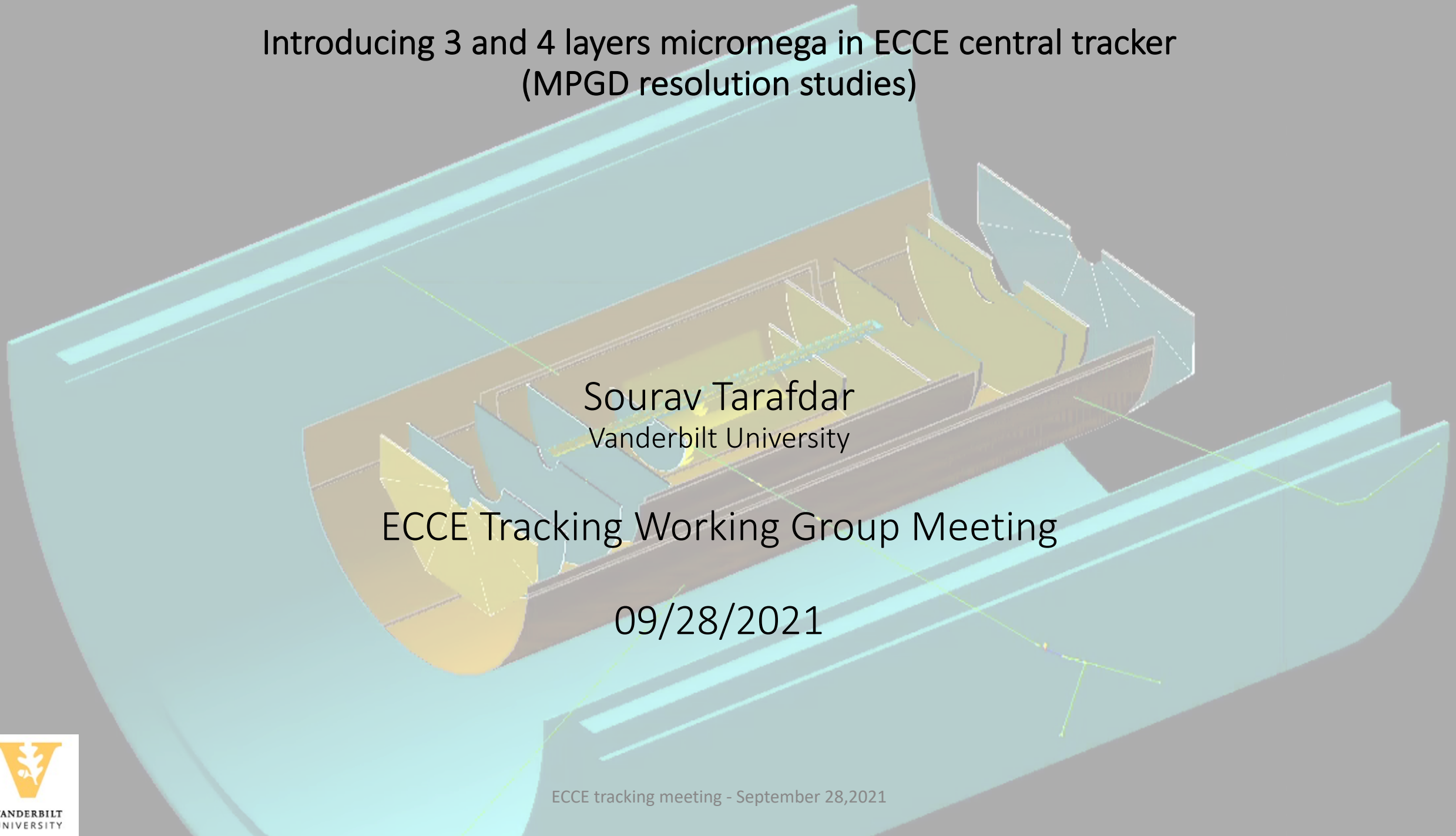
Introducing 3 and 4 layers micromega in ECCE central tracker (MPGD resolution studies)



Sourav Tarafdar
Vanderbilt University

ECCE Tracking Working Group Meeting

09/28/2021

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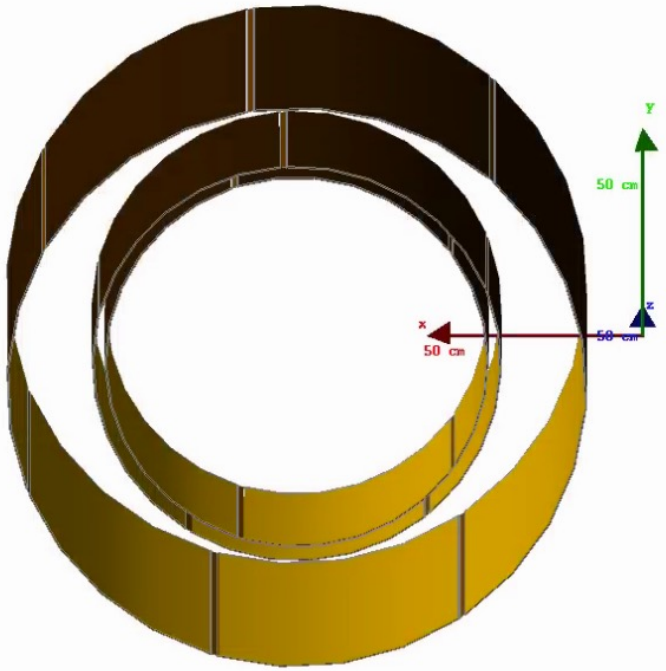
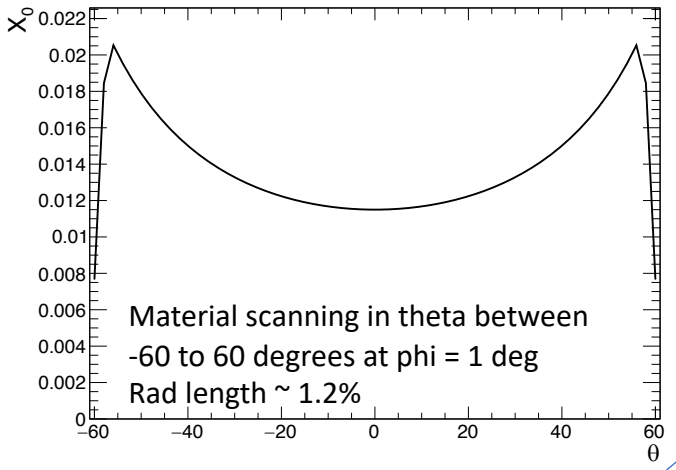
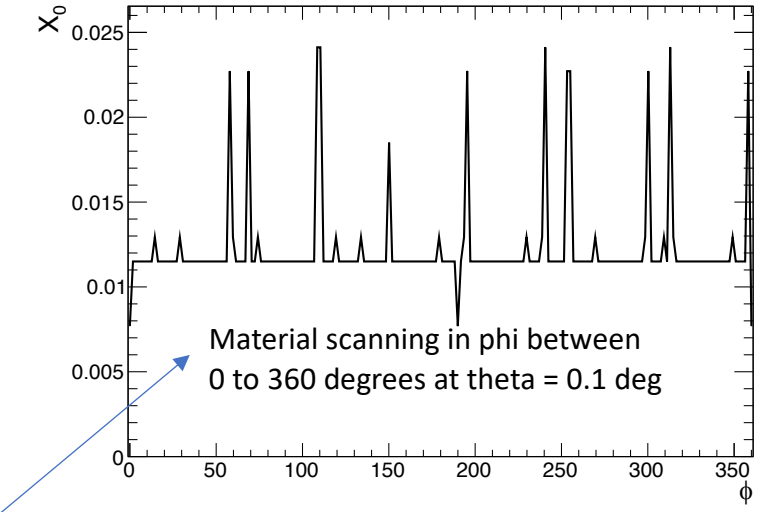
3 layers Micromega (MMG) in ECCE barrel region

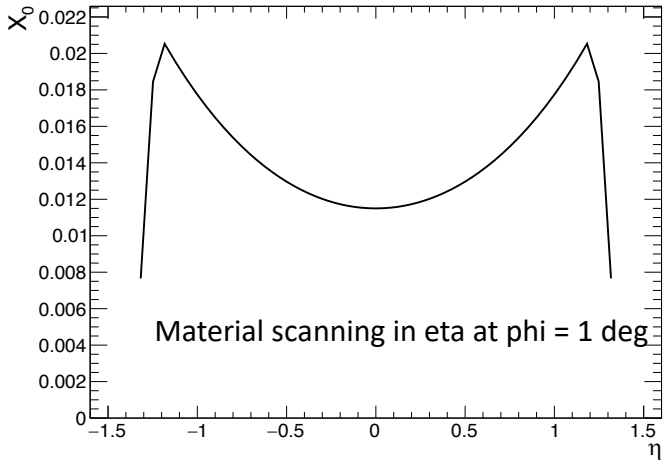
- Micromegas @ R = 44, 47 and 67 cm with length along z = 140, 150 and 280 cm
- Each layers are not uniform cylinder rather in form of tiles in phi. Each tile has maximum width of 50 cm
- Each tiles have a frame of hollow Carbon fiber. Additional materials implemented for mimicking cabling.
- Materials are based on CLASS 12 with each layer having radiation length of 0.4%.
- Material scan of all three micromega layers are below







Structures in phi because of support materials of the tiles.



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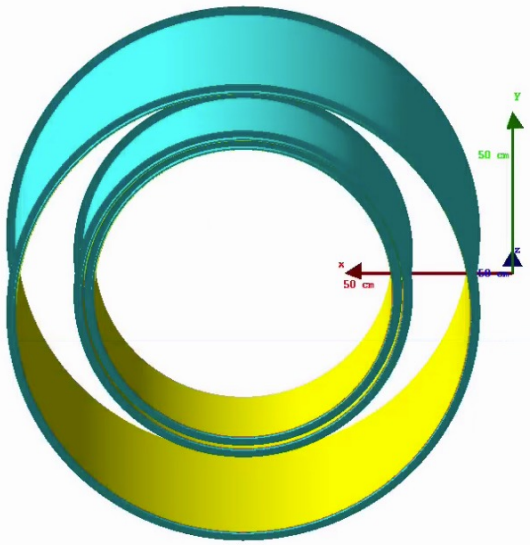
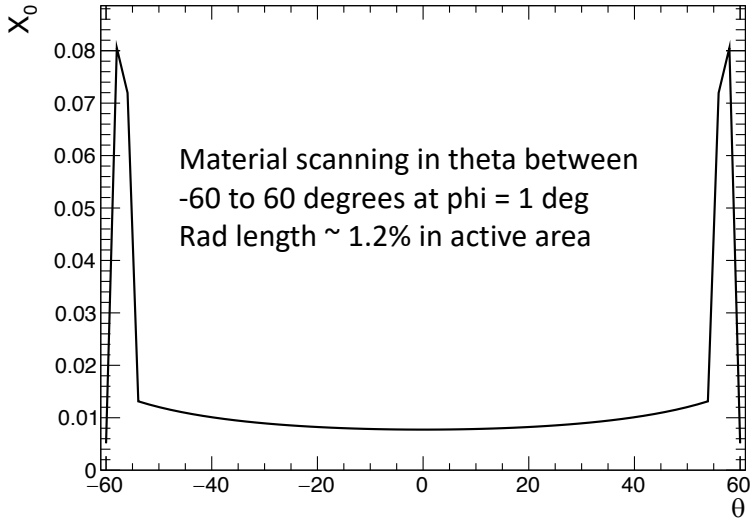
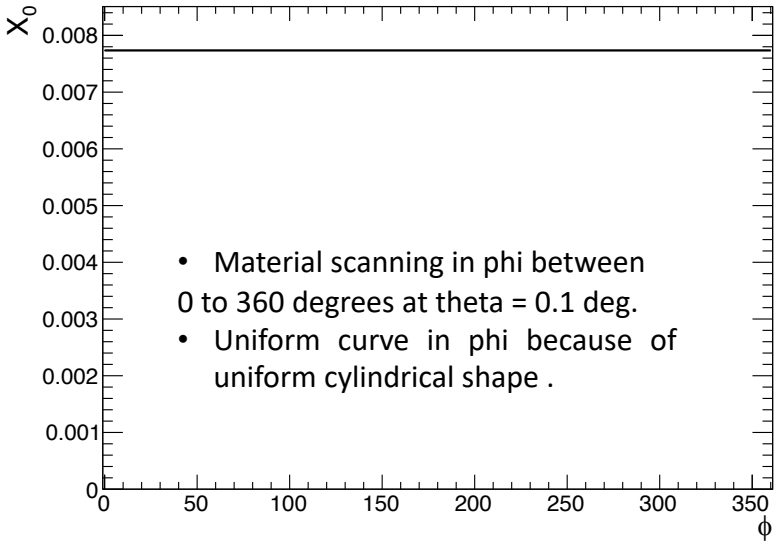
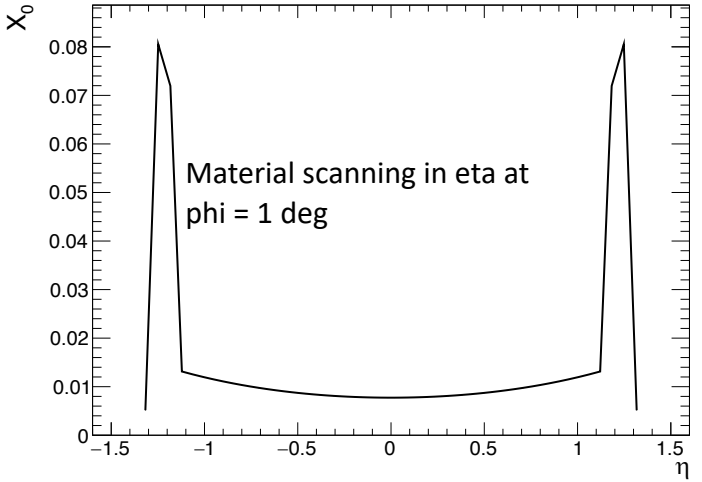
Micro-Rwell @ R = 44, 47 and 67 cm with length along z = 140, 150 and 280 cm

- mRwell @ R = 44, 47 and 67 cm with length along z = 140, 150 and 280 cm
- Each layers are uniform cylinder with single tile covering the entire phi and z range. Too idealistic approach.
- Each layer has support structure at the end.
- Material scan of all three mRwell layers are below









- Implemented materials based on small size detector (10x10) cm^2
- Not sure whether the same materials can be used for large scale detector in cylindrical geometry. Need lot of R&D .

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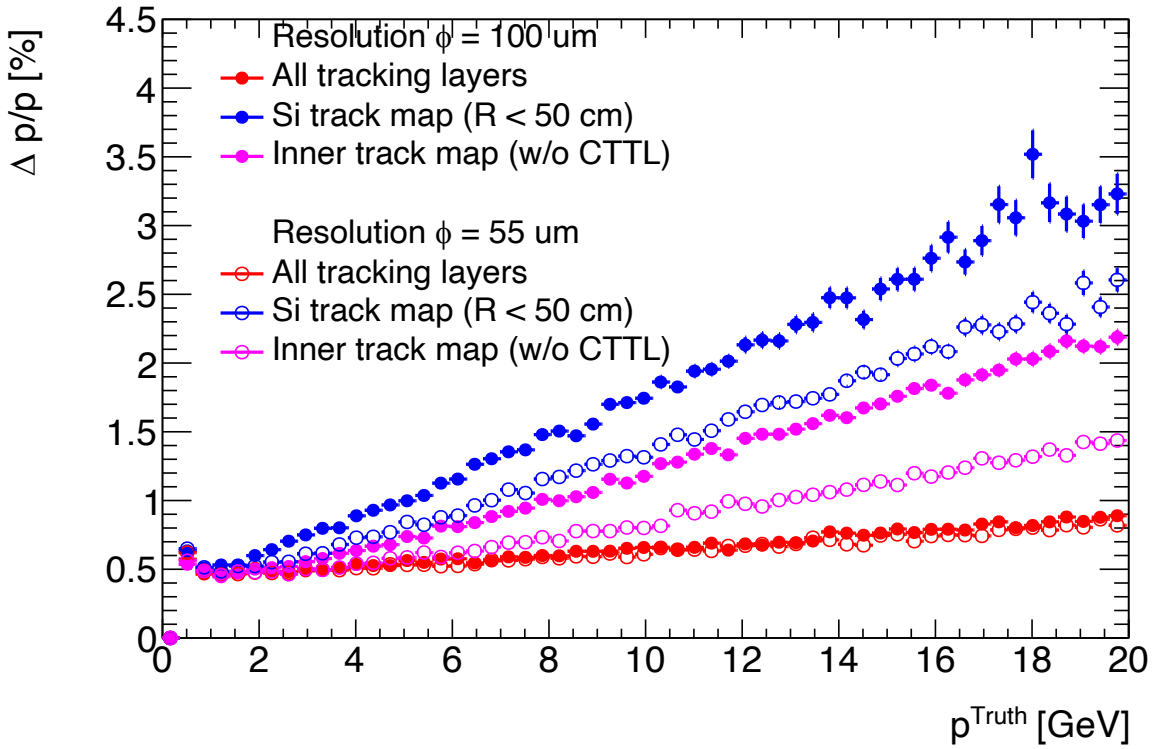
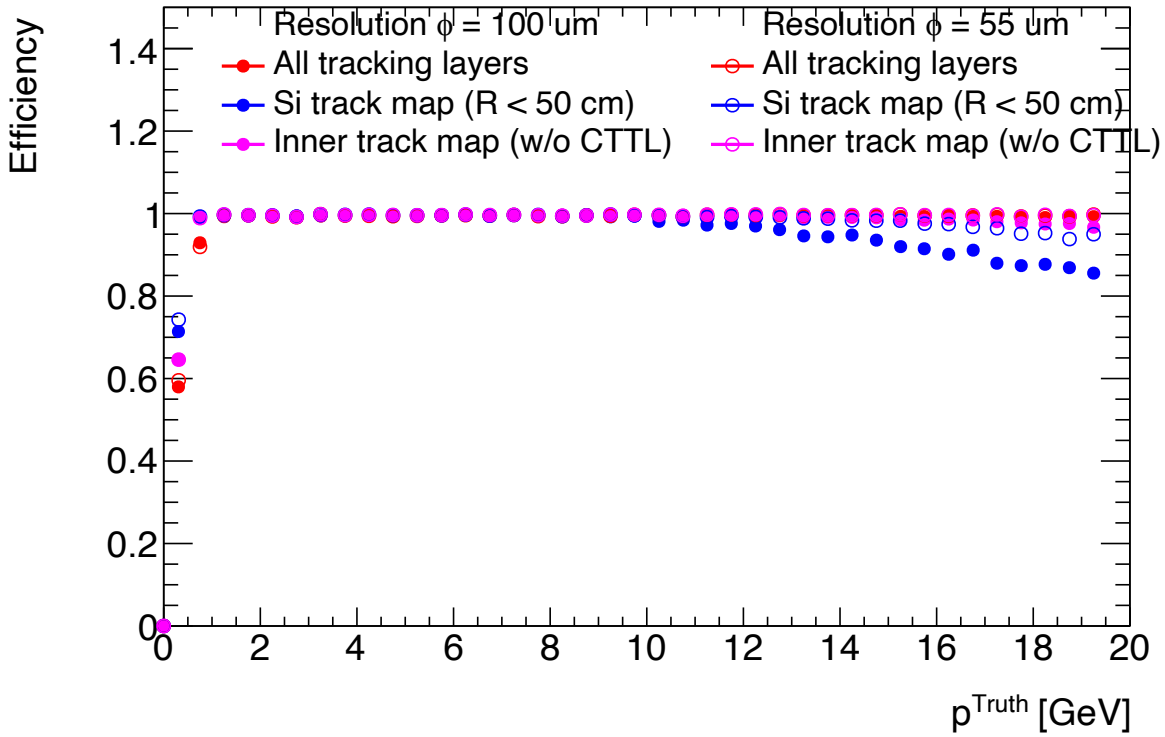
Inner , Silicon and all track maps for mRwell with 50 um and 100 um resolutions (w/o) tracking services)





- w/o CTTL and with 55 microns (overly optimistic) resolution for each MPGD layers one can achieve YR track performance requirement. 55 microns is hard to defend in front of review committee.
- w/o CTTL and with 100 microns (more realistic and easily achievable) resolution for each MPGD layers one is off from Physics WG requirement for high momentum tracks.

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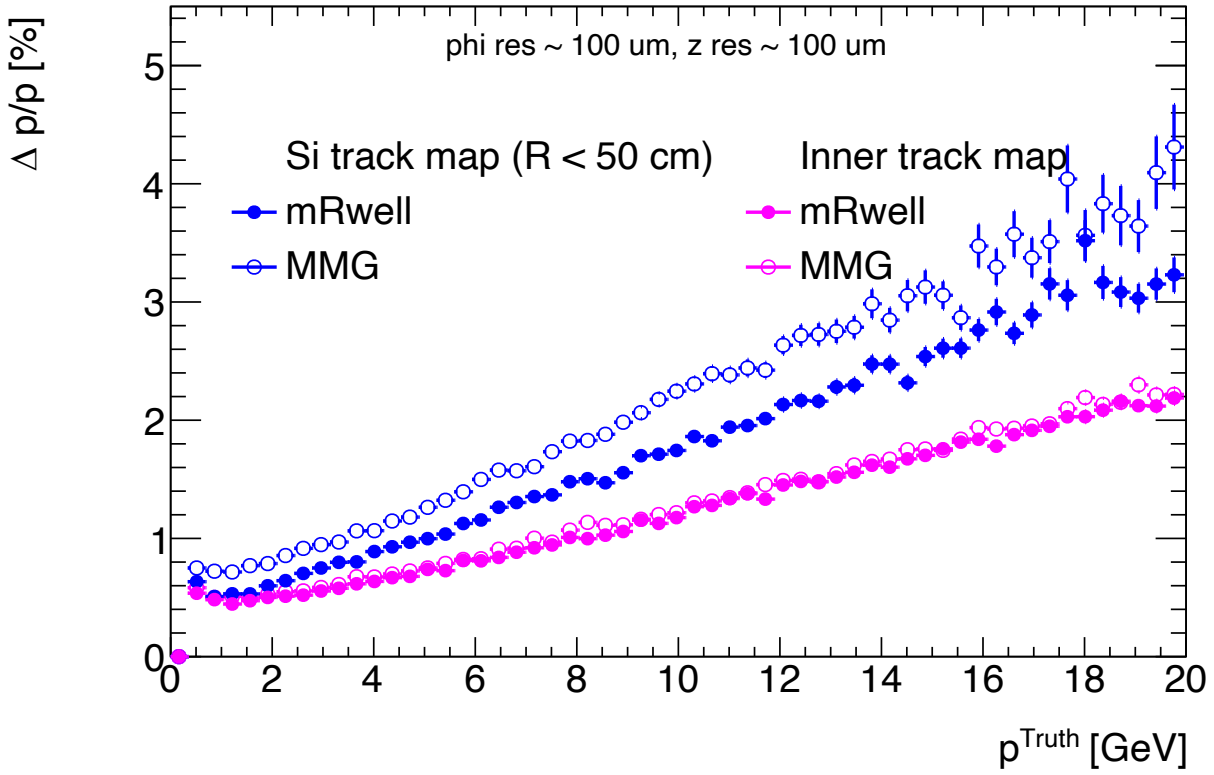
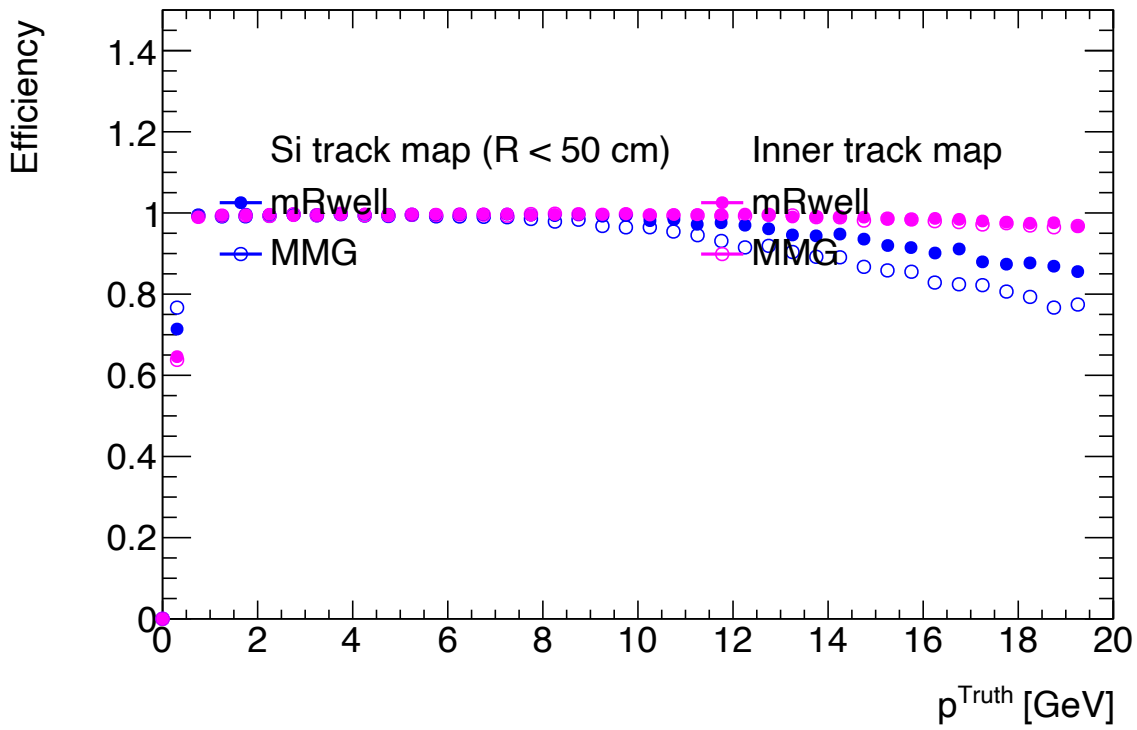
Inner , Silicon and all track maps for MMG and mRwell with realistic detector resolutions (100 um) (w/o tracking services)





- Performance of mRwell and micromega w/o CTTL and considering all three layers has same performance.
- Si track map for MMG shows degrading performance. This might be because of tile structure of MMG instead of idealistic smooth cylinder as implemented in mRwell.

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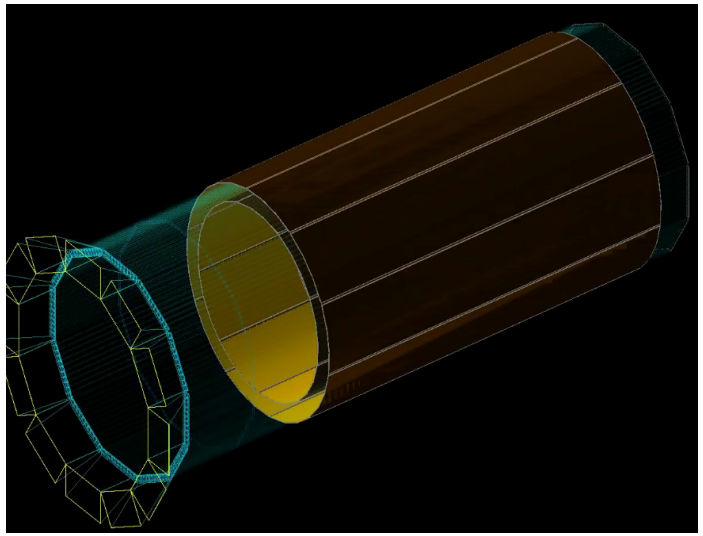
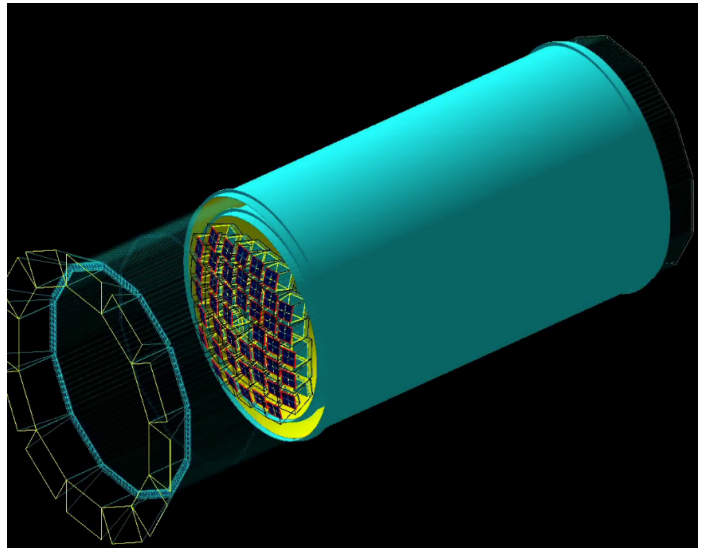
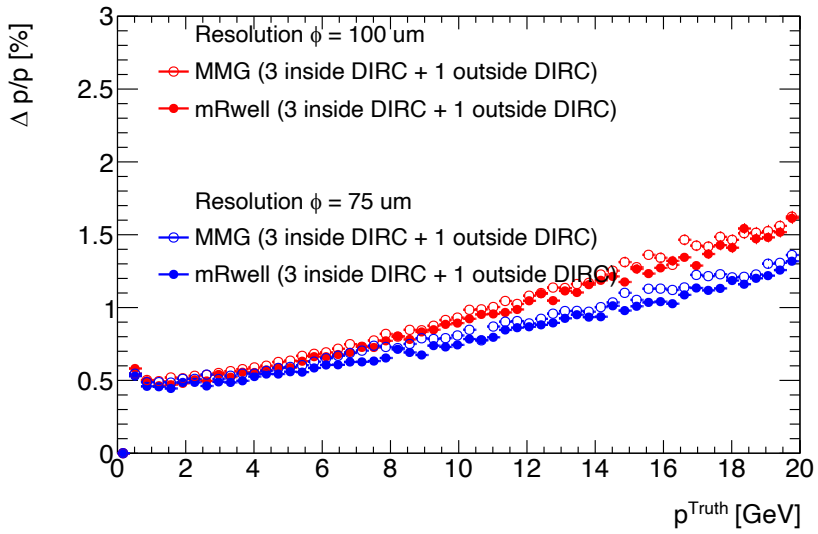
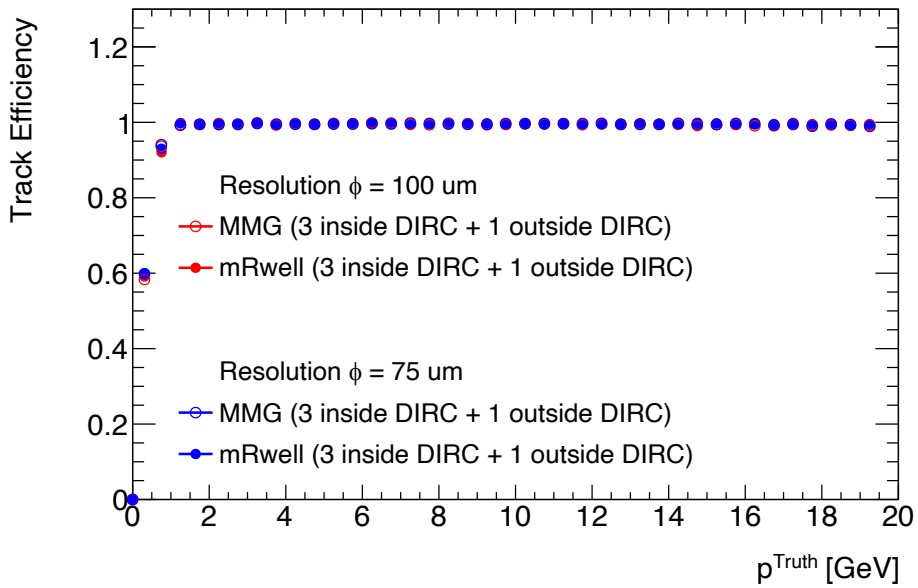
4 layers for MMG and mRwell (3 inside DIRC + 1 outside DIRC) with different detector resolutions and without CTTL (w/o tracking services)









- Added additional layer of MMG/mRwell at R = 80 cm (after DIRC) with length of 280 cm .
- With more realistic resolution (100 microns) for mRwell/MMG performance gets closer to PWG requirement. Still high momentum tracks are above requirement.
- 55 microns MPGD resolution in 1.5 T magnet too optimistic but can 75 microns be reached ? With 75 microns resolution and 4 layers of MPGD results look promising (comparing slide #9 Inner tracking evaluation results from Xuan's results https://indico.bnl.gov/event/12860/contributions/54893/attachments/37316/61492/ECCE_tracking_20210924_XuanLi.pdf)
- Should we consider adding additional MPGD layer after DIRC ? This will be issue for mRPC TOF.

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Backup

3 layers Micromega (MMG) in ECCE barrel region

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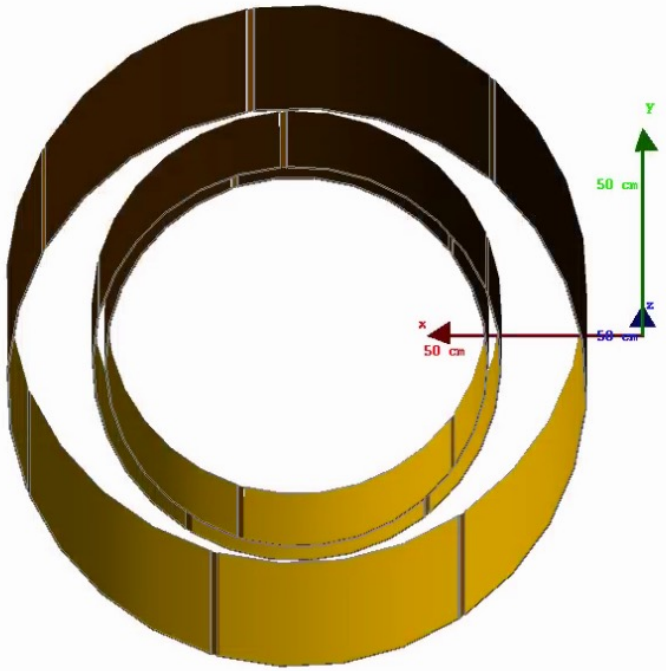

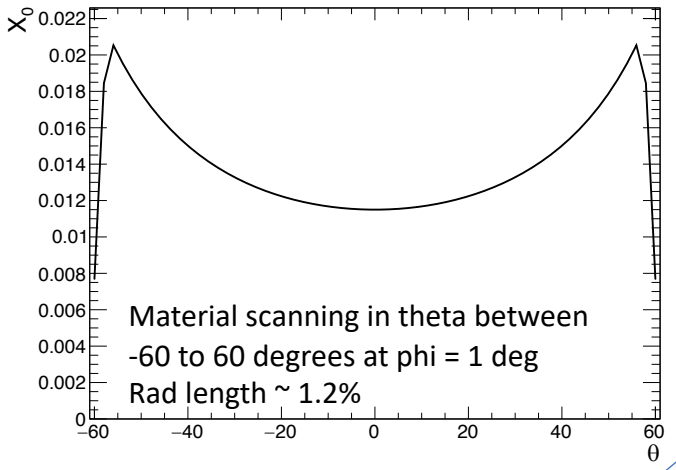

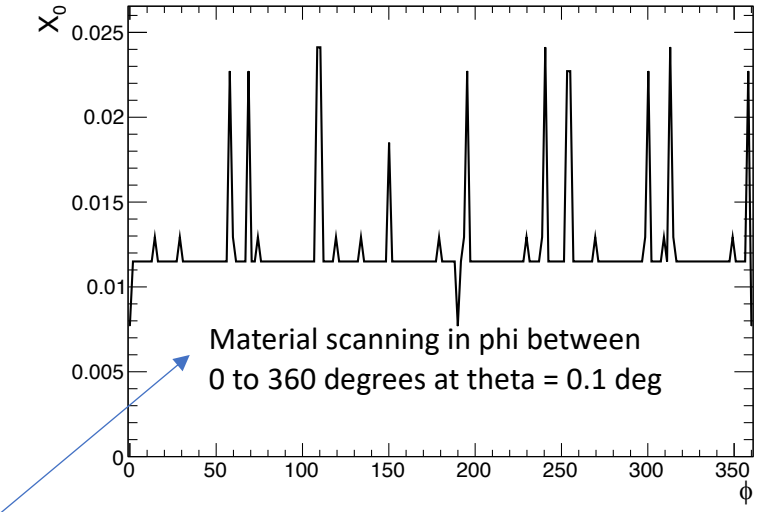

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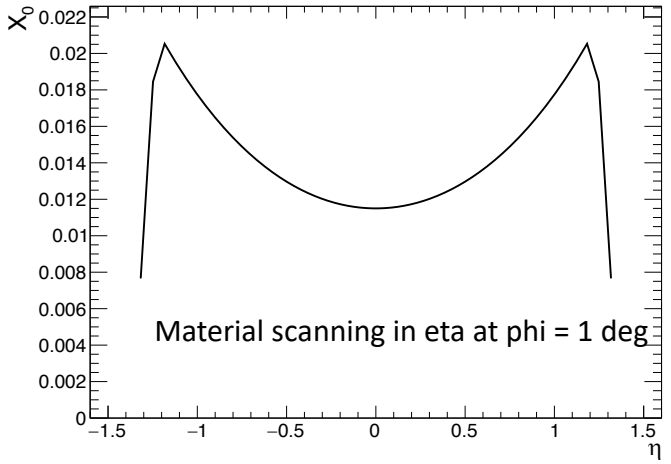

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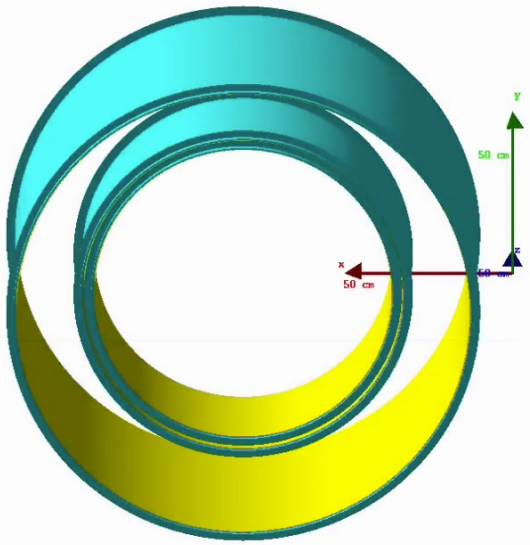

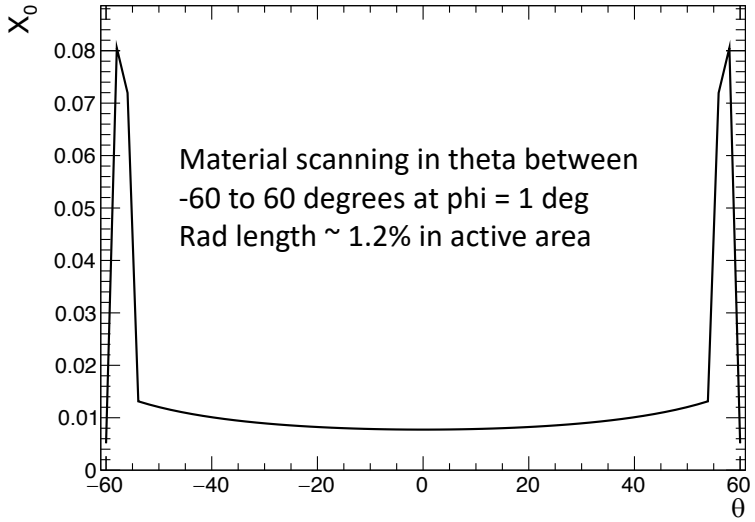

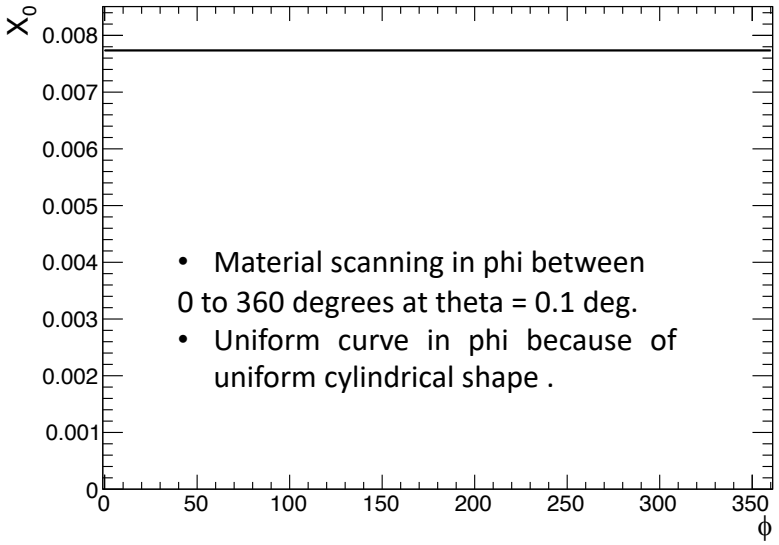

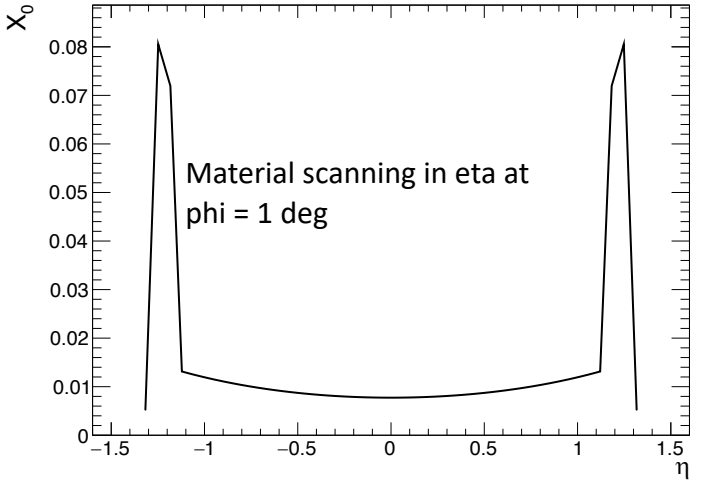

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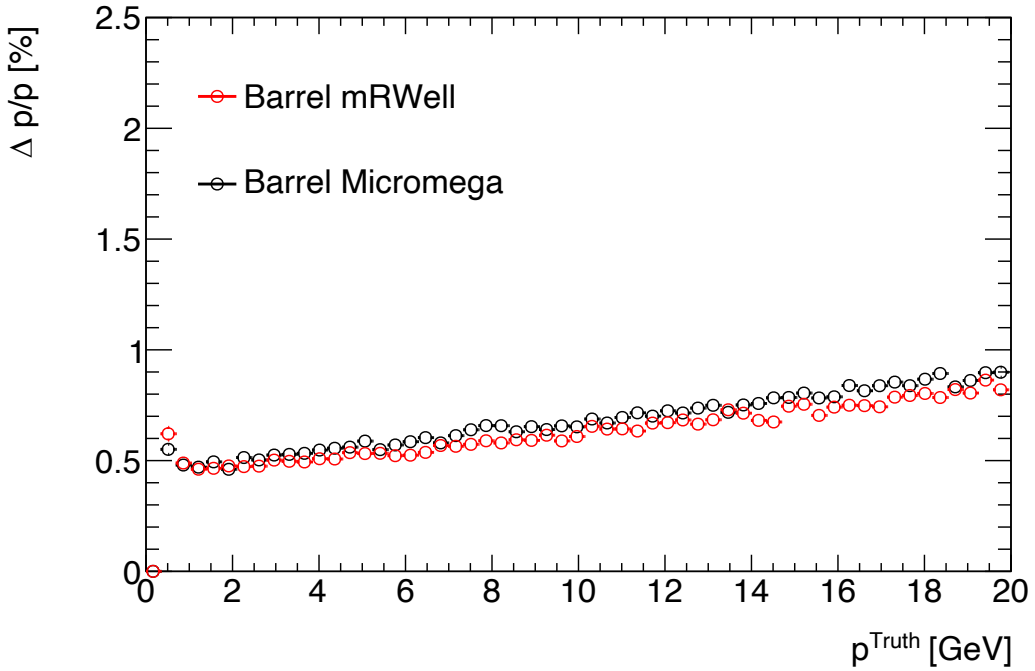
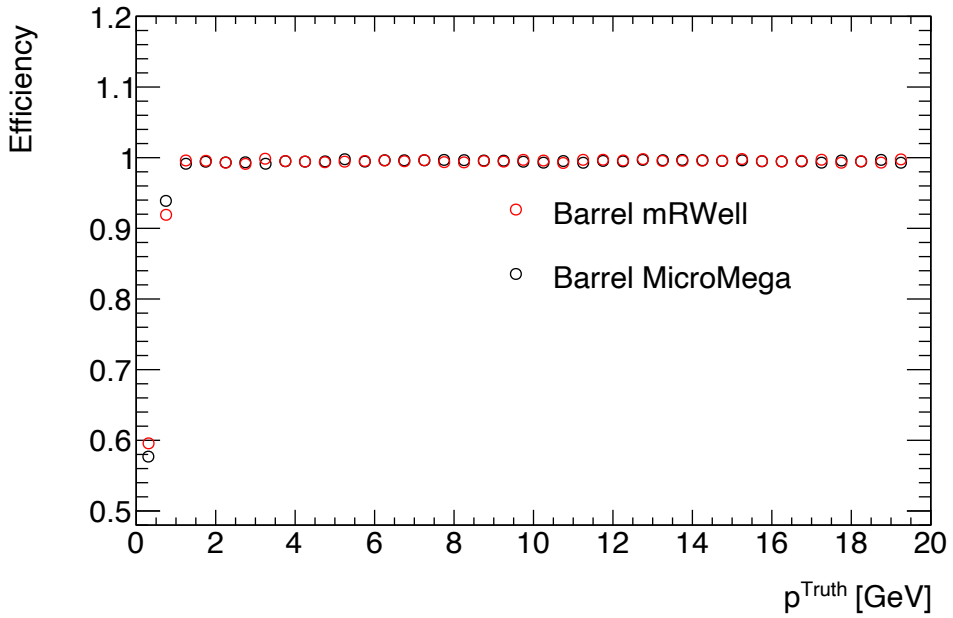
ECCE Geant4 simulation, MPGD central tracker

- Tracking performance using 5 pions per event with 0.1 < p < 20 GeV , |eta| < 1.0 and 0 < phi < 2*pi.
- Active detectors in barrel region – Barrel (Si) + 3 layers MMG/mRwell + CTTL + inner HCAL + DIRC in 1.5 T magnet and without tracking support for this study





- Both micromega and mRwell were set to resolution of 55 microns .
  - Not taken into account Lorentz effect and angle of track w.r.t detector surface
- Performance is almost same for both micromega and mRwell.
- mRwell geometry is too ideal in current Geant4 . Not achievable in real life.
- micromega active area in current geometry has radiation length of 1.2% (3 layers). Can be reduced further.

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ECCE Geant4 simulation, MPGD central tracker

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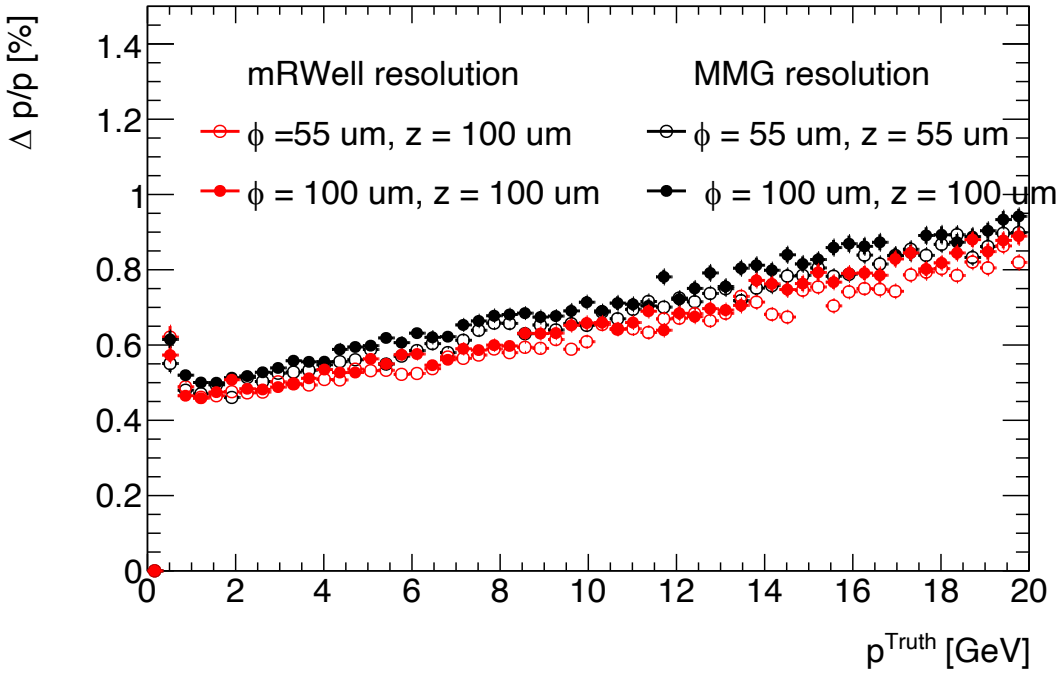
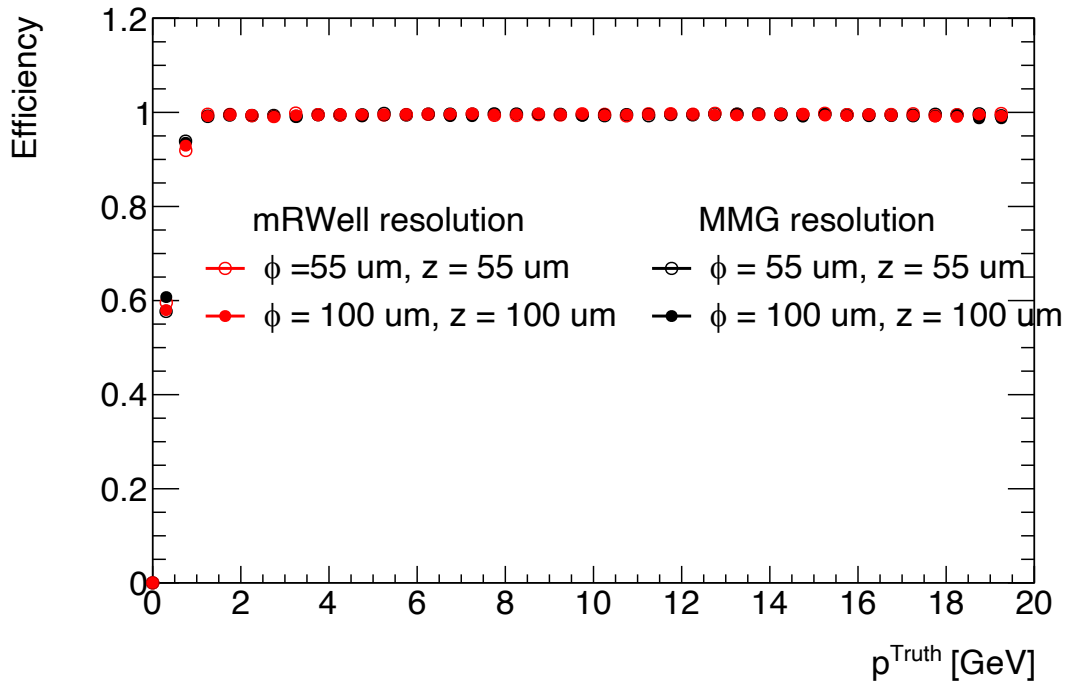
- Active detectors in barrel region – Barrel (Si) + 3 layers MMG/mRwell + CTTL + inner HCAL + DIRC in 1.5 T magnet and without tracking support for this study
- Set mRwell and MMG pad plane resolution more close to reality





Not that much effect on tracking performance.

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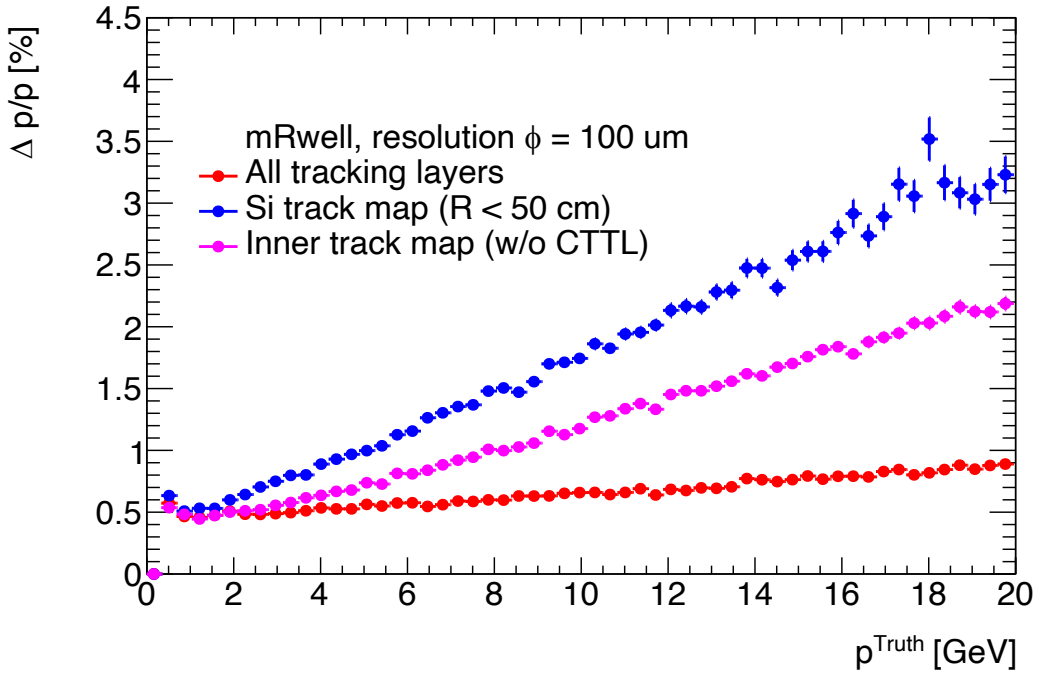
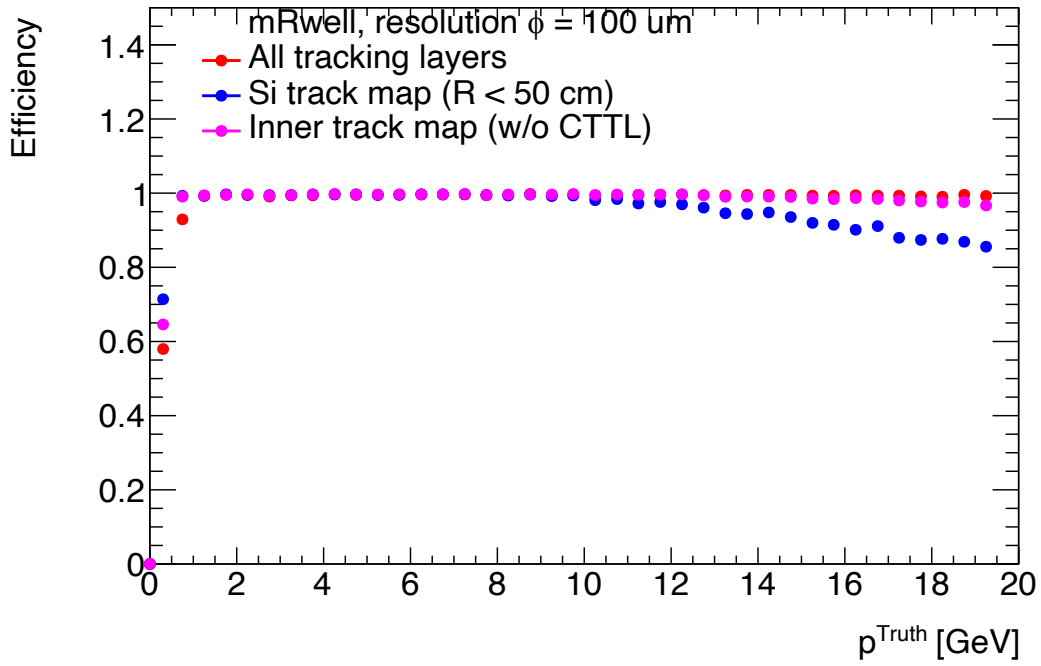
ECCE Geant4 simulation, MPGD central tracker

- Comparison between Si track map (R < 50 cm) and Inner track map (w/o CTTL) in mRwell.
- Same detector subsystems were kept active as in previous slides.





- As expected, CTTL plays big role in tracking performance .
- Need to implement Si track map and Inner track map evaluator for micromega barrel rapidity layers as well.
- Any studies done by replacing CTTL with mRwell ?

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Conclusions about micromegas :

- Detailed G4 geometry of micromegas implemented in ECCE Fun4all. Pull request https://github.com/eic/fun4all_eicdetectors/pull/49 .

- More realistic geometry for micromegas in terms of having multiple tiles with frames along phi instead of uniform cylinder, implementation of materials equivalent to cable radiation length, similar geometrical configuration already implemented in CLASS 12 experiment. Currently each layer has X0 ~ 0.4% and ongoing R&D to reduce it to the level of 0.07%.

- Micromega pad plane resolution in simulation more close to reality with 2D strip and implementation of additional materials equivalent to cabling. More R&D needed to optimize pad plane pitch and number of channels.

- Tracking performance at par with mRwell.

- Well proven technology (is being used in CLASS 12 and ATLAS experiments) .

- Should be seriously considered as barrel tracking layers .

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