Summary of Integration and Installation Session

Prakhar Garg (Yale University)

Silvia Dalla Torre (INFN, Trieste)

ePIC Collaboration Meeting

Lehigh University

July 27, 2024

Large Participation and lots of discussion:

~50 in-person

~10 online

~10 Engineers

We would wish to further increase these numbers

Session Info:

This session was included the first time during ePIC Collaboration Meeting

We received many positive feedbacks

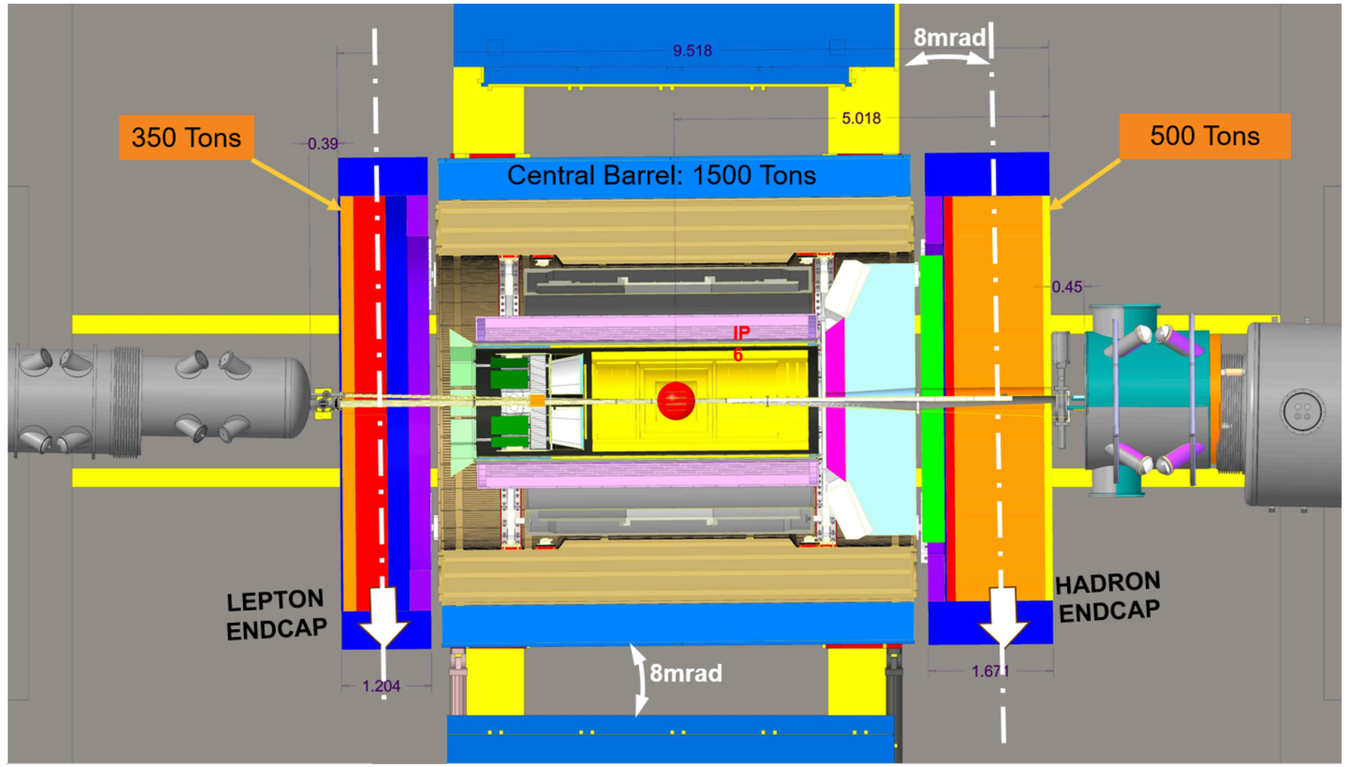
Your inputs are are always welcome to improve further

Session: https://indico.bnl.gov/event/20727/sessions/7432/#20240725

Introduction/ Current status of ePIC Detector & discussion
By Rahul Sharma

8mrad Rotation

2



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

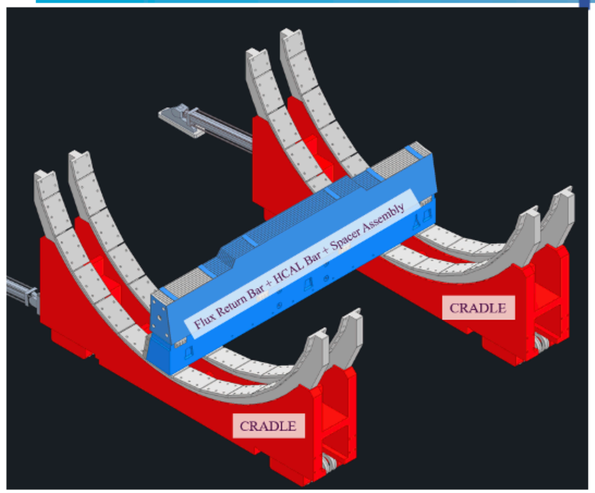
ePIC is a Complex Detector

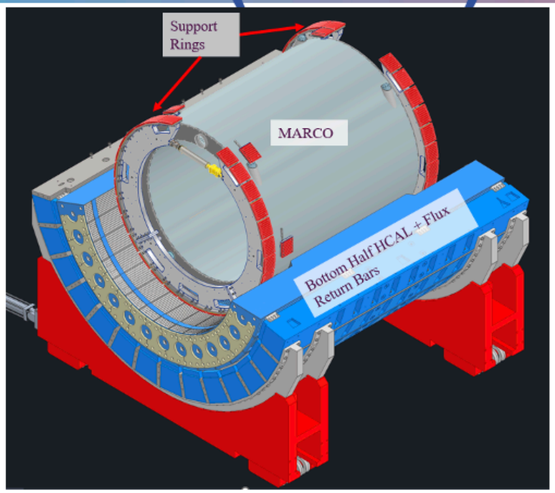
I hope we all agree!

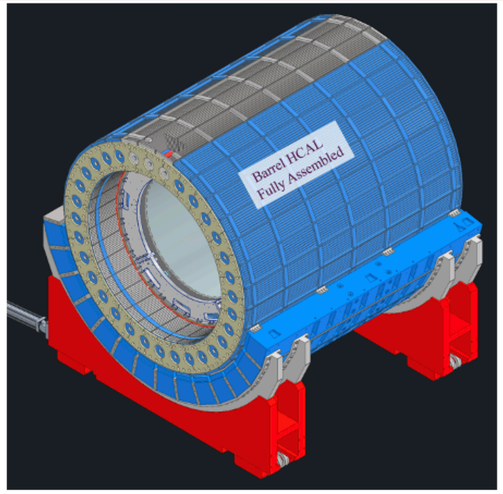
Introduction/ Current status of ePIC Detector & discussion By Rahul Sharma

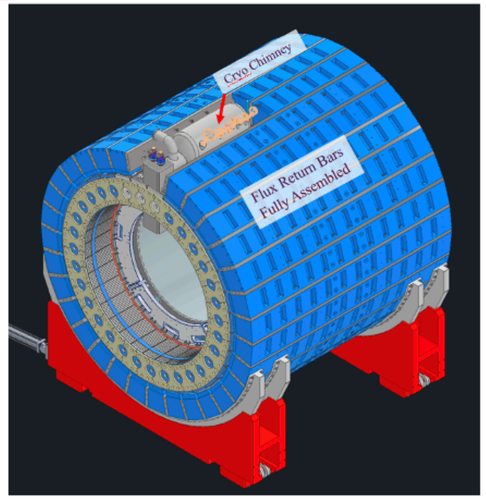
Installation Sequence (Barrel)

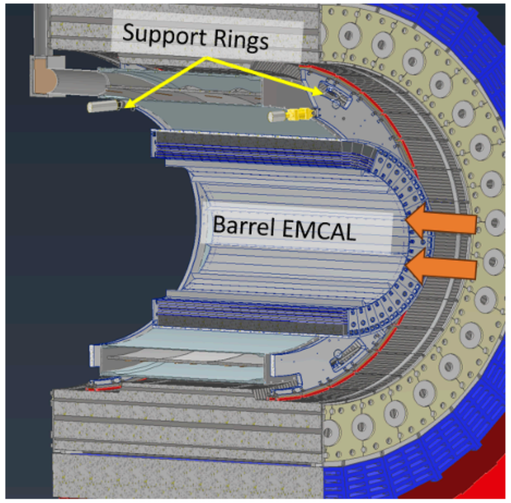
2

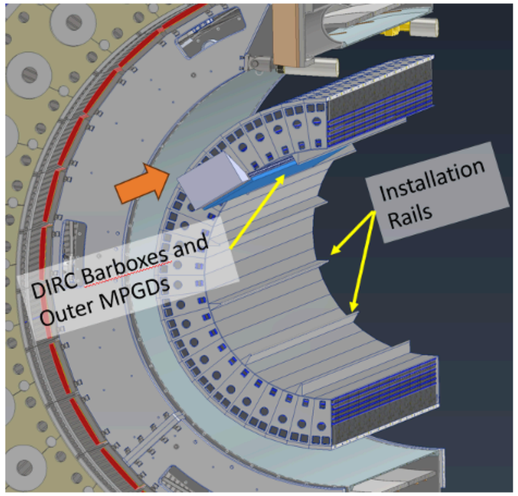


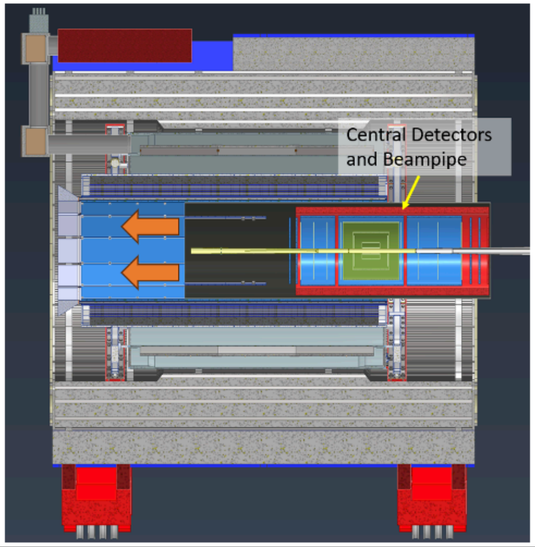


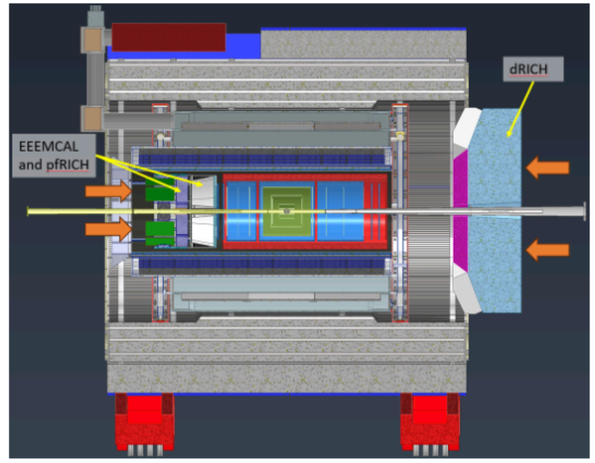






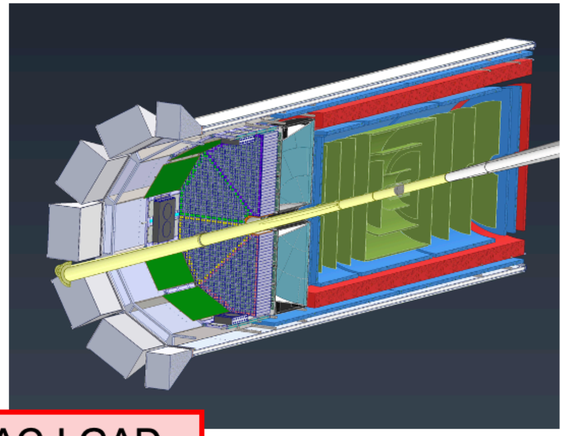


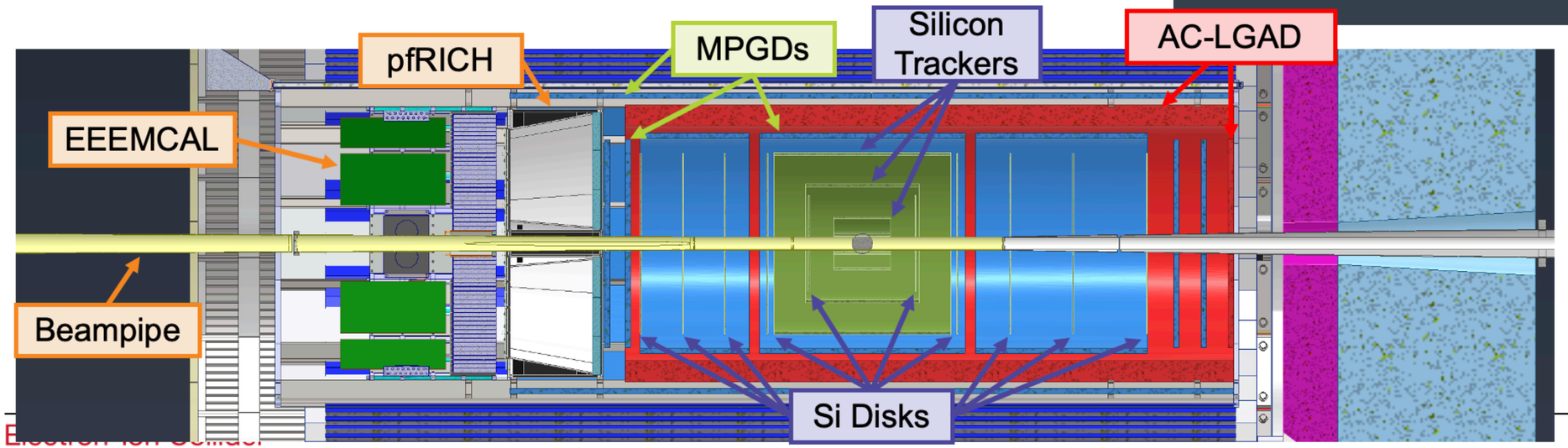




Model Overviews (Inner Detectors)

- **EEEMCAL:** Will be slid in on rails at 3 & 9 O'clock positions
- **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



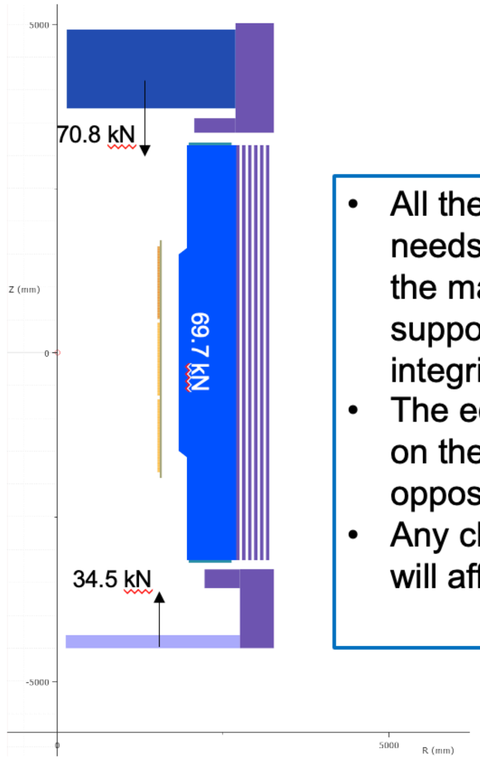


Many different detectors in limited space!

Installation is tricky and should be paid close attention by all

Force on Various Steel Objects

Object	Fz	Units
Dogbone Hadron side	-3.3	kN
Dogbone lepton side	2.6	kN
HCAL Hadron	-70.8	kN
HCAL Lepton	34.5	kN
Steel Hadron Barrel	-8.4	kN
Steel Lepton Barrel	8.6	kN
Steel Oculus Hadron	-7.7	kN
Steel Oculus Lepton	7.7	kN
HCAL Barrel	69.7	kN
Steel Barrel	-1.0	kN



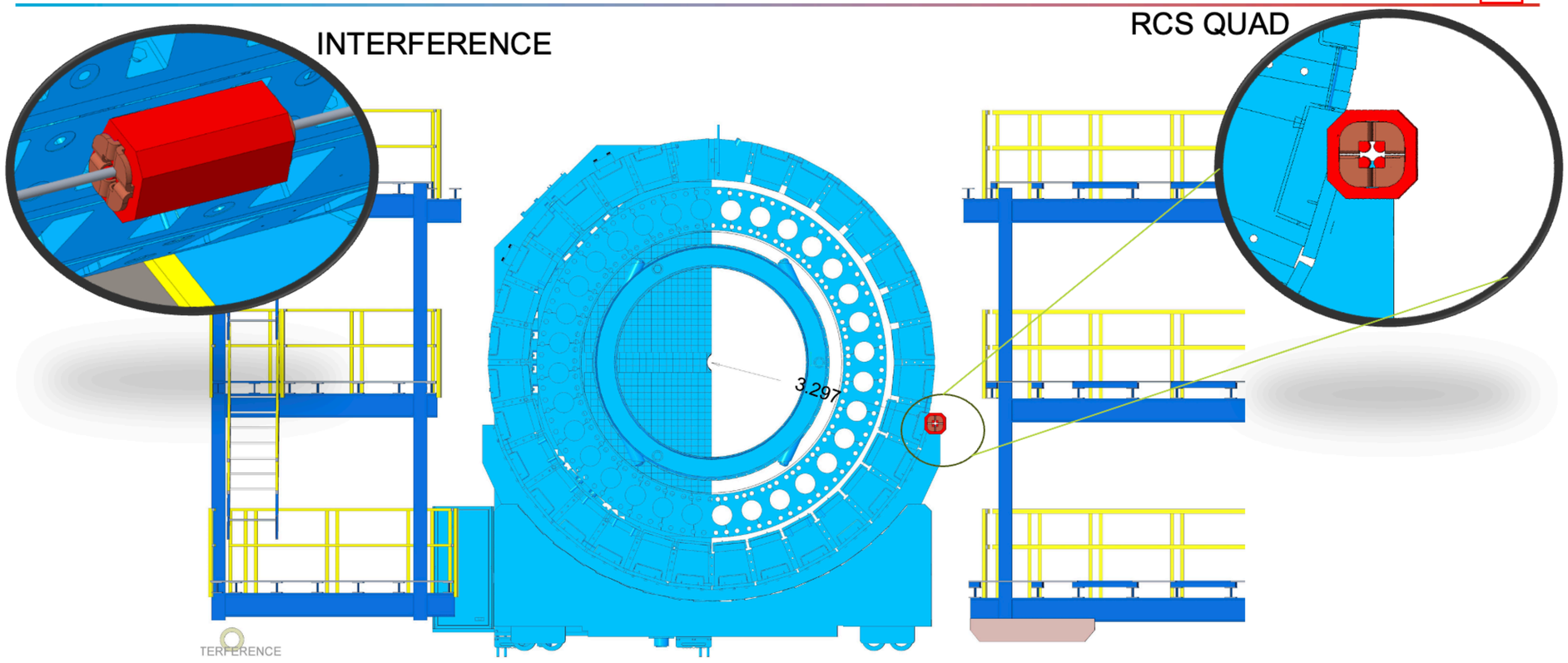
- All the steel components needs to be analyzed for the magnetic forces and supported for mechanical integrity
- The equivalent force is on the coil system in the opposite direction
- Any changes in the steel will affect these forces

Don't forget

Eddy currents during Magnet quench for subsystems !

RCS (Rapid Cyclic Synchrotron) Beampipe

2



Current Design of RCS creates interference with the flux return steel. It is not clear if the quadrupole in the RCS is needed. It is under study.

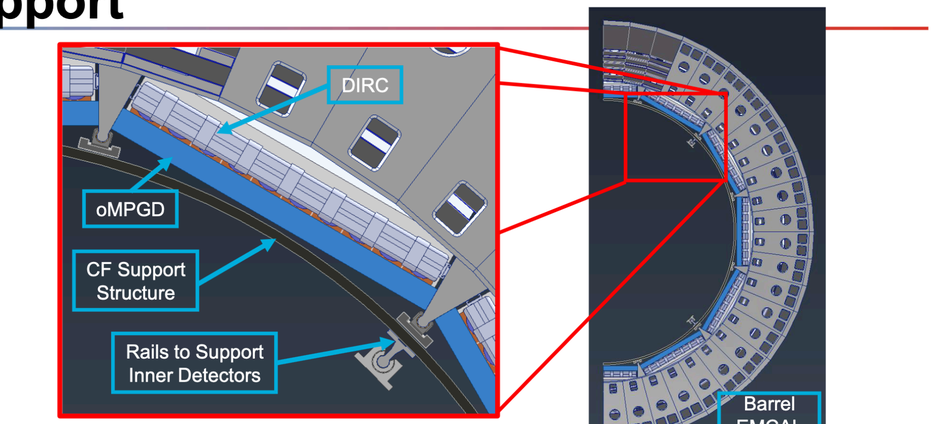
Open question

Central Detector Integration and Installation

By: Dan Cacace, Josh Harvey & Nathaniel Speece-Moyer and Contributions from Rahul Sharma & Roland Wimmer

DIRC and oMPGD Support

- Use barrel EMCAL for support of inner detectors
- Outer MPGDs and DIRC will be nested in the area between rails.
- A carbon fiber support structure attached to the 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 out



- Installation Choreography
- Installation and Support for various sub-detectors
- A lot of progress has been made!! and still continuing

CAD EIC Project ⟷ ePIC, Full Geometry Exchange, Both Ways

By: Wouter Deconinck

Physics and Engineers use CAD differently

Engineers

- Sketch & feature-based geometry
- All parts are ‘material’ objects
  - no inclusion of air/helium/vacuum volumes
- Inclusion of details down to fasteners
- Assembly/installation sequence
- Envelopes for subsystems

Physicists

- Focus on overall material volume (maximum material conditions preferred)
- Layered geometries are used: volumes in volumes in volumes
- Desire for high computational performance of simple volumes (cylinder, box, trapezoid)
- Avoid tessellations in automatic exports

Joint Uses of CAD

- Avoid for overlaps/interferences between and within subsystems
- Dimensional accuracy not affected by approximations inherent in tessellations
- Ability to refer to versioned reference information (e.g. drawing number, release version)

Discussion Starting Point for EIC Project Process

- **What is required?**
  - Regular release of versioned CAD files as reference, in order to include service and support structures in TDR and production simulation campaigns
- **Scope**: current design to the extent it affects signal and background rates:
  - Beamlines, including far-backward to far-forward
  - Central detector geometries, up to flux return barrel and endcaps
  - Support structures inside central detector
  - Not required: cradle, accelerator tunnel, etc.
- **What is missing?**
  - Process for EIC Project approval before versioned CAD files are shared with ePIC

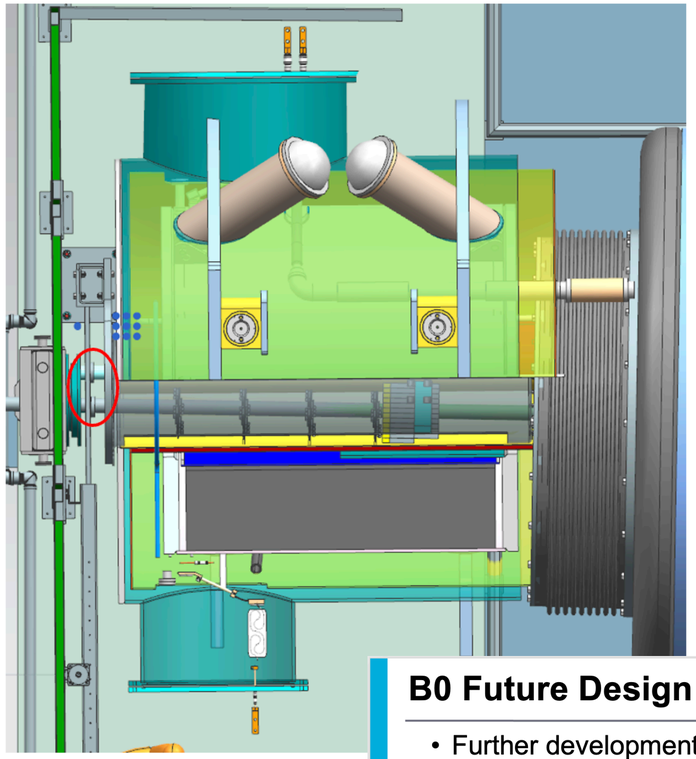
There seems to be an agreement to establish the baseline first and then handshake at regular intervals in coming months

Far-Detector Integration and Installation
By: Jonathan Smith (JLAB), Ron Lassiter (JLAB)

- CAD model synchronization
- Far-Forward, Sector 5
  - Zero Degree Calorimeter (ZDC)
  - Roman Pots/Off-Momentum
  - B0 Magnet Detectors
    - B0 Magnet Sub-Components
- Far-Backward, Sector 6
  - Lumi Calorimeter & Detectors
  - Low Q2 Tagger Tables

B0 Challenges

- No access in the rear, very limited access in front
- Anticipating a bellows around electron beampipe in front access
- Unable to remove Calorimeter for maintenance.
  - Calorimeter will need to be installed prior to placing B0 Magnet in beamline.
- Space limitations for electronics and cooling lines.



B0 Future Design Development

- Further development of detector layers and calorimeter maintenance/removal rail system.
- Pending R&D detector updates for heating/cooling requirements.
- Ongoing discussions with accelerator, magnet, and vacuum that will likely have impact future design.
- Potential for a removable access platform
- Currently 3D printing a prototype for Track/Roller detector removal/install system

Routing & Services
By: Roland Wimmer (BNL)

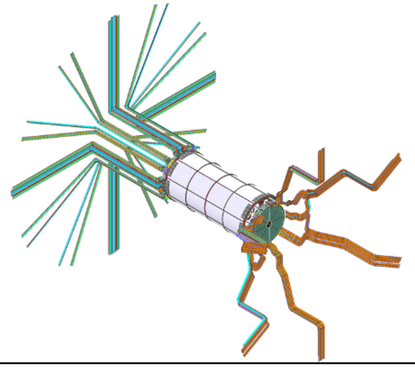
- **Several locations of high concern**

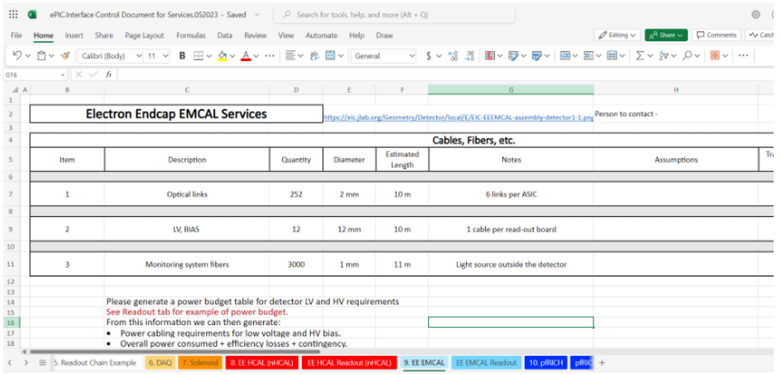
Subsytem	Quantity	Cross Area (cm^2)	+50% Packing for Bundles	+50% for MISC spacing needs	Available Space		
Red Path IP to pfRICH Inner face							
Total	5503	754.98	1132.48	1698.71	1800.00	Used space:	94.37%
Red Path From pfRICH to EEEMCAL Inner face							
Total	6584	915.41	1373.12	2130.17	2251.00	Used 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%

Update Me!

ePIC.Interface Control Document for Services.052023.xlsx

- Please go through and update the values for your detectors
  - Quantities / Diameters / Cooling & Gas needs / Power estimates / etc.
  - Adding your level of confidence in these numbers to the descriptions would be very helpful
- As we get further along accommodations for any necessary changes become harder to make
- Space is a commodity and were already running out!
- If you don't have access request it





- We should be careful because after the safety approval for various cables etc. the model number/specs might to be changed!!

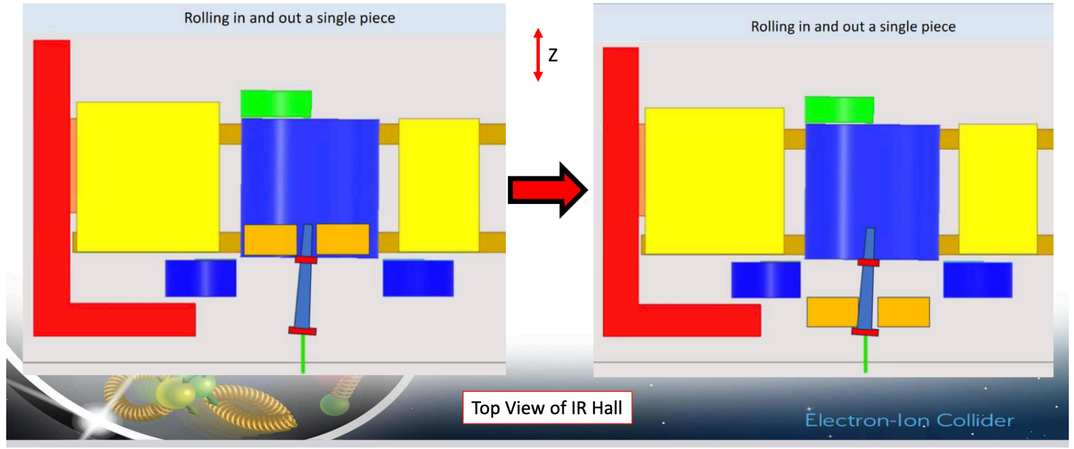
Subsystem focused contributions

dRICH Removal Considerations
By: Alex Eslinger (JLab)

- Two scenarios are being investigated:
  1. Keep the dRICH as one-piece
     - Move the dRICH back as far as practical (to the gate valve location)
     - Perform maintenance inside the barrel and on the primary dRICH electronics
  2. Split the dRICH in two halves (vertically)
     - Modify the beam pipe design so that the flange is placed in front of the dRICH instead of directly behind.
     - Move the dRICH just outside of the barrel and clear the existing services
     - Split the dRICH apart and pull one or both halves out of the way
     - Perform maintenance inside the barrel and on the primary dRICH electronics

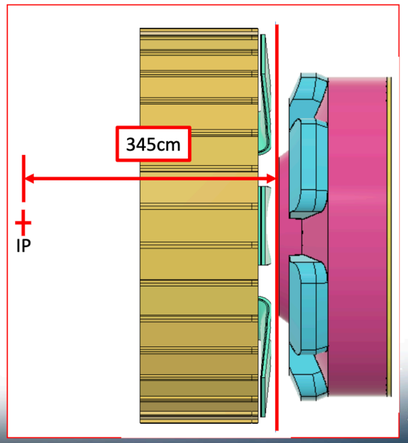
The CAD models for both bore options have been distributed to be used as simulation inputs to determine the best option.

Option 1: Beam Pipe Flange Remains/One-Piece dRICH



Option 2: Move Beam Pipe Flange & Two-Piece dRICH

1. The dRICH is pulled back to it's "removal location" which is just far enough back to clear the inner detector services (150cm)
2. The dRICH is split apart and one or both halves are moved away from the barrel
3. The first beam pipe flange is relocated to just in front of the dRICH
4. 5mm clearance is added radially for every feature that needs to clear the beam pipe



BOT and ECT
By: Seung Joon Lee (JLab)

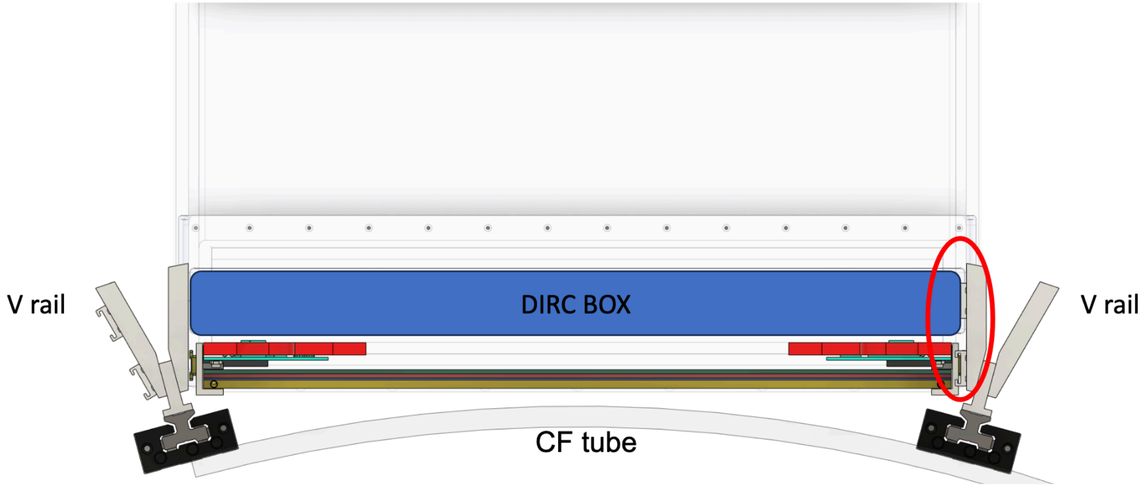
- Both BOT and ECT design is still underway

- BOT service plan requires extra support structure
- More modification is expected by FEB specification

- ECT has a tight space for FEB vertical mount
- ECT will use extra rim support that handles detector, services, and integration into IB

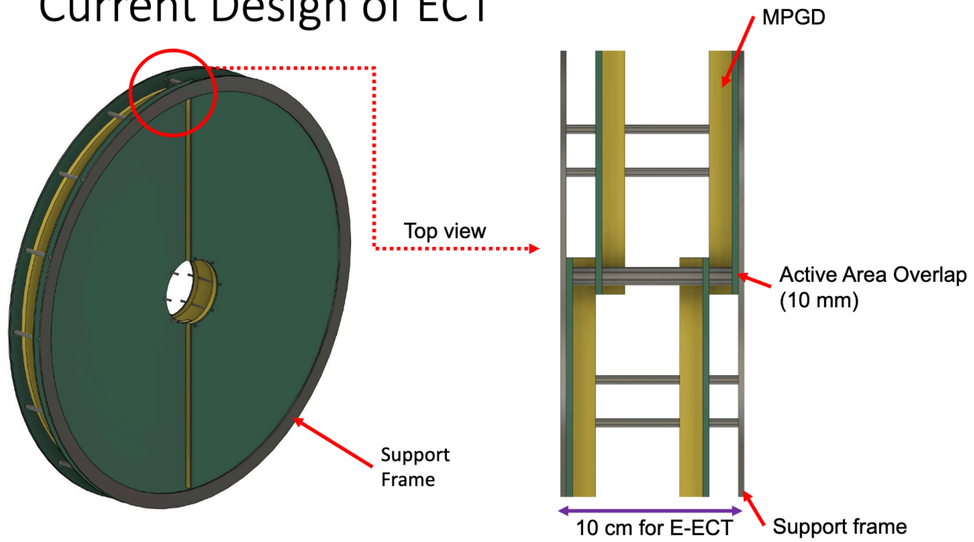
It's important to estimate the heat load to decide which cooling option is required

Integration (BOT)



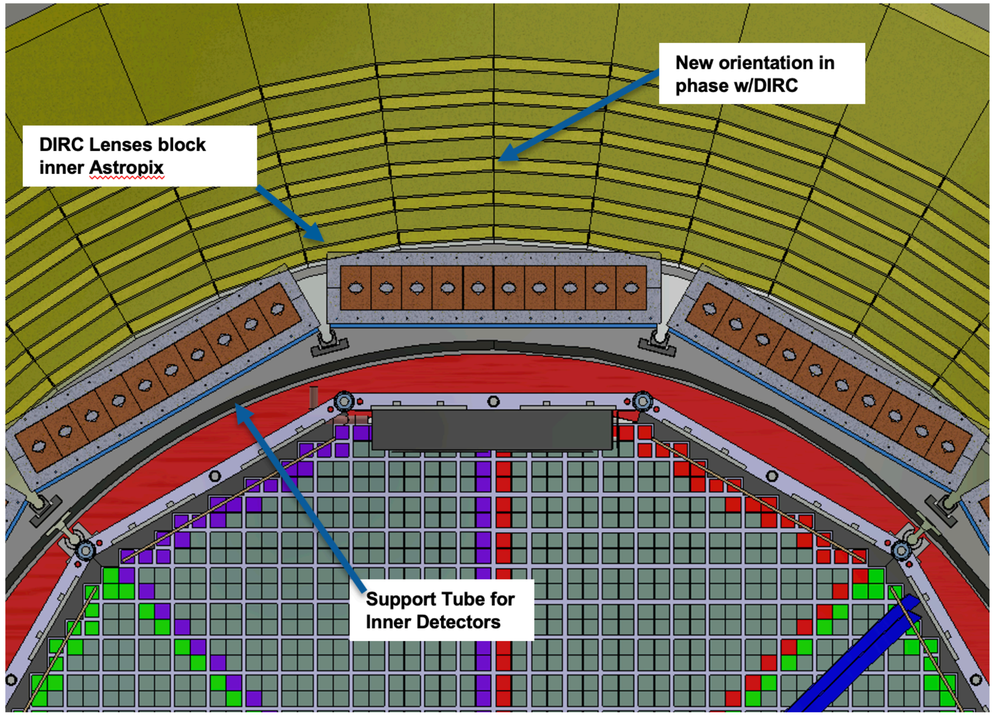
- V shape support has two Rails on each side for slide inserts from the DIRC and BOT
- BOT thickness is only 25 mm.
- 5 mm installation clearance on each side (DIRC, CF tube)
- Open box design: No space to make a box. Cooling may be required.

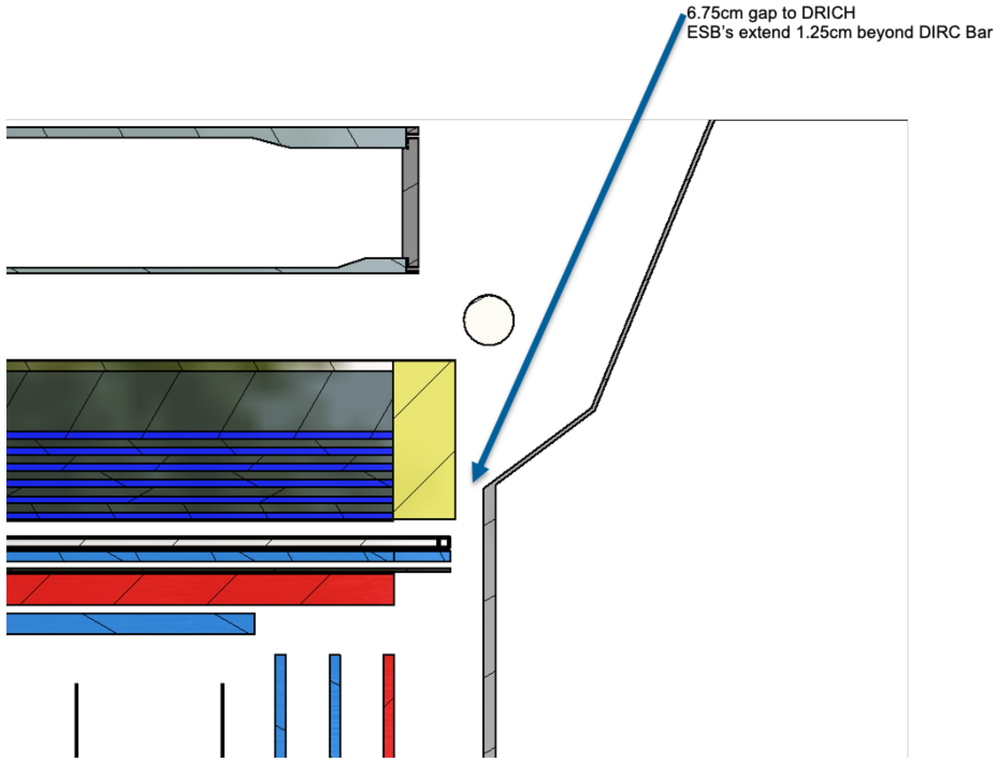
Current Design of ECT



Barrel EMCAL Engineering Update
By: Kevin Bailey & Tom O'Connor (ANL)

Dirc Interference, Astropix Access:





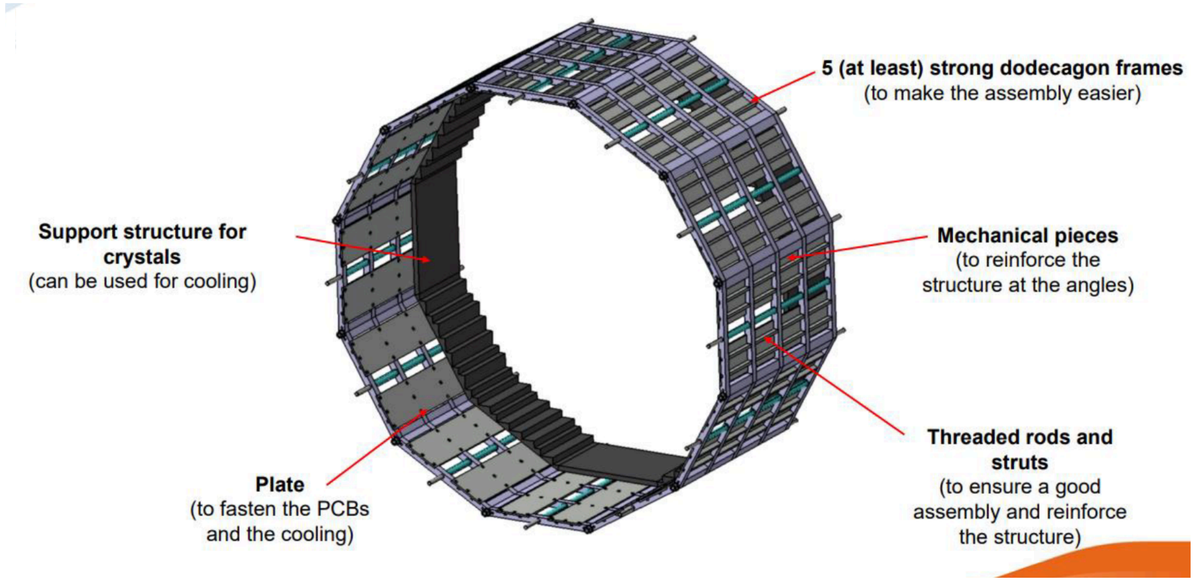
Barrel EMCAL group is investigating if reducing the layers radially will impact the physics to make more space.

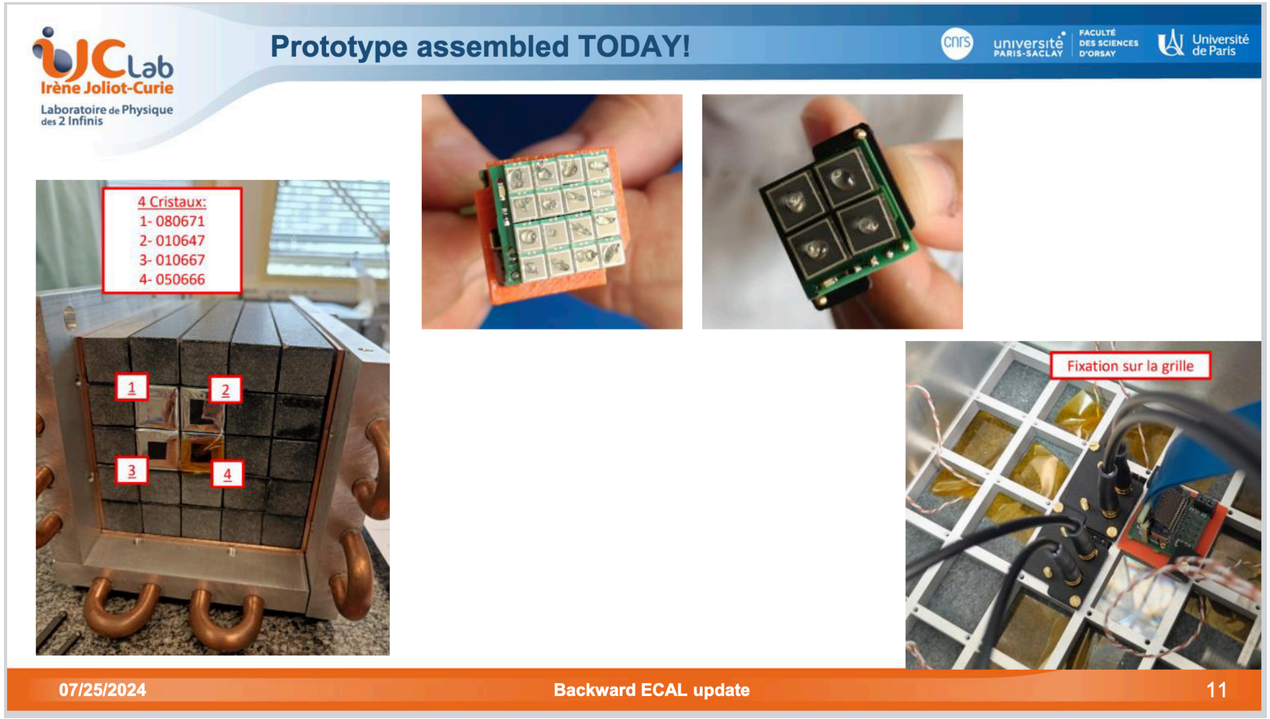
Backward ECAL Engineering Design Update

By: Carlos Muñoz Camacho IJCLab (Orsay, CNRS/IN2P3)

- Mechanical conceptual design relatively advanced
- Main outstanding item: choice of front-end electronics
- Ongoing work: cooling & monitoring system

- Plan is to start final/construction drawings in 2025
- Detector construction could start in ~2026.





Summary

- It was nice to meet many Eng. for the first time in-person.

- Full Geometry Exchange is essential both ways EIC project <-> ePIC
  - Some discussions are already ongoing to make it more regular

- A lot of progress have been made, but still there are open and unsolved questions.

Many Thanks to Project and ePIC for their support to organize this session

Special Thanks to all the Engineers and participants for their contributions