Angular Resolution Impact of μRWELL-BOT

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April 22nd, 2024

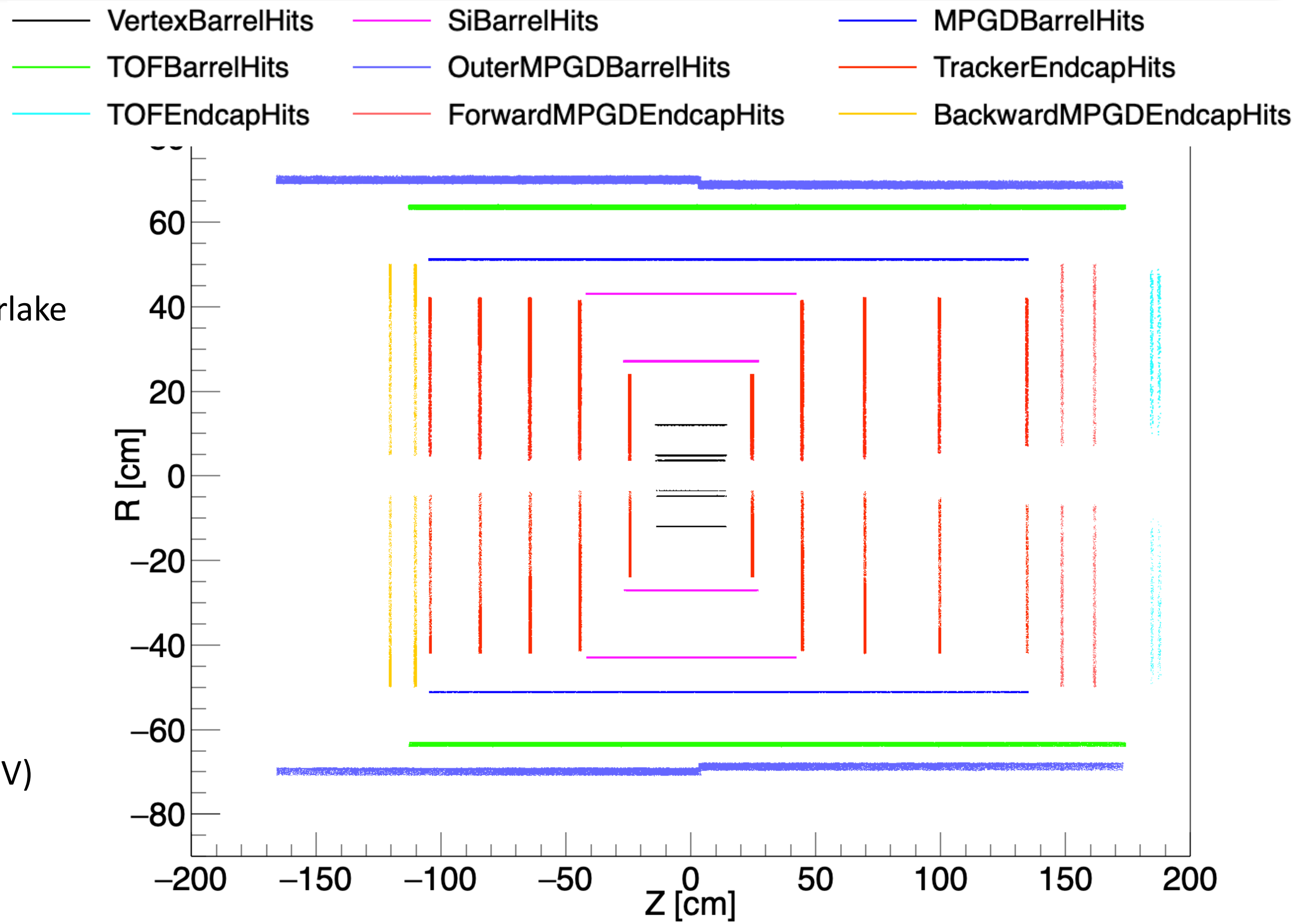
ePIC Tutorial Sessions

- ePIC tutorials will be presented Wednesday at the ePIC Software and Computing Meeting (at CERN)
  - Free remote registration and participation
  - [Indico page: https://indico.cern.ch/event/1343984/overview](https://indico.cern.ch/event/1343984/overview)
  - Listed times are local Zurich time

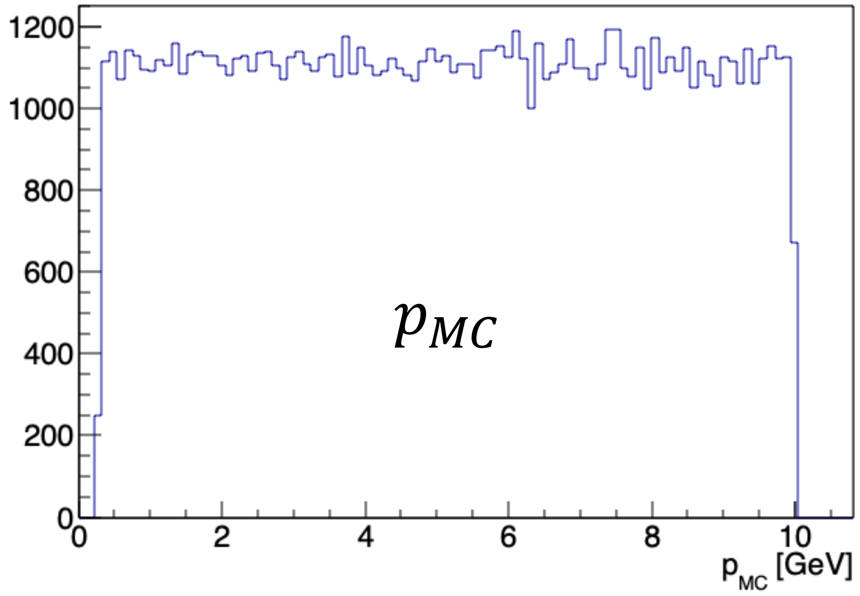
09:00	**Tutorial: Introduction to ePIC Software: Getting Started with Detector and Physics Studies for the TDR**	*Holly Szumila-Vance*	*40/S2-D01 - Salle Dirac, CERN*	09:00 - 10:00
10:00	**Tutorial: Working with Simulation Output**	*Dr Stephen Kay*	*40/S2-D01 - Salle Dirac, CERN*	10:00 - 12:00
13:30	**Tutorial: Simulating Detectors and Their Readout**	*Simon Gardner*	*40/S2-D01 - Salle Dirac, CERN*	13:30 - 15:30
15:30	**Tutorial: Developing Reconstruction Algorithms**	*Nathan Brei*	*40/S2-D01 - Salle Dirac, CERN*	15:30 - 17:30

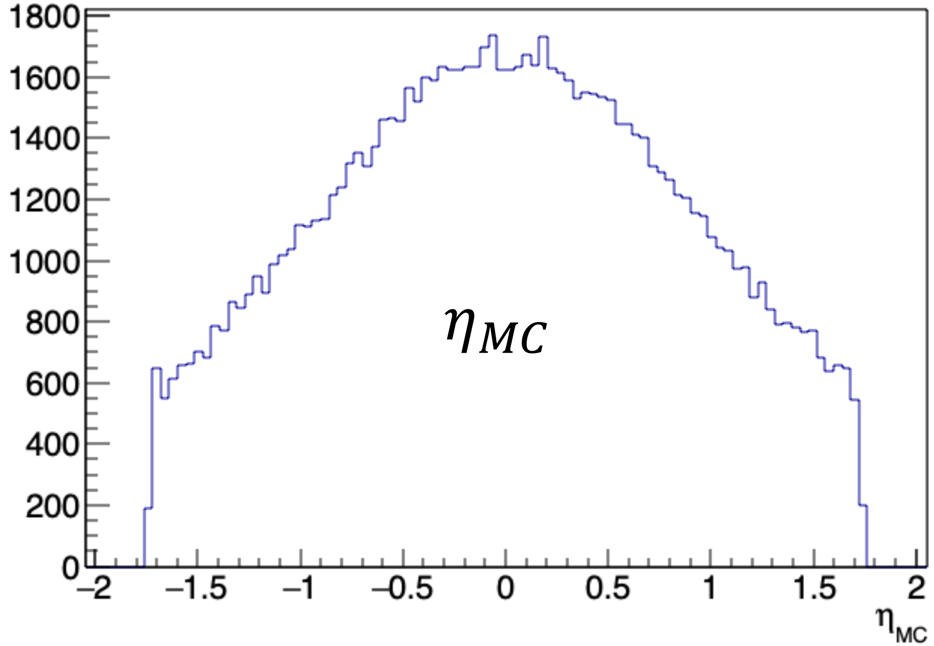
Simulation Details

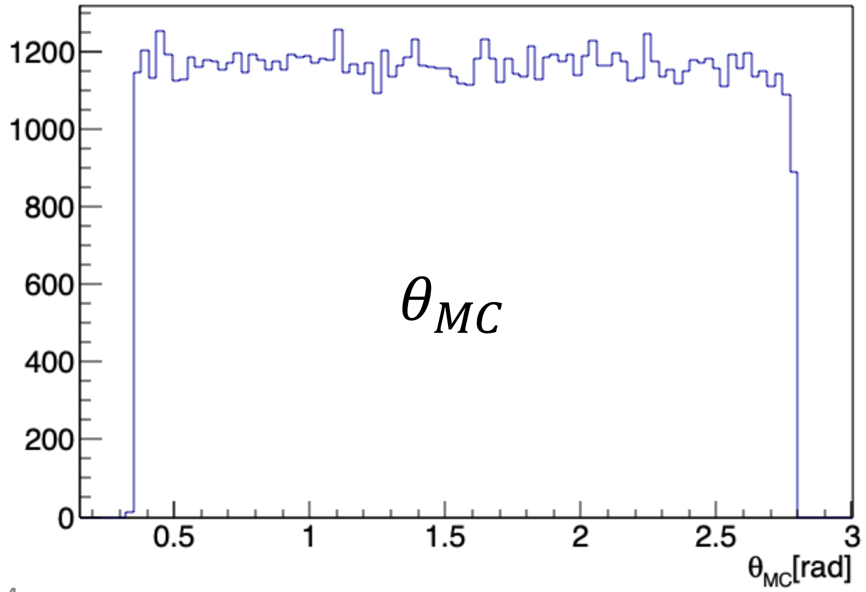
- Software Version
  - ePIC = 23.07.2
  - Detector Configuration = Craterlake
  - EICRecon = v1.5.1
- Generator
  - Particle Gun = proton, pion
  - ϕ (uniform) = $(0^o, 360^o)$
  - θ (uniform) = $(20^o, 160^o)$ /
    $(|\eta| \leq 1.73)$
  - p (uniform) = (0.3 GeV, 10.0 GeV)

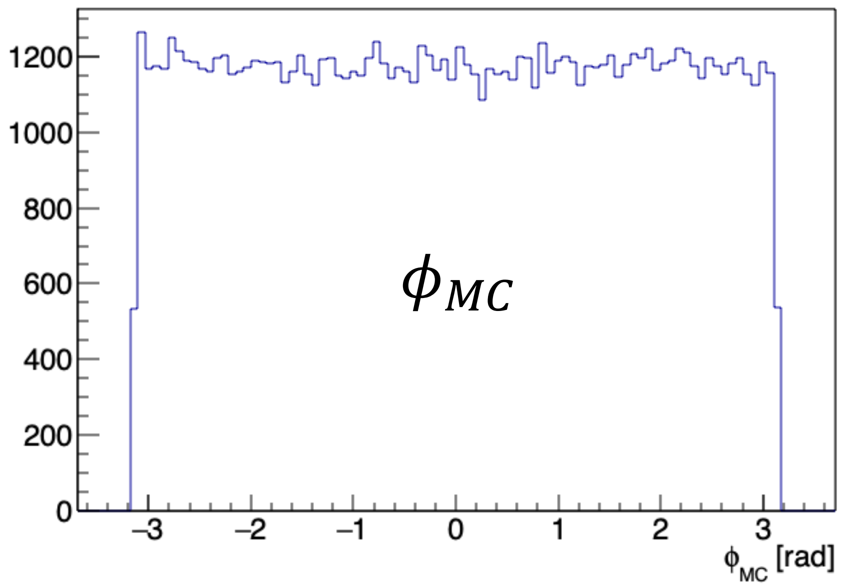


Simulation Distributions: Representative Sample









Angular Resolution: Method 1

- Use projected position point vectors of projected track point (H1) and **nearest** DIRC hit (H2) to obtain angles:
  - Projected Point (x,y,z) hits → θ_{proj} , ϕ_{proj}
  - DIRC Point (x,y,z) hits → θ_{dirc} , ϕ_{dirc}

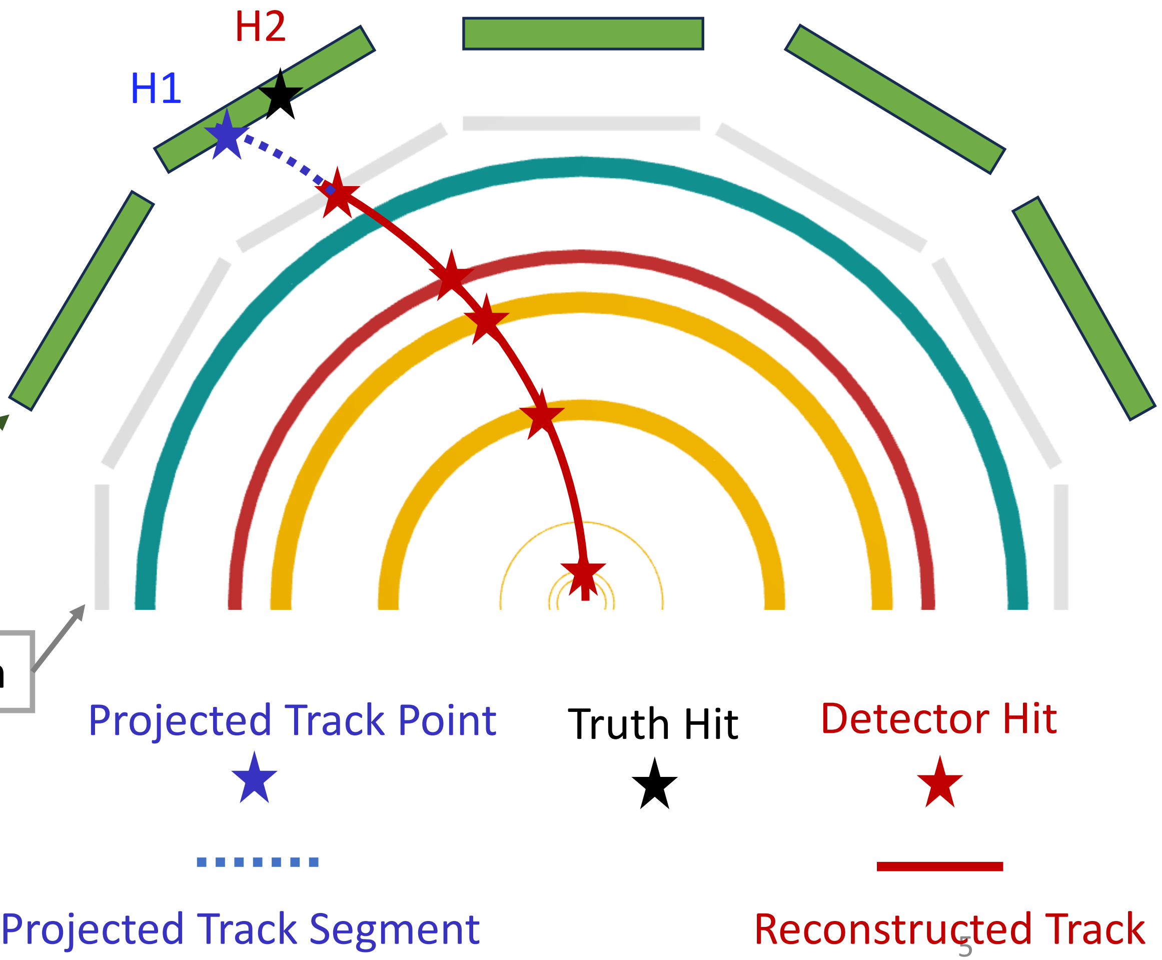
Details in Tracking WG: 10/26/2023

- Angular differences are:
  - $\theta_{proj} - \theta_{dirc}$
  - $\phi_{proj} - \phi_{dirc}$
- Angular resolution $\sigma_\theta, \sigma_\phi$ are extracted from width of assumed Gaussian distribution
- hpDIRC Mods:
  - Make DIRC bars sensitive volume (provides DIRC hit)
  - Turn off optical photons

hpDIRC: R = ~71 cm

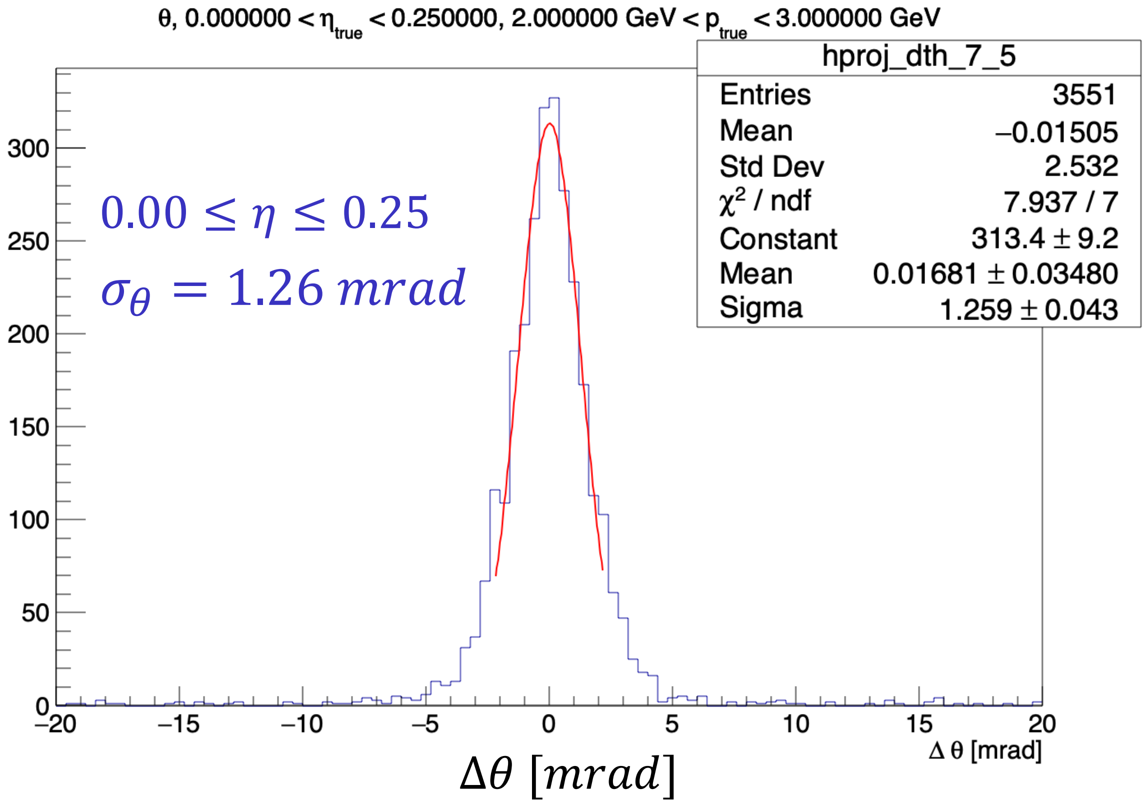
Outer MPGD Barrel: R= ~69 cm

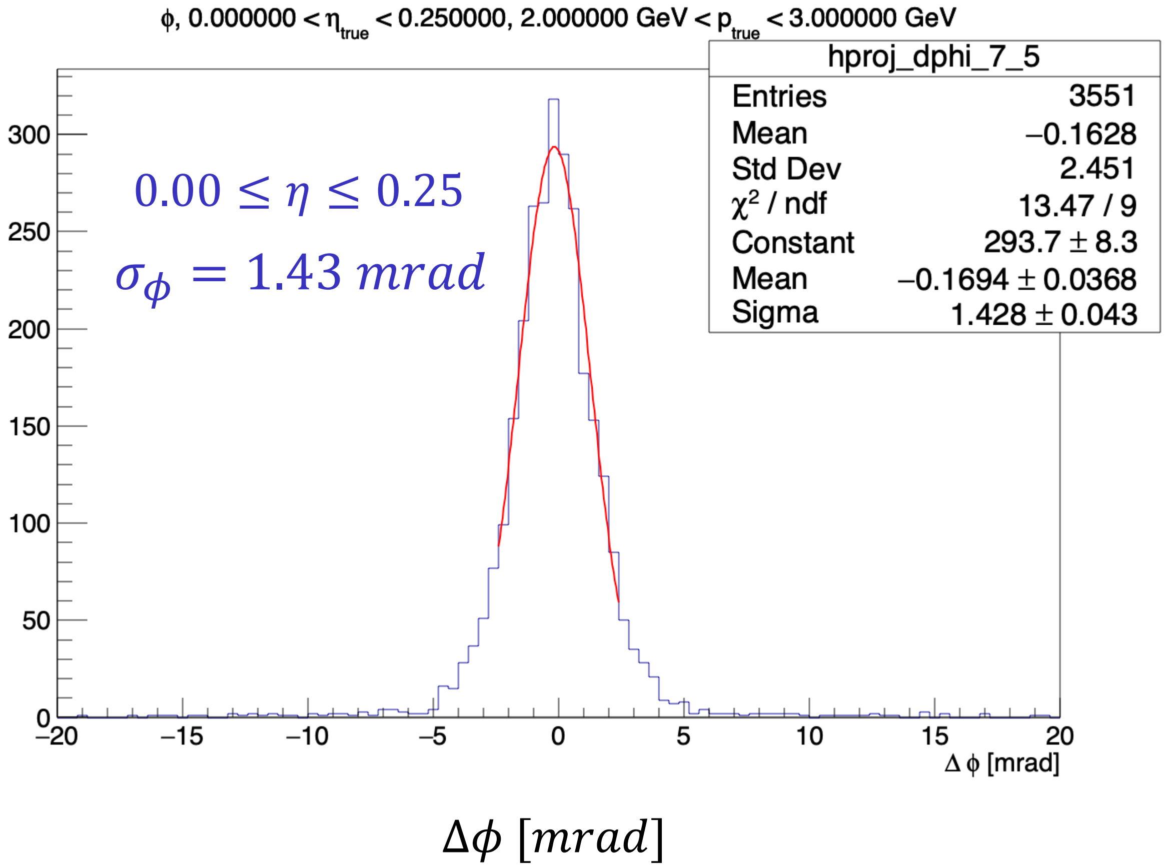
Projection Surface: R = 71cm



Method 1: Extracting θ Angular Resolution

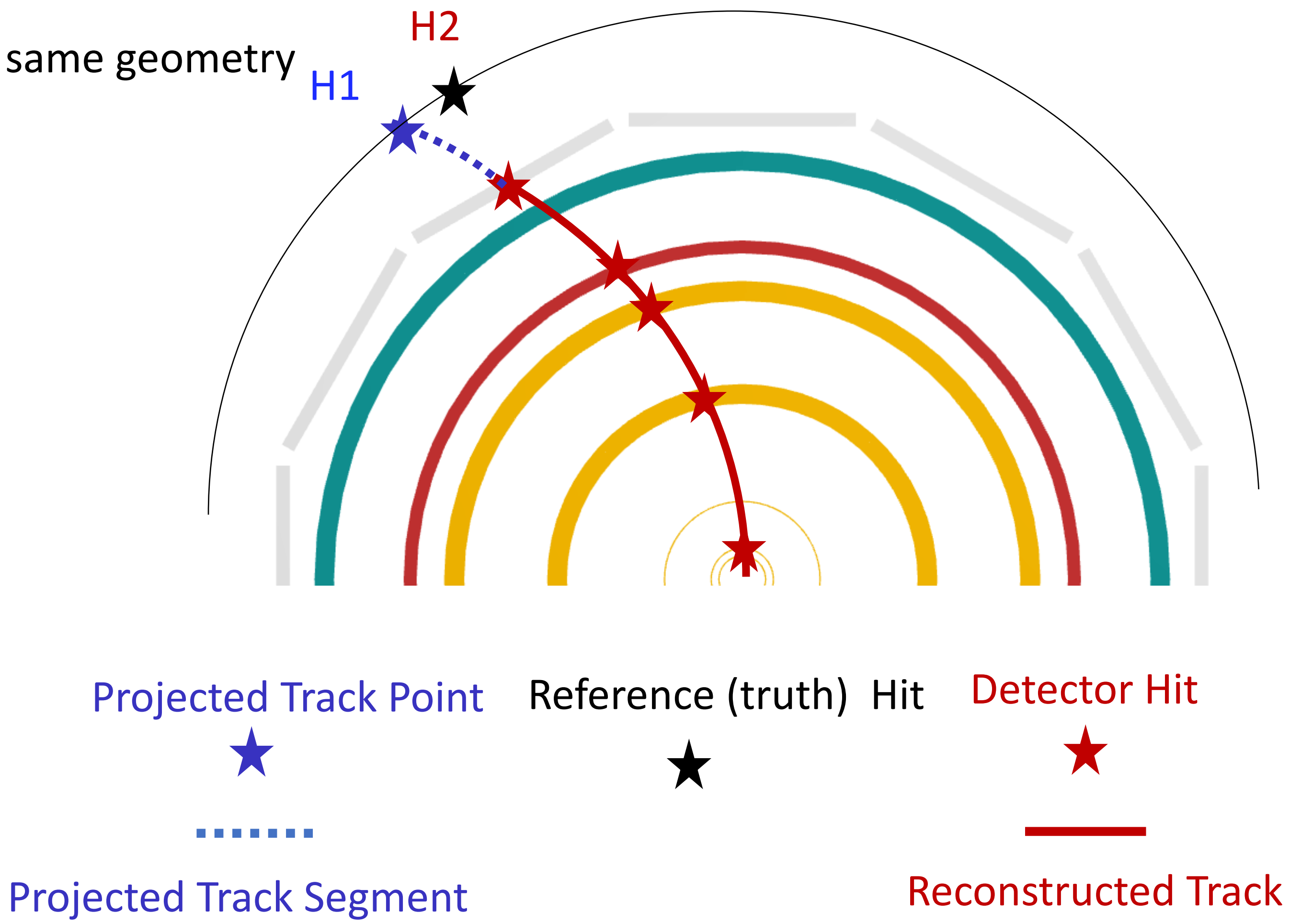
$2.00\ GeV \leq p \leq 3.00\ GeV$





Angular Resolution: Updated Method 1

- Define low mass cylindrical reference layer located at DIRC position (R = 71 cm) to store truth hit
- Propagate reconstructed track to this surface
  - Reference layer and ACTS propagation surface have same geometry
- PID detector mods not needed

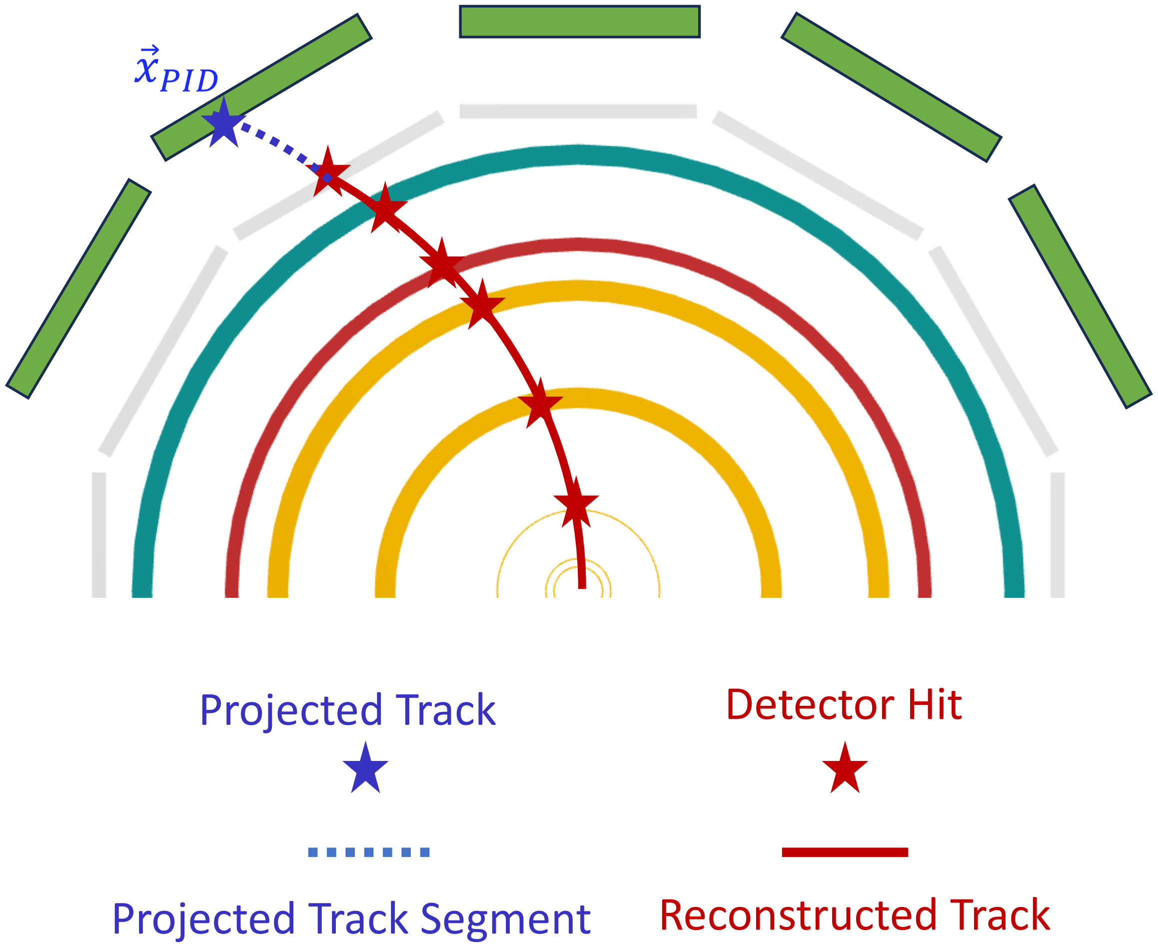


Details in [PID WG: 11/17/2023]

Angular Resolution: Method 2

Track Errors

- Use projected track state vector a to get track direction impacting PID surface
  - $\vec{x}_{PID} = \left(l_0, l_1, \theta, \phi, \frac{q}{p}\right)$
- Obtain track direction uncertainty from covariance matrix
  - $var(\theta), var(\phi), cov(\theta, \phi)$

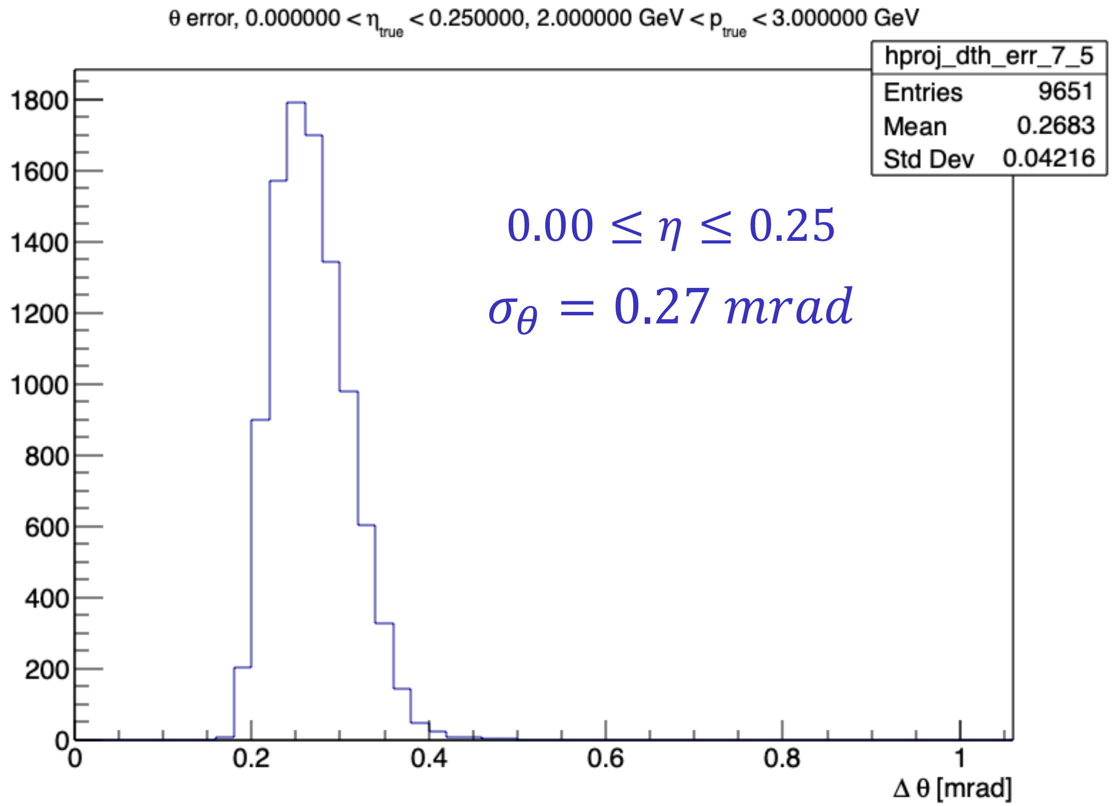


Details in [Tracking WG: 10/26/2023]

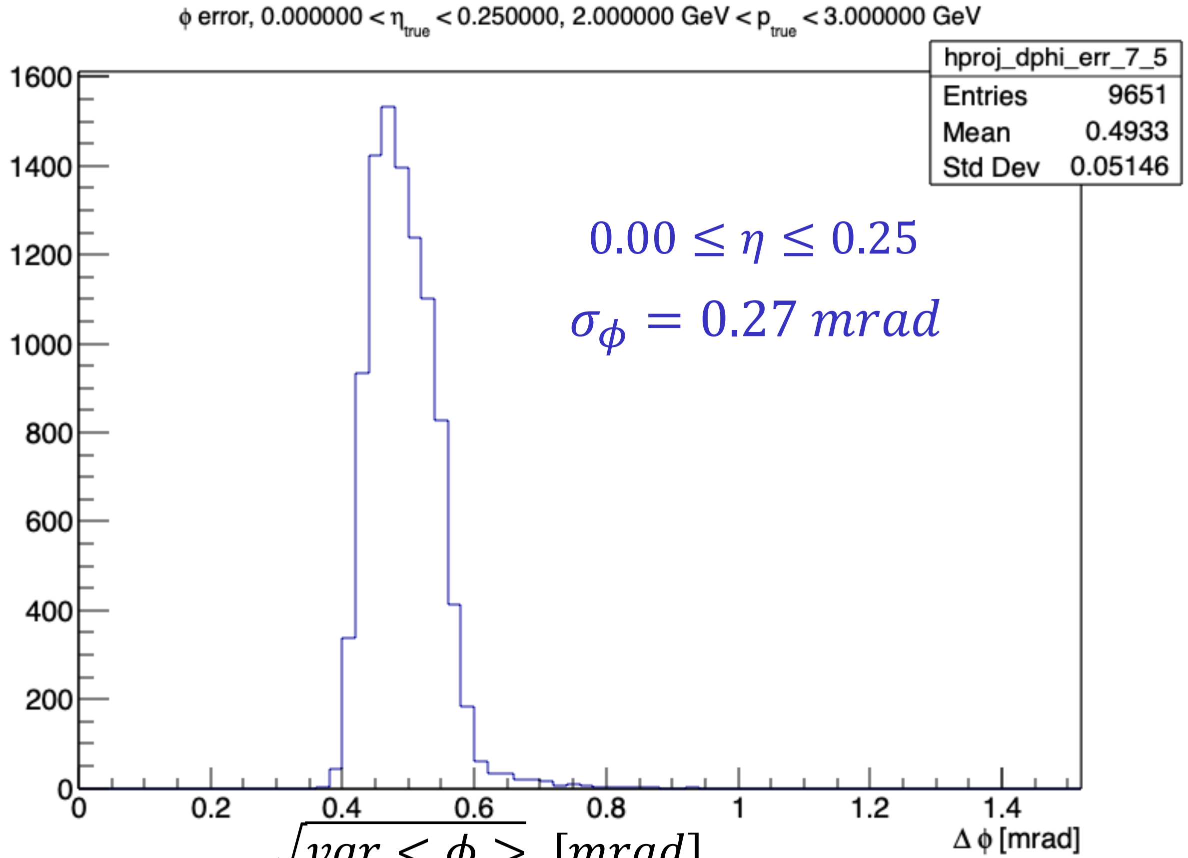
Method 2: Extracting θ Angular Resolution

- Histogram sqrt(variance), variance obtained from covariance matrix
  - Histogram mean = angular uncertainty
  - Histogram RMS = error bar

$2.00\ GeV \leq p \leq 3.00\ GeV$



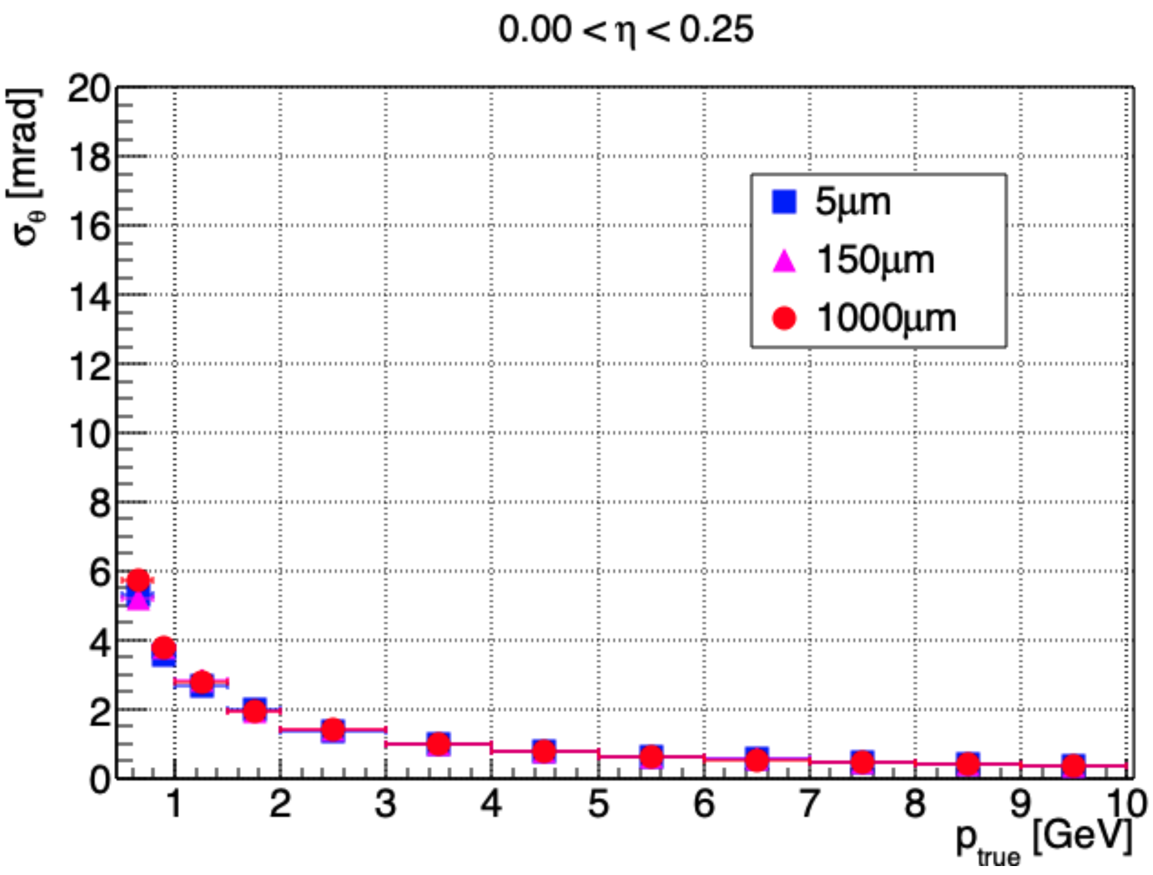
$\sqrt{var < \theta >}\ [mrad]$

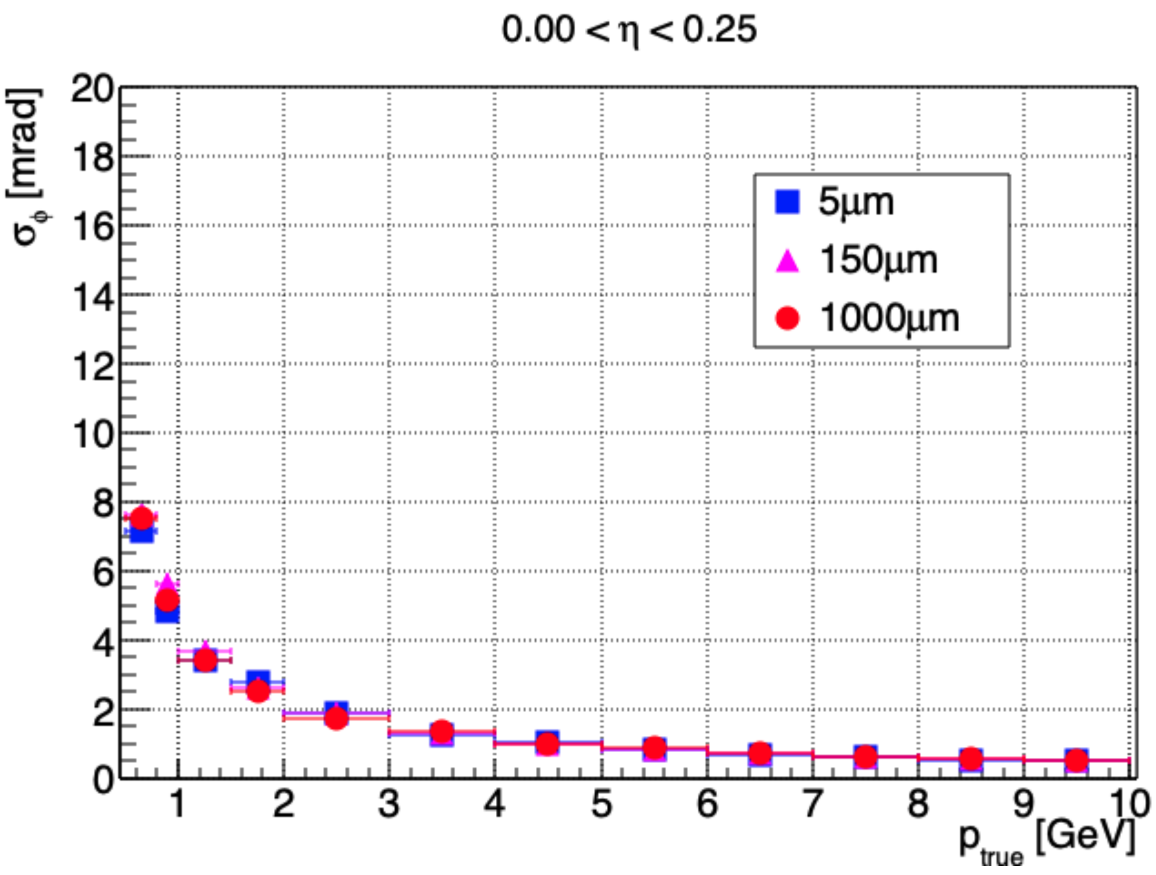


$\sqrt{var < \phi >}\ [mrad]$

ePIC Simulation: $0.0 < \eta < 0.25$

- Evaluated at R = 71 cm, using Method 1 (not updated method 1)
  - Angular resolutions not very sensitive to MPGD resolutions
  - Similar sensitivity seen over $|\eta| < 1.75$ → see backup

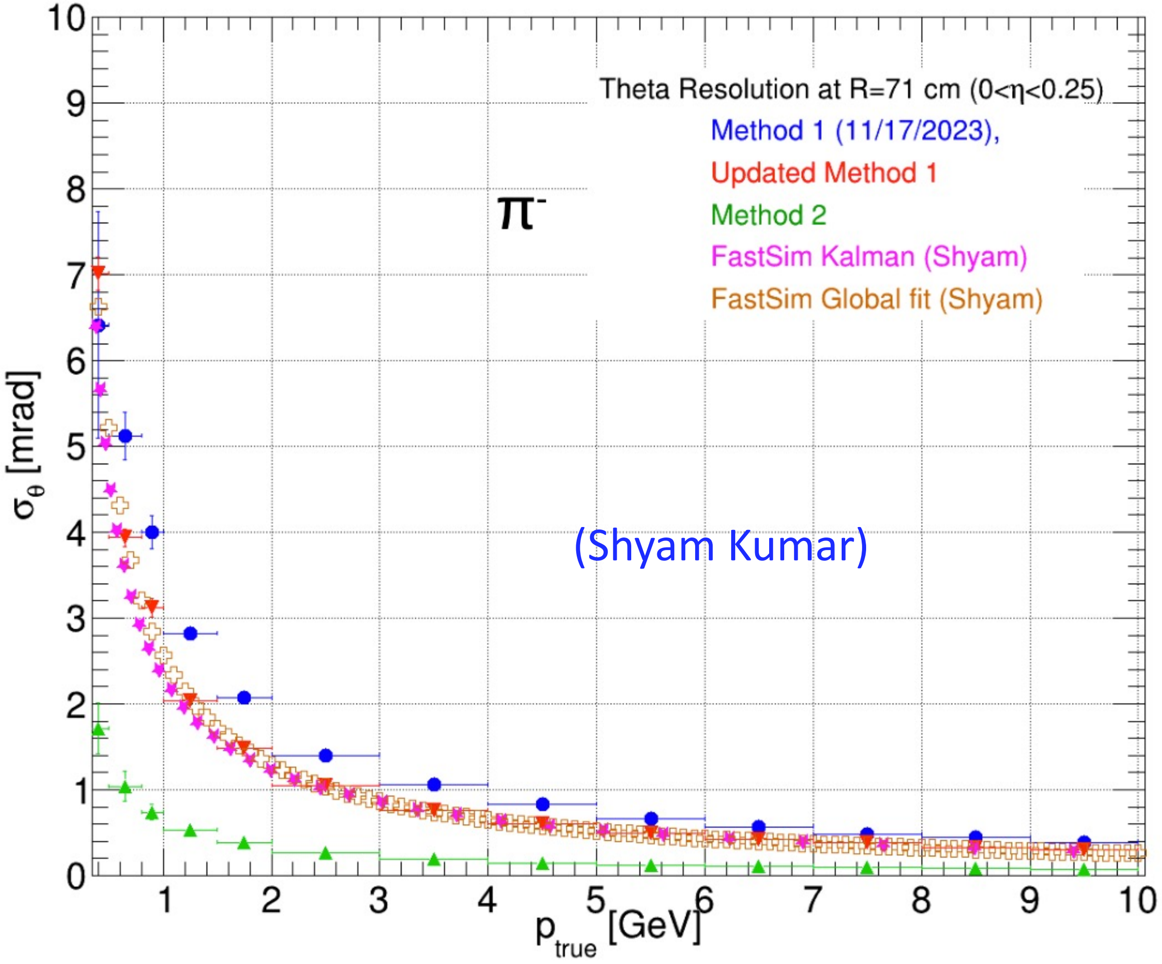


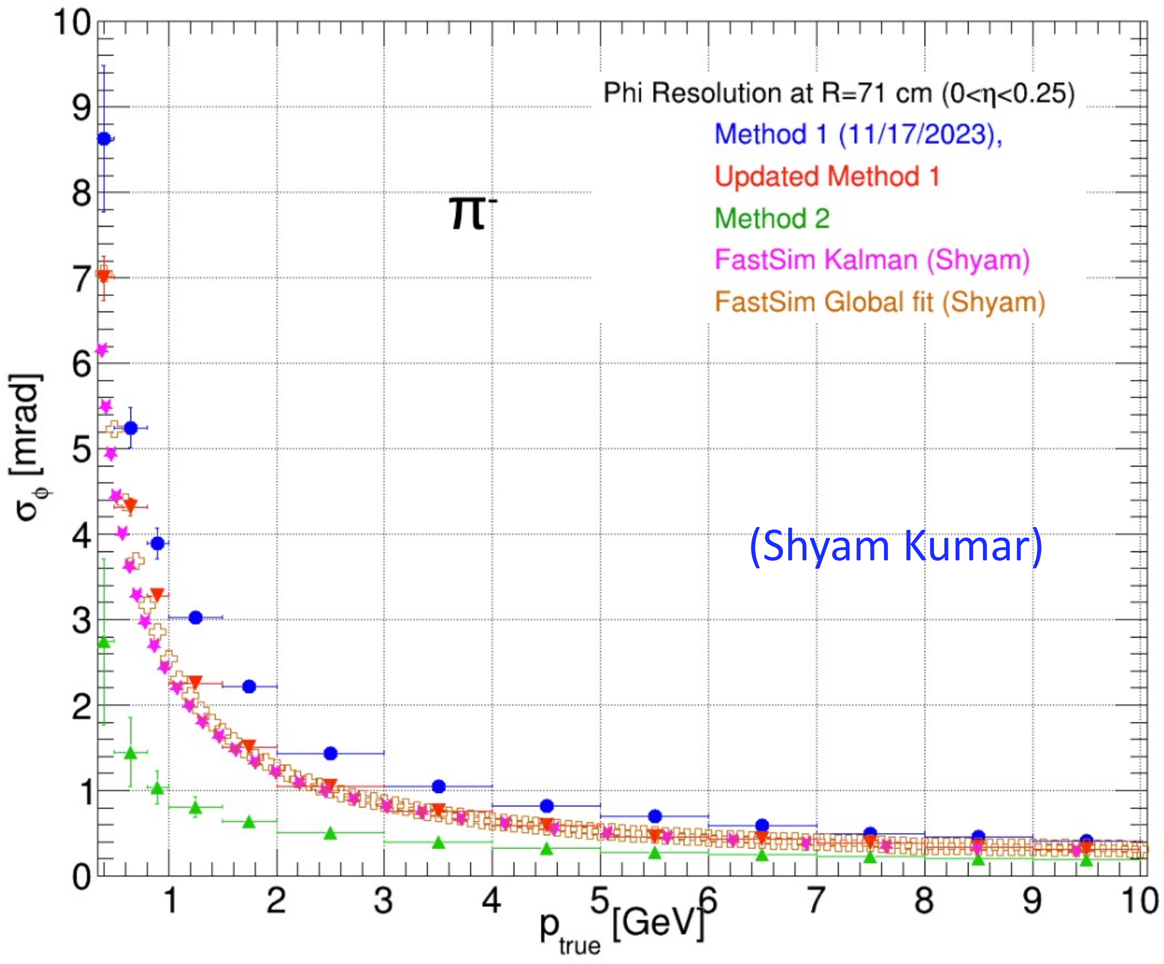


Comparison to Fast Simulation Results

- Good agreement between ePIC (Updated Method 1) and fast simulations

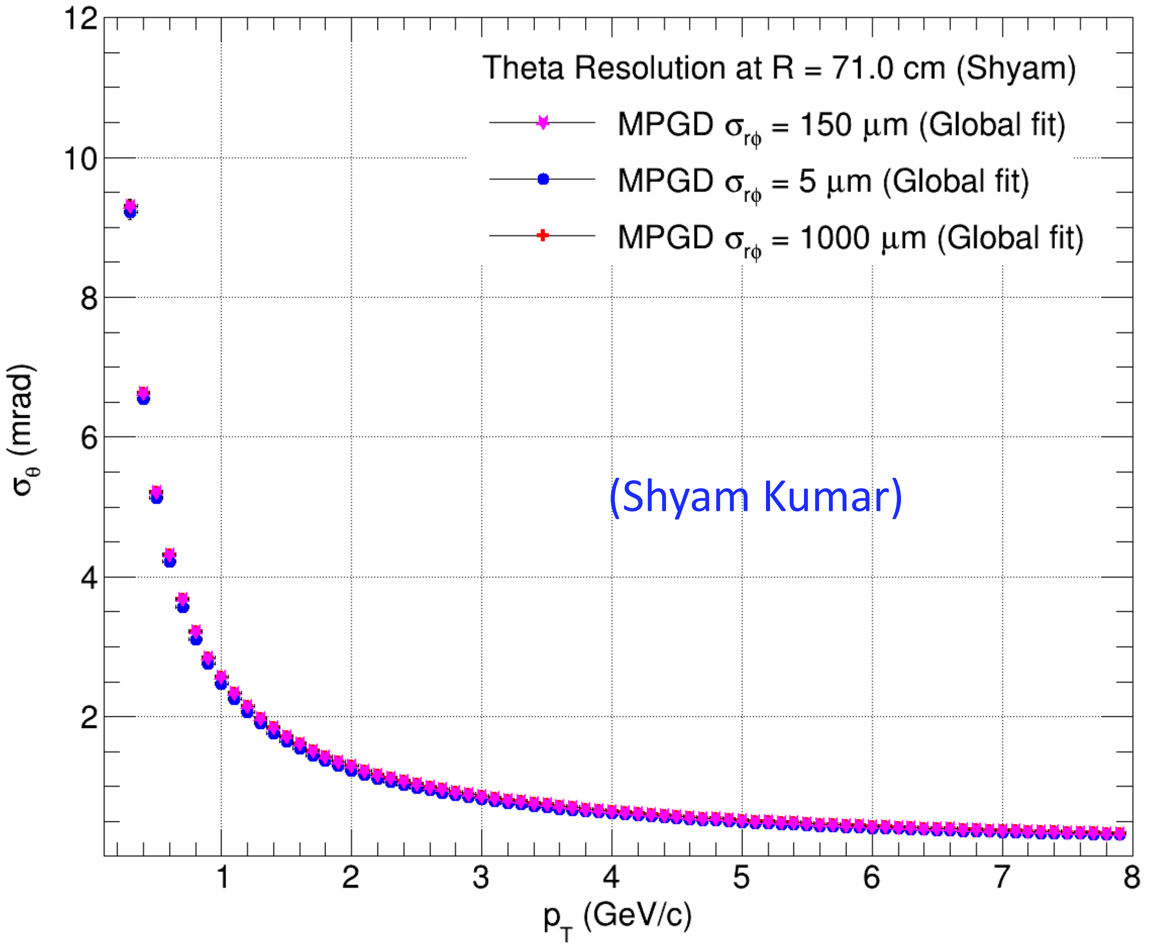
ePIC January 2024 Collaboration Meeting – Shyam Kumar

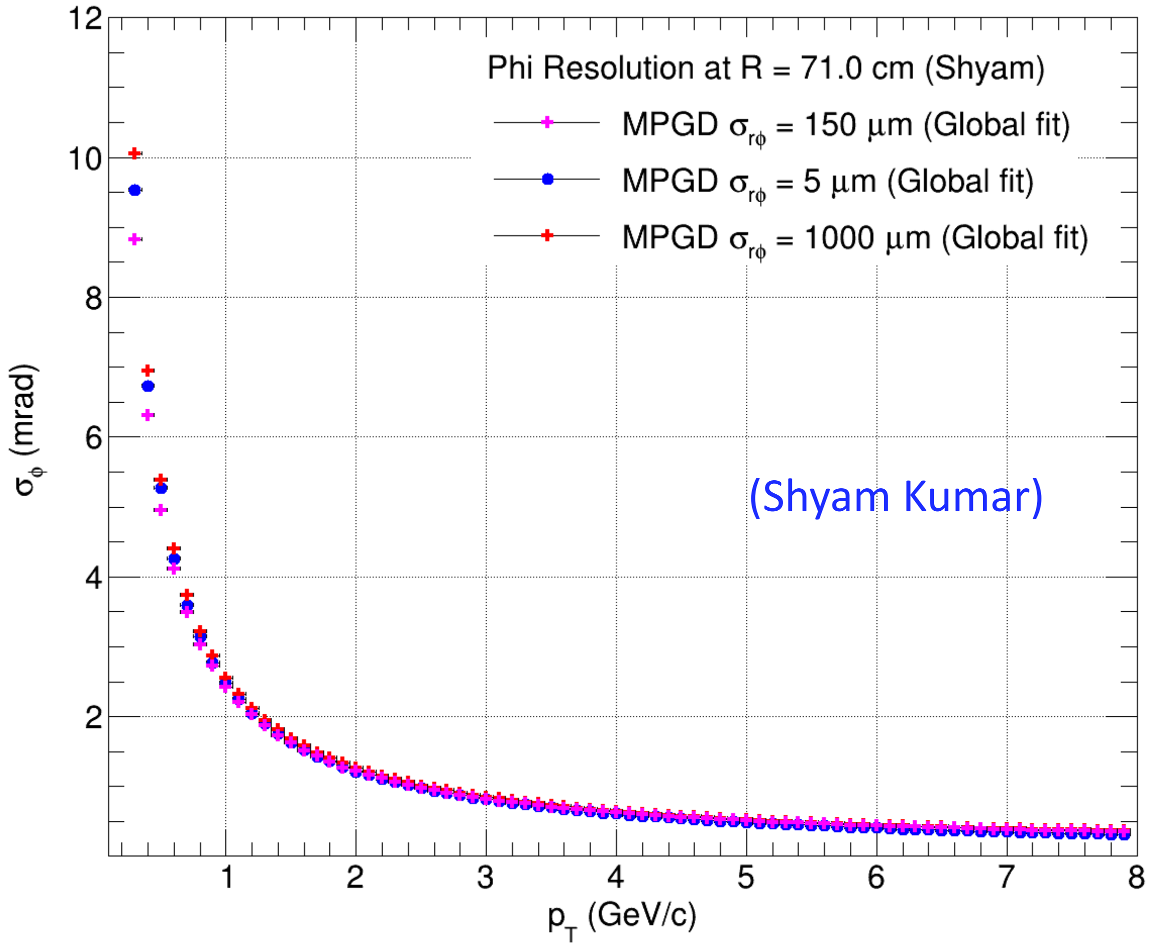




Impact of MPGD Resolutions: Fast Simulation

- Fast simulations show angular resolutions not very sensitive to MPGD resolution
  - Agrees with behavior found in ePIC simulations





Angular Resolution Contributions: Fast Simulation

- Fast simulation shows angular resolutions dominated by multiple scattering
  - Consistent with angular resolutions not being very sensitive to MPGD spatial resolutions (S.R.)

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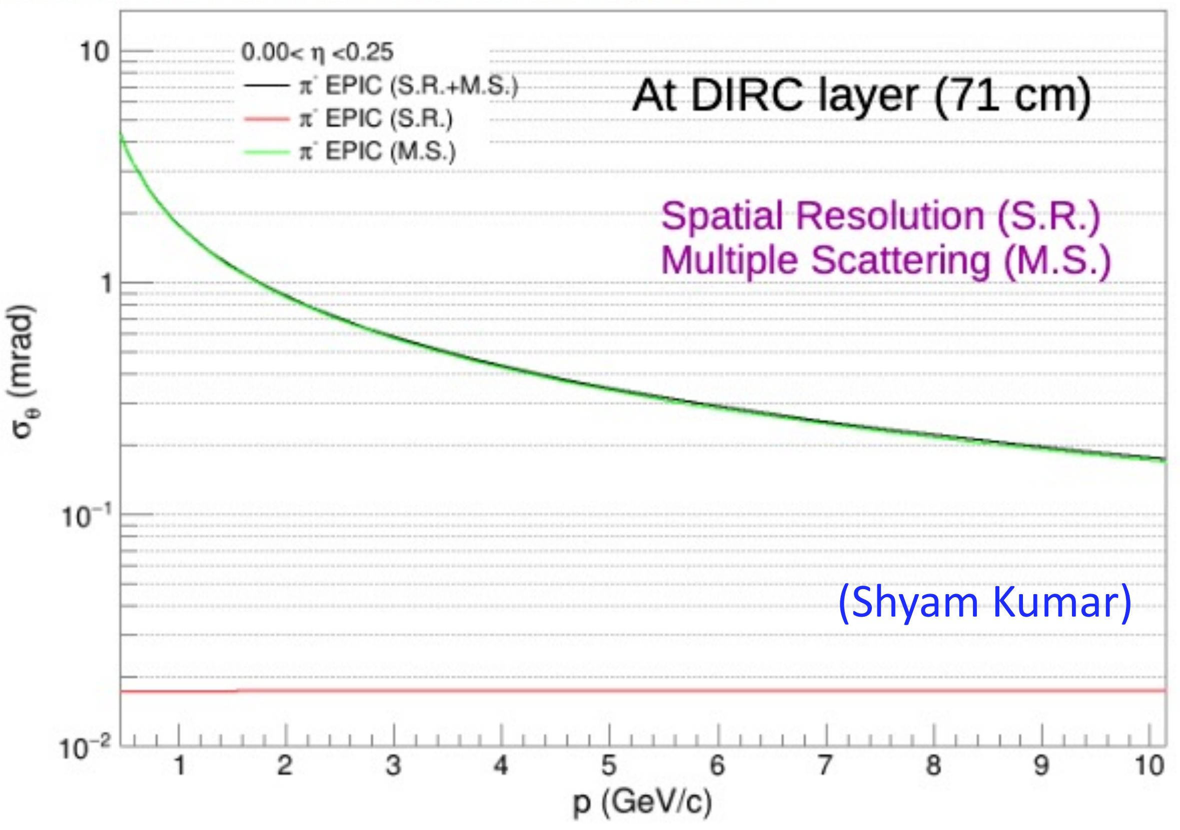
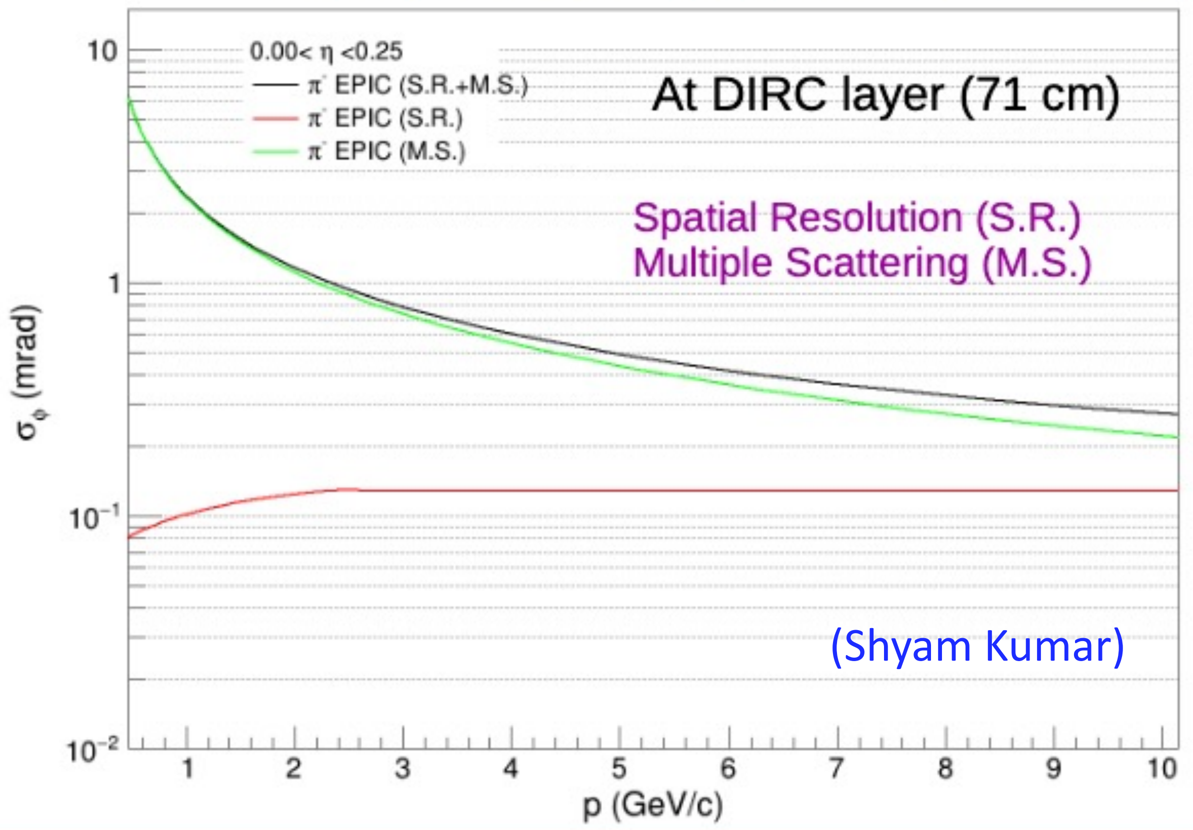




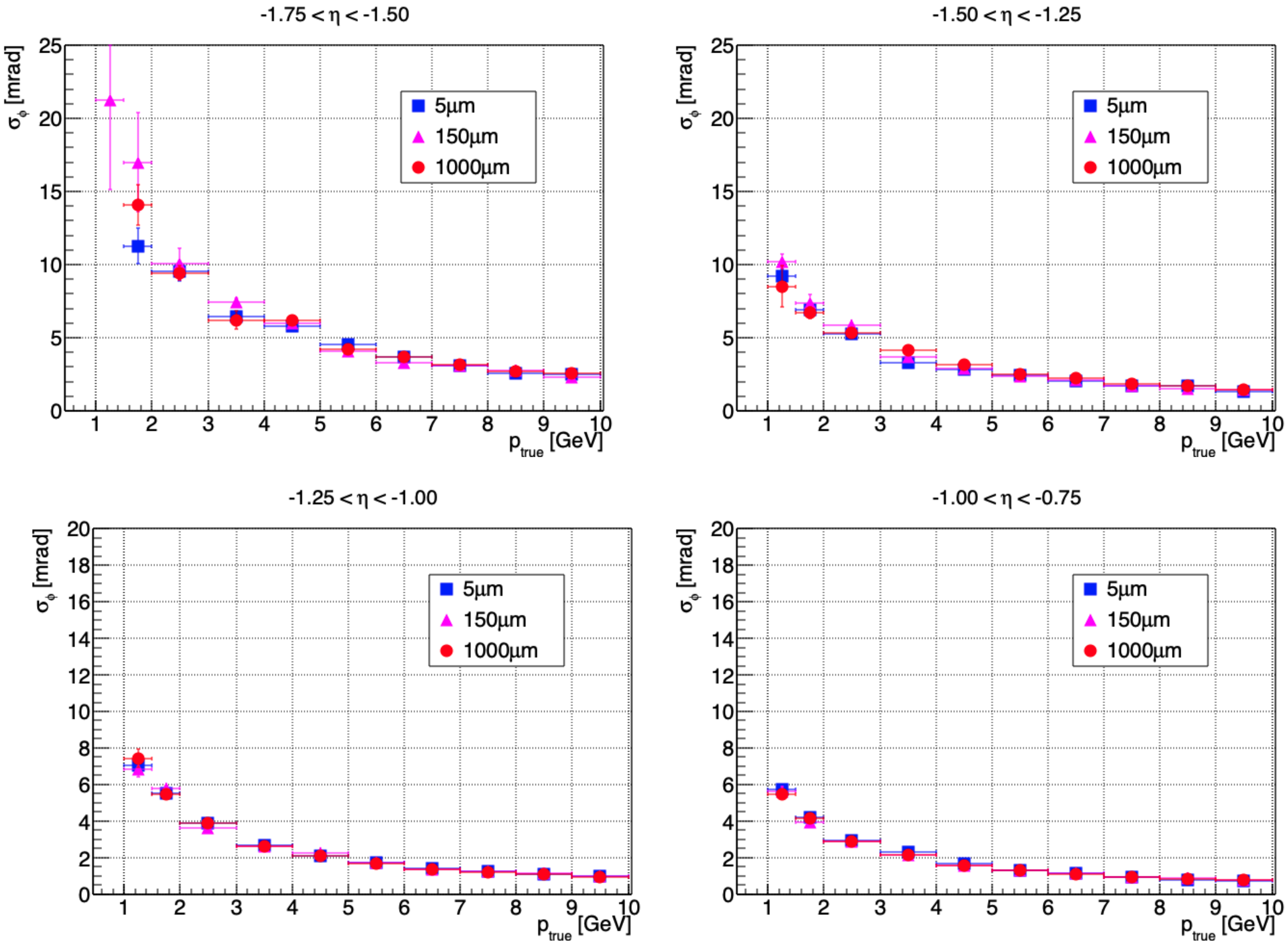
Next Steps

- ePIC simulation results presented here were done in 2023, much has changed since then
  - Track reconstruction algorithms, material budgets, detector locations, tracking covariance matrix, data models
- Calculate angular resolutions with current setup at all PID surfaces (pfRICH, ToFs, hpDIRC, and dRICH) using updated method 1
  - These will serve as the baseline values
- Vary MPGD spatial resolutions to investigate angular resolutions at each PID surface
  - Never investigated effect on MPGD disks

Backup

ePIC Simulation: ϕ Resolution @ R = 71 cm (Method 1)

- ❑ Evaluated at R = 71 cm,
- ❑ Using Method 1
  - (not updated method 1)



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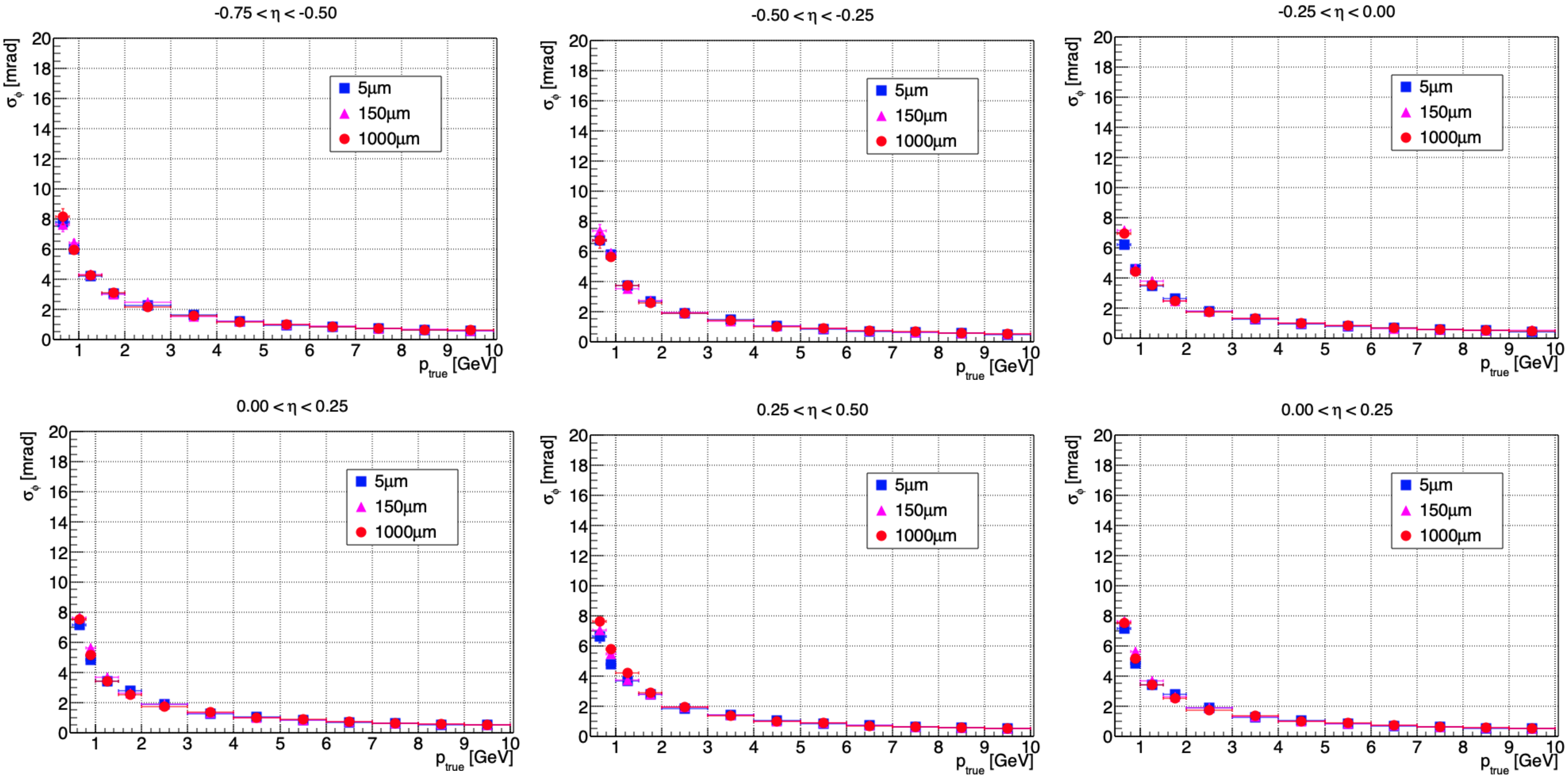

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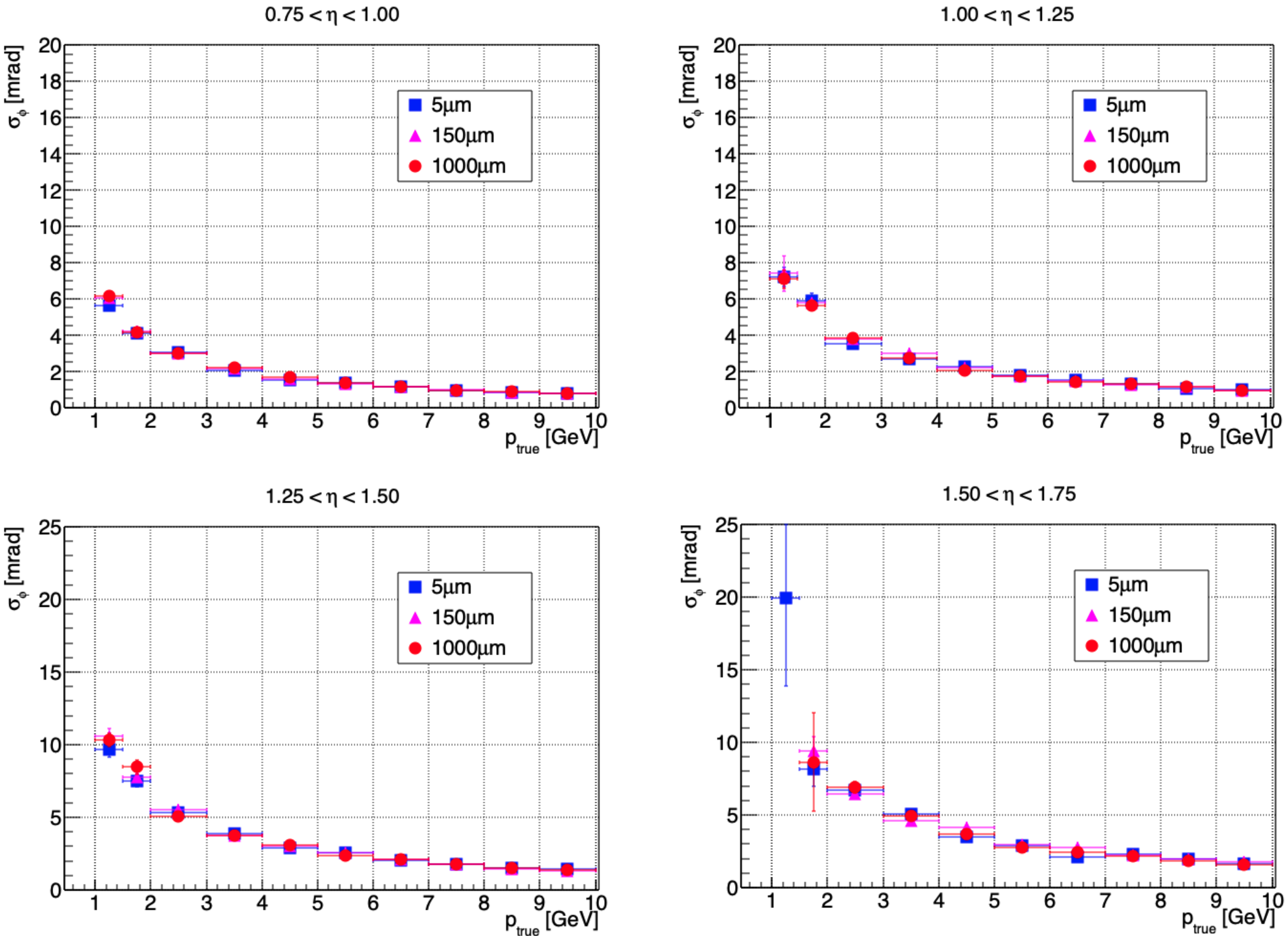

ePIC Simulation: θ Resolution @ R = 71 cm (Method 1)

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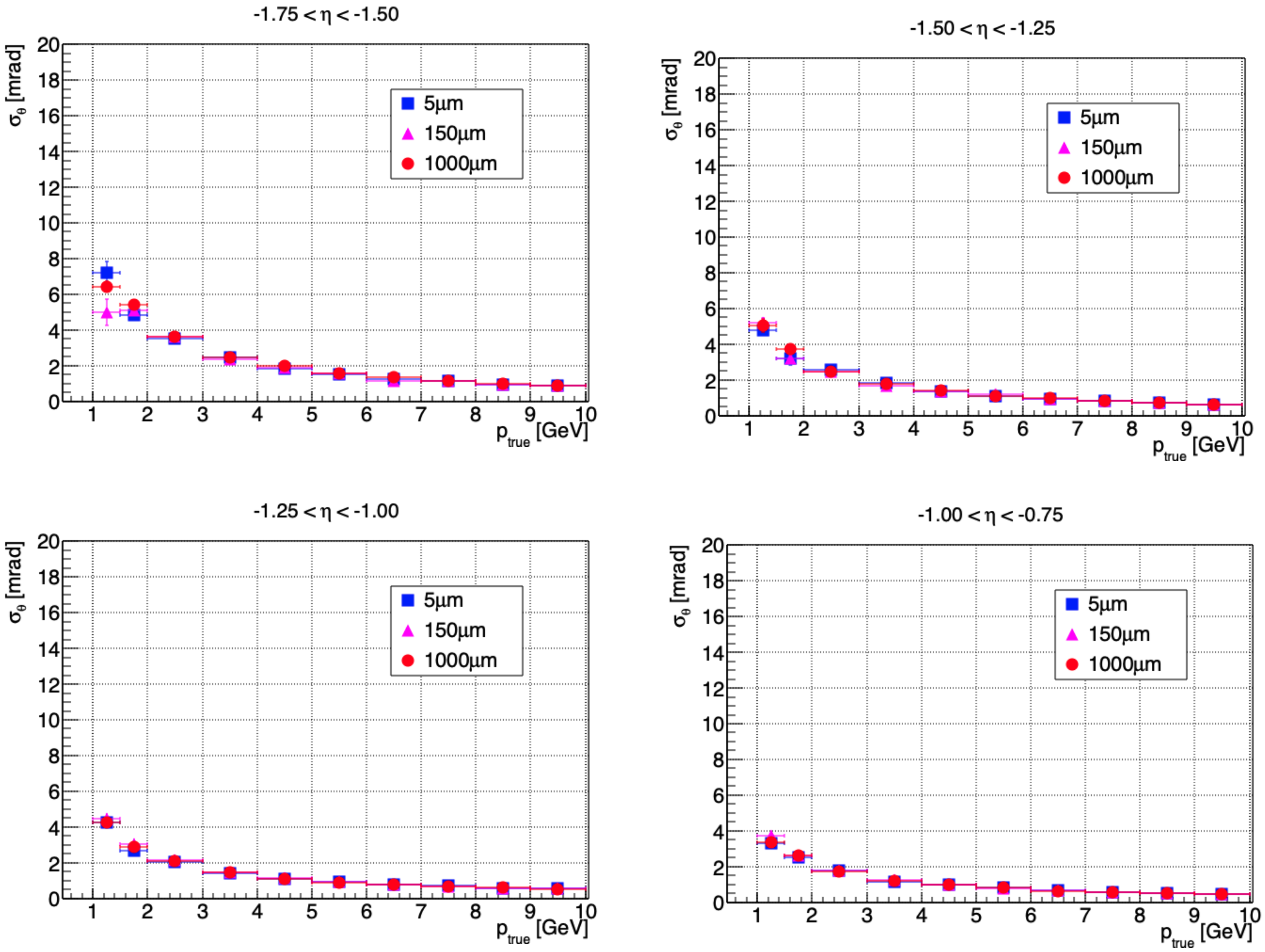
    - (not updated method 1)



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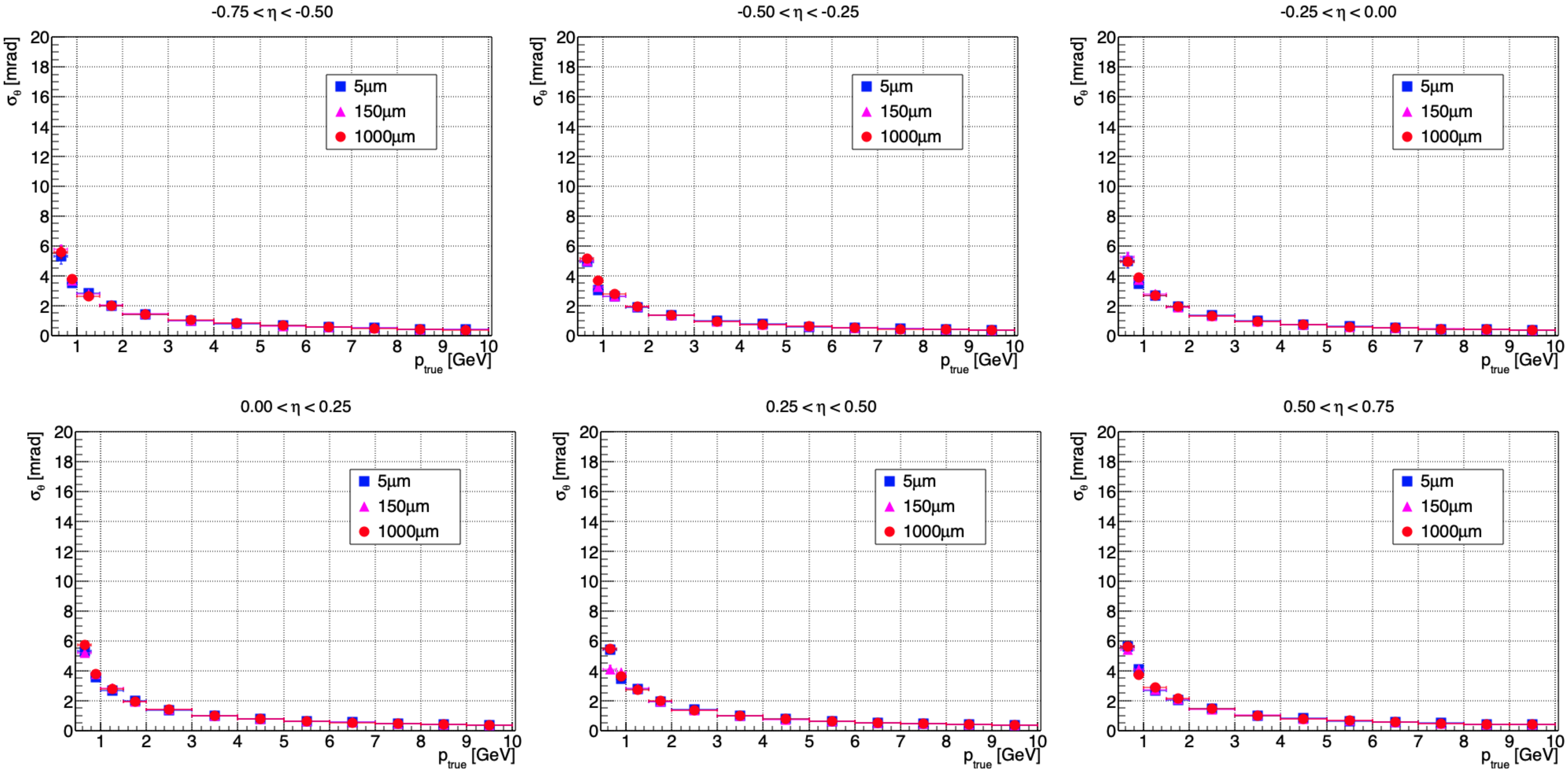

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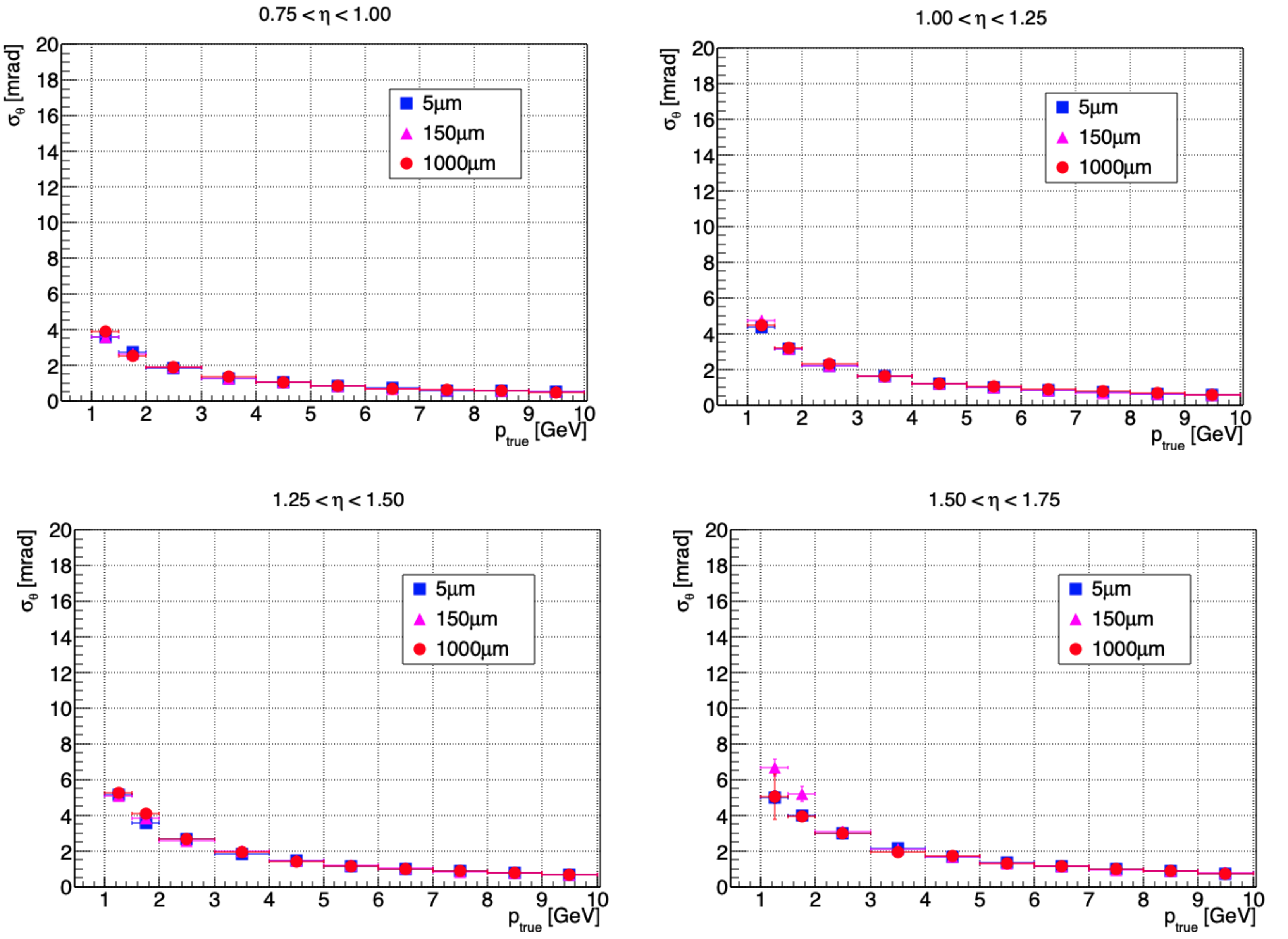
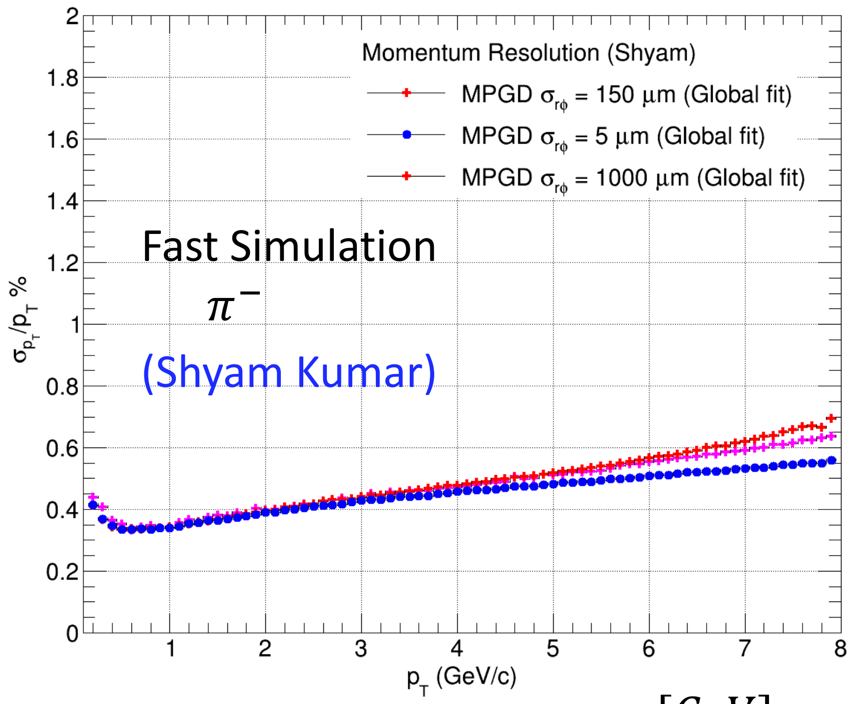
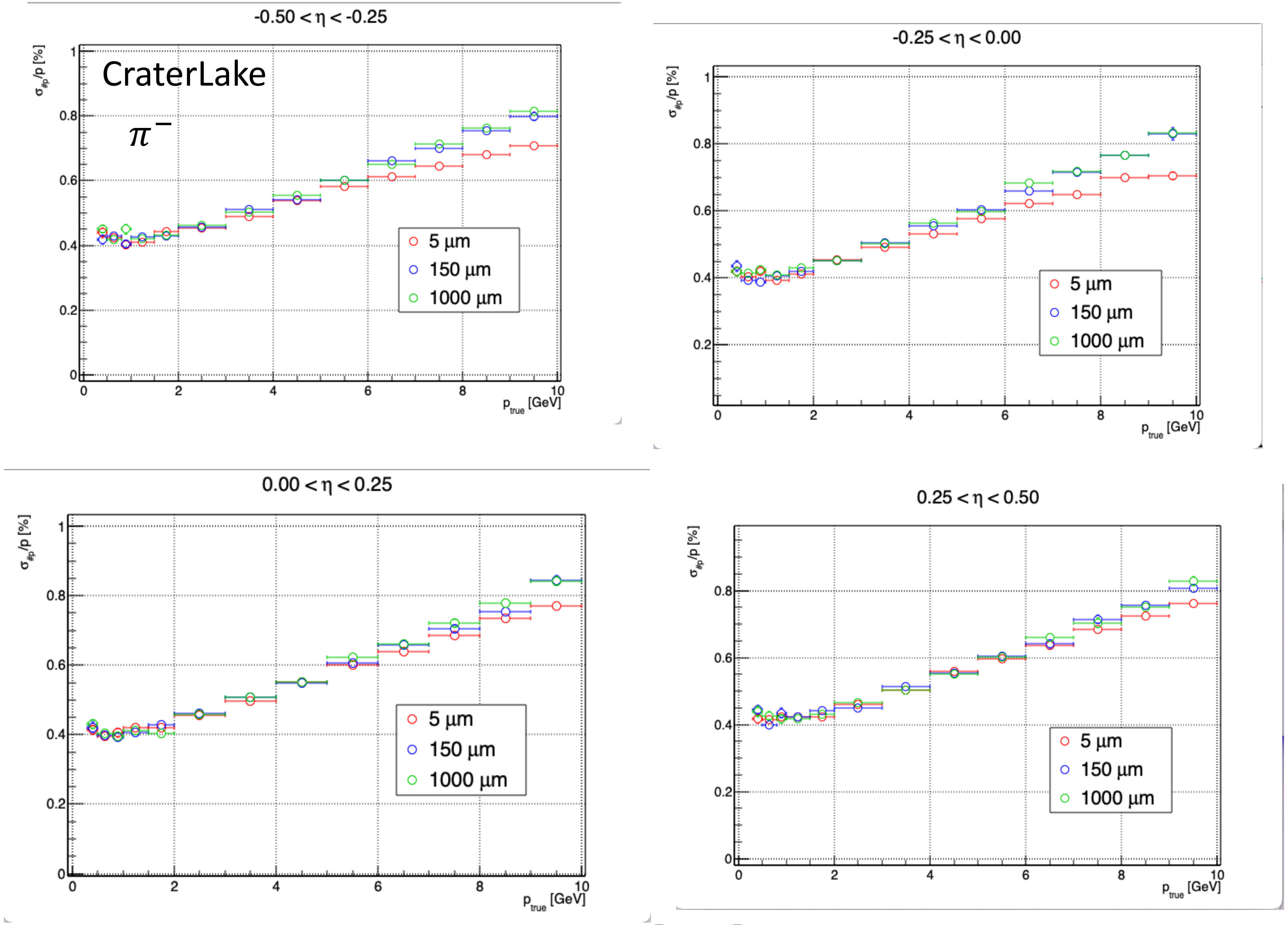


Momentum Resolution Trend

- Similar MPGD resolution behavior between ePIC and fast simulations
  - Note: not a 1-to-1 comparison



p_T $[GeV]$



p $[GeV]$