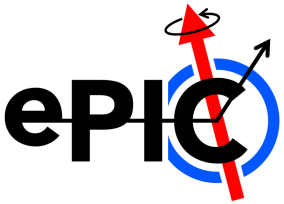


MPGD Tracking

Matt Posik
Temple University

Outline

- ❑ MPGD Tracking Goals
- ❑ Software Framework
- ❑ MPGD Impact on Tracking
  - Detector Hits (Coverage)
  - Angular Resolution into PID
- ❑ Summary

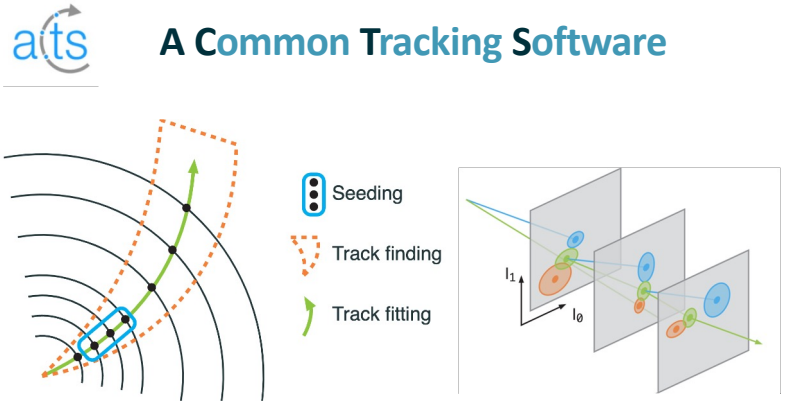
MPGD Tracking Goals

❑ Tracking Goals

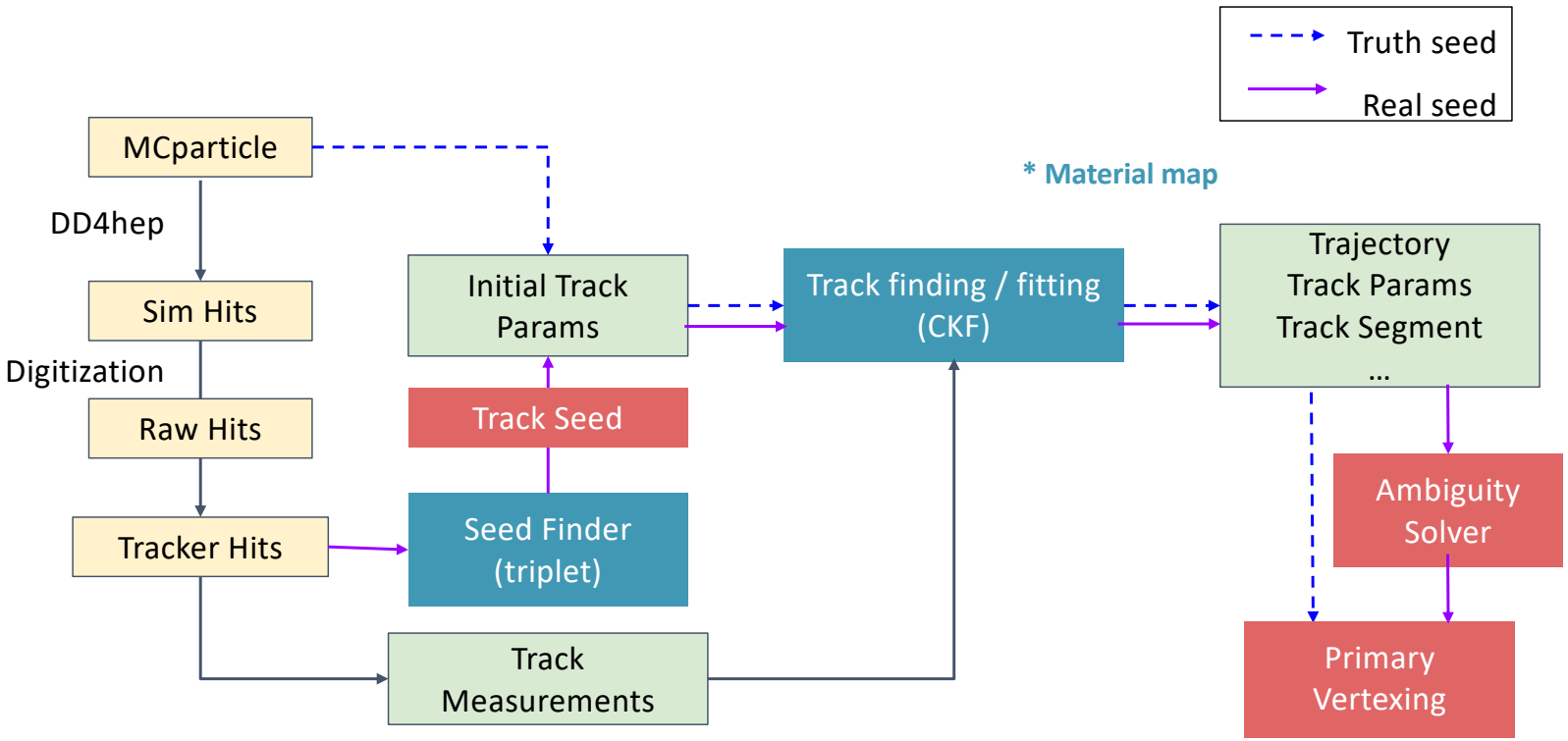
1. Provide precise timing information
   - Separate event bunches
   - Improve track purity – reduce Si-hits from tracking that are likely associated with backgrounds
2. Provide additional hits for track reconstruction
   - Aides in pattern recognition
   - Makes track fitting more robust
3. Aide in PID reconstruction by improving angular resolution at the PID detectors
   - hpDIRC performance is highly dependent on the angular resolution of tracks passing through its volume

Software Framework

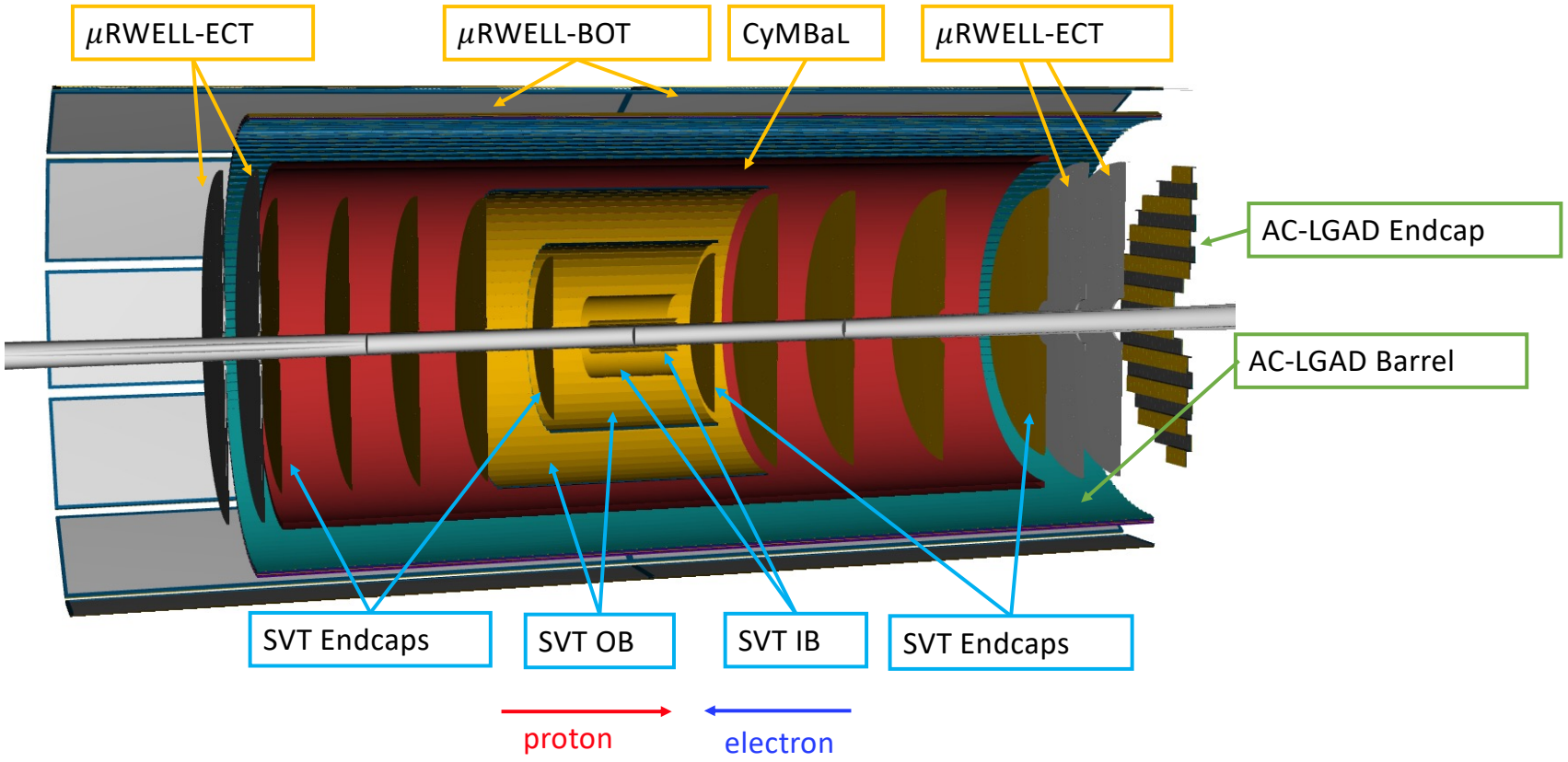
- Geometry Framework (epic)
  - Material and segmentation
  - Based on DD4HEP
- Reconstruction Framework (EICRecon)
  - Based on PODIO/JANA
  - Digitization
  - Track Reconstruction
    - Based on ACTS Combinatorial Kalman Filter (CKF)
    - Combined track finding and fitting
    - Realistic seeder
- ePIC data structure (EDM4eic) modeled after EDM4hep



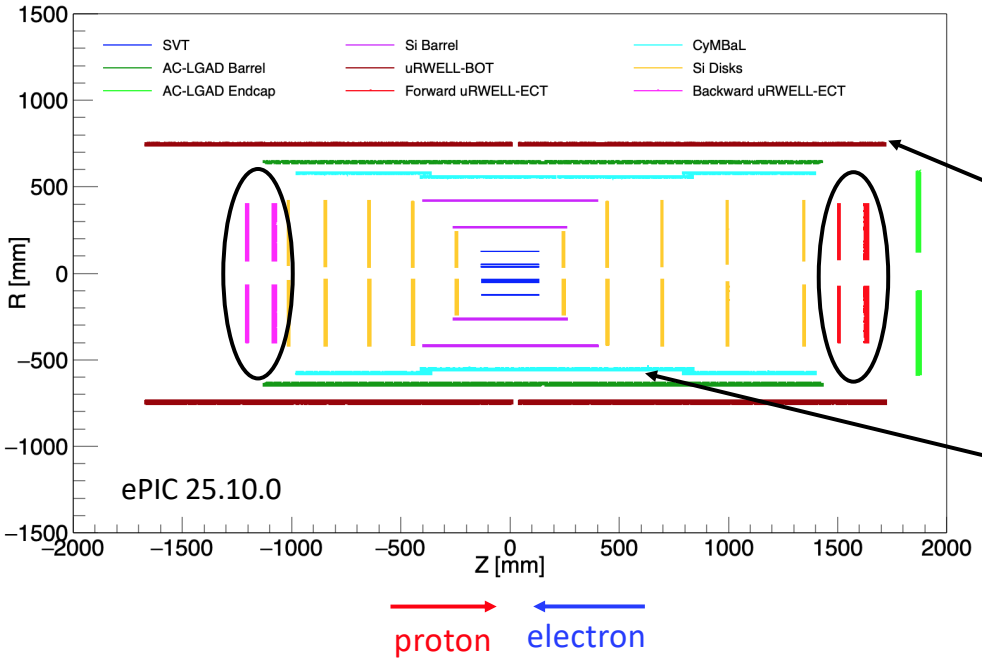
Simulation Framework

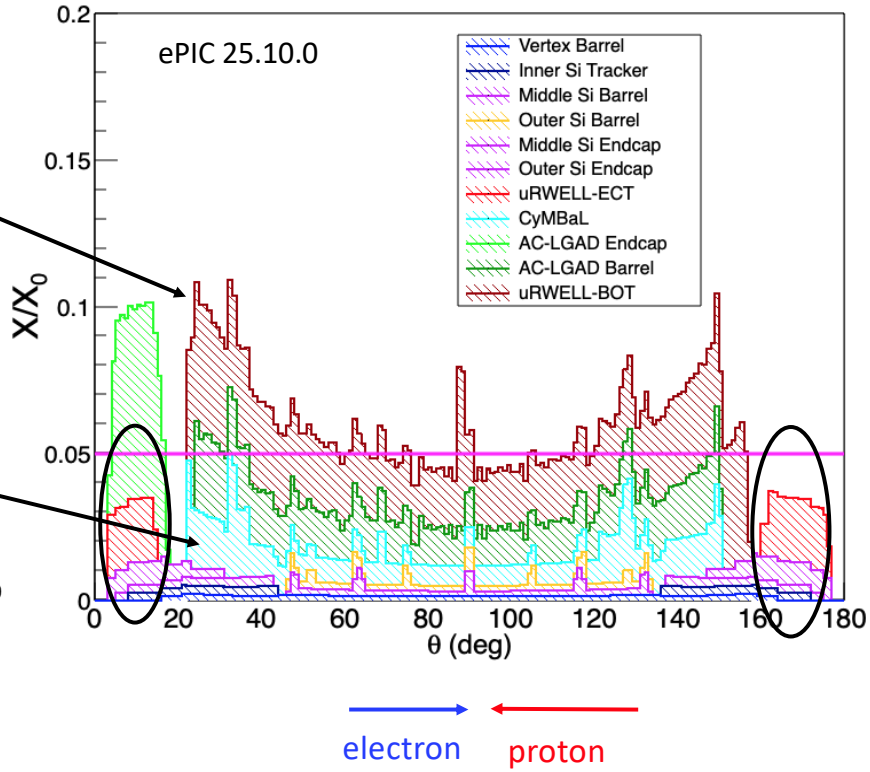


ePIC Tracking Detector in DD4HEP



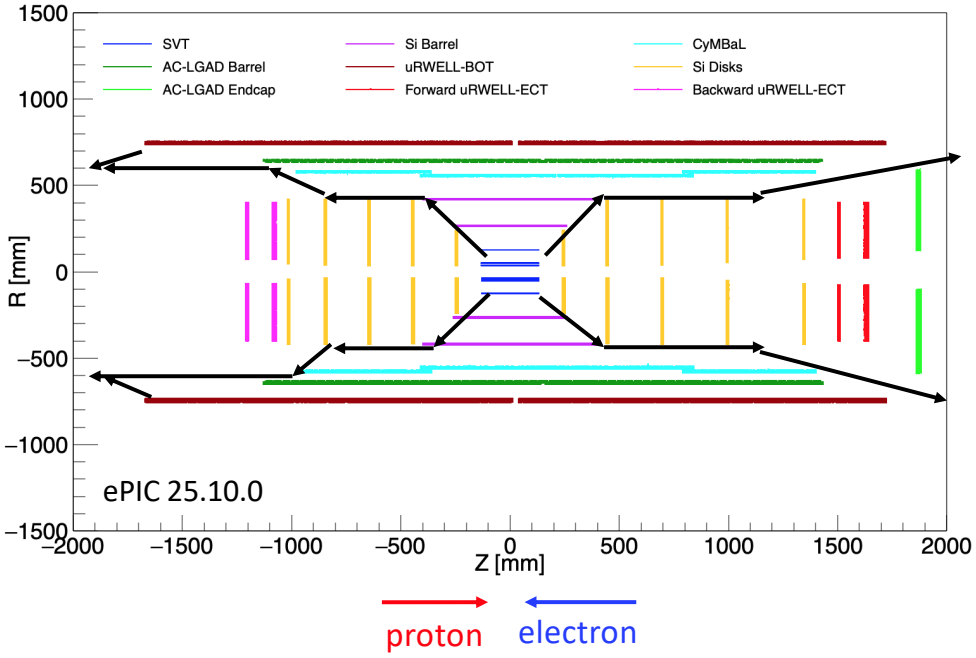
Detector Material



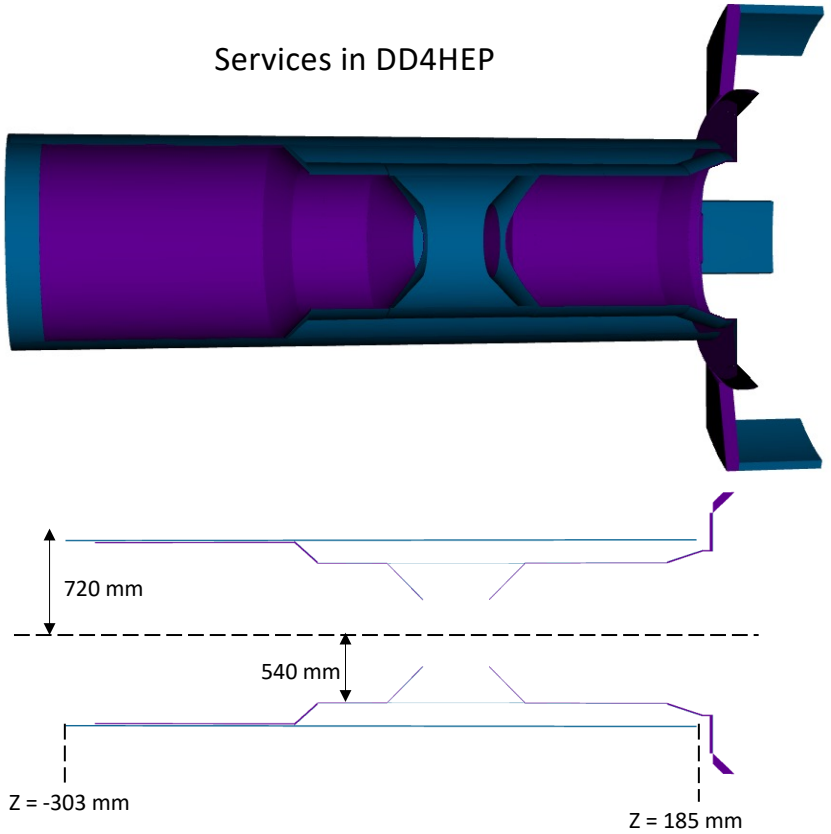


Detector Material: Services

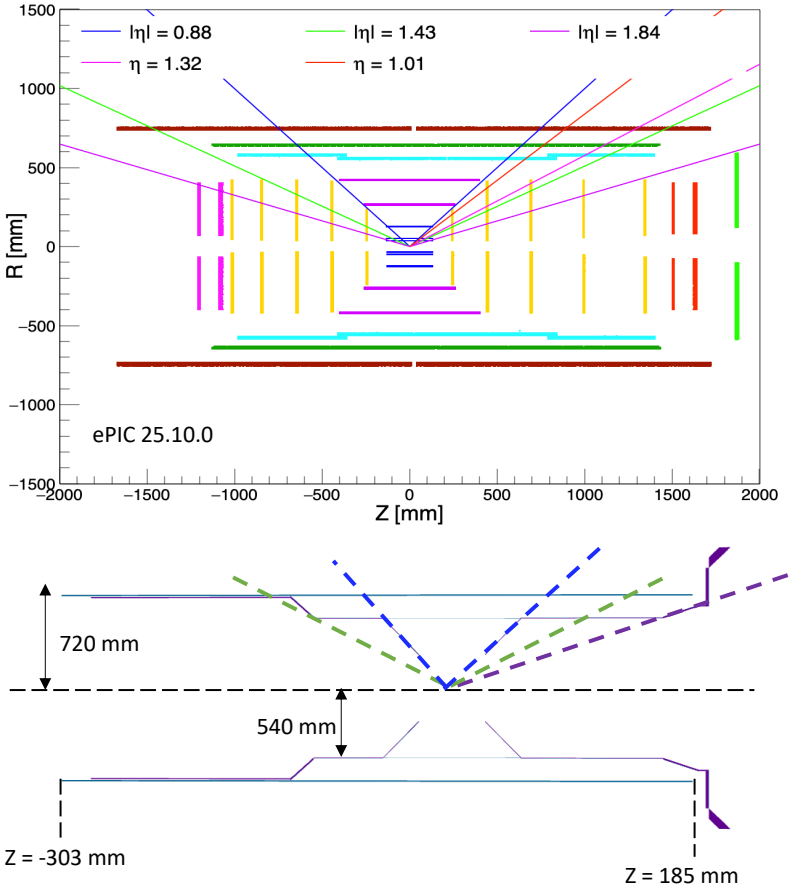
Service Routing

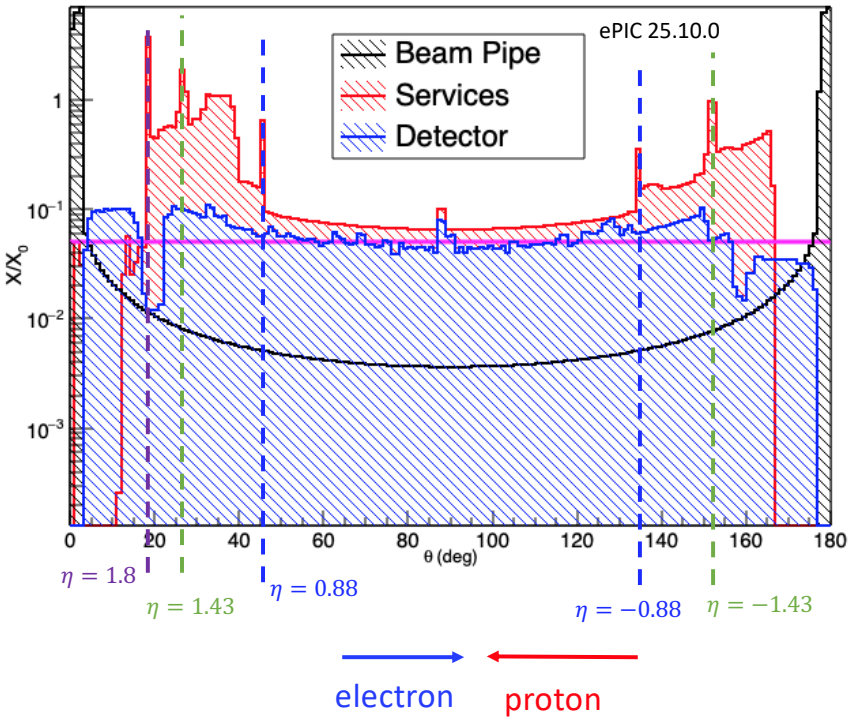


Services in DD4HEP



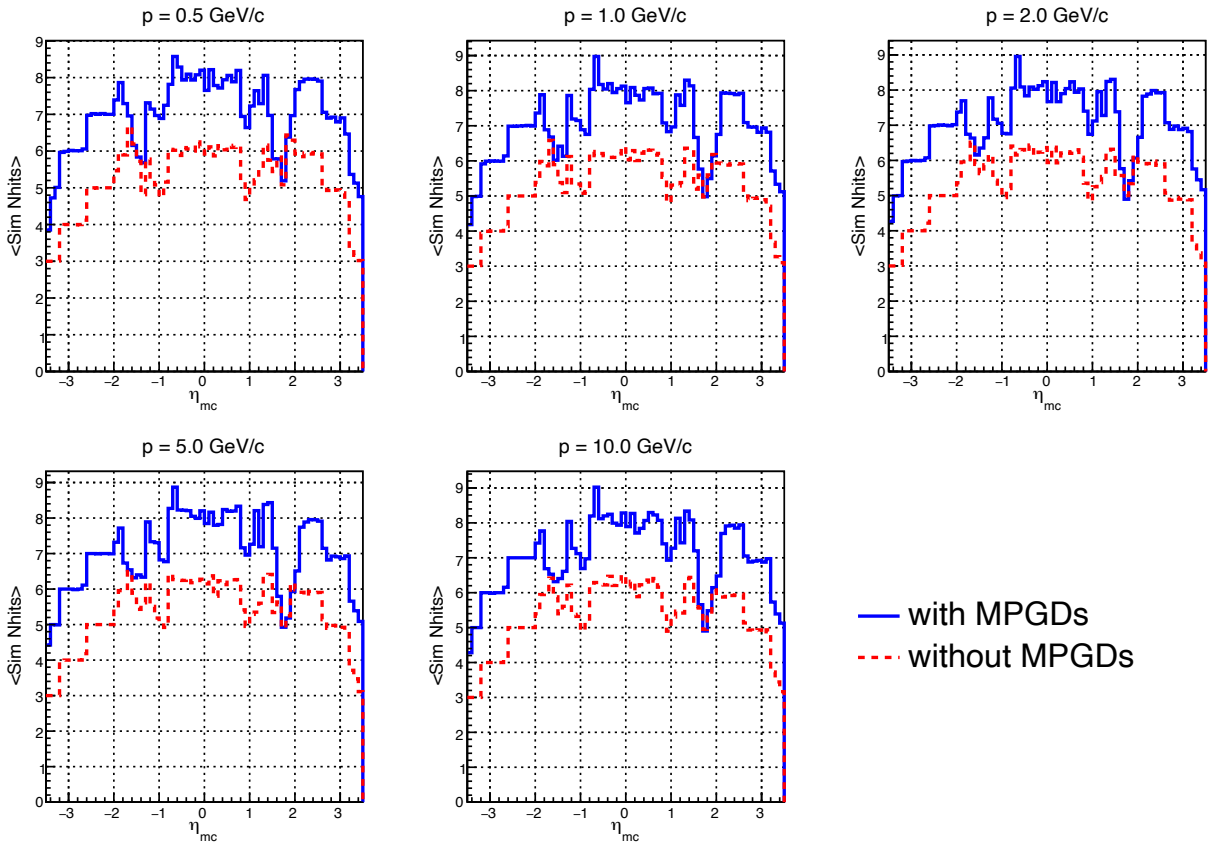
Detector Material: Services





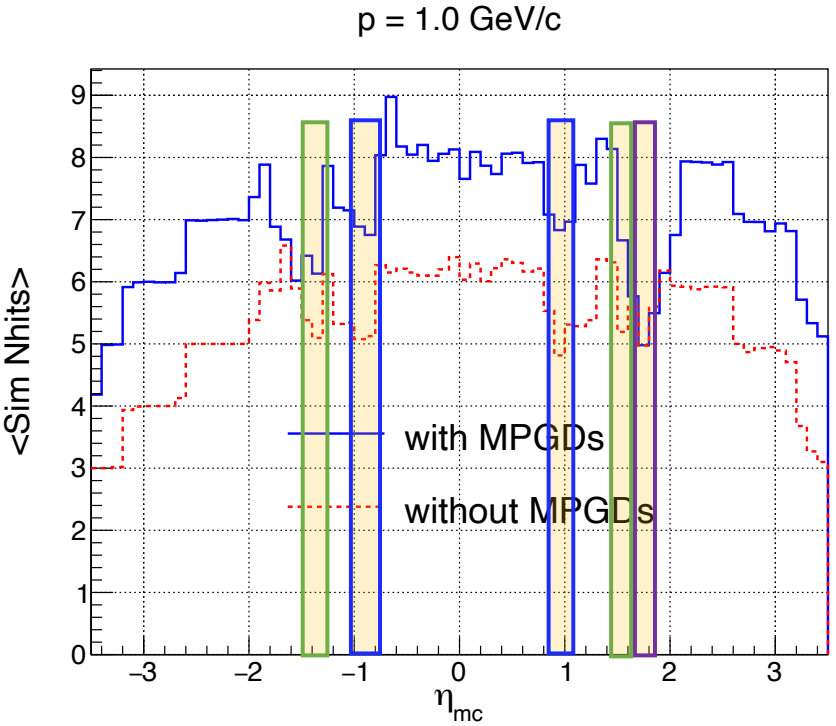
MPGD Tracker Hits

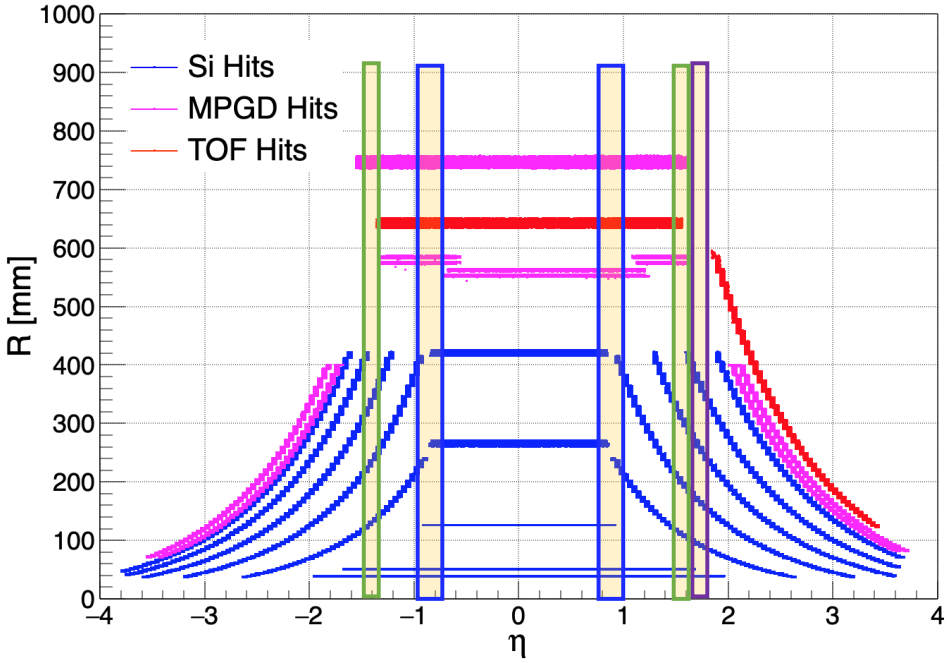
- Additional MPGD layers increased number of hits
  - Hits vs. η (Generator Level)



Detector Coverage

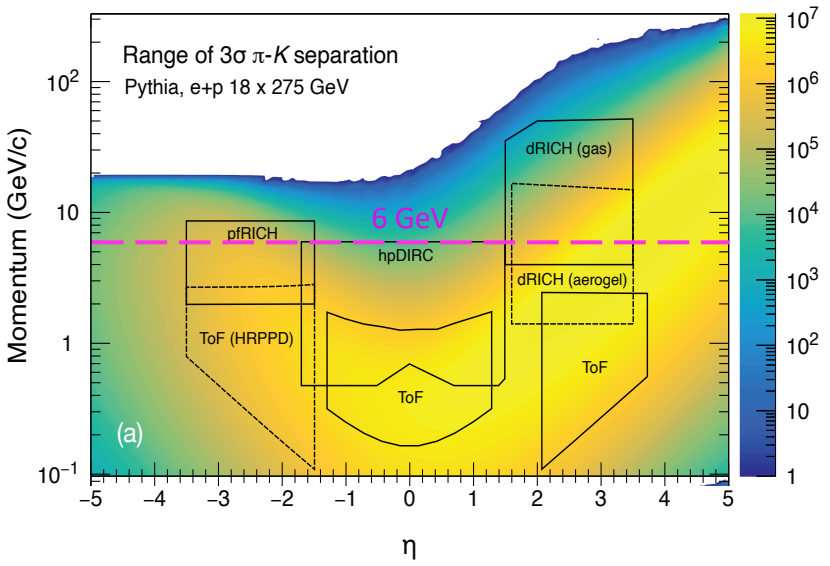
- Drop in hits can be correlated to transition regions
  - Hits at $\eta \approx 1.8$ are out of MPGD coverages





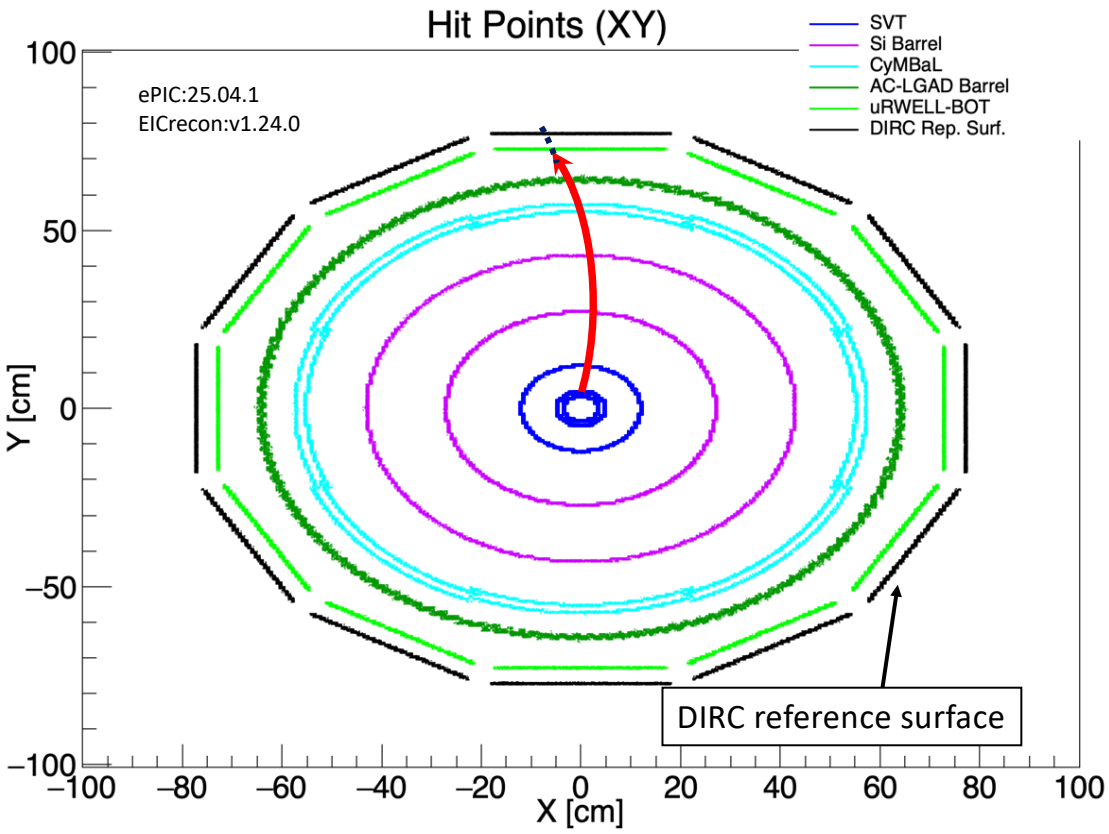
Pushing hpDIRC Performance

- Majority of hadrons in DIRC acceptance is around ~ 1GeV
  - Hadron yield drops quickly with increasing momentum
- Extending the DIRC PID performance out to a momentum of 6 GeV requires excellent angular resolution from tracking
  - ~0.5 mrad at p = 6GeV
  - The µRWell-BOT can help



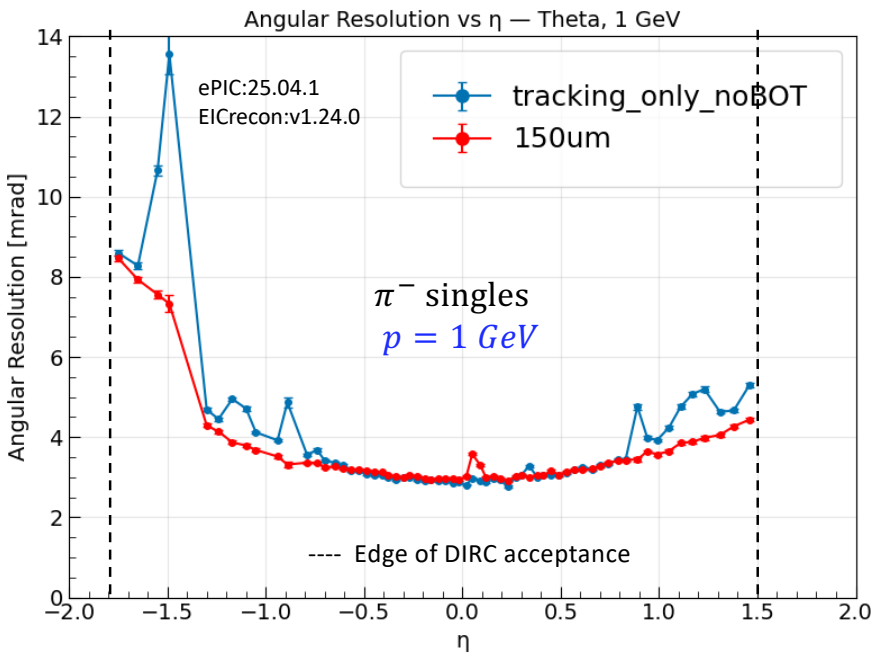
Angular Resolutions at hpDIRC

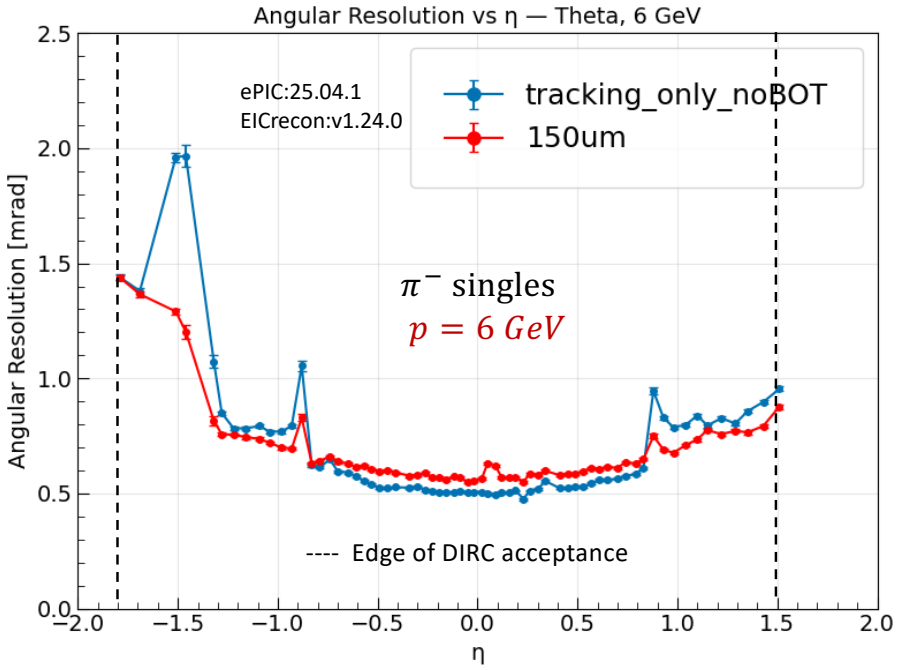
- Momentum vector information accessed via track propagation to desired target surface (e.g. hpDIRC)
  - Reference surface provides true momentum vector via SimHit
  - ACTS target surface provides reconstructed momentum vector via trajectory propagation
- Simulation Details
  - Constant MPGD spatial resolution of $150\mu m$
  - π^- singles



θ (Polar) Resolutions at hpDIRC

- Impact of μRWELL-BOT seen at $|\eta| > \approx 0.8$
  - Improvement seen particularly at areas where there is a larger amount of material and transition regions





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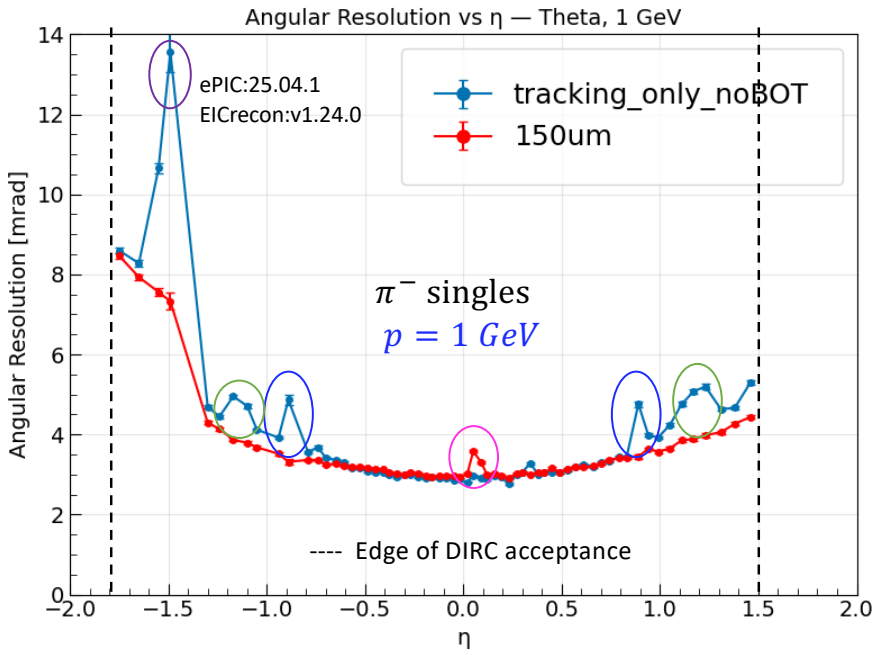

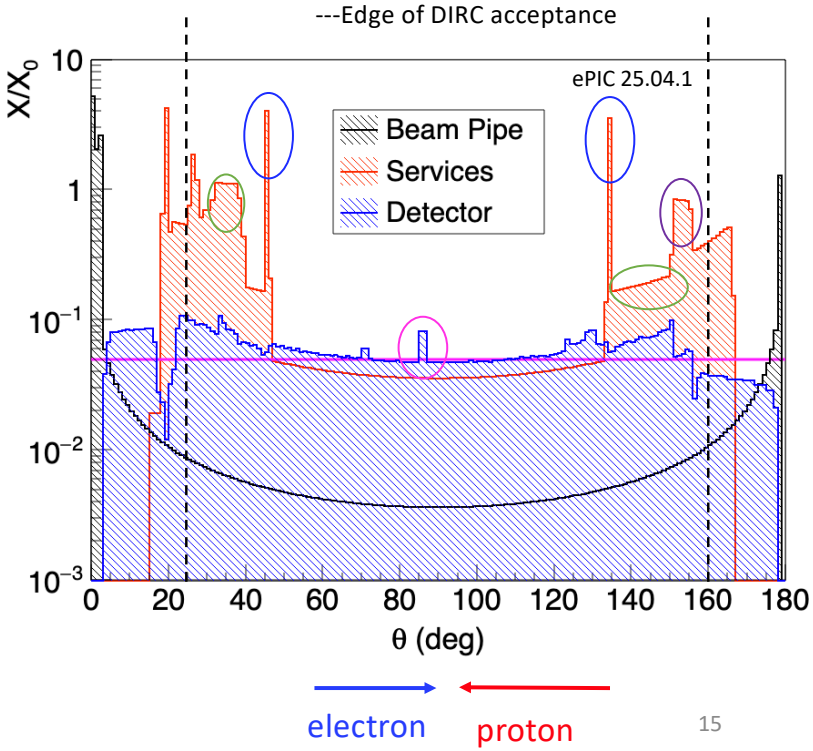

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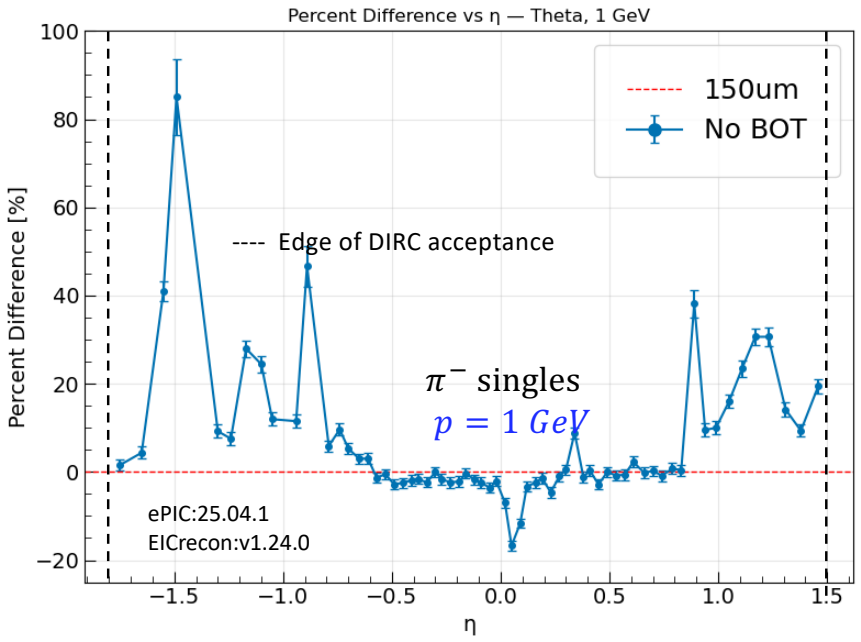
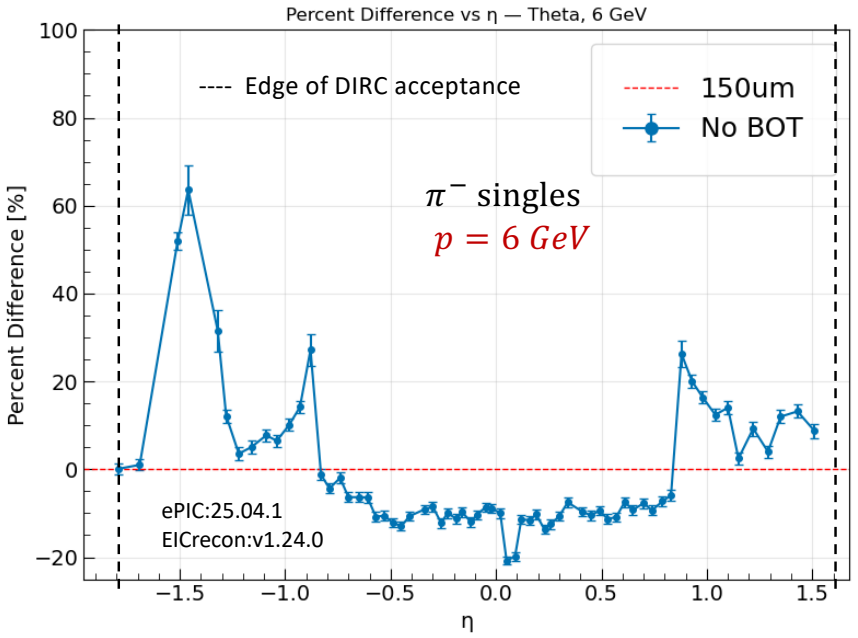
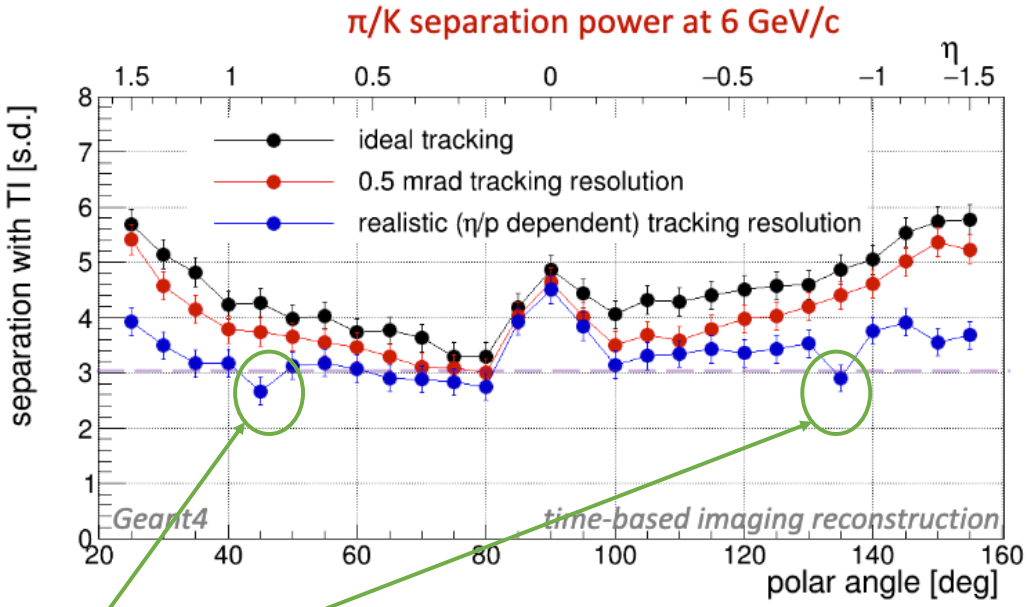




Angular Resolutions at hpDIRC

- ePIC simulation was used to map the angular resolutions as a function of momentum and η
- Resolution maps were used in stand alone hpDIRC Geant4 simulation to assess PID separation power
- π/K separation is near 3 s.d. for most polar angels at p = 6GeV

ePIC Collab. Meeting June 2025

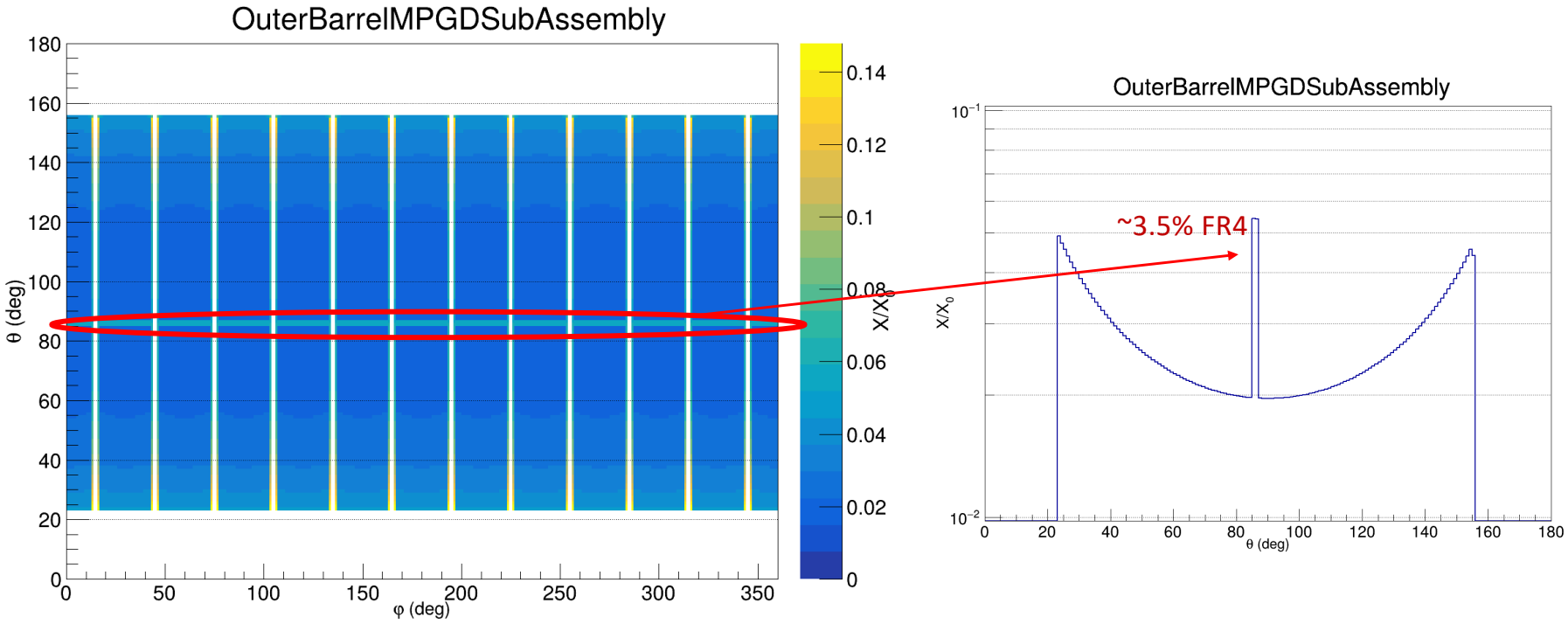


Summary

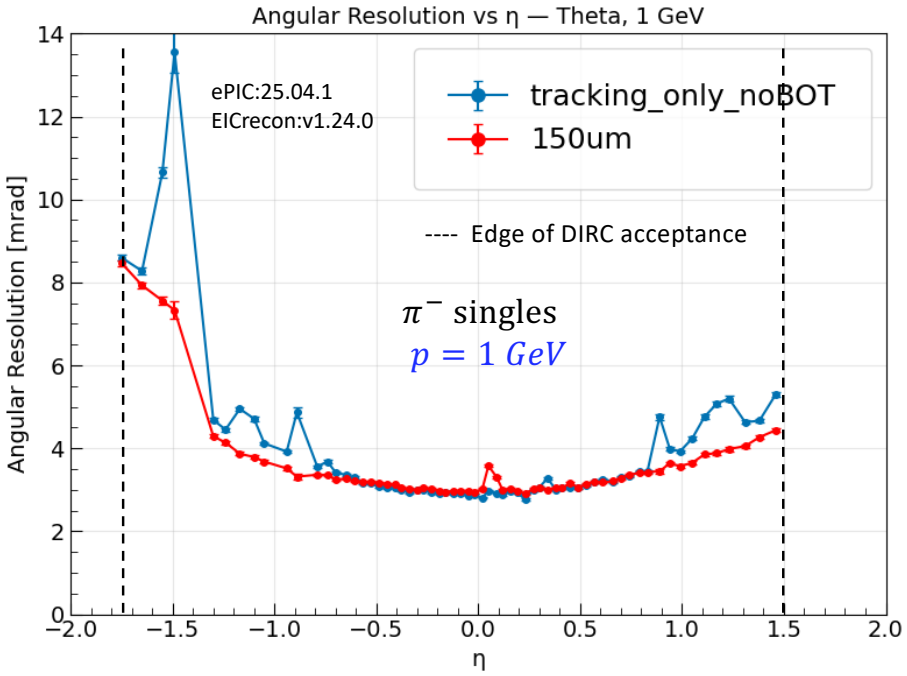
- Inclusion of MPGDs raise minimum number of tracking hits
  - Provide better track fits/robustness, particularly at large $|\eta|$ and in transition regions
  - Will contain more precise time stamp compared to Si-based hits
- MPGD Impact on Angular Resolutions
  - Improvement seen at larger $|\eta|$, particularly in areas of larger material budgets
  - When $|\eta| > \approx 0.2$, separation is near 3 s.d.
  - $|\eta| < \approx 0.2$ separation power is well above 3 s.d.
- Software framework and tools are now in place to begin studying MPGD impact on tracking within a background environment
  - Quantify impact on tracking efficiency/purity and impact of timing

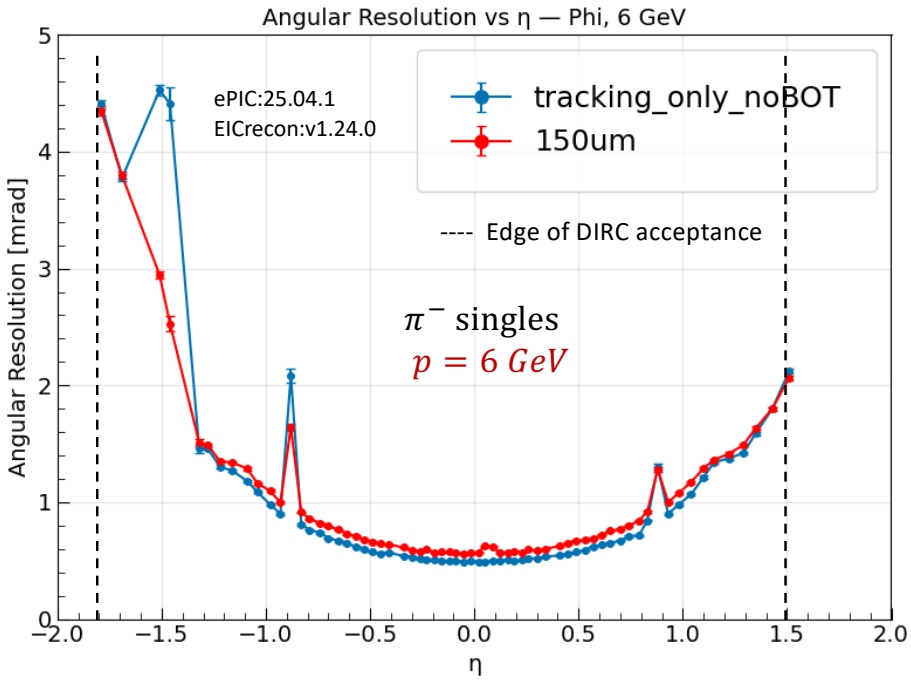
Backup

- Spike in material distribution for µRWell-BOT due to frame material of the two adjacent modules
  - Simulation assumed: 7mm thick FR4 material

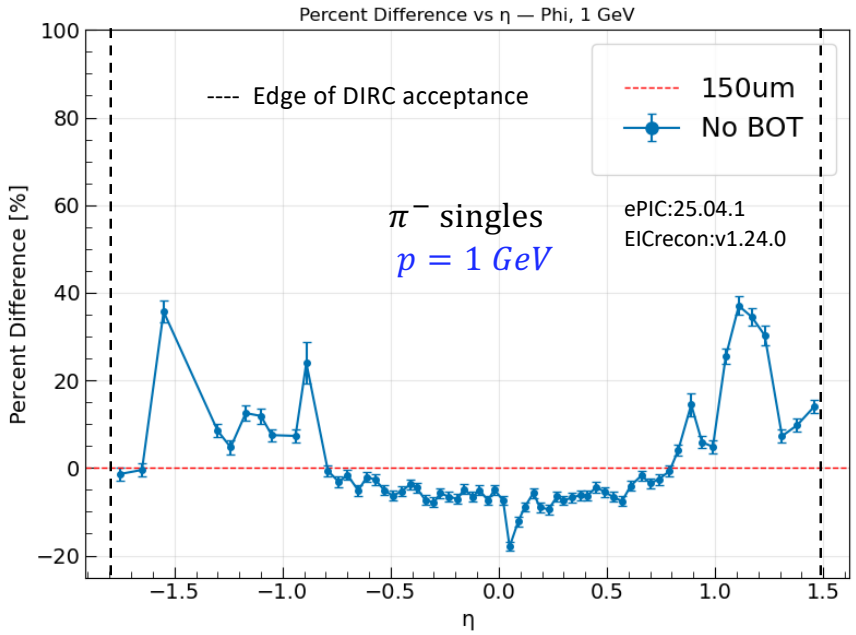


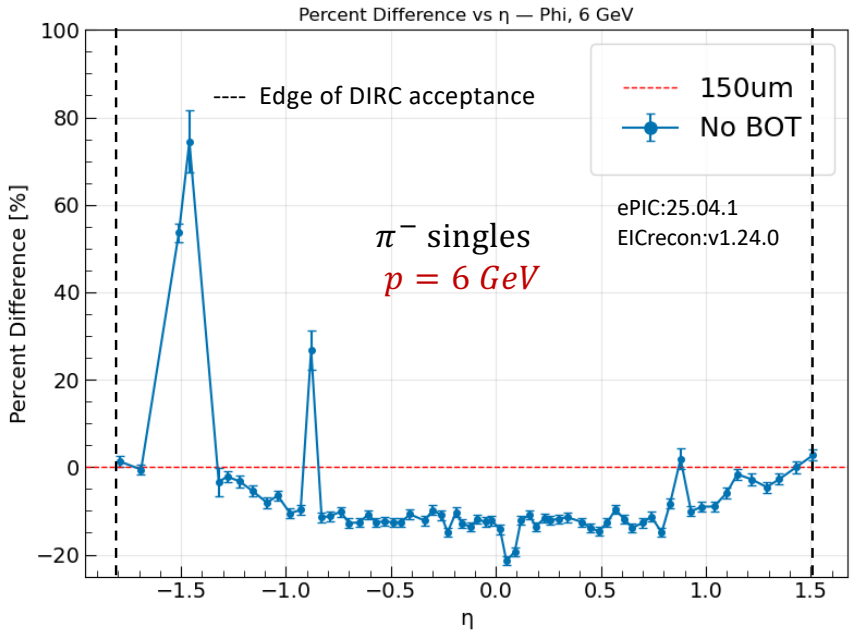
Backup


Angular Resolution vs η — Theta, 1 GeV
ePIC:25.04.1
EICrecon:v1.24.0
tracking_only_noBOT
150um
---- Edge of DIRC acceptance
π^- singles
$p = 1\ GeV$
Angular Resolution [mrad]
η


Angular Resolution vs η — Phi, 6 GeV
ePIC:25.04.1
EICrecon:v1.24.0
tracking_only_noBOT
150um
---- Edge of DIRC acceptance
π^- singles
$p = 6\ GeV$
Angular Resolution [mrad]
η

Angular Resolutions at hpDIRC





Structure for Tracking in Background

- HEPMC Admixing code implemented
  - merges signal and background files
- Considers three main background contributions
  - Synchrotron radiation, hadron beam-gas, and electron beam-gas