Brookhaven National Laboratory

U.S. DEPARTMENT of ENERGY

SRF Test Facility Upgrade

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5th Workshop on Particle Accelerator Upgrade Removal and Installation
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Bad Zurzack, Switzerland

@BrookhavenLab

About Me - Jean Clifford Brutus

Current Role:

- C-AD Mechanical Engineer
- Matrix to EIC Mechanical Engineering Group
- C-AD Test Facilities Project Engineer
- Lead Project Engineer for Coherent Electron Cooling (CeC) and Low Energy RHIC Cooling (LEReC)

Experience:

- 14+ years as an accelerator engineer
- February 2021 – Present: SRF Test Facilities Project Engineer
- June 2018 – Present : CeC Project Manager
- June 2014 – June 2018 Lead Project Engineer for Low Energy RHIC Cooling (LEReC) Warm RF Cavities
- June 2011 – June 2018: CeC Mechanical Engineer

Education:

- Stony Brook University - Master of Engineering in Mechanical Engineering Graduate
- Stony Brook University - Bachelor of Engineering in Mechanical Engineering Undergraduate
- New York State Education Department (NYSED) - New York State Professional Engineering (PE) License
- Project Management Institute (PMI) - Project Management Professional (PMP) Certification

Outline

I. Project Scope
II. The RF Test Facility Complex
III. Horizontal Test Facility (HTF)
IV. High Power Test Facility (HPTF)
V. EIC SRF Installation
VI. Summary

Project Scope

- **Scope:** Multi-frequency, long term 2.0 K testing capabilities for BNL by upgrading the SRF Test Facility.
  The existing SRF Block House in Bldg. 912 is not practical and needed extensive facilities upgrades to use.

- **Need:** The EIC Cryomodules need to be tested and validated at full power after transport. Delicate equipment (high power couplers, tuners, 2K vacuum integrity, cryogenic lines and RF connections) are easily damaged during transport and must be checked; e.g., LCLS-II experience.

- **Deliverables:**
  - Convert the C-AD Horizontal Test Facility (The old Energy Recovery Linac test facility) to an accelerator facility.
    - This was an accelerator facility prior to 2022.
    - DOE Order 420.2D compliant.
  - Support systems for the SRF Test Facility.
    - Cooling water
    - New mechanical equipment (Room/Floor space, pumps, Cryo compressors, vacuum skids, etc.)
    - Cryo valve boxes, cryo distribution lines, etc.
    - RF Amplifier installation, waveguides, HVAC for RF.

The RF Test Facility Complex

Upgrades

- Large Vertical Test Facility (LVTF) approved for <10 MeV operation.
- HTF being used currently to test BLAs and FPCs.
  - Work in progress to make the facility compliant with DOE 420.2D
- SRF Cleaning and Assembly Facility with class 100 cleanrooms equipped with vacuum oven, Ultrasonic cleaning tanks, and HPR system.
- One Horizontal Test Facility and two Vertical Test Facilities.
- High RF Power Test Facility with a 1 MW CW 704 MHz klystron and its 2 MW DC power supply.
- SRF Technical Support Facility with machining and welding shops.

Class 100 Clean room

High Pressure Rinse

CeC 704 MHz in the Class 100 Clean room

Ultra Pure Water Room
Ultra Pure Water Room

High Power Test Facility (HPTF)

Cryo Plant

LVTF Cryogenic Vessel

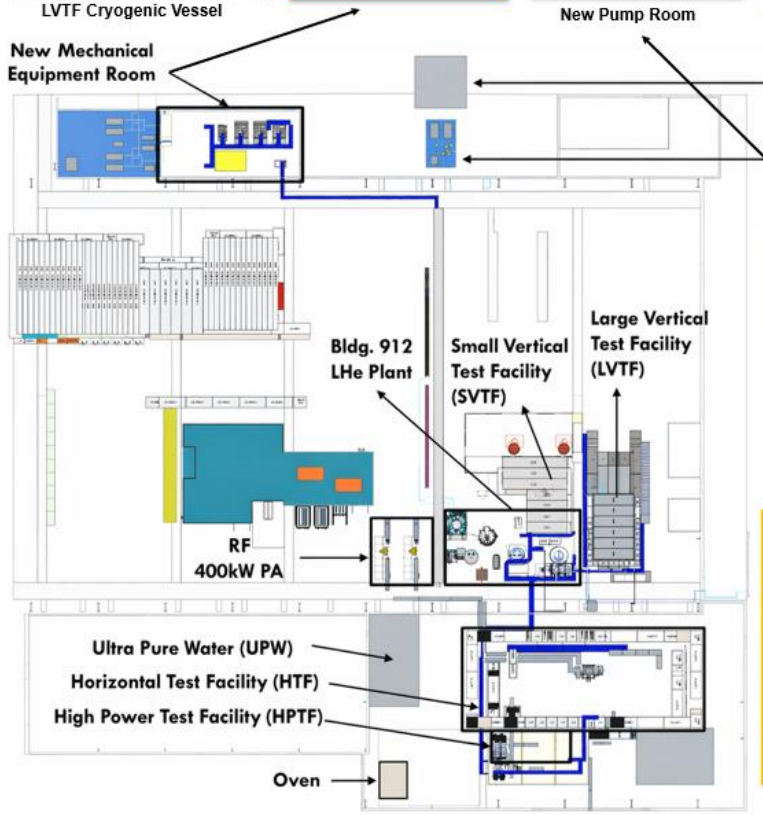
New Pump Room

2.86MW PHENIX Tower

Cryo Vacuum Skids

Cryo Compressor

SRF Shop + Clean Room + High Pressure Rinse (HPR)

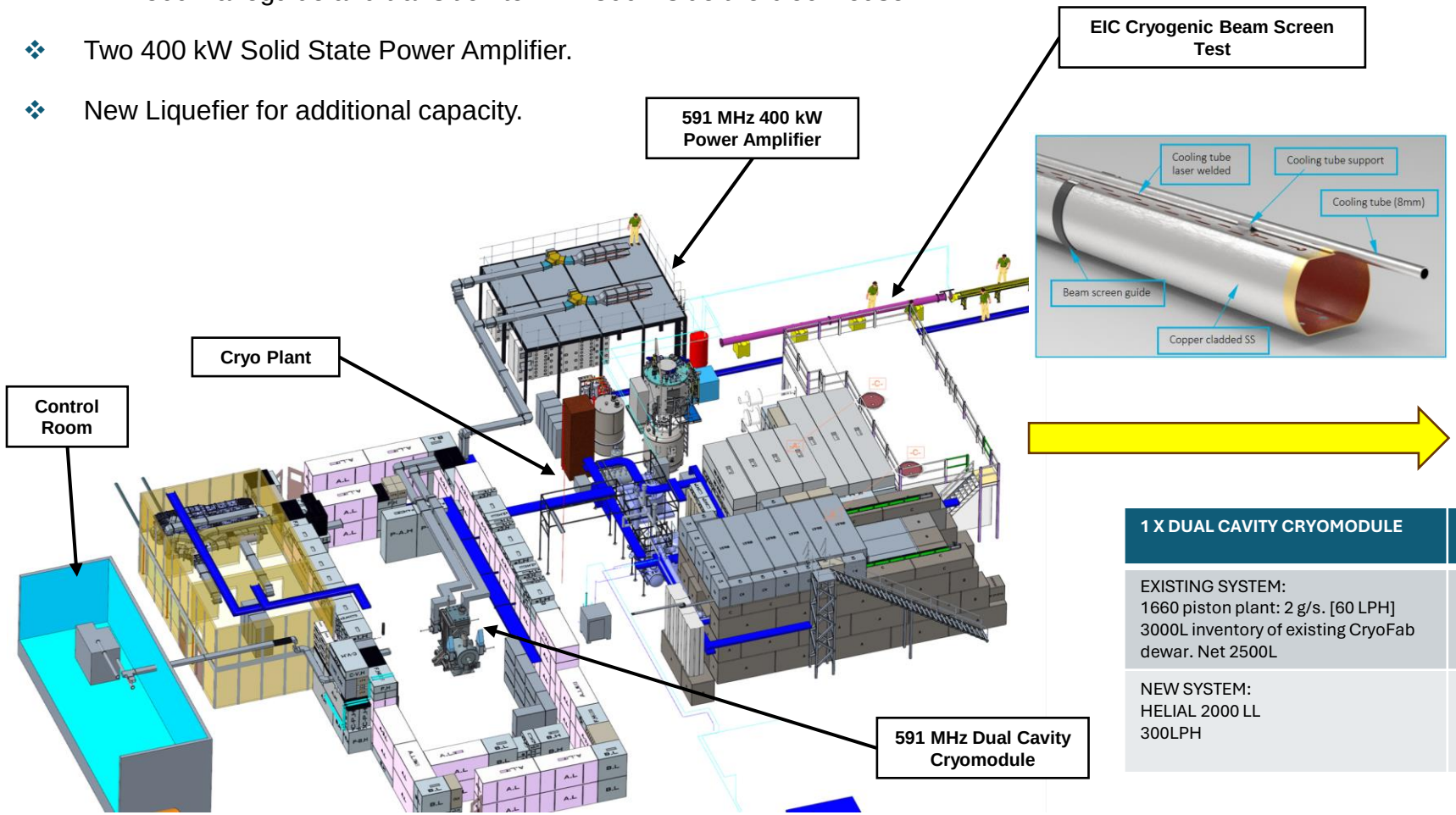


VTF Cleanroom

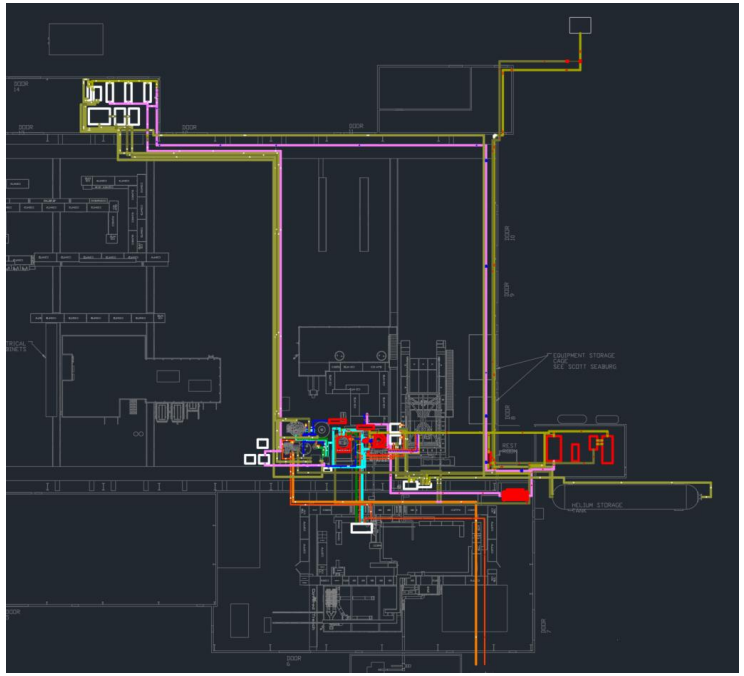
Horizontal Test Facility

Horizontal Test Facility (HTF)

- Strategically located adjacent to other technical support facilities, for SRF cleaning and assembly.
- The facility will support the acceptance testing of SRF cryomodules upon reception at BNL for the EIC Project.
- WR1500 waveguide and transition to WR1800 inside the blockhouse.
- Two 400 kW Solid State Power Amplifier.
- New Liquefier for additional capacity.



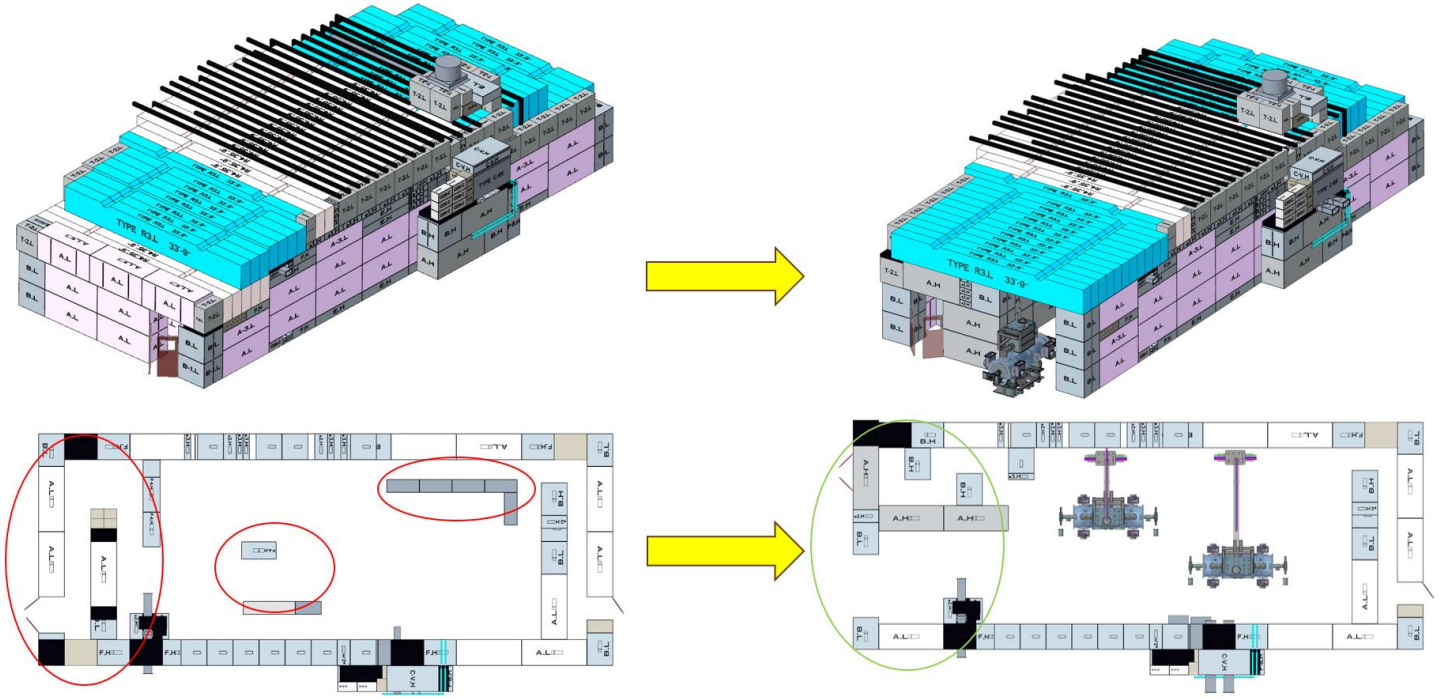
Cryo Distribution Line Schematics

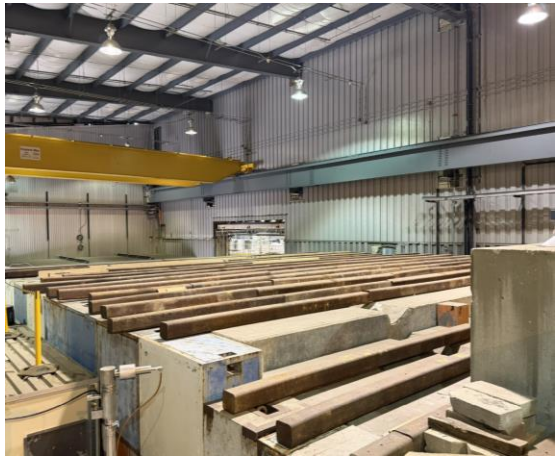


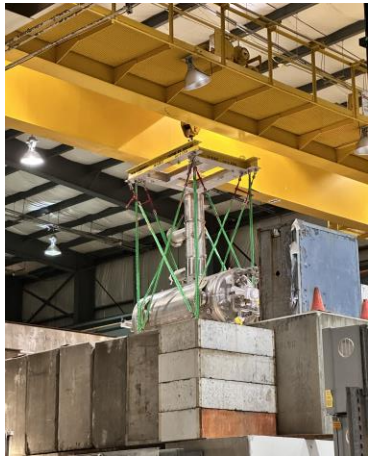
1 X DUAL CAVITY CRYOMODULE	Run time at 2K for 1 X Dual-Cavity-591MHz-1-cell CRYOMODULE	Run time at 2K for 2 X Dual-Cavity-591MHz-1-cell CRYOMODULE
EXISTING SYSTEM: 1660 piston plant: 2 g/s. [60 LPH] 3000L inventory of existing CryoFab dewar. Net 2500L	• 8-9hrs • 2.5-3days recovery time	• 2-3hrs • One cryomodule at full power • One cryomodule static loading
NEW SYSTEM: HELIAL 2000 LL 300LPH	We can run continuous with 1 x Dual-Cavity-591MHz-1-cell CRYOMODULE.	70hrs

Horizontal Test Facility (HTF)

- Leading edge operation, time consuming and Critical Lift.
- Access control door and labyrinth relocation.
- Raised roof height to accommodate the cryomodules.
- Removal of obsolete shielding blocks.





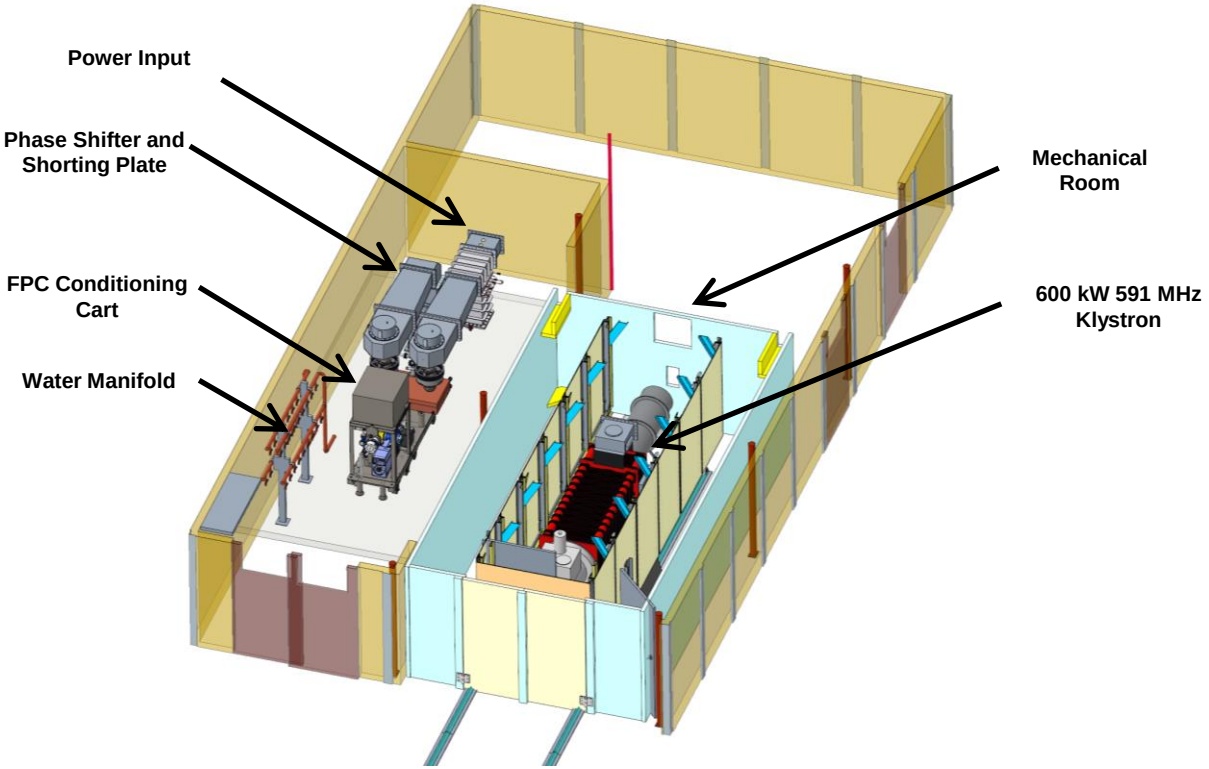


Cryomodules are loaded through the roof. (Left) HTF with partial roof removed (Right) 56 MHz SRF Cryomodule being craned into the HTF.

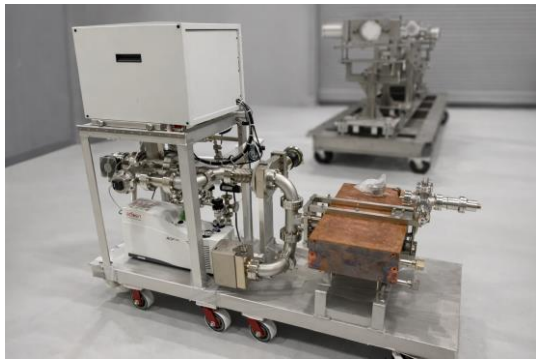
RHIC 56 MHz SRF Cryomodule installation in the HTF

High-Power Test Facility (HPTF)

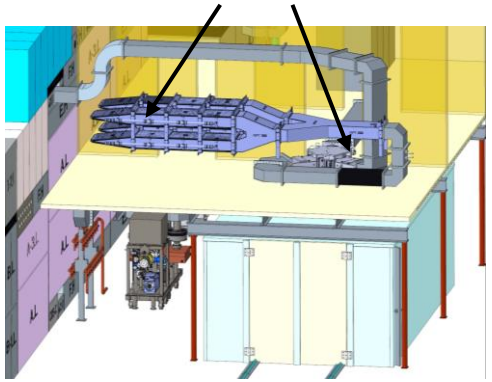
- The facility will host high-power RF testing of fundamental power couplers (FPC) and beam line absorbers (BLA).
- Decouple cryogenic test facility from high power non-cryogenic test.
- Currently the facility hosts a 1 MW 704 MHz klystron with its 2 MW power supply.
- Upgrade 591 MHz klystron with 600kW 591 MHz dummy load and circulator.
- Plan to test 2 different suppliers for the dummy loads and circulators.



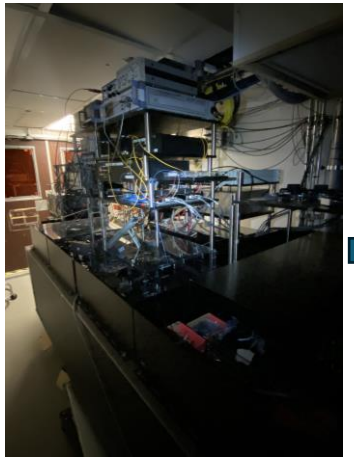
FPC Conditioning Cart



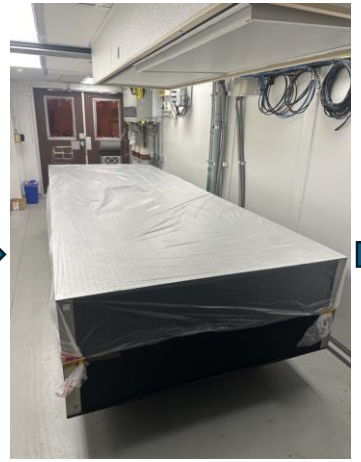
600 kW 591 MHz Dummy Load and Circulator



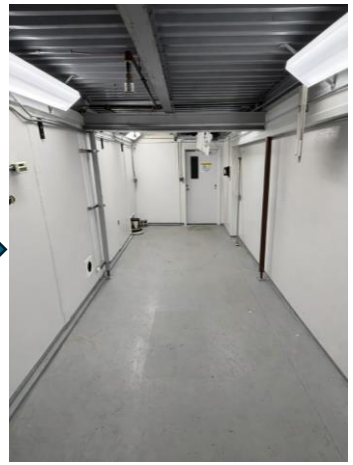
Energy Recovery Linac Laser Setup



Laser table removal

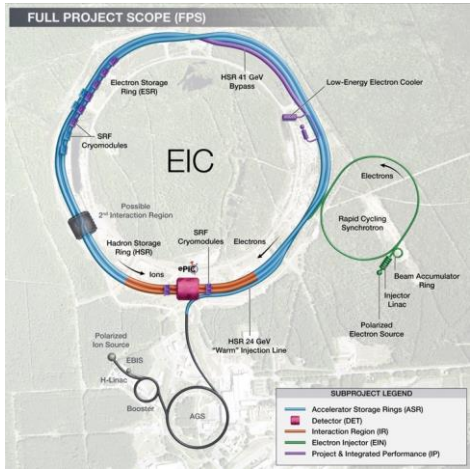


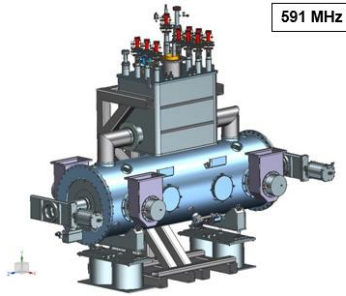
High Power Test Room



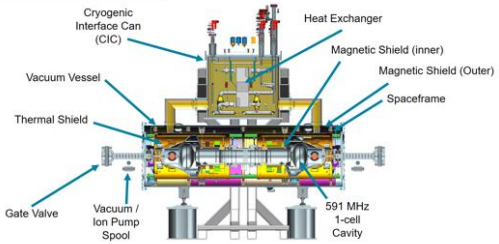
EIC SRF Installation

- The EIC Project will require to test over 27 cryomodules in a broad frequency range (197 MHz to 591 MHz) starting in 2029. First component available for testing will be the EIC 591 MHz SRF cryomodule.
  - Most EIC SRF cryomodules are “buried” behind significant other accelerator equipment.
    - Many SRF cryomodules issues will only be apparent after 2K testing and, if found once installed in the accelerator, require varying levels of accelerator shut-down and extensive disassembly for cryomodule removal/repair.
    - Delicate equipment (high power couplers, tuners, 2K vacuum integrity, cryogenic lines and RF connections) are easily damaged during transport and must be checked; e.g., LCLS-II experience.



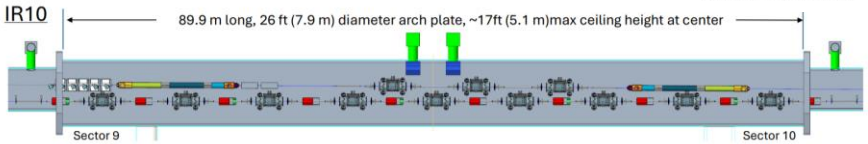


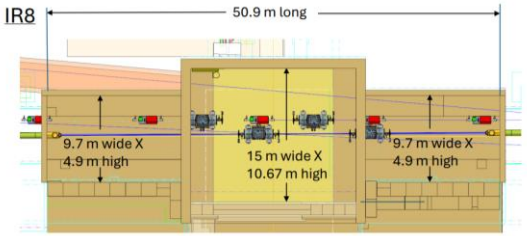
591 MHz Dual Cavity Cryomodule

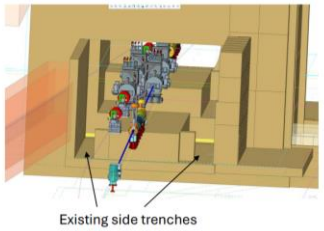


- Door Jam is **70.75” wide x 94.625” high** (note: these dims are to the red frame of door. Will need to remove silver weather seals for max width).
- The utility tunnel is **120” wide x 102” high**

IR 10 Tunnel Access



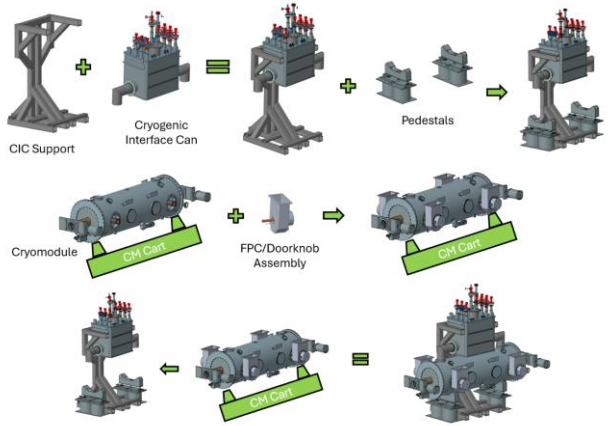




- 1.3 miles (IR8) to 1.6 miles (IR10) trip from test facility to final location EIC tunnelno

High Level Installation Sequence for the 591MHz Cryomodule

- **Weight:** Cryomodule ~8700 lbs (4.35 tons), with CIC 11700 lbs (5.85 tons), with support structure ~15,500 lbs (7.75 tons)
- **Dimensions:** Height: 160.4 inches Length: 182.1 inches Width: 82.8 inches



1. Presurvey cryomodule and stands.
2. Cryogenic Interface Can (CIC) Support frame delivered and roughed surveyed in place
3. CIC moved into hall and secured to CIC support frame
4. Pedestals secured in place
5. Cryomodule without FPC/Doorknob assembly brought into main tunnel hall
6. FPC’s installed with CM sitting on Handling cart depending on the location
7. Cryomodule with FPC’s installed on Pedestals and surveyed in place
8. CIC connections made to Cryomodule
9. Connect 2K Trunks to CIC
10. Clean room set-up
11. Beamline installation

Summary

- The proposed upgrade to the SRF Test Facility is in the best interest of BNL and EIC:
  - Will be used for testing RF components at various frequencies, for EIC and potential future DOE projects.
  - Mitigate the high risk associated with installing cryomodules in the beamline without testing.
- The Air Liquide Helium plant contract was awarded August 2025 with 2 years delivery.
- Work closely with the R&R team for the equipment being repurposed from Coherent electron Cooling (CeC) and Low Energy RHIC electron Cooling (LEReC) experiments at RHIC.
- Work closely with EIC to ensure that the requirements do not change and the EIC deliverables are on schedule.
- EIC Installation challenges (space) are being addressed as the design matures.

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Thank You

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