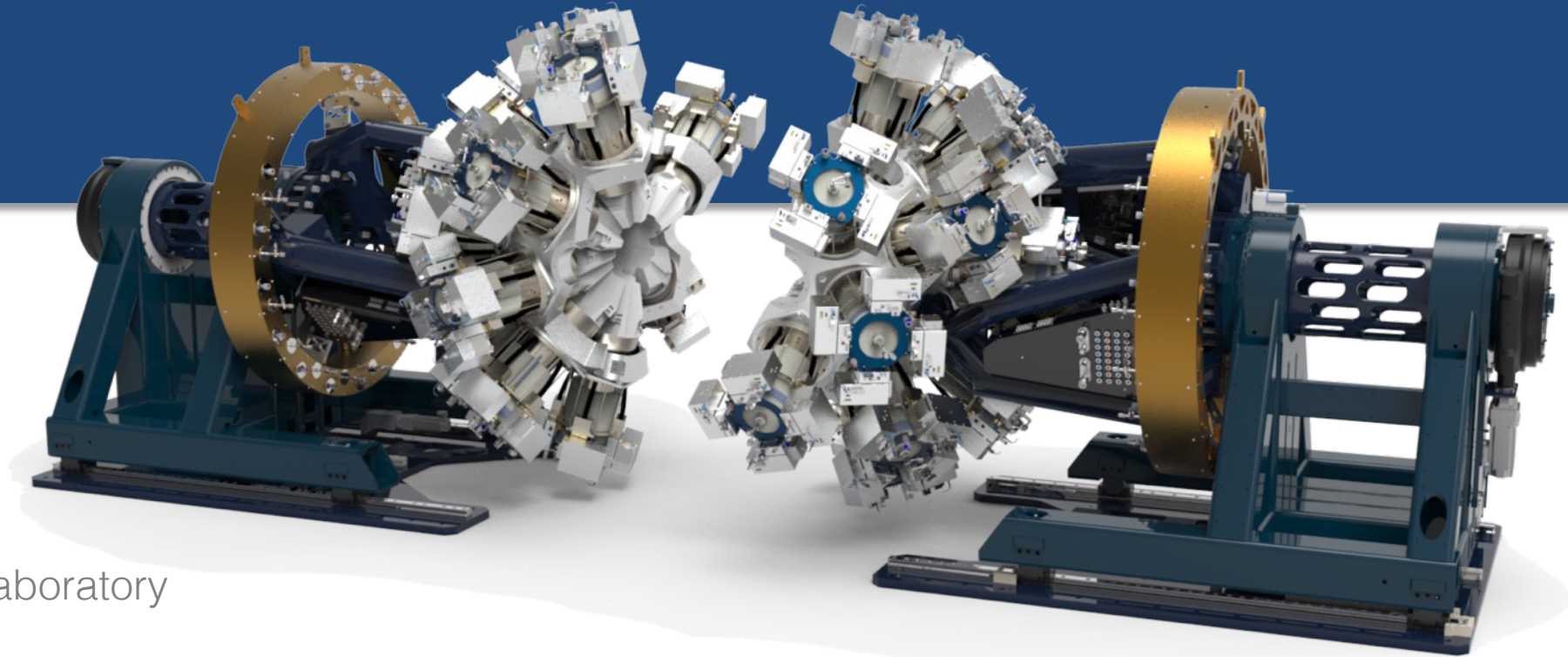


GRETA

Gamma-Ray Energy Tracking Array



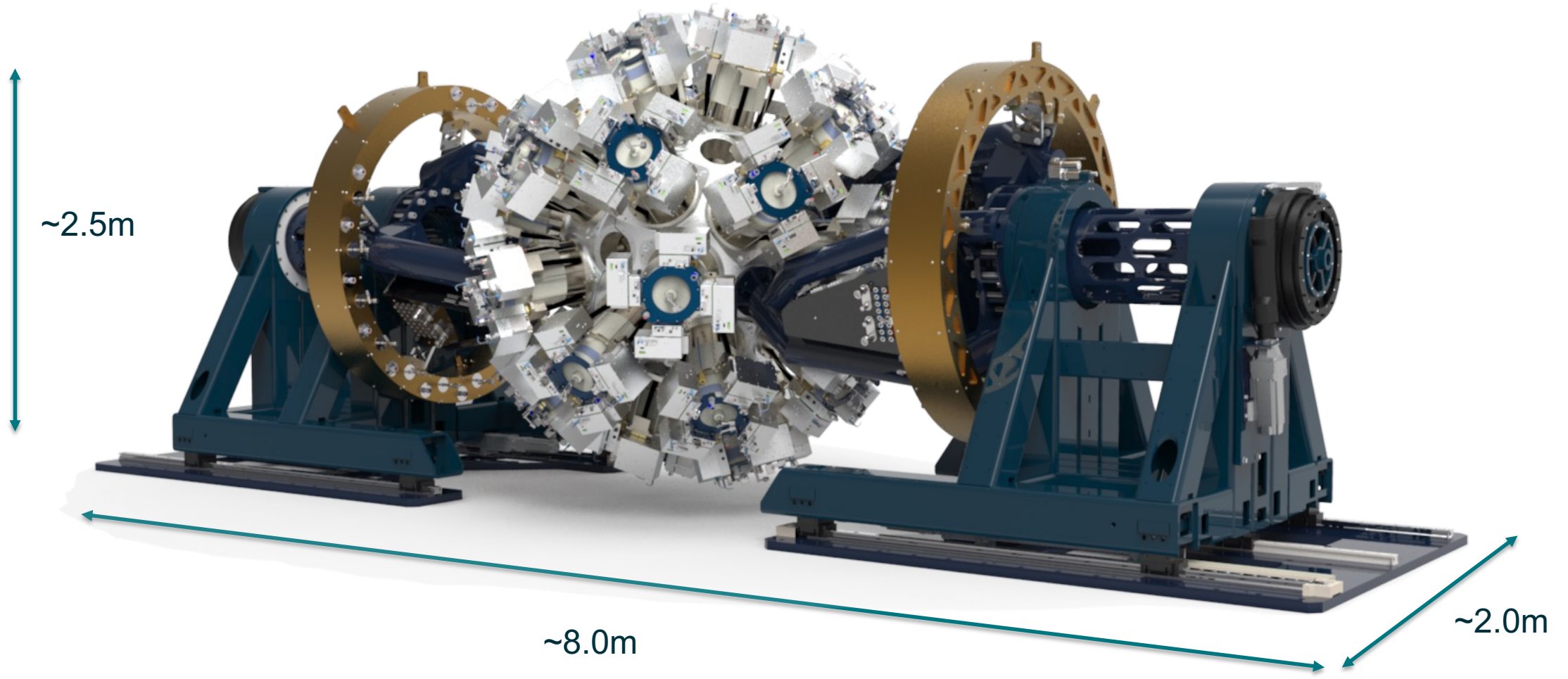
Paul Fallon

Project Director

Nuclear Science Division

Lawrence Berkeley National Laboratory

GRETA: A 4π Gamma-Ray Energy Tracking Array

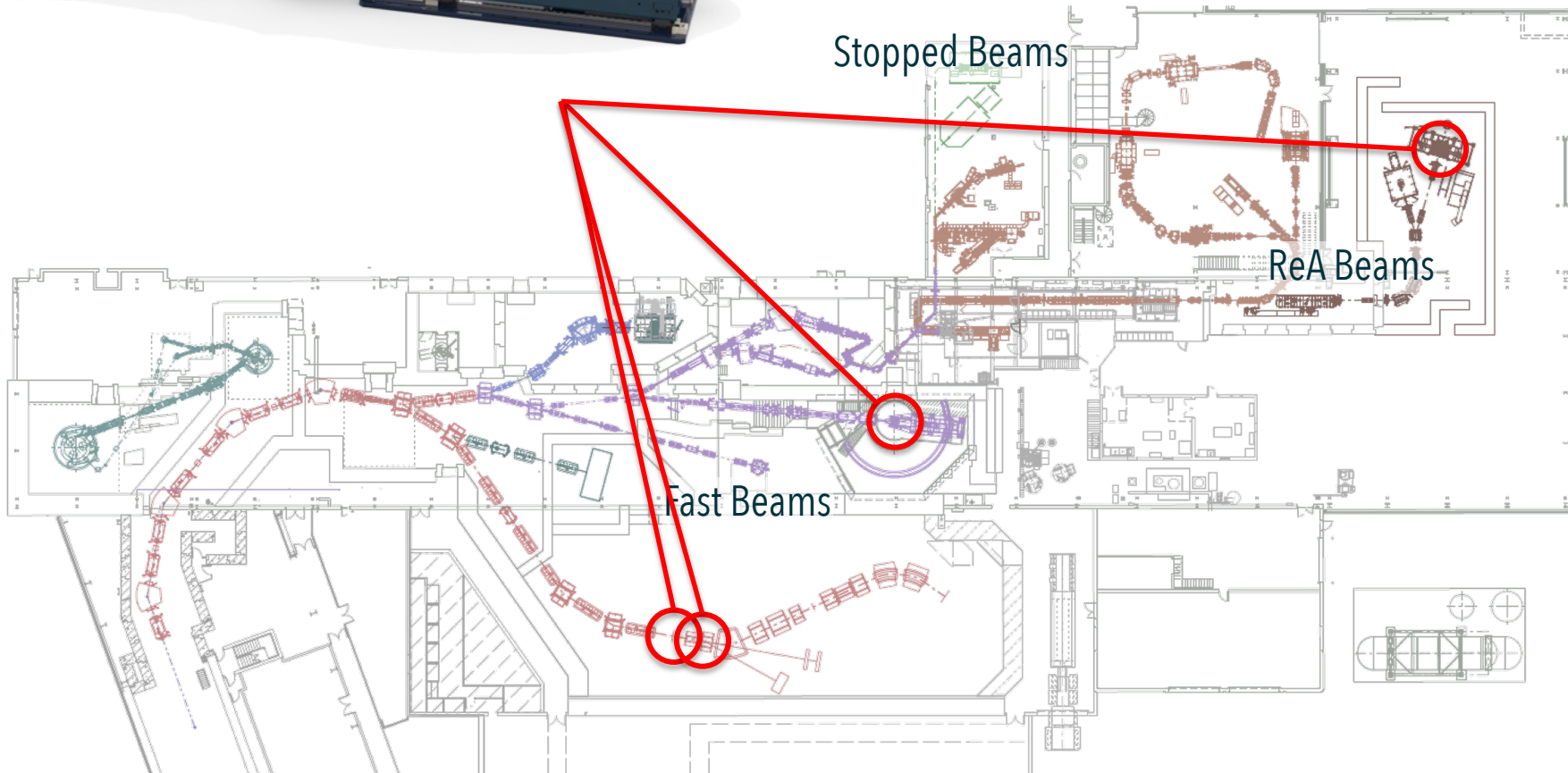


GRETA: A Major instrument at FRIB



GRETA will be a major instrument at FRIB and provides the sensitivity to enable a broad range of physics with both fast-fragmentation and reaccelerated beams

Designed (and expected) to be used on multiple beam lines

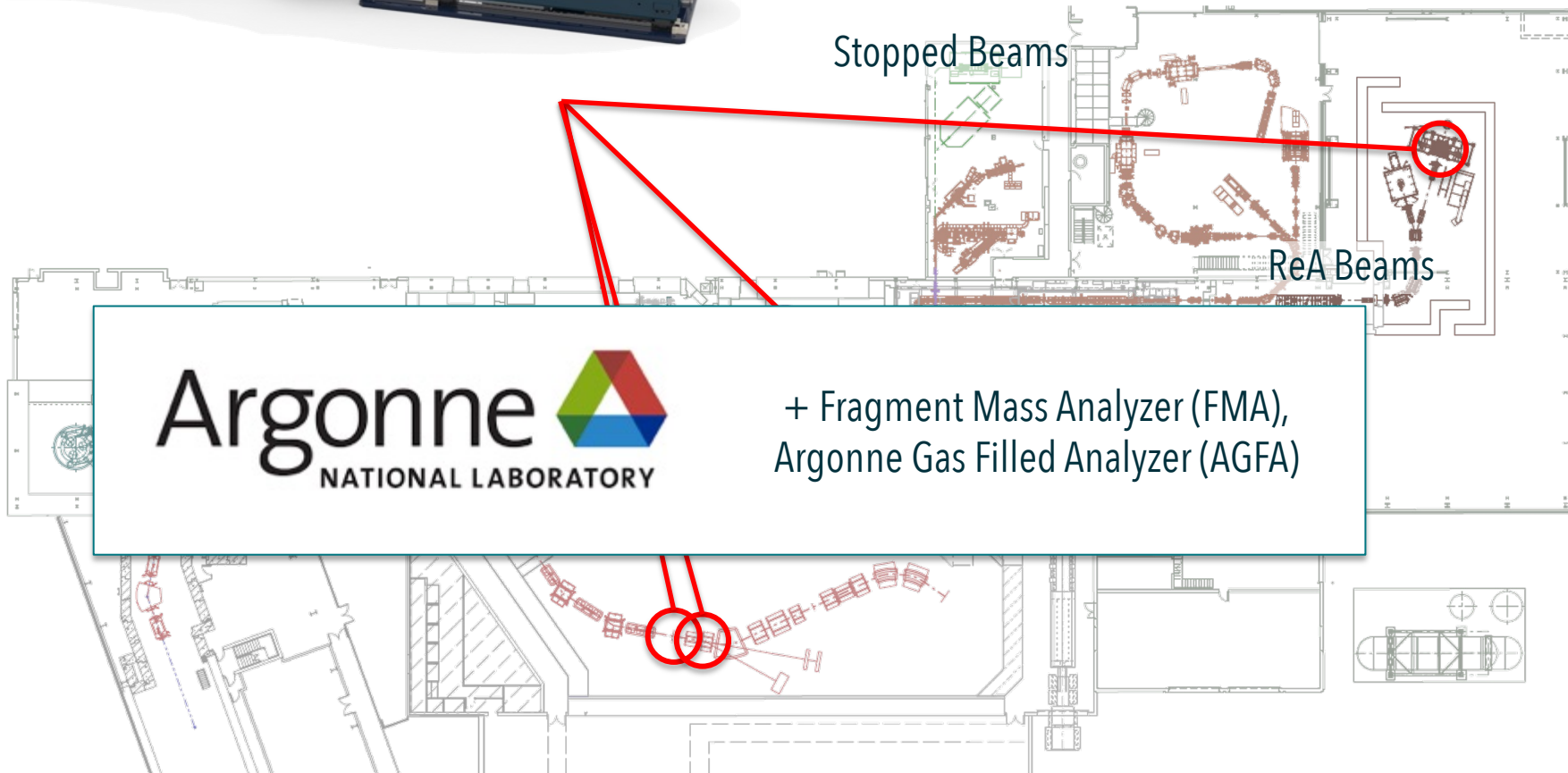


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GRETINA – *first stage to get to GRETA*

- Gamma-Ray Energy Tracking In-beam Nuclear Array

Between 2003 and 2011, the US low-energy nuclear physics community constructed GRETINA, a 1π tracking detector employing the same segmented detector and signal decomposition technology as GRETA.

GRETINA was a \$20M project funded by US DOE-Nuclear Physics Office

- Covered $\sim\frac{1}{4}$ of a sphere with 7 Quad Detector Modules

GRETINA science operations at MSU and ANL have demonstrated the technology and scientific impact of a γ -ray tracking array.

Added Quad Detector Modules – total of 12 (+ 1 spare)



GRETINA Science Campaigns

Campaigns

NSCL I: August 2012 - June 2013
24 experiments ~3500 hours

ATLAS I: March 2014 - June 2015
18 experiments ~2700 hours

NSCL II: October 2015 - July 2017
24 experiments ~3600 hours

ATLAS II: August 2017 – April 2019
16 experiments ~2900 hours.

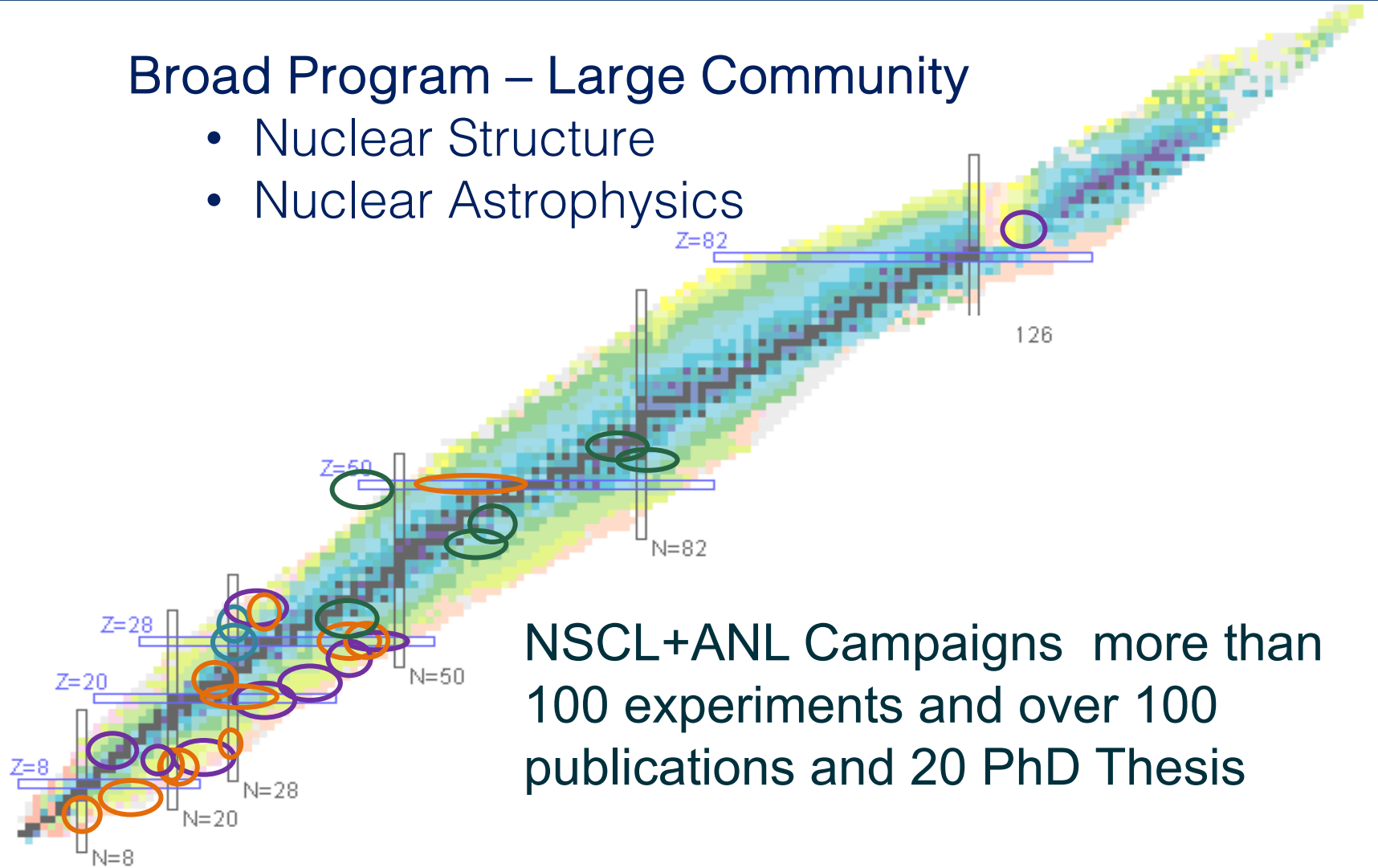
NSCL III: June 2019 – August 2020
11 experiments ~1500 hours.

ANL III: February 2021 – May 2022
26 experiments ~3000 hours

FRIB I: July 2022 – May 2024
ANL IV: August 2024 –

Broad Program – Large Community

- Nuclear Structure
- Nuclear Astrophysics



NSCL+ANL Campaigns more than 100 experiments and over 100 publications and 20 PhD Thesis

GRETINA uses ~50% of available running time

GRETINA has successfully demonstrated the science reach and impact of a γ -ray tracking array

The GRETA Project

GRETA builds on the existing GRETINA array to subtend the full 4π coverage of γ -ray tracking detectors.



- 18 (+ 2 spares) Quad modules, to be combined with 12 GRETINA modules for a total of 30
- Full mechanical structure for a 30 module, close-packed array, covering 80% of solid angle
 - Removable forward and rear detector rings
 - Rotation and translation capabilities
- Electronics to instrument all 30 Quad modules
 - Detector-mounted digitizer modules with continuous streaming of waveforms to FPGA-based signal filter boards
 - New trigger, timing and controls systems
- Computing cluster to support full array
 - Real-time signal decomposition up to total through-put of 480k decompositions/s
 - High-speed local network
 - Large local RAID storage



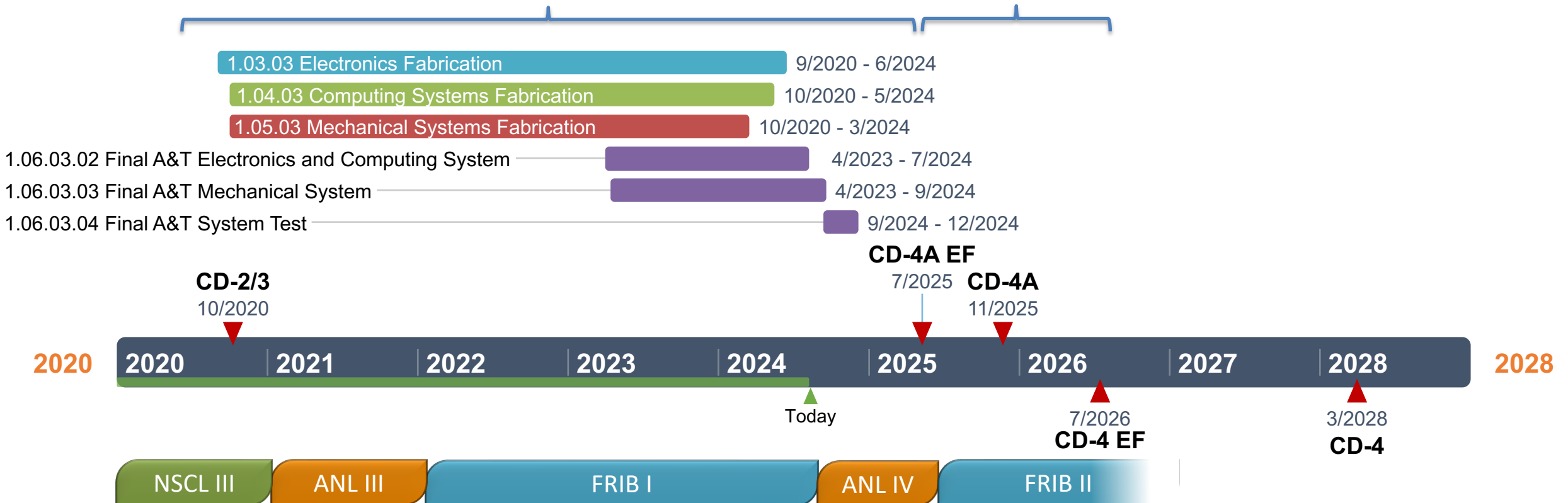
GRETA Project Phased for Early Science Operation at FRIB

CD-4A Scope

- Electronics, Computing and Mechanical systems for 30 Quad Detector Modules
- Subset of Detector Modules (6)
- Delivered to FRIB for Science Operation

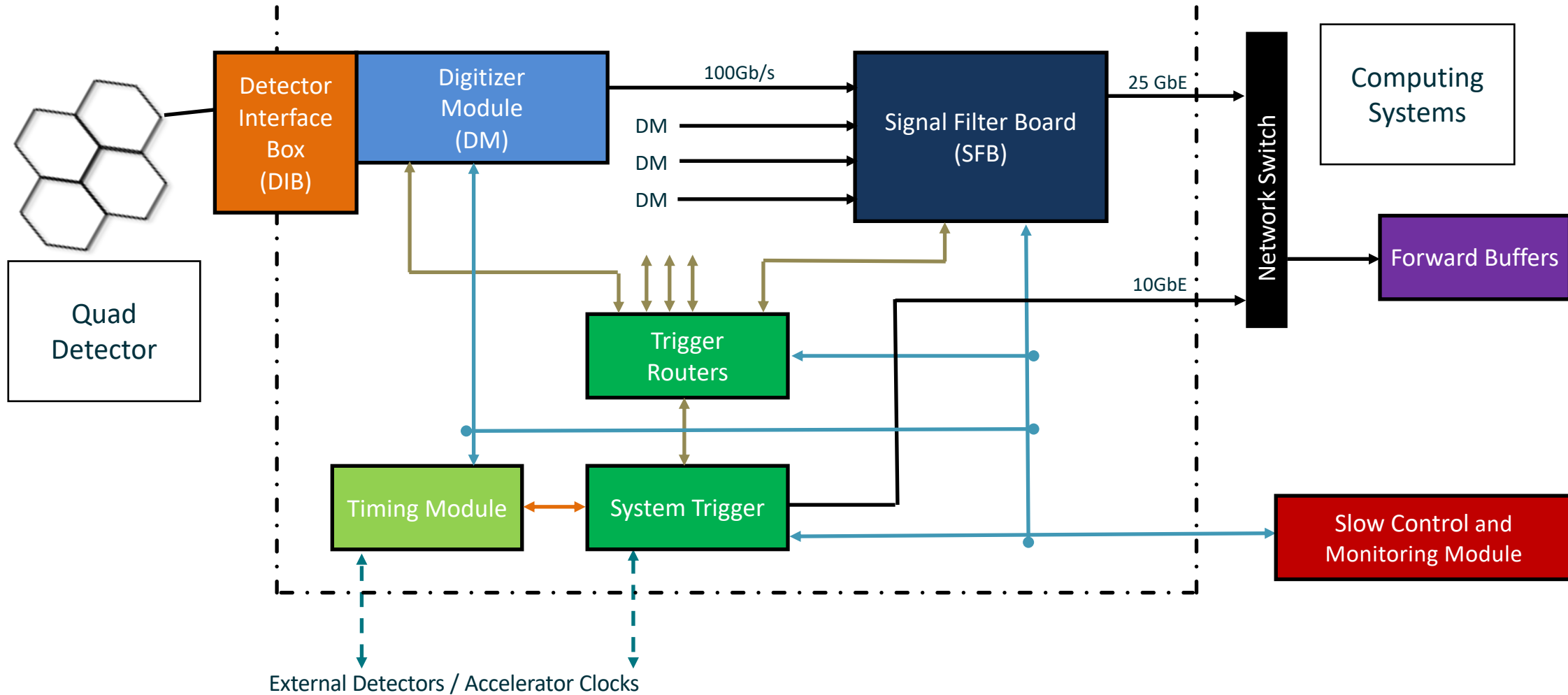
CD-4 Scope

- Accept the remaining Quad Detector Modules (For a total of 20)



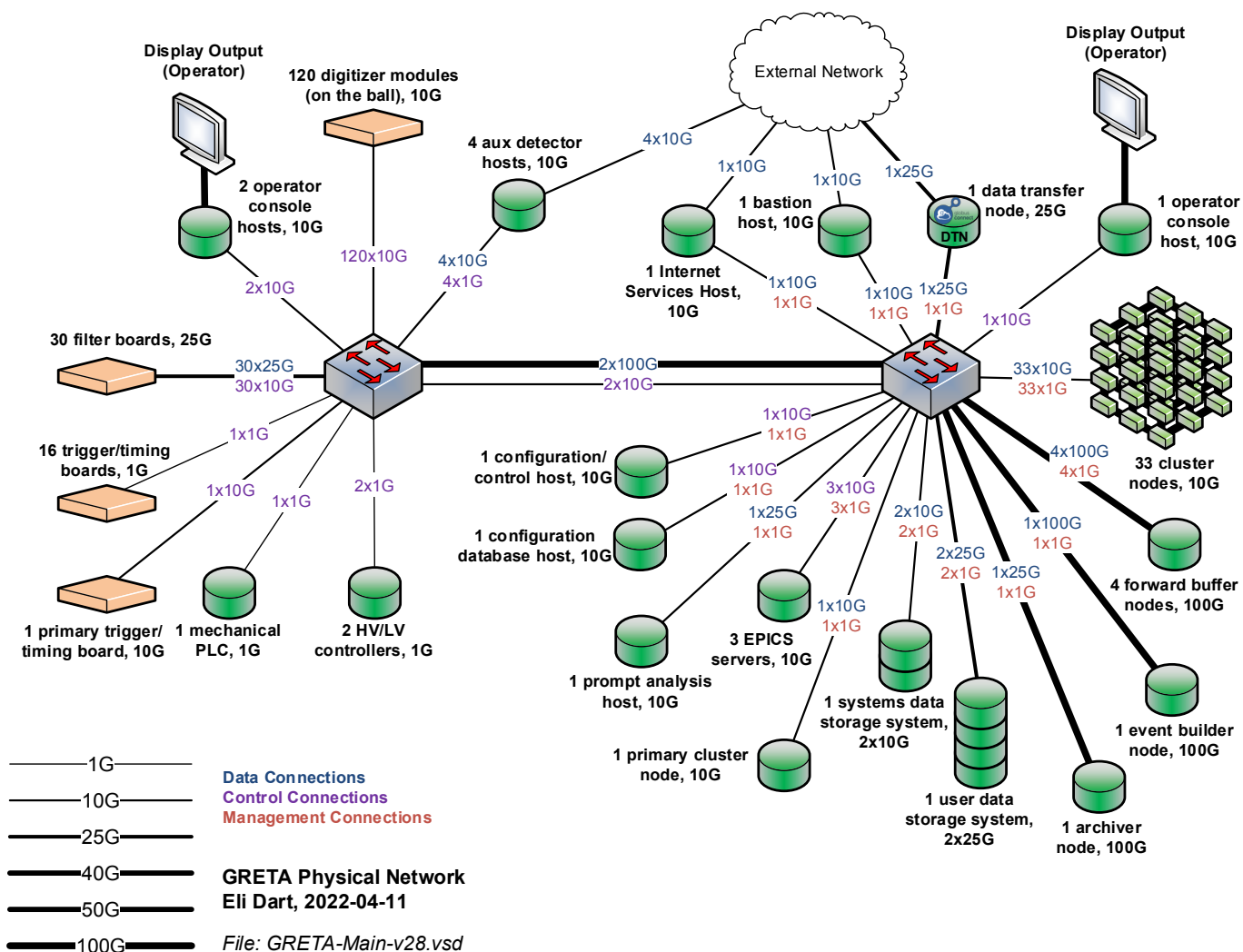
GRETA Electronics Systems

- Digitize at the Detector, fiber-based network carries data and controls



GRETA Computing Systems

- Pipeline-Based Network Architecture Enables Cutting-Edge Performance



- 300TB full SSD storage array improves ability to sort online, move data quickly off the cache to the DTN
- High-performance computing cluster enables in-line compression and will support 500k signal decomposition calculations per second

Technical Progress

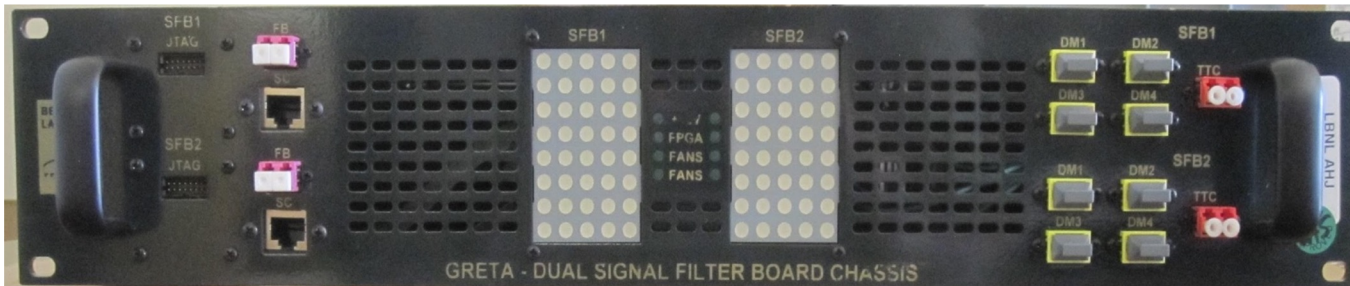
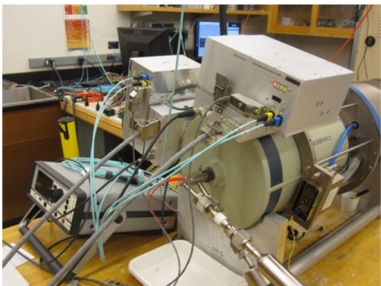
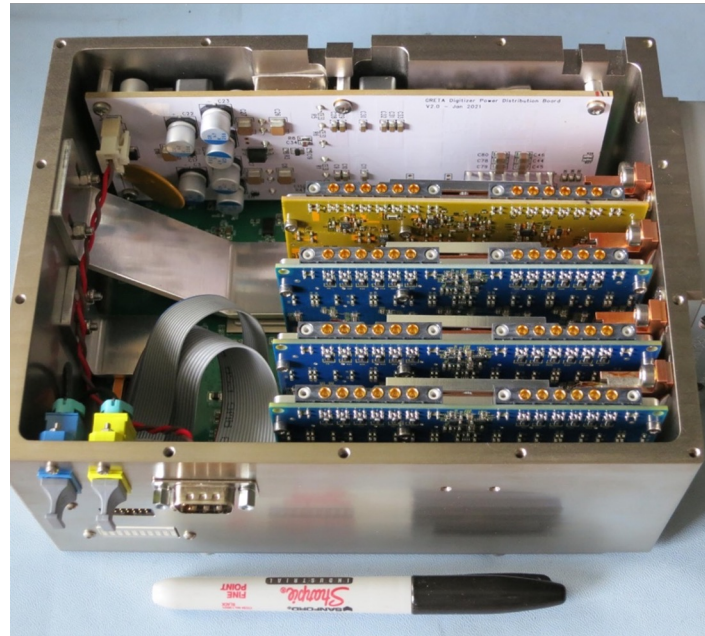
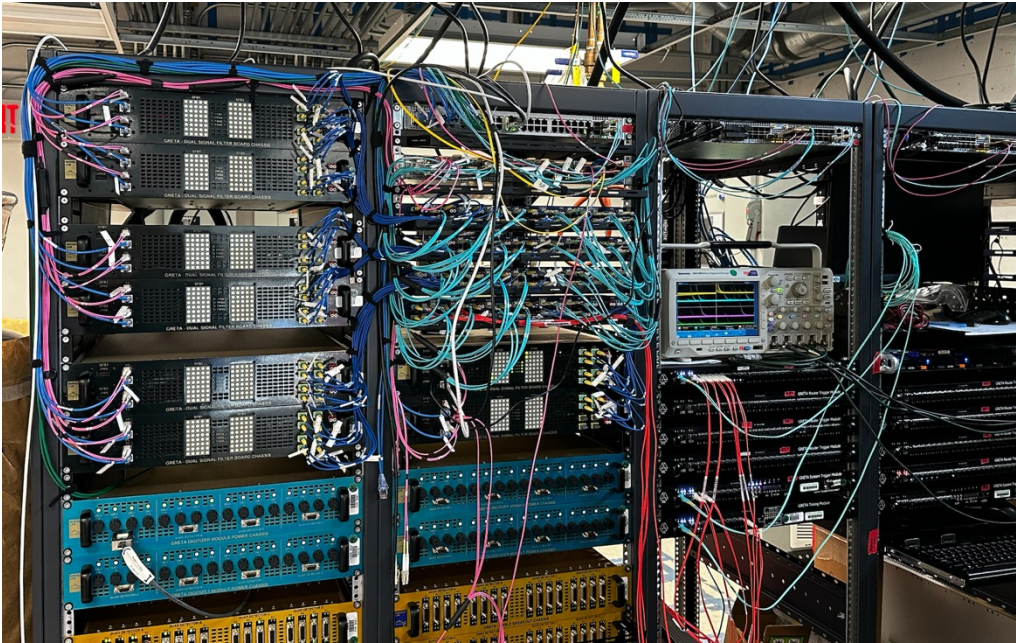
- Technical systems nearing completion and System Assembly is well underway with detector installation planned for October 2024 and working towards CD-4A with deliver of GRETA Phase-1 to FRIB in Summer 2025.



Support frames installed and aligned in the K-area in building 88

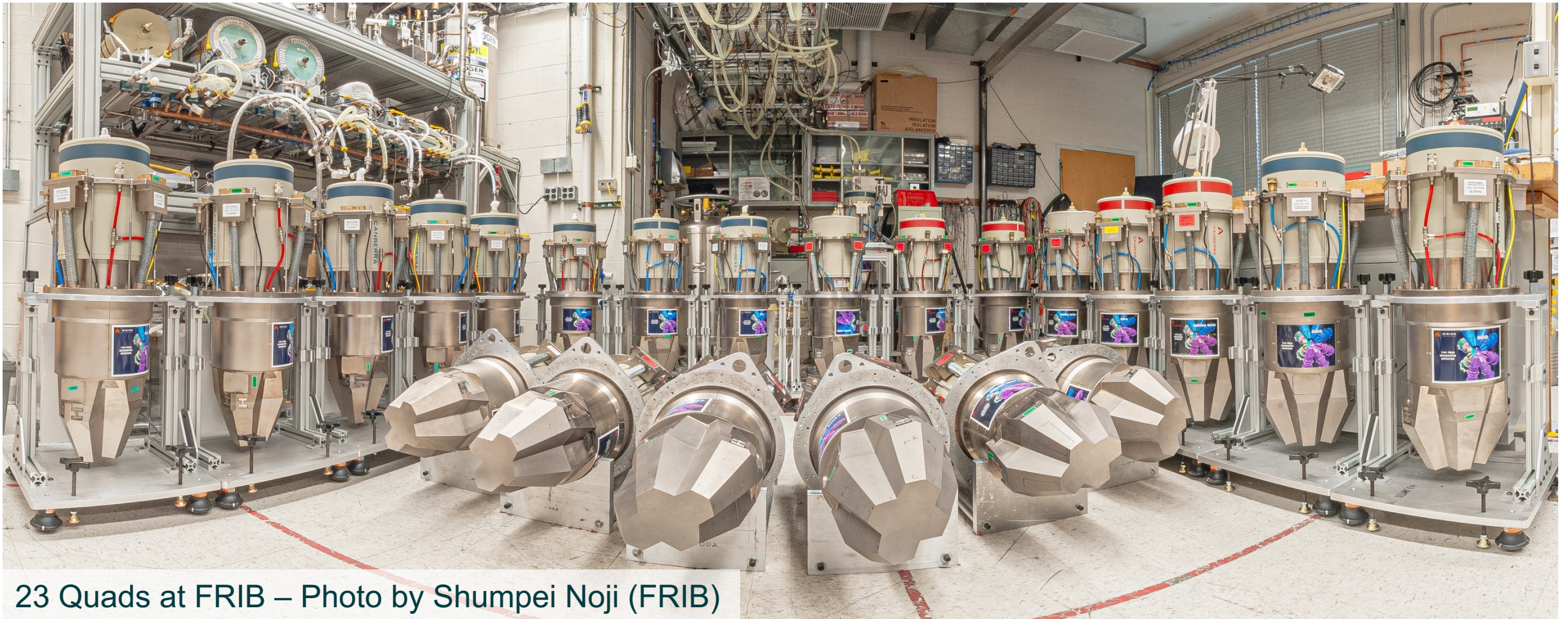
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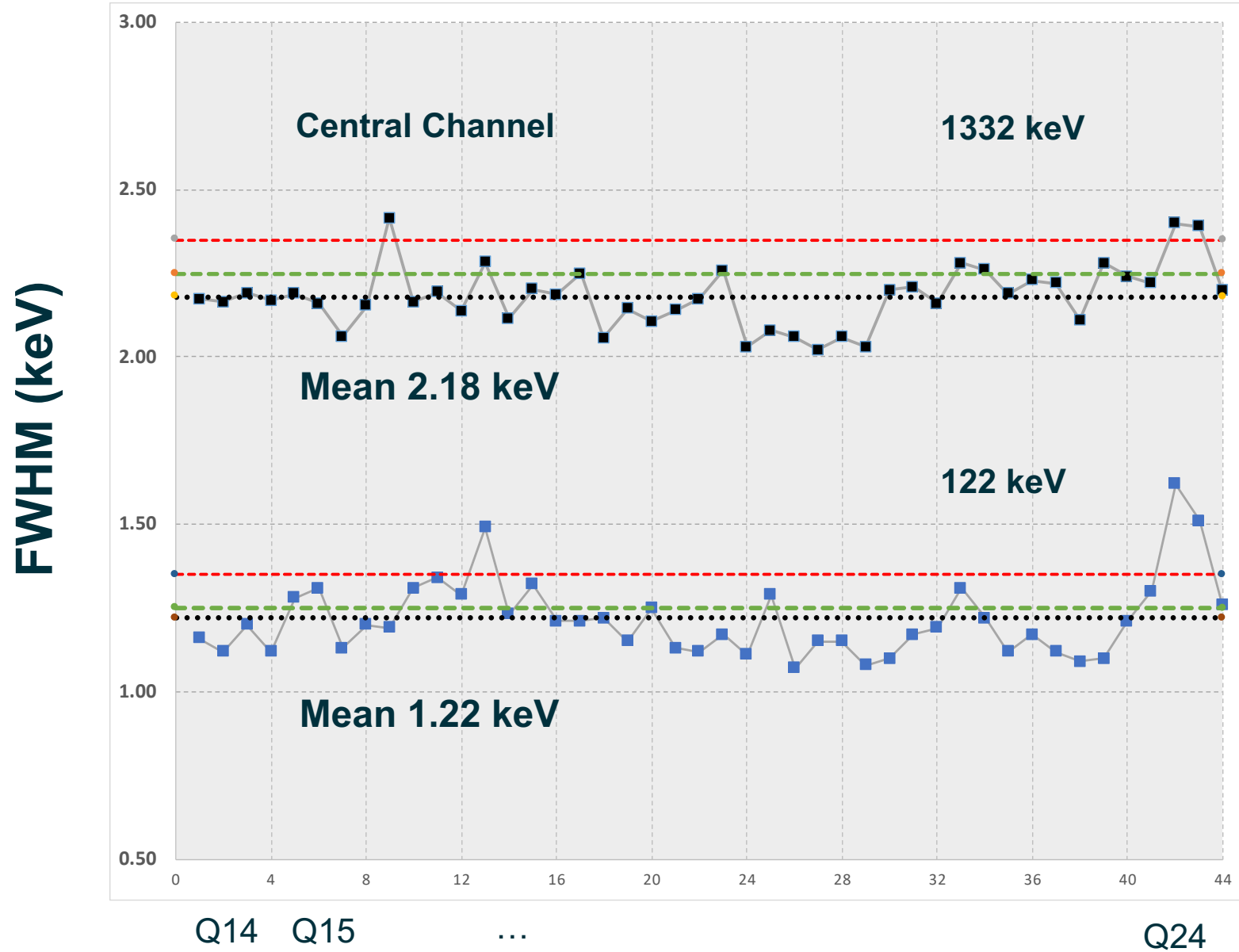
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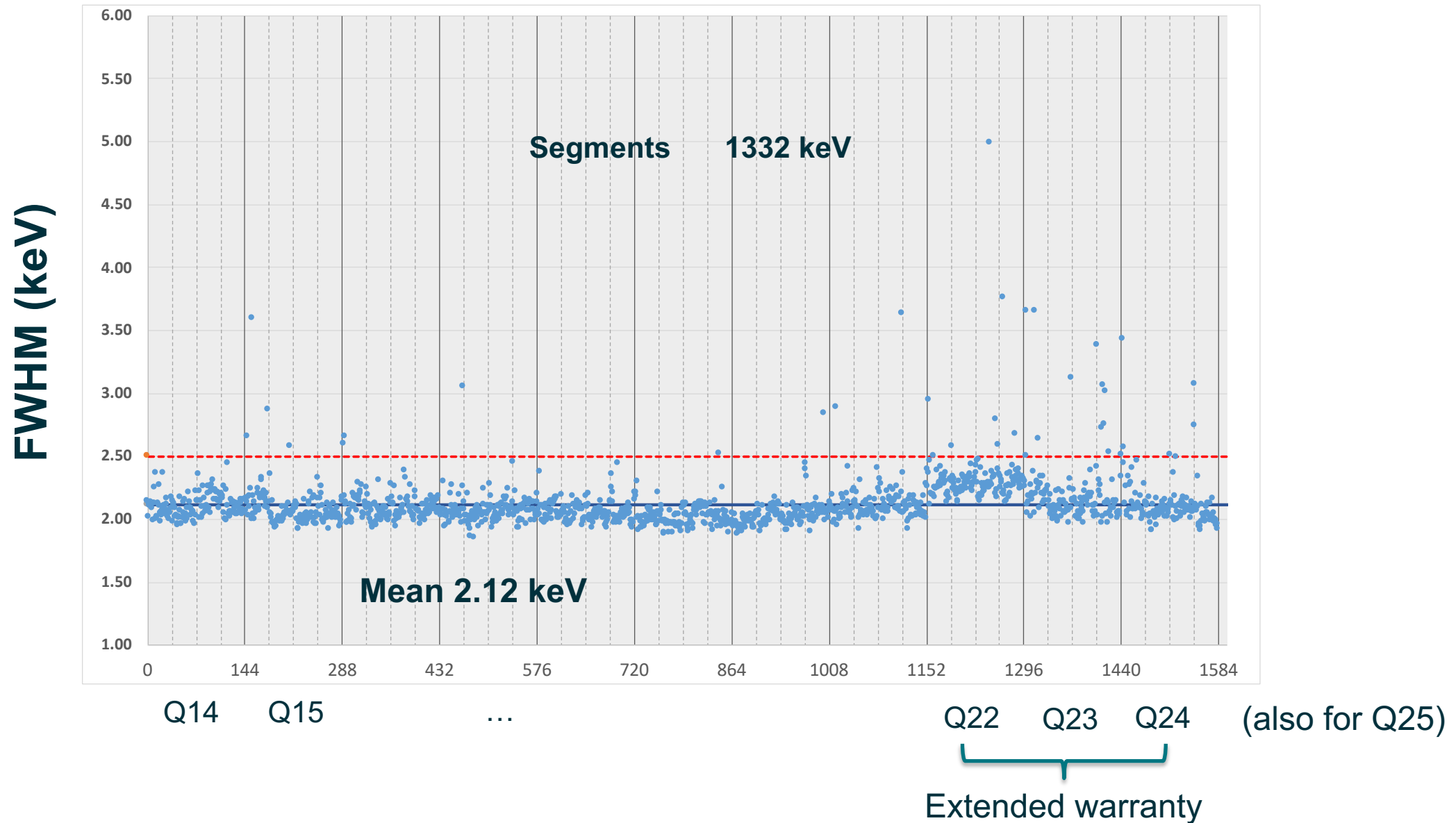


23 Quads at FRIB – Photo by Shumpei Noji (FRIB)

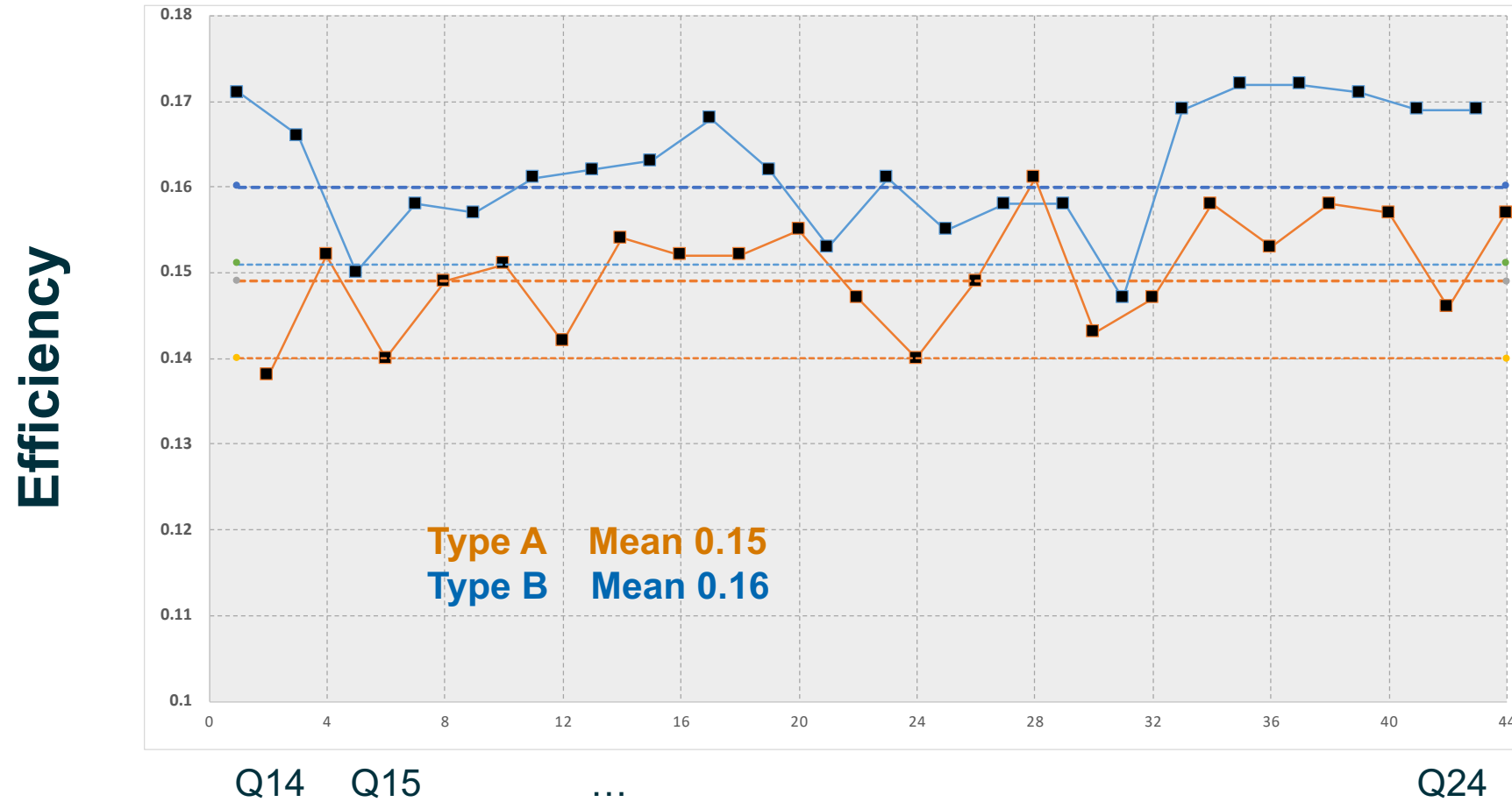
Quad Performance Summary: Central Contacts



Quad Performance Summary: Segments



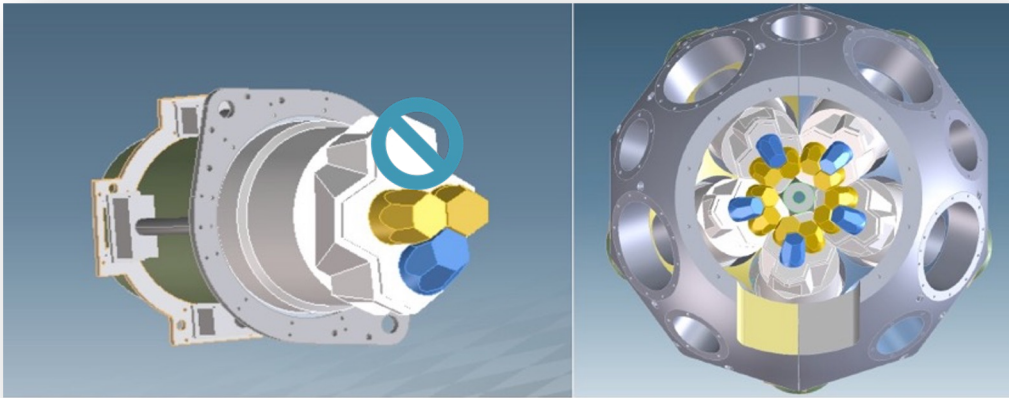
Quad Performance Summary: Efficiency



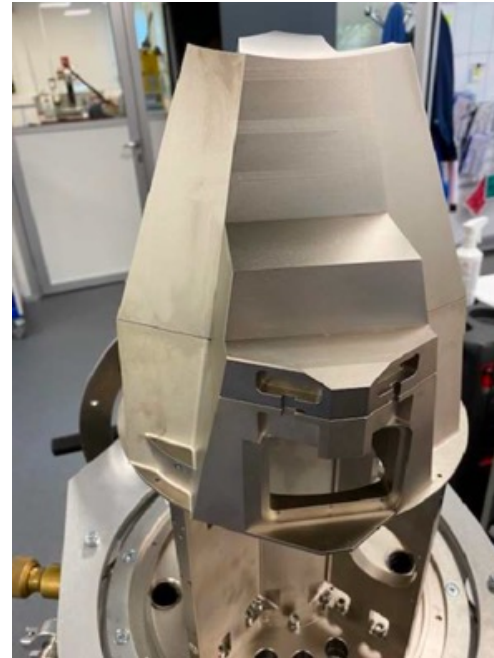
The Triplet End-Cap

Removal of the 5 capsules surrounding the in/out pentagon holes optimizes trade-off between array-efficiency and beam-pipe size requirements for certain experiments (coupling to auxiliary devices and/or specialized beam optics).

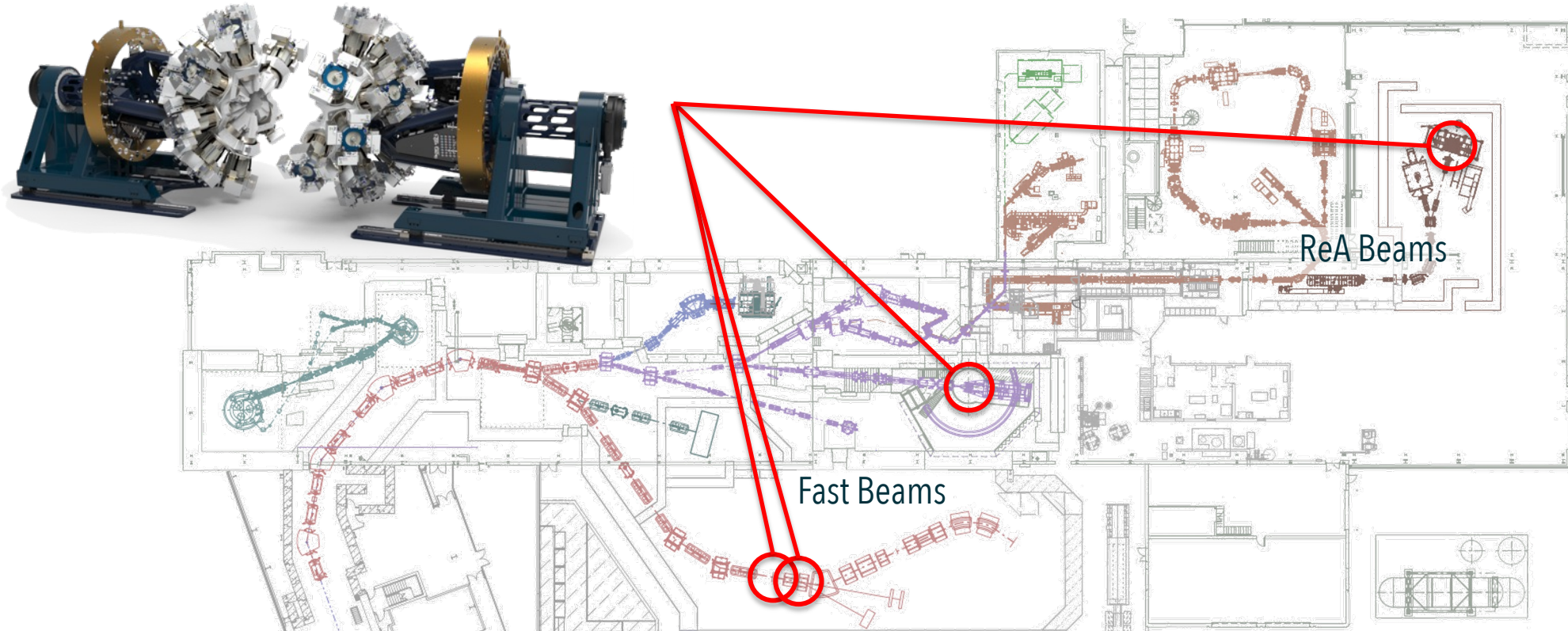
Remove single crystal and replace end-cap to convert standard Quad module to Triplet module



~12 cm diameter pipe can be accommodated vs. standard 5 cm diameter

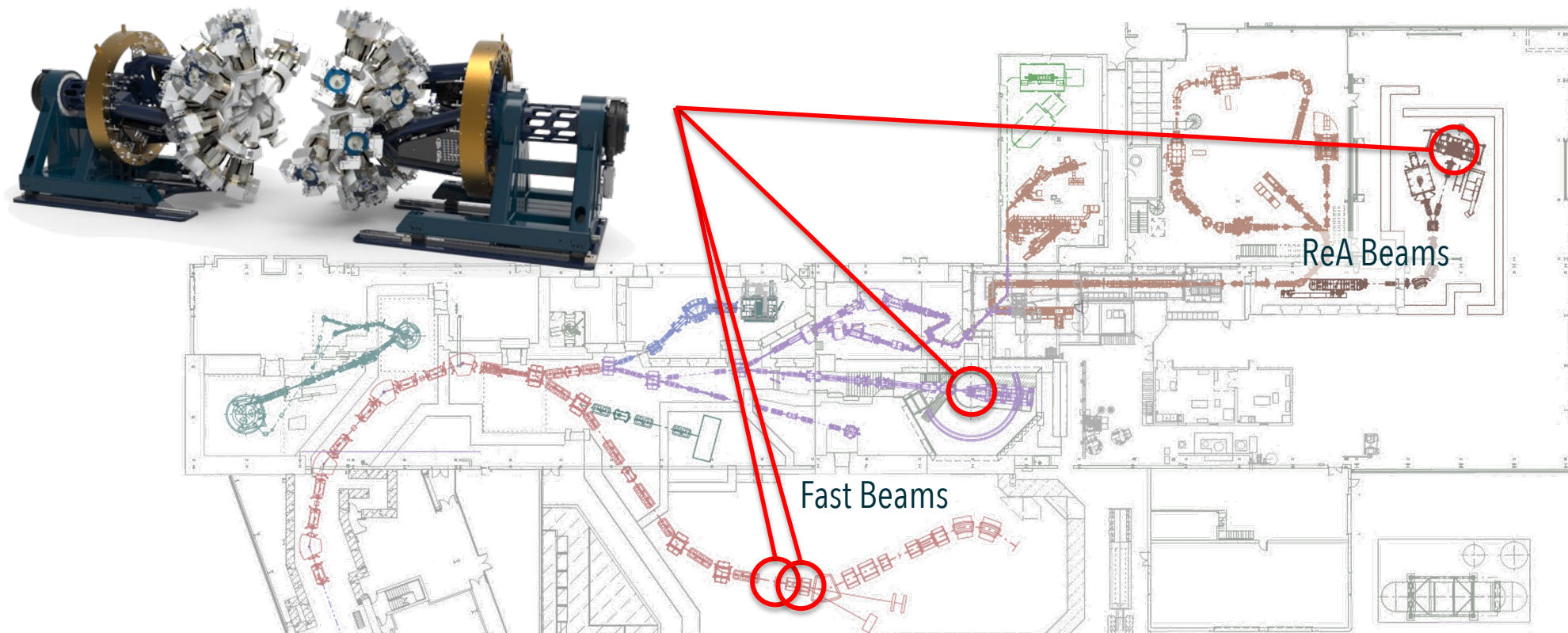


GRETA Initial Operations (delivery to FRIB ~mid-2025)



- Reaccelerated beams
 - GRETA at ReA beam Line
- Fast Beams
 - GRETA frame is not designed for S3 vault (S800) before HRS
 - Plan to modify GRETA frame to be able to have up to ~20 QUADS in front of the S800, with the new GRETA electronics and computing and cooling (to maximize HPGe coverage and science opportunities)

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- **LoI for FRIB PAC3**

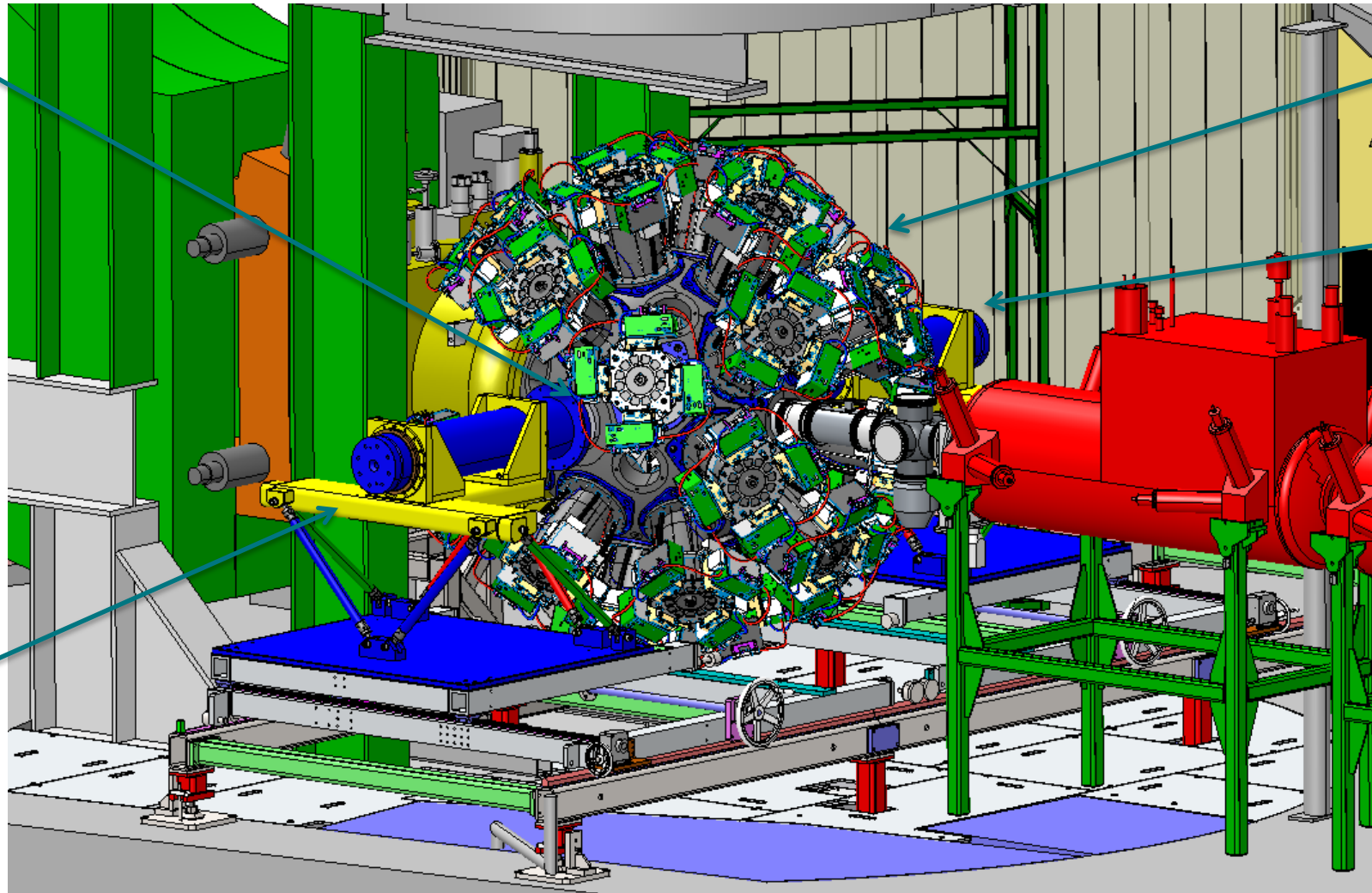
Modification to the GREYINA Frame

5" Long Axle
Extension

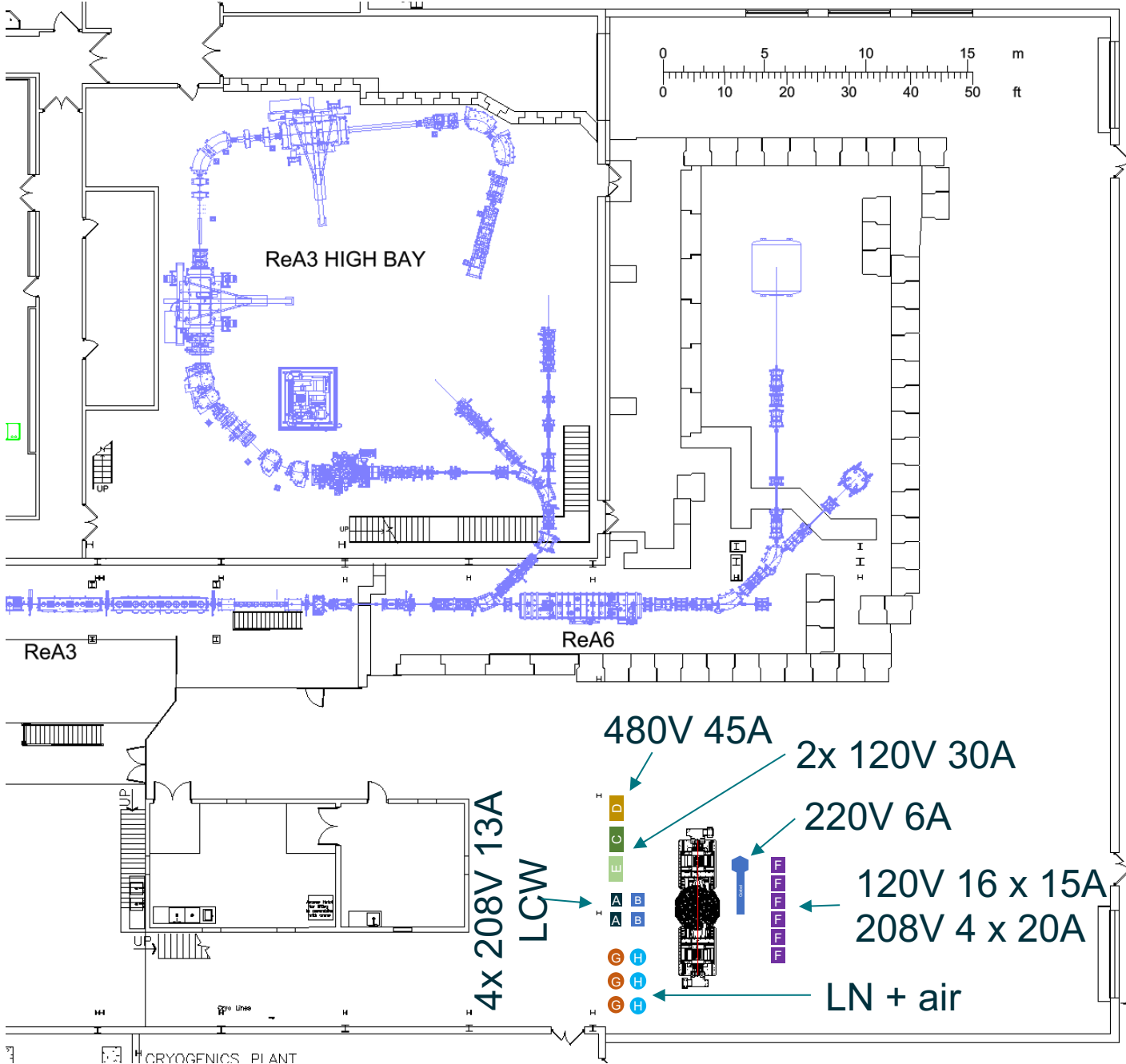
GRETA Detectors
in every available
position

South
Hemisphere

North
Hemisphere



Initial setup in the high-bay
Re-affirm performance



Summary

- Final assembly of the GRETA systems is underway, with detectors to be installed for the final stage of integration in October 2024
- Detector Systems – All 20 ordered, 12 delivered, and 12 accepted
 - CD-4A KPP detector scope complete
- Electronics, computing and infrastructure for all 30 Quads will be delivered to FRIB along with available Quad modules after CD-4A, planned for late Spring 2025

Acknowledge the GRETA project team, GRETINA project and operations team, community (GUEC) and agency's (DOE/NP) support.

