



中国科学技术大学
University of Science and Technology of China

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CEPC EMCaI Status

Yunlong Zhang

On behalf of CEPC EMCaI Group



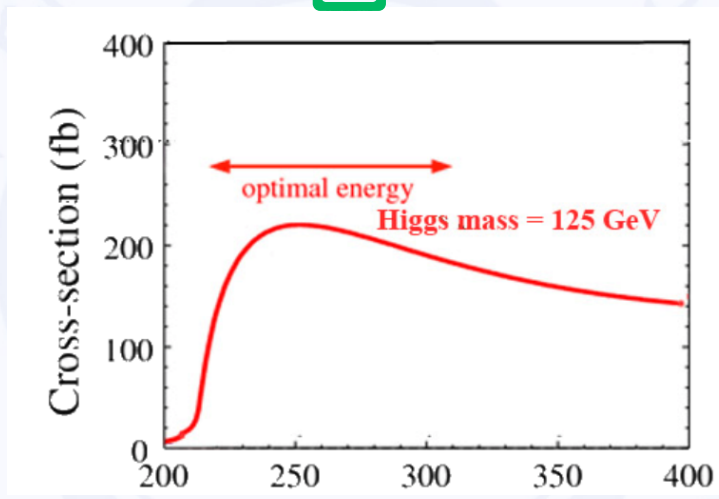
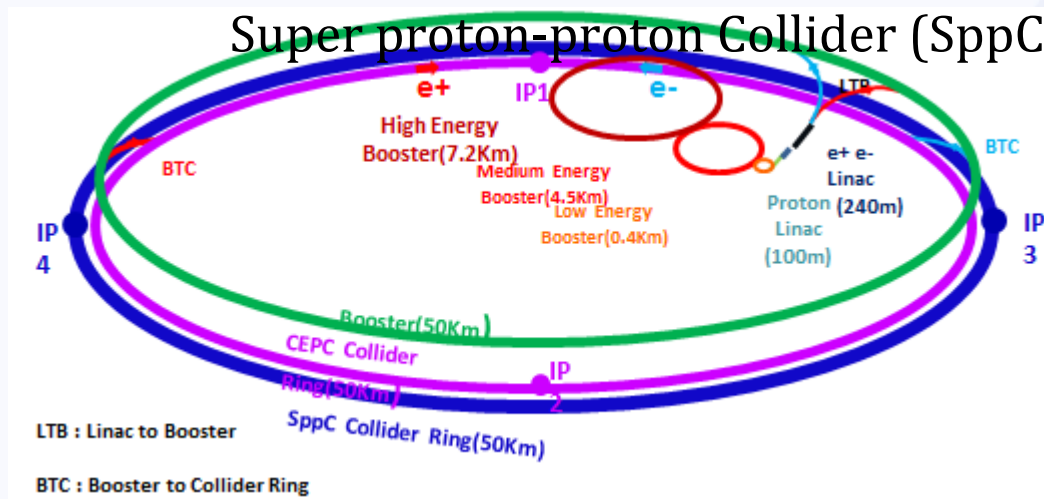
Outline

- Motivation
- The EMCal in CEPC
- Progress and Status
- Summary

Phase 1: e^+e^- Higgs (Z) factory two detectors, 1M ZH events in ~10yrs
Circular Electron Positron Collider (CEPC)

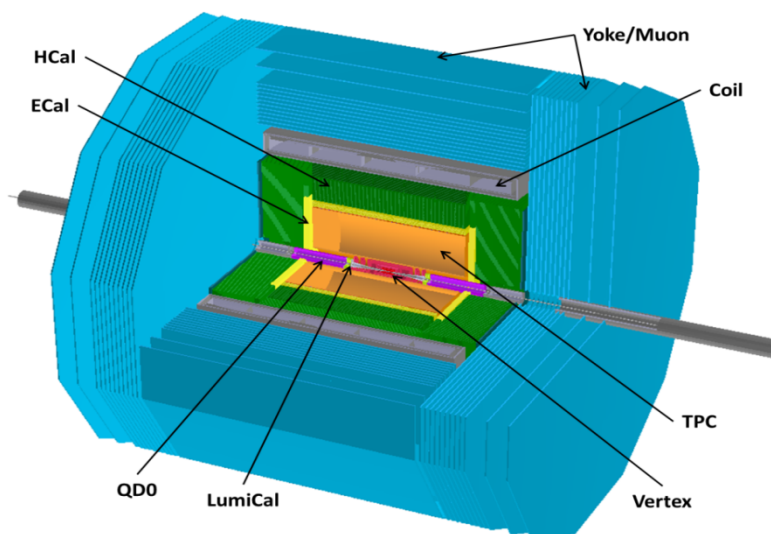
$E_{cm} \approx 240\text{GeV}$, luminosity $\sim 2 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ can also run at the Z-pole
 Precision measurement of the Higgs boson (and the Z boson)

Phase 2: a discovery machine; pp collision with $E_{cm} \approx 50-100\text{TeV}$; e^+e^- Higgs options
Super proton-proton Collider (SppC)





CEPC Detector



- **ILD-like detector with additional considerations.**
- **Similar performance requirements to ILC detectors**

Challenges:

- **Momentum:**
- **Impact parameter:**
- **Jet energy:**

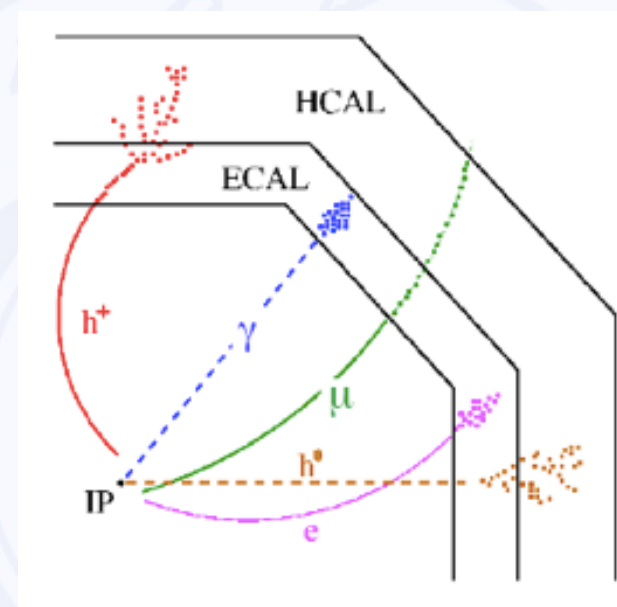
$$\sigma_{1/p} < 5 \times 10^{-5} \text{ GeV}^{-1}$$

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

$$\frac{\sigma_E}{E} \approx 3 - 4\%$$

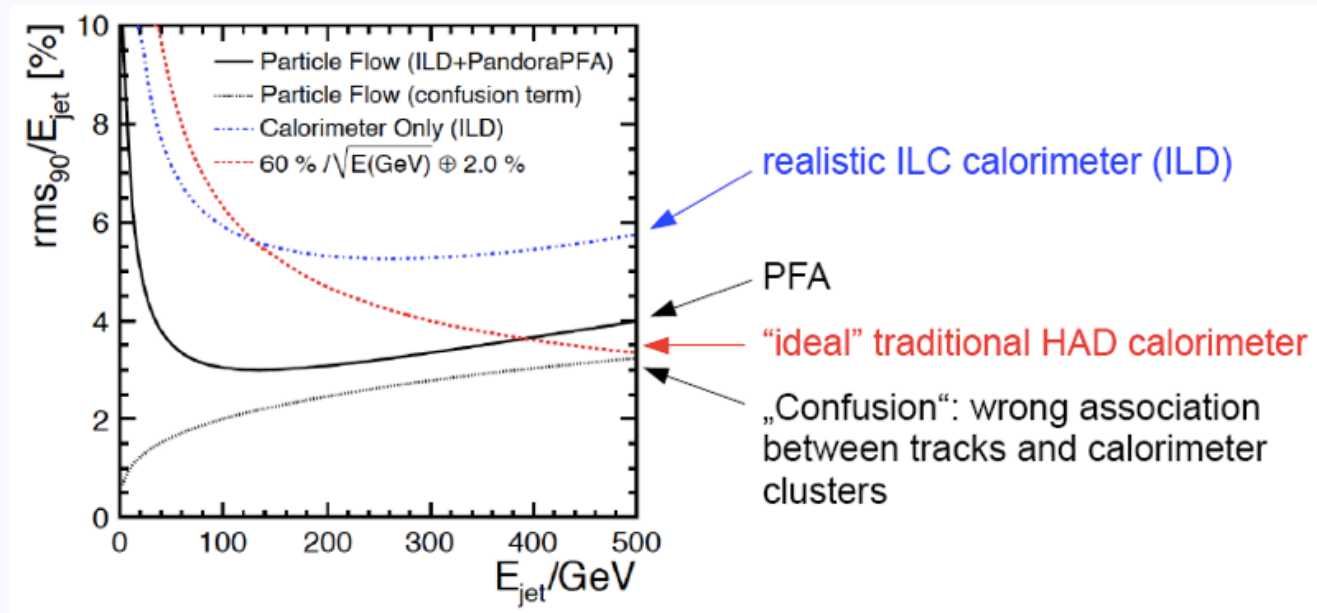
The requirement of EMCal

- Good separation of particles
 - Large detector size
 - Large magnet field
- Compact showers to minimize overlap
 - Small moliere radius
- Minimum amount dead material
 - Calorimeter inside the magnet coil
- Detailed information of showers
 - High granularity





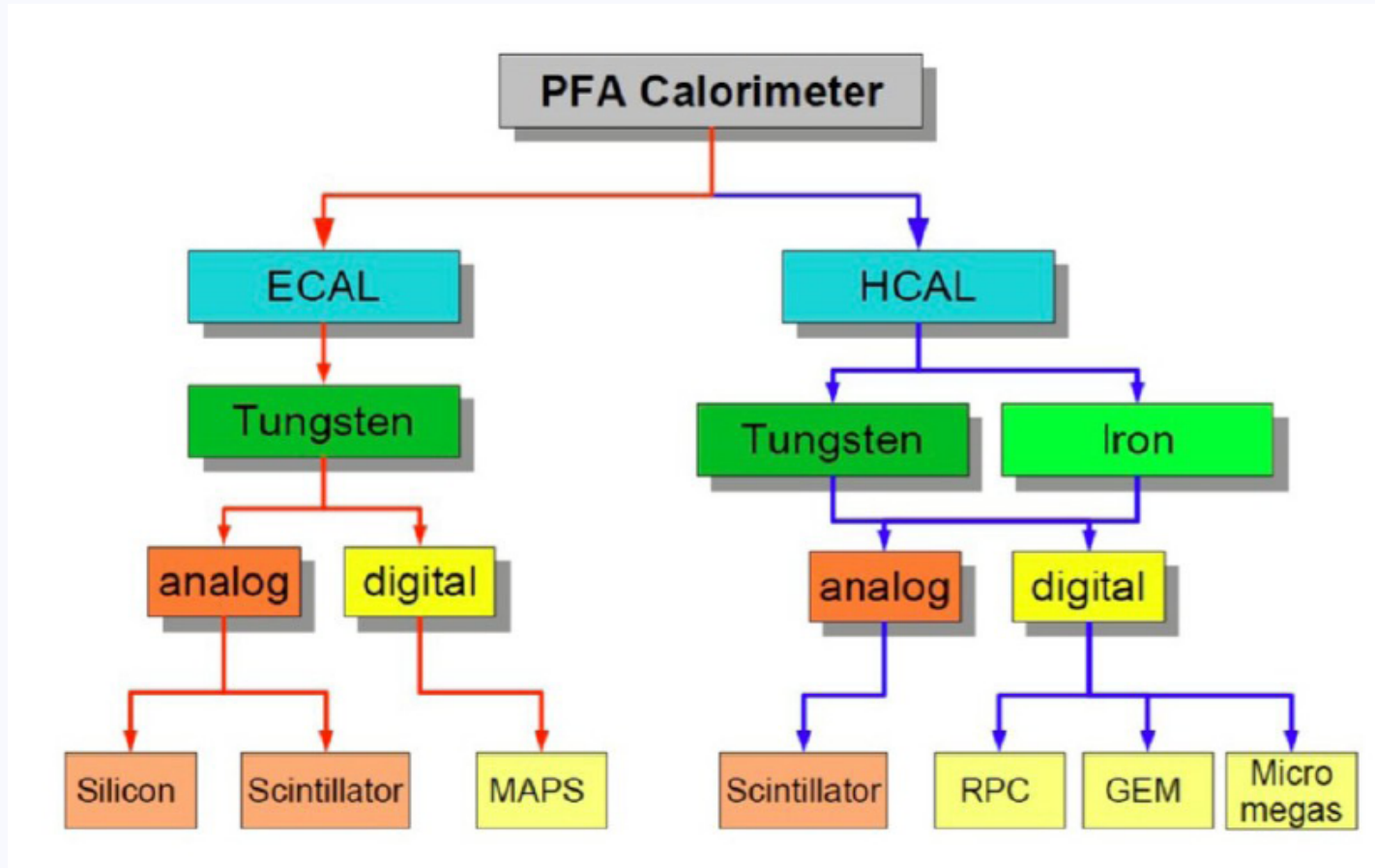
The PFA Calorimeter



- PFA+Calorimeter is clear better than calorimeter alone
 - At high energy, correct association between tracks and calorimeter clusters is very important



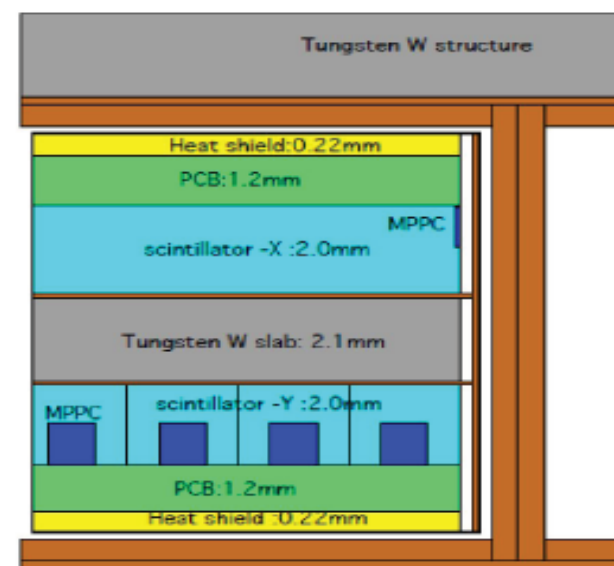
PFA Calorimeter



The Structure of EMCal of CEPC

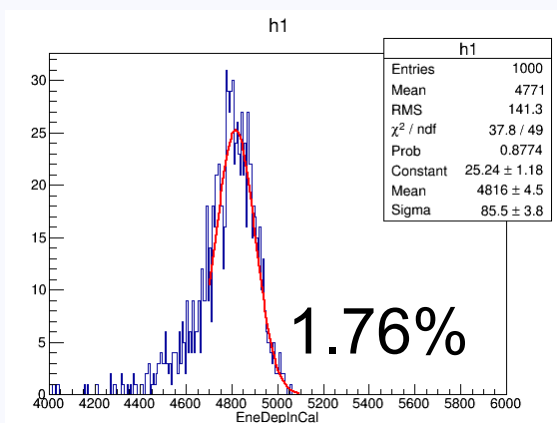
- Sandwich structure
 - W+SD+PCB
- SD
 - Scintillator+SiPM
 - 5mm*45mm*2mm
- Absorber
 - Tungsten
 - 2.8mm(0.8X0)

模拟方案2：闪烁体+SiPM 灵敏层

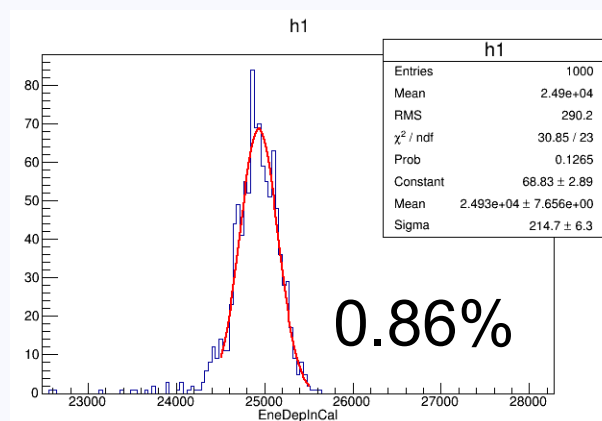


The performance of EMCal (MC)

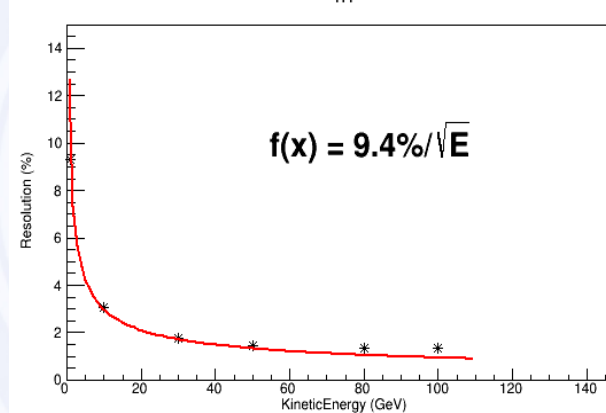
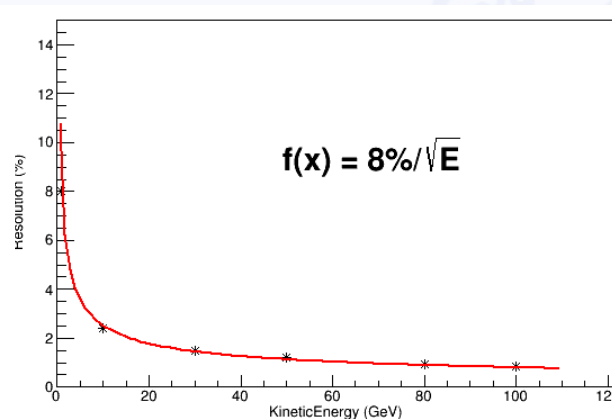
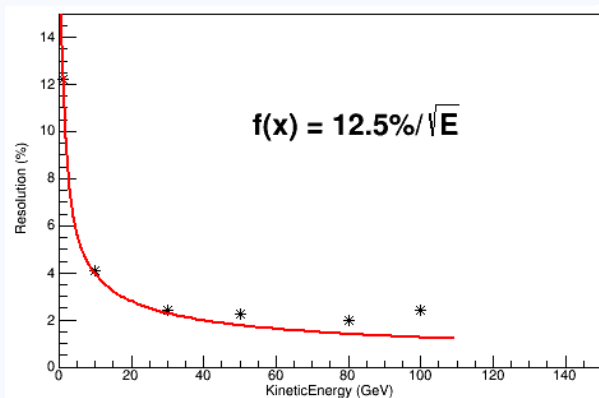
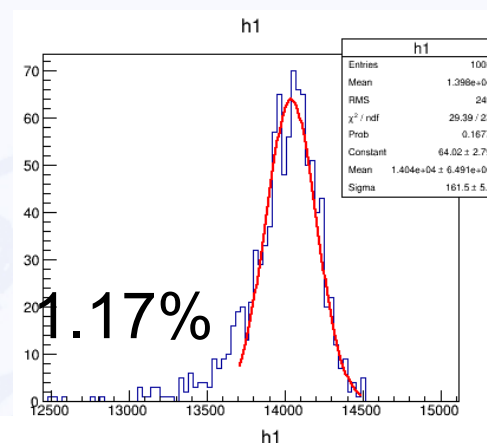
PSD:2mm



LSO:2mm



LSO:1mm





➤ PSD:2mm thickness

– The light yield (do not consider the nonlinearity of SiPM):

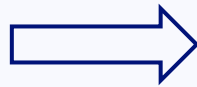
- 1 MIPs: $\sim 10pe$
- 600 MIPs: $\sim 6000 pe$



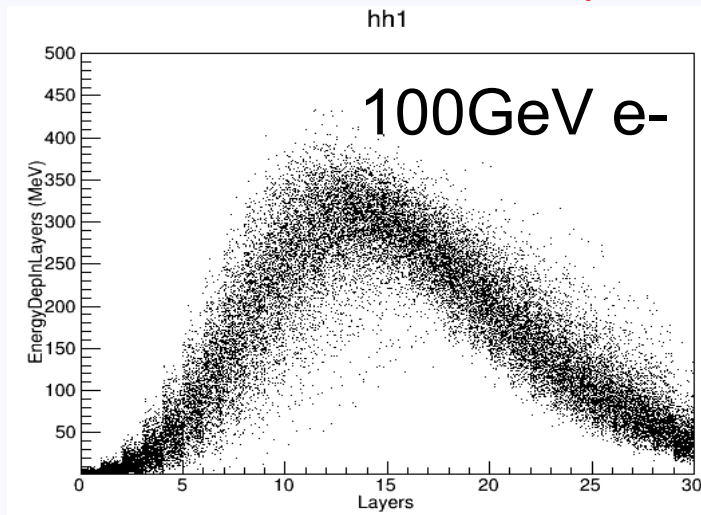
Determine the SiPM model:
 $\sim 10,000 pixels$

– Gain of the SiPM is $\sim 2 \times 10^5$

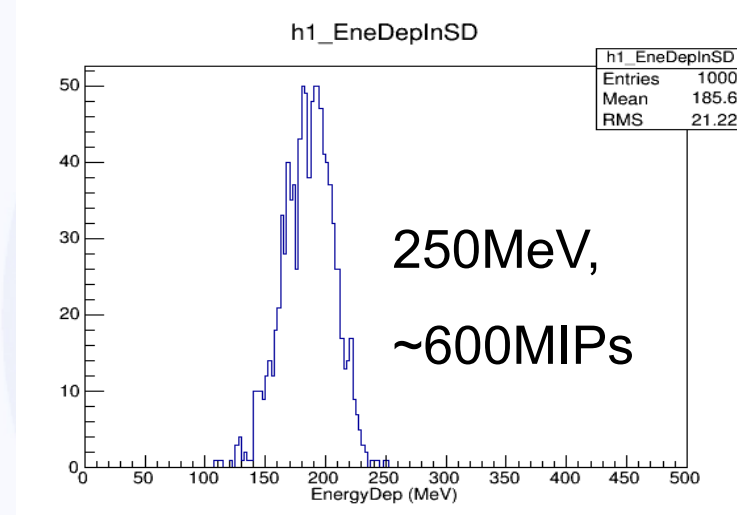
- 1MIPs: $\sim 320fC$
- 600MIPs: $\sim 200pC$



Determine the FEE Chip model:
dynamic range $\sim 100fC - \sim 200pC$

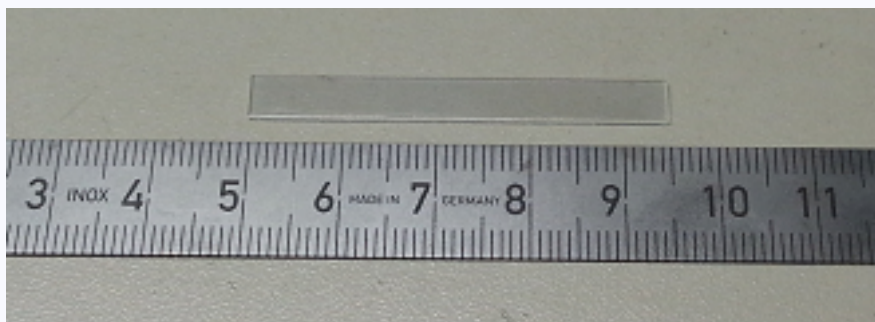


Edep in each SD layers



The MAX edep in one SD

The element selection



Scintillator (5mm*45mm*2mm)



SiPM (1mm * 1mm 10000 pixels)



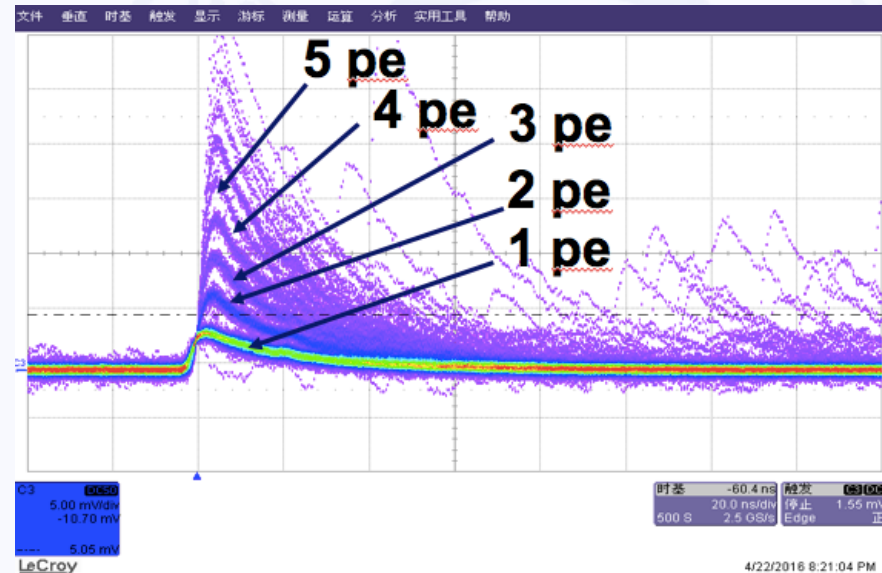
- Dynamic range: $\sim 100\text{fC} \sim 320\text{pC}$
- channels: 36
- Dead time: 2ms
- Polar: positive
- power: 8mW/channel



Key Technologies of SiPM

➤ The SiPM

- The dynamic range
- The temperature effect
- Radiation damage

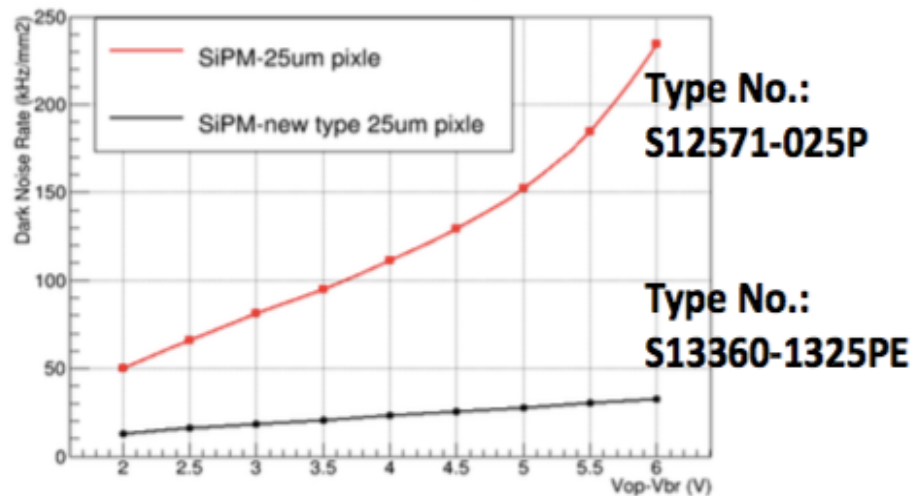
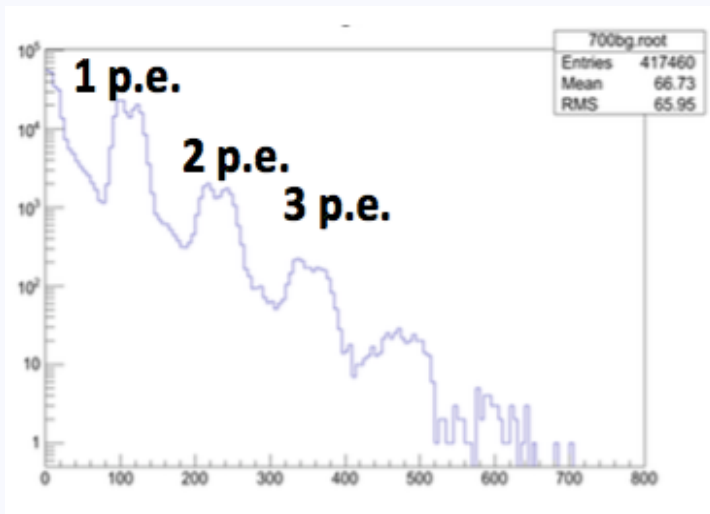




SiPM Test

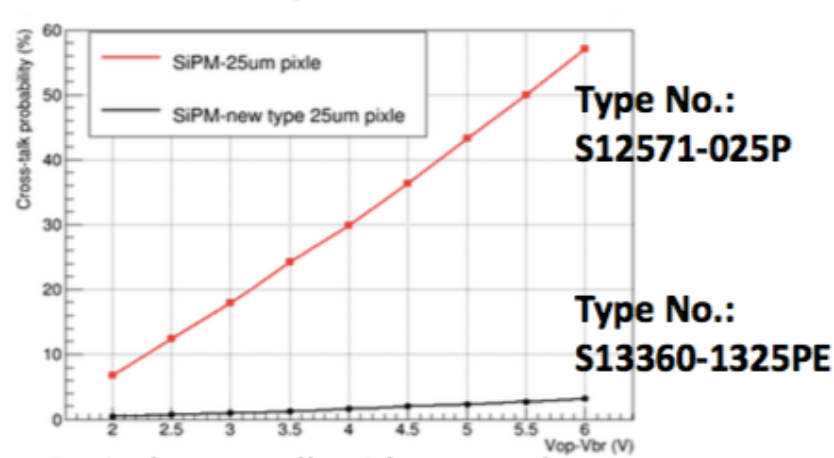
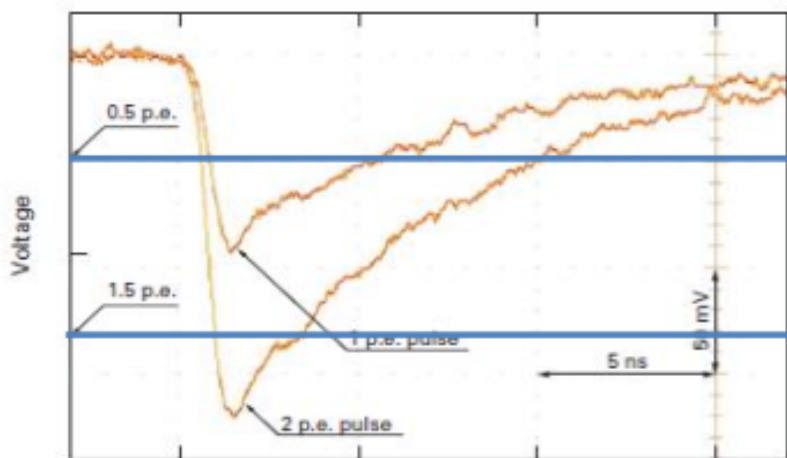
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Dark Count



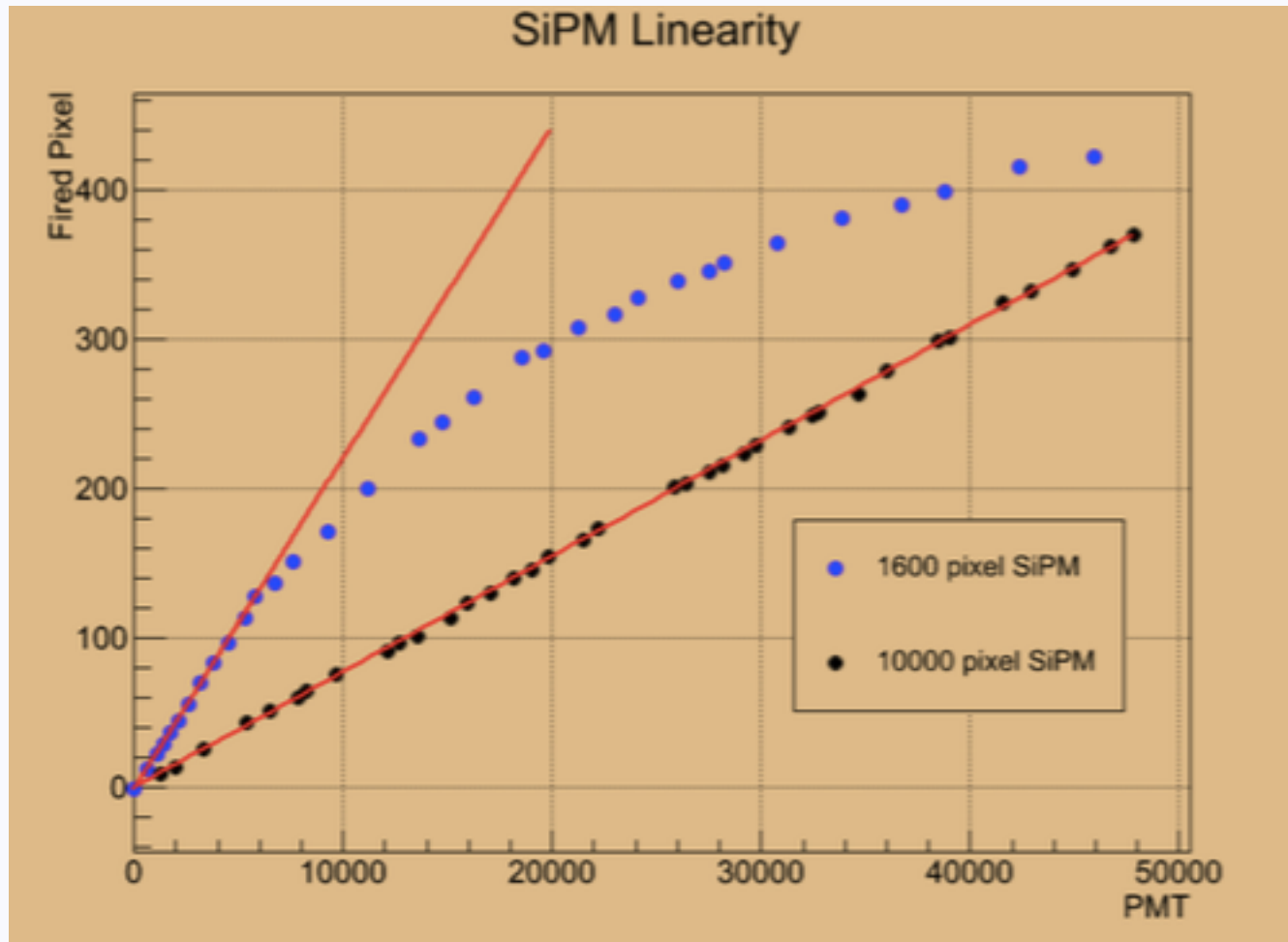
Cross talk

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The linearity



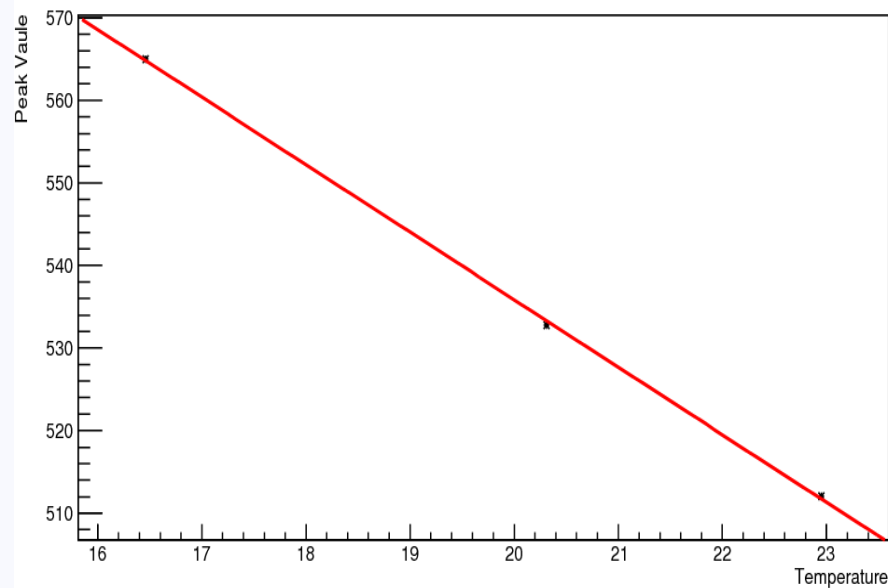
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Temperature effect

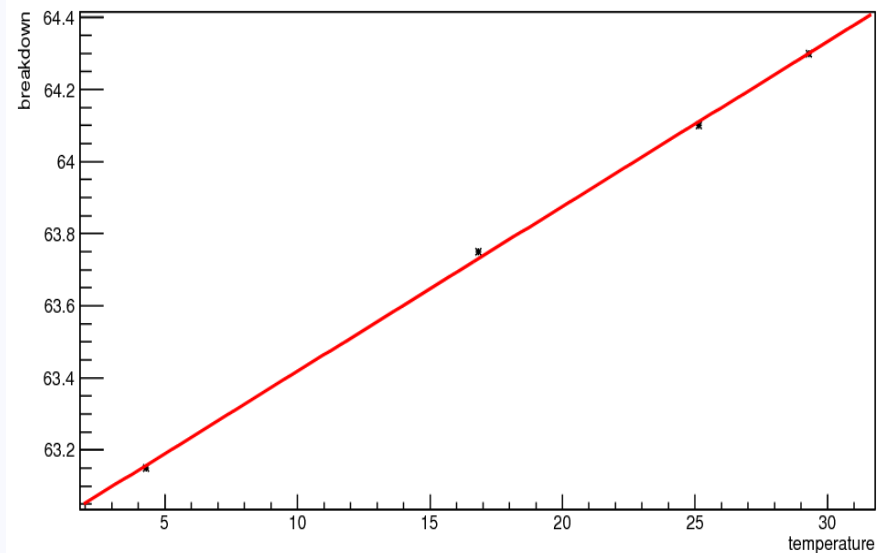
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Graph



**gain vs.
temperature**

Vbreakdown vs temperature



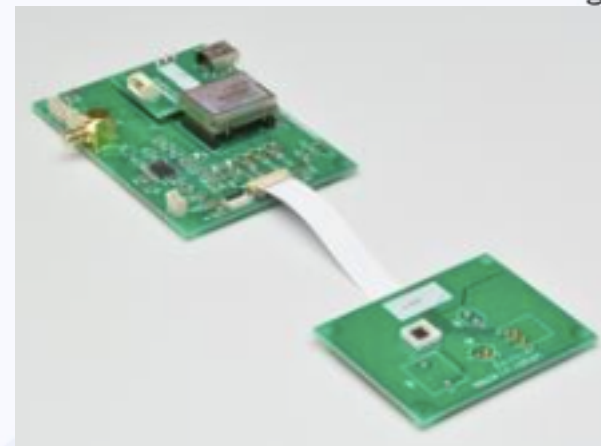
Vbr vs. temperature



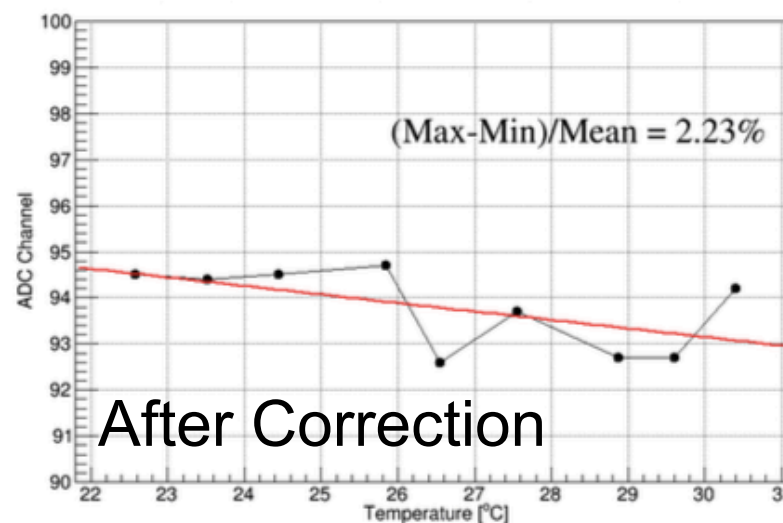
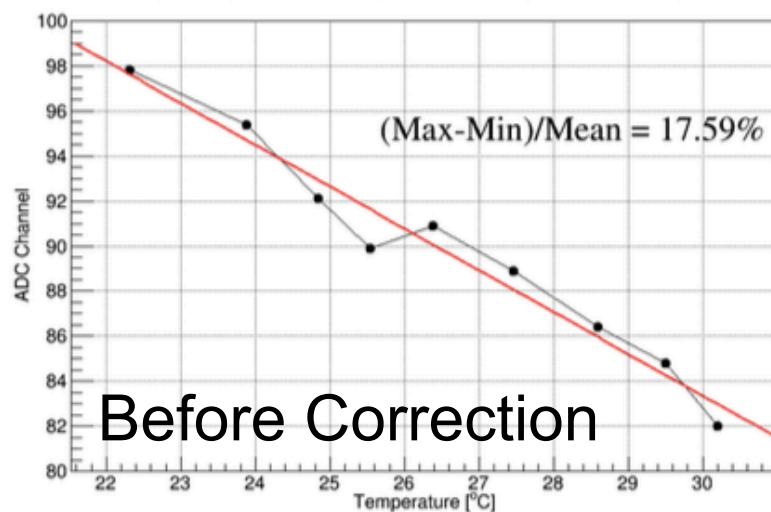
Temperature effect

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According to the calibration constants, use the temperature-compensation circuit to correct the relation of gain and temperature



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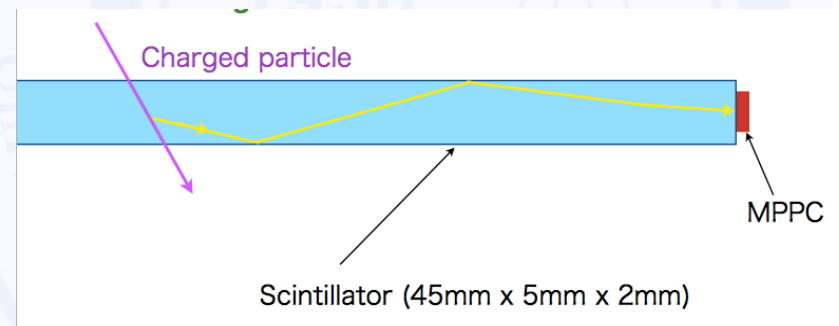




Key Technologies of Scintillator

➤ The Scintillator

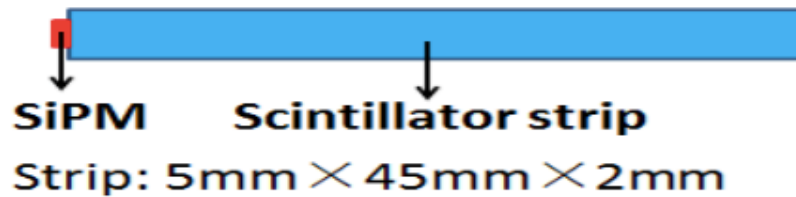
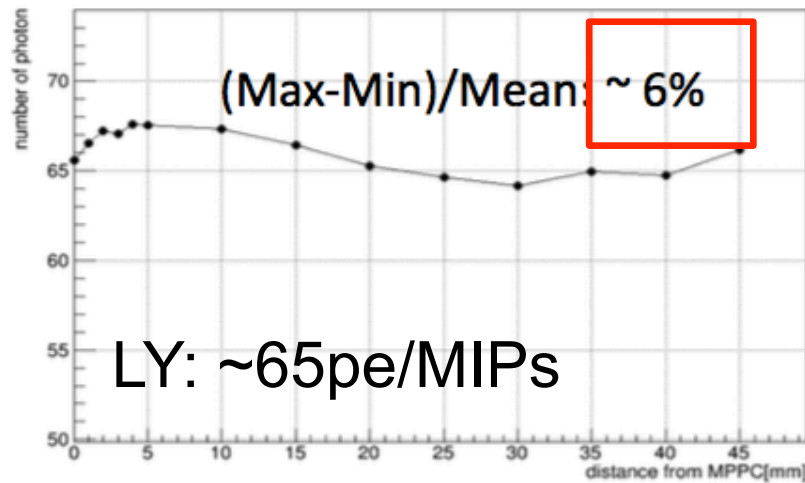
- The light yield uniformity
- The packing model
 - Paper or Paint?
- The coupled model with SiPM



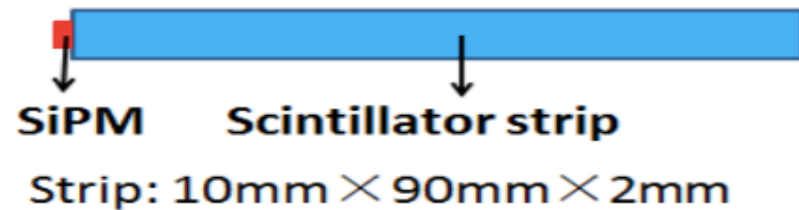
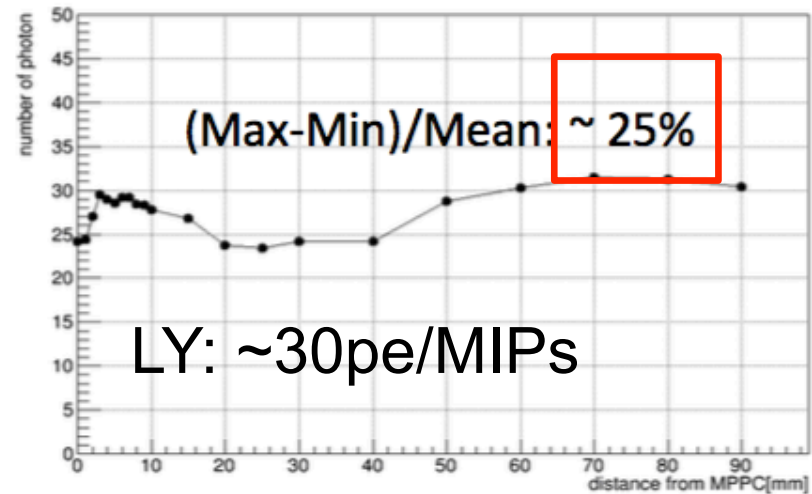


The scintillator test

5mm × 45mm scintillator strip



10mm × 90mm scintillator strip



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

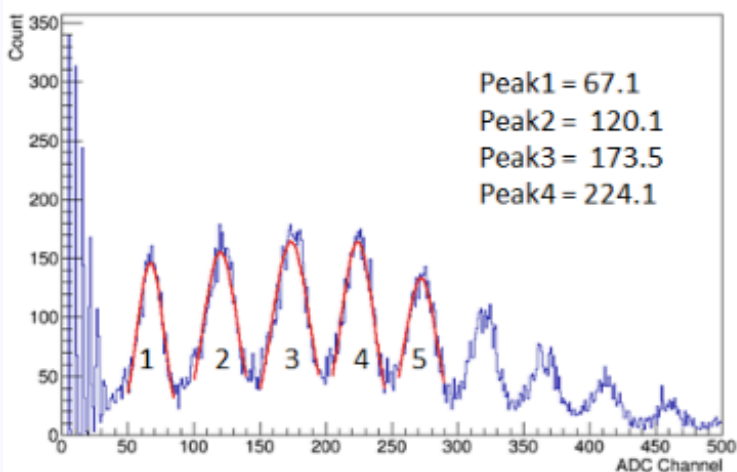
Scintillator test

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PSD coupled with S12571-010C (pixel size is 10um*10um)

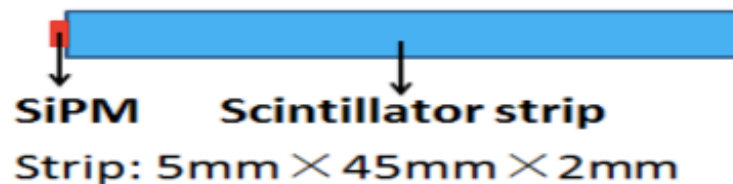
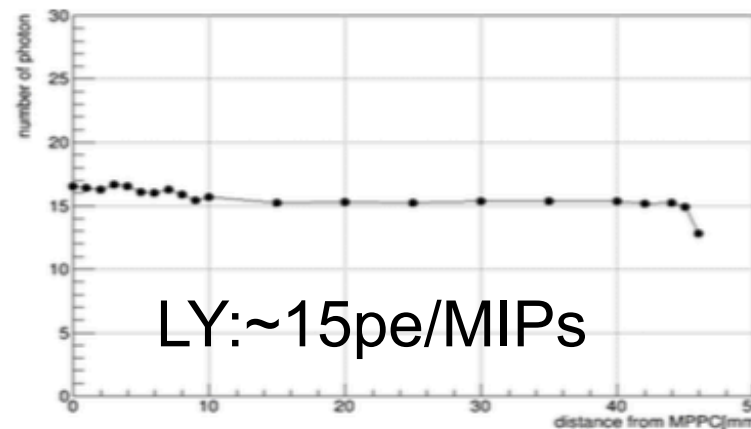
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SiPM type No.: S12571-010C



Pulse height spectrum

Light output of 45mm strip coupled with 10um SiPM



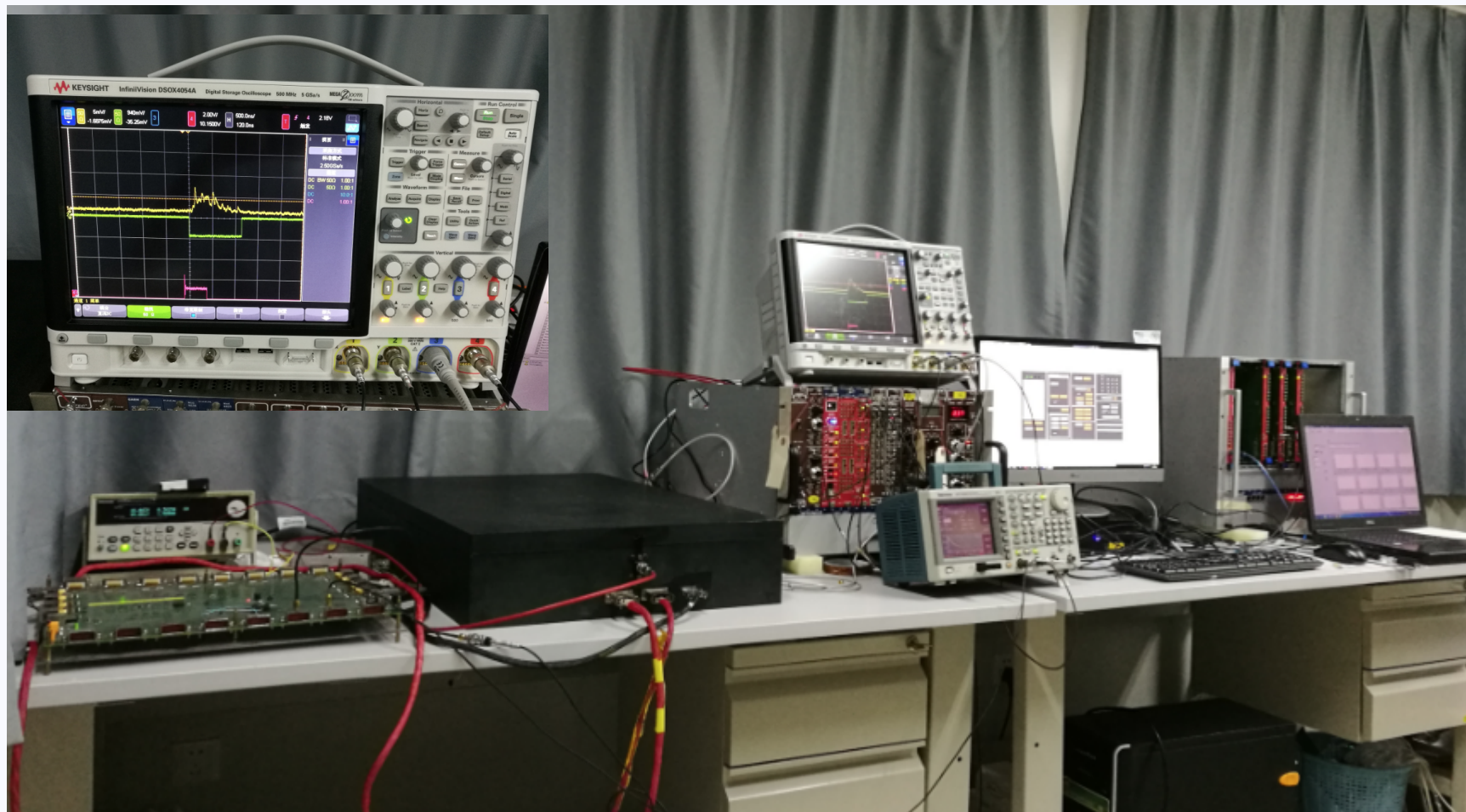


The Schedule

- 2016-2018
 - Fix the sensitive detector type (Scintillator, SiPM, FEE)
 - Finish the key technologies
- 2018-2020
 - Manufacture the prototype
 - The cosmic test
- 2020-2021
 - Beam test

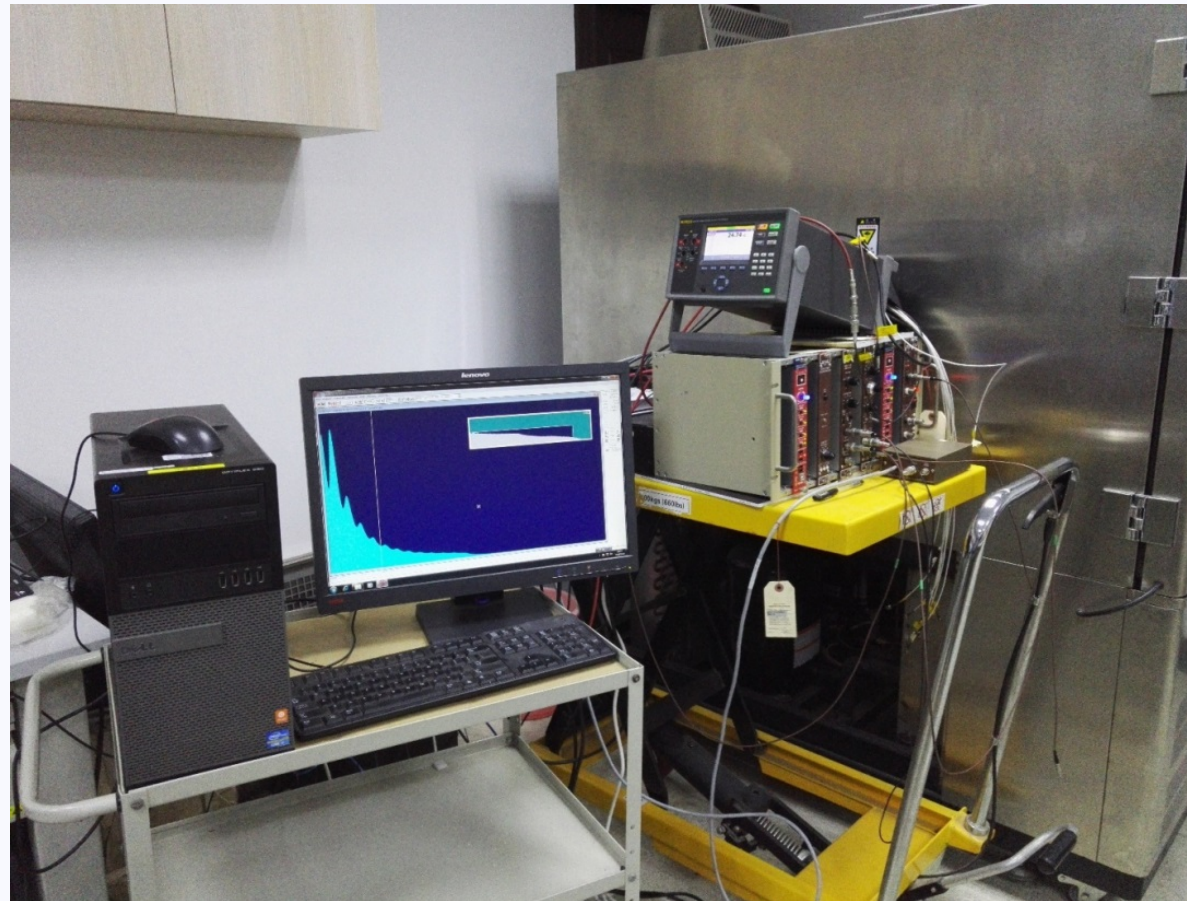
LED calibration system

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The temperature effect test system

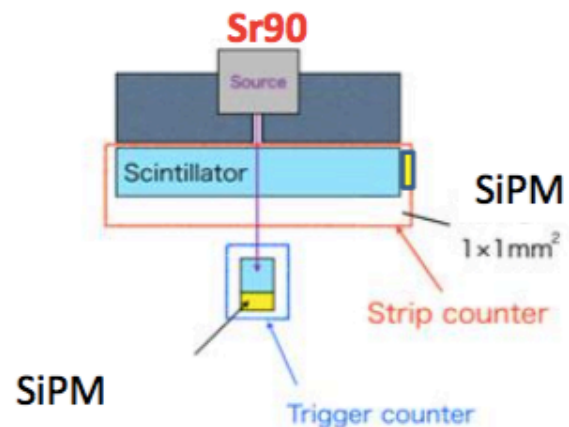


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The Light uniformity test system



Scintillator strip and SiPM



SiPM

Test setup

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Waveform of strip counter and trigger counter

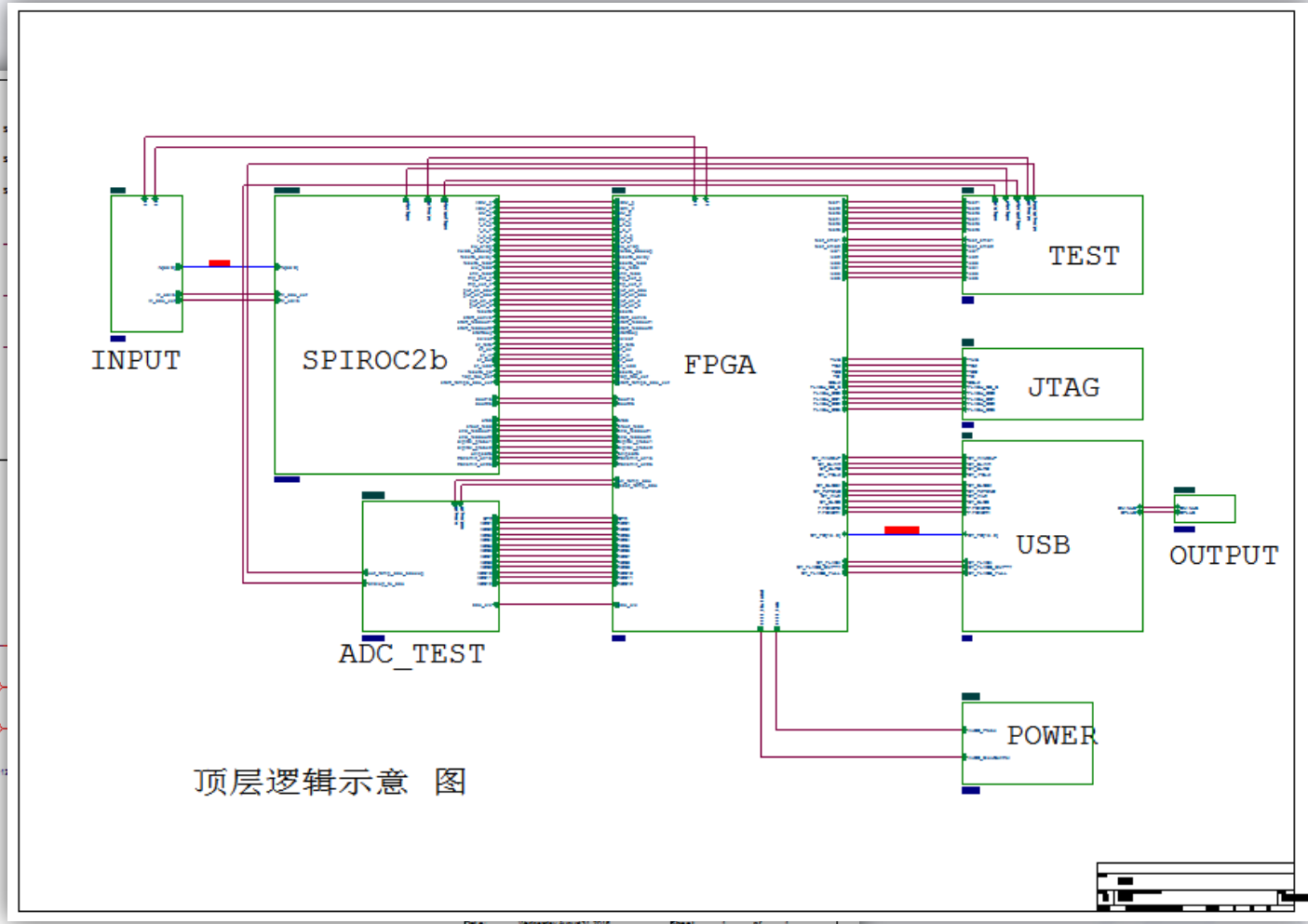
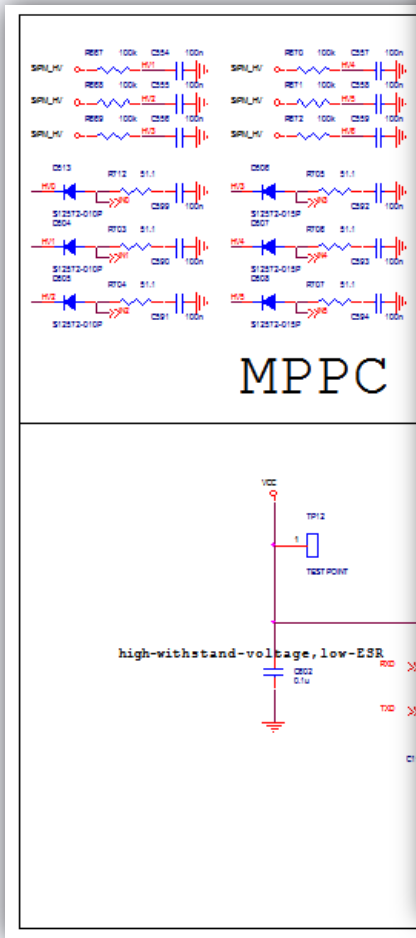


The DT5751 is a 2-4 Channel 10 bit 2/1 GS/s Desktop Waveform Digitizer .

Data acquire system



The FEE board





Summary

- The EMCal of CEPC based on scintillator was determined
- Some key technologies should be studied carefully
 - Scintillator
 - SiPM
- A schedule for EMCal prototype was made



THANKS



Back up



