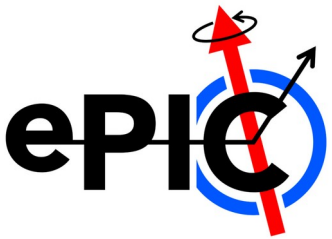
Impact of current tracking estimates on DIRC performance



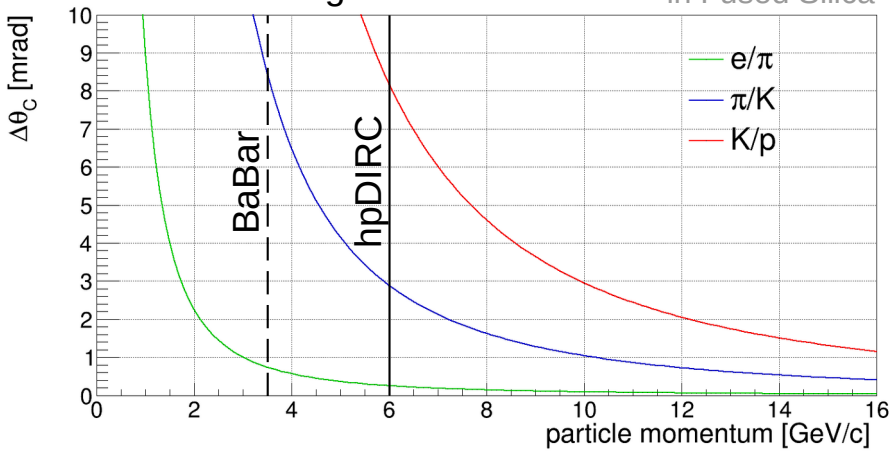
January 2024 ePIC Collaboration Meeting

Roman Dzhygadlo GSI

CUA GSI Stony Brook University Old Dominion University University of South Carolina Wayne State University William & Mary Jefferson Lab

Cherenkov Angle Resolution

Cherenkov angle difference: in Fused Silica



Cherenkov angle resolution per track:

$$\sigma_{\theta_c}(particle) \approx \sqrt{\left(\frac{\sigma_{\theta_c}(photon)}{\sqrt{N_\gamma}}\right)^2 + \sigma^2_{correlated}}$$

improve angular resolution of tracking system, mitigate multiple scattering impact

use photon detectors better PDE, improve Cherenkov angle resolution per photon

$$\sigma_{\theta_c}(photon) \approx \sqrt{\sigma^2_{bar} + \sigma^2_{pix} + \sigma^2_{chrom}}$$

BABAR DIRC $\sigma_{\theta_c}(photon) = 9.6$ mrad

Limited in BABAR by:		Improve for future DIRCs via:
▪ size of bar image	~4.1 mrad	▪ focusing optics
▪ size of PMT pixel	~5.5 mrad	▪ smaller pixel size
▪ chromaticity (n=n(λ))	~5.4 mrad	▪ better time resolution
	9.6 mrad	5-6 mrad per photon

SUPERB, BELLE II, PANDA & EIC

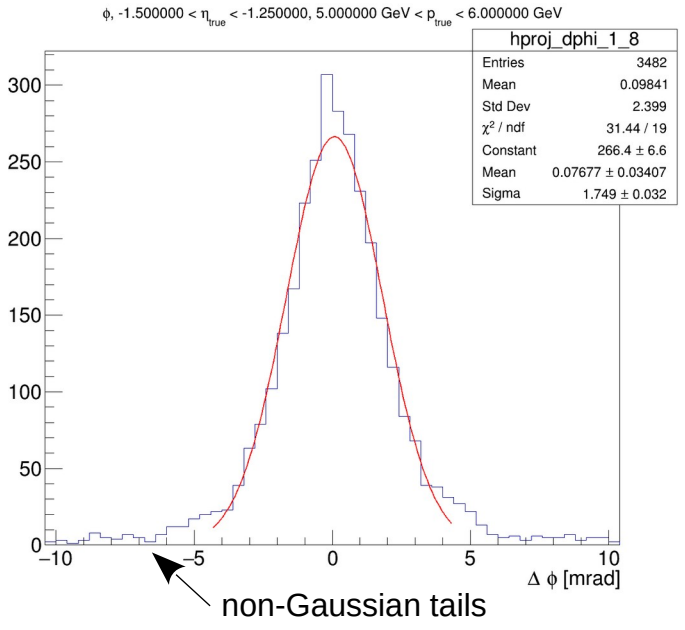
correlated term: $\sigma_{correlated} \approx \sqrt{\sigma^2_{tracking} + \sigma^2_{ms}}$ ⇨ track's angular resolution has direct impact on PID performance

~0.5 mrad angular resolution is required (Yellow Report)

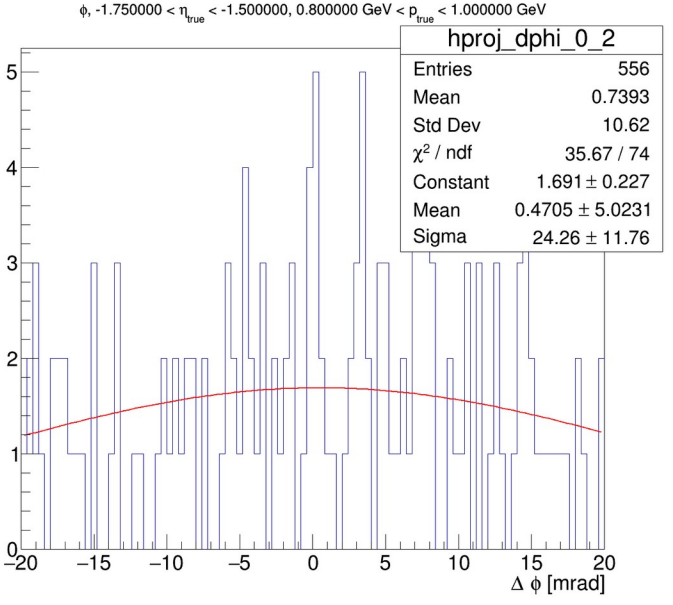
Angular Resolution

- input from Matt: craterlake_angle_method1b.root
- 13 bins in momentum [0.3, 10] and 14 bins in eta [-1.75, 1.75]

typical bin:

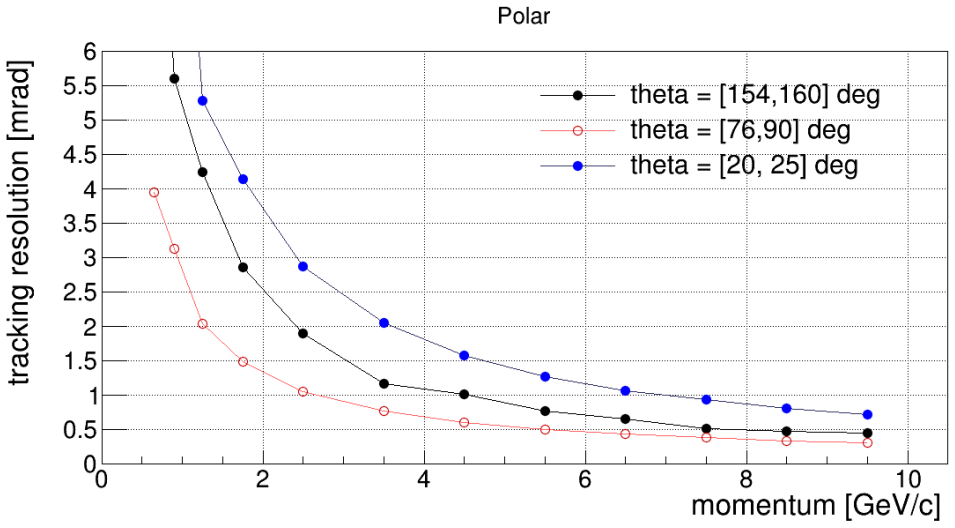


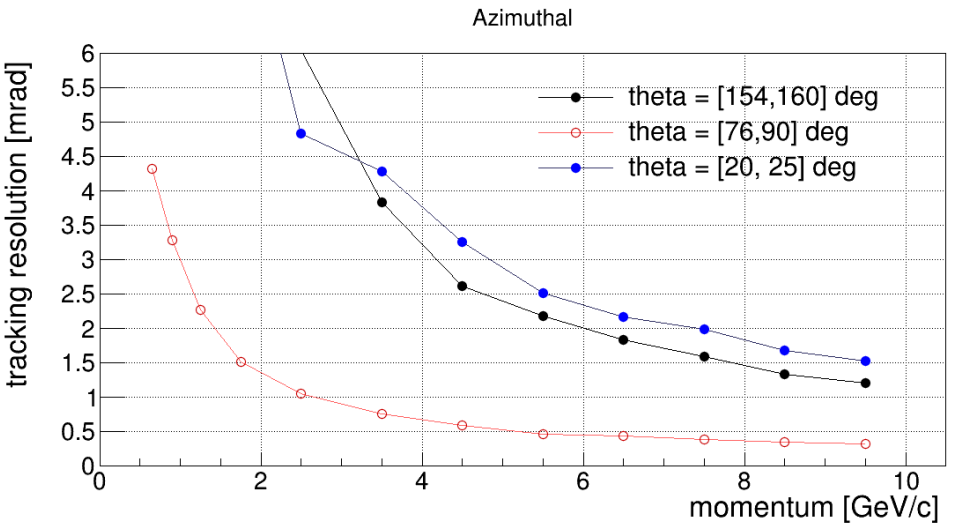
bin with low stat (@ low momenta):



Angular Resolution

Resolution (sigma of the Gaussian fit) as a function of momentum

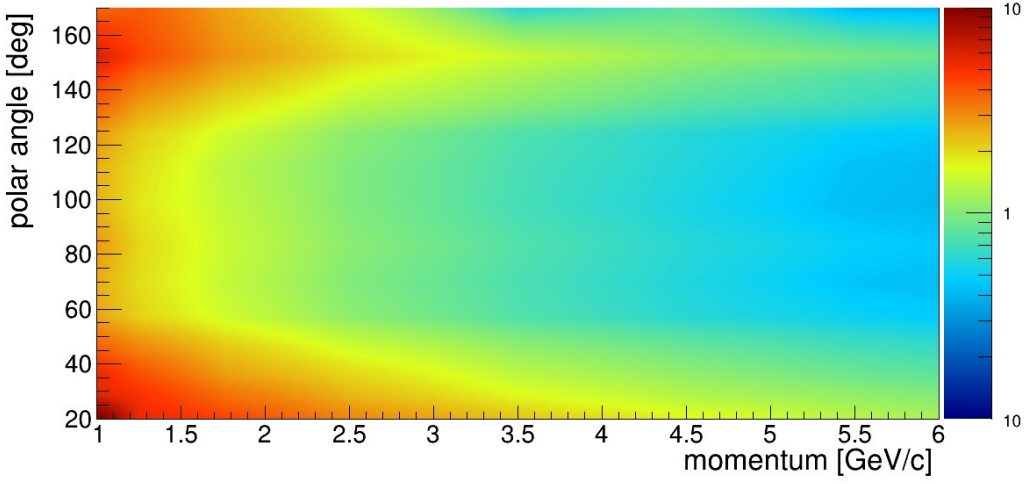




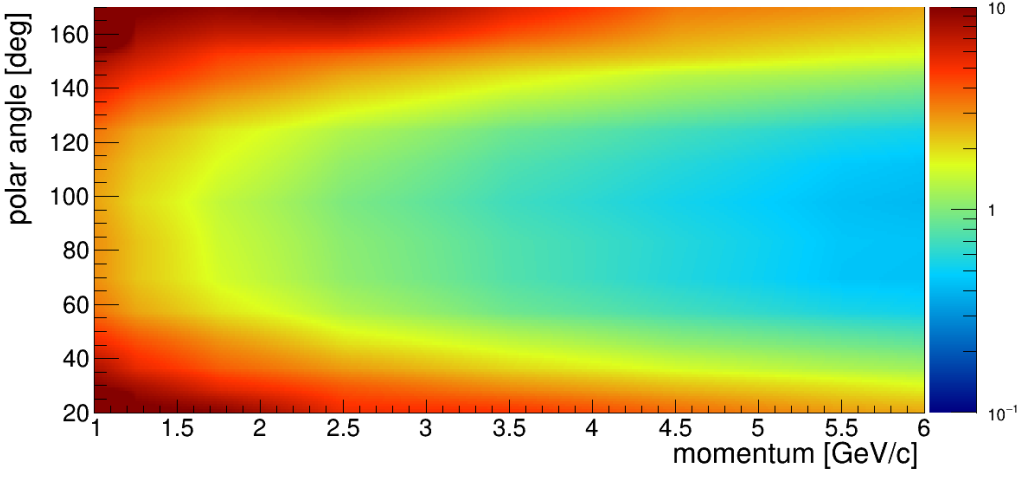
Yellow report requirement 0.5 mrad @ 6 GeV/c

Interpolated Angular Resolution Map

polar angle resolution [mrad]:

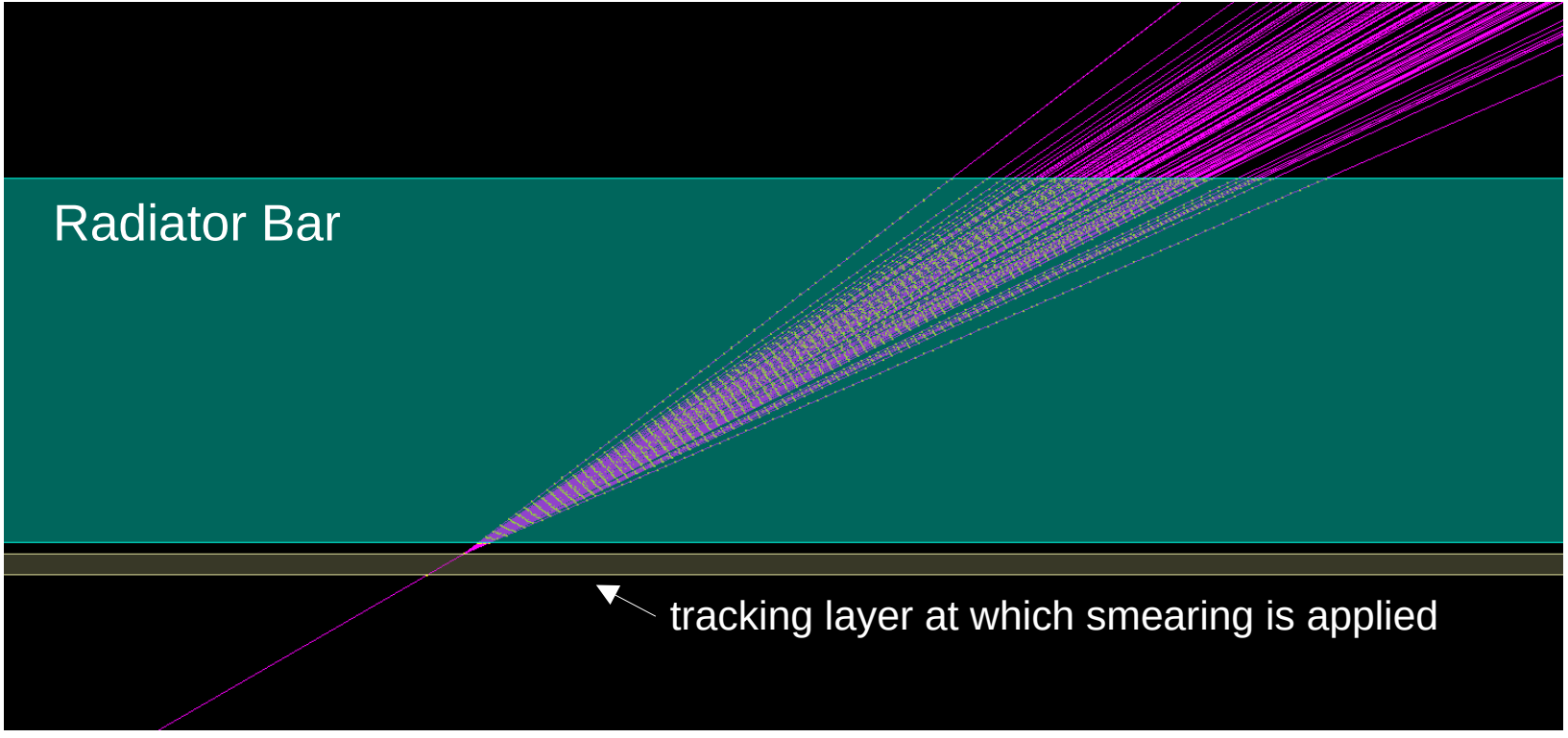


azimuthal angle resolution [mrad]:



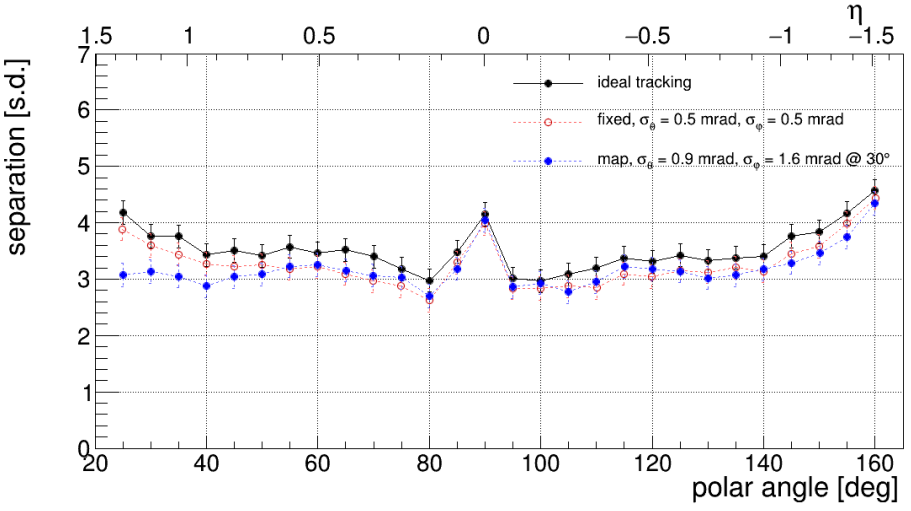
Implementation of Track Smearing

Event display of 100 pions @ 6 GeV/c smeared at tracking layer with 50 mrad

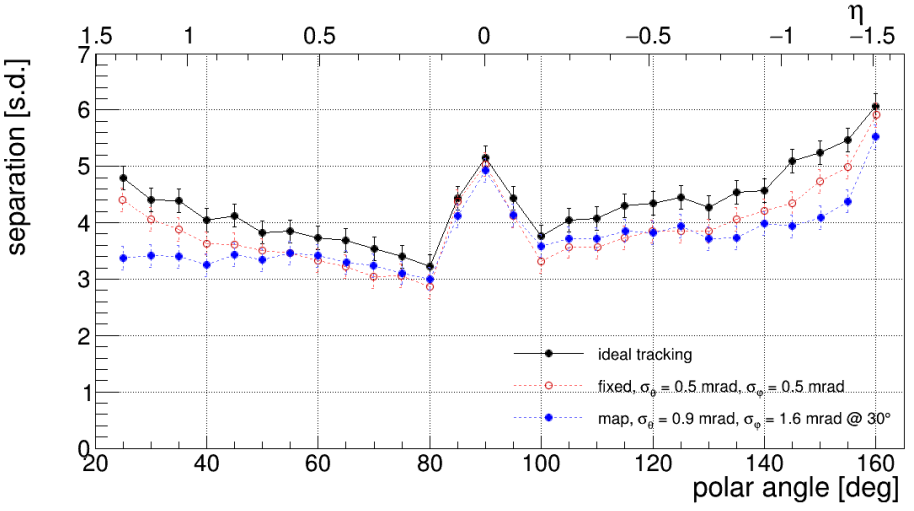


DIRC Performance for π/K @ 6 GeV/c

geometrical reconstruction:



time imaging:

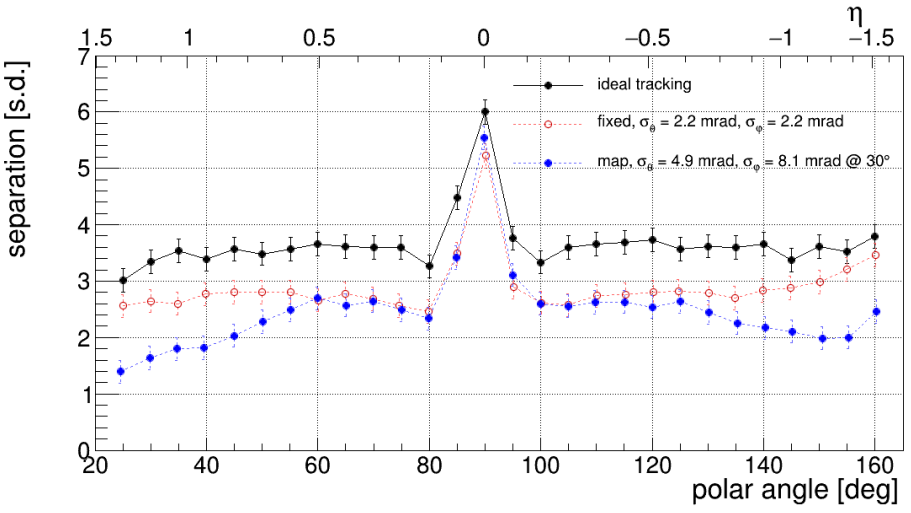


Caveats:

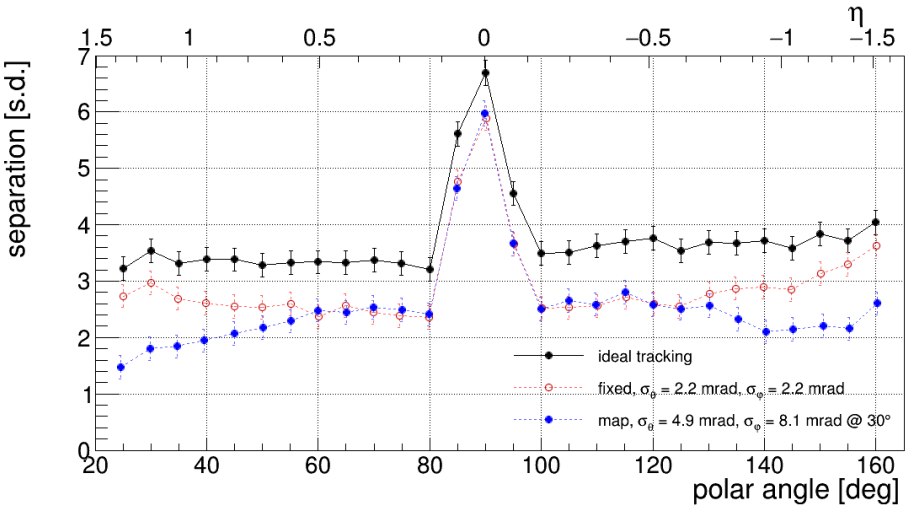
- standalone geant4 sim/reco without magnetic field
- no background events (for performance with bg events see talk by W. J. Llope)

DIRC Performance for e/π @ 1.2 GeV/c

geometrical reconstruction:



time imaging:



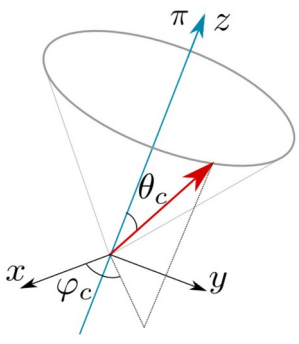
Caveats:

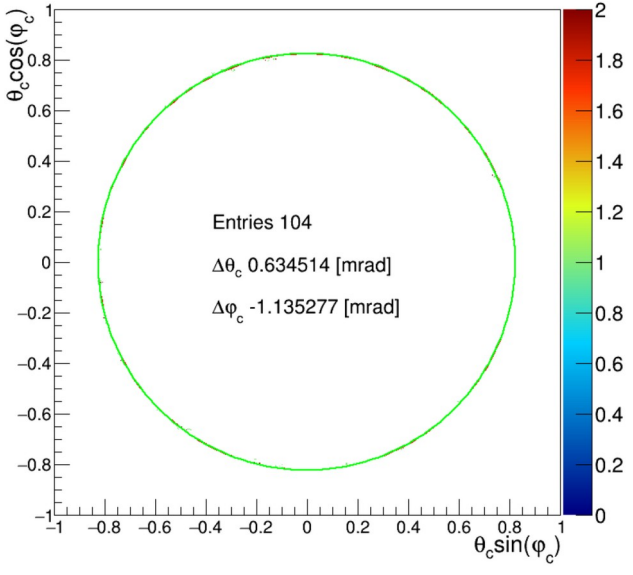
- standalone geant4 sim/reco without magnetic field
- no background events (for performance with bg events see talk by W. J. Llope)

Multiple Scattering Mitigation

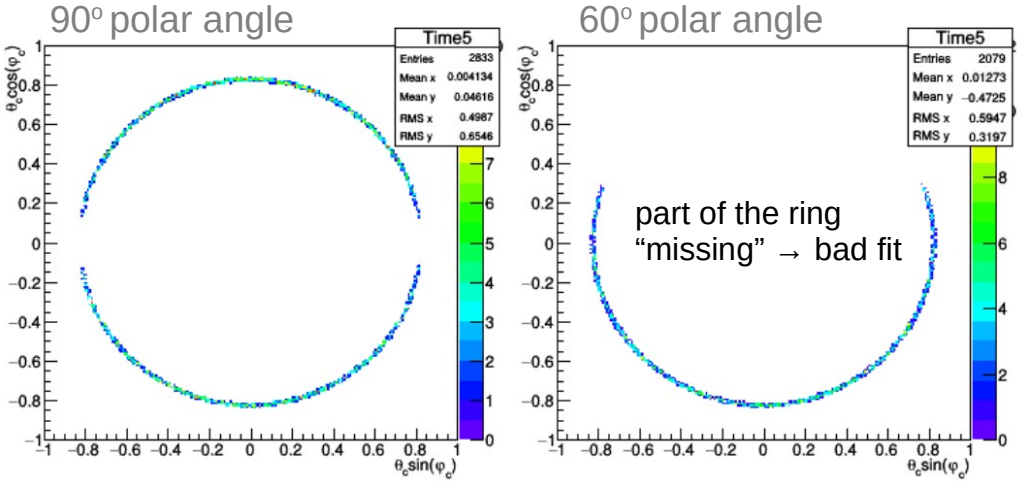
- Post-DIRC tracking (AstroPix layer). Needs to be implemented in ePIC sim to evaluate benefits.
- Cherenkov ring fit (corrects the direction of the charged track).

Cherenkov photons are distributed on a ring:





Accumulated pattern for 100 pions @ 6 GeV/c:



- works well for polar angles around 90°
- works well for small angle deviation (< 0.5 mrad)

Summary

- Angular resolution has direct impact on PID
- Current angular resolution is larger then expected (×2 in polar angle, ×3 in azimuthal angle)
- DIRC PID goal for π/K @ 6 GeV/c is barely reached with current tracking

  and not reached for e/π @ 1.2 GeV/c
- Cherenkov ring fit is aimed to mitigate MS inside the radiator (but not to improve external tracking)

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Thank you for your attention!