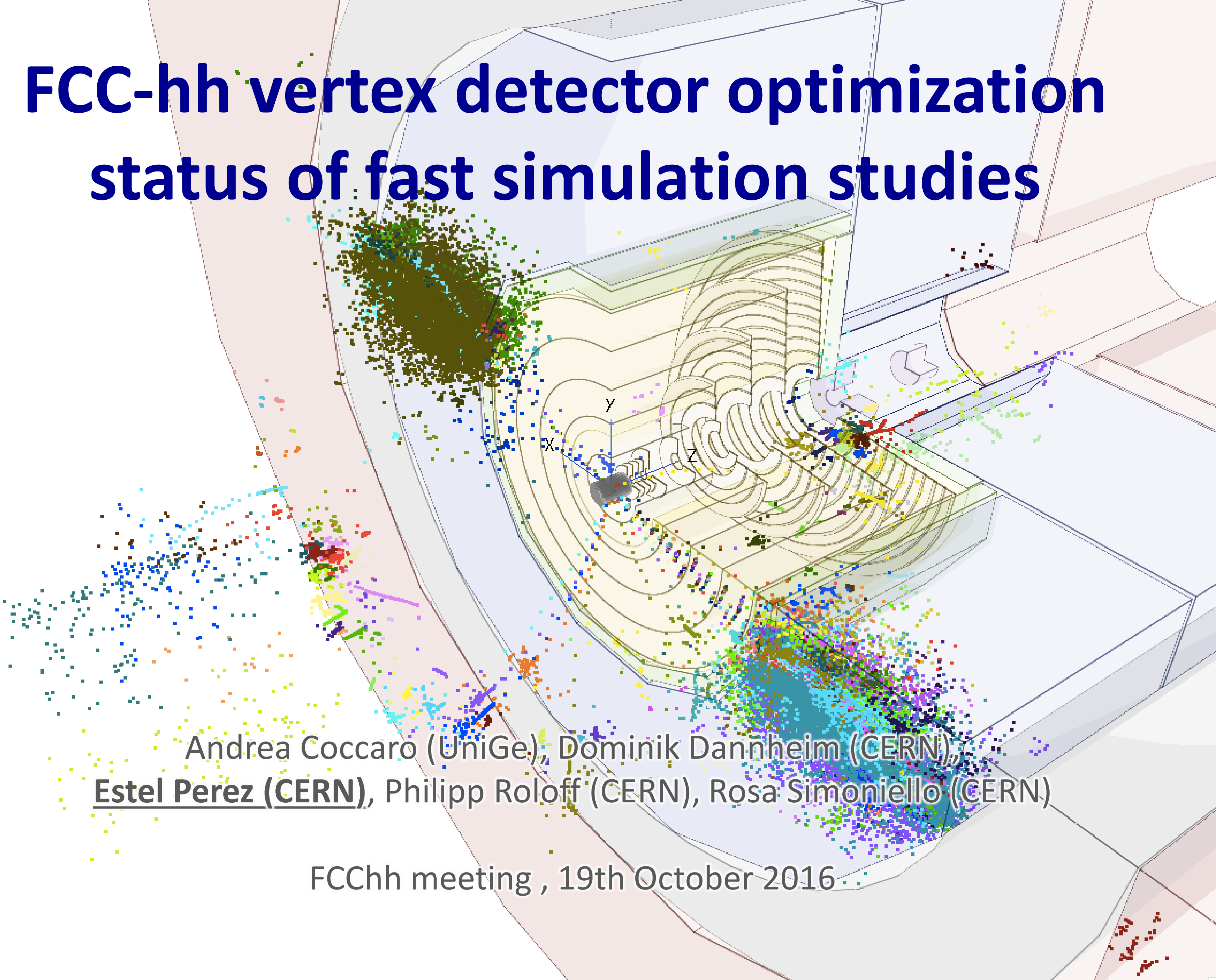
FCC-hh vertex detector optimization status of fast simulation studies



Andrea Coccaro (UniGe), Dominik Dannheim (CERN),
Estel Perez (CERN), Philipp Roloff (CERN), Rosa Simoniello (CERN)

FCChh meeting , 19th October 2016

Fast Simulation Status

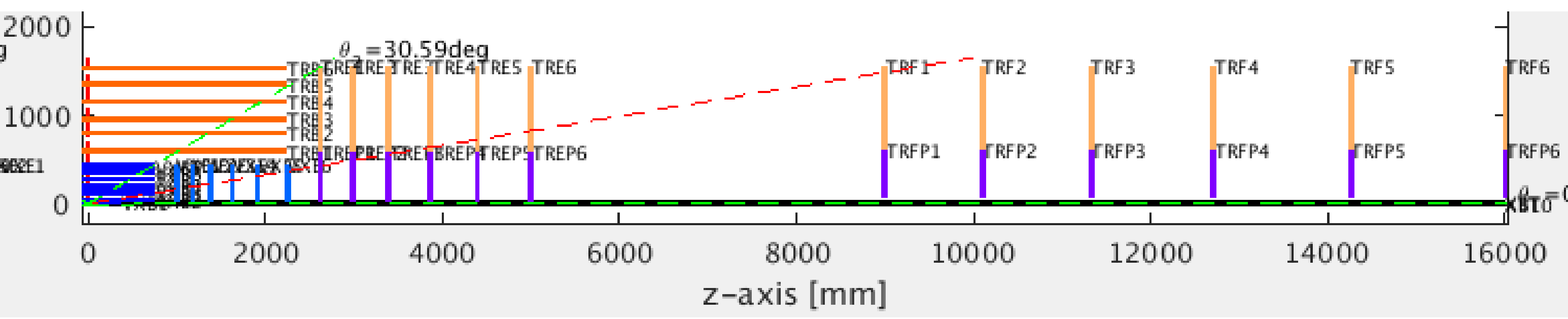
- Using LiC Detector Toy
  - Includes multiple scattering (uses Kalman filter)
  - Models single planes: cylinders or disks (no module structure)

- Step 1: Cross-check TrkLayout results by Zbynek → shown at last FCChh meeting 28/09 (slides updated)
- Step 2: Variations on geometry and resolution → today
- Step 3: Occupancy studies → ongoing

Baseline Detector parameters

- Taken from: http://fcc-tklayout.web.cern.ch/fcc-tklayout/FCChh-Option3/index.html
  - Used as baseline throughout this presentation

	Single-point resolution:	Material budget $[X/X_0]$:
Pixels	5x25µm	0.015
Pixels	10x25µm	0.015
Strips	10x25µm	0.03
Beampipe		0.00286



Plan

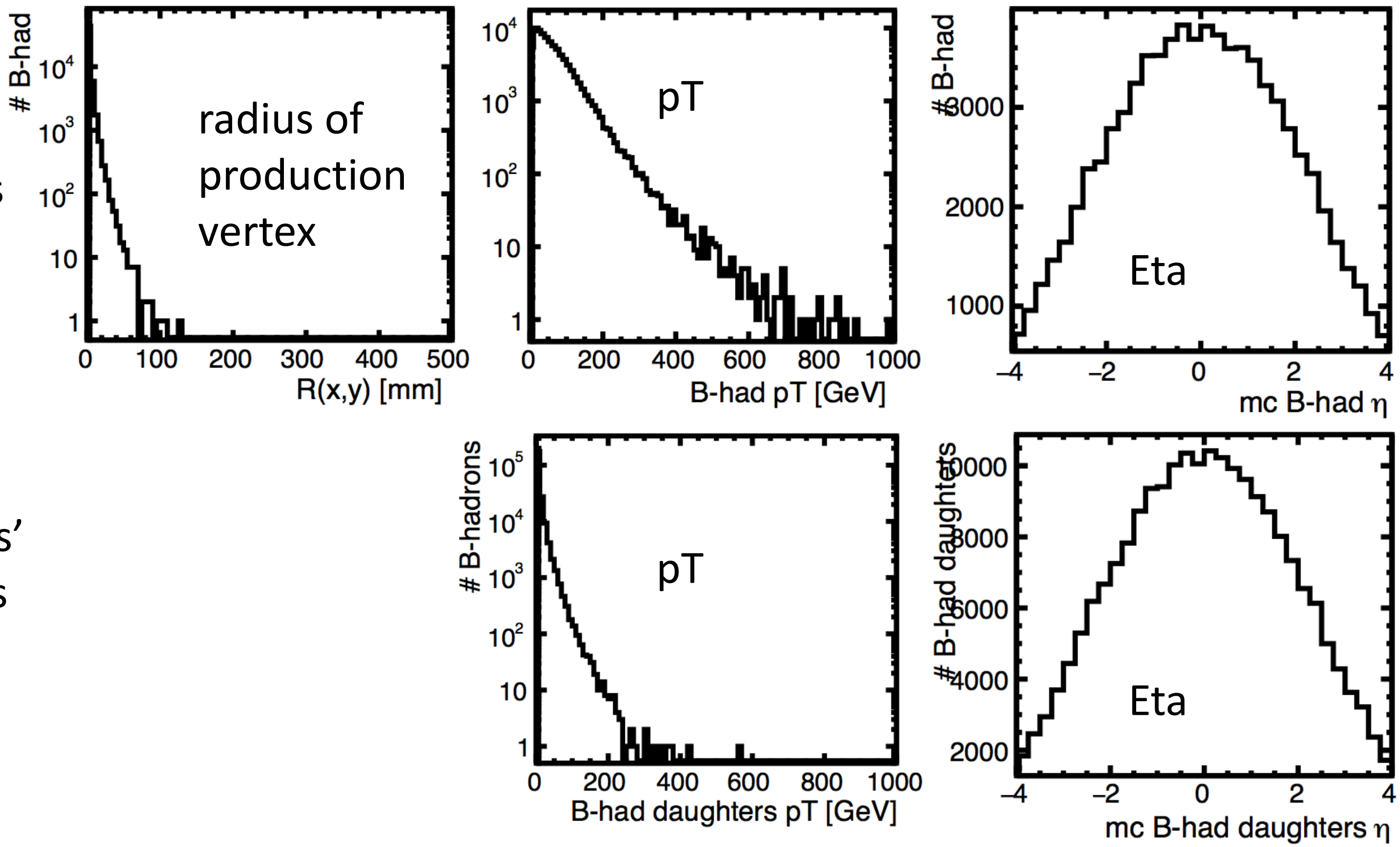
- Reproduce some of the studies done for CLIC:
  - https://cds.cern.ch/record/1443503/files/LCD-2011-031.pdf
- Start with geometry & material variations
  - vertex layers radius -> shown last FCChh meeting
  - single point resolution -> shown last FCChh meeting
  - beampipe radius -> **today**
  - beampipe & layers material -> **today**
- Calculate occupancies -> ongoing
  - Variation of the distance between endcap and fwd disks -> **today**
  - Variation of single point resolution -> **today**
- Implement Cables & supports (?)
  - Variation on barrel layers length (and therefore on material – cables- between the barrel and the endcap)

Benchmark kinematic ranges

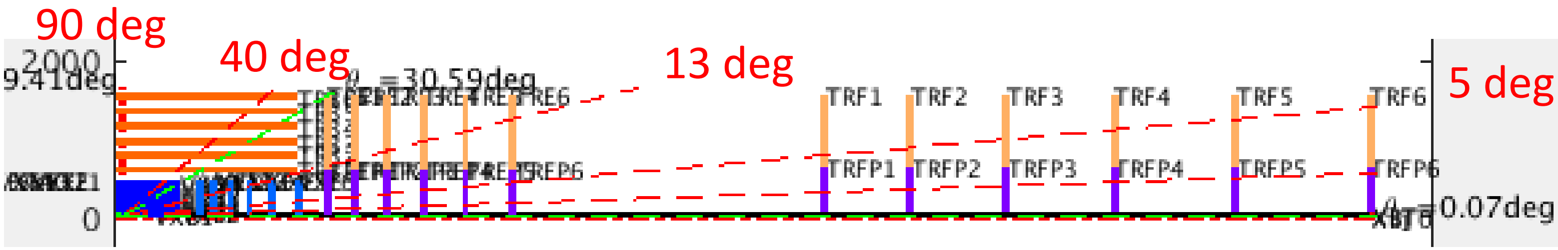
- Use double higgs production with H->bb @100 TeV
  - (from https://test-fcc.web.cern.ch/test-FCC/LHEevents.php)
- Kinematics of long-lived B-hadrons and their charged daughters

B-hadrons

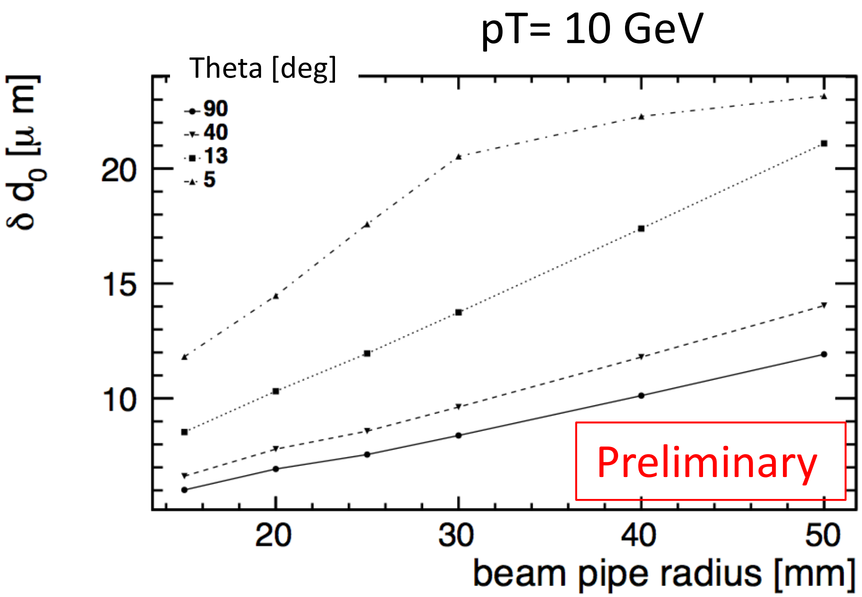
B-hadrons' daughters



d0 resolution dependence on the beampipe radius



Baseline value: 20 mm



Scan on beampipe radius, move the vertex layers accordingly:

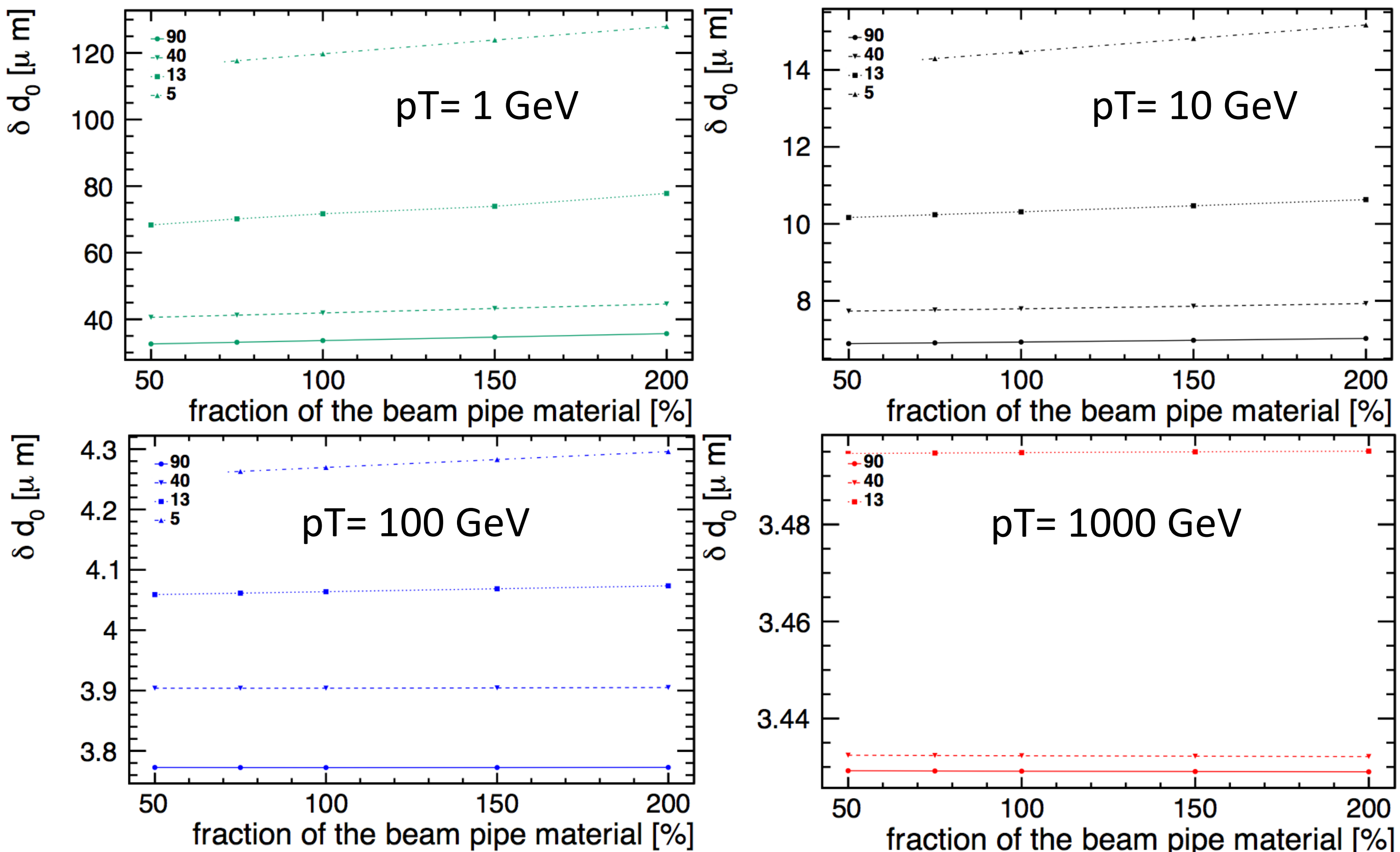
- 1st layer always at 1mm from the beampipe
- 2nd layer always at 29mm from the 1st layer
- last layer always at the same position (434mm)
- Layers in between: equi-spaced

Linearly correlated in the central region.
For very forward tracks, at large radius barrel hits are lost

d0 resolution dependence on the beampipe material

Baseline: beampipe X/X_0=0.00286.

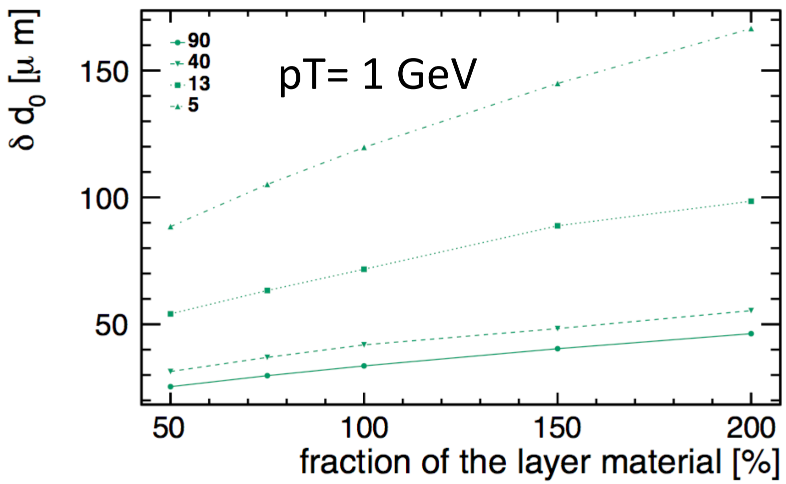
Reduce/increase the beampipe material by: 50%, 75%, . . , 150%, 200%

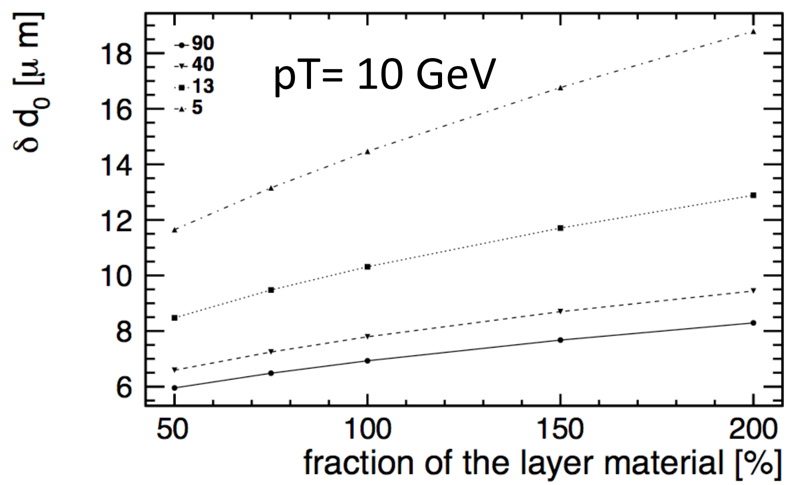


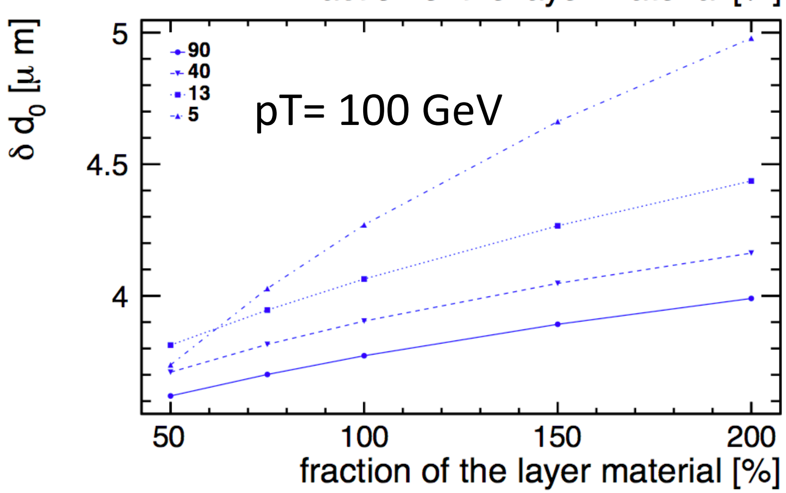
significant dependence only for low pT forward tracks

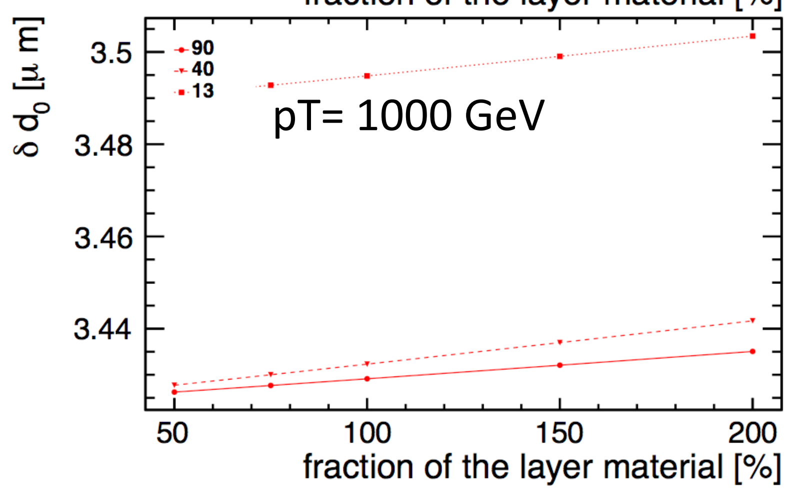
d0 resolution dependence on the layers material

Reduce/increase all layers material by: 50%, 75%, . . , 150%, 200%









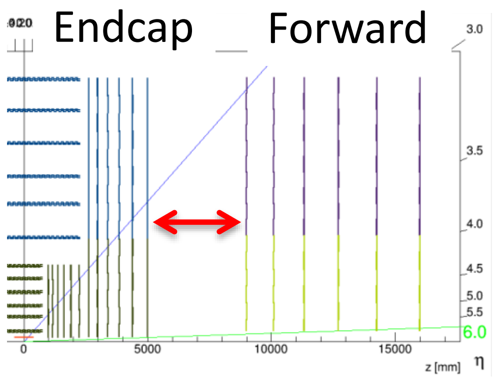
Reducing the material budget by 50% would improve the d0 resolution by 15%(4%) at pT=10GeV(100GeV)

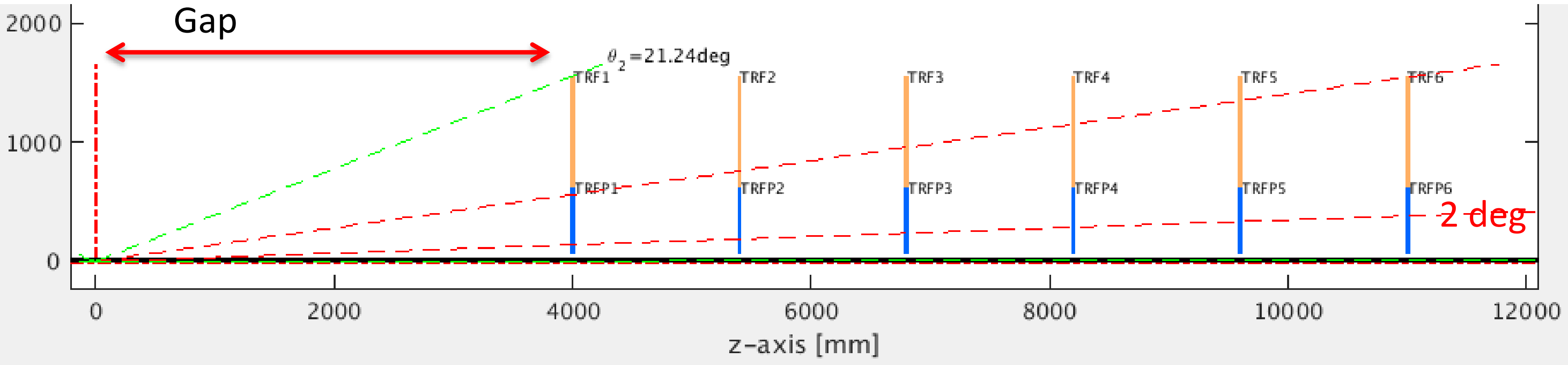
Occupancy in track extrapolation area: procedure

- LiC Toy uses outside-in tracking.
- To study the **occupancy in the last endcap disk**, project there the track's covariance matrix
- Calculate area of the error ellipse:
  - A= ¼ * π * res(Rphi) * res(z) * tan(theta)
- For a **very forward track**: 1.2 deg (goes through all pixel layers only), study:

1. **Area as a function of the gap distance** (endcap – forward)
2. **Area as a function of the single-point resolution** of the forward layers

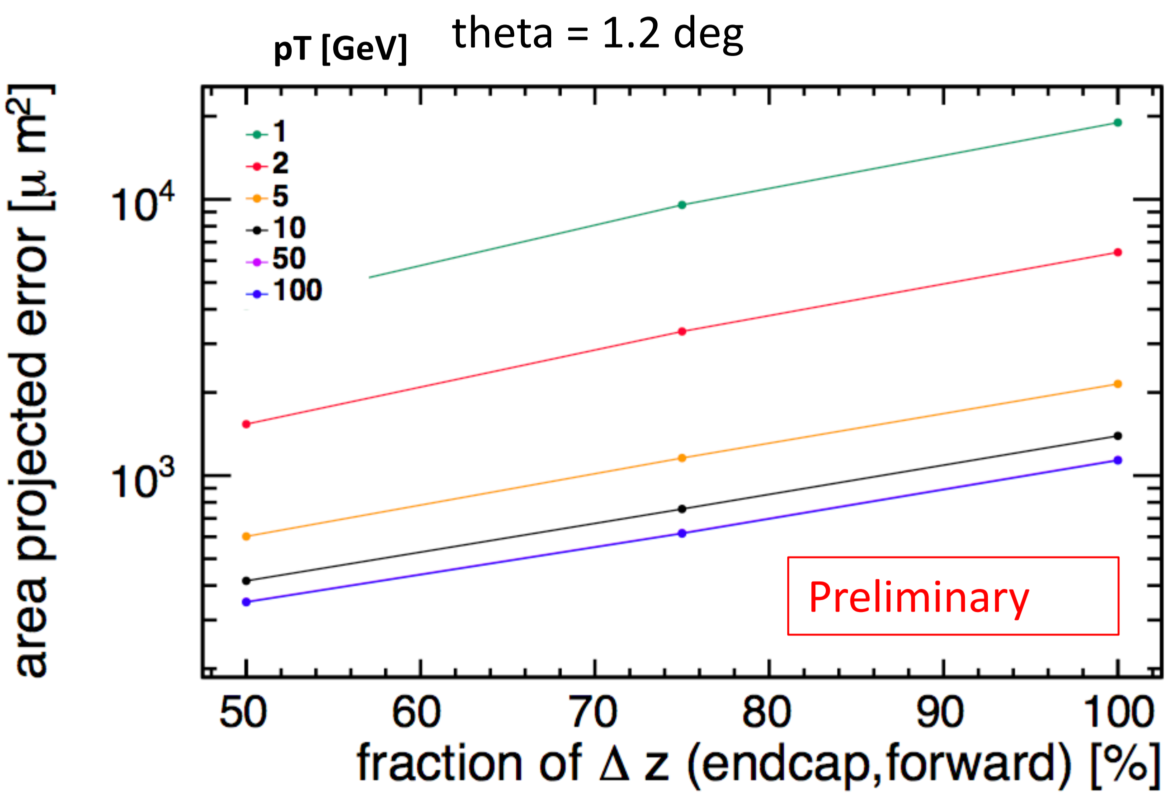
- Use Fluka simulations to convert this area into occupancy





Area as a function of distance between endcap and forward disks

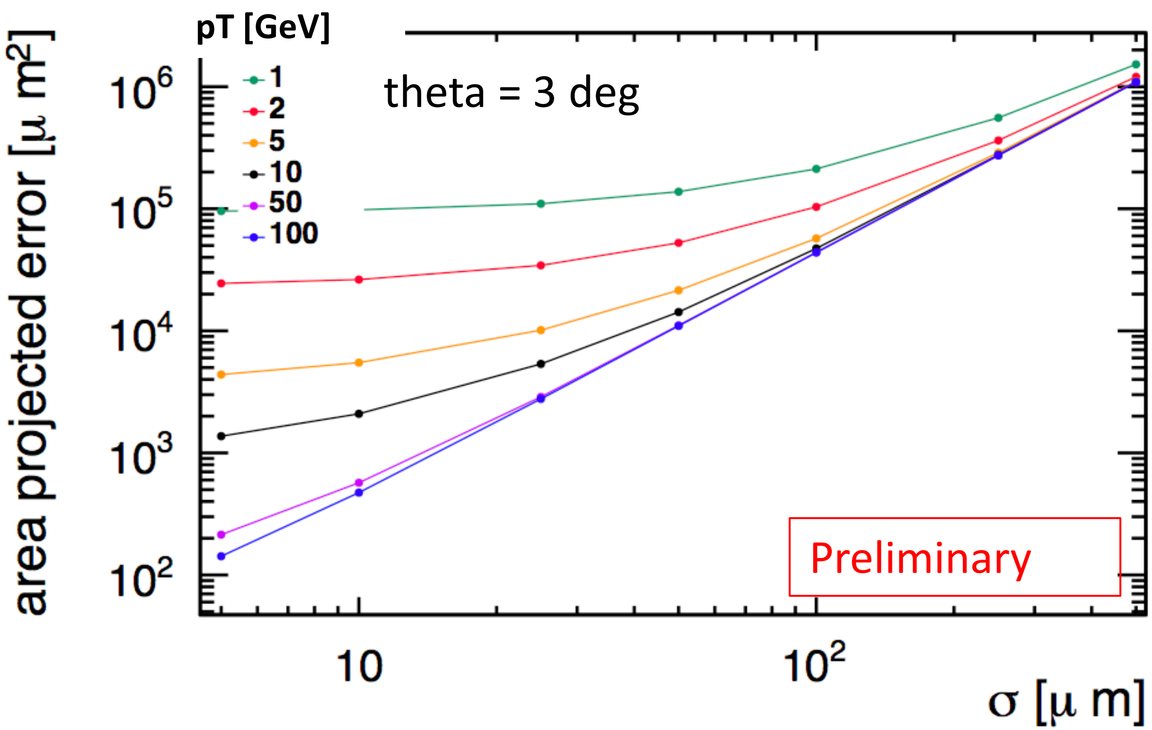
- Test fraction of the distance: ½, ¾ , 1 (move first forward layer, keep last fwd layer fixed, others equi-spaced)



Error ellipse area increases with gap distance:
if gap reduced to half, area (proportional to occupancy) reduced by ~80%

Area as a function of single point resolution of forward disks

- Use very forward track (theta=3 deg). **Assume squared pixels**
- Plot error ellipse area as a function of the **single point resolution (σ) of the forward pixel layer**
  - Variations: σ= 5x5, 10x10, 25x25, 50x50, 100x100, 250x250 μm



Slide updated after the presentation

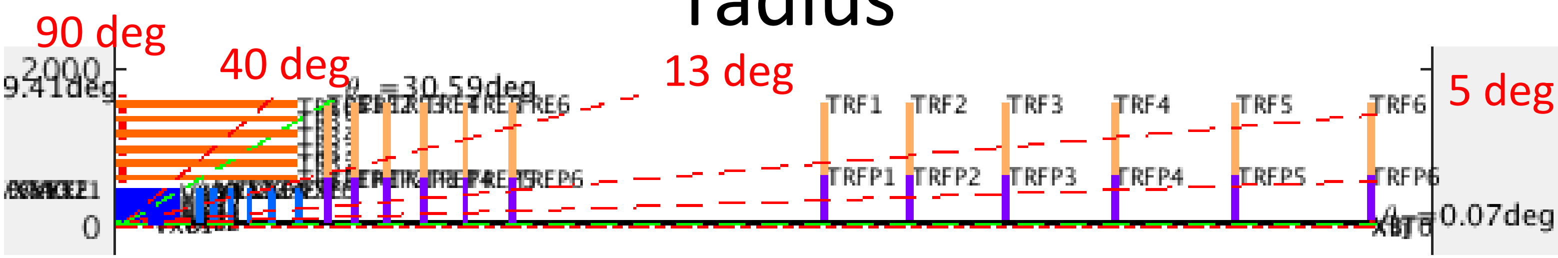
Next: Scale area to the occupancy to extract required granularity

Next steps on fast simulation studies

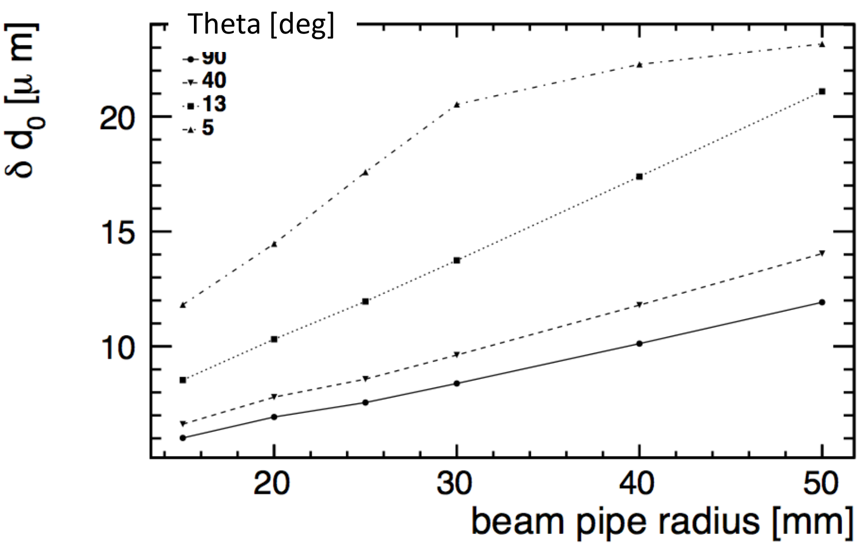
- Finish occupancy studies
  - Extract required granularity
- Include cables (& supports) (?)
  - Optimize barrel length

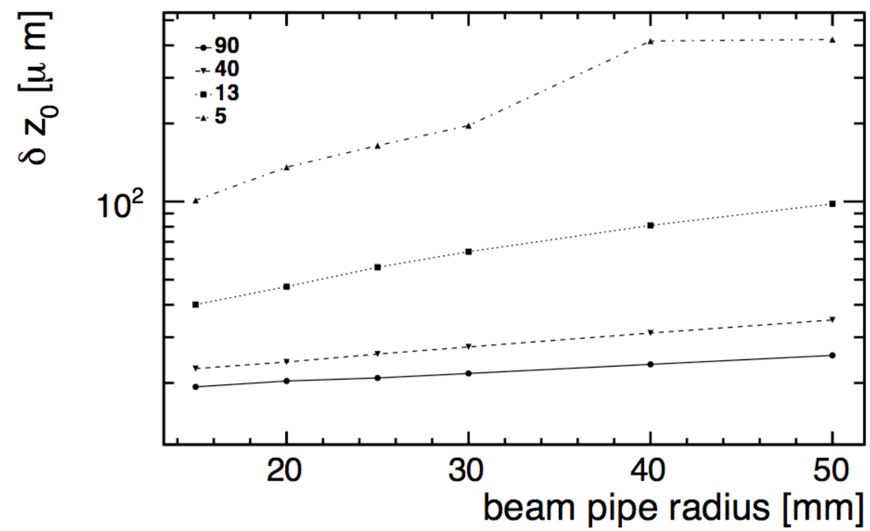
Backup

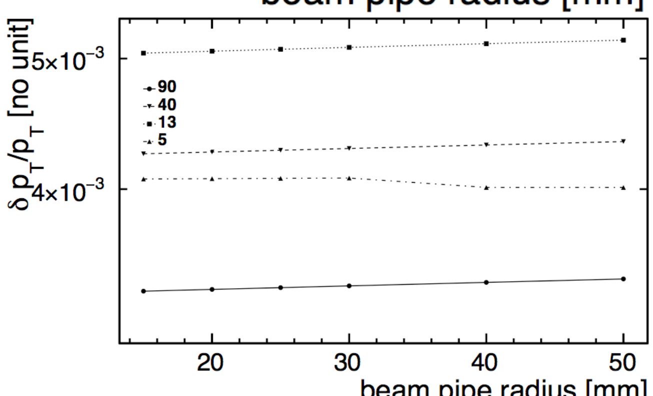
d0 and z0 resolution dependence on the beampipe radius



10 GeV







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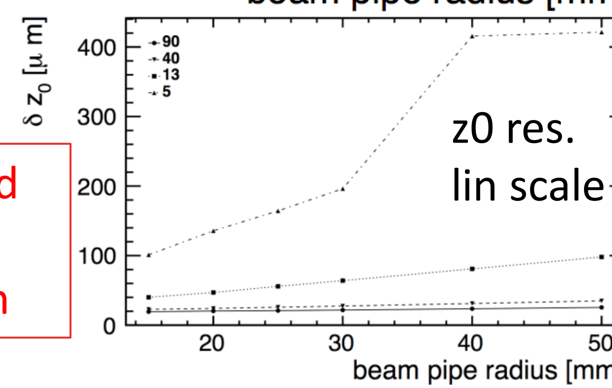
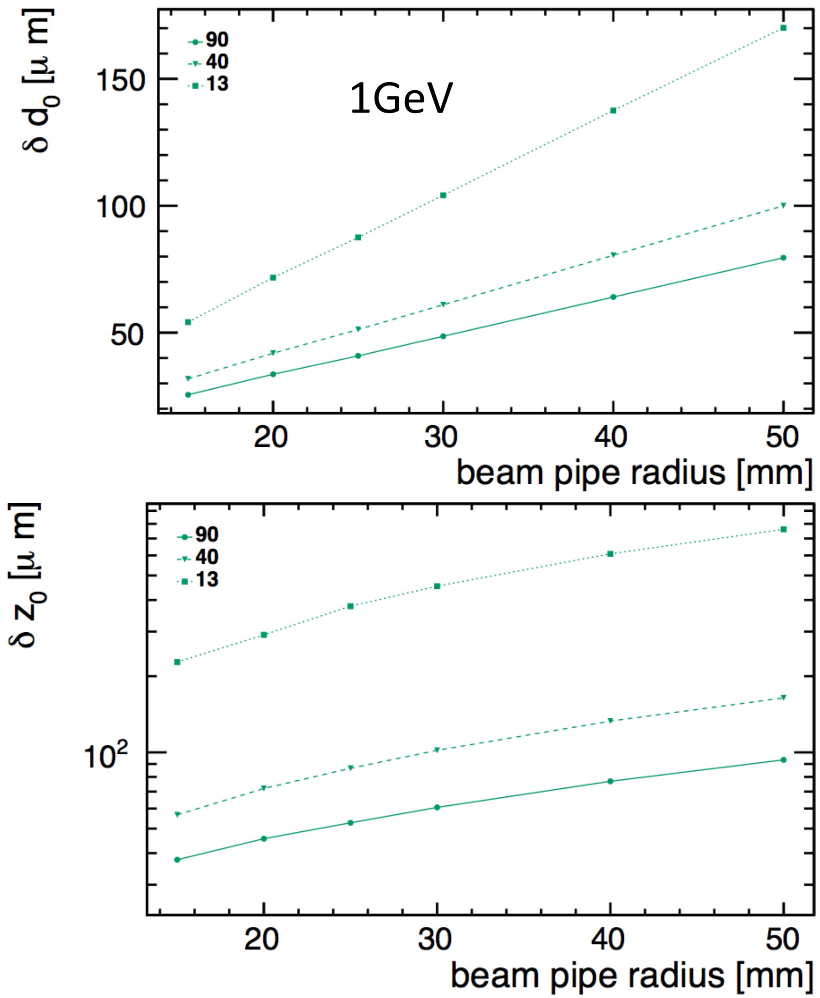


d0 & z0 res vs beampipe radius

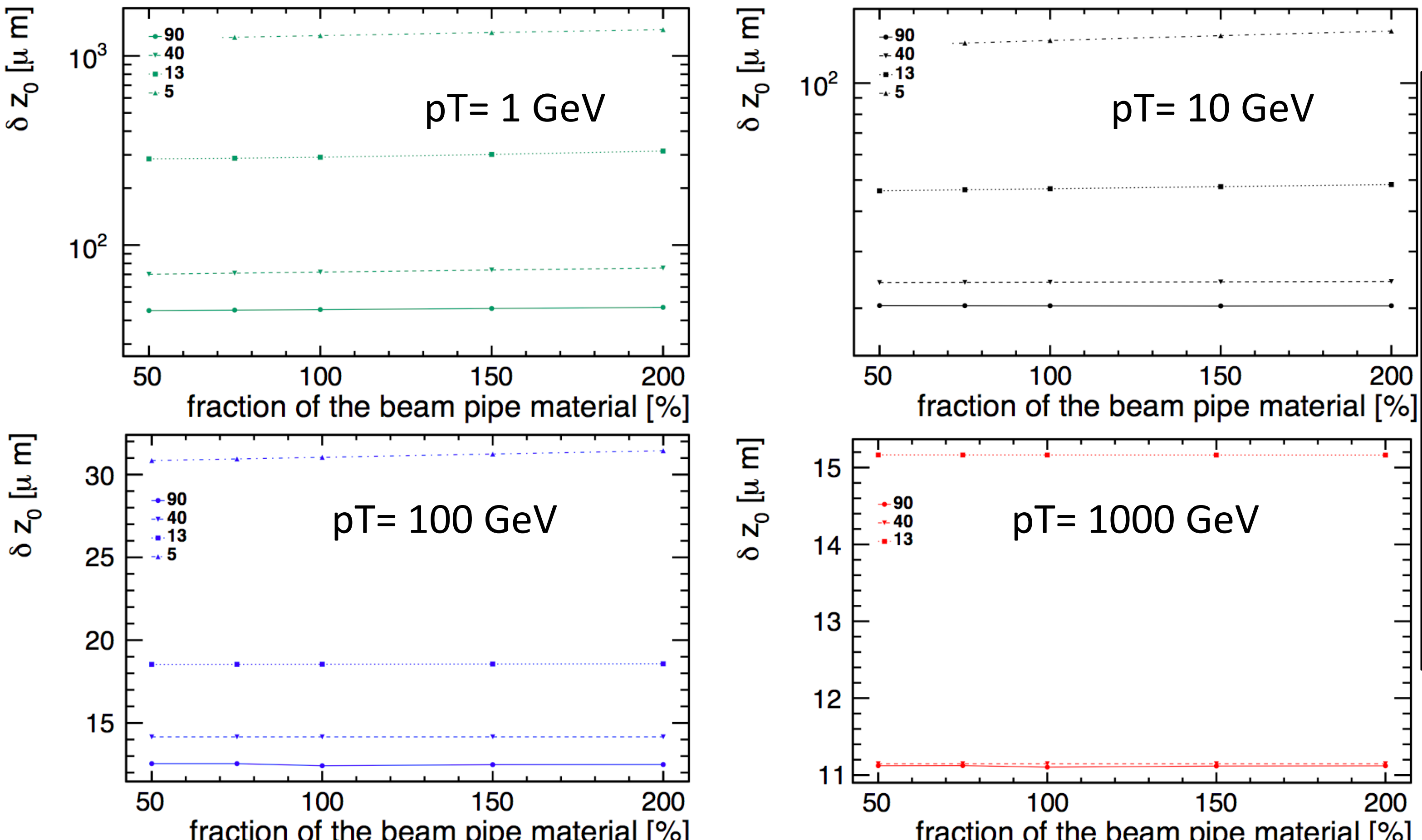


z0 resolution dependence on the beampipe material

Slide updated after the presentation

Baseline: beampipe X/X_0=0.00286.

Reduce/increase the beampipe material by: 50%, 75%, . , 150%, 200%

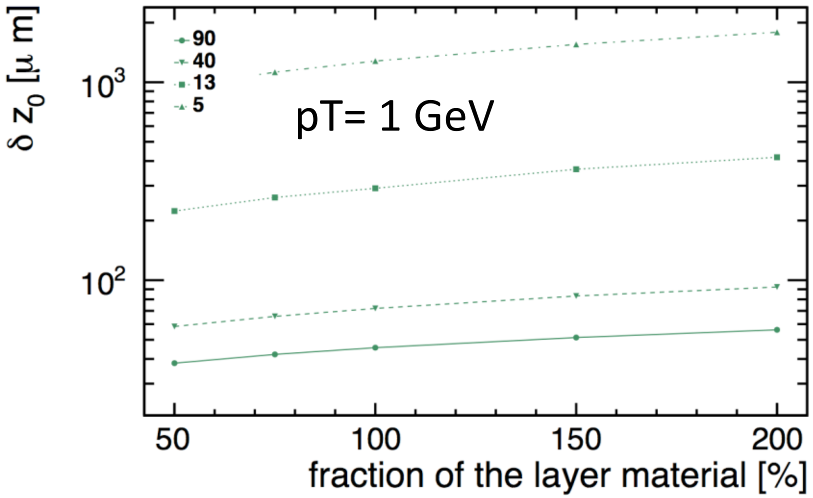


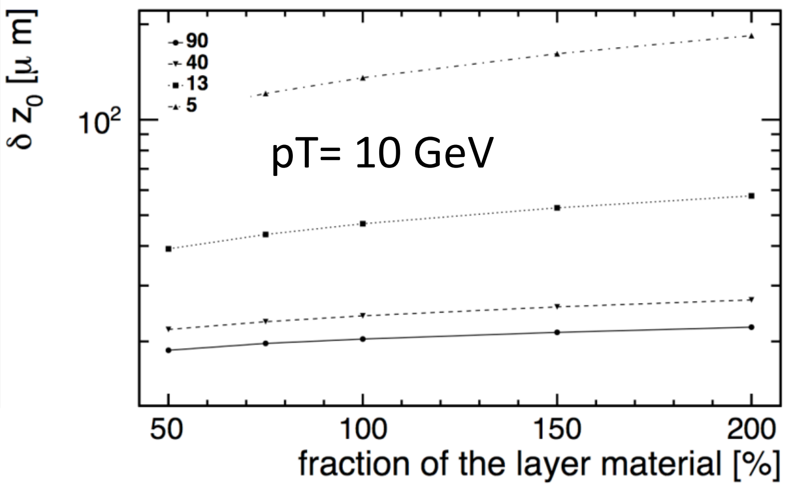
tiny dependence only for low pT forward tracks:

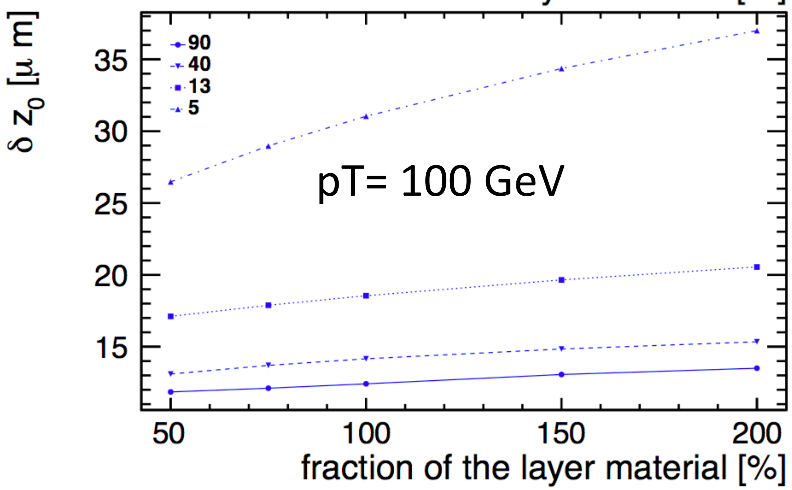
half the material improves z0 resolution by <4% @5deg pT=10GeV

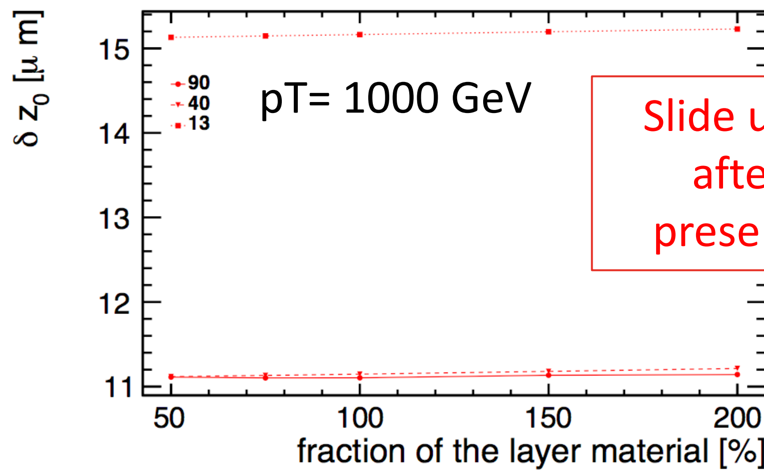
z0 resolution dependence on the layers material

Reduce/increase all layers material by: 50%, 75%, . . , 150%, 200%









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Reducing the material budget by 50% would improve the z0 resolution by 23%(16%) at pT=10GeV(100GeV) @5deg