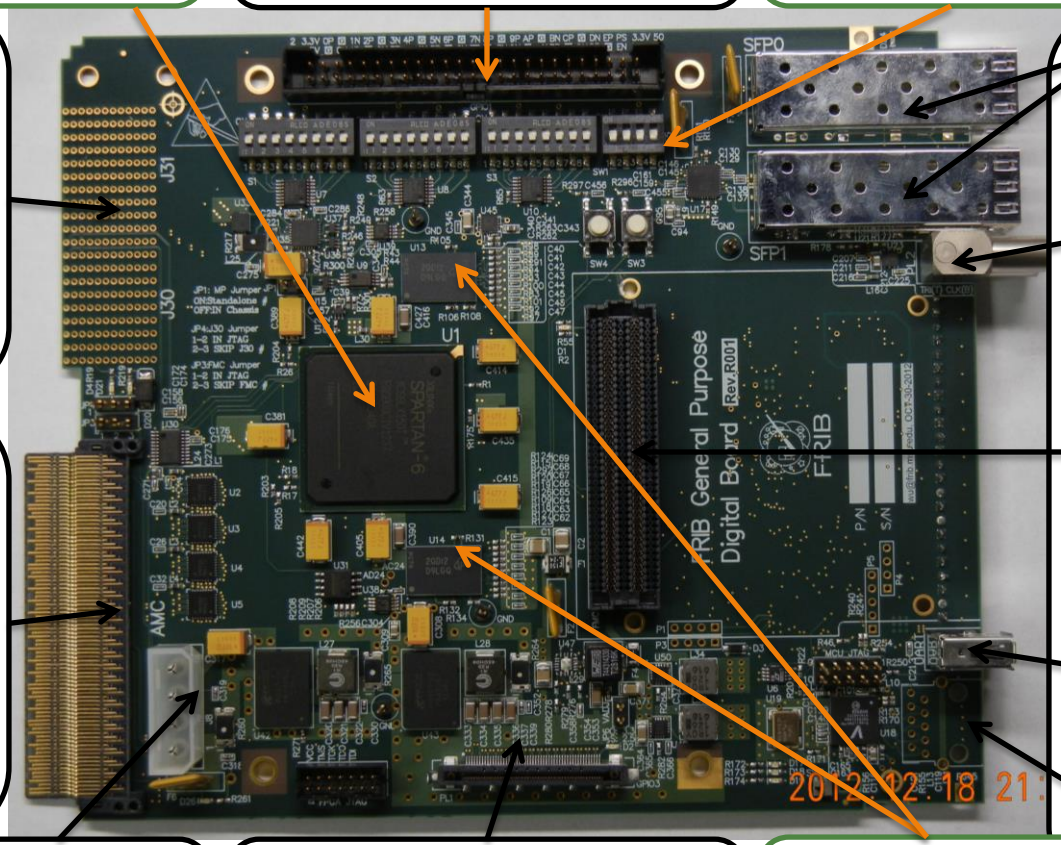
Low-speed GPIO1 Connector
15 pairs differential or 30 single-ended programmable signals

Switches and LEDs
20 positions switches
12 user defined LEDs on the panel

µRTM Connector
66 pairs differential or 132 single-ended programmable signals

Two pairs differential output clocks

Two channels MGTs



SFP Connector
Two 3.125Gbps fiber channels SFPs with a 4x4 cross-point switch

LEMO Connector
One LVTTL external clock signal input
One LVTTL external trigger signal input

FMC Connector
Reserved to extend I/Os with FMC-LPC daughter card

USB-A Connector
Provide UART-to-RS232 debug interface

RJ45 Connector
10/100/1000 Ethernet

AMC Connector
PCI Express 1x channel
Giga-Ethernet channel

Eight ports user defined M-LVDS transceivers

Two ports user defined point-to-point clocks

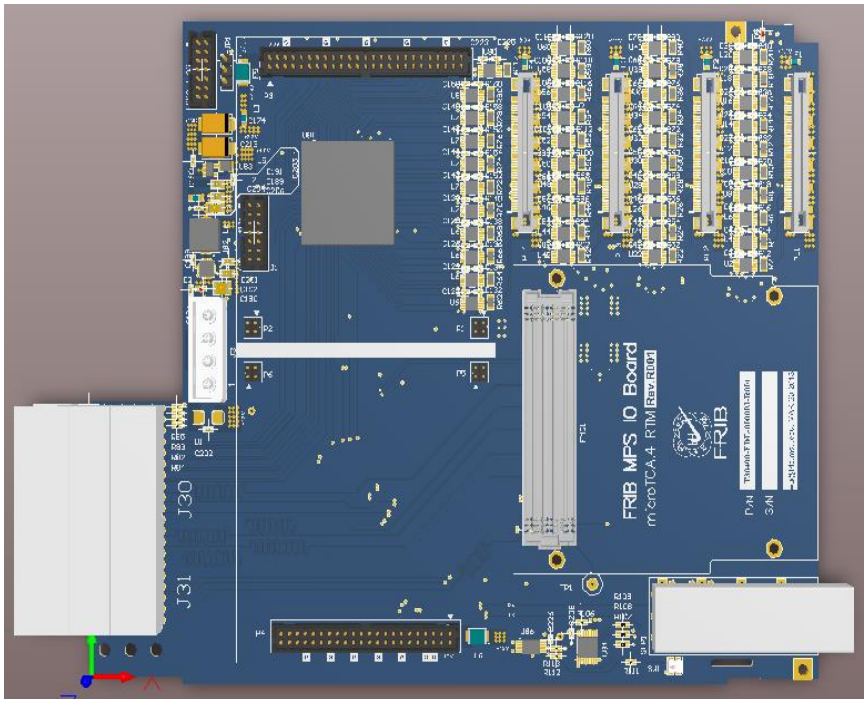
Power Connector
Single 12V power supply

High-speed GPIO3 Connector
17 pairs differential or 34 single-ended programmable signals

DDR3
Two independent 2Gbits DDR3 chips

Needed

- Need low cost, new generation of fanout/concentrator
  - MTCA form factor
  - 1:12 ideally
- Always keep Pizzabox option



- Develop more MTCA board with inter-changeable IO modules (RTM):
  - Working with BNL
    - » Potential high-end general purpose digital board
  - BPM front end (RTM)
  - LLRF front end (RTM)
  - MPS front end (RTM)
  - You are welcome to join!

Q&A

- Wants to know more about FRIB

pengs@frib.msu.edu

☺Welcome to Michigan!