

# SoLID EM calorimeter study and general test system in SDU

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# Outline

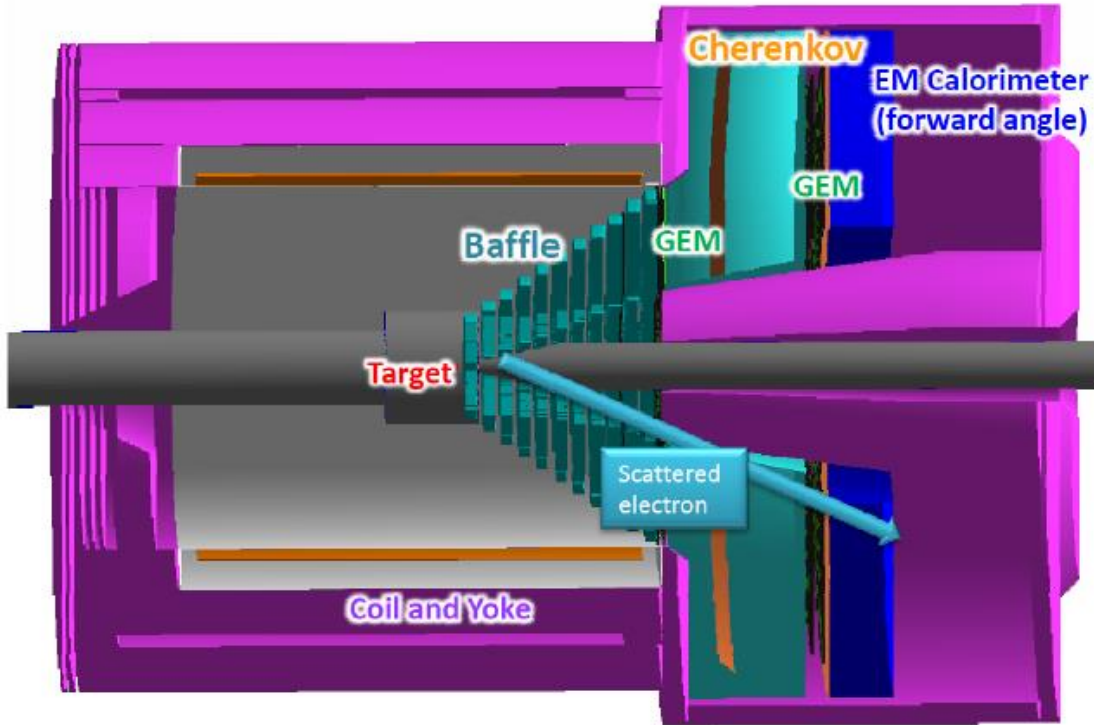
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- SoLID Electromagnetic calorimeter introduce
- Pre-shower module and test
- Pre-shower module simulation
- MAPMT test
- PMT test bench
- CoRaRS(Cosmic Ray reference System )
- Summary



# Electromagnetic calorimeter in SoLID

SoLID CLEO PVDIS



SoLID CLEO J/ψ

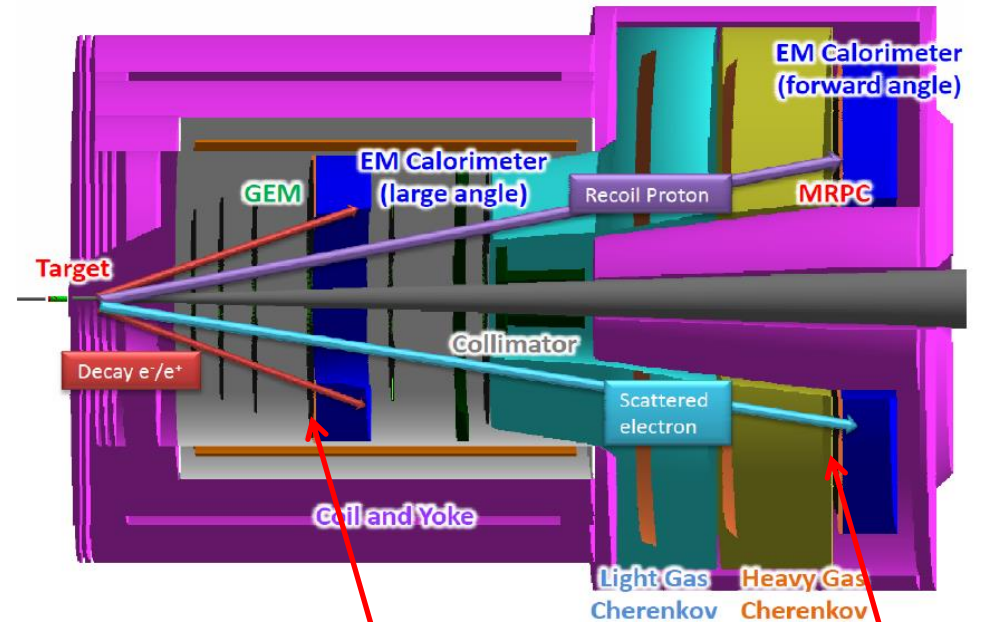


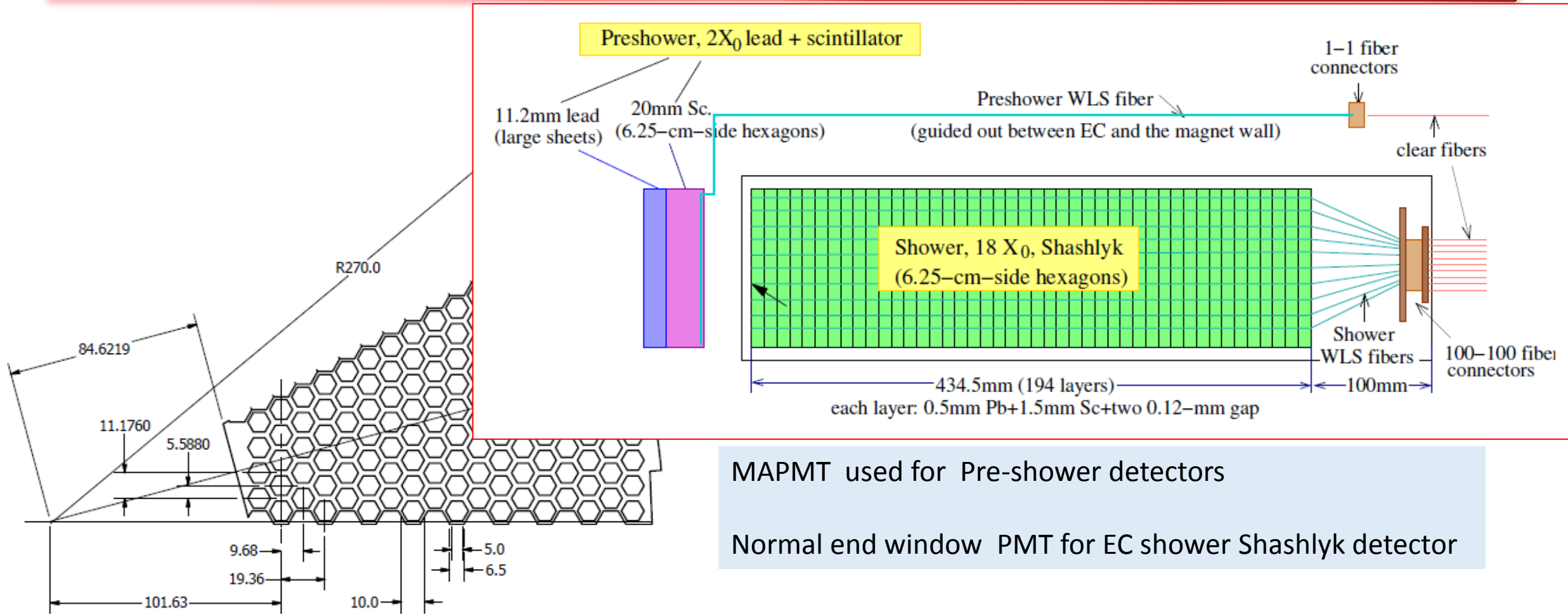
Figure 24: The experimental layout for the SoLID-J/ψ. The sub-detectors are labeled and the four final state particles are illustrated with arrows. The scattered electron and recoil proton are detected

SP just before LAEC

SP between C and MRPC



# Layout of the EM calorimeter



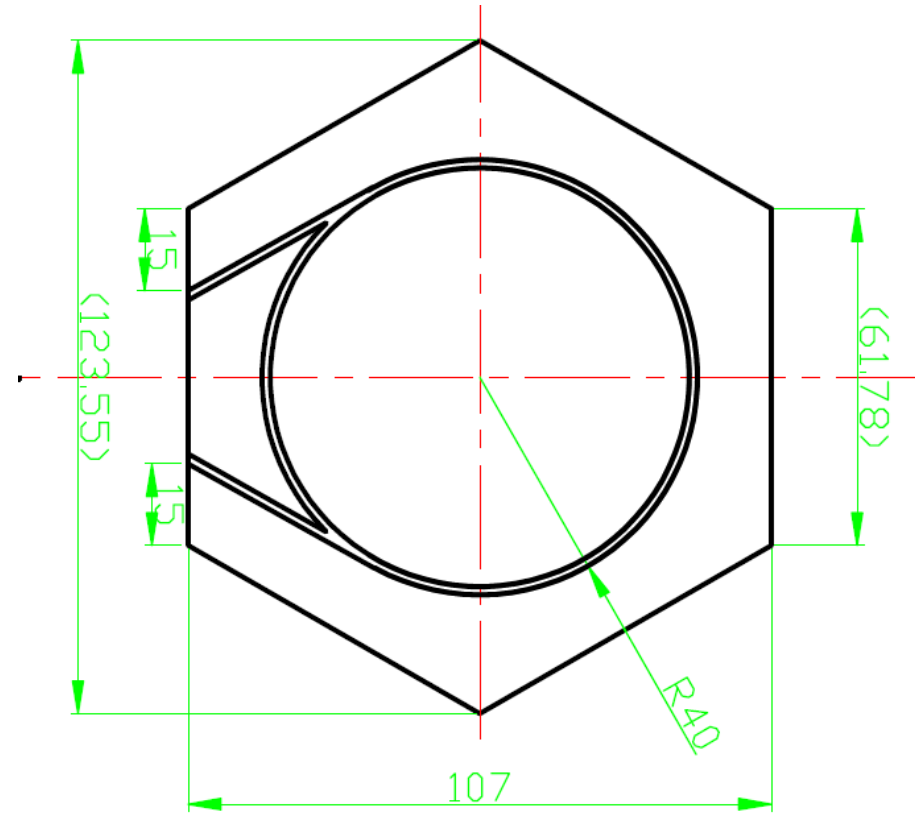
MAPMT used for Pre-shower detectors

Normal end window PMT for EC shower Shashlyk detector



# Pre-shower module in SDU

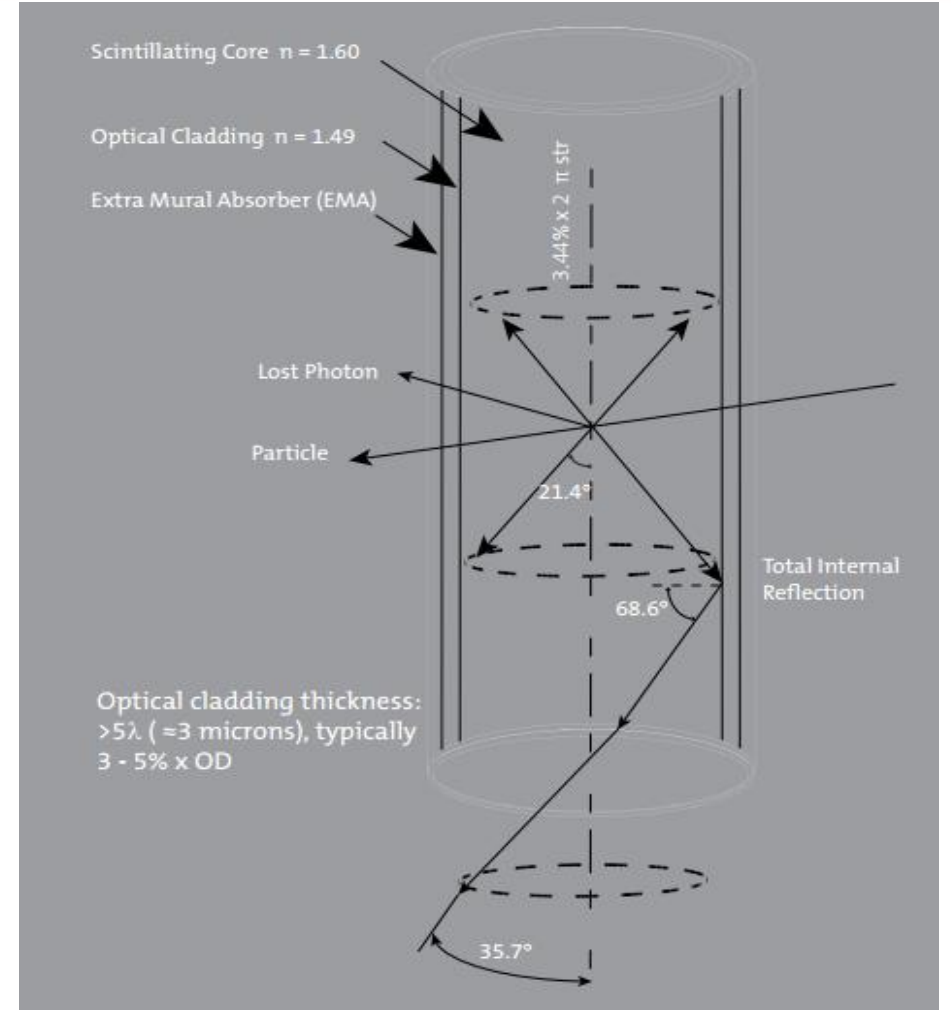
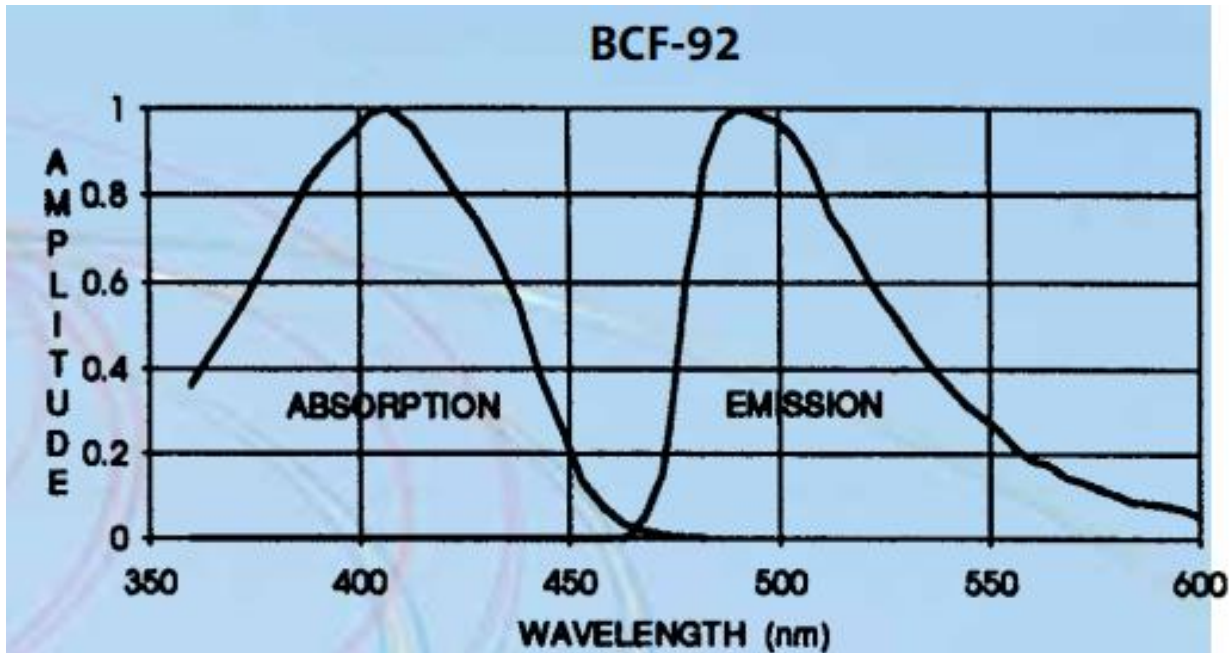
- HND-S2: Kedi, China
  - Density:  $1.05\text{g/cm}^3$
  - Refraction index: 1.59
  - Emission peak : 420nm
  - Light yield(photons/MeV): 8000
- Thickness: 20 mm
- Depth of groove: 2 mm
- Shape 1: Hexagon, side 6 cm
- Shape 2: Square,  $10*10$  cm





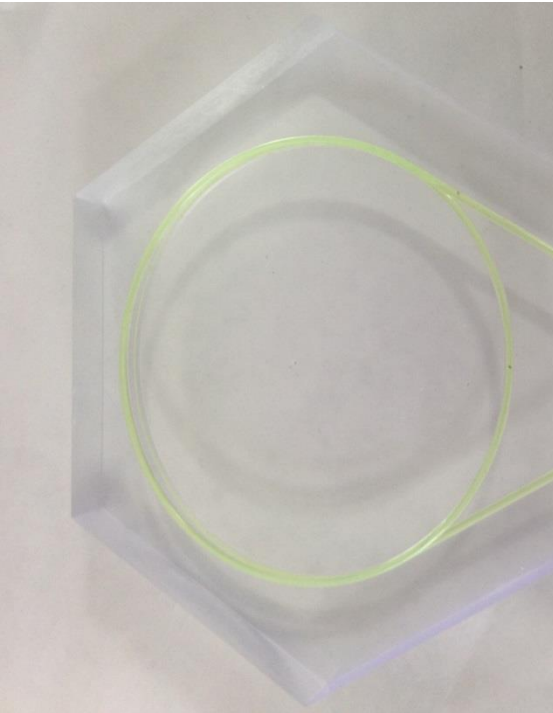
# WLS BCF-92

- Type: BCF-92(Saint-gobain)
- Diameter: 1.5 mm

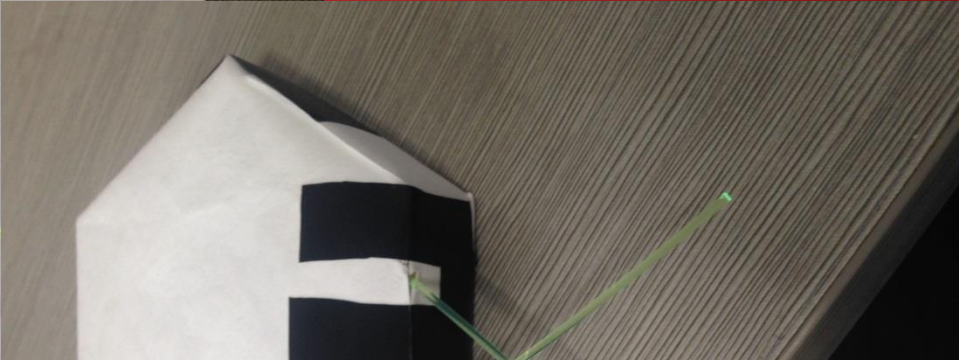




# Scintillator module



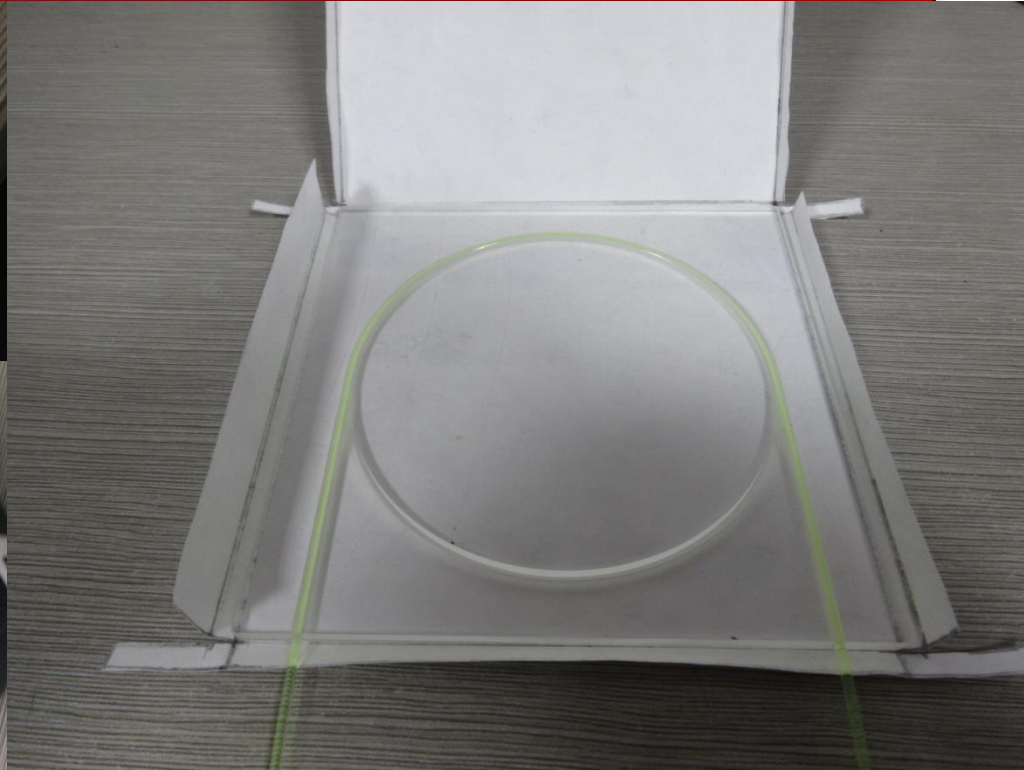
WLS Fiber air couple to scintillator



Packaged with



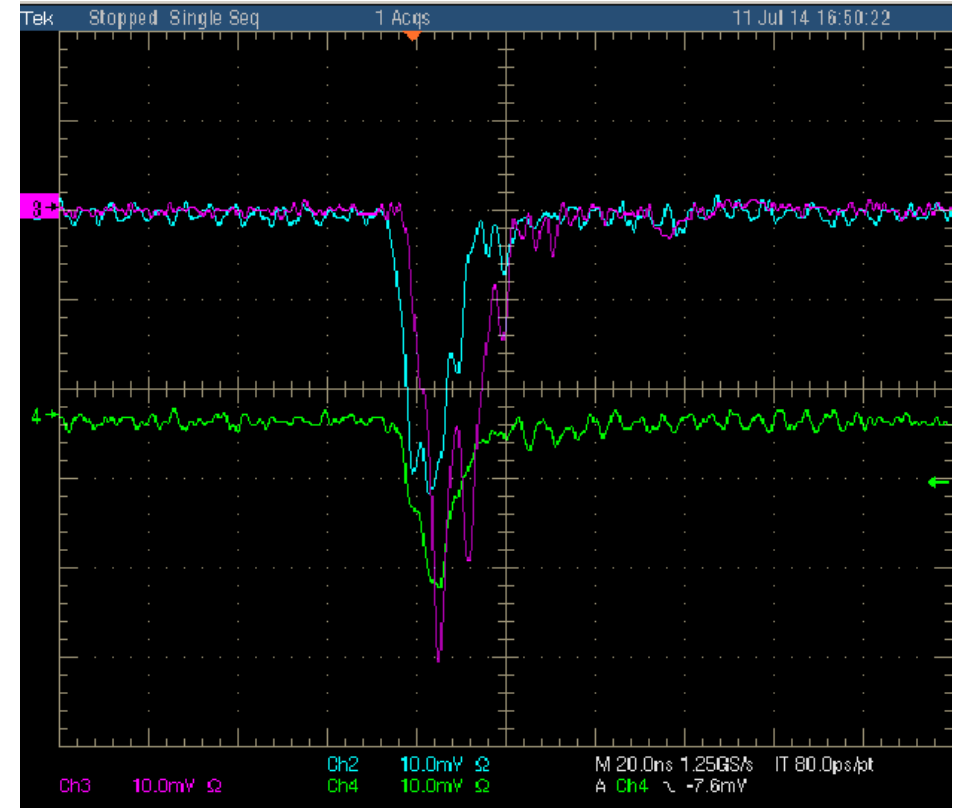
Packaged with black tape



Square scintillator with fiber before package



# Light yield preliminary test



PMT type: HAMAMATSU R11102,

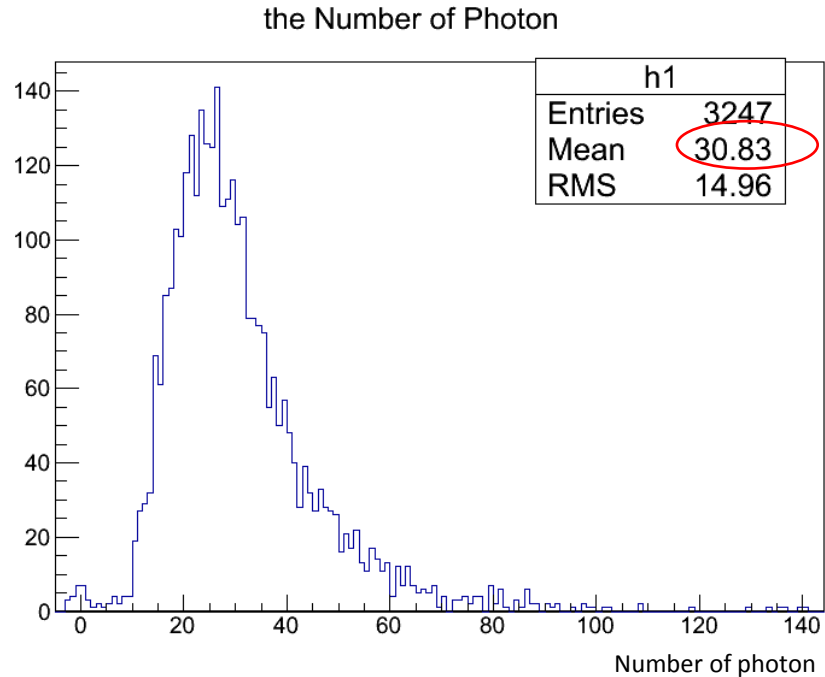
Gain:  $10^6$ .

One LABVIEW program record the waveforms.



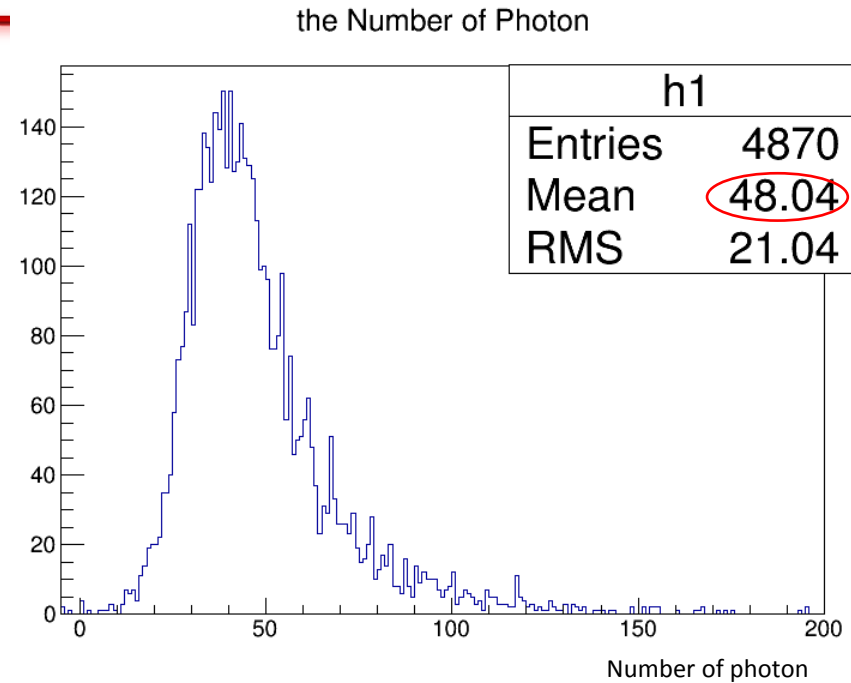


# Hexagon shape module test results



Fiber: 1 turn

Mean number of photons recorded by the PMT is 31

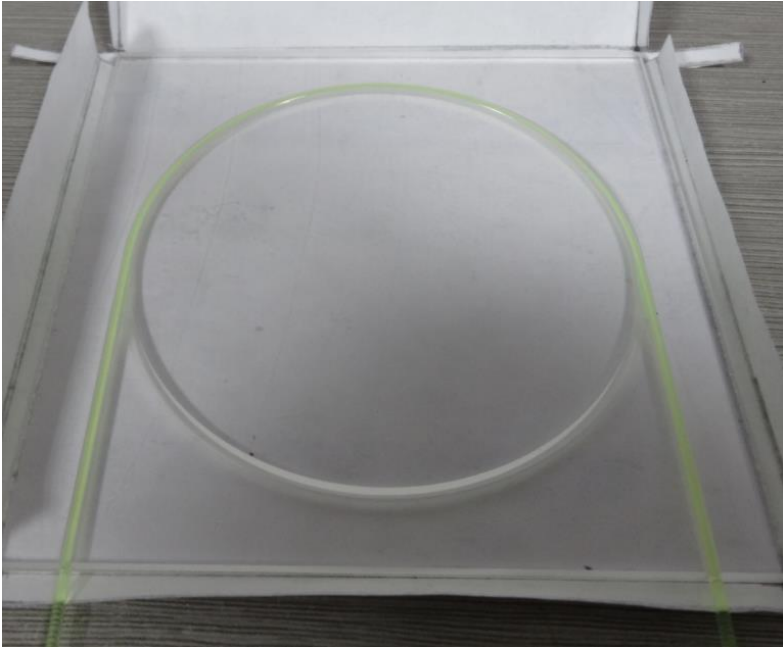


Fiber: 2 turn

Mean number of photons recorded by the PMT is 48



# Square module test result



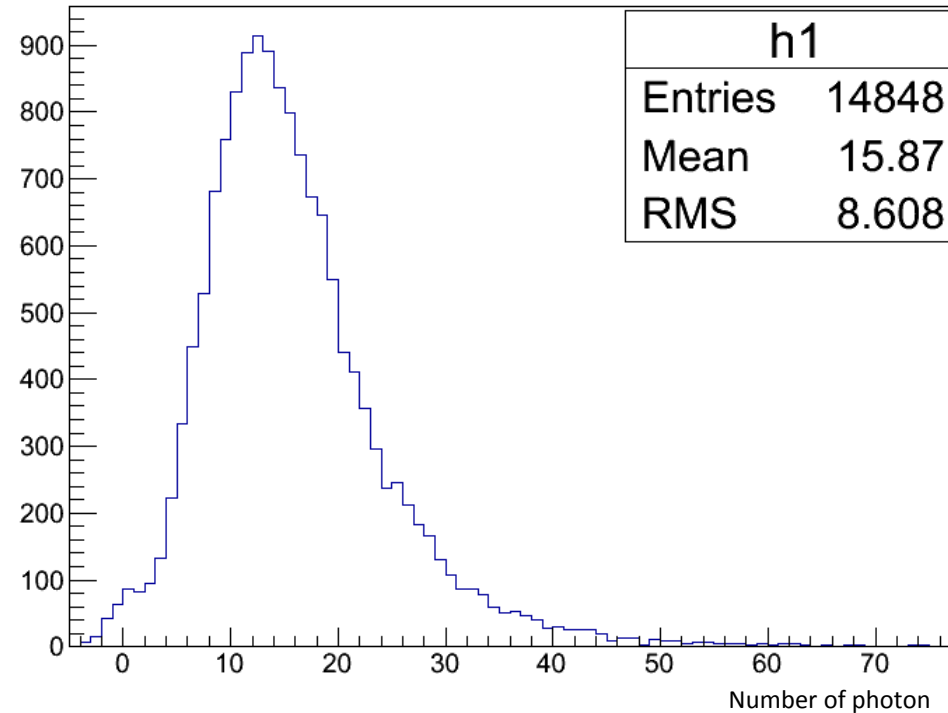
Size:  $10 \times 10 \text{ cm}^2$

Thickness: 2 cm

Diameter of circular groove: 9 cm

Only 1 turn of fiber, too shallow for 2 turn

the Number of Photon

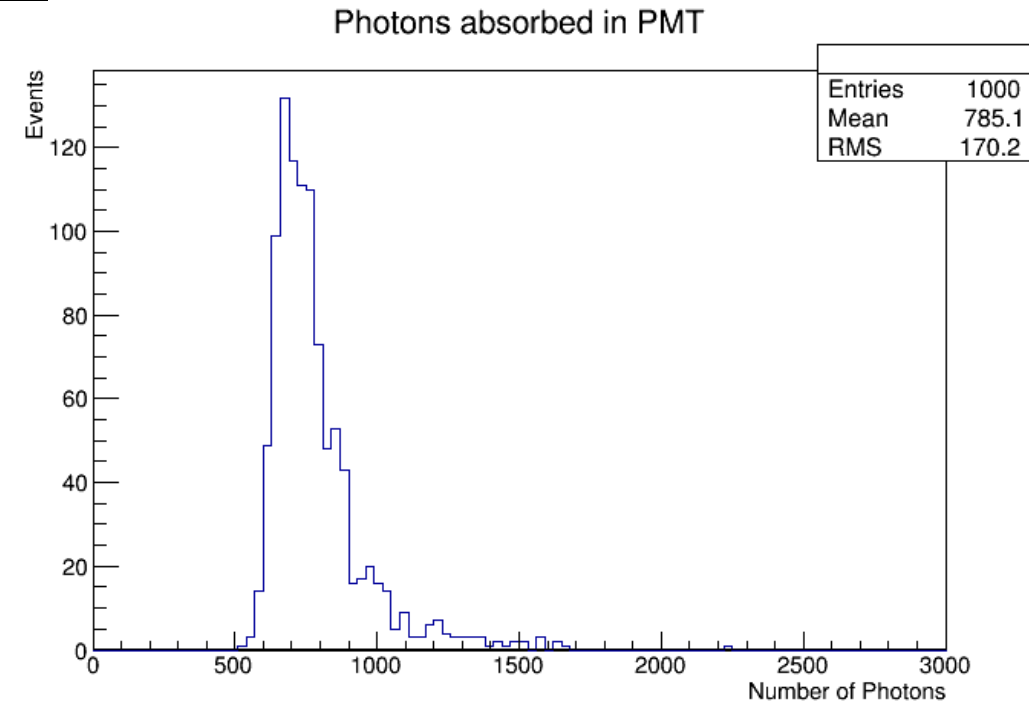
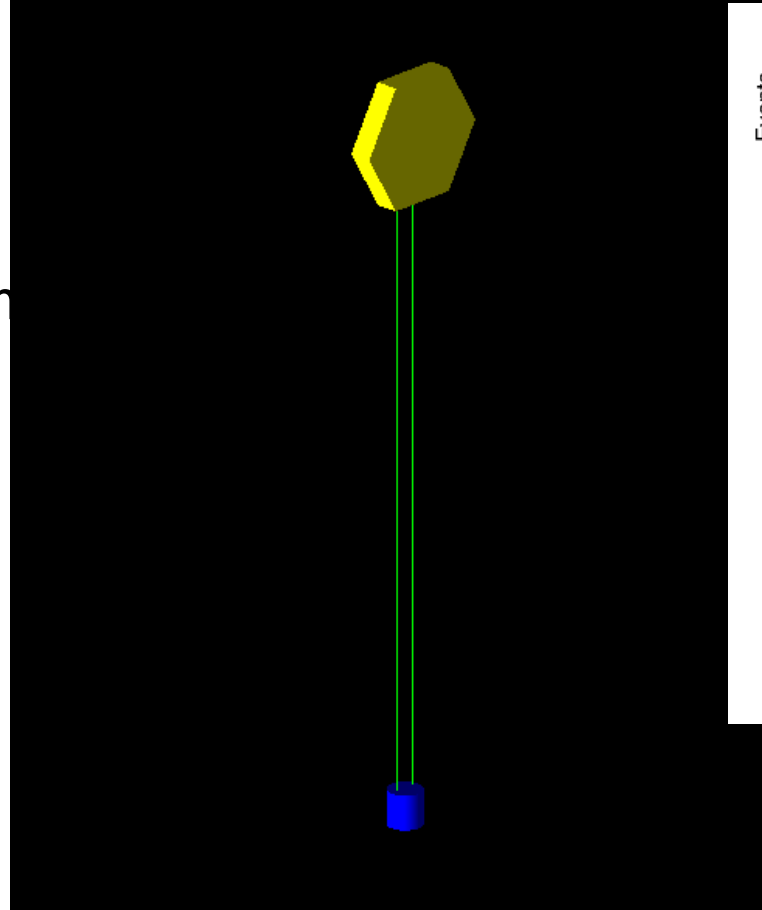


Less photons(16) than hexagon shape(31).  
Need to confirm.



# Simulation with GEANT4

- Scintillator thickness: 2cm
- Fiber : one turn,  $\Phi$  1.5 mm
- Package: tyvek paper

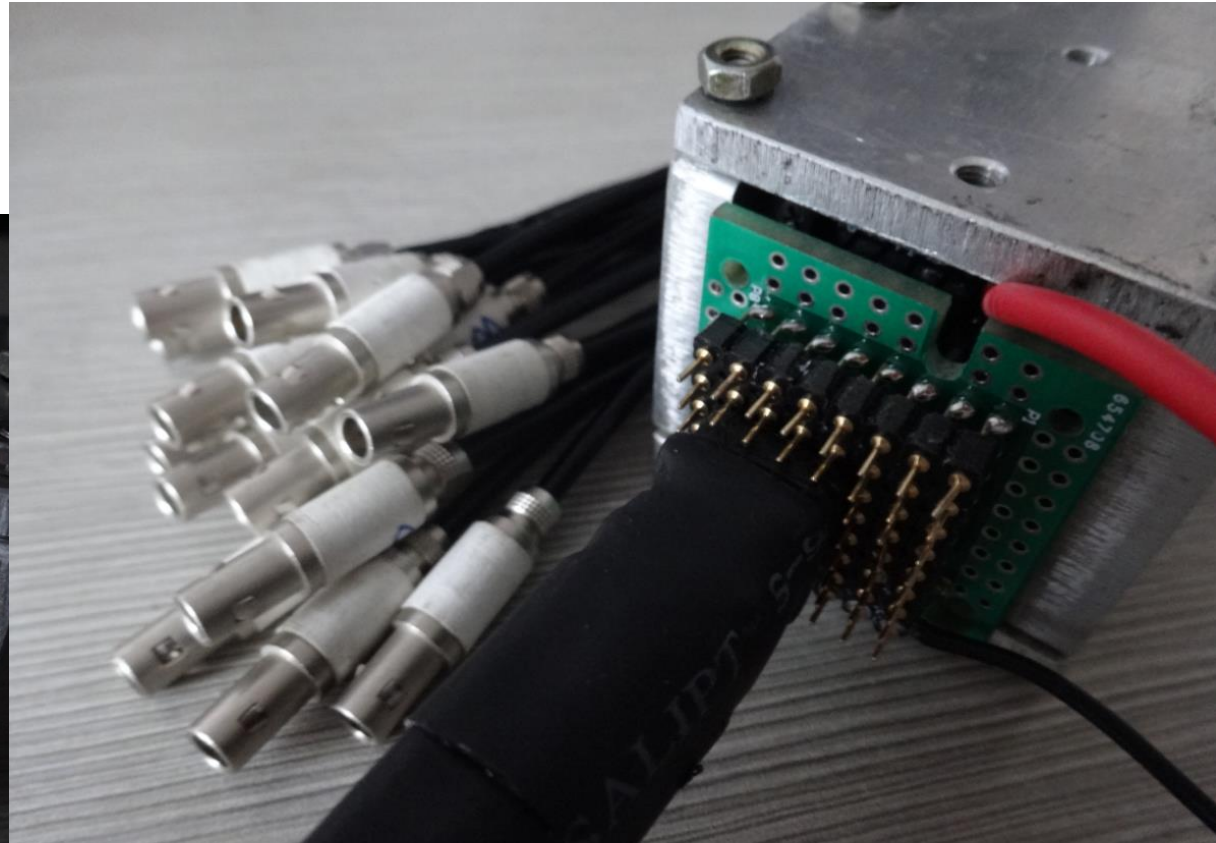
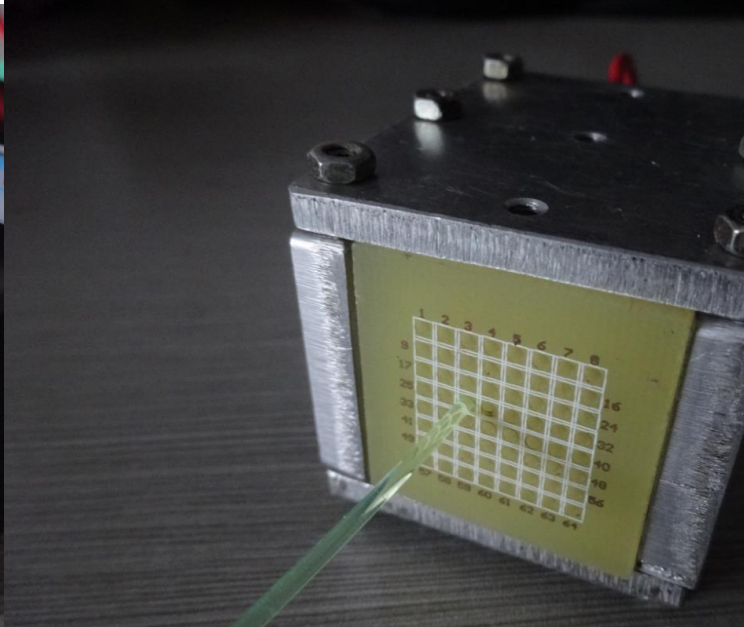
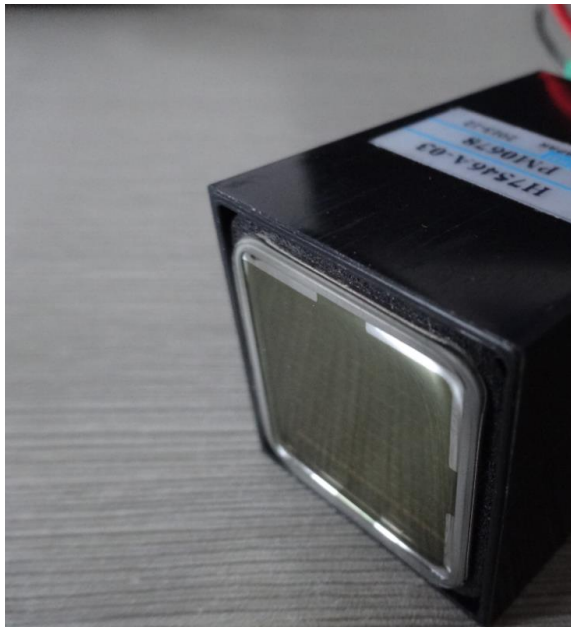


The number of photons which reach the PMT cathode is recorded, no quantum effect and collection of PMT is considered



# Multi-anode PMT

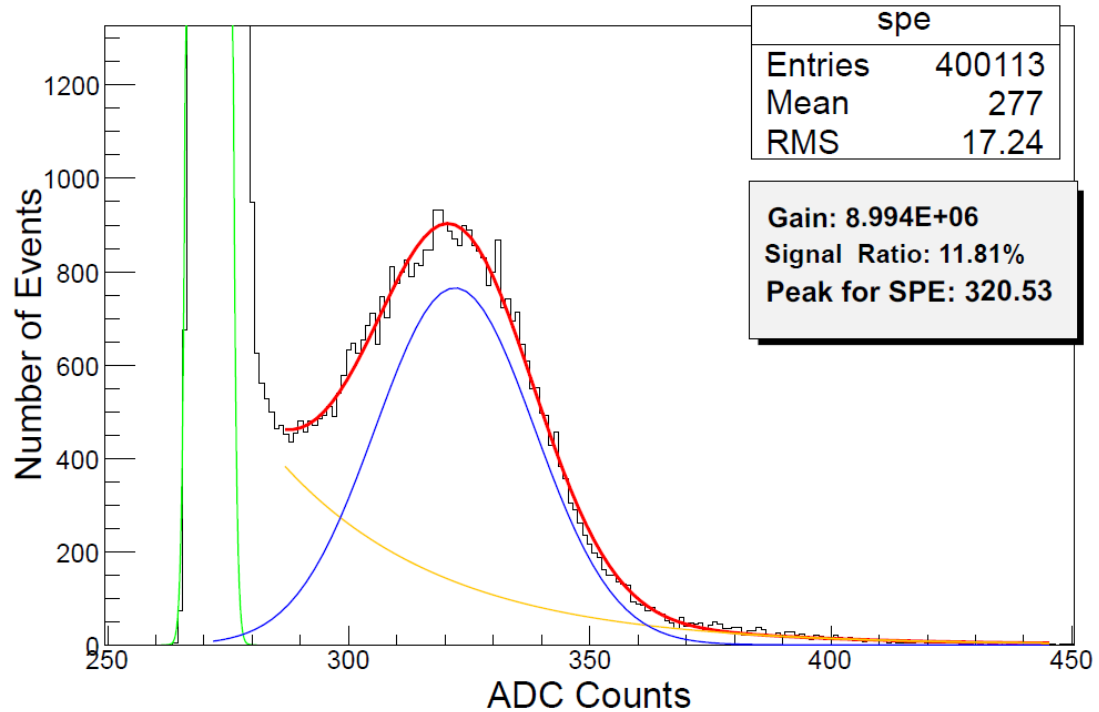
- HAMAMATSU, H7546A
  - 8\*8 anodes, anode size: 2\*2mm/anode
  - Cross-talk: 2% type
  - 12-stage
  - Voltage-divider circuit: 3:2:2:1...1:2:5





# Preliminary test results of MAPMT

The fitting of the Pedestal and SPE



Single photoelectron peak

<1%	3.2	<1%
4.15	81	3.85
<1%	3.1	<1%

Cross talk for the central channel. The amplitude (mV) for this channel and neighbor. Cross talk is larger than specification sheet due to 1.5 mm fiber.



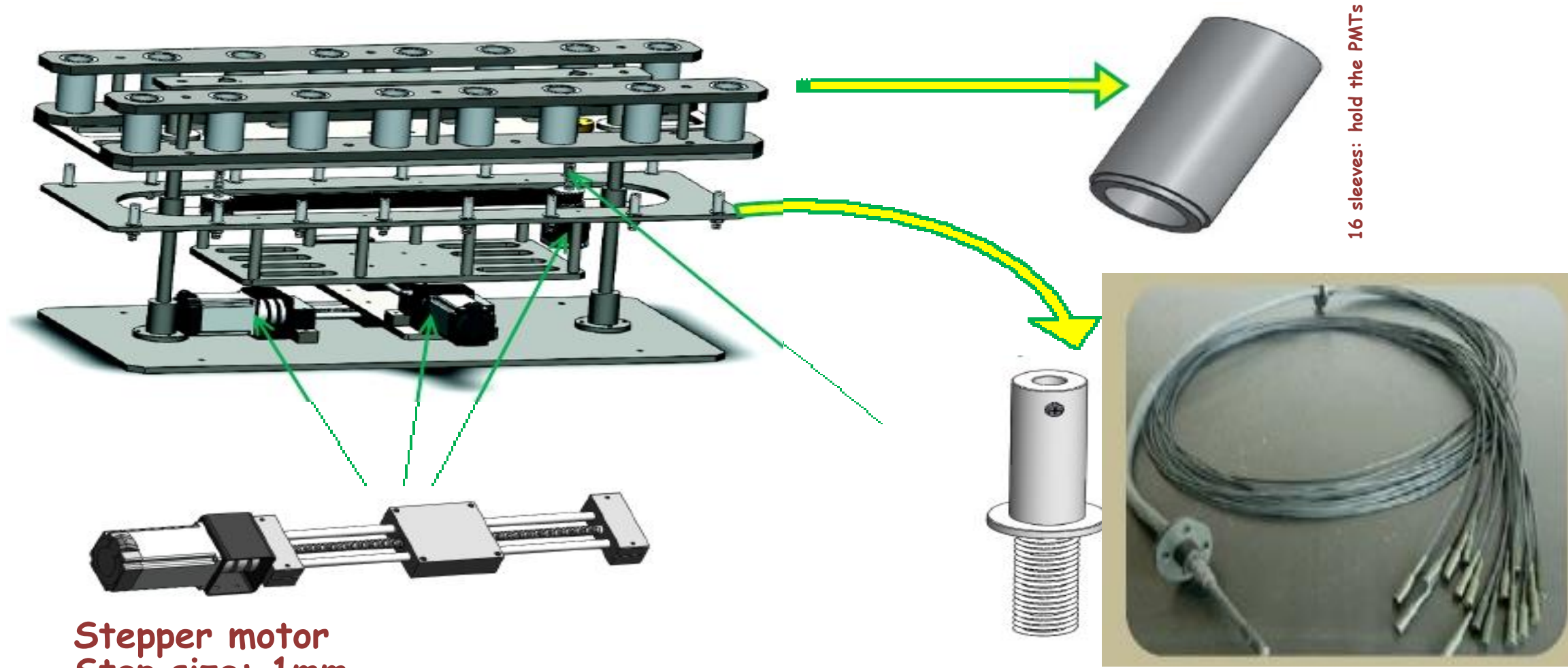
# PMT test bench in SDU

A PMT test bench was setup in SDU, which include:

- ✓ One light tight box
  - Hold 16 PMTs
  - 2D scanning system
- ✓ Picosecond pulse laser: PLP-10, Hamamatsu
- ✓ Multi-channel High voltage power supply: SY1527, CEAN
- ✓ VME DAQ system:
  - TDC: LSB=35ps
  - QDC: dual range, 100/900pC, 12-bit
  - Scaler
  - NIM module
- ✓ Artificial climate box: -40~150 °C
- ✓ 16 PMTs can be test in one patch with this bench



# The chart of machinery architecture in light tight box



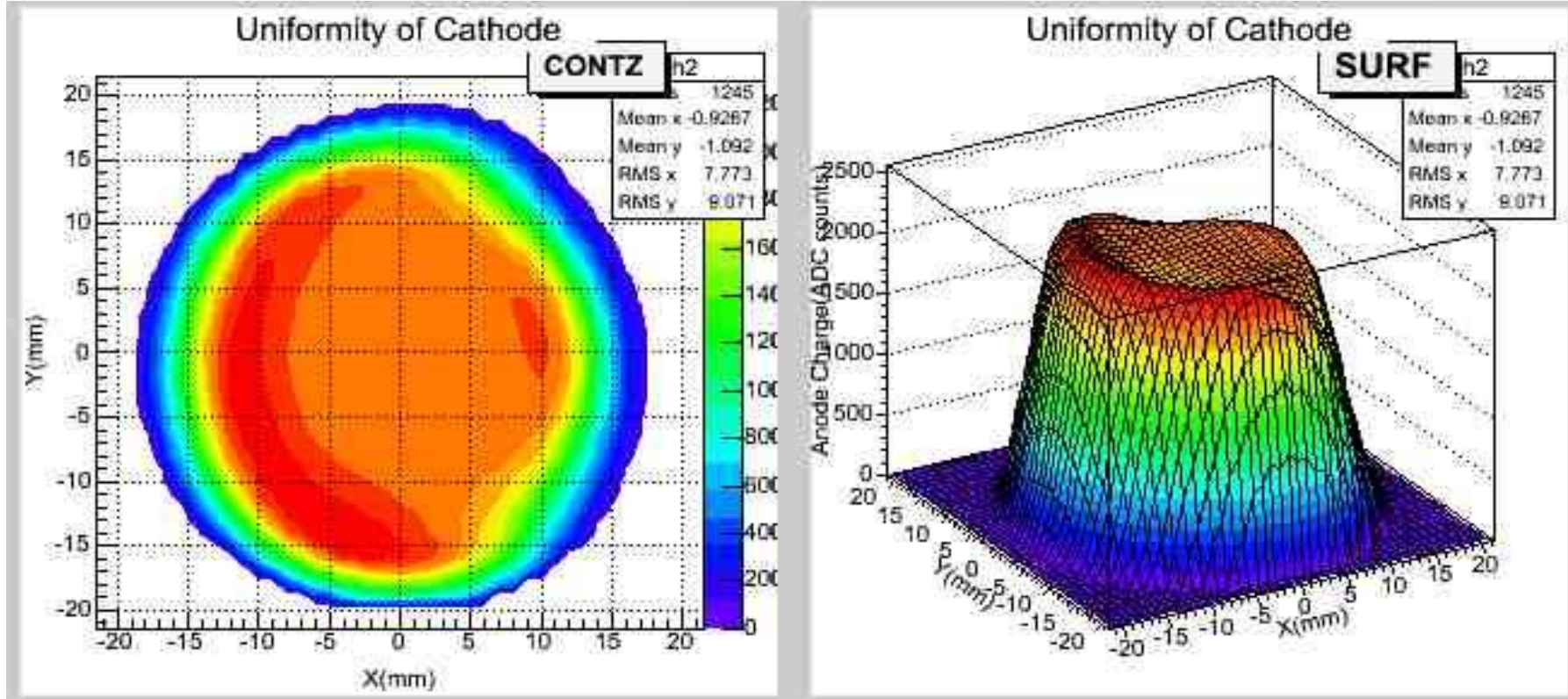
**Stepper motor**  
**Step size: 1mm**  
**Step range: 5 cm in x and y, 10cm in Z**

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A bunch of 16 clean optical fibers, guide the pulse light into PMT.



# Uniformity of cathode test results



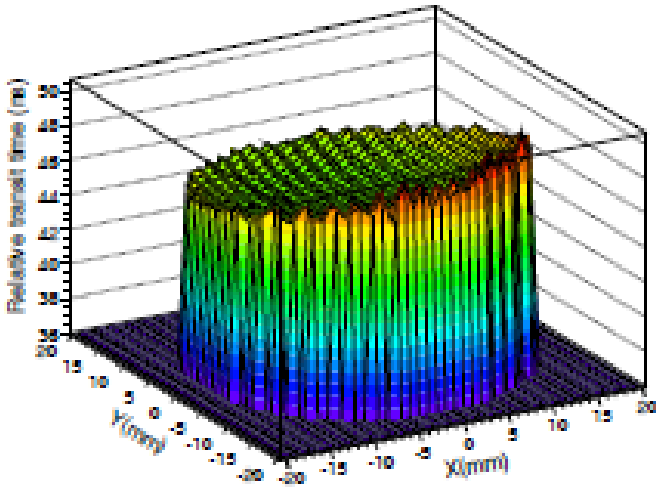
Step size: 1mm. The PMT: R11102. The non-uniformity of the cathode are visible.



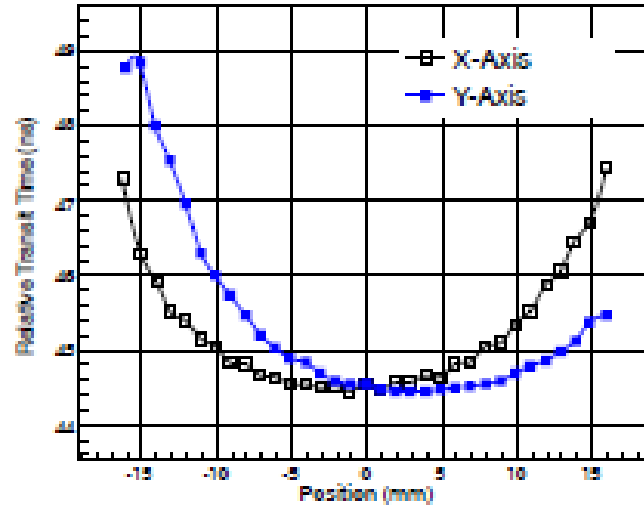


# Cathode transit time difference

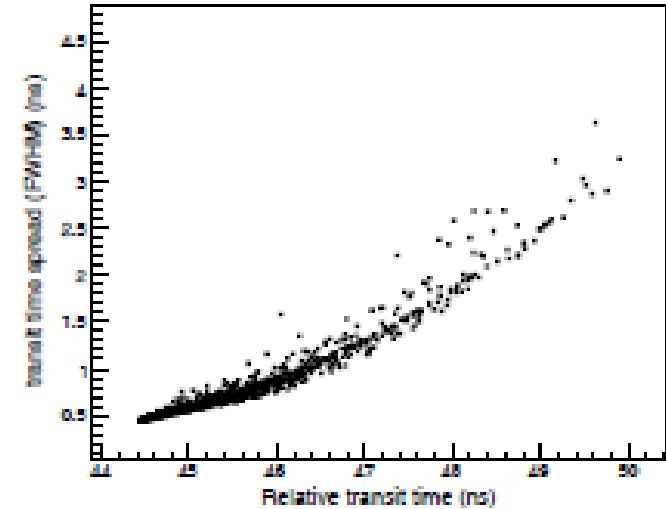
Relative transit time uniformity



(a) Surface plot



(b) X-Y Axis

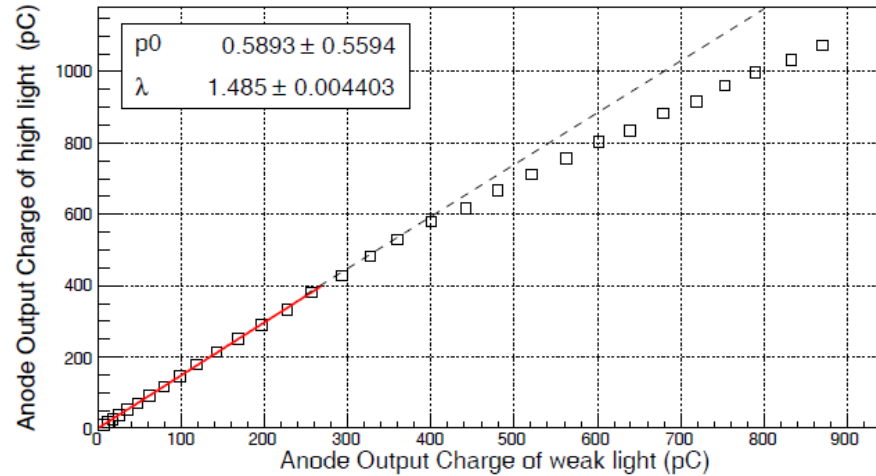
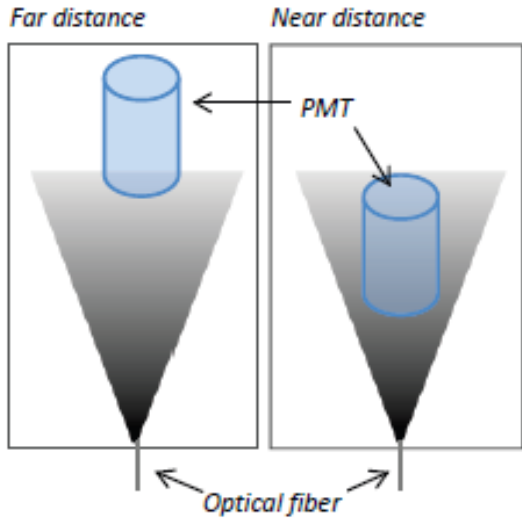


(c) Transit time spread vs. transit time

Test with same scanning system. The relative transit time is difference for light incident from different cathode position.



# Linear dynamic range

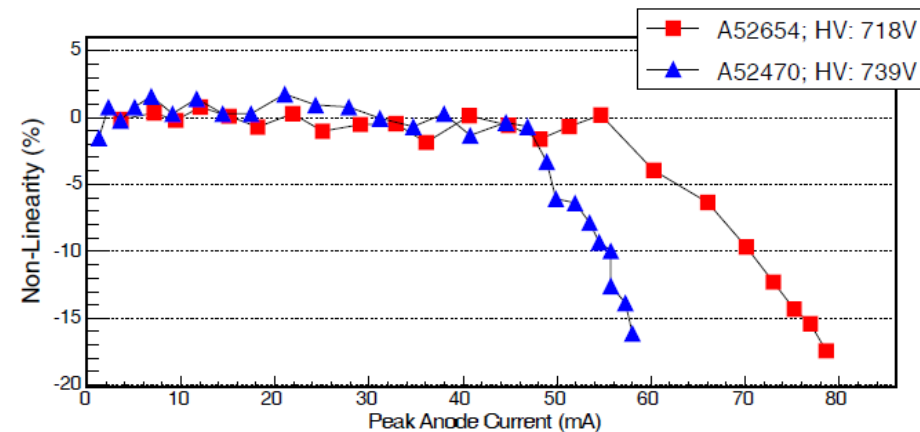


$\lambda$  : Fit first few point

Di-distance method. The ratio of incident light intensity on PMT for both distance is constant  $\lambda$ .

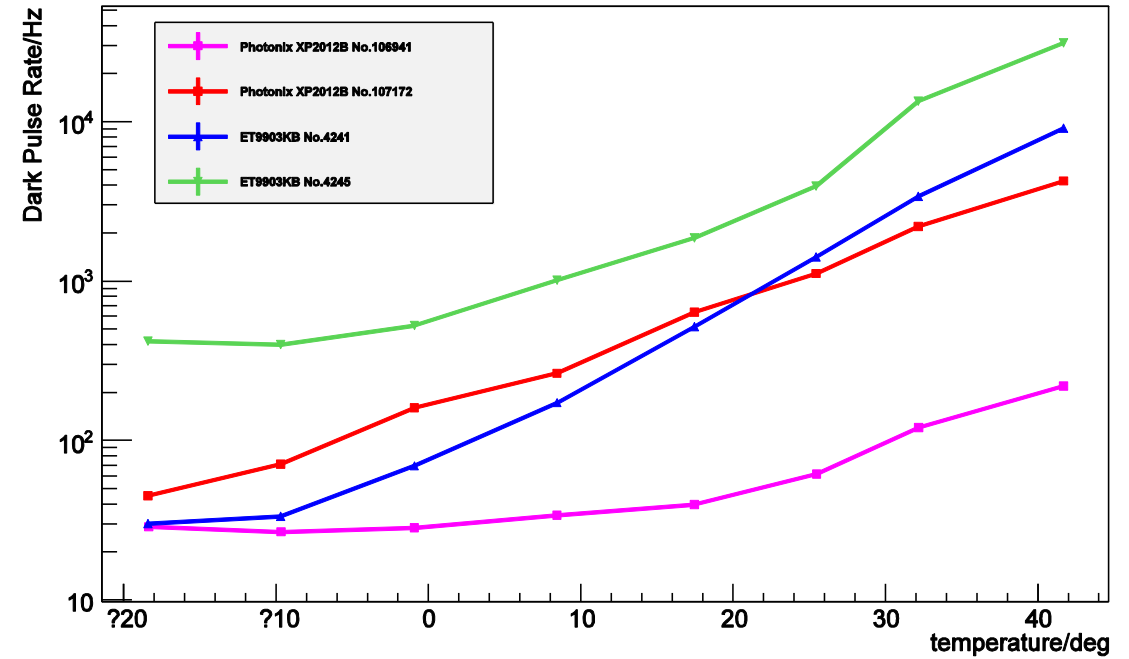
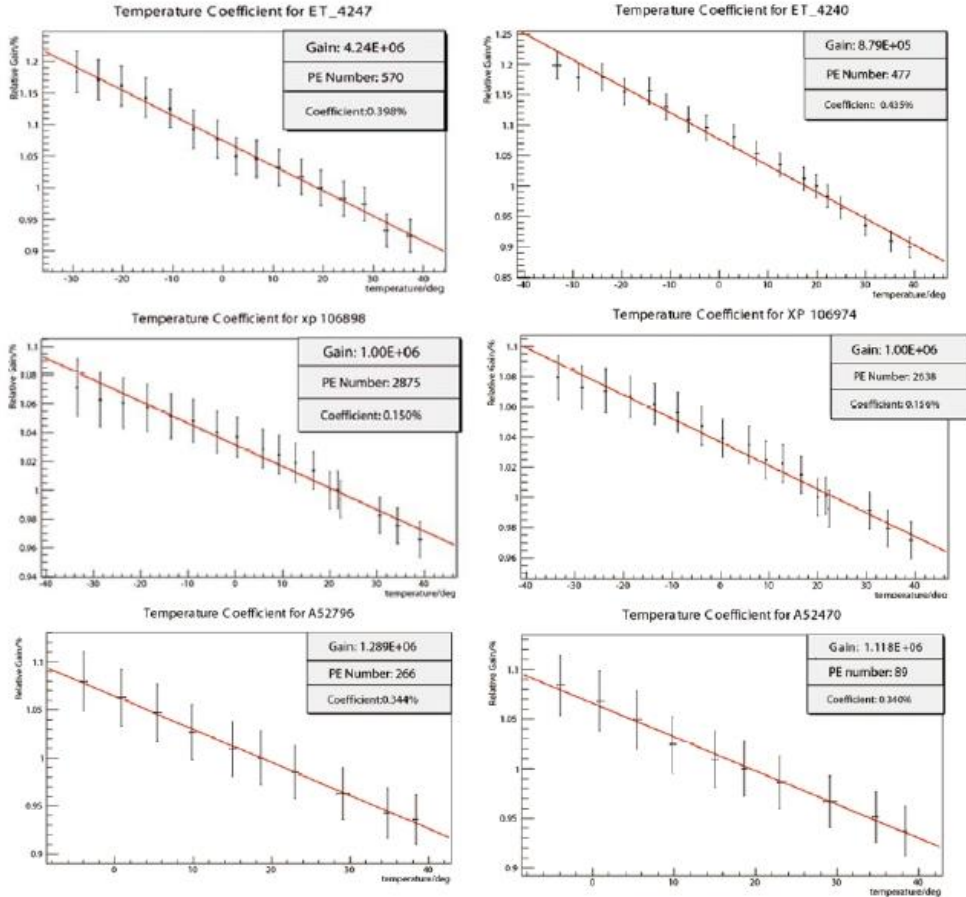
$$Non-Linearity = \left( \frac{S_{near}}{S_{far}} - \lambda \right) / \lambda$$

The test range depends on the electronic and light source. We can test from SPE to 900 pC.





# Effect of temperature

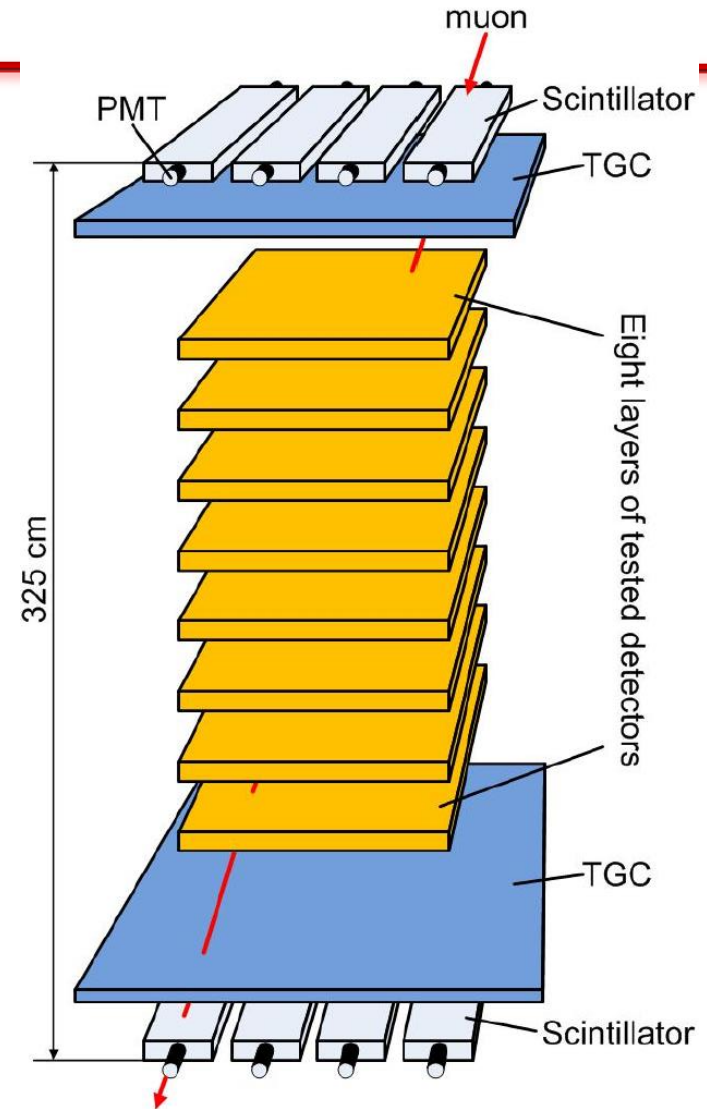


Dark pulse rate increase following the temperature increasing .

Gain decrease following the temperature increasing.



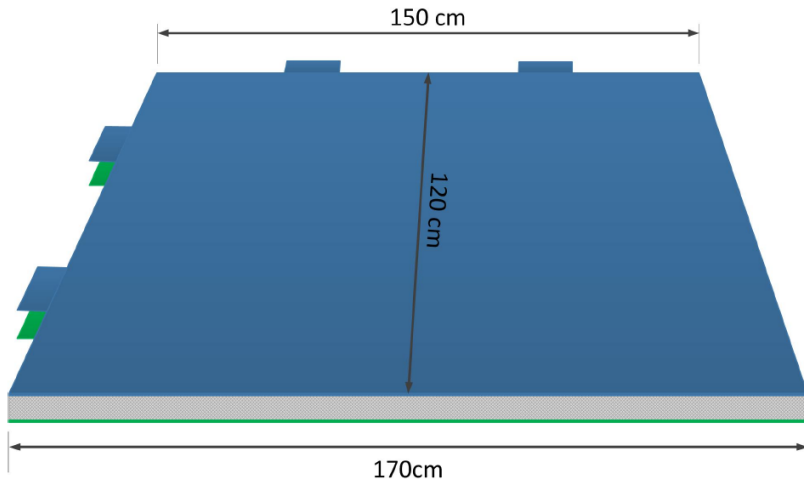
# Cosmic Ray reference System (CoRaRS)



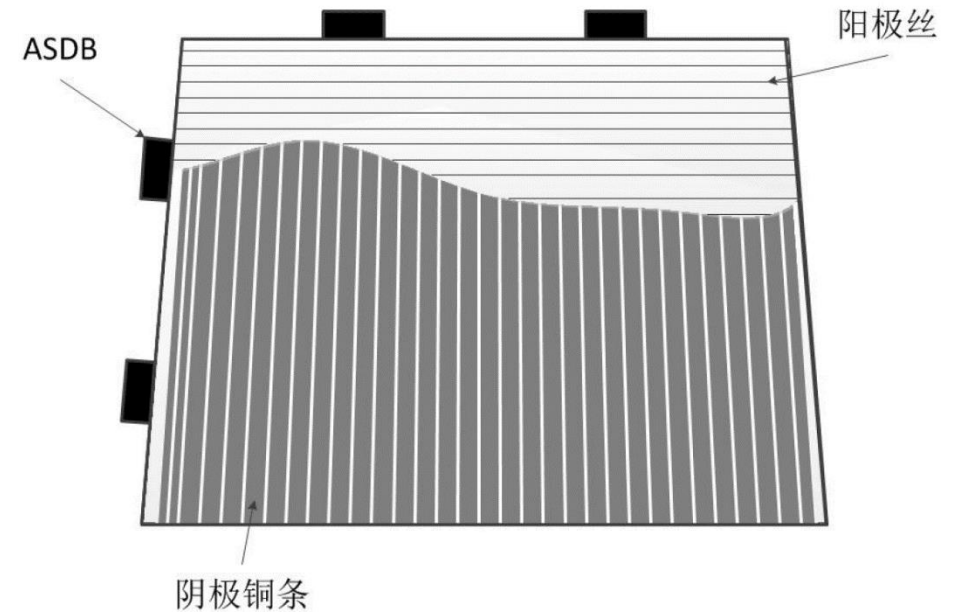
Picture of the CoRaRS laboratory and the diagram of the system.



# CoRaRS: TGC



Tine Gap Chamber, used in ATLAS as muon trigger detector.



2 dimension read out

Wire: Width of wire group: 1.9 cm,

Resolution: 0.6 cm

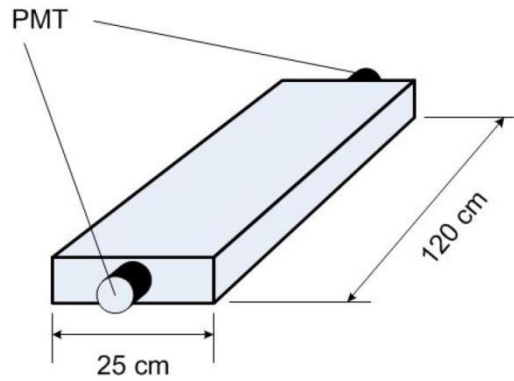
Strip: Width: 2.5 cm

Resolution: 0.7 cm

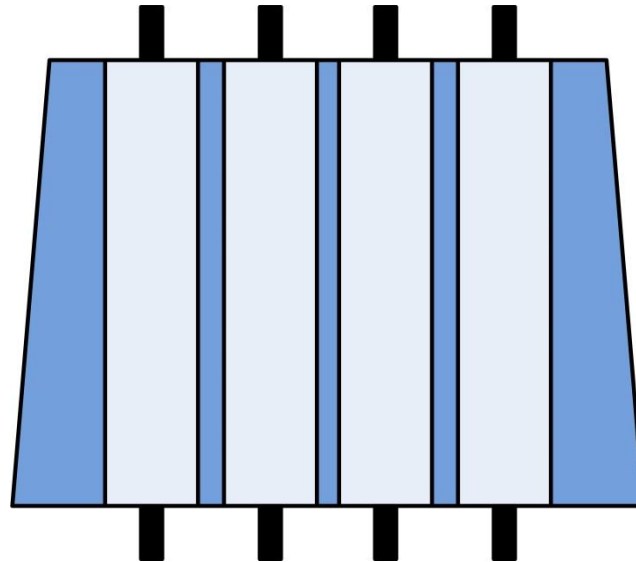


# CoRaRS: trigger

8 scintillators used for trigger



One scintillator module



4 top/down scintillators

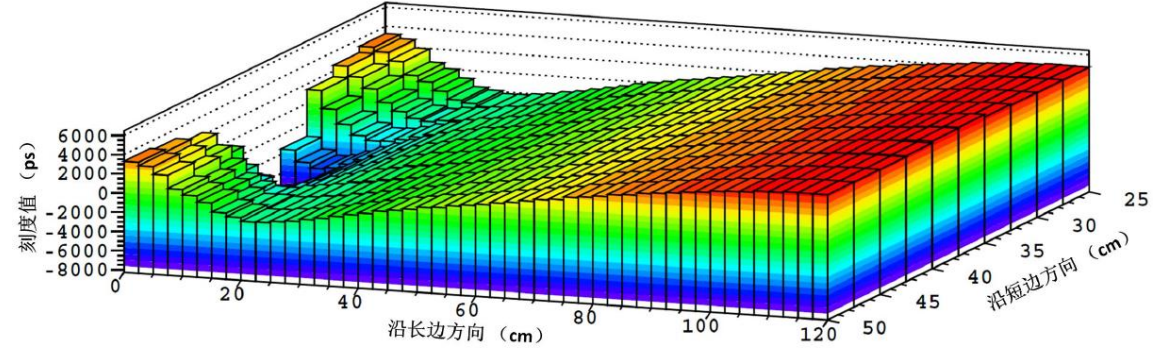
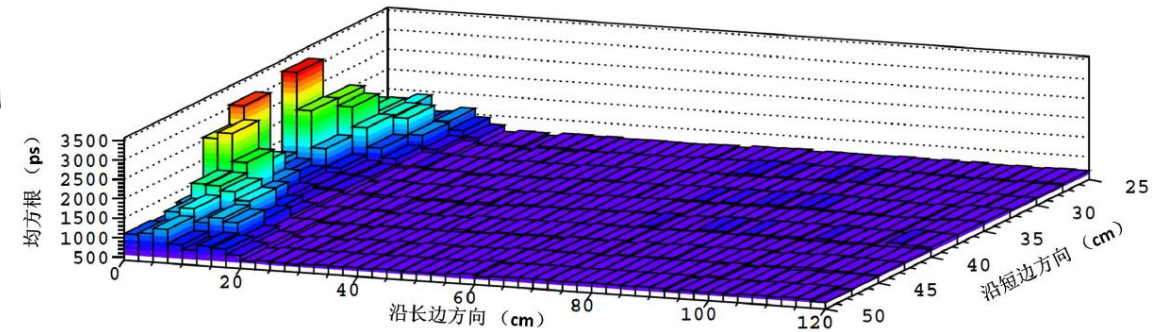


图 7.23: 下层最左侧的闪烁体探测器各区域的刻度值的平均值的分布



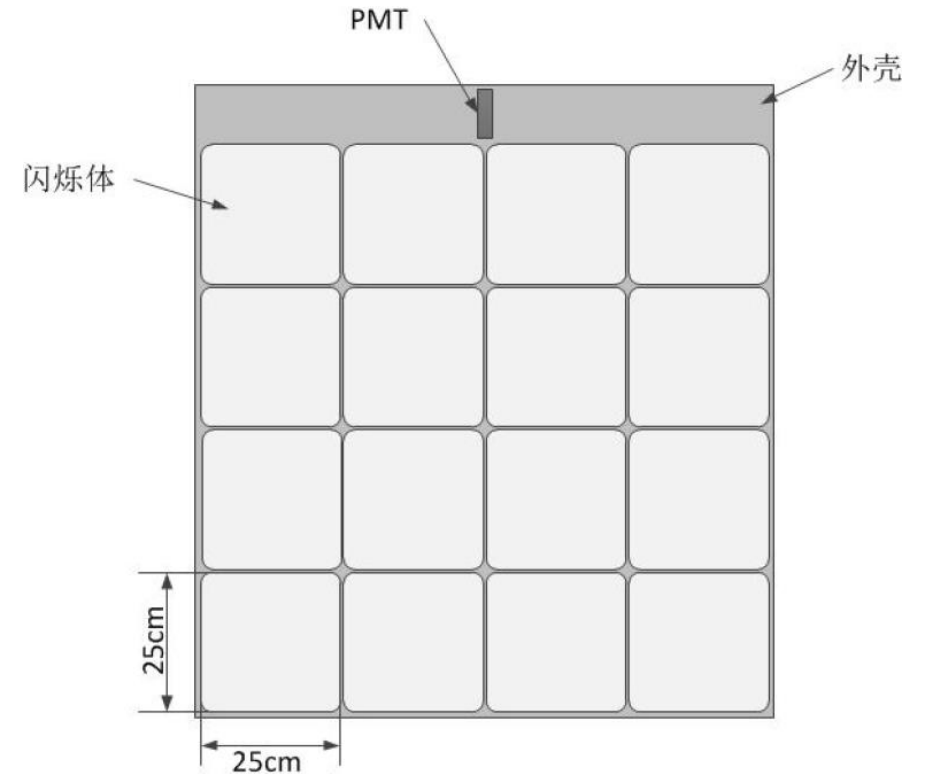
Time calibration. time resolution: 630 ps



# Prototype electromagnetic detector of LHAASO

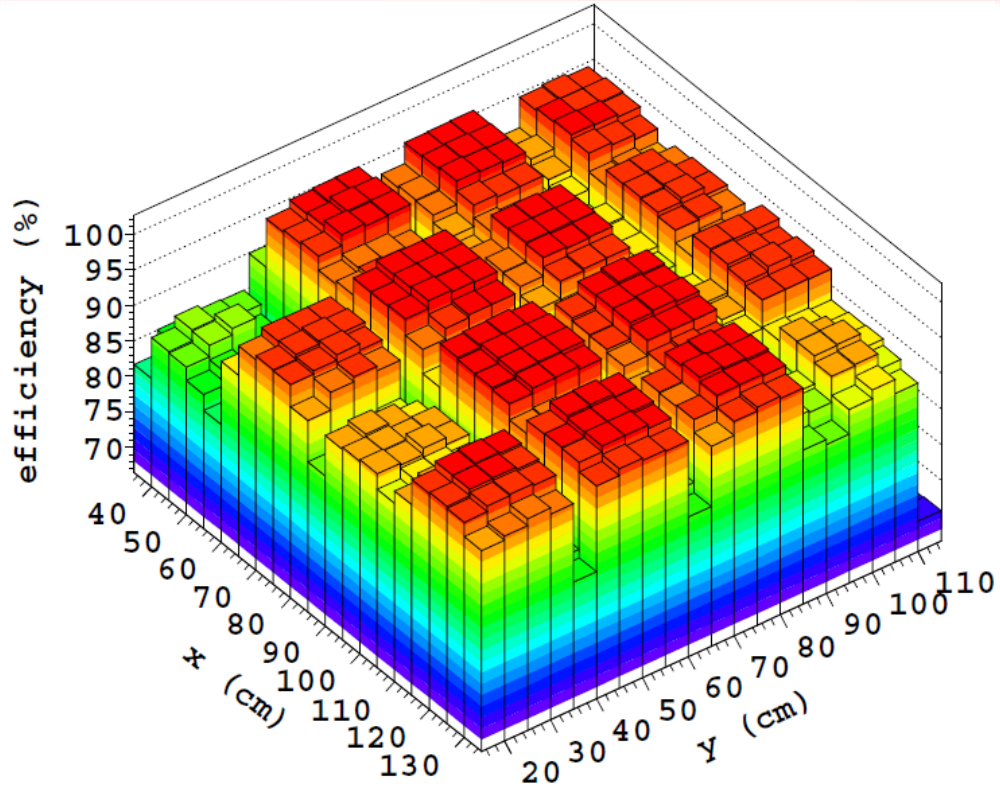


Sensitive area: 1 m<sup>2</sup>

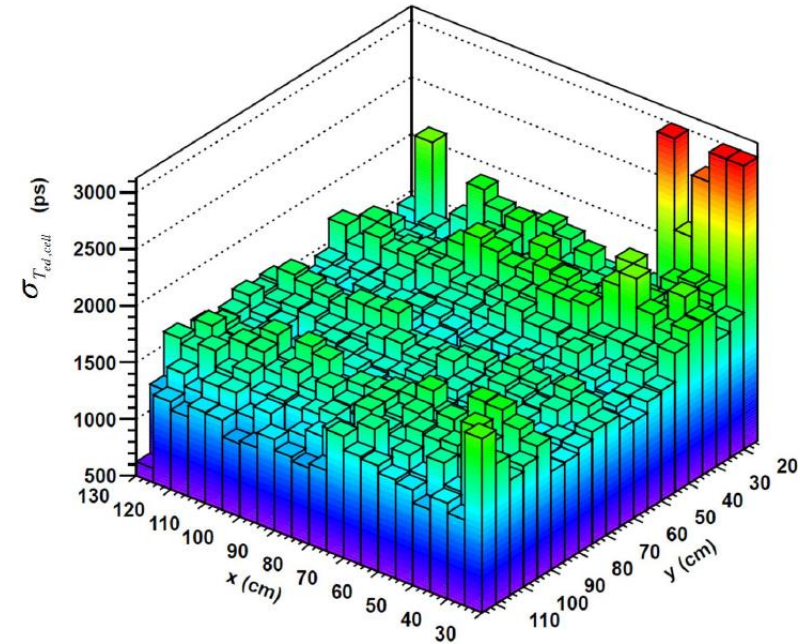




# Test results of the ED



Detect efficiency of each point. Low efficiency region due to detector problem.



Time resolution of each point on ED.





# Summary

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- Pre-shower detector preliminary study.
- One PMT test bench can test the end window PMT for SoLID in batch.
- The CoRaRs system can test the detector performance.

# Thanks !