BERKELEY LAB
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U.S. DEPARTMENT OF ENERGY
Office of Science

WP9: SVT Simulation Updates

March simulation campaign | Plan for next 6 months

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ePIC SVT General Meeting

03.17.2026

March Simulation Campaign Recap

Change:

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

Motivation:

- reduce synchrotron radiation background

Request from Feb 23 TIC meeting:

Feedback on progress by a set of slides to be present at TIC within 1 month:

a) DSCs: Impact on detector performance (PID postponed); step 1

b) EI/R-O/DAQ CC WG: Impact on data flow, requested bandwidth and potential dead-time; step1

c) DSCs: radiation/fluence damages; using the new summed maps

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c) DSCs: radiation/fluence damages; using the new summed maps

Status or volunteers?

DSC responsibility

- **Re-evaluate the ionizing dose and neutron fluence** on your detector (average, hottest zone) by integration over 150 fb using the summed maps;
- Compare these doses/fluences with the safety doses/fluences for your sensors;
- Estimate the damage in terms of decreased performance (performance as discussed above) after 150 fb

March Simulation Campaign Recap

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

- **DIS+background:**
  - SVT average hit rate per tile reduced by a factor of >4 (see my talk at the ePIC Jan meeting)
  - Data rate (10um):

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

- 3 pixels per hit
- 32 bits per pixel on average

Total rates out of SVT (no sensor noise):

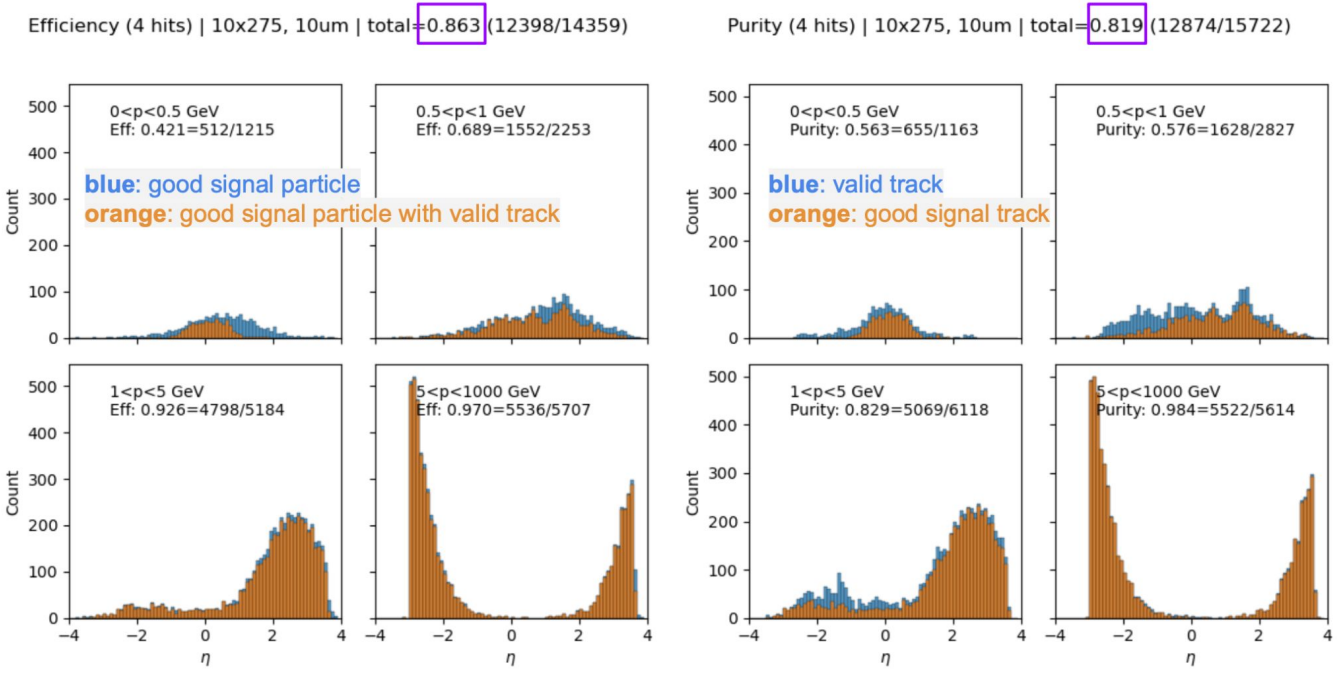
- IB (L0,L1,L2): 74 Gbps
- OB (L3, L4): 78 Gbps
- Disks (E): 73 Gbps
- Disks (H): 30 Gbps
- Total: **254 Gbps**

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, 10um gold coating, at least 4 hits per track: OK efficiency, OK purity



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

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

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

March Simulation Campaign Recap

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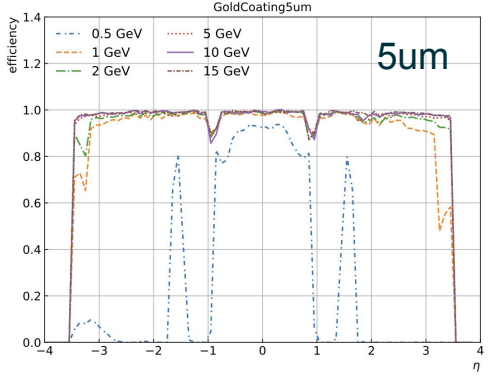
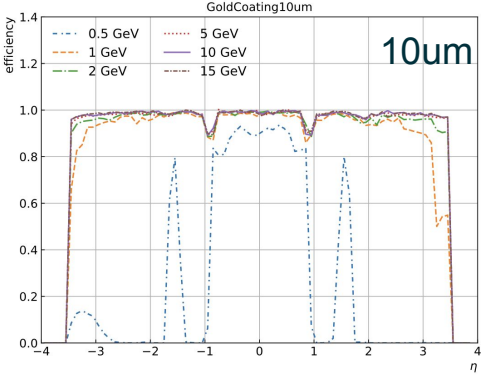
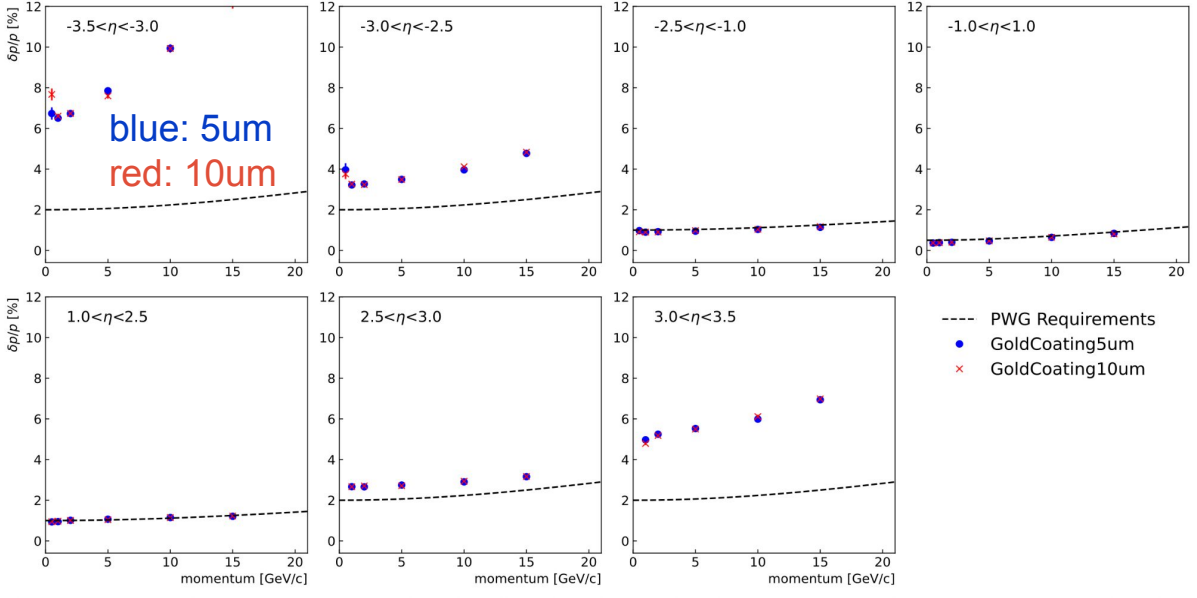
- **Single particle (pi+) study:**
  - efficiency and dp/p: no change



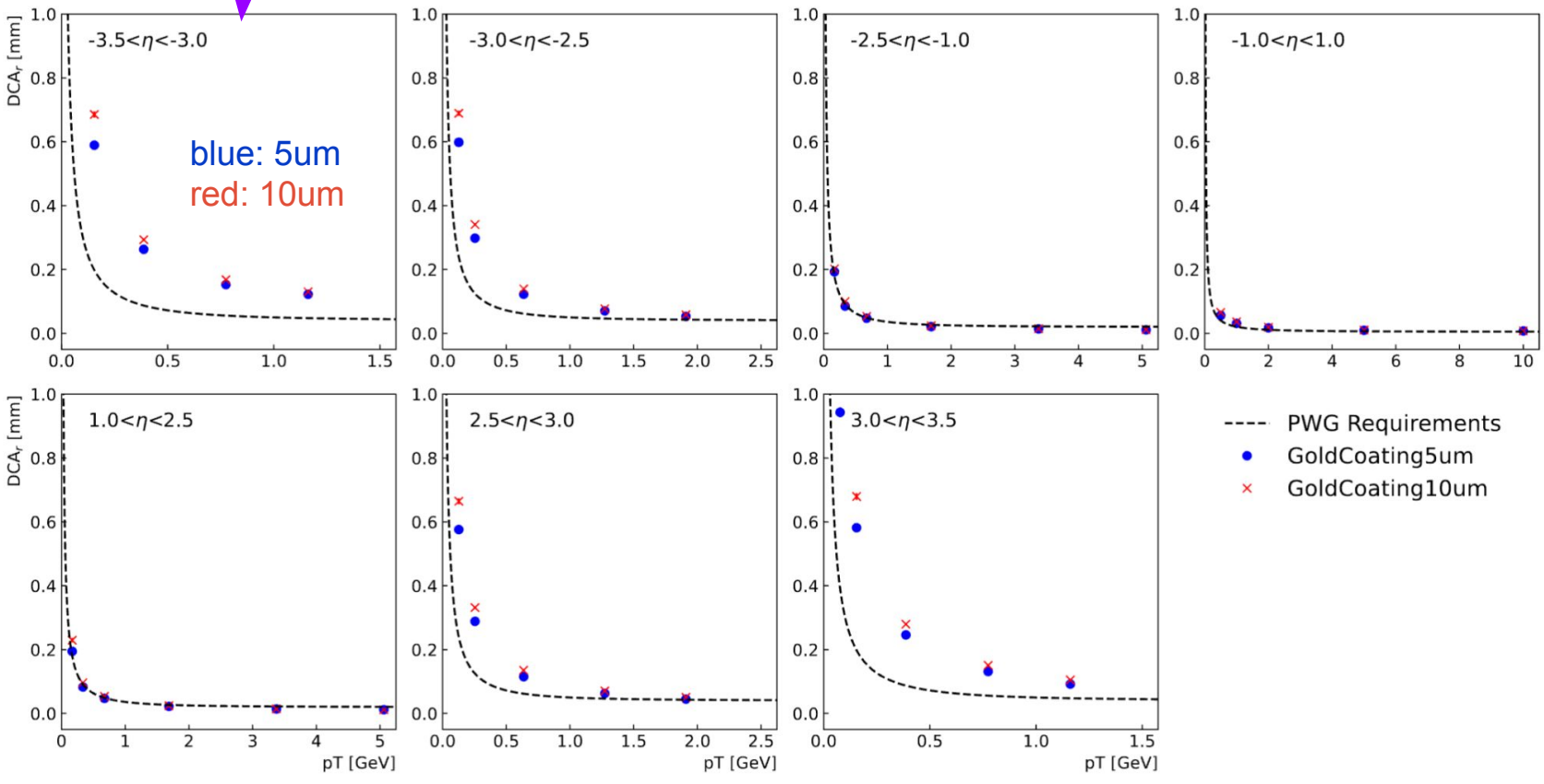




March Simulation Campaign Recap

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

- **Single particle (pi+) study:**
  - DCAr, theta, phi resolution: up to 20% increase

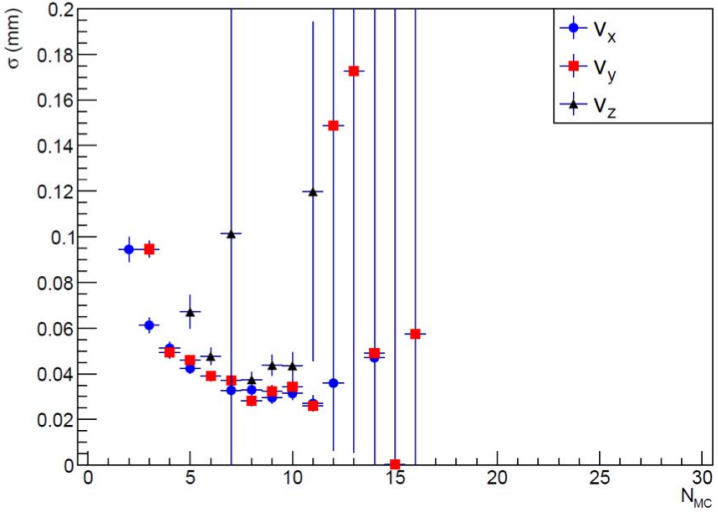


March Simulation Campaign Recap

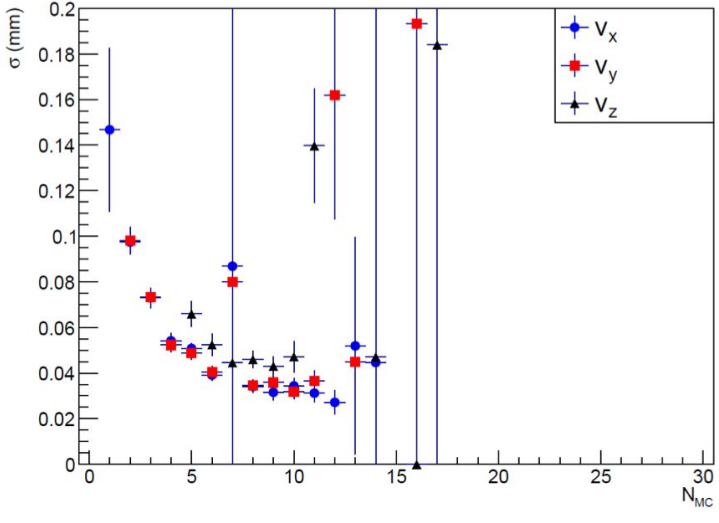
Impact on tracking performance (with highest beam background rate from 10x275 beam)

- **DIS only:**
  - Primary vertex resolution: < 20% increase (see Barak's talk at the tracking++ meeting)

5 um gold coating



10 um gold coating



March Simulation Campaign Summary

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Motivation:

- reduce synchrotron radiation background

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

- **DIS+background:**
  - SVT average hit rate per tile reduced by a factor of >4 (see my talk at the ePIC Jan meeting)
  - much better purity and efficiency
- **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

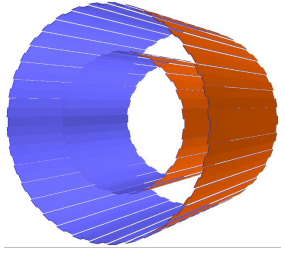
❖ This simulation campaign will be used for ePIC early science study. (workshop this week)

Next Step: Geometry

1. **Forward Disks envelope (Planned for 04.2026)**
- MPGD forward disks zmin: 1500mm (until 03.2026) → 1285mm PR
- SVT H disk positions: HD3, 4: 1000, 1350mm → 950, 1200mm PR
- Both changes will be merged at once after the MPGD overlaps are resolved

2. **Disk layout** (worker: SL)
- **Goal:** module shapes: trapezoid → EIC-LAS modules with RSU structure
- technical **challenge**:
  - Geometry overlaps due to beampipe fanout. The previously developed plugin which addressed this issue no longer work after recent software upgrades.
- **Plan**:
  - find an alternative way to implement the EIC-LAS module plugin, then place modules according to current design

3. **OB staves** (worker: TBD)
- **current**: constellated flat staves (work by the UK group: Sam, Athanvan, Stephen …)
- **work in progress:** git branch on curved_ob and curved_modular_ob (Sam Henry)
- **Plan:**
  - finish the curve geometry, or
  - keep the flat stave, add RSU structure



4. **IB and PST** were implemented in Oct 2025. Any updates needed?

Next Step: Sensor

1. **Sensor response**

Current implementation:

- In DD4hep:
  - 40um thick of sensitive silicon
  - particle steps/hits within one tracker volume will be **combined** and assigned to **one** pixel according to Geant4TrackerWeightedSD
  - no diffusion/skin effect
- In EICrecon:
  - no clustering
- In previous hit rate estimation:
  - assume 3 pixels per hit (a chosen overestimation according to ITS3 TDR)

Ongoing investigation at LBL:

- distinct energy deposit mechanism for
  - high energy charged particle ionization (one particle going through multiple pixels, charge sharing and clustering) → beam test (Tucker, Zhenyu et al.)
  - low energy photon absorption → geant4 simulation vs DD4hep (Shujie, Zhenyu)
- signal charge collection by sensor electrodes → TCAD and Garfield++ simulation (Yu, Zhenyu)
- improve the pixel structure description in dd4hep e.g. active SI thickness

Next Step: Sensor

2. Pixel random noise injection (workers: Beatrice Liang-Gilman, Joshua Sobajic @UCB)

- **Plan**:
  - In EICrecon, randomly assign noisy pixels according to the nominal rate of 5e-7/pixel/event (close to finish)
  - performance study with noise injected:
    - single particle, DIS …

Next Step: Performance Study

1. **SVT bad channels and sensor acceptance**

- Required by the recent **pTDR review**
  - *"An understanding is needed of the tolerable level of dead channels for sensor acceptance. This can be studied in simulation."*

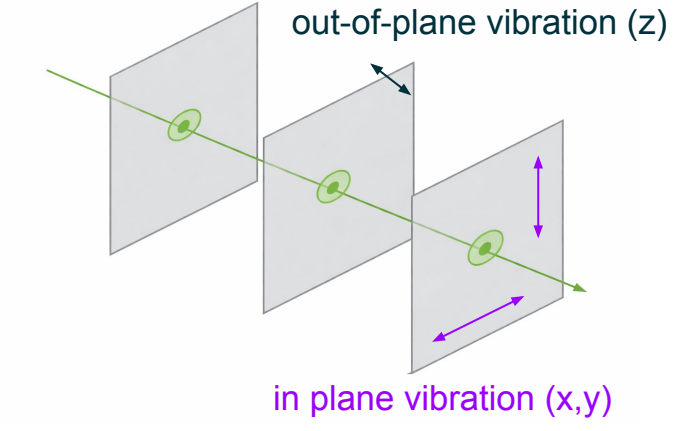
- **Developing a plan and coordination** (SVT/tracking/physics WGs …)
  - **mechanism:**
    - random bad pixel: similar approach as the noise study
    - random bad RSU/tile: need to update the OB and disks geometry first
    - what else?
  - **evaluation**:
    - simulate a range of 0.2% to 5% of bad channels on each layer
    - single pi+ study, DIS, DIS+background study
    - specific physics channels to be evaluated by physics WGs

Next Step: Performance Study

2. mechanical stability study in simulation

- required by the recent **pTDR review**
  - *"For the OB the definition of mechanical stability requires understanding of alignment and track reconstruction."*
- Can also provide useful verifications for the disk design (w/ Nikki et al.)

- **Concepts:**
  - (mis-)alignment: permanent displacement, need a separate effort.
  - **vibration**: high frequency sinusoidal wave with given amplitude, over time the effect is equivalent to an increase in x,y, or z resolution by A/sqrt(2)



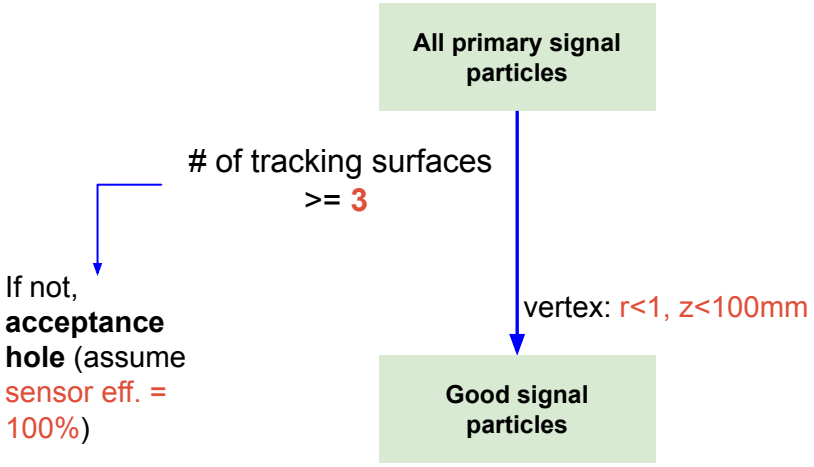
- **Existing study:** fast simulation for all barrels by Ernst link

- **Plan** with full simulation (workers: Vassu Doomra + 2 undergrads @ UCB):
  - enable layer-by-layer pixel resolution configuration in EICrecon
  - simulate a range (1 to 10um) of in-plane vibration as increased pixel resolutions.
  - study impact with single pi+ performance
  - Depends on the outcome, will look into out-of-plane degrees of freedom, and other complexities as needed.

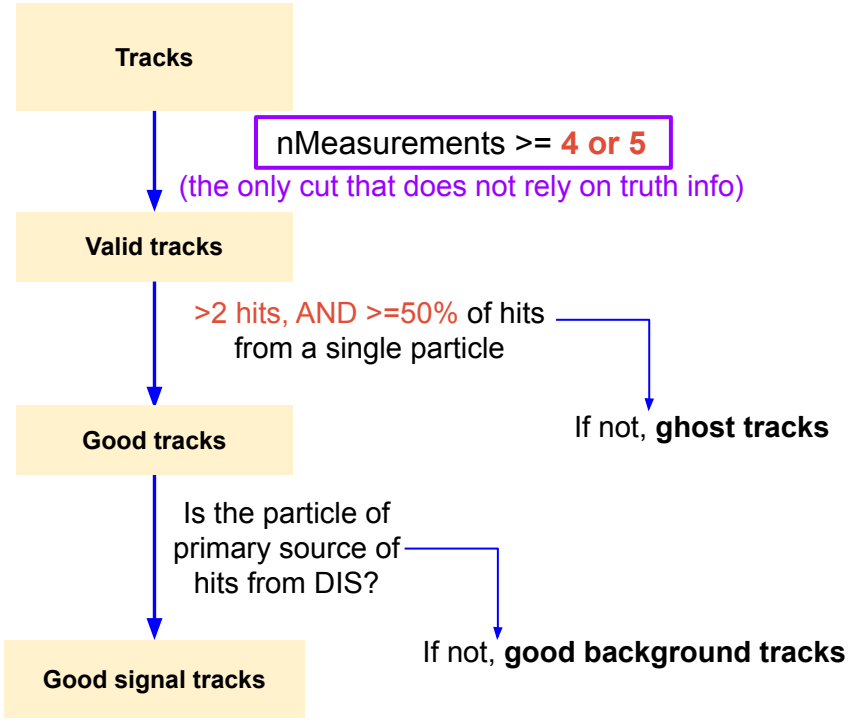
Backups

Hit-based Tracking Study Workflow (03.2026)

- **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

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