X Collaboration Meeting of the MPD Experiment at the NICA Facility

The progress of ECal production in China

Reporter: Yulei Li [a]
Yi Wang for China ECal group

2022/11/9

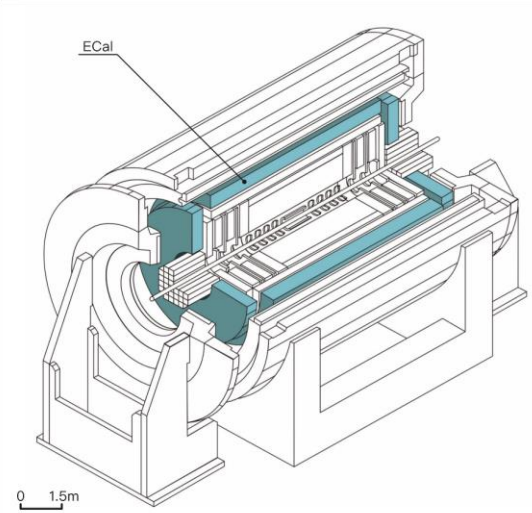
[a] *Department of Engineering Physics, Tsinghua University*
[b] *Shandong University*
[c] *Fudan University*
[d] *University of South China*

CONTENTS

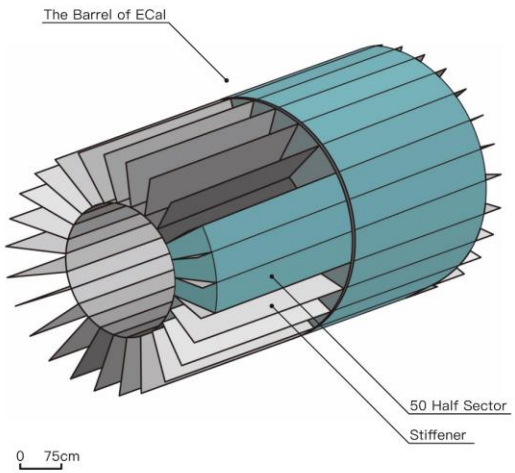
- MPD-ECal introduction
- ECal module production
- Cosmic test of module
- Simulation of ECal
- Summary

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.

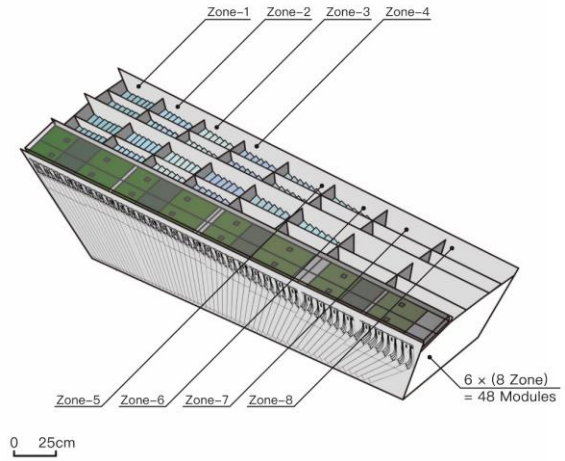


MPD-ECal

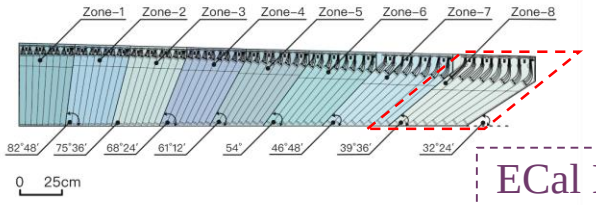


The Barrel of ECal

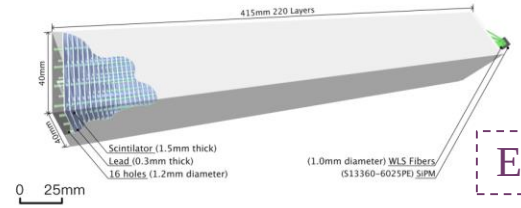
ECal Half-Sector



ECal 8-Zone



ECal Module



ECal Tower

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

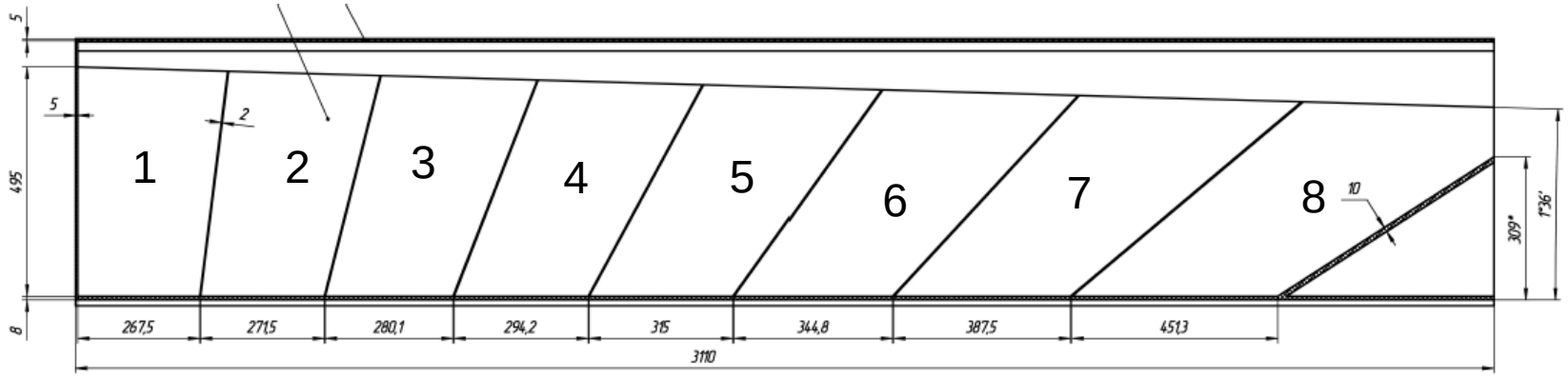
China MOST MPD-ECal project

- Hardware:
  - Construction of 8 sectors ECal prototype. 768 modules in total.
  - Production of FEE PCB (1800 FEEs)
  - R&D on fast readout electronics, time resolution is less than 150ps
- Software and simulation
- Schedule: 2020.6-2024.5
- Institutes:
  - Tsinghua University 100%
  - Shandong University 100%
  - University of South China 100%
  - Fudan University 90%
  - Huzhou University

Module production in China

- In the first stage (2020.6-2022.5), 8 sectors have been produced in China

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

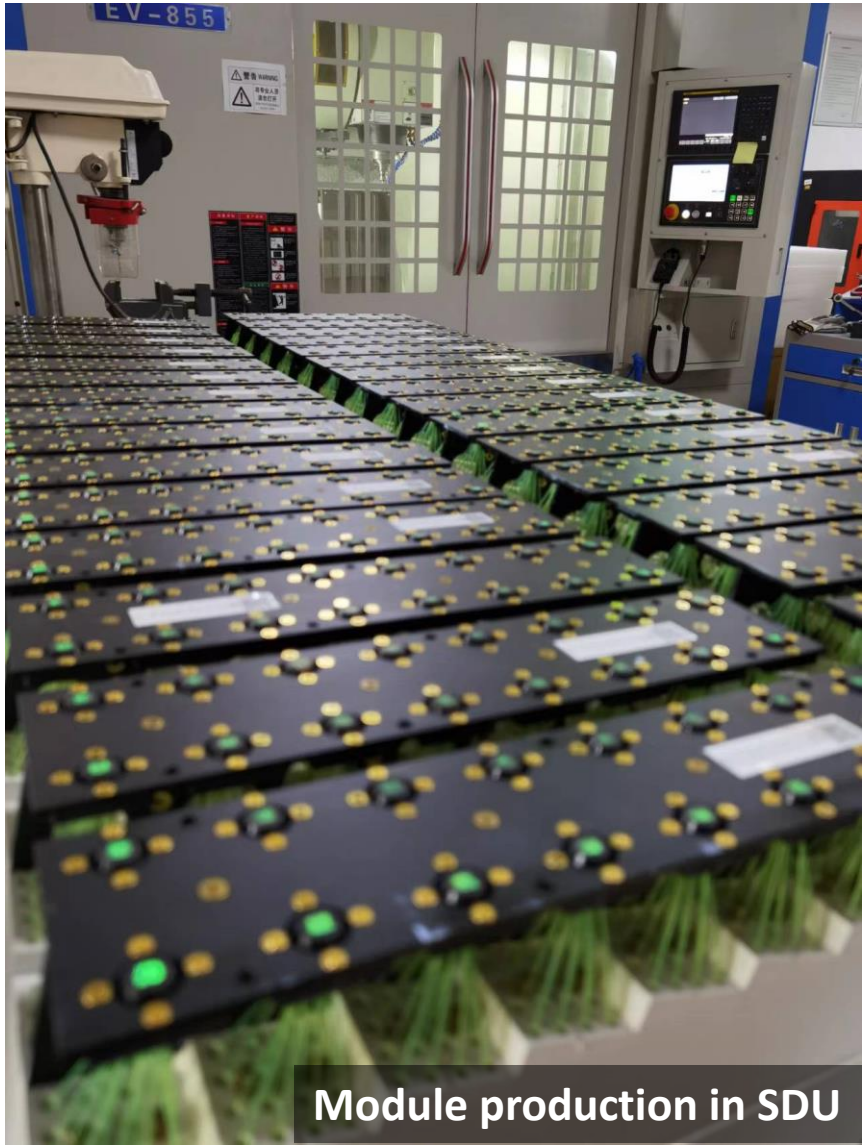


Modules produced in each institutes

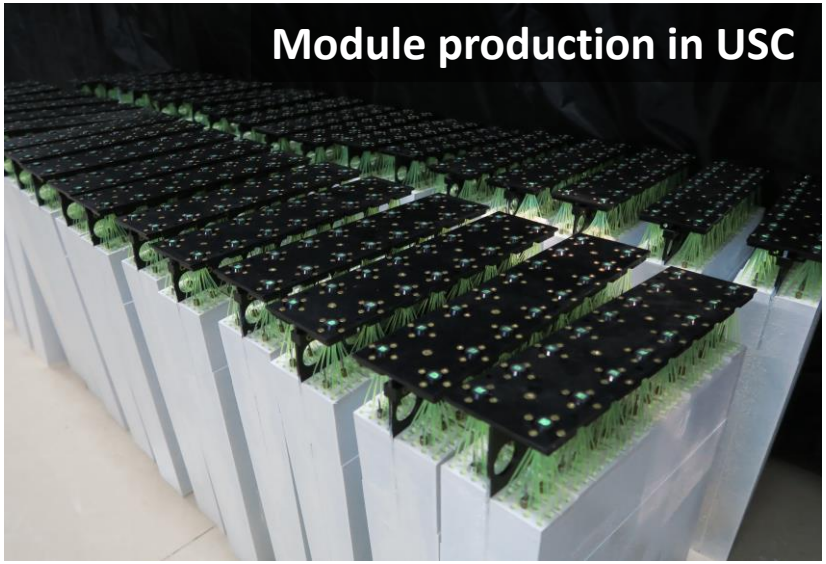
Material: JINR: scintillator tiles
China: Other material

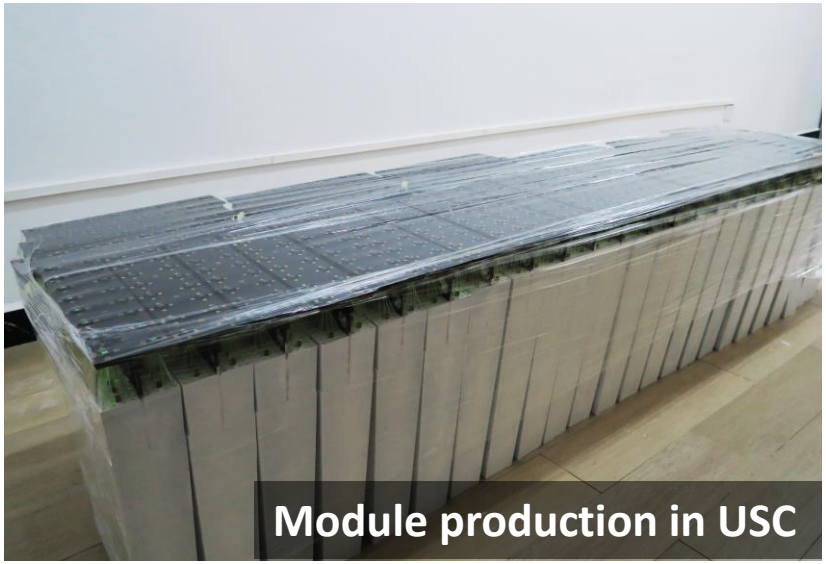
	1	2	3	4	5	6	7	8	Total	Progress
THU	19	19		38	96	96	96	96	460	Finished
SDU			96	58					154	Finished
FDU		77							77	Finished after cutting the fiber
USC	77								77	Finished

Module production in China



Module production in China





Shipment

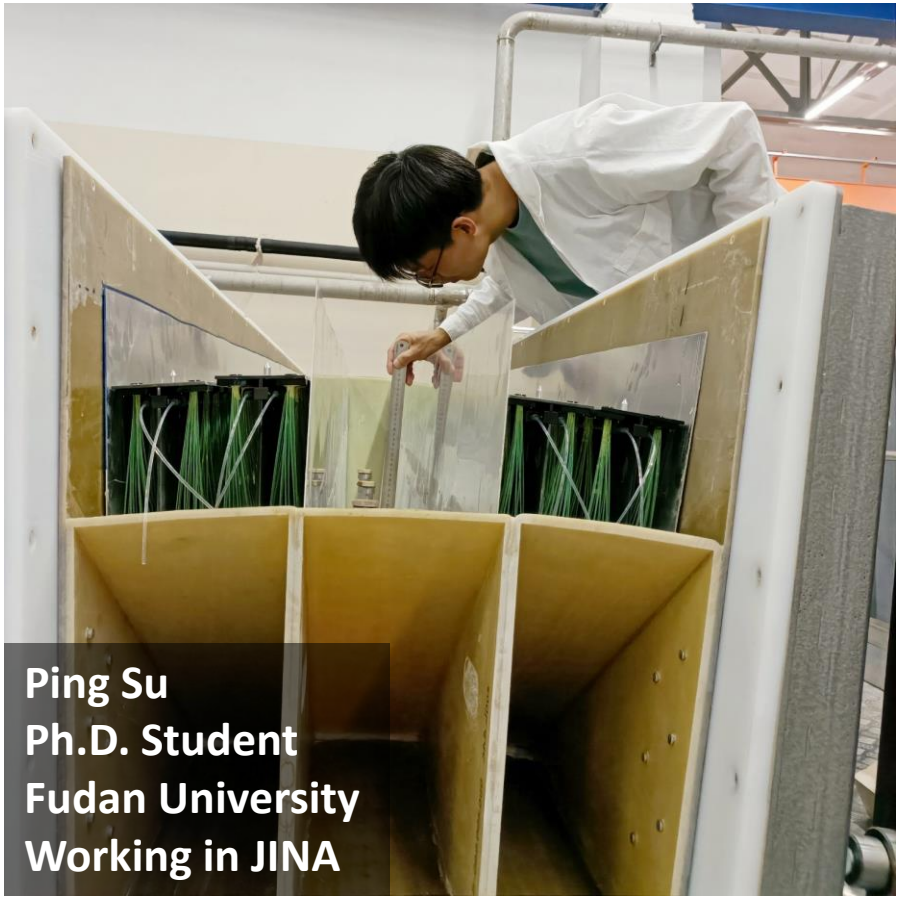
First container, 279 modules (31 boxes), have been shipped from China to JINR via the China-Europe train on 2022.04.21.

Second container, 296 modules (32 boxes), have been shipped from China to JINR via the China-Europe train on 2022.09.17.

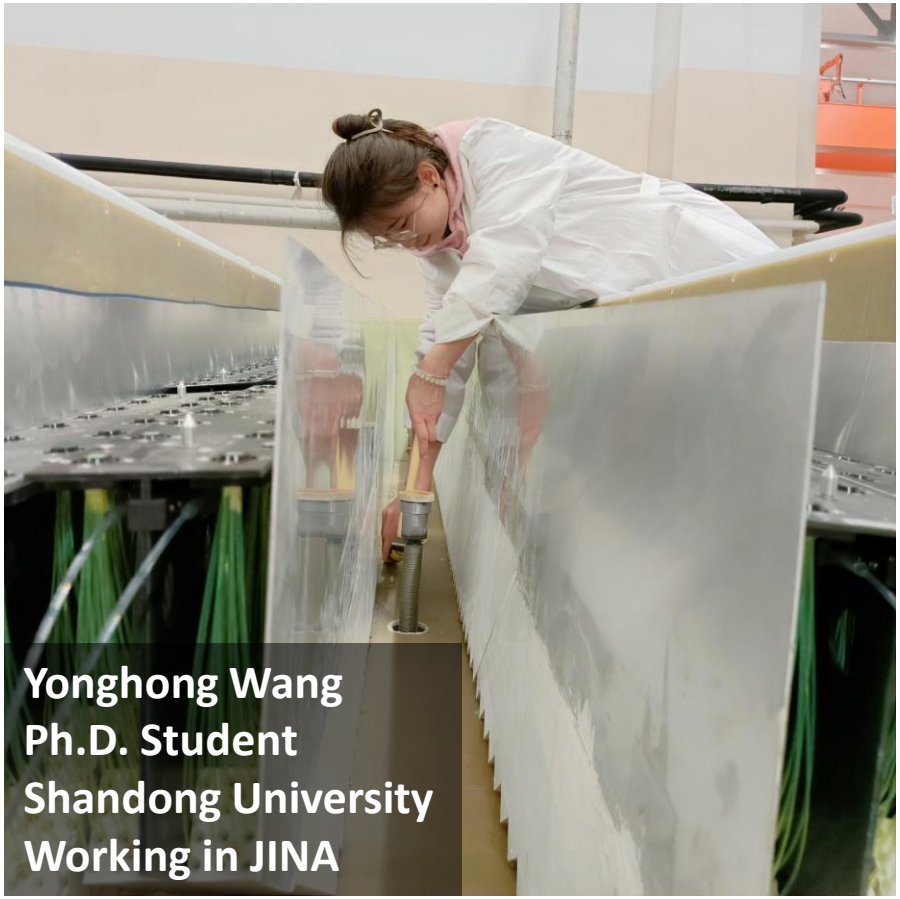
Last container, 186 modules

Zone1 77//Zone2 77// Zone5 5-1// Zone6 6-1// Zone7 15-1// Zone8 11-2 **Total: 191-5**

Student communications



Ping Su
Ph.D. Student
Fudan University
Working in JINA

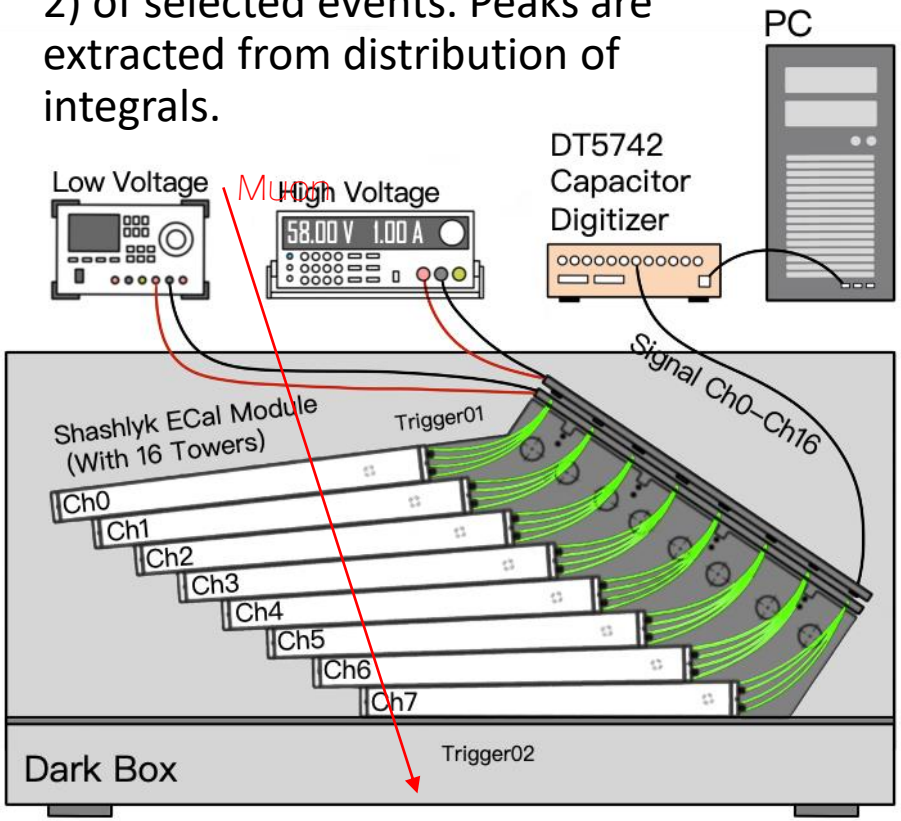


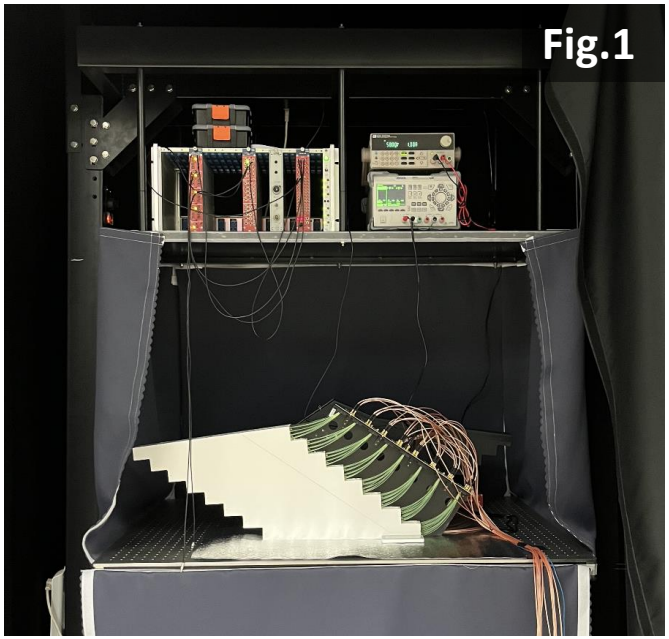
Yonghong Wang
Ph.D. Student
Shandong University
Working in JINA

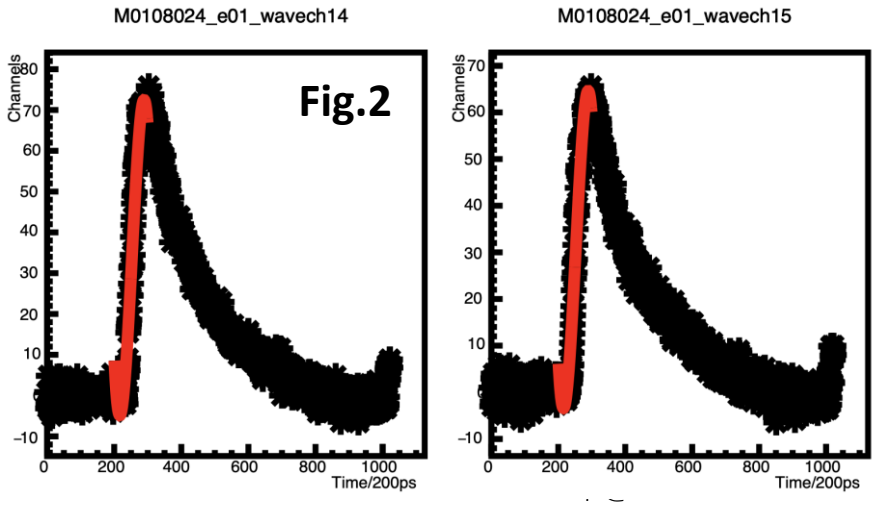
- Dr. Linmao Li from Tsinghua University will come to JINR on January 15, 2023, to focus on software development and analysis.

Cosmic ray test

- 10 modules were tested during the period of August, 2022. Modules are placed horizontally (Fig. 1) in the dark rooms.
- 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.

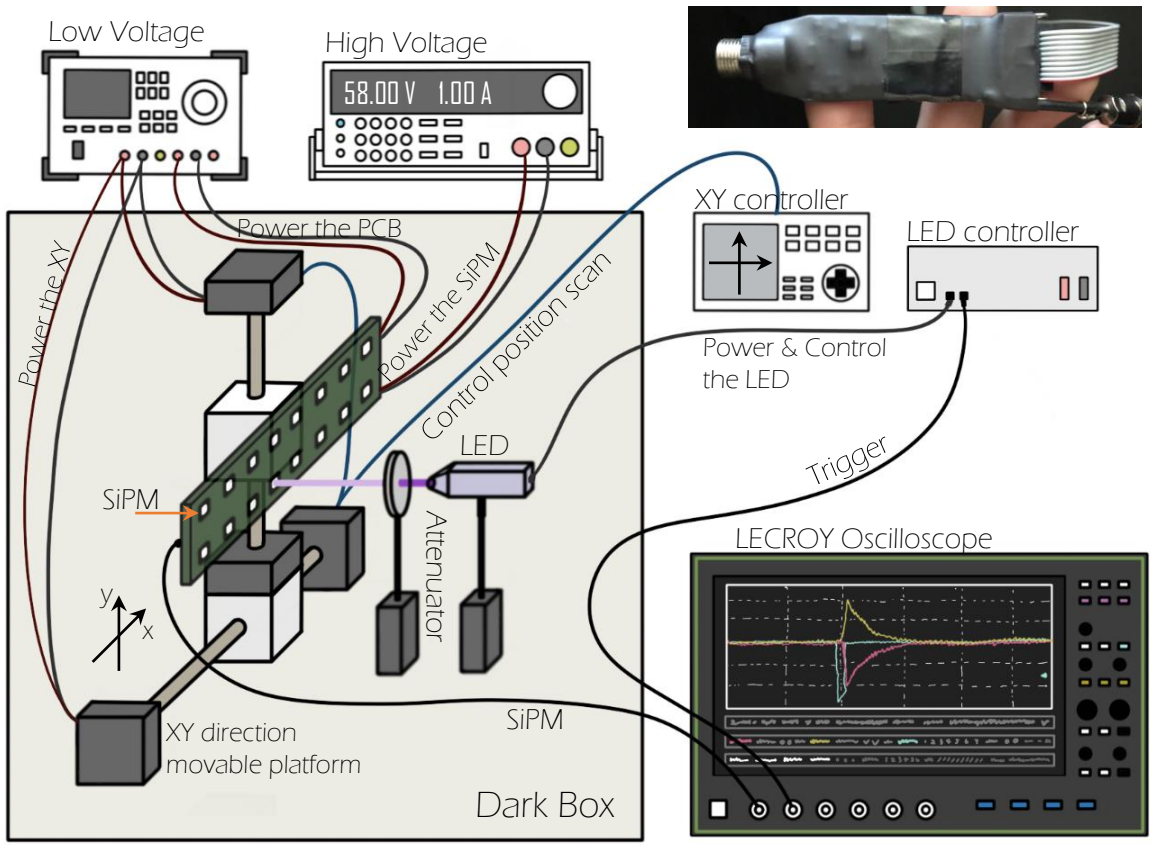


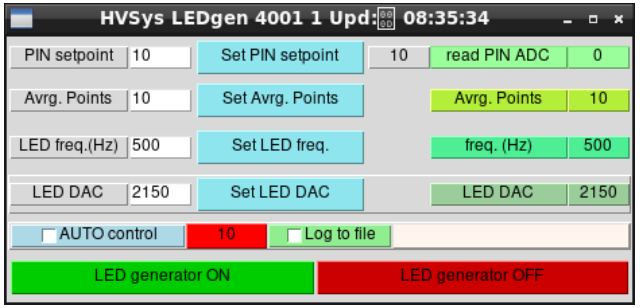


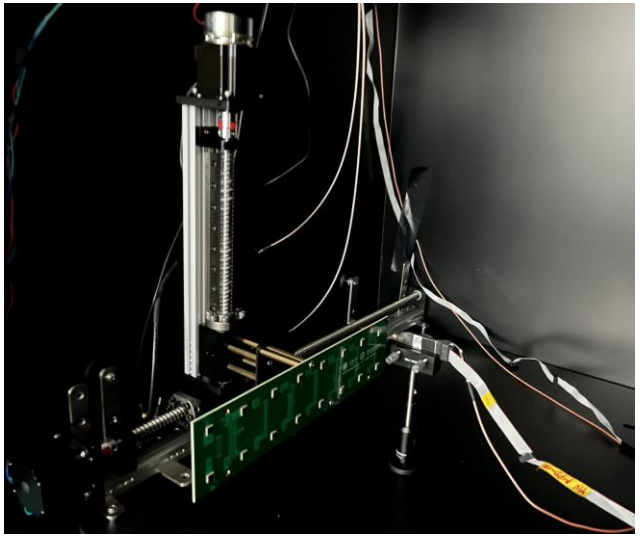


SiPM test

setup	
XY plateform (precision is 0.03mm)	LED 420nm (from JINR)
Optical Attenuator, 20X	1.5*1.5m dark box

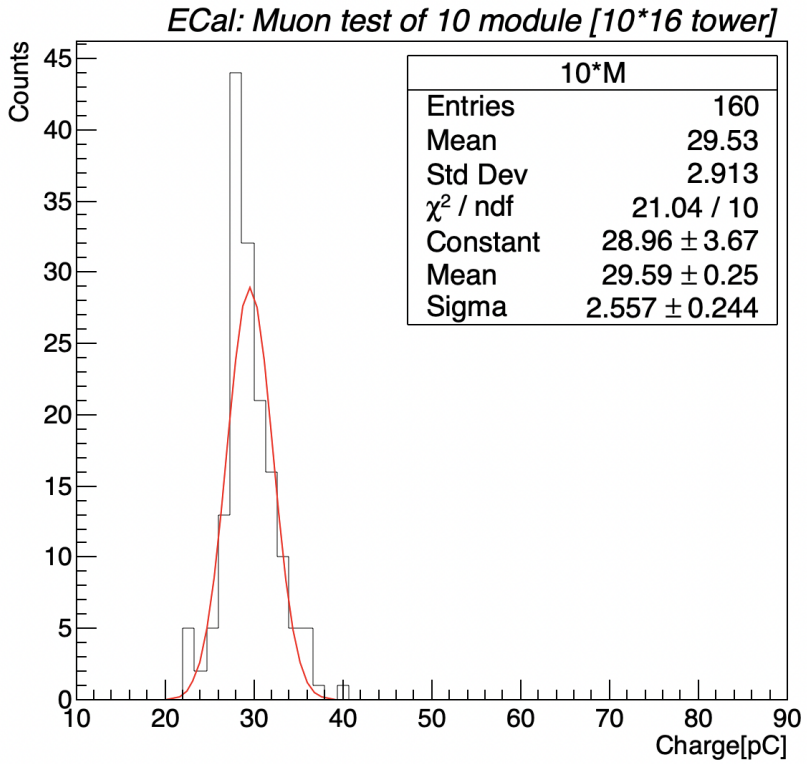


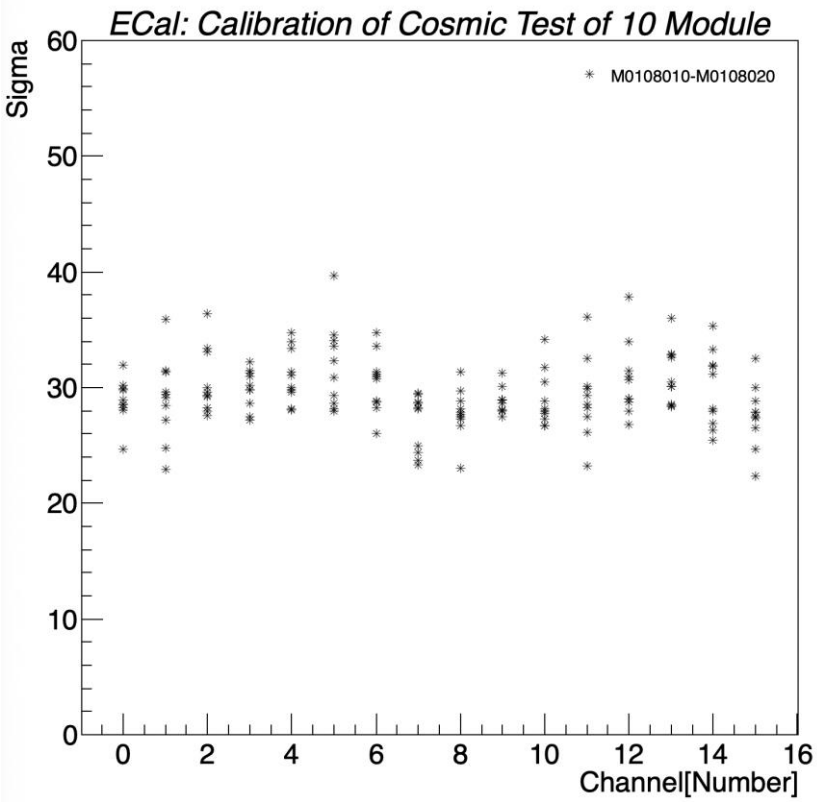




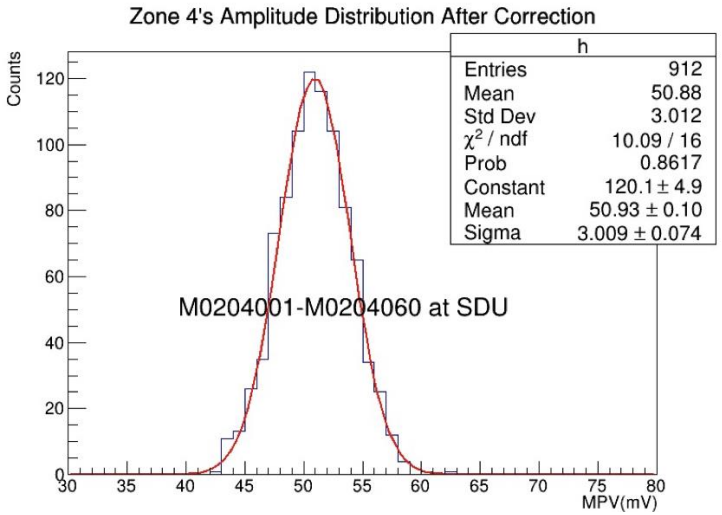
SiPM calibration

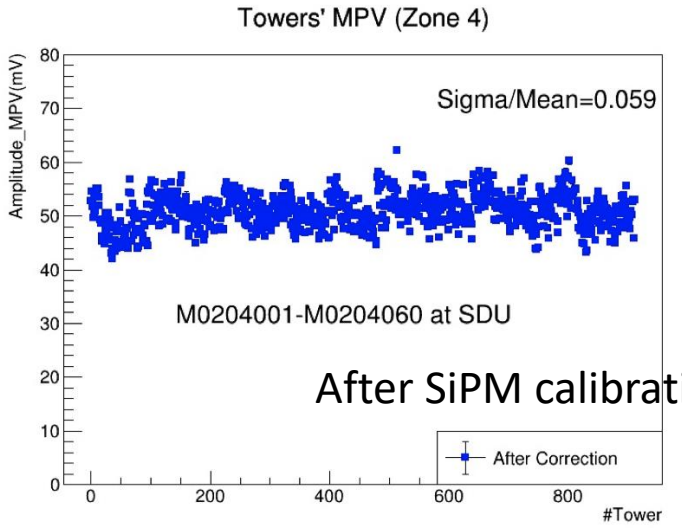
	SiPM1	SiPM2	SiPM3	SiPM4	SiPM5	SiPM6	SiPM7	SiPM8
Mean[V]	0.1213	0.1118	0.1041	0.0959	0.1031	0.1108	0.1078	0.1123
X0	378	328	278	228	178	122	66	0
	SiPM9	SiPM10	SiPM11	SiPM12	SiPM13	SiPM14	SiPM15	SiPM16
Mean[V]	0.1218	0.1063	0.1123	0.1128	0.1067	0.113	0.115	0.09109
X0	378	328	278	228	178	122	66	0



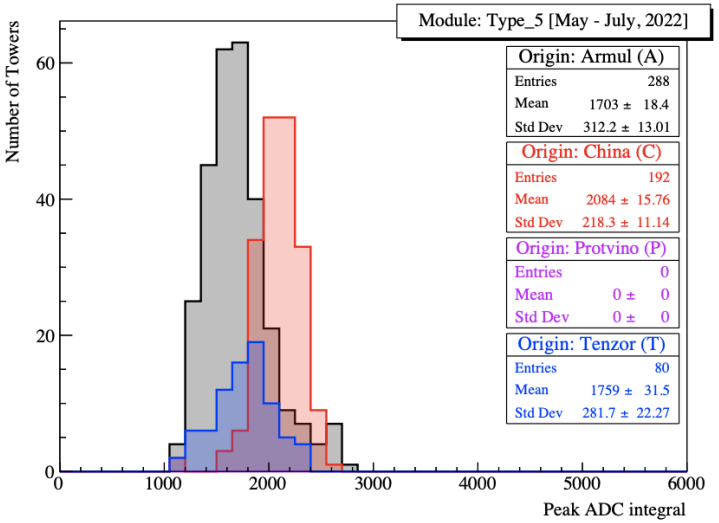


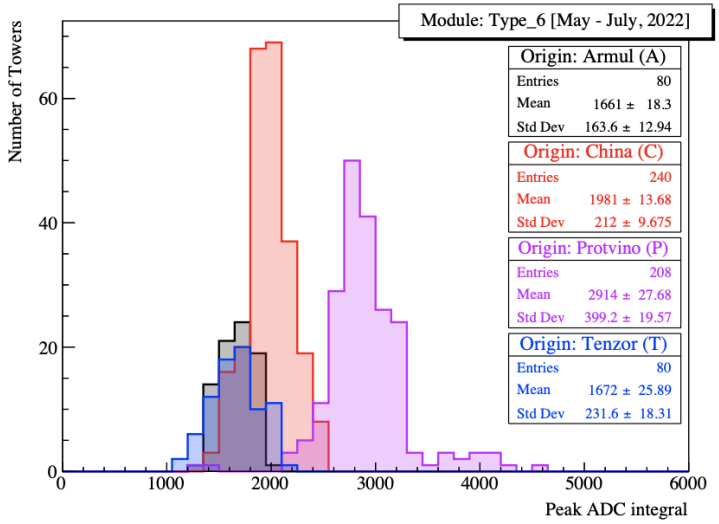
The cosmic test in SDU





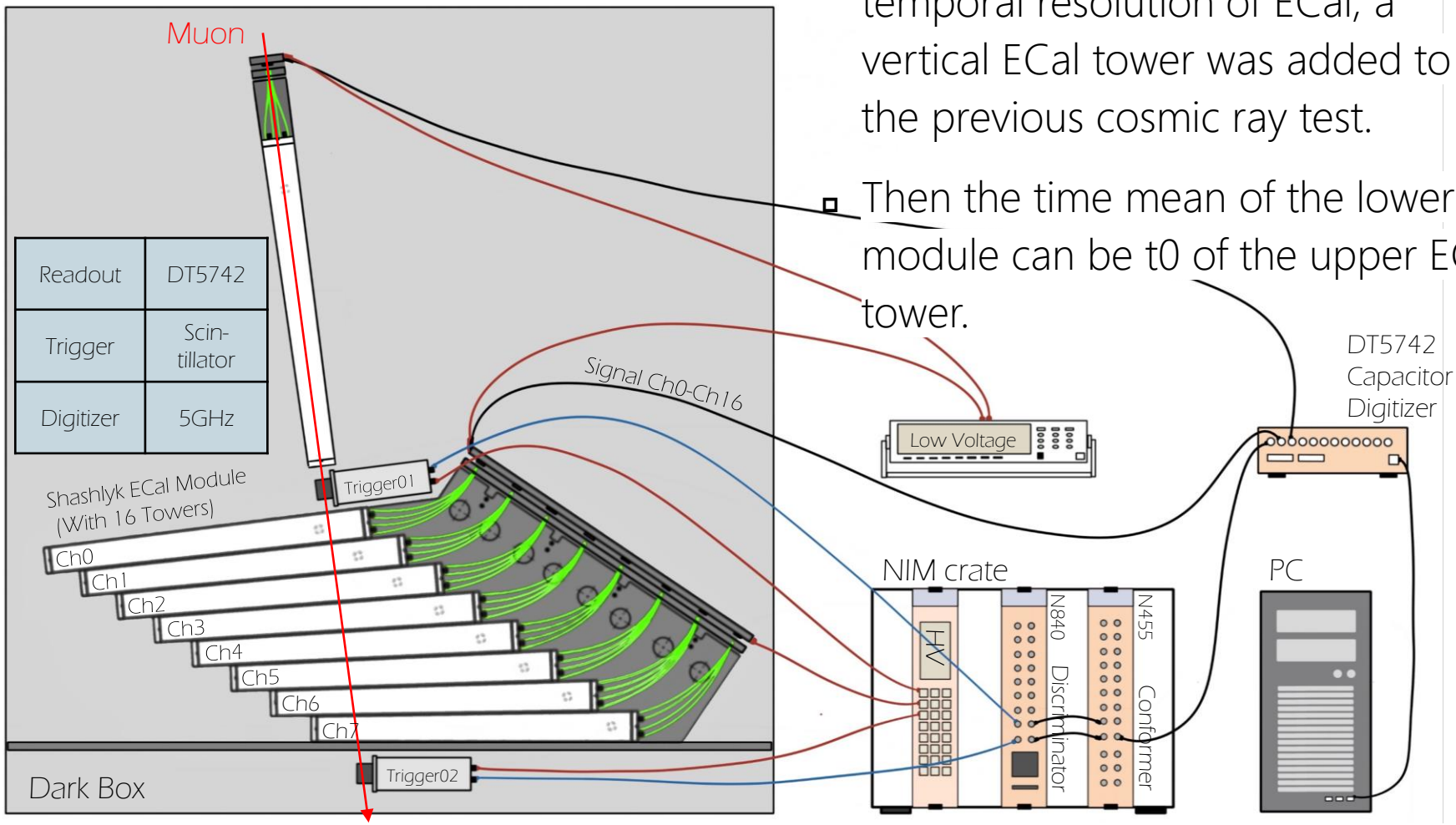
The cosmic test in JINR





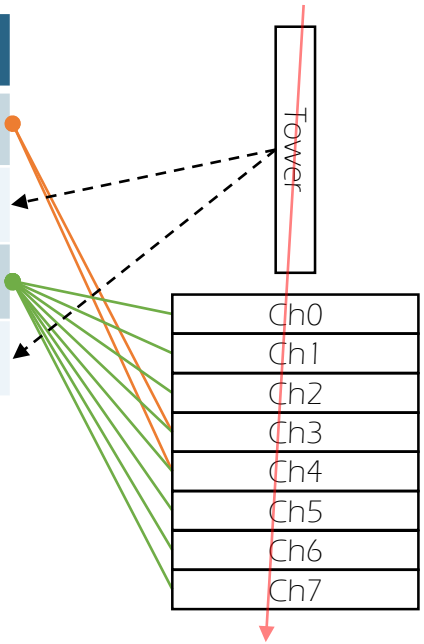
Cosmic time test

- In order to better study the temporal resolution of ECal, a vertical ECal tower was added to the previous cosmic ray test.
- Then the time mean of the lower module can be t0 of the upper ECal tower.



Time resolution

T	Before slewing	After slewing	After SiPM
Ch3-Ch4	830	382.5	380.2
Tower-Ch43	2204	642.7	610
Ch7531-Ch6420	505.8	252.5	230.1
Tower-Ch76543210	1767	549.1	424.4



- Time resolution of one tower placed horizontally

$$\frac{T_{ch3-ch4}}{\sqrt{2}} = 270ps$$

$$\delta(T_0) = \delta(\frac{\sum_{i=0}^{i=7} T_i}{8}) = \delta(\frac{\sum_{i=0}^{i=3} T_i - \sum_{i=4}^{i=7} T_i}{8})$$

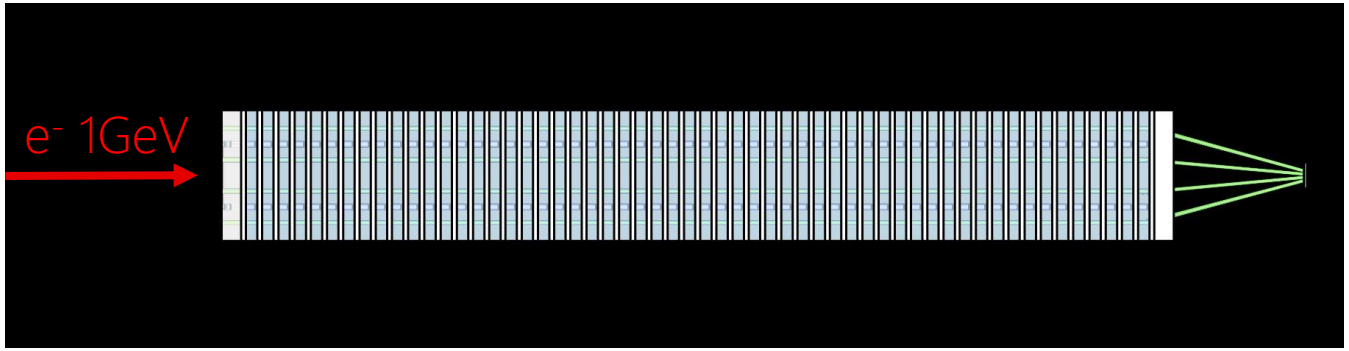
$$= \delta\frac{(T_1+T_3+T_5+T_7)-(T_0+T_2+T_4+T_6)}{8}$$

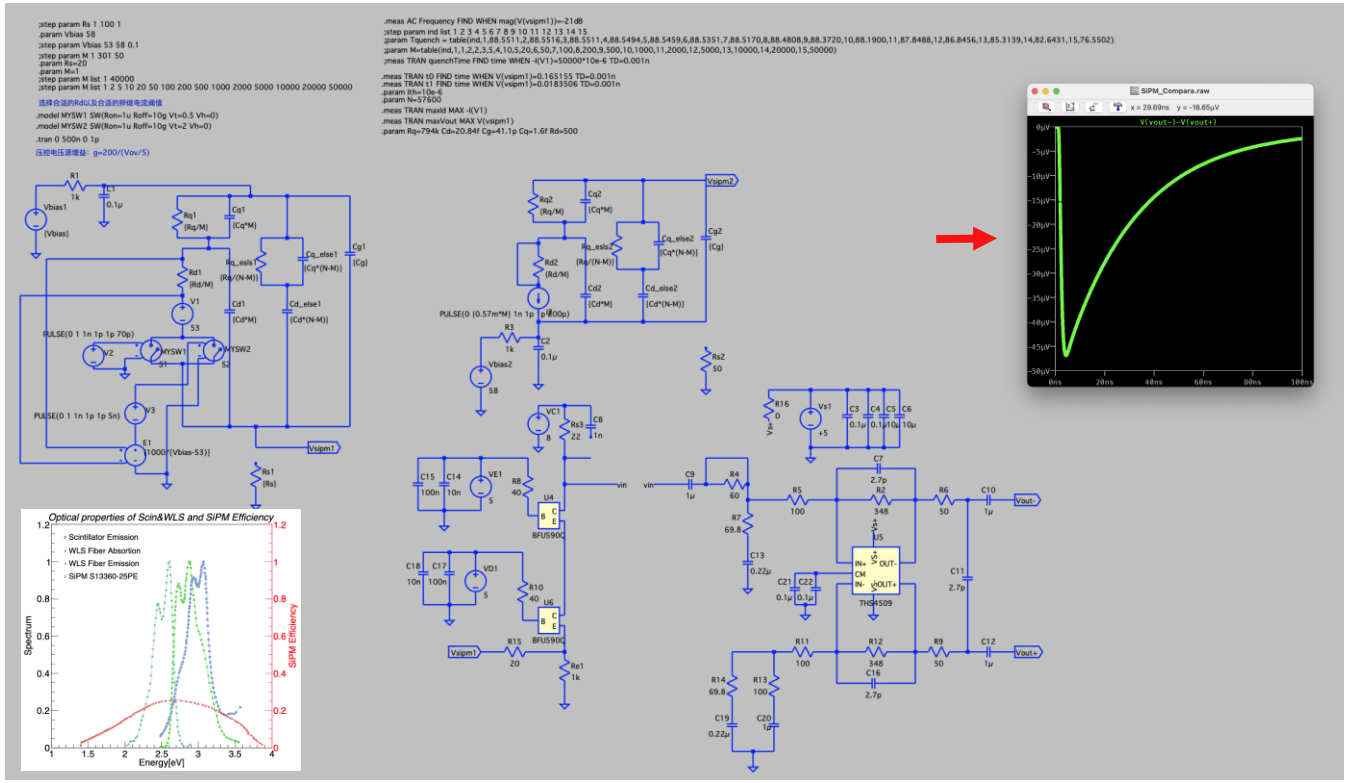
$$\delta(T_{tower-0}) = \delta(T_{tower}) - \delta(T_0) = \delta(T_{tower} - \frac{(T_1+T_3+T_5+T_7+T_0+T_2+T_4+T_6)}{8})$$

- Time resolution of one tower placed vertically: 356.6ps

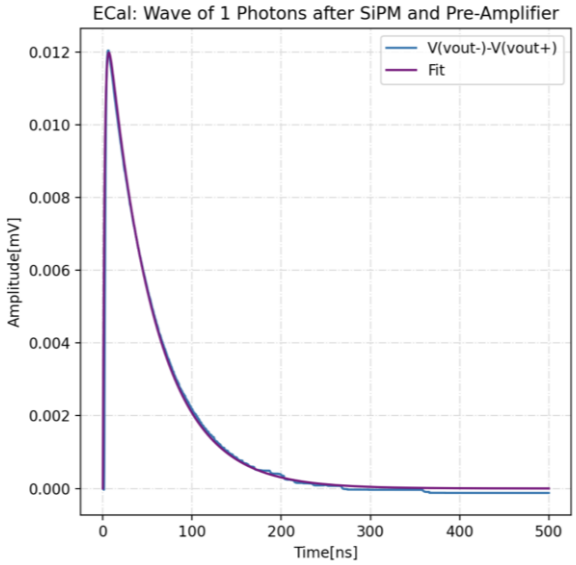
ECal simulation

- Detector reconstruction
- Particle source
- Particle energy deposition
- Material/boundary optical property definition
- The photon reaches time
- Electronic response





Signal waveform comparison



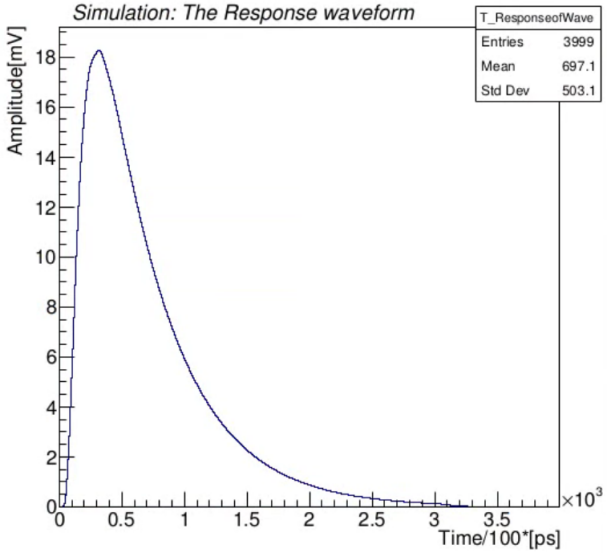
Superimpose SiPM + electronic response + noise on the photon arrival time spectrum

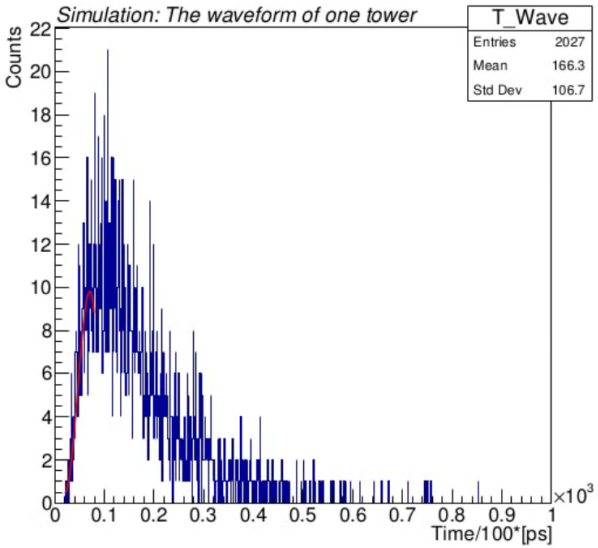
$$f(t) = A(e^{-\frac{t}{\tau_1}} - e^{-\frac{t}{\tau_2}})$$

$\tau_1 = 2\ ns$

$\tau_2 = 52\ ns$

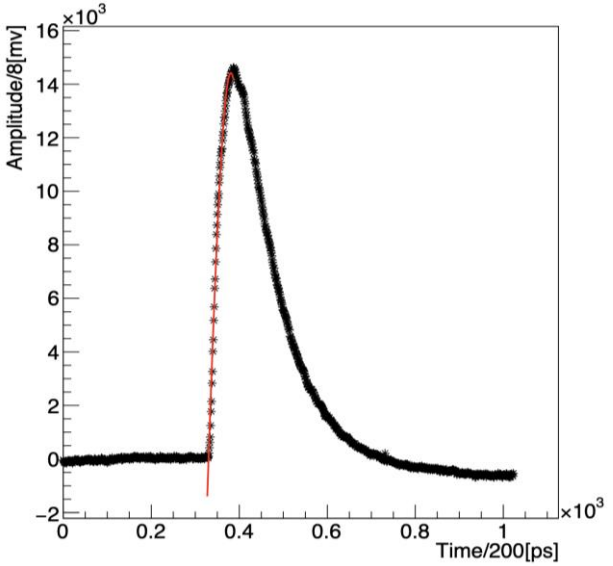
$A = 0.0142\ mv$



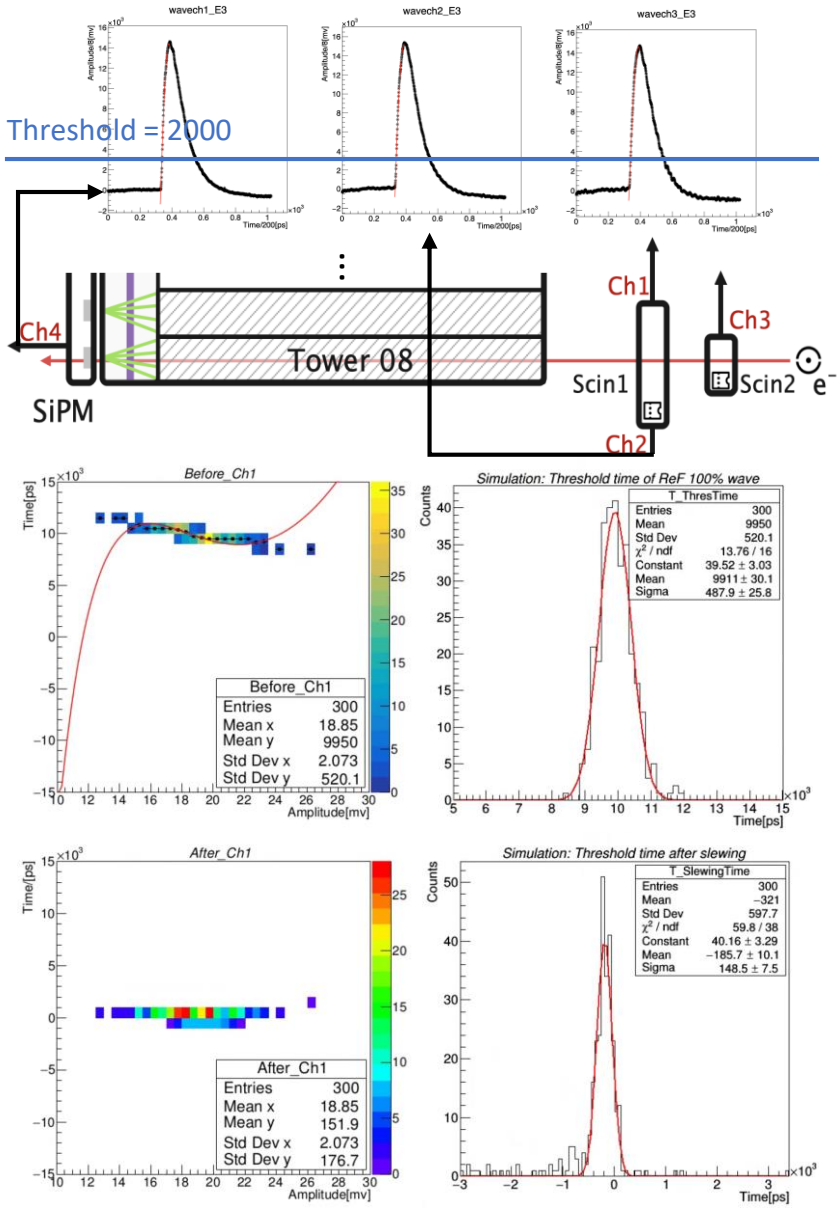


Beam test at DESY
Time scanning @1GeV

	The Npe@1GeV
Simulation	3276
Beam test	3230



Time resolution



The three transthreshold time distributions were corrected for time and amplitude relationships using the following formula.

$$t = a + \frac{p_1}{\sqrt{a}} + \frac{p_2}{a} + p_3 a$$

	T-S13	S1-S3	(S1-S3)/2
Before Slewing	701	362	188
After Slewing	233	141	76

$$\delta(T_T) = \delta(T_{T-S13}) - \delta(T_{S13})$$
$$= \sqrt{(T_{T-S13})^2 - (T_{S1-S3})/2^2} = 190\ ps$$

	Correction	Time[ps]
Beam test	Before Slewing	**823**
	After Slewing	**190**
Simulation	Before Slewing	**469**
	After Slewing	**146**

Summary

- ✓ The China Group has established a complete QA& QC system. QA & QC of Material, Tower and Module have reached the requirements.
- ✓ The cosmic test results show that the light yield of different tower is very consistent. Time resolution is 270ps.
- ✓ The results of the covered optical simulations are consistent with the beam test.
- ✓ 575 modules produced in THU and SDU have been shipped to JINR, now is arrived. 2 more containers will be shipped to JINR as soon as possible.
- ✓ 100% module have been completed in China.
- ✓ The third container will be sent out by December 2022.

Thanks for your attention!

Yulei Li

Department of Engineering Physics, Tsinghua University, Beijing, China