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U.S. DEPARTMENT OF
ENERGY

Office of Science

SVT L4 and HD4 Impact Study

Shujie Li

ePIC tracking++ meeting

Aug 19, 2026

Background

Aug 14 [general meeting](#):

10:40

Status of UK In-Kind Funding

Speaker: Paul Newman (University of Birmingham, UK)



ePICReport.202608...

10:55

EIC Project News

Speakers: Dr E. C. Aschenauer (BNL), Rolf Ent (Jefferson Lab)



ePIC_08.14.2026.pp...

11:25

SVT DSC - Configuration Scenarios and Impact Evaluations

Speaker: Ernst Sichtermann (Lawrence Berkeley National Laboratory)



20260814 - SVT.pdf

Impact Study

Goal: understand the change in tracking performance without L4 and HD4.

Simulation setup:

- 2 geometry configurations:
 - epic v26.08.0
 - epic - L4 - HD4
 - L4 and HD4 detector description removed, service cable routing unchanged.
 - New material map generated
- track reconstruction:
 - eic-recon v1.40.0
 - default tracking algorithm with all available detector hits from each configuration
 - optional SVT sensor noise ($2e-7/\text{pixel}/2\mu\text{s}$)

Impact Study

Goal: understand the change in tracking performance without L4 and HD4.

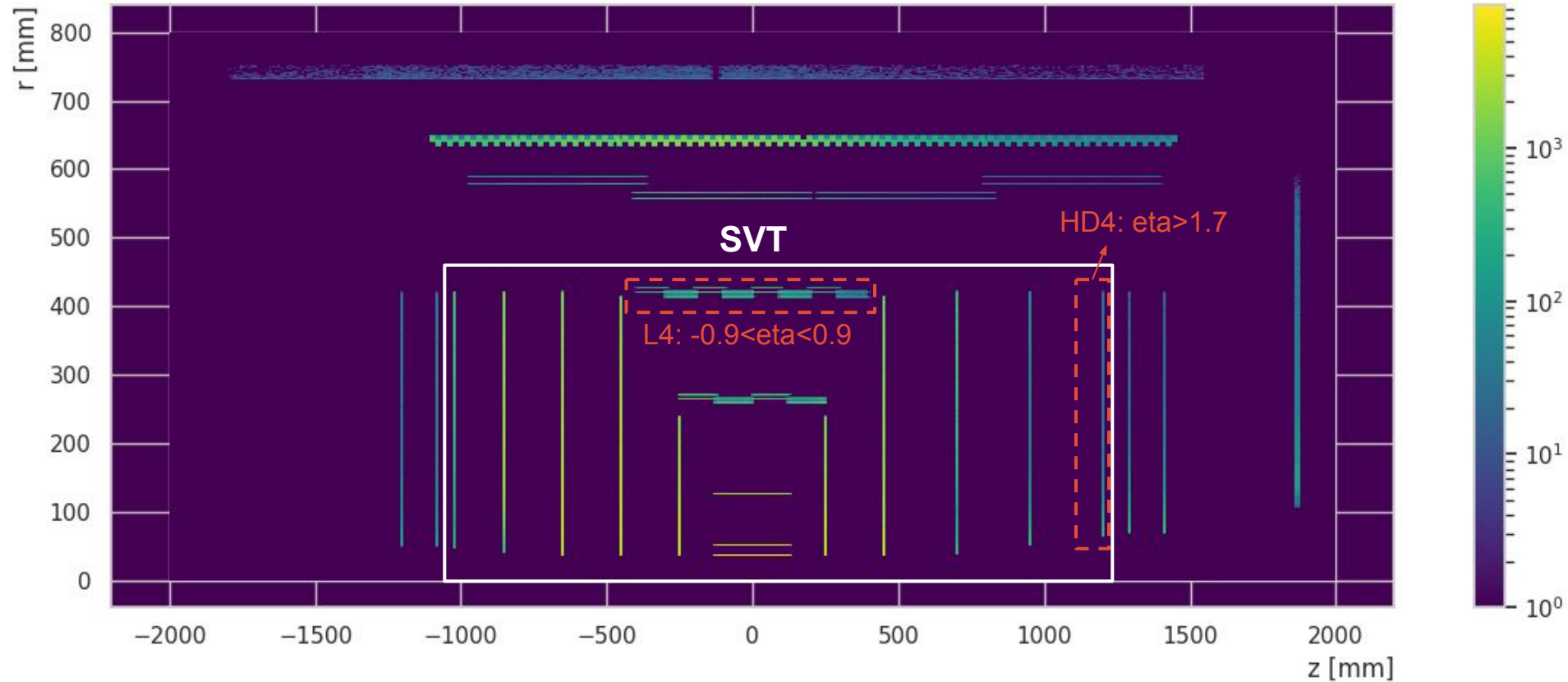
Event samples:

- single π^+ (10k events per eta and momentum bin):
 - uniformly distributed in phi and eta
 - eta [-3.5,-3], [-3,-2.5], [-2.5,-1], [-1,1], [1,2.5], [2.5,3], [3,3.5]
 - momentum 0.5, 1, 2, 5, 10, 15 GeV/c
 - check efficiency, resolutions (momentum, angle, DCAr) [[scripts](#)]
- forced DIS+all beam background (10k events in total)
 - 10x275, $Q^2 > 1$ GeV² (highest background rate)
 - The official simulation campaign didn't store hepmc source files → extract initial particles (`MCParticle.simulatorStatus==0`) from latest available npsim output at

```
root://hpcceph-xrootd.twgrid.org:1094//cephfs/epic//FULL/26.07.1/epic_craterlake/Bkg_Exact1S_2us/GoldCt/10um/DIS/NC/10x275/minQ2=1/pythia8NCDIS_10x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_1.0001.edm4hep.root
```
 - optional SVT sensor noise (2e-7/pixel/2us)
 - check efficiency, purity, momentum and angle resolutions [[scripts](#)]

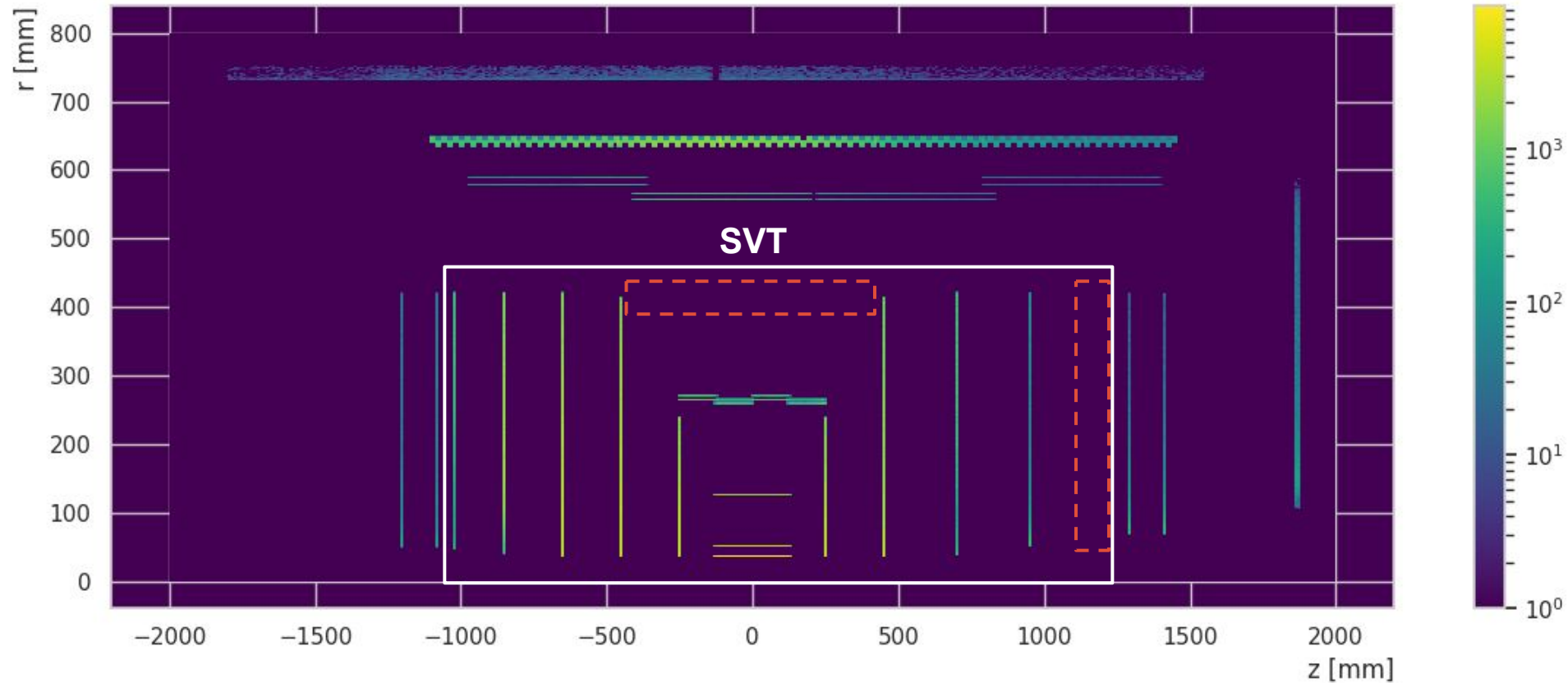
Central Tracker Hit Map

config 1: default epic



Central Tracker Hit Map

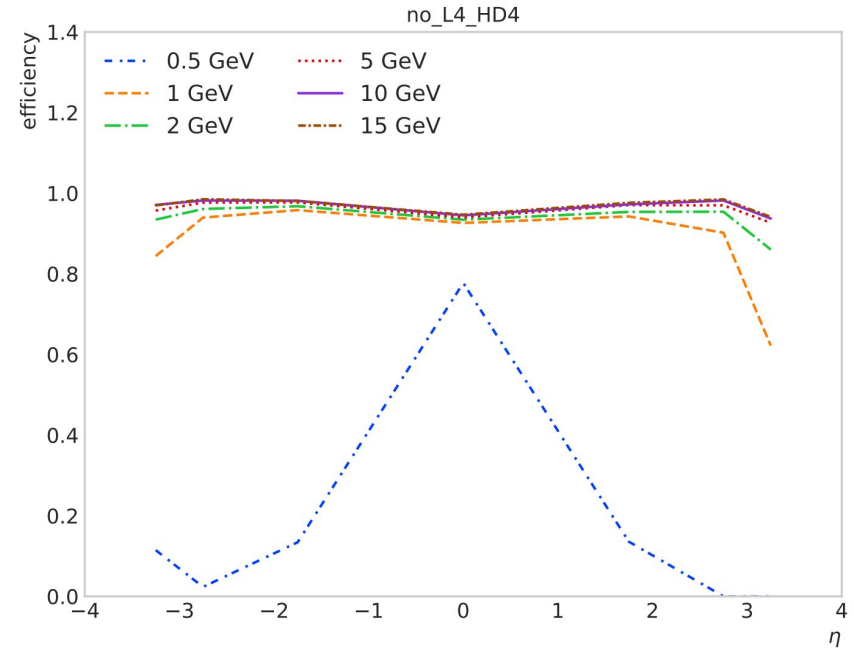
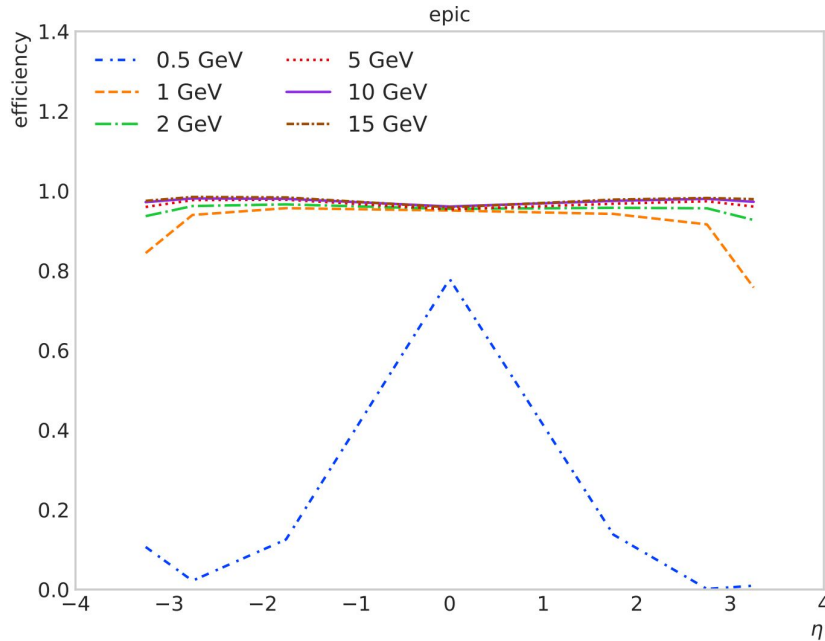
config 2: No L4, No H-Disk 4



Single Pion Results

more plots available at [\[folder\]](#)

- Efficiency integrated for each of 7 eta bins:
 - $-1 < \eta < 1$ (L4): no noticeable change
 - $\eta > 2.5$ (HD4): a few percent drop



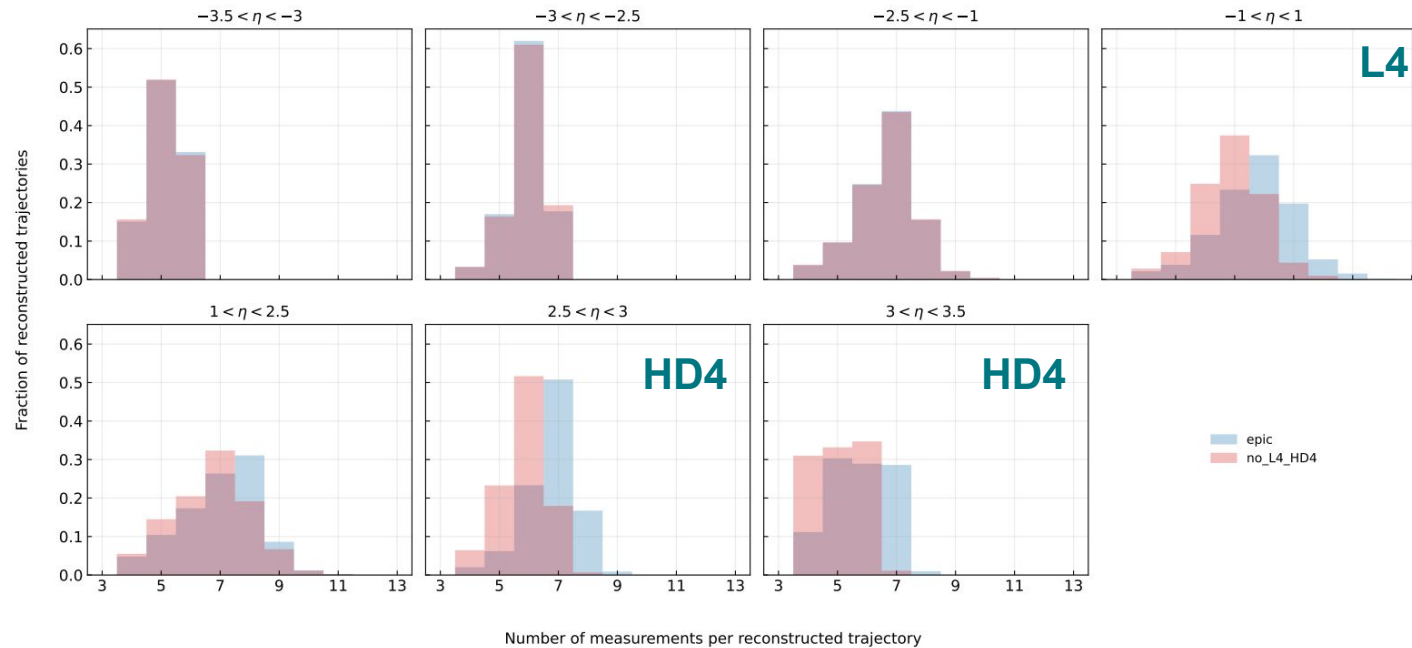
Single Pion Results

more plots available at [\[folder\]](#)

- **Number of hits per track**

- $-1 < \eta < 1$: 1 hit less
- $\eta > 2.5$: 1 hit less

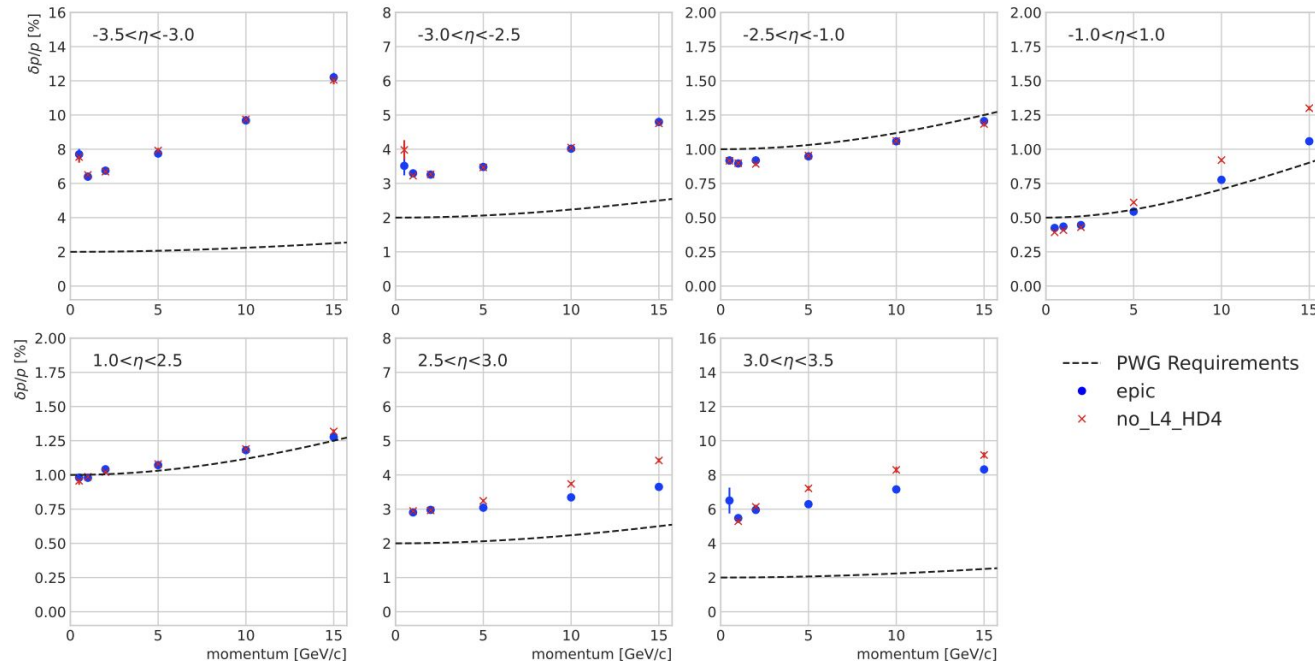
π^+ , $p = 1 \text{ GeV}/c$



Single Pion Results

more plots available at [\[folder\]](#)

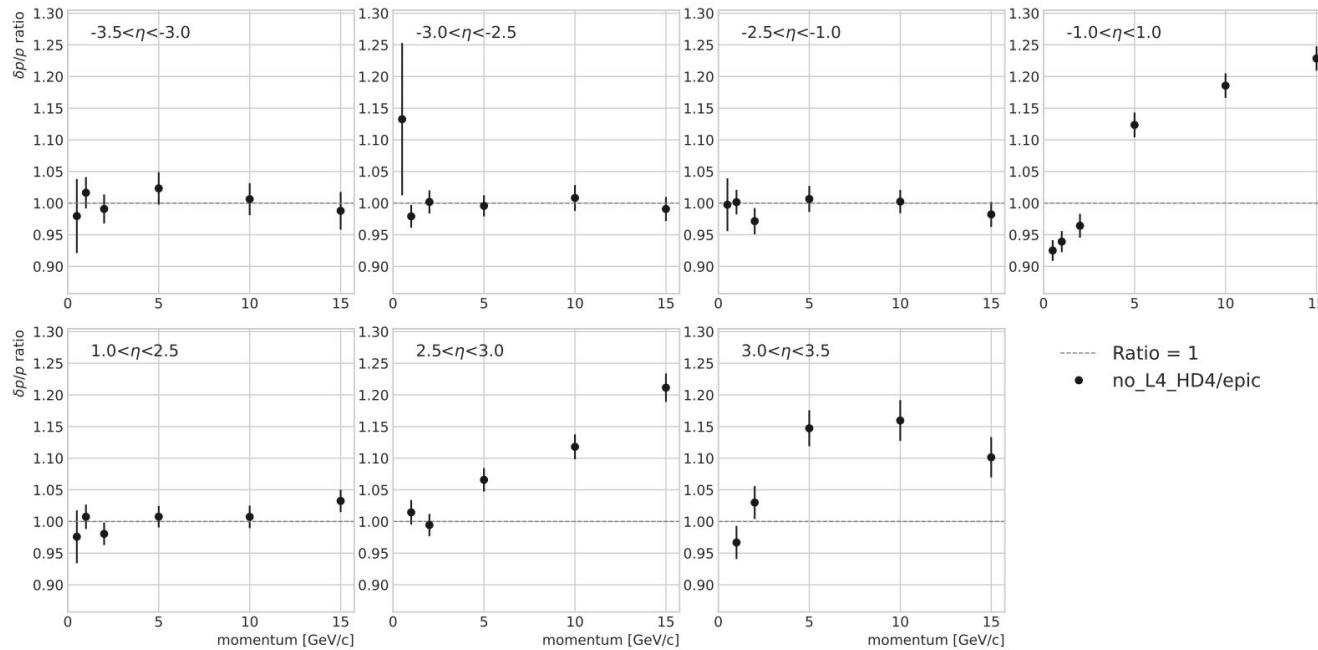
- **dp/p resolution:**
 - $-1 < \eta < 1$: up to 20% increase at high momentum
 - $\eta > 2.5$: up to 20% increase at high momentum



Single Pion Results

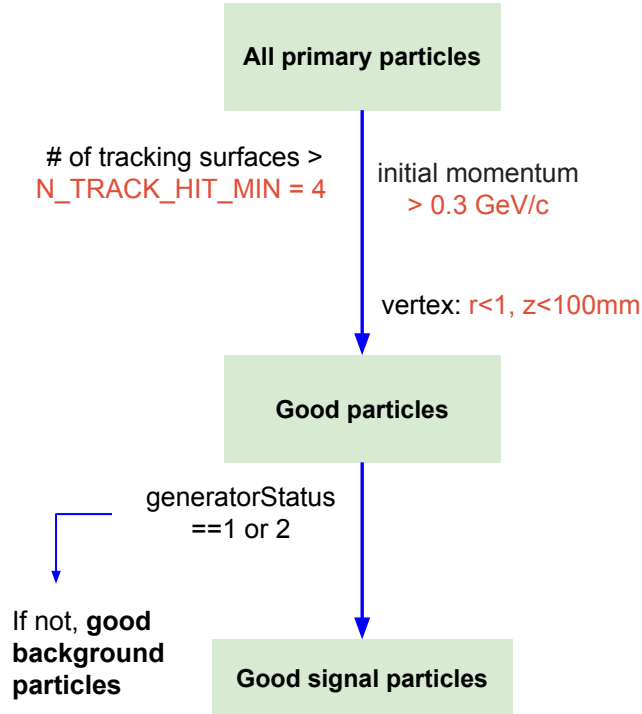
more plots available at [\[folder\]](#)

- **$\delta p/p$ resolution:**
 - $-1 < \eta < 1$: up to 20% increase at high momentum
 - $\eta > 2.5$: up to 20% increase at high momentum



DIS + Background Analysis

- Truth info from MC

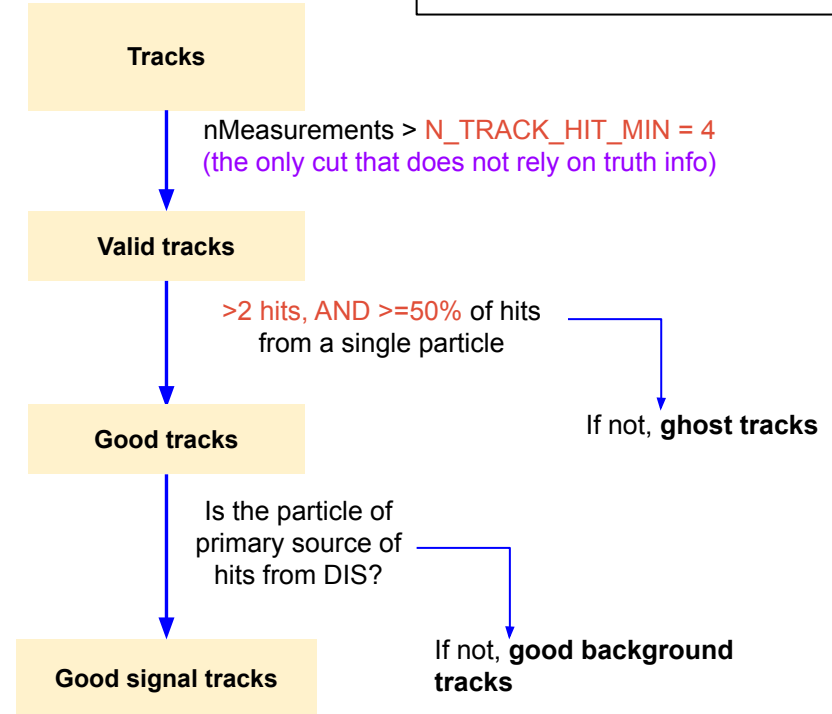


Tracking efficiency:

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

- Reconstructed tracks

RED text: tunable parameters



Tracking Purity:

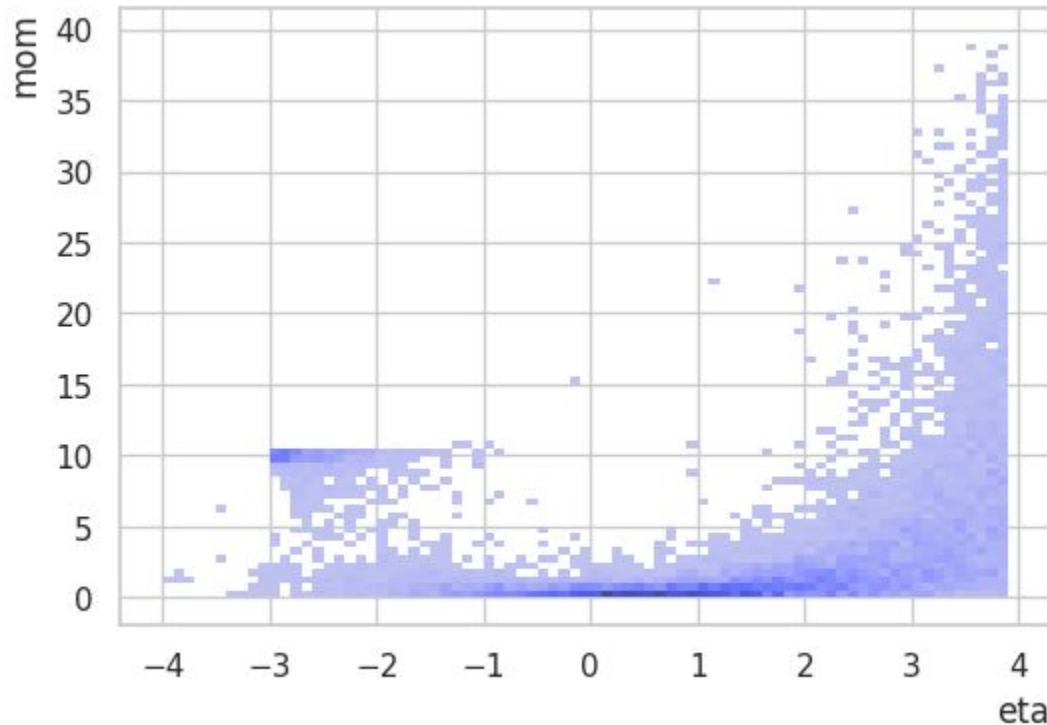
good signal tracks / valid tracks

Inspect DIS Kinematics

DIS kinematics from pythia8NCDIS_10x275_minQ2=1_beamEffects_xAngle=-0.025_hiDiv_4

- $-1 < \eta < 1$: mostly low momentum tracks
- $\eta > 2.5$: widely spread in total momentum

⇒ will show analysis results in four momentum bins of [0, 0.5, 1, 5, 1000] GeV



epic vs. no_L4_HD4

- no noise
- $p > 0.3 \text{ GeV}/c$
- eta range:
 - $[-4,4]$
 - $[-1,1] \rightarrow$ focus on L4

epic ($-4 < \eta < 4$)

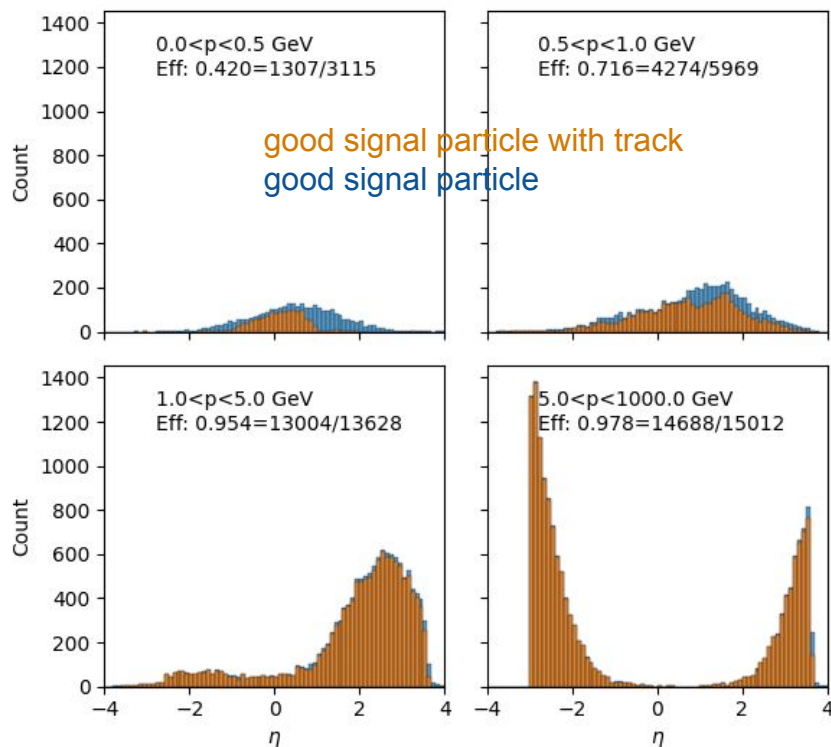
Efficiency:

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

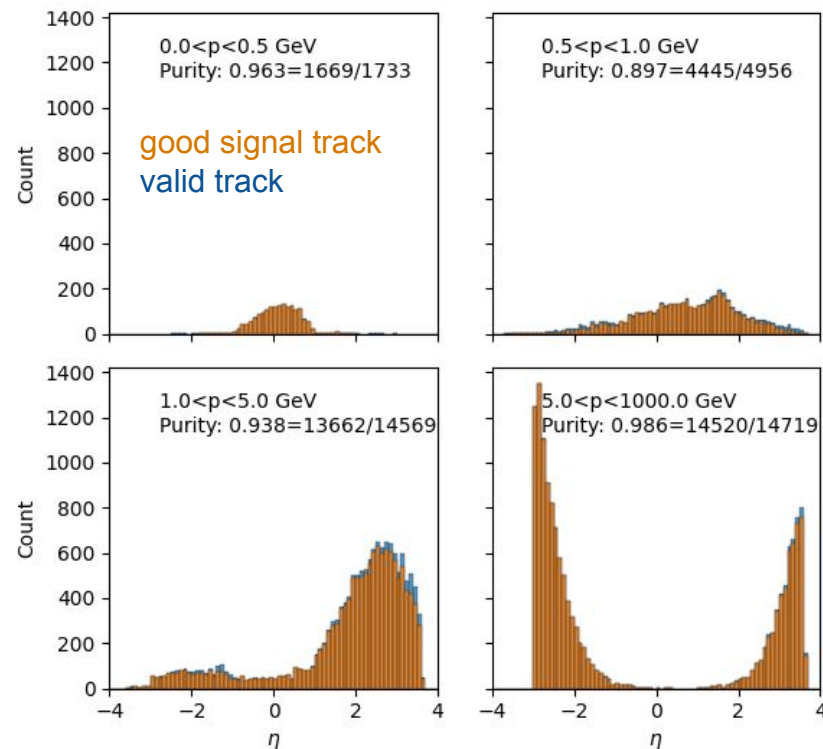
Purity:

good signal tracks / valid tracks

Efficiency (4 hits) | 10x275, epic | total=0.882 (33273/37724)

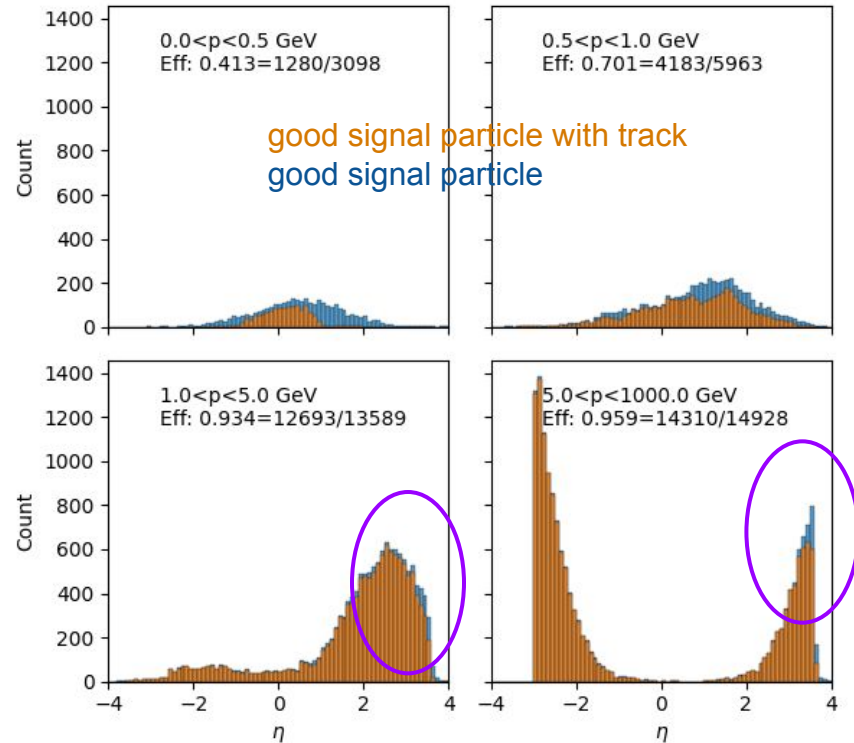


Purity (4 hits) | 10x275, epic | total=0.953 (34296/35977)

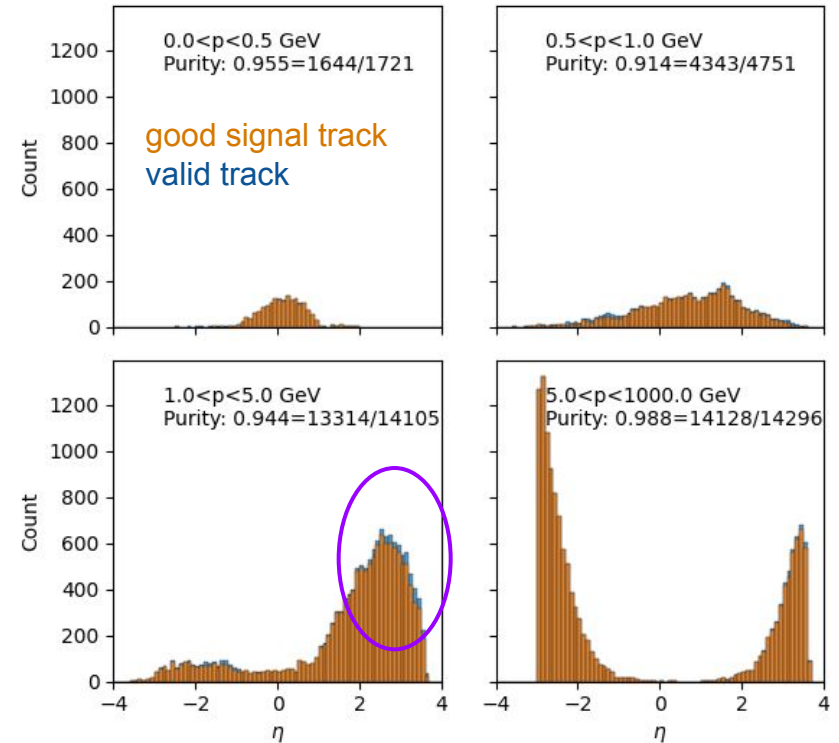


no_L4_HD4 ($-4 < \eta < 4$) : slightly lower efficiency, comparable purity

Efficiency (4 hits) | 10x275, no_L4_HD4 | total=0.864 (32466/37578)

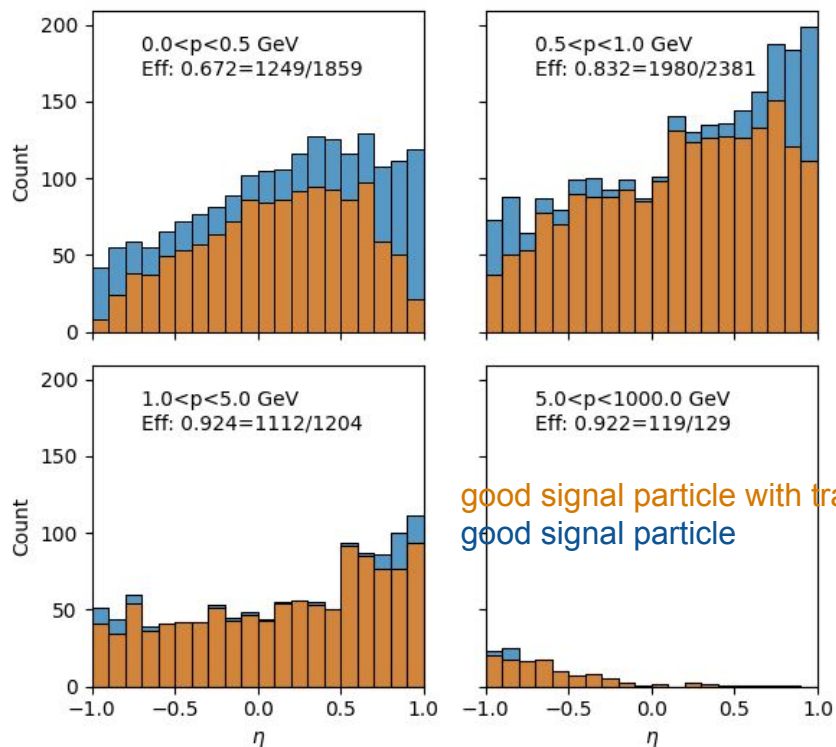


Purity (4 hits) | 10x275, no_L4_HD4 | total=0.959 (33429/34873)

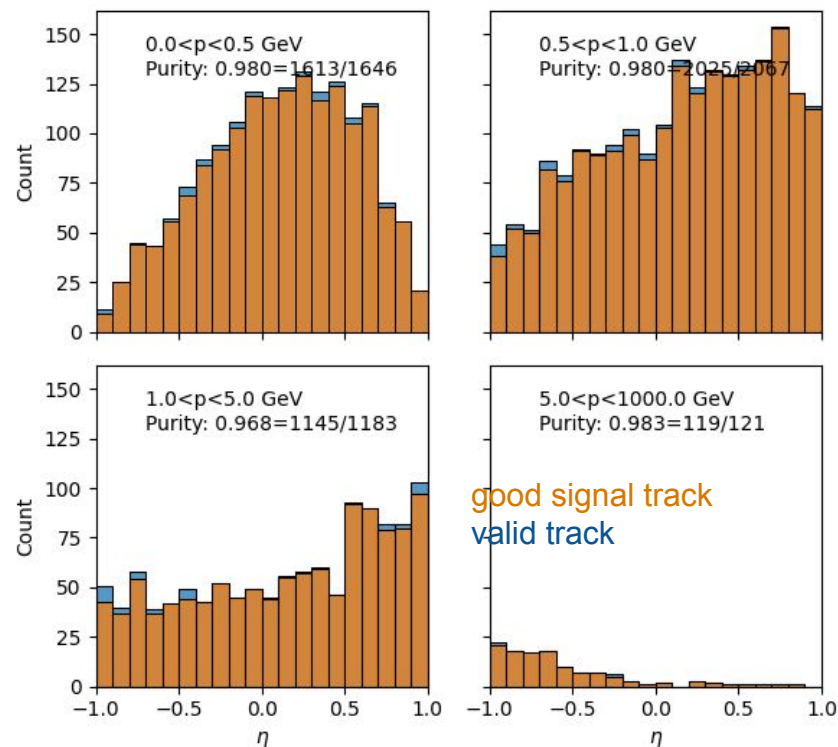


epic: ($-1 < \eta < 1$ for L4)

Efficiency (4 hits) | 10x275, epic | total=0.800 (4460/5573)

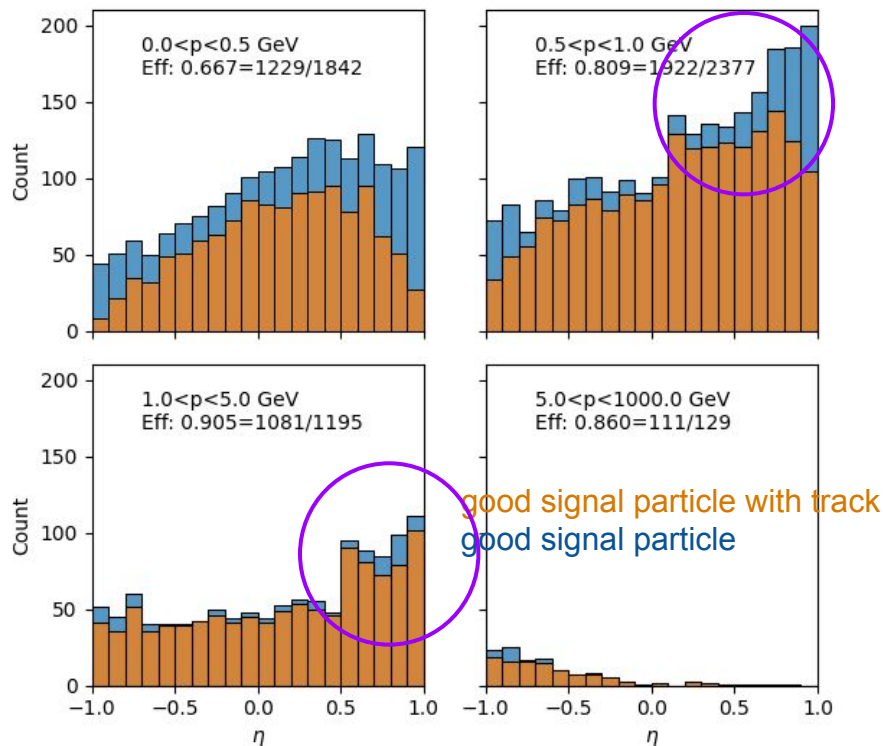


Purity (4 hits) | 10x275, epic | total=0.977 (4902/5017)

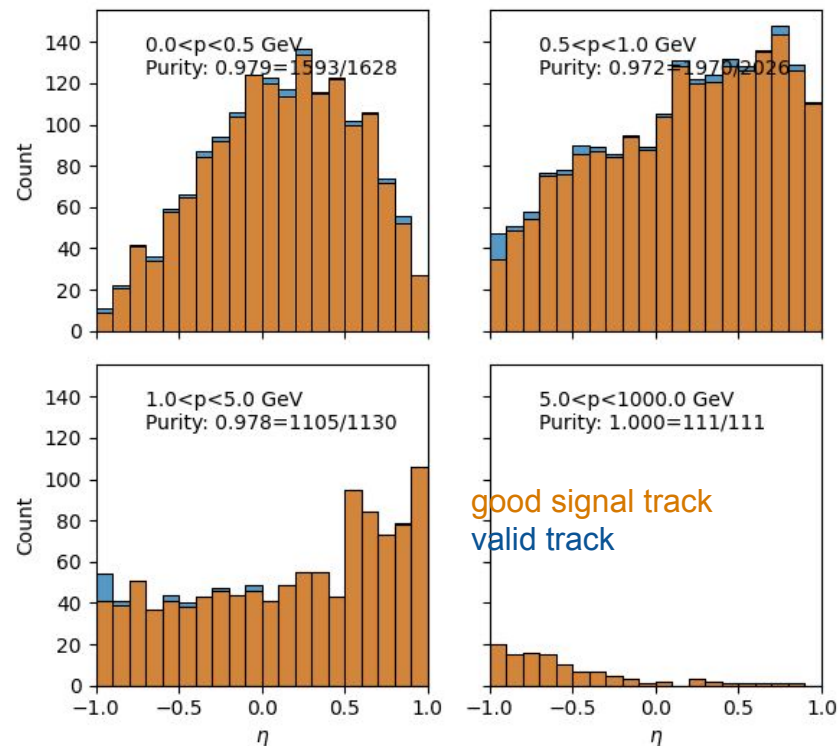


no_L4_HD4 (-1<eta<1 for L4): slightly lower efficiency, comparable purity

Efficiency (4 hits) | 10x275, no_L4_HD4 | total=0.784 (4343/5543)

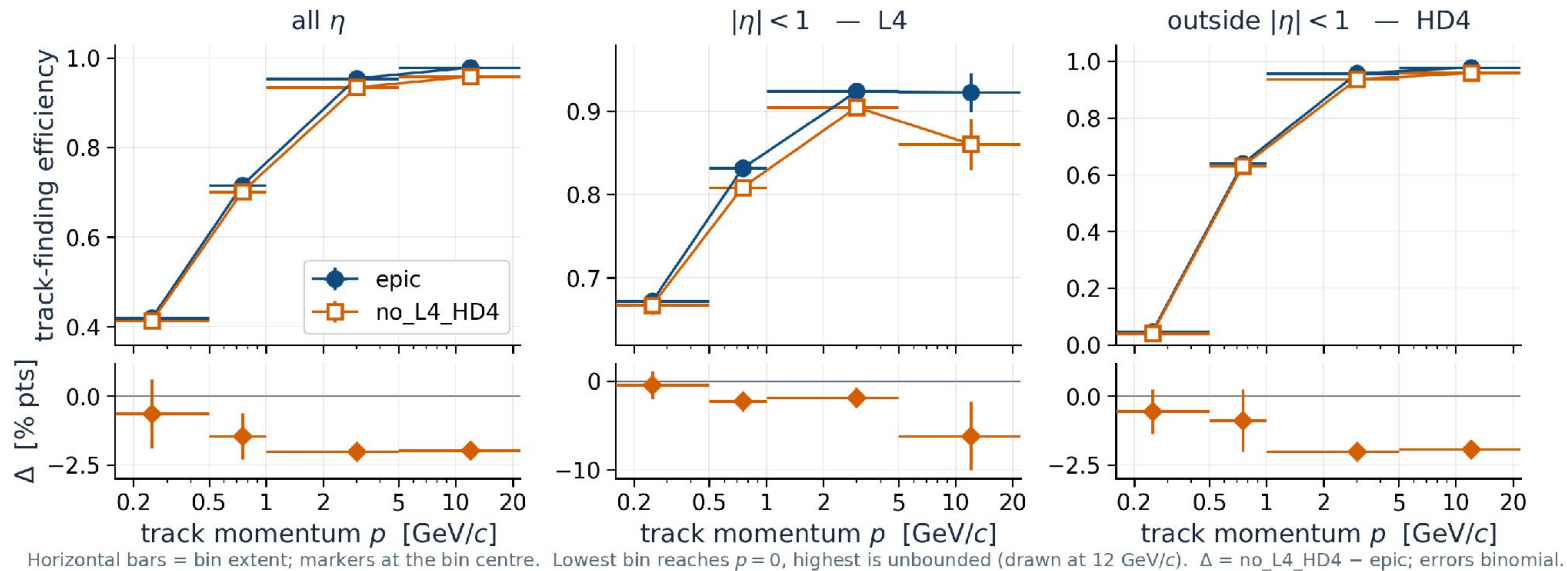


Purity (4 hits) | 10x275, no_L4_HD4 | total=0.976 (4779/4895)



Simulated efficiency summary — by region, so both components are visible

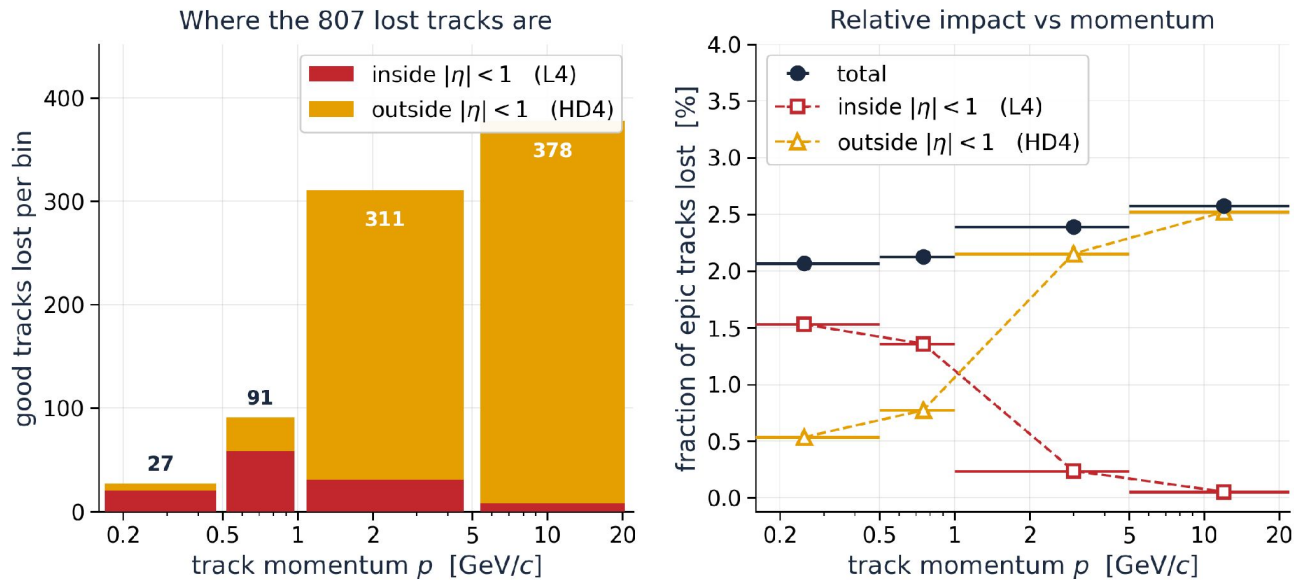
Track-finding efficiency, full simulation — 10×275, forced DIS + background, no noise



Same full simulation. Left: all η . Centre: $|\eta| < 1$, the L4 acceptance. Right: outside $|\eta| < 1$, which contains HD4.

Simulated track losses – acceptance

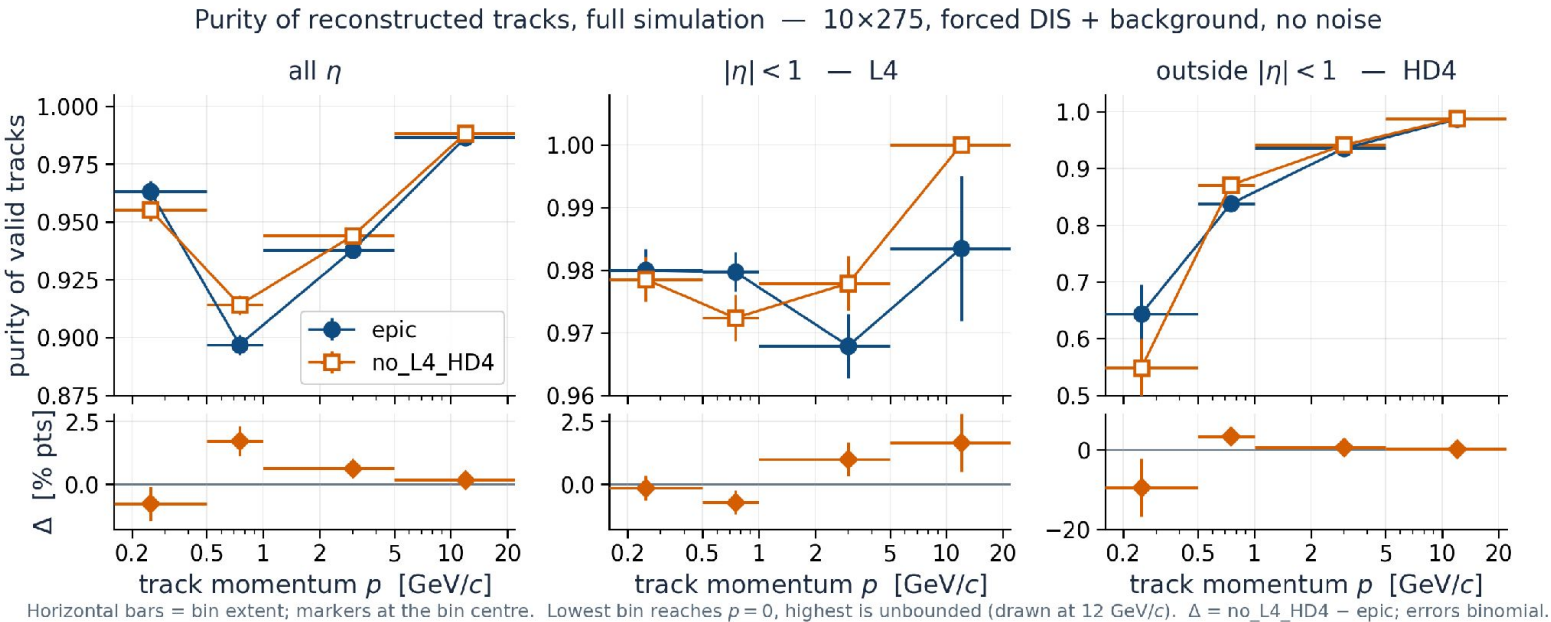
Decomposition of the efficiency loss by acceptance — full simulation, no noise



L4 covers $|\eta| \leq 0.9$ and HD4 $1.8 \leq \eta \leq 3.7$, so the two η slices separate them. 690 of the 807 lost tracks (85%) lie outside $|\eta| < 1$.

Same full simulation. Loss split by the two disjoint acceptances of slide 4. Counts include both acceptance and reconstruction effects.

Simulated purity of reconstructed tracks — by region



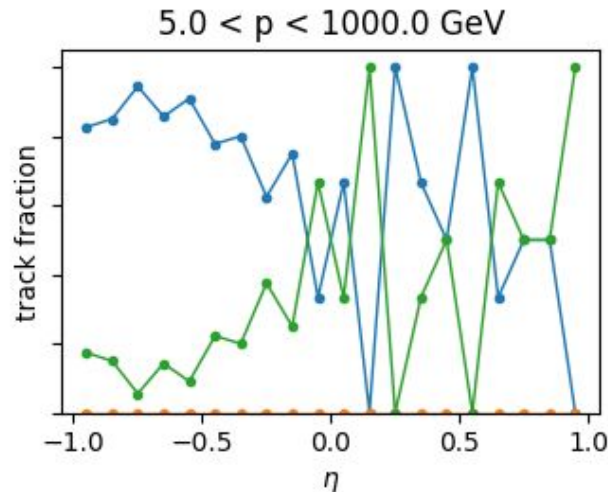
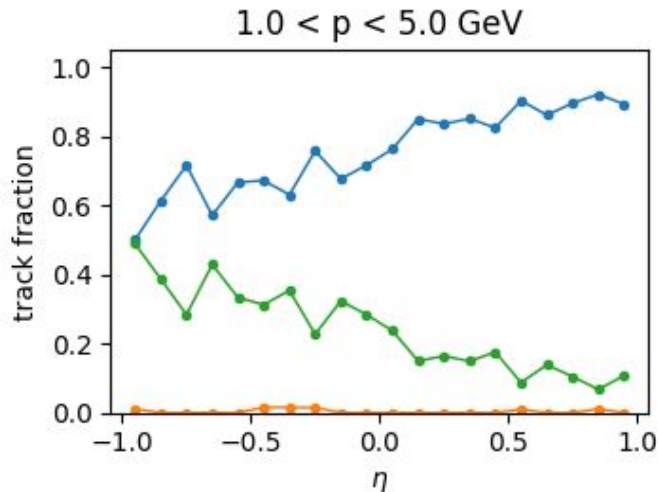
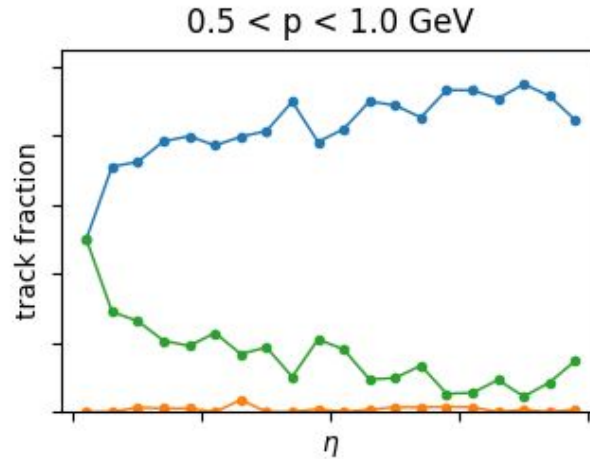
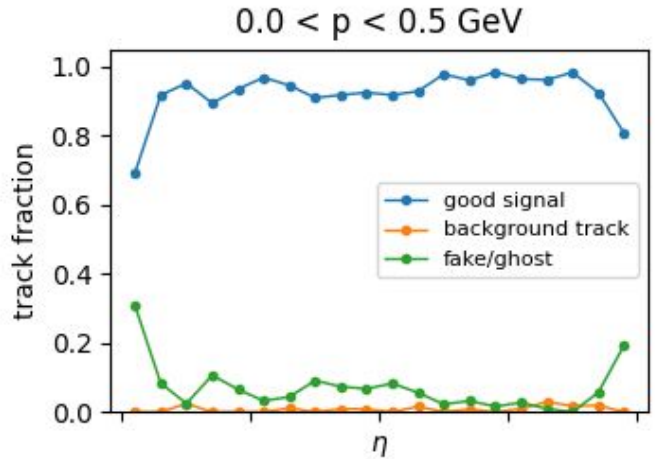
Purity is unchanged within the sensitivity of this study. Pure tracks are still found with the deferred or descoped SVT configurations in current simulations including backgrounds.

epic vs. no_L4_HD4

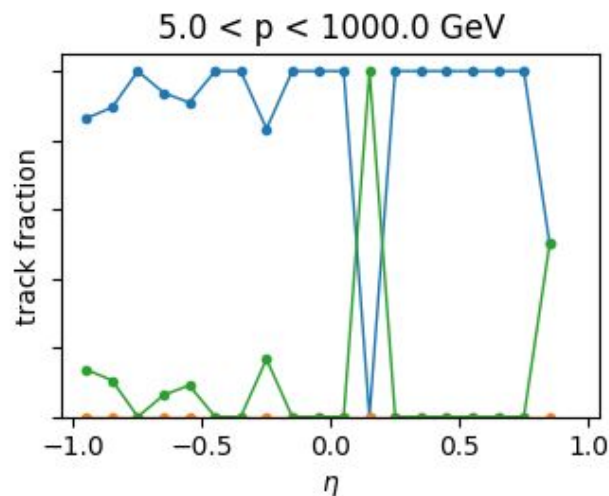
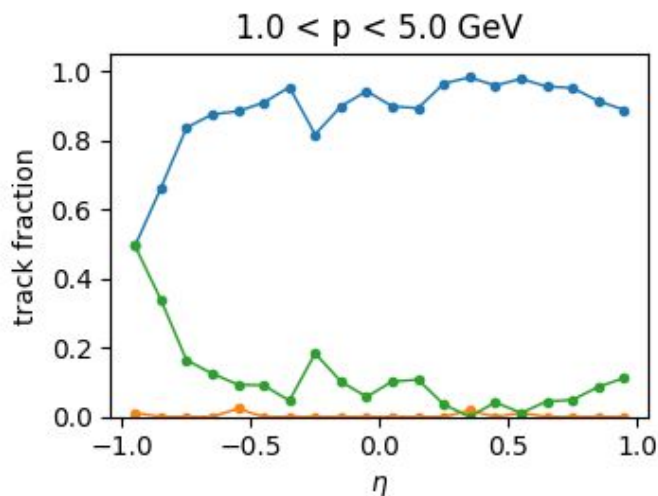
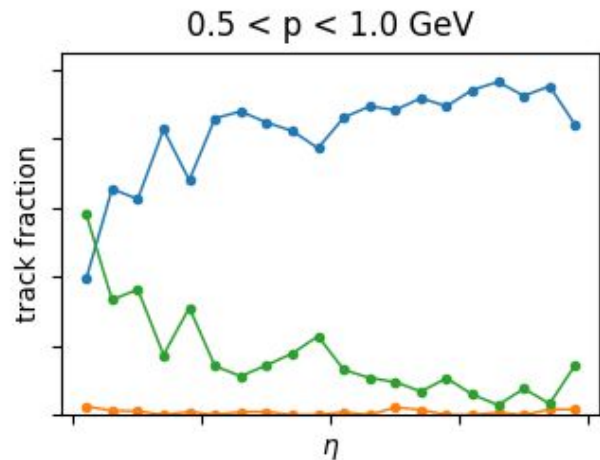
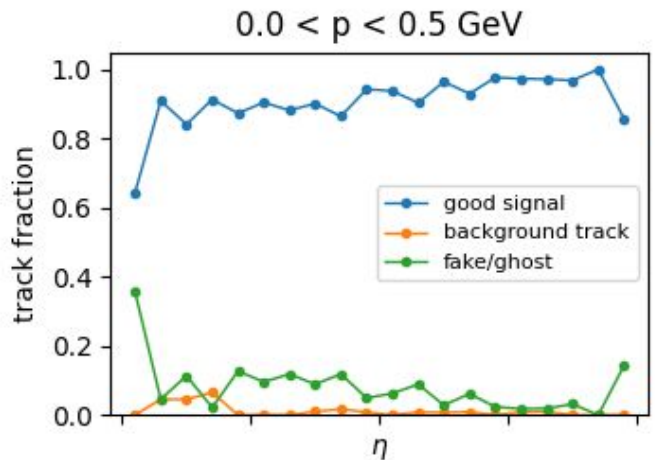
- with $\text{FHR} = 2\text{e-}7/\text{pixel}/2\text{us}$
- $p > 0.3 \text{ GeV}/c$
- eta range:
 - $[-1,1] \rightarrow$ focus on L4

Track classification | epic_noise

epic with noise, $-1 < \eta < 1$



valid tracks =
good signal tracks +
background tracks +
ghost / noise tracks

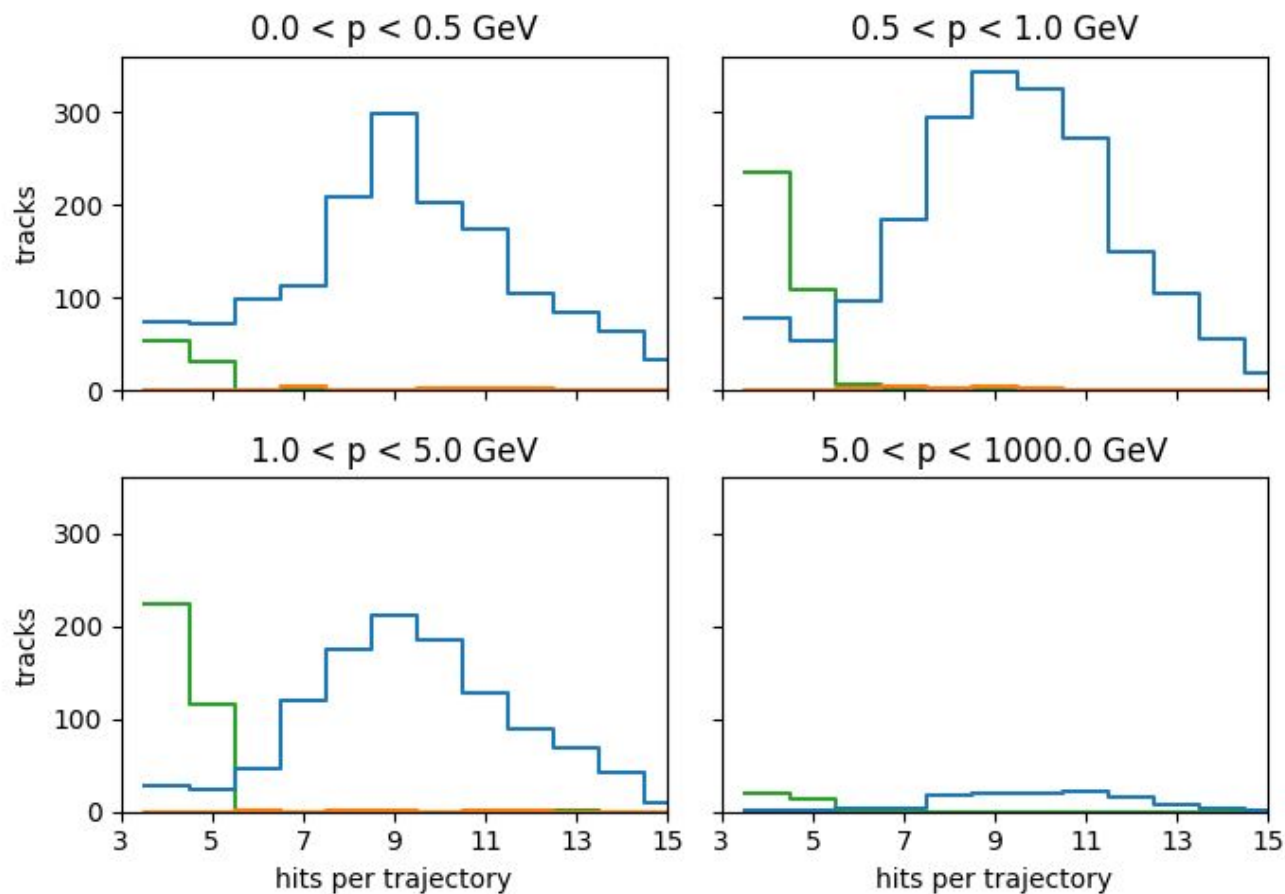
no_L4_HD4 with noise, $-1 < \eta < 1$ 

valid tracks =
 good signal tracks +
 background tracks +
 ghost / noise tracks

Candidate-track hit counts | epic_noise

epic with noise, $-1 < \eta < 1$

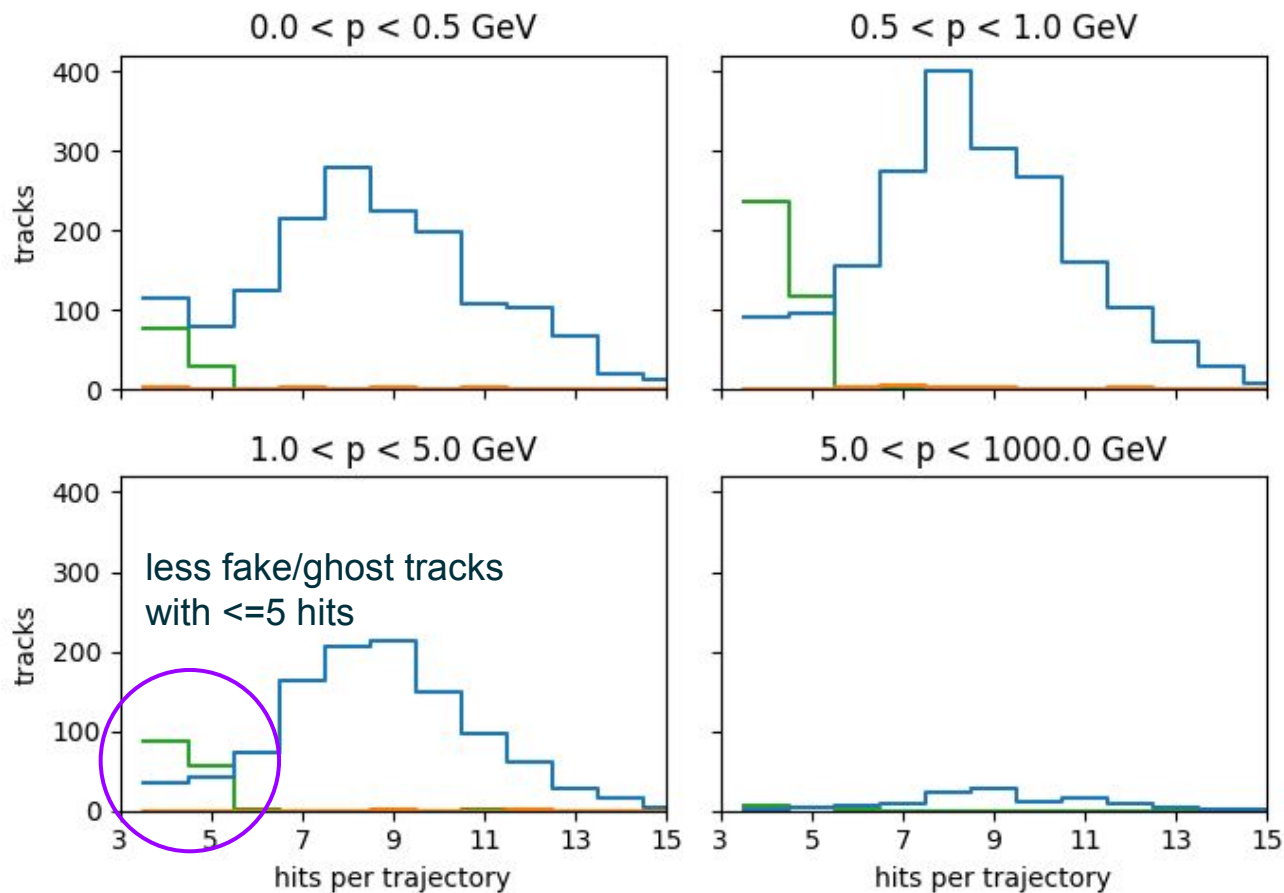
— good signal — background track — fake/ghost



Candidate-track hit counts | no_L4_HD4_noise

— good signal — background track — fake/ghost

no_L4_HD4 with noise, $-1 < \eta < 1$



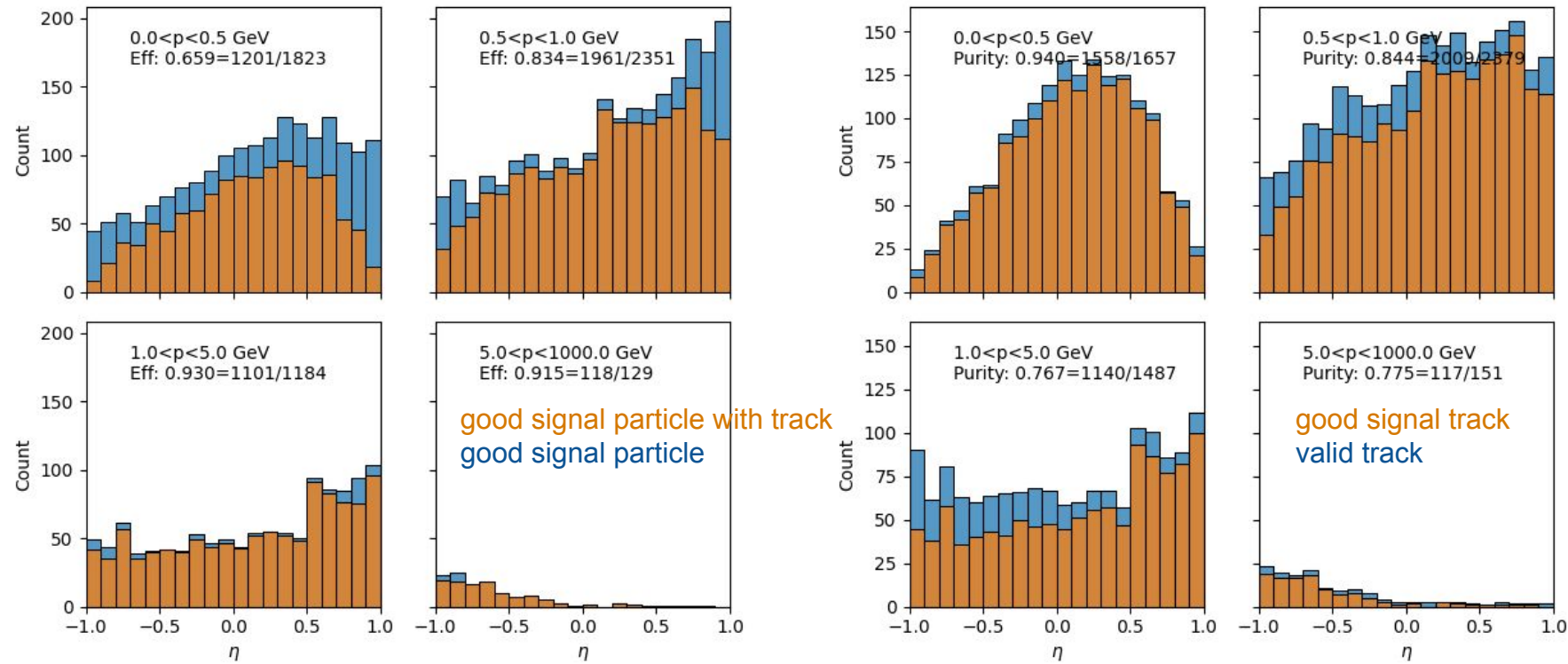
epic with noise, $-1 < \eta < 1$

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

Purity:
good signal tracks / valid tracks

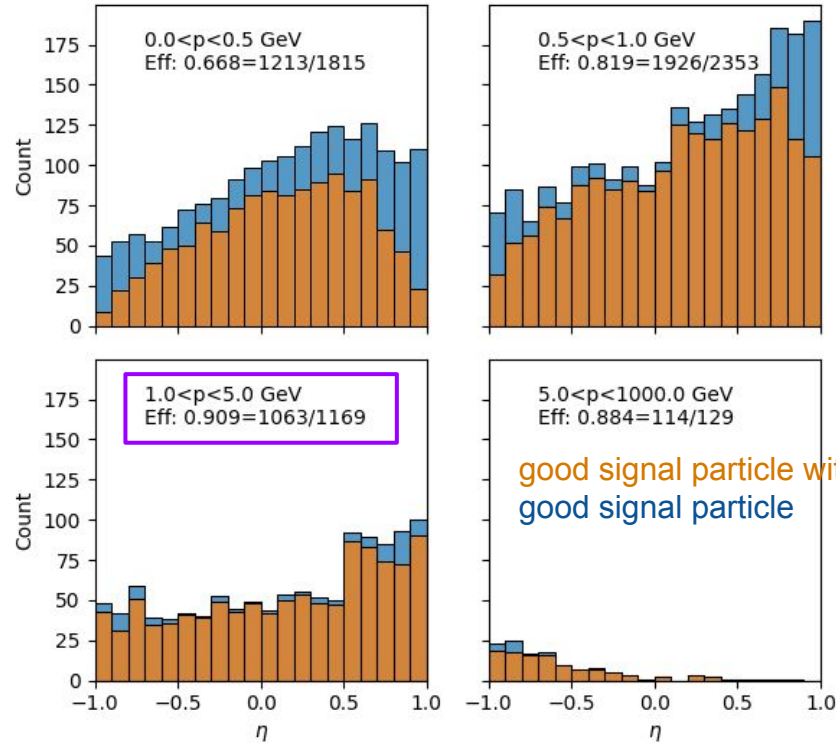
Efficiency (4 hits) | 10x275, epic_noise | total=0.798 (4381/5487)

Purity (4 hits) | 10x275, epic_noise | total=0.850 (4824/5674)

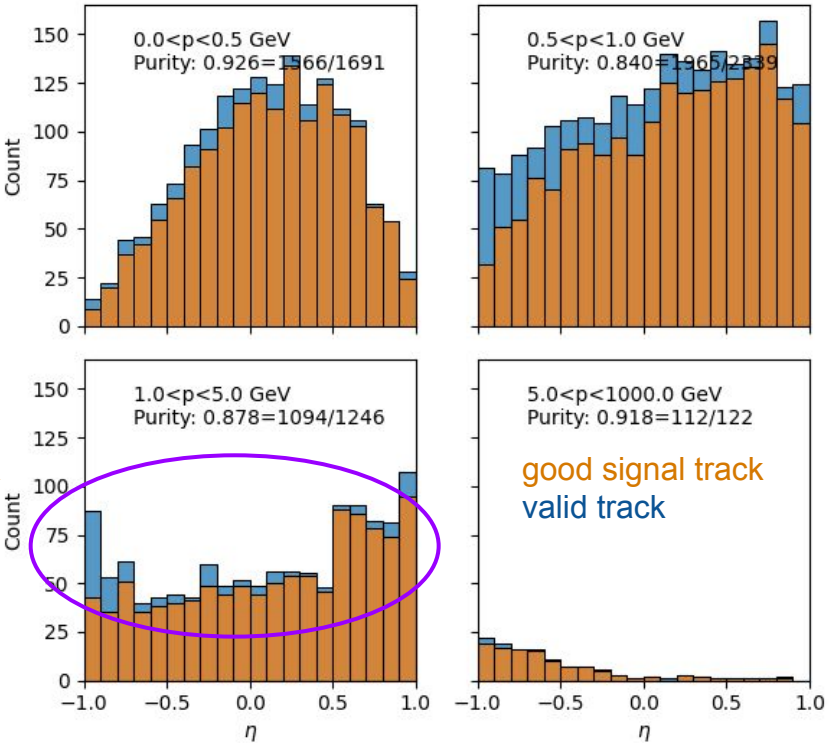


no_L4_HD4 with noise, $-1 < \eta < 1$: slightly lower efficiency, higher purity (less 4- and 5-hit junks)

Efficiency (4 hits) | 10x275, no_L4_HD4_noise | total=0.790 (4316/5466)



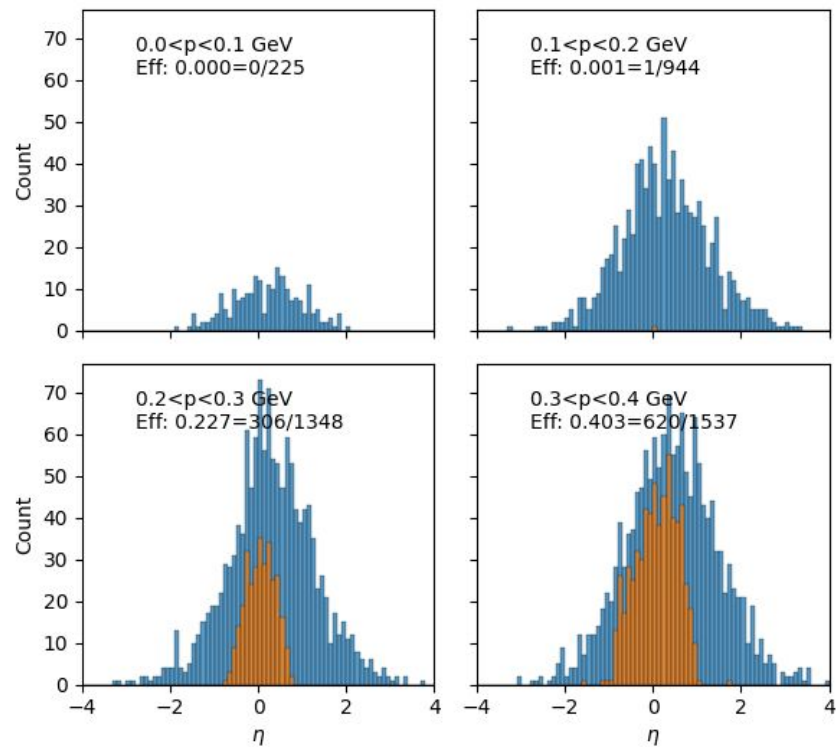
Purity (4 hits) | 10x275, no_L4_HD4_noise | total=0.878 (4737/5398)



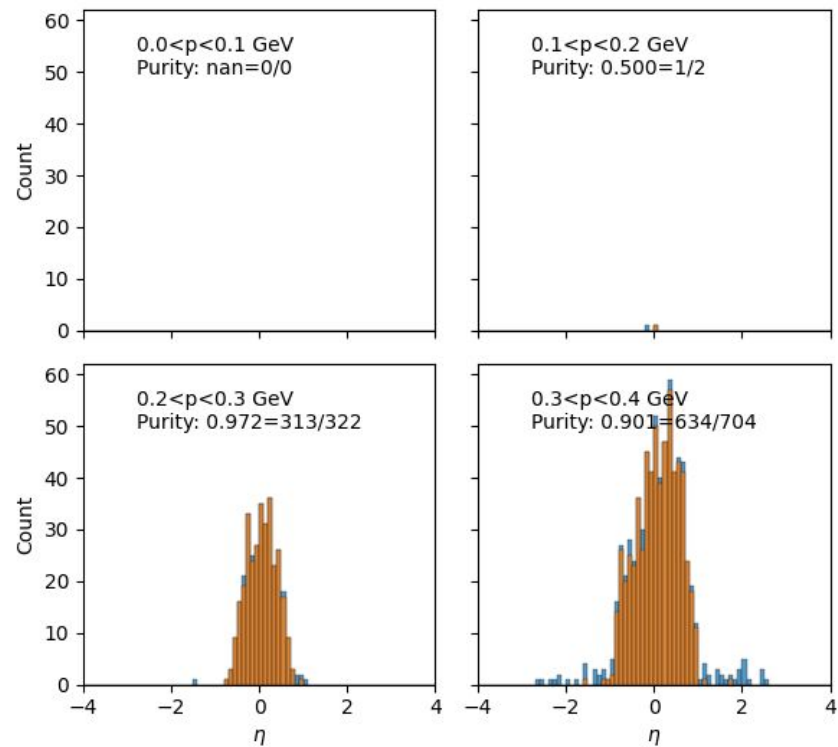
epic vs. no_L4_HD4

- $\text{FHR} = 2\text{e-}7/\text{pixel}/2\text{us}$
- $p < 0.4 \text{ GeV}/c$
- eta range:
 - $[-4,4]$
 - $[-1,1] \rightarrow \text{focus on L4}$

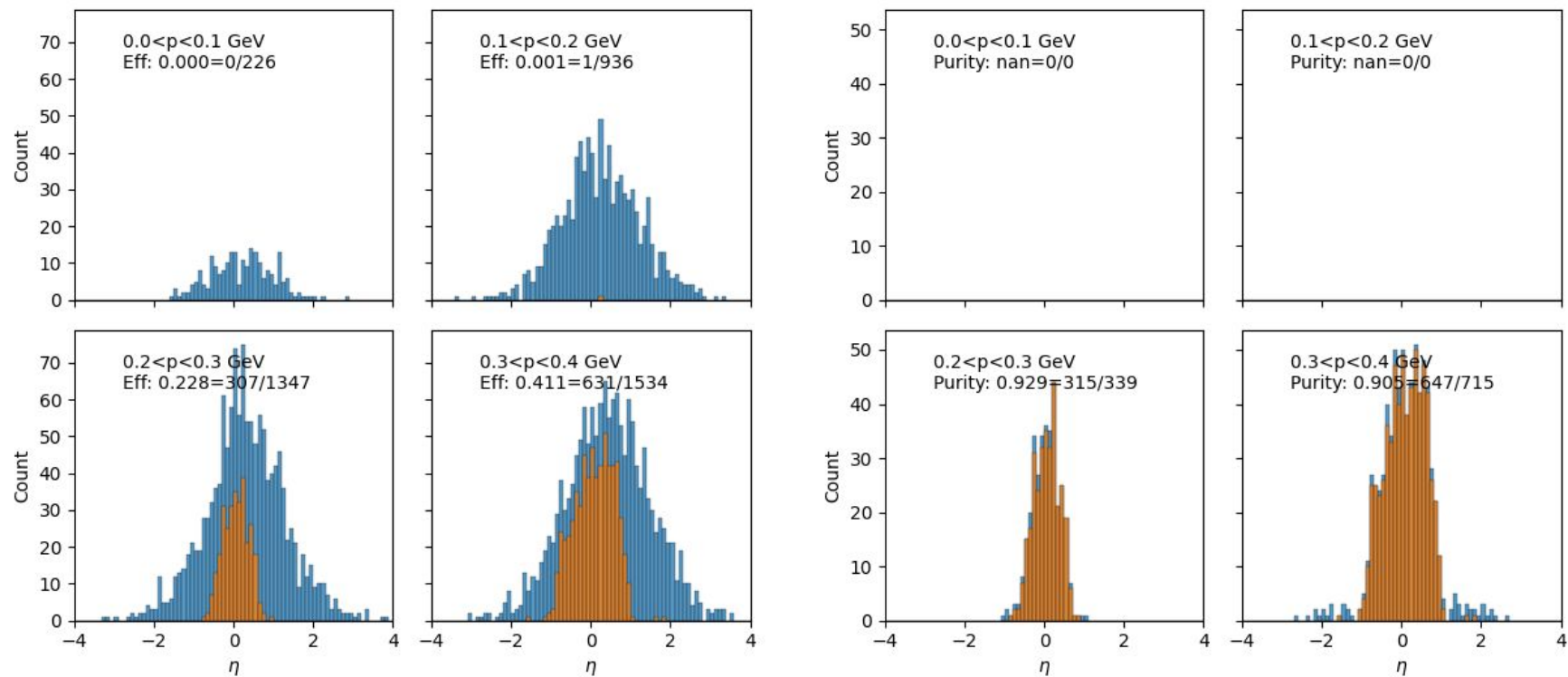
Efficiency (4 hits) | 10x275, epic_noise_low_p | total=0.229 (927/4054)



Purity (4 hits) | 10x275, epic_noise_low_p | total=0.922 (948/1028)



iciency (4 hits) | 10x275, no_L4_HD4_noise_low_p | total=0.232 (939/40, 'urity (4 hits) | 10x275, no_L4_HD4_noise_low_p | total=0.913 (962/1054



200 MeV tracks can reach MPGD but are not reconstructed: issue with tracking (seeding) algorithm rather than the detector geometry.

Summary

Without L4 and HD4 hits in tracking, the simulation studies find no show-stopper within what they address:

L4 $|\eta| \lesssim 0.9$

- Momentum resolution degraded — up to $\approx +23\%$ at 15 GeV/c
- Modest acceptance loss concentrated at low momenta
- Purity unchanged
- Impact-parameter resolution, DCA_r , preserved
- Angular resolution at the vertex unchanged

HD4 $1.8 \lesssim \eta \lesssim 3.7$

- Momentum resolution degraded by +10 to +21% above 5 GeV/c
- Sizable acceptance loss concentrated at high η and high p
- Purity unchanged
- Impact-parameter resolution, DCA_r , preserved to within $\sim 8\%$
- Angular resolution at the vertex unchanged to within $\sim 10\%$

courtesy of Ernst

Further studies to consider:

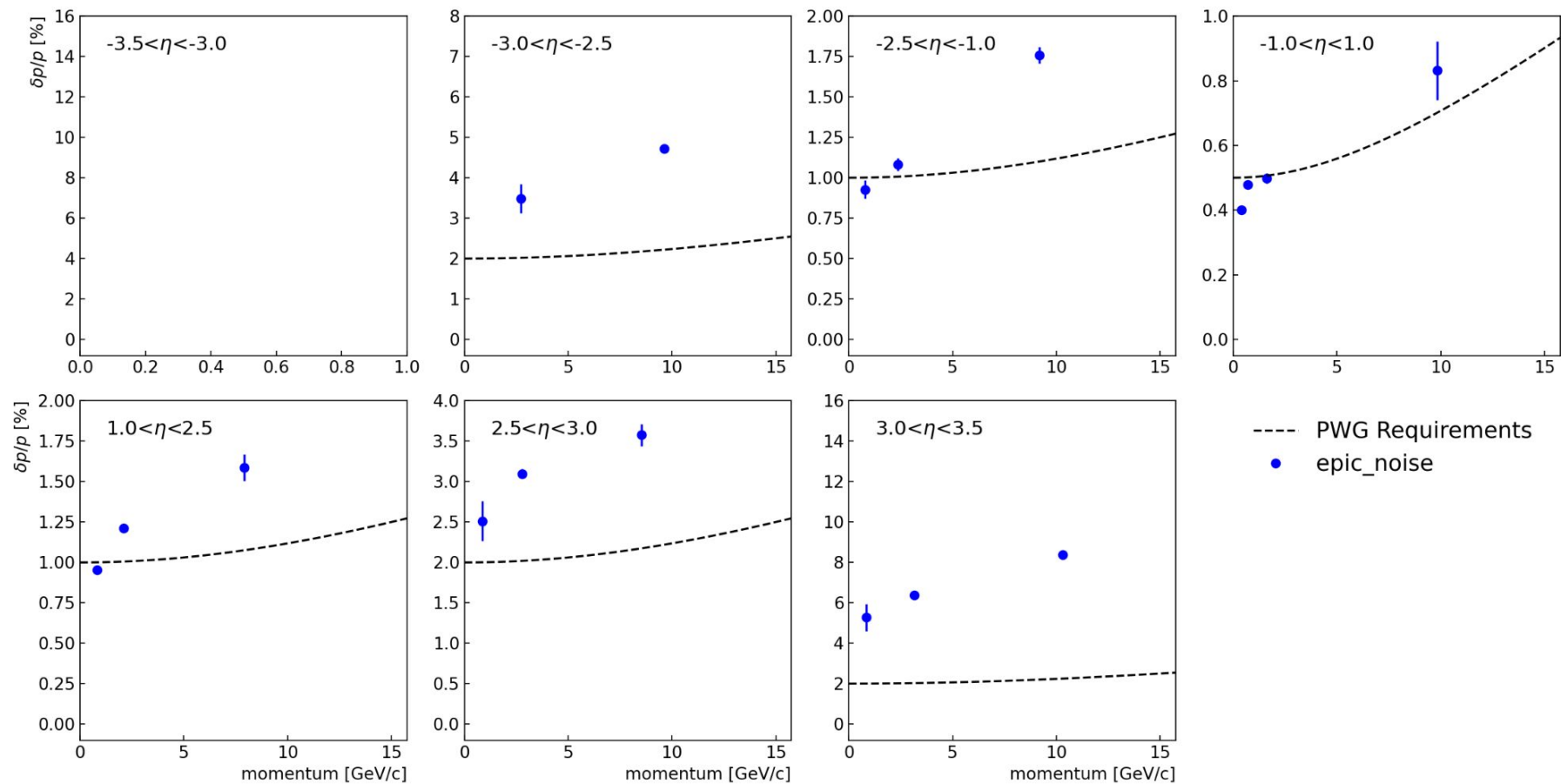
- Study with more signal and background configurations.
- Keep L4 / HD4 structure/ materials but remove the hits from tracking
- L3 vs. L4? Disk position optimization.
- Role of TOF/MPGD with realistic resolutions and noise?
- Impact on track projection into PID detectors

Simulation infrastructure and validation:

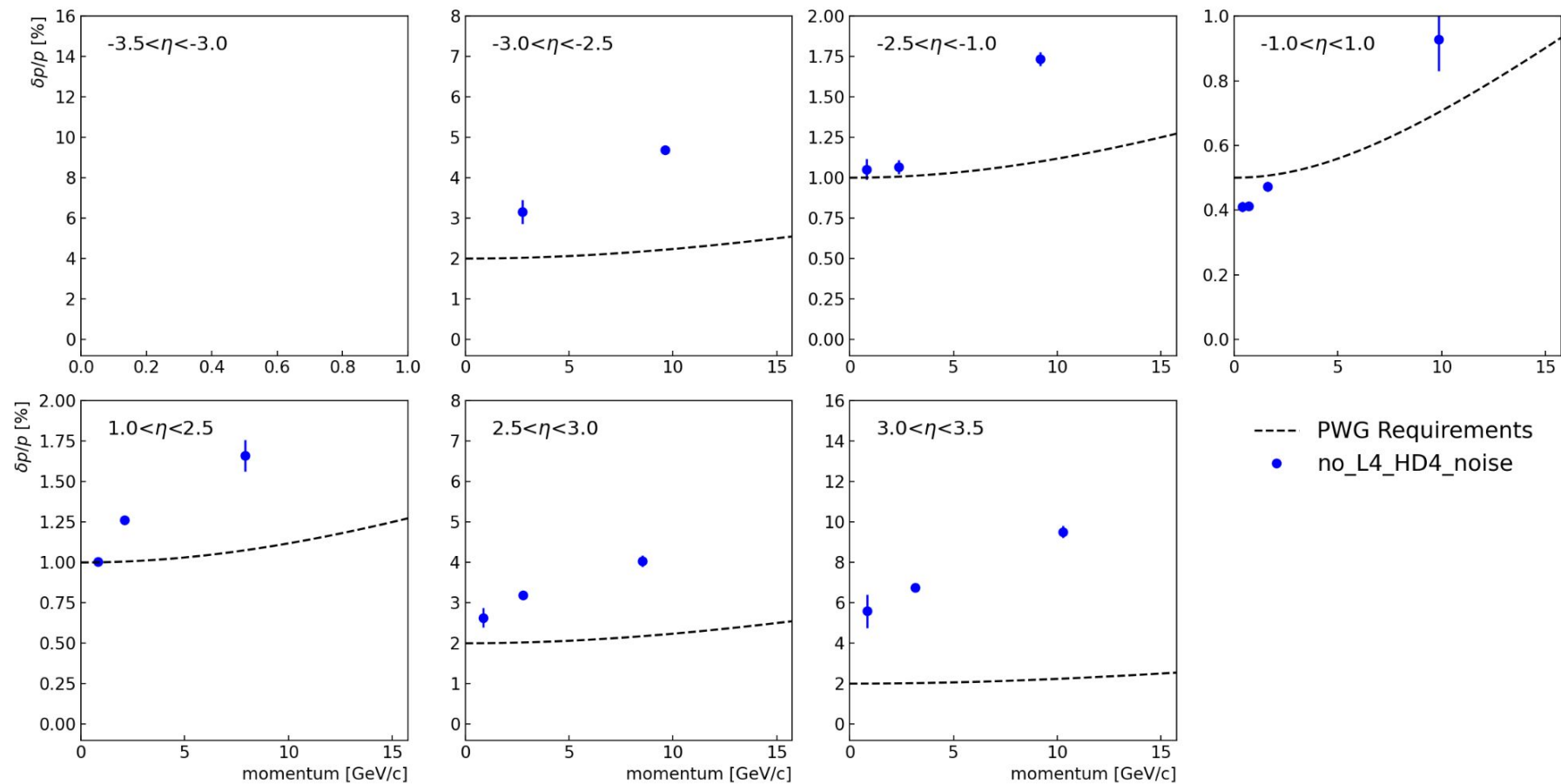
- analysis scripts are available at epic/snippets, and should be part of the CI benchmark.
- better to make event source files available in simulation campaigns.
- TOF raw hits was found to not in eicrecon output so couldn't link them back to mcparticles [\[PR\]](#) which affects all files before 26.08 campaign. This and similar checks should be part of code review and benchmarks.

backup

DIS + Background: signal track resolutions



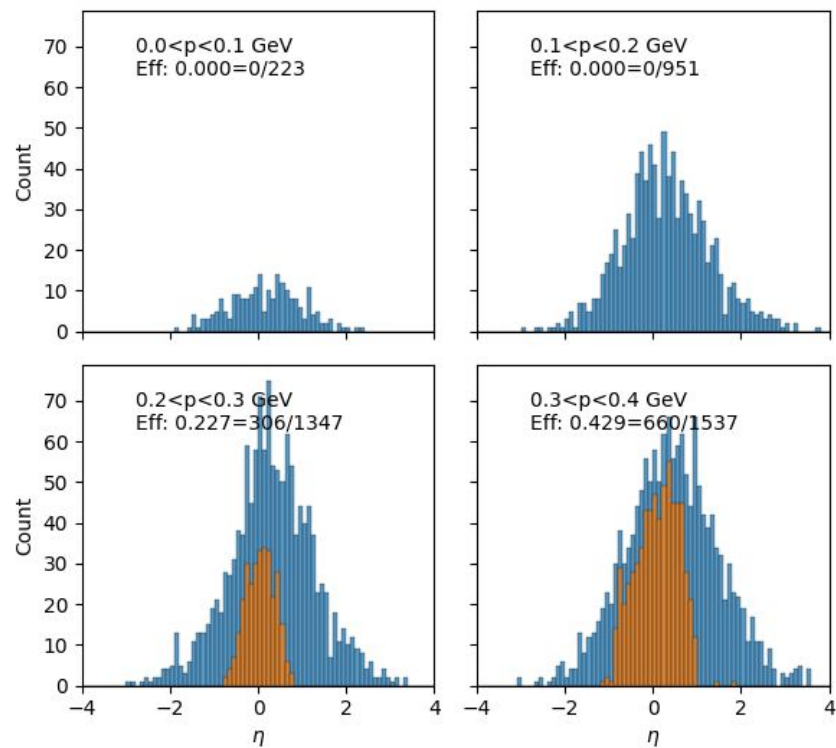
DIS + Background: signal track resolutions



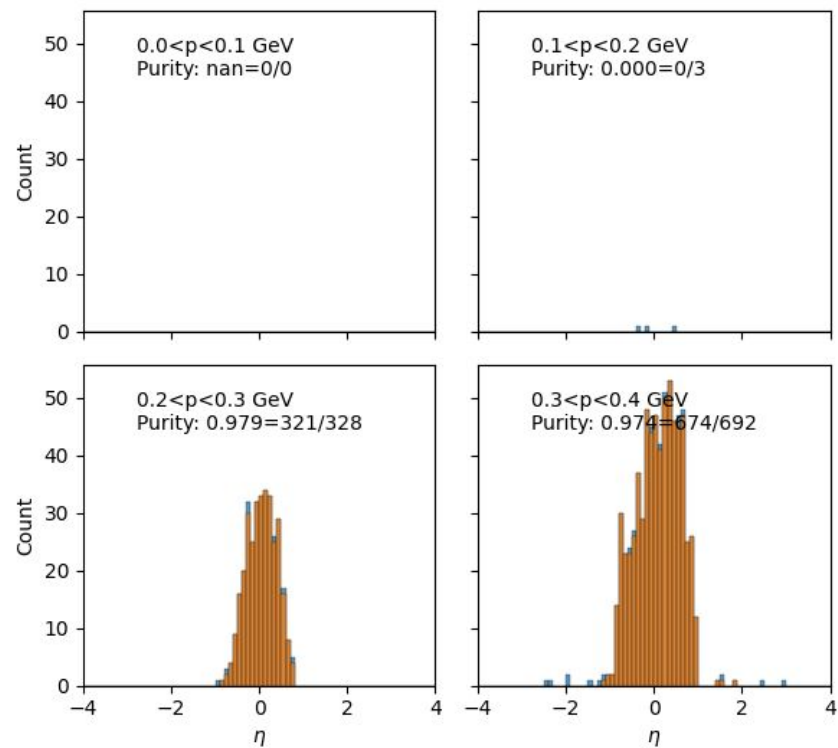
epic vs. no_L4_HD4

- no noise
- $p < 0.4 \text{ GeV}/c$
- eta range:
 - $[-4,4]$
 - $[-1,1] \rightarrow$ focus on L4

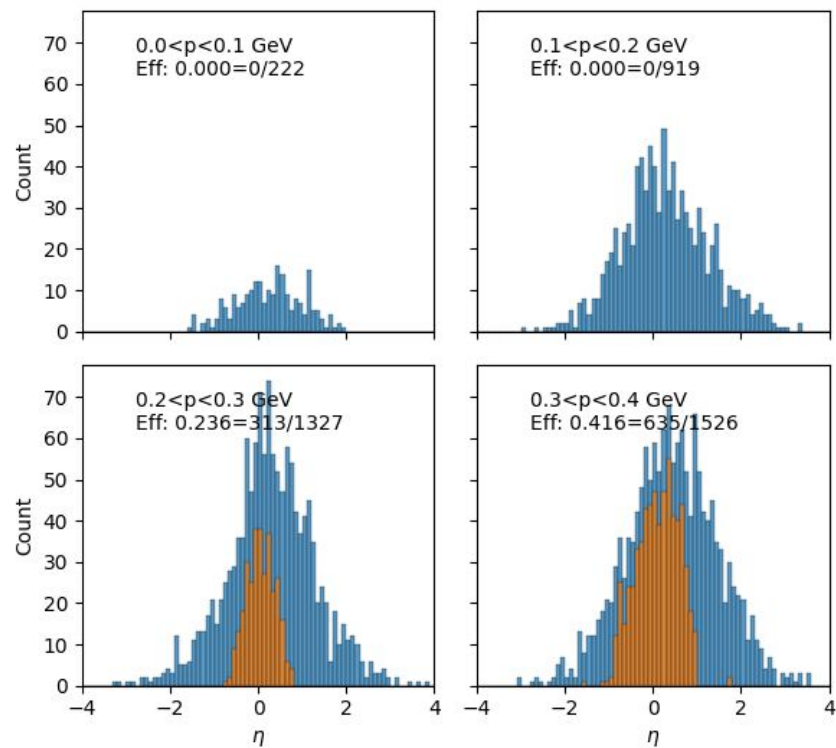
Efficiency (4 hits) | 10x275, epic_low_p | total=0.238 (966/4058)



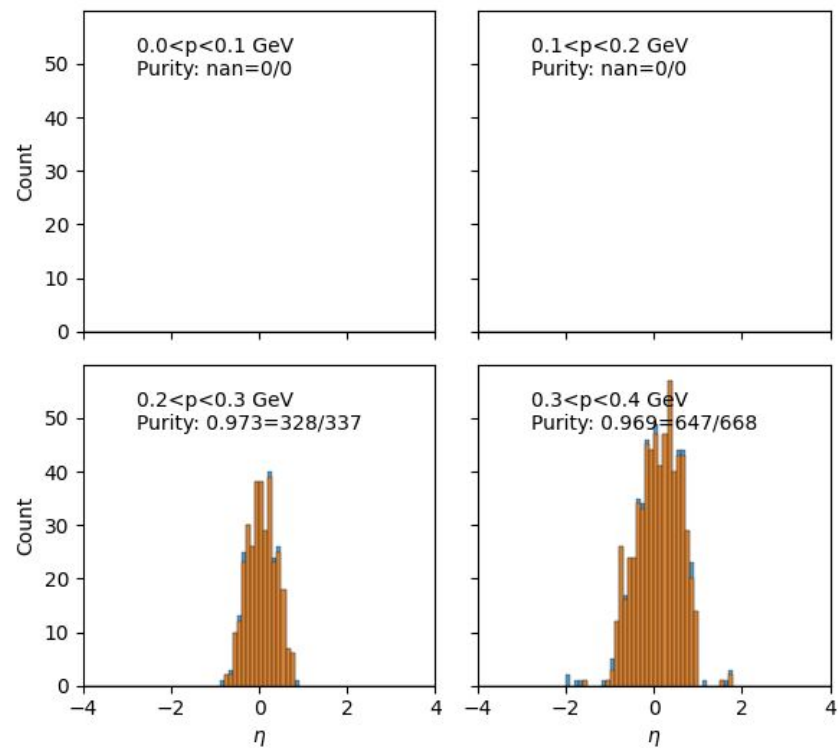
Purity (4 hits) | 10x275, epic_low_p | total=0.973 (995/1023)



Efficiency (4 hits) | 10x275, no_L4_HD4_low_p | total=0.237 (948/3994)

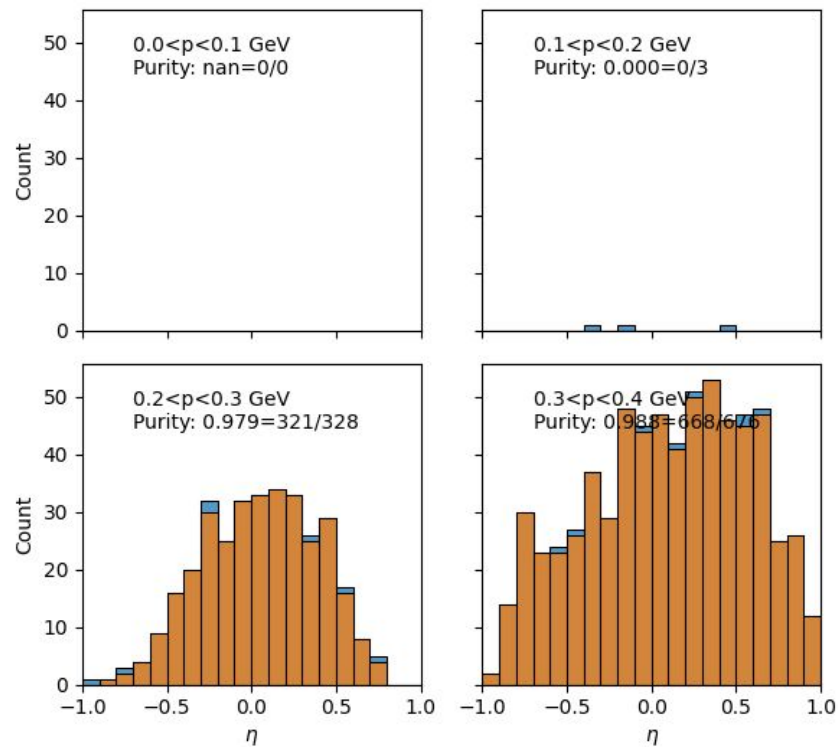
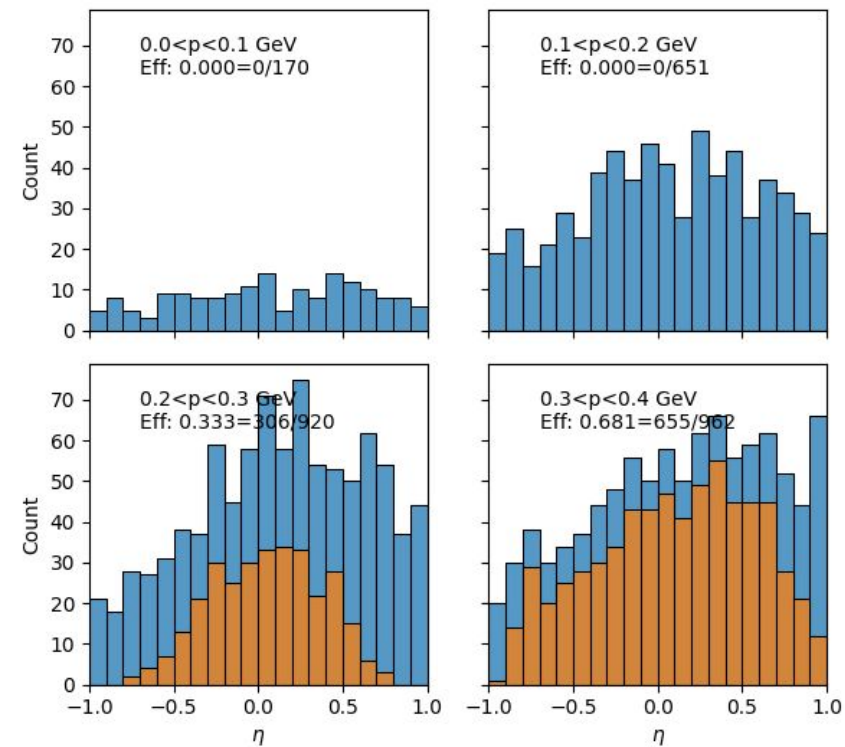


Purity (4 hits) | 10x275, no_L4_HD4_low_p | total=0.970 (975/1005)

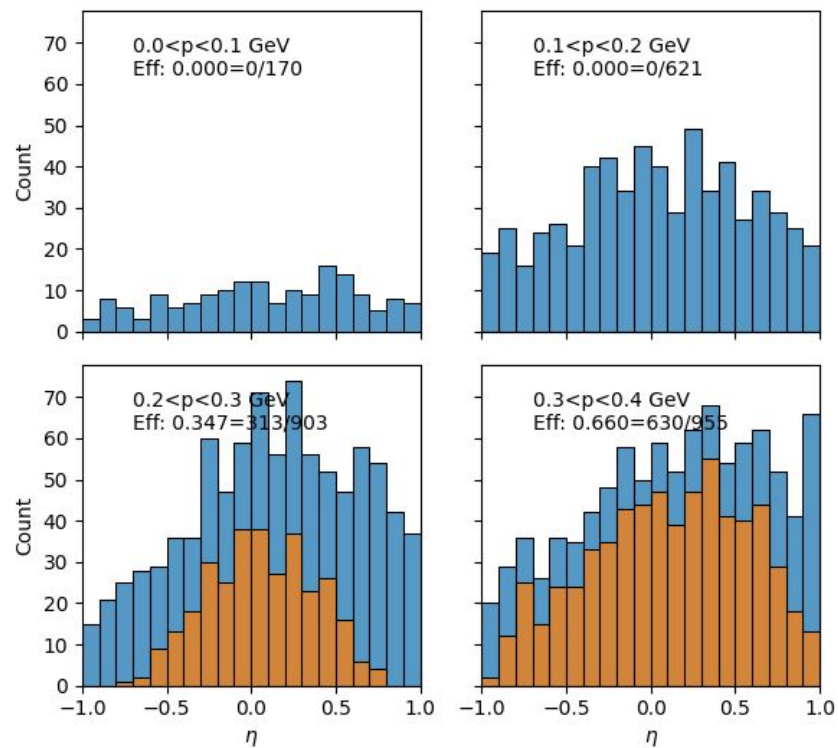


Efficiency (4 hits) | 10x275, epic_low_p | total=0.356 (961/2703)

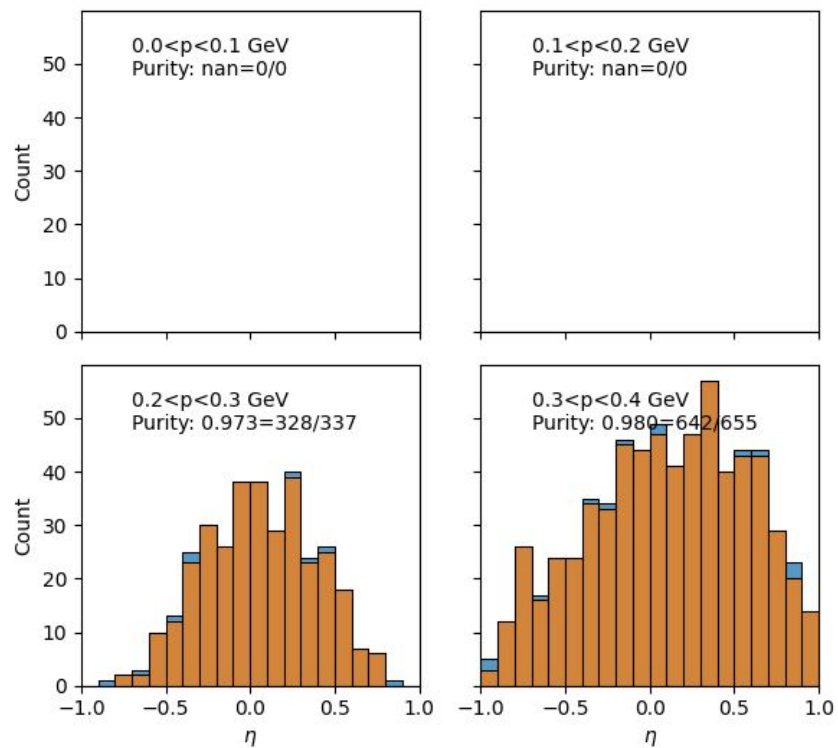
Purity (4 hits) | 10x275, epic_low_p | total=0.982 (989/1007)



Efficiency (4 hits) | 10x275, no_L4_HD4_low_p | total=0.356 (943/2649)



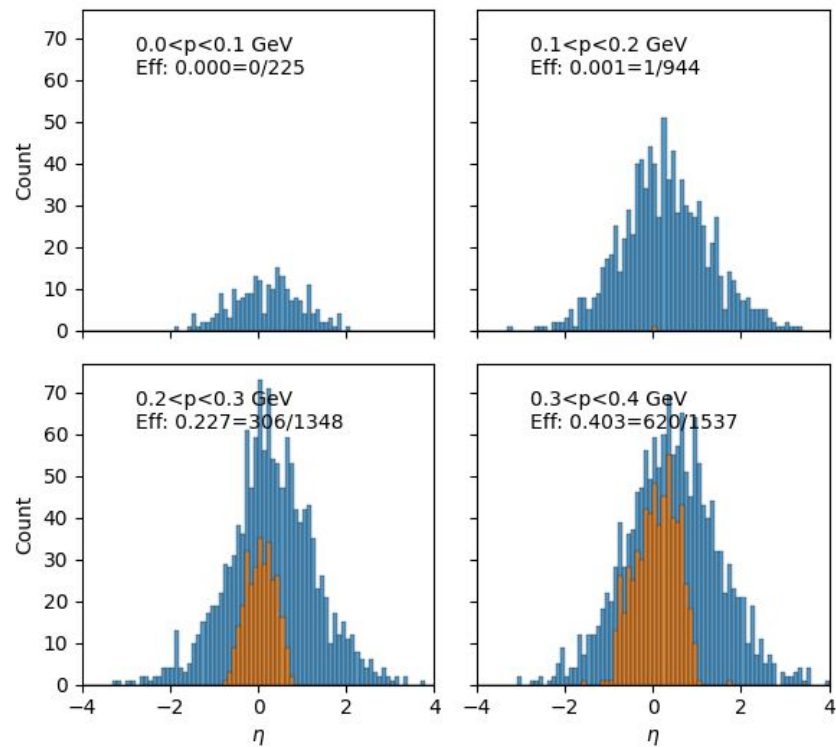
Purity (4 hits) | 10x275, no_L4_HD4_low_p | total=0.978 (970/992)



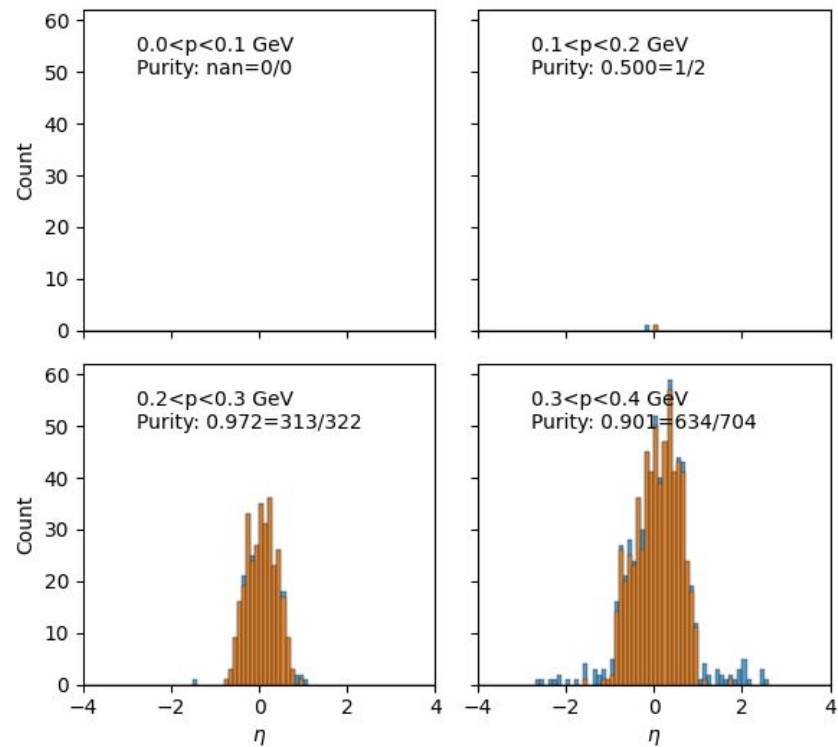
epic vs. no_L4_HD4

- $\text{FHR} = 2\text{e-}7/\text{pixel}/2\text{us}$
- $p < 0.4 \text{ GeV}/c$
- eta range:
 - $[-4,4]$
 - $[-1,1] \rightarrow \text{focus on L4}$

Efficiency (4 hits) | 10x275, epic_noise_low_p | total=0.229 (927/4054)

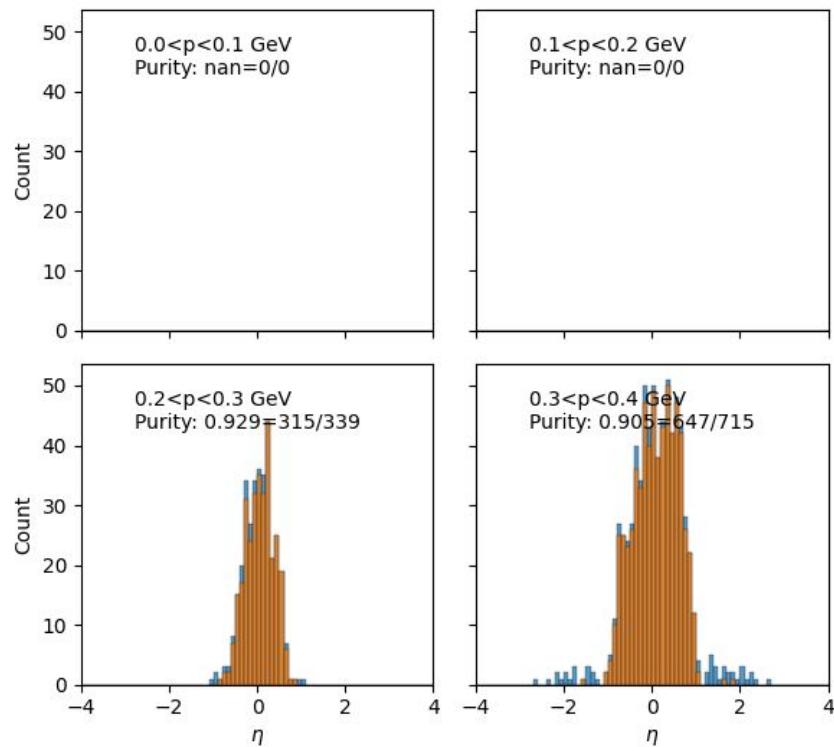
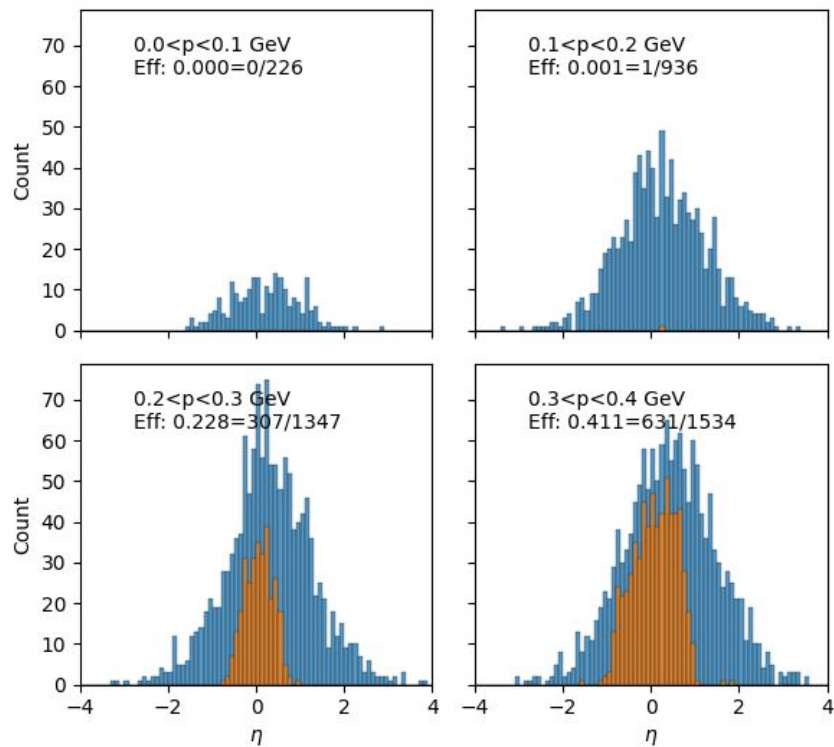


Purity (4 hits) | 10x275, epic_noise_low_p | total=0.922 (948/1028)

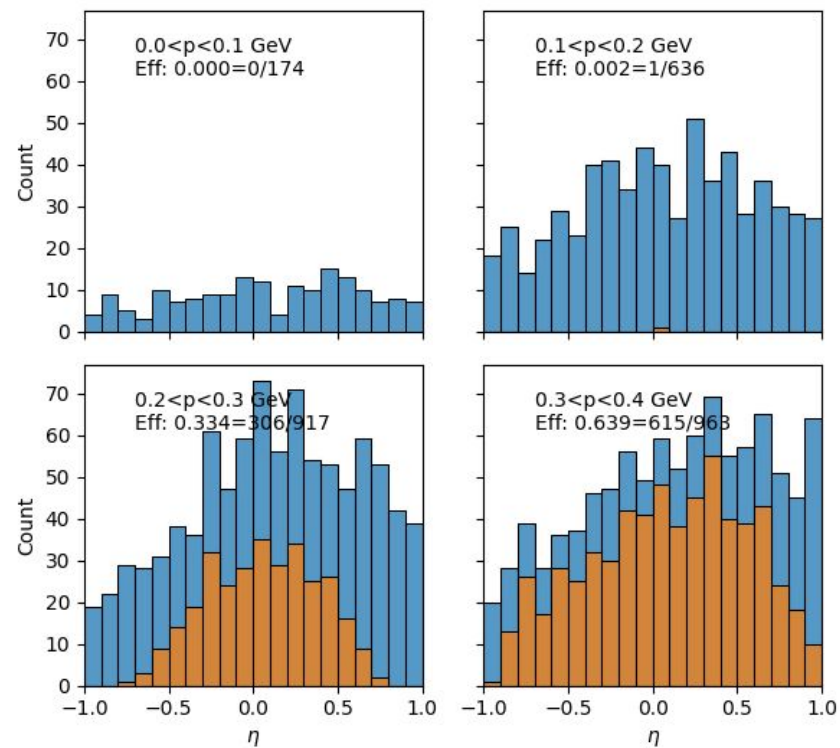


iciency (4 hits) | 10x275, no_L4_HD4_noise_low_p | total=0.232 (939/40,

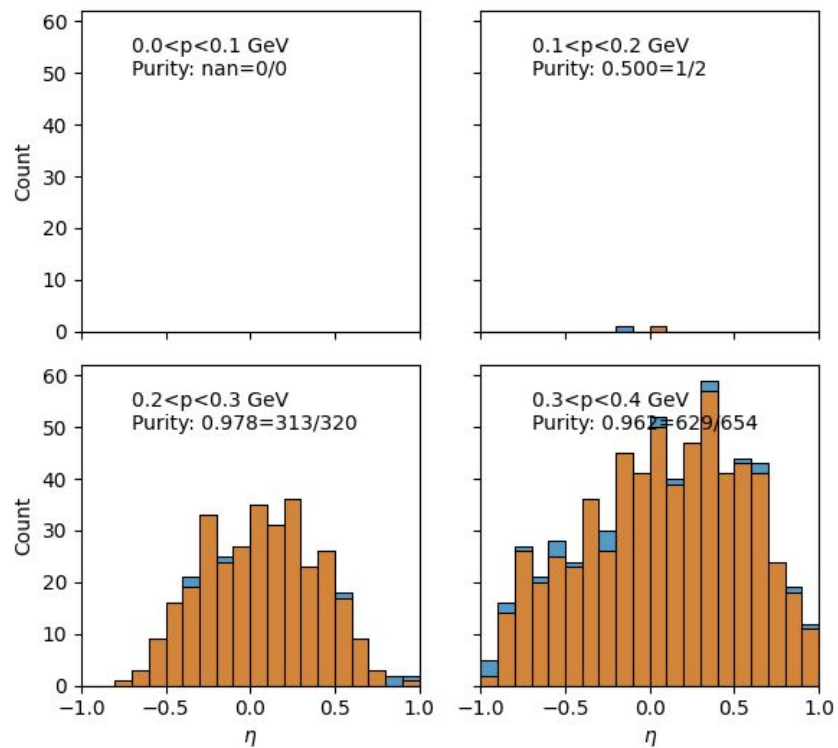
urity (4 hits) | 10x275, no_L4_HD4_noise_low_p | total=0.913 (962/1054



Efficiency (4 hits) | 10x275, epic_noise_low_p | total=0.343 (922/2690)



Purity (4 hits) | 10x275, epic_noise_low_p | total=0.966 (943/976)



iciency (4 hits) | 10x275, no_L4_HD4_noise_low_p | total=0.348 (932/267)

urity (4 hits) | 10x275, no_L4_HD4_noise_low_p | total=0.954 (955/1001)

