Tracking Impact on hpDIRC Performance

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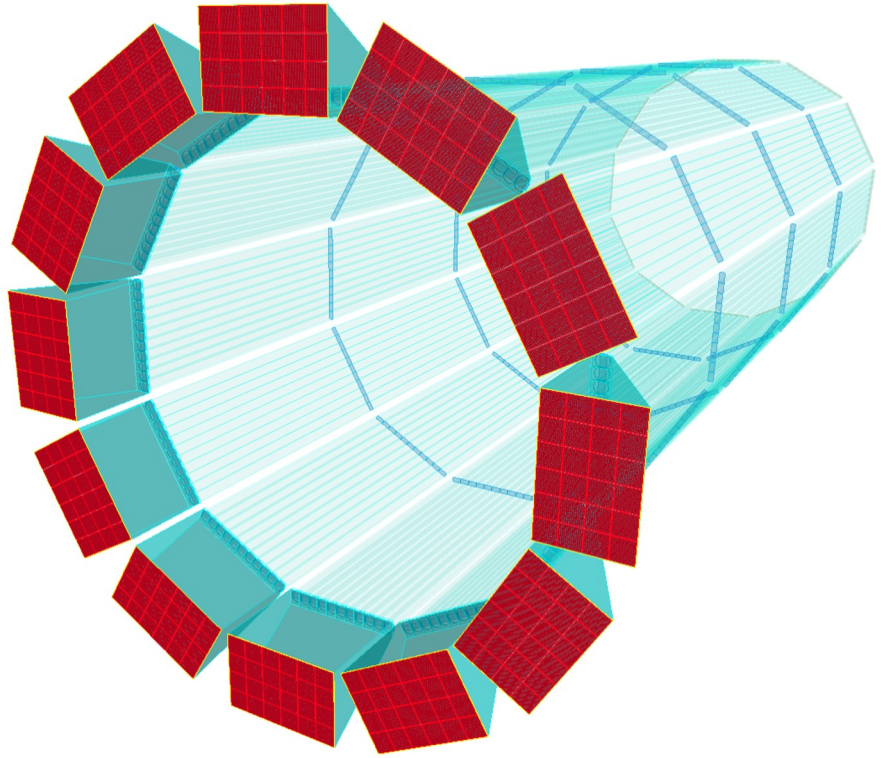
CUA



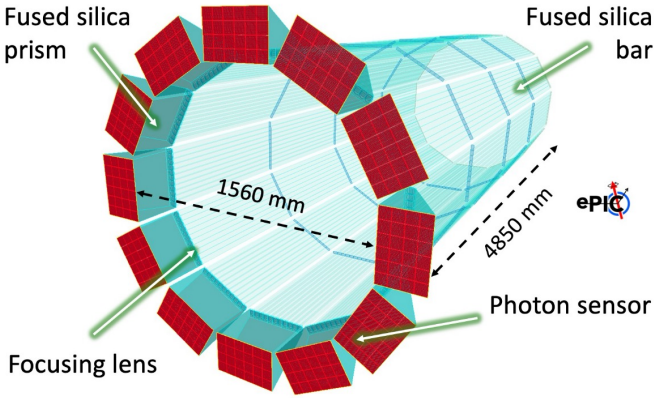
ePIC Collaboration Meeting

July 16th, 2025

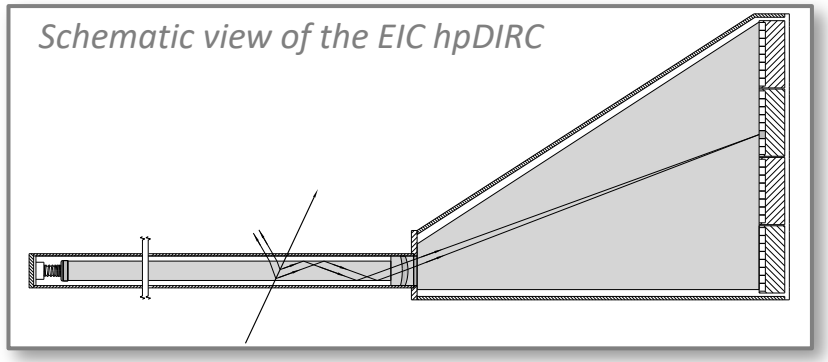
CUA GSI Jefferson Lab Old Dominion Stony Brook University University of South Carolina Wayne State University William & Mary

HIGH-PERFORMANCE DIRC

Extending DIRC π/K separation coverage to 6 GeV/c



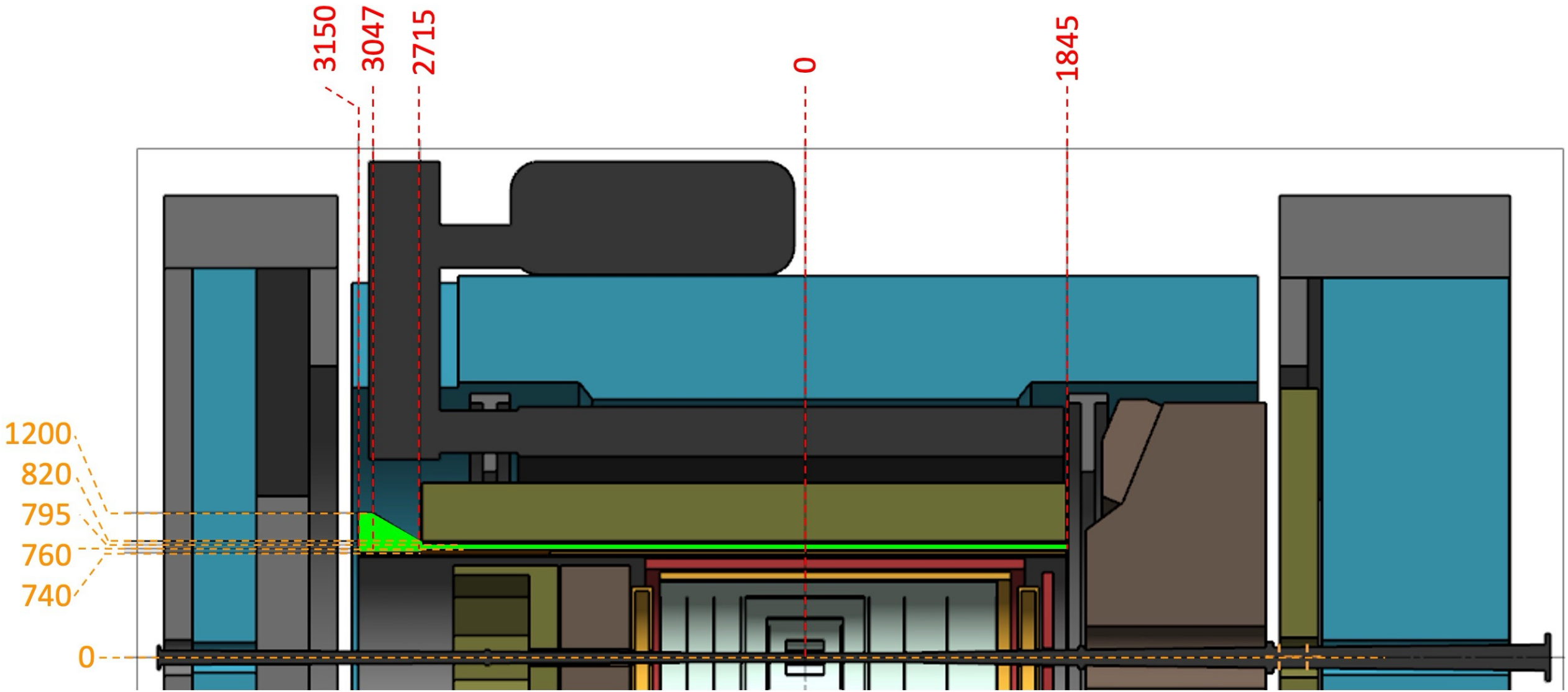
- Concept: fast focusing DIRC, utilizing high-resolution 3D (x,y,t) reconstruction.
- Radiation-hard 3-layer spherical lens to reduce bar image size and shape imaging plane;
- Lifetime-enhanced MCP-PMTs with fine anode segmentation to reduce pixel size;
- Fast photon timing for chromatic dispersion mitigation and background rejection;
- Narrow bars for robust performance in high-multiplicity jet events;
- Compact expansion volume to simplify integration into central detector.
- Benefit from additional ePIC detector improvements:
  - High-precision tracking, expect 0.5 mrad polar angle resolution;
  - Post-DIRC tracking layer (EMCal AstroPix) for multiple scattering mitigation.



- Predicted performance for central rapidity range $-1.5 \le \eta \le +1.5$:

  3σ π/K separation up to at least 6 GeV/c (Cherenkov angle resolution per particle ≤ 1 mrad), supplemental e/π separation up to 1.1 GeV/c.

HPDIRC IN EPIC

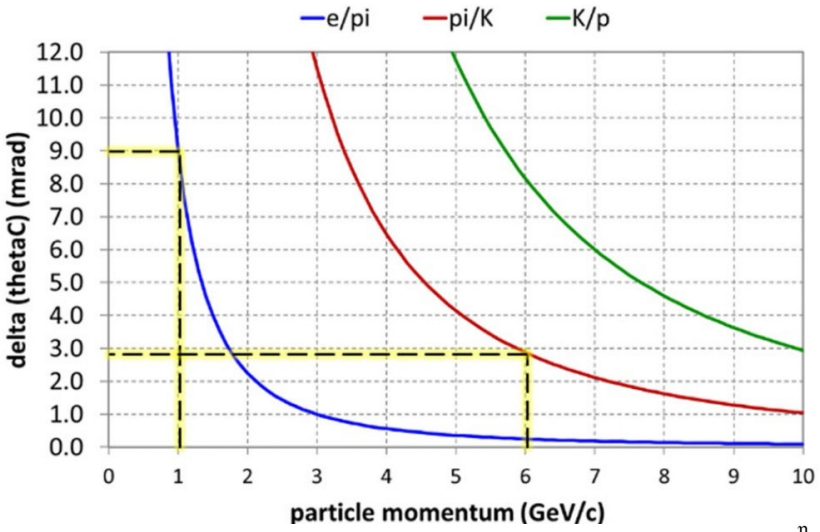


HPDIRC PERFORMANCE GOAL

Most challenging ePIC hpDIRC PID goals:

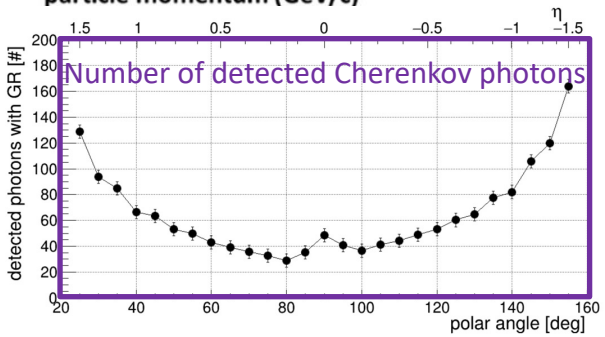
- π/K separation up to at least 6 GeV/c → $\Delta\theta_c \approx 2.9$ mrad
  - 3 s.d. requires $\sigma_{\theta_c}(particle)$ ≤1 mrad @ 6 GeV/c
- e/π separation up to 1–1.2 GeV/c → $\Delta\theta_c \approx 6 - 9$ mrad
  - 3 s.d. requires $\sigma_{\theta_c}(particle)$ ≤3 mrad @ 1 GeV/c (2 mrad @ 1.2 GeV/c)

Cherenkov angle difference in fused silica

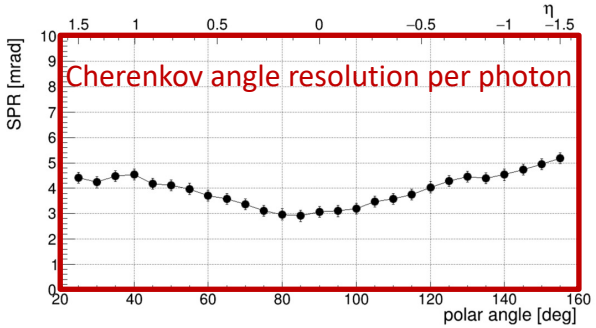


Cherenkov angle resolution per particle can be written as

$$\sigma_{\theta_c}(particle) \approx \sqrt{\left(\frac{\sigma_{\theta_c}(photon)}{\sqrt{N_\gamma}}\right)^2 + \sigma^2_{correlated}} \qquad \sigma_{correlated} = \sqrt{\sigma^2_{tracking} + \sigma^2_{m.s.} + \ldots}$$



Correlated term: quadr. sum of angular resolution from tracking system and multiple scattering inside DIRC bar (plus alignment, etc)



For ePIC hpDIRC: $\sigma_{\theta_c}(photon) = 3 - 5\ mrad,\ N_\gamma = 30 - 170$

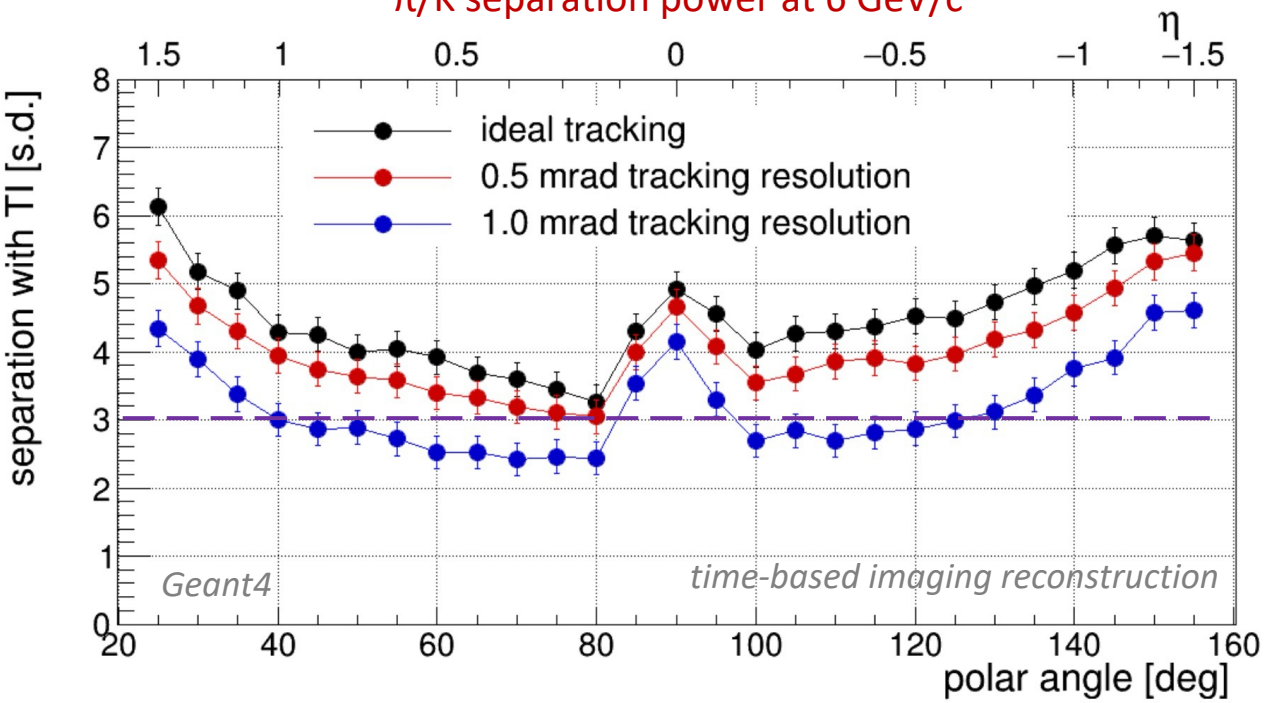
EXPECTED HPDIRC PERFORMANCE VS. TRACKING

Impact of tracking angular resolution on hpDIRC performance

- π/K Cherenkov angle difference at 6 GeV/c: $\Delta\Theta_c \approx 3$ mrad
- Yellow Report tracking requirement: 0.5 mrad resolution at 6 GeV/c
- Track position (x_{bar}, z_{bar}) at DIRC with few mm precision

→ High-precision angular resolution crucial for reaching required hpDIRC performance.

π/K separation power at 6 GeV/c



Simulation studies performed with

- Stand-alone Geant4 simulation
- Single particles from particle gun
- 1.7T magnetic field, no other ePIC subsystems
- 100ps resolution

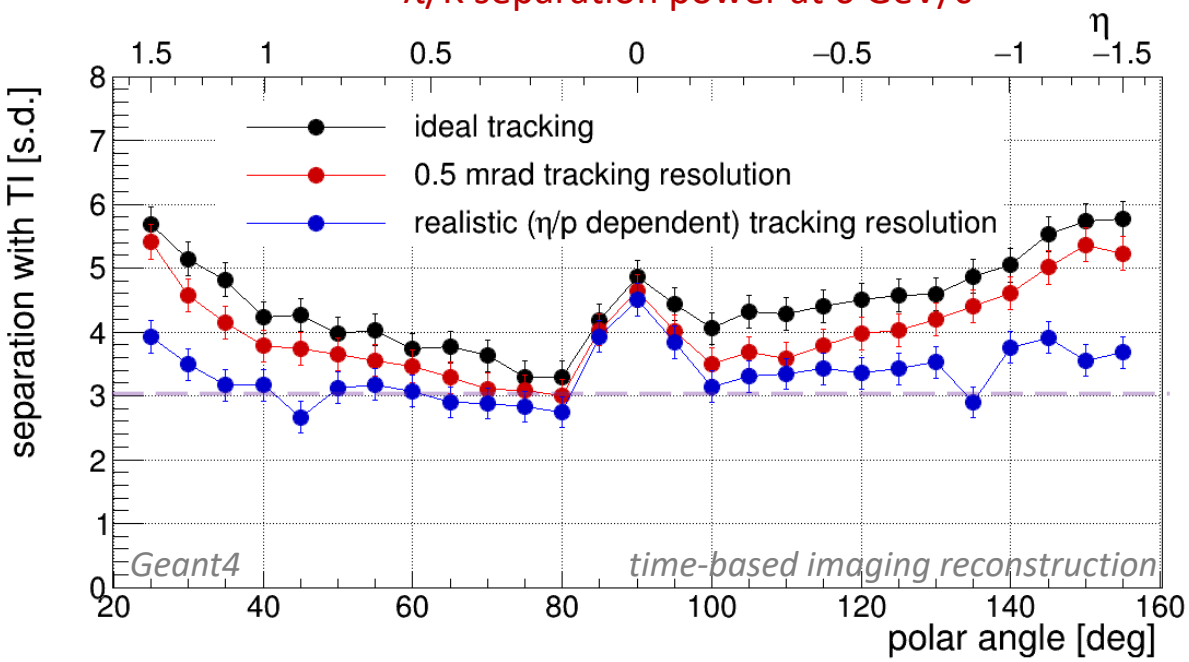
HPDIRC SIMULATION

Roman Dzhygadlo (GSI)
Matt Posik (TU)

Performance with latest ePIC angular track resolution maps (June 2025)

- Performance loss is smaller than for early predictions, but still concerning
- π/K separation drops close to or below 3 s.d for most polar angles

π/K separation power at 6 GeV/c



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BACKUP

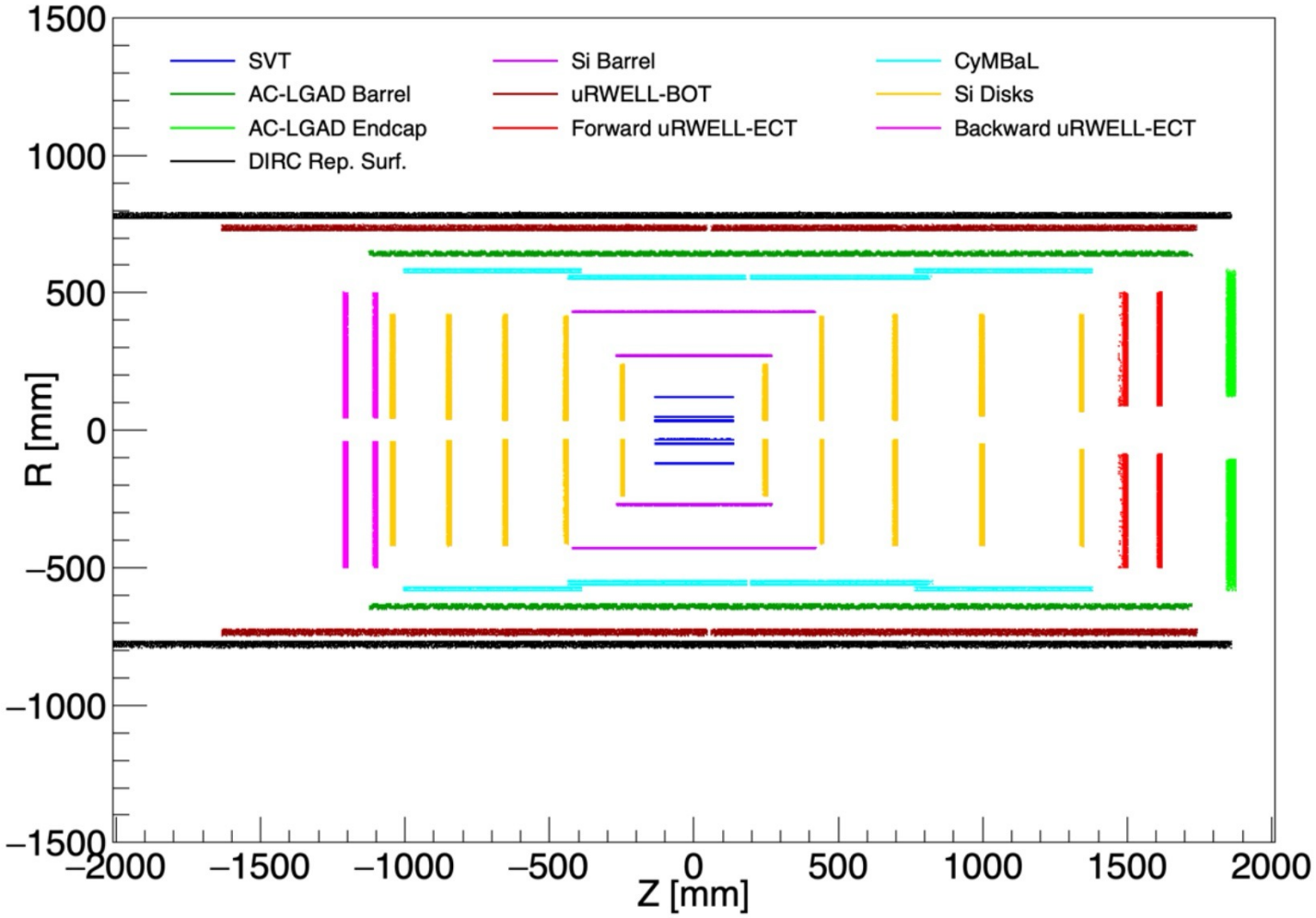
ePIC Track Resolution

Simulation Details

- ePIC: 25.04.1
- EICrecon: v1.24.0
- π^- single particle
- Fixed momenta values
- $\Delta\theta = 2^o,\ \Delta\phi = 360^o$
- DIRC Reference Surface

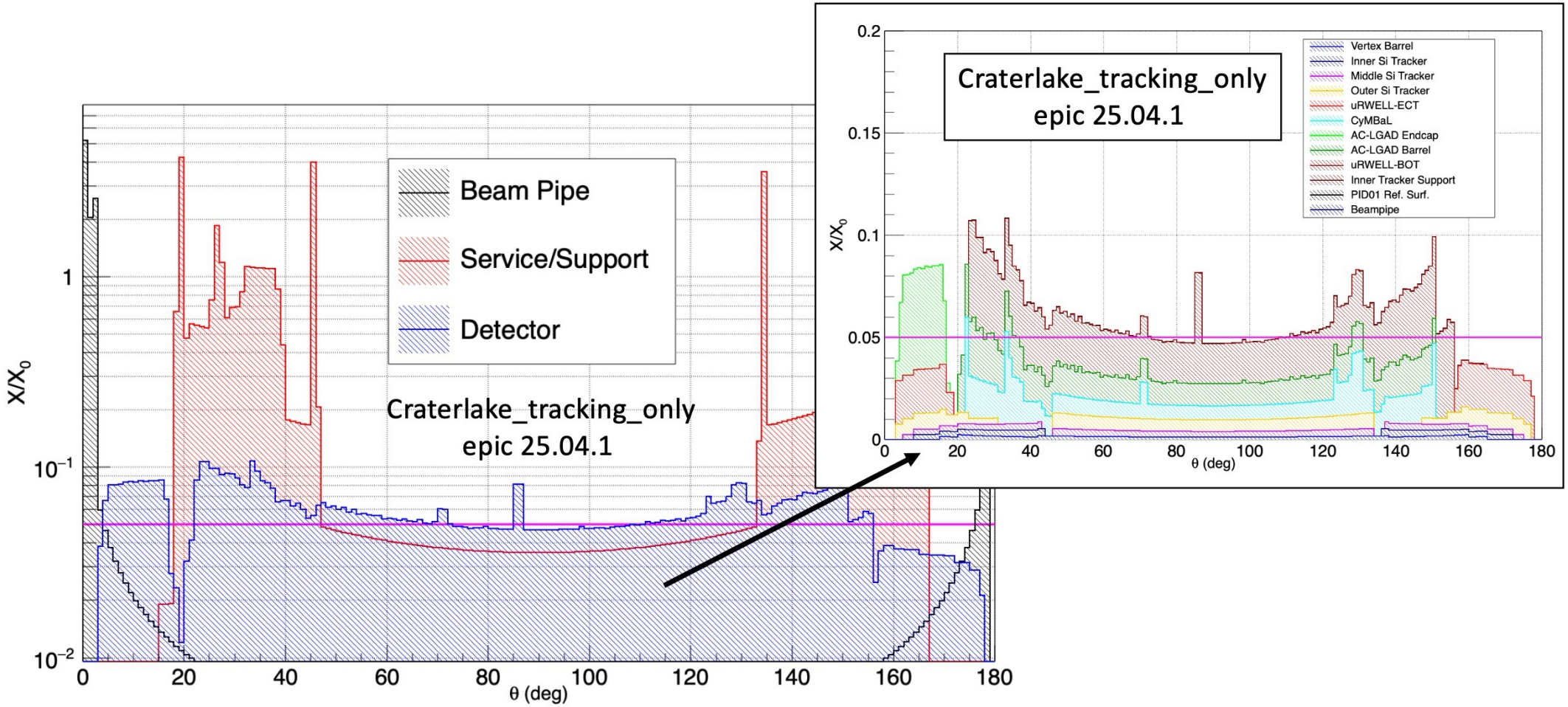
  R = 770.5 mm

➢ All resolutions presented are with respect to R = 770.5mm surface



Matt Posik (TU)

Material: DD4HEP



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