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Status of CEPC ref-TDR Chapter06

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On behalf of the gaesous tracker group

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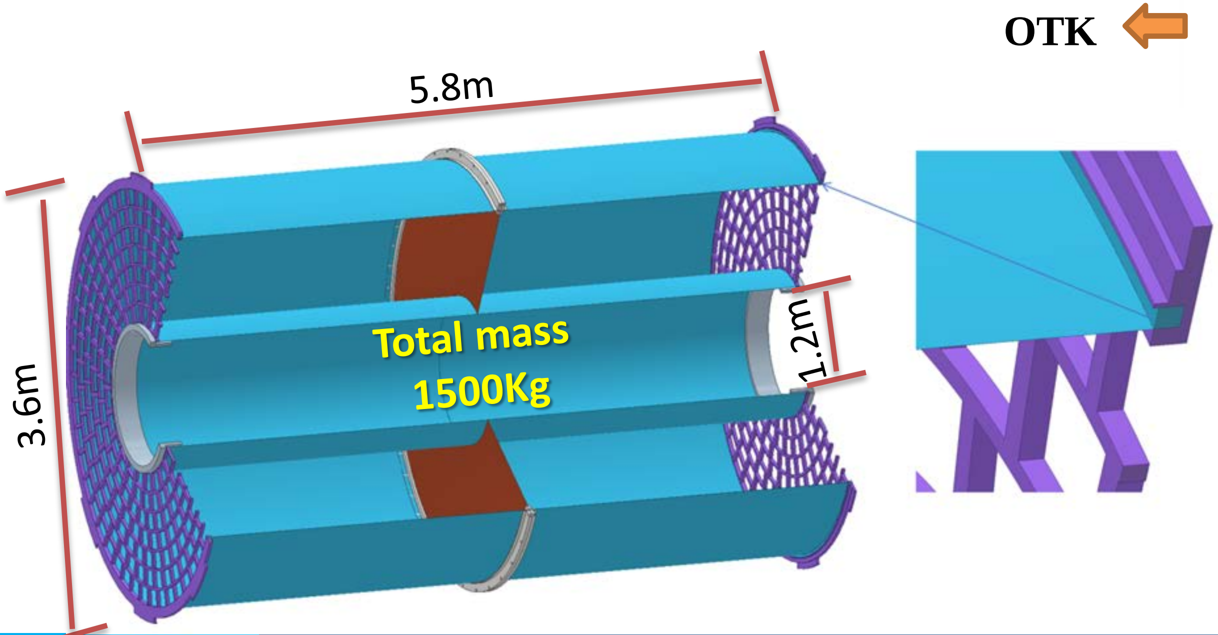
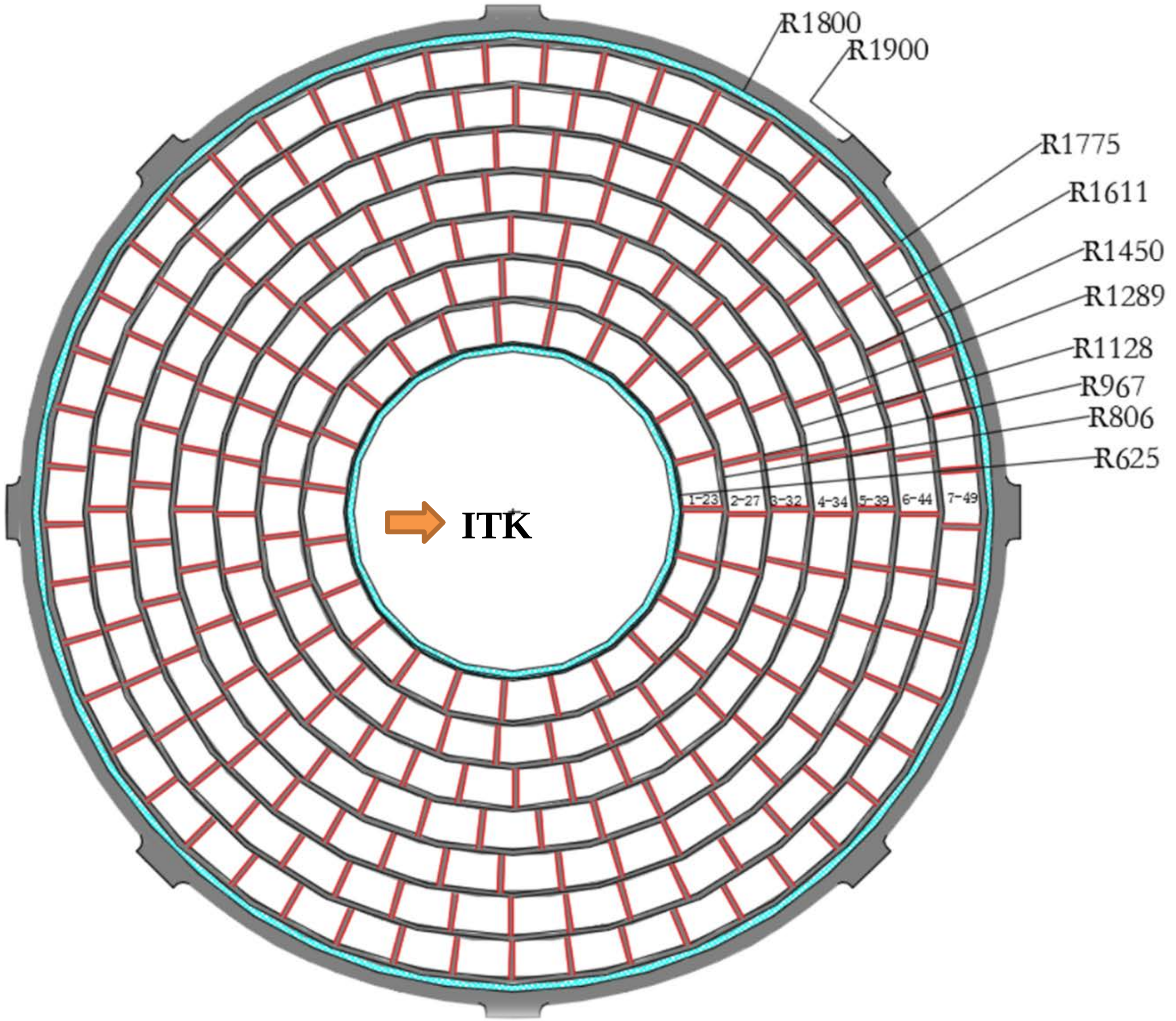
Content

- **Status of Chapter6**
- **Timeline of the editing**
- **Work plan and discussion**

Detailed design of mechanics

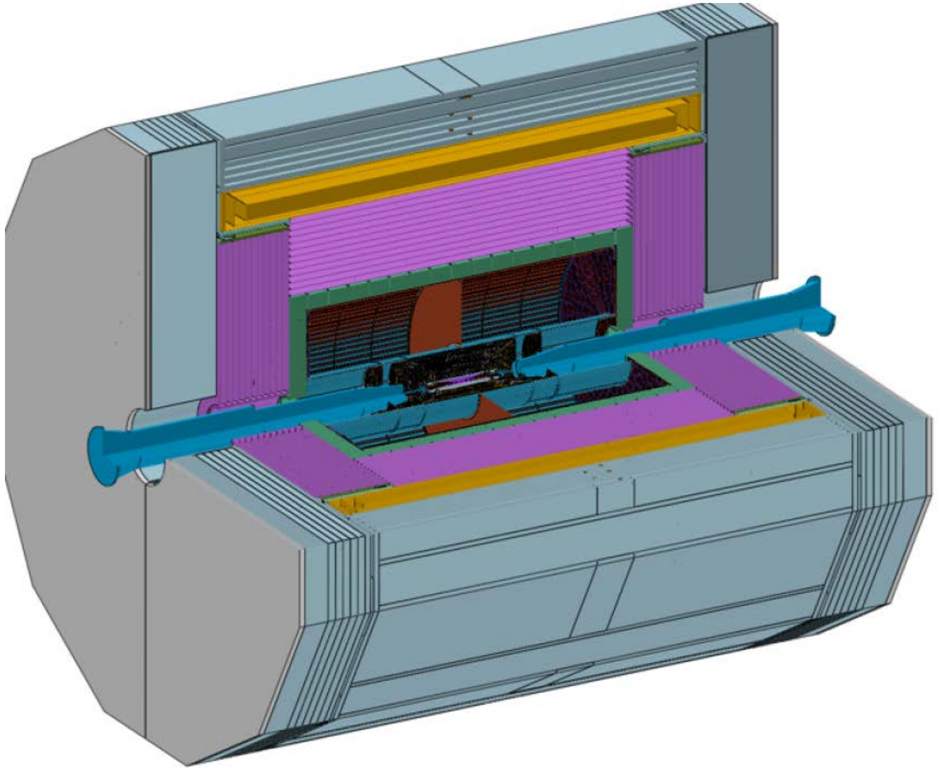
TPC detector	Key Parameters
Modules per endcap	248 modules /endcap
Module size	206mm×224mm×161mm
Geometry of layout	Inner: 1.2m Outer: 3.6m Length: 5.9m
Potential at cathode	- 62,000 V
Gas mixture	T2K: Ar/CF4/iC4H10=95/3/2
Maximum drift time	34μs @ 2.75m
Detector modules	Pixelated Micromegas





Detailed design of TPC detector in ref-TDR

Status of Chapter6



Technical Design Report of the CEPC Reference Detector

Technical Design Report of the CEPC Reference Detector

Author: the CEPC study group
Institute:
Date: June 9, 2025
Version: 0.1
Bio: Information

Status of Chapter6

https://www.overleaf.com/project

Chapter 1 Gaseous Tracker

1.1 Physics requirements

The CEPC gaseous tracker has been designed to optimize physics performance while respecting operational constraints. The operational environment is relatively benign compared to that at a hadron collider. The magnetic field needs to be at least 3T to confine electron pairs from beamstrahlung to within the beam pipe. Even so, the first vertex layer cannot be closer than 15mm to the beamline. The bunch structure does not give strong constraints: the very short idle period between bunches facilitates the use of triggerless readout schemes and allows for power pulsing in the front end electronics to save power, which limits the necessary cooling power and thus minimises the amount of associated material.

There are also important physics performance considerations. At 250 GeV, Higgs strahlung is the dominant Higgs production mode. Independent from its decay mode, the production of a Higgs boson can be inferred through the detection of the associated Z boson, allowing unambiguous cross section measurements. The Z boson is selected by its momentum, which puts stringent requirements on the tracker. The tracker has to be highly efficient and have excellent resolution. In order to make sure that the Higgs recoil mass measurement in the channel $e^+e^-\to$H, Z$\to \mu^+\mu^-$ is dominated by the beam energy spread, the asymptotic momentum resolution goal is set to $\sigma_1/P_T = 2\times10^{-5}$GeV^{-1}.

The Higgs boson decays need to be differentiated by quark and lepton flavor, requiring great flavor tagging. This requires a high precision and low material vertex detector, as well as a calorimeter with sufficient granularity to identify leptons in jets. The calorimeter performance requirements are predominantly set by the need to identify top quarks, W bosons and Z bosons. This requires good spatial separation and a jet energy resolution σ_E/E of better than 4%, which can be achieved by particle flow calorimetry. In particle flow, information from the trackers and the calorimeters is combined to acquire the best possible jet energy resolution. The performance is optimal when the calorimeter clusters are well separated and can efficiently be matched to tracks. Therefore the calorimeters are highly granular and placed inside the coil, close to the tracker.

The main goal of the tracking detectors is to measure the trajectory and momentum of charged particles. A charged particle leaves a trail of detectable interactions called hits in the tracker that can be reconstructed as a track. From the curvature of the track in the magnetic field, the momentum is determined. If an interaction produces multiple tracks, the point of interaction, called the vertex, can be reconstructed. In order not to disturb measurements in the tracker and in the more outward detectors, the amount of material has to be minimized. The CEPC tracker consists of a number of silicon trackers and a Time Projection Chamber (TPC). The most central detectors are silicon trackers, which have an excellent position resolution important for the reconstruction of the vertex and to determine the direction of the particles. Silicon trackers require a relatively large amount of material per measurement point, so only a few measurement points are taken. Around the central silicon trackers a large TPC is foreseen. As a gaseous detector, the amount of material per measurement point is relatively small. Therefore the TPC takes a large number of measurement points to aid pattern recognition, over a large radial distance for a precise determination of the momentum. In addition, the gaseous TPC can identify particles by the characteristic energy loss dE/dx.

The tracker requirements are mainly set by lepton momentum measurements from Z boson decays in the Higgs recoil measurements. For a centre-of-mass energy of 500 GeV, the Higgs decay to two muons is seen as a benchmark for high momentum tracks. The flavor tagging requirements of jets with c and b quarks drives the vertex detection requirements. The primary benchmark process is the Higgs branching ratio measurements to these types of jets. The minimal required resolution is μm level in both r and ϕ directions. For the momentum resolution of high momentum tracks $(\sigma_{P_t}/P_T)res. \propto 1/(BL^2)$ holds. So in order to acquire a comparable momentum resolution for high momentum tracks, the reduced lever arm is compensated by increasing the magnetic field of 3.0 T.

For some technologies multiple mature options and developing alternatives are given. A baseline choice is to be taken when the CEPC detector develops into a detector proposal.

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Timeline of the editing

Work plan and discussion

Comments and suggestions are welcomed.

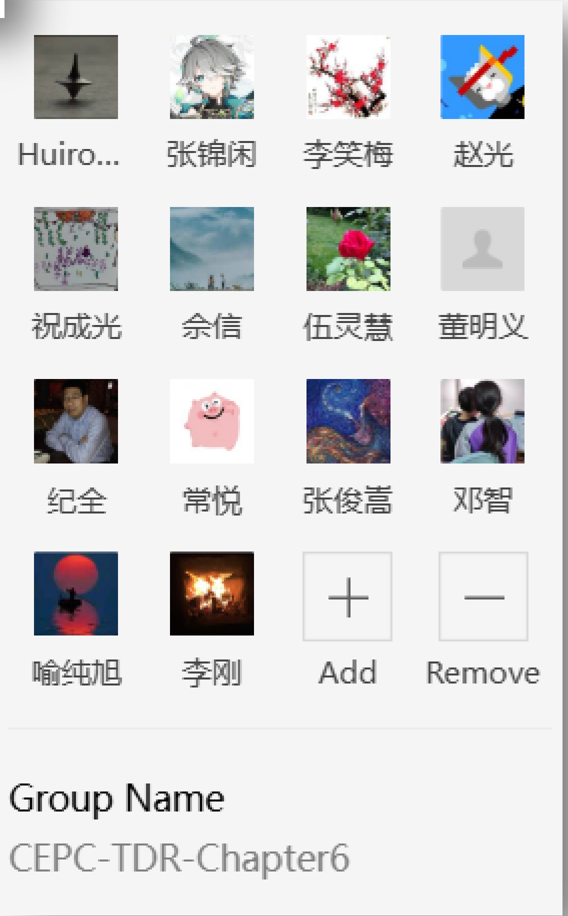
腾讯会议

CEPC ref-TDR Chapter6 讨论会

348 794 465

- Core of the research team (**10 staffs + TPC group**)
  - IHEP: **8 staffs + 4 students**
  - Tsinghua: **2 staffs + 3 students**
- Collaboration of the research team (**6 staffs +10 students + 5 LCTPC members**)
  - **TPC:** CIAE, Shandong University, Nankai University, Zhengzhou University and Liaoning University
  - **DC:** INFN, Wuhan University, Jilin University
  - **TPC and DC**: DRD1 collaboration and LCTPC collaboration
- Organization of team
  - Regular weekly meeting from April 2024
  - Collaboration regular meeting with some international groups

Shared editing chapter from overleaf



Many thanks!

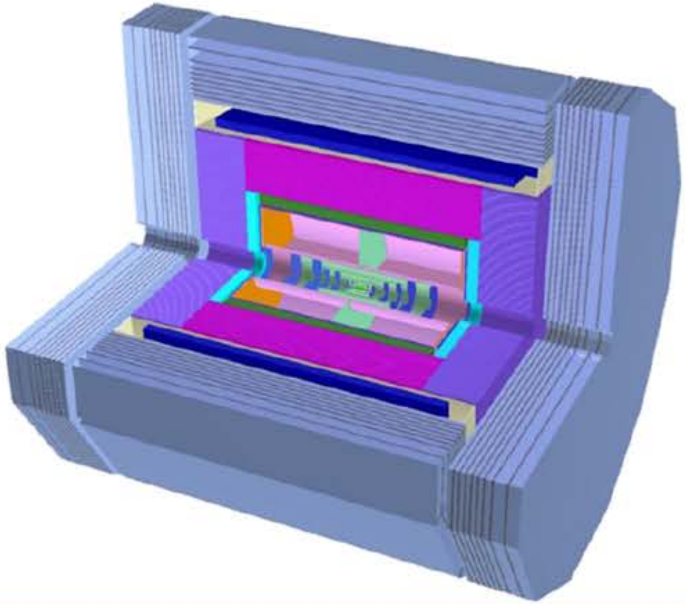
Status of CEPC refTDR

- International Detector Review Committee (IDRC) held its inaugural meeting at IHEP, Oct 21-23, 2024 , to review the status and plan of CEPC Ref-TDR .

Status of CEPC refTDR

- From January 2024, the CEPC community initiated the technical comparison and selection, balancing factors including **R&D efforts, detector performance, cost, power consumption and construction risks**.

System	Technologies	
	Baseline	For comparison
Beam pipe	Φ20 mm	
LumiCal	SiTrk+Crystal	
Vertex	CMOS+Stitching	CMOS Pixel
Tracker	CMOS SiDet ITrk	
	Pixelated TPC	PID Drift Chamber
	AC-LGAD OTrk	SSD / SPD OTrk
		LGAD ToF
ECAL	4D Crystal Bar	PS+SiPM+W, GS+SiPM, etc
HCAL	GS+SiPM+Fe	PS+SiPM+Fe, etc
Magnet	LTS	HTS
Muon	PS bar+SiPM	RPC
TDAQ	Conventional	Software Trigger
BE electr.	Common	Independent



Foundations:

- CEPC Instrumentation R&D
- LHC detector upgrade projects
- other HEP experiments
- progress in HEP worldwide R&D
- development in industry