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LYSO scintillation light measurement with an ultra-fast MCP-PMT

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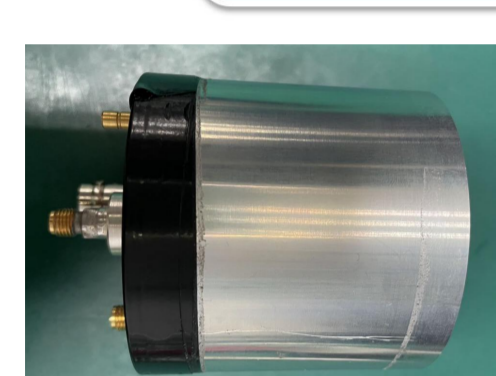
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Introduction

Abstract: The scintillator can be seen as a wavelength shifter which converts the incident particle into a number of photons. The decay time of scintillators is measured by coupling the scintillation with the photosensitive device. Through the scintillation light waveform sampling and the decay time exponential fitting, we can obtain the decay time of the scintillation. Traditionally the photosensitive device used to measure the scintillation light have a rise time on the order of nanoseconds. In our experiment, an ultra-fast MCP-PMT with a rise time of 100 ps and a transit time spread of 46 ps at single-photon mode was used to be coupled with the $\text{Lu}_{1.8}\text{Y}_2\text{SiO}_5:\text{Ce}$ (LYSO) scintillator and obtain the scintillation light waveforms. The waveform obtained is not a complete scintillation pulse, the photons in one scintillation event are distinguished and becomes discrete pulses. A new method is introduced to measure the decay time of the scintillator and the result of LYSO with the new method is compared to the results with the XP2020.

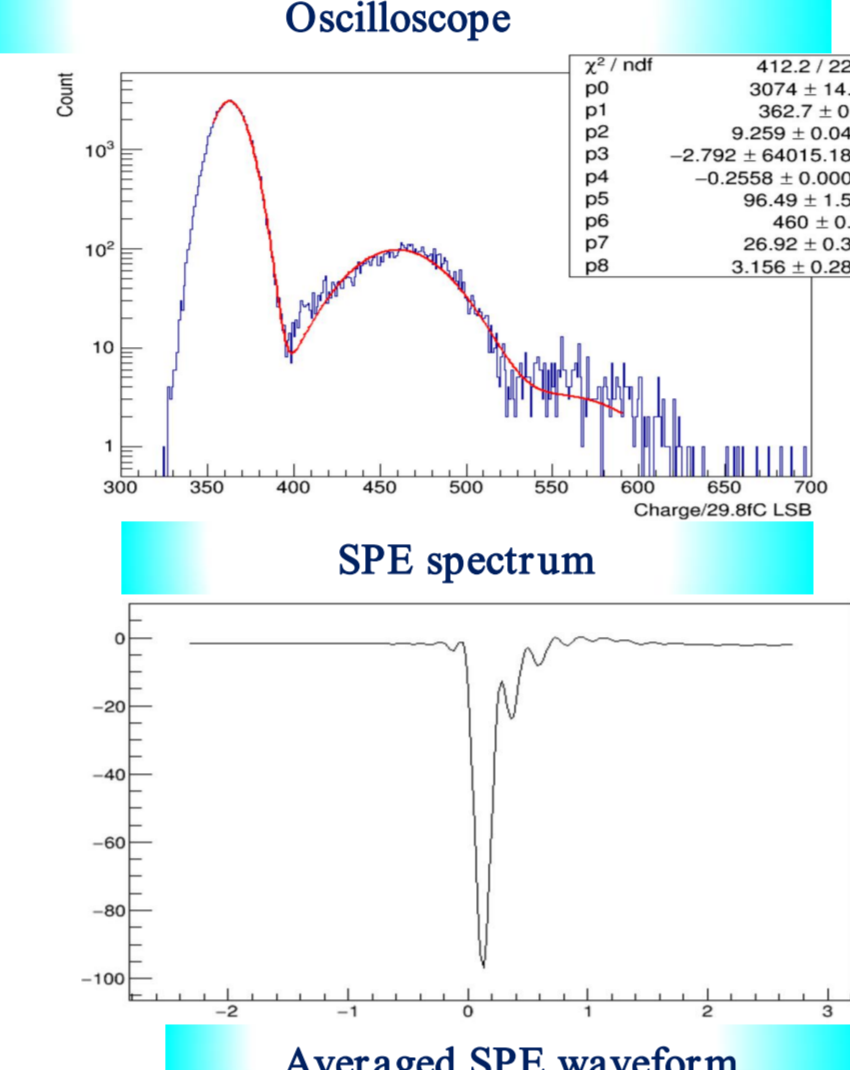
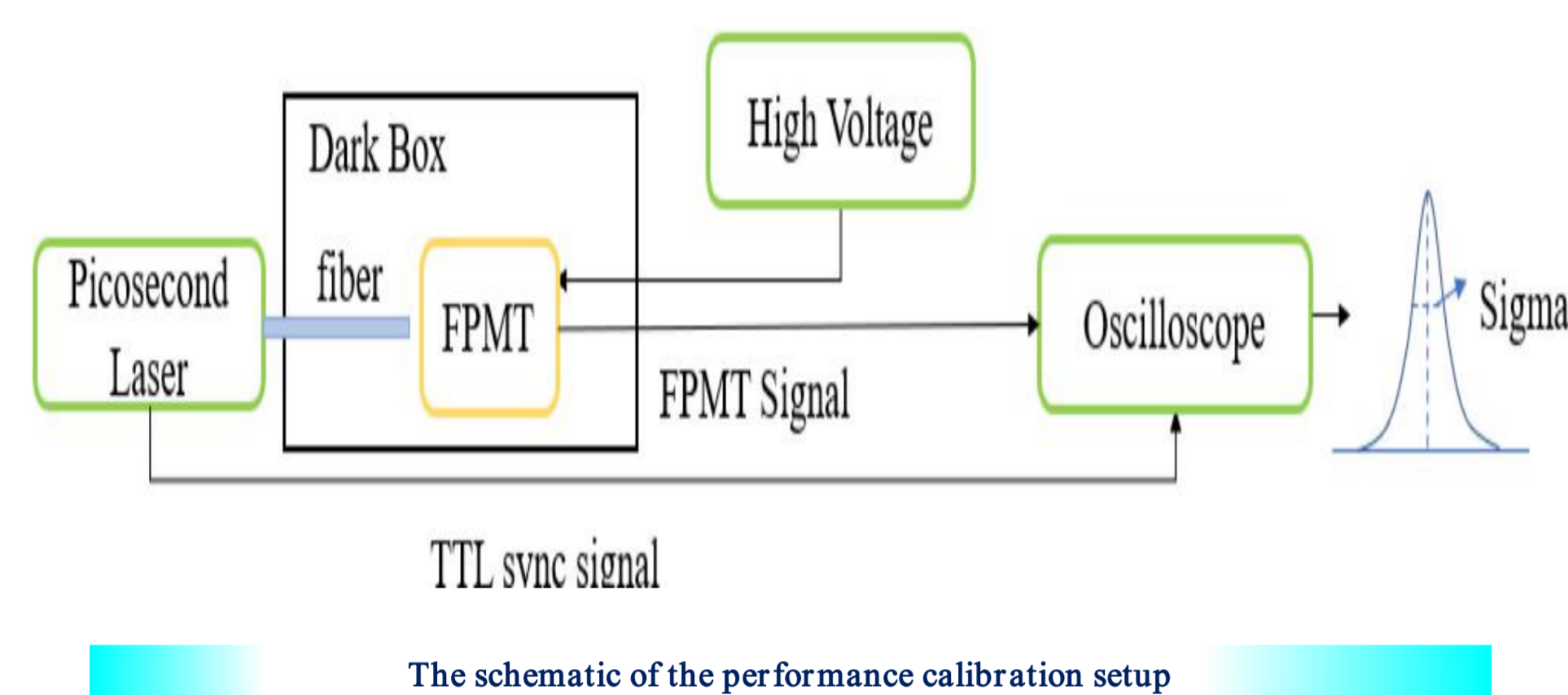
1. Calibration of the ultra-fast MCP-PMT



Pulse Width: 40 ps
Frequency: 1kHz
Light Intensity: SPE

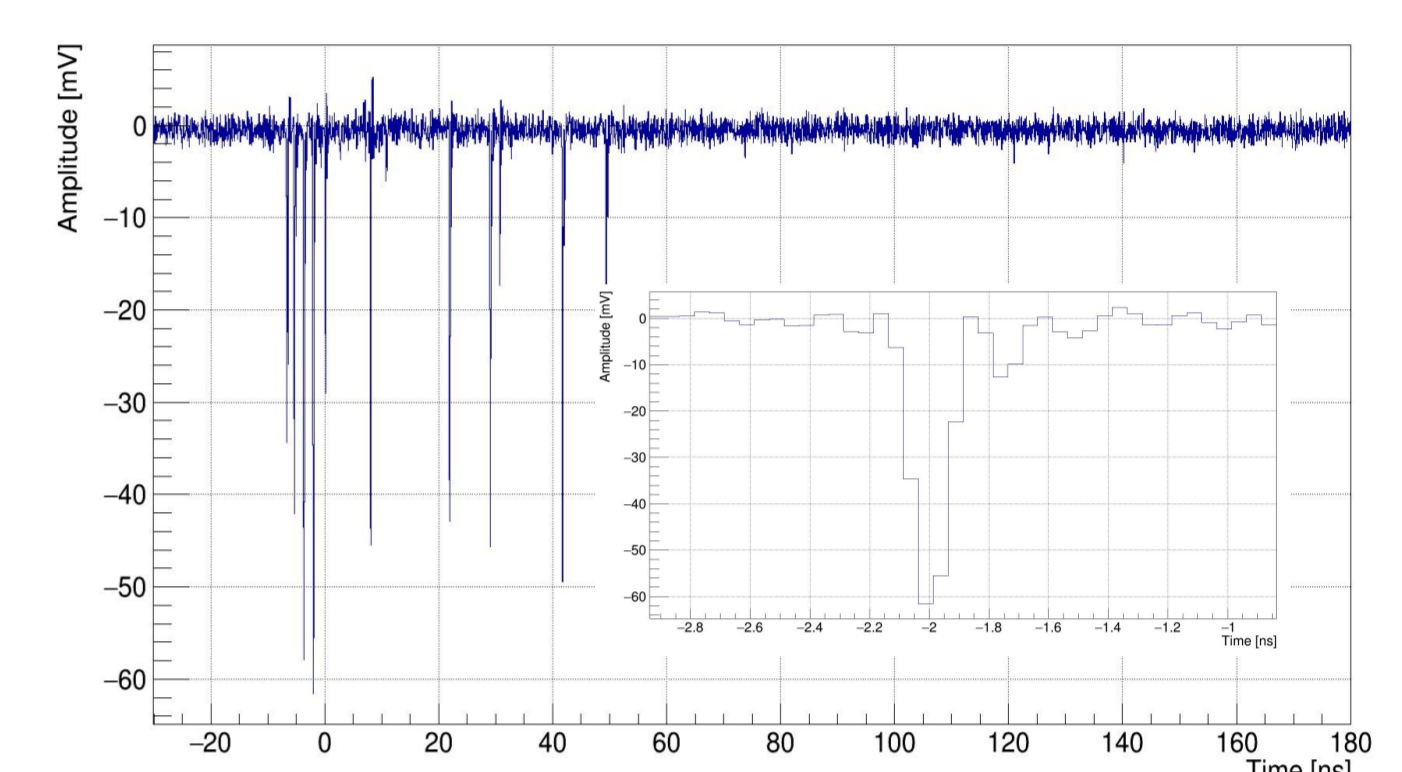
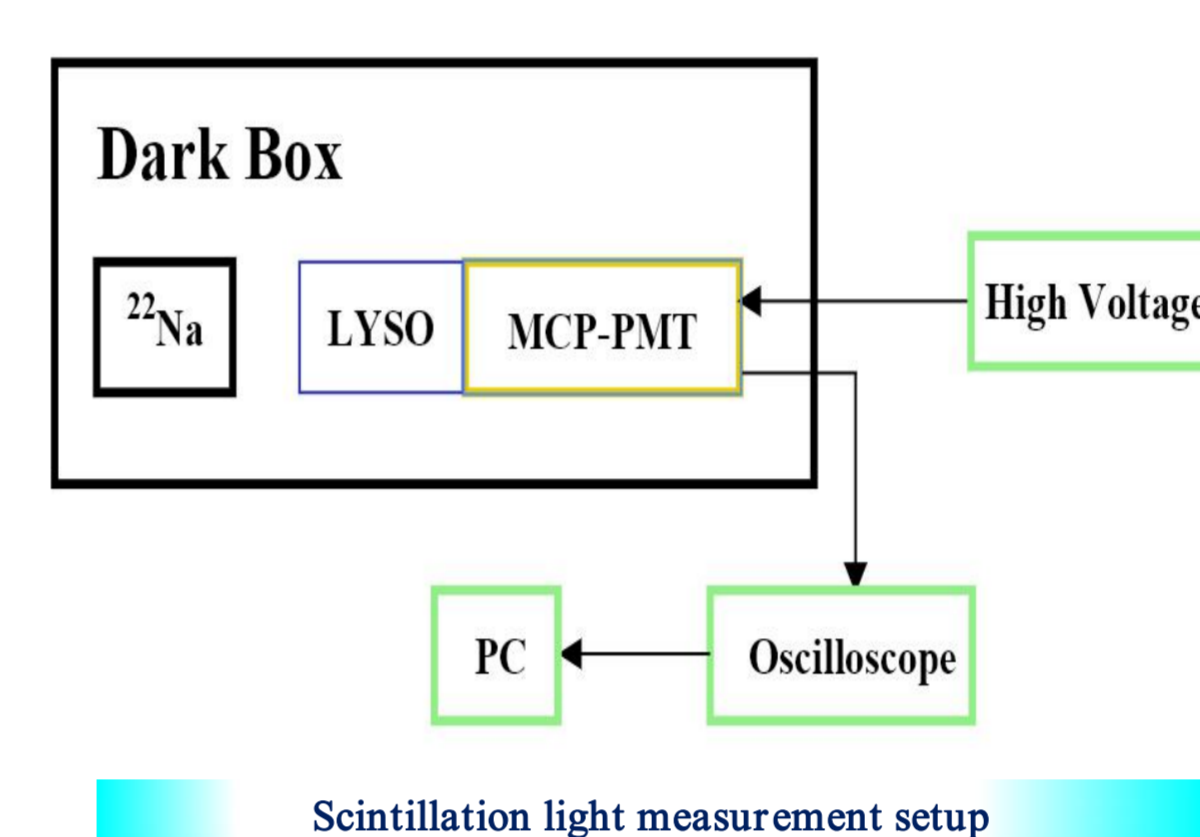


LeCroy HDO9404
Sampling rate: 40GS/s
Bandwidth: 4GHz

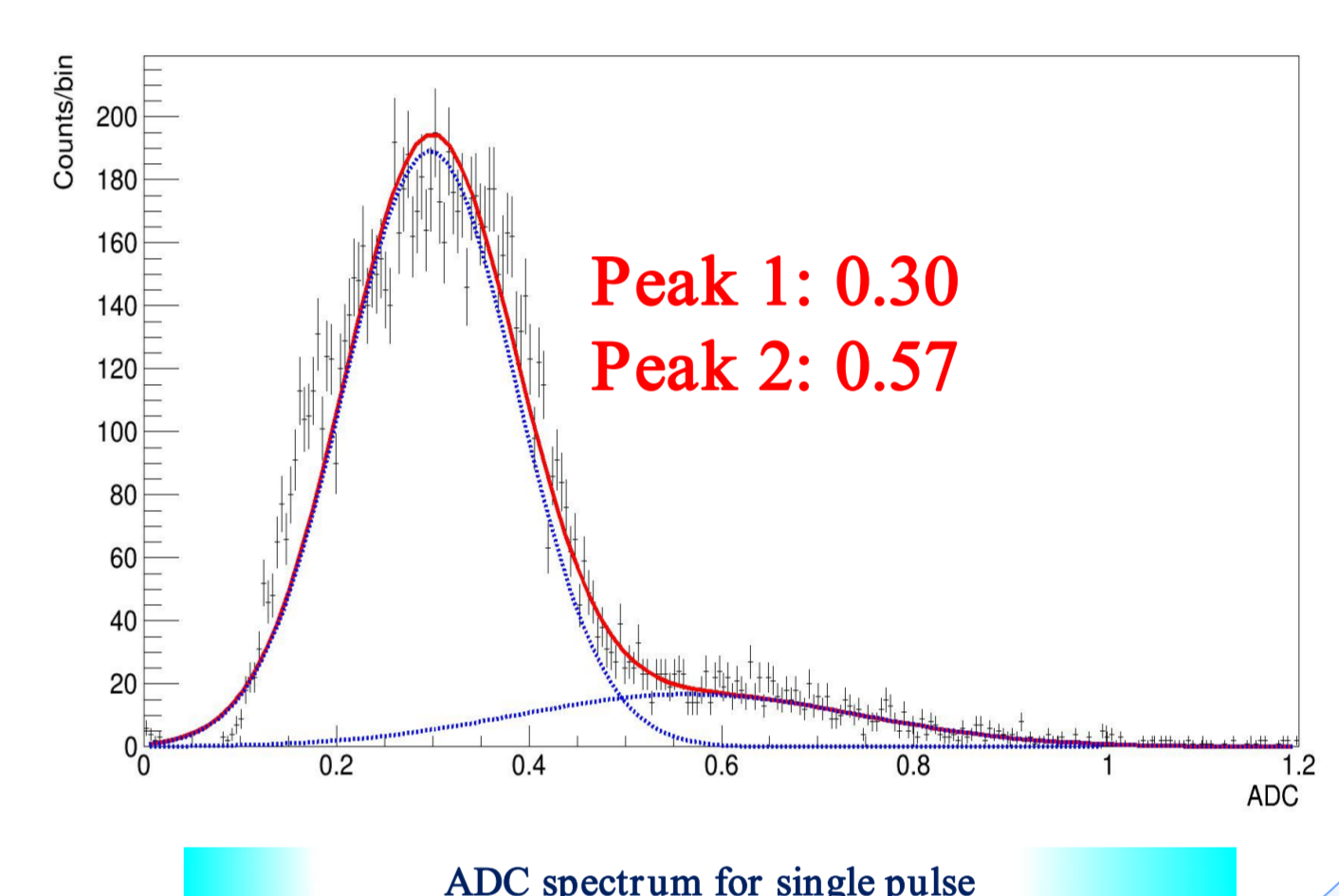


Parameters	HV	Gain	P/V	Amplitude (Noise)	Amplitude (SPE)	RT	FT	Width	TTS @SPE
Ultra-fast MCP-PMT	-4800 V	1.9E6	4.5	93.9 mV	96.7 mV	100 ps	275 ps	150 ps	46 ps

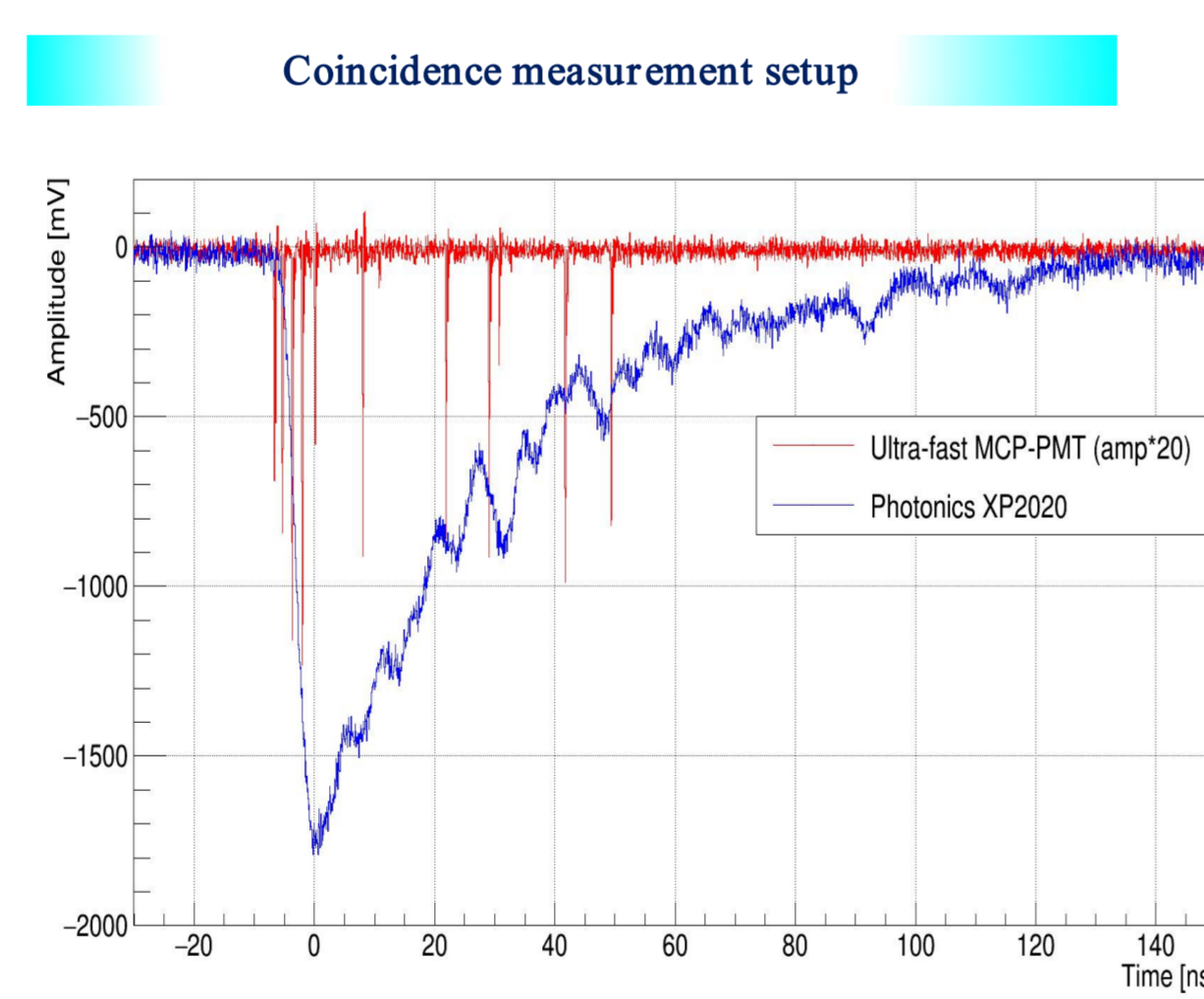
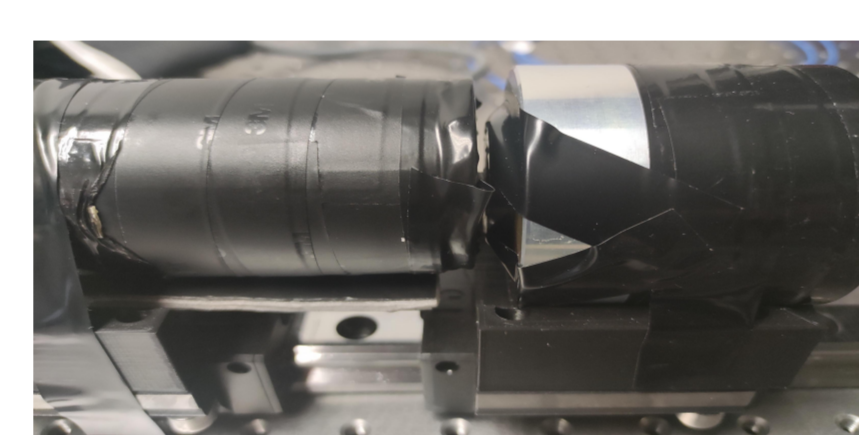
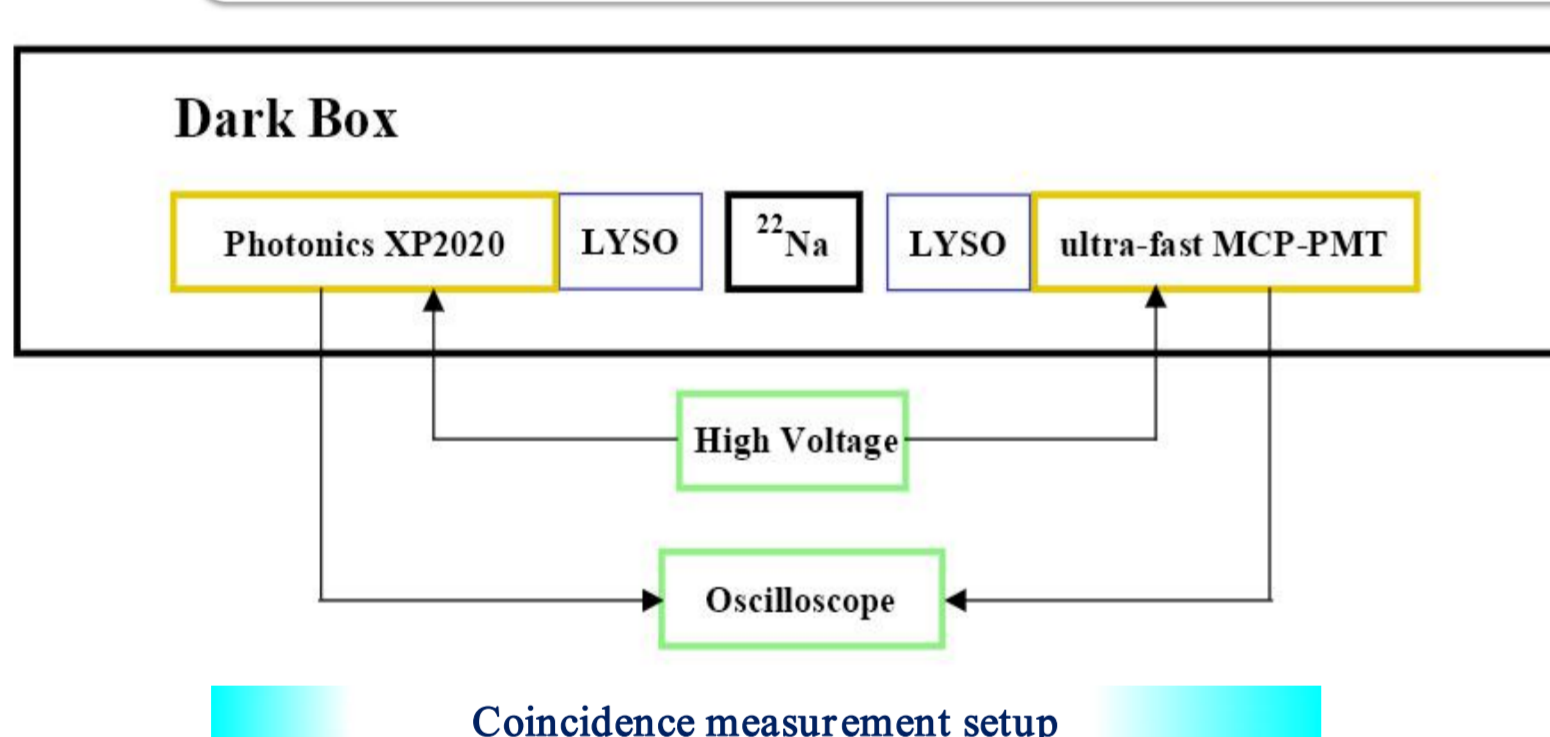
2. LYSO scintillation light measurement



--Using the ^{22}Na radioactive source, the typical waveform for LYSO obtained by the oscilloscope is not a complete scintillation light event.
---The ADC spectrum shows that the waveforms obtained by the ultra-fast MCP-PMT are mostly single-photon events.

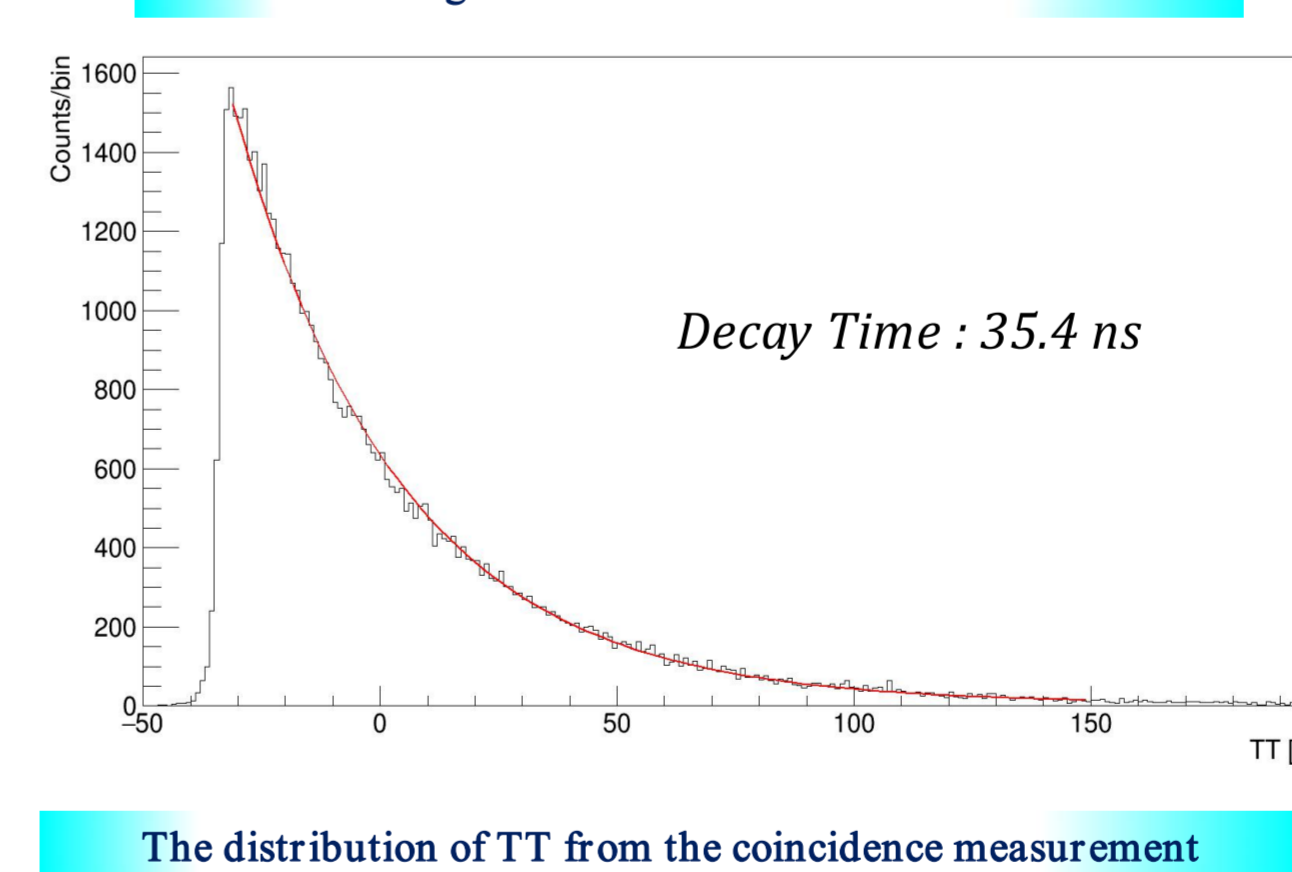
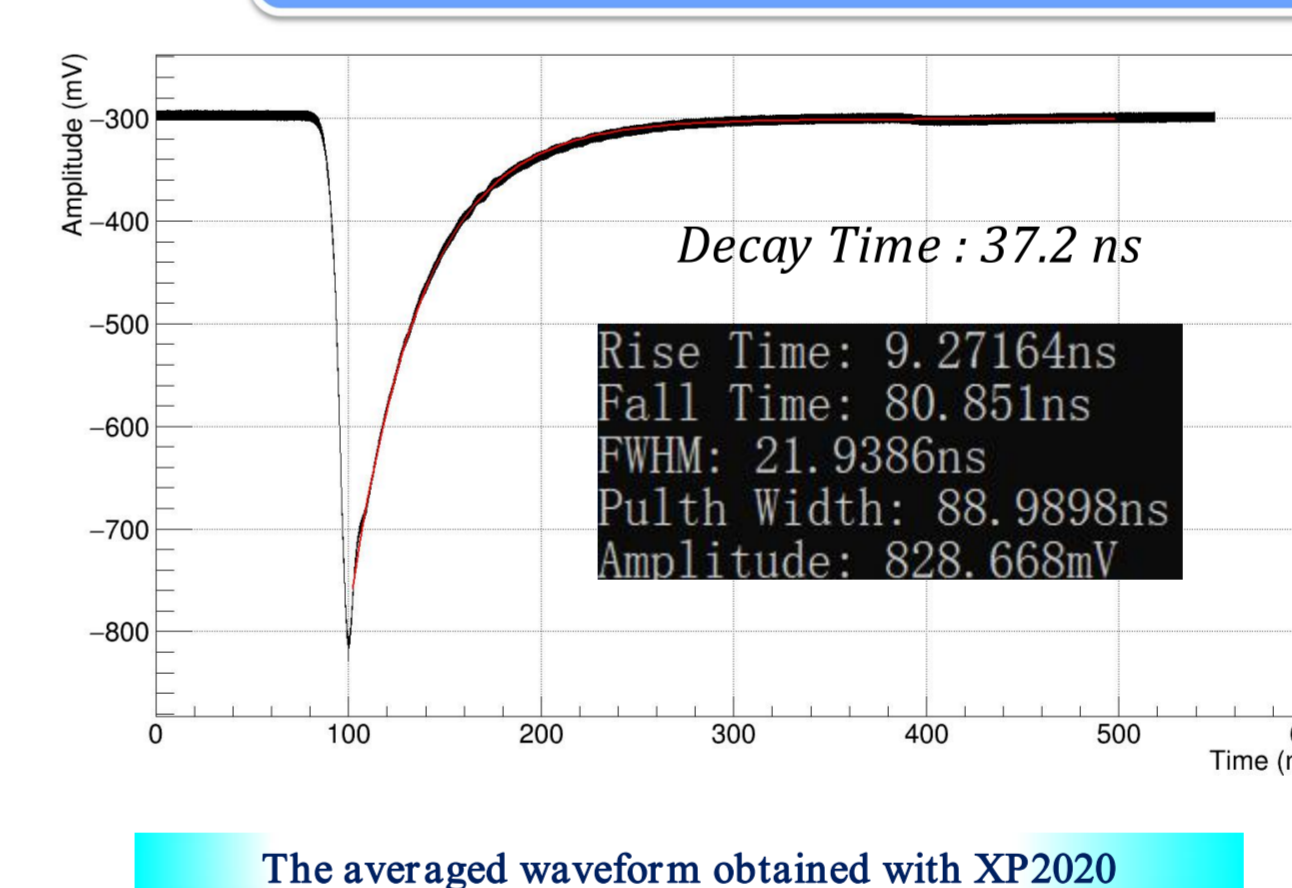


3. Coincidence measurement

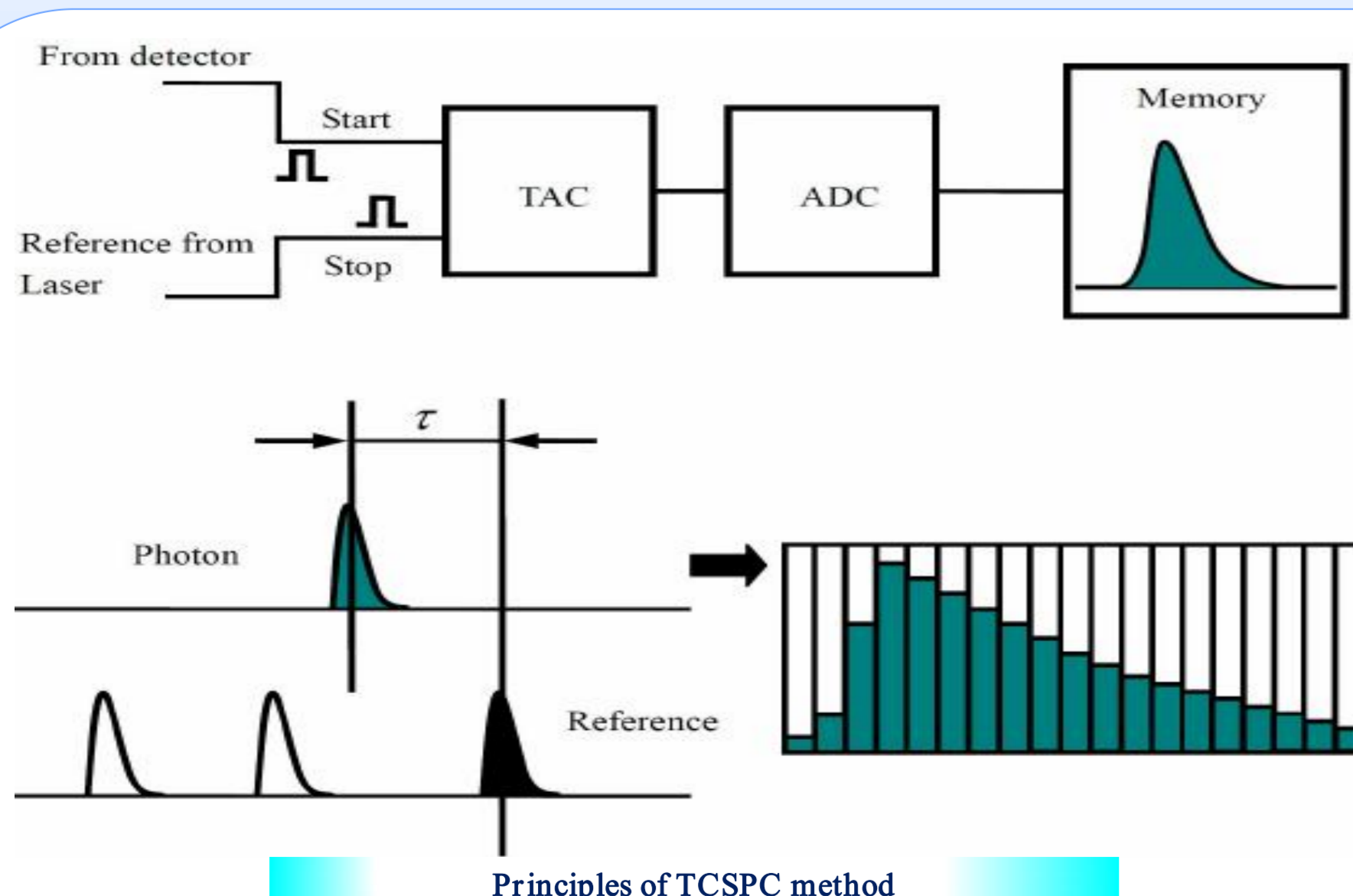


- A coincidence measurement setup was built in the lab.
- 50% of the signal amplitude from the XP2020 is used as the start and multiple stops for the ultra-fast MCP-PMT in single event are all recorded.
- The stop is allowed to be earlier than the start signal within the 500 ns time window.

4. Decay Time Measurement Results



- The decay time directly obtained from the averaged waveform from XP2020 is 37.2 ns which is larger than the reconstruction result from the TT distribution as 35.4ns.
- This is because the bandwidth of the oscilloscope and the performance of the PMT will inevitably affect the decay waveform directly obtained from the oscilloscope;
- The decay time is a combination of the real decay photon intensity and the equivalent circuit of the oscilloscope.



5. Conclusions

- The ultra-fast MCP-PMT shows great photon discrimination ability which leads to the separation of single scintillation waveform when coupled with the LYSO crystal.
- The coincidence measurement method can be used to reconstruct the TT of the photons which is similar to the traditional TCSPC method but is more sufficient.
- The result obtained is better than the waveform directly obtained from the oscilloscope.

Acknowledgement

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