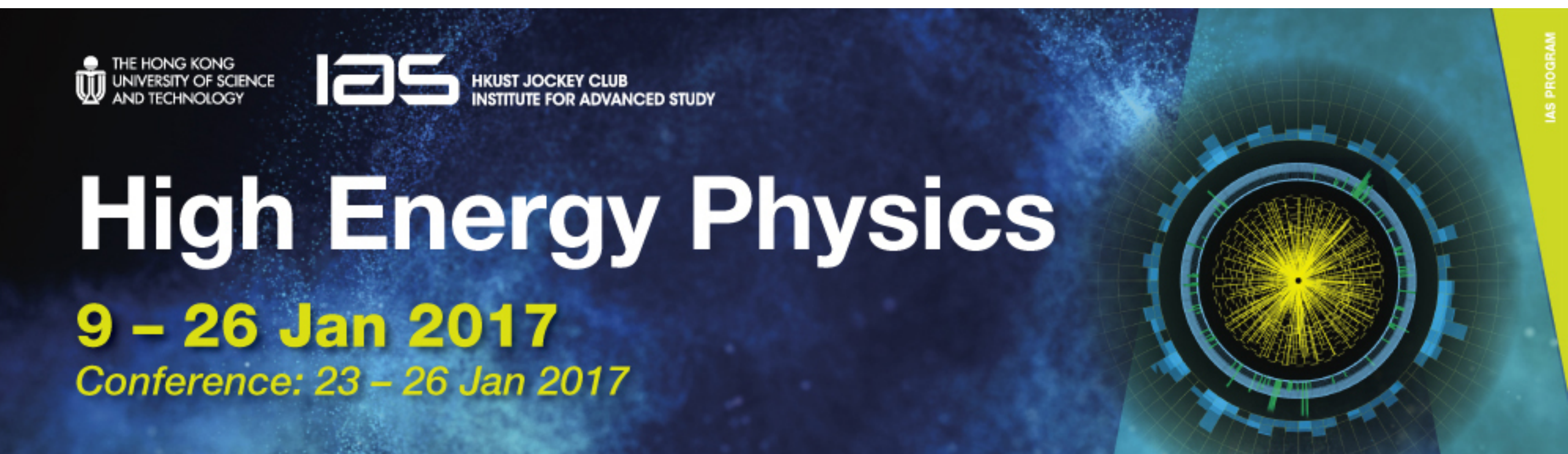
CEPC Detector
Status & Tasks for CDR

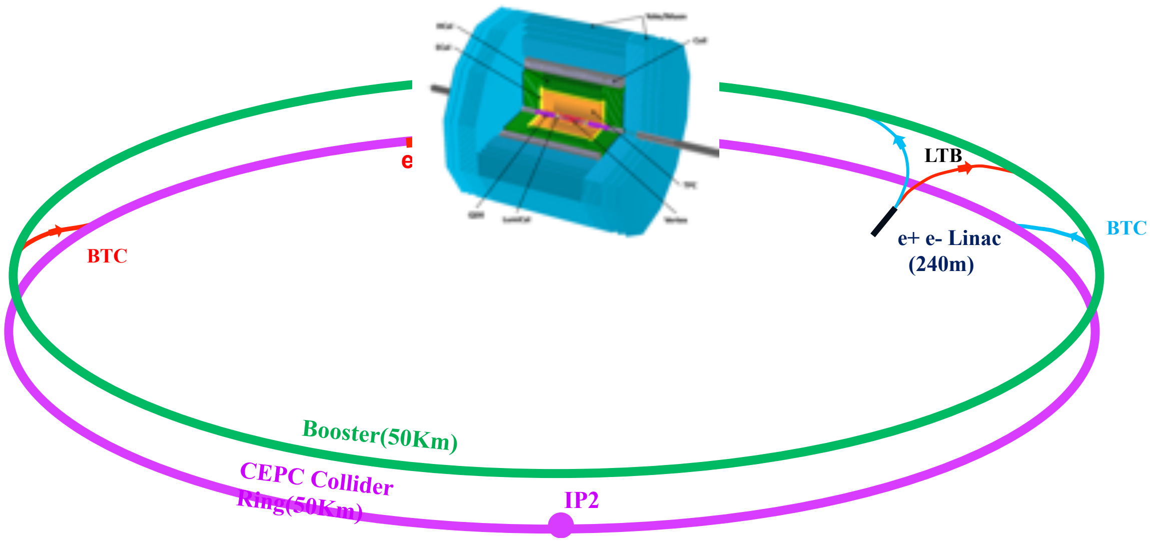
Yuanning Gao (Tsinghua University)

On Behalf of the CEPC-SppC Study group



Outline

- Performance requests
- Status and goals for detector R&D
- Urgent tasks
- Plan for CDR
- Summary



Physics Program at CEPC

- Baseline
  - $10^6\ H$ @ 240 GeV
  - $10^{10-11}\ Z$ @~ 91 GeV
  - $10^{6-8}\ W^+W^-$ @~160 GeV

    (w/ beam energy measurement)
- Upgrade phases (optional)
  - high luminosity Z-pole physics, 10^{35-36} cm^{-2}s^{-1}
  - polarized beam(s) for Z, W
  - $t\bar{t}$ at ~350 GeV
  - …

A detector at CEPC

- The detector design could benefit from 20+ years' world-wide studies for ILC

- Performance requests:

Vertexing $(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$

– ~1/5 $r_{beampipe}$,~1/30 pixel size (wrt LHC)

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

➢ extremely good space resolution
➢ low material budget

A detector at CEPC

- The detector design could benefit from 20+ years' world-wide studies for ILC

- Performance requests:

Tracking $(e^+e^- \to Zh \to \ell^+\ell^- X; \quad \text{incl.}\ h \to \text{nothing})$

– ~1/6 material, ~1/10 resolution (wrt LHC)

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

➢ precise tracking, low X0

A detector at CEPC

- The detector design could benefit from 20+ years' world-wide studies for ILC

- Performance requests:

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

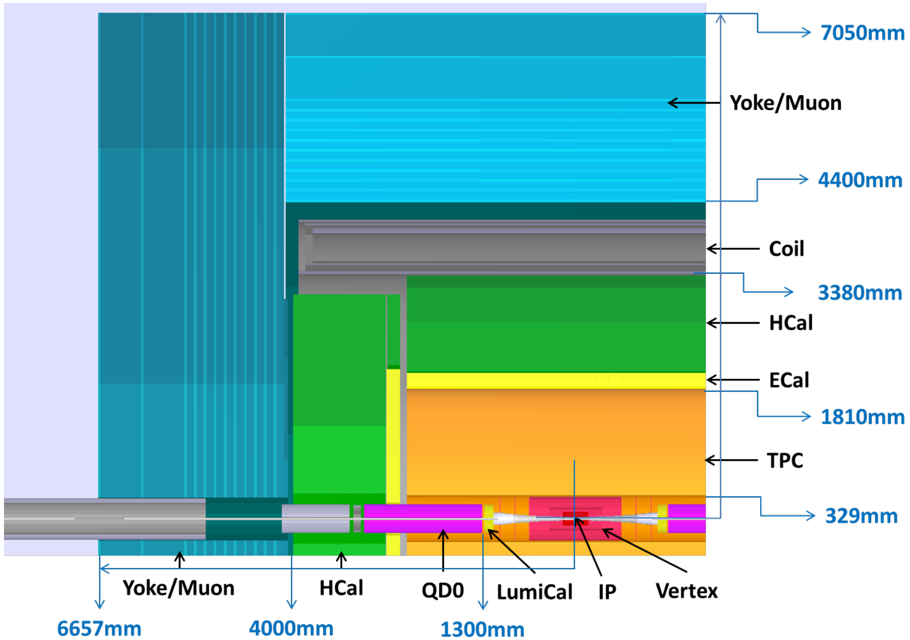
$$\sigma_E / E = 0.3 / \sqrt{E(\mathrm{GeV})}$$

  - ➢ high granularity calorimeters
  - ➢ Particle Flow Algorithm (PFA)
  - ➢ less demanding wrt ILC detectors

ILD-like design in PreCDR

- ILD-like design as a *reference for feasibility studies*

- New MDI design with a shorter L*=1.5m
- Silicon pixel vertex detector, strip trackers
- TPC as main tracking device
- B field 3.5T
- Very high granularity
  ECAL (0.5cm x 0.5cm)
  HCAL (1.0cm x 1.0cm)

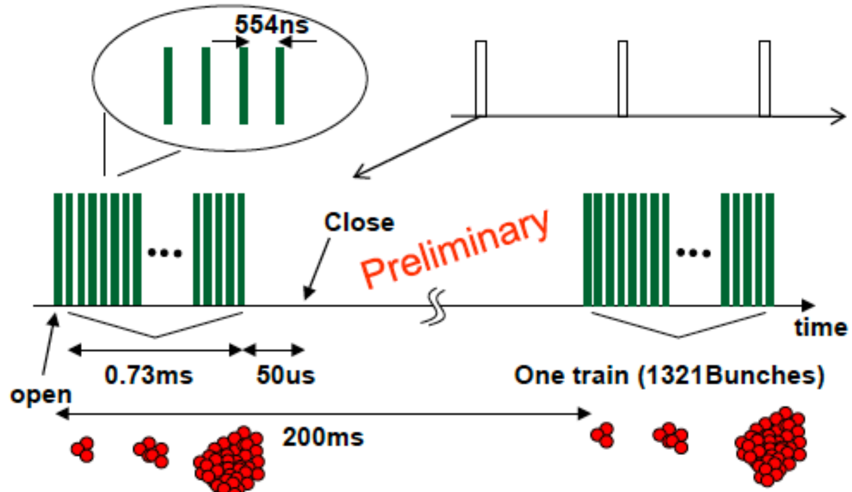


ILD-like design in PreCDR

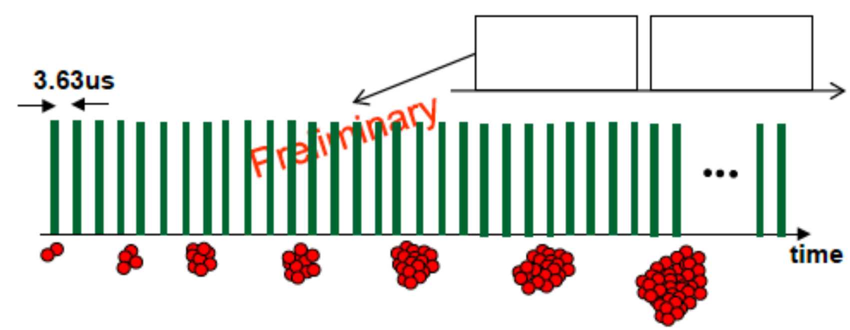
- Not so obvious the challenging issues could be resolved …

- beam structure
  - detector cooling
  - vertex detector readout
  - ion feedback in TPC

- Z pole
  - event rate (< 1kHz)
  - hermeticity ?
  - π/K separation?



Beam structure of ILC



Beam structure of CEPC

Strategies for studies after PreCDR

- Explore technologies for each sub-detector could reach the performance requests: *ILD is just a reference*

- Starting critical R&D listed in PreCDR

- *Meanwhile keep in mind the machine has not been fully defined yet…*

Vertex detector R&D: Status and Plan

- R&D target: still not reach the request, 1st step

– Single point resolution near the IP: $\leq 3\ \mu m$ → *high granularity*

– Power consumption: <100 mW/cm^2

– Material budget: $\leq 0.15\% X_0$/layer → *Low power dissipation, thinned, monolithic pixel sensor*

– Pixel occupancy: $\leq 1\%$ → *High granularity and/or short readout time*

– Radiation tolerance: ~100 krad/y (TID) and ~10^{11} N_{eq}/cm^2/y (NIEL)

– Integration time: 10-100 μs

- CMOS Pixel sensor (CPS)

– Small pixel size

– In-pixel functionality circuitry

– Novel readout scheme → faster and less power

– Tower Jazz CiS 0.18μm process

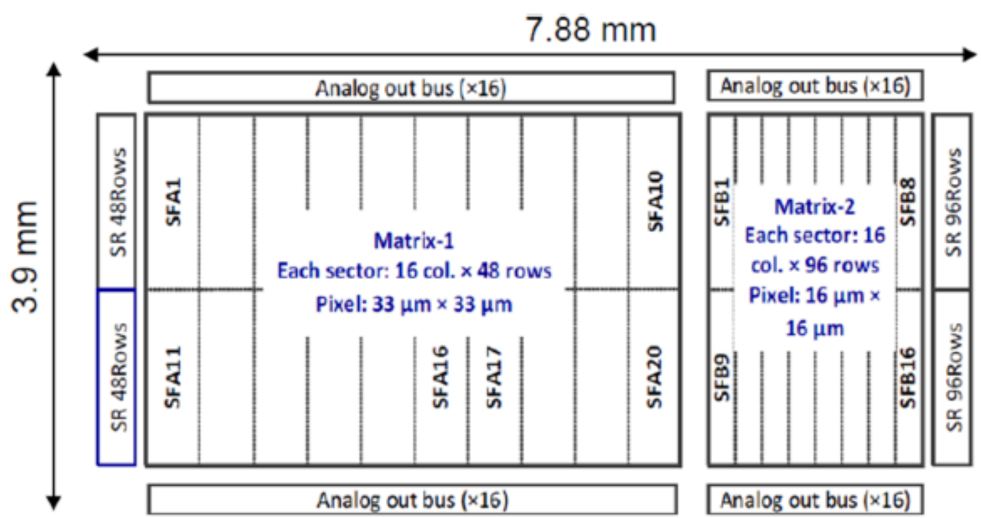
Vertex detector R&D: Status and Plan

- 1st CPS prototype design

Joint TowerJazz 0.18 um CMOS process MPW submission with IPHC in Nov. 2015

Goal: sensor optimization and in-pixel pre-amplifier study

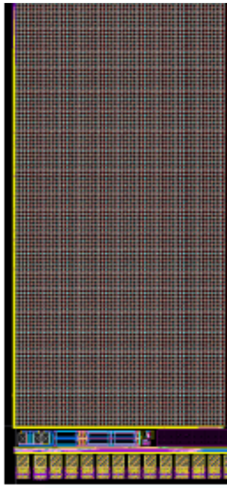
- Floorplan overview:
  - Two independent matrices: Matrix-1 with 33 × 33 μm² pixels (except one sector SFA20 with 16 × 16 μm² pixels), Matrix-2 with 16 × 16 μm² pixels.
  - Matrix-1 includes 3 blocks with in-pixel pre-amplifier
  - SFA20 in Matrix-1 contains pixel with AC-coupled pixels



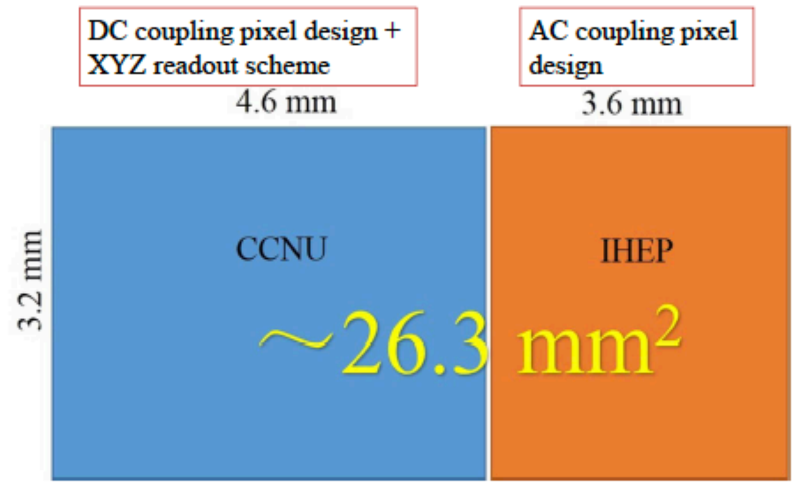
- Tower Jazz CIS 0.18 μm, November 2015 submission
- Two types of wafer:
  - 18μm HRES epi-layer wafer
  - 700Ω Czochralski wafer
- Sensor arrival at IHEP June 2016
- Test board and system in preparation, including the NIEL measurement.

Vertex detector R&D: Status and Plan

- 2nd CPS prototype design



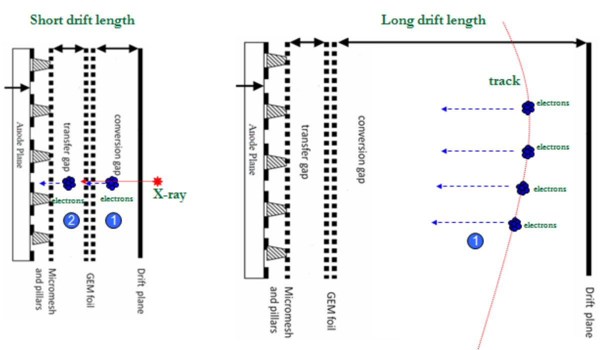
- Purpose: small-size digital pixel design verification, fast readout
- Pixel design:
  - Pixel size: smaller than 22 $\times$ 22 μm^2
  - Each pixel contains a sensing diode, a pre-amplifier and a discriminator
  - AC coupling: rolling-shutter readout with higher biased voltage
  - DC coupling: asynchronous readout with high gain and low noise
- Readout design:
  - Matrix readout using XYZ solution
  - Pixel size: $26 \times 26 \mu m^2$
  - Signal duration time: $< 3 \mu s$
  - Readout speed: 25 ns/hit
  - Power consumption: < 80 mW/cm^2



MPW submission：Feb., 2017

TPC studies: Status and Plan

- Target
  - understand the effect of ion feedback
  - GEM+Micromegas to suppress ion back flow (0.1%)



	GEM+MMG 420LPI (IHEP)	2GEMs + MMG 450 LPI (Yale University)	Micromegas only 450 LPI (Yale University)
Ion Back Flow	0.1~0.2% Edrift = 0.25 kV/cm	(0.3 –0.4)% Edrift = 0.4 kV/cm	(0.4 –1.5)% Edrift= (0.1-0.4) kV/cm
<GA>	4000~5000	2000	2000
ϵ-parameter(=IBF*GA)	4~5	6~8	8~30
E –resolution	~16%	<12%	<= 8%
Gas Mixture (2-3 components)	Ar + iC4H10	Ne+CO2+N2, Ne+CO2,Ne+CF4, Ne+CO2+CH4	X + iC4H10 (Ar+CF4+iC4H10)
Sparking (^{241}Am)	$<10^{-8}$	< 3.*10^{-7}(Ne+CO2) (N.Smirnov report)	~ 10^{-7} (S. Procureur report)
Possible main problem	Thin frame	More FEE channel	#
Goals	CEPC TPC	ALICE upgrade	#

TPC studies: Status and Plan

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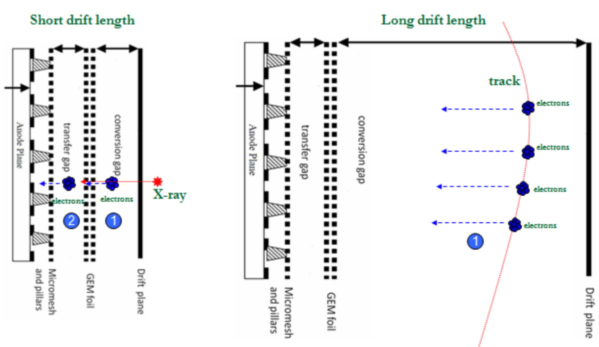

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TPC studies: Status and Plan

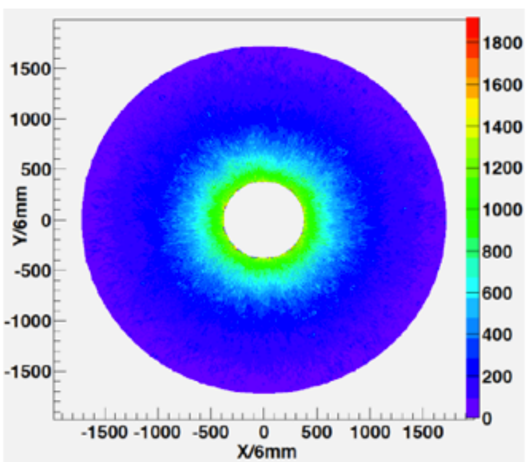
- Preliminary results from simulation studies

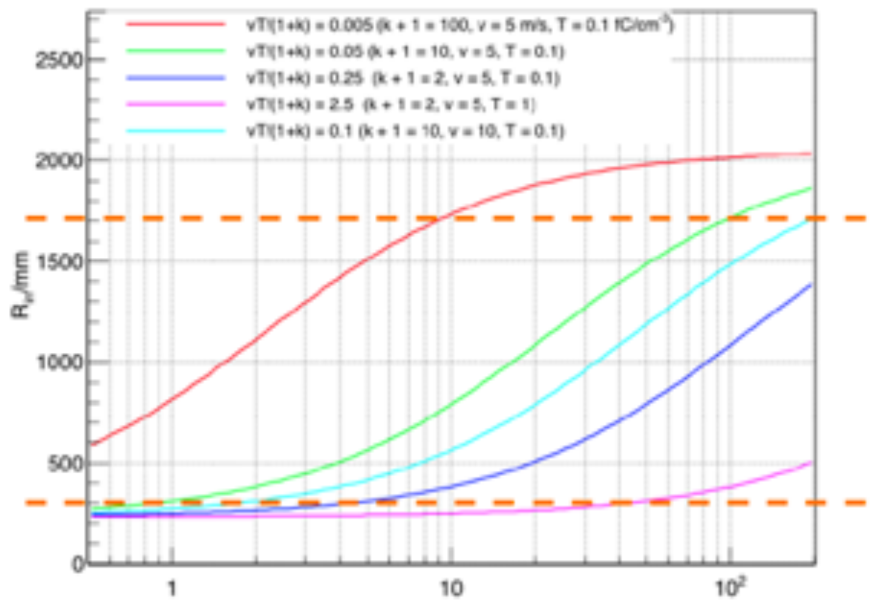
  - ion back suppression to 0.1% is possible

  → beam test in 2017-2018 with GEM+Micromegas module

  - occupancy is very low even for Z-pole

  - distortion by ions acceptable up to 10^{34}cm^{-2}s^{-1}



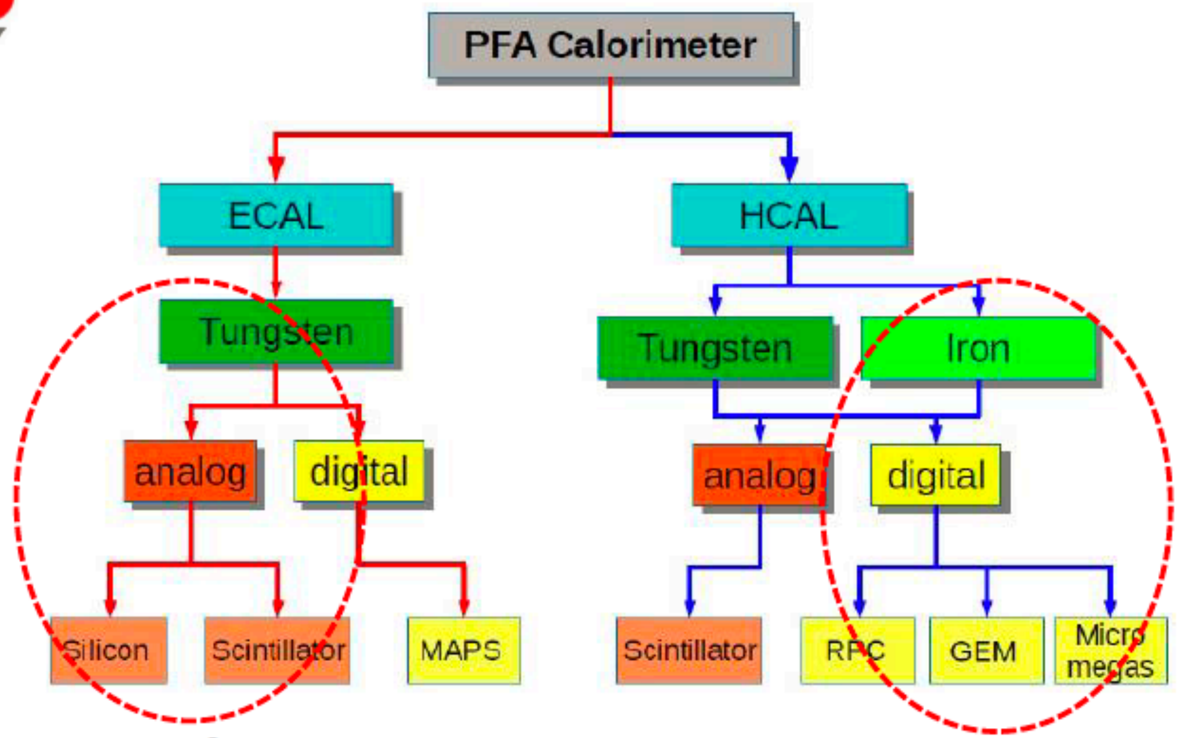


Calorimeters: Status and Plan

- CALICE studies

Calorimeter for ILC

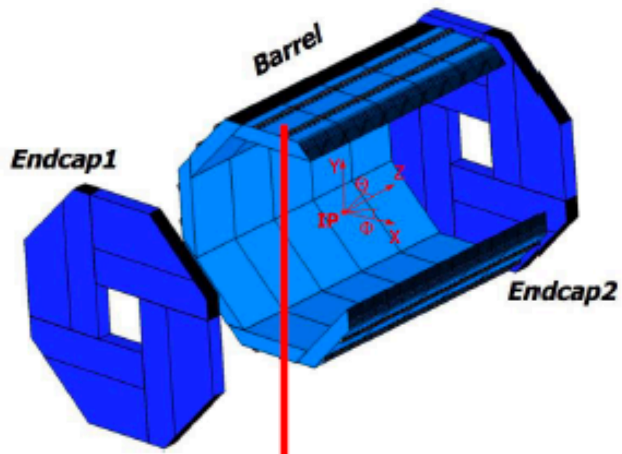
https://twiki.cern.ch/twiki/bin/view/CALICE/CalicePapers



Readout cell size: 144 - 9 cm^2 → 4.5 cm^2 → 1 cm^2 → 0.25 cm^2 → 0.13 cm^2 → 2.5x10^{-5} cm^2

Technology: Scintillator + SiPM/MPPC; Scintillator + SiPM/MPPC; Gas detectors Silicon; Silicon; Silicon; Silicon (MAPS)

ECAL R&D: Scintillator-W



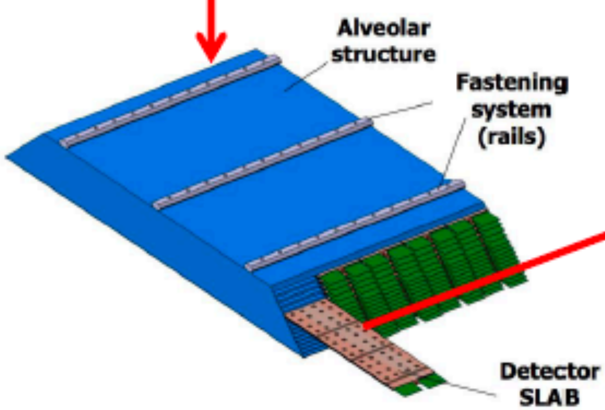
The CEPC ECAL consist of a cylindrical barrel system and two end caps.

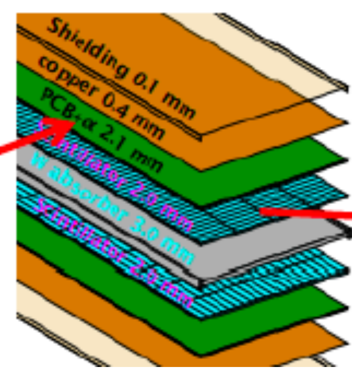
One of the proposal for CEPC ECAL is based on scintillator strip with SiPM readout.

Total readout channel: ~8 Million

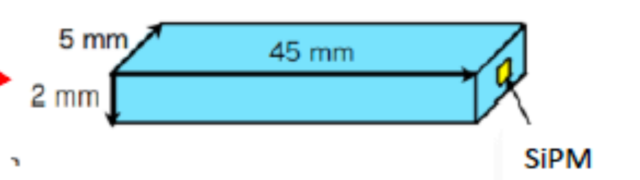
Two scintillator layers make a sandwich structure with a tungsten absorber.

The strips in adjacent layers are perpendicular to each other to achieve a 5×5 mm^2 cell size.



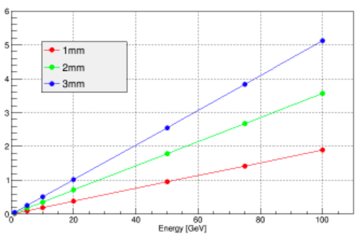


Baseline design of scintillator and SiPM

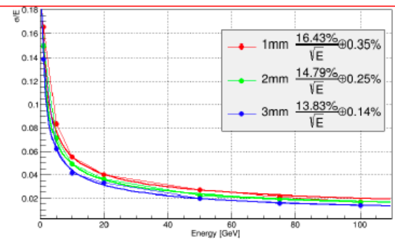


Detector Simulation: **scintillator thickness**

Zhigang Wang, Hang Zhao, Tao Hu (IHEP)



Linearity



Energy Resolution

The dependency of the linearity and energy resolution on the scintillator thickness.

Particle: photon, Cell Size: 5x5mm
Sensitive Layer：W:3;Air:0.5;Scintillator:1,2,3;Air:0.5;PCB:2;Air:0.5(mm)
Layer number: 50

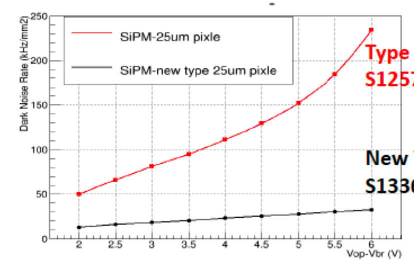
The thickness of scintillator can be reduced to 1 mm.

SiPM study: **Dark Noise Rate**

Zhigang Wang, Hang Zhao, Tao Hu (IHEP)

Electron hole pairs generated without the involvement of photons give rise to unwanted noise.

Spectrum of SiPM dark noise



Type No.: S12571-025P

New Type No.: S13360-1325PE

Dark noise rate with over-voltage

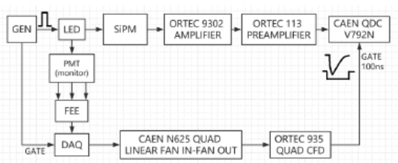
- **Dark noise rate rises exponentially with the applied over-voltage.**

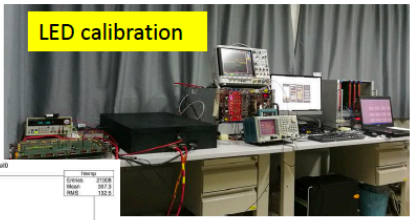
Very recently, SiPMs with trenches between pixels dramatically reduced dark rate and pixel to pixel cross-talk.

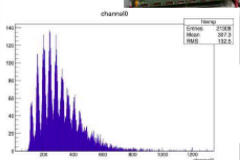
- **The dark noise rate of the new SiPMs (30kHz/mm^2) is 1/3 of the old ones (100kHz/mm^2), with the same gain.**

ECAL Test facilities (IHEP, USTC)

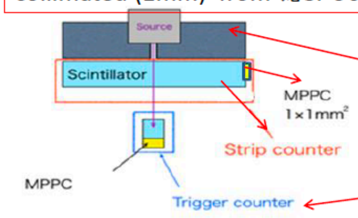
➔ **ECAL Test facilities at USTC and IHEP.**

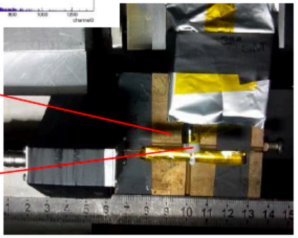






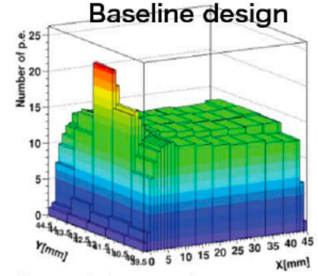
Scintillator strip irradiated with β collimated (1mm) from 锶Sr-90



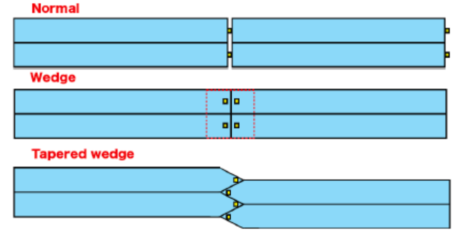


Optimization of Sct. Strip

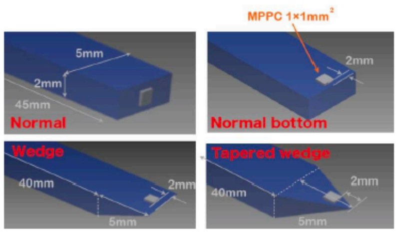
Z.G. Wang et.al.

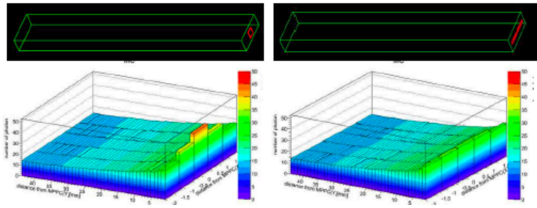


Optimizing the geometry and connection of scintillators.



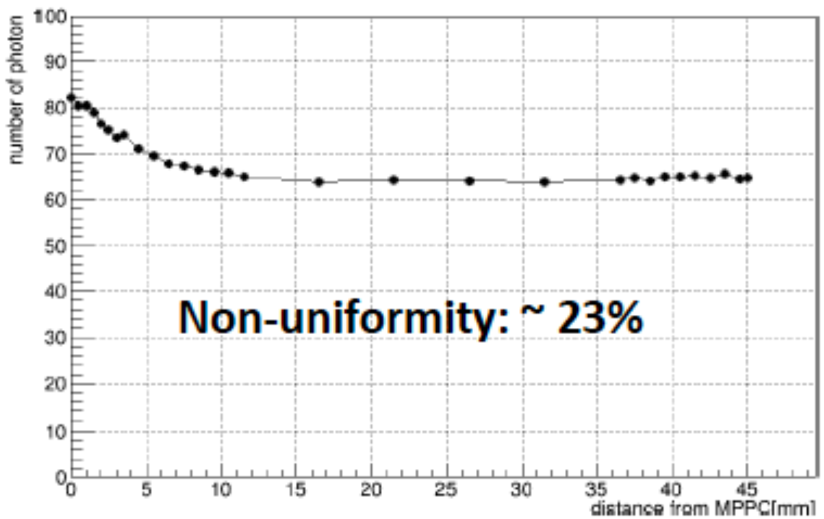
SiPM area: 1×1 mm^2 ➔ 0.25×4 mm^2:





Scintillator strip light output

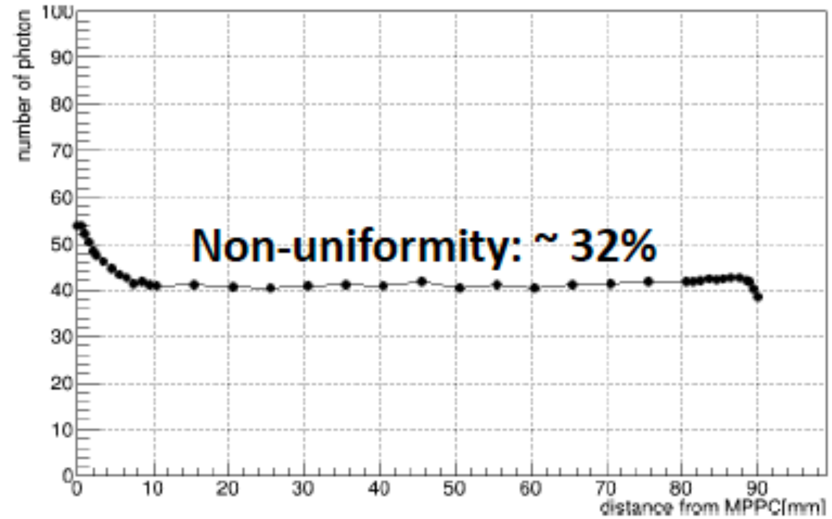
5mm×45mm scintillator strip

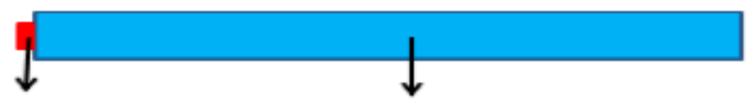


SiPM **Scintillator strip**

Strip: 5mm×45mm×2mm

10mm×90mm scintillator strip





SiPM **Scintillator strip**

Strip: 10mm×90mm×2mm

Scintillator: BC408， SiPM: 1mm×1mm,25um pixel size

The uniformity of scintillator strip light output need to be optimized.

CEPC HCAL

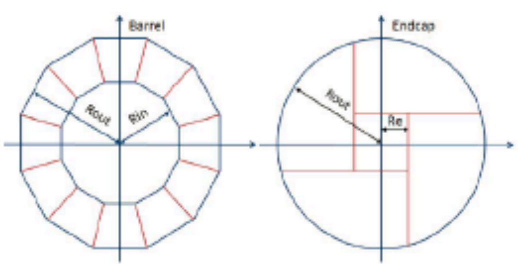
- The HCAL consists of
  - a cylindrical barrel system: 12 modules
  - two endcaps: 4 quarters
- Absorber: Stainless steel

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

CEPC DHCAL OPTIMIZATION

- To full fill the requirements of CEPC PFA, the DHCal is optimized by the following:
  - layers of DHCal, scanned from 20 layers to 48 layers.
  - size of each cell, scanned from 10 mm to 80 mm.
  - digitization (Q spectrum, spatial resolution, semi-Digi, etc..)

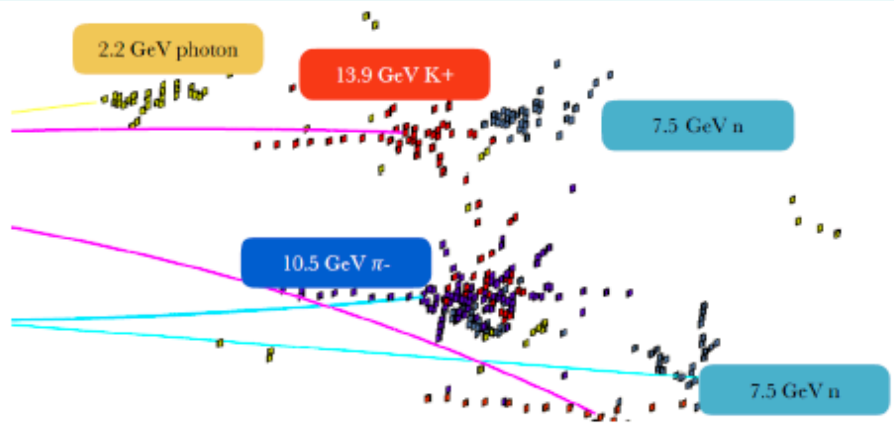
- The HCAL consists of
  - a cylindrical barrel system: 12 modules
  - two endcaps: 4 quarters
- Absorber: Stainless steel



10

SIMULATION - PRELIMINARY

By **Shi CHEN** (UCAS)

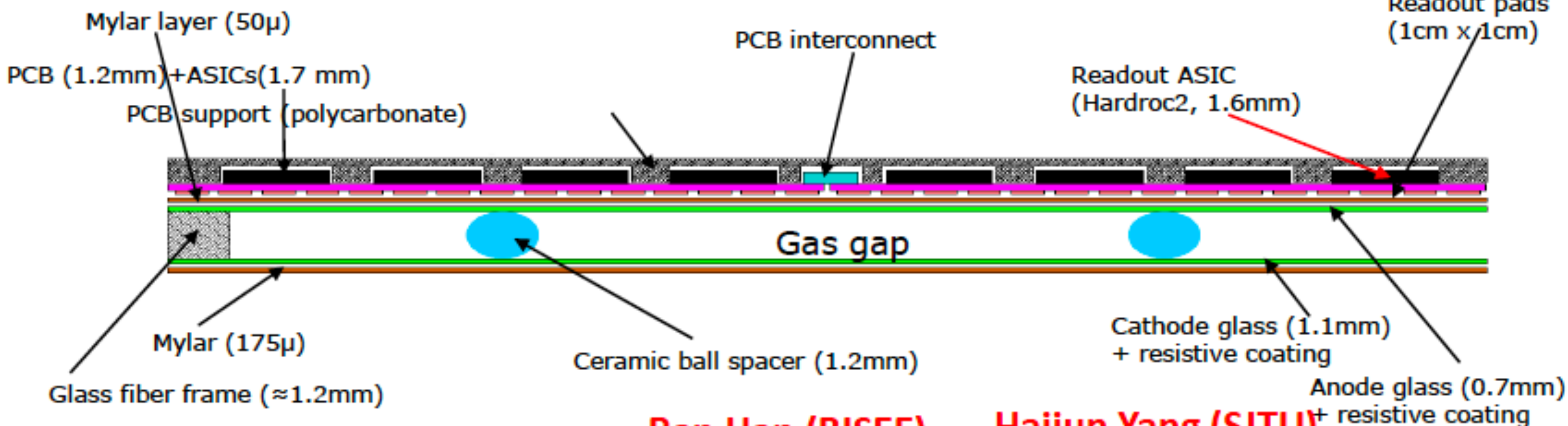


„typical" jet:		$(\sigma_{jet})^2$
~ 60% charged particles	tracking	$= (\sigma_{tracks})^2$
~ 30% photons	EM calorimeter	$+ (\sigma_{EMCalo})^2$
~ 10% neutral hadrons	HAD calorimeter	$+ (\sigma_{HADCalo})^2$
~~ 1% neutrinos~~		$+ (\sigma_{loss})^2 + (\sigma_{confusion})^2$

6

Schematic of RPC

Join the R&D activities in CALICE



Ran Han (BISEE)

Haijun Yang (SJTU)

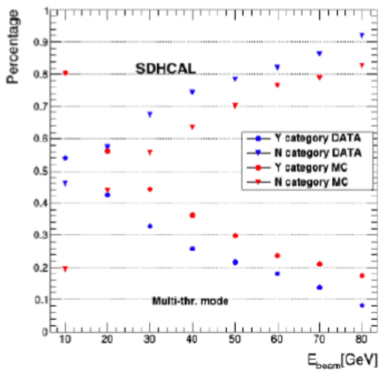
Large area gRPC:

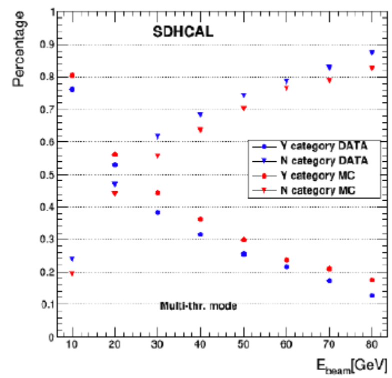
- ✓ Negligible dead zone (tiny ceramic spacers)
- ✓ Large size: 1 × 1 m^2
- ✓ Cost effective
- ✓ Efficient gas distribution system
- ✓ Homogenous resistive coating

Improve the Muon Rejection

Bing Liu, Haijun Yang, Imad

Nhits/Nlayer > 2.2 → Update → Nhits/Nlayer > 3.2





There is a large difference between MC and data

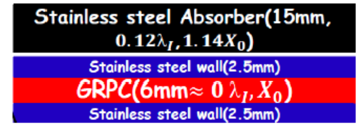
After updating , the difference between MC and data is very little

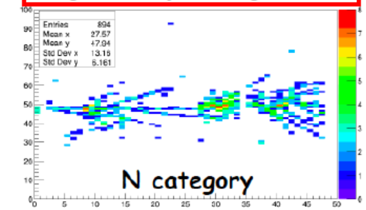
Energy Resolution vs No. of Layers

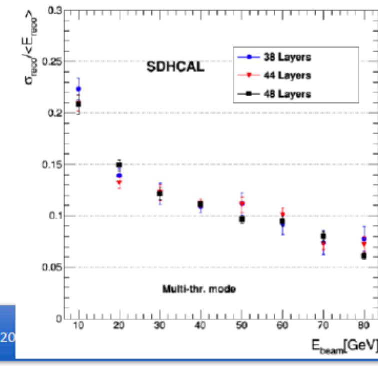
Bing Liu, Haijun Yang, Imad

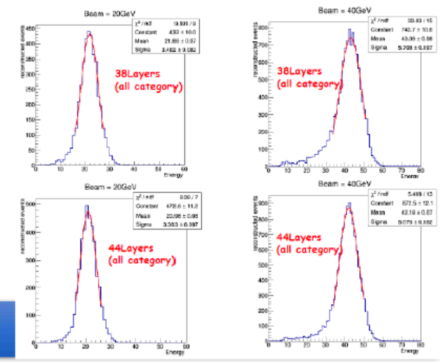
SDHCAL has 48 layers which aims for ILC Detector
- 6mm RPC and 20mm Stainless steel absorber

➔ Optimization no. of layers for CEPC at 240GeV



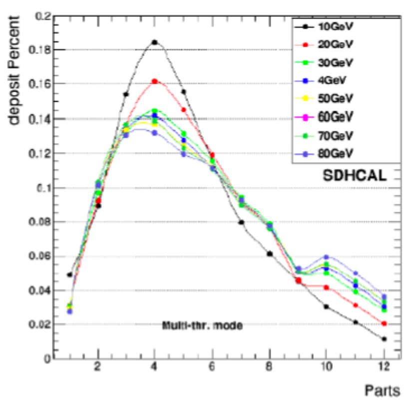




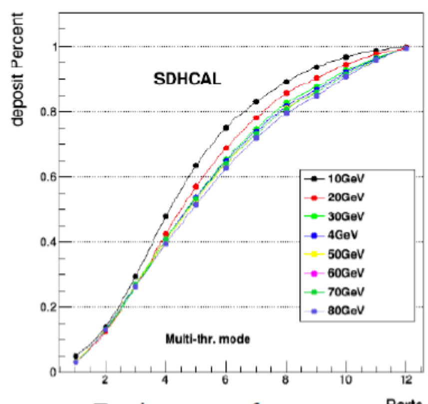


Energy deposited in every 4 layers

Bing Liu, Haijun Yang, Imad

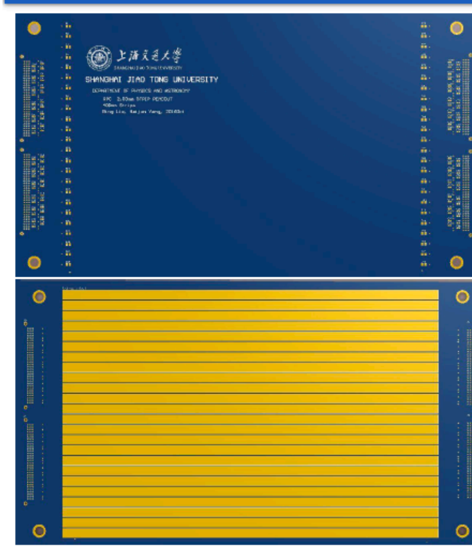


Percent of energy deposit in per parts



Total percent of energy deposit before a part you choose;

Design of PCB for RPC

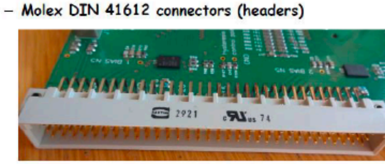


Bing Liu, Haijun Yang (SJTU)

24 strips with 1cm/strip, gap = 1mm, length = 40cm

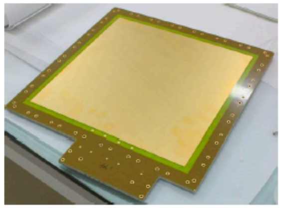
- PCB Output: 3 bins x 32 column = 96 pins
  - Molex DIN 41612 connectors (receptacles)

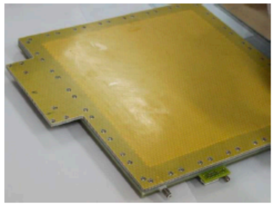
- NINO Input:
  - Molex DIN 41612 connectors (headers)

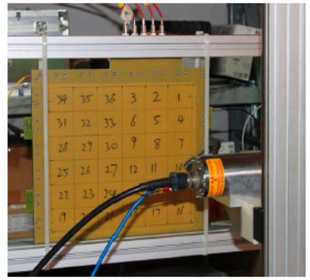


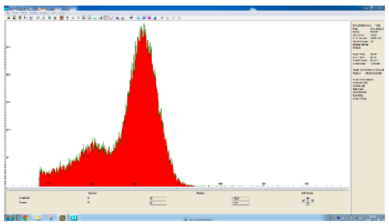
HCAL Based on GEM (USTC)

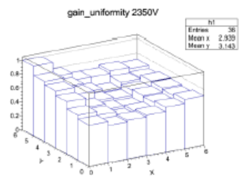
- Construction of GEM at USTC

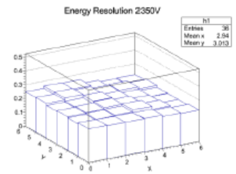










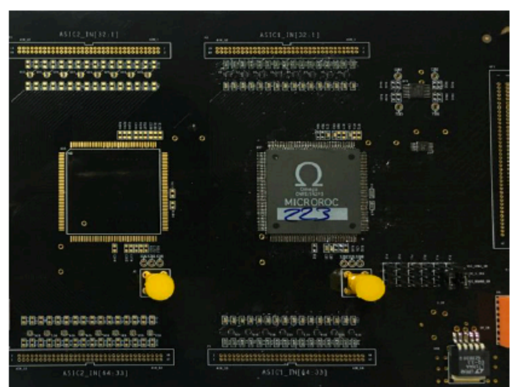


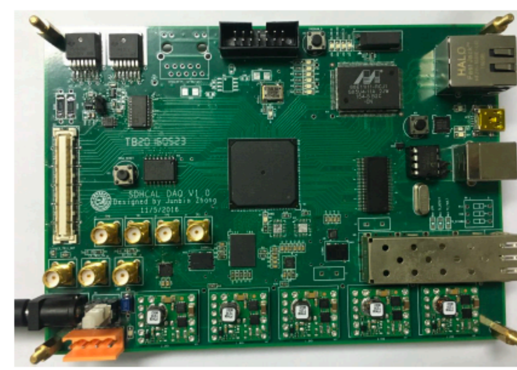
✓ **Gain:** ~4000
Non-uniformity ~15.6%

✓ **Energy resolution:** ~24.1%
✓ Non-uniformity: ~5.4%

HCAL Based on GEM (USTC)

- Design of readout electronics by USTC

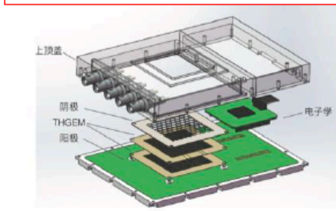


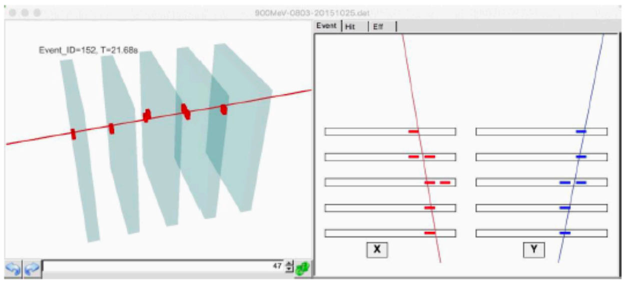


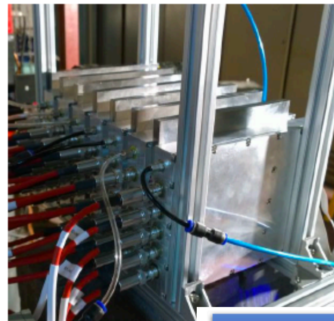
WELL-THGEM Beam Test @ IHEP

Hongbang Liu, Qian Liu (UCAS)

- 7 THGEMs ware installed, and 5 of them were used, and flushed with Ar/iso-butane = 97:3.
- 1 threshold, binary readout
- 900 MeV proton beam was used
- 5x5cm2 sensitive region
  → 20 x 20 cm2





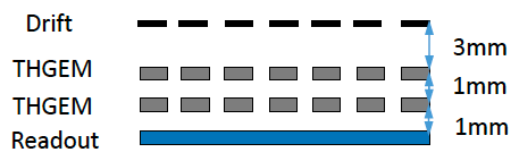


CEPC-DHCAL research base on THGEM detector

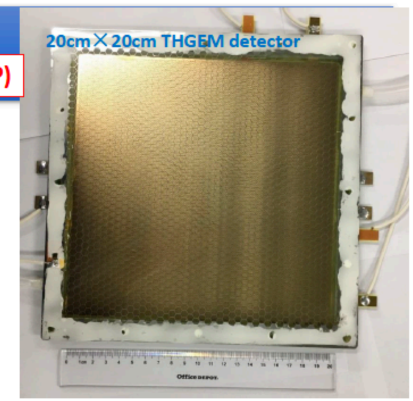
Boxiang Yu (IHEP)

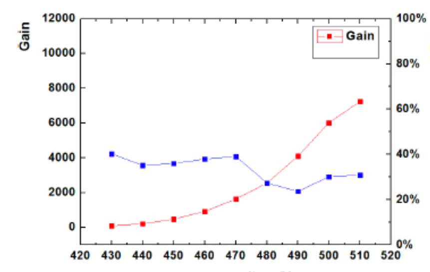
The active detector thickness of CEPC-DHCAL is important to reduce the cost, the thickness of THGEM should be reduce to 6mm. Some work has been done.

The thinner 5cm×5cm detector has been developed. Some result has been obtained. The 20cm×20cm thinner THGEM detectors are under development.



New thinner structure of THGEM detector





Simulation studies: Optimization

- Granularity: Wi/wo active cooling
  - Geometry in ILD (ild_o2_v05):
    - *ECAL, 5 mm Cell Size & 30 layers, 5 kw with power pulsing*
    - *HCAL, 10 mm Cell Size & 48 layers.*
  - @ CEPC:
    - *Wi Active cooling: + 2mm thick cooper per active layer, in progressing*
    - **Wo Active cooling: reduce the granularity by ~ 1 order of magnitude (in considering Electronics/Sensor progress...)**
  - Performance:
    - Lepton ID
    - Physics benchmarks:
      - *Z→di lepton, Higgs to inc;*
      - *Z→νν; H→WW→lνqq;*
      - *Z→νν; H→ZZ→llqq;*
- ECAL Saturation studies on H→γγ measurements

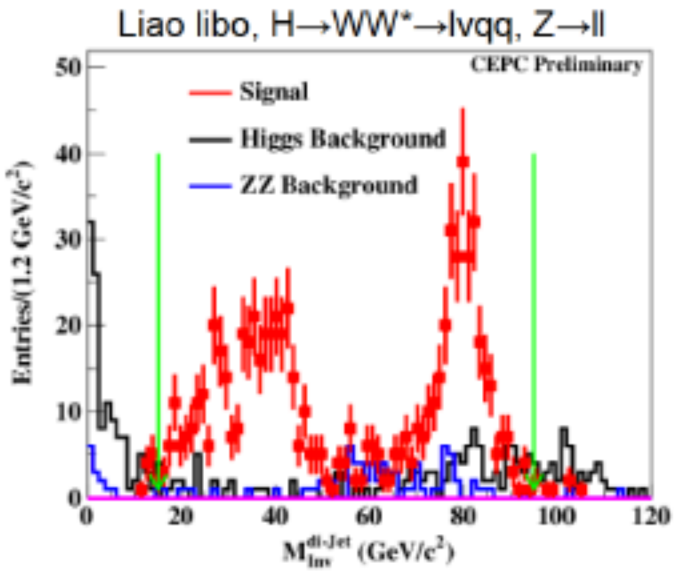
Global efficiencies… preliminary

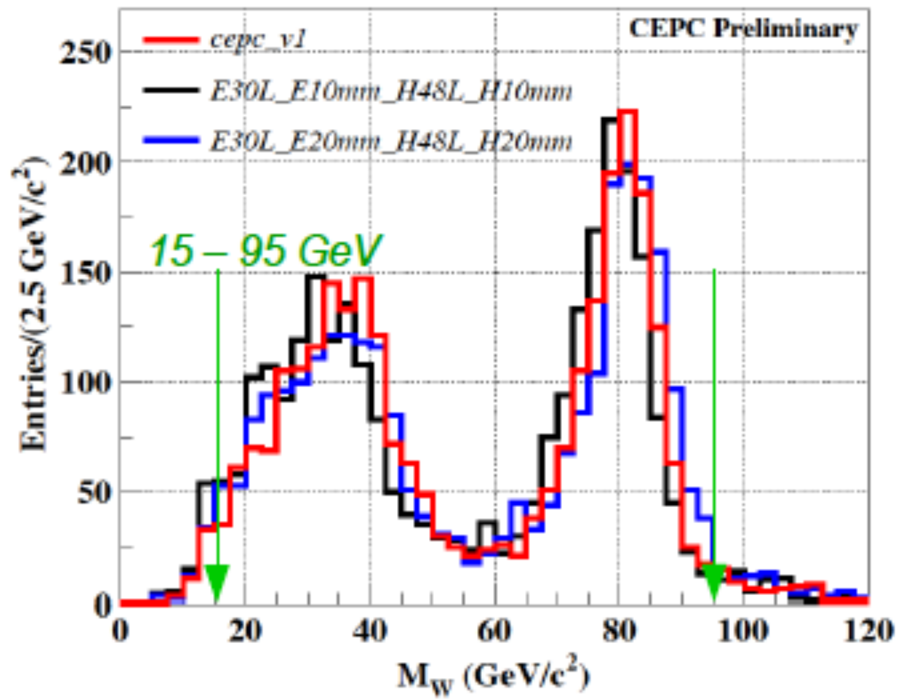
	Geom 1		Geom 2	
	$\mu\mu$H	eeH	$\mu\mu$H	eeH
Cut_μ	0.1	0.1	0.1	0.1
Cut_e	0.01	0.001	0.01	0.001
ε_E	93.41 ± 0.92	98.64 ± 0.08	91.60 ± 1.02	97.89 ± 0.11
η_E	92.02 ± 1.00	99.74 ± 0.04	89.89 ± 1.10	99.67 ± 0.04
ε_μ	99.54 ± 0.05	95.53 ± 0.76	99.19 ± 0.06	86.48 ± 1.26
η_μ	99.60 ± 0.04	96.31 ± 0.70	99.83 ± 0.03	95.38 ± 0.81
ε_{event}	98.92 ± 0.11	93.93 ± 0.24	97.92 ± 0.14	96.19 ± 0.19

Result @ Sep. meeting

		CEPC_v1, ILD	Test Geo 1	TG 2	TG 3
ECAL	Cell Size/mm	5	10	20	20
	# Layers	30	30	30	20
HCAL	Cell Size/mm	10	10	20	20
	# Layers	48	48	48	20
Ratio of Channels (X/ILD)	ECAL	1	1/4	1/16	1/24
	HCAL	1	1	1/4	1/10
Event Recon. Efficiency	$\mu\mu$H	95.7%*	98.0%	96.5%	95.2%
	eeH	91.1%*	89.6%	89.1%	74.5%(???)

Lepton + Jets: Br(H→WW)





Br(H→WW) via ννH, H→WW*→lνqq

No lose in the object level efficiency;
JER slightly degraded, ~ 5/10% at 10/20 mm
(*ill. behaviors: stay to be tuned*)

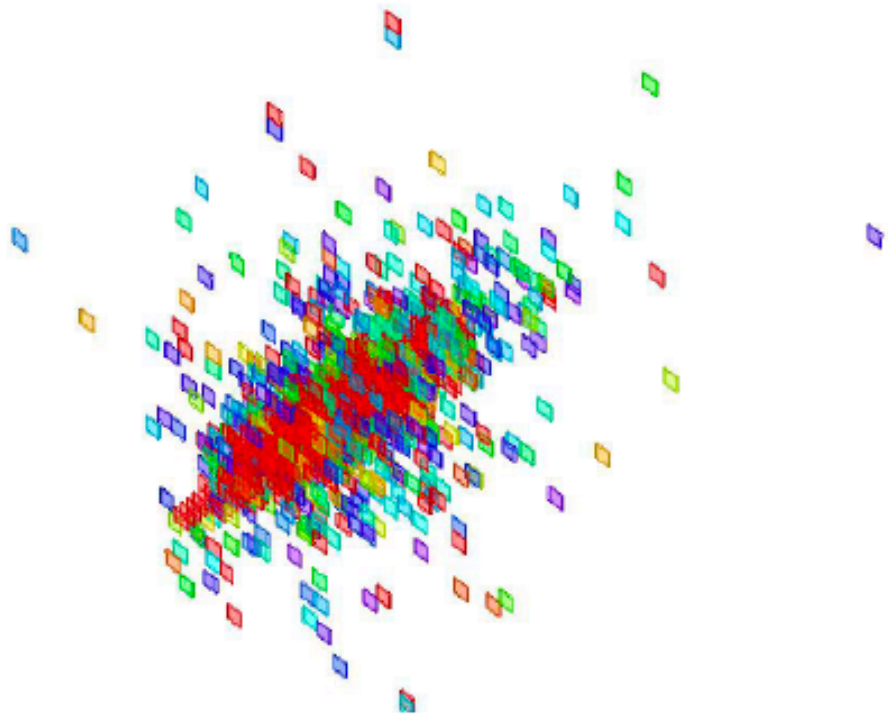
Over all: event reco. efficiency varies ~1%

	Simu.	Recon.	Efficiency
CEPC_v1	2885	2783	96.5%
TG1	2878	2814	97.8%
TG2	2878	2807	97.5%

TG1: E30L_H48L_10mm, TG2: E30L_H48L_20mm

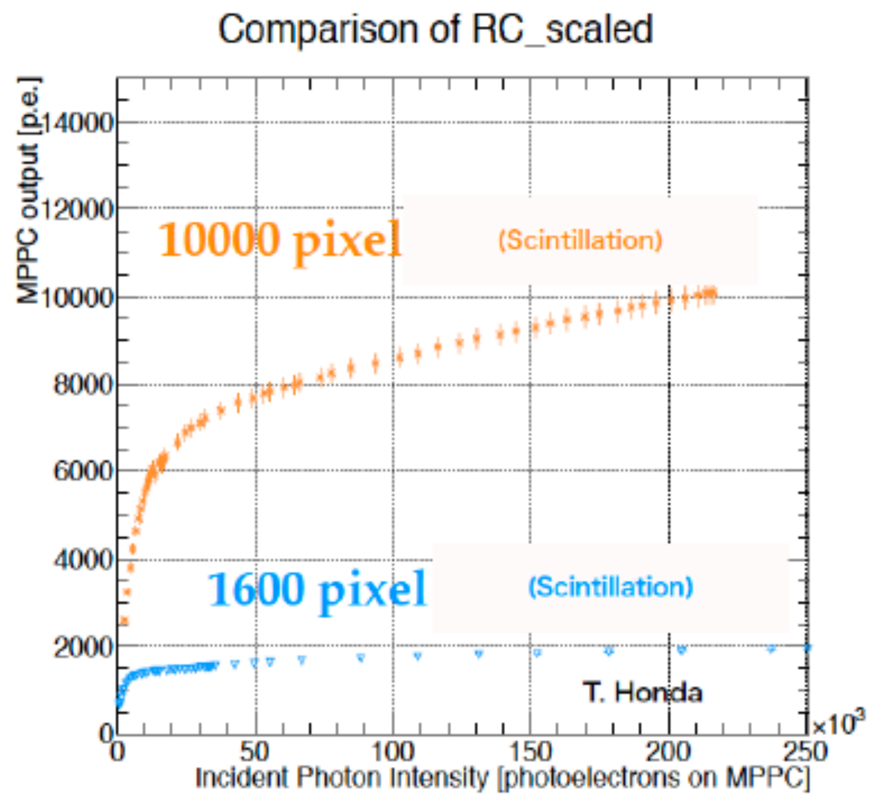
ECAL Saturation/Linear Range Study

Impact on Scintillator-W ECAL ?



50 GeV Photon Cluster
at ECAL with 10 mm Cell Size

~o(1k) hits, hottest hit with E ~ 1k MIP.



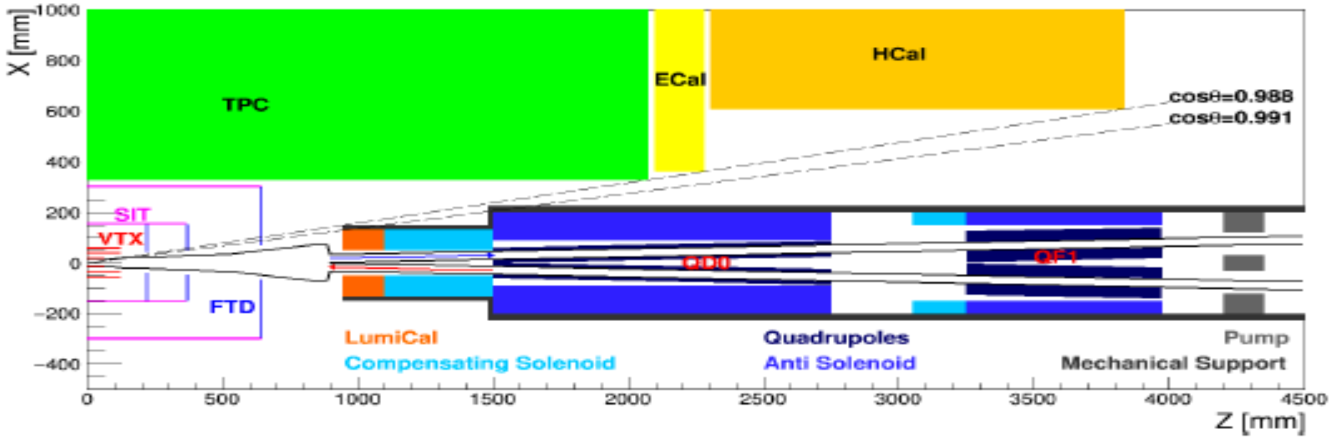
T.Takeshita, ILDDET@KEK

Scintillator: MIP→Photon→P.E

Preliminary studies on MDI

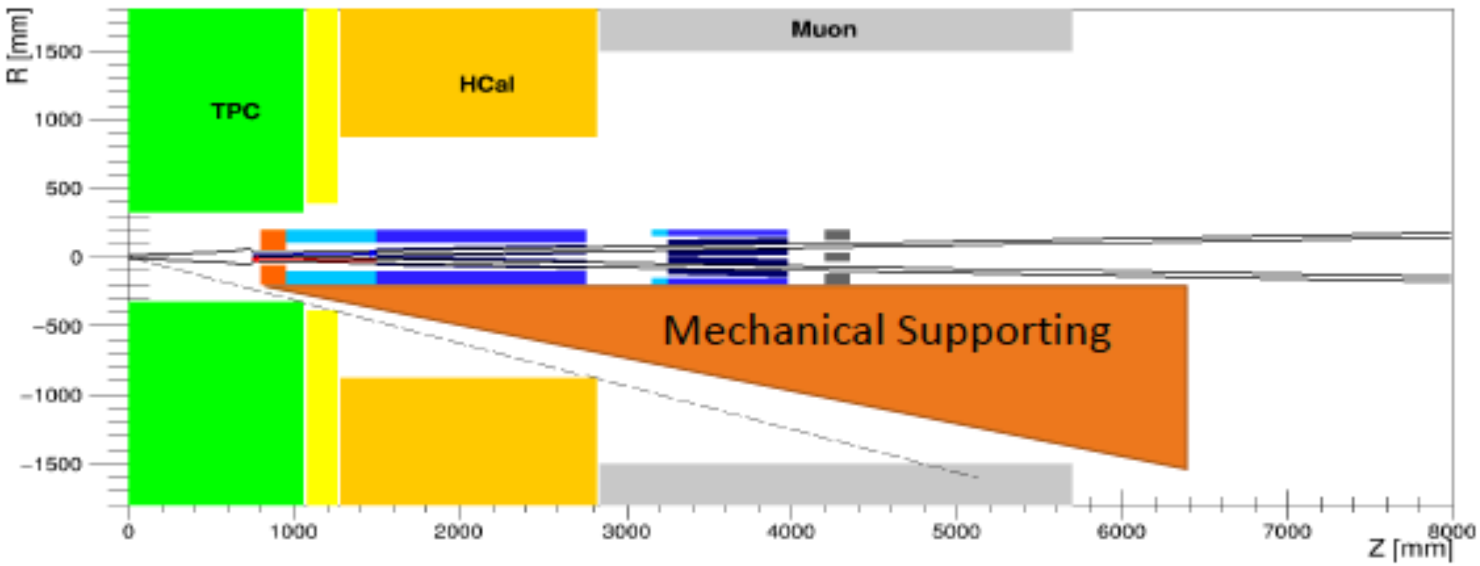
- MDI is crucial for CEPC. A design of MDI relies on the design of the machine.

Interaction Region Design



- Shorter TPC to reduce the impacts of showers introduced by the forward machine elements
- Cone-shaped forward region design to give space for the mechanical support (next slide)
- Weaker solenoid field to shrink the compensating magnet
- Extremely limited space for the luminosity calorimeter

Mechanical Support



- Required space for the mechanical supporting structure: 150 - 300 mrad
- Supporting point ~6 m away from the IP
- Feasibility studies on-going:
  - Stress, deformation and vibration

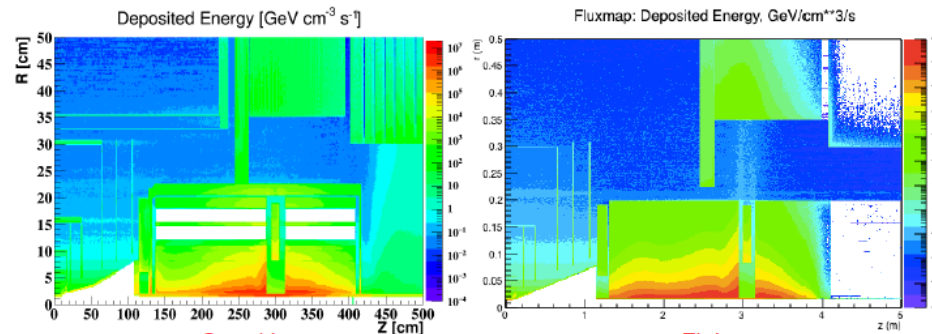
ELEMENT	WEIGHT (kg)
LumiCal	130
QD0 (Including solenoids)	900
QF1	600
Pump	20

Background without Shielding

Source	Simulation Tool	Sub-Type	Particle Flux at VTX $[\mathrm{cm}^{-2}\mathrm{BX}^{-1}]$	Particle Energy [GeV]	Priority
Synchrotron Radiation	Geant4; BDSIM	Dipole	~ 10^{10}	~ 0.001	★★★
		Quadrupole	~ 10^{6}	~ 0.007	
Beam Lost Particles	BBBrem; SAD	Radiative Bhabha	~ 10	~ 120	★★
		Beam Gas Scattering	↑	↑	
Beamstrahlung	Guinea-Pig++; PYTHIA6	Pairs	~ 10^{-2}	~ 0.05	★
		Hadrons	~ 10^{-5}	~ 2	

- Software framework to study all beam induced backgrounds fully implemented and well maintained
- Background levels for the single ring design evaluated
- Next step: background levels for the (partial)-double ring

Geant4 vs Fluka: Energy Deposition



Geant4 Fluka

- Radiation backgrounds evaluated with both Geant4 and Fluka → almost consistent results
- Implemented geometries still slightly different → *to be harmonized*

Exercises…

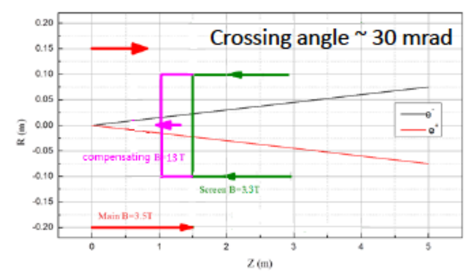
QD0 Design Progress

- Compact and high gradient quadrupole magnets for (partial)-double ring design

Field gradient (T/m)	Magnet length	Field harmonics	Coil inner radius (mm)
200	1.3	$B_n/B_2 < 5.0\times10^{-4}$ @ r=8 mm	12.5

- Minimum distance between two aperture centerlines ~45mm (coil inner radius of 12.5mm) → extremely tight radial space
- Serpentine winding coil using direct winding selected to achieve high efficiency and high compactness (experience from BEPCII)
- Serpentine coil adopted for BEPCII, J-PARC, ATF2, Super-KEKB, ILC baseline design, etc.

Compensating/Screening Solenoids



Compensation conditions:

*B_main*L_main+B_comp*L_comp=0*

*L** = *L*_main +*L*_comp = 1.5m

- To minimize the effects of the longitudinal detector solenoid field on the accelerator beam
- Integral longitudinal field generated by the detector solenoid and solenoid coils should cancel out.
- **Screening solenoid** (outside of QD0): the longitudinal field inside the quadrupole bore should be 0.

- **Compensating solenoid options** (before QD0):
  - 1m long, center field: 5.2T (NbTi) → 0.7m long, center field: 7.4T (NbTi) → 0.4m long, center field: 13T (Nb3Sn)

Urgent tasks

- Physics @Z
  - → EW phjysics based on 10^{10-11} Z
    vs. 10^{12} Z (FCC-ee studies)
  - → flavor physics
- Beam energy measurement
  - → beam depolarization at Z, W
  - → at 240 GeV?
- Anything else ?

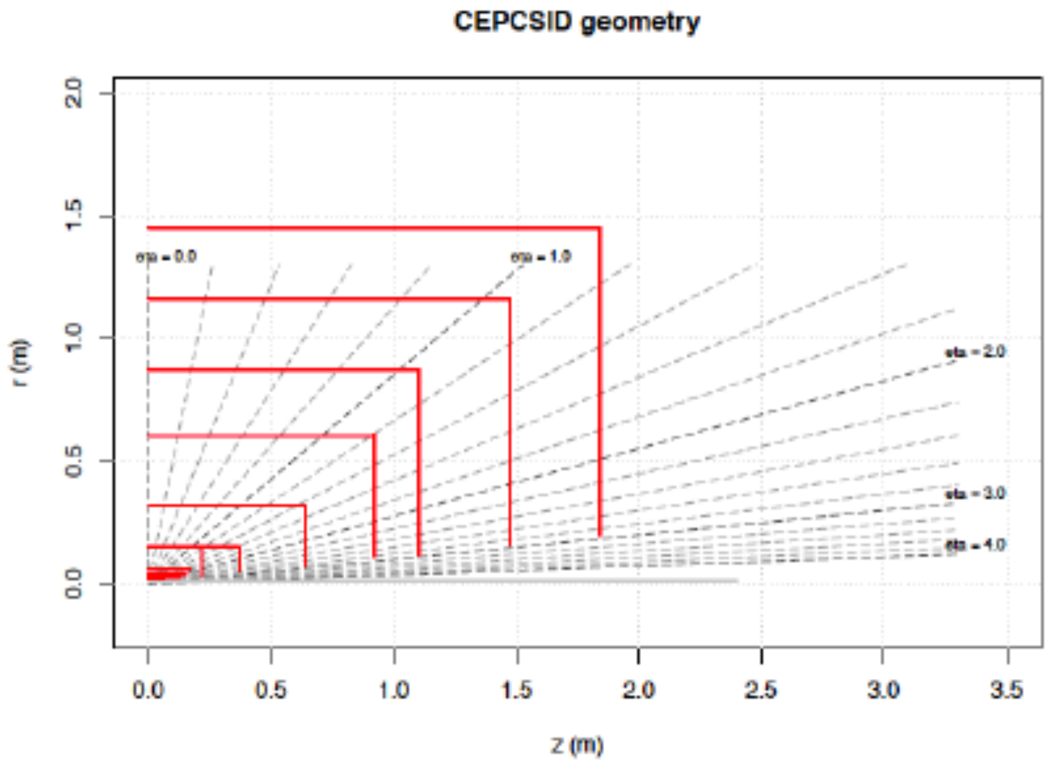
Plan for CDR

- By international collaboration !
- 1st draft by end 2017
- Optimization based on ILD-like design *as a reference*
- Develop 2+ concepts?
  - full silicon tracking
  - drift chamber + dual readout copper calorimeter

Full Silicon Tracker Concept for CEPC*

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

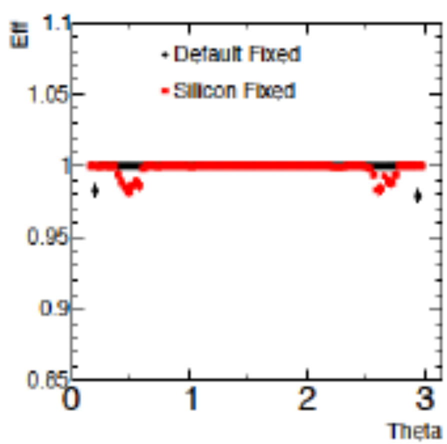
- CEPC full silicon has been implemented in Mokka.
- Based on CEPC V1 silicon tracker, we replace TPC with additional SIT layers and FTD endcaps.
- The advantage is to recycle CEPC silicon tracking.



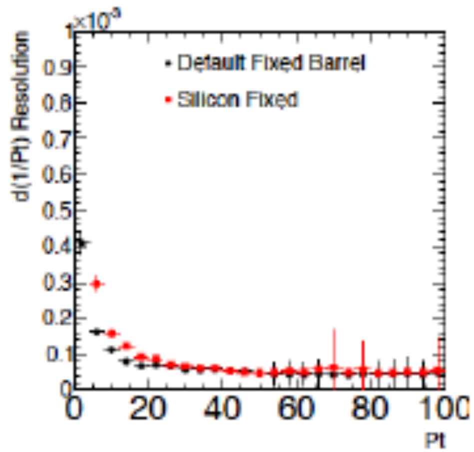
Prof. Weiming Yao

Full Detector Simulation and Reconstruction

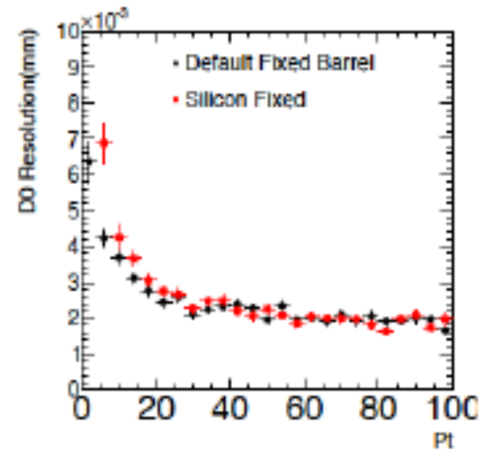
- Generated single muon with CEPC full silicon
- Reconstructed using Marlin Silicon only.
- The performance is comparable to CEPC V1.



(a) Eff vs theta



(b) sigma(1/pt) vs Pt



(c) sigma(D0) vs Pt

Funding from Ministry of Science and Technology

R&D'S on Physics and Key Technologies for High Energy Electron-Positron Circular Collider

- 2016.07-2021.06
- 36M RMB
- Accelerator Physics & collider design 3.88
- Key accelerator technologies 11.60
- Simulation & detector design 5.24
- Key detector technologies 15.28

Another MOST fund (~40M) in 2018

Summary

- Program made after the PreCDR
  - R&D on key technologies
  - need more efforts on MDI (after the machine design?)
  - Physics @Z/W, beam energy measurements to be studied soon

- Plan for CDR
  - develop/collect (new) ideas for 2+ detector concepts
  - critical R&D

- CEPC is an international project, you are all welcome to join us!

Detector talks at this workshop

Day 2

14:00-14:20	**Detector Optimization and Physics Simulation Toward the CEPC CDR** Manqi Ruan (Institute of High Energy Physics, Chinese Academy of Sciences)
14:20-14:40	**Status of CEPC Calorimeters R&D** Haijun Yang (Shanghai Jiaotong University)
14:40-15:00	**Status of CEPC Software** Gang Li (Institute of High Energy Physics, Chinese Academy of Sciences)
15:00-15:20	**ILC Software & Grid Usage** Jan Strube (Pacific Northwest National Laboratory)
15:20-15:40	**SUSY Searches at LHC and Beyond** Xuai Zhuang (Institute of High Energy Physics, Chinese Academy of Sciences)

Day 3

14:00-14:20	**CEPC TPC** Huirong Qi (Institute of High Energy Physics, Chinese Academy of Sciences)
14:20-14:40	**A Second Detector Concept for CEPC** Franco Bedeschi (Italian Institute of Nuclear Physics)
14:40-15:00	**Test Beam Results of a Silicon Photomultiplier Based Dual Readout Calorimeter Module** Massimo Caccia (Italian Institute of Nuclear Physics)
15:00-15:20	**RICH Detectors and Gaseous Single Photon Detectors** Silvia Dalla Torre (Italian Institute of Nuclear Physics)
15:20-15:40	**Machine Detector Interface for CEPC** Qinglei Xiu (Institute of High Energy Physics, Chinese Academy of Sciences)

Day 4

16:10-16:30	**CEPC Vertex Detector** Ping Yang (Central China Normal University)
16:30-16:50	**SiD - An All-silicon Detector for the ILC** Marcel Stanitzki (Deutsches Elektronen-Synchroton)
16:50-17:10	**Depleted CMOS Status and Prospects** Daniela Bortoletto (University of Oxford)
17:10-17:30	**A Drift Chamber Option for the CEPC** Franco Grancagnolo (Italian Institute of Nuclear Physics)
17:30-17:50	**Discussions**