



# Detector envelopes within the BABAR magnet

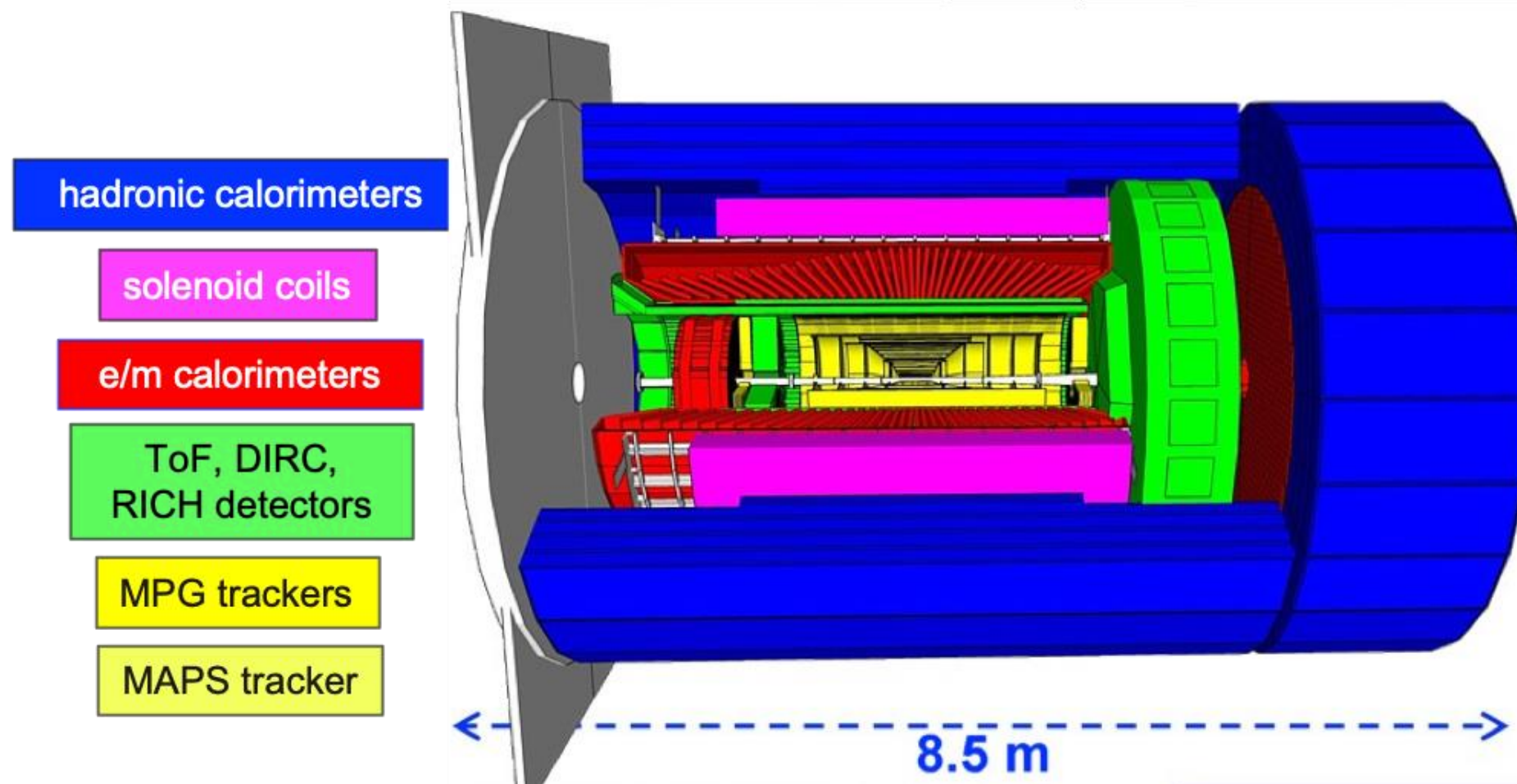
Jin Huang

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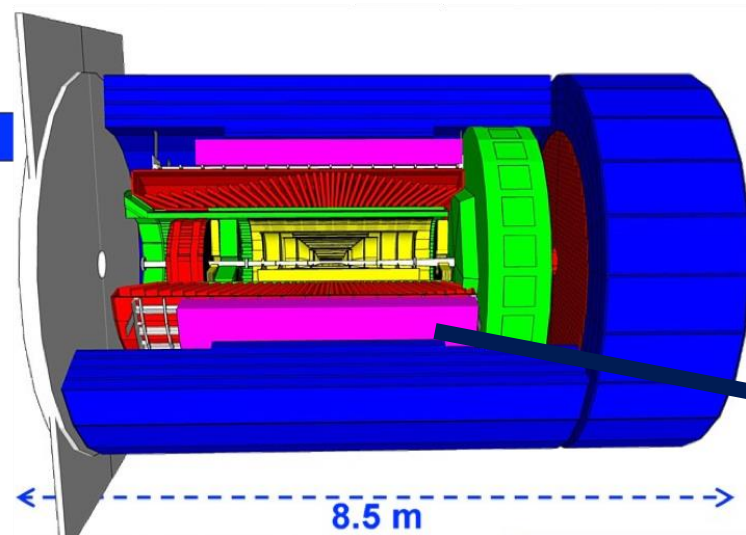
# Introduction

- ▶ Global Detector Integration (GD/I) WG @ EIC Detector-1:
  - Indico: <https://indico.bnl.gov/category/415/>
    - First kick off meeting on Monday.
    - May 16: global design considerations in proposals
    - **May 23: BaBar magnet**
  - Sign up email list: <https://lists.bnl.gov/mailman/listinfo/eic-projdet-globalint-l>
  - Wiki: <https://wiki.bnl.gov/eic-project-detector/index.php/DetectorIntegration>
- ▶ What will be discuss today
  - Babar magnet geometry
  - Top level space assignment in the past ECCE, negotiated between simulation and engineering design
  - Further (personal) thoughts
- ▶ What can't be quantified today
  - Any quantitative update to the PID detector envelop for EIC Detector-1, which require discussion/negotiation in GD/I WG in association with project engineering

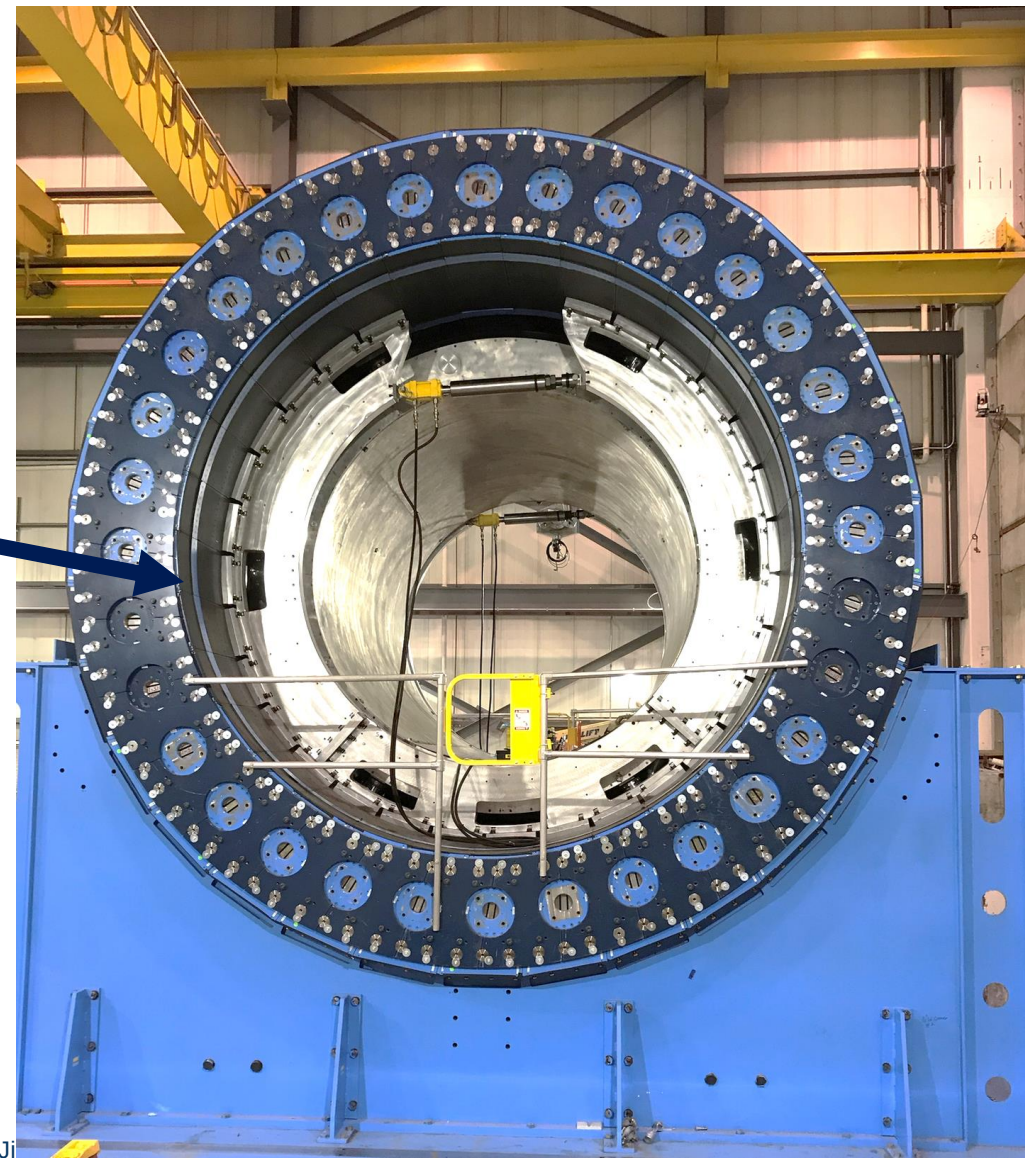
# Detector-1 reference design: magnet and central field return



# Detector-1 reference design: magnet and central field return

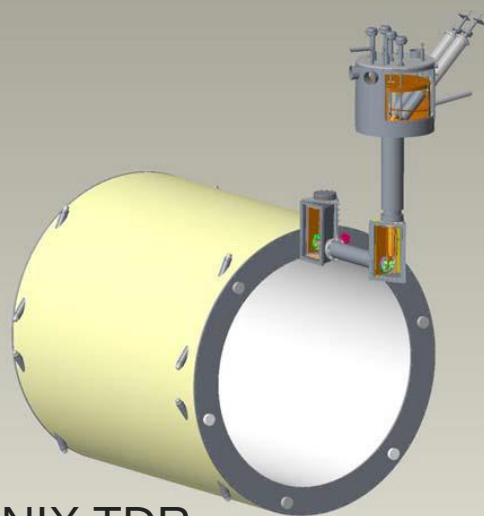


Feb 2022:  
Completed Outer HCal installed around the magnet



# BaBar magnet

- ▶ Experimental solenoid in the reference design is based on the Babar super conducting magnet installed in the sPHENIX barrel flux return (double as the barrel outer hadronic calorimeter).
- ▶ This magnet was manufactured by Ansaldo in 1997 and commissioned in 1998. It was transferred to BNL in 2015 for use in the sPHENIX experiment and passed an initial high-field test in 2018.



SPHENIX TDR

## Field Parameters:

Central Field 1.5 T Max.  
Stored Energy 27 MJ

## Main Coil Parameters

Mean Diameter of Current Sheet 3060 mm  
Current Sheet Length 3513 mm  
Number of layers 2  
Operating Current 4596 A  
Conductor Current Density 1.2 kA/ mm<sup>2</sup>  
Inductance 2.57 H

## Cryostat Parameters

Inner Diameter 2840 mm  
Radial Thickness 350 mm  
Total Length 3850 mm  
Total Material (Al) ~ 126 mm

## Outer HCal Steel

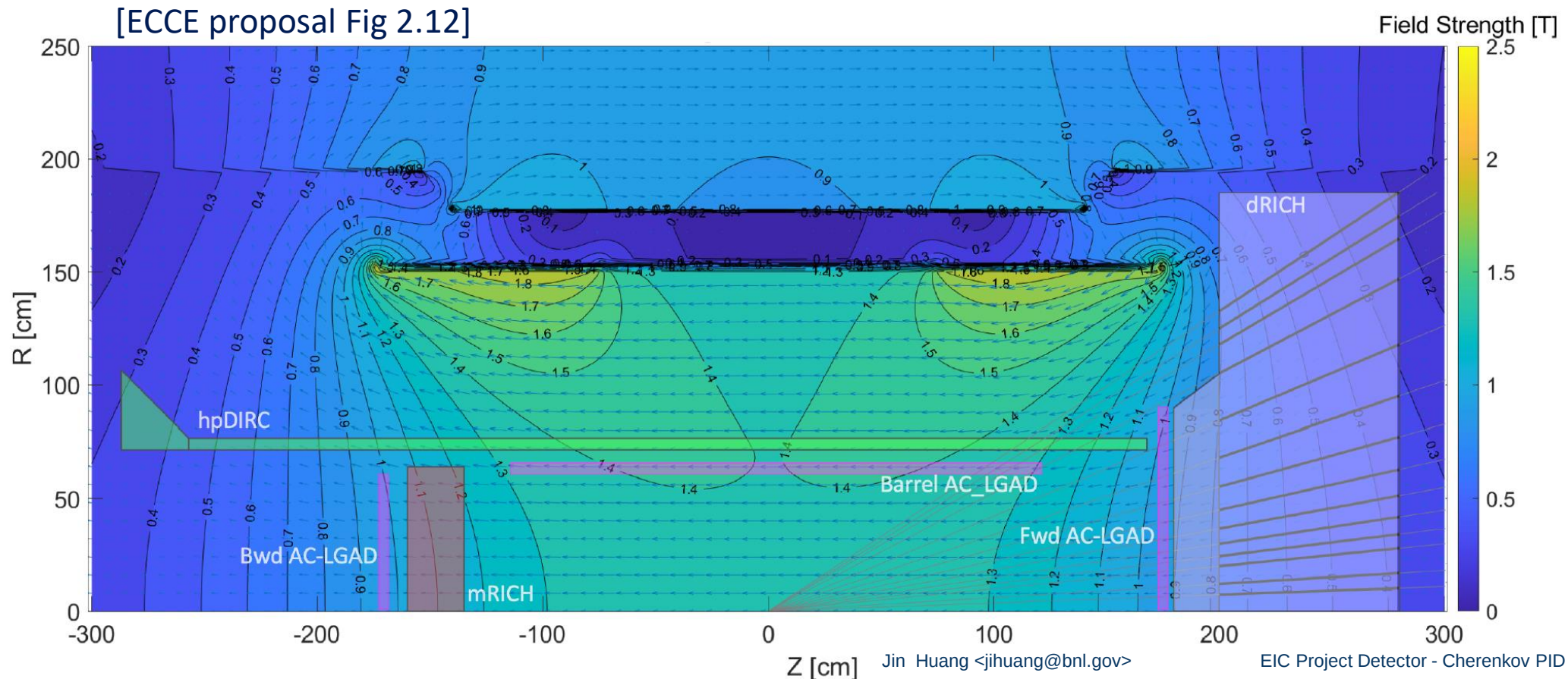
ID/OD 1780/2595 mm  
Length 6010 mm  
Weight 320 plates @ 1.44 metric Tons ea = 461 metric tons

## Doors (each)

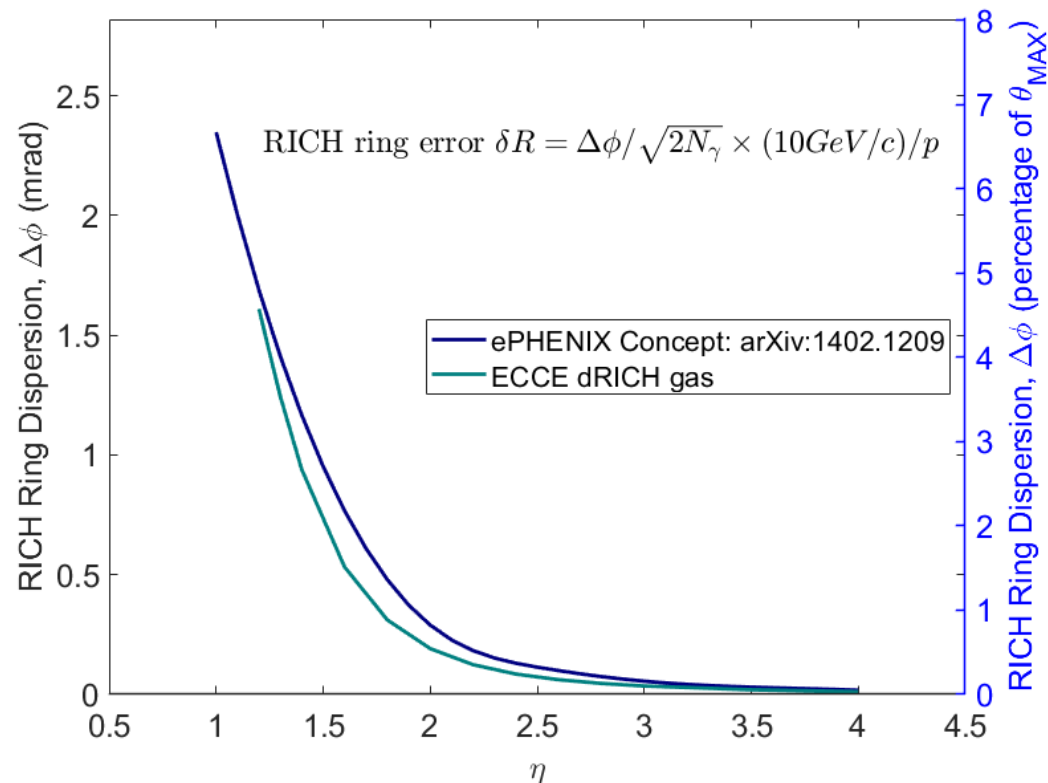
ID/OD 562/5190 mm  
Thickness 30 mm  
Weight 50 metric tons

# Field region with RICH detector

- ▶ Field map available at [https://wiki.bnl.gov/eic-project-detector/index.php/Experimental\\_Solenoid](https://wiki.bnl.gov/eic-project-detector/index.php/Experimental_Solenoid)
- ▶ Field return: backward field return, sPHENIX barrel HCal and forward magnetic HCal (LFHCAL)

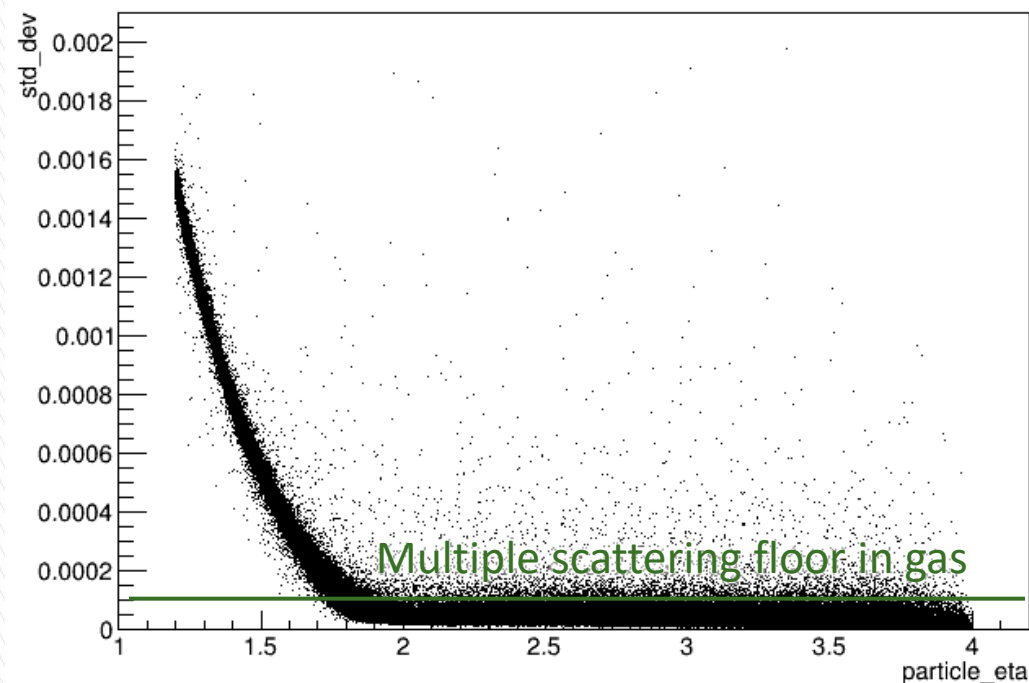


# Field projectivity in dRICH gas radiator



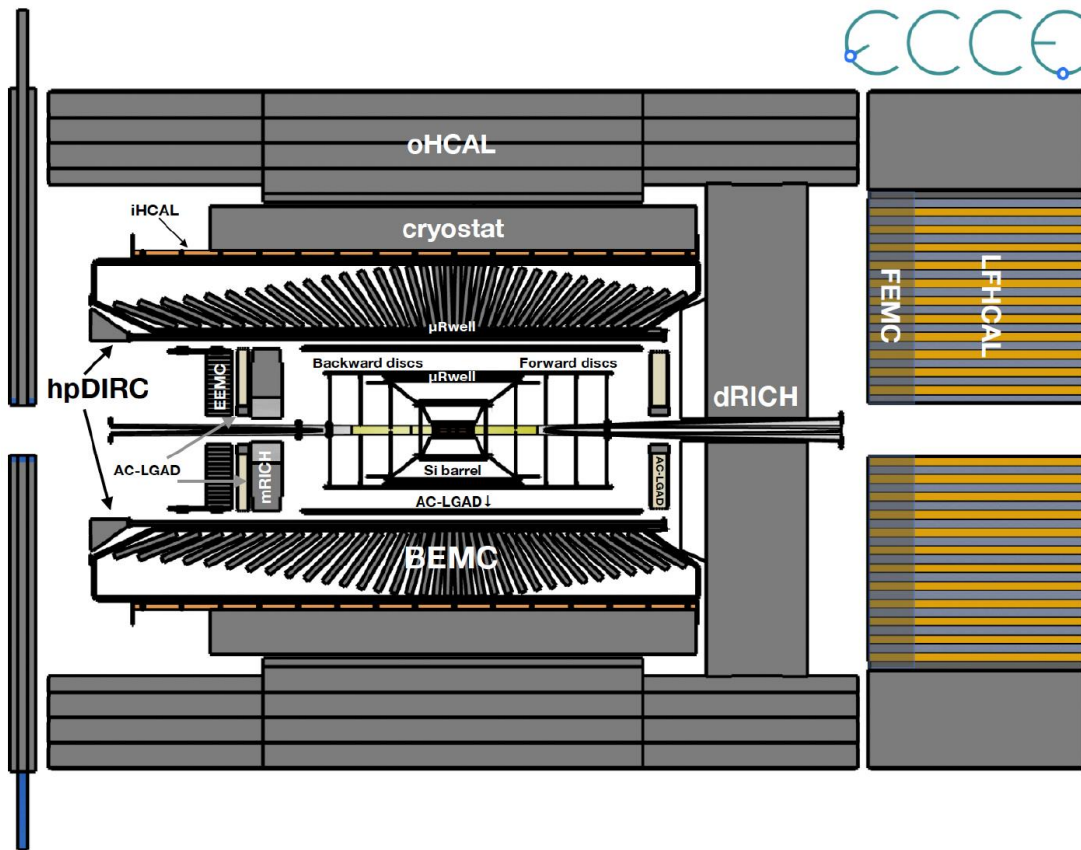
Analytical calculation

10 GeV/c muon in dRICH gas vol. (filled with air)

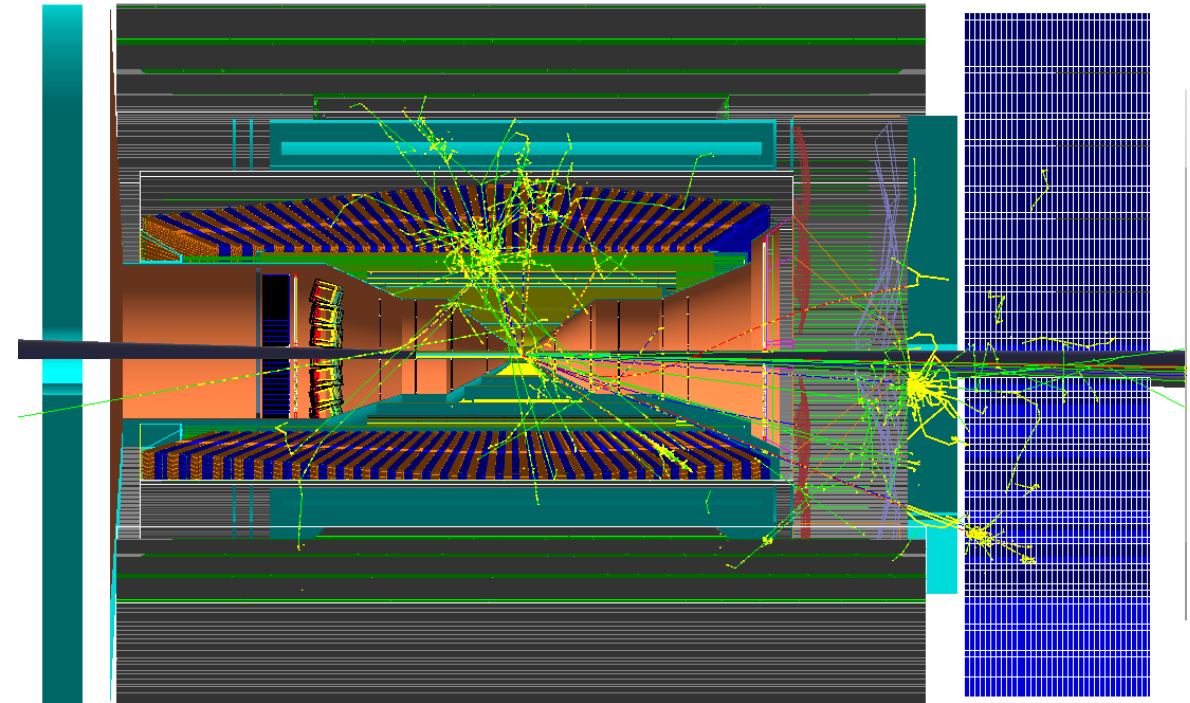


Geant4 verification (C. Dean)

# Leading order envelope from ECCE



Mechanical model [ECCE proposal]



Geant4 model [ECCE prop.6 tagged build]

# Leading order envelope from ECCE

| Top level layers             | R-in [cm] | R-out [cm] | R-Thickness |
|------------------------------|-----------|------------|-------------|
| Magnet                       | 140       | 170        | 30          |
| EMCal support (instrumented) | 134       | 140        | 6           |
| EMCal Readout (near eta=0)   | 125.5     | 134        | 8.5         |
| EMCal Glass                  | 80        | 125.5      | 45.5        |
| EMCal Inner support          | 79.5      | 80         | 0.5         |
| muRwell (plane type)         | 77        | 79.5       | 2.5         |
| Outer Frame                  | 74.5      | 77         | 2.5         |
| DIRC (10bar * 12 sector)     | 71.5      | 76.6       | 5.1         |
| Inner Frame                  | 65        | 71.5       | 6.5         |
| AC LGAD ToF tracker          | 63        | 65         | 2           |
| (Not used, low mass BdL)     | 51        | 60         | 9           |
| Inner tracker                | 3         | 51         | 48          |

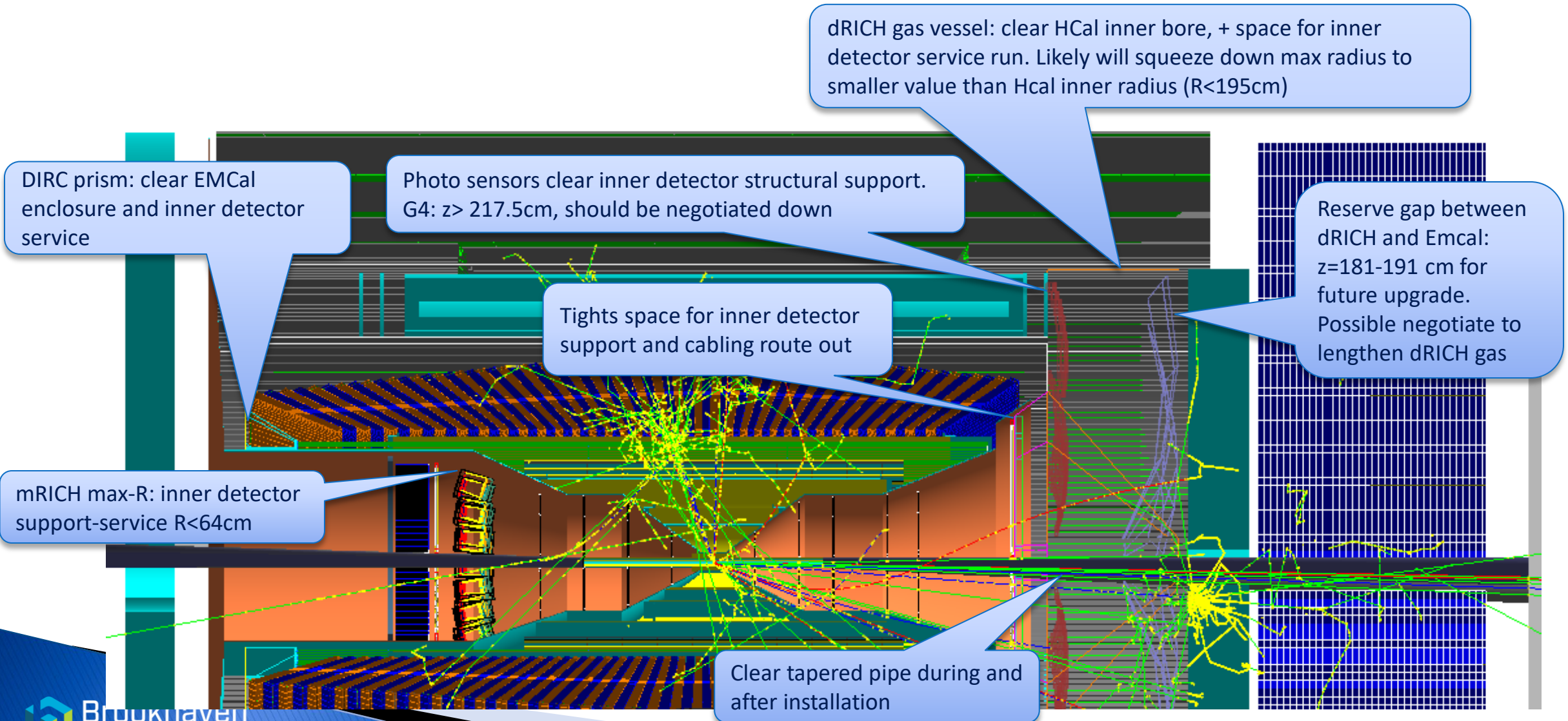
| Top level layers            | z_min [cm] | z_max [cm] | z_center [cm]             | max radius [cm] | dZ [cm] |
|-----------------------------|------------|------------|---------------------------|-----------------|---------|
| Backward field return       | -410       | -300       | -360                      | 267             | 110     |
| Backward EMCal              | -235       | -175       | -185                      | 64              | 60      |
| Backward TOF/Tracker        | -171       | -161       | -169, -172                | 64              | 10      |
| mRICH                       | -161       | -135       | -148                      | 64              | 26      |
| Backward MPGD               | -130       | -120       | -130                      | 64              | 10      |
| Backward Silicon tracker    | -120       | -30        | -z=25, 52, 79, 106 cm     |                 | 90      |
| Vertex tracker              | -30        | 30         | 0                         |                 | 60      |
| Forward Silicon tracker     | 30         | 150        | z=25, 52, 73, 106, 125 cm |                 | 120     |
| Forward AC LGAD Tof/Tracker | 156        | 180        | 180                       | 80              | 25      |
| dRICH                       | 180        | 280        | 230                       | 195             | 100     |
| Forward MPGD                | 281        | 291        | 285                       | 180             | 10      |
| Forward EMCal               | 328        | 366        | 310                       | 190             | 38      |
| Forward HCal                | 328        | 500        | 404                       | 267             | 172     |

Radial assignment

Longitudinal assignment

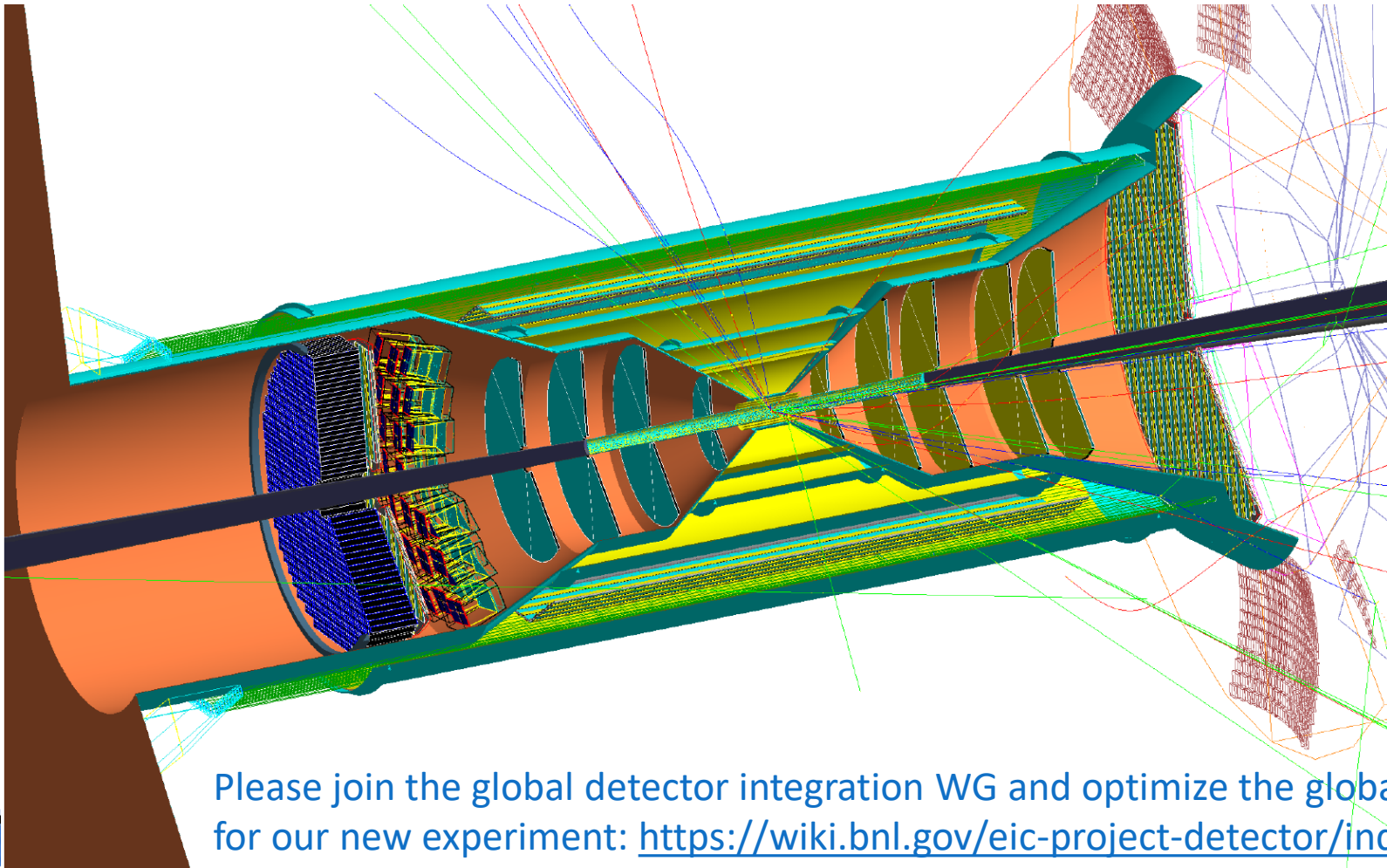
See also on wiki: <https://physdiv.jlab.org/EIC/Menagerie/docs/DetectorParameterTable.pdf>

# Further comments on geometric constraints



# Final words:

## PID is part of the tightly integrated core for EIC detector

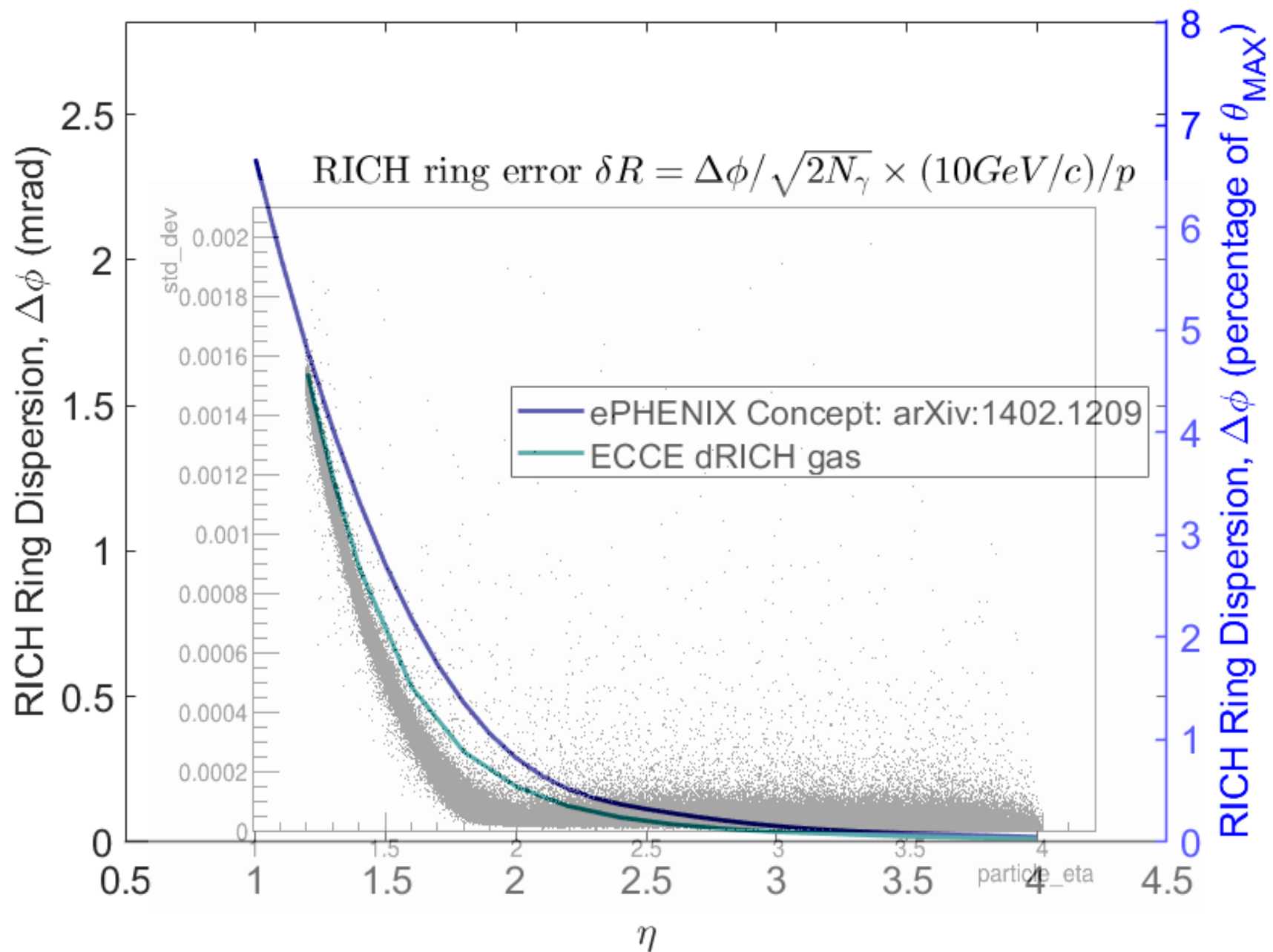


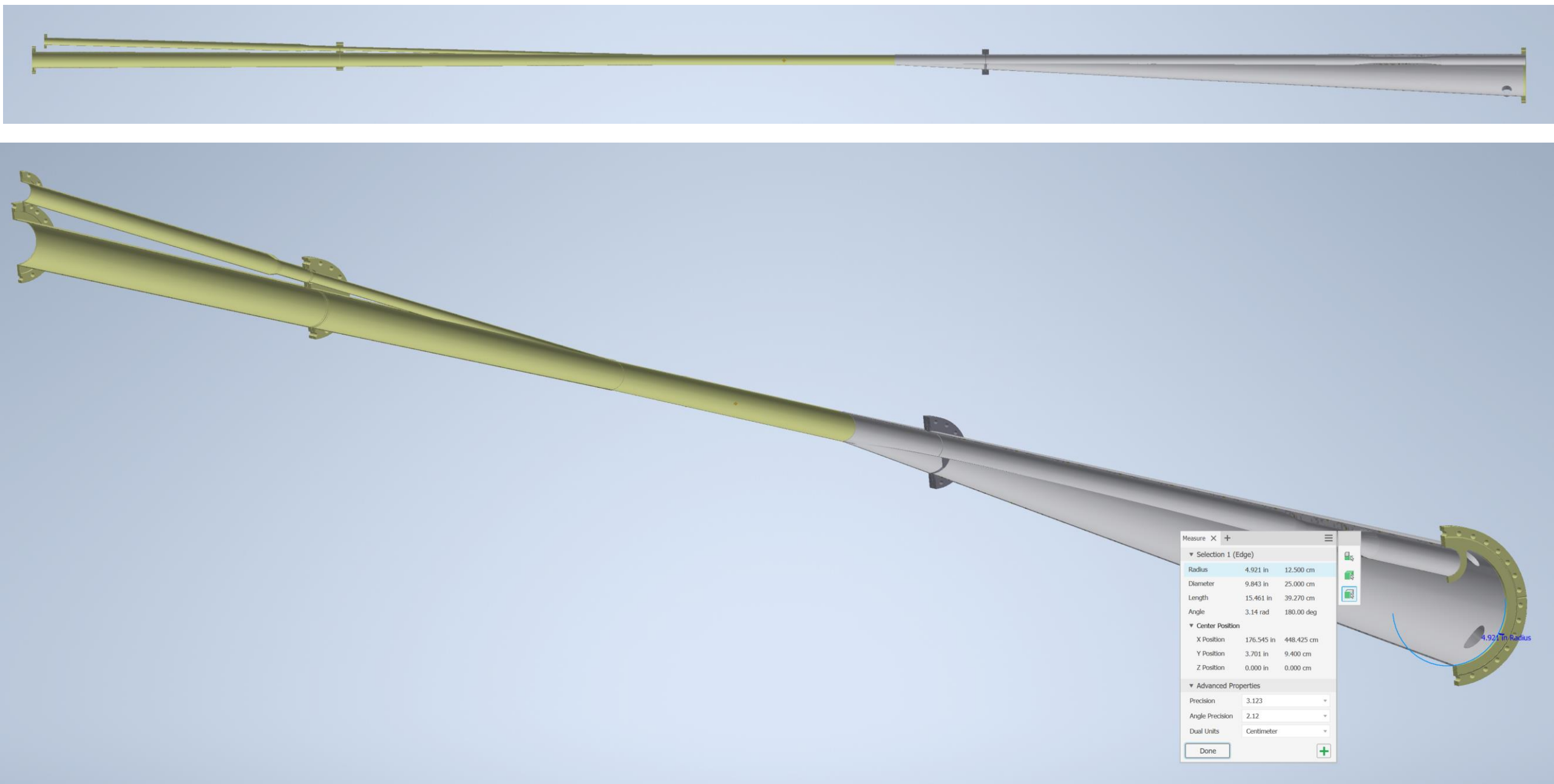
Please join the global detector integration WG and optimize the global performance for our new experiment: <https://wiki.bnl.gov/eic-project-detector/index.php/DetectorIntegration>

# Extra information



| Region                   | Component                     | Sub-Component    | WBS     | Length (cm) | Inner Radius (cm) | Outer Radius (cm) | Offset from Center (cm) | Physical Start (cm) | Physical End (cm) | Volume (m³) | Weight (kg) | Technology             | Notes                                                                                                                                                                                                                                     |
|--------------------------|-------------------------------|------------------|---------|-------------|-------------------|-------------------|-------------------------|---------------------|-------------------|-------------|-------------|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HADRON DIRECTION END CAP | Hadron Calorimeter            |                  | 6.10.06 | 171         | 30                | 267               | 328                     | 499                 | 328               | 33.611645   | 215,210     | FeSc, WSc last segment | Tower size: 5cm x 5cm x 140cm, 20cm readout<br>Offset: measured from face nearest to interaction point<br>Volume: calculated as cylindrical volume minus the volume of the embedded ECAL<br>Weight: estimated as 79% iron and 21% plastic |
|                          | Electromagnetic Calorimeter   |                  | 6.10.05 | 38          | 30                | 190               | 328                     | 366                 | 328               | 4.2021943   | 27,165      | Pb/Sc                  | Tower size: 1cm (1.65cm) x 1cm(1.65cm) x 37.5cm, 5cm readout<br>Offset: measured from face nearest to interaction point<br>Weight: estimated as 85% lead glass and 15% steel                                                              |
|                          | Service Gap                   |                  |         | 8           |                   |                   | 320                     | 328                 | 320               |             |             |                        | Offset: measured from location nearest to interaction point                                                                                                                                                                               |
| CENTRAL DETECTOR         | Barrel Hadron Calorimeter     |                  | 6.10.06 | 640         |                   | 267               | 0                       | 320                 | -320              | 72.60       | 464,834     | FeSc                   | Offset: measured from center of detector<br>Volume: calculated as sum of the sub-sections<br>Weight: estimated as 79% iron and 21% plastic                                                                                                |
|                          |                               | HD Section       |         | 170         | 194               | 267               | 150                     | 320                 | 150               | 17.97       |             |                        | Offset: measured from face nearest to interaction point                                                                                                                                                                                   |
|                          |                               | Central Section  |         | 300         | 180               | 267               | 0                       | 150                 | -150              | 36.65       |             |                        | Offset: measured from center of detector                                                                                                                                                                                                  |
|                          |                               | LD Section       |         | 170         | 194               | 267               | -150                    | -150                | -320              | 17.97       |             |                        | Offset: measured from face nearest to interaction point                                                                                                                                                                                   |
|                          | Dual RICH                     |                  | 6.10.04 | 100         | 10                |                   | 180                     | 280                 | 180               | 10.29       | 1,911       | Aerogel/Gas            | Offset: measured from face nearest to interaction point<br>Volume: calculated as sum of the sub-sections<br>Weight: based on parametric estimate from CLAS LTCC                                                                           |
|                          |                               | Detector Section |         | 80          | 10                | 195               | 200                     | 280                 | 200               | 9.53        |             |                        | Offset: measured from face nearest to interaction point                                                                                                                                                                                   |
|                          |                               | Aerogel Section  |         | 20          | 10                | 110               | 180                     | 200                 | 180               | 0.75        |             |                        | Offset: measured from face nearest to interaction point                                                                                                                                                                                   |
|                          | Solenoid Magnet               |                  | 6.10.07 | 384         | 142               | 177               | 0                       | 192                 | -192              | 13.47       | 45,956      | Solenoid               | Weight: based on parametric estimate from CLEO II                                                                                                                                                                                         |
|                          | EMCal Outer Support           |                  |         | 445         | 134               | 140               | -30                     | 192.5               | -252.5            | 2.30        | 3,608       | Steel, Instrumented    | Weight: calculated as 20% of total volume as steel (balance is air)                                                                                                                                                                       |
|                          | EMCal Electronics             |                  |         | 480         | 125.5             | 134               | -45                     | 195                 | -285              | 3.33        | 1,938       | Near eta=0             | Weight: calculated as 25% silicon (balance is air)                                                                                                                                                                                        |
|                          | Barrel EMCal                  |                  | 6.10.05 | 480         | 80                | 125.5             | -45                     | 195                 | -285              | 14.10       | 49,463      | Sci Glass              | Weight: based on parametric estimate from CMS EMCal                                                                                                                                                                                       |
|                          | EMCal Inner Support           |                  |         | 480         | 79.5              | 80                | -45                     | 195                 | -285              | 0.12        | 944         | Steel                  | Weight: calculated as 100% steel                                                                                                                                                                                                          |
|                          | Barrel Gem Tracker            |                  | 6.10.03 | 340         | 77                | 79.5              | -5                      | 165                 | -175              | 0.42        | 84          | muRWell (plane type)   | Weight: based on parametric estimate from SBS Gem                                                                                                                                                                                         |
|                          | DIRC Support                  |                  |         | 455         | 65                | 77                | -257                    | 168                 | -287              | 2.60        | 1,019       | Steel                  | Offset: measured from point where DIRC bar connects to the readout<br>Volume: calculated as sum of sub-sections<br>Weight: estimated as 5% of total volume as steel (balance is air & detector)                                           |
|                          |                               | Bar Support      |         | 425         | 65                | 77                | -257                    | 168                 | -257              | 2.28        |             |                        |                                                                                                                                                                                                                                           |
|                          |                               | Readout Support  |         | 30          | 65                | 105               | -257                    | -257                | -287              | 0.32        |             |                        | Readout support is triangular frame, therefore volume is halved.                                                                                                                                                                          |
|                          | DIRC Detector                 |                  | 6.10.04 |             | 71.5              | 76.6              | -257                    | 168                 | -287              | 1.28        | 893         | Fused silica bars      | Detector is totally enclosed by DIRC Support.<br>Weight: calculated as sum of sub-components                                                                                                                                              |
|                          |                               | DIRC Bar         |         | 425         | 71.5              | 76.6              | -257                    | 168                 | -257              | 1.01        | 702         |                        | Weight: calculated as 30% quartz (balance is air & support system)                                                                                                                                                                        |
|                          |                               | DIRC Readout     |         | 30          | 71.5              | 104.4             | -257                    | -257                | -287              | 0.27        | 191         |                        | Readout is triangular, therefore volume is halved.<br>Weight: Calculated as 30% silicon(balance is air & support system)                                                                                                                  |
|                          | Barrel Time of Flight/Tracker |                  | 6.10.03 | 270         | 63                | 65                | 15                      | 150                 | -120              | 0.22        | 43          | AC/LGAD                | Weight: based on parametric estimate from SBS Gem                                                                                                                                                                                         |
|                          | HD Time of Flight/Tracker     |                  | 6.10.03 | 15          | 12                | 62                | 155.5                   | 170.5               | 155.5             | 0.17        | 35          | AC/LGAD                | Offset: measured from face nearest to interaction point<br>Weight: based on parametric estimate from SBS Gem                                                                                                                              |
|                          | Silicon Tracker               |                  | 6.10.03 | 228         | 3                 | 45.9              | 0                       | 126                 | -102              | 1.50        | 227         | MAPS                   | Weight: calculated as 3% aluminum and 3% silicon (balance is air)                                                                                                                                                                         |
|                          | Modular RICH                  |                  | 6.10.04 | 25          | 10                | 64                | -135                    | -135                | -160              | 0.31        | 58          | Aerogel                | Offset: measured from face nearest to interaction point<br>Weight: based on parametric estimate from CLAS LTCC                                                                                                                            |
|                          | LD Time of Flight/Tracker     |                  | 6.10.03 | 10          | 12                | 64                | -161                    | -161                | -171              | 0.12        | 25          | AC/LGAD                | Offset: measured from face nearest to interaction point<br>Weight: based on parametric estimate from SBS Gem                                                                                                                              |
|                          | LD EMCal                      |                  | 6.10.05 | 60          | 9                 | 63                | -175                    | -175                | -235              | 0.73        | 4,738       | PbWO4                  | Offset: measured from face nearest to interaction point<br>Weight: estimated as 85% lead glass and 15% steel                                                                                                                              |
|                          | Service Gap                   |                  |         | 10          |                   |                   | -320                    | -320                | -330              | 0.00        |             |                        | Offset: measured from location nearest to interaction point                                                                                                                                                                               |
| LEPTON DIRECTION ENDCAP  | Backward Field Return         |                  | 6.10.06 | 20.32       |                   |                   | -330                    | -330                | -350.32           | 5.18        | 40,649      | Iron                   | Offset: measured from face nearest to interaction point<br>Weight: calculated as 100% iron.                                                                                                                                               |
|                          |                               | Return Cylinder  |         | 20.32       | 20                | 270               | -330                    | -330                | -350.32           | 4.63        |             |                        |                                                                                                                                                                                                                                           |
|                          |                               | Support Panel    |         | 7.62        | 454               | 664               | -336.35                 | -336.35             | -343.97           | 0.55        |             |                        | Height: specified in outer radius<br>Width: specified in inner radius                                                                                                                                                                     |





| Parameter                                           | Units                 | Value                  |
|-----------------------------------------------------|-----------------------|------------------------|
| Inner radius (envelope)                             | mm                    | 1820                   |
| Outer radius (envelope)                             | mm                    | 2700                   |
| Length (envelope)                                   | mm                    | 6316                   |
| Material                                            | 1020 low carbon steel |                        |
| Number of towers in azimuth ( $\Delta\phi$ )        |                       | 64                     |
| Number of tiles per tower                           |                       | 5                      |
| Number of towers in pseudorapidity ( $\Delta\eta$ ) |                       | 24                     |
| Number of electronic channels (towers)              |                       | $64 \times 24 = 1536$  |
| Number of optical devices (SiPMs)                   |                       | $5 \times 1536 = 7680$ |
| Number of modules (azimuthal slices)                |                       | 32                     |
| Number of towers per module                         |                       | $2 \times 24 = 48$     |
| Total number of absorber plates                     |                       | $5 \times 64 = 320$    |
| Tilt angle (relative to radius)                     | °                     | 12                     |
| Absorber plate thickness at inner radius            | mm                    | 10.2                   |
| Absorber plate thickness at outer radius            | mm                    | 14.7                   |
| Gap thickness                                       | mm                    | 8.5                    |
| Scintillator thickness                              | mm                    | 7                      |
| Module weight                                       | kg                    | 12247                  |
| Sampling fraction at inner radius                   |                       | 0.037                  |
| Sampling fraction at outer radius                   |                       | 0.028                  |
| Calorimeter depth                                   | $\lambda$             | 3.8                    |

Table 4.3: Mechanical design parameters for the Outer Hadronic Calorimeter.

