C-AD Organization

- Facility consolidation
- Workforce development
- Resource planning
- CBETA, CeC

Thomas Roser

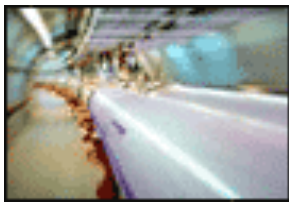
DOE NP RHIC S&T Review

September 17 – 19, 2019

The Collider-Accelerator Department

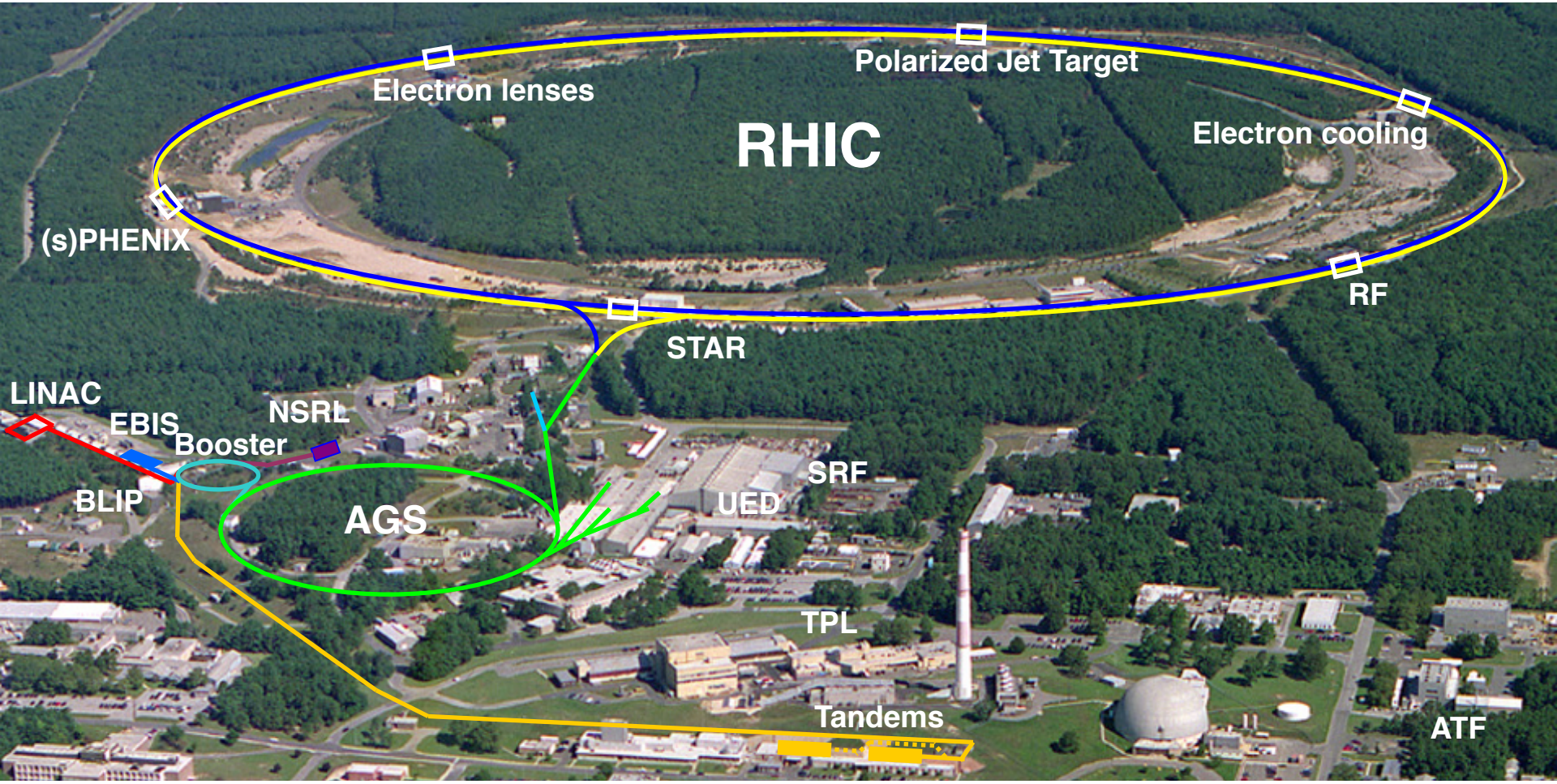




- Mission: Design, develop, commission and operate state-of-the-art accelerators to carry out accelerator-based experiments in an environmentally responsible and safe manner. Perform accelerator R&D towards the next generation of accelerator facilities and accelerator applications in support of national needs.
- ~ 430 direct FTEs
- Excellent and continuously improving safety record through early adoption of thorough work control and planning and rigorous conduct-of-operations approach.
- Significant legacy infrastructure issues (AGS started operation in 1960) are being addressed through continuous renovation and replacement of obsolete equipment.
- Recently added Accelerator S&T expertise:
  - Special purpose SRF systems
  - High brightness electron sources

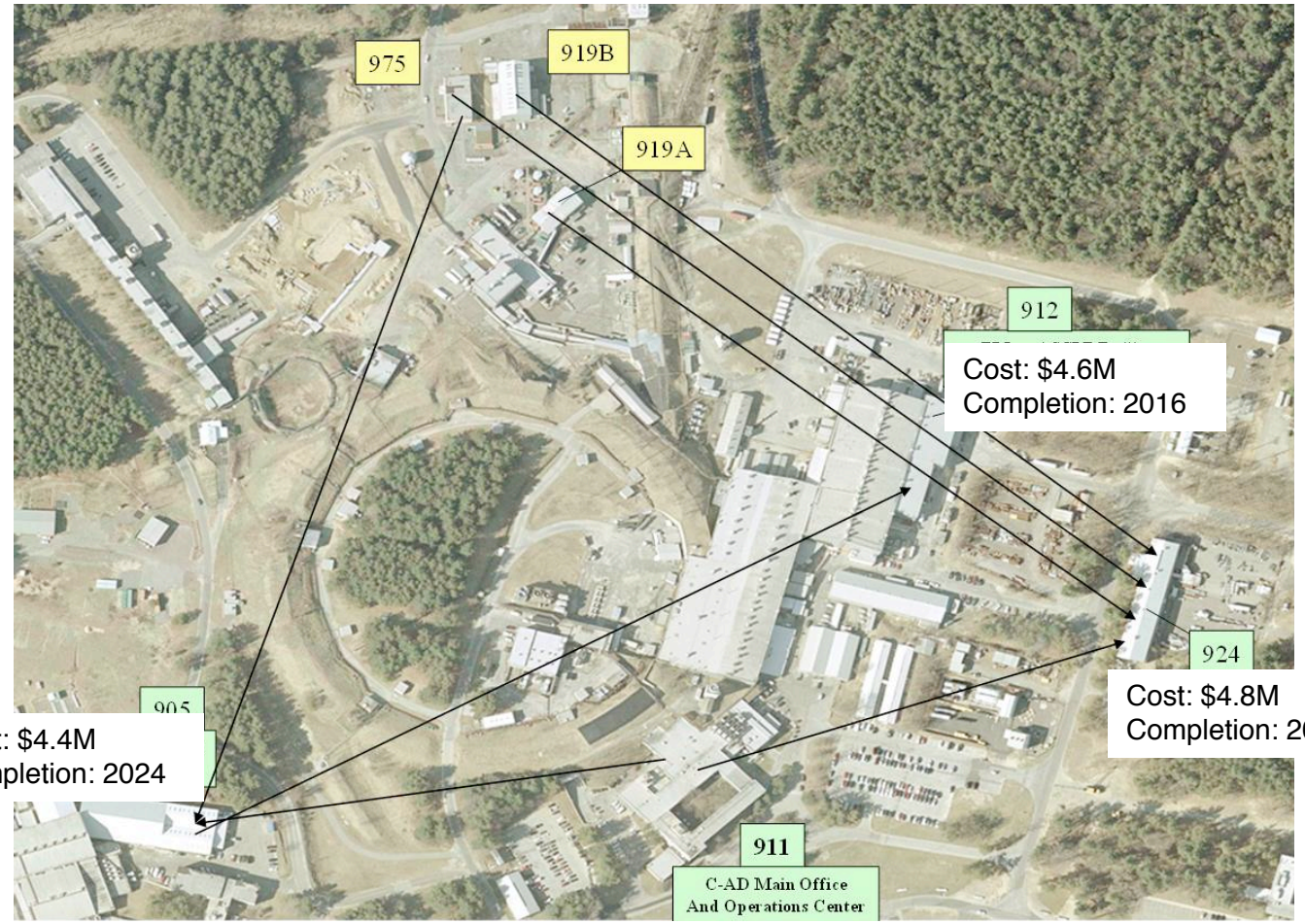
The RHIC Accelerator Complex



- Highly flexible and only US Hadron Collider exploring the QCD phase diagram and the spin of the proton
- Injectors also provide beams for unique applications: Isotope production (BLIP/TPL); Cosmic radiation simulation (NSRL); Commercial applications (Tandem)
- R&D for future facilities and accelerator applications (SRF, ATF, Cooling)

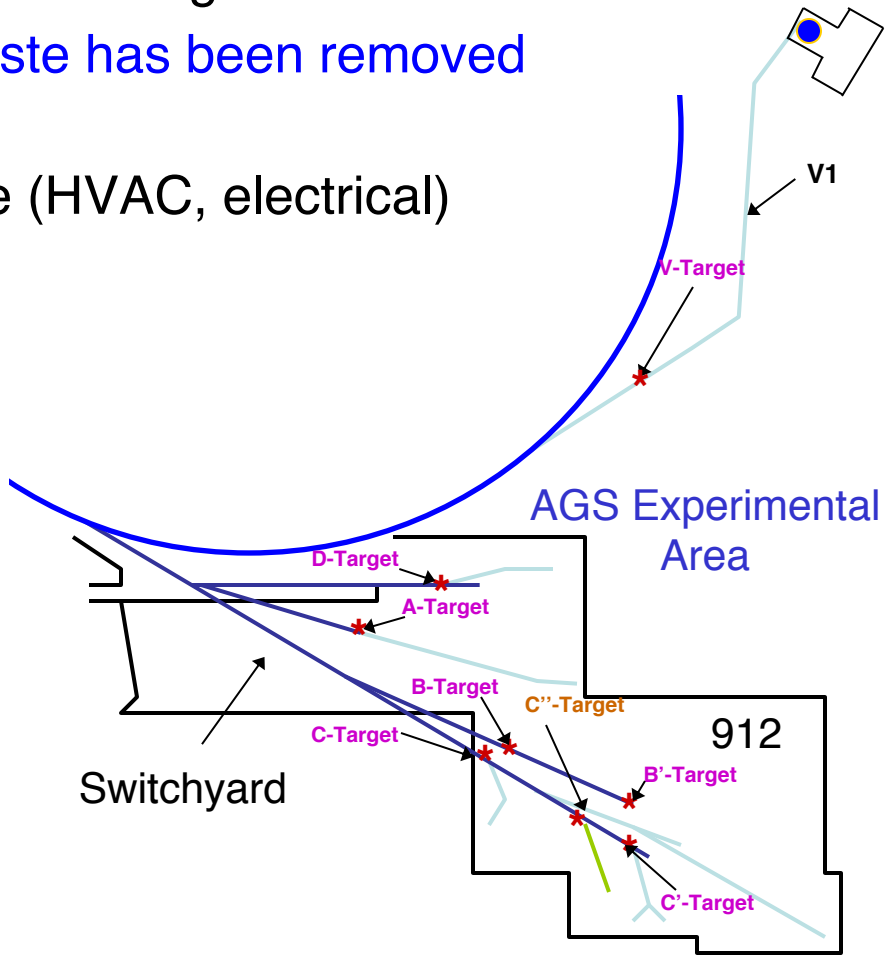
C-AD consolidation plan

- Plan was developed by BNL F&O and C-AD as part of an integrated set of investment needs across BNL.
- SRF facilities in Bldg. 912
- Instrumentation technical space in Bldg. 924
- Vacuum technical space in Bldg. 905

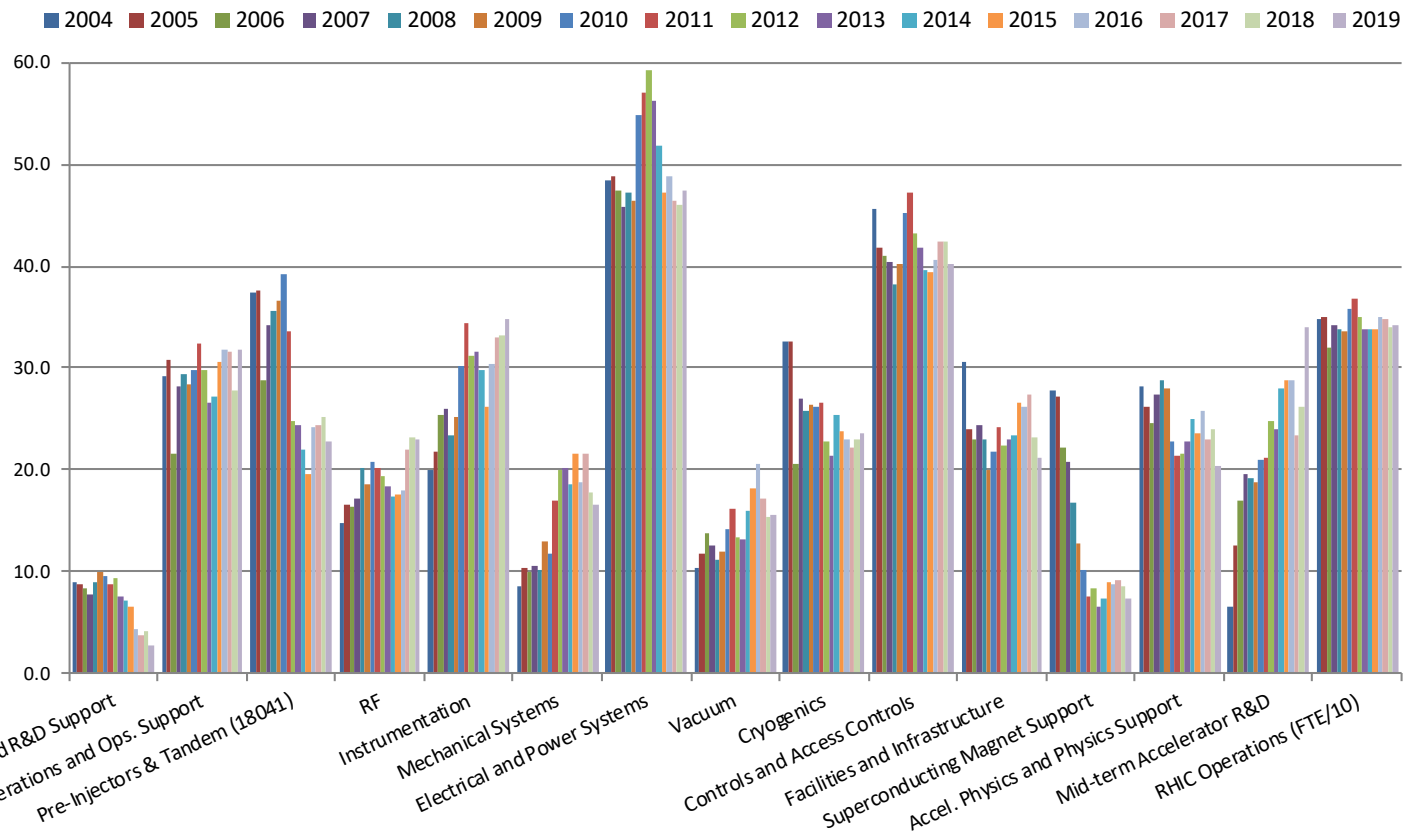


Cleanup of areas previously used by HEP

- HEP research at BNL (AGS) for nearly four decades induced low levels of radioactivity in soils, shielding, equipment, and cooling water systems.
- End-point of cleanup will be facilities that will allow for reuse for similar functions and will remain under Federal oversight.
- About 60% of low-level radioactive waste has been removed to date.
- Infrastructure upgrade of 912 for reuse (HVAC, electrical) completed:
  - SRF facilities
  - sPHENIX detector staging
  - EIC R&D efforts
- Removal of switchyard area is underway. Possible future location for Proton Radiography.



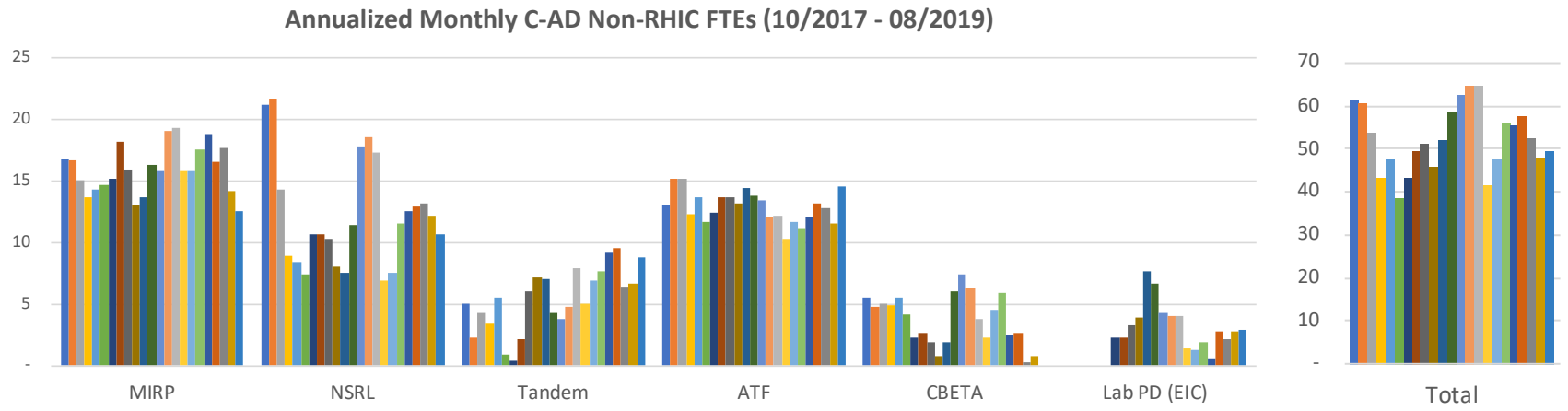
C-AD RHIC operations staffing



- C-AD based RHIC ops staff: ~ 345 FTEs; this includes:
  - ~ 25 FTEs for RHIC accelerator upgrades
  - ~ 20 FTEs of exp. support (PHENIX component redirected to sPHENIX project)
  - ~ 8 FTEs for support of superconducting magnet expertise at SMD
  - ~ 30 FTEs for mid-term accelerator R&D (EIC R&D). Includes competitive EIC R&D effort (FOA).

C-AD Staff Planning

- There are an increasing number of projects that require C-AD resource scheduling
  - **Part of RHIC operations or redirect:** LEReC construction, installation, and commissioning; EIC R&D; sPHENIX
  - **Not funded by RHIC operations:** MIRP; NSRL; Tandem; ATF; CBETA; lab funds
    - *Substantial expansion of electronics testing at NSRL in progress (~ 1000 hrs/yr)*
    - *Possible return of proton radiography to the AGS (~ $5-10M/yr)*
- 5 MoUs with sPHENIX project to deliver C-AD responsibilities on schedule with available resources



Demographics and Diversity of C-AD staff

- Overall C-AD staff:
  12% female (12% last year)
  8% URM (8% last year)

- Heads/Group Leaders:
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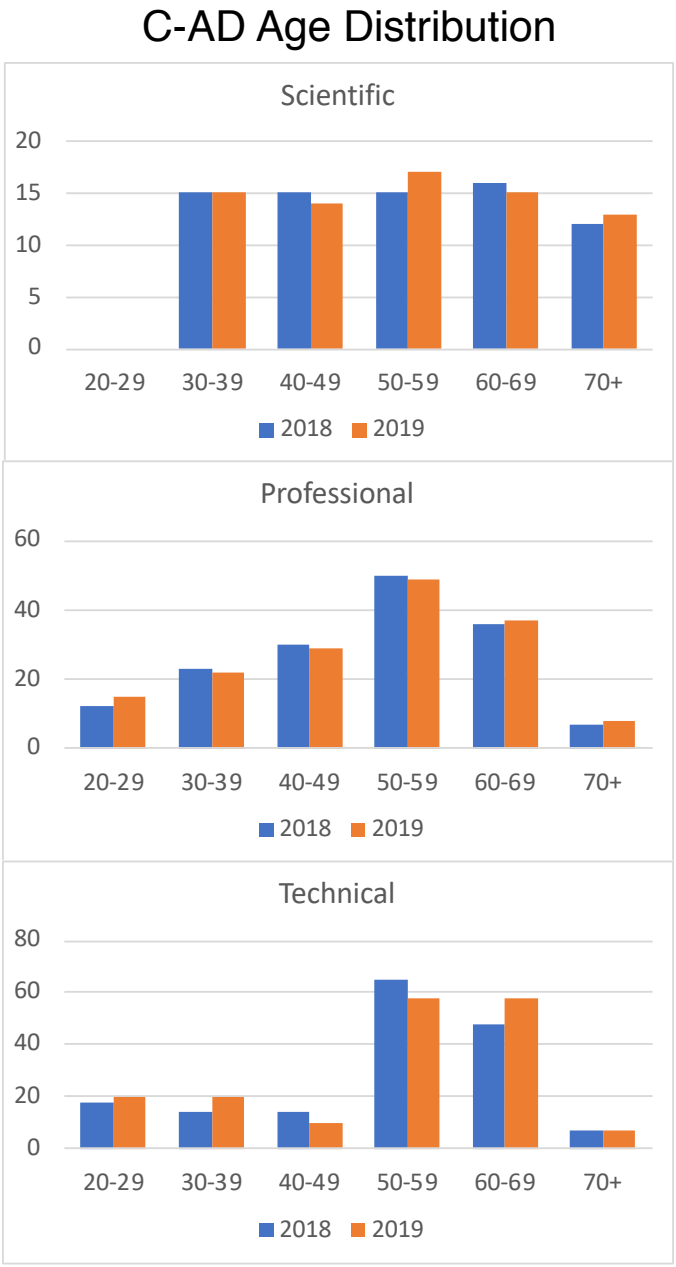
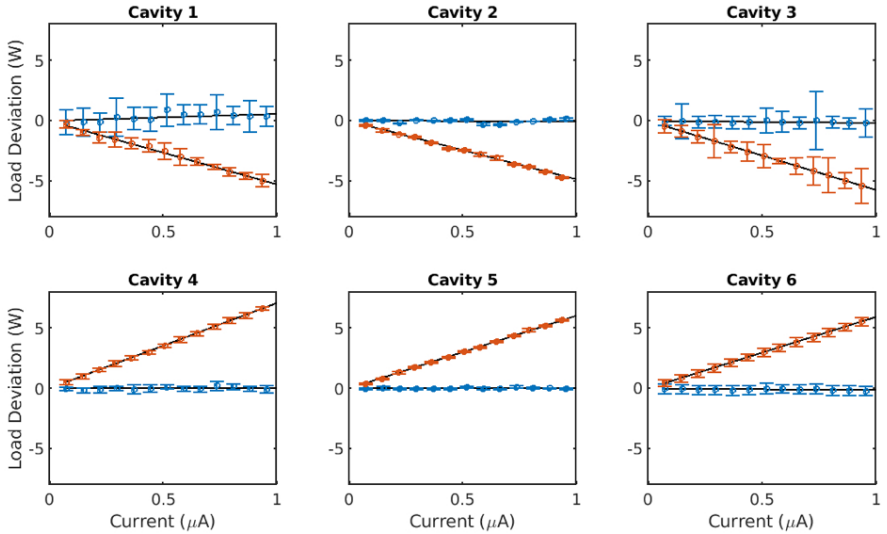
- Increase diversity through entry level positions and then retain staff with attractive career opportunities and inclusive work environment:
  - RHIC operators
  - Engineering interns
  - Post-doc/assistant scientist
  - “Apprentice program”

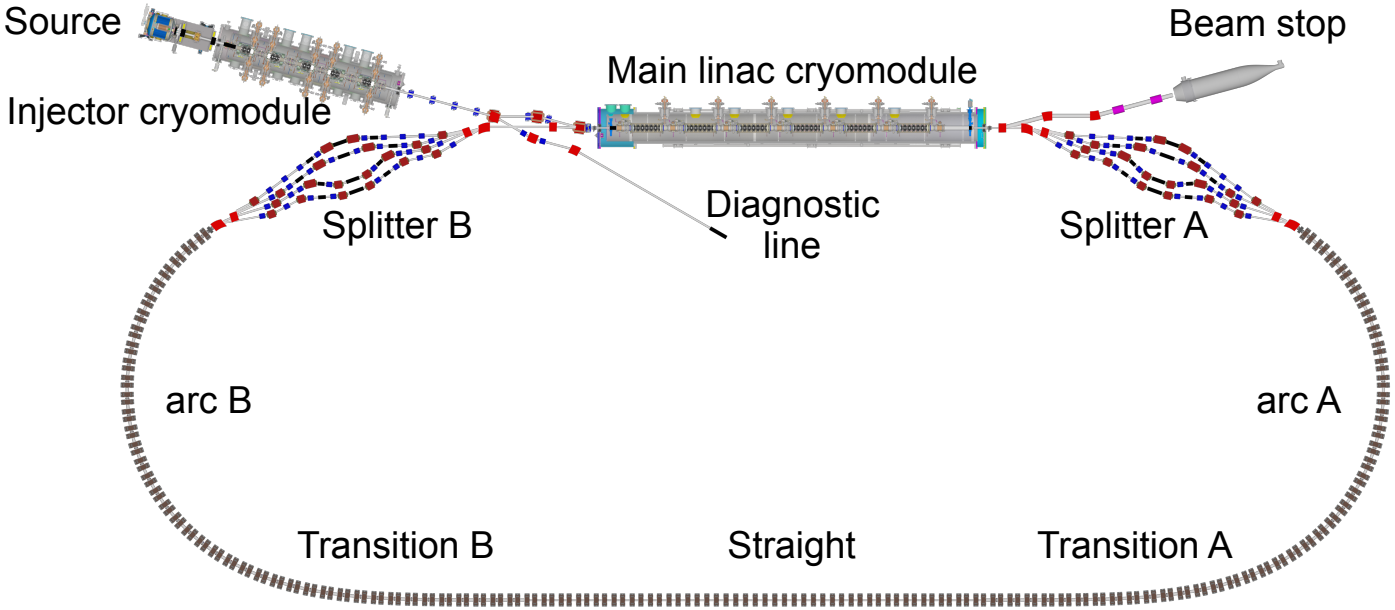


CBETA – 150 MeV multi-pass test-ERL
(NY State funded, BNL-Cornell Collaboration)

- Uses existing 6 MeV low-emittance and high-current injector and 36 MeV CW 1.3 GHz SRF Linac at Cornell
- Energy Recovery Linac (ERL) with single four-pass recirculation arc with x4 momentum range
- One-pass ERL demonstrated, x2 momentum acceptance of arc demonstrated.
- Four-pass ERL by December 2019
- Active collaboration with JLab, CERN, Saclay (LHeC test accel. PERLE), Berlin-Pro, Mainz, STFC (UK)



- Measured rf power load in main linac for single pass mode (orange) and energy recovering mode (blue)



Continuation of strong hadron cooling test at RHIC

- Previous test of FEL-based CeC was hampered by excessive 10 THz intensity noise in the electron beam
- Cause of noise was identified in tests during Run-19 and sufficient noise suppression was demonstrated
- External committee (S. Nagaitsev (FNAL, Chair), D. Ratner (SLAC), M. Borland (ANL), I. Bazarov (Cornell), R. Li (Jlab)) reviewed proposal to test CeC again, now with low noise electron beam and with Plasma Cascade Amplifier (compatible with BES II aperture requirements).
- Review was positive with a number of improvement suggestions (draft report is uploaded to Indico site)

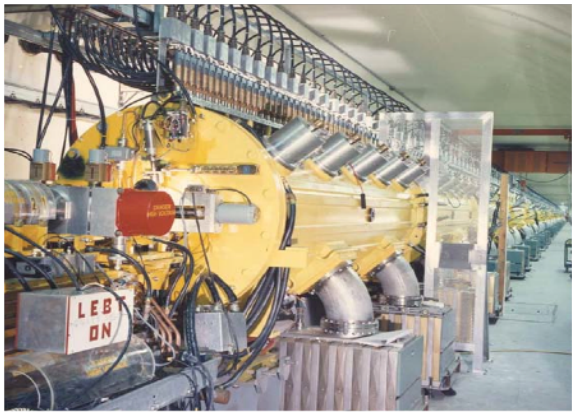
Summary

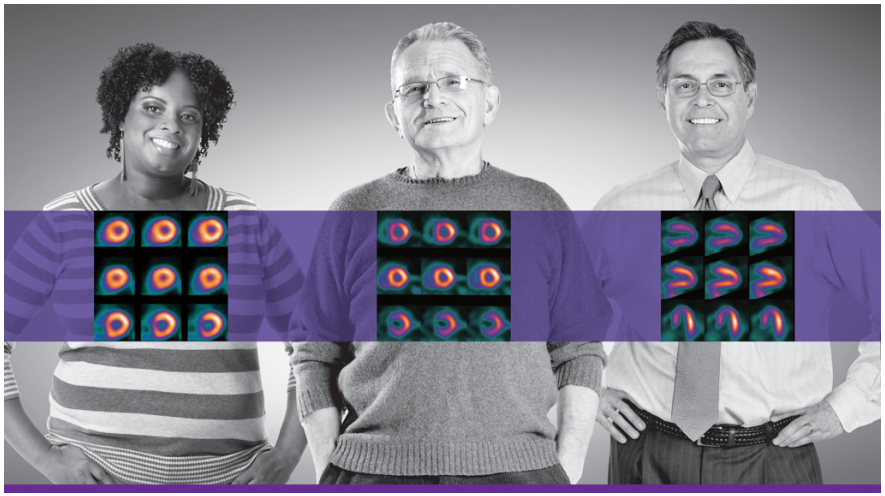
- Continued synergistic and efficient operation of RHIC with BLIP, NSRL, and ATF
- Substantial progress in facility consolidation, tech space refurbishment and waste cleanup from fixed target program
- Safely managed the increased complexity of two new electron accelerators (CeC, LEReC) in the RHIC tunnel
- Active resource planning for RHIC operation, redirect projects, and efforts not funded by RHIC operations

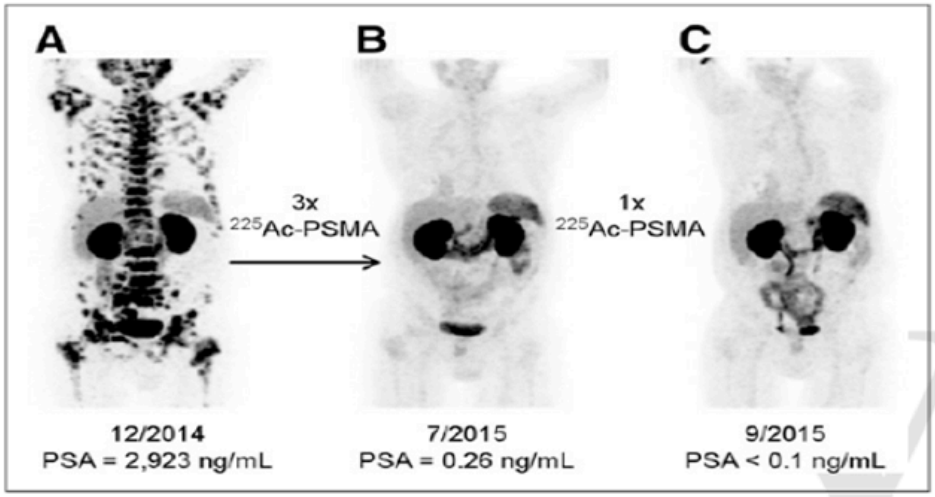
Back-up slide

Brookhaven Linac Isotope Producer (BLIP)

- Target irradiation with 116 – 200 MeV, 160 μA proton beam
- Production of medical radio-isotopes for U.S.:
  - Mainly Sr-82, shared between LANL and BNL
  - R&D of new radio-isotopes for diagnosis and therapy (Ac-225, needs ~ 200 MeV protons)
- Significant expansion is underway:
  - BLIP target and proton beam intensity upgrades
  - Refurbishment of additional hot cells for Ac-225 processing
  - 17 MeV cyclotron for isotope production at lower beam
  - Energies
- Radiation damage testing of production target material (RADIATE) and detectors





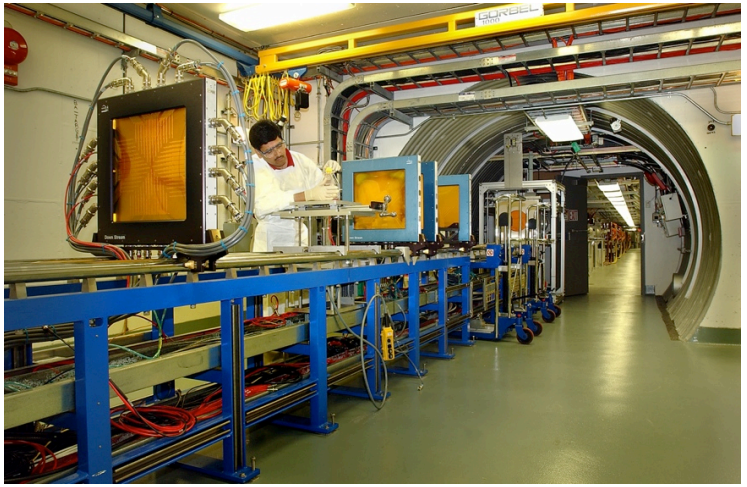


- Sr-82:
  - coronary artery disease diagnosis
  - used under rest and stress conditions
- Ac-225:
  - Alpha emitter for treatment of metastatic prostate cancer

NASA Space Radiation Laboratory (NSRL)

- Started in 2003, simulates galactic radiation for human space flight
  - Heavy ion beams from AGS Booster
  - Electron Beam Ion Source (EBIS) provides all necessary ion beams
  - New laser ion source for EBIS allows for rapid species switching to simulate energy and species spectrum of deep space radiation field

- Additional uses of NSRL
  - Radiation effects studies (rapidly growing demand for satellite electronics testing)
  - R&D of ion beam cancer treatment
  - Agreement with NASA in place for non-NASA users (“non-designated user facility”)

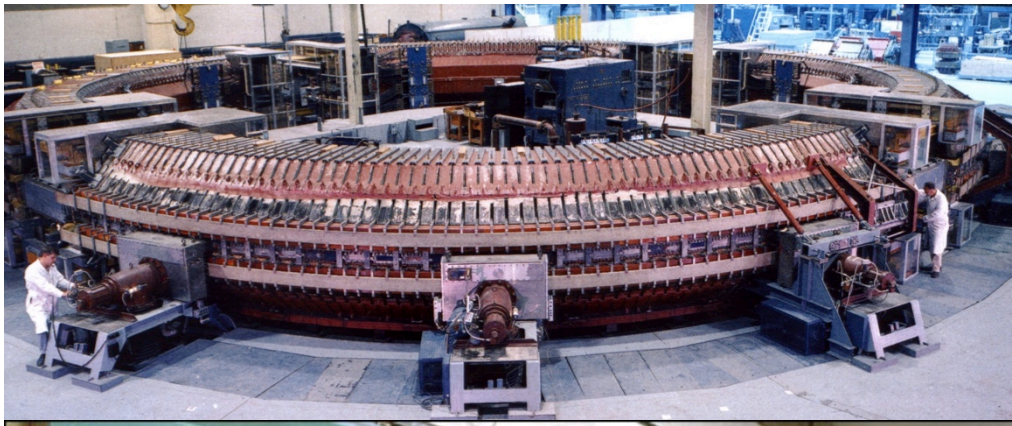


HEP Accelerator Test Facility at BNL

- Started in 1990 as a user facility for Advanced Acceleration studies
- High power, pico-second infrared laser and high brightness electron beam
- Achievements at ATF:
  - First high-brightness electron beams from photocathode RF gun
  - Self-Amplified Spontaneous Emission (SASE) in visible wavelength
  - Seeded high gain harmonic generation
- Moved from Physics Department to C-AD in 2013 to take advantage of synergies and C-AD accelerator operations expertise
- Use of 912 experimental area (cleaned up with HEP waste removal funds):
  - UED

A Hallmark of BNL: Focusing of Particle Beams

- Weak focusing synchrotron
  - 3 GeV Brookhaven Cosmotron
  - Completed in 1952
  - Bending magnetic field provides x and y focusing

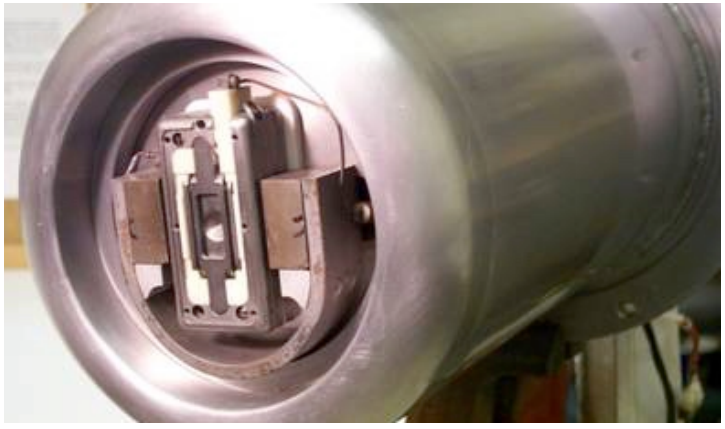


- Strong focusing synchrotron
  - 30 GeV Brookhaven AGS
  - Completed in 1960
  - Strong quadrupoles with alternating gradients

- Very strong focusing
  - CBETA Fixed Field transport
  - Many, very strong quadrupoles provide bending and focusing for large energy span
  - Tested at ATF

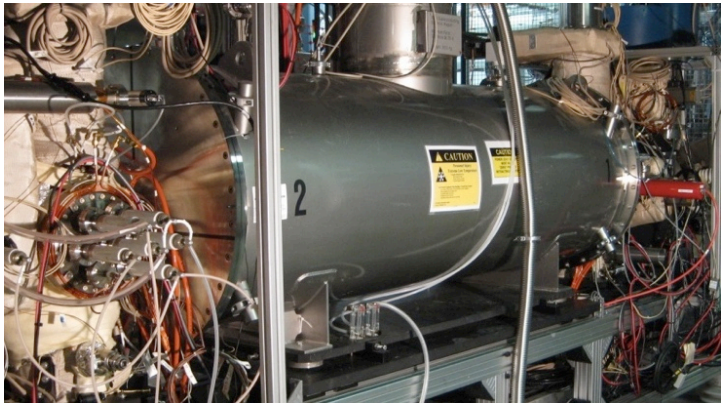
Ion Sources at BNL

- BNL Magnetron H- source
  - Hydrogen plasma interacts with Cs-Mo surface
  - Highest H- peak current (100 mA)



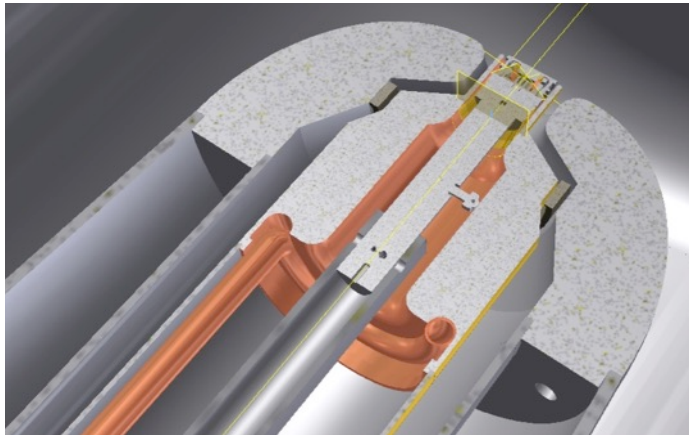
- BNL Optically Pumped Polarized Ion Source (OPPIS)
  - Polarized electrons from optically pumped Rubidium are used to generate polarized H- ions
  - Highest intensity (1 mA) polarized (83%) H- source

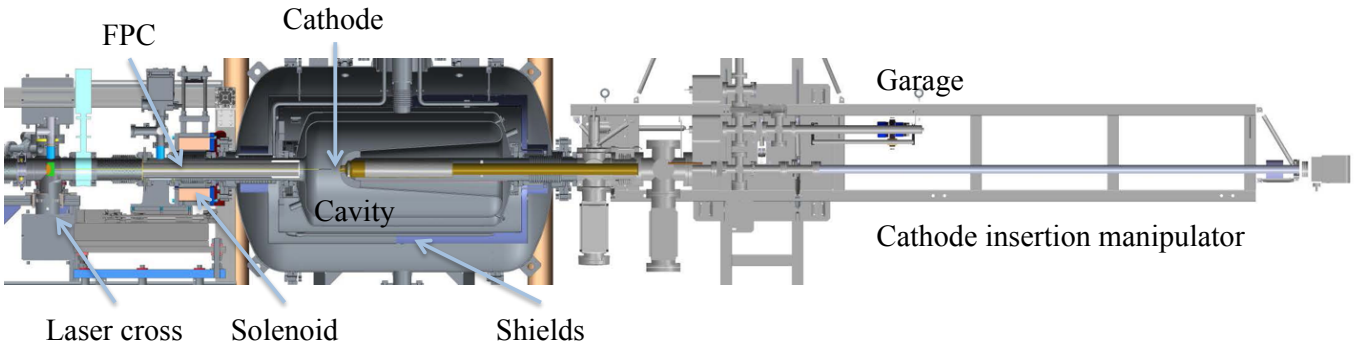
- BNL Electron Beam Ion Source (EBIS)
  - Intense electron beam inside high-field solenoid is used to stepwise ionize heavy ions. Reaches Au^{32+} after about 40 ms.
  - Highest intensity EBIS, polarized He-3



High intensity electron sources

- Active photocathode development at Instrumentation Division
  - Bi-alkali antimonide cathodes with QE up to 9%
- DC photo-electron gun for LEReC
  - Built by Cornell and installed at RHIC IR2
  - 400 kV operation
  - 30 mA CW current so far, 50 mA design
- SRF photo-electron gun for CeC
  - High brightness: 1.56 MeV, 0.5 nC and 0.3 um
  - High bunch charge: up to 10 nC
  - CW operation at 80 kHz with little QE drop
  - High current operation limited by FPC





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