Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

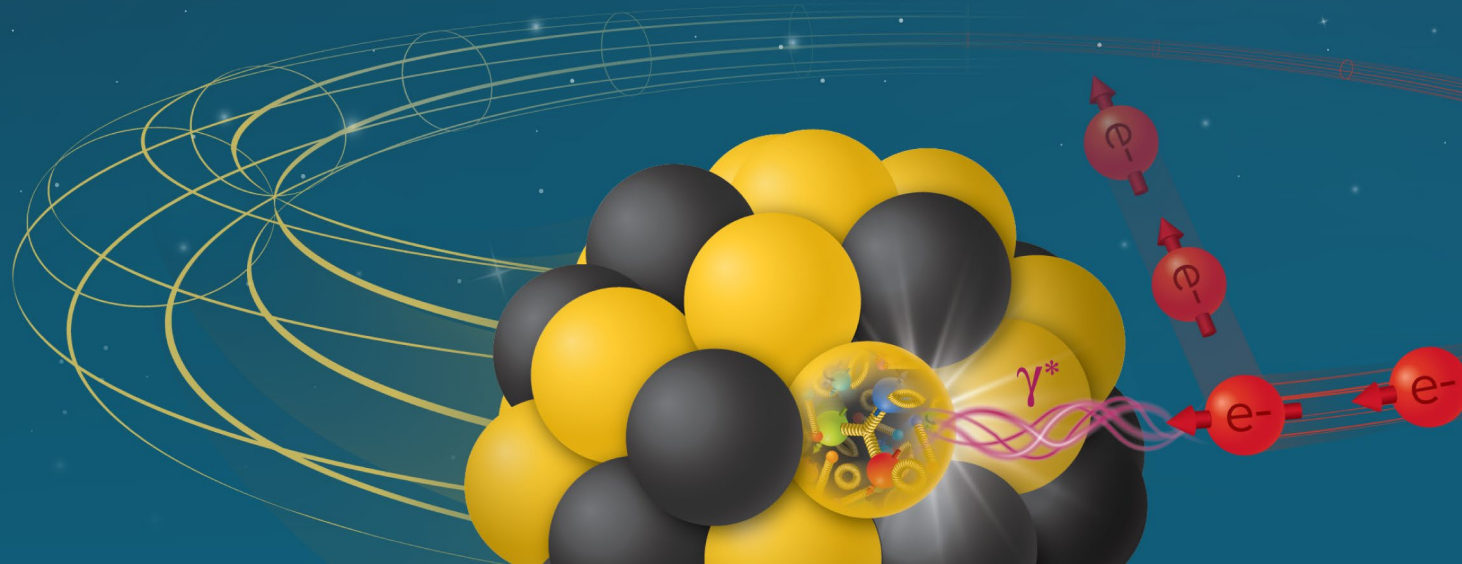
Integration, Installation and Infrastructure (Triple I Group)

Collaboration Meeting, WBS 06.10.10

Rahul Sharma (L3 Manager)
Alex Eslinger, Dan Cacace, Roland Wimmer (Mechanical Engineering Team)

WBS 6.10.10

SC-4 Detector
January 2024

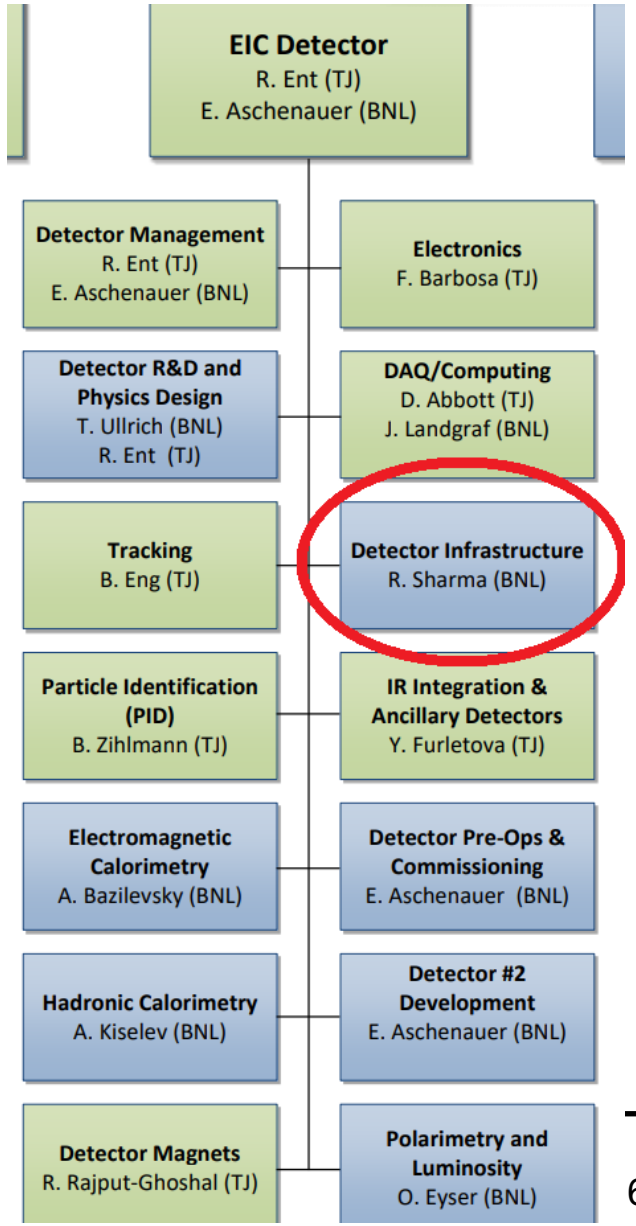


Electron-Ion Collider

Outline

- Scope Description
- EPIC Triple I Team
- In Kind/Reused Items
- Design Maturity with focus on LLP items – Note that LLP items are highlighted in red with appropriate WBS numbers.
- Power
- Cooling and Gas Systems
- Summary

Scope Description:



WBS	WBS Name	WBS Manager	LLP Scope Description
06.10.10	Integration, Installation and Infrastructure	R. Sharma	**Scope Definition:** **This WBS item covers the following:** **Effort needed to design and build new infrastructure, modify/repurpose existing infrastructure and Integration of various subdetectors for construction of ePIC detector in Bldg 1006 Assembly Hall and Experimental Hall.** **Deliverables:** **Designing, Manufacturing, Assembly and Installation of Support Structures for various sub detectors.** **Includes the support to complete the installation scope prior to commissioning.** **Integration of various sub detectors and other detector components in ePIC detector.** **Defining and Managing interfaces between experimental equipment, magnet, various sub detectors, other detector components and collider and provide guidance to various detector subgroups regarding design of their respective detectors.** **Providing and Managing utilities (Power, Water, Cooling, HVAC) for Detector and the building.**

Scope Description:

Effort needed to design and build new infrastructure, modify/repurpose existing infrastructure and Integration of various subdetectors for construction of ePIC detector in Bldg 1006 Assembly Hall and Experimental Hall.

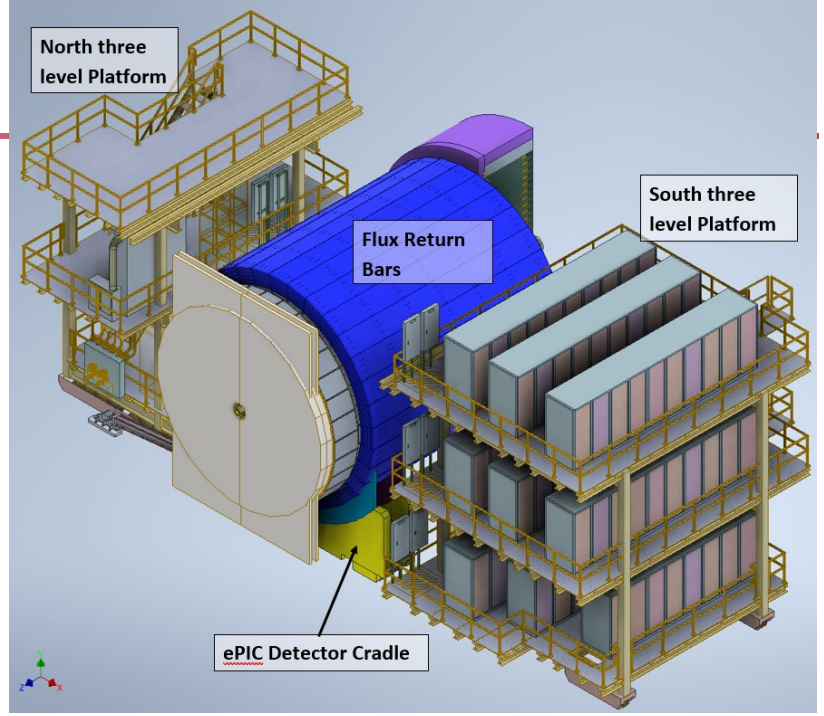
EPIC Triple I Team:

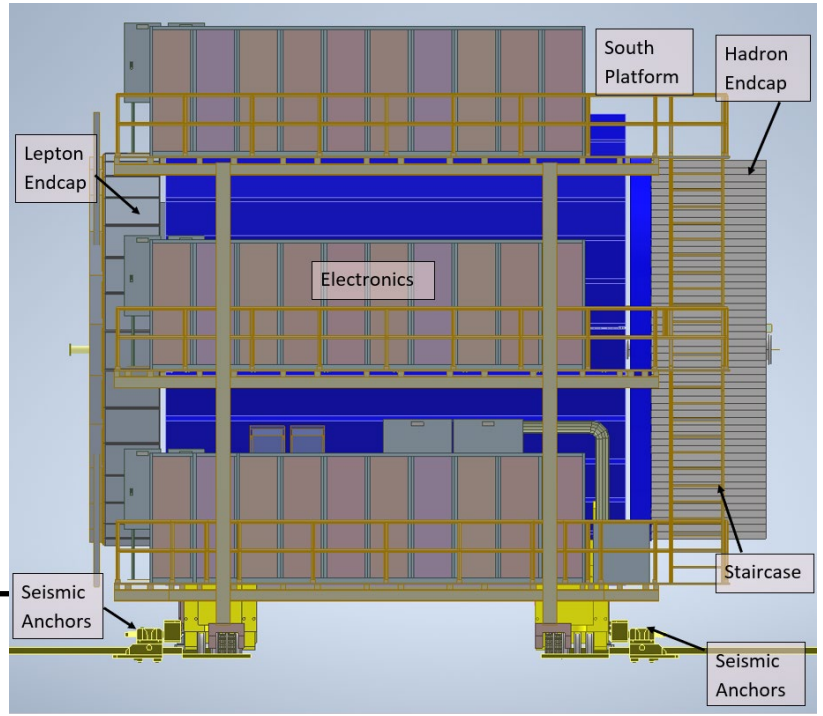
- Rahul Sharma (BNL) – Chief Mechanical Engineer
- Walt Akers (JLAB) – Systems Integration
- Roland Wimmer (BNL)– Mechanical Engineer
- Dan Cacace (BNL) – Mechanical Engineer
- Alex Eslinger (JLAB) – Mechanical Engineer – pfRICH and dRICH Design
- Ron Lassiter (JLAB)– Forward Detectors - Mechanical Engineer
- Karim Hamdi (BNL)– Mechanical Designer
- Tim Camarda (BNL) – Electronics Engineer
- Jim Kelsey (MIT Bates) – Mechanical Engineer
- Avishay Mizrahi (MIT) – Mechanical Engineer - DIRC
- Joshua Crafts (CUA) – Postdoc - EEEMCAL
- Tom O'Connor and Kevin Bailey (ANL) – Barrel EMCAL Design
- Andreas Jung (Purdue University) – AC LGAD and Carbon Fiber Support Structure
- Johnathan Smith (JLAB)
- Eric Anderssen and Joe Silber (LBNL)

Regular weekly engineering meetings are held to discuss and resolve engineering problems and check progress. Hope to add 2 more Mechanical Engineers and a Mechanical Designer to the group soon as the project evolves.

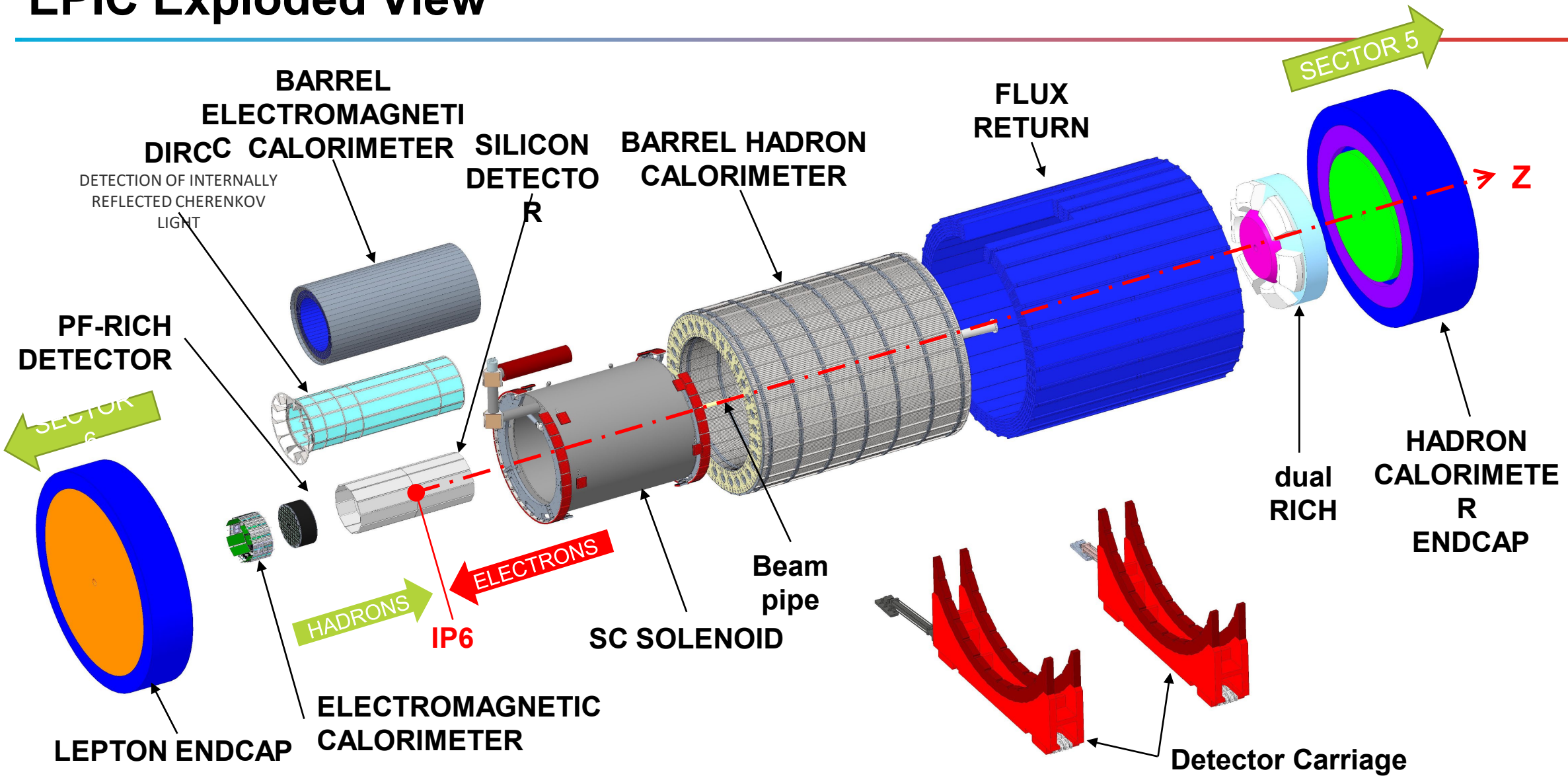
In Kind/Reused Items

- We reuse infrastructure from existing detector (STAR) in 1006.
  - North and South Platform for STAR will be modified and used for EPIC. Modifications needed to clear the path for opening of End Caps.
  - Detector Cradle from existing detector will also be reused.
  - Plan on using same pistons and moving mechanism from STAR. Pistons will be refurbished and new control unit with hydraulic lines is also needed.
- Barrel HCAL will be reused from sPHENIX.
- Existing Seismic Anchors will also have to be repositioned
- Endcaps are designed in two halves and need to be moved out of the way to Access Barrel:
  - Endcaps will be designed in two halves
  - New Design for Moving Mechanism for Endcaps (shown on later slides). New Rails needed as well for End caps.
- Support Rings, Custom Jacks and Pushers for Supporting MARCO (SC Magnet) will be reused from sPHENIX.
- **Barrel EMCAL (06.10.05.02)** Installation Tooling will be reused from sPHENIX.
- Water cooled lead with current capacity >4000 Amps are in place and can be used. Trying to find legacy documents from STAR is turning out to be a challenge.

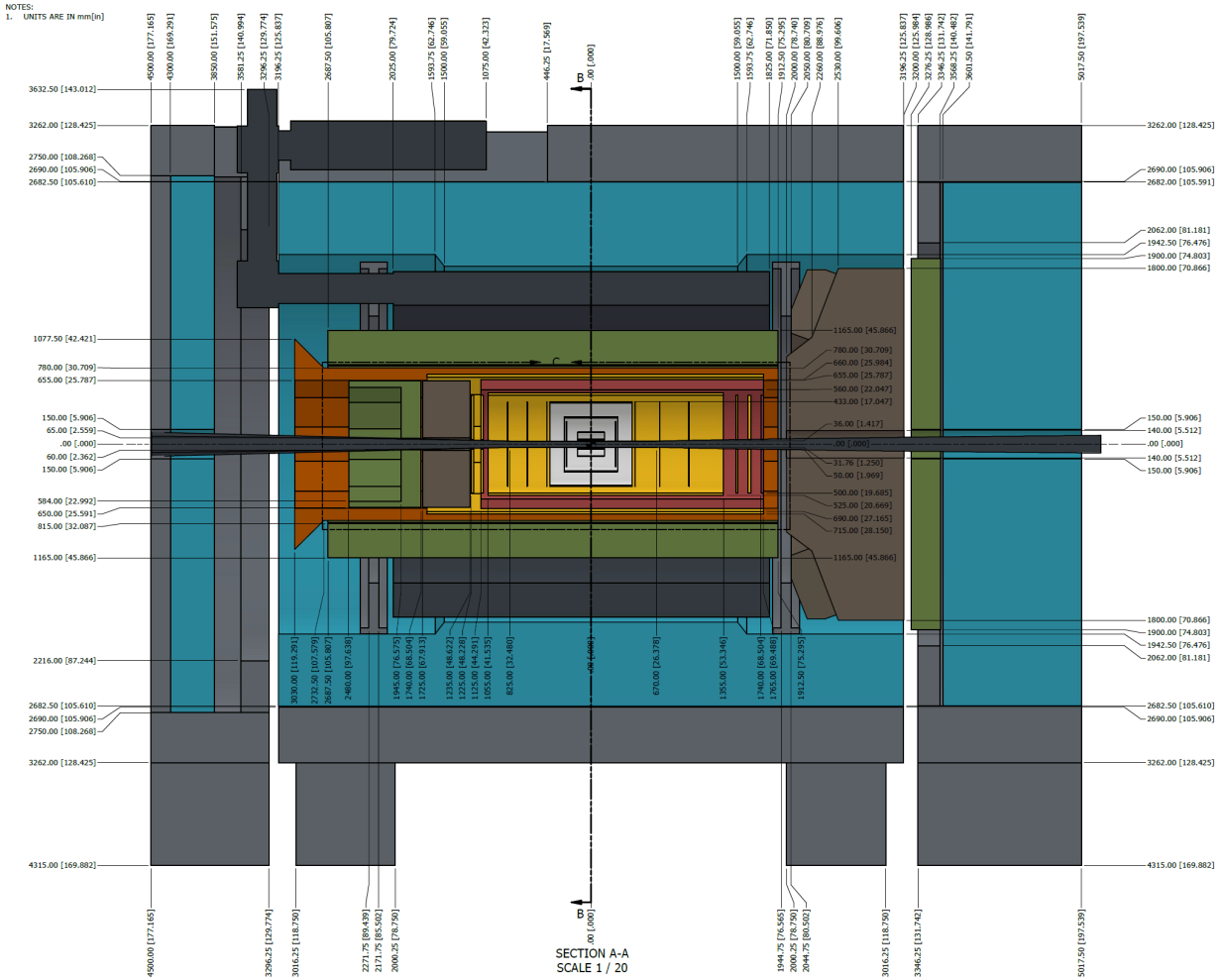


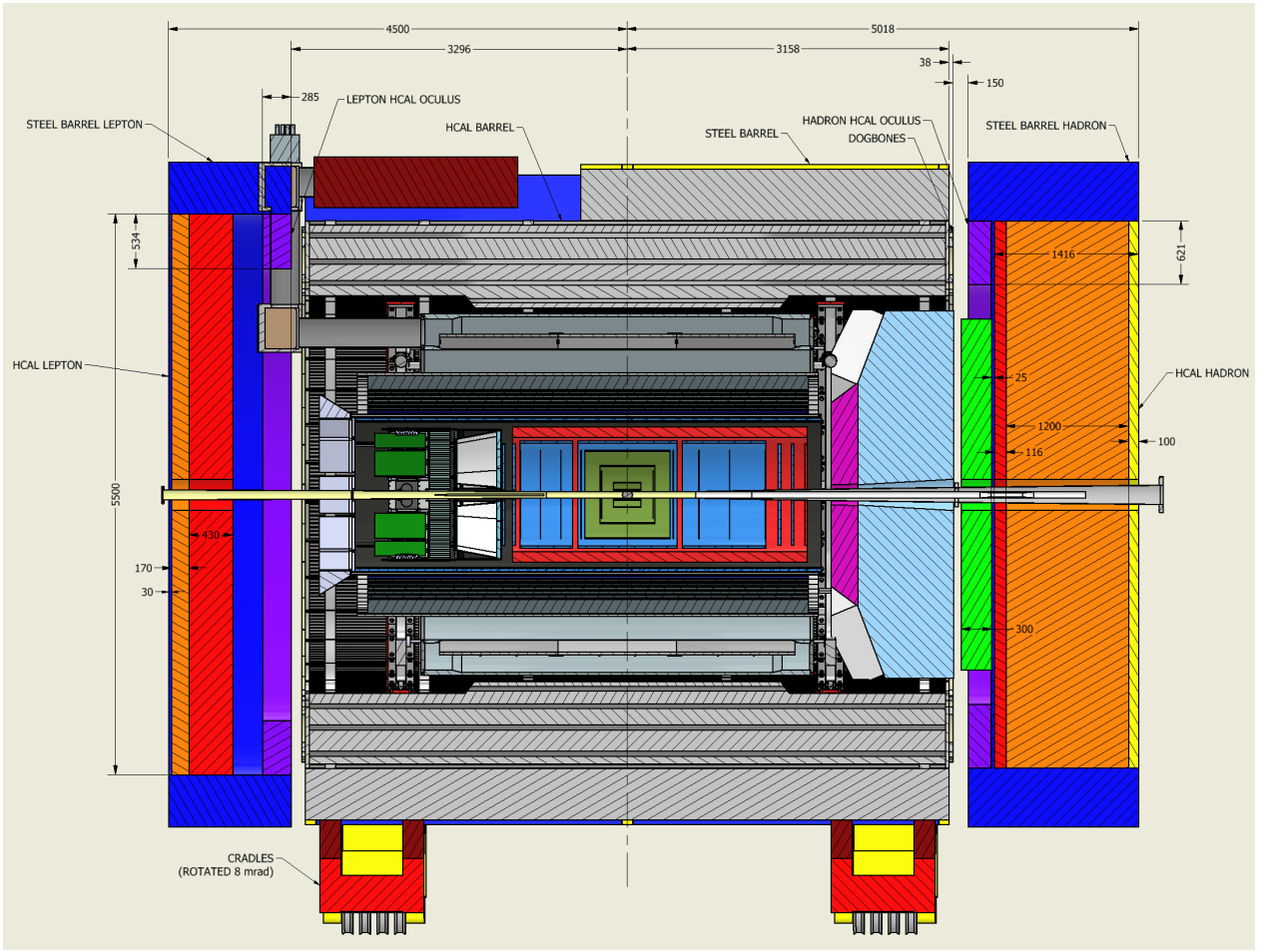


EPIC Exploded View



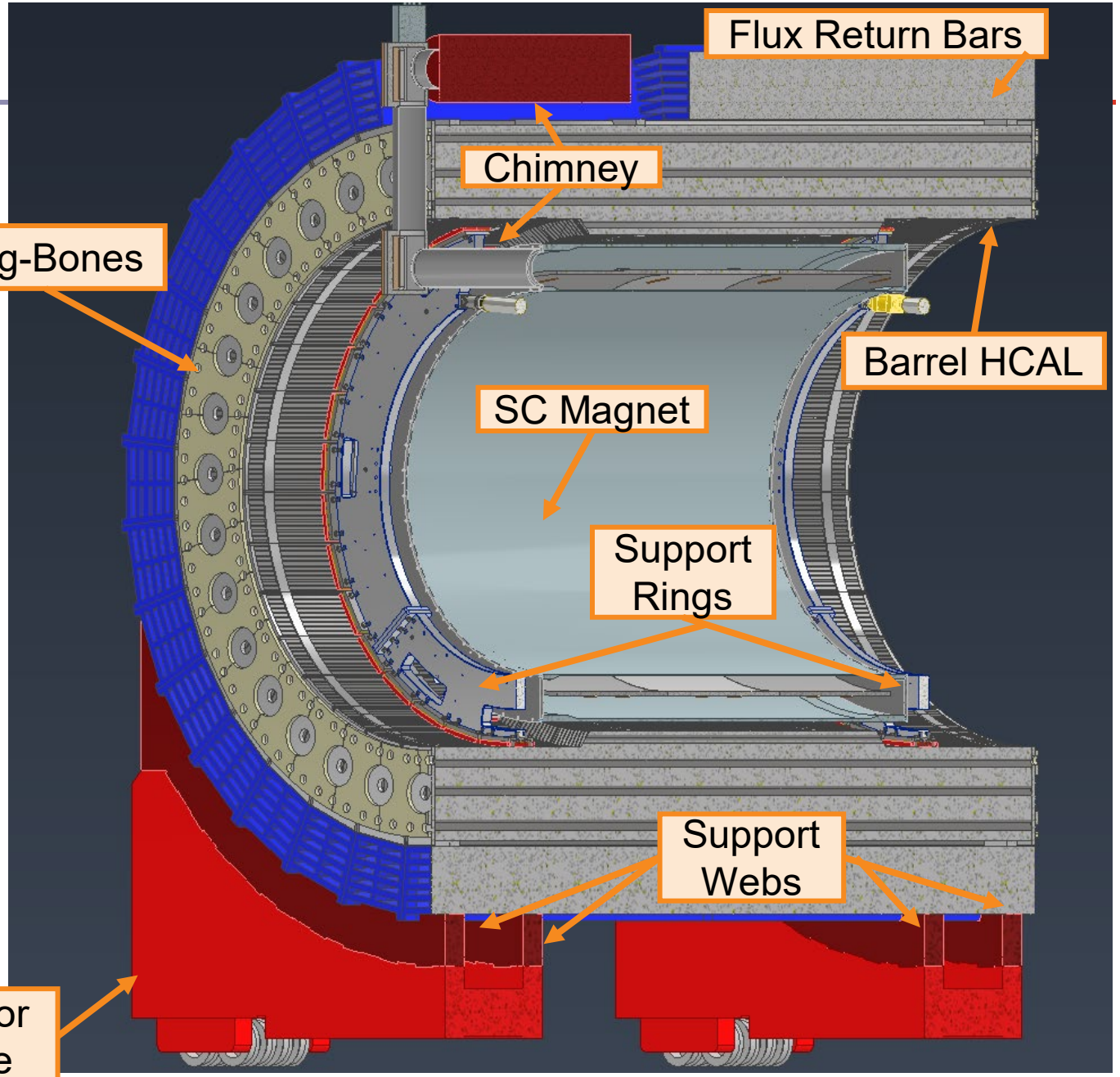
ePIC Full Model Overview (R.Wimmer)





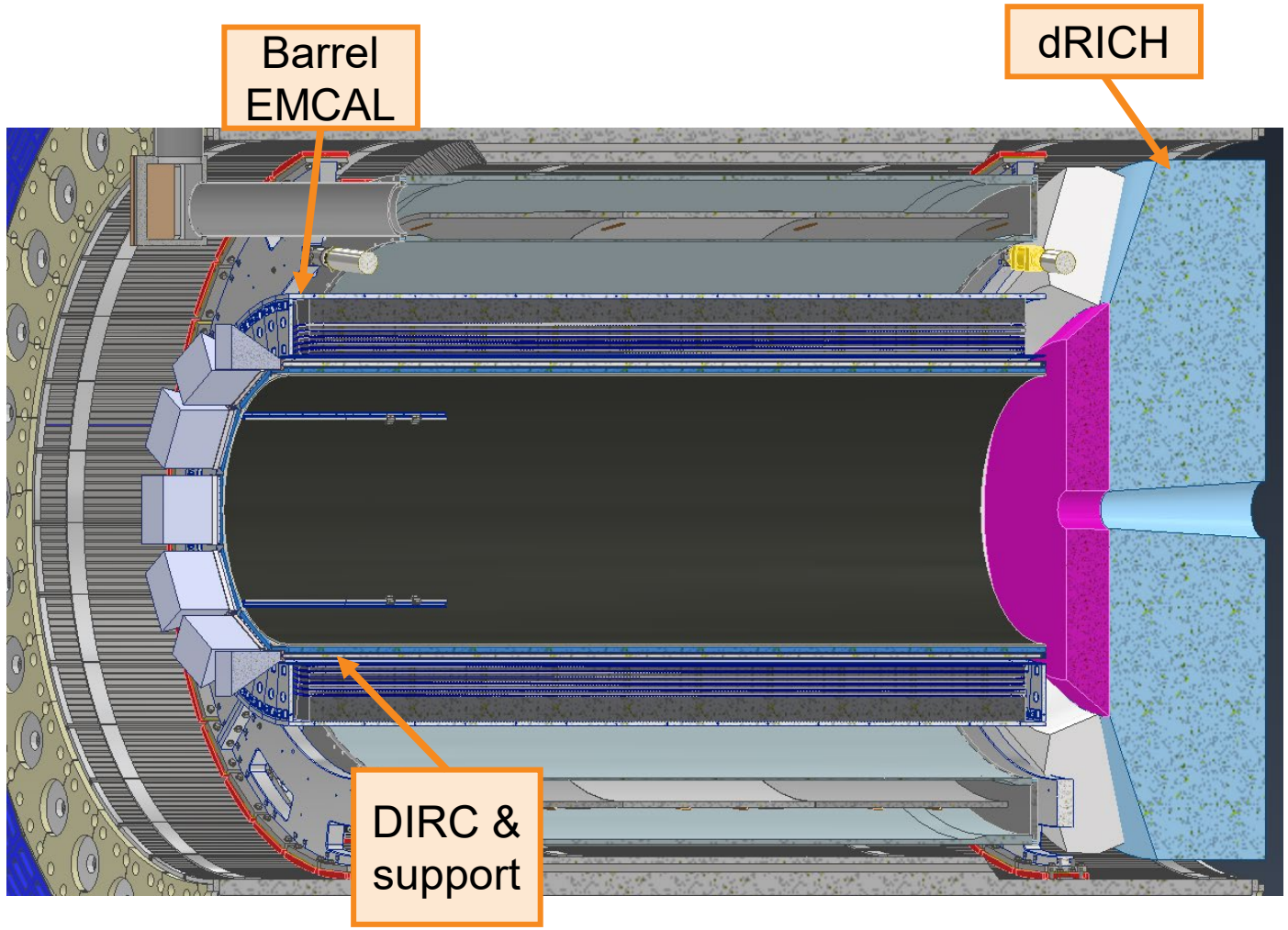
Model Overview (R.Wimmer)

- **Barrel HCAL (06.10.06.02):**
  - Reusing the sPHENIX barrel HCAL
  - sPHENIX dog-bones and inner support rings provide support for the HCAL
- **Detector Cradle:**
  - STAR Cradle will be the base of the Barrel Structures. It will have the mechanism to Roll EPIC in and out of the Experimental Hall.
- **Solenoid (06.10.07) :**
  - Using the same jack placement and leveling system that sPHENIX uses for its magnet
- **Support Rings:**
  - Reusing the sPHENIX support rings
  - Tobe altered slightly to accommodate end rings for the barrel EMCAL supports



Model Overviews (R.Wimmer)

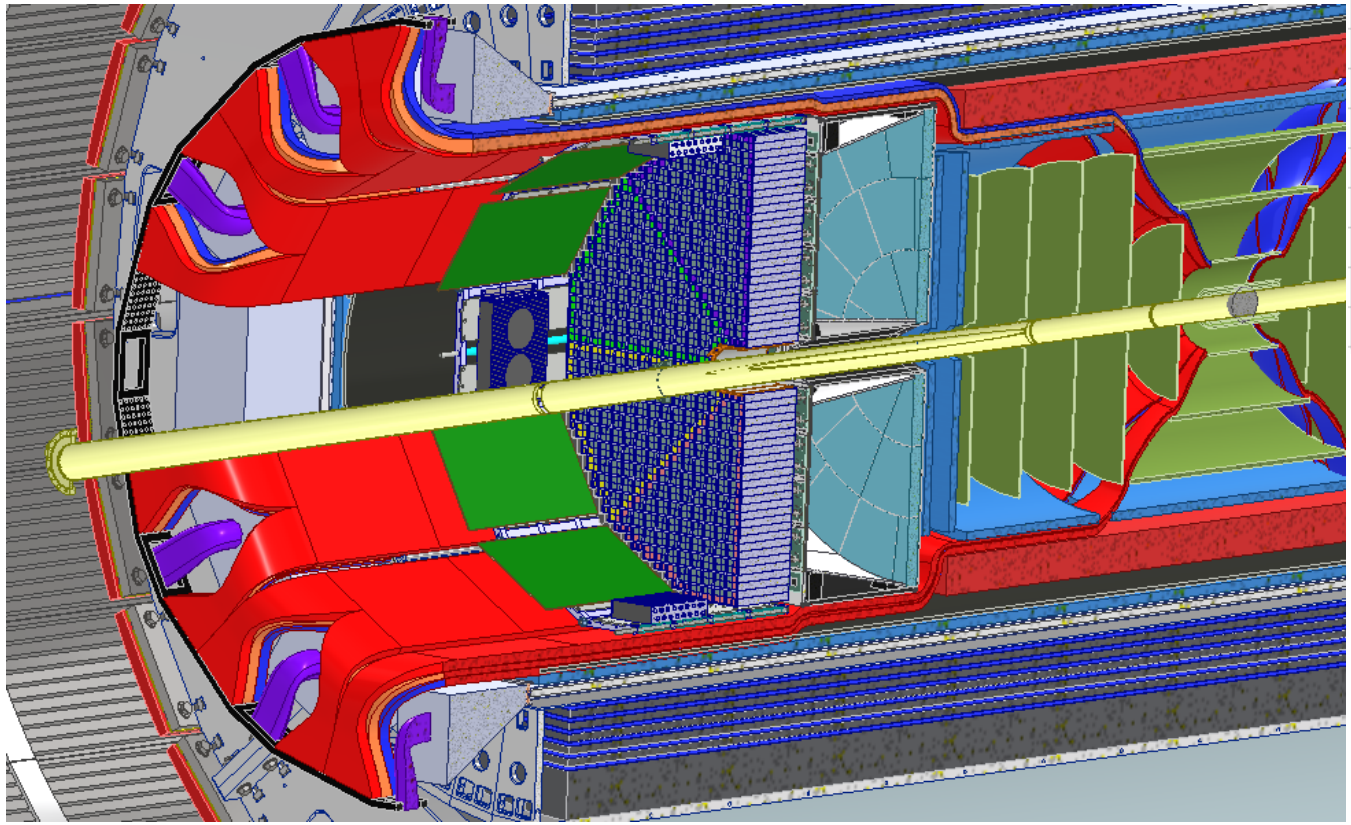
- **Barrel EMCAL (06.10.05.02):**
  - Will be supported by the inner support rings from sPHENIX
  - There will be 2 end rings that will mount the EMCAL to the support rings
- **dRICH:**
  - Currently there are slight interference issues that are being addressed.
  - Services from the inner detectors need space to pass in between the sensor boxes
  - Will be discussed in more detail in later slides
- **DIRC:**
  - Still being developed and is being modified heavily as constraints change
  - Will be discussed in more detail in later slides

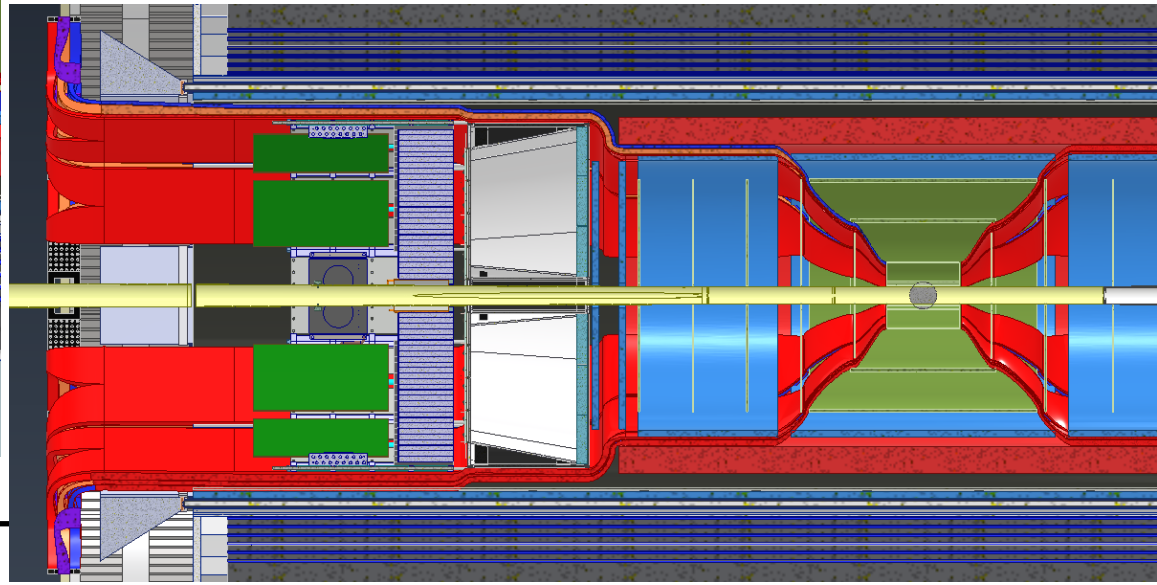


Services Layout (R.Wimmer)

- Services (Cable and Cooling Line Estimates) were collected from various subgroups.
- Services Layout is shown in snapshots below:

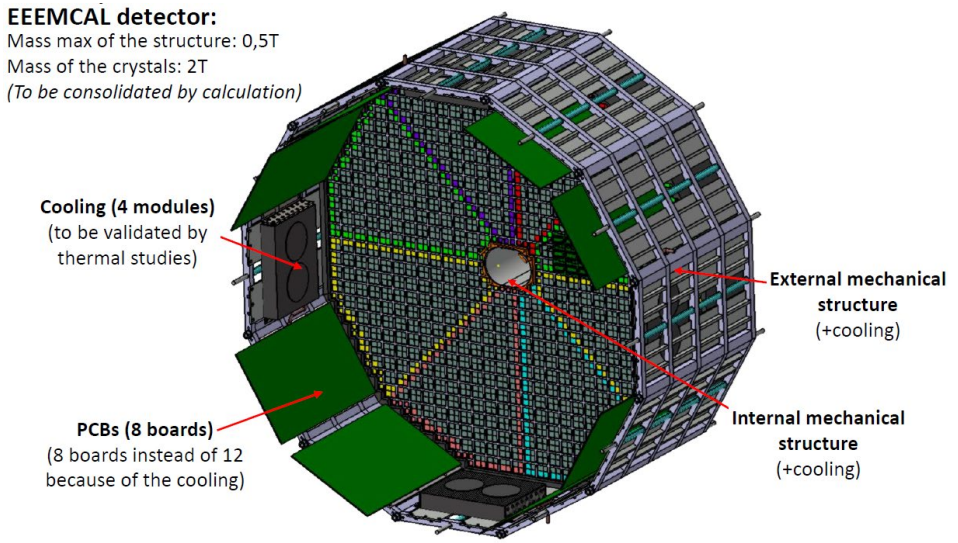
Subsytem	Quantity	Cross Area (cm^2)	+50% Packing for Bundles	+50% for MISC spacing needs	Available Space
Red Path IP to pfRICH Inner face					
Total	6003	853.72	1280.58		1800.00
Red Path From pfRICH to EEEMCAL Inner face					
Total	7244	1290.06	1935.10	2418.87	2240.00
Red Path From EEEMCAL to Flux Return Bars					
Total	20158	2867.21	4300.81	5483.67	9650.97
Orange Path From IP to AC-LGAD Disk					
Total	5499	759.74	1139.61		1998.05
Orange Path From AC-LGAD disk to Aerogel					
Total	7735	1559.01	2338.51	1894.25	4084.07
Orange Path From dRICH Aerogel to Dogbones					
Total	8311	1597.23	2395.84	1980.25	3965.46
Orange Path From 4 to 5					
Total	12801	2274.49	3411.74	3504.09	12189.38

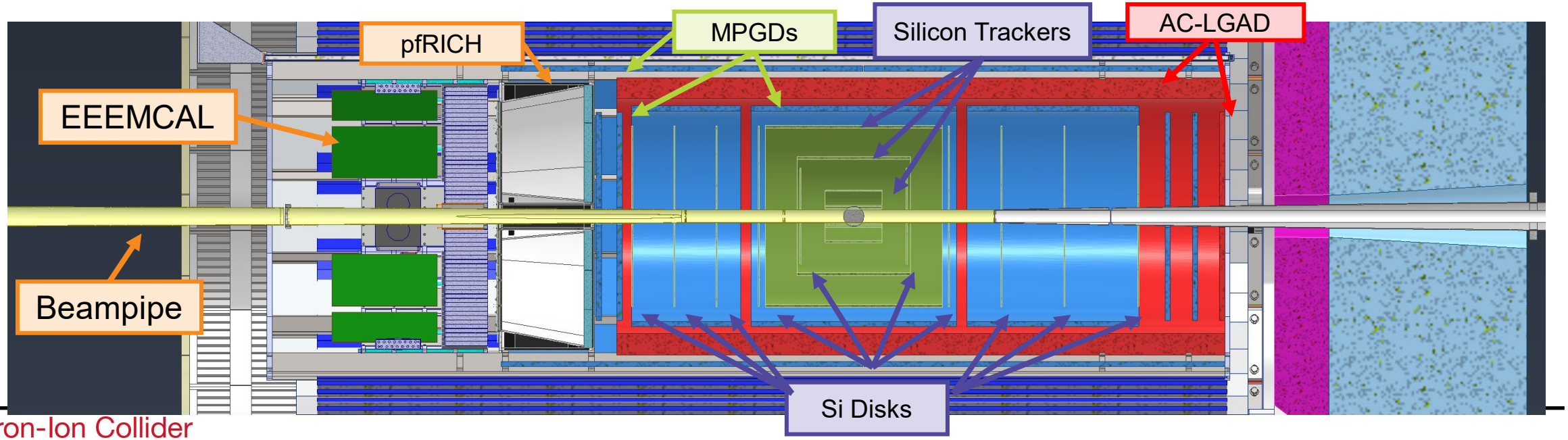




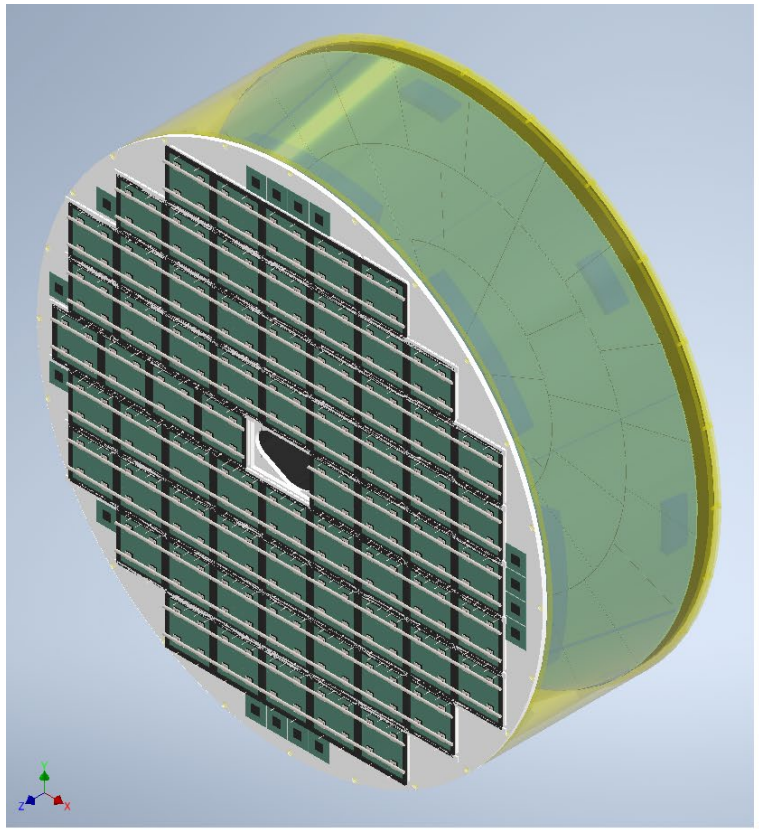
Model Overviews (Inner Detectors)

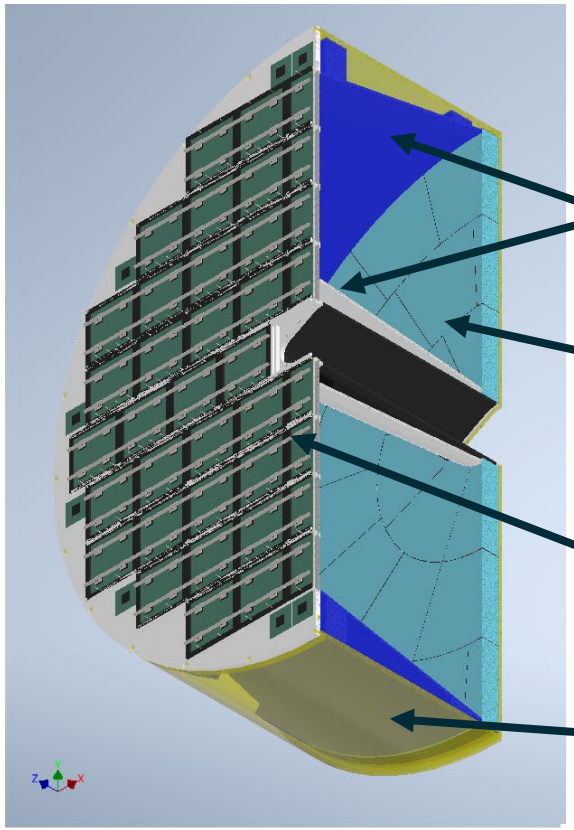
- **EEEMCAL (06.10.05.01):** Support Structure design in progress.
- **pfRICH:** Will most likely use the same rail structure that the EEEMCAL uses
- **AC-LGAD:** Cylinder and disk models are placeholders. A support structure is being developed that will house the AC-LGAD, Inner MPGDs & disks and all the Silicon Trackers
- **MPGDs:** Consists of outer and inner barrel layers along with 4 disks, 2 on each end Outer layer will be supported with the DIRC
- **Silicon Vertex & Sagita Silicon:** Will use same support structure as other inner detectors
- **Si Disks:** 10 Disks total, 5 each side, using same support structure as other inner detectors

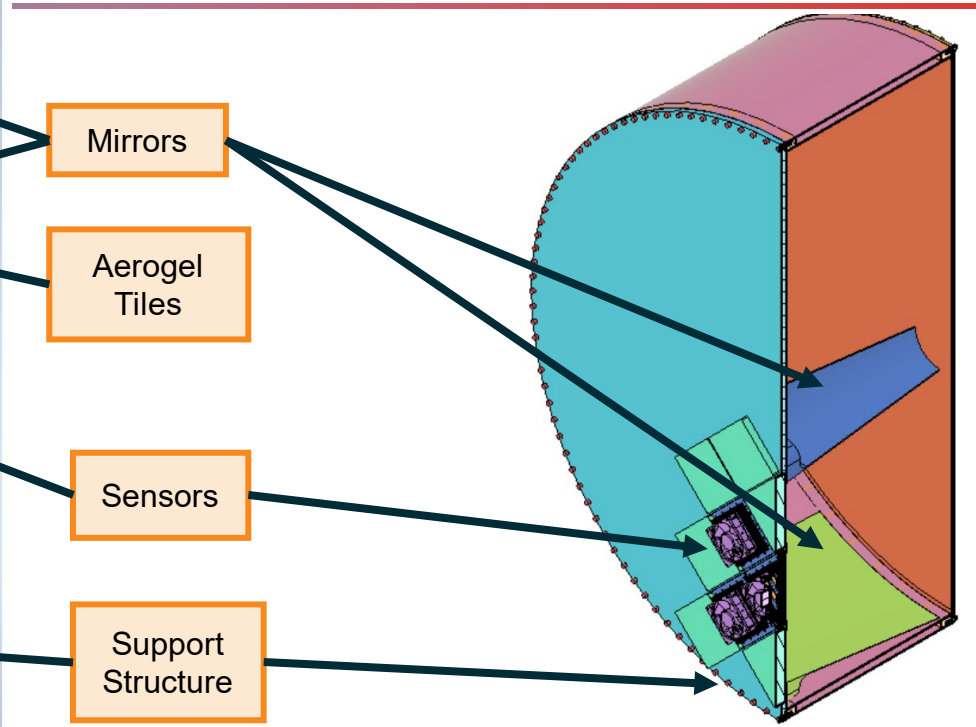




pfRICH (A.Eslinger)







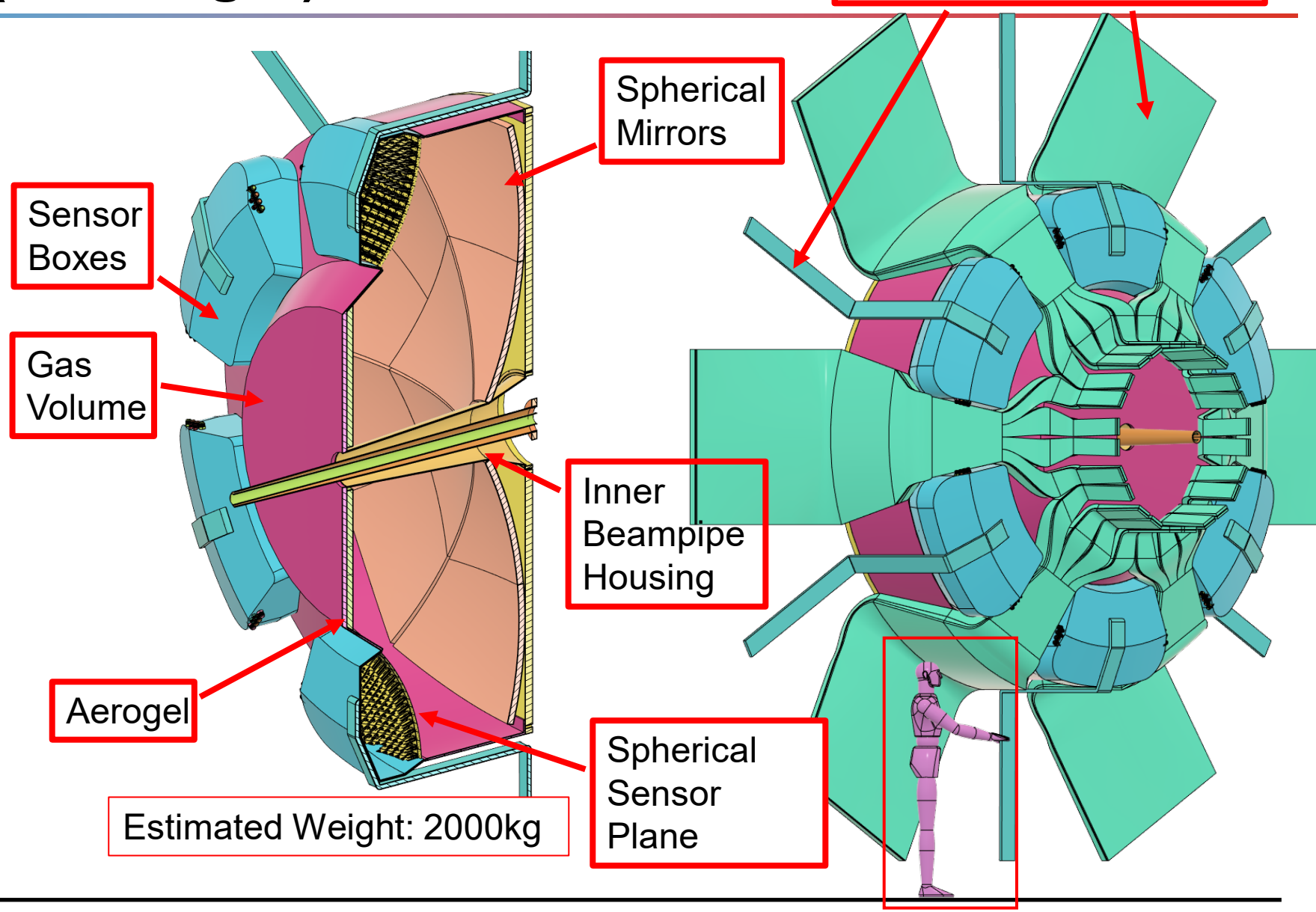
pfRICH Full Detector Model

pfRICH Prototype

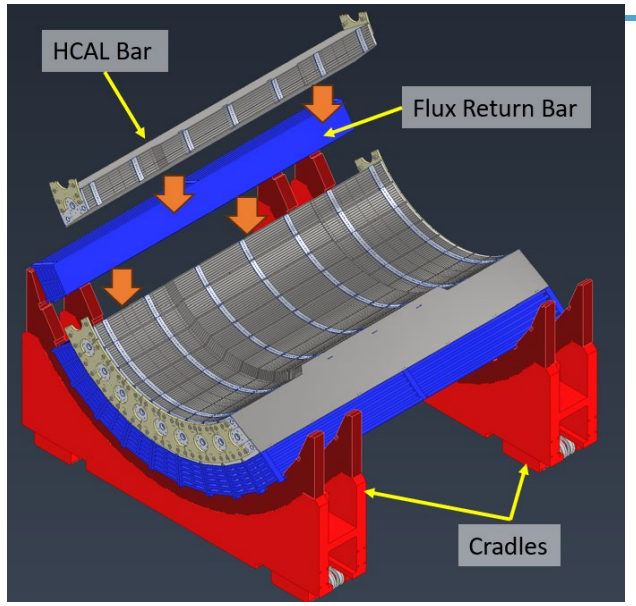
- Detail design in progress, to include gas and light tightness and manufacturability.
- Design of prototype is being advanced in parallel with the overall design. Building and testing the prototype for Fermilab in 2024. The purpose is to address technical risks associated with the detector. Specific parameters of its main components will be evaluated for their impact on performance, such as the HRPPD photosensors, the aerogel tiles and the Time-of-Arrival (ToA)/ADC based electronics.

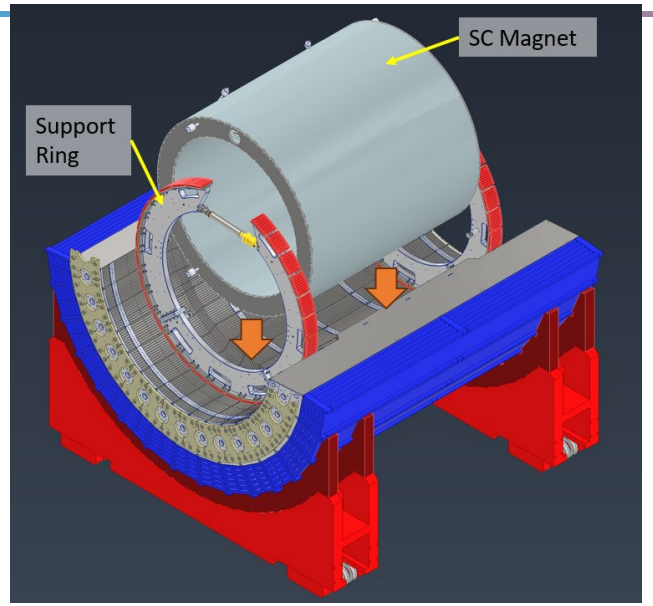
dRICH Overview (A.Eslinger)

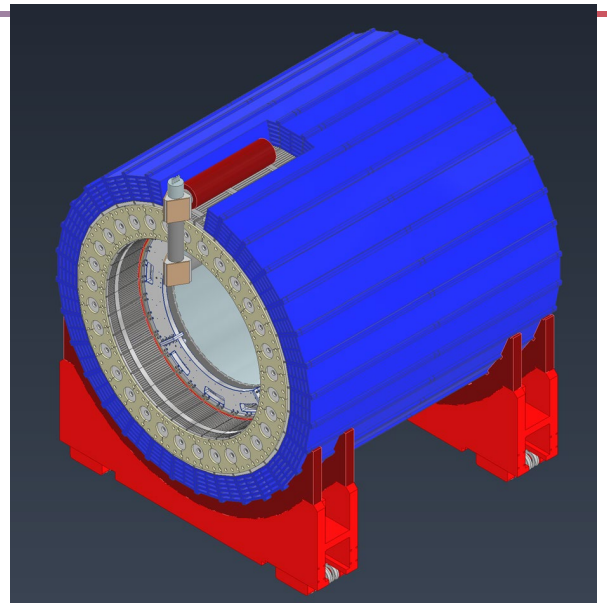
- Recent global positional changes have reduced integration interferences, however there are still a few minor areas of concern that are being addressed
- Installation and support designs for the dRICH are still being developed but consistent with the overall design schedule
- Current design development is associated with the sensor box and quartz window.
- Small scale prototyping for the sensor electronics completed in late October ’23 with a structural prototype for the frame in the works.

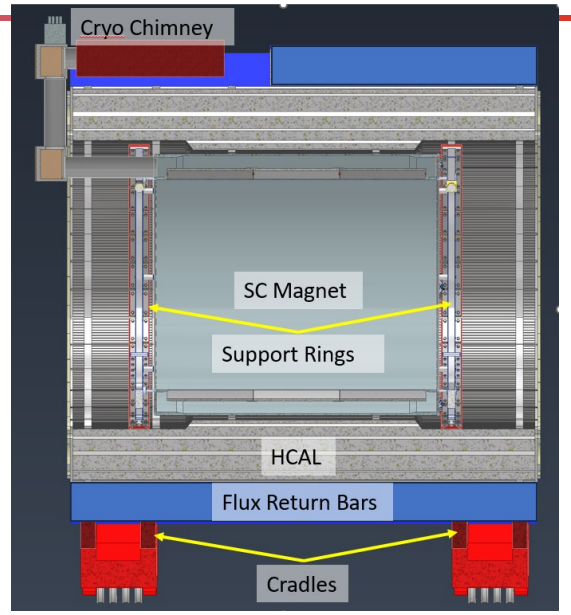


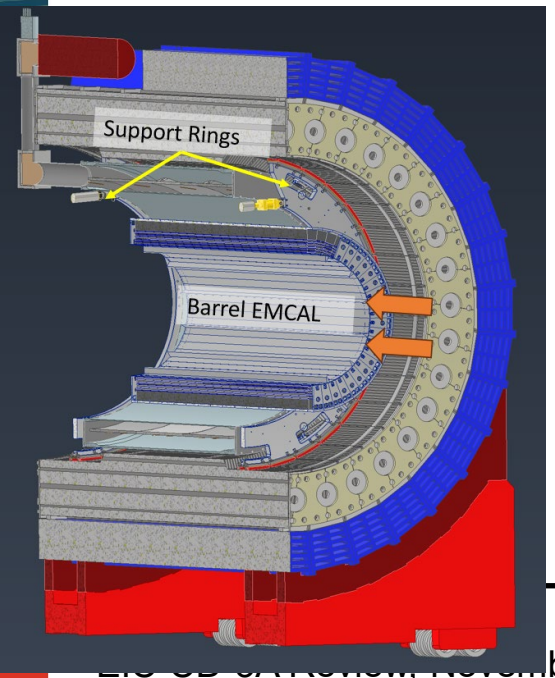
Installation Sequence (Barrel)

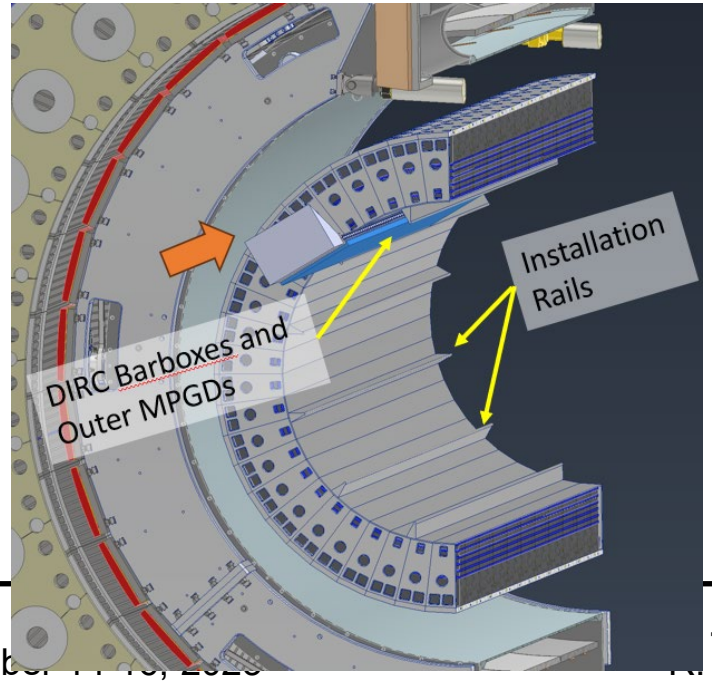


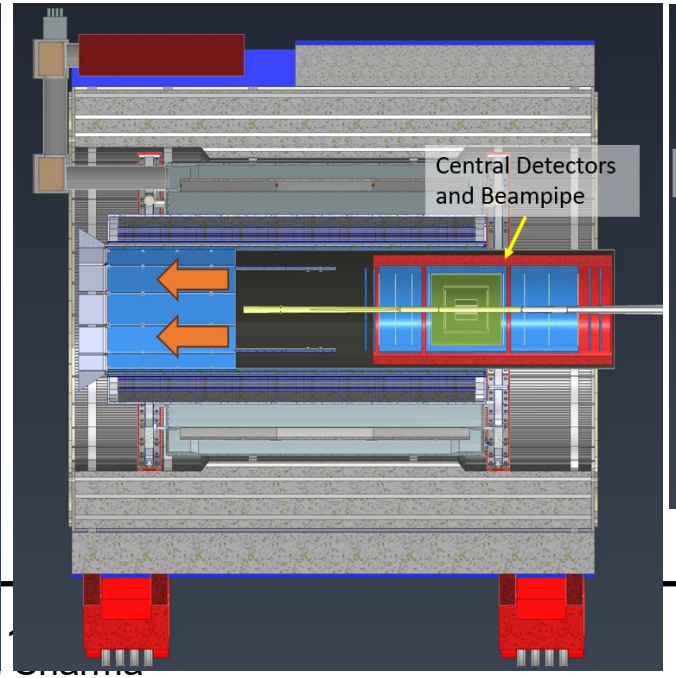


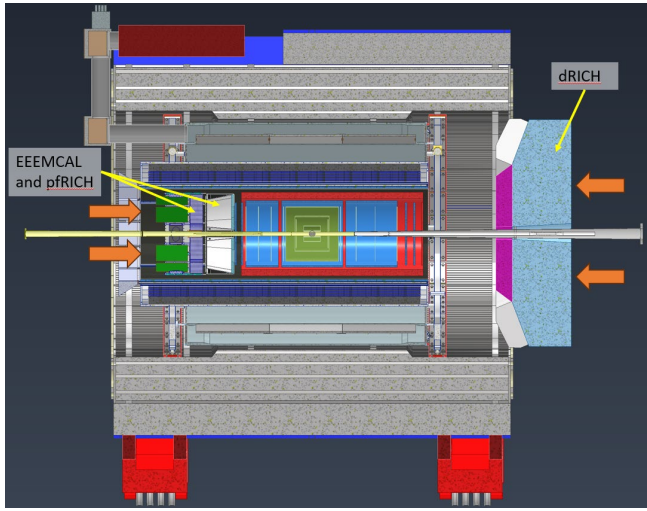






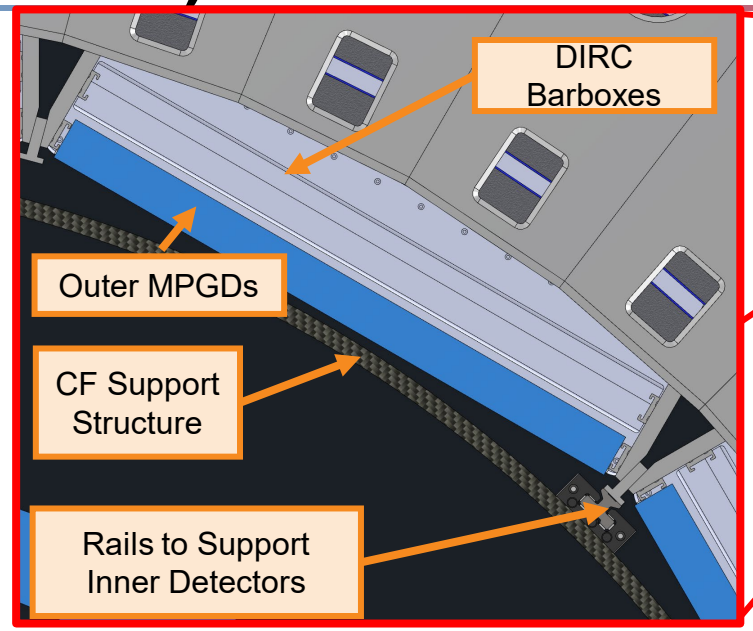


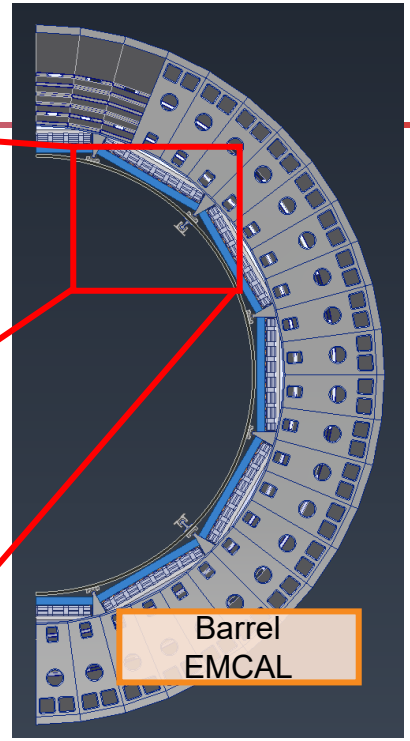


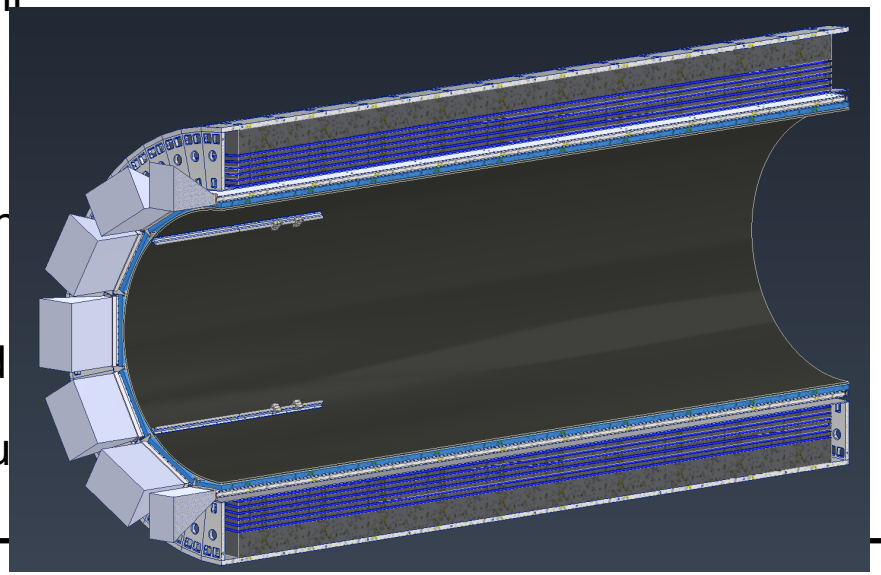


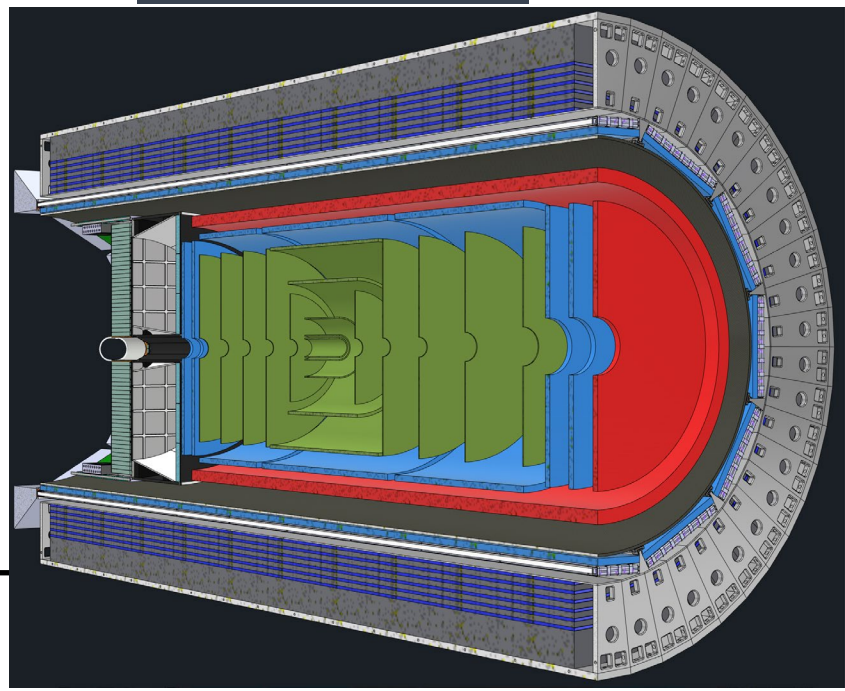
DIRC Support (D.Cacace)

- Current plan is to use barrel EMCAL for support of Inner Detectors/Waiting for Barrel EMCAL group to confirm the design of Barrel EMCAL.
- Outer MPGDs and DIRC barboxes will be nested in the area between rails.
- A carbon fiber Support Structure supported using Barrel EMCAL will support all the inner detectors
- Separate Rails will be used for EEEMCAL and pfRICH Installation
- Gaps between the EEEMCAL and the carbon fiber cylinder will allow for inner services to be brought ou



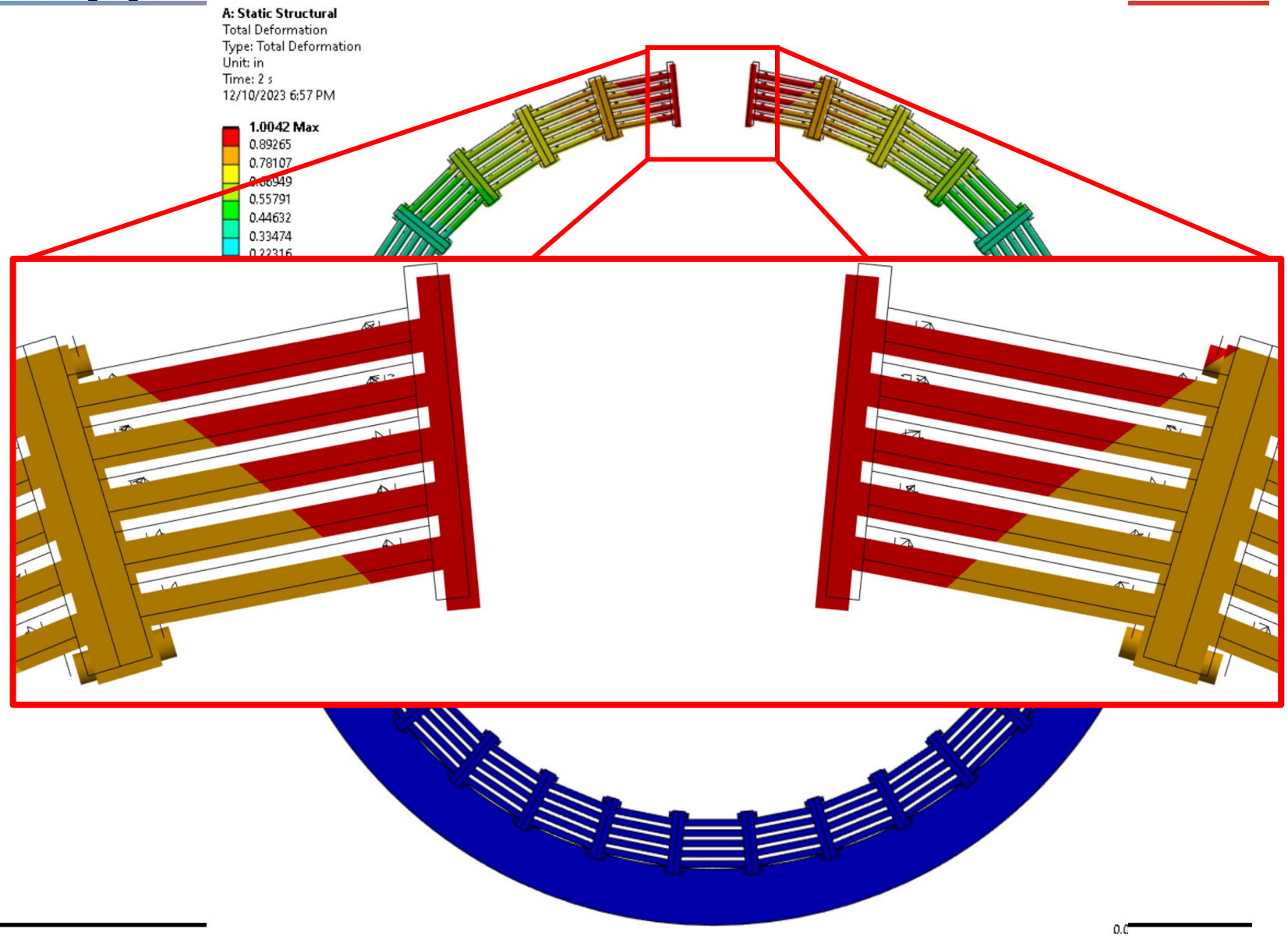






Barrel Flux Return Support (D.Cacace)

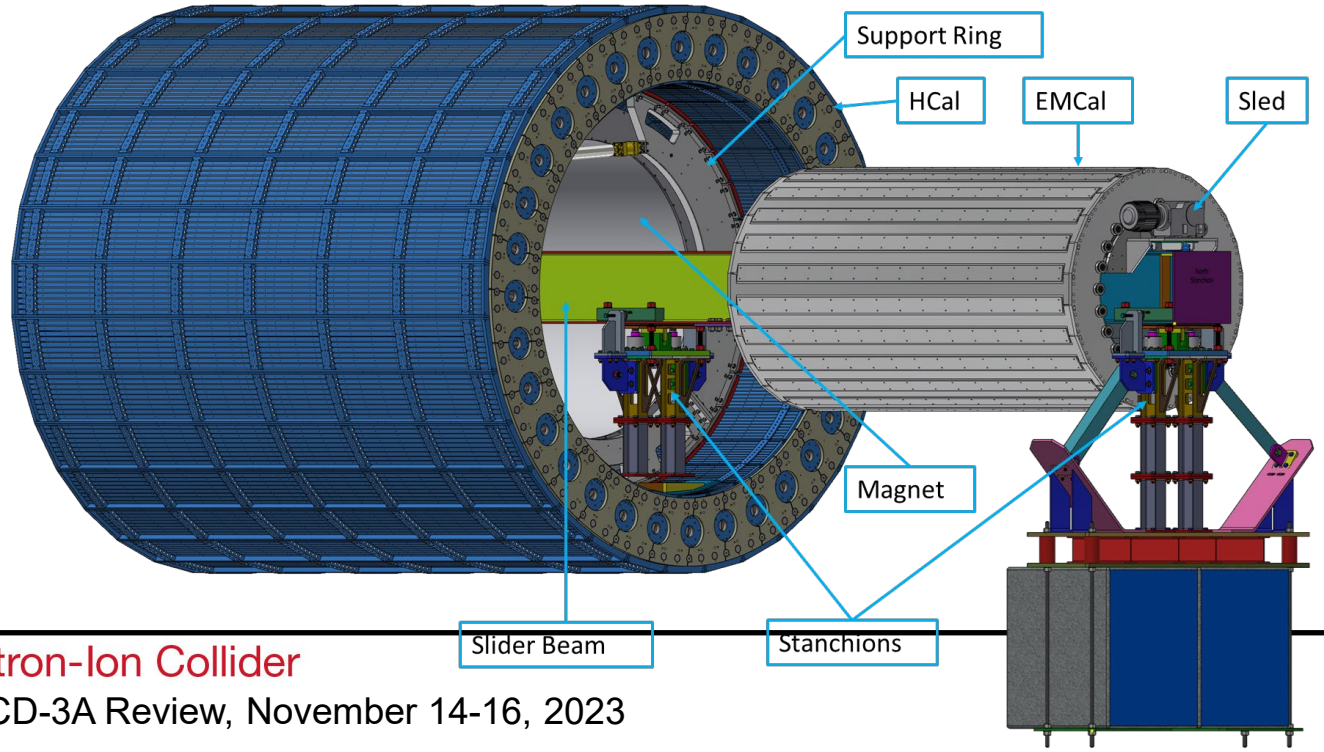
- Very preliminary FEA of a conceptual design of the barrel flux return.
- Concept is to assemble barrel flux return and HCal independently.
- Current design cannot be assembled, and modifications may affect FEA results.
- Deflections are reasonable and can either be accommodated by a gap or attachment to HCal, though there is concern about additional load on the HCal.
- Stresses are reasonable.
- Seismic and magnetic loads have not yet been considered.



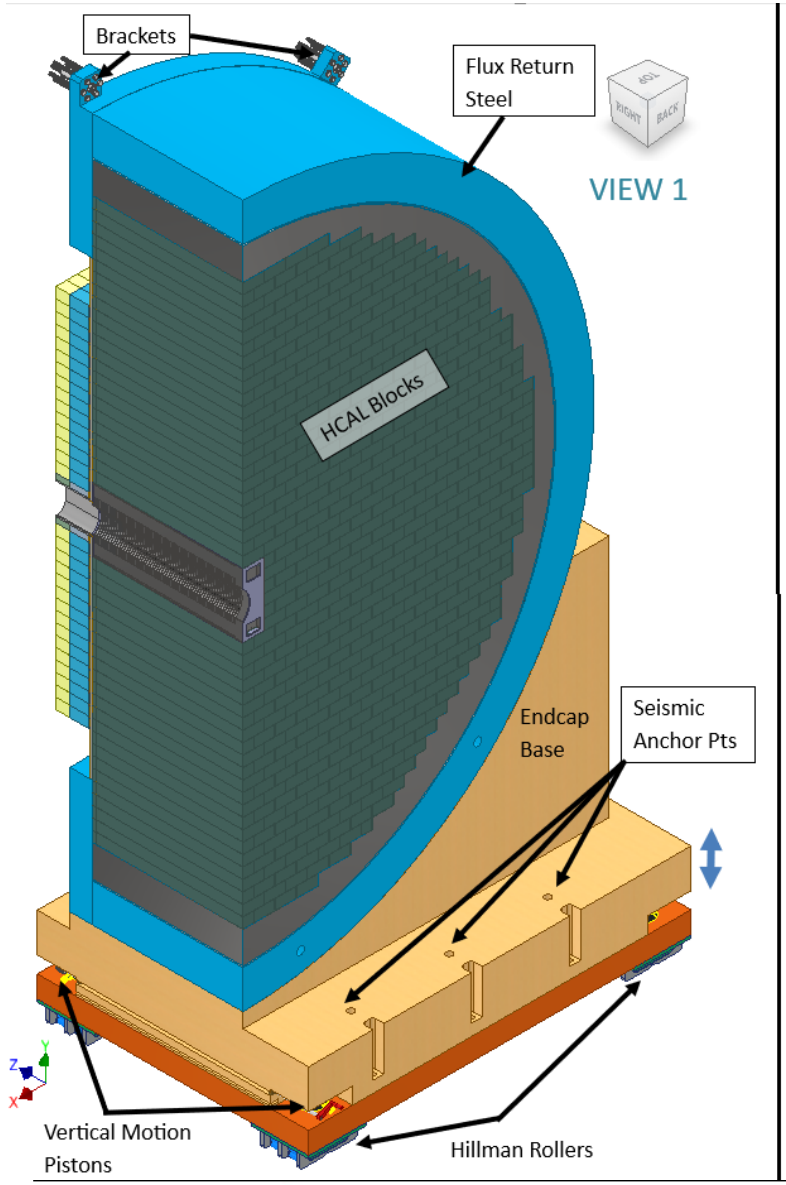
Barrel EMCAL (D.Cacace)

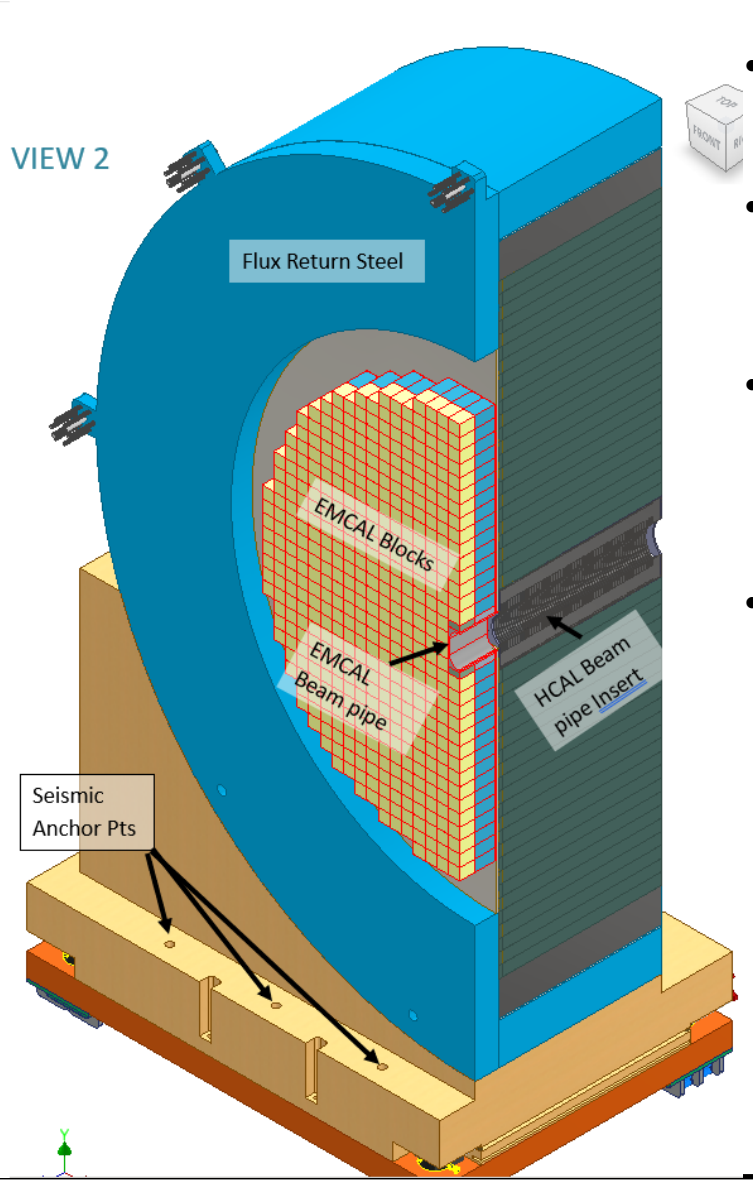
Installation Tooling

- We plan to use existing installation tooling from sPHENIX that was used to install Inner HCAL as shown in photos.
- Assemble Barrel EMCal on sled, A-frames and section of I-beam.
- The I-beam is inserted into the HCal and supported on stanchions.
- The Barrel EMCal is rolled in via the sled on the I-beam.
- The Barrel EMCal is attached to the support rings.
- The I-beam and stanchions are removed.



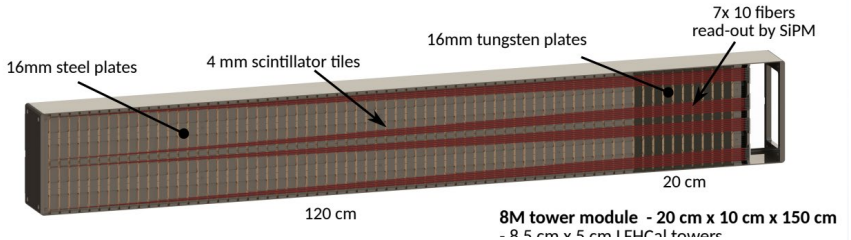
Hadron Endcap Design (06.10.05.03 and 06.10.06.03)

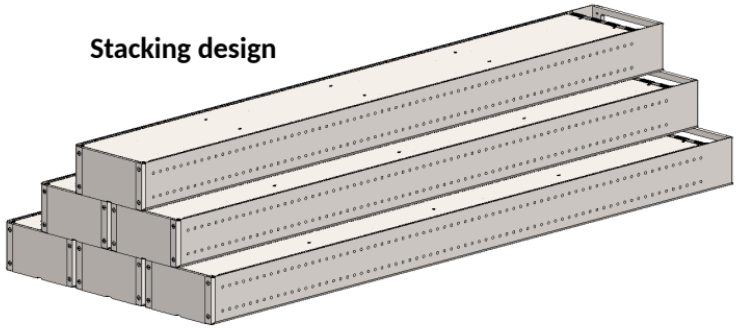


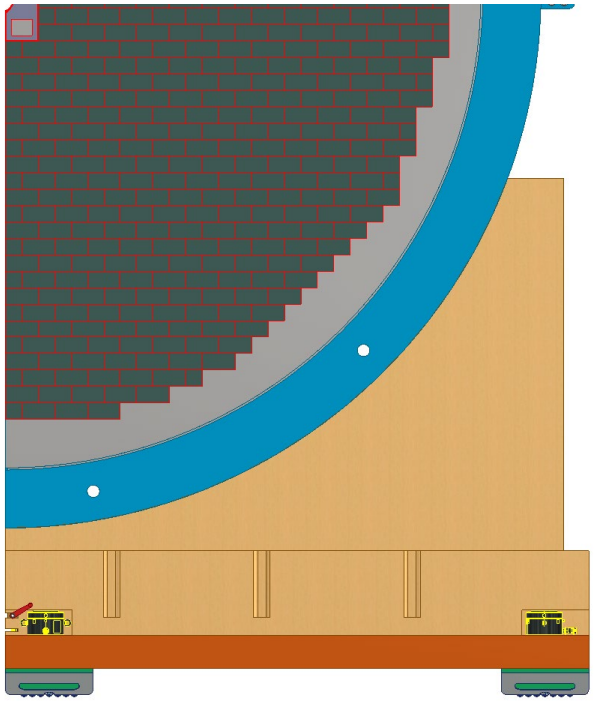


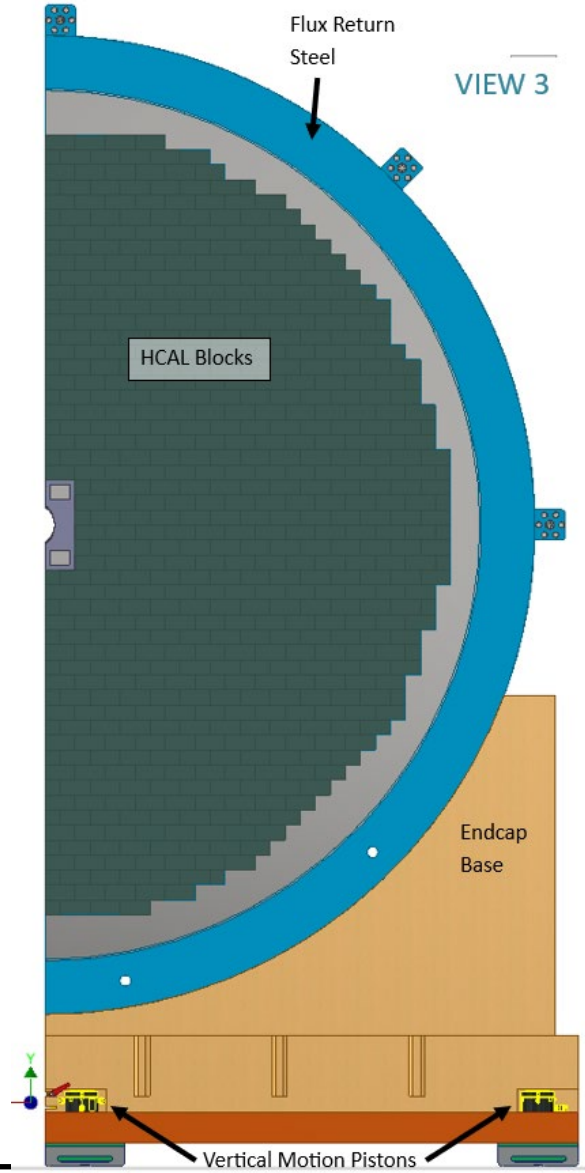
- End Cap Structures accommodate HCAL (06.10.06.03) and EMCAL Detectors (06.10.05.03)
- End Caps will be designed as two halves with a vertical split that will allow opening of End Caps for maintenance of detectors in the Barrel
- Endcaps will be assembled in the Experimental Hall and will not impact Barrel Assembly/Installation. It can also be done in parallel with Barrel Assembly if additional resources are available.
- Following Design and Analysis tasks need to be completed as next steps:
  - Seismic Analysis – Detailed Seismic Analysis required to figure out size of anchors and to determine stability during movement.
  - Analysis of Magnetic Forces for HCAL blocks and pins needed.
  - Pinning/Securing of HCAL/EMCAL detector Blocks
  - Rails for Endcaps
  - Moving Mechanism presenting challenge due to one corner being inaccessible.
  - Guiding Mechanism for Endcaps
  - North and South Platform Modifications to resolve interference issues

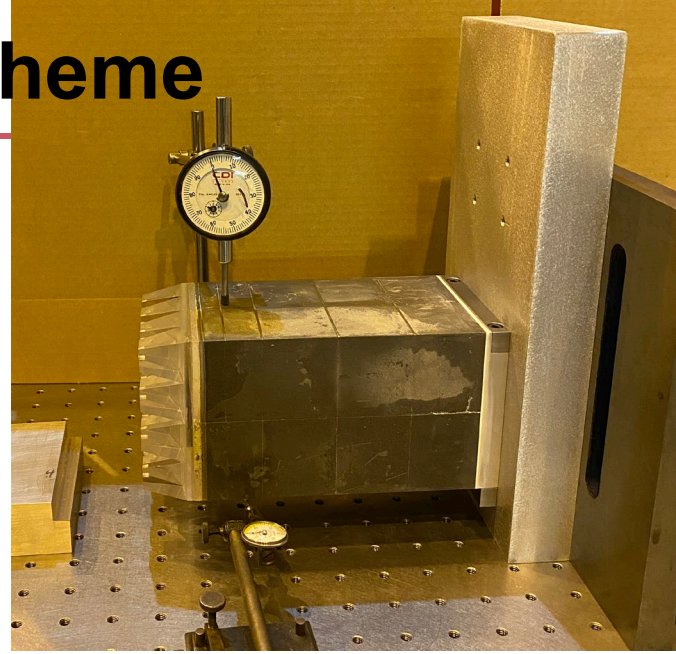
Hadron Endcap ECAL and HCAL Mounting Scheme











Power

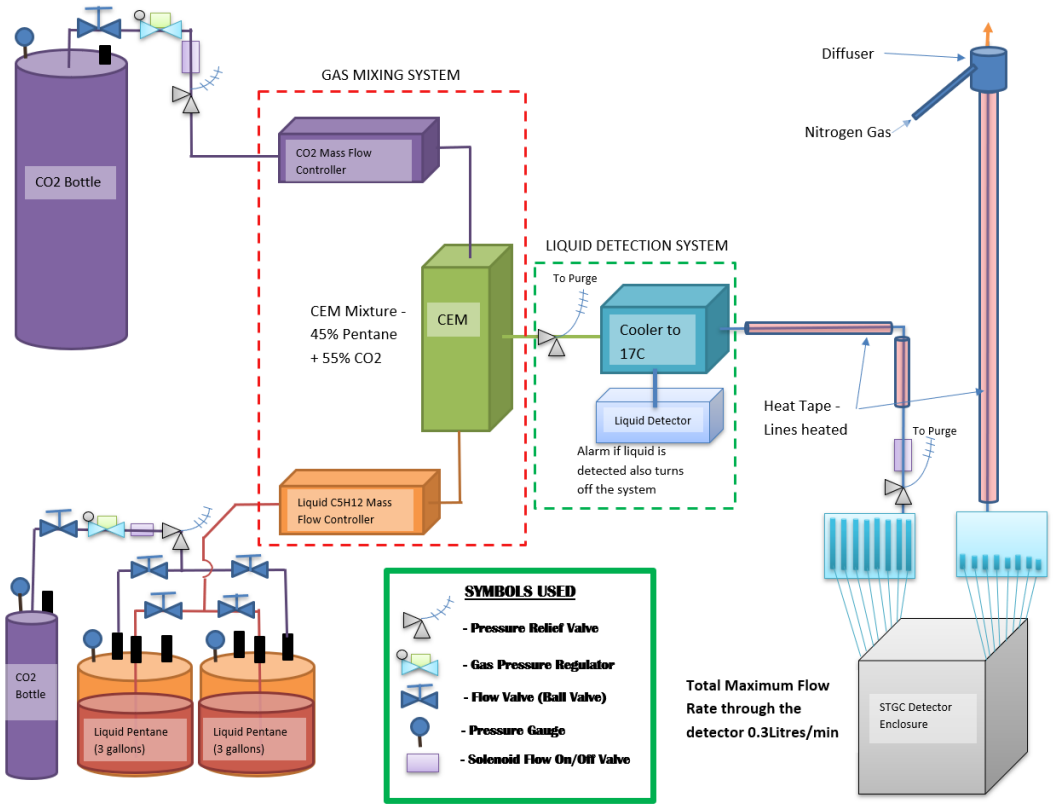
- New Power Supplies will be used for MARCO (SC Magnet 06.10.07). New DAQ Rack will be placed on Third Level.
- Power requirements for detectors are being estimated and compared to available power.
- Detector Electronic Racks on South Platform: Current assumption is that available power is enough. Trying to collect requirements and verify the assumption.
- Shown below is the snapshot from Electronics, power and services spreadsheet. Full version in backup slides for reference.

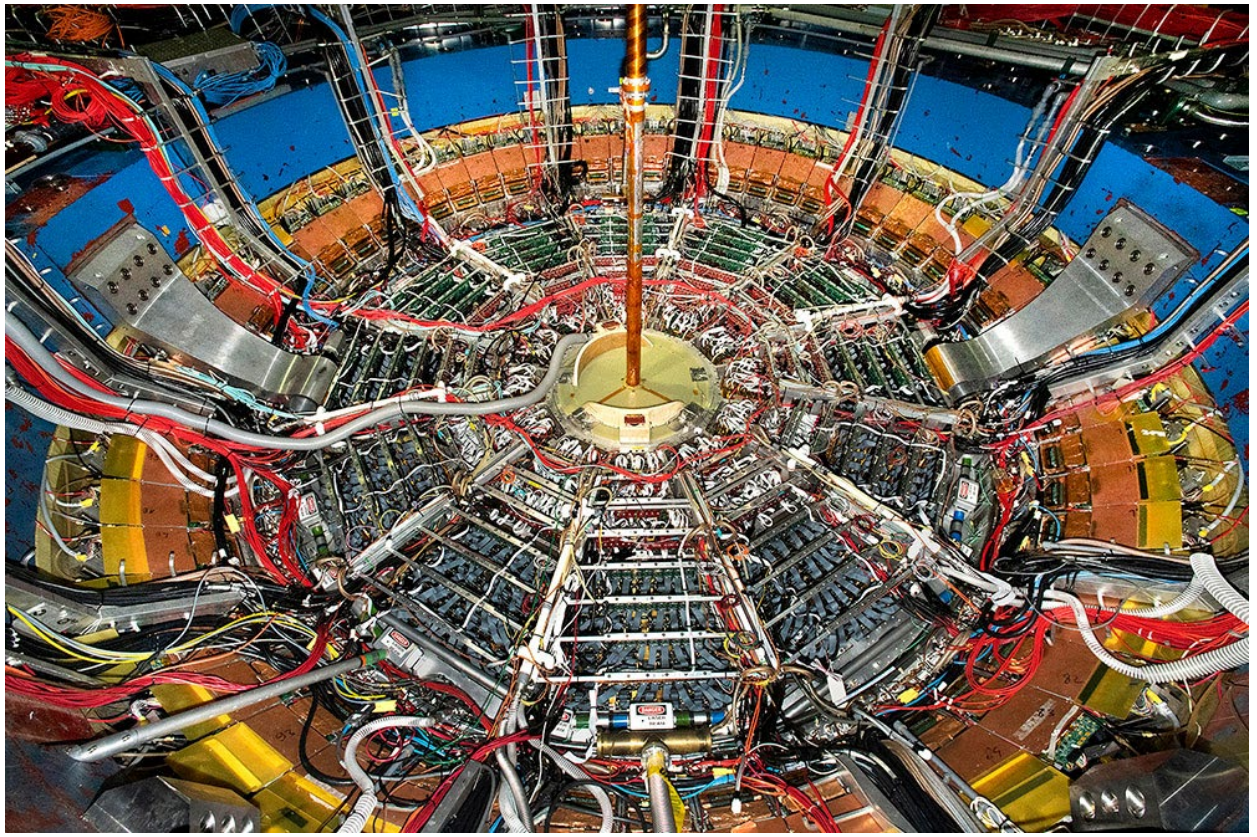
ePIC Detector Electronics Power & Services

Page 1

Detector	Type	Front End LV Power	HV Bias	LV Power Supply Type	HV Power Supply Type	Power Supply Location	LV Power Feed	LV Feed Cables (Tray Rated)	Cooling (Board Electronics)
E-EE EMCAL	SiPM	500W	500W@50V	MPV 4016I	Wiener MPV 8120I	W. Platform, 19" rackmount	10V @ 50A	4x 12AWG	Convection
Barrel ECAL	SiPM + AstroPix	1.6kW	1W @50V & 100W @ 400V	MDH-07/16	MPV 8120I & EHS F005p	S. Platform, 19" rackmount	10V @ 160A	16x 12AWG	Liquid
FWD ECAL	SiPM	2.8kW	750W@ 50V	PL506	MPV 8120I	W. Platform, 19" rackmount	10V @ 280A	20x 12AWG	Liquid
HE HCAL	SiPM	1.7kW	3kW@ 50V	PL506	MPV 8120I	E. Platform, 19" rackmount	10V @ 170A	12x 12 AWG	Convection

Cooling Systems and Gas Systems





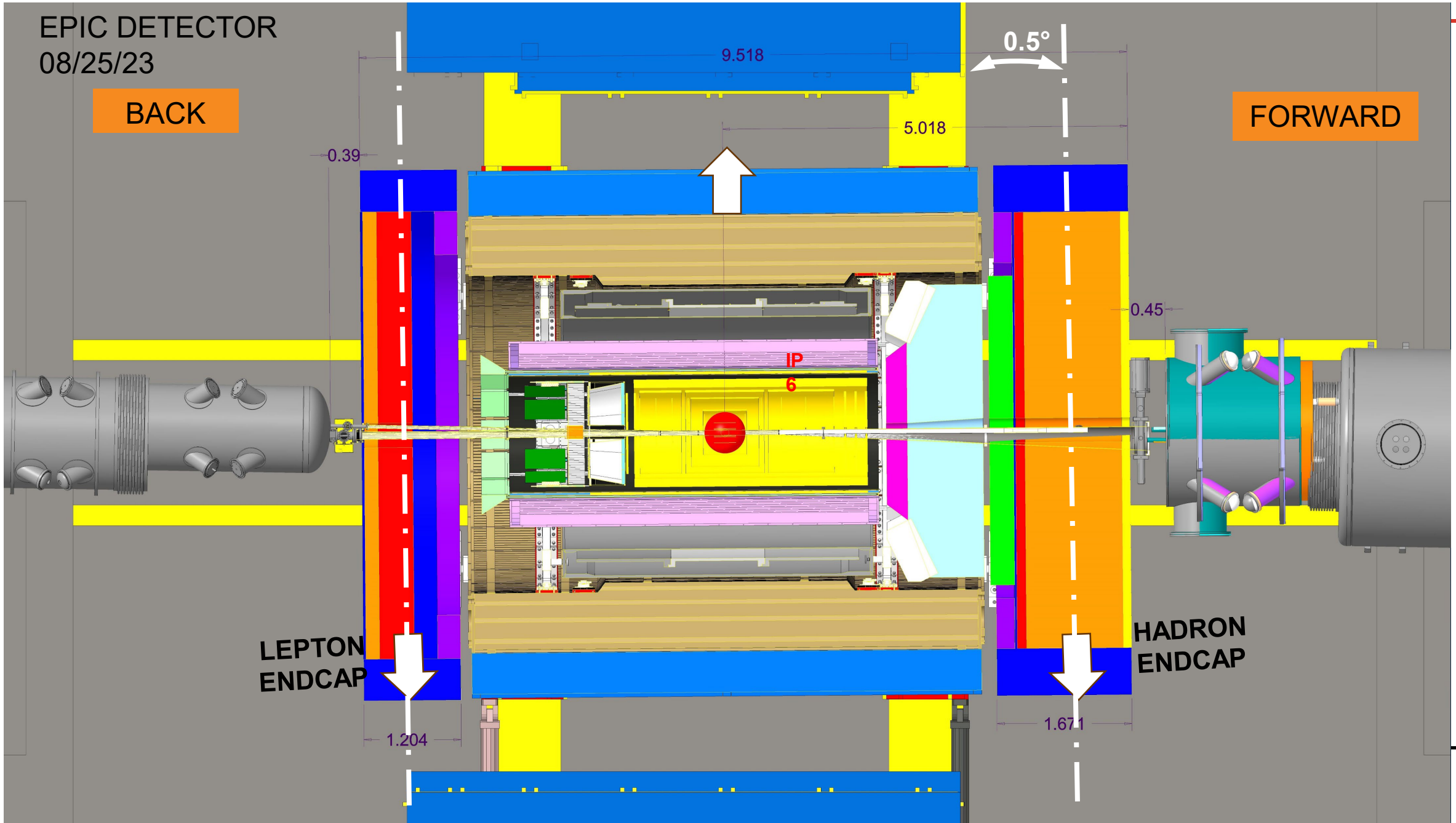
- Gas Systems
  - Gas Detectors such as MPGDs need Gas Systems for mixing and delivery of required gases. We will design and build gas systems for the required detectors.
- Cooling Systems
  - Need to fully gather cooling requirements for all the detectors and integrate cooling in the design.

Summary/ Next Steps

- As shown in the slides, preliminary design of the support structures for LLP items looks promising.
- Developing the designs of various sub detectors and their support structures.
- Identification of conflicts and resolution.
- Cabling plan needs to be further developed with cable trays etc.
- All detectors and structures need to be analyzed for Seismic and Magnetic Forces but should not affect LLP items.
- Moving Mechanisms for Endcaps need to be finalized and integrated into the design.
- Power requirements for various detectors and electronics need to be further developed.
- Grounding scheme for Magnet and detectors need to developed.
- Cooling Requirements need to be further developed.
- Gas Systems need to be designed (This can wait for now).
- Safety systems (Fire Suppression, Smoke Detection and Interlock systems) need to be designed.

Backup Slides

ePIC Top View



ePIC Detector Electronics Power & Services

Detector	Type	Front End LV Power	HV Bias	LV Power Supply Type	HV Power Supply Type	Power Supply Location	LV Power Feed	LV Feed Cables (Tray Rated)	Cooling (Board Electronics)
EE HCAL	SiPM	200W	50W@ 50V	MPV 4016I	Wiener MPV 8120I	S. Platform, 19" rackmount	10V @ 20A	4x 14 AWG	Liquid
E-EE EMCAL	SiPM	500W	500W@50V	MPV 4016I	Wiener MPV 8120I	W. Platform, 19" rackmount	10V @ 50A	4x 12AWG	Convection
pfRICH	HRPPD	260W	70W@3kV	MPV 4018I	CAEN A1515BV	S. Platform, 19" rackmount	1.2V@ 220A	14x 12AWG	Liquid/ Neg. pressure
EE MPDG Disk	uRWELL	350W	1.5W@1.5kV	MDH-07/16	CAEN A1515BV	S. Platform, 19" rackmount	10V @ 315A	2x 10AWG	Liquid
Outer Barrel MPGD	uRWELL	1.6kW	1.5W@1.5kV	MDH-07/16	CAEN A1515BV	S. Platform, 19" rackmount	10V @160A	12x 12AWG	Liquid
Inner Barrel MPGD	uRWELL	700W	1.5W@1.5kV	MDH-07/16	CAEN A1515BV	S. Platform, 19" rackmount	10V@120A	15x 12AWG	Liquid
MAPS Disk	EIC-LAS	3kW	Derived from LV system	MPV 4018I	N/A	S. Platform, 19" rackmount	3.6V@ 960A	48x 10AWG	Liquid
MAPS Sagita Layer3	EIC-LAS	680W	Derived from LV system	MPV 4018I	N/A	S. Platform, 19" rackmount	2.4V@ 194A	16x 12AWG	Liquid
MAPS Sagita Layer4	EIC-LAS	1.4kW	Derived from LV system	MPV 4018I	N/A	S. Platform, 19" rackmount	4.8V @ 235A	18x 12AWG	Liquid
MAPS Vertex	EIC-LAS	200W	Derived from LV system	MPV 4018I	N/A	S. Platform, 19" rackmount	1.2V @ 60A	4x 12 AWG	Liquid

ePIC Detector Electronics Power & Services

(PAGE 2) Continued….

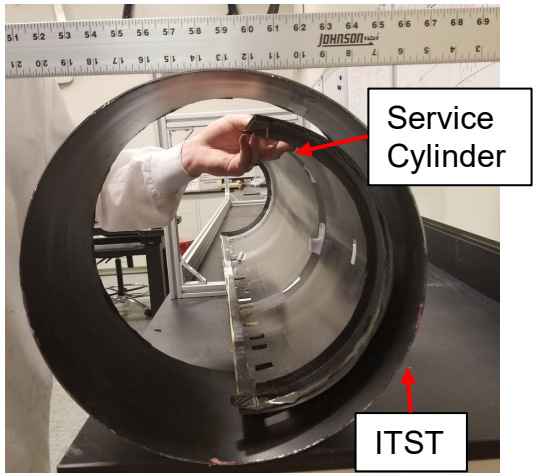
Detector	Type	Front End LV Power	HV Bias	LV Power Supply Type	HV Power Supply Type	Power Supply Location	LV Power Feed	LV Feed Cables (Tray Rated)	Cooling (Board Electronics)
Barrel HCAL	SiPM	220W	1.6W @50V	MPV 8016I	MPV 8120I	S. Platform, 19" rackmount	10V @ 22A	8x 16AWG	Liquid
Barrel ECAL	SiPM + AstroPix	1.6kW	1W @50V & 100W @ 400V	MDH-07/16	MPV 8120I & EHS F005p	S. Platform, 19" rackmount	10V @ 160A	16x 12AWG	Liquid
DIRC	HRPPD	300W	70W@3kV	MPV 4018I	CAEN A1515BV	S. Platform, 19" rackmount	1.2V@ 250A	16x 12AWG	Liquid
Barrel TOF	AG-LGAD	2400W	4W@400V	PL506	CAEN A1625	S. Platform, 19" rackmount	10V @ 240A	12x 10AWG	Liquid
HE TOF	AG-LGAD	10.6kW	4W@400V	PL506	CAEN A1625	S. Platform, 19" rackmount	10V @ 1,060A	48x 10AWG	Liquid
dRICH	SiPM	300W	23W@70V	MPV 4016I	MPV 8120I	S. Platform, 19" rackmount	10V @ 30A	4x14AWG	Liquid
FWD ECAL	SiPM	2.8kW	750W@ 50V	PL506	MPV 8120I	W. Platform, 19" rackmount	10V @ 280A	20x 12AWG	Liquid
HE HCAL	SiPM	1.7kW	3kW@ 50V	PL506	MPV 8120I	E. Platform, 19" rackmount	10V @ 170A	12x 12 AWG	Convection

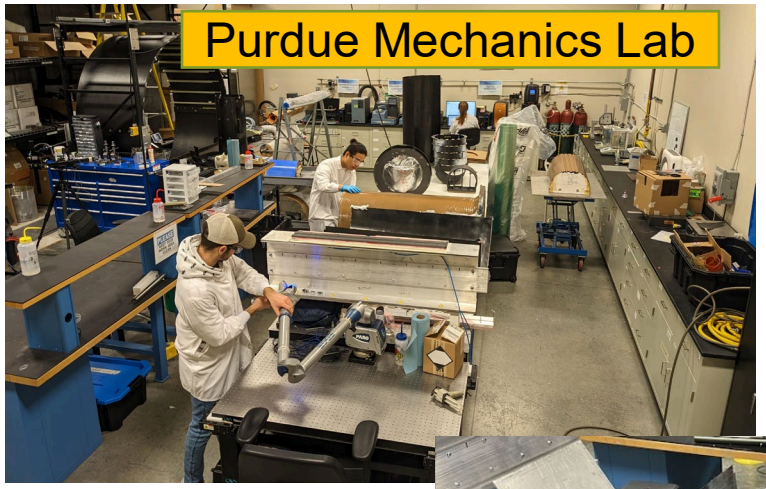
Note: Refer to ePIC Services on-line Spreadsheet for details of power distribution

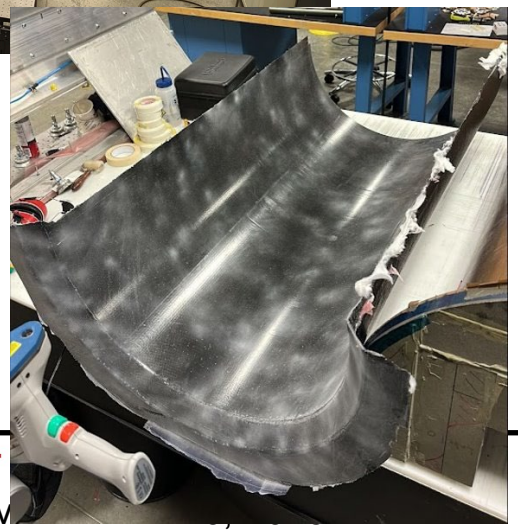
August 2023, T.Camarda for BNL EE Group

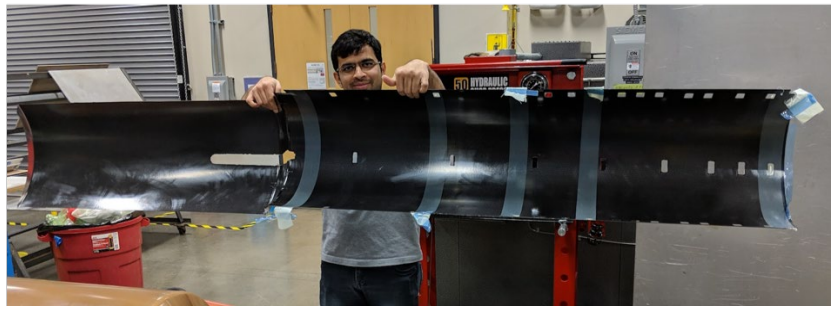
Carbon Fiber Support Structures for Inner Detectors

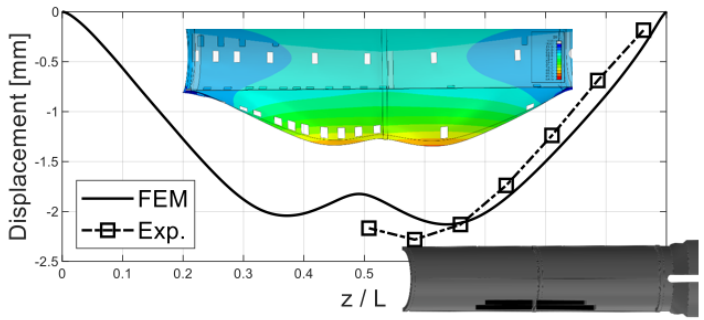
- Carbon Fiber Strucutures as shown used at other experiments (STAR, CMS etc.) will be used for supporting Inner Detectors.
- Plan to prototype and test structures for strength as well as deflections to compare it with FEA results.



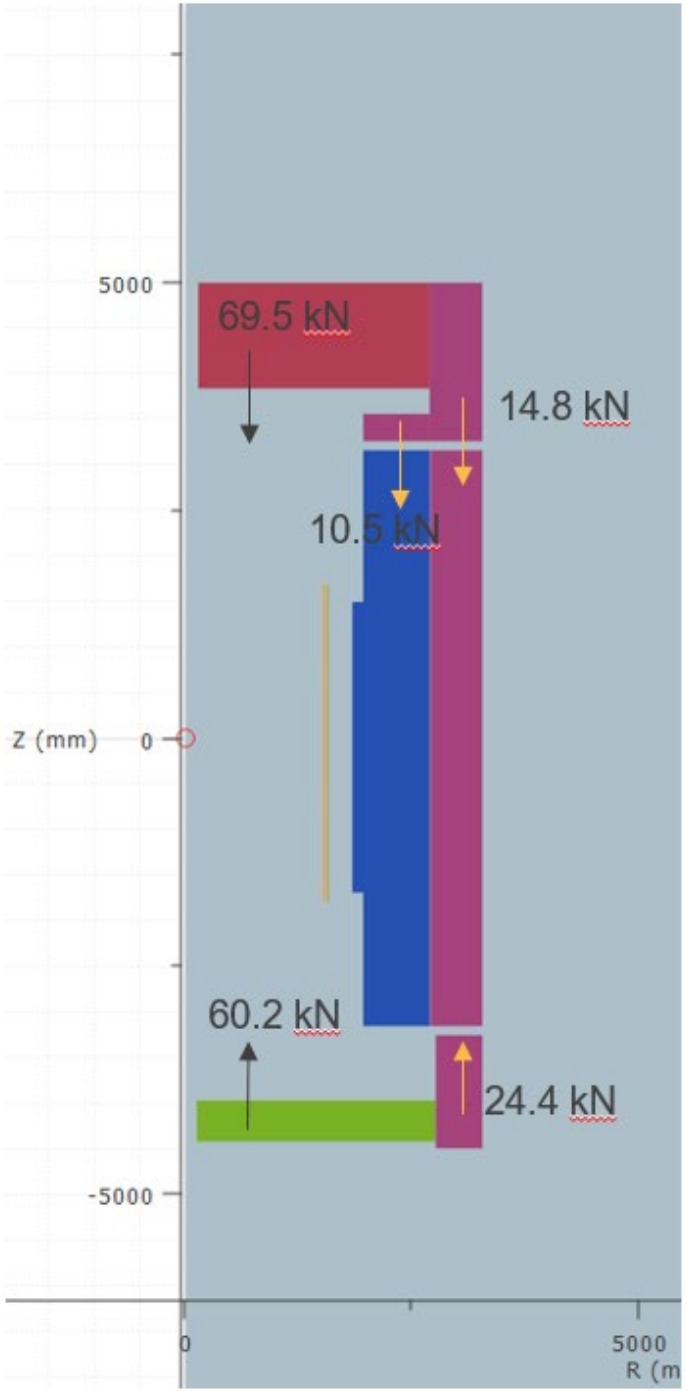








MARCO Yoke Forces (Magnetic Forces)



Object	Fz	Unit
Hadron HCAL	-69.5	kN
Lepton HCAL	60.2	kN
Steel Hadron BARREL	-14.8	kN
Steel Plate	-10.5	kN
Steel Lepton BARREL	24.4	kN

- Detail Analysis of Magnetic forces on all magnetic components need to be analyzed.
  - EPIC Carriage
  - Flux Return Bars
  - End Caps
  - HCAL and EMCAL detectors with magnetic components

Endcap Rails and Moving Mechanisms

- Endcap moving mechanisms need to move Endcap Halves along X axis with vertical adjustment capability (Y axis). Movement in Z may be required?
- Concepts being considered:
  - Hillman Rollers and Hydraulic Pistons (Currently used at STAR).
  - Air Bearings/Air Pallets
  - Hydraulic Skidding System
  - Motorized Trolley System
- Currently evaluating Concepts as viable design choices against design criteria.
- Moving mechanism can also be combinatior of two concepts.
- May need to visit companies before making design decision.