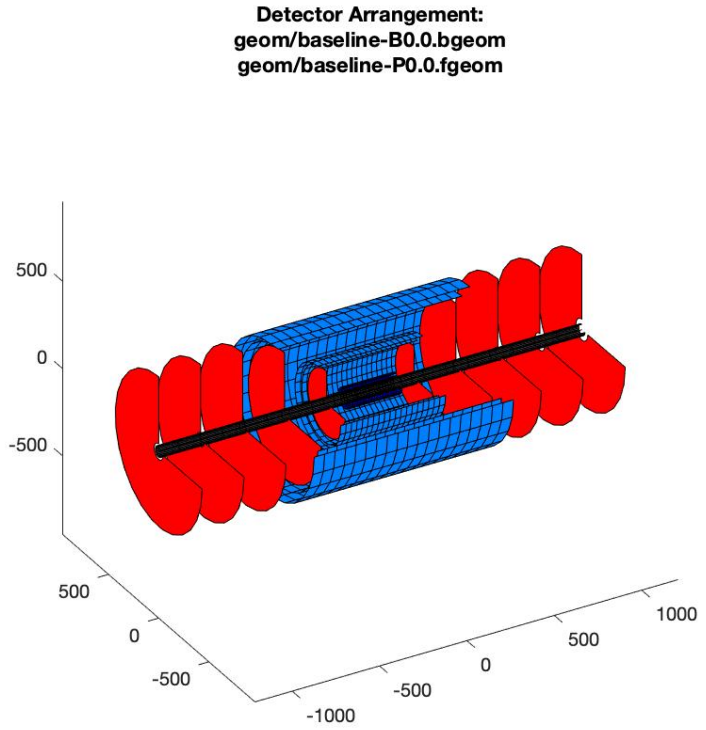
Material budget(s) and routing of services

- Shujie Li presented *an* initial implementation of supports and services in the ATHENA framework for the baseline all-silicon tracker past August 24, c.f. https://indico.bnl.gov/event/12596/

- The X/X_0 ~20% traversed material for part of the acceptance region appears to have started to live a bit of its own life,

- Now that ATHENA as a whole is further along, let's revisit several of the underlying assumptions, and arrive at an alternative,



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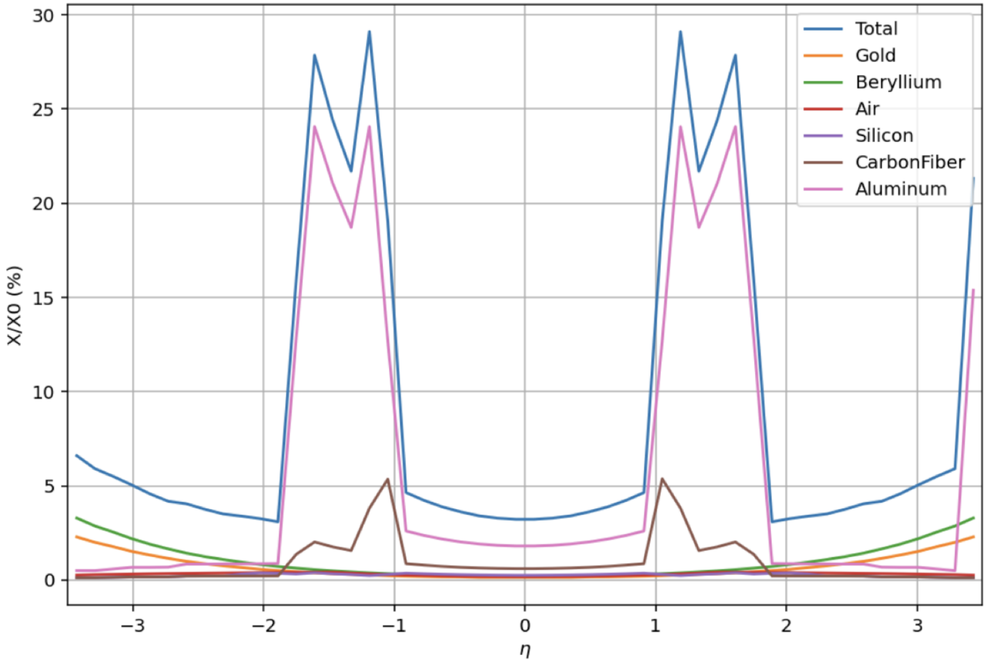
- The X/X_0 ~20% traversed material for part of the acceptance region appears to have started to live a bit of its own life, unfortunately,

- Now that ATHENA as a whole is further along, let's revisit several of the assumptions that went in, and arrive at an alternative,



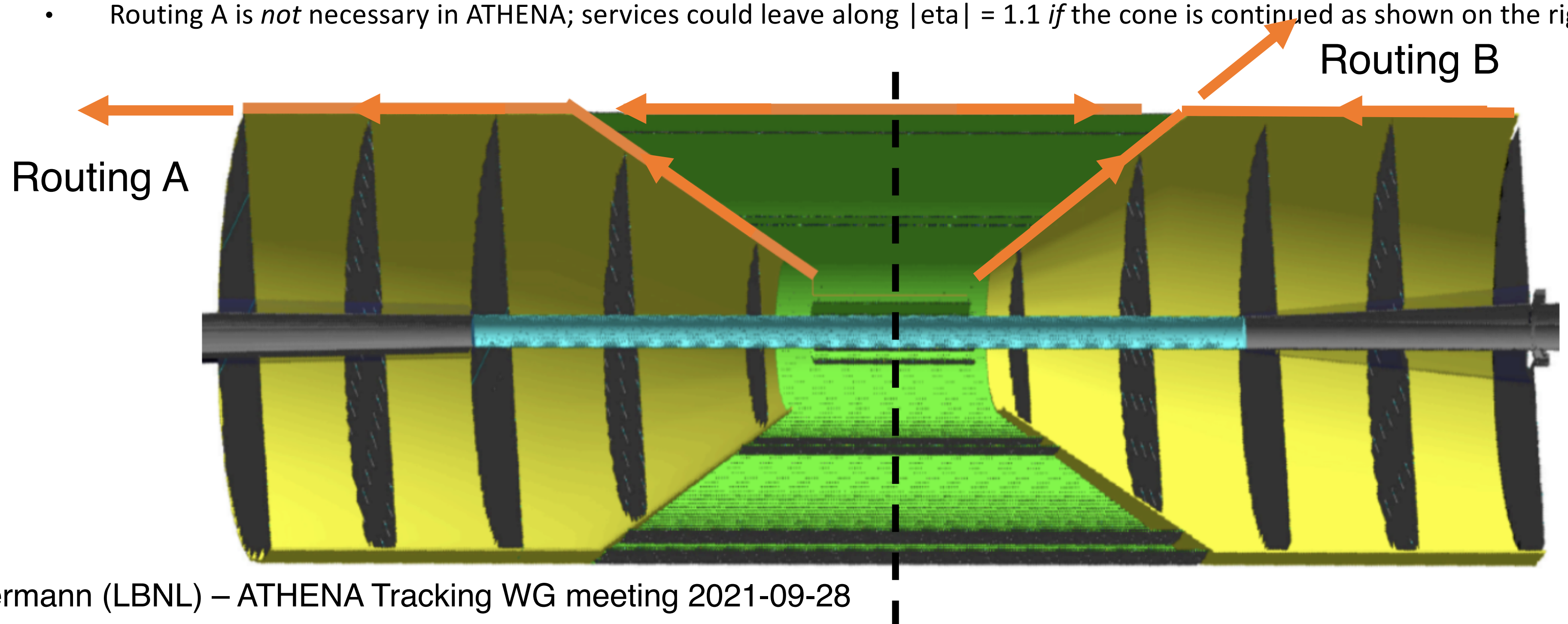
From Shujie's slide 6

Material budget(s) and routing of services

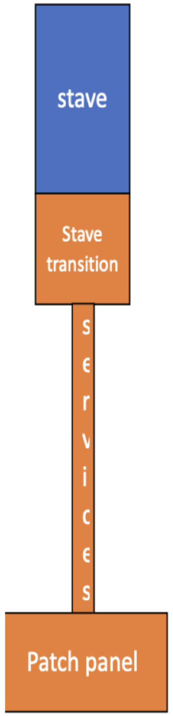
- 3 groups of barrel layers:
  - 2 vertex layers (ITS3, 0.05% X0 / layer) + 0.3mm carbon fiber support shell
  - 2 inner barrel layers and 2 outer barrel layers (staves, 0.55% X0 /layer = silicon + aluminum + triangular carbon fiber frame)
- 5 disks on each side:
  - ITS3, 0.24% / disk = silicon + aluminum
- 2mm carbon fiber support frame along cone and outer barrel/disks (thick orange line)

- The above captures support and services within the the active areas; this is sub-dominant and somewhat “irreducible”,

- Conductors out of the staves and disks add significant material; essentially all of the material for 1.1 < |eta| < 1.7 *if* these conductors leave the subsystem at max(|z|); this was the initial working assumption and is shown schematically on the left as “routing A”
- Routing A is *not* necessary in ATHENA; services could leave along |eta| = 1.1 *if* the cone is continued as shown on the right as “routing B”



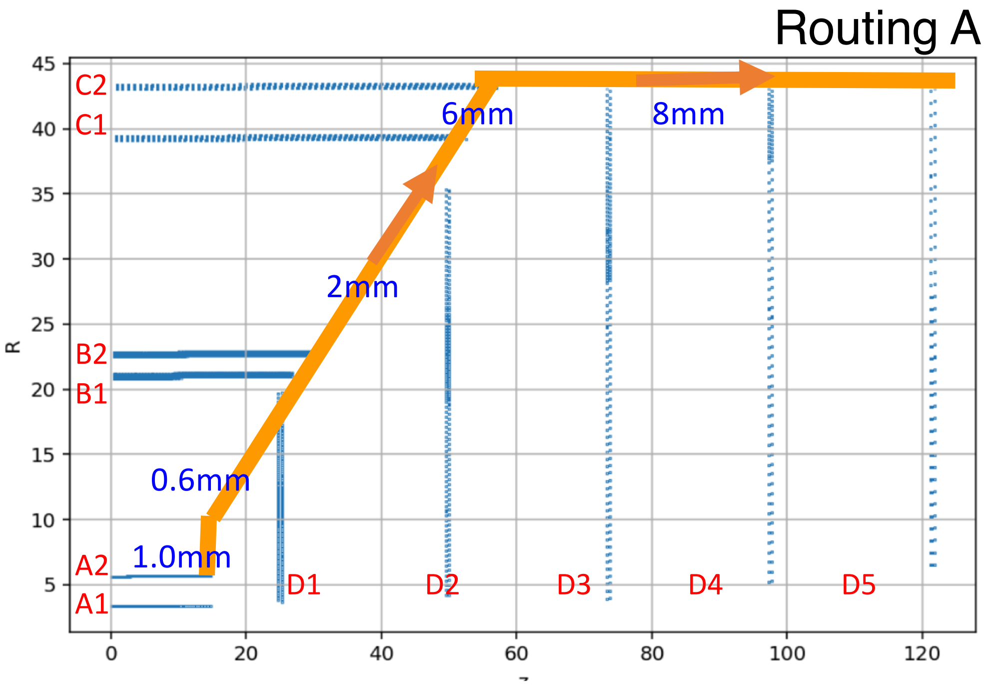
Summary of ITS3 like Si tracking

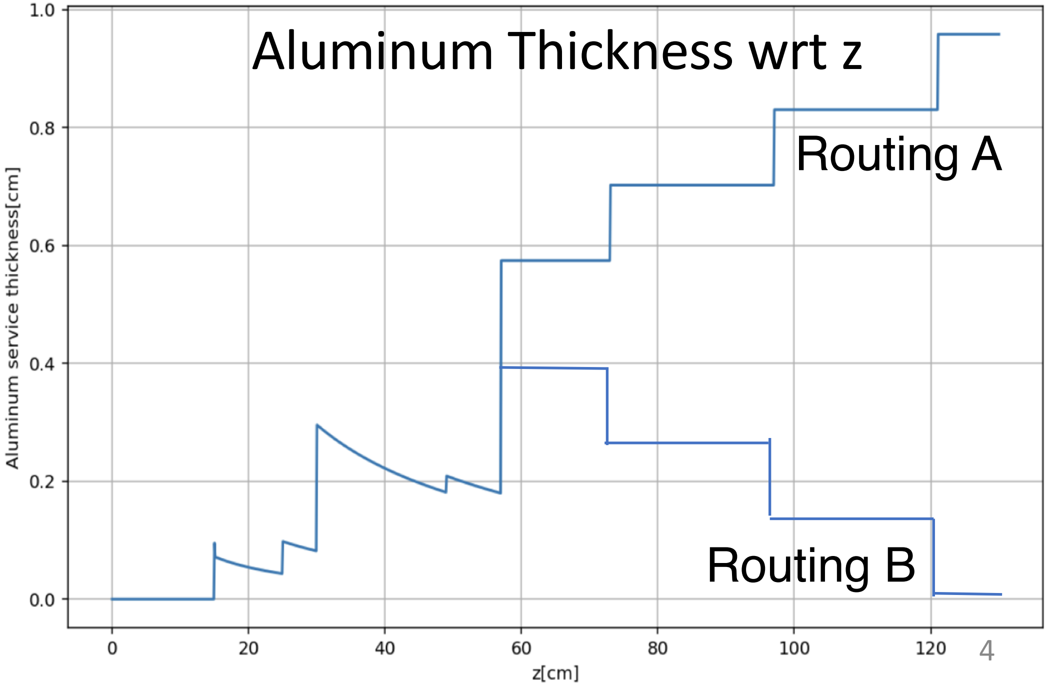


	Stave X/X0	Stave transition (per 100 cm^2 of Si surface)*	Services (per 100 cm^2 of Si surface)*	Patch panel (per 100 cm^2 of Si surface)*
ITS3 like vertexing	~0.1%	6.66 cm^3 of material with X/X0 of 0.0684 per traversed cm	2.96 cm^2 cross section with X/X0 of 0.022 per traversed cm	4.32 cm x 1cm x 1 cm with 0.102 X/X0 per traversed cm
ITS3 like barrel (up to 1.5m length)	0.55 %	4.286 cm^3 of material with X/X0 of 0.0684 per traversed cm	1.905 cm^2 cross section with X/X0 of 0.022 per traversed cm	2.778cm x 1cm x 1 cm with 0.102 X/X0 per traversed cm
ITS3 like disc (up to 60 cm diameter)	0.24%	6.66 cm^3 of material with X/X0 of 0.0684 per traversed cm	2.96 cm^2 cross section with X/X0 of 0.022 per traversed cm	4.321 cm x 1cm x 1 cm with 0.102 X/X0 per traversed cm

* Corrected 2021_03_13

DRAFT 2021_06_15_EIC_Si_material_projections LG 23

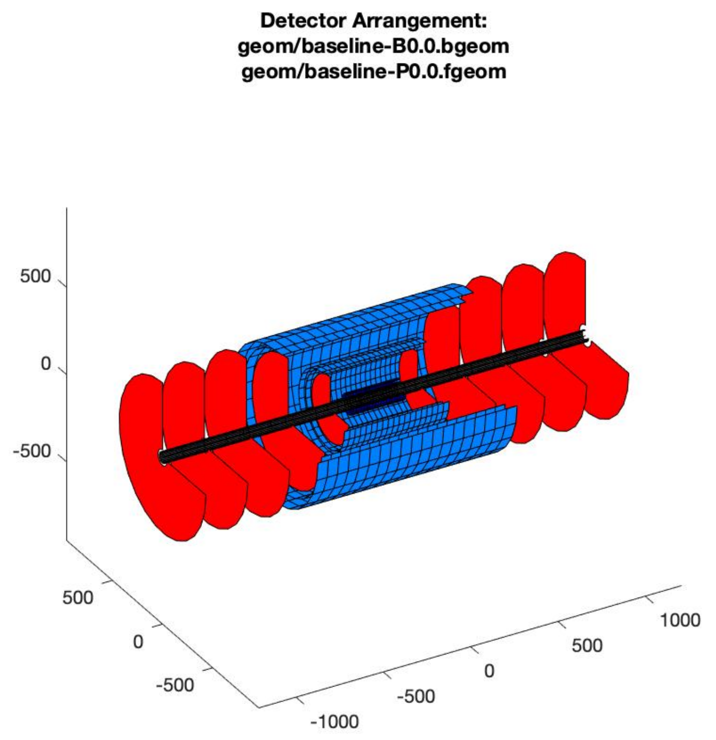


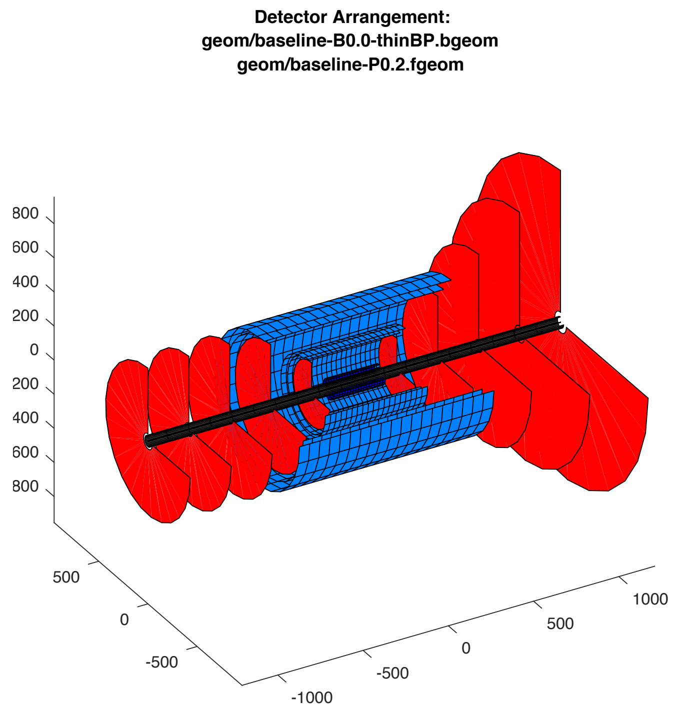


- Initial material implementation and scan uses the ITS2-derived services parametrization and routing A, modeled as Aluminum equivalent thickness,
- Routing B reduces the material in the cylinder around the disks at large-|z| by a factor and results, furthermore, in decreasing thickness as this material is traversed at shallower angles,
- The service material on the cylinder was a constant 8mm of Aluminum (routing A) in Shujie’s initial material scan and is a constant 2mm in the latest round of ATHENA simulations,
- eRD104 R&D aims to further reduce the overall services by a factor (still to be assessed quantitatively),

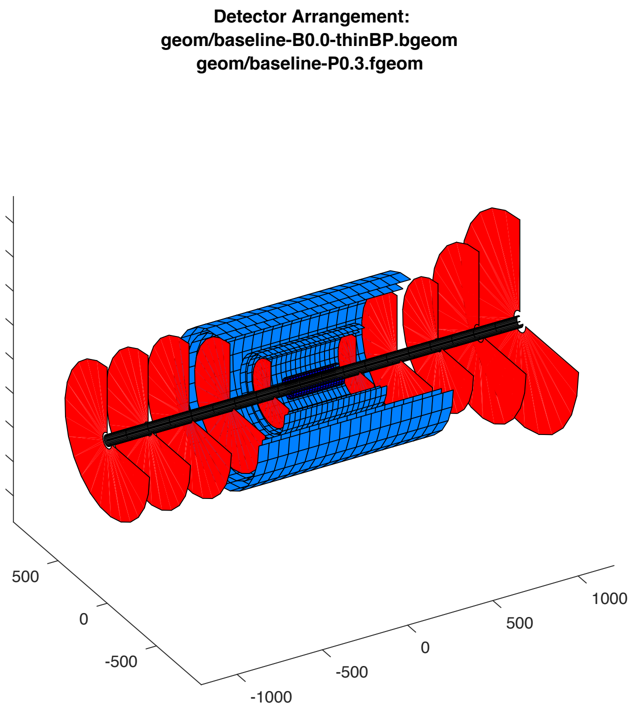
Switching topics…

Baseline, projective, and double projective configurations





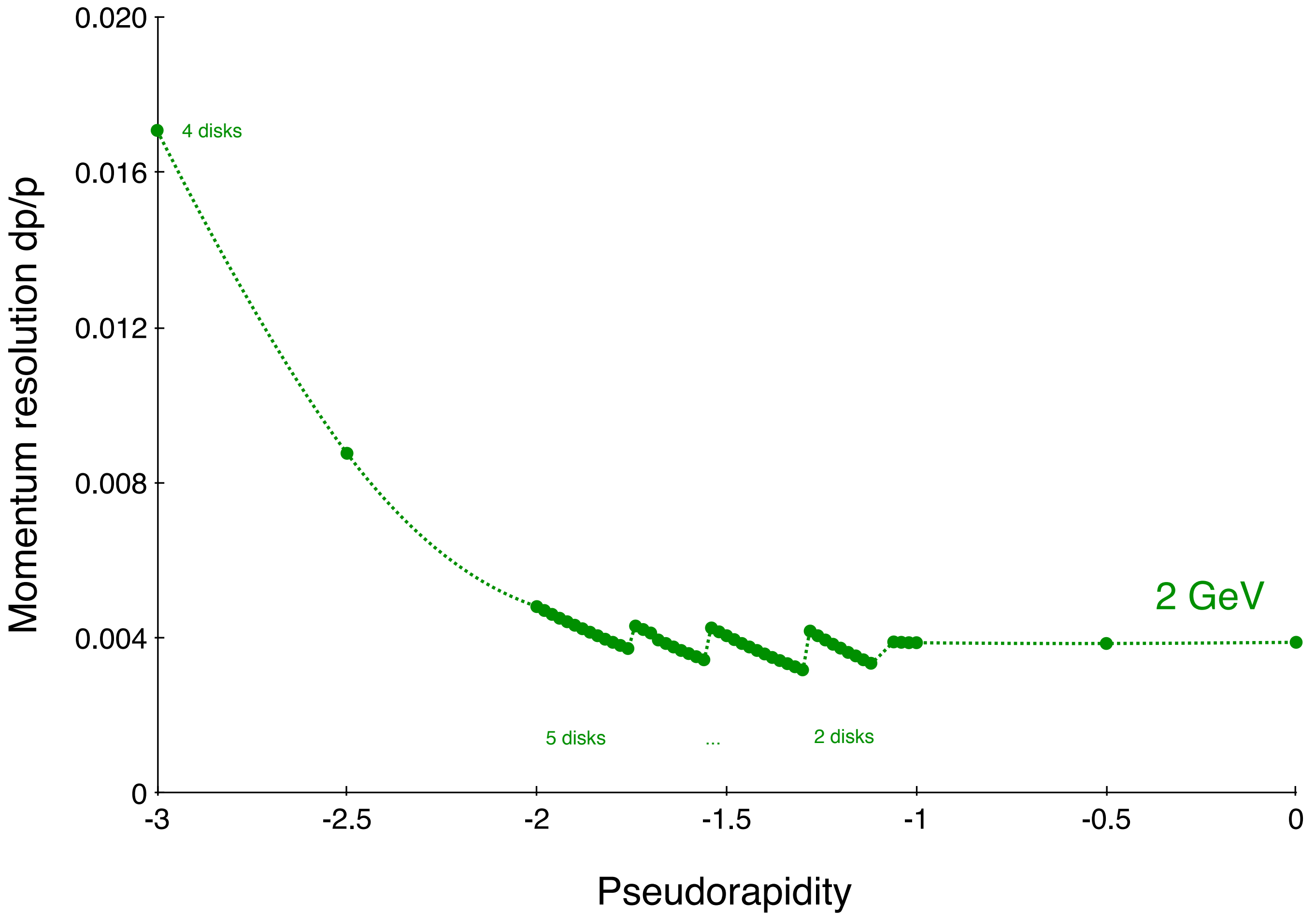
Single cone near $\eta = 1.1$

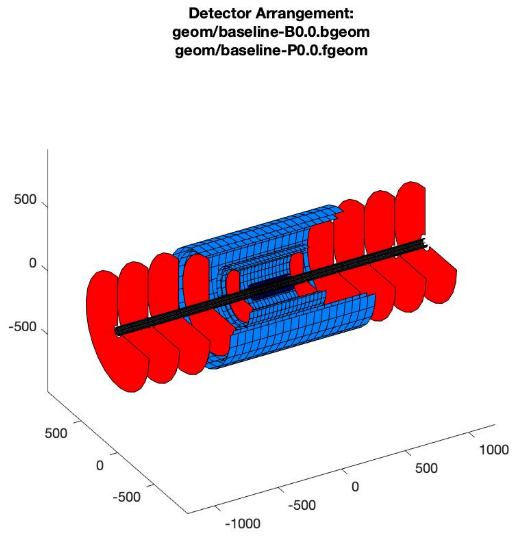


Cones near $\eta = 1.1, 1.5$

Note, configurations are shown here and on the next slides at positive z for clarity; results on next slides use these for negative η

Baseline, projective, and double projective configurations



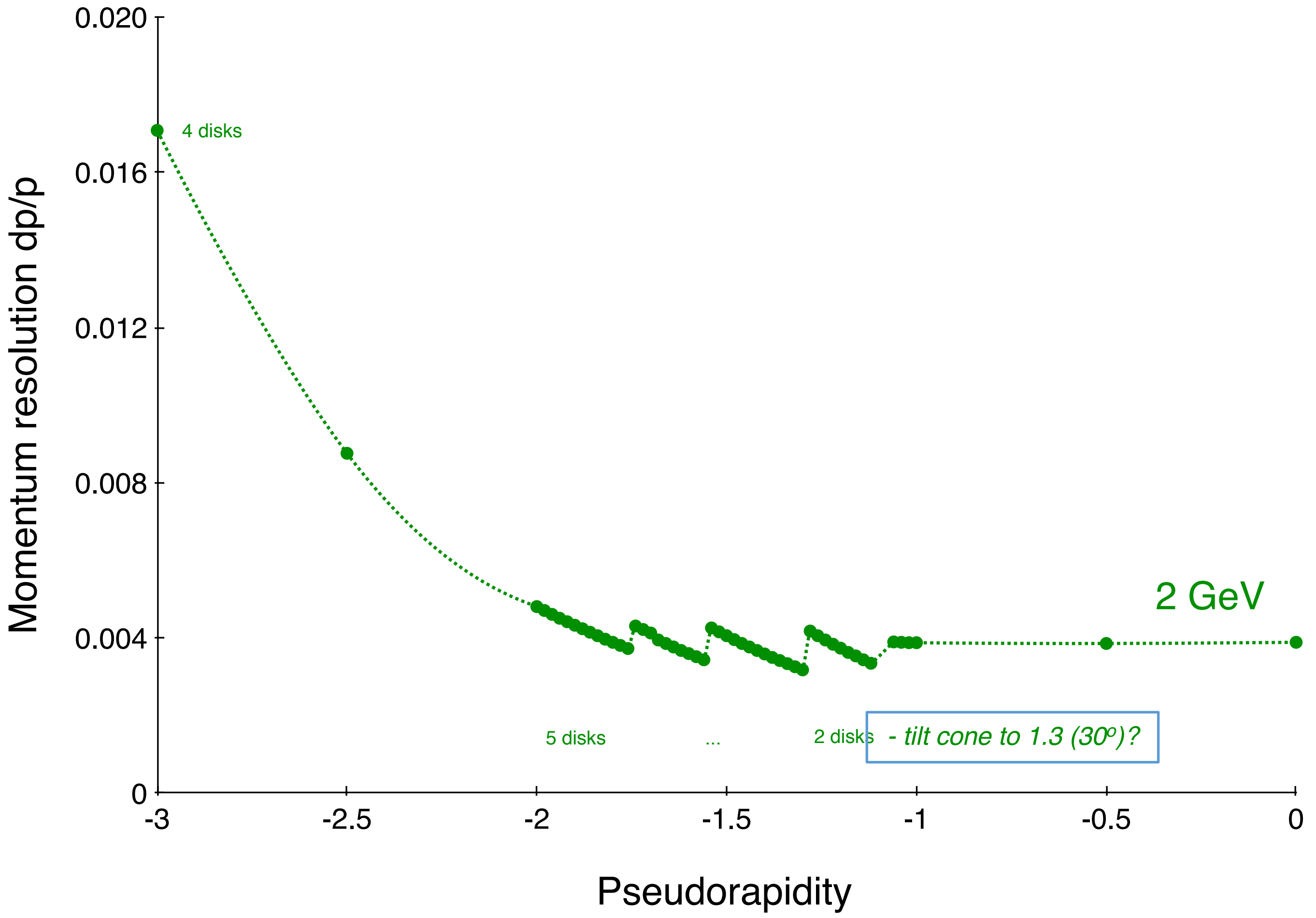


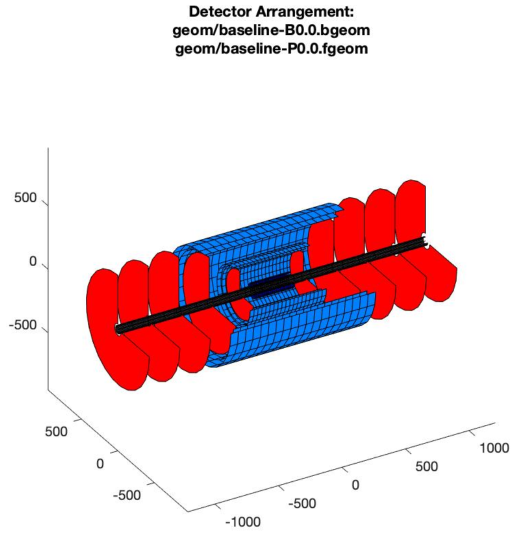
Filled points will show baseline in this and following slides,

Open points will show alternate,

Momenta are total momenta,

Baseline, projective, and double projective configurations





Filled points will show baseline in this and following slides,

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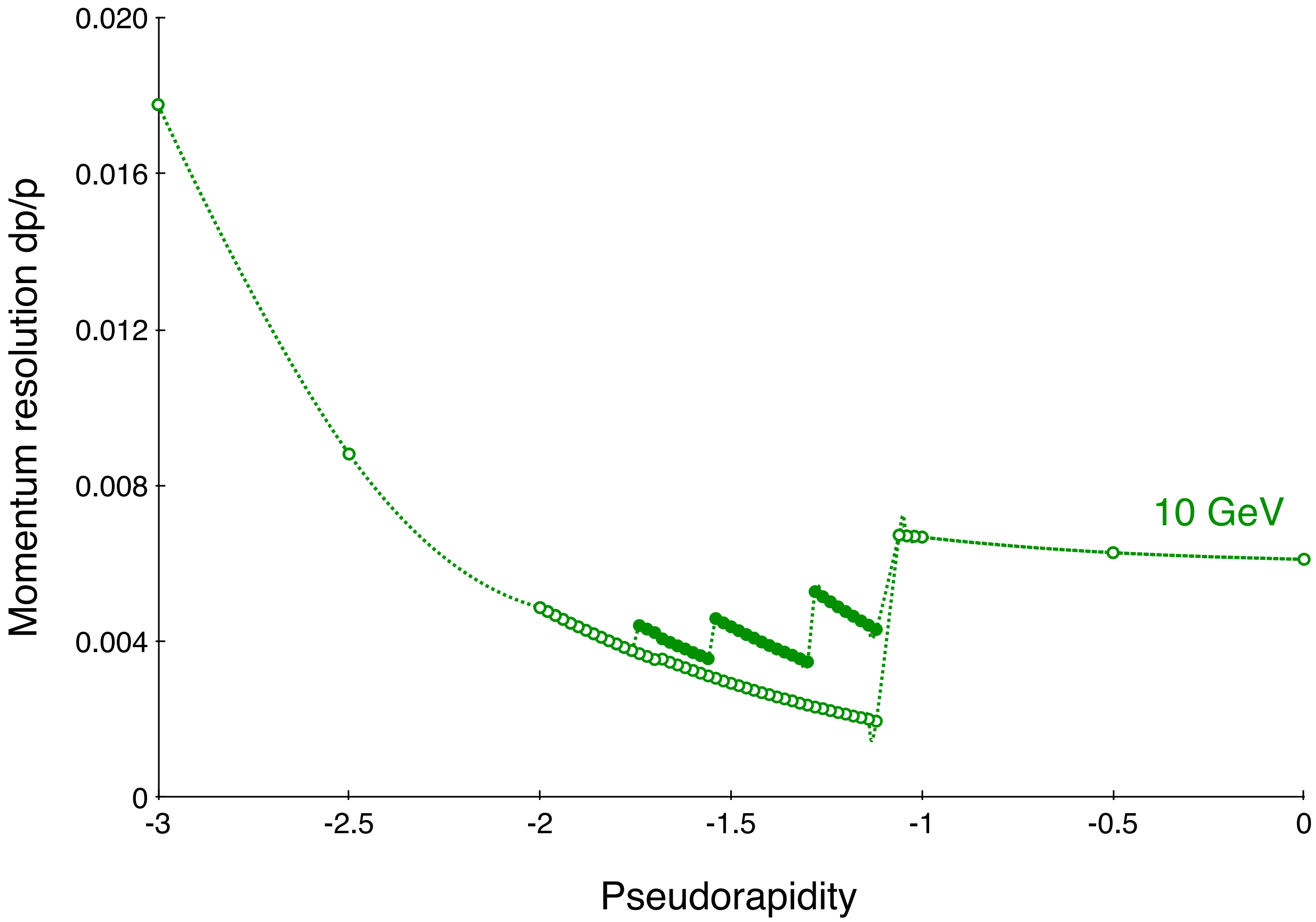
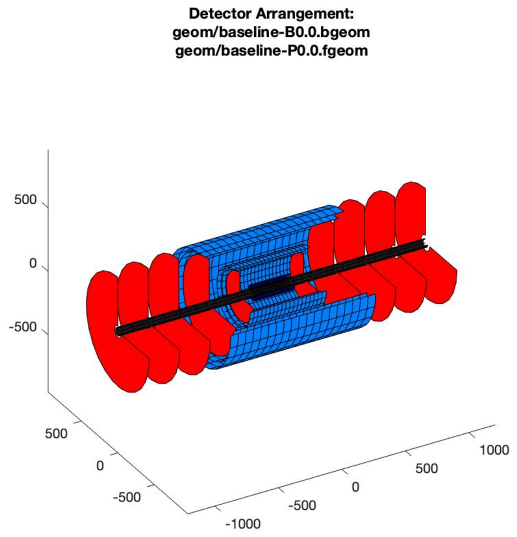
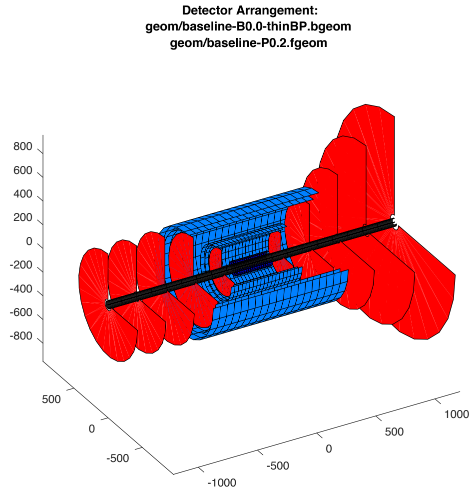
Momenta are total momenta,

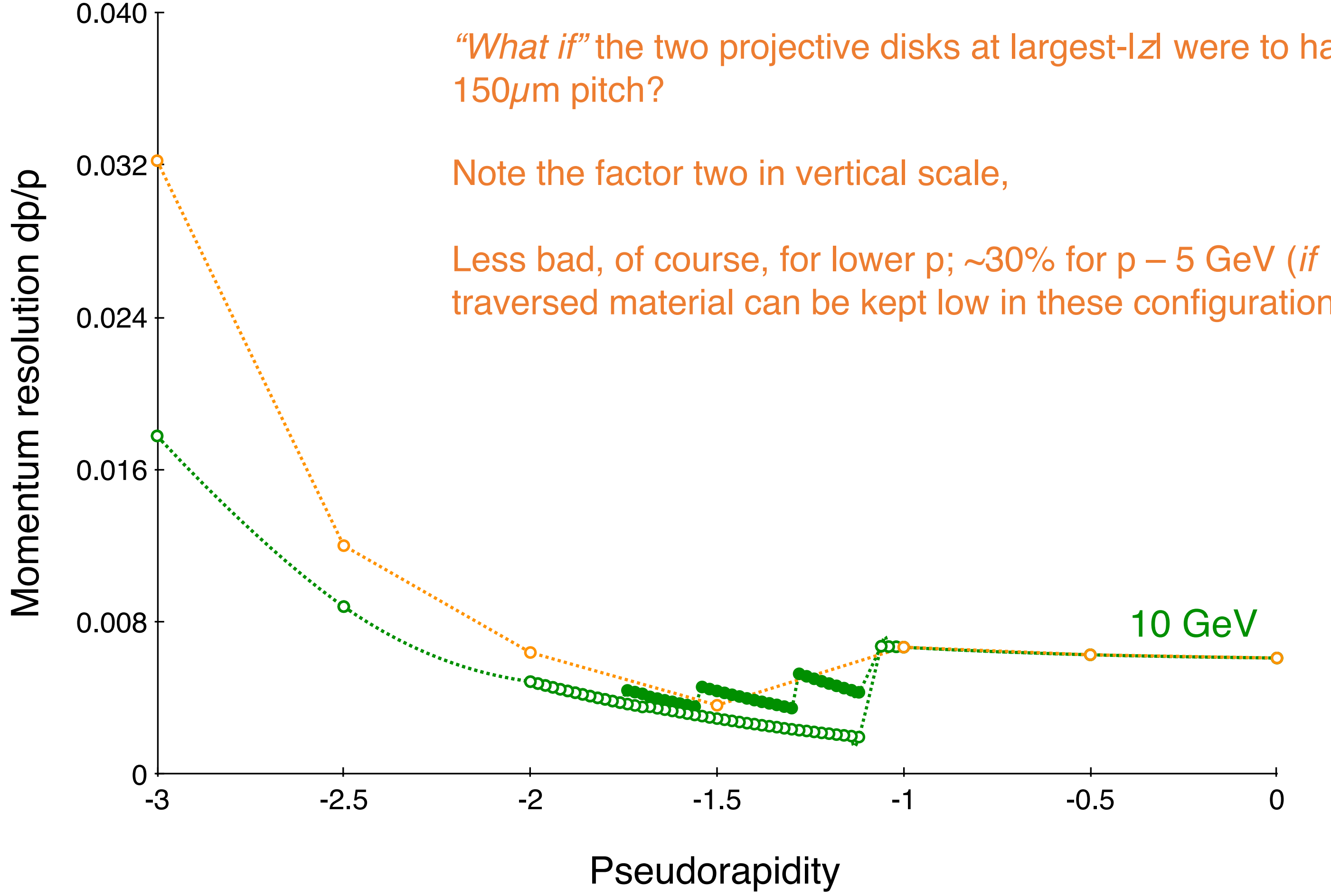
Baseline, projective, and double projective configurations







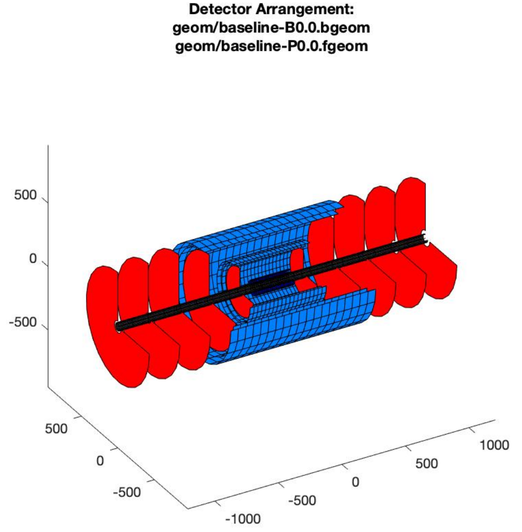
Baseline, projective, and double projective configurations

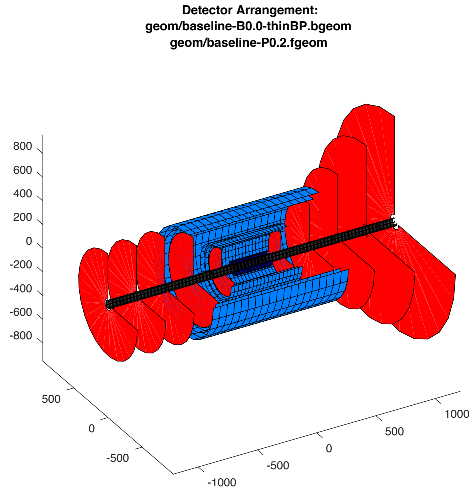


"What if" the two projective disks at largest-|z| were to have 150μm pitch?

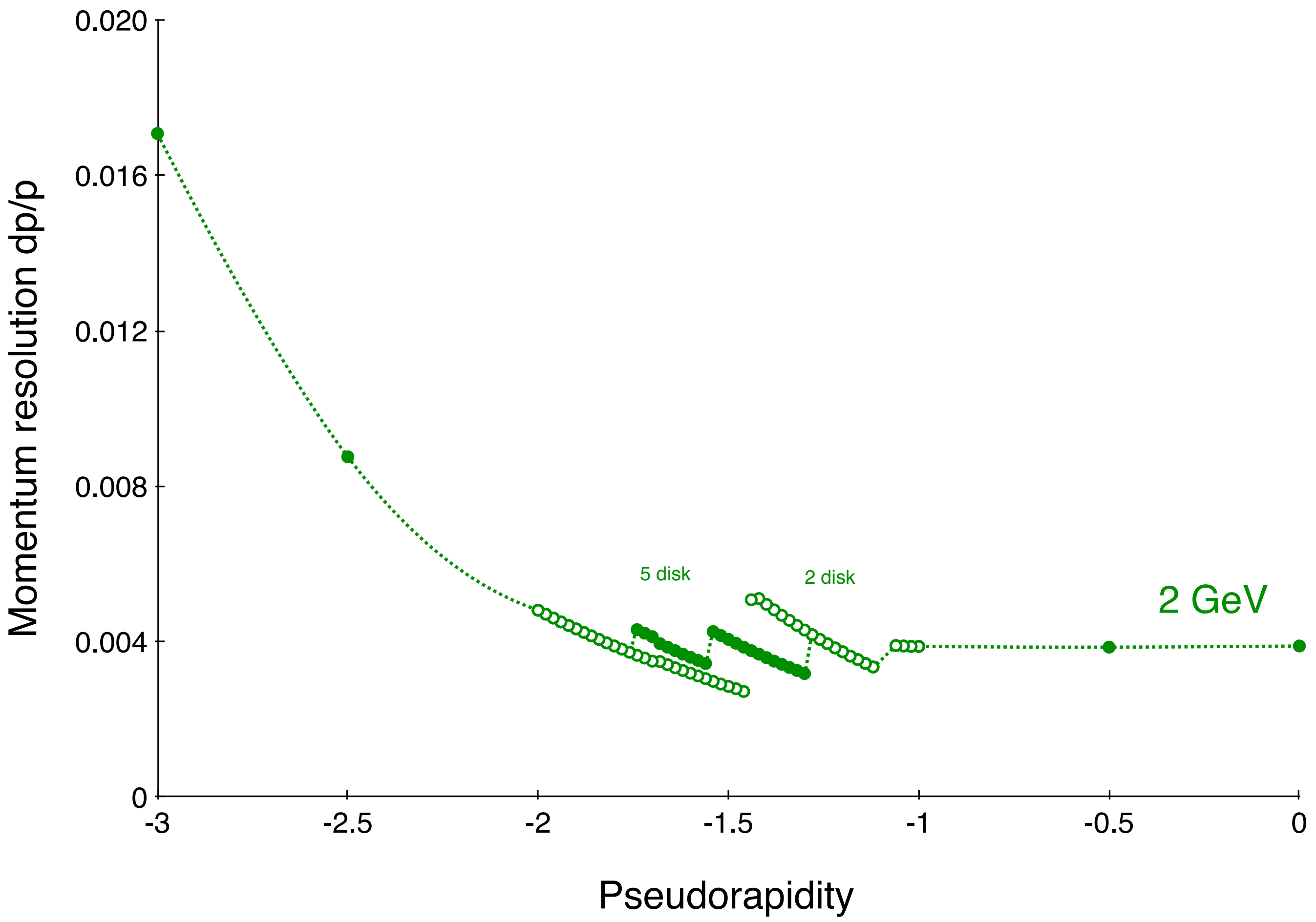
Note the factor two in vertical scale,

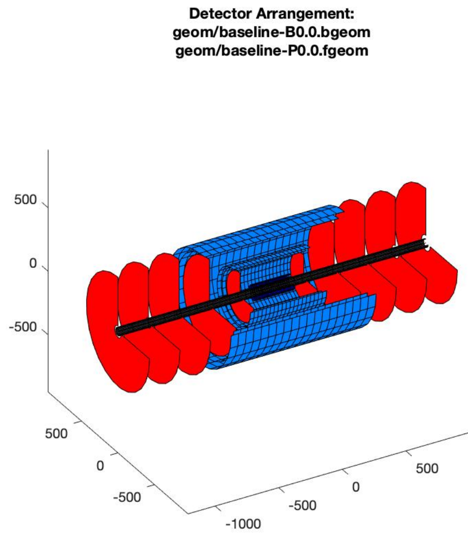
Less bad, of course, for lower p; ~30% for p – 5 GeV (*if* traversed material can be kept low in these configurations).

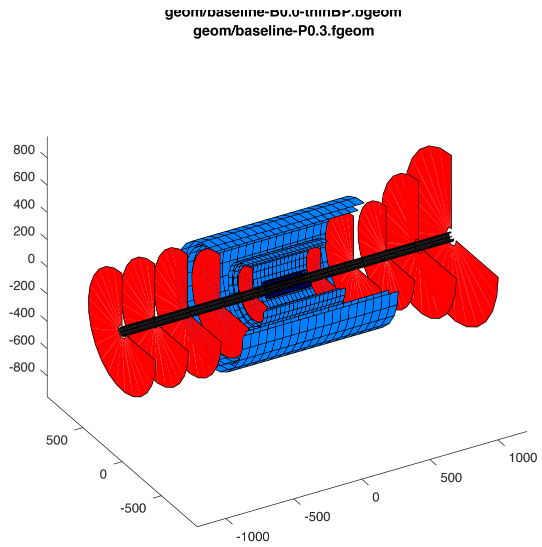




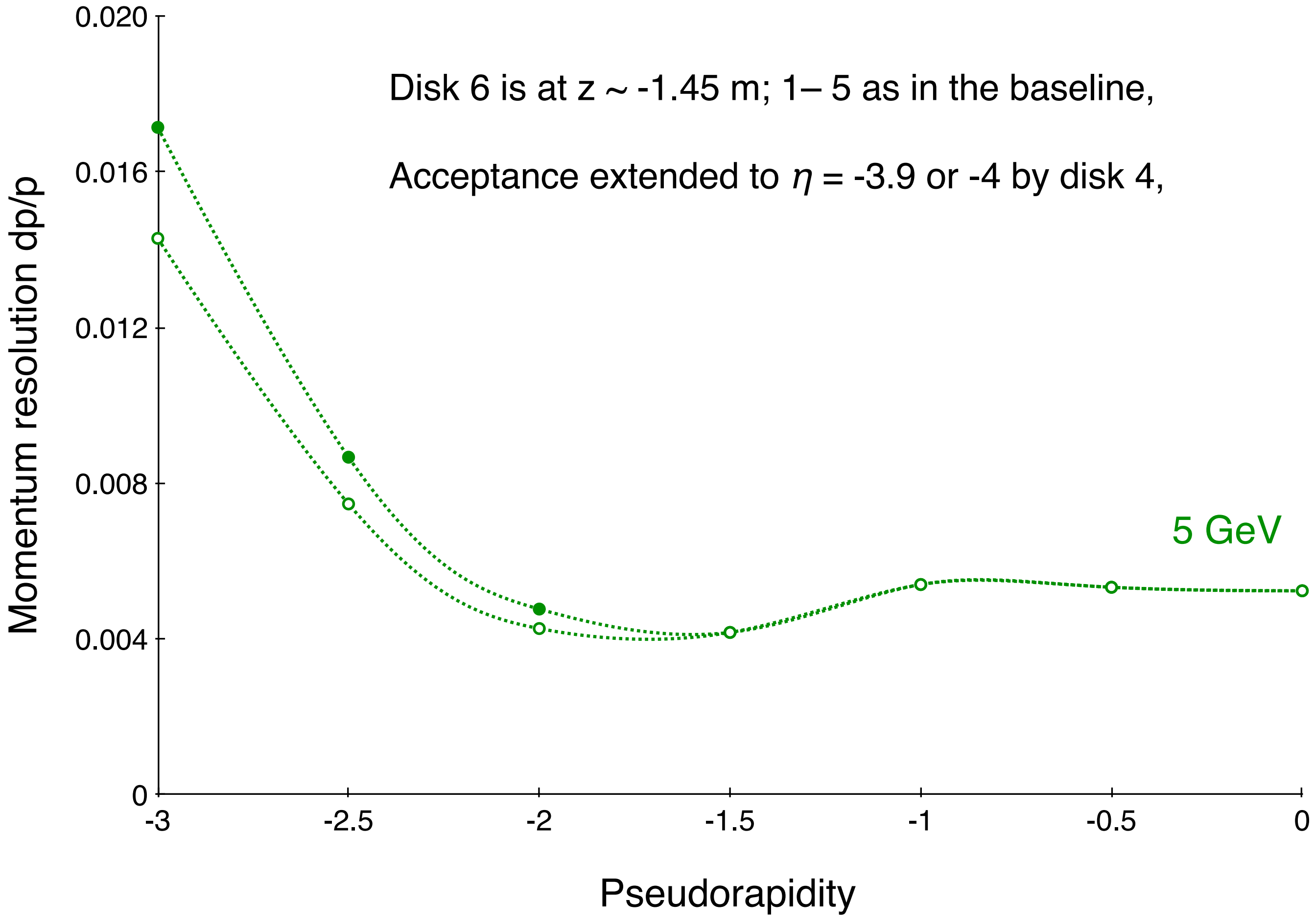
Baseline, projective, and double projective configurations

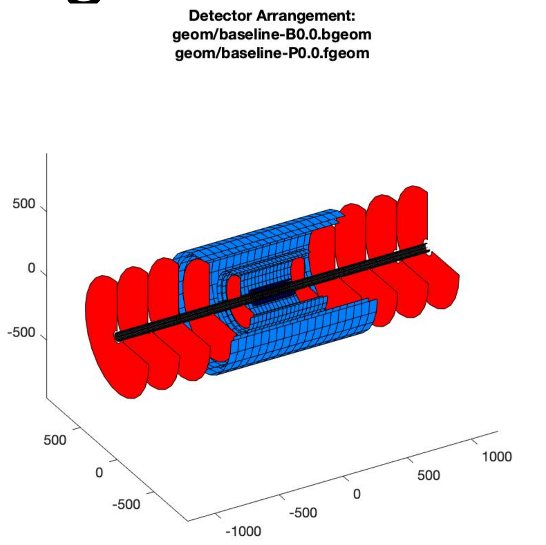


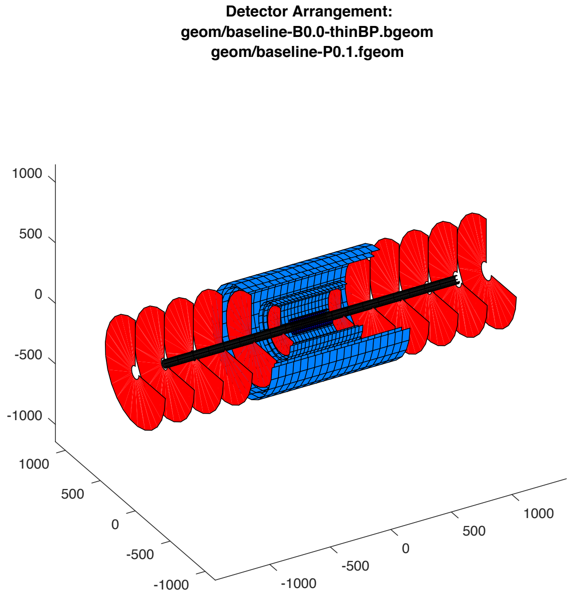




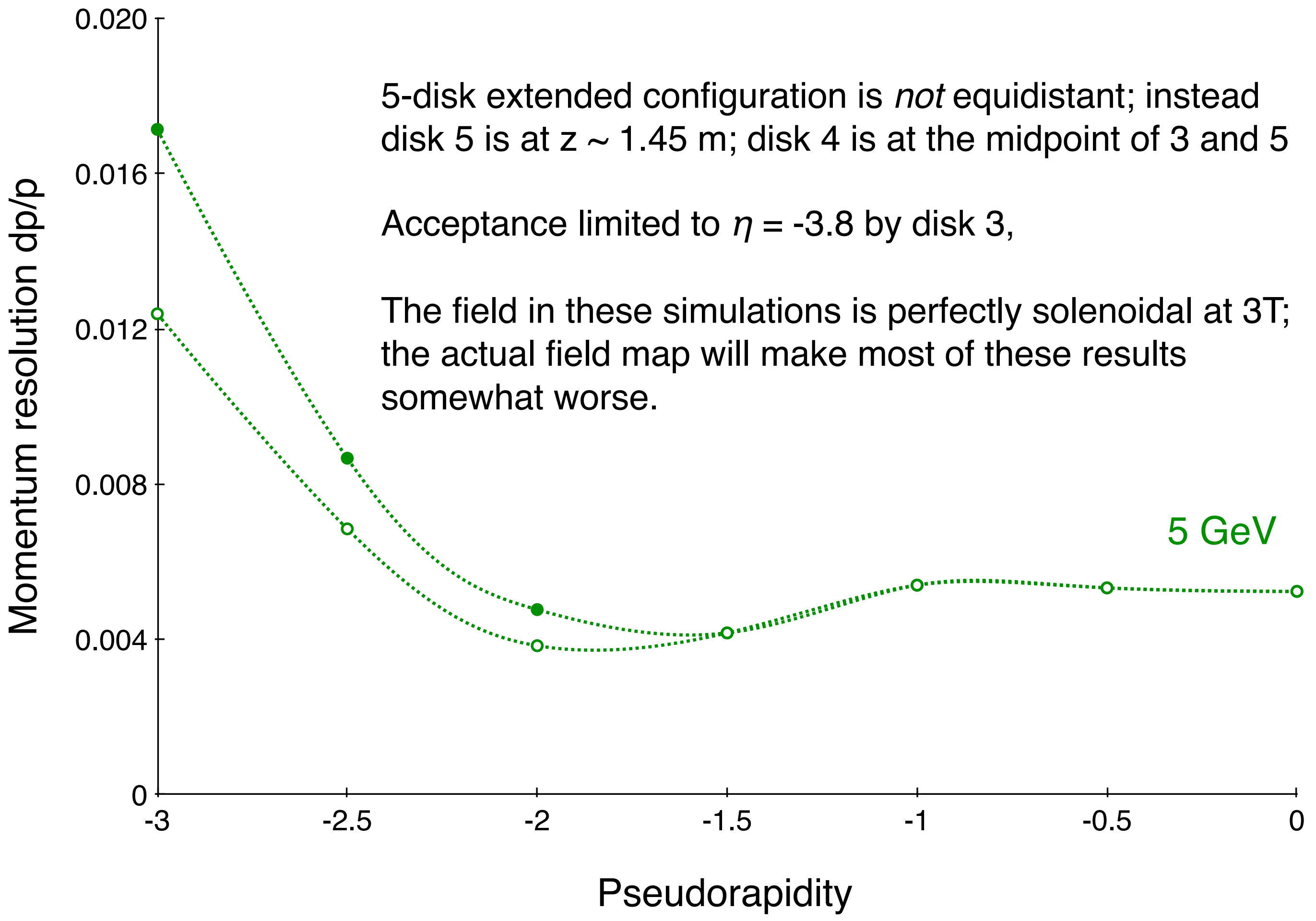
Baseline versus an extended 6-disk configuration







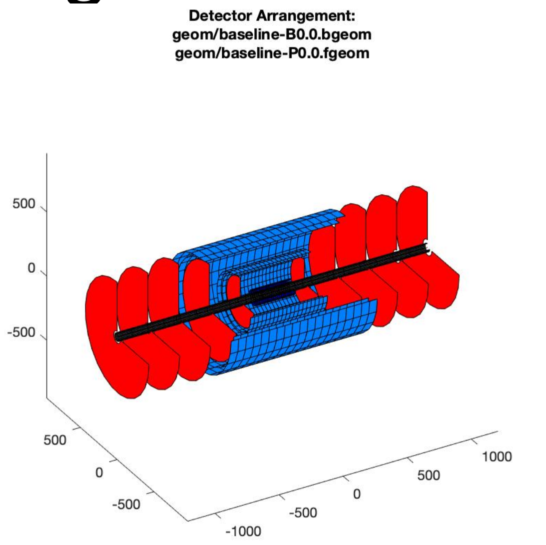
Baseline versus an extended 5-disk configuration

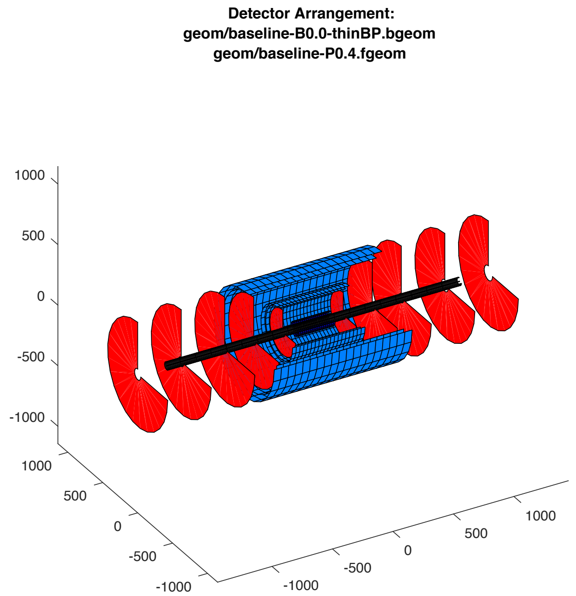


5-disk extended configuration is *not* equidistant; instead disk 5 is at z ~ 1.45 m; disk 4 is at the midpoint of 3 and 5

Acceptance limited to η = -3.8 by disk 3,

The field in these simulations is perfectly solenoidal at 3T; the actual field map will make most of these results somewhat worse.



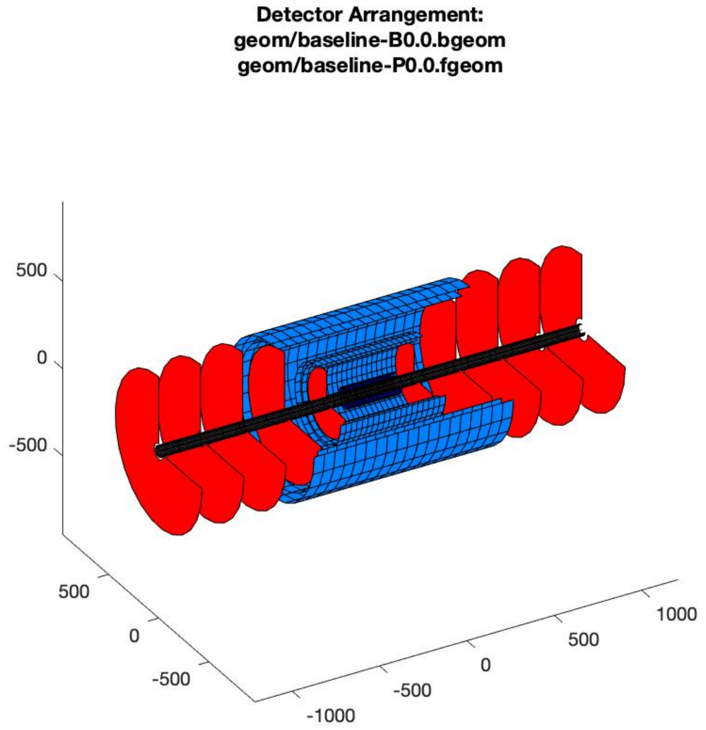


Switching topics once more…

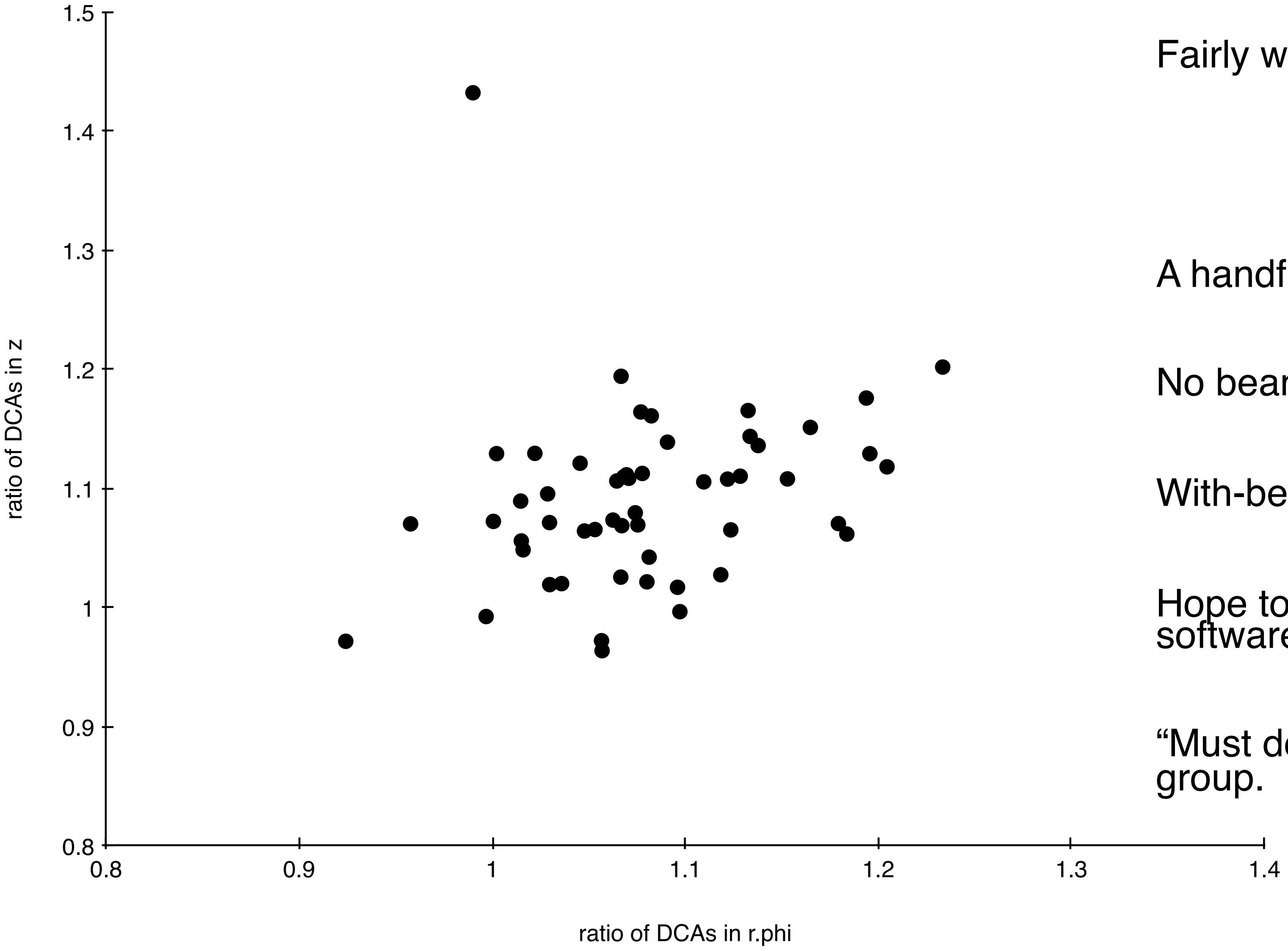
Single-track DCA resolutions from Fast Simulations

- Choices for vertex layers seem somewhat ad-hoc (to me),

- In what follows, I chose to work with the standard (baseline-0) all-silicon concept; let me not repeat all parameters here,
- The two innermost vertexing layers have a half-length of 150mm,
- At radii of 33mm and 57mm, this corresponds to pseudorapidities of ~2.2 and ~1.7,



Ratios of DCAs from Fun4All to Fast Simulations



Fairly wide parameter range,

p = 1, 2, 5, 10 … 50 GeV,

eta = 0.0, 0.5, 1.0, … 3.0

A handful of missing points in Fun4All fits,

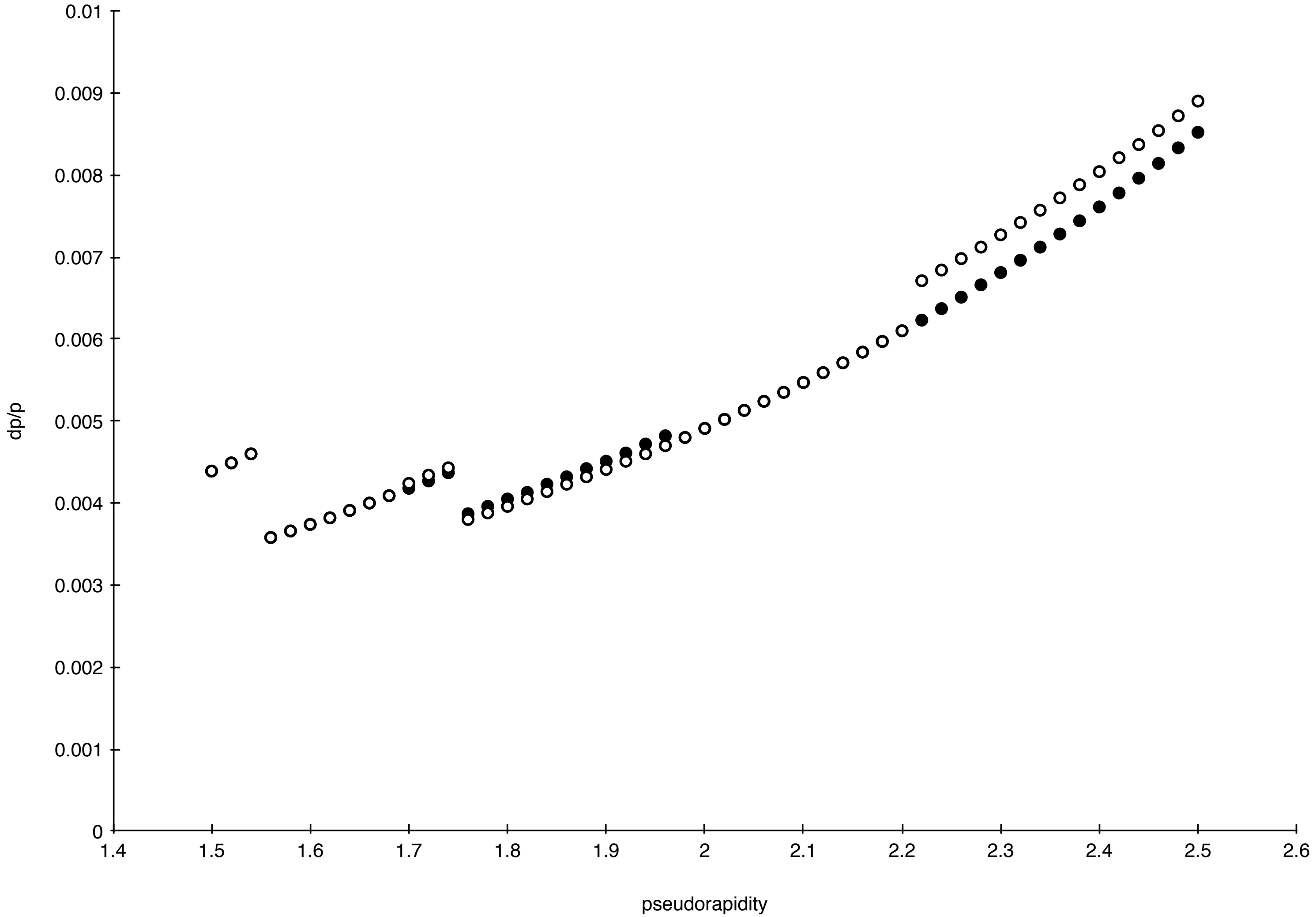
No beampipe in this comparison,

With-beampipe comparison in progress,

Hope to be able to do this soon w. ATHENA software,

"Must do <u>now</u>" for heavy-quark working group.

Momentum resolution with 200mm half-length



Fine-binned fast simulation results,

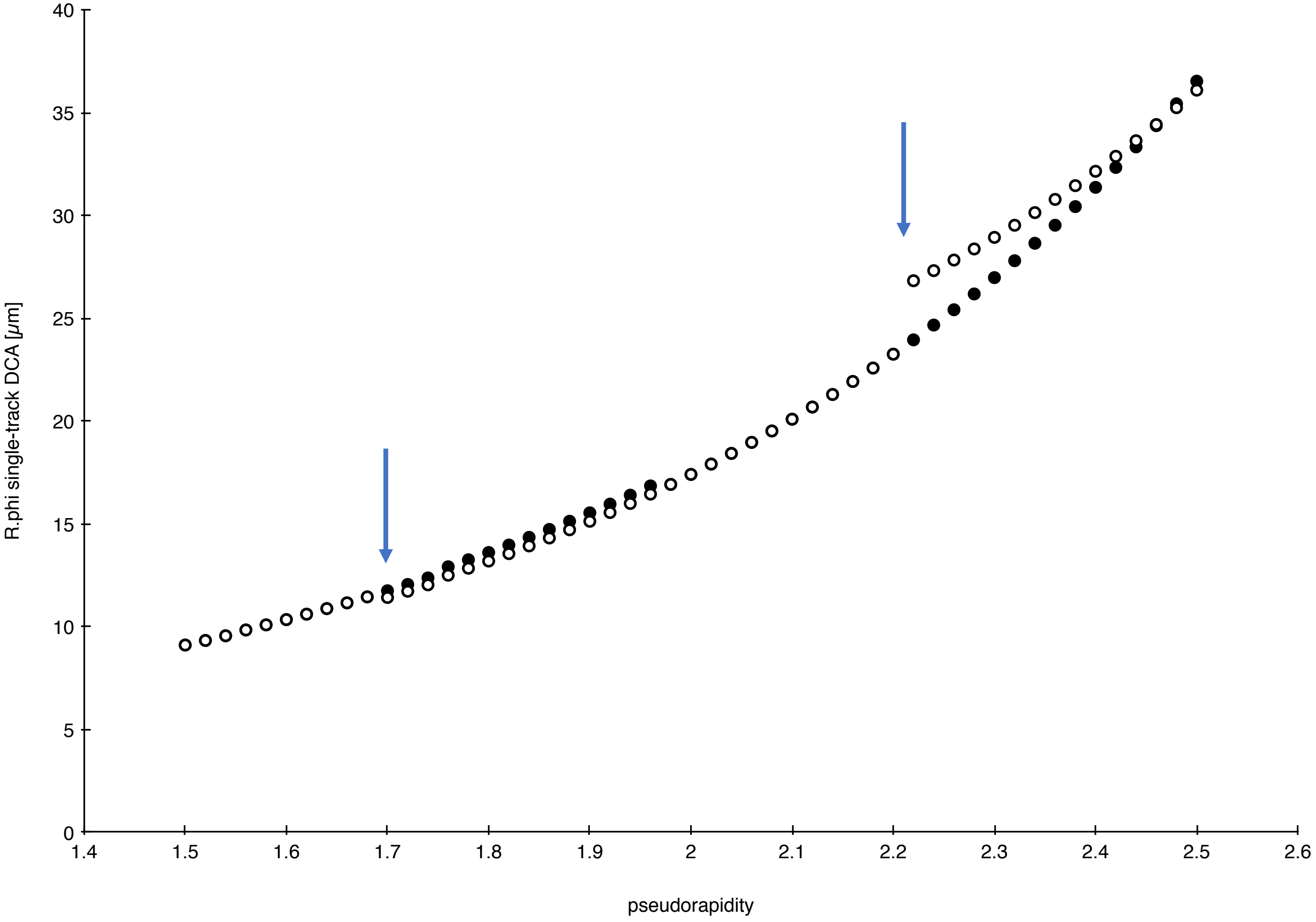
Here, p = 10 GeV,

Note, this includes the beampipe,
but *not* the service-transition,

Open points are baseline-0,

Closed points are 200mm half-length;
33 and 57 mm radii correspond to
2.5 and 2.0 in pseudo-rapidity

R.phi single-track DCA with 200mm half-length



Fine-binned fast simulation results,

Here, p = 10 GeV,

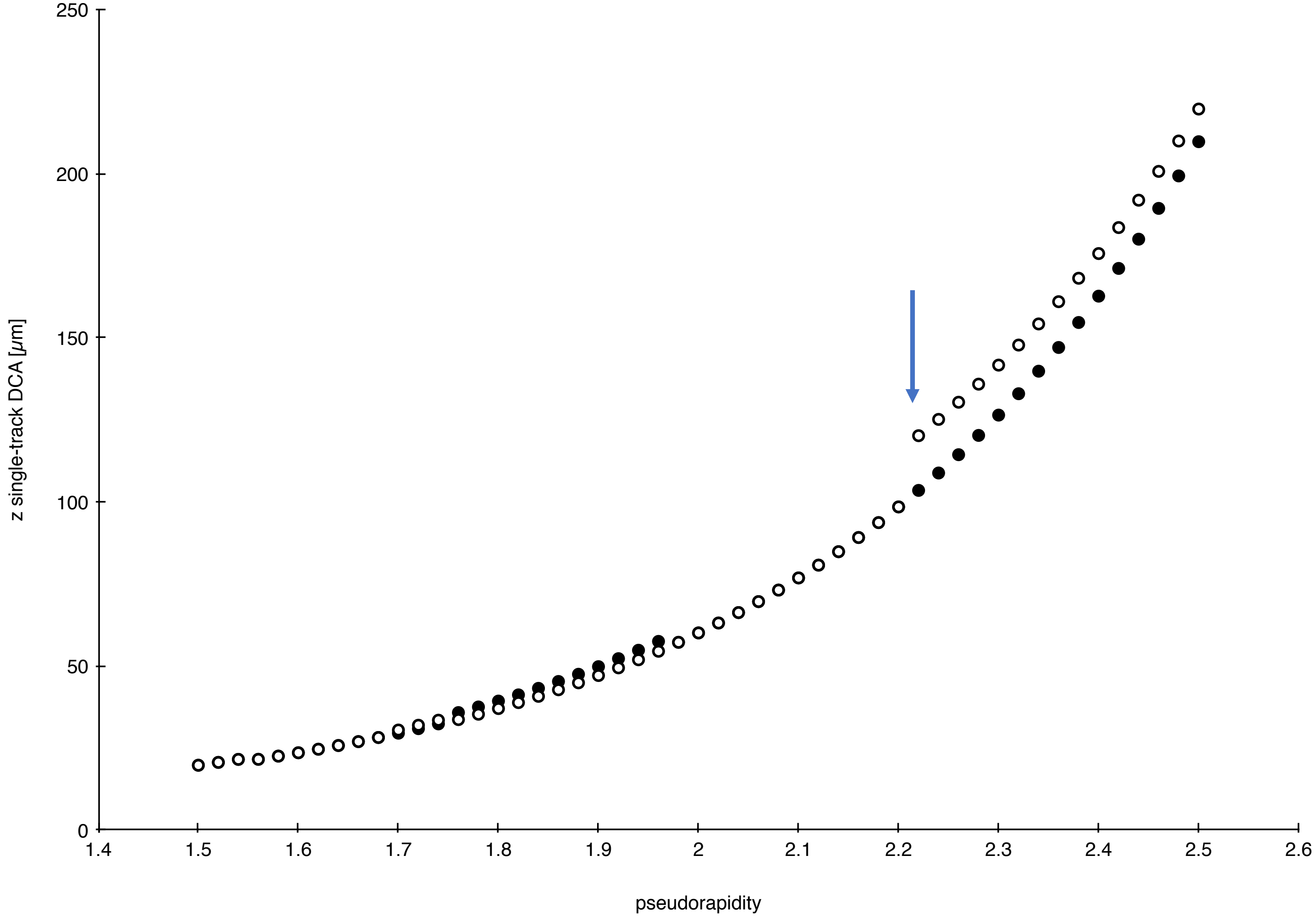
Note, this includes the beampipe,

but *not* the service-transition,

Open points are baseline-0,

Arrows show baseline-0 acceptance edges,

z single-track DCA with 200mm half-length



Fine-binned fast simulation results,

Here, p = 10 GeV,

Note, this includes the beampipe,
but not the service-transition,

Open points are baseline-0,

Effects from service-transition need study,

Vertex-spread will favor longer length,

Shorter (140mm) half-length will enable single-sided services.