Status of the CEPC Drift Chamber Software

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CEPC Physics and Detector Plenary Meeting

1. IHEP

2. Shandong University

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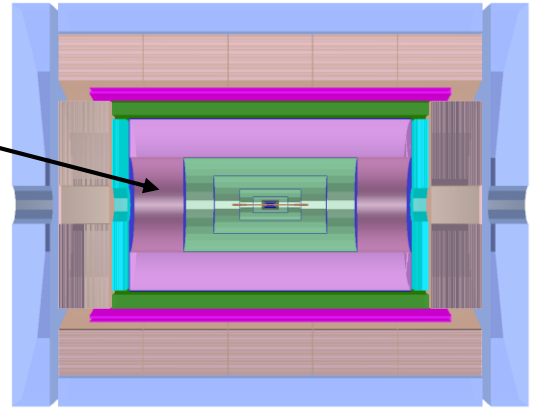
Outline

- Motivation
- CEPC v4 track fitting
- Performance validation
- Summary

Drift Chamber(DC) Software

- Drift chamber is the key detector in the 4th conceptual detector design to provide PID
  - Good PID ability (2σ π/K separation at P < ~ 20 GeV/c)
  - Precise momentum measurement (eff. ~100%, σp<=0.1%)



- Motivation of DC software project
  - Development of simulation and reconstruction for DC
  - Support the detector design, optimization and performance study
  - Support physics sensitivity study

- Requirements for DC software
  - Modular design and friendly interfaces
  - Easily integrated with common tools (ACTS, Genfit etc.)
  - Reuse existing algorithms from other experiments
  - Application of advanced technic (ML) to simulation and reconstruction

Physics process	Measurands	Detector subsystem	Performance requirement
$ZH, Z \to e^+e^-, \mu^+\mu^-$ $H \to \mu^+\mu^-$	$m_H, \sigma(ZH)$ $\mathrm{BR}(H \to \mu^+\mu^-)$	Tracker	$\Delta(1/p_T) =$ $2 \times 10^{-5} \oplus \frac{0.001}{p(\mathrm{GeV})\sin^{3/2}\theta}$

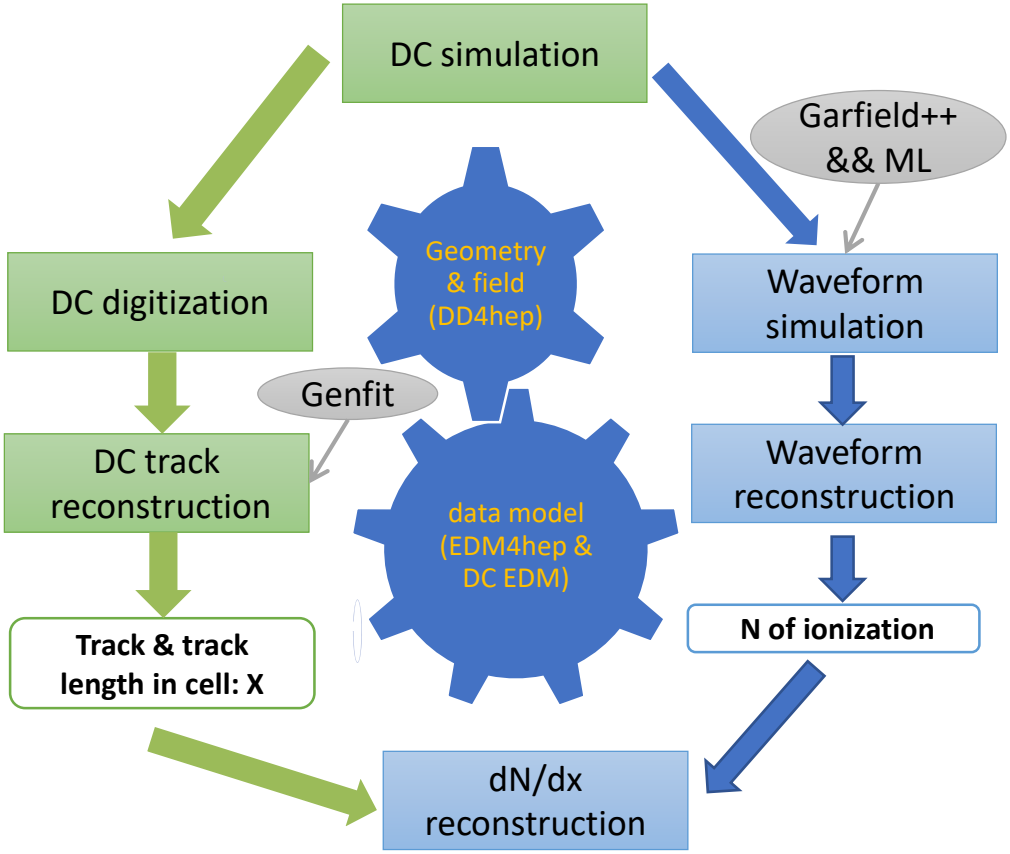
Requirements of The CEPC tracker

- Manpower
  - IHEP: Yao Zhang, Tao Lin, Wenxing Fang, Chengdong Fu, Ye Yuan, Weidong Li
  - SDU: Mengyao Liu, Xueyao Zhang, Xingtao Huang

DC software

The drift chamber software has been developed from scratch

- CEPCSW
  - Gaudi based framework
  - External libraries and tools
- Geometry and field map
  - DD4hep
  - Non-uniform magnetic field: **done**
- Data model
  - EDM4hep and FWCore
  - dN/dx event model: done
- Drift chamber
  - DC simulation: **done**
  - DC digitization: **done**
  - Waveform simulation: in progress
  - Waveform reconstruction: in progress
  - Track fitting with measurement: done
  - dN/dx reconstruction: in progress
  - **Multi track reconstruction: done**
  - **Performance check: done**

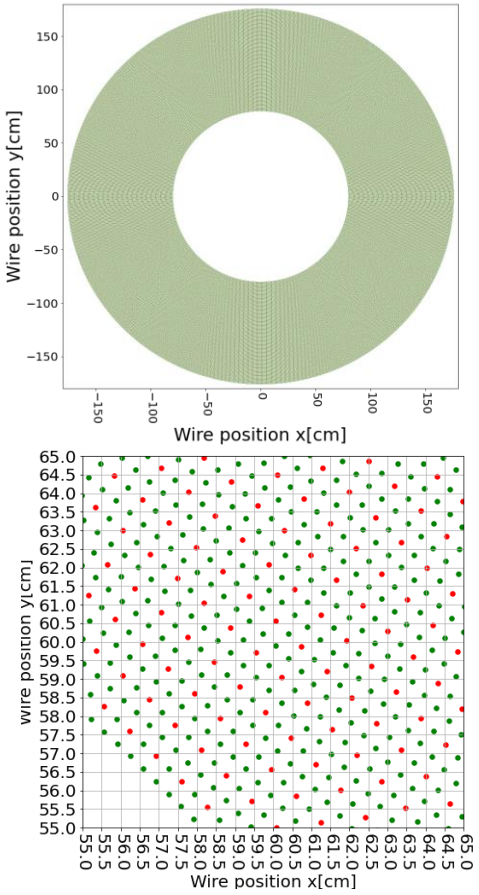


Drift chamber simulation and reconstruction flow

Drift Chamber Parameters in CEPCSW

- The base line configuration of DC in CEPCSW

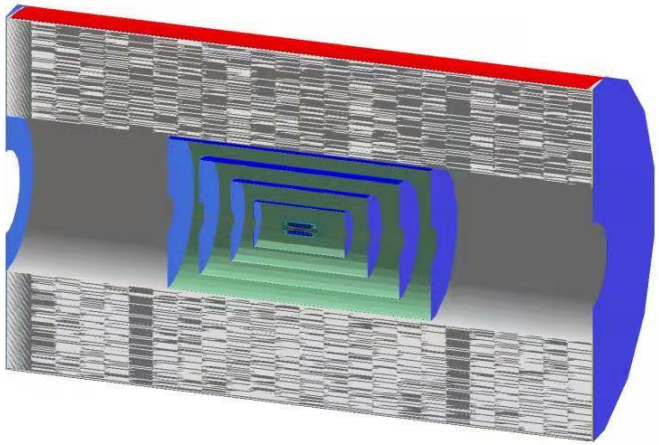
Half length	2980 *mm*
Inner and outer radius	800 to 1800 *mm*
# of Layers	100/55
Cell size	~10x10mm/18x18mm
Gas	He:C_4H_{10}=90:10
Single cell resolution	0.11 *mm*
Sense to field wire ratio	1:3
Total # of sense wire	81631/24931
Stereo angle	1.64~3.64 *deg*
Sense wire	Gold plated Tungsten ϕ=0.02*mm*
Field wire	Silver plated Aluminum ϕ=0.04*mm*
Walls	Carbon fiber 0.2 *mm*(inner) and 2.8 *mm(*outer)



Cell structure

Silicon detectors Parameters in CEPCSW

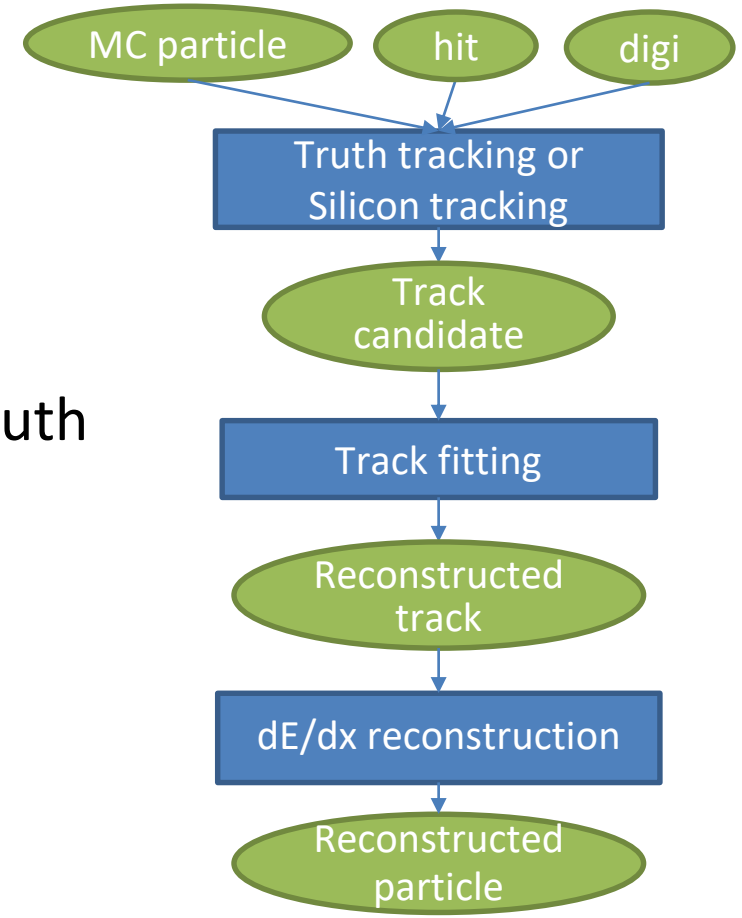
Silicon detecor	*Number of layer*	*Radius(mm)*	σ_U (μm)	σ_V(μm)
VXD	3 double layers	16-58	2.8/6/4/4/4/4	2.8/6/4/4/4/4
SIT	4 layers	230	7.2	86
SOT(SET)	1 layer	1815	7.2	86



CRD tracker o1 v01

Progress of CEPC v4 tracker reconstruction

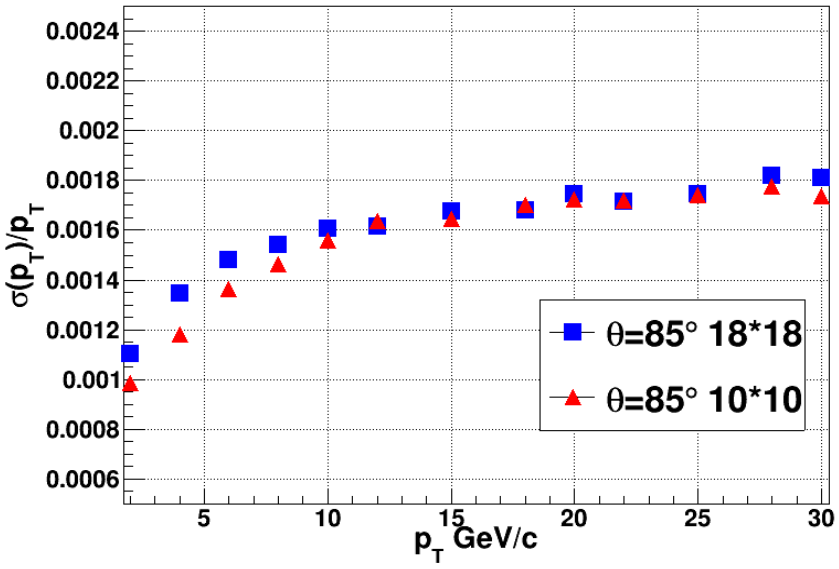
- CEPC v4 tracking flow is implemented
- Track fitting with tracker measurements
  - Silicon measurement + Drift chamber measurement
- Multi-track track finding based on MC truth
- Performance check has been done
  - Preliminary result is reasonable
  - Consistent with fast simulation

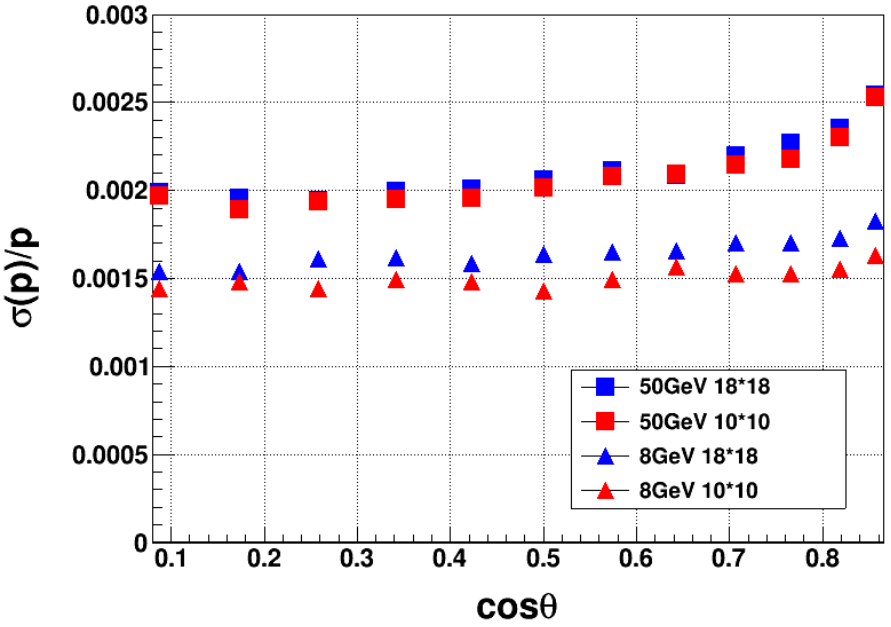


Data flow of DC reconstruction

Effect of cell size

- Two cell size setups are studied
  - 10mmx10mm and 18mmx18mm

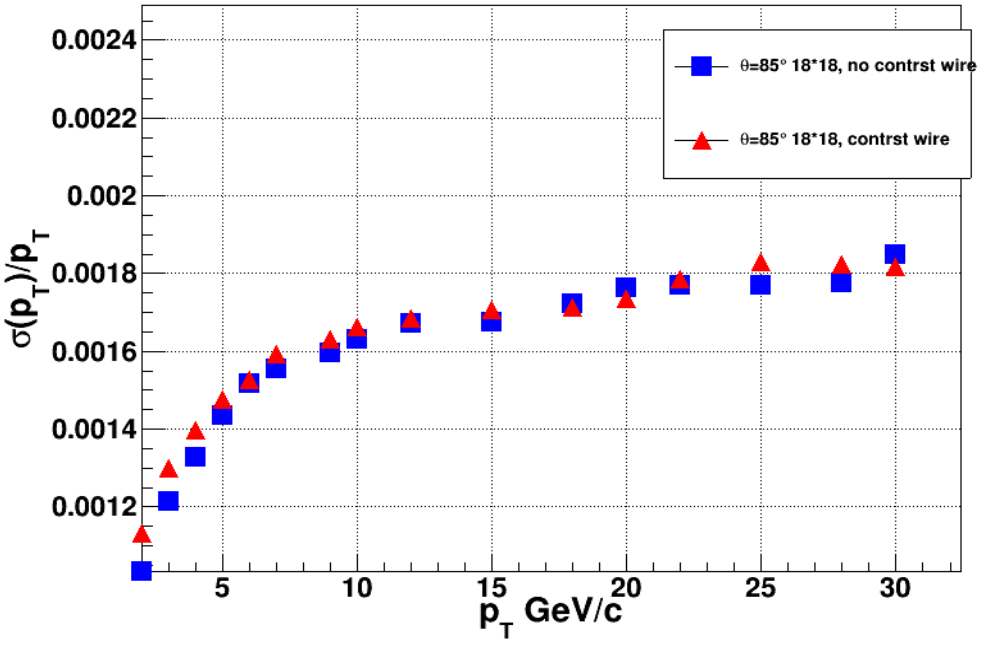




- Almost no effect on high momentum region

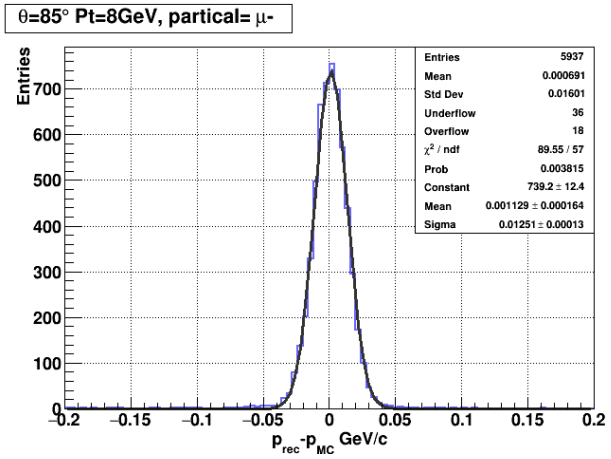
Effect of drift chamber wire material

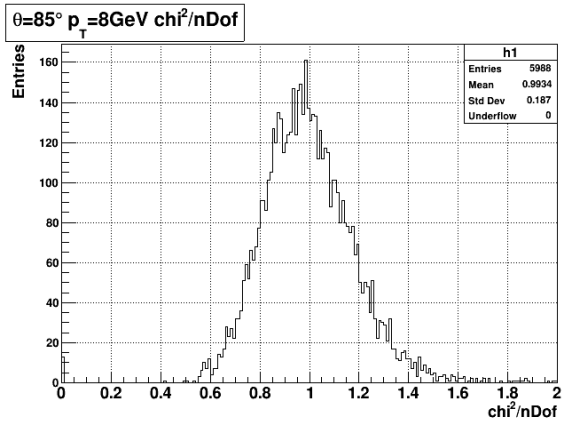
- With and without wire construction in simulation

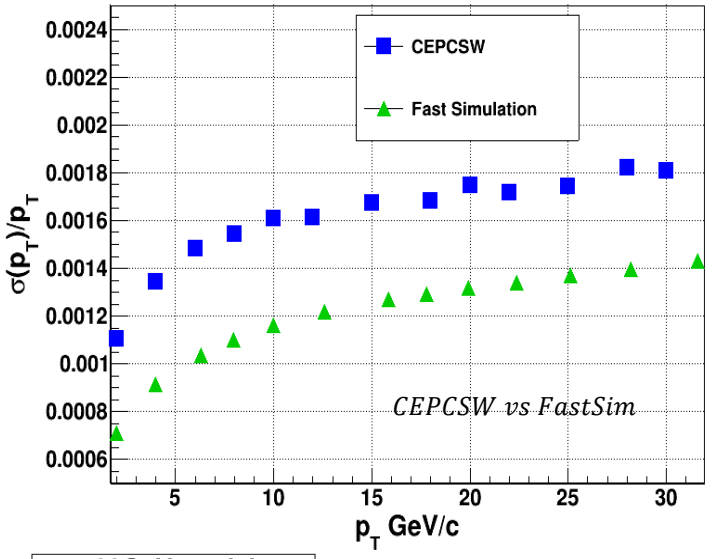


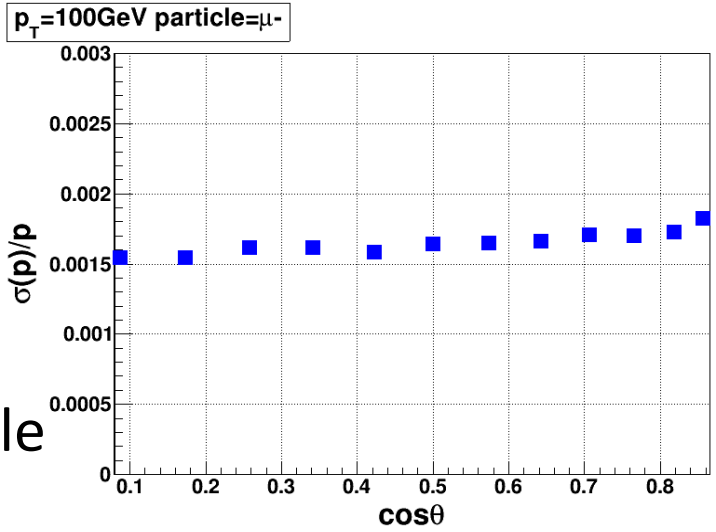
- Small effect on low momentum region(pt<5GeV)

Momentum resolution





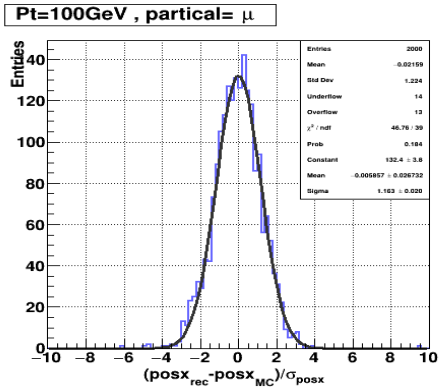


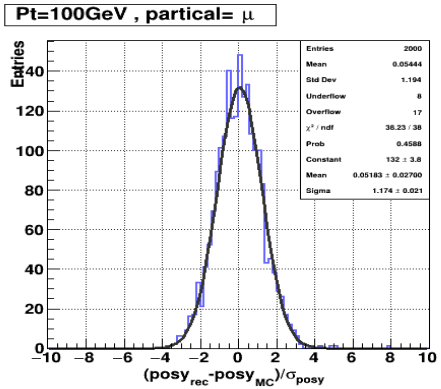


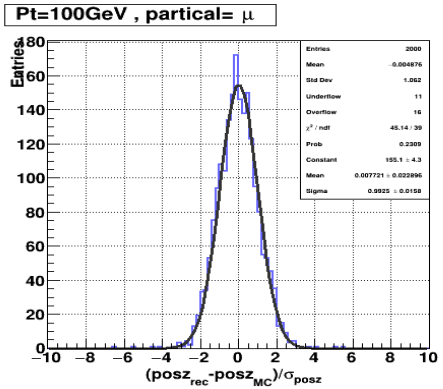
- The momentum resolution is reasonable

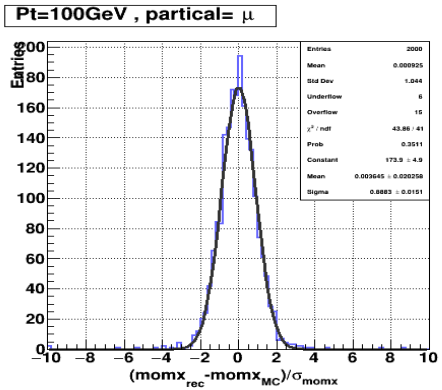
Single track performance validation

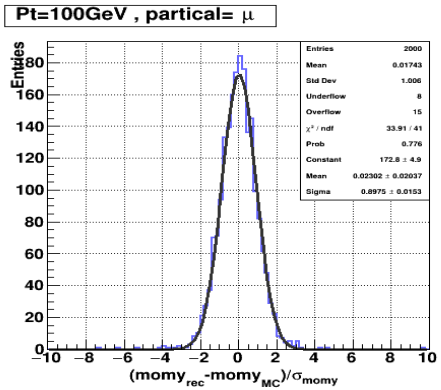
- Track parameters pull distribution is reasonable

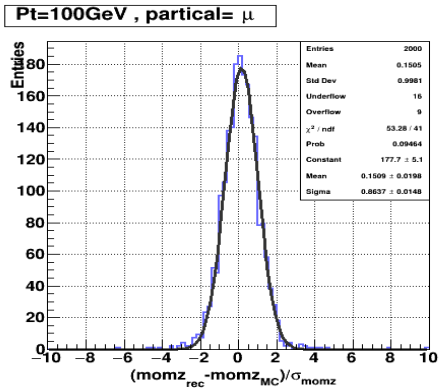






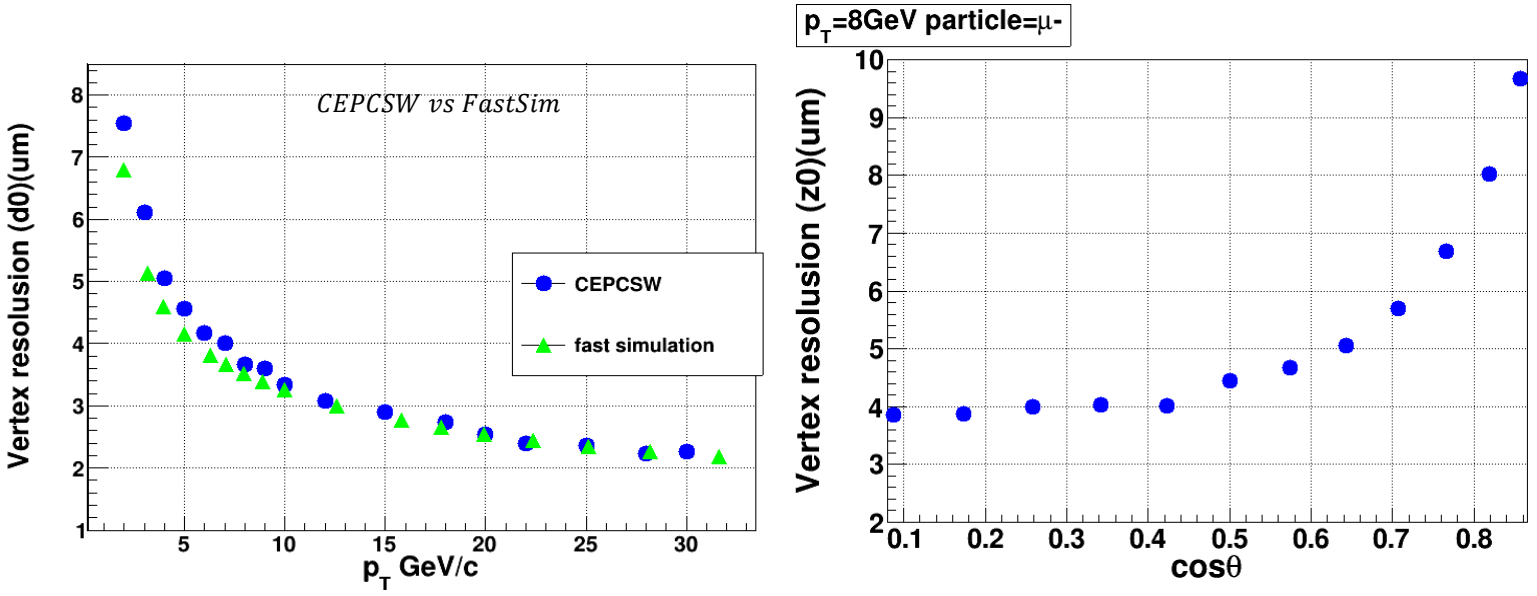






Impact parameter

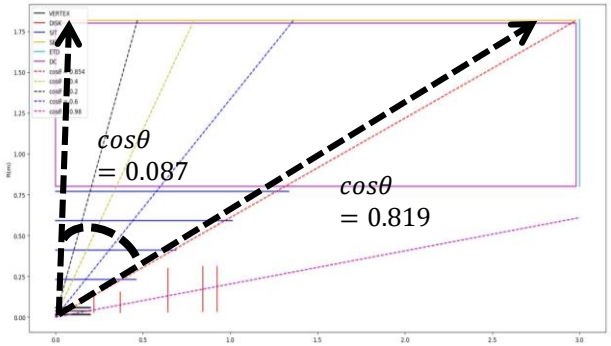
- Impact parameter d_0&Z_0 distribution

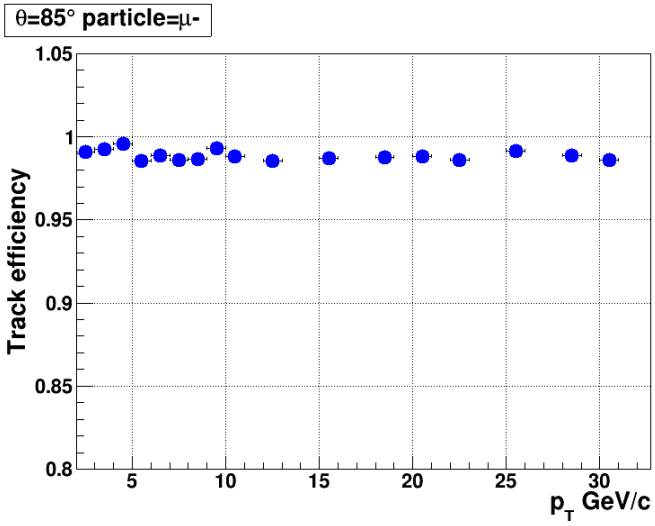


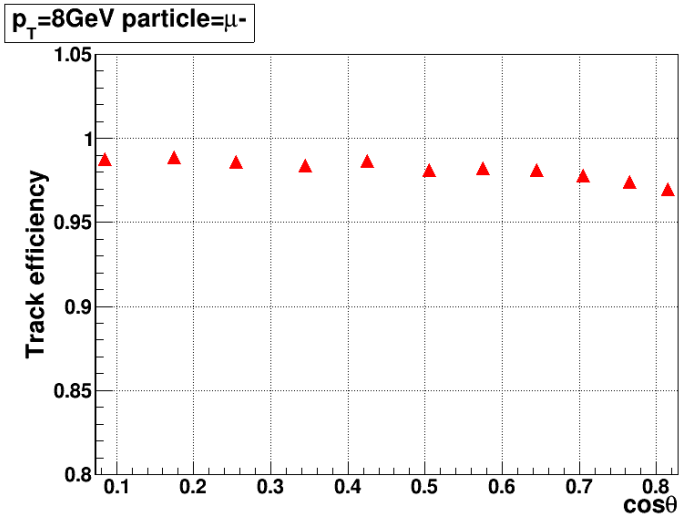
- Consistent with the fast simulation

Fitting efficiency

- Efficiency $\varepsilon (= \frac{The\ number\ of\ \text{track fitted}\ successful}{The\ number\ of\ \text{total track}})$

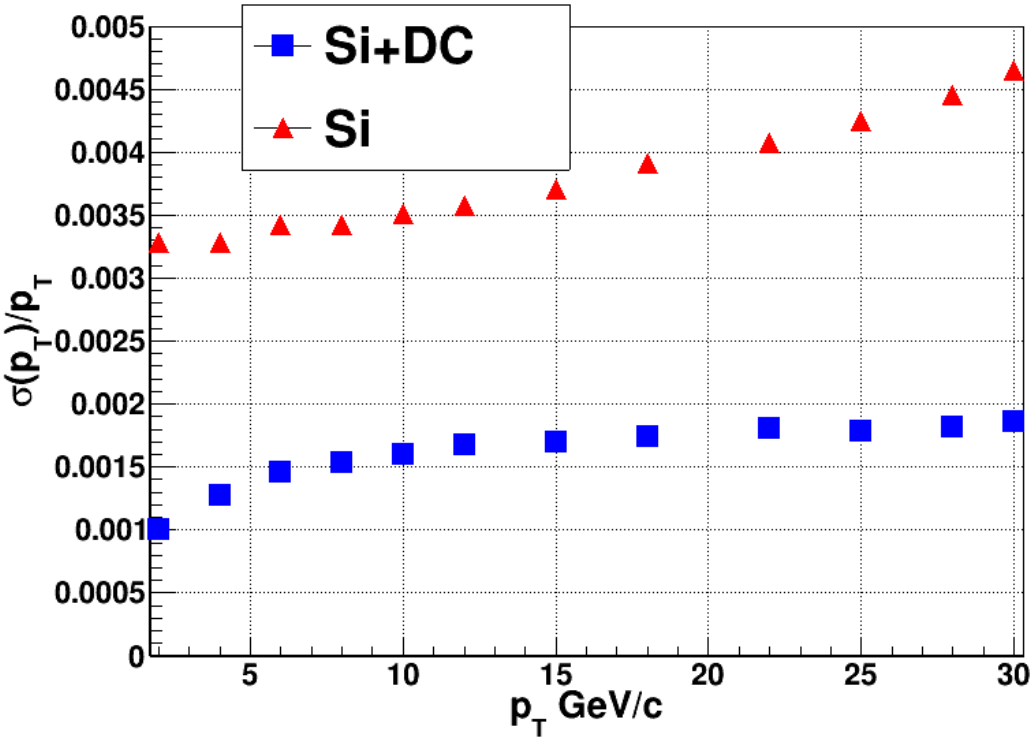






- Fitting efficiency is around 99%

Silicon+DC vs Silicons



- Got better momentum measurement with the drift chamber

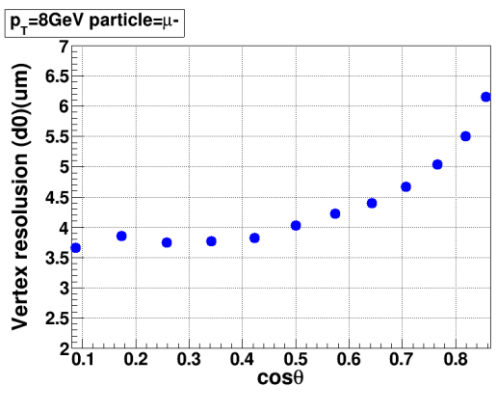
Summary

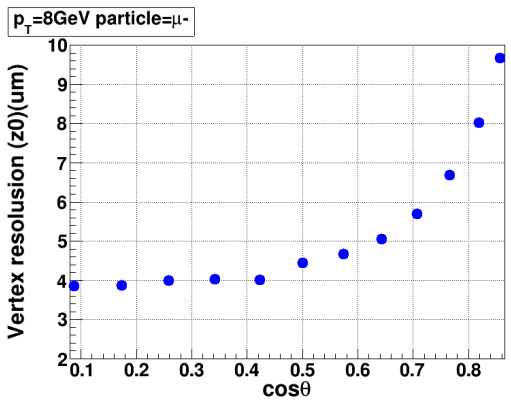
- The track fitting with Si+DC combined measurement is realized
- The multi-track fitting has been developed
- The performance check for Silicon+DC is done
- The first release of CEPC tracking software is ready

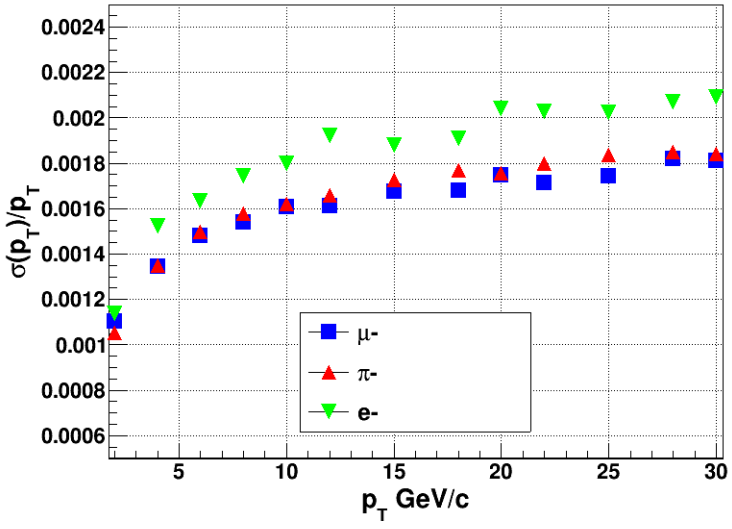
- Future plan
  - dN/dx
    - Waveform simulation and analysis study
    - Fast simulation according to data with NN
  - Background in simulation and reconstruction
  - Track finding development
    - Machine learning
    - Track finding from silicon seed or self-tracking
  - Release for detector and physics performance study

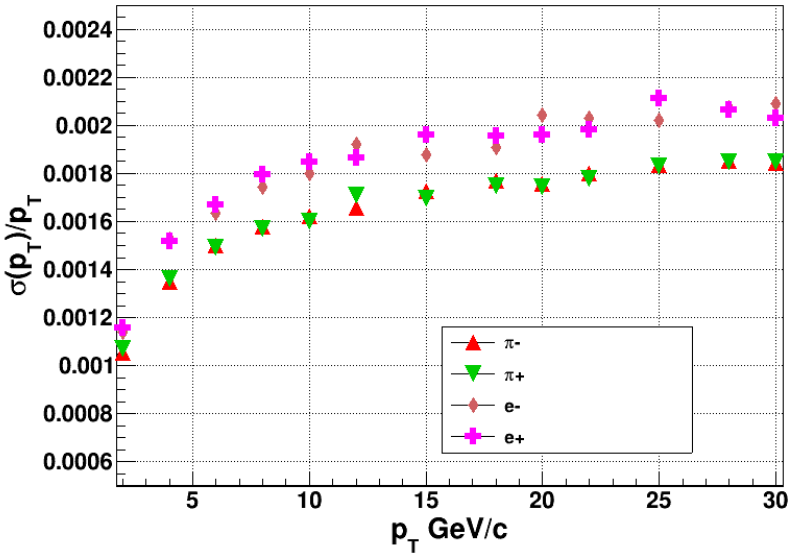
Thank you!

Backup


p_T=8GeV particle=μ-
Vertex resolusion (d0)(um)
cosθ


p_T=8GeV particle=μ-
Vertex resolusion (z0)(um)
cosθ


σ(p_T)/p_T
p_T GeV/c
μ-
π-
e-


σ(p_T)/p_T
p_T GeV/c
π-
π+
e-
e+