Tracking Geometry toolkit and Digitization

Chengdong FU (IHEP)

The 3rd CEPC Physics-Software Workshop

Beijing, Nov. 29 2016

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Motivation

- CEPC-SPPC project is in conceptual design research (CDR), bla bla bla …

- TPC and full-silicon tracker are competitive, which are both used in other designs of large particle experiments (TPC in ILD, full-silicon tracker in SiD, etc.)
  - Optimized design for physics, respectively
  - Compare performance (resolution of single particle, physical parameters)
  - One or both ? CEPC-SPPC have own specialty different to ILD/SiD.

Tracking Geometry toolkit

- Mokka is used smoothly, based on a pre-design (cepc_v1) from ILD. In cepc_v1, VXD/FTD (silicon) and TPC are combined as tracker.
  - Radius of inner
  - Radius of outer
  - Height of pad
  - Width of pad
  - Others
- A new geometry driver SiTrackerX in Mokka is usable to implement the full-silicon tracker.
  - Not depend on database, defined in steering file (.macro)
  - Layer built by silicon-multiple-support-silicon or silicon-multiple support planar
  - More flexible
    - Layer number
    - Layer position
    - Support material
    - Sub-layer thickness

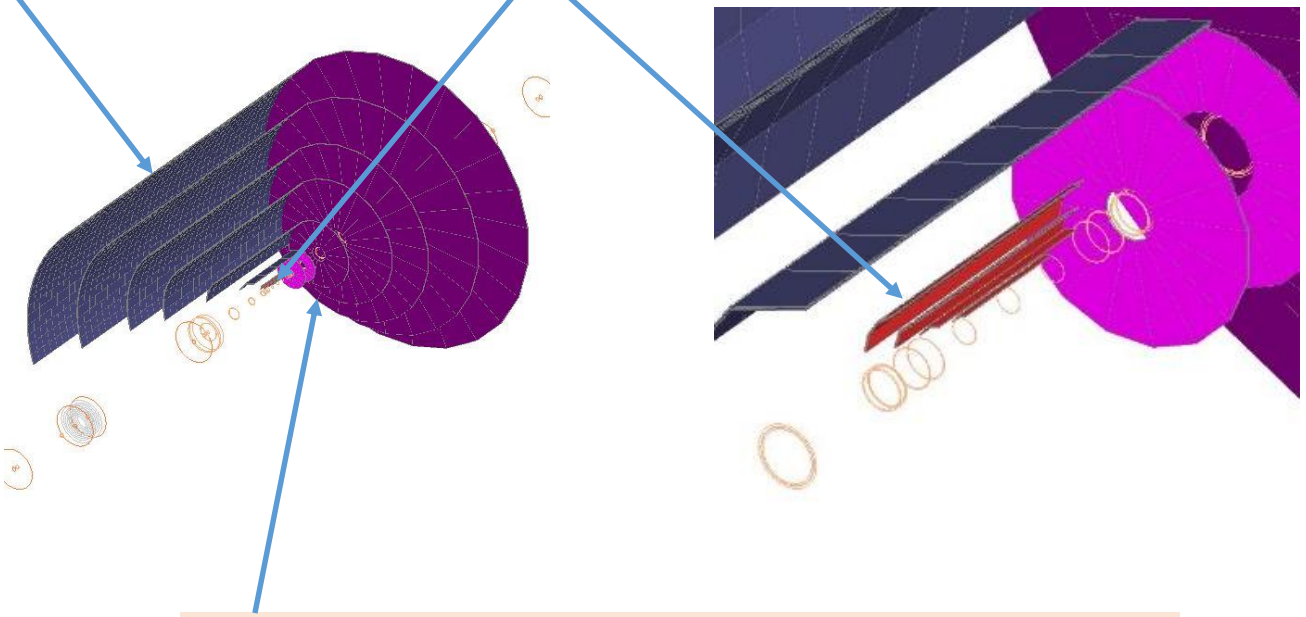
    VXD,15.9,78,10;VXD,25,125,10;VXD,36.9,150,11;
  - sub-layer structure
    - A support can be implemented by a layer without sensistive sub-layer easily
    - Example:

    SIT,**Si:-0.15**,Si:0.0024,Peek:0.1,CarbonFiber:0.08,Rohacell50D:0.9,Epoxy:0.08,CarbonFiber:0.08

An preliminary design:

SIT: 6 double-layers

VXD: 3 double-layers

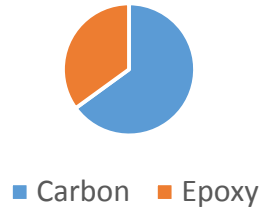


FTD: 2 single-layers for pixel + 5 double-layers foir strip

Material of sub-layer

- Any composition of sub-layer material (predefined) is possible/easy

- If un-defined material, one way to approximate



1 mm thickness

Carbon:0.2,Epoxy:0.8

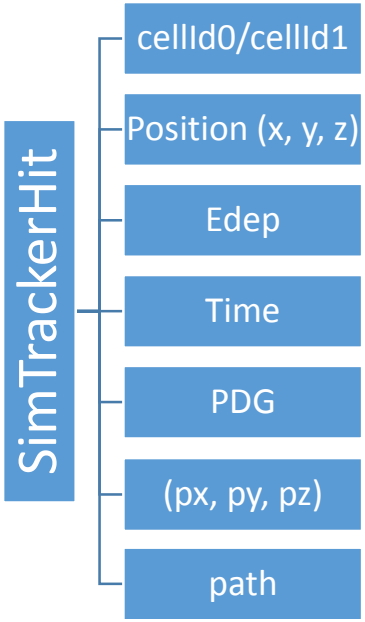
$$frac\_t_1 = \frac{n - n_2}{n_1 - n_2}$$

- 1 mm Carbon fiber with 50% density

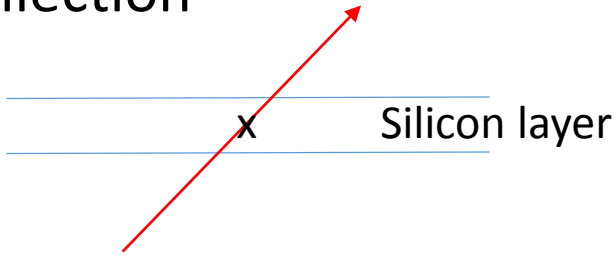
  CarbonFiber:0.5,Air:0.5

Hits output before Digitizating

- Hit type: **SimTrackerHit** (lcio)



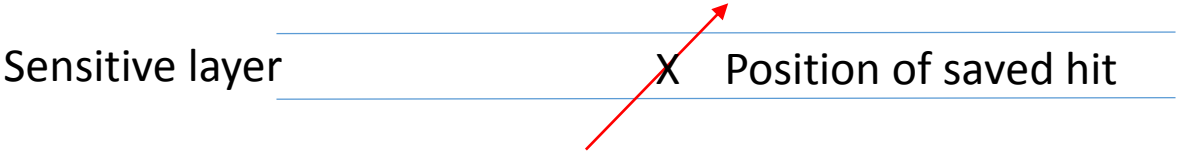
- Collection
  - VXDCollection
  - SITCollection
  - FTD_PIXELCollection
  - FTD_STRIPCollection



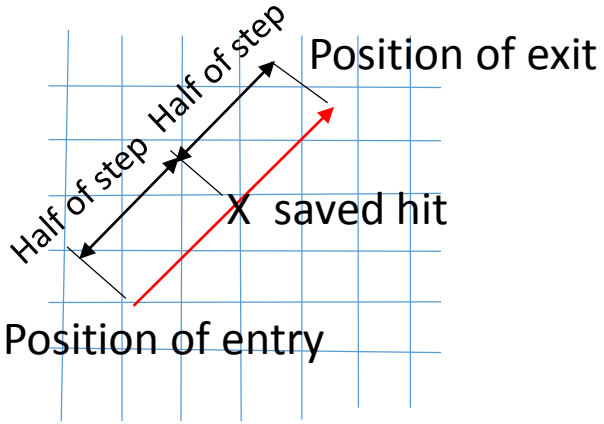
- Position

Digitization of silicon-tracker

- Hits in sensitive detector (silicon) is created as SimTrackerHit
  - Position of center of each step

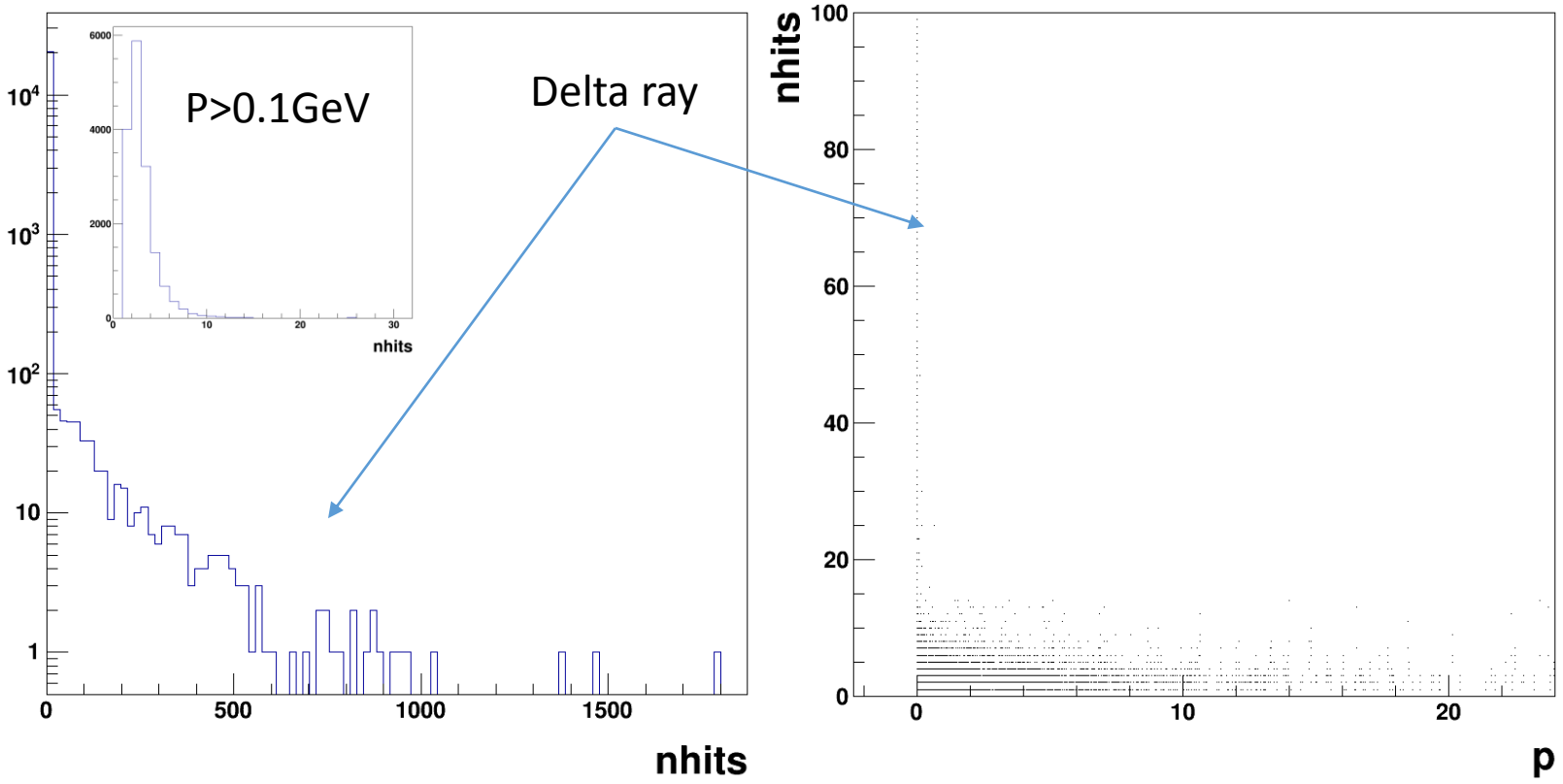


- Digitization in Marlin process
  - Old: smearing by the resolution
  - New: center of pixel/strip
    - Merge all hits in same pixel/strip
    - multi-hits



Multi-hits

- One SimTrackerHit will produce more than one TrackerHit



Preliminary design of software

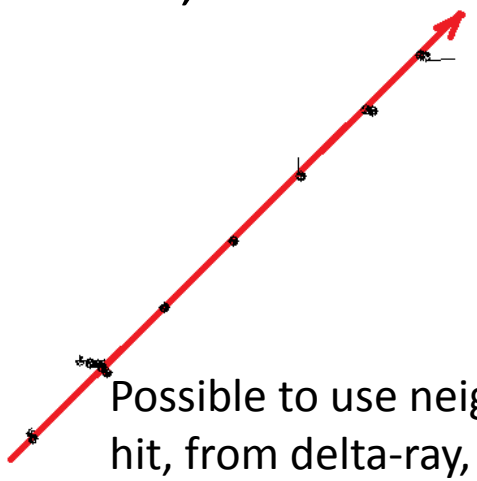
- Parallel processor with old
  - PlanarDigiProcessor_cepc
  - Example:

  <processor name="SITPlanarDigiProcessor" type="PlanarDigiProcessor_cepc">
- Option for multi-hits (ProduceMultiHits)
  - 0: no multi-hits
  - 1: multi-hits except delta ray
  - 2: all multi-hits

  <parameter name="ProduceMultiHits" type="int">2 </parameter>
- Relation
  - 1 SimTrackerHit $\Rightarrow$ n TrackerHit
  - 1 TrackerHit $\Leftarrow$ n SimTrackerHit
- New parallel processor to deal with m-n relation
  - SpacePointBuilder_cepc

Validation

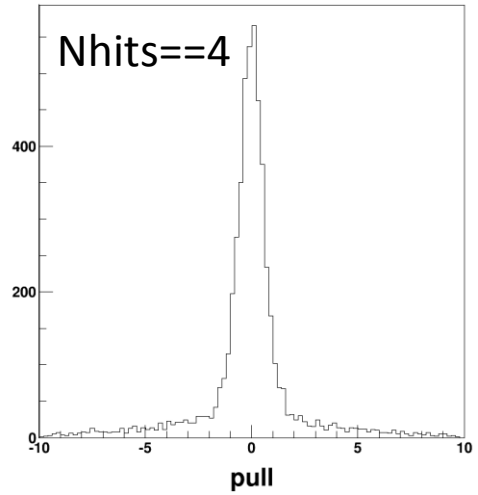
- Hits level
- Reconstruction level
- MC truth match algorithm
  - Use LCRelation only to link reconstructed track to MC truth track, cut on number of hits
  - Find out all possible hits close to track, linked MC particle requirement
    - Has >=3 hits
    - Most hits than others

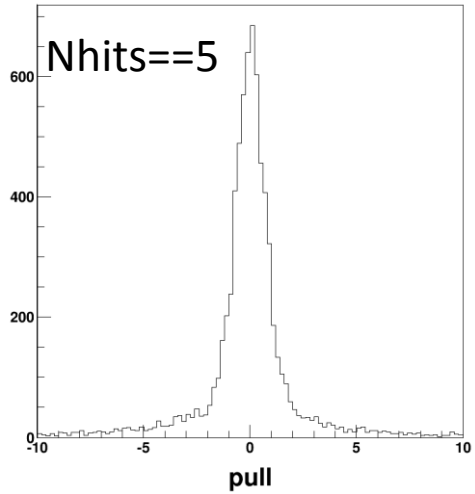


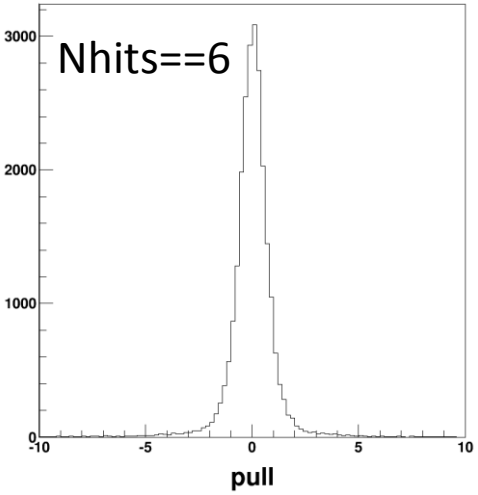
Possible to use neighbor hit, from delta-ray, noise, etc.

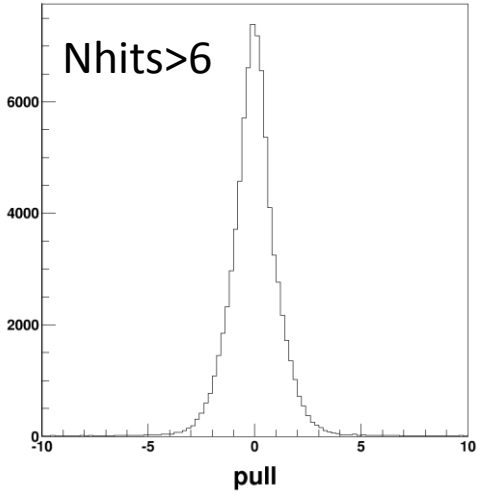
Pull of omega (ProduceMultiHits = 0)

- e2e2h sample (from Yu Dan)
- Estimation of covMatrix need to be updated

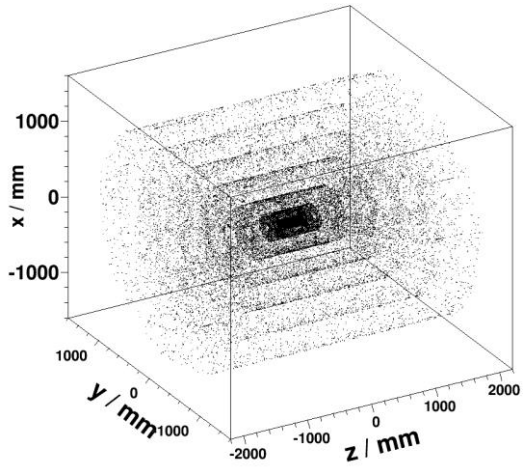


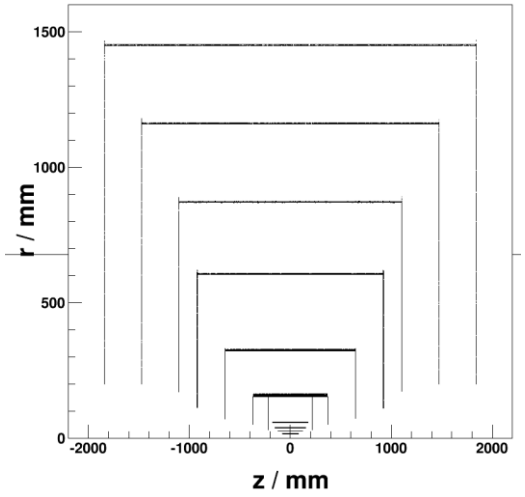


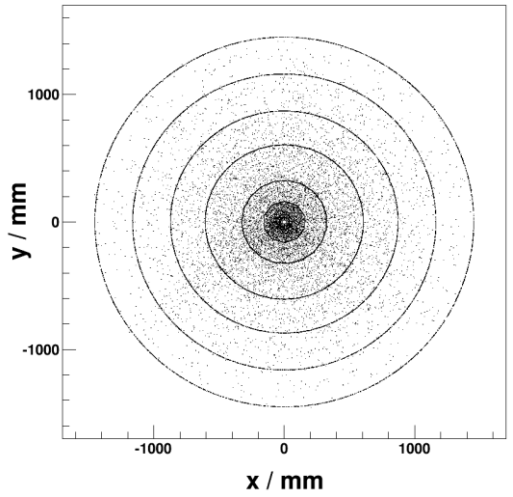


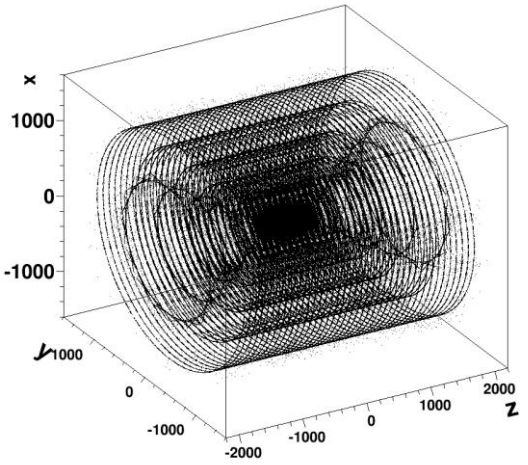


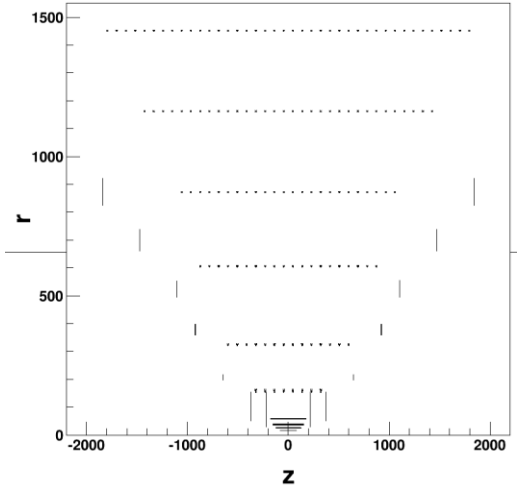
Hits before and after digitization

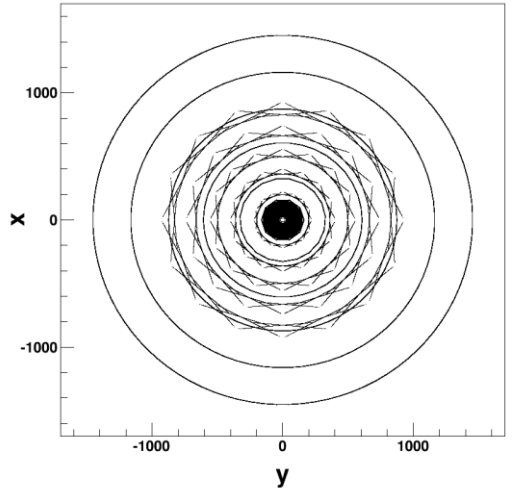








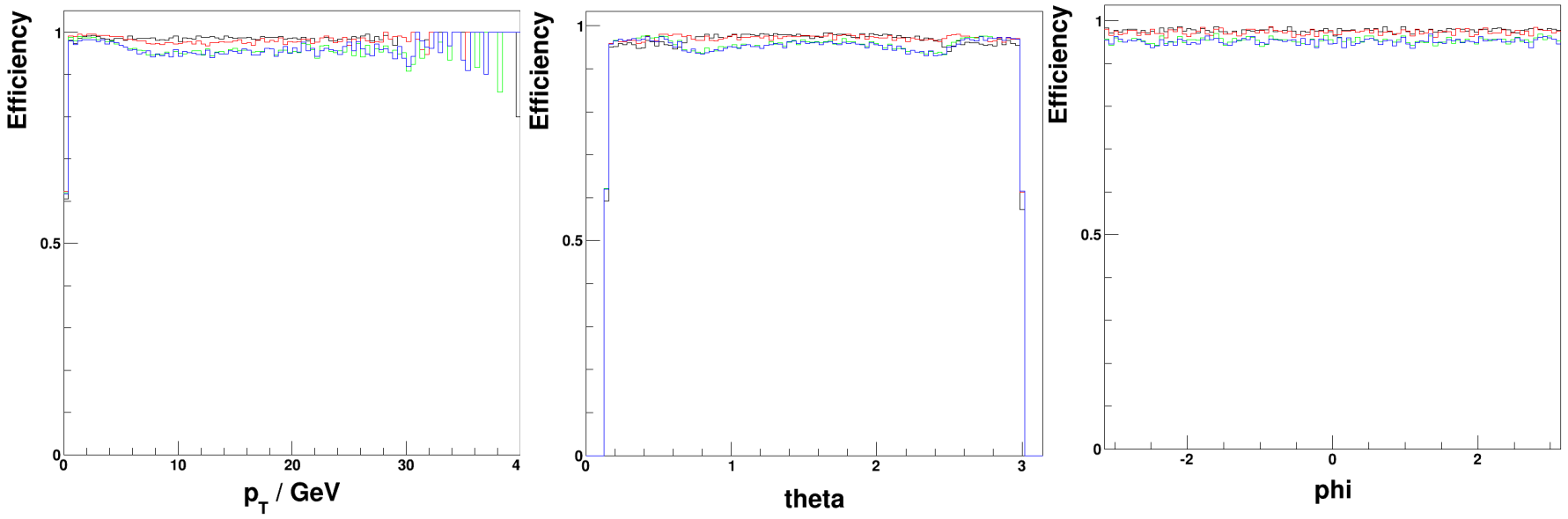




Efficiency of muon

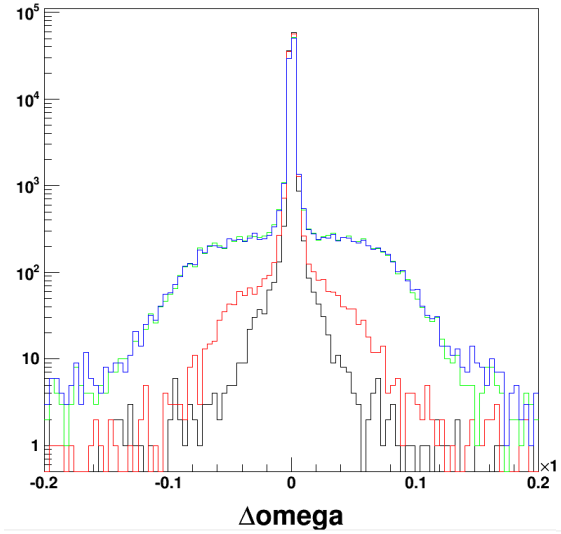
- particleGun
  - /gun/momentum 10 GeV
  - /gun/momentumSmearing 9.0 GeV

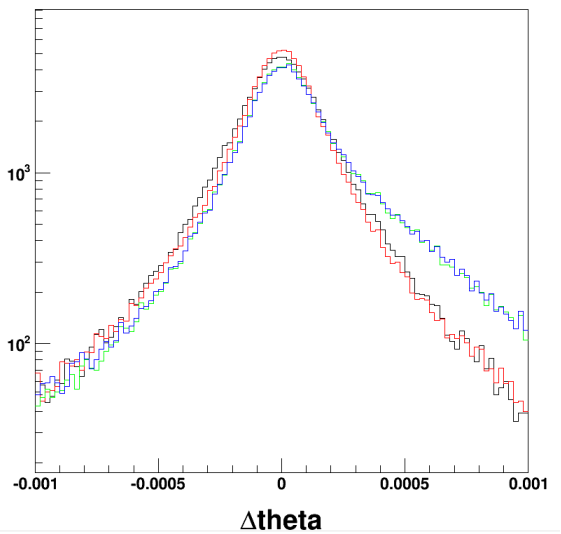
- Smear, ProduceMultiHits = 0, ProduceMultiHits = 1, ProduceMultiHits = 2

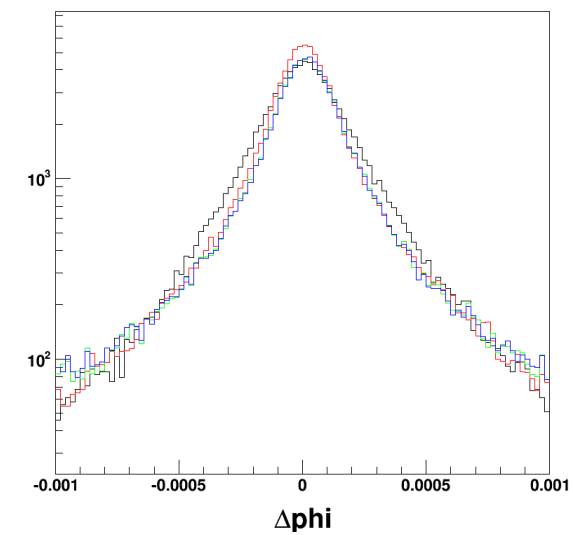


Input-output

- muon
- Pt>1GeV
- Smear, ProduceMultiHits = 0, ProduceMultiHits = 1, ProduceMultiHits = 2

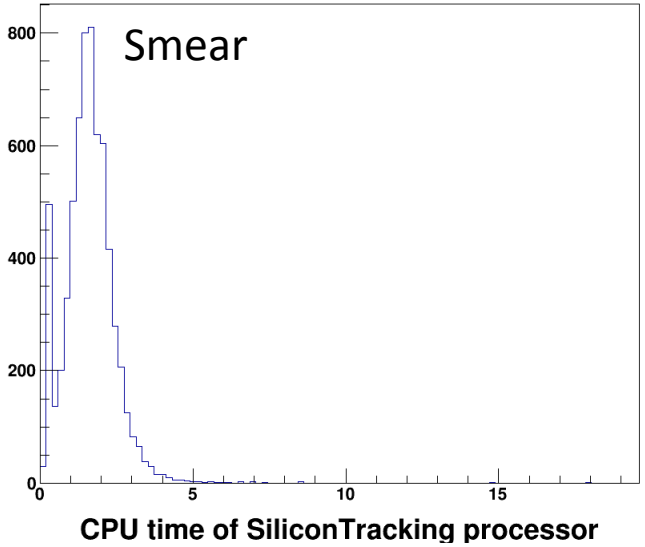


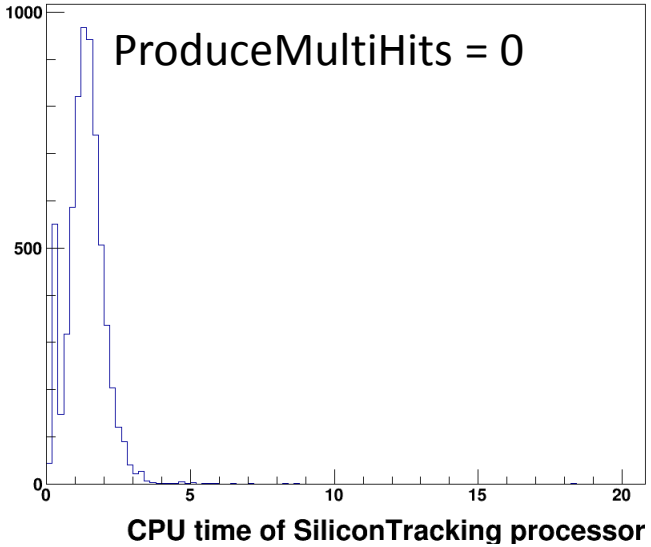


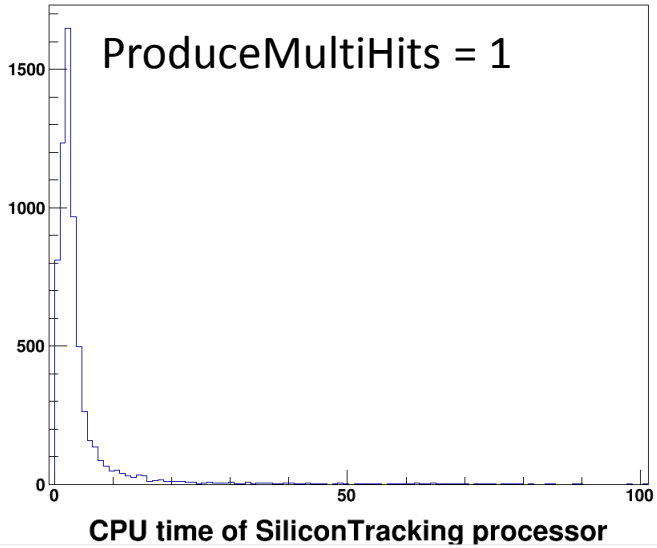


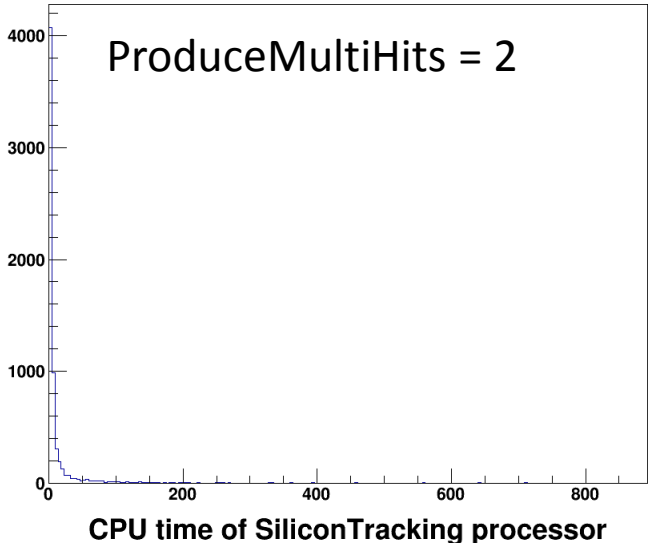
CPU Time

- e2e2h sample (from Yu Dan)









Outlook of tracking software for CEPC

- Through clustering, the CPU time of tracking will be reduced, while adding multi-hits

- More update for performance
  - Fix hit lost problem to improve efficiency
  - pull

Summary

- TPC and full-silicon tracker are both possible to be simulated for CEPC CDR.
- Performance with new digitization (ProduceMultiHits = 0) are close to smearing case.
- Reconstruction should be updated if multi-hits are included.

Thank you!