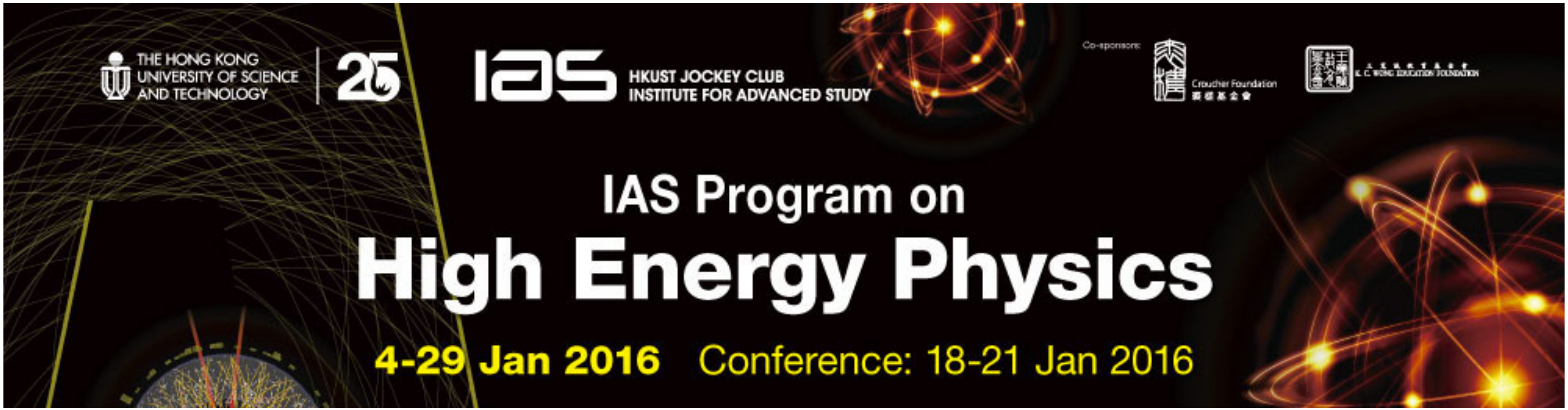
CEPC Detector

Preliminary design and future R&D

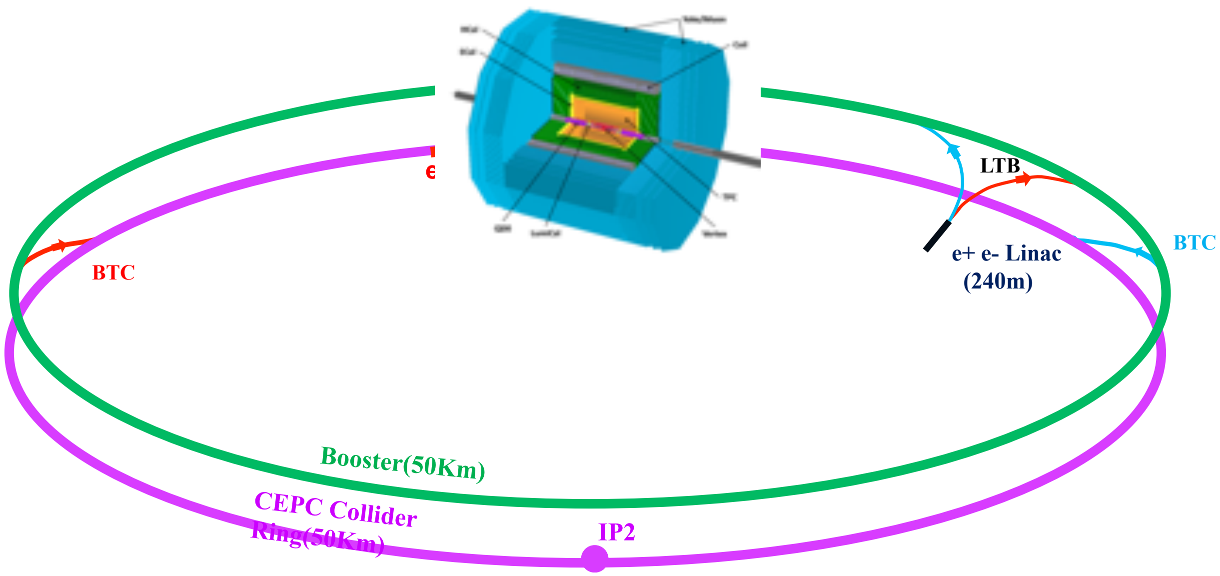
Yuanning Gao (Tsinghua University)

On Behalf of the CEPC-SppC Study group



Outline

- The baseline detector in PreCDR
- From PreCDR to CDR
- Near plan & international collaborations
- Summary



CEPC Physics Program

- Not extremely ambitious goal for CEPC

  (Yes CEPC+SppC !)

  - 5 ab^{-1} for Higgs studies @240-250 GeV
  - 10^{10-12} Z's @~ 91 GeV
  - 10^{6-8} W's @~160 GeV
  - ...

- But rather ambitious timeline!

CEPC-SppC Schedule (Preliminary)

J. Gao, ICHEP2014

- CPEC
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-15 ➔ Pre-CDR by 2014
    - R&D: 2016-2020
    - Engineering Design: 2015-2020
  - Construction: 2021-2027
  - Data taking: 2030-2036

- SPPC
  - Pre-study, R&D and preparation work
    - Pre-study: 2013-2020
    - R&D: 2020-2030
    - Engineering Design: 2030-2035
  - Construction: 2036-2042
  - Data taking: 2042 -

Baseline design in PreCDR

- Tasks for a baseline design
  - a detector concept could work for CEPC
  - at the same time explore the physics potentials

- ILC detectors, especially ILD as a reference
  - state of the art detector, maximize the potential of the (rather expensive) machine
  - (hopefully) less technology challenges than ILD
  - take advantages from world-wide studies
  - sharing future critical R&D with ILC community

Performance requirements of ILC detectors

- Vertexing $(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$
  - ~1/5 $r_{beampipe}$,~1/30 pixel size (wrt LHC)

$$\sigma_{ip} = 5\mu m \oplus 10\mu m / p\sin^{3/2}\theta$$

✔ **CEPC**

- Tracking $(e^+e^- \to Zh \to \ell^+\ell^- X; \quad \text{incl.}\ h \to \text{nothing})$
  - ~1/6 material, ~1/10 resolution (wrt LHC)

$$\sigma(1/p) = 5\times10^{-5}/GeV \quad \text{or better}$$

✔ **CEPC**

- Jet energy (Higgs self-coupling, W/Z separation)
  - ~1/2 resolution (wrt LHC)

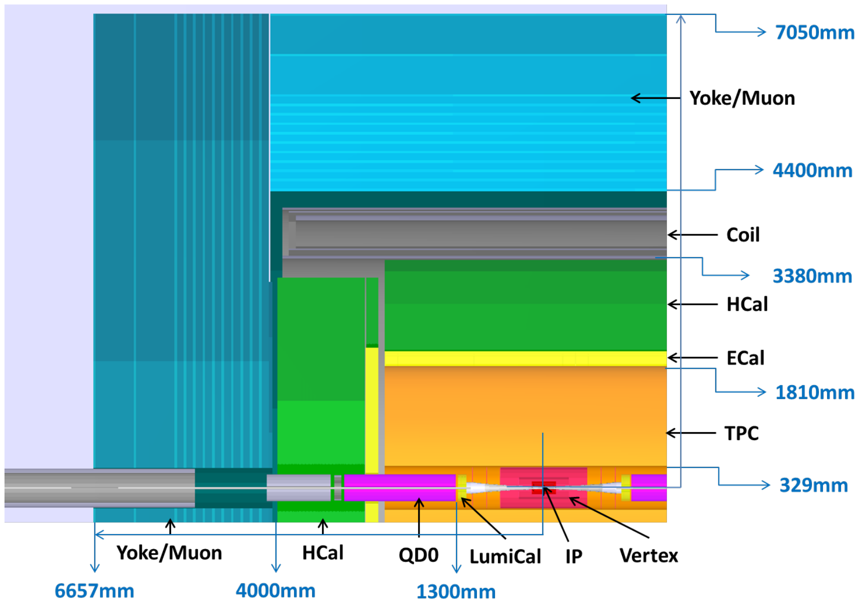
$$\sigma_E / E = 0.3/\sqrt{E(GeV)}$$

less demanding at CEPC

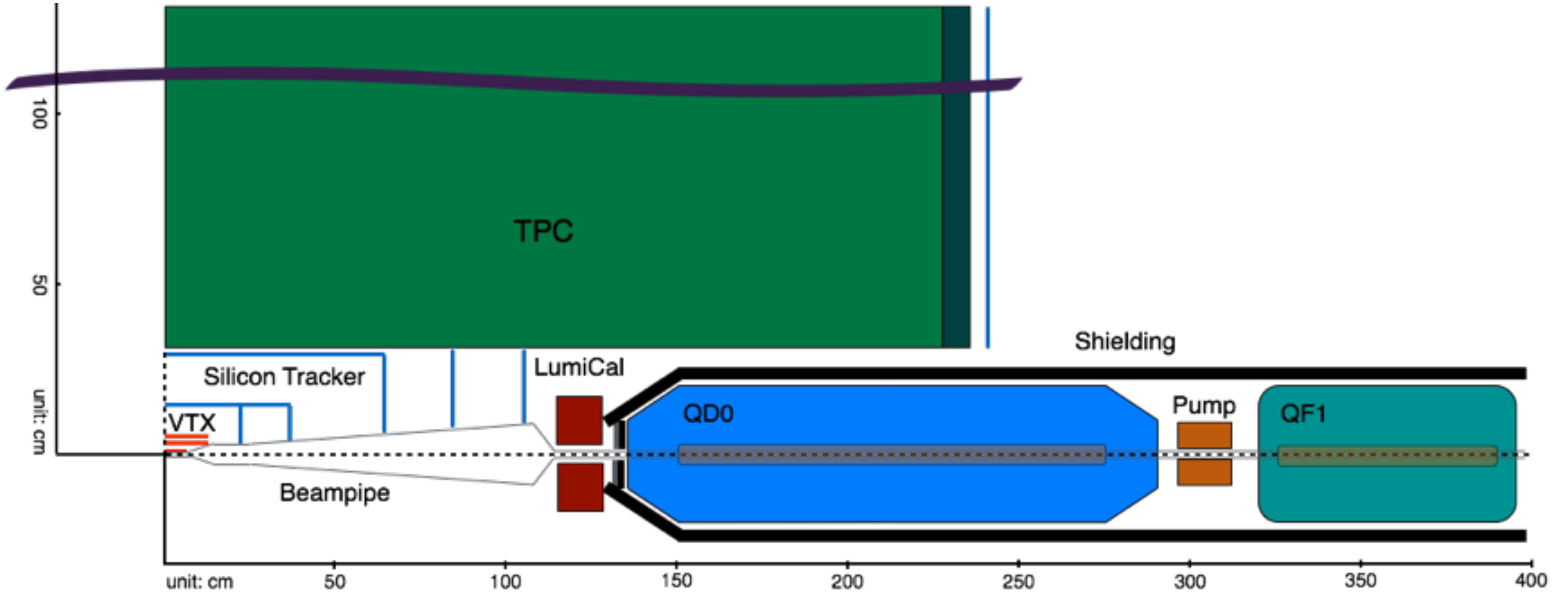
The baseline detector in PreCDR

- ILD-like, with modifications/considerations
  - No push-and-pull → Less Yoke
  - Shorter L*=1.5m → Challenges for MDI
  - Power pulsing not possible → less power consumption + active cooling

(http://cepc.ihep.ac.cn/preCDR/volume.html)



Interaction region layout



- Short focal length of L* = 1.5 m (cf. ~3.5m at ILC)
- Final focusing magnets inside the detector →→ constraints on the detector design + QD0/QF1 design
  - No. of FTD's reduced to 5 (cf. 7 for ILD)
  - redesign of offline/online luminosity instrumentation
  - design of QD0/QF1

Vertex Detector and Silicon Trackers

- Vertexing $(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$
  - ~1/5 $r_{beampipe}$, ~1/30 pixel size (wrt LHC)

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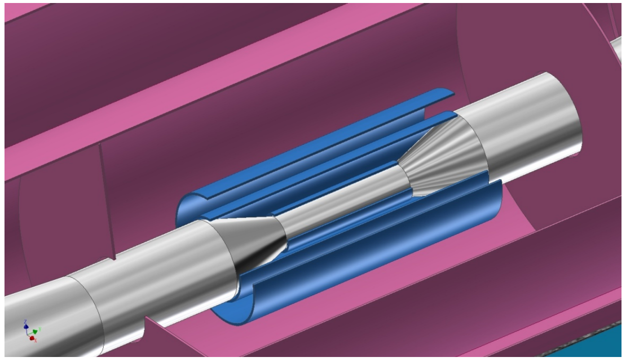
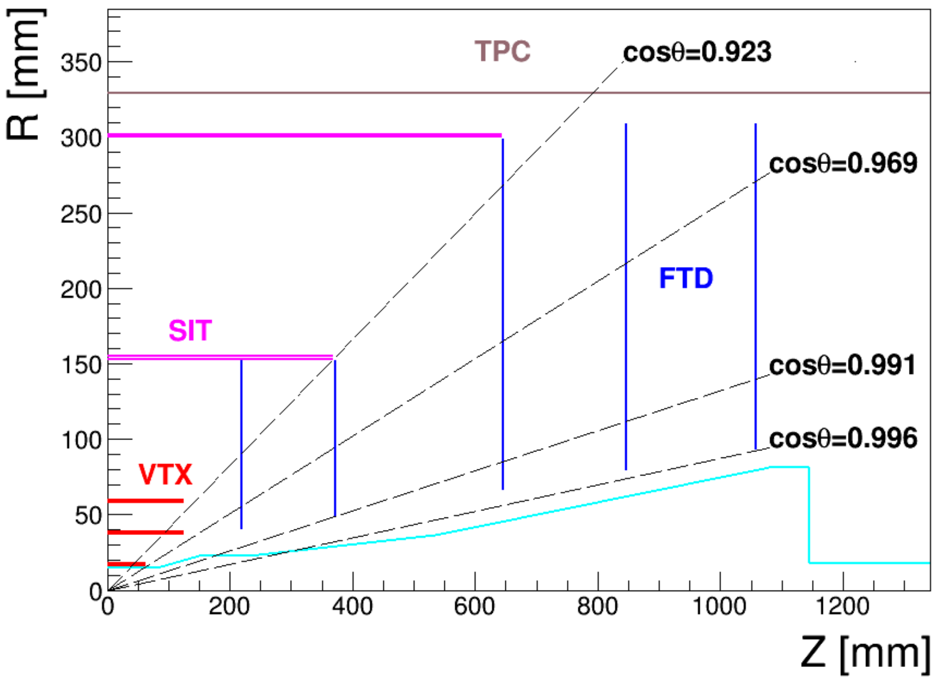




Vertex detector：

- 3 cylindrical and concentric double-layers of pixels

Silicon Internal Tracker (SIT)

- 2 inner layers Si strip detectors

Forward Tracking Detector (FTD)

- 5 disks (2 with pixels and 3 with Si strip sensor) on each side

Silicon External Tracker (SET)

- 1 outer layer Si strip detector

End-cap Tracking Detector (ETD)

- 1 end-cap Si strip detector on each side

Vertex Detector and Silicon Trackers

Vertex detector specifications:

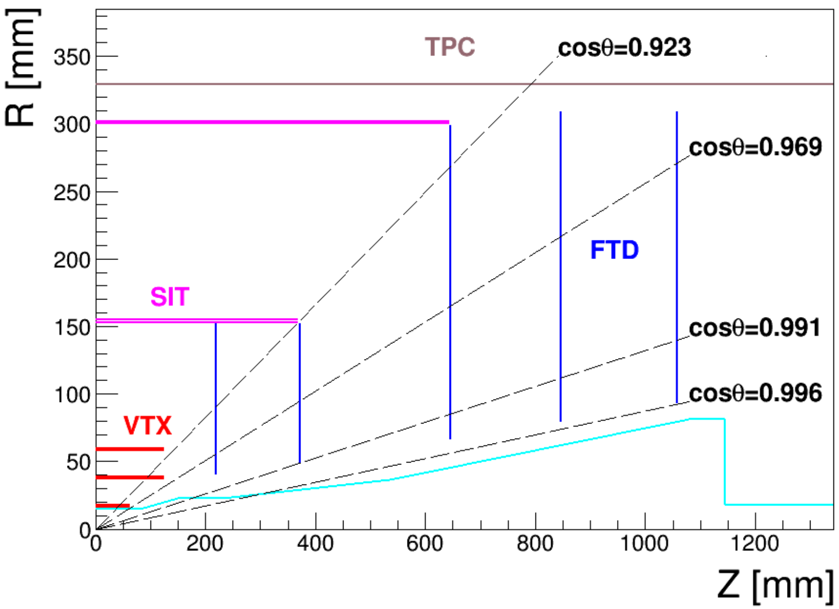
- σ_{SP} near the IP: *≤3 μm*
  → small pixels 16×16μm^2 or below, digital readout
- material budget: *≤ 0.15%X_0/layer*
  → low power circuits, air cooling
- pixel occupancy: *≤ 1 %*
- radiation tolerance:

  Total Ionising Does *≤100 krad/ year*

  Non-Ionising Energy Loss *≤3×10^{11} n_{eq}/ (cm^2 year)*
- first layer located at a radius: *~1.6 cm*

$$\sigma_{r\phi} = 5\mu m \oplus \frac{10}{p(GeV)\sin^{3/2}\theta}\mu m$$

$$\sigma_{1/p_T} = 2\times10^{-5} \oplus 1\times10^{-3}/(p_T \sin\theta)$$

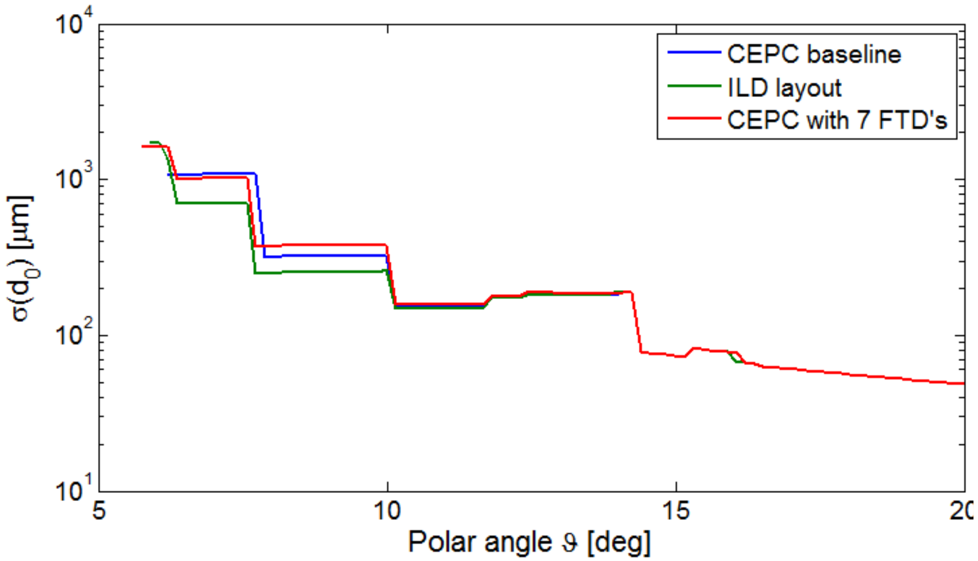


Silicon tracker specifications:

- σ_{SP} : *≤ 7 μm* → small pitch (50 μm)
- material budget: *≤ 0.65%X_0/layer*

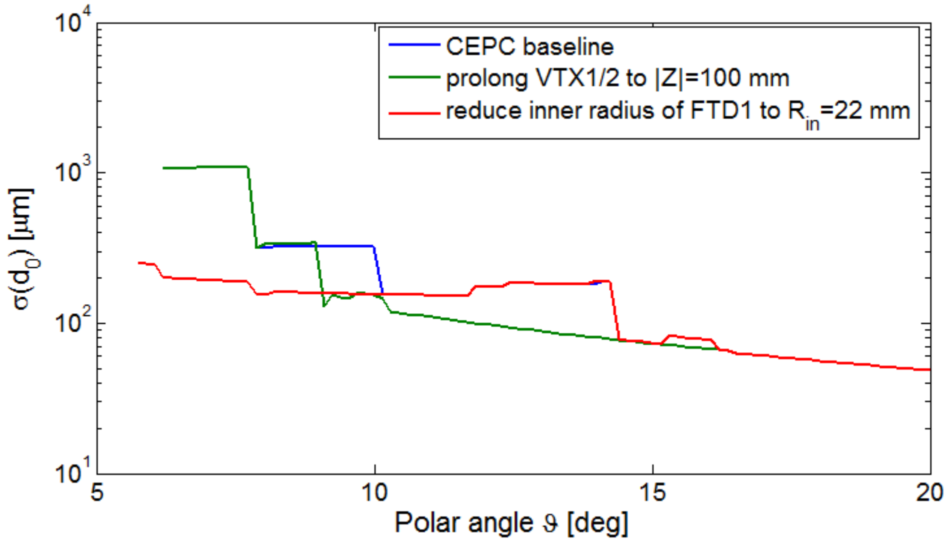
Forward region with L*=1.5m

- Impact parameter resolution studied with LDT - fast simulation using Kalman filter



Performance loss in the low polar angle region (< 10°) with reduced number of FTD disks

The performance loss can be recovered with extended coverage of the pixel detector layers, either by prolonging first two VTX barrel layers or extending the first FTD disk down to r=22mm



Technology options

Pixel sensor: power consumption < 50mW/cm^2, if only air cooling used (CLIC study)
readout time ≤ 20μs

- HR-CMOS sensor with a novel readout structure —ALPIDE for ALICE ITS Upgrade
  - relatively mature technology
  - <50mW/cm^2 expected
  - Capable of readout every ~4μs
- SOI sensor with similar readout structure
  - Fully depleted HR substrate, potential of 15μm pixel size design
  - Full CMOS circuit
- DEPFET: possible application for inner most vertex layer
  - small material budget, low power consumption in sensitive area

Silicon microstrip sensor: p$^+$-on-n technology
pixelated strip sensors based on CMOS technologies

TPC

- Vertexing $(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$
  - ~1/5 $r_{beampipe}$, ~1/30 pixel size (wrt LHC)

$$\sigma_{ip} = 5\mu m \oplus 10\mu m / p\sin^{3/2}\theta$$ ✔ CEPC

- Tracking $(e^+e^- \to Zh \to \ell^+\ell^- X;\quad \text{incl. } h \to \text{nothing})$
  - ~1/6 material, ~1/10 resolution (wrt LHC)

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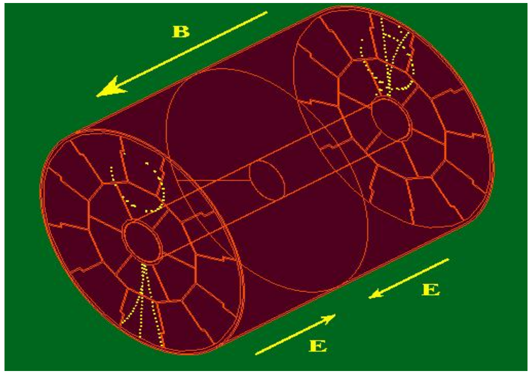
less demanding at CEPC

Performance/Design goals

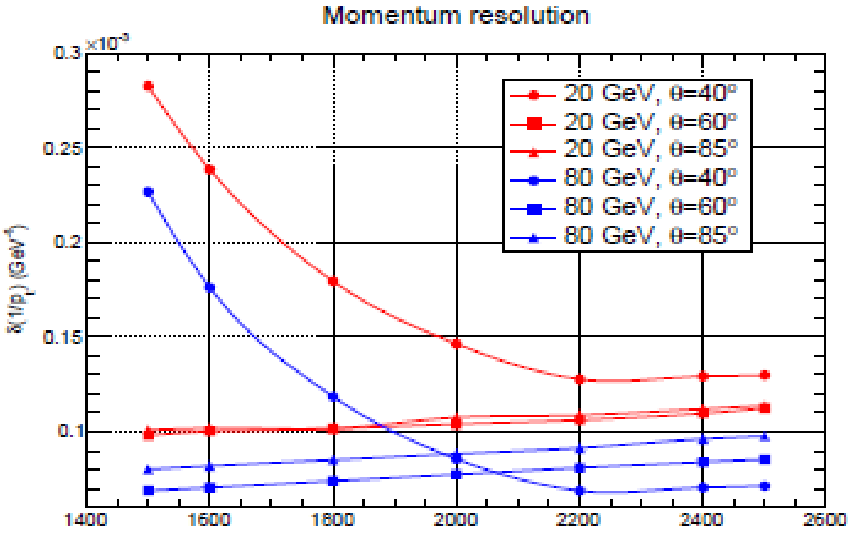
- ILD TPC Design adopted for the baseline detector at CEPC



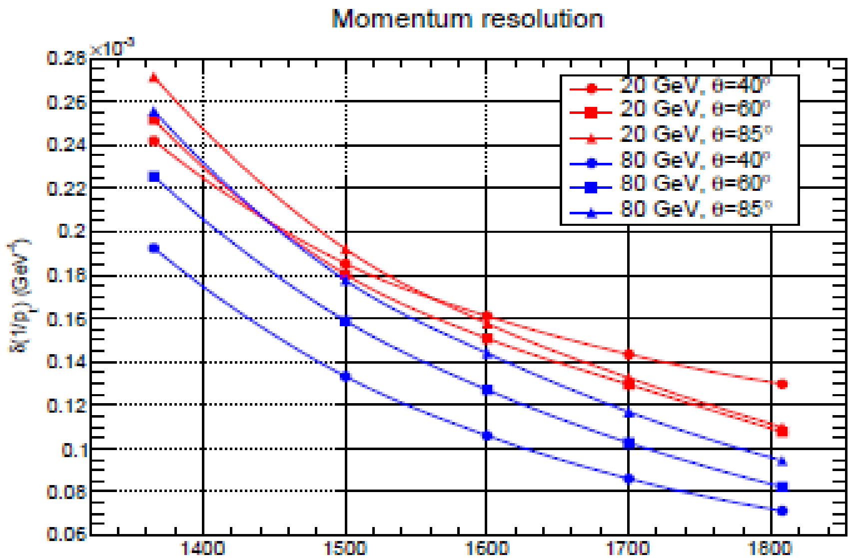
Momentum resolution at B=3.5T	**$\delta(1/pt) \approx 10^{-4}$/GeV/c TPC only**
δ_{point} in rΦ	**<100μm (avg for straight-radial tracks)**
δ_{point} in rz	**≈0.4~1.4mm (for zero – full drift)**
Inner radius	**329mm**
Outer radius	**1800mm**
Half length	**2350mm**
TPC material budgt	**≈$0.05X_0$ including the outer field cage in r** **<$0.25X_0$ for readout endcaps in z**
Pad pitch/no. padrows	**≈1mm×4~10mm/≈200**
2-hits resolution in rΦ	**≈2mm (for straight-radial tracks)**
Performance	**>97% efficiency for TPC only (pt > 1GeV/c)** **>99% all tracking (pt > 1GeV/c)**

Design of the TPC Geometry

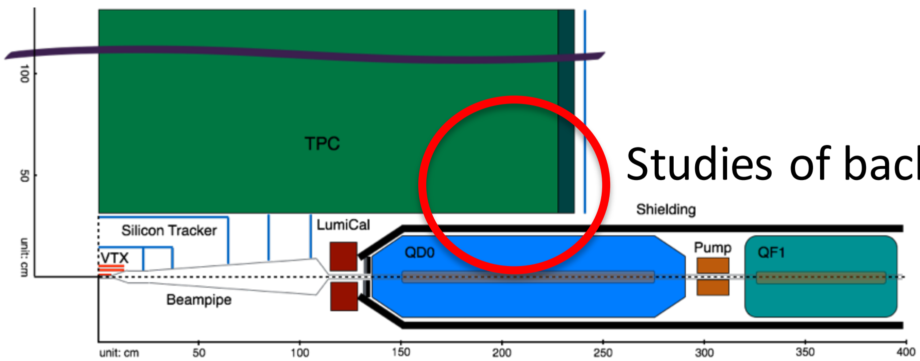
- Performance vs. the size of TPC studied with fast simulations



Half length (mm)



Outer radius (mm)



Studies of background needed

Calorimetry system

- Vertexing $(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$
  - ~1/5 $r_{beampipe}$,~1/30 pixel size (wrt LHC)

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less demanding at CEPC

Global R&D of Imaging Calorimeters

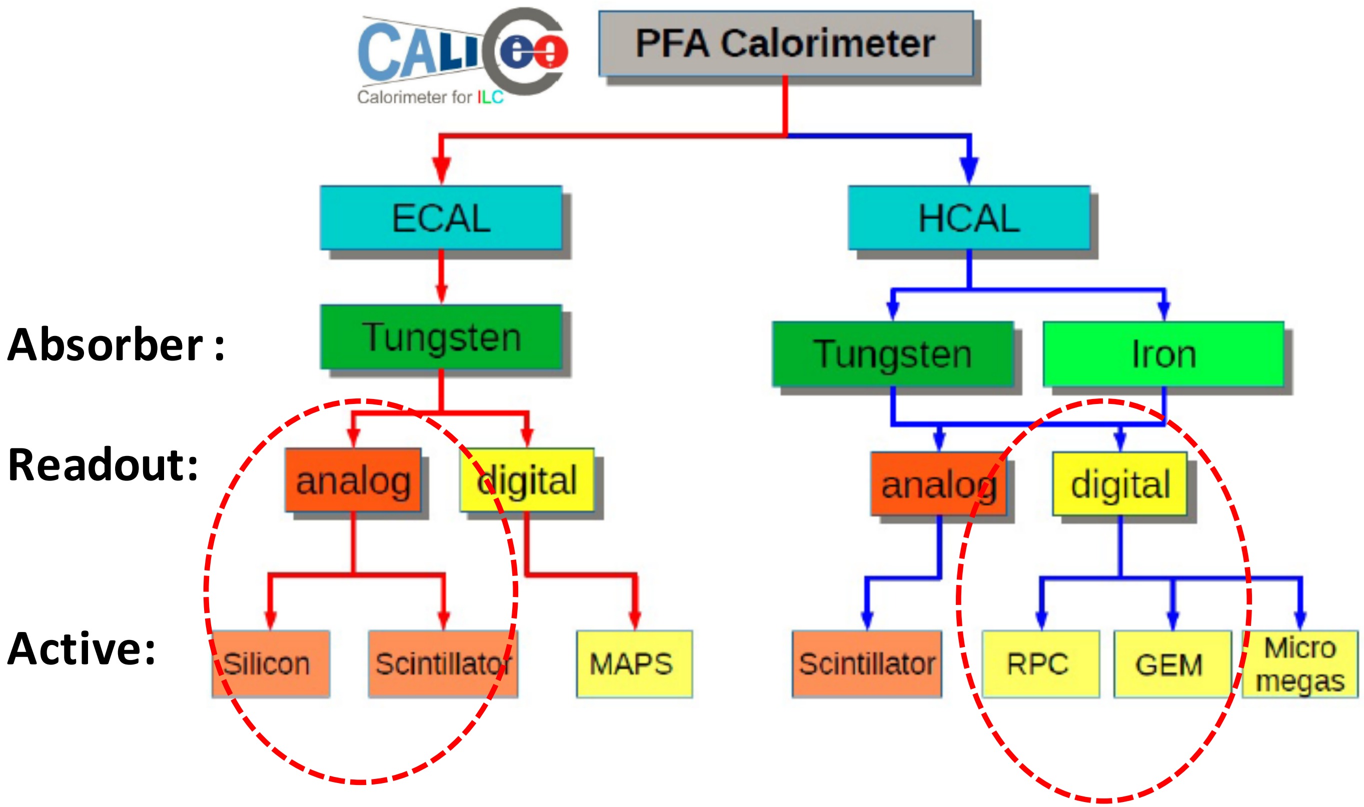
- Concept of Particle Flow Algorithm

  -> calorimeters with very fine granularity
- The calorimetry system at CEPC should be allowed to consider:

  - easier (less challenging) options

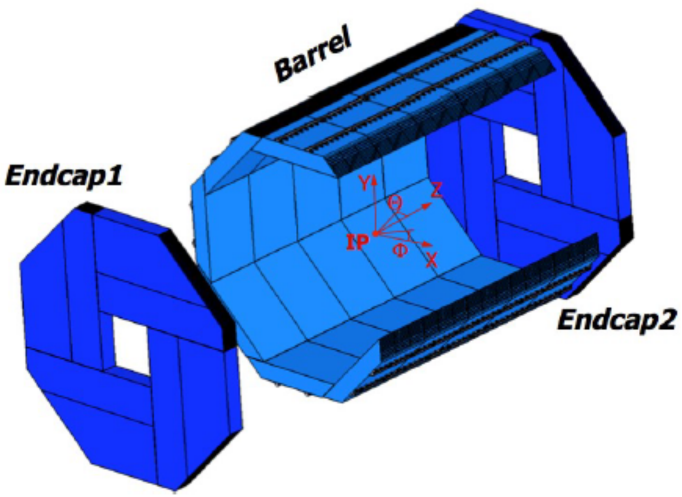
  - cost effective

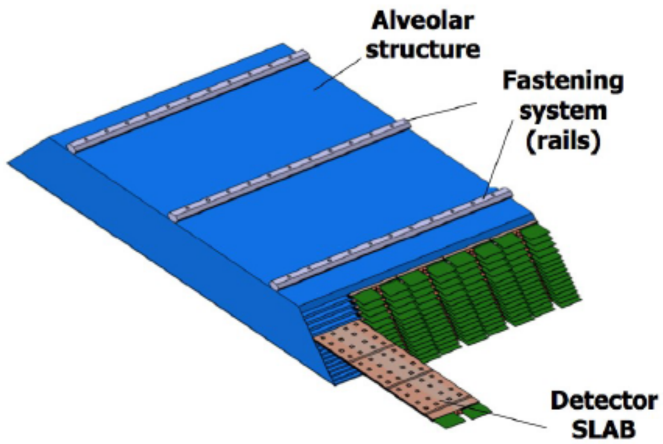
  - active cooling



ECAL option: Silicon-W

- One of the ILD/SiD options
- The ECAL consists of a cylindrical barrel system and two large end caps.
  - One Barrel: 5 octagonal wheels
  - Two Endcaps: 4 quarters each
- 2 active sensors interleaved with tungsten absorber
  - silicon pixel 5 x 5 mm^2 with 725μm in thickness
  - PCB with Very Front-End ASIC

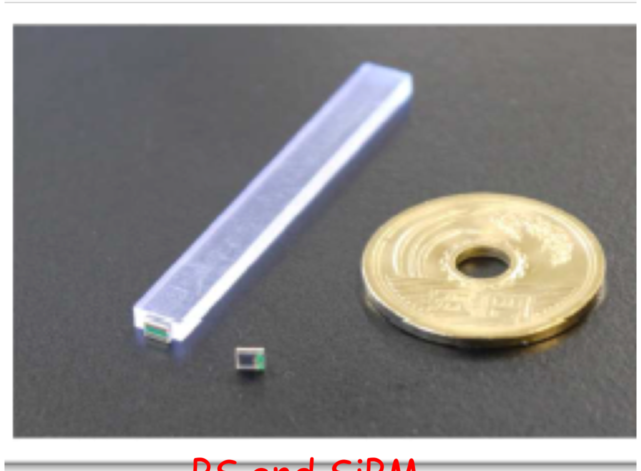




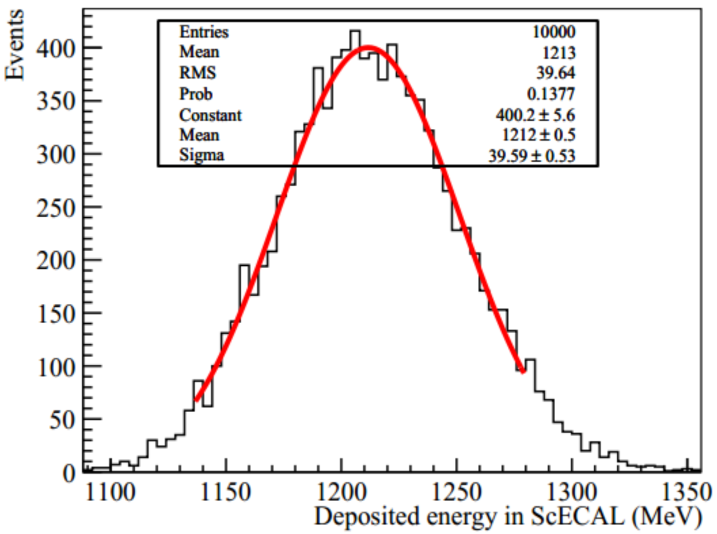
ECAL option: Scintillator-W

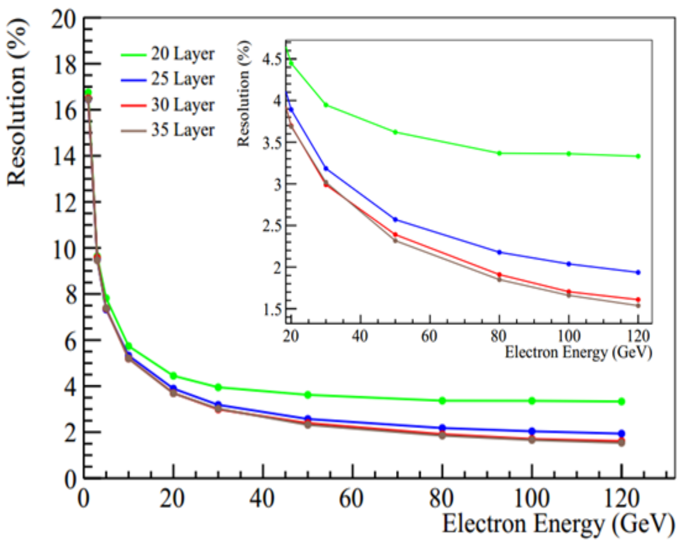
- **A super-layer (7mm) is made of**
  - tungsten plate (3 mm thick)
  - 5 x 45 mm^2 plastic scintillator strips (2 mm thick)
  - a readout/service layer (2 mm thick)

- **The energy resolution of 25 GeV electron is about 3.3% (cf. CALICE TB results)**
- **To achieve required energy resolution, the number of layers should be ~ 25.**



PS and SiPM

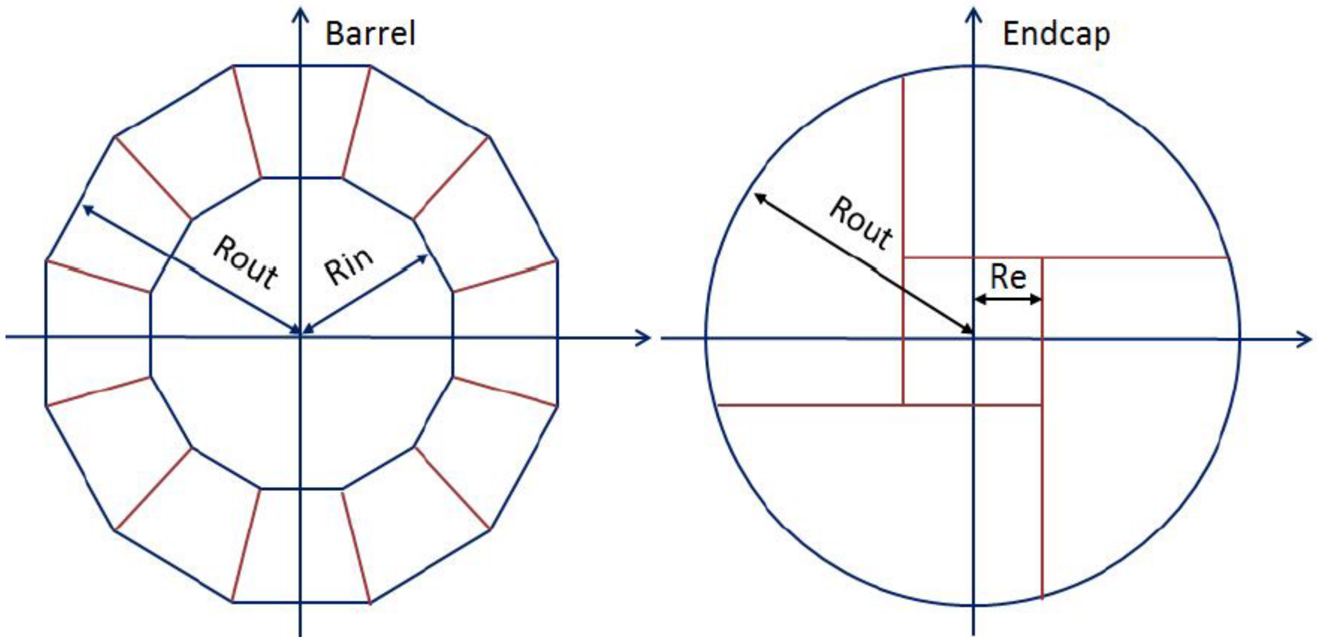




Hadron calorimeter

- The HCAL consists of
  - a cylindrical barrel system:
    self-support & negligible dead zones
  - two endcaps: 4 quarters
- Absorber: Stainless steel

- **Active sensor**
  - Glass RPC
  - Thick GEM
- **Readout (1×1cm^2)**
  - Digital (1 threshold)
  - Semi-digital (3 thresholds)

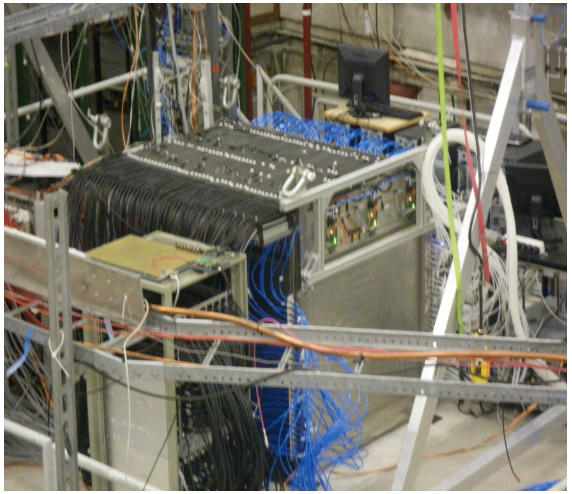


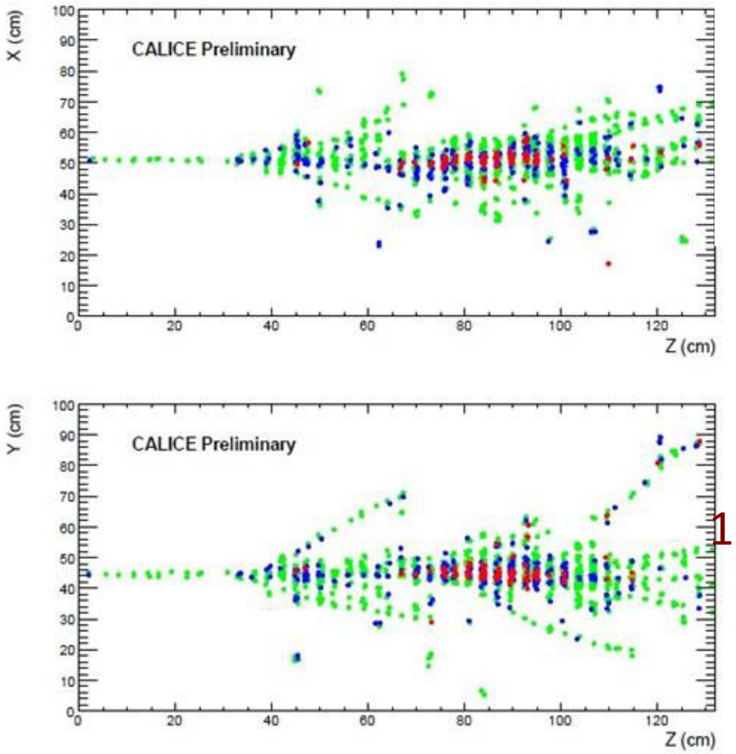
CALICE test beam studies

Prototypes of DHCAL based on RPC

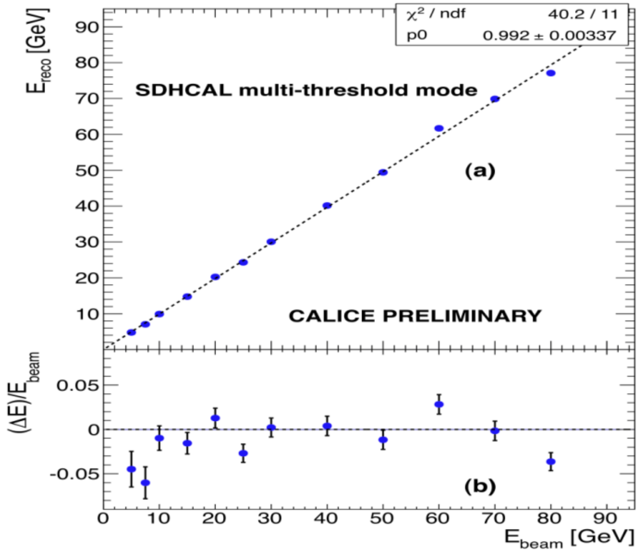
- **IPNL (I. Laktineh, R. Han et.al.)**

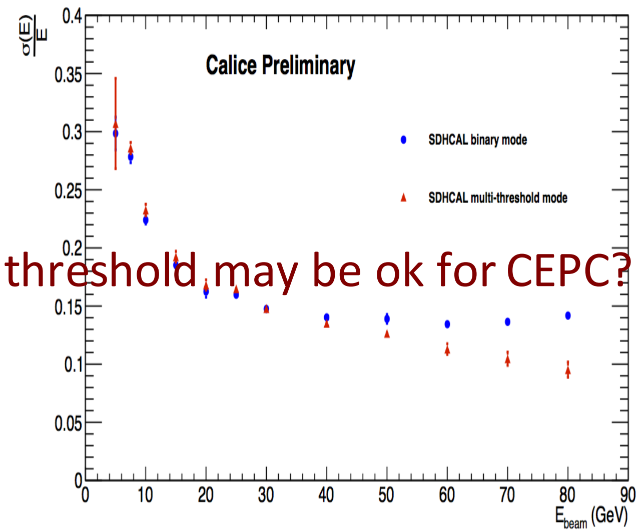
  1m^3, 3 thresholds, Test Beam at CERN





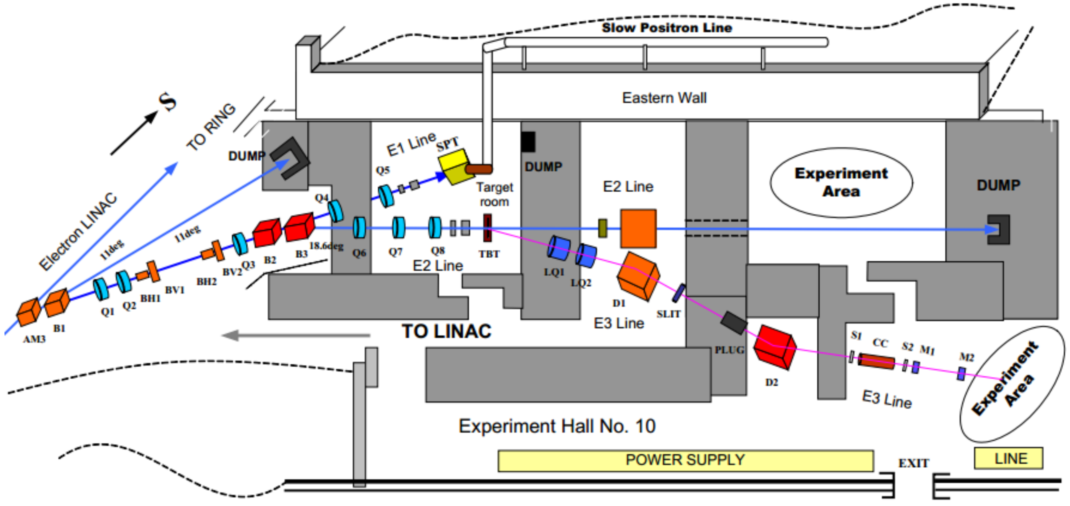
80 GeV Pion





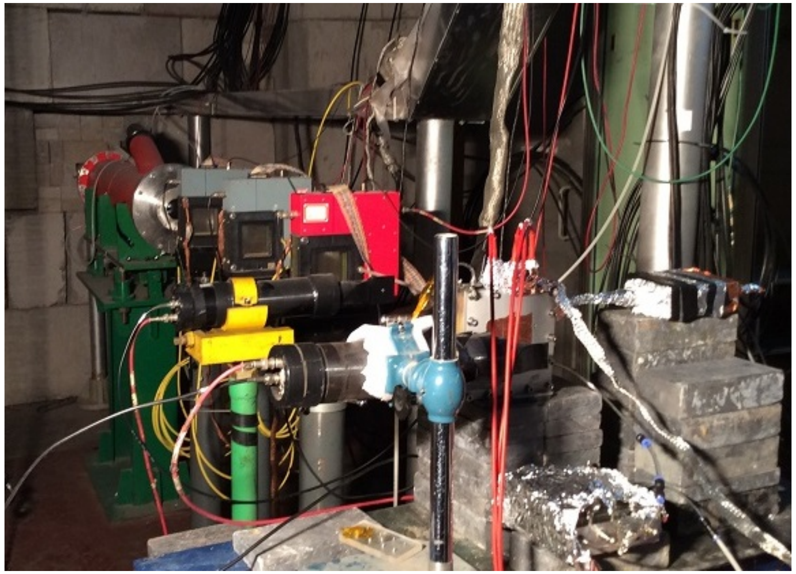
1 threshold may be ok for CEPC?

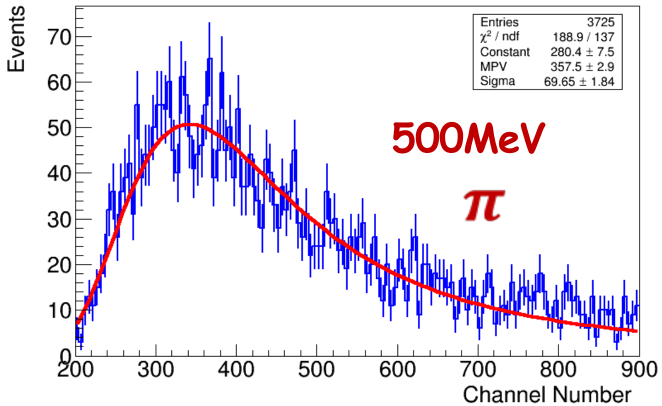
WELL-THGEM test beam at IHEP

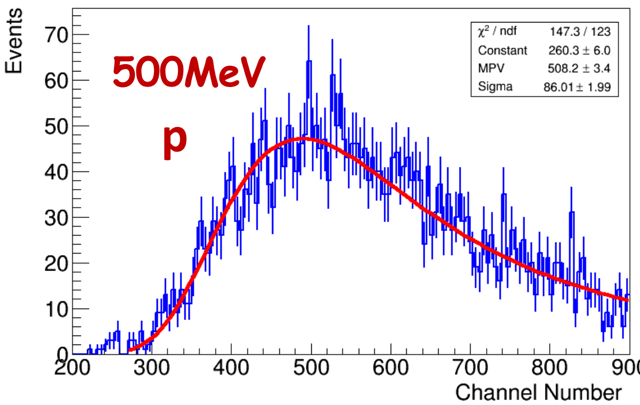


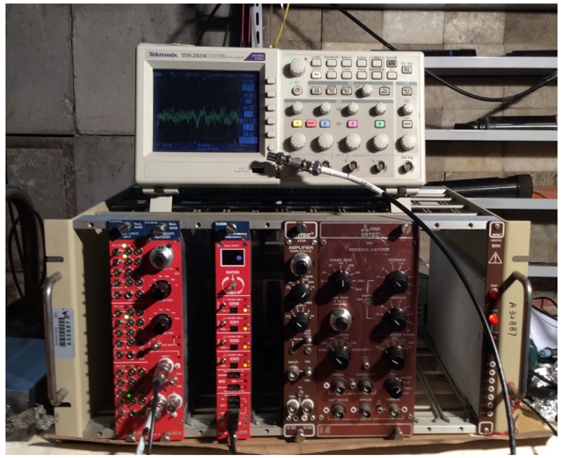
AM3、B1、B2、B3 Bending Magnets,
BH1、BH2、BV1、BV2 Dipole Corrector
Q1、Q2、Q3、Q4、Q5、Q6、Q7、Q8、LQ1、LQ2 Quadrupole
SPT: SLOW POSITRON TARGET; TBT: TEST BEAM TARGET; S1、S2、Scintillator, M1、M2 Multi-wire Proportional Chanber
CC : Cherenkov

IHEP BEPC-LINAC
THE CONFIGURATION OF TEST BEAM





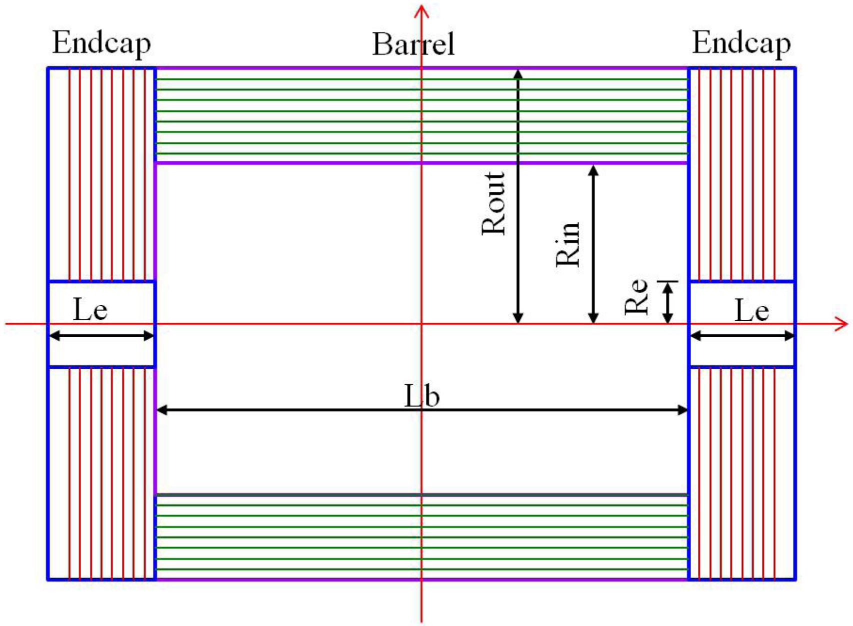




Well-THGEM, Ar/3%iC_4H_{10};

MUON System

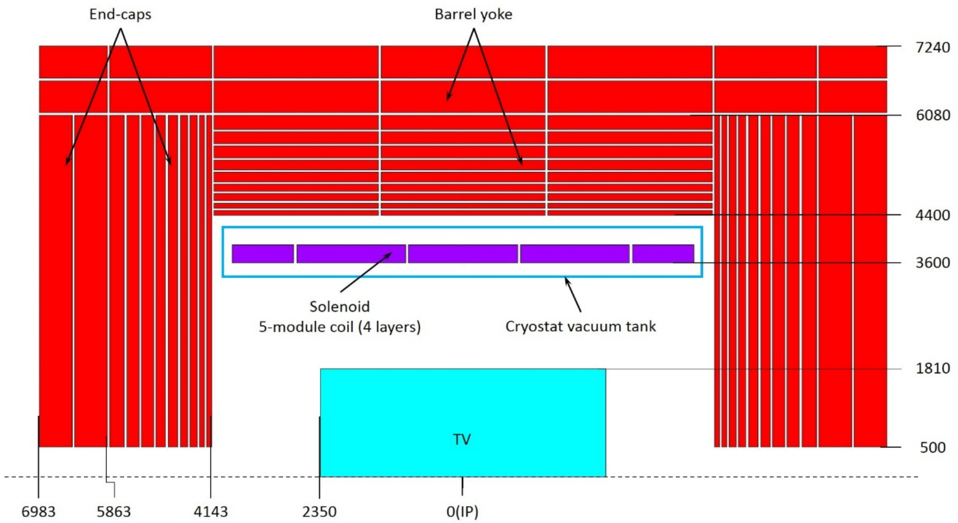
- Outside of the HCAL
  - a cylindrical barrel + two endcaps
  - Solid angle coverage 0.98 x 4π
- Options
  - RPC (bakelite RPC / glass RPC)
  - Scintillator strip (WLS+SiPM)

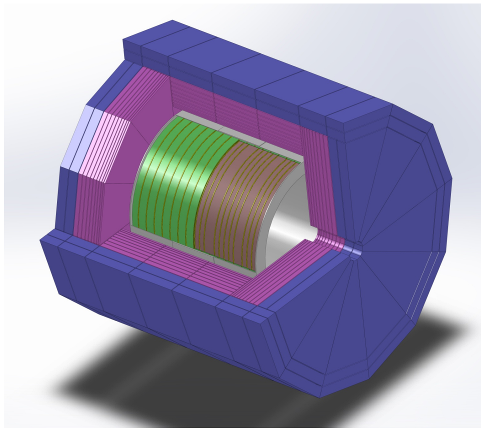


Item	Option	Baseline
Lb [m]	3.6 – 5.6	4.0
Rin [m]	3.5 – 5.0	4.4
Rout [m]	5.5 – 7.2	7.0
Le [m]	1.6 – 2.4	2.6
Re [m]	0.6 – 1.0	0.8
Segmentation	8/10/12	12
Number of layers	6 – 10	8 (∼4 cm per layer)
Total thickness of iron	6 – 10λ (λ = 16.77 cm)	8 (136 cm) (8/8/12/12/16/16/20/20/24)
Solid angle coverage	0.94 – 0.98×4π	0.98
Position resolution [cm]	$\sigma_{r\phi}$: 1.5 – 2.5	2
	σ_z : 1 – 2	1.5
Average strip width [cm]	Wstrip: 2 – 4	3
Detection efficiency	92% – 98%	95%
Reconstruction efficiency (E_μ > 6 GeV)	92% – 96%	94%
P($\pi \to \mu$)@30GeV	0.5% – 3%	< 1%
Rate capability [Hz/cm^2]	50 – 100	∼60
Technology	RPC	RPC (super module, 1 layer readout, 2 layers of RPC)
	Scintillating strip	
	Other	
Total area [m^2]	Barrel	∼4450
	Endcap	∼4150
	Total	∼8660
Total channels	Barrel	26500
	Endcap	29000
	Total	∼ 5.55 × 10^4 (3 cm strip width, 1-D read-out, 2 ends for barrel, 1 end for end-cap)

Magnet

- A new design for baseline detector at CEPC



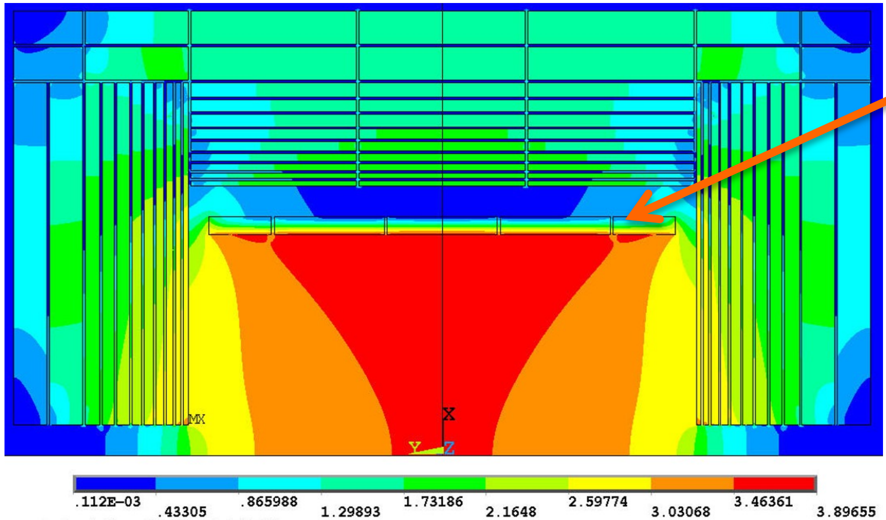


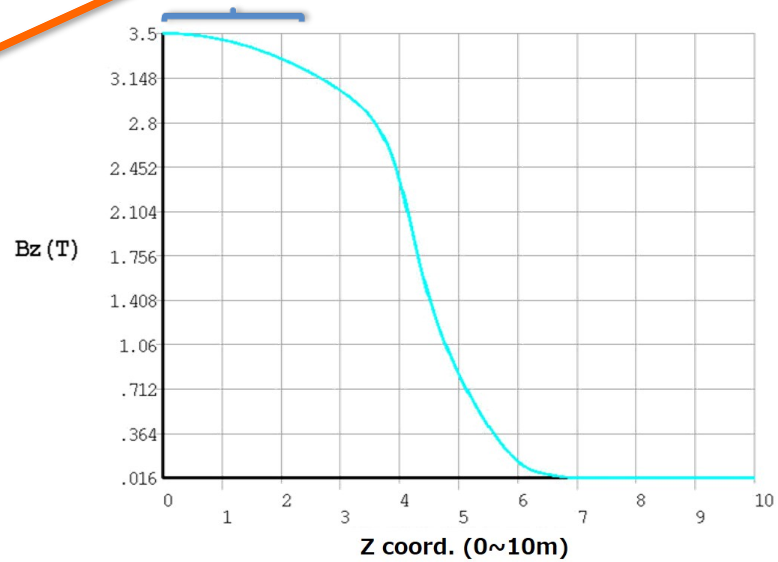
Cryostat inner radius(mm)	3400	Barrel yoke outer radius(mm)	7240
Cryostat outer radius(mm)	4250	Yoke overall length(mm)	13966
Cryostat length(mm)	8050	Barrel weight(t)	5775
Cold mass weight(t)	165	End cap weight(t)	6425
Barrel yoke inner radius(mm)	4400	Total yoke weight(t)	12200

Field Map

- Simulated field distributions

correction/fine tuning possible





The solenoid central field(T)	3.5	Nominal current(KA)	18.575
Maximum field on conductor(T)	3.85	Total ampere-turns of solenoid(MAt)	23.925
Coil inner radius(mm)	3600	Inductance(H)	10.4
Coil outer radius(mm)	3900	Stored energy(GJ)	1.8
Coil length(mm)	7600	Stored energy per unit of cold mass(KJ/kg)	10.91

From PreCDR to CDR

- Accelerator CDR to be completed in 2016, options may be fixed (hopefully)
  - → $\bar{t}t$ threshold (~350 GeV) ?
  - → single/double/partial double ring ?
  - → configuration/luminosity/background at Z pole?
  - …
- Plan for Detector CDR not yet decided
  - → by international collaboration !

Tasks for CDR studies

- Optimization based on *the CEPC design (Acc. CDR)*
- Study items not covered in PreCDR
- Explore new ideas/technologies

  → 2+ detector concepts for CEPC CDR

- Critical R&D's

Task 0: Physics at *Z*-pole

- Not been considered seriously in PreCDR
  - Can TPC stand for (extremely) high event rate?
  - Particle Identification ($\pi/K/p$) for flavor physics?
  - Special designs to reduce systematic uncertainties of EW observables ?
  - New observables?

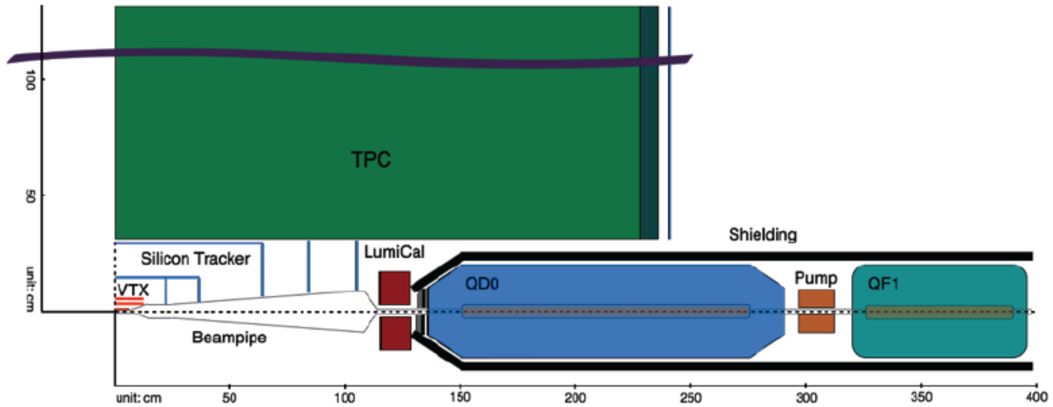
→ new benchmark at *Z* pole?

→ new/modified sub-detectors or a new detector concept?

Task 1: MDI

Hongbo Zhu's talk

- Related to the accelerator design
  - single/ (partial) double ring – crossing angle?
  - L*=1.5m is good enough?
  - beam & background
  - QD0 & QD1



IR layout in pre-CDR

- Detector design
  - Luminosity monitor
  - VTX and FTD's
  - inner radius of TPC
  - uniformity of B-field in tracking area
  - ....

Radiation Backgrounds

- Critical for detector and machine design, originating from various sources:
  - **Collision induced backgrounds:**
    - Beamstrahlung, (+consequent pair production, hadronic events …)
    - Radiative Bhabha scattering
  - **Machine induced backgrounds:**
    - Synchrotron radiation
    - Beam-gas interaction
    - Touschek
    - Beam halo
    - …
- Always have to carefully evaluate each background, **importance of which might differ from machine to machine**

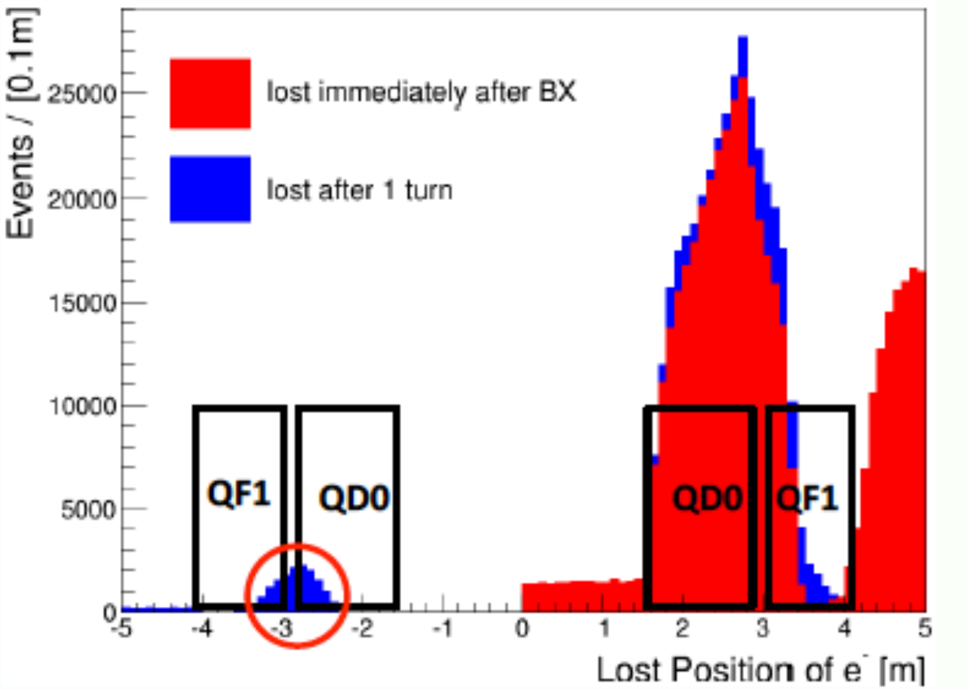
Beamstrahlung cont.

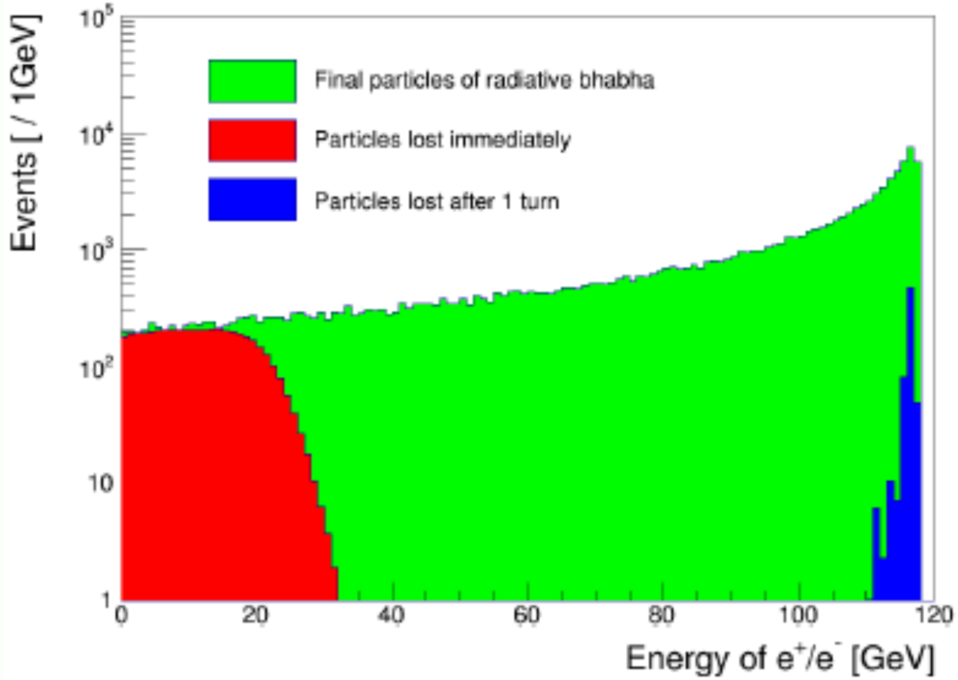
Parameters	Symbol	LEP2	CEPC	FCC-ee	ILC250
Center of mass energy	E_{cm} [GeV]	209	240	240	250
Bunch population	N [$\times 10^{10}$]	58	37.1	37	2
Horizontal beam size at IP	σ_x [nm]	270000	73700	61000	729
Vertical beam size at IP	σ_y [nm]	3500	160	120	7.7
Bunch length	σ_z [μm]	16000	2260	2110	300
Horizontal beta function at IP	β_x [mm]	1500	800	500	13
Vertical beta function at IP	β_y [mm]	50	1.2	1	0.41
Normalized horizontal emittance at IP	$\gamma\epsilon_x$ [mm $\cdot$ mrad]	9.81	1594.5	1761.3	10
Normalized vertical emittance at IP	$\gamma\epsilon_y$ [mm $\cdot$ mrad]	0.051	4.79	3.52	0.035
Luminosity	L [10^{34} cm^{-2}s^{-1}]	0.013	1.8	5.08	0.75
Beamstrahlung parameter	Υ_{av} [$\times 10^{-4}$]	**0.25**	**4.7**	**6.1**	**200**
Relative averaged energy loss per BX due to Beamstrahlung	δ_{av} [%]	**0.0001**	**0.005**	**0.0075**	**1.0**

Beamstrahlung effects not concerned for low energy machines, dominant backgrounds for ILC but less critical for CEPC

Radiative Bhabha Scattering

- Backgrounds from the original process ($e^+e^- \to e^+e^-\gamma$) not prominent
- **Dedicated to circular machines**: beam particles loosing energy (larger than the machine acceptance 2%) can be kicked off their orbits when returning to the IR and hit machine/detector elements (e.g. the final focusing magnets) → → → **particle shower**





Final Focusing Magnets

- **Final focusing magnets inside the CEPC detector due to short L***

Magnet	Length (m)	Field gradient (T/m)	Coil inner radius (mm)
QD0	1.25	304	20
QF1	0.72	309	20

- The magnetic fields at the pole region exceed 7T, and the two quadruple magnets are embedded inside the detector solenoid magnet of 3.5T → preferably with the **Nb_3Sn** technology
  - Coils in Rutherford type Nb3Sn cables clamped by stainless steel collar
  - Conceptual design performed based on typical quadrupole block coil; magnetic field calculated with OPERA from Cobham Technical Services.

Luminosity Measurement

- Desired luminosity uncertainty of ~1‰ (achieved for LEP experiments!) as required by Higgs/Z precision measurements at CEPC/ILC
  - **LumiCal**: Calorimeter with silicon-tungsten sandwich structure to measure small angle radiative Bhabha scattering events
  - **Limited space before QD0 (CEPC)**: $z \in [115, 128\text{ cm}]$ and $\theta \in [60, 90\text{ mrad}]$ requiring angular precision of $\Delta\theta/\theta\text{min} < 5\times10^{-4}$
  - **Other sources of uncertainties**: theoretical calculation of cross-section, polar angle bias, physics background subtraction, etc.

    → **Nontrivial to achieve the target luminosity uncertainty**
- Online luminosity monitor allowing fast tuning of beam parameters
  - Even smaller angle Radiative Bhabha scattering events: → **ILC (BeamCal)**
  - Radiation-hard sensors (e.g. CVD diamond) to measure radiative Bhabha events at zero photon scattering angle → **CEPC/SuperKEKB**

Task 2: VTX

Xiangming Sun's talk

- Critical R&D's for the baseline design

  "fit 1 GigaPixel in a Diet Coke can & keep it cool!"

  -- Massimo Caccia

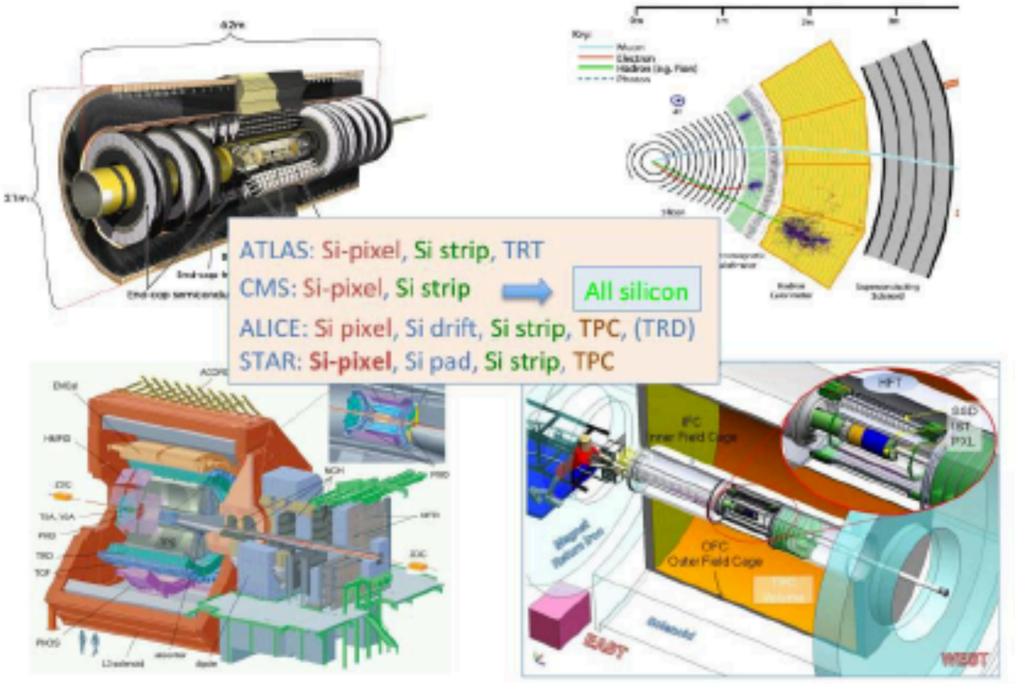
- New ideas

→ detailed R&D plan

milestones?

joint efforts with other projects, ATLAS upgrade?

baseline solution



MAPS (CMOS pixel)
carbon fiber structure
lvds + optical link

example applications：

STAR HFT
ALICE ITS upgrade

task:
design chip matching CEPC requirement

Task 3: Main Tracker

Huirong Qi's talk

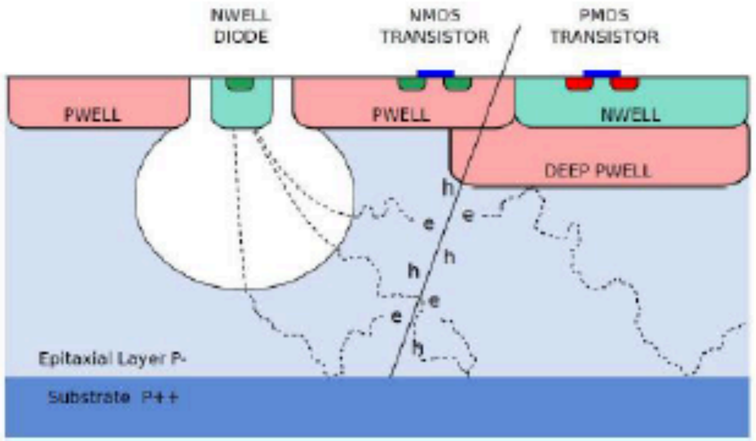
- Challenges for TPC
  - ion feedback – can TPC stands for Z pole
  - detector alignment
  - …

- With TPC (ILD)
  or full silicon tracker (SiD)
  or hybrid

- Large area silicon detector (even with the TPC option)

- Other ideas?

CMOS MAPS



Integrated sensor and readout electronics on the same silicon bulk with "standard" CMOS process → low material budget, low power consumption, low cost …

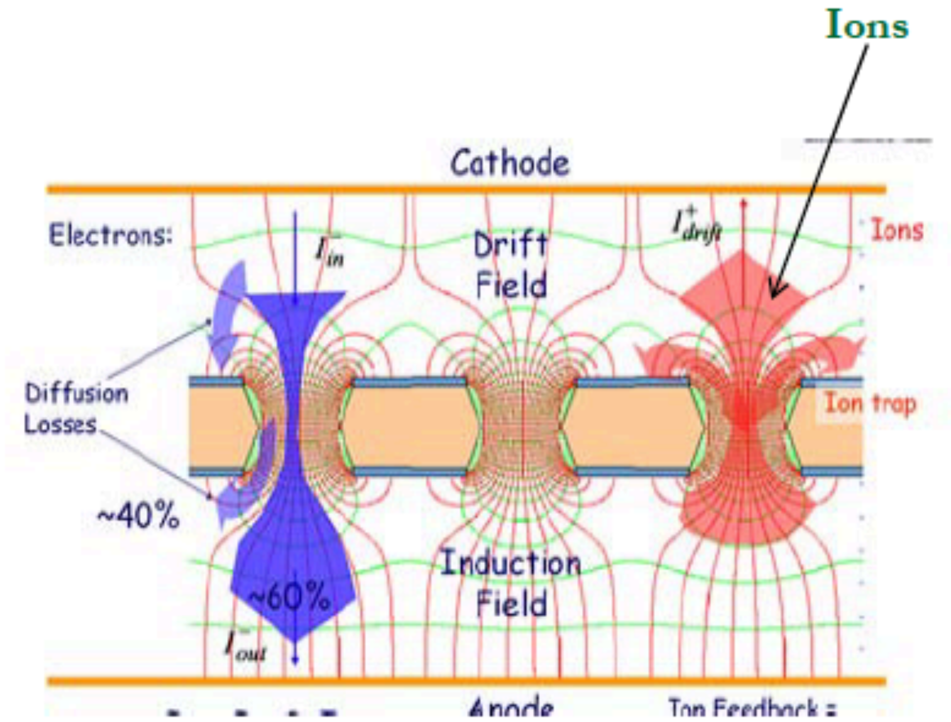
Ultimate (Mimosa 28) installed for STAR PXL, technology for ALICE ITS Upgrade

- Selected TowerJazz 0.18 μm CIS technology for R&D, featuring:
  - Quadruple well process: deep PWELL shields NWELL of PMOS transistors, allowing for full CMOS circuitry within active area
  - Feature size of 0.18 μm and 6 metal layers: high-density and low power
  - Thick (20 – 40 μm) and high resistivity (1 kΩ cm) epitaxial layer
  - Thin gate oxide (3 nm): radiation tolerance

Some considerations

- GEM detector could be as the amplification detector, Micromegas could be as the amplification device too.
- GEM detector could be reduced the IBF as the gating, Micromegas could be decrease the IBF too.

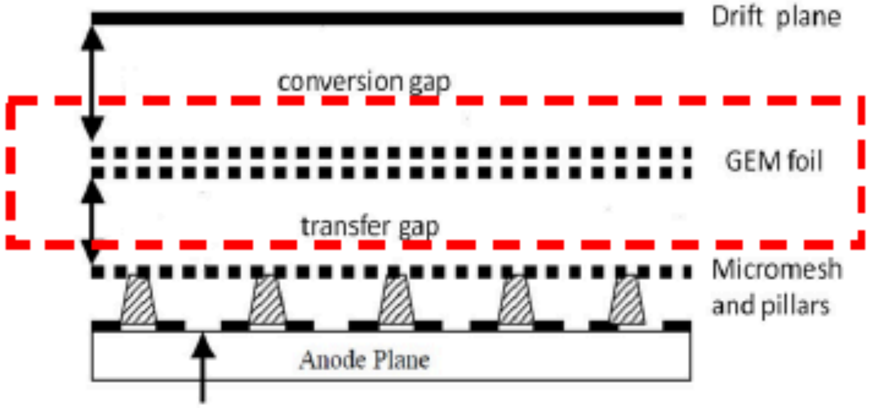
- GEM+Micromegas detector module
  - GEM as the preamplifier device
  - GEM as the device to reduce the ion back flow continuously
  - Stable operation in long time



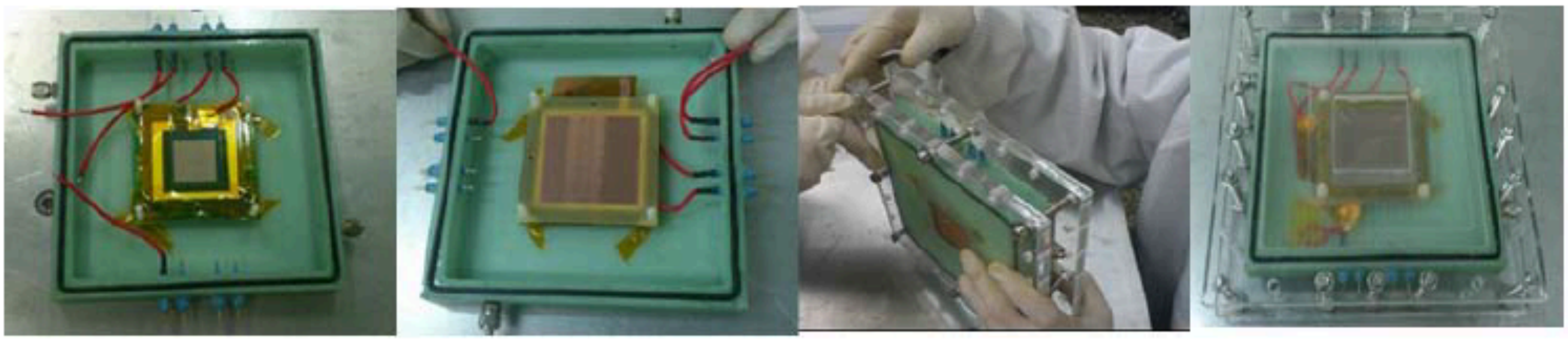
IBF of GEM

Hybrid structure module

- Hybrid structure detector
  - Active area:50mm×50mm
  - One GEM as the pre-amplifier device under Micromegas
  - GEM as the device to reduce the ion back flow continuously
  - Hybrid detector has the more stable working time than standard GEM or Micromegas at the same gain
  - Meet to the very smaller IBF

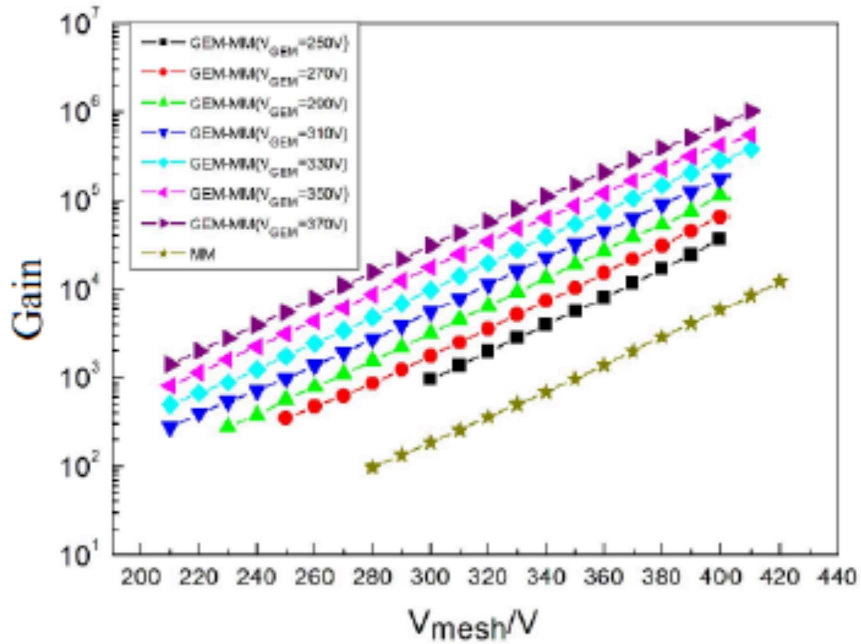


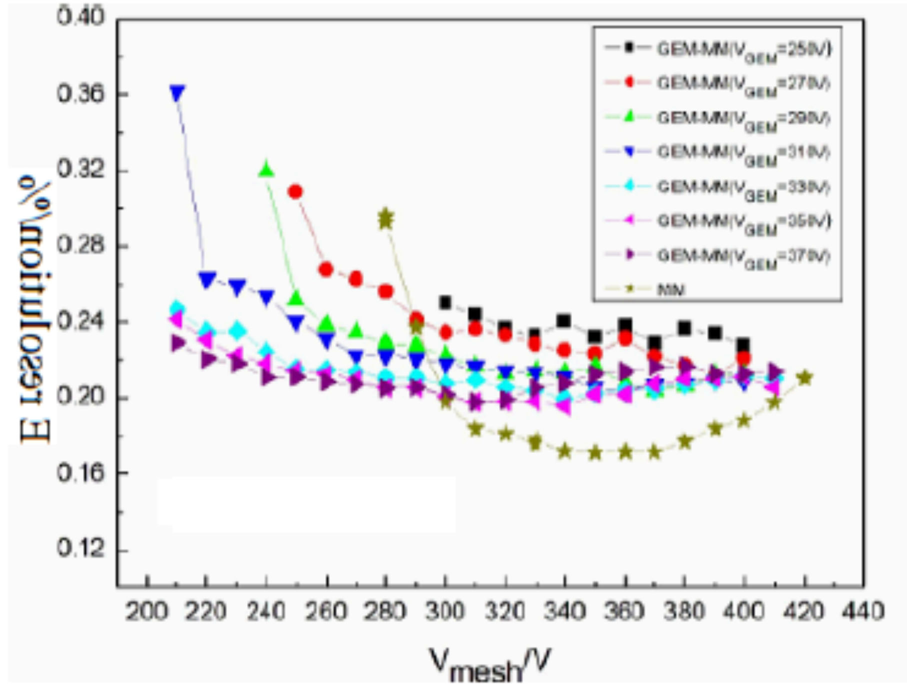
GEM+Micromegas detector



GEM+Micromegas assembled

Gain and energy resolution





- Test with Fe-55 X-ray radiation source
  - Reach to the higher gain than standard Micromegas with the pre-amplification GEM detector
  - Similar Energy resolution as the standard Micromegas
  - Increase the operating voltage of GEM detector to enlarge the whole gain

Critical R&D with LCTPC

- LCTPC Collaboration has identified some critical R&D's

  - **Field distortion near boundaries**
    - **Insulator surface facing drift volume should be removed; Avoid charge up effects in GEM detector**
    - **Electric field distortion near module boundaries should be shaped away**
  - **High B-field performance**
    - **Is Neff at B=3.5T the same as at B=1T?**
    - **Is electron attachment by CF4 in amplification region negligible?**
    - **Tracking in non-uniform B-field: ExB and deviation from helix**
  - **Positive ions and Gate**
    - **Develop ion gate: transparency, distortion, ion leak**
    - **Is primary positive ion effect really negligible? (effects of heavy micro-curlers?)**
    - **Establish distortion correction method**
  - **Resolution near endcaps**
    - **Hodoscope effect?**
    - **Angular effect? (primary ionization statistics)**
  - **Neutron BG**
    - **Is gas mixture with a hydrocarbon molecule such as iso-C4H10 OK?**
  - **P/T control of gas volume**
    - **2P CO_2 cooling of the whole gas volume?**

From K. Fujii

Task 4: Performance requirements for calorimeters

Haijun Yang's talk

- Vertexing $(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$
  - ~1/5 $r_{beampipe}$, ~1/30 pixel size (wrt LHC)

$$\sigma_{ip} = 5\mu m \oplus 10\mu m / p\sin^{3/2}\theta$$

✔ CEPC

- Tracking $(e^+e^- \to Zh \to \ell^+\ell^- X;\quad \text{incl. } h \to \text{nothing})$
  - ~1/6 material, ~1/10 resolution (wrt LHC)

$$\sigma(1/p) = 5\times 10^{-5}/GeV \quad \text{or better}$$

✔ CEPC

- Jet energy (Higgs self-coupling, W/Z seperation)
  - ~1/2 resolution (wrt LHC)

$$\sigma_E / E = 0.3/\sqrt{E(GeV)}$$

less demanding at CEPC

Refine the requirements for calorimeters

- Jet energy resolution is less demanding for CEPC

- Power pulsing is not possible at CEPC

  → new performance requirement to be defined

    → large cell, less channels
    new design, new technologies?
    active cooling?

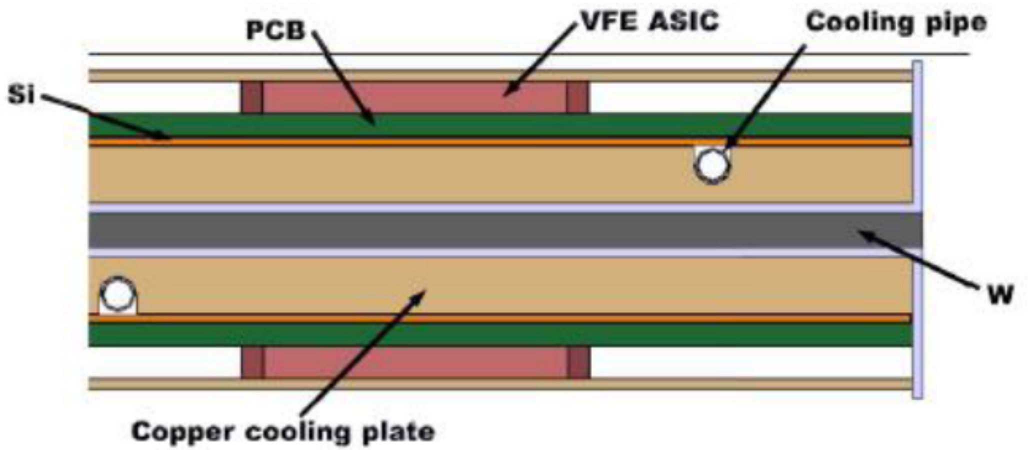
  → plan & milestones?

Example of active cooling

- CEPC is designed to operate at continuous mode with beam crossing rate: 2.8×10^5 Hz. Power pulsing will not work at CEPC.
- Passive Cooling: Too much gradient in Silicon …
- Active Cooling
  - Evaporative CO_2 cooling in thin pipes embedded in Copper exchange plate.
  - For CMS-HGCAL: 33 mW/cm^2, down to 0.6×0.6 cm^2 is OK (safety margin of 2)

➔ Transverse view of the slab with one absorber and two active layers.

➔ The silicon sensors are glued to PCB with VFE chips, cooled by the copper plates with CO_2 cooling pipes.



More questions/tasks

- Superconducting magnet
- Readout electronics for all sub-detectors?
- Software, computing?
- Need a muon detector?
- …

Near future plan

- 1st funding request to *Ministry of Science and Technology of China* soon (in two months?), to support a few most critical R&D activities – a list still under discussion:
  - design and optimization
  - LumiCAL
  - *a sensor design* for the vertex detector
  - Ion feedback effects of TPC
  - cooling for ECAL/HCAL
  - …
- Ready to welcome international collaborations

International collaborations

- CEPC will be an international project ! International collaborations for the detector R&D will be guided by the *international advisory committee of CEPC*. Very preliminary ideas:

- working on critical R&D topics with common interests (for ILC, FCC, CLIC, LHC upgrade,…) in existing international groups, like LCTPC, CALICE, RDXX, …

- (jointly) organizing workshops for sub-detector/technology

- working groups for CDR

- proto-collaborations for R&D towards CEPC detectors

- collaborations

(welcome YOUR ideas/advices/inputs…)

Summary

- PreCDR: feasibility studies for a detector at CEPC
  - ILD-like design
  - modifications due to short L*
  - power consumption/cooling is challenging
  - some critical R&D identified
- From PreCDR to CDR
  - develop/collect (new) ideas for 2+ detector concepts
  - critical R&D
- CEPC is an international project, you are all welcome to join us !