DETECTOR-1 biweekly meeting, 5/27, 2022

Global Detector Integration WG Update

Jin Huang — BNL
Richard Milner — MIT
Silvia Dalla Torre — INFN-Trieste
Thomas Ullrich — BNL

WG Weekly meetings: on Monday at 9.00-10.30 am

No meeting on next Monday (5/30)

- Sign up email list for WG announcement: https://lists.bnl.gov/mailman/listinfo/eic-projdet-globalint-l
- WG wiki landing page: https://wiki.bnl.gov/eic-project-detector/index.php/DetectorIntegration

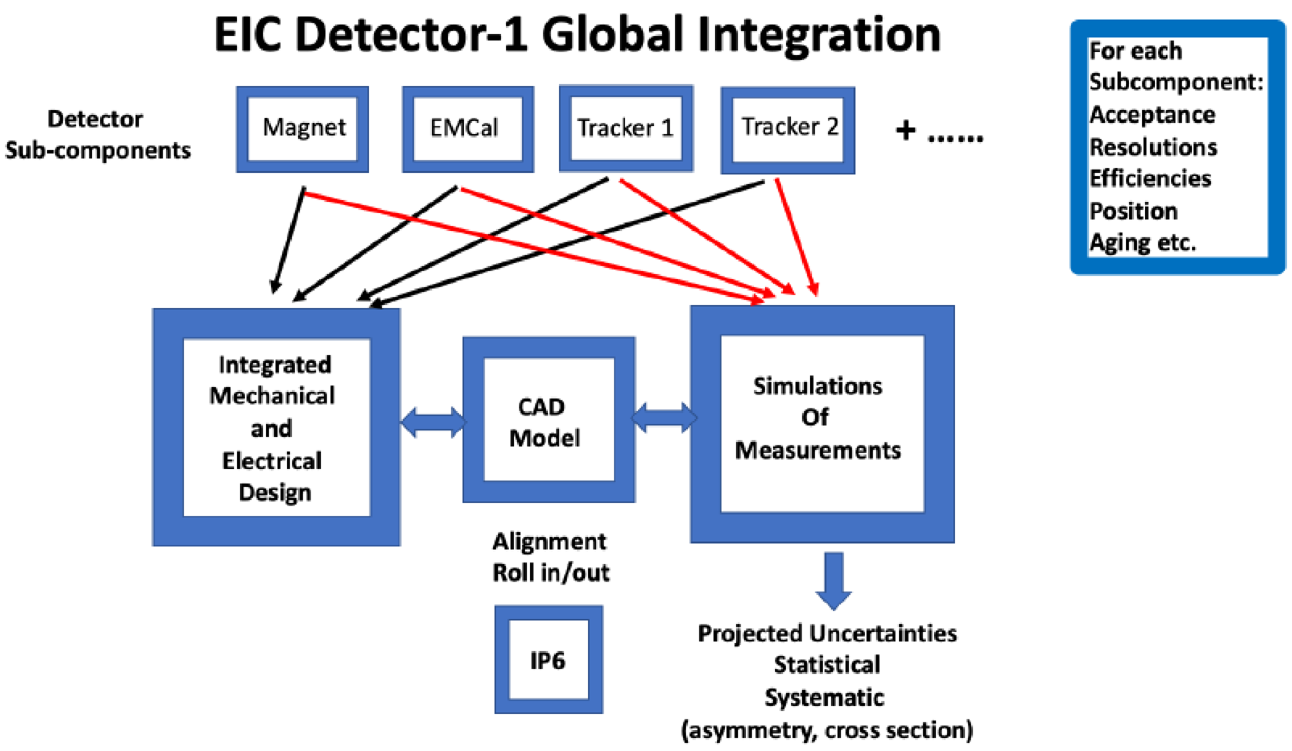
REMINDER (slide from 5/20 Convener meeting)

Specific charge elements for GD/I WG

REMINDER

Your working group is fundamentally quite different from the joint detector and physics working groups that have been recently formed, in that we are asking your working group to take a broad view of the EIC project detector as it evolves to a technical design. The global charge to your WG is as follows:

- Work with the project and the joint working group to develop a detailed, integrated technical design of the project detector. This includes the integration of various detector systems, the necessary supports and services, and the requirements imposed by the ability to service the detector between EIC running periods.
- Work with the detector and physics working groups, as well as project management, to ensure that the integrated project detector remains capable of the full science program outlined in the EIC Whitepaper and NAS report. Where compromises need to be made in the integration of the project detector, ensure that the proper simulations studies are completed to ensure they do not unduly compromise the EIC science program.



DETECTOR-1, GD/I - agenda

- MAY 9 KICK-OFF meeting: Touch base with the DWG conveners
- MAY 16 Review global design consideration in both proposals
  https://indico.bnl.gov/event/15771/
- MAY 23 Review Babar magnet's features,
  first feedback from project engineers
  https://indico.bnl.gov/event/15892/

INFORMATIVE PHASE

In the following:

- specific detector items, requiring dedicated attention and, often, inputs from more than a single WG
- Coordinating service, readout material; global acceptance gap management; assembly principle and access for maintenance
- Establish integrated detector model and subsystem envelops
- Update and advance background studies
- Review/coordinate consistency between simulation v.s. CAD detector models and detector parameters, with the aim of verifying that the projected measurements from the simulations of Detector-1 performance will deliver the WP/YR scientific program

OPERATIVE PHASE

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

global design consideration – ATHENA and ECCE reports

- The purpose it to improve the understanding of the proposals within the enlarged community
- The reports confirm that both concepts are aiming at covering the whole EIC physics scope and at as large coverage as technically possible
- The speakers of the two reports have selected slightly different focus and this is reflected in their slides, which partially address different aspects

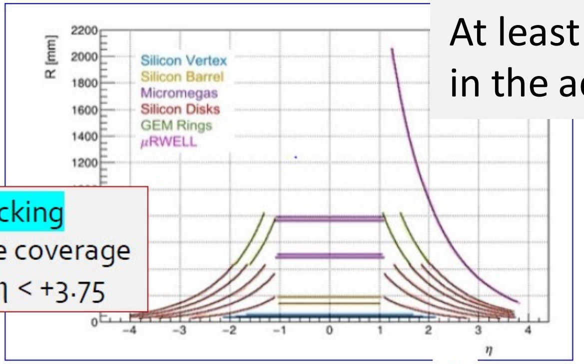
→ *Visit the Indico page (indicated in previous slide) for a more complete view!*

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

global design consideration – ATHENA (report by Thomas Ullrich)

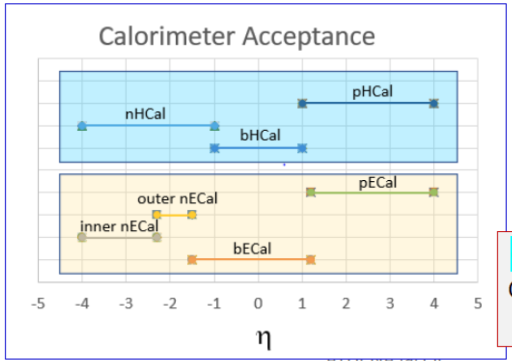
- Complete CD coverage, with accurate material minimization to preserve Ecal performance

Examples form ATHENA slides

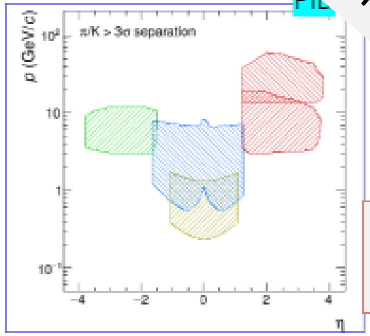


At least 7 trackers at all eta in the acceptance

Tracking
Complete coverage
$-3.8 < \eta < +3.75$



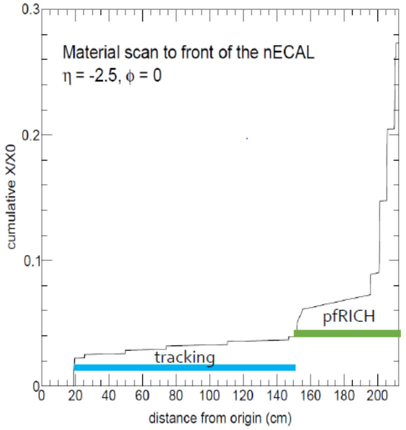
Calorimetry (E & H)
Complete coverage
$-4 < \eta < +4$



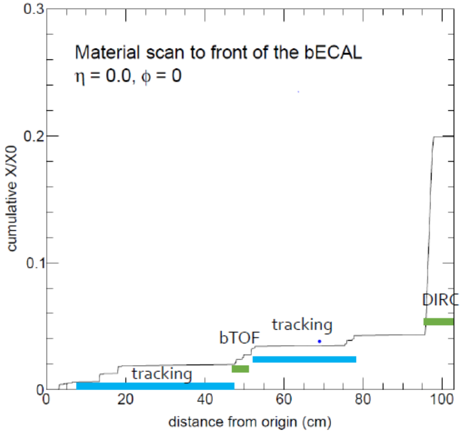
PID
Complete coverage
$-3.8 < \eta < +3.7$

Material budget in front of ECals

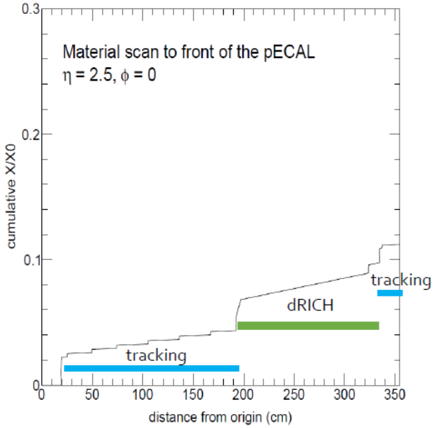
Backward endcap



Barrel



Forward endcap



DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

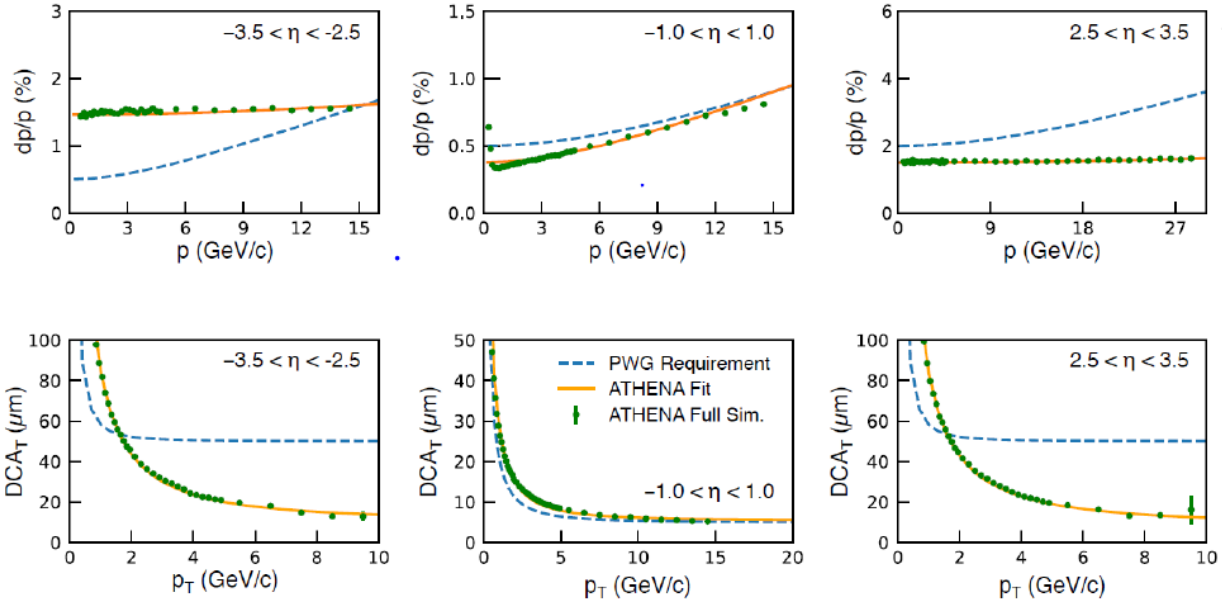
global design consideration - ATHENA

- Tracking strategies towards fine p resolution and vertex resolution

Examples form ATHENA slides

Momentum resolution vs p in 3 η-bins

Transfer distance of closest approach to the primary vertex vs p in 3 η-bins



KEY INGREDIENTS for these PERFORMANCES

- High magnetic field / Maximized lever-arm/ Minimized material /Sensor pitch

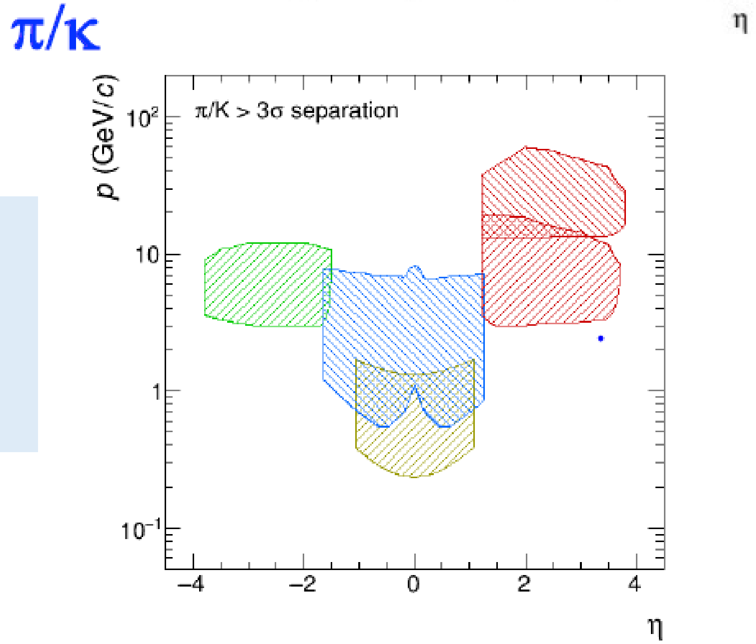
DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

global design consideration - ATHENA

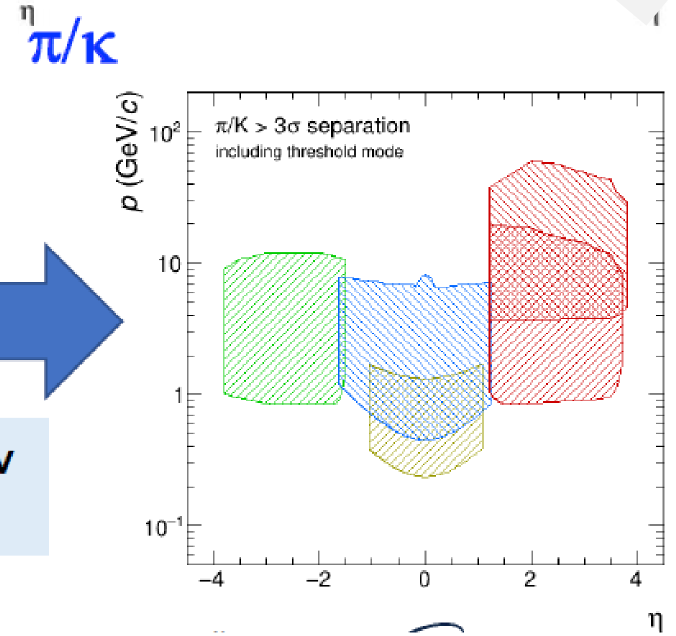
- PID momentum range increased making use of Cherenkov threshold properties

Examples form ATHENA slides

With positive identification of the higher mass particle in the couple



Using also the Cherenkov threshold information



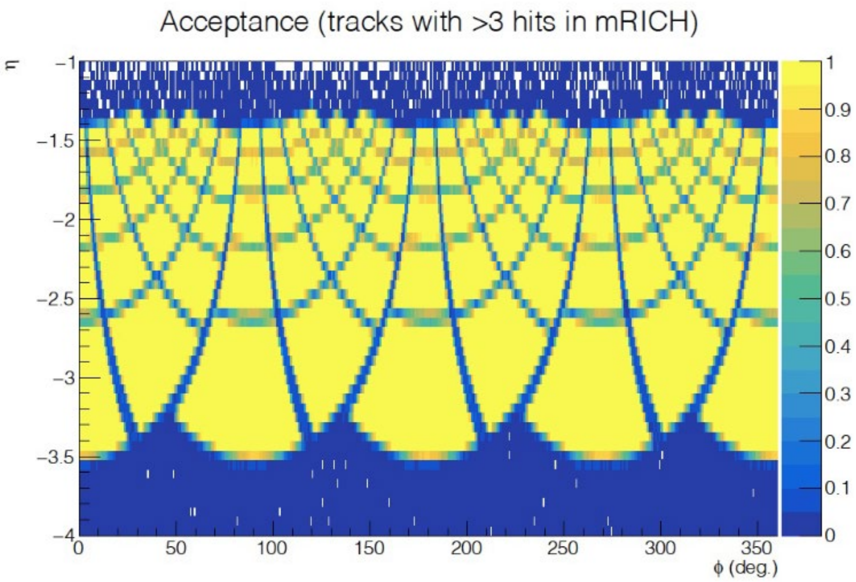
DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

global design consideration - ATHENA

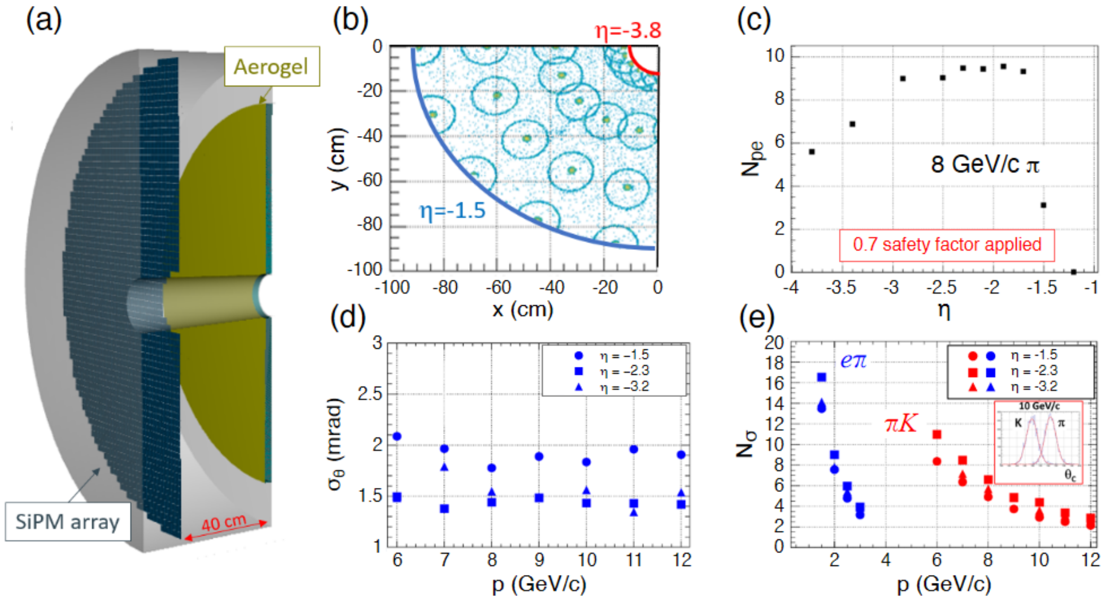
- Proximity focusing RICH in the backward

Examples form ATHENA slides

Analysis of acceptance for YR mRICH



pfRICH



DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

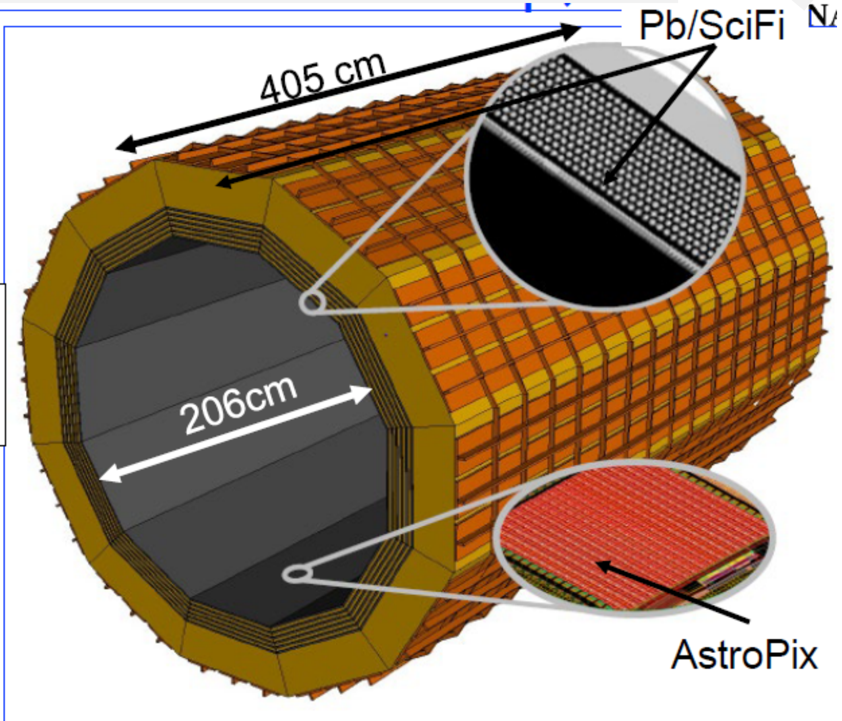
global design consideration - ATHENA

Examples form ATHENA slides

- Hybrid imaging Ecal in the barrel

… and fine resolution space-point extrernal to the DIRC

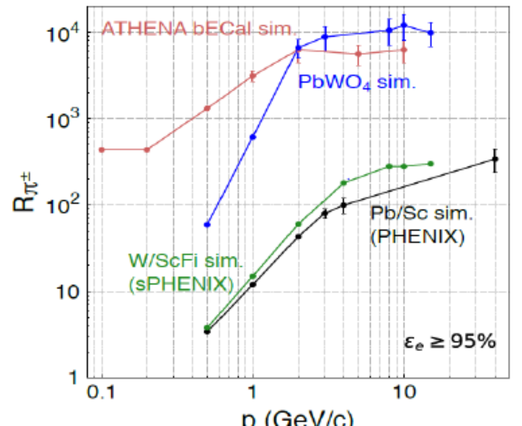
- Hybrid concept:
  - 6 imaging layer: AstroPix and Pb/SciFi
    - ✓ AstroPix, monolithic Si sensor, developed (from ATLASPix)
    - ✓ Pb/SciFi following KLOE, GlueX



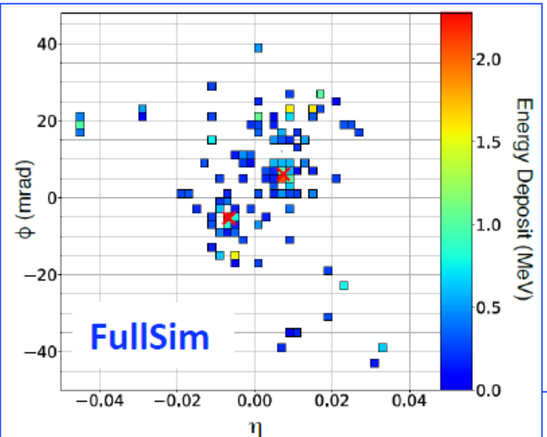
also >1 λ_I contributing to bHCal

- Reconstruct scattered and secondary electrons
- Separate e/π
- Identify and reconstruct γ (also radiated from e)
- Identify π^0 also at high momenta

Separate e/π at low p



γ's from 15 GeV/c π^0 decay



expected performance

Energy Resolution	$5.5\%/\sqrt{E} \oplus 1\%^a$
e/π separation	> 99.8% pion rejection with 95% electron efficiency at $p \geq 0.1$ GeV/c^b.
$E^{\gamma}_{\min}$	< 100 MeV^c
Spatial Resolution	Cluster position resolution for 5 GeV photons at normal incident angle is below $\sigma = 2$ mm (at the surface of the stave $r = 103$ cm) or 0.12°. For comparison, the minimal opening angle of photons from $\pi^0 \to \gamma\gamma$ at 15 GeV is $\sim 1.05^{\circ}$ (about 19 mm – 37 pixels – of separation at $r = 103$ cm).

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

global design consideration – ECCE (report by Tanja Horn)

Examples form ECCE slides

Key:
the re-use of BaBar magnet

- The ECCE detector is a physics-driven balance of
  - the reuse of equipment
  - the use of mature detector technologies where possible, and
  - the use of detector technologies that are at the near-end of an extensive R&D effort and were judged absolutely essential for the EIC science.

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

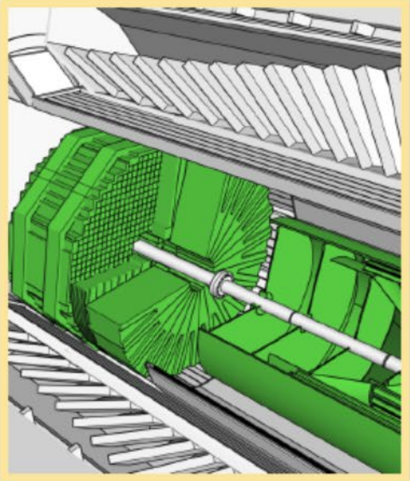
global design consideration – ECCE

- Technology overview

Examples form ECCE slides

The ECCE Reference Technologies

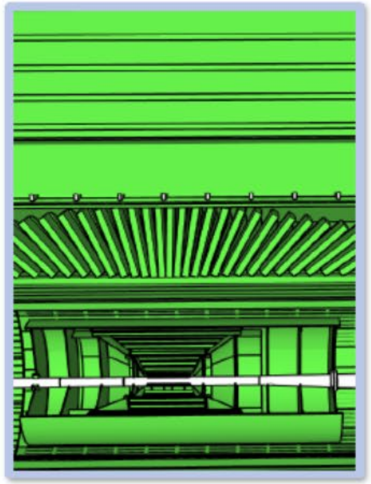
For additional technical details if desired please see the ECCE technical notes: https://www.ecce-eic.org/ecce-internal-notes (PW: ECCEprop)



Backward Endcap

Tracking:
- ITS3 MAPS Si discs (x4)
- AC-LGAD

PID:
- mRICH
- AC-LGAD TOF
- $PbWO_4$ EM Calorimeter (EEMC)



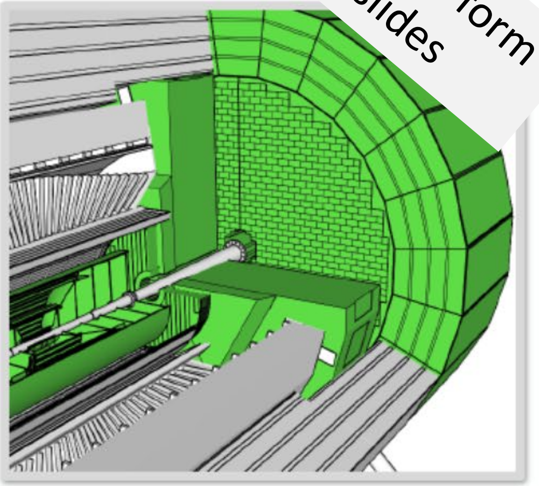
Barrel

Tracking:
- ITS3 MAPS Si (vertex x3; sagitta x2)
- μRWell outer layer (x2)
- AC-LGAD (before hpDIRC)
- μRWell (after hpDIRC)

h-PID:
- AC-LGAD TOF
- hpDIRC

Electron ID:
- SciGlass EM Cal (BEMC)

Hadron calorimetry:
- Outer Fe/Sc Calorimeter (oHCAL)
- Instrumented frame



Forward Endcap

Tracking:
- ITS3 MAPS Si discs (x5)
- AC-LGAD

PID:
- dRICH
- AC-LGAD TOF

Calorimetry:
- Pb/ScFi shashlik (FEMC)
- Longitudinally separated hadronic calorimeter (LHFCAL)

ECCE

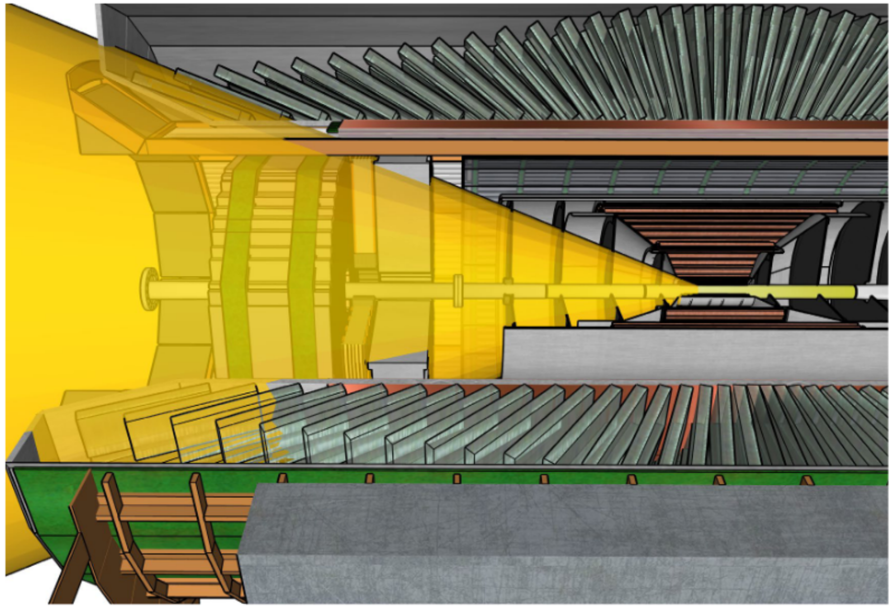
DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

global design consideration – ECCE

Hermetic electron coverage

Examples form ECCE slides

- ❑ DIRC readout on electron side to avoid interference with PID and forward detectors
- ❑ Move eEMCAL inside the DIRC to optimize for continuous calorimeter coverage electron ID



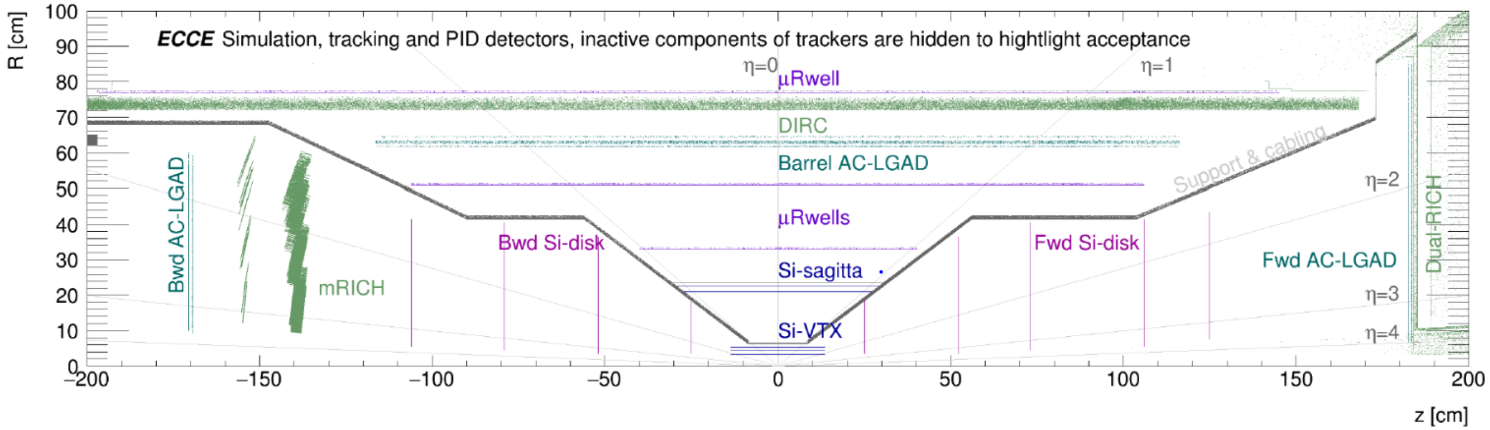
- ❑ **After moving the eEMCAl inside the DIRC there is still a gap in sensitive area of the EMCals (barrel and endcap) – this gap needs to be reduced**
  - ❑ Extend barrel EMCAL backward
  - ❑ Reduce the cooling/support for the backward EMCal → save a few cm
  - ❑ Absorb a thin MPGD (for DIRC PID) into the DIRC frame → saves a few cm
  - ❑ Further reduce the gap by reducing the backward tracking by ~15cm to shift detector in along z towards the IP – no negative impact on tracking as checked in simulation

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

global design consideration – ECCE

Examples form ECCE slides

ECCE Tracking System



- ❑ Hybrid tracking detector design: Monolithic Active Pixel Sensor (**MAPS**) based silicon vertex/tracking subsystem, the **muRWELL** tracking subsystem and the **AC-LGAD** outer tracker, which also serves as the ToF detector. Ordering and resolution optimization were driven by AI.
  - ❑ MAPS 3-layer silicon vertex, 2-layer silicon sagitta layers, five disks in the hadron endcap, four disks in the electron endcap for primary and secondary vertex reconstruction
  - ❑ muRWell 2 layers in the barrel following silicon and cylindrical muRWell gas trackers at large radii providing a tracking layer after the DIRC – integrated with PID/DIRC performance
  - ❑ AC-LGAD ToF layer provides precision space-time measurement on each track – integrated with PID

Motivations behind the choices

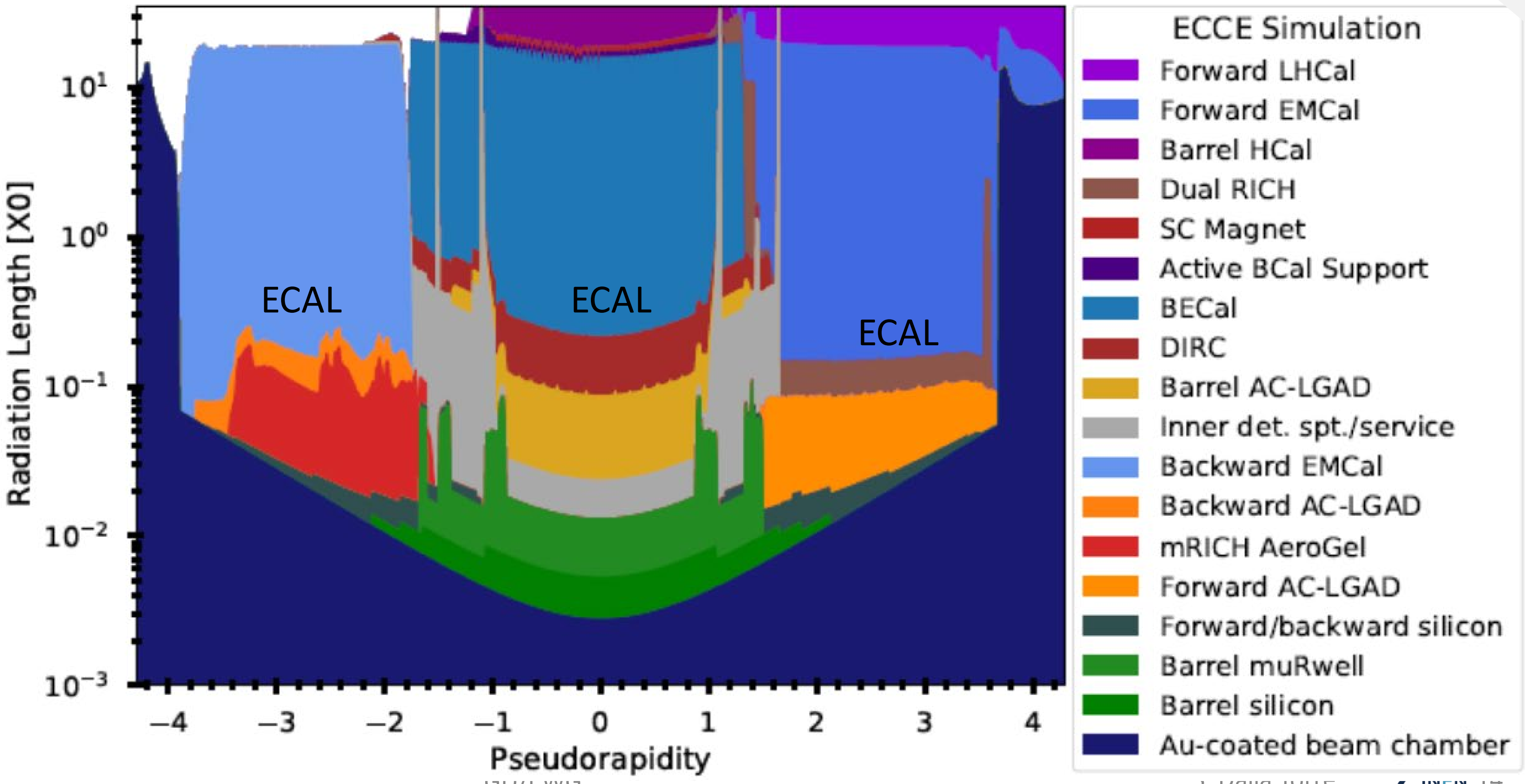
- ❑ Information provided by experts (EICSC, eRDxxx, E&D, ….)
  - ITS3 for sagitta layer
  - CAD model with estimates for services
- ❑ Several iterations of optimization of the design layout performed with AI-assistance
  - Suggests MPGD behind PID in forward direction does not improve tracking performance (and not absolutely needed for PID)
  - Material for readout and services has a large impact on tracking performance – investigated projective design
- ❑ All tracking elements were implemented in the mechanical model - barrel MPGD layer added last with limited time to check details on cm scale

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

global design consideration – ECCE

Examples form ECCE slides

- Material budget



DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

Examples form ECCE slides

global design consideration – ECCE

- Barrel Ecal, Advanced design

Homogeneous Design based on PANDA

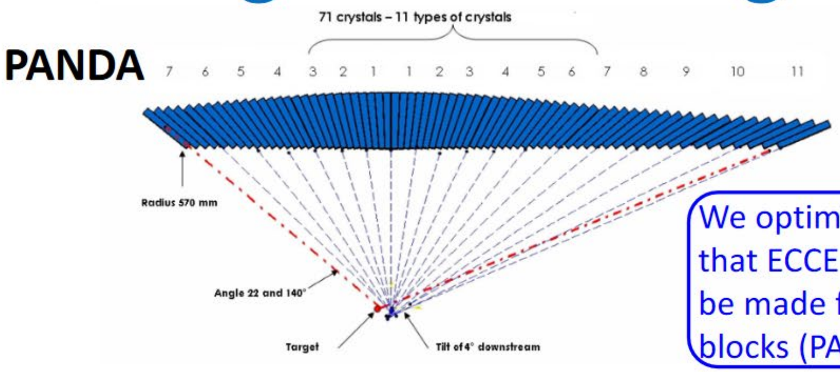
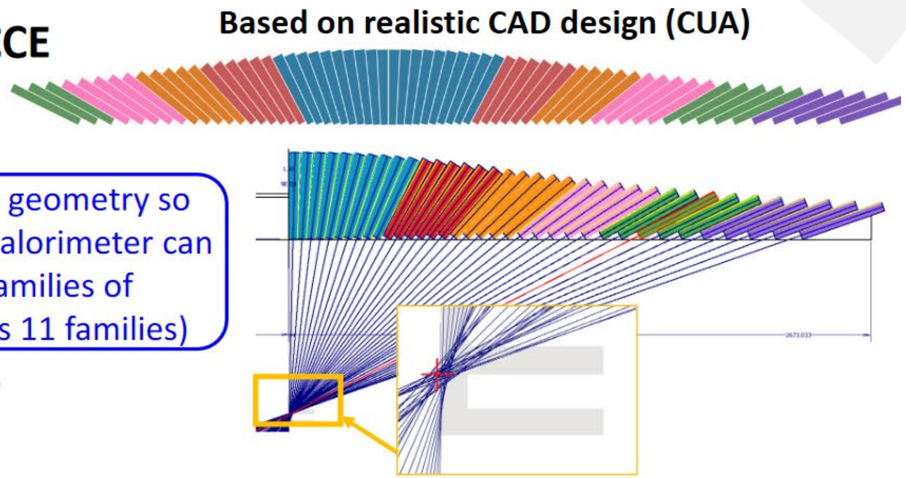


Figure 5.4: Crystal arrangement of the barrel along the beam axis. Positions of the different crystal types are indicated. Due to the mirror symmetry, 11 types are sufficient instead of 18.



We optimized the geometry so that ECCE barrel calorimeter can be made from 6 families of blocks (PANDA has 11 families)

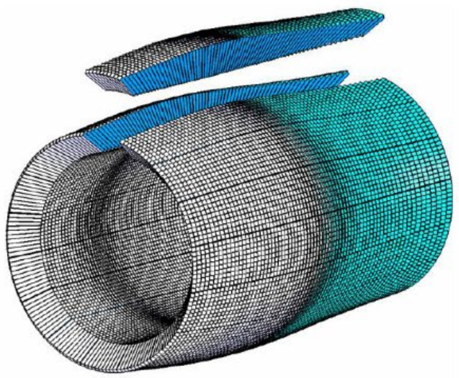
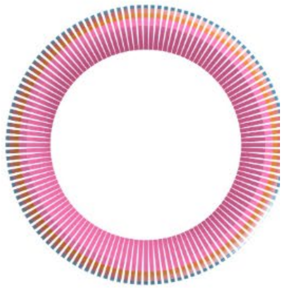
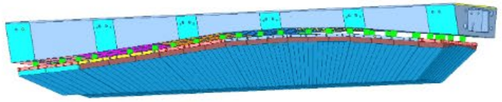


Figure 5.5: View of the total barrel volume with a separated single slice of 710 crystals. A slice covering 1/16 of the barrel volume.

With these families we already reduced any gap both angular and radially between glass blocks to <5mm





DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

BaBar magnet report (report by Ranuka Rajput-Ghoshal)

- Reminder of BaBar magnet main parameters and of its history

Parameter	Detector 1- ECCE
Status	Old BaBAR/sPHENIX magnet New magnet as risk mitigation
Central Field (T)	1.5
Warm bore diameter (m)	2.84
Coil Length (m)	3.5
Operating Temperature (K)	4.5
Stored Energy (MJ)	27
Conductor	Aluminum Stabilized NbTi Rutherford cable Copper Stabilized NbTi Rutherford cable

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

BaBar magnet report (report by Ranuka Rajput-Ghoshal)

- The tests and intervention in view of the magnet use in sPHENIX

- BaBAR magnet- JLab Risk Analysis

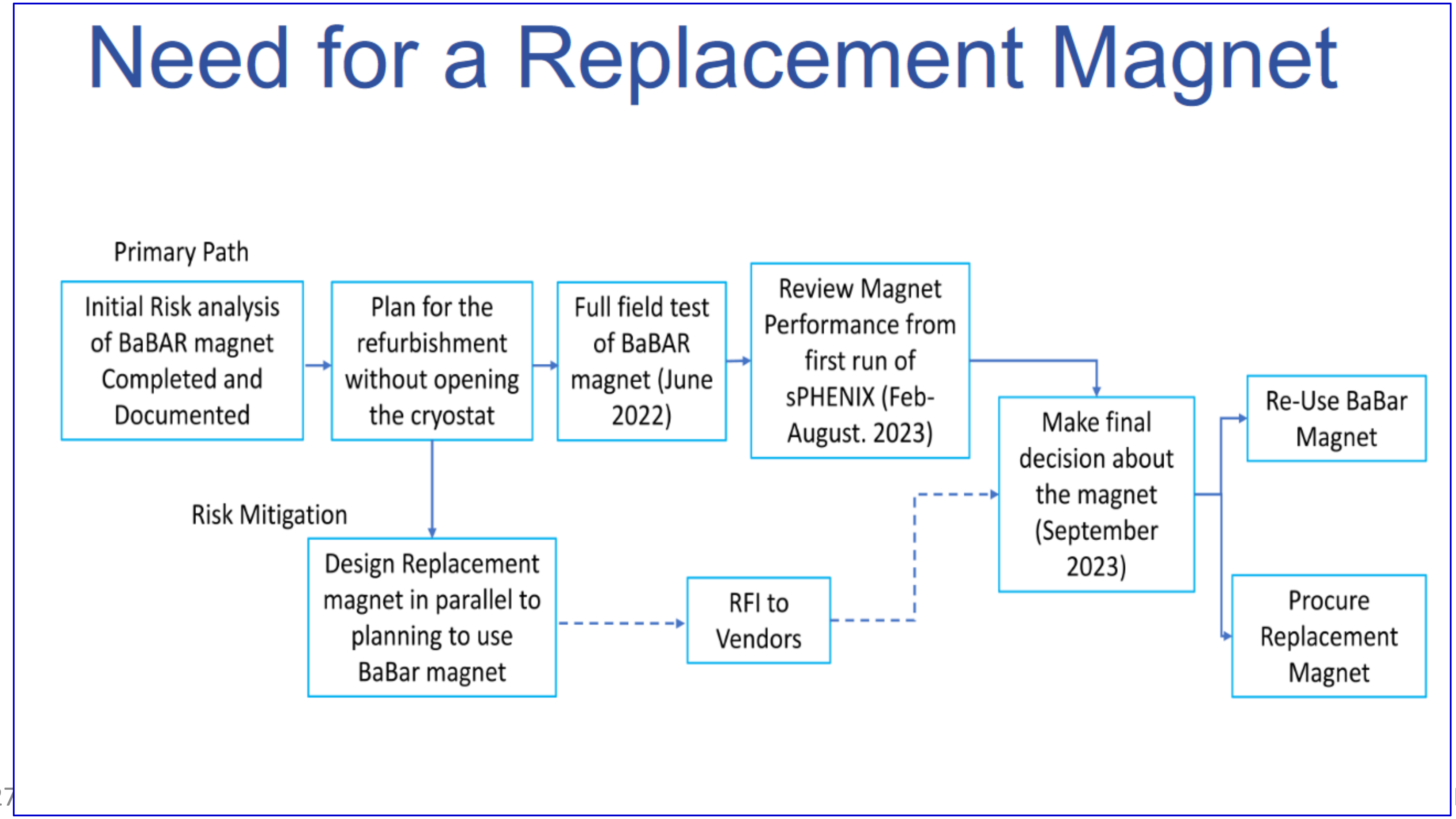
Risk Rating	Before Risk Mitigation	After Risk Mitigation	Comments
HIGH	1	0	
MODERATE	5	4	Requires disassembly which can introduce additional risk
LOW	2	4	
Total	**8**	**8**	

- Perspective for use at EIC:
  - An engineering study and risk analysis in 2020 concluded that the "magnet should be suitable for prolonged use as part of the detector system for the EIC project."

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

BaBar magnet report (report by Ranuka Rajput-Ghoshal)

- The path to the DETECTOR-1 magnet

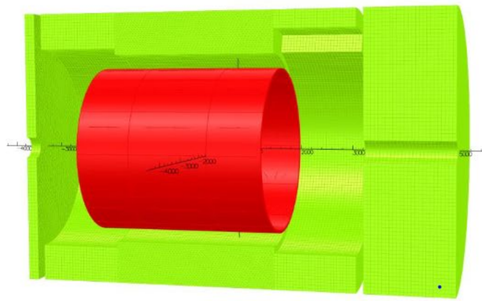


DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

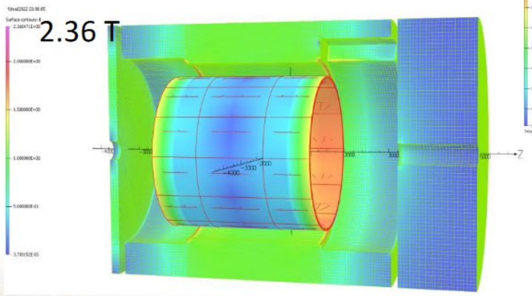
BaBar magnet report (report by Ranuka Rajput-Ghoshal)

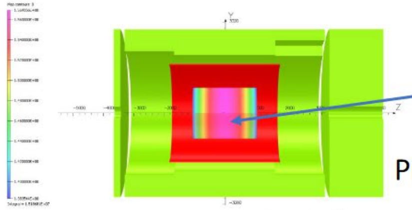
- Existing magnet vs design parameters

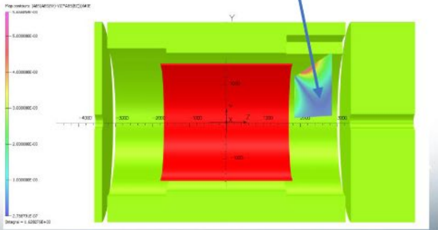
Detector-1 Existing Magnet- Design parameters



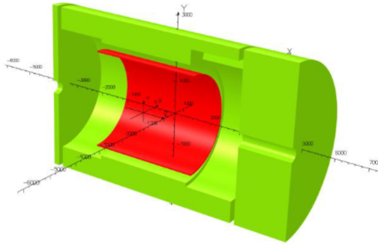
Parameter	Design Value	Specification	Unit
Central field	1.404	1.5	T
Nominal Current	4596		A
Peak field in the Coil	2.36		T
Stored Energy of the magnet	25.43		MJ
Homogeneity in the central region	2.2	8.5	%
Projectivity in RICH area	3.51	10	A/Tmm^2
Field at (0,0,-5.3 m)	35	5	G
Field at (0,0,7.4 m)	30	5	G



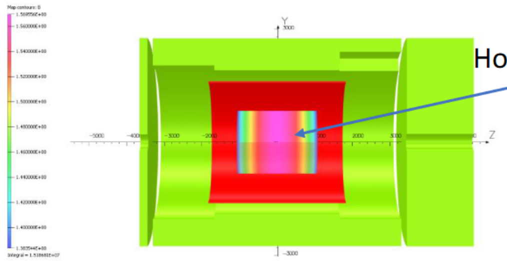


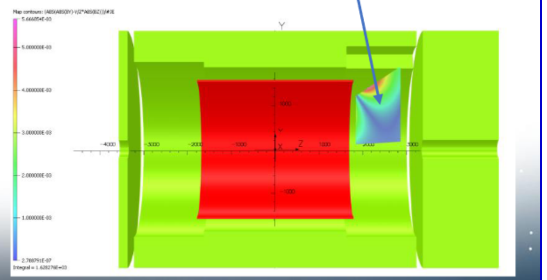


Detector-1 New Magnet- Design parameters (Preliminary)



Parameter	Design Value	Specification	Unit
Central field	1.5	1.5	T
Nominal Current			A
Peak field in the Coil	2.2		T
Stored Energy of the magnet	25.254		MJ
Homogeneity in the central region	12.34	8.5	%
Projectivity in RICH area	1.63	10	A/Tmm^2
Field at (0,0,-5.3 m)	30	5	G
Field at (0,0,7.4 m)	20	5	G





DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

BaBar magnet report (report by Ranuka Rajput-Ghoshal)

- A couple of other relevant messages

Solenoid- Long Lead procurement

- The Detector solenoid is foreseen as a long-lead procurement item.
  - The detector solenoid is required to install all the detectors. The estimated installation time is 17 months.
  - The average time to procure a superconducting magnet from a vendor is approximately 5 years. This is based on experience with JLab-12GeV upgrade SC magnet procurement.
  - There are not many vendor for making this large size magnet nationally or internationally.
  - The conductor required for this magnet is also a long lead item. The conductor will be Al-cladded Rutherford cable and the Rutherford cable will be made with small SC strands.
  - The estimated time for Rutherford cable delivery is about 2 years, this is based on discussions with one vendor.

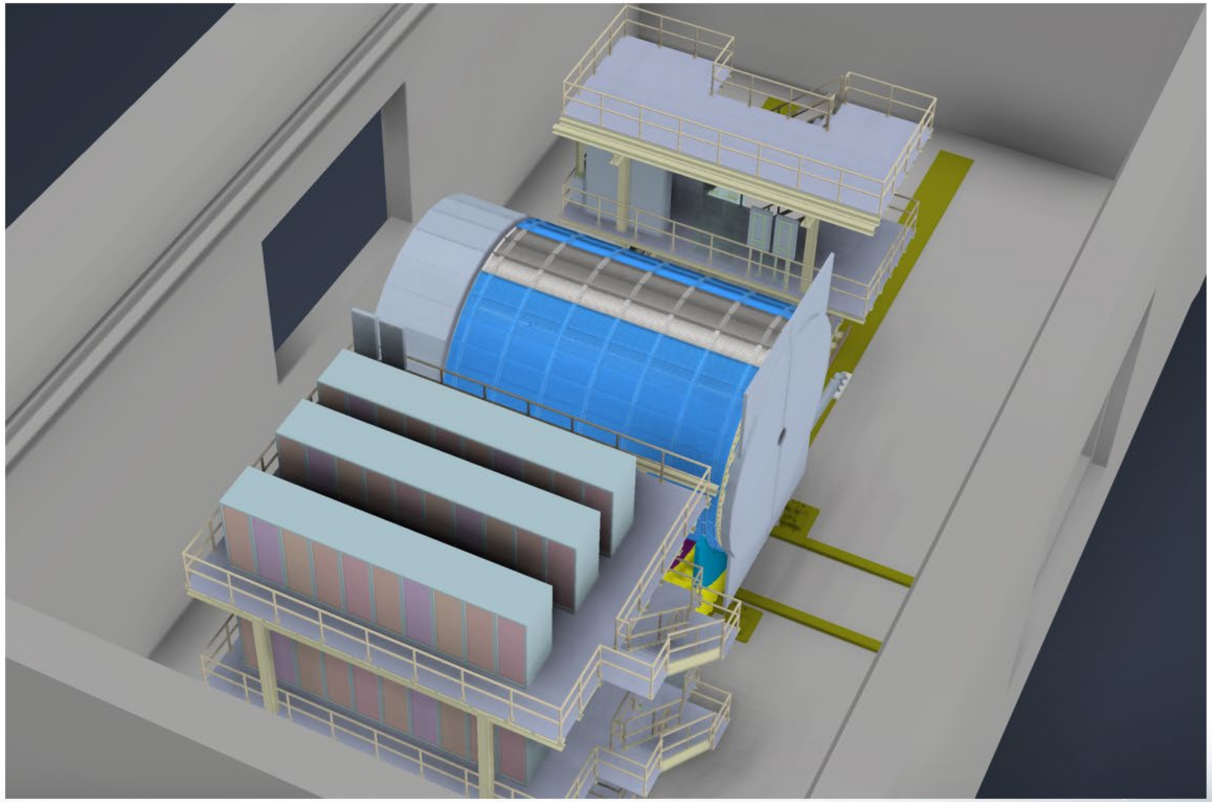
Work with CEA

DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

Engineering aspects (report by Roland Wimmer)

Overview

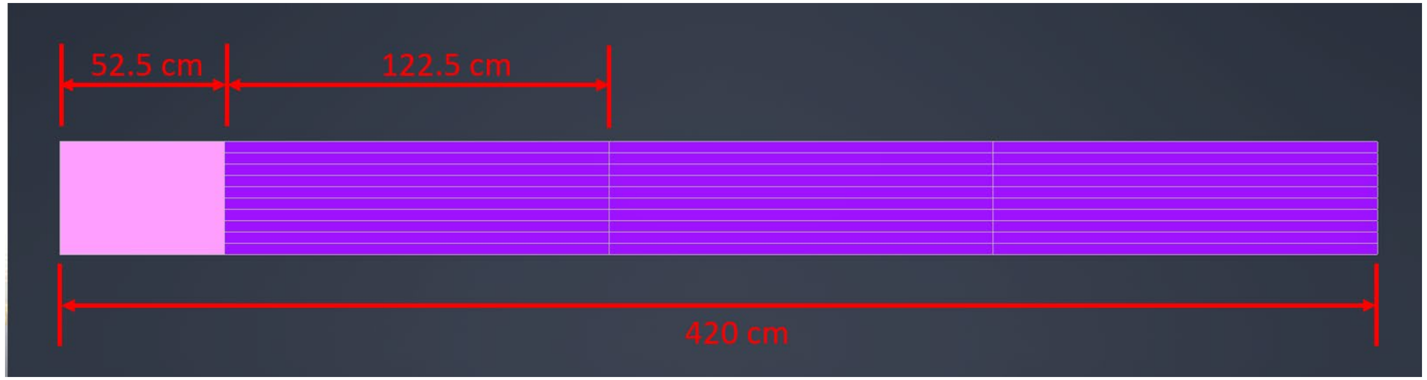
- CAD Overview
- DIRC
  - Bars
  - Bar Boxes
  - DIRC & GEM Support
- Silicon Detector
  - Overview
  - Installation & Assembly
- Next Steps

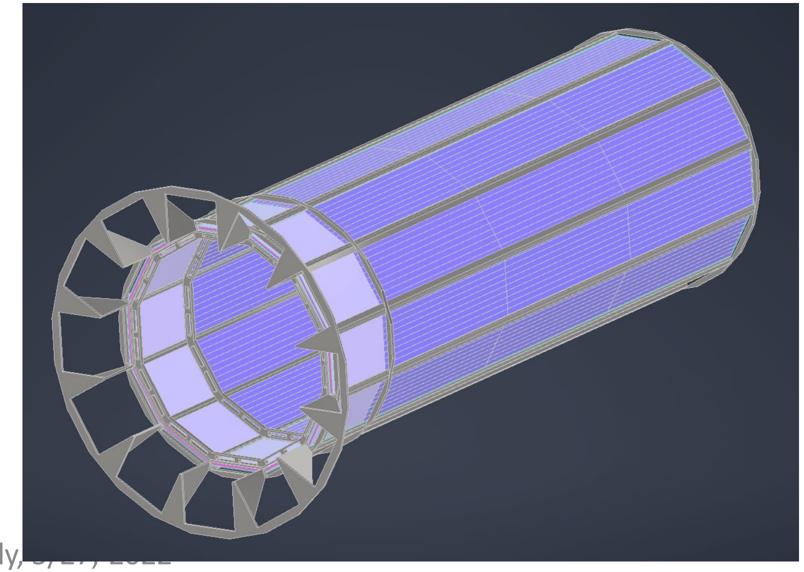


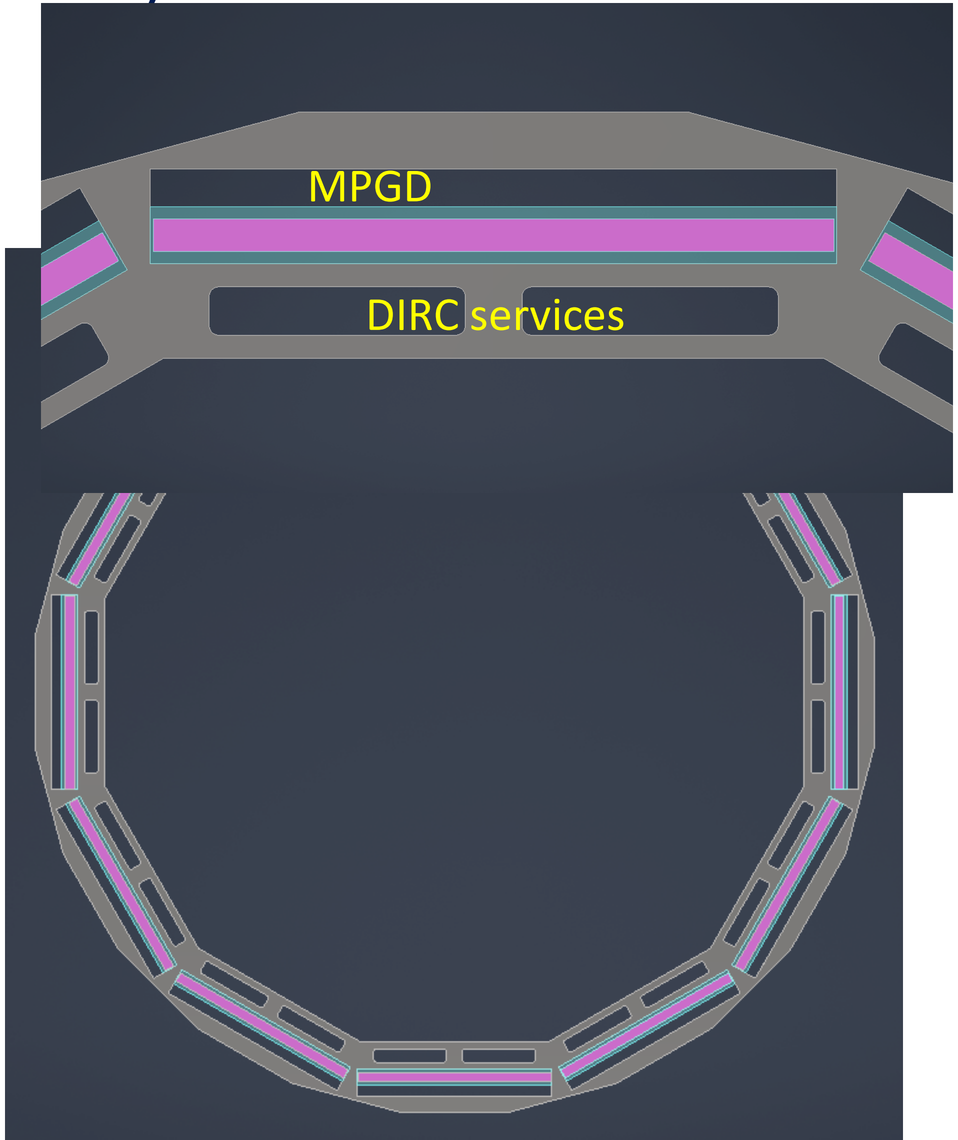
DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

Engineering aspects (report by Roland Wimmer)

- About DIRC ar boxes abd arrangement



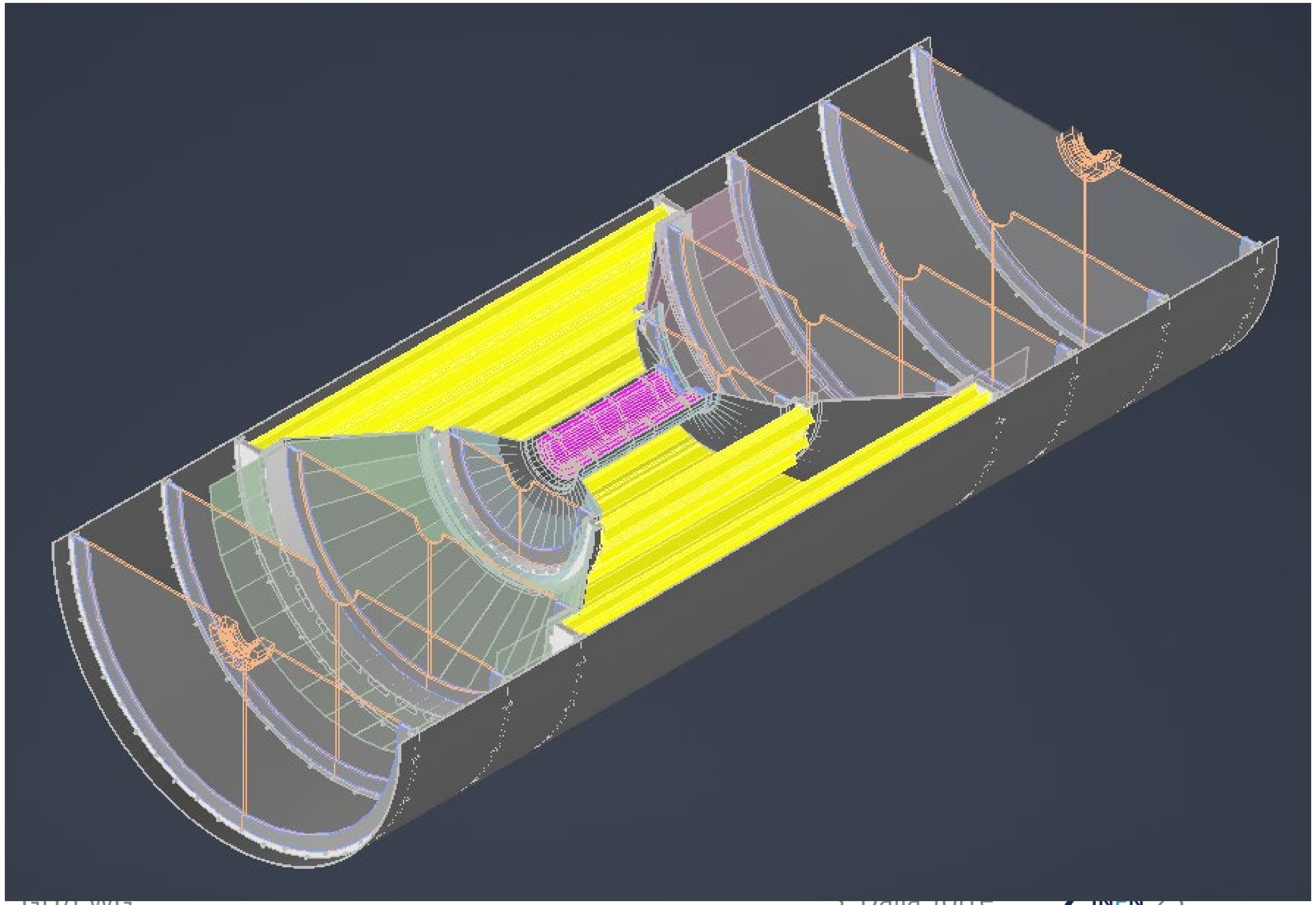




DETECTOR-1, GD/I – HIGHLIGHTS of the recent activity

Engineering aspects (report by Roland Wimmer)

- Si tracker and beam-pipe installation :
  - a preliminary complete model
  - Tracker supports in carbonfiber



DETECTOR-1, GD/I - agenda

The first steps of the operative phase:

OPERATIVE PHASE

- June 6 (https://indico.bnl.gov/event/16045/)
  - Tracking update: Tracking WG
  - Quantifying physics case of TOF: SIDIS and HF WGs

- June 13
  - Understanding constrains and needs for the dRICH envelope: Cherenkov PID WG
  - Comparative considerations about the two approaches for the backward RICH: Cherenkov PID WG