SoLID ECAL R&D China Side

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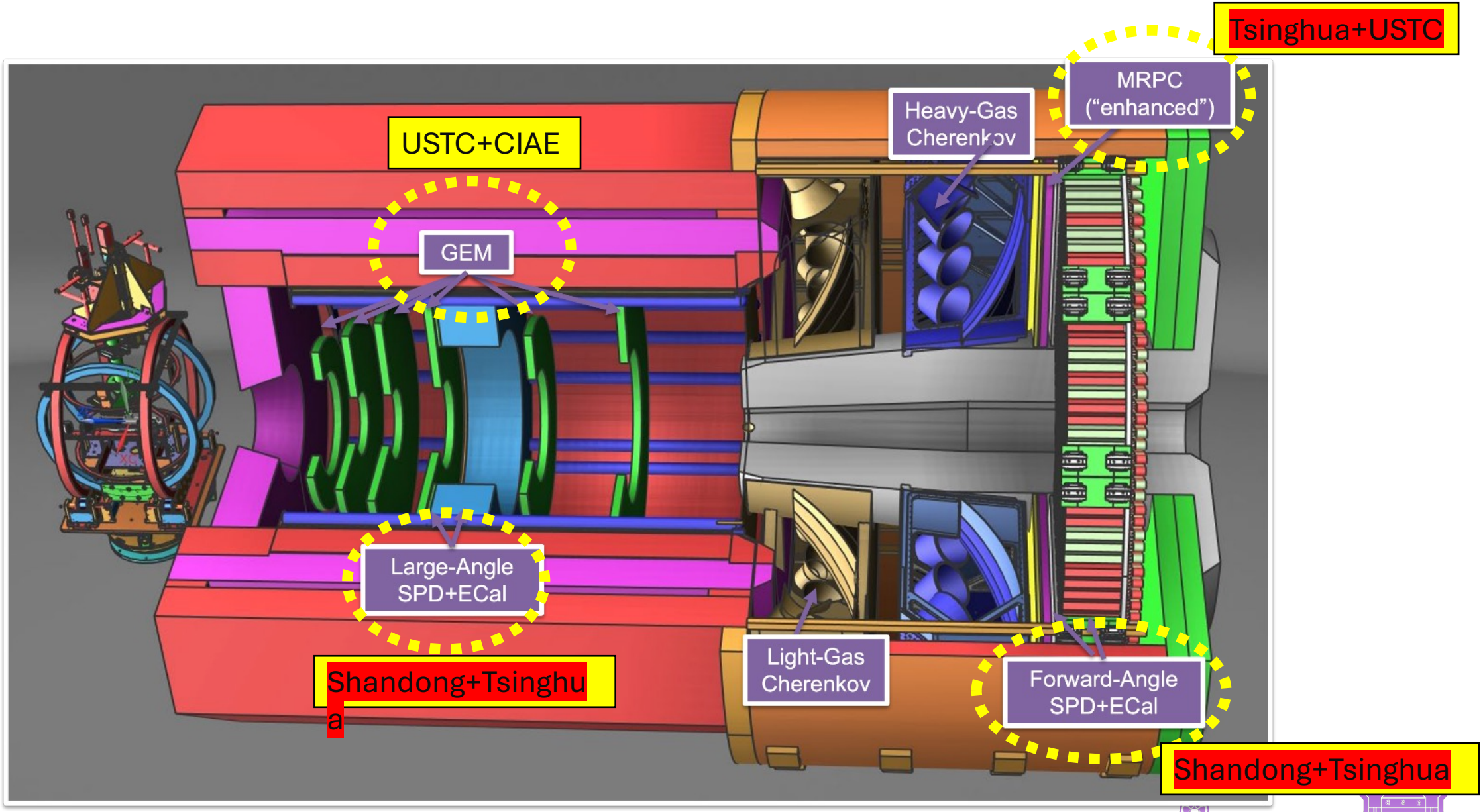
On behalf of THU&SDU ECAL Group

SoLID Collaboration Meeting, Updated on 02/19/2026

SoLID Detectors

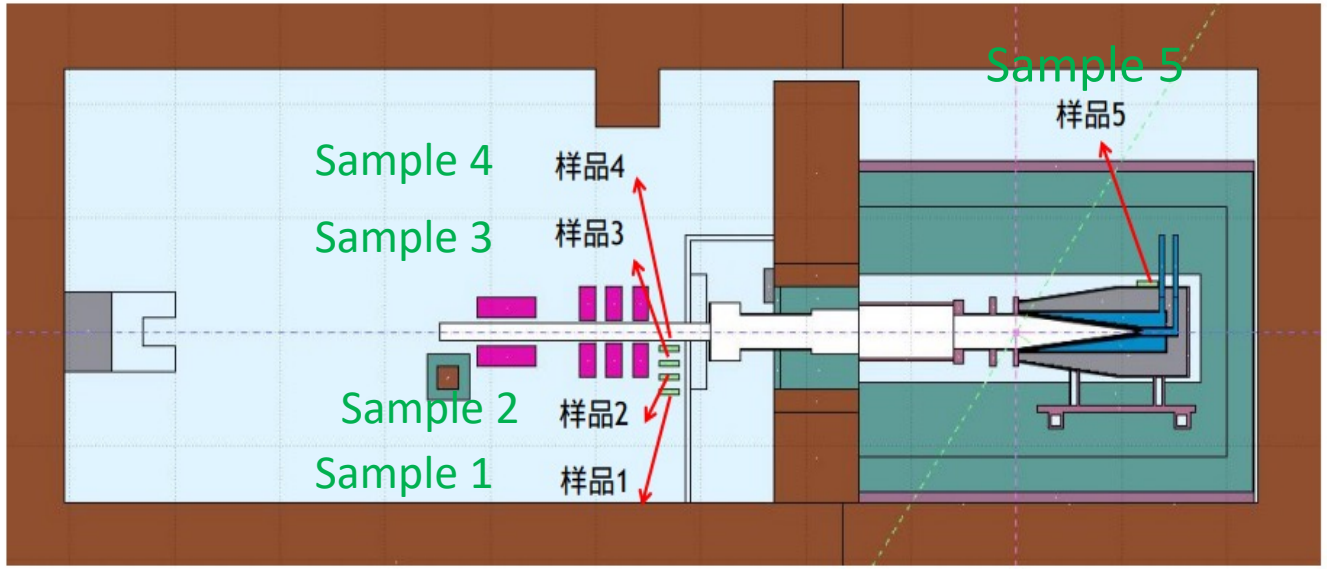


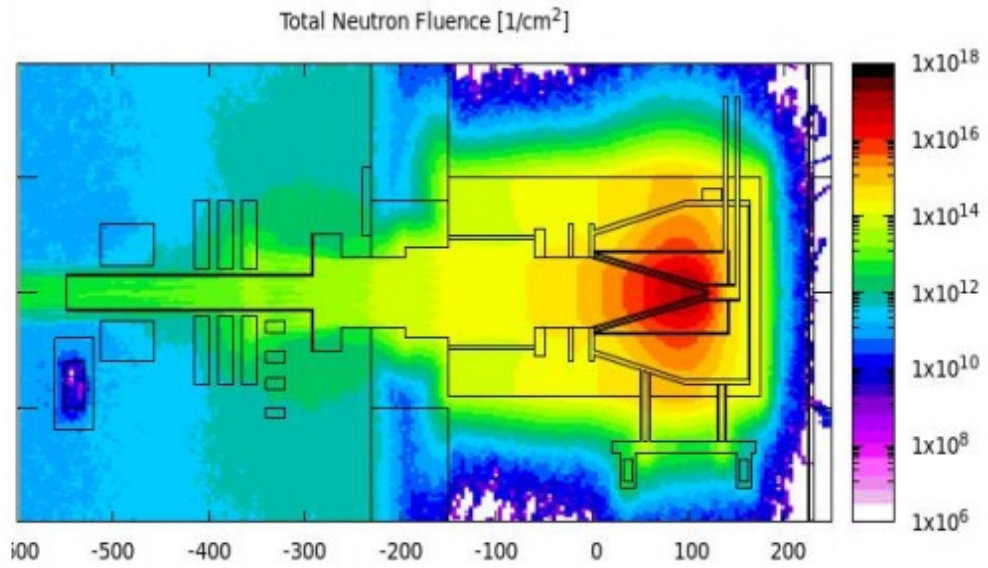
Radiation & Aging Test by SDU

清華大學
Tsinghua University

Experimental Design

Irradiation test at Institute of Modern Physics, Lanzhou



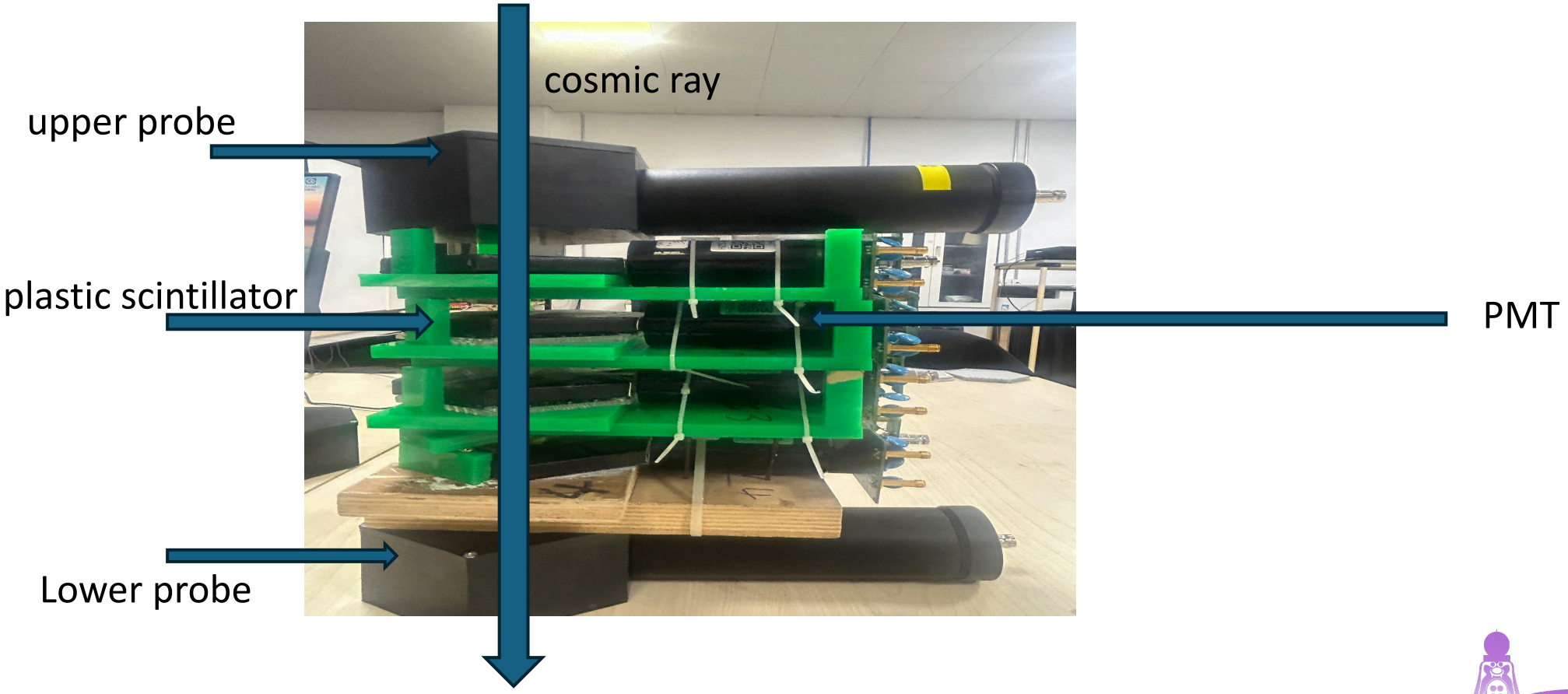


	reference fiber	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Irradiation dose（MeV/cm^2）	0	8.569E+11	1.360E+12	2.807E+12	3.665E+13	1.070E+14
Test materials	BCF91A-MC	Clear fiber	Clear fiber BCF91A-MC Scintillator	Clear fiber BCF91A-MC Scintillator	Clear fiber BCF91A-MC Scintillator	BCF91A-MC Scintillator

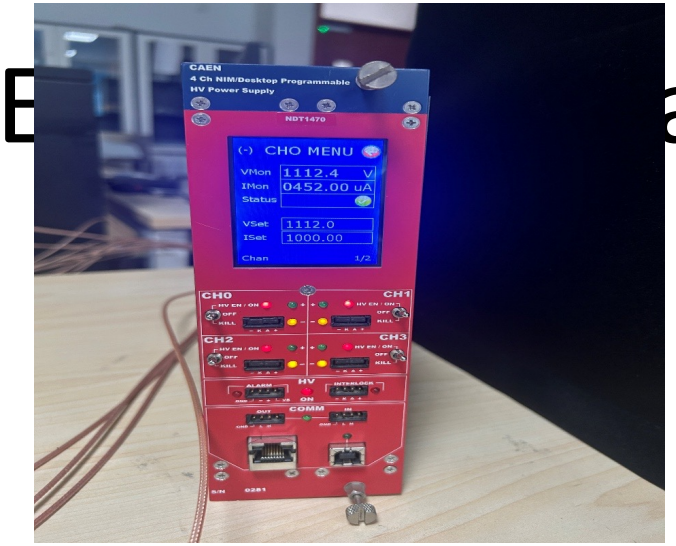
Experimental Design

- Irradiate several groups of scintillators to different degrees
- Four groups‘ scintillators are tested with Cosmic ray muon
- Cosmic ray muon is triggered by the coincidence of upper and lower probes

Scintillator irradiation test:

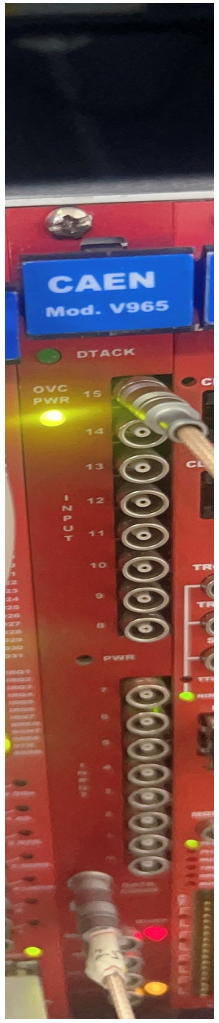


Experimental Apparatus



high voltage power supply

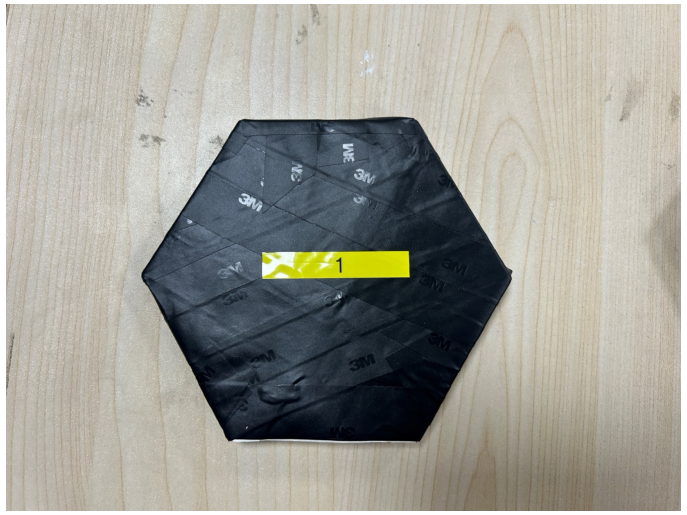
DT5742 digitizer(5GS/s)



v965 module

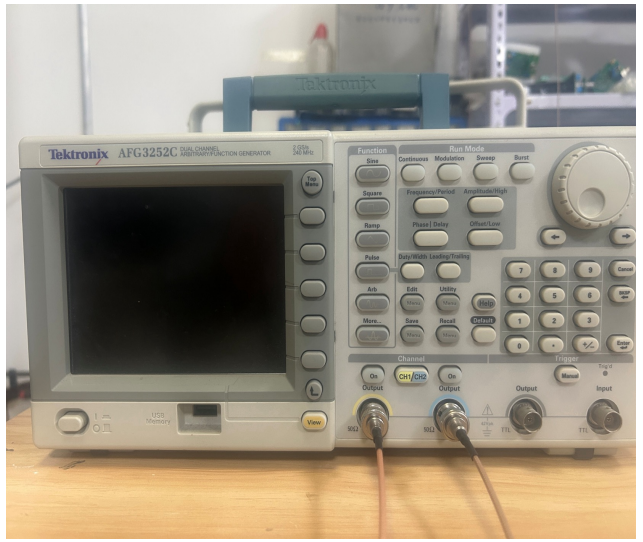
LED
Wavelengths around 400-500nm are used to simulate scintillator luminescence, or wavelength-shifting optical fibers

Experimental Apparatus



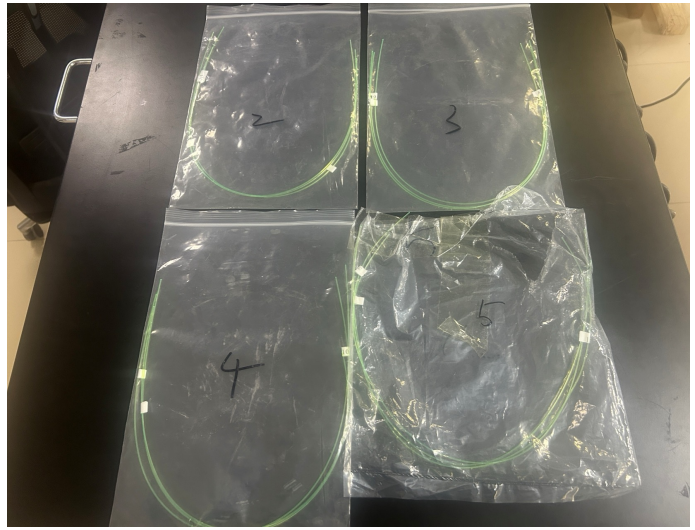
Irradiated plastic scintillators
(Hengxin factory, Jimo District, Qingdao, China)
wrapped with reflective film

PMT
(Hamamatsu cr-285, gain 3.4E+5, 1.5inches)



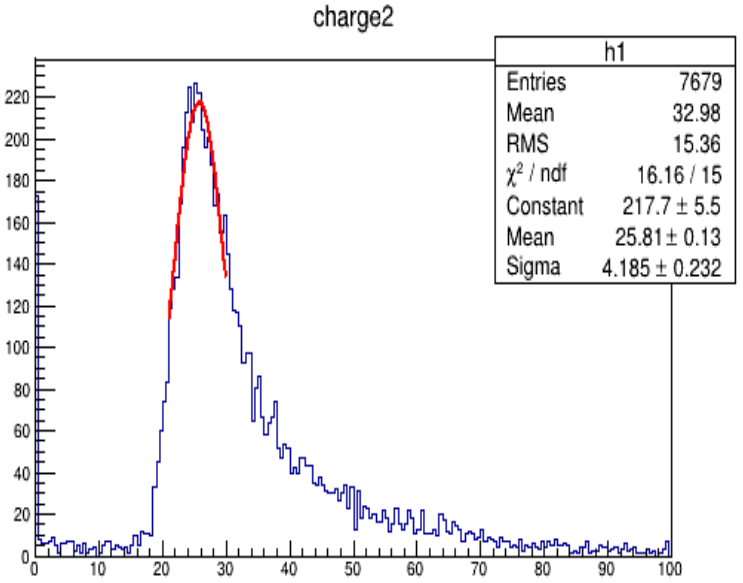
signal generator

oscilloscope



optical fibers with different irradiation levels
(BCF91A-MC,Saint-Gobain company,0.60m)

Test of Scintillators

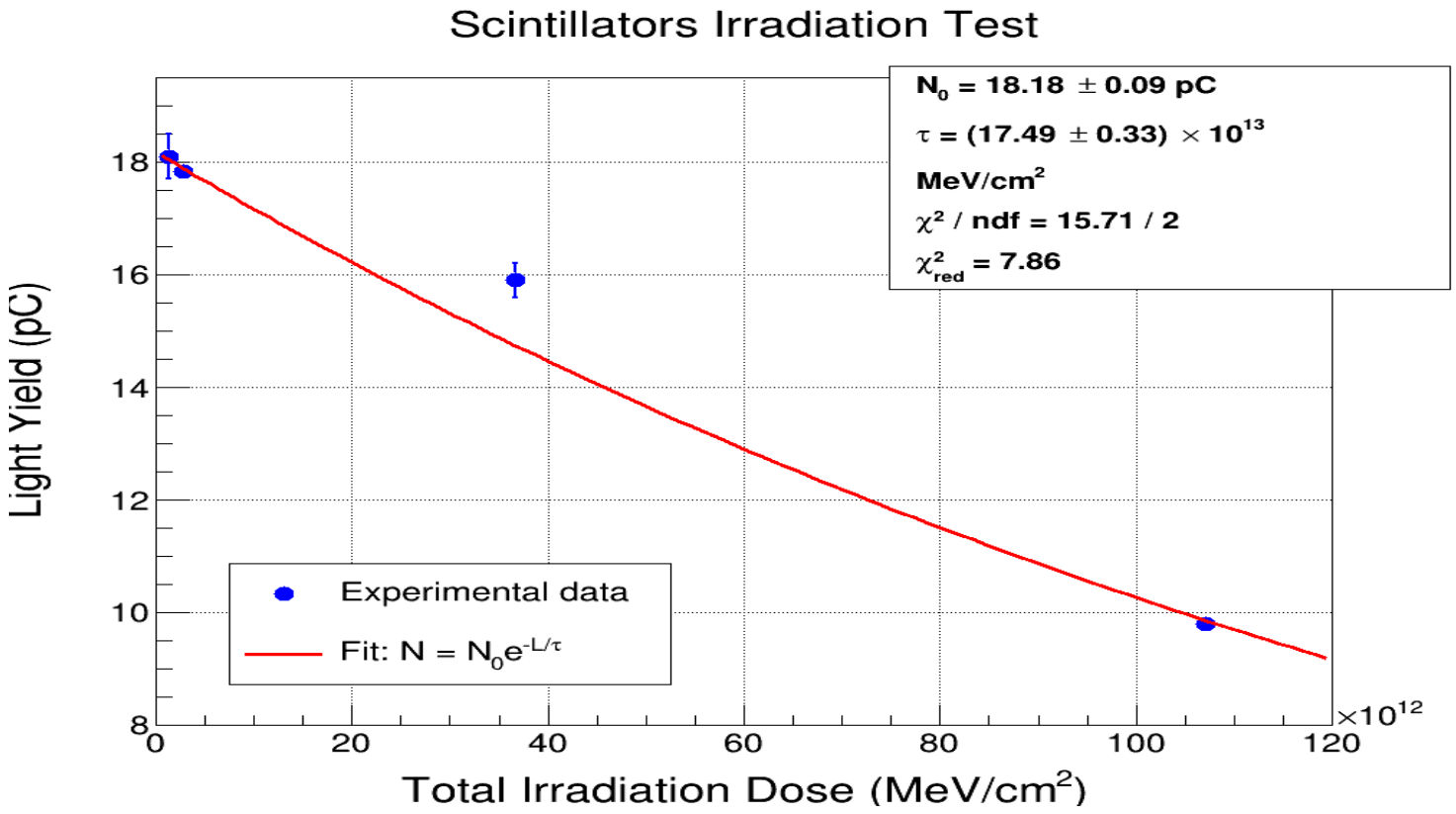


Gaus Fit to get the mean &sigma value

Scintillators were measured four times and the following is the raw data

	Light yield(pC)				Average (Error)
Sample 2	18.88 (0.08)	18.4 (0.1)	17.6 (0.2)	17.5 (0.2)	18.1 (0.4)
Sample 3	17.6 (0.1)	18.02 (0.07)	17.9 (0.2)	17.8 (0.2)	17.83 (0.09)
Sample 4	16.01 (0.07)	15.8 (0.1)	15.68 (0.06)	16.21 (0.08)	15.9 (0.3)
Sample 5	9.63 (0.06)	9.83 (0.07)	9.73 (0.1)	10.07 (0.06)	9.8 (0.1)

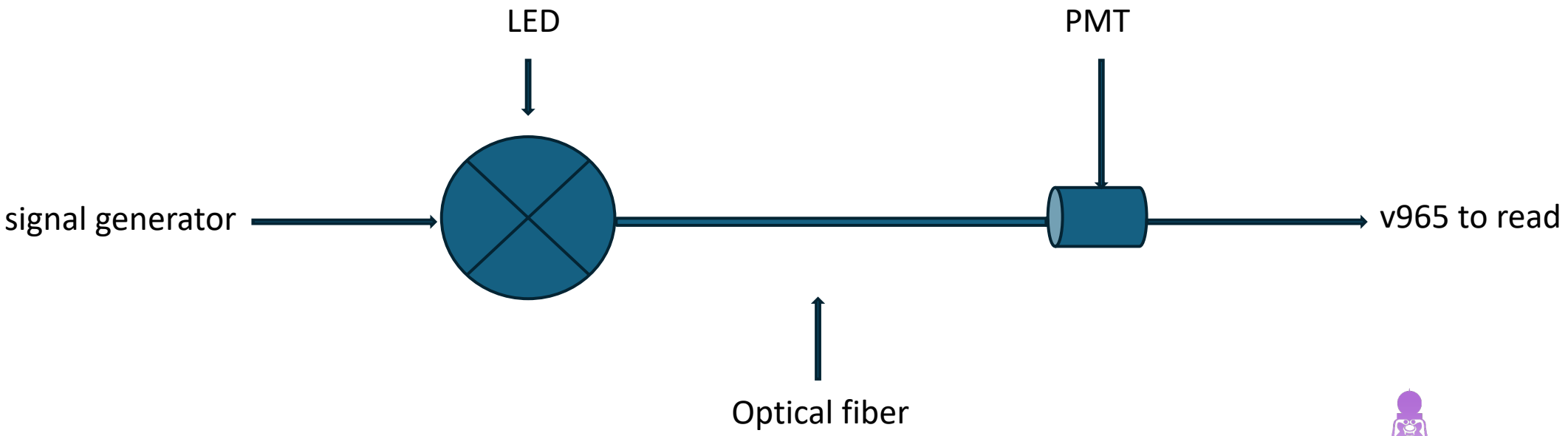
Test of Scintillators



According to the fitting results of the exponential function, with a dose of (1.75±0.04) MeV/cm^2, light yield of the scintillators decrease to 1/e of its original value

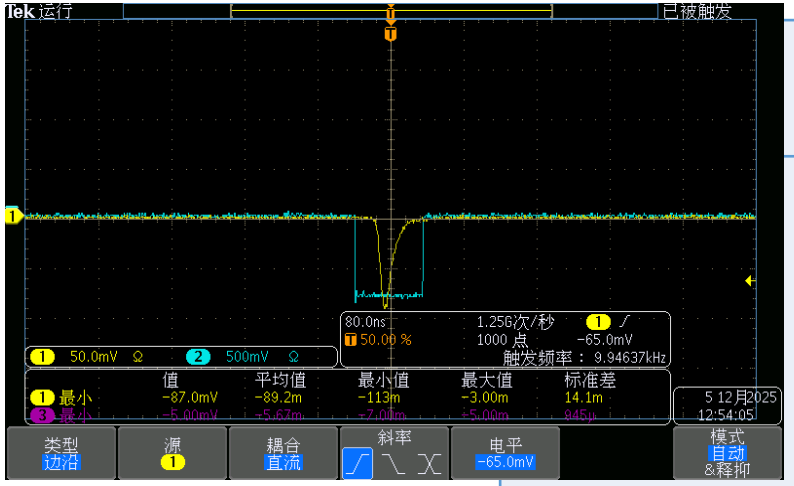
Test of Fibers

- Irradiate several groups of optical fibers to different degrees
- LED is driven by the signal generator to emit light, and the light is transmitted to the PMT through the optical fiber
- Caen v965 module reads PMT integrated power



Test of Fibers

Example of fiber test waveform



	Sample 2		Sample 3		Sample 4		Sample 5		reference fiber	
	Fiber	Signal (ADC)	Fiber	Signal (ADC)	Fiber	Signal (ADC)	Fiber	Signal (ADC)	Fiber	Signal (ADC)
BCF91A	5	740	7	729	10	709	1	696	48	899
	5	733	7	721	10	708	1	686	48	911
	5	737	7	724	10	728	1	680	48	913
	6	737	8	725	11	695	2	667		
	6	717	8	742	11	720	2	661		
	6	727	8	739	11	714	2	657		
			9	783			3	663		
			9	739			3	667		
			9	751			3	665		

Three sets of measurement data are taken from each optical fiber, and the following are the raw data

Test of Fibers

- Calculate the mean value of each group of optical fiber signals

	reference fiber	Sample 2	Sample 3	Sample 4	Sample 5
Average(ADC)	908±5	732±4	739±7	712±5	671±5

- Calculate the attenuation distance using the conversion formula

	reference fiber	Sample 2	Sample 3	Sample 4	Sample 5
Attenuation distance(m)	3.28±0.02	1.45±0.01	1.49±0.02	1.36±0.01	1.20±0.01

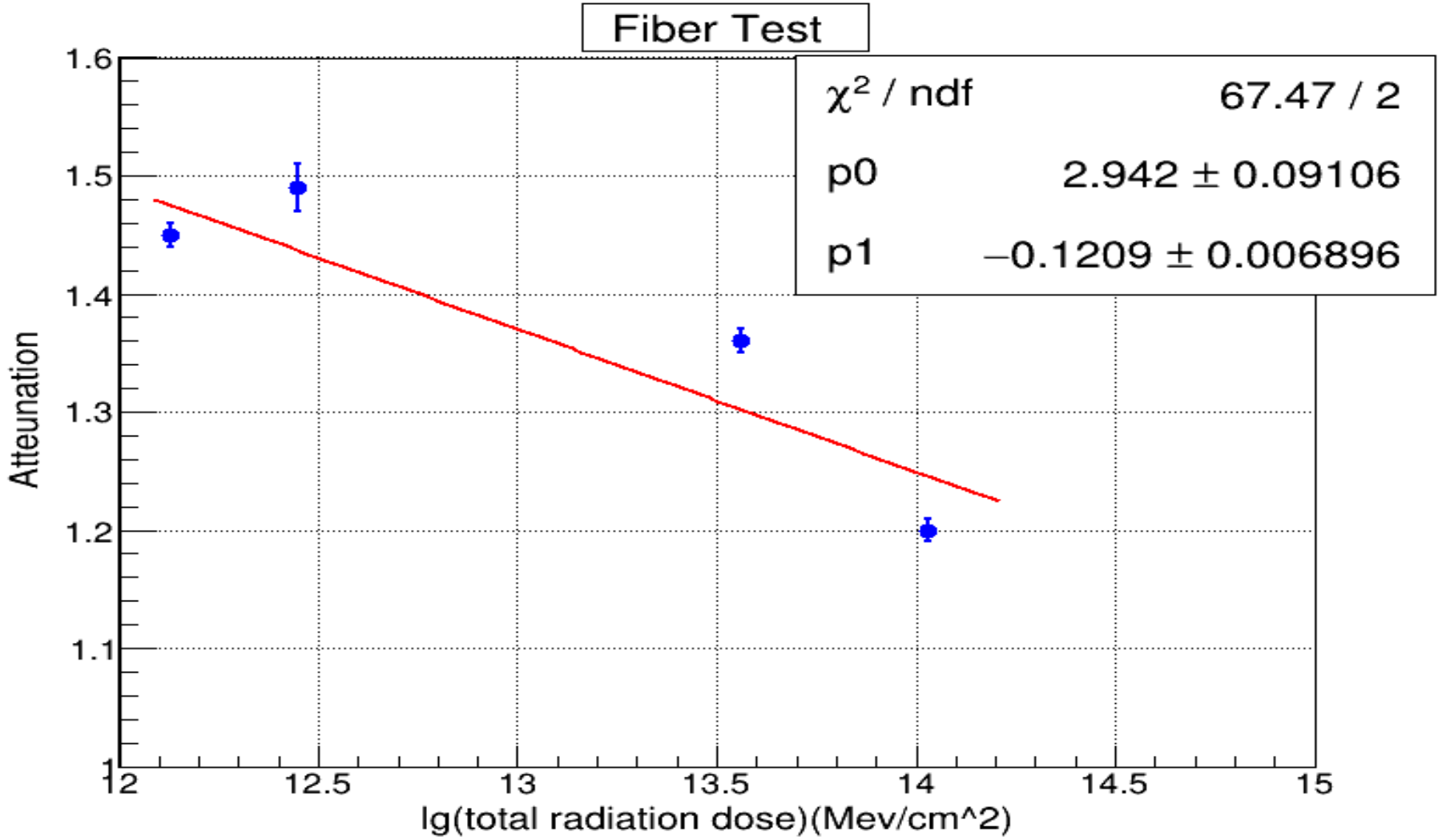
conversion formula: $$\frac{I_1}{I_2} = \frac{I_0 \cdot e^{\left(-\frac{x}{\lambda_1}\right)}}{I_0 \cdot e^{\left(-\frac{x}{\lambda_2}\right)}} = e^{\left(-\frac{x}{\lambda_1}+\frac{x}{\lambda_2}\right)}$$

Reference:Mengjiao Li,Dong Liu. Effect of radiation on the attenuation length of clear fiber[J]. Journal of Instrumentation,2024,Vol.19(11): P11009.

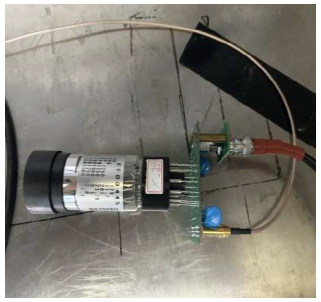
Test of Fibers

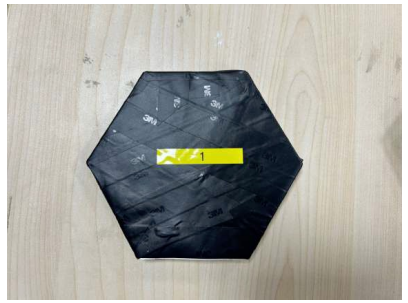
- According to the linear fitting results:

  Attenuation=-0.121x+2.9(m), x=lg(total radiation dose(Mev/cm^2))

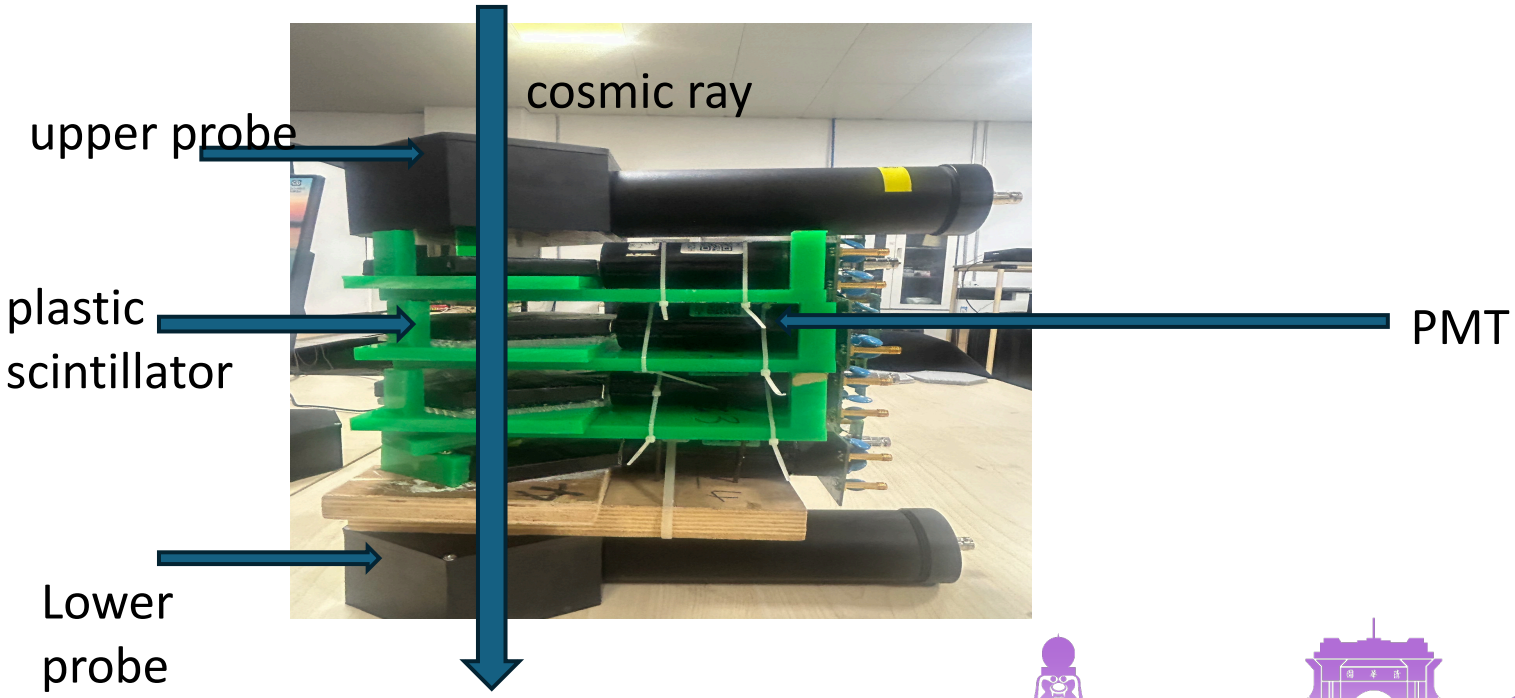


Aging Experiment Design





- Six groups‘ scintillators are tested with Cosmic ray muon
- 1day test -> 6 days in temperature control box -> 1day test -> 6 days in temperature control box -> 1day test -> …….
- Total 13 weeks
- Cosmic ray muon is triggered by the coincidence of upper and lower probes



Theoretical Model

Van't Hoff rule equivalent time conversion formula：

$$t_{eq} = t_{ag}\tau^{\frac{T_2 - T_1}{10}}$$

References: [1] Hai-Tao Chen, Bo-Xiang Yu, Qing Shan, et al. Aging of LAB-based liquid scintillator in stainless steel containers[J]. Chinese Physics C, 2015, 39(6): 066002.

[2] H. Song, X. Li, B. Yu, et al. Accelerated long-term aging study of new antioxidant plastic scintillators[J]. Journal of Instrumentation, 2023, 18(01): P01019.

t_{eq}=equivalent time at room temperature(25℃),

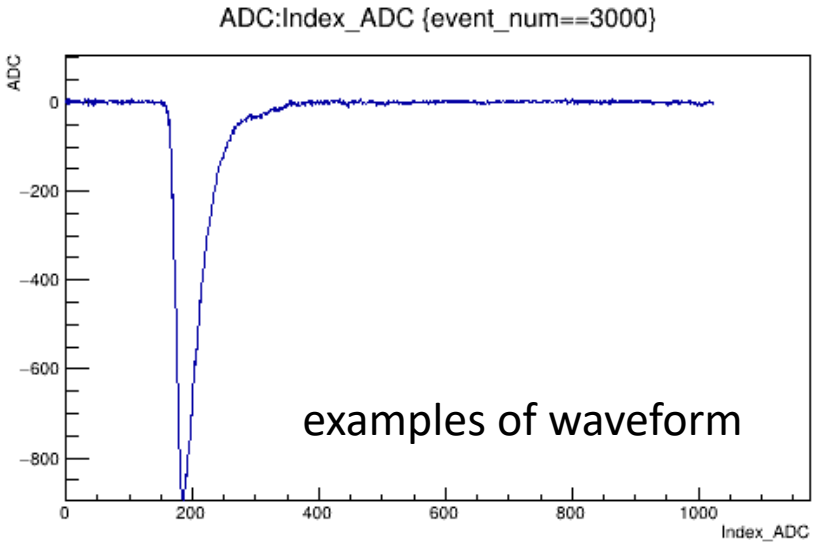
t_{ag}=the actual time at 60 ℃ ,*τ=3(time constant)*

T_2=the actual temperature

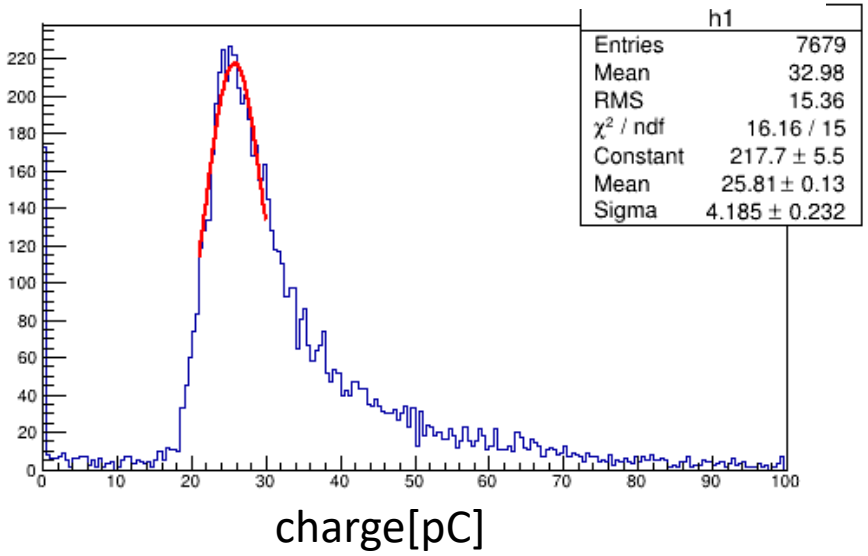
T_1=the equivalent temperature(25℃)

78 days @60℃ = 10 years @25℃

Experimental Results

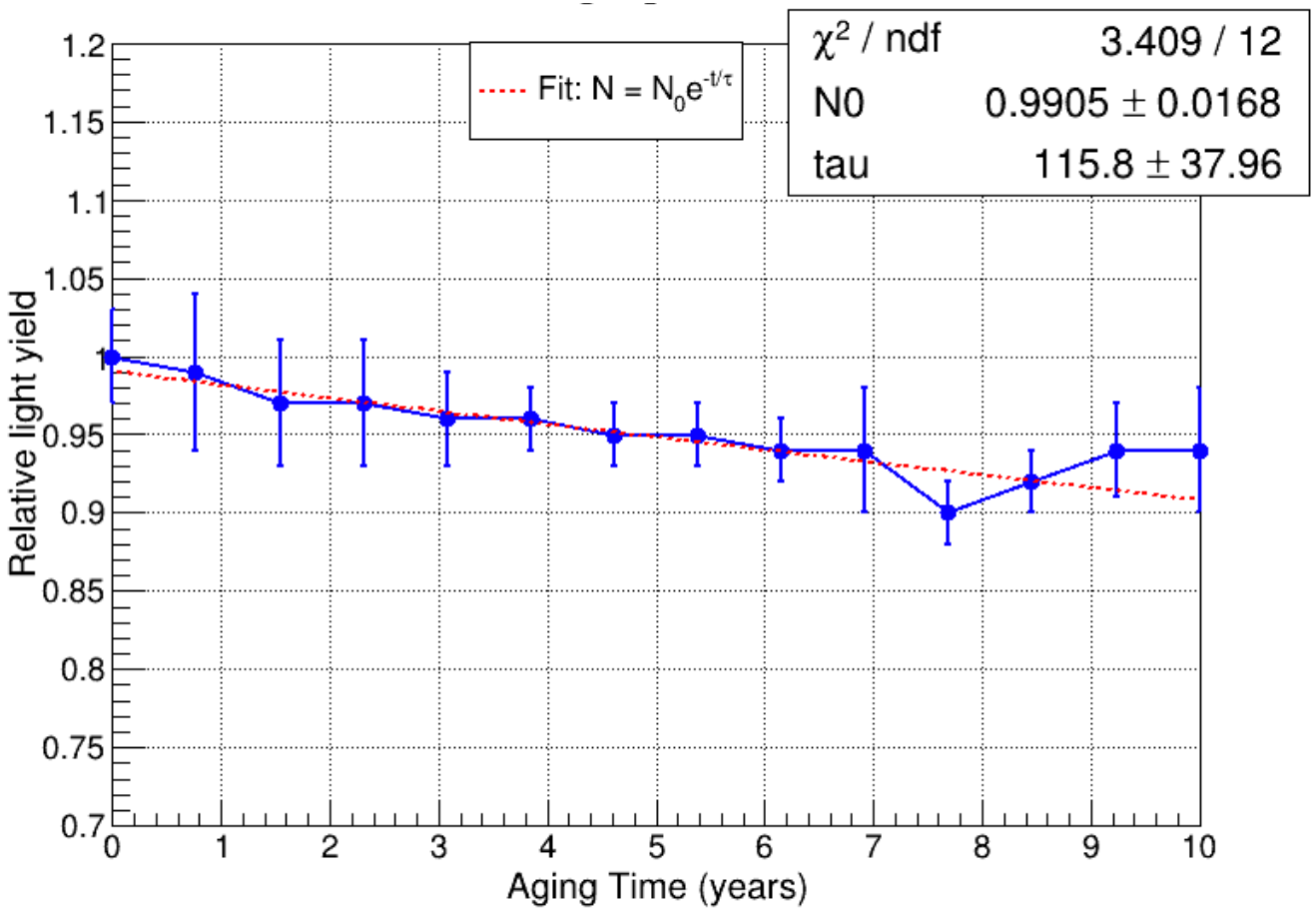


Gaus Fit to get the mean &sigma value



According to the fitting results, light output fell by：

- 0.86% in one year, 1.72% in two years,8.28 % in ten years.
- About 115.8 years, it dropped to the original 1/e.

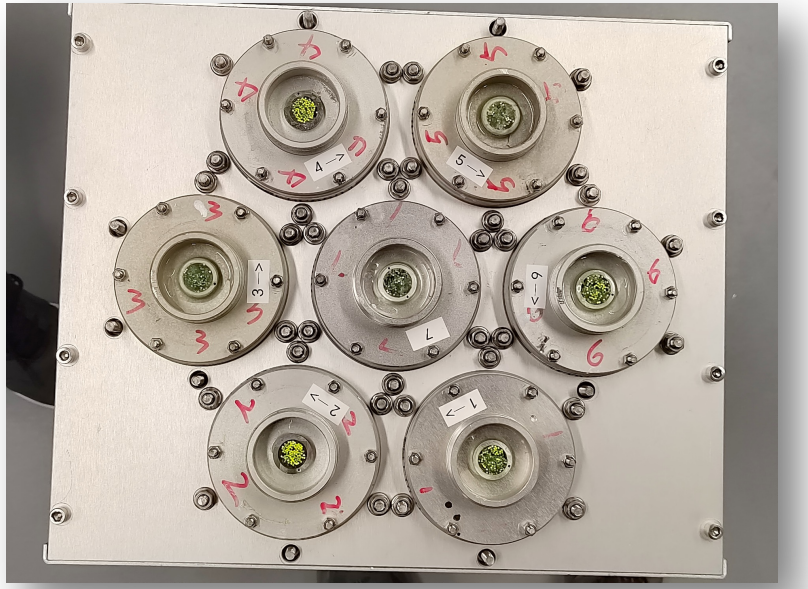


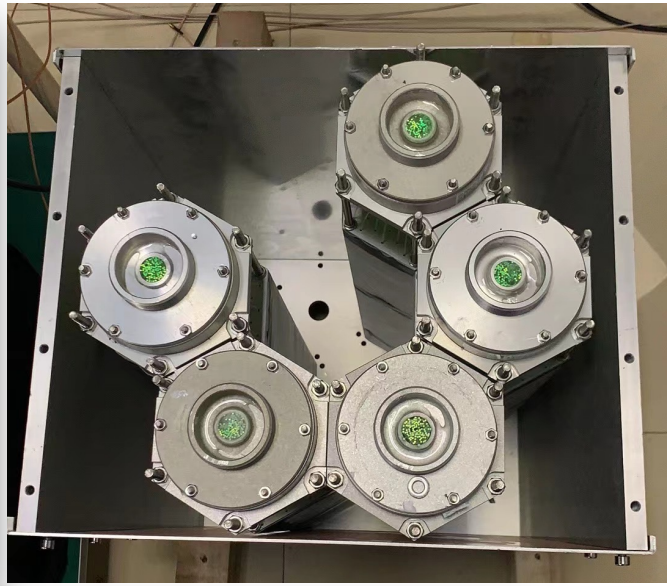
Super-module Test

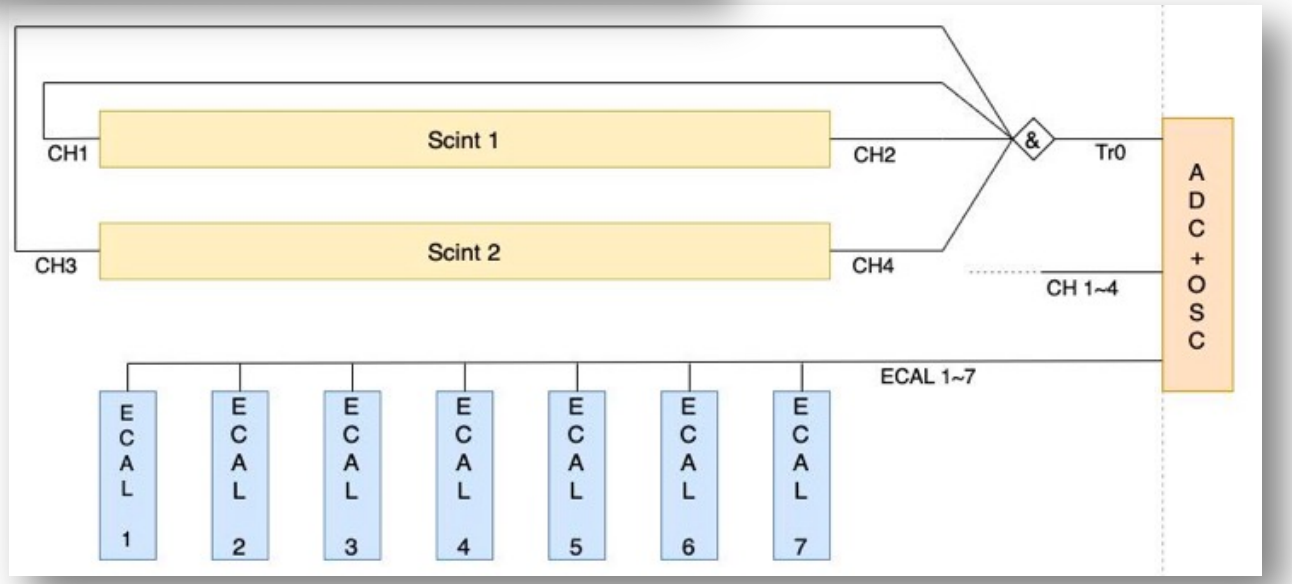
by THU

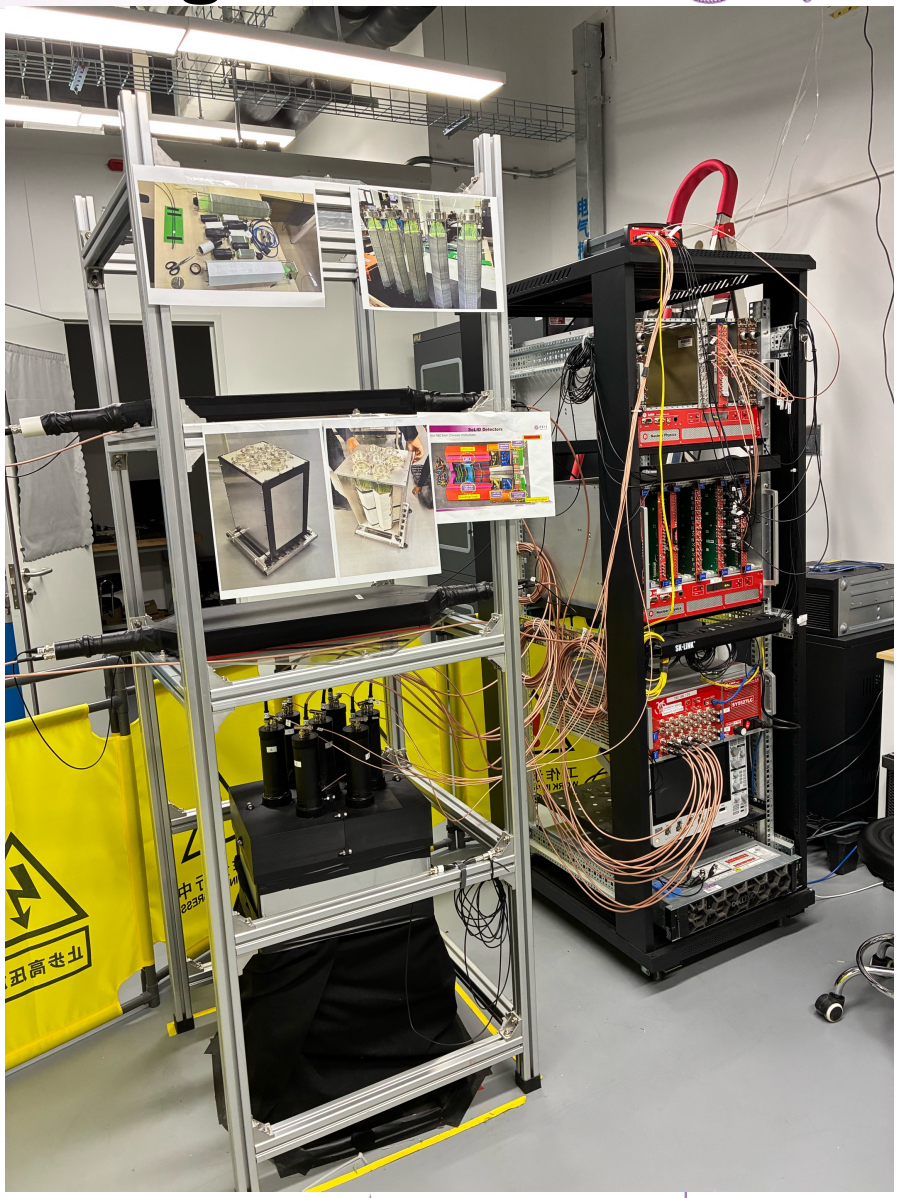
清華大學
Tsinghua University

ECAL Supermodule at Tsinghua







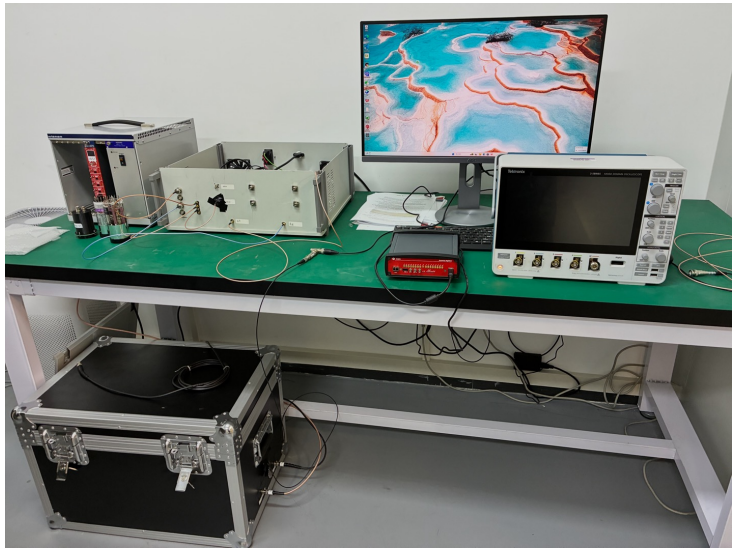


ECAL Test Stand @THU

ECAL LED Test

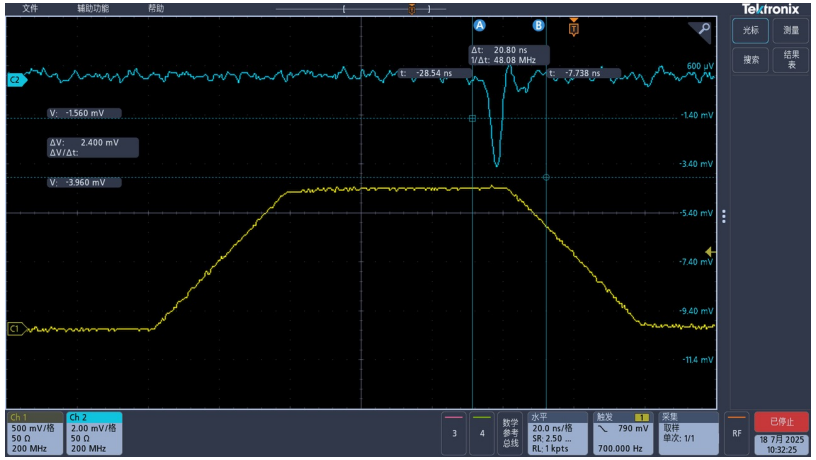
➢ LED Test (since last July)

- Use our LED test stand to benchmark PMTs

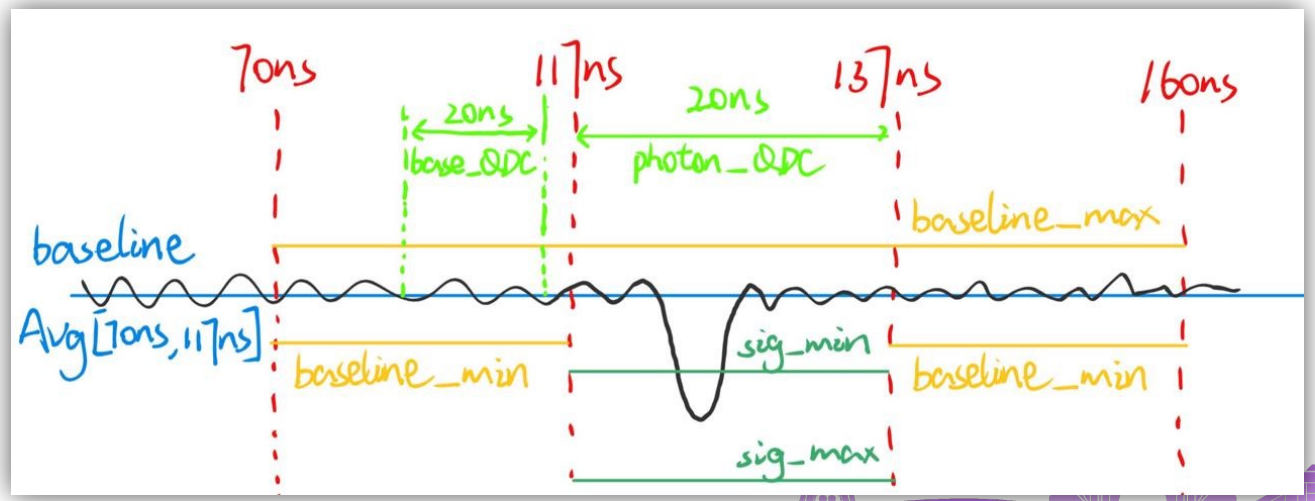


- Adjust function generator to power LED and produce near single photons (700Hz, continuous pulses)

- 20ns of wave-form sampling window



- Select noise and single-photon electron (SPE) events

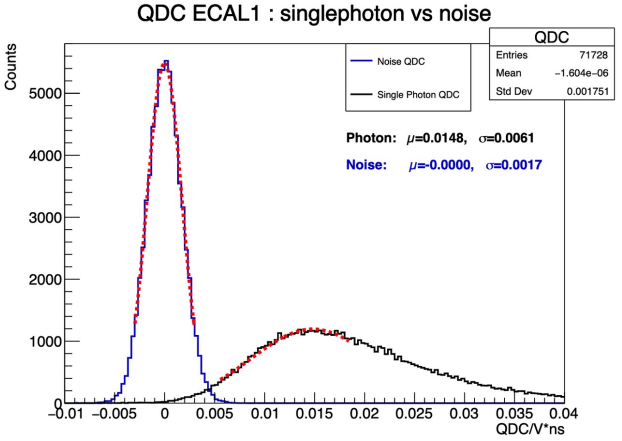


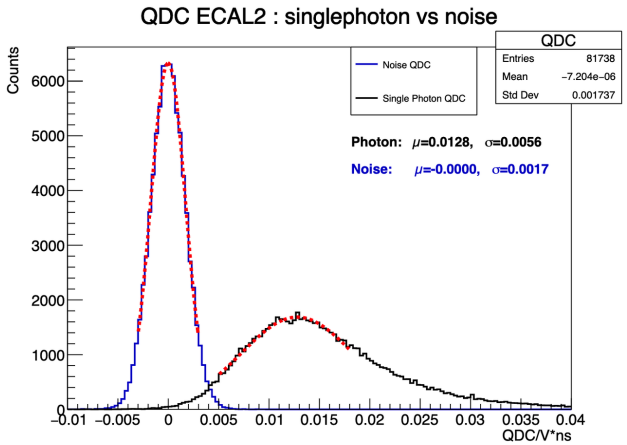
ECAL LED Test

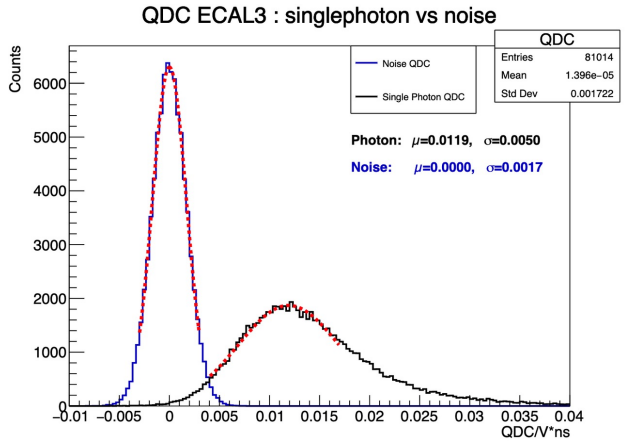
➢ SPE Alignment (since last July)

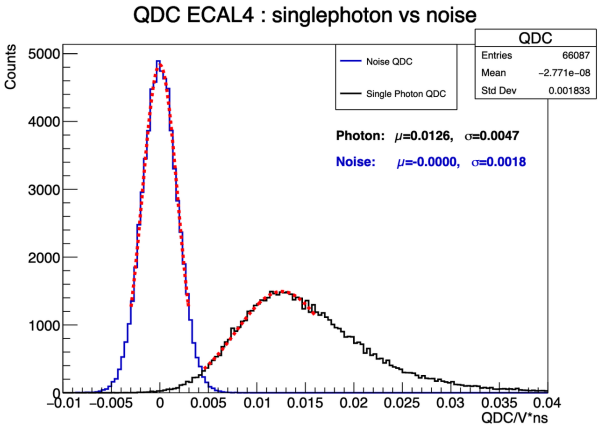
- ❑ Use weak LED lights to check the location of SPE peak
- ❑ Adjust HV to align the location of SPE for each PMT

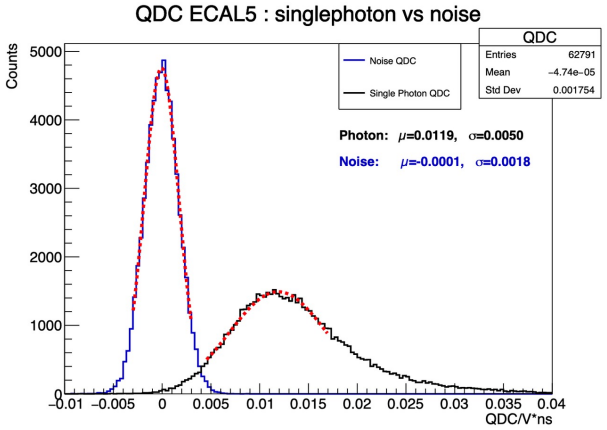
ECAL	PMT	Base	HV_Neg
1	01	01	815
2	10	02	860
3	03	03	775
4	09	04	805
5	05	05	800
6	06	06	790
7	07	07	790

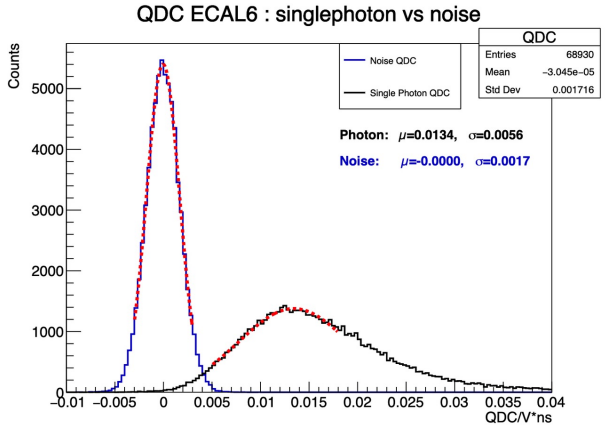


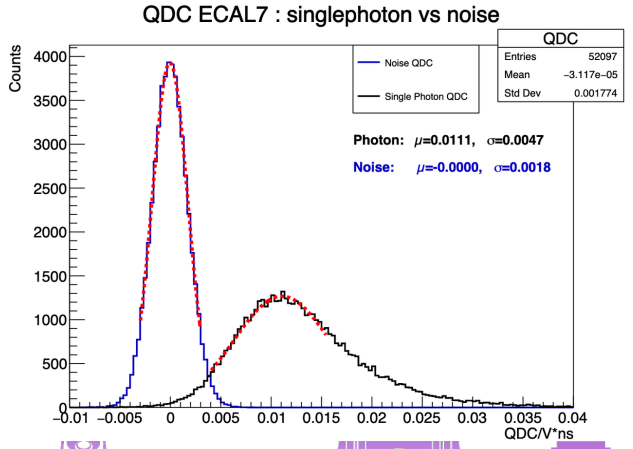






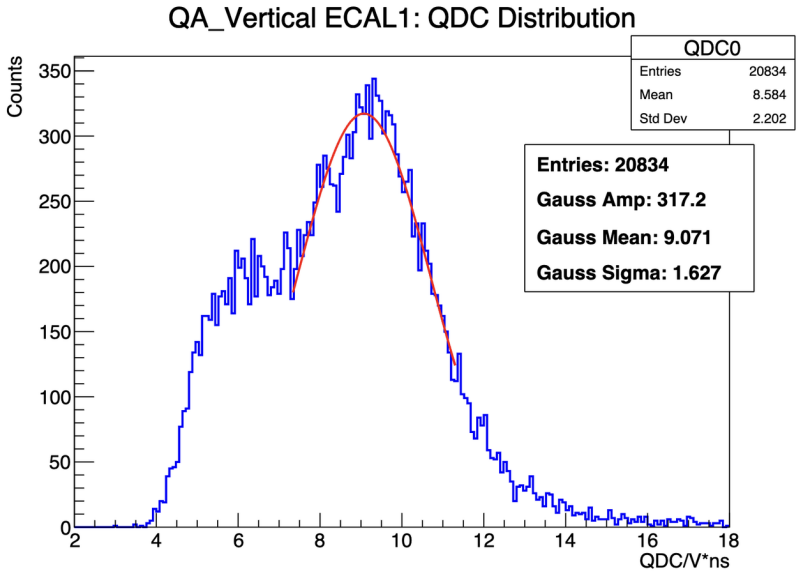


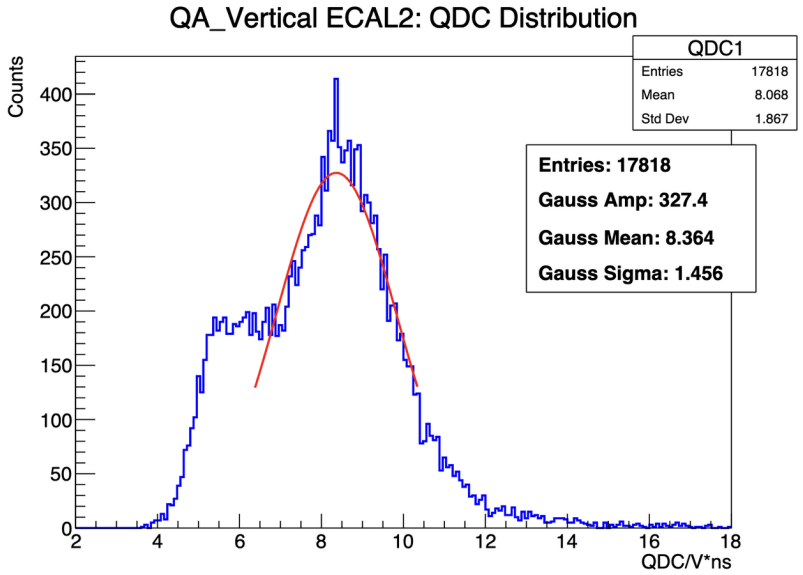


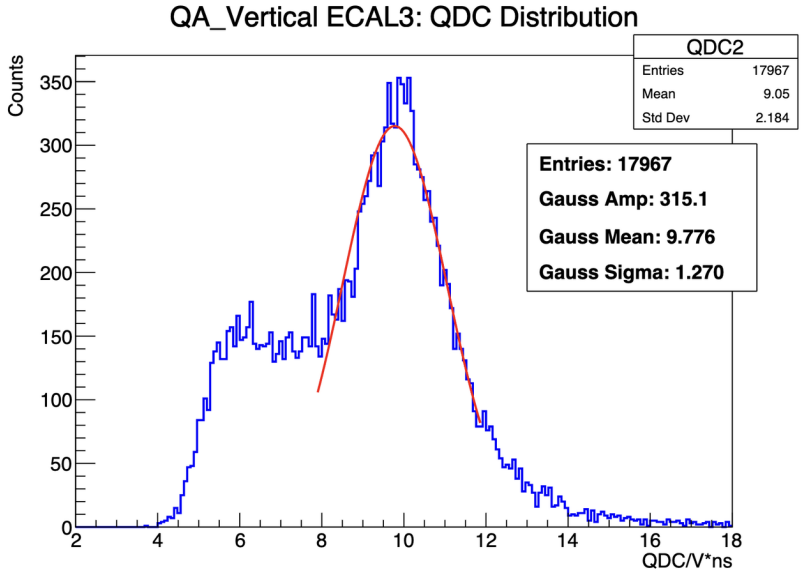


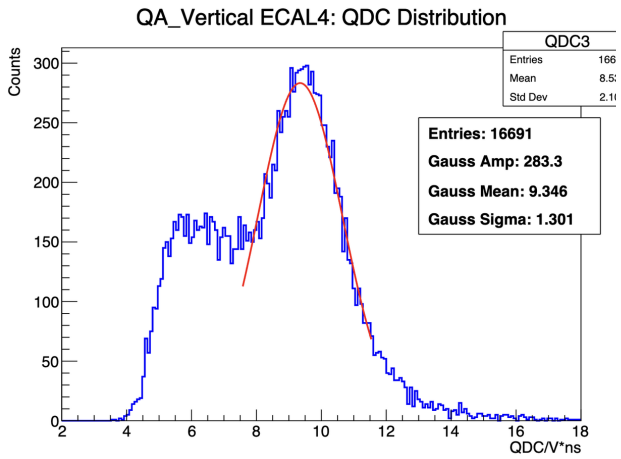
ECAL Cosmic Ray Test

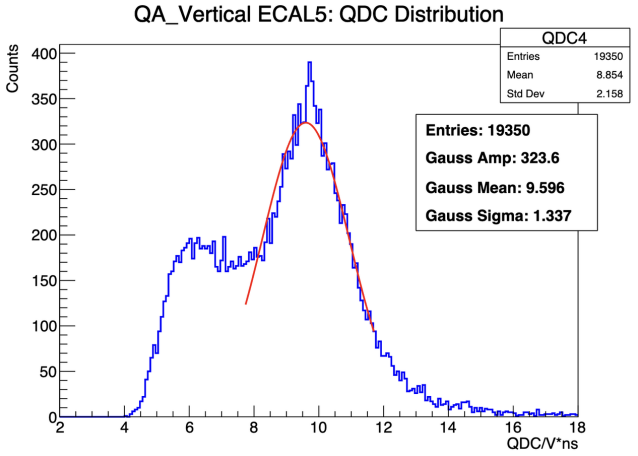
- In average, every cosmic ray muon produces roughly 880 photons

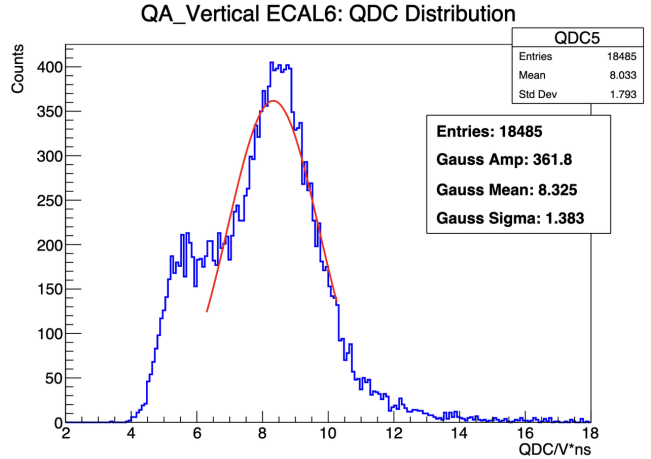


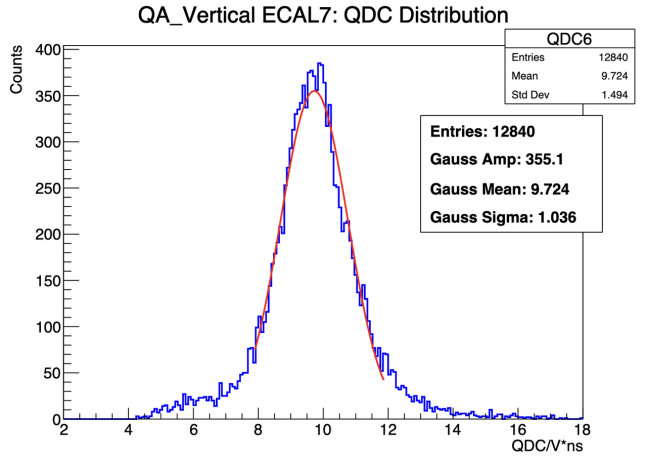








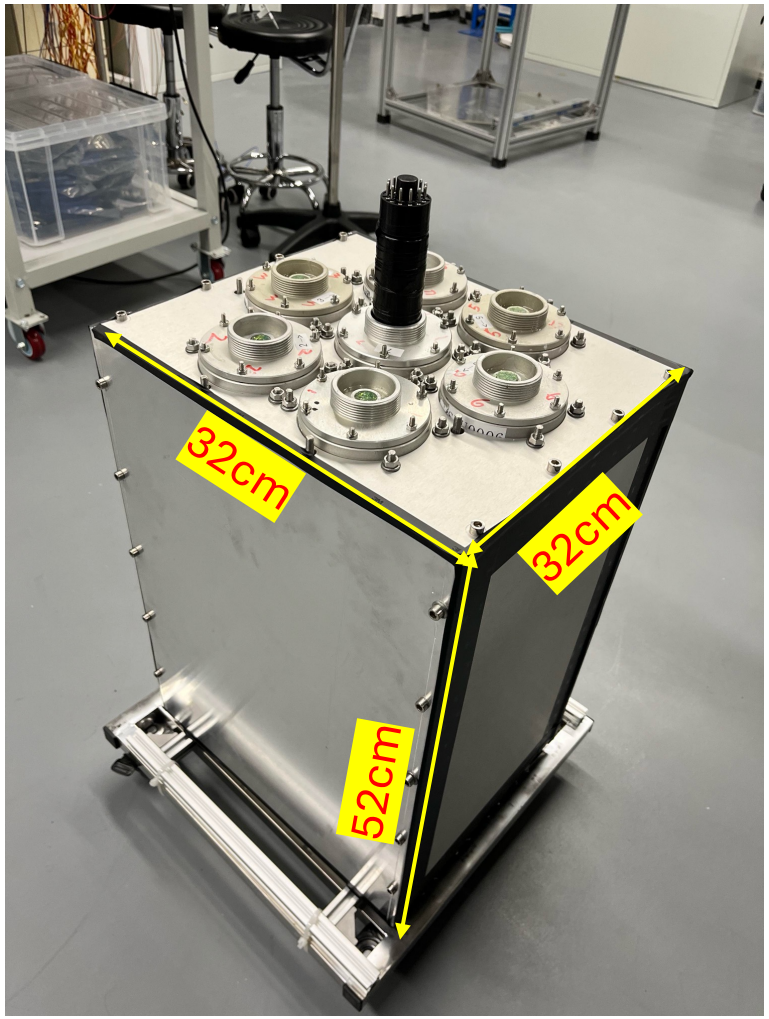




1st ECAL Super-module

➢ Preparing Shipment to JLab

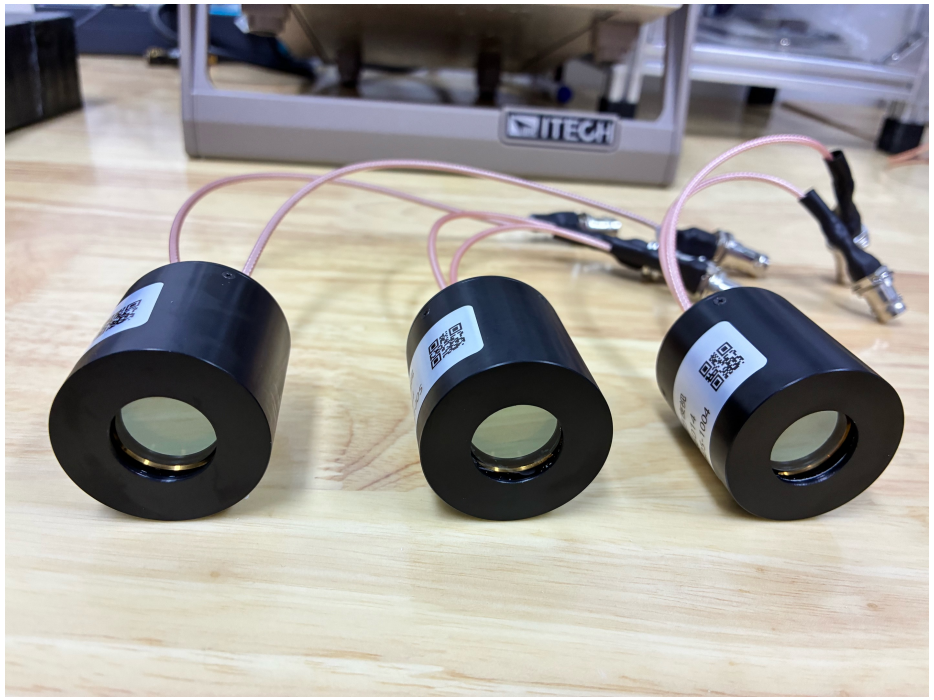
- ☐ Weight = 15kg x 7 Modules + 20kg Frame = 126kg totally
- ☐ Geometry: Frame: 32cm x 32cm x 52cm
- ☐ Preparing Shipping:
  - Modules will be NOT be dissembled (except PMTs)
  - While supermodule to be shipped
  - Along with 7 PMTs&9 bases
  - + 5 PreShower tiles
  - Ship by air on early March (take roughly a week)

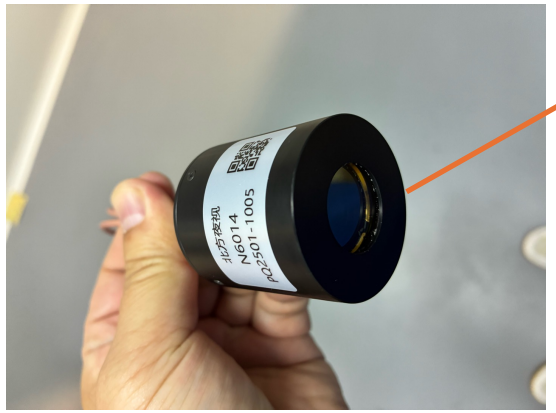


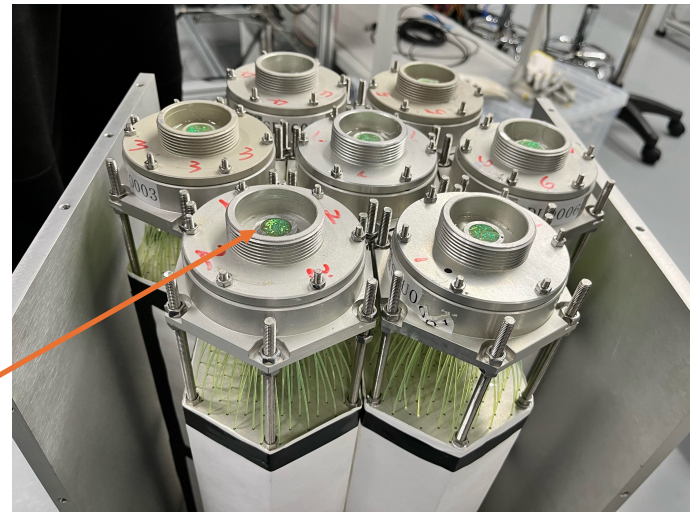
MCP Readout Option

➢ 3x MCP-PMT as ECAL's light readout option

- Night-Vision (China) N6014, Inner Φ18mm, Outer Φ36.6mm
- Potential to replace current design (WLS fiber+clear fiber+MaPMT)





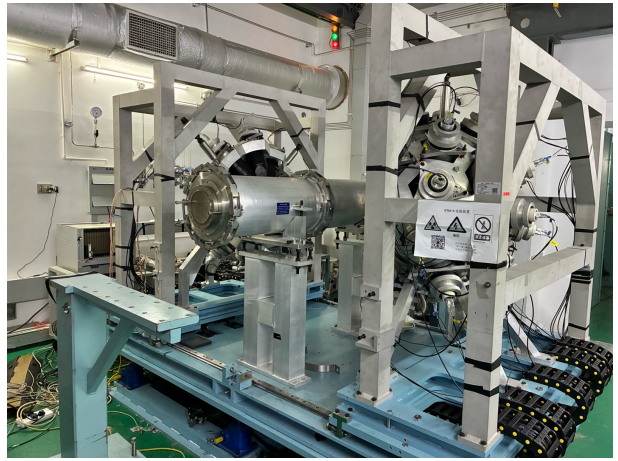


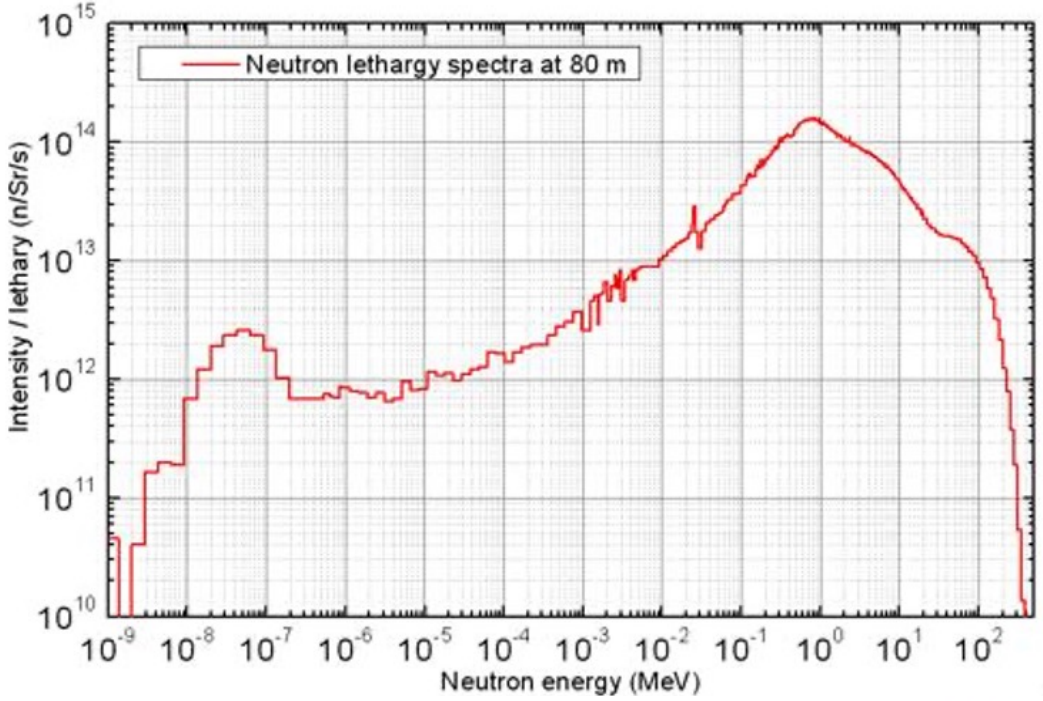
MCP#	HV	Gain	P/V	σ[%]	DR(KHz)	DC(nA)
PQ2501-1005	1990	1.03e6	10.189	21.534	1.27	18.26
	1900	1.02e6	14.9	21.73	0.458	92.48
PQ2501-1007	1870	1.02e6	27.08	19.96	6.13	35.19
	1780	1.05e6	21.67	18.96	3.64	30.76
PQ2501-1004	1600	1.01e6	13.11	22.42	4.21	126.31
	1715	1.08e6	25.16	18.02	13.96	309.8

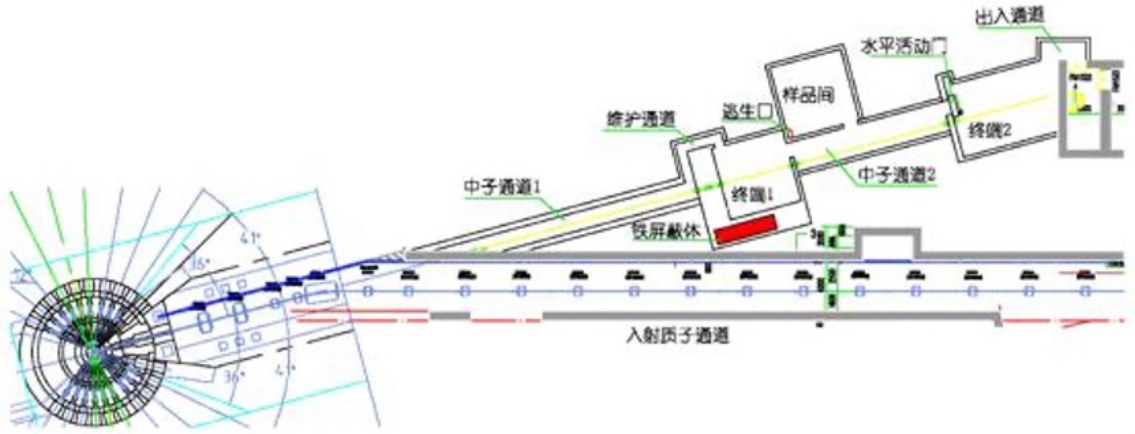
MCP Readout Option

➢ China Spallation Neutron Source (CSNS, Dongguan, Guangdong Province)

- ☐ Use the white-spectrum back-angle neutron source
- ☐ To be done in Spring or Summer







Summary

- SDU Performed radiation and aging tests on scintillators and fibers
- THU performed tests on the 1st super-module
- Prepare to ship supermodule to JLab in early March by air
- Prepare radiation tests on MCPs which will be used on the second supermodule
- THU & SDU use limited grant to continue ECAL R&D, not sustainable!
- Suggest the US collaborators to take over more R&D efforts

  e.g. readout & front-end electronics, radiation & aging, mechanics support,

  alignments, calibration (Q&A), reconstruction,

  LED monitoring and slow control,

  or maybe assemble modules?

THANKS!

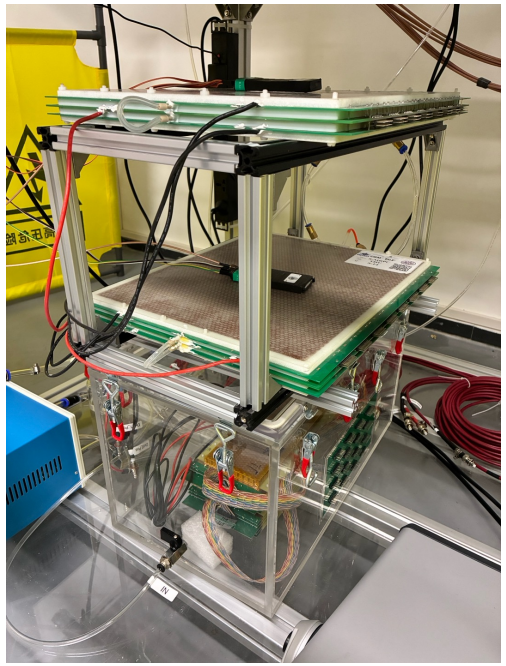
清華大學
Tsinghua University

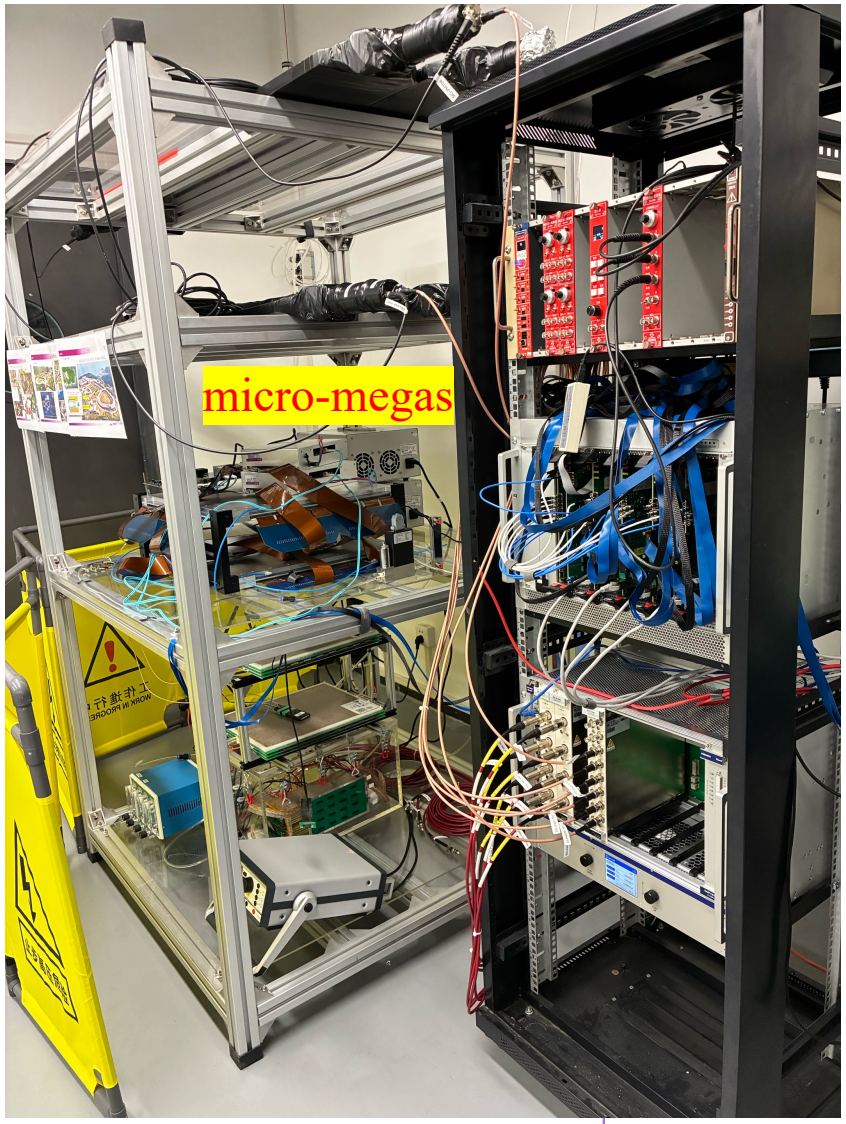
MRPC at Tsinghua

➢ Cosmic-ray Test at Ye's Lab

- ❑ Complete new test setup in the new lab (December 2024)

  (high-rate MRPC + USTC FEE + picoTDC)
- ❑ Gas circulation system completed (March 2025)
- ❑ Added micro-megas tracker (March 2025)
- ❑ Designed new box for high-rate mRPC (March 2025)
- ❑ Tested sealed mRPC (April 2025)

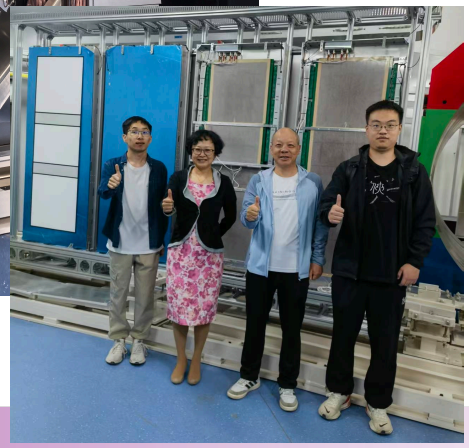




MRPC at Tsinghua

➢ Cosmic-ray Test at Ye's Lab

- ❑ Tsinghua's sealed mRPC detectors are functioning on CEE detector now
- ❑ My team is analyzing the data and understand better on the mRPC-TOF



CSR @ Lanzhou, Gansu