



面向水切伦科夫探测器的 波长位移光纤增强光电倍增管

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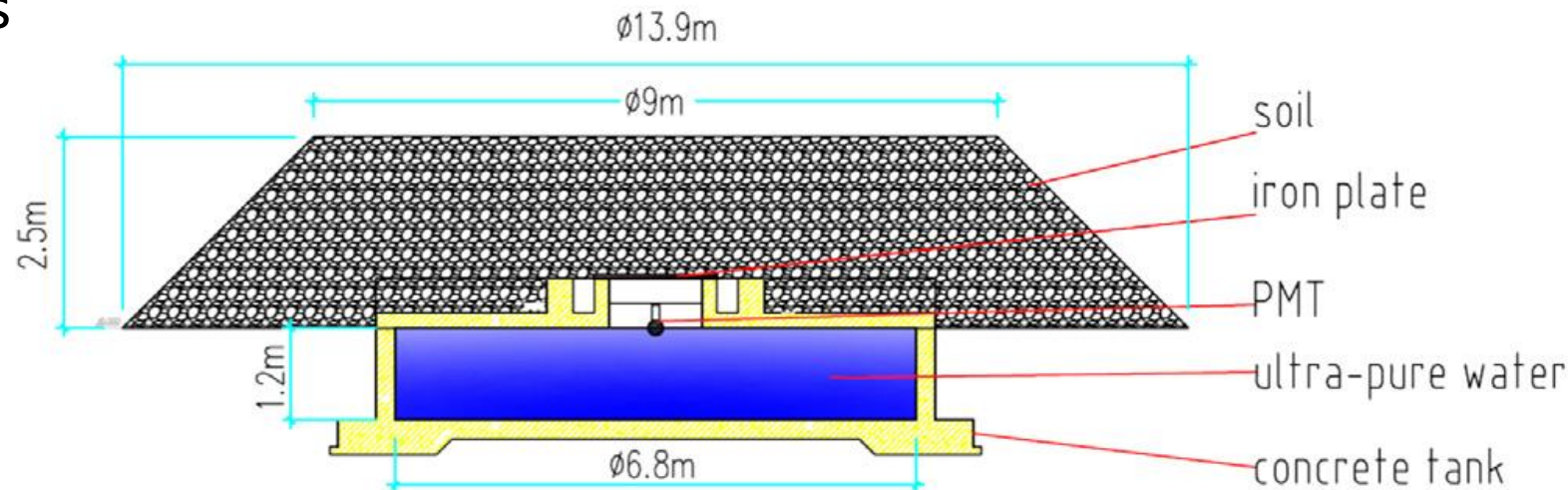
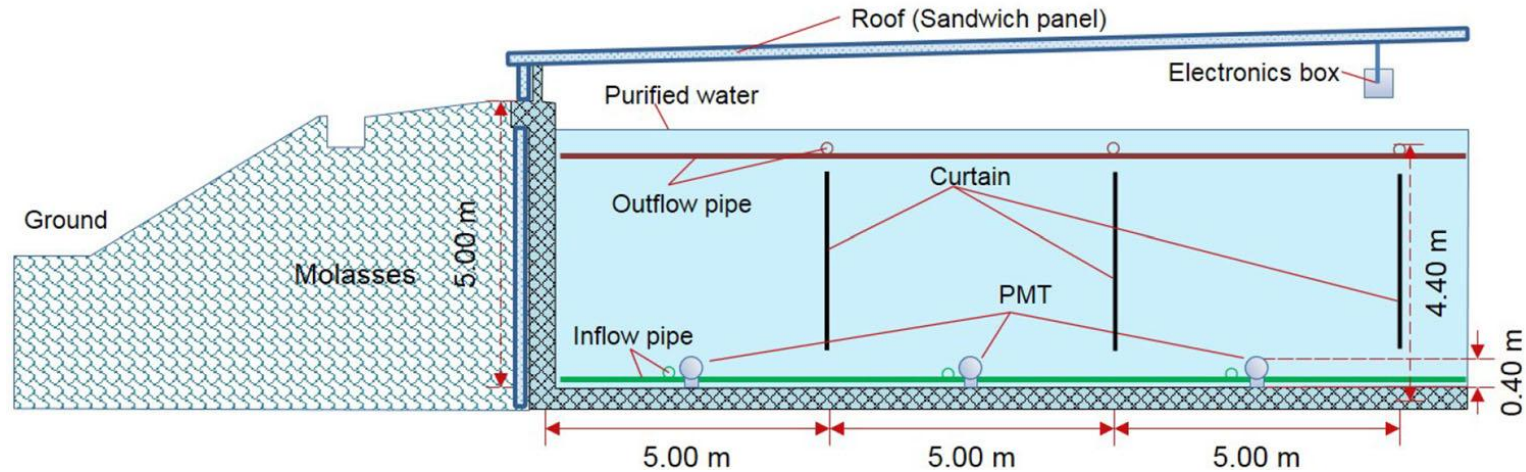
Outline

- Water cherenkov detector and PMT
- WLS fiber enhanced PMT
- Time performance test
- Performance test with small size water tank
- Summary

WCD (Water Cherenkov detector) in LHAASO

Large photocathode PMT used to collect the photon of WCD

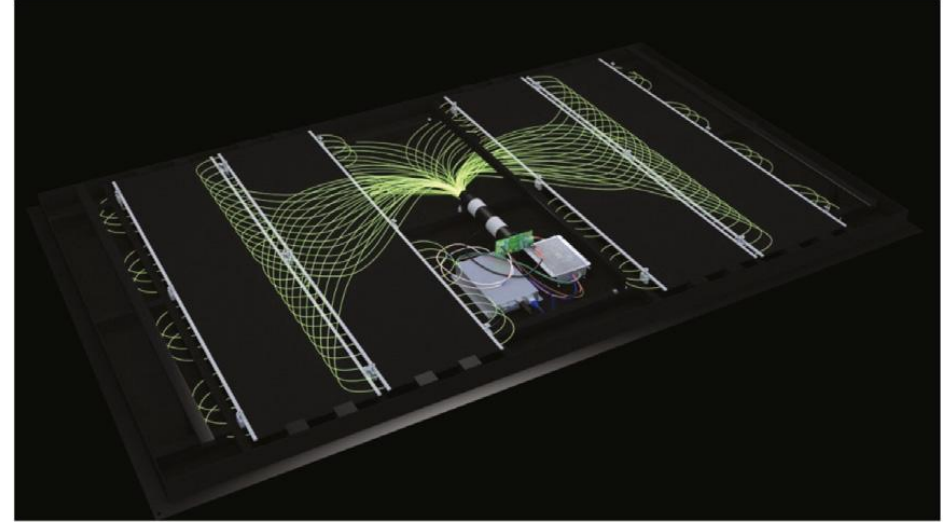
- WCDA: cell size: 5 m* 5 m* 4m
20" PMT + 3" PMT in pond 2/3
- Muon detector: $\phi 6.8$ m* 1.2 m
8" PMT, time resolution < 10ns



LHAASO ED (Electromagnetic particle Detector)

WLS (Wave length shift) fiber + small PMT (XP3960)

- ✓ WLS fiber couple to scintillator (25 cm width)
- ✓ PMT TTS: ~ 1 ns
- ✓ ED time resolution: < 2 ns
- ✓ VME: ~ 20 PE



In the future WCD experiment such as SWGO:
Small PMT (or SiMP) + WLS Fiber for WCD
WLS fiber enhance the collecting efficiency for
water Cherenkov light



WLS Fiber enhanced PMT

- WLS Fiber

- Saint-Gobain BCF91A: ϕ 1 mm,

- Saint-Gobain BCF92: improved absorption spectrum for shorter wave length

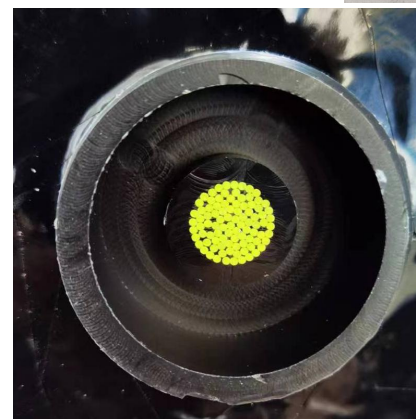
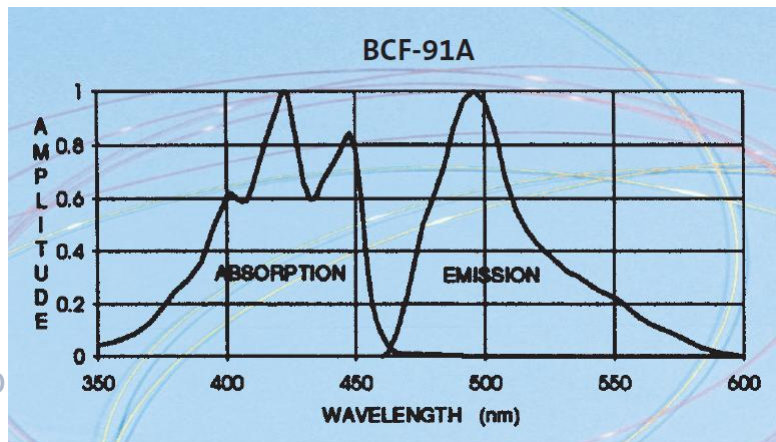
- PMT

- HZC XP3960: 1.5",

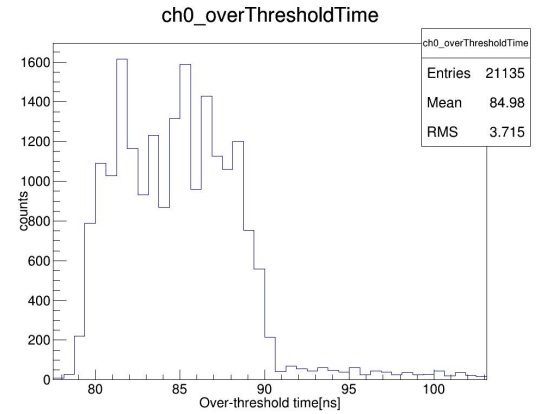
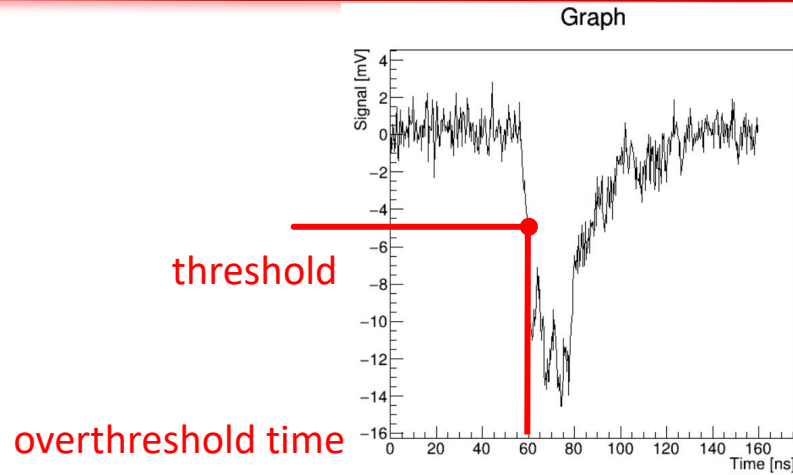
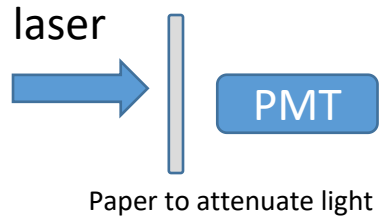
- Fiber bunch couple to PMT through flange

- ✓ 50 fibers (1 m length) banded,

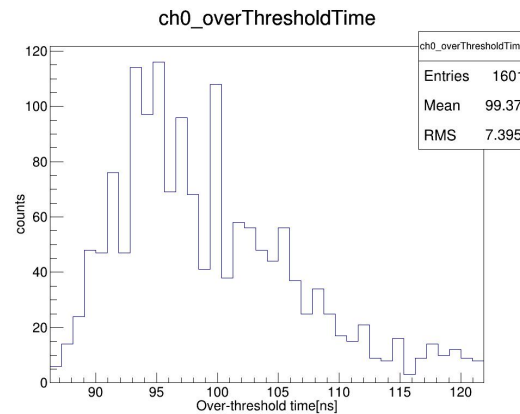
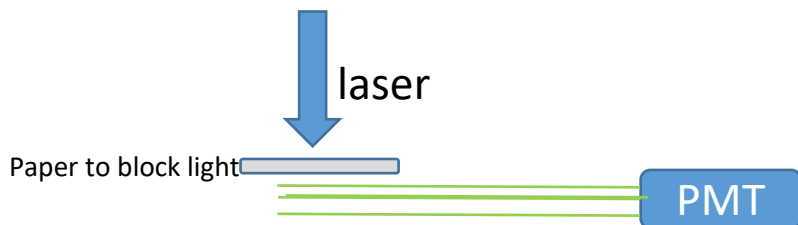
- ✓ fiber ends polished



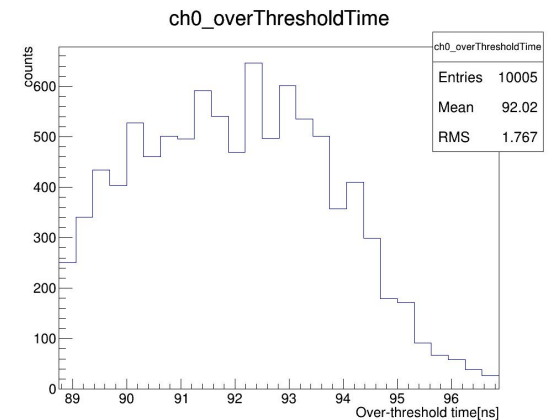
Time shift (at single photoelectron)



PMT time shift: rms 3.7 ns



Fiber +PMT time shift: rms 7.4 ns

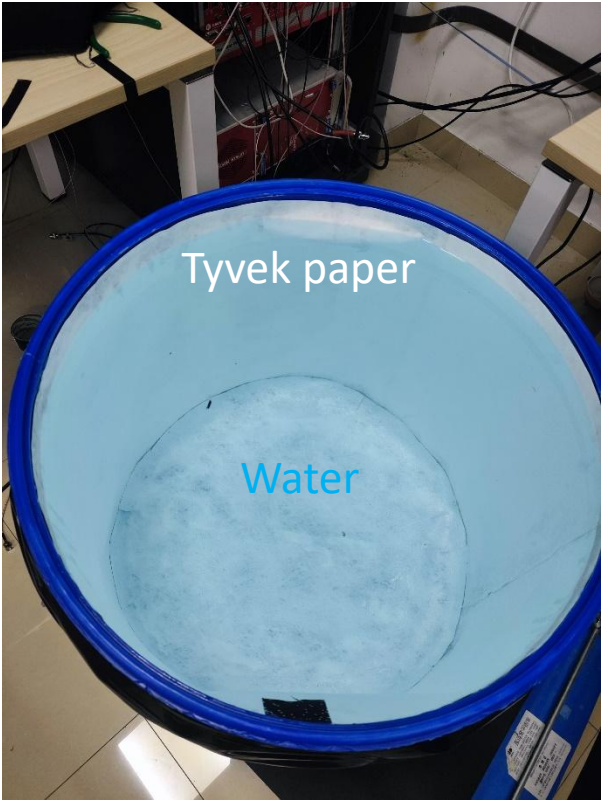


multi-photoelectron : rms ~1.8ns

Performance Test of Fiber-PMT in WCD



Pure Water tank with Fiber-PMT



Reflect layer:
Tyvek (1085D): reflectivity 93.5%

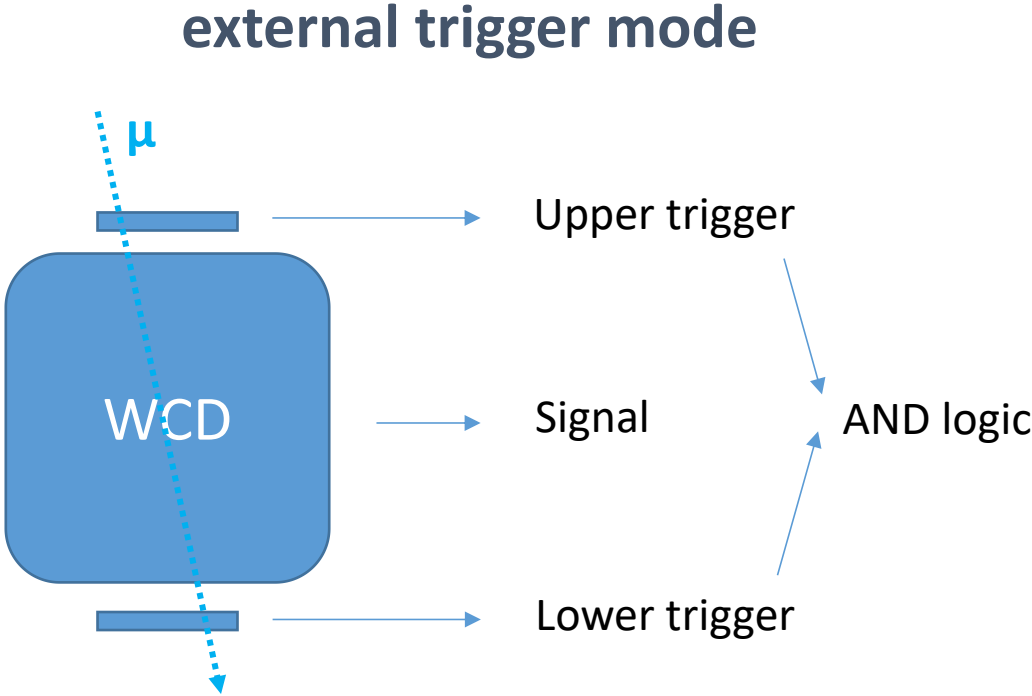


Fig.1 External trigger diagram

Performance Test with VEM (Vertical equivalent muon)

- test result of fiber enhanced PMT in WCD

Graph

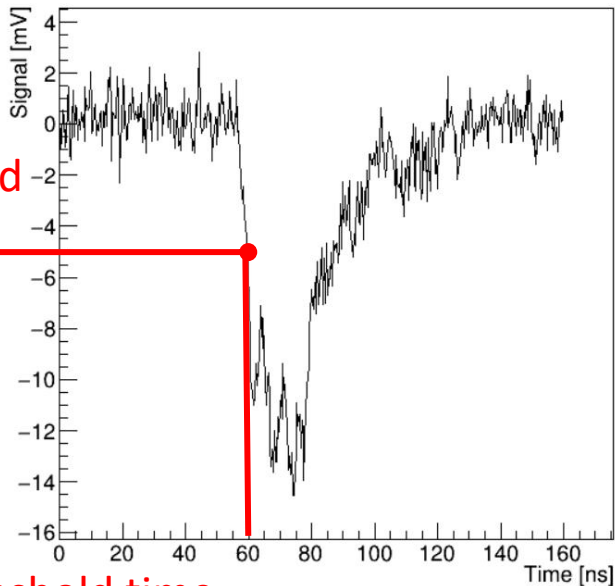


Fig.1 waveform of one event

Threshold: 5mV
PMT Gain: 3.4E5

ch0_NPE

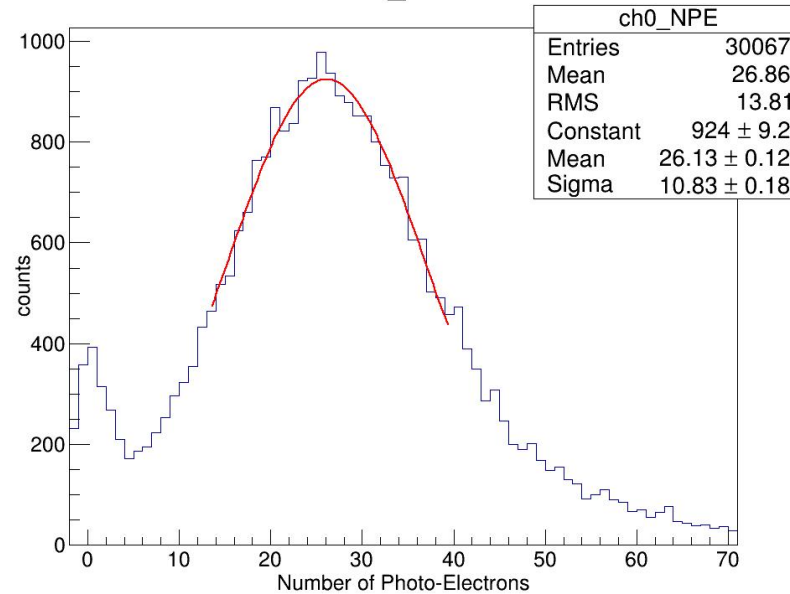


Fig.2 Number of PE for VEM.
Peak value: 26.1 PE,
resolution: 42%

ch0_overThresholdTime

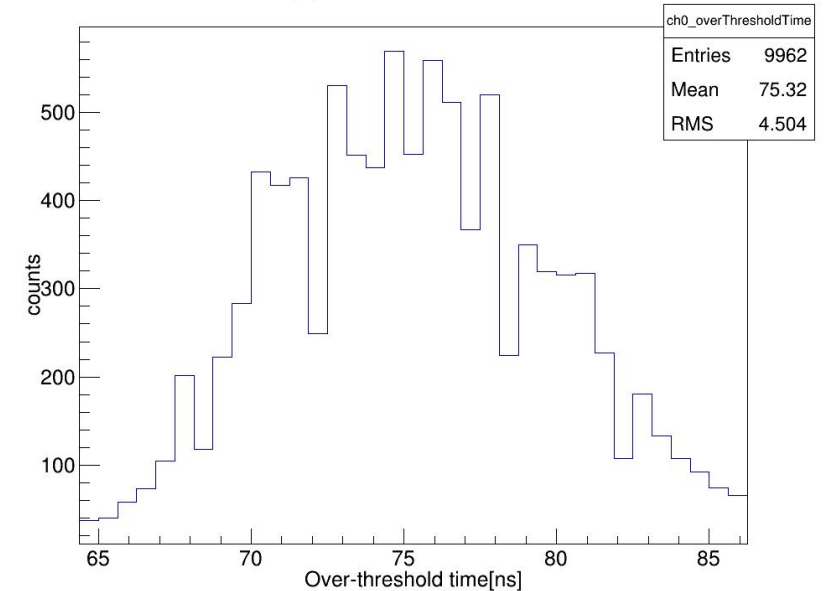


Fig.3 overthreshold time. The time resolution about 4.5 ns

Performance Test

- tilted incidence

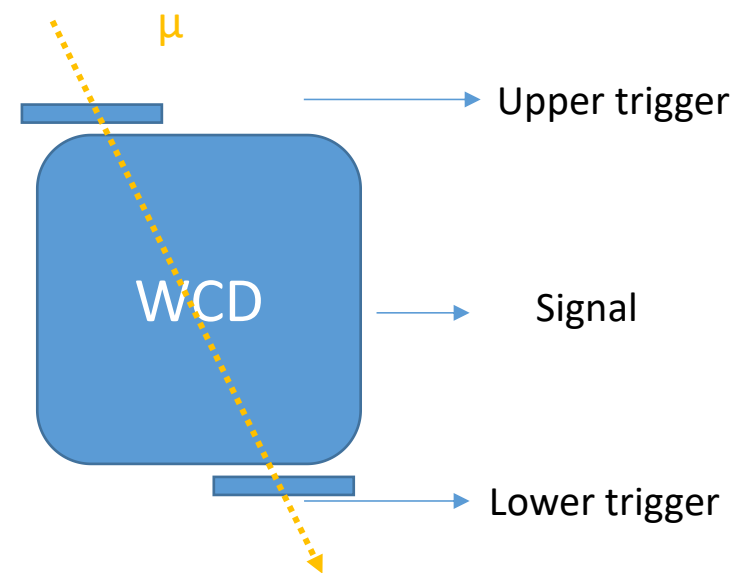


Fig. tilted trigger diagram

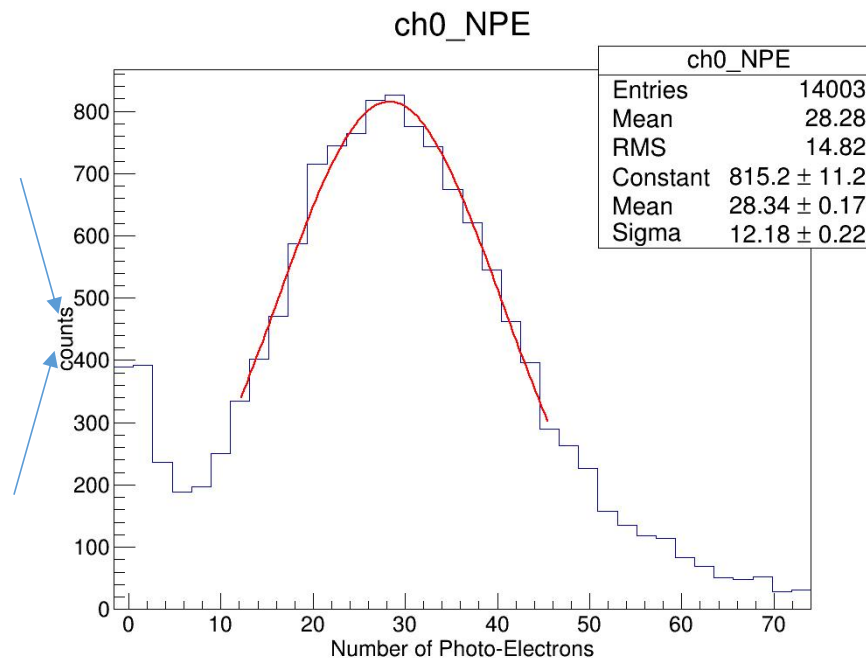


Fig.2 Number of PE. little large than VEM peak value: 28.3

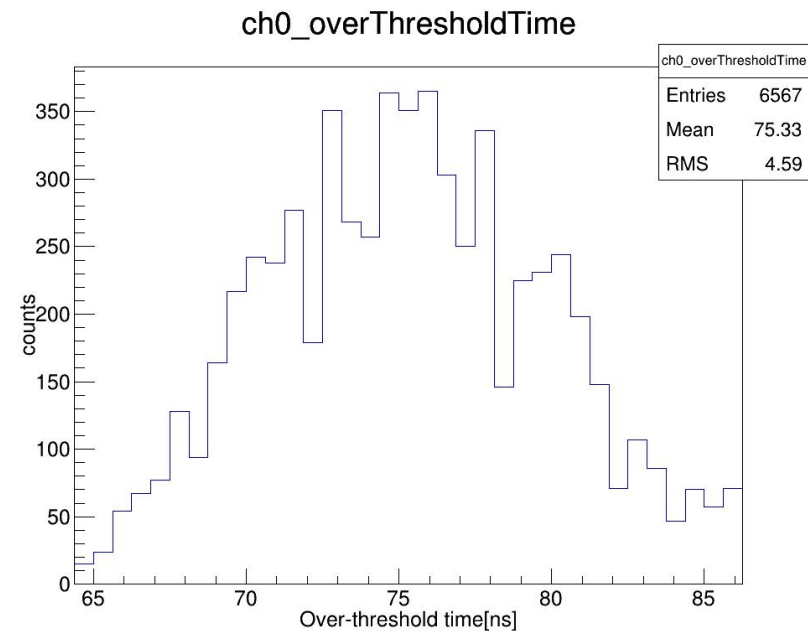
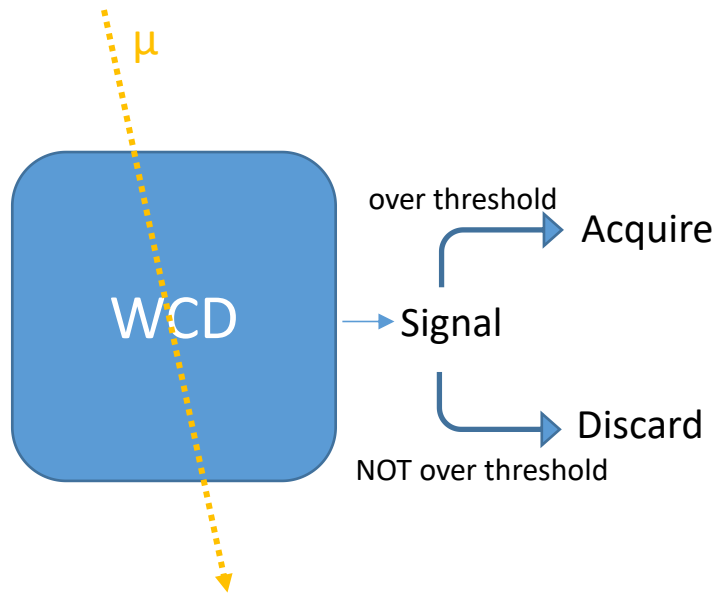


Fig.3 overthreshold time. The time resolution about 4.6 ns. Siimilar as VEM.

Performance Test

- Self trigger test



self trigger diagram

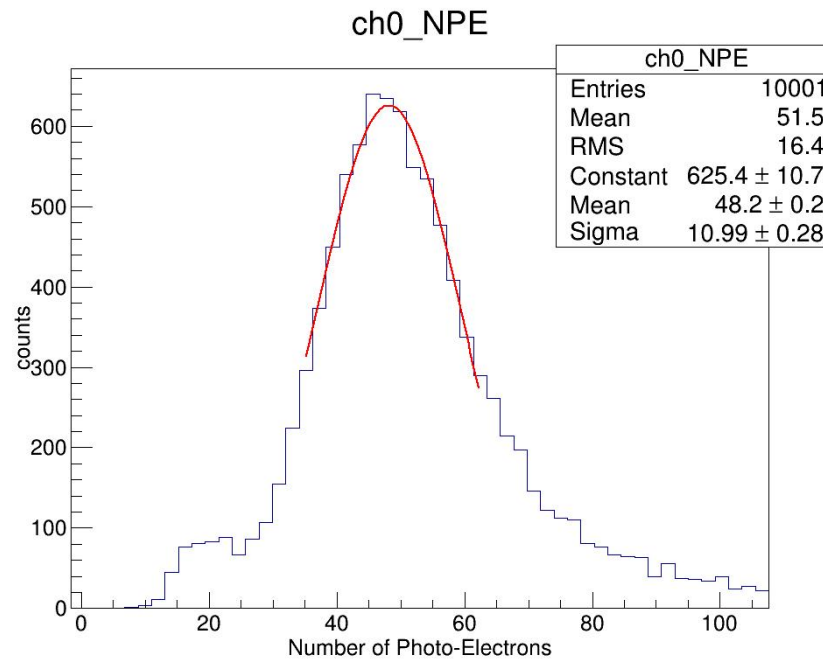


Fig.2 Number of PE.
peak value: 48.2

WCD test for PMT without WLS fiber

- removed WLS fiber



without fiber

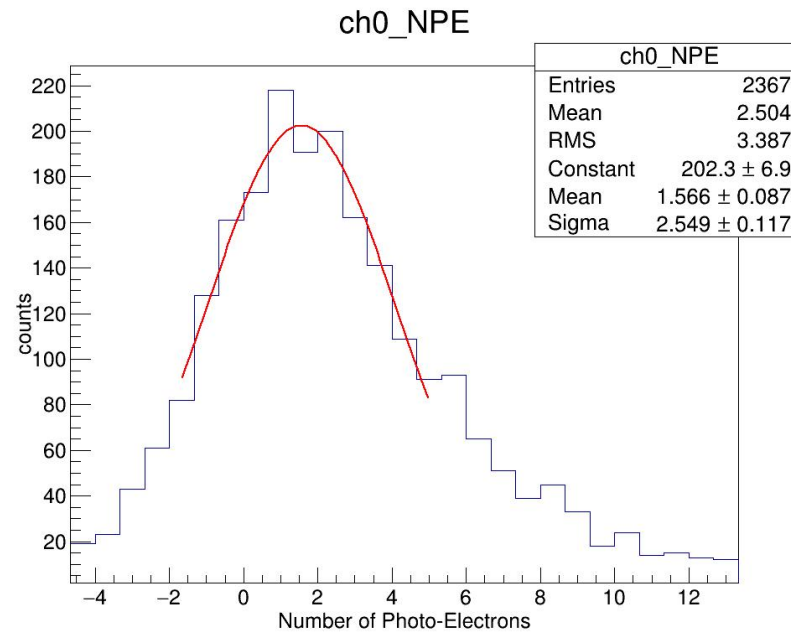


Fig.2 Number of PE without fiber.
peak value: 1.6

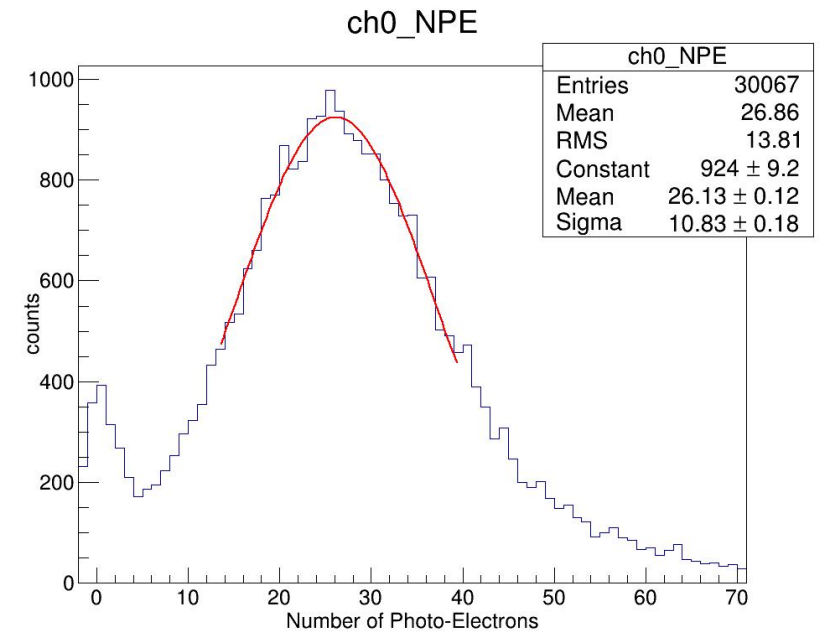


Fig.2 Number of PE with fiber.
peak value: 26.1

Summary

- WLS fiber enhanced PMT was proposed to use in WCD
 - The time resolution(TTS): 7.4 ns
- The performance of Fiber-PMT test in small water tank
 - **The WLS fiber improved the PMT light collection in WCD**
 - Peak value of vertical muon: >20 PE
 - Time resolution: ~4.5 ns

Thanks for your attention!

Backup slides

Reflectance of Tyvek

