UNIVERSITY OF BIRMINGHAM | SCHOOL OF PHYSICS AND ASTRONOMY

Disk Acceptance and Beamspot studies

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Detector Configuration (Fun4All)

- Symmetric silicon layout implemented
  - Disks layout in electron going direction based on envelope with mRICH
  - Note: for the October simulation campaign, asymmetric layout, with smaller, pfRICH compatible, envelope in negative direction

- Complemented by AC-LGAD ToFs and µRWELLs
- Sphenix Fieldmap rescaled to 1.7T

- Barrel

```
Layer 1: r = 36 mm, l = 270 mm, 0.05% X/X0
Layer 2: r = 48 mm, l = 270 mm, 0.05% X/X0
Layer 3: r = 120 mm, l = 270 mm, 0.05% X/X0
Layer 4: r = 270 mm, l = 540 mm, 0.25% X/X0
Layer 5: r = 420 mm, l = 840 mm, 0.55% X/X0
support barrel: r=135mm, l=270mm, 100um carbon fiber, X/X0 = 0.036%
support cone angle: 45 degrees
```

- Disks

```
|z| = 250, 450, 700, 1000, 1350 mm
r_out = 43 0mm at |z|>430mm,~230mm at|z|=250mm
r_in ~ 5 mm away from beam pipe
X/X0 ~ 0.24% per disk
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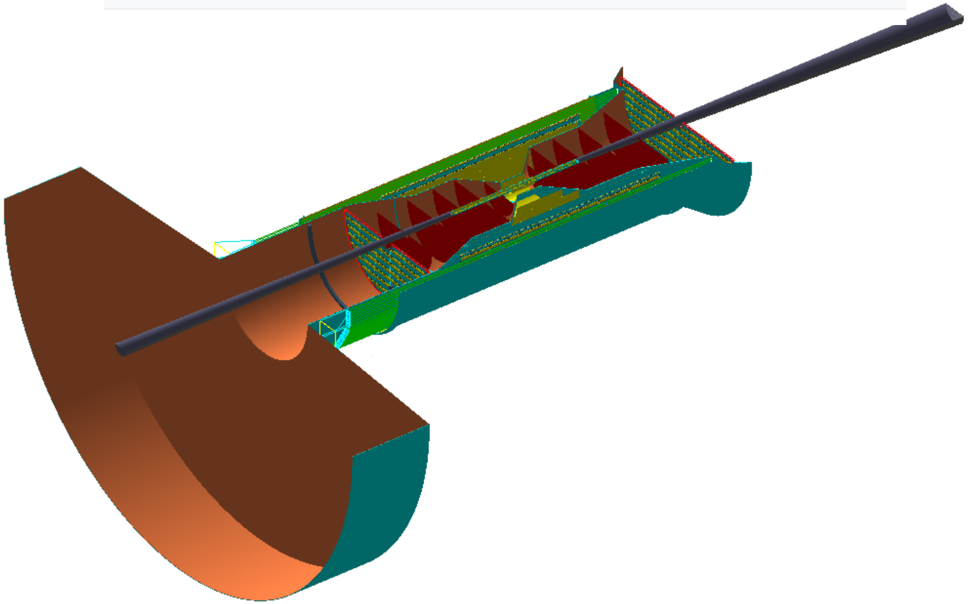
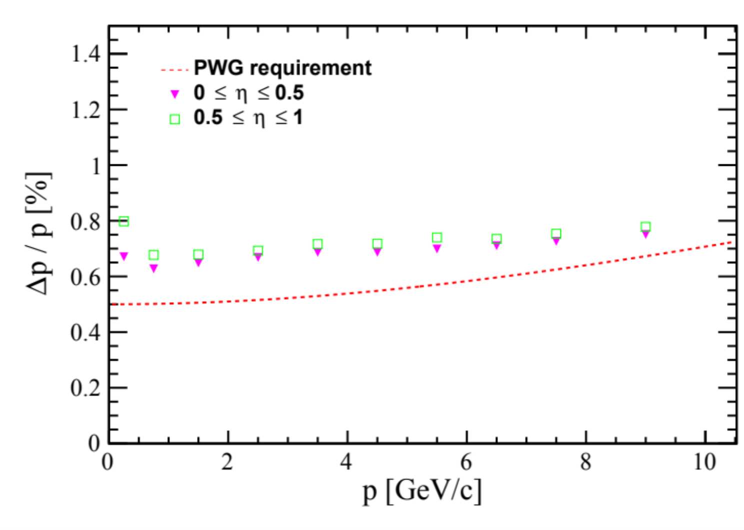
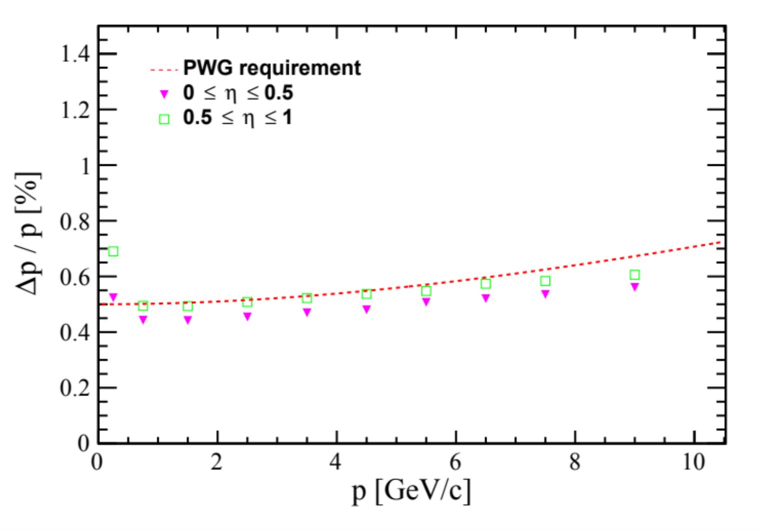


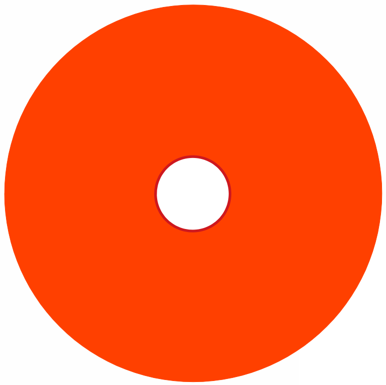
Amendment to results shown 6th October

- Unexpected poor momentum resolution appeared in central region
  - This was due to a difference in material for Layer 3 support (r~13cm)
  - Updated material and re-benchmarked → performance recovered, in agreement with simulations from others



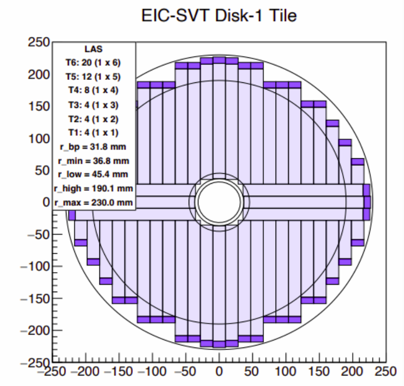


Acceptance around beampipe (recap)



Disks in simulations

- Disks consist of tiles of ITS3-like sensors, with length and width determined by the ITS3 reticle
  - The result is that the inner opening of the disks is not perfectly circular → instead they are squared off
  - This means that there isn’t full azimuthal acceptance at the inner radii we’ve been using (beampipe radius +5mm)



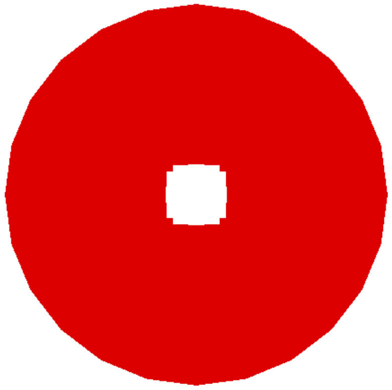
Realistic disks

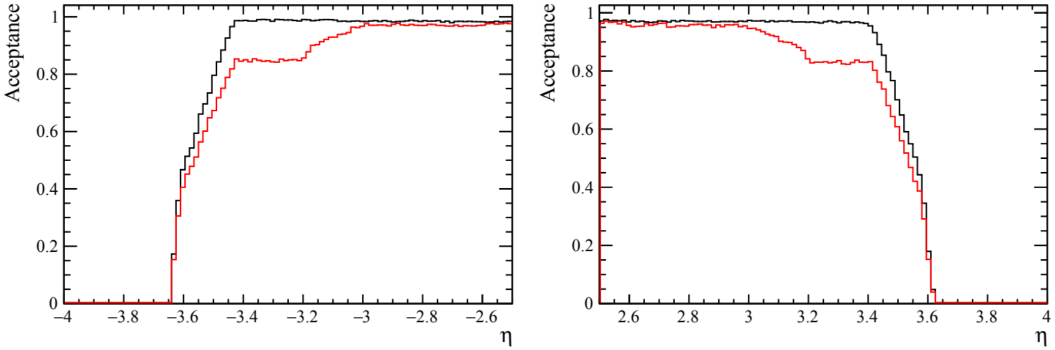
* P. G. Jones
https://indico.bnl.gov/event/15486/contributions/62590/attachments/40656/67919/EIC-Sensors-Jones.pdf

Disk acceptance vs η

- Implemented disk modules with inner cutouts in the same shape as the disks as produced by the tiling algorithm
- Generated events in far forward/backward region and studied acceptance in η bins:

$$Acceptance = \frac{Number\ of\ events\ with\ at\ least\ 3\ hits}{Total\ number\ of\ events}$$

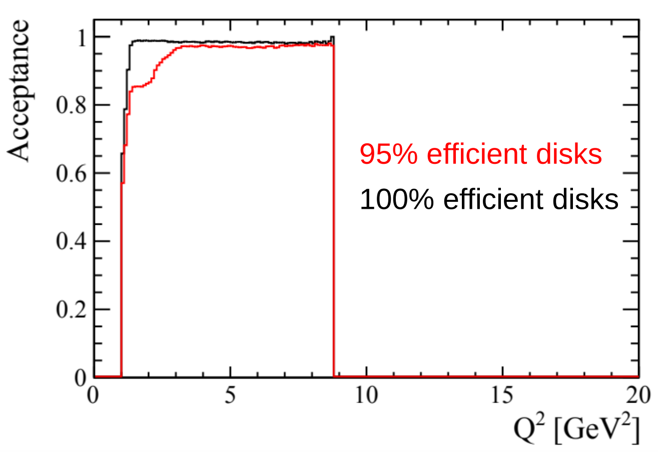


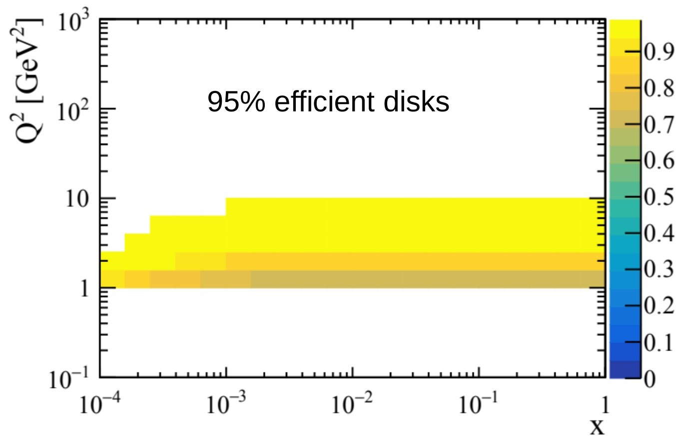


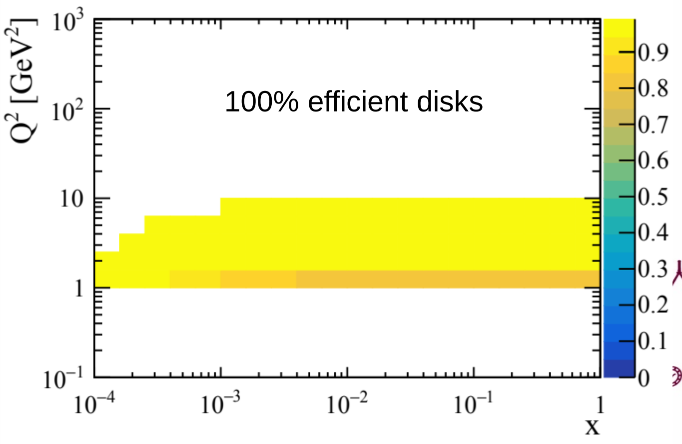
95% efficient disks
100% efficient disks

Disk acceptance vs (x-)Q^2

- Looked at 18x275 GeV^2 NC-DIS events (Pythia8, Q^2 > 1 GeV^2)
  - Mapped scattered electron to relevant η bin and weighted number of reconstructed events by acceptance in this η bin and recorded x-Q^2 for the event
    → Acceptance here is fraction of events reconstructed in a given x-Q^2 range



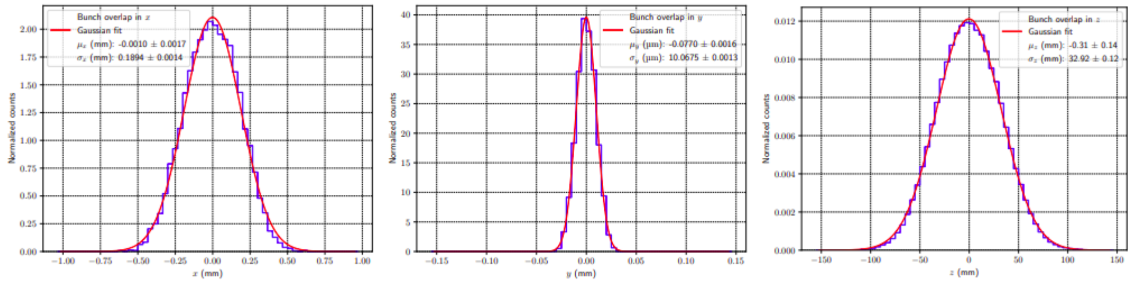




Higher x lower Q^2 bins lose acceptance https://github.com/eic/documents/blob/master/reports/general/Note-Simulations-BeamEffects.pdf

Effect of beamspot on tracking performance

- A very helpful report on beam conditions at EIC was produced last year
  - This included a transport model which allows one to obtain the primary vertex distribution in terms of x, y, z



- → Generated single particle events in Fun4All with the origin vertex distributed according to these distributions

Accelerator and beam conditions critical for physics and detector simulations for the Electron-Ion Collider

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Abstract

We identify accelerator and beam conditions at the Electron-Ion Collider (EIC) that need to be included in physics and detector simulations. For our studies, we implement accelerator and beam effects in the Pythia 8 Monte Carlo event generator and examine their influence on the measurements in the central and far-forward regions of the detector. In our analysis, we demonstrate that the accelerator and beam effects can be also studied accurately by modifying the Monte Carlo input to detector simulations, without having to implement the effects directly in the event generators.

1 Interaction Regions at the Electron-Ion Collider

The present interaction region (IR) and detector designs for the Electron-Ion Collider (EIC) are the result of considerations which fulfill all of the below requirements:

- Versatile center-of-mass energy, E_{CM}, within the range of 30 GeV to 140 GeV.
- A luminosity of up to $10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$.
- High polarization of electron and light ion beams with arbitrary spin patterns, with time-averaged polarization of up to 70%.
- Beam divergences at the interaction point (IP) and apertures of the interaction region magnets that are compatible with the acceptance requirements of the colliding beam detector.
- Collisions of electrons with a large range of light to heavy ions (protons to uranium ions).
- Up to two interaction regions.

To realize these requirements a couple of design choices have been made, which need to be included in the physics and detector simulations to get the most accurate description. The purpose of the interaction region is to focus the beams to small spot sizes at the collision point and to separate them into their respective beam lines while providing the space and geometry required by the physics program for the detector. The separation is accomplished by a total crossing angle of 25 mrad (or 35 mrad) between the two beams, which has the advantage of avoiding the introduction of separator

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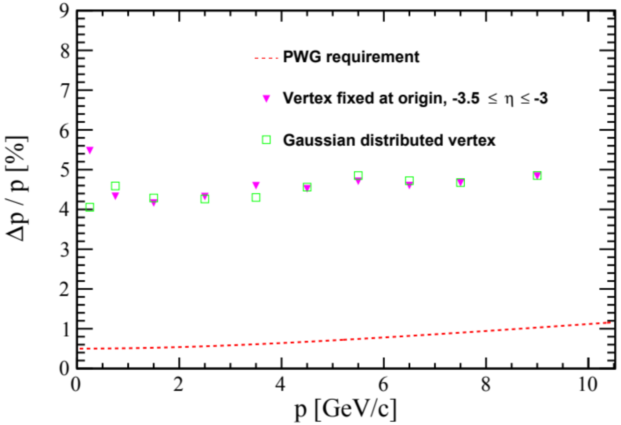
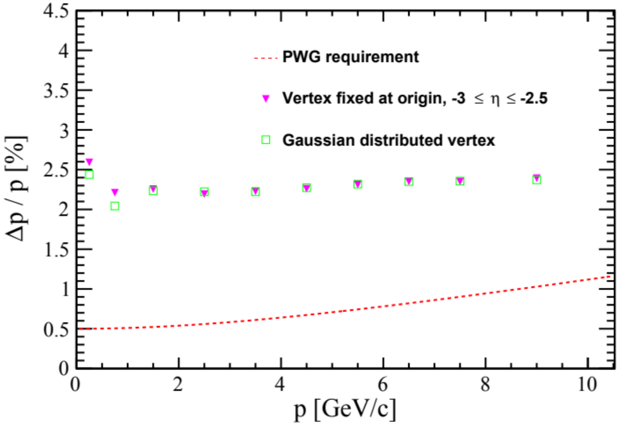
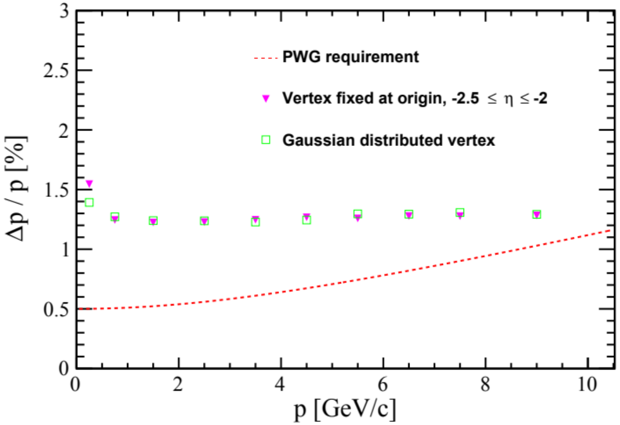
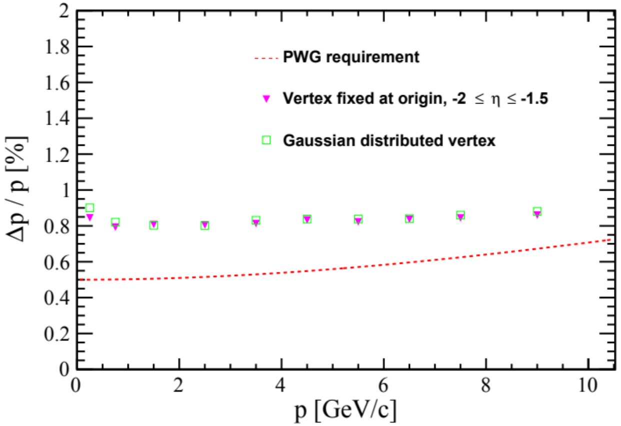
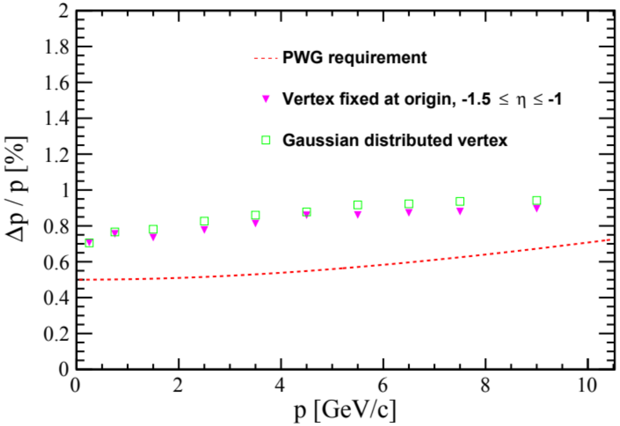
Momentum resolution - Backward





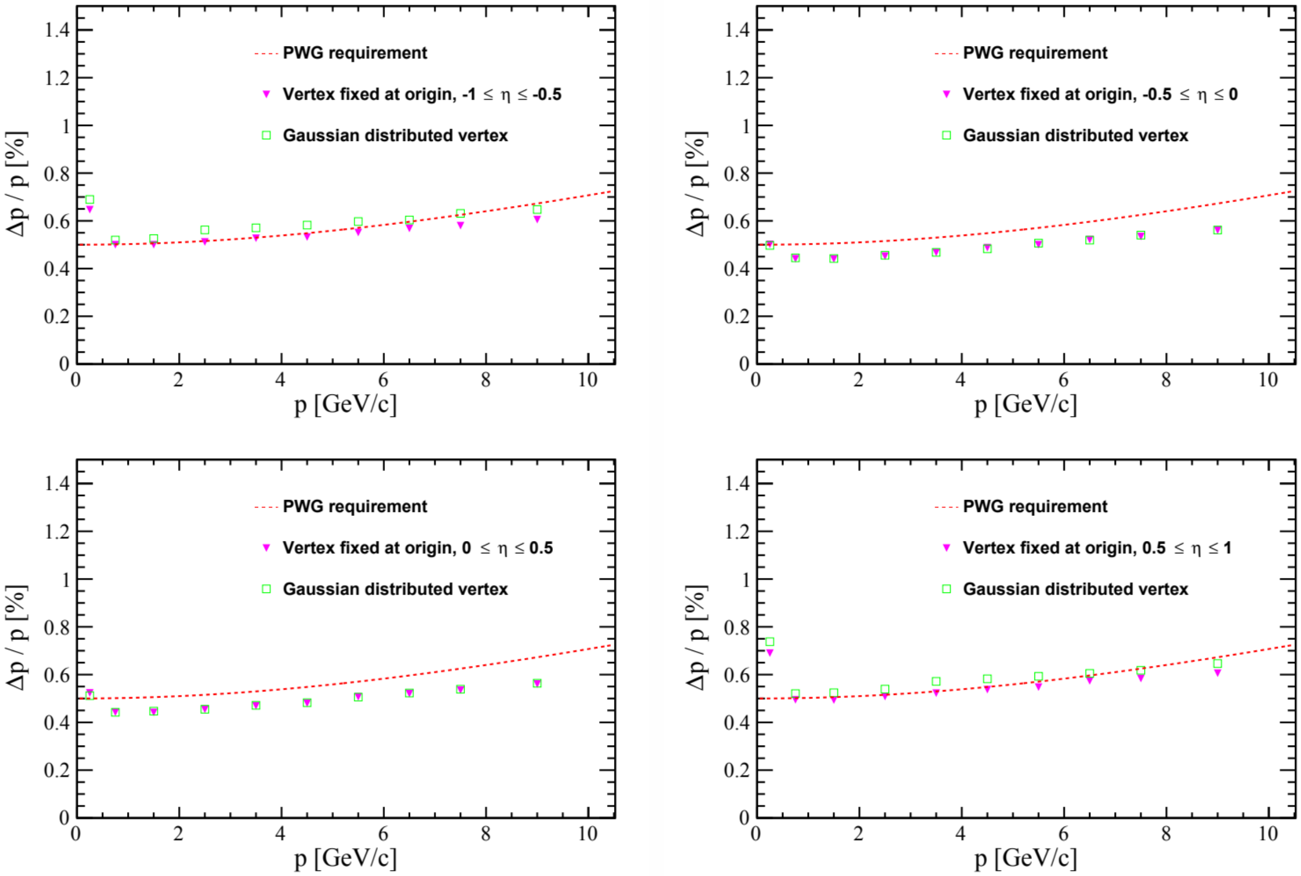






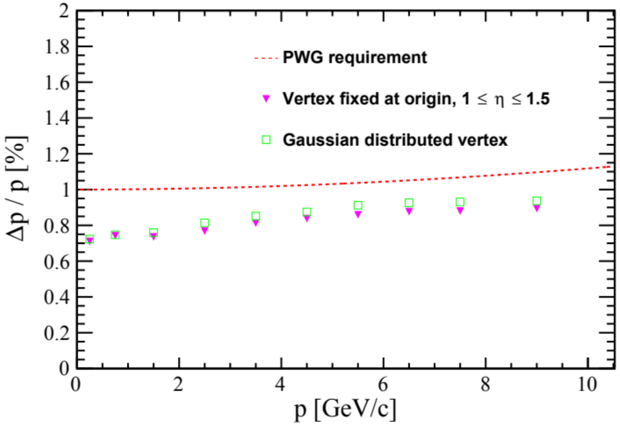
- A very small loss of performance for -1.5<η<-1, with other regions being mostly the same

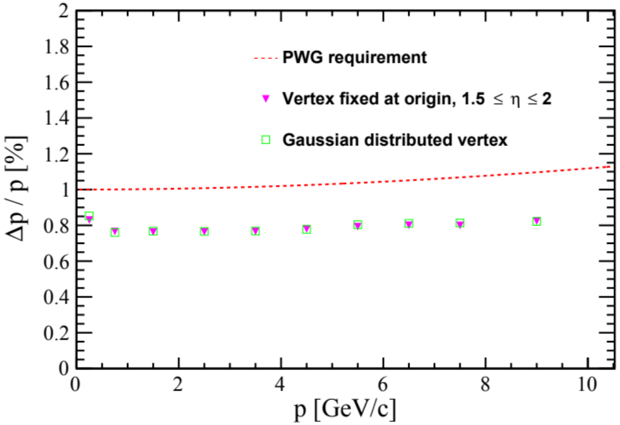
Momentum resolution - Central

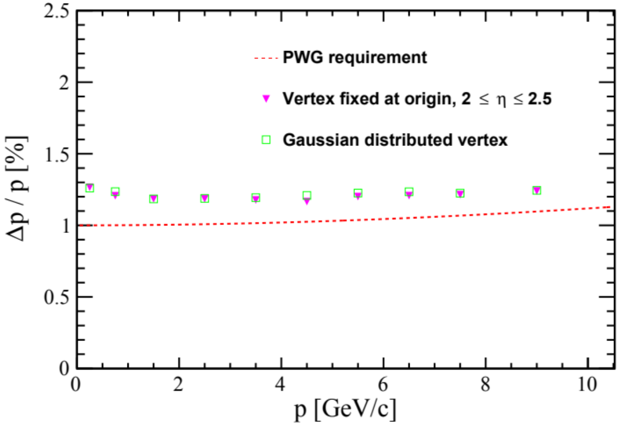


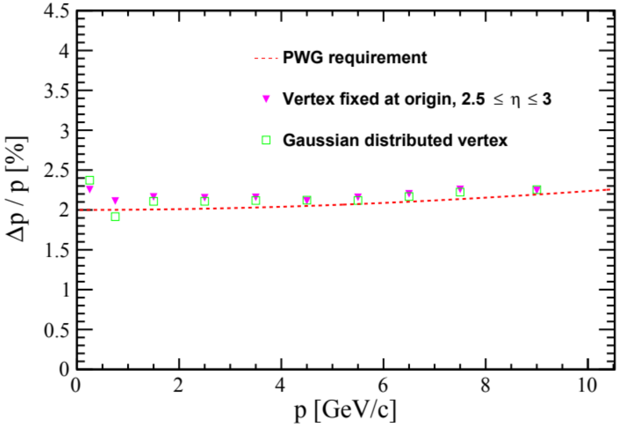
- Small difference in performance for 0.5<|η|<1

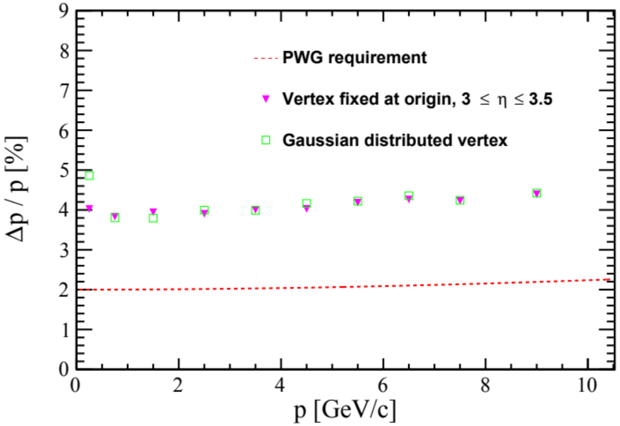
Momentum resolution - Forward





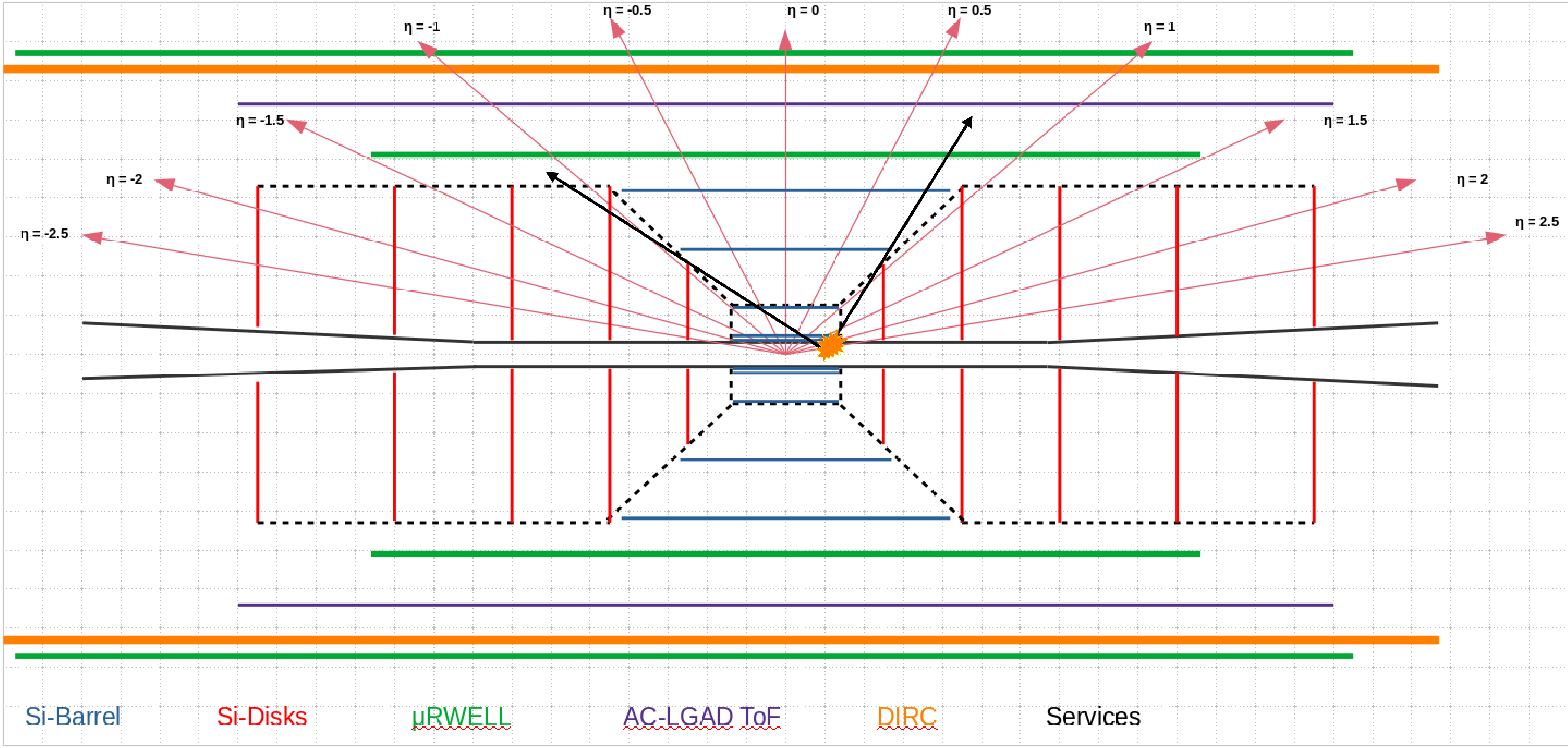




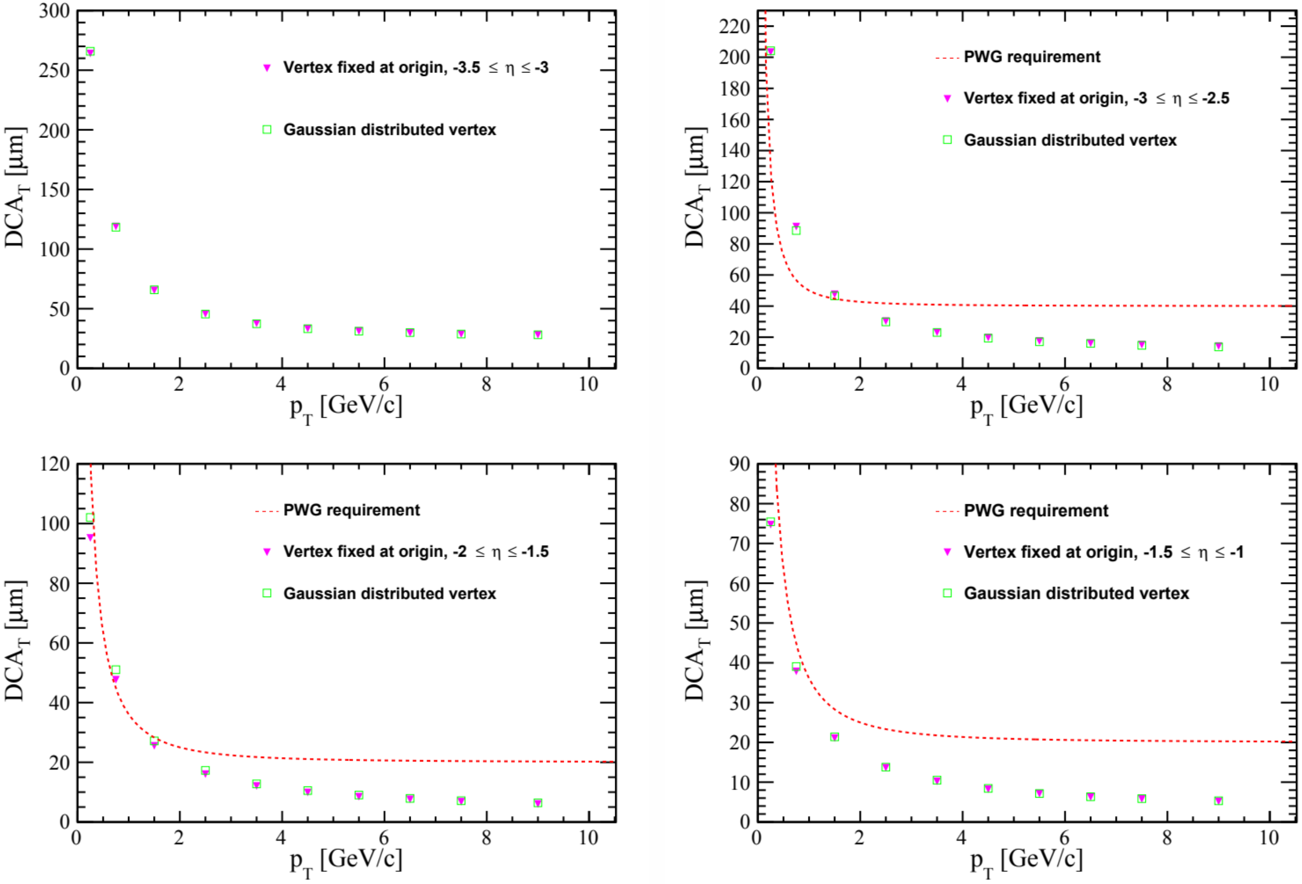


- Same trend as for Backward: only 1<η<1.5 shows a small loss of performance
- Can attribute this to extra material seen when crossing over service cone

Extra material seen by particles from offset vertex if they traverse service cone

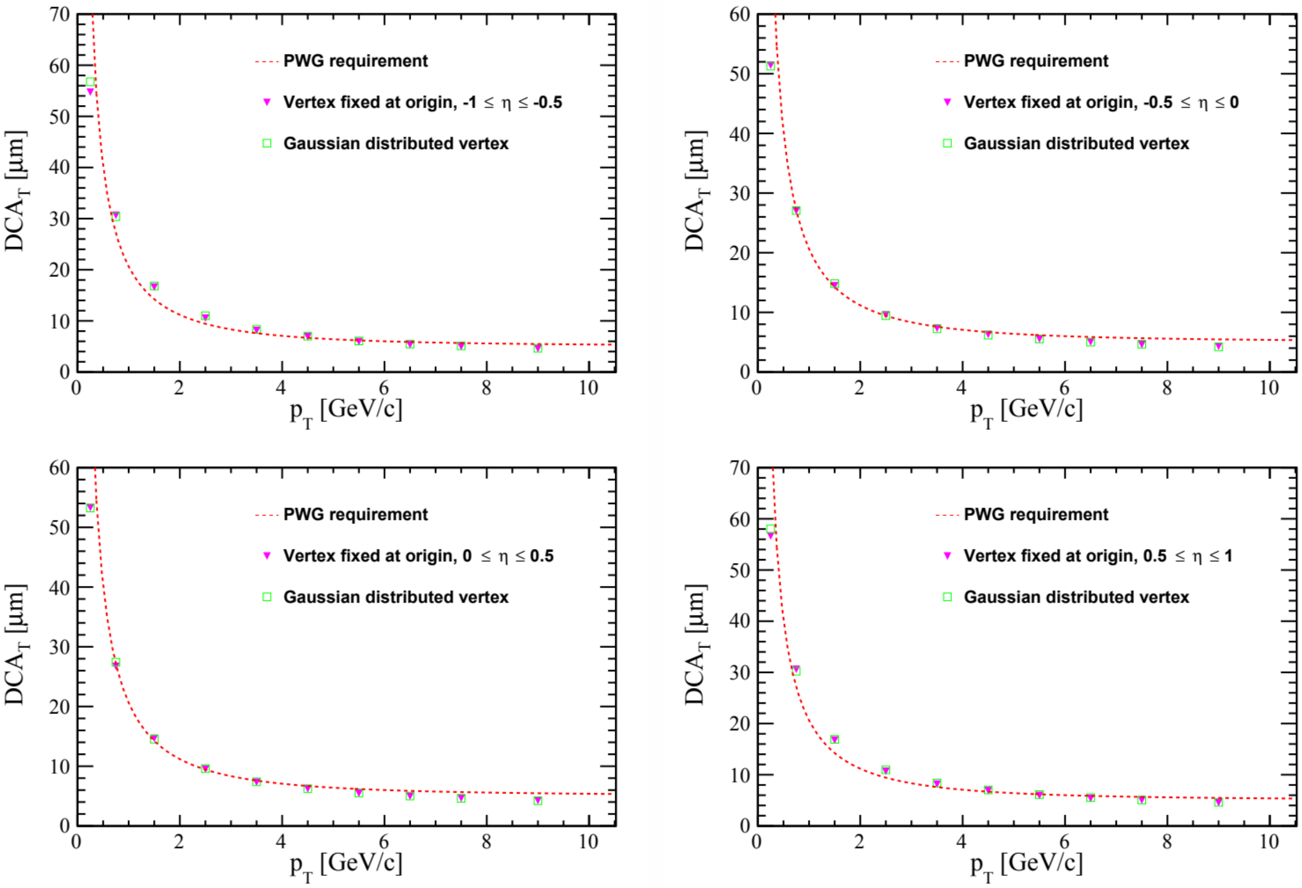


Transverse pointing resolution - Backward



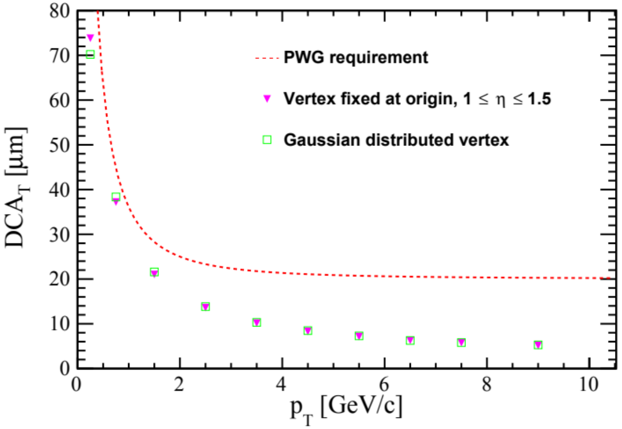
- No significant differences in transverse pointing resolution

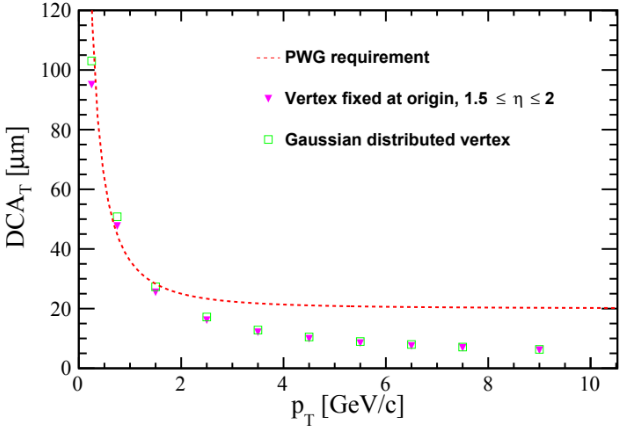
Transverse pointing resolution - Central

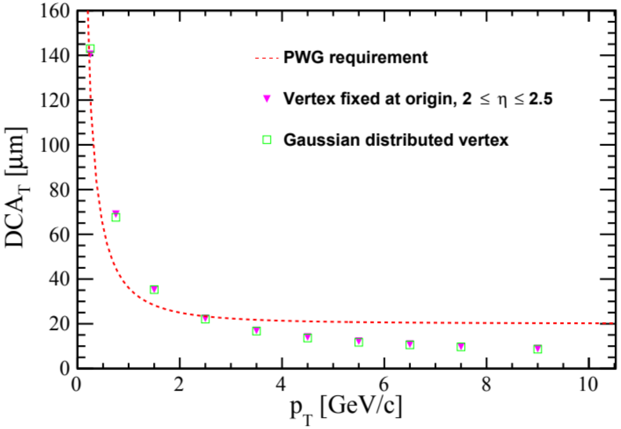


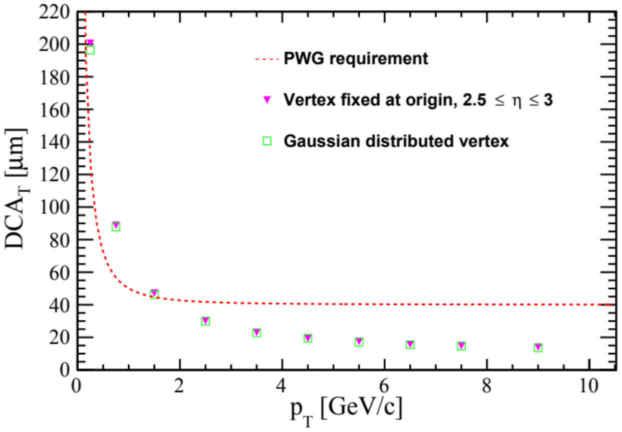
- No significant differences in transverse pointing resolution

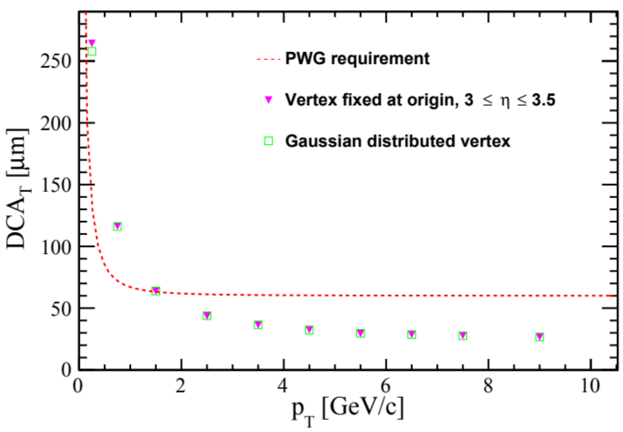
Transverse pointing resolution - Forward











- No significant differences in transverse pointing resolution

Summary

- Acceptance of disks around the beampipe measured as a function of η for 95% vs 100% efficient disks → used this to obtain acceptance in x-Q^2
  → Acceptance lost with decreasing Q^2 → ~80% for some bins
- Studied effect of a more realistic beamspot on tracking performance
  → losses are minimal, mainly resulting from particles traversing service cone

Next Steps

- Extend disk acceptance studies to lower Q^2 events and other beam configurations
- Implement more realistic disks in DD4hep, repeat with DD4hep + juggler/jana2