

Software for CEPC Ref-TDR

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on behalf of the CEPC software working group

CEPC Day meeting

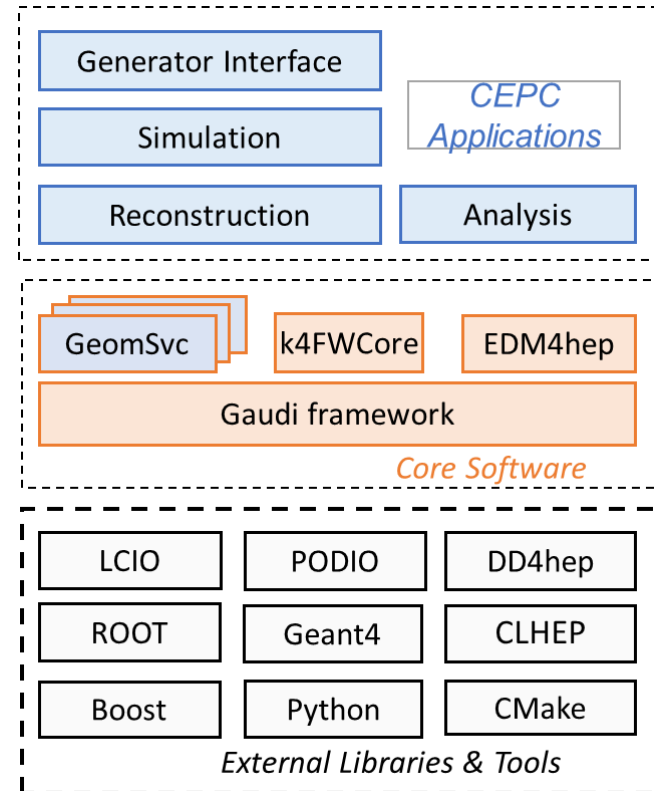
23-April-2024

CEPCSW Software Structure

❖ CEPCSW software structure

- Applications: simulation, reconstruction and analysis
- Core software
- External libraries

<https://github.com/cepc/CEPCSW>



❖ Core software

- Gaudi/Gaudi Hive: defines interfaces to all software components and controls their execution
- EDM4hep: generic event data model
- k4FWCore: manages the event data
- DD4hep: geometry description
- CEPC-specific components : GeomSvc, detector simulation, beam background mixing, fast simulation, machine learning interface, etc.

Work plan

- ❖ At the software meeting on 4th March, software release plan was discussed
 - <https://jupyter.ihep.ac.cn/faX6jrBATtGiKBfVbkLH5Q>
- ❖ Through 4 releases, put together all the software needed by Reference Detector studies
 - <https://code.ihep.ac.cn/cepc/CEPCSW/-/issues/1>

Software Progress (1)

- ❖ Release tdr24.3 (March 2024)
 - Key4hep related packages
 - Event data model
 - Simulation framework
 - External libraries

Software Progress (2)

- ❖ The TDR April version (tdr24.4.0) is released.
 - <https://code.ihep.ac.cn/cepc/CEPCSW/-/releases/tdr24.4.0>
 - `/cvmfs/cepcsw.ihep.ac.cn/prototype/releases/tdr24.4.0/setup.sh`
- ❖ 6 MR (Merge Request) are included:
 - The silicon tracking is updated by Chengdong (PR #269 in GitHub)
 - Update geometry GEAR parameter and HelixFit by Chengdong (MR !10)
 - Improve the performance of TPC Clupatra tracking by Chu Wang (MR !11)
 - Add 32 polygon crystal ECAL geometry by Fangyi (MR !9)
 - Allow to generate multiple particles from beam-related backgrounds by Tao (MR !12)
 - Add ref-TDR Geometry by Chengdong (MR !13)
- ❖ Merge Requests will be included in the tdr24.4.1:
 - Add Tracking algorithm based on CKF from Belle2 by Mengyao (MR !6)
 - Support ROOT based input of beam bkg simulation by Fangyi (MR !15)

Software Release in April

- ❖ Release tdr24.4 (April 2024)
 - Background event mixing
 - Software for silicon detectors
 - Software for TPC
 - Software for drift chamber

Beam-related Background Simulation

- ❖ Simulation tool is available in [git](#):
 - Support the simulation of 2 types of beam background processes:
 - Single beam background: sampling N particles from the dataset, $N = \text{beam process rate} * \text{detector time window}$.
 - Luminosity background: 1 ROOT file for each bunch crossing, randomly choose 1 file from the dataset.
 - Need the info from MDI and sub-det groups:
 - Beam process samples.
 - Beam process rate estimation.
 - Sub-detector system time window.
 - Would be good if detector group could have a try.

Silicon Tracking SW

❖ Geometry

- Two preliminary versions have been built
 - long barrel vertex
 - Short barrel vertex + endcap vertex
- Updating according to design of vertex and inner tracker

❖ Digitization

- Fixed spatial resolution
- Parameterized according to incident angle: need input

❖ Track reconstruction

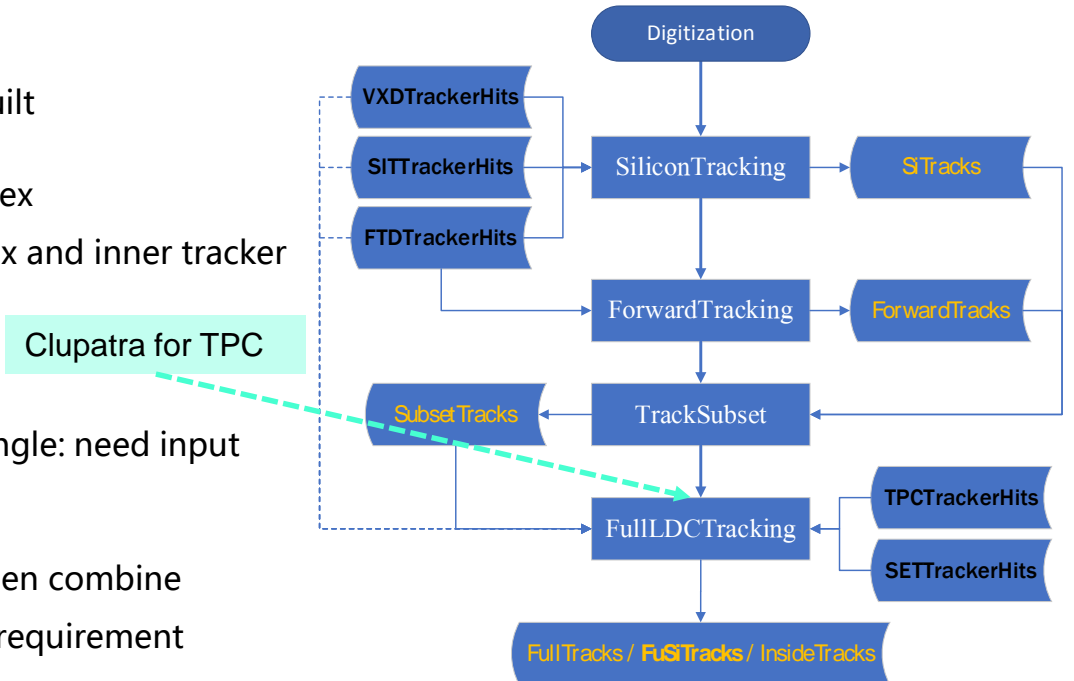
- Barrel tracking, endcap tracking and then combine
- External hit to add according to study requirement
 - Outer tracker hit
 - TPC/DC hit

❖ Optimization ongoing

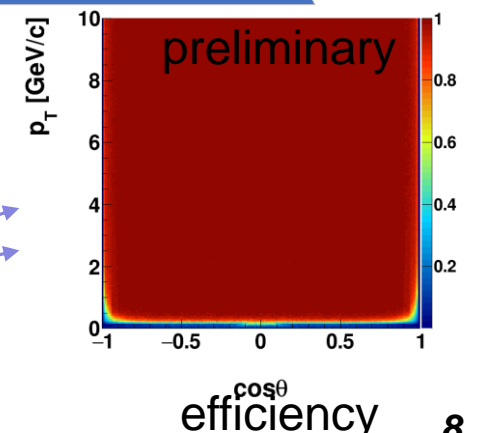
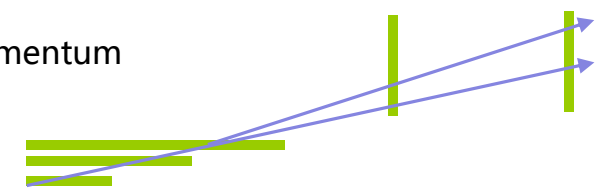
- Based on tracker design
- Efficiency of forward region at low momentum

❖ First release

- Two track chain for different vertex



Large distance caused by multiple scattering far away



TPC Tracking SW

❖ Geometry

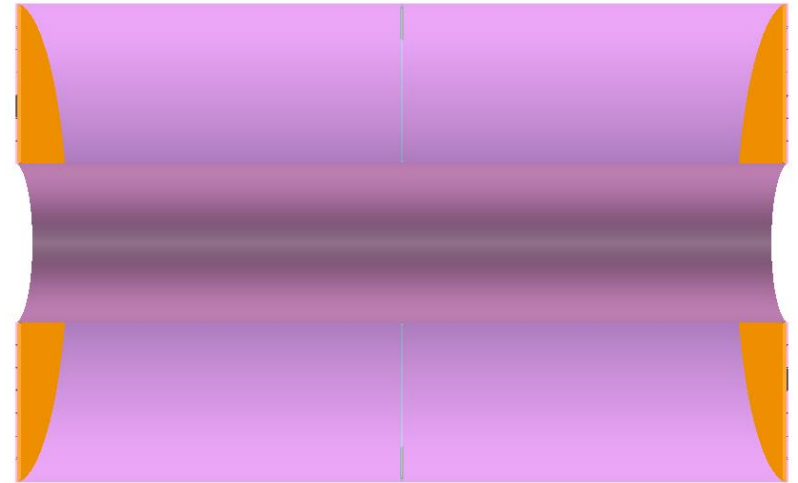
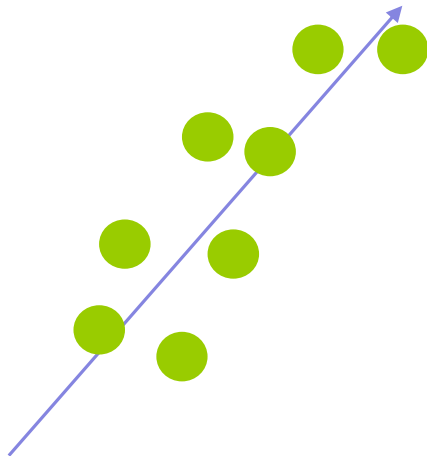
- Update to 600-1800mm
- Optional pad or pixel size
- At least one guy will join for more detail update

❖ Track reconstruction

- Standalone track finding and Kalman filter
- Combine with tracks from silicon tracking

❖ Issue for pixelated readout

- Worse spatial resolution for single hit
- Worse initialization for track seed



❖ Optimization ongoing (WANG Chu)

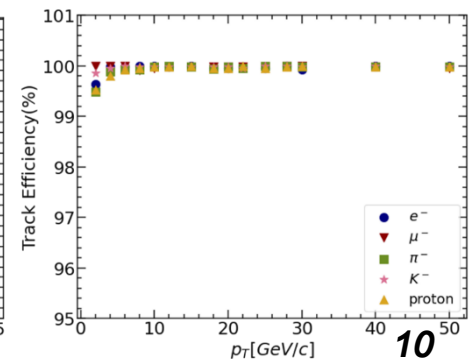
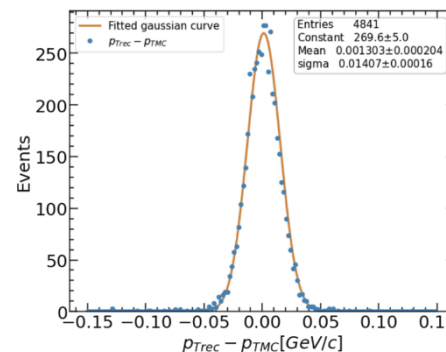
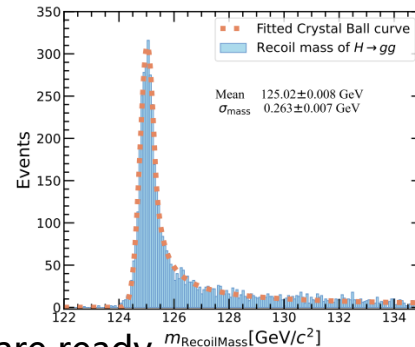
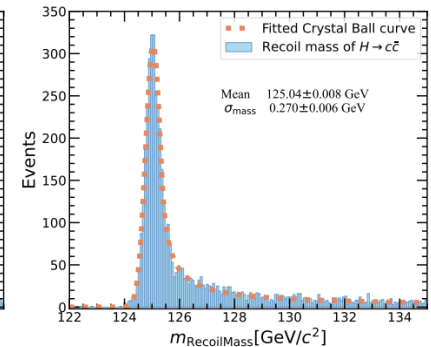
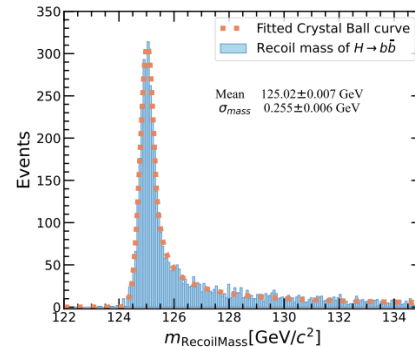
- Track seed & cut
- Digitization & clustering: merge multi hits to one hit, close to CDR tracking, but better spatial resolution while merging hits in each 6mm height (according to ZHAO Guang's study)

❖ First release

- Tracking for one hit in each 6mm

DC Software

- ❖ Physics events:
 - Check the recoil mass of higgs boson
 - $e^+e^- \rightarrow \mu^+\mu^-H, H \rightarrow b\bar{b}, c\bar{c}, gg$
- ❖ Updated DC geometry parameters
 - inner radius: 800mm \rightarrow 600mm
 - Diameter of field wire: 40 μ m \rightarrow 60 μ m
- ❖ DC software be ready and released
 - The compact file of new DC geometry
 - DC_Simple_v01_06.xml
 - CKF algorithm as an external project
 - The codes of simulation and reconstruction are ready
 - good performance and meet requirements for tracker
 - $\sigma_{p_T}/p_T \approx 0.14\%$
 - Track efficiency close to 100%
 - To be released new version before **24.04.25**



Software Releases in May and June

- ❖ Release tdr24.5 (May 2024)
 - PID simulation at track level
 - Software for muon detector
- ❖ Release tdr24.6 (June 2024)
 - Software for Calorimeters

PID Software

❖ dN/dx in gaseous detectors

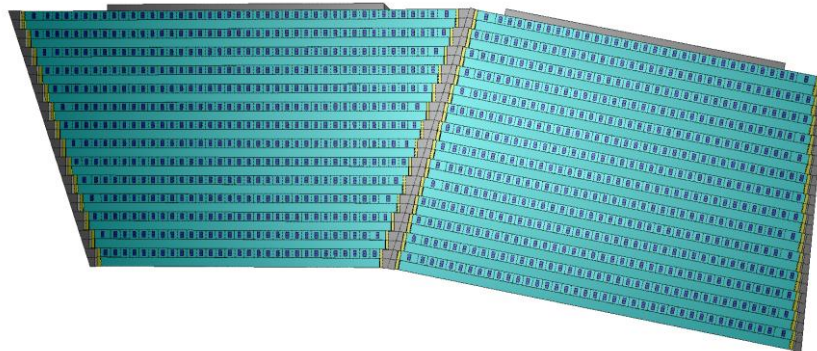
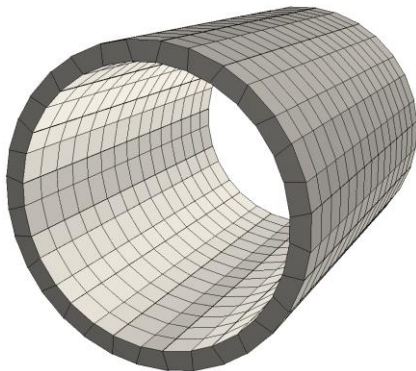
- Goal: To implement a track-level parameterization model.
- Status:
 - Drift chamber: Working on a parameterization model with machine learning reconstruction. To make the implementation in CEPCSW.
 - Time projection chamber: Working on the pixel-size optimization.

❖ Time-of-flight

- Goal: To implement a track-level parameterization model.
- Status:
 - There is no datatype related to ToF information in EDM4hep. Will create a new datatype in EDM4hep.

Calorimeter software

- ❖ New geometry for Ref-Det in CEPCSW Rel. tdr24.4.0 (By Weizheng)
 - 32-polygon crystal bar ECAL
 - Inner R = 1900mm, outer R = 2200 mm, Z length = 5900 mm.
 - Dead material in the crack region are considered: total width ~ 20 mm. Including: supporting, electronics, cooling.
 - 16-polygon glass tile HCAL with AHCAL symmetric layout.
 - Glass + steel, totally 48 layers, glass tile size 40 * 40 mm.
 - Still updating with mechanical and electronic design.
- ❖ Digitization and reconstruction: migrating to the new geometry and validating the performance.



CEPCSW Training

❖ The 3rd CEPCSW training on Apr 22nd.

- The major goal is to support the detector development.
 - 3 Sub-detectors: MUON, ECAL, TPC
 - 9 Students & Postdoc from IHEP and 4 Universities
 - Wuhan University, Nankai University, Shandong University, South China Normal University
 - 6 hours tutorial and hands-on by the 3 tutors from software group
 - Overview of CEPCSW, Tao Lin
 - CEPCSW Core Software, Jiaheng Zou
 - Detector description & Simulation, Chengdong
 - Hands-on
-
- The 1st training: Dec 27-29, 2023, [tencent docs](#)
 - The 2nd training: March 8th, 2024, [indico link](#)

CEPCSW Training (24.04.22)

会议信息

地点: 多学科 226

时间: 09:00 - 15:00

Zoom Link

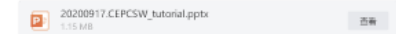
Topic 主题: CEPCSW Training
Meeting ID 会议号: 93027587744
Begin Time 开始时间: 2024-04-22T09:00:00
Duration 持续时间: 360
Meeting URL 会议链接:
<https://zoom.us/j/93027587744?pwd=omhMdkJkZjNlU243TWVhYnVseDFlZDZ09>
HostKey 主持人密钥: 844341
Password 会议密码: 687838

Agenda

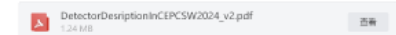
- CEPCSW 介绍, 林韬



- CEPCSW 软件框架介绍, 郭佳恒



- 探测器几何与模拟, 傅成栋



- Hands-on

技术细节

- 关于 DDH 远程连接时的探测器可视化, 林韬
 - 可视化命令: `geoDisplay -input DetectorDetCRD/compact/CRD_o1_V01/CRD_o1_V01-onlyTracer.xml`
 - Linux 系统的 X server 应该能够支持
 - macOS 和 Windows 可能会有问题。
 - 这里介绍采用 VNC 连接的方式。
 - 在 `linux7` 上面设置 vnc 密码: `vncpasswd`
 - 执行 `~init/bin/vncserver` 启动 VNC server, 需要知道主机名和端口。
 - 在本机执行 VNC 客户端去连接 VNC 服务端, 这里使用 TigerVNC

问题收集

[Tencent docs](#)

Thank You !

谢谢