# Full Silicon Detector for CEPC Detector Concept

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* http://cepc.ihep.ac.cn/~ cepc/cepc_twiki/index.php/Pure_Silicon_Detector

* http://atlaswww.hep.anl.gov/hepsim/detectorinfo.php?id=sidcc3

# Outline

- What's New.
- Silicon tracker designs and their performances.
- Detector simulation and reconstruction.
- Comparing with CEPC V4 performance.
- Conclusion

# What's New

- We have updated two designs of full silicon tracker, inspired by ILC detectors.
    - CEPCSID: replacing TPC with extra silicon strip barrel and disks(Chengdong+Weiming)
    - SIDB: expanding the SID design to full tracking volume (Sergei+Argonne)
    - The rest of detectors are kept same as CEPCV4 and SID.
    - The B field is assumed to 3.0 T
    - The radius of tracking volume is increased up to 1.87 m
- Tracking performance studies
    - Single muon
    - $ZH \to \nu\nu\mu\mu, \nu\nu GG$
- Adaptation of Arbor PFA with full silicon tracking (Manqi+Dan)
- Results are summarized in CDR as part of options for CEPC tracker.

# Full Silicon Tracker Concepts

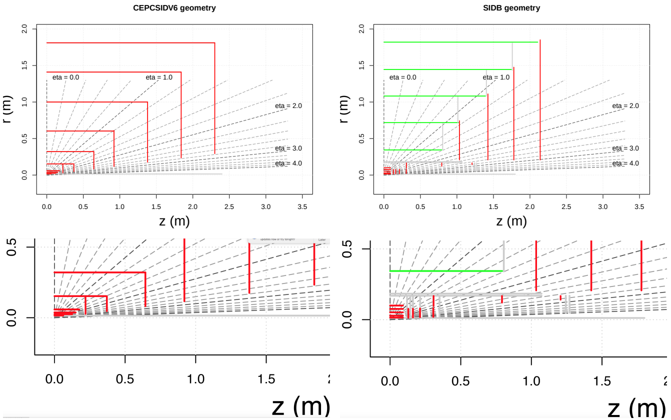



Figure: Full silicon tracker: CEPCSIDV6 and zoomed (left); SIDB and zoomed (right).

# SIT Geometries

| | CEPC-SID | | | | SID-like | | | |
|---|---|---|---|---|---|---|---|---|
| Barrel | R | | ±z | Type | R | | ±z | Type |
| layer 0 | 0.153 | | 0.368 | D | 0.344 | | 0.793 | S |
| layer 1 | 0.321 | | 0.644 | D | 0.718 | | 1.029 | S |
| layer 2 | 0.603 | | 0.920 | D | 1.082 | | 1.391 | S |
| layer 3 | 1.000 | | 1.380 | D | 1.446 | | 1.746 | S |
| layer 4 | 1.410 | | 1.840 | D | 1.820 | | 2.107 | S |
| layer 5 | 1.811 | | 2.300 | D | | | | |
| Endcap | $R_{in}$ | $R_{out}$ | ±z | Type | $R_{in}$ | $R_{out}$ | ±z | Type |
| Disk 0 | 0.082 | 0.321 | 0.644 | D | 0.207 | 0.744 | 1.034 | D |
| Disk 1 | 0.117 | 0.610 | 0.920 | D | 0.207 | 1.111 | 1.424 | D |
| Disk 2 | 0.176 | 1.000 | 1.380 | D | 0.207 | 1.477 | 1.779 | D |
| Disk 3 | 0.234 | 1.410 | 1.840 | D | 0.207 | 1.852 | 2.140 | D |
| Disk 4 | 0.293 | 1.811 | 2.300 | D | | | | |

Figure: The proposed geometry parameters for the outer strip barrel layers and disks, where D and S stand for double and single-strip layer.

# Full Silicon Tracker in 3D

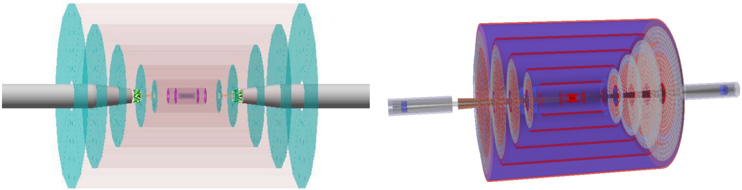


Figure: CEPCSIDV6 (left) and SIDB(right).

# Expected Number of Hits and Radiation Length

- The number of hits and radiation length are comparable between two designs.

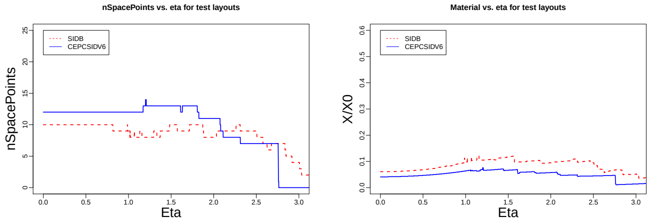



Figure: Expected nhits and radiation length as function of pseudo-rapidity

# Excellent Resolutions

- The expected resolutions from toy simulation are comparable.
- Solid in Barrel $\theta = 80^0$; Dash in Endcap $\theta = 20^0$.

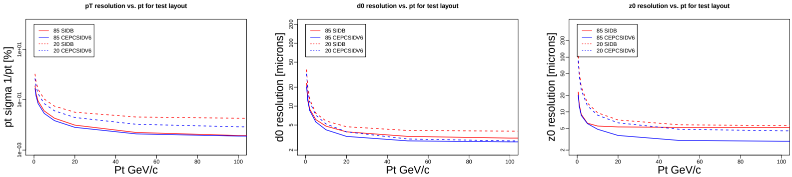
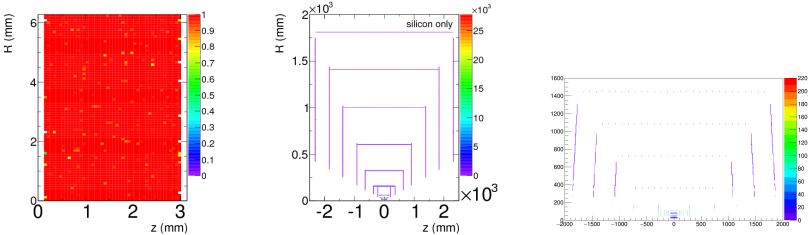



Figure: Resolutions for $1/\mathrm{pt}$, d0, and z0.

# Full Detector Simulation and Reconstruction

- Generated single muon in CEPC full silicon.
- Reconstructed using Marlin Silicon only.
- Modifying pattern recognition to use more silicon layers.




(a) CEPC V4(Default) (b) CEPCSID (c) SIDB

Figure: Hits r vs z from the track from the single muons.

# Single Muon Track Efficiencies

- Requiring $P_T > 1.0$ GeV and $0.18 < \theta < 2.96$.

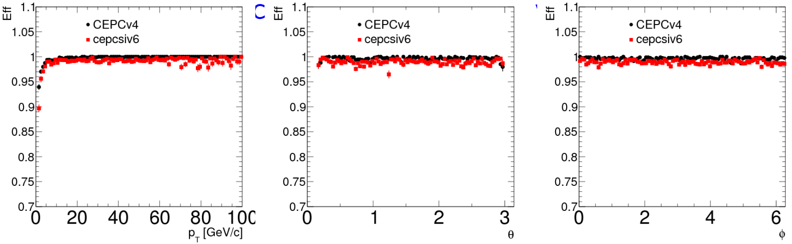



Figure: Efficiencies vs pt, theta and phi

# Pt. d0 and z0 Resolution

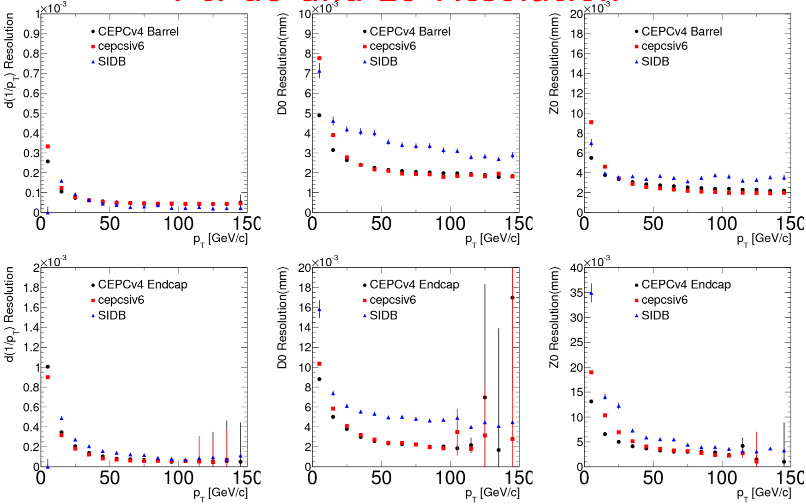
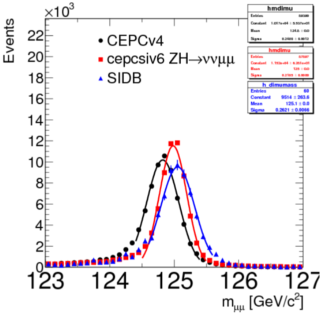



Figure: Pt, d0, z0 resolutions in Barrel(top) and Endcap(bottom).

# $H \to \mu\mu$ Mass Resolution

- Generated some $ZH \to \nu\nu\mu\mu$ events to compare the di-muon mass resolution.
- CEPCSIDV6 has 20-25% better $\sigma_m$ due to a better z resolution.

| | CEPC V4 | CEPCSID | SIDB |
|---|---|---|---|
| $\Delta m$ (GeV) | 0.2 | 0.0 | 0.0 |
| $\sigma_m$ (GeV) | 0.25 | 0.21 | 0.26 |



# Tracking Efficiencies in Jets

- Generated some $ZH \to \nu\nu G(gluon)G(gluon)$ events to measure tracking efficiencies in jets.
- The efficiencies are low for the full silicon tracking is due to the limitation of the current silicon tracking.

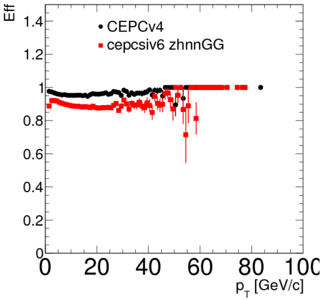



Figure: Tracking efficiencies as function of pt inside the jets.

# Silicon Tracking Strategies

- Start with seed-triplet search in fixed solid angle sectors in given sets of seed-layer-triplets.
- A helix $\chi^2$-fit is applied to the seed triplets.
- Once the seeds found, a road search is followed in layers not used in the seeding.
- Leftover hits are assigned to the seed tracks, ordered with ascending $\chi^2/\mathrm{ndf}$.
- A refit with the Kalman filter is applied to the final Si-tracks.
- The same procedures are used in the forward tracking using hits in the endcap region.
- Two set of tracks are merged together at the end.

# Issues of Inefficiencies

- Truth tracking runs perfectly, in principle, the hits are available.
- Digitization and clustering are based on true hit smearing, to be improved (Chengdong)
- Silicon tracking is seeded by set of layers, but only the best candidate saved for each seed, which causes some inefficiencies by picking a wrong hit nearby.
- Petal has a trapezoid shape, which requires a special care to check the hits in fiducial or not.
- Clustering merging in the dense jets will be important, requiring a realistic digitization and clustering.
- Minimizing the materia budget inside the detector will improve resolution and reduce the secondary interactions.

# Conclusion

- The concepts of full silicon tracker have been implemented and seem working.
- Its single particle performances are comparable to CEPC V4, meeting the physics requirements.
- There are rooms for improvement and new ideas from LHC upgraded detectors.
- The results are summarized in CDR as one of tracking options for CEPC.
- Silicon usages (double strip layer counted twice):

| Area $m^2$ | Pixel | Strip | Total |
|---|---|---|---|
| CEPC V4 | 1.3 | 154.2 | 155.6 |
| CEPCSID | 1.3 | 307.3 | 308.6 |
| CEPCSID/CEPC | 1.0 | 2.0 | 1.96 |