C-AD Outlook to 2025 and Beyond

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RHIC retreat
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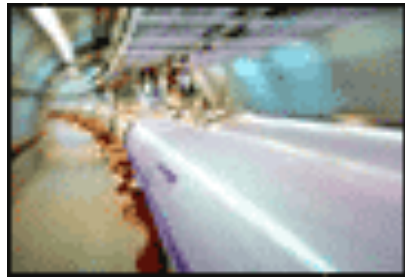
BROOKHAVEN NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

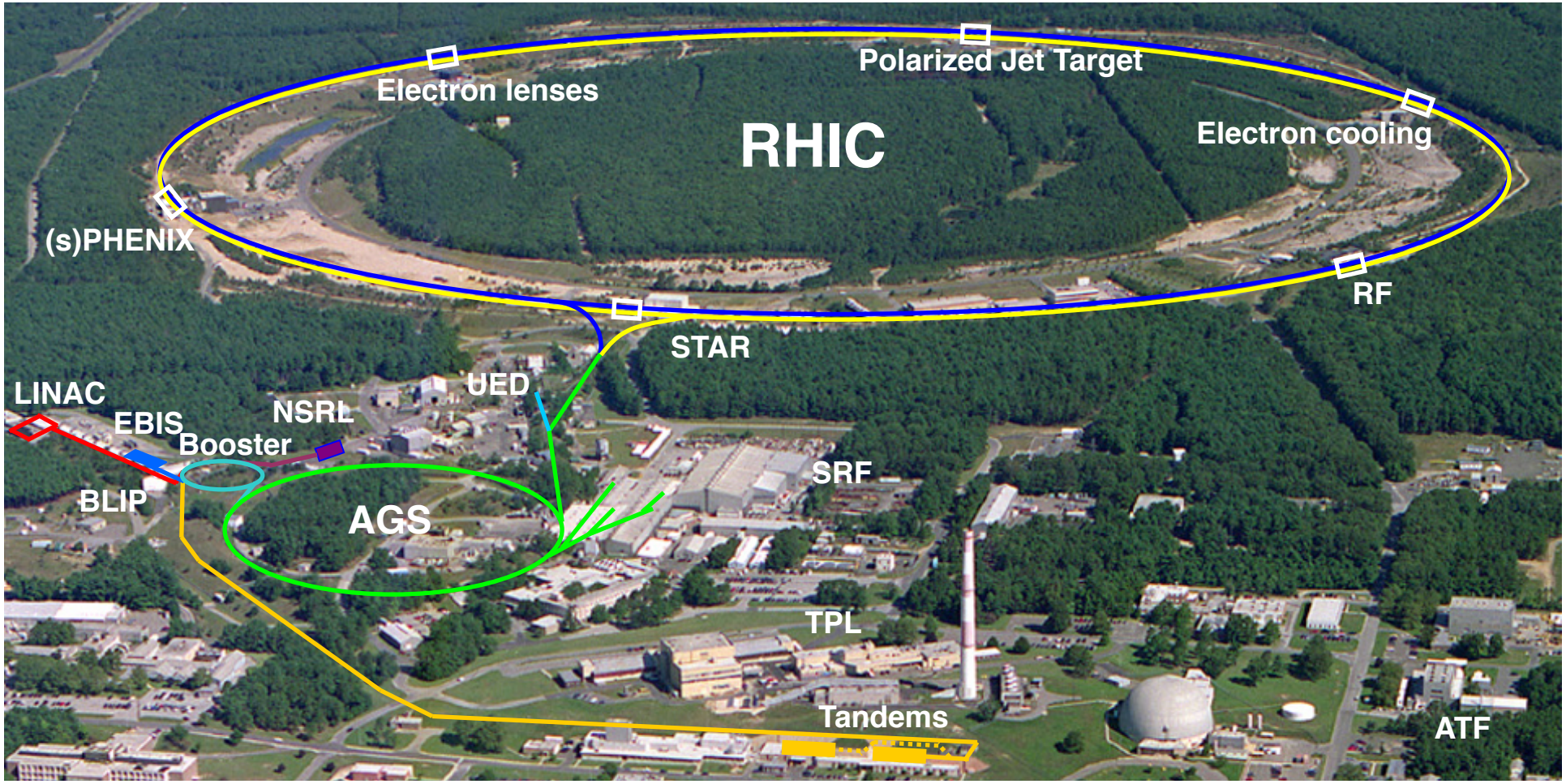
The Collider-Accelerator Department

- 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.
- ~ 420 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



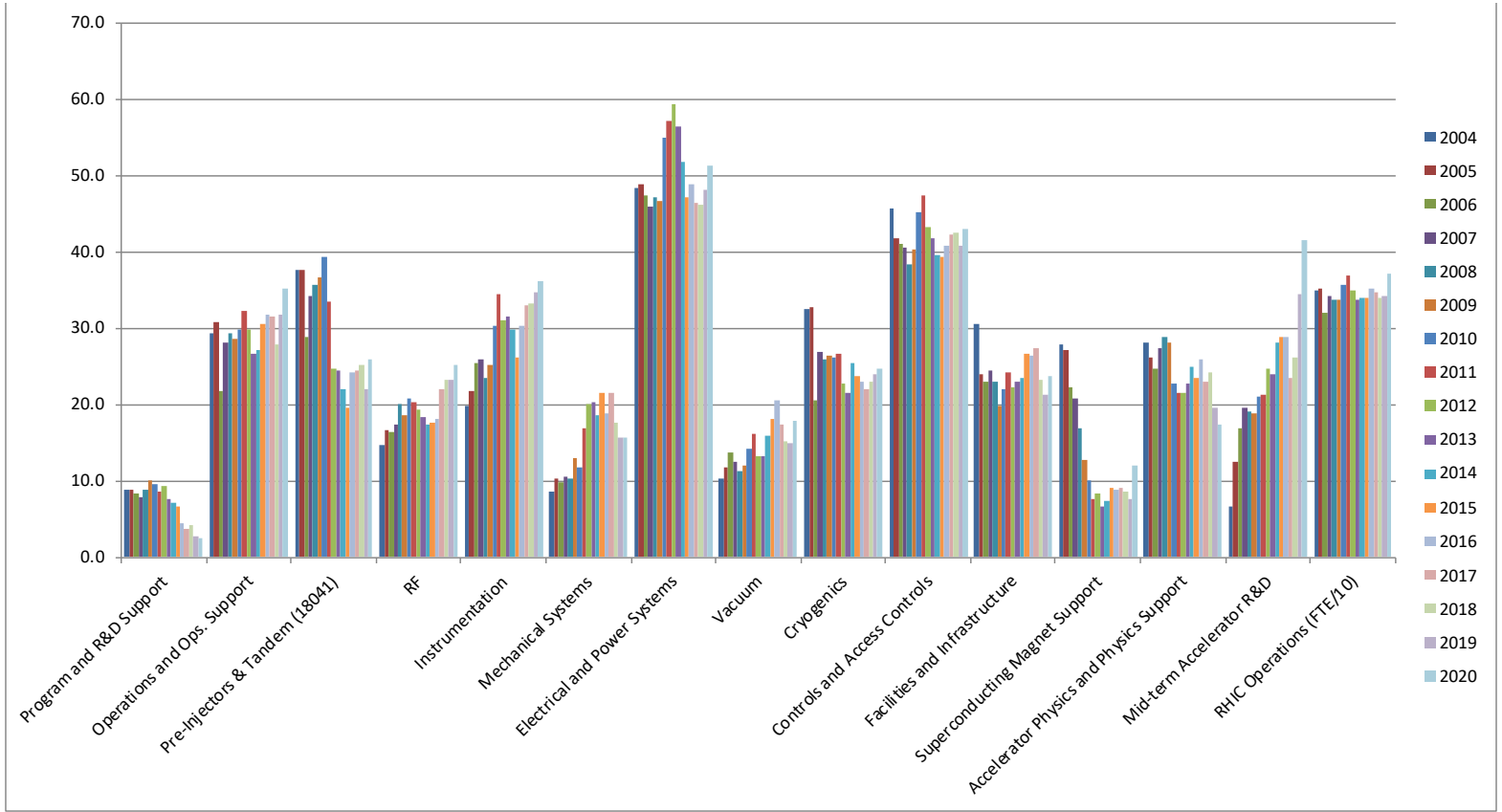
The RHIC Accelerator Complex

- 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 RHIC operations staffing

- C-AD based RHIC ops staff: ~ 350 FTEs; this includes:
  - ~ 25 FTEs for RHIC accelerator upgrades
  - ~ 20 FTEs of exp. support (PHENIX component redirected to sPHENIX project)
  - ~ 8 FTEs at SMD (funding will be moved to EIC)
  - ~ 40 FTEs for mid-term accelerator R&D, including FTEs working on FOAs and pCDR (funding will be mostly moved to EIC).

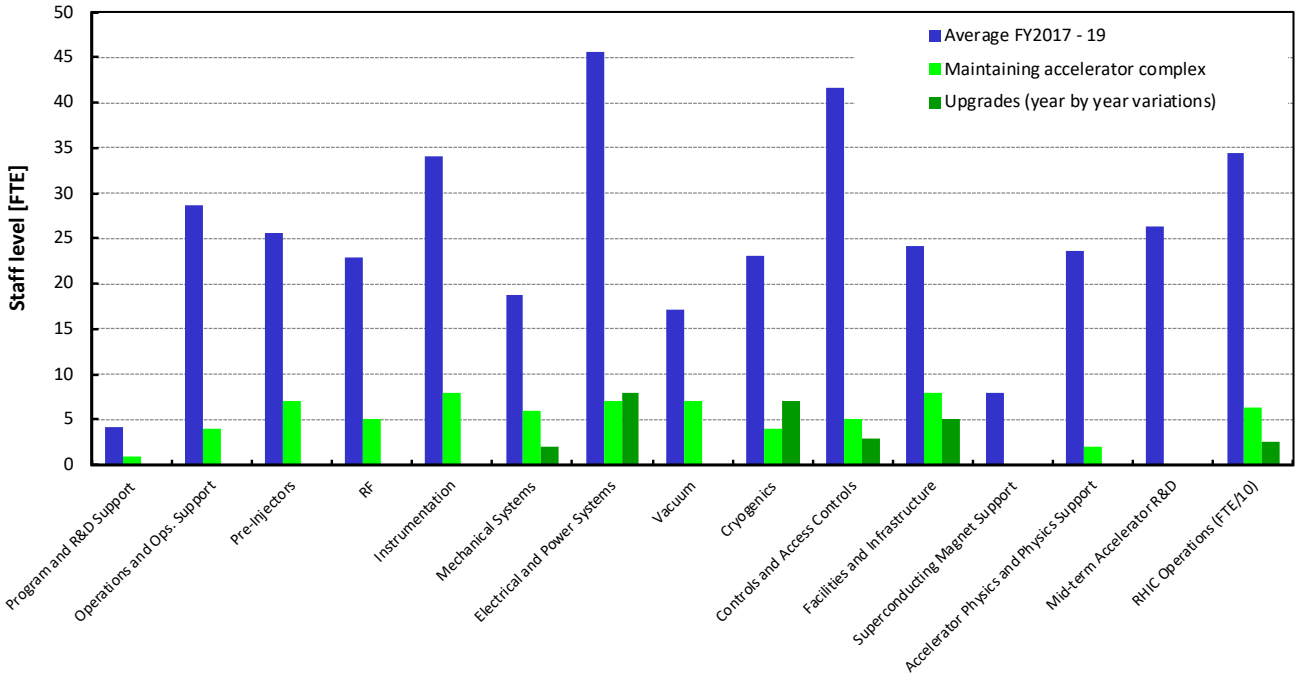


Relation to EIC project

- The EIC project is organizationally outside of the NPP Directorate.
- However, a large fraction of the expertise and staff required by the EIC project resides at C-AD within NPP
- Three main approaches to provide the EIC project with this expertise. This is similar to the approach taken with sPHENIX:
  - Staff transfer: a significant number of staff have (31, so far) and will soon transfer from C-AD to the EIC project. Initial transfers are mainly WBS level 2/3 leaders and accelerator physicists. Expect additional significant transfers at CD-1 and CD-3.
  - Staff matrixing: Fraction of C-AD staff's effort is assigned to the EIC project. Percentages are documented in individual MOUs and are reviewed periodically.
  - EIC project scope assigned to C-AD (under discussion): where appropriate, scope of the EIC project could be provided by C-AD at a contracted cost and schedule. The hadron ring modifications are possible items.

Accel. Ops: RHIC-to-EIC transition/redirect model

- Partial funding for accelerator R&D and SMD redirected to EIC (~ 20 FTEs)
- RHIC ops upgrade staff (~ 25 FTEs) and AIP/CE funding maintained for accelerator complex infrastructure improvements
- Partial electrical power funding redirected to EIC project in FY22
- In FY26 (RHIC off) $114M (~ 230 FTEs) is redirected to EIC project. The remaining $53M support 89 FTEs to accomplish the accelerator infrastructure upgrades and to maintain the facility in a state that allows efficient restart of future EIC operation. With this level of support MIRP and NSRL operations will not see a significant increase in the “stand alone” rates beyond COL during this period.
- Last year of RHIC ops (FY25): half year of full operations and half year of RHIC off budget.

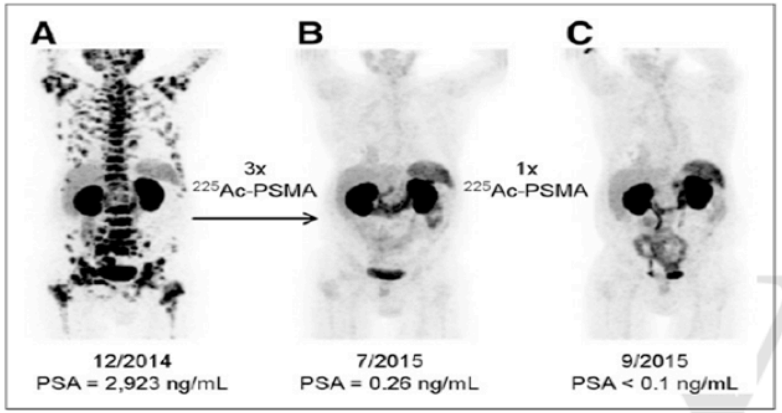


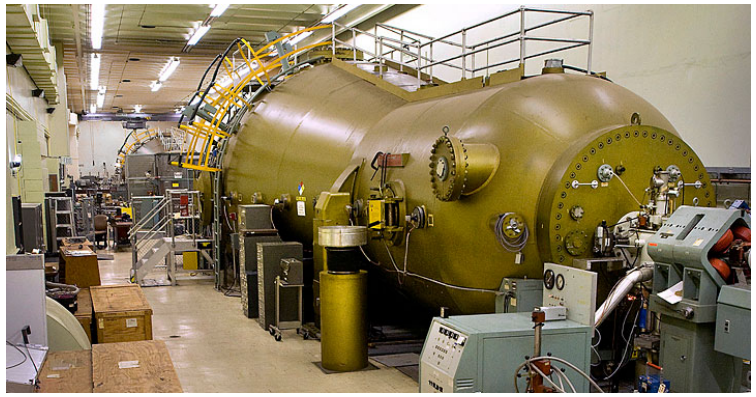
Accelerator R&D at C-AD, not part of EIC project

- **Within RHIC operations:**
- Pursue accelerator R&D in support of further improving RHIC performance through upgrade projects, improved operation and new operating modes.
  - Improved polarized proton acceleration in AGS and RHIC
  - Maximize Au-Au luminosity for sPHENIX and its reduced vertex region
- Transformational accelerator technologies in support of future NP facilities, including EIC
  - R&D towards strong hadron cooling: CeC demonstration
  - Polarized He-3 production, acceleration and polarimetry
  - Development of high intensity high brightness electron source for strong hadron cooling
- **Not within RHIC operations:**
- Possibly funded by NP Accelerator R&D FOA or HEP/BES Accelerator R&D funding:
  - high intensity, high brightness SRF e gun development (NP R&D FOA; LCLSII-HE e gun development, funded by BES)
  - high intensity ERL development (not funded presently, single pass CBETA?)

Accelerator application facilities of the RHIC/AGS complex

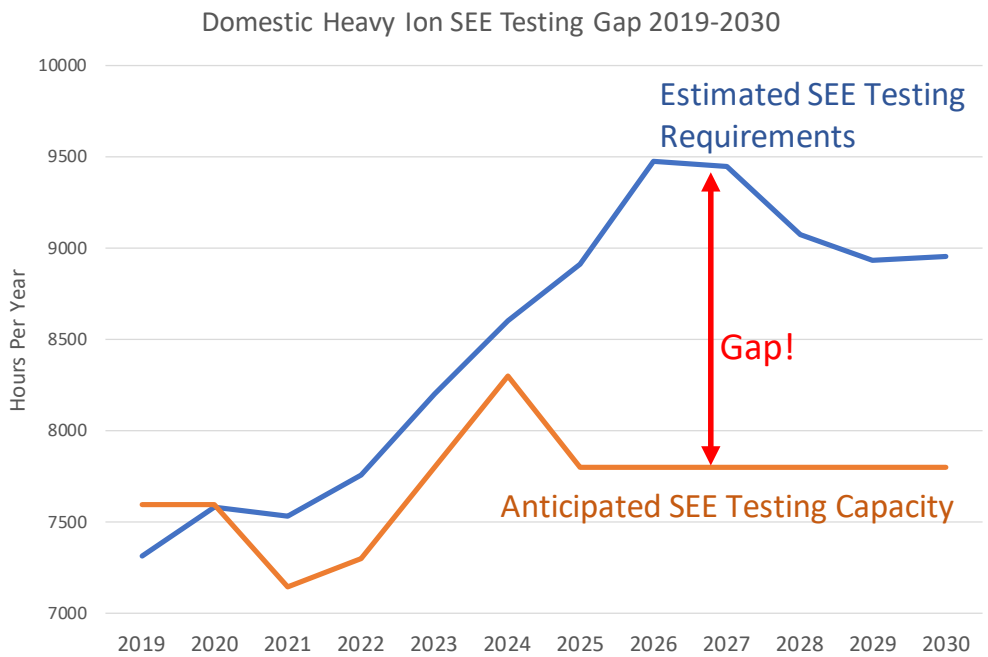
- Medical Isotope Research and Production (MIRP): Uses 200 MeV Linac for producing medical radio-isotopes for U.S.:
  - Sr-82 production; R&D of new alpha-emitters (Ac-225); radiation damage testing
  - Significant expansion is underway and planned: BLIP target and proton beam intensity upgrades; refurbishment of additional hot cells for Ac-225 processing; 17 MeV cyclotron for isotope production at lower beam energies; study of new/expanded isotope production facility
- NASA Space Radiation Laboratory (NSRL): Uses beams from AGS Booster, EBIS, Tandem, and Linac to simulate galactic radiation for human space flight
  - Significant expansion: radiation effects studies (rapidly growing demand for satellite electronics testing); 5-year MDA funding for 1000 hrs/year for SEE testing
  - Established as “Non-designated user facility” available to federal and commercial users
- Tandem Van de Graaff facility: Uses CW and pulsed ion beams from two 15 MV Tandems for irradiation tests
  - Government and commercial users; in the process of becoming a “Non-designated user facility”
  - Growing number of users and applications

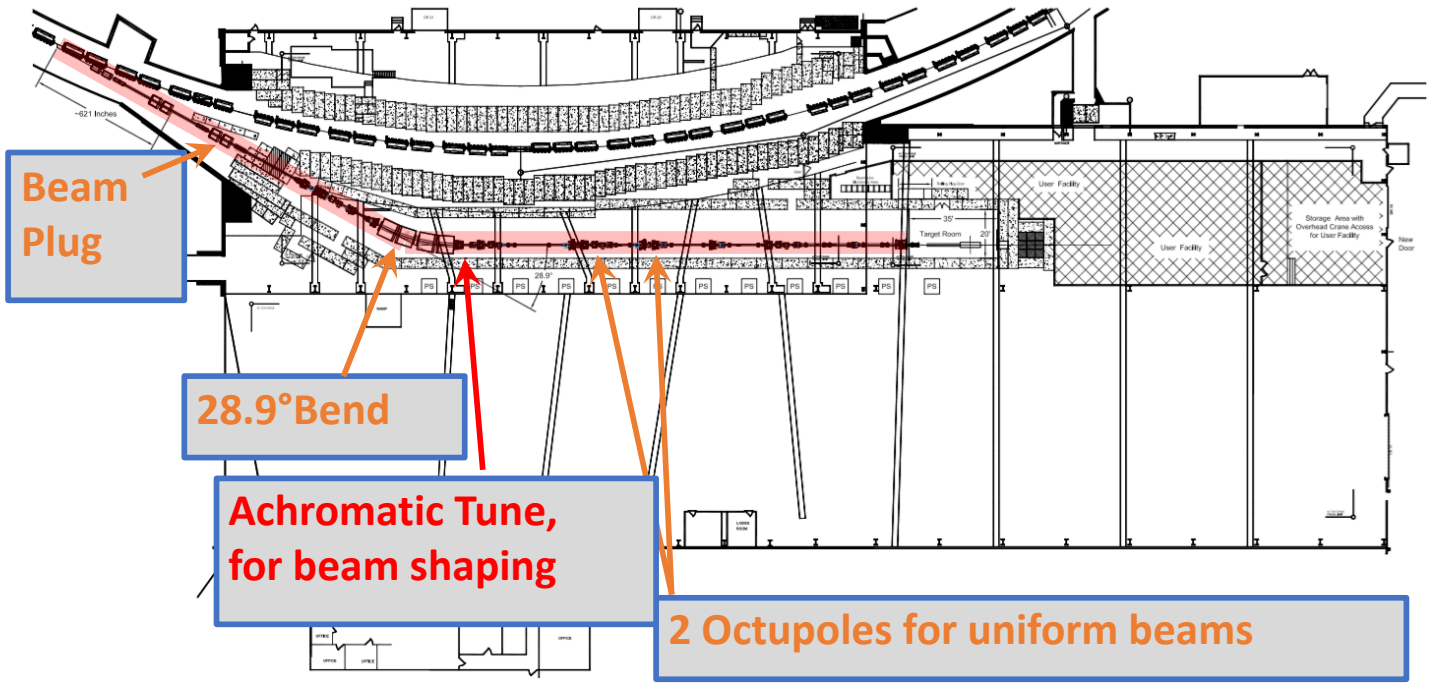




Possible future growth opportunities for the use of the AGS/RHIC complex

- Expanded need for Single Event Effects (SEE) test facilities in the US for commercial and National Security applications. Strong interest by DoD in a new facility at BNL.
  - A slow extracted beam from the AGS into the previous fixed target experiment hall would provide similar performance and capabilities as the present NSRL in a cost-effective way. Construction cost: ~ $50M; operations cost: ~ $15M/year
- There is interest in a dynamic Proton Radiography facility to support stockpile stewardship using the 28 GeV AGS beam. This could easily be accommodated on the AGS floor
  - Achievable parameters: Up to 50 28 GeV proton beam bunches with arbitrary timing pattern with 0.1 – 10 us spacing





Summary

- C-AD provides continued efficient operation of RHIC and synergistic and efficient operation of MIRP, NSRL, and Tandem. There is a very active program of accelerator applications at C-AD.

- C-AD supports ongoing RHIC upgrade projects, accelerator R&D, EIC needs, and expansions of the accelerator application facilities.

- Accelerator applications of the AGS/RHIC complex are expanding and there are possibilities of new facilities, in particular using beams from the AGS.

Back-up slide

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
- Four-pass ERL demonstrated on 12/24/2019
- Active collaboration with JLab, CERN, Orsay (LHeC test accel. PERLE), Berlin-Pro, Mainz, STFC (UK), KEK
- Contract with NYSERDA complete in February 2020, two months ahead of schedule.