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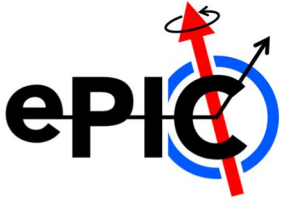
U.S. DEPARTMENT OF ENERGY
Office of Science

Update on Backgrounds in SVT

Shujie Li

ePIC TIC meeting

03.30.2026



Overview

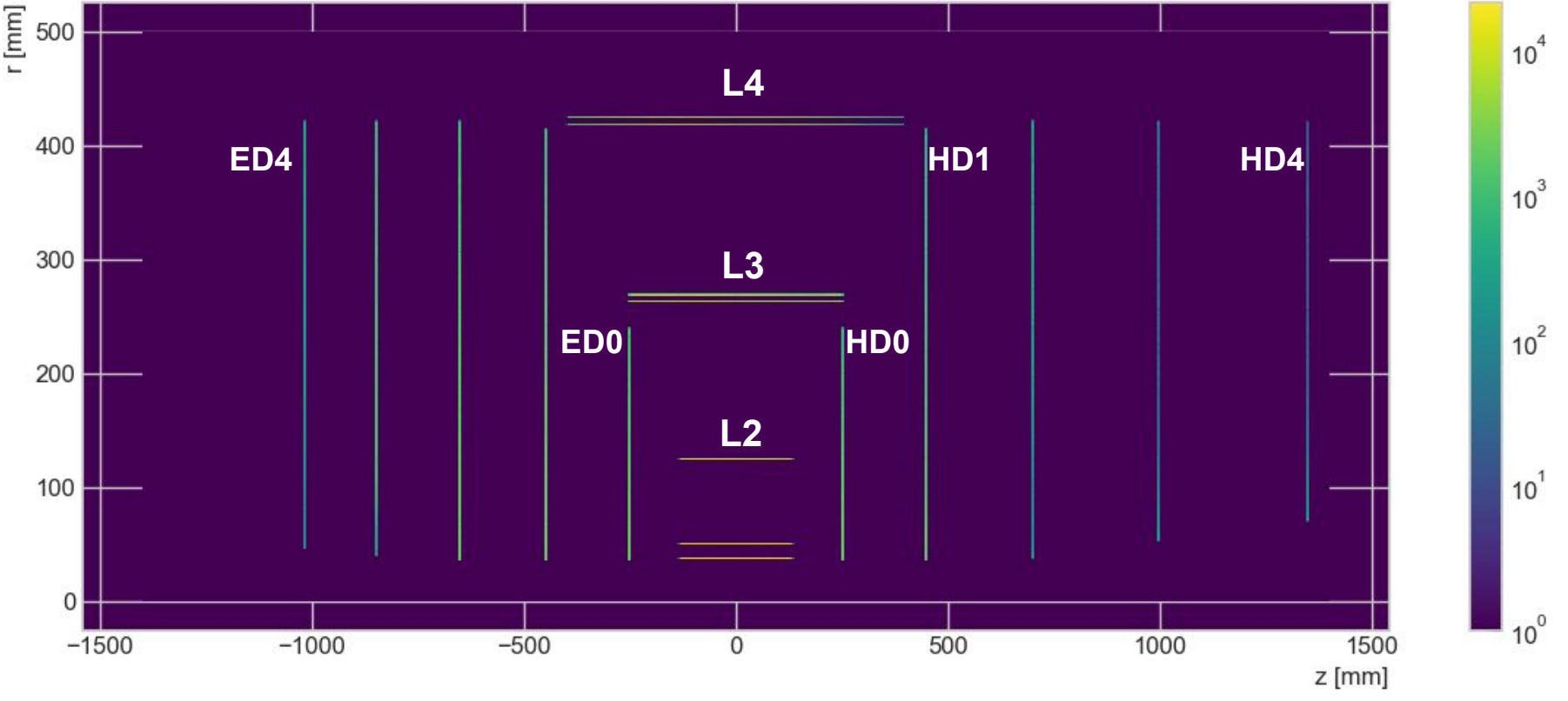
Configurations:

- forced DIS + all beam background
- 10um beampipe gold coating
- 10x275 beam energy (highest total rate)

Impact Studies:

- SVT occupancy map and data rate
- tracking performance (with full set of central tracker = SVT+MPGD+AC-LGAD)
  - purity and efficiency
  - spatial and angular resolutions
  - primary vertexing
- ~~radiation exposure~~

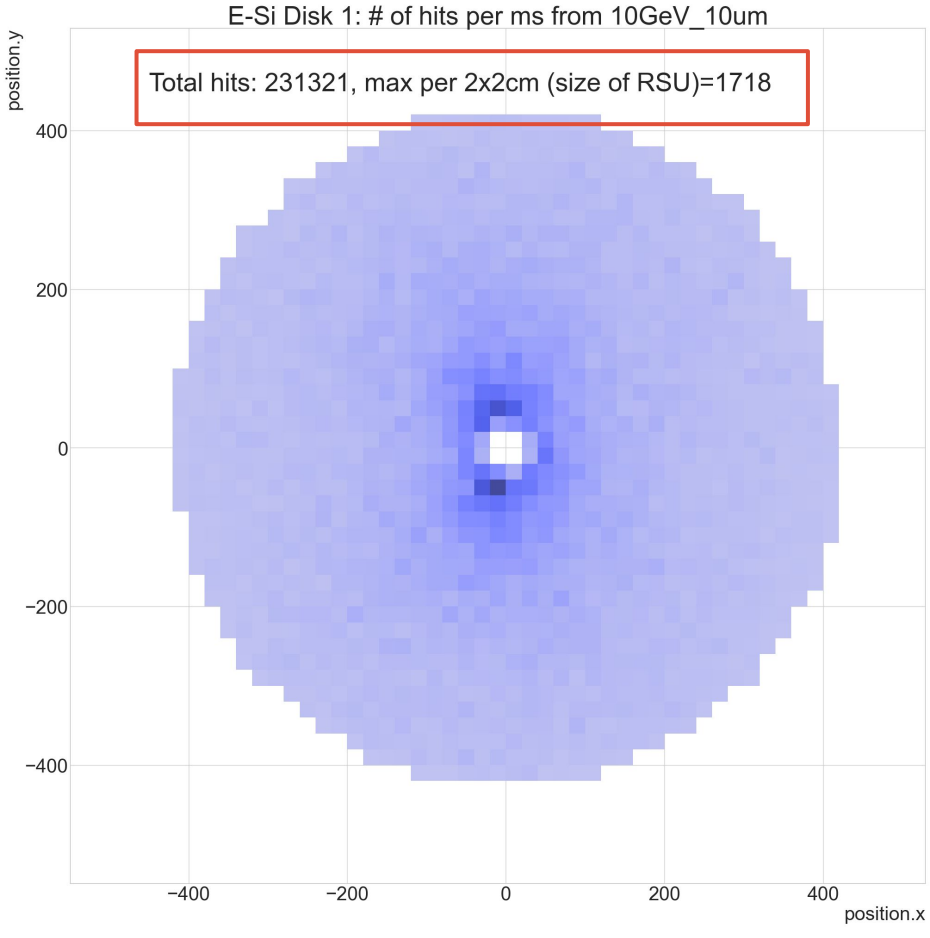
SVT Hit Map


L4
ED4
HD1
HD4
L3
ED0
HD0
L2
r [mm]
500
400
300
200
100
0
−1500
−1000
−500
0
500
1000
1500
z [mm]
10^4
10^3
10^2
10^1
10^0

SVT Hit Map

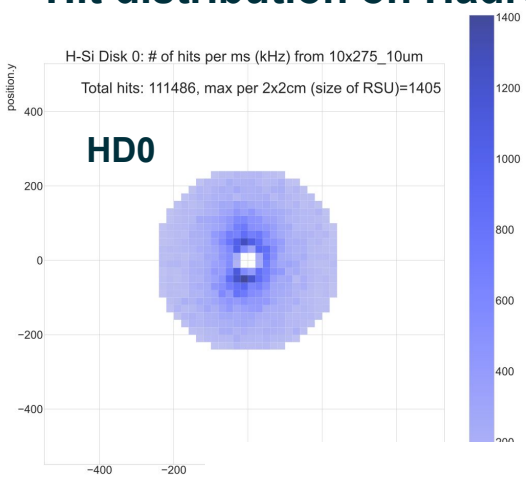
Steps:

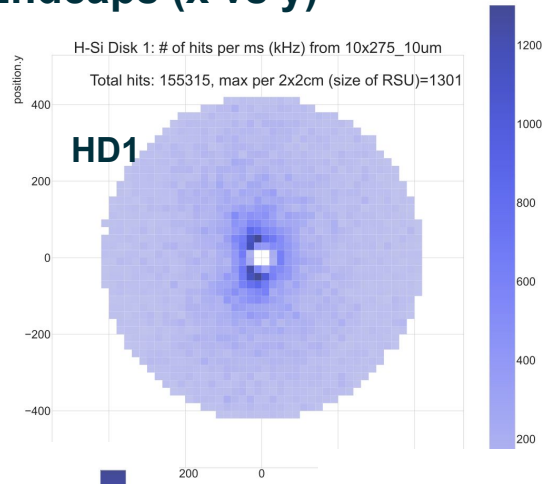
- ➔ plot digitized hits (edep > 0.54 keV) on each SVT surface
  - Rphi v.s. Z on barrels
  - x v.s. y on disks
- ➔ accumulate number of hits per
  - 2x2cm square (roughly size of one RSU = 12 tiles),
  - or 9.8x3.5mm (tile)
- ➔ Record **accumulated/averaged** counts per **ms** (500 x 2us slices → kHz)
  - for the entire detector layer
  - and the max rate per RSU / tile

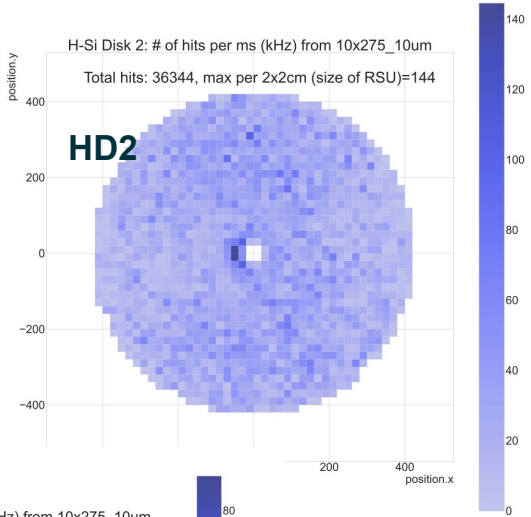


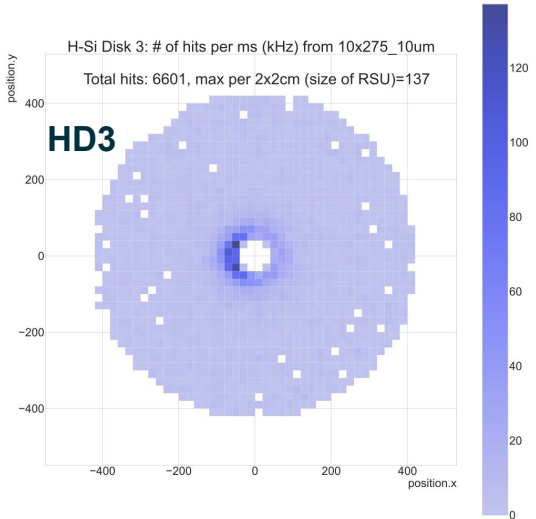
SVT Hit Map

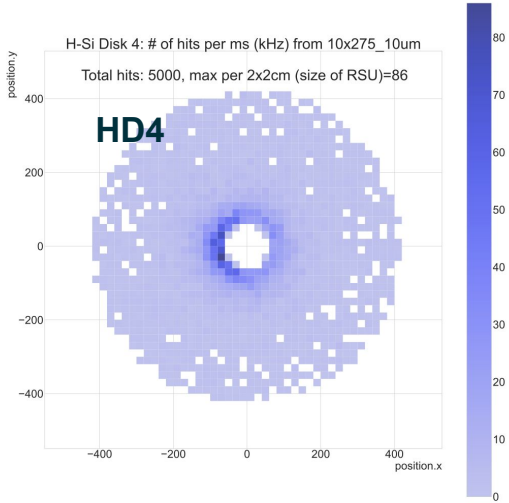
Hit distribution on Hadron Endcaps (x vs y)





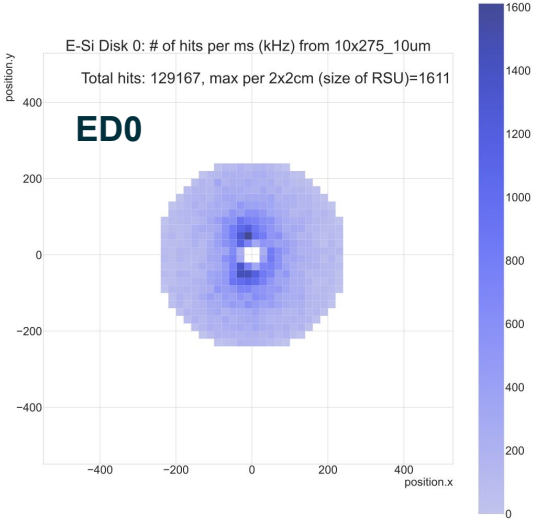


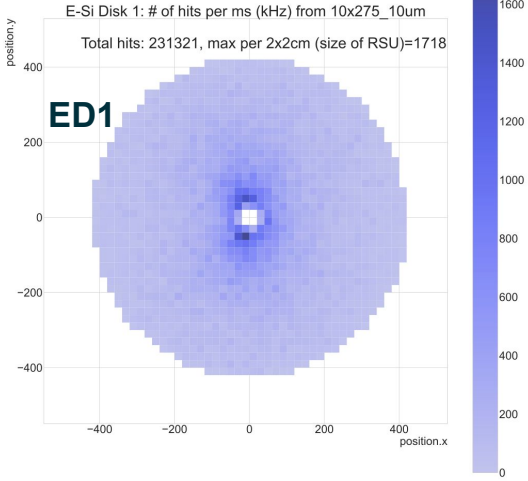


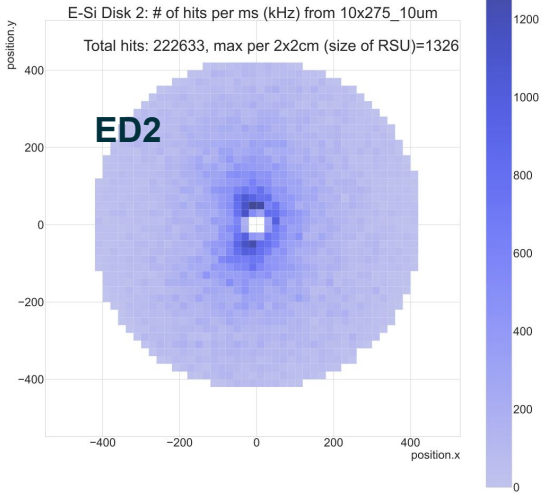


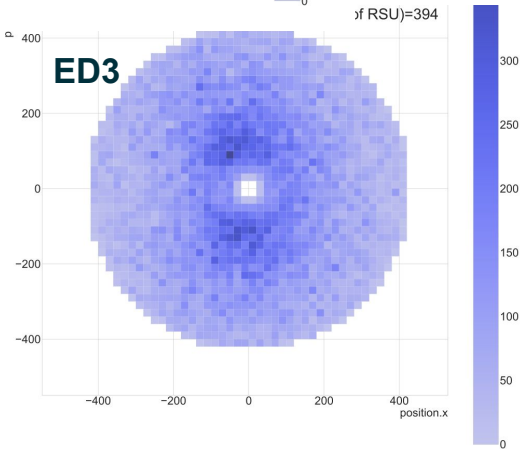
SVT Hit Map

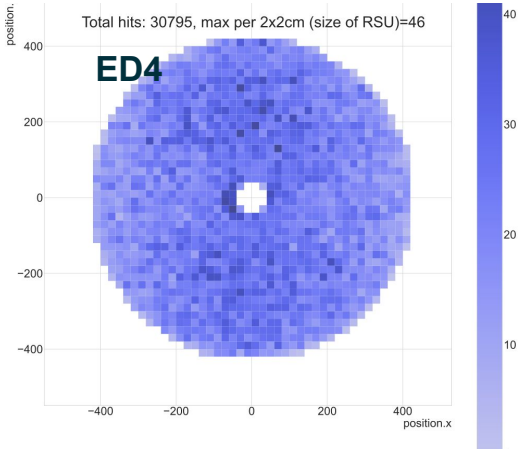
Hit distribution on Electron Endcaps (x vs y)





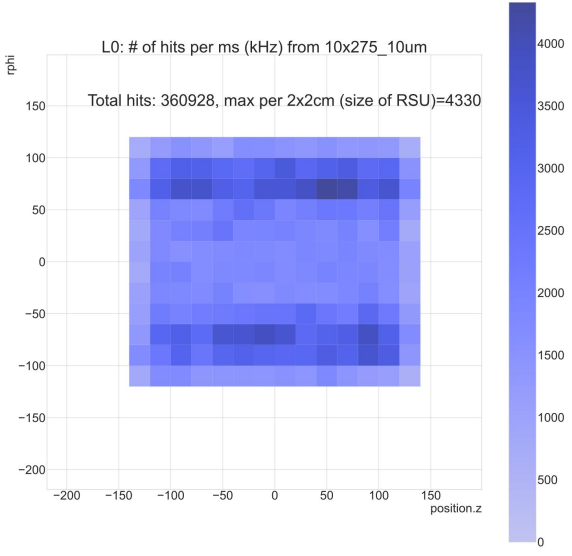


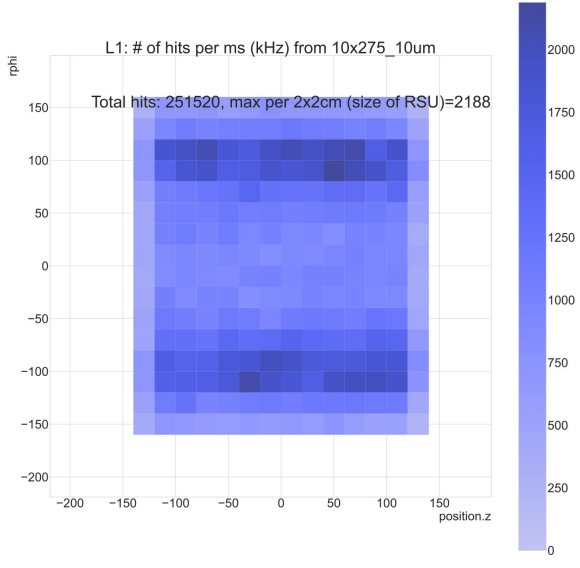


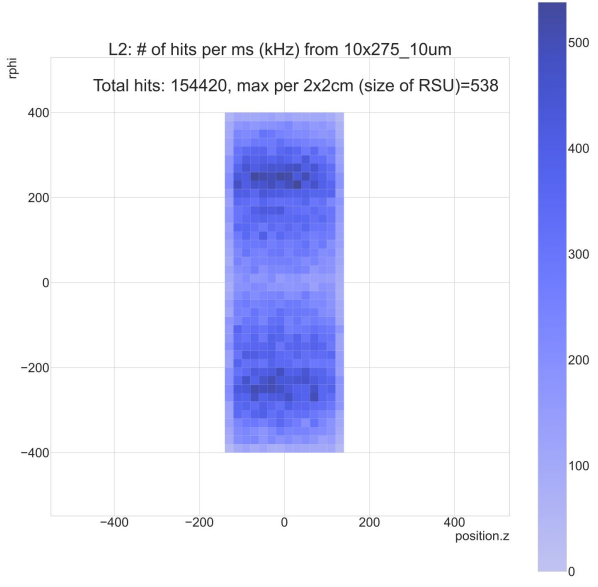


SVT Hit Map

Hit distribution on Inner Barrels (rphi v.s. Z):







Link to all SVT rate plots (DIS+background, and DIS only)

Hits to Data Rate

Ref: Jo Schambach, and Joao de Melo at SVT Oxford working meeting

10x275 beam, 10um gold coating, **accumulated/averaged** 1ms of stats:

Layer name	Total hits	MAX hit on a single RSU (20x20mm)	Tile (9.8x3.5mm)
E-Si Disk 4	30,796	46	12
E-Si Disk 3	144,894	394	71
E-Si Disk 2	222,634	1326	212
E-Si Disk 1	231,321	1718.5	230
E-Si Disk 0	129,168	1611.5	258
H-Si Disk 0	111,486	1405.5	201
H-Si Disk 1	155,315	1301	250
H-Si Disk 2	36,345	144.5	35
H-Si Disk 3	6,602	137	28
H-Si Disk 4	5,001	86	18
L0	360,929	4330	594
L1	251,520	2188.5	250
L2	154,420	538	73
L3	493,530	711.5	110
L4	314,902	217.5	39

Work within SVT-DSC has focused on the bandwidth out of MOSAIX and EIC-LAS. Assume:

- 3 pixels per hit for both charged particles and photons
- 32 bits per pixel on average

Max rates per unit:

OB and disk (max on ED0):

- 258 hits/tile/ms * 3 pixels/hit * 32 bits/pixel = **25 Mbps/tile**
- 1720 hits/RSU/ms * 96 bits/hit = **165 Mbps/RSU**

Multiply by 5 (6) for EIC-LAS with 5 (6) RSUs (12 tiles/RSU)

IB (max on L0):

- 594 hits/tile/ms ⇒ **57 Mbps/tile**
- 4330 hits/RSU/ms ⇒ **415 Mbps/RSU**

Sensor noise, estimated at 5 Mbps/RSU, is not included in these estimates.

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Work within SVT-DSC has focused on the bandwidth out of MOSAIX and EIC-LAS. Assume:

- 3 pixels per hit for both charged particles and photons
- 32 bits per pixel on average

Total rates out of SVT (no sensor noise)**:**

- IB (L0,L1,L2): 74 Gbps
- OB (L3, L4): 78 Gbps
- Disks (E): 73 Gbps
- Disks (H): 30 Gbps
- Total: **254 Gbps**

Rates receive a large contribution from SR

For reference, total rate is **76 Gbps** at **18x275 GeV,** for 5um gold coating.

Tracking Performance

Configuration:

- epic 26.03: full central tracker = SVT+MPGD+AC-LGAD

Background will affect tracking through:

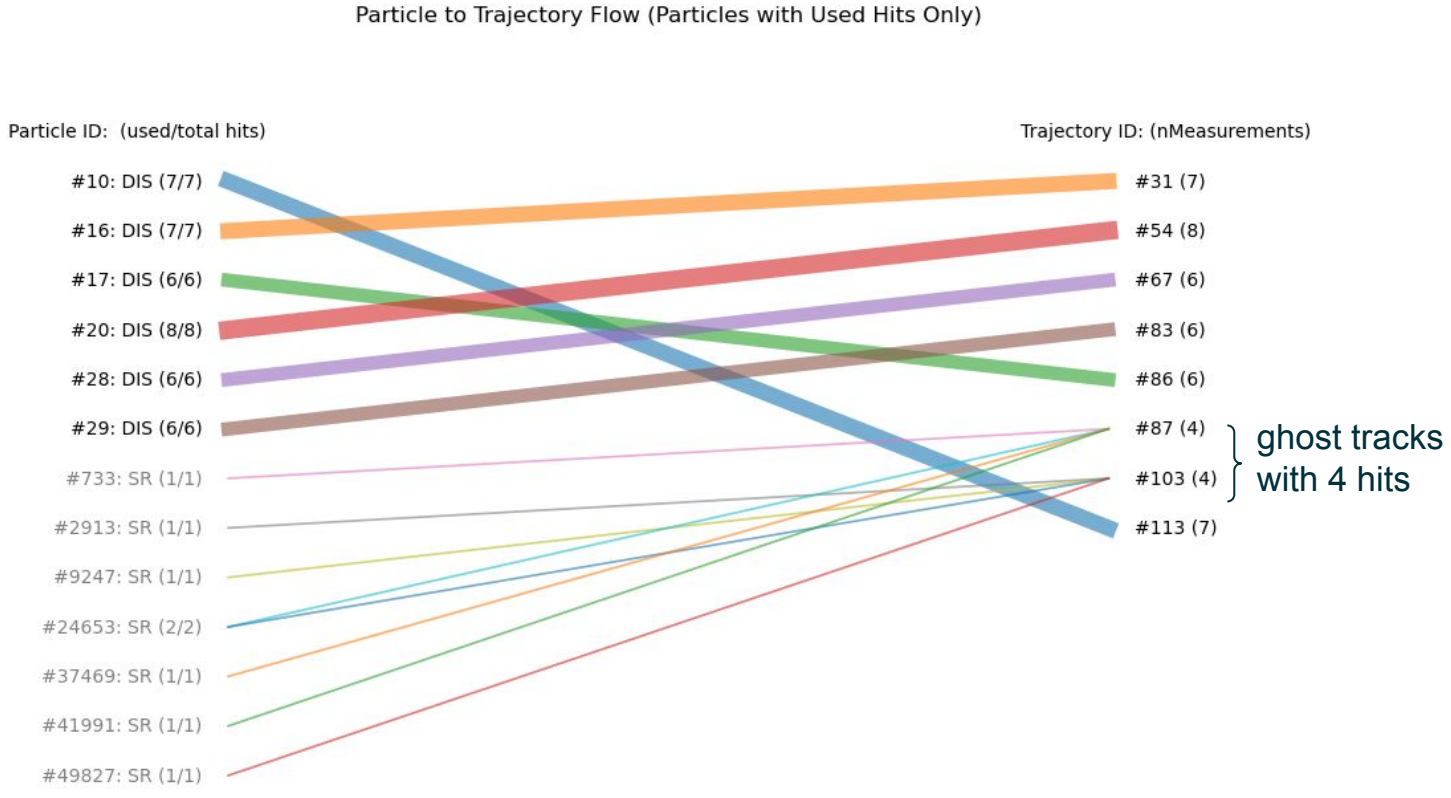
1. background hits → **purity and efficiency**
2. thicker Au coating (5 to 10um) → **resolutions**
    - ❖ single pion+ resolutions against
        - ➢ PWG requirements
        - ➢ 5um v.s. 10um Au coating
    - ❖ primary vertex resolution from DIS only sample
    - ❖ resolutions from DIS+background samples:
        - ➢ expected to be consistent with no background cases given reasonable purity cuts. TBD

1+2⇒ impact on downstream algorithms:

- primary vertex efficiency
- 2nd vertex (TBD)

Tracking Performance

Purity and efficiency

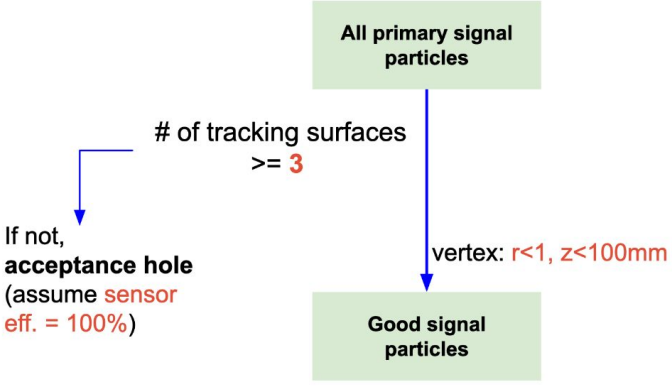


Tracking Performance

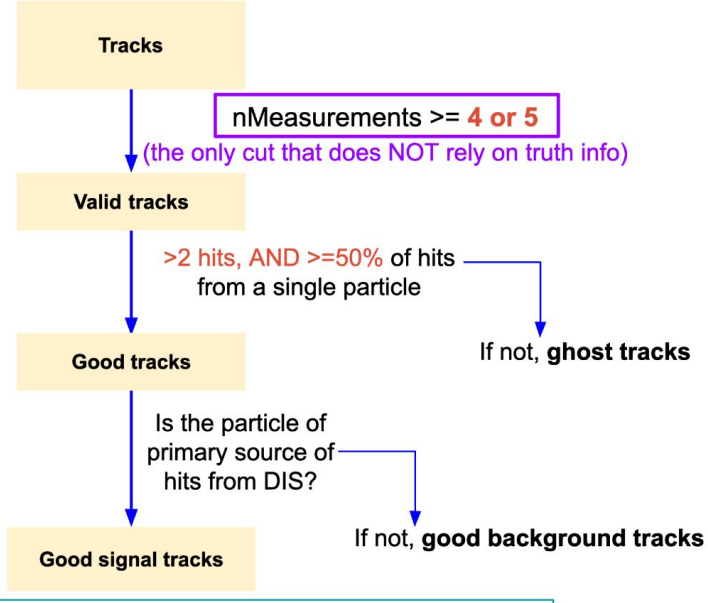
analysis code available on github

Purity and efficiency

- **Truth info from MC**



- **Reconstructed tracks**



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

Tracking efficiency:
good signal particle with a good signal track / good signal particles

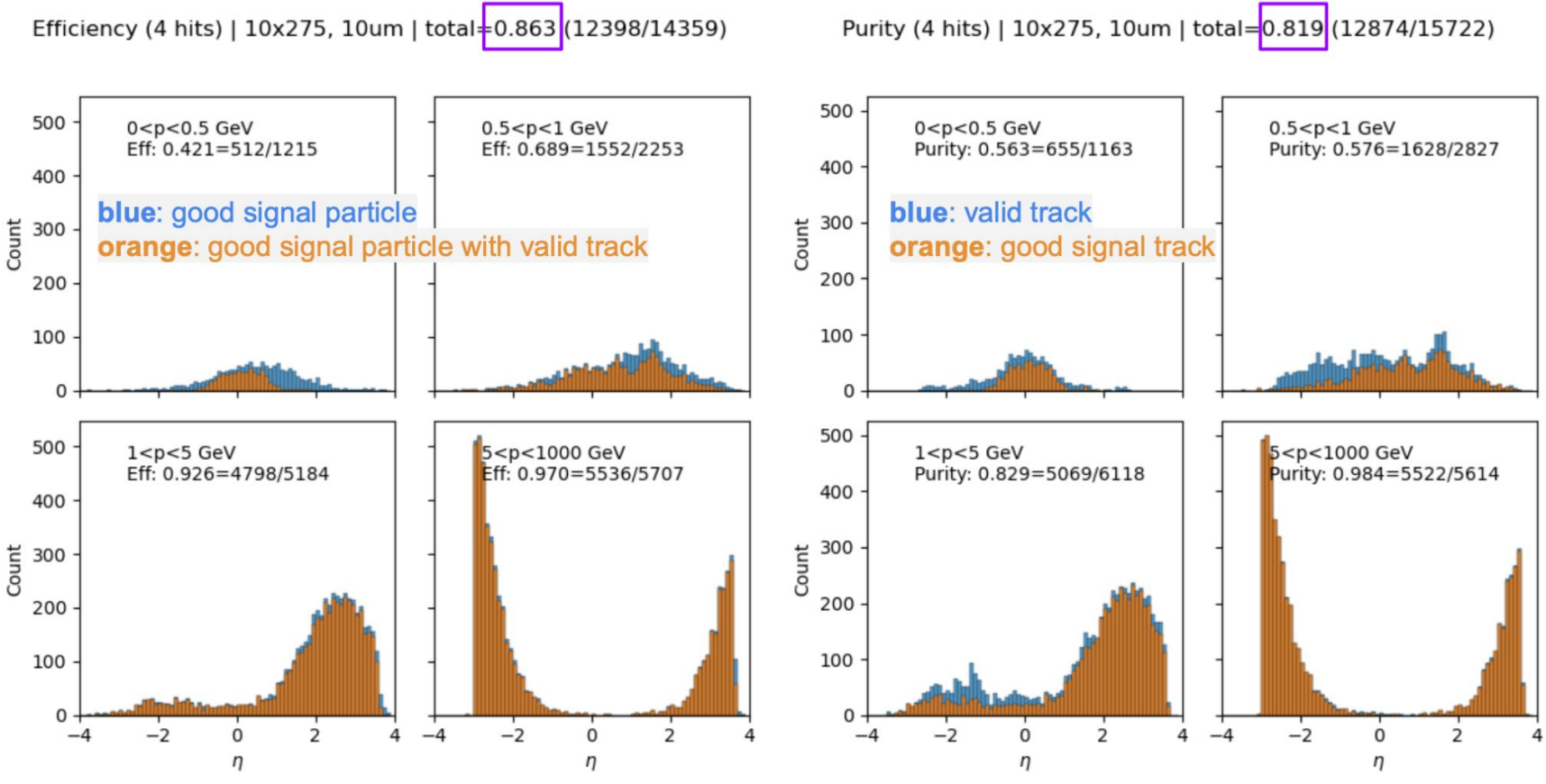
Tracking Purity:
good signal tracks / valid tracks

Purity of Track Hits:
In a given valid track, the fraction of hits from the particle of primary source

Tracking Performance

Purity and efficiency

- 10x275 beam (highest rate), DIS, NC, Q2>1, 10um gold coating
- >= 4 hits per track



Tracking Performance

Purity and efficiency

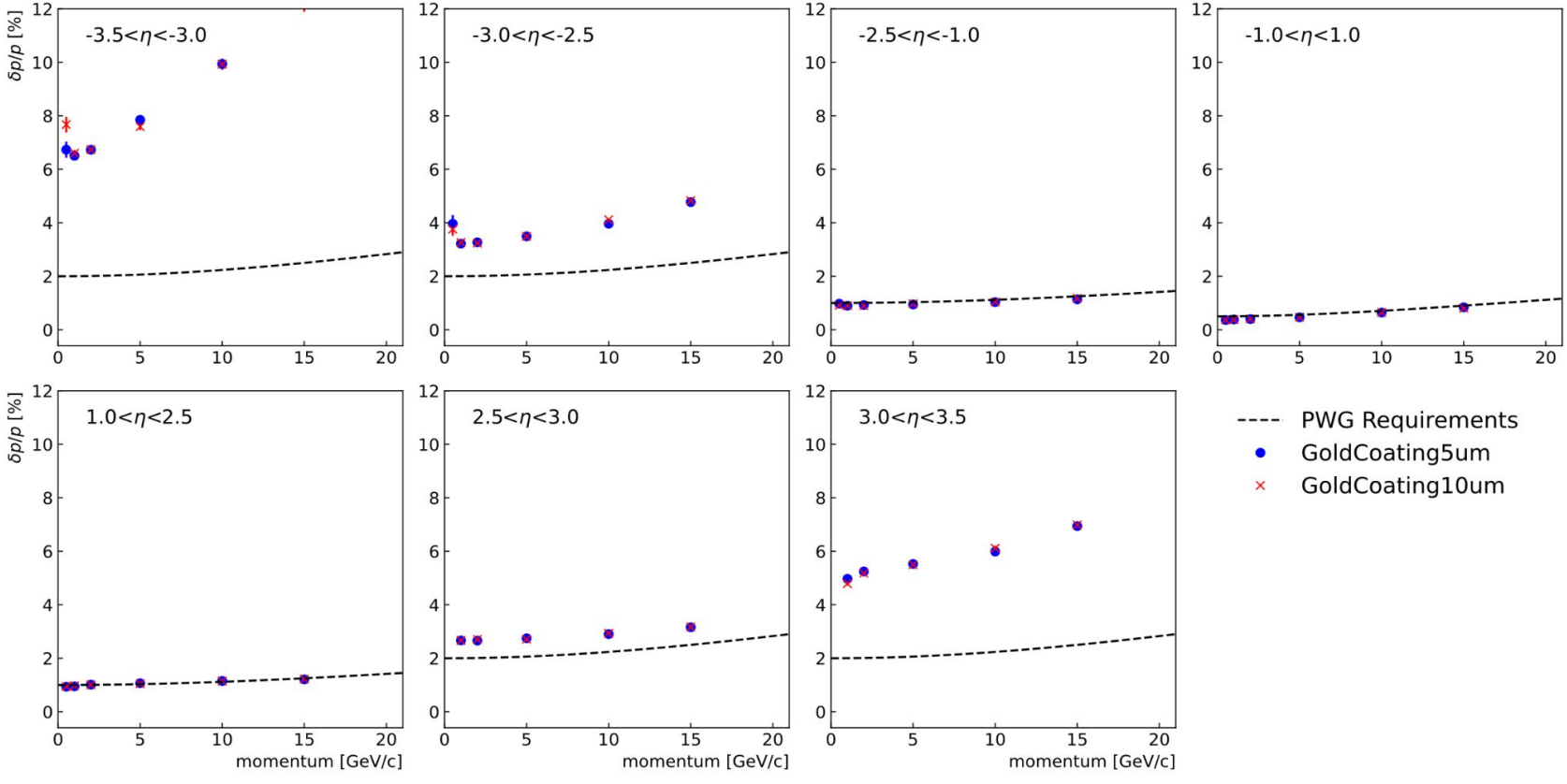
- 5um → 10um: both purity and efficiency improved
- 4 hits → 5 hits cut: lower efficiency, higher purity

❖ 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 Performance

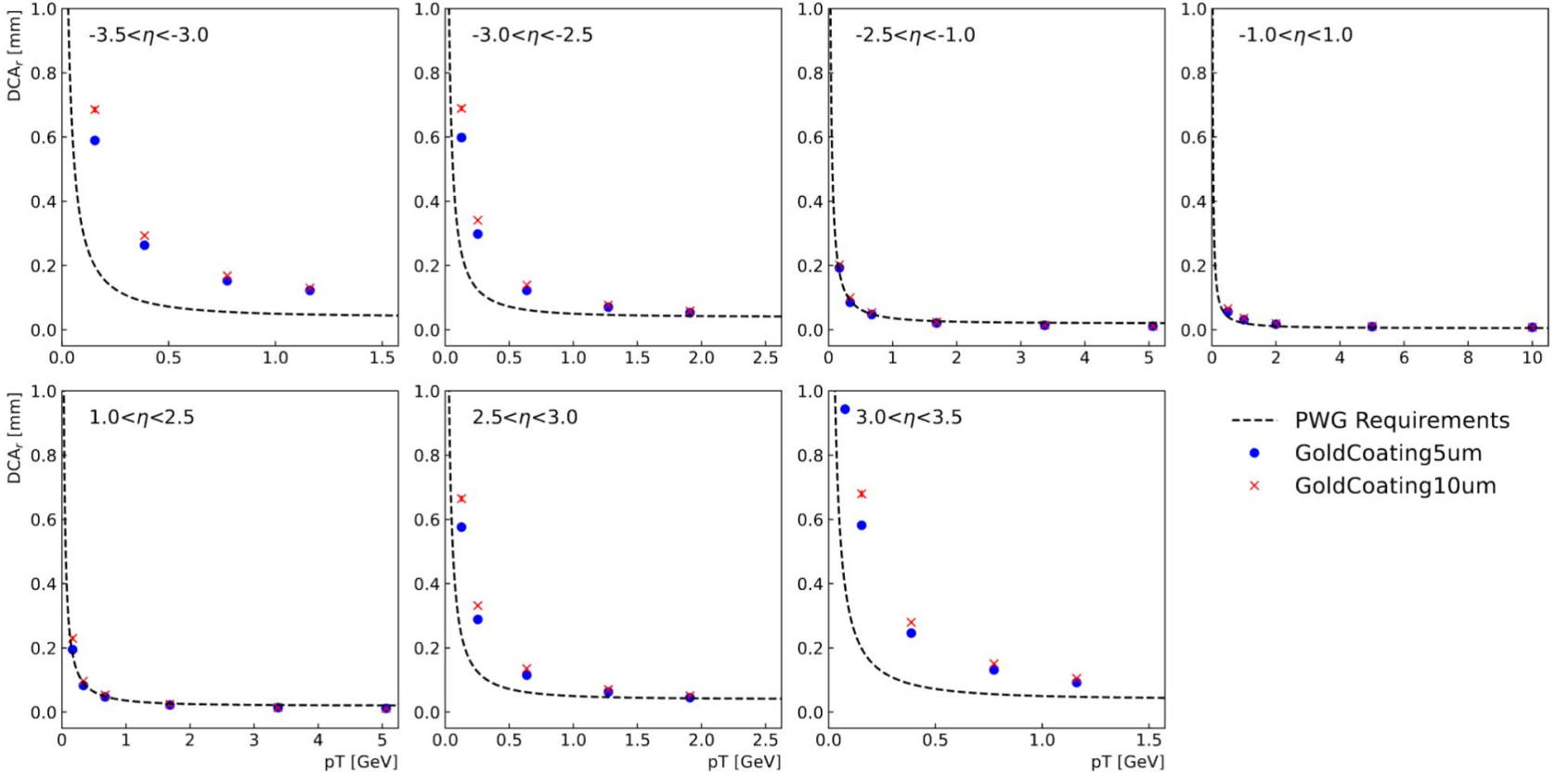
Tracking resolutions (single pion): **dp/p no changes**



theta, phi show similar impact. see details here

Tracking Performance

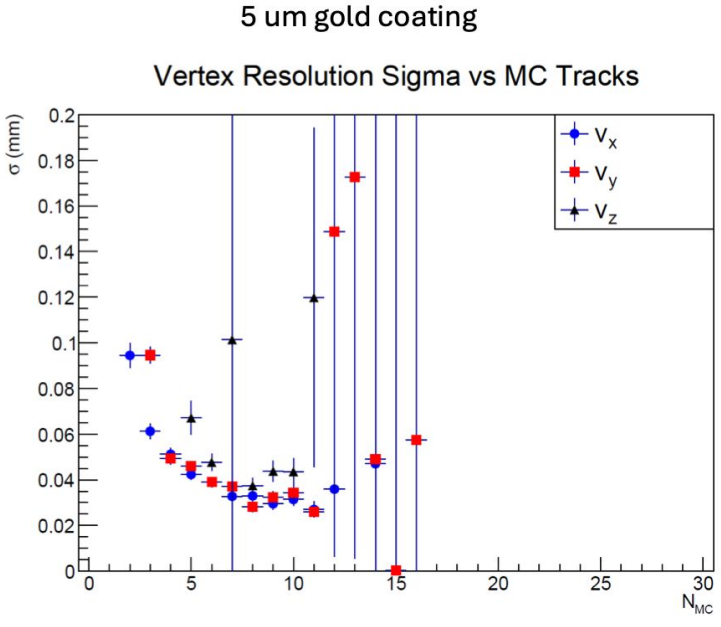
Tracking resolutions (single pion): **DCAr** sees <20% increase from 5um to 10um Au coating. No significant change against PWG curves.

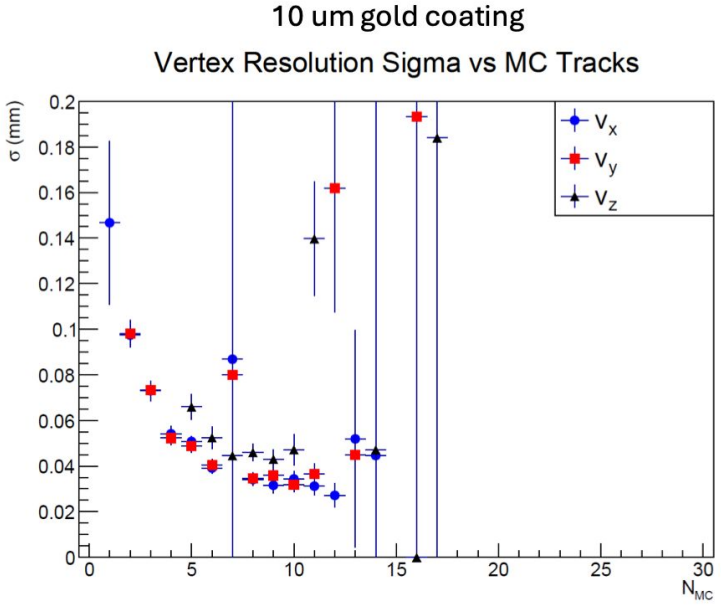


Tracking Performance

Primary vertexing (DIS only)

resolution slightly increased with 10um Au coating (see Barak Schmookler's talk)

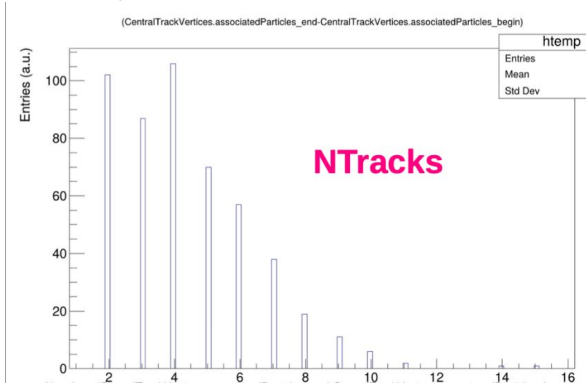




Primary vertexing:

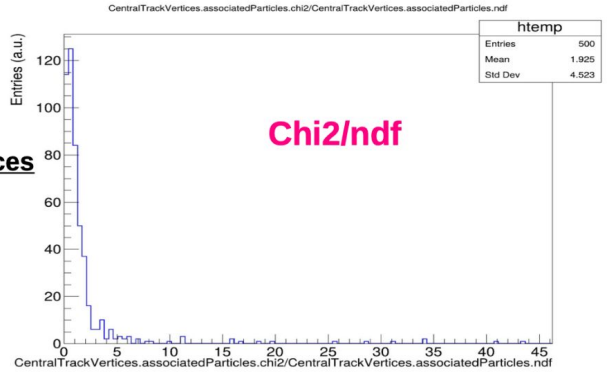
See Shyam Kumar's talk

DIS only, 3 hits per track cut:

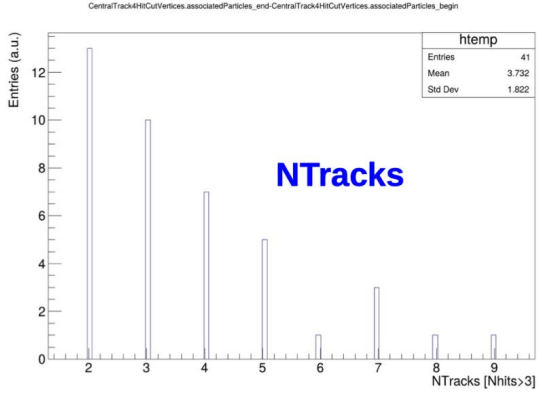


CentralTrackVertices

w/o Machine Bkg
Total events = 591



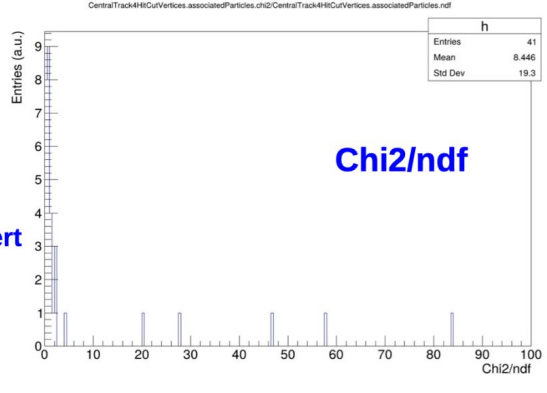
DIS+background, 4 hits per track cut:



ndf = 3*Ntracks -3

Min 4 hits

10 µm Au coating
CentralTrack4HitCutVertices
Total events = 39



- Lower efficiency, larger chi2 with background as expected
- TBD: D0 reconstruction performances

Summary

With 10x275 beam and 10um Au coating

SVT Readout rate (averaged over time):

- total rate out of SVT: 254 Gbps
- max rate on EIC-LAS: 25 Mbps/tile
- max rate on MOSAIX: 57 Mbps/tile

study on frame-to-frame fluctuation, and sensor response ongoing

Tracking Performance:

- **Purity and efficiency:**
  - 4 hits per track cut is recommended
  - purity and efficiency >80% with rooms to improve
- **Tracking resolutions:**
  - dp/p, theta, phi, DCAr resolutions with single pion+ show no red flag. Studies with DIS+background ongoing
  - Primary vertexing seems under control with 4 hits cut. D0 study ongoing

SVT radiation exposure:

- study exists for 5um beampipe [link], update will be done but is not now in hand.

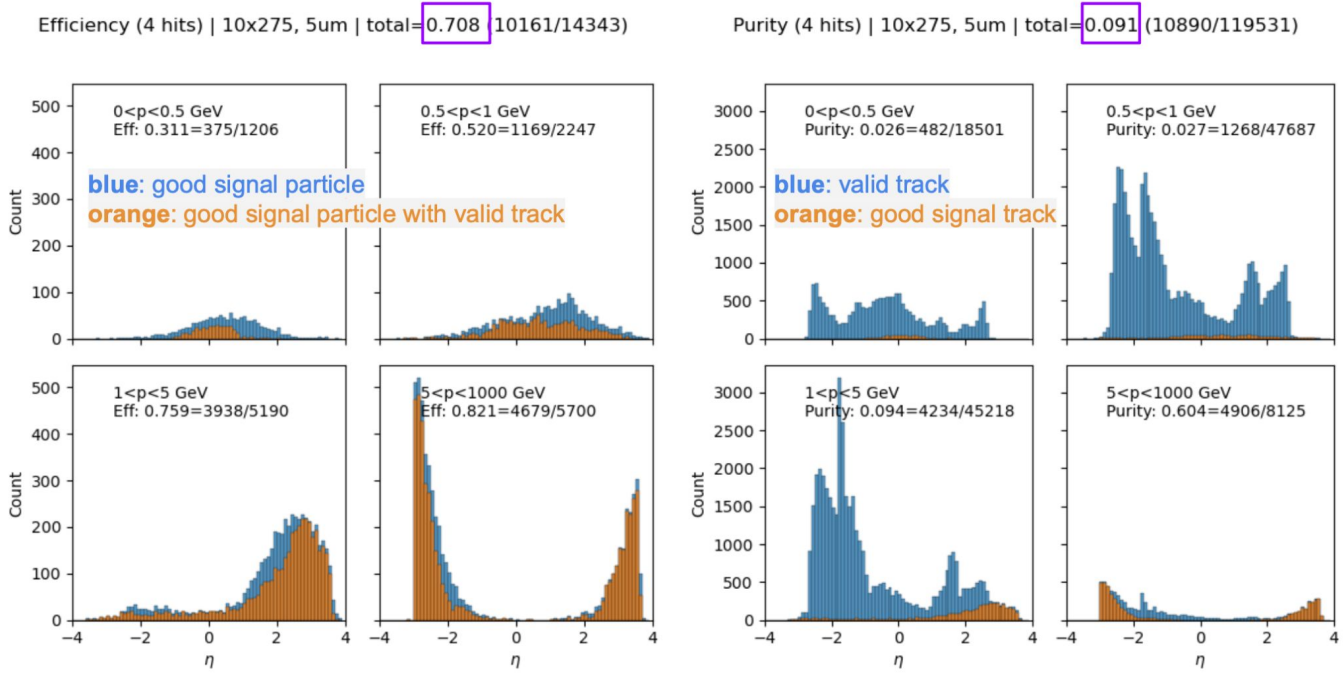
Backups

March Simulation Campaign Recap

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

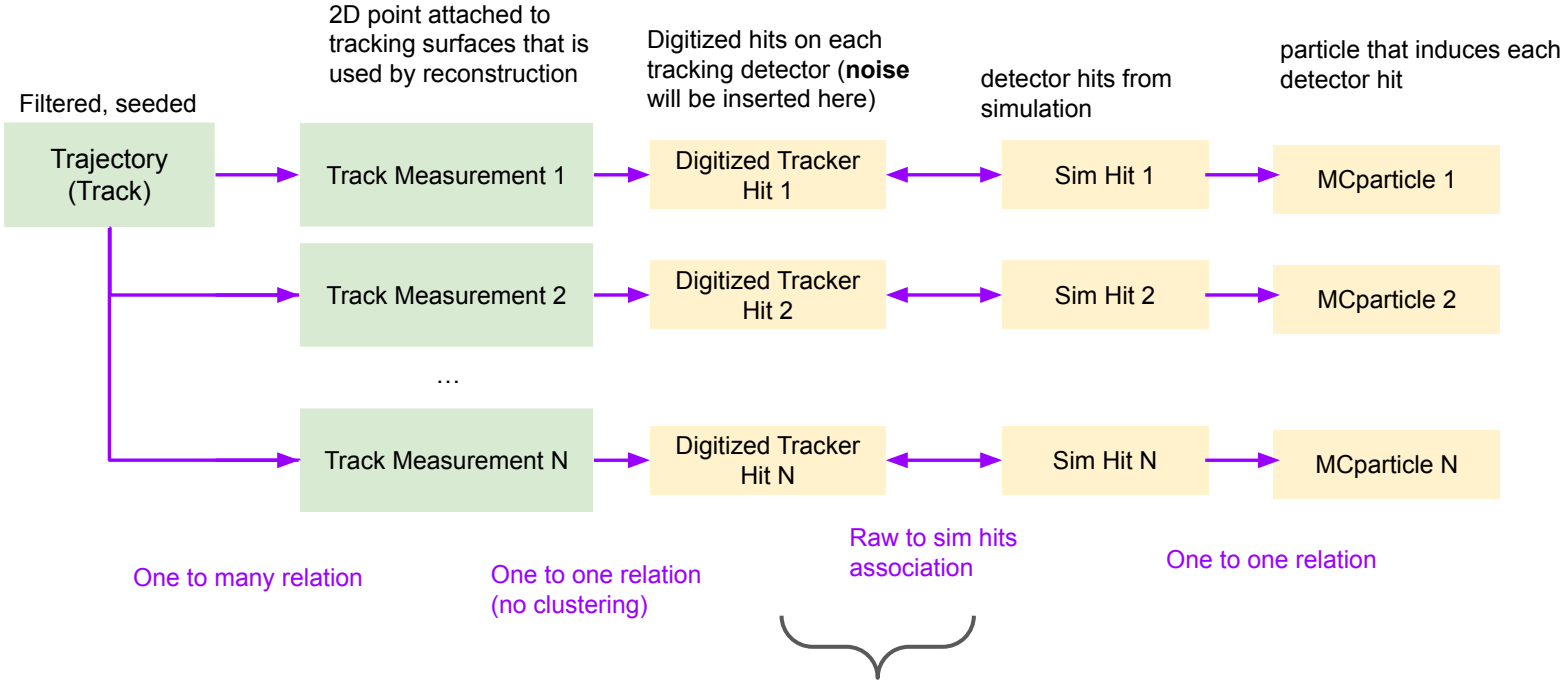
- **DIS+background:**
  - purity and efficiency: significantly better with 10um coating with 4 hits per track cut, thanks to the reduced number of background hits.

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

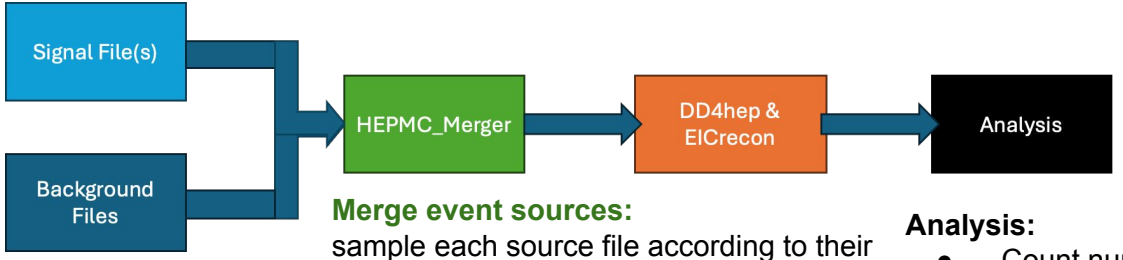


Hit-based Tracking Study Workflow

- **Match trajectory, detector hits, and simulated particles**



Signal+Background Event Samples



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

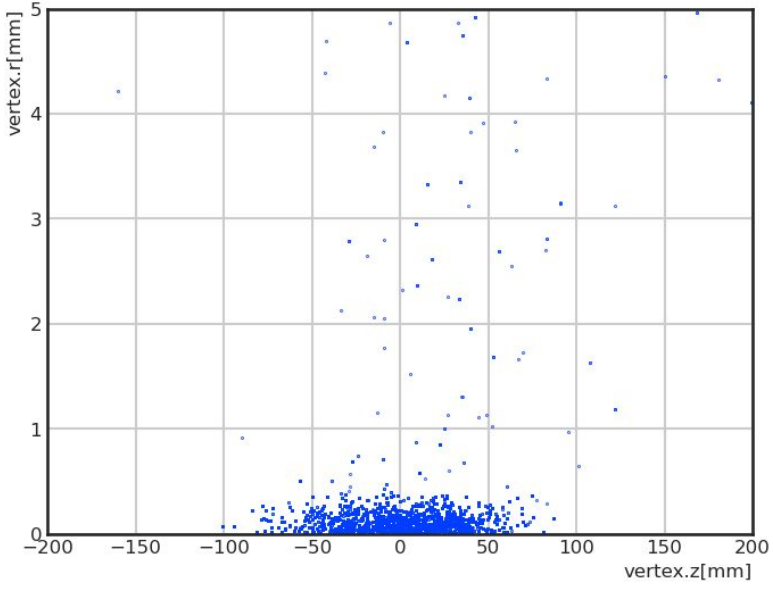
Analysis:
- Count number of digitized hits on STV per area per time

One event = one collision → (merged) One event = one 2us time slice that contains (in this presentation):
- One Q^2>1 GeV^2 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

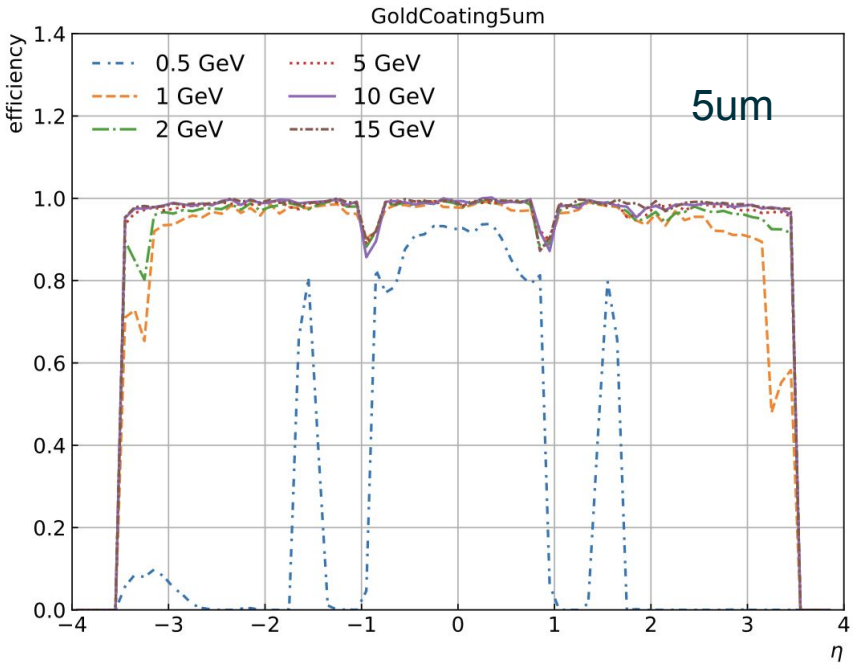
- Electron beam-gas rates consider larger region of -5 to +15 meters along the IP, hadron beam-gas rates consider region of -5.5 to +5 meters.
- For more details on background sources, check the ePIC wiki and also

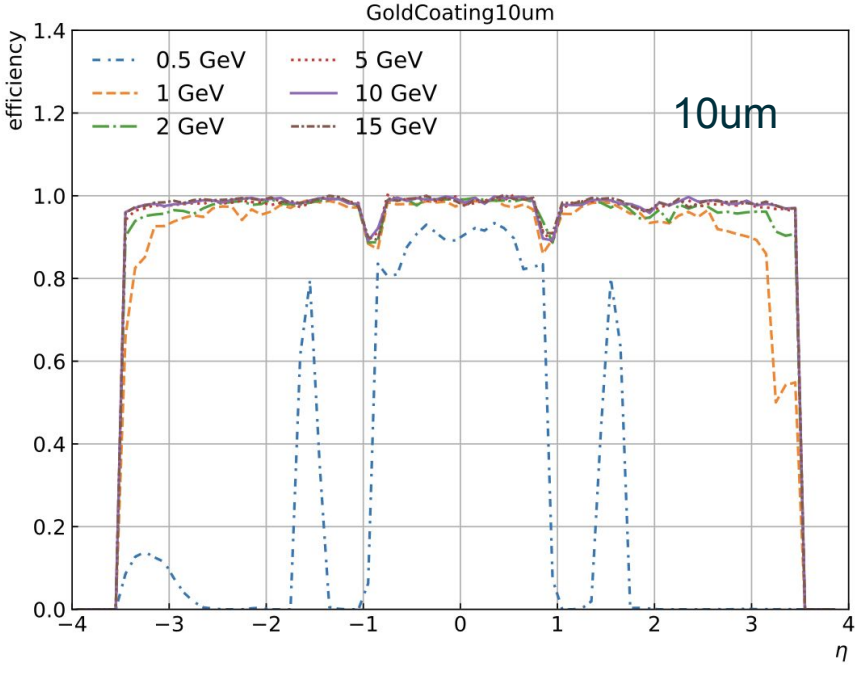
Vertex abs(r)<1mm, abs(z)<100mm seems to be a good sanity cut for DIS events

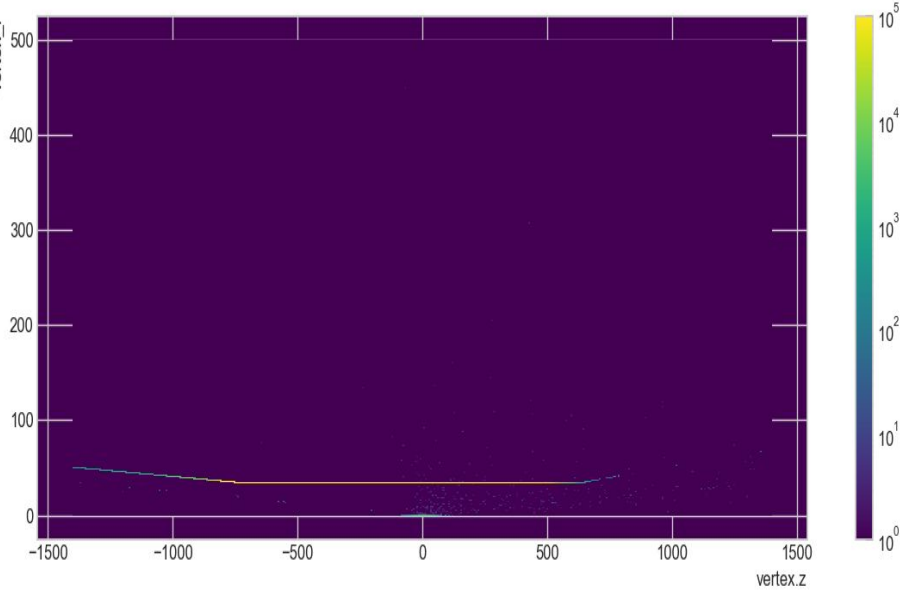


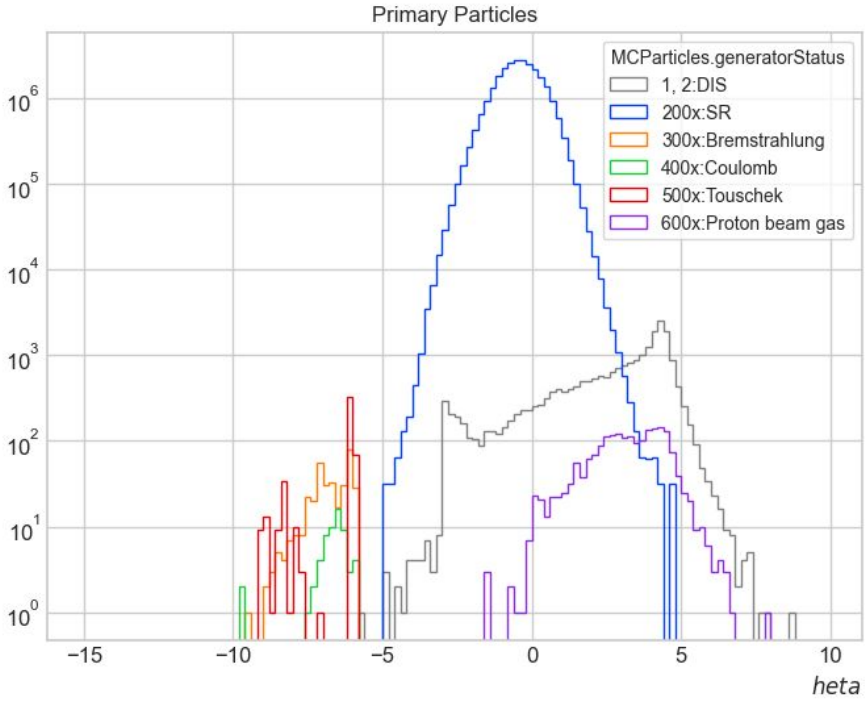
1. Single pi+ study

Impact on **Efficiency**: negligible






500
400
300
200
100
0
−1500
−1000
−500
0
500
1000
1500
vertex.z
10^5
10^4
10^3
10^2
10^1
10^0


Primary Particles
MCParticles.generatorStatus
1, 2:DIS
200x:SR
300x:Bremstrahlung
400x:Coulomb
500x:Touschek
600x:Proton beam gas
10^6
10^5
10^4
10^3
10^2
10^1
10^0
−15
−10
−5
0
5
10
heta

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