Feedback and Update Plan
—CEPC Gaseous Tracker

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Content

- Some comments
- Feedback from IDRC review
- Work plan before TDR

IDRC review meeting

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

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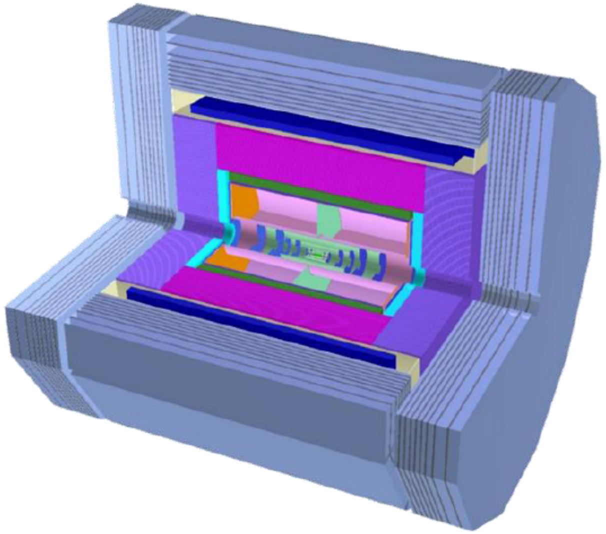
  - **The CEPC study group is in process to produce TDR of a reference detector (ref-TDR) by June 2025, aiming mainly for domestic endorsement**
  - **CEPC will continue to seek for better technologies, and decide the final detectors within the CEPC international collaborations**

Date	Actions and/or Expectations
Jan 1, 2024	Start the process by comparing different technologies
Jun 30, 2024	Baseline technologies, general geometric configuration and key issues are decided
Oct 31, 2024	Discuss the ref-TDR at the CEPC workshop, report progresses to the CEPC IAC
Dec 31, 2024	The first draft of the ref-TDR is ready for internal reviews
Apr 15, 2025	international review
Jun 30, 2025	The ref-TDR for ready for public reviews
Oct 30, 2025	Submit the ref-TDR for publication

IDRC review meeting

- The CEPC study group is in process to produce TDR of a reference detector (ref-TDR) by June 2025, aiming mainly for domestic endorsement
- An international review committee has been formed to guide and review the design
- CEPC will continue to adopt better technologies; final detectors will be determined by international detector collaborations

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

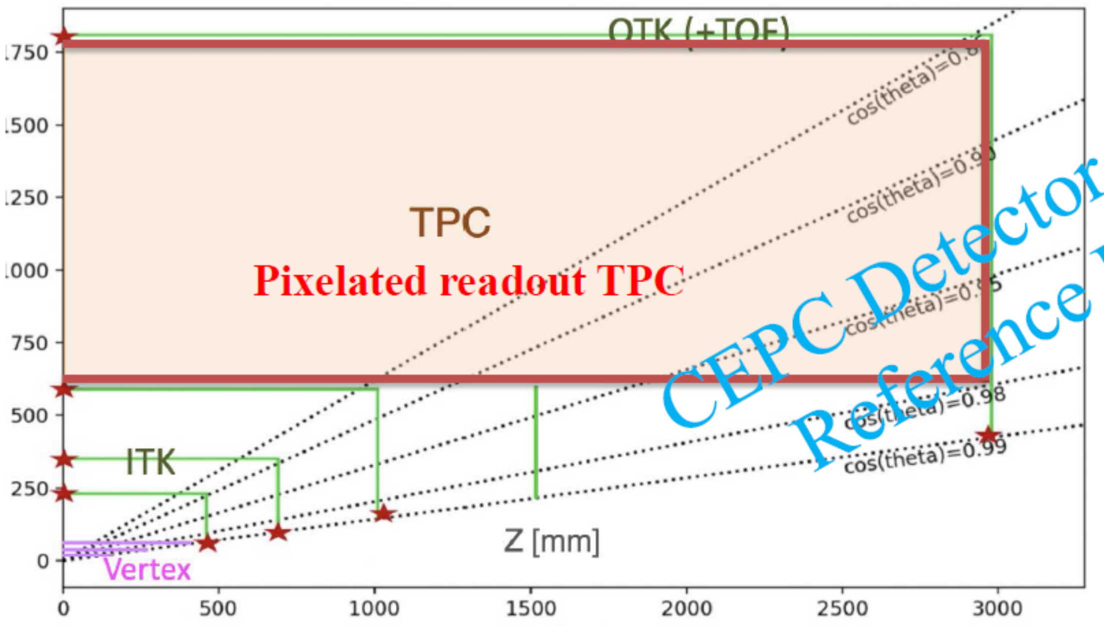


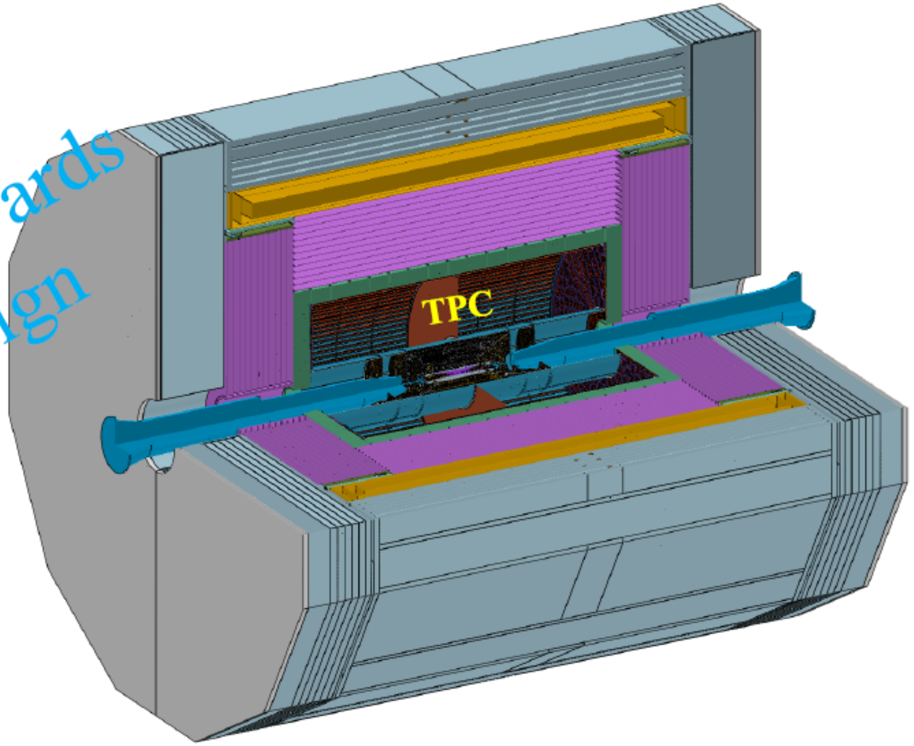
Foundations:

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

Baseline gaseous detector: Pixelated TPC

- Tracking system: Silicon combined with gaseous chamber for the tracking and PID
    - Pixelated readout TPC as the **baseline gaseous detector** in the CEPC ref-TDR.
        - Radius of TPC from 0.6m to 1.8m





Geometry of the tracking detector system of the CEPC TDR

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Peter's talk

Design of a CEPC detector

- Concerning the design of a CEPC detector
  - It is important that the B =3 T (or higher) option is studied
    - beam-beam backgrounds are smaller
    - the performance of the whole detector improves
  - the MDI should be further optimized to reduce the beam-beam background
    - This is good for all detectors (note that the vertex detector is quite exposed)
  - Concerning pixel sizes for a TPC
    - A pixel size of 55 (110) microns is optimal; one can profit from cluster counting and high precision tracking
    - Larger pixel/pad sizes have larger occupancies and one should question whether they can handle the very high beam-beam rate
  - It is important to surround the TPC by silicon trackers

Huirong's talk

- **Just the optimization can be started in this ref-TDR at IHEP to meet Higgs/Z at 3T.**

Performance of the pixelated readout TPC

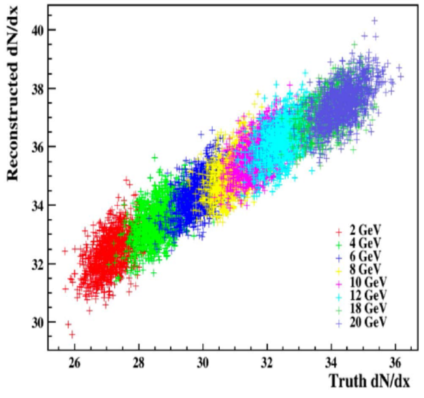
Reconstruction:

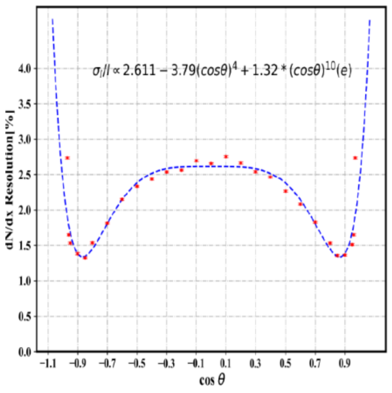
- Reconstruction by counting the number of fired pixels over threshold
- Reconstruction with good linearity and reliability

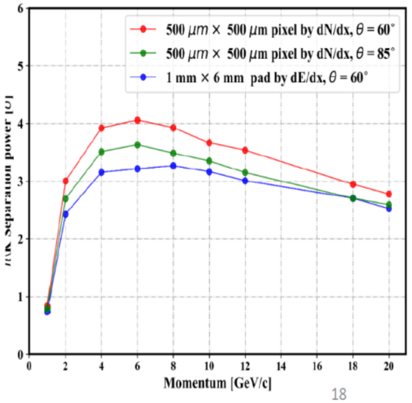
Preliminary PID performance:

- π/k separation power simulation with different momentum

Separation power: $\frac{|\mu_A-\mu_B|}{\frac{\sigma_A+\sigma_B}{2}}$







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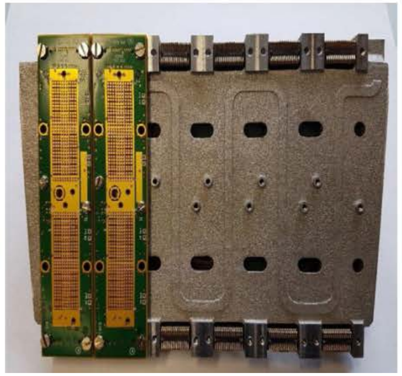
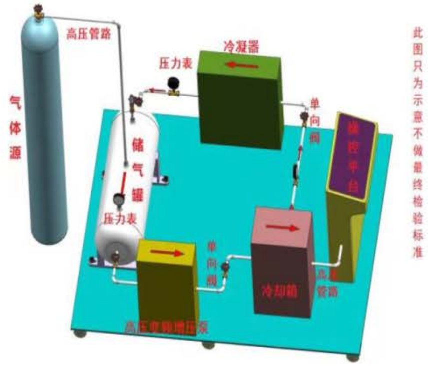
Optimization of the readout size

- Timepix (55μm×55μm) readout TPC prototype has been validated four times using DESY beam.
  - Power consumption: 2W/cm^2 ; Low power mode: 1W/cm^2 (Too high power consumption.)
- Simulation results showed that the readout size can be optimized at 500μm×500μm.
  - Number of the readout channels and power consumption need to be optimized.
  - Focused on 100mW/cm^2 and 500μm readout for CEPC ref-TDR (2-phase CO_2 cooling OK!)

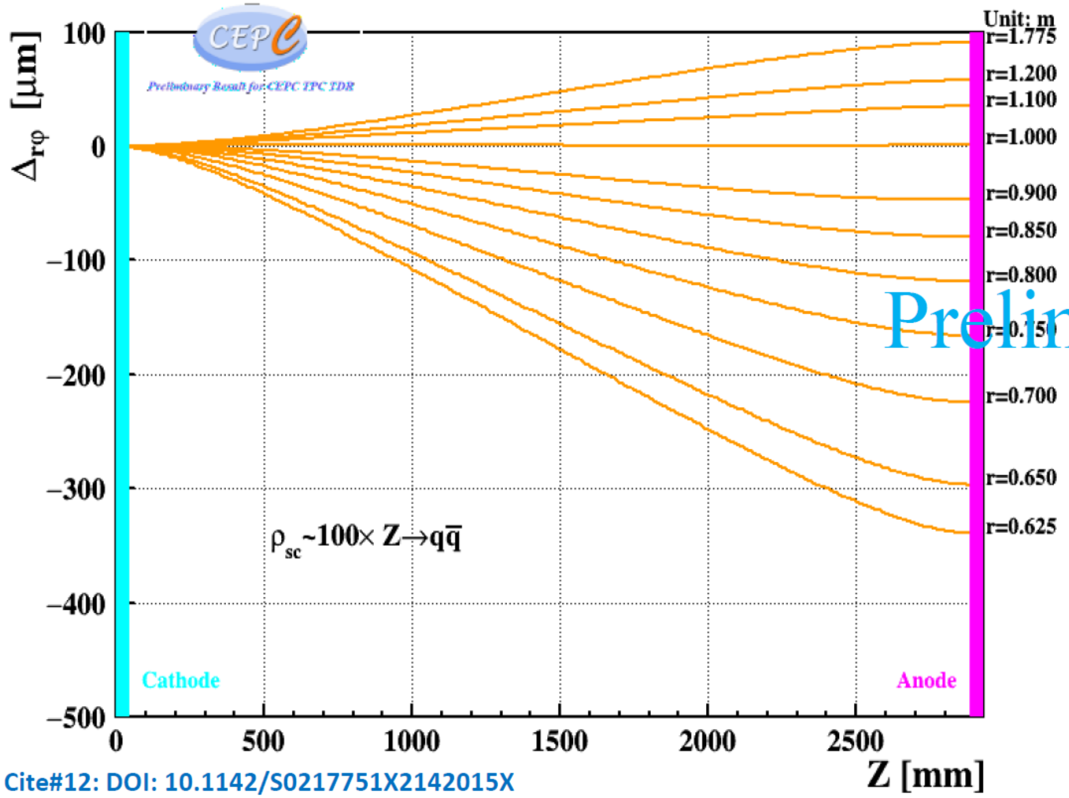


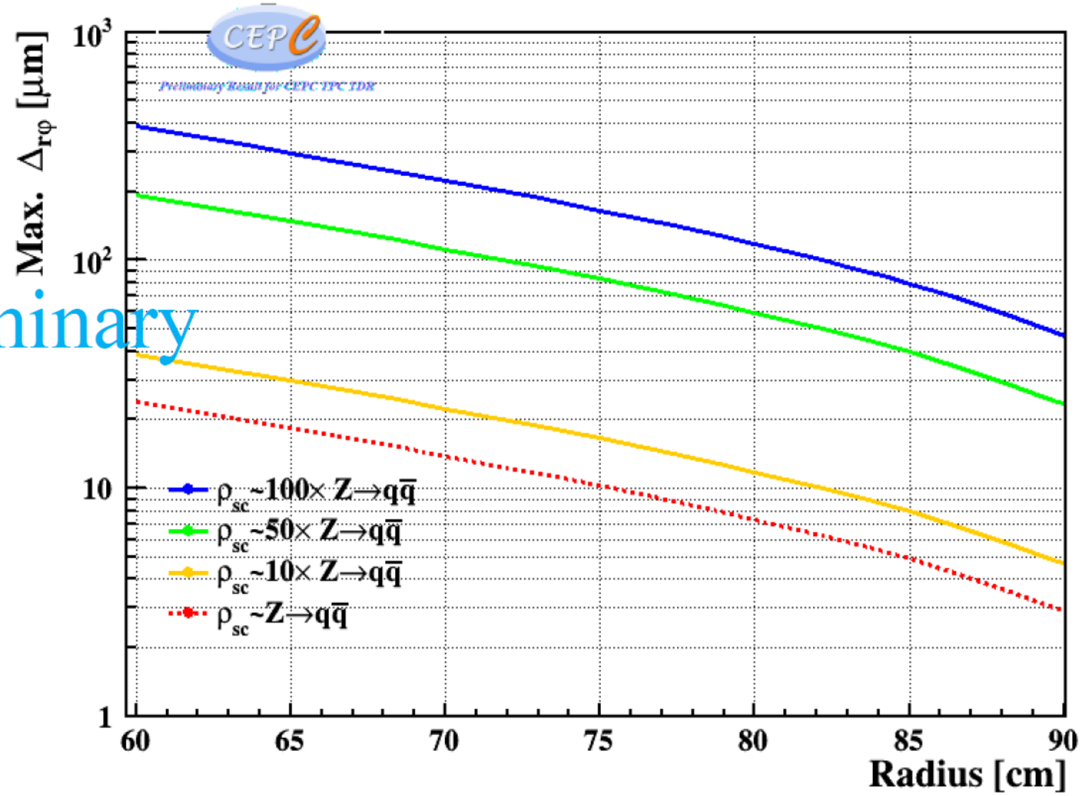


Huirong's talk

#7. Beamstrahlung and distortion √

- Maximum distortion with e+e- to qq at Z pole (Physics events only)
- Maximum distortion under the different Beamstrahlung background （×10, ×50 , ×100 times Physics events)
  - MDI design at Z need carefully optimized with MDI group in CEPC





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Comments

- **This week, I have confirmed with Xin She and Jin Xian the possibility of making corrections.**
- **Additionally, the low-luminosity Tera-Z operation is beginning to be considered within the CEPC community.**
- **The first phase of operation is a 10-year Higgs run in the CEPC-TDR, and I need to confirm that the TPC can operate at the low luminosity of Tera-Z at 3T in scaling mode..**

10-years Higgs → 2-years Z pole → 1-year W

Feedback#1 : Simulation

- **A full simulation is necessary to optimize** the pixel/pad size. Microscopic pixels present the advantage of low noise, allowing single electron efficiency for a digital readout. Larger pads (more than 500µm) allow a measurement of the ionization track element by track element, but require an electronics with an ADC for each pad, and this part is power consuming.

- Comments and work plan:
  - Full simulation using Geant4 and Garfield++
  - Balance the pad size, the physics requirements and detector construction

Feedback#2 : IBF at Tera-Z

- The build-up of a space charge has to be very limited to avoid a transverse electric field which causes distortion of the trajectories of the ionization electrons, leading to track distortions. Beam backgrounds have to be kept to a minimum to avoid this space charge build-up, or mitigation and correction techniques have to be designed to limit these distortions. This problem makes a TPC improper at the Z peak at very high luminosity.

- Comments and work plan:
  - To optimize at low luminosity Z peak. (0.5× or 0.1×) ! 10^{-35}
  - Double misaligned meshes (NIKHEF)
  - graphene filter(Shandong University)

Feedback#3： Beam background

- Beam backgrounds have to be estimated carefully, as they produce ionization in the TPC. Especially low-energy X-rays and muons from thermal neutron interaction (the beam halo) can lead to low-pT particles (curlers) which deposit a huge ionization in the gas. These effects are amplified by ion feedback : ions created in the amplification gap can escape and drift all the way to the cathode. This takes typically half a second. Thus ion feedback has to be very well.

- Comments and work plan:
  - Collaboration with MDI group

Feedback#4 : Mechanical

- The mechanical alignment of the modules has to be excellent (a few tens of microns) to avoid systematics on the sagitta measurement. The electric and magnetic fields have to be precisely parallel to avoid ExB distortions. This calls for a very uniform magnetic field (see magnet section).

- Comments and work plan:
  - Collaboration with Mechanical and magnet group

Feedback#5 : T0

- A precise T0 has to be determined for each interaction using the other tracking detectors.

- Comments and work plan:
  - T0 is possible from ITK and OTK.

Feedback#6： Protection Chip

- The readout chip itself has to be protected against damage from sparks. An adequate resistive coating has to be applied on each chip, with a surface resistivity tuned for maximal protection without excessive rate limitation.

- Comments and work plan:
  - Prototyping of chip + mesh + protection
  - Discussion with Tsinghua, the protection resistive layer will be coated with ASIC chips.

Many thanks!