EIC Detector 1 Tracking Subsystem Developments and Plan

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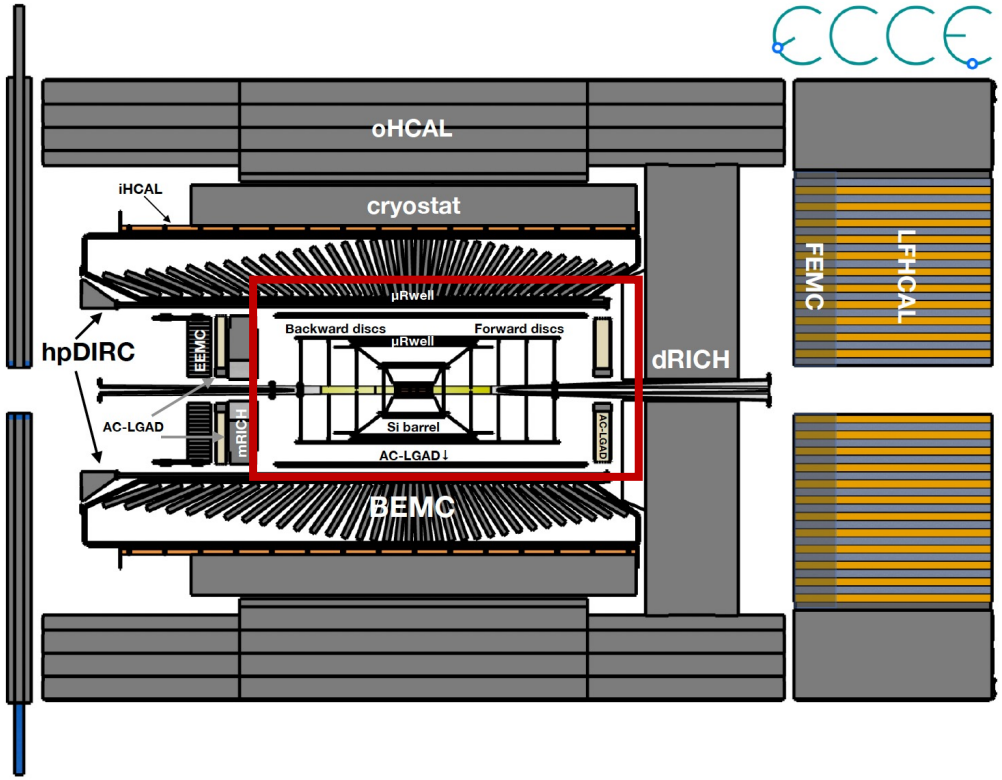
on behalf of the EIC Detector 1 Tracking Working Group

Outline

- Introduction to the EIC reference detector: ECCE tracking detector.
  - Design
  - Performance
- EIC Detector 1 tracking detector development and plan
  - Detector geometry optimization.
  - Performance validation
  - Technology options, mechanical and readout developments
- Summary and Outlook

EIC reference detector selection

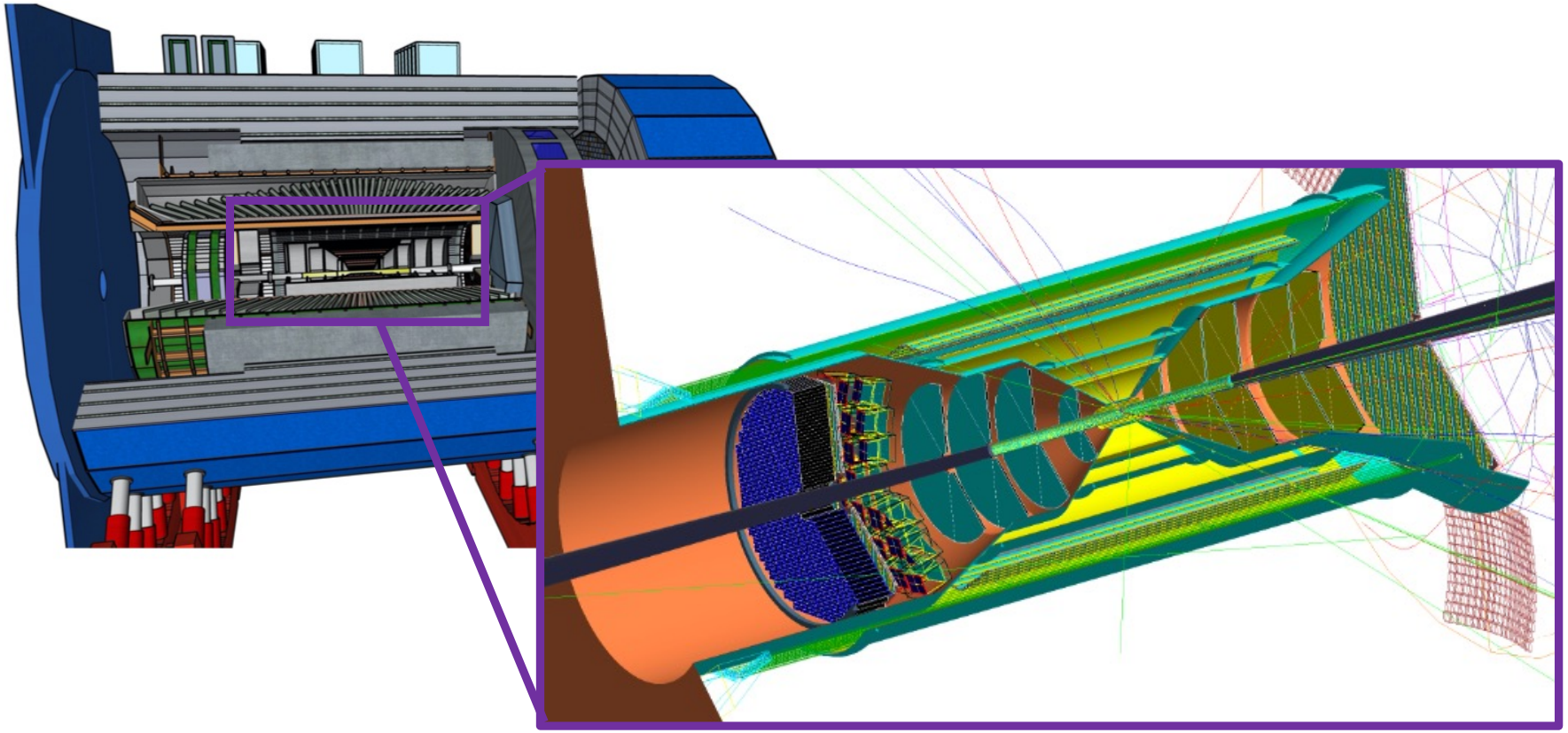
- The ATHENA, ECCE and CORE consortia (proto-collaborations) submitted detector proposals for the EIC reference detector design selection.
- The ECCE detector, which will reuse the 1.4T Babar magnet, has been selected as the EIC reference detector design.



- The EIC detector 1 proto-collaboration has been formed to proceed with the technical design for the EIC project detector at IP6 with optimizations based on the ATHENA and ECCE detector designs.

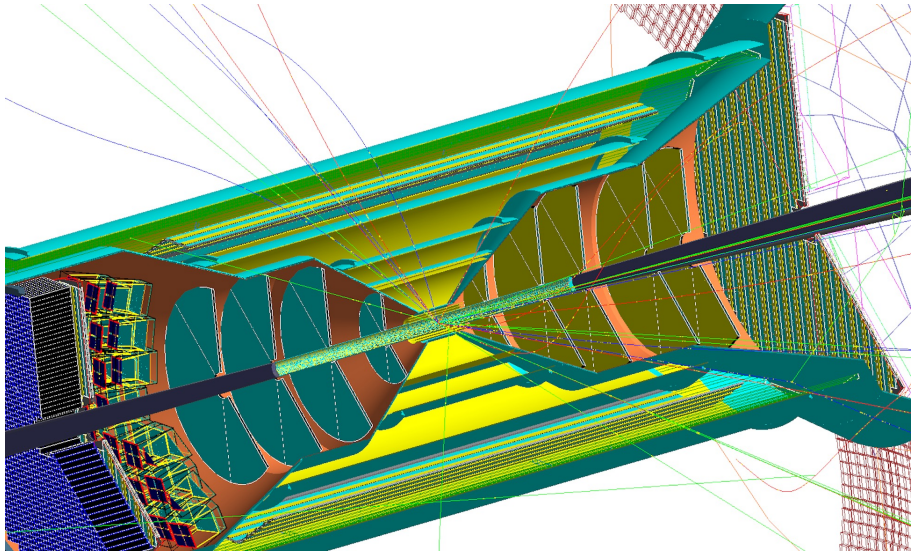
Detector 1 reference design: tracking detector (I)

- The EIC reference tracking detector consists of integrated MAPS, MPGD (or μRwell) and AC-LGAD tracking detectors. Detailed detector segmentation and service parts have been implemented in the Fun4All framework.



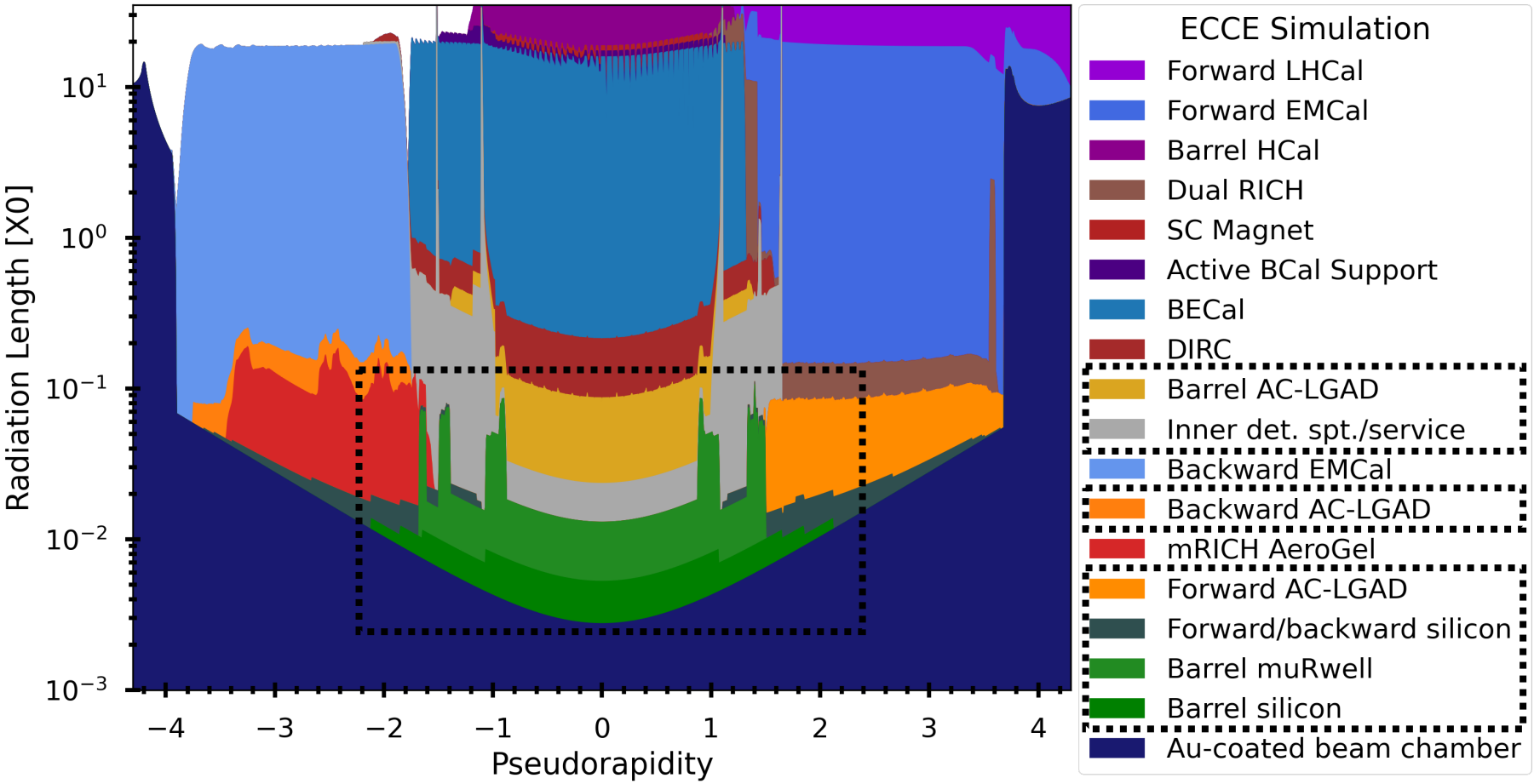
Detector 1 reference design: tracking detector (II)

- The EIC reference tracking detector consists of integrated MAPS, MPGD (or μRwell) and AC-LGAD tracking subsystems. Detailed detector segmentation and service parts have been implemented in the Fun4All framework.
- The tracking detector layout:
  - Barrel: 5 MAPS layers, 3 μRwell layers and 1 AC-LGAD layer. Inner Radius: 3.3 cm, Outer Radius: 77.0 cm.
  - Hadron endcap: 5 MAPS planes and 1 AC-LGAD plane. Minimum z: 25 cm, Maximum z: 182 cm.
  - Electron endcap: 4 MAPS planes and 1 AC-LGAD plane. Minimum z: -155.5 cm, Maximum z: -25 cm.



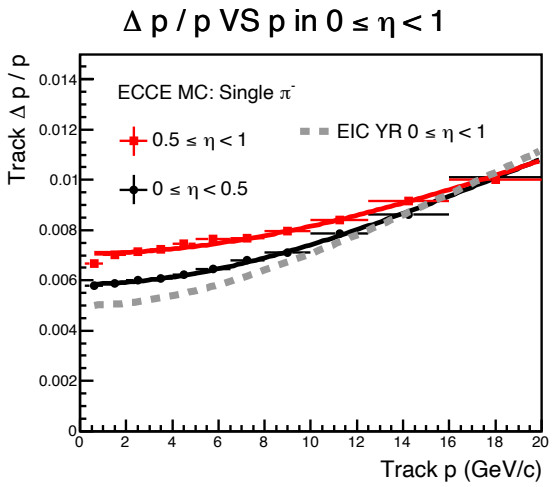
Material budget scan

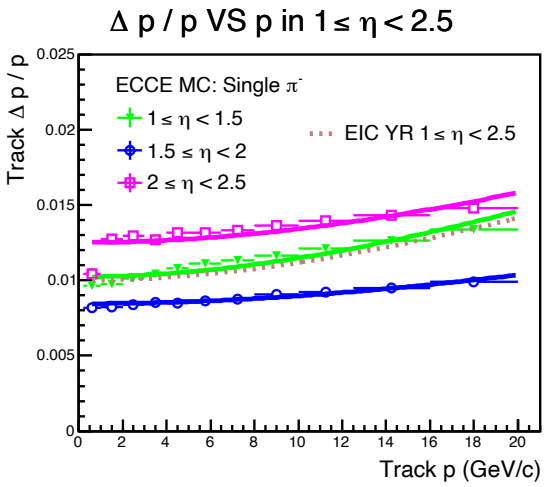
- From the Fun4All simulation, material budget scan of the EIC reference detector subsystems.

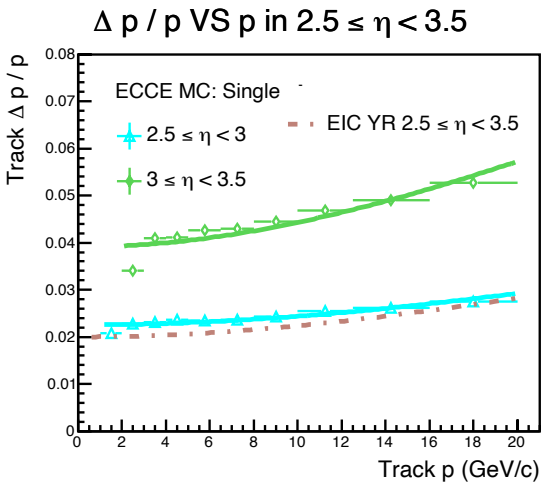


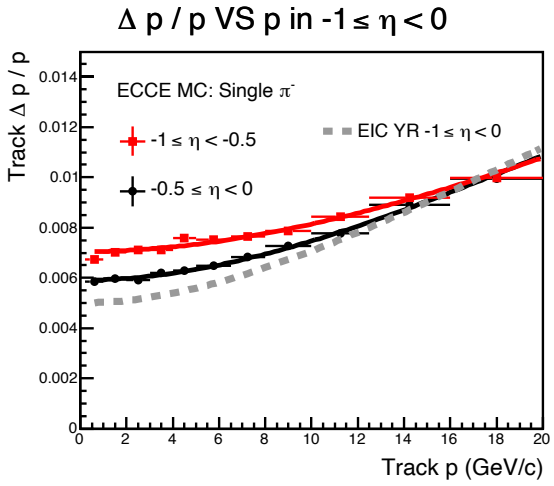
EIC reference detector tracking momentum resolution

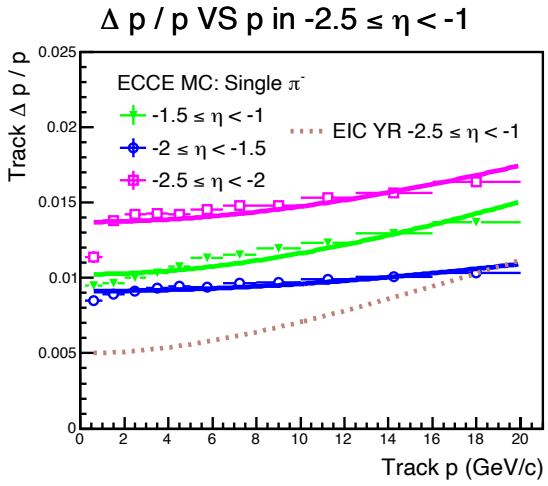
- Track momentum dependent momentum resolution.

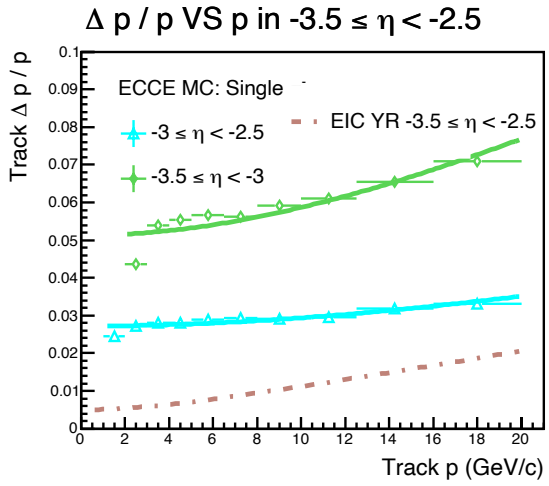






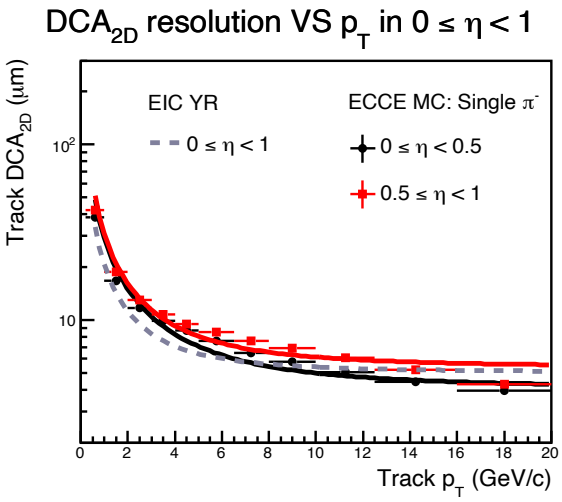


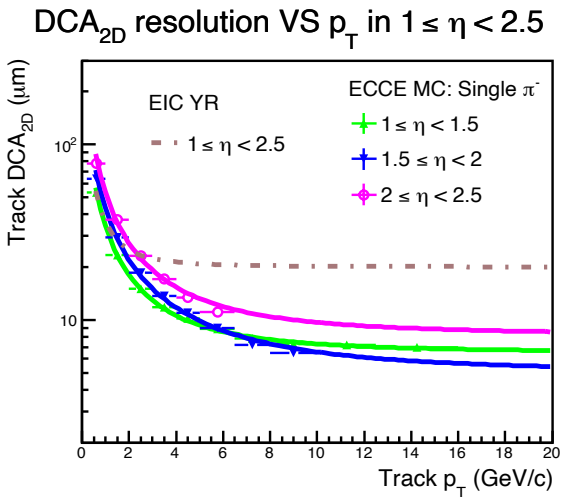


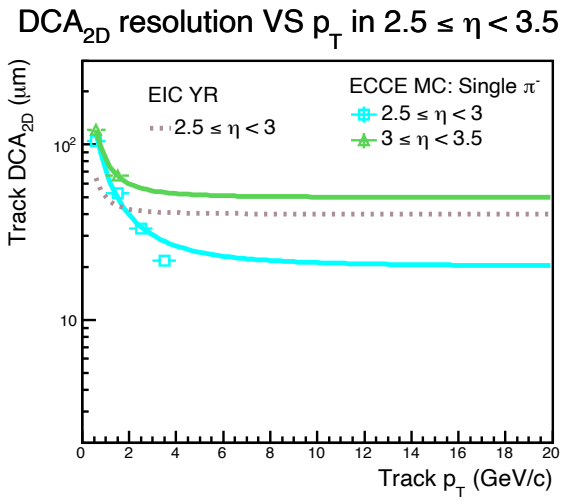


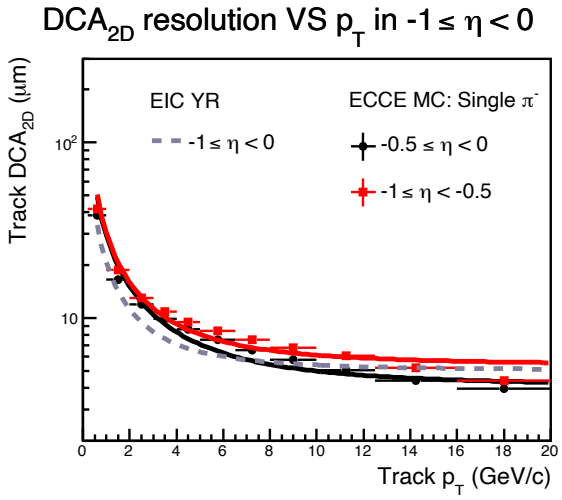
EIC reference detector tracking DCA_{2D} resolution

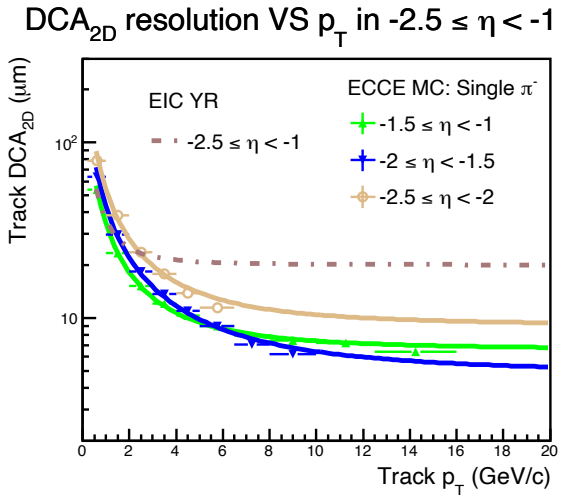
- Track p_T dependent DCA_{2D} resolution.

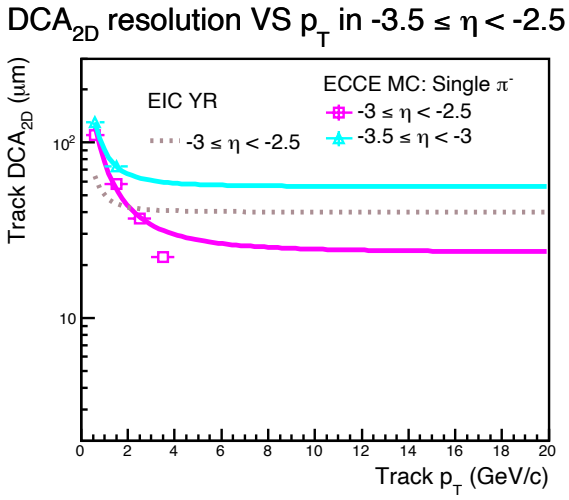












EIC Detector 1 Tracking Detector developments

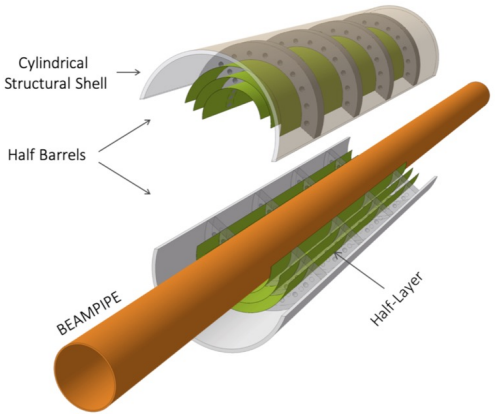
- About the EIC detector 1 tracking working group:
  - Conveners: Xuan Li (xuanli@lanl.gov), Kondo Gnanvo (kagnanvo@jlab.org), Laura Gonella (laura.gonella@cern.ch), Francesco Bossu (francesco.bossu@cea.fr)
  - Email mailing list: eic-projdet-tracking-l@lists.bnl.gov
  - We have bi-weekly meetings scheduled at 11:00AM US eastern time every other Thursday and the meeting indico link: https://indico.bnl.gov/category/404/
  - Mattermost channel: https://eic.cloud.mattermost.com/main/channels/tracking
  - WIKI page: https://wiki.bnl.gov/eic-project-detector/index.php/Tracking#EIC_Project_Tracking_Working_Group
- Welcome new collaborators to join us!

EIC Detector 1 Tracking work plan and goal

- Simulations:
  - Simulation task break down and priority list in https://docs.google.com/spreadsheets/d/1Jp1-V7MavZFejn2SG185YarbMIpGCByGfF7yz4Y-Azc/edit?usp=sharing
- Technology review:
  - Complete review of the choice of tracking technologies.
  - Identify risks & fallback solutions for each technology.
  - Establish the timelines to CD2/3A.
  - Close coordination with the detector consortia (EIC-SC, eRD108).
- EIC Tracking Detector configuration:
  - By July EICUG, the baseline configuration "***aka advanced conceptual design***" of the tracking detector is established
- Requirements inputs from the physics WGs:
  - List of key tracking requirements such as momentum resolution, vertex and projection spatial resolutions.

Geometry optimization and simulation studies for the silicon tracker

- Vertex layers
  - The radii need to be adjusted as 5 mm clearance from the beam pipe are needed because of beam pipe backout.
- Tracking layers
  - The material assumed in the ECCE proposal is 0.05%X/X0 per barrel layer. This need to be updated to 0.55% X/X0 that is what is suggested by the EIC SC.
  - Also, check the impact on performance by switching the sagitta middle layers with the ATHENA design (i.e., smaller radii).

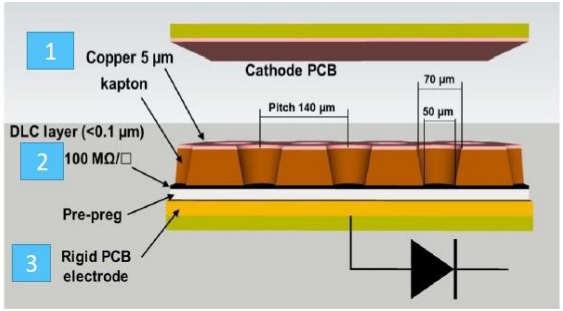


See Nicole Apadula's talk about eRD104 &111 activities.
See Zhenyu Ye's talk about eRD112 activities.

- Disks
  - The last disk on both side in the ECCE design is currently floating and not supported. Service cone needs updating to make the required support connections.
- Hits per track as function of rapidity and p_T/momentum
  - The average number of hits per track in the electron going direction is more than 4 hits on average.
  - Needs further verification in simulations.
- EIC Background impacts on the tracking performance.

Geometry optimization and simulation studies for the MPGD tracker

- Detectors
  - Redundancy vs number of hits per track
  - Forward: impact of a MPGD layer behind the dRICH to be studied
  - Barrel: Technology selection (MM, µRWELL or both)
- Detector thicknesses
  - Redefine the requirements in material thickness for each MPGD layer in the barrel region based on simulation studies and physic needs
  - Do we need low mass 0.5%X/X0 MPGD behind DIRC or can we relax this requirement to the order of ~1 – 2 % X/X0 instead ?



1 **a WELL** patterned kapton foil acting as **amplification stage** (GEM-like)

2 **a resistive DLC layer (Diamond-Like-Carbon)** for discharge suppression w/ surface resistivity ~ 50÷100 MΩ/□

3 a standard readout PCB

See Sourav Tarafdar's talk on eRD108 activities

- FEE, concentrators, DC-DC…
  - Reference design: 280k channels
  - The large number of channels will translate in a large number of FEE cards.
  - Space limitations to be considered
- Services
  - Review number of detector modules
  - Service routing
  - Support structures to be studied.

EIC Detector 1 Tracking work status

- The simulation software selection: Fun4All or DD4HEP, 1st meeting about the software status has been held on Jun. 2. Decided the simulation tasks and the priority list.
- Upcoming meetings will focus on:
  - Background studies and impacts on the tracking performance.
  - Detector technology inputs from consortium (e.g., EIC Si consortium, MPGD consortium) and eRD (e.g., eRD108, eRD 111, eRD112).
  - Tracking performance evaluation with the geometry optimization.
  - Detector integration with other detector subsystems.
  - Physics studies feedback.
  - …

Summary and Outlook

- The EIC detector 1 tracking working group has been formed and focuses on the tracking detector geometry optimization, updates and implement more technical details towards the pre-CDR submission.
- The charge, plan and path forward has been defined for the EIC detector 1 tracking detector related studies.
- We welcome your suggestions, inputs and feedback about the EIC detector 1 tracking developments.

Backup

EIC reference silicon vertex/tracking detector geometry

- The ECCE tracking detector geometries have been archived in the Fun4All ECCE associated repositories.

Barrel index	R (cm)	z_{min} (cm)	z_{max} (cm)
1	3.3	-13.5	13.5
2	4.35	-13.5	13.5
3	5.4	-13.5	13.5
4	21.0	-27	27
5	22.68	-30	30

H-endcap index	z (cm)	r_{in} (cm)	r_{out} (cm)
1	25	3.5	18.5
2	49	3.5	36.5
3	73	4.5	40.5
4	106	5.5	41.5
5	125	7.5	43.5

e-endcap index	z (cm)	r_{in} (cm)	r_{out} (cm)
1	-25	3.5	18.5
2	-52	3.5	36.5
3	-79	4.5	40.5
4	-106	5.5	41.5