Brookhaven National Laboratory

Jefferson Lab

U.S. DEPARTMENT of ENERGY | Office of Science

Beamline Design and Integration

Charles Hetzel

EIC Vacuum Group Leader

10th EIC DAC Review

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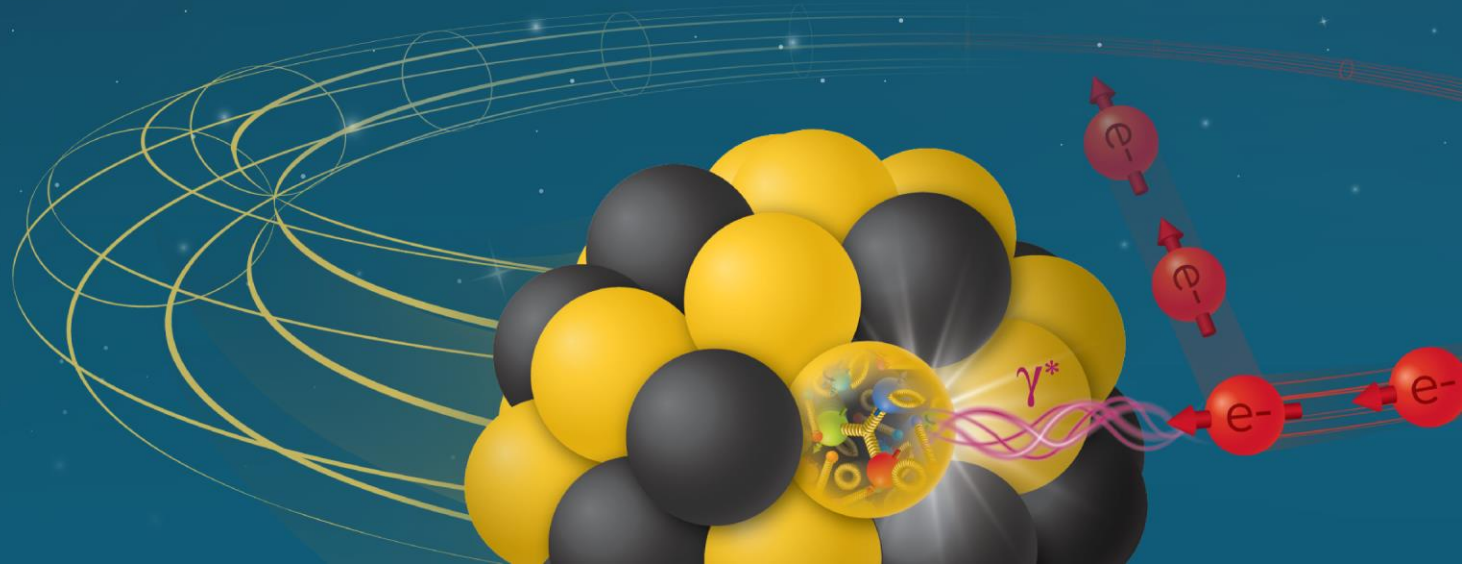
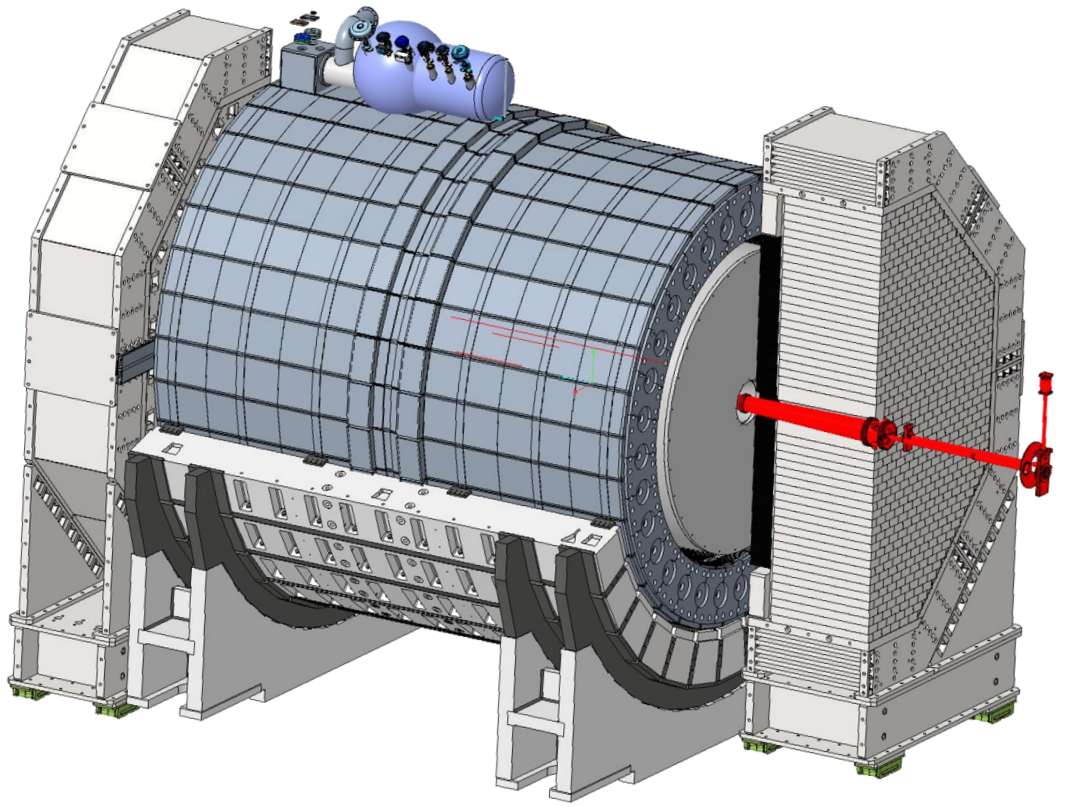


Electron-Ion Collider

Outline

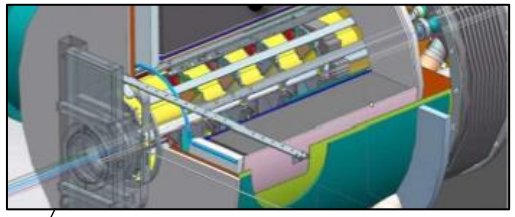
- Interaction Region Vacuum Overview
- Design Status and Progress
  - Central Detector Chamber
  - Forward Side
  - Rear Side
- Next Steps
- Summary



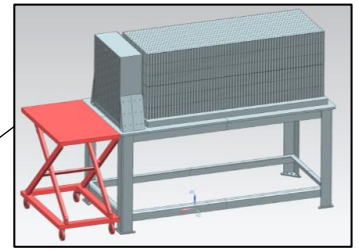
IR Vacuum overview

- Complicated integrations between detectors and magnets
- Very different requirements between rings
  - Electron cloud in HSR
  - Synchrotron radiation in ESR

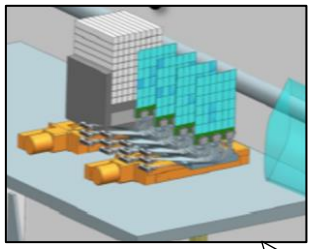
B0 magnet spectrometer



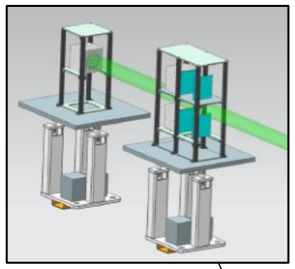
Zero-degree calorimeter



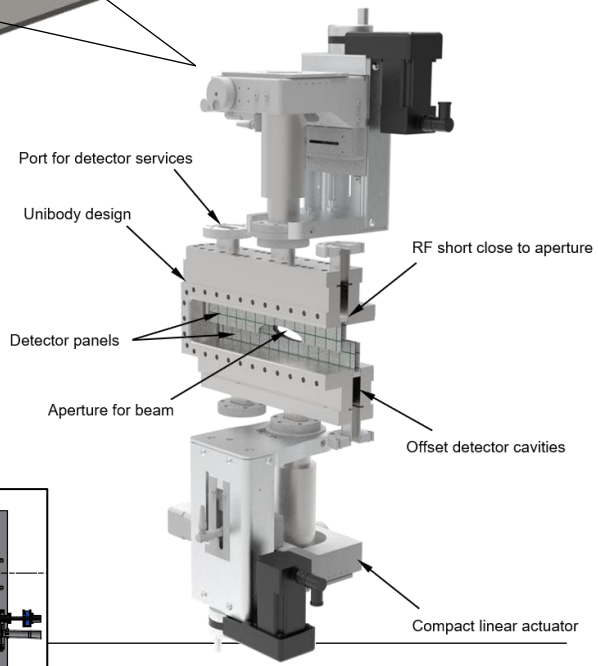
Low Q^2 taggers



Luminosity system



Central detector



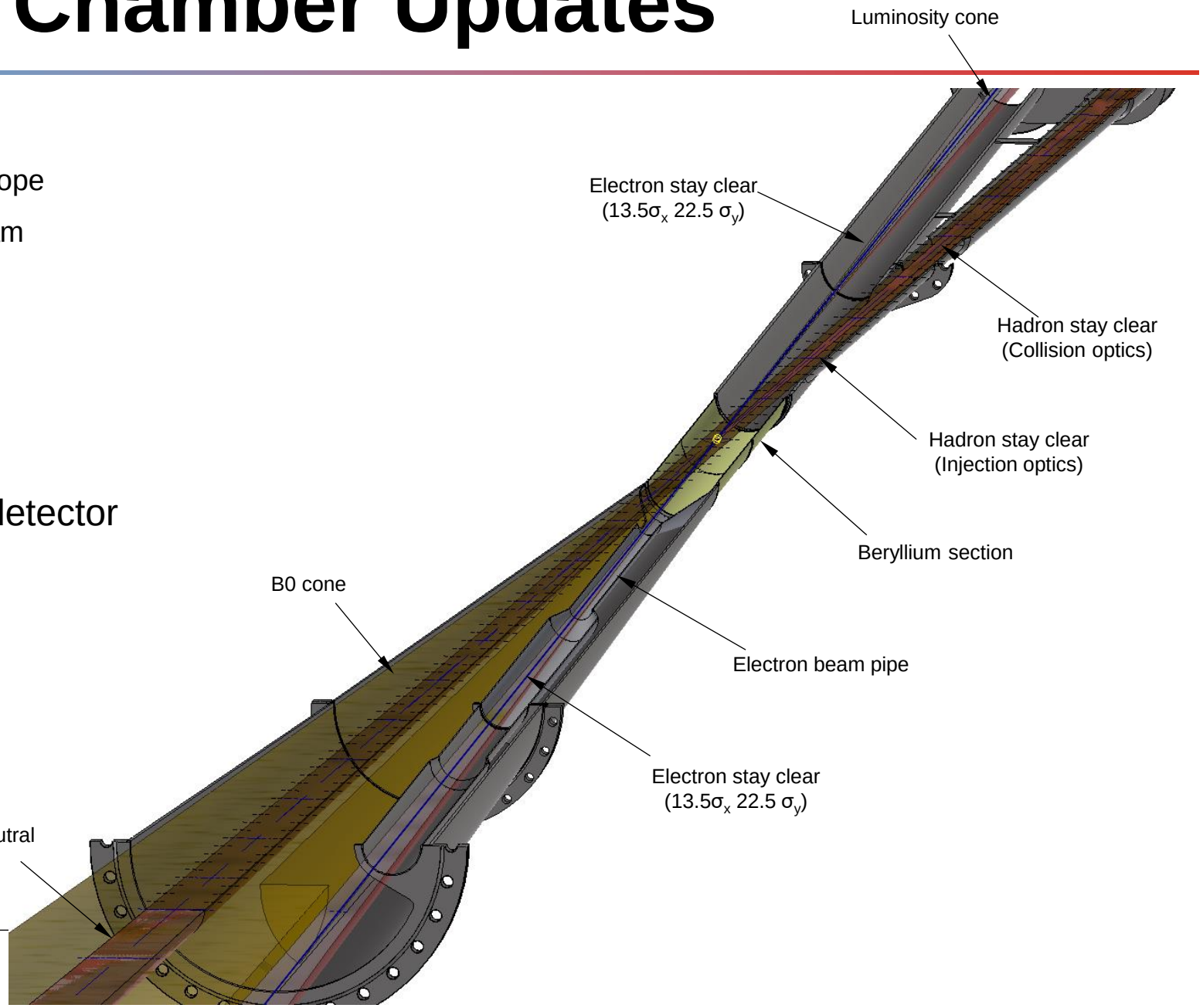
Roman pot and off momentum detectors

Requirements and Challenges

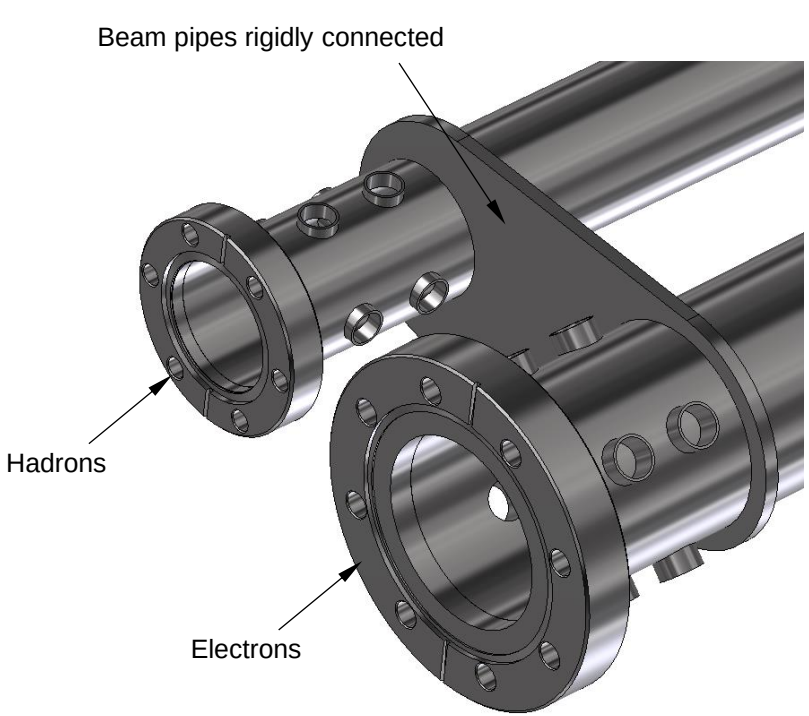
- Cryostats will be assembled in the tunnel
- Low dynamic pressure required to minimize beam-gas interactions (< 1 x10^{-9} mbar)
- Electron forward side
  - Large beam sizes due to strong focusing (β_x > 900m)
  - Synchrotron radiation from upstream dipoles (26mrad bend 30m away -> 38 kW)
- Electron rear side
  - Synchrotron radiation
- Hadron forward side
  - Large aperture required to transport off-momentum and neutral particles
  - Chamber integration, alignment and support system
- Hadron rear side
  - Injection and ramping optics

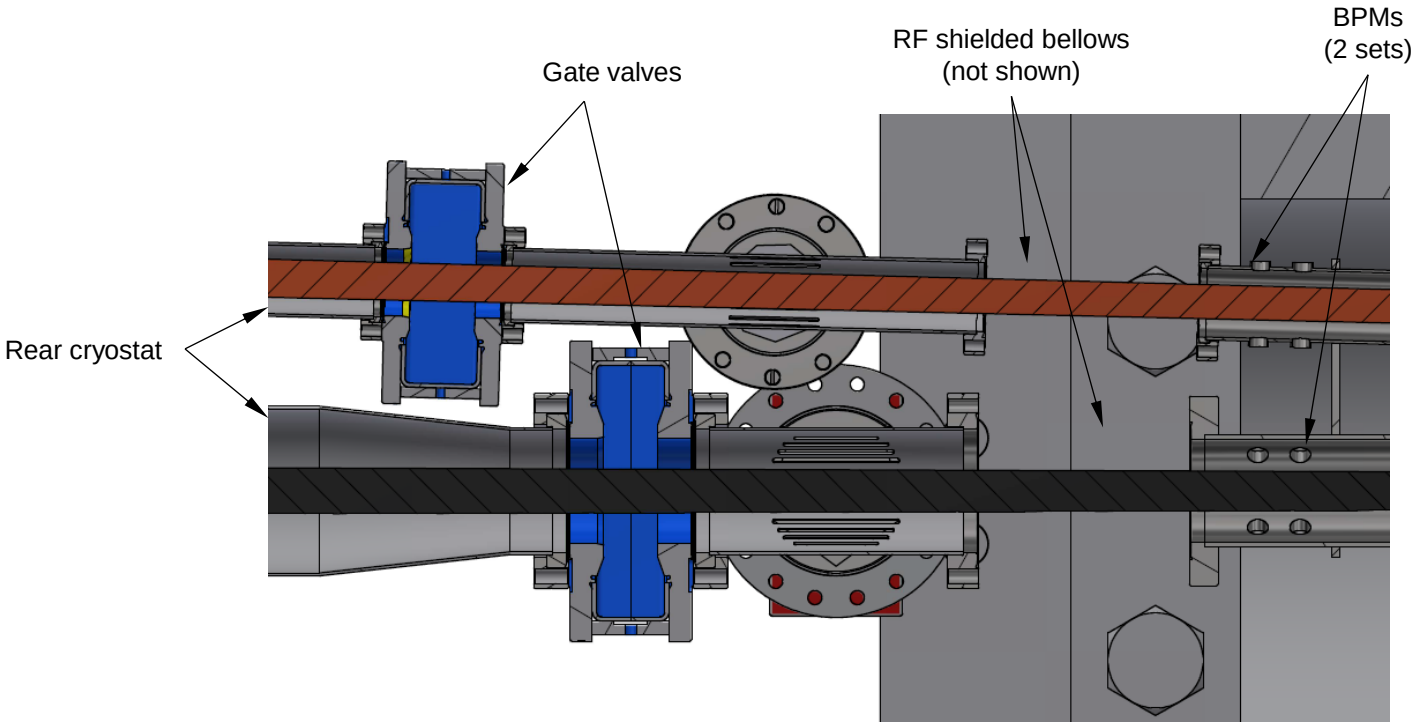
Central Detector Chamber Updates

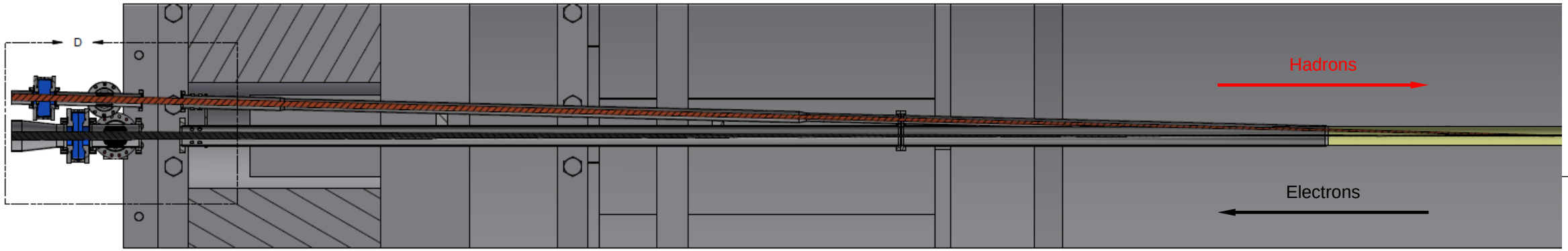
- Improved electron beam pipe
  - Diameter steps down with stay clear envelope
  - Collimates scattered photons from upstream
- Better integration with detector
  - Optimized flange locations
  - Removed flange before DRICH
- Integration of BPMs
- Gate valve solution for both sides of detector



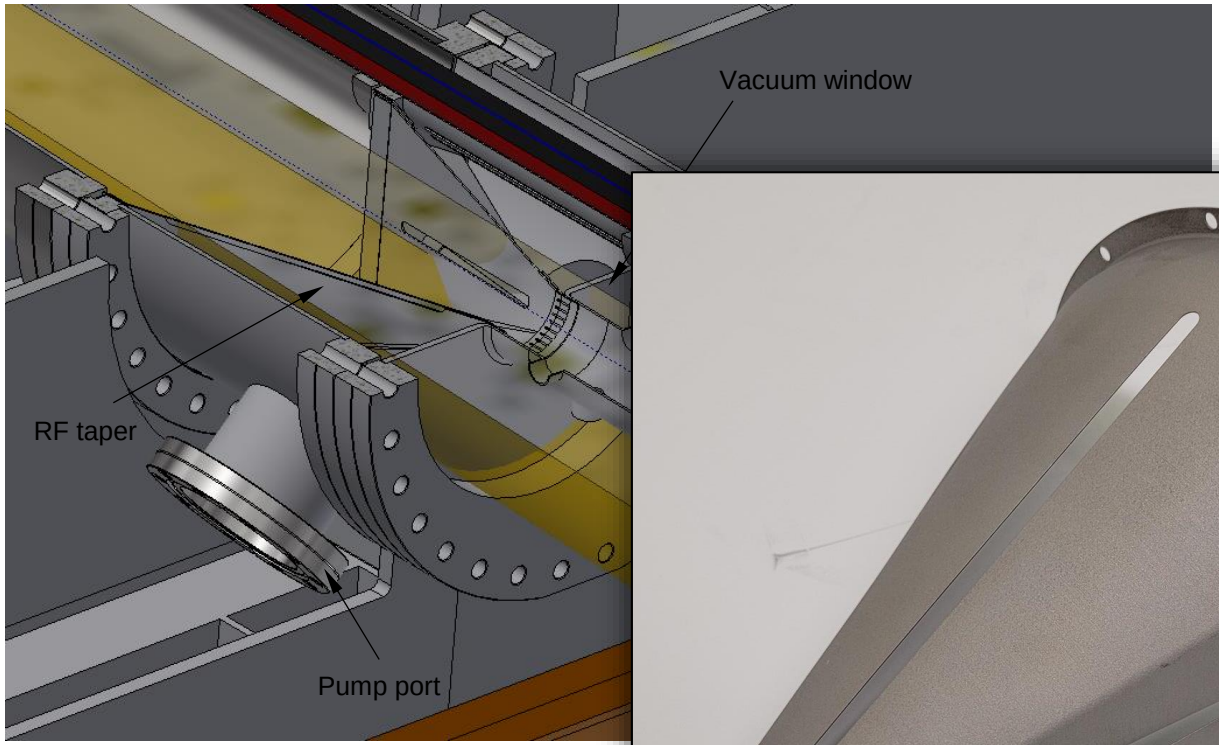
Central Detector Chamber - Rear Side

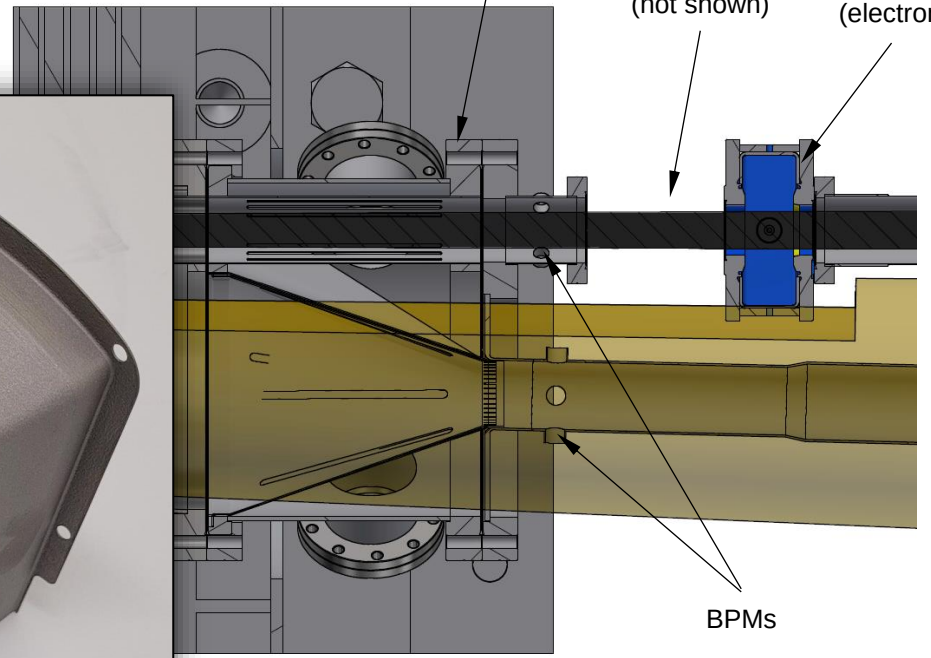






Central Detector Chamber – Forward Side

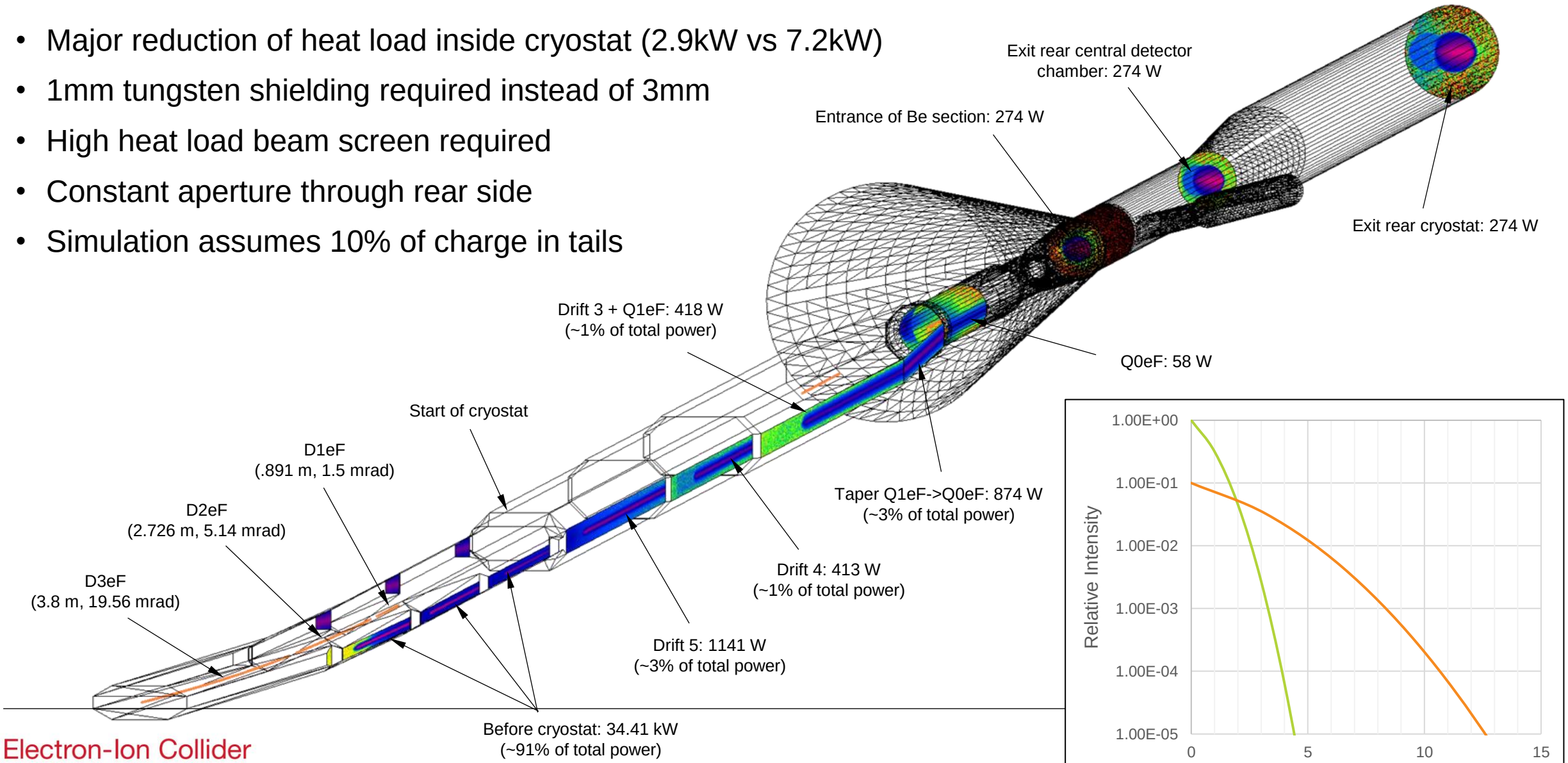




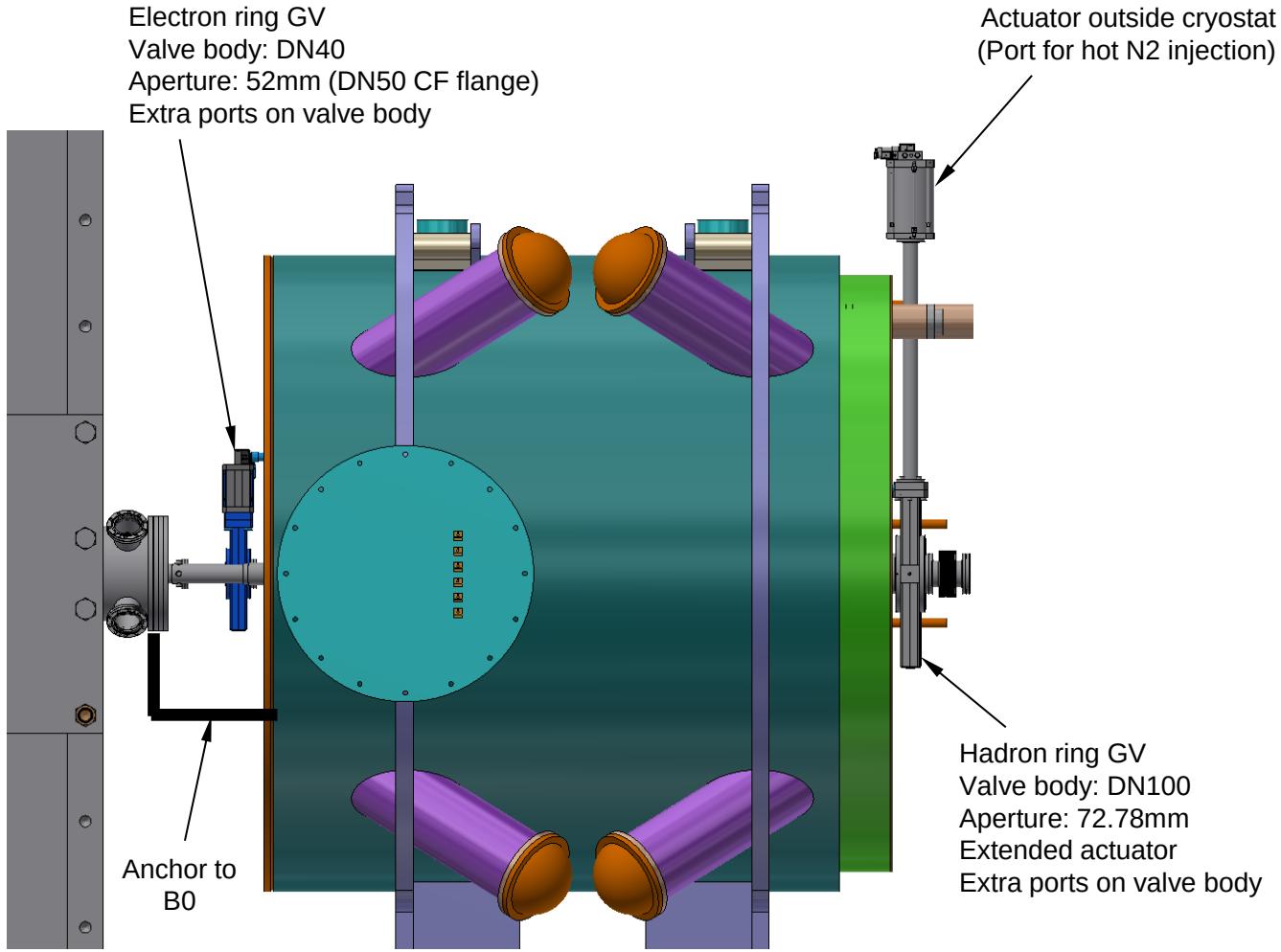
DETAIL B

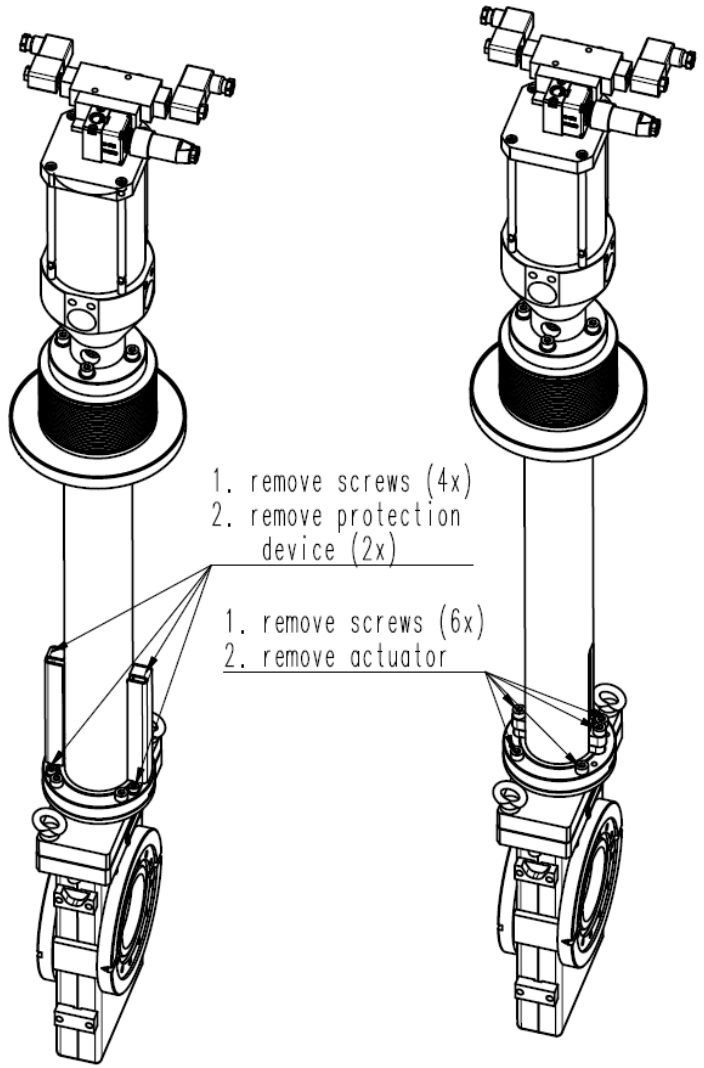
Modified Lattice Improvements

- Major reduction of heat load inside cryostat (2.9kW vs 7.2kW)
- 1mm tungsten shielding required instead of 3mm
- High heat load beam screen required
- Constant aperture through rear side
- Simulation assumes 10% of charge in tails



B0 Vacuum Chambers





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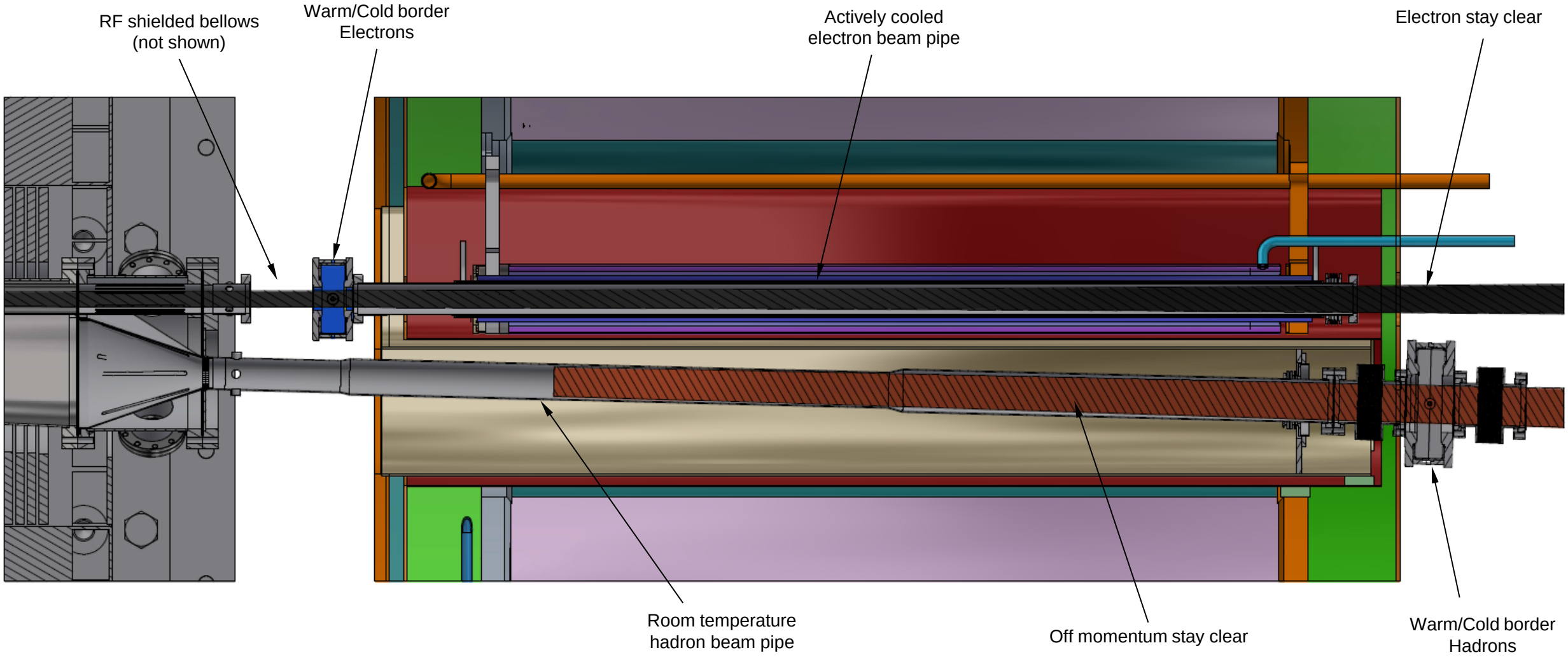
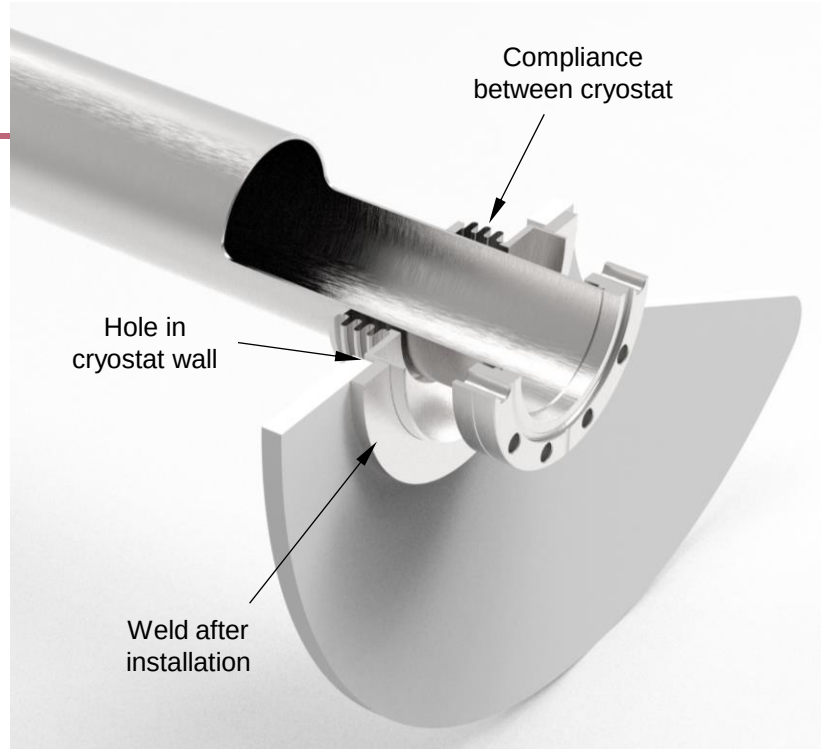
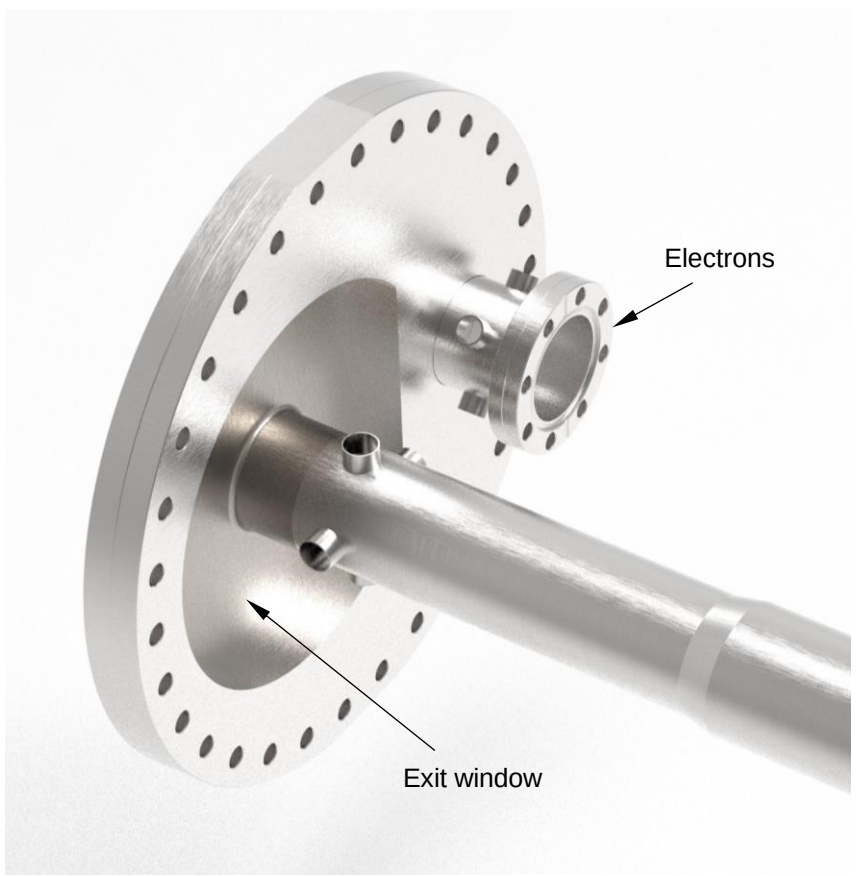
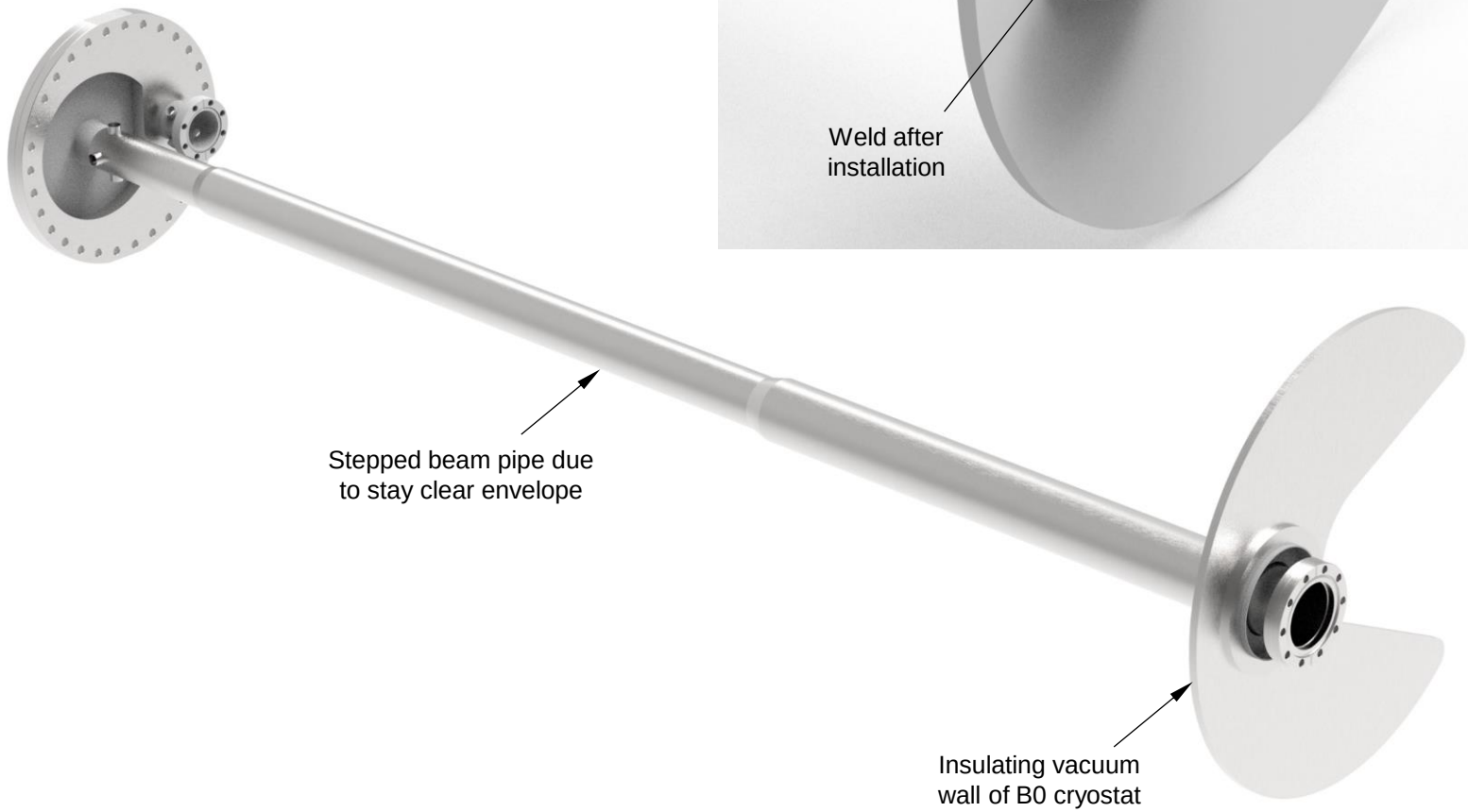


B0 Hadron Vacuum Chamber

- Requires copper platting and aC coating
- Integral part of B0 magnet
- BPMs for both beam lines on single part
  - Weld-in to minimize footprint

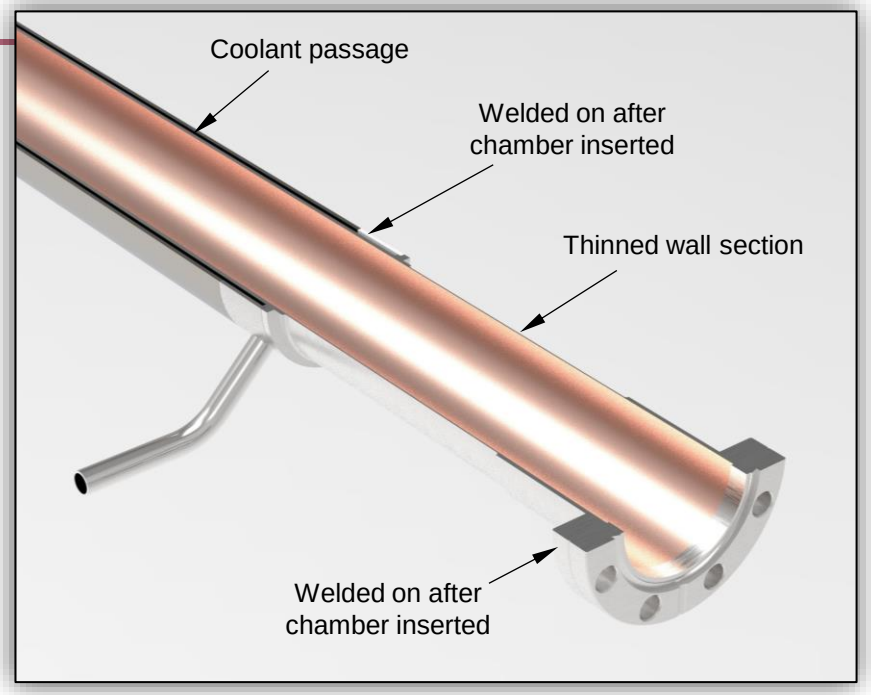


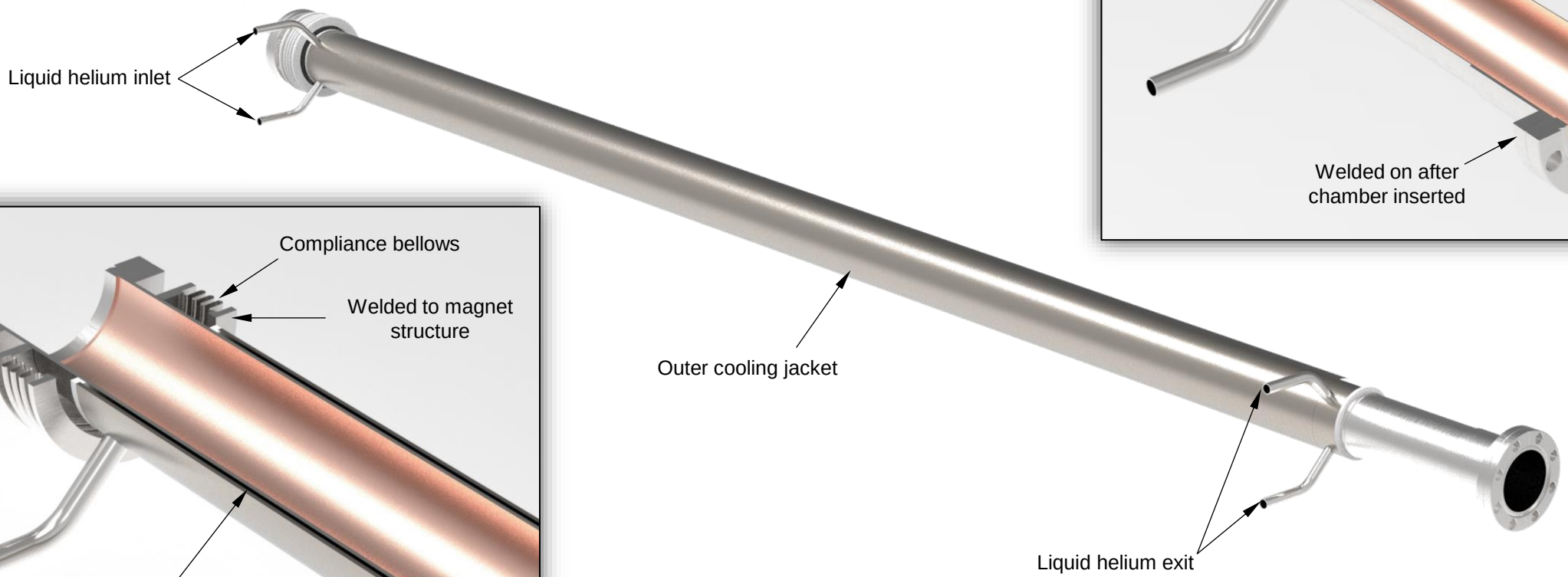




B0 Electron Vacuum Chamber

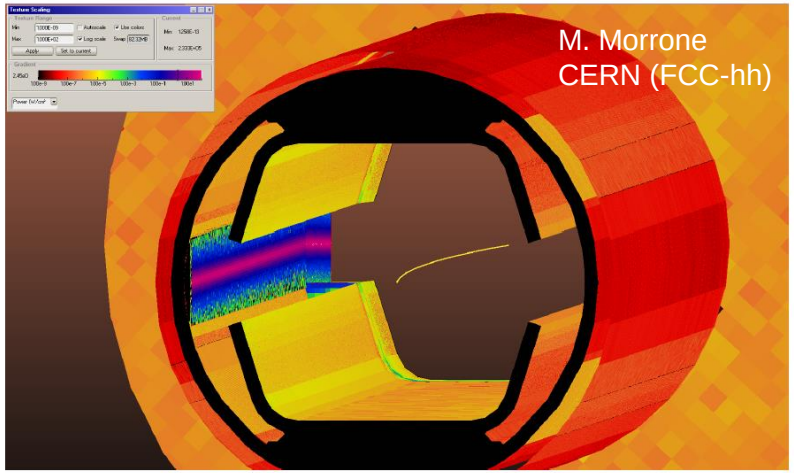
- Requires copper platting
- Integral part of B0 magnet
- Final welding after installed in cold mass



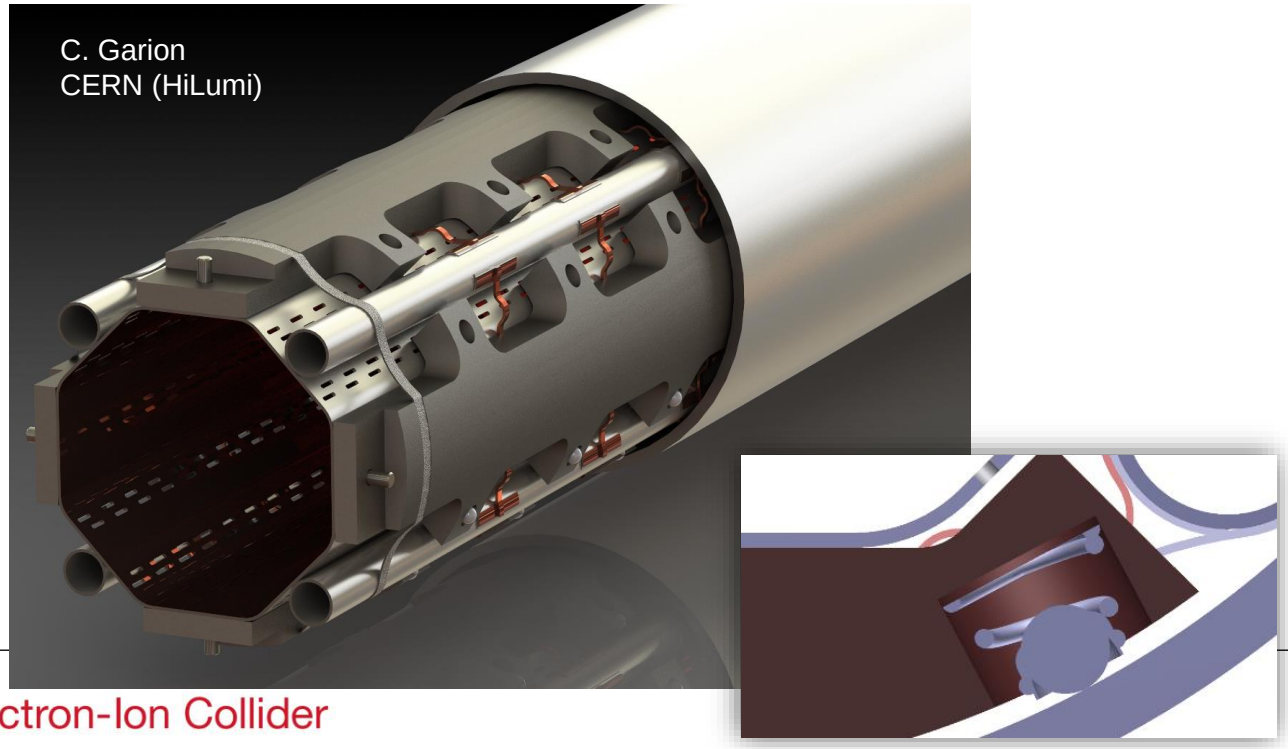


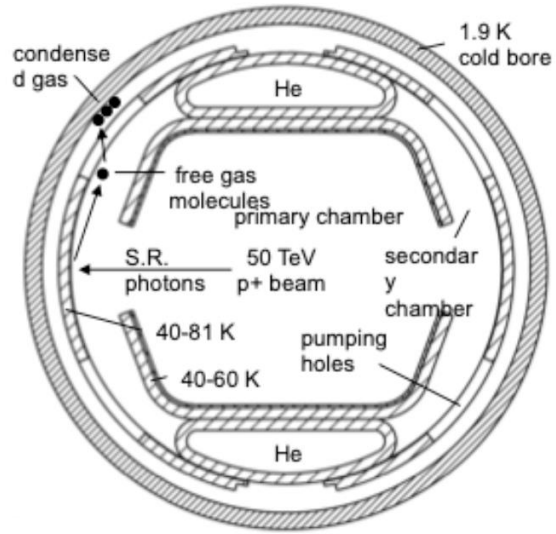
Electron Beam Screen

- Very high heat load in first section and taper (375 W/m)
- Added complication due to shielding
  - May be easier to increase beam screen wall thickness
- Need to take advantage of 2K cryopumping from cold bore
  - Beam screen <80K



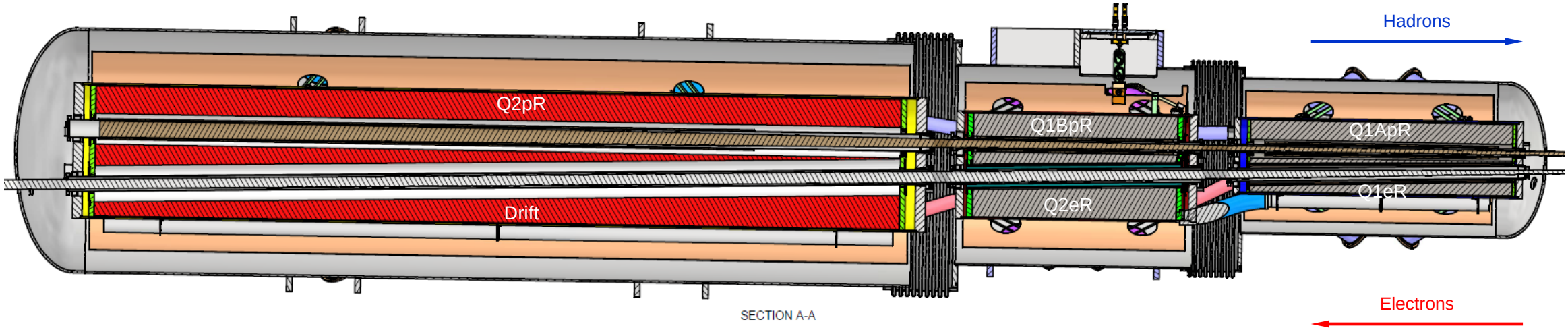
Max **synchrotron radiation** power ~ 42 W/m
Beam intensity: 0.5 A, 50 TeV





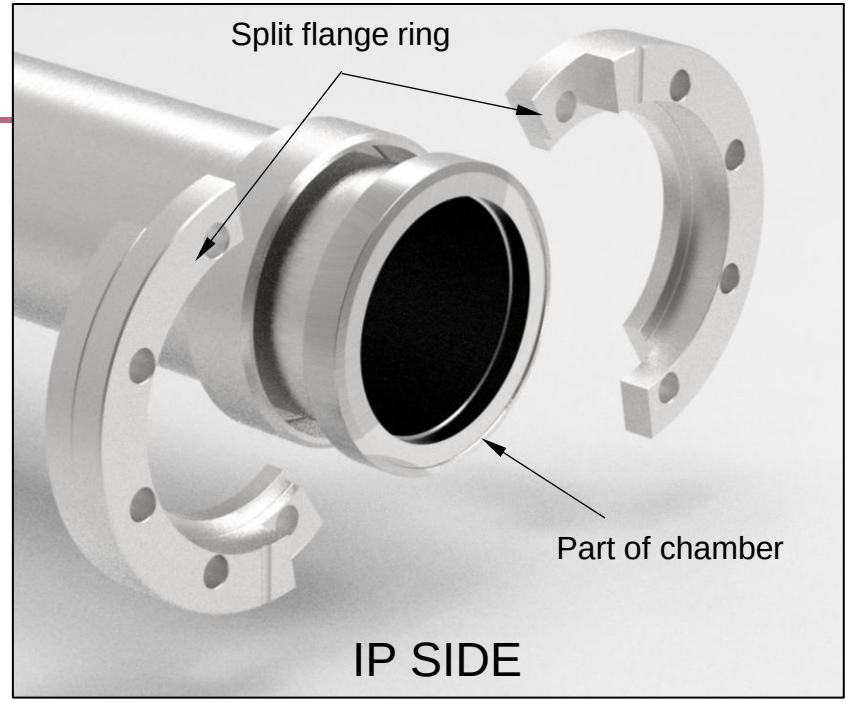
FCC-hh - 898 l/(s·m) for H_2 at 40 K
35.4 W/m emitted SR

Rear Cryostat Assembly



- Hadron stay clear based on points provided
  - 10 σ_x and 10 σ_y high divergence (no orbit offsets)
  - Gold injection at 2.5 micron normalized, 8/7 sigma (x/y), 10m horizontal 0.9m vertical betas
  - Points provide at beginning, middle and end of each lattice magnet element plus every 10cm through the detector
- Electron stay clear based on 18 GeV collision optics
  - Envelope for other energies are smaller (V6.3.1)
  - Stay clear includes 13.5 σ_x and 22.5 σ_y only (no orbit offsets)
- RF bellows required between each cold mass (both beam lines)
- BPM required in each interconnect

Chamber Concept



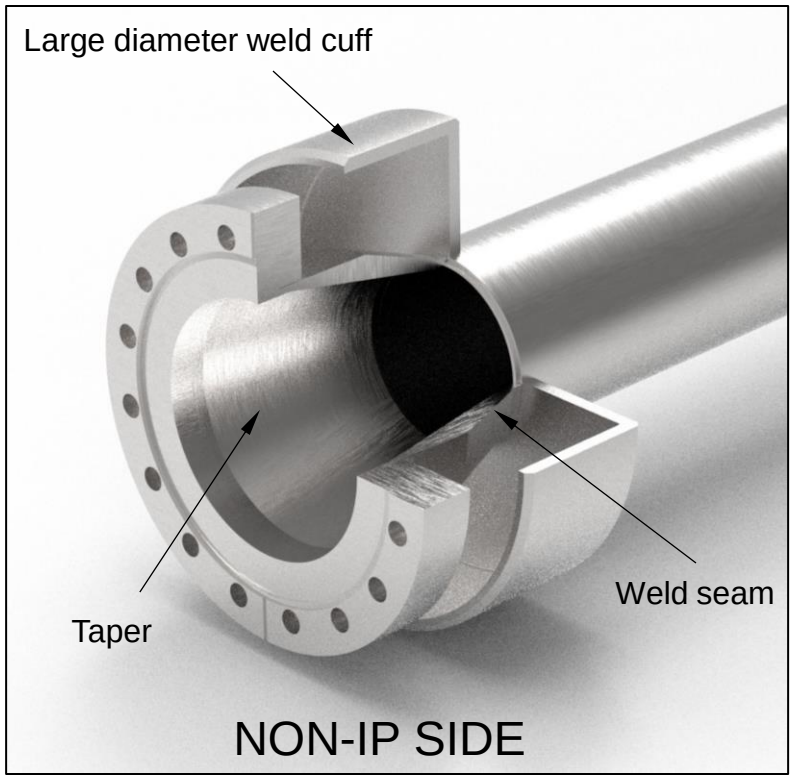
Liquid He interface
(no UHV – He interface)

Intermediate spacers not shown

Standard tubing

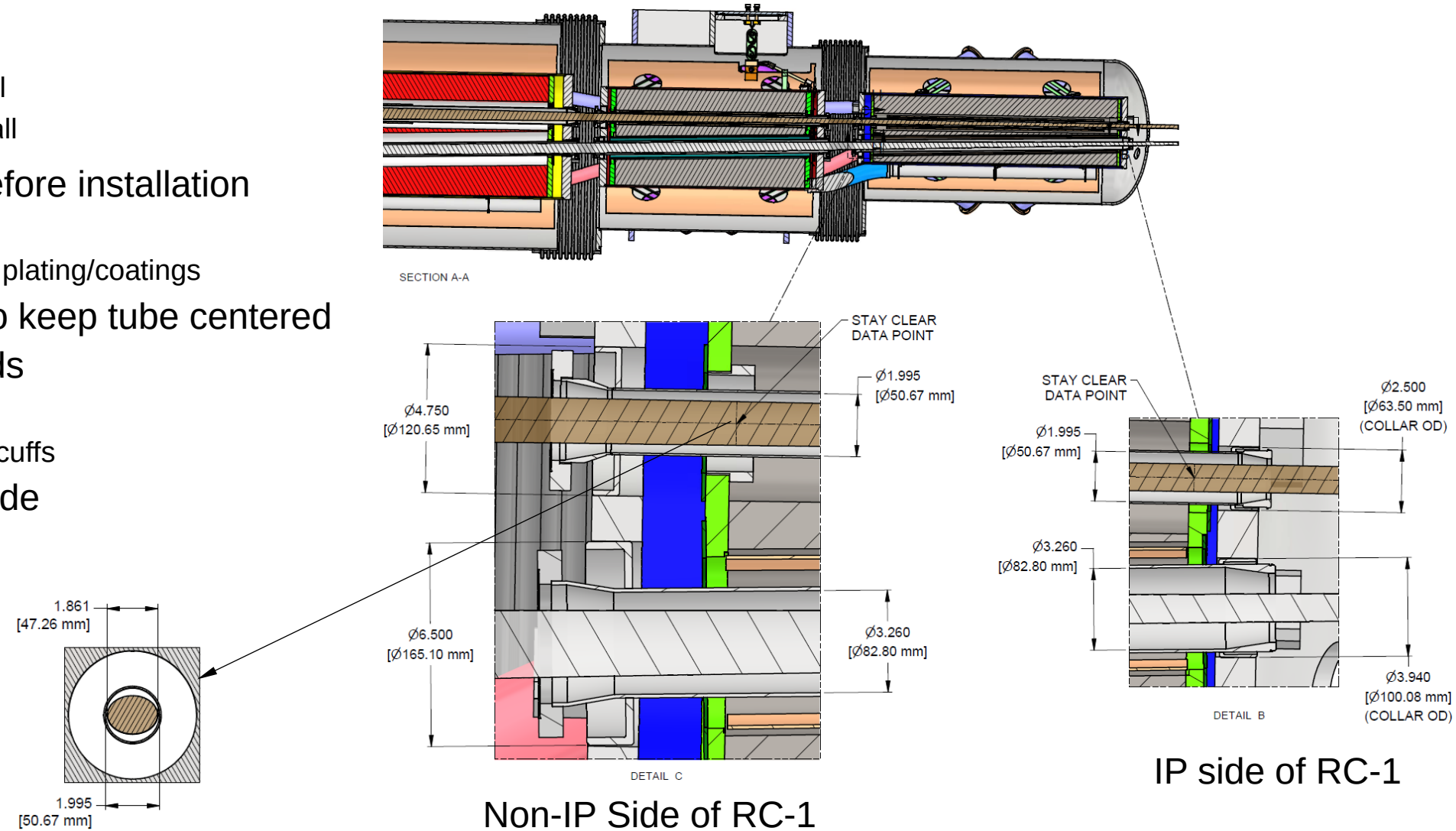
Split ring installed after
magnet installation

Small diameter weld cuff
(slightly larger than flange insert)



Rear Interconnects

- Standard tubing sizes
  - Hadrons : 2” x .065” wall
  - Electrons: 3.5” x .12” wall
- Chambers complete before installation
  - Slid in from non-IP side
  - Welding cuffs to protect plating/coatings
- Intermediate spacers to keep tube centered
- Taper transitions at ends
  - Sperate weld on piece
  - Weld joint protected by cuffs
- Bellows welded to IP side



Non-IP Side of RC-1

IP side of RC-1

Next Steps

- Finalize and document apertures through final focusing magnets
  - Beam stay clear envelopes defined
  - Record of decision in draft
- Central detector chamber
  - Water cooling to mitigate synchrotron radiation
  - Chamber integration, alignment and support system
  - Finalize in situ bake out system
- Beam screen design for forward electron side
  - High heat load, radiation shielding required
  - Optimize to maximize cryo-pumping from cold bore (decrease beam-gas events)
- Update pressure profile through IR area
- Geometry for rear side electron vacuum chambers
  - Luminosity exit window, low Q^2 taggers
- Advance mechanical design of far forward side vacuum system

Summary

- Integration of detector systems with the accelerator components progressing
  - Geometry shared as it is being developed
- Experimental requirements are key drivers in designs
- Compromises are negotiated when needed
- Active discussions between stake holders to resolve remaining challenges
  - Experimental program, magnet division, accelerator physics, technical systems, etc.