Geometry of The Silicon Tracker

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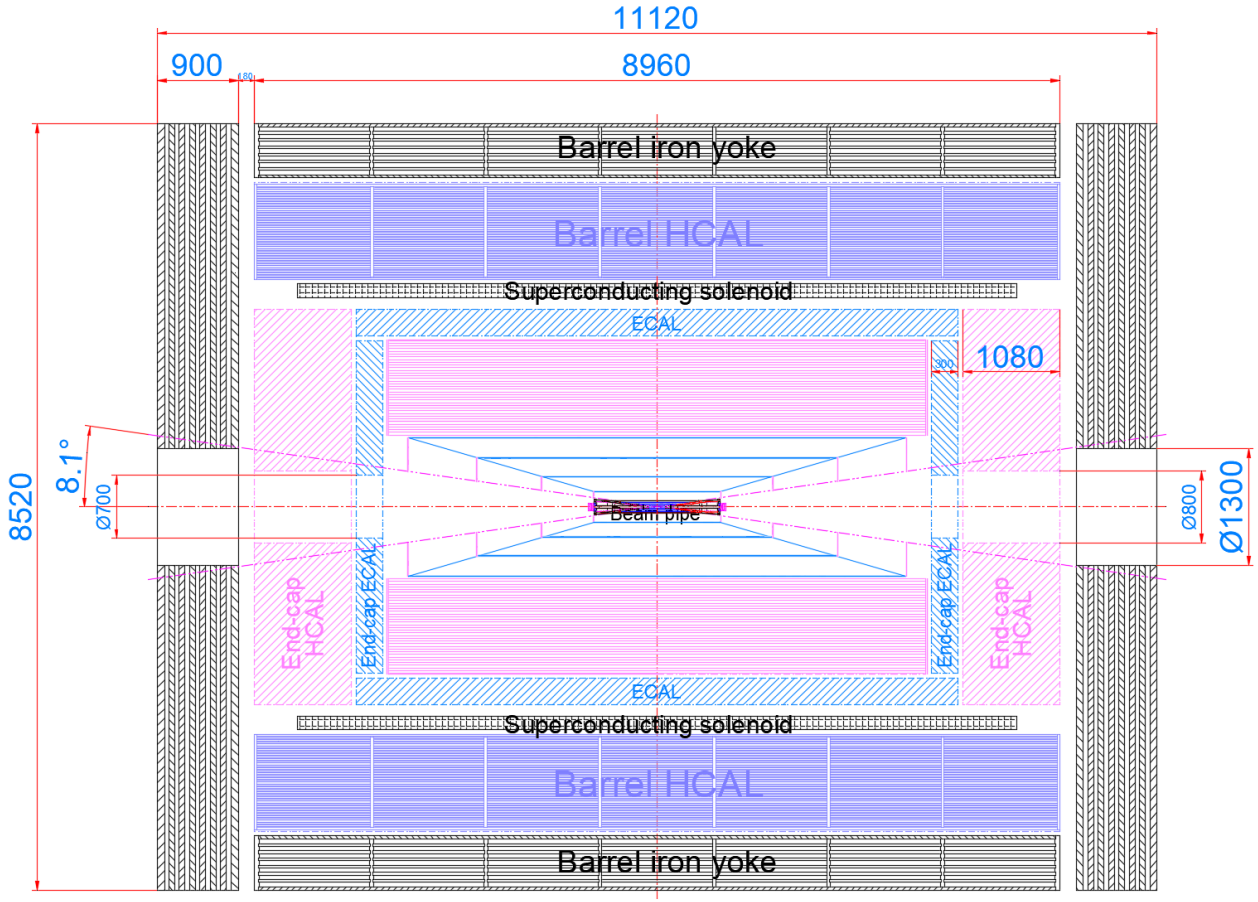
Contents

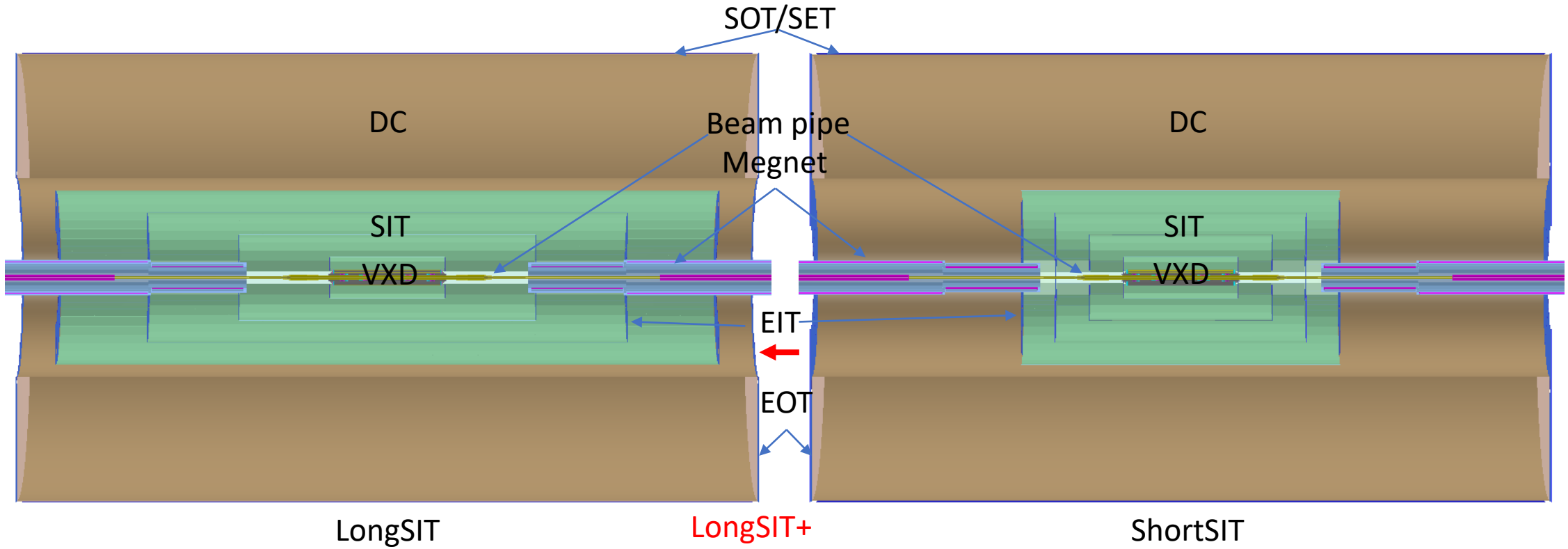
Introduction

Physics process	Measurands	Requirement on tracker
ZH, $Z\to e^+e^-(\mu^+\mu^-)$, $H\to\mu^+\mu^-$	m_H, $\sigma(ZH)$, BR($H\to\mu^+\mu^-$)	$\Delta(1/p_T) = 2\times10^{-5} \oplus \frac{0.001}{p(GeV)\sin^{3/2}\theta}$

- Fast estimation and some preliminary full simulation on the silicon tracker at barrel has been performed, but the endcap part of the silicon tracker has not been studied clearly.
- As the mechanics design progresses and TDR, the endcap silicon tracker should be in good status
  - Different with barrel, the endcap has more possible change
- First step, to estimate the performance of the first version in the mechanics design and understand the dominant influence on the endcap tracker
  - Benefit from complete silicon tracking



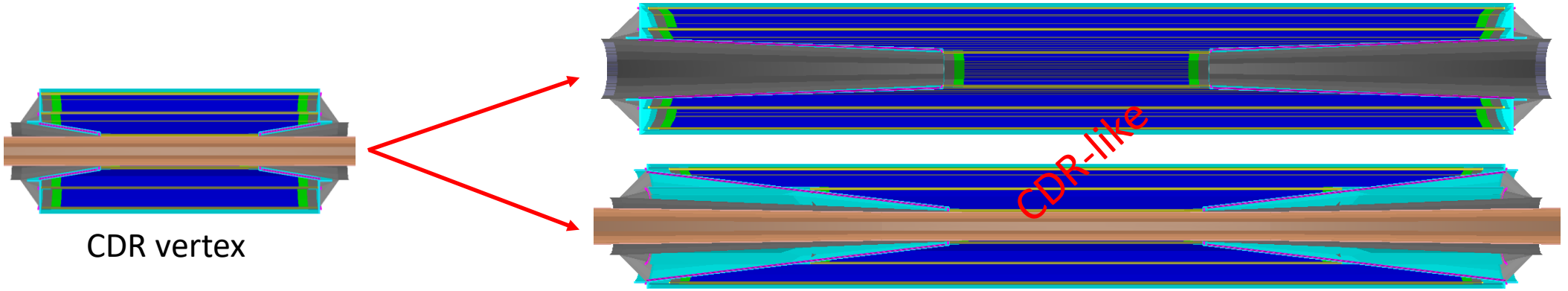
Tracker Options



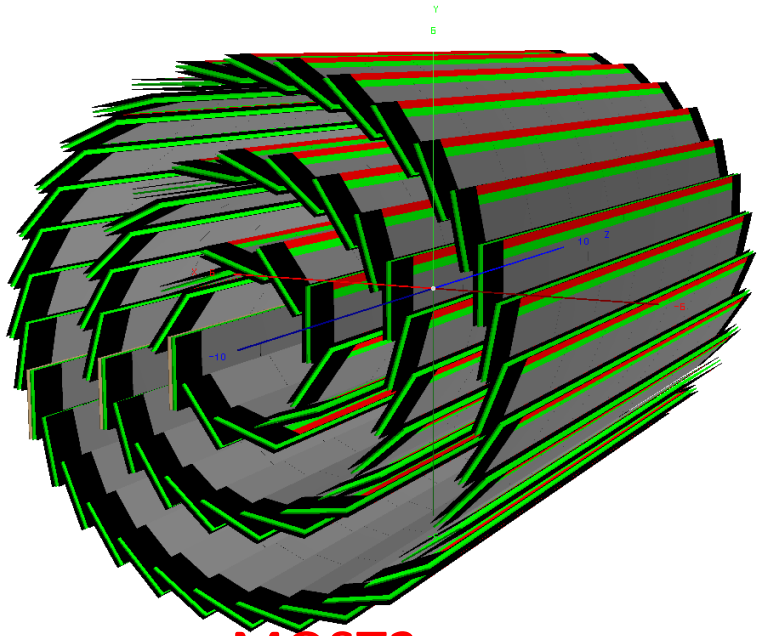
(last FTD layer covers cosθ=0.99)

- Silicon tracker
  - Vertex detector
  - Silicon internal tracker (SIT)
  - Silicon outer tracker (SOT/SET)
  - Endcap tracker (EIT/EOT)
- Drift chamber

Vertex Detector

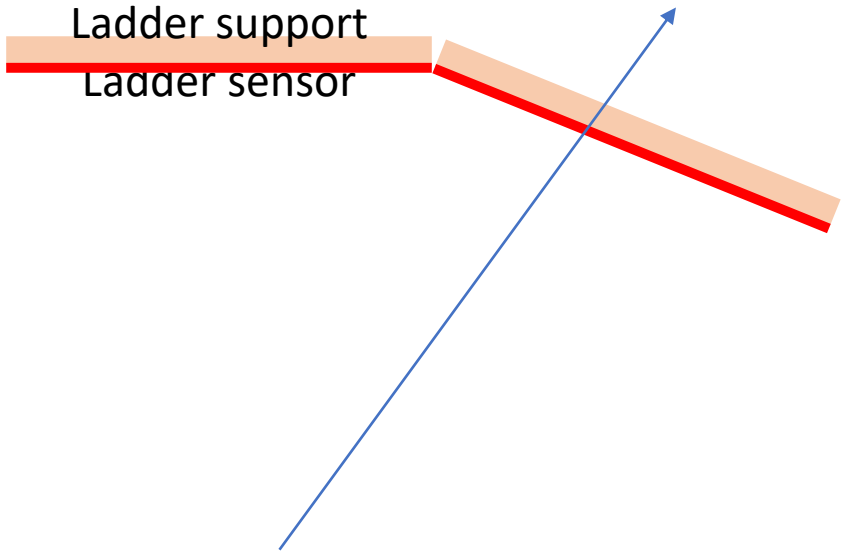


- Options
  - CDR, CDR-like, MOST2
- CDR-like vertex
  - all six sensor layers covering to $|\cos\theta|=0.99$
  - More simple endcap tracker
    - ✓ Easy to keep same layer number at different θ



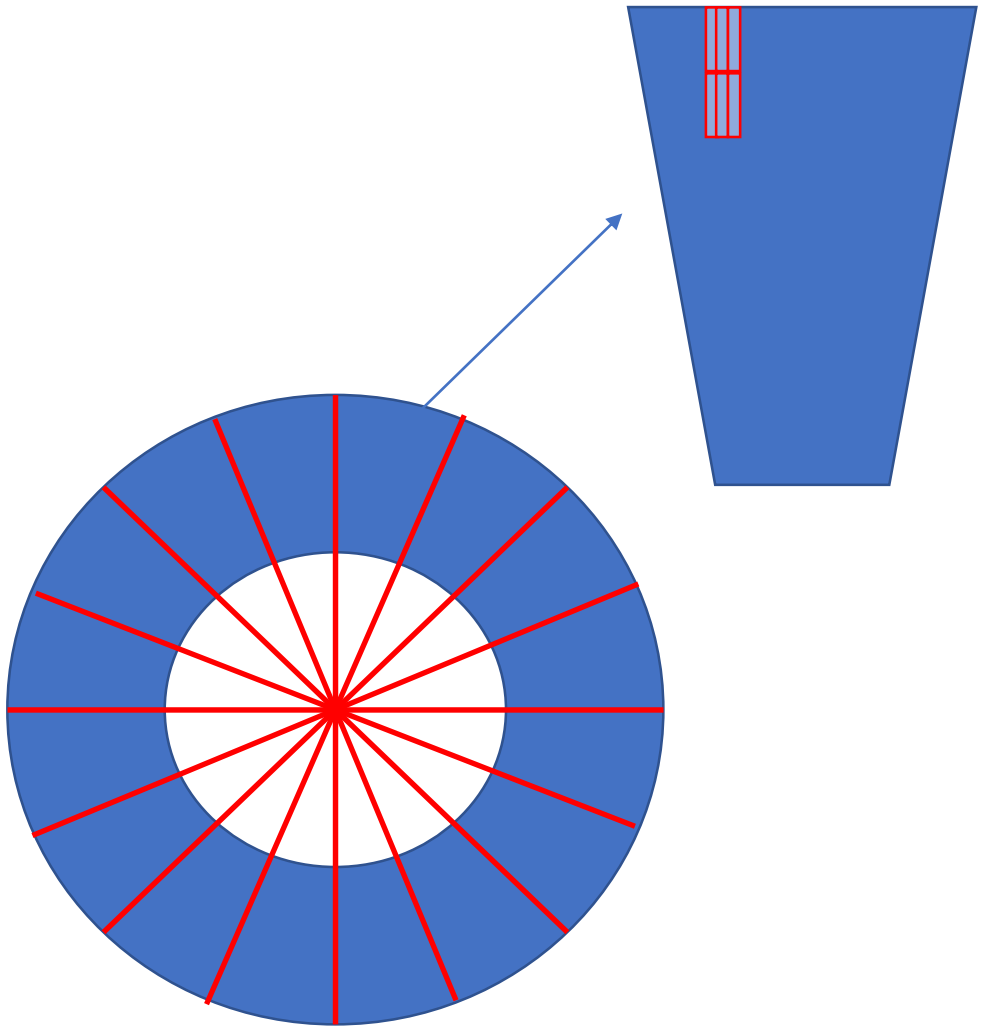
SIT&SOT

- 4+1
  - Consider secondary particle produced after VXD
- Sensor length: 92mm
- Sensor number per ladder
  - LongSIT: 10, 26, 42, 58, 64
  - ShortSIT: 10, 16, 22, 28, 64
- Ladder number per layer
  - LongSIT: 11, 23, 35, 47, 123
  - ShortSIT: 11, 23, 35, 47, 123
- Ladder thickness→0.65% of X0
  - Silicon: 170μm
  - Carbon: 1mm

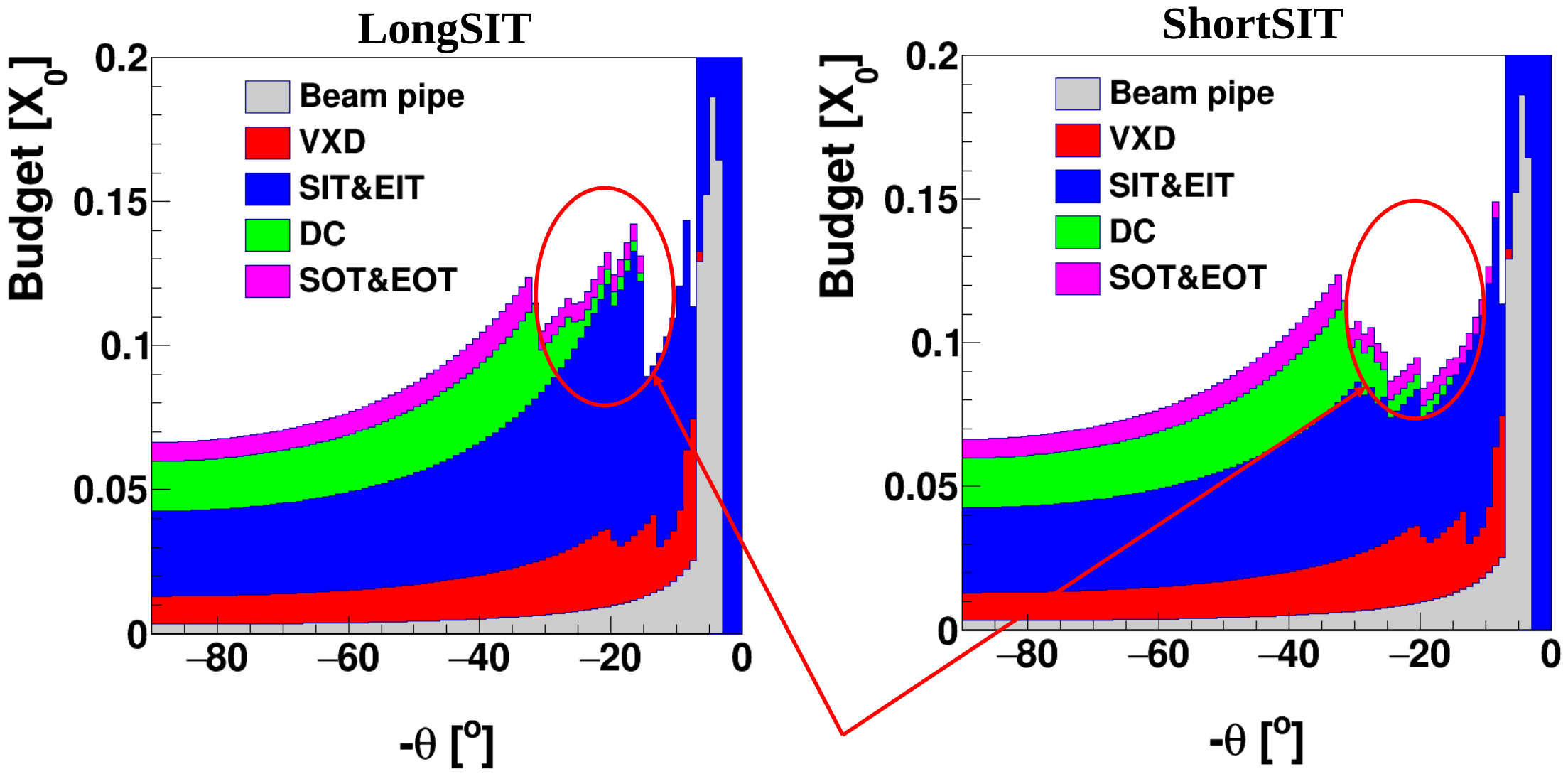


EIT & EOT

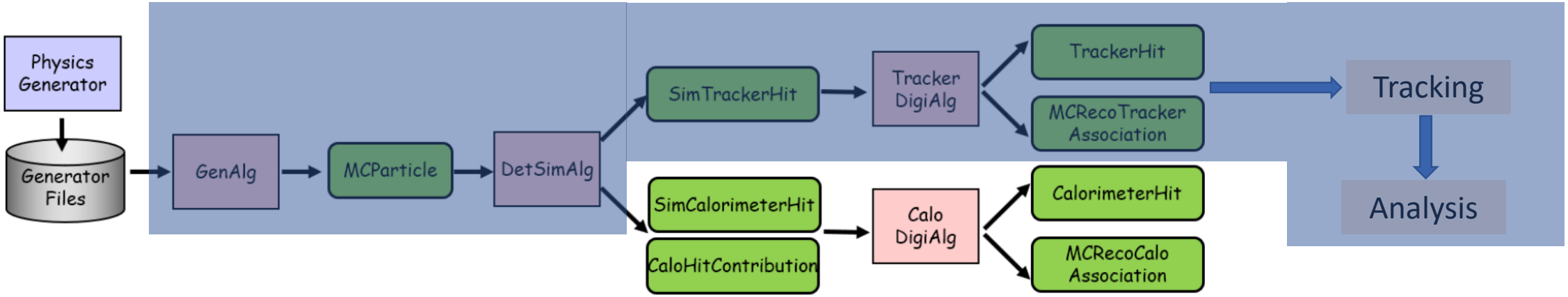
- 4+1
  - LongSIT: short last one
  - LongSIT+: long last one
  - ShortSIT: long last one
- Petal number per layer: 16
- Narrow pitch for rϕ in each petal
- Ladder thickness
  - Silicon: 200μm
  - CFRP: 1mm



Material Budget



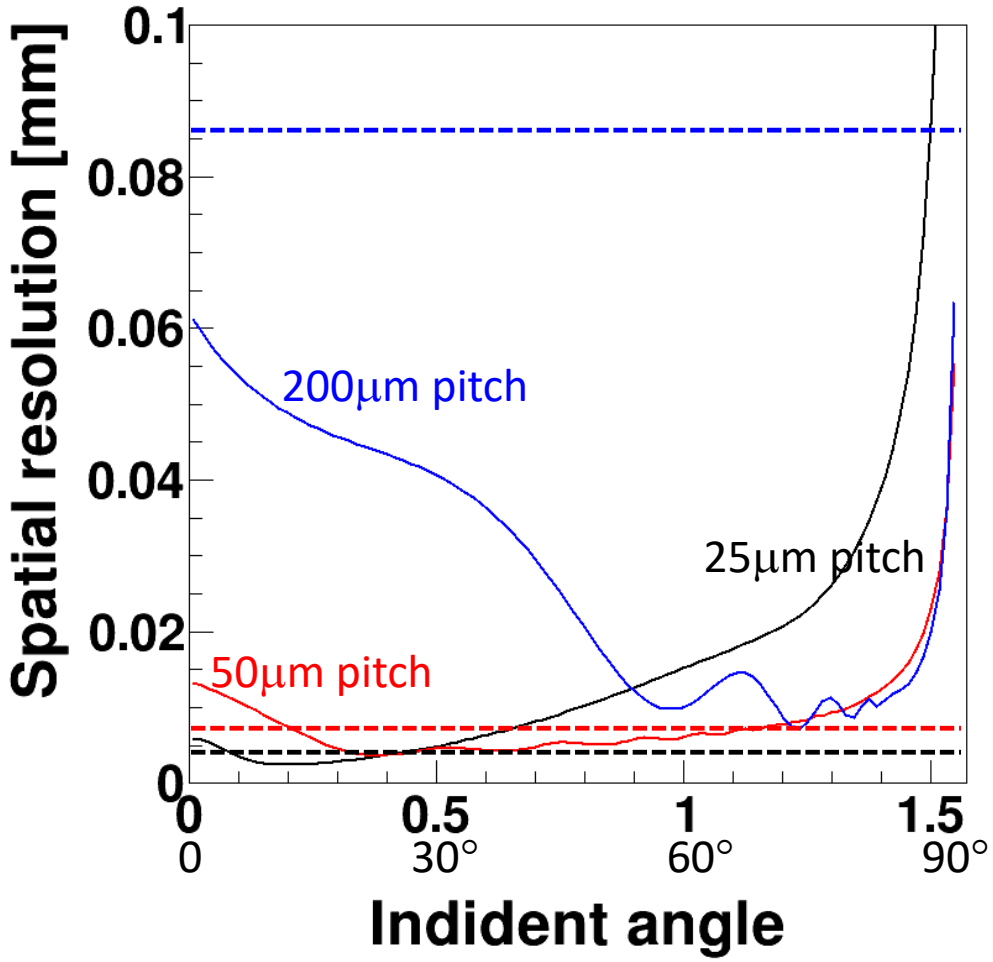
Full Simulation in CEPCSW



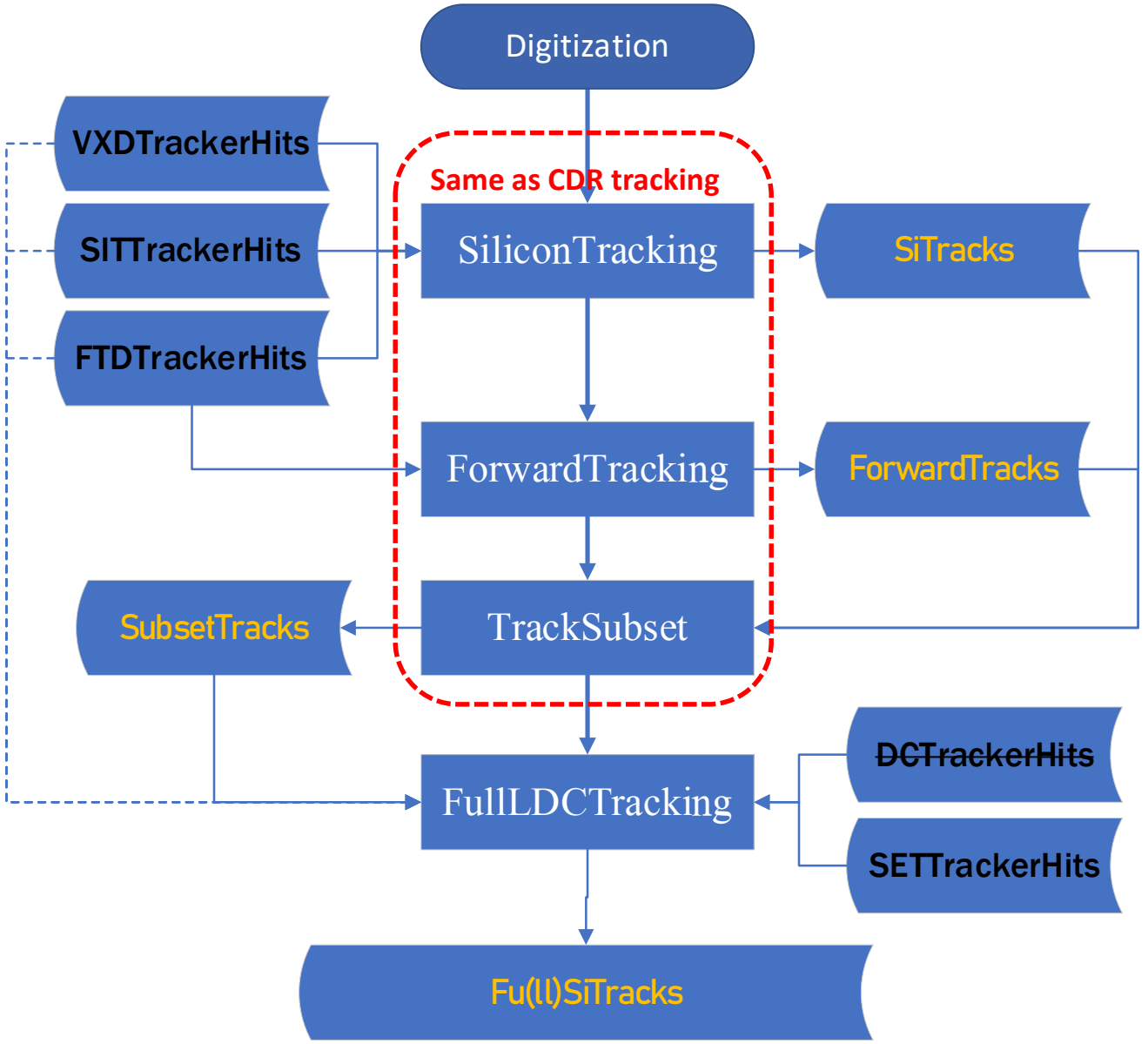
- CEPCSW is a Gaudi-based framework
  - Core software, application, external libraries
- EDM4hep for event data model
- DD4hep for detector description
  - Compact xml files for LongSIT, ShortSIT, LongSIT+ respectively
- Generator:
  - GtGunTool for single muon particle as resolution estimation
  - GtGunTool+ for multi particles per event as efficiency estimation

Digitization

- Gaussian smearing on SimTrackerHit at measurement dimension (u,v)
  - pixel: 2D (u,v)
  - strip: 1D (u,0) or (0, v)
- Fixed spatial resolution
  - VXD
    - ✓ $\sigma_{rphi,z}$=2.8μm, 6μm, 4μm, 4μm, 4μm, 4μm
  - SIT
    - ✓ σ_{rphi} =7.2μm, σ_z=86μm
  - SOT/SET
    - ✓ σ_{rphi} =7.2μm, σ_z=86μm
  - Endcap tracker
    - ✓ σ_{rphi} =7.2μm, σ_z=86μm
- Parameterized spatial resolution
  - Riccardo del Burgo's parametrization model
    - ✓ $\sigma_{u,v} = p_0 + p_1 x + p_2 e^{-p_9 x}\cos(p_3 x + p_4) + p_5 e^{-\frac{(x-p_6)^2}{2p_7^2}} + p_8\sqrt{x}$
  - parameters are relative to pitch size (for CMS PhaseII)
    - ✓ VXD: 25μm×25μm
    - ✓ others: 50μm×200μm



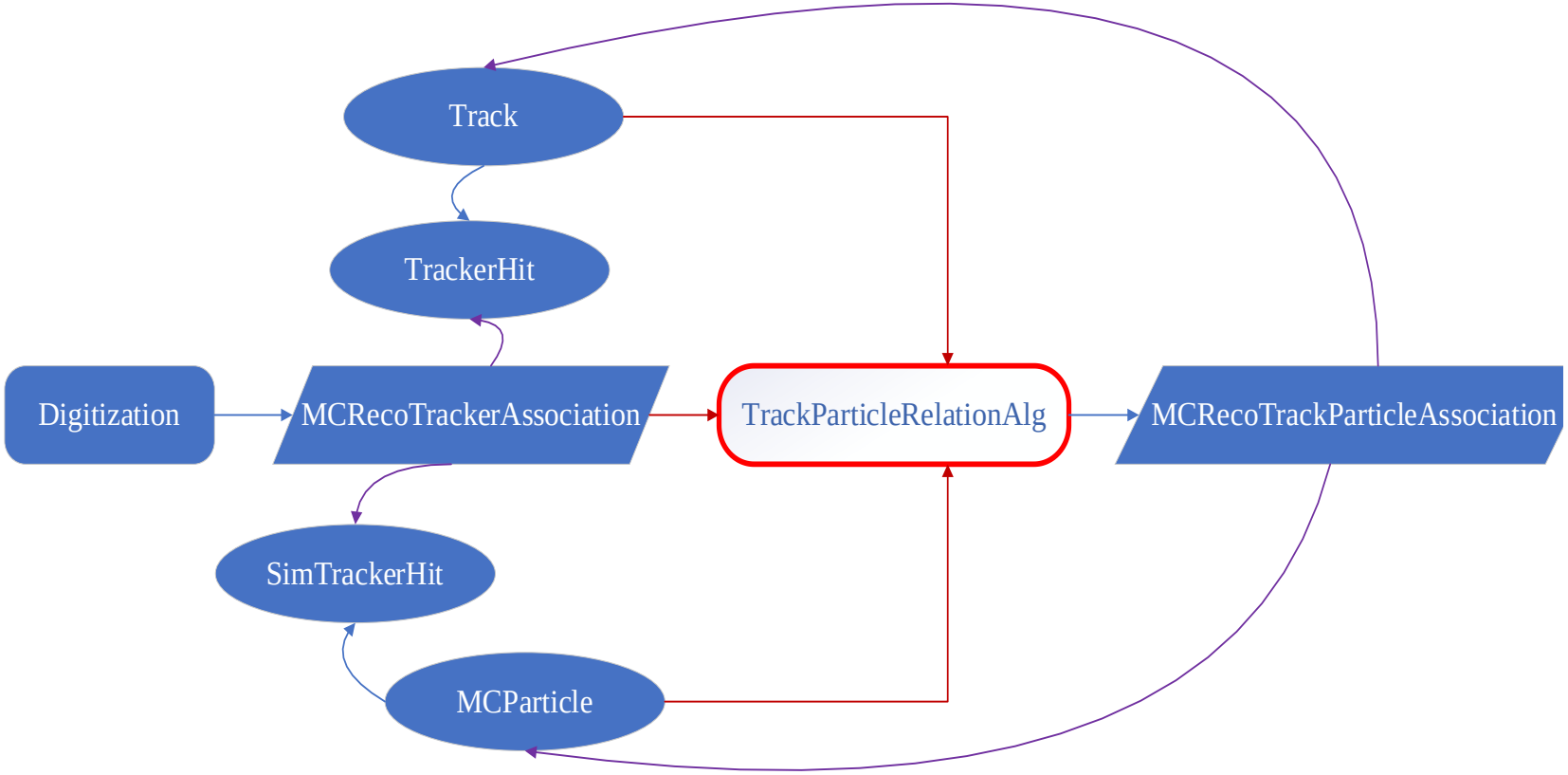
Tracking Option

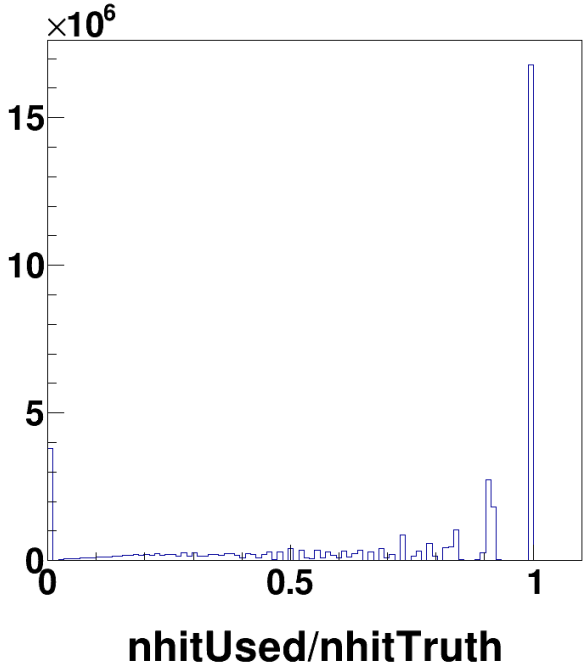


- Use KalTest as Kalman filter tool, same as CDR
- DC not included in tracking

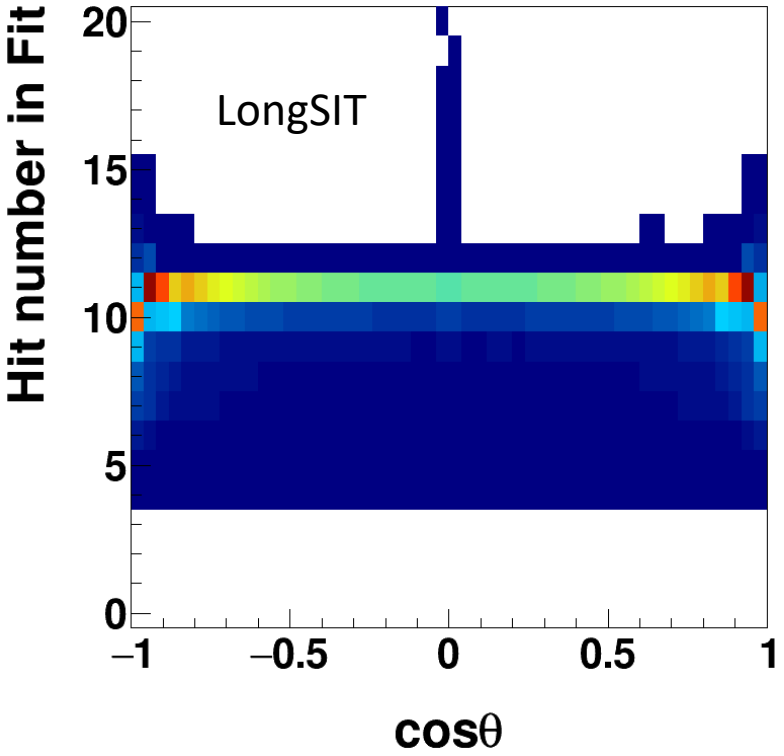
Association

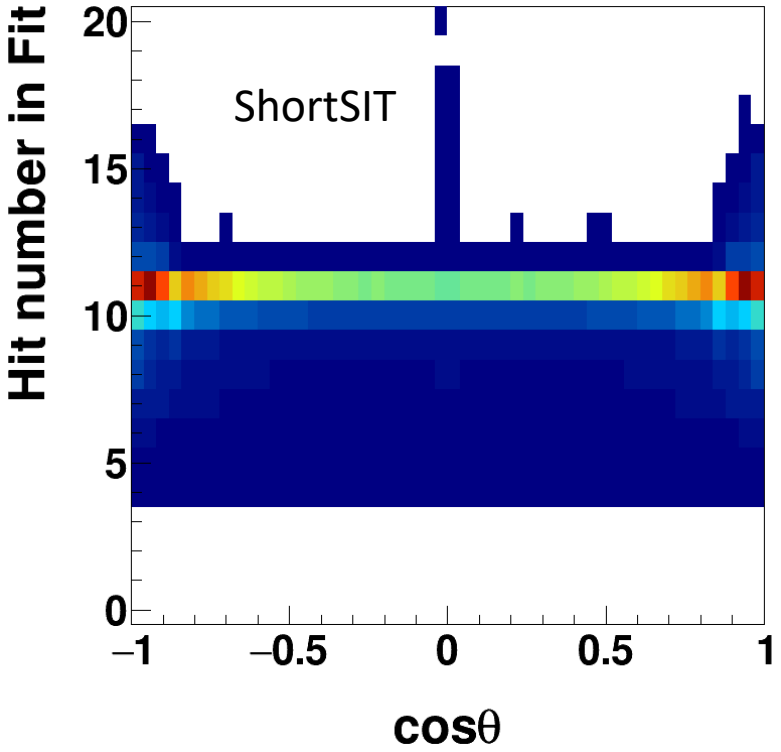
- MCRecoTrackParticleAssociation
  - Track
  - MCParticle
  - weight: number of tracker hit linked between MCParticle and Track (NL), for a particle, found track (minimum requirement: NLmaximum≥4)



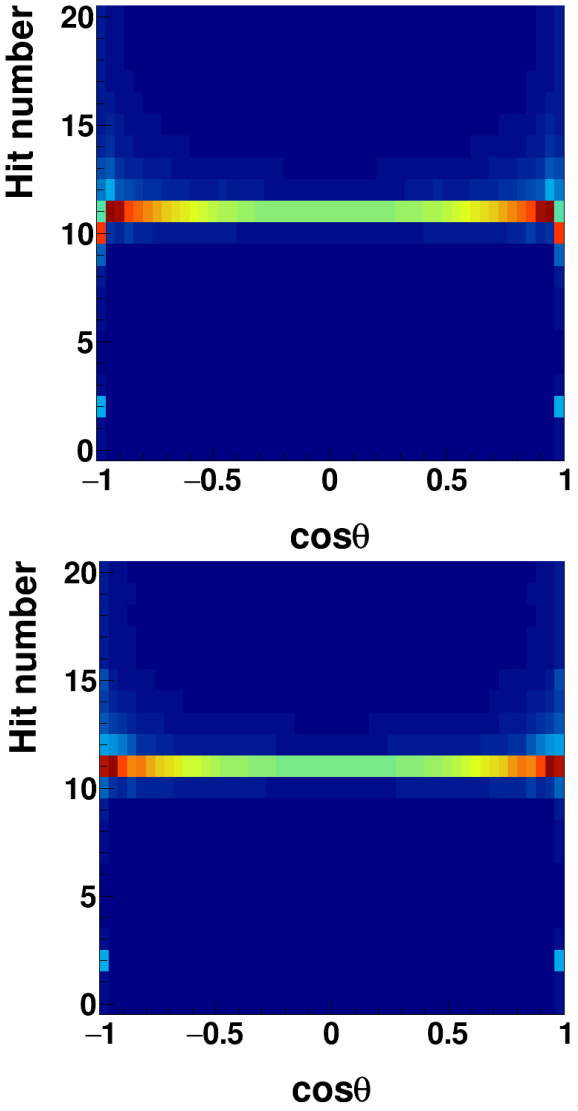


Hits Number



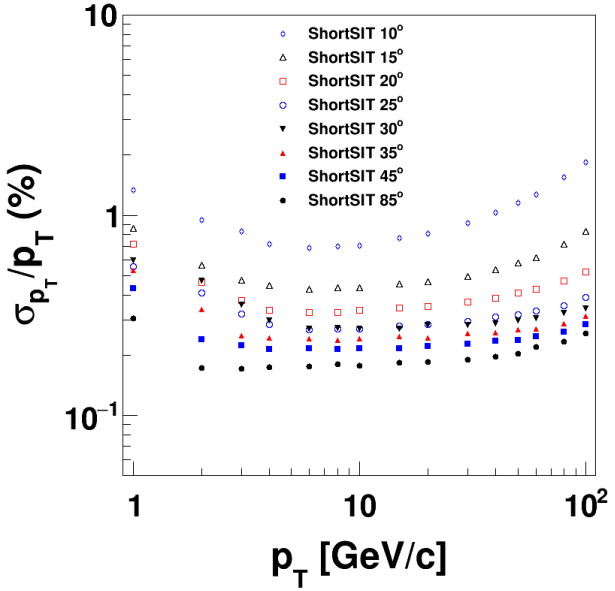


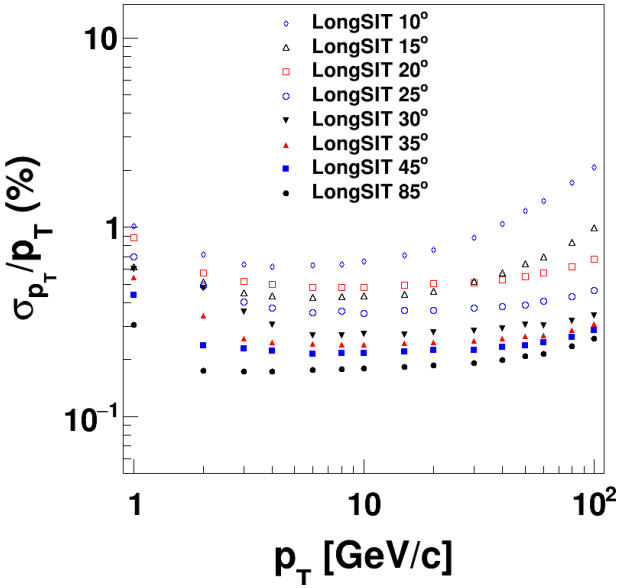
MC tructh

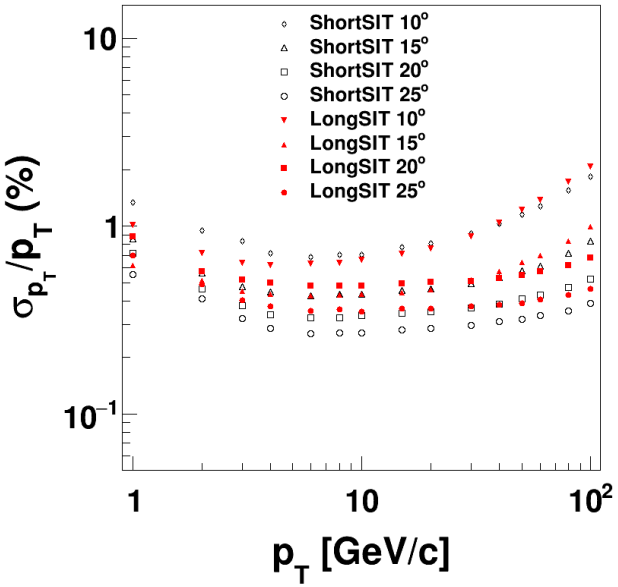


Resolution of p_T

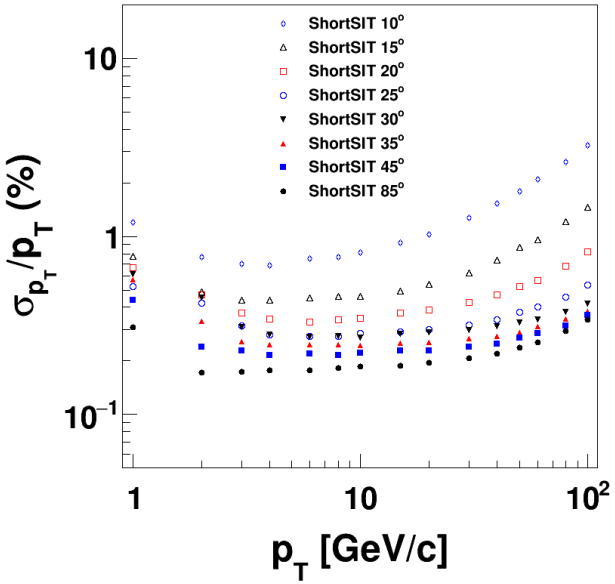
Fixed

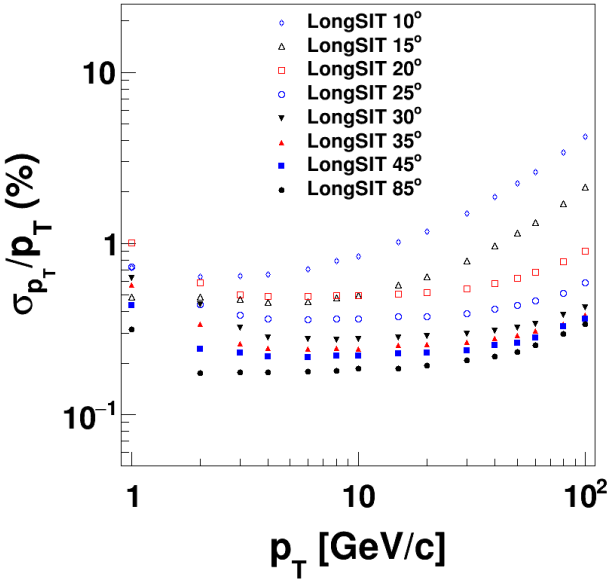


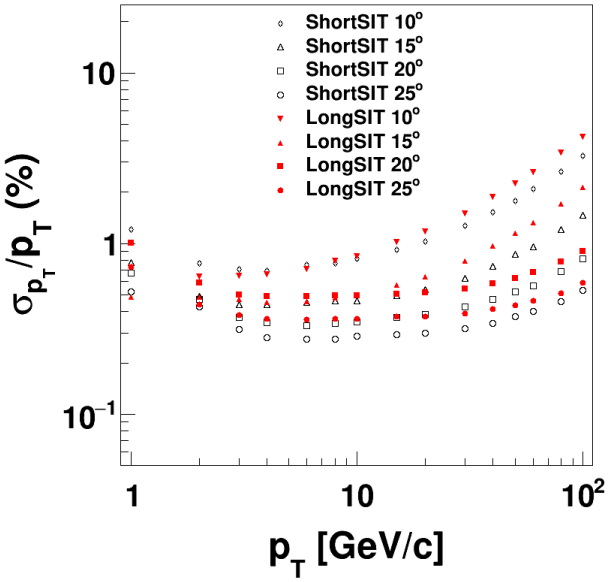




Parametrization



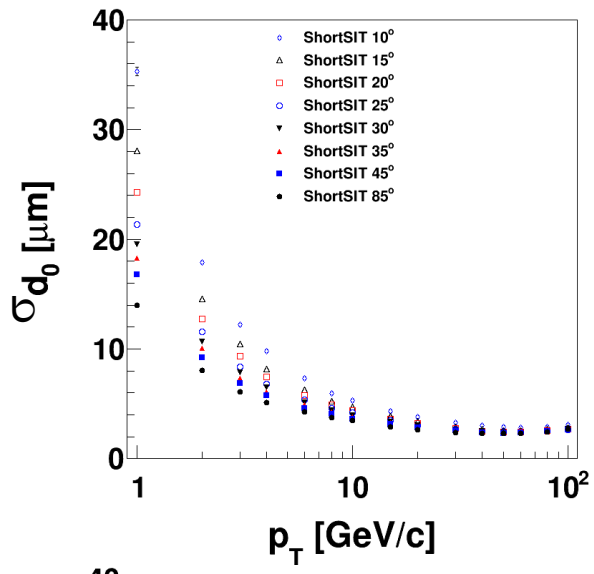


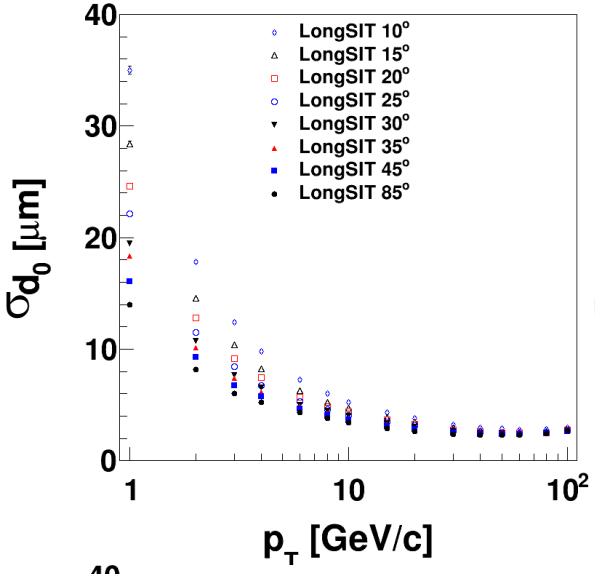


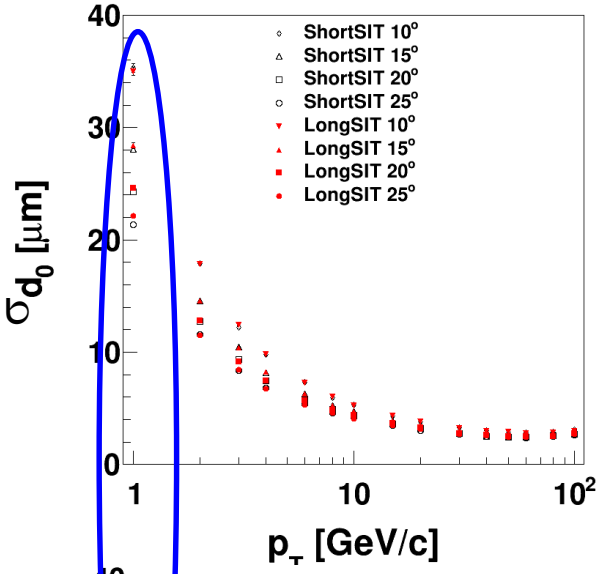
Resolution of d0

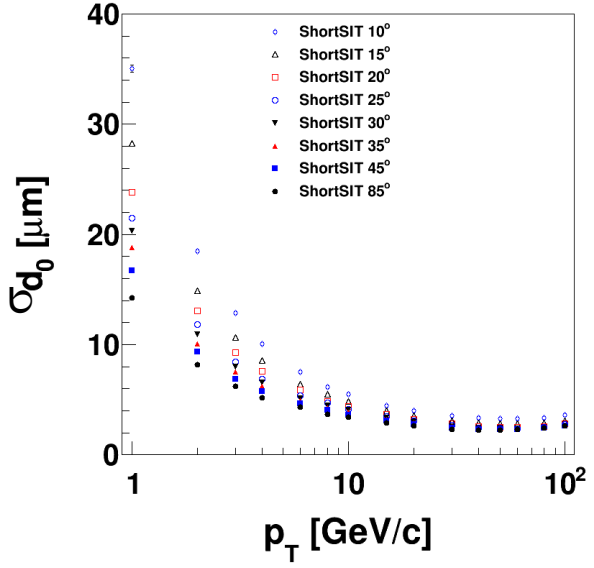
Fixed

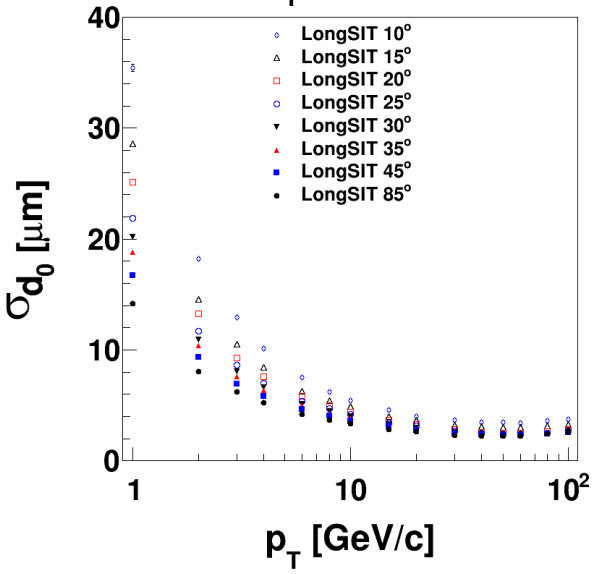
Parametrization

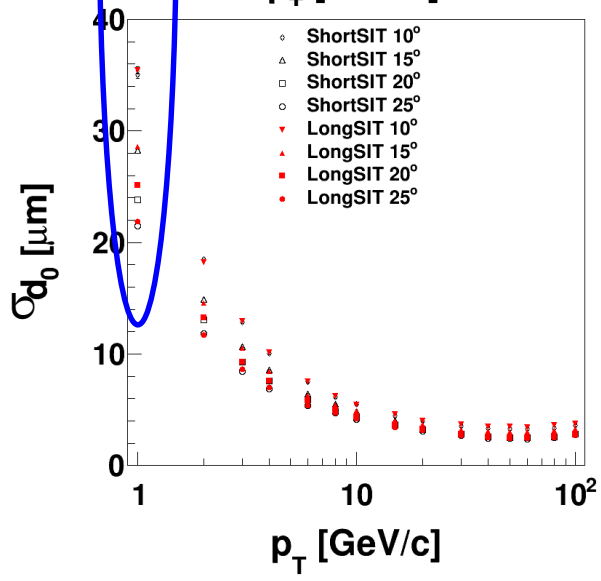






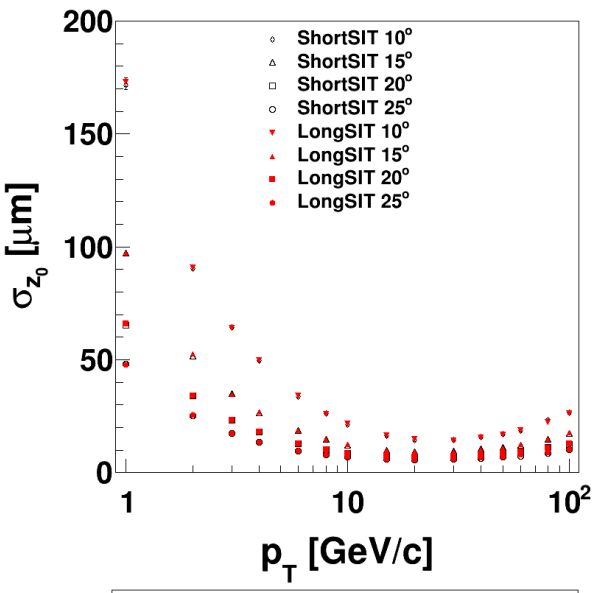


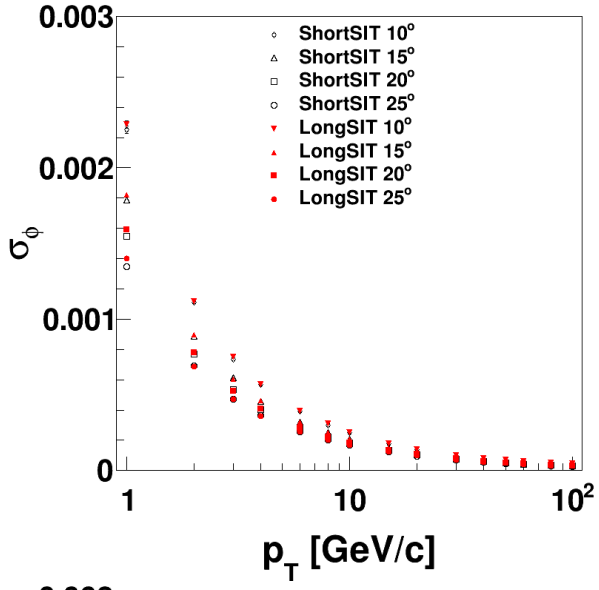


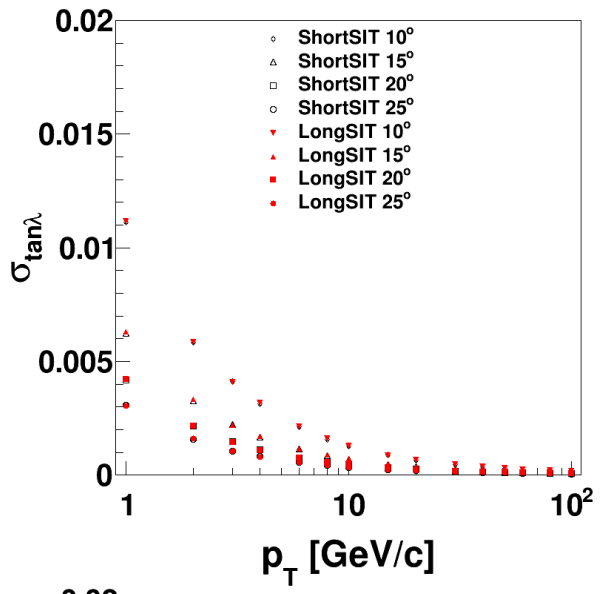


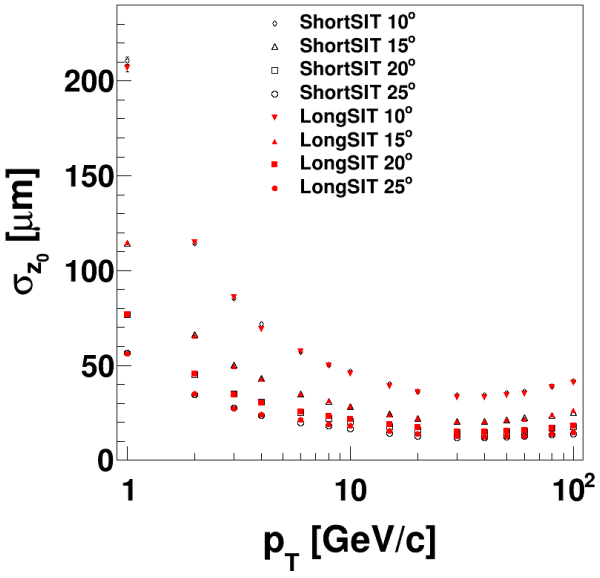
Resolution of Z_0, ϕ & $\tan\lambda$

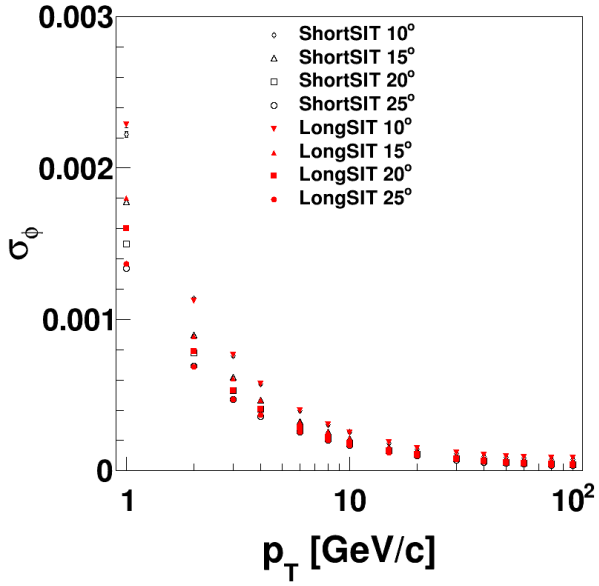
- Fixed
- Parametrization

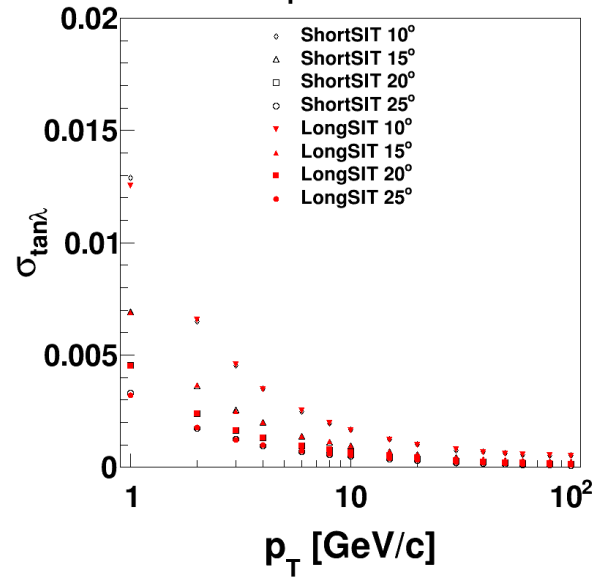






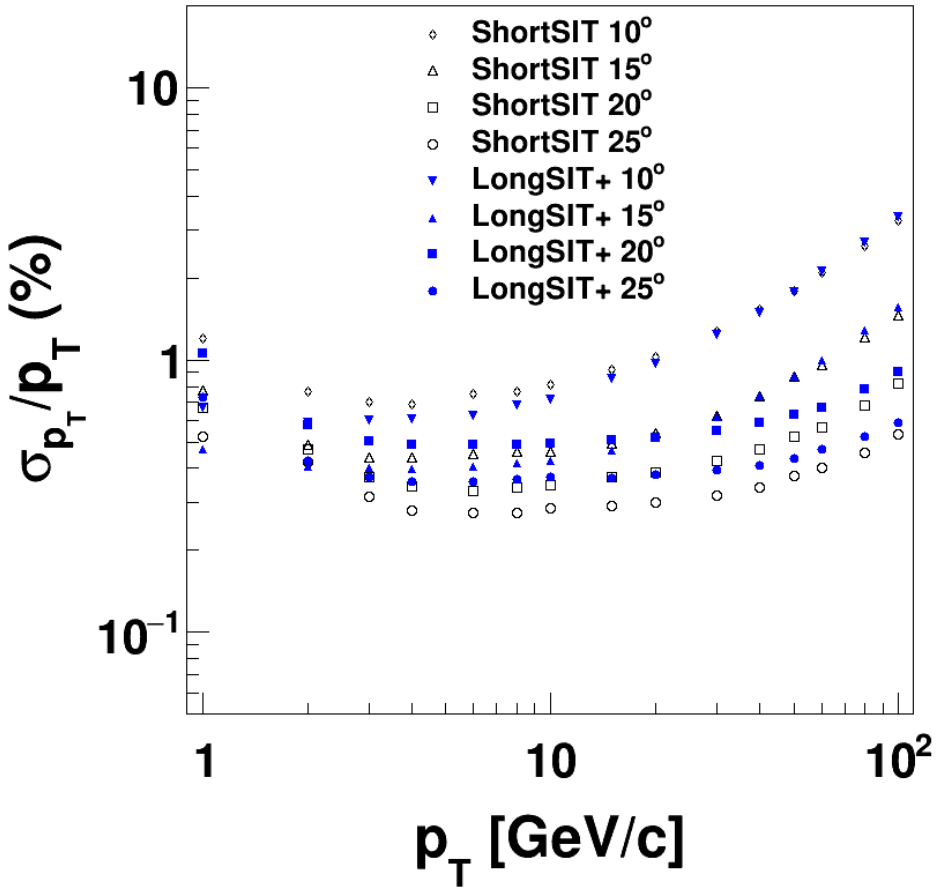


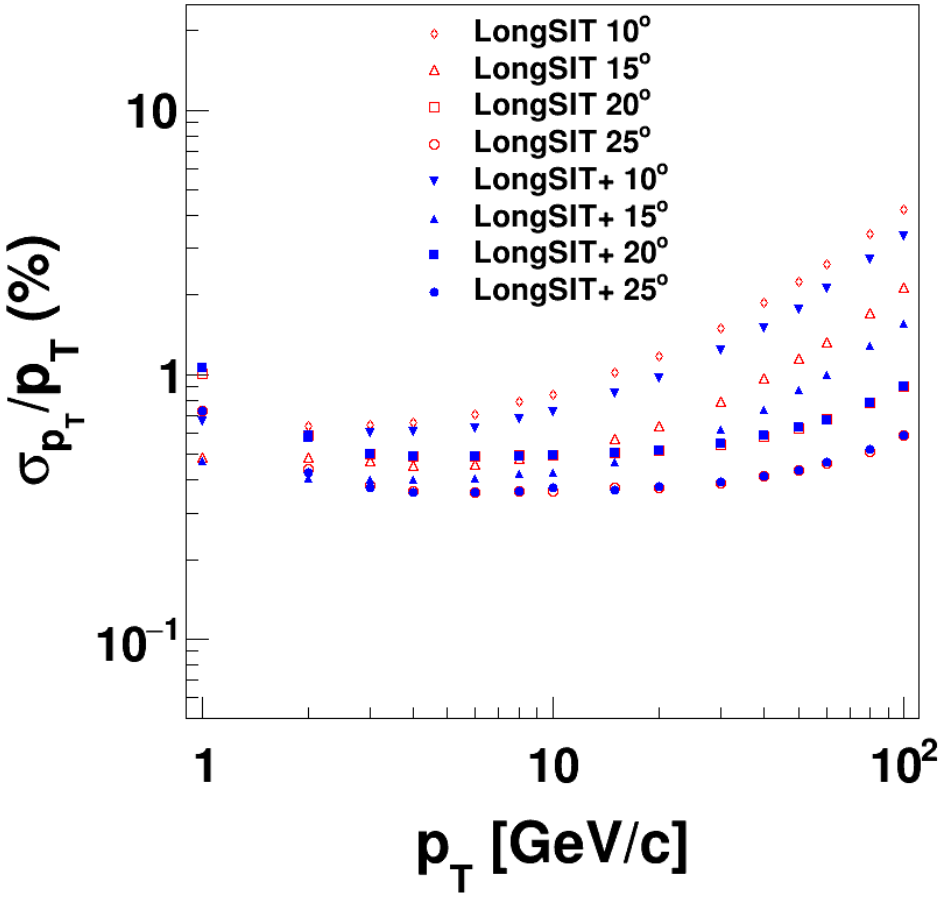




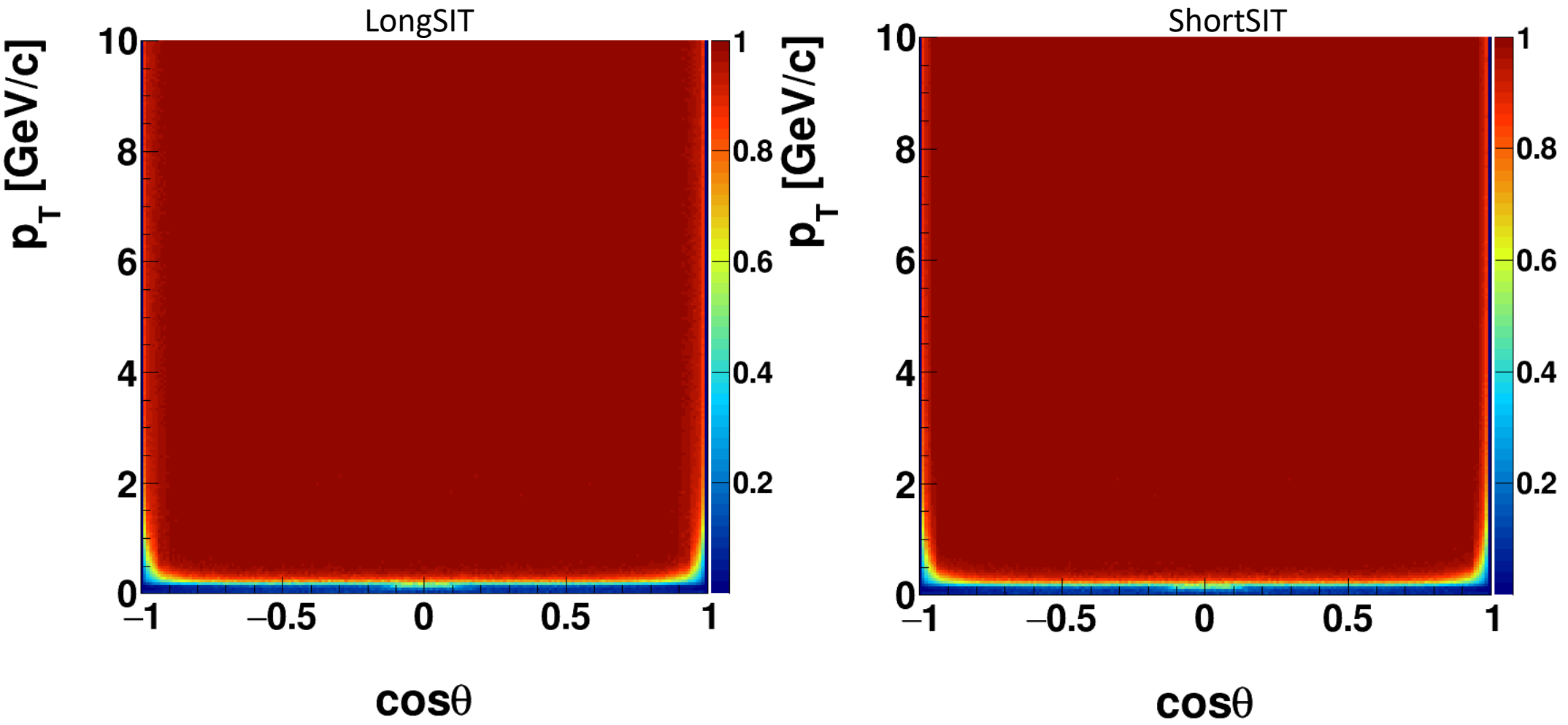
Comparison

- Almost same hit number for LongSIT+ and ShortSIT, different from material effect and point positions
- Close material for LongSIT and LongSIT+, different from measurement points





Efficiency



- ~86% @cosθ=(0.98-0.99)

Discussion & Conclusion

- Three silicon tracker options are implemented into CEPCSW, and full simulation is performed to estimate their performance
- The preliminary results show
  - With same vertex detector, small effect on d0, z0, ϕ, tanλ from different endcap tracker, only effect on ω(or p_T) is observably changed
  - Lower material is helpful to improve resolution
  - 4+1 layers better than 4 layers at small angle
    - ✓ Larger radius of last hit
    - ✓ more measurement point

    which is dominant? To implement more options as comparison
  - All options are in same track resolution level as barrel
    - ✓ LongSIT is worse than ShortSIT at high transverse momentum, but close and event better at low transverse momentum
  - All options have >99% efficiency for most direction, >85% close to detector edge
- Based on presumptive module, in future, the parameters of real modules are needed as input