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ePIC Tracking Updates

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Jun 05, 2025

ePIC tracking++ meeting

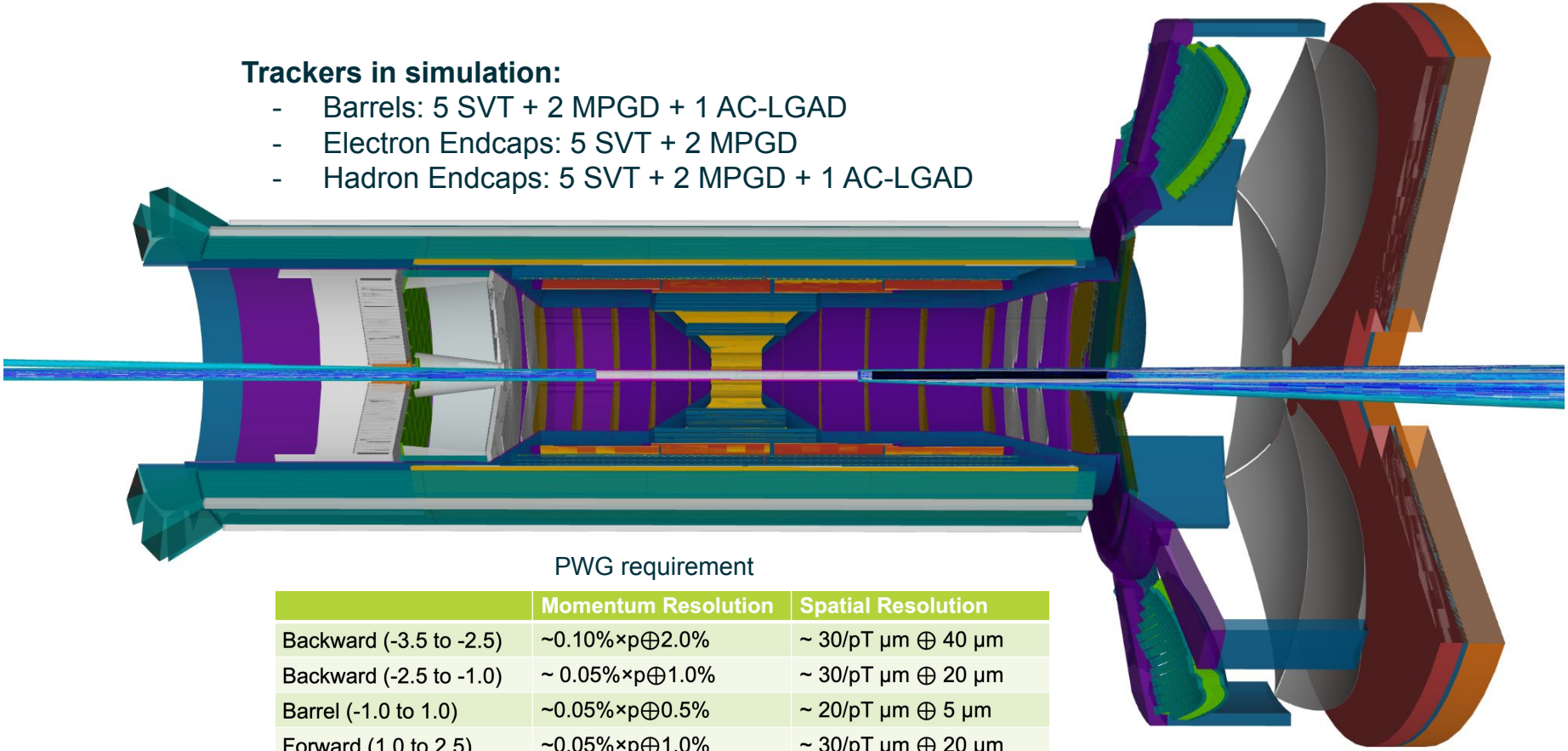
Outline

- Current tracking configuration in simulation
- Performance study with single track
  - Missing hit study
    - Disable each SVT layer
      - MPGD and TOF study will be available soon
  - Double material thickness
- Analysis plan for DIS+background sample (see the follow-up talk next week)

ePIC Central Tracker

Trackers in simulation:

- Barrels: 5 SVT + 2 MPGD + 1 AC-LGAD
- Electron Endcaps: 5 SVT + 2 MPGD
- Hadron Endcaps: 5 SVT + 2 MPGD + 1 AC-LGAD



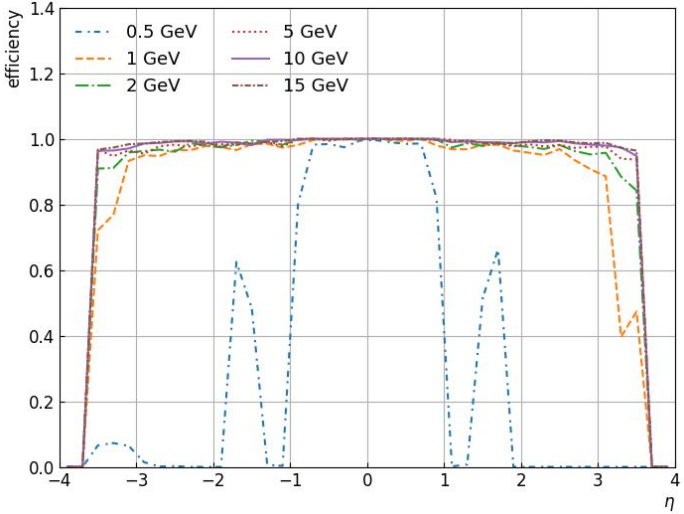
PWG requirement

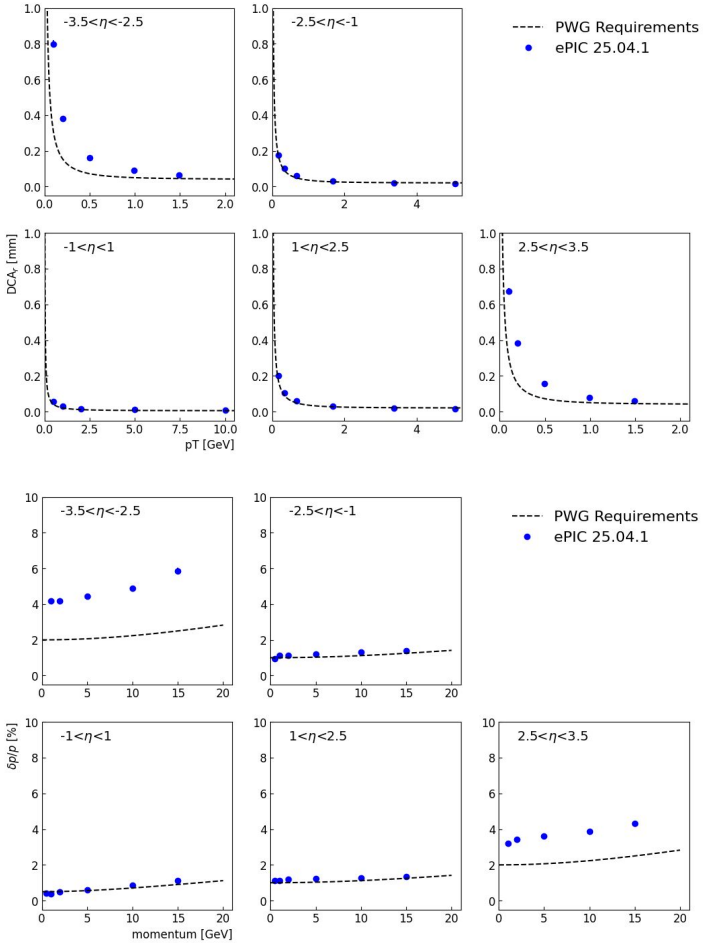
	Momentum Resolution	Spatial Resolution
Backward (-3.5 to -2.5)	~0.10%×p⊕2.0%	~ 30/pT μm ⊕ 40 μm
Backward (-2.5 to -1.0)	~ 0.05%×p⊕1.0%	~ 30/pT μm ⊕ 20 μm
Barrel (-1.0 to 1.0)	~0.05%×p⊕0.5%	~ 20/pT μm ⊕ 5 μm
Forward (1.0 to 2.5)	~0.05%×p⊕1.0%	~ 30/pT μm ⊕ 20 μm
Forward (2.5 to 3.5)	~0.10%×p⊕2.0%	~ 30/pT μm ⊕ 40 μm

Current Status

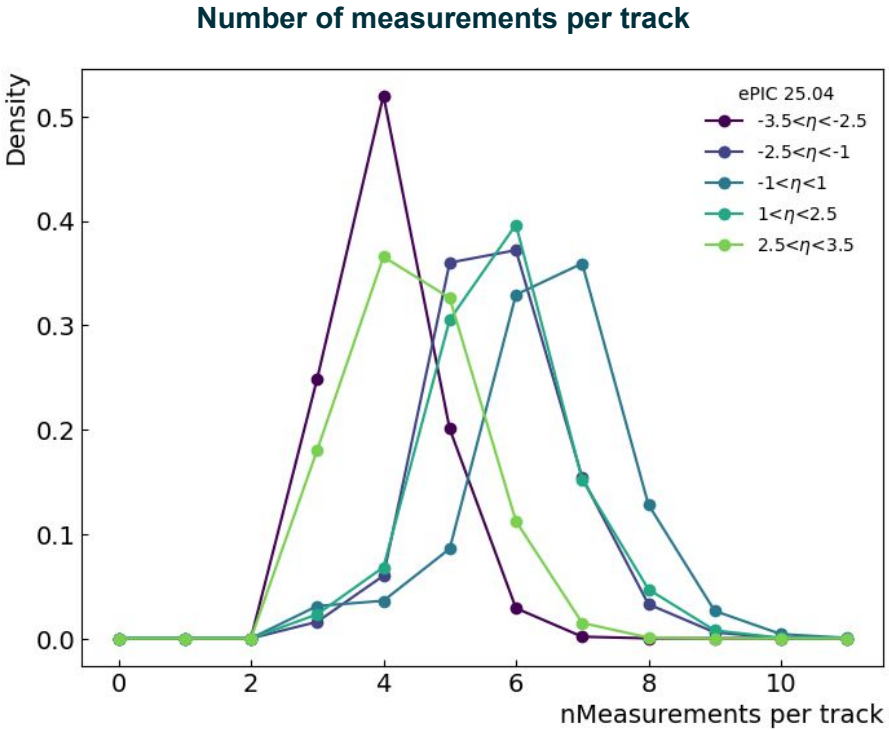
Tracking performance (Default configuration)

- uniformly-generated single pion+ events
- Orthogonal seeding + Combinatorial Kalman Filter + ambiguity solver
- Geometry:
  - IB: smooth silicon layers, no RSU structure
  - OB: uniform layers
  - Disk: trapezoids
  - eic-shell 25.04.1, epic 25.05, didn't include later TOF updates





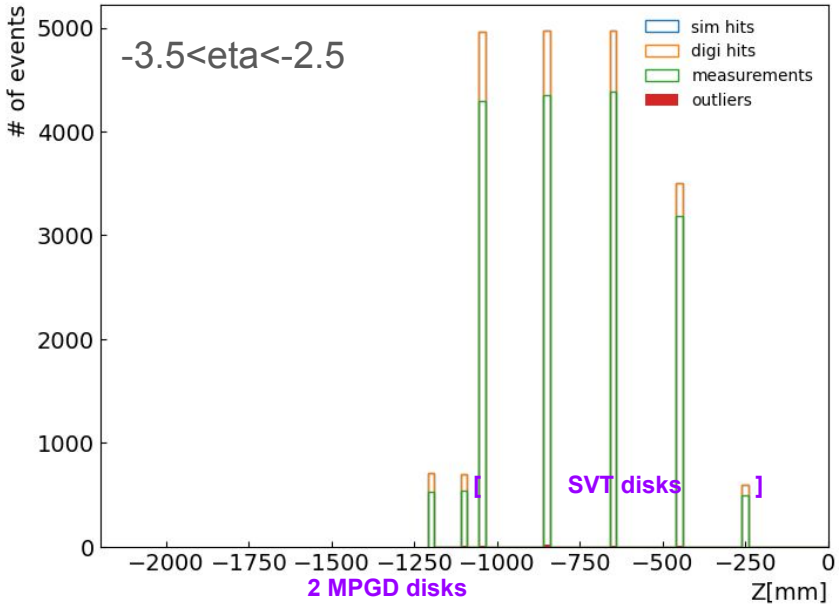
Impact study: missing hits

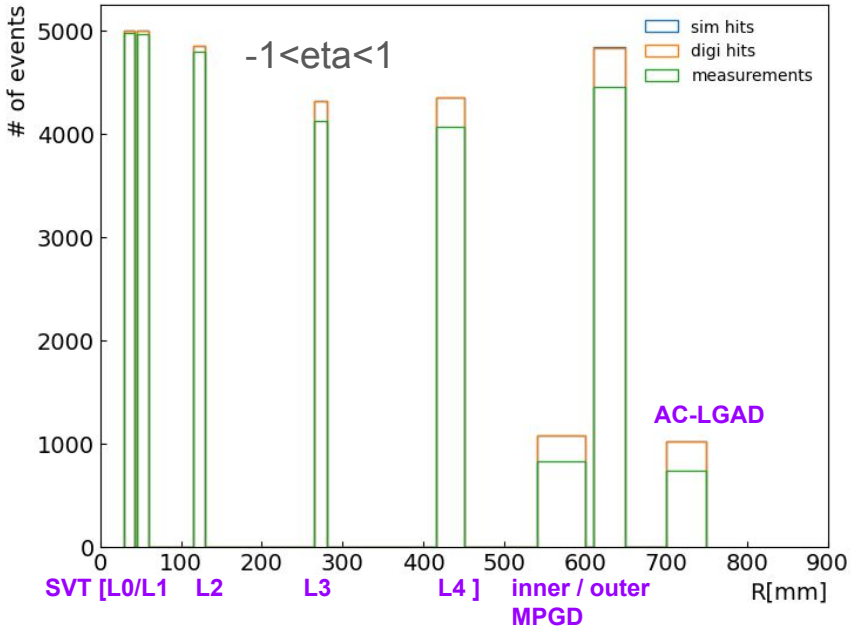


- Our tracking algorithm takes 3 hits to form the initial guess (seeding), and CKF works best with >= 5 hits
- Vertex hits are important for DCA, Sagitta hits have significant impact on momentum resolution
- The ePIC central tracker can provide up to 8 track measurements by design

- The tracker hits can be “missing” when the detector pad/channel is broken or noisy. To demonstrate the robustness of the tracking system in simulation:
  - Use single particle event:
    - uniformly distributed in phi, eta
    - Fixed momentum: 0.5, 1, 2, 5, 15 GeV
    - Fine eta bin of 0.1 to catch the change in acceptance
  - Keep the detector structure and materials unchanged, in DD4hep xml file, set sensitive=False for one tracking layer each time to check the impact on efficiency and resolution
  - Parsl-based workflow to handle batch processing of detector configuration, simulation, and analysis on NERSC (Amir Abdou, UC Berkeley)

Impact study: missing hits

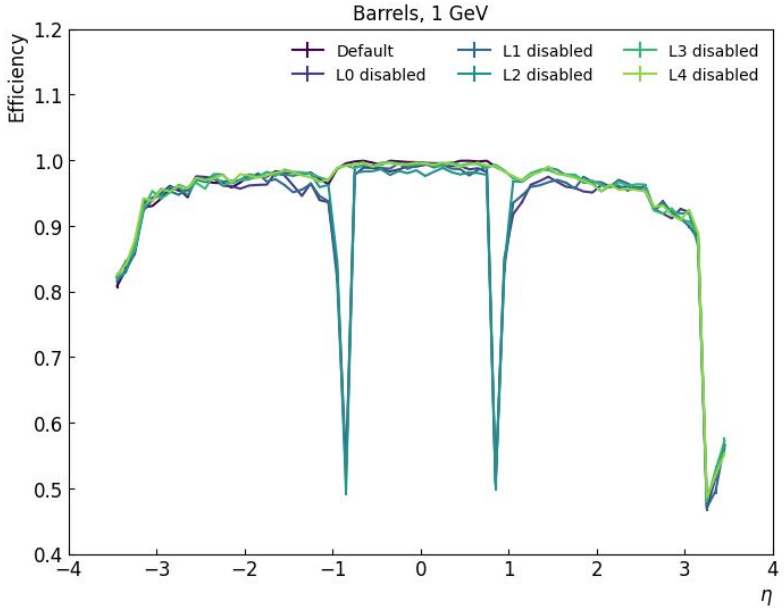


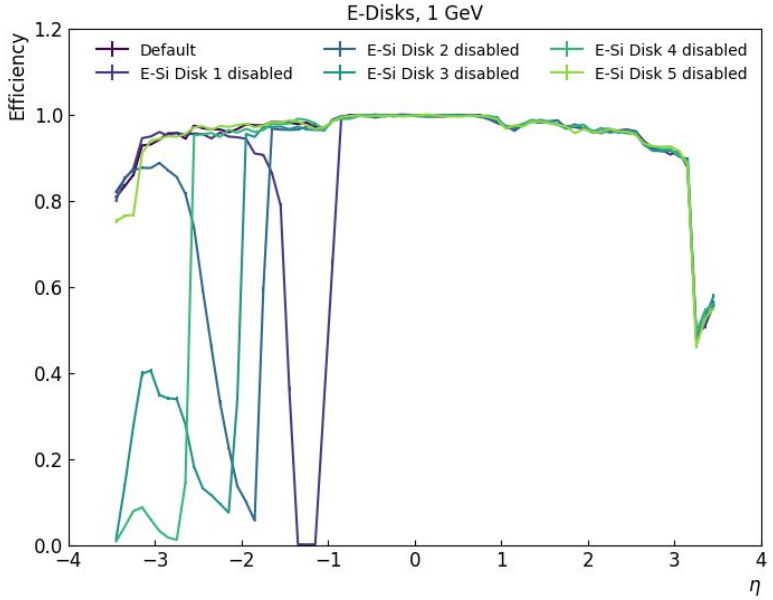


Note: the existing tracker hits can be ignored in reconstruction if they deviate from the projected trajectories i.e. chi2 too large
This algorithm-level (in)efficiency is not considered in this study

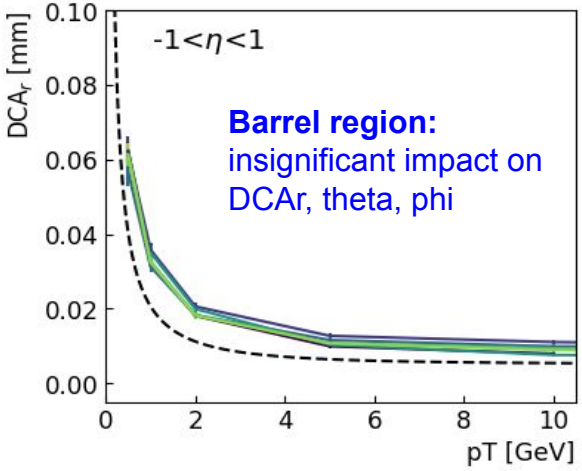
Efficiency

Tracking layers closer to vertex have larger impact on efficiency

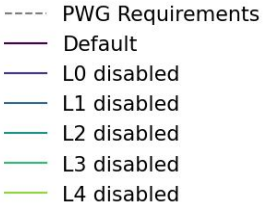


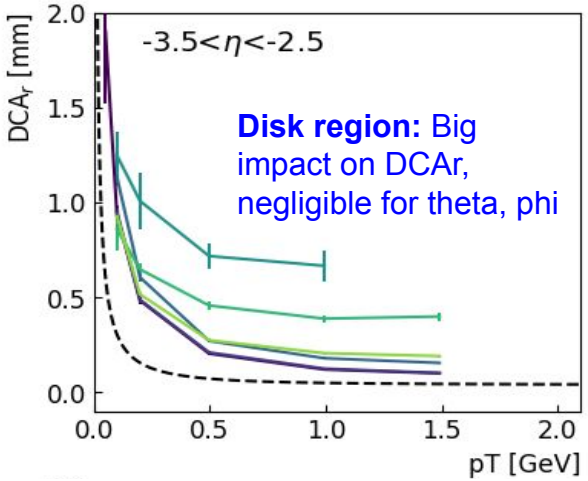


Resolutions

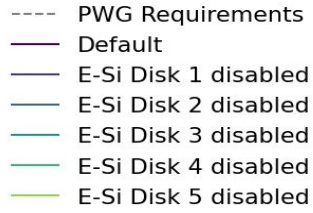


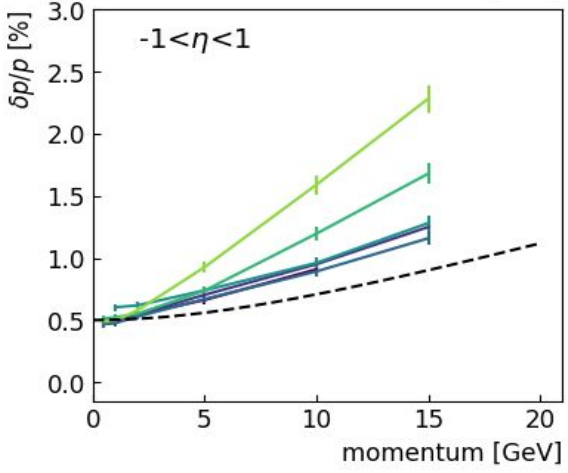
Barrel region: insignificant impact on DCAr, theta, phi



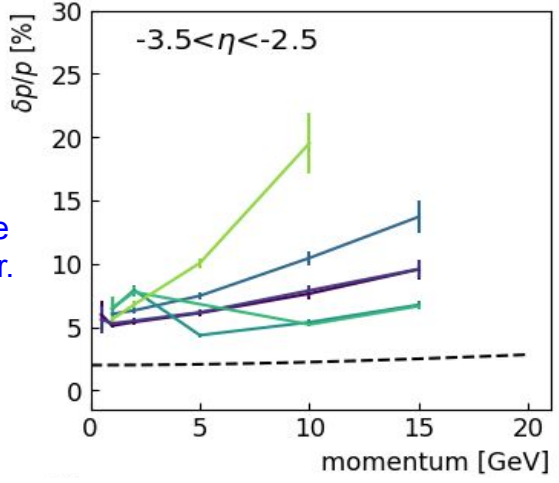


Disk region: Big impact on DCAr, negligible for theta, phi

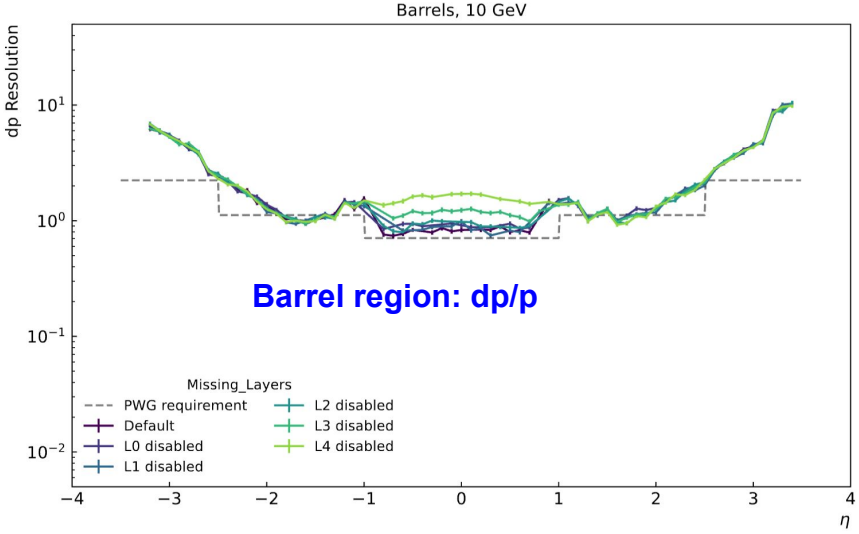




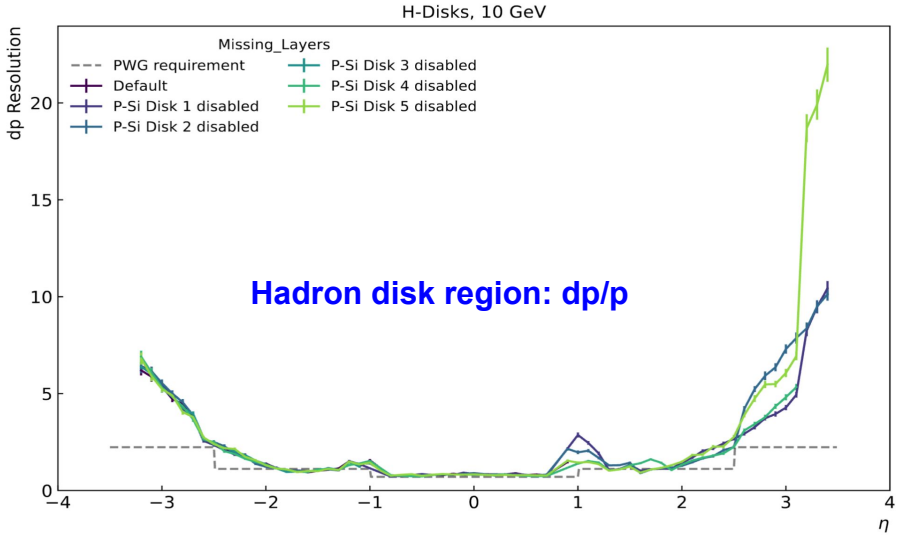
Both region: impact on momentum resolution is highly correlated with the location of disabled layer.



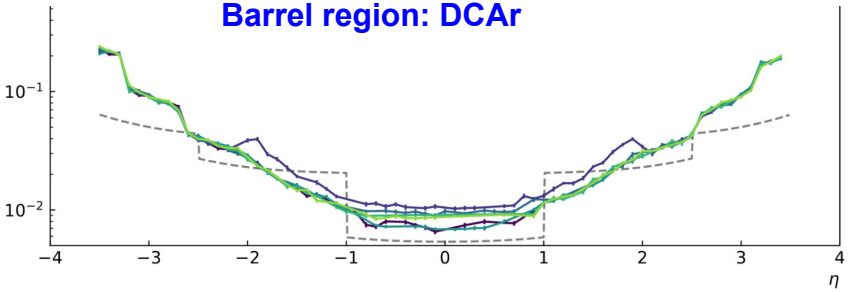
Resolutions v.s. eta



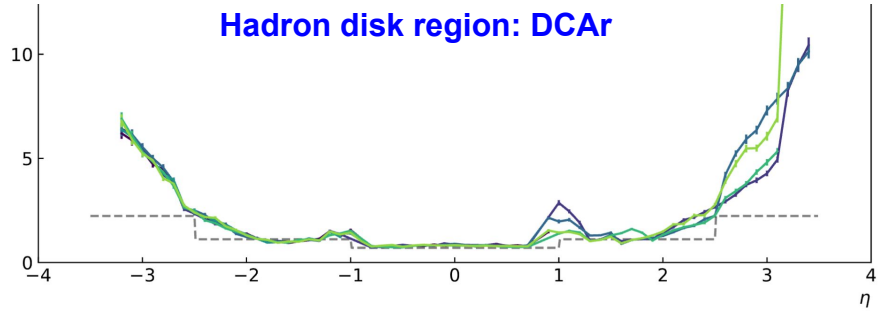
Barrel region: dp/p



Hadron disk region: dp/p

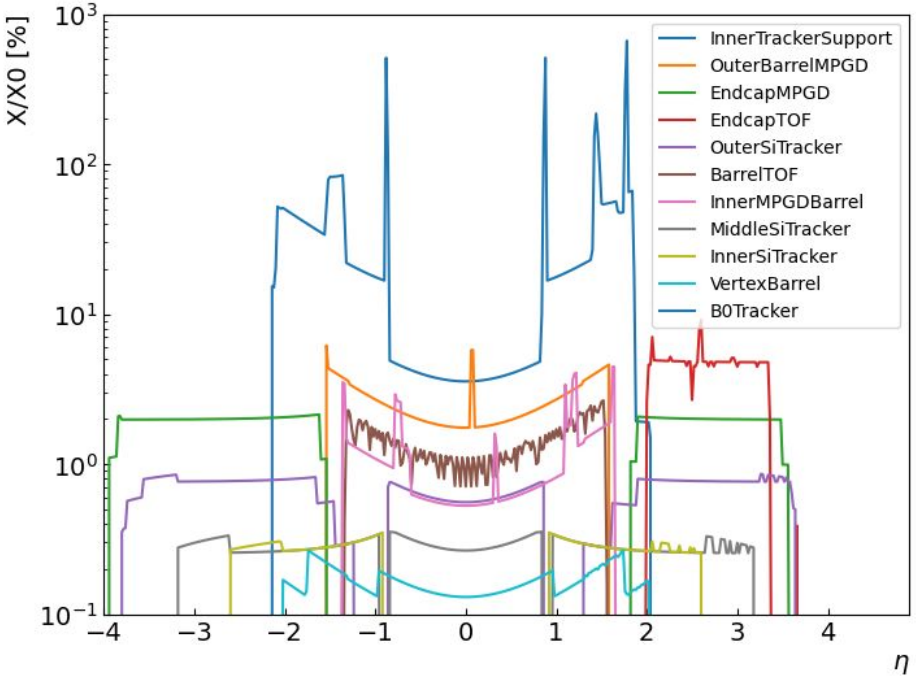


Barrel region: DCAr



Hadron disk region: DCAr

Impact study: material thickness



The nominal SVT thickness per layer:

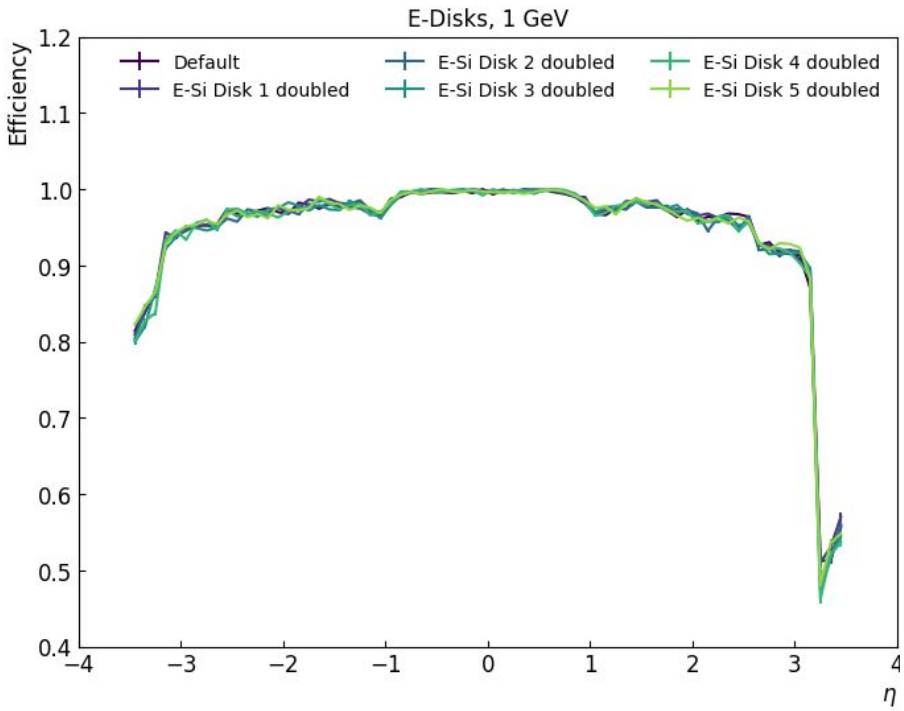
- Si Vertex barrel: 0.05%
- Si Outer Barrel: 0.25 - 0.55%
- Si disk: 0.24%

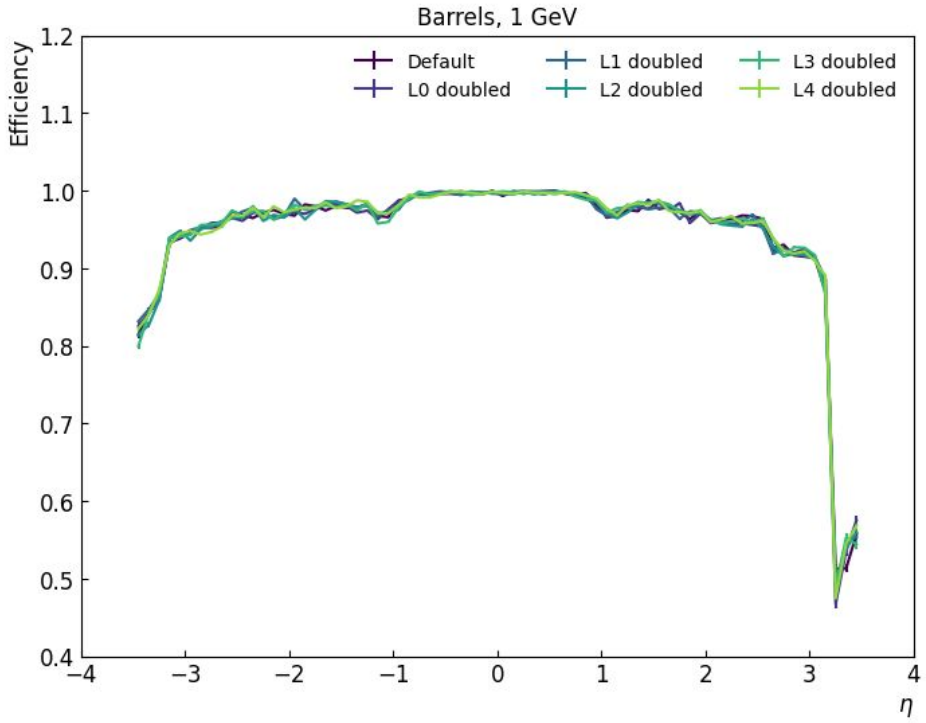
More materials from service, support structure etc will induce more rescattering

In single particle simulation, double the thickness of each layer to check the impact on reconstructed resolution

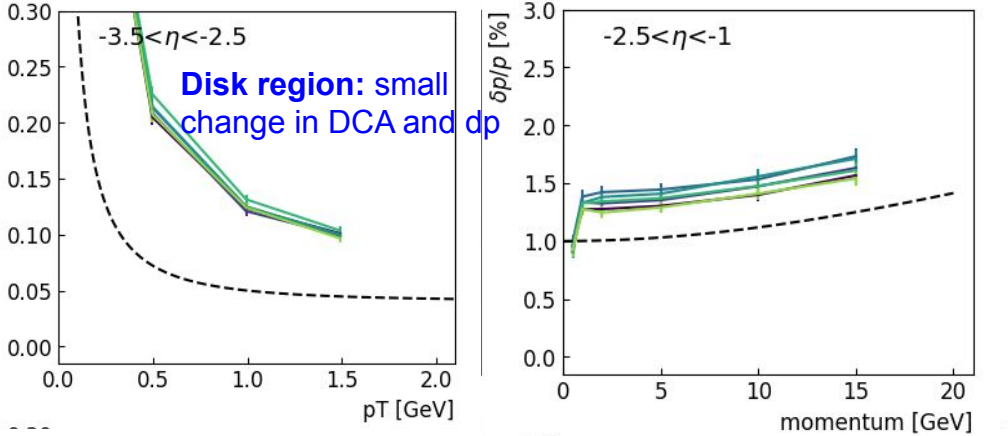
Efficiency

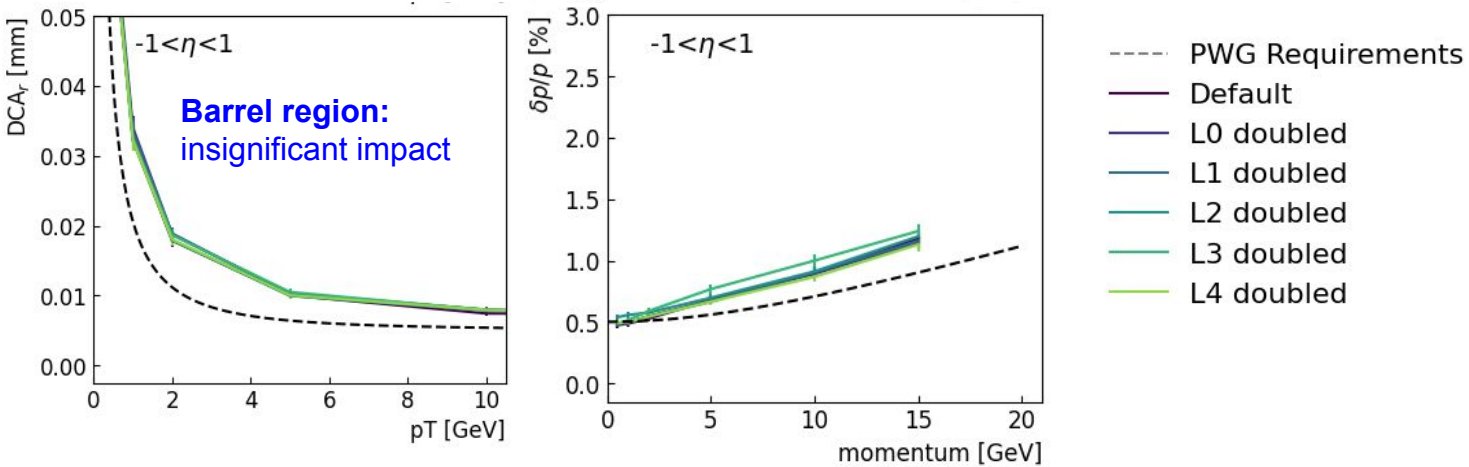
No noticeable impact anywhere with doubled thickness





Resolutions



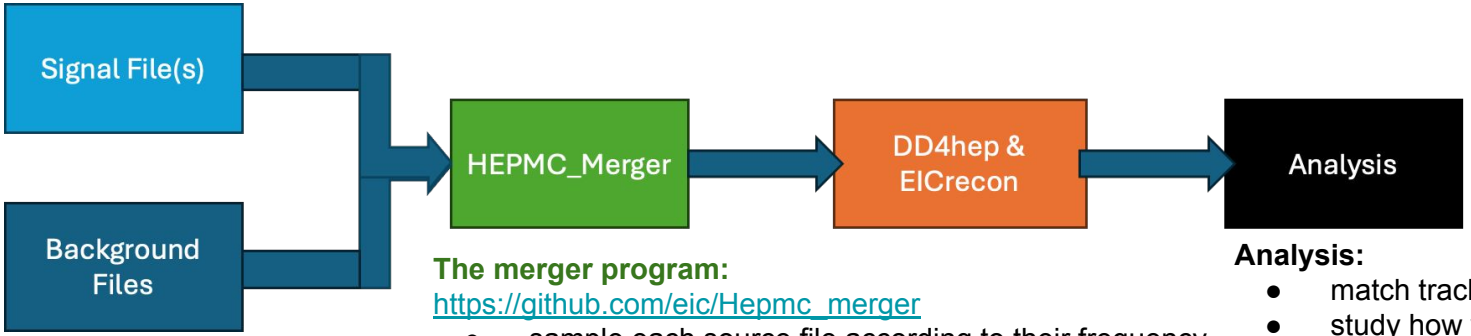


DIS+Background Sample

- See discussion at the ePIC TIC meeting

In one merged DIS+Background event (2us time window, 18x275 GeV beam as an example):

	DIS(Q2>1)	minBias (SIDIS)	Electron beam gas	Synchrotron radiation	Proton beam gas
# of events	0.002	0.9	6.4	28	0.7
# of particles	0.037	14.9	12.8	28	12.4



The merger program:
https://github.com/eic/Hepmc_merger

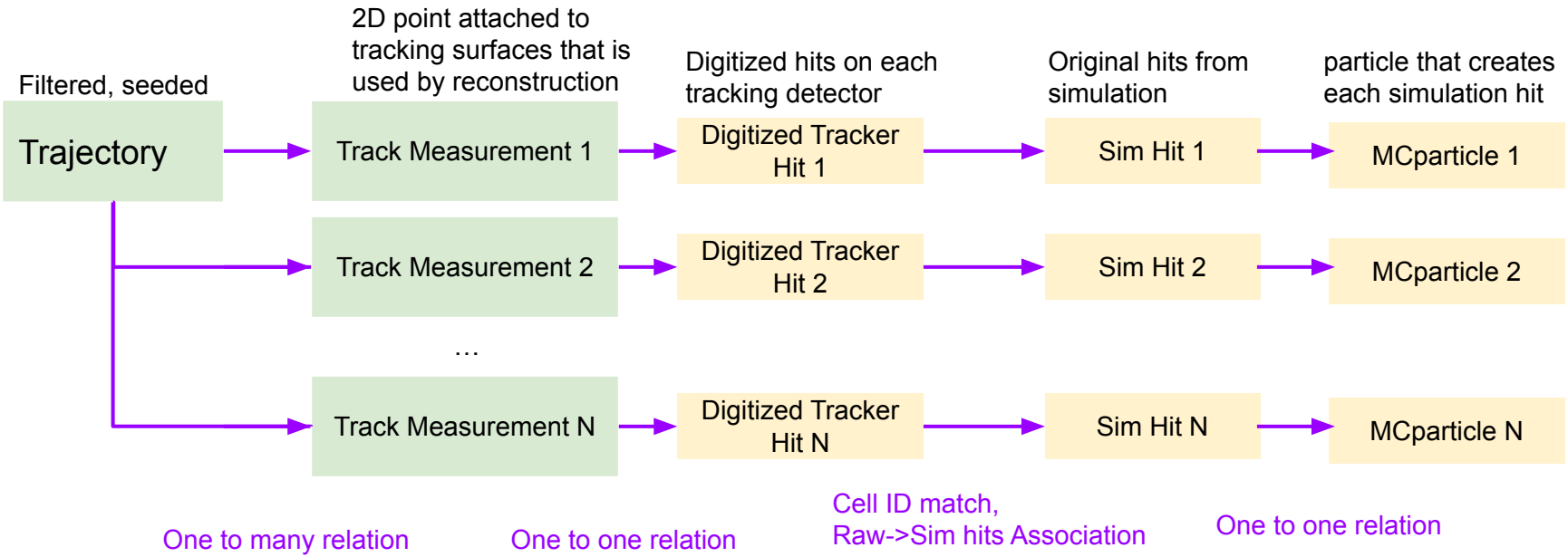
- sample each source file according to their frequency within a fixed-length (2us) time window
- Will be able to label each source particle with custom generator code in DD4hep v1.32

Analysis:

- match track to particles
- study how well we can reconstruct signal particles

Background Study Workflow

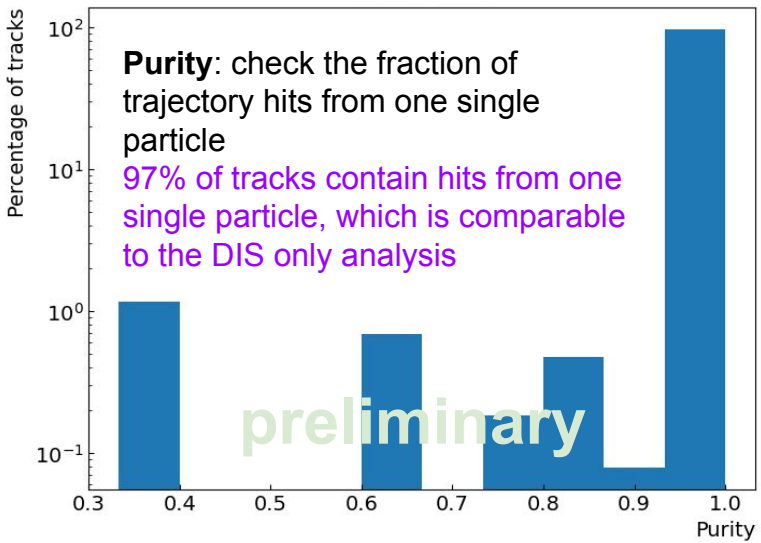
- **Match trajectory to simulated particles**

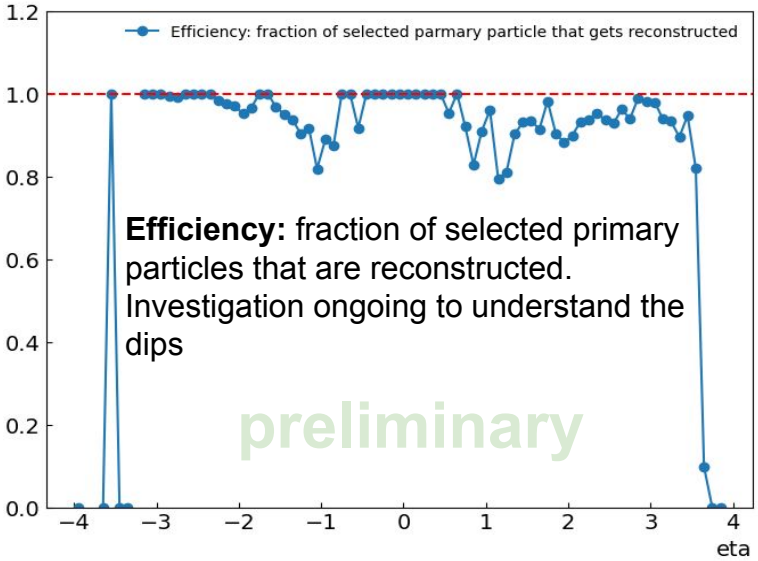


Tracking Performance

- **Particle selection:**
  - Primary (un)decayed particle:
    - generatorStatus==1 or 2, charged
  - Momentum>500 MeV, Particle endpoint > 10 cm
  - Vertex.r < 2 mm
- Used a sample of 1000 events, each event is forced to have DIS signal

To do:
- Identify DIS v.s. beam particles in the merged event
- Check resolutions
- Repeat missing hits study with DIS+background samples





Thanks!