Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

ePIC Performance on Coherent J/ψ Diffractive Pattern

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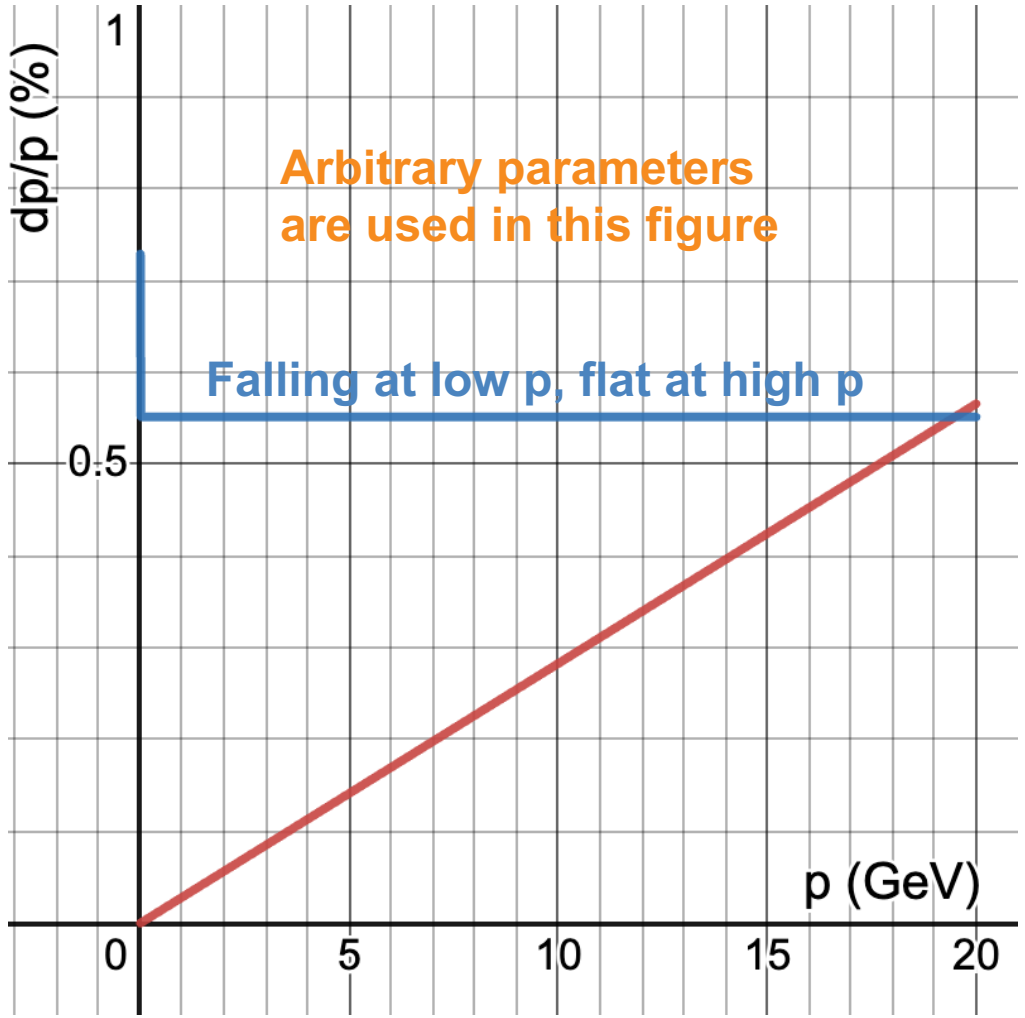
@BrookhavenLab

Analytical Calculation of Momentum Resolution

** For an equal distance, spatial resolution, multiple scattering tracker **

https://www.desmos.com/calculator/trrpytarr4



Error from detector design

$$\frac{\Delta p}{p}_{res} = \frac{12 \cdot \sigma_{pix} \cdot p}{0.3BL^2}\sqrt{\frac{5}{N+5}}$$

Error from multiple scattering

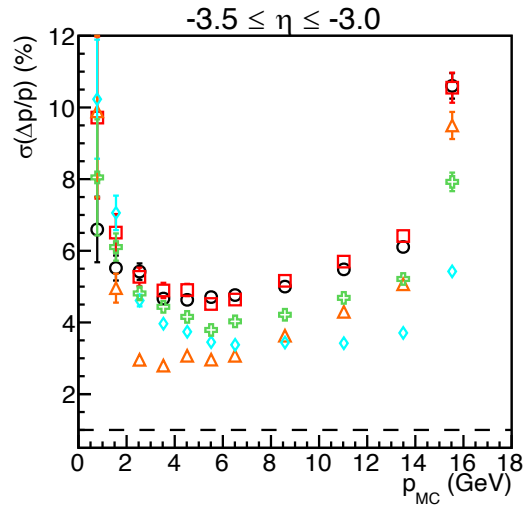
$$\frac{\Delta p}{p}_{ms} = \frac{0.0136}{0.3BL \cdot \frac{p}{\sqrt{m^2+p^2}}}\sqrt{X_0/X}$$

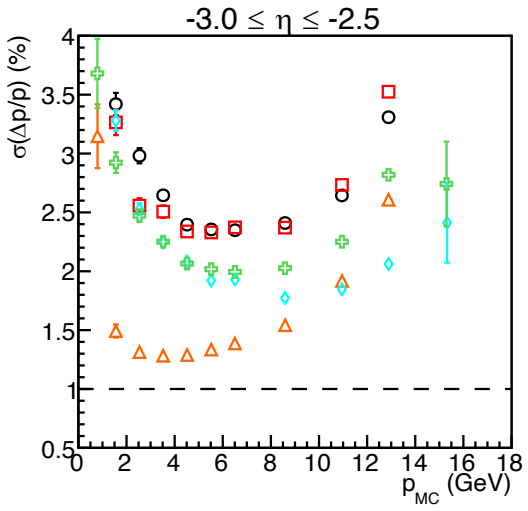
$$\approx \frac{0.0136}{0.3BL}\sqrt{X_0/X} \qquad \text{for } p \gg m$$

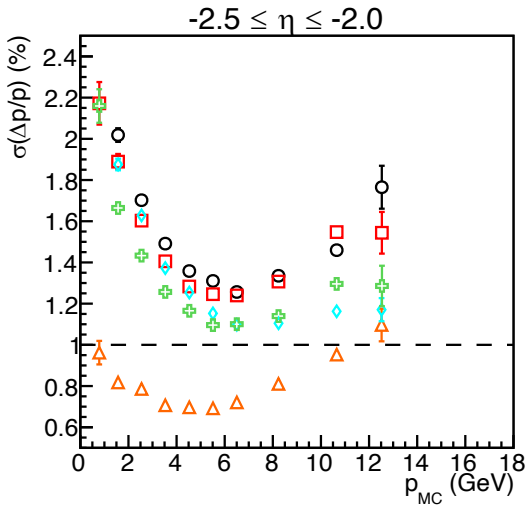
$$\frac{\Delta p}{p}_{tot} = \sqrt{\left(\frac{\Delta p}{p}_{res}\right)^2 + \left(\frac{\Delta p}{p}_{ms}\right)^2}$$

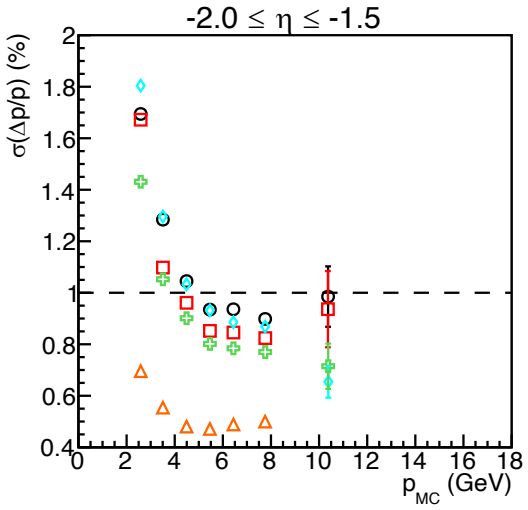
https://arxiv.org/abs/1805.12014

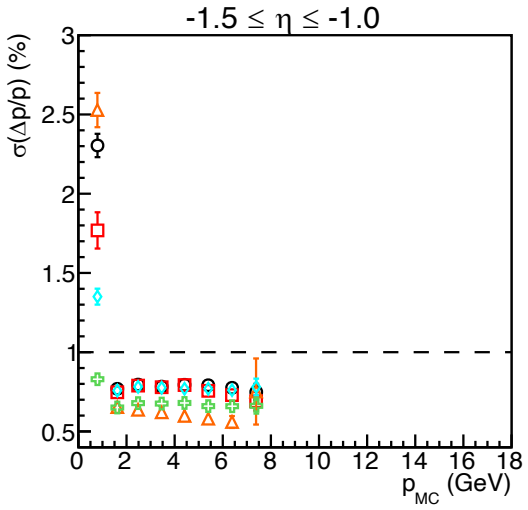
Momentum Resolutions of Backward Muon











Modified backward disk location

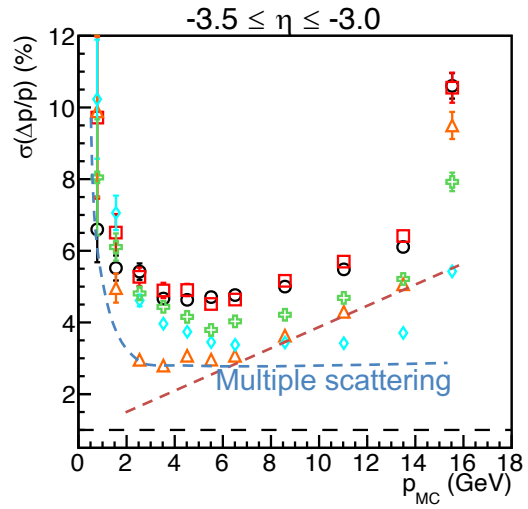
- Backward silicon disks placement is identical to the forward disk
- MPGD z position (zmin) is pushback from -110cm to -150cm, which is close to the forward MPGD (148cm)

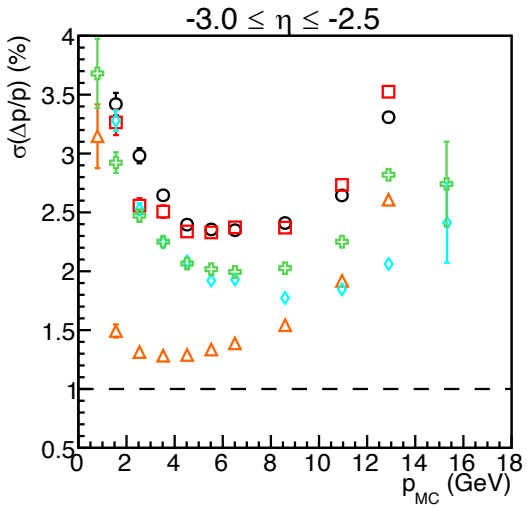
- ePIC
- ePIC, $t_{backward\ silicon}$=5um
- ePIC, t_{alumi}=5um, t_{CF}=5um
- ePIC, modified bk disk location (also removed the pfRICH)
- ePIC, B=2T

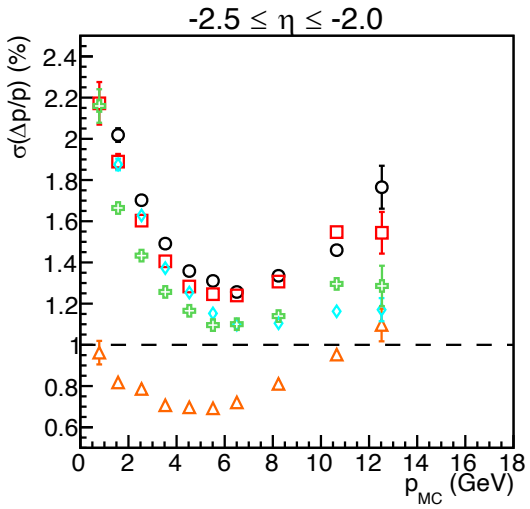
$$\frac{\Delta p}{p}_{res} = \frac{12 \cdot \sigma_{pix} \cdot p}{0.3BL^2}\sqrt{\frac{5}{N+5}}$$

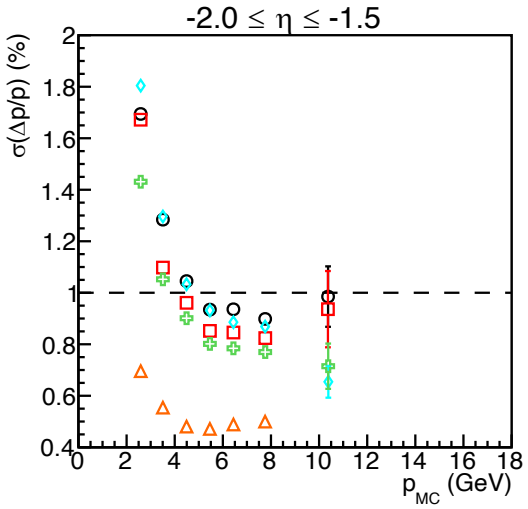
$$\frac{\Delta p}{p}_{ms} = \frac{0.0136}{0.3BL \cdot \frac{p}{\sqrt{m^2+p^2}}}\sqrt{X_0/X}$$

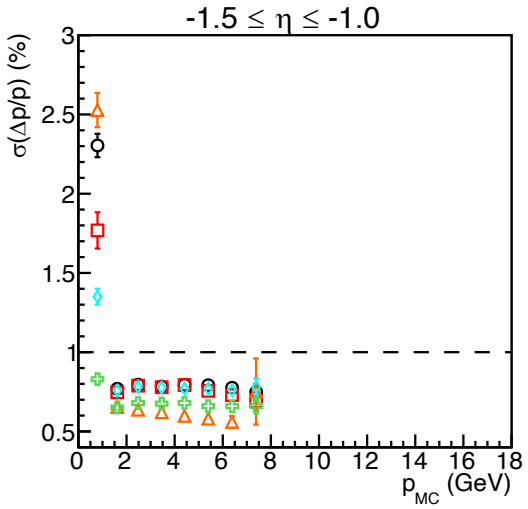
Momentum Resolutions of Backward Muon











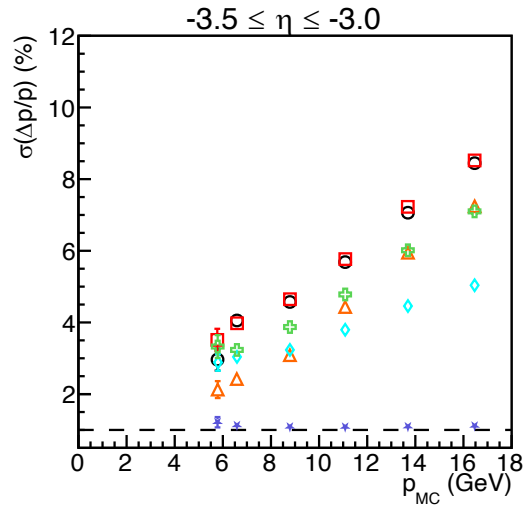
- Momentum resolution at low momentum is dominated by multiple scattering
- Momentum resolution at high momentum is dominated by detector pixel size, dimension, etc

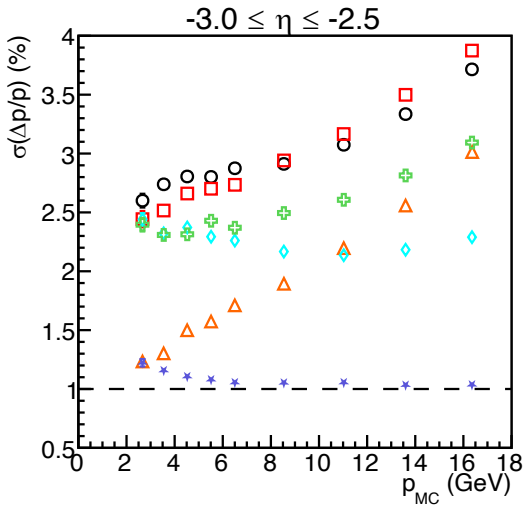
- ePIC
- ePIC, $t_{\text{backward silicon}}$=5um
- ePIC, t_{alumi}=5um, t_{CF}=5um
- ePIC, modified bk disk location
- ePIC, B=2T

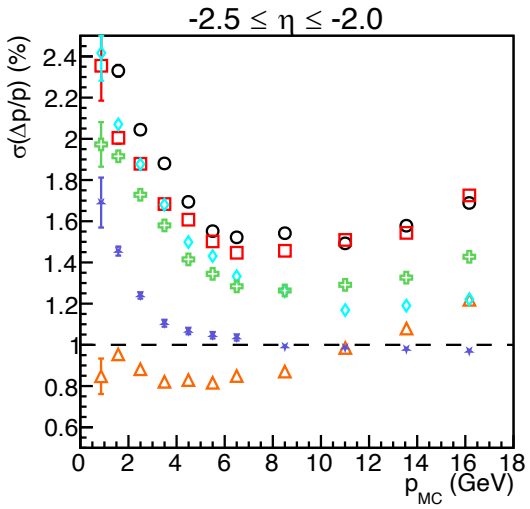
$$\left(\frac{\Delta p}{p}\right)_{res} = \frac{12 \cdot \sigma_{pix} \cdot p}{0.3BL^2}\sqrt{\frac{5}{N+5}}$$

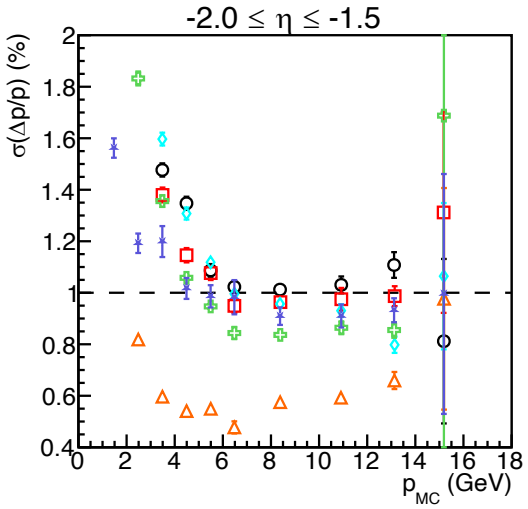
$$\left(\frac{\Delta p}{p}\right)_{ms} = \frac{0.0136}{0.3BL \cdot \frac{p}{\sqrt{m^2+p^2}}}\sqrt{X_0/X}$$

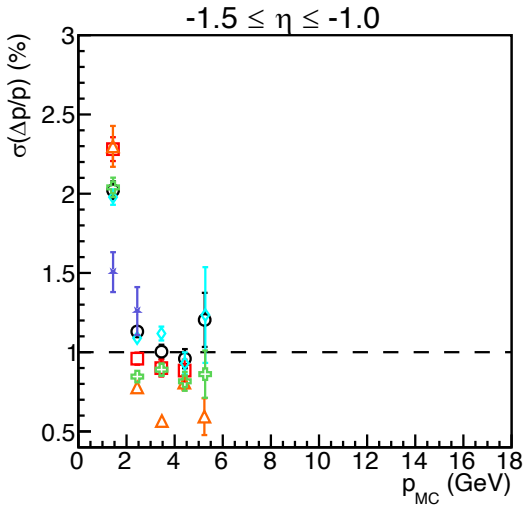
Momentum Resolutions of Scattered Electron







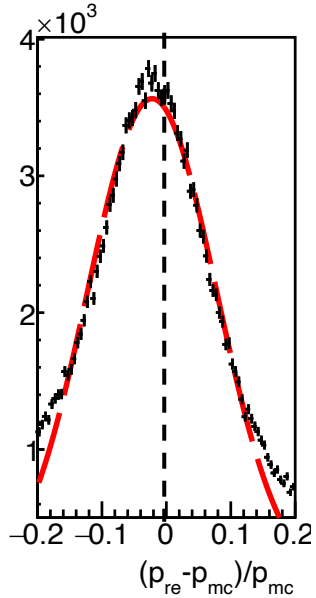




- ePIC
- ePIC, $t_{backward\ silicon}$=5um
- ePIC, t_{alumi}=5um, t_{CF}=5um
- ePIC, modified bk disk location
- ePIC, B=2T
- Ecal e

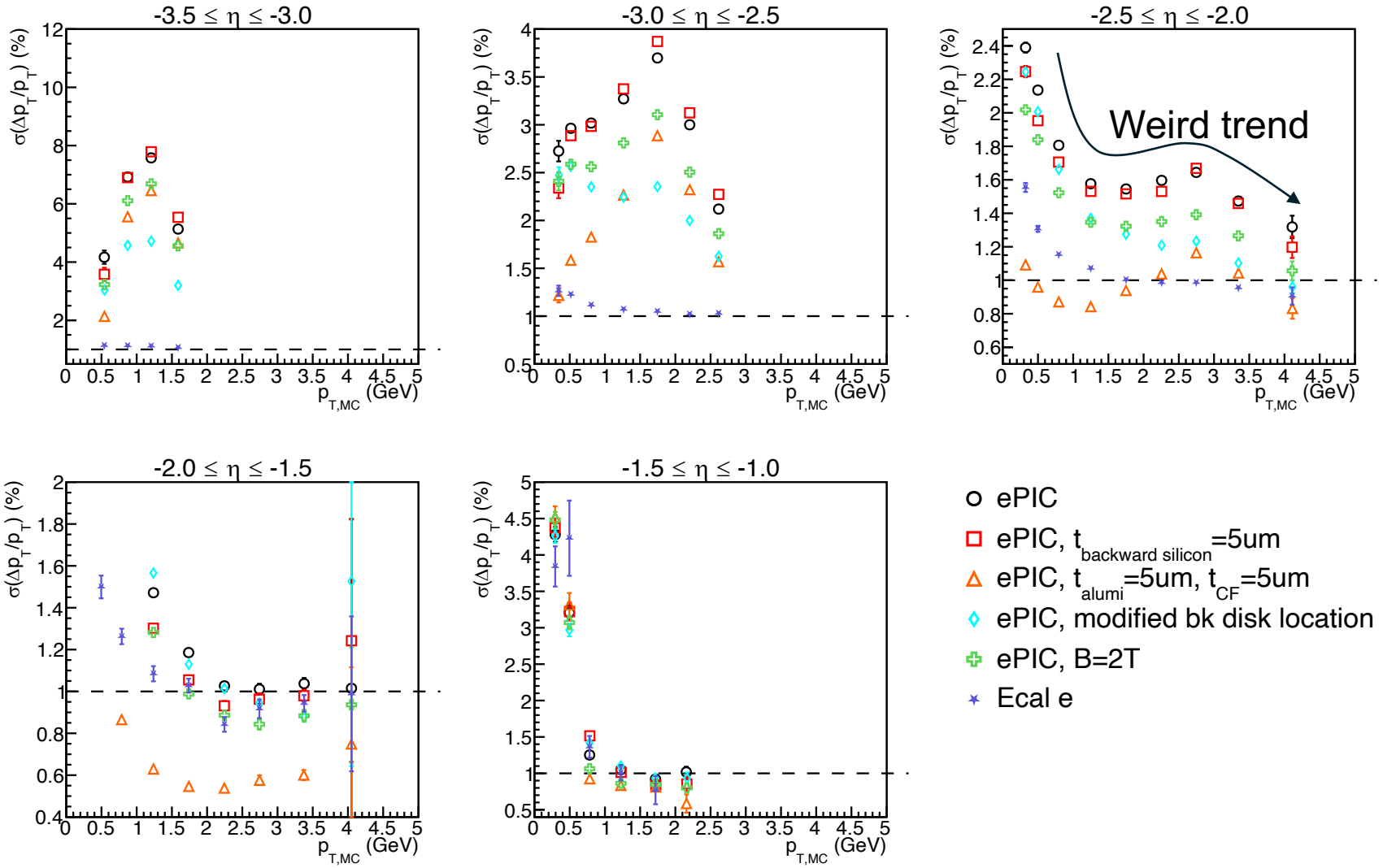
Electron beam: 18 GeV

$-3.5 < \eta < 3, 12 - 15$ GeV



Off center

Transverse Momentum Resolution of Scattered Electrons



Ways to Improve Tracking Resolution

- ✓ Material budgets
  Supporting/service material is the dominant factor
  →Reduce error due to multiple scattering.
  At low momentum especially
- ❑ Pixel pitch/size
  The default grid size is 20x20 um^2
- ✓ Disk placements
  → Reduce momentum resolution at high momentum
- ❑ More disks
- ✓ Magnetic field

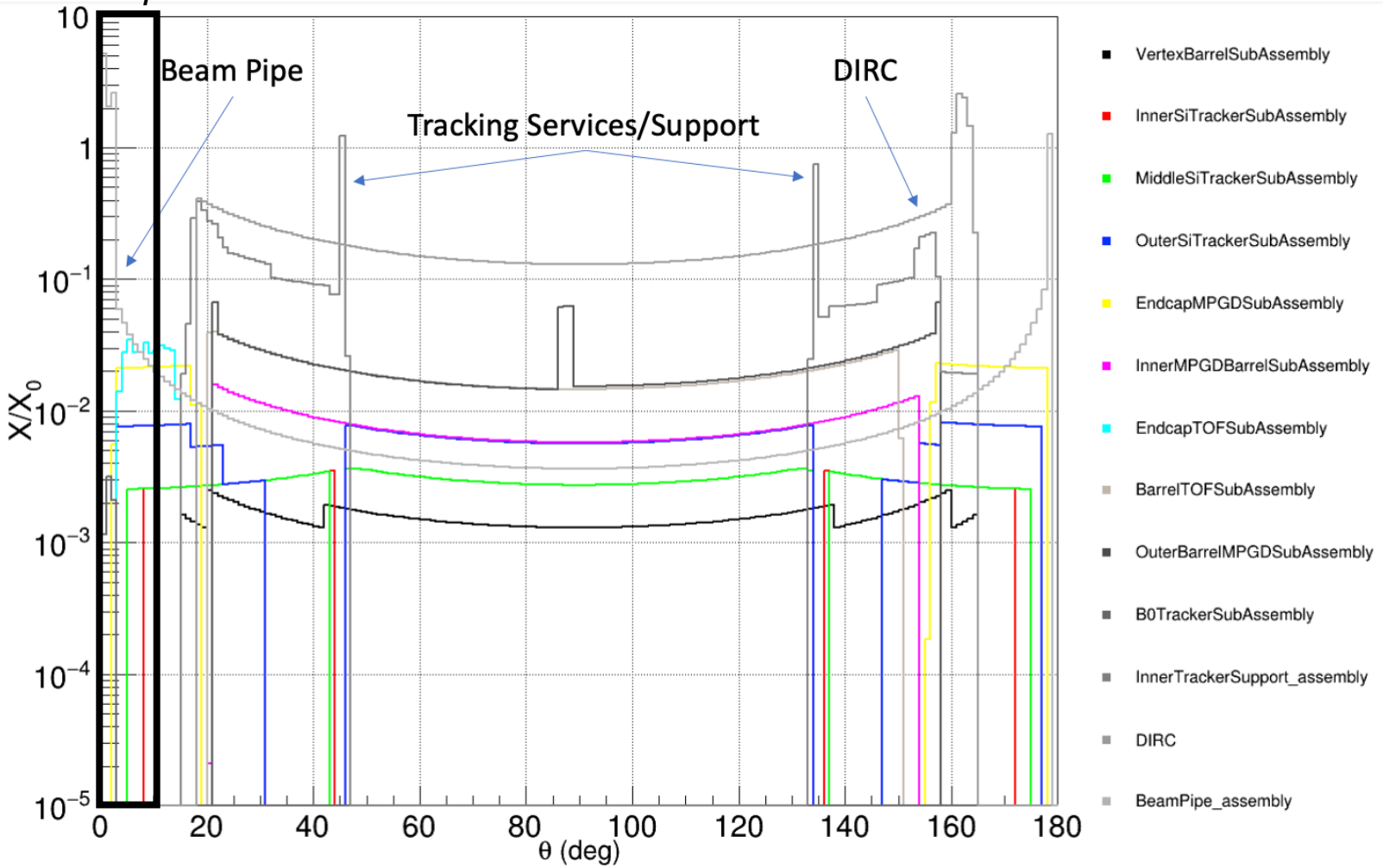
Ways to Improve Tracking Resolution

- ✓ Material budgets
  Supporting/service material is the dominant factor
  →Reduce error due to multiple scattering
  At low momentum especially
  ⟵ Try to remove the beam pipe (see next slide)
- ❑ Pixel pitch/size
  The default grid size is 20x20 um^2
- ✓ Disk placements
  → Reduce momentum resolution at high momentum
  ⟵ How much space do we have?
- ❑ More disks
- ✓ Magnetic field
  ⟵ Max at 2T

Material Budget

$-3.5 < \eta < -3$

https://indico.bnl.gov/event/20915/contributions/82404/attachments/50655/86613/10262023Tracking_WG_AngularResolution.pdf



Trying to reduce the beam pipe material budget in the simulation, But have not made the simulation work yet

Backup

ePIC Setup with Modified Backward Tracker Locations