Brookhaven National Laboratory

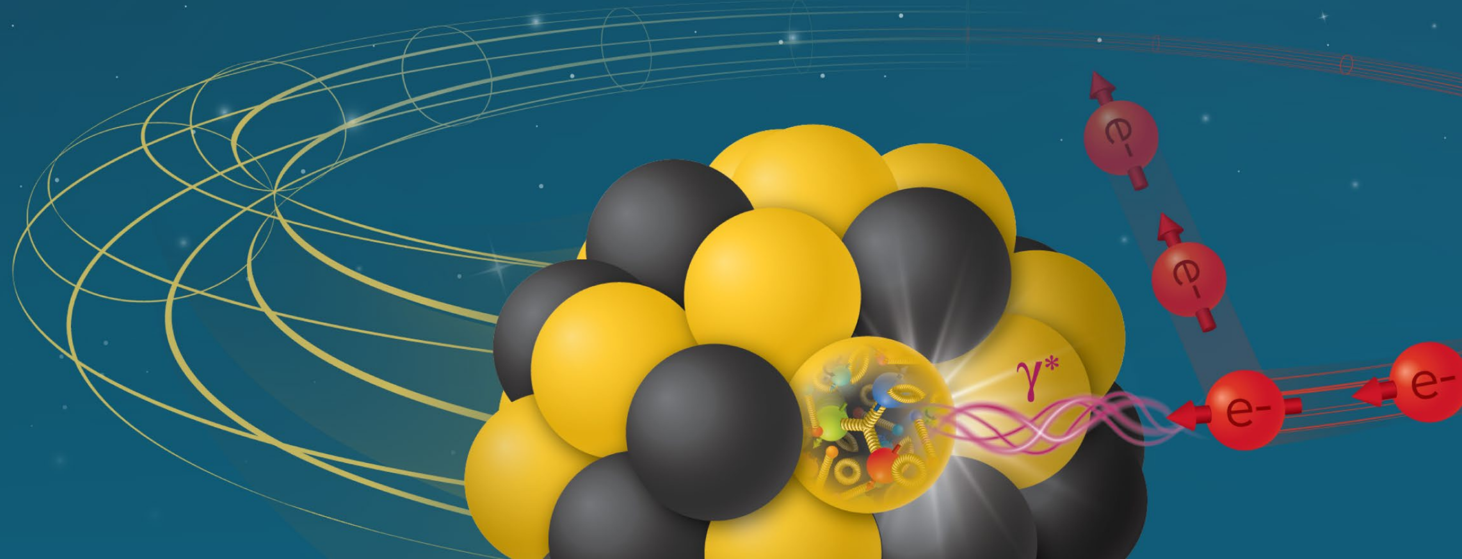
U.S. DEPARTMENT OF ENERGY

Integration, Installation and Infrastructure

Rahul Sharma (BNL)
Chief Mechanical Engineer/L3 CAM
6.03.09 Triple I group

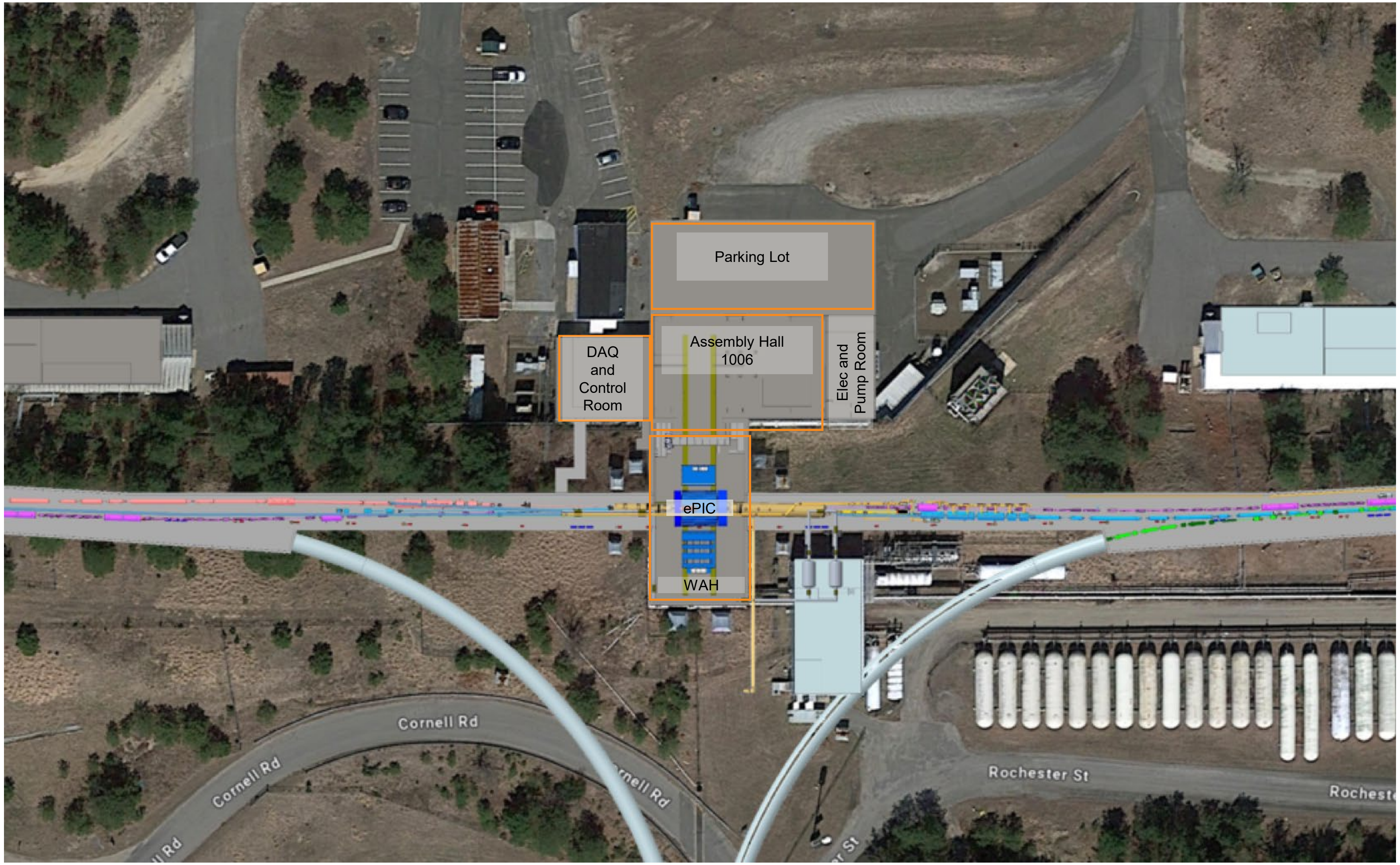
10th EIC DAC Review
June 11th – 13th, 2025

Electron-Ion Collider



Outline

- Charge Questions
- Scope Description
- Triple I Team
- EPIC Detector 1006 Halls
- In Kind/Reused Items
- Infrastructure and Utilities
- EPIC Full Model Overview
- 8mrad Rotation
- Services Layout & Management
- Installation Sequence (Barrel)
- Magnetic Forces Analysis
- Power
- Summary/Next Steps



Charge Questions

1. Is the design of the ePIC detector and its sub-systems appropriate and progressing well?
2. Are the remaining work and technical, cost and schedule risks adequately understood? Are there opportunities?
3. Will the detector be technically ready for baselining by late 2025?
4. Are the detector integration and planning for installation and maintenance progressing well? Are there areas where further ideas should be pursued?
5. Will the detector be ready for start of construction by late 2026?

Scope Description:

6.03 Detector

- **6.03.01** Detector Management
- **6.03.02** Tracking
- **6.03.03** Particle Identification
- **6.03.04** EM Calorimetry
- **6.03.05** Hadronic Calorimetry
- **6.03.06** Detector Magnet
- **6.03.07** Electronics
- **6.03.08** DAQ / Computing
- **6.03.09** Integration, Installation, Infrastructure
- **6.03.10** IR Integration, Anc. Detectors
- **6.03.11** Detector Non-Beam Commissioning
- **6.03.12** Polarimetry, Luminosity

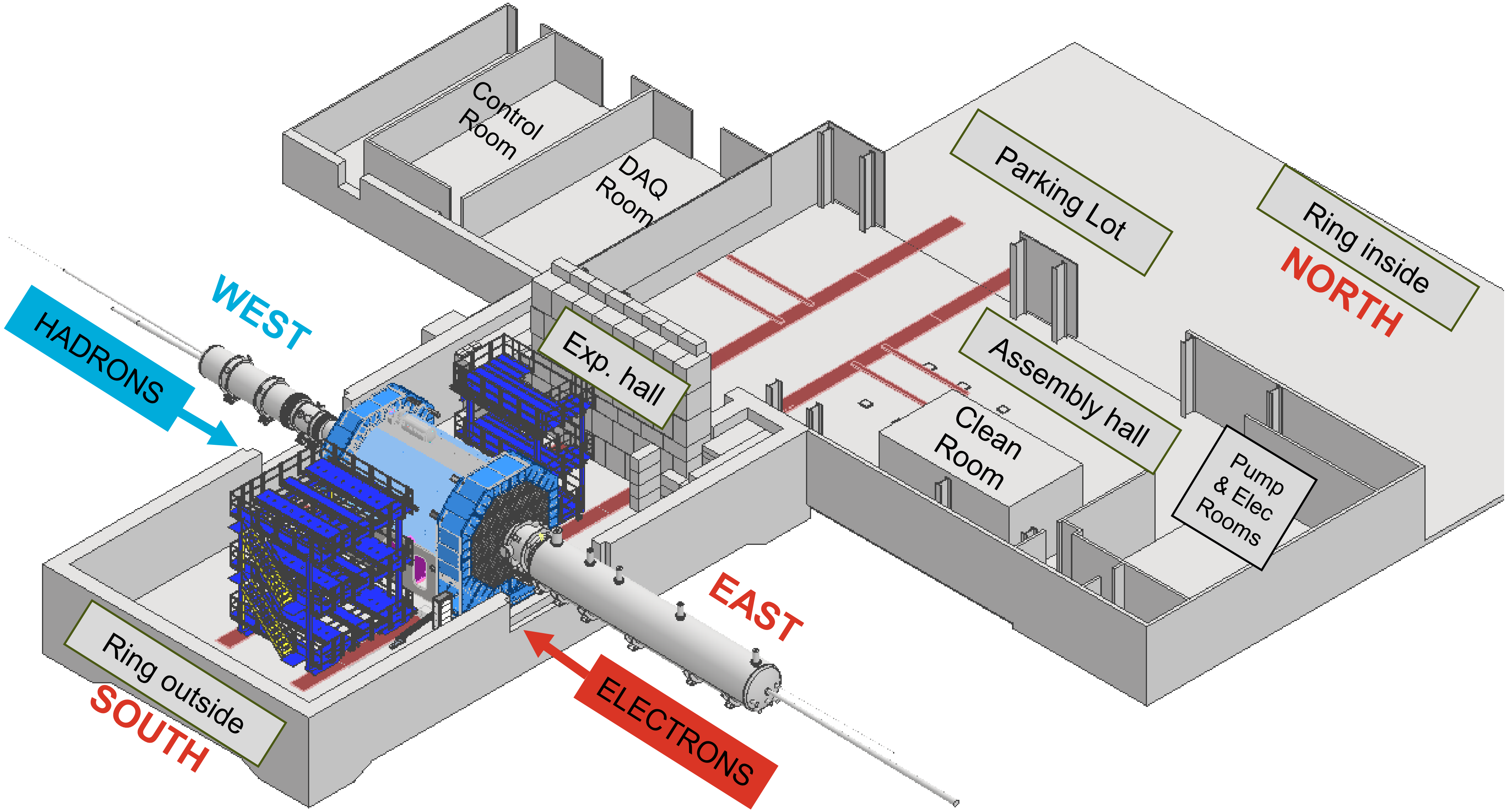
WBS	WBS Name	WBS Manager	LLP Scope Description
06.03.09	Integration, Installation and Infrastructure	R. Sharma	**Scope Definition:** **This WBS item covers the following:** **Effort needed to design and build new infrastructure, modify/repurpose existing infrastructure and Integration of various subdetectors 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.**

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:

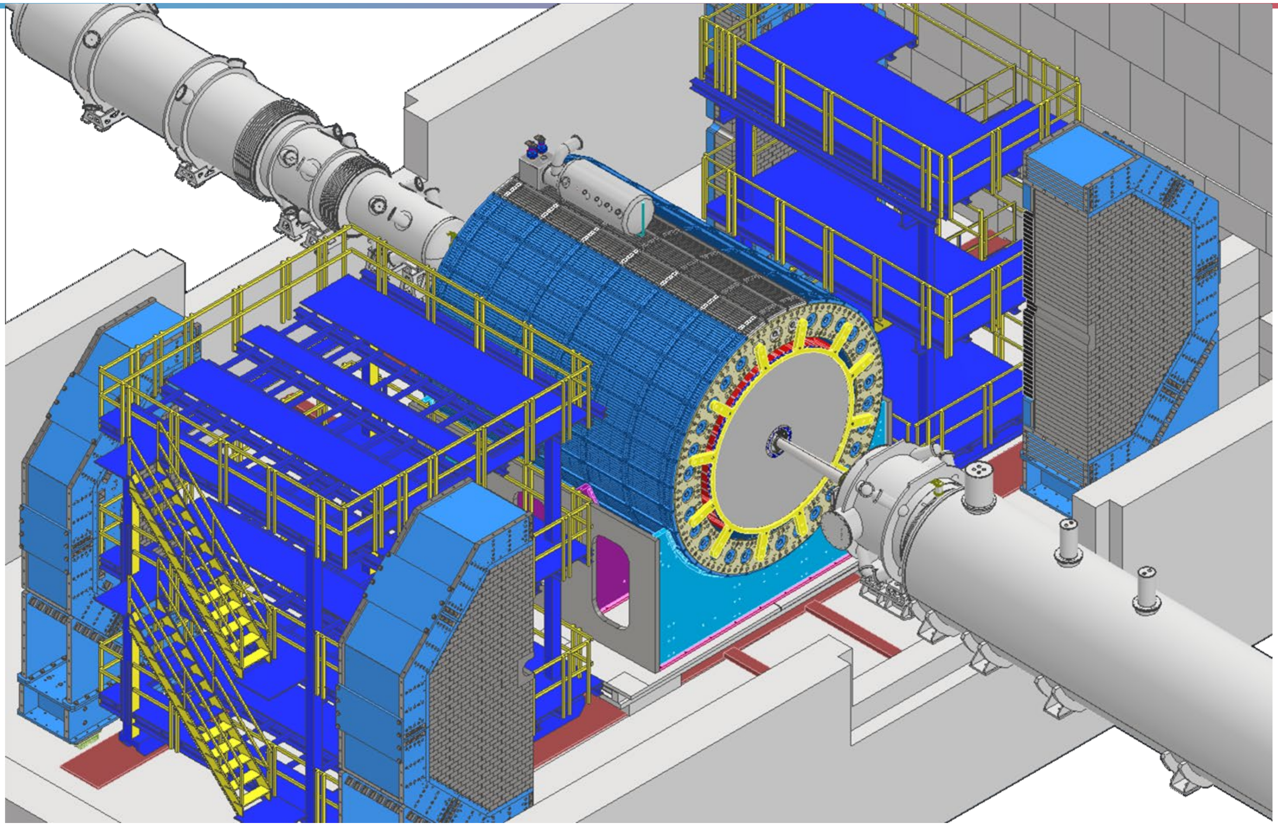
- Rahul Sharma (BNL) – Chief Mechanical Engineer
- Walt Akers (JLAB) – Systems Integration
- Roland Wimmer (BNL)– Mechanical Engineer
- Dan Cacace (BNL) – Mechanical Engineer
- Alex Eslinger (JLAB) – Mechanical Engineer – pfRICH and dRICH Design
- Ron Lassiter (JLAB)– Forward Detectors - Mechanical Engineer
- Johnathan Smith (JLAB)- Mechanical Engineer
- Andreas Jung (Purdue University) – AC LGAD and Carbon Fiber Support Structure
- Karim Hamdi (BNL)– Mechanical Designer
- John Tuozzolo (BNL) – Mechanical Designer
- Nathaniel Speece-Moyer (BNL) – Mechanical Engineer
- Seung Joon Lee (JLAB) – Detector Scientist
- Avishay Mizrahi (Tel Aviv) – Mechanical Engineer - DIRC
- Julien Bettane (**IJC Lab**-Orsay)
- Joshua Crafts (CUA) – Postdoc - EEEMCAL
- Tom O'Connor and Kevin Bailey (ANL) – Barrel EMCAL Design
- Girish Gowda (BNL) – CFD and Thermal Analysis Engineer

EPIC Detector, Assembly Hall and Experimental Hall



- EPIC Detector Barrel will be assembled in the Assembly Hall and End Caps will be assembled in the Experimental Hall
- During maintenance shutdowns, detector barrel (central detector) can be rolled out from Experimental Hall to the Assembly Hall

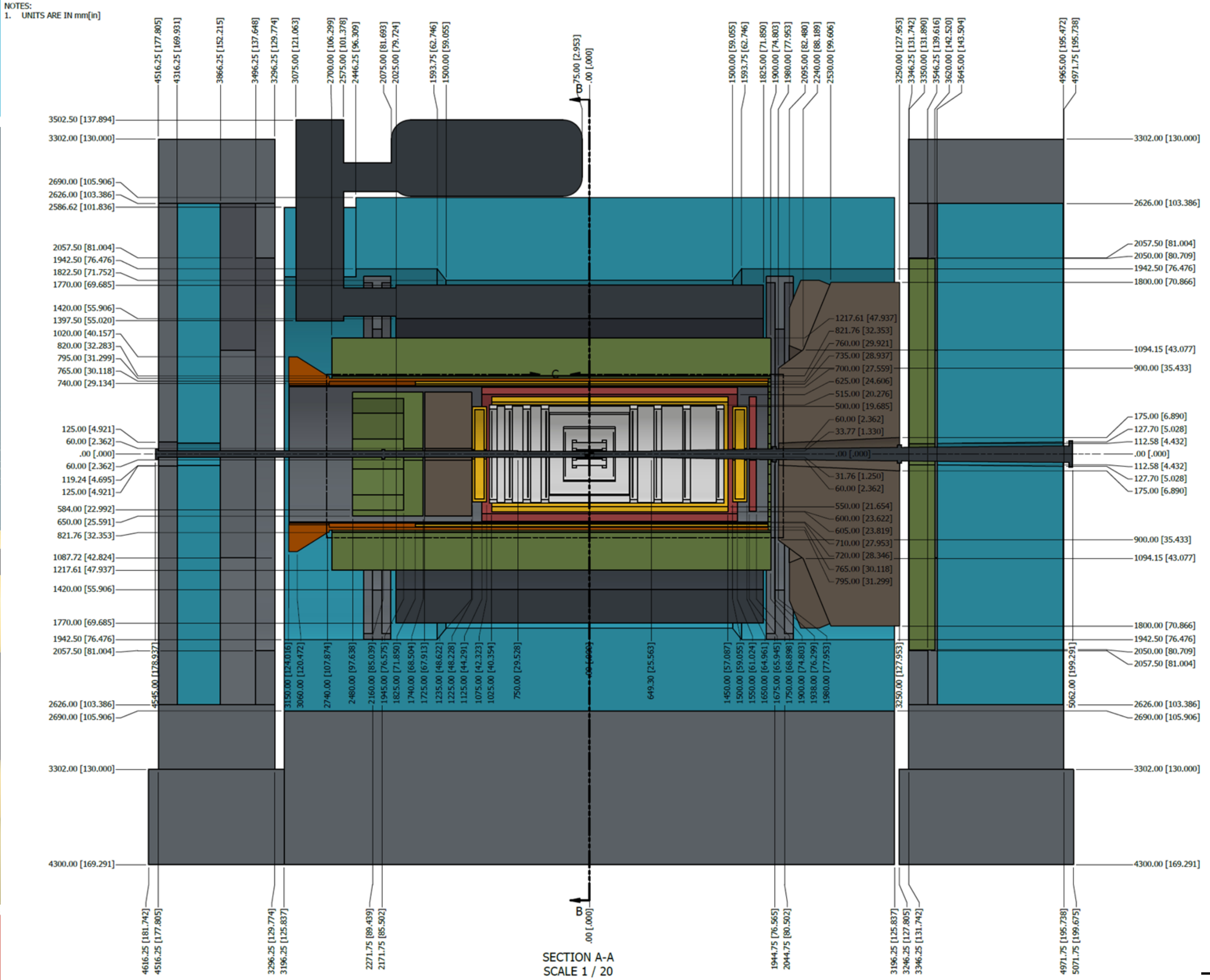
In Kind/Reused Items



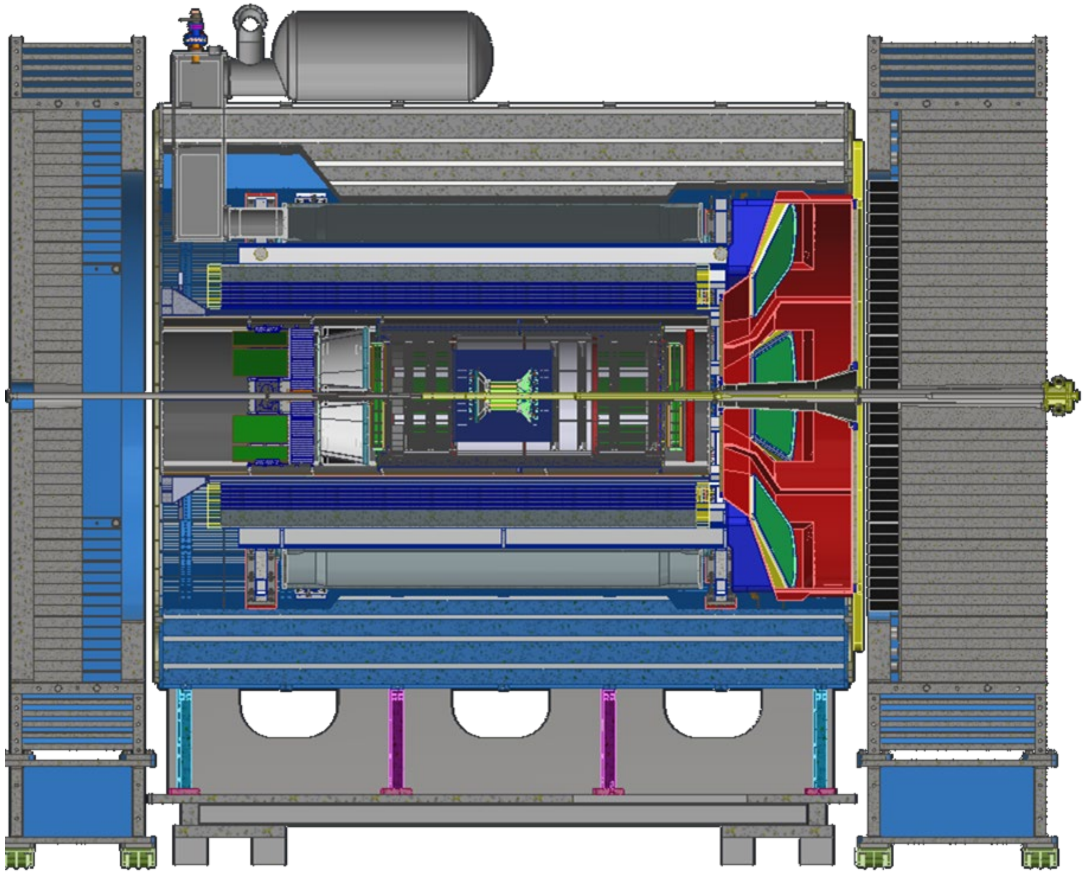
- From STAR (Existing detector in Bldg. 1006)
  - North and South Platform for STAR will be modified and used for ePIC. Modifications needed to clear the path for opening of End Caps.
  - Plan on using same pistons and moving mechanism from STAR. Pistons will be refurbished and new control unit will be used.
- sPHENIX (Existing detector in Bldg.1008)
  - Barrel HCAL Detector
  - Detector Cradle from existing detector (sPHENIX) will also be reused.

ePIC Full Model Overview

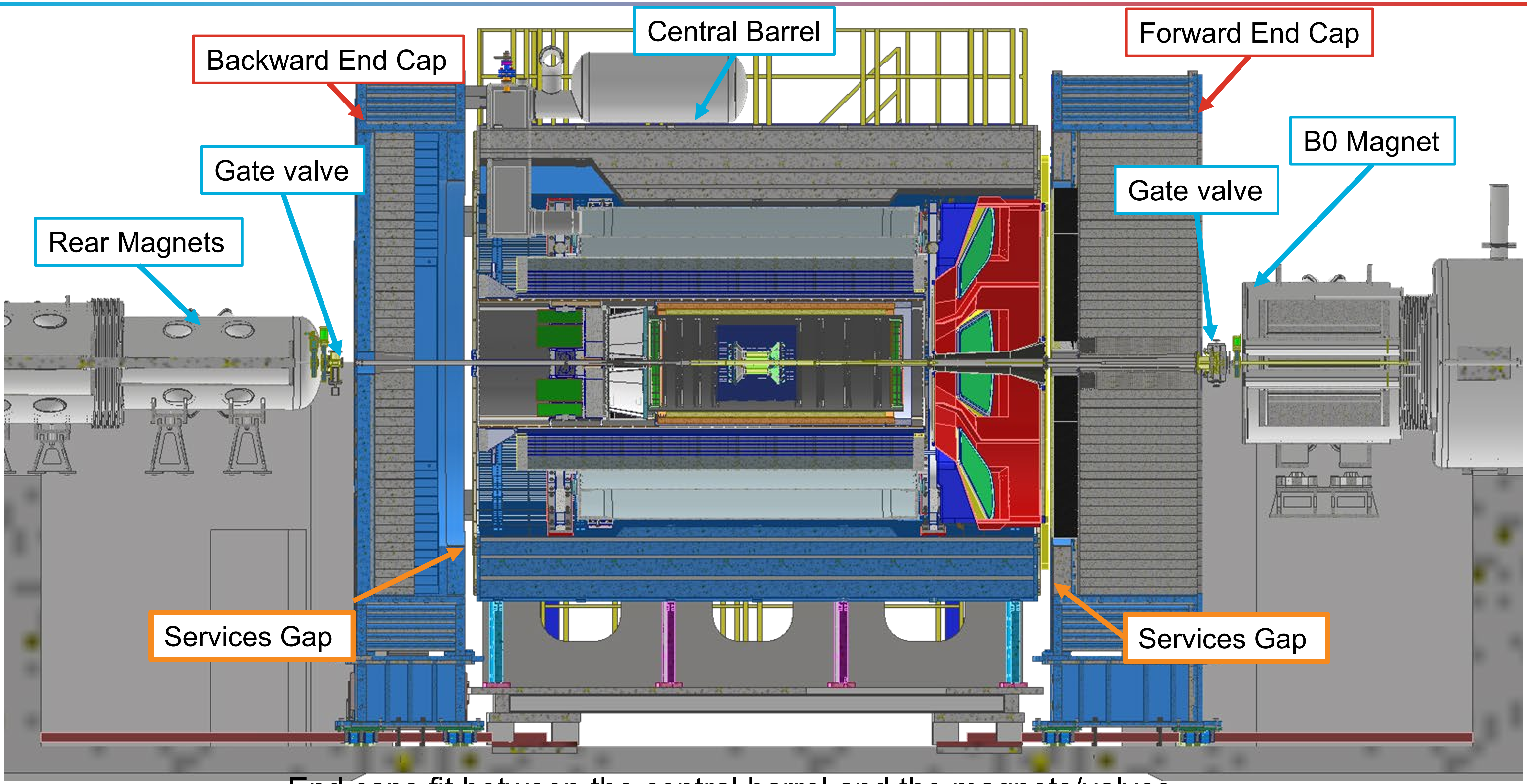
ePIC Sub-detectors Envelopes Model



ePIC Integrated Model

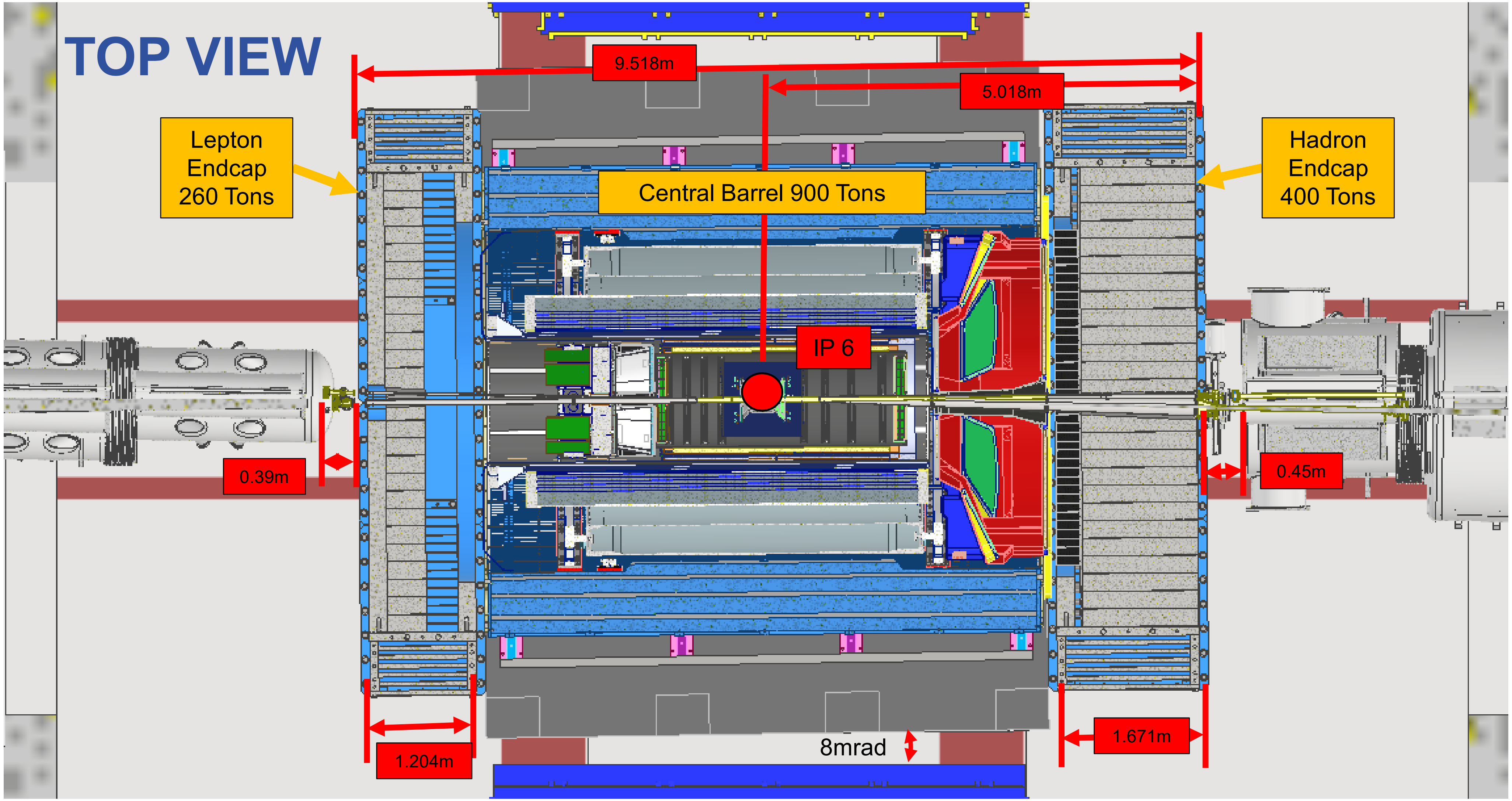


Overall Integration



End caps fit between the central barrel and the magnets/valves

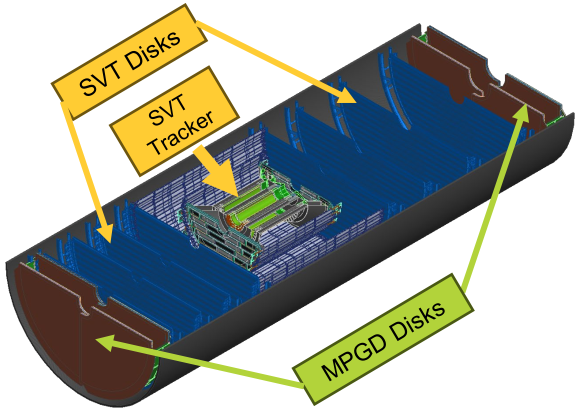
8mrad Rotation



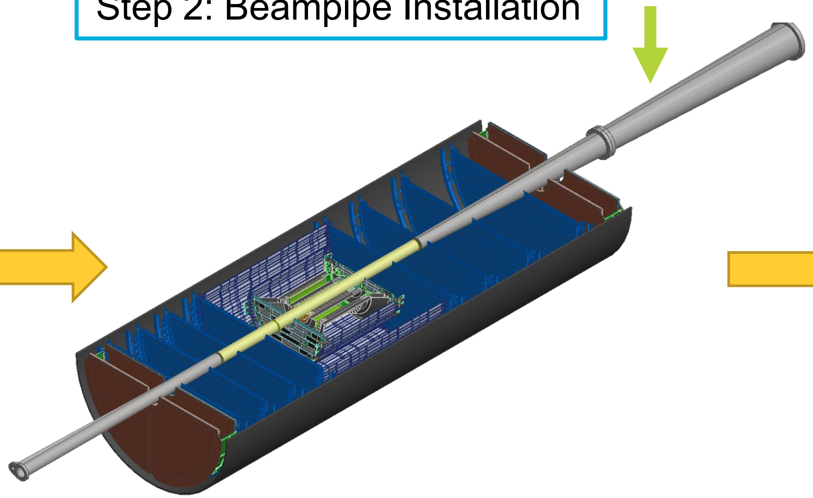
ePIC Detector is aligned with the Electron beam which is at 8 mrad angle through the Hall. It creates some design complications for various detector components.

Global Support Tube (GST) Assembly

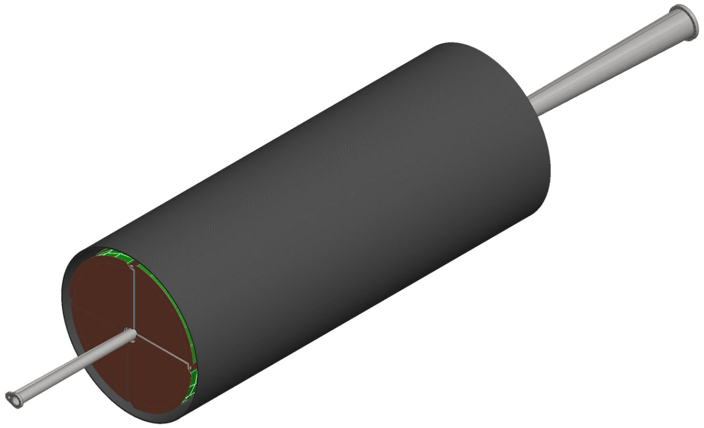
Step 1: PST Bottom half assembly



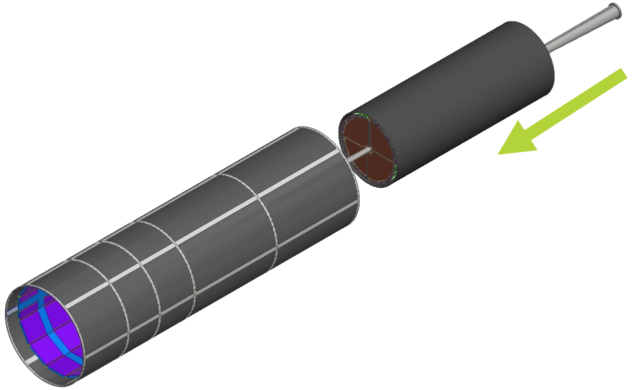
Step 2: Beampipe Installation



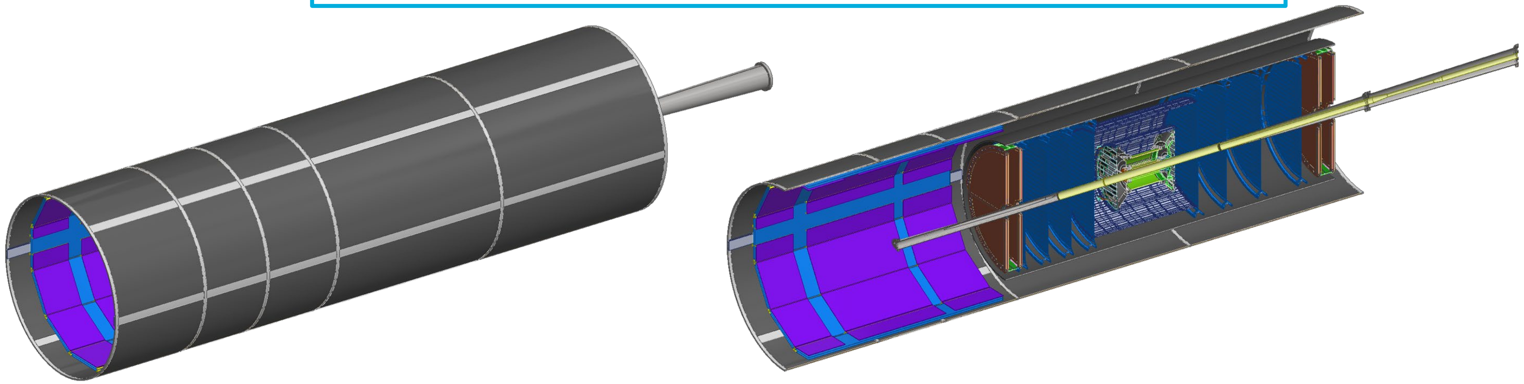
Step 3: PST Top half Installation



Step 4: PST Installation into GST



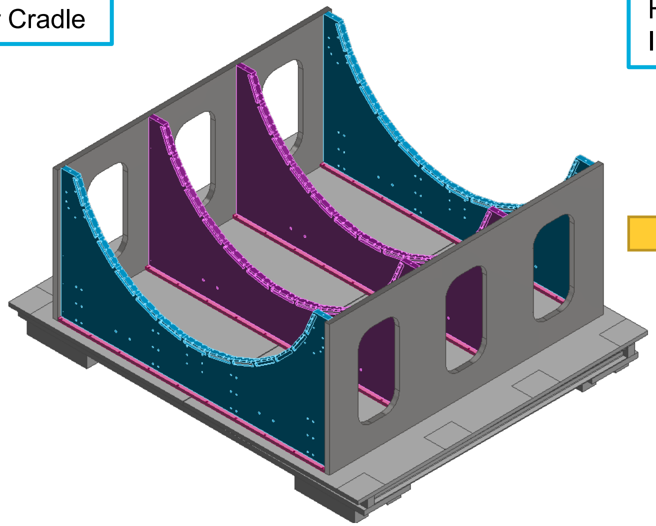
Step 5: GST ready for installation into Central Barrel



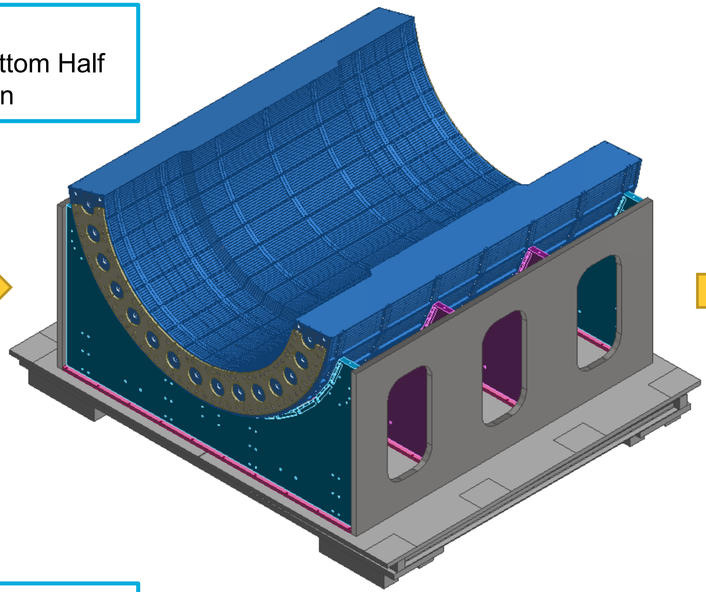
- Global Support Tube (GST) is the Carbon fiber support structure for inner detectors. GST assembly will take place in the Assembly hall on a set of carts
- Cymbal (Inner MPGD) and Barrel TOF detector trays will be installed after GST is installed in Barrel during initial installation.
- Cymbal and Barrel TOF detectors can be removed for maintenance in the experimental hall without removing GST assembly from Barrel.

ePIC Barrel Assembly

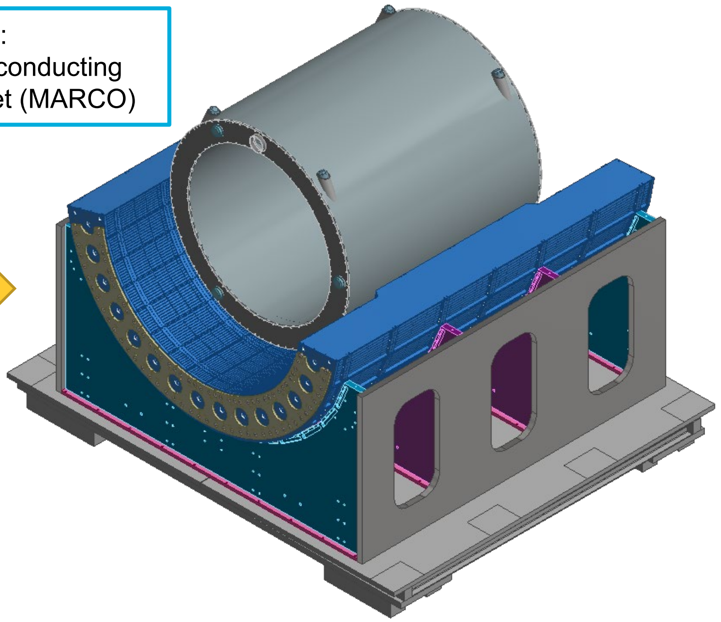
Step 1:
Detector Cradle



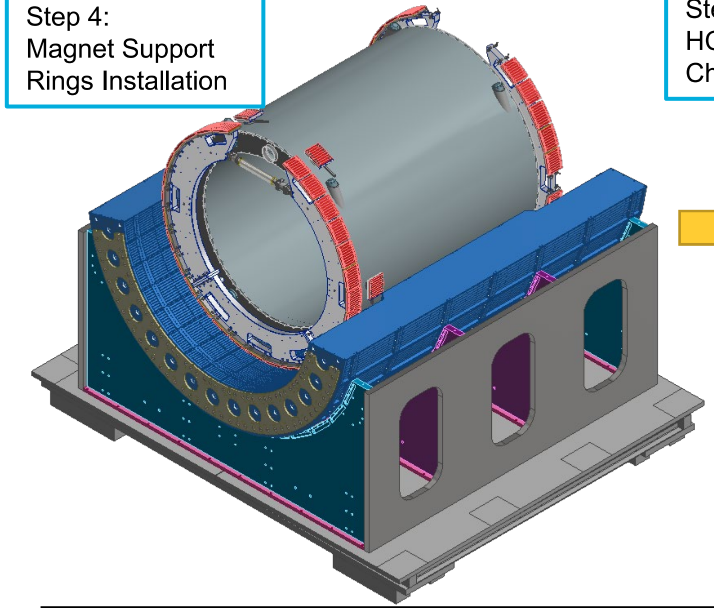
Step 2:
HCAL Bottom Half Installation



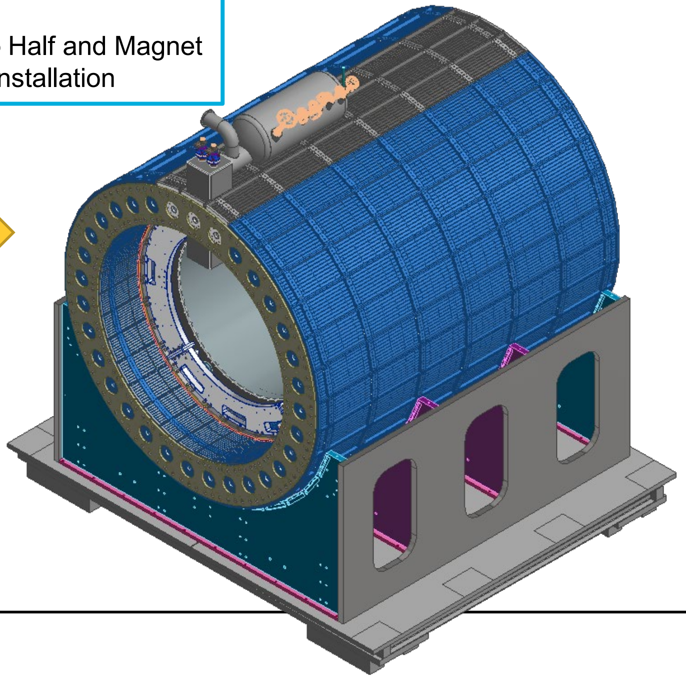
Step 3:
Superconducting Magnet (MARCO)



Step 4:
Magnet Support Rings Installation

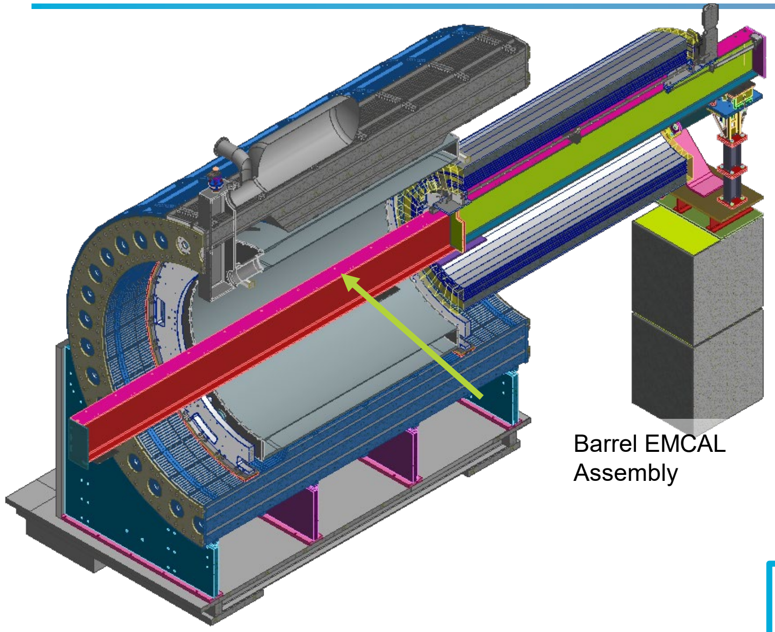


Step 5:
HCAL Top Half and Magnet Chimney Installation



Photos of Magnet Installation from sPHENIX Experiment

ePIC Barrel Assembly

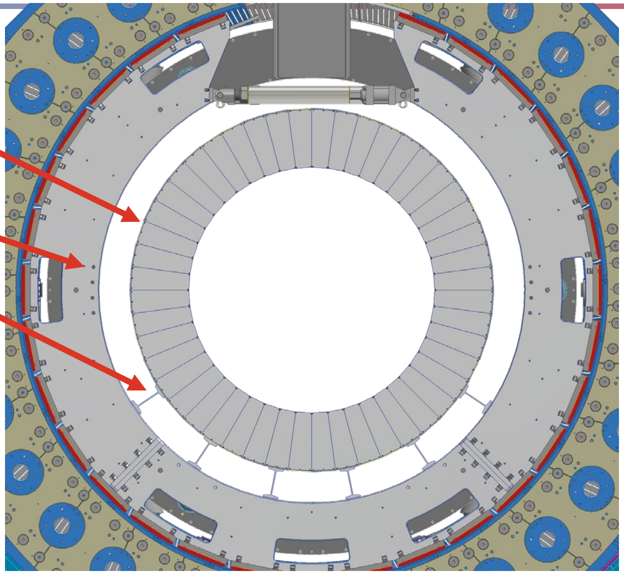


Barrel EMCAL Assembly

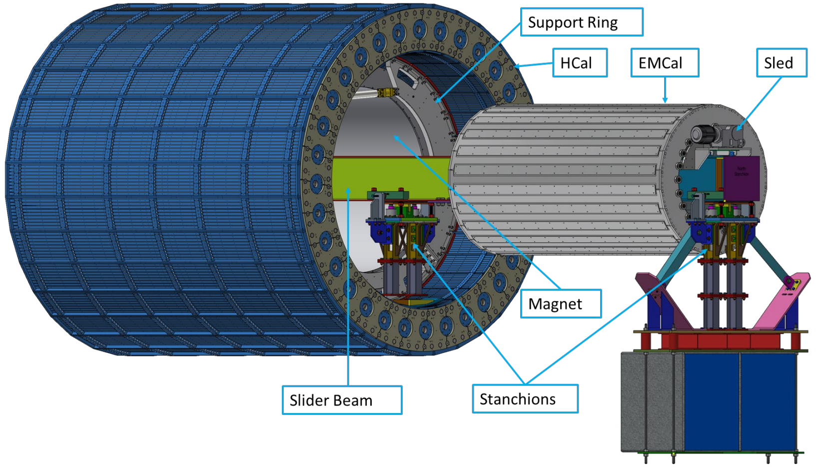
Barrel EMCAL

Support Ring

Support I Beams



ePIC

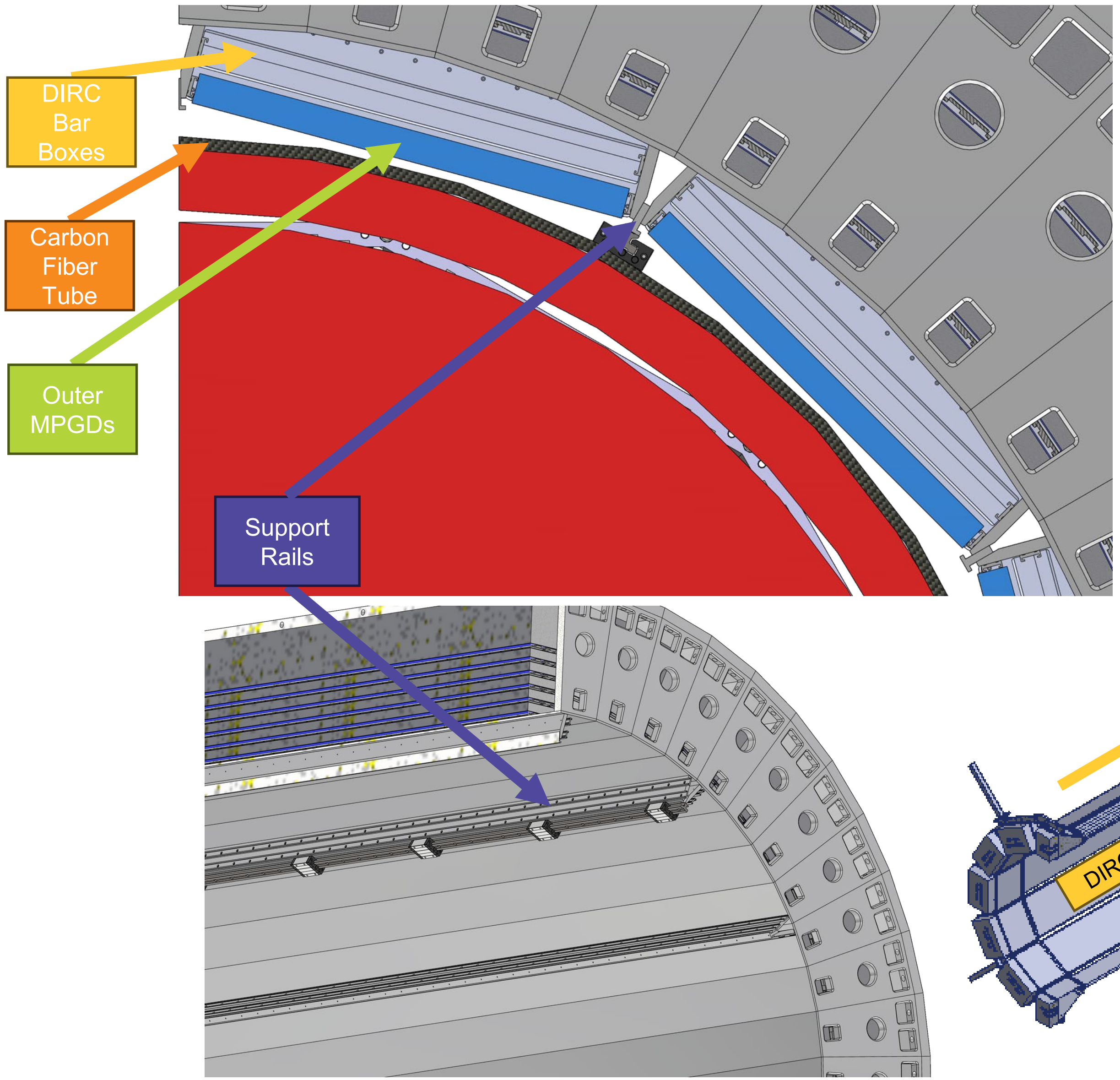


sPHENIX

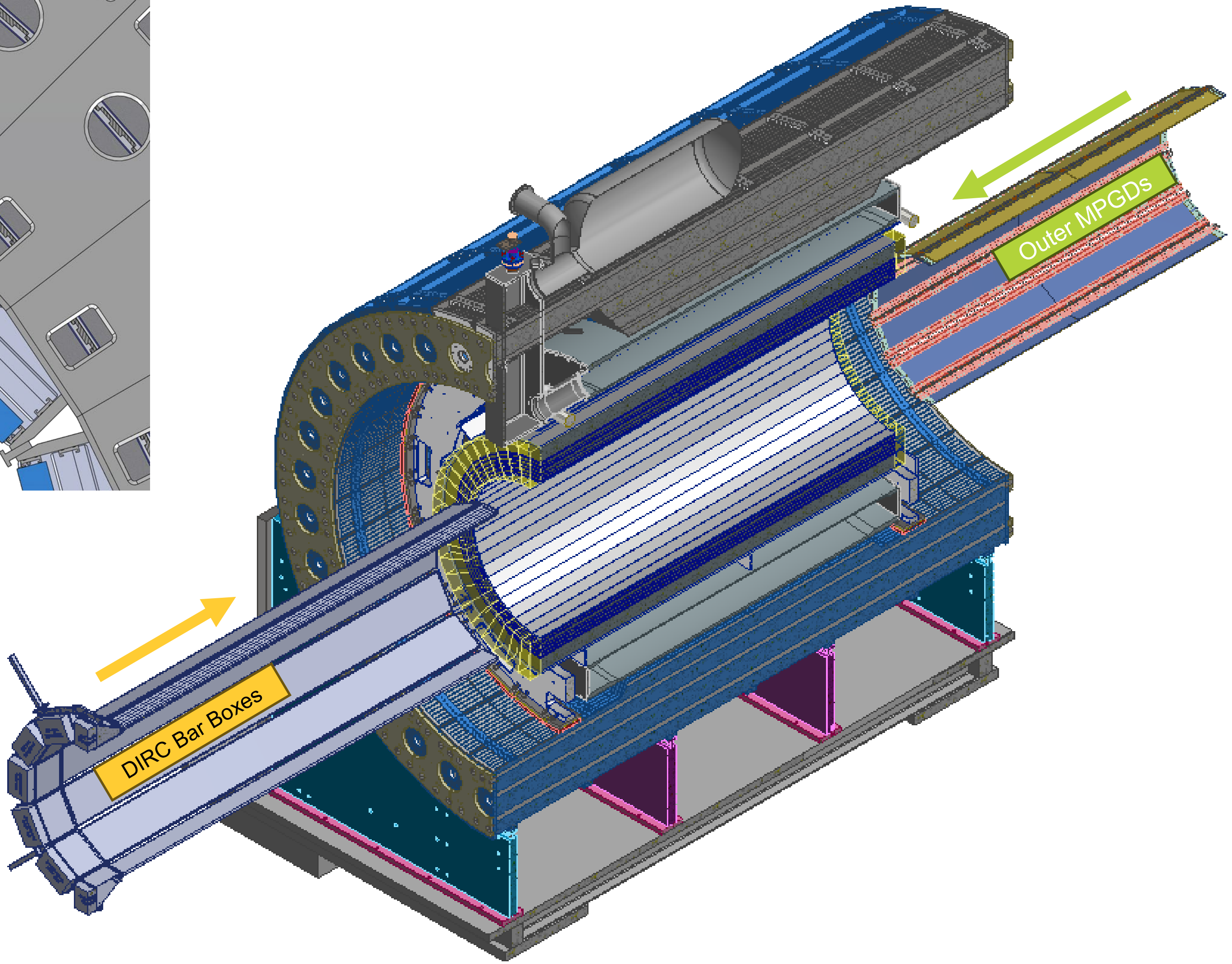
Step 6: Barrel EMCAL Installation:

- We plan to use existing installation tooling from sPHENIX that was used to install Inner HCAL as shown in photos
- The I-beam is inserted into the HCal and supported on stanchions.
- Barrel EMCal will be assembled in front of ePIC Barrel
- 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.
- Barrel EMCal will be supported via the sPHENIX inner support rings
- At both inner support rings there will be aluminum I-Beams for support
- Support Hierarchy:
  - Cradle → HCal → Inner Support Rings → EMCal Support → Barrel EMCal → Carbon Fiber Support Tube → Inner Detectors

ePIC Barrel Assembly

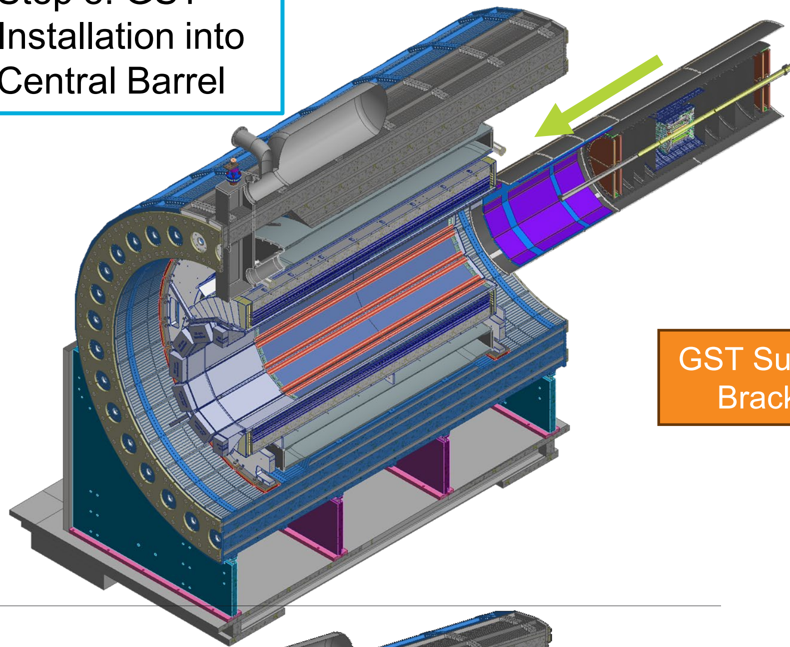


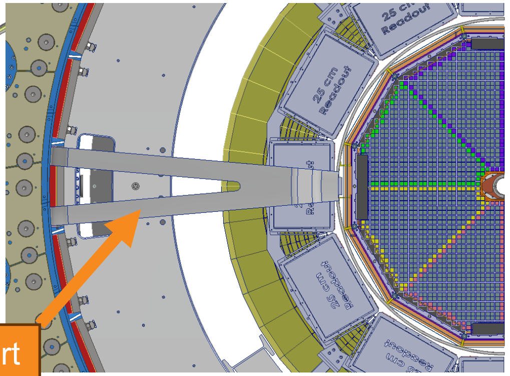
Step 7: DIRC Bars and Outer MPGDs Installation



ePIC Barrel Assembly

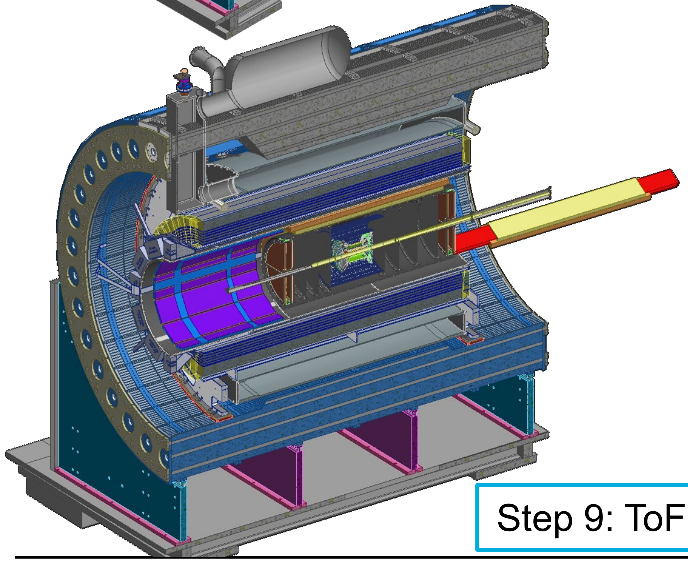
Step 8: GST Installation into Central Barrel

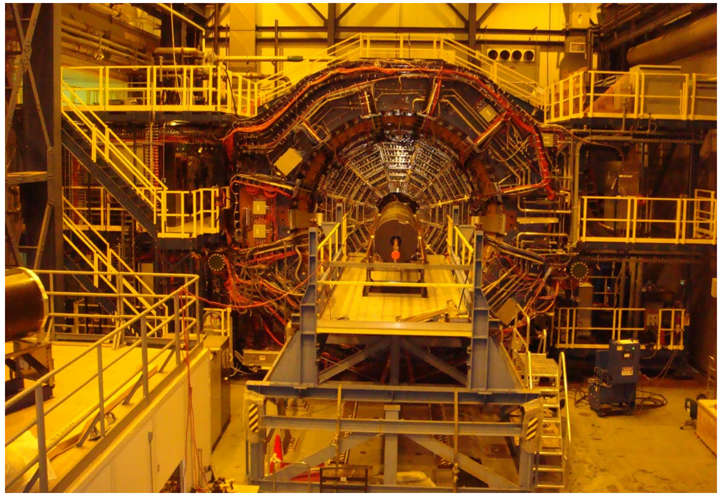


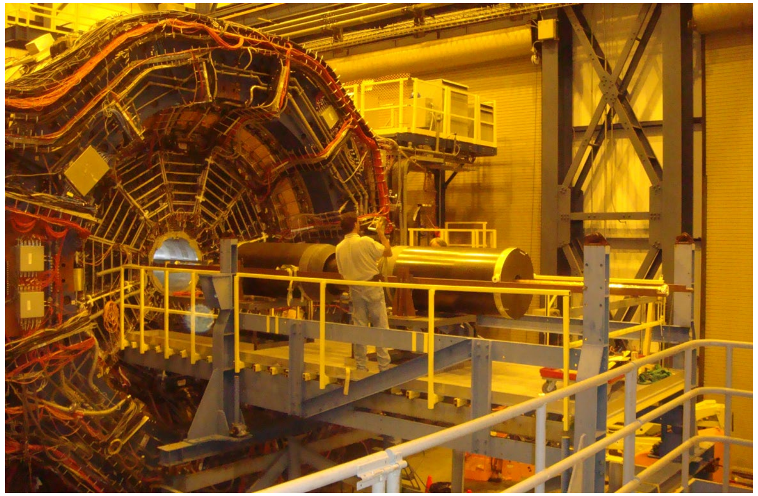


GST Support Bracket

Planning on reusing STAR IDS Platform for GST Installation





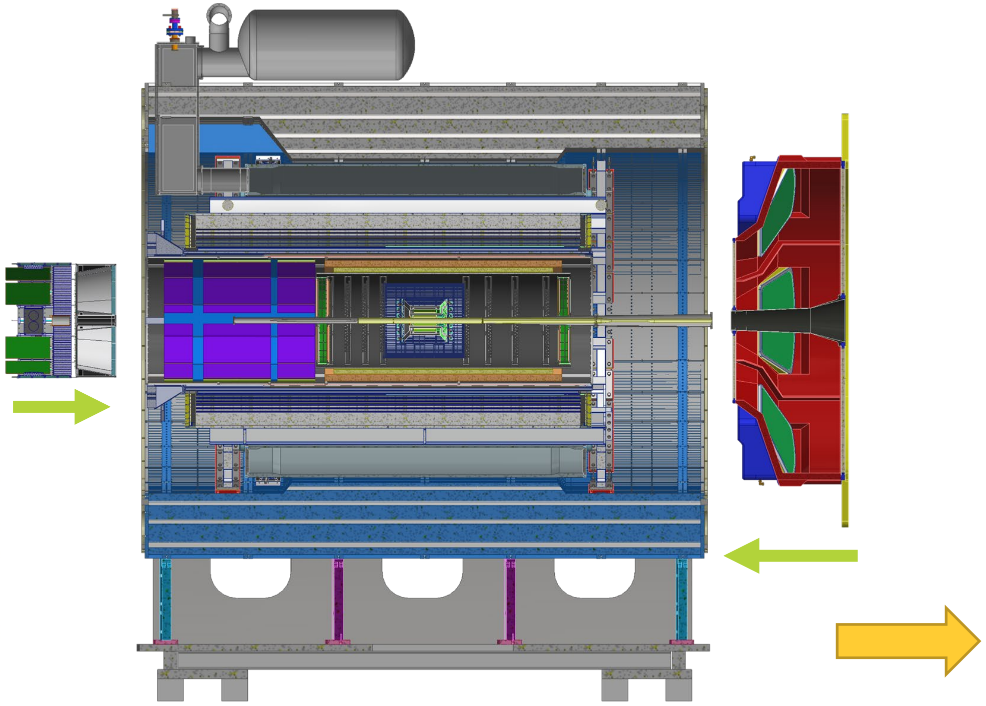


STAR Carbon Fiber detector Support Structure Installation

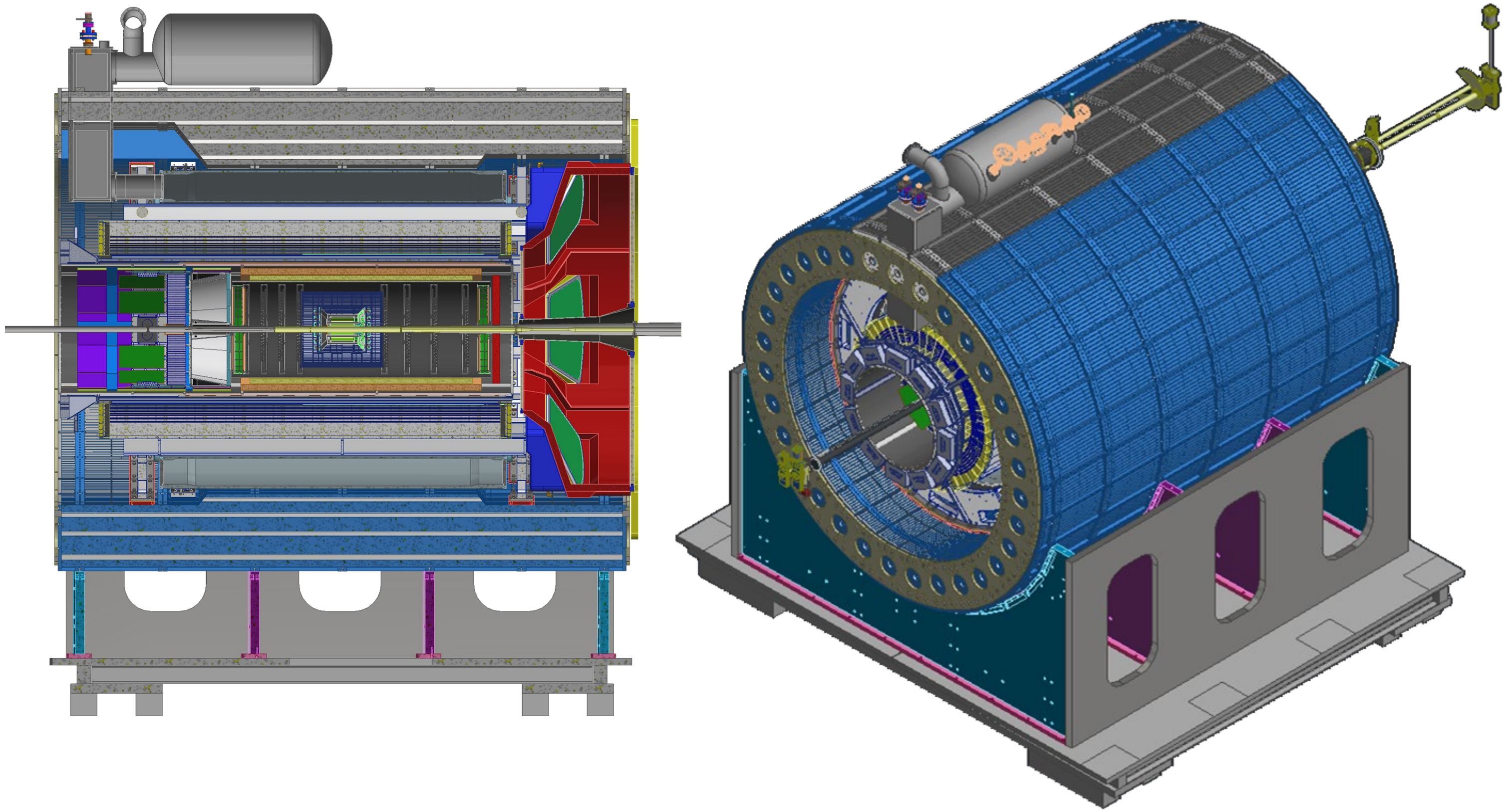
Step 9: ToF & CYMBAL Installation into GST

ePIC Barrel Assembly

Step 10: EEEMCAL, pfRICH, & dRICH Installation



Step 11: Assembly Complete

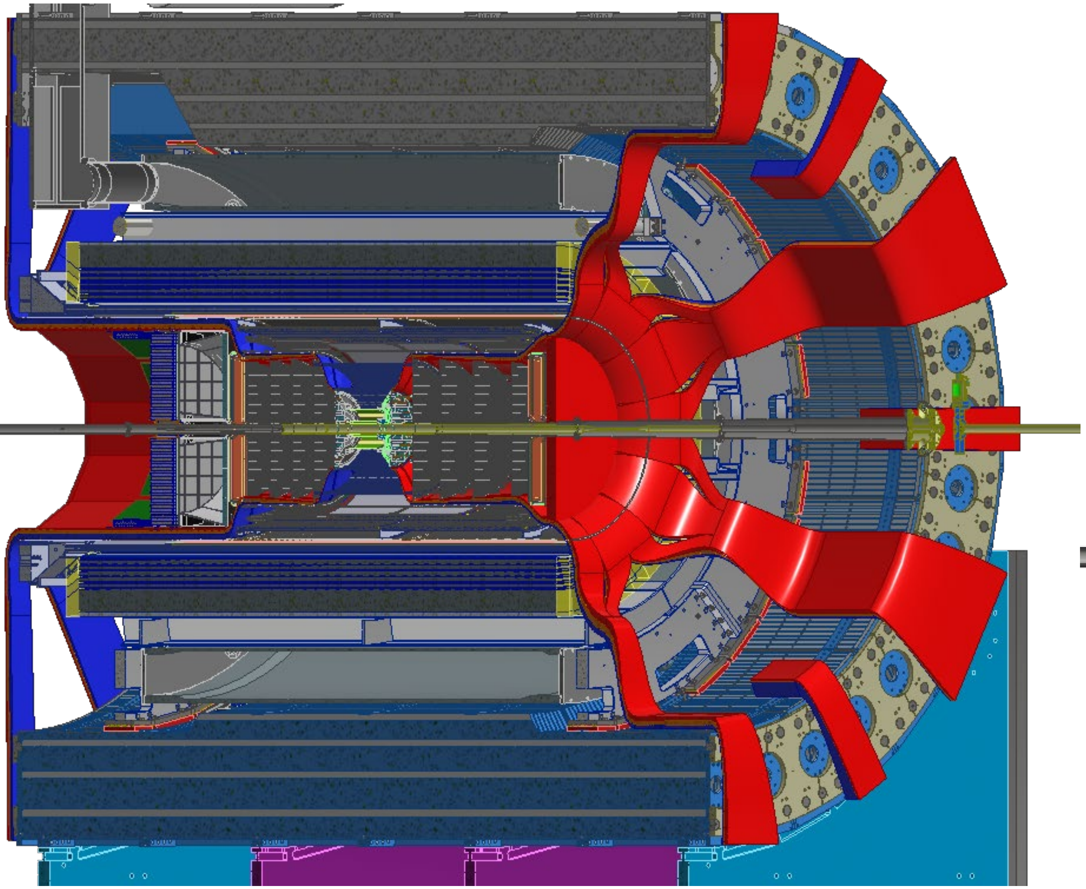


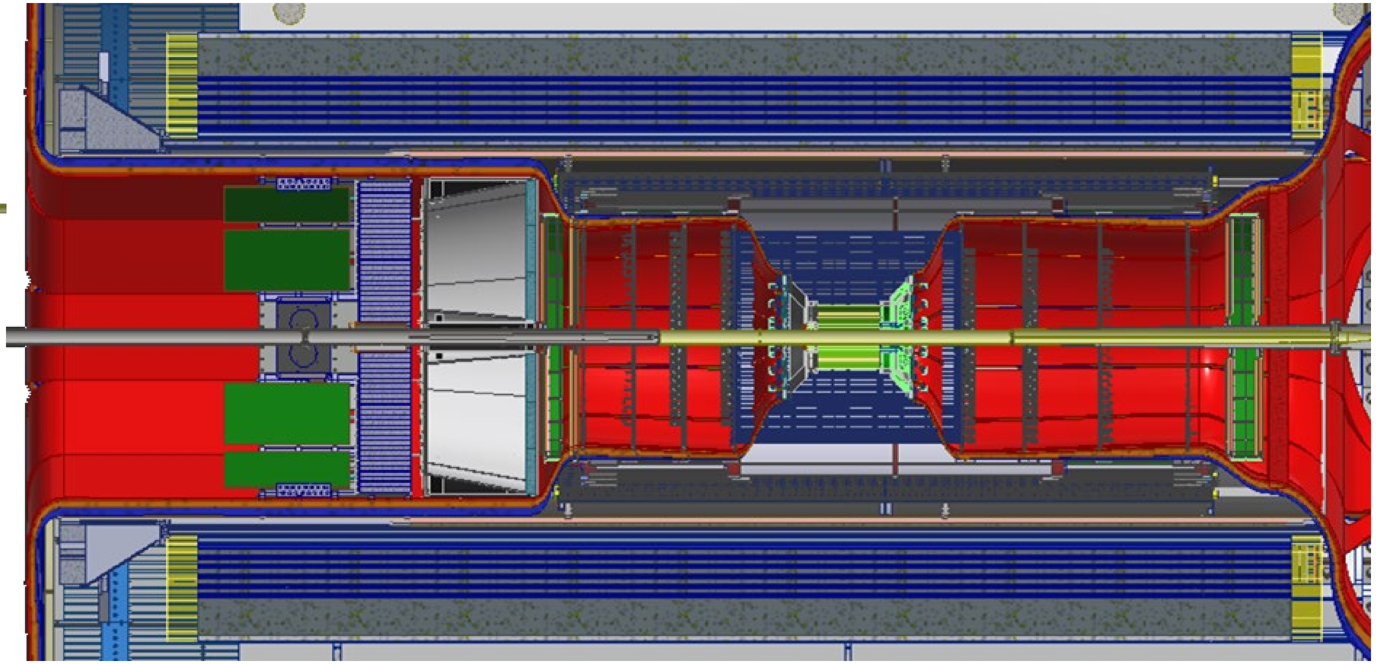
- pfRICH and dRICH detectors are installed from backward side and dRICH detector is installed from Forward side.
- After Final Assembly, detector is ready to be rolled in to the experimental hall.

Services Layout

- Services (Cables and Cooling Lines etc.) must pass through the gap between Endcaps and detector barrel
- Services Estimates were collected from various subgroups.
- Layout is shown in snapshots below.

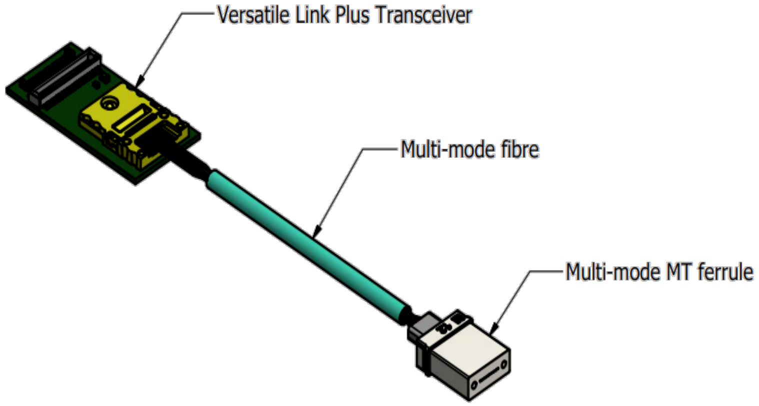
Subsytem	Quantity	Cross Area (cm^2)	+50% Packing for Bundles	+50% for MISC spacing needs	Available Space		
Red Path IP to pfRICH Inner face							
Total	5503	754.98	1132.48	1698.71	1800.00	Used space:	94.37%
Red Path From pfRICH to EEEMCAL Inner face							
Total	6584	915.41	1373.12	2130.17	2251.00	Used space:	94.63%
Red Path From EEEMCAL to Flux Return Bars							
Total	19502	2487.80	3731.70	4906.26	9650.97	Used space:	50.84%
Orange Path From IP to AC-LGAD Disk							
Total	5503	754.98	1132.48	1698.71	1998.05	Used space:	56.68%
Orange Path From AC-LGAD disk to Aerogel							
Total	7739	1554.25	2331.38	3497.07	3568.85	Used space:	97.99%
Orange Path From dRICH Aerogel to Dogbones							
Total	8363	1720.87	2581.30	3968.25	4964.00	Used space:	79.94%
Orange Path From 4 to 5							
Total	12841	2281.32	3421.97	5229.26	12189.38	Used space:	42.90%

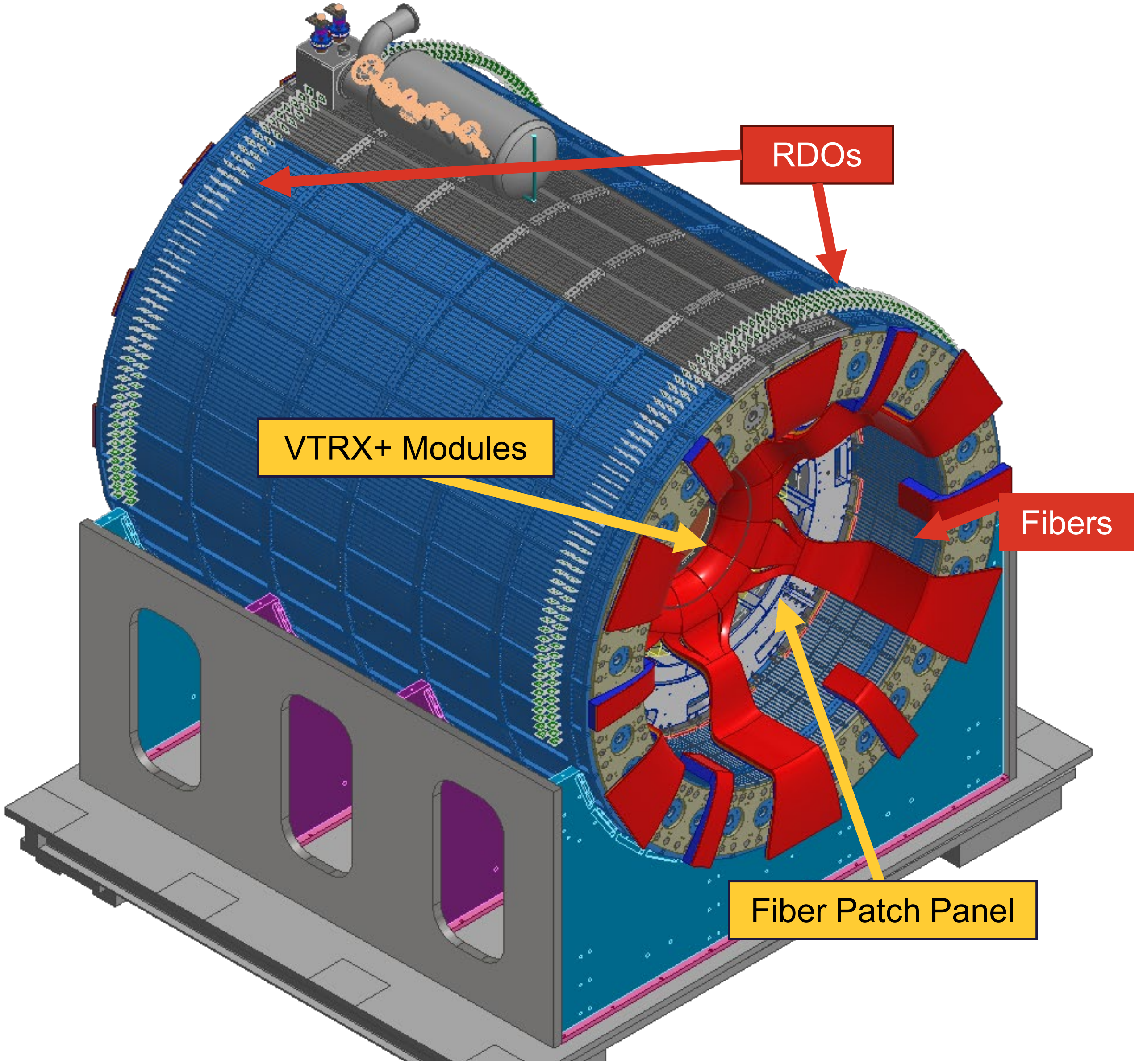




RDO Placement

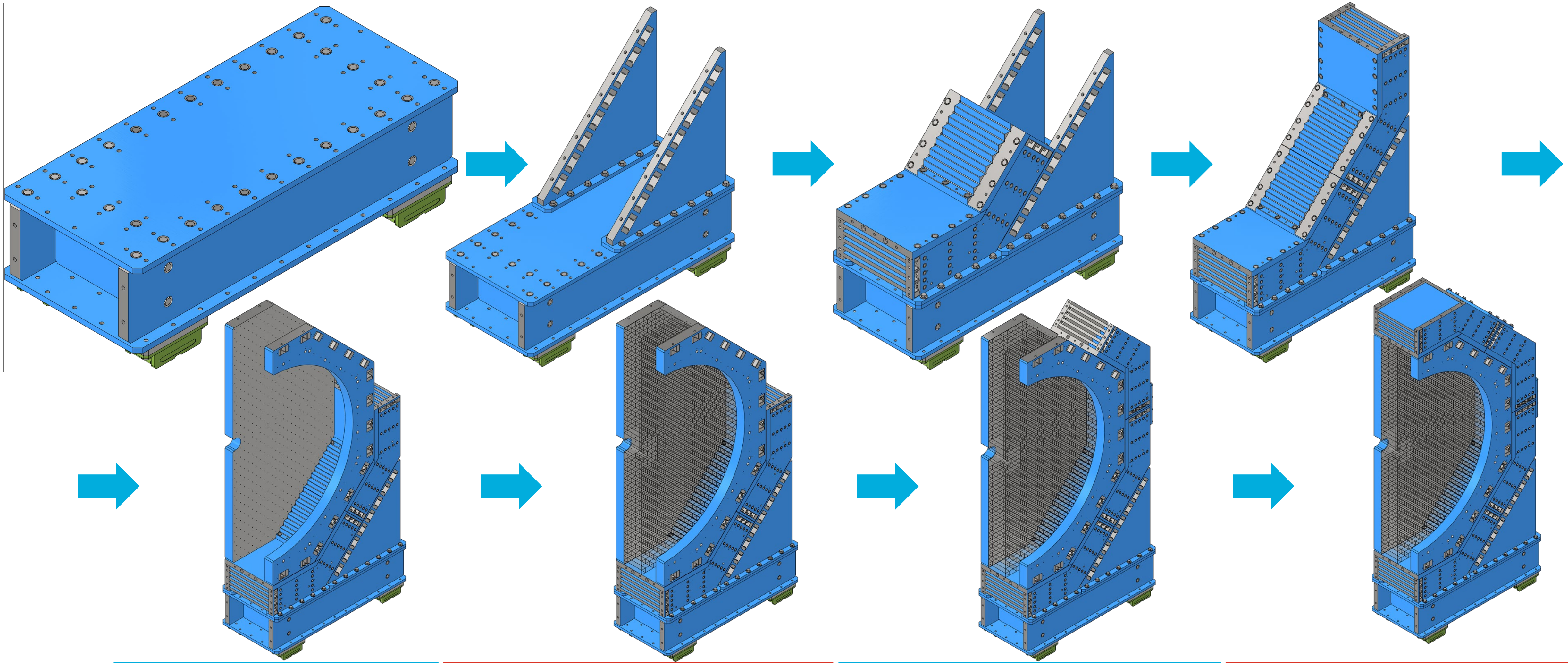
- Summer 2024 added VTRX+ modules
- The RDOs can now be placed much farther away, outside the detector
- RDOs will be mounted to the outside diameter of the sPHENIX HCAL where space is available
- VTRX+ Modules will be placed on each detector adjacent to their FEBs





Endcap Assembly Steps

1. Base shimmed to height and anchored
   FE: 11.25ton BE: 9.5ton
2. Flux return support attached
   FE: 15ton BE: 13.25ton
3. First flux return module attached
   FE: 28.25ton BE: 23.5ton
4. Second flux return module attached
   FE: 41.5ton BE: 33.75ton



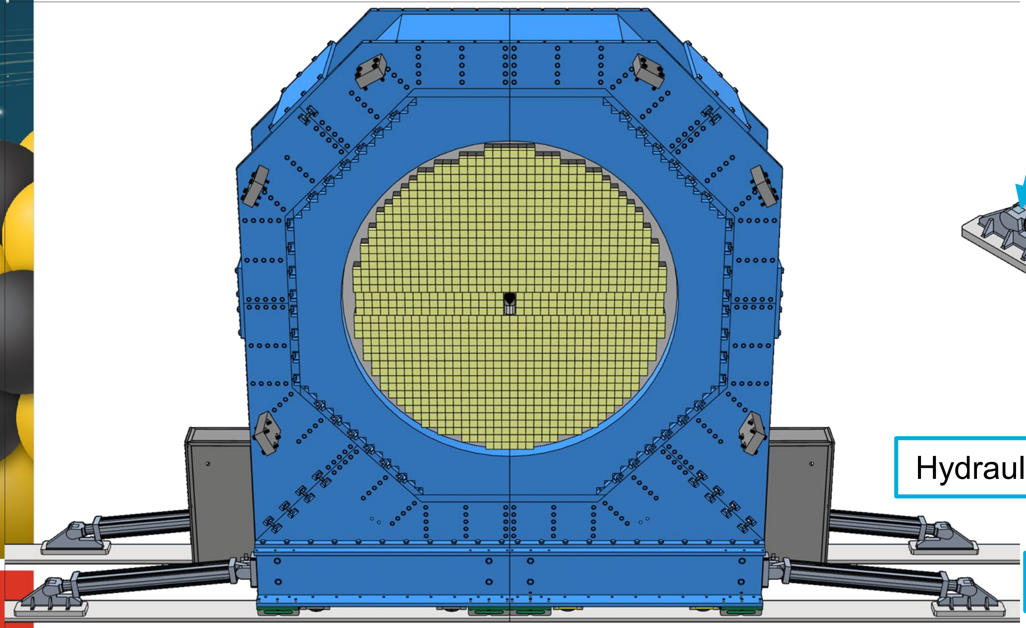
5. Pole tip and half annulus attached
   FE: 51.5ton BE: 60.5ton
6. Detector installed
   FE: 51.5ton (+100ton) BE: 60.5ton (+30ton)
7. Third flux return module attached
   FE: 65.5ton (+100ton) BE: 71.25ton (+30ton)
8. Forth flux return module attached
   FE: 79.5ton (+100ton) BE: 82ton (+30ton)

EndCaps

1&4

Status:

- FDR completed
- Design and analysis completed
- Drawings completed and being reviewed
- Vendor Quotes available
- Possibility of reduction of flux return steel if magnet simulations can show it works. Potential for some cost savings.
- PRRs planned for Summer 2025

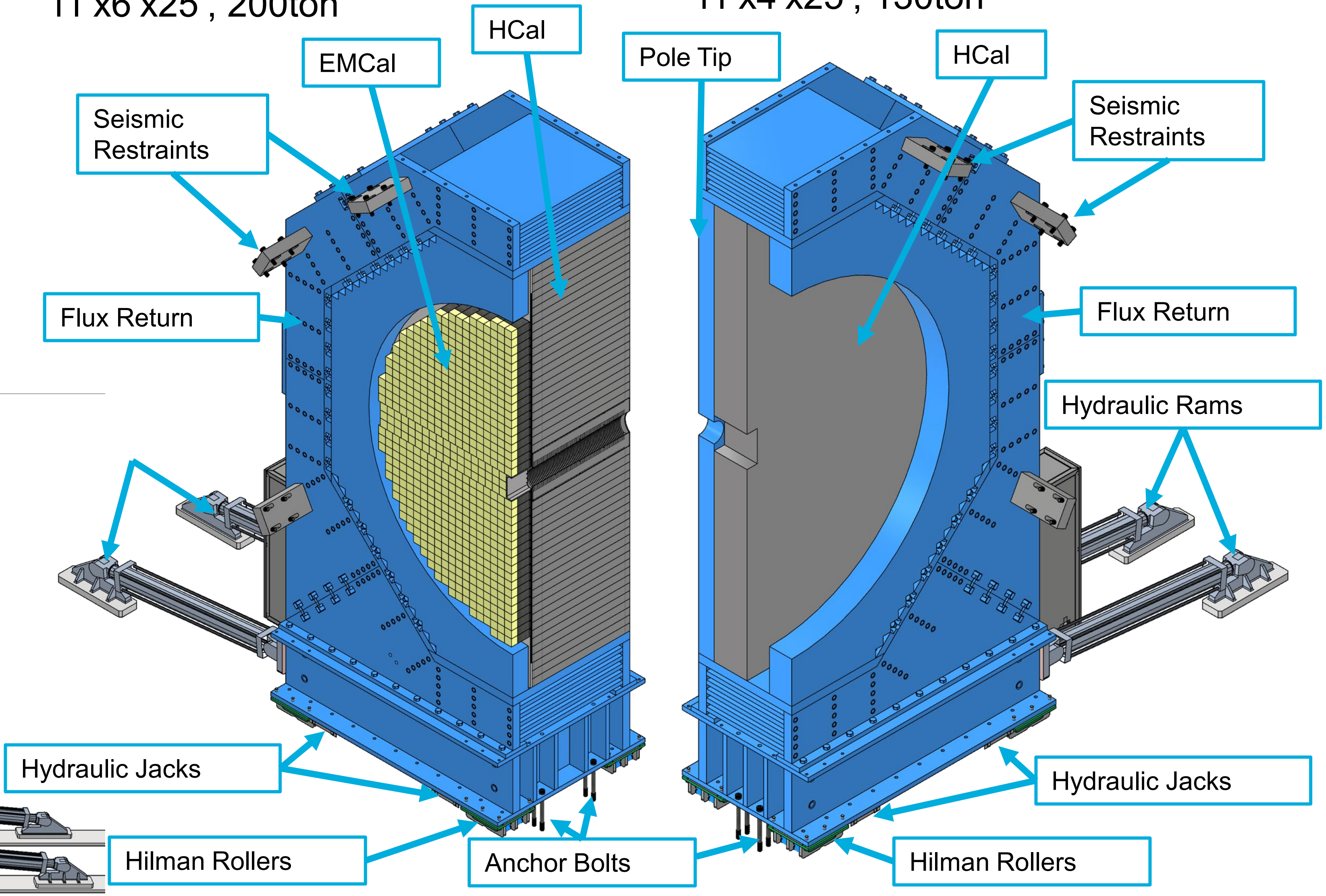


Forward Endcap (FE)

11'x6'x25', 200ton

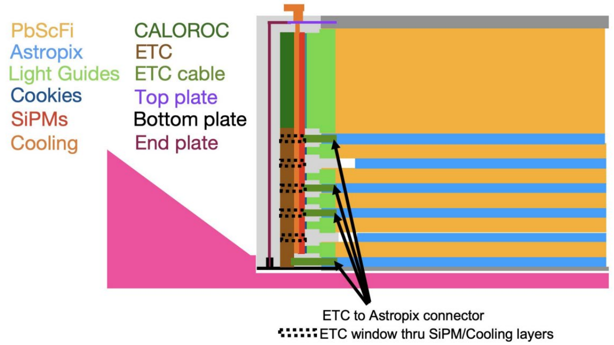
Backward Endcap (BE)

11'x4'x25', 130ton

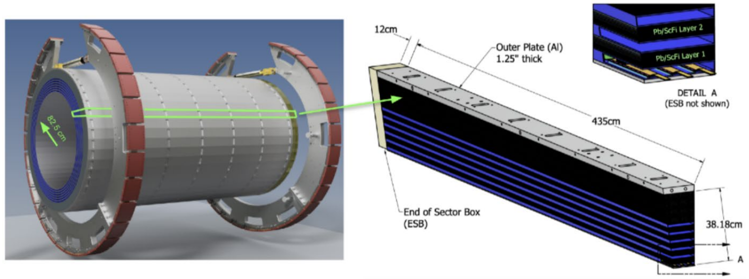


Barrel EMCAL Cooling

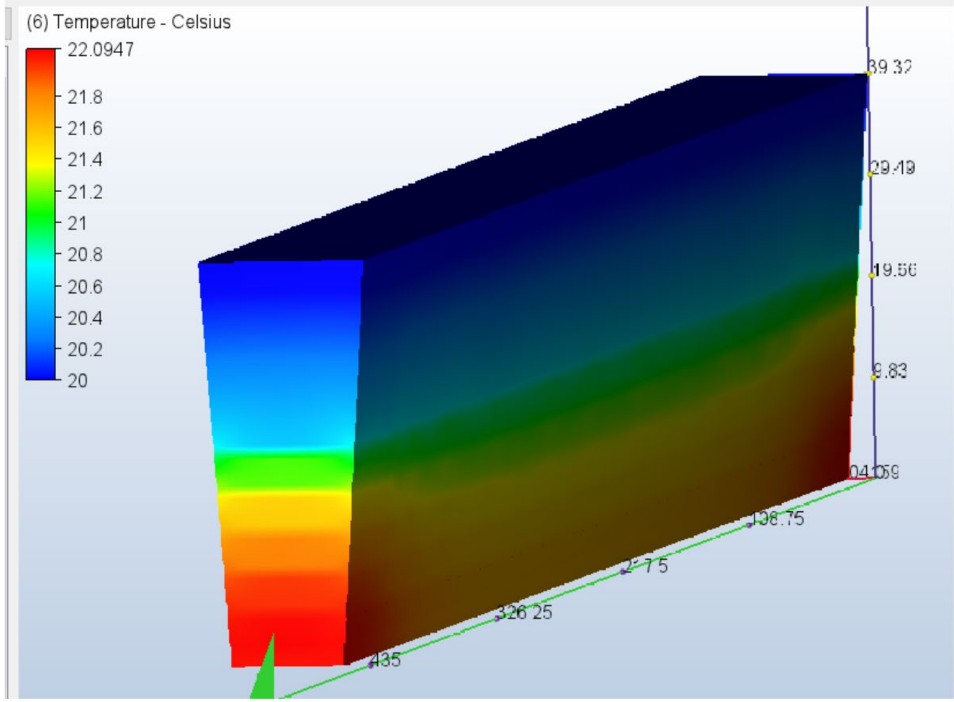
End of Sector Box (ESB) Napkin Sketch



University of Manitoba – Thermal Analysis of BIC single sector



Computational design of BIC with 48 sectors, showing one of the sectors in detail



Cooling comments and assumptions

UManitoba is currently looking at: a) thermal conduction of Astropix through the lead SciFi and b) ESB cooling for SiPM stability and ETC and CALOROC heat removal.
We may use a thermal pad behind the SiPM layer or a metal-core PCB for heat removal
Forced air in the ESB? Still considering this for pushing out heat from AstroPix trays if needed (i.e. if heat conduction through the PbScFi is not sufficient)
Regina can build the cooling lines. Assuming a cooling snake that runs by all the SiPMs, we could fit a 1-cm-diameter copper line between SiPM rows.
NASA: roughly 1 W per ETC card (the FPGA basically), so 4 W per box; Connector at the end of each the Astropix tray, then we can use cables to go to the ETC cards which could sit in the volume unde
Regina-design SiPM summing and amplification, 8 W total per ESB box (upper limit) but some of the electronics processing will be undertaken by CALOROC and there for the 8W should drop
HGCROC chip: 4W each and operate at 40 C without cooling (from interface document)

Coolant	Chilled water at 5C on chiller, 7 C on SiPMs/ N2 or dry air to push out condensation
Flow	Not known yet
Material Budget	Possibly 1-cm-diameter copper inside the ESB could by PVC lines outside' not verified yet

Cooling sources

SiPMs	Their summing and amplification boards (OPamps)	
ETCs	FPGA	
CALORO	ASIC	
AstroPix	ASIC	2 mW/cm^2
AstroLinx	hybrid PC	power regulators

Cooling requirements

SiPMs	Temperature stability similar to GlueX-BCAL: +/-2 C with chilled water; gain is stabilizedusing a custom circuit that adjusts the bias voltage based on the measured temperature
ETCs	heat removal; keep below 40 C?
CALORO	heat removal; keep below 40C?
AstroPix	heat removal; maintain room temperature (20 +/- 3 C)
AstroLinx	heat removal; maintain room temperature (20 +/- 3 C)

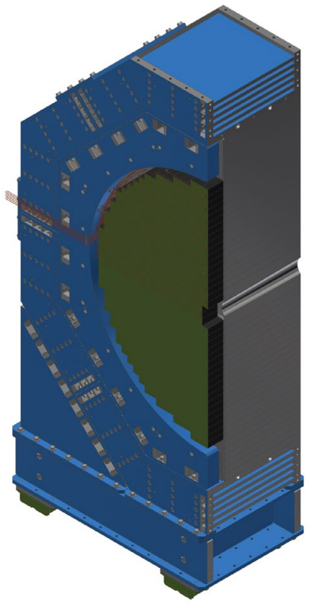
Very preliminary estimate of power per ESB

Item	Power per ESB	Notes
AstroPix Chip	43.5W	9x12, 7 staves/layer, 6 layers, (including 20% margin)
End-of-tray card	7.2W	1 FPGA/layer, 6 layers, +20% margin
AstroPix Module PCB	10.9W	20% of Chip, (including 50% margin)
FEB	3W	Info from designer (Norbert) (including 20% margin)
Total	64.6W	1 ESB

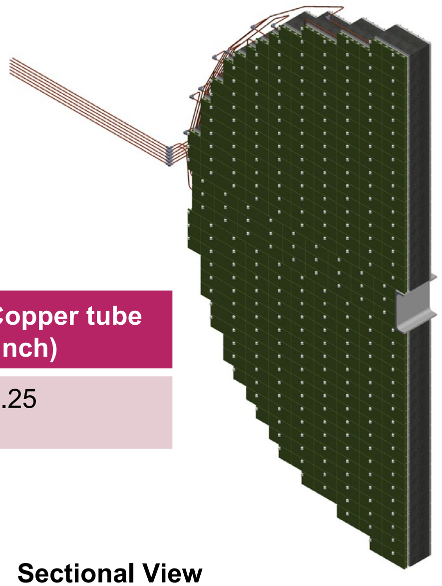
Example | SVT Inner | SVT Outer | SVT Disks | MPGD Disks | MPGD Outer | MPGD Inner | ToF Barrel | ToF Forward | RICH Forward | RICH Backward | DIRC | ECal Barrel PbScifi + AstroPix

- Gathered all the cooling requirements from various sub detector groups.
- Cooling Requirements Spreadsheet is posted with prebrief material.
- Design being worked on to be ready for PDR.

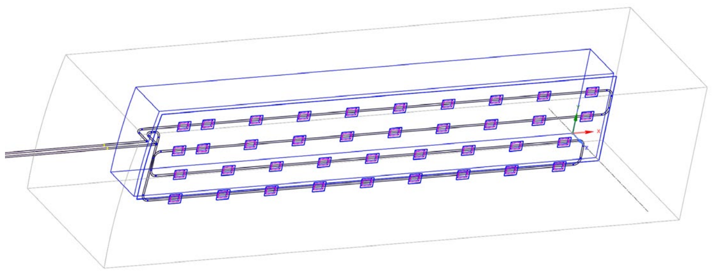
Forward EMCAL Cooling



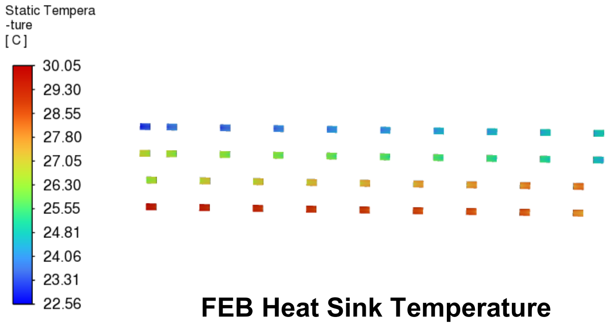
Copper tube (inch)
0.25



Sectional View



Sector Geometry



FEB Heat Sink Temperature

Water flow rate (litre/min)	Flow velocity (m/s)	Tube Length (m)	Pressure drop (psi)	Temperature rise (C)	FEB Heat load (W)	SiPM Heat load (W)
0.83	0.76	6	2.1	2	4.5	0.17

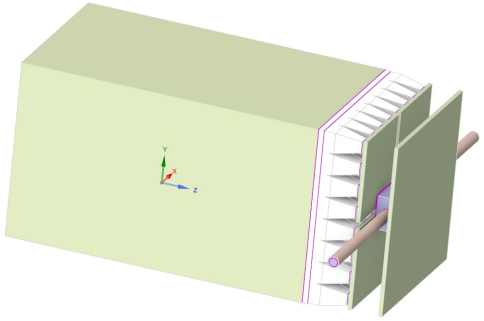
Relative Humidity (%)	Dew Point Temperature (C)	Water Inlet Temperature (C)	FEB Temperature (C)	SiPM Temperature (C)
100	20	22	25.9	23.8

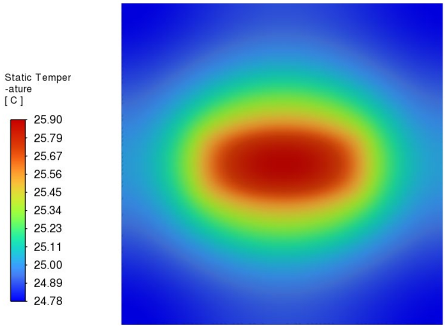
Temperature Requirements
Maintain FEB temperature 3 C above dew point
Cooling the SiPMs to be determined

Materials
Copper thickness (10 %) in FEB
Copper thickness (5%) in SiPM Board
FEB and SiPM Board thickness : 2 mm

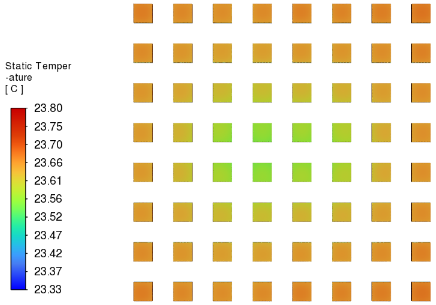
Way Forward:

Design being worked on to be ready by PDR.





FEB Temperature



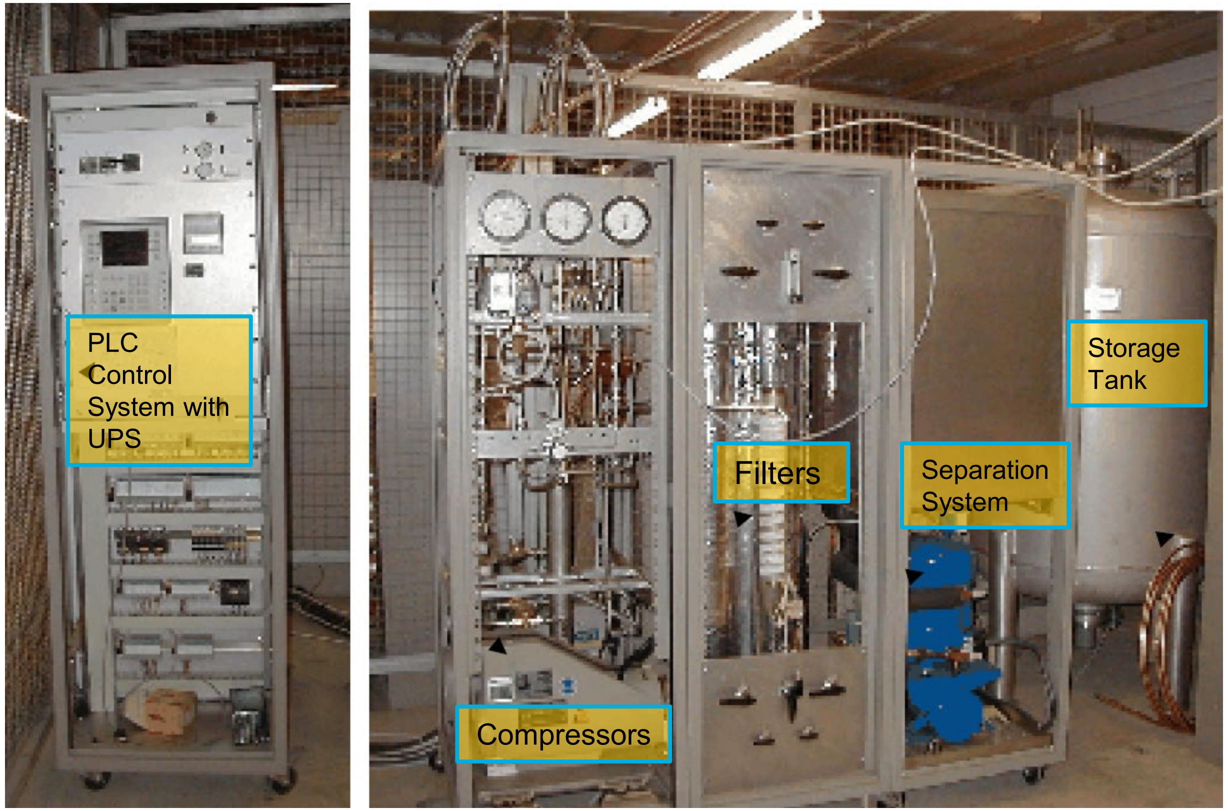
SiPM Temperature

Gas Systems for ePIC

1. **pfRICH & hpDIRC**
   - Uses dry Nitrogen
   - Design requirements are understood and easy to implement.

2. **MPGD**
   - Uses a mixture of **Argon, CO_2, and isobutane**
   - **Gas mixture ratios** still need to be finalized
   - A **dedicated safety system** is required due to the flammability of isobutane
   - Design is **relatively straightforward** and can be implemented with standard practices

3. **dRICH**
   - Uses **Hexafluoroethane (C_2F_6)** as the radiator gas
   - Due to C_2F_6 being a **greenhouse gas**, a **recirculation/recovery system** is necessary
   - System is **more complex** than the others
   - Leveraging designs from **existing experiments** will help accelerate development
   - Combination of gas filtering and phase separators will be used for the recovery system.
   - **STAR TPC gas system plumbing** from gas pad to experimental hall is a potential candidate for reuse



COMPASS RICH Gas system seves as a baseline to dRICH Gas System

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	Cooling
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
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

- MARCO (SC Magnet) Power:
  - New Power Supplies will be used. Existing Water cooled leads for STAR (Length 300 feet) with current capacity >4000 Amps were evaluated by ePIC Magnet Group can be used. New Magnet DAQ Rack will be placed on Third Level of South Platform and Dump Resistors on the Third Level of North Platform.
- Looking at the STAR Detector Power One Line Diagram and comparing it with the EPIC Detector power requirements for various subdetectors, it seems like we have adequate power for EPIC needs. The EPIC detector Electronics power was estimated using table above which is available on sharepoint. **Refer to ePIC Services on-line Spreadsheet for details of power distribution.**

Maintenance Plan for ePIC

Detailed ePIC Installation Schedule and Maintenance Schedules were created and are posted as prebrief materials. Following maintenance plan will be followed for detectors:

- HCAL: HCAL Sectors are not removable. All the electronics will be on the exterior and is accessible for maintenance.
- Magnet: Cryostat is not removable. Chimney and Phase separator are on top of HCAL and are accessible for maintenance.
- Barrel EMCAL: Is removable only in case of full upgrade of the detector. All electronics are accessible on both ends.
- DIRC : Bar Boxes can be removed but not needed. Electronics are accessible from the backward end.
- Outer MPGD: Modules can be removed inside the experimental hall for full maintenance.
- Cymbal & Barrel TOF: Modules can be removed inside the experimental hall for full maintenance.
- EEEMCAL and pfRICH: Detectors can be removed inside the experimental hall for full maintenance.
- dRICH: Detector can be removed inside the experimental hall for full maintenance.
- Inner Detectors (Si Disks, Si Tracker, MPGD Disks): GST can be removed in the assembly hall for full maintenance.
- TOF Disk: Detector can be removed inside the experimental hall for full maintenance.
- Forward HCAL: Towers/Modules not removable. Electronics accessible from the back end.
- Forward EMCAL: Modules removable. Electronics accessible from the back end.
- Backward HCAL: Towers/Modules not removable. Electronics accessible from the front end.
- Electronics racks/chillers/cooling systems/gas systems are accessible from north and south platforms.

ES&H

- Harnesses, safety glasses, work gloves and other PPE will be identified for work required.
- Follow all OSHA guidelines and BNL SBMS for designing scaffolds and other access provisions for assembly and installation of all components.
- All components are designed and analyzed to a reasonable factor of safety to mitigate any risk of structural failure.
- Cranes and other access equipment such as scissor lifts and bucket lifts are periodically inspected as per guidelines in SBMS.
- We identified that ePIC detector and all its components weigh more than STAR detector. Requisition for floor load analysis is pinned.
- Safety systems (Fire Suppression and Smoke Detection):
  - Are part of existing bldg. 1006 and need to be updated during refurbishment of facility.
- Sniffers will be installed next to MPGD detectors on both Forward and Backward Ends to detect leakage of any flammable gas.
- ODH Safety standards will need to be evaluated.

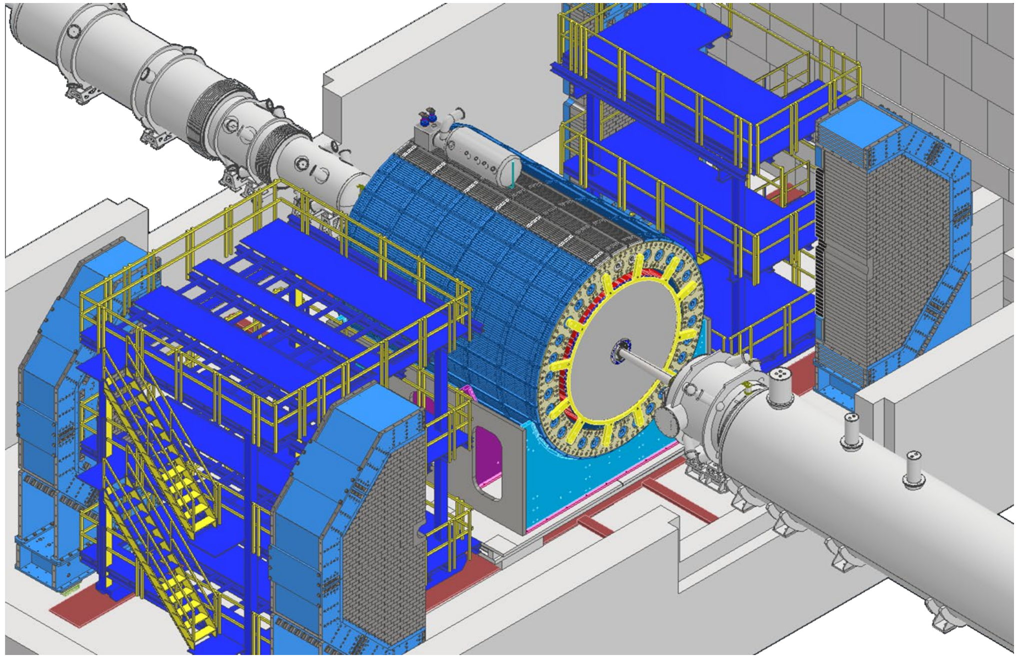
Outlook to CD-2 and Summary

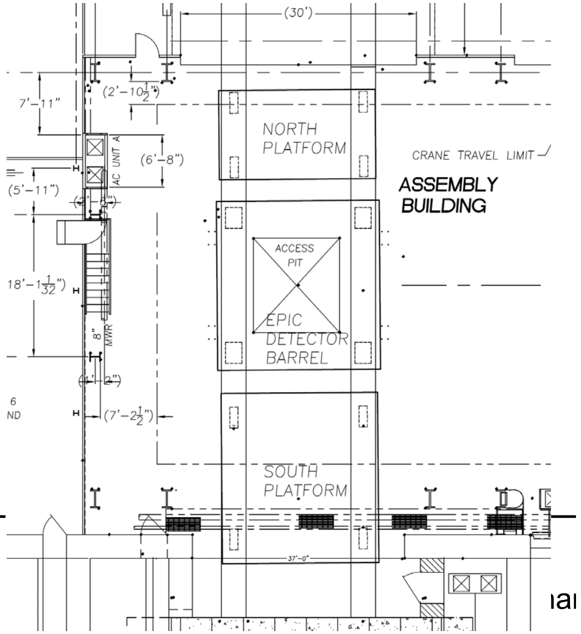
- PDRs for Support Structures, Integration and Installation to be done from Oct to Dec 2025.
- We will further refine the designs of various sub detectors, their support structures.
- Identification of conflicts and resolution.
- Cabling plan and RDO placements needs to be further refined with cable trays etc.
- Seismic and Magnetic Forces are taken into consideration for design of support structures.
- Cooling and Power requirements for various detectors and electronics are continuously being refined.
- Gas Systems preliminary design to be finished and reviewed by end of calendar year.
- Safety Engineers are integrated in the Engineering Meetings to help with design development.

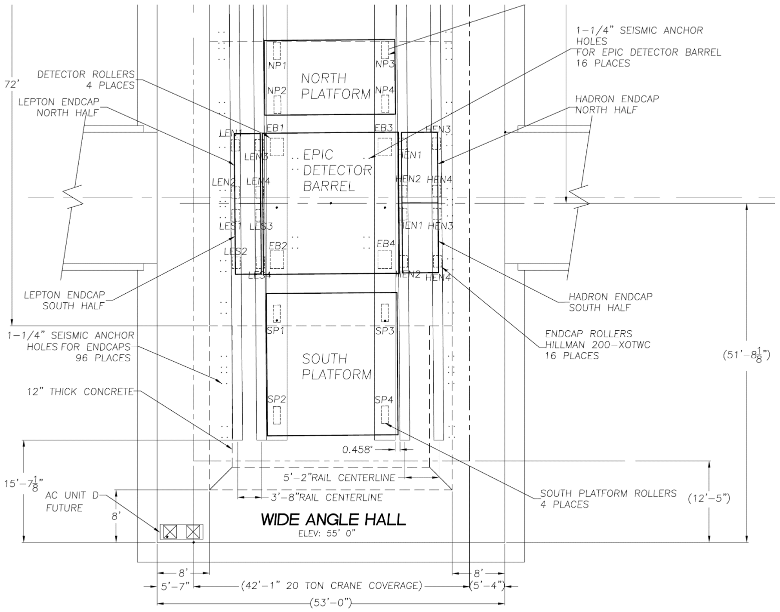
BACK UP

Infrastructure and Utilities

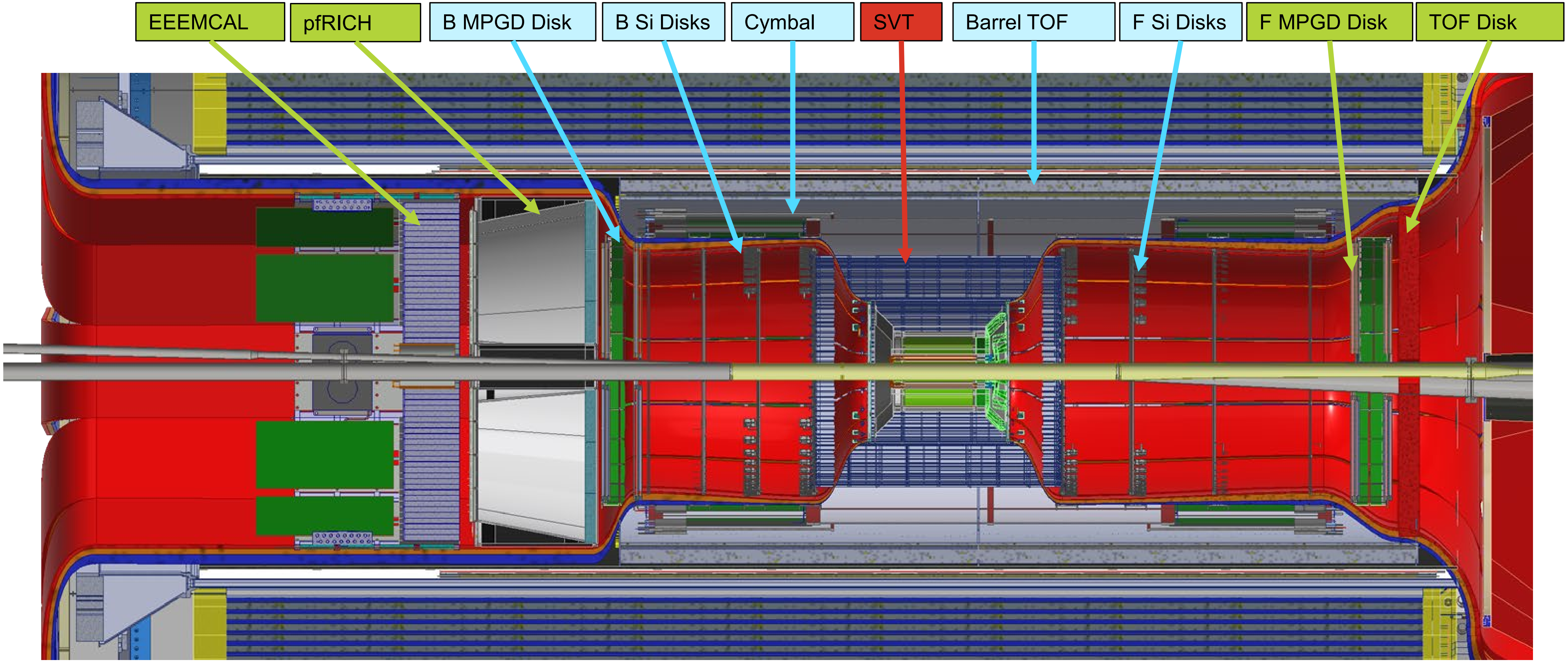
- ePIC detector weight including Endcaps is more than existing STAR detector.
- Analysis required to find out if any modifications are needed to the current concrete floor.
- New rails will be needed for the Endcaps
- Detailed explanation of following details were put together in the document “EPIC Floor Loads and Placement” and have been provided to EIC Infrastructure Group.
  - Hillman Rollers and their placement,
  - Location of new rails,
  - Weights of EPIC Barrel, Hadron & Lepton Endcaps
  - Other relevant details with detailed drawings and model snapshots.
- SOW with Requisition in BNL Procurement System.
- External consulting firm to analyze loads on concrete floor.
- Detailed explanation of utilities and upgrades needed were also put together in the document “EPIC Utilities” and have been provided to EIC Infrastructure Group.





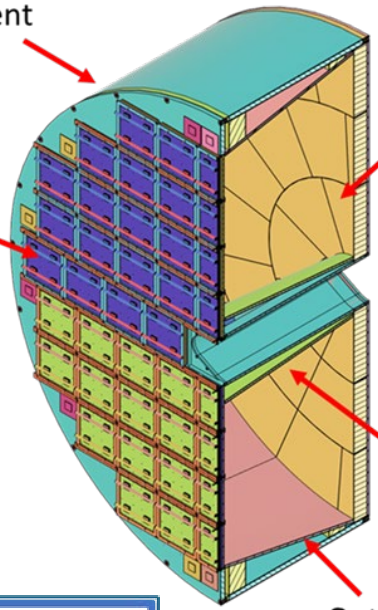


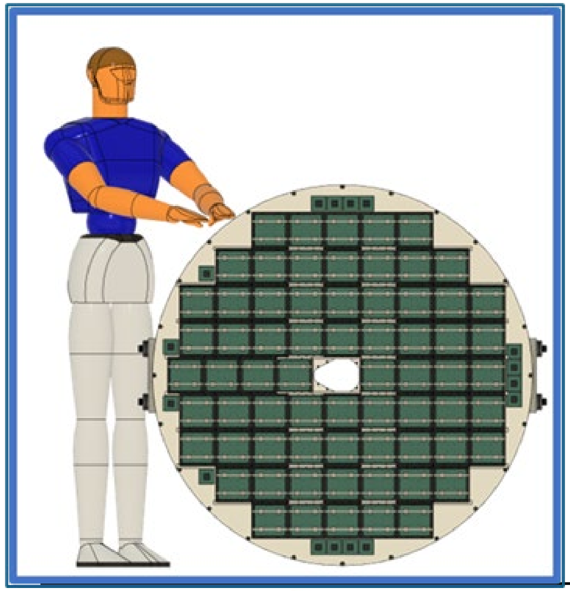
GST Model with Detectors



- Current Inner Detector Models inside GST.
- Working on design modifications to make Barrel TOF and Cymbal detectors serviceable in the experimental hall.

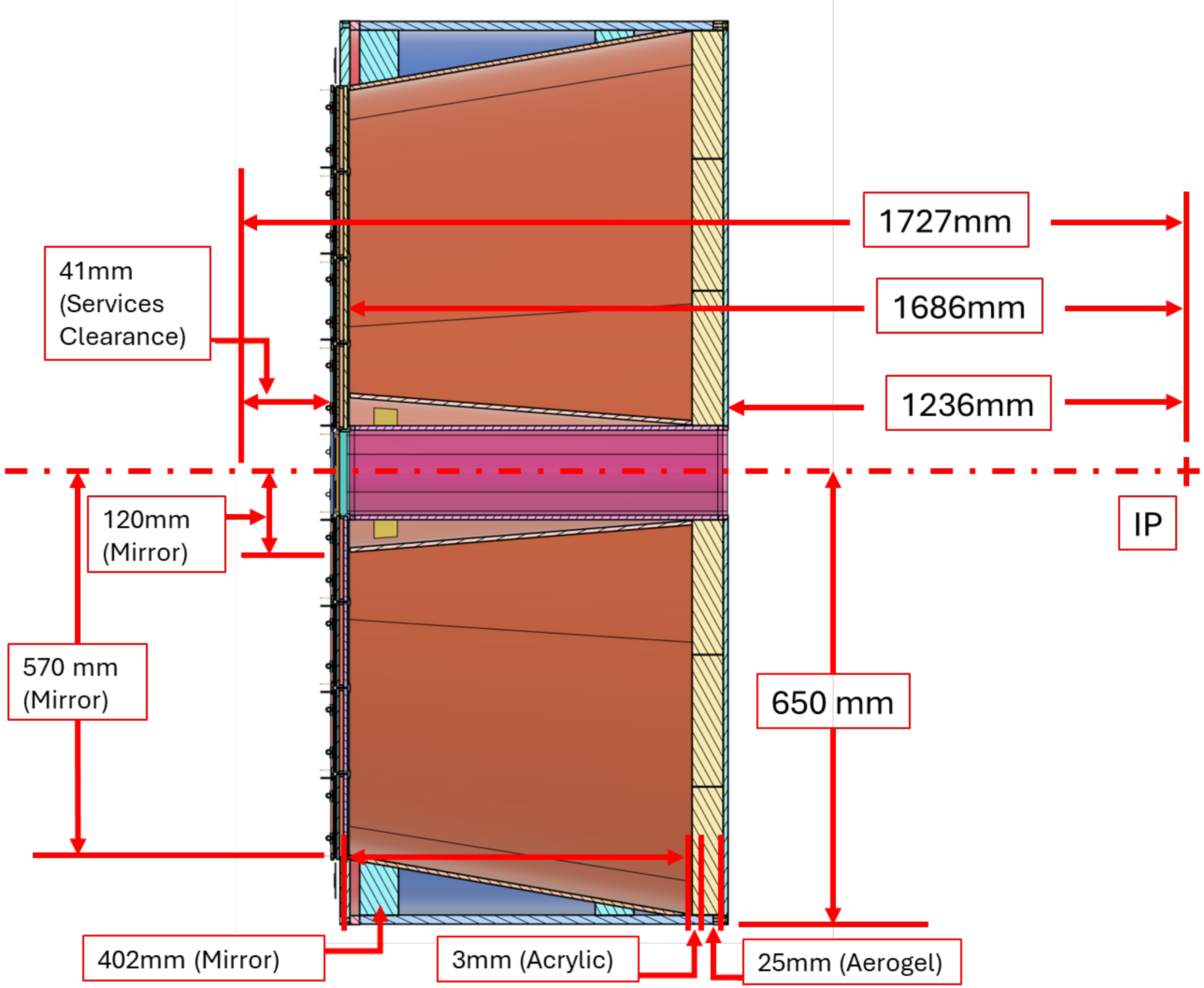
pfRICH





Major Components:

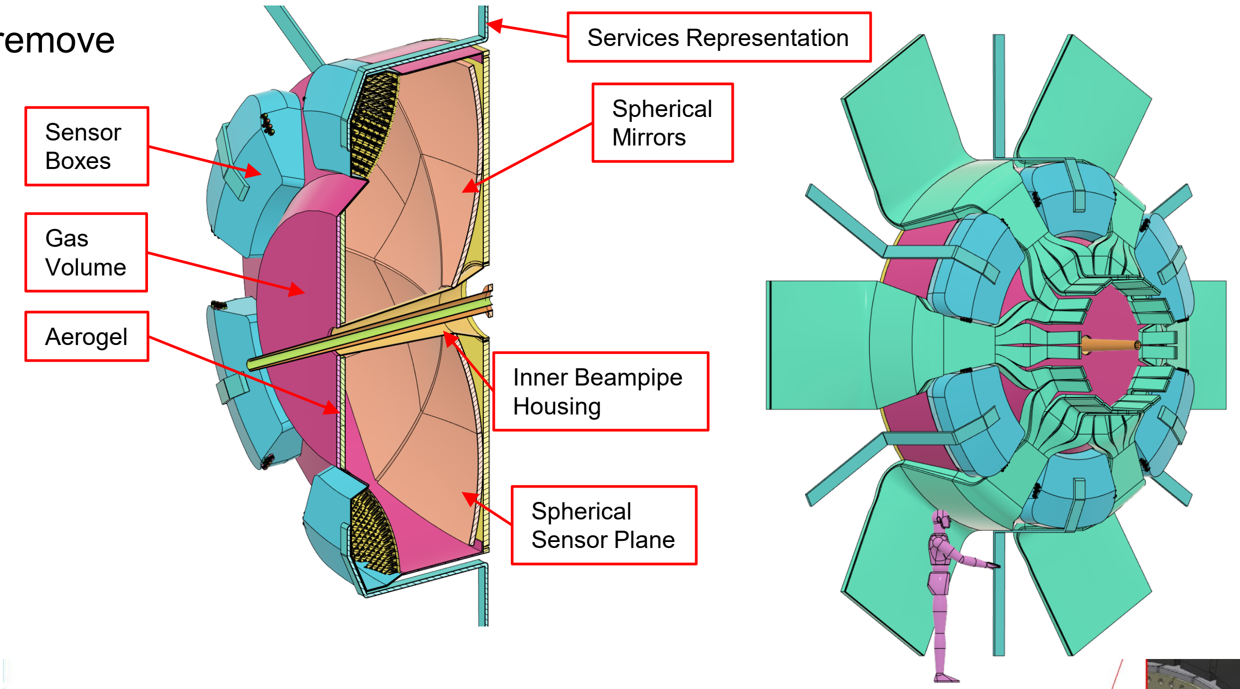
- Vessel
- Sensor Plane
- Mirrors
- Aerogel Wall

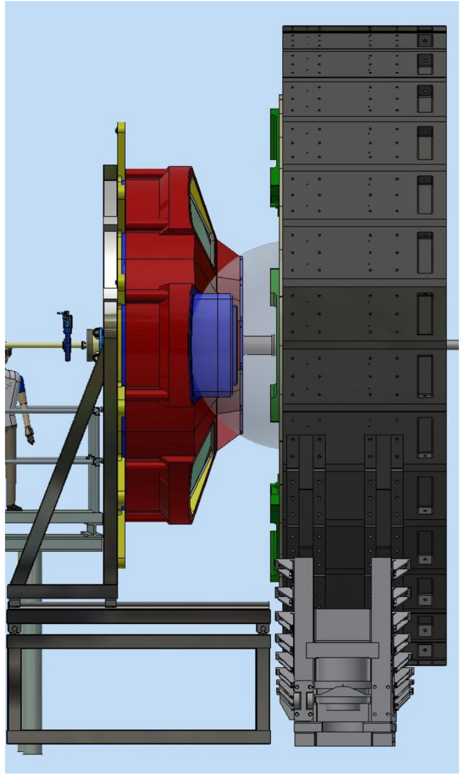


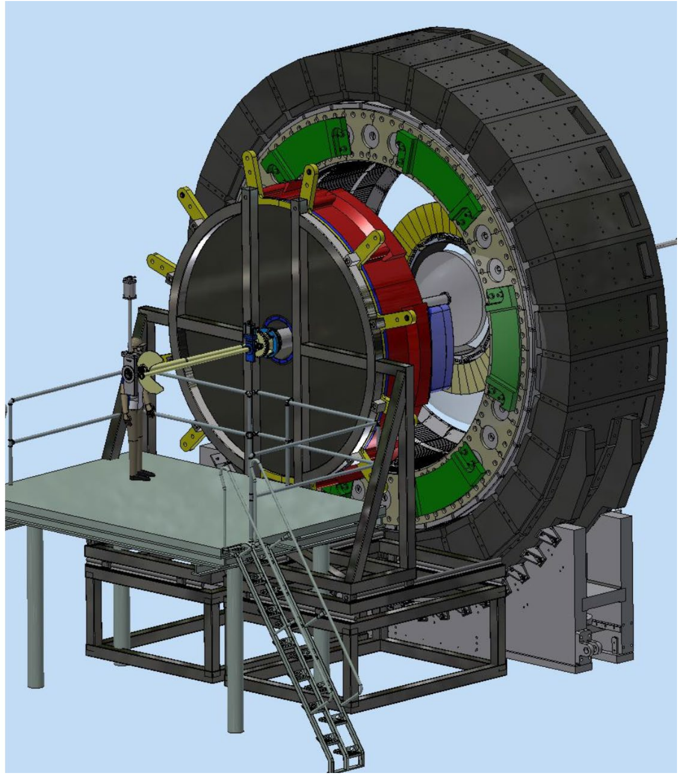
dRICH

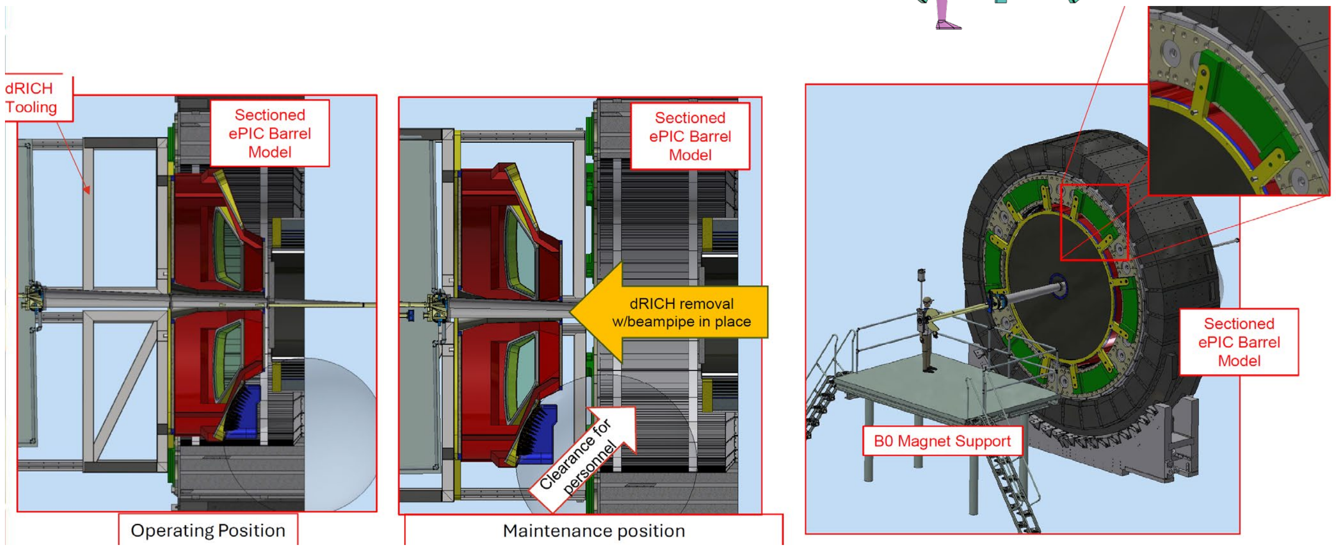
- Due to the anticipated need for maintenance in the hall, options to remove the dRICH were investigated.
- dRICH is kept whole and slid as far back as possible.

Estimated Weight: 2000kg



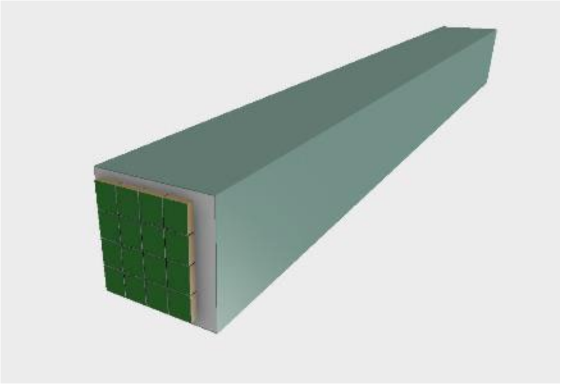




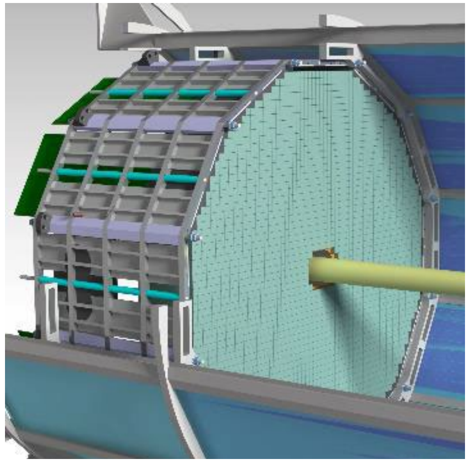


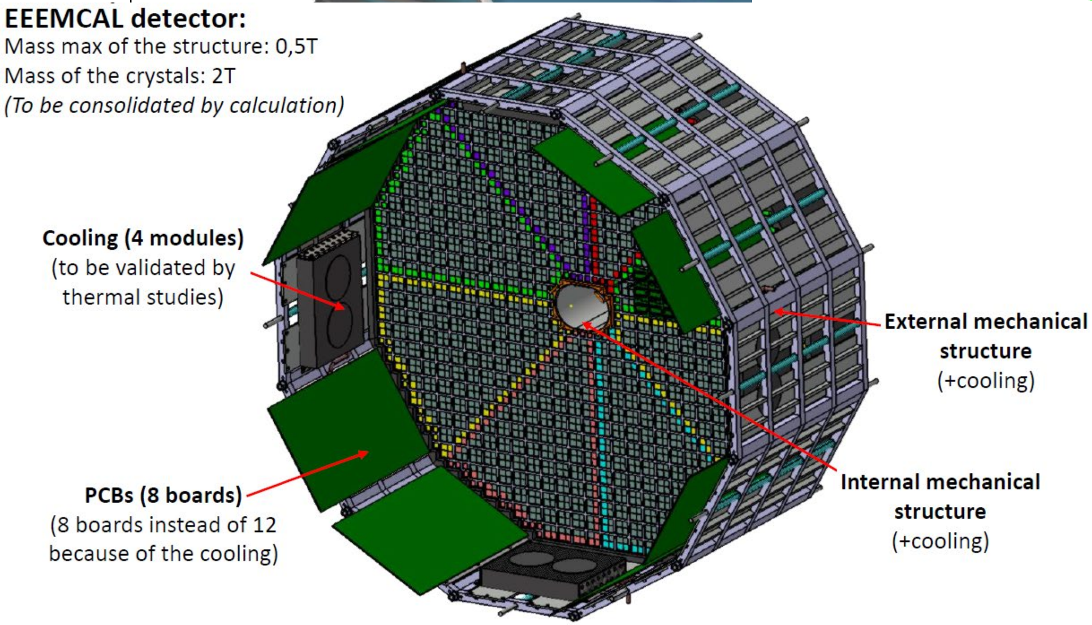
EEEmCAL

SiPM and crystals configuration



Mechanical design & Clearances





Cooling

- Stability required : +/- 0,1 °C
- Power: 50 W (by box)
- Copper plate in front < 5 mm
- Water cooling plate (internal & external)
- Air cooling for the electronic boxes