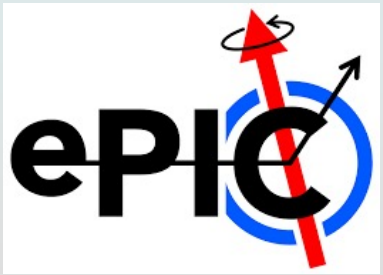
Track Reconstruction and Vertexing status & ongoing work

Barak Schmookler, Ernst Sichtermann,
Shujie Li, Barbara Jacak

January 23, 2026

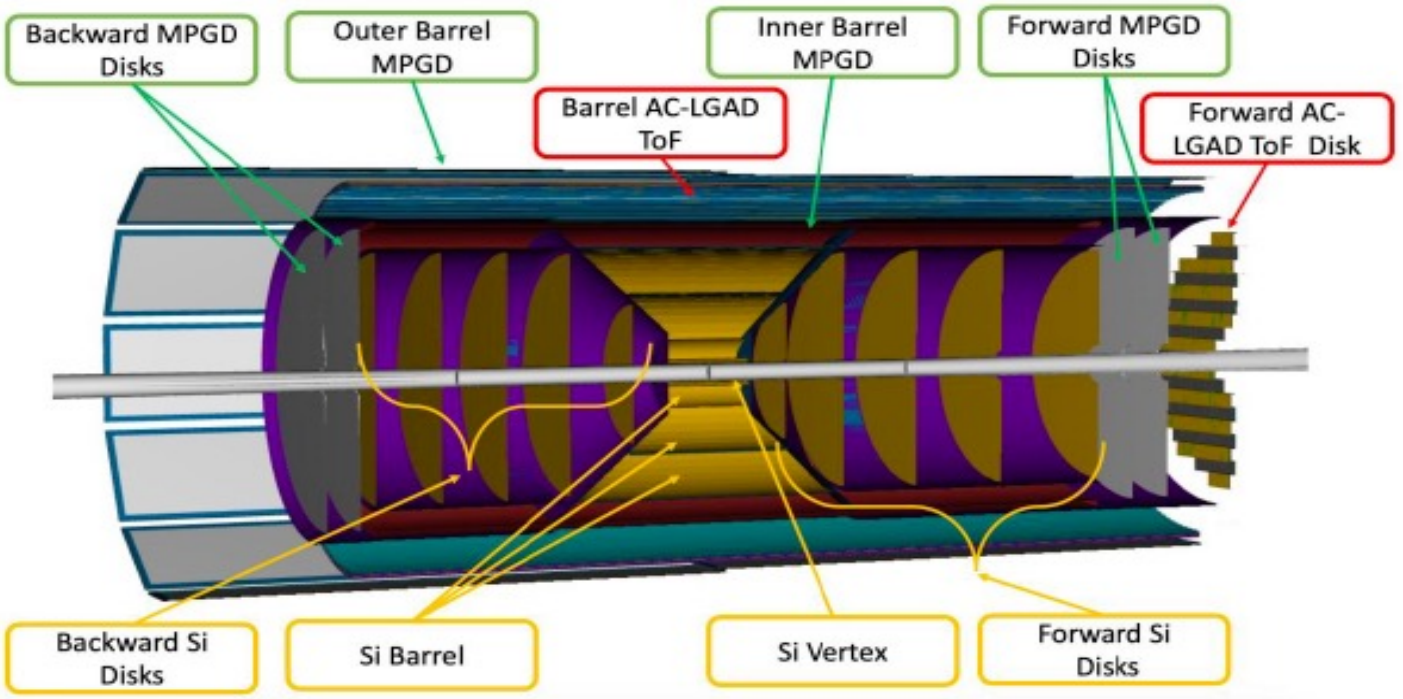


Summary

- Geometry updates for SVT & MPGD
- Effects of backgrounds
  - Detector hit rates
  - Track reconstruction performance
  - ***Need to require 4 hits on a track!***
- Secondary vertex software developments
- Pointing resolution into the DIRC

Central Tracker

Full tracking system: Silicon Vertex Tracker (SVT) + MPGDs + AC-LGAD TOF detectors

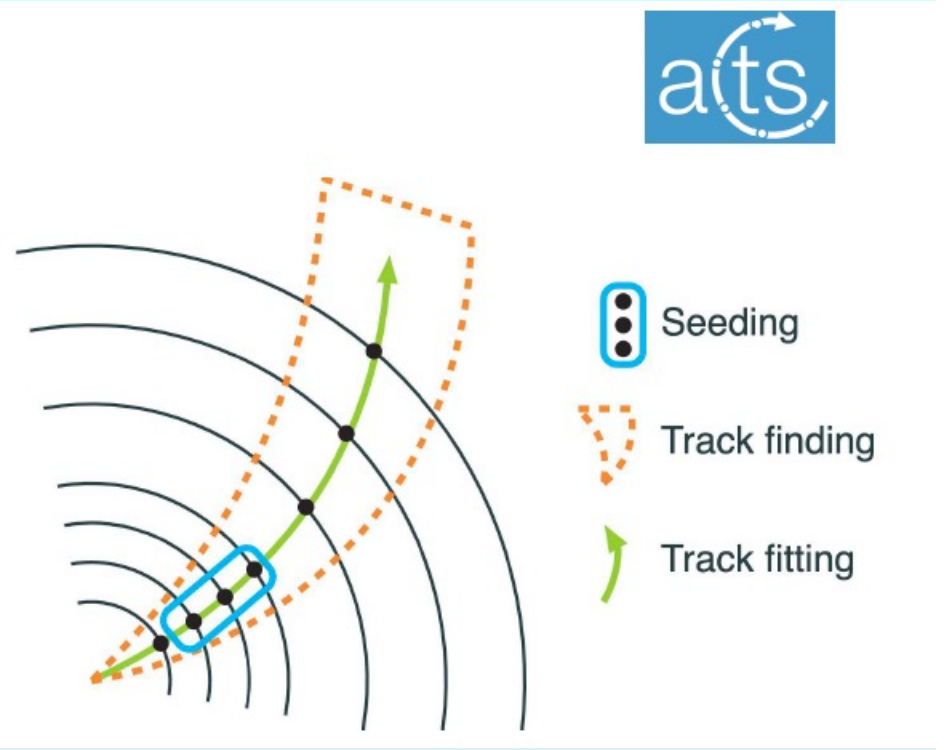


MPGDs and AC-LGADs provide

- additional hit points for track reconstruction (<150 μm, 30 μm)
- fast timing hits for background rejection (10-20 ns, 30 ps)

Tracking workflow

- Build seeds from triplets of contiguous hits
  - Use loose cuts
- Project track seeds to other tracking layers
  - Attach additional SVT, MPGD, & TOF hits
- Fit using Kalman filter
- Apply ambiguity solver to select best track using common hits
  - Removes redundant seed results
- Save track parameters & point closest to the z-axis (beamline)



Progress since summer

MPGD geometry updated

Modified for Oct. release to match CAD drawing from 03/2025

- Barrels

Source	Detector	Inner Radius [mm]	Outer Radius [mm]	dR [mm]	Z-Negative [mm]	Z -Positive [mm]
CAD	CyMBaL	550	605	55	1025	1450
Previous Sim		550	592	42	1050	1430
CAD	*BOT	735	760	25	1825	1875
Previous Sim		725	750	25	1645	1745

* µRwell-Bot:
  - Implementation in simulation runs from -1795 mm < z < 1845 mm, within CAD envelope
  - PCB board extended for FEB placement

- Endcaps

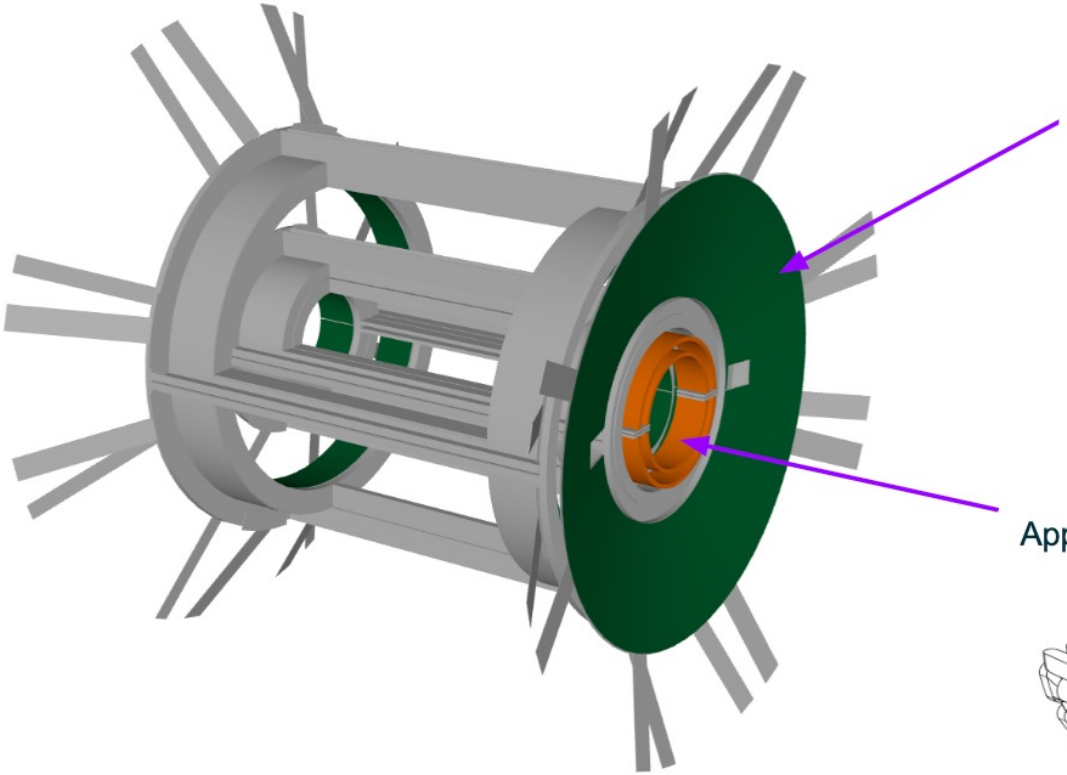
Source	Detector	Inner Radius [mm]	Outer Radius [mm]	Z Front [mm]	Z Back [mm]	dZ [mm]
CAD	Backward Disk 1/2	70 / 70	400 / 400	1075 / 1200	1100 / 1225	25 / 25
Previous Sim		46.53 / 46.53	500 / 500	1100 / 1200	1125 / 1225	25 / 25
CAD	Forward Disk 1/2	81.24 / 81.24	400 / 400	1500 / 1625	1525 / 1650	25 / 25
Previous Sim		90 / 90	500 / 500	1480 / 1610	1505 / 1635	25 / 25

MPGD module geometry & digitization also updated

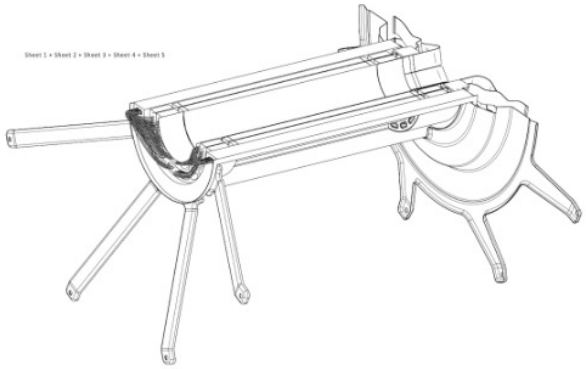
Matt Posik

SVT Inner Barrel geometry updated

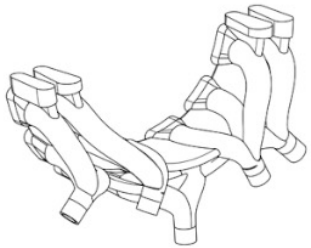
Build Mechanical structures with Simple TGeo Shapes



Distribute cables along the cone.



Approx. air tube connector as a ring



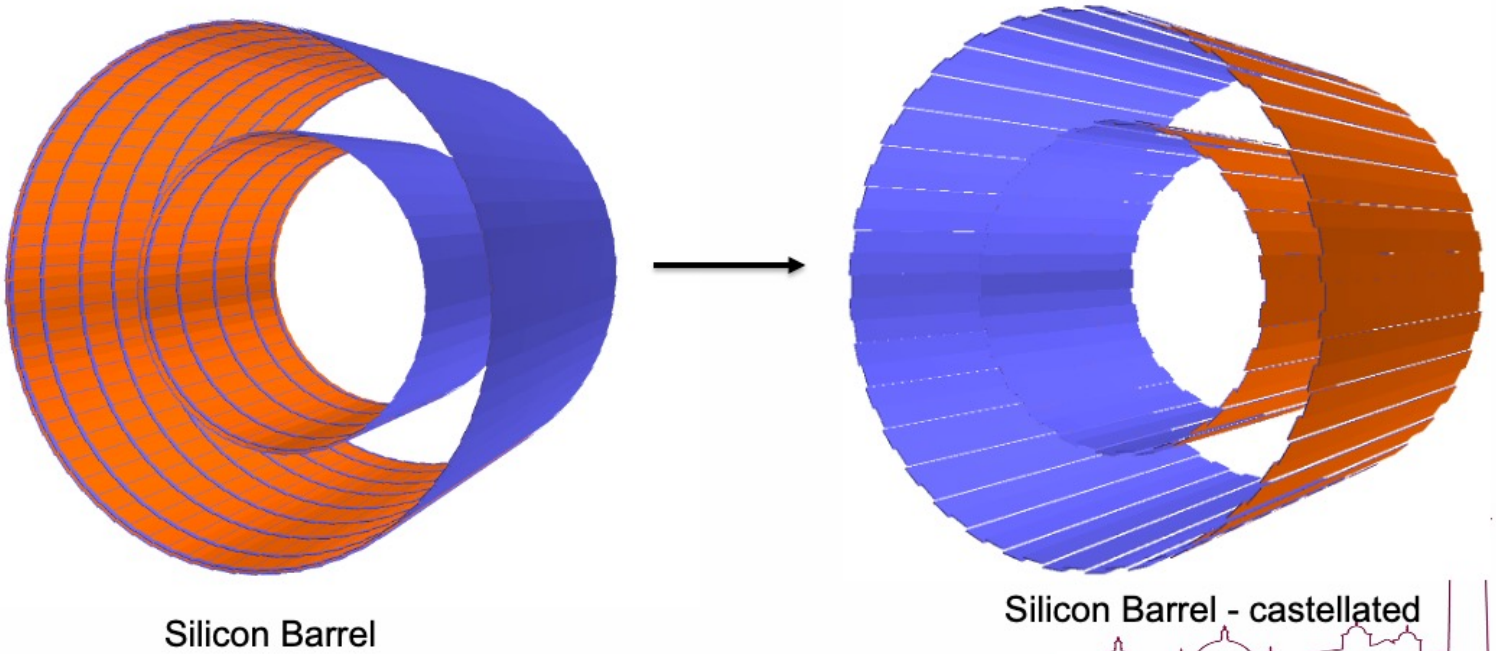
Shujie Li
Provakar Datta

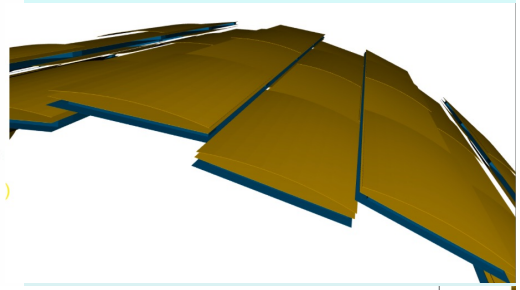
IB active material has also been updated

SVT Outer Barrel geometry updates

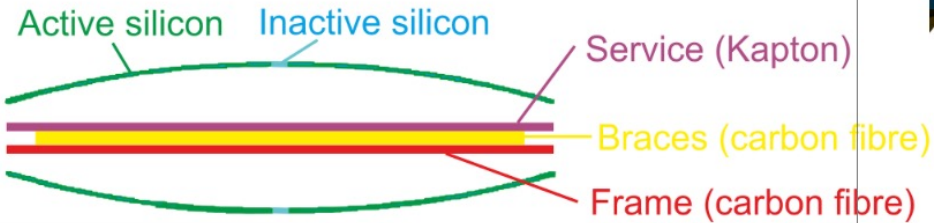
Comparison of flat_OB past to present

Sam Henry Athavan Ramalingam

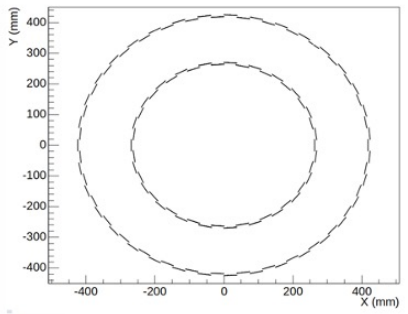




Work ongoing to verify that material map automatically generated matches the geometry used for simulating performance



100k single particle simulations of π^-



Monitor impact of changes

- "pull" distributions added to benchmarks for monitoring

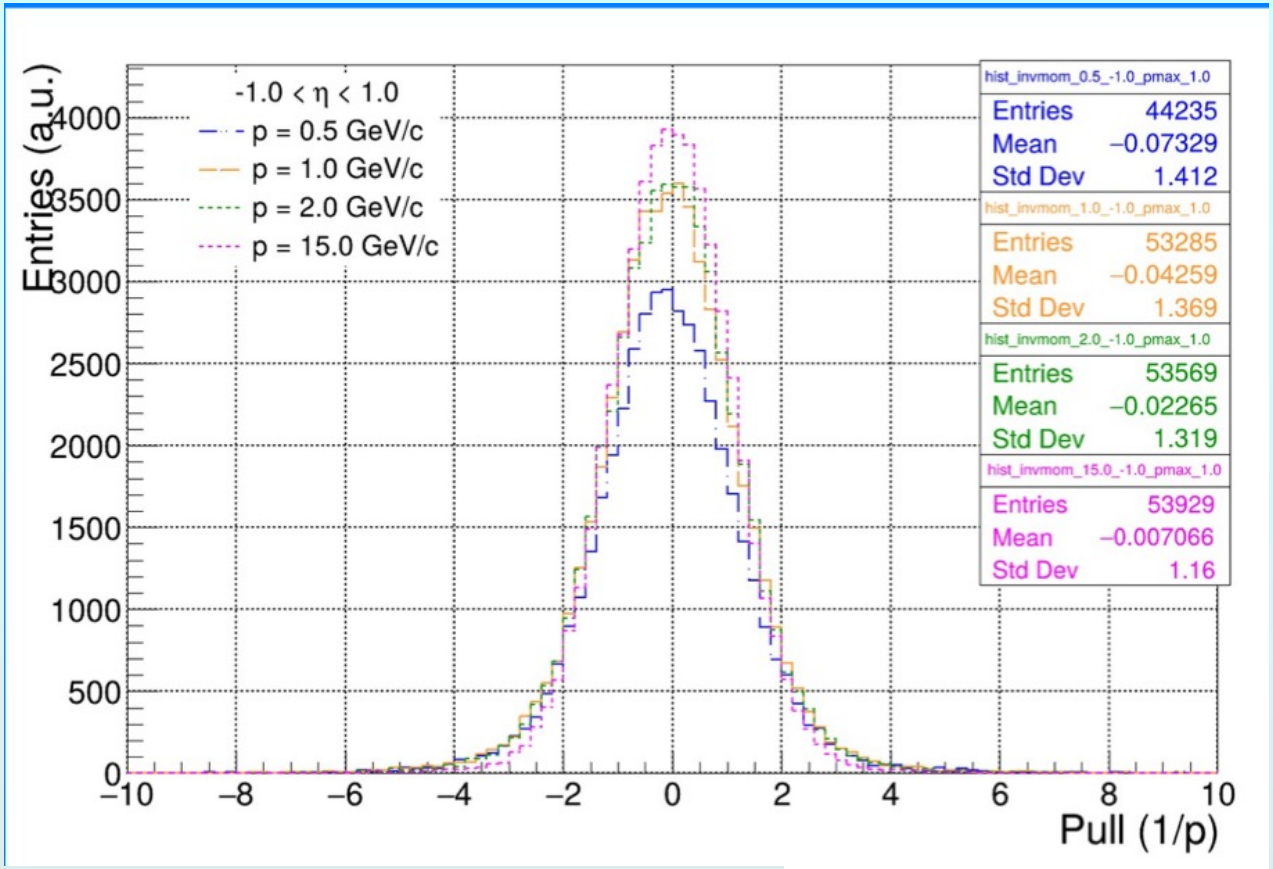
$$\text{Pull } q/p = \frac{(q/p_{rec} - q/p_{gen})}{\sigma_{q/p}}$$

$$\text{Pull } \phi = \frac{(\phi_{rec} - \phi_{gen})}{\sigma_{\phi}}$$

$$\text{Pull } \theta = \frac{(\theta_{rec} - \theta_{gen})}{\sigma_{\theta}}$$

Pull = normalized residual

"pulls" estimator's distribution toward a standard Gaussian

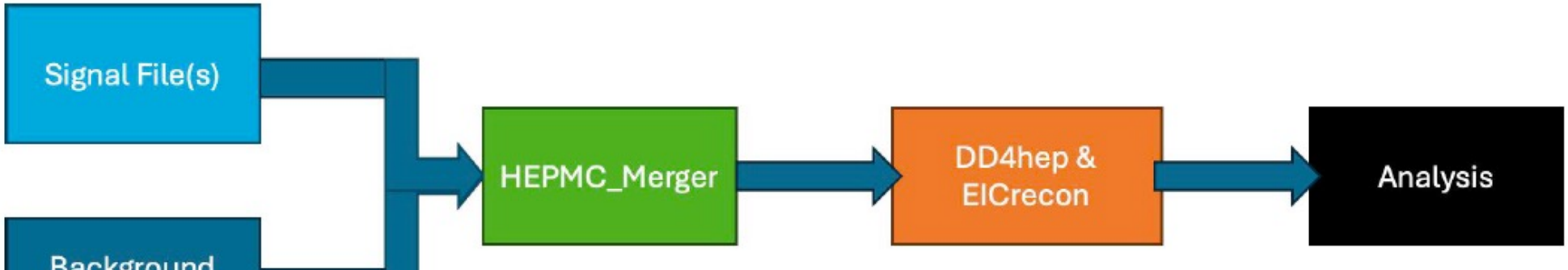


Shyam Kumar
Athavan Ramalingam

Ensure that material map matches!

Work is ongoing to quantify track reconstruction and seeding performance impacts

Track reconstruction with realistic backgrounds



The merger program

- https://github.com/eic/Hepmc_merger
- sample each source file according to their frequency
- within a fixed-length (2us) time window label each source particle with custom generator code

One event = one collision → **merged** → one 2us time slice contains (in simulation setting shown here)

One DIS event with $Q^2 > 1\ GeV^2/c^2$

Both 18 x 275 GeV and 10 x 275 GeV beam configurations

Beam backgrounds considered: SR, electron bremsstrahlung, proton beam-gas, electron beam-gas

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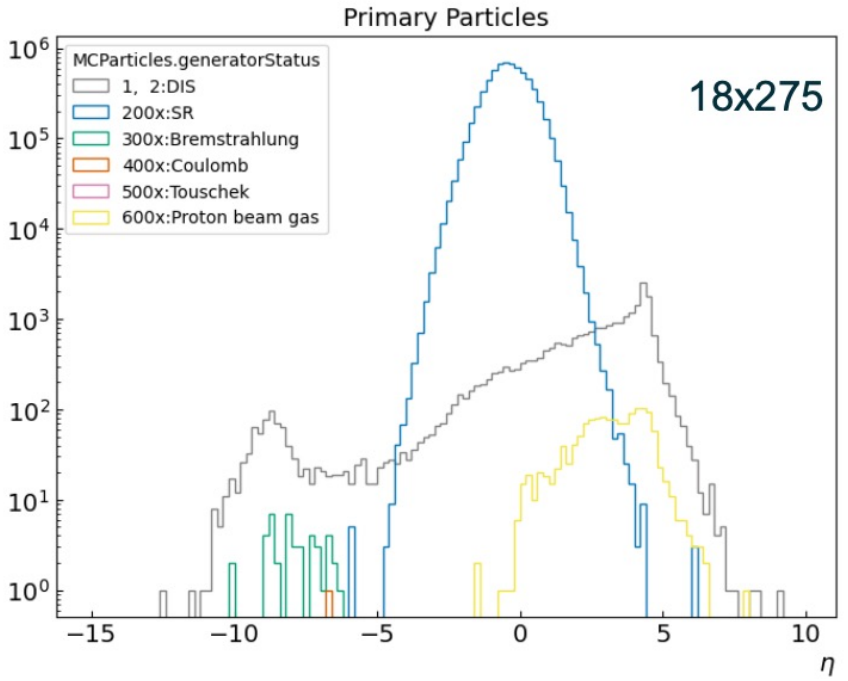
Beam background rate study

For each time slice of 2us (1 merged event), mix 1 DIS signal event with beam background according to their calculated freq.

Event	signal	synrad	ebrems	etouschek	ecoloumb	p.b.gas
Event 1	●	●●●●	●			
Event 2	●	●●●●			●	●
Event 3	●	●●●		●		
Event 4	●	●●●	●			●
Event 5	●	●●●●	●			

rates in kHz	10x275 GeV	18x275 GeV
	2.5A@10kAhr	0.227A@10kAhr
DIS eA	/	/
electron Synchrotron Radiation	36608 MHz	3324 MHz
electron beam gas (Bremsstrahlung scatterings)	3177.25 kHz	316.94 kHz
electron beam gas (Coulomb losses,)	29 kHz	1.3 kHz
electron intrabeam (Touschek losses)	240 kHz	0.72 kHz
hadron beam gas	32.6kHz	22.5kHz



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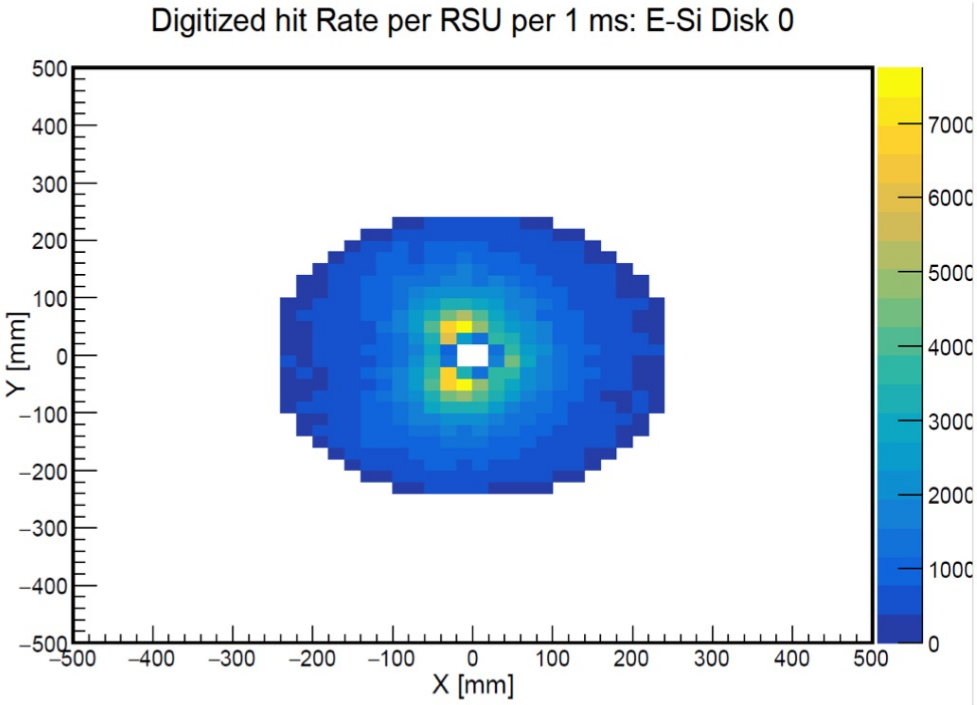
Synchrotron radiation from 10 GeV electron beam is 10x larger than for 18 GeV!

Shujie Li

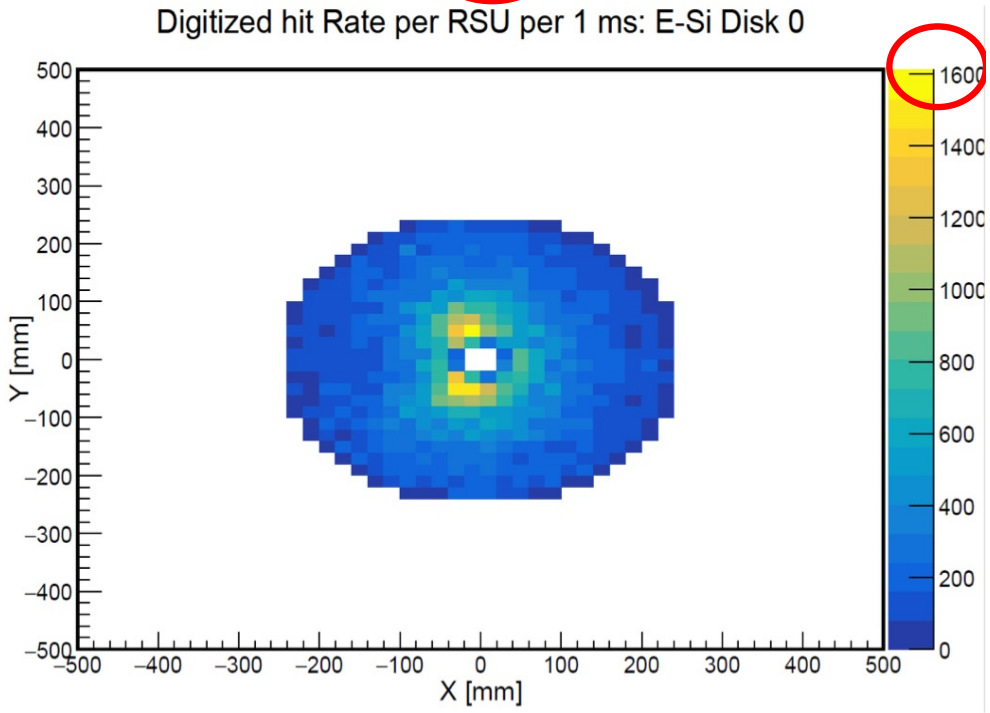
10 GeV e beam Synchrotron Radiation

SVT disks digitized hit rates: E-Si Disk 0

Previous results with 5um gold coating



Results with 10um gold coating



Maximum average RSU rate decreases by about a factor of 4.5

Shujie Li
Barak Schmookler
Ernst Sichtermann

Background study next steps

- Look at track reconstruction performance at 10x275 GeV*
- Finalize hit rate studies for MPGD with background at 10x275 GeV (underway)
  - Detector rate upper limit is 100kHz/cm^2, so OK for both 18 and 10 GeV electron beams
  - Data rate under study
- Finalize work on pointing resolution with increased coating thickness
- NB: hit clusters not yet included in either SVT or MPGD
  - → Factor of 2-3 in hit rates

** Now in the official simulation campaign. Need some help from Physics WG members to evaluate*

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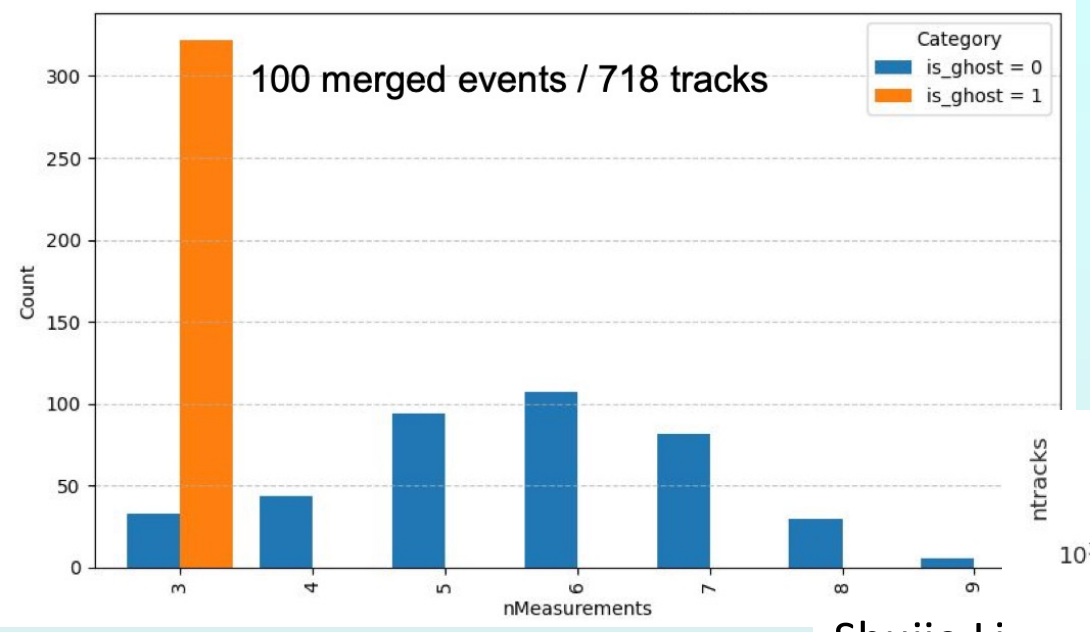
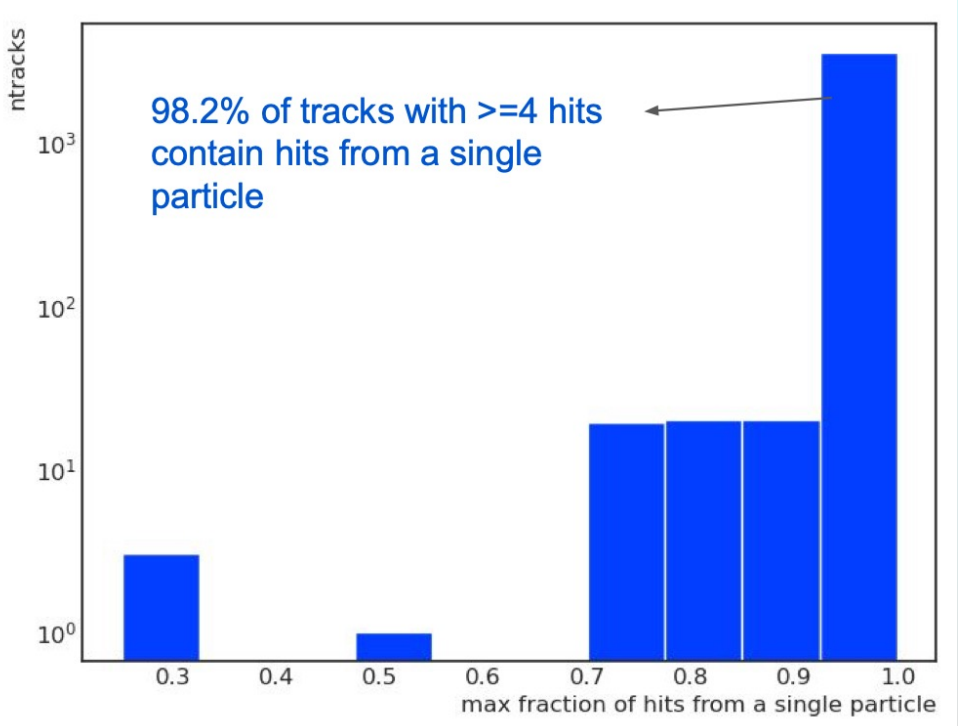
Tracking performance with background

- **Require 4 hits for a good track to remove ghosts due to background hits**



Shujie Li

Physics working groups should apply this cut!!!!



- **Purity is good with 4 hits!**
  18 GeV electron beam

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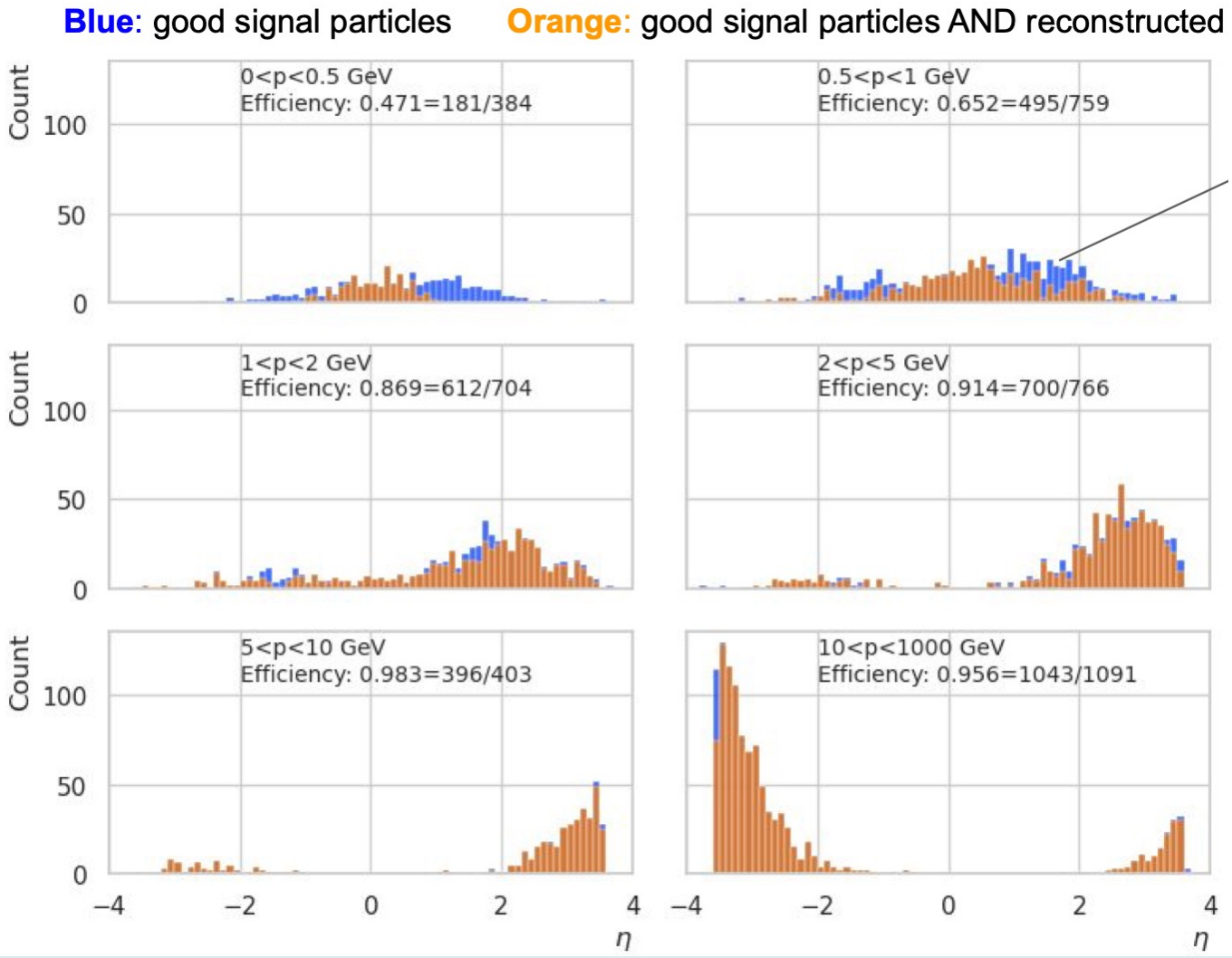
Tracking performance studies



Low momentum inefficiency recovered by opening χ2 cut.

Optimization underway At both seeding and track fitting levels

Help from PWG's needed for 10 GeV electron beam performance optimization!

Shujie Li

Vertex reconstruction

Xin Dong

Recent Progresses:

1) PODIO-based SecondaryVertexFinder using the Helix method integrated into EICrecon
   - *analysis use of the tool and output strongly encouraged*
2) ACTS-based AMVF secondary vertex finder - PR #1915 under review
3) Proposed SecondaryVertex object for edm4eic under review - PR #132

Near Term To-Dos:

1) Continue PODIO-based SecondaryVertexFinder developments
   - Improvements on Helix method (error propagation)
   - Integration of other methods (e.g. KFParticle etc.)
2) Develope benchmark QA tools and integrate them in EICrecon
3) Work with S&C team to resolve questions in above PRs and get them merged
4) Work with Physics WGs and utilize these tools for physics analysis

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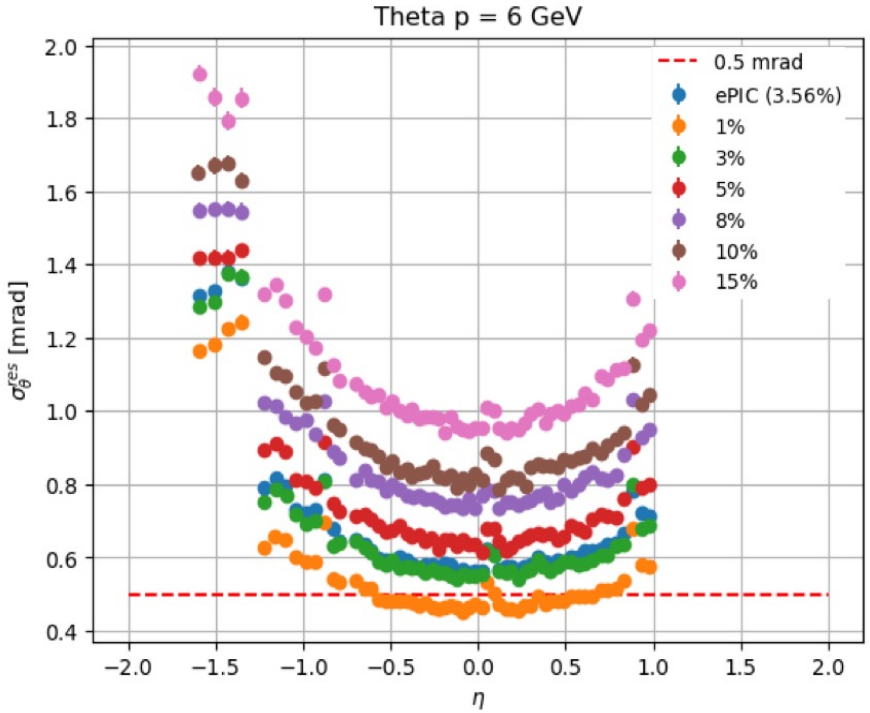
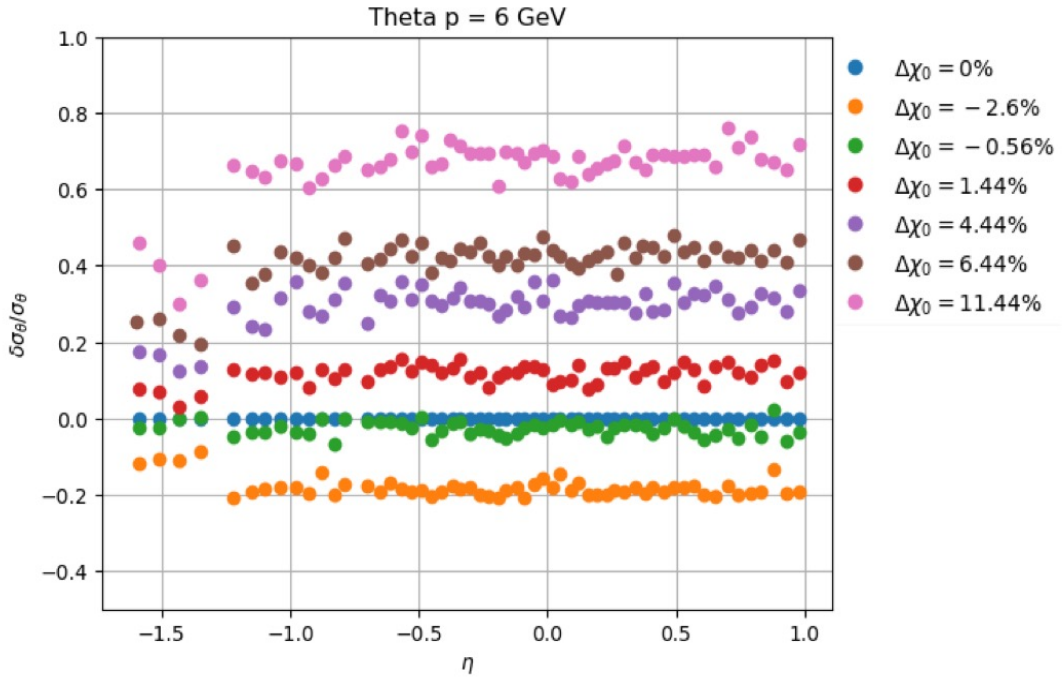
At the DIRC reference surface R = 770.5mm

Material Impact on Angular Resolutions: Theta

$$\frac{\delta\sigma}{\sigma_0} = \frac{\sigma_i - \sigma_0}{\sigma_0}\ ,\ \sigma_0 = \text{resolution from official ePIC detector}$$





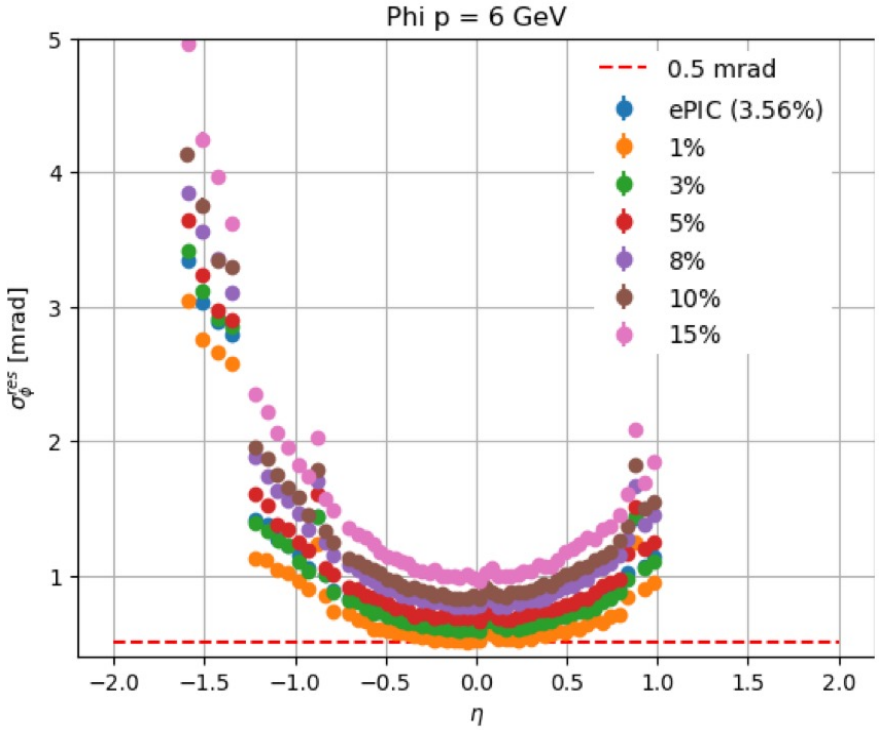
Matt Posik

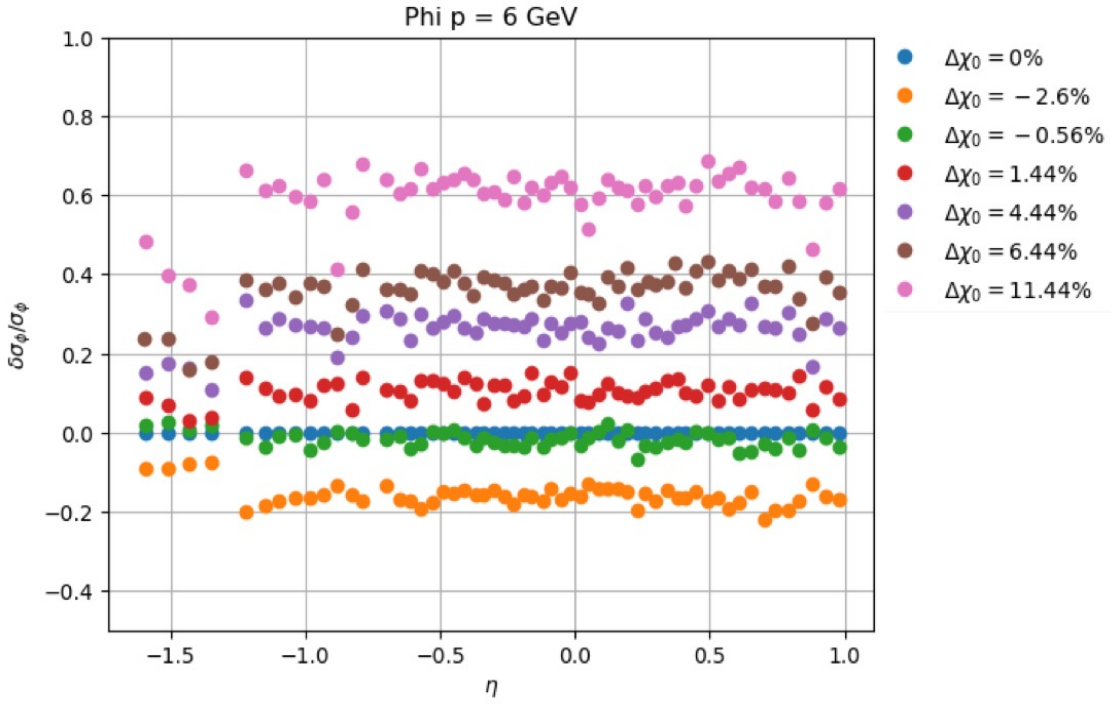
Work is underway to include hit positions from the imaging barrel emcal

At the DIRC reference surface R = 770.5mm

Material Impact on Angular Resolutions Phi

$$\frac{\delta\sigma}{\sigma_0} = \frac{\sigma_i - \sigma_0}{\sigma_0}\ ,\ \sigma_0 = \text{resolution from official ePIC detector}$$

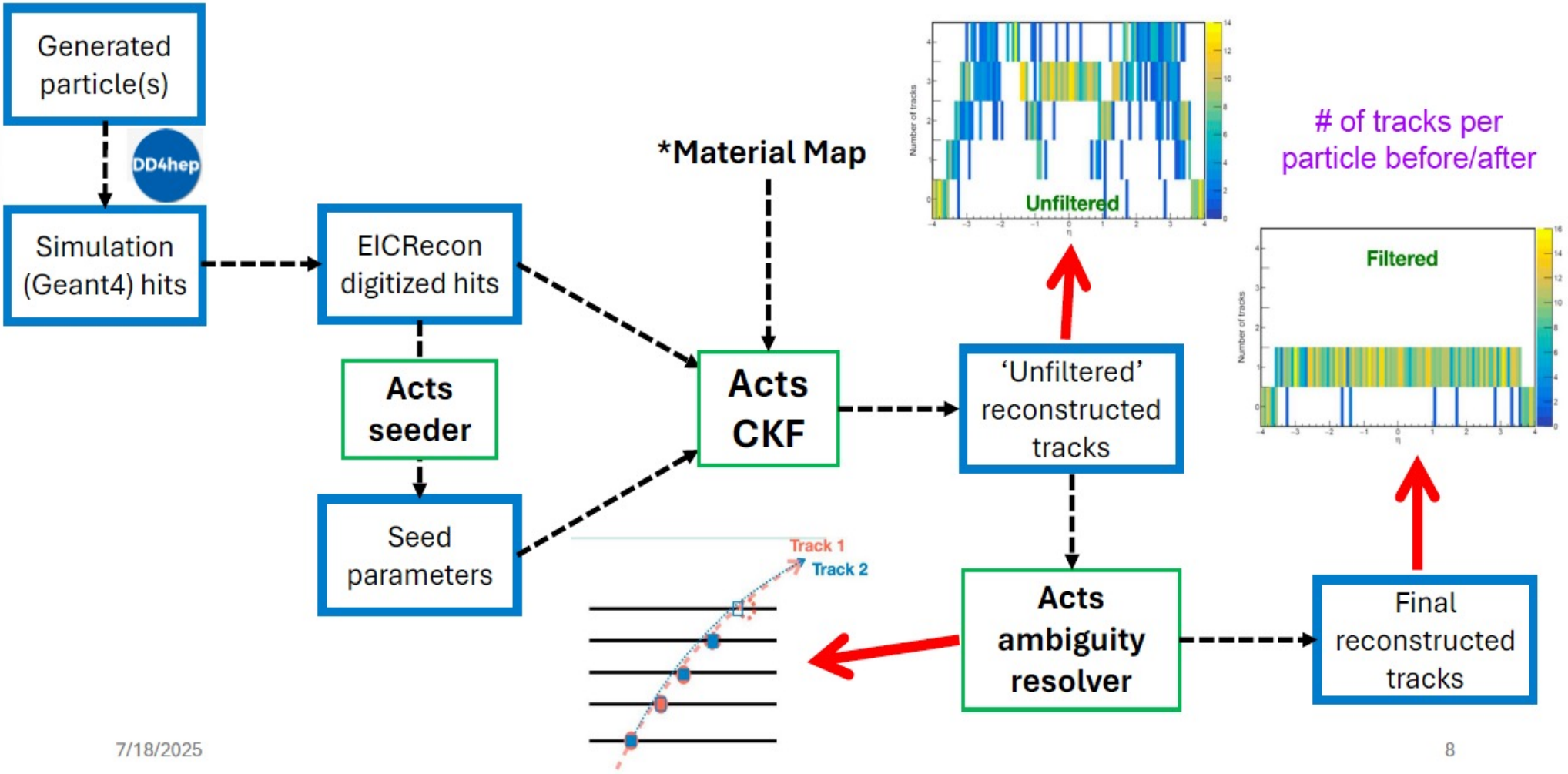




Matt Posik

backup

Tracking workflow



B. Schmookler

Vertex Finders