Sci-W ECAL Status for CEPC

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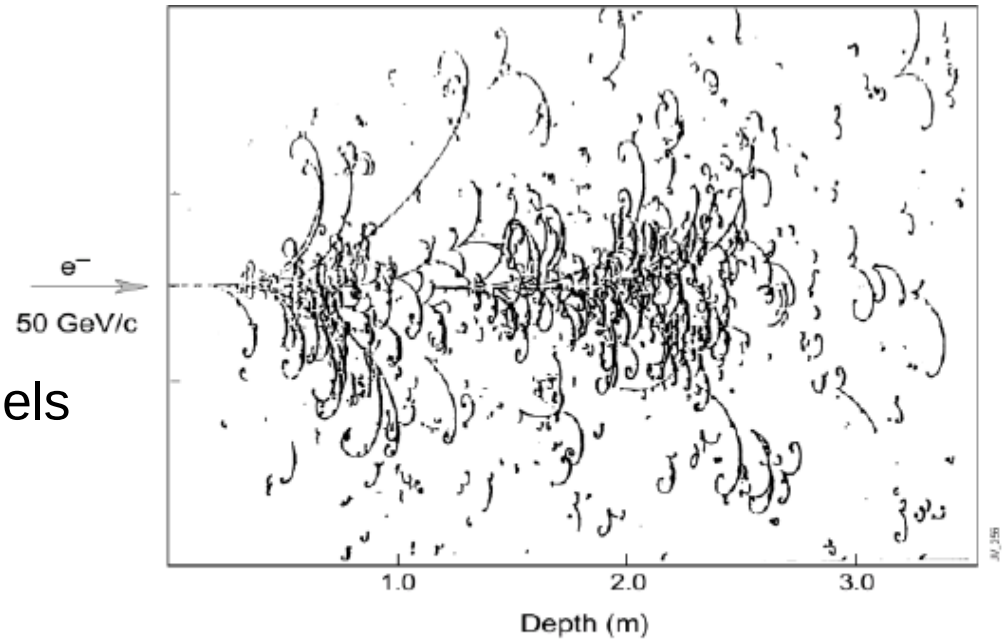
On behalf of CEPC Calorimeter working group

Outline

- Brief review of Sci-W ECAL of CEPC
- CEPC ECAL Status
  - Multi-layers cosmic ray test
  - Temperature compensation
  - Time calibration
  - Super-layer trial assembly
- Summary and outlook

PFA Calorimeter

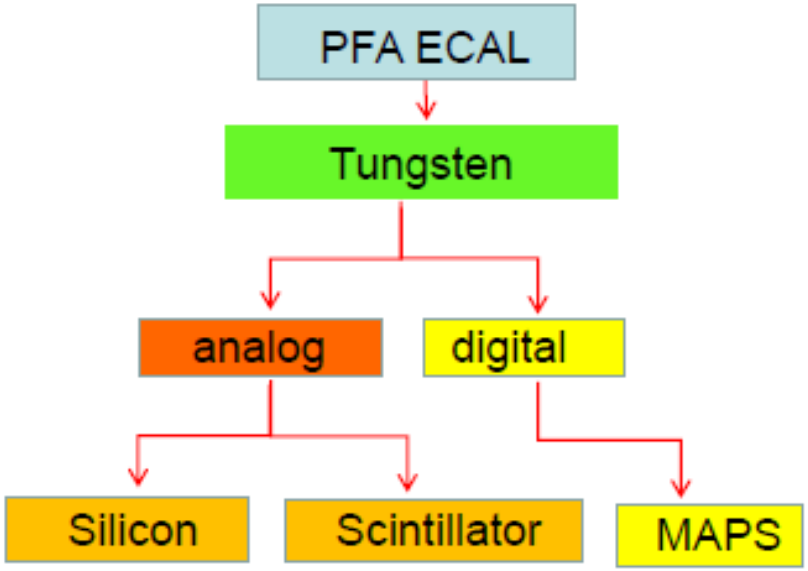
- Challenges
  - High granularity
    - ECAL ~10 million channels
  - Compact design
  - High power
    - ECAL about 100 kW
      - EBU: 80 kW (without power pulsing)
      - DIF: 20 kW

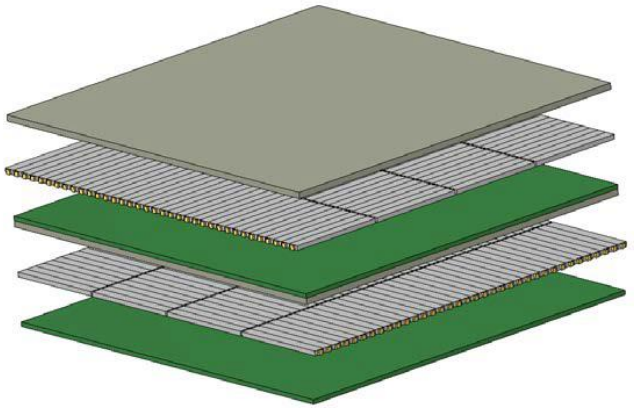


Big European Bubble Chamber filled with $Ne:H_2$ = 70%:30%, 3T Field, L=3.5 m, $X_0 \approx 34$ cm, 50 GeV incident electron

Sci-W PFA ECAL of CEPC

- Sampling Calorimeter
  - Sandwich structure
  - Absorber+SD+Electronics
- Absorber
  - Tungsten
- Sensitive Detector
  - Scintillator+SiPM
- Electronics
  - ASIC Chip





Elements of ECAL

Scintillator （5mm*45mm*2mm）

SiPM（1mm＊1mm, 10k pixels）

- Dynamic range：~100fC~200pC
- channels：36
- Dead time：2ms
- Polar: positive
- power：8mW/channel

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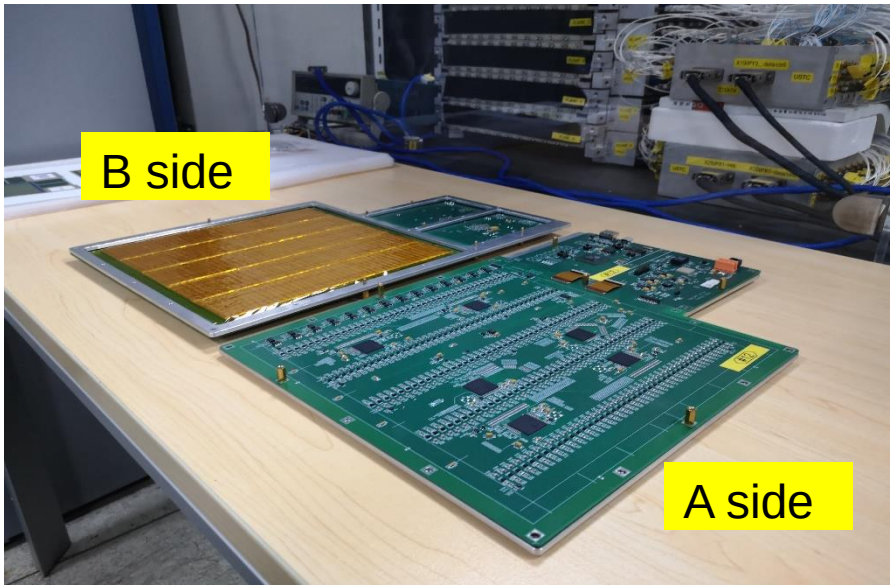
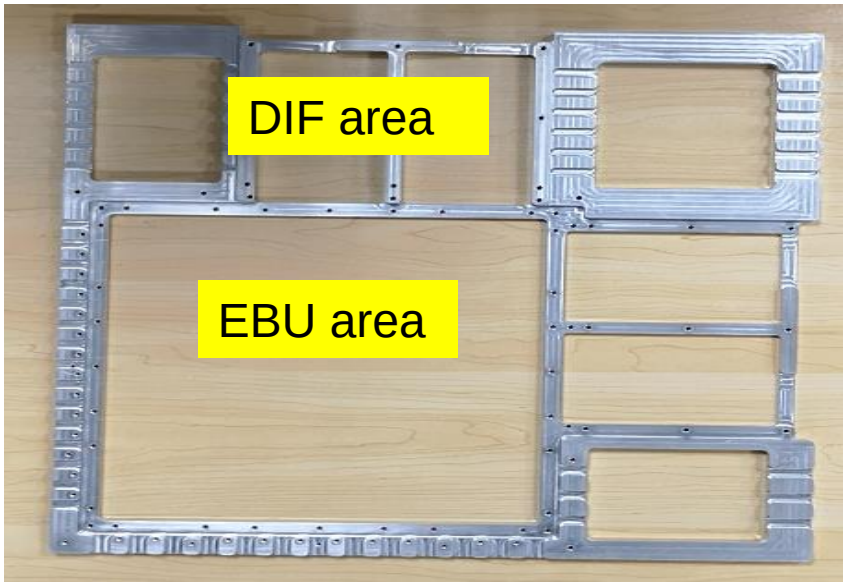
General Status

- All of the sensitive layers of the ECAL have been assembled
  - 30 layers were assembled in SIC and transported to USTC on 3/25/2020 for prototype assembly
- Mechanical structure for the sensitive layers have been finished in factory
  - 15 super-layer frames (aluminum material) were processed and transported to USTC on 4/25/2020
- W-Cu alloy Absorber plates were processed in factory
  - 2 plates were transported to USTC for trail assembly
  - Others will be transported next week

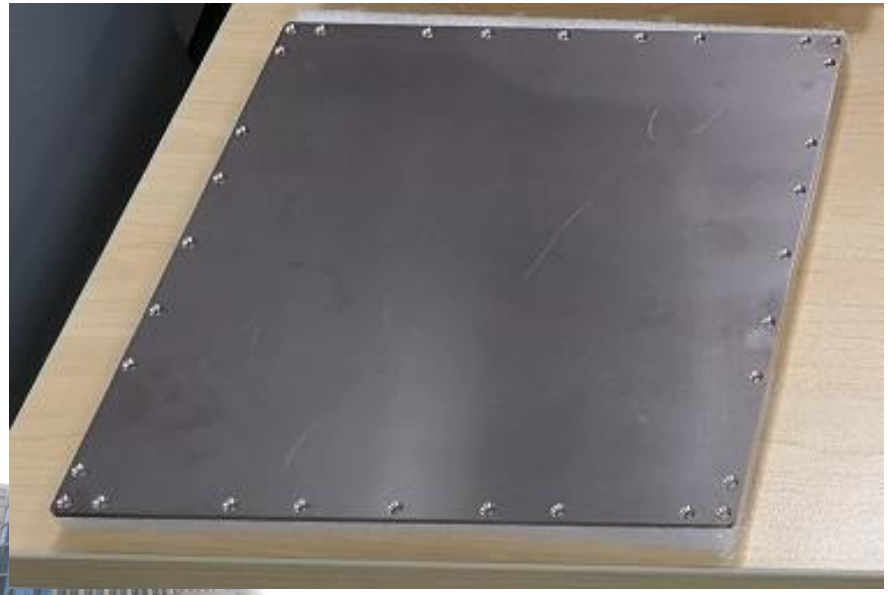
Sensitive layer detector



Super-layer mechanical frame



W-Cu alloy plate



- 30 layers sensitive detectors
- 15 super-layer mechanical frame, each frame will support two layers
- W-Cu alloy, W:Cu 85%:15%, thickness is 3.2 mm ~ 0.73 X_0

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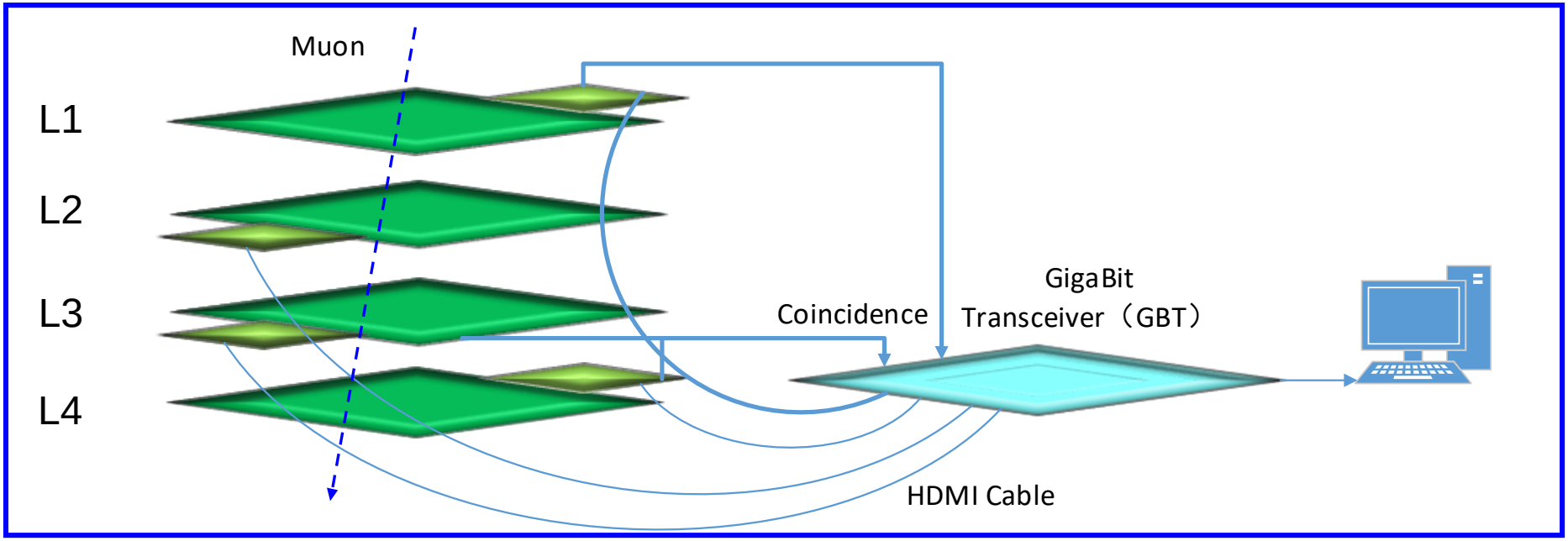
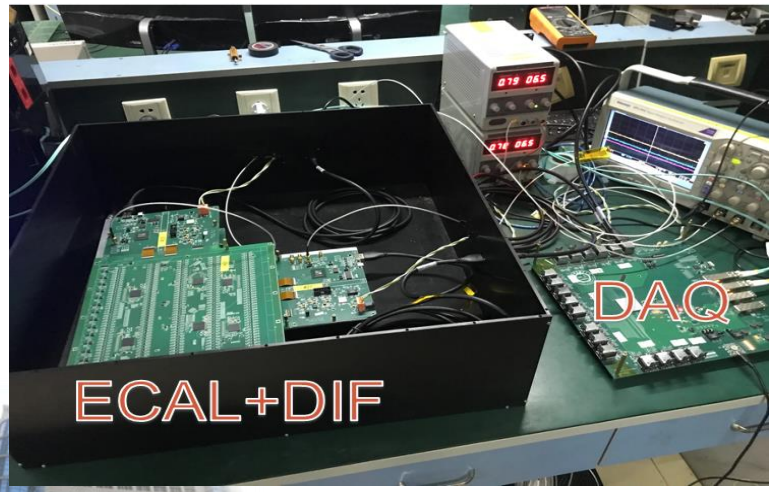
Multi-layers cosmic ray test

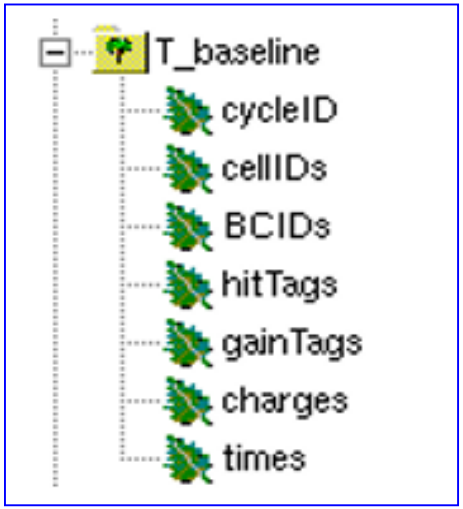




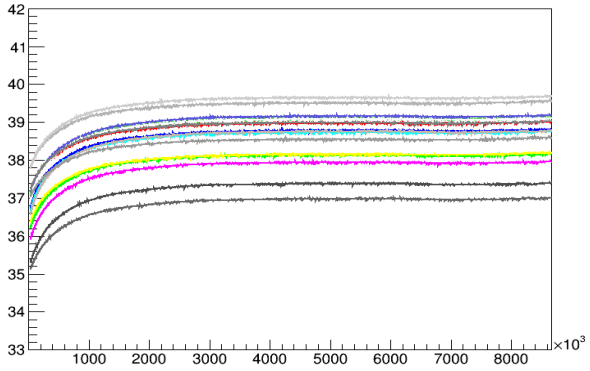
- A small prototype with 4 layers
- The SiPM pixel size is 15 um of L1 and L4 (high gain, high PDE), and10 um of L2 and L3.
- The coincidence signal of L1 and L4 is used as trigger

Functions of the small prototype

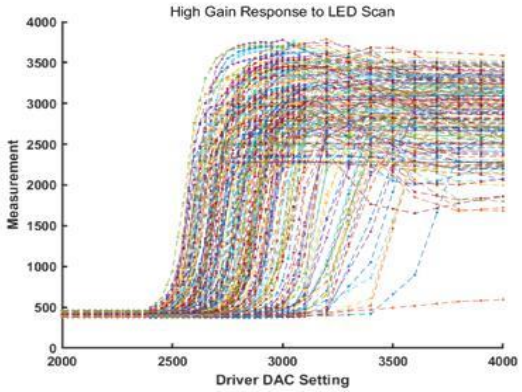
- TriggerID of each layer alignment
- Temperature monitor
- DAC calibration
- LED calibration



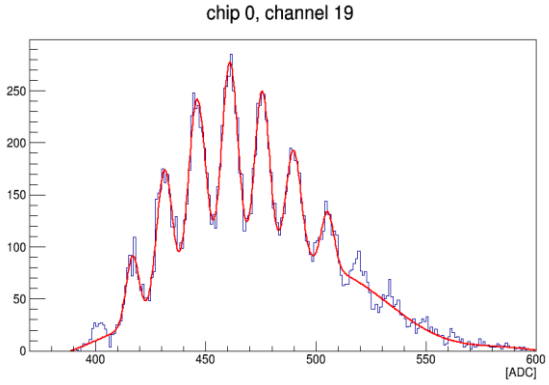
Event data mode



Temperature



DAC Calibration

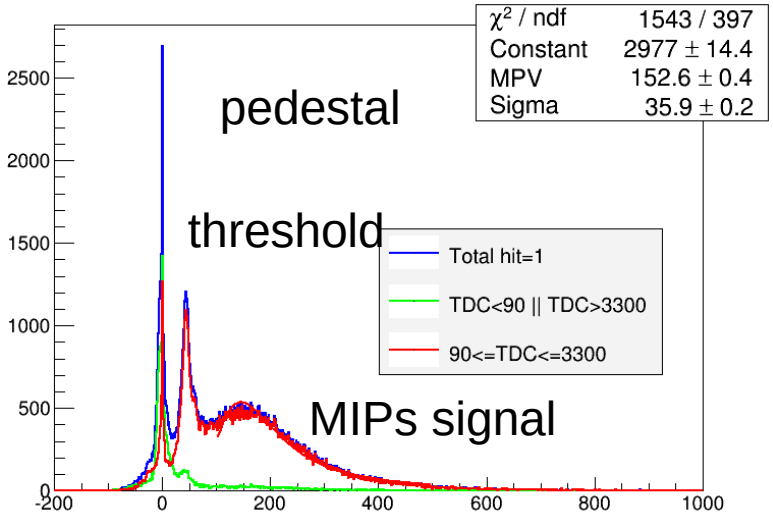


LED Calibration

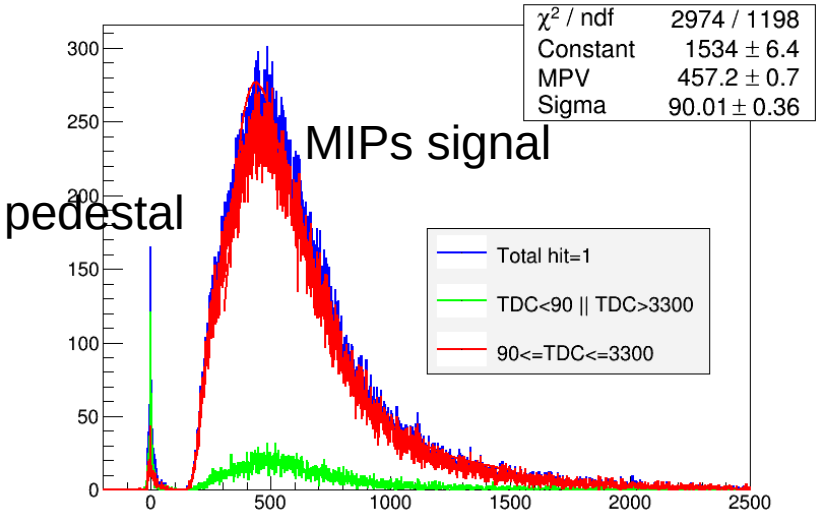
Cosmic Ray Test

- MIPs signal

L2 MIPs signal (10 um SiPM)



L1 MIPs signal (15 um SiPM)



- The MIPs signal amplitude of L1 is about 3 times than L2
  - The gain and the photon detection efficicency

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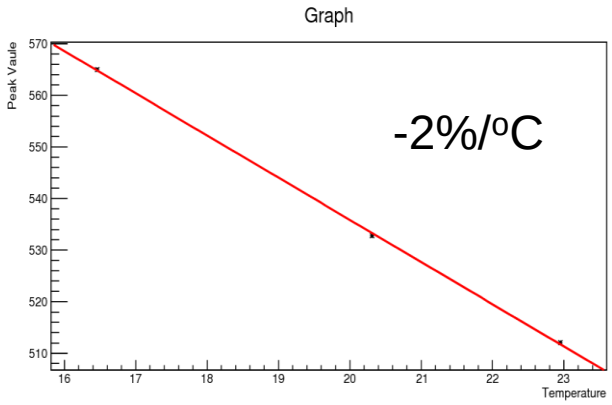
Temperature correction

- SiPM is a semiconductor device which worked in G-M region. The gain is temperature dependent (~ -2%/^{o}C), because the carriers mobility is temperature dependent.
- So we need to adjust the operation voltage of SiPM according to the temperature change to ensure its gain stability

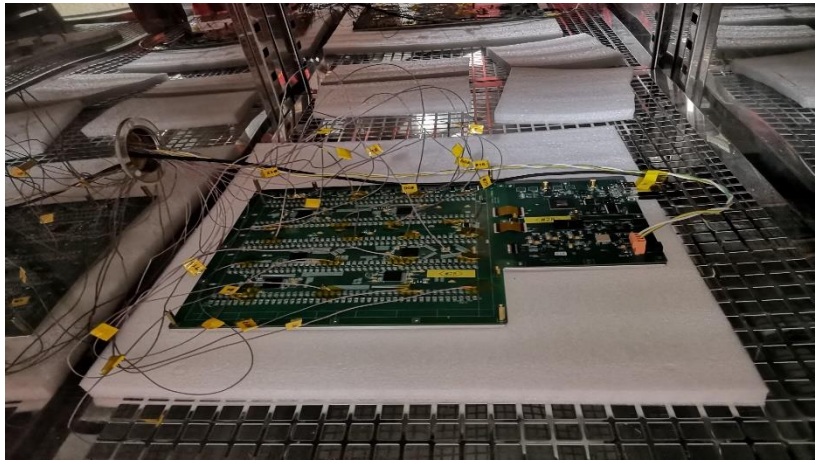


Temperature vs. Gain

Each EBU has 16 sensors to monitor the temperature real time. The temperature of SiPM at each position is calculated by interpolation method, and the working voltage is adjusted according to the temperature change and the gain coefficient.

Temperature correction

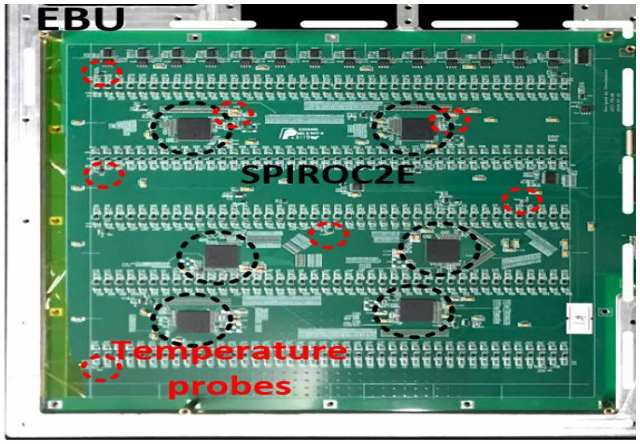
- In order to check this interpolation method, 20 thermocouples are pasted on the EBU to monitor the temperature change on the EBU in different position.
- Put the EBU into a high and low temperature box, and change the temperature from 20 - 45 degree.
- Both the temperature sensors of EBU and the pasted thermocouples could measure the temperature in real time



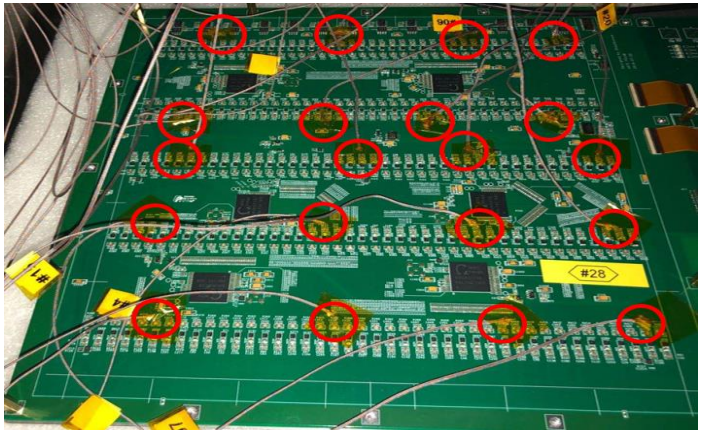
EBU in the high-low temperature box

Temperature correction

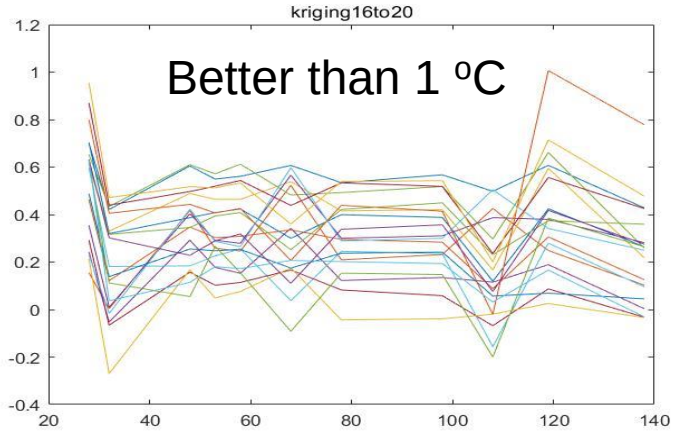
Position of temperature sensor of EBU



Position of the pasted thermocouples



- According to the temperature measured by the sensors on the EBU, the temperature of the thermocouple position is calculated by interpolation method using the values of these sensors and compared with it measured by thermocouple itself.



ΔT between calculated and measured

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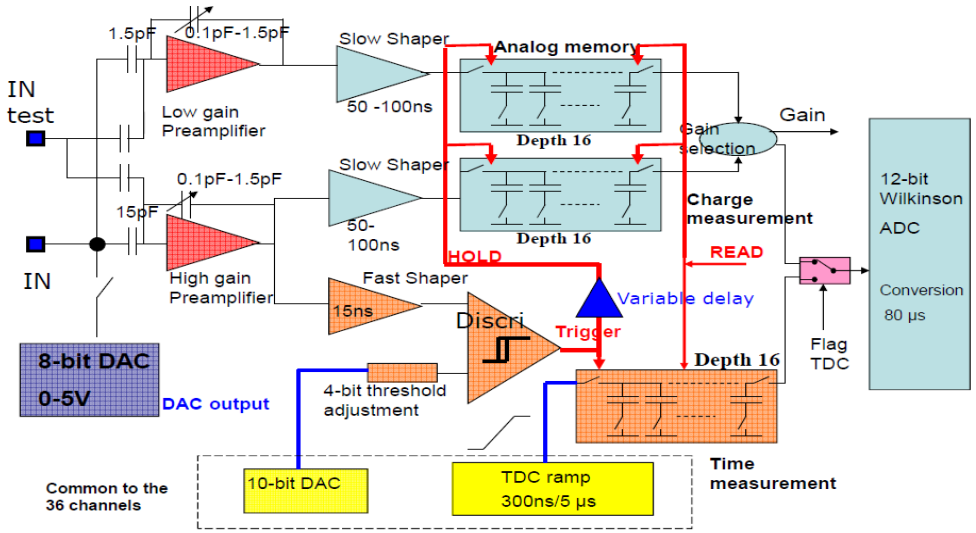
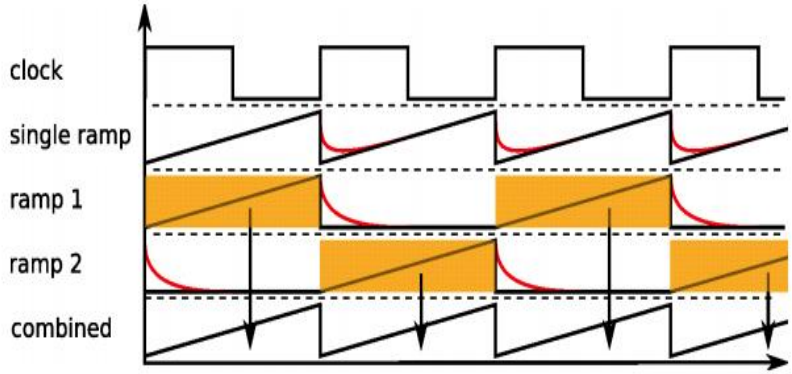
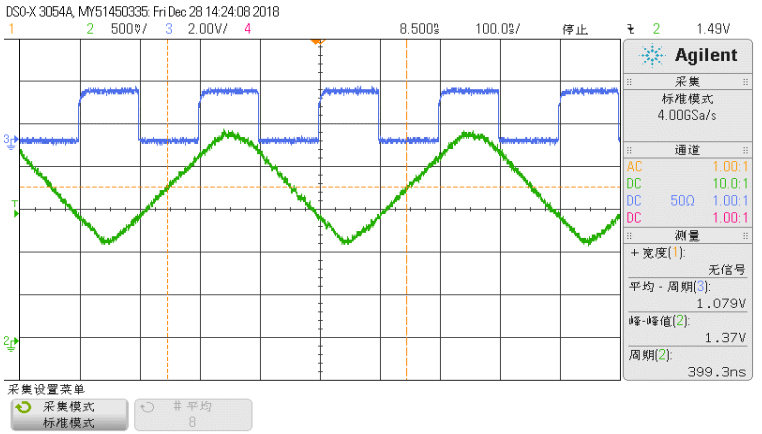
Time measurement

- Channel schematic of SPIROC2E chip
  - High gain
  - Low gain
  - Time measurement





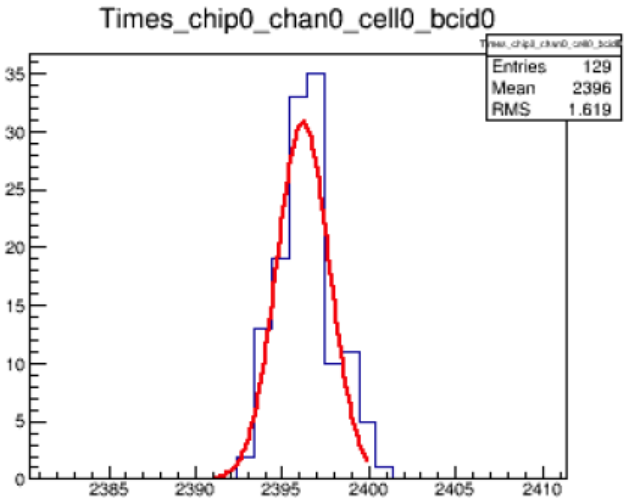
SPIROC2B chip



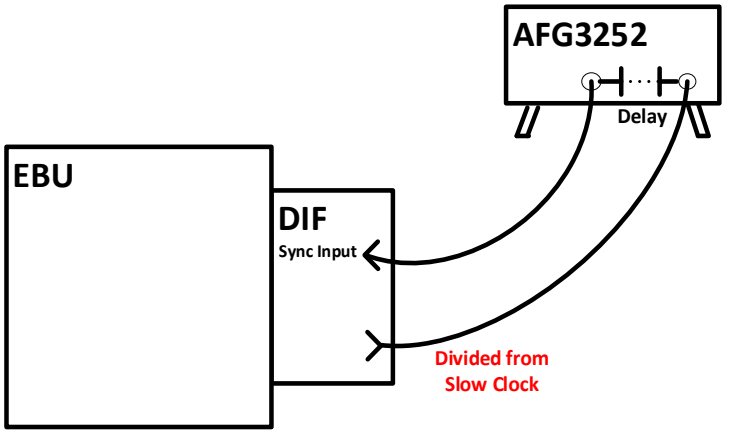
SPIROC2E chip

Time Calibration

- Fan-out signal synchronized with slow clock to AFG3252
- Delay *t* ns then give it to DIF
- Trigger charge injection (Ecalib) and valid it as external trigger



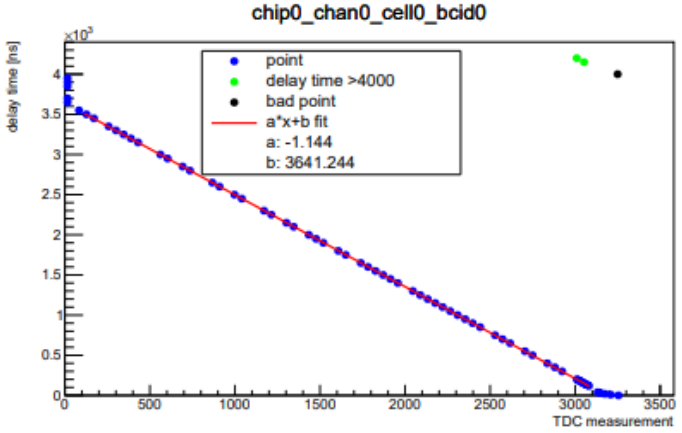
TDC response for a fix delay time

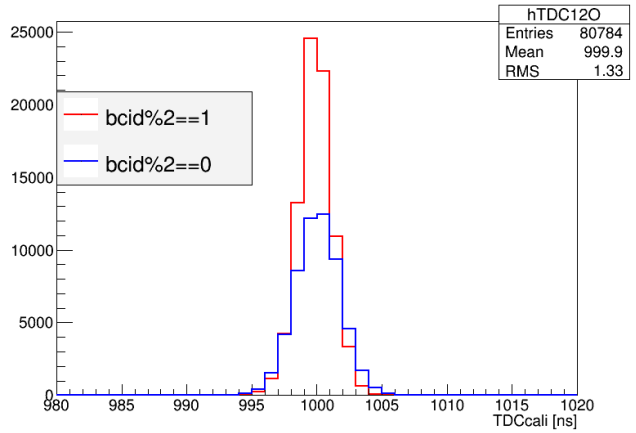


TDC Calibration

Time calibration

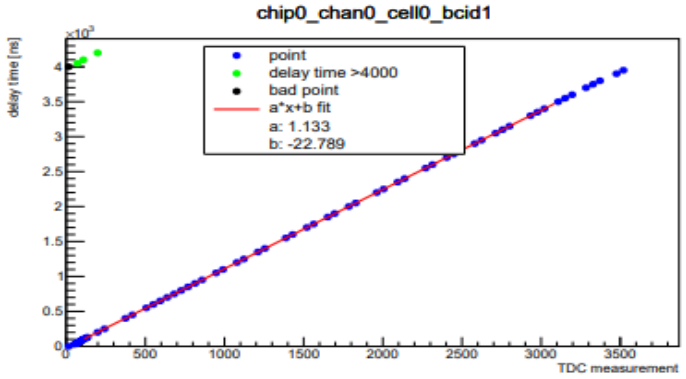
Negative slope ramp



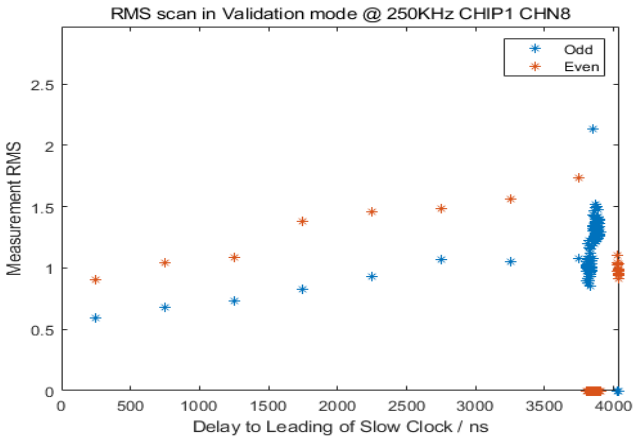


Time resolution at 1000 ns

Positive slope ramp

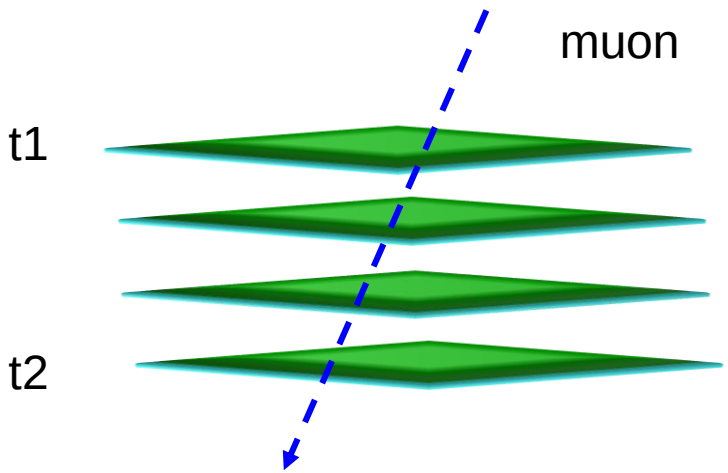


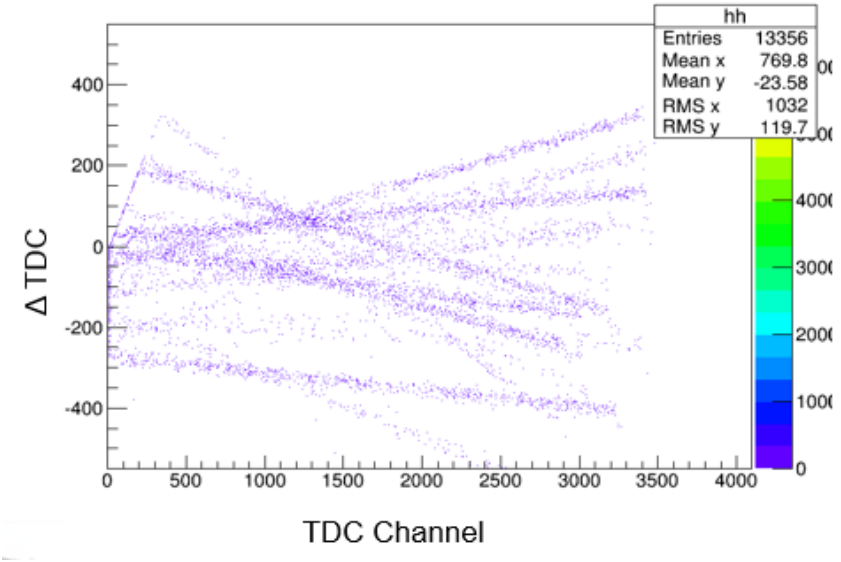
TDC Channel vs. delay time



Time resolution of TDC

Time measurement in cosmic test





Muon hits the different layers. The distance is about several cm

There are several bands here. Each ban is very narrow. The calibration parameters could be used to correct the different between of them.

This work is under way!

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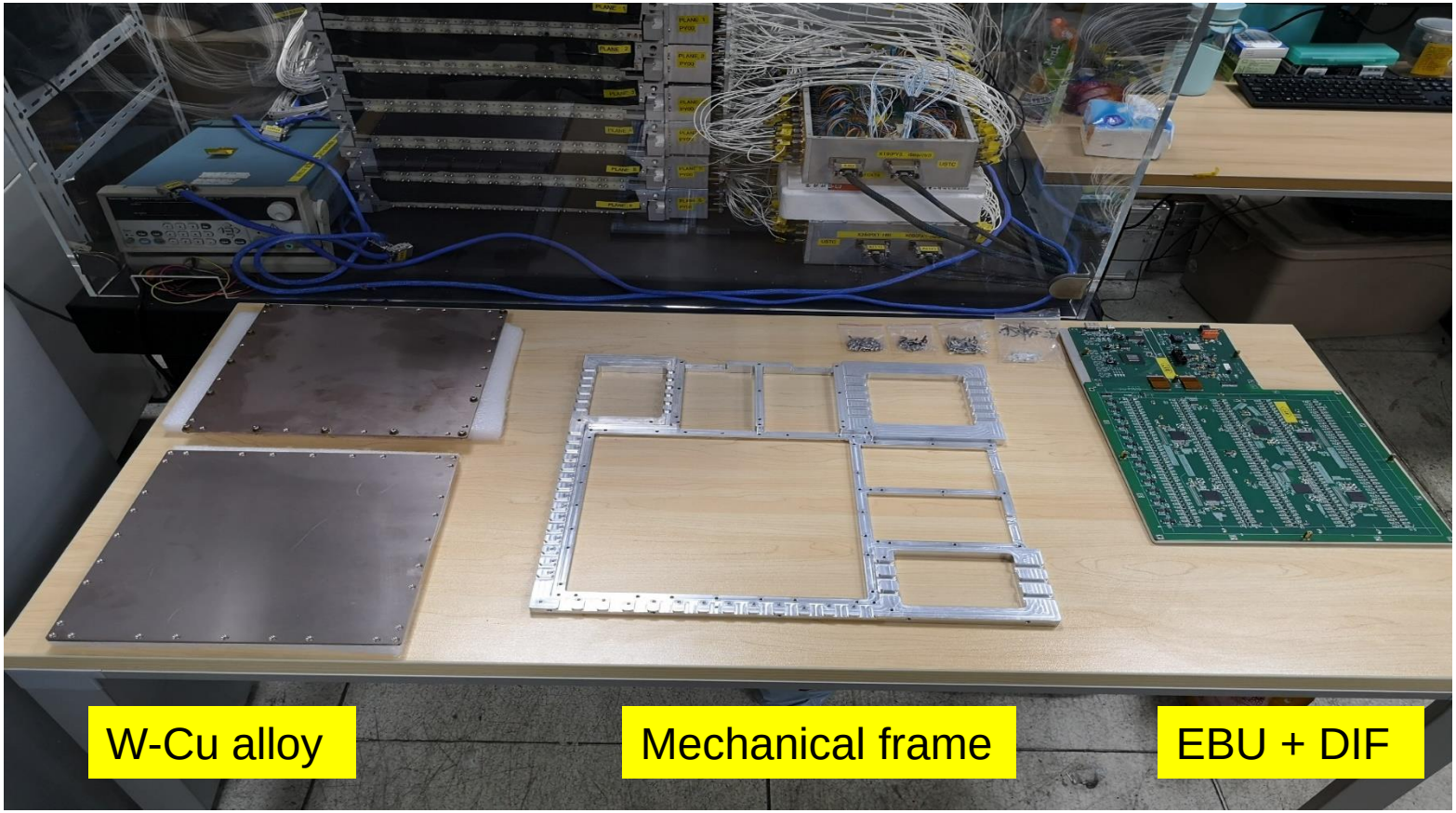
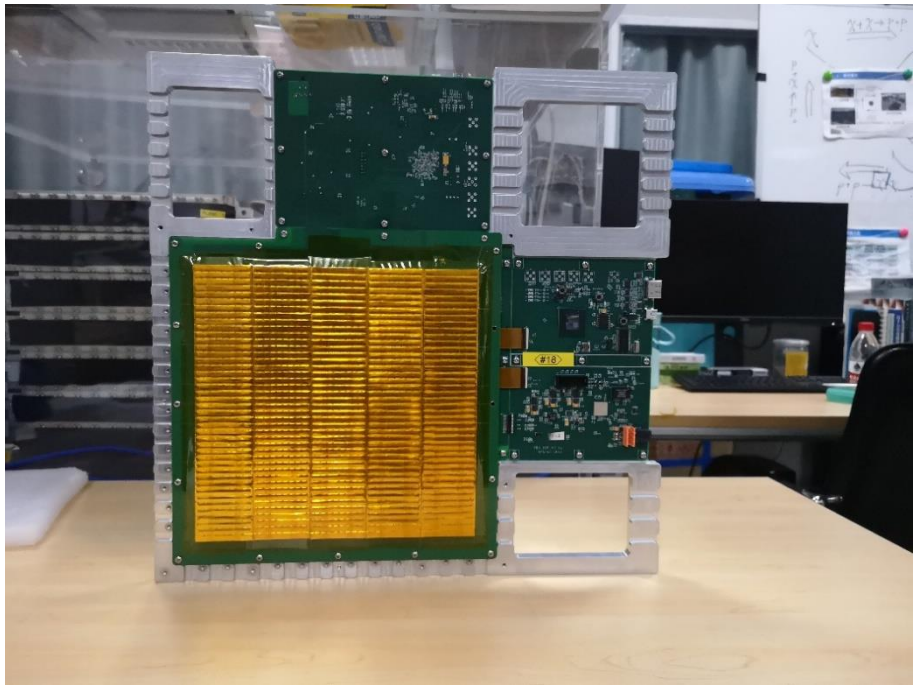
Super-layer assembly



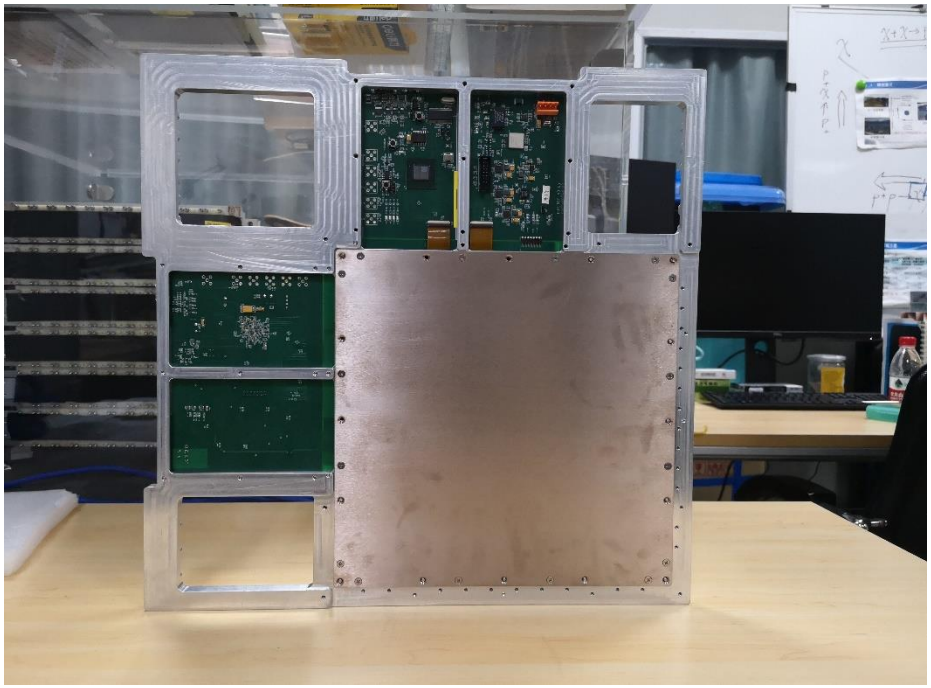
Super-layer assembly

Super-layer assembly

A super-layer is composed of 2 sensitive layers and 2 W-Cu alloy plates



A-side



B-side

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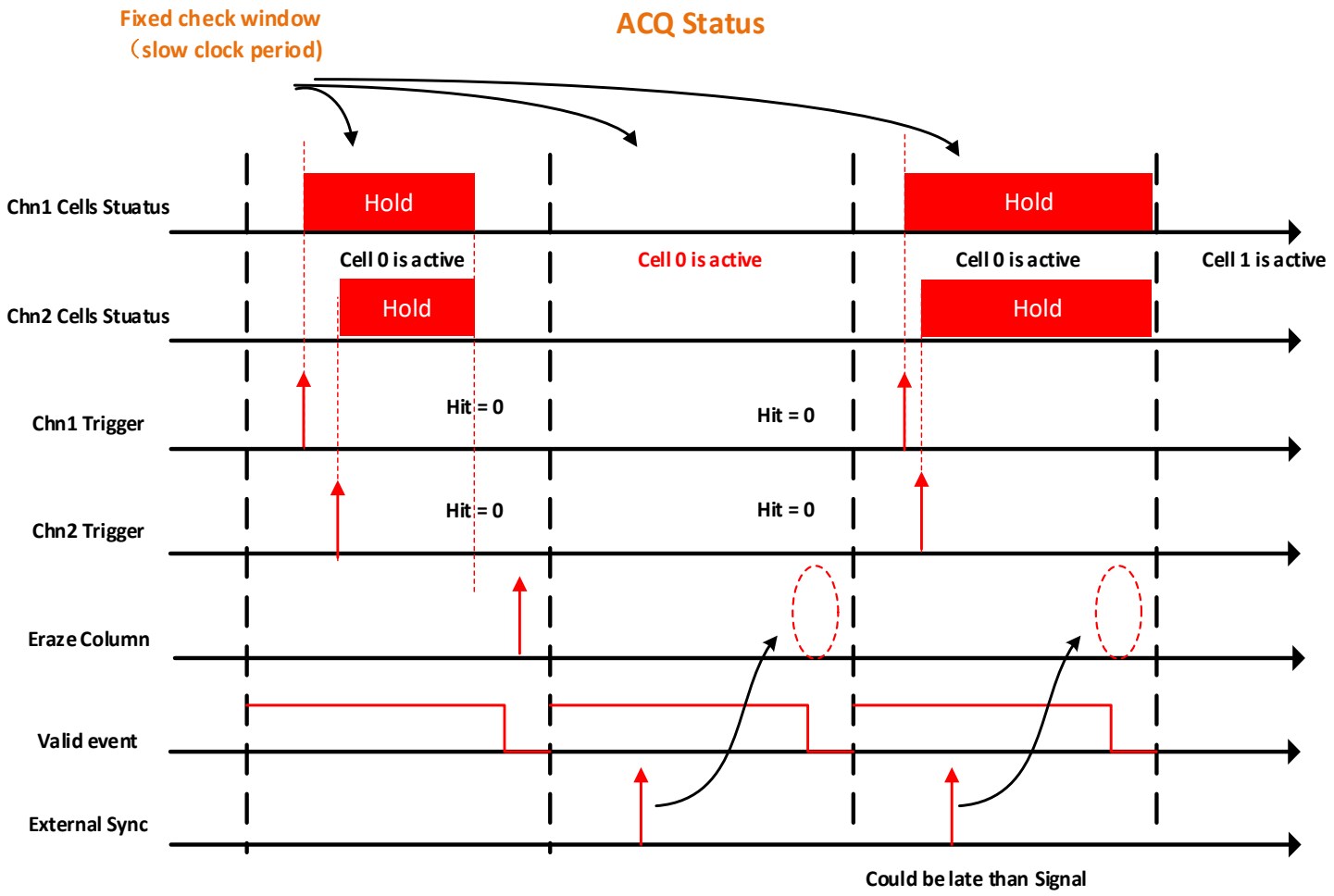
Summary and outlook

- All the sensitive layers and mechanical frames are processed
- A 4 layers mini-prototype was tested by cosmic ray, the MIPs signals are clearly
- Some other work are still progress, such as temperature and time calibration and correction
- A super-layer was trial assembled
- Next step, we will assemble more super-layers for the whole prototype.

backup

ECAL trigger

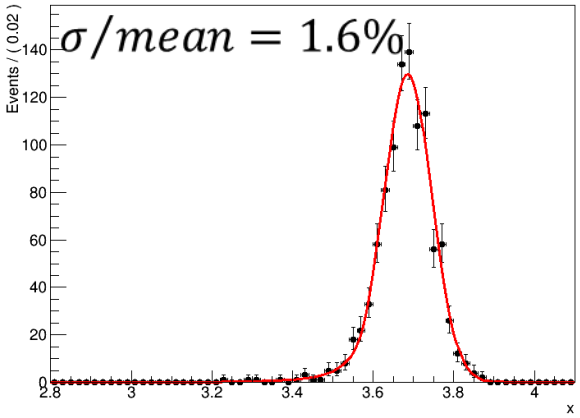


Validation Mode

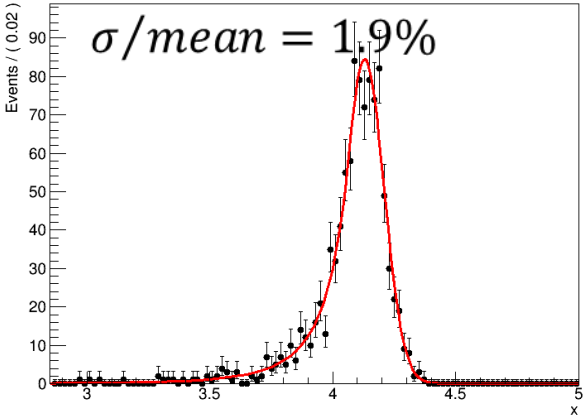
Absorber parameter

Energy resolution @ 100 GeV γ. 30 layers, each layer is 2.8 mm

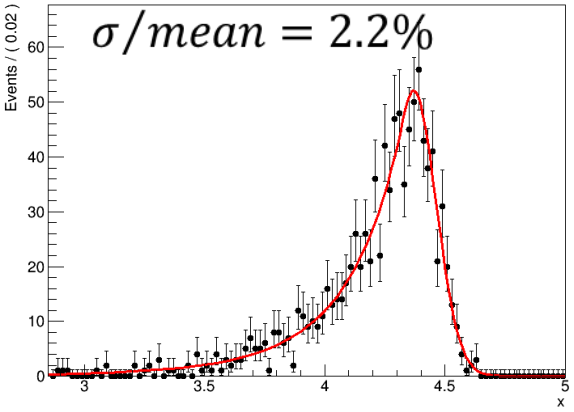
W:Cu 100:0



W:Cu 85:15

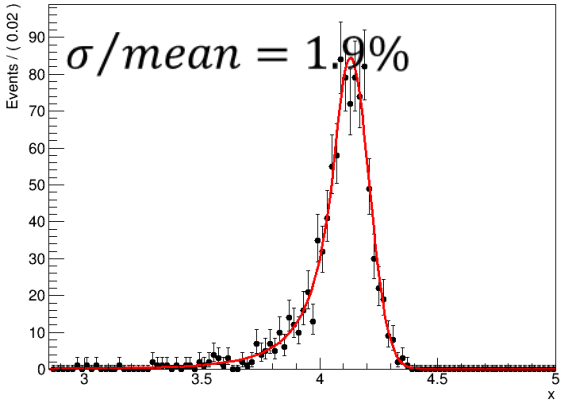


W:Cu 75:25

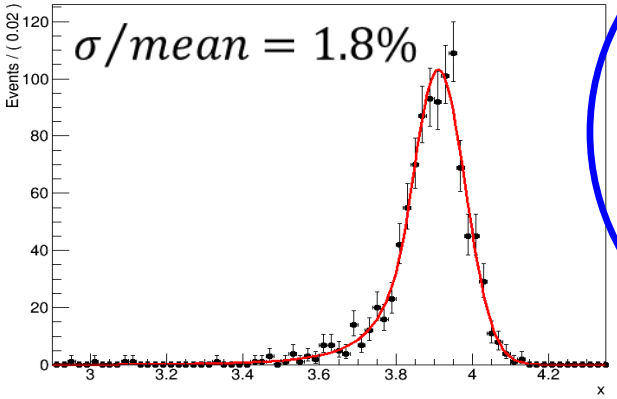


Energy resolution @ 100 GeV γ. 30 layers, W：Cu 85:15

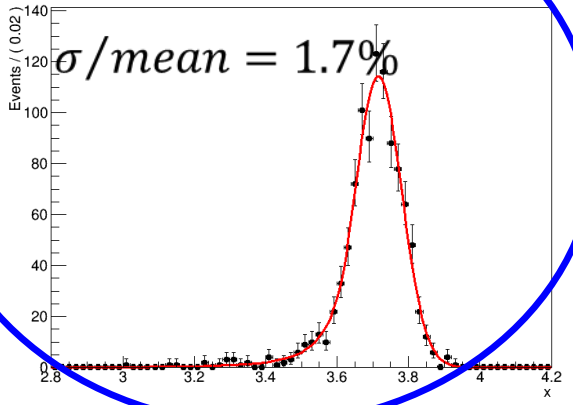
2.8 mm



3.0 mm



3.2 mm



Prototype assembly

Cutting

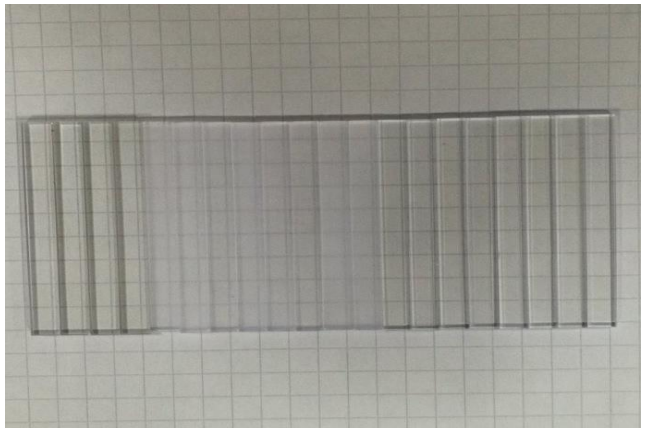
Grooving

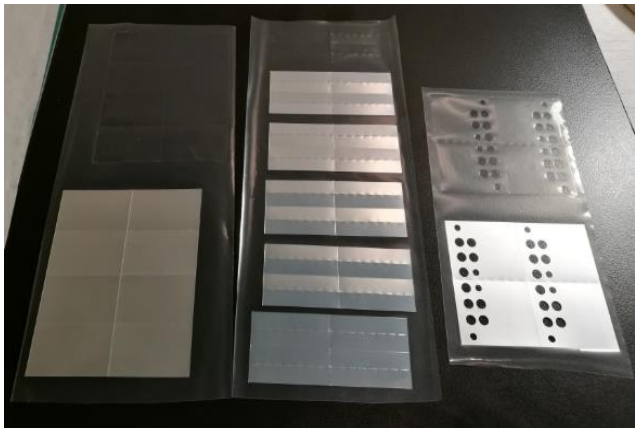
Polishing

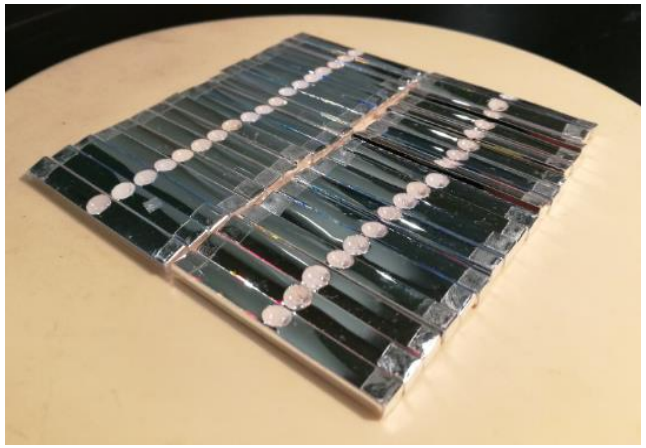
Annealing

Cleaning

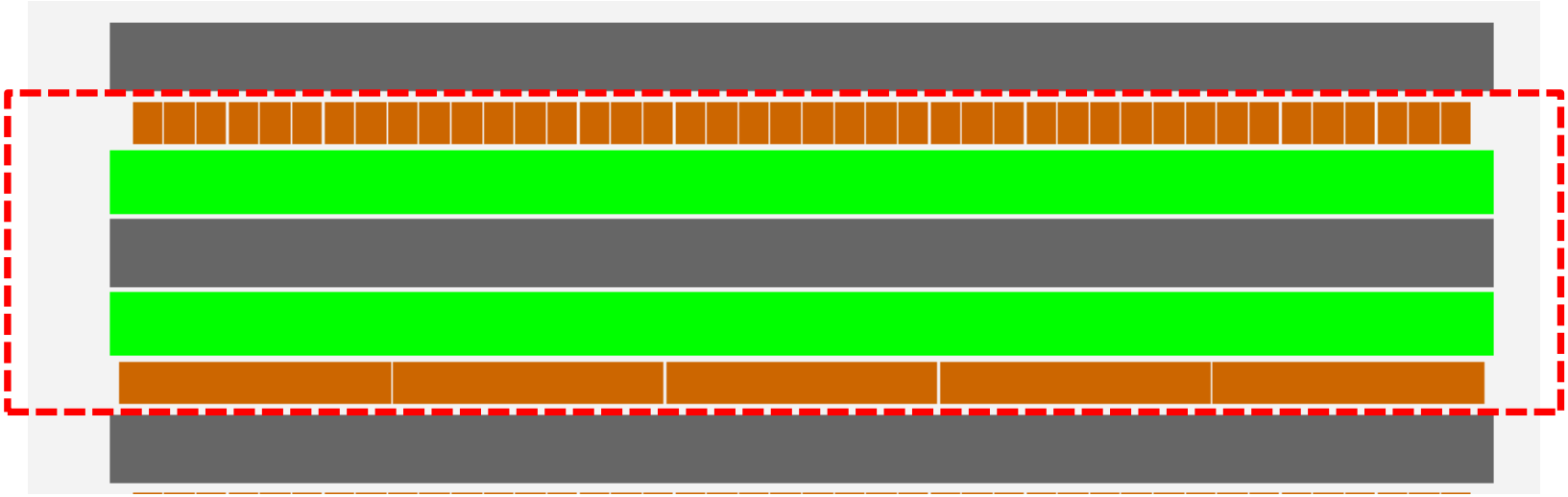
Packing







ECAL prototype

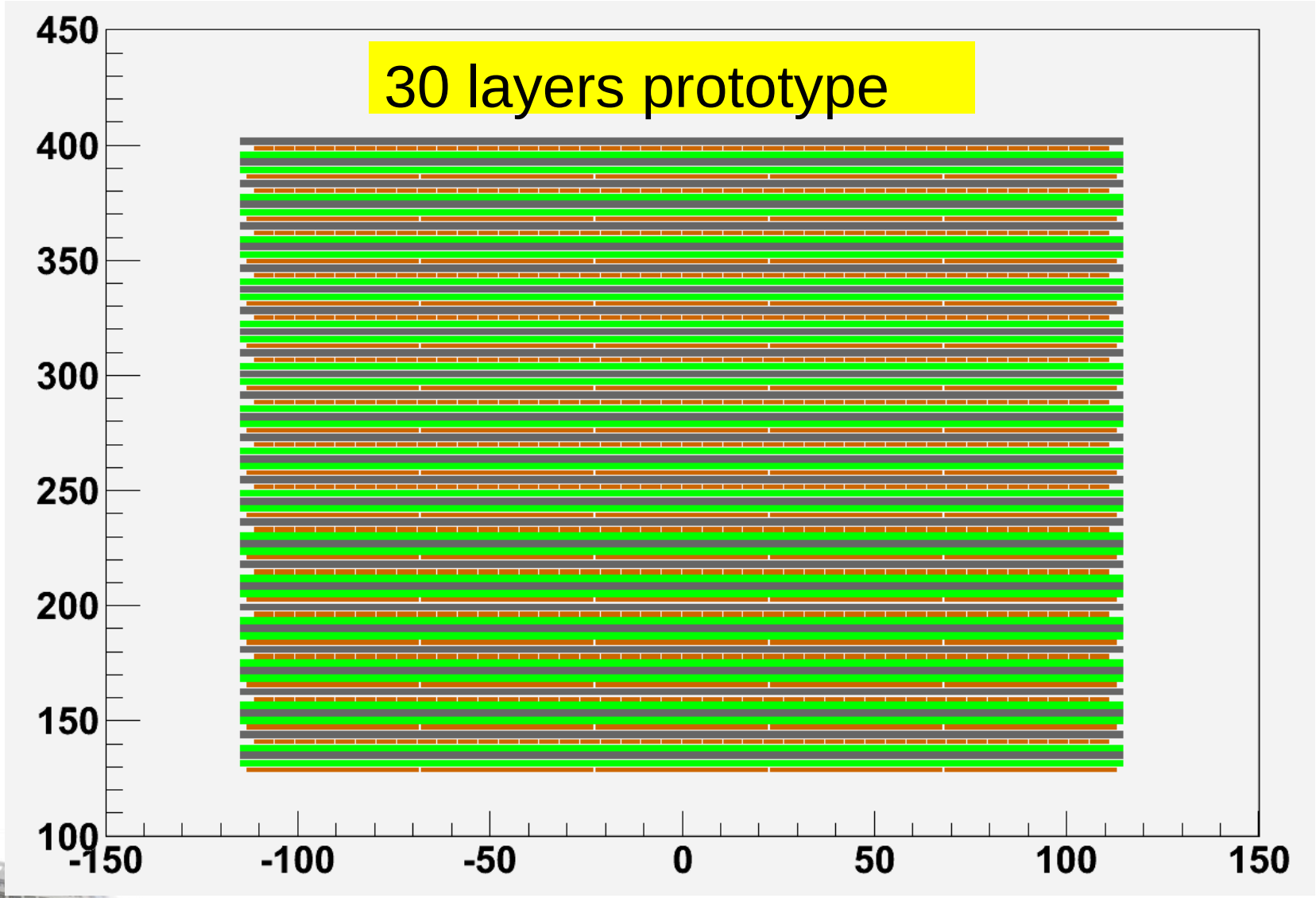


tungsten

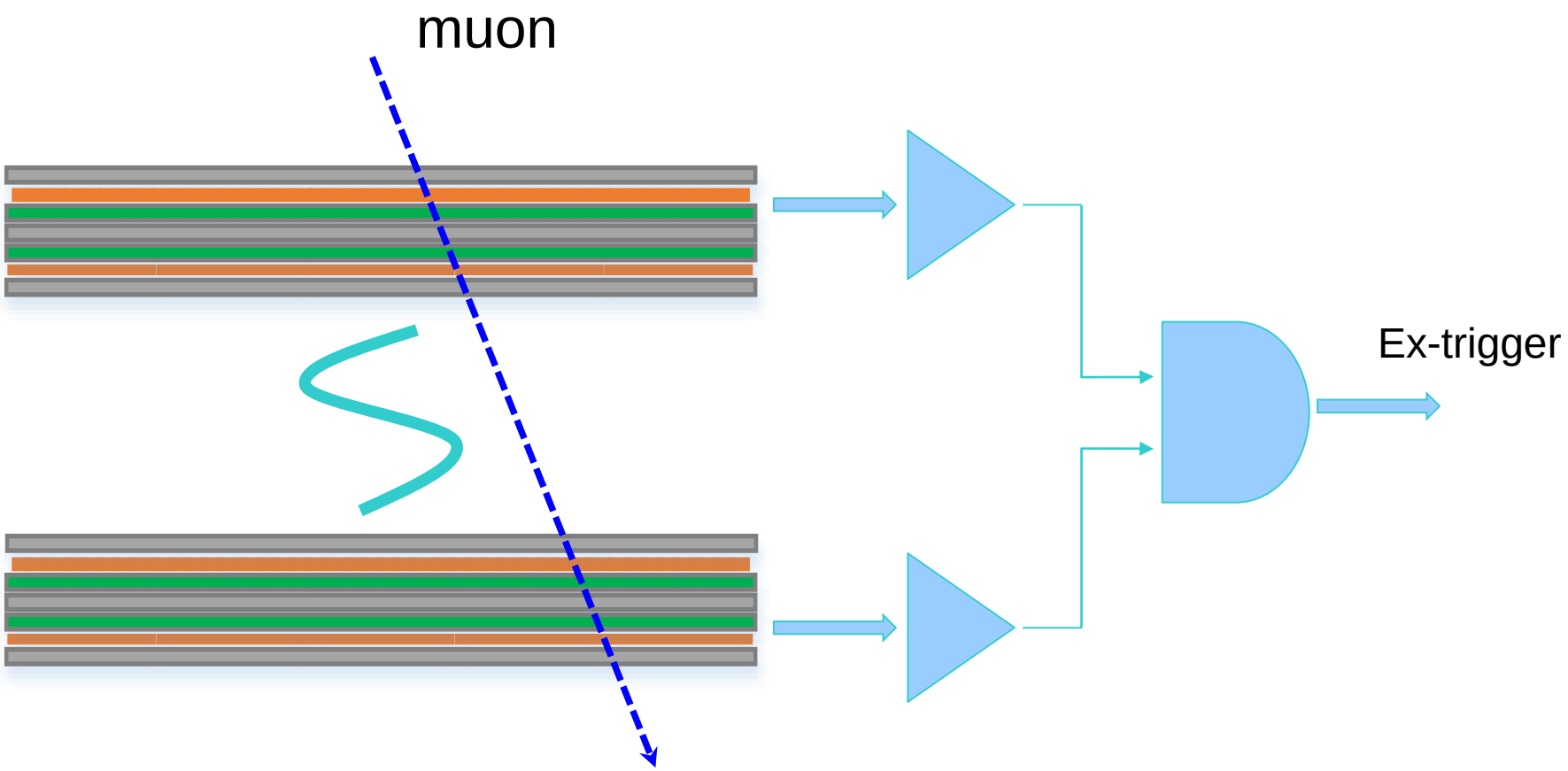
scintillator

PCB

ECAL prototype



ECAL test trigger



The schedule of ECAL

- According to the MOST funding task, a prototype should be assembled in the beginning of next year (2020.2)
- Then the cosmic ray test in laboratory and Beam test in IHEP and DESY respectively.