Software and Reconstruction @CEPC

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- A high energy **C**ircular **E**lectron **P**ositron **C**ollider (CEPC) is being planed as a Higgs and/or Z factory in future. The CEPC project is on the stage of CDR.

Pre-CDR	**CDR**	TDR	…
2015	**2018**	202?	

- In order to study and optimize the CEPC detector, software as tools is necessary, which include simulation and reconstruction.

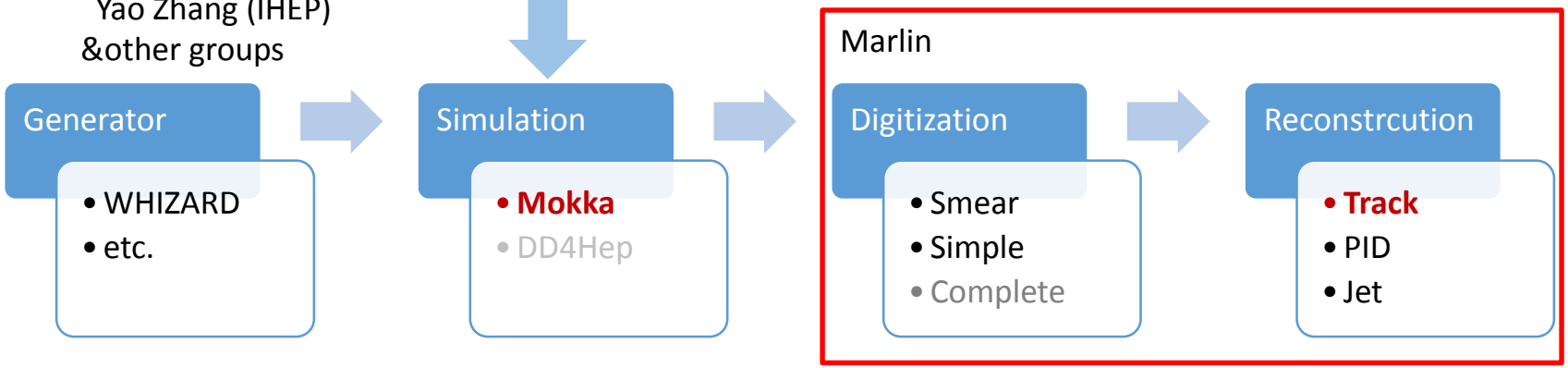
Man power:

Chengdong Fu (IHEP)
Gang Li (IHEP)
Manqi Ruan (IHEP)
Yin Xu (Nankai)
Yao Zhang (IHEP)
&other groups

Detector model

As quick starting, following ILC software is taken.

- ■ Bug fix
- ■ Algorithm develop
- ➢ Server for physical study and detector optimization
- ➢ Aim to software framework development



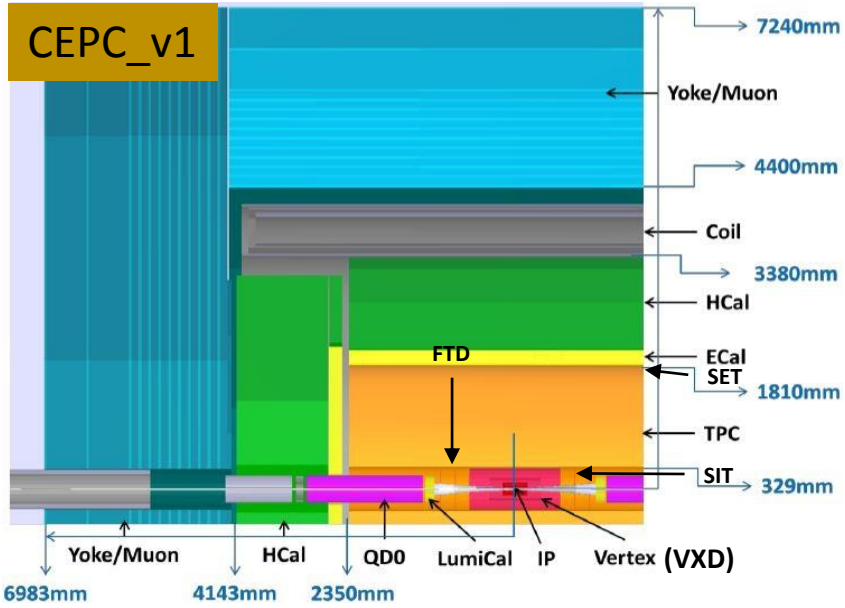
Simulation Tool—Mokka

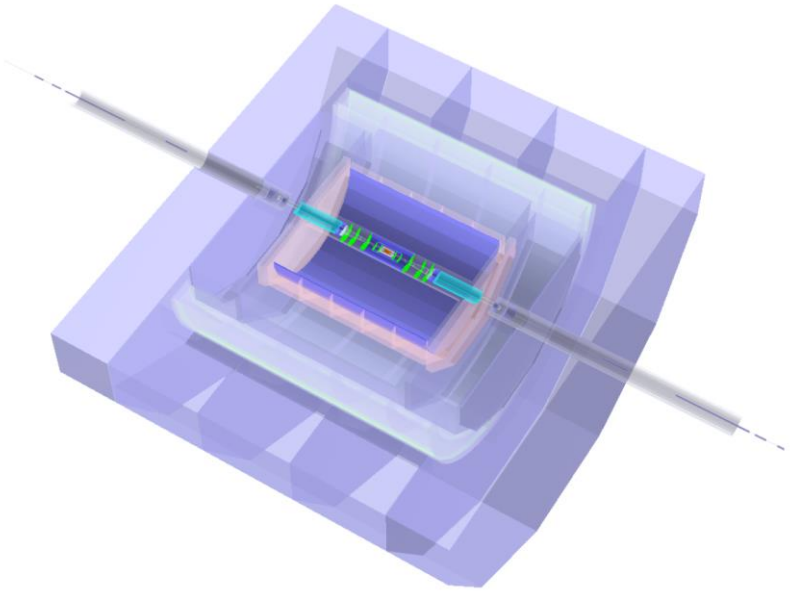
- **M**odellierung mit **O**bjekten eines **K**ompakten **Ka**lorimeters
- Object Modeling for compact calorimeters
- Mokka is a Geant4-based full simulation framework, in the original version, its detector data driven model is strongly based on MySQL
  - Store models information
  - Store geometry parameters

- It is modified to break away from database partly, in order to compact new sub-detectors quickly and modify them flexibly.
  - Add new sub-detector into CEPC model
  - Input parameters through steering file
- New more type of sub-detectors have been built.
  - A simple general calorimeter: silicon-based, BGO, LGO, Scintillator, THGEM, RPC, LYSO, BC420…
  - Silicon-based tracker: replace TPC

CEPC Detector Model

- For simplicity, the CEPC detector started from ILD, the International Linear Collider (ILC), another further electron positron collider.
- Models have been built and compared
  - CEPC_v1
  - CEPC_v2
  - User defined





Tracking @CEPC

- Clupatra
  - For TPC
- SiliconTracking_MarlinTrk
  - For silicon vertex detector

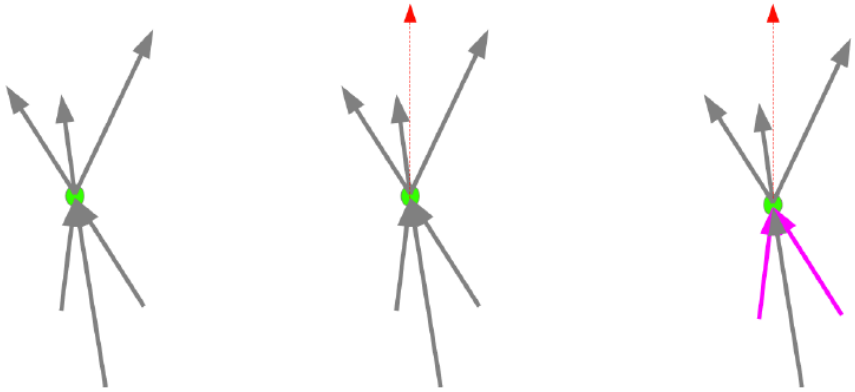
ILC/ILD

- General tracking
  - ArborTrk:
    - Arbor is a clustering algorithm used for calorimeter reconstruction. [arxiv:1403.4784]
    - The hit structure of TPC is similar with calorimeter: hits have neighbor at any direction.
    - Ongoing
  - GenFit

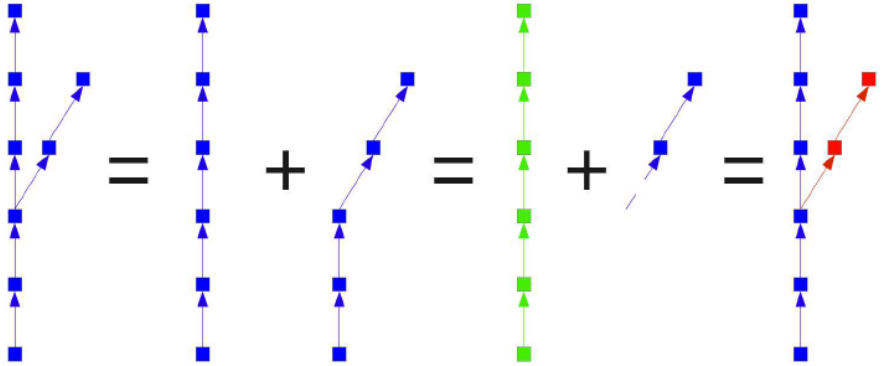
Arbor

- Arbor link any two closed (distance smaller than threshold) hits by connector (orientated arrow) first

- Clean connectors of hits⇒tree
  - One entry connector for each hit

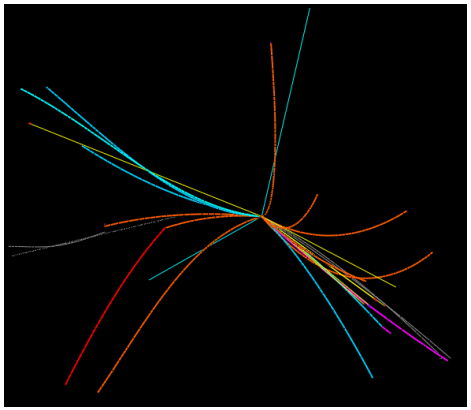


- Separate tree⇒branch



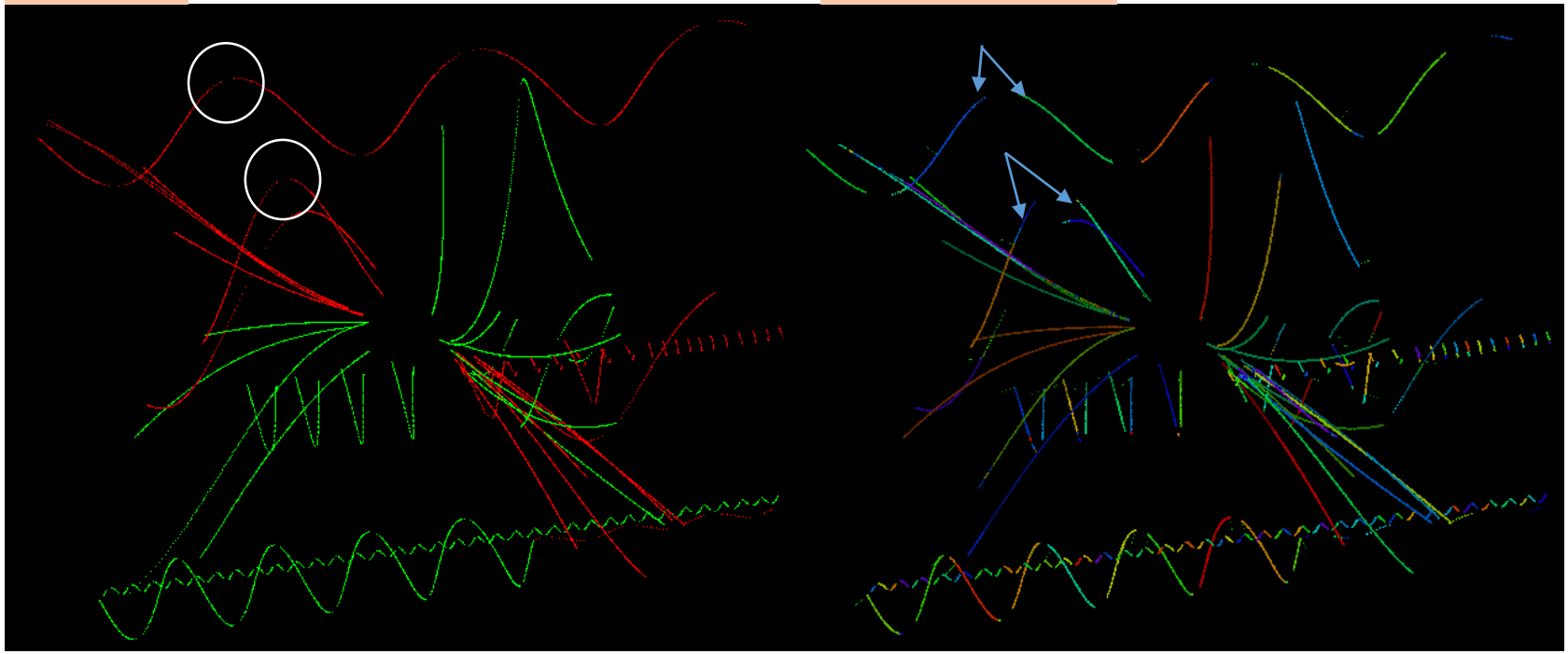
The branch composed by hits in TPC will just be candidate track.

Higgs→νν̄H Example



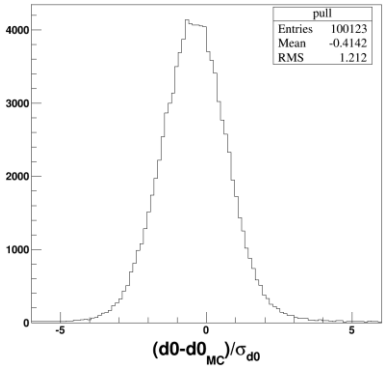
TPC hits

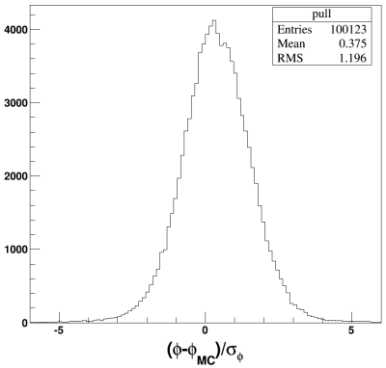
Arbor branchs

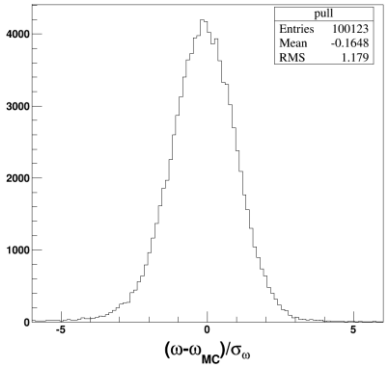


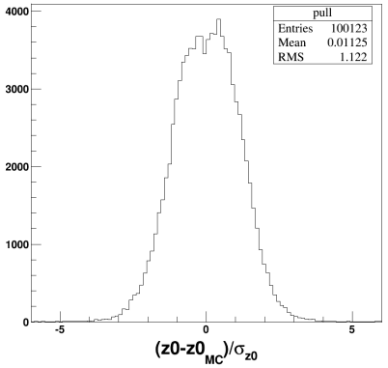
Pull Distribution

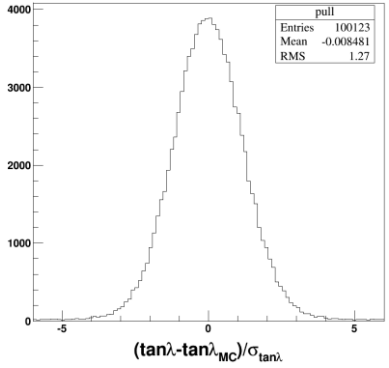
Single muon (0.5GeV,49.5GeV)

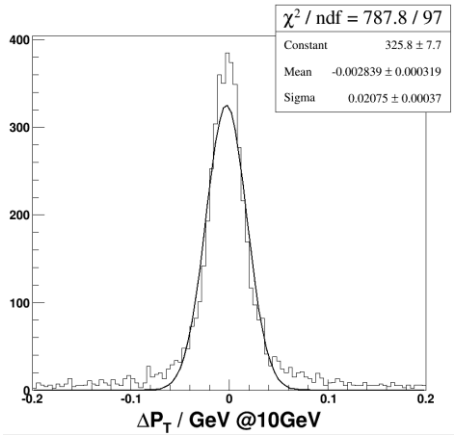




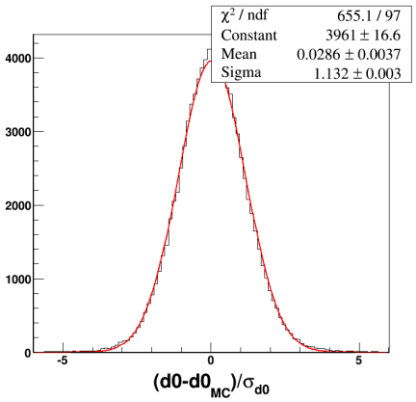


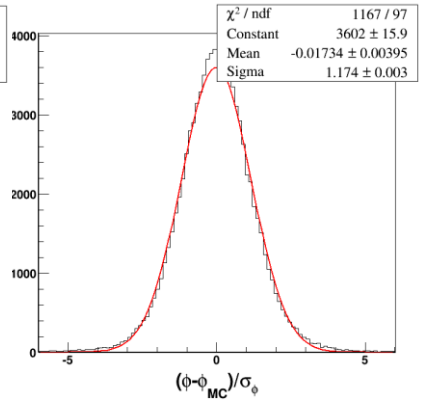






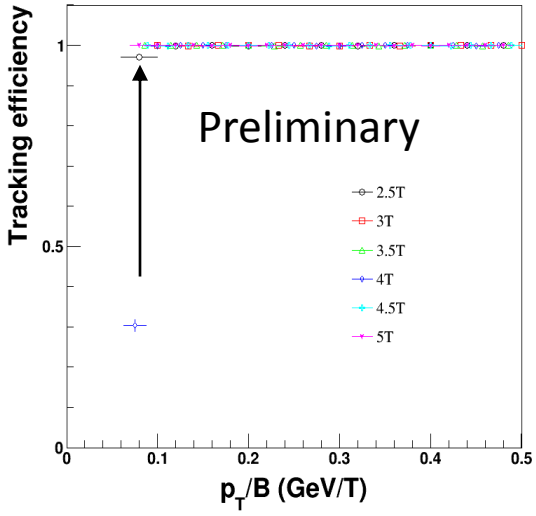
Add silicon hits (VXD, SIT/SET, FTD)



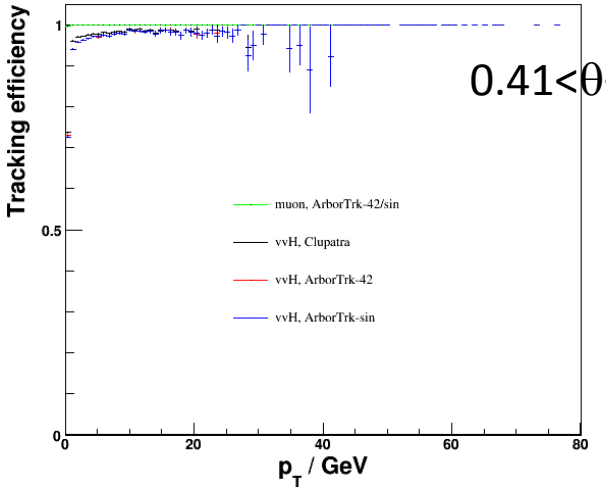


Tracking efficiency

- Tracking efficiency = N_{fit}/N_{MC}
  - N_{fit} : MC truth Particles matched with fitted tracks
  - N_{MC}: stable MC truth Particles, vertex inside beam-pipe
- The low limit of transverse momentum: ~0.08×B(Tesla) GeV
  - 280MeV at 3.5T
- Fake rate ~20% for vvH sample

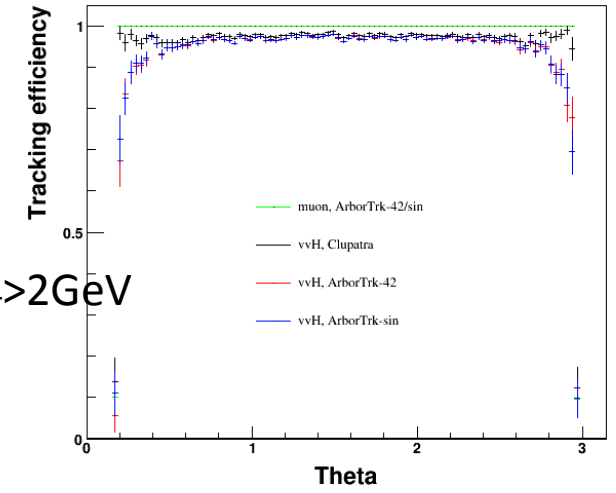


ArborTrk-42: threshold 42mm
ArborTrk-sin: threshold 16mm/sinθ



0.41<θ<2.73

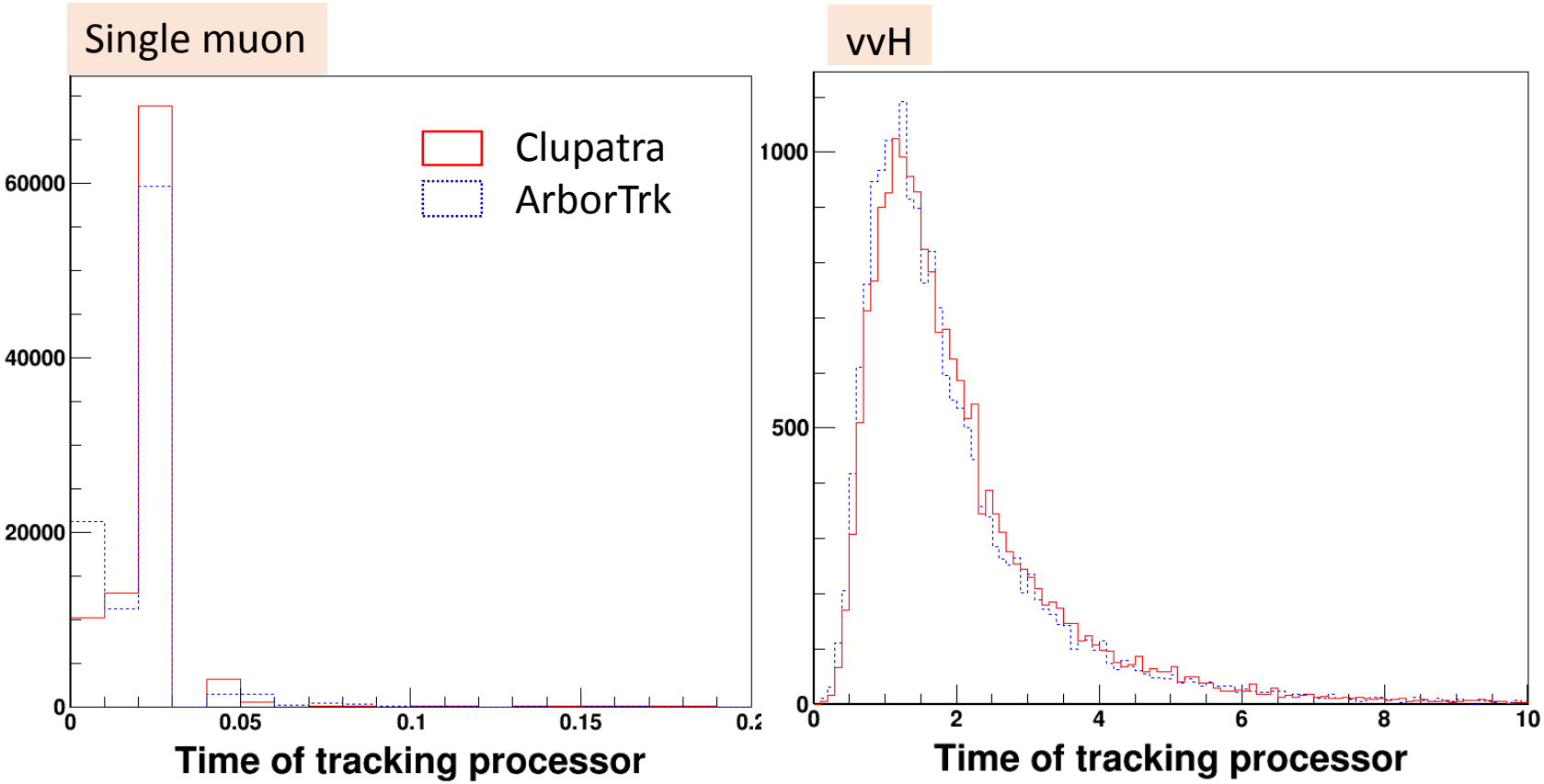
For single muon, ArborTrk and Clupatra both have high efficiency close to 100%, but for vvH, ArborTrk still has tracks to find back at small angel.



p_T>2GeV

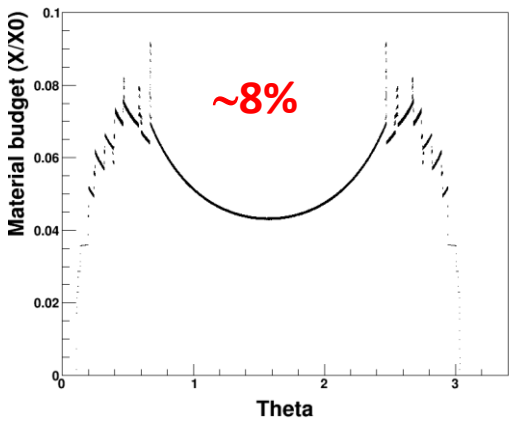
Time

- Average ~40 tracks per vvH event



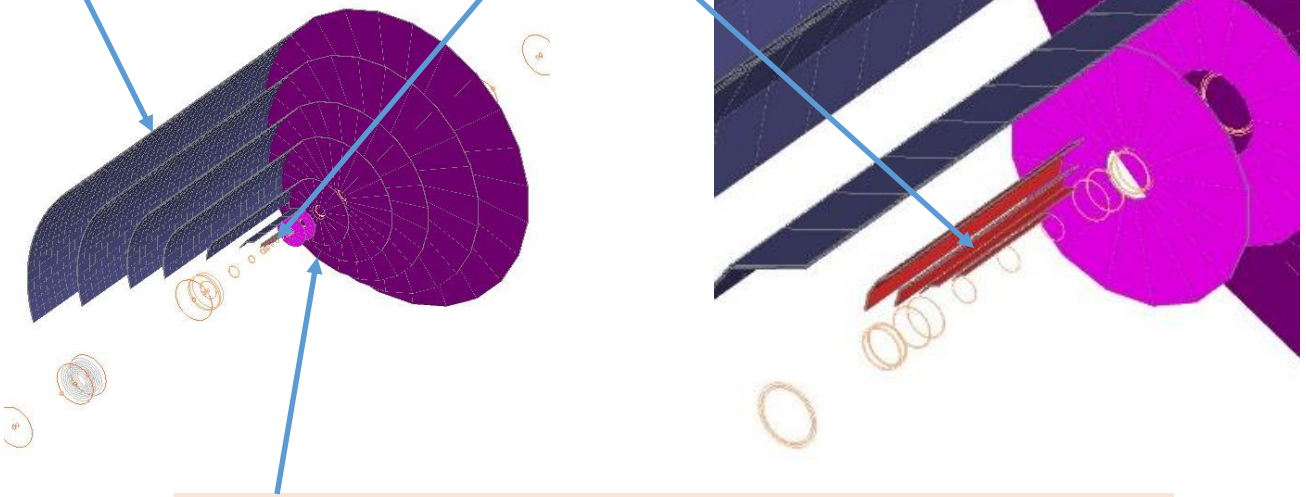
Full Silicon-based Tracker

- Preliminary designed by Weimin YAO (LBNL)



SIT: 6 double-layers

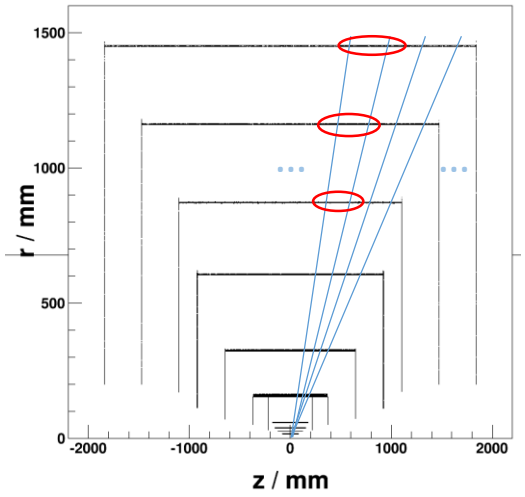
VXD: 3 double-layers

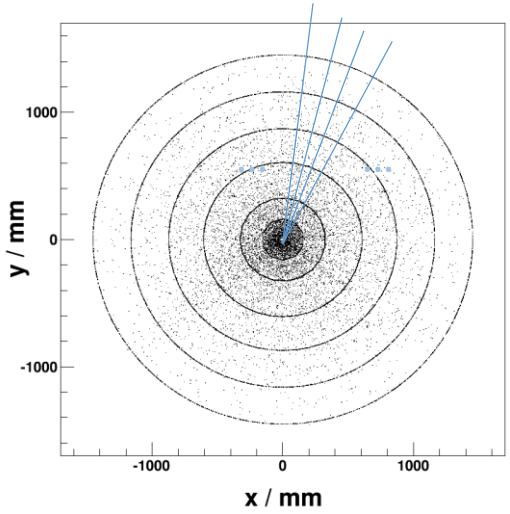


FTD: 2 single-layers of pixel + 5 double-layers of strip

SiliconTracking

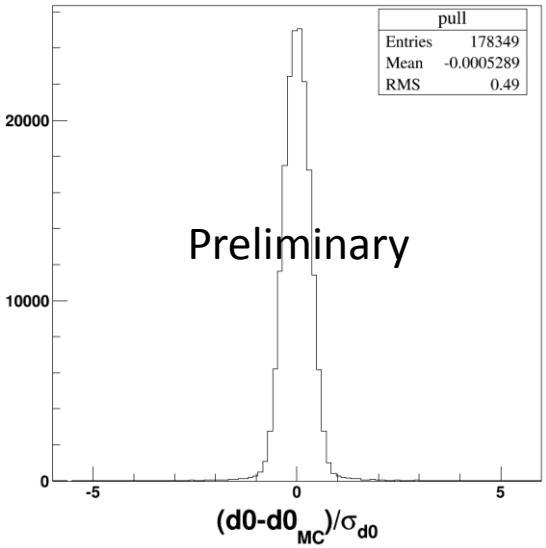
- SiliconTracking is one of algorithms in Marlin, used for tracking by VXD and SIT
  - Divide detector to theta-phi sectors for Triplet searching.

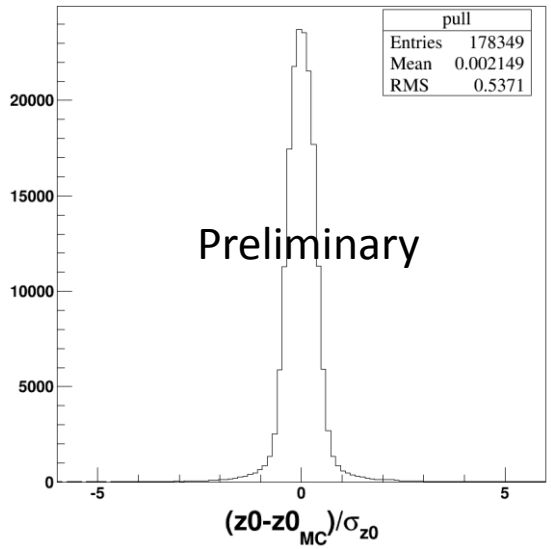




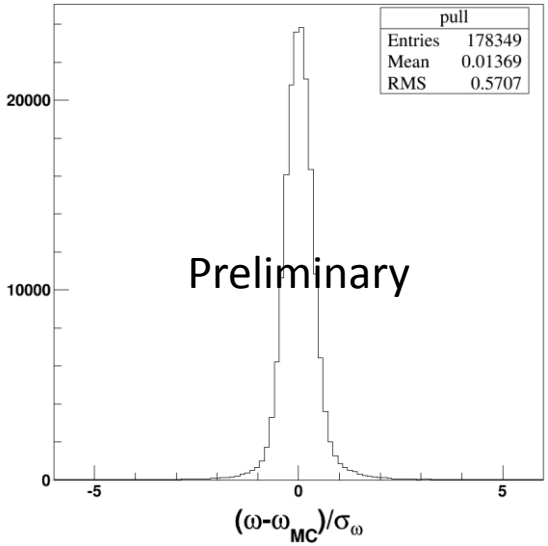
- This algorithm works well for only VXD and one SIT, now it is tried for more SITs. Some issues will happen.

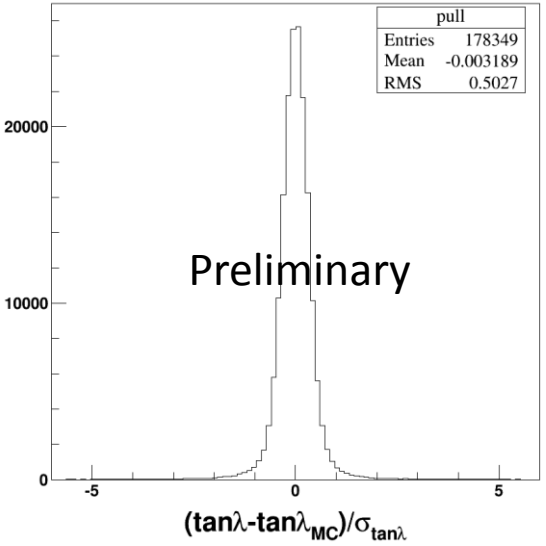
Pull Distribution

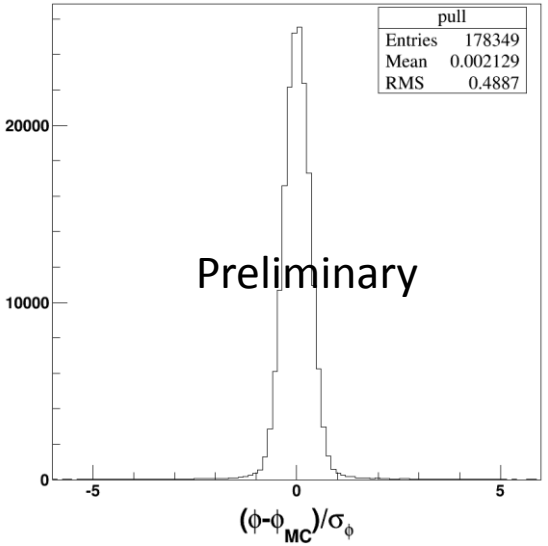




The pull distributions are narrow than (0,1) normal distribution, about half of, need to be fixed.



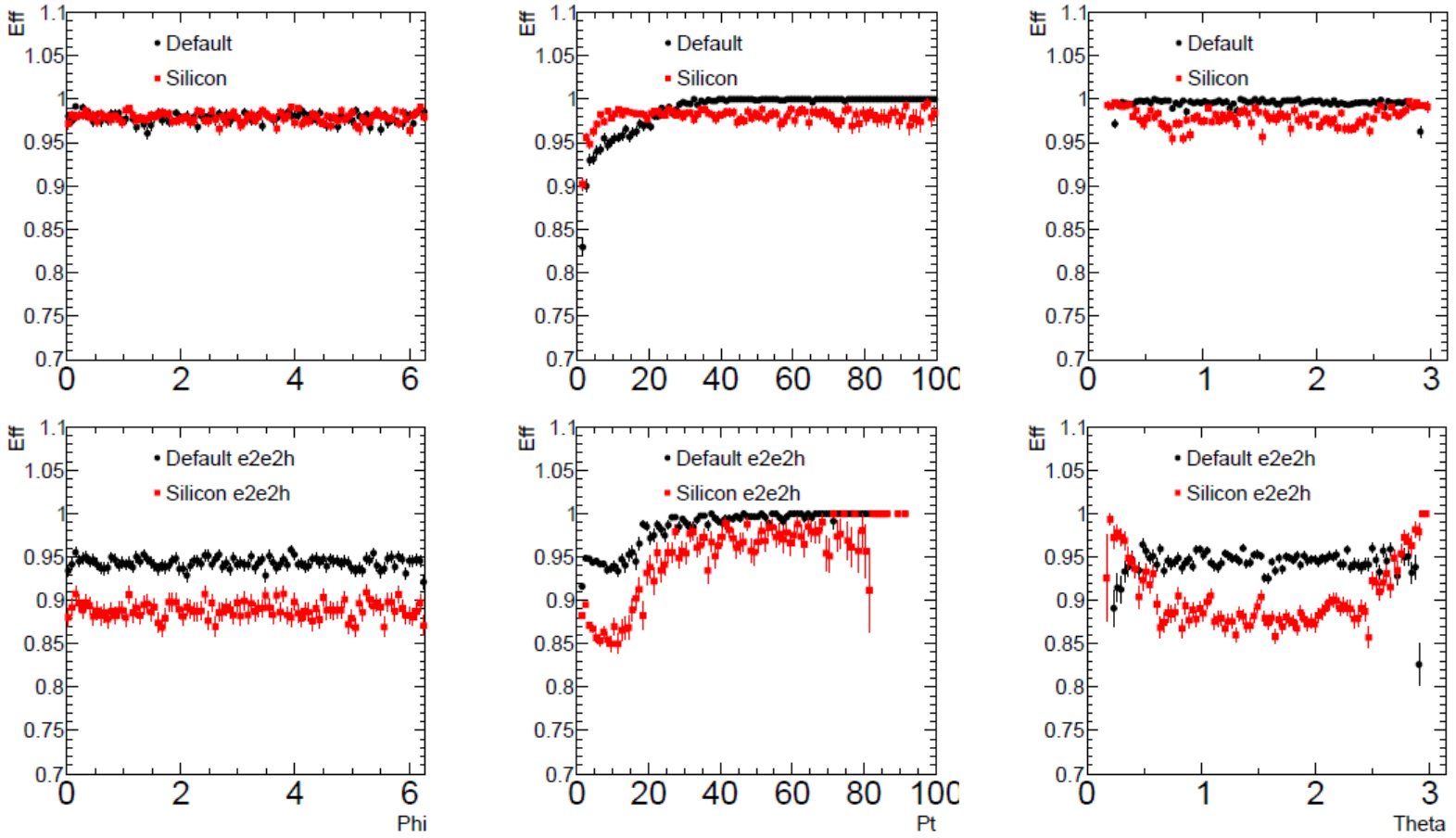




Tracking efficiency (Weimin)

http://cepc.ihep.ac.cn/ cepc/cepc_twiki/index.php/Pure_Silicon_Detector

- Tracking efficiency denominator:
  - Stable charged particle (Pt>1.0 GeV/c, $0.18 < \theta < 2.96$)
  - isDecayedInTracker=0
- Tracking efficiency numerator:
  - Matched based on most truth hits
  - $\delta\phi < 0.1$,
  - $\delta\omega/\sigma_\omega<100$, $\delta\theta/\sigma_\theta<100$, $\delta\phi/\sigma_\phi< 100$



Discussion and Next to do

- We have a workable software for CDR
  - ILC software based
  - New development:
    - simple general calorimeter
    - full silicon-based tracker : need to understand and fix efficiency loss
  - Bug fix

- A general tracking algorithm ArborTrk
  - For TPC, un-disappointed performance
  - improve tracking efficiency
  - Merge splited tracks

- Software for more sub-detector designs are ongoing, e.g. wire chamber, fiber-based dual readout calorimeter…

- Validation & release

Thanks