# The progress of ECal production in China

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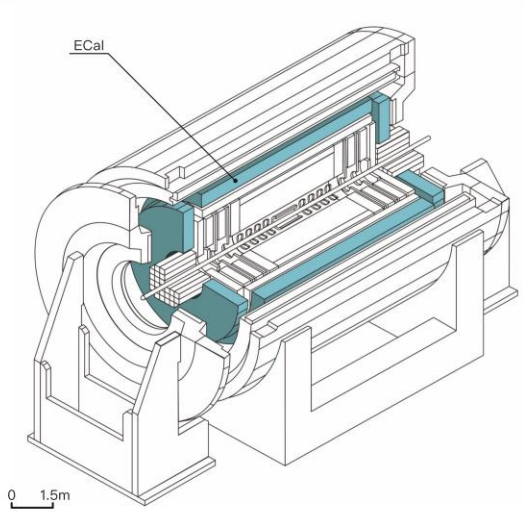
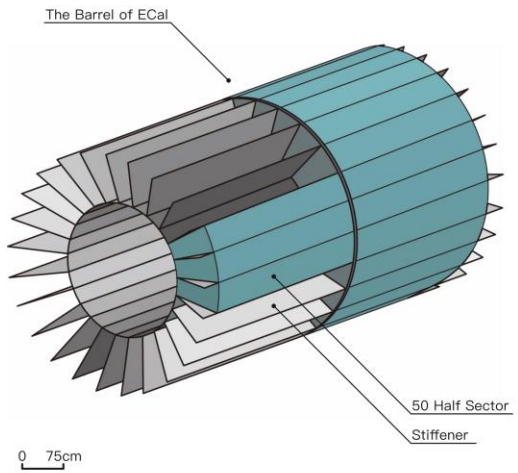
# MPD-ECal production

**MPD-ECal requirements**:
particle occupancy : < 5%
Time resolution : <1ns
Energy resolution : < 5%
@1GeV
Operate in the magnetic FIELD :
~ 0.5T
Adequate space resolution.

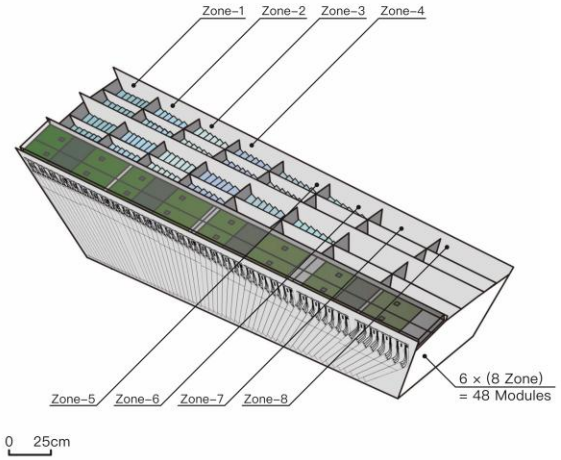



MPD-ECal

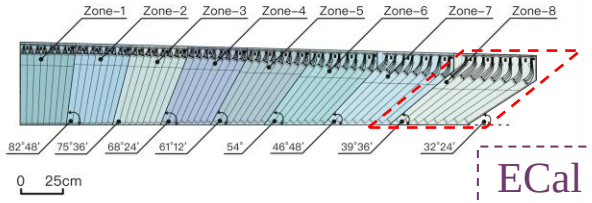



The Barrel of ECal

ECal Half-Sector




ECal 8-Zone




ECal Module


ECal Tower

| The ECal-MPD |
|---|
| 1 Barrel |
| 50 Half-sector |
| 300 8-Zone module |
| 2400 Module |
| 38400 Tower |

# ECal module and PCB production in China

- **ECal module:**

  **Construction of 8 sectors. 768 modules in total.**

  **Institutes: Tsinghua University 60%**

  **Shandong University 20%**

  **Fudan University 10%**

  **University of South China 10%**

  **Huzhou University**

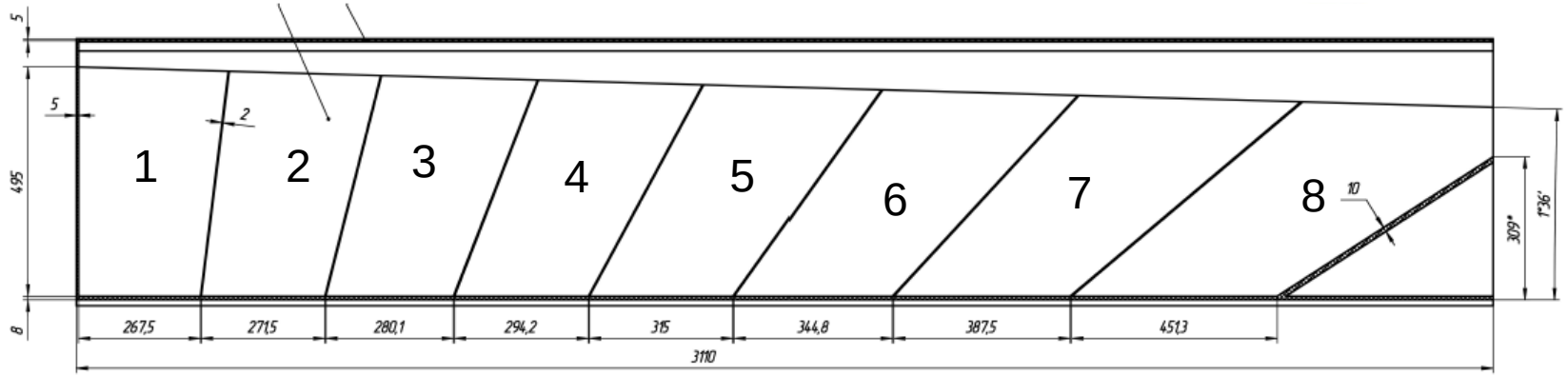
- **ECal PCB:**

  **Production of 1200 PCBs (without SiPMs).**

# Modules production in China

## In the first stage, 8 sectors have been produced in China

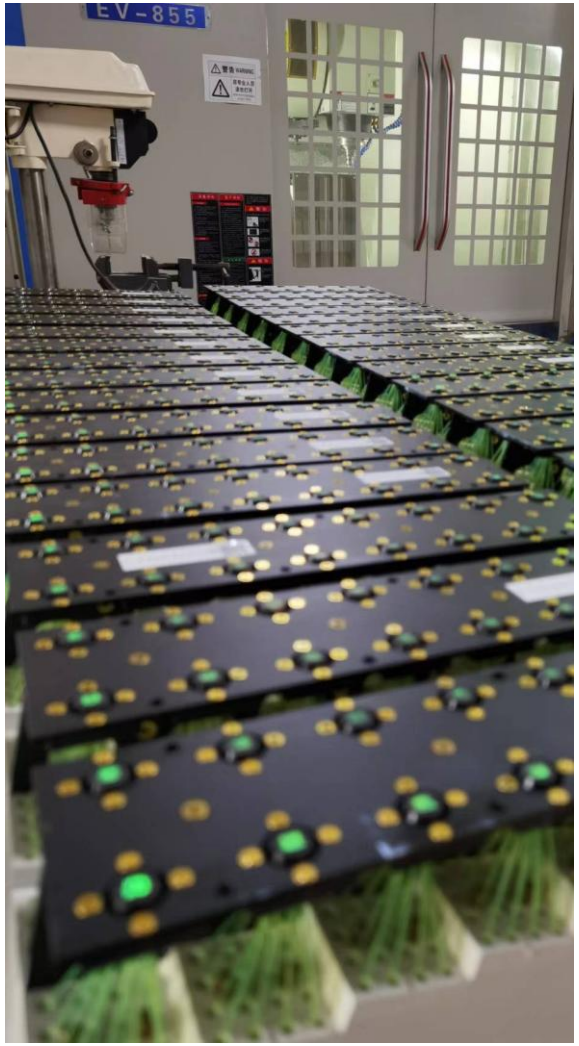
*8 sectors=16 half sectors=768 modules=12288 towers*

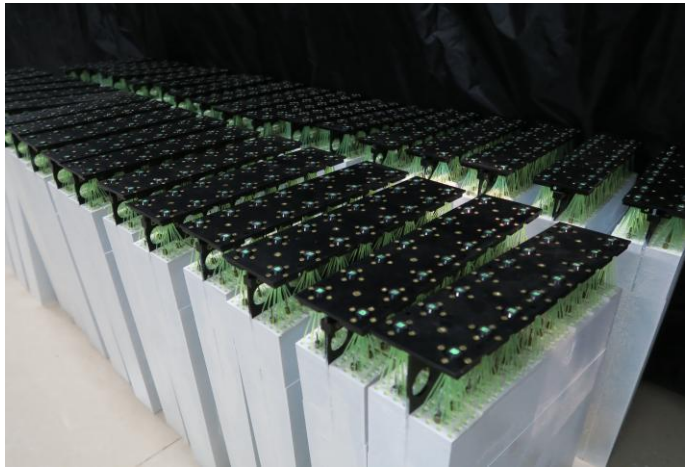


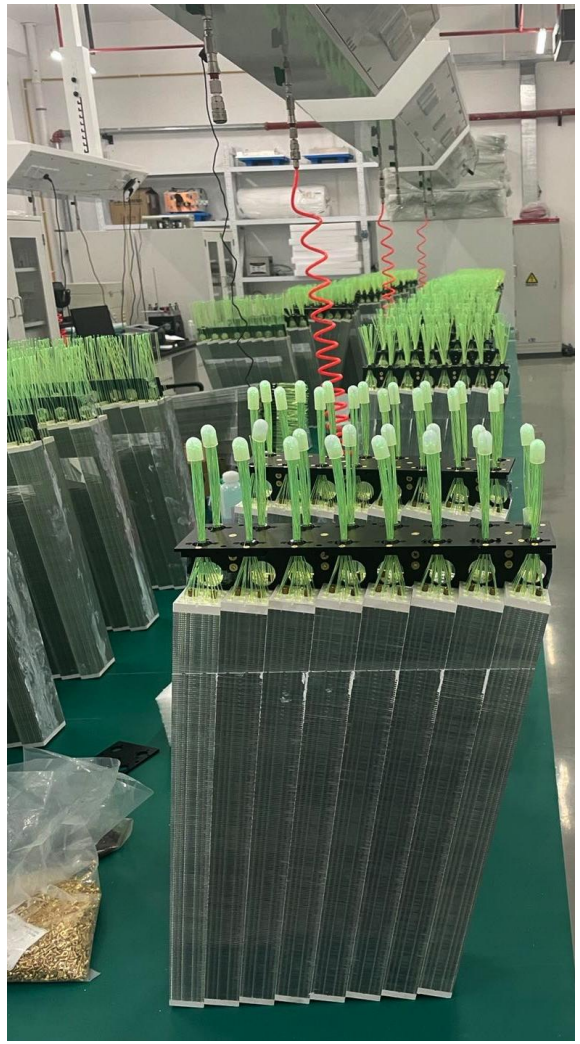

**Modules produced in each institutes**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total | Progress |
|---|---|---|---|---|---|---|---|---|---|---|
| THU | 19 | 19 | | 38 | 96 | 96 | 96 | 96 | 460 | Finished |
| SDU | | | 96 | 58 | | | | | 154 | Finished |
| FDU | | 77 | | | | | | | 77 | Finished |
| USC | 77 | | | | | | | | 77 | Finished |

# Mass production in China

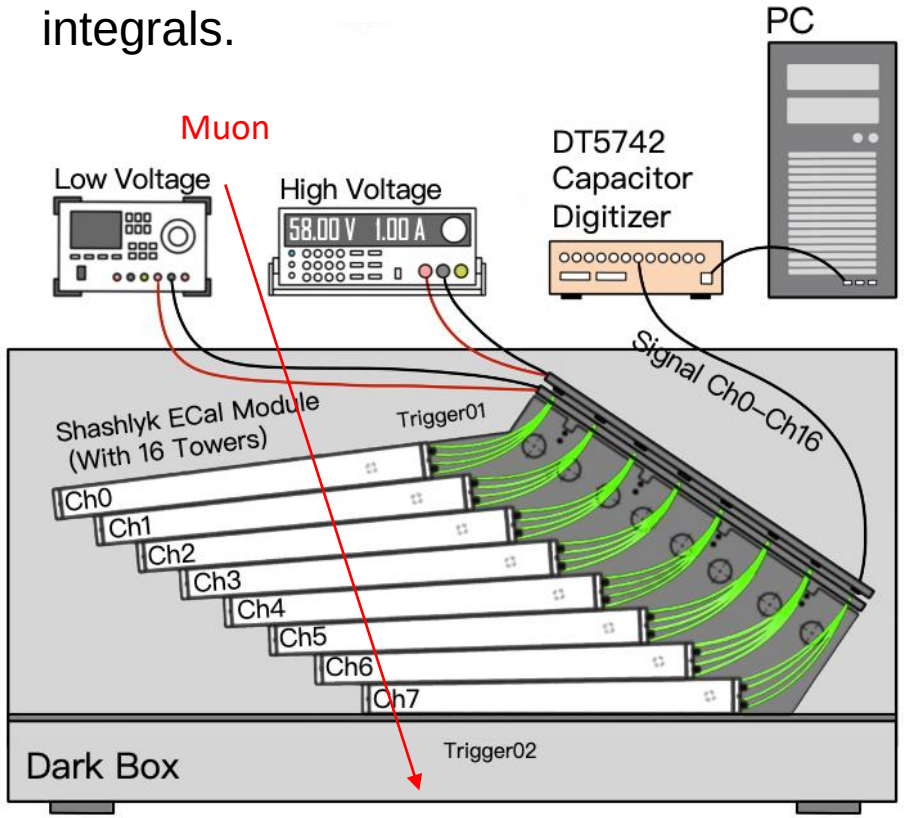


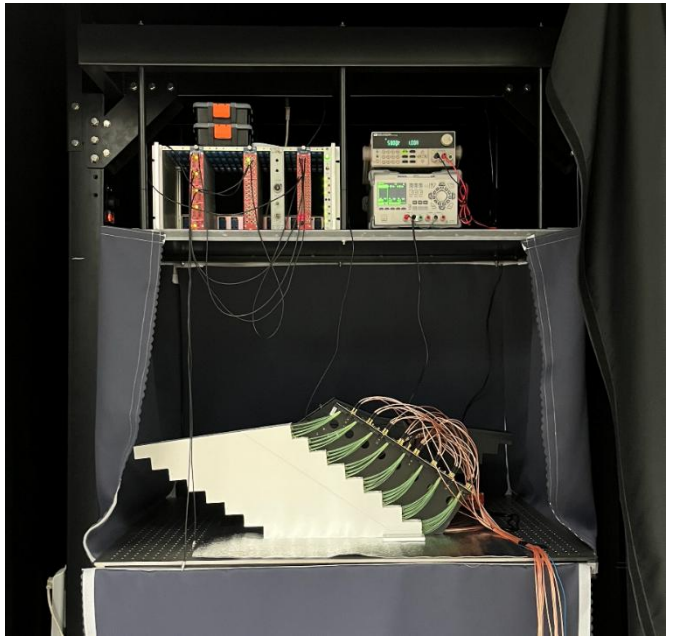



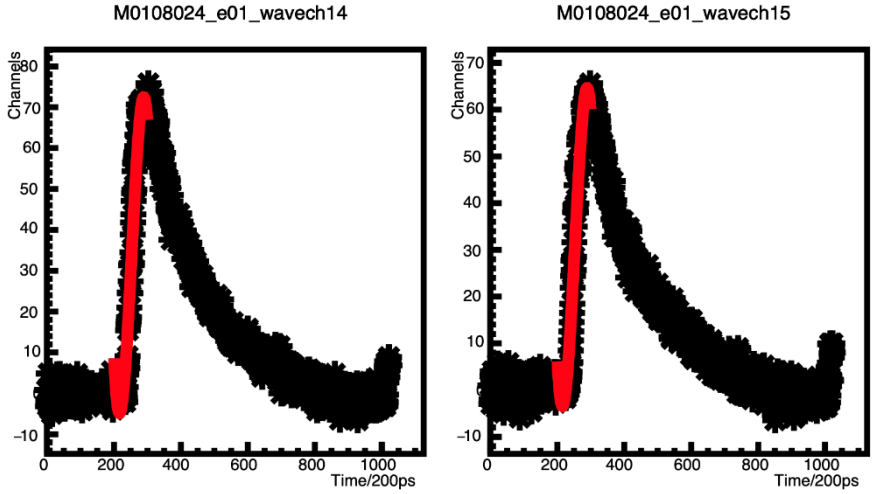


# Cosmic ray test

- A special dark room for test.
- The auto-triggering of DT5742 is used.
- ADC integrals are calculated from waveform (Fig. 2) of selected events. Peaks are extracted from distribution of integrals.

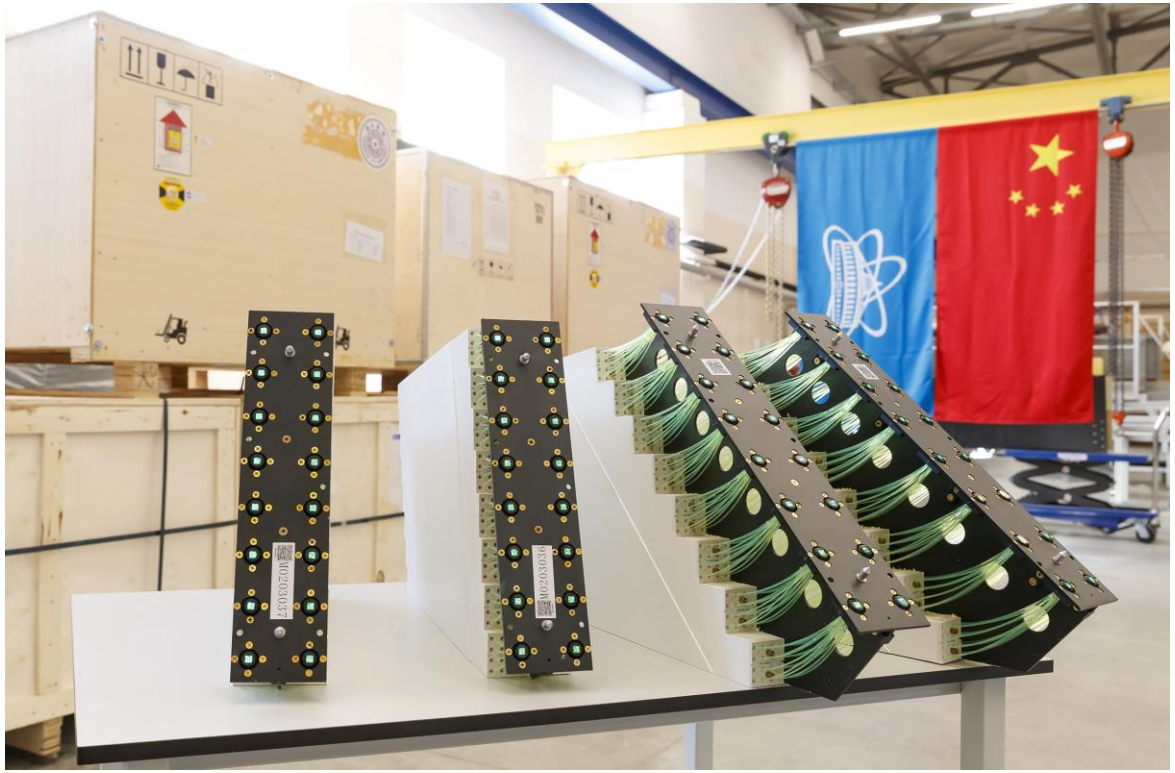


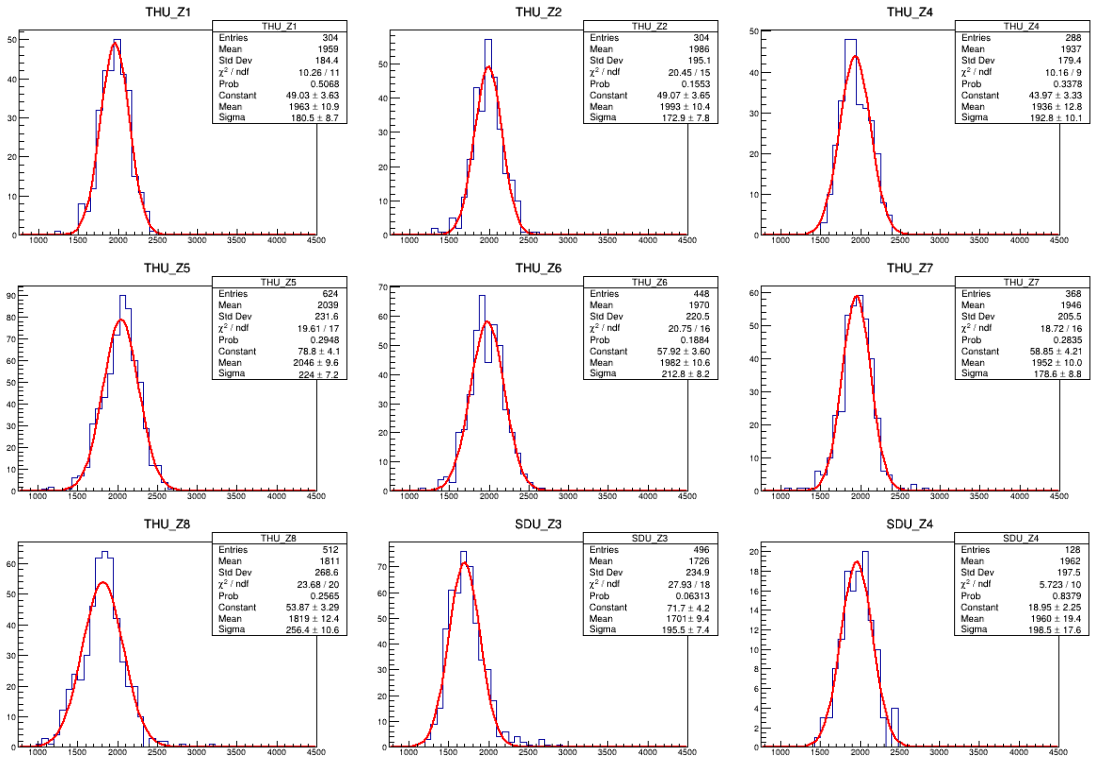





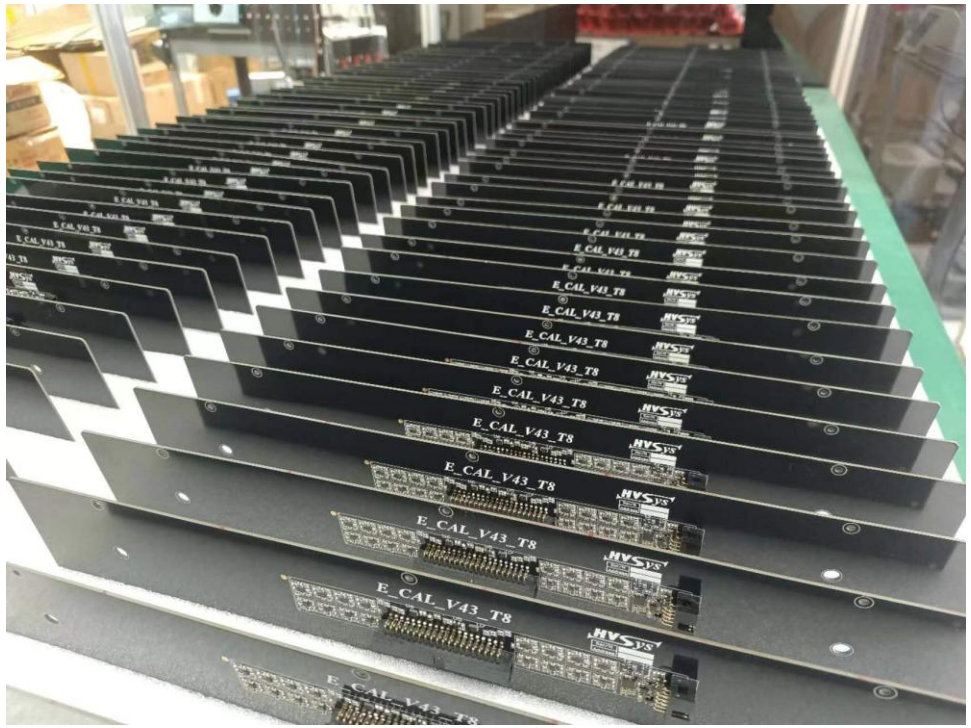
# Cosmic Test of 217 Modules from China

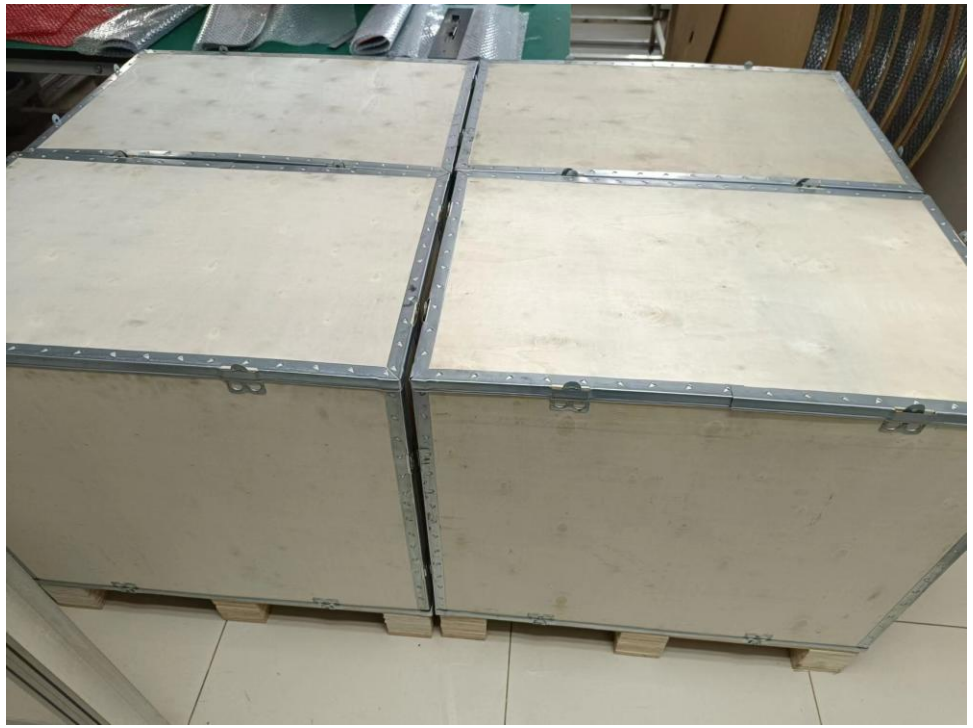
## ➢ Cosmic test in JINR





# PCBs production in China



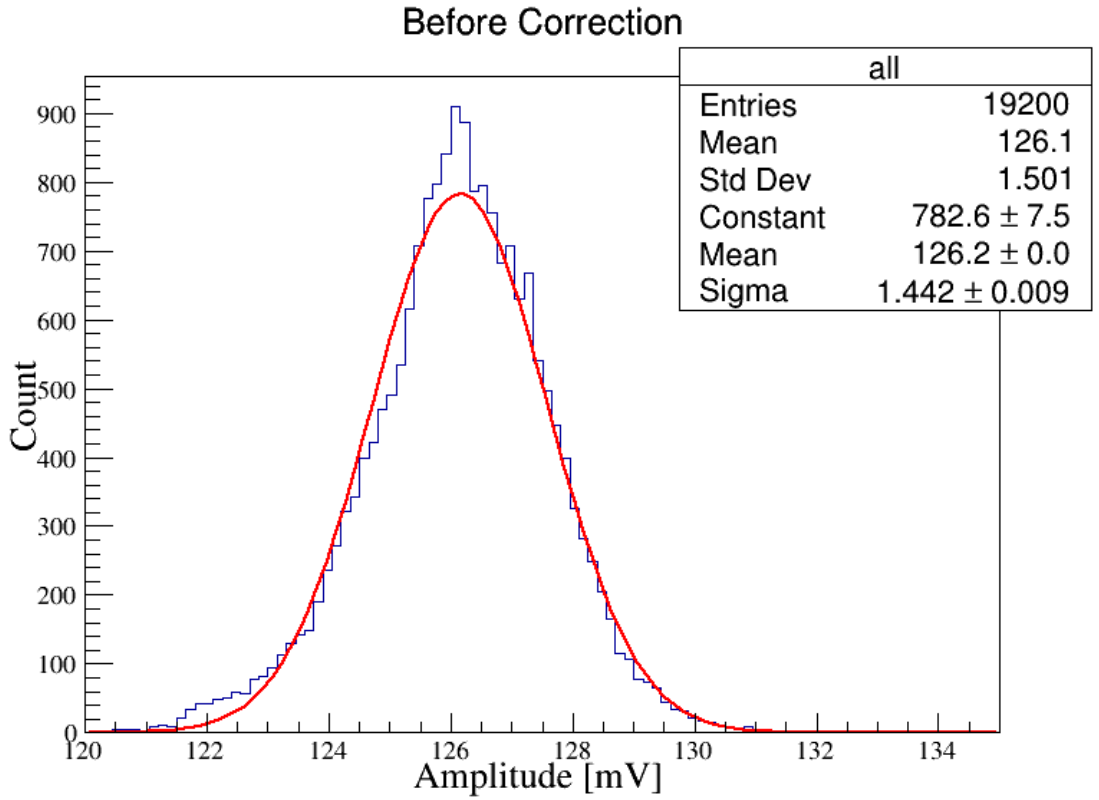



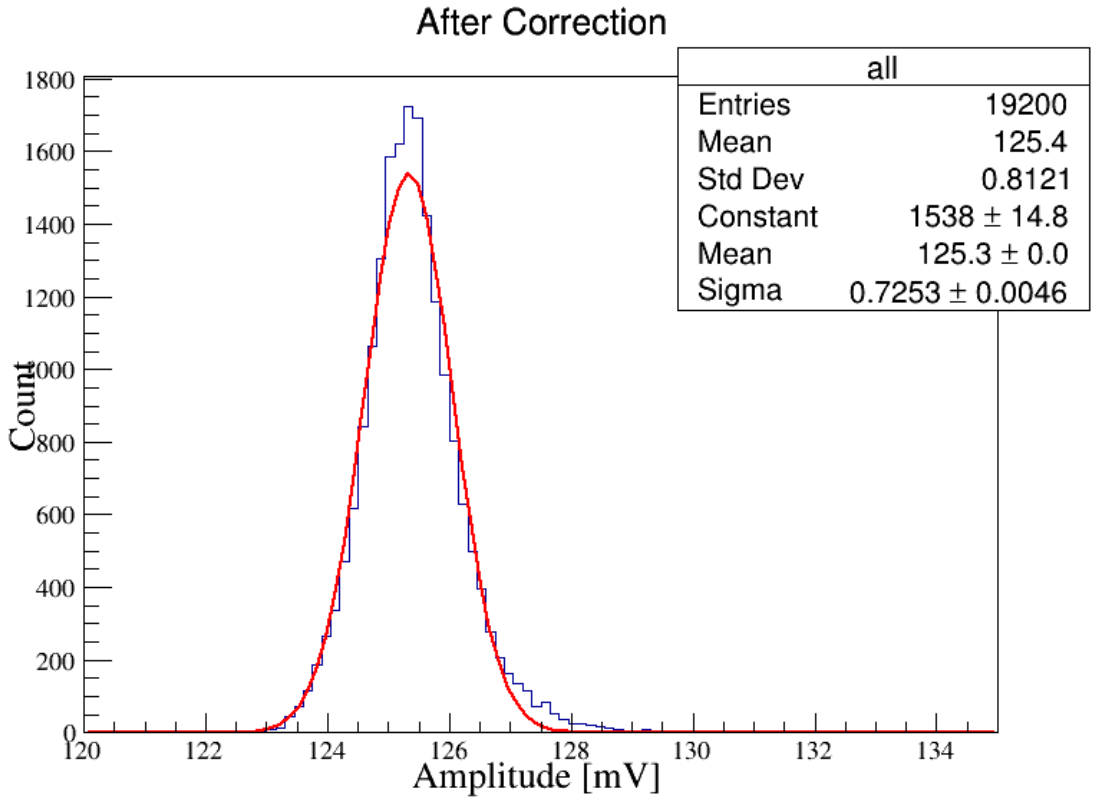
| | T123 | T4 | T5 | T6 | T7 | T8 | Total | Production | Test | Shipment |
|---|---|---|---|---|---|---|---|---|---|---|
| THU | 450 | 150 | 150 | 150 | 150 | 150 | 1200 | Finished | Finished | Finished |

# Batch test of ECal PCBs

- The performance of PCBs is very consistent

*1200 boards, 19200 channels*

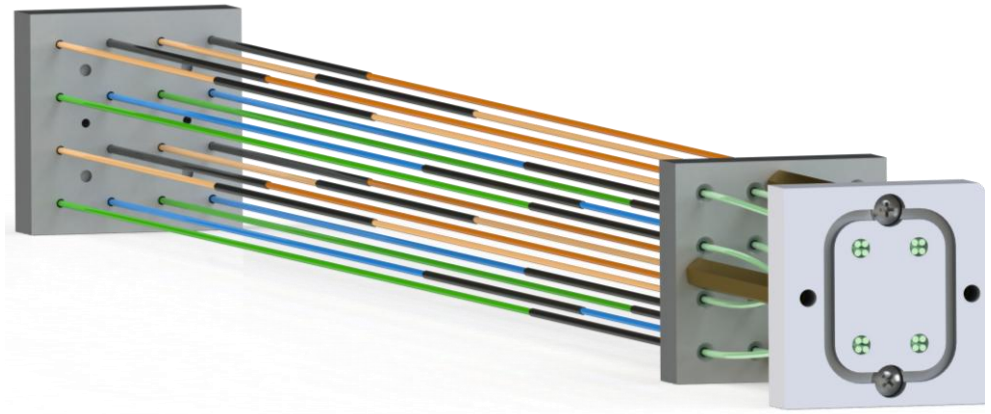


# Development of of 5D ECAL

## Specfications of 5D Ecal prototype

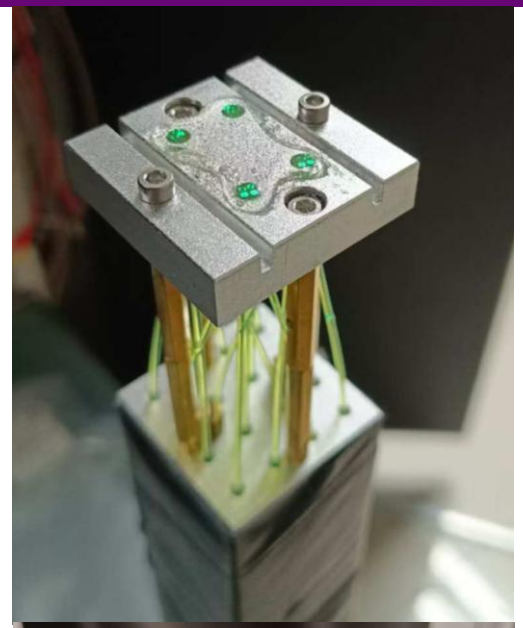
| | |
|---|---|
| Transverse size, $mm^2$ | 40×40 |
| Number of layers | 216 |
| Thickness of scintillator, mm | 1.5 |
| Thickness of lead absorber, mm | 0.3 |
| Moliere radius, mm | 62 |
| Number of radiation length, X0 | 11.8 |
| Number of WLS fibers | 16 |
| Shading material | Aluminum ally tubes<br>internal: ϕ1.3mm<br>external: ϕ1.5mm |

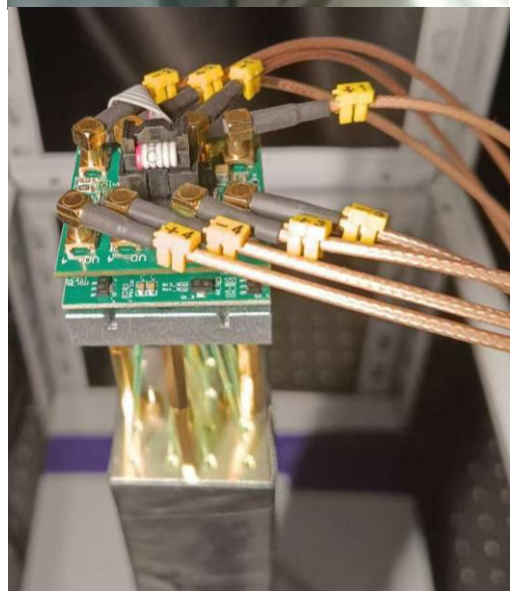


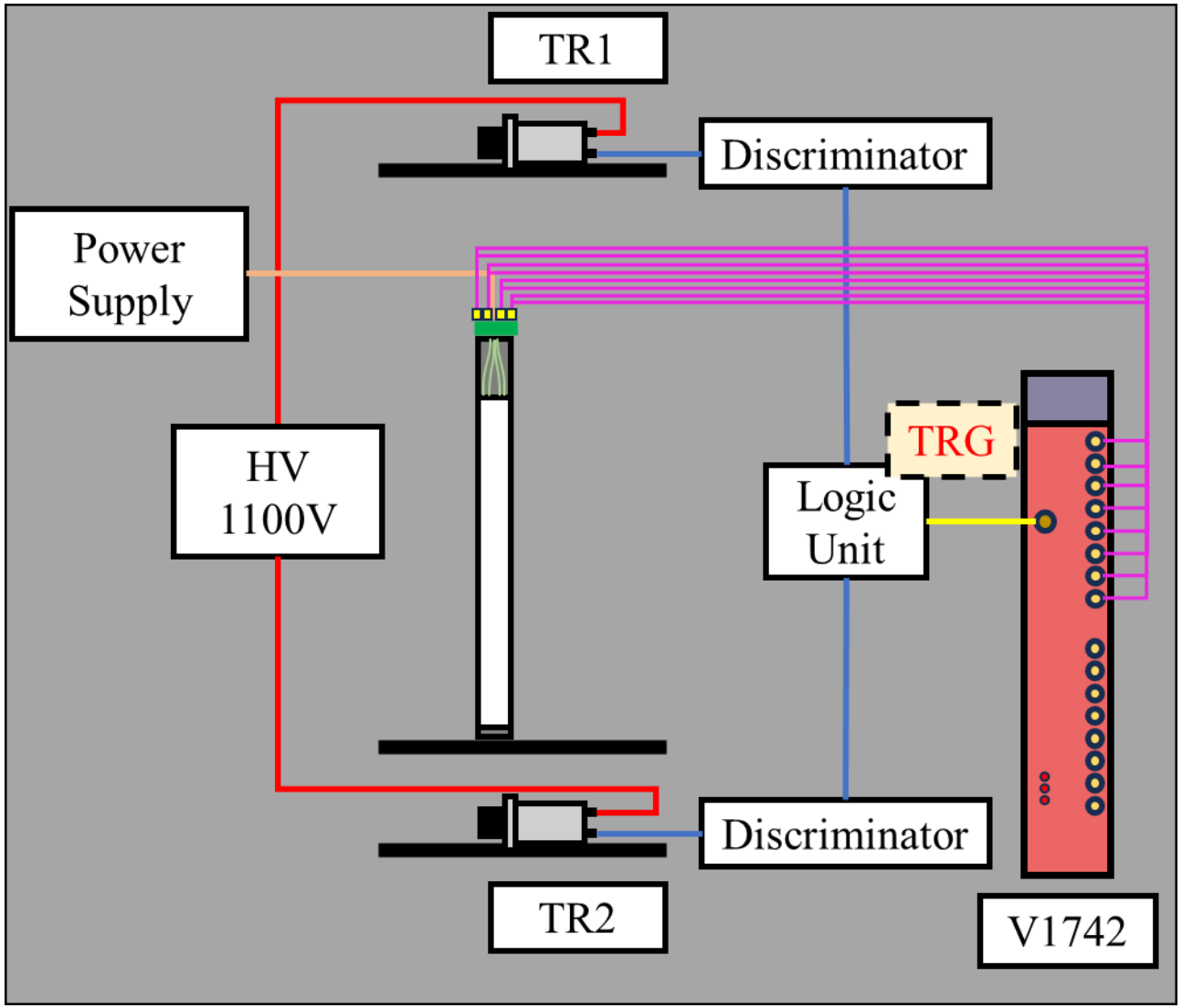
- 216 layers are separated into 4 parts, each part consists of 54 layers
- Readout with 16 WLSFs, each part is readout with 4 WLSFs+SiPM
- Mask technology of WLSF
- 5D: x,y,z, energy (~5%), time (~100ps)

1) It can obtain the thickness distribution of energy deposition
2) Good timing can improve the PID, especially for neutron

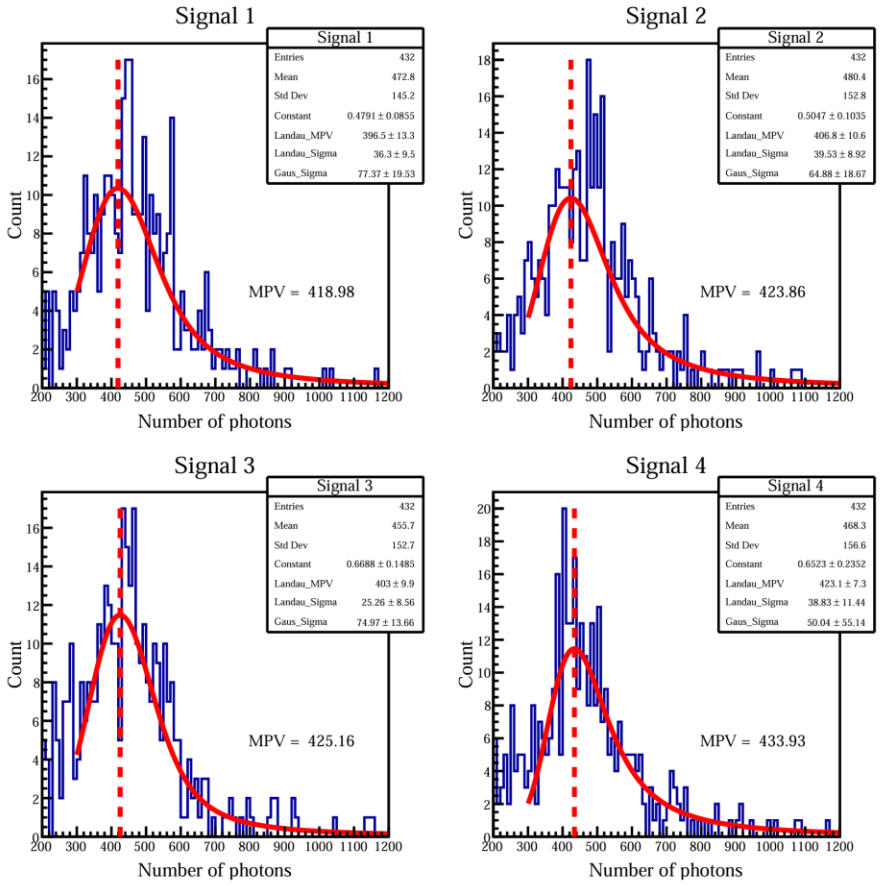
# Performance of prototype (Cosmic test)

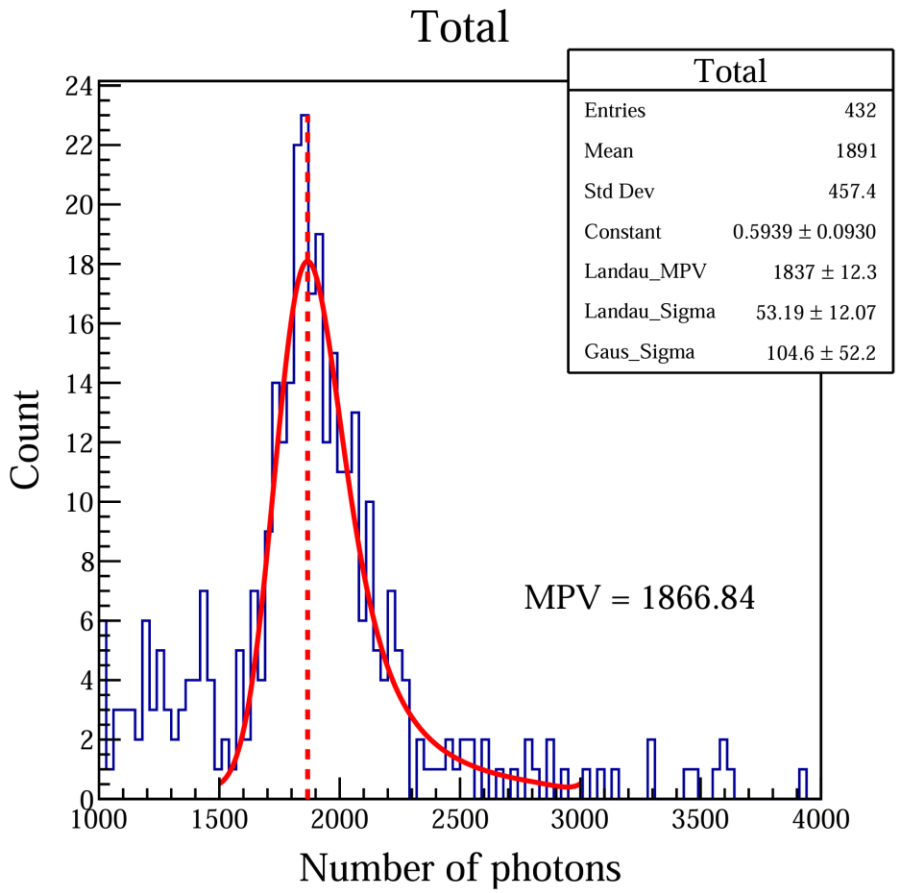






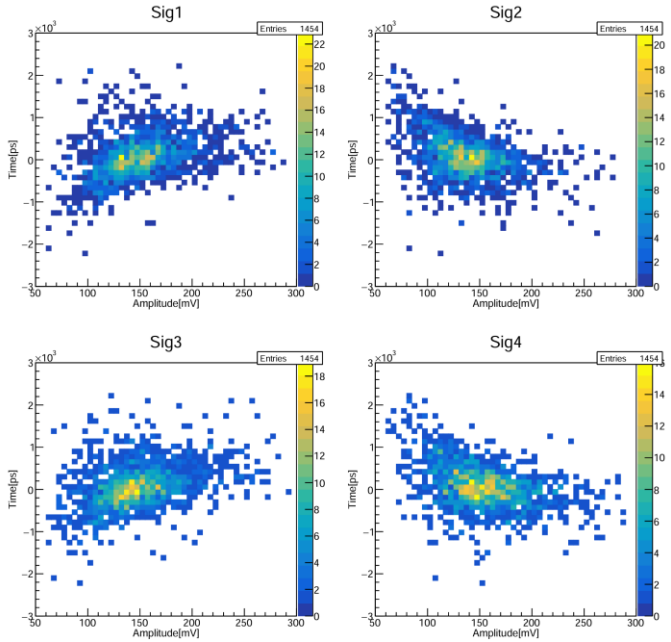
# Performance of prototype (Cosmic test)



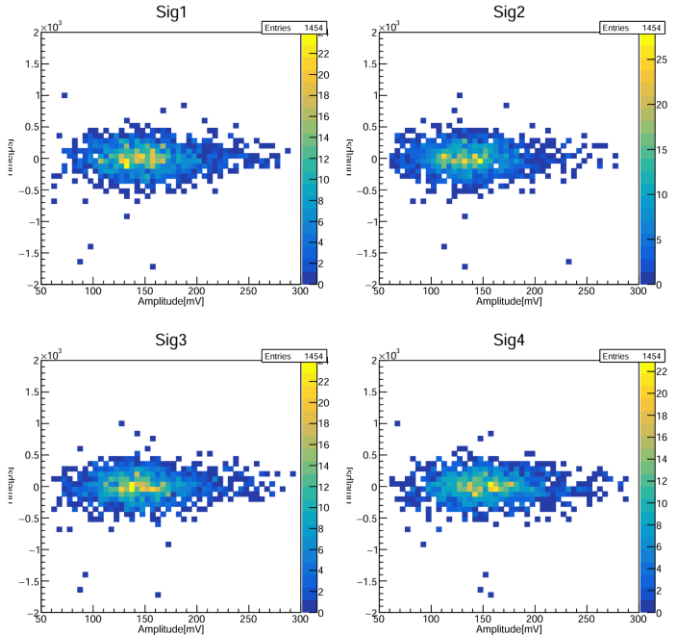



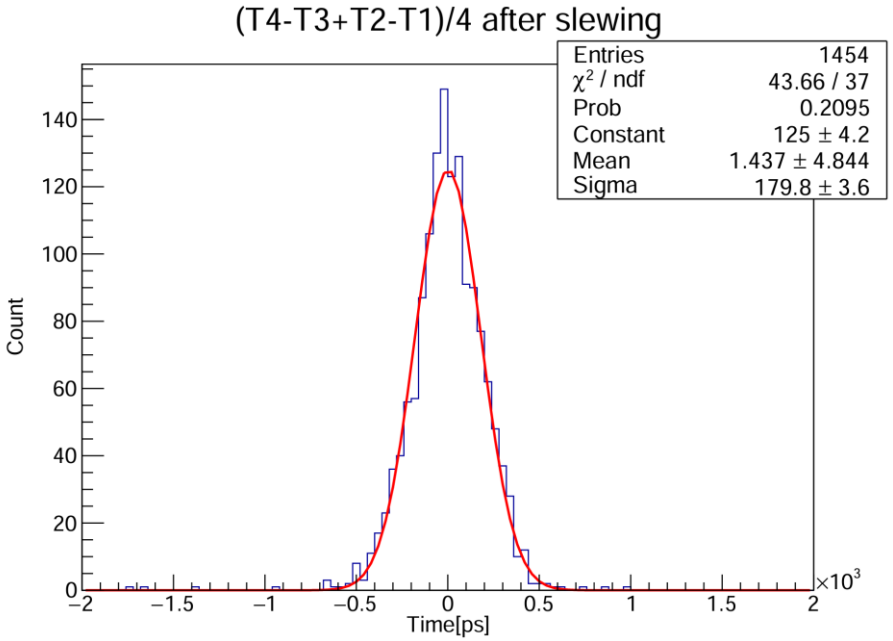
# Performance of prototype (Cosmic test)

## Before Slewing




## After Slewing

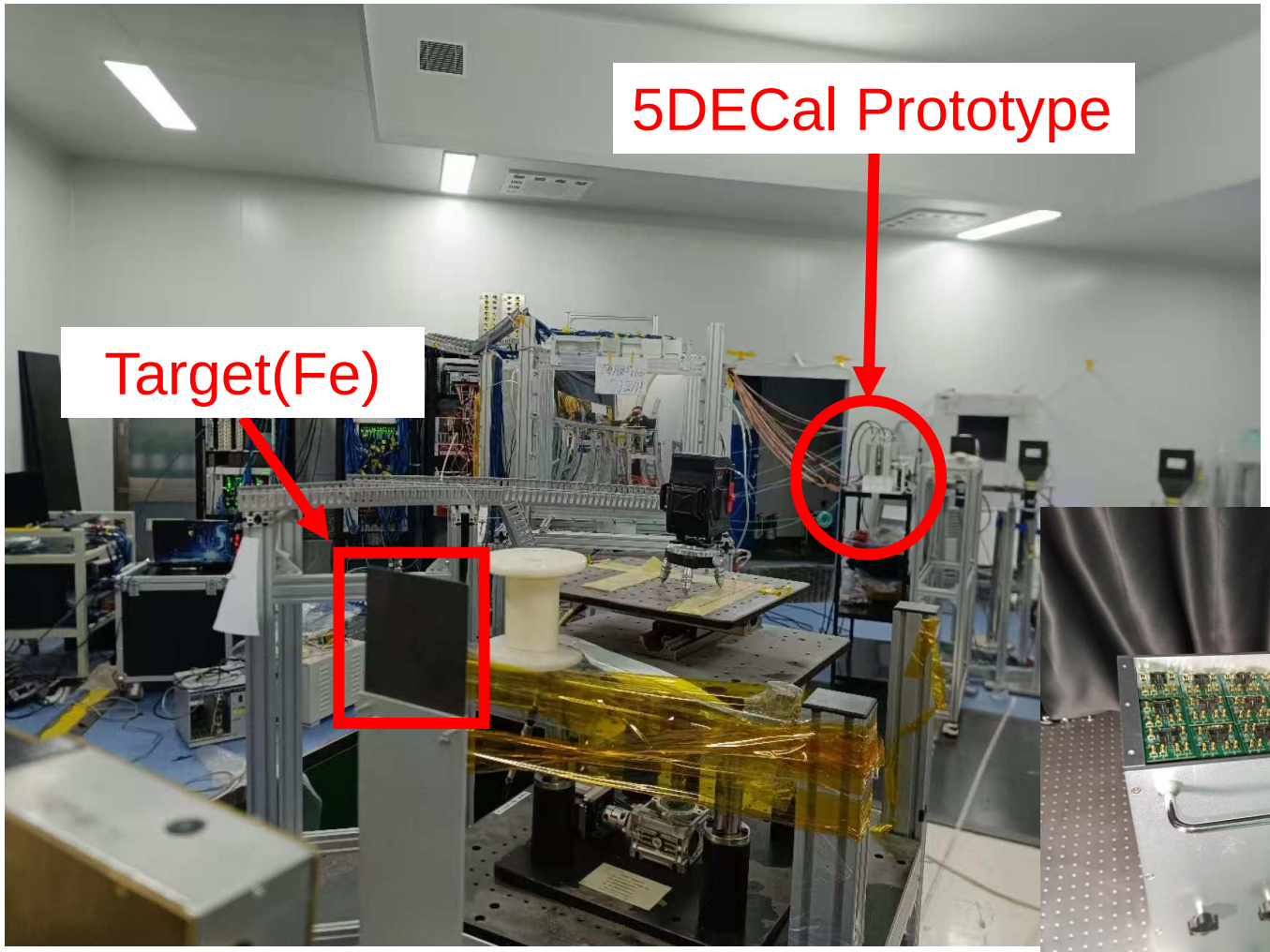


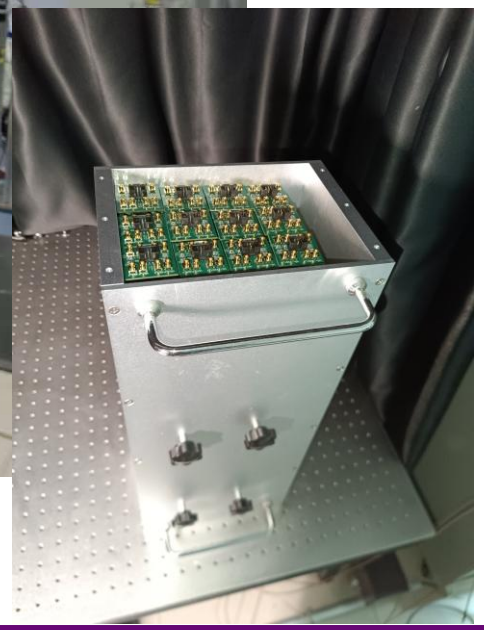



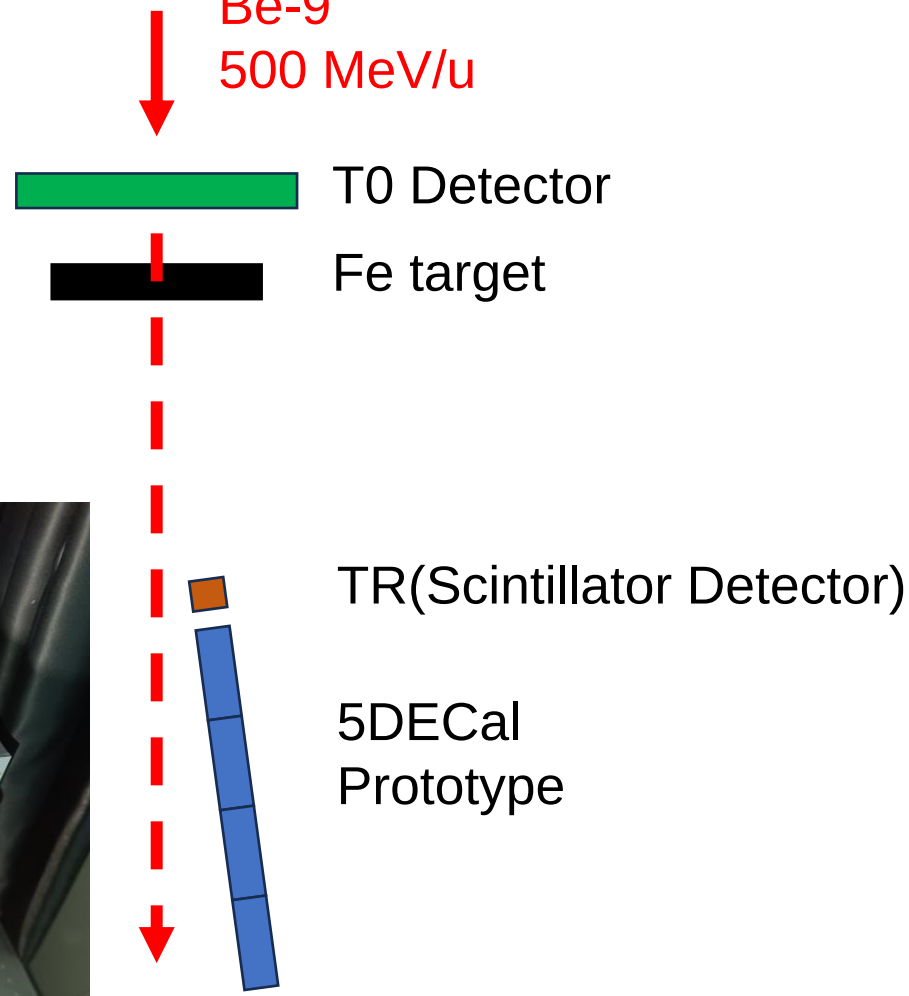

Time resolution

$\sigma_t = 179.8\ ps$

# Beam test of prototype at CSR@IMP



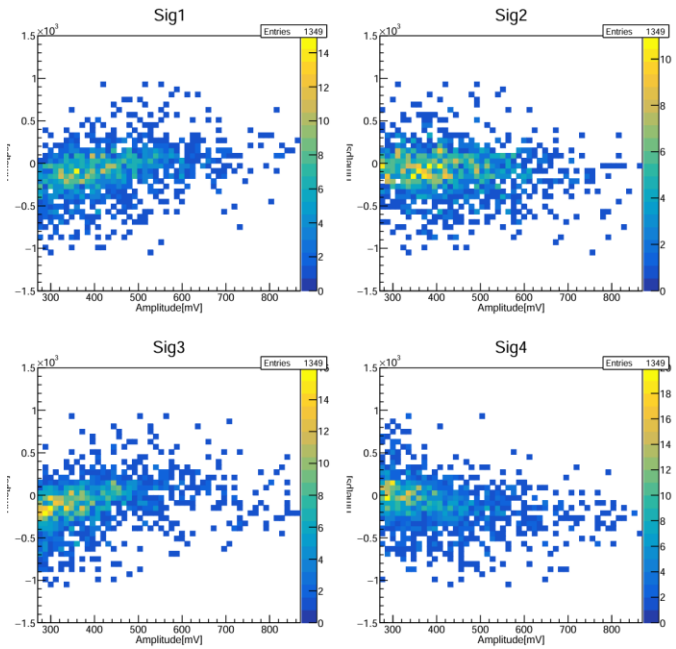





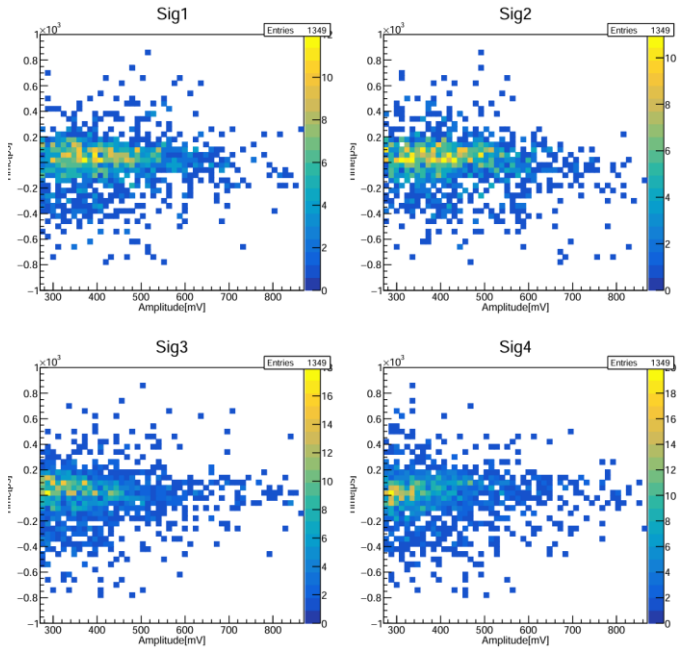
# Performance of prototype (Beam Test)

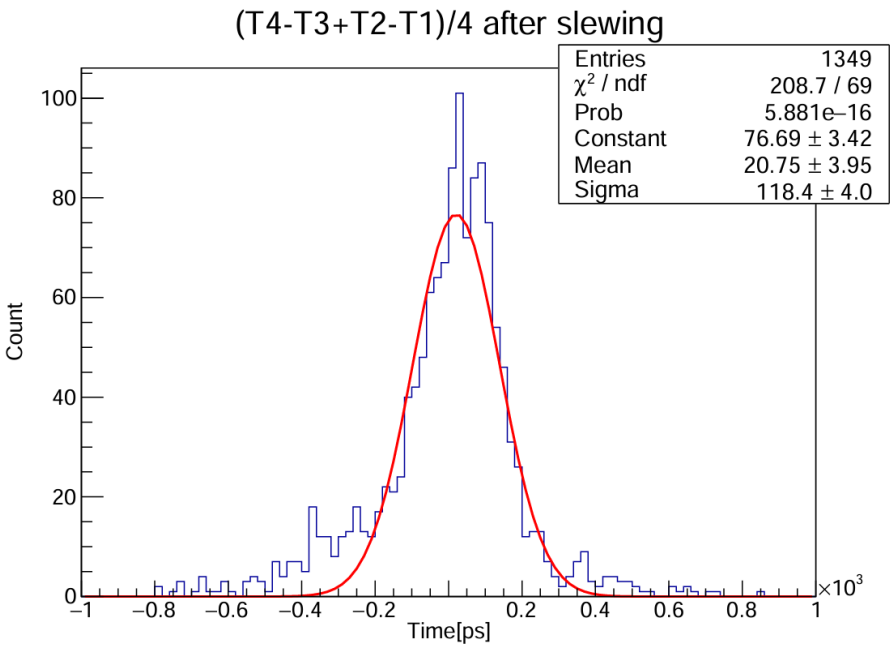
- Select the events with larger signals (>270mV)
- Corresponding to $Nph_{total} > 3000$

## Before Slewing




## After Slewing

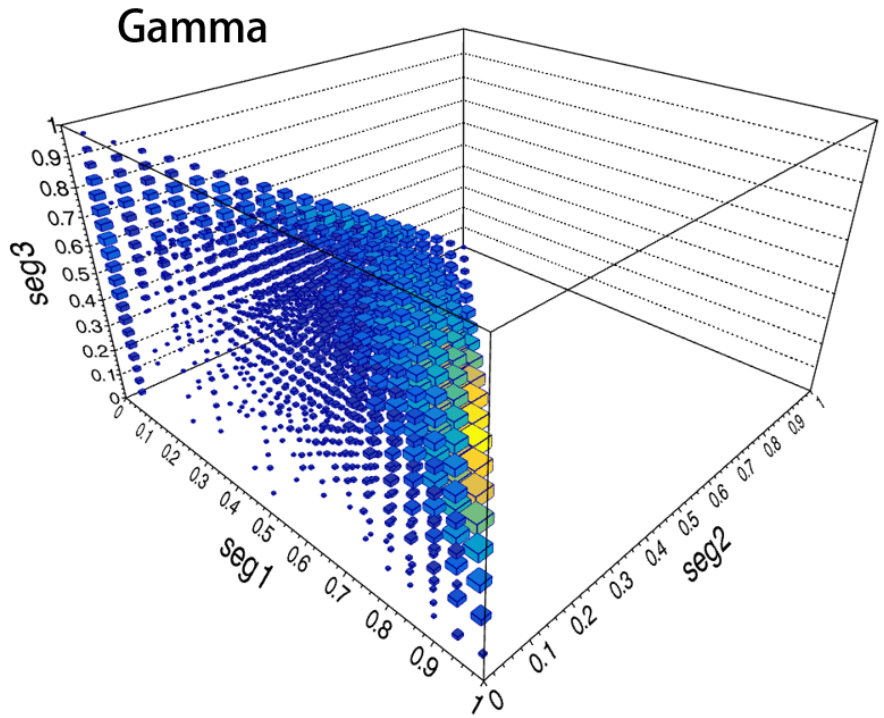


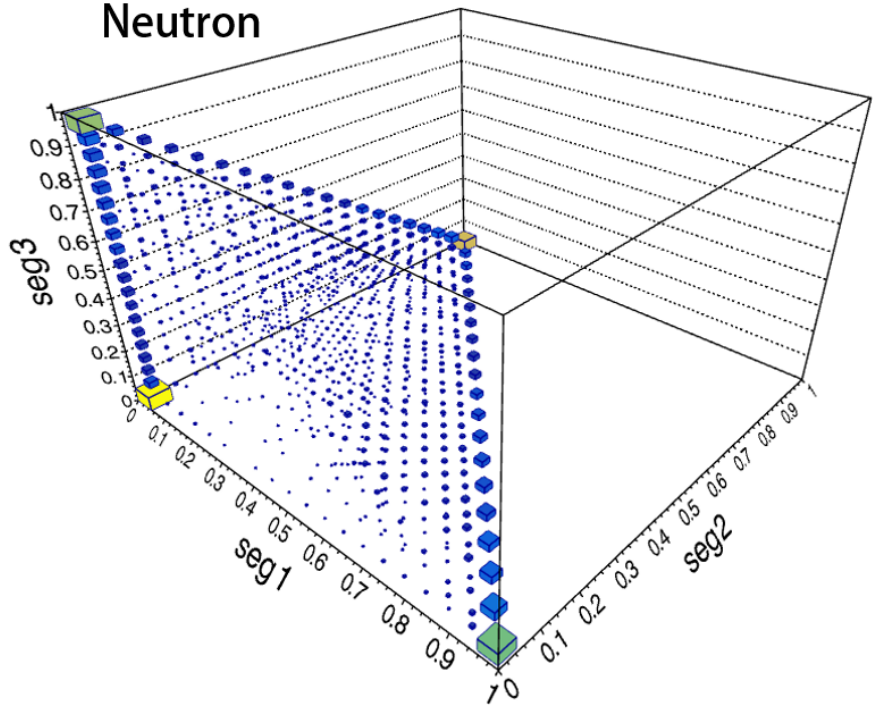




Time resolution
$\sigma_t = 118.4\ ps$

# Performance of prototype (gamma-neutron PID)

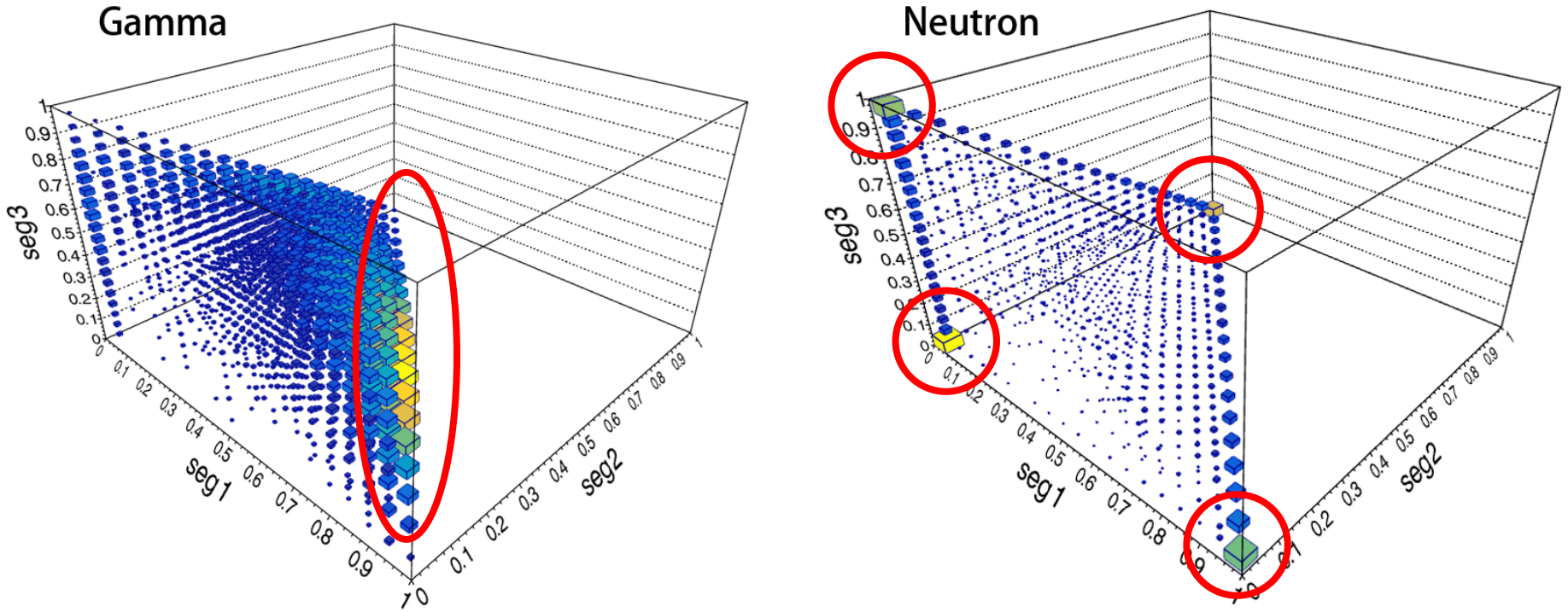
- Geant4 simulation result of gamma (400-600 MeV) and neutron (1.5-2.5 GeV)
- Select the events that the energy deposition in scintillator are 100-150 MeV
- The values of three axes represent the proportion of energy deposition in Segment 1, Segment 2, and Segment 3. $\mathrm{seg4} = 1 - (seg1 + seg2 + seg3)$



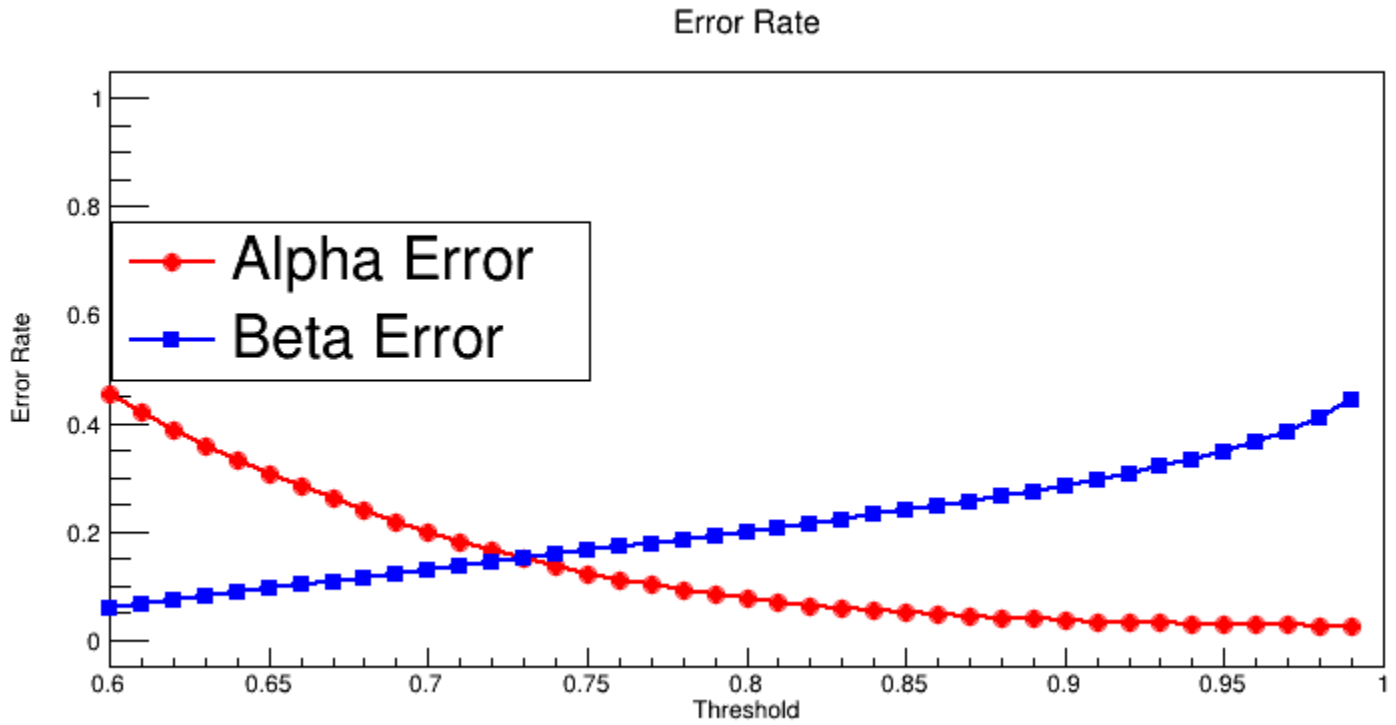
# Performance of prototype (gamma-neutron PID)

- The energy deposition of neutrons is concentrated within a single segment $(seg1 = 0, seg2 = 0, seg3 = 0, \text{seg4} = 1 - (seg1 + seg2 + seg3) = 0)$.
- The majority of gamma events cluster near the plane defined by $seg1 + seg2 + seg3 = 1$ and the line $seg1 + seg2 = 1$ (where $seg3 = 0$).

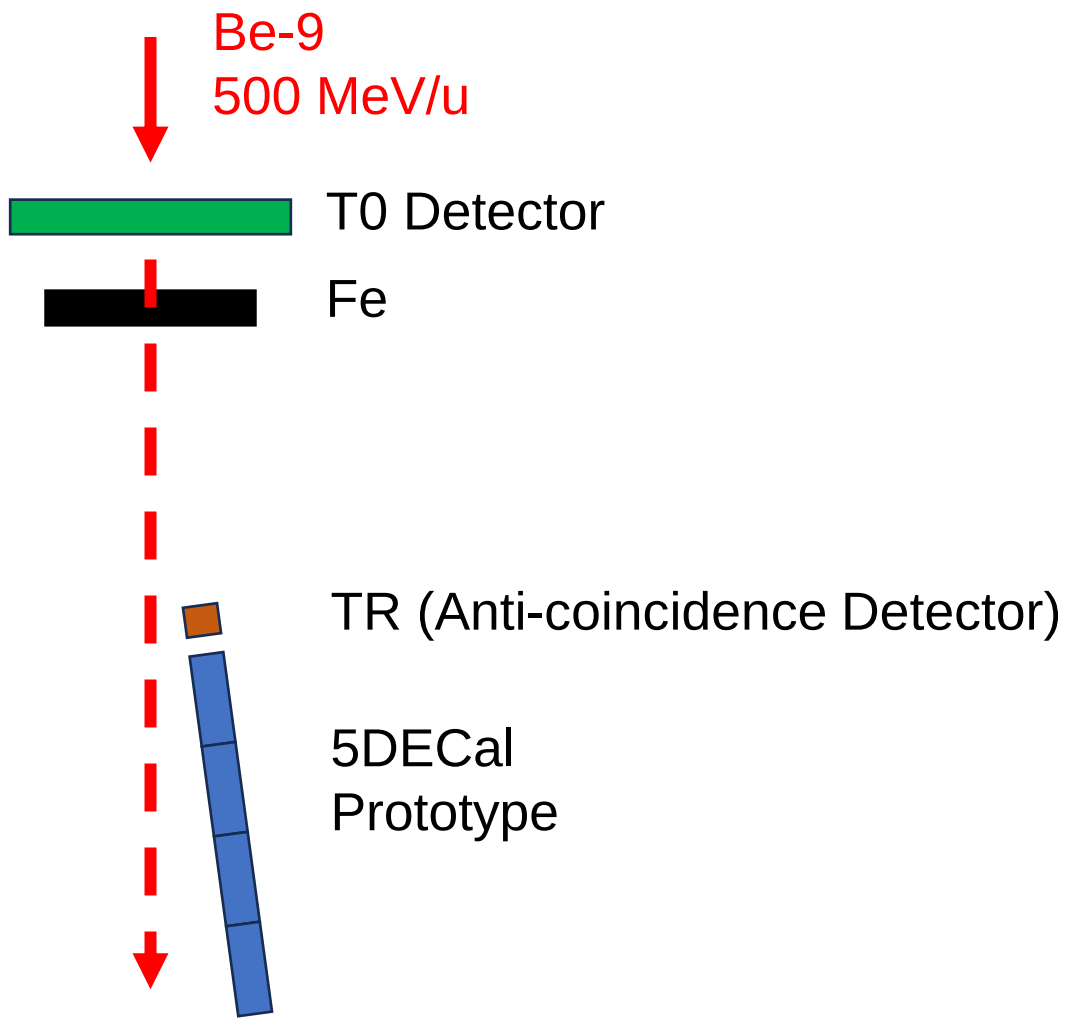


# Performance of prototype (gamma-neutron PID)

- Neutron: $seg1 > threshold, or\ seg2 > threshold, or\ seg3 > threshold, or\ seg4 > 0.3$
- Alpha Error: a gamma event is mistakenly labeled as a neutron event
- Beta Error: a neutron event is mistakenly labeled as a gamma event
- When $threshold = 0.85$, $\alpha = 5\%$, $\beta = 23\%$

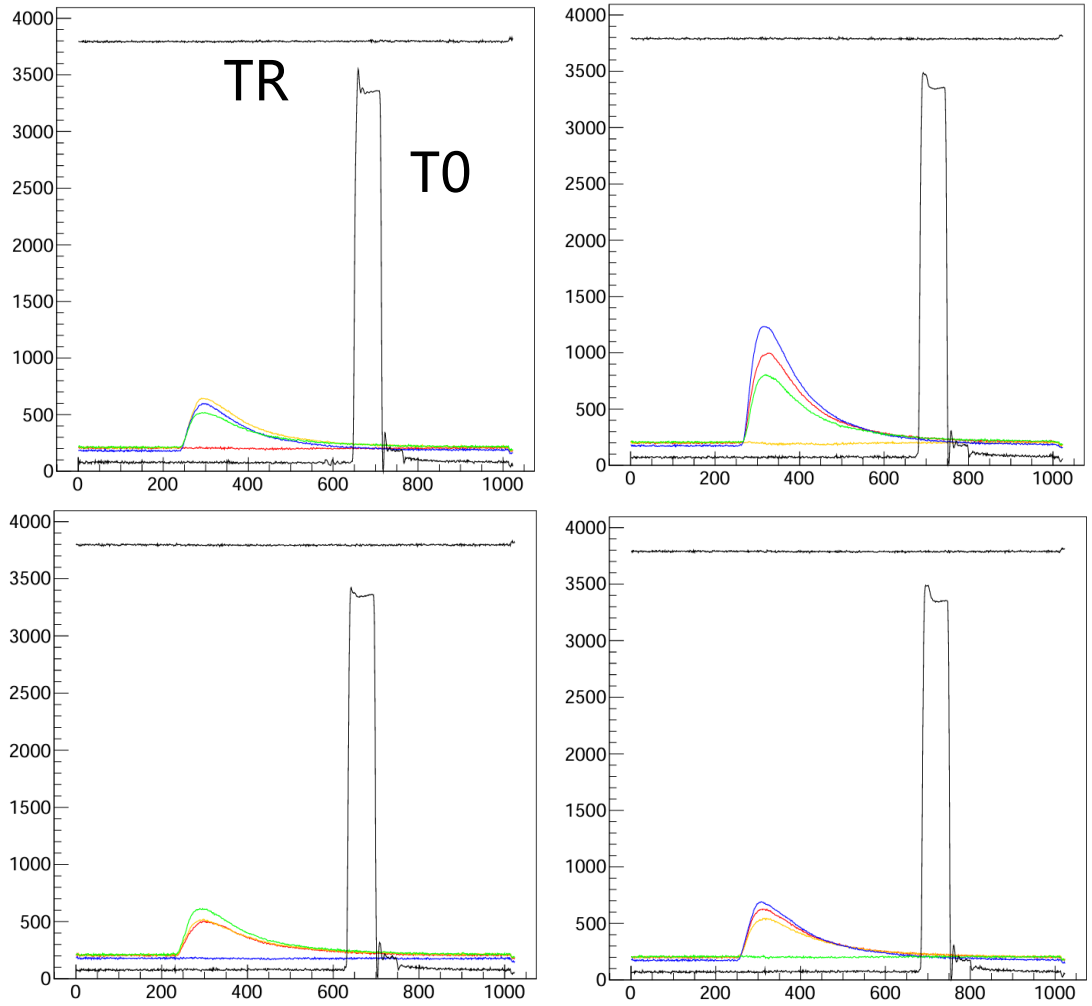


# Prototype response to neutron (Beam test)



# Prototype response to neutron (Beam test)

- Signals of different SiPMs are presented with different colors.
- SiPM1 response to energy deposition in seg2, seg3, and seg4.
- Event that energy deposited only in 1 segment and TR=0 is considered as a neutron event.
- The analysis of neutron events is in progress.




4 events that energy deposited only in 1 segment

# Summary

- **ECal design and production is a key project for China-NICA cooperation**
- **The energy resolution of Ecal module < 5%**

  **Position resolution <5mm**

  **Time resolution <200ps**
- **800 Modules have been produced and delivered to JINR**
- **1200 FEE PCBs have been delivered to JINR**
- **The new 5D Ecal system can improve PID capability (especially for $\gamma$ and n) greatly**