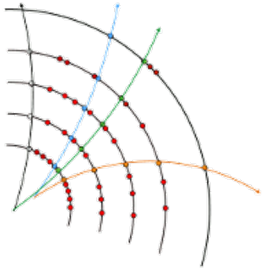


Status and plan of ACTS

G. Li

For CEPC-ACTS group

Dec 14th, 2020

Outline

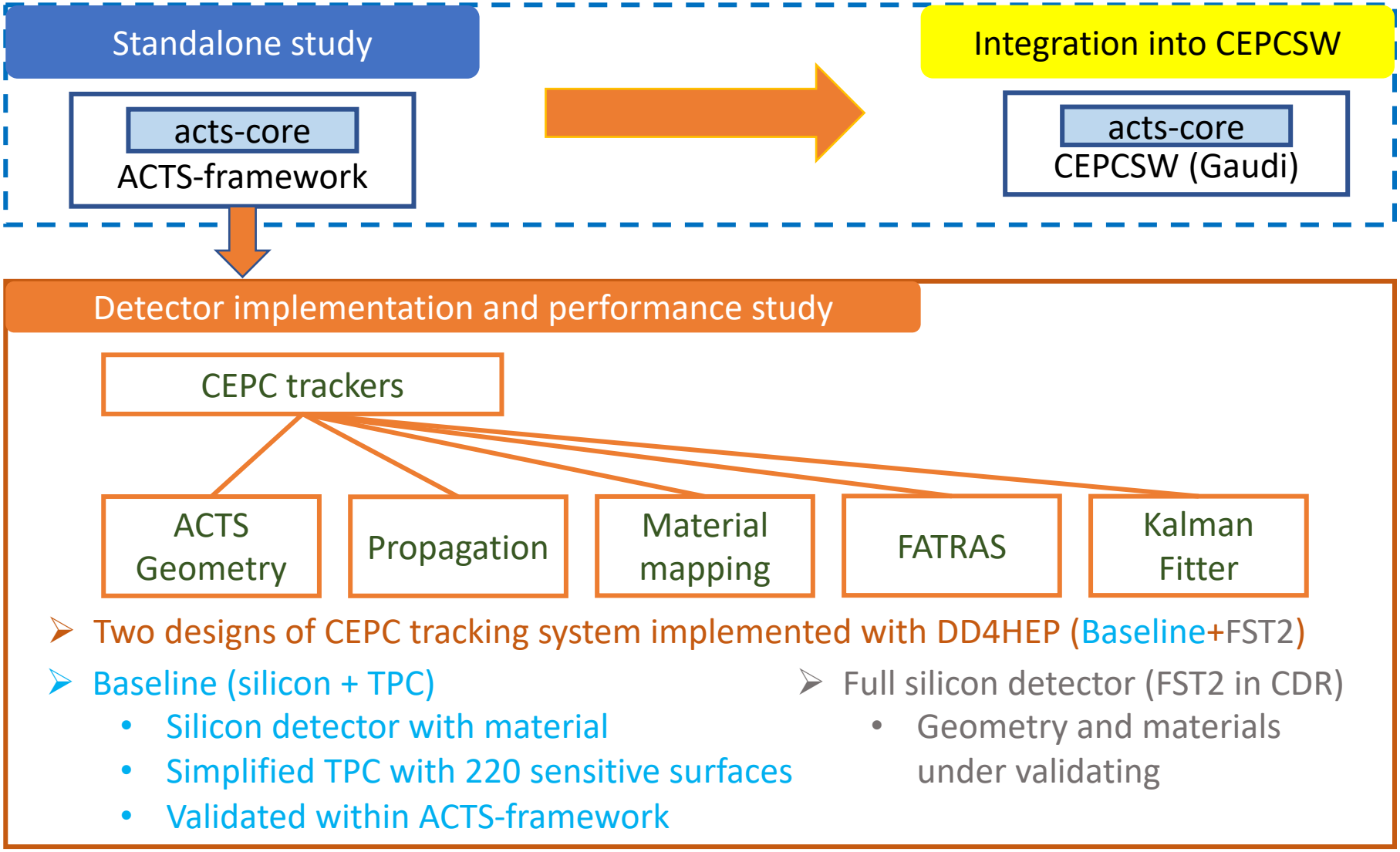
- **CEPC ACTS activities**
  - **Implementation**
  - **Performance study**
- **Plan and problem to be sovlved**

Introduce ACTS to CEPC

- From ATLAS, driven by the core idea to become **A** **C**ommon **T**racking **S**oftware
  - Encapsulating the well-tested ATLAS tracking code – high performance in the past
  - Independent from detectors and framework
- Modern technologies
  - Dealing with the CPU problem in dense tracking environment
  - Generic programming with C++ 17
  - Thread-safe design and efficient memory allocation
- Active group for the developing
  - Potential to become the future ATLAS tracking software
  - Other experiments are also trying
    - BELLE-2, sPHENIX, FASER, CEPC … *
- In term of CEPC, our activities started from last year
  - Participate in the ACTS development
  - Implement different detector designs
  - Detector details and tracking performance studies
  - ☐ Layout optimization and framework integration

CEPC ACTS Activities

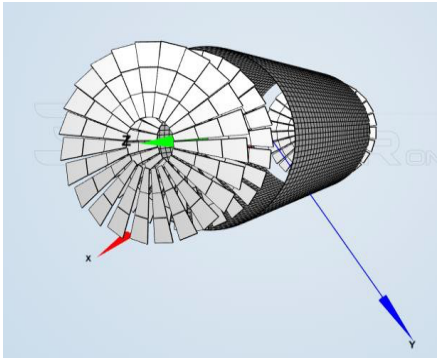
https://gitlab.cern.ch/jinz/acts-framework-cepc



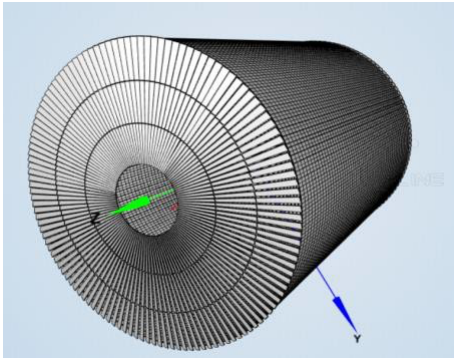
- Two designs of CEPC tracking system implemented with DD4HEP (Baseline+FST2)
- Baseline (silicon + TPC)
  - Silicon detector with material
  - Simplified TPC with 220 sensitive surfaces
  - Validated within ACTS-framework
- Full silicon detector (FST2 in CDR)
  - Geometry and materials under validating

Implementation

- DD4hep based geometry to describe CEPC inner tracker and built with XML file
  - Easy to modify the detector parameters
  - Good readability
  - Easy to integrate to CEPCSW
  - One of the standards in the future

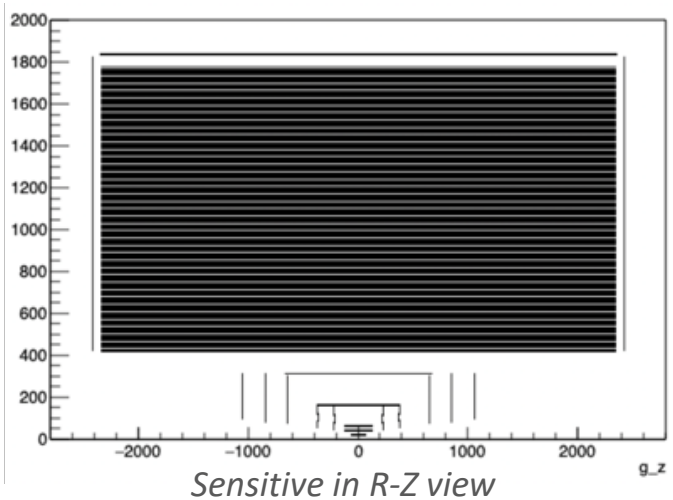


SIT2 & FTD4,5

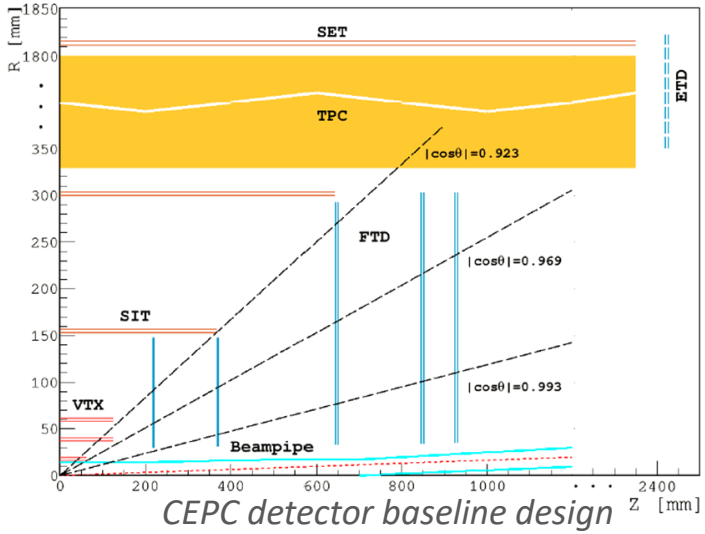


SET & ETD

- Propagation
  - A powerful tool to debug the geometry



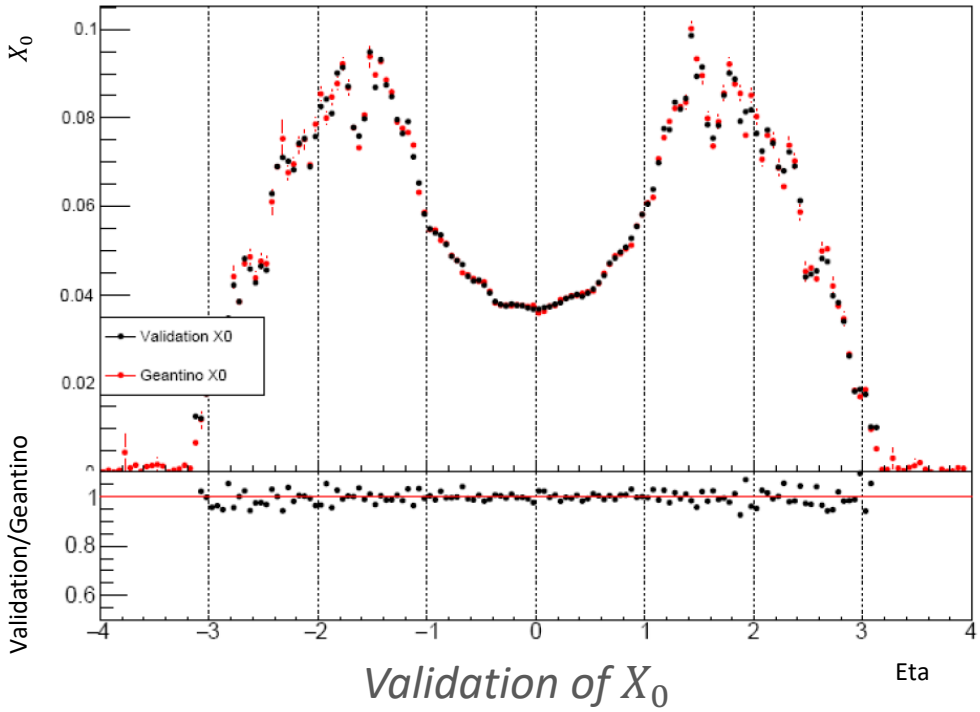
Sensitive in R-Z view



CEPC detector baseline design

Implementation

- Material mapping
  - Details of Material in the DD4hep xml file
  - Geantino to record the original material
  - Original material is mapped to surfaces → json output



Validation of X_0


```
"volumes": {
    "14": {
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        "Name": "",
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            "2": {
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                        "binPhi",
                        "closed",
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                            3.1415927410125732
                        ]
                    ],
                    "bin1": [
                        "binR",
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                        [
                            70.0999984741211,
                            300.9956970214844
                        ]
                    ],
```
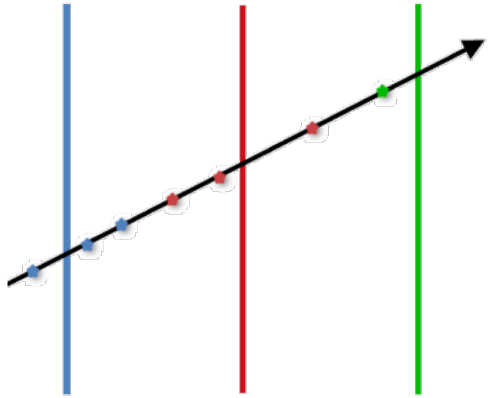


Json output



Surface mapping

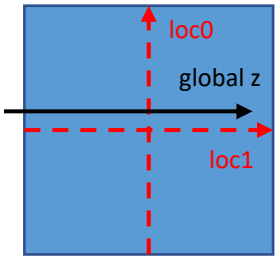
- Generally match with Geantino output

Implementation

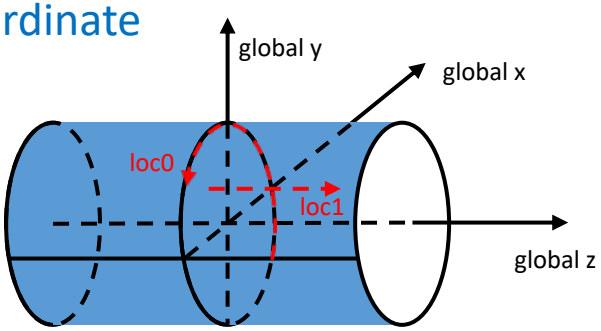
Resolutions of sub-detectors

Sub-detector			loc0_res [μm]	loc1_res [μm]	
Barrel	Vertex	1	3	3	pixel
		2	4	4	pixel
		3	4	4	pixel
	SIT 1, 2		5	250	strip
	TPC		100	5000	TPC
	SET		5	250	strip
Endcap	FTD 1, 2		3	3	pixel
	FTD 3, 4, 5		5	250	strip
	ETD		5	250	strip

Local coordinate



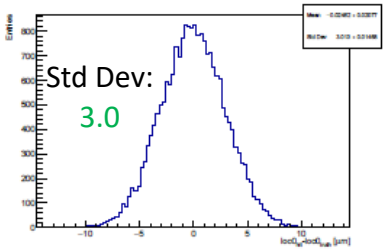
Silicon module

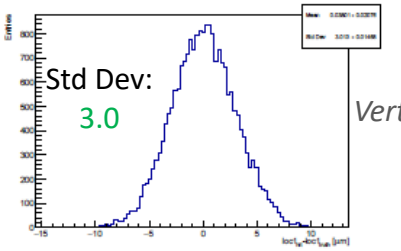


TPC layer

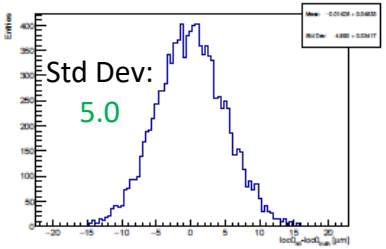
FATRAS (Fast ATLAS Track Simulation) to do the simulation

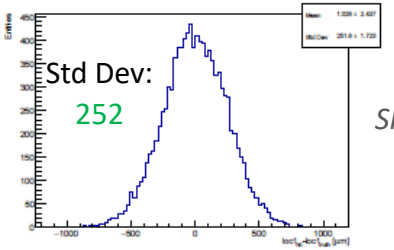
- Smear true position → hit



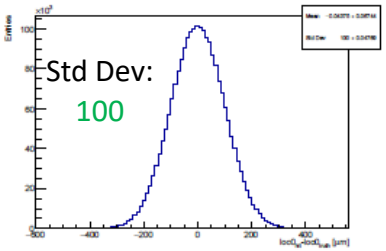


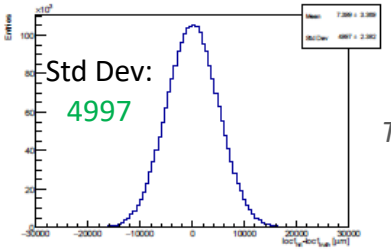
Vertex 1





SIT 1



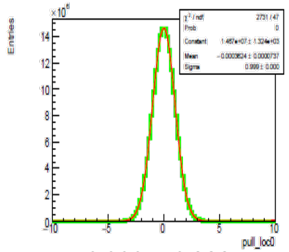
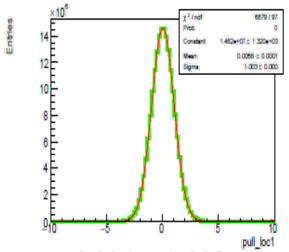
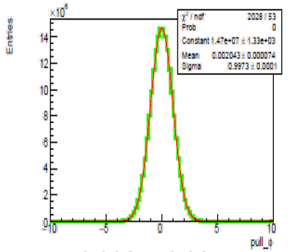
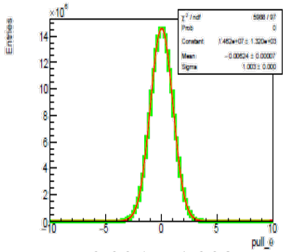
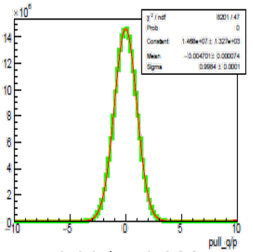
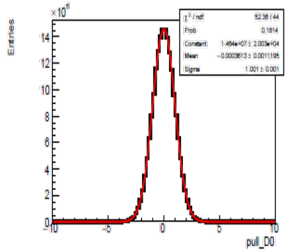
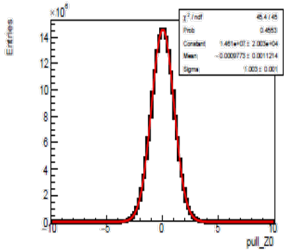
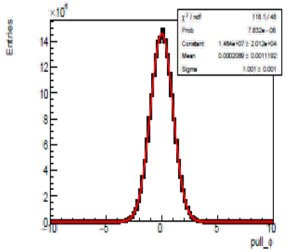
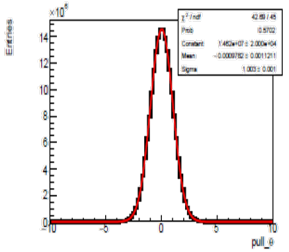
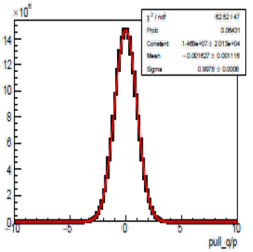


TPC

$loc0_{hit} - loc0_{truth}\ [\mu m]$ $loc1_{hit} - loc1_{truth}\ [\mu m]$

Performance study

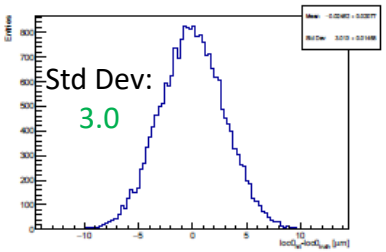
- FATRAS
  - Particle gun: 800,000 single μ^- from (0, 0, 0)
  - Magnetic field: (0, 0, 3T)
  - p_T: 100GeV, θ: 85°, φ: uniform distribution
- Kalman Filtering
  - Pull distribution of track parameters

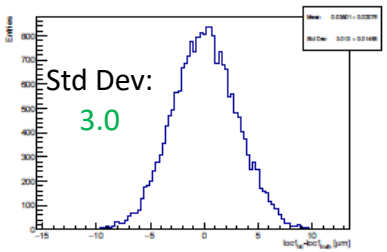
$\mu \pm \sigma$	Loc0 or D0	Loc1 or Z0	phi	theta	q/p
Smooth	 -0.000 ± 0.999	 0.006 ± 1.003	 0.002 ± 0.997	 -0.006 ± 1.003	 -0.005 ± 0.998
Perigee	 -0.000 ± 1.001	 -0.001 ± 1.003	 0.000 ± 1.001	 -0.001 ± 1.003	 -0.002 ± 0.998

- Following standard normal distribution

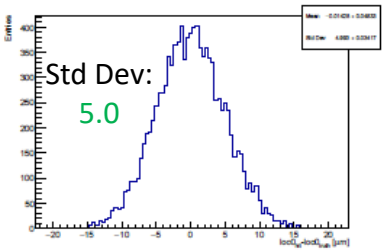
Performance study

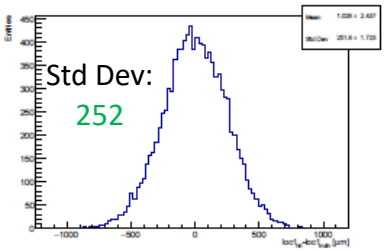
➢ Smear resolution in FATRAS



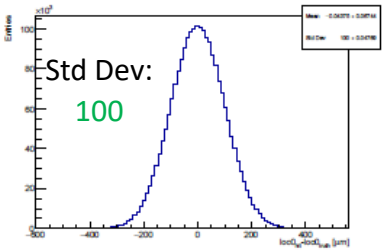


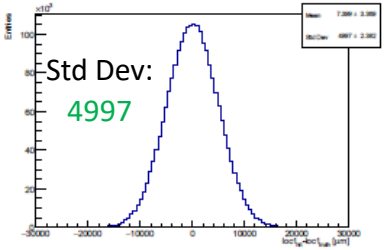
Vertex 1





SIT 1

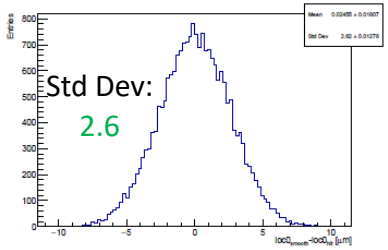


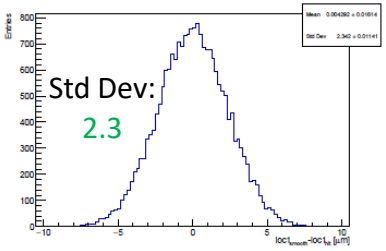


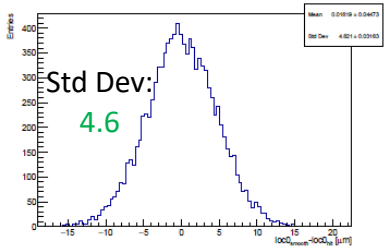
TPC

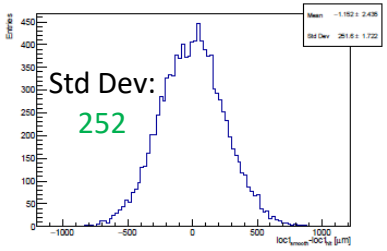
$loc0_{hit} - loc0_{truth}\ [\mu m]$ $loc1_{hit} - loc1_{truth}\ [\mu m]$

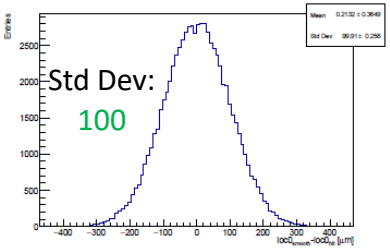
➢ Tracking Residuals

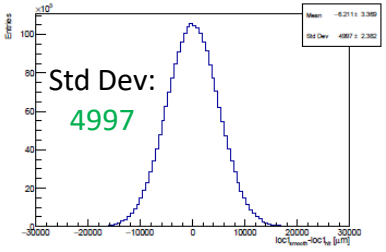








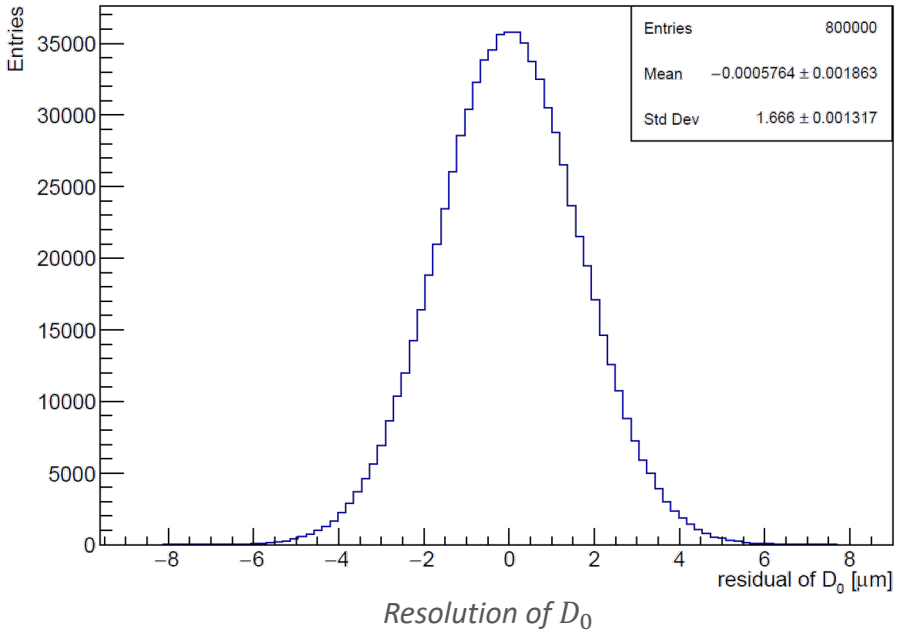




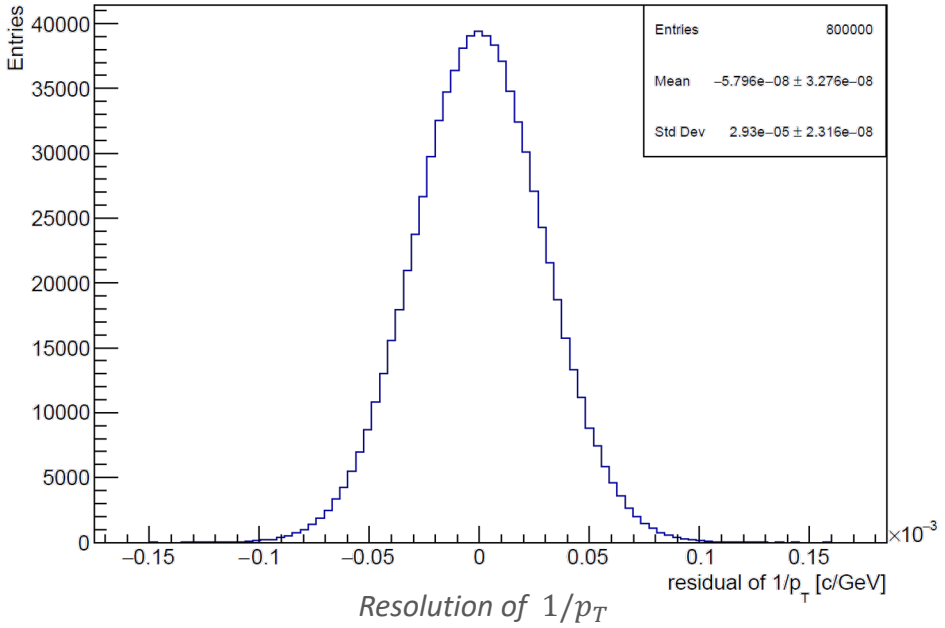
$loc0_{smooth} - loc0_{hit}\ [\mu m]$ $loc1_{smooth} - loc1_{hit}\ [\mu m]$

Performance study

➢ Resolution of vertex and momentum



Resolution of D_0

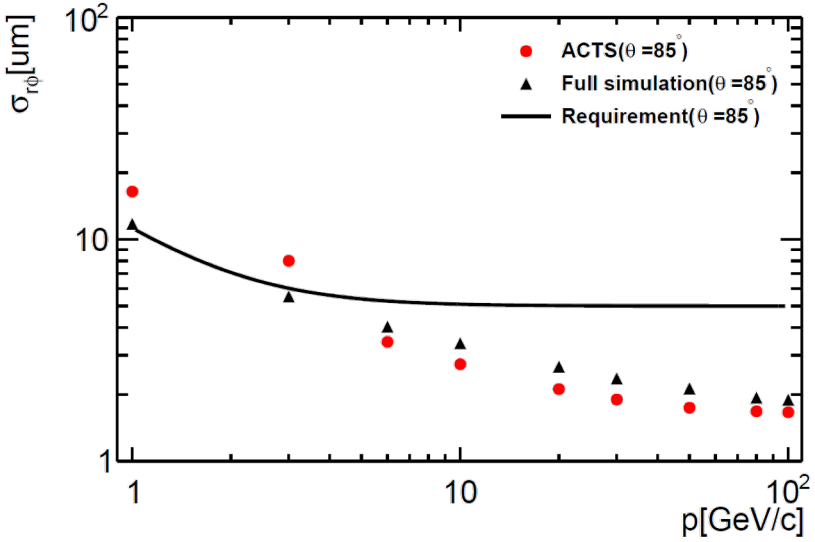


Resolution of $1/p_T$

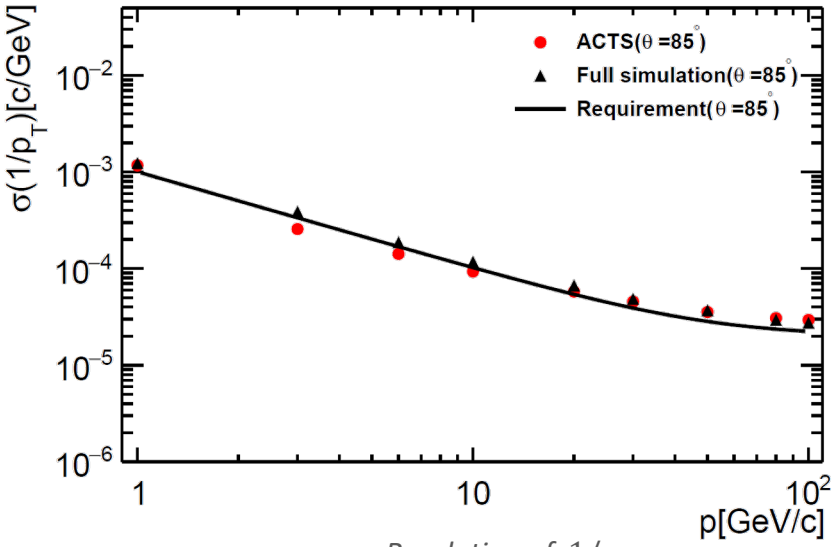
- Result in ACTS (p_T: 100GeV, θ: 85°)
  - $\sigma_{r\varphi} = 1.67\ \mu m$ $\quad \sigma_{1/p_T} = 2.93\times10^{-5}\ c/GeV$
- Full simulation resolution in CDR
  - $\sigma_{r\varphi} = 1.89\ \mu m$ $\quad \sigma_{1/p_T} = 2.75\times10^{-5}\ c/GeV$

Performance study

- Resolution of vertex and momentum
  - Full simulation data are according to CDR
  - The CEPC physics program requires
    - $\sigma_{r\varphi} = a \oplus \frac{b}{psin^{3/2}\theta}$, a~$5\mu m$ and b~$10\mu m \cdot GeV/c$
    - $\sigma_{1/p_T} = a \oplus \frac{b}{psin^{3/2}\theta}$, a~$2\times10^{-5} c/GeV$ and b~1×10^{-3}



Resolution of D_0



Resolution of $1/p_T$

- ■ Generally match with full simulations in CDR
- □ Further validation

Plan

- FST implementation and validation
- Migrated to CEPCSW
  - ✓ACTS version in FWCore (Lin Tao)
  - ✓DD4hep （working with Chengdong）
    - ➢ Implementation
    - ➢ extensions
  - ✓Geometry/material parameters used in tracking (Chengdong)
  - ✓Develop a tracking algorithm in CEPCSW based on ACTS
  - ✓Using existing truth tracking
  - ✓Fast simulation of trackers …
  - ✓Detector and physics study …