New All-Silicon Tracker Studies in the Forward Region

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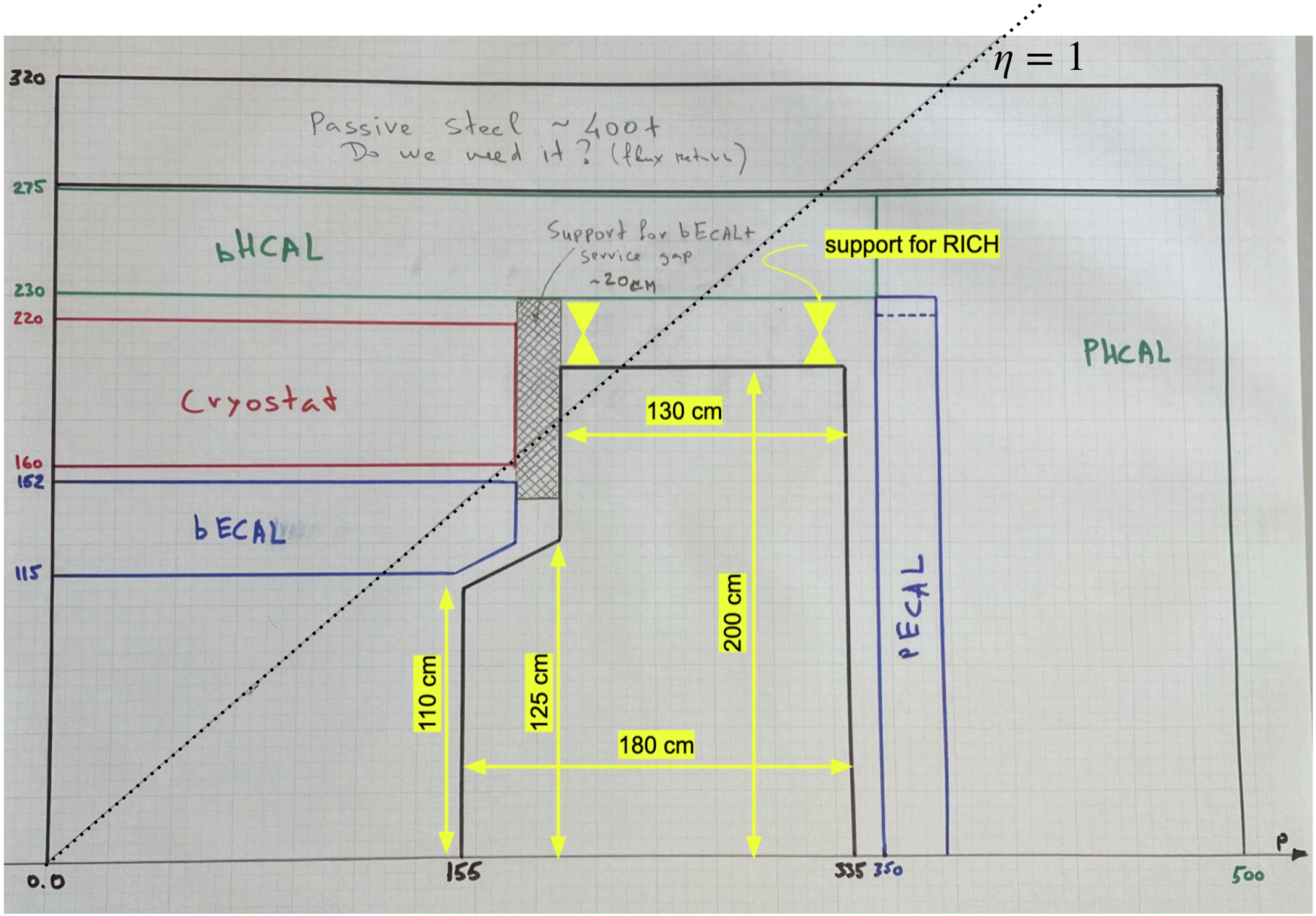
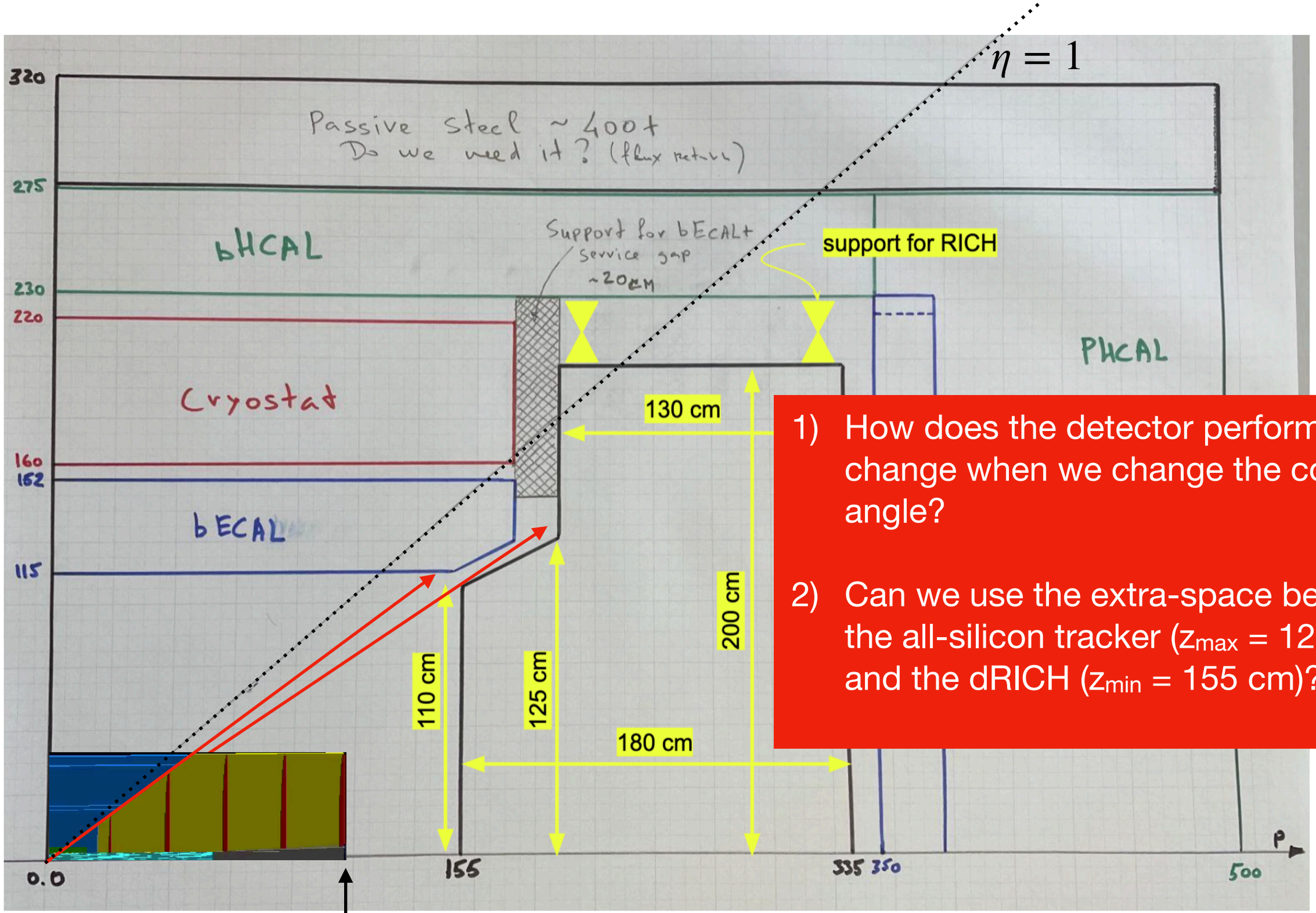
ATHENA Tracking Meeting

08/17/2021

Goal


$\eta = 1$
320
Passive steel ~400t
Do we need it? (flux return)
275
bHCAL
Support for bECAL+
service gap
~20cm
230
220
support for RICH
PHCAL
Cryostat
130 cm
160
162
bECAL
115
110 cm
125 cm
200 cm
PECAL
180 cm
P
0.0
155
335
350
500

Goal

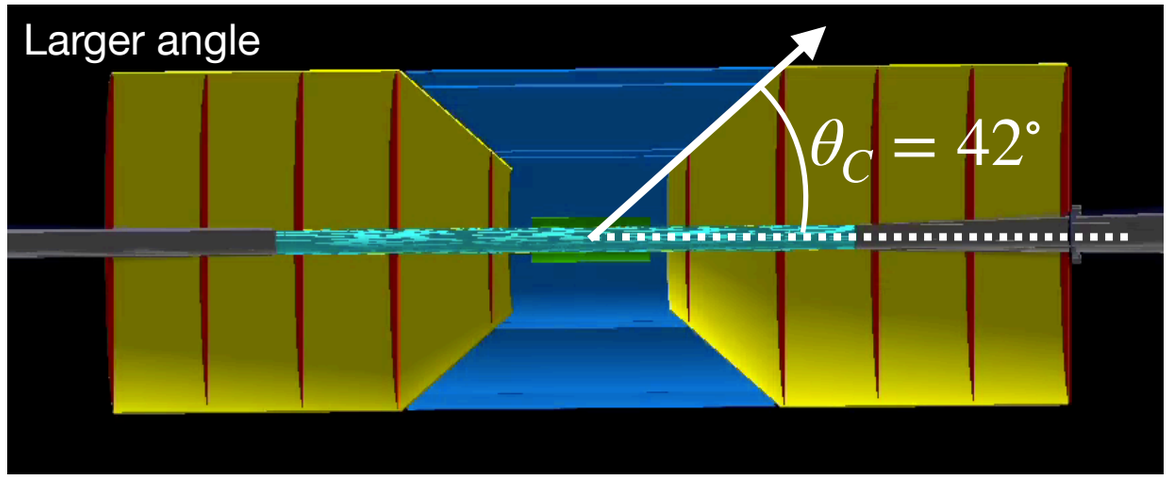


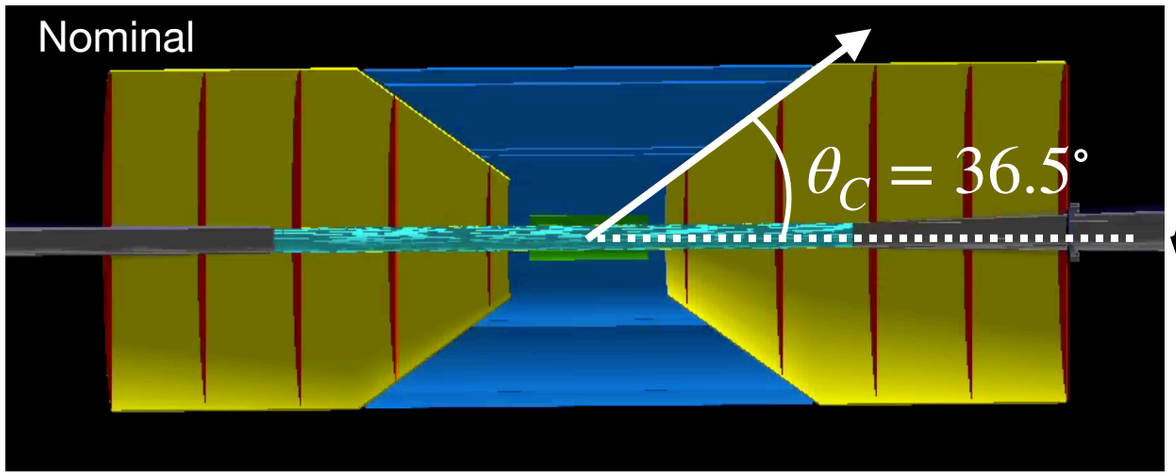
1) How does the detector performance change when we change the cone angle?

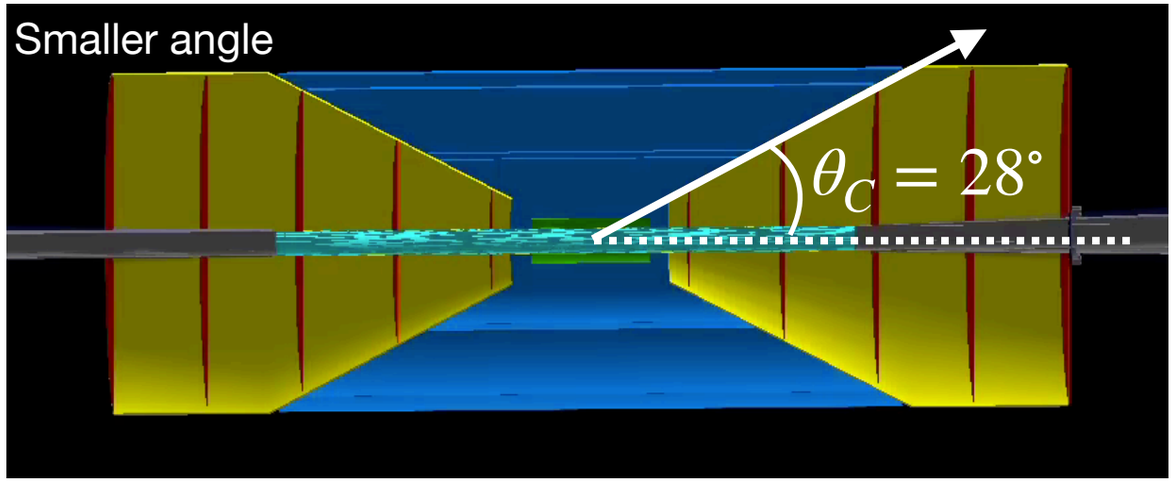
2) Can we use the extra-space between the all-silicon tracker (z_{max} = 121 cm) and the dRICH (z_{min} = 155 cm)?

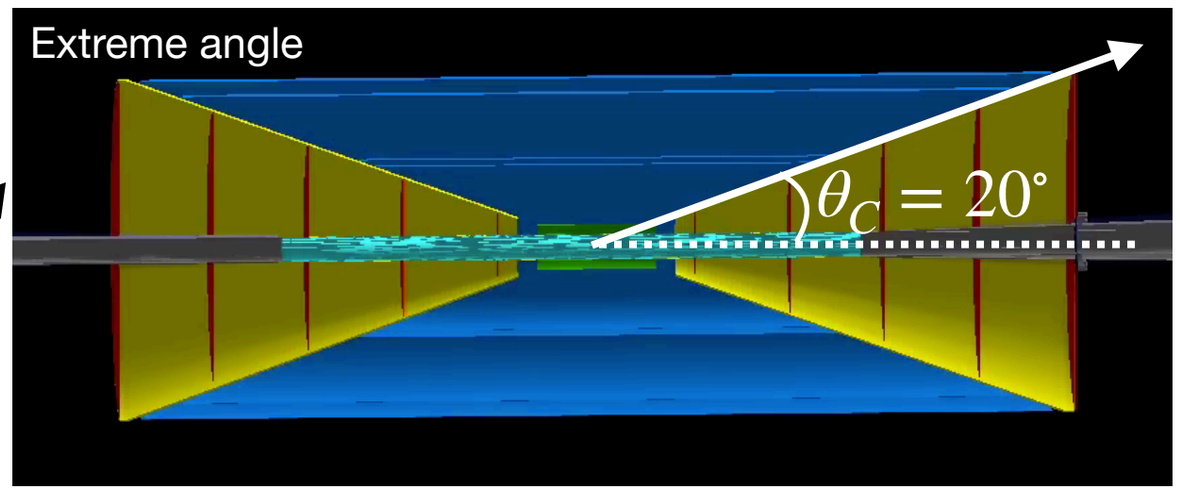
How does the detector performance change when we change the cone angle?

Support Cone Angle



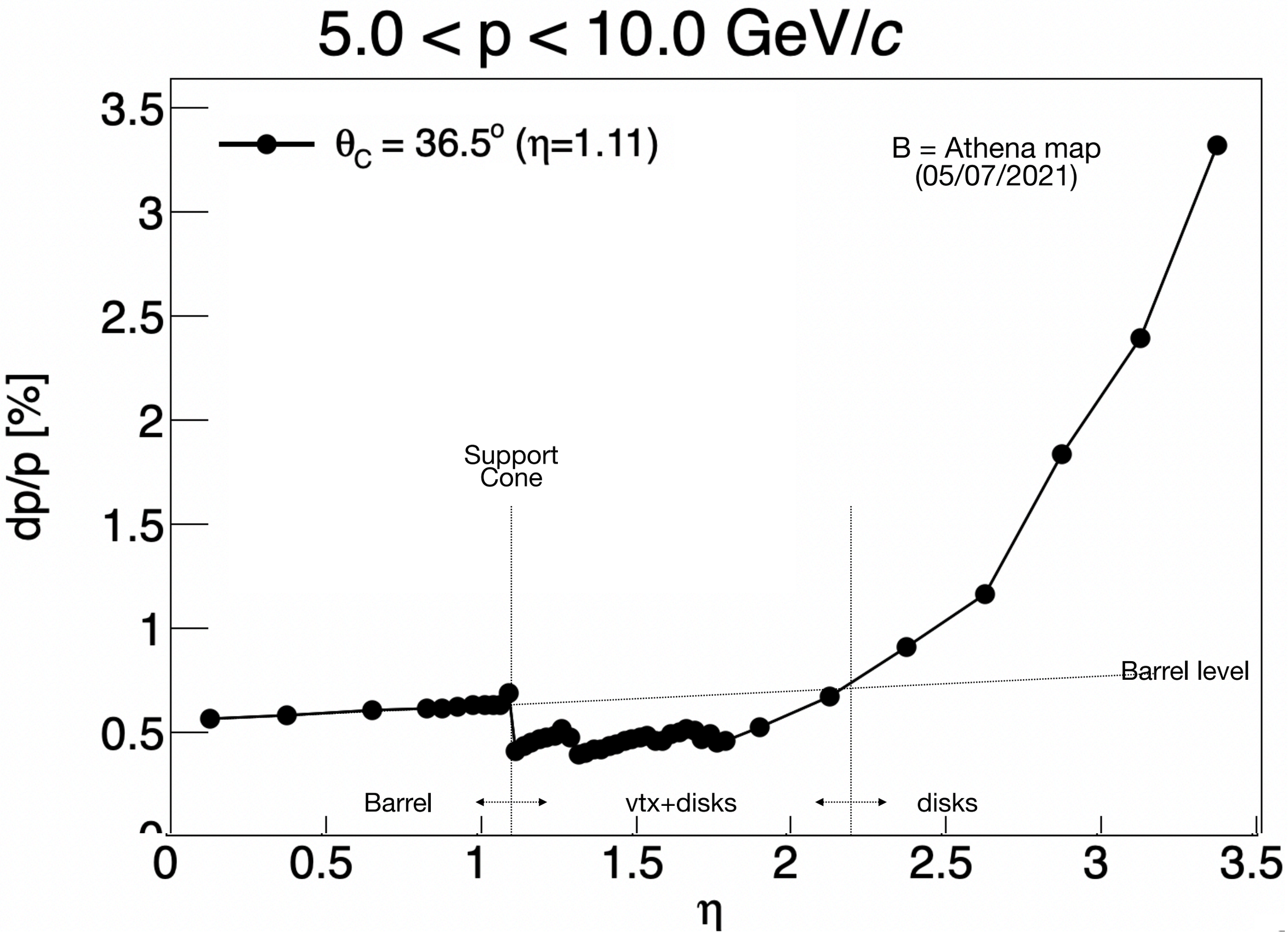




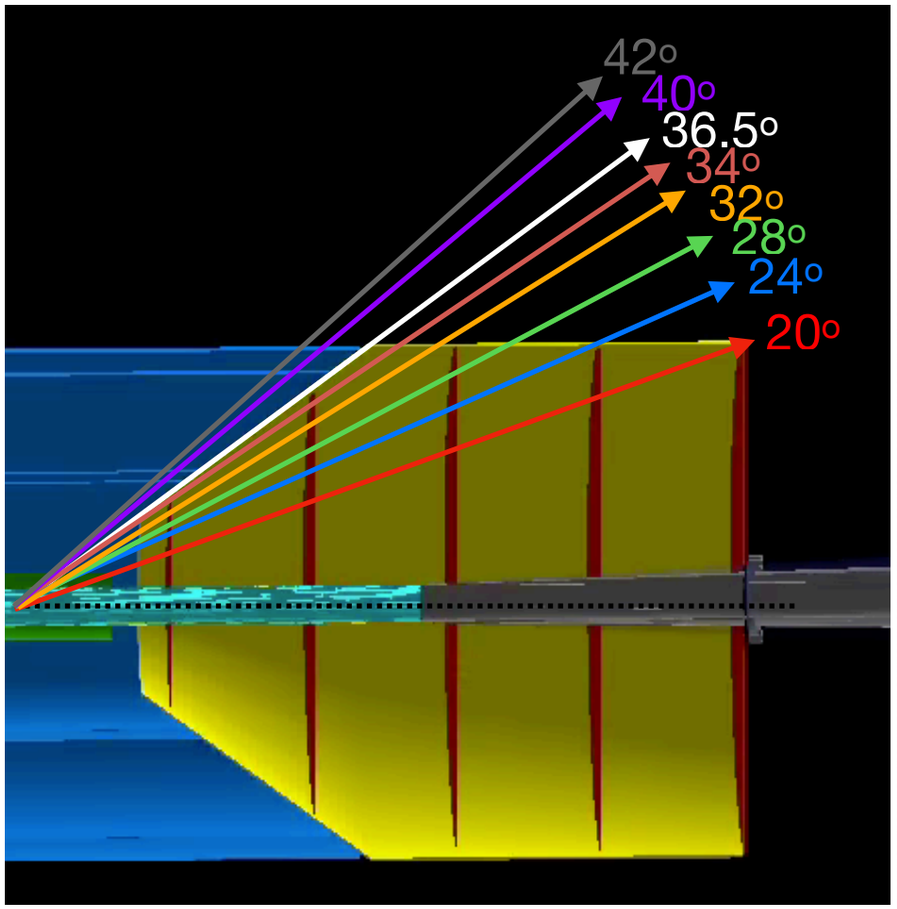


Nominal angle: 36.5°
New angle ~ 34°

Momentum Resolution dependence on Cone Angle

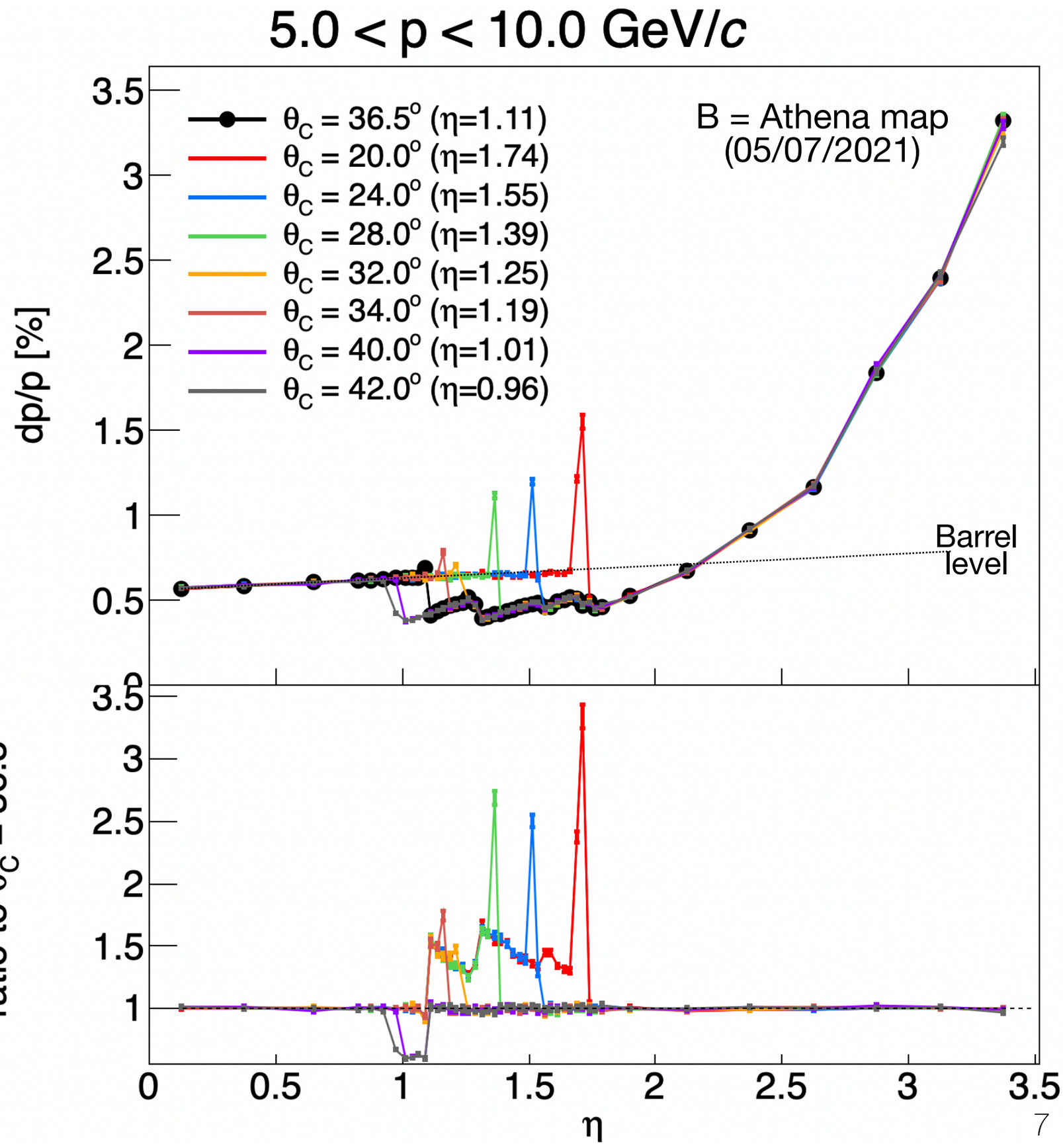


Momentum Resolution dependence on Cone Angle



Nominal angle: 36.5°
New angle ~ 34°

‘Spike’ in the transition region gets bigger for smaller cone angles

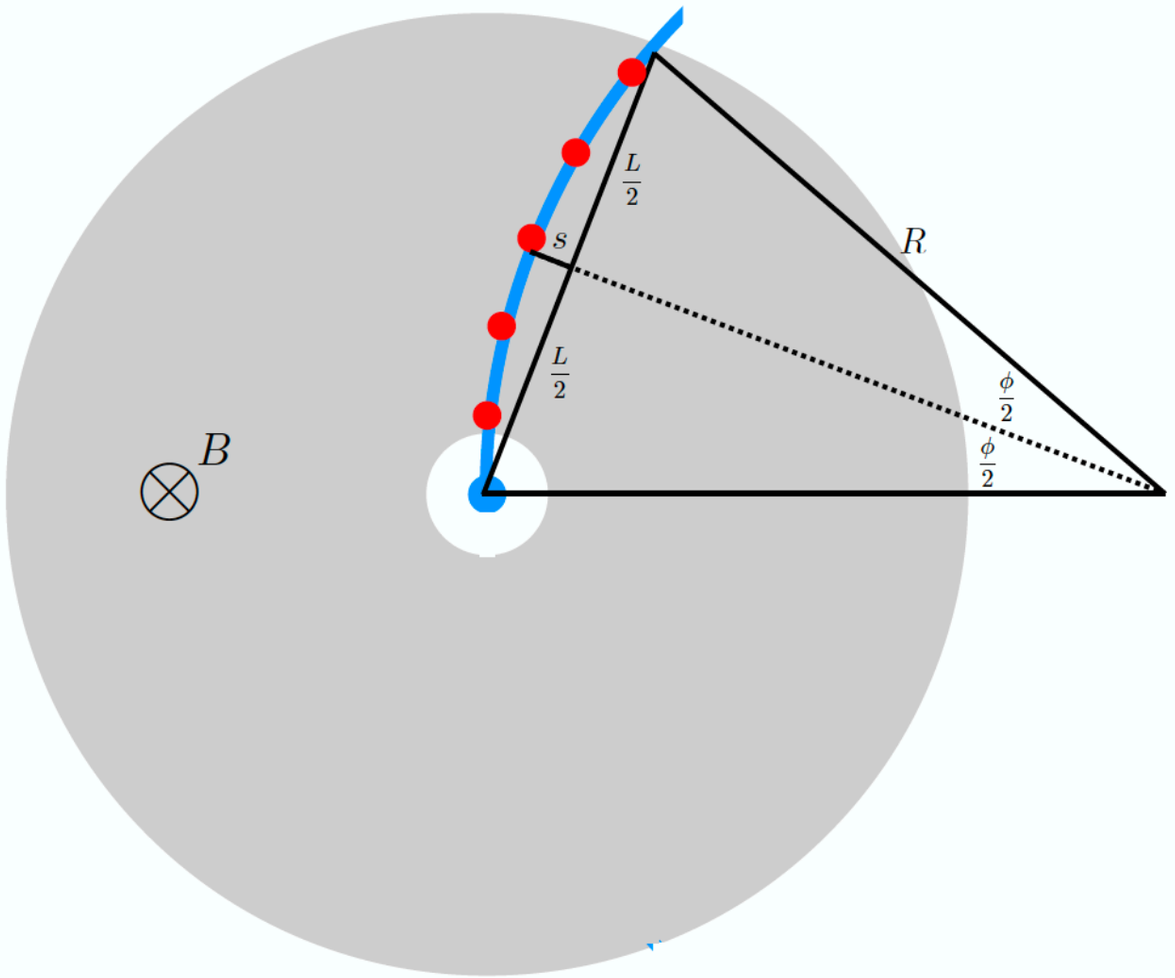


Can we use the extra-space between the all-silicon tracker (z_{max} = 121 cm) and the dRICH (z_{min} = 155 cm)?

Why would we want to make the tracker longer?

Slide by E. Sichtermann

The basics can be captured by straightforward considerations. Imagine a view along the beam and a helical track model inside a solenoidal field. Then,



$$p_{\mathrm{T}}\,[\mathrm{GeV}] = 0.3B\,[T]\;R\,[m]$$

$$s = R - R\cos\frac{\phi}{2} \approx R\frac{\phi^2}{8} \qquad \phi = \frac{L}{R}$$

Hence,

$$\frac{\Delta p_{\mathrm{T}}}{p_{\mathrm{T}}} = \frac{\Delta R}{R} = \frac{\Delta\phi}{\phi} \approx \frac{\Delta s}{L^2}\cdot\frac{8p_{\mathrm{T}}}{B}$$

In other words, a good (transverse) momentum resolution requires:

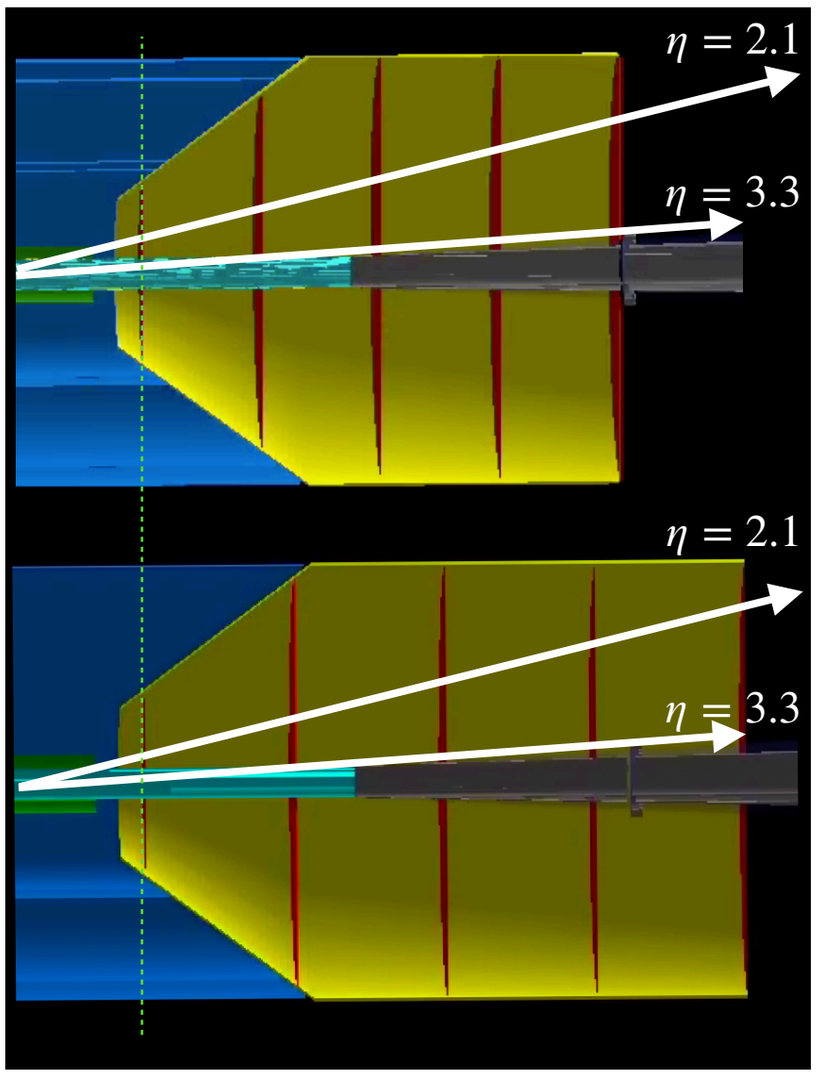
- a large path length *L* (scales as L^2)
- a large magnetic field (scales as *B*)
- good Sagitta measurement.

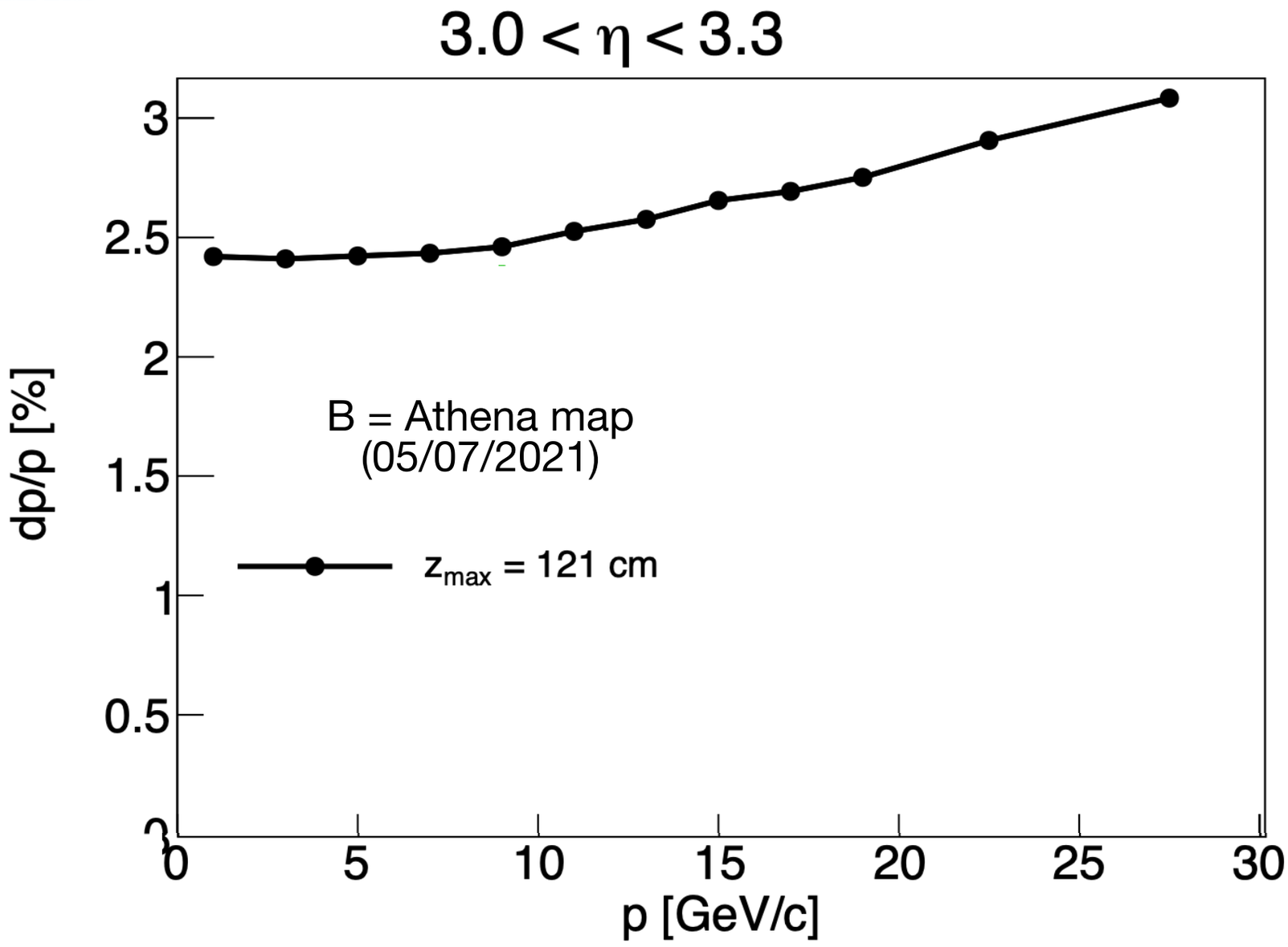
$$\Delta s = \frac{\Delta_{r\phi}}{8}\sqrt{\frac{720}{N+5}}$$ (Glückstern, 1963)

Note, however, that multiple scattering through the material of the disks matters.

Extended all-si tracker momentum resolution

* First disk kept at the same position
* Last disk moved from 121 to 145 cm
* Remaining disks distributed equidistantly in z





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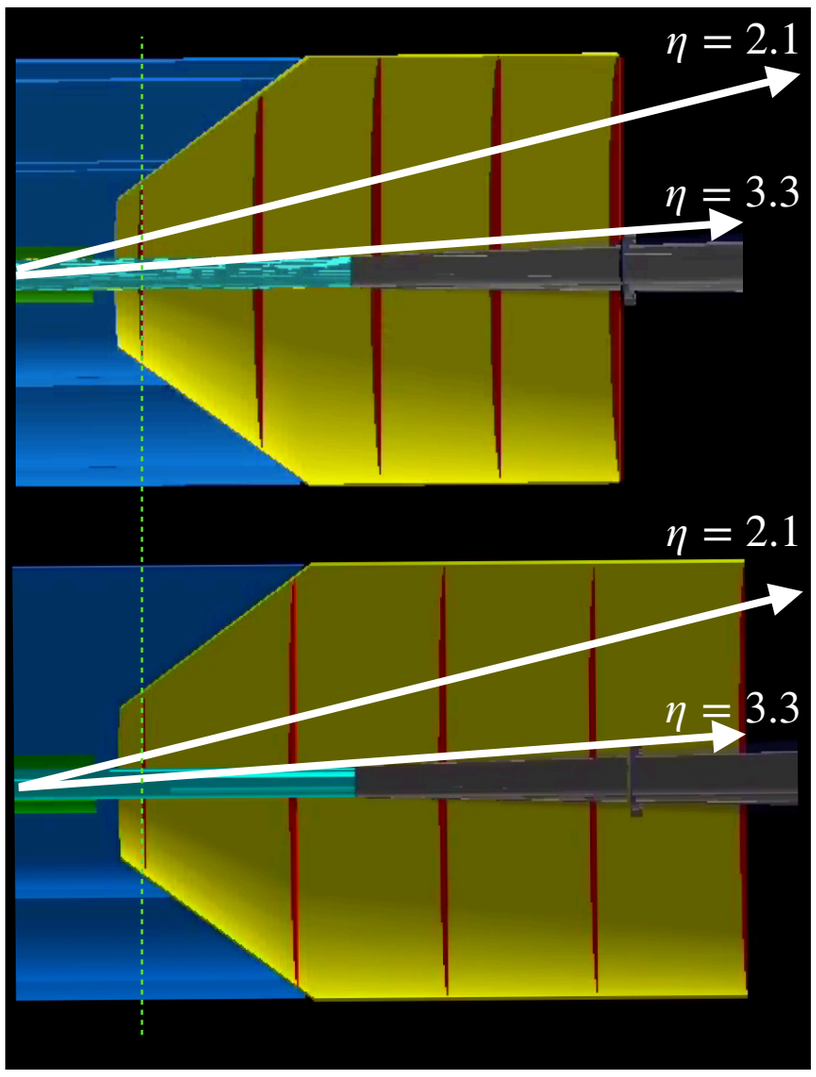

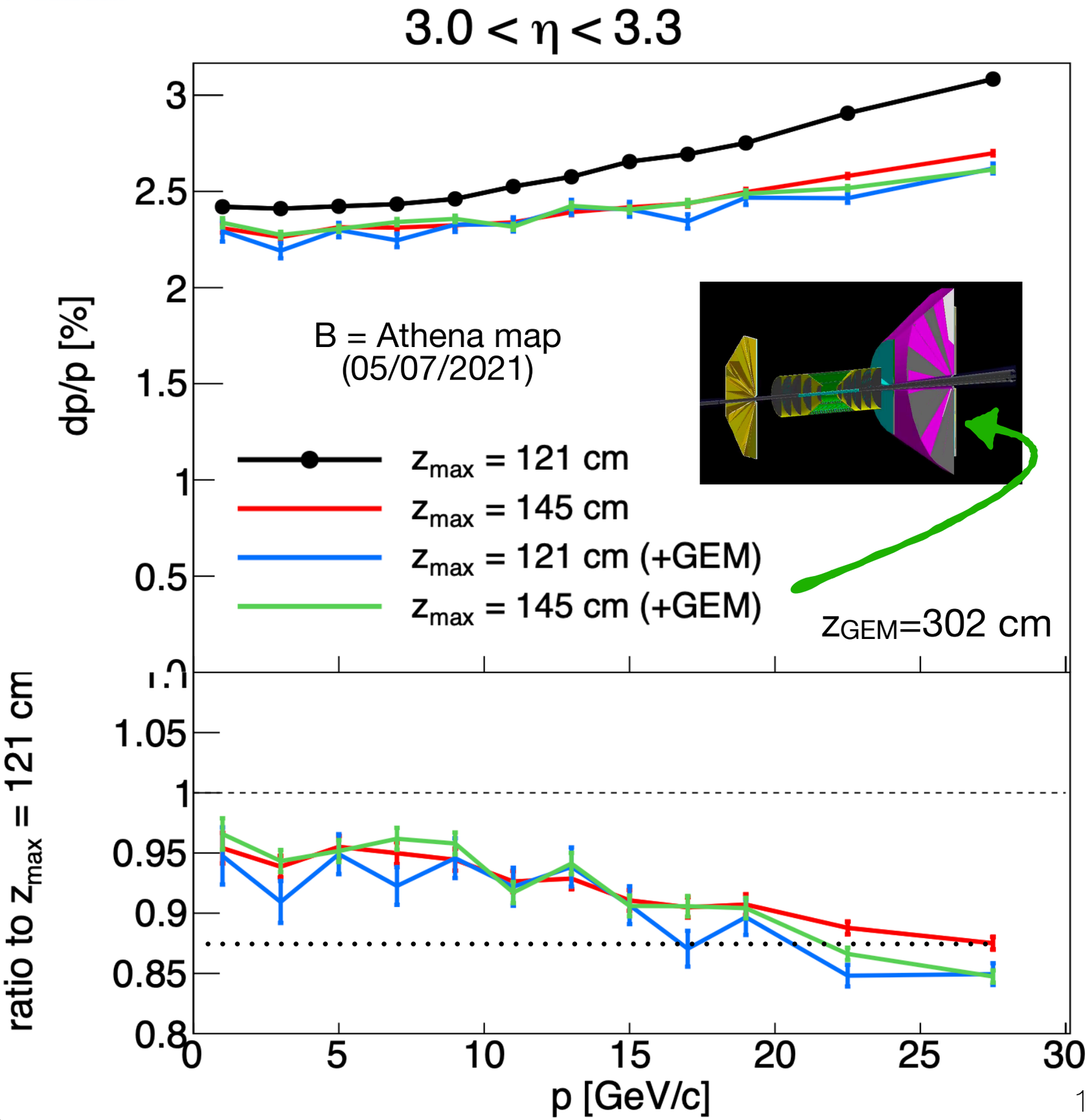

Summary

- As cone angle becomes smaller, momentum resolution degrades more in the transition region between barrel and the disks

- For $\theta_C = 34^\circ$ the momentum resolution degrades by ~ 50% (with respect to nominal) in $1.11 < \eta < 1.16$ (consistent otherwise)

- Extending the all-silicon tracker from z = 121 cm to z = 145 cm improves the high-η momentum resolution from ~ a few % (lower momentum end) to ~ 10% (higher momentum end).

- This improved performance is consistent with the all-silicon tracker + GEM (behind RICH) configuration.

- Only considered momentum resolution in these studies. Other performance quantities (e.g. efficiencies) need to be checked as well.