Main Tracker Geometry & Performance

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Thanks to the tracker optimisation group

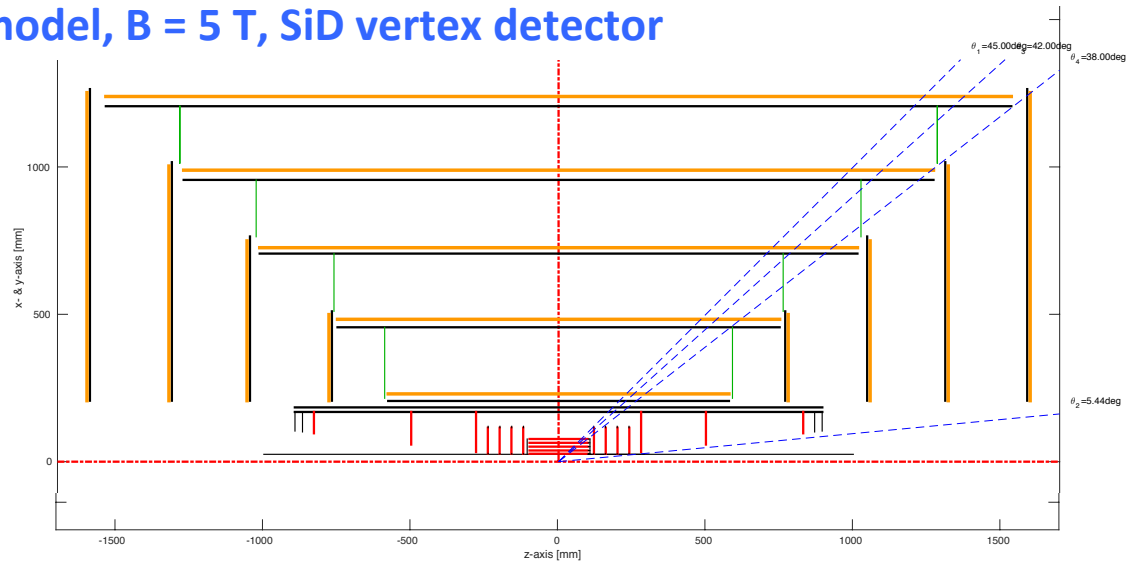
Outline

- Main tracker layout
- Comparison with CDR
- Material budget towards a realistic model:
  - Cables, cooling and supports
  - Support tube
- Optimisation of the layer layout inside the model:
  - Change length/r position of first barrel layer
  - Optimise gaps between barrel and endcap disks
  - Change position of inner tracker disks w.r.t. outer tracker disks
  - Change length of barrel layers

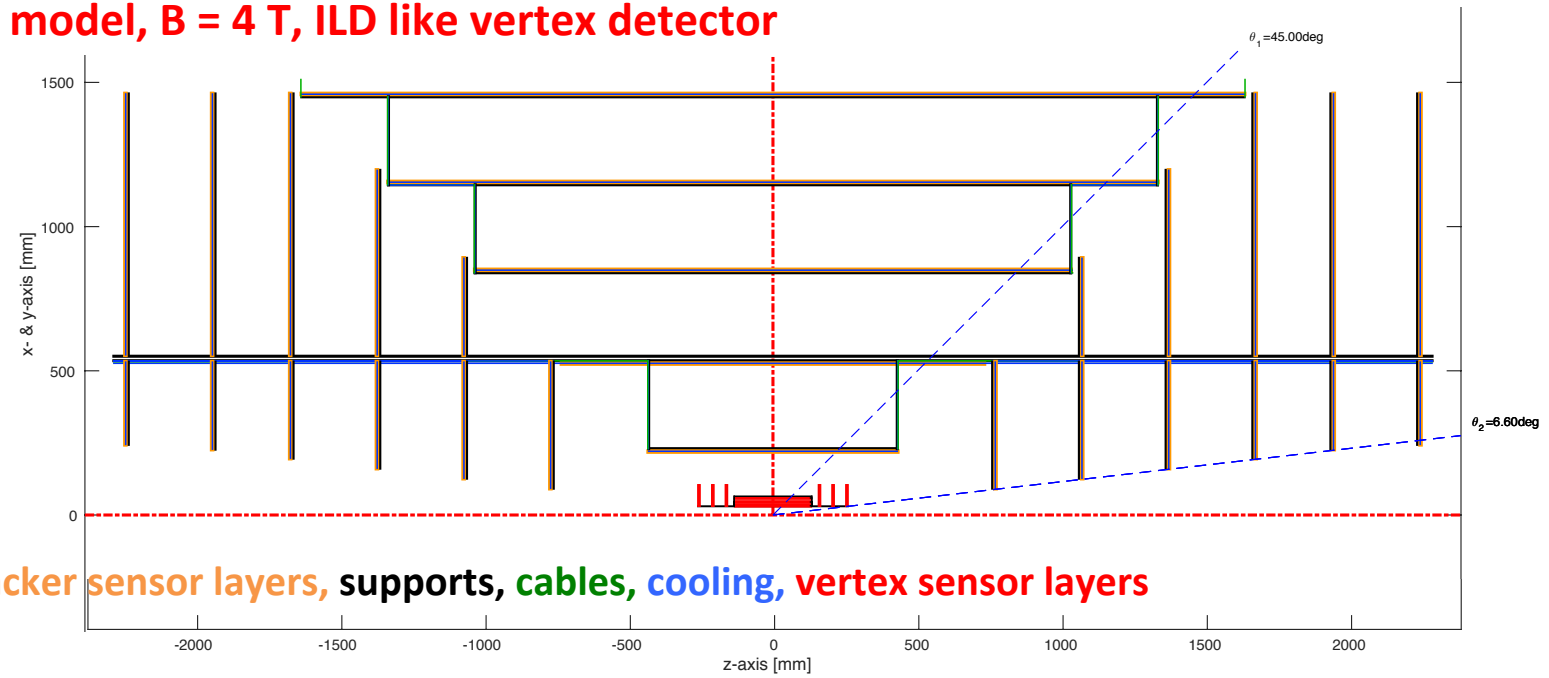
Fast simulation (LDT), single point resolution 7μm

Layout comparison

CLIC_SiD, CDR model, B = 5 T, SiD vertex detector



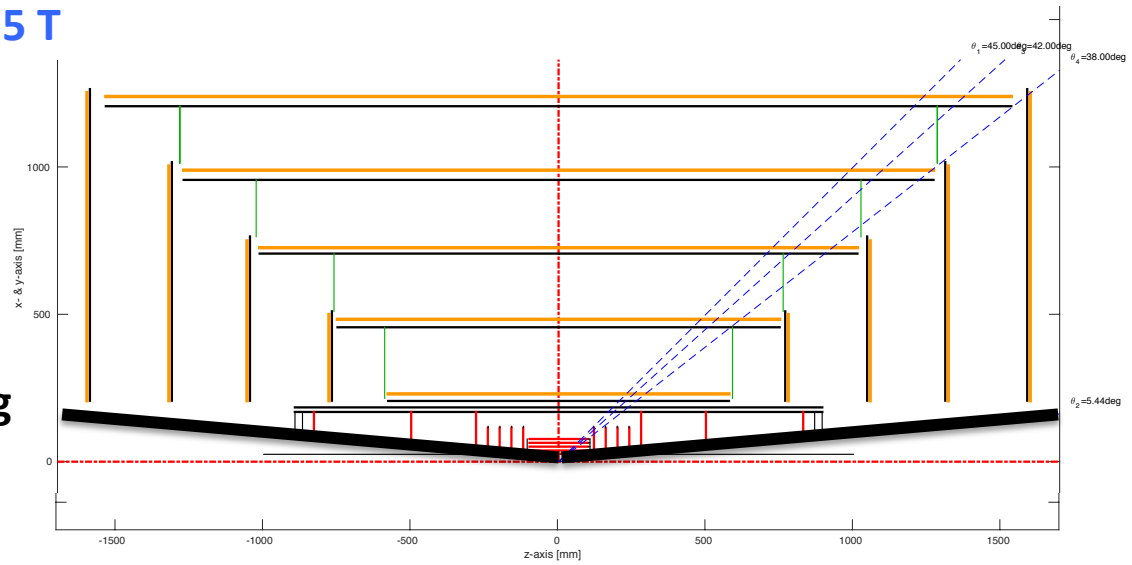
New model, B = 4 T, ILD like vertex detector



Tracker sensor layers, supports, cables, cooling, vertex sensor layers

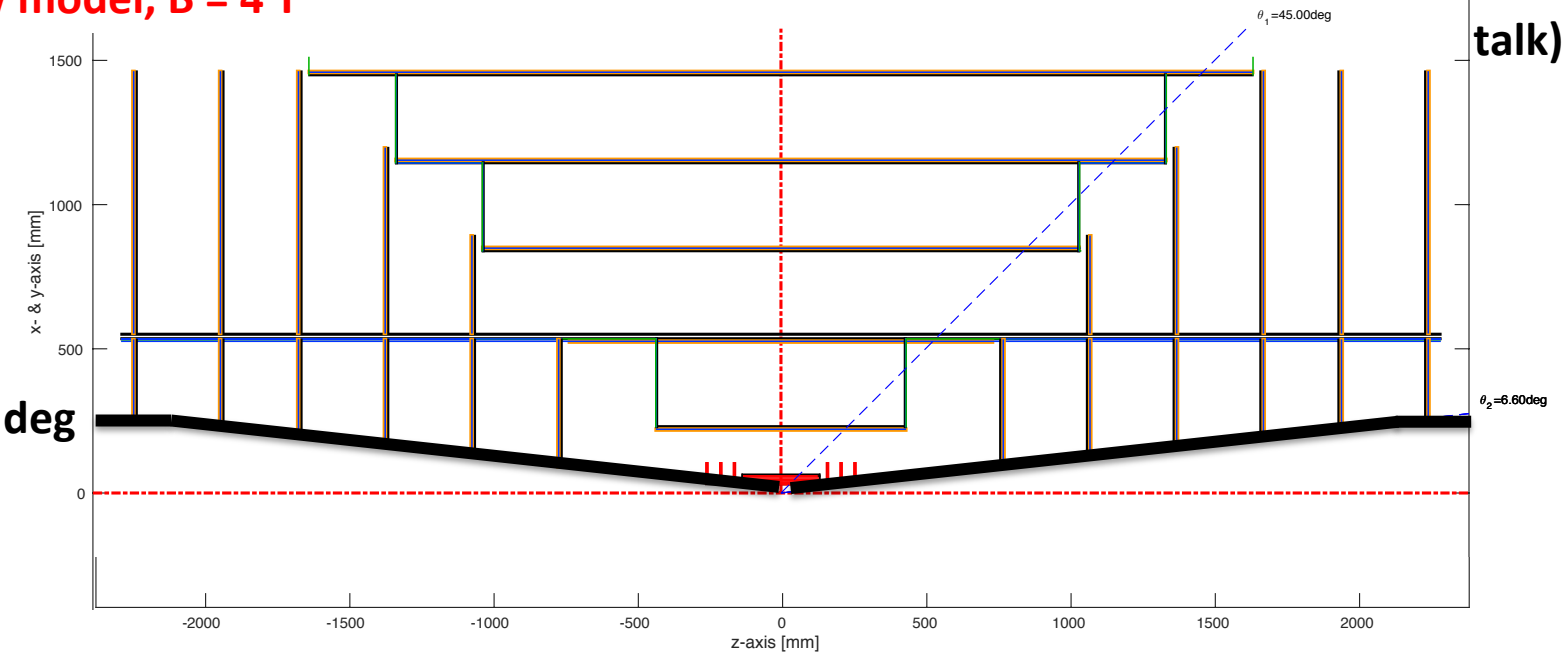
Beam pipe

CDR model, B = 5 T



5.4 deg

New model, B = 4 T



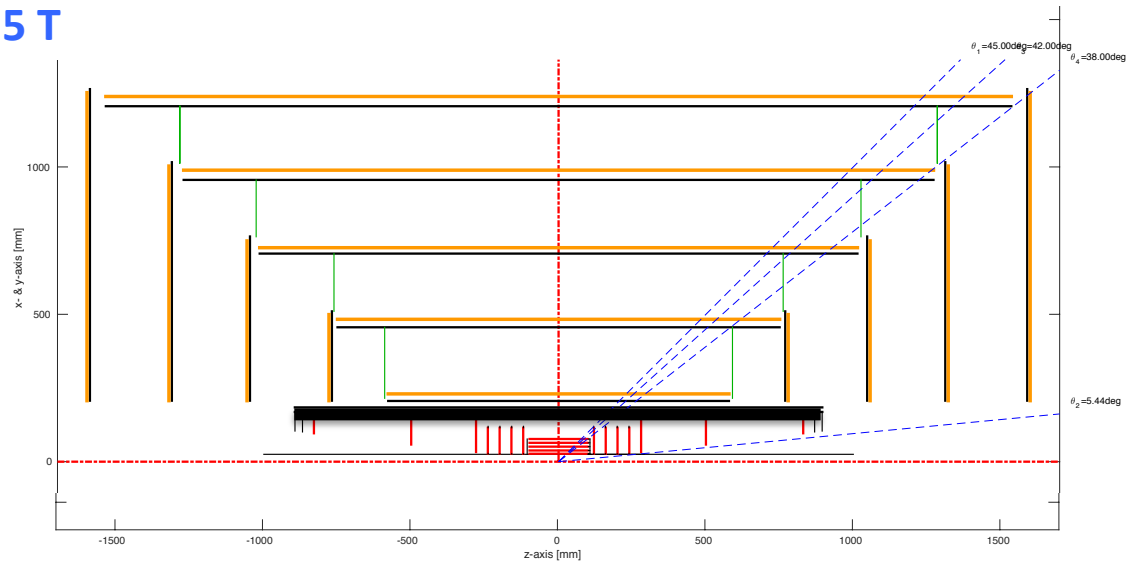
6.6 deg

Beam pipe:

- **adopted ILD model**
- **no material in front LumiCal for Luminosity measurement**
- **space for taking in air for vertex cooling (more in Fernando's talk)**

Support tube

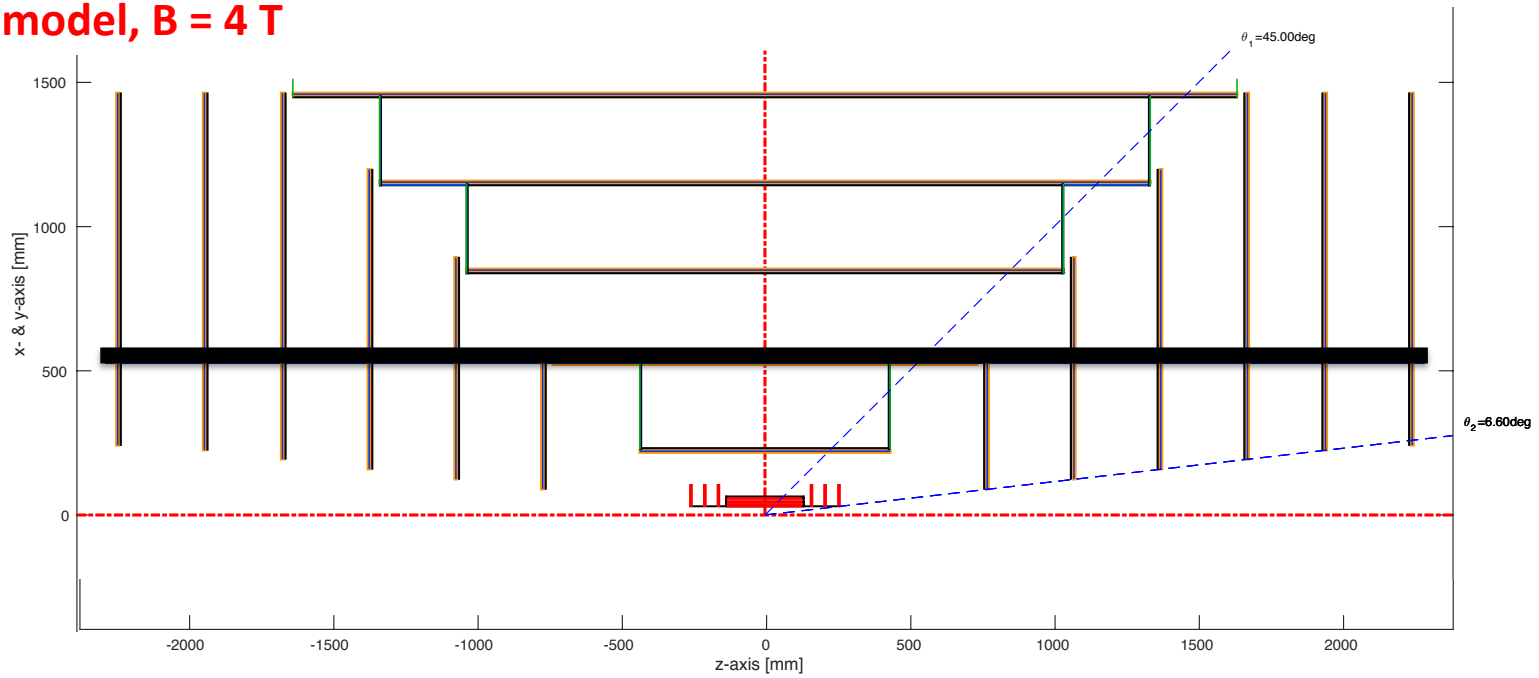
CDR model, B = 5 T



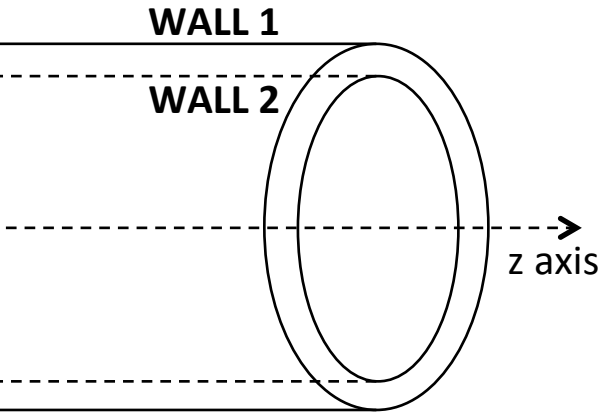
Support tube:

- **It allows first layer at 230mm**
- **It allows to drop support for the second barrel layer**

New model, B = 4 T

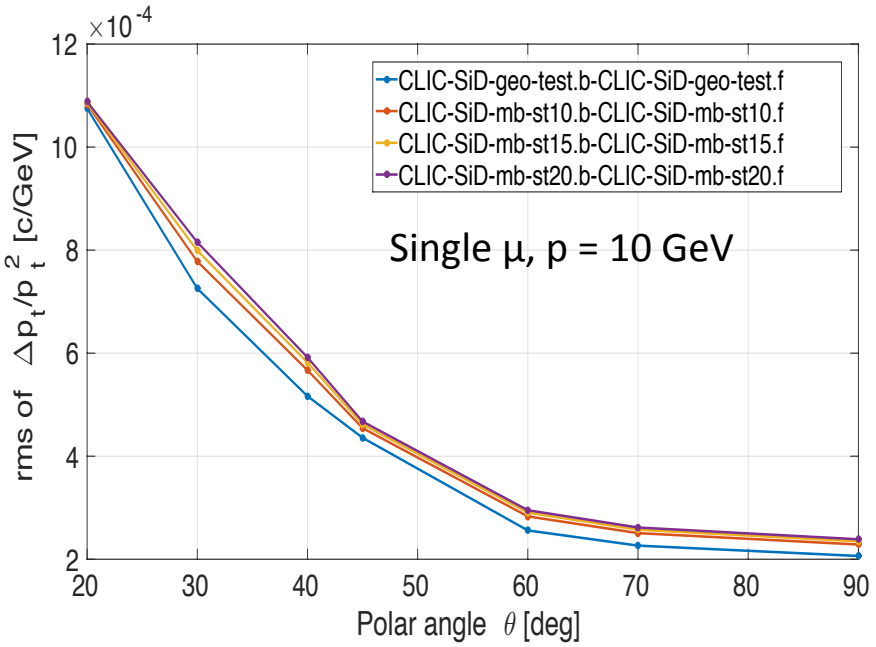


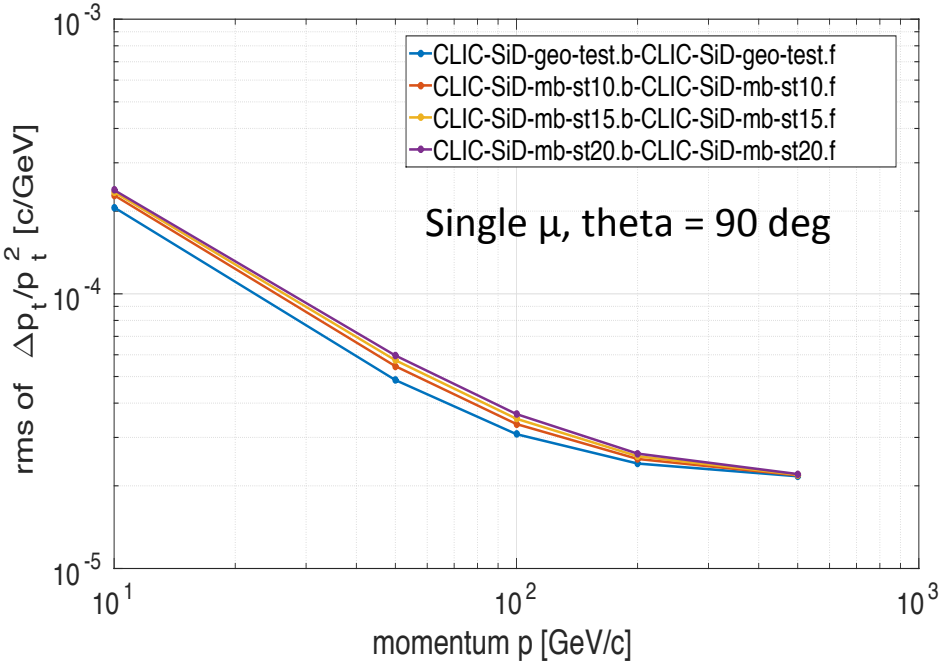
Model for the support tube



VERY PRELIMINARY

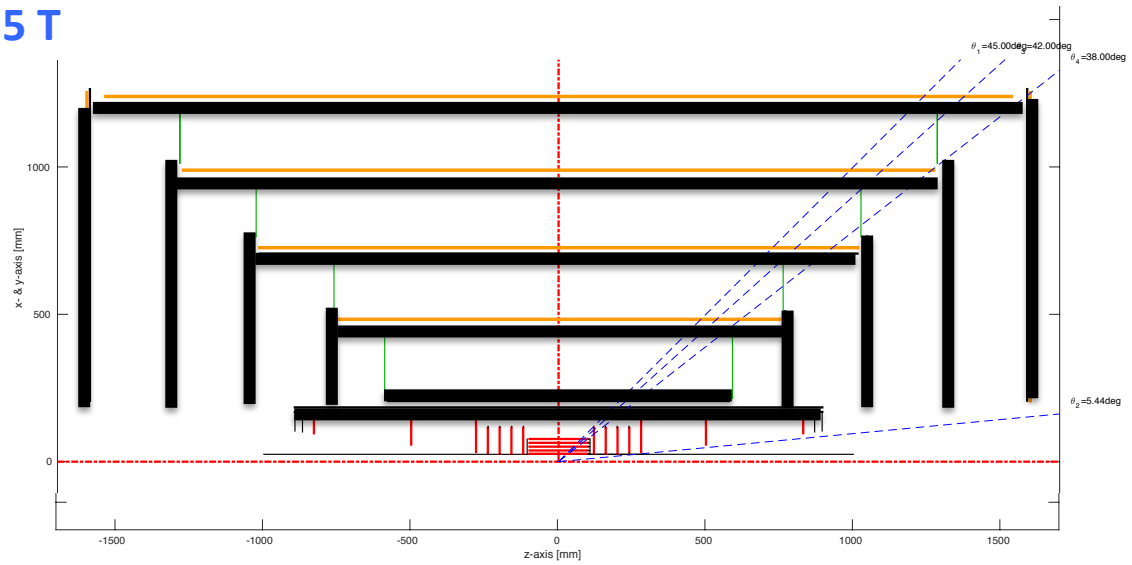
- In the CDR design the support tube was supporting only the vertex detector. **X ~ 0.18%X_0**
- Hypothesis for realistic support tube: **5mm of carbon → X ~ 3%X_0 => 1.5%X_0 per wall**
- M.b. scan performed around the realistic support tube value: 1.0%X_0, **1.5%X_0**, 2.0%X_0





Supports

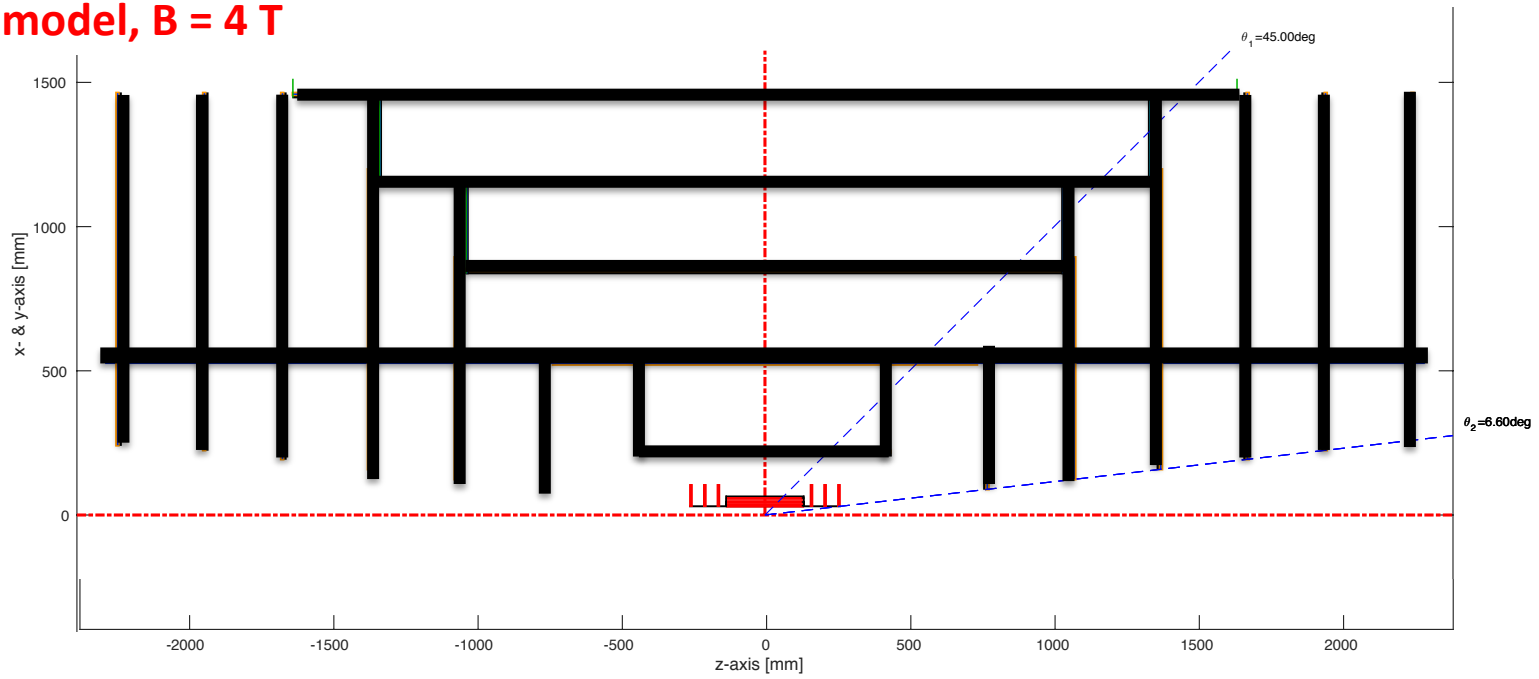
CDR model, B = 5 T



Support m.b.:

- **Increased m.b. → towards a realistic model**
- **More supports added**

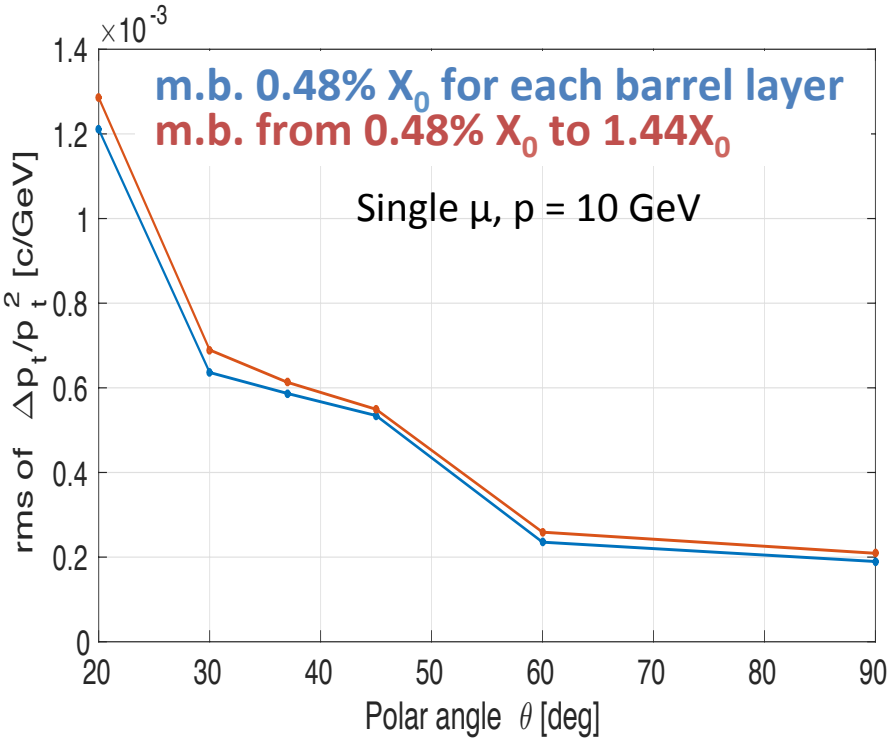
New model, B = 4 T

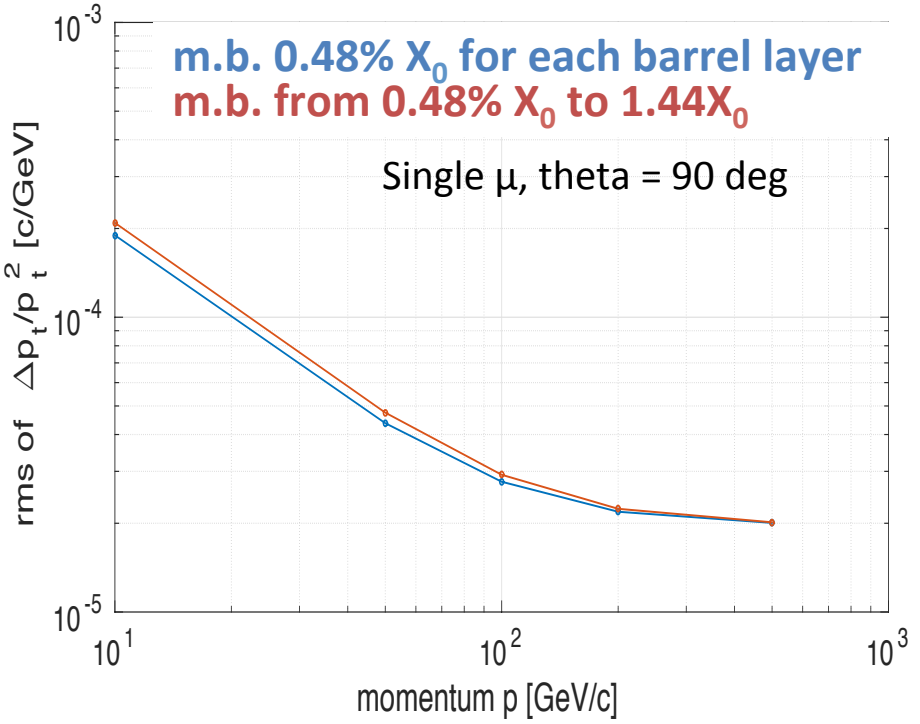


Model for supports

- For outer radii larger material is needed in order to match stability requirements
- *Rough implementation:* material for outermost layer 3 times larger than for innermost, linearly rescaled for layers in between → Szymon is studying possibilities on the engineer side

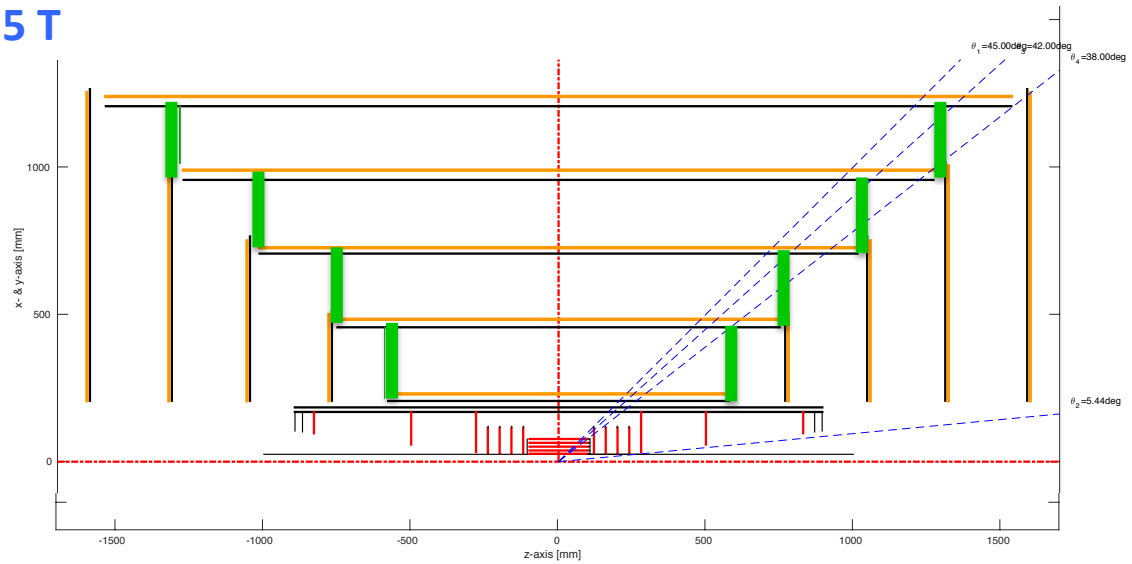
m.b. after scaling:
barrel 1: 0.48% X_0
barrel 2: /
barrel 3: 0.96% X_0
barrel 4: 1.20% X_0
barrel 5: 1.44% X_0





Cables

CDR model, B = 5 T

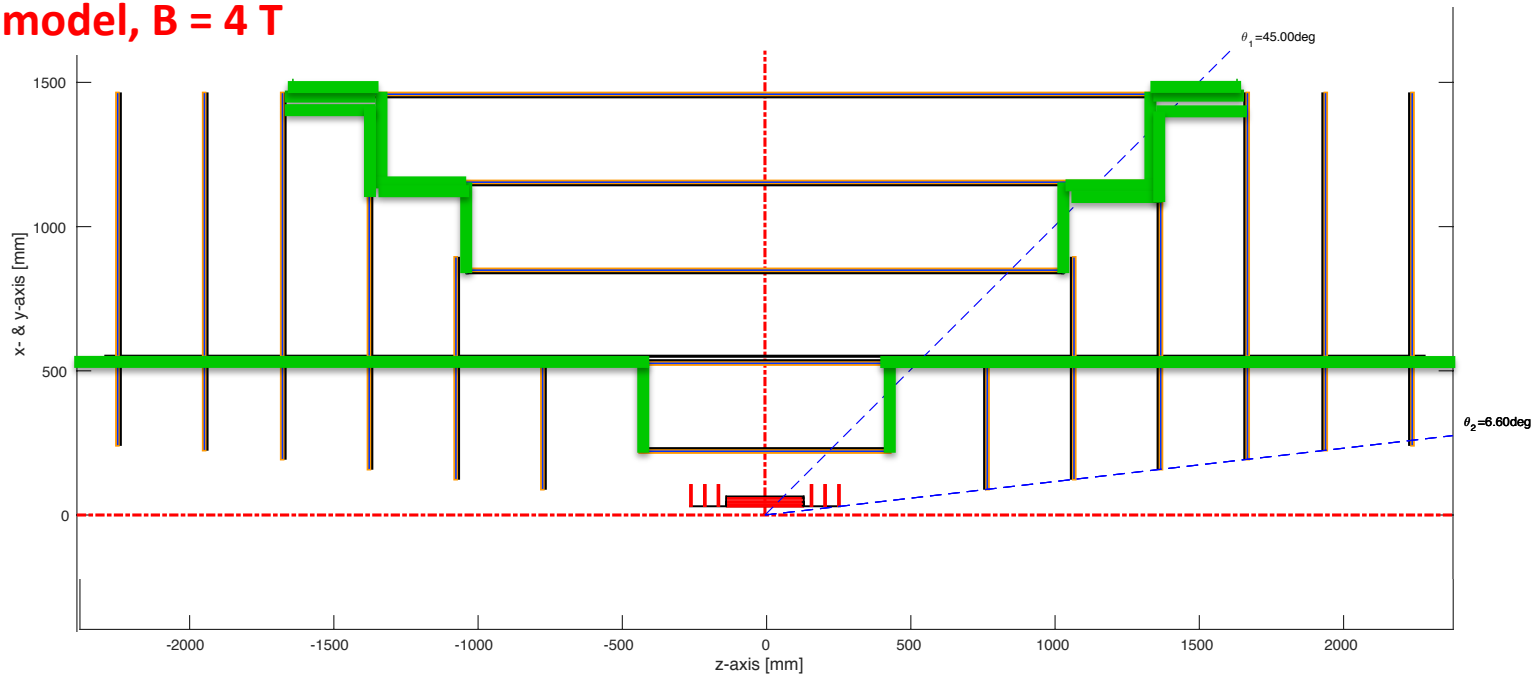


Cables:

- **Added cables**
- **m.b. properly rescaled assuming constant density**

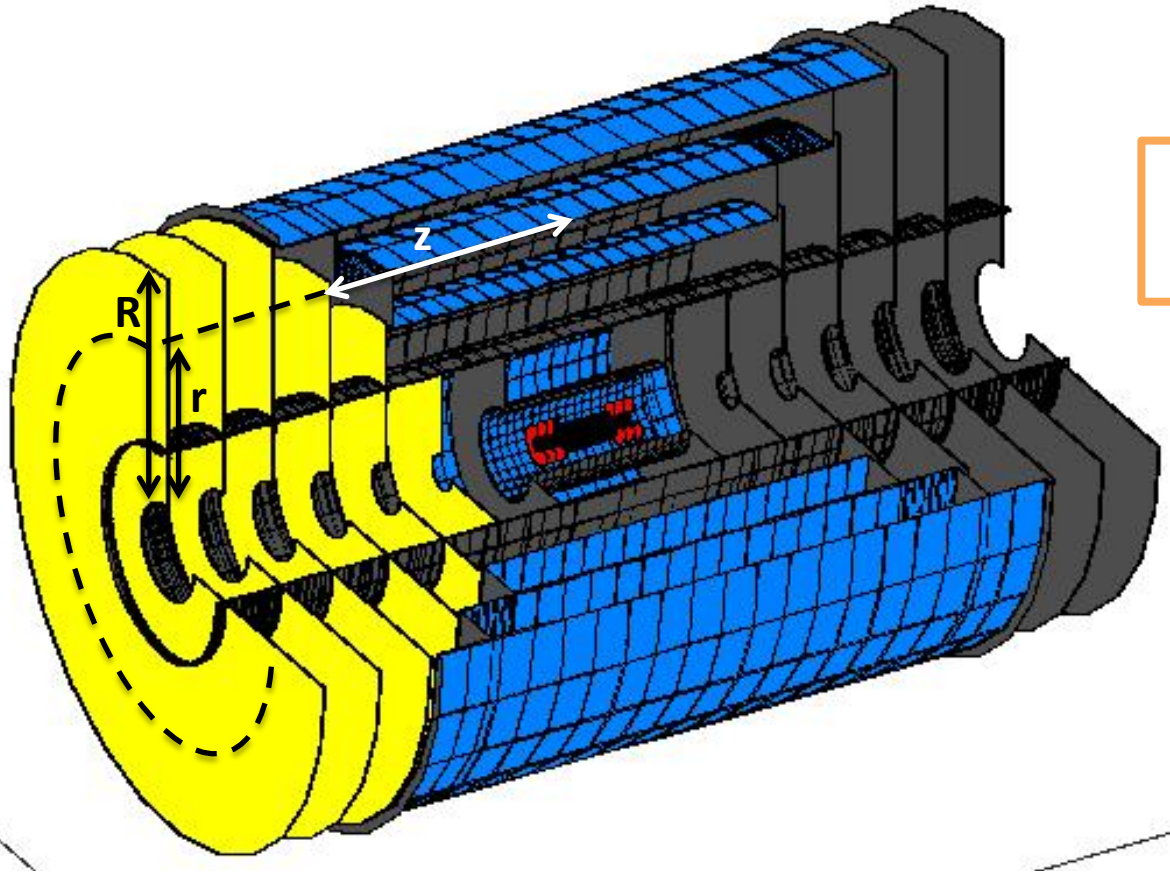
Still missing m.b. for connectors

New model, B = 4 T



Model for cables

- Material budget for cables and cooling should scale according to the layers size and position
- Assumed constant cable/cooling density $x_{cyl} : A_{cyl} = x_{ring} : A_{ring}$



$$A_{cyl} = 2\pi r z$$
$$A_{ring} = \pi(R^2 - r^2)$$

$$x_{ring} = \frac{x_{cyl}(R^2 - r^2)}{2rz}$$

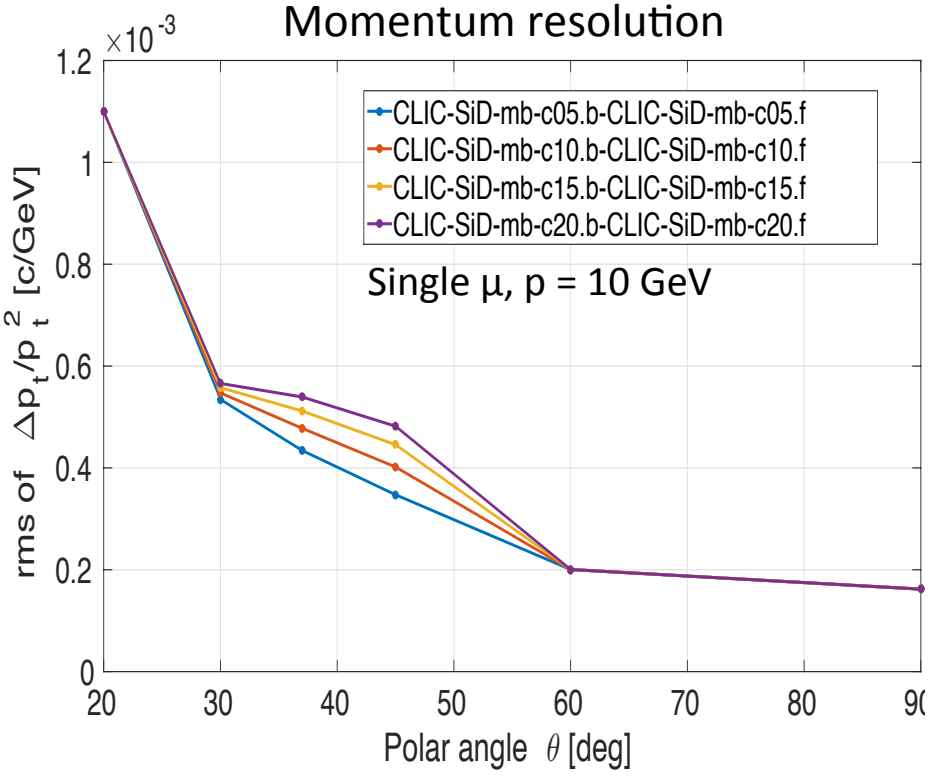
$$x_{ring}^{i,tot} = x_{ring}^{i} + \sum_{j<i} x_{ring}^{j}$$

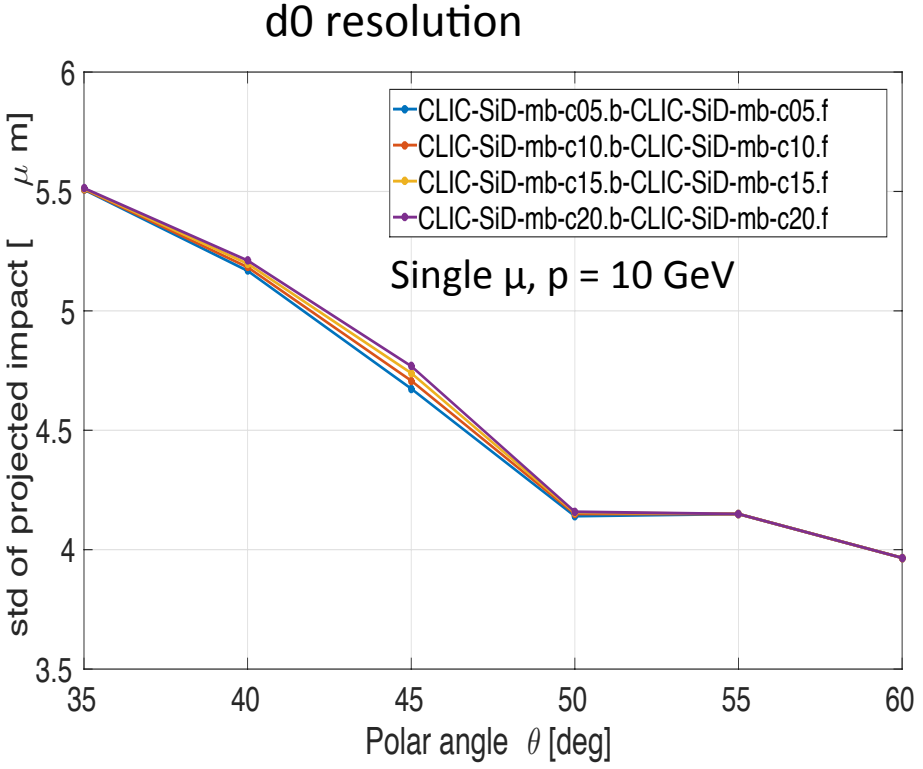
1.0%X_0

Results changing m.b. for cables

- Material budget for **support** fixed: **0.48%X_0 (barrel), 0.5%X_0 (forward)**
- Material budget for **sensor** fixed: **0.5%X_0 (barrel), 0.88%X_0 (forward)**
- Material budget for **cables** varied: **0.5%X_0, 1.0%X_0 , 1.5%X_0, 2.0%X_0**

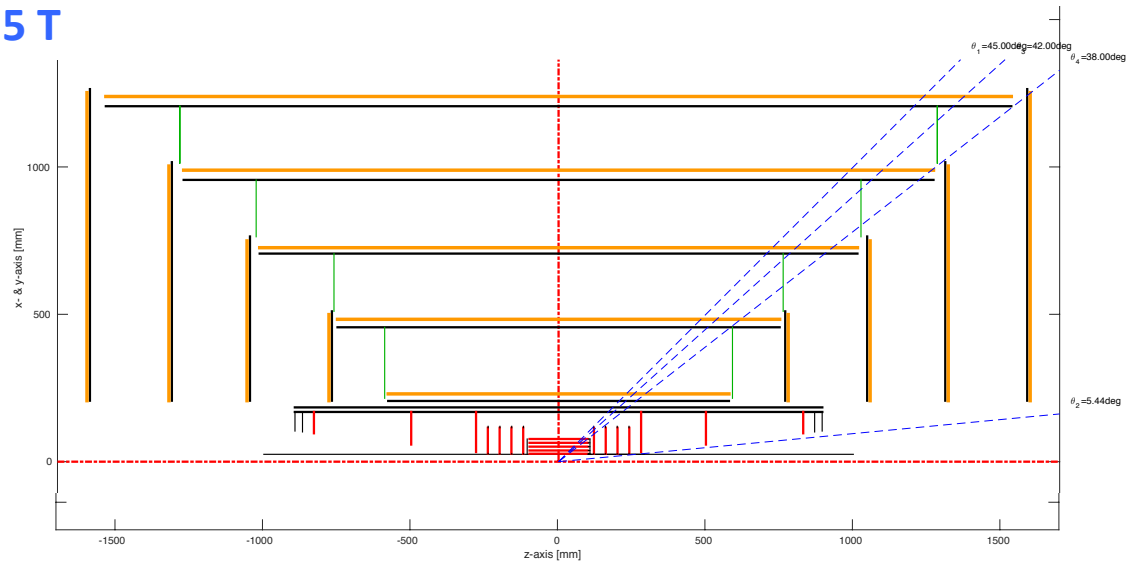
→ *As expected in the cable region (30°–50°) worsening of the p_T resolution, small effect on the d_0 resolution (dominated by vertex detector)*



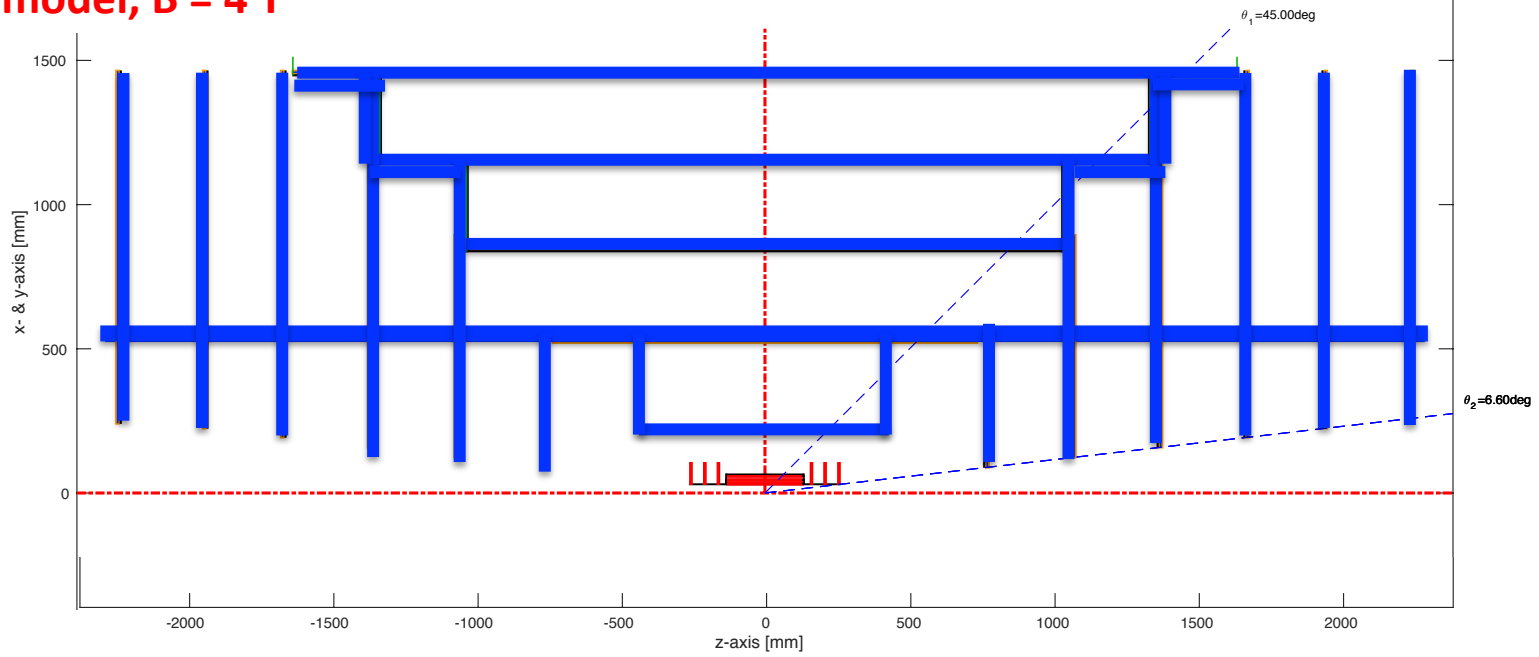


Cooling

CDR model, B = 5 T



New model, B = 4 T



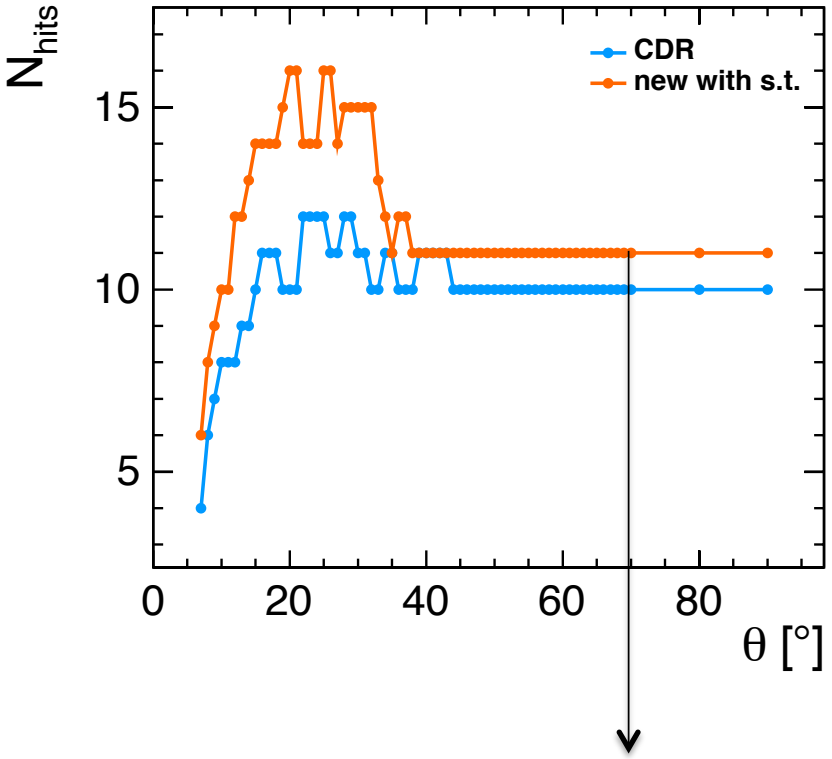
Cooling:

- **Add material for liquid cooling: $X = 0.5\%X_0$**
- **M.b. rescaled assuming constant density for taking the cooling out**

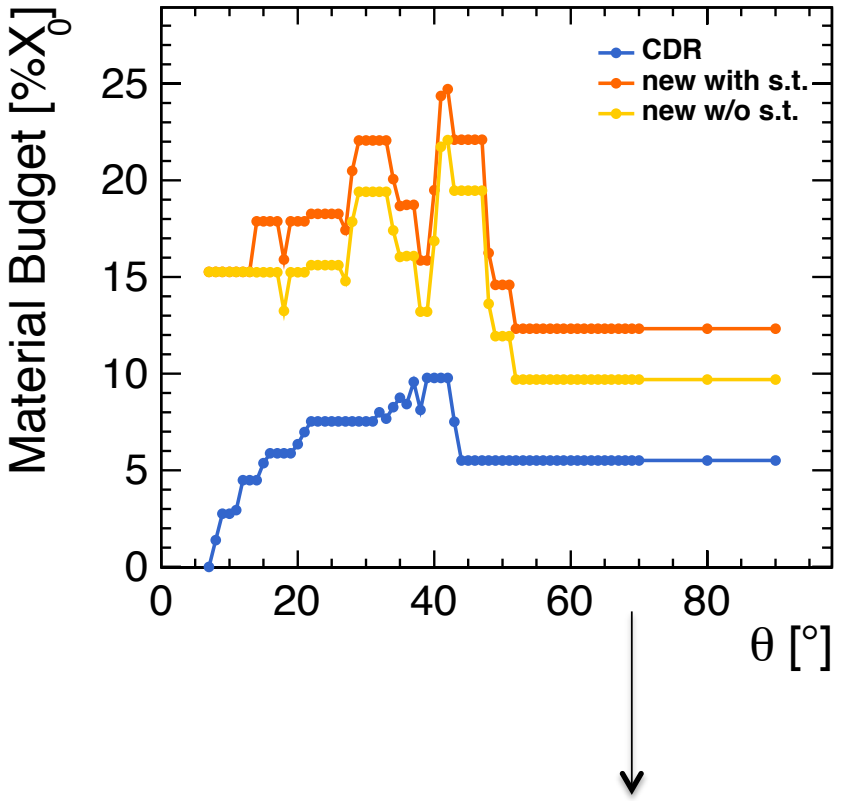
PUTTING ALL TOGETHER: PERFORMANCE COMPARED WITH CDR

Nhits vs theta

CDR, B = 5T
New model, B = 4 T
New model (not s.t.), B = 4 T

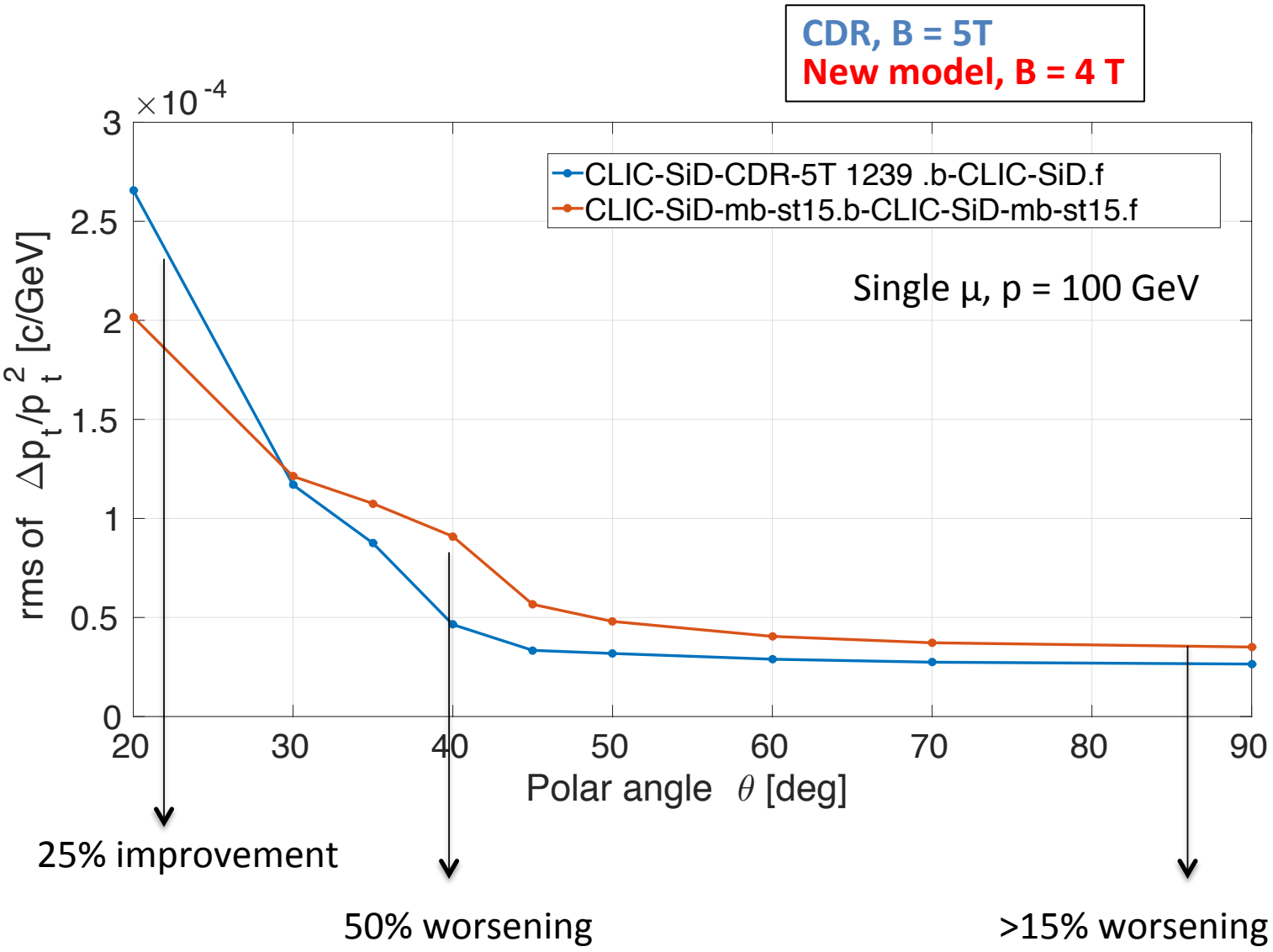


Larger nhits due to double layer vertex detector

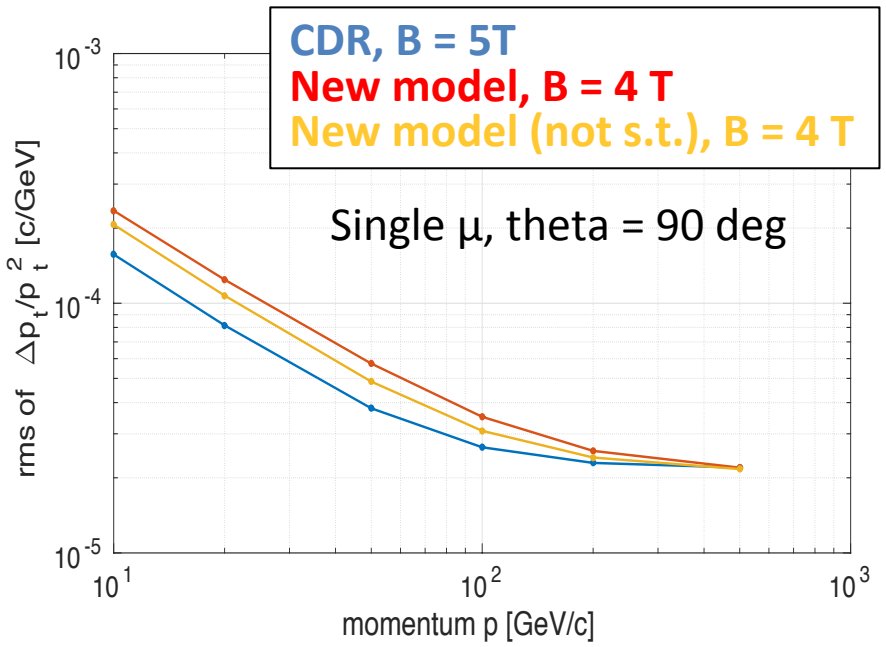


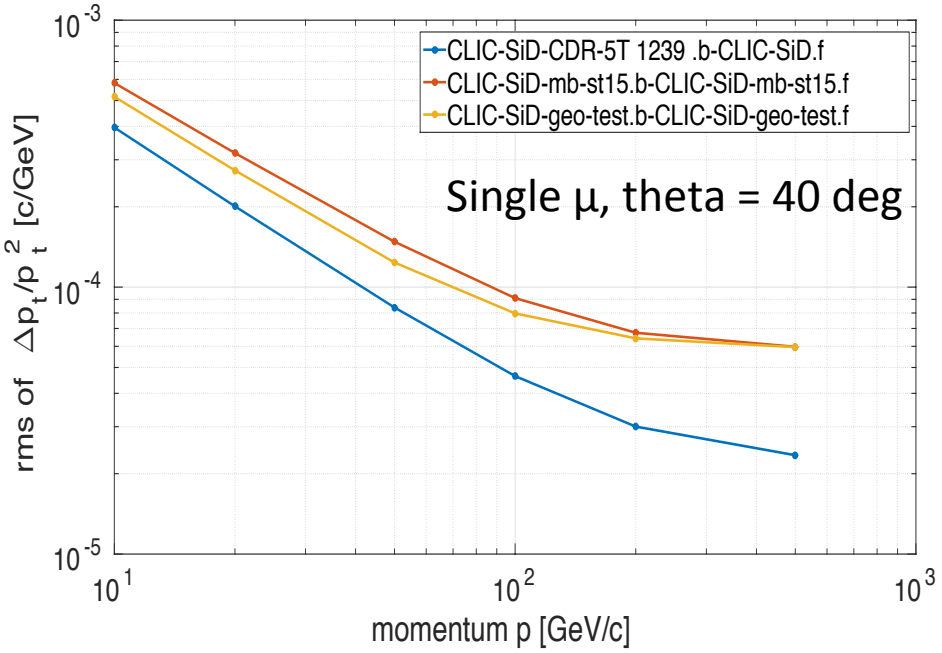
more than double m.b. in CDR

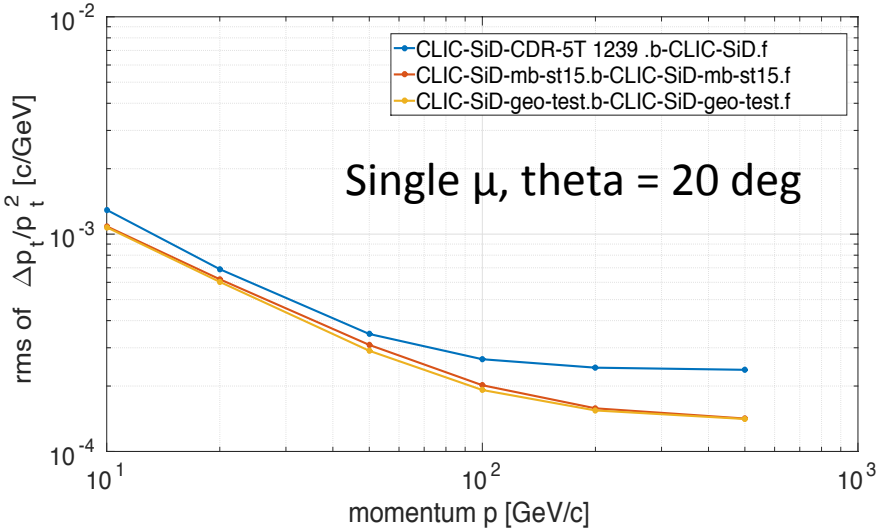
Momentum resolution vs theta



Momentum resolution vs p







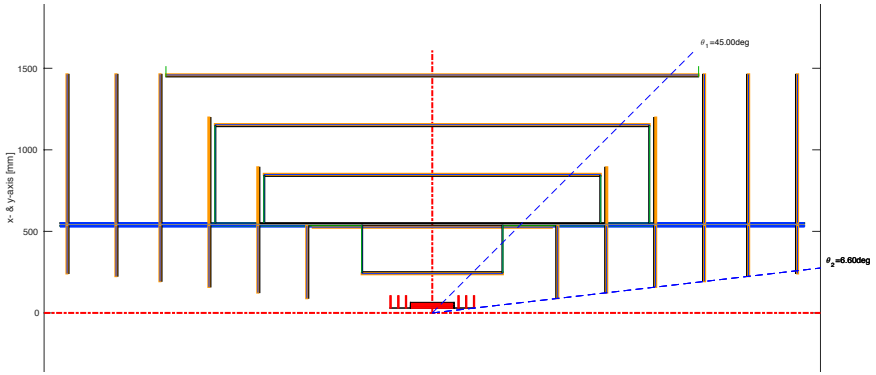
- In the barrel region >15% worsening for low pT tracks
- Transition region to be investigated more
- Still better than the CDR in the forward region

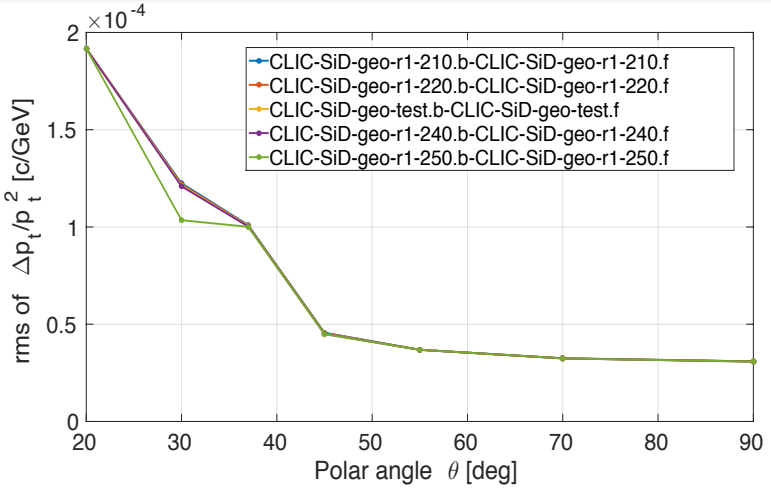
Optimisation of the model

- Compensating effects between extra hits and extra m.b.
- Repeat studies in full simulation to look at the variation in the track parameters and errors

Move r position of the first barrel layer

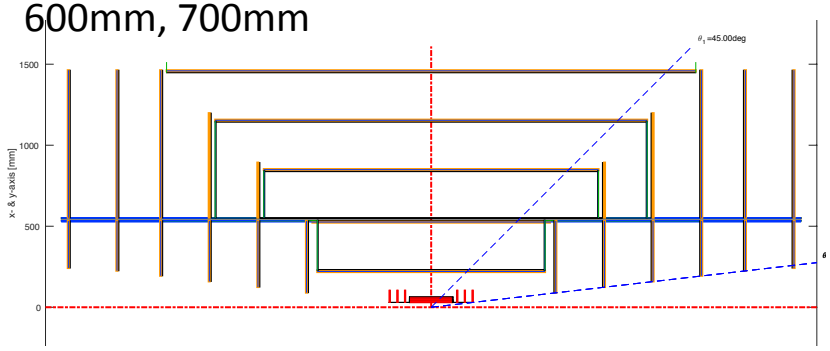
Scan of r1 from 230mm to 210, 220, 240, 250mm





Change length of the first barrel layer

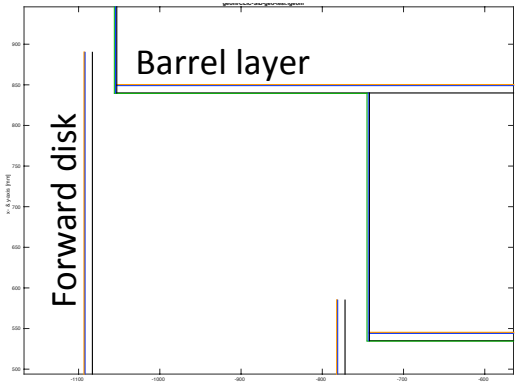
z1 varied from 430mm to 450mm, 500mm, 600mm, 700mm



Optimise gap between barrel/forward and the outer radius of the forward disk

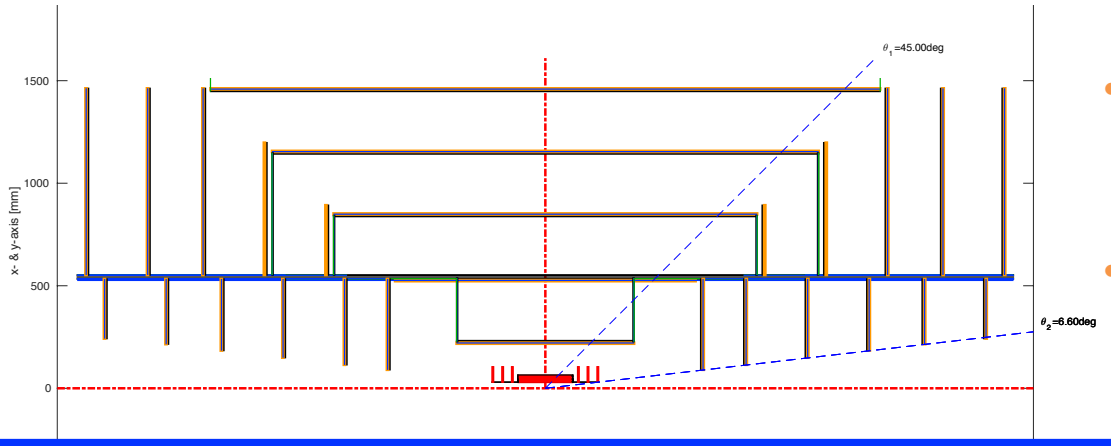
- Δr = 40 mm
- Gap = 30 mm

- Not full scan performed yet
- Gaps are not pointing to IP

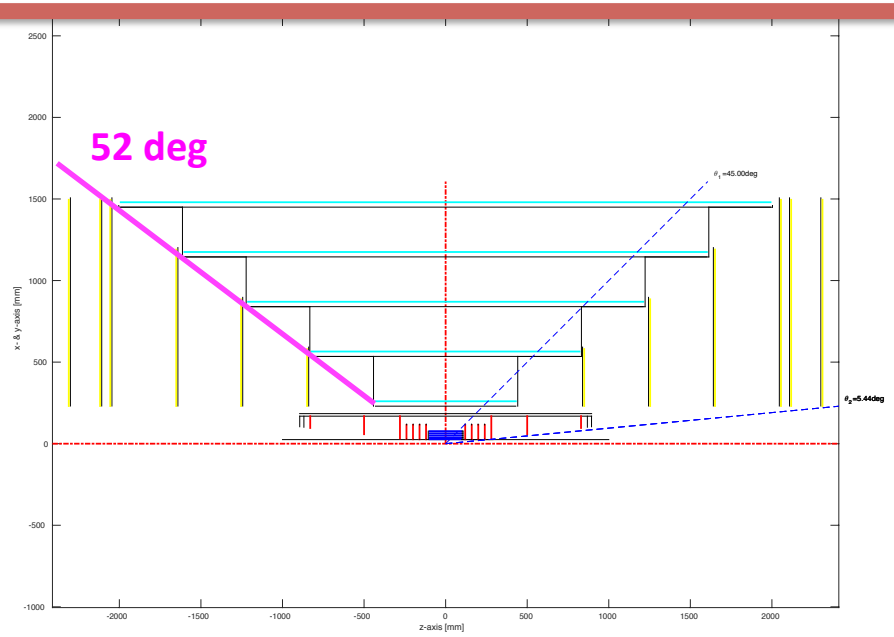


Possible variations of the model

- So far, not very promising, but still to look at



- Displacement of 30-60-90mm between position of the inner layers and the outer layers
- No change in performance, gaps are not poiting to IP



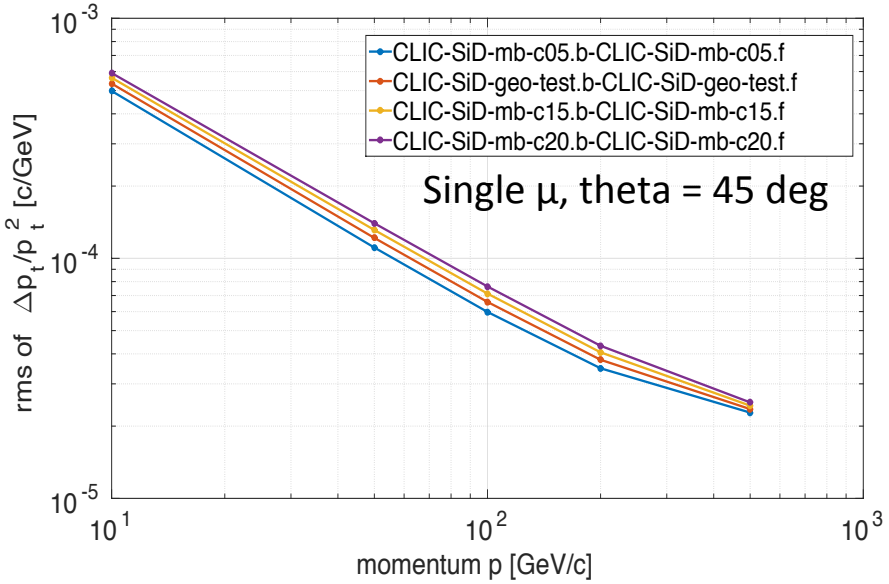
- Change of the length of the barrel layers → need to increase m.b. for support for stability requirement (possible?)
- Drop a forward disk

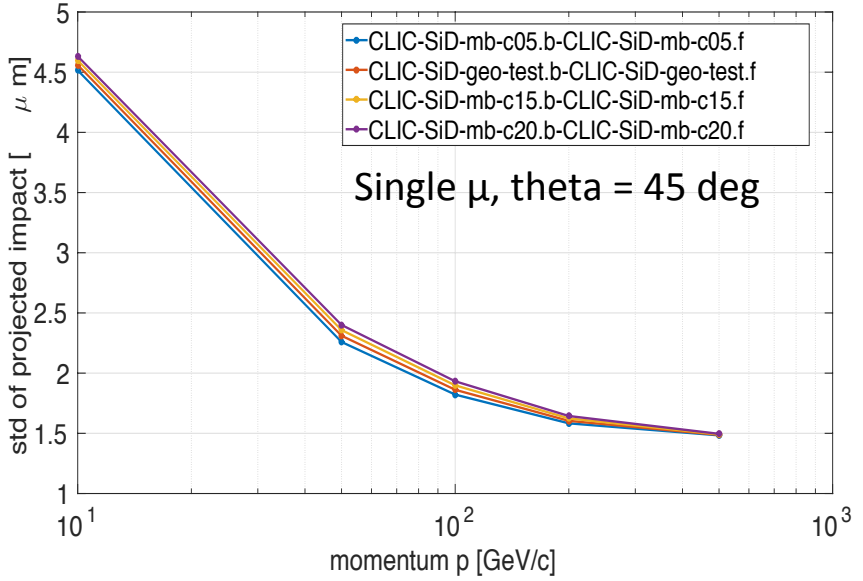
Conclusion

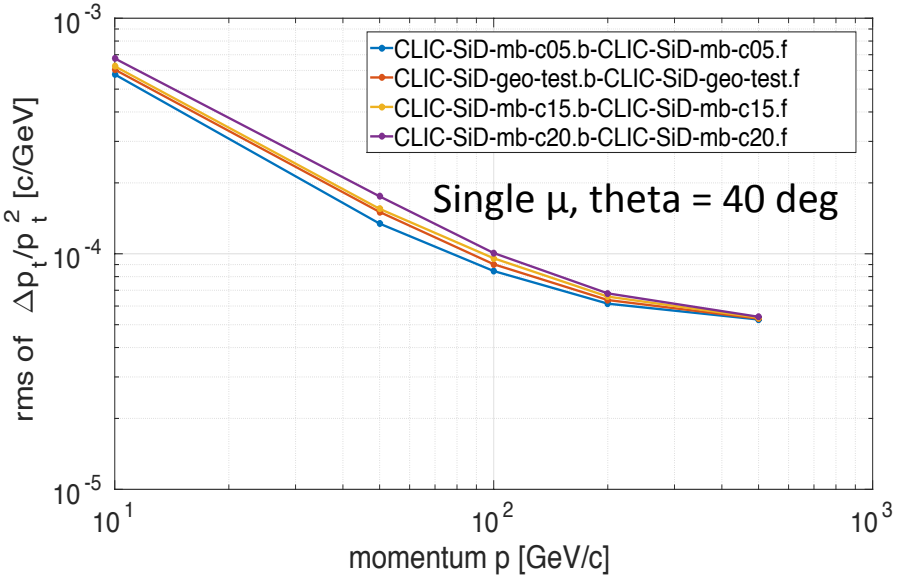
- Model for the tracking is not final yet, but we are converging:
  - Optimisation still ongoing
  - Moving towards a more realistic model
    - m.b. and space for services started to be taken into account
- Soon, validation in full simulation and reconstruction (status report tomorrow):
  - Information on the tracking quality
  - Different topologies available

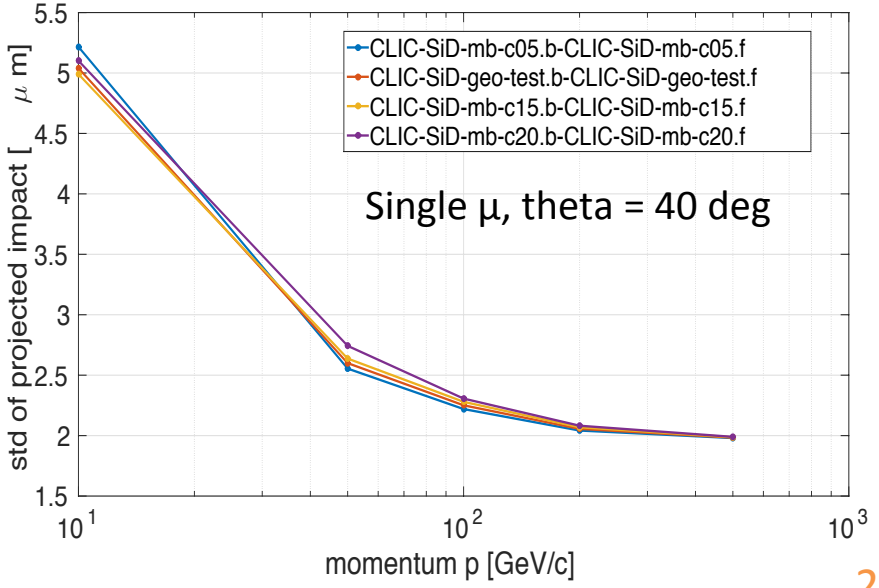
BACK-UP

M.b. for cables :results vs momentum





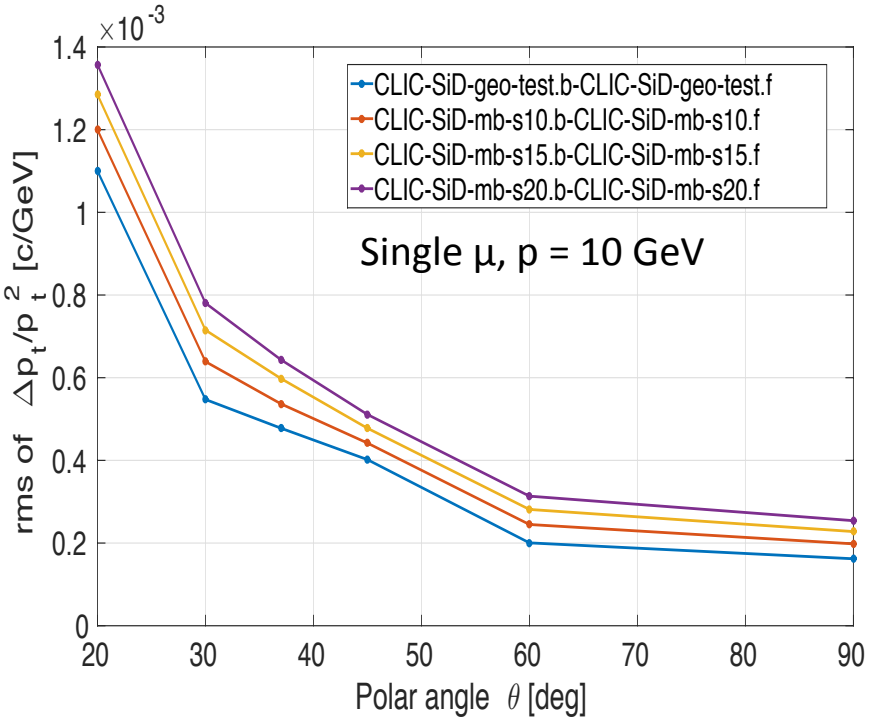


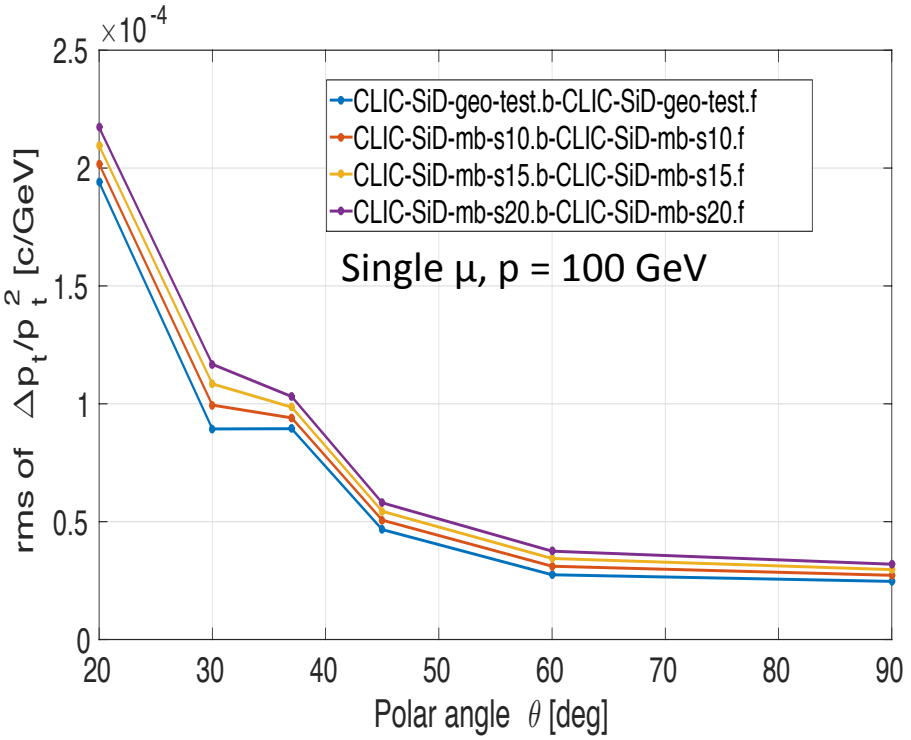


Results changing m.b. for supports

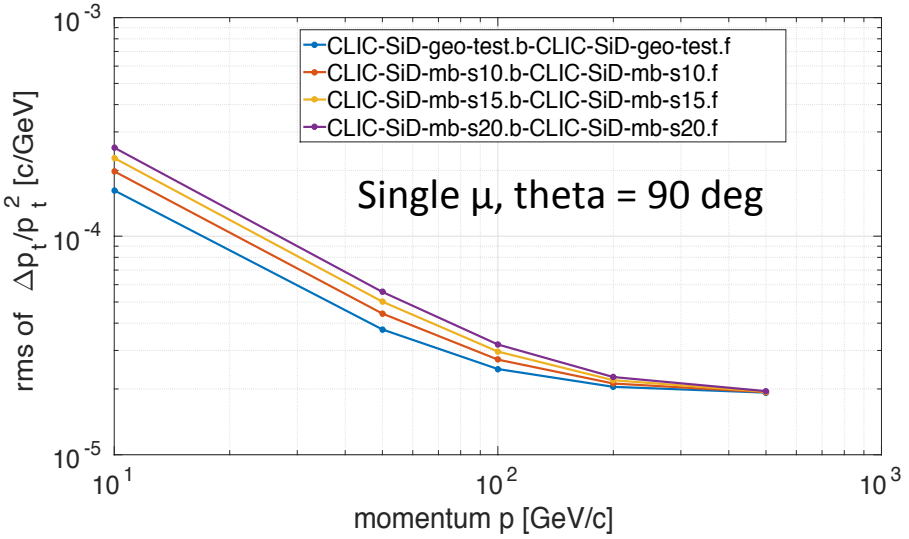
- Material budget for **cables** fixed: **1.0%X_0**
- Material budget for **sensor** fixed: **0.5%X_0 (barrel), 0.88%X_0 (forward)**
- Material budget for **support** varied: **0.5%X_0 (starting point) , 1.0%X_0, 1.5%X_0, 2.0%X_0**

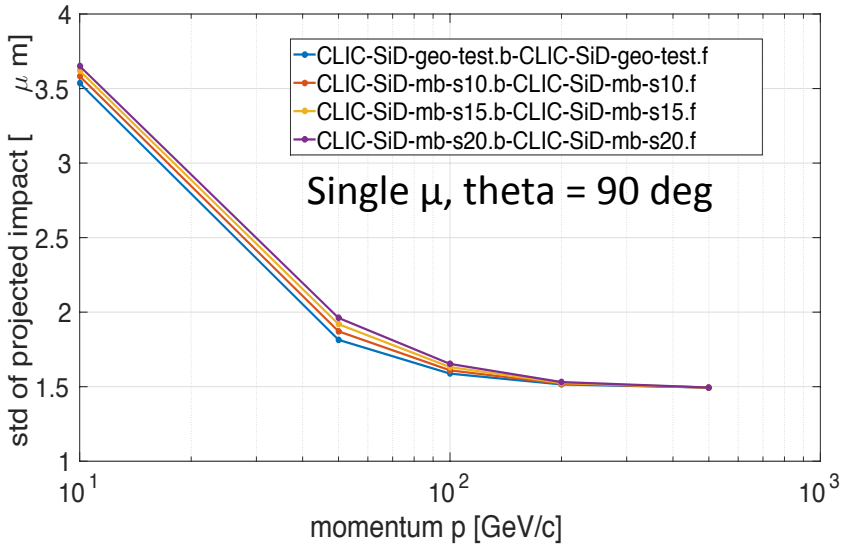
→ *As expected worsening of the performance at the increasing of the m.b.*

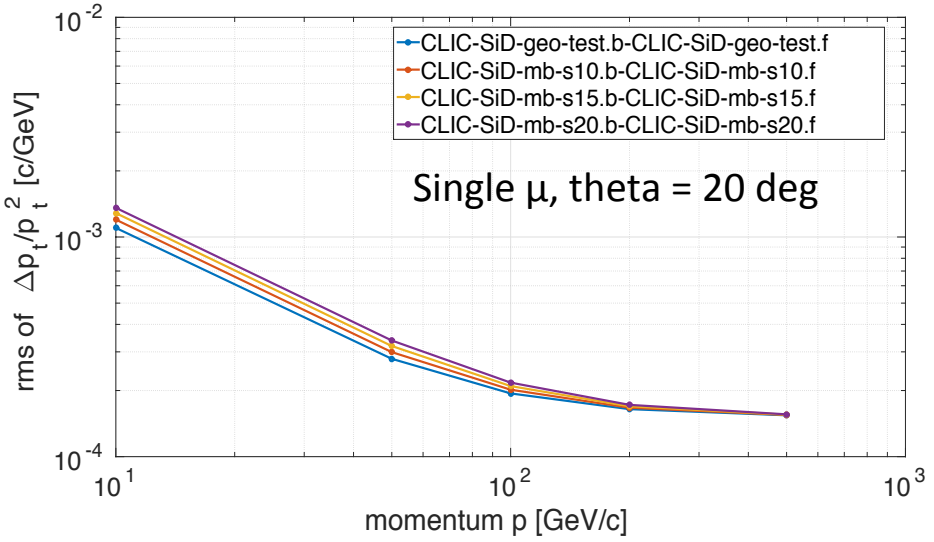


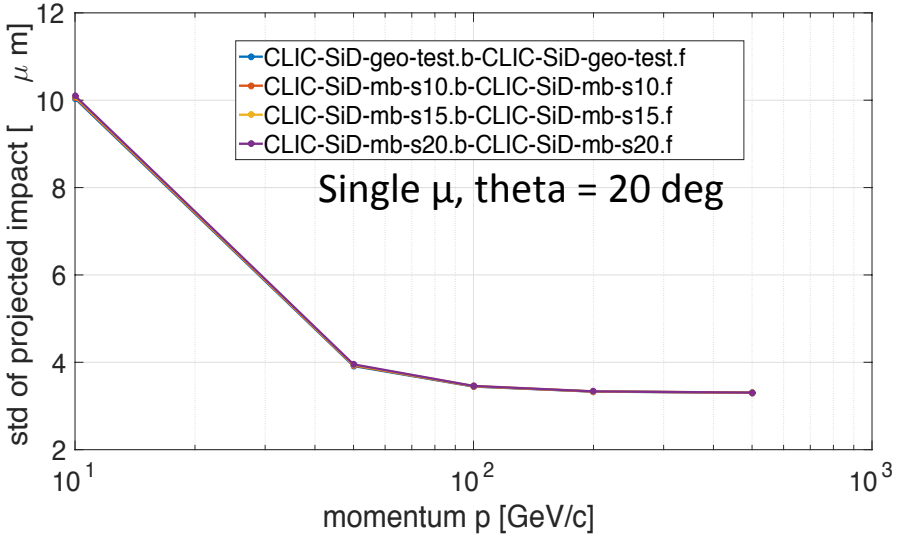


m.b. for supports: results vs momentum

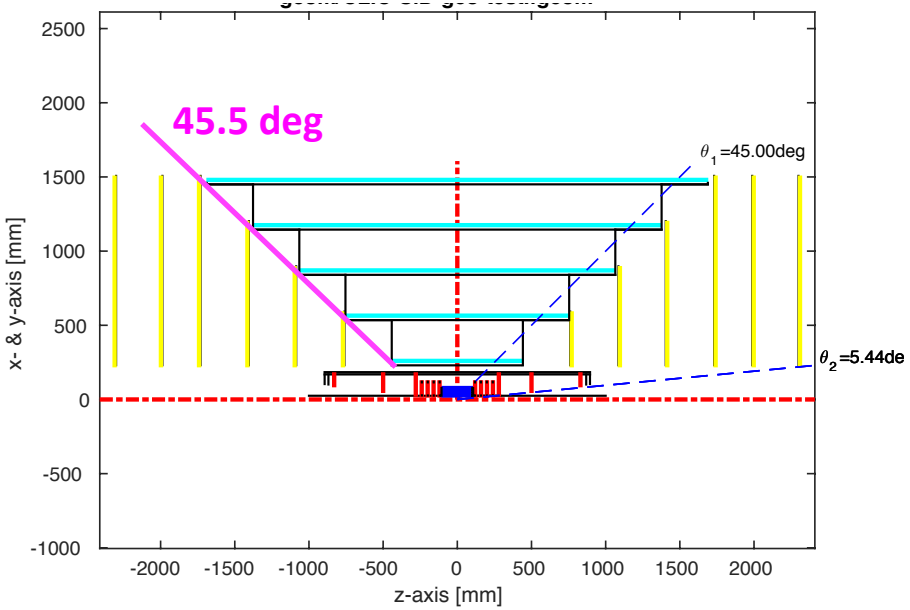


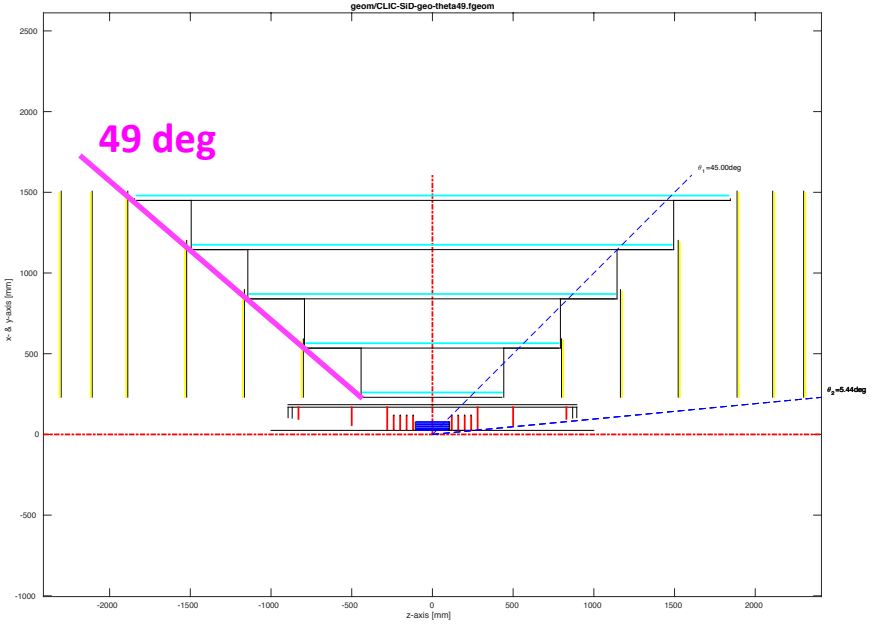


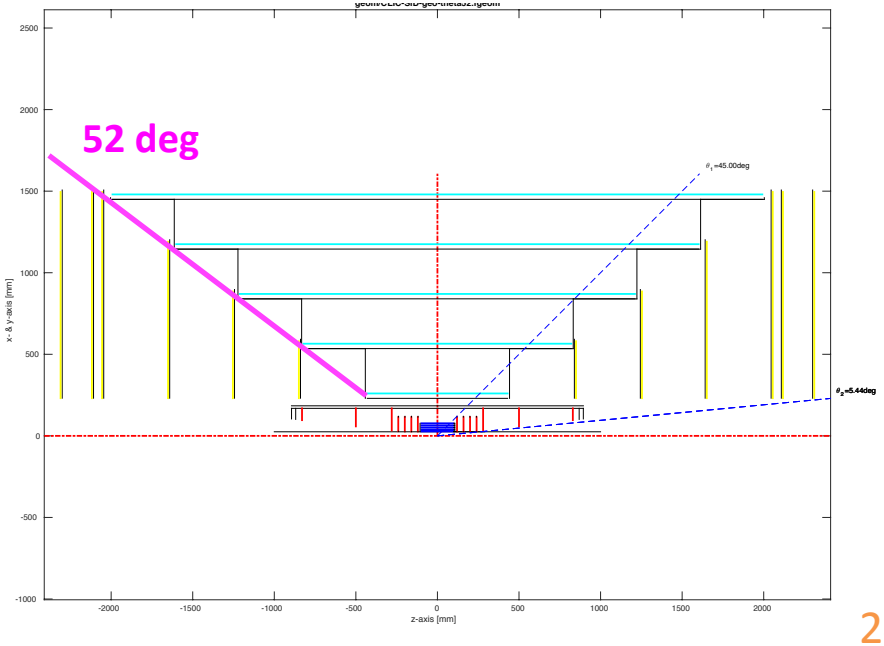




Layout: change “barrel-endcap angle”

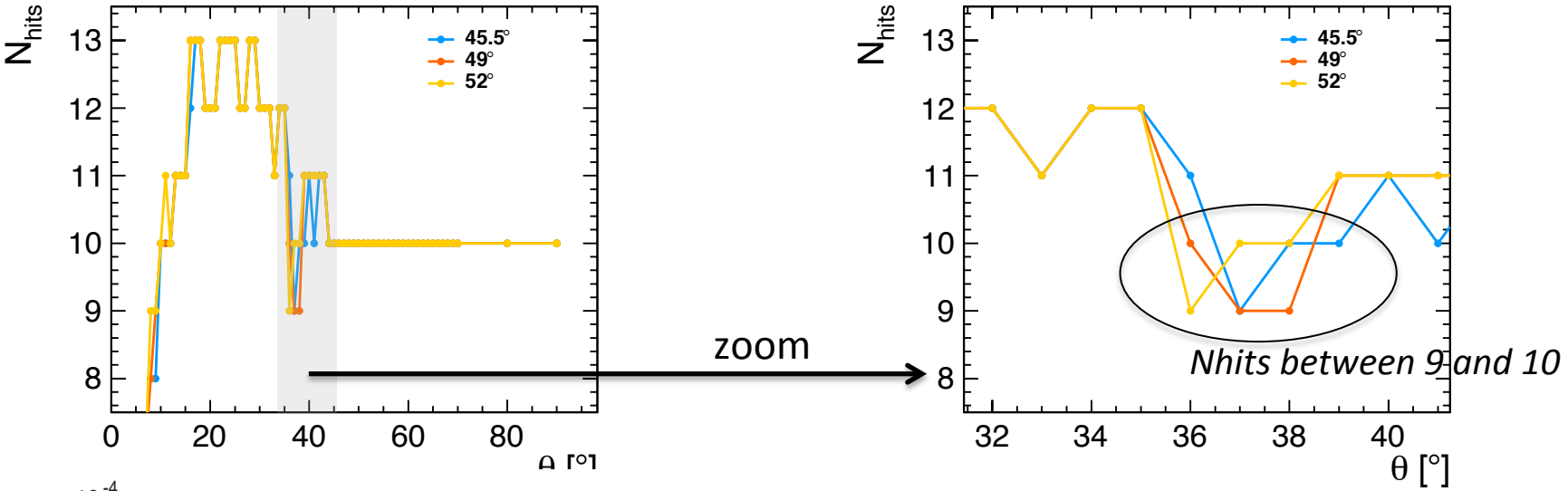


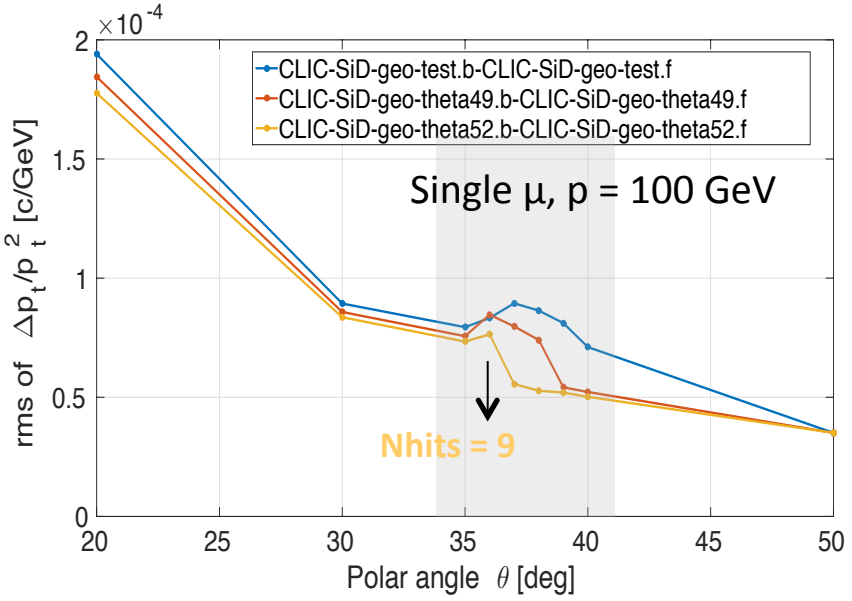


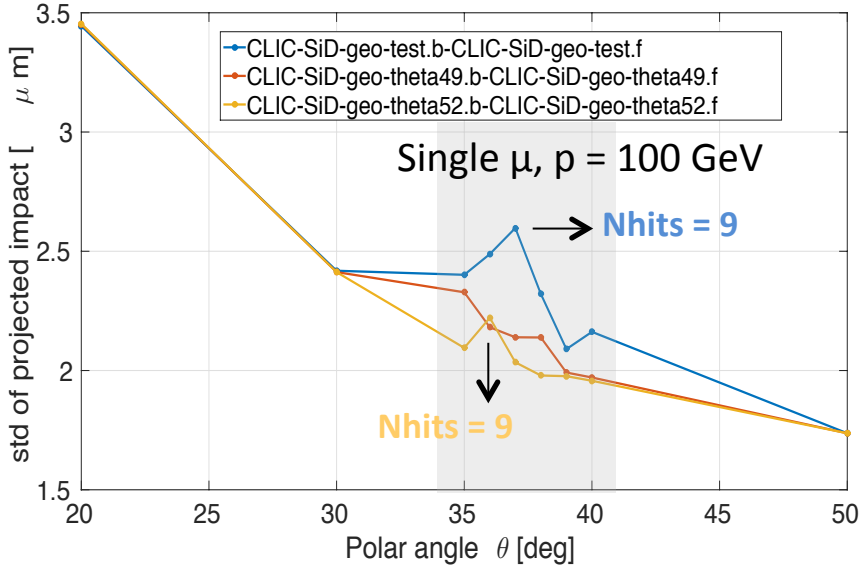


Results – single μ, p = 100 GeV

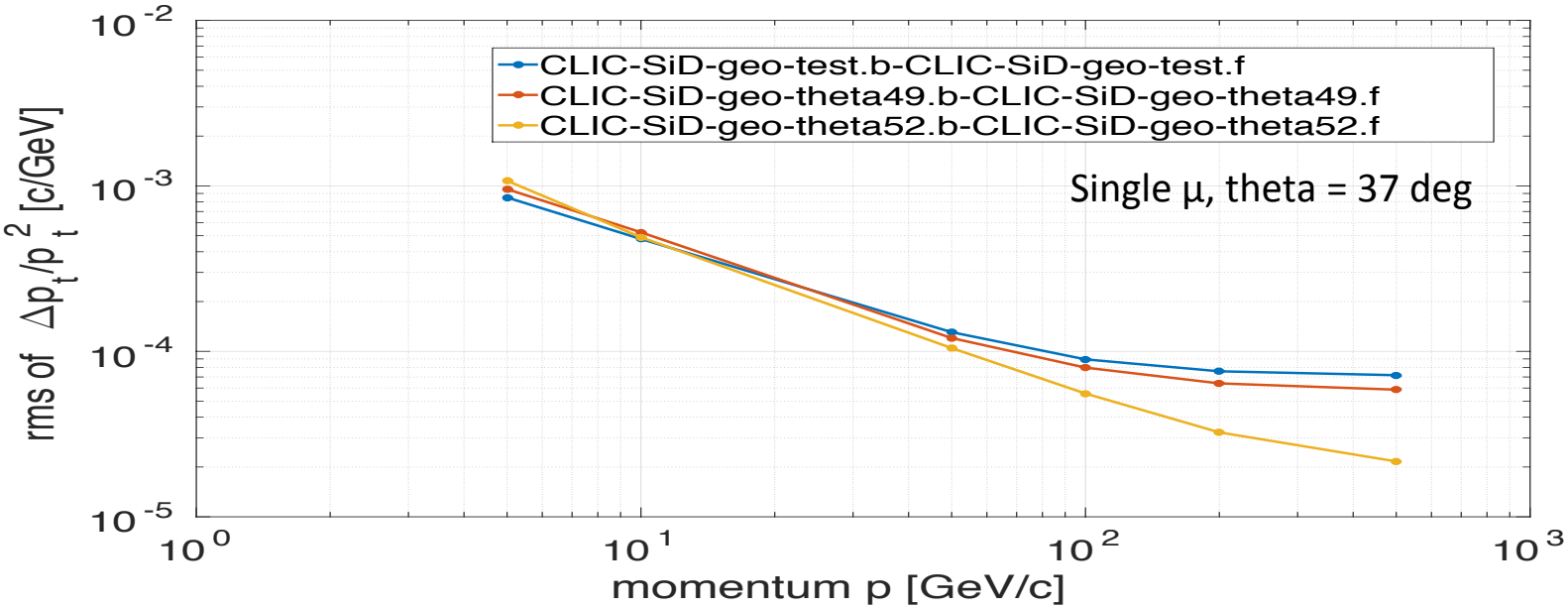
- Some "peaks" in distributions correspond to low nhits but correlation not completely clear

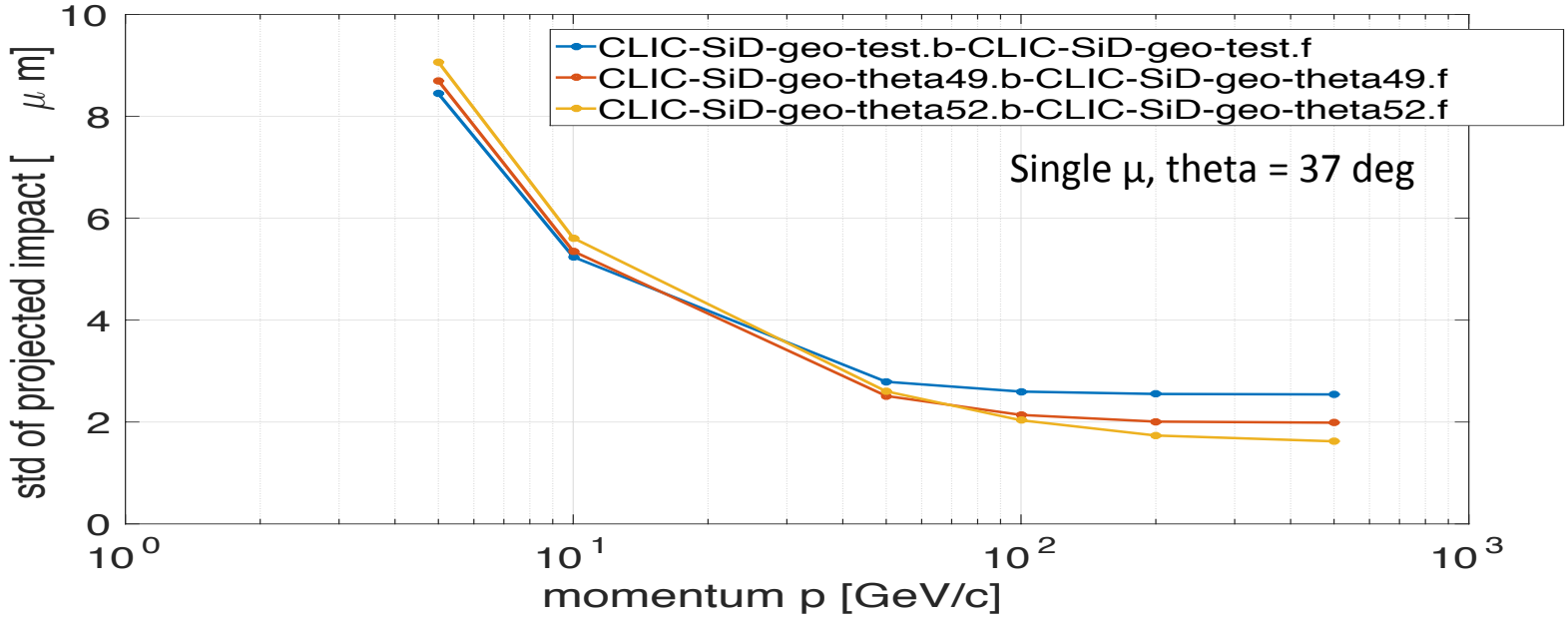




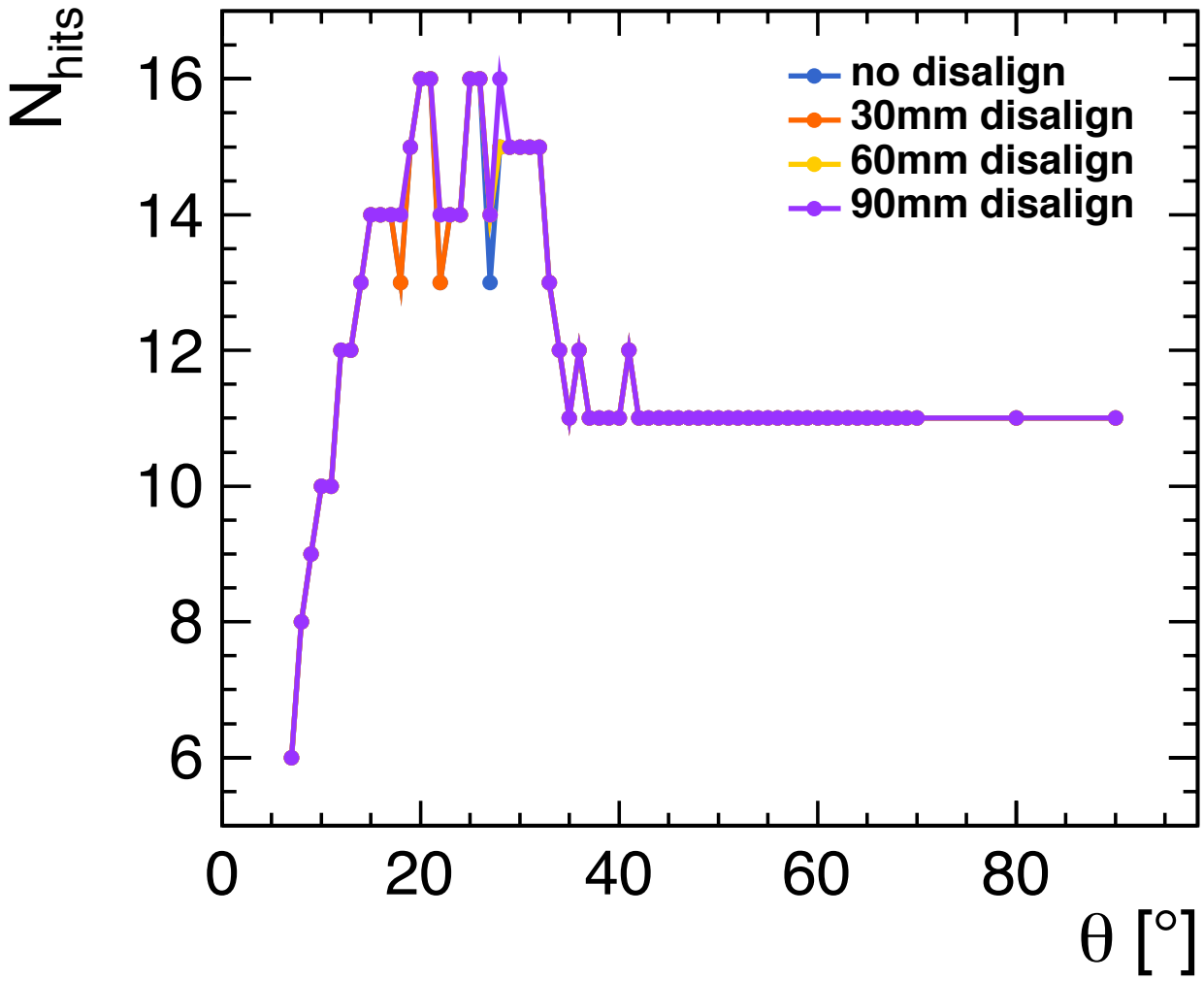


Results vs momentum



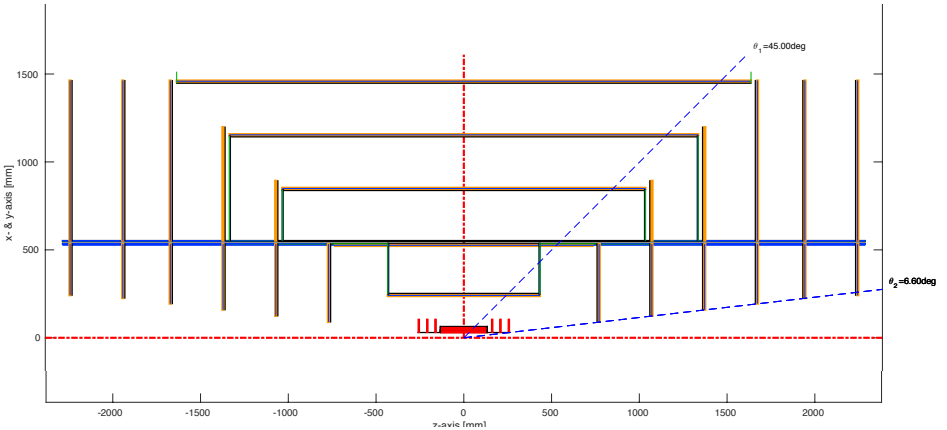


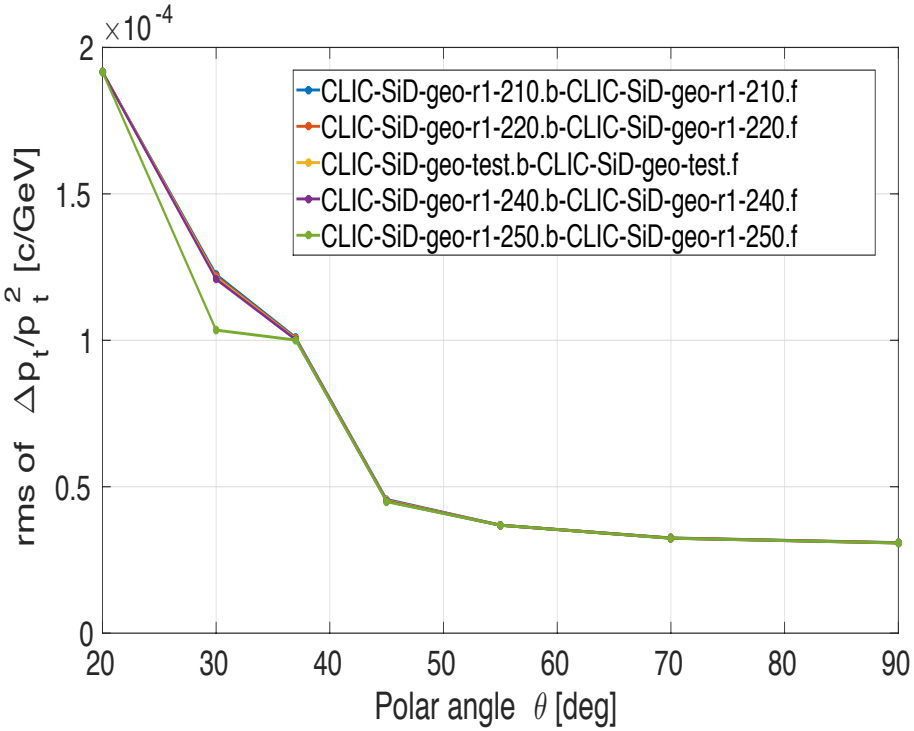
Displacement

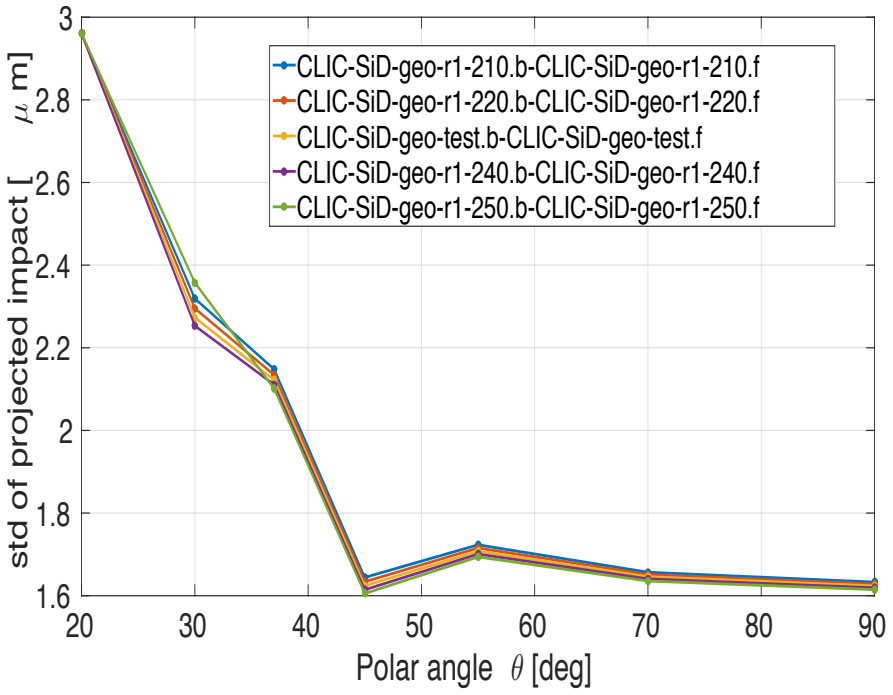


Change r position of first barrel layer

- Scan of r1 from 230mm to 210, 220, 240, 250mm
- Small changes in performance → if needed for occupancies reason the layer can be moved.

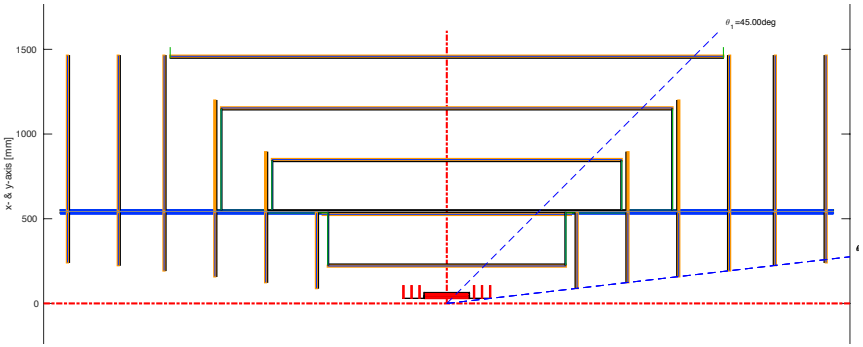


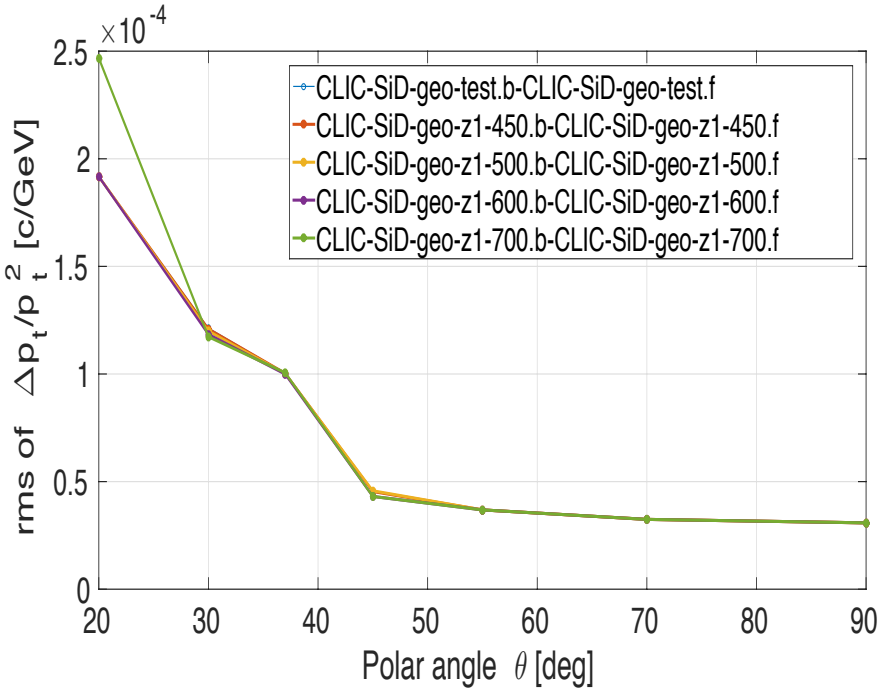


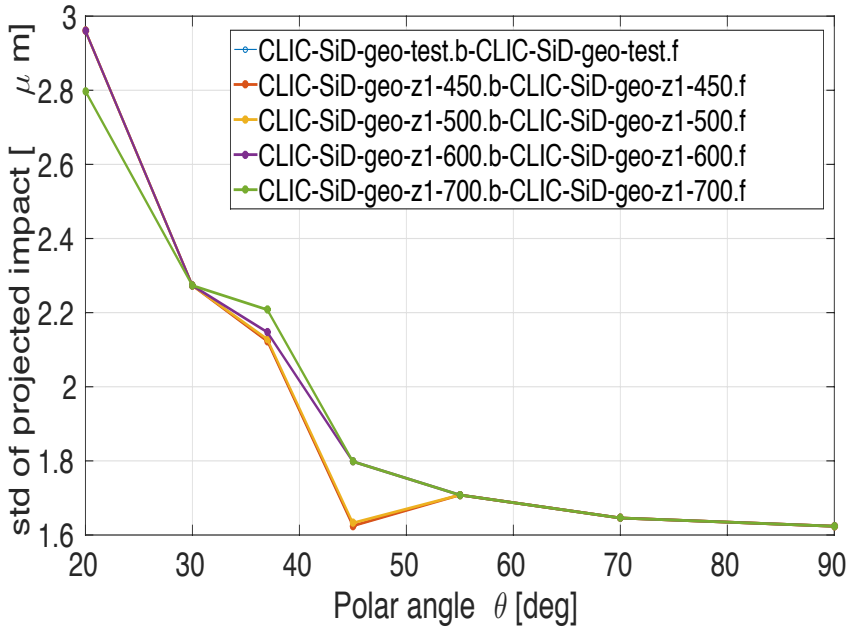


Change length of first barrel layer

- The only constraint (beyond cost) for the length of the first barrel layer is the position of the first forward inner disk
- z1 varied from 430mm to 450mm, 500mm, 600mm, 700mm → for d_0, for 30-45deg, shorter barrels are preferred probably due to the less m.b. crossed by the particle







N hits for r1 and z1 scan