ePIC MPGDs
Angular Resolution

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Study Overview

- Role of MPGDs in ePIC
  1. Additional hit points
  2. Fast timing hits for pattern recognition
  3. **Provide precision hit point over large angular range for PID detectors (~ 1 mrad)**
- **Study Goal:** Determine spatial resolution needed for outer MPGD layer to meet PID angular resolution requirement of 1 mrad
  - Understand central rapidity first before moving out to larger rapidity where there is more material and shallower angles where interoperation can be more complicated
  - Access angular resolution via multiple scattering calculations, and two simulation assessments (Method 1 and Method 2)

Currently, not all information is in hand for the tracking working group to make a definite conclusion on the needed MPGD spatial resolution to meet PID angular resolution.

However, what we have studied…

Multiple Scattering Calculations

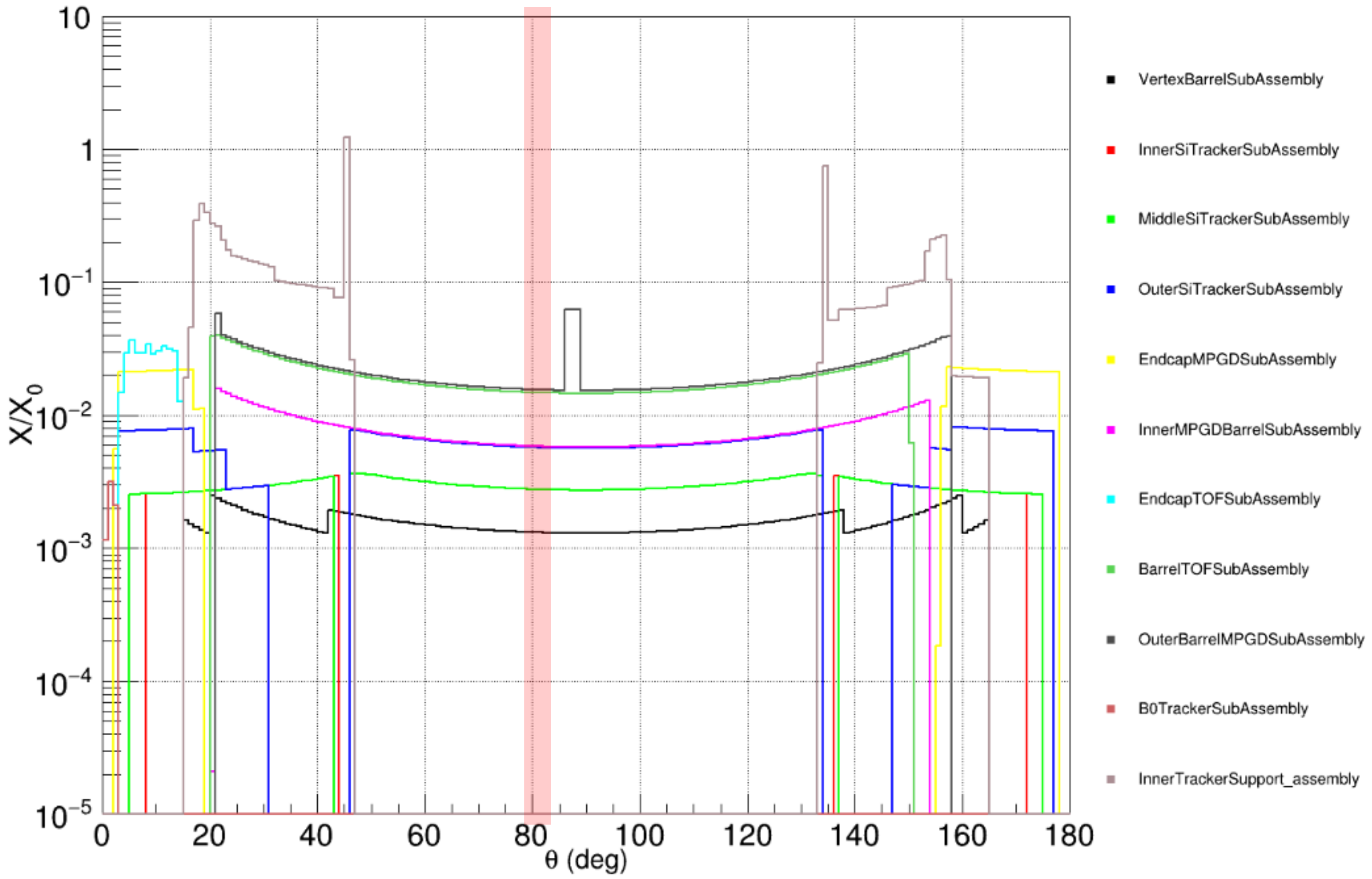
- Use ePIC simulation material to calculate multiple scattering near $\eta = 0.175.$, with assumptions:
  - Treat cumulative materials as one layer - an actual tracking algorithm will handle this differently
  - $\beta = c = z = 1$
  - Use PDG θ_0 formula

$$\theta_0 = \theta^{\rm rms}_{\rm plane} = \frac{1}{\sqrt{2}} \theta^{\rm rms}_{\rm space} \,,$$

$$\theta_0 = \frac{13.6 \text{ MeV}}{\beta c p} z \sqrt{\frac{x}{X_0}} \left[1 + 0.088 \log_{10}\left(\frac{x z^2}{X_0 \beta^2}\right)\right] = \frac{13.6 \text{ MeV}}{\beta c p} z \sqrt{\frac{x}{X_0}} \left[1 + 0.038 \ln\left(\frac{x z^2}{X_0 \beta^2}\right)\right]$$

Computed near $\theta = 80^o = \eta = 0.175$

	x/X0
Full Tracker	0.0504
No outer MPGD Barrel	0.0344
Si Only	0.0135



Shyam: Tracking WG

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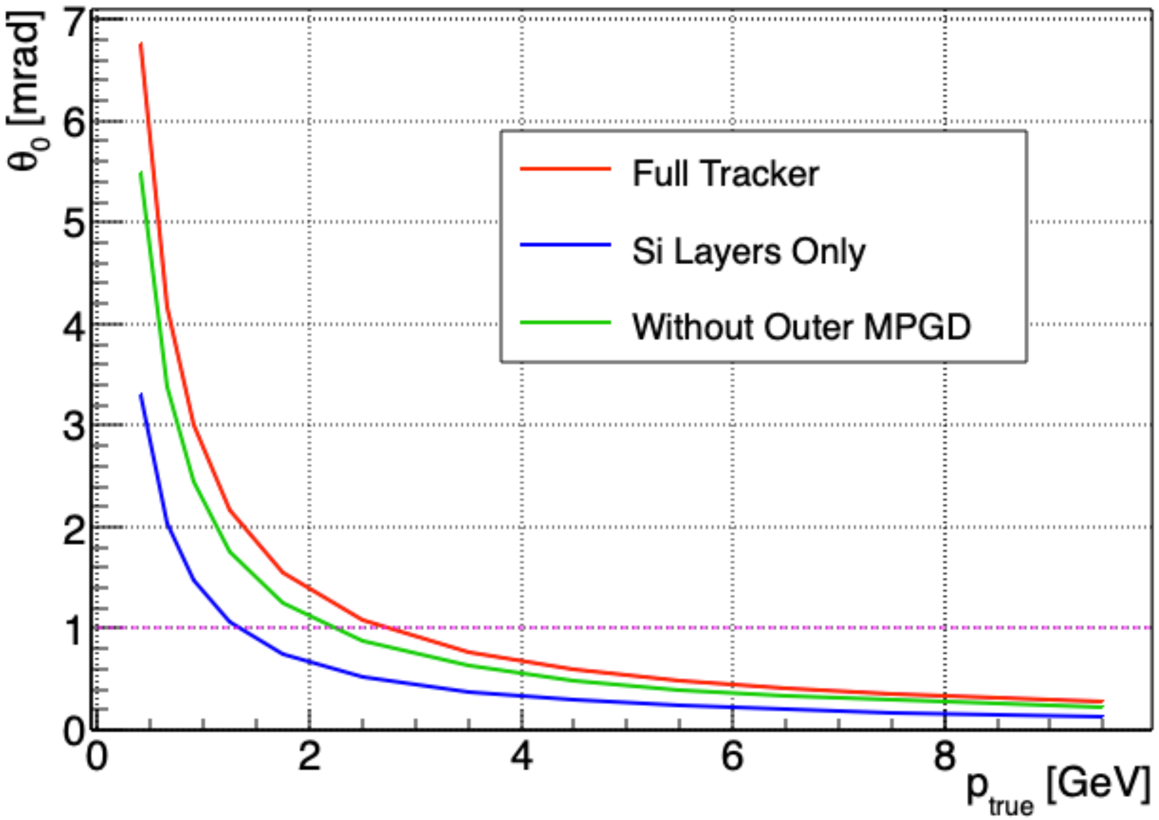

These calculations are for η = 0.175 and entail simplifying assumptions.

ePIC Simulation Angular Resolution Definition: Method 1

- Agreed upon method between tracking and PID. (meeting page)
- DIRC photon propagation turned off and volume made sensitive to provide "truth" reference hit
- Use position projected 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}
- 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
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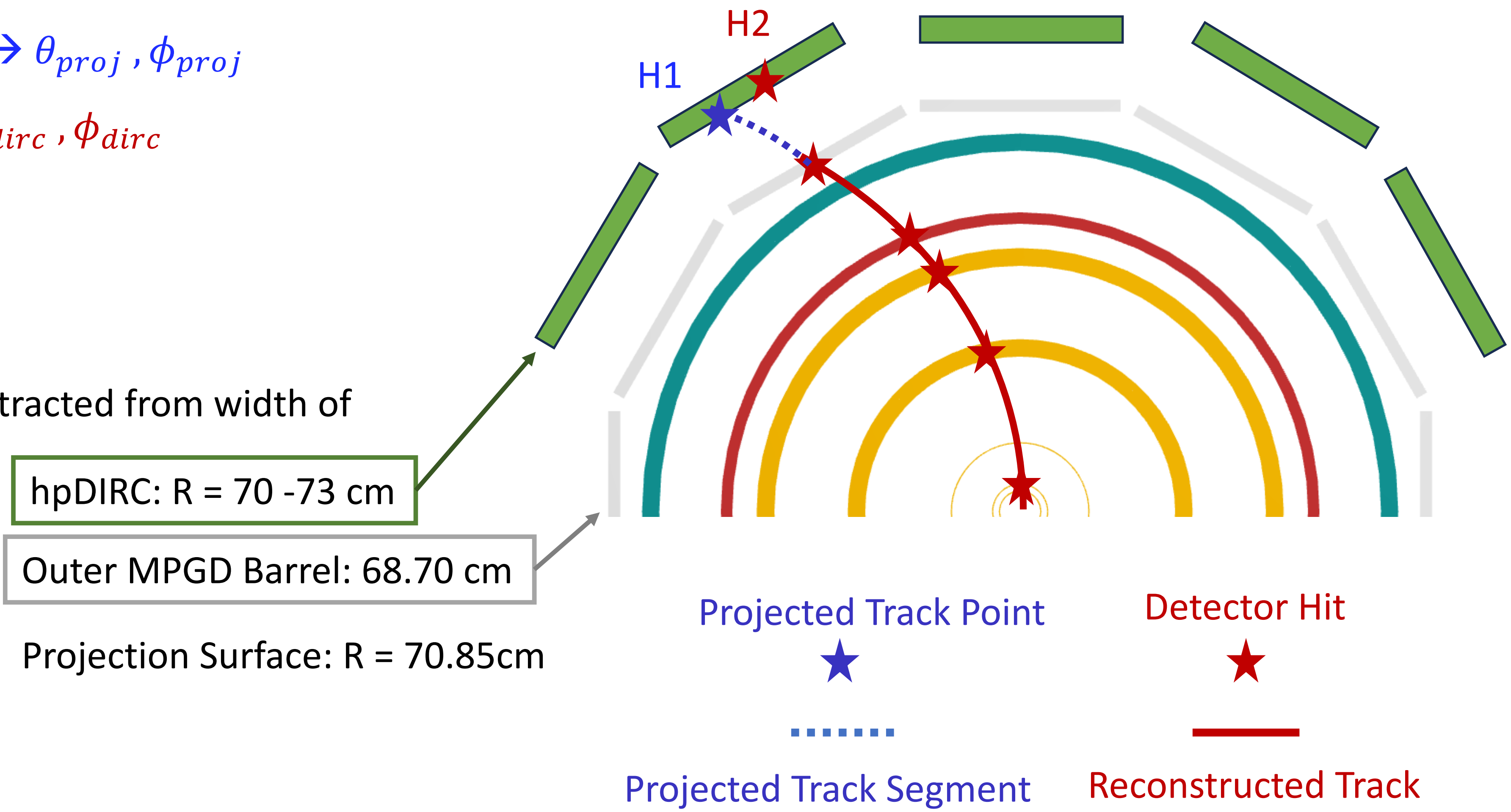
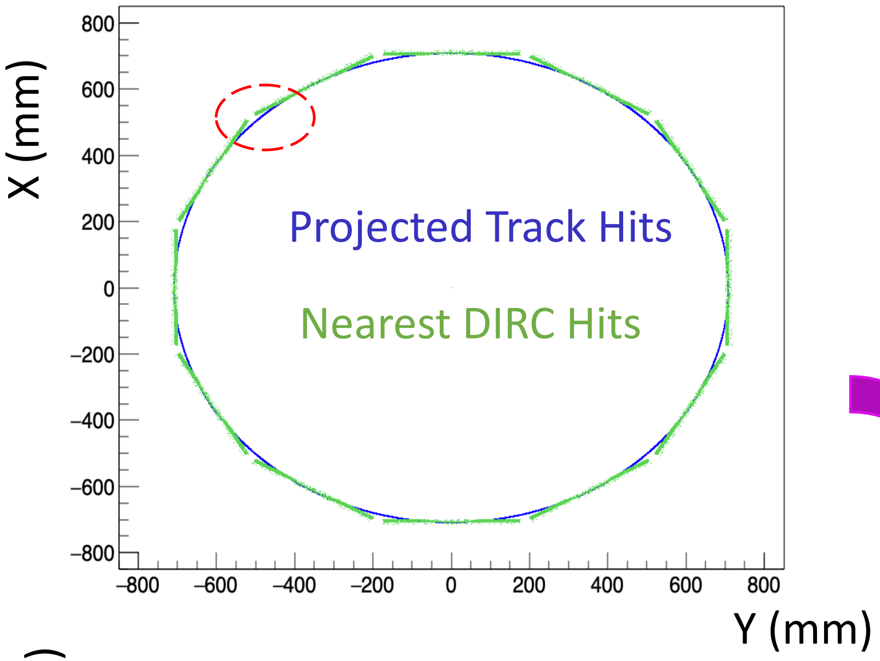
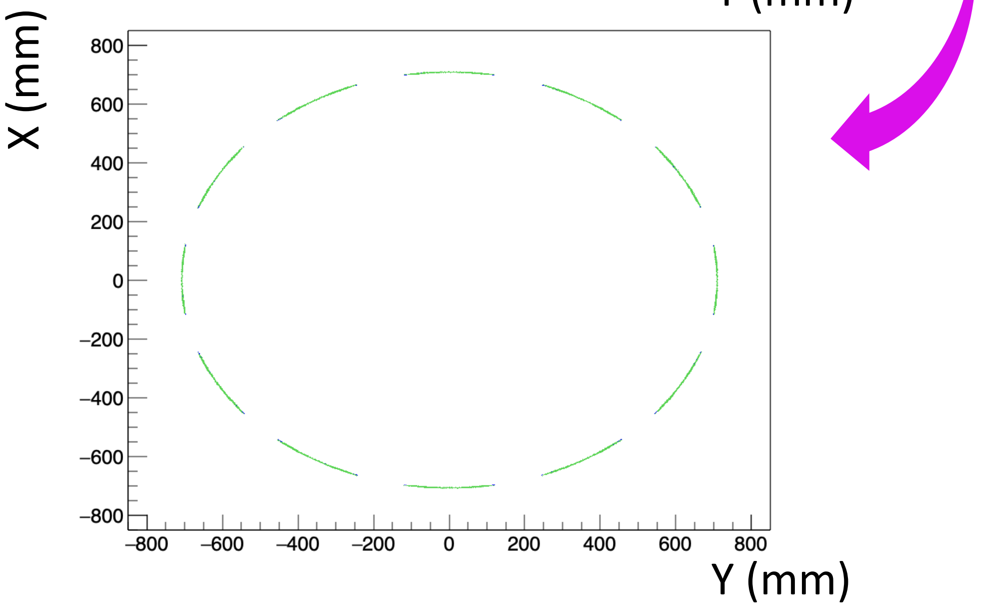


ePIC Simulations Method 1: Complications

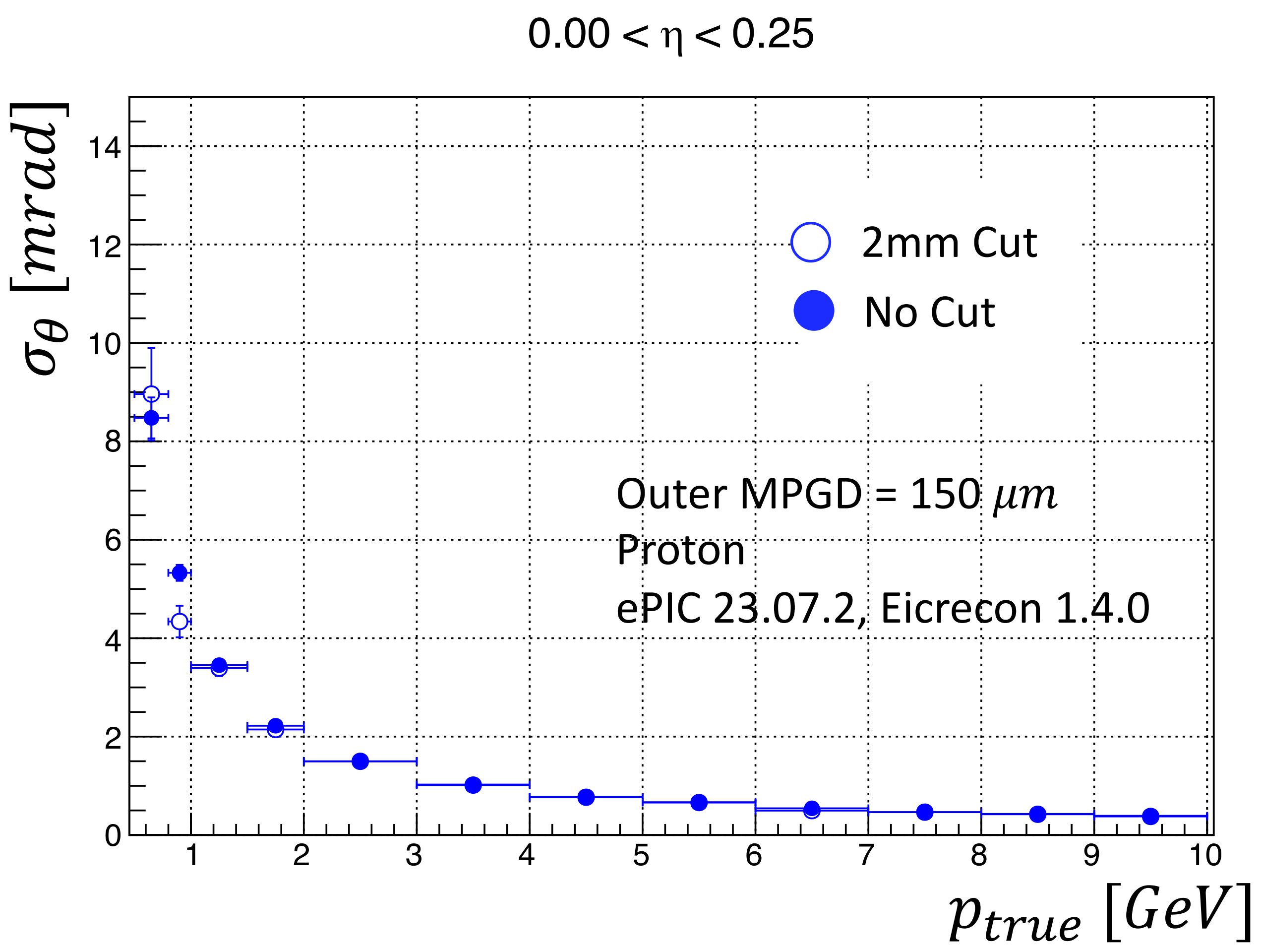
- Two complications found in Method 1 approach
  1. Spatial resolution used in DIRC hit point found to be $3\text{mm}/\sqrt{12}$, this leads to angular angular uncertainty of ~1.2 mrad
  1. ACTS projection surface is cylindrical, while DIRC volume is planar, which leads to geometrical mismatch
     - Mostly removed by applying cut
       - $\left|(x,y)_{proj} - (x,y)_{DIRC}\right| < 2\ mm$
     - Resolutions have minimal sensitivity to tighter cuts, particularly at larger momentum (>2 GeV)

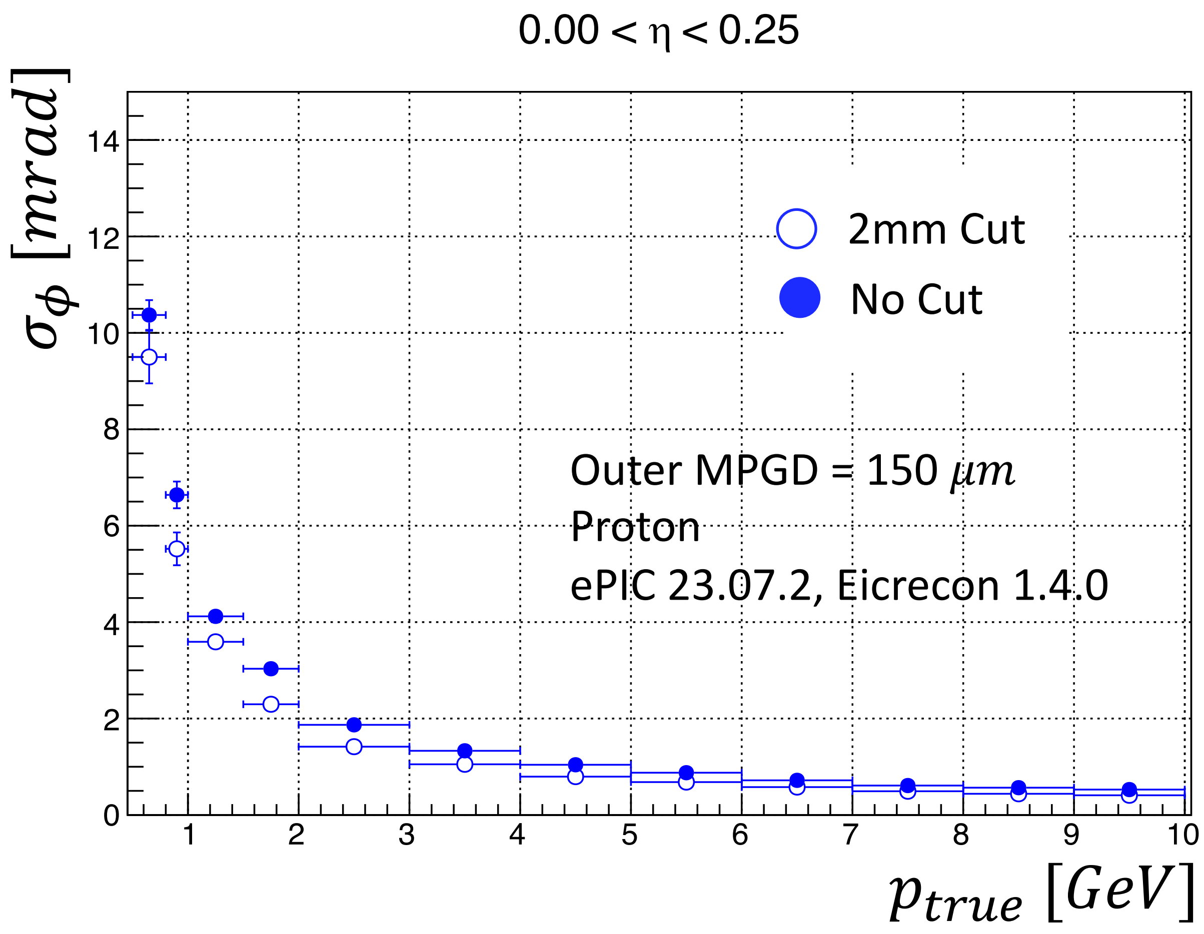




ePIC Simulations Method 1: Results

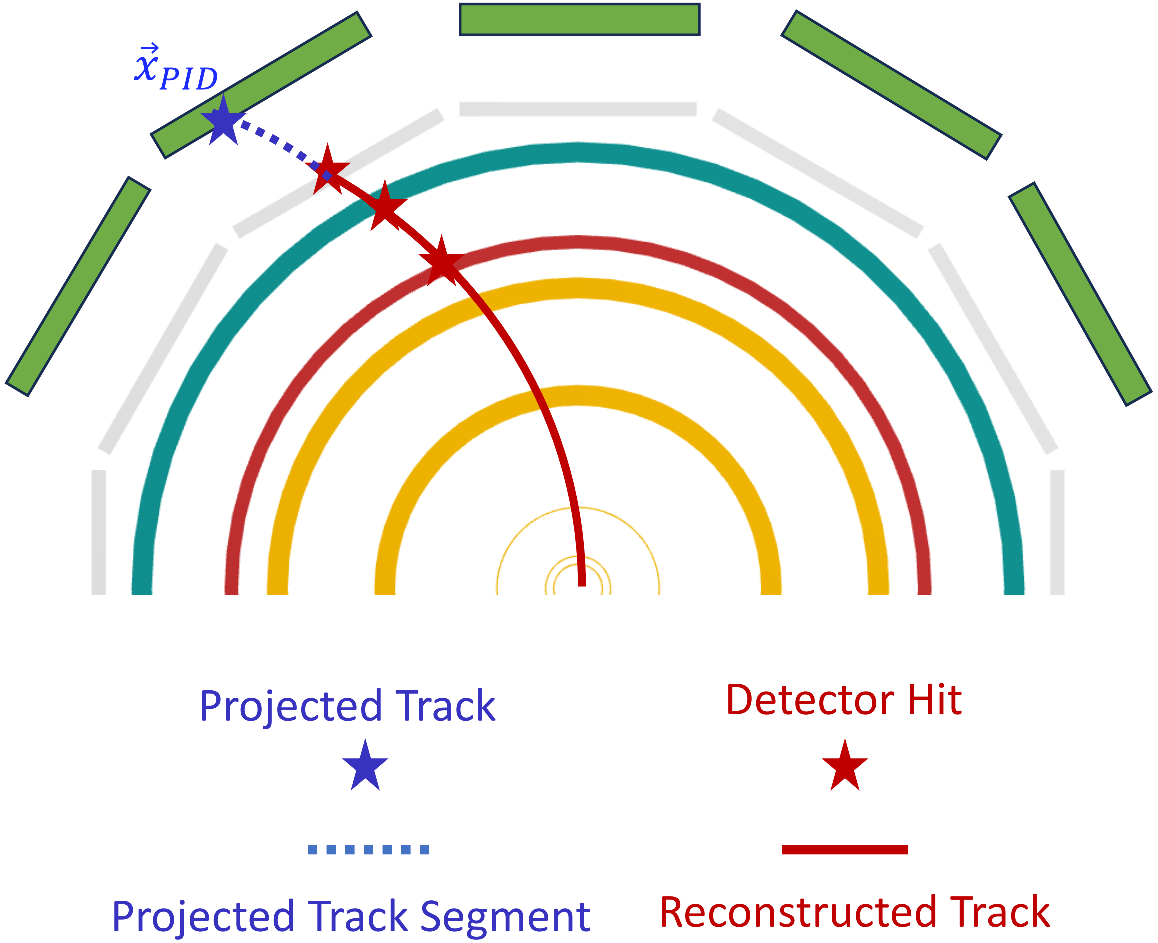
- Generally, cut provides better resolution, mainly at lower momentum





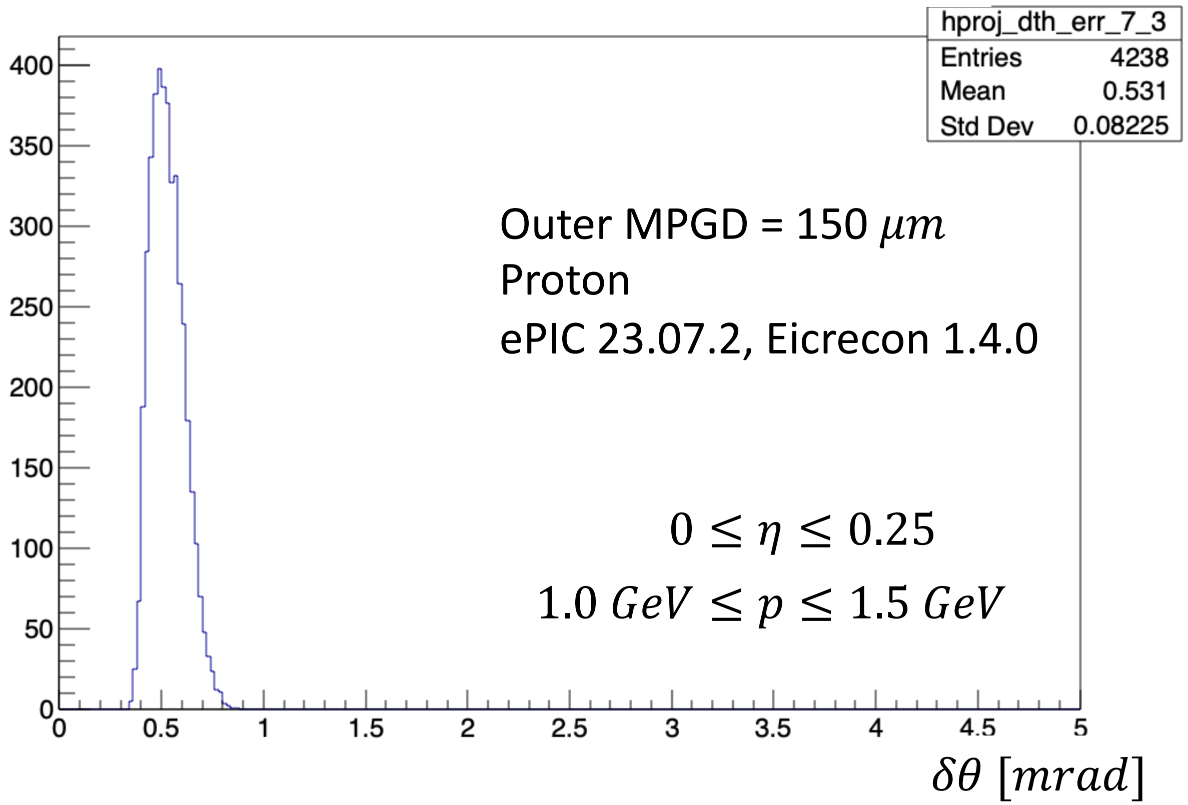
ePIC Simulations Angular Resolution Definition: Method 2

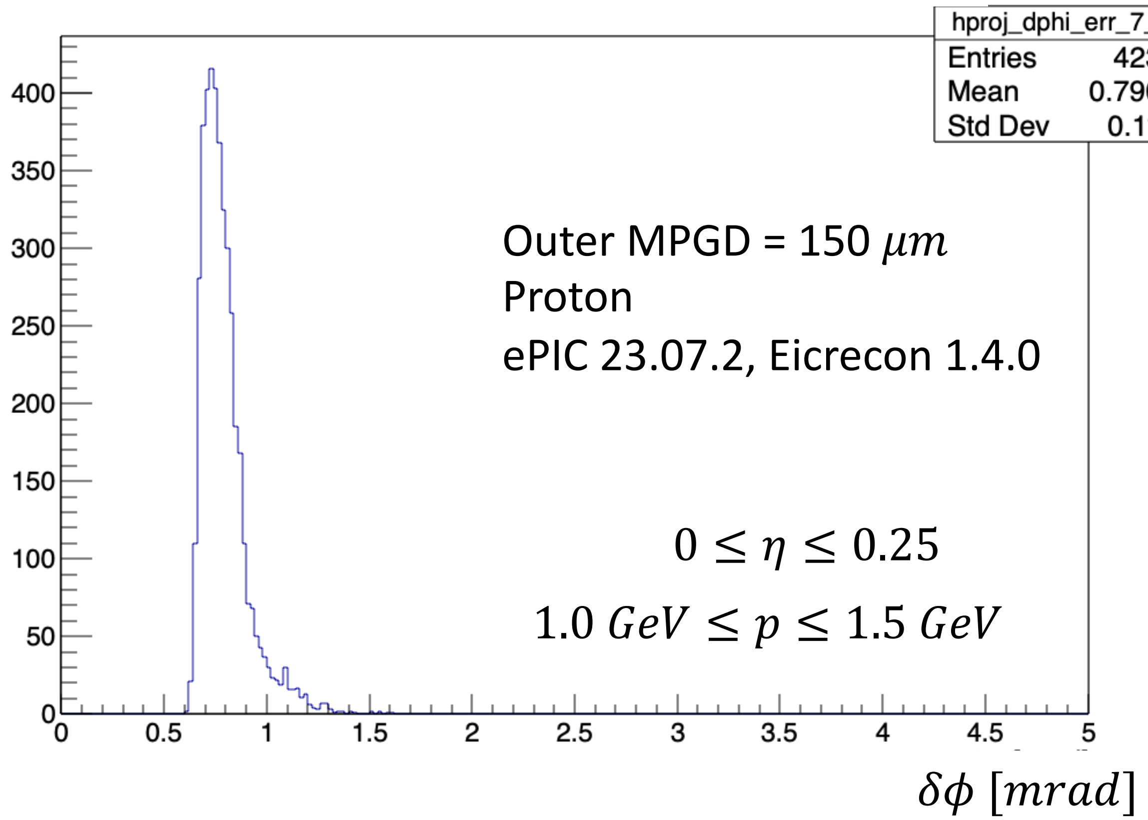
- Use projected track state vector a to get track direction impacting PID surface
  - $\vec{x}_{PID} = \left(l_0, l_1, \theta, \phi, \frac{q}{p}\right)$
- Obtain track direction uncertainty from covariance matrix from the fitted track
  - $var(\theta), var(\phi), cov(\theta, \phi)$



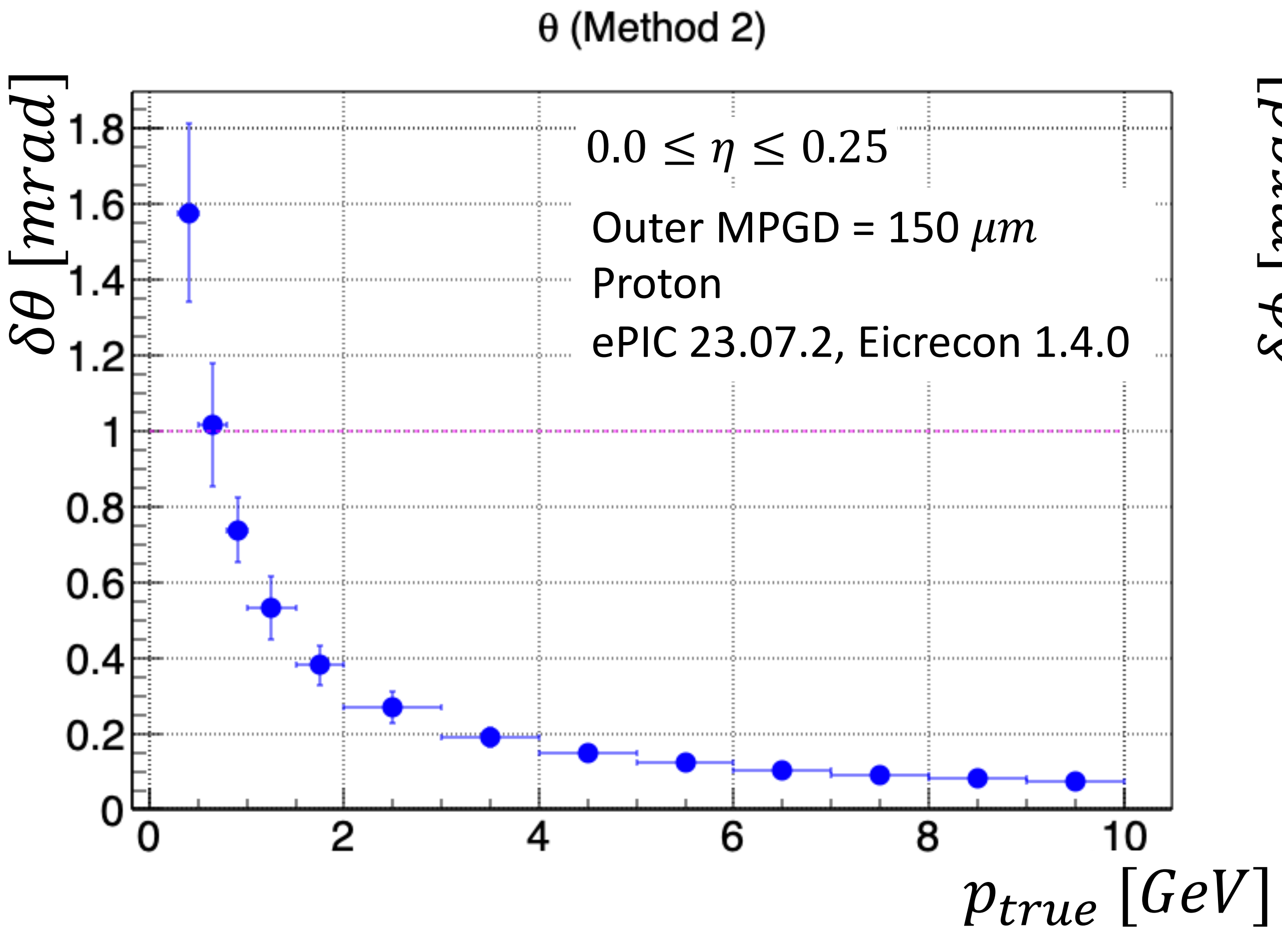
ePIC Simulations Angular Resolution Definition: Method 2

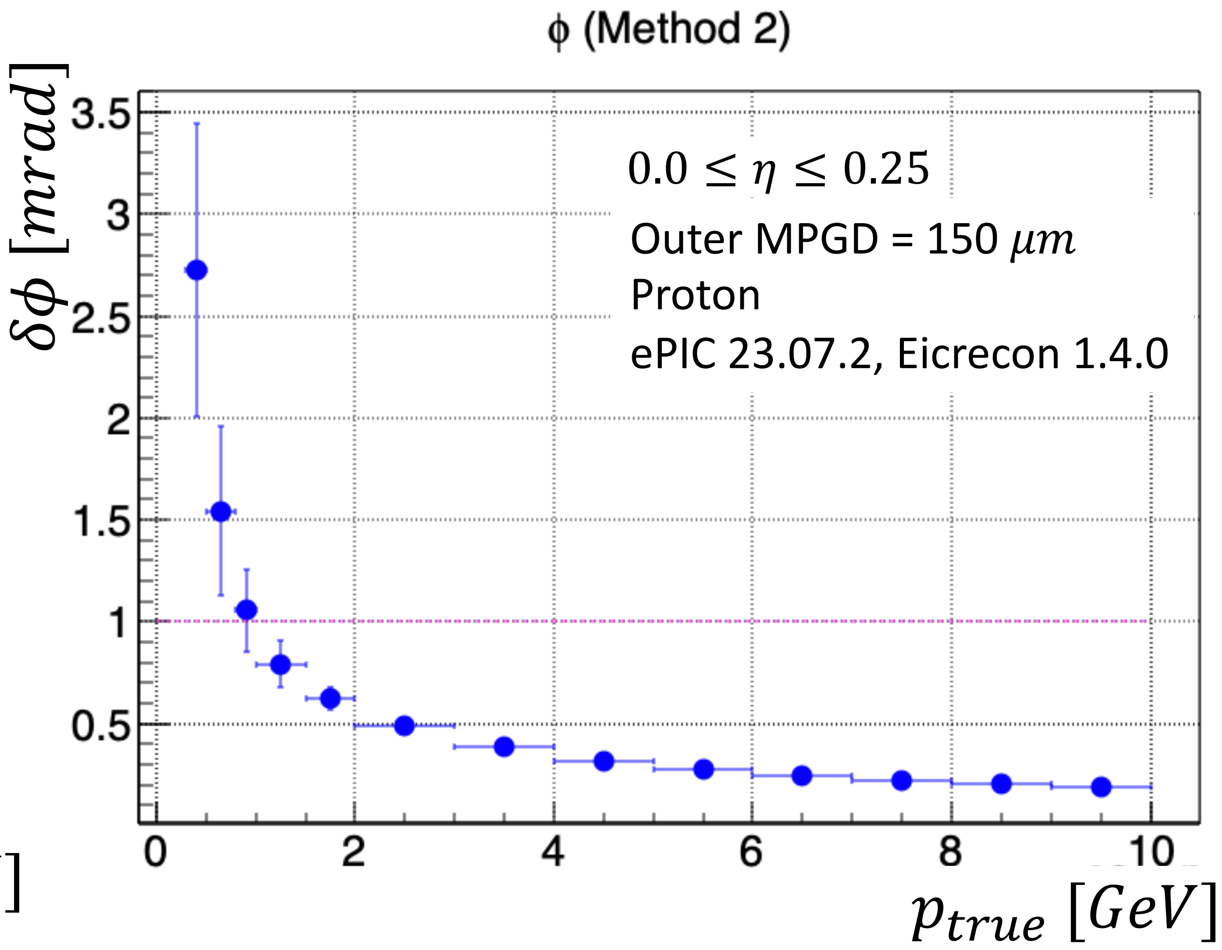
- Plot sqrt(variance)
  - Variance obtained from covariance matrix taken from the fitted track
  - Histogram mean = angular uncertainty $(\delta\theta, \delta\phi)$





ePIC Simulations Method 2: Results





- Angular uncertainties much smaller than in Method 1
  - Method 1 includes 3mm/sqrt(12) DIRC space point resolution, which needs to be removed.

Summary and Next Steps

- **Summary**
  - Discrepancy between angular resolutions of Method 1 and Method 2
  - Within the central region, both Method 1 and Method 2 show no sensitivity to outer MPGD resolutions between $100\mu m - 300\mu m$
  - Currently, not all information is in hand for the tracking working group to make a definite conclusion on the needed MPGD spatial resolution to meet PID angular resolution.
- **Next Steps**
  - Estimate multiple scattering within simulation of outer MPGD layer
    - Compare angular resolution of no outer MPGD (no material) to removing MPGD hits from track reconstruction (material)
  - Discrepancy between angular resolutions of Method 1 and Method 2
    - Modify hit resolution of DIRC in method 1
    - Verify accurate error propagations and information in track fit covariance matrix
  - Extend measurements to larger pseudorapidity, where services play a larger role