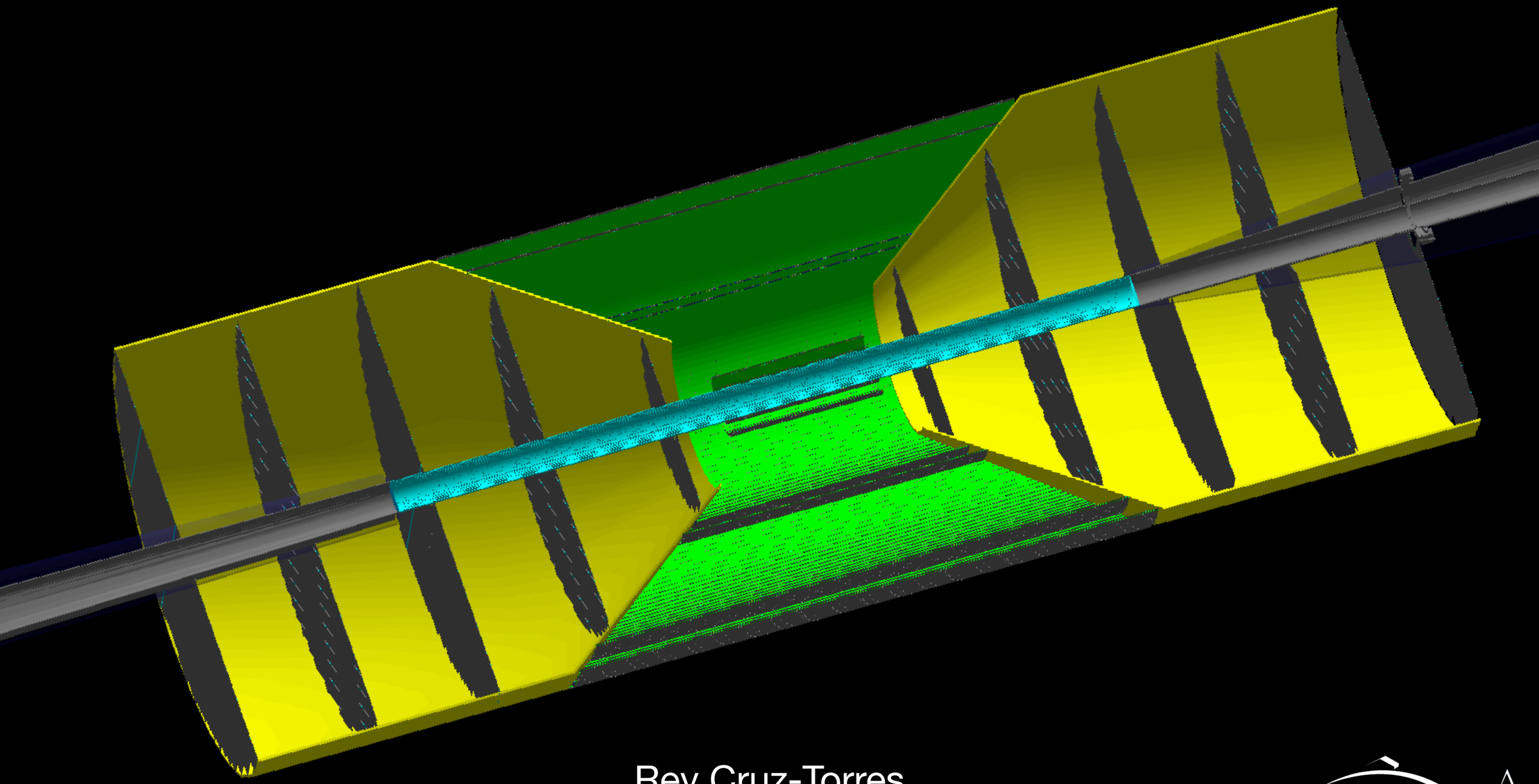
All-Si tracker layout & jet reconstruction



Rey Cruz-Torres

SVT EIC Workshop

09/02/2020

BERKELEY LAB

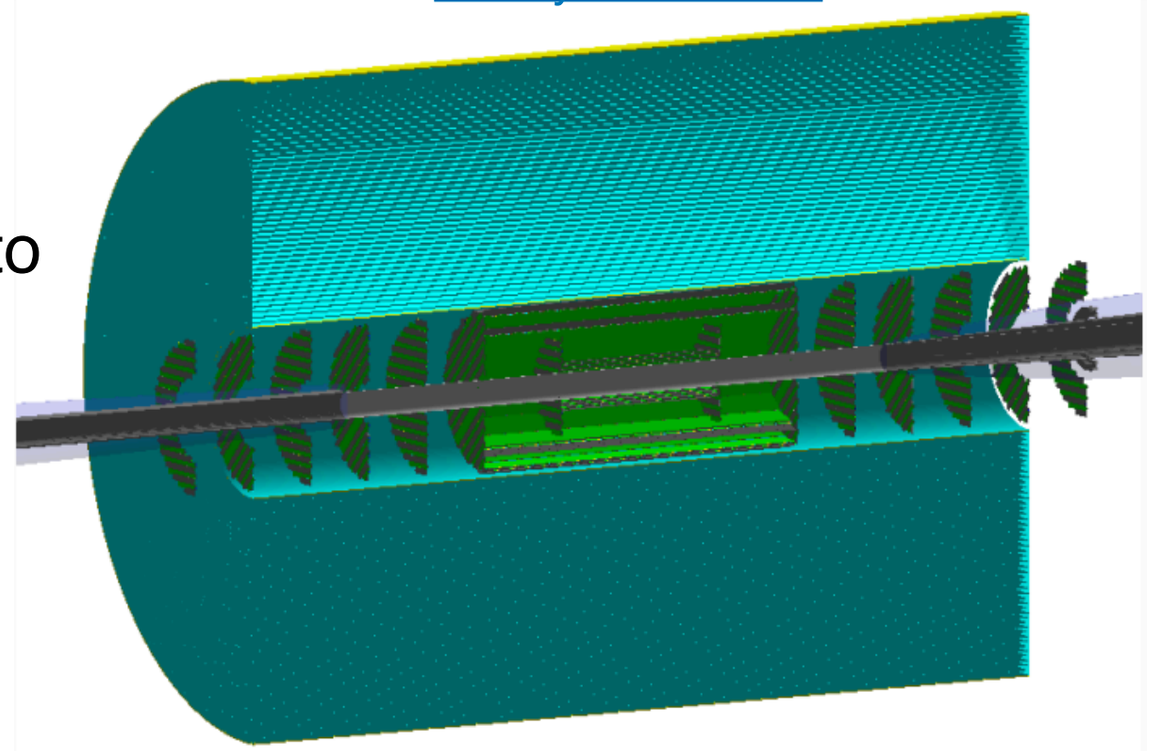
Introduction

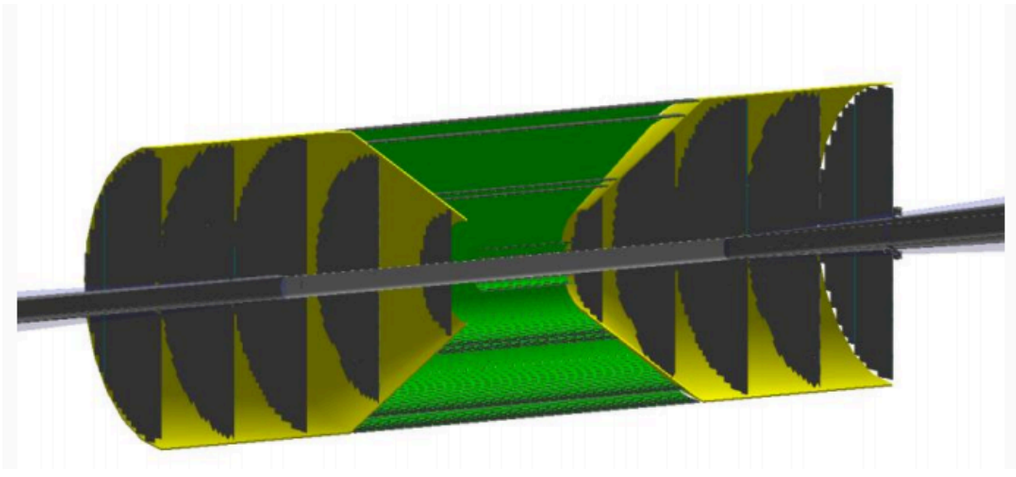
Requirements for an EIC tracker according to the EIC detector handbook:

- Hermetic
  - * ($|\eta| < 4,\ 0 \leq \phi < 2\pi$ coverage)
- Compact
- Low-material-budget tracker
  - * (3-5% of X_0)
- Excellent momentum, angular, and vertex resolutions
  - * (dp/p ~ few %)
- Aid in particle identification (PID).

Hybrid tracker

See talk by H. Wennlöf





in this talk: All-Si tracker

Outline

- Detector layout and Material budget

- Detector performance
  - Single-particle resolutions
  - Jet resolutions

  - momentum
  - angular

  * for vertex see X. Dong's or H. Wennlöf's talks

- Outlook
  - Can we do better?

    Complementing the All-Si tracker with other tracking stations.

  - Word of caution in the forward direction

    Azimuthal asymmetry from crossing angle.

- Summary and Conclusions

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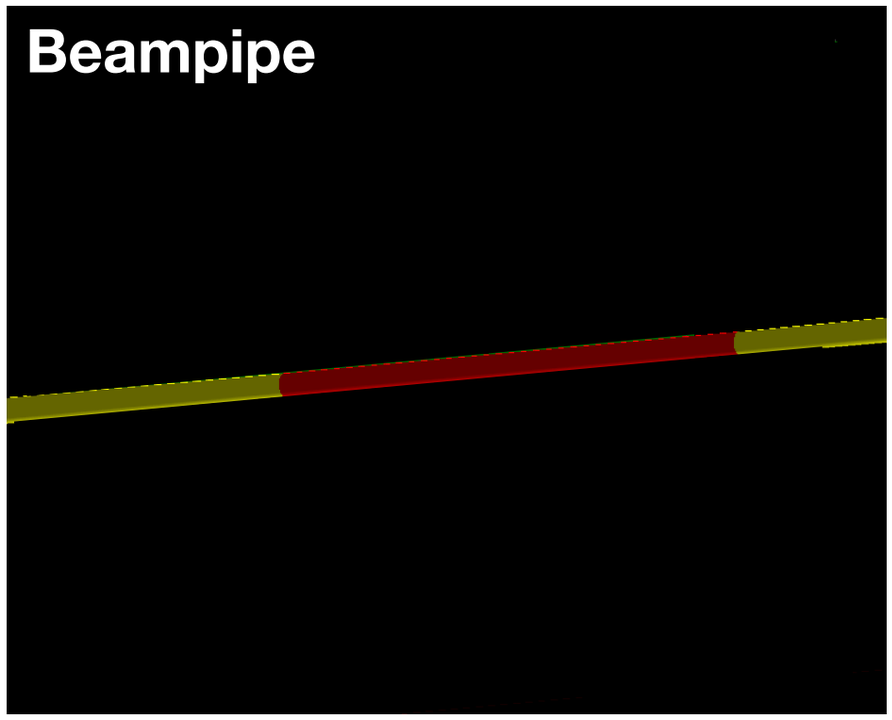
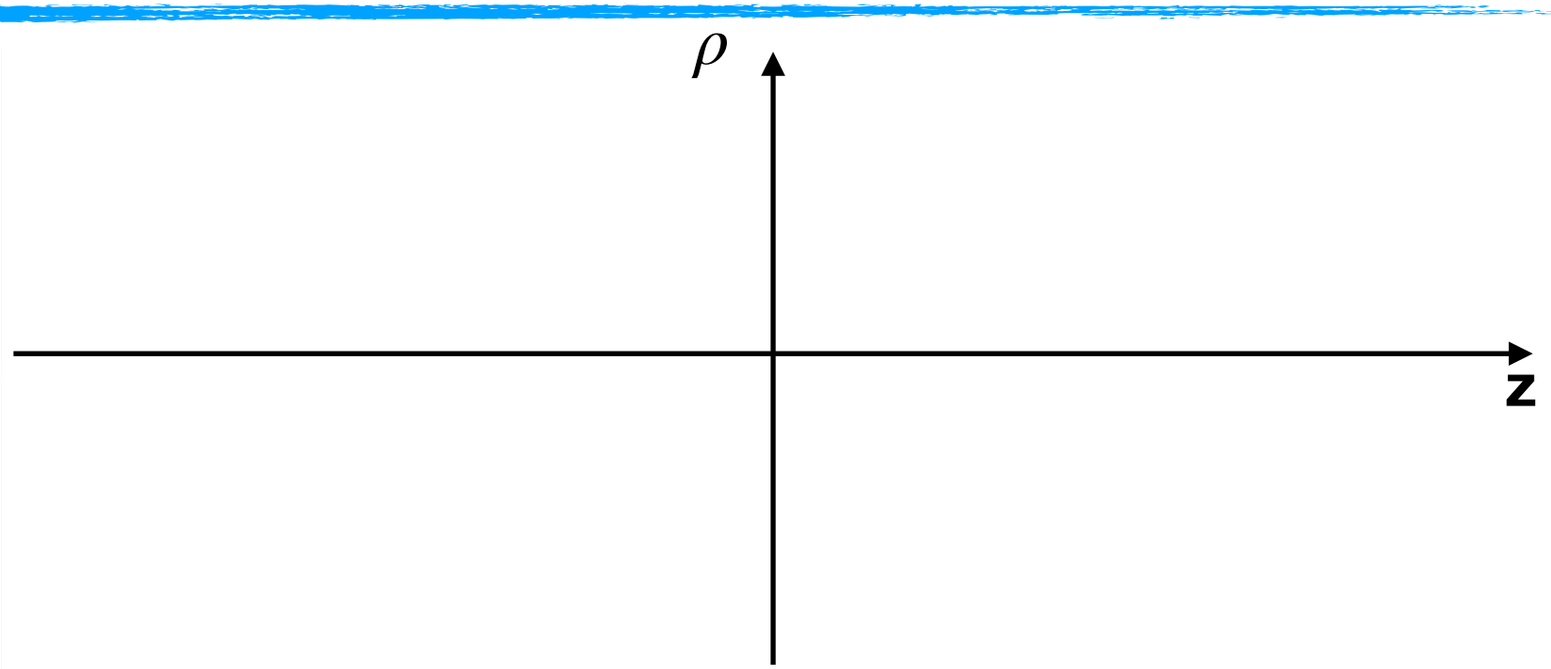
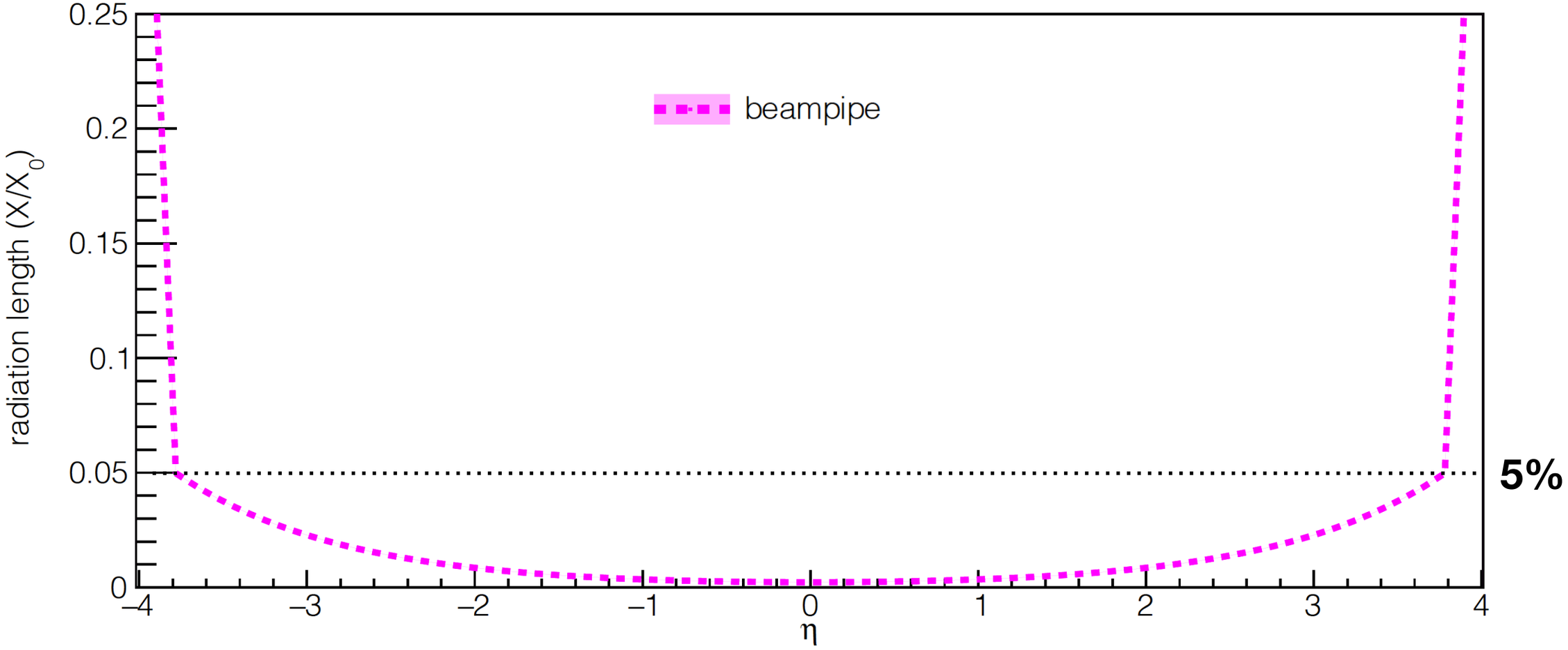
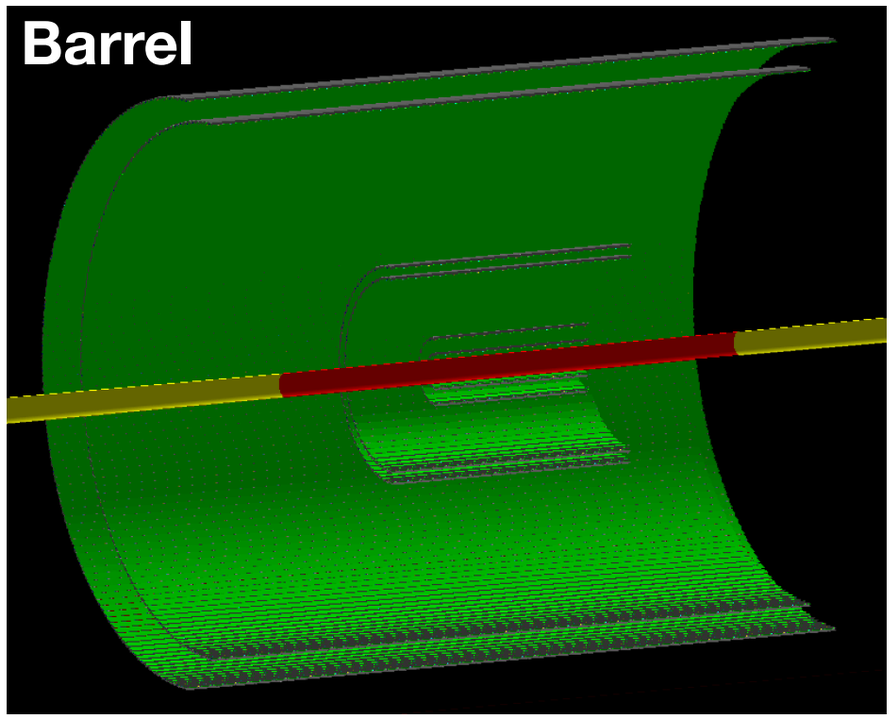
Detector Layout and Material Budget

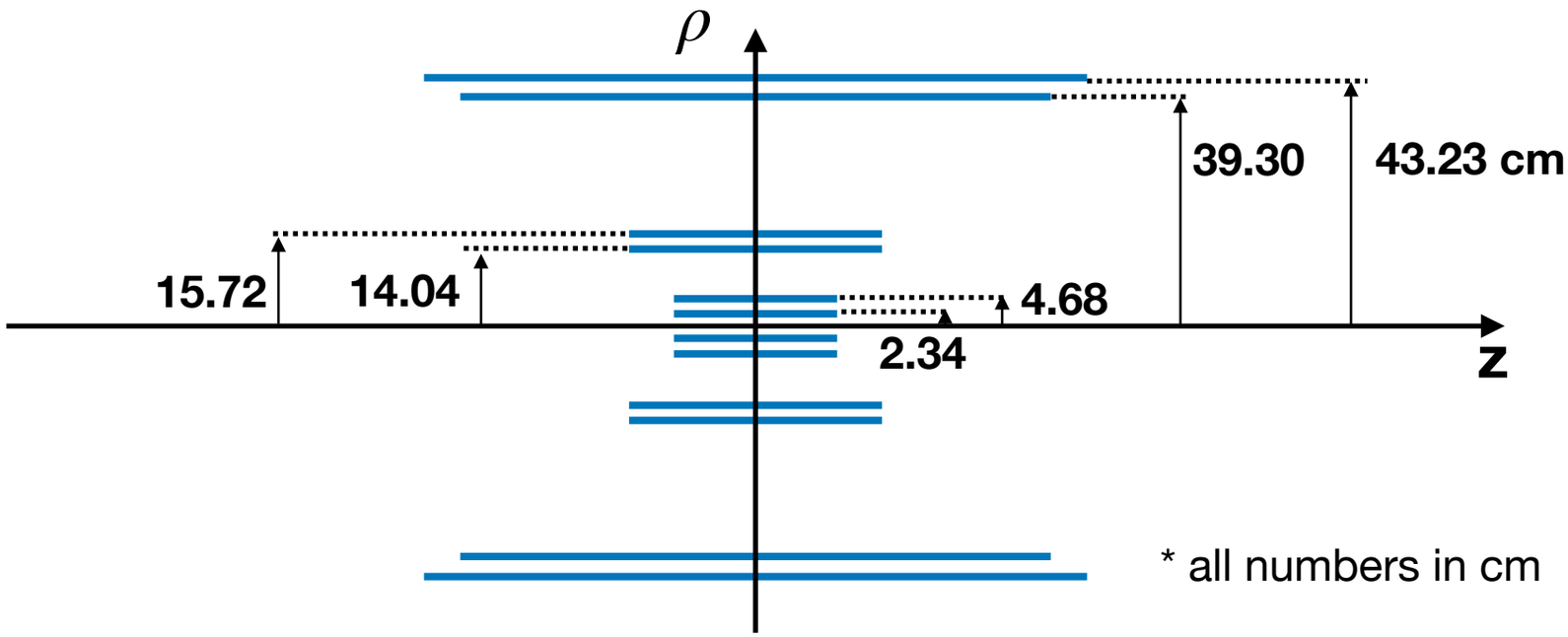


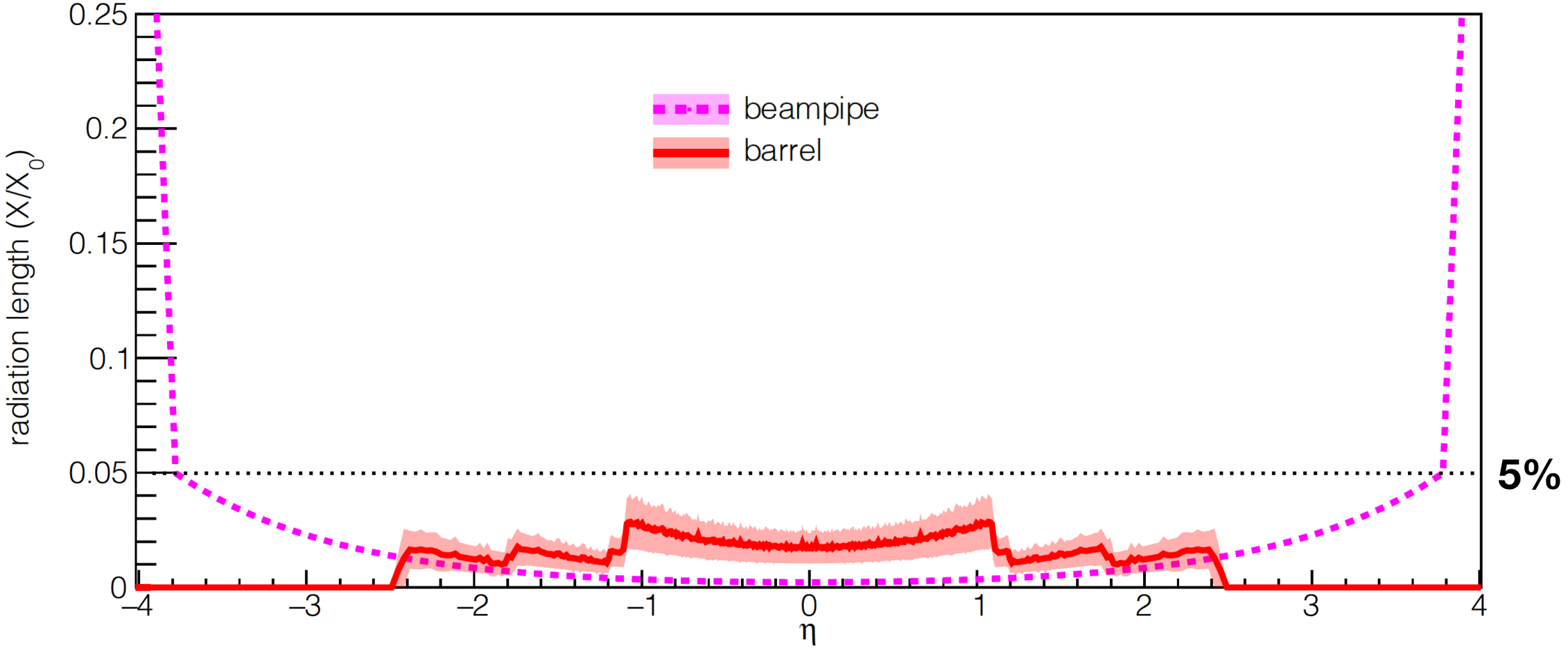




Detector Layout and Material Budget







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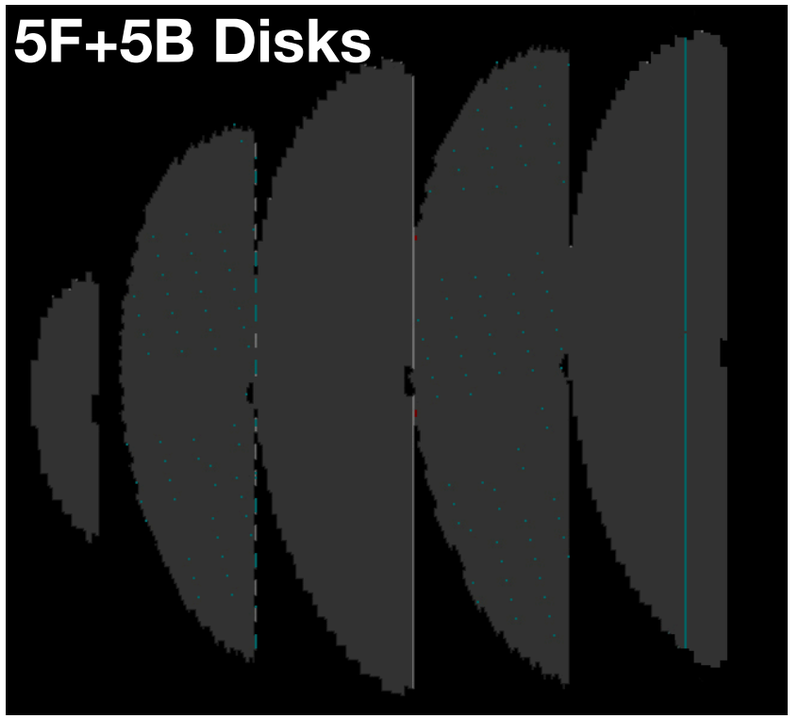

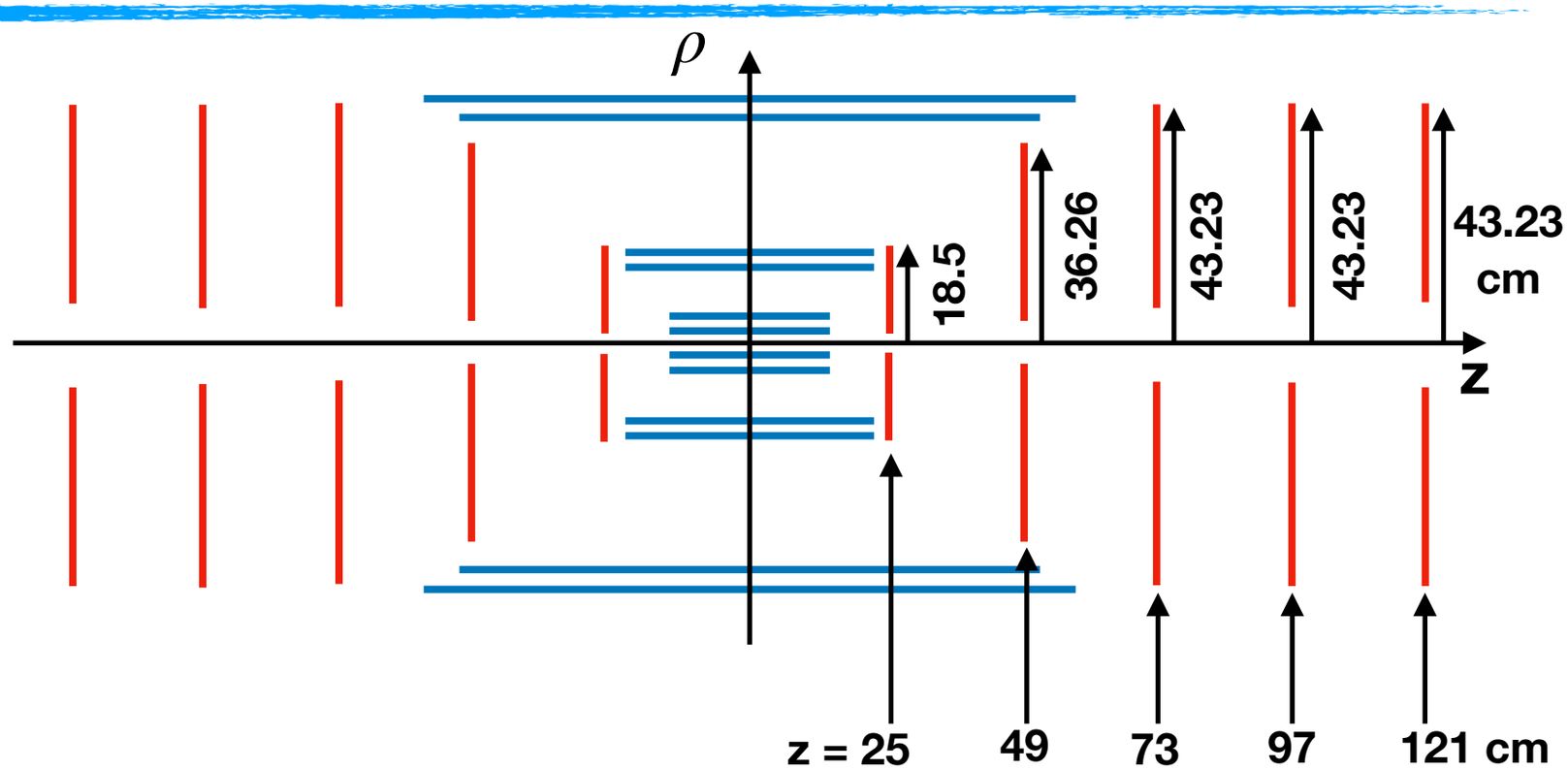

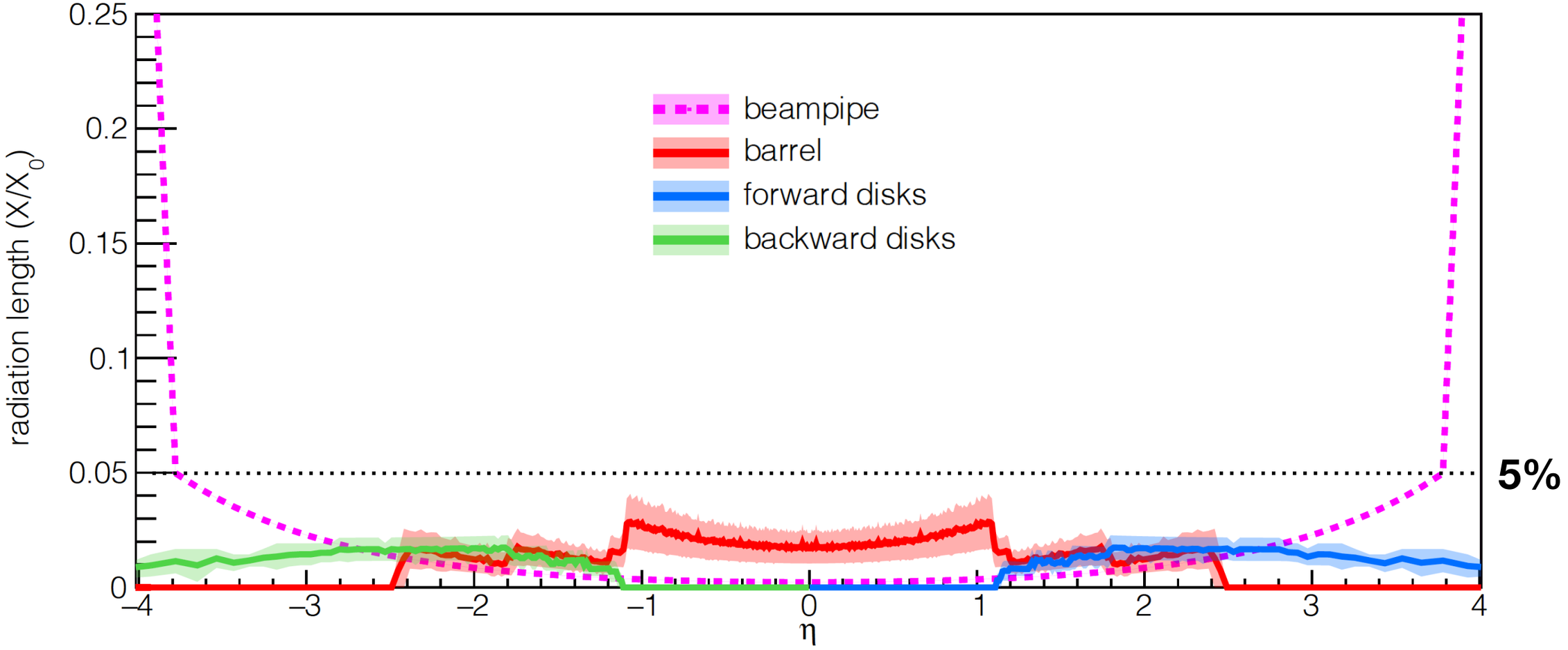

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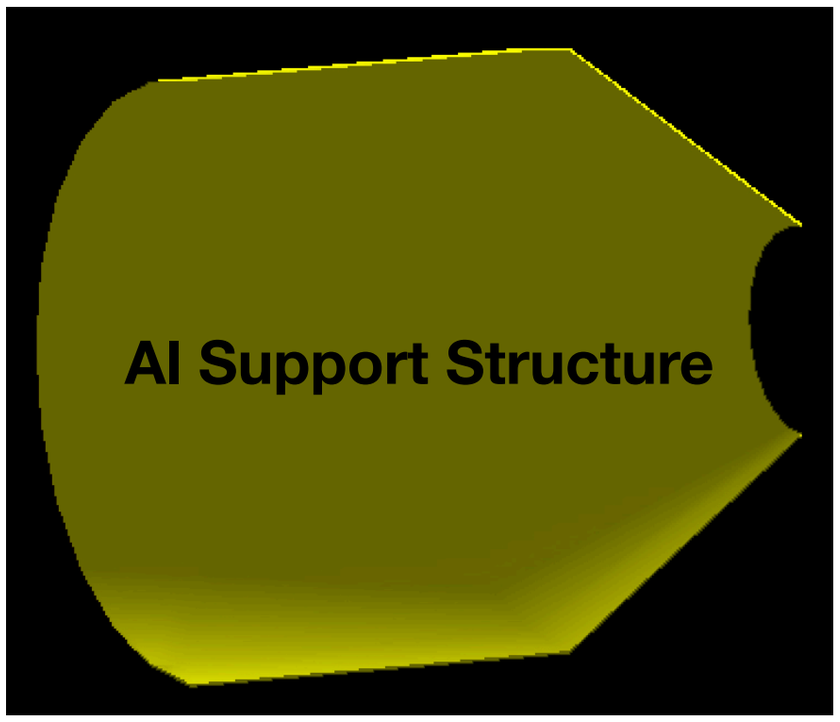
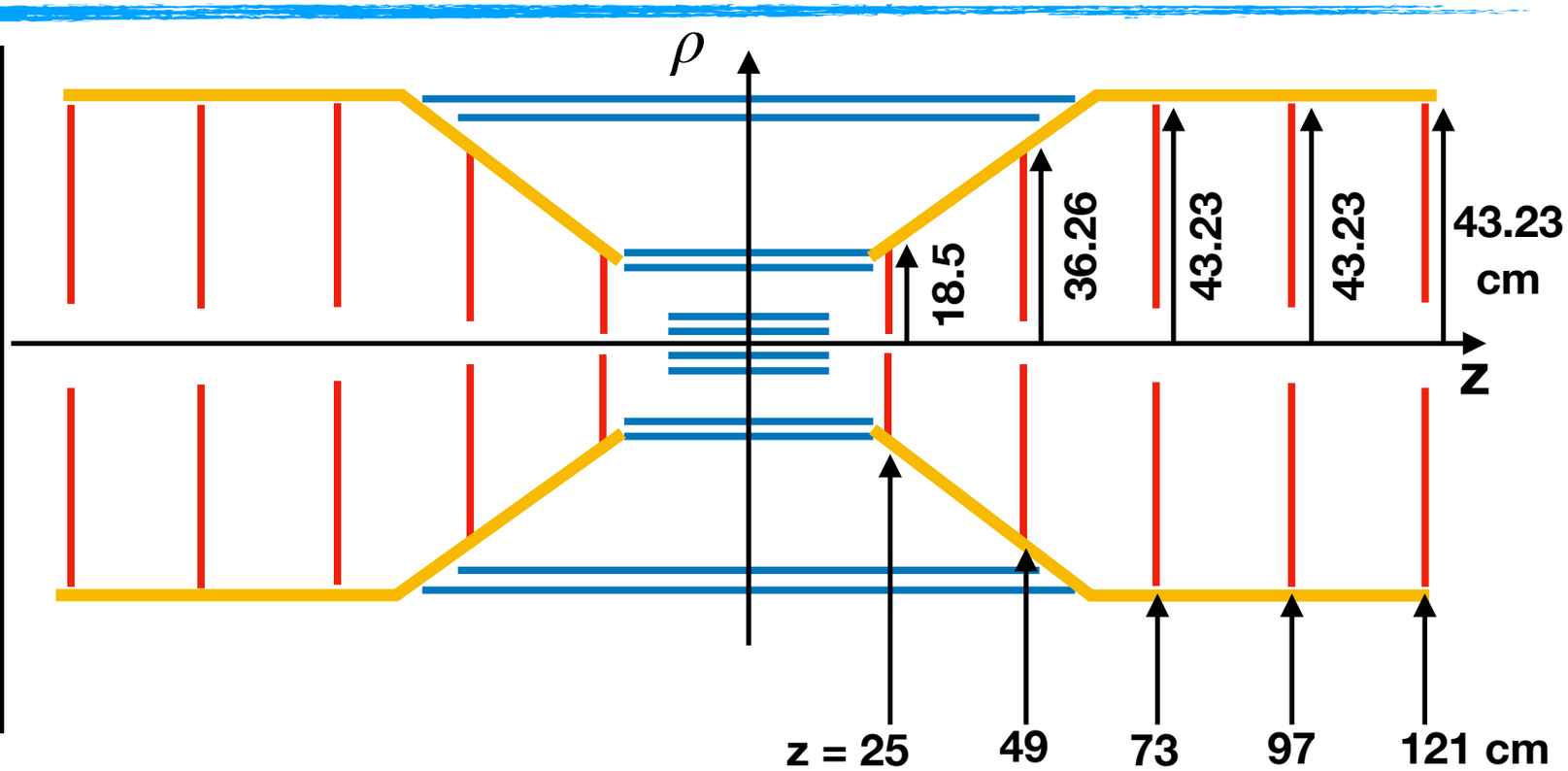
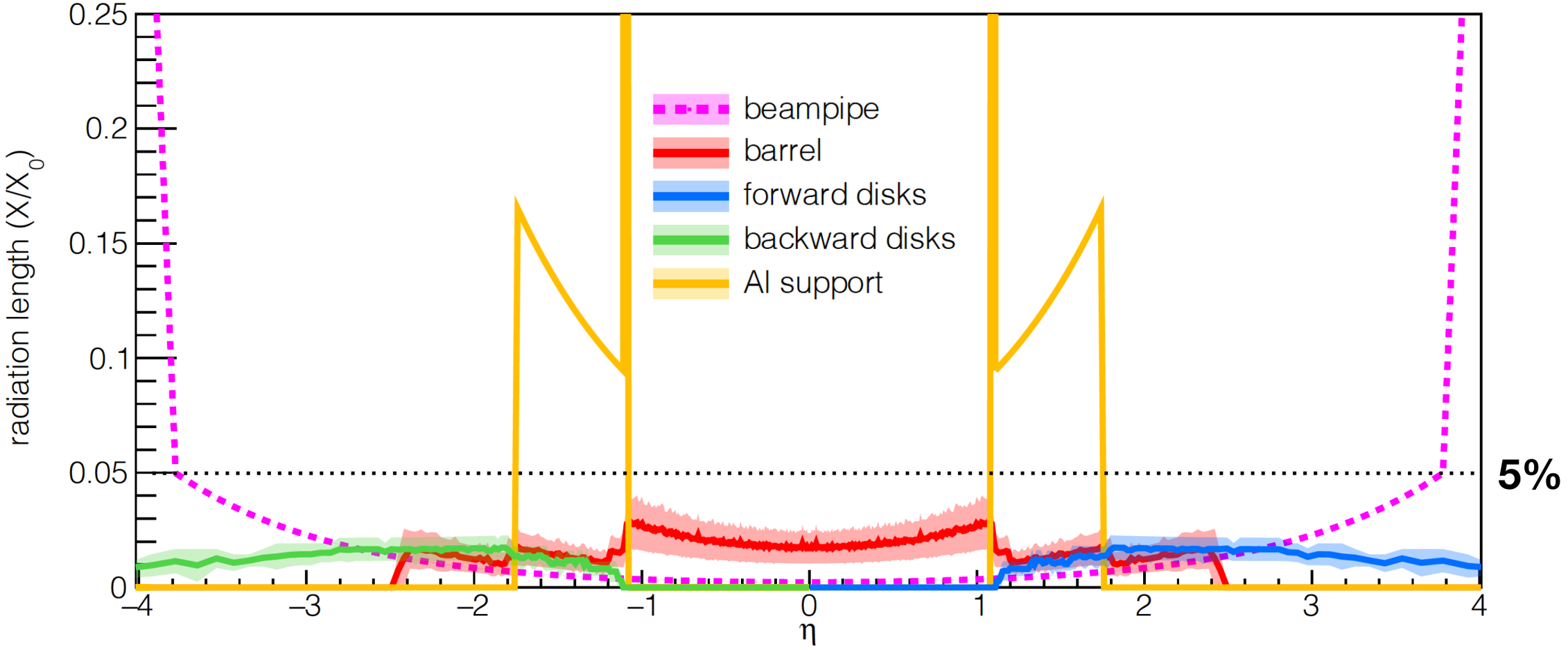
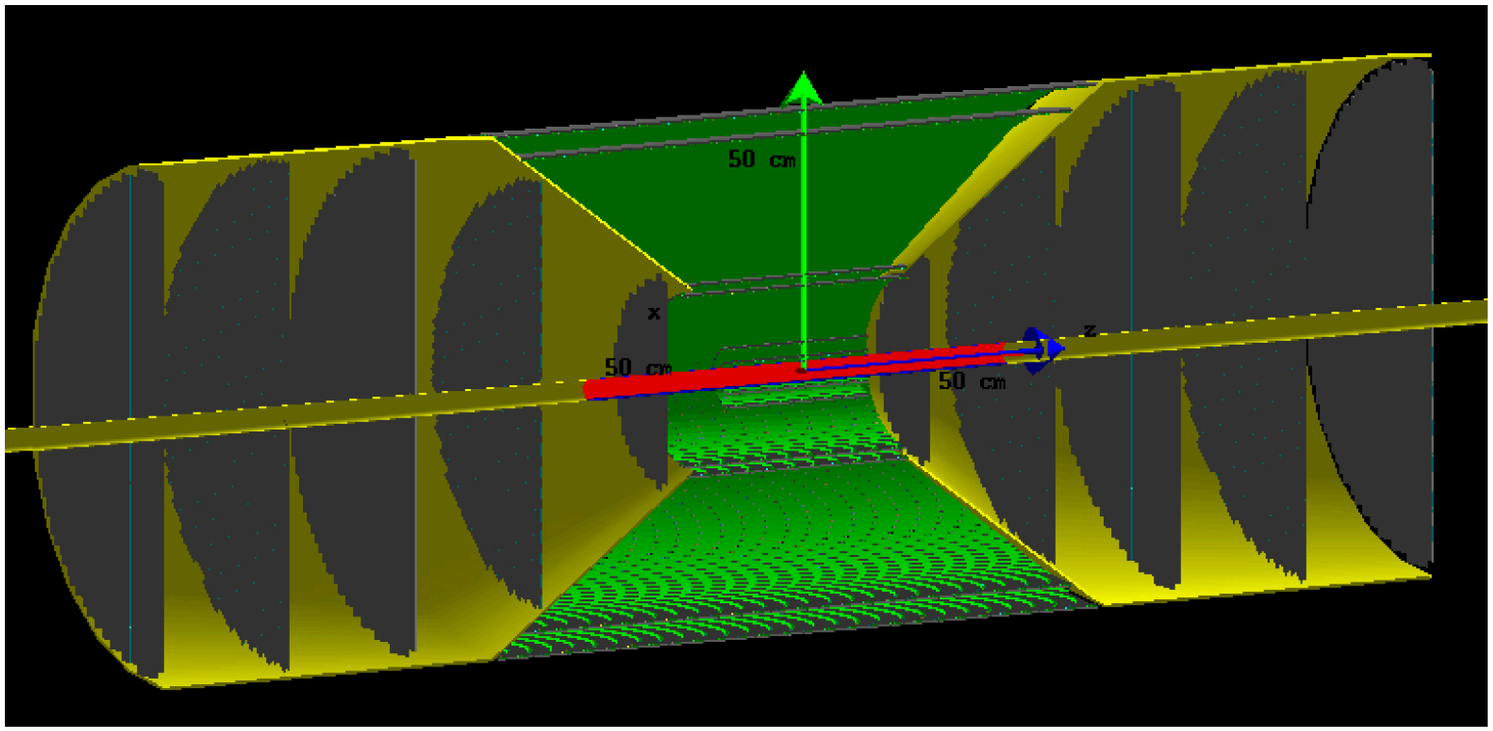


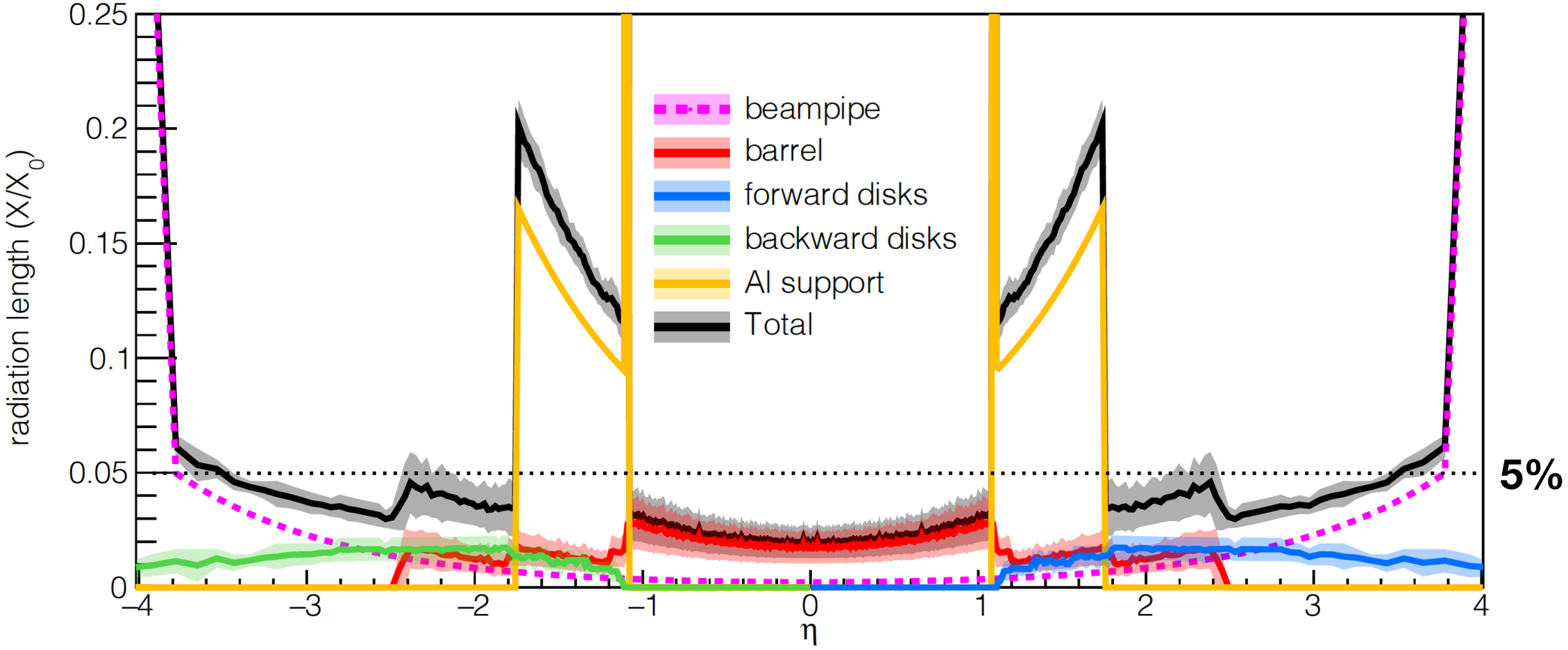




Detector Layout and Material Budget

- Geometry by E. Sichtermann and Y. Lai in EICroot
- Exported as TGeo file
- Imported into Fun4All with help from C. Pinkenburg and J. Huang





Outline

- Detector layout and Material budget

- Detector performance
  - Single-particle resolutions
  - Jet resolutions

- Outlook
  - Can we do better?

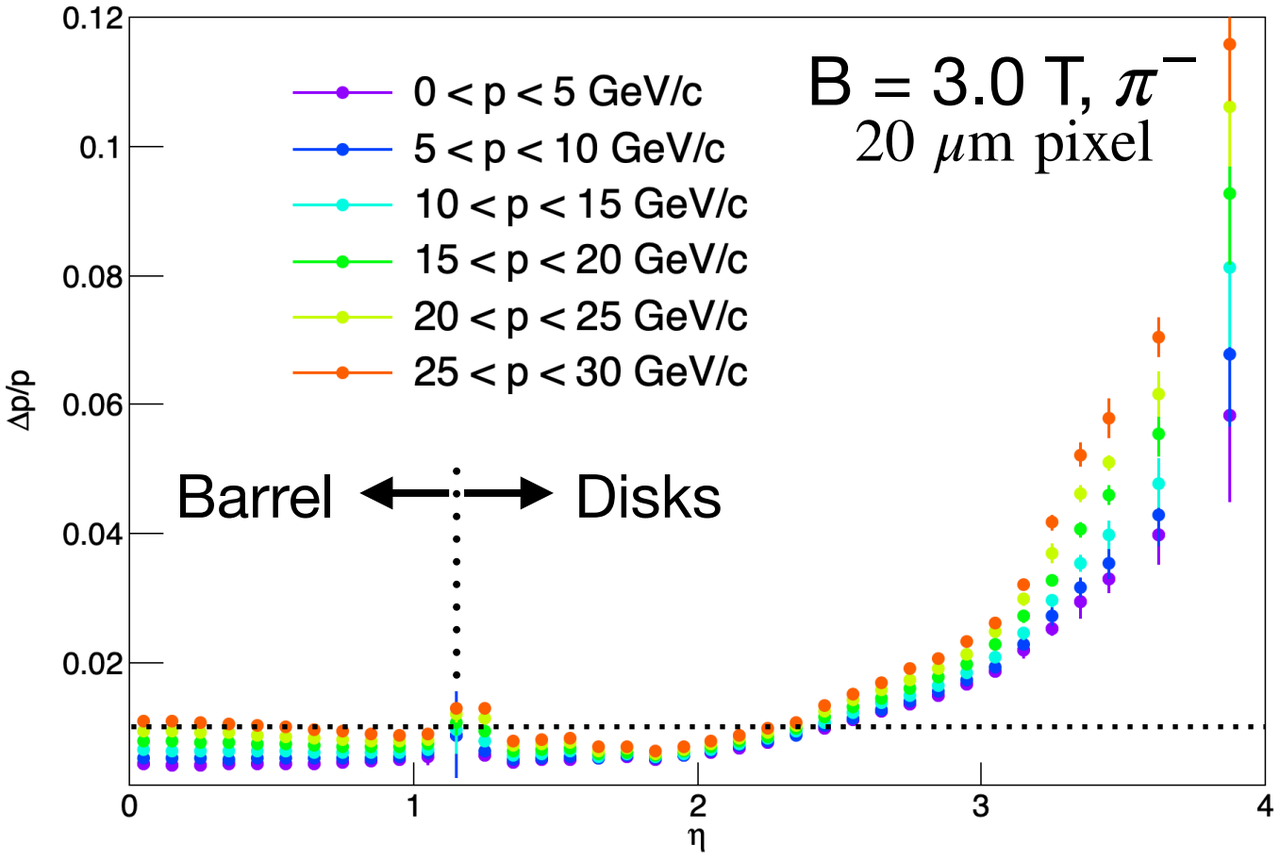
    Complementing the All-Si tracker with other tracking stations.

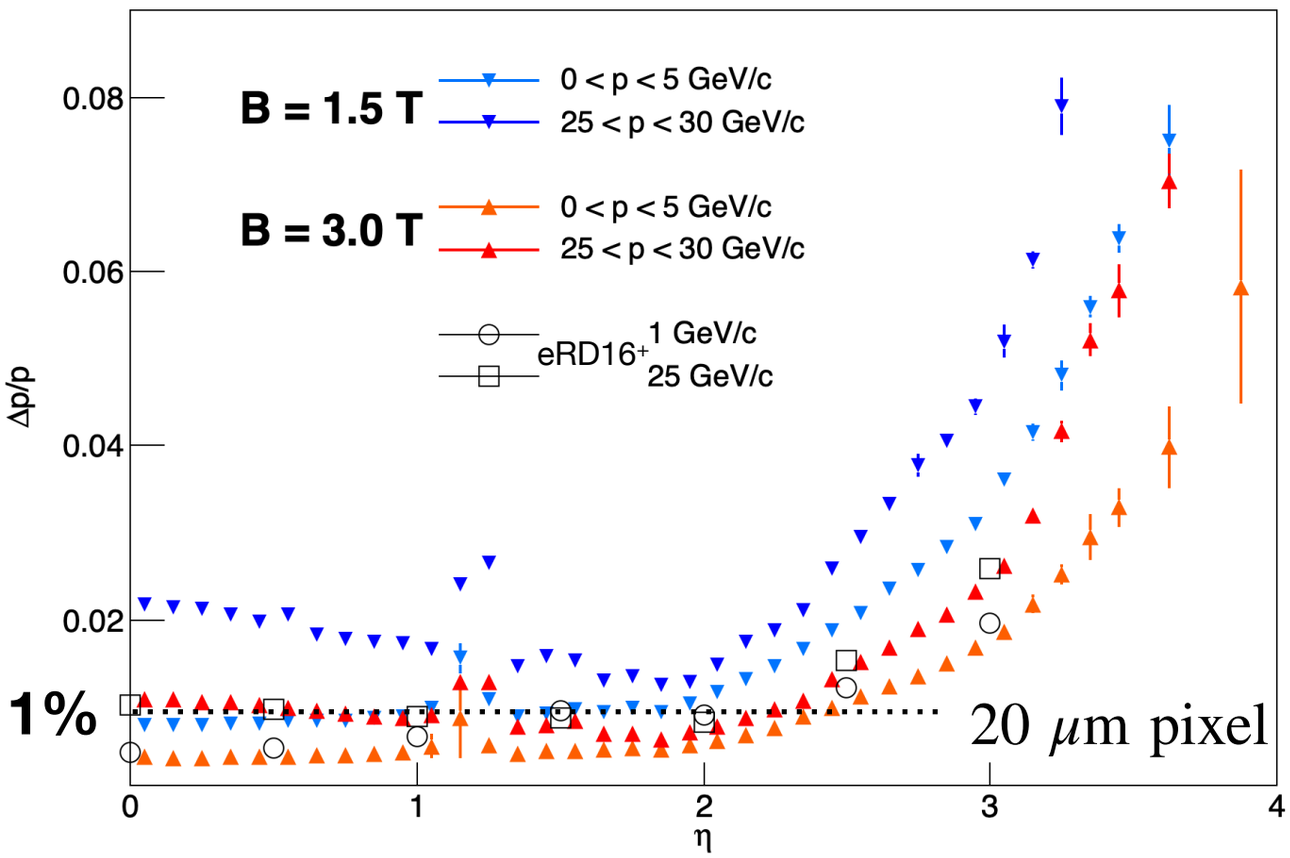
  - Word of caution in the forward direction

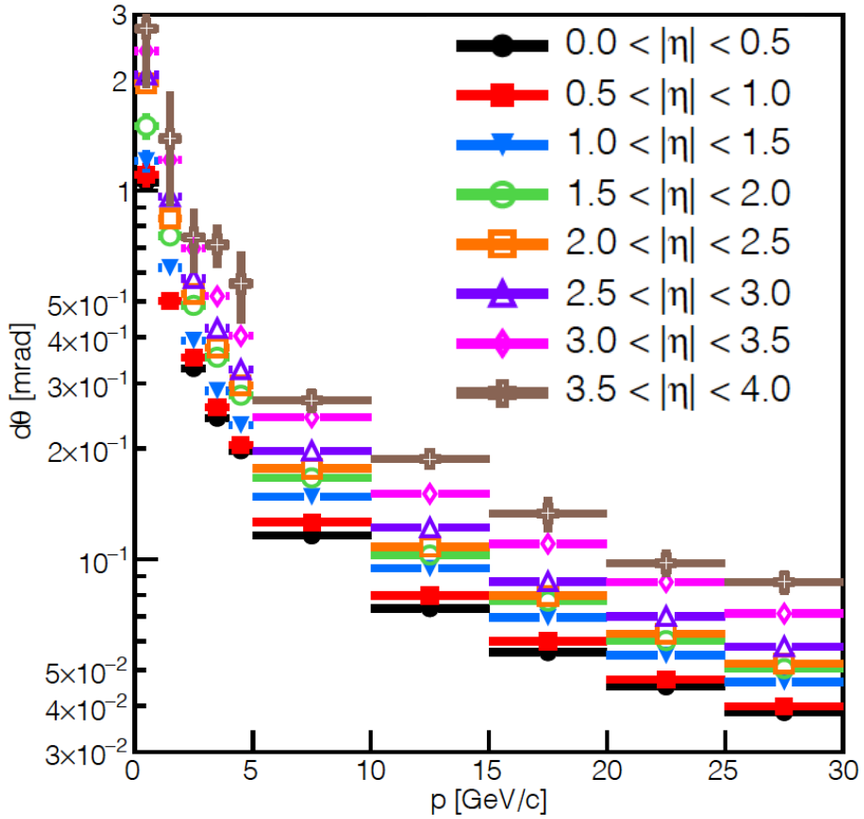
    Azimuthal asymmetry from crossing angle.

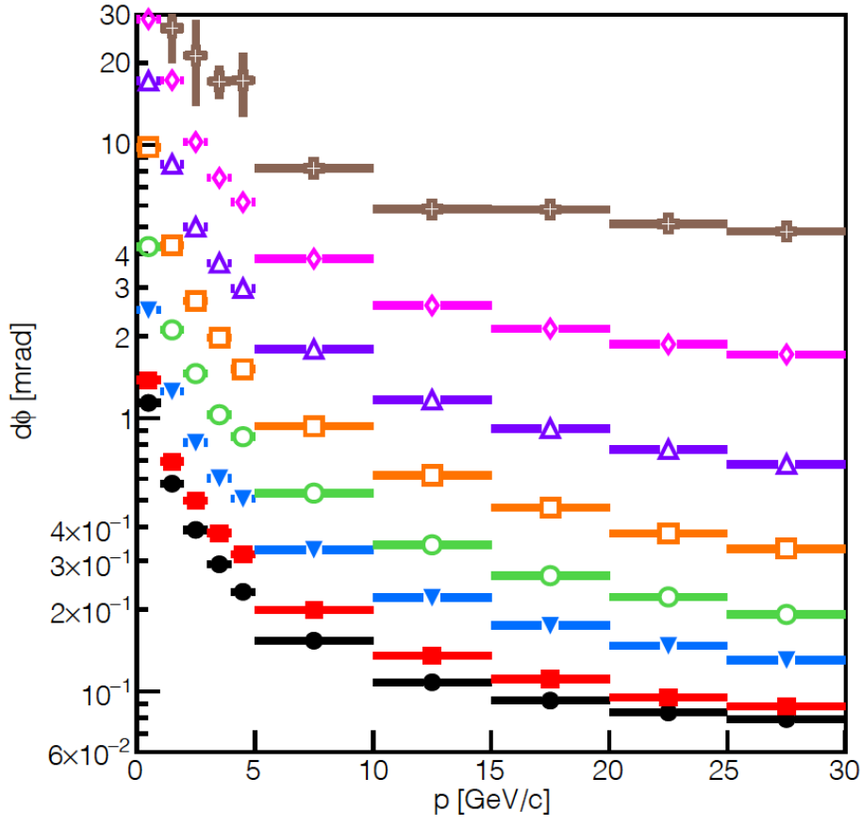
- Summary and Conclusions

Single-Particle Resolutions







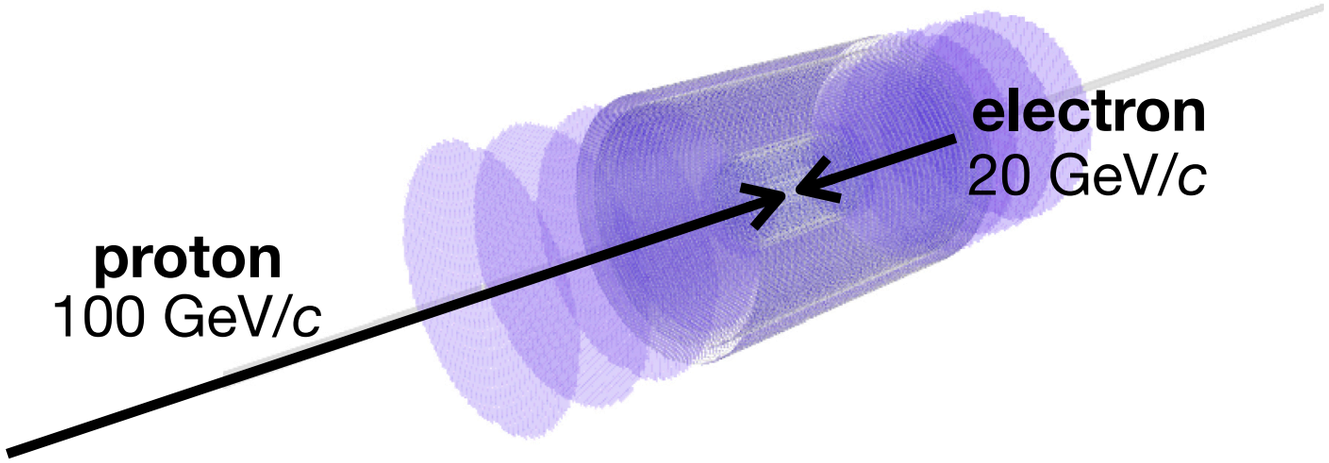


B = 3.0 T

20 μm pixel

Pythia 8 and jet configuration*

- Back-to-back beams with different energies:
  - Beams:frameType=2



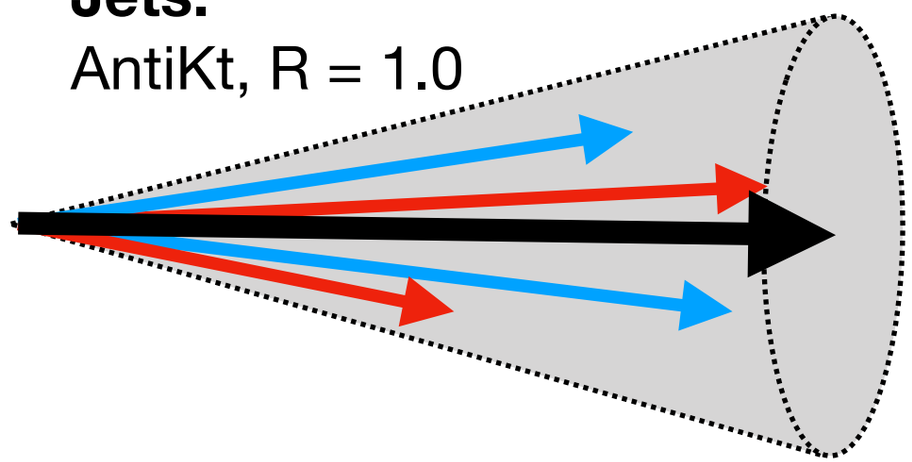
- Scattering $ff' \rightarrow ff'$ via γ^*/Z^0 t-channel exchange (full interference between the γ^* and $\gamma^* Z^0$):
  - WeakBosonExchange:ff2ff(t:gmZ) = on

- All Hard QCD processes on:
  - HardQCD:all = on

$$Q^2 > 16\ (\mathrm{GeV}/c^2)^2$$

*Config file used in arXiv:1912.05931

Jets:
AntiKt, R = 1.0

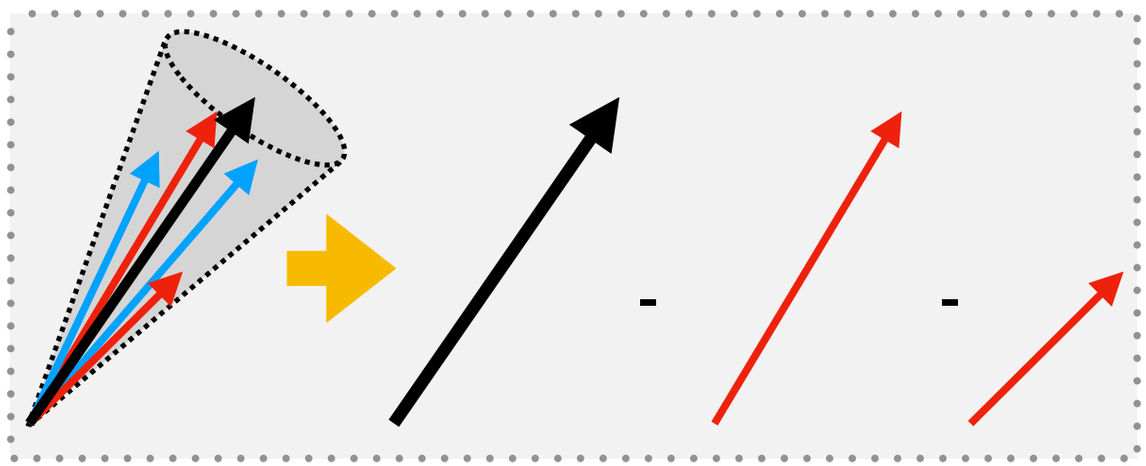


We are using at the moment only tracker (i.e. the detector cannot "see" neutrals)

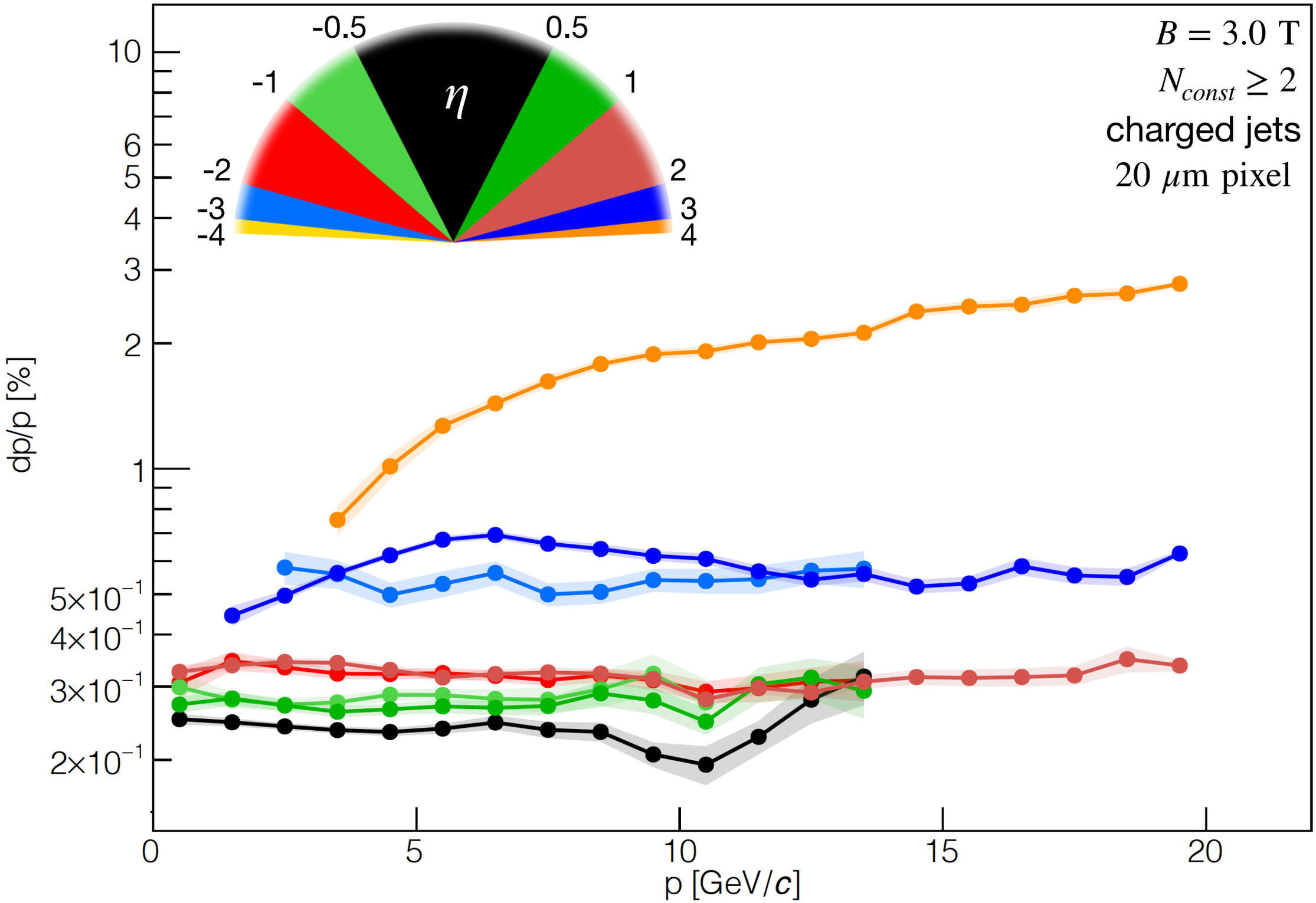
$$p^{jet,\,\mu}_{\mathrm{truth}} = p^{jet,\,\mu}_{\mathrm{charged}} + p^{jet,\,\mu}_{\mathrm{neutral}}$$

Sum of charged constituent 4-momenta

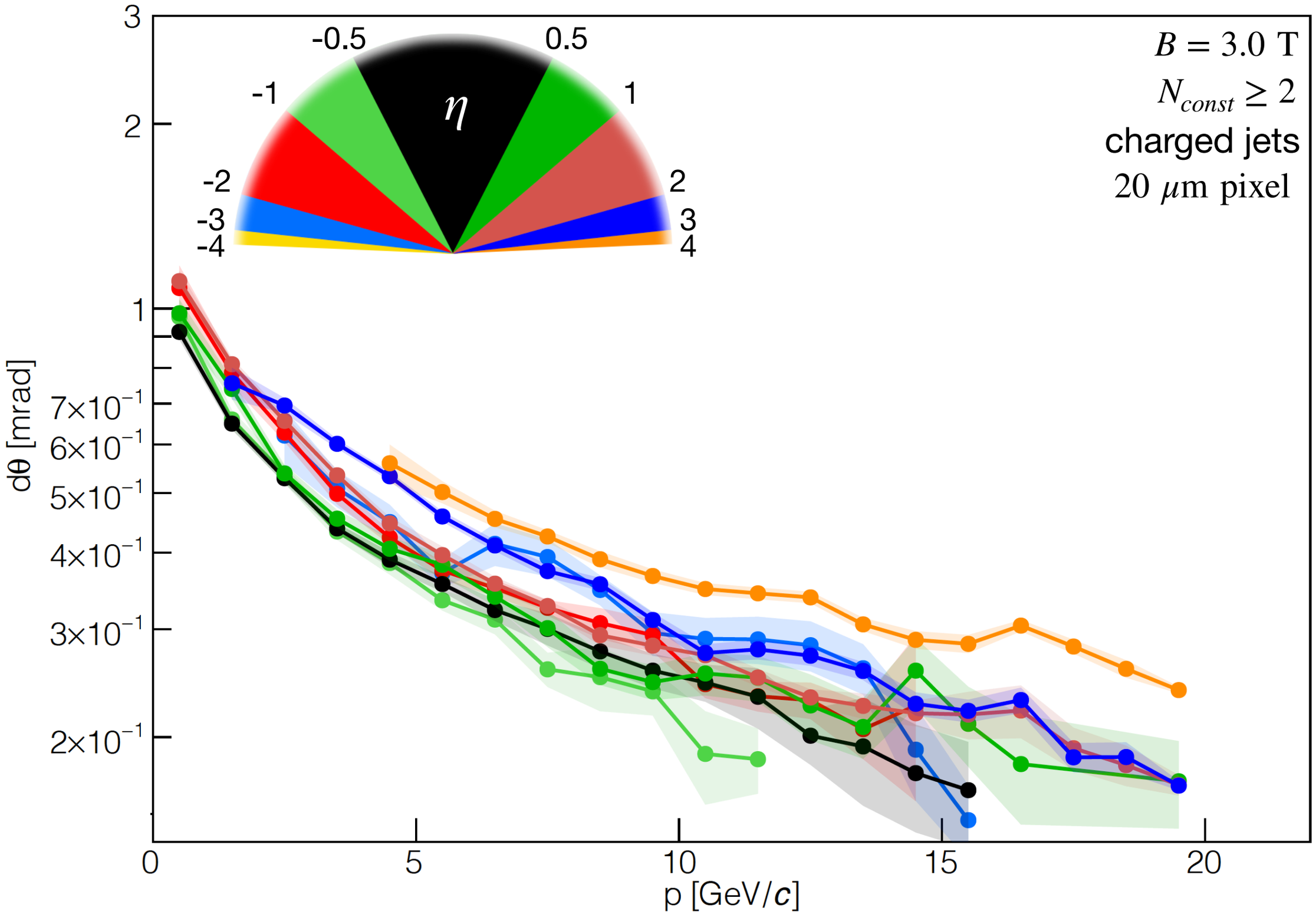
Sum of neutral constituent 4-momenta



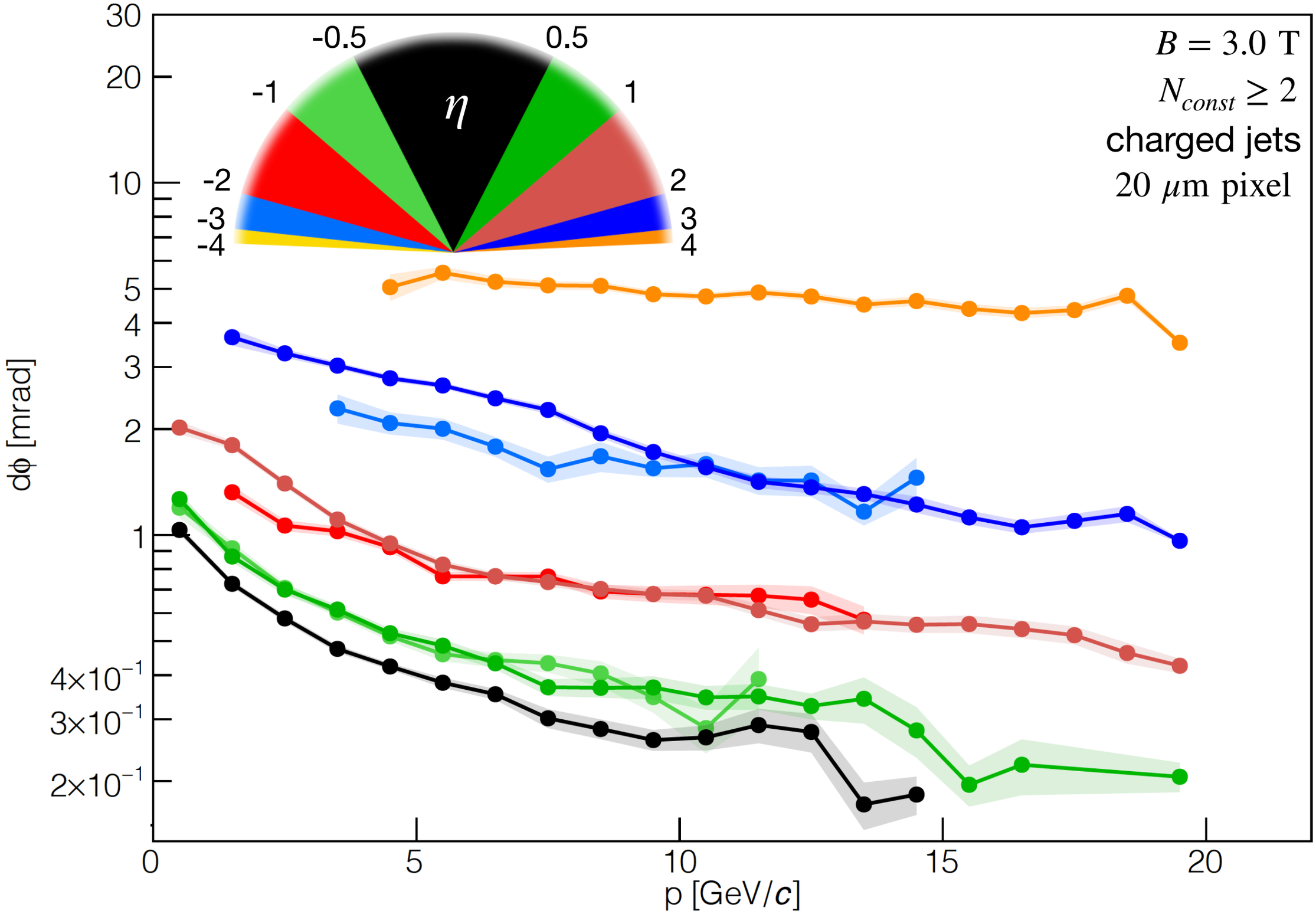
Jet momentum resolution



Jet theta resolution



Jet phi resolution



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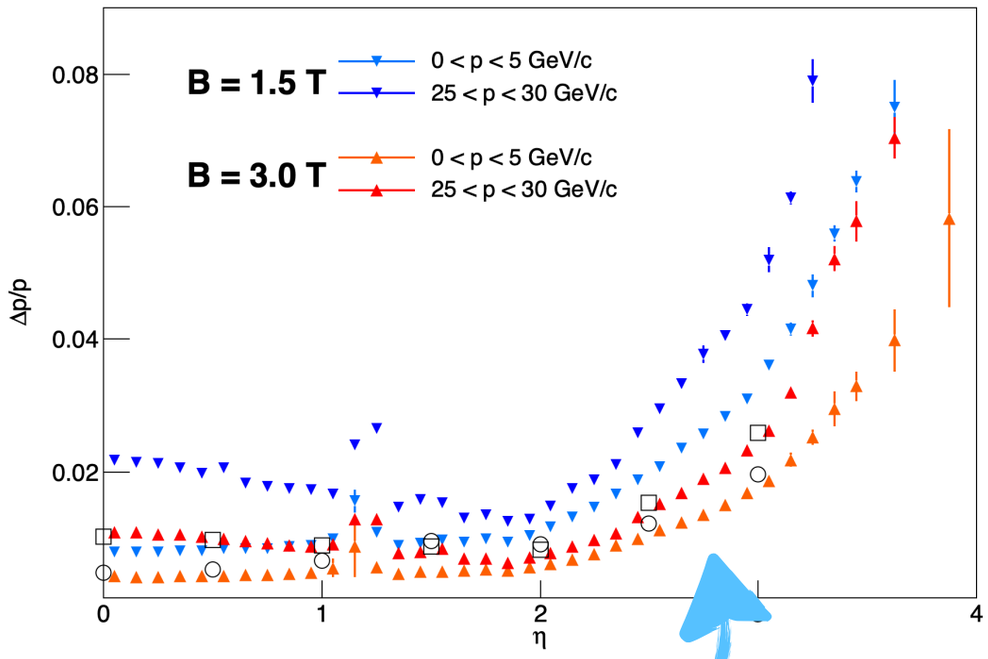

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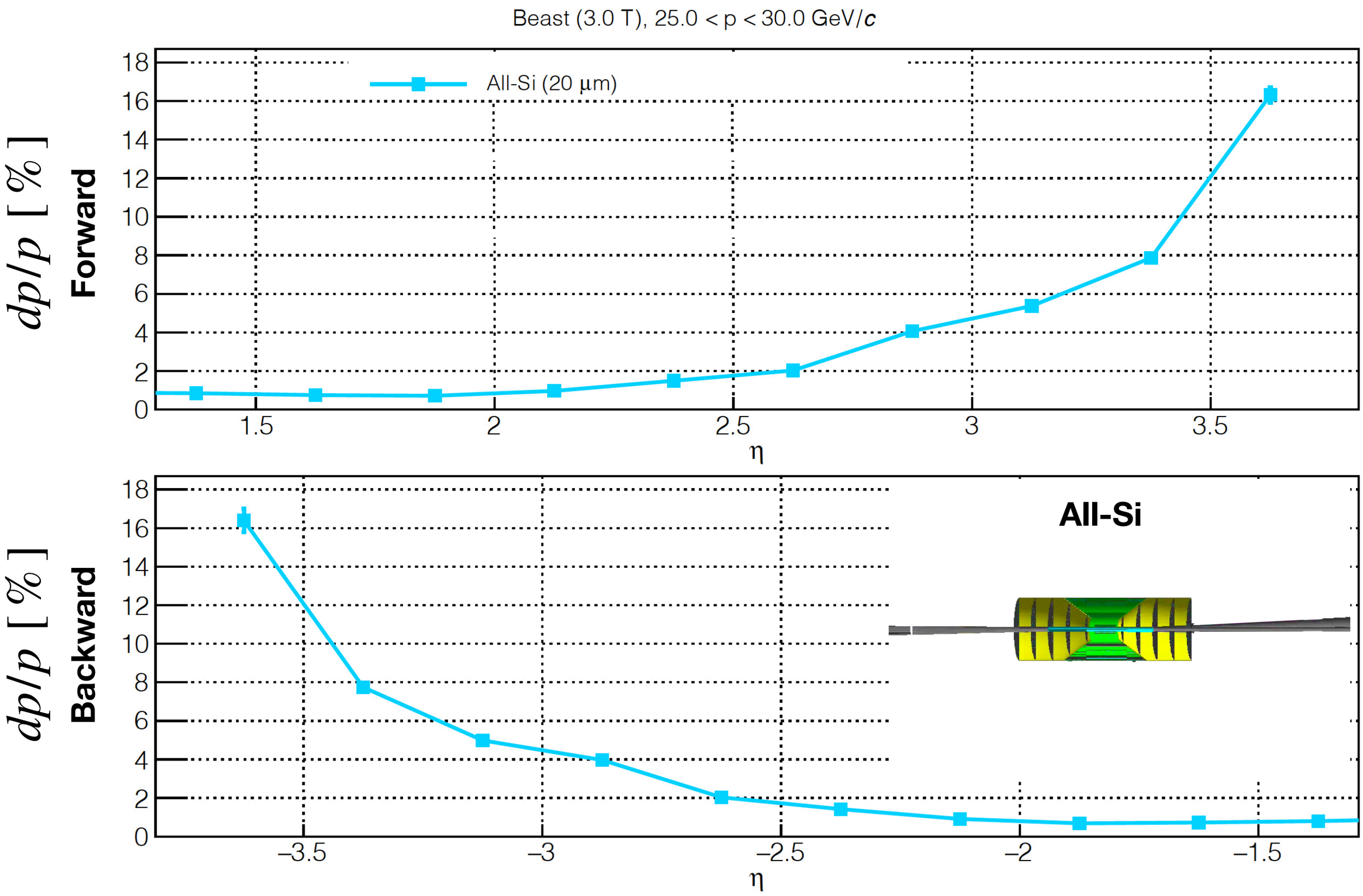
Complementing All-Si tracker with other detectors



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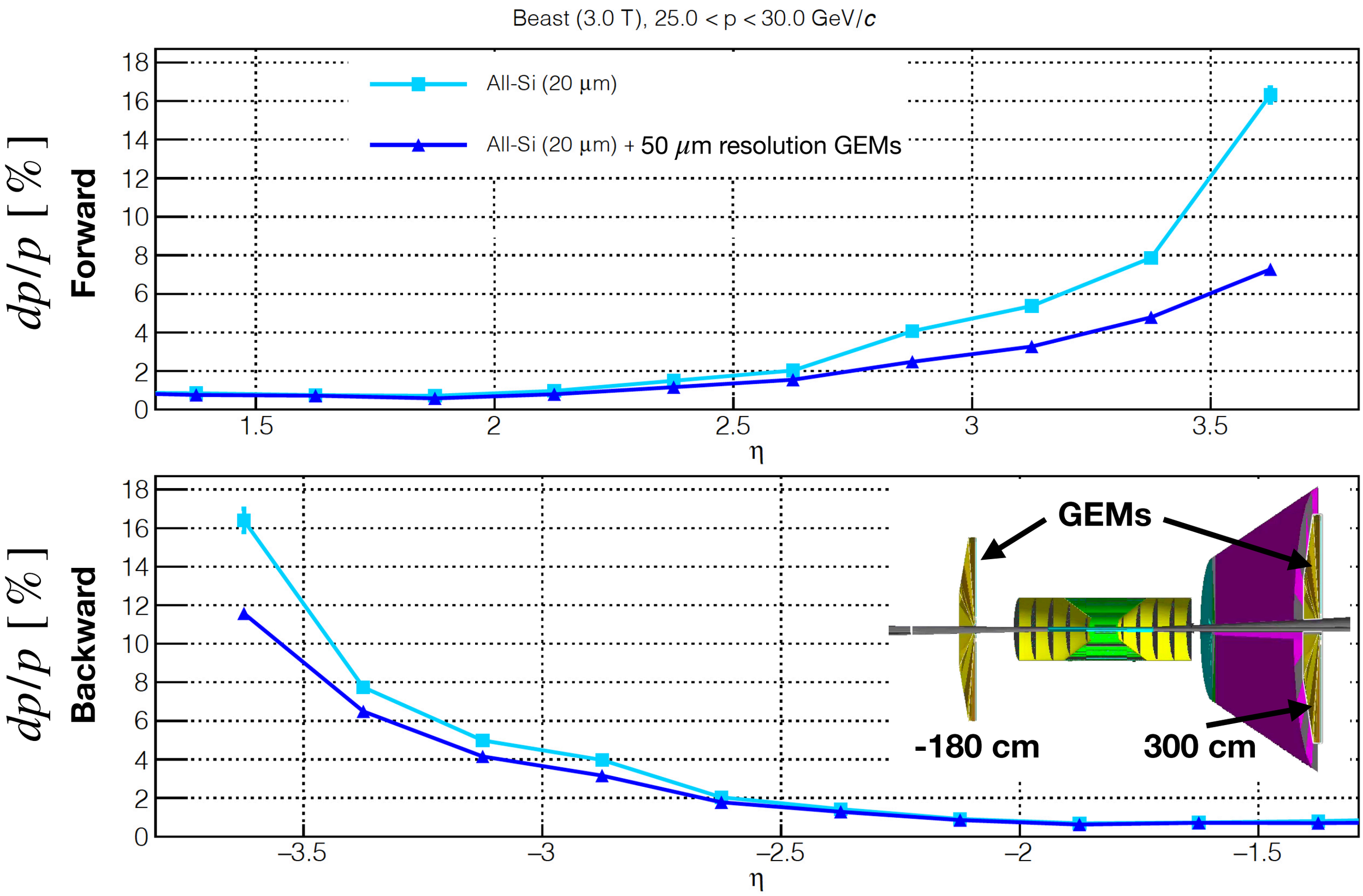

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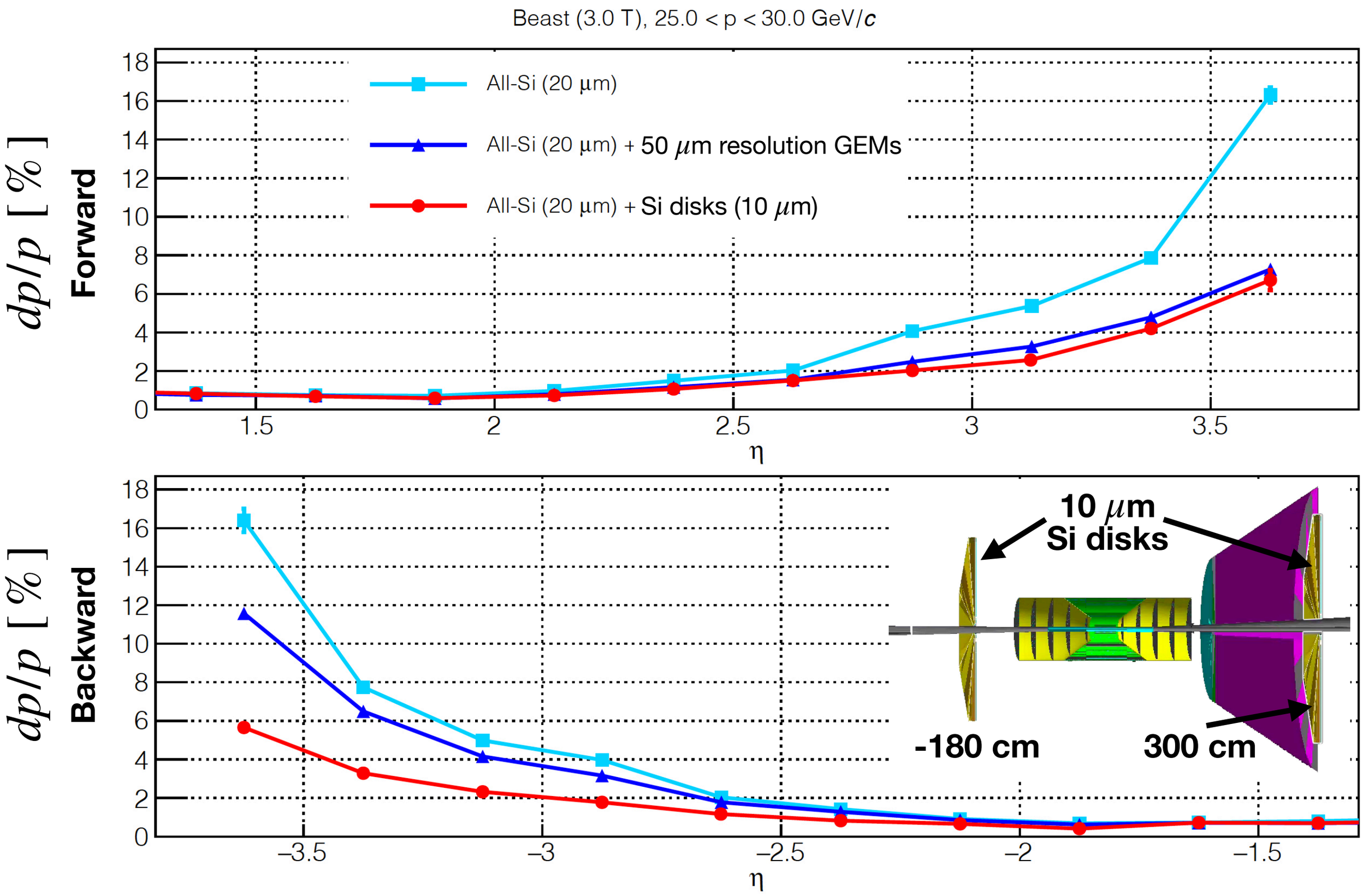

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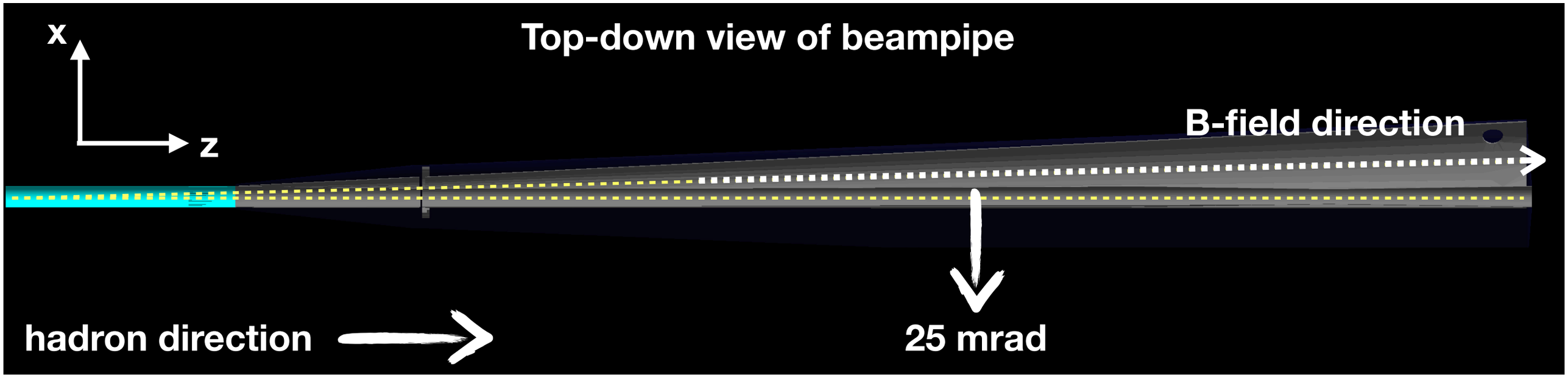
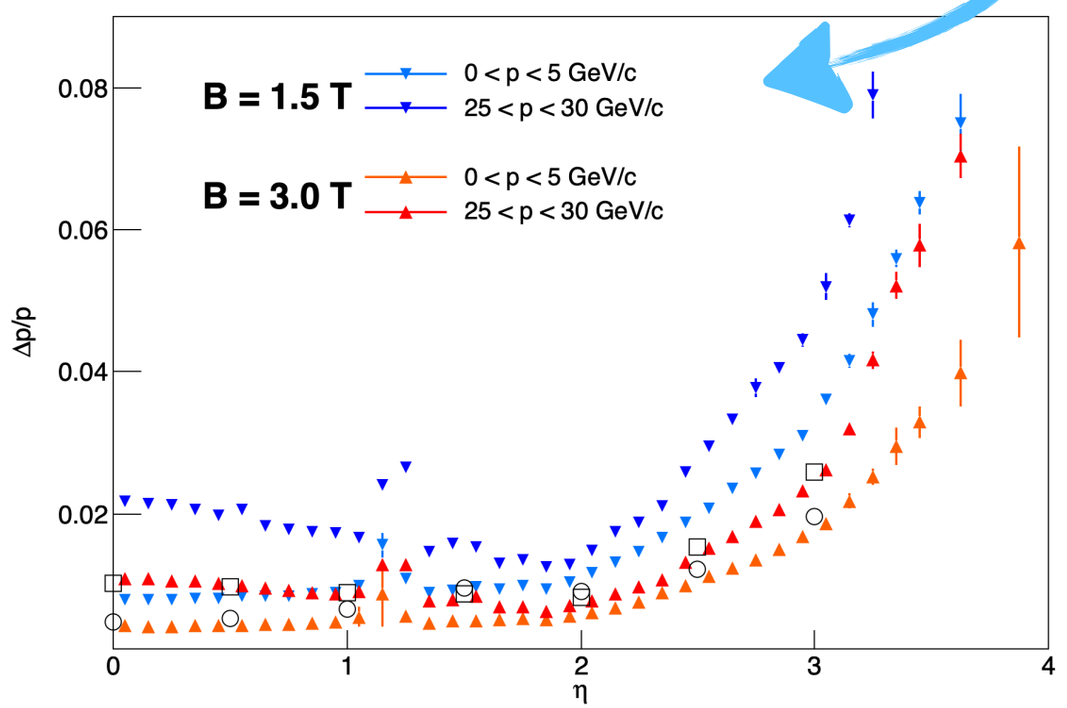
Momentum resolution asymmetry in forward direction

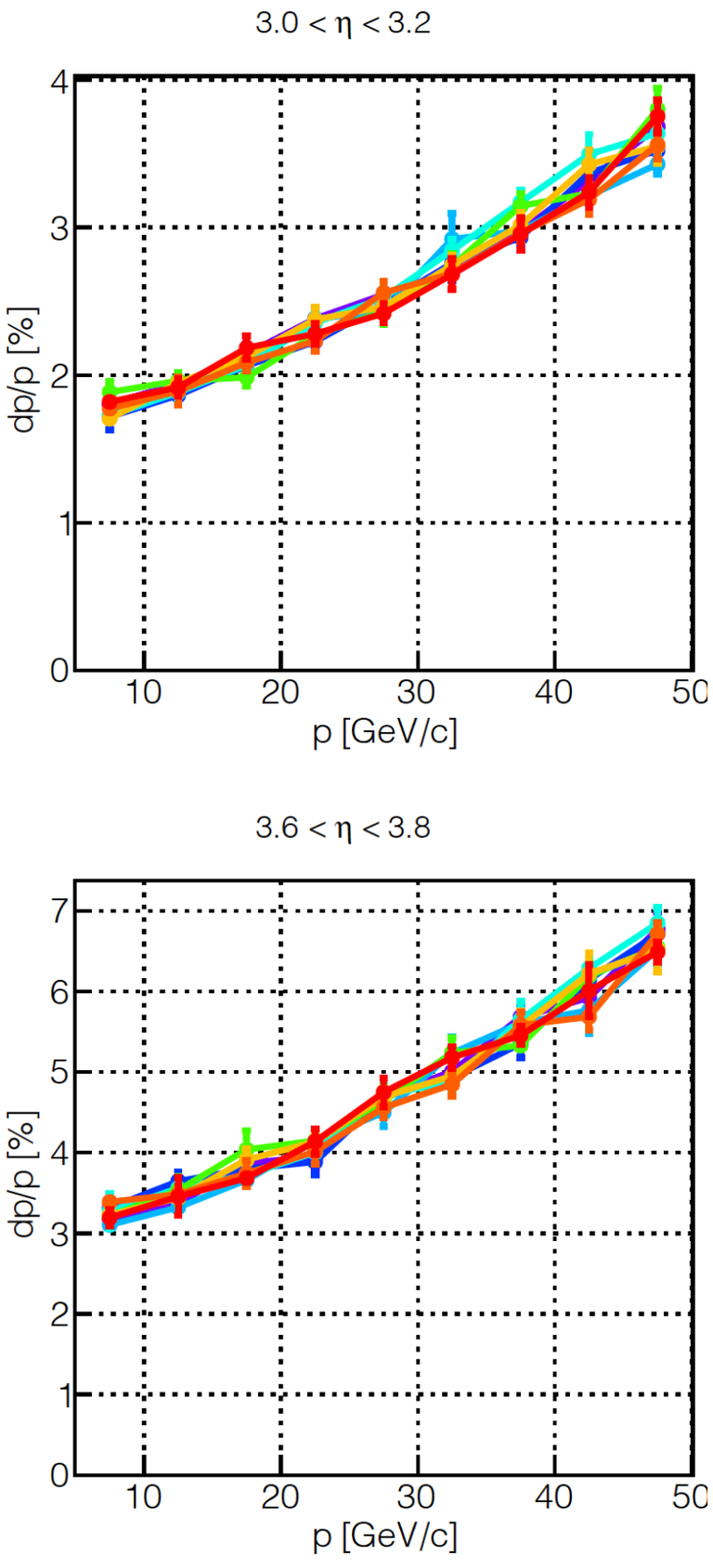


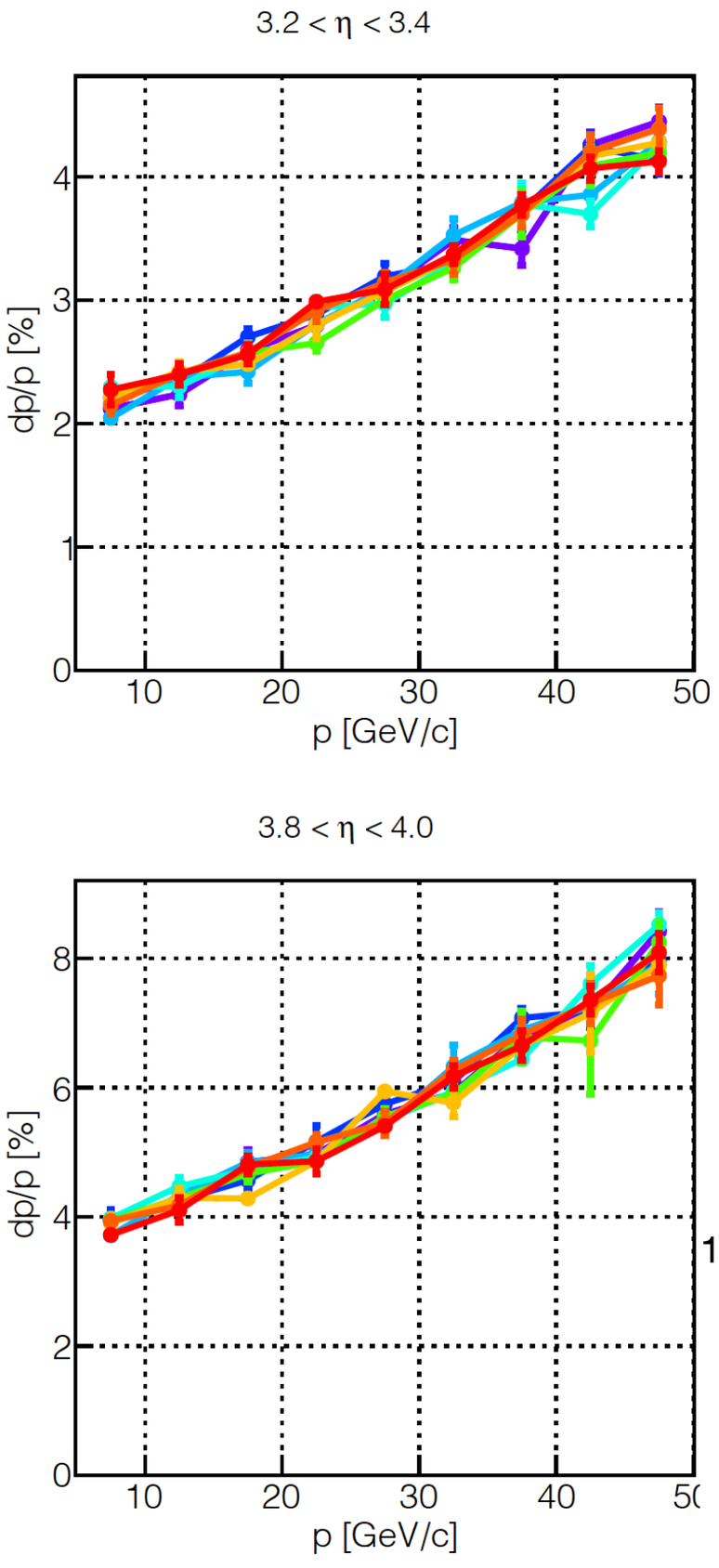
- Results shown so far assuming ϕ independence

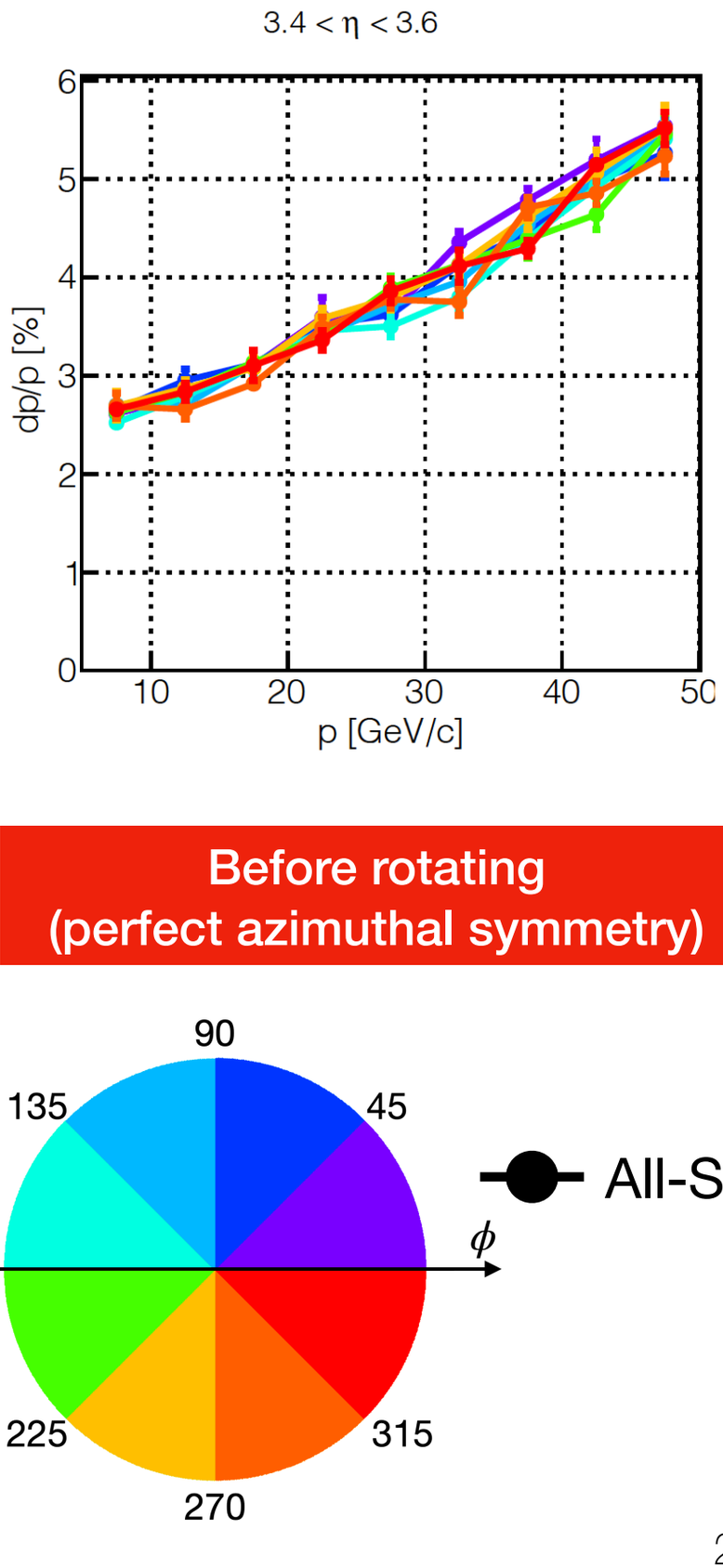
- B field rotated by 25 mrad in hadron-going direction
- $\int B \cdot dl$ depends on ϕ
- Need to take into account asymmetry impact on momentum resolution



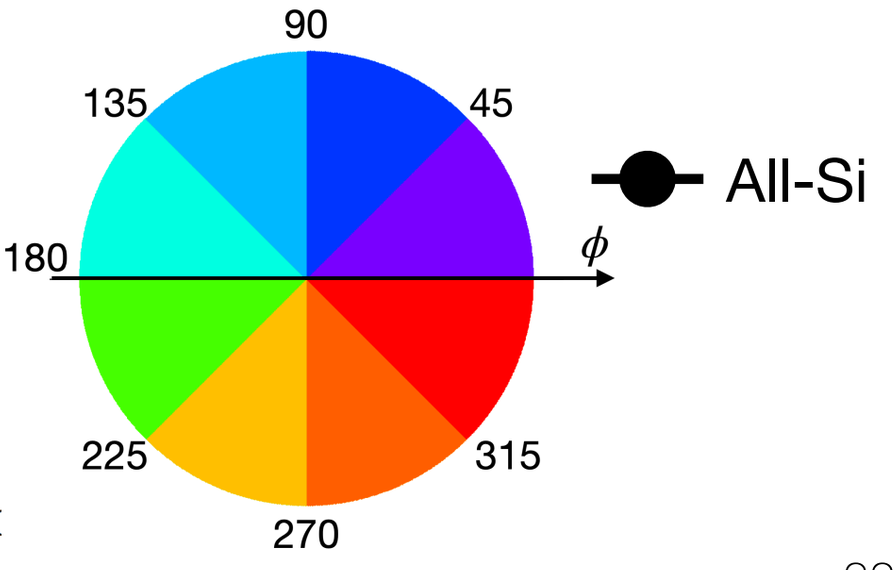
Momentum resolutions before rotation



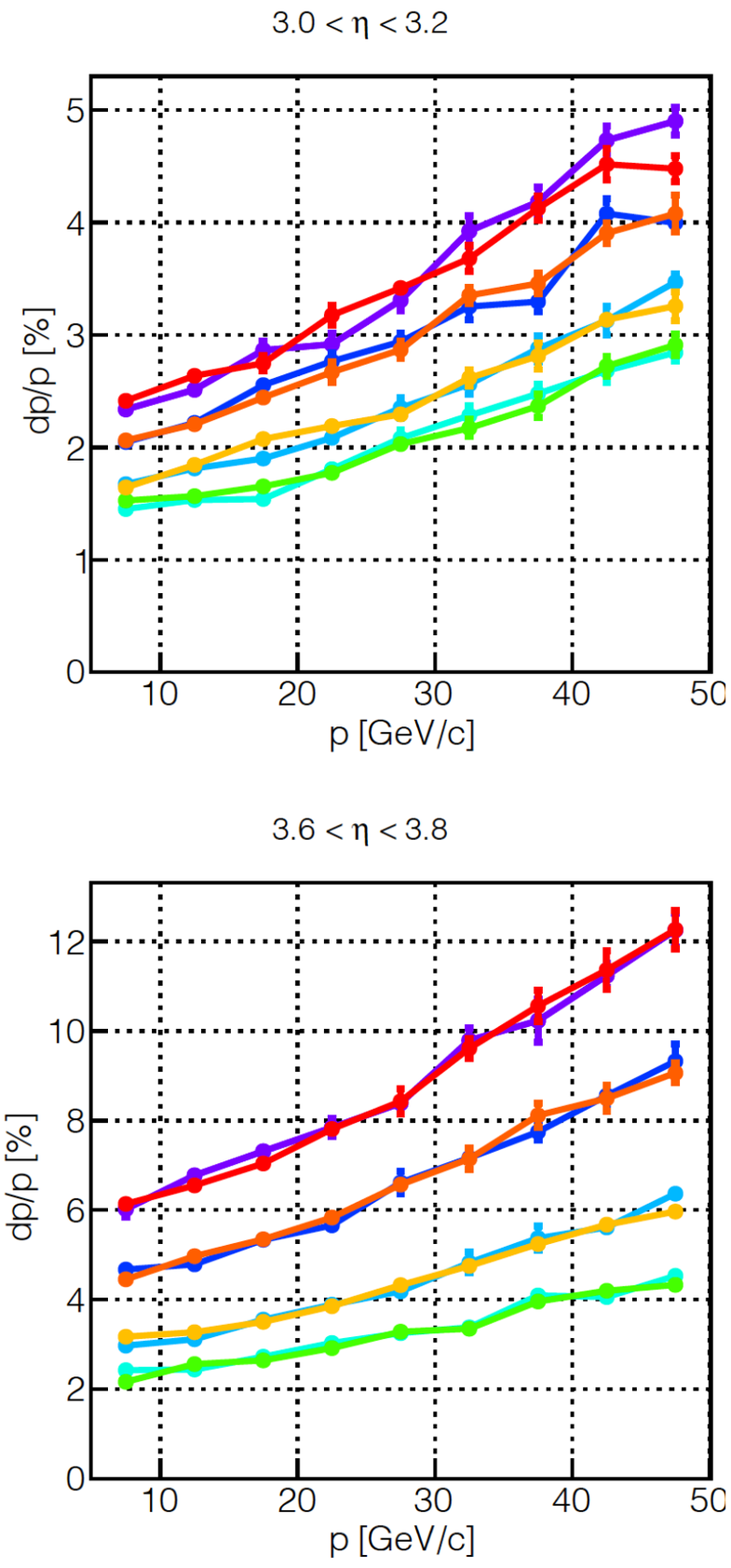


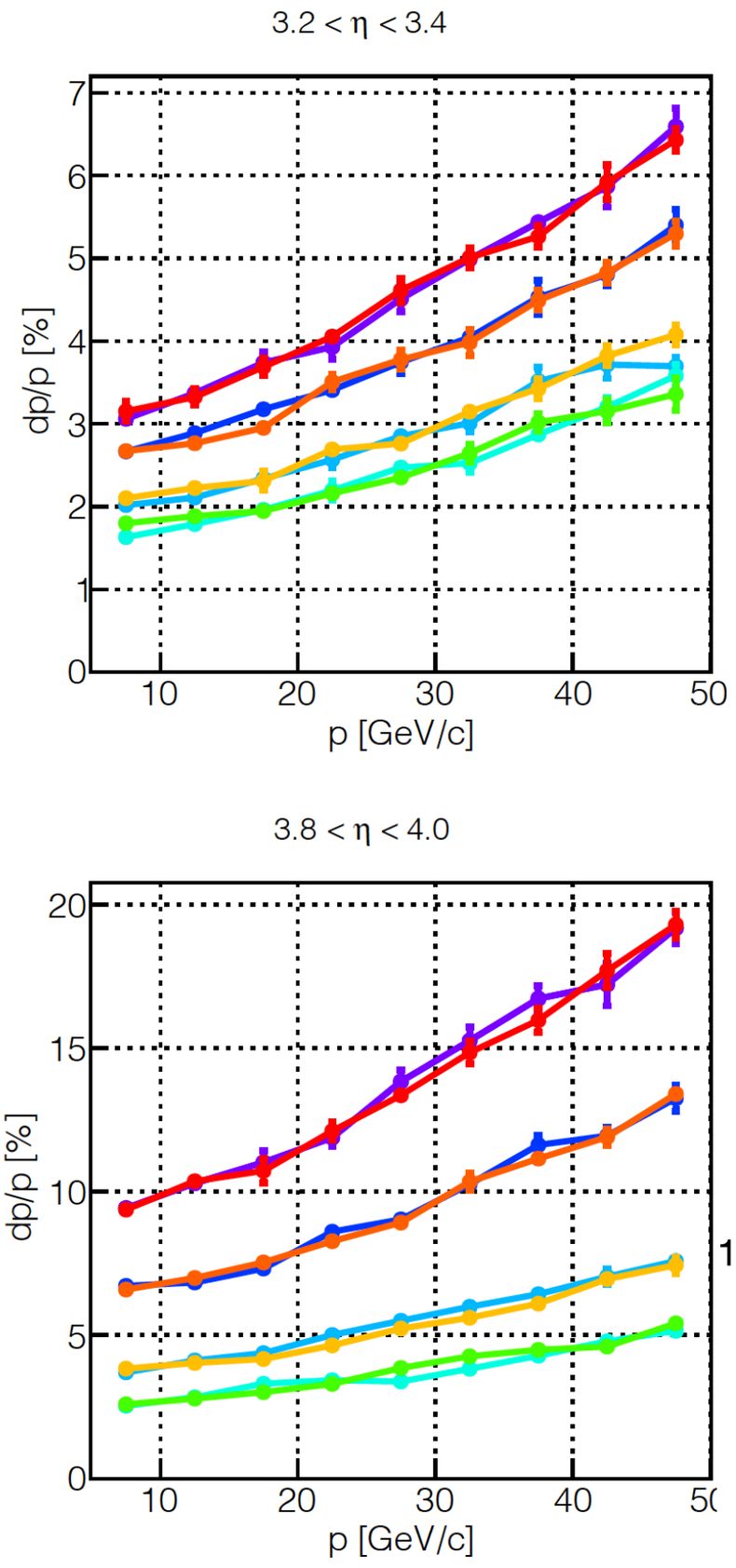


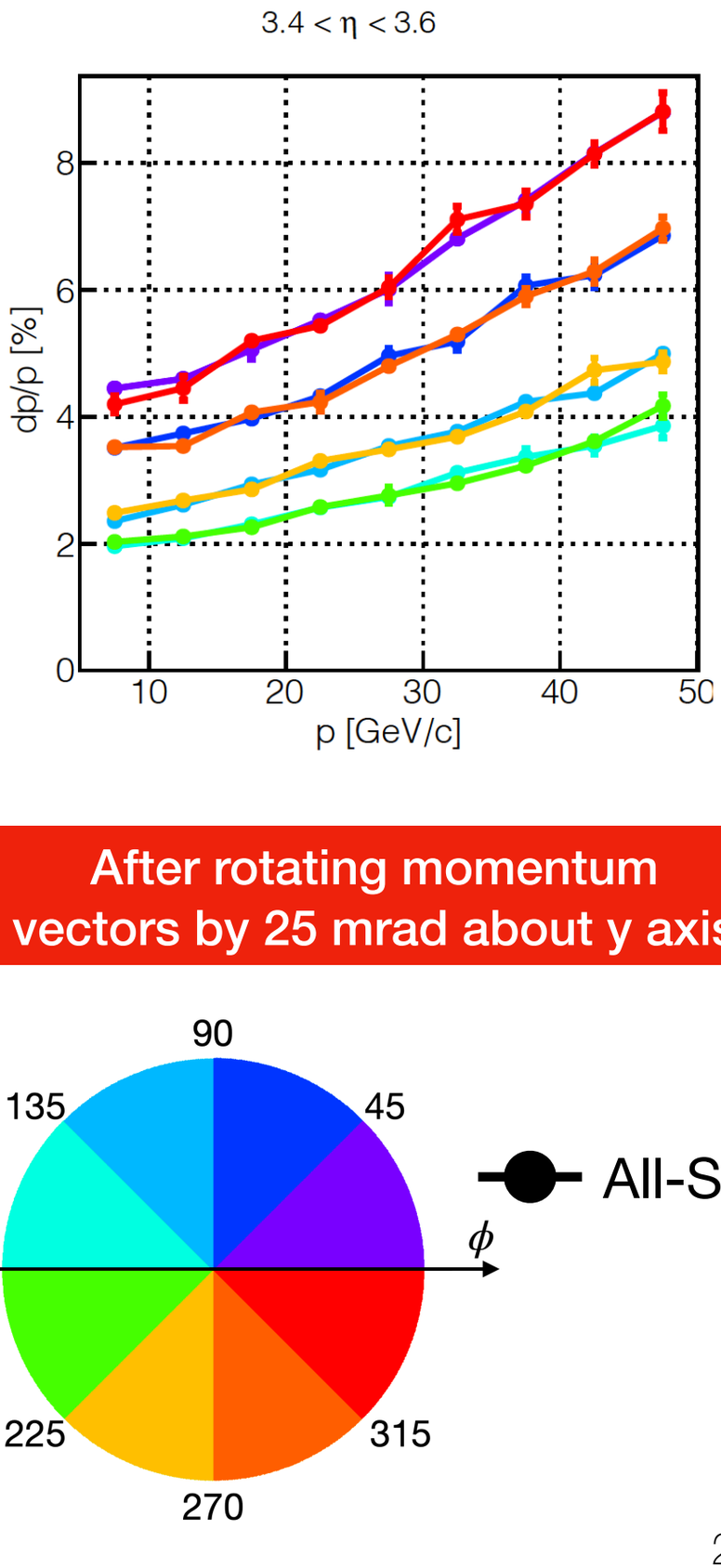
Before rotating (perfect azimuthal symmetry)



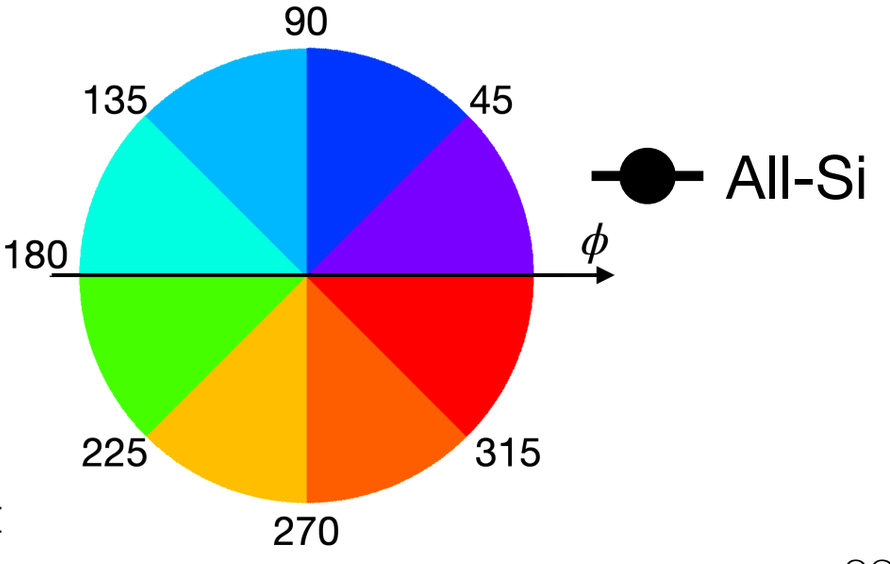
Momentum resolutions after rotation



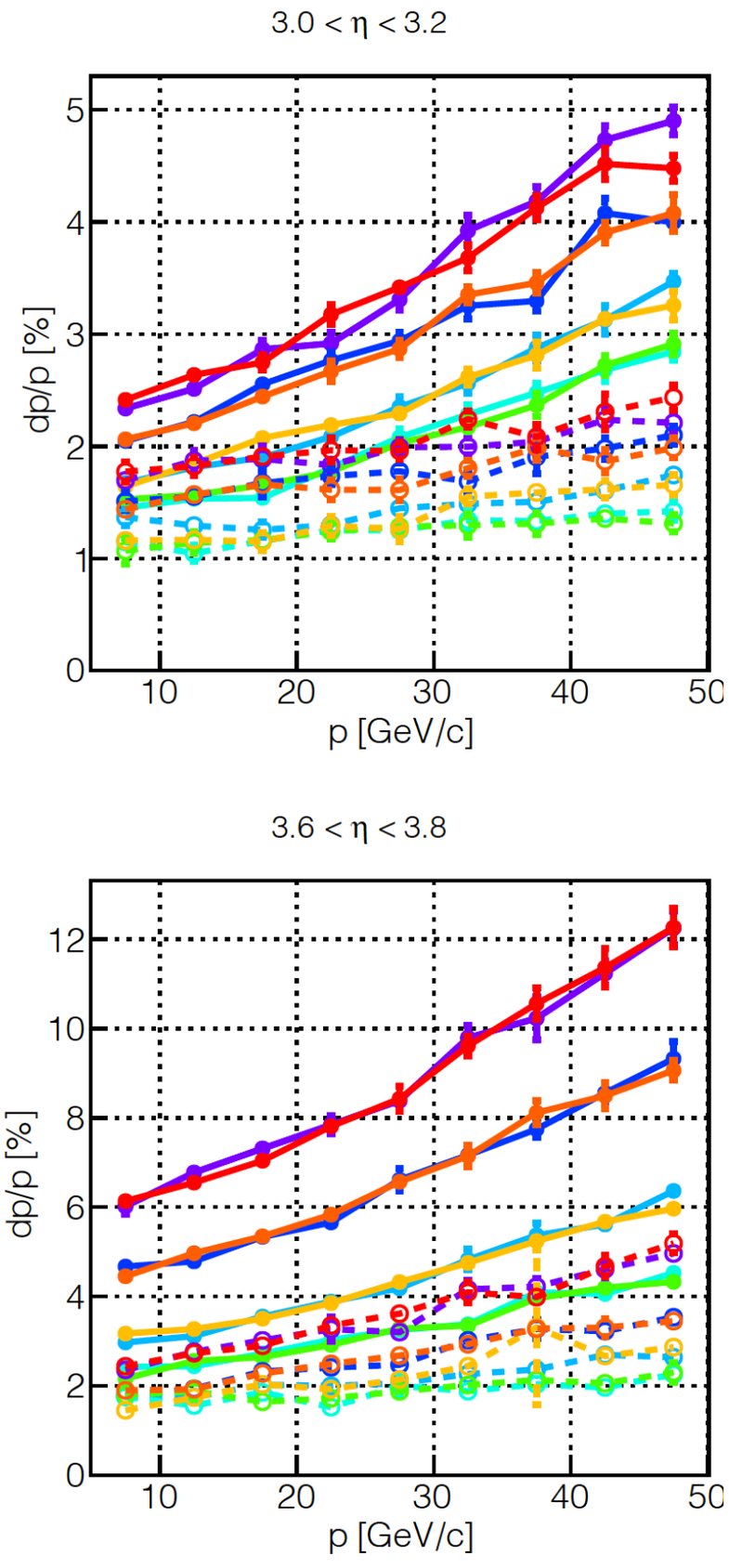


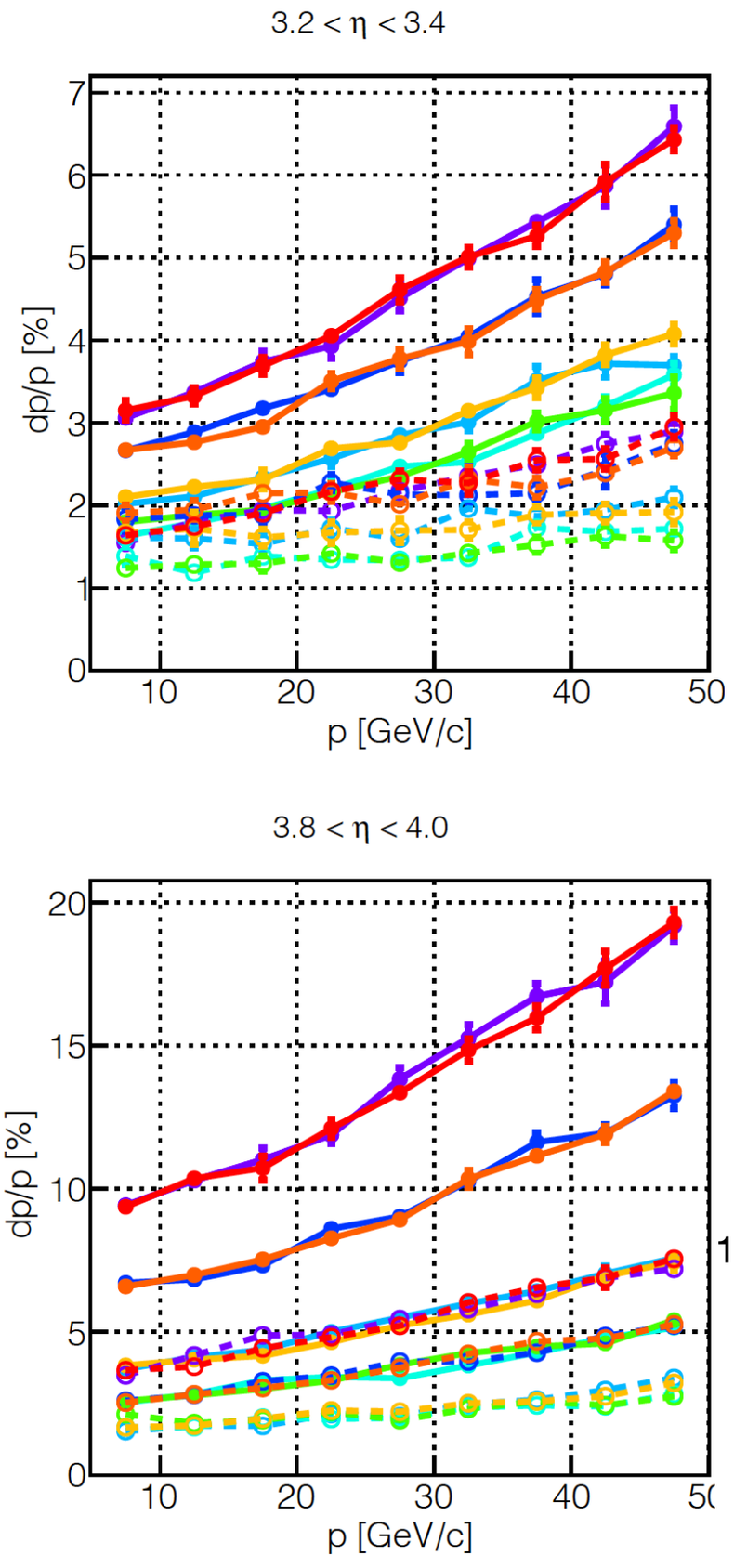


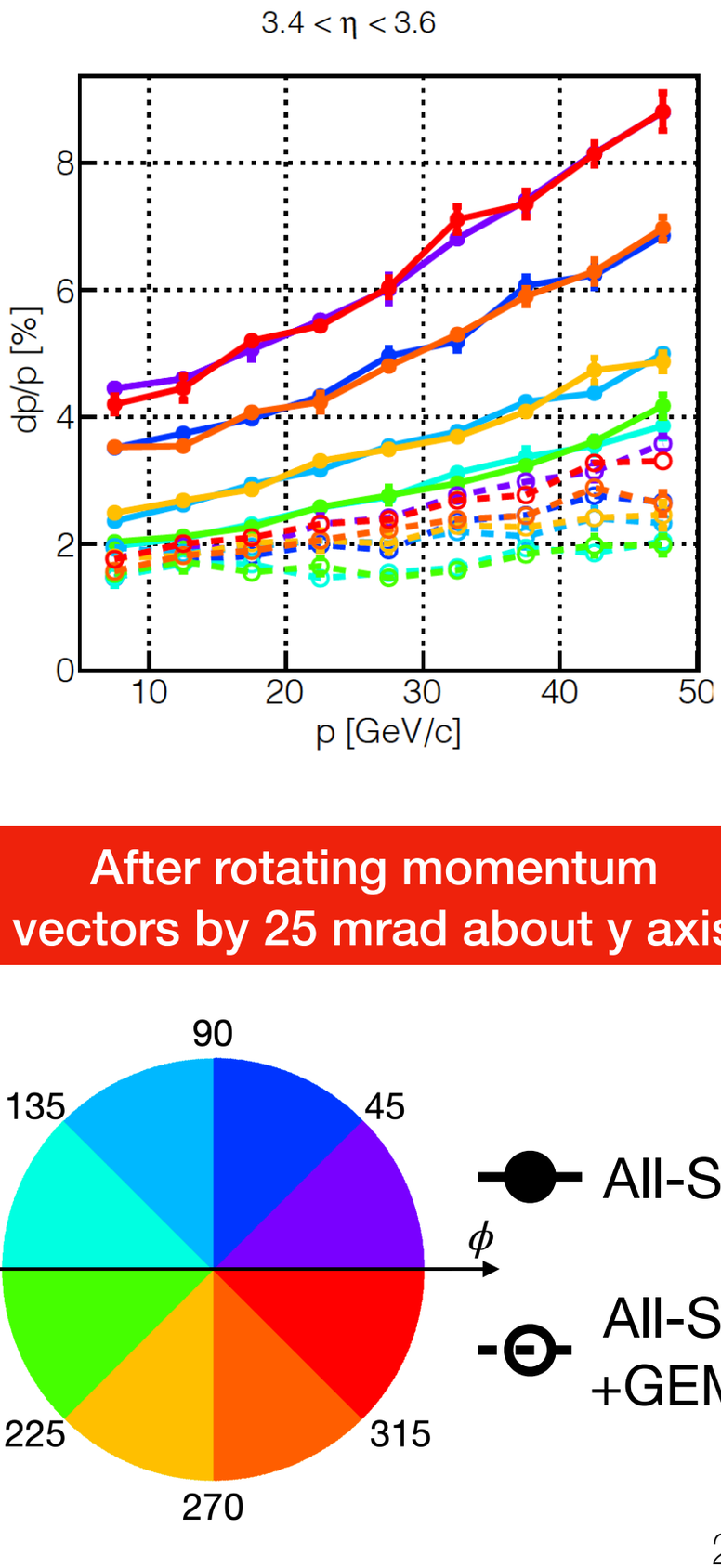
After rotating momentum vectors by 25 mrad about y axis



Momentum resolutions after rotation







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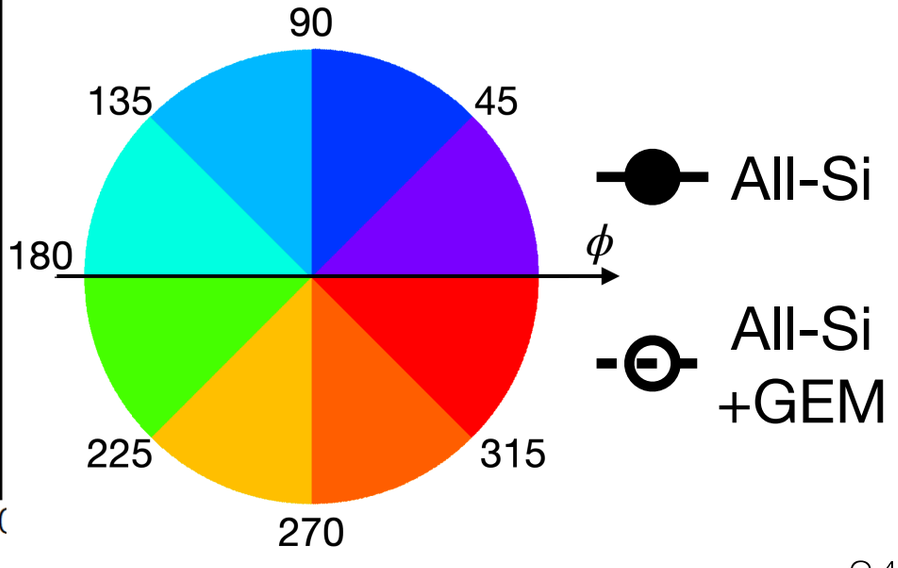

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Summary and Conclusions

- Studied All-Silicon tracker prototype for the EIC in Fun4All
- Single particles:
  - **momentum** resolution: **~1%** for $|\eta| \lesssim 2.5$ (B = 3T)
  - $d\theta < 0.2$ **mrad**, $d\phi < 1$ **mrad** for $|\eta| \lesssim 2.5, p > 5$ GeV/*c*
- Tracker satisfies requirements outlined in EIC detector handbook
- Studied **jet** resolutions (for jets with $p < 20$ GeV/c):
  - **momentum** resolutions **< 0.7%** (for $|\eta| < 3$)
  - θ resolutions **< 1 mrad**
  - ϕ resolution **0.2 - 6 mrad**
- Can get significantly better resolutions by complementing All-Si tracker with other tracking stations in the forward / backward pseudorapidities.
- Azimuthal momentum-resolution asymmetry in the hadron-going direction.

Thanks for your attention