

Tracking performance studies for a 100 TeV detector

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Goals

- Optimize track reconstruction for FCC-hh “performance” detector (100 TeV, pp) collisions
- Troubleshoot and understand tracking in the momentum range $P=2-32,000$ GeV

Workflow

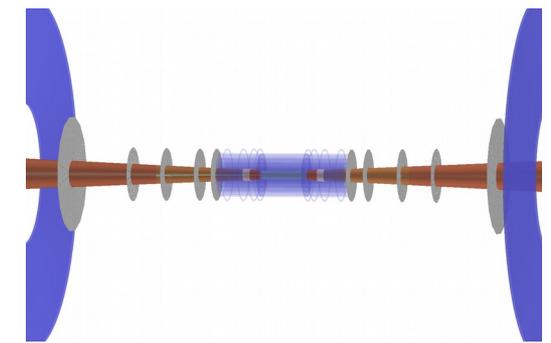
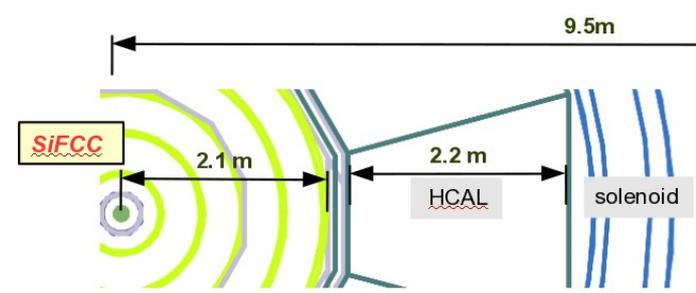
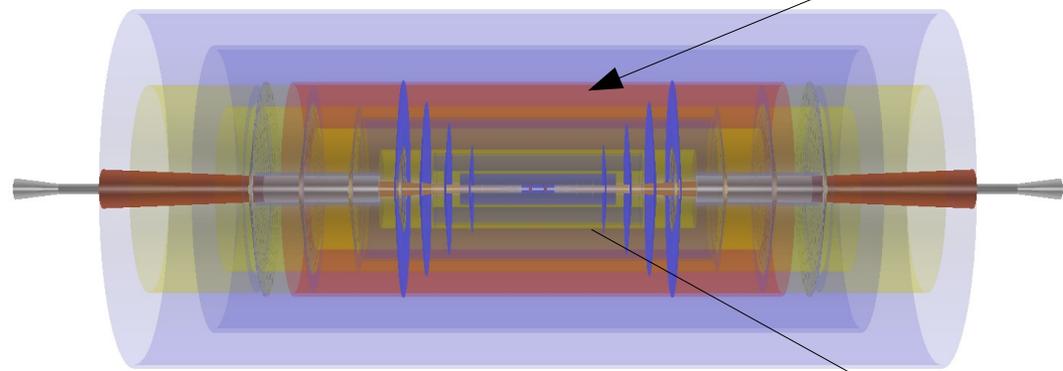
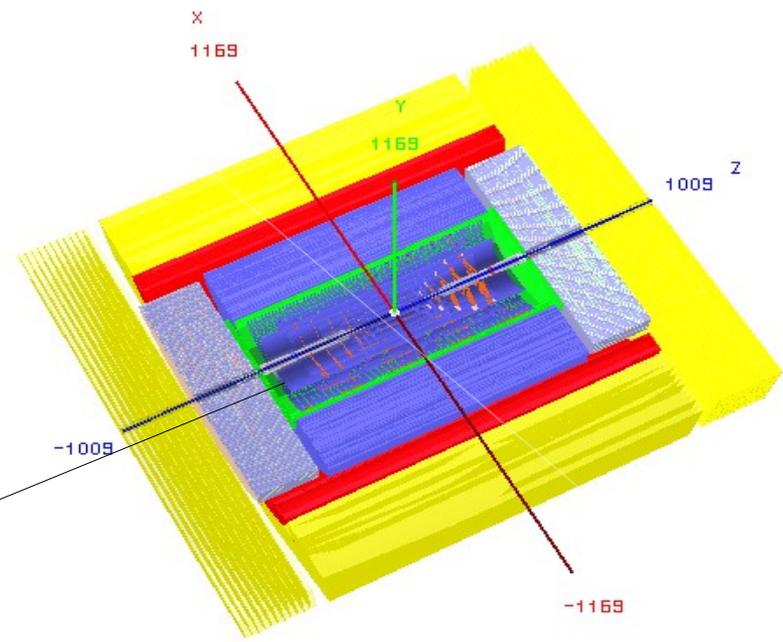
- Use single muons randomly distributed in Eta with $p_T=2,4,8 \dots 2^n$ GeV
 - <http://atlaswww.hep.anl.gov/hepsim/info.php?item=212>
- Run full simulations using HepSim with SLIC software (on the grid)
- Use visualization tools (ROOT, Jas4pp) to identify problems
- Edit geometry files (XML) and rerun single-particle reconstruction
- Analyse fully reconstructed tracks and look at track efficiency and resolution

SiFCC-v4 tracker

Full detector (sifch4) description:

<http://atlaswww.hep.anl.gov/hepsim/soft/detectors/>

- Scaled up 'all-silicon' SiD detector
- Outer tracker R=2.1 meter
- B=5 Testla solenoid
- Outer and Inner silicon trackers (25 and 50 um readout sizes)



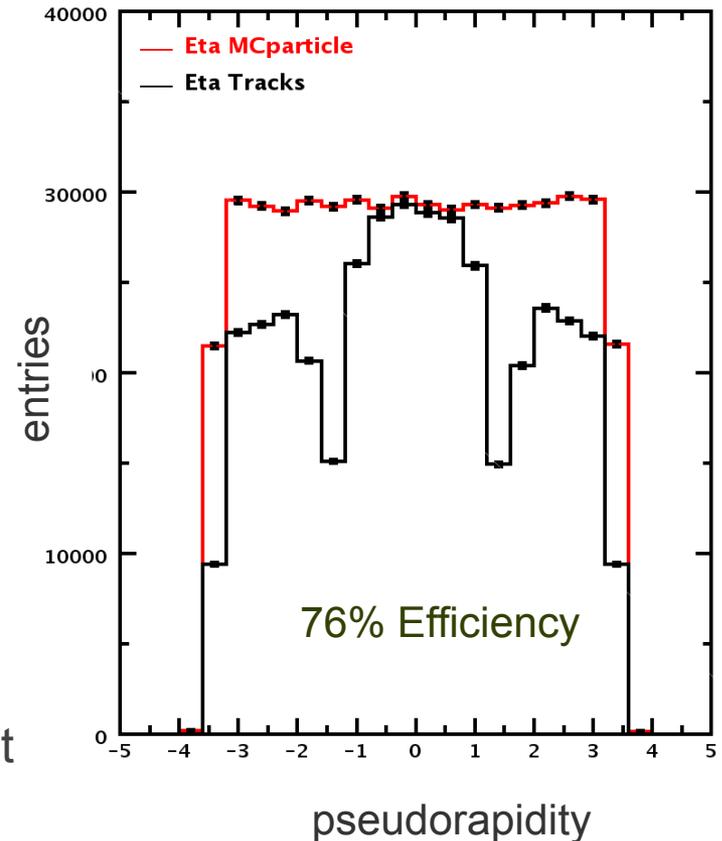
SiFCC tracking studies



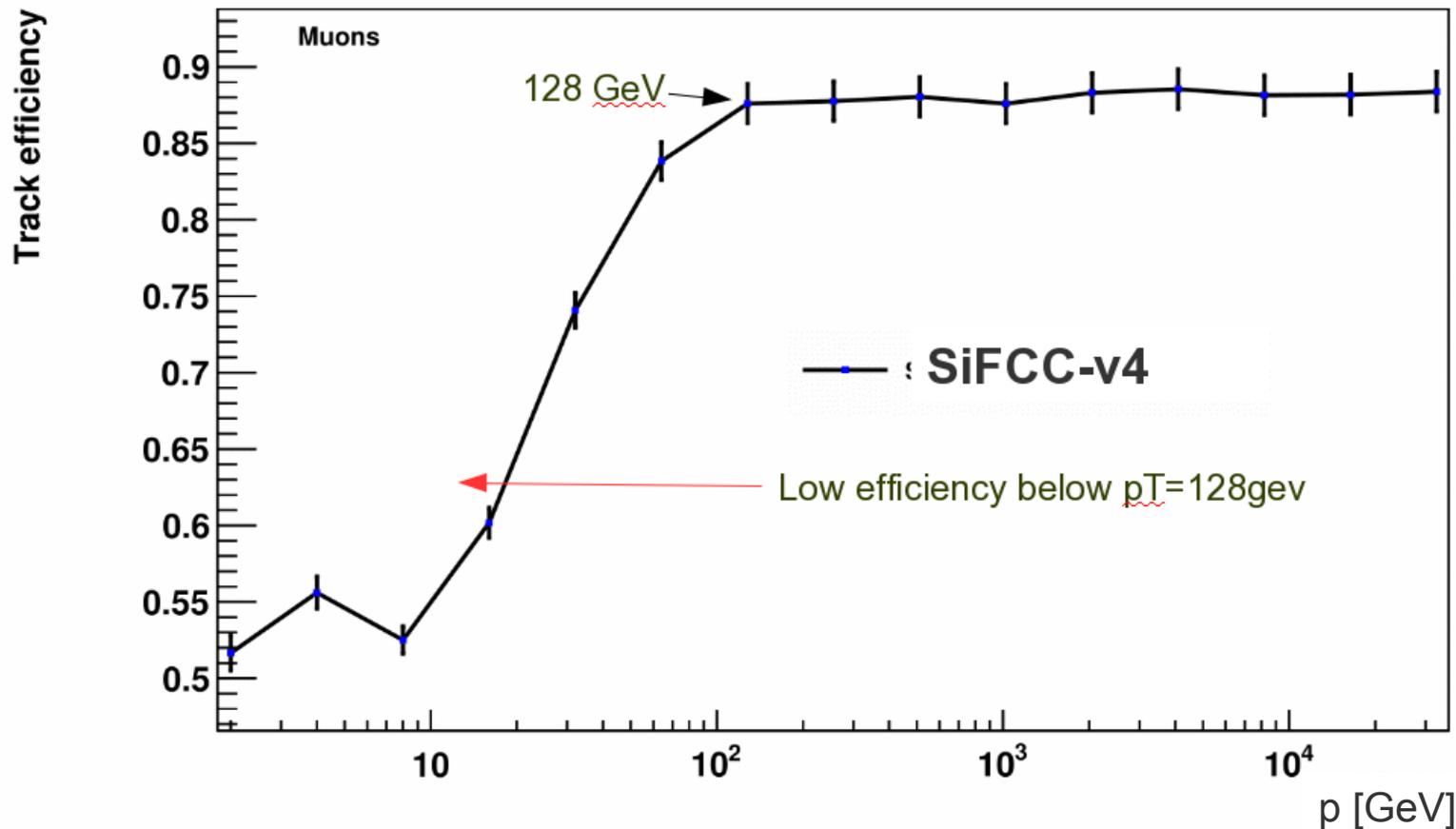
Tracking efficiency

- Single muons randomly distributed in Eta-Phi and reconstructed using HepSim/SLIC software
- Tracks are reconstructed from the hits using SLIC/lcsim
- Reconstruction strategy:
 - MaxDCA=6
 - MinHits=7
 - MaxZ0=10
 - MaxChi2=10
 - BadHitChiq=5
- Problems:
 - Low efficiency around $|\eta| \sim 1.5$
 - Low efficiency at $|\eta| > 1.5$
 - 50-70% of particles detected at low pT
- It was found that the original SiD detector did not have this inefficiency problem → this feature is introduced after scaling the SiD detector to ~100 TeV energy

Single muons 2-32768 GeV

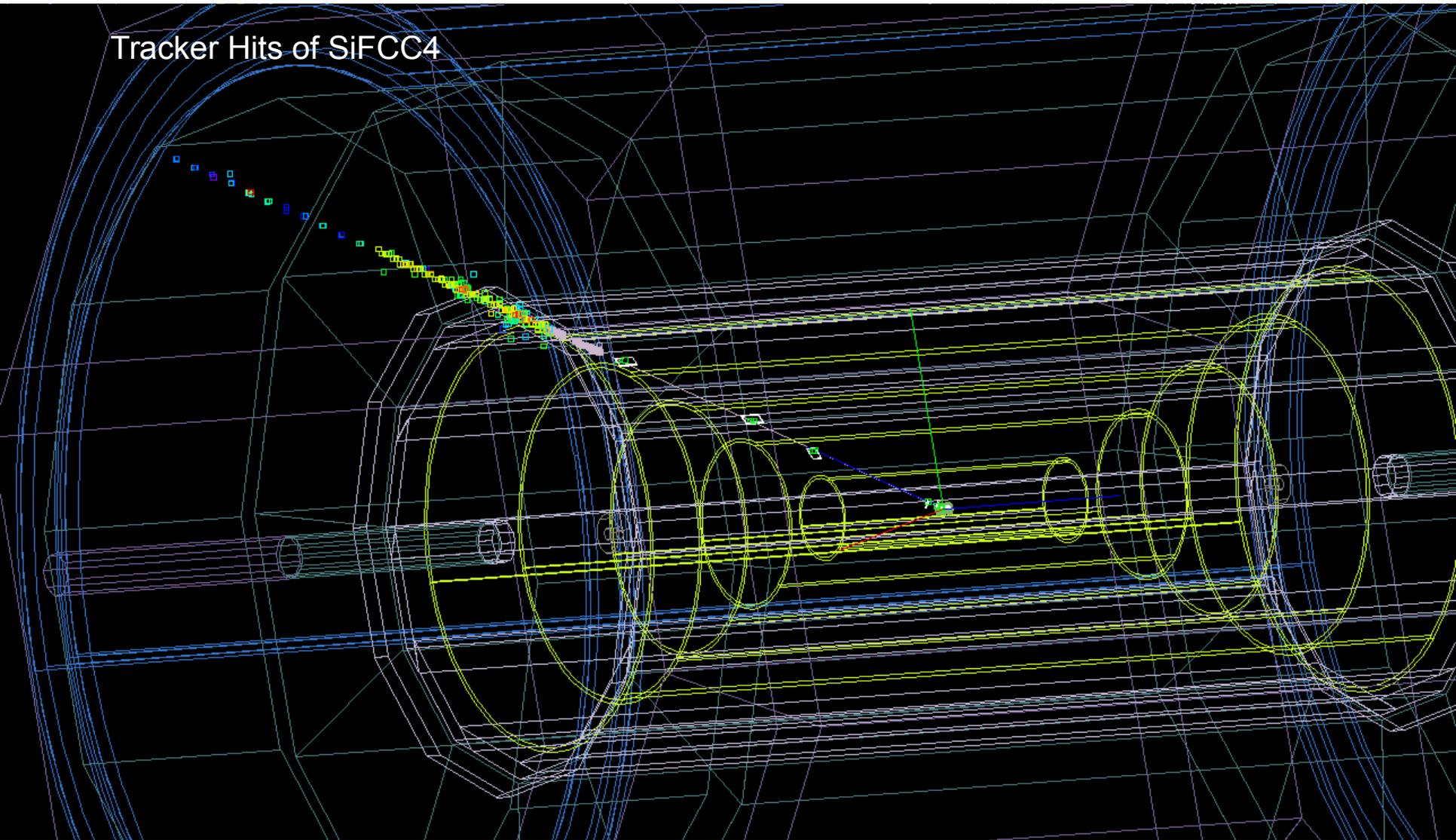


Track efficiency as a function of p_T



More Troubleshooting

Tracker Hits of SiFCC4

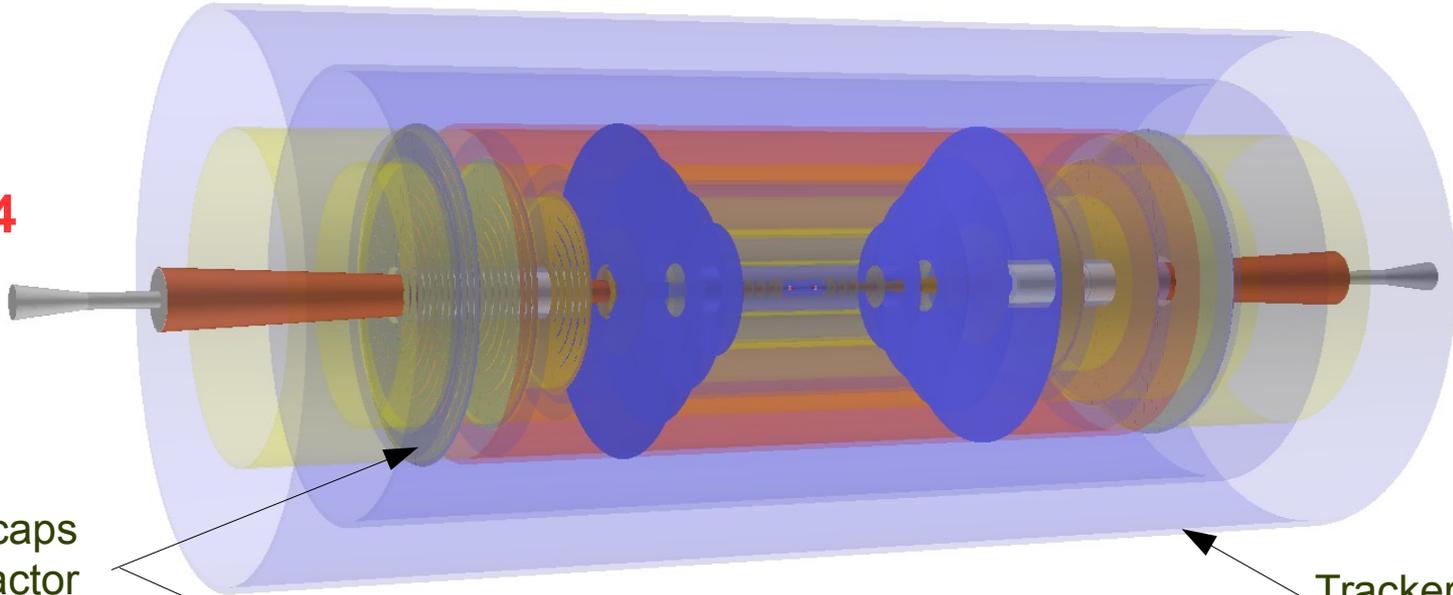


Analysis

- What is wrong?
 - Possibly, high magnetic field (5 T) curves high-Eta tracks and reconstruction does not correctly reconstruct these tracks.
 - The track reconstruction required Min=7 hits.
 - Large dips around $|\eta|=1.5$ $\eta \rightarrow 25$ degrees
 - Visual scan of events show missing trackers due to 7-hit requirement \rightarrow needs more forward disks!

Before and After

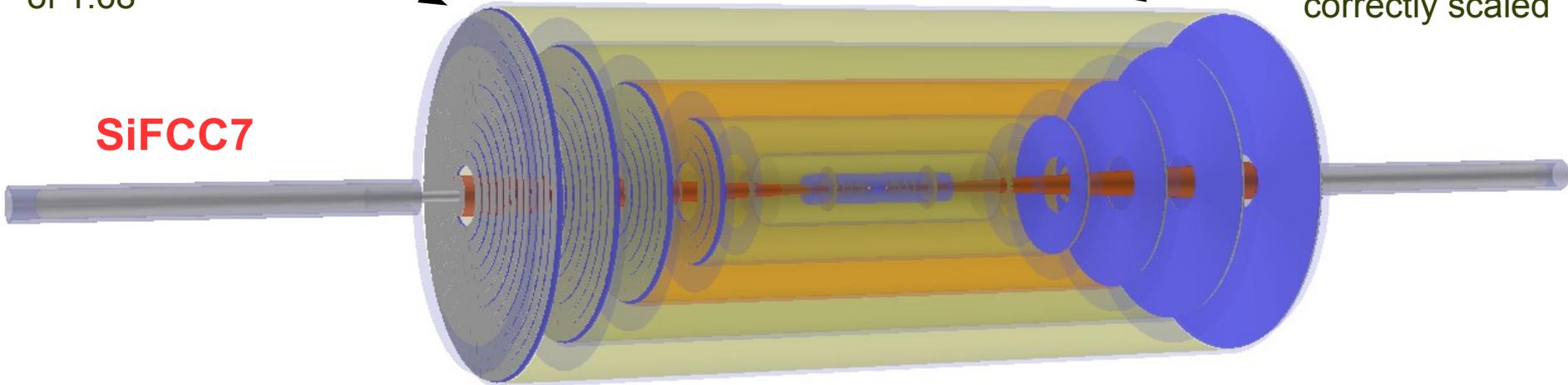
SiFCC4



Tracker Encaps
scaled by factor
of 1.68

Tracker Barrels
correctly scaled

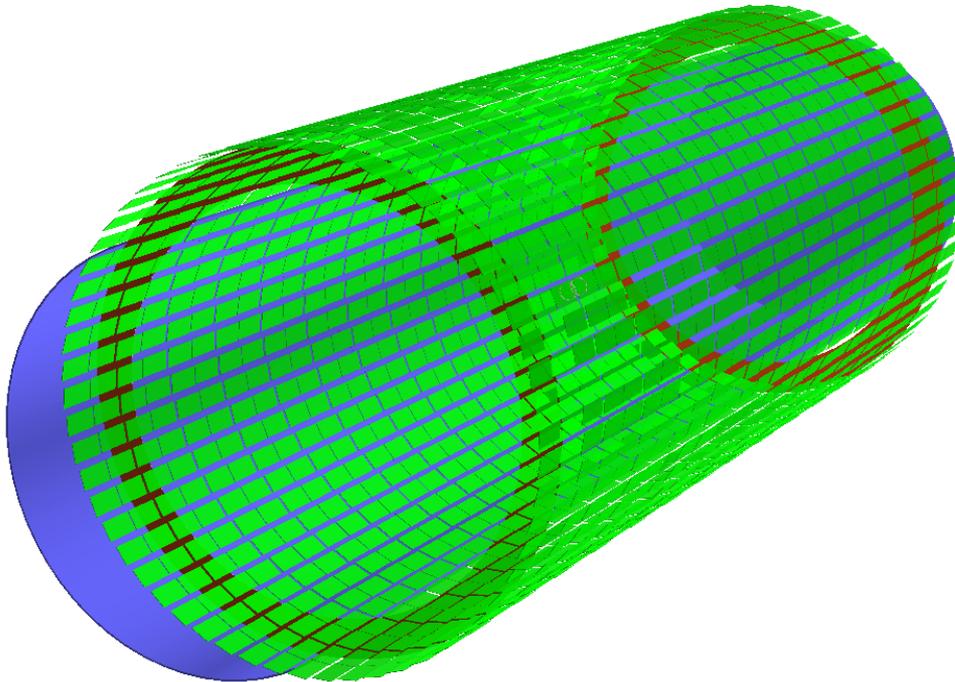
SiFCC7



Geometrical Optimization

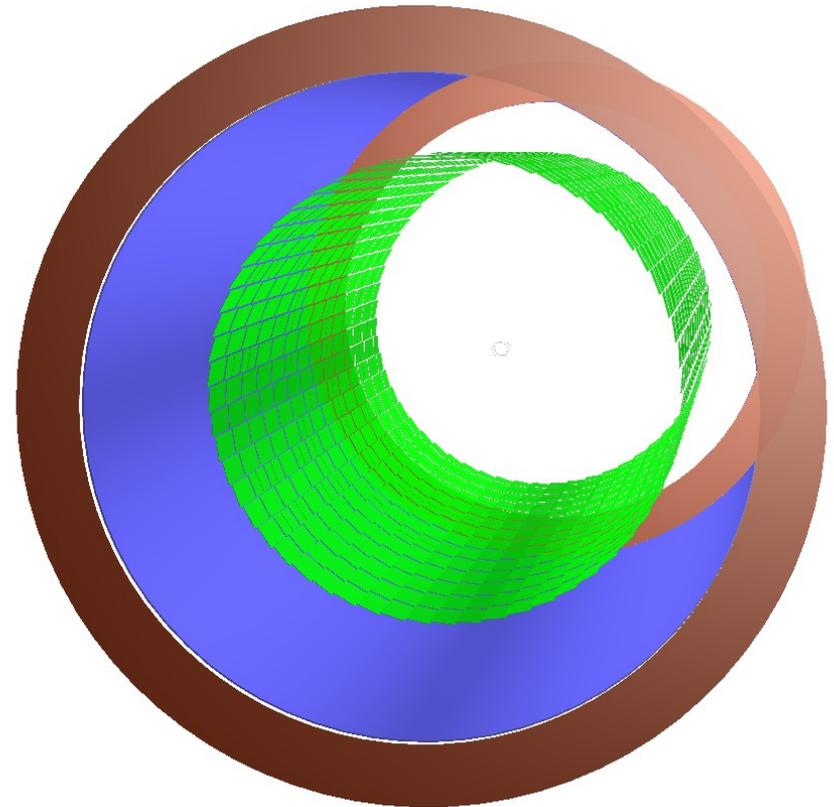
Before

- Large gaps
- Detector modules scaled
- Support and readout unscaled

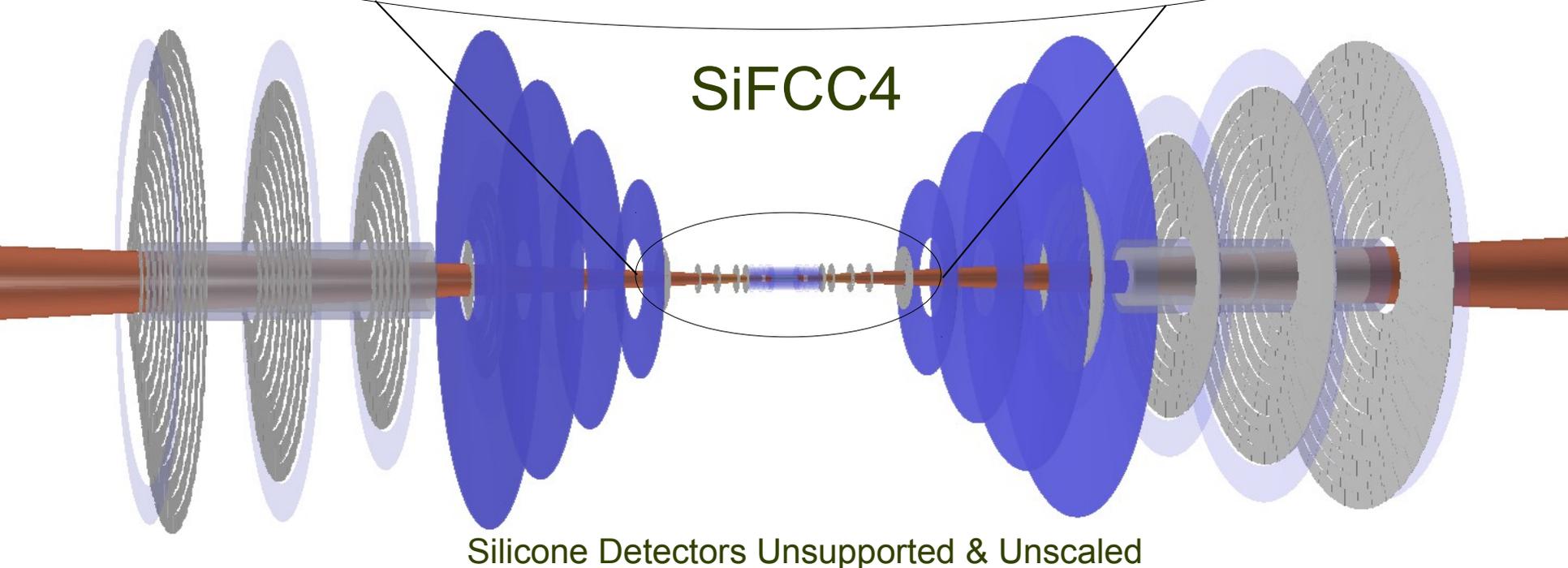
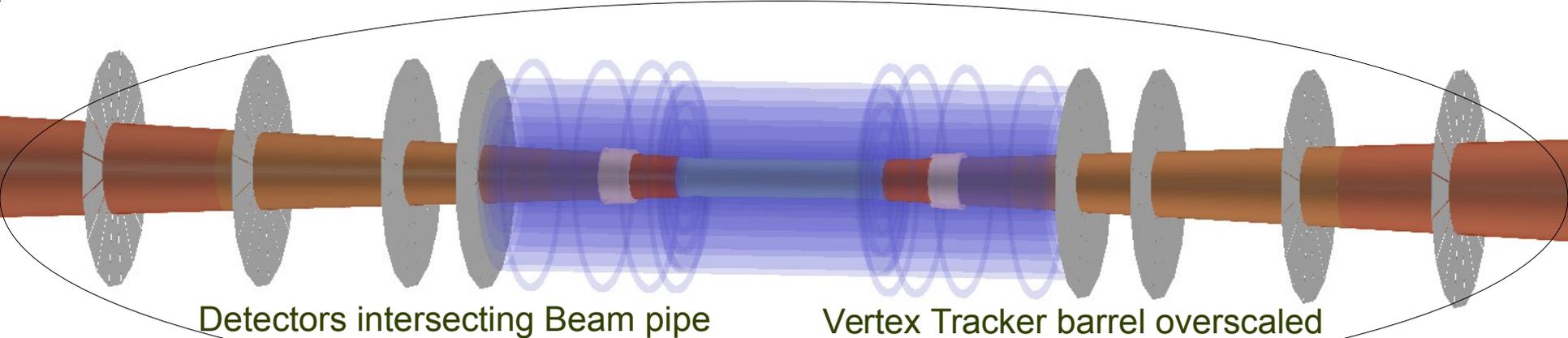


After

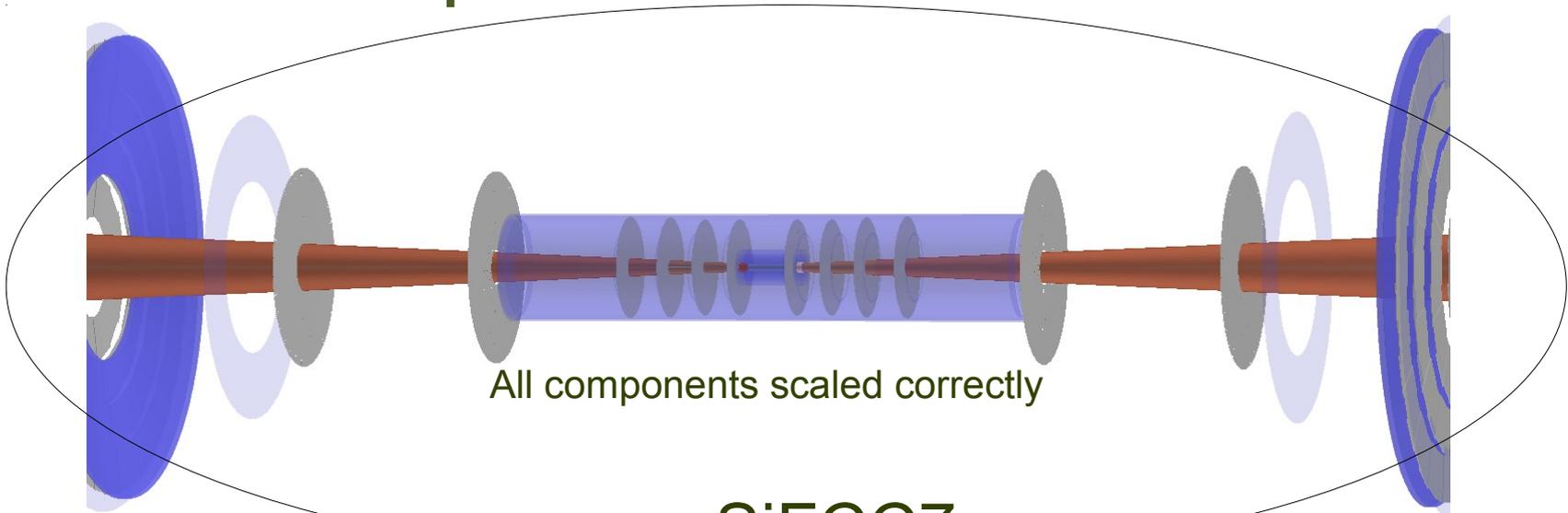
- No gaps
- All structures correctly scaled
- Space added for readout wires



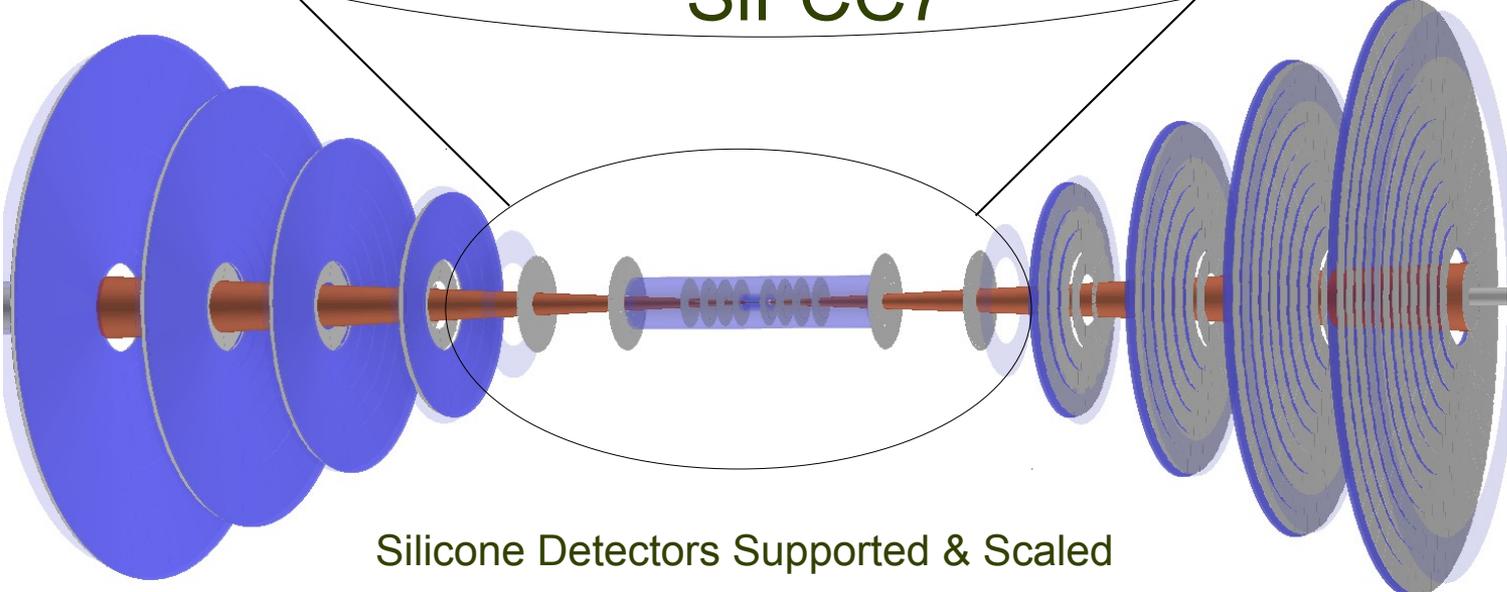
Geometrical Optimization



Geometrical Optimization



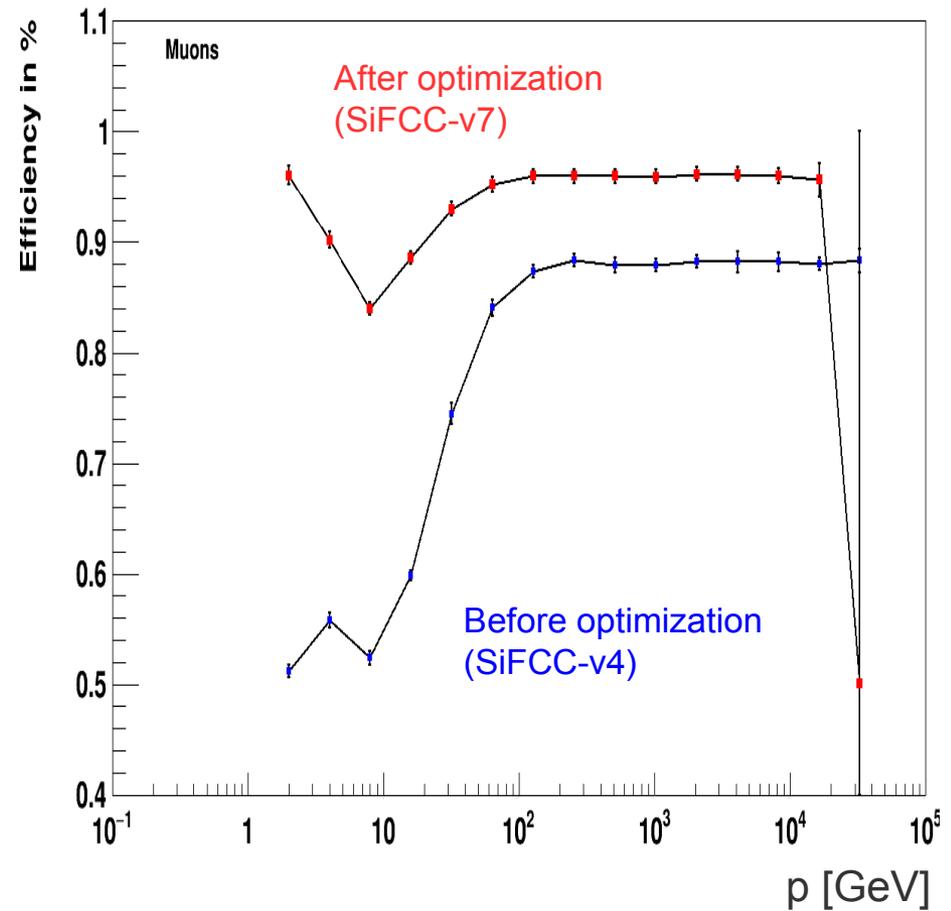
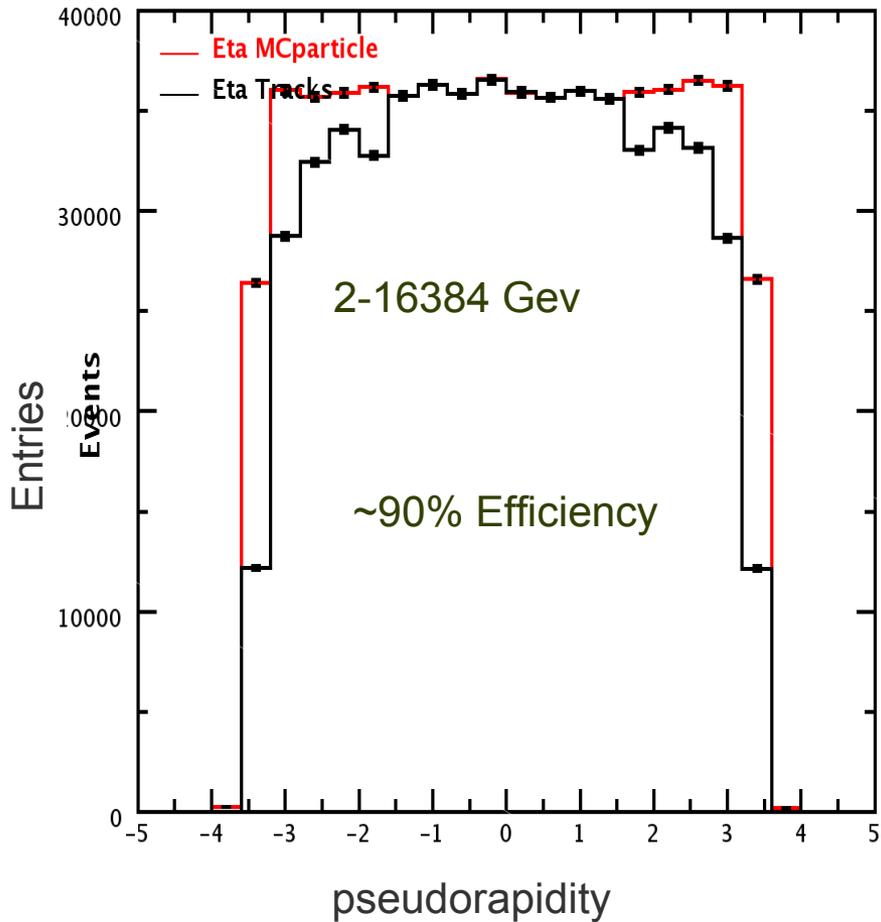
SiFCC7



Solution

- Gaps between tracking modules minimized
- Discs and Support infrastructure moved closer to readout modules
- Reduced min number of hits from 7 to 6
- Much higher efficiency between 1 and 2 eta
- Much higher efficiency at lower pT
- Average efficiency ~95%
- Fake track rate is around 0.2%
 - Fake rate was estimated by matching tracks with MCParticles and calculation the fraction of tracks without match
- Fake rate can be further decreased to 0.02% requiring Min=7 hits, but we expect a drop in efficiency

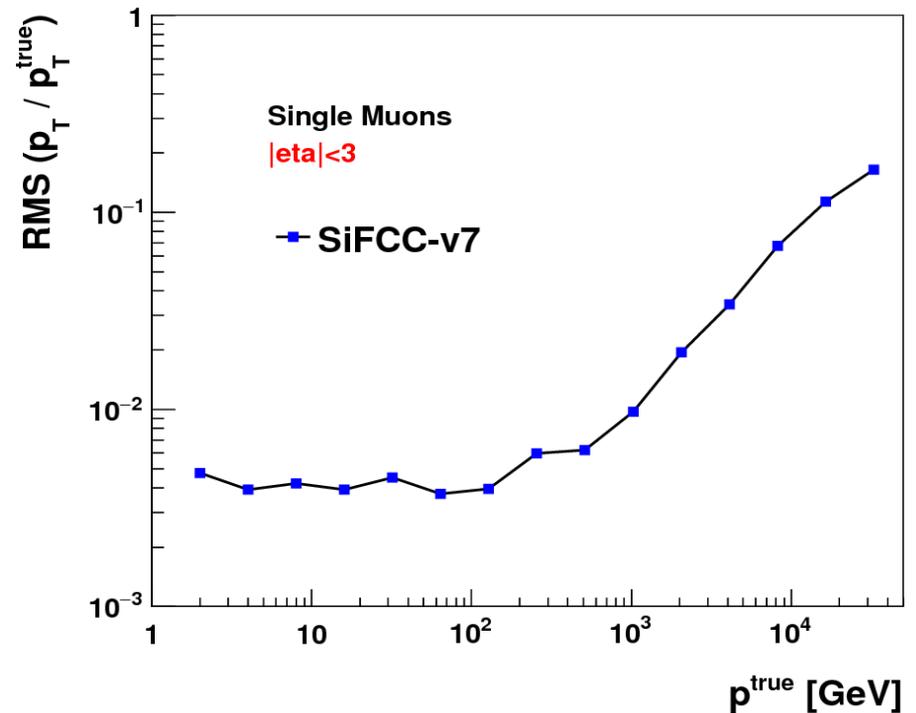
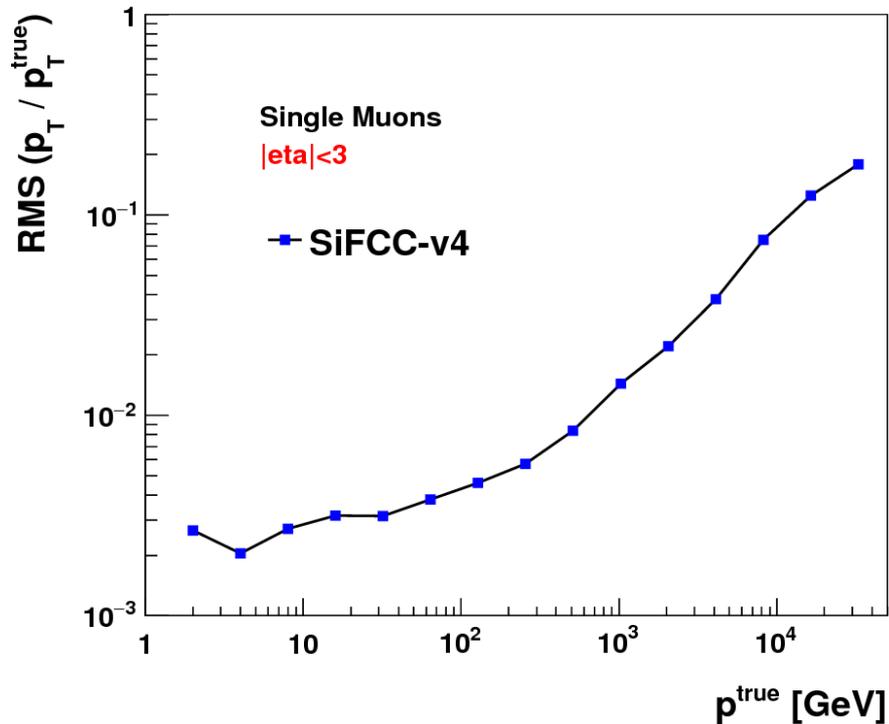
Result for SiFCC-v7



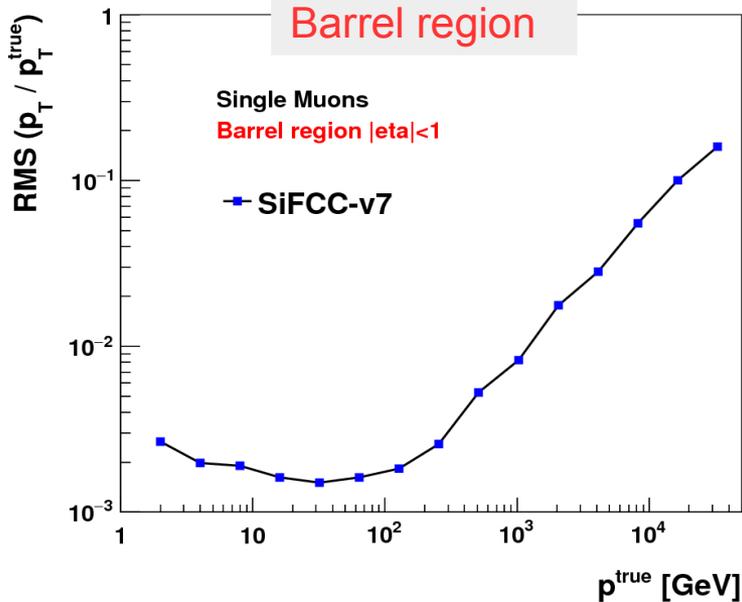
Track resolution

- Use single muon samples ([pgun_muon_eta35](#))
- Single track resolutions as a function of p_T approximately the same before and after geometry modifications
 - \rightarrow expected: pixel sizes, B-files and outer radius are identical to the previous geometry
- $\delta p_T / p_T \sim 10\%$ for $p \sim 16$ TeV
- $\delta p_T / p_T \sim 15\%$ for $p \sim 30$ TeV

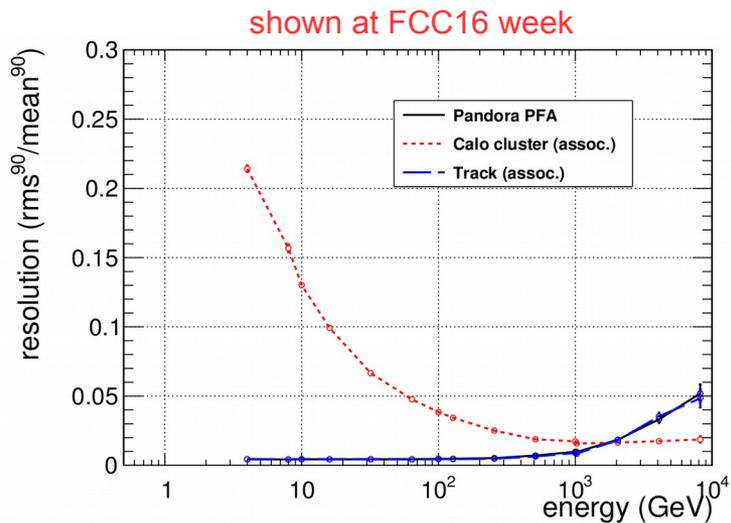
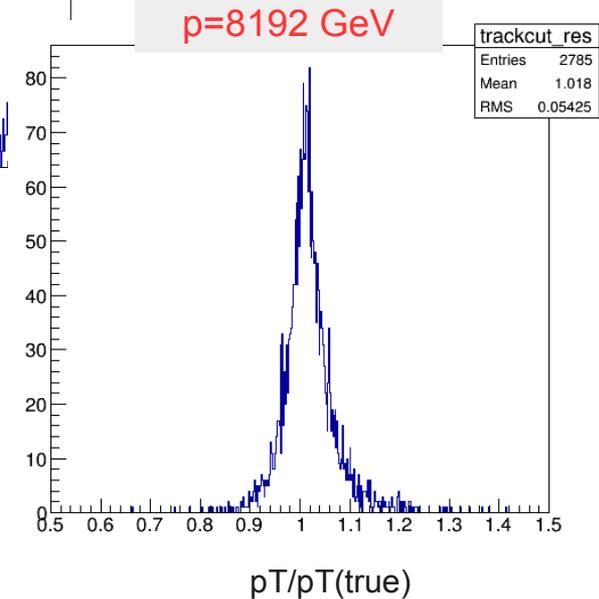
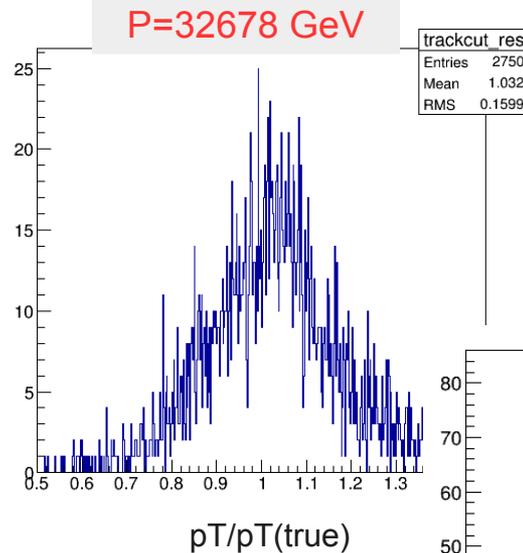
after modifications



Track resolution in the barrel region



- Resolution at $p_T \sim 100$ GeV is better than for all $|\eta|$
- Resolution for high- p_T region did not change



~ agrees with the result by N. Tran shown at FCC 2016 week (presented by S.C.)

Conclusions

- Tracking geometry has been significantly improved
 - Efficiency has been increased in forward regions and at low p_T , no drop in efficiency at $|\eta| \sim 1.5$
- Support structure scaled and moved to active modules
- Geometry additionally adapted for wires and readouts
- Small increase in fake track rates compared to SiFCC-v4 (7-hit requirement)
- Tracking resolution is similar to SiFCC-v4:
 - 10% for $p \sim 16$ TeV
 - 15% for $p \sim 32$ TeV
- New tracking geometry is included in the release of SiFCC-v7
- Single muons reconstructed using SiFCC-v7 can be downloaded from <http://atlaswww.hep.anl.gov/hepsim/info.php?item=212> → **(rfull008)**