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Bringing Science Solutions to the World



Background Effects in Tracking

March Campaign | Performance Studies | Ongoing Discussions

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2nd ePIC and EIC Physics Readiness Workshop

03.19.2026



March Simulation Campaign Recap

Change:

- beampipe gold coating: 5um (until 2026.02) ⇒ 10um

Motivation:

- reduce synchrotron radiation (SR) background

Potential impact on tracking:

- thicker beampipe material → worse **resolution** (NOT in Feb campaign, see [explanation here](#))
- ~4 times fewer particles from SR (with 10x275 beam) → less noise hits → better tracking **efficiency** and **purity** (exist in Feb campaign if using `.../Bkg_Exact1S_2us/GoldCt/10um/...`)

Existing Studies:

tracking performance for [18x275](#) and [10x275](#) beam, DIS, NC, Q2>1

1. Single pi+ study

Goal:

compare the tracking resolutions with 5 vs 10um Au coating

Set up:

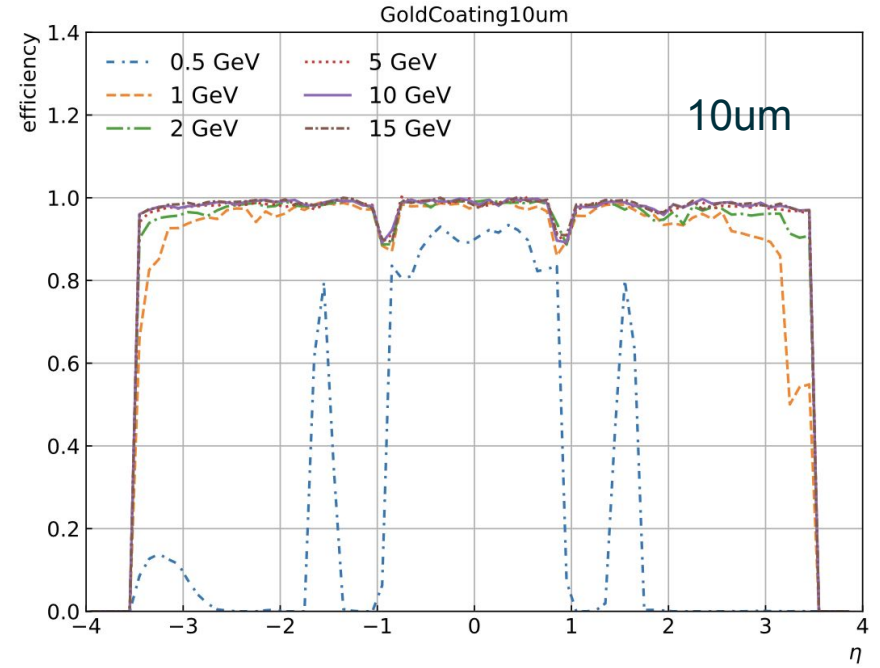
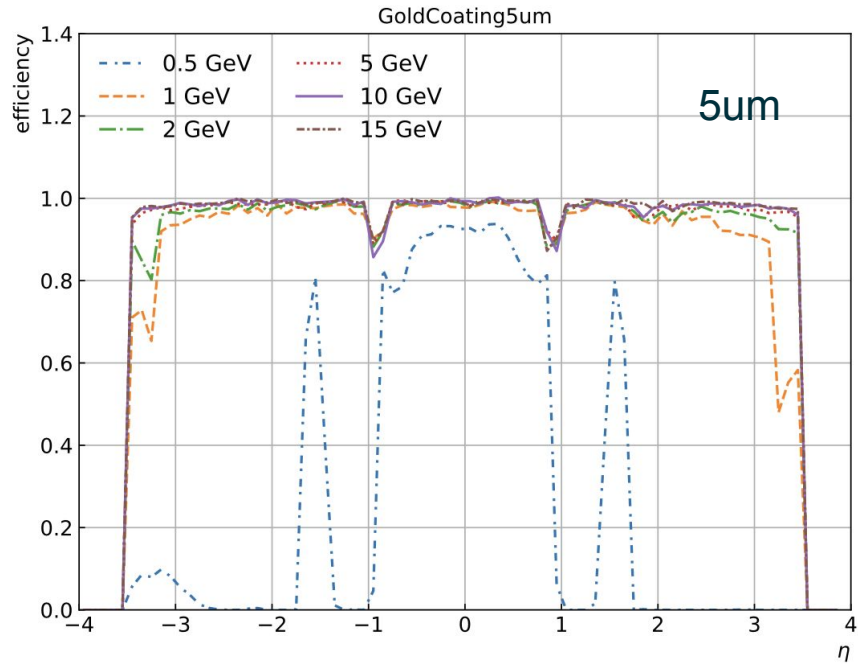
- **eic-shell:** 26.02-stable
- **epic:** commit on Feb 24, 2026

Simulations:

- 7 eta bins, fixed momentum, **uniform in phi and eta**, 10k events / setting
- Beampipe Au coating:
 - default: 5um
 - modified: 10um → updated xml + updated material map
- analysis scripts (efficiency, pull/resolution, chi2, residuals...) available on [github](#)

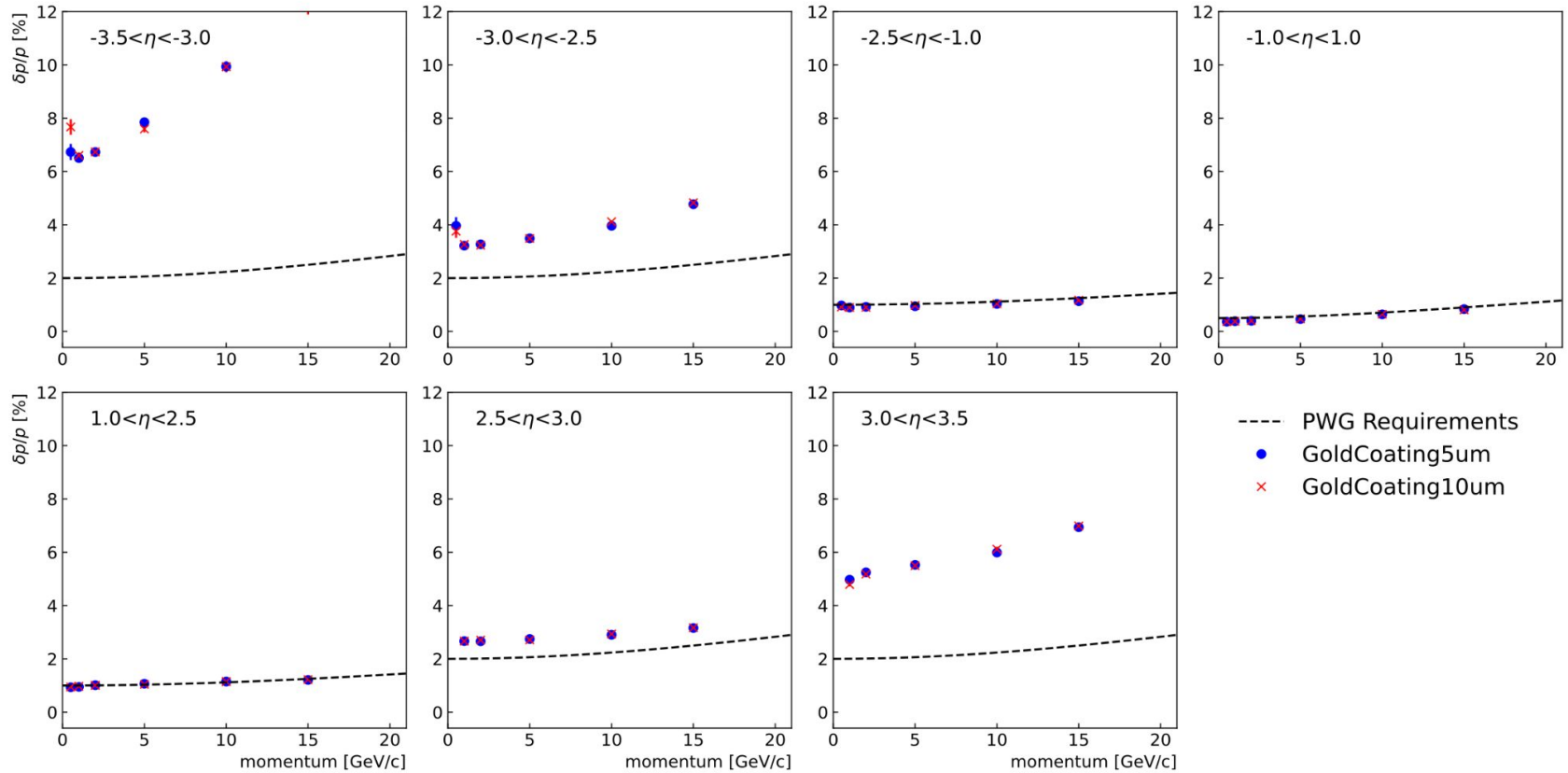
1. Single pi+ study

Impact on **Efficiency**: negligible



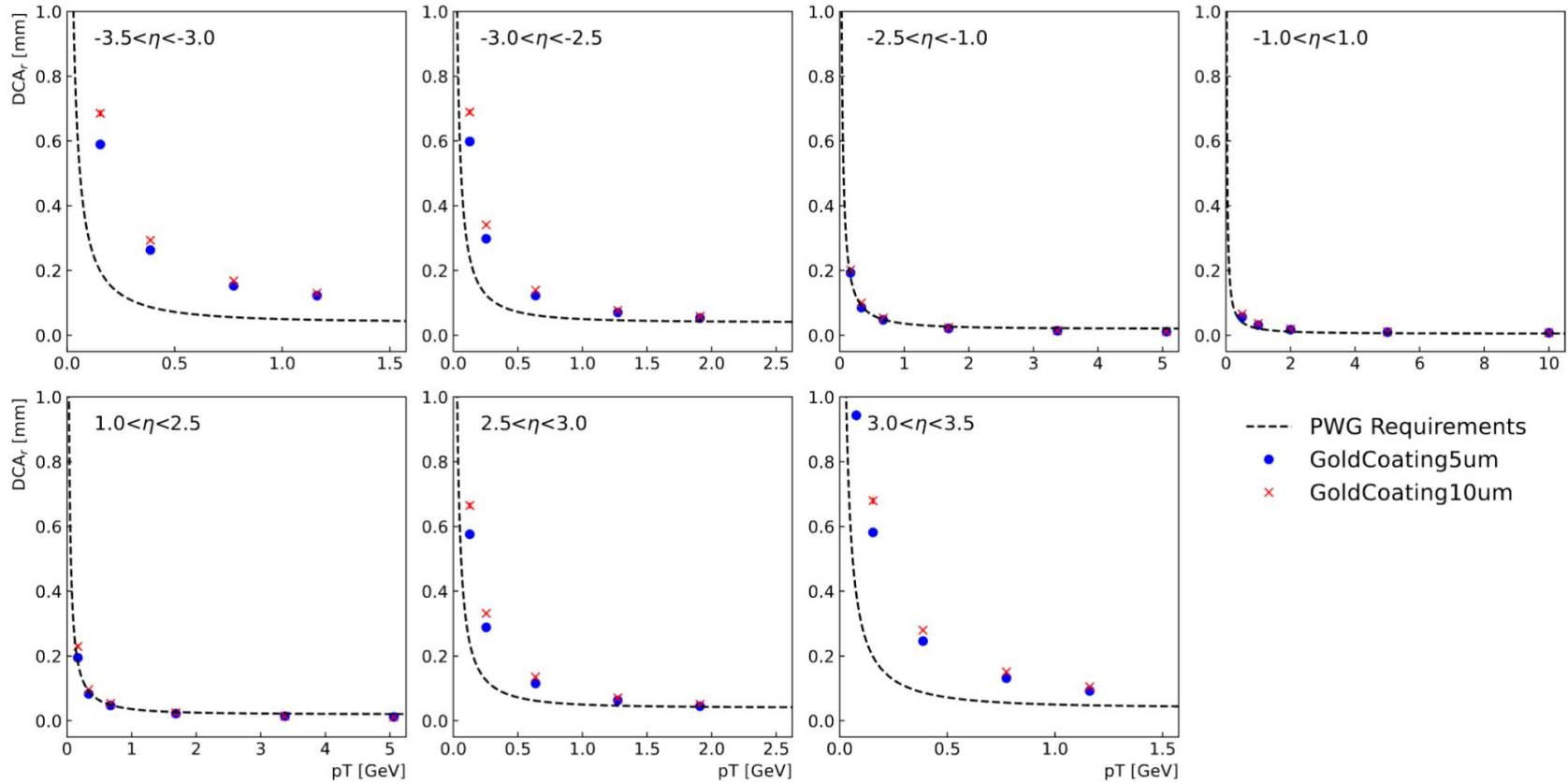
1. Single pi+ study

Impact on $d\rho/p$: negligible



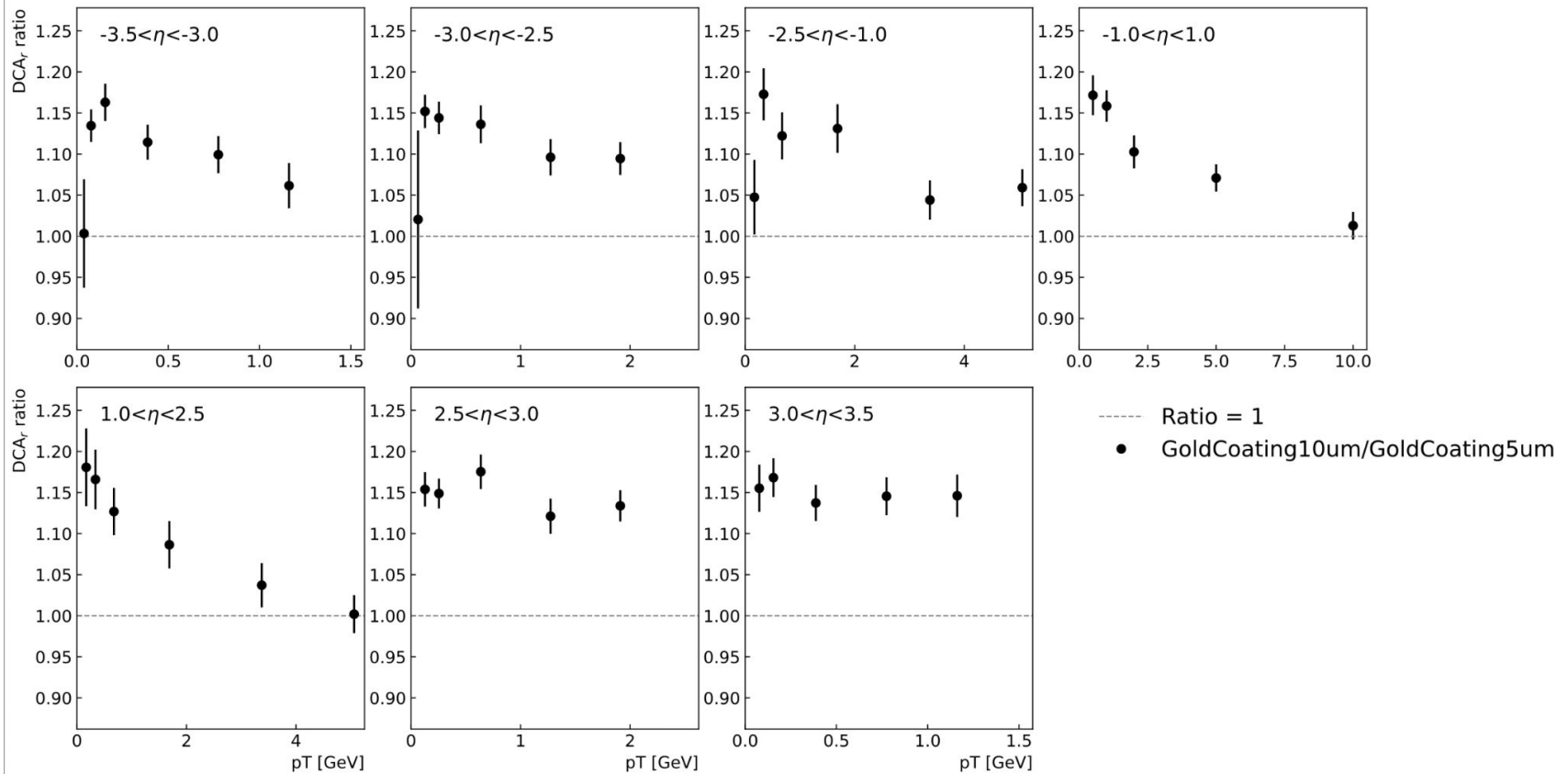
1. Single pi+ study

Impact on **DCAr**: didn't make a qualitative difference wrt requirements



1. Single pi+ study

Impact on **DCA_r** (shown in ratio): 0-20%



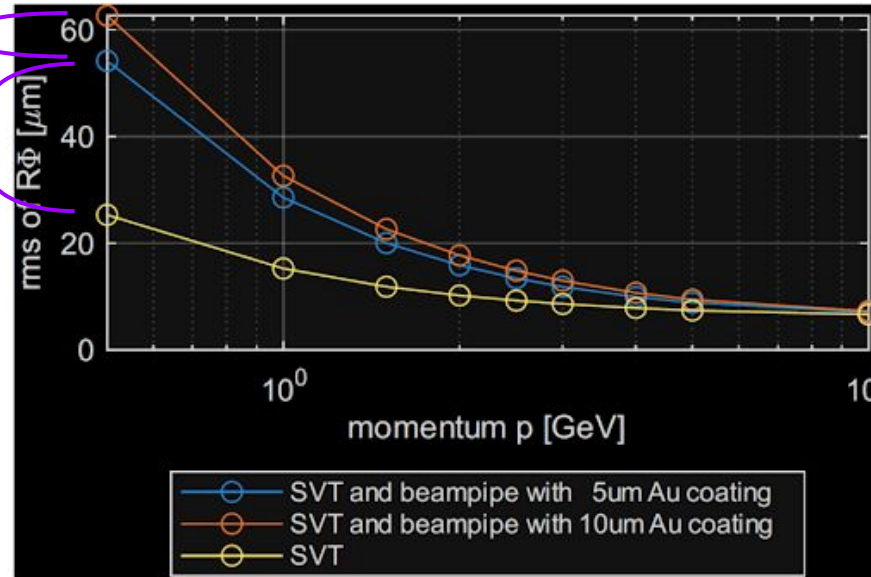
1. Single pi+ study

Impact on **DCAr**: role of beampipe

fast simulation from Ernst at eta=0

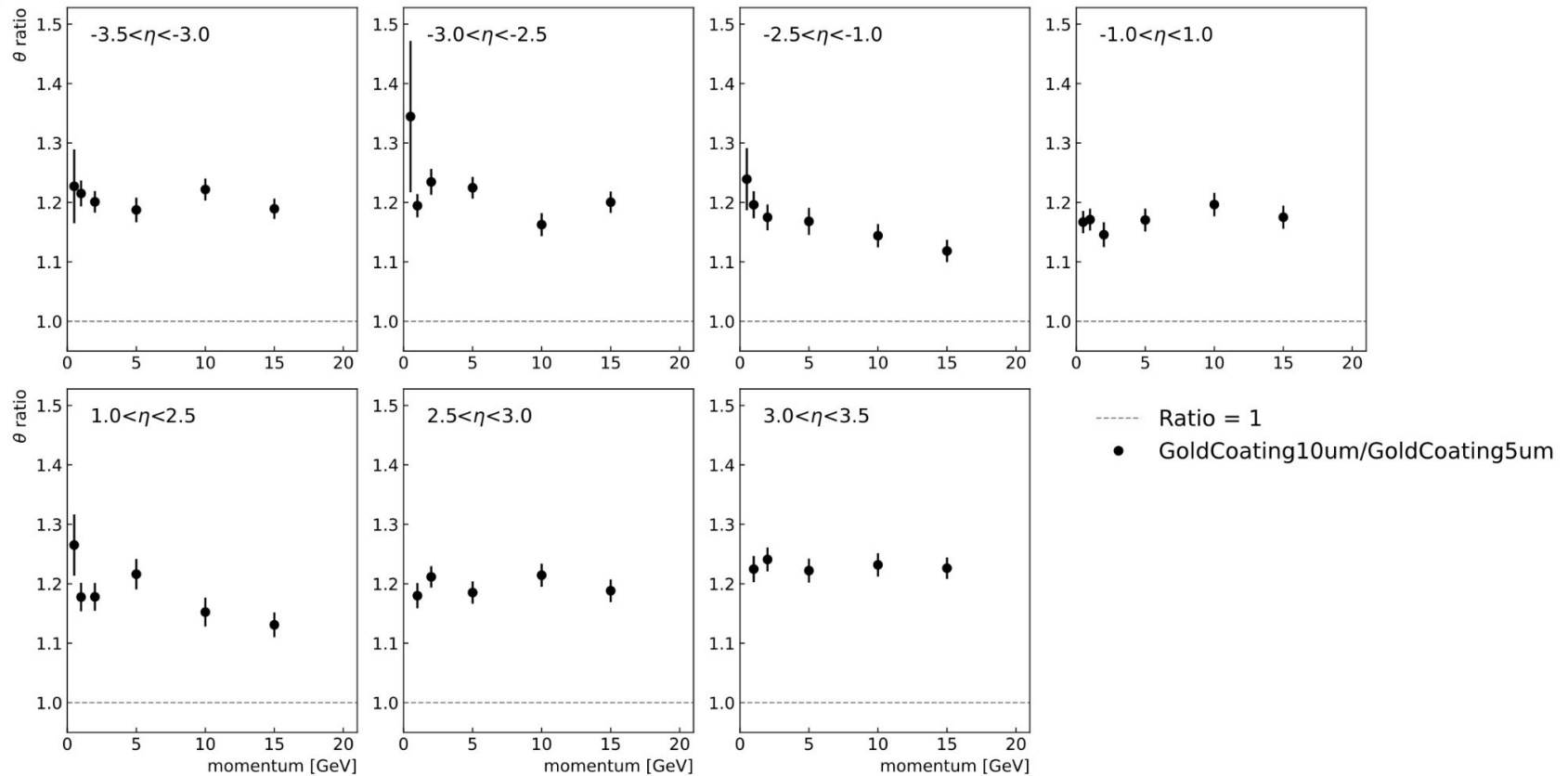
effect of the Au coating
change: 5 → 10um

effect of the entire
beampipe



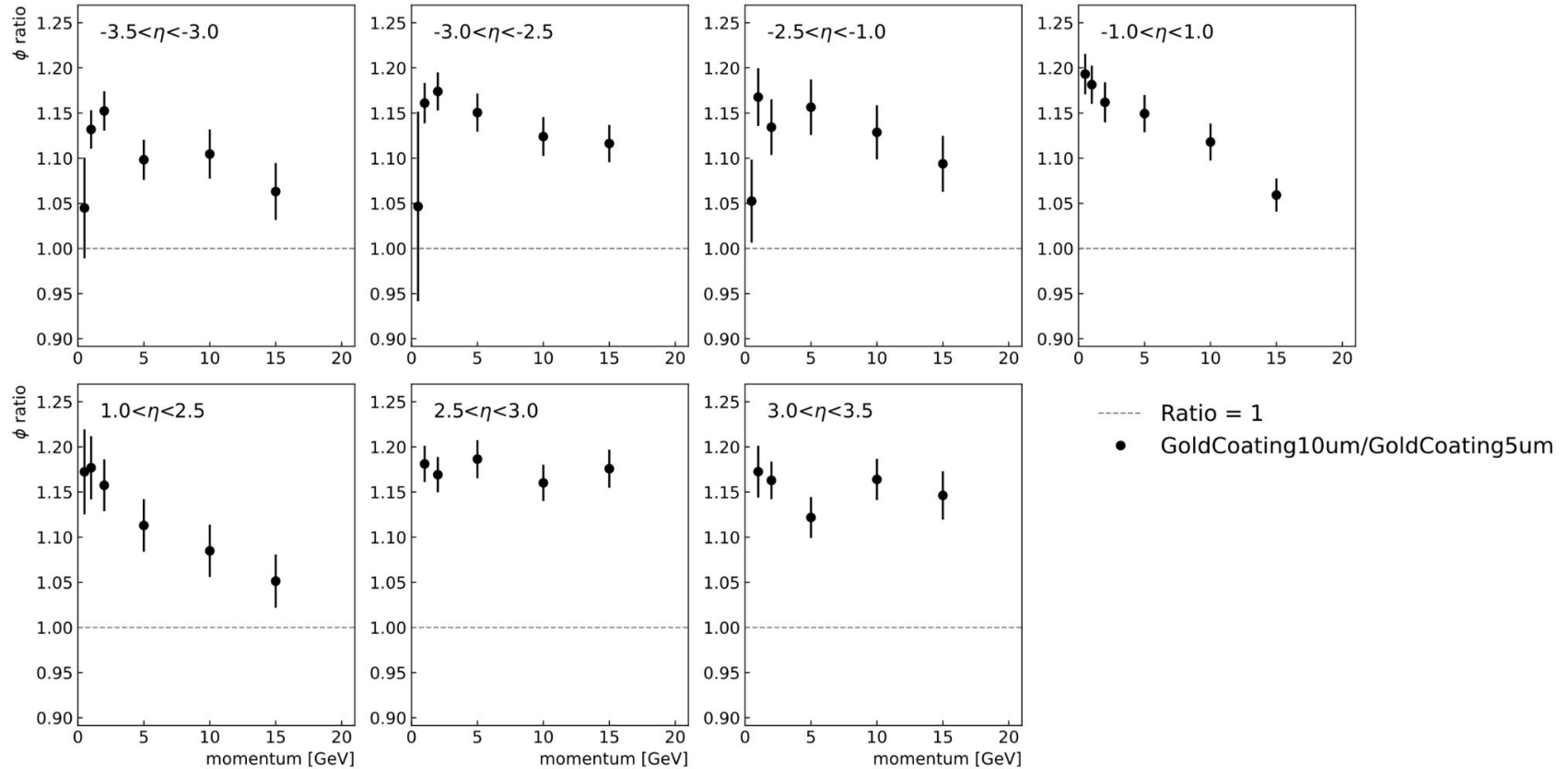
1. Single pi+ study

Impact on **theta** (shown in ratio): ~20%



1. Single pi+ study

Impact on ϕ (shown in ratio): 5-20%

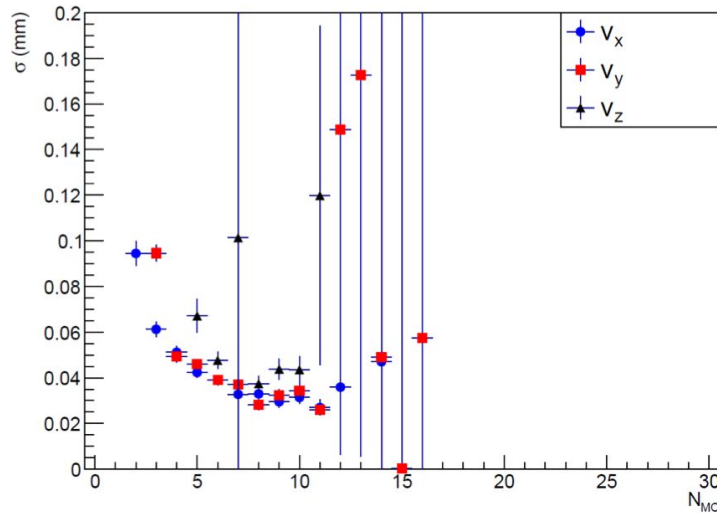


2. DIS-only Study (10x275 beam)

- Impact on **primary vertex resolution**: comparable to single particle resolutions (see [Barak's talk](#) at the tracking++ meeting)

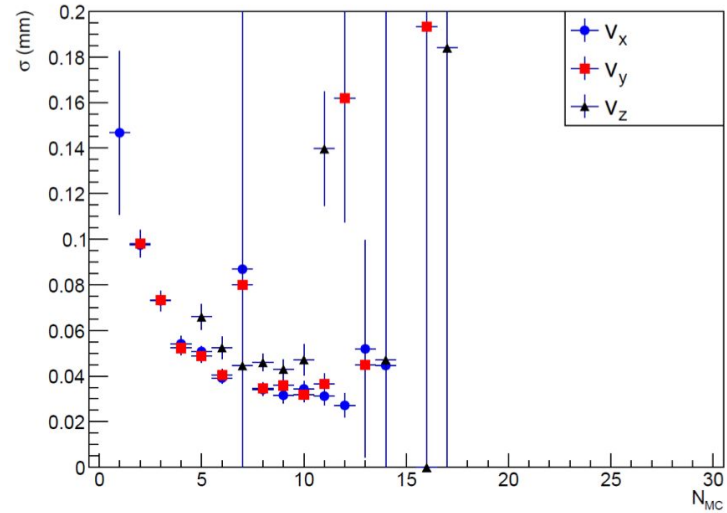
5 um gold coating

Vertex Resolution Sigma vs MC Tracks



10 um gold coating

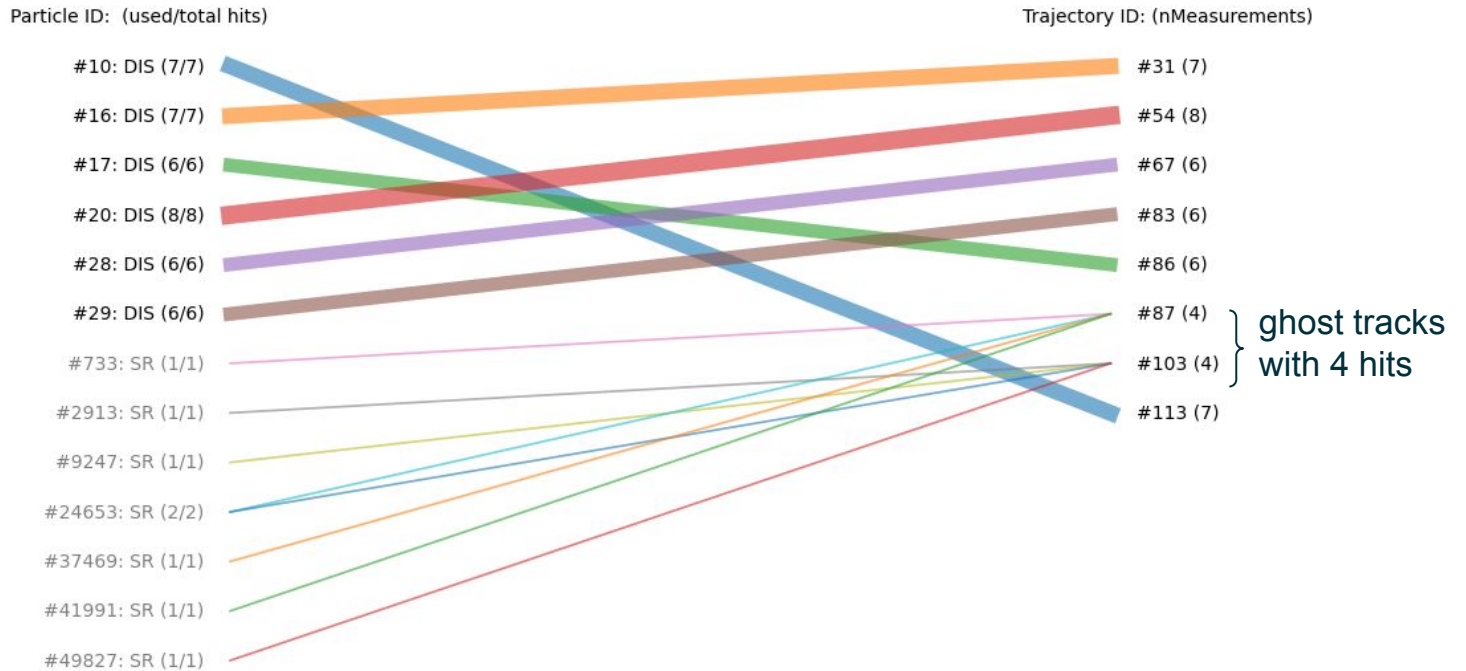
Vertex Resolution Sigma vs MC Tracks



3. DIS + All Beam Background

Hit-based Tracking Study Workflow (03.2026)

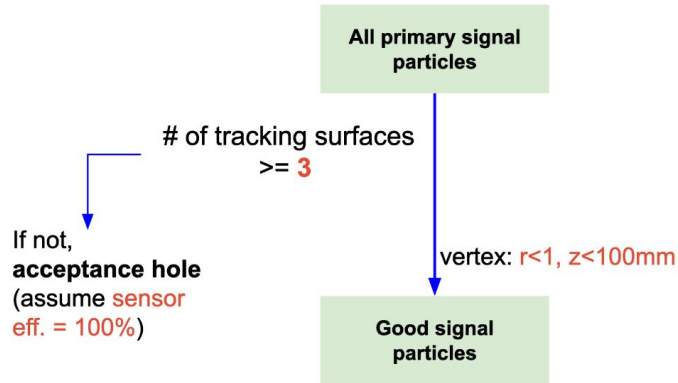
Particle to Trajectory Flow (Particles with Used Hits Only)



3. DIS + All Beam Background

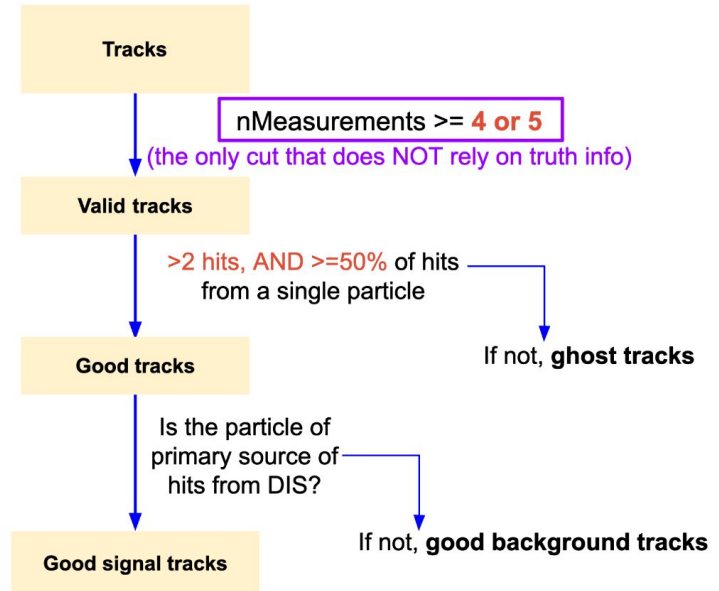
Hit-based Tracking Study Workflow (03.2026)

- Truth info from MC



❖ **Example:** if a particle leaves 3 hits, but track requires 5, then it's counted against efficiency.

- Reconstructed tracks



Tracking efficiency:

good signal particle with a good signal track / good signal particles

Tracking Purity:

good signal tracks / valid tracks

Purity of Track Hits:

In a given valid track, the fraction of hits from the particle of primary source

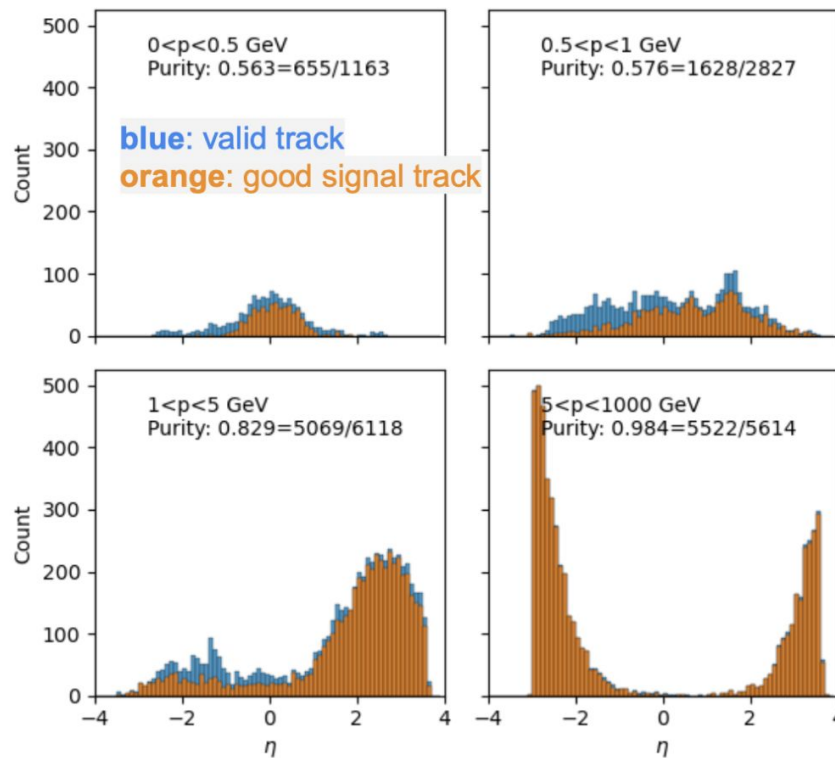
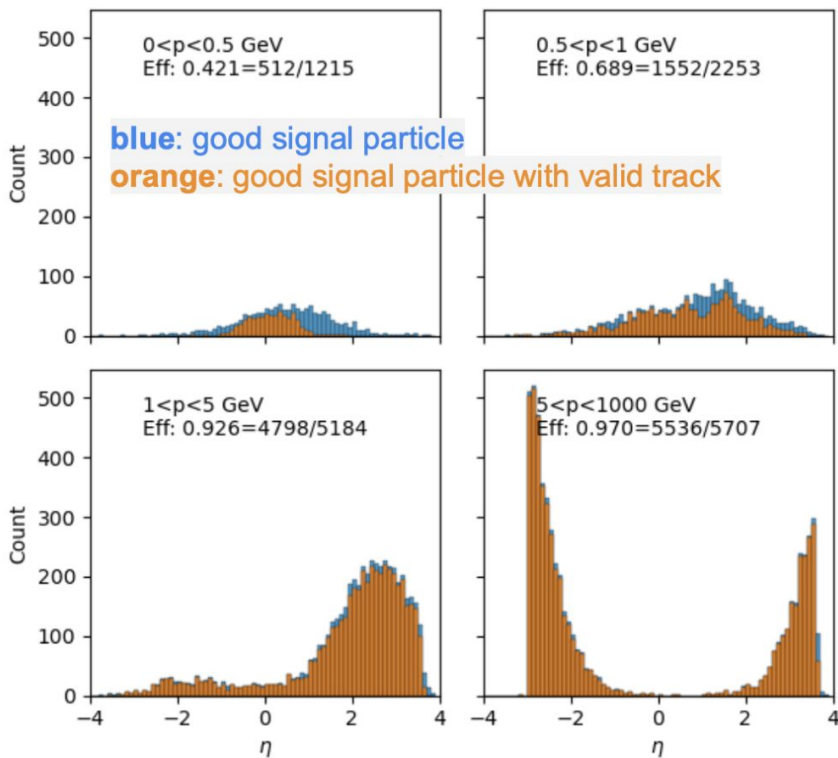
3. DIS + All Beam Background

Purity and efficiency

- 10x275 beam (highest rate), DIS, NC, $Q^2 > 1$, 10um gold coating
- ≥ 4 hits per track

Efficiency (4 hits) | 10x275, 10um | total=0.863 (12398/14359)

Purity (4 hits) | 10x275, 10um | total=0.819 (12874/15722)



3. DIS + All Beam Background

Purity and efficiency

- 5um \rightarrow 10um: both improved
- 4 hits \rightarrow 5 hits cut: lower efficiency, higher purity

❖ further improvement is expected with hit number, chi2 cut, and seed finder optimization

Au coating thickness	≥ 4 hits per track		≥ 5 hits per track	
	Efficiency	Purity	Efficiency	Purity
5 μm	0.708	0.091	0.668	0.909
10 μm	0.863	0.819	0.822	0.982

Tracking+Background Study Summary

Change in March Simulation Campaign:

- beampipe gold coating: 5um (until 2026.02) \Rightarrow 10um

Impact on tracking performance

- **Single particle (pi+) study:**
 - efficiency and dp/p: no change
 - theta, phi, DCAr: up to 20% change
- **DIS only event:**
 - <20% change in primary vertex resolution
- **DIS+background:**
 - SVT average hit rate reduced by a factor of >4 (see [my talk](#) at the ePIC Jan meeting)
 - much better purity and efficiency (with ≥ 4 hits per track cut)

NOT covered by the tracking study:

- low Q2 events being mis-identified as high Q2
 - simulation sample available for PWGs: $Q2 < 1$ + background
- background particles being mis-identified as physics signal:
 - simulation sample available for PWGs: source-by-source background simulations, no signal

Ongoing Discussions

1. Minimum number of hits per track:

Coordinator: Barak Schmookler

- Default (2026.03): **3 hits**
- Related settings in EICrecon:
 - CKF tracking [config](#)
 - Ambiguity Solver [config](#)
 - Primary Vertex Finder [config](#) → [previous study](#) with 3 hits have issues.
Needs to check vertexing performance with 10um coating and 4 hit cut
- Learned from tracking studies:
 - 3 → 4 hits: much better purity, slightly lower efficiency
 - 4 → 5 hits: trade off between purity and efficiency
- Each physics WG is strongly encouraged to check this cut dependence with your physics channels of interest.
- Plan to **change the default** from 3 to 4 hits if it will not hurt the physics analysis concerning the detector acceptance gaps.

Ongoing Discussions

2. Understand the impact of detector (SVT etc) bad channels

Coordinators: Ernst Sichtermann(SVT), Barbara Jacak(Tracking), Rachel Montgomery (PWG)

- **Question:** detector can have bad channels, modules... What is the **acceptable** percentage?
- **Need plan and coordination:**
 - **Tracker:**
 - in EICrecon, update the digitization algorithm to randomly disable a fraction of sensor units at a given tracking surface
 - Check the impact on tracking through the standard set of performance studies
 - **Other detectors:**
 - is similar study desired?
 - **PWGs:**
 - Acquire simulation with disabled sensor channels, evaluate the impact on specific physics, define “acceptable”.

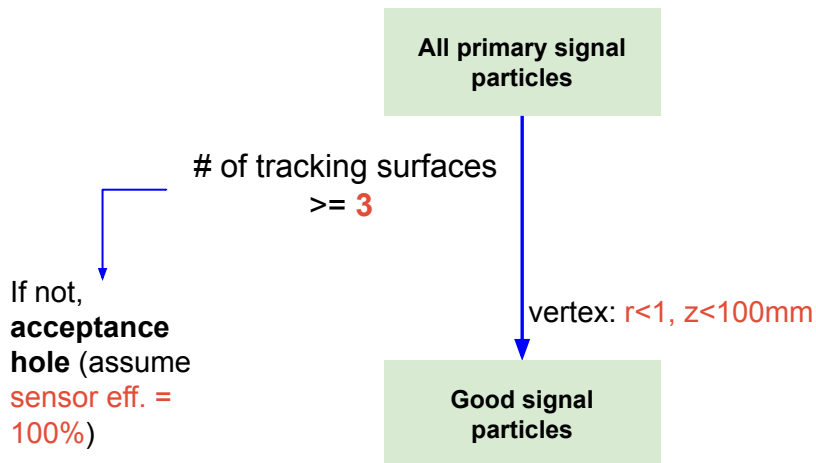
Summary

- The March simulation campaign introduced major change in background studies due to the 10um beampipe gold coating
- For your physics analysis, please [use March or later simulation campaign](#) (instead of Feb) to get the complete sets of impact on resolutions (up to 20%) and purity/efficiency.
- Tracking performance study is done with $Q_2 > 1$ DIS + all background. Please look into other background mix schemes as needed, i.e. $Q_2 < 1$ + background, and source-by-source pure background.
- [\$\geq 4\$ hits per cut](#) is recommended for analysis. Please check the impact carefully. The official reconstruction file (tracking, vertexing etc) are produced with the [default 3 hits per track](#) cut. May change the default to 4 in the near future.
- Ongoing studies on [acceptable level of detector bad channels](#) need inputs from PWGs.

Backups

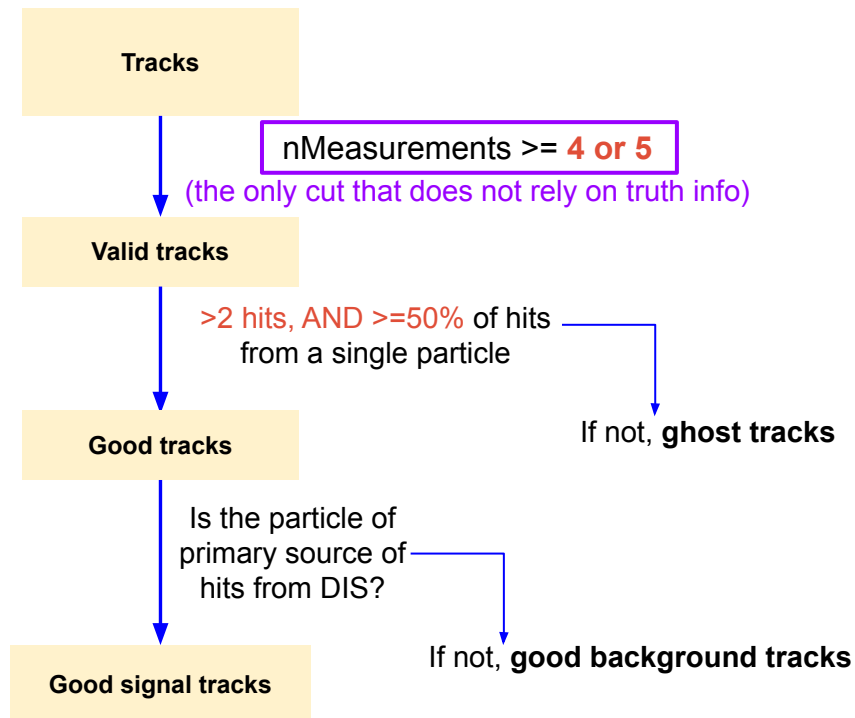
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Tracking Purity:

good signal tracks / valid tracks

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March Simulation Campaign Recap

Impact on tracking performance (with highest beam background rate from 10x275 beam)

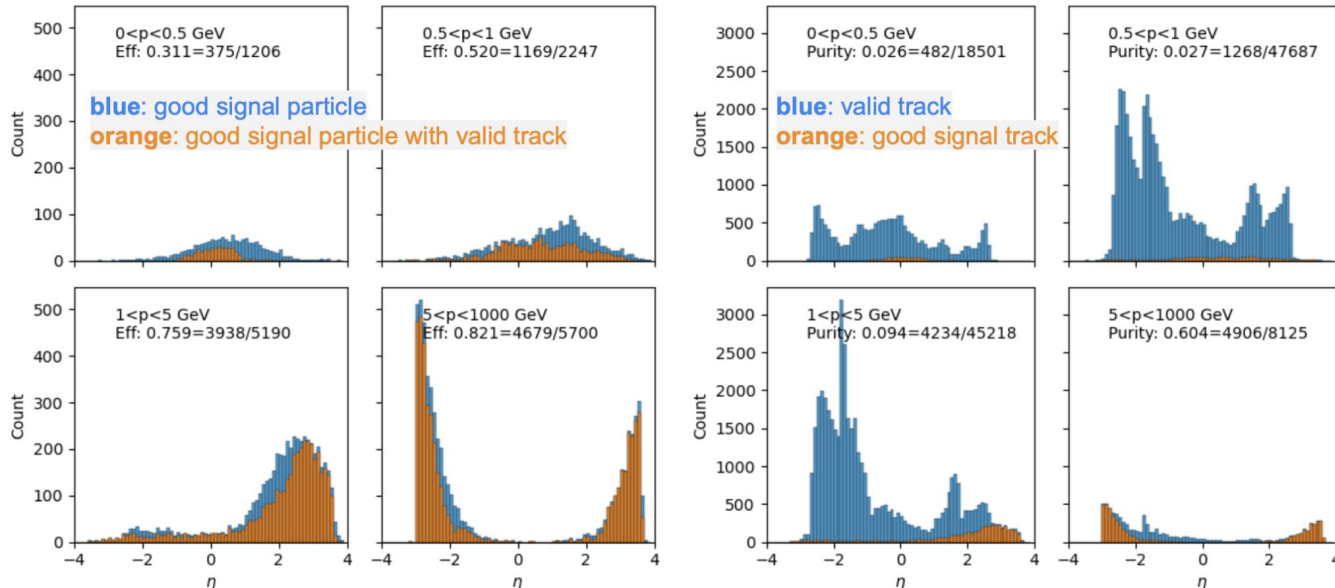
- DIS+background:

- **purity and efficiency:** significantly better with 10um coating with 4 hits per track cut, thanks to the reduced number of background hits.

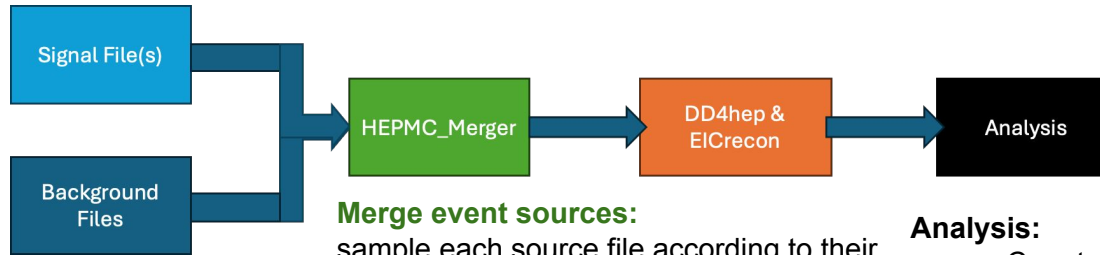
10x275, 5um gold coating, at least 4 hits per track: low efficiency, very low purity

Efficiency (4 hits) | 10x275, 5um | total=0.708 (10161/14343)

Purity (4 hits) | 10x275, 5um | total=0.091 (10890/119531)



Signal+Background Event Samples



Merge event sources:

sample each source file according to their frequency within a fixed-length (2us) time window

Analysis:

- Count number of digitized hits on STV per area per time

One event = one collision

→ merged

One event = one 2us time slice that contains (in this presentation):

- One $Q^2 > 1$ GeV² NC DIS events
- Beam background at calculated freq. (new SR, new [electron](#) Bremsstrahlung, Coulomb, Touschek, proton beam gas)

rates in kHz	10x275 GeV	18x275 GeV
	2.5A@10kAhr	0.227A@10kAhr
DIS eA	/	/
electron Synchrotron Radiation		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

- Electron beam-gas rates consider larger region of -5 to +15 meters along the IP, hadron beam-gas rates consider region of -5.5 to +5 meters.
- For more details on background sources, check the ePIC [wiki](#) and also

Vertex $\text{abs}(r) < 1\text{mm}$, $\text{abs}(z) < 100\text{mm}$ seems to be a good sanity cut for DIS events

