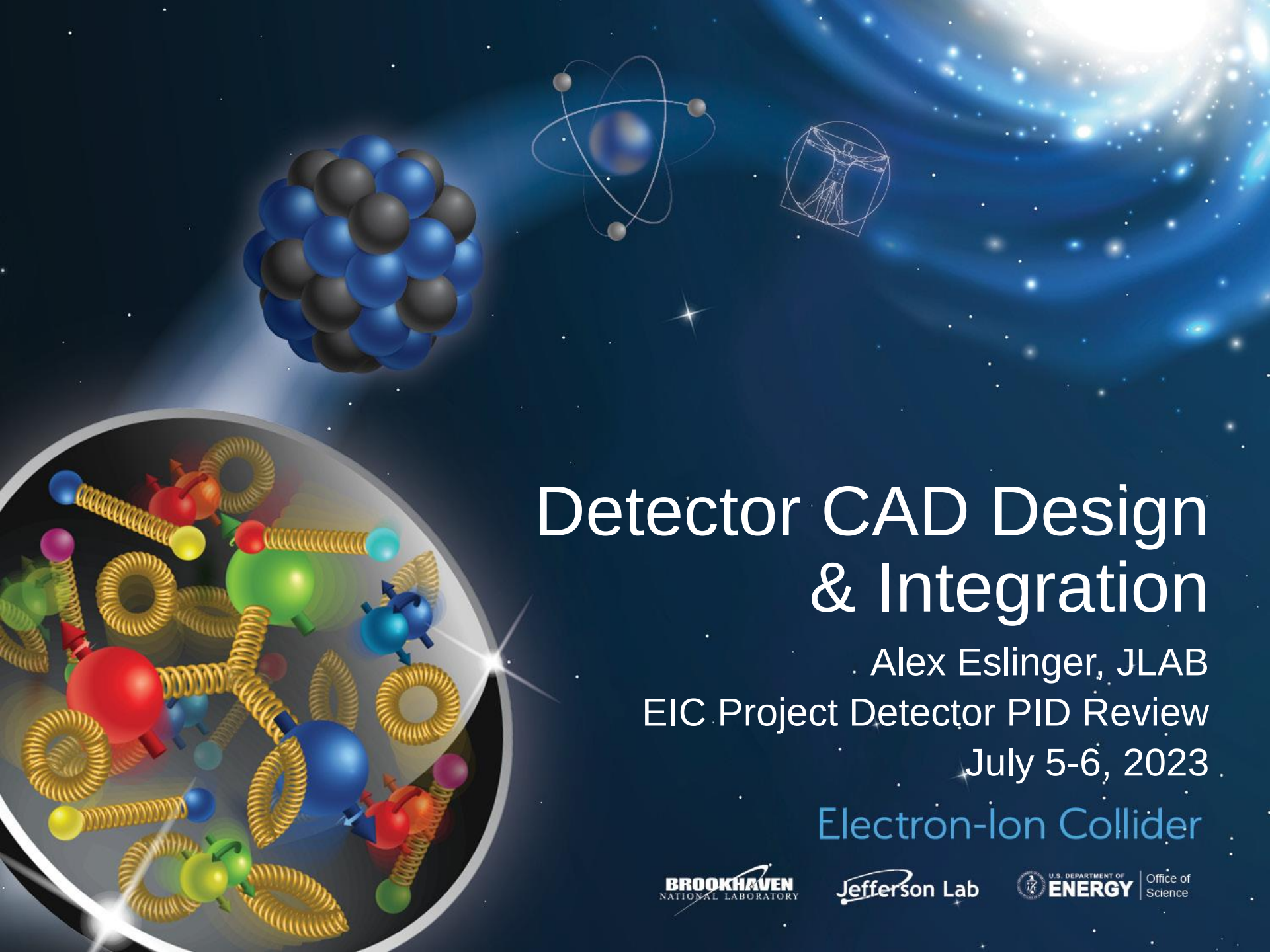


Detector CAD Design & Integration

Alex Eslinger, JLAB

EIC Project Detector PID Review

July 5-6, 2023

Electron-Ion Collider

BROOKHAVEN NATIONAL LABORATORY

Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

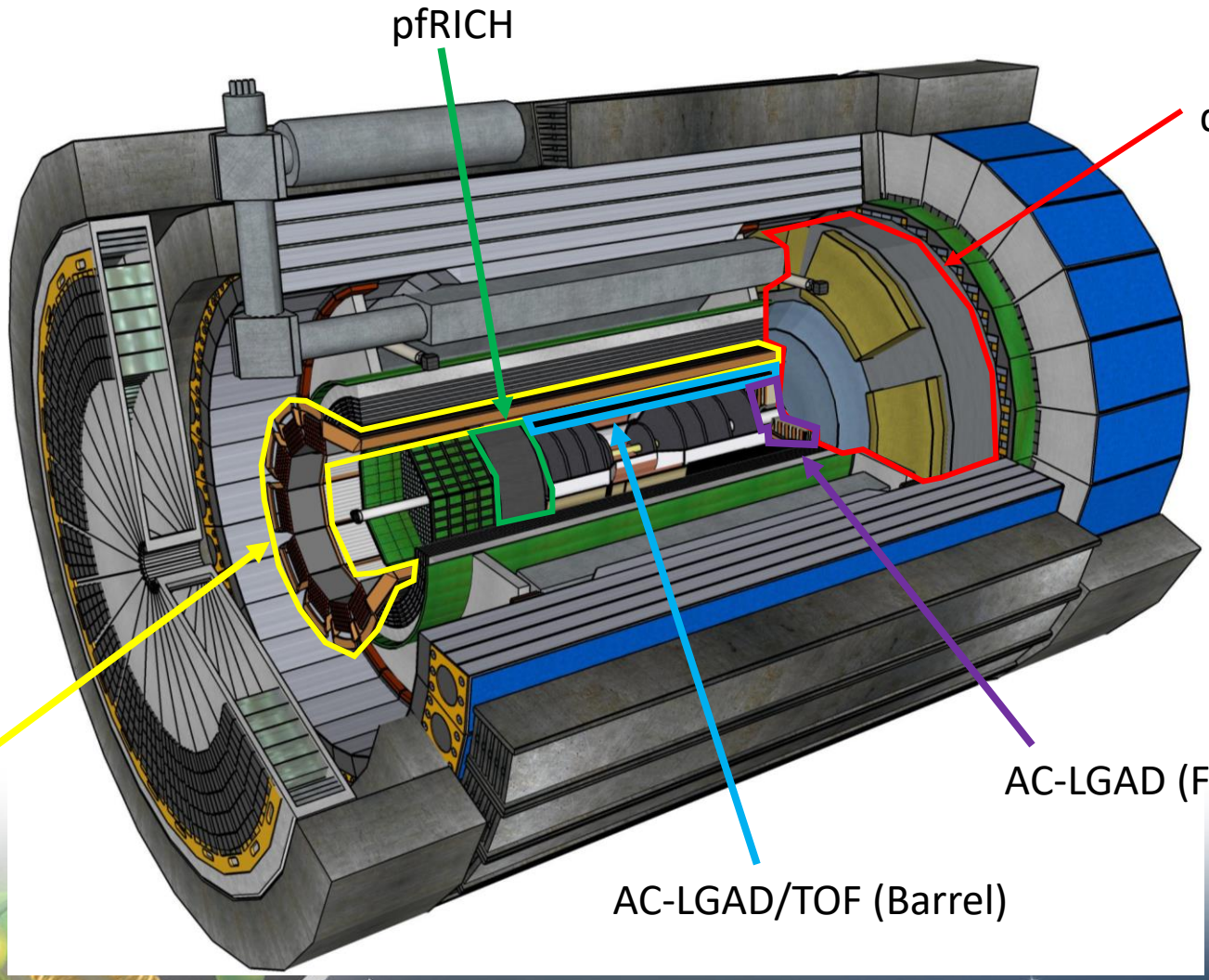
Outline

- ES&H Design Considerations
- ePIC model
- pfRICH (Alex Eslinger)
- dRICH (Alex Eslinger)
- hpDIRC (Avishay Mizrahi)
- AC-LGAD/TOF (Barrel) (Andreas Jung)
- AC-LGAD (Forward) (Andreas Jung)

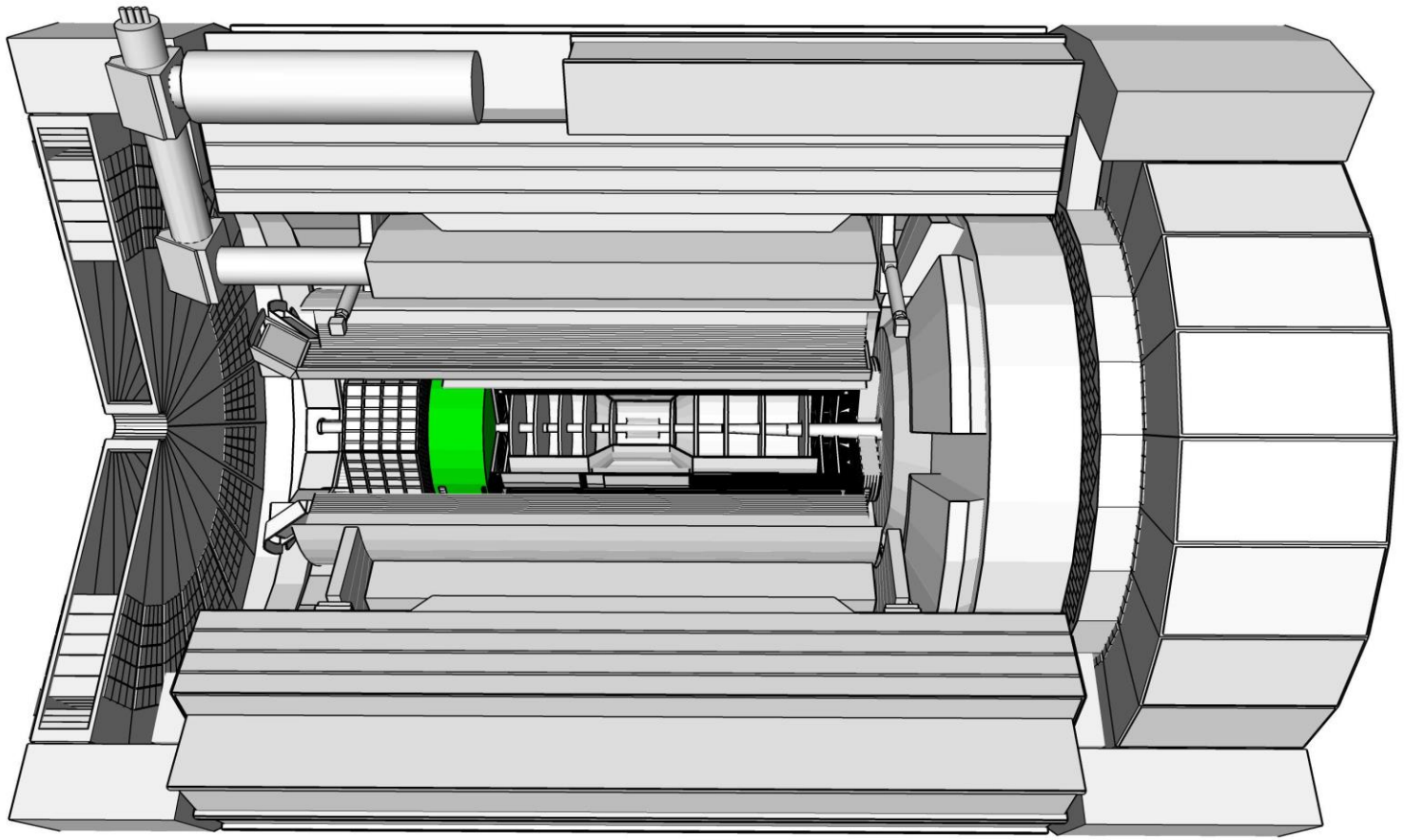
ES&H Design Considerations

- All installation platforms will be designed in compliance with OSHA standards
  - General Duty Clause
  - Walking-Working Surfaces
  - Fall Protection
  - Stairways and Ladders
- SBMS will be followed for safe work practices and work around beampipe
- Critical Lift or Engineering lift procedures will be used where applicable.
  - Determining load capacity
  - Ensuring Structural Integrity
  - Stability and Balance
  - Appropriate Lift Points

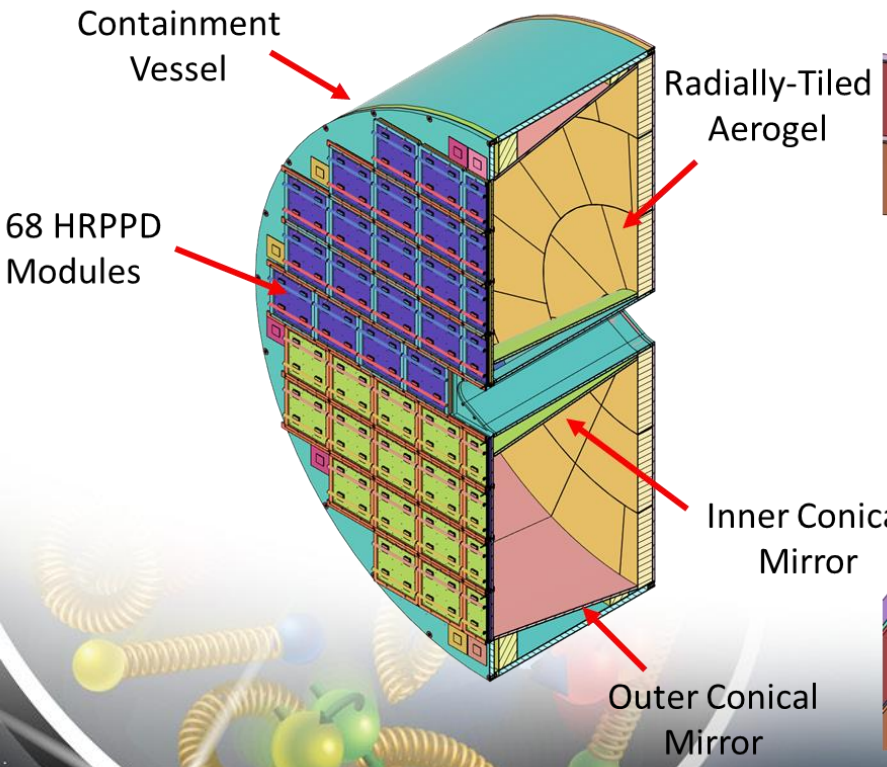
ePIC Model

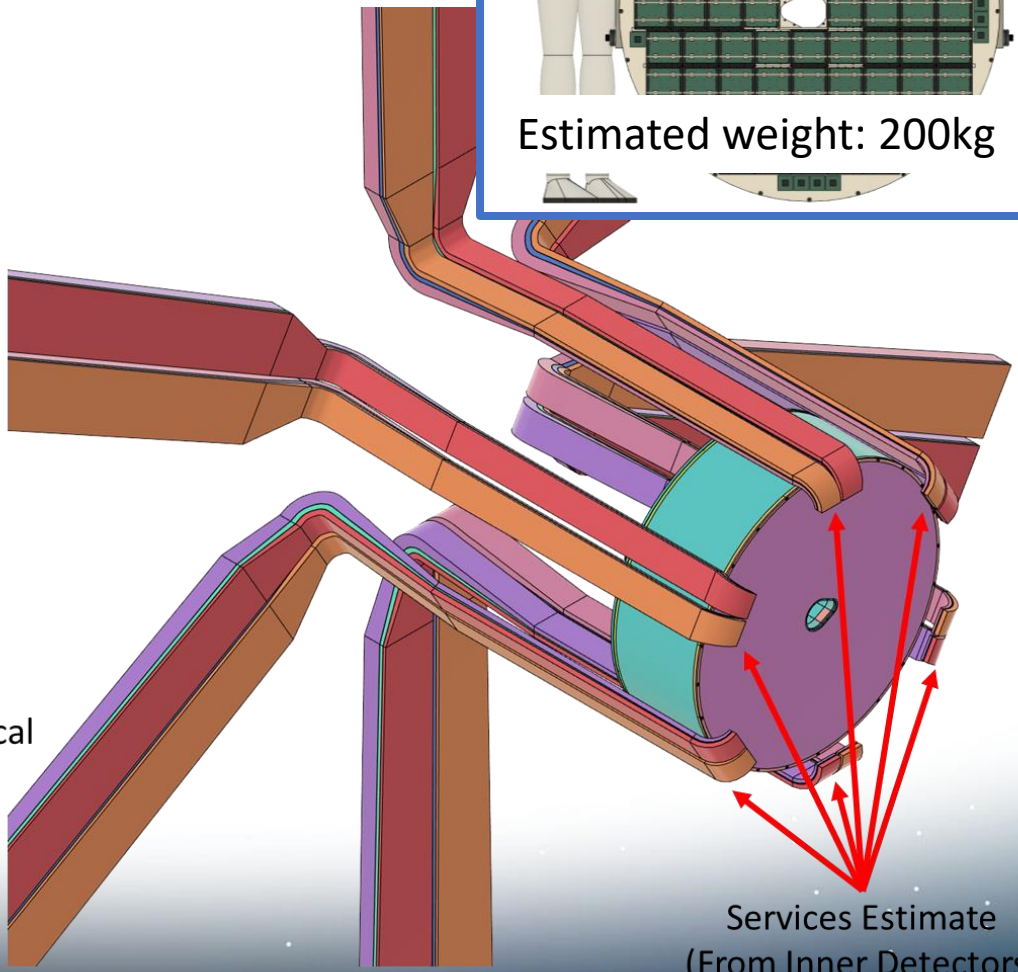


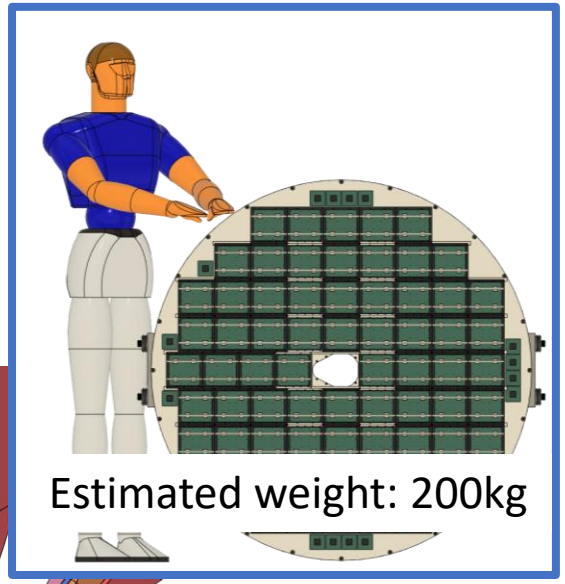
pfRICH



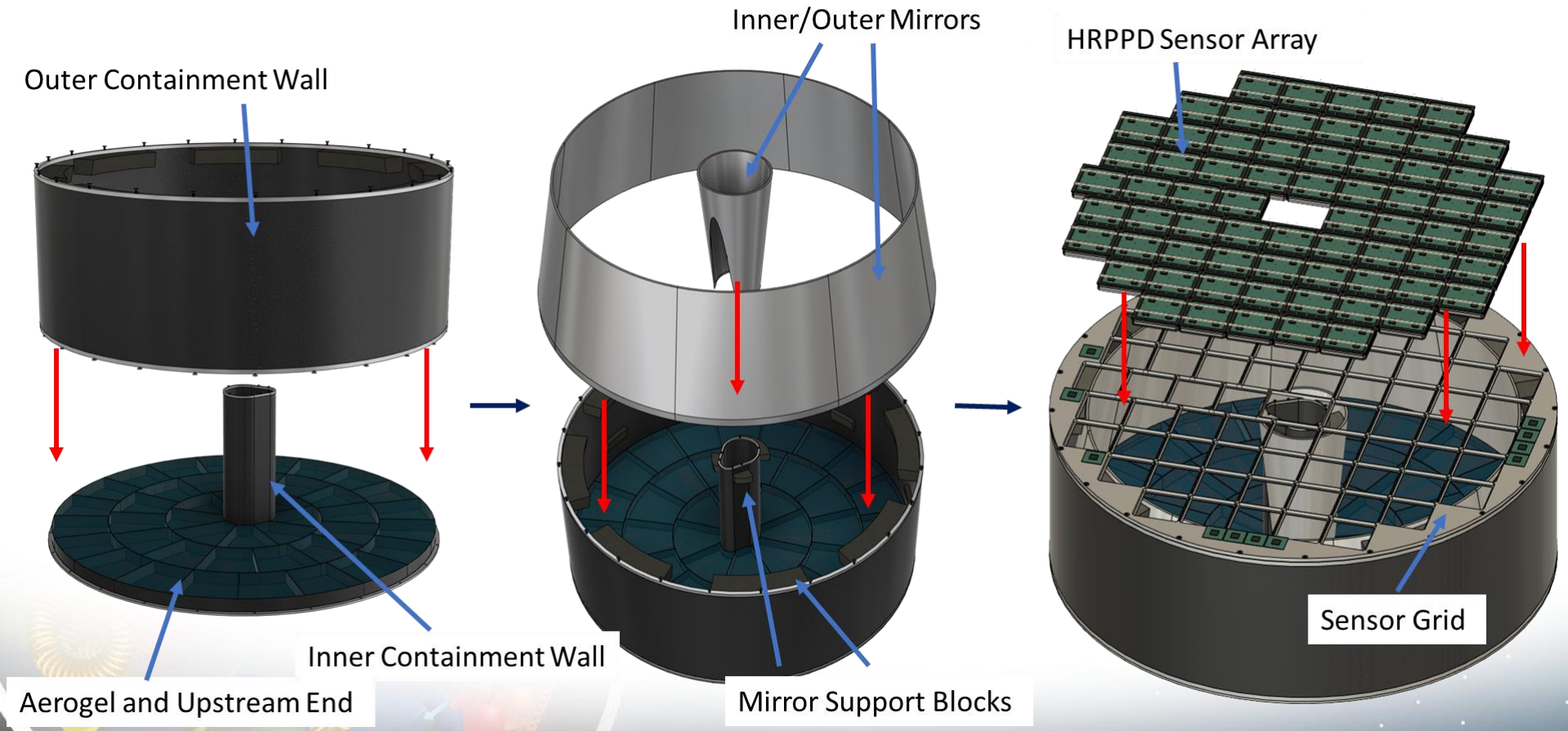
pfRICH Overview



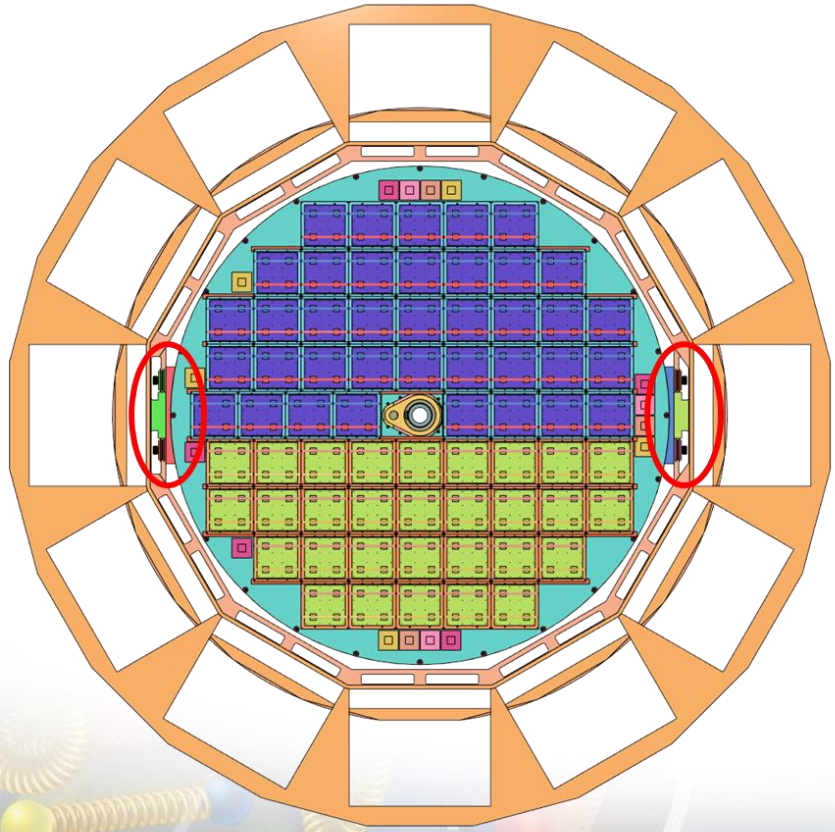


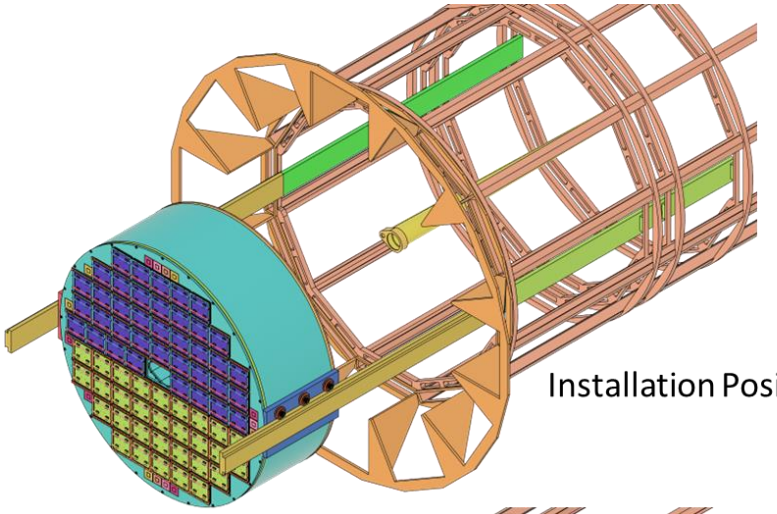


pfRICH Assembly/Sub-Components

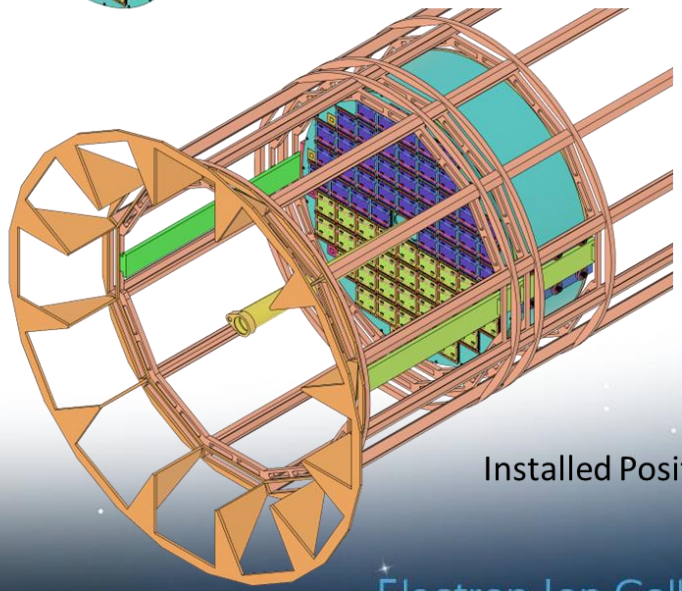


pfRICH Installation & Support





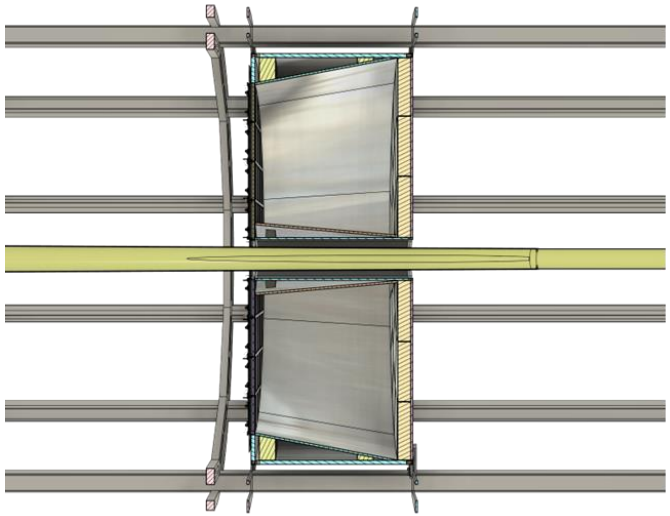
Installation Position

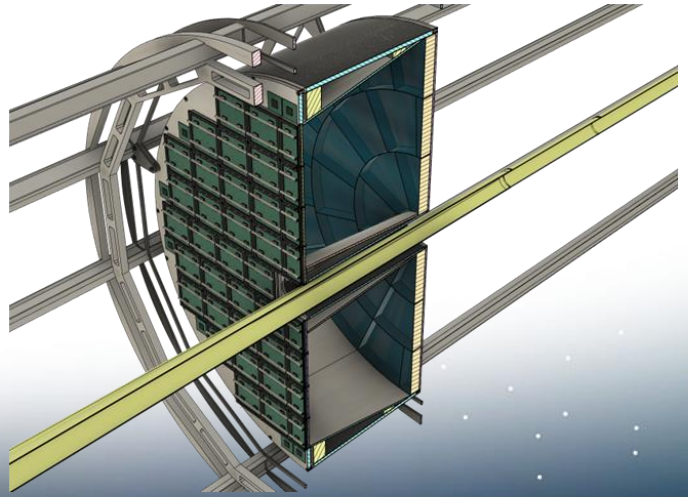


Installed Position

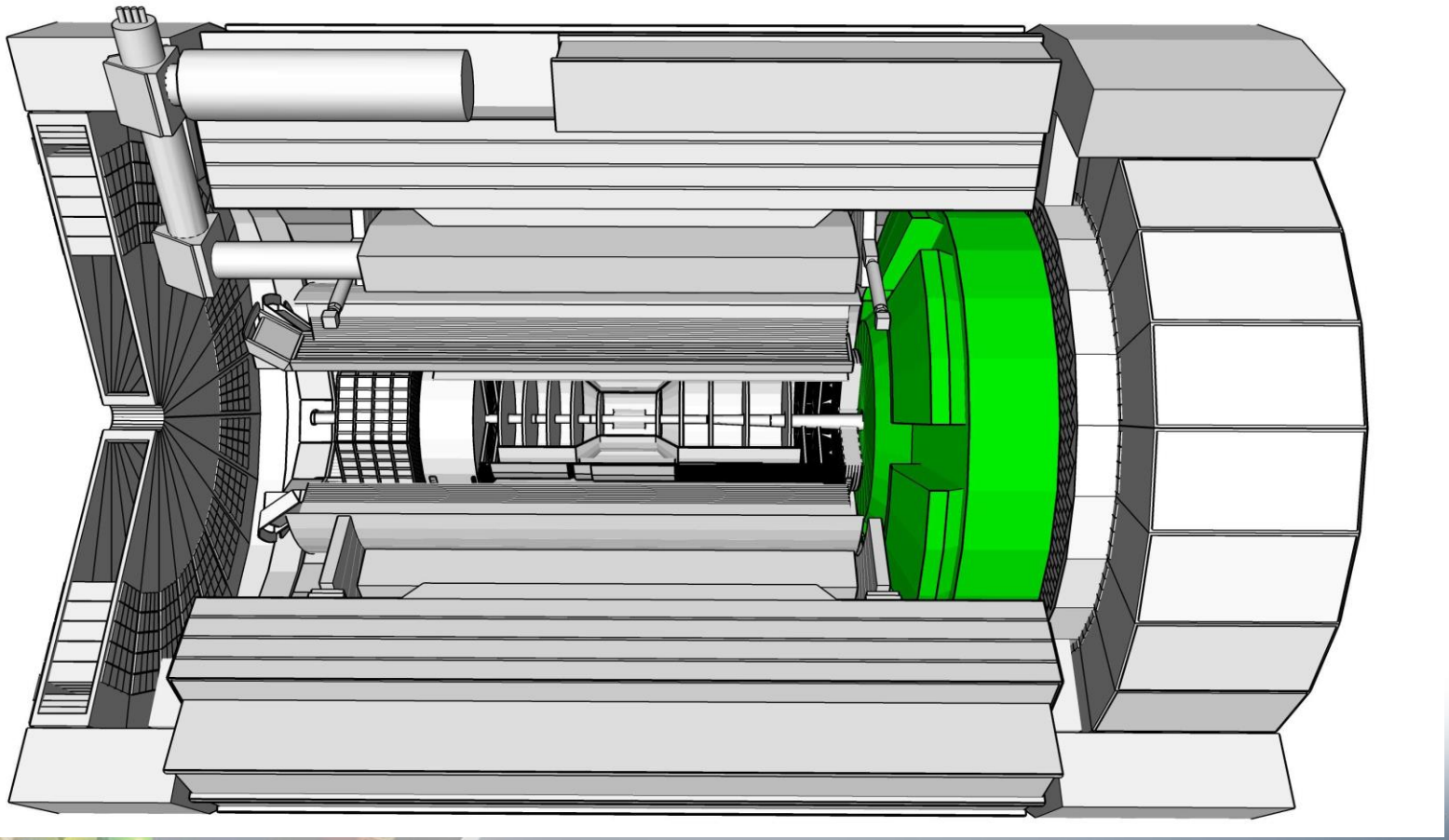
pfRICH Design Summary

- CAD model has developed rapidly since last October while an emphasis has been placed on ensuring that the CAD design agrees with the simulation software
- Sub-Assemblies are developing further detail as discussions with industry and other fabrication plans progress
- Assembly plans, installation, and support structures are in a preliminary stage and are being analyzed
- Services have been identified with on/off detector system designs in the works
- Detector prototype is being developed to evaluate componentry and fabrication techniques

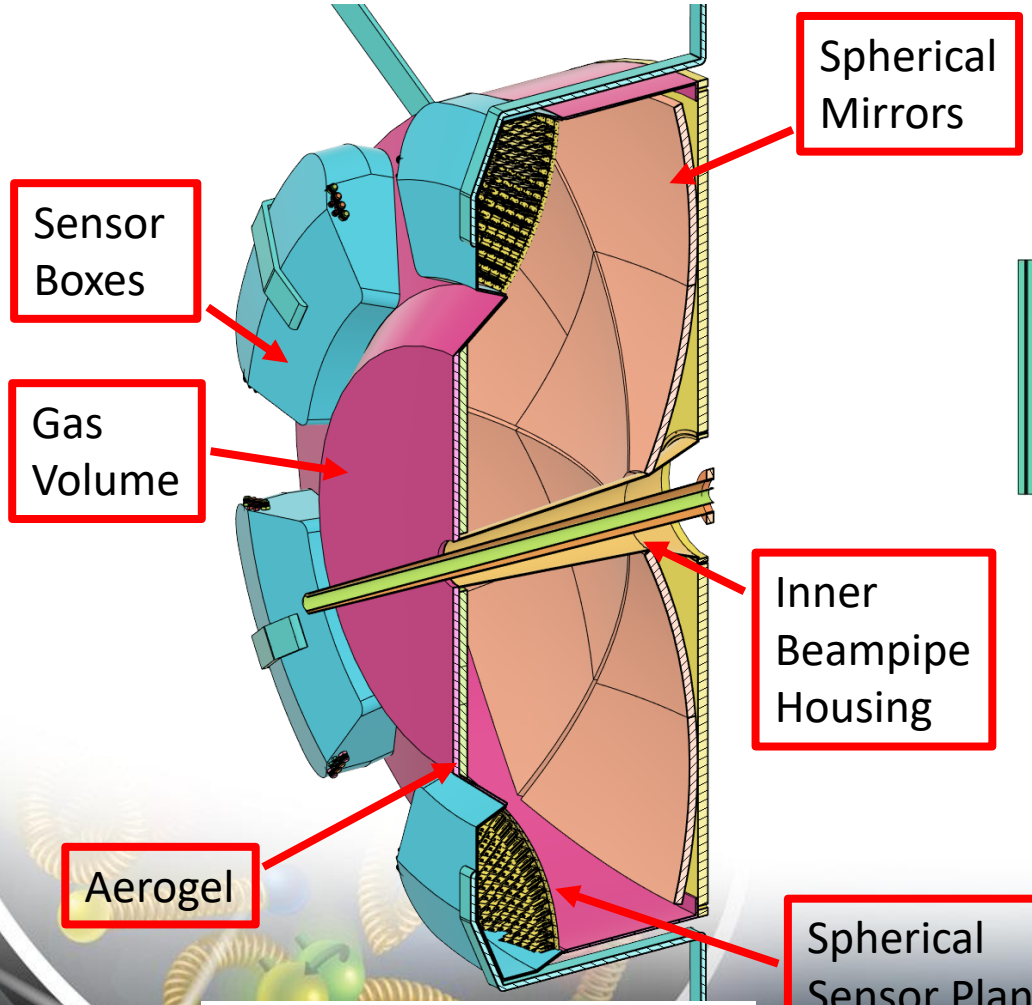




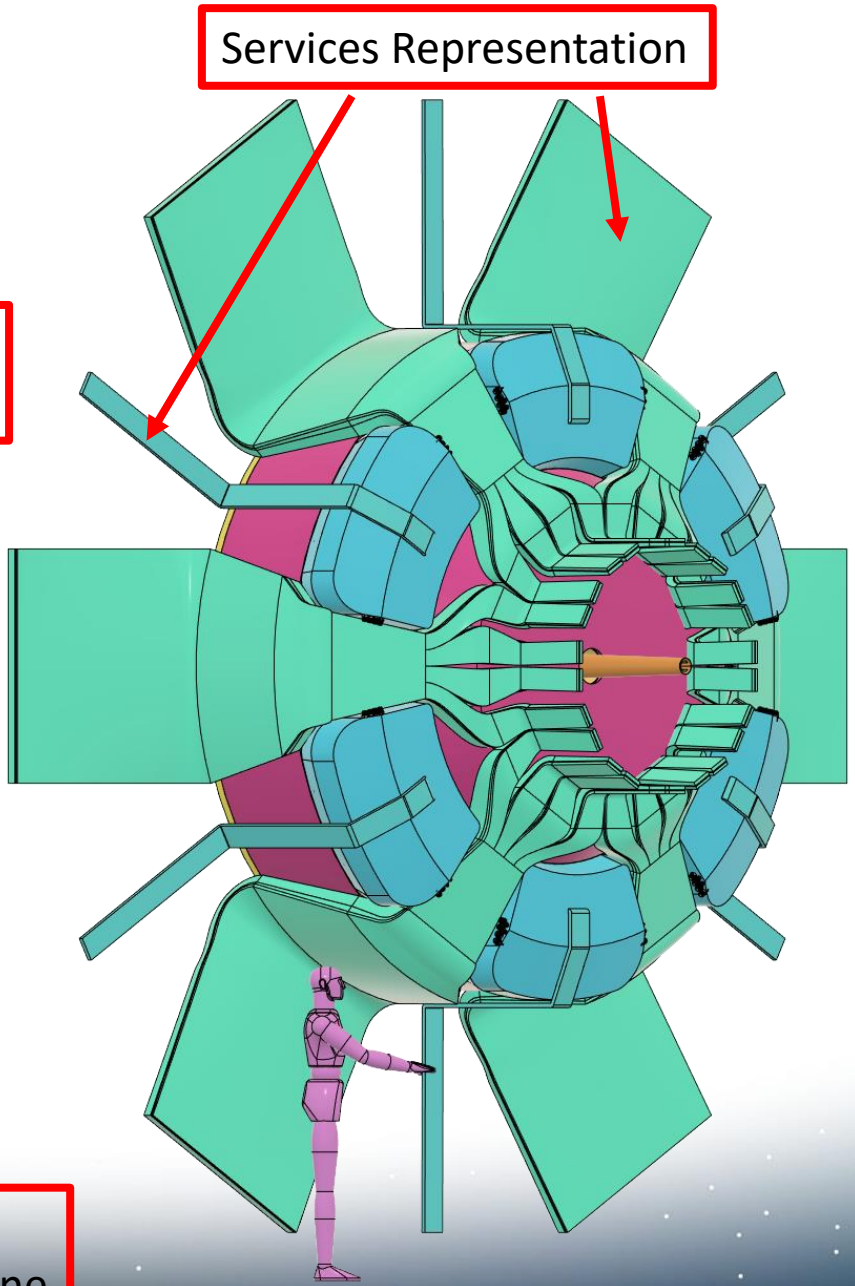
dRICH



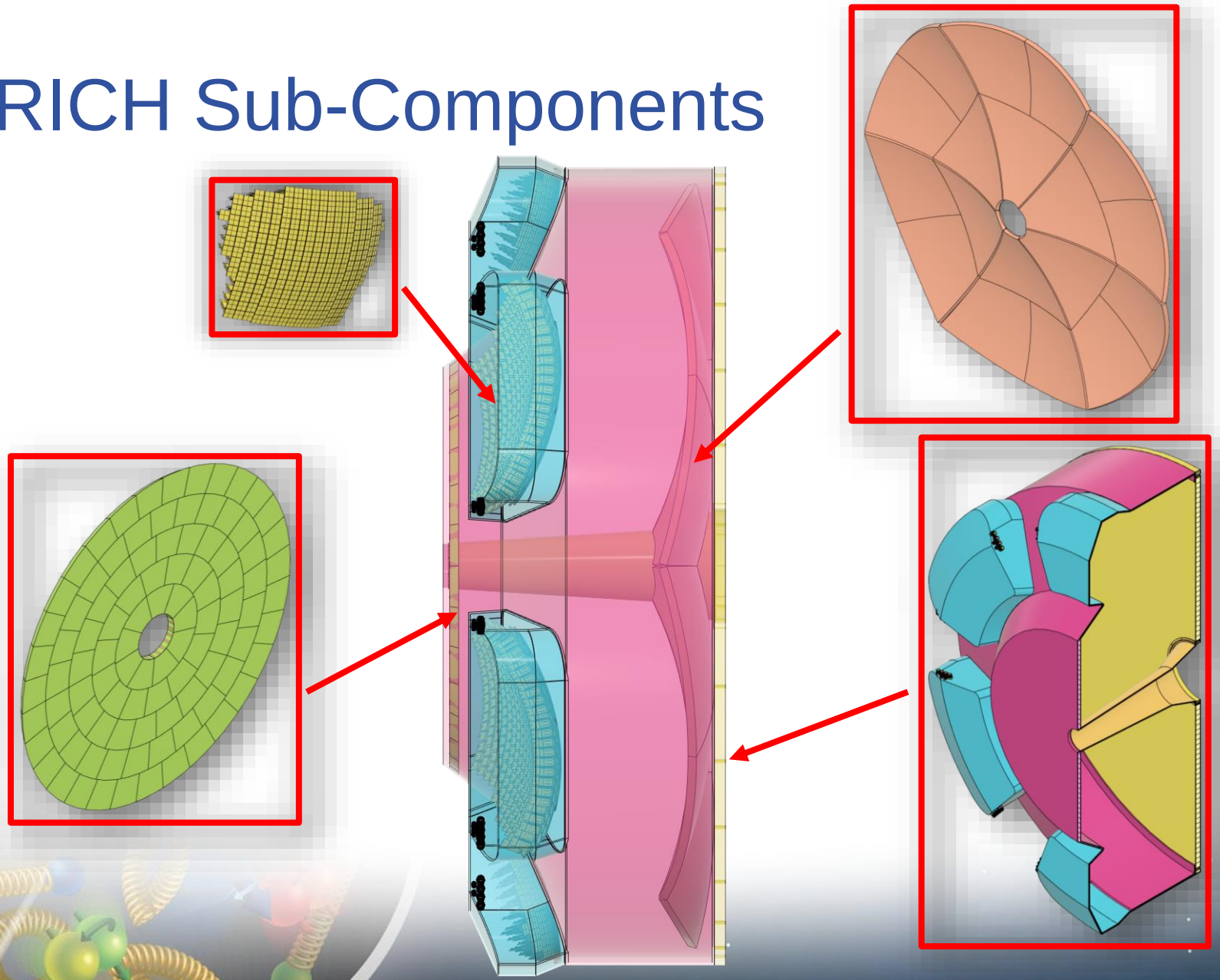
dRICH Overview



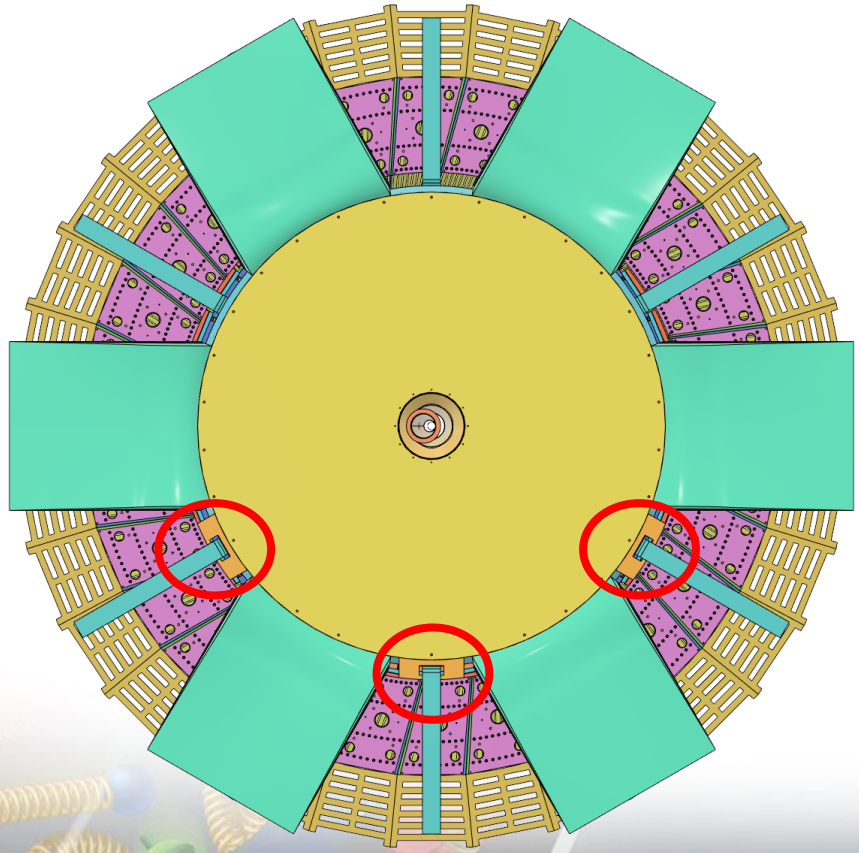
Estimated Weight: 2000kg

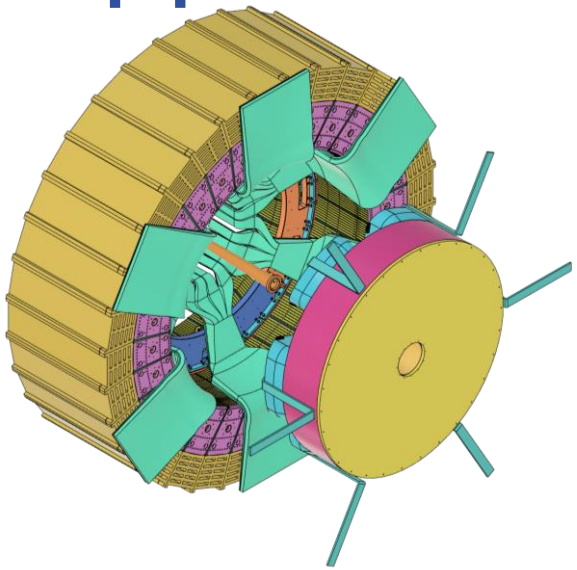


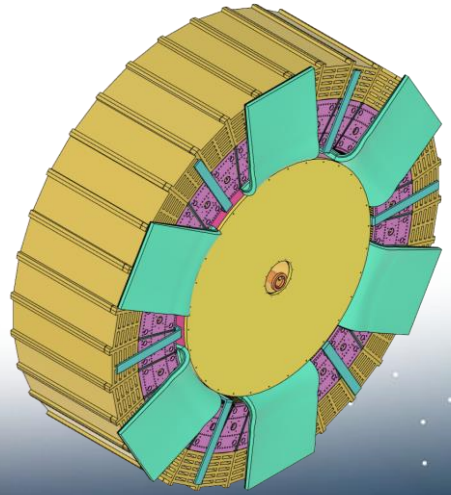
dRICH Sub-Components



dRICH Installation & Support

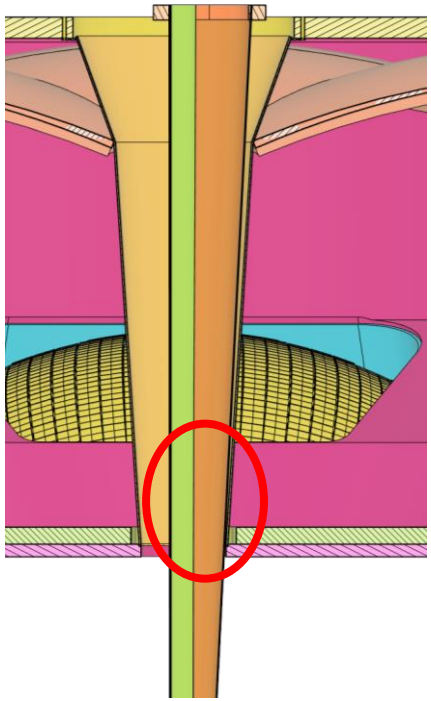


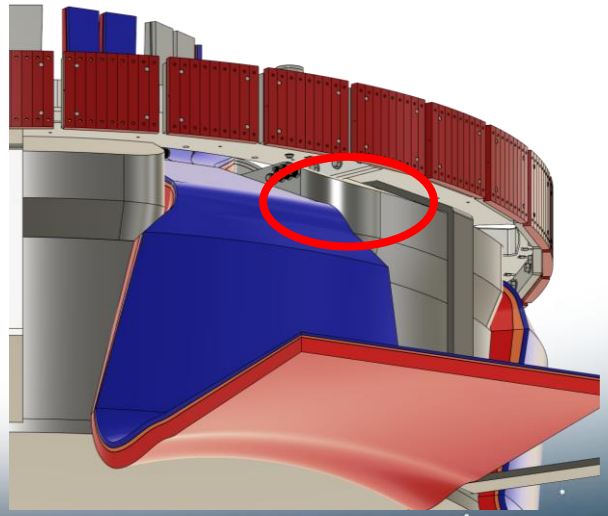




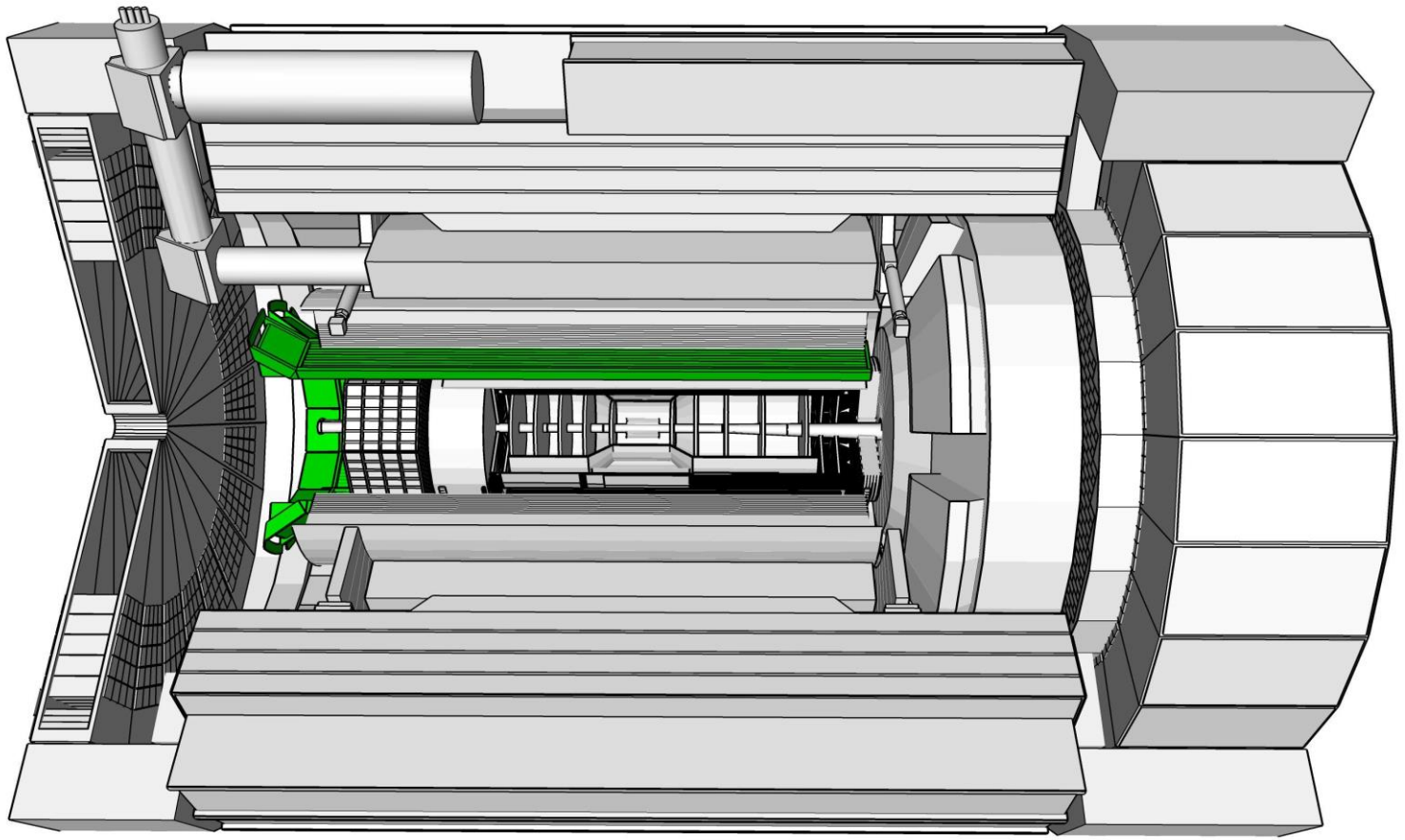
dRICH Design Summary

- Recent global positional changes have reduced integration interferences, however there are still a few minor areas of concern that are being addressed (circled red)
- Installation and support designs for the dRICH are still being developed but consistent with the overall design schedule

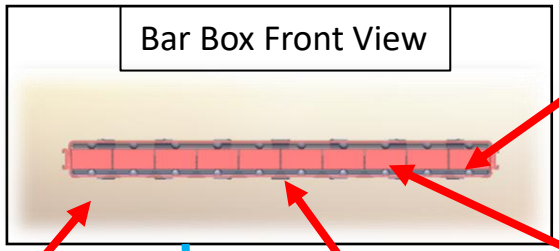




hpDIRC



hpDIRC Overview

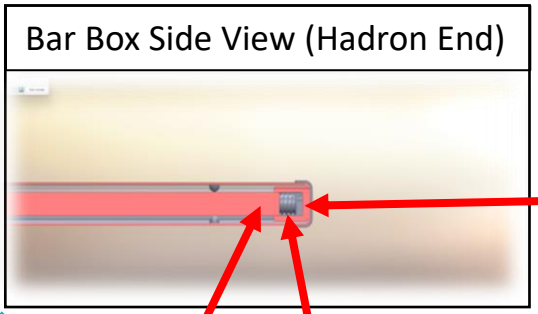


Spring Buttons

Linear Rails

Carbon Fiber Covers

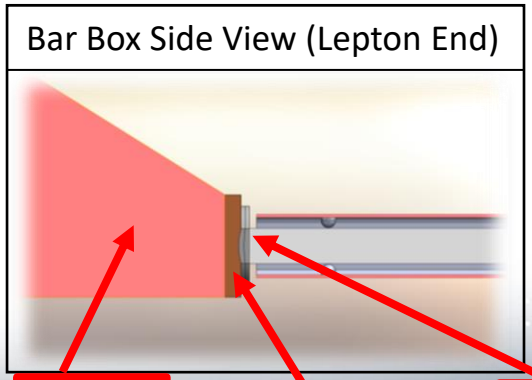
Fused Silica Bars



Spring

Mirror

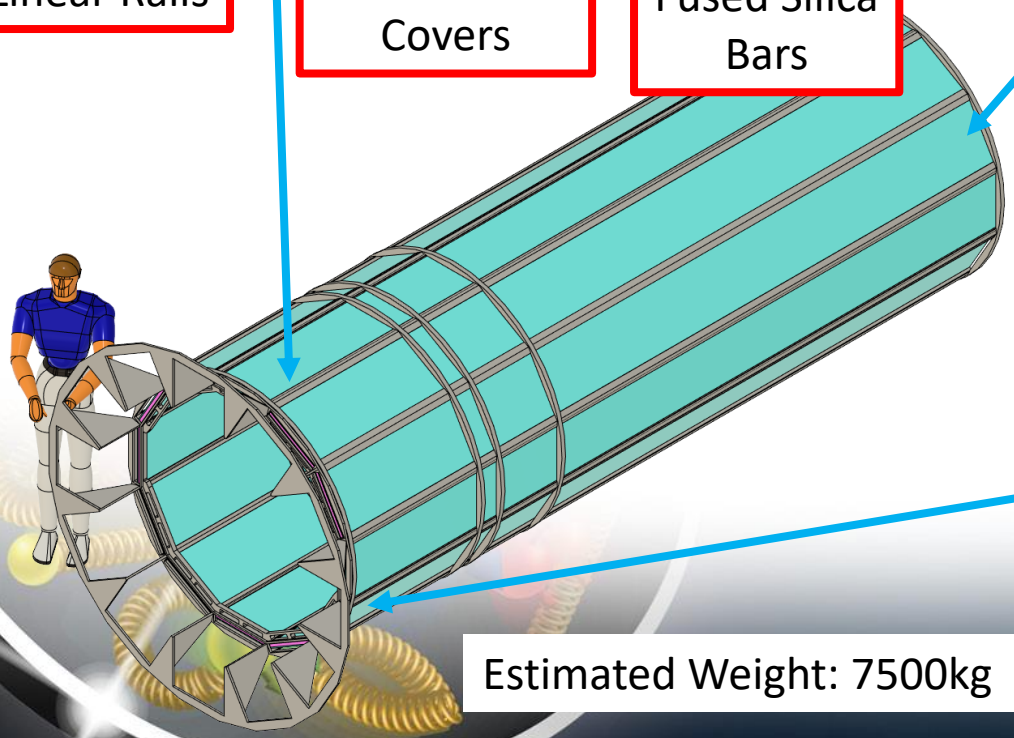
Mirror Plunger



Prizm

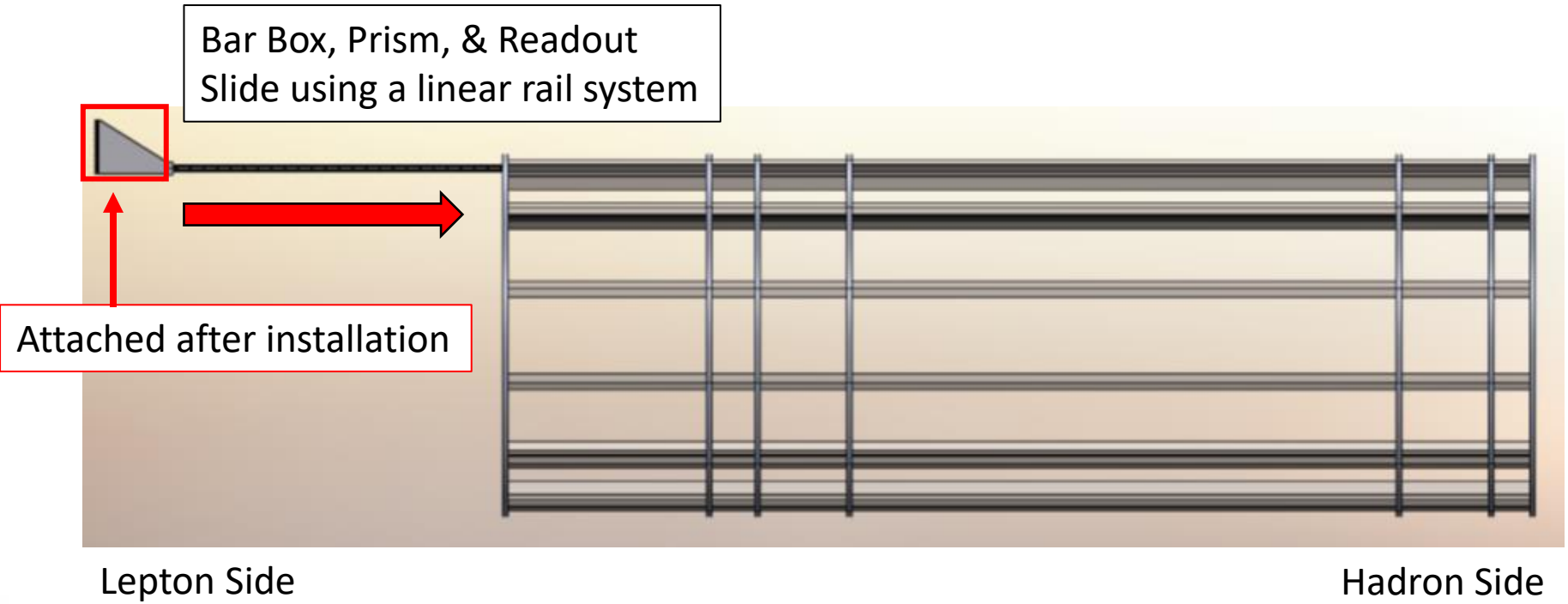
Lens 1

Lens 2 & 3

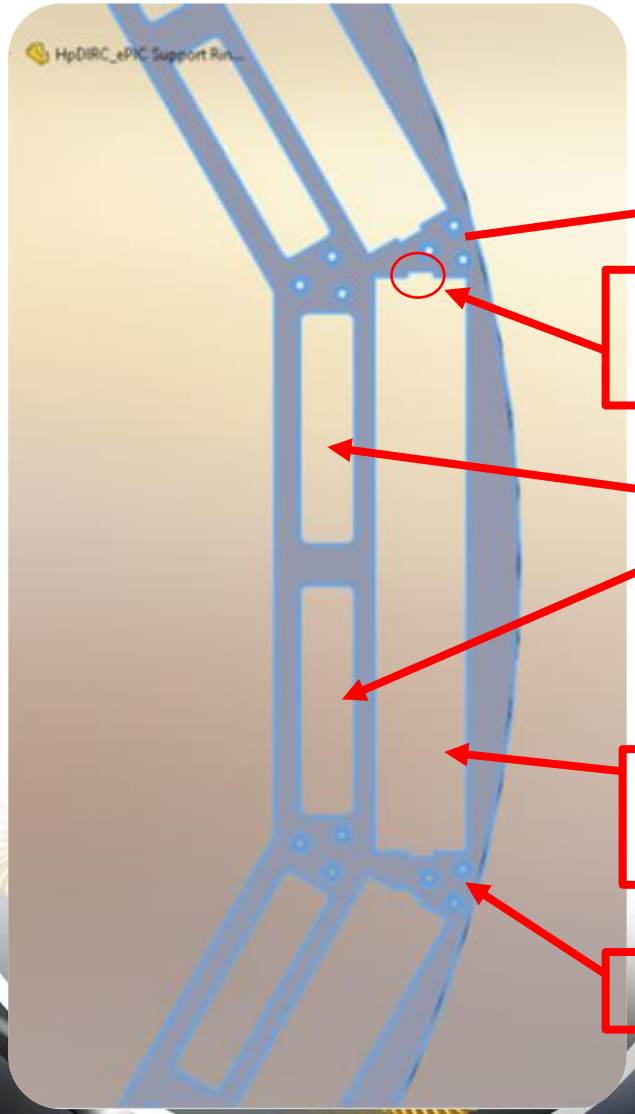


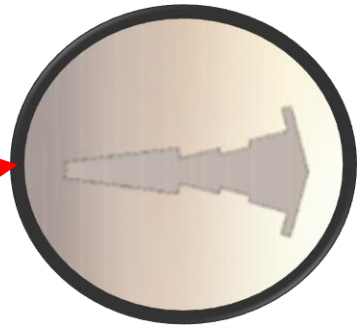
Estimated Weight: 7500kg

hpDIRC Installation

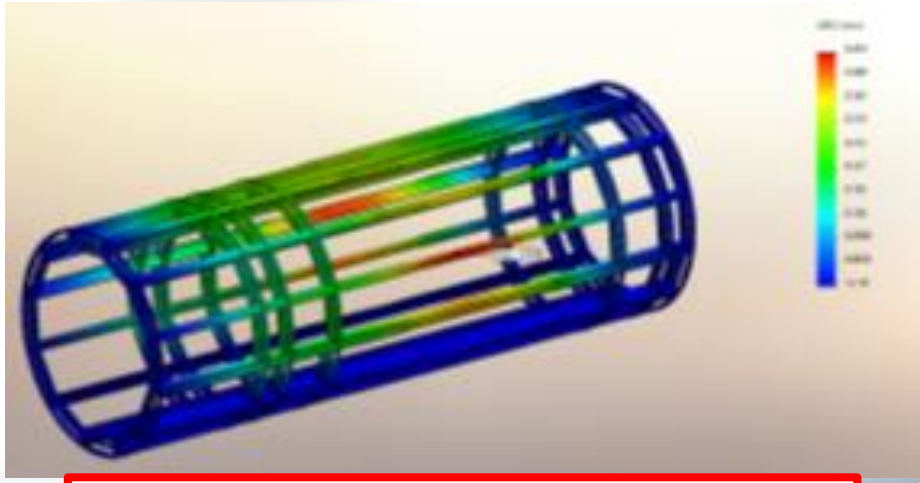


hpDIRC Support Structure





Cross-Section Designed for Maximum Material

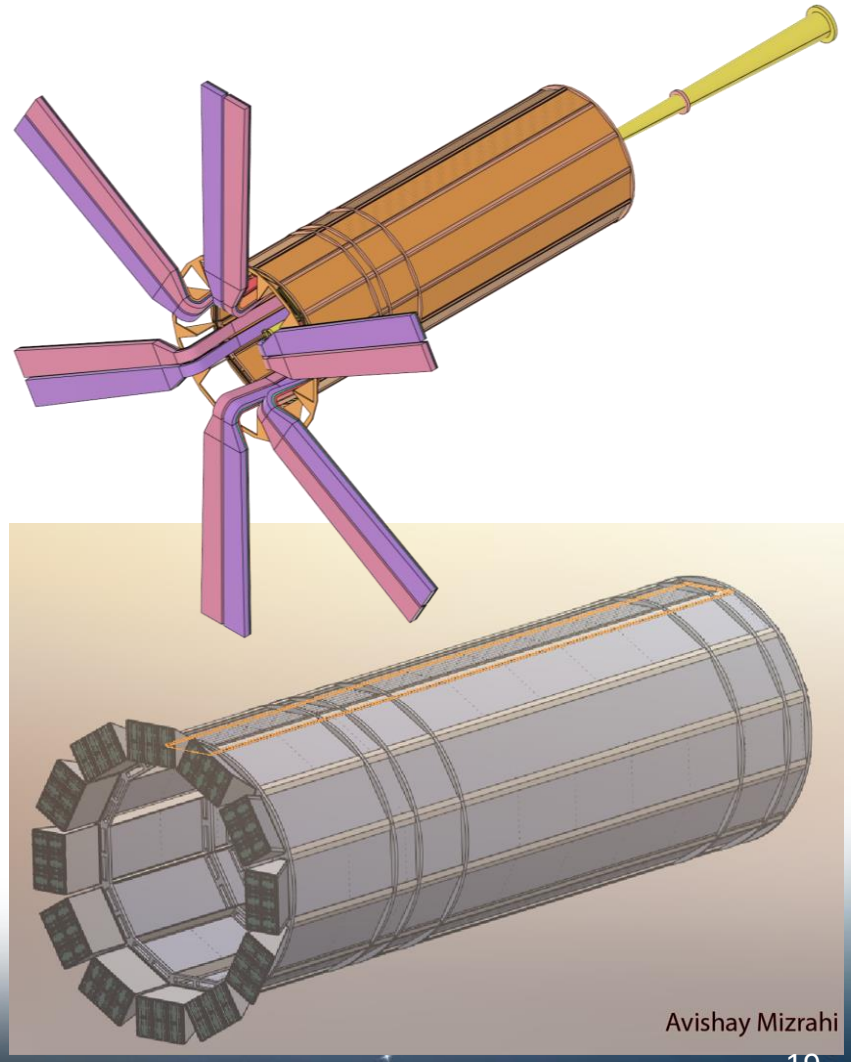


Max Deflection <0.5mm w/AISI 341 SS

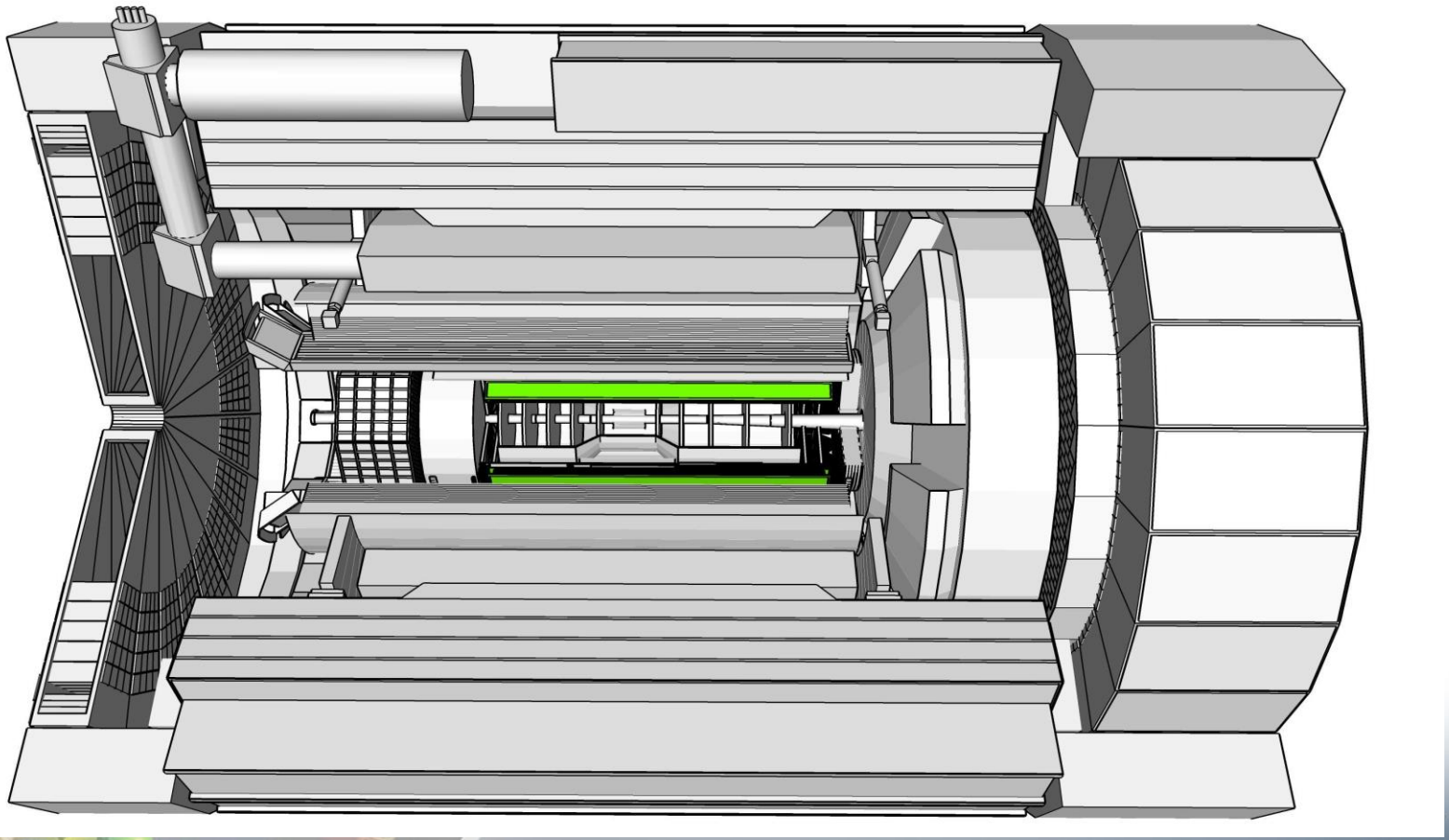
hpDIRC Design Summary

Sub-components and systems in progress:

- Dry nitrogen piping to Bar Boxes and Prisms
- Investigating and analyzing additional support material to the radial axis
- Design of a light-tight carbon fiber box for the prism with a disconnect method
- Mechanical support for the readout that would also include services

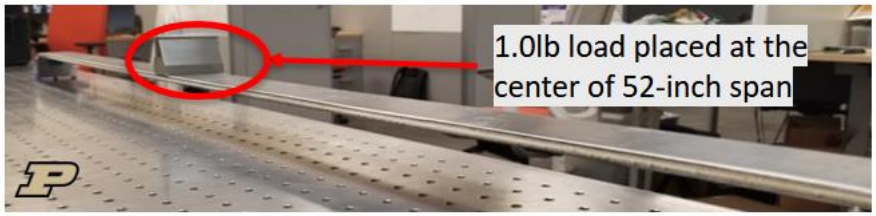


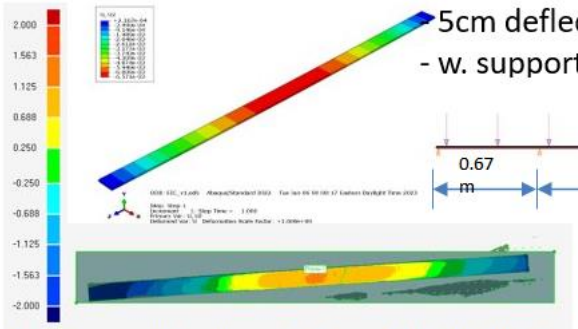
AC-LGAD (Barrel)



AC-LGAD (Barrel) Details

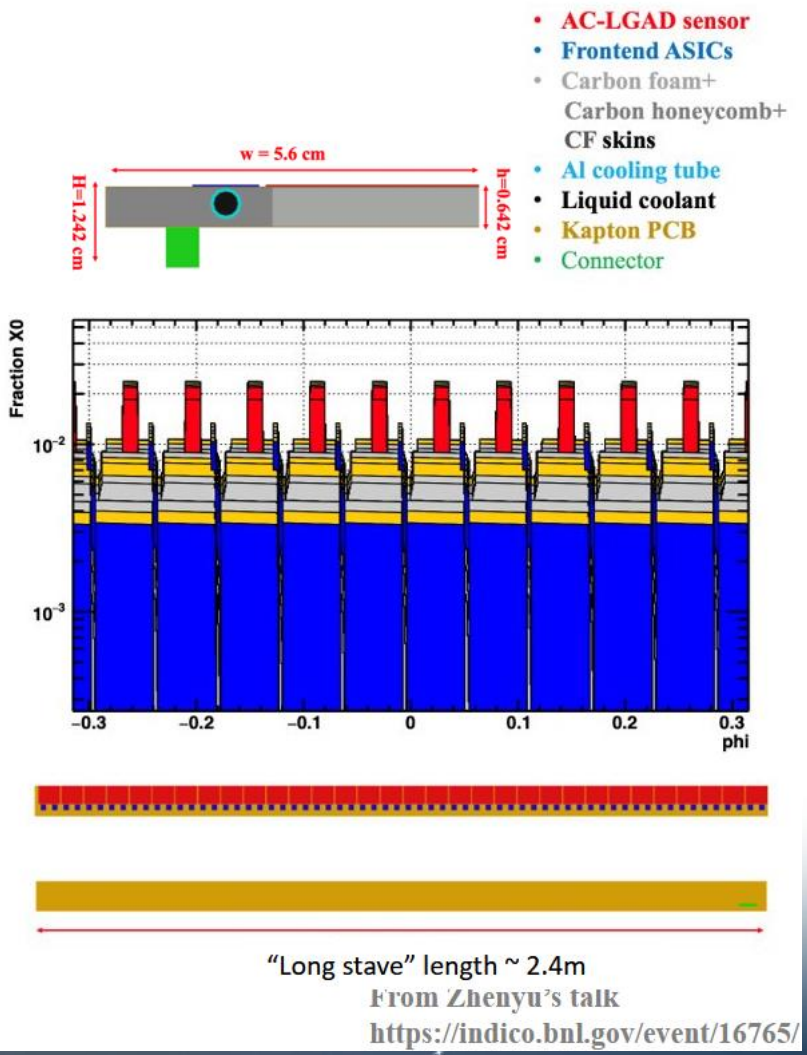
- Total of 144 barrel TOF modules
  - 9216 sensors, 18,432 ASICs, 2.4 M channels
  - Mass ~70kg and 4kW heat load
- 1st Preliminary stave structure made
  - FEA and prototype for full length
  - Deflection of 700 micron – further optimization possible





Unit: mm

Top-down view of the loaded stave.

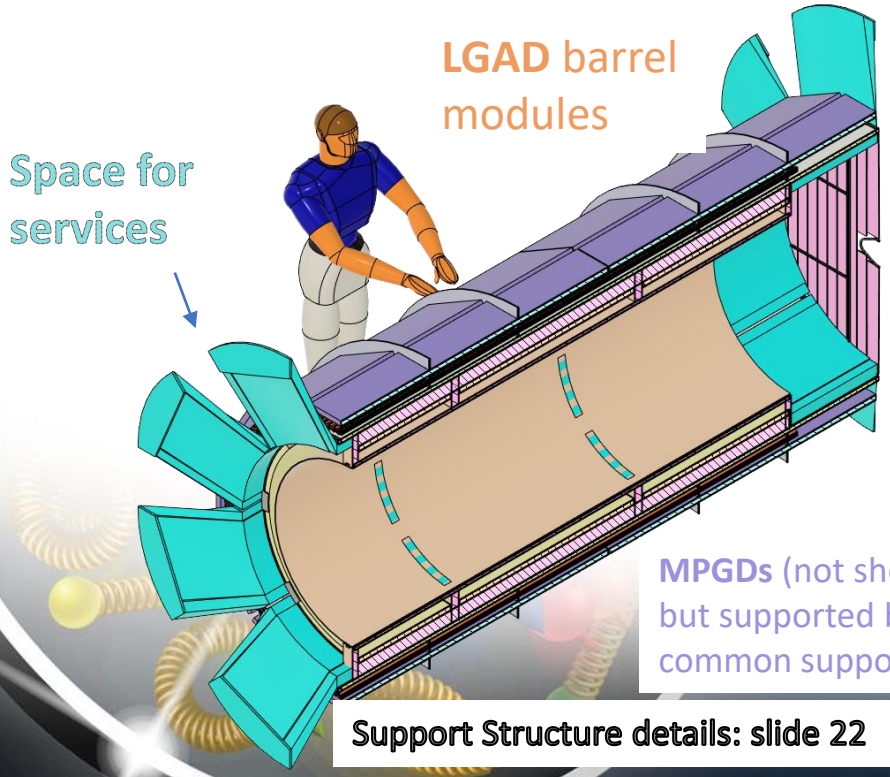


"Long stave" length ~ 2.4m

From Zhenyu's talk
https://indico.bnl.gov/event/16765/

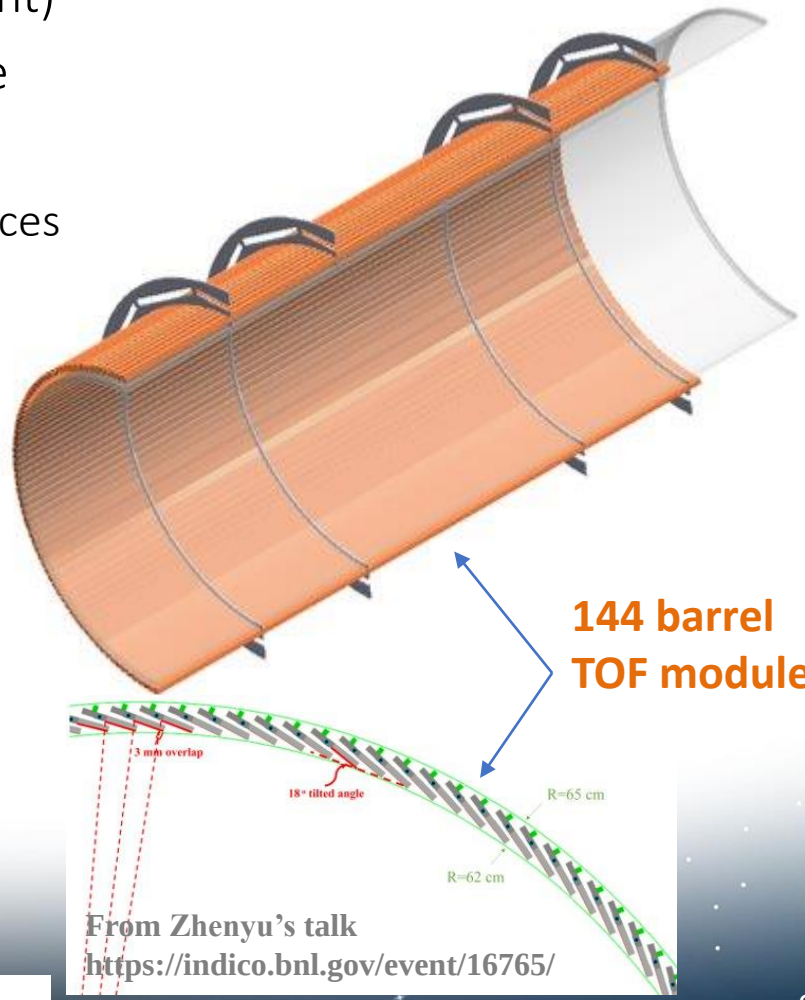
AC-LGAD (Barrel)

- Use similar concept of STAR IST (starting point)
- LGADs supported by “long staves”, next slide
- Common support structure
  - Barrel TOF, MPGDs, space & support of services



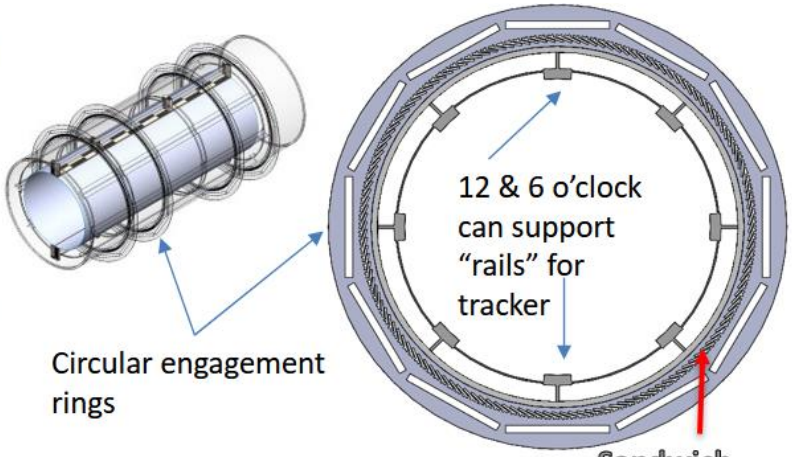
MPGDs (not shown) but supported by common support

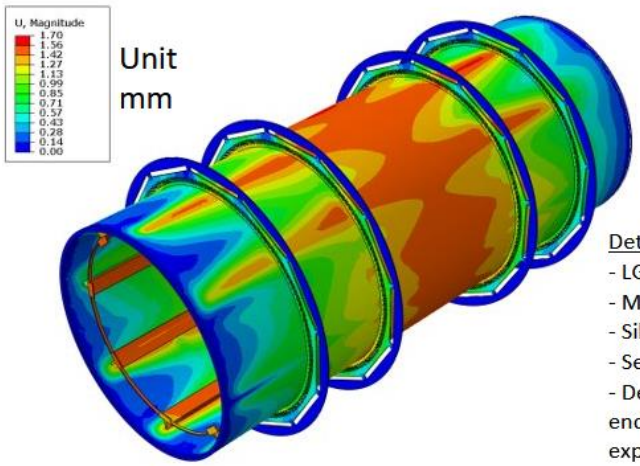
Support Structure details: slide 22



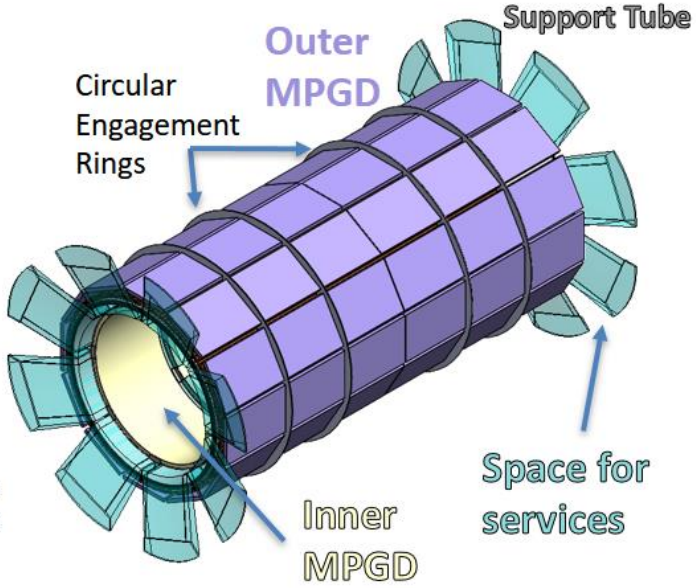
AC-LGAD (Barrel) Installation & Support

- **Concept idea of joined mechanics structure for barrel TOF, inner & outer MPGD layers, services, and even tracker**
  - 1+8+1 mm sandwich composite structure w "end-rings" to support beam pipe during installation & integration
- Integration
  - Move/Place end cap TOF closer to dRICH to ease access to inner tracking volume
  - "Rail" system (internal and external) to support half-cylinders for tracker installation after barrel TOF system is in place
- First preliminary FEAs for this design
  - 1.7mm deflection and weak regions at engagement rings – needs to be optimized!



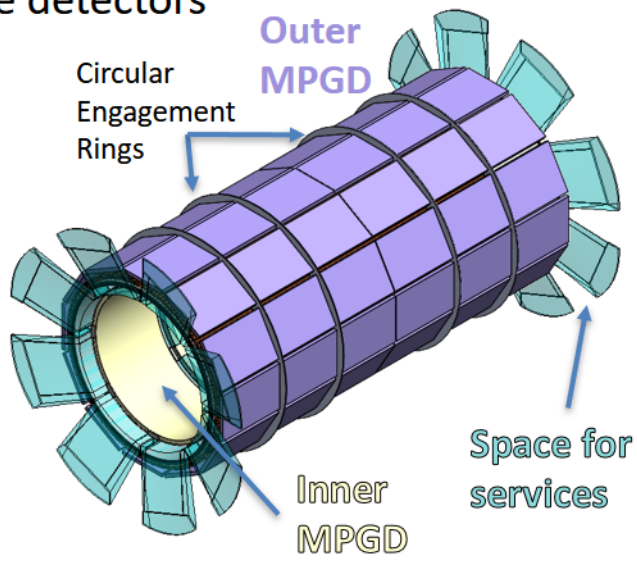


Details:
- LGADs = 70 kg
- MPGDs = 24 + 24 kg
- Silicone tracker = 10 kg
- Services (smeared) = 100 kg
- Designed engagement rings, end rings following CMS experience at Purdue

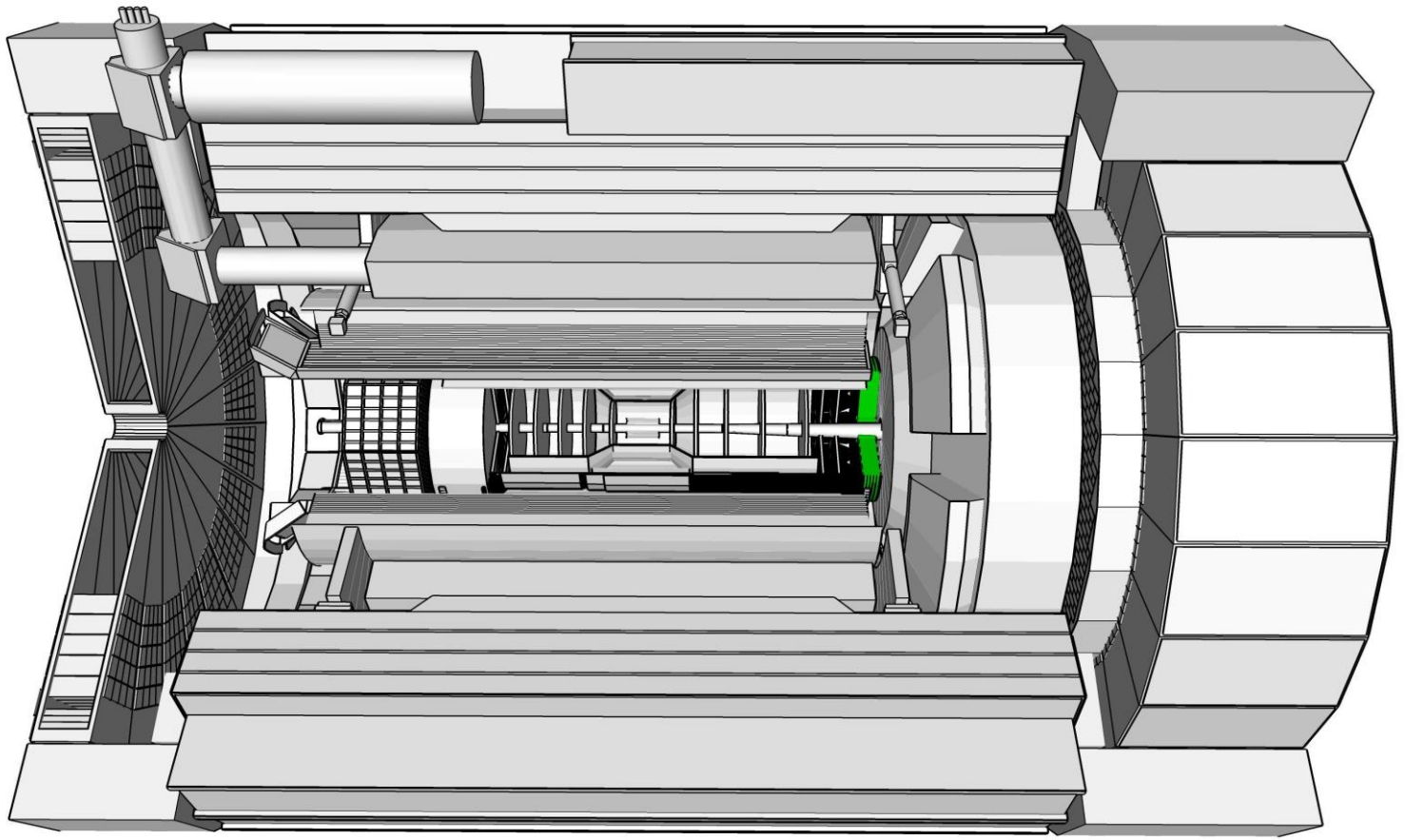


AC-LGAD (Barrel) Design Summary

- **Current concept of joined mechanics structure for barrel TOF, inner & outer MPGD layers, services, and even tracker**
  - First design and FEAs are done, optimizations needed to structure
  - **Reduced mass by using a common structure for all**
  - First preliminary FEAs for this design show its doable
- Integration
  - Design allows for integration of multiple detectors
- First real prototype of a barrel stave
  - Manufacture 3-5 more staves with cooling pipes & study "cooling solution" by mock heaters
  - On schedule to meet targets for CD2 in Jan 2025

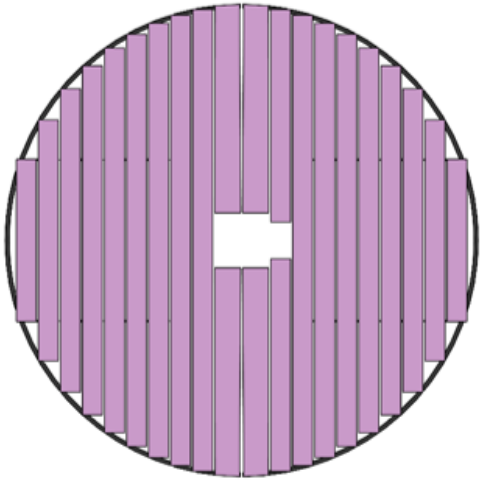


AC-LGAD (Forward)

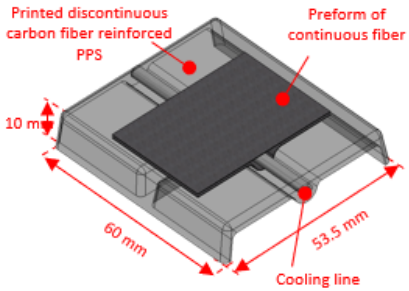


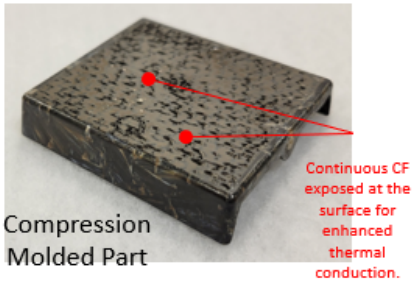
AC-LGAD (Forward) Details

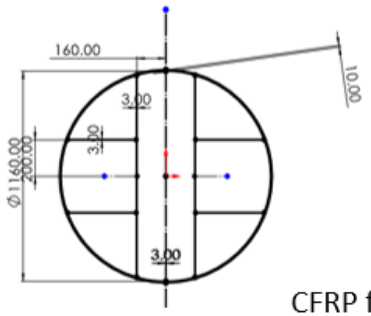
- Material budget critical for performance of dRICH
  - Heat load: 13.6 kW (Aim for 1mW / channel)
  - 5% material budget and possible to reduce to 2.5% w advanced composites
  - Detailed X_0 studies under way
- Following two design choices
  - More "traditional" composite structure with sandwich + metal thin pipes
    - Re-use "staves" or wedges
  - Cutting-edge: "no-pipe" design

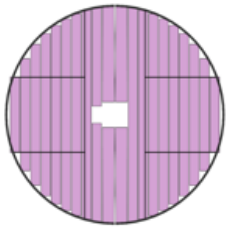


front







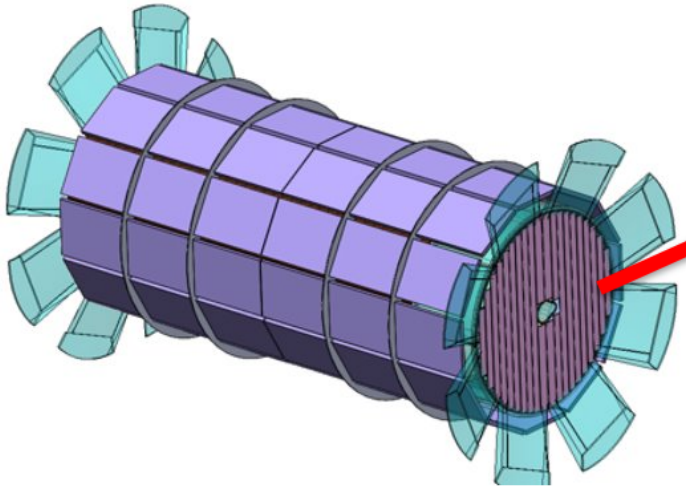


back

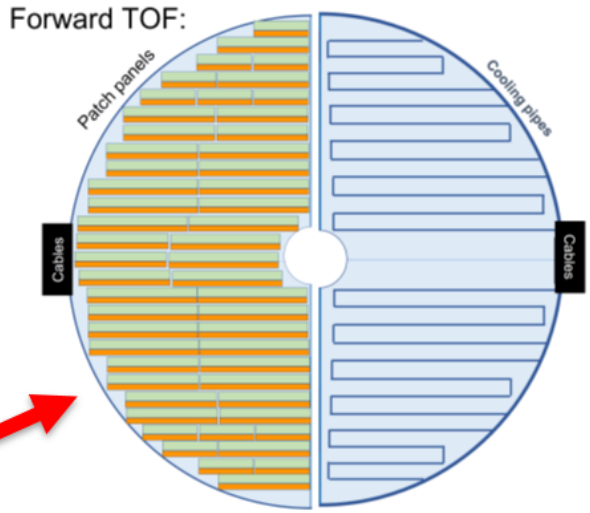
CFRP face sheets and integrated cooling stave structure

AC-LGAD (Forward)

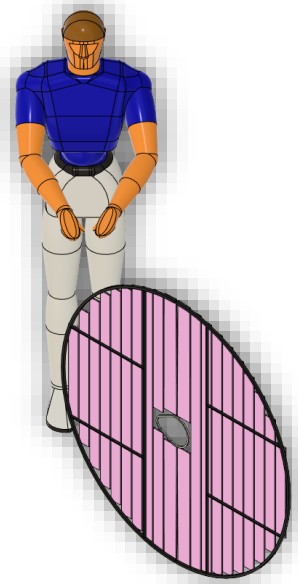
- Endcap TOF supported by common structure supporting barrel TOF system
- Under study: Integration & access to tracking volume eased if endcap TOF moved in front of dRICH



- "Clam shells" or DEEs
  - Convenient for installation/maintenance
  - Each is patched by TOF modules (one or more types) on both faces
  - No backward TOF



From the talk of Wei Li
https://indico.bnl.gov/event/16742/



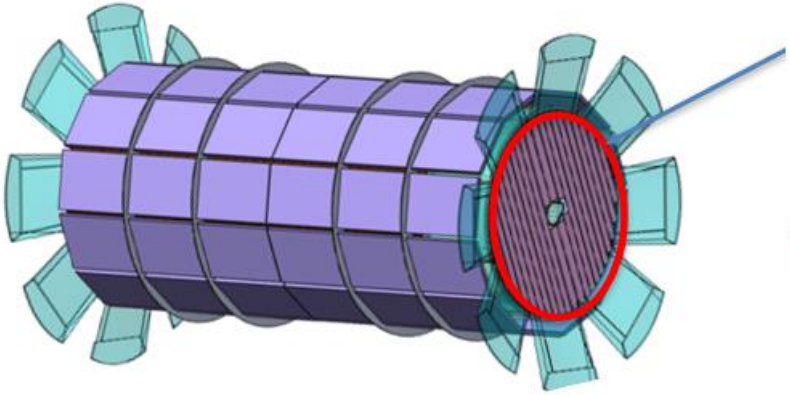
Power Budget

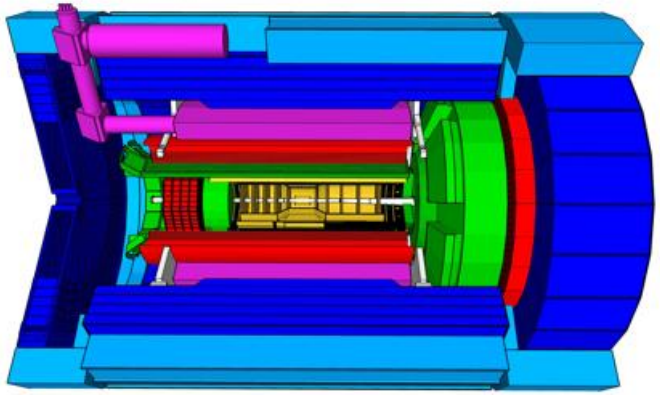
	Endcap TOF [kW]
Sensors	0.6
ASIC	8.5
DC-DC	3.5
lpGBT, VTRx+, SCA	0.5
Power cables	0.5
Total	13.6

AC-LGAD (Forward) Installation & Support

- Barrel TOF support structure allows for support of endcap TOP
  - Design for “end-rings” to support endcap TOF and temporarily support beam pipe during installation

End ring structure on either ends to temp. support beam pipe and endcap

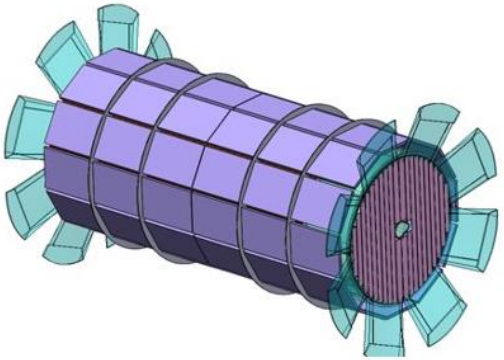


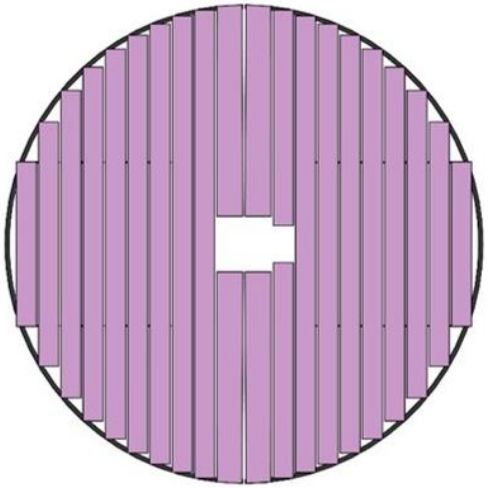


- Design of the ”end-rings” follows CMS experience at Purdue
- But, to ease access mounting at/near dRICH is being investigated

AC-LGAD (Forward) Design Summary

- Material budget of endcap TOF critical
  - Two design choices: “standard” composite vs cutting edge ”no-pipe” design
  - Aim to reduce material budget: 5% to 2.5%
  - Barrel TOF support structure allows for support of endcap TOF
- Integration
  - Supported directly by barrel TOF structure or – to ease access to tracker volume – move closer to dRICH
- First larger prototype of standard composite support within next 12 months
  - On schedule to meet CD2 schedule





Q&A