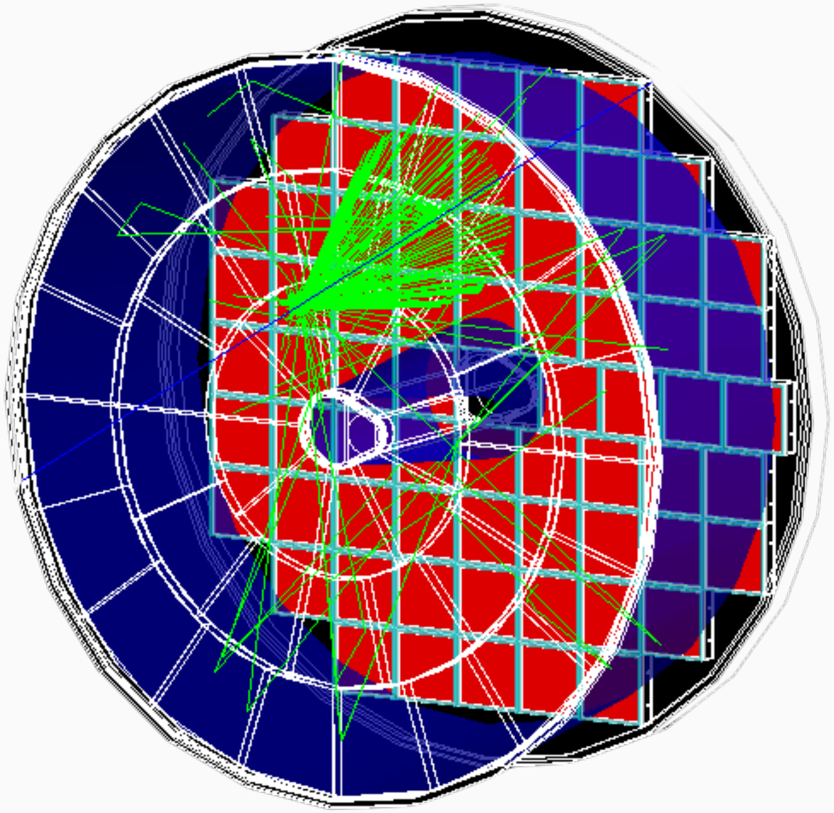
Stony Brook University | Jožef Stefan Institute | CHIBA UNIVERSITY | MISSISSIPPI STATE UNIVERSITY

Mechanical Design, Integration, Aerogel



ePIC pfRICH:

- ❑ Rapid design progression while maintaining CAD and Simulation agreeance
- ❑ Utilization of existing design methodologies where possible
- ❑ Services are being developed concurrently to be added into the final model

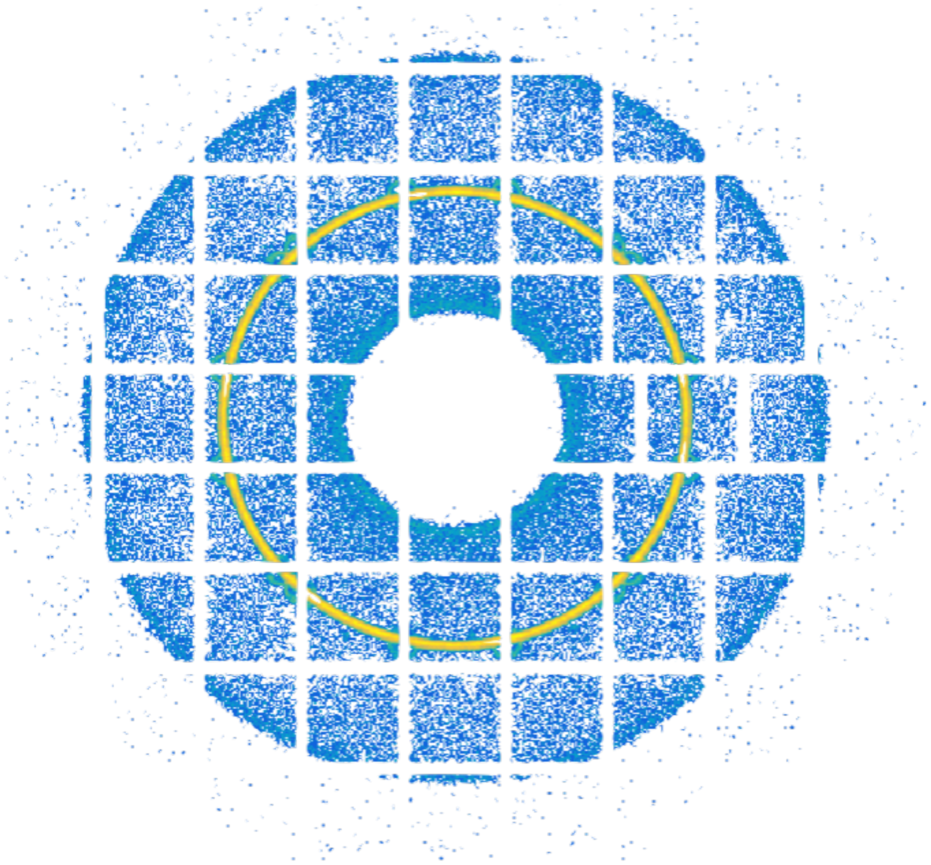
Alex Eslinger (JLAB)
Alexander Kiselev (BNL)

Brookhaven National Laboratory | INFN | Jefferson Lab | TEMPLE UNIVERSITY | Duke UNIVERSITY | Yale

Charge Topics addressed in this Talk

6. **Integration**:
   1. **Status of the proposed detector integration** into the current baseline detector?
      1. z-space and effect to tracking: in coordination with the tracking DWG, produce backward momentum resolution for the tracker that fit into the z-spaced allowed by the proposed RICH detector
      2. Material effect to backward EMCal: in coordination with the calorimeter DWG, produces electron lineshape in the backward EMCal with the proposed RICH detector in front.
   2. Status of the **design of the electrical/electronic infrastructure** (channels, power supplies, heat, rate)?
   3. **Cooling** strategies?

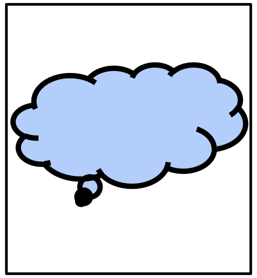
4. **Aerogel Radiator**
   1. Status of **radiator selection**
   2. **Status of the radiator** development and related potential issues?
   3. **Perspectives of radiator mass production** and timelines for the production period?



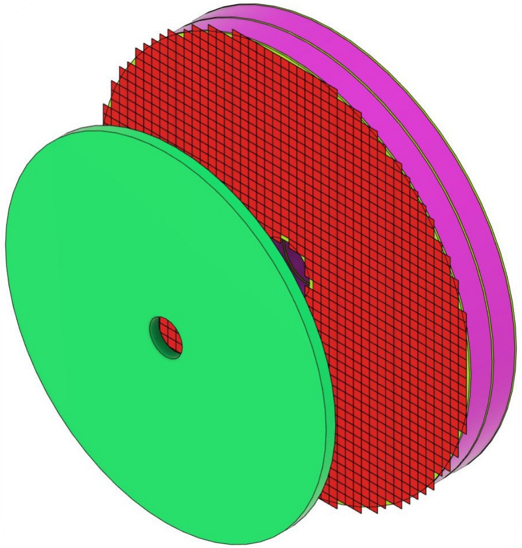
Mechanical Design

Design Progress

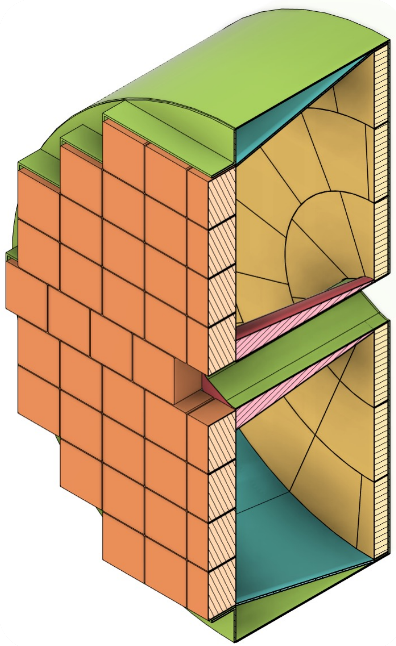
- Fully implemented in GEANT4



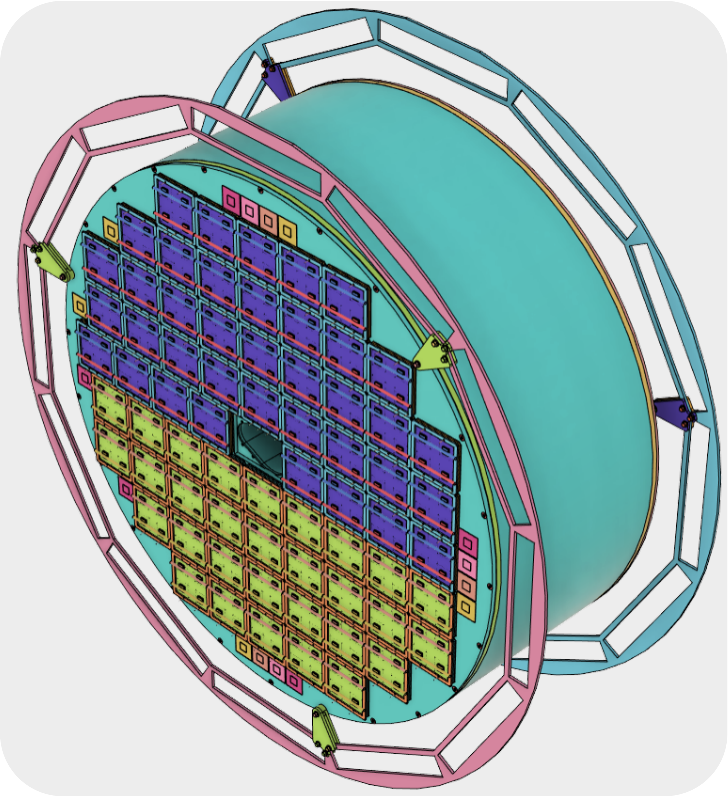
October 2022



Early November 2022



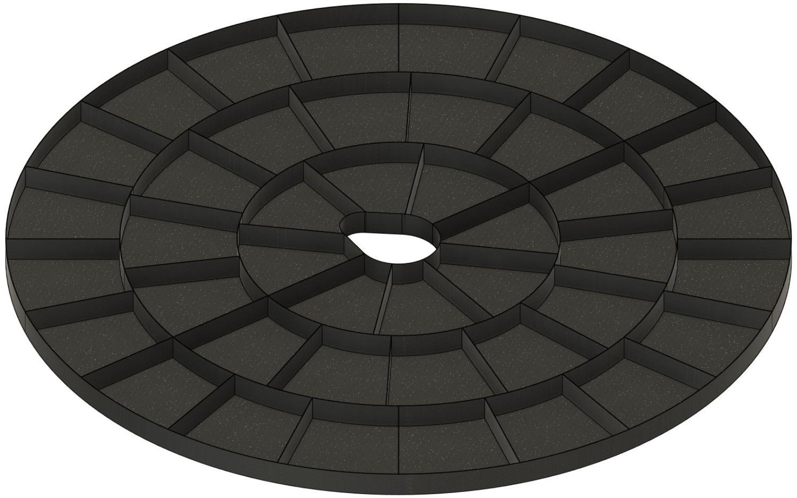
Mid December 2022

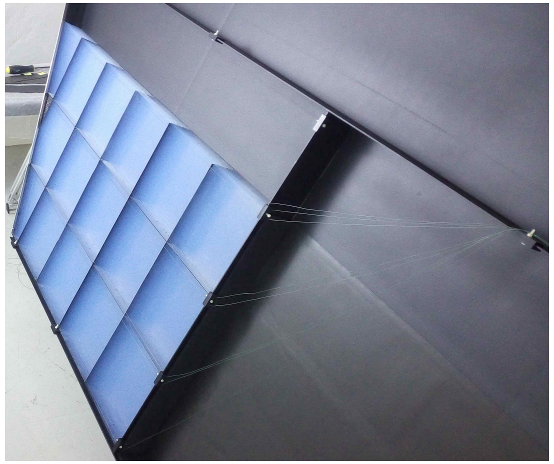


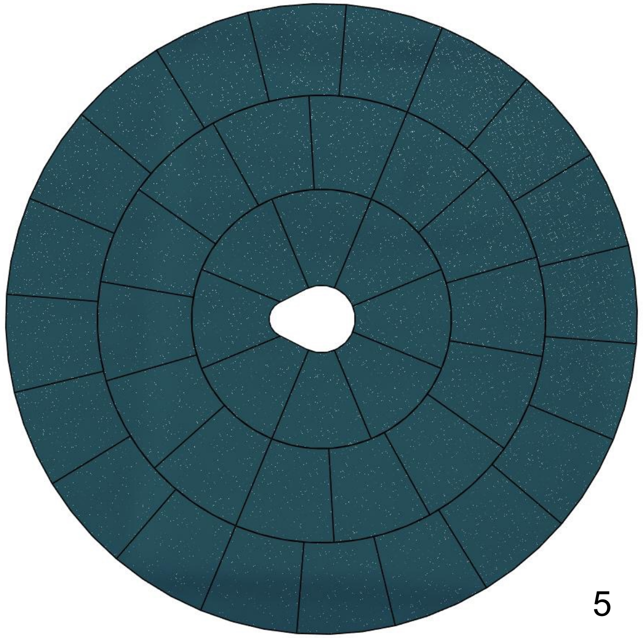
Today

Aerogel Wall Details

- Material: Carbon Fiber Disc/Dividers (~0.5mm thickness).
- Dimensions:
  - Outer Radius -> ~62.5cm
  - Inner Dimension -> Beam pipe flange + 5mm clearance for installation.
- More Details:
  - Thin clear filament to be strung across the grid to hold tiling into place. (Detail not shown; conceptual)
  - Estimated weight: ~1.8kg

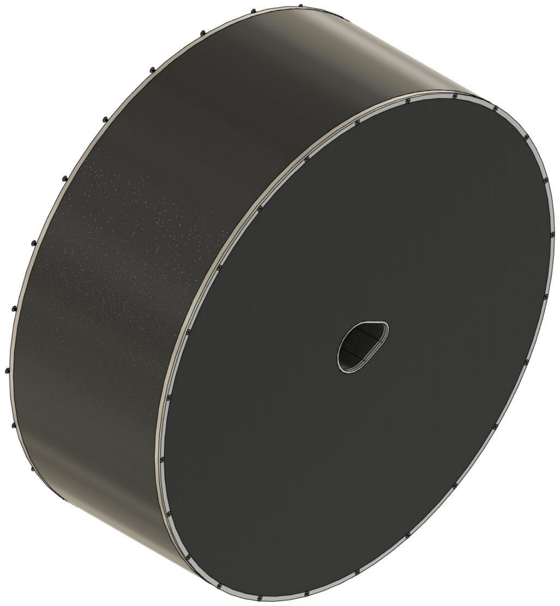






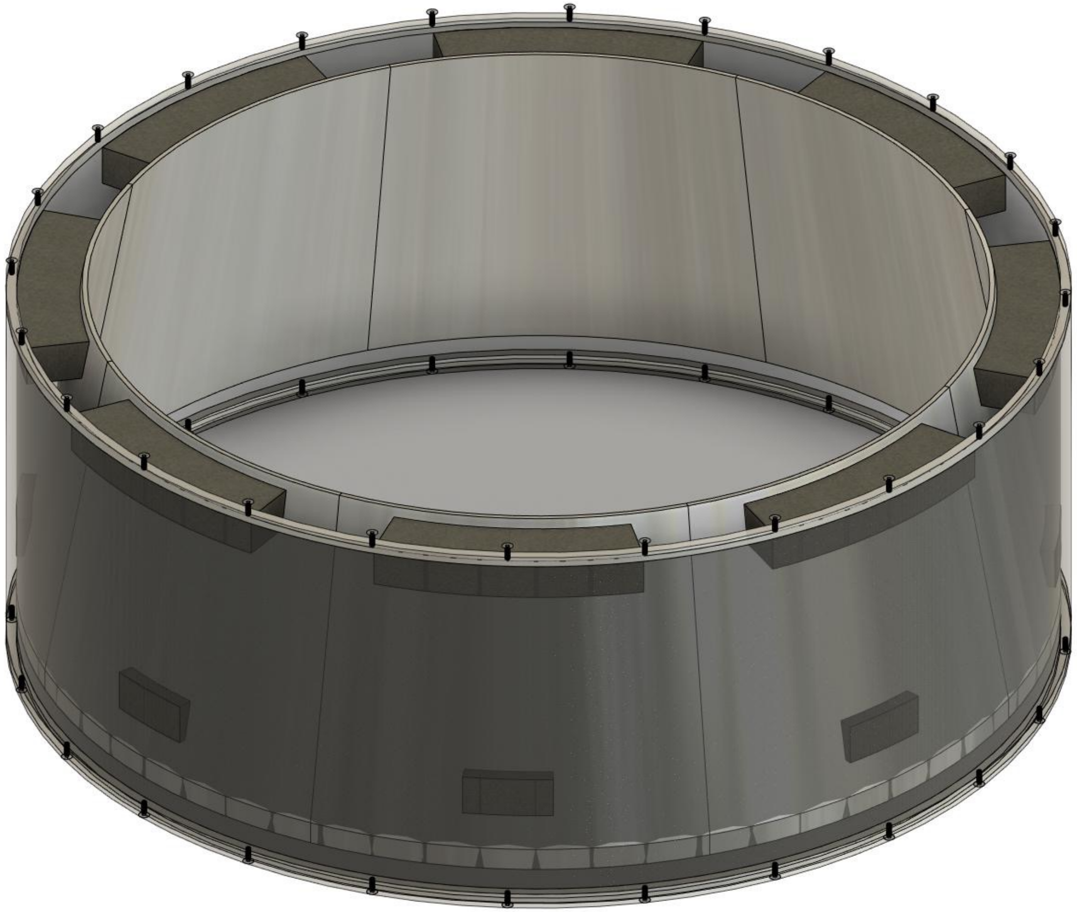
Containment Walls

- Material: Carbon Fiber Sandwich Structure with PEEK rings around the edge
- Dimensions:
  - Outer Radius -> ~63.8cm
  - Inner Dimension -> Beam pipe flange + 5mm clearance for installation.
- More Details:
  - Front Wall and Inner Wall thickness = ~1/4” (6.35mm)
  - Outer Cylindrical Wall thickness = ~1/2” (12.7mm)
  - Aluminum sealing rings around outside perimeter are 1/2“ (12.7mm) in size
  - PEEK around beam pipe are 1/4“ (6.35mm) in size
  - Estimated Total (with hardware): ~10.7 kg



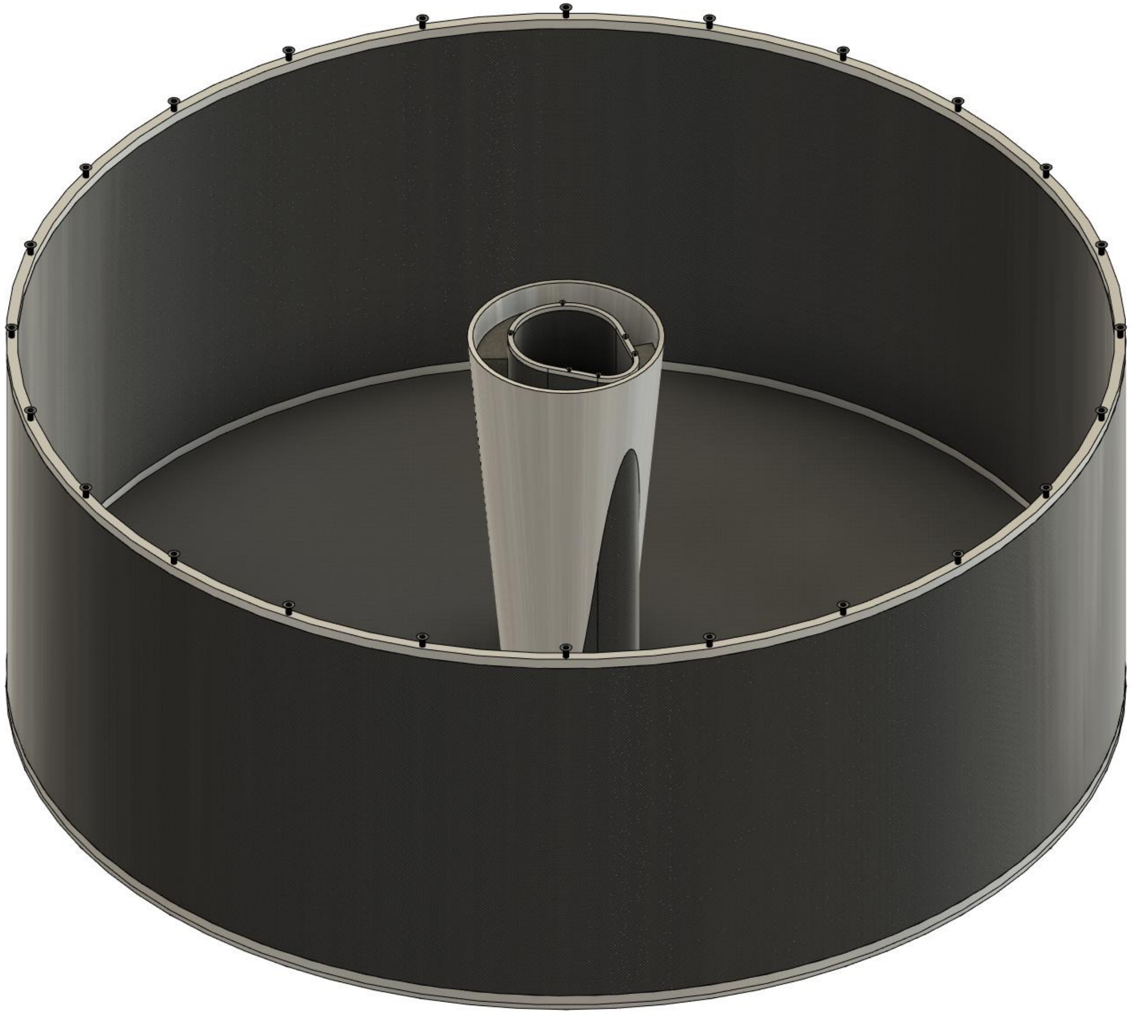
Outer Conical Mirror System

- Material: **Carbon fiber sandwich with reflective surface (~1/4” [6.35mm] thick)**
- Dimensions:
  - Upstream Radius: ~62.4cm
  - Downstream Radius: 54cm
- More Details:
  - Intended to be segmented into **8 sections** radially
  - Mounting points will be provided by machinable foam pads around the circumference
    - Current thought for foam is polyurethane foam available in different densities
    - 3 mounting points per mirror segment
  - Mirrors have a tapered section as they approach the aerogel to maximize internal space
  - Weight per mirror (total): ~0.3kg (~2.5kg)



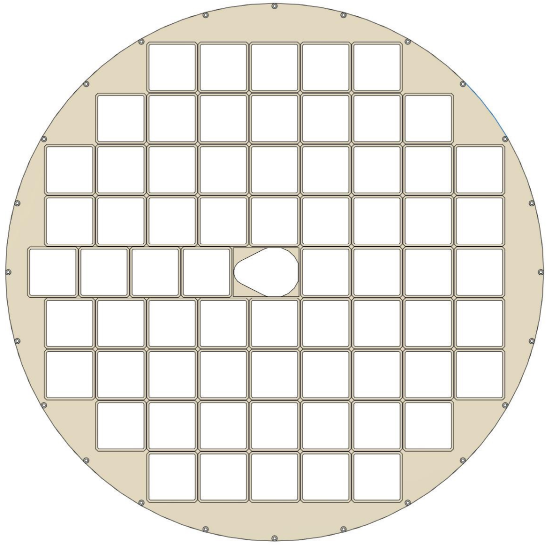
Inner Conical Mirror System

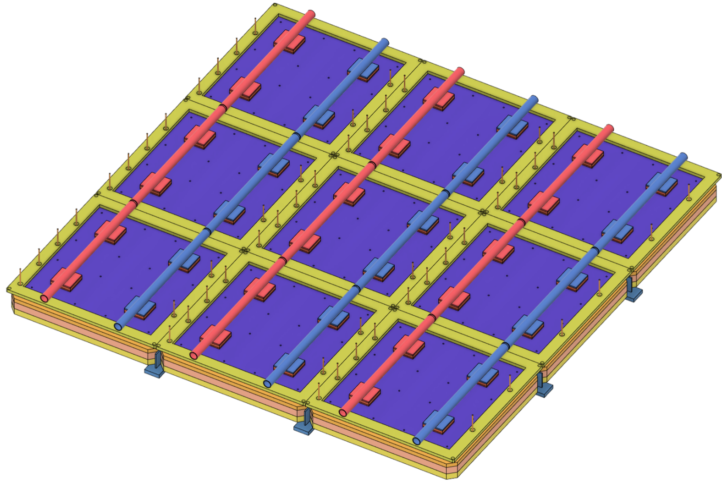
- Material: **Carbon fiber sandwich with reflective surface (~1/4” [6.35mm] thick)**
- Dimensions:
  - Upstream Radius: 66 mm
  - Downstream Radius: 12 cm
- More Details:
  - Mirror cut around the inner containing wall creating a saddle shape
  - Mounting points will be provided by machinable foam pads around the inside circumference
    - Current thought for foam is a polyurethane foam available in different densities
  - Weight: ~0.4kg

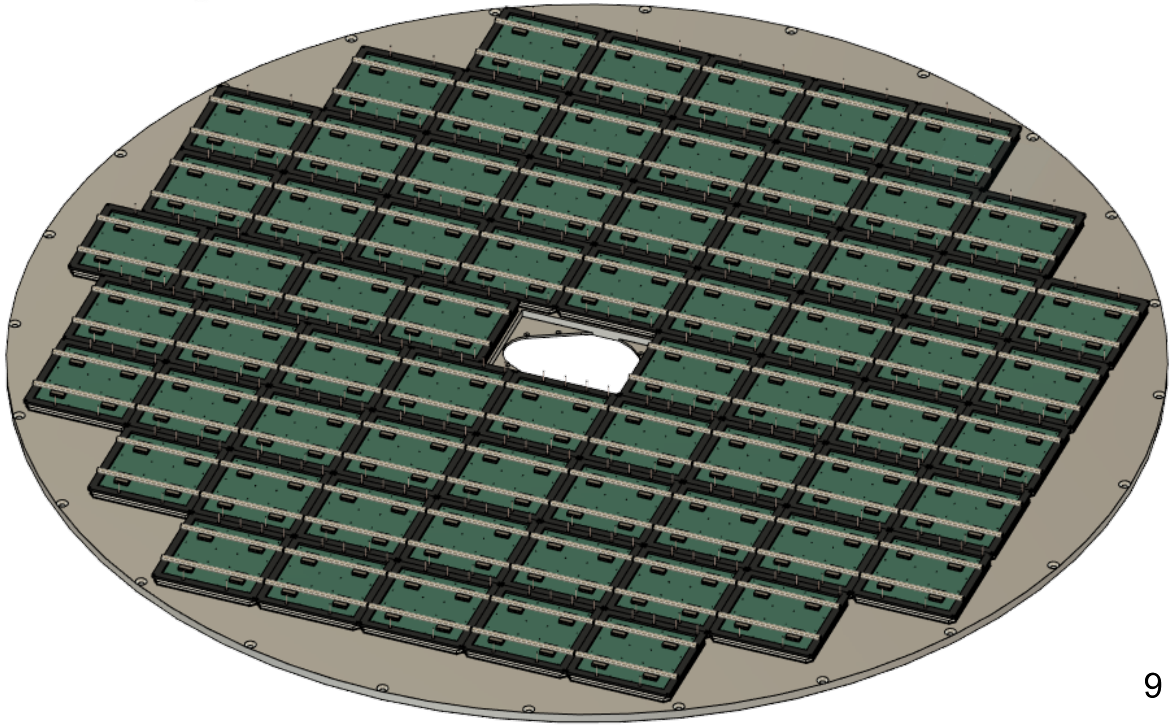


Sensor Wall/Grid

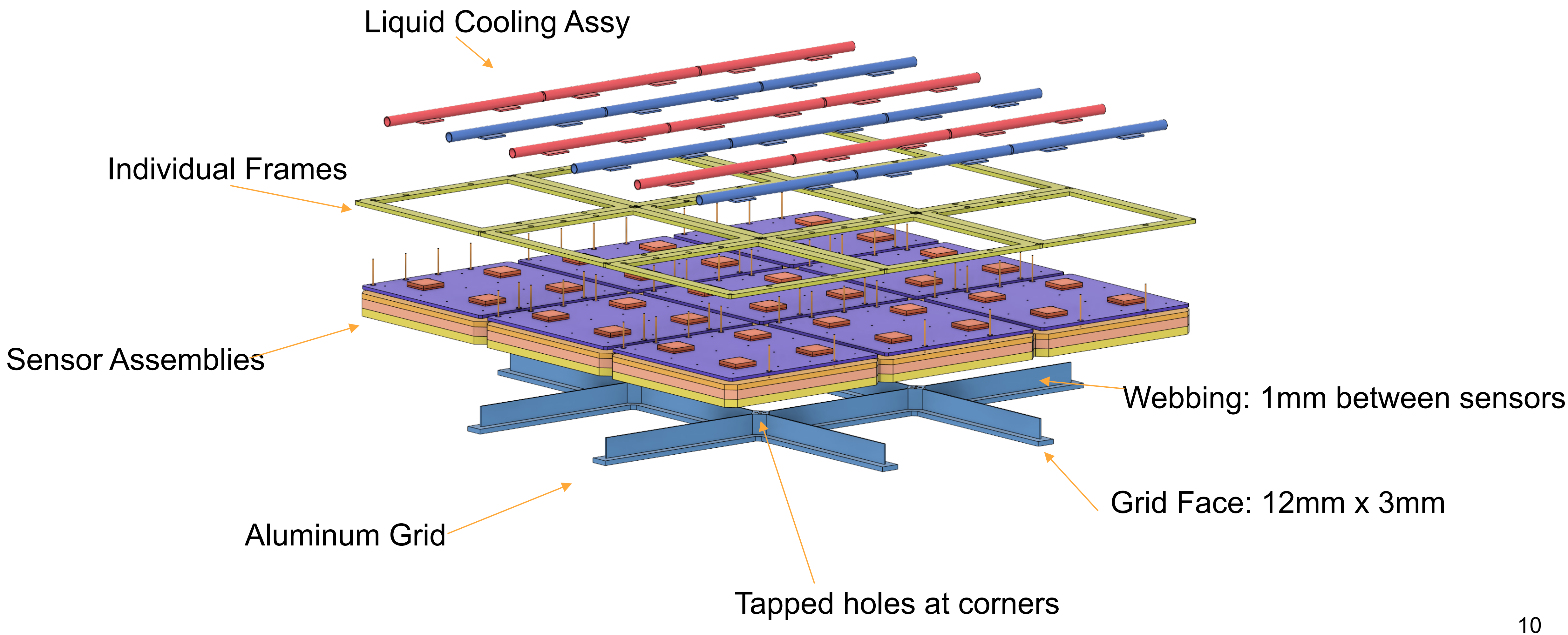
- Material: Aluminum (1/2” [12.7mm] maximum thickness)
- Dimensions:
    - Outer Radius -> ~63.8cm
    - Inner Dimension -> Beam pipe flange + 5mm clearance for installation.
- More Details:
    - 68 Sensors; 12cm x 12cm
    - Estimated weight for Aluminum Disc = ~10.7kg
    - Countersunk fasteners along perimeter allow bolting and sealing to center cylinder section of the containment structure.
    - Intended to be machined from one piece of aluminum for rigidity
    - Exterior frames hold in individual sensors
        - Allows for mounting of the pipes
        - Creates a more rigid structure
        - Intended to be standard 1/8” (3.175mm) thick material

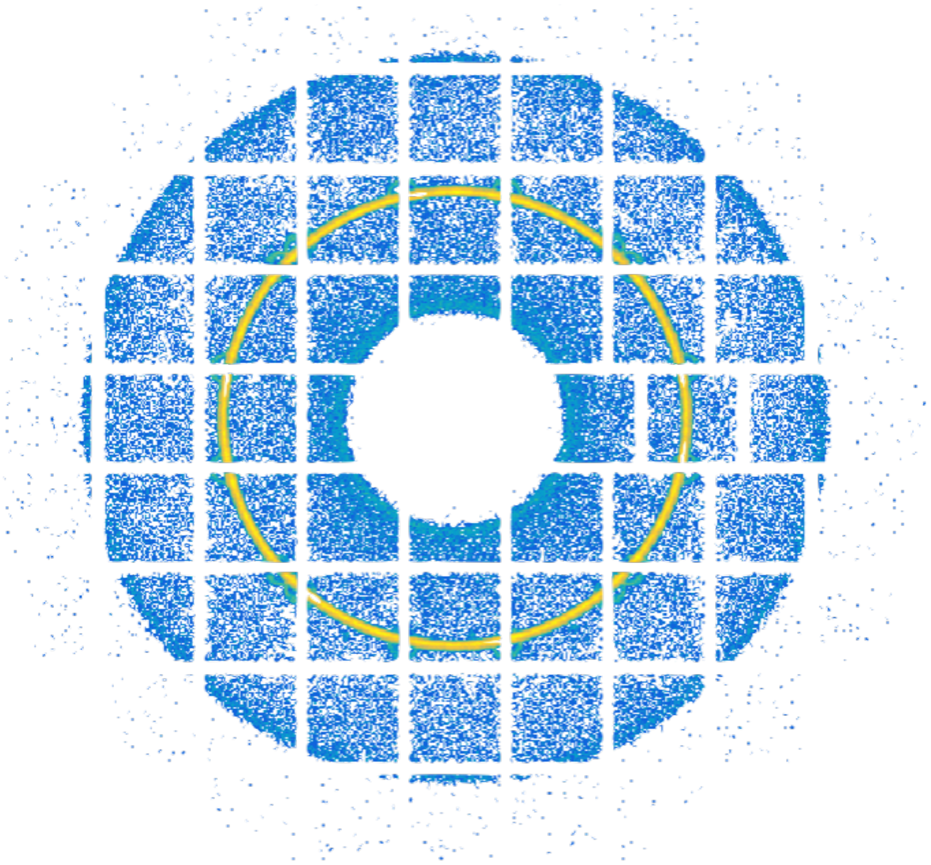






Sensor Wall/Grid (Cont'd)





Integration

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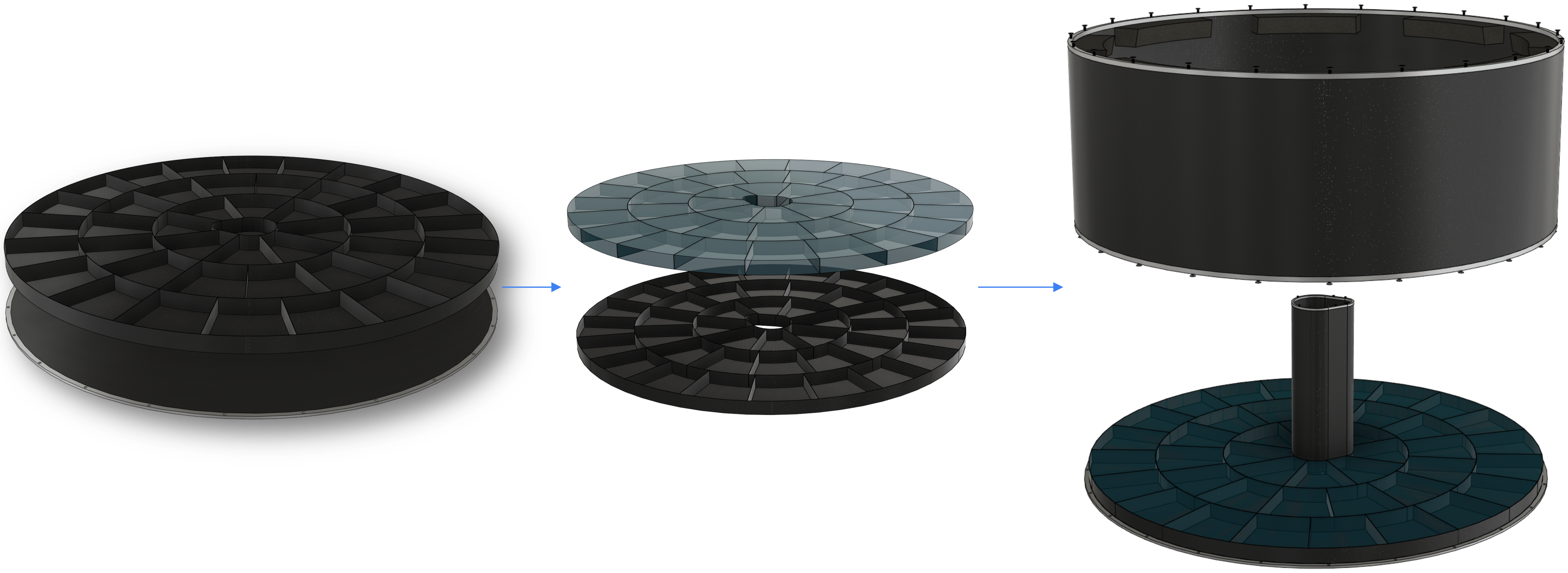
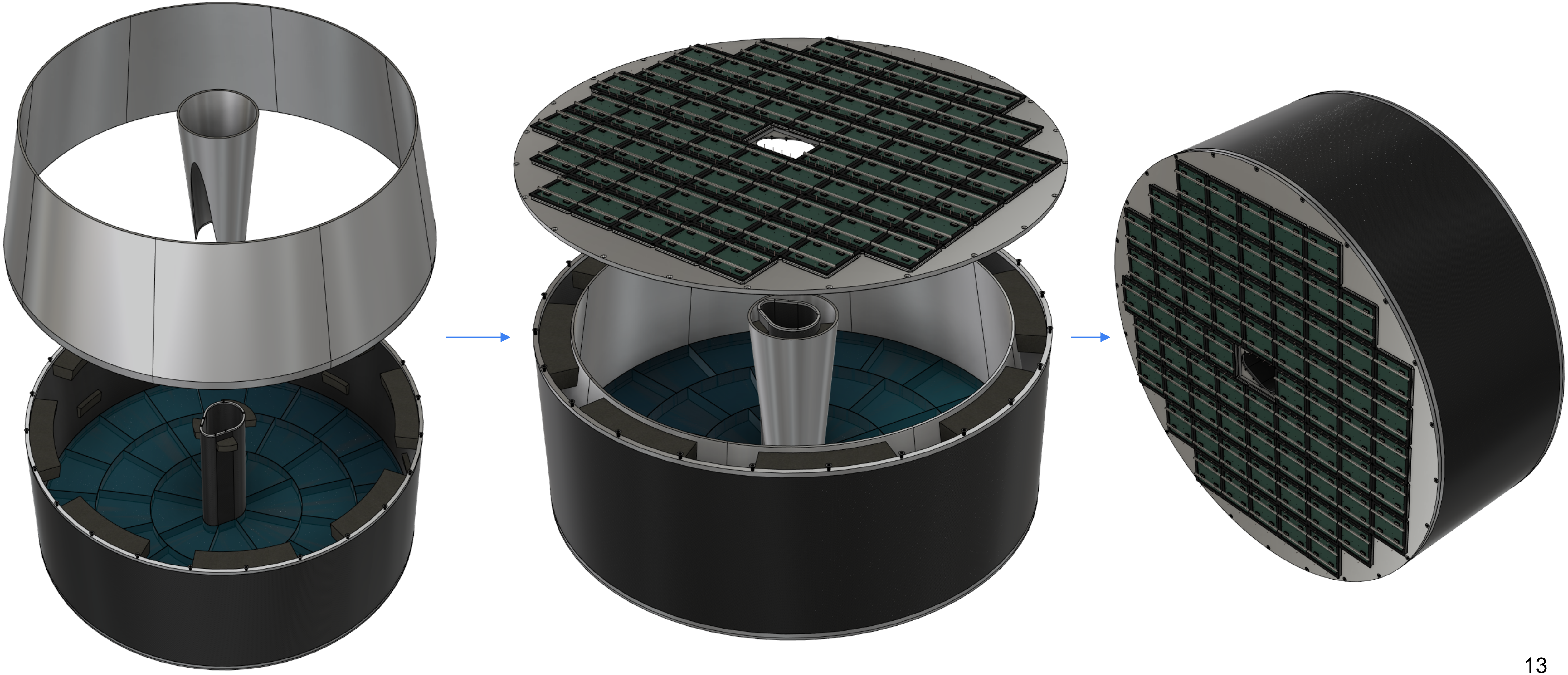
Detector Assembly

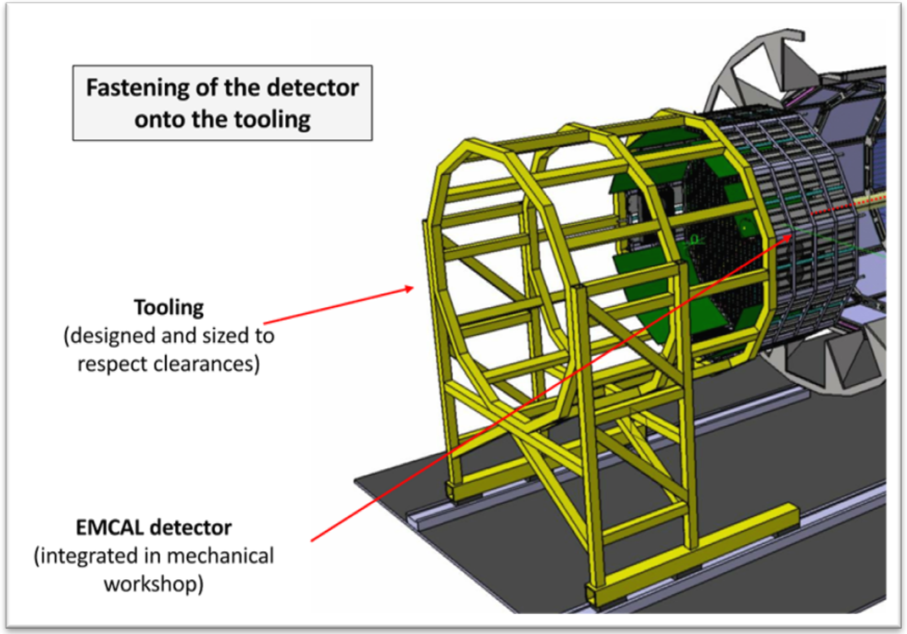


Detector Assembly (Cont'd)

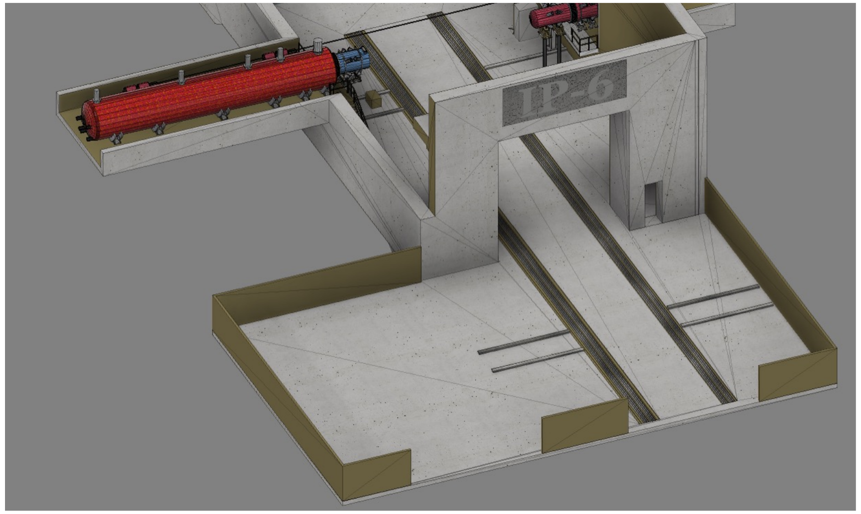


Detector Installation

- Backwards EMCAL is downstream of pfRICH and must be removed in the assembly hall due to space constraints
- pfRICH can collaborate with backwards EMCAL for tooling and railings
  - Utilize the same railings for both detectors
  - Backwards EMCAL estimated at 3T; pfRICH estimated at 100kg
- Install the detector in one piece on the tooling (to be designed)
- Utilize the aluminum sensor plate as a fixturing location for the tooling

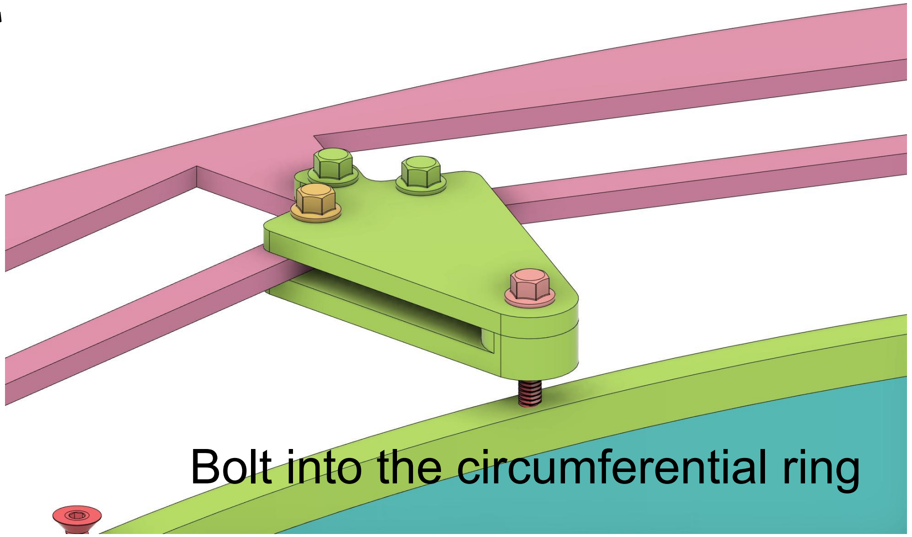


Obtained from J. Bettane's EIC Calorimetry Review slide on December 6-7, 2022.

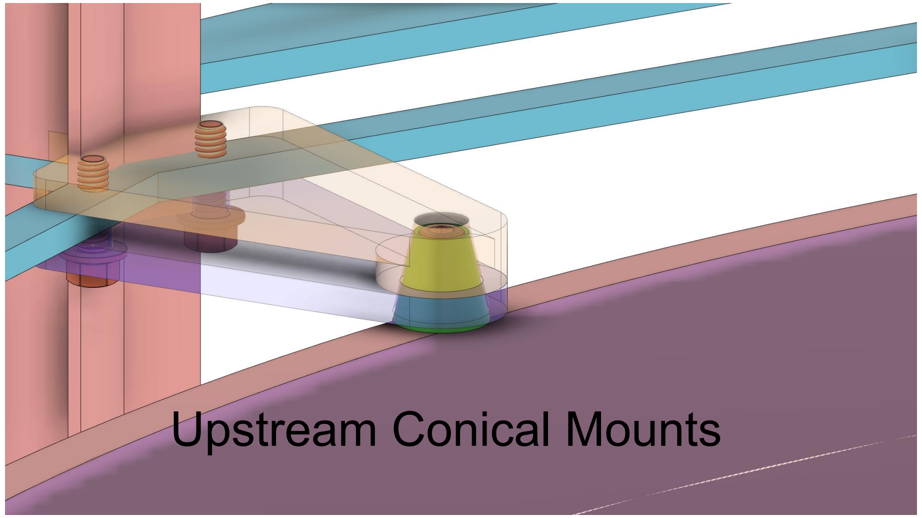


Detector Support

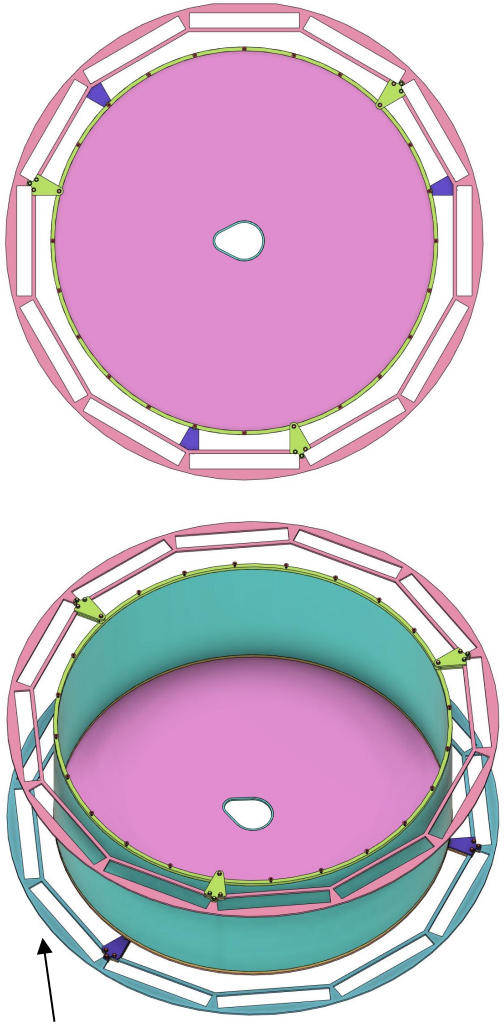
- Propose we add two additional rings into the DIRC structure at the specified locations.
- Conical mounting mechanism on the upstream side
- Bolt through into the half-inch circumferential ring on the downstream side
- Easily scalable depending on final requirements



Bolt into the circumferential ring



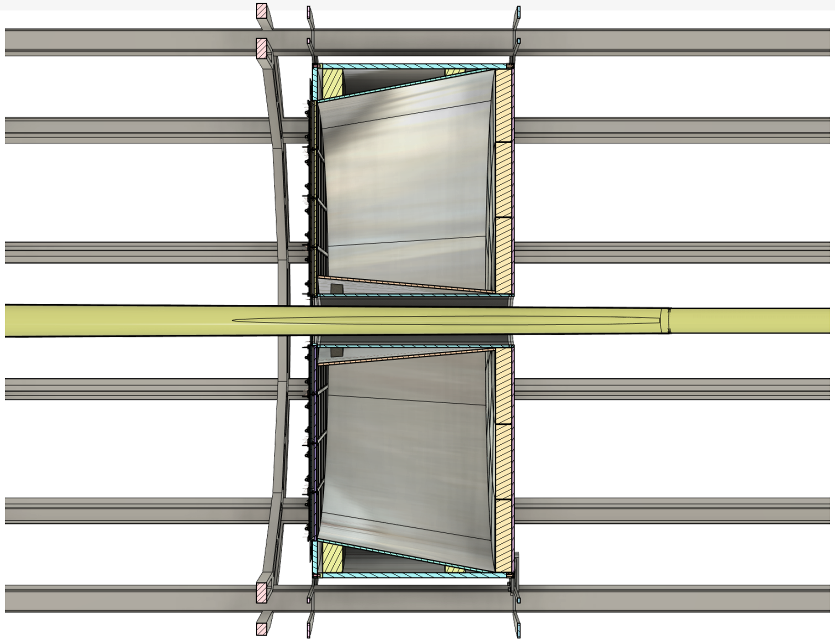
Upstream Conical Mounts

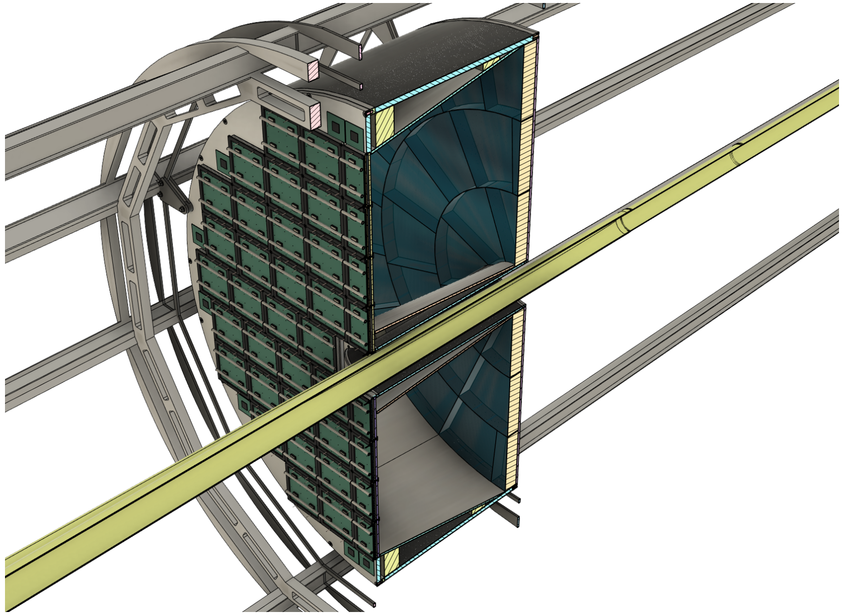


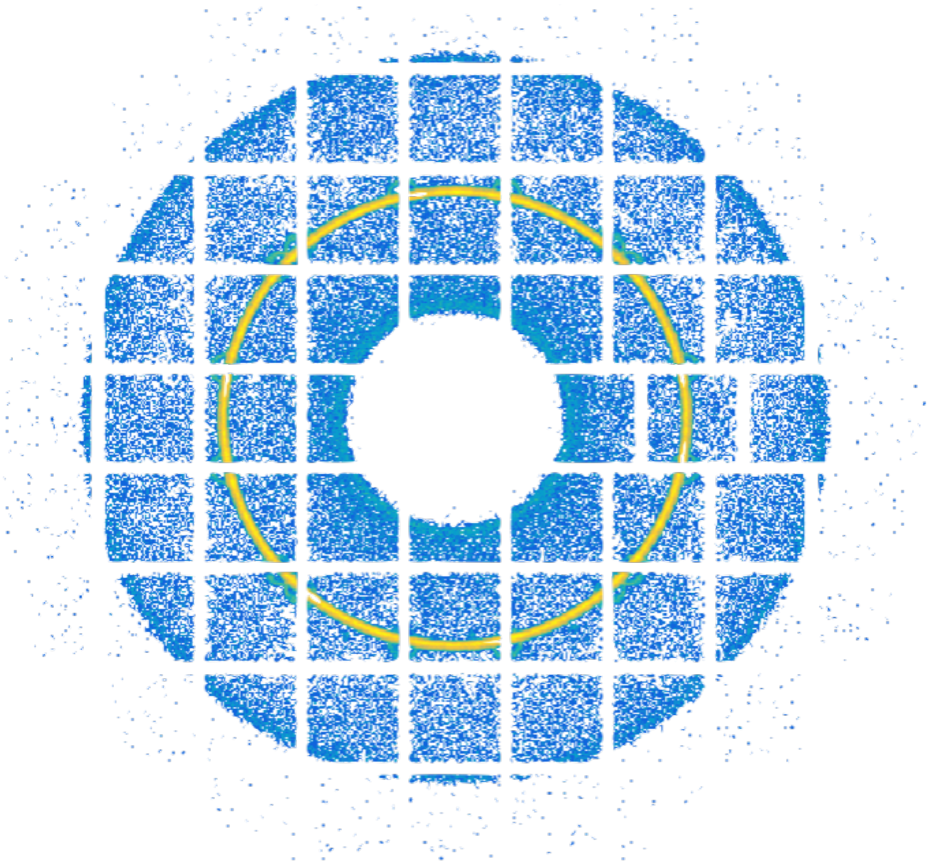
Proposed additional support rings

Design/Integration Summary

- Design has progressed rapidly from last October until now and ongoing collaboration means that the CAD design agrees with simulation software
- Sub-assemblies are developing details that can be translated toward a final design
- Assembly plans, installation, and support structures have been conceptualized and are ready to be developed further
- Industry is starting to give design feedback as we reach out to discuss manufacturing options during market research

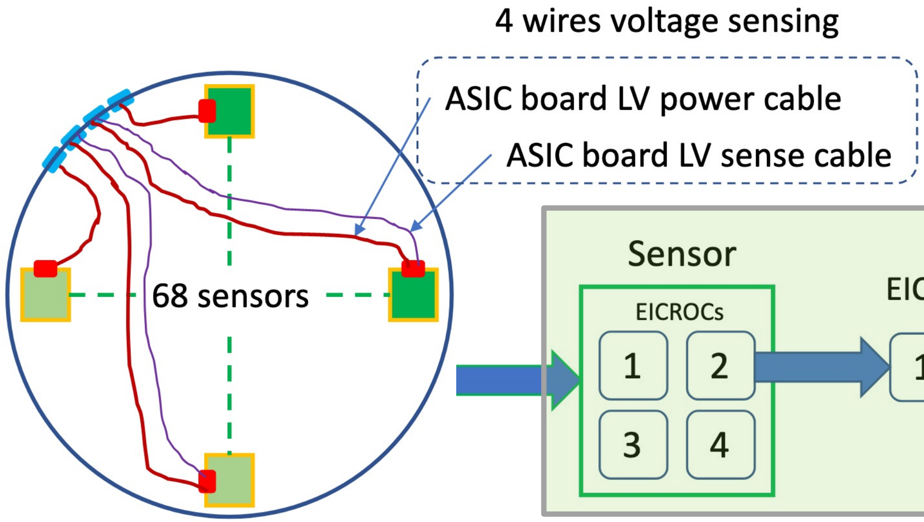




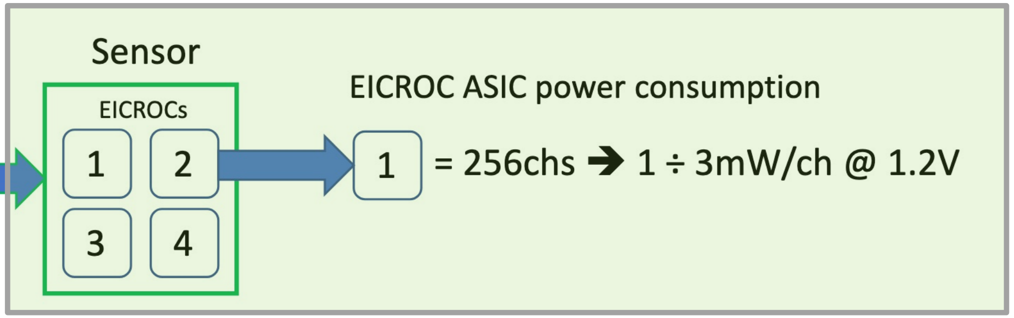


Services

Low Voltage System

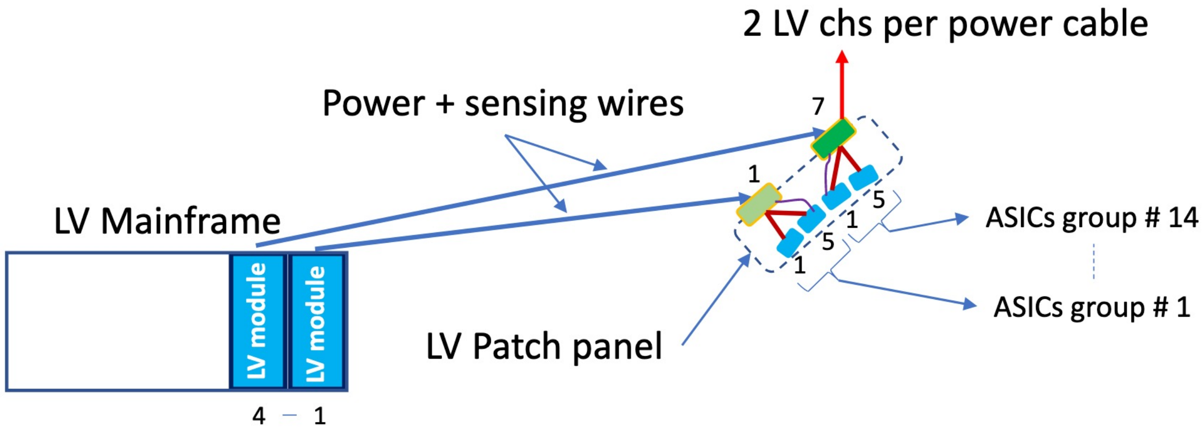


Wiener LV mainframe and modules



by Saverio Minutoli (INFN Genova)

- Each Sensor
  - 4EICROCs x 256chs = 1024chs/sensor ➔ @3mW/ch ➔ ~3W/se
- Whole detector
  - 68sensors x 2.5A ➔ 170A@1.2V ➔ 204W
  - Add 20% extra current for the ancillary electronic components
    - 170A + 20% = 204A@1.2V ➔ 245W
  - Add 20% extra current for safety margin
    - 204A + 20% = **245A@1.2V** ➔ **294W**

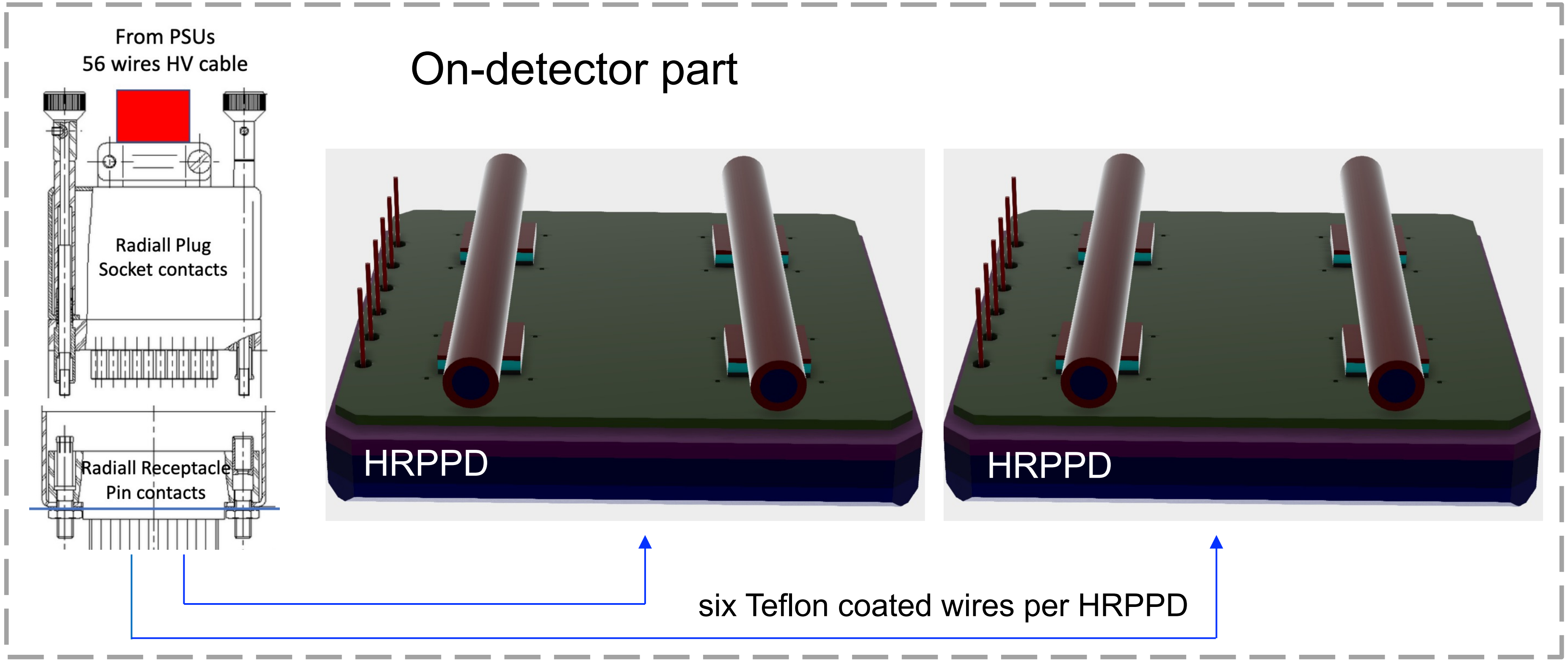


Fully costed; on-detector part implemented in GEANT as an effective copper layer

High Voltage System

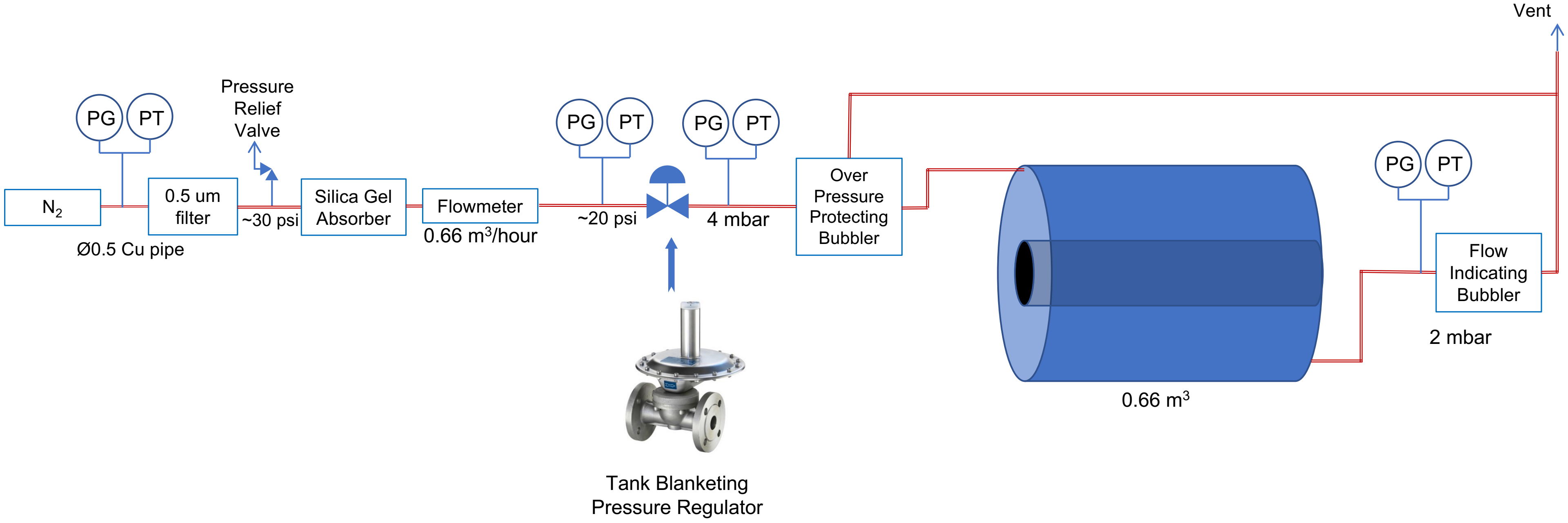
by Saverio Minutoli (INFN Genova) and AK (BNL)

- CAEN HV mainframes and *stackable* HV modules
- CERN-approved Radiall connectors



Fully costed; on-detector part implemented in GEANT as an effective copper layer

Gas System



by Prashanth Shanmuganathan (BNL)

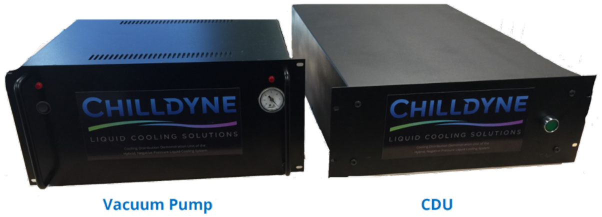
- ➢ Assume nitrogen only configuration
- ➢ One volume exchange per hour at a pressure 2-4 mbar

Fully costed

Cooling System

Off Detector

- Chilldyne Circulator
  - 8 lpm
  - -10 psi
  - 5°C to 40°C



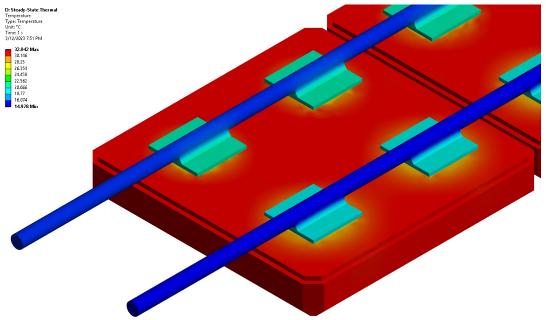
- Polyscience Chiller
  - 9.8 l/min @ 43.4 psi
  - -20°C to 40°C ±0.1°C
  - 800 W @ 10°C

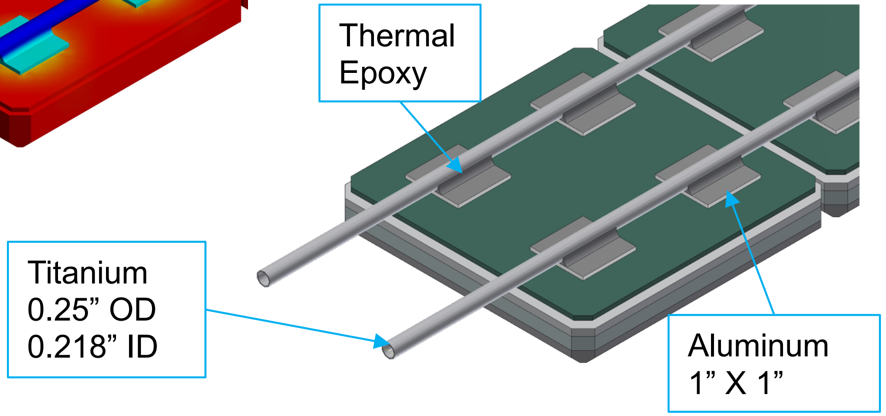
- Distribution Panel
  - Flowmeters
  - Flow Transmitters

On Detector

- Heat dissipation: 400W
- Tube @ Δ2°C: ~3 lpm
- ΔP ~0.25 psi

- 9 Modules:
  - ~50W,
  - ~Δ17°C
  - Water ~Δ1.2°C



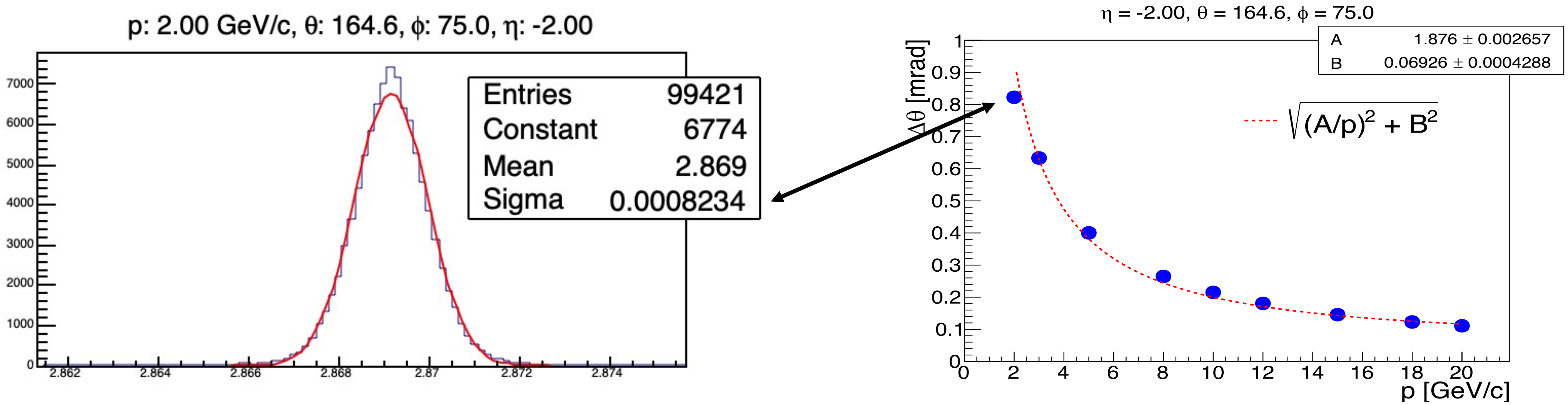


Fully costed; on-detector part implemented in GEANT as shown

6.1.1 Backward Tracker Angular Resolution

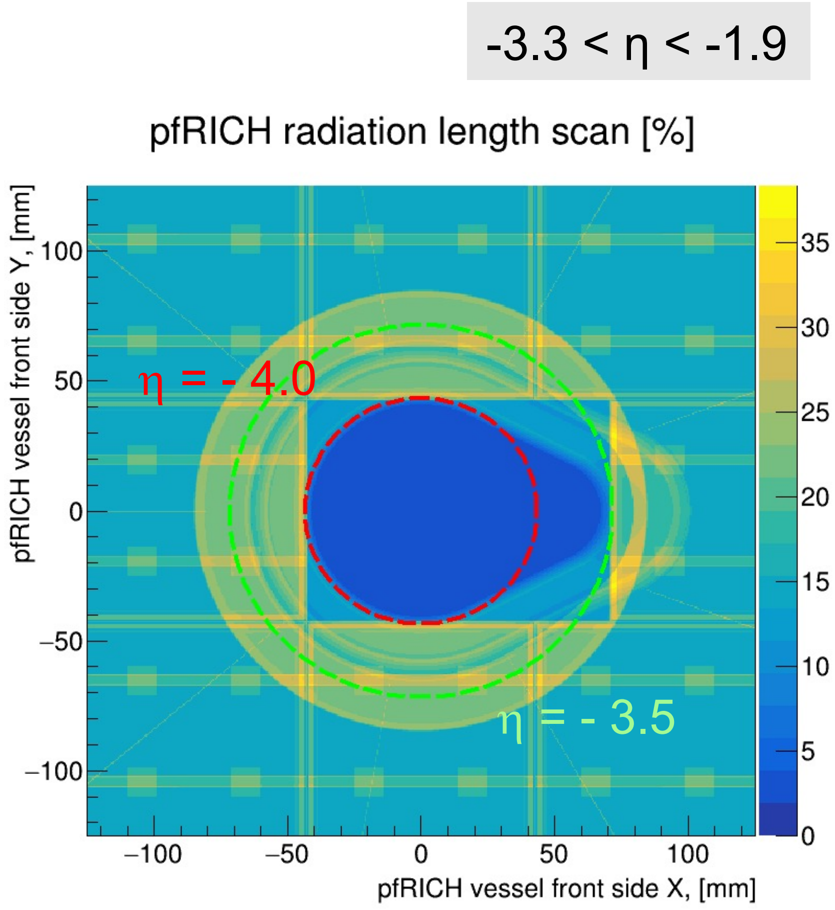
- Used official ePIC software (DD4HEP/EicRecon), Bryce Canyon geometry
- Procedure:
  - Use particle gun (pions) at fixed momentum, theta and azimuthal settings
  - Project the reconstructed tracks to plane at z = -1200 mm
  - Parameterize angular resolutions ($\Delta\theta$ and $\Delta\phi$) as a function of {η, p}
  - **Apply as additional smearing to the Cherenkov angle resolution in Delphes files**

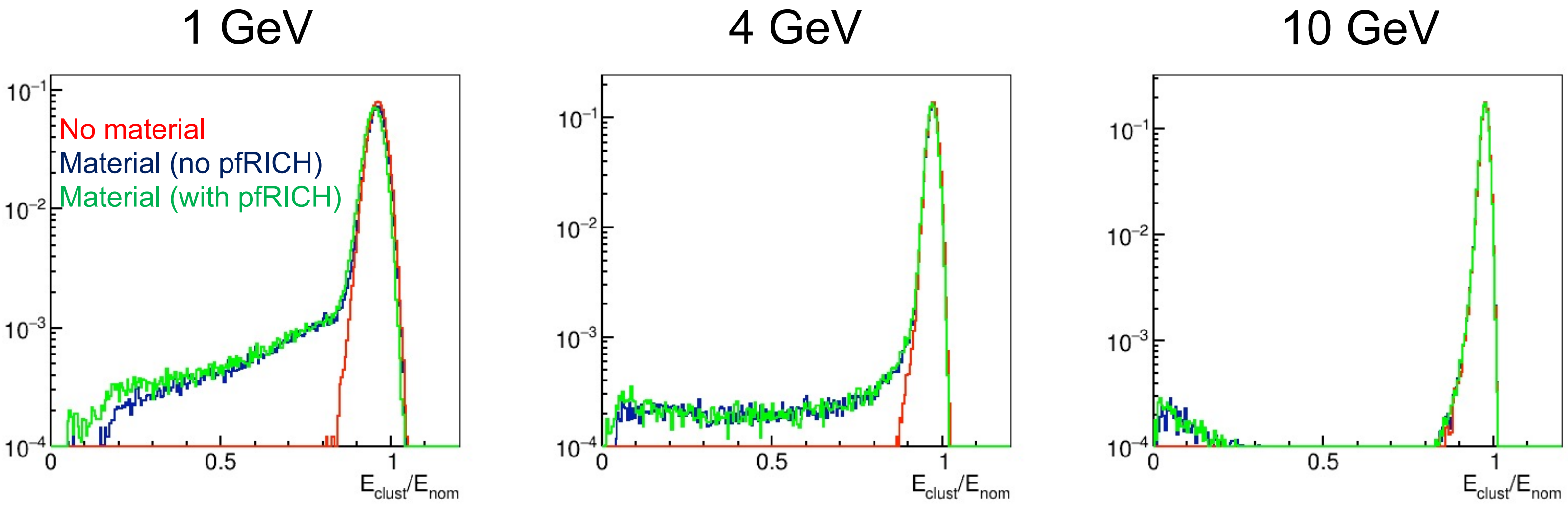
by Matt Posik (Temple)



6.1.2 pfRICH Material Effect to Backward EmCal

- pfRICH GEANT implementation imported in ePIC framework as a GDML file
  - Material implemented to the best of our knowledge (vessel, HRPPDs, cooling system, etc)

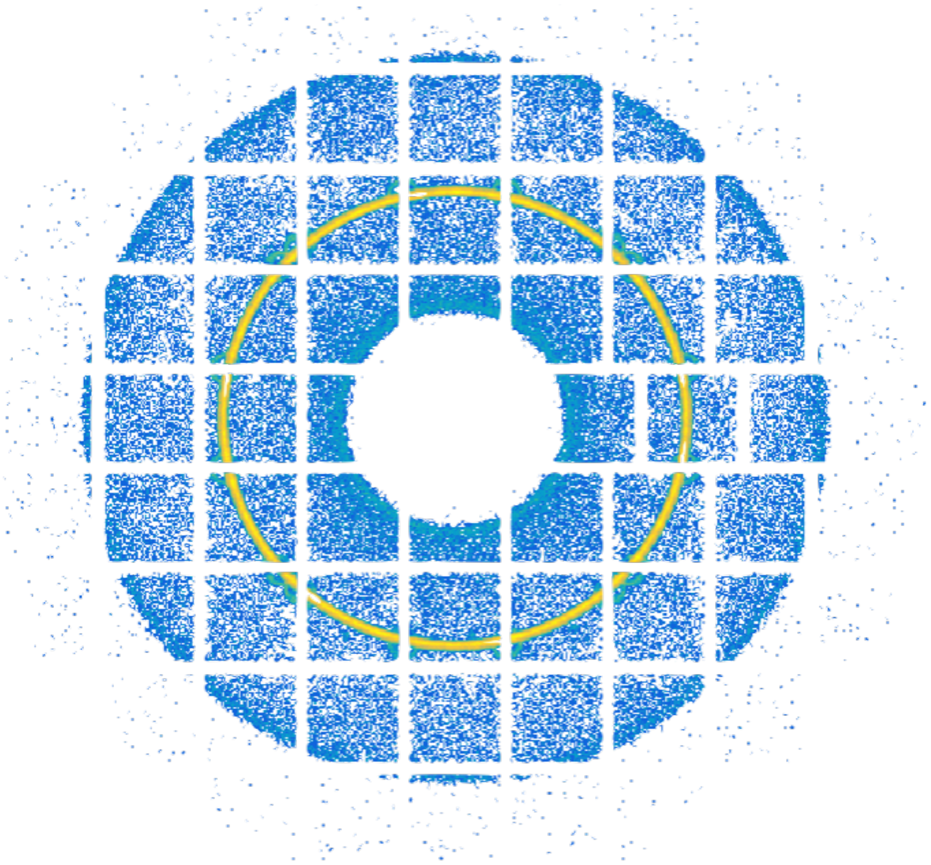




- No effect on (~gaussian) peak width
- Lower energy tails (the largest at 1 GeV)
- No effect for high energy electrons (10 GeV)

- Minimal effect from pfRICH overall

by Alexander Bazilevsky (BNL)



Aerogel

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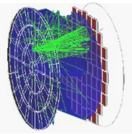
4.1 Proposed configuration

- Simulations were performed using *parameterizations* of Belle II
  - <n> ~ 1.045, RINDEX / ABSLENGTH / RAILEIGH as provided
  - 2.5cm thick tiles, three radial bands, trapezoidal shape (3 varieties), ~19 cm size
  - Assume water jet shaping up (tile sides of poor optical quality) -> opaque separators

- Options for the implementation in ePIC:
  - 2.5 cm thick Belle II type tiles possible (as communicated by the manufacturer)
  - Can almost certainly use J-PARC type (~14 cm size, <n> ~ 1.040) -> four radial bands
  - Should be able to go down to <n> ~ 1.030 and ~3.0 cm thickness if needed

  - Would consider (much) smaller tiles if they can be produced *with transparent sides*

- Required quantity: 42 tiles total (+ spares)



4.2 / 4.3 R&D, QA, Cost and Schedule

- Meeting with Makoto Tabata (Chiba University & Aerogel Factory Co., Ltd) set up by the EIC project in December 2022

- Follow up communication between Makoto, Marco Contalbrigo (INFN Ferrara) & AK
  - Quote for the first few types of tiles with <n> ~ 1.020 & 1.030 received
  - Production is expected to start in April 2023

  - Full scale order for pfRICH: ~50 tiles, cost estimate included in the provided Excel sheet
  - Two months for a test production, then 5-6 months for the whole order

  - *By now Makoto Tabata became a member of the pfRICH DSSC*

- An aerogel QA test station will be set up at Temple

Summary of Services / Aerogel

- pfRICH Low Voltage, High Voltage, Gas and Cooling System layout is defined
- All these services are costed, and adequately described in a CAD model and in the GEANT simulations
- Aerogel type is selected, and consistently used in the Monte-Carlo simulations
- Test samples will be received by Fall 2023