Layout Optimization for Silicon Tracker by tkLayout

Chengdong FU

Introduction

- Impact parameter and momentum measurement are important for CEPC physics
- Physical requirements in CDR

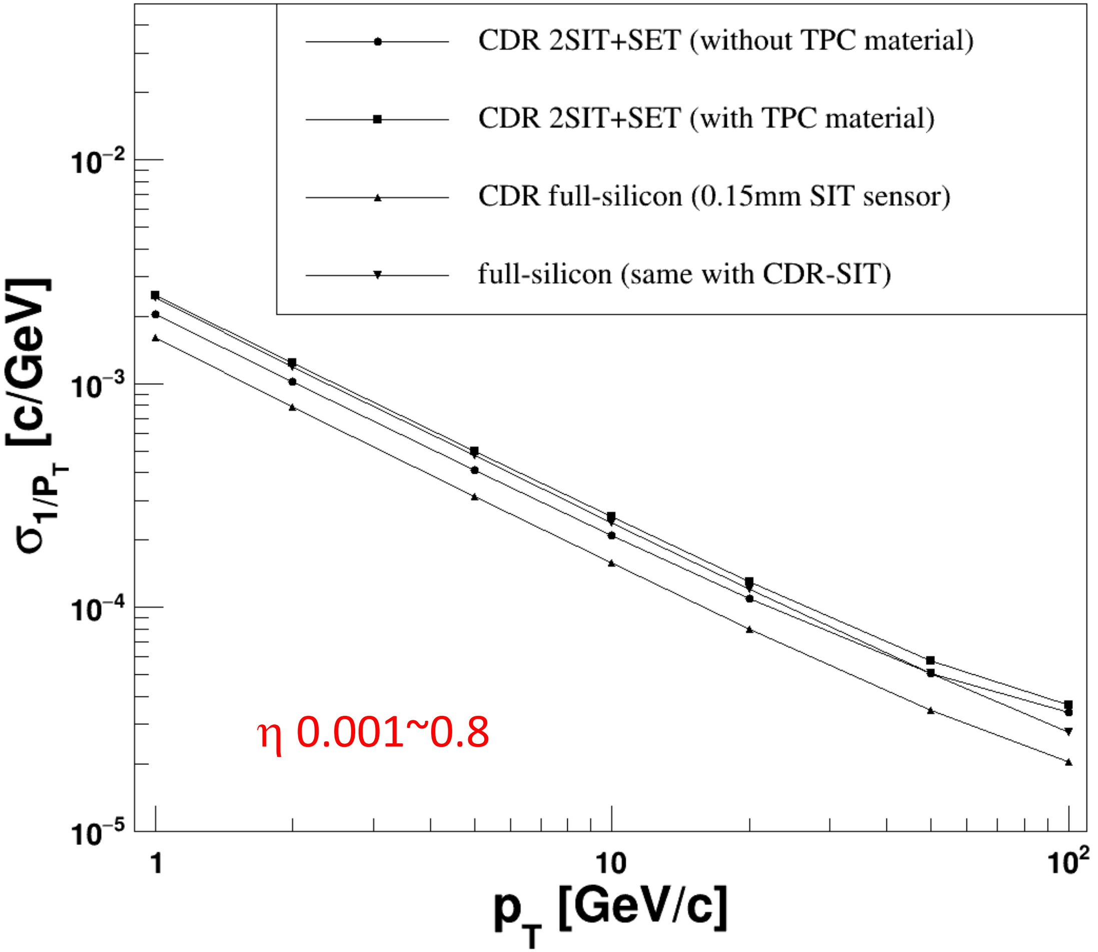
$$\sigma_{1/p_T} = a \oplus \frac{b}{p \sin^{3/2}\theta} \quad [\mathrm{GeV}^{-1}]$$

$$a \sim 2 \times 10^{-5}\,\mathrm{GeV}^{-1} \quad \textbf{and} \quad b \sim 1 \times 10^{-3}$$

- tkLayout: a optimization tool for silicon tracker @CMS
- CEPC reference detector
  - silicon tracker
  - Drift Chamber (DC)
- Optimization chain
  - barrel layout $\rightarrow$ barrel mechanics $\rightarrow$ forward layout $\rightarrow$ total mechanics

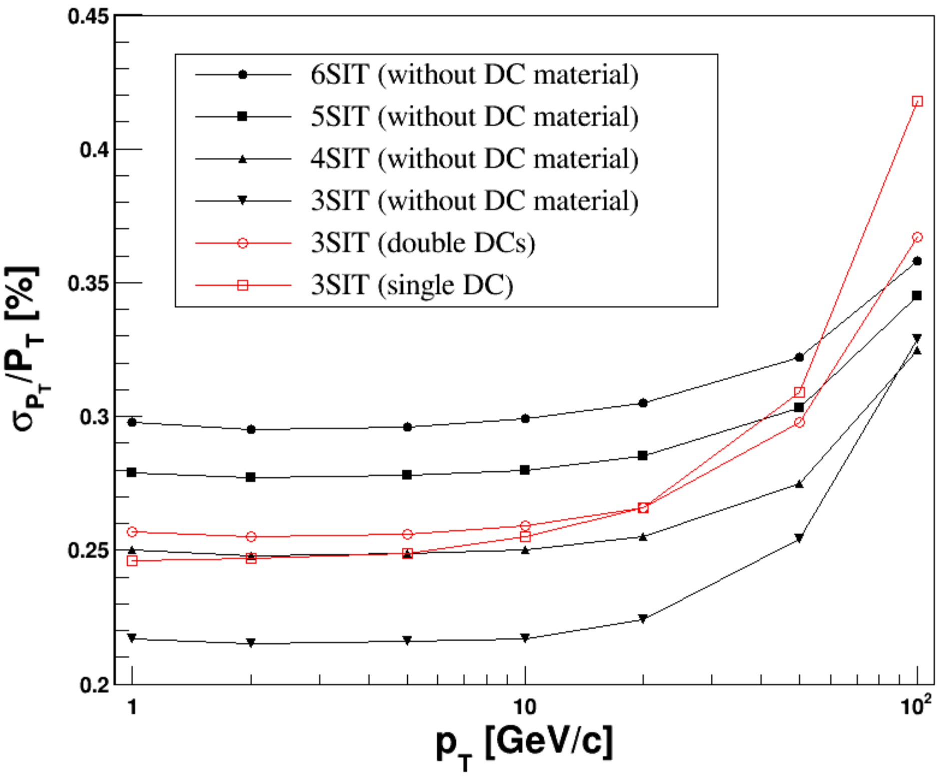
tkLayout results for CDR

- Baseline:
  - VXD: 3 doubly layers, 0.15%x6
  - SIT: 2 doubly layers, 0.65%x4
  - SET: 1 doubly layer,   0.65%x2
- FST (full silicon tracker)
  - VXD: 0.15%x6
    - 2 single layers
    - 2 doubly layers
  - SOT: 0.44%x6
    - 6 doubly layers



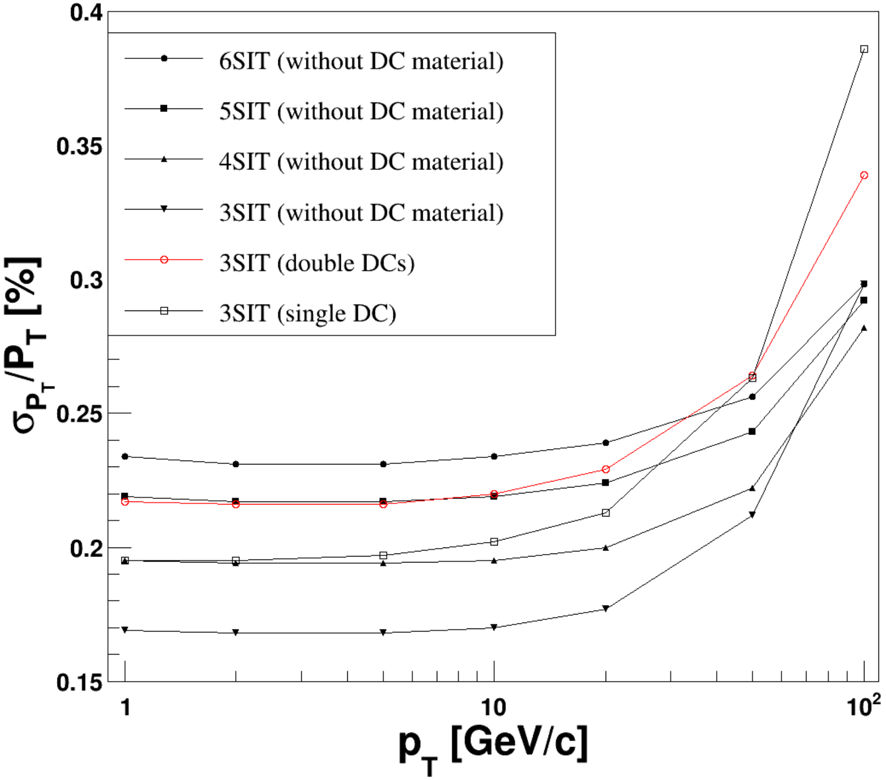
silicon layer number

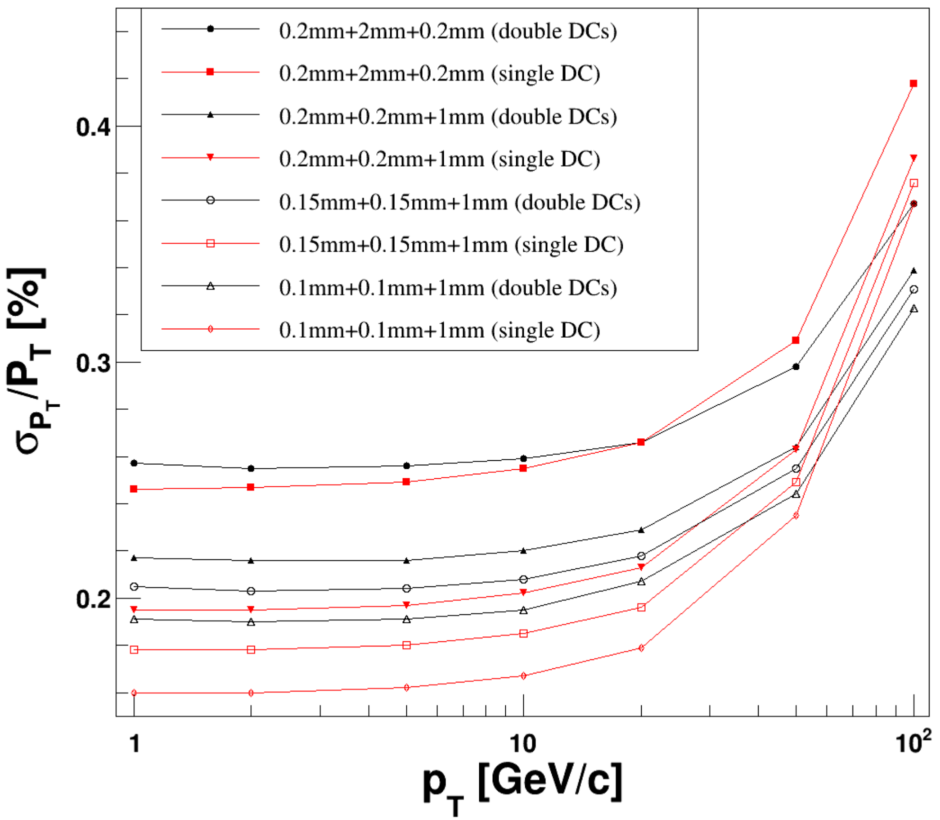
- full silicon layers (Rmax=1.5m and B=3T for baseline)
- silicon + DC
  - carbon fiber wall of each DC: 0.2mm inner + 2.8 mm outer
  - only silicon hits



silicon module thickness

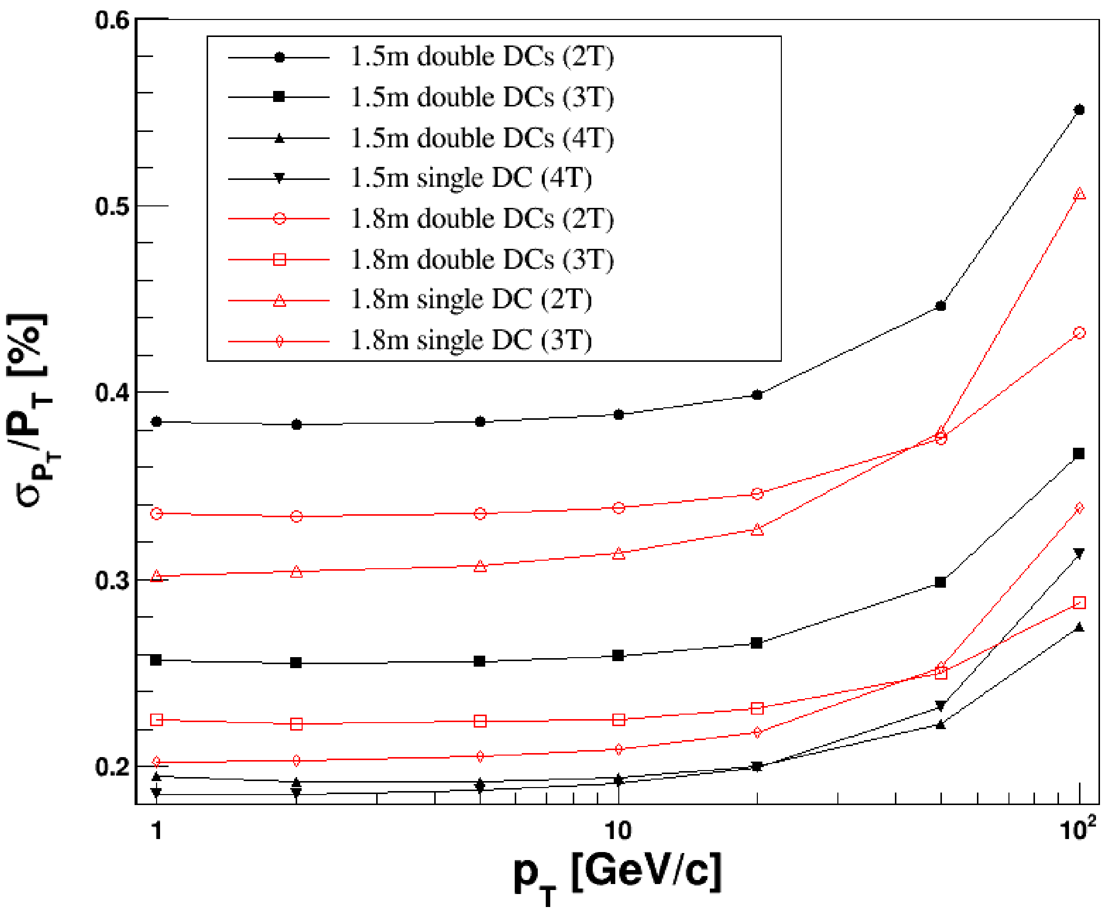
- If only silicon hits (strip), the DC material will make resolution poor
  - Low Pt: single DC better than double DCs
  - High Pt: double DCs better than single DC
- Close sensor layers (sensor+sensor+support) will make resolution better





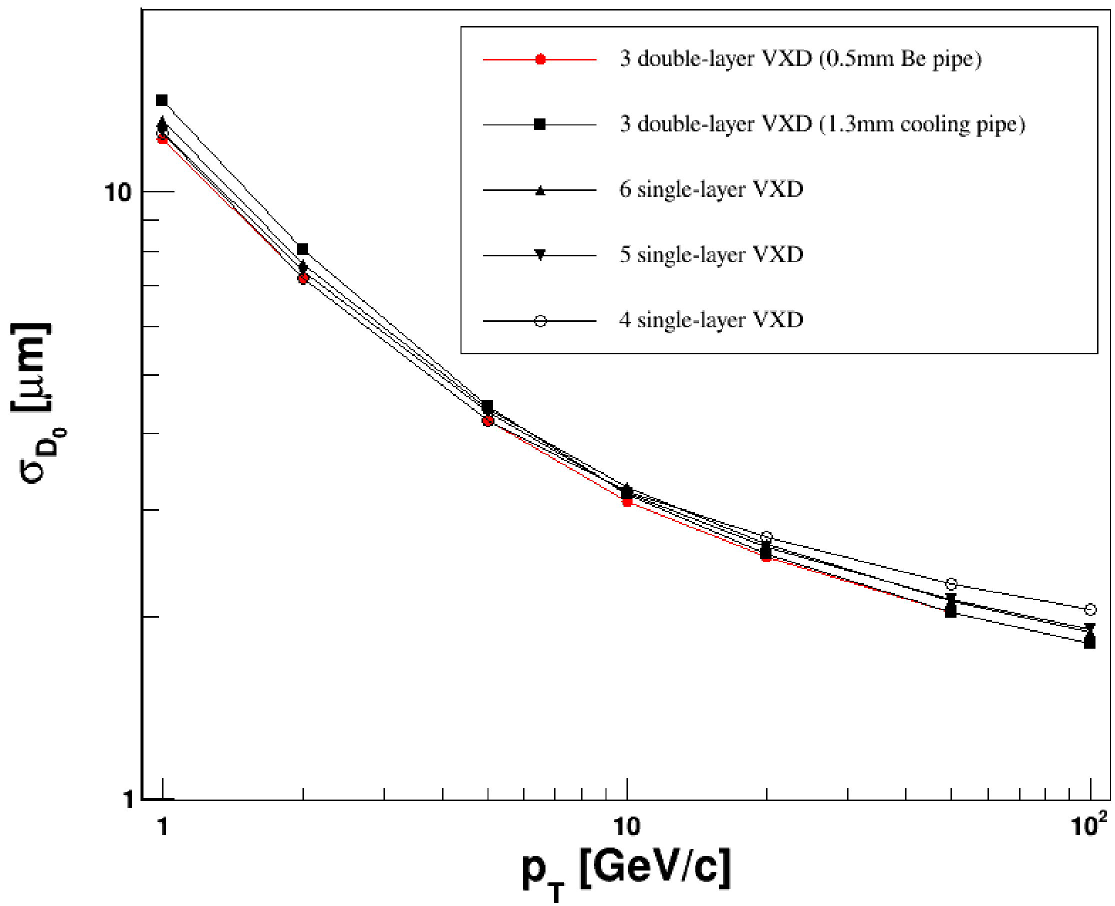
Tracker size & magnetic field

- Radius of most outer layer and magnetic field significantly effect on the momentum resolution, close to proportional.



Impact parameter

- Impact parameter is not much sensitive on outer tracker.
- Momentum resolution not sensitive on position of vertex layer.



Tracker Optimization Tool based on DD4hep

Chengdong FU

Introduction

- tkLayout does not support gaseous module
- LDT needs Matlab

- DD4hep provides flexible detector options to modify and easy to navigate the materials and sensitive module in DD4hep geometry
  - More easy to build new module for DD4hep user

- It is possible to directly switch to full simulation, and even to obtain results from design tool/fast simulation/full simulation at the same time in one job

Status

- First runnable/simple version has been built, based on CEPCSW (Gaudi)
  - Standalone in future
- Gaseous modules is optional sensitive/non-sensitive in tool
- Each volume in geometry is calculated standalonly for MS effect
  - $\Delta\theta_{MS}{}^{2} = \left(\frac{13.6\text{MeV}\times 13.6\text{MeV}}{p_T}\right)^2 \frac{L}{X_0}\left(1 + 0.038\ln\frac{L}{X_0}\right)^2$
- Currently tkLayout-like calculation is used
  - LDT-like estimation can also consider to implement

Preliminary results

For Gang suggested, total 5.2% of X0, air included

DC hits improve momentum resolution better!