Jefferson Lab Injector Beamline Upgrade

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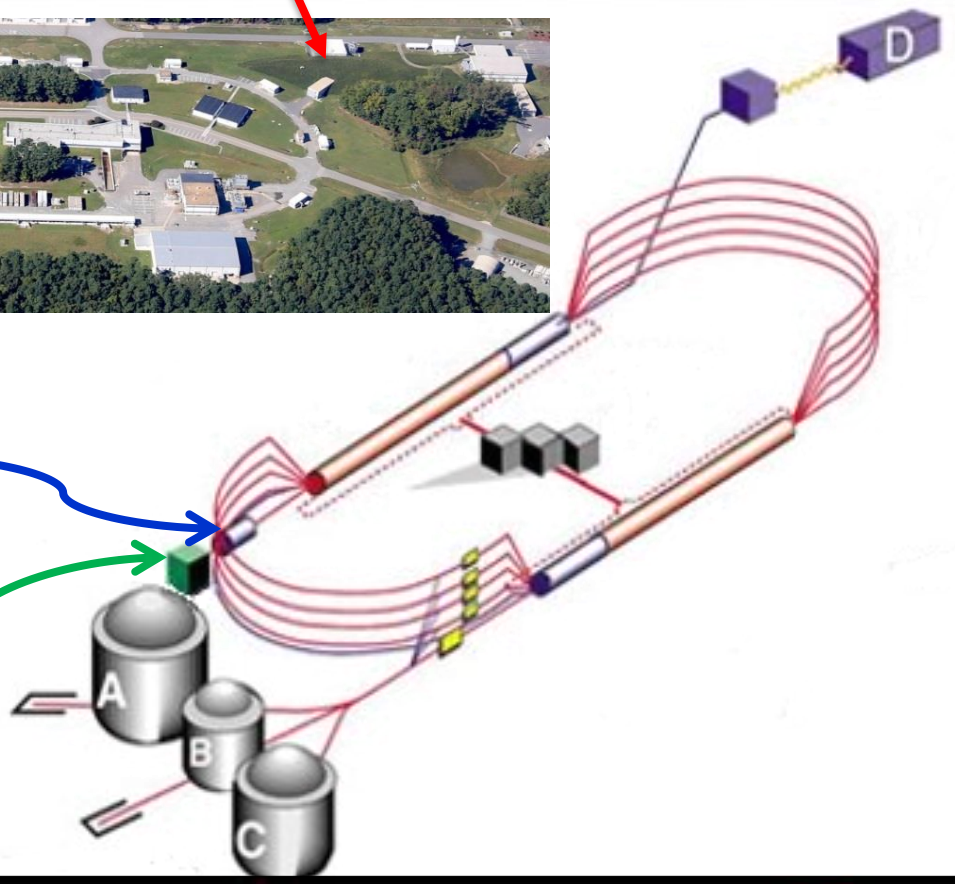
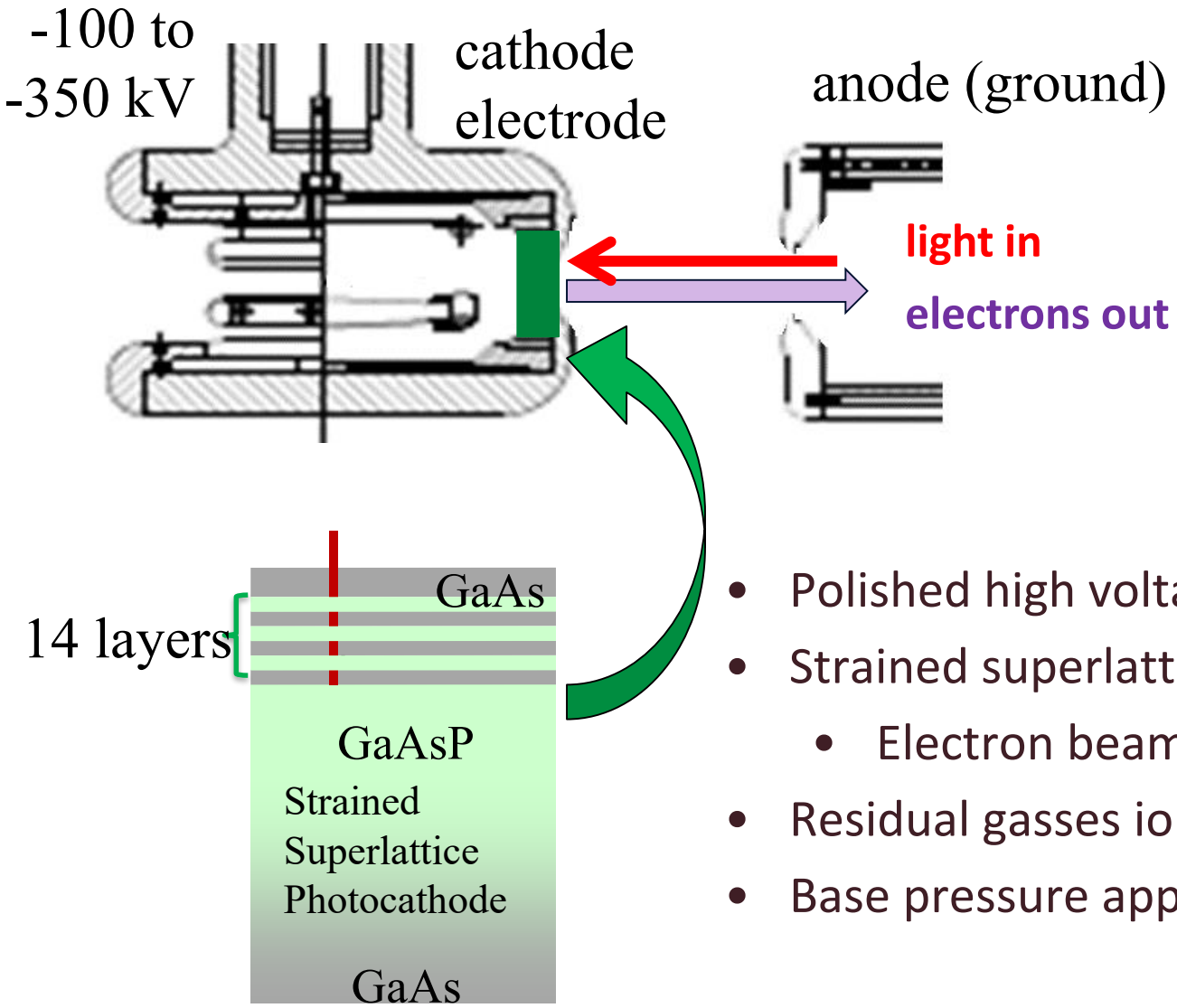
Thomas Jefferson National Accelerator Facility

- US Department of Energy, 12 GeV electrons, recirculating linear accelerator
- Up to 90% polarization from DC photoemission source
- Electron currents to 200μA beam (CW) to four experimental halls

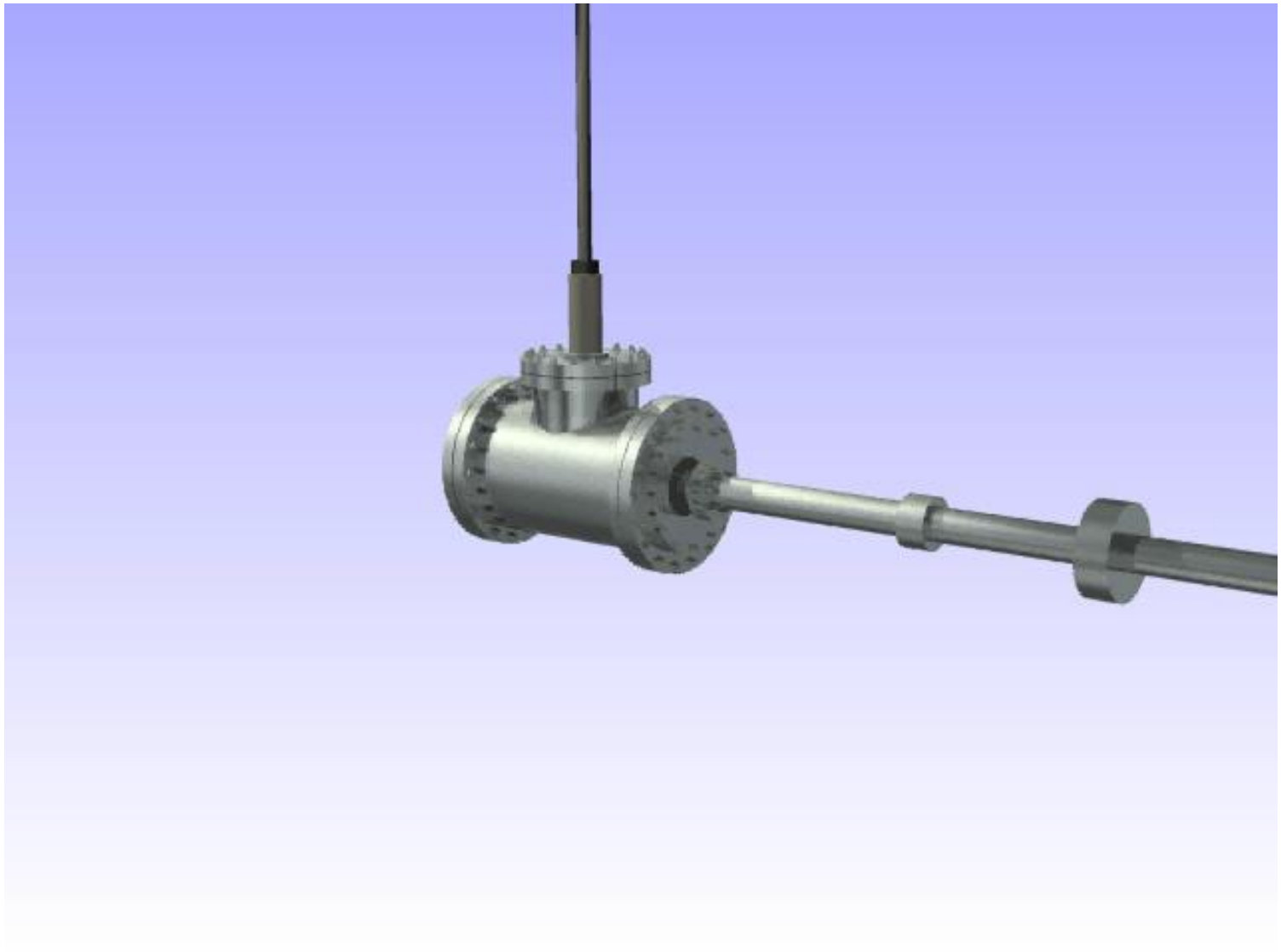


DC Photoemission Source

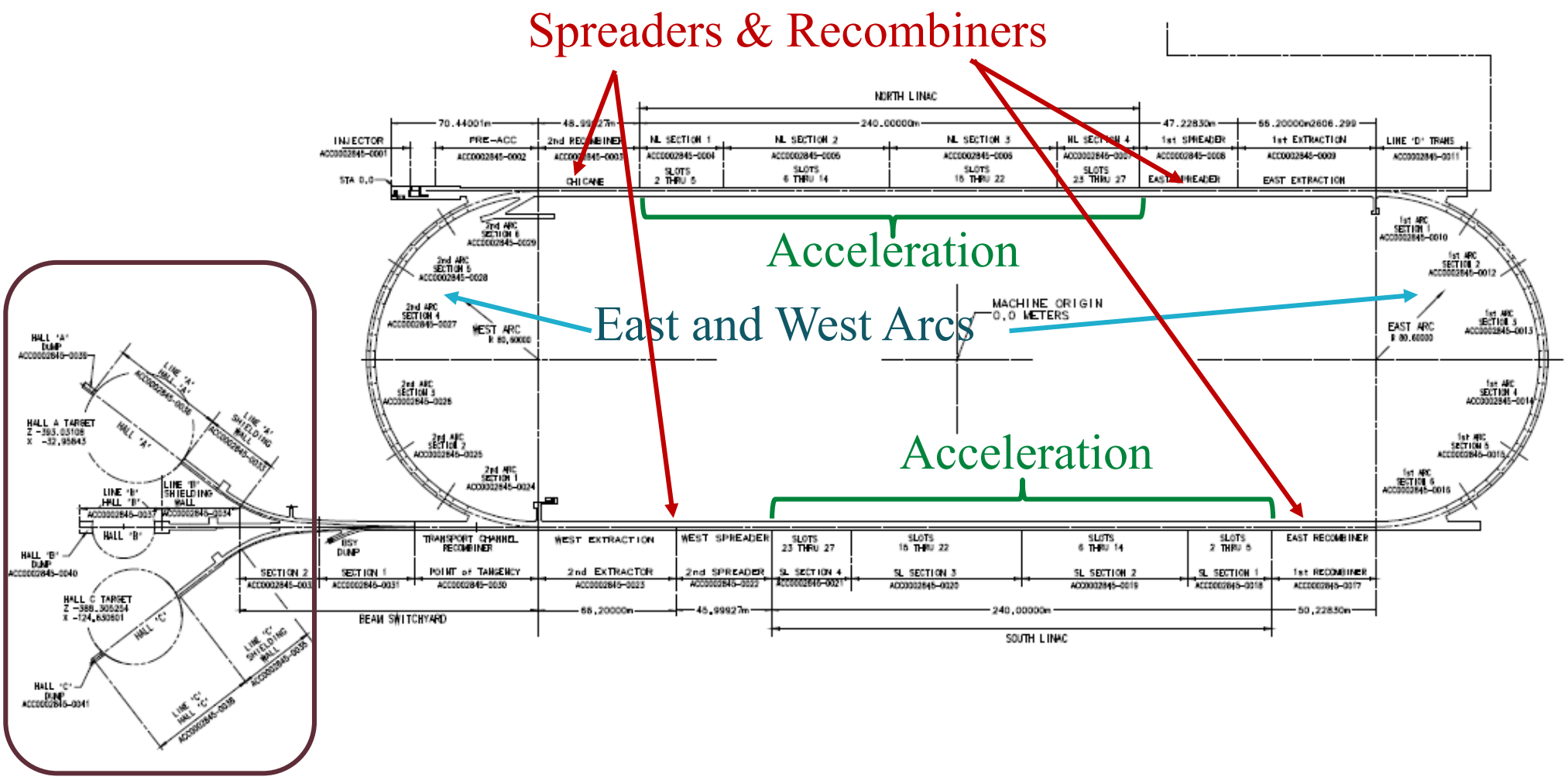


- Polished high voltage electrodes
- Strained superlattice GaAs/GaAsP photocathode
  - Electron beam polarization ~90%
- Residual gasses ionized, limit operational lifetime
- Base pressure approaching XHV ≡ P < 1×10^{-12} Torr

Ion back-bombardment

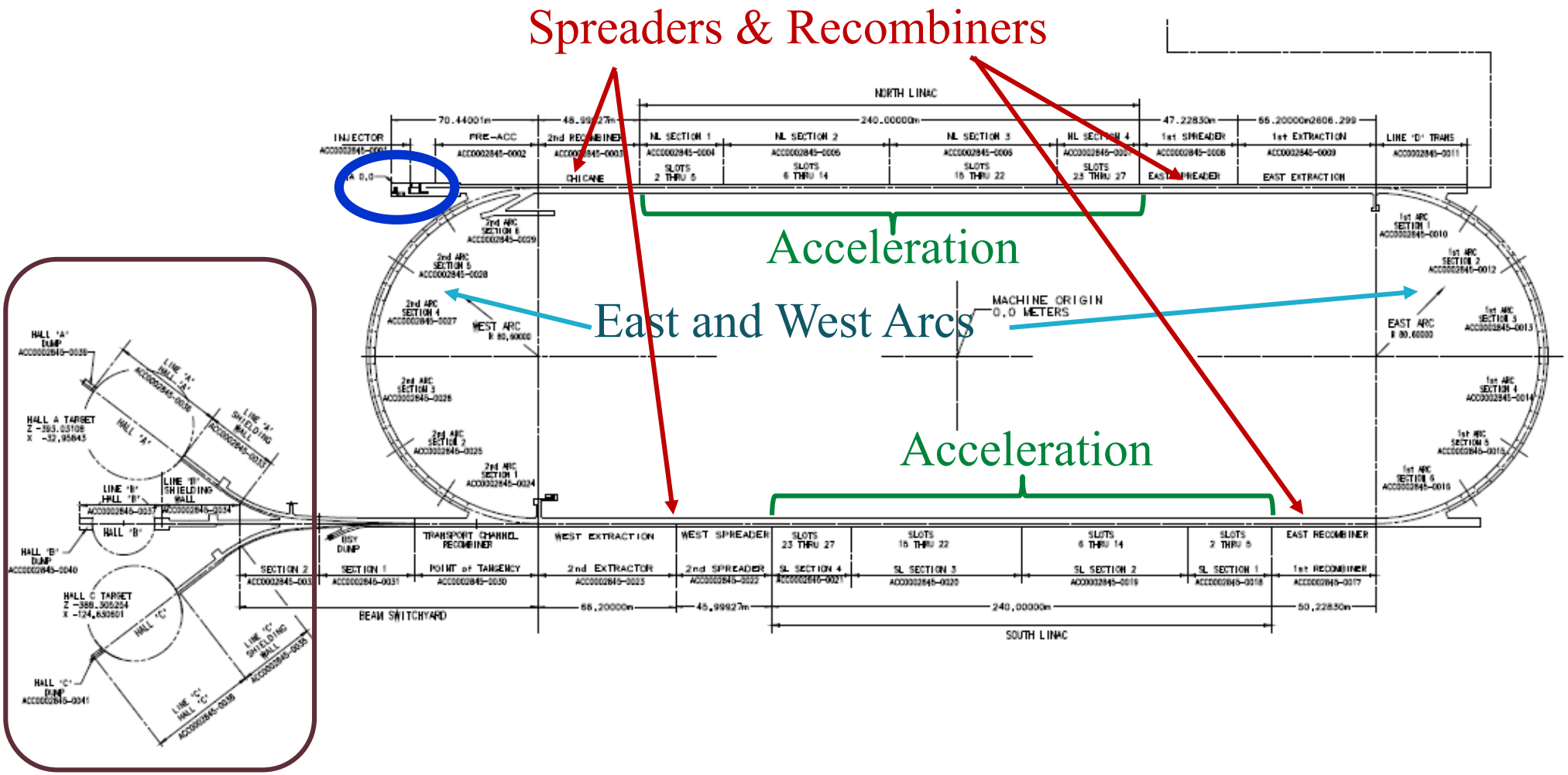


Beamline contribution to gun vacuum



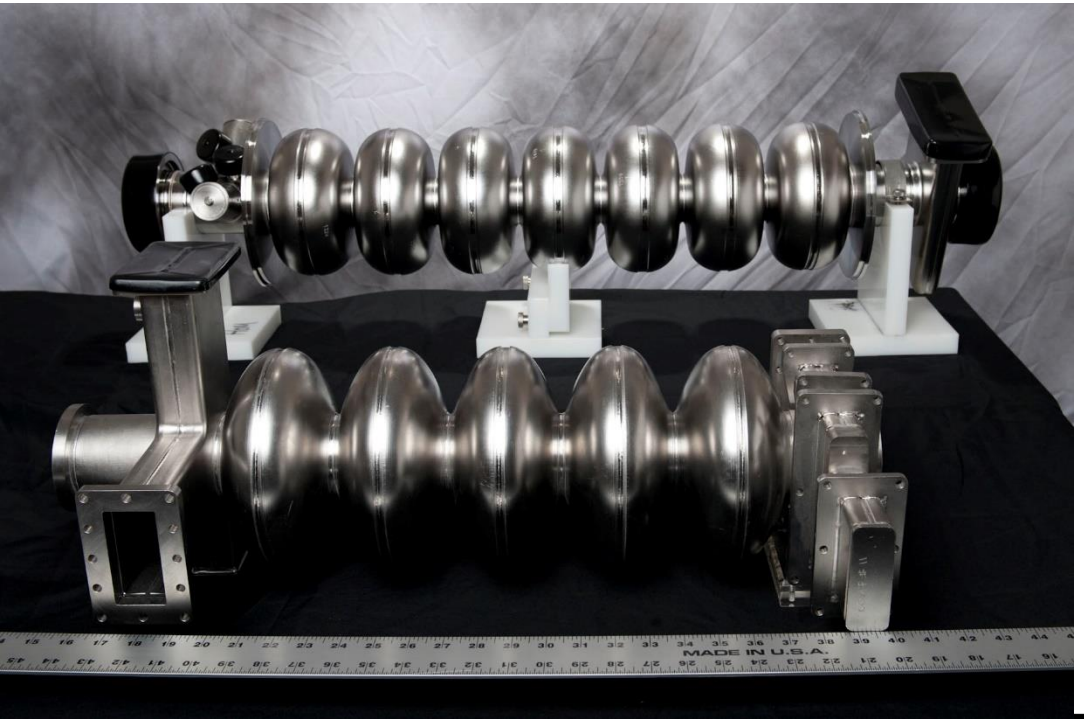
CEBAF accelerator tunnel

CEBAF Injector Beamline



CEBAF Injector Upgrade Motivation

- CEBAF began operation at 4 GeV in 1995
- Upgrade to 12 GeV operations 2014
  - Accelerator Cavity Redesign
  - Higher Gradient
  - Higher beam current capability



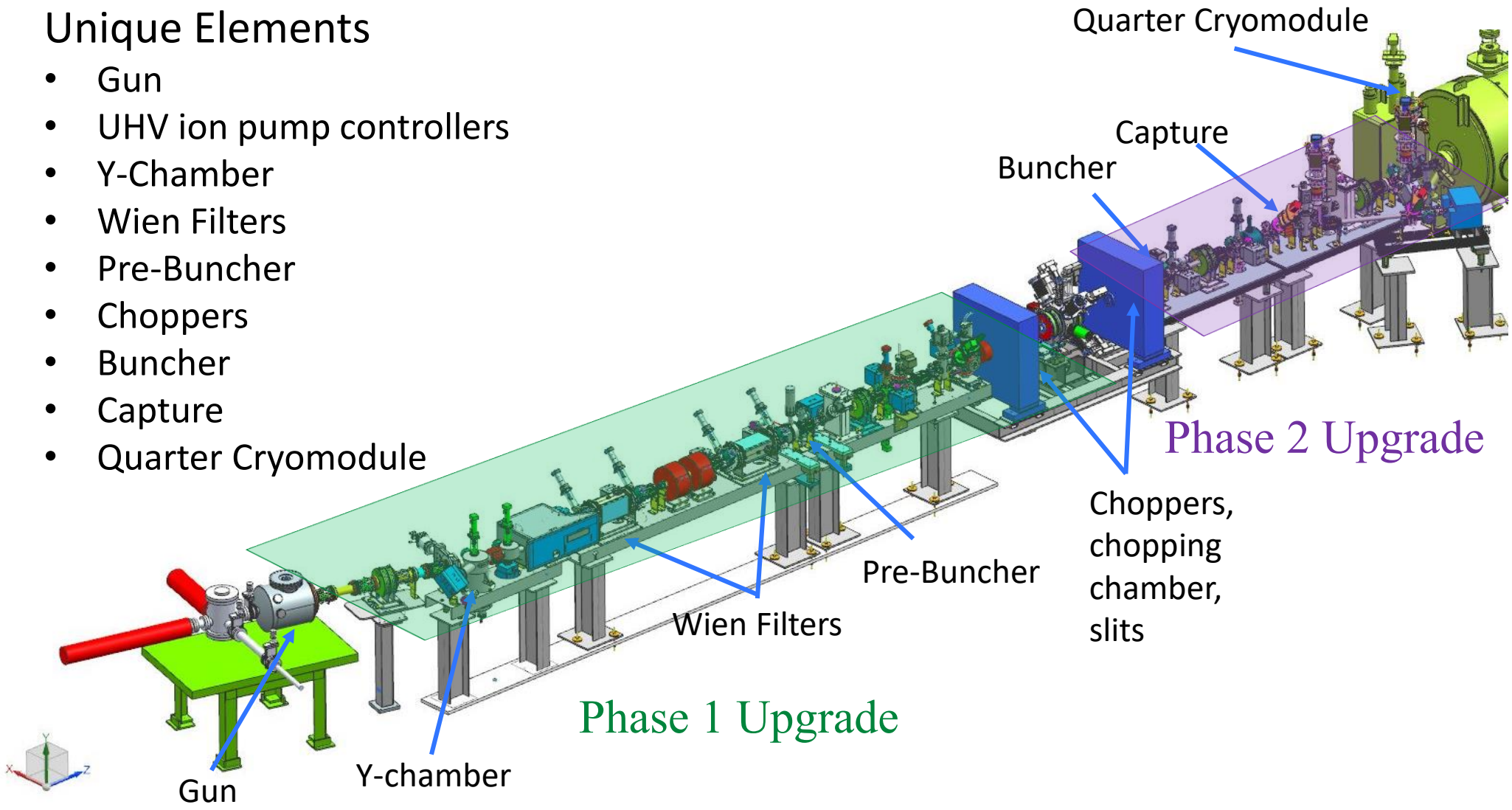
CEBAF Injector Acceleration

- Capture (warm RF)
- Quarter Cryomodule
  - In operation since 1991
  - Strong steering, low gradient
- Replace with new SRF “Booster”
- Requires Gun energy from 130keV to 200 keV
  - Higher power Wien filters
  - Higher power pre-buncher
  - New & improved Magnets
  - Improve vacuum system throughout

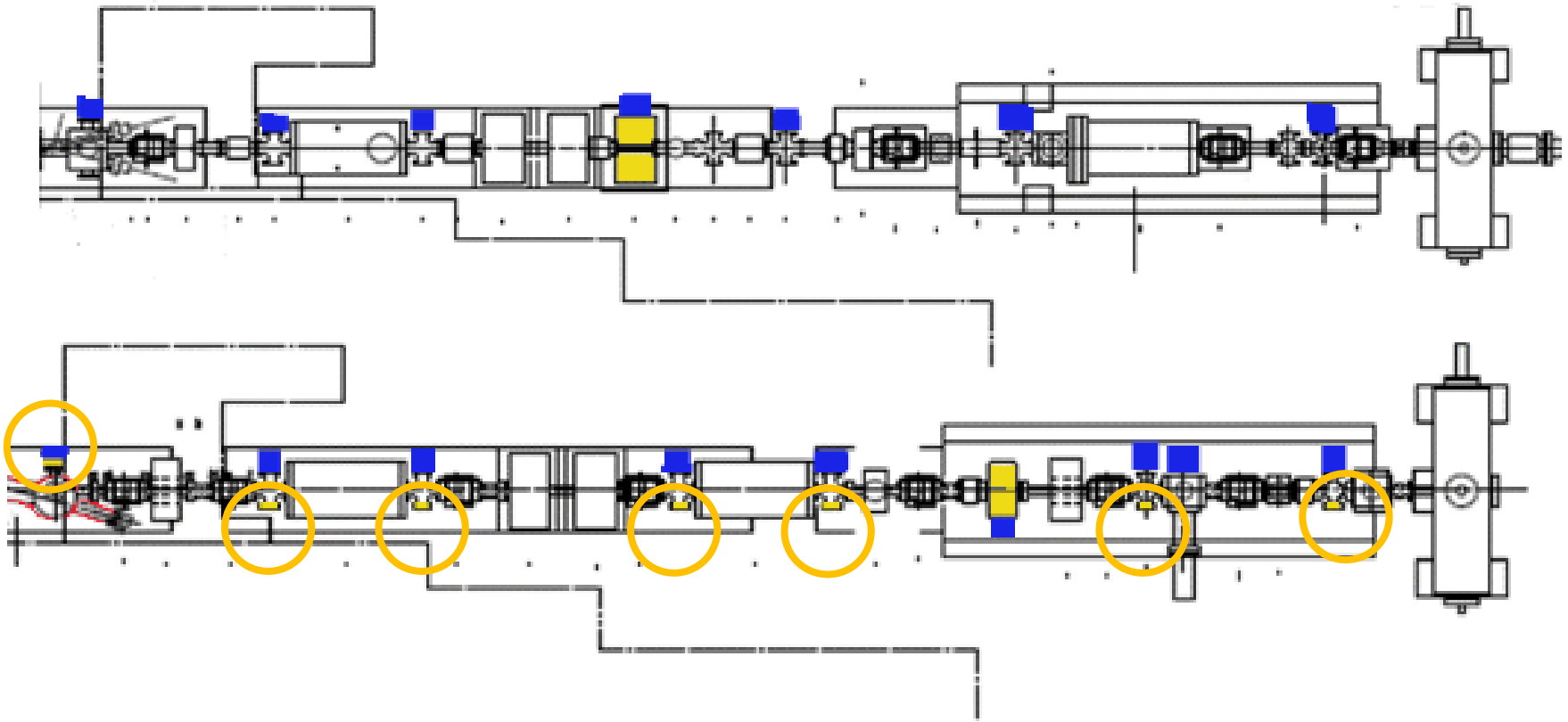
CEBAF Injector Vacuum system

Unique Elements

- Gun
- UHV ion pump controllers
- Y-Chamber
- Wien Filters
- Pre-Buncher
- Choppers
- Buncher
- Capture
- Quarter Cryomodule



Vacuum Improvements: Girders 2 and 3

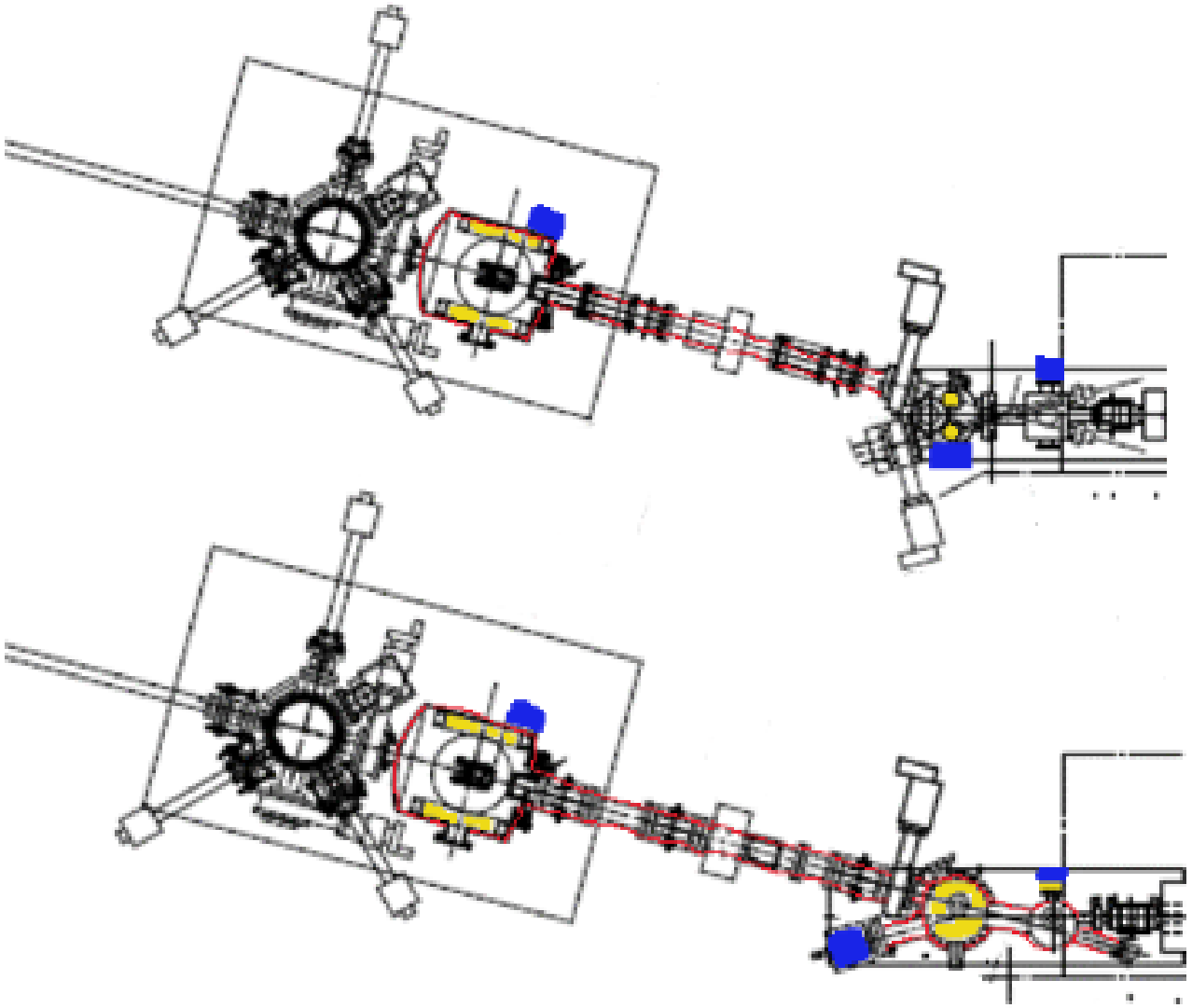


Components heat treated where possible

Z100 NEG pumps added

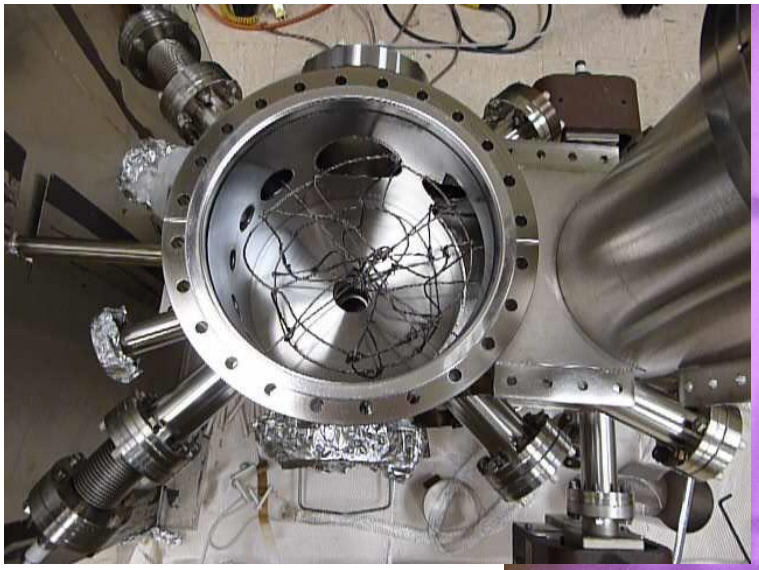
Ion pump upgrades to “XHV” style

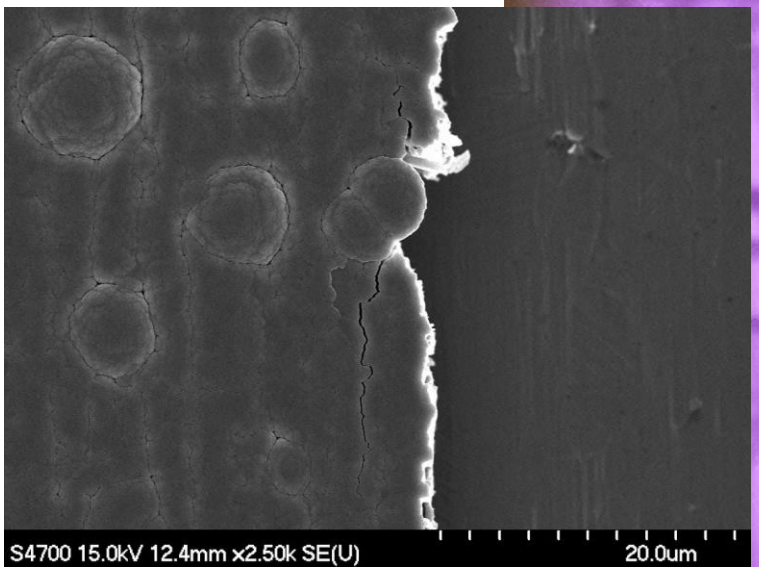
Vacuum Improvements



- Gun Chamber not changed
- NEG tube: One BPM added, new NEG coating
- Y and Laser Chambers: NEG coated
- Y chamber: 4x UHV 1400 ZAO pumps installed (Replacing 2x Capacitorr 100)

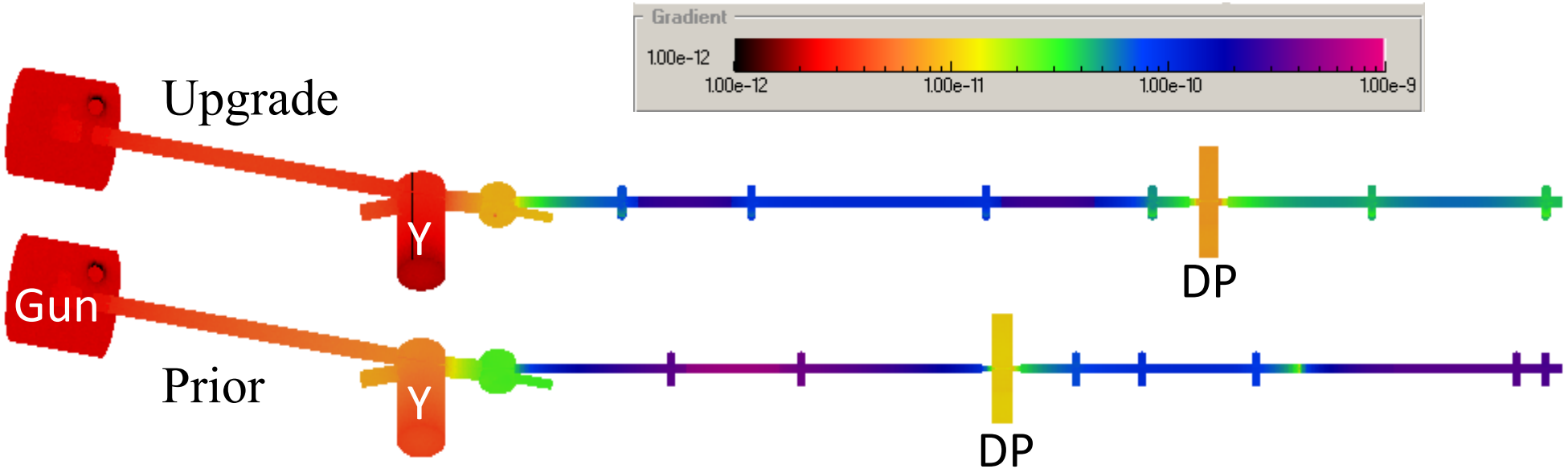
NEG coatings





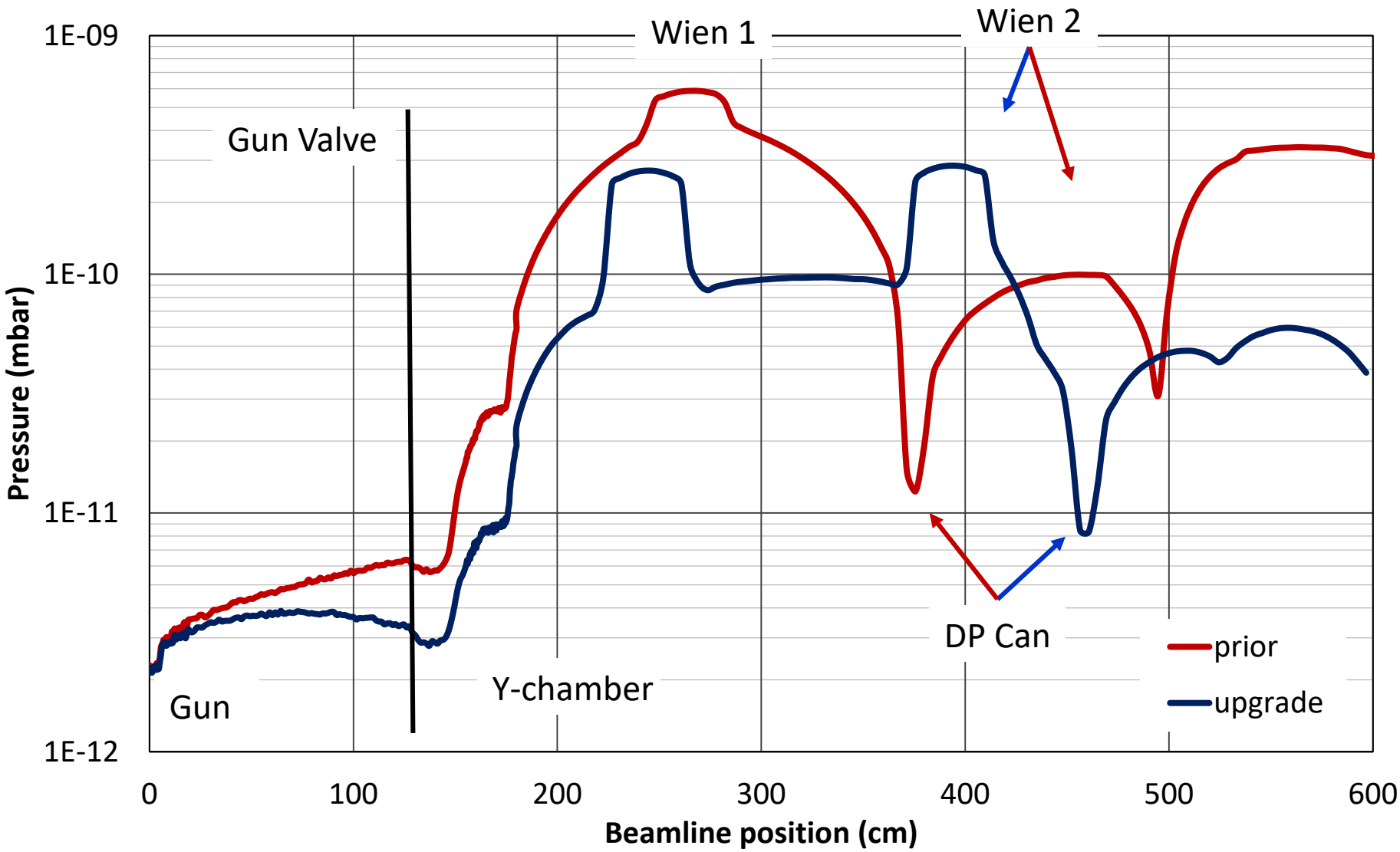
- In house Ti-Zr-V NEG coating
- Sputter deposition, Kr, without magnetron
- Freestanding, isolated “basket” of twisted NEG wires
- Dense, Columnar structure
- Up to 5 μm thick
- Small pump speed (0.05 L/s)
- Barrier to outgassing

Molflow+ Simulations

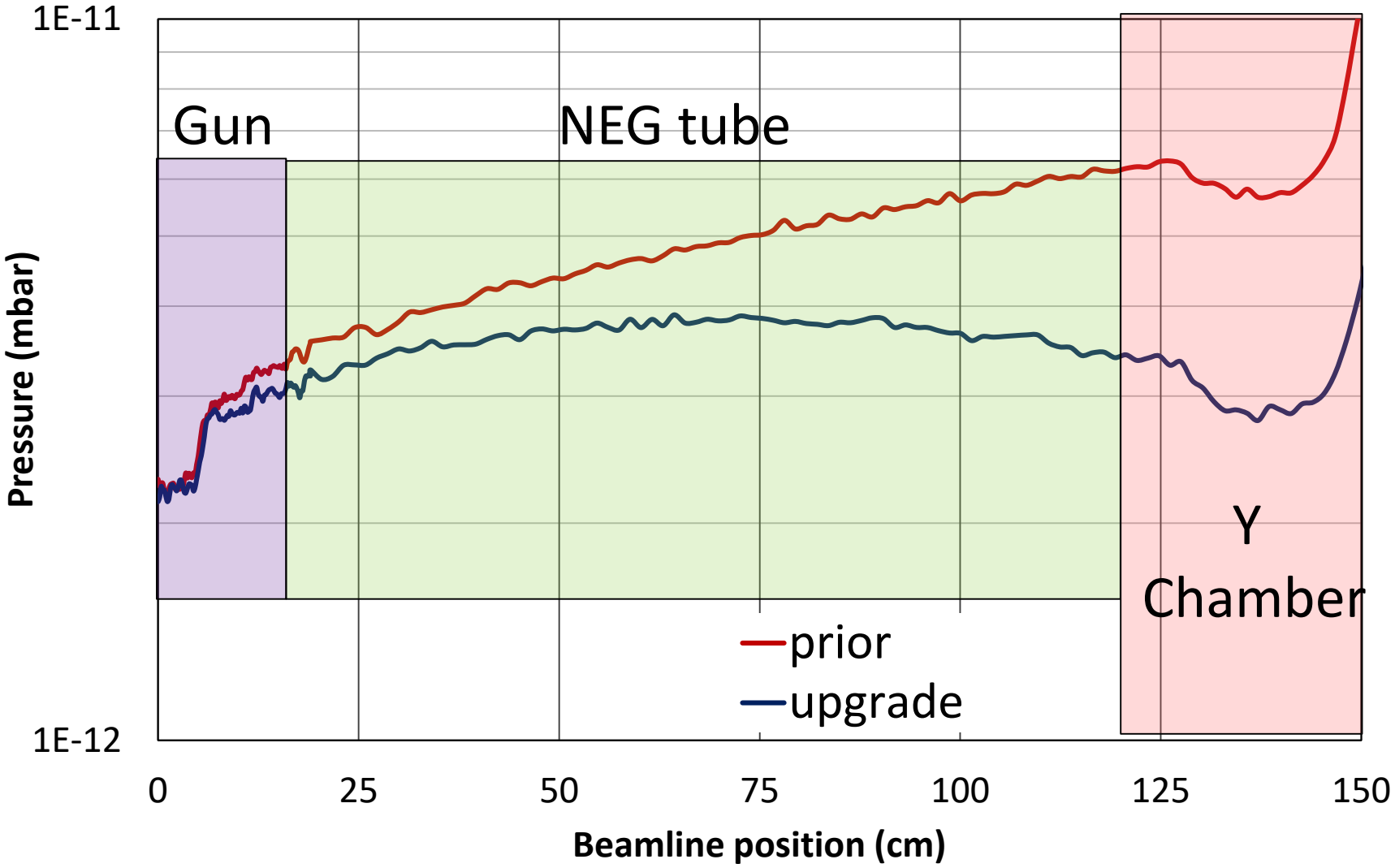


- Beamline components moved for better spin management, beam dynamics
- Additional NEG pumps at crosses and Y chamber
- Beamline components heat treated when possible
  - 400°C for 24 hours

Vacuum Simulations: Molflow+



Gun pressure



Gun Lifetime improvement

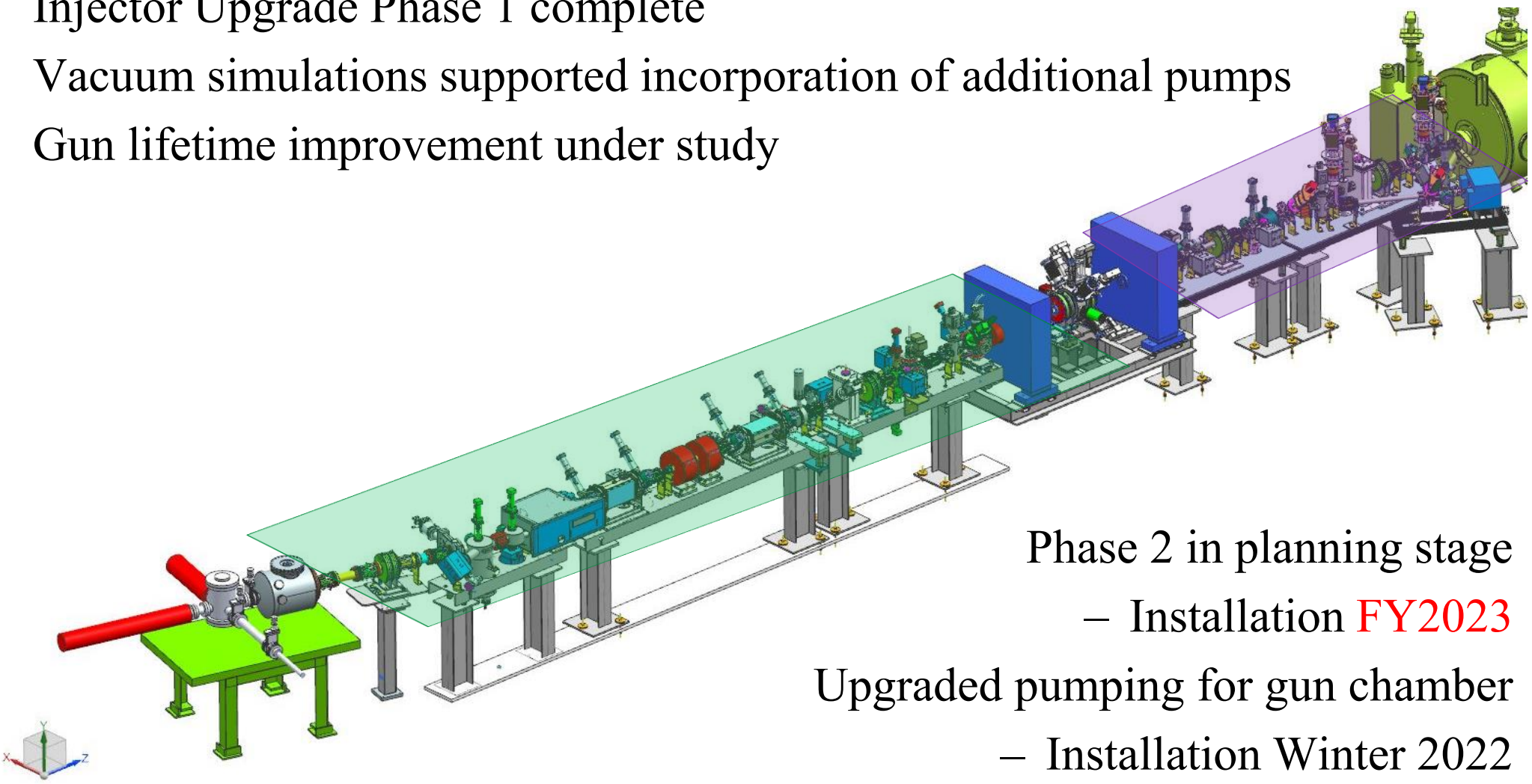
- ???

Conclusions

Injector Upgrade Phase 1 complete

Vacuum simulations supported incorporation of additional pumps

Gun lifetime improvement under study



Phase 2 in planning stage

– Installation FY2023

Upgraded pumping for gun chamber

– Installation Winter 2022

Acknowledgements

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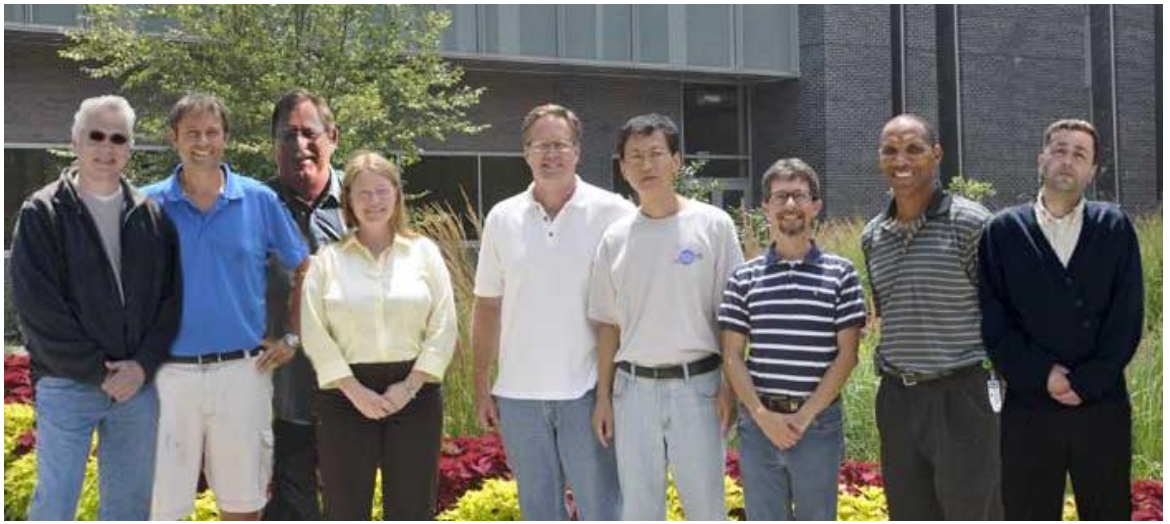
Jefferson Lab
Center for
Injectors and
Sources



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Backup