



BERKELEY LAB

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SVT Background Challenge Update

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ePIC TIC meeting

Oct.05.2026



Overview

Previous TIC updates:

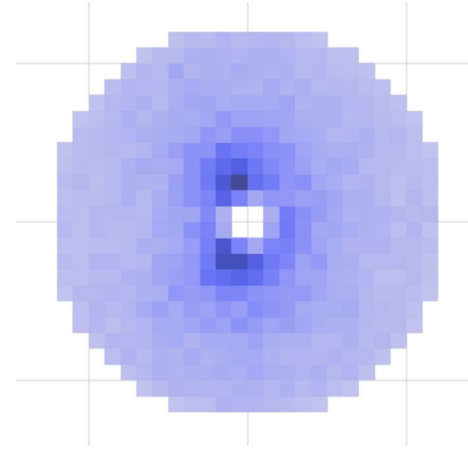
- March 23 by Shujie Li: 10x275 GeV [link](#)
- May 18 by Barak Schmookler: 10x100 GeV, hit rate by sources [link](#)

New developments:

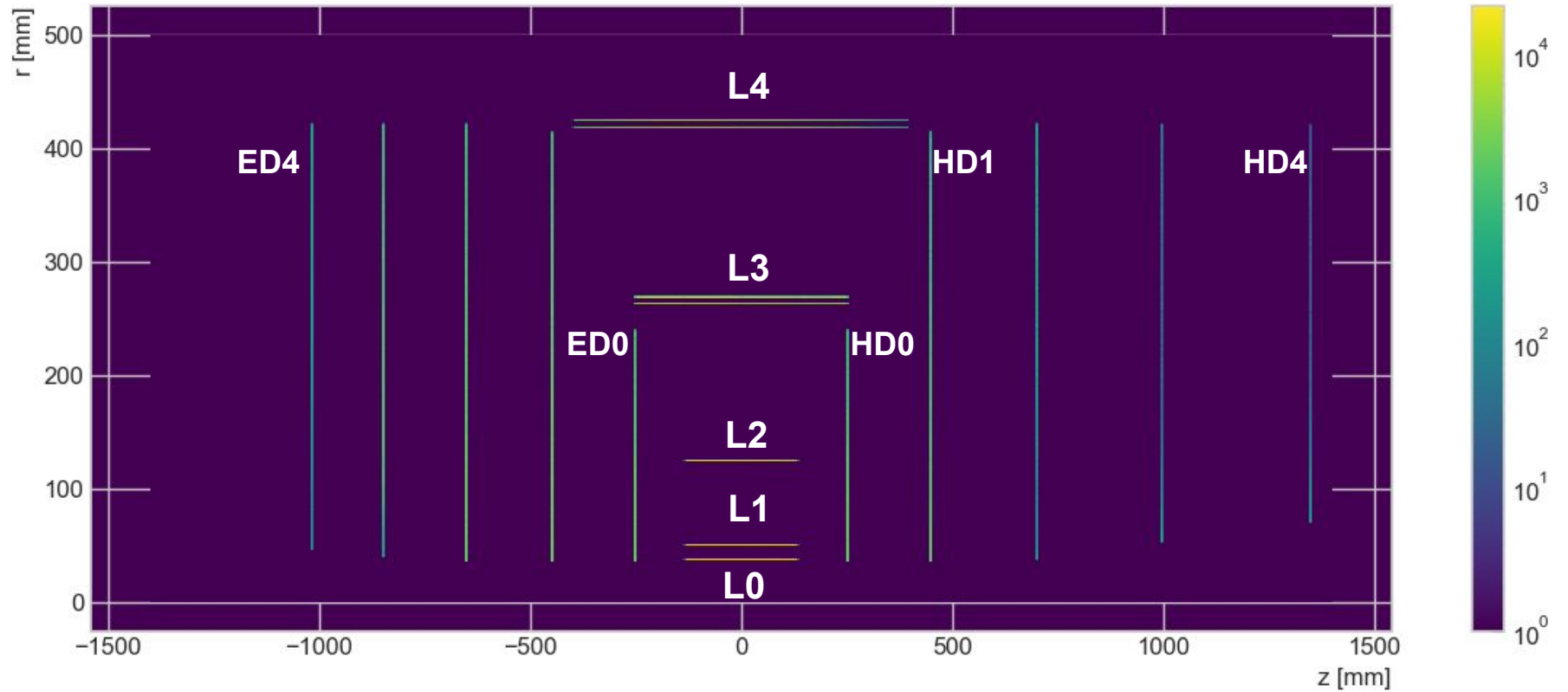
- SVT geometry and sensor response
- noise injection

This presentation:

- **configuration:**
 - forced DIS + all beam background at 10x275 GeV (highest total rate)
 - eic-shell 26.08 and corresponding epic geometry
- **performance studies:**
 - SVT hit rate
 - tracking performance (with full set of central tracker = SVT+MPGD+AC-LGAD)



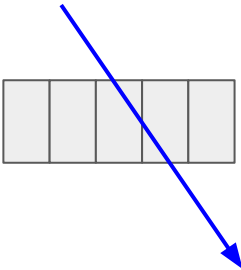
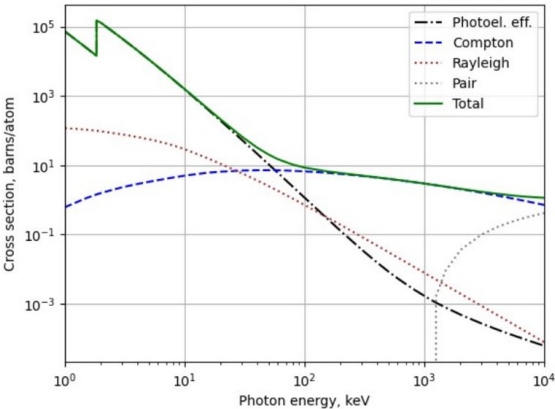
SVT Hit Map



Sensor Response

	Low energy photons	Charged Particles
Interaction probability	Sensitive to material thickness	-
Cluster size	-	Mainly geometric dependent e.g. pitch size, thickness, incident angle

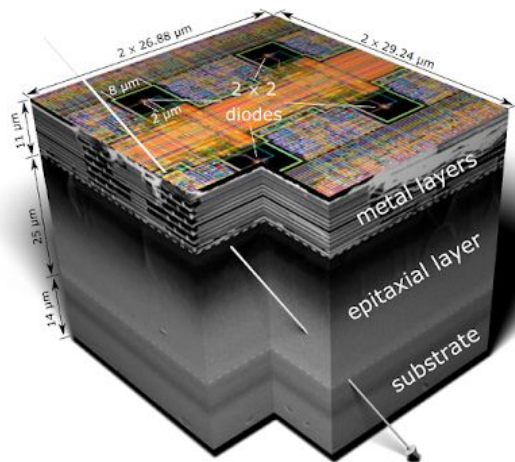
Photon Interaction with Silicon



Sensor Structure

Previously in DD4hep: 1 layer of 40um of sensitive Si

Sensor Design:



Particles interact with sensor and generate signal charges

⇒ Signal charges been collected through drifting and diffusion

⇒ Collected charges are processed by integrated readout electronics

Sensor Structure

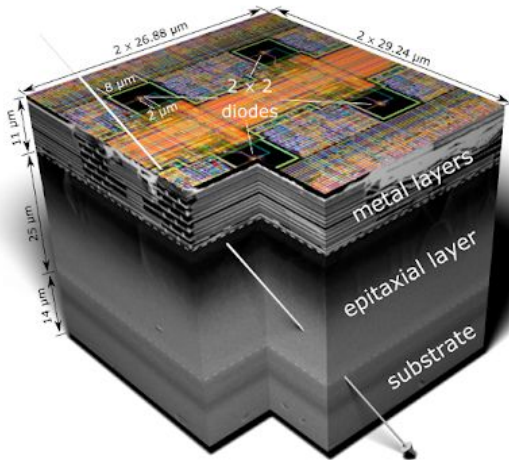
Previously in DD4hep: 1 layer of 40um of sensitive Si



Sensor Design:

Match sensor response between stand-alone **Geant4** and **TCAD+Allpix2** simulation, and validate against beam test data

- Months of effort led by Zhenyu Ye and Yu Hu (LBNL) [\[link\]](#)
- Tune effective thickness in Geant4 to match the **interaction probability**:
2.5um Cu (metal layer) + 14um active Si (epitaxial) + 36um inactive Si (substrate)
- Benchmark b/w DD4hep and Geant4 has been performed

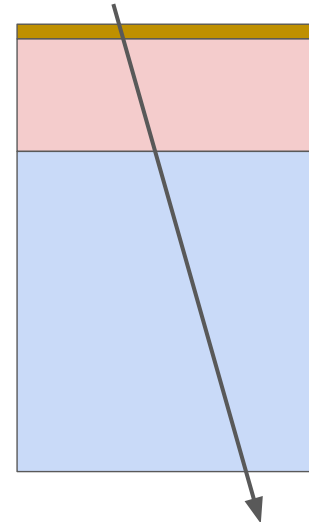


Sensor structure in Simulation

Cu ~ 2.5 um

Epitaxial (Si)
~ 14 um

Substrate (Si)
~ 36 um

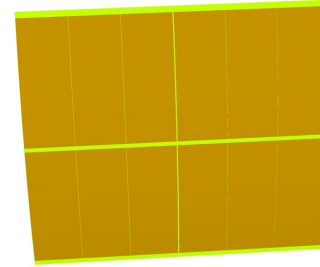


Sensor Structure

Geometry changes in 26.08 [\[PR\]](#):

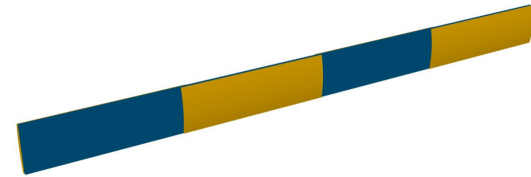
Inner Barrel: Each **RSU** contains

- One Cu layer always facing outward (larger R)
- One Si layer with 12 active tiles + insensitive areas (shown on the right)
- One Inactive Si layer



Outer Barrel: each **module** (representing 5 or 6 RSU) contains:

- a Cu layer always facing the external side i.e. away from the support stave, following by active and inactive Si layers.
- Sam Henry (Oxford) is leading a [separate effort](#) to produce a detailed description with support structures and fully curved RSU/tile.

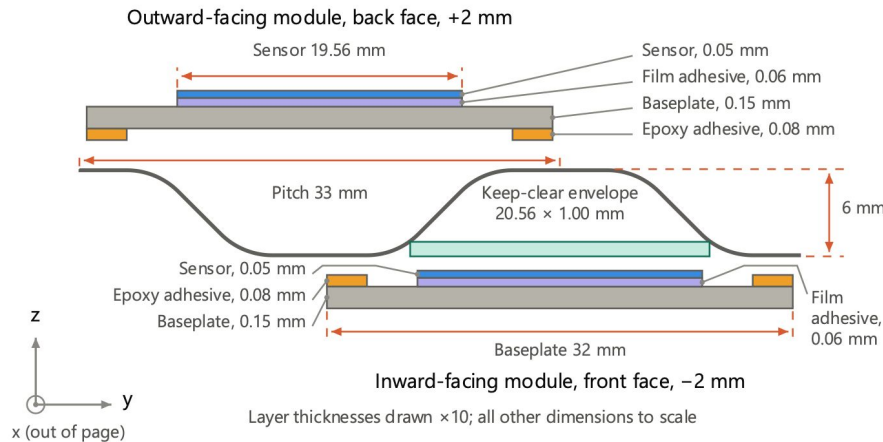


Sensor Structure

Ongoing development on disk geometry [\[PR\]](#):

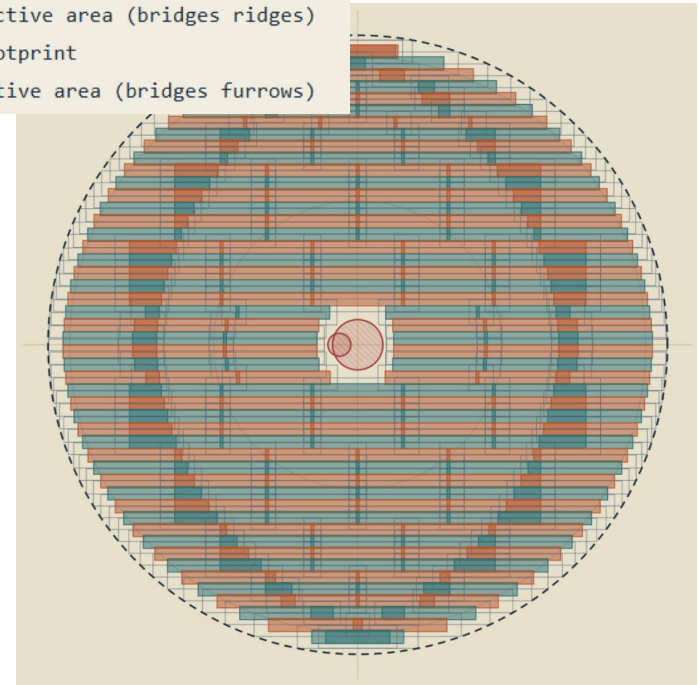
work by Ernst Sichtermann, Nicole Apadula, Provakar Datta (LBNL)

- 40um active Si $\Rightarrow$ EIC-LAS modules with 3-layer RSU structure
- smooth trapezoid surface $\Rightarrow$ disk assembled with overlapped modules (inward/outward-facing) on two sides of the corrugated carbon frame.



LEGEND

- front-face active area (bridges ridges)
- baseplate footprint
- back-face active area (bridges furrows)



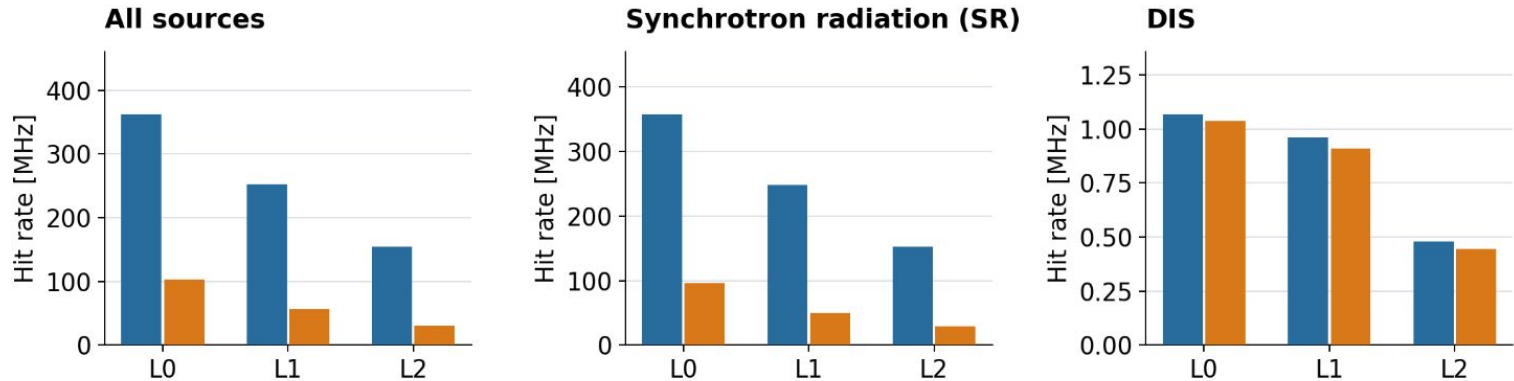
courtesy of Ernst Sichtermann

Sensor Structure

Impact on hit rate (example with IB, no noise):

- ePIC 26.04: 40um-thick active silicon. used in the recent data rate estimation [link](#)
 - ePIC 26.08: updated three-layer (Cu/Si/Si) structure.
 - 1 event = 2us, rates are averaged over time.
-
- ~a factor of 3 reduction in **total** rate per layer driven by the reduced SR rate as expected.
 - Further study will be performed after the OB and disks geometry updates.

■ ePIC 26.04 · 1,900 events ■ ePIC 26.08 · 9,900 events



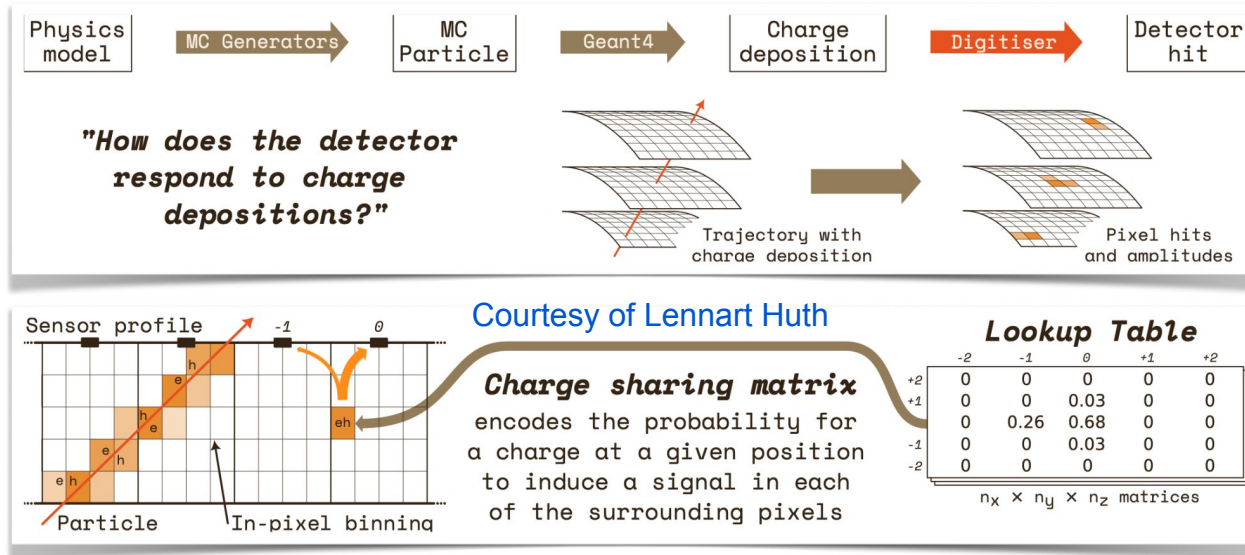
Clustering

DD4hep simulation:

- No explicit clustering mechanism. 1 hit $\rightarrow$ 1 fired pixel
- **diffusion/charge-sharing** is not considered in dd4hep but very small
- **Geometry** effect is missing because npsim is configured to record only one hit (weighted sum) per sensitive surface per particle. Recording intermediate steps is computationally expensive.

Post-processing:

- **Now:** no clustering algorithm. Assume **1 hit = 3 pixels** (upper limit from ITS3) in data rate estimation.
- **Planned:** TCAD+Allpix2 lookup table for clustering (see below [example](#) from OCTOPUS) in EICrecon, followed by a clustering algorithm to form the measurement for tracking.

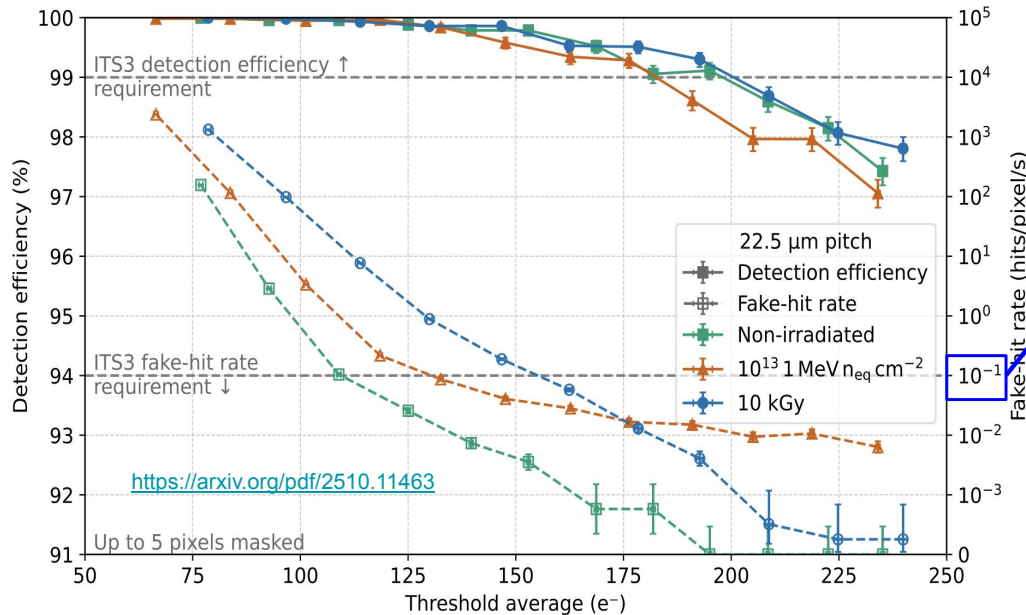


Beam Background + Sensor Noise

Noise hit: uniform distribution, proportional to SVT surface area (# of pixels)

Background: strong geometry dependence and source dependence

Their impact on [track reconstruction](#) varies on each surface, e.g. at larger R: noise hit density unchanged, background hit density drops sharply. See more discussions [here](#)



Use the ITS3 upper limit of 0.1/second:

- $2e-7 \text{ hit/pixel/2us} \Rightarrow 0.08\text{MHz} / \text{RSU}$
- Assume randomly distributed on all RSU surfaces

(a) Pixel matrix with pitch 22.5 μm irradiated to different levels.

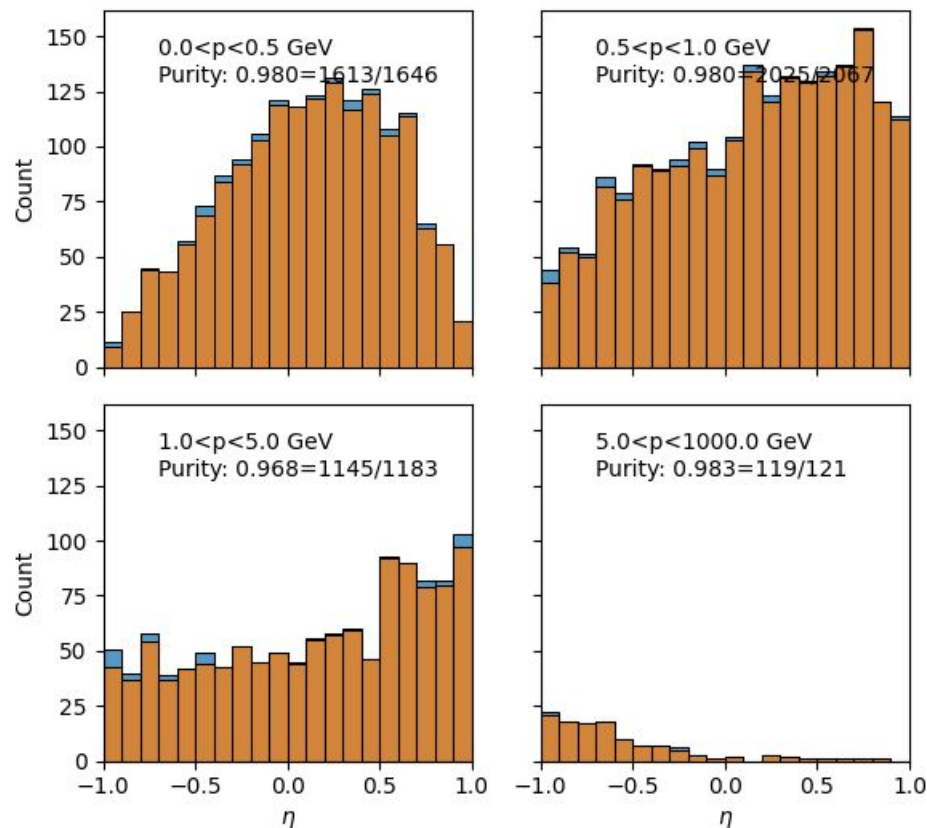
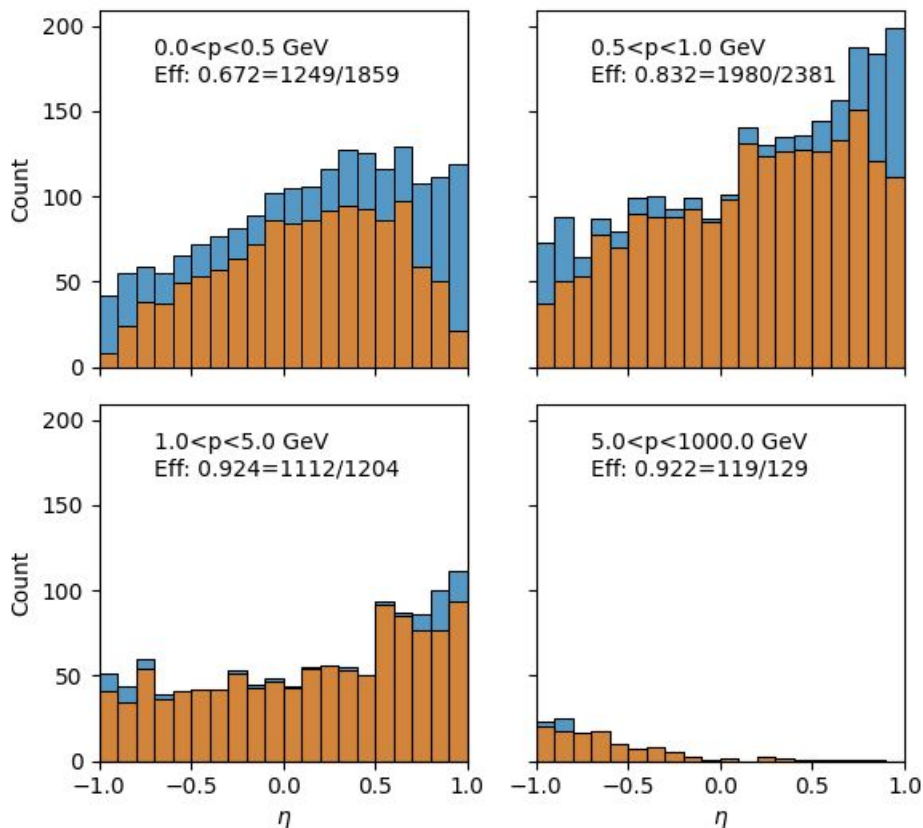
Tracking Performance

Same datasets from the baseline of L4 study [link](#)
blue: input; orange: reconstructed

- Barrel region ($-1 < \eta < 1$), no noise

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

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

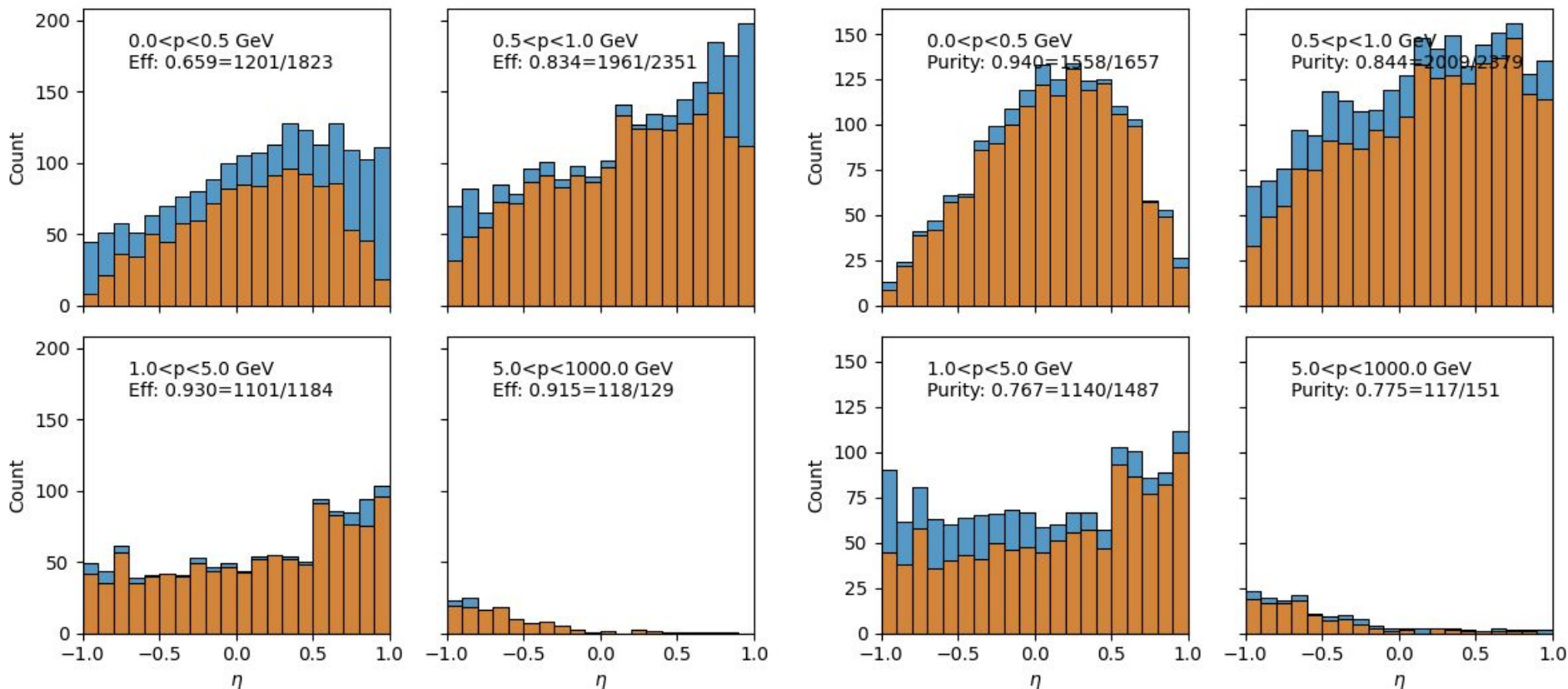


Tracking Performance

- Barrel region ($-1 < \eta < 1$), with noise: **comparable efficiency, lower purity**

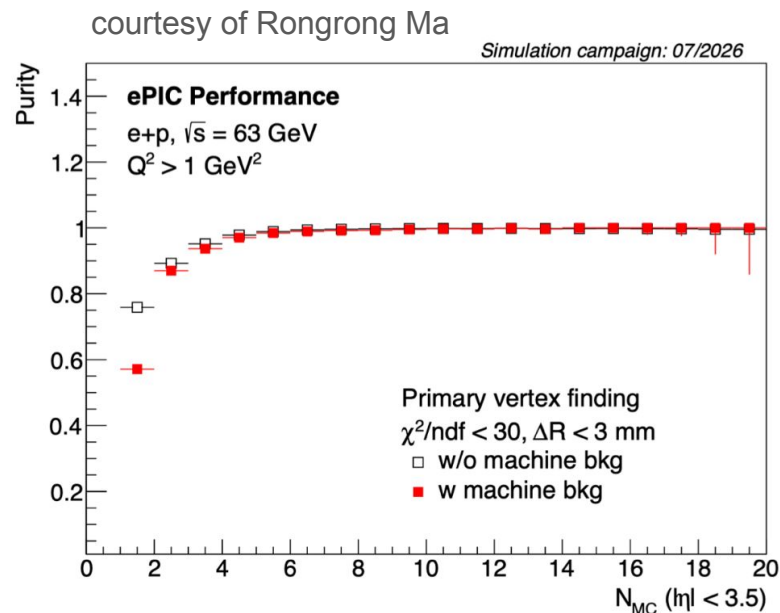
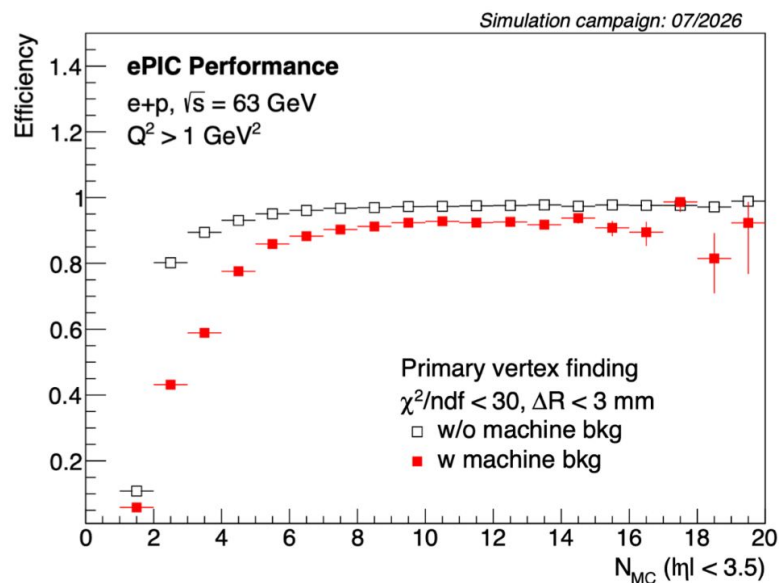
Efficiency (4 hits) | 10x275, epic_noise | total=0.798 (4381/5487)

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



Vertexing Performance

- Work by Rongrong Ma (BNL) [link](#):
 - 10x100 GeV beam
 - epic 26.07 (before sensor structure update)



- Efficiency: fraction of good RC vertex to all MC vertex
- Purity: fraction of good RC vertex to RC vertex with $\chi^2/\text{ndf} < 30$
- Good RC vertex: $\chi^2/\text{ndf} < 30, \Delta R < 3$ mm

Next Step

Development:

- Update disk geometry with EIC-LAS module placement.
- Implement hit-to-pixel parameterization and the corresponding clustering algorithm.
- Extract hit rate from each RSU sensitive component instead of a 2d binning on the surface, track event-by-event fluctuation.

Analysis:

- full set of rate and tracking performance evaluation with various beam energy and event sample (DIS, minbias etc) configurations.
- Dedicated SVT missing layer and bad sensor studies with realistic signal + background.
- Radiation exposure study.