Full Silicon Tracker

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(on behalf of full silicon tracker group)

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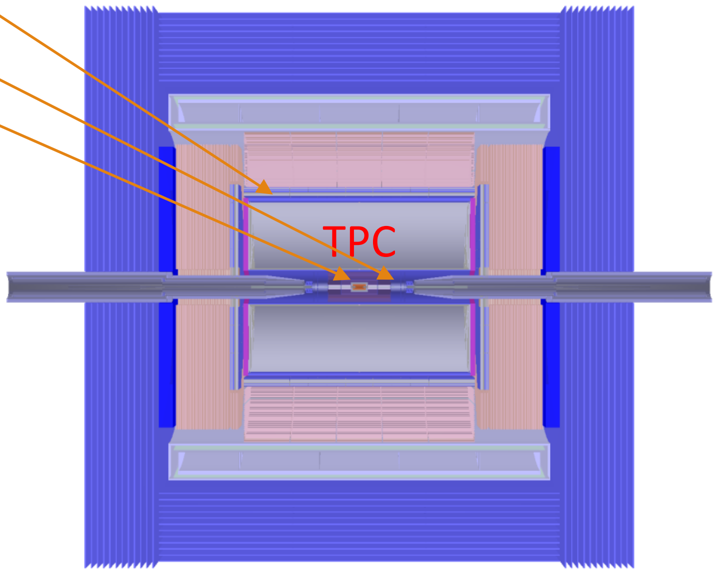
Contents

Introduction

- Partial silicon tracker (VXD, FTD, SIT/SET) + TPC is designed as the tracker in the baseline detector for CepC. But other one or more tracker is still needed as the design for the potential second IP or as a backup tracker for the preferred tracker.
  - ➢ CepC silicon study group have studied their technology and ongoing
- ILD, FCC-ee, CLIC, HL-LHC have proposed the full silicon tracker as their main tracker.

Baseline detector @CepC



- The study on full silicon tracker: technology, layout design and performance.
  - ➢ The technology can benefit from the partial silicon tracker study.
  - ➢ The full silicon tracker designs in other colliders can be referenced.

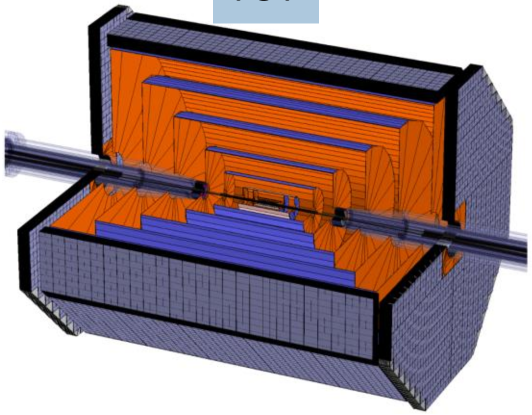
Technology

- Planary layers cover solid angle as much as possible.
  - support layer + silicon layer:
    - ✓ double side
    - ✓ single side
  - other support
  - electronics
- Silicon sensor technology (CMOS) is same as the VXD, FTD, SIT/SET in the baseline detector.
  - VXD:
    - ✓ Toward 16 μm pitch (2.8 μm single-point resolution)
  - SIT/SET and FTD_STRIP:
    - ✓ 50μm pitch
    - ✓ <200μm thickness
  - FTD_PIXEL:
    - ✓ 50μm
- Electronics
  - Same as the baseline, not yet considered in simulation

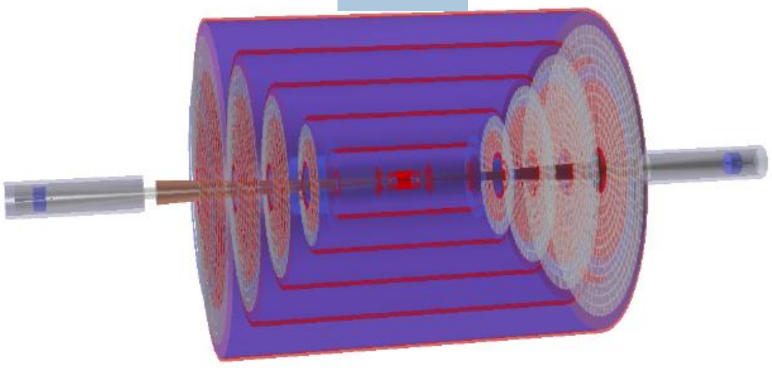
Full Silicon Tracker (FST) Concept designs

- Replace TPC with silicon tracker and re-design silicon parts in the baseline, same beam pipe and calorimeters
  - 3.0 Tesla
  - 14.5 mm outer radius for Be beam pipe
  - Maximum 1.83 m outer radius and 4.6 m length at Z direction
- Two options
  - FST: expand extra SIT layers and FTD disks to fill the tracker space, and rename the parts
  - FST2: expanding the SID design to full tracking volume
- Double strip layer for FST and single strip layer for FST2
  - FST: more expensive and high performance

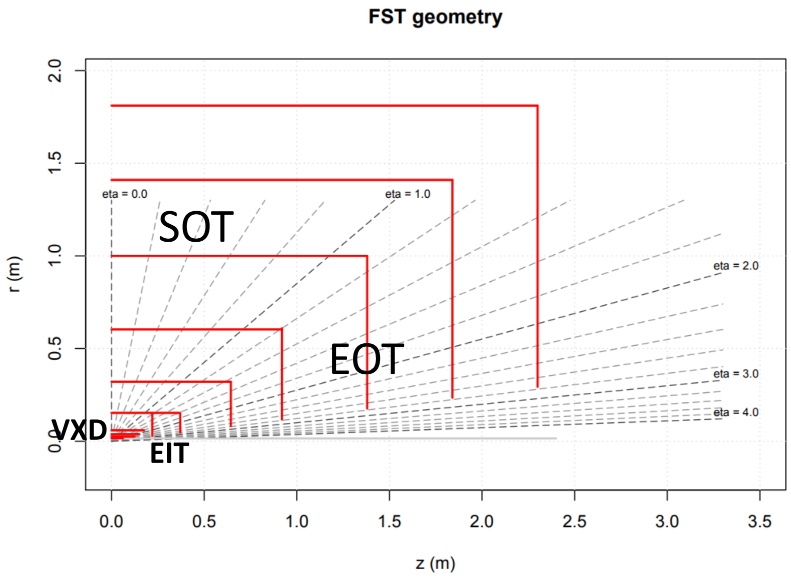
FST

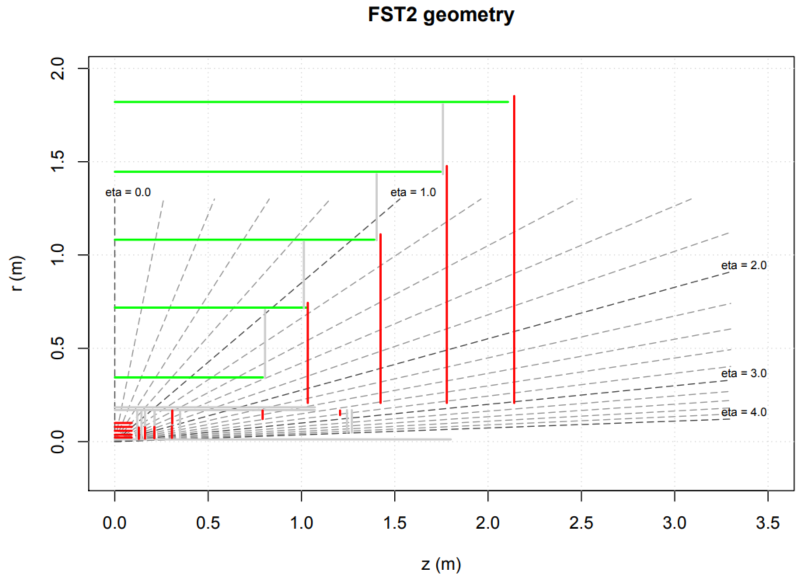


FST2

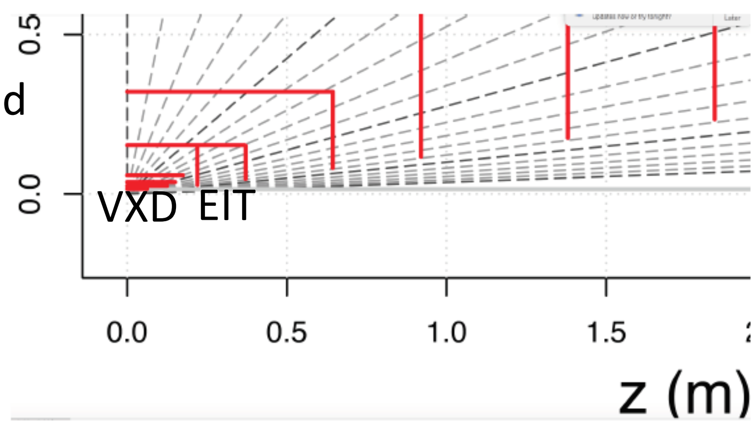


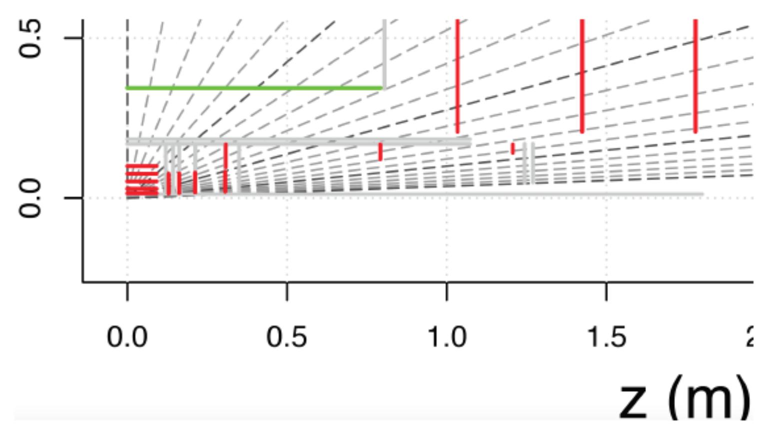
Layouts



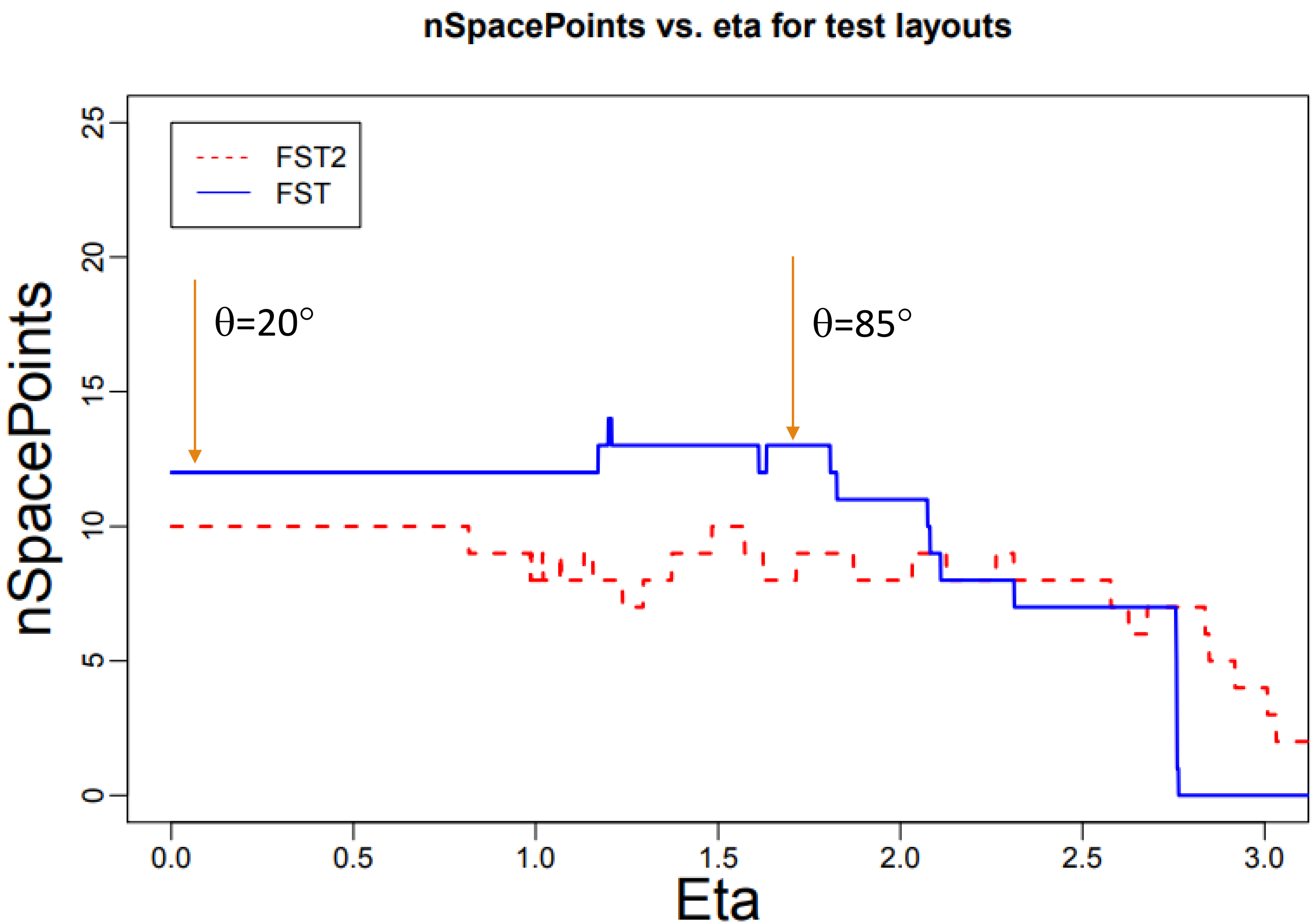


Zoomed





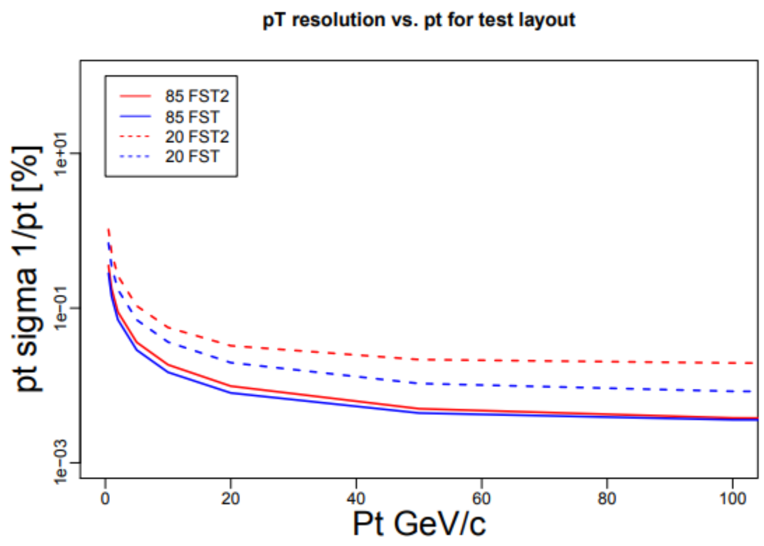
Space point

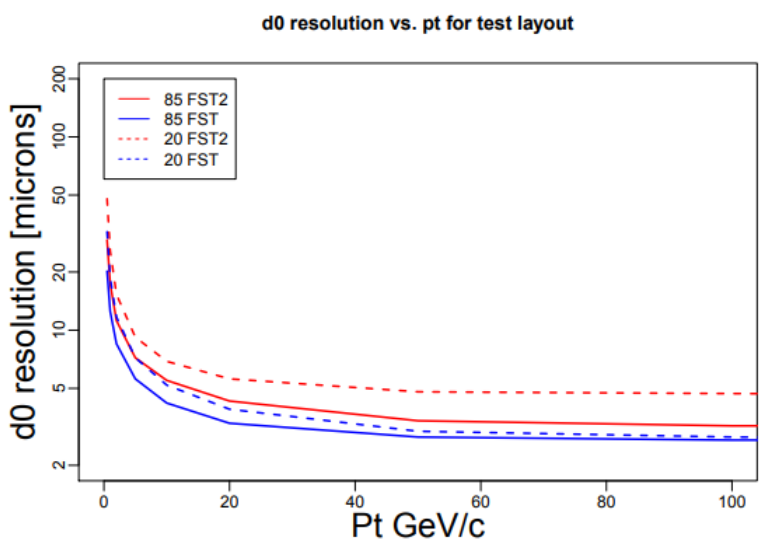


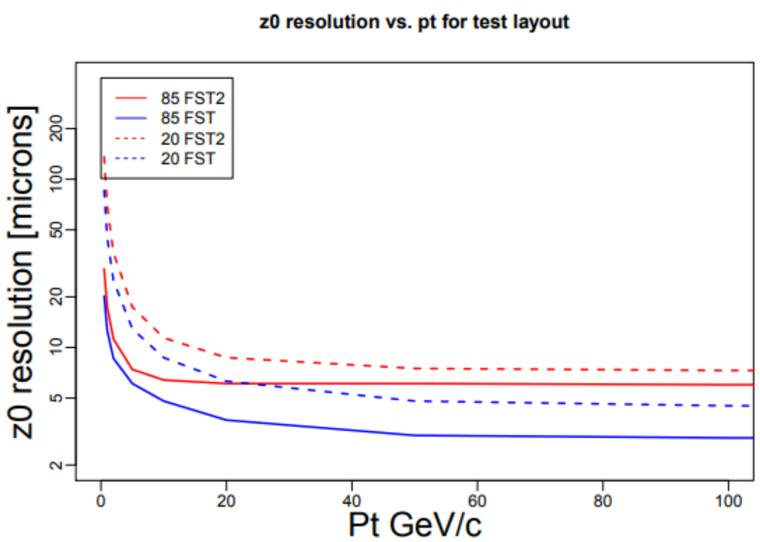
nSpacePoints vs. eta for test layouts
FST2
FST
θ=20°
θ=85°
nSpacePoints
Eta
0
5
10
15
20
25
0.0
0.5
1.0
1.5
2.0
2.5
3.0

Fast simulation

- Resolutions for tracks with θ=85° and 20°, represent for endcap and barrel
  - FST has better resolutions, benefit from more space points
  - Detail FST2 study http://atlaswww.hep.anl.gov/hepsim/detectorinfo.php?id=sidcc3







Layer Materials of FST

- Mechanical properties have not been studied in detail

VXD (pixel)	silicon	kapton	aluminium	foam	Total support
Thickness(mm)	0.05	0.05	0.01	0.94	1

SOT (strip)	silicon	peek	Carbon fiber	Rohacell 50D	epoxy	Carbon fiber	Total support
Thickness(mm)	0.15+0.0024	0.1	0.08	0.9	0.08	0.08	1.2424

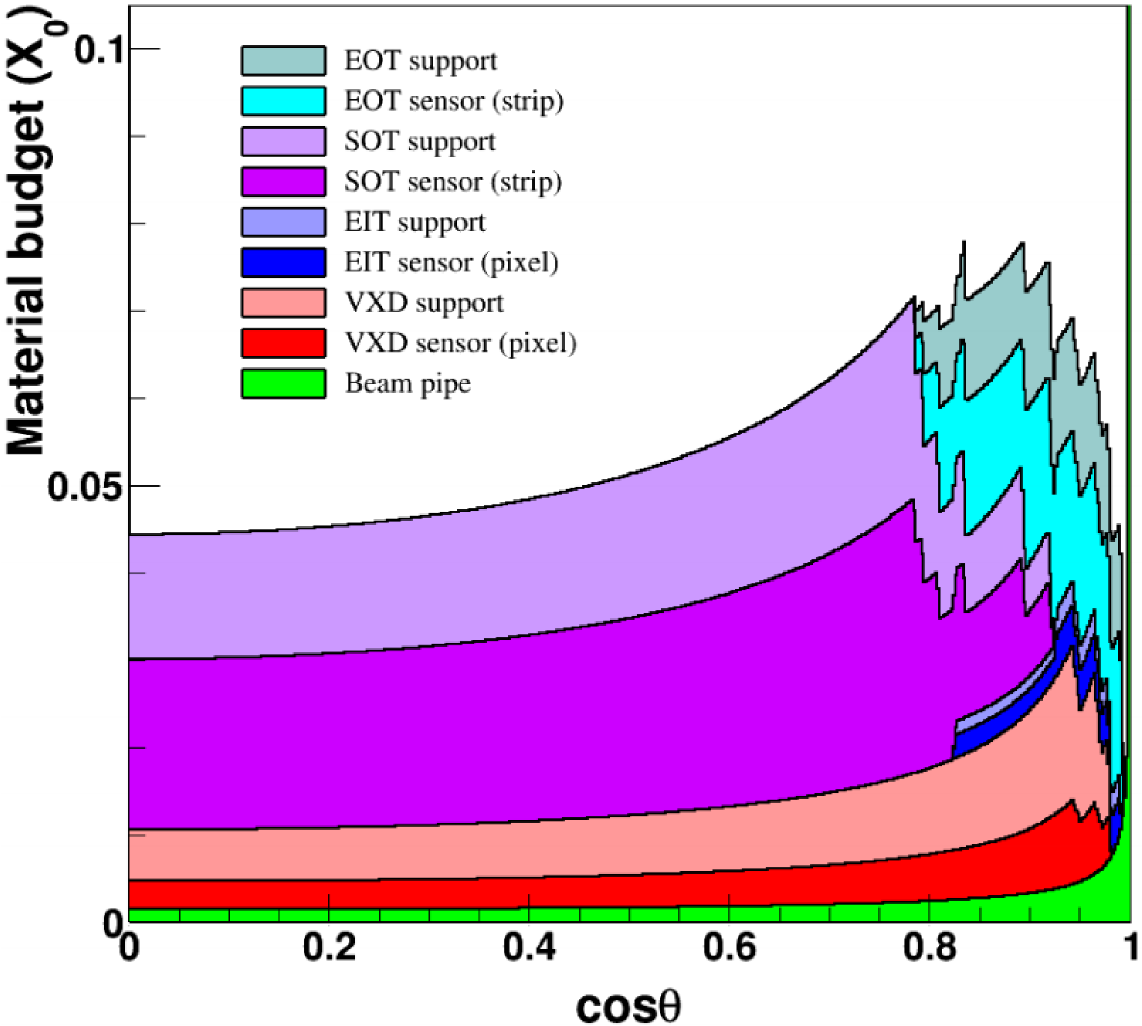
SiD-like, half of support layers, considering for two single-side layers combined as one double-side layer.

EIT (pixel)	silicon	Carbon fiber	Rohacell50D	peek	Total support
Thickness(mm)	0.2+0.0048	0.16	1.8	0.2	2.1648

EOT (strip)	silicon	peek	Carbon fiber	Rohacell 50D	epoxy	Carbon fiber	silicon	Total support
Thickness(mm)	0.15	0.2	0.16	1.8	0.175	0.16	0.15+0.0048	2.4998

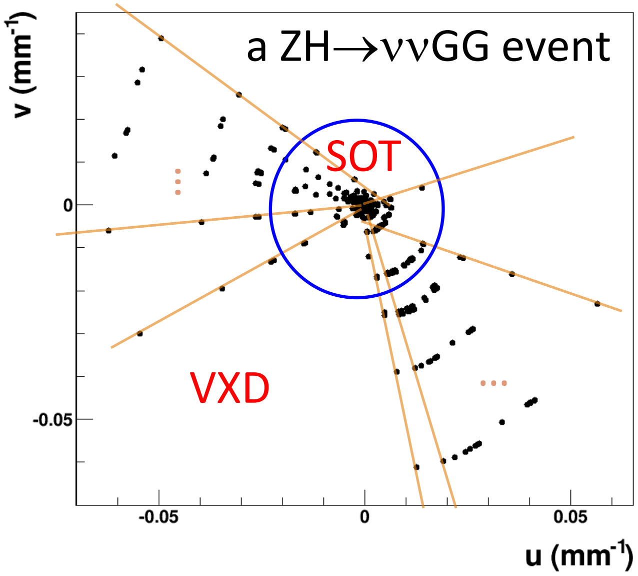
Material Budget of FST

- From ~4.5% of X0 to ~8.1% (cosθ<0.99)



Simulation and Reconstruction Tools

- MokkaC—a developed Mokka version @CepC
  - http://cepcgit.ihep.ac.cn/cepcsoft/MokkaC
- Tracking and fit
  - ConformalTracking
    - ✓ used as the main track pattern recognition algorithm at CLIC, and FCC-ee are also performing



✓ Conformal space:

$$u = \frac{x}{x^2 + y^2}, \qquad v = \frac{y}{x^2 + y^2}$$

✓ In conformal space, a track in magnetic field is a straight line

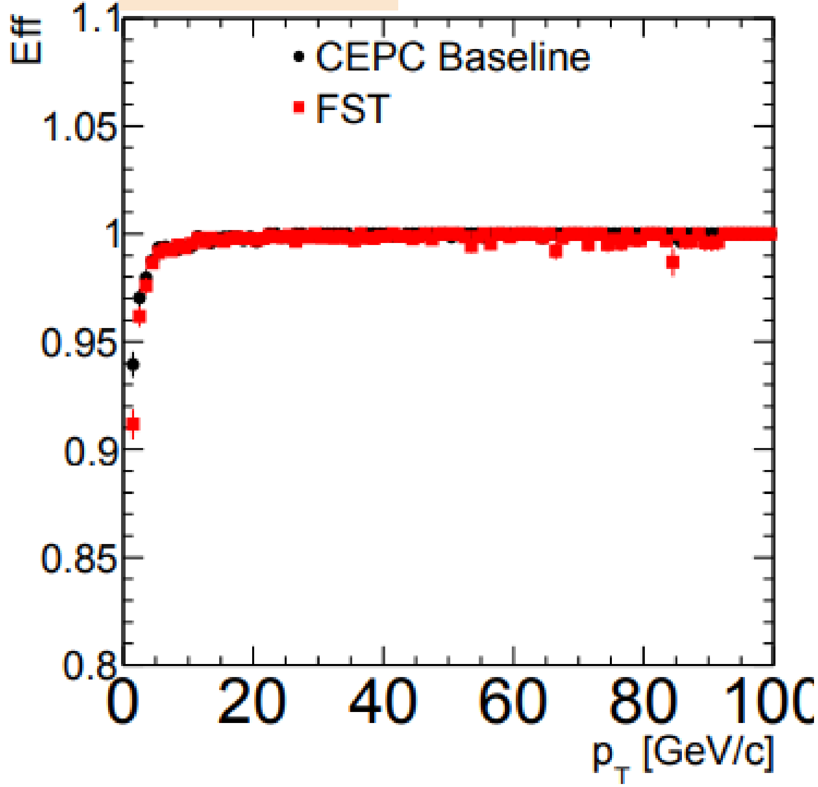
✓ Track finding becomes straight line searching by pattern recognition (cellular automaton)

✓ Implemented into CepC software, and ongoing

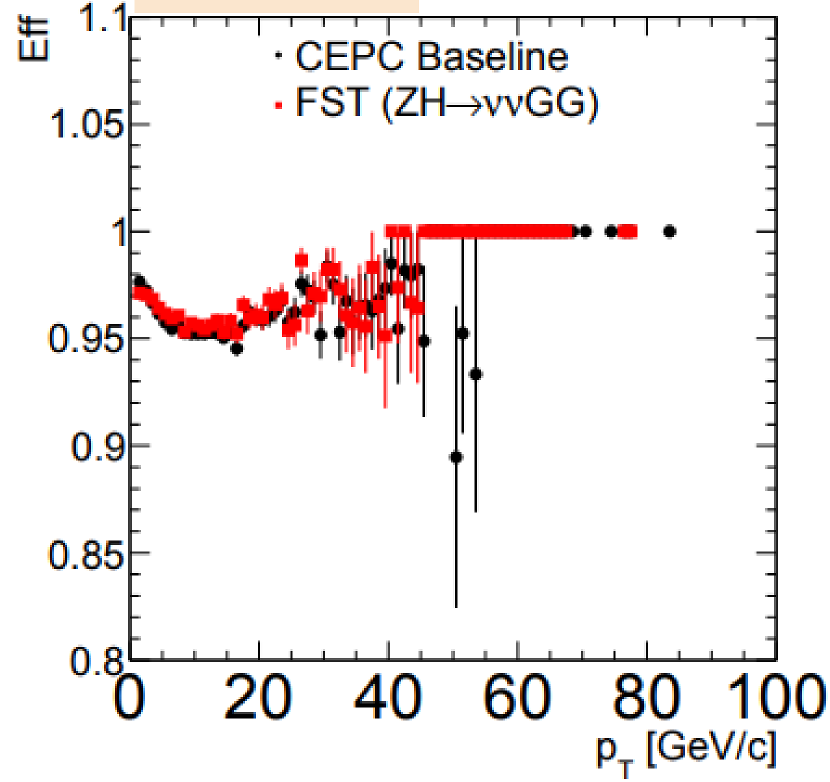
Tracking(?) Efficiency of FST

- ε= tracks matched with MC truth (>50% hits) / stable tracks (no decay in tracker, sinθ>0.18)
  - relative to stable tracks and matching algorithm, tracks in jets are influenced more

single muon



tracks in jets

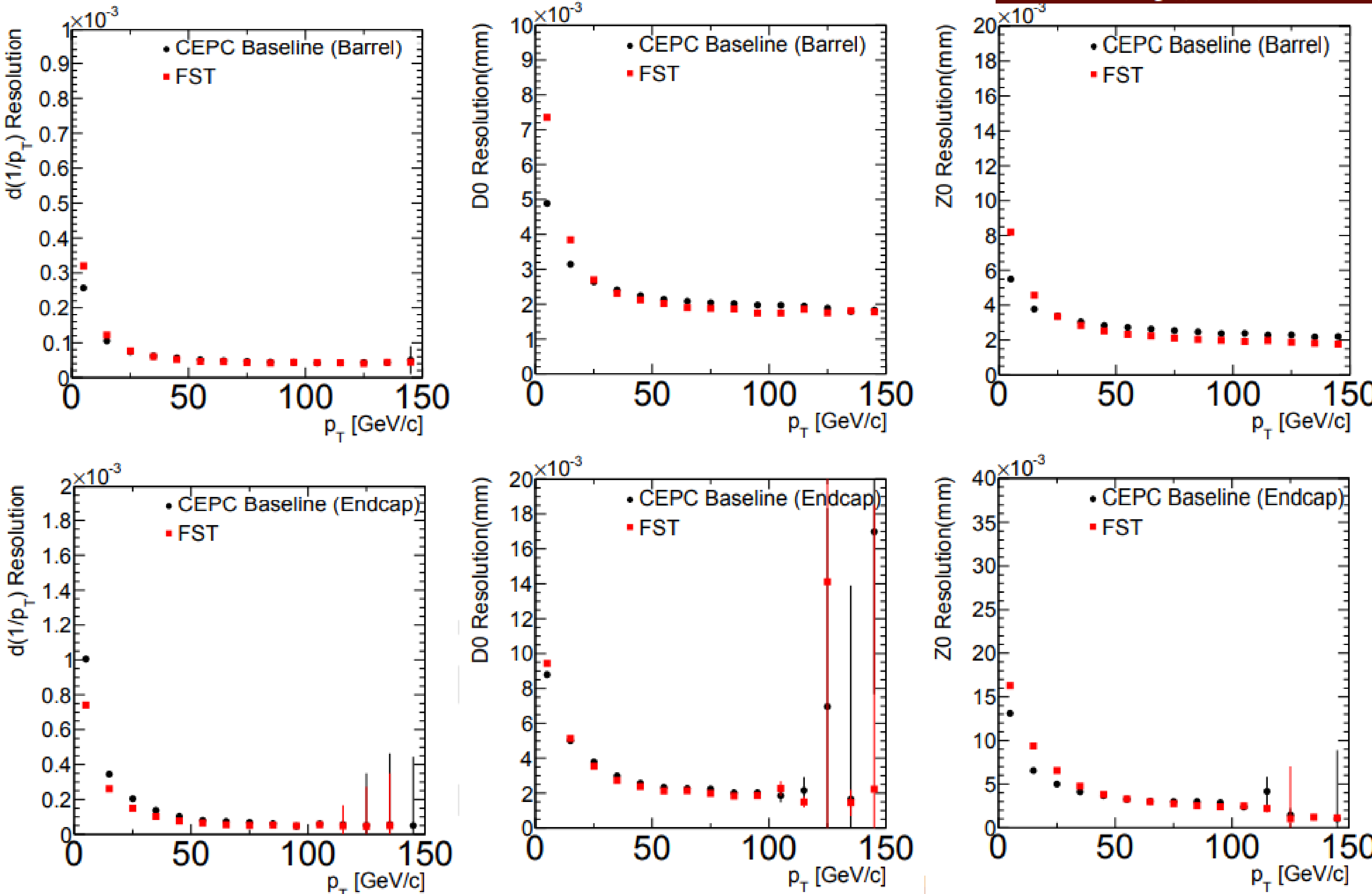


Resolution of FST (Single Muon)

Gang's talk

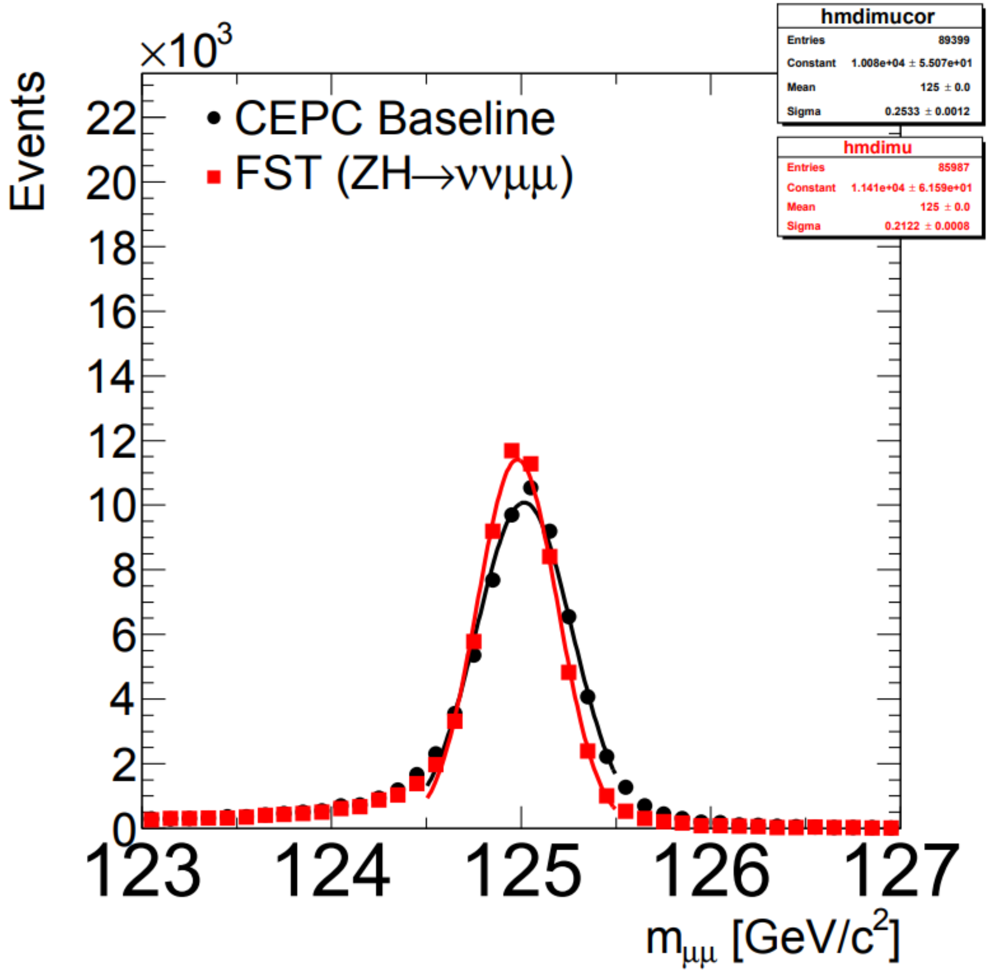
$$\Delta(1/P_T) = 2\times10^{-5} \oplus \frac{0.001}{P(\mathrm{GeV})\sin^{\frac{3}{2}}\theta}$$

$$\sigma_{r\phi} = 5 \oplus \frac{10}{p(\mathrm{GeV})\sin^{3/2}\theta}(\mu\mathrm{m})$$



Mass Resolution (H→μμ)

- Comparing to the baseline detector without PFA
  - ➢0.21 GeV by FST



Future plan

Area/m^2	pixel (B+E)	strip (B+E)	total
baseline	0.37 + 0.13	111.76 + 1.69	113.95
FST	0.46 + 0.13	225.62 + 41.96	268.17
FST/baseline	1.18	2.36	2.35
FST Channels(10^6)	~900	~60	~1000

- Issues in algorithm and software
- Optimize layouts
  - silicon thickness
  - support structure
- Electronics in simulation
- If necessary, balance cost and performance
- Study on physical performance, implement into PFA

Conclusion

- The concepts of full silicon tracker have been implemented and seem working.
- Two options have been considered, one for expensive and higher performance, close to the baseline detector, another for cheap
  - Performance for more options can be estimated as between them.
- Based on comparison with the baseline detector, it is expectable that the full silicon tracker can provide close performance for those particles with long life.
- More optimization and study are in plan.

Thank you for your attention!