Assessing Angular Resolutions

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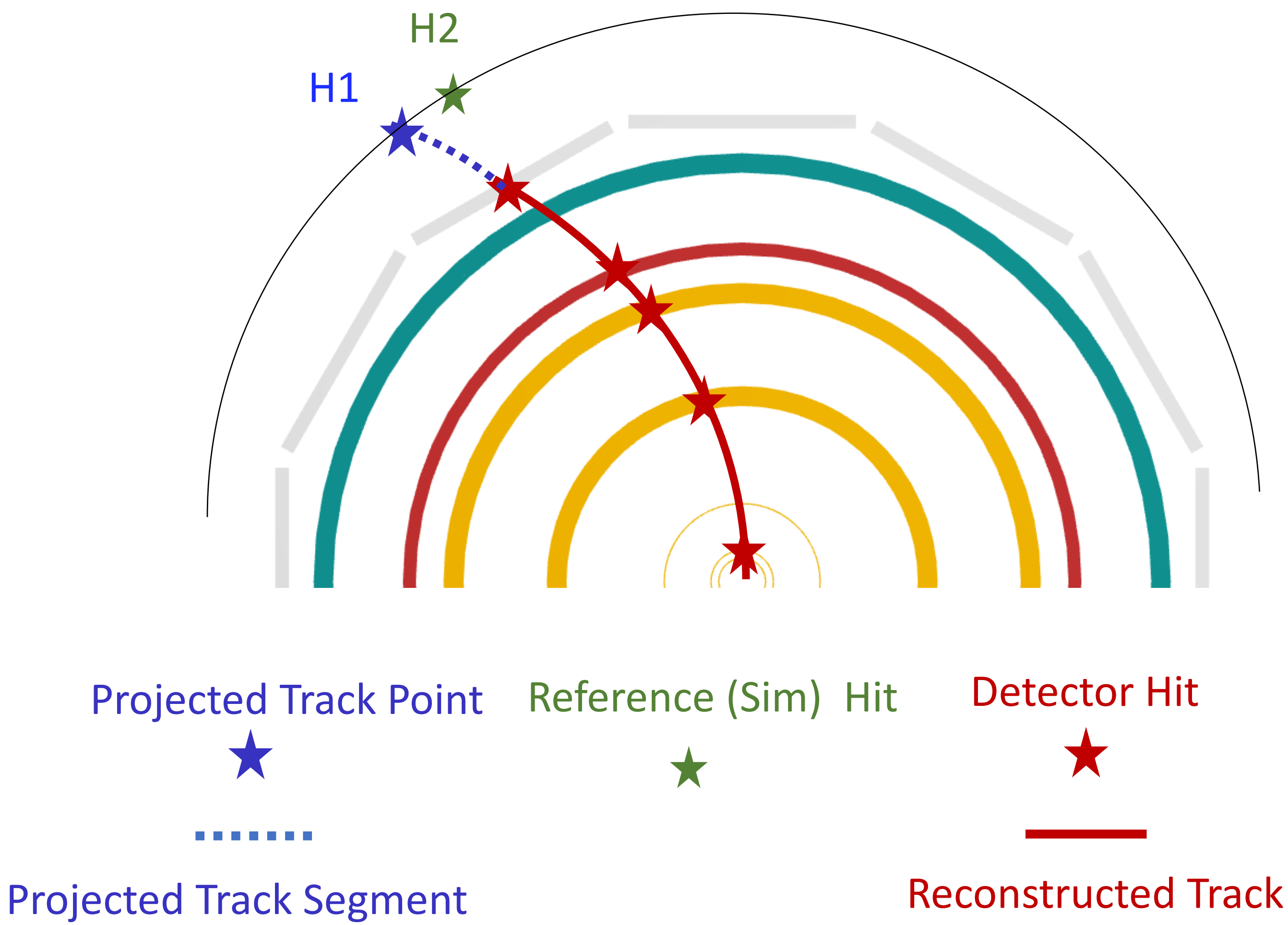
Angular Resolution: Method 1

**Simulation running details found in backup*

- Use projected position point vectors of projected track point (H1) and **nearest** Reference surface hit (H2) to obtain angles:
  - Projected Point (x,y,z) hits → $\theta_{H1}\ ,\phi_{H1}$
  - Reference Point (x,y,z) hits → $\theta_{H2}\ ,\phi_{H2}$
- Angular differences are:
  - $\theta_{H1}\ -\theta_{H2}$
  - $\phi_{H1}\ -\ \phi_{H2}$
- Angular resolution $\sigma_\theta, \sigma_\phi$ are extracted from width of assumed Gaussian distribution



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  - Reference Point (x,y,z) hits → θ_{H2} , ϕ_{H2}
- Angular differences are:
  - $\theta_{H1} - \theta_{H2}$
  - $\phi_{H1} - \phi_{H2}$
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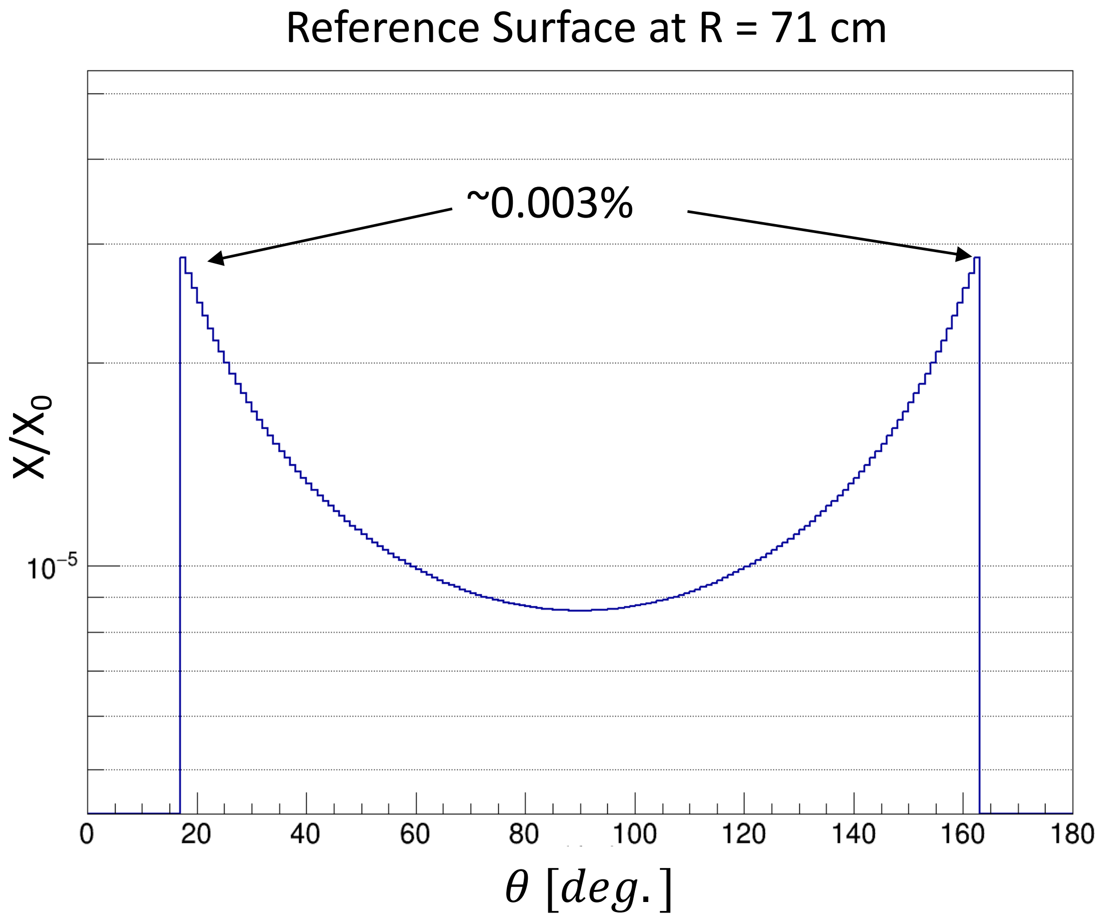
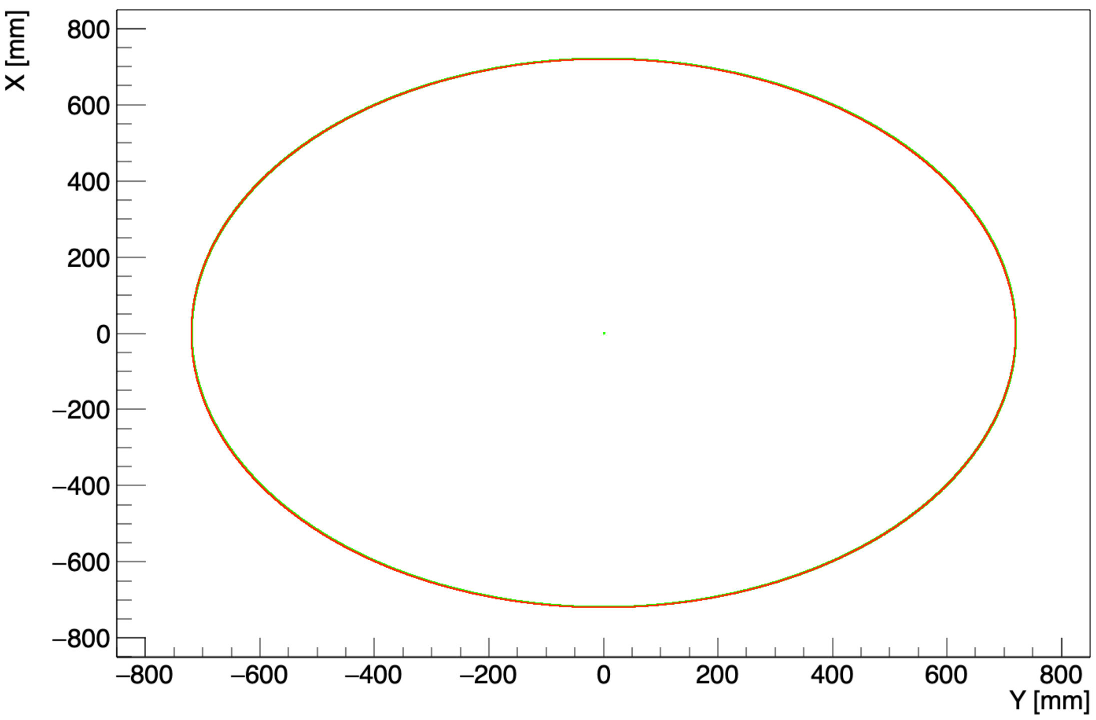
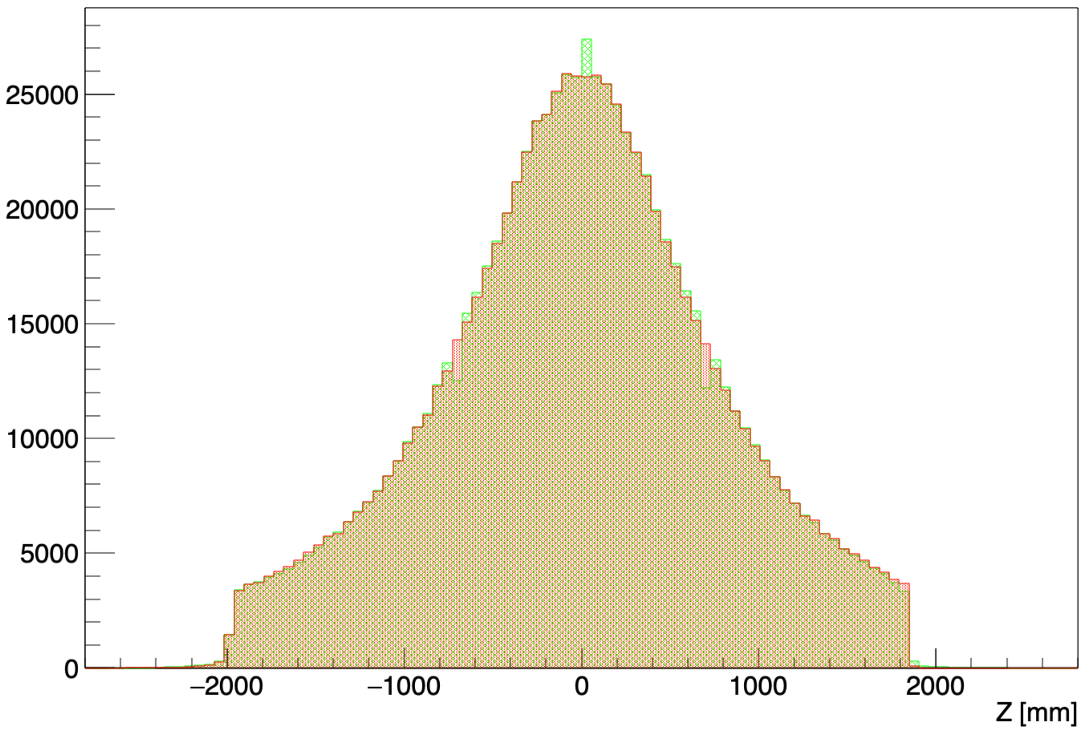
➢ Reference surface nearly massless



Surface Comparisons

Simulation Hit Surface
Propagation Surface

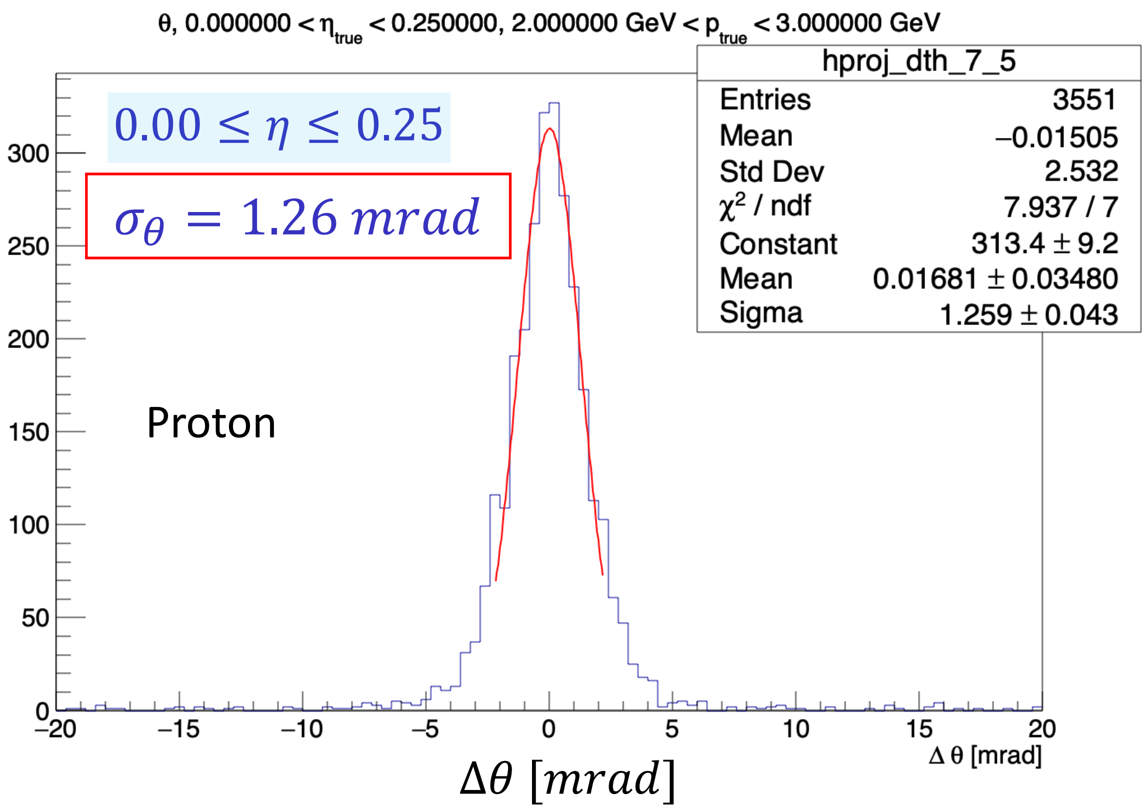


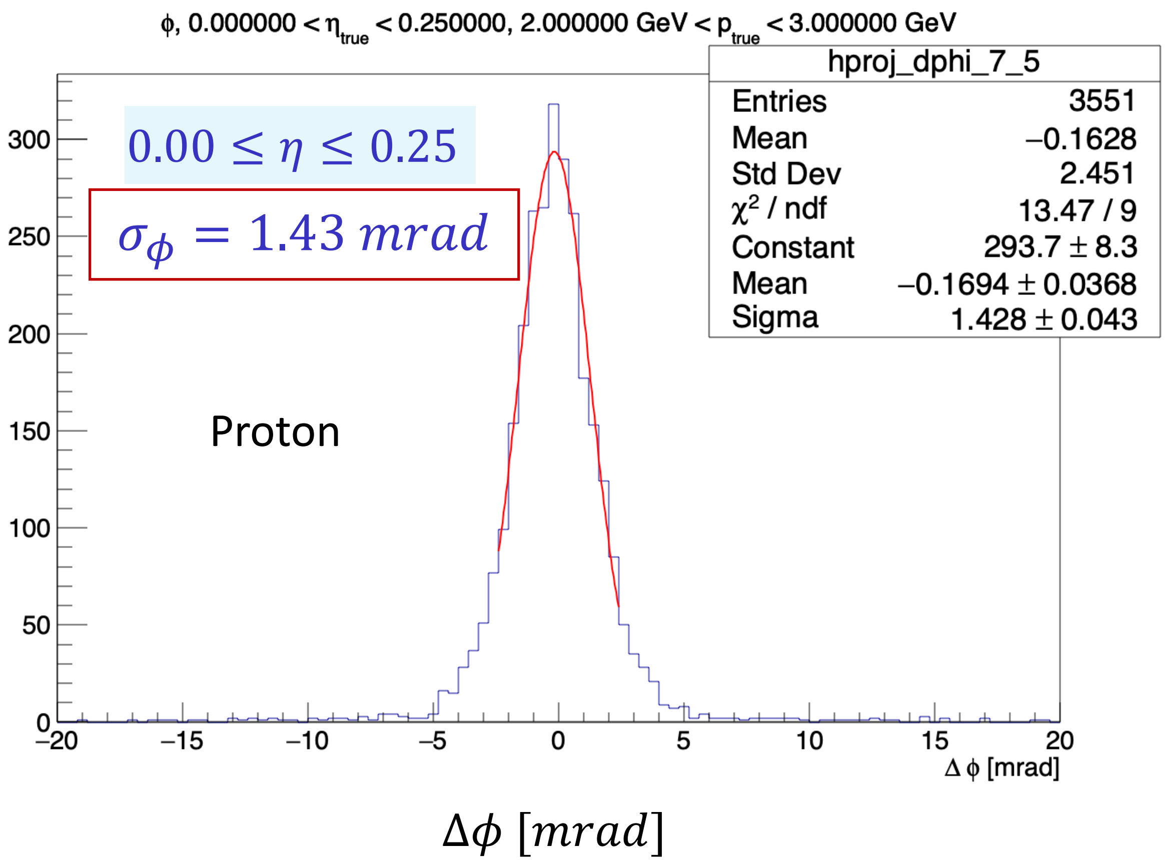


Method 1: Extracting Angular Resolution

Example

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



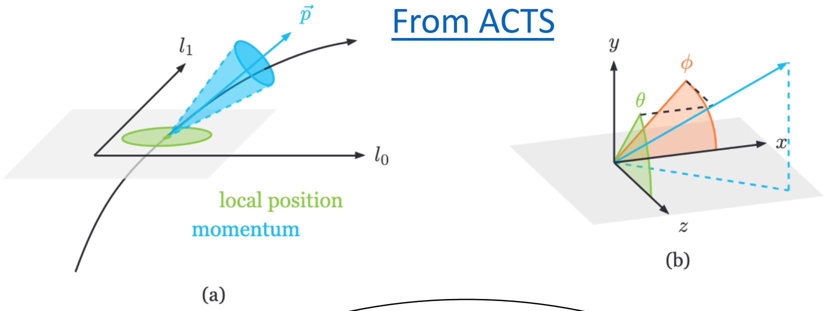


Angular Resolution Method 2

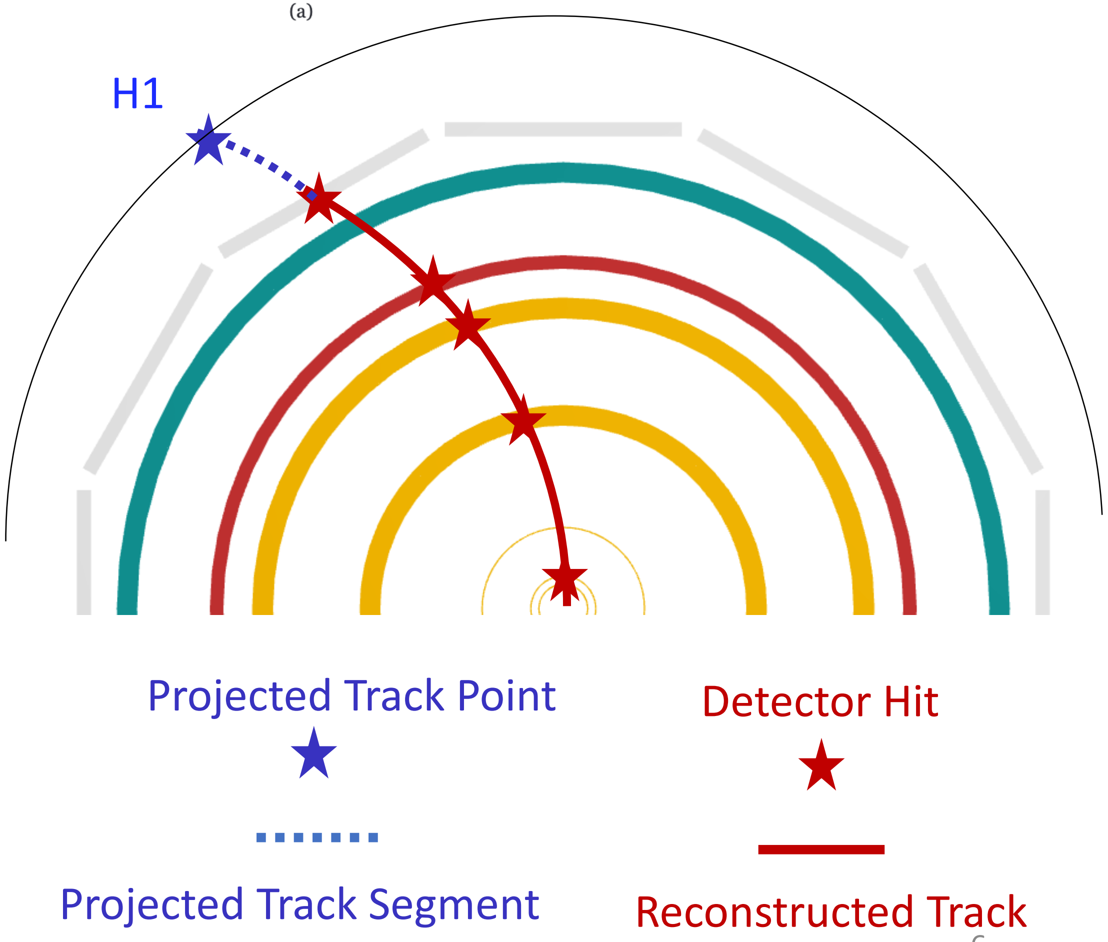
- Track Errors
  - Use propagated trajectory and track point vector to get track direction impacting PID surface
    - $\vec{x}_{H1} = \left(l_0, l_1, \theta, \phi, \frac{q}{p}\right)$
  - Obtain track direction uncertainty from covariance matrix, C

$$C = \begin{bmatrix} \sigma^2(l_0) & \mathrm{cov}(l_0, l_1) & \mathrm{cov}(l_0, \phi) & \mathrm{cov}(l_0, \theta) & \mathrm{cov}(l_0, q/p) \\ . & \sigma^2(l_1) & \mathrm{cov}(l_1, \phi) & \mathrm{cov}(l_1, \theta) & \mathrm{cov}(l_1, q/p) \\ . & . & \sigma^2(\phi) & \mathrm{cov}(\phi, \theta) & \mathrm{cov}(\phi, q/p) \\ . & . & . & \sigma^2(\theta) & \mathrm{cov}(\theta, q/p) \\ . & . & . & . & \sigma^2(q/p) \end{bmatrix}$$

From ACTS



From ACTS

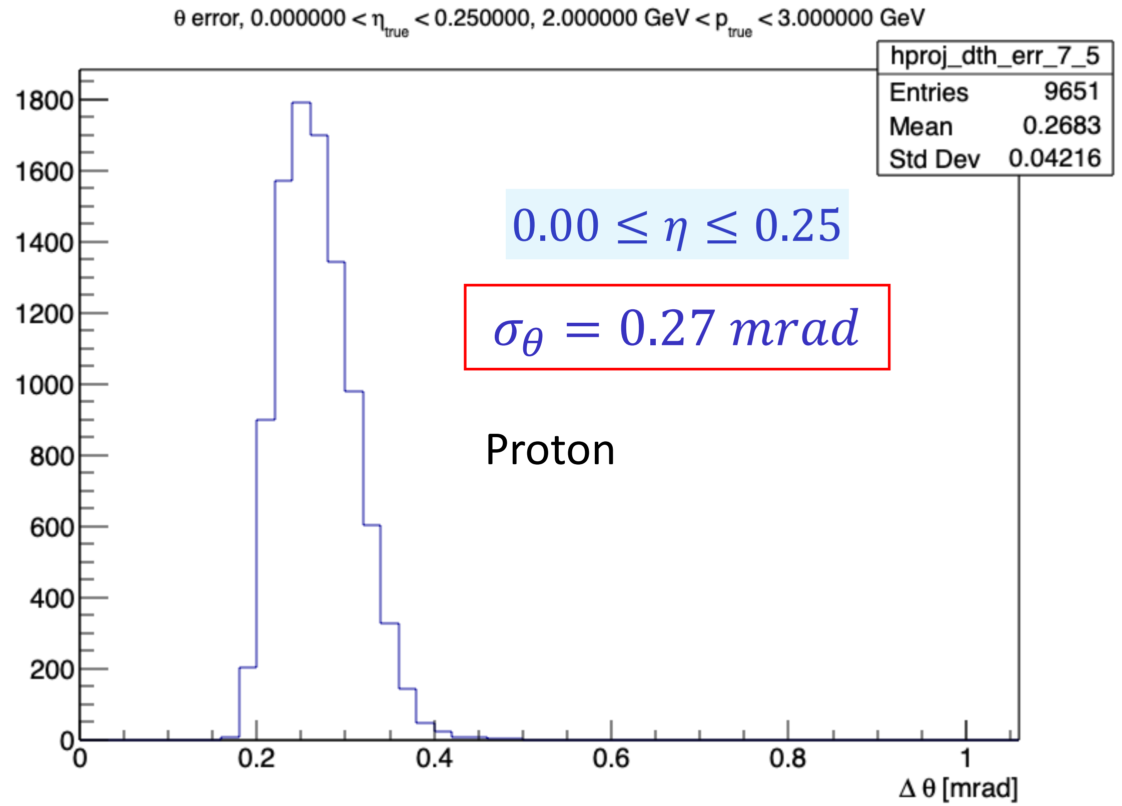


Method 2: Extracting Angular Resolution

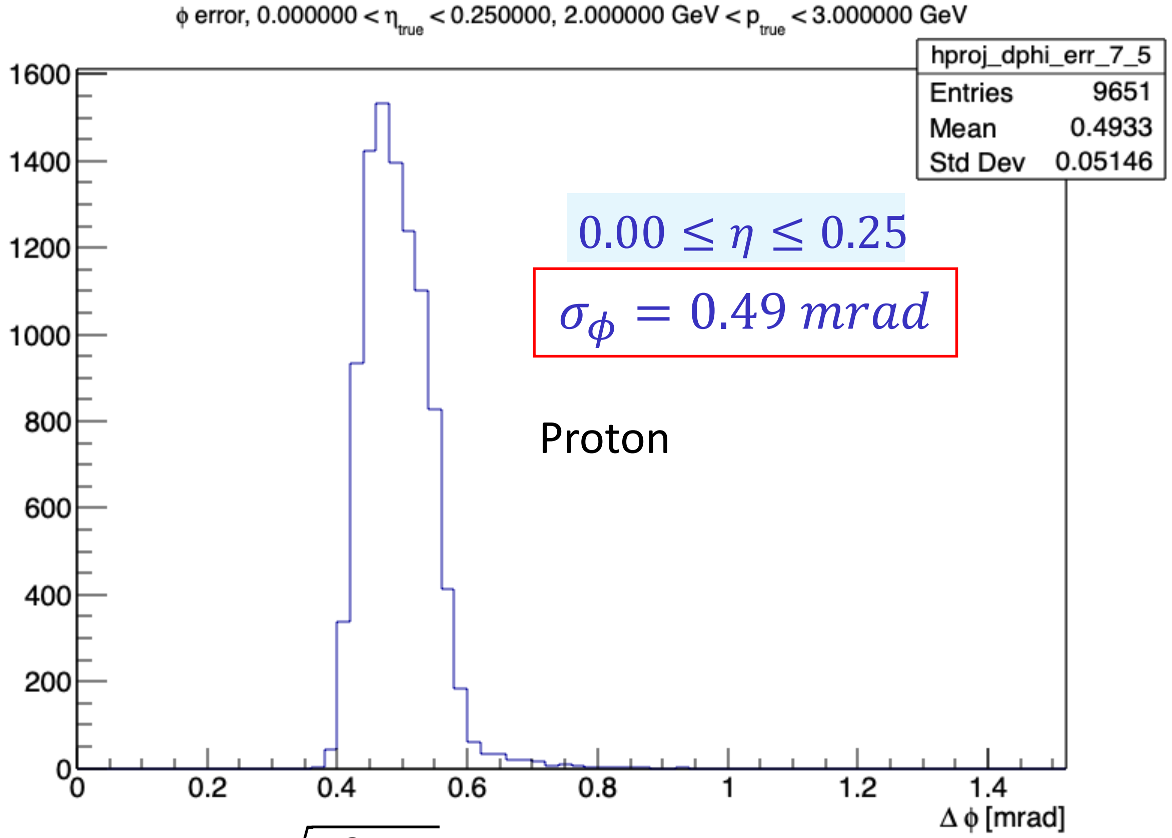
- Histogram sqrt(variance), variance obtained from covariance matrix
  - Histogram mean = angular resolution
  - Histogram RMS = error bar

Example

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



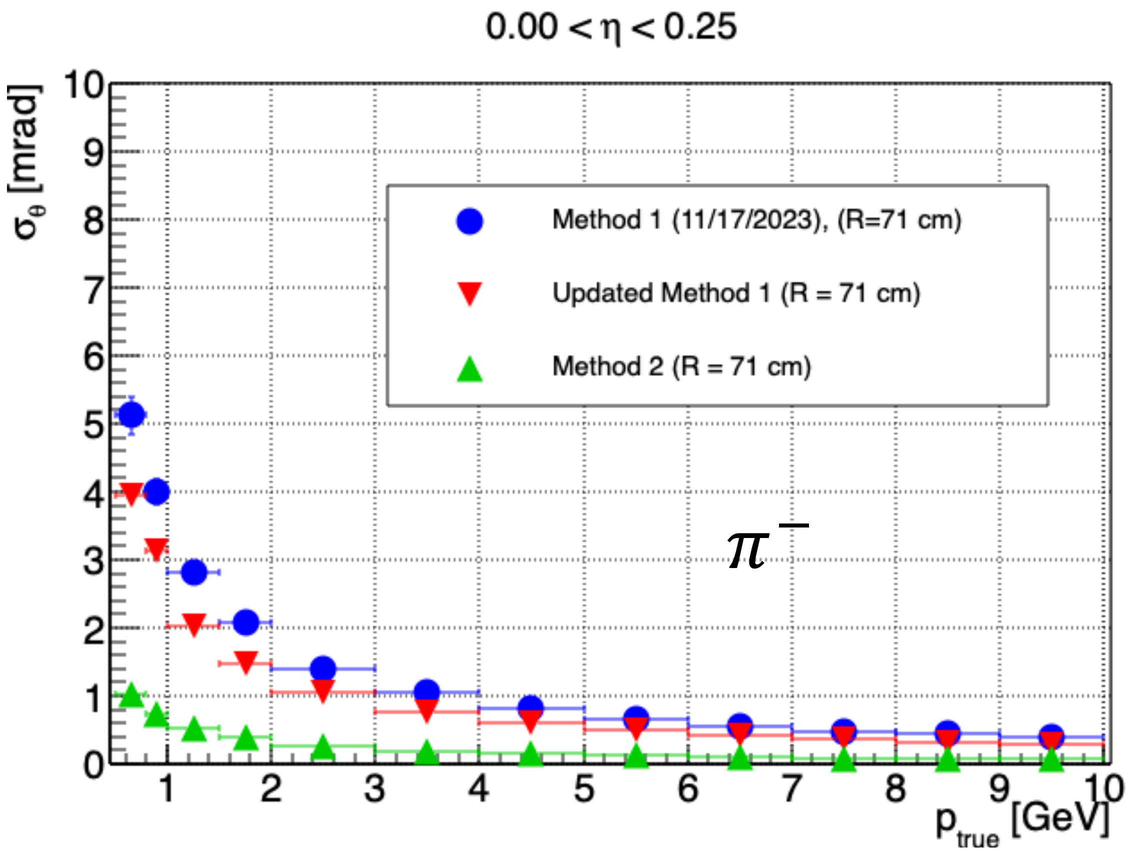
$\sqrt{\sigma^2(\theta)}\ [mrad]$

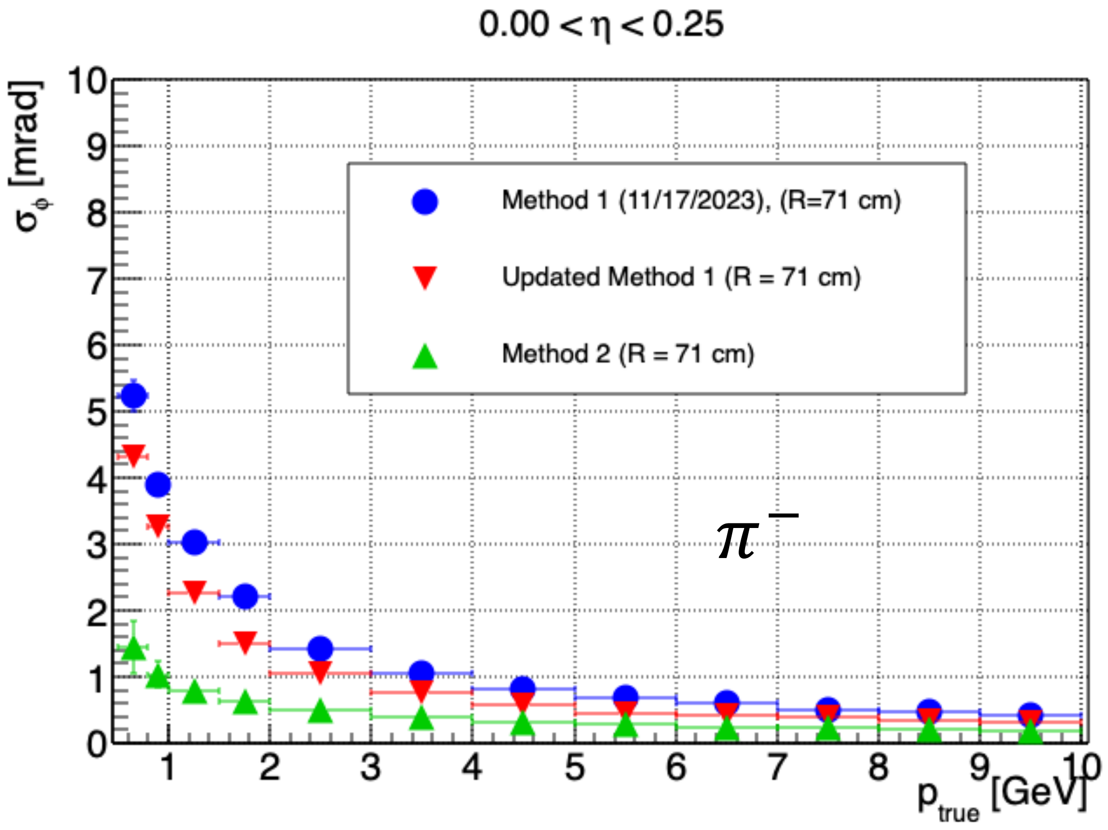


$\sqrt{\sigma^2(\phi)}\ [mrad]$

Comparisons: Pions ($0.00 < \eta < 0.25$)

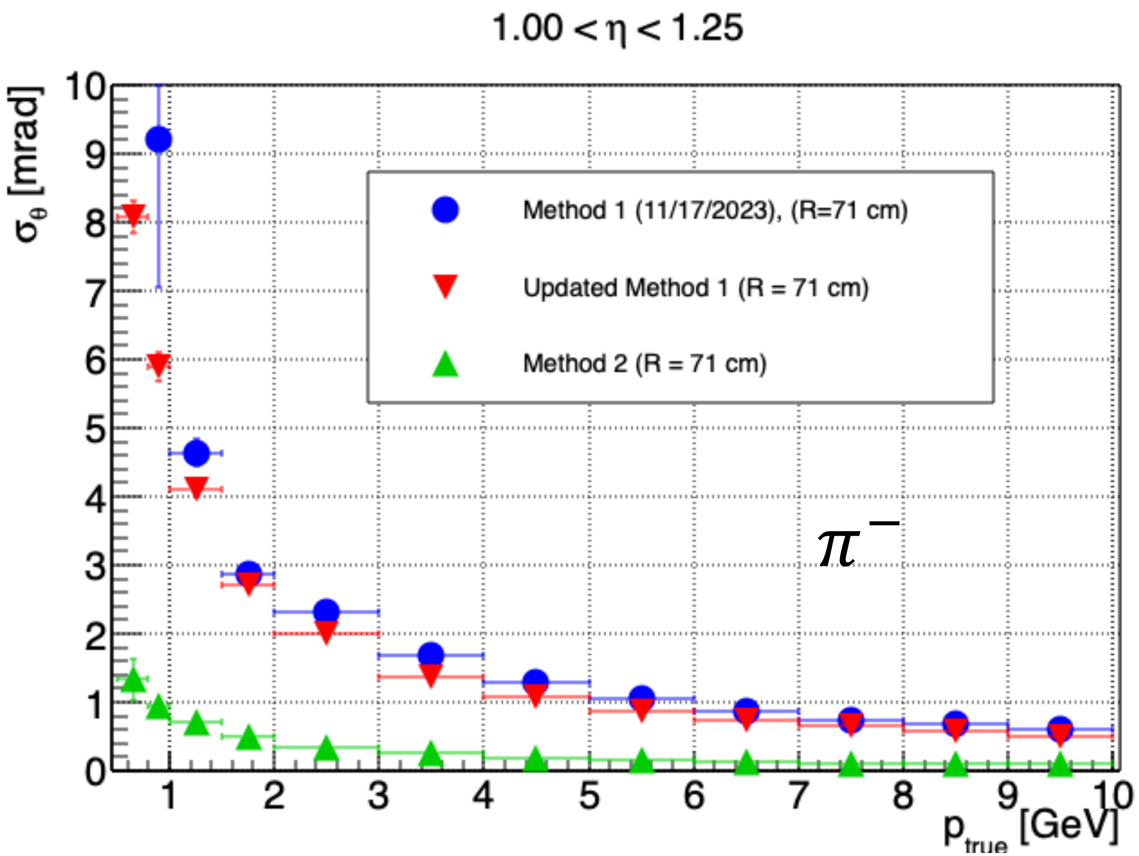
- Revised Method 1 shows improvement in angular resolution, in particular at low momenta
  - For details on revised method 1 see: PID WGM 11/17/2023

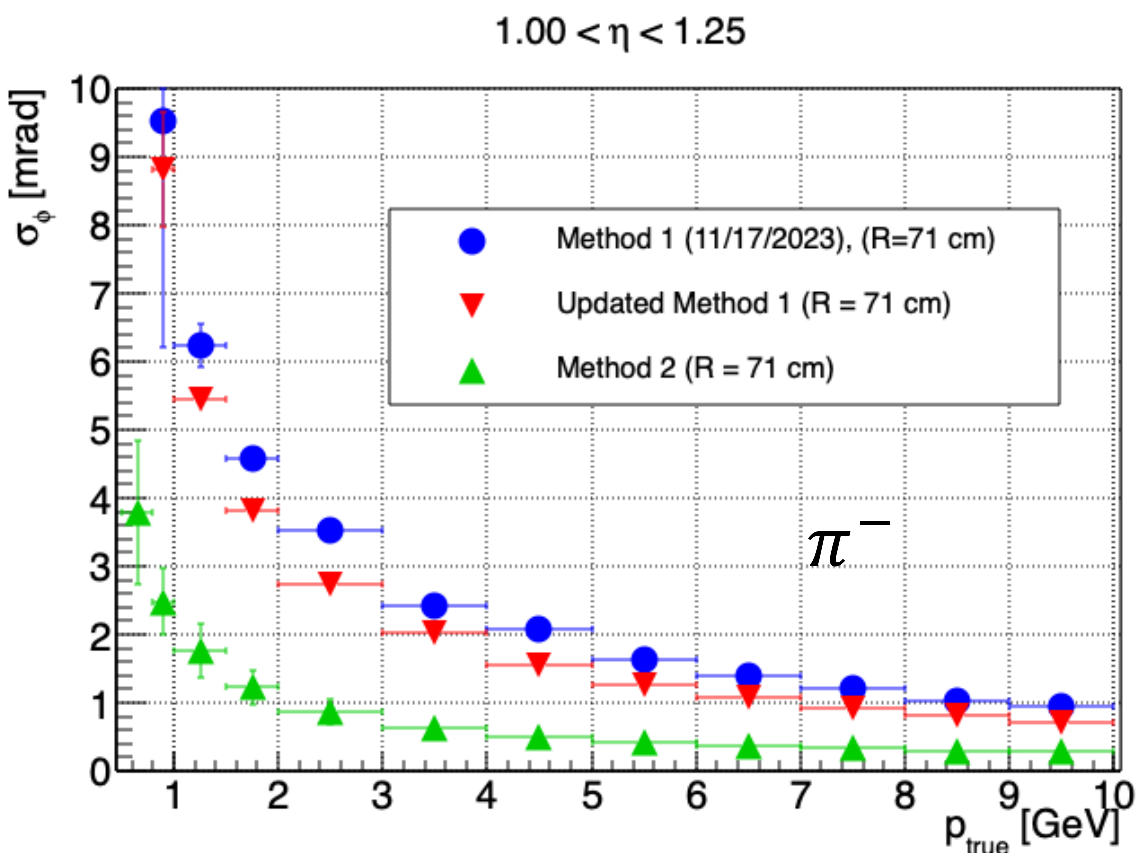




Comparisons: Pions ($1.00 < \eta < 1.25$)

- Revised Method 1 shows improvement in angular resolution, in particular at low momenta





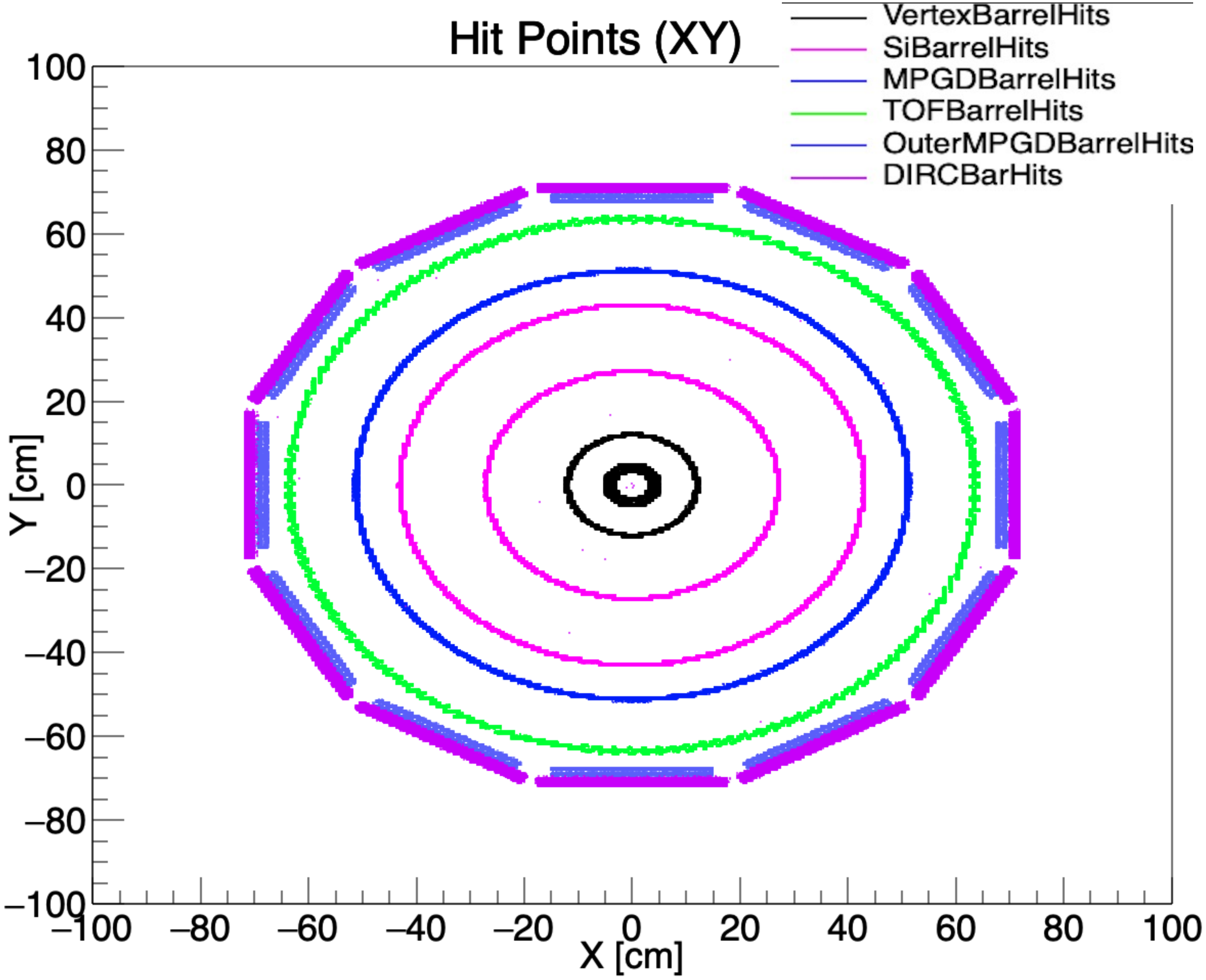
Summary

- Methods 1 and 2 can be used to assess angular resolutions for any detector
- **Difference seen between the two methods:**
  - **Method 1** takes difference between propagated trajectory track point and the true hit (via Reference surface Sim hit) to extract angular resolution
  - **Method 2** assigns uncertainty at each surface from Kalman Filter
    - Gives uncertainty related to KF (filtering uncertainty)
    - Doesn’t know where true hit location is
  - Use fast simulation to try and understand the difference better

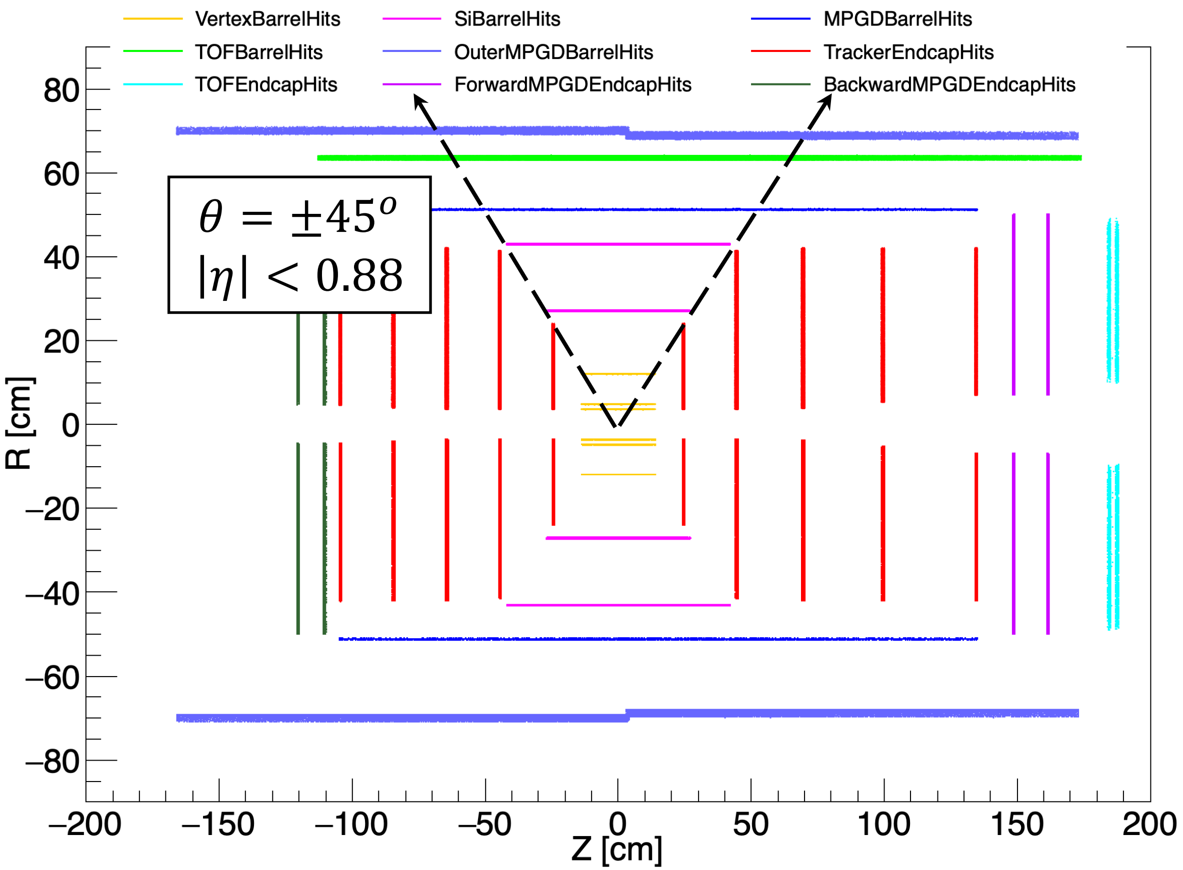
Backup

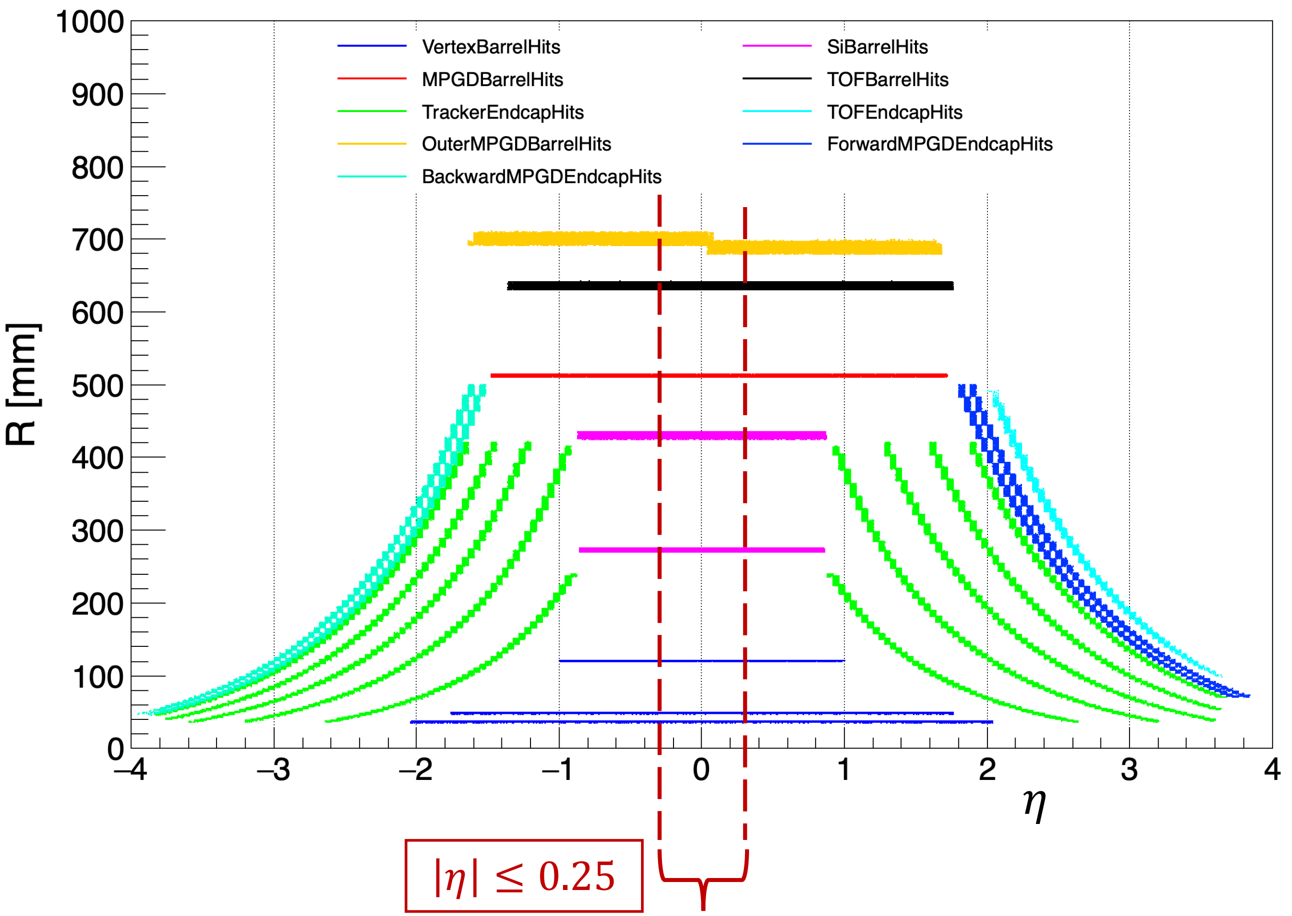
Simulation Details

- Software Version
  - ePIC = 23.07.2
  - Detector Configuration = Craterlake
  - EICRecon = v1.5.1
- Generator
  - Particle Gun = 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)

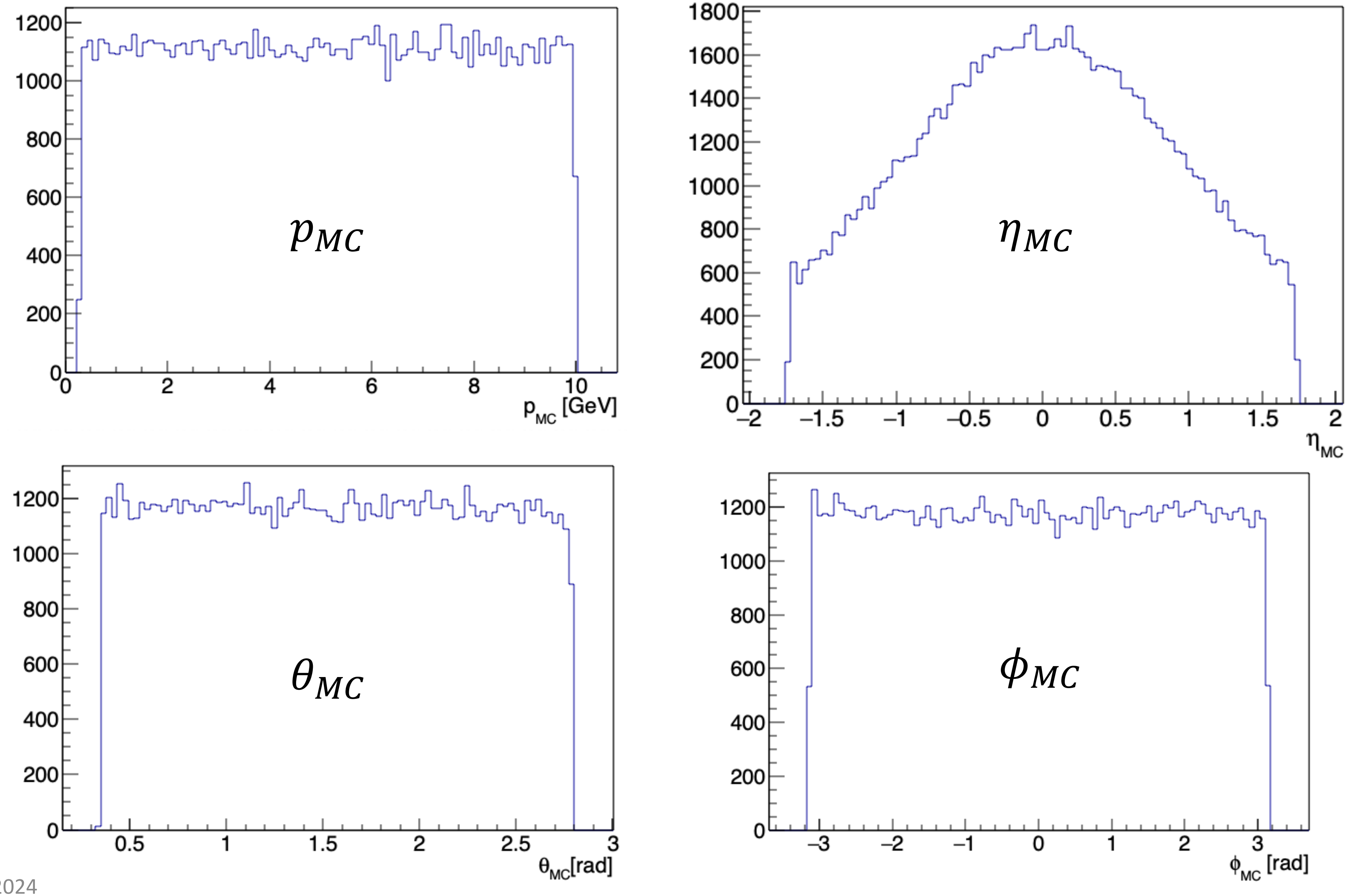


Simulation Details





Simulation Distributions: Representative Sample



Material Budget