SoLID EM calorimeter study and general test system in SDU

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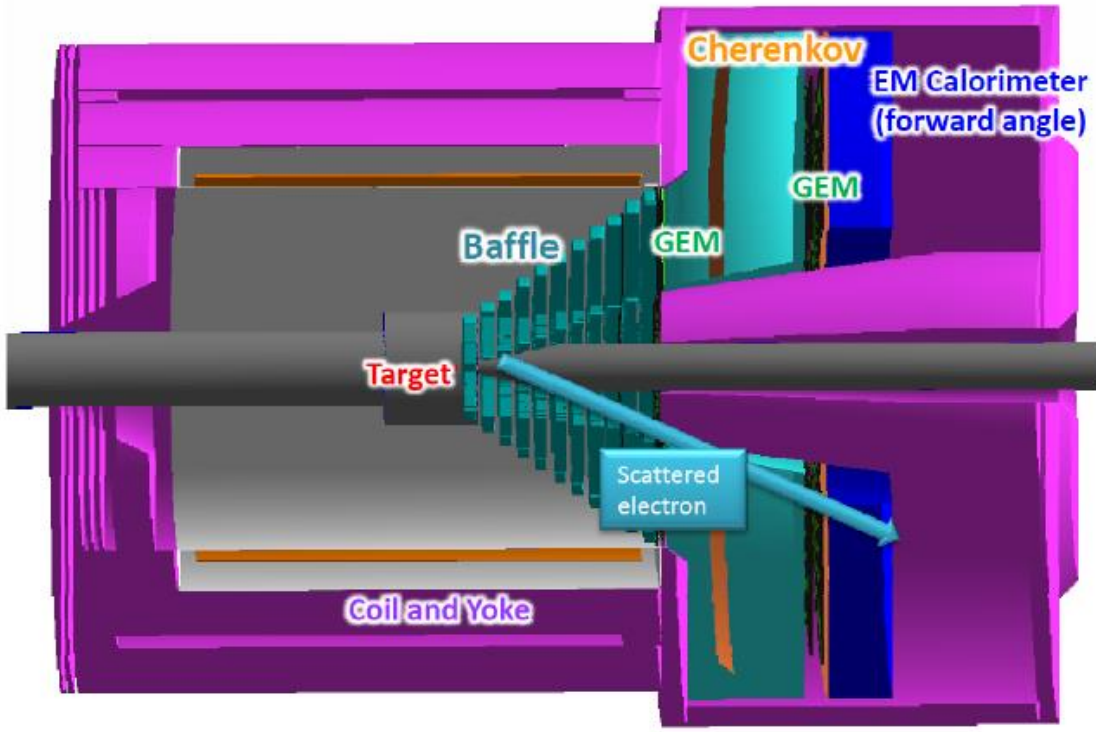
Outline

- 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

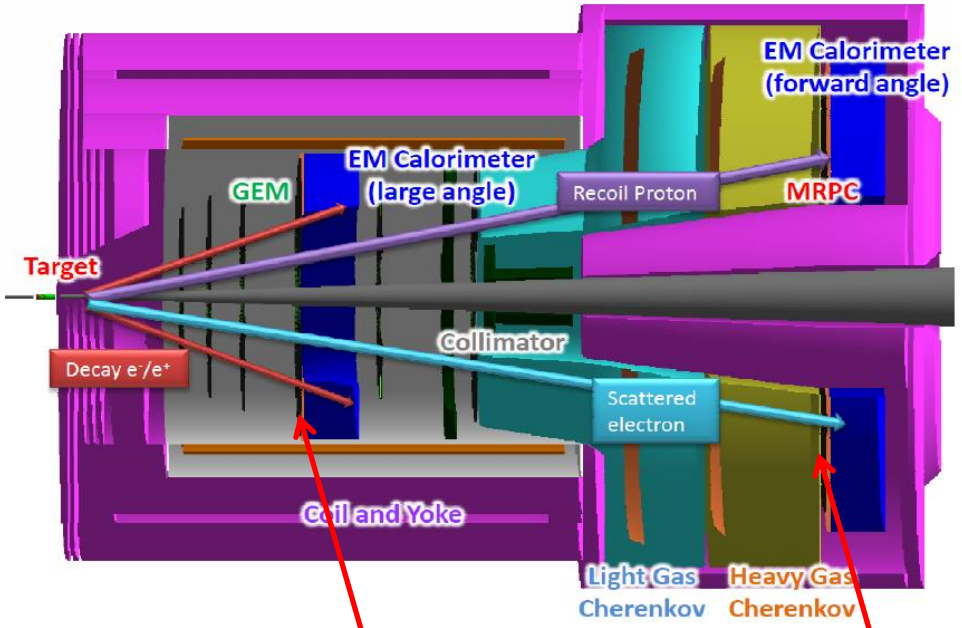
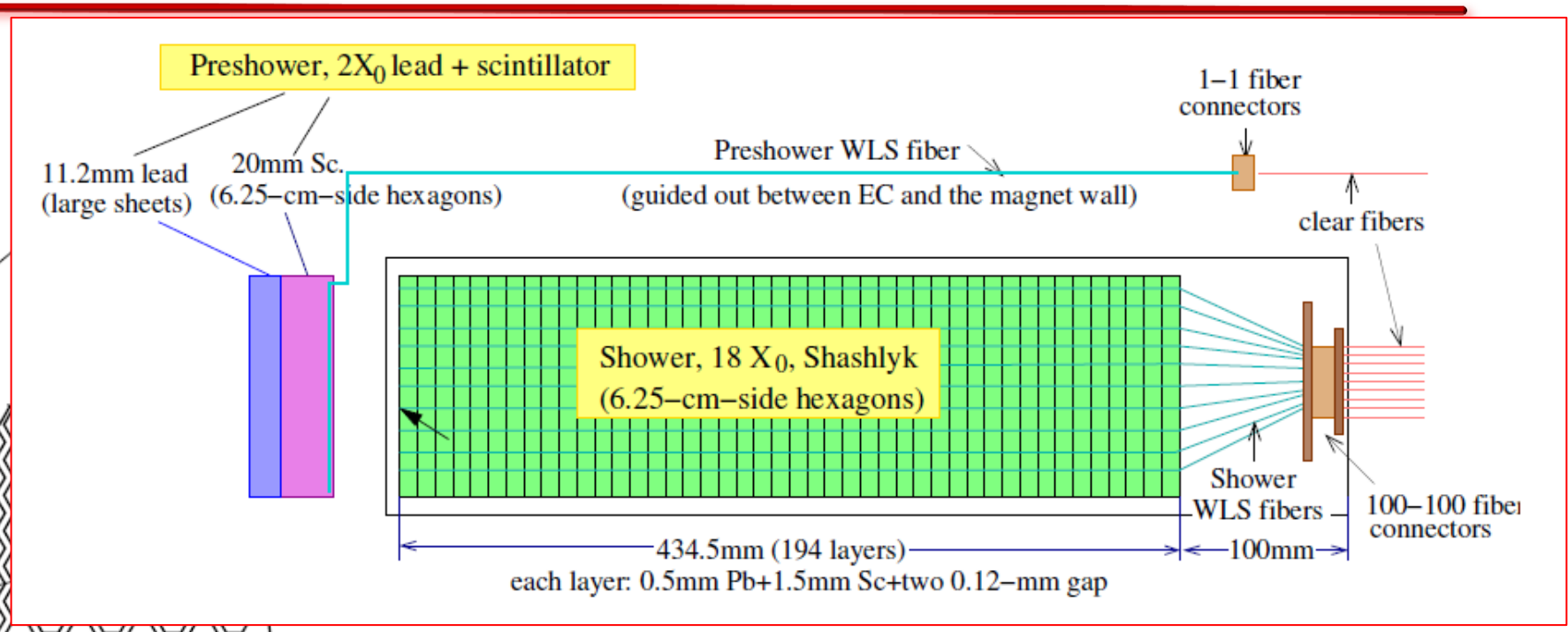


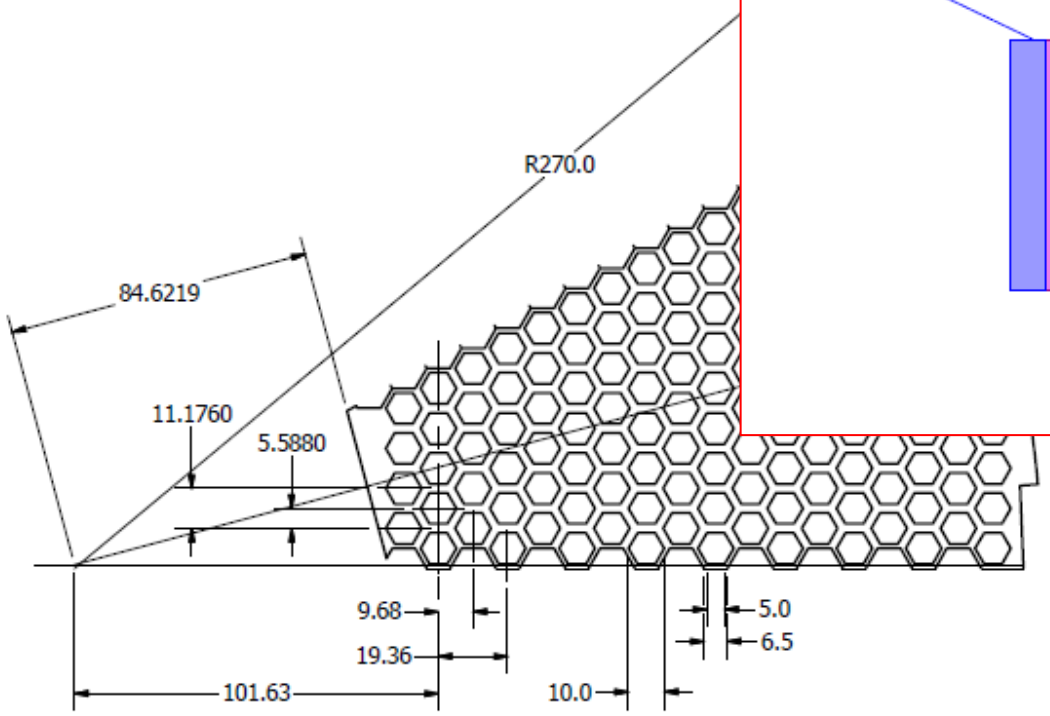
Figure 24: The experimental layout for the SoLID-J/ψ. The sub-detectors are labeled and the four final state particles are illustrated with arrows. The scattered electron and recoil proton are detected

SP just before LAEC

SP between C and MRPC

Layout of the EM calorimeter





MAPMT used for Pre-shower detectors

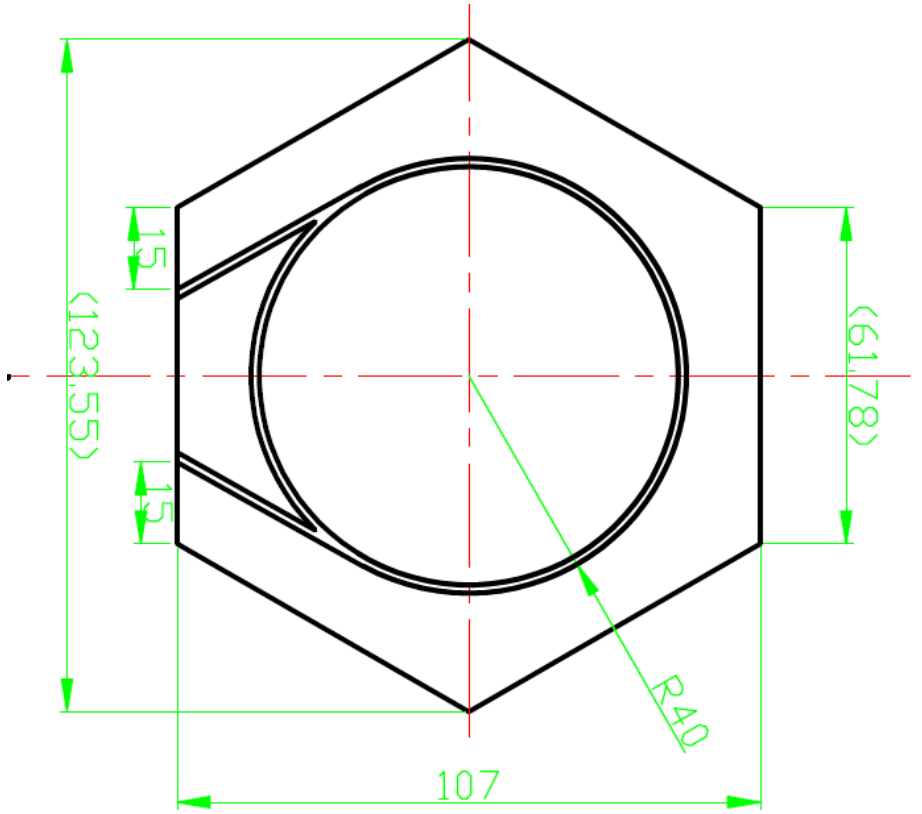
Normal end window PMT for EC shower Shashlyk detector

1: Layout of the hexagon-shaped modules with their support for a 30-degree wedge of the

Pre-shower module in SDU

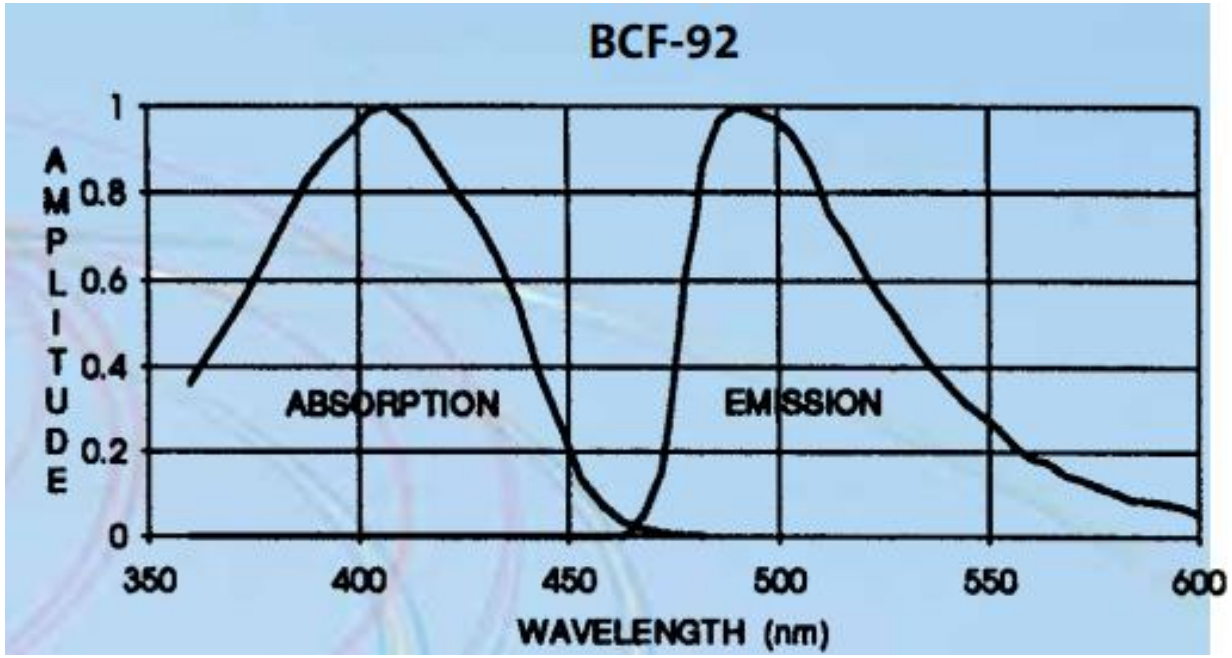
- HND-S2: Kedi, China
  - Density: 1.05g/cm^3
  - Refraction index: 1.59
  - Emission peak : 420nm
  - Light yield(photons/MeV): 8000

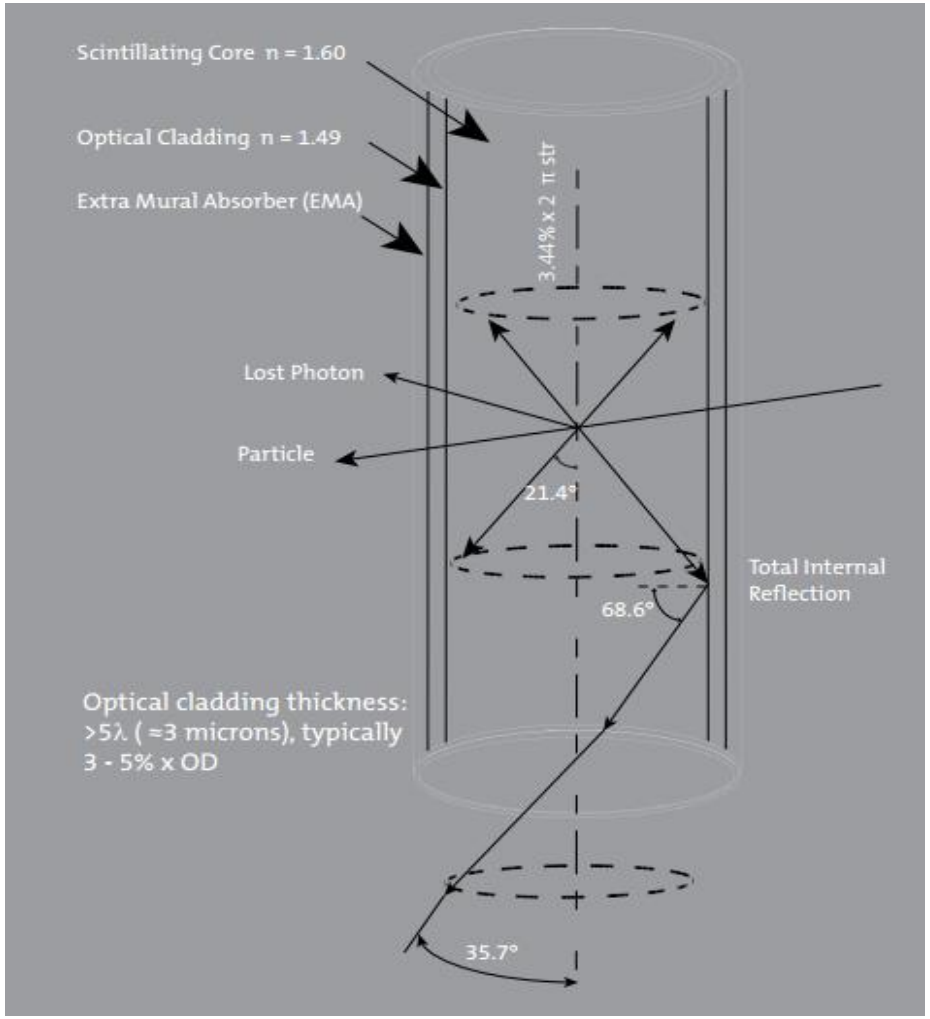
- Thickness：20 mm
- Depth of groove：2 mm
- Shape 1: Hexagon, side 6 cm
- Shape 2: Square, 10*10 cm



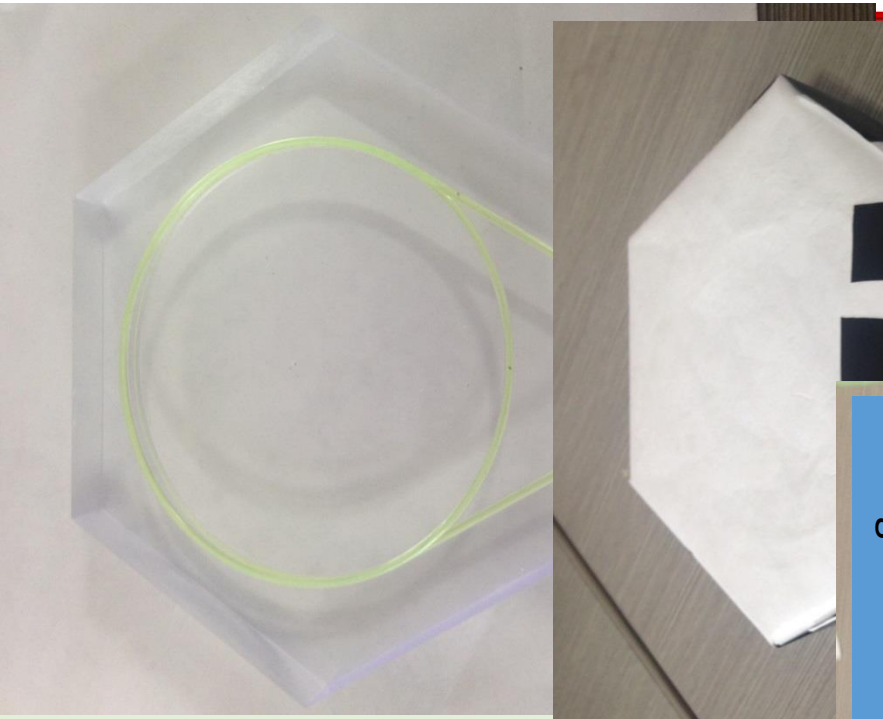
WLS BCF-92

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





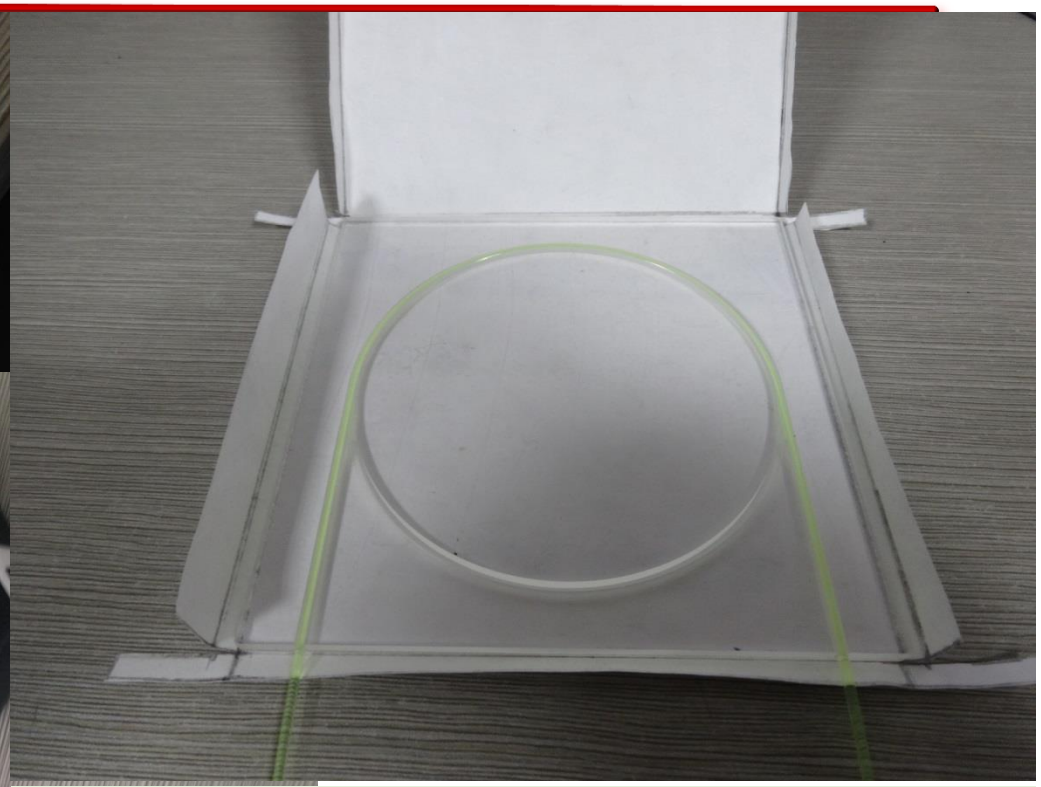
Scintillator module



WLS Fiber air couple to scin

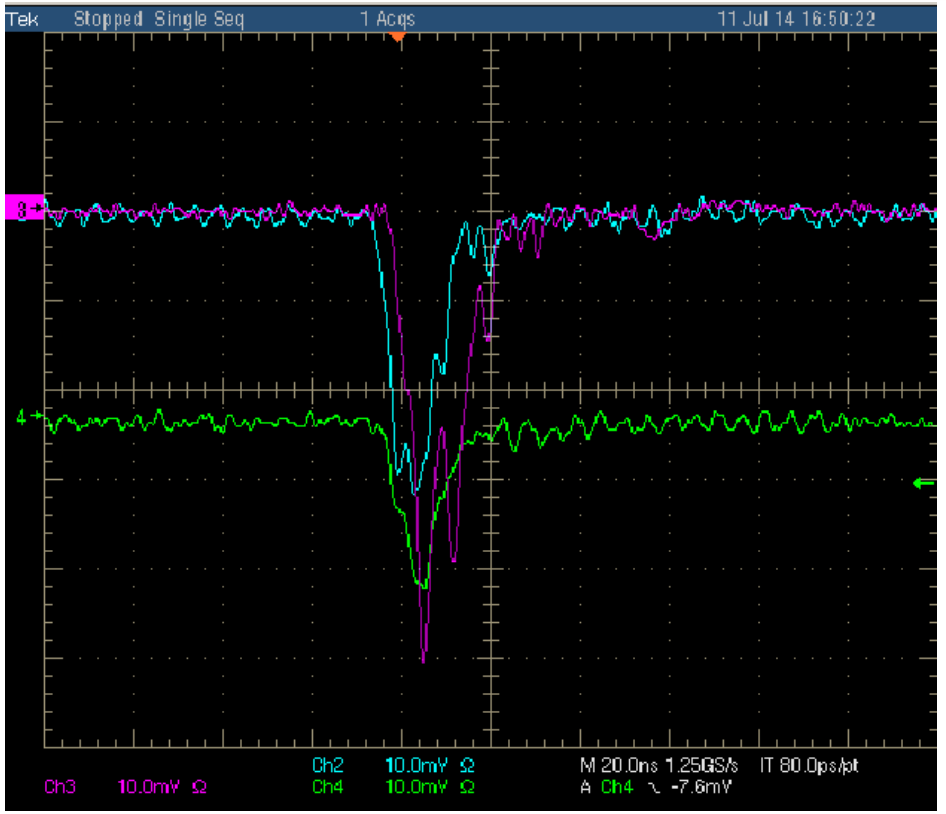
Packaged with

Packaged with black tape



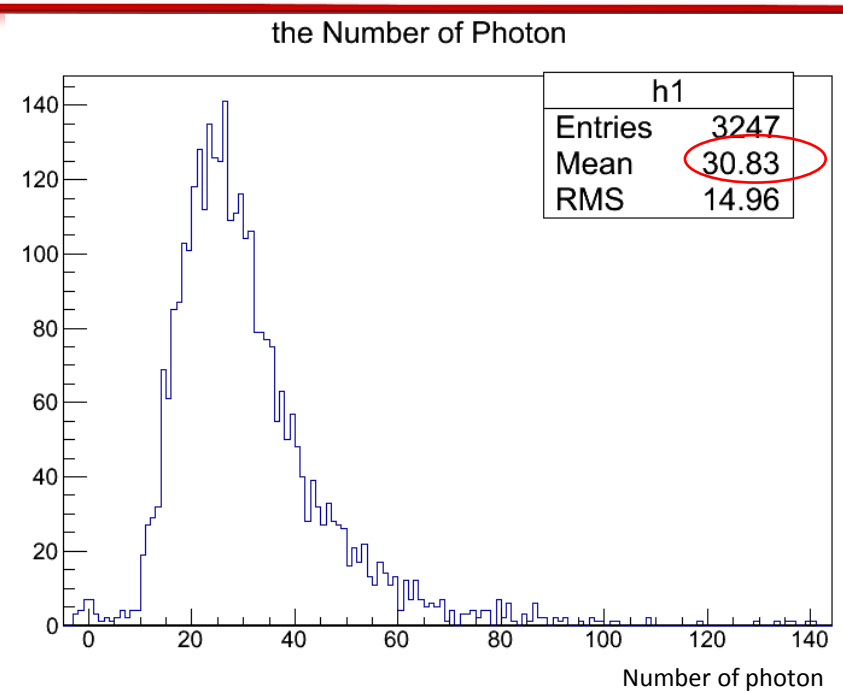
Square scintillator with fiber before package

Light yield preliminary test



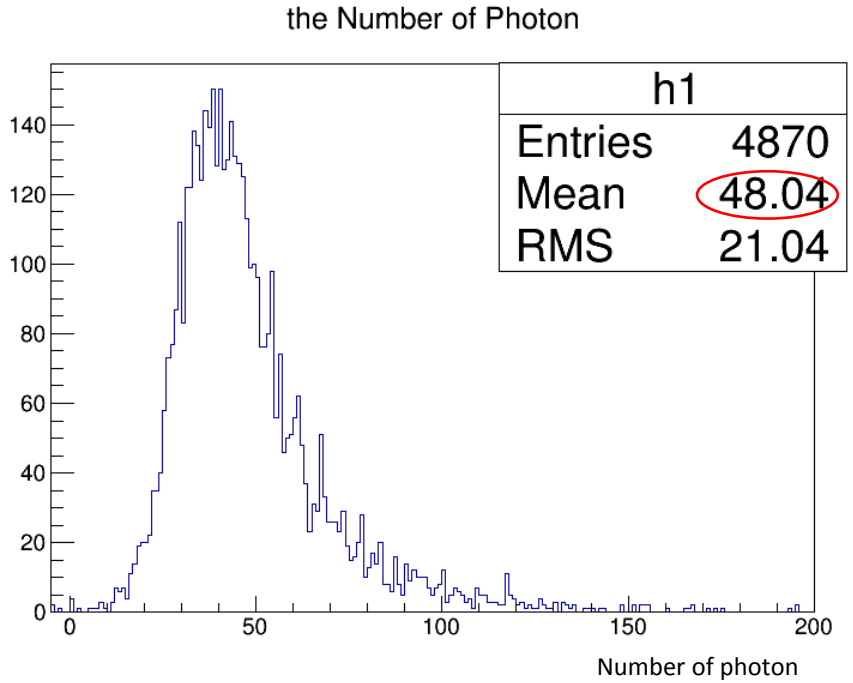
PMT type: HAMAMATSU R11102, Gain: 10^6. One LABVIEW program record the waveforms.

Hexagon shape module test results



Fiber: 1 turn

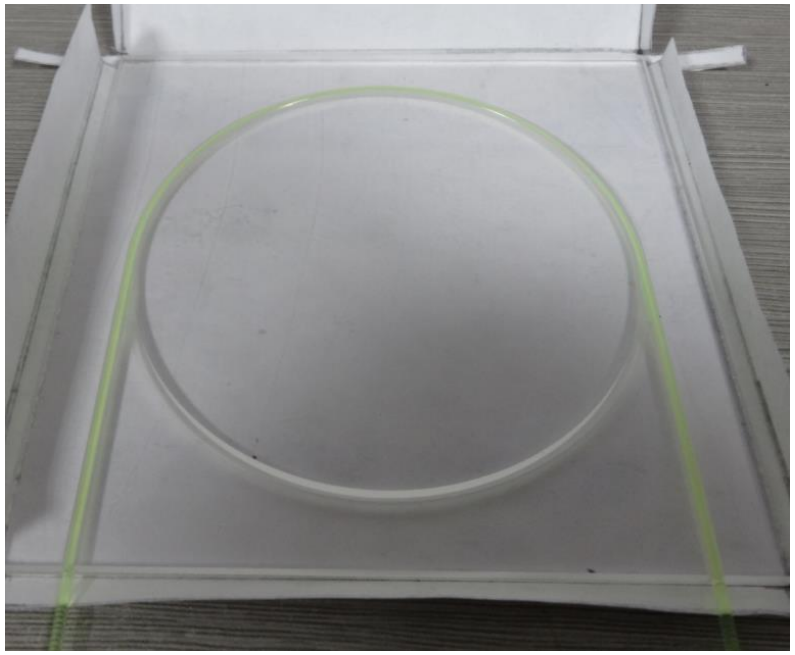
Mean number of photons recorded by the PMT is 31



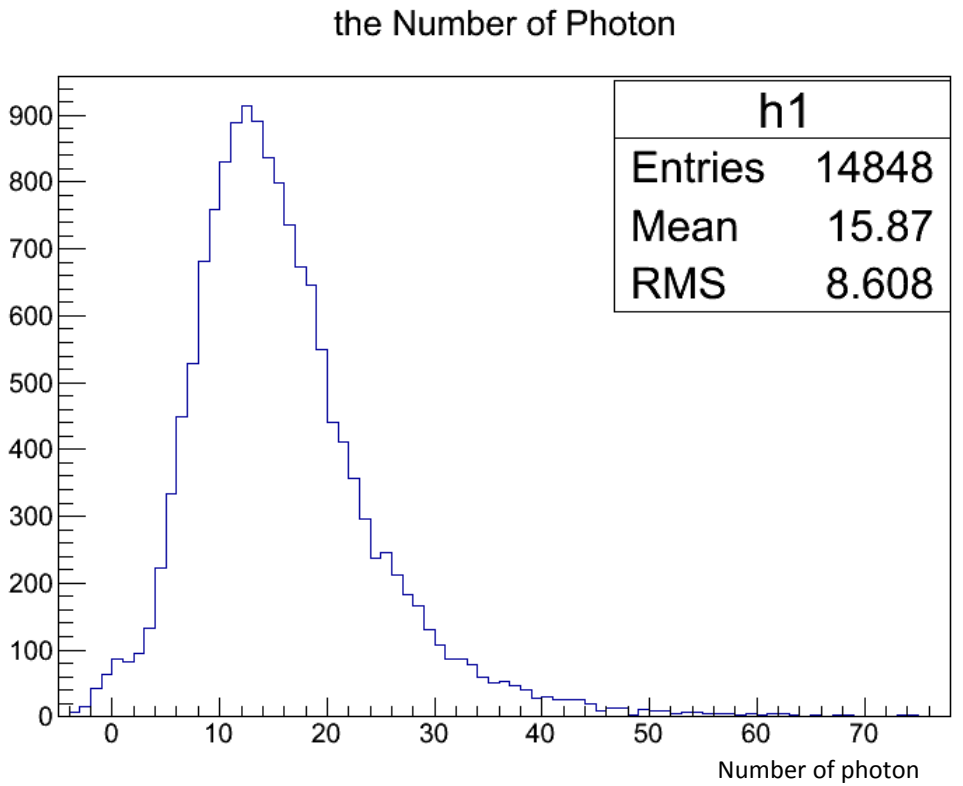
Fiber: 2 turn

Mean number of photons recorded by the PMT is 48

Square module test result



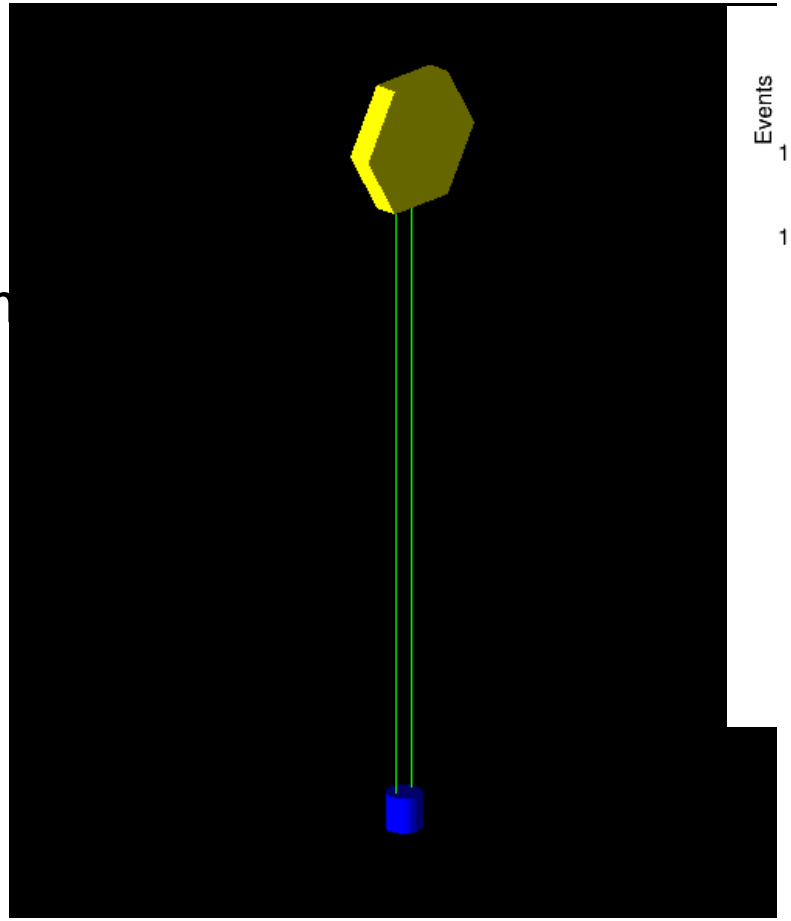
Size: 10*10 cm^2
Thickness: 2 cm
Diameter of circular groove: 9 cm
Only 1 turn of fiber, too shallow for 2 turn

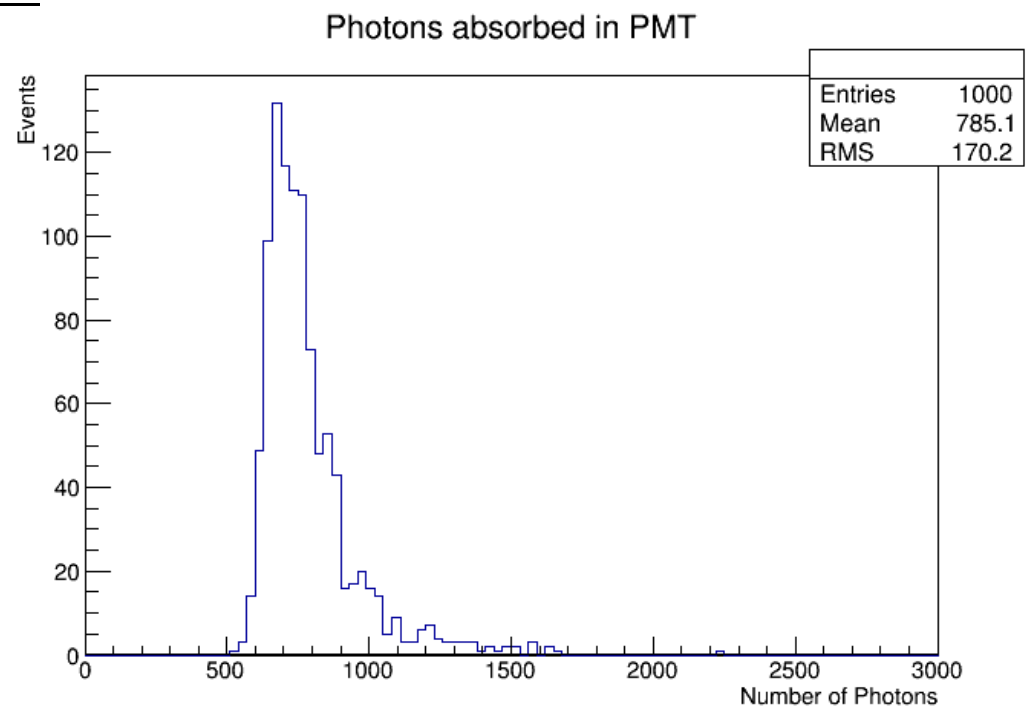


Less photons(16) than hexagon shape(31).
Need to confirm.

Simulation with GEANT4

- Scintillator thickness: 2cm
- Fiber : one turn, Φ 1.5 mm
- Package: tyvek paper

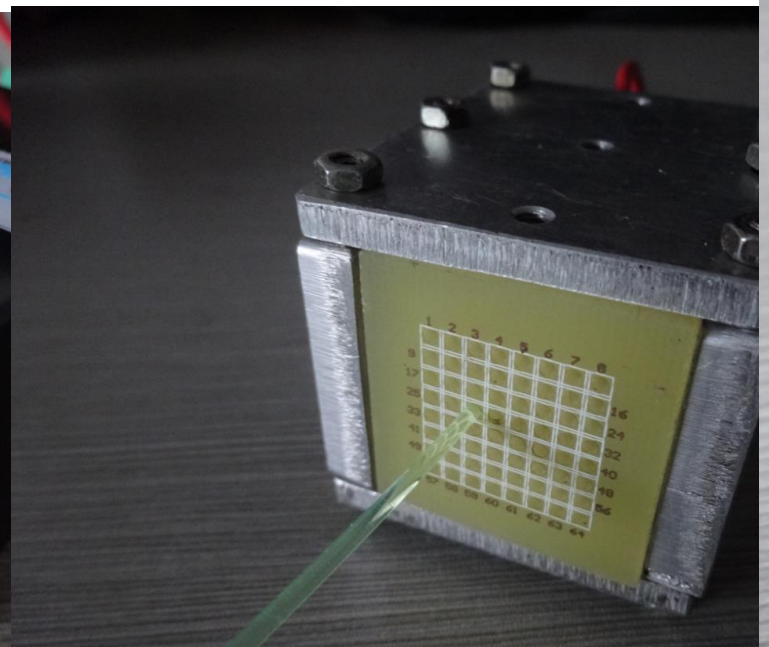


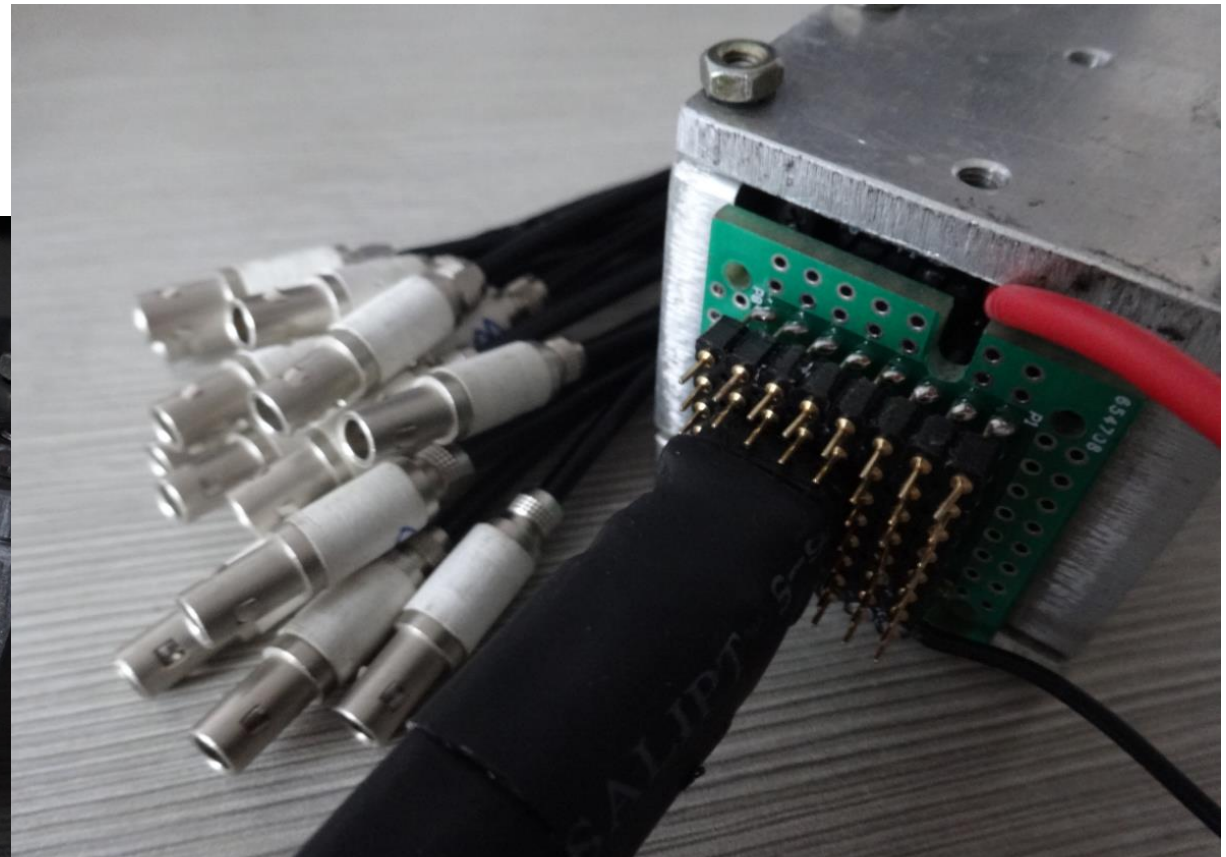


The number of photons which reach the PMT cathode is recorded, no quantum effect and collection of PMT is considered

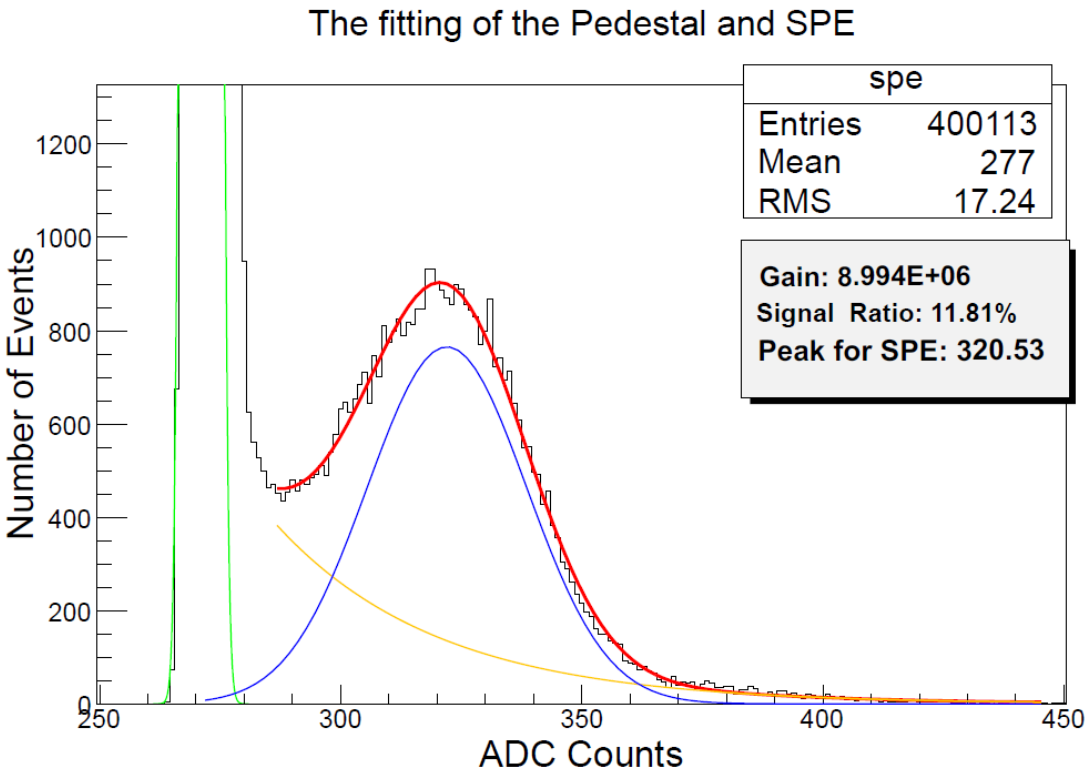
Multi-anode PMT

- 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



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.

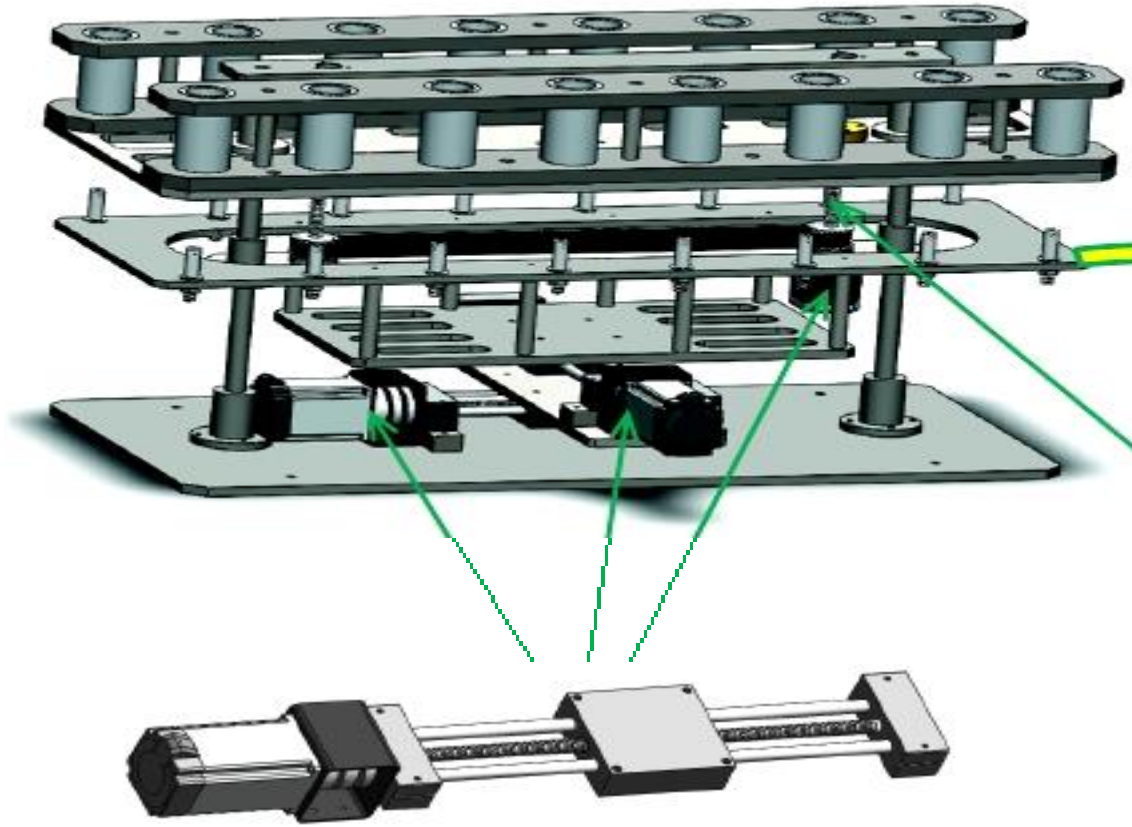
PMT test bench in SDU

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 ^{o}C

- ✓ 16 PMTs can be test in one patch with this bench

The chart of machinery architecture in light tight box

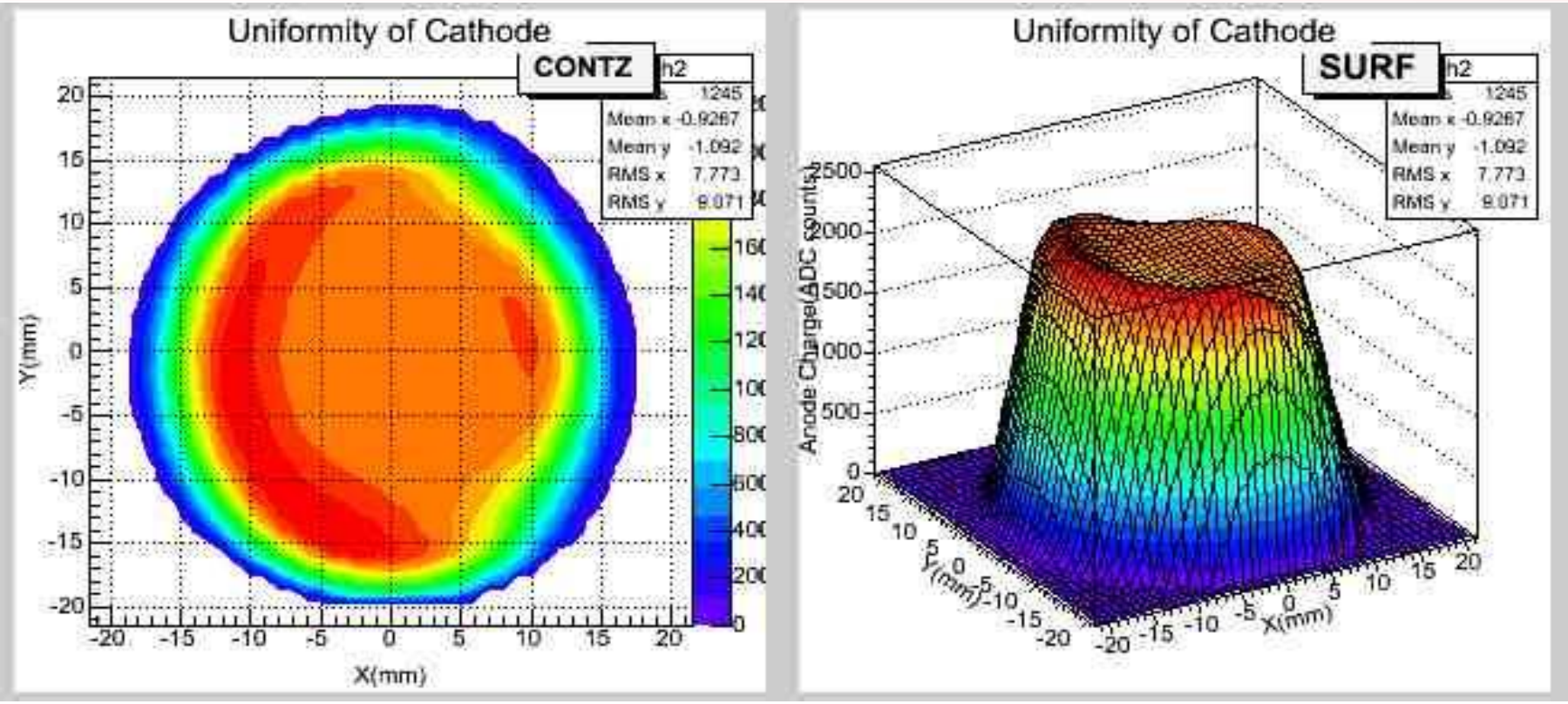


16 sleeves: hold the PMTs

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

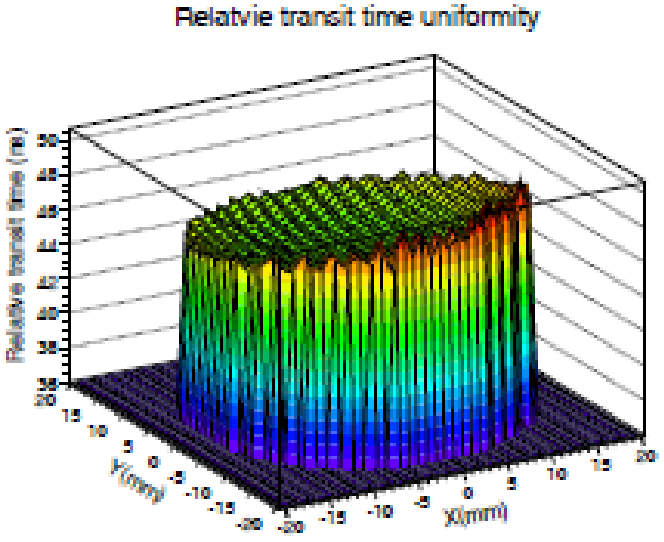
Stepper motor
Step size: 1mm
Step range: 5 cm in x and y, 10cm in Z

Uniformity of cathode test results

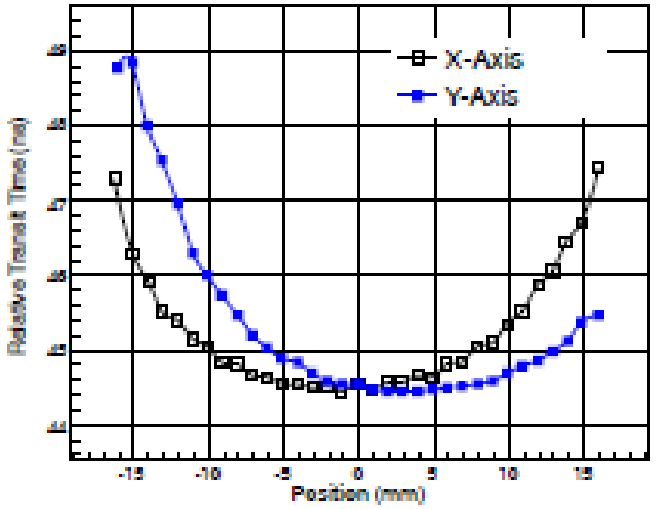


Step size: 1mm. The PMT: R11102. The non-uniformity of the cathode are visible.

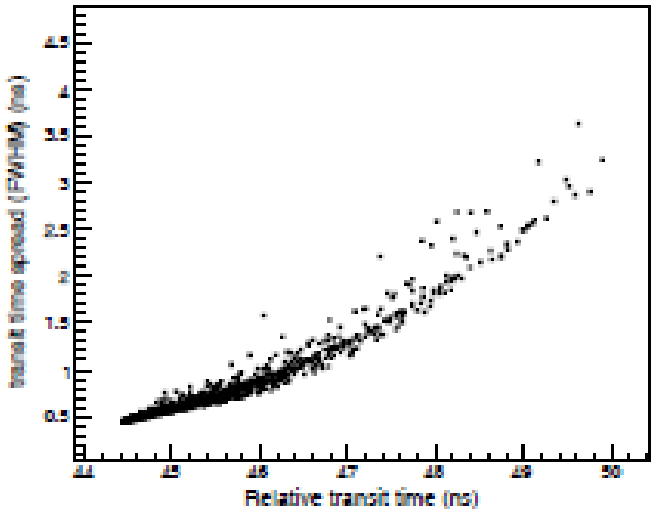
Cathode transit time difference



(a) Surface plot



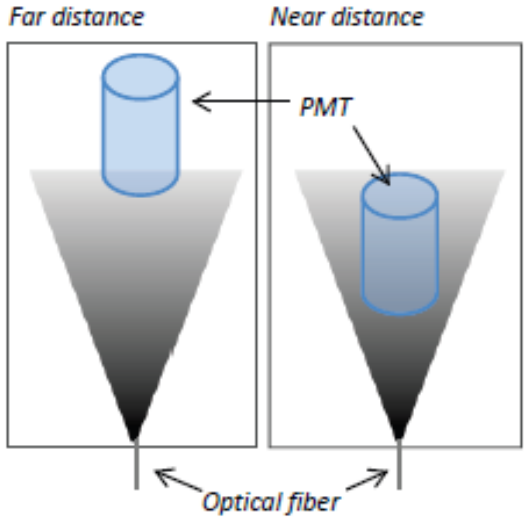
(b) X-Y Axis



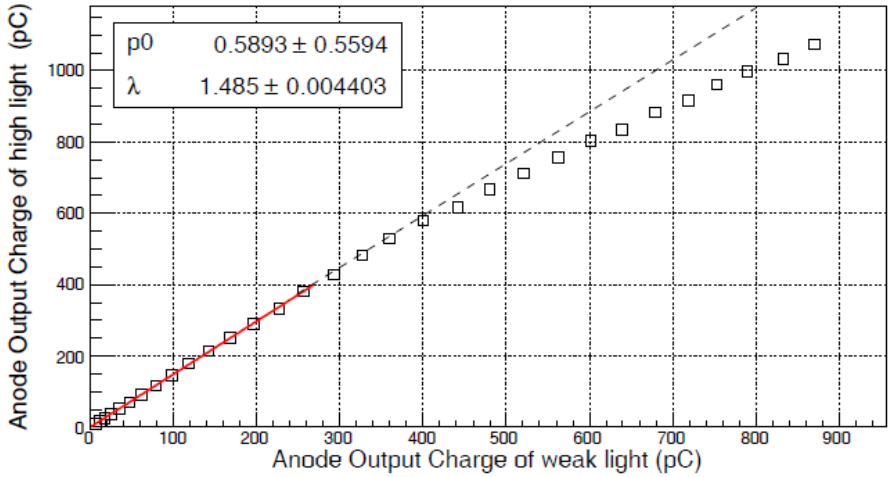
(c) Transit time spread vs. transit time

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

Linear dynamic range

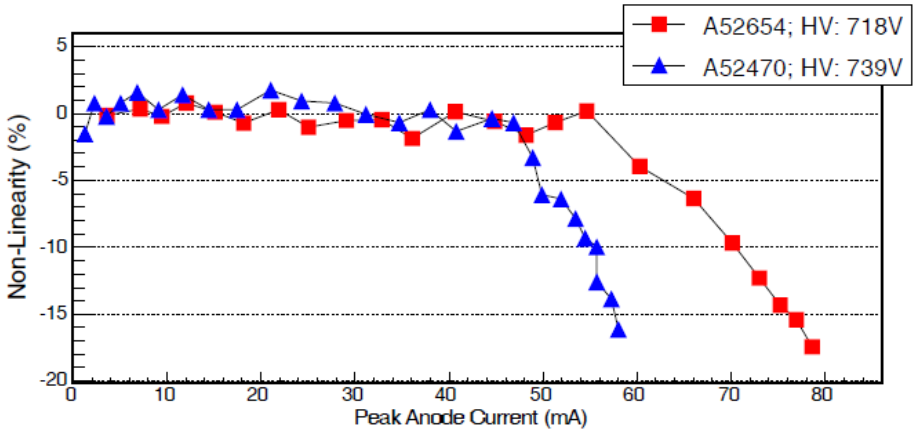


Di-distance method. The ratio of incident light intensity on PMT for both distance is constant λ.



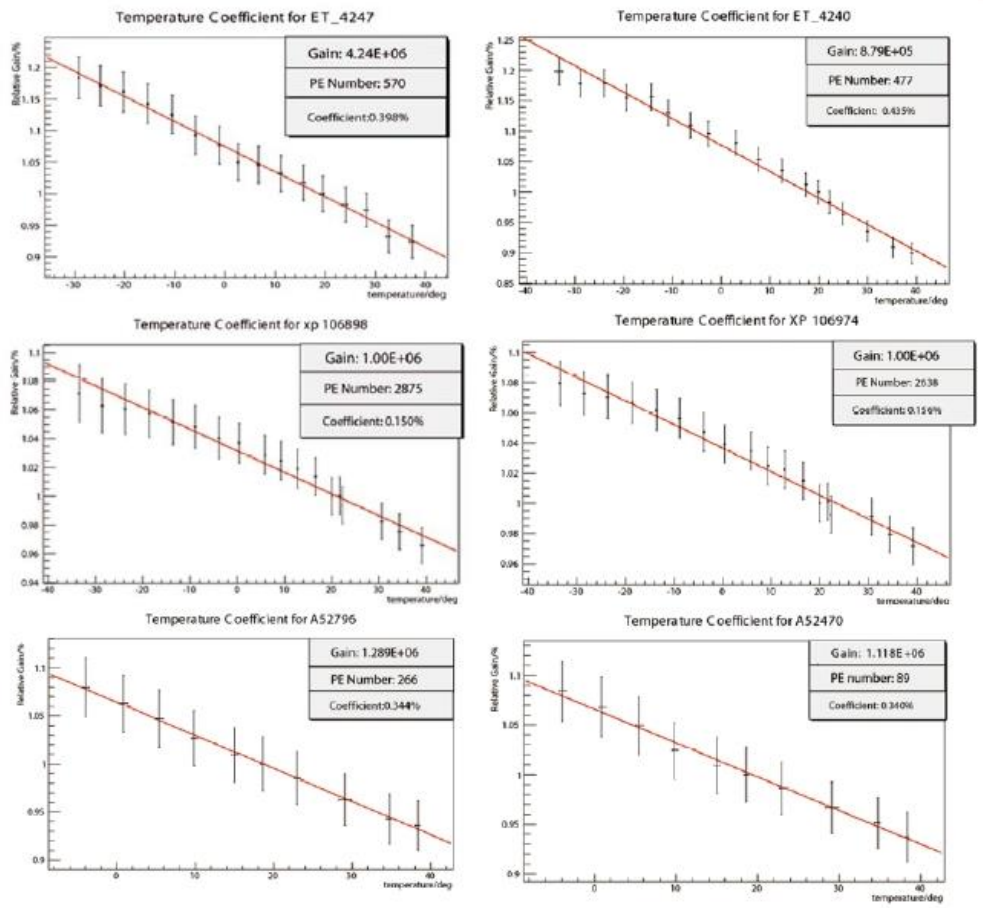
λ : Fit first few point

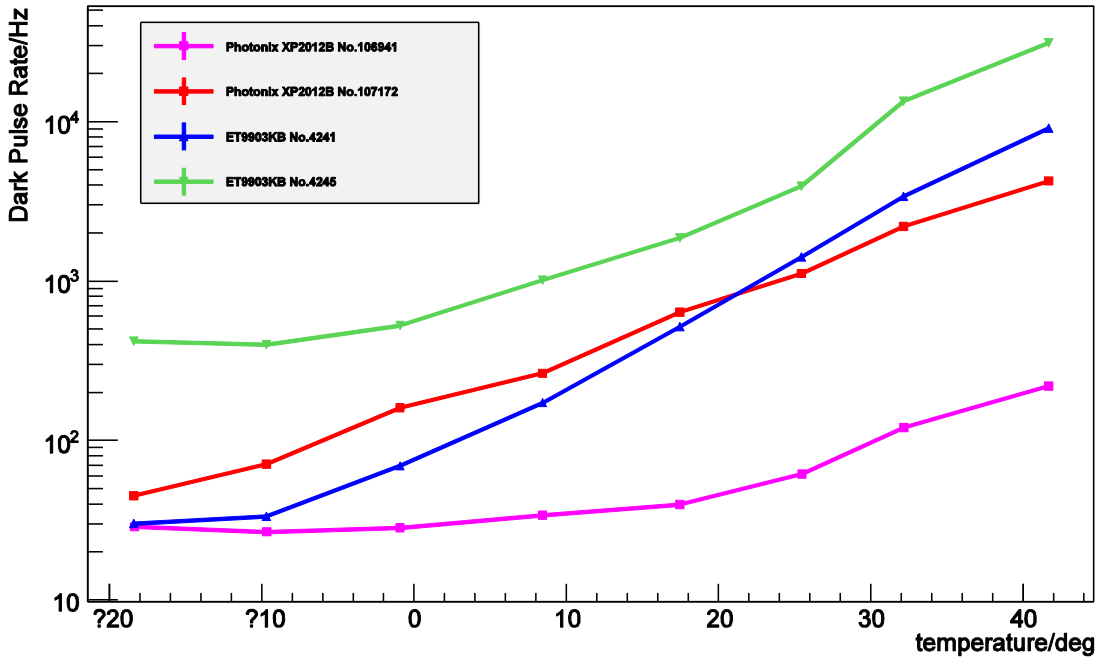
$$Non\text{-}Linearity = \left(\frac{S_{near}}{S_{far}} - \lambda\right)/\lambda$$



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

Effect of temperature

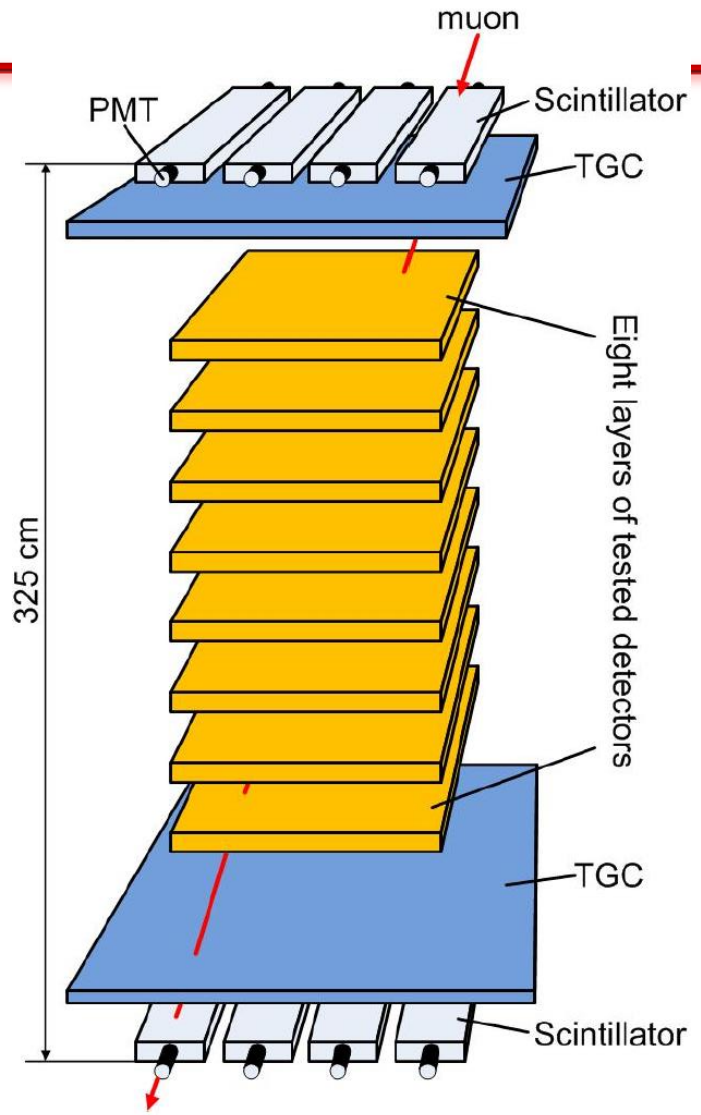




Dark pulse rate increase following the temperature increasing .

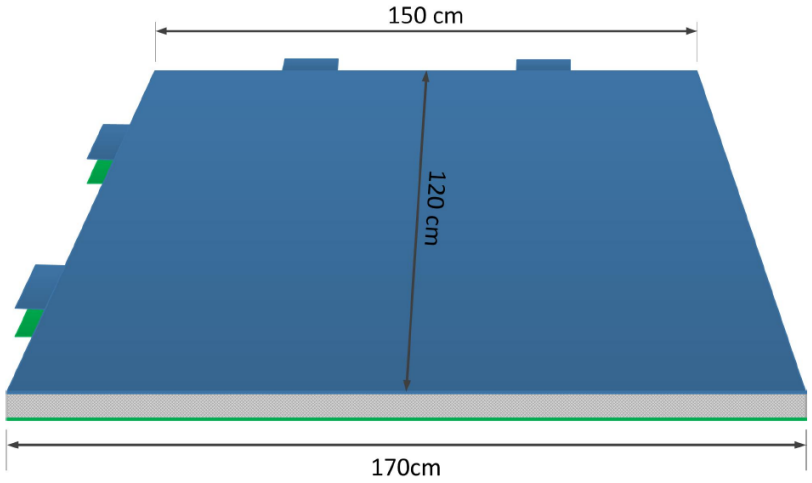
Gain decrease following the temperature increasing.

Cosmic Ray reference System(CoRaRS)

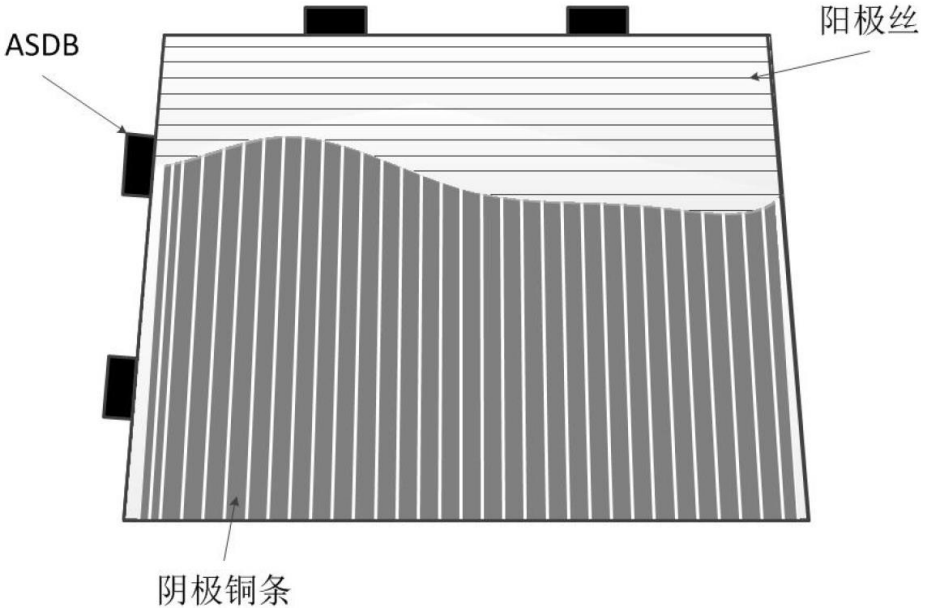


Picture of the CoRaRS laboratory and the diagram of the system.

CoRaRS: TGC



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



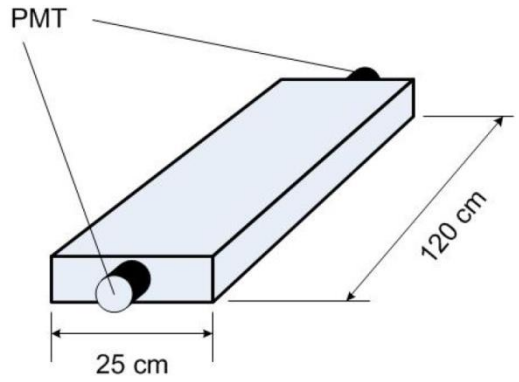
2 dimension read out

Wire: Width of wire group: 1.9 cm,
Resolution: 0.6 cm

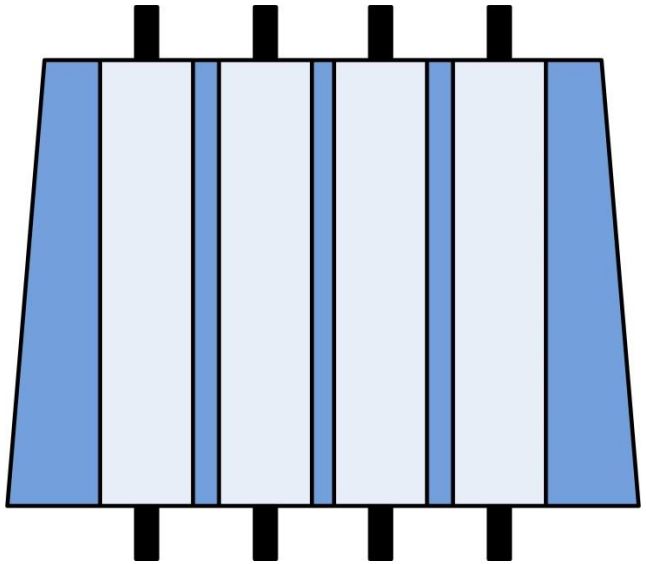
Strip: Width: 2.5 cm
Resolution: 0.7 cm

CoRaRS: trigger

8 scintillators used for trigger



One scintillator module



4 top/down scintillators

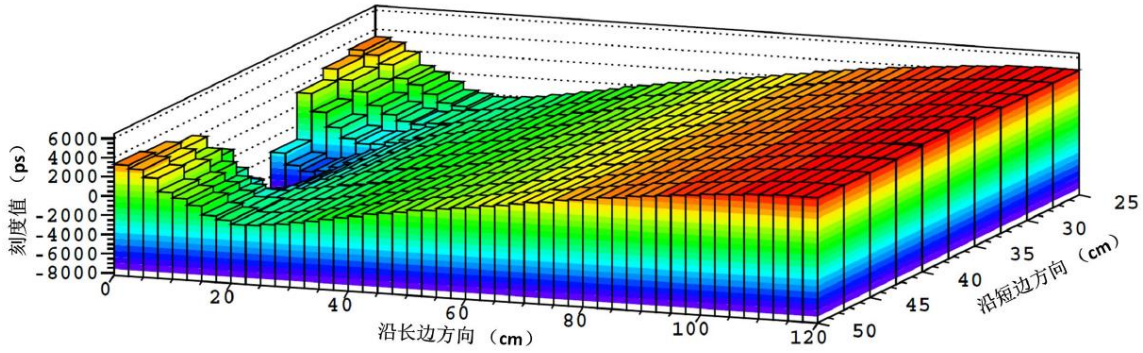
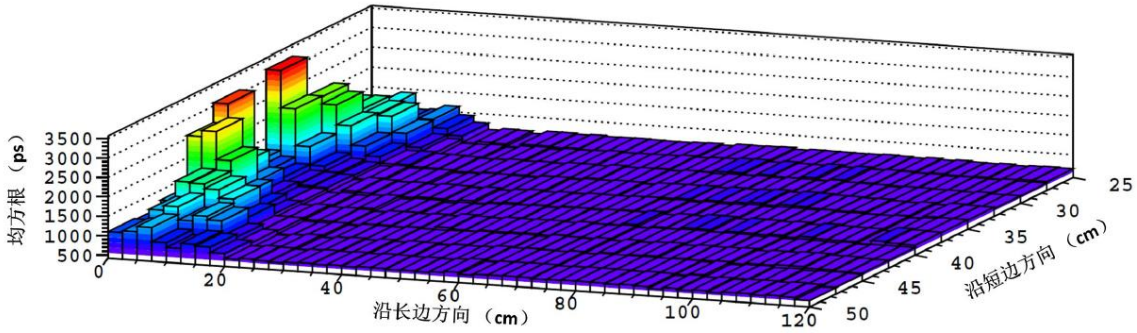


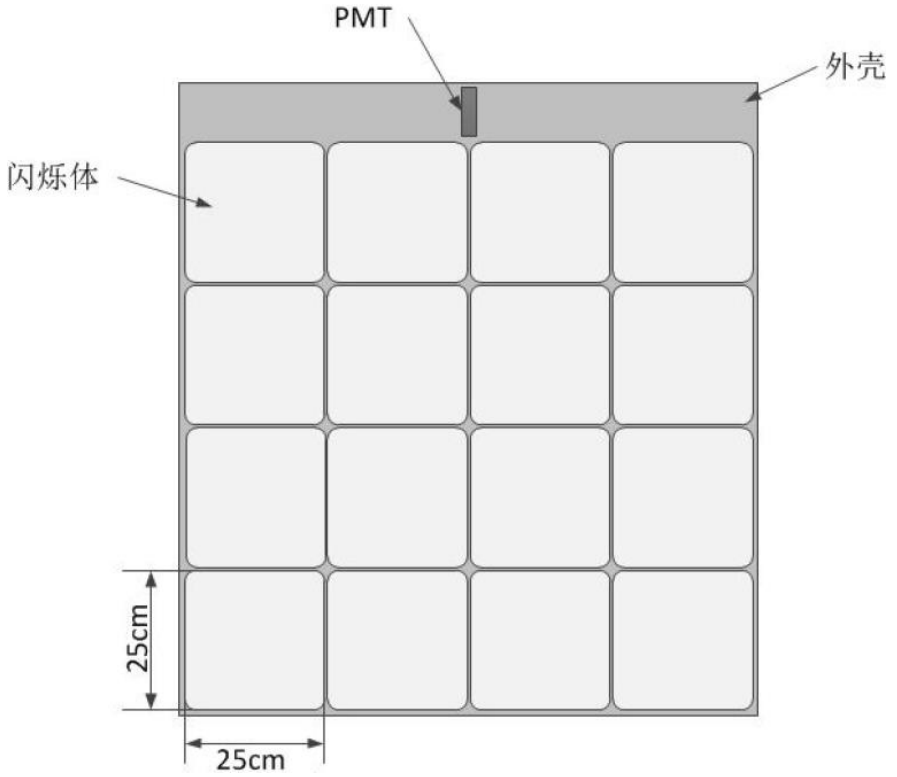
图 7.23: 下层最左侧的闪烁体探测器各区域的刻度值的平均值的分布



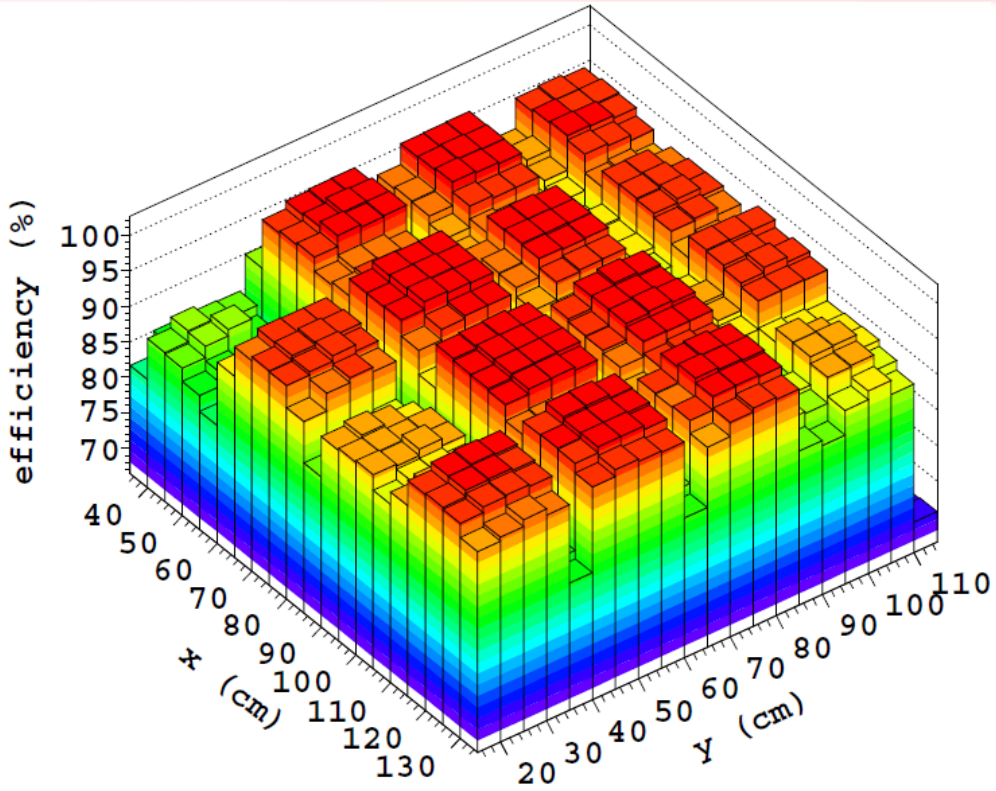
Time calibration. time resolution: 630 ps

Prototype electromagnetic detector of LHAASO

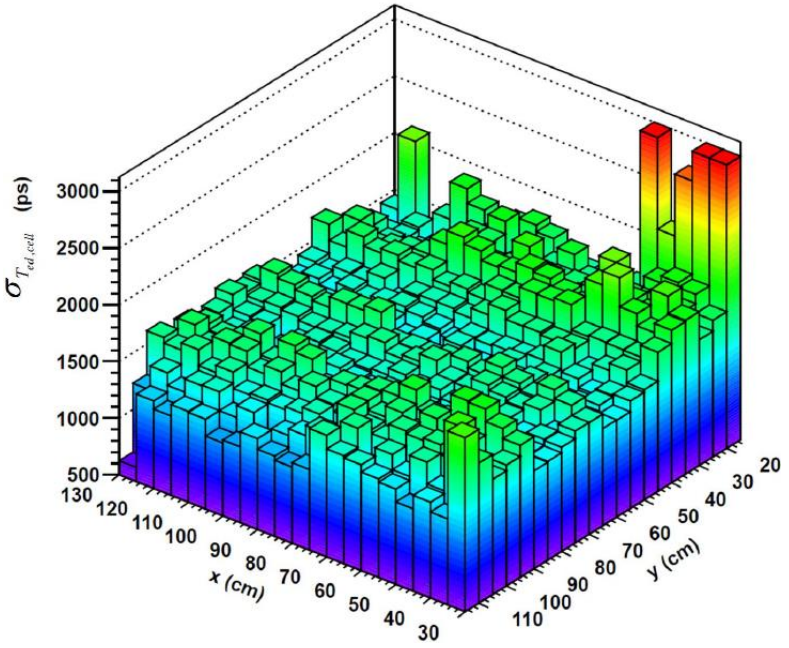
Sensitive area: 1 m^2



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

- 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 !