Time resolution study for muon detector

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Joint workshop of the CEPC physics, software and new detector design

Yangzhou, April 16, 2021

Outline

Method for time resolution measurement

- Leading edge discriminator（LED）
- Constant fraction discriminator（CFD）

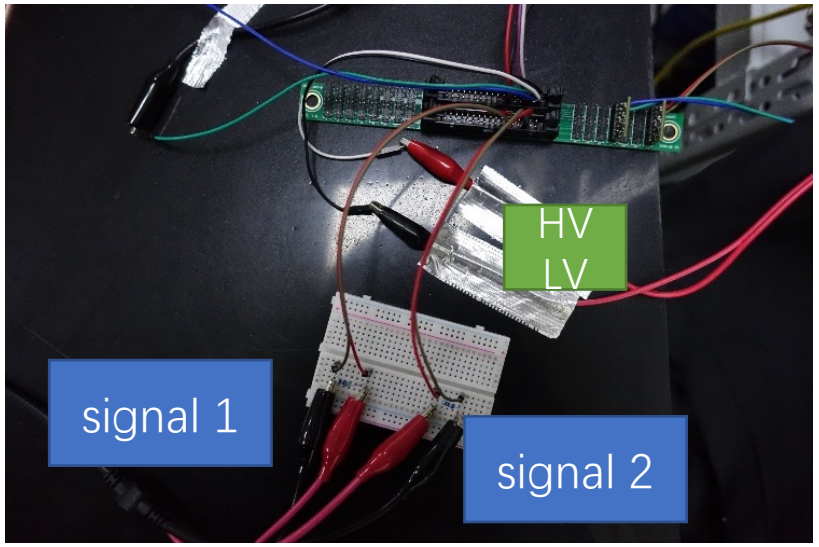
Results of time resolution

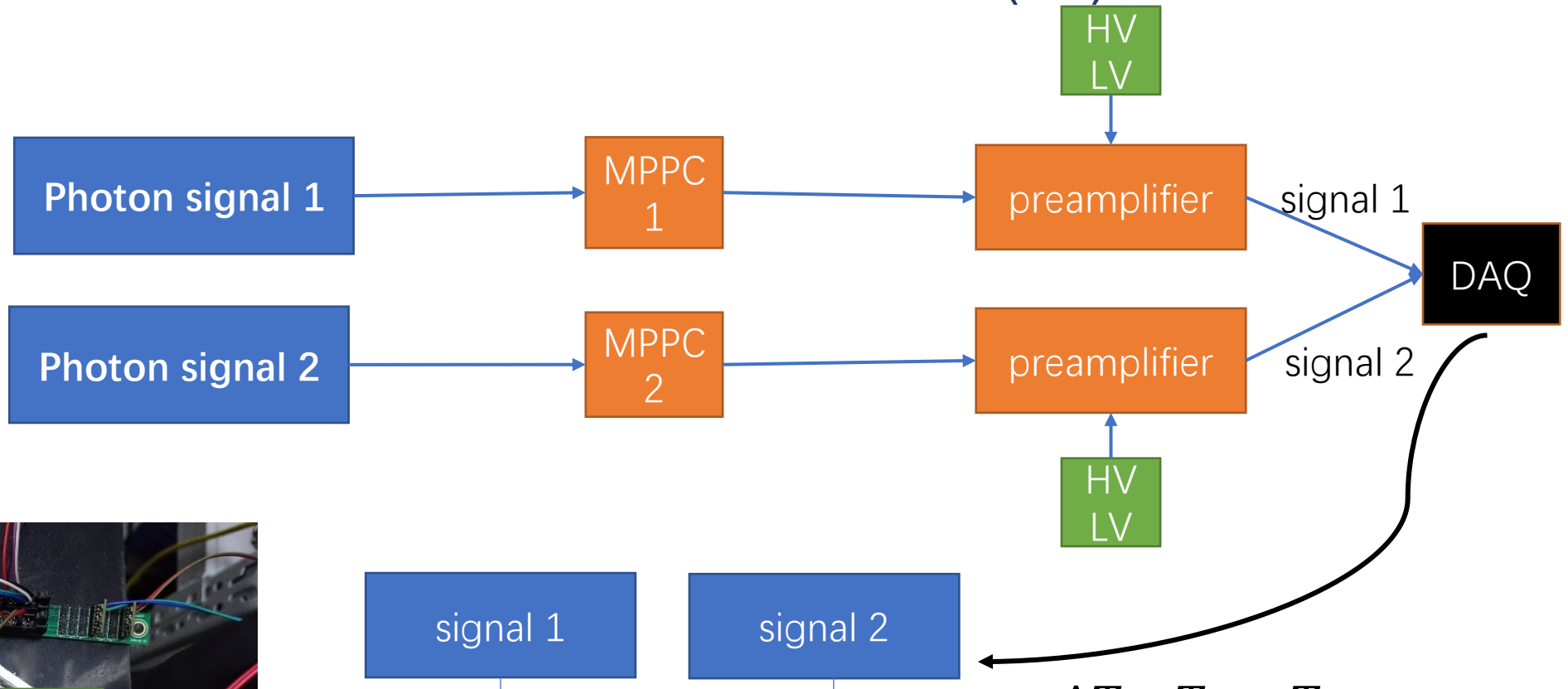
- Preamplifier
- MPPC
- Scintillator

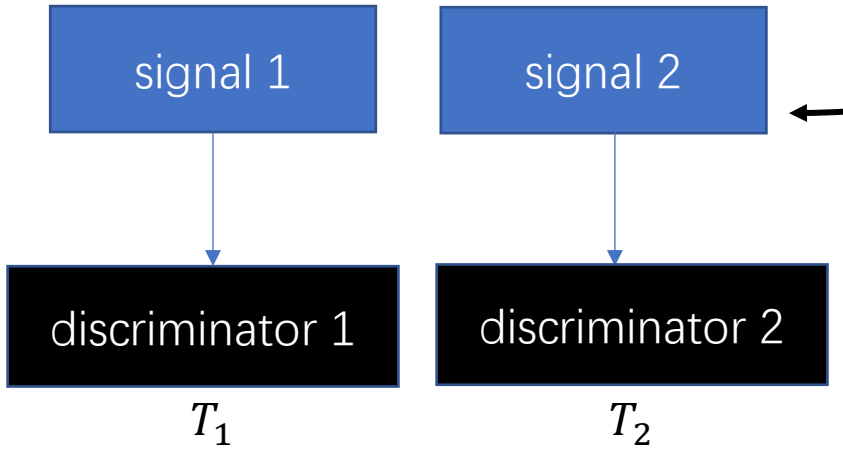
Method

Measurement of time resolution (δT)

Generator driving LED







$\Delta T = T_1 - T_2$

σ_T : standard error of ΔT

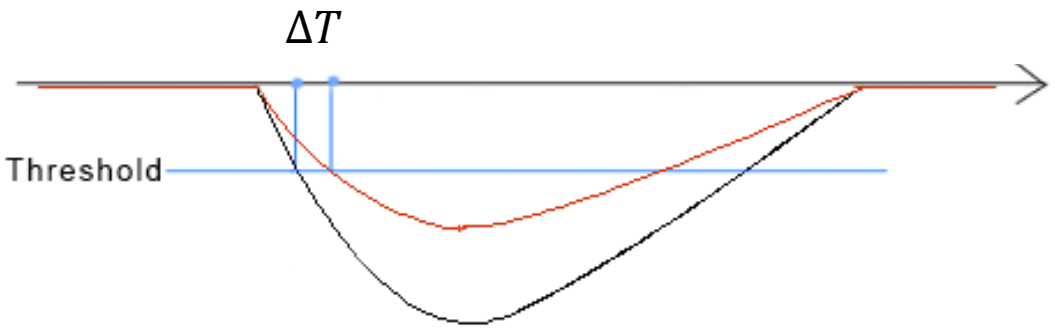
$$\delta T = \frac{\sigma_T}{\sqrt{2}}$$

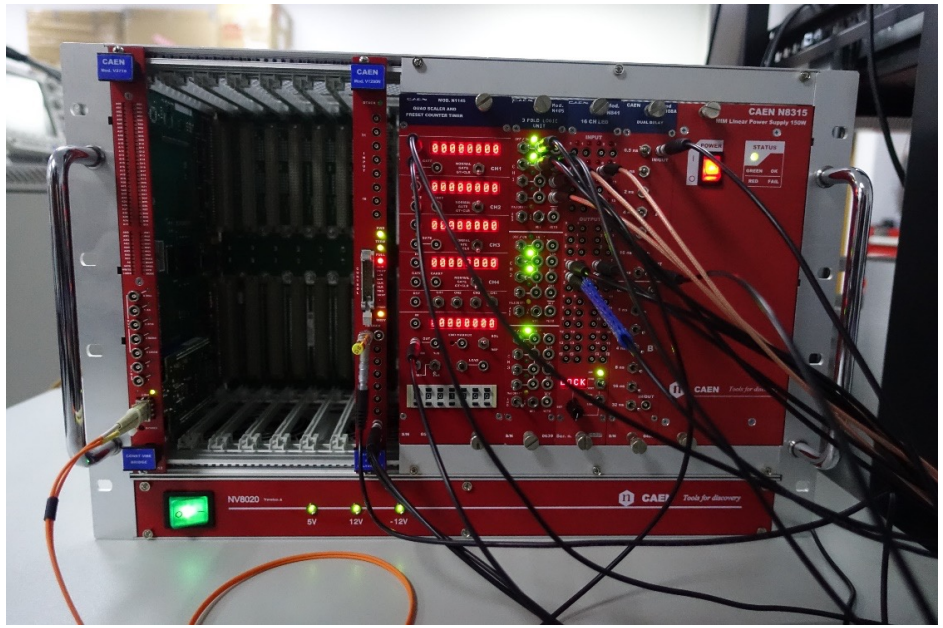
Method

Time measurement (I)

- Leading edge : LE (N841) +TDC (V1290)
  - Trigger : coincidence of two signals

    TDC resolution : 25 ps





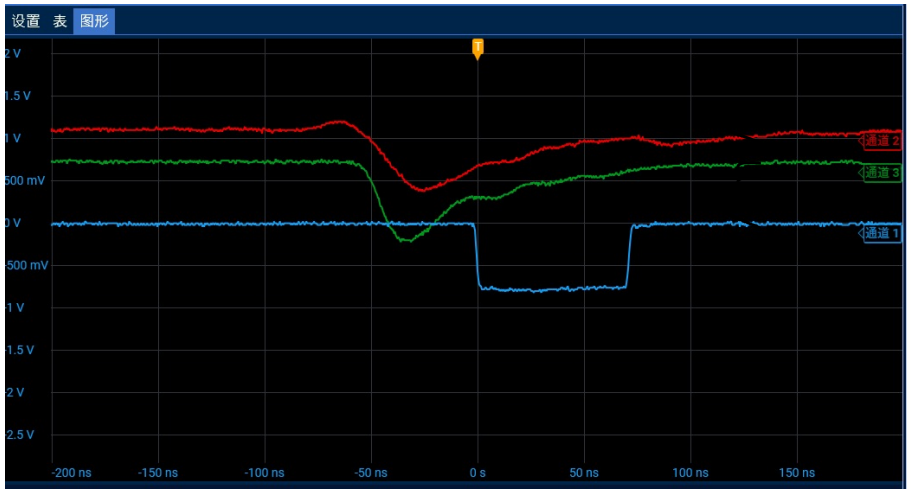
The working NIM and VME modules

ΔT: Time difference caused by variation of amplitude

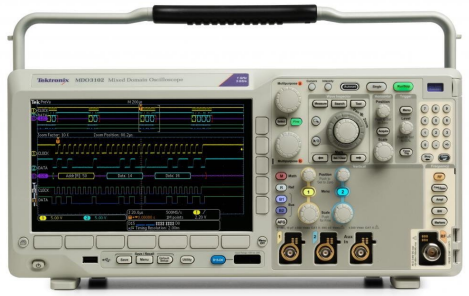
Method

Time measurement (II)

- CFD : Oscilloscope (startkick) +CFD



Waveform from Oscilloscope



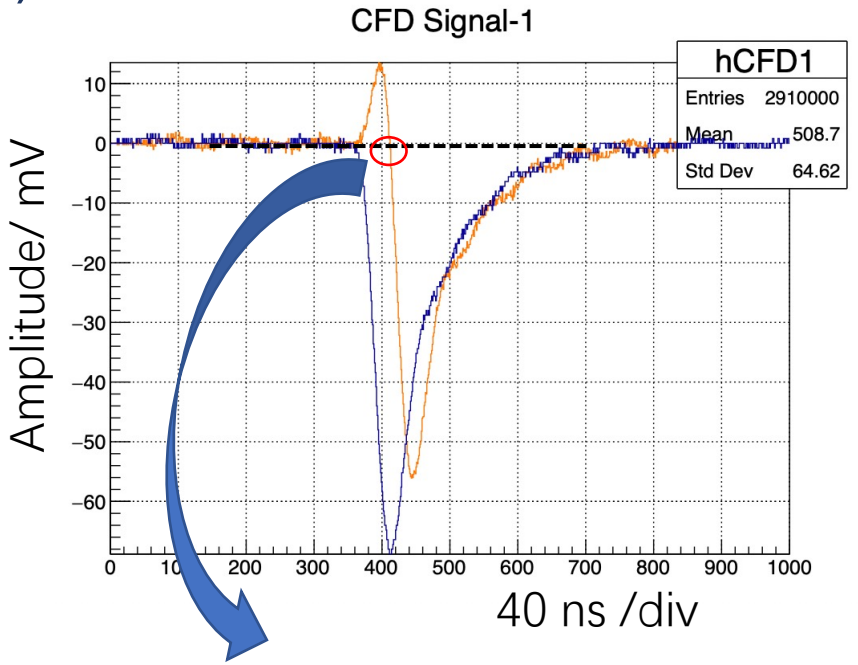
MDO3024

400ps

MSO 56

160ps

Time resolutions of oscilloscopes



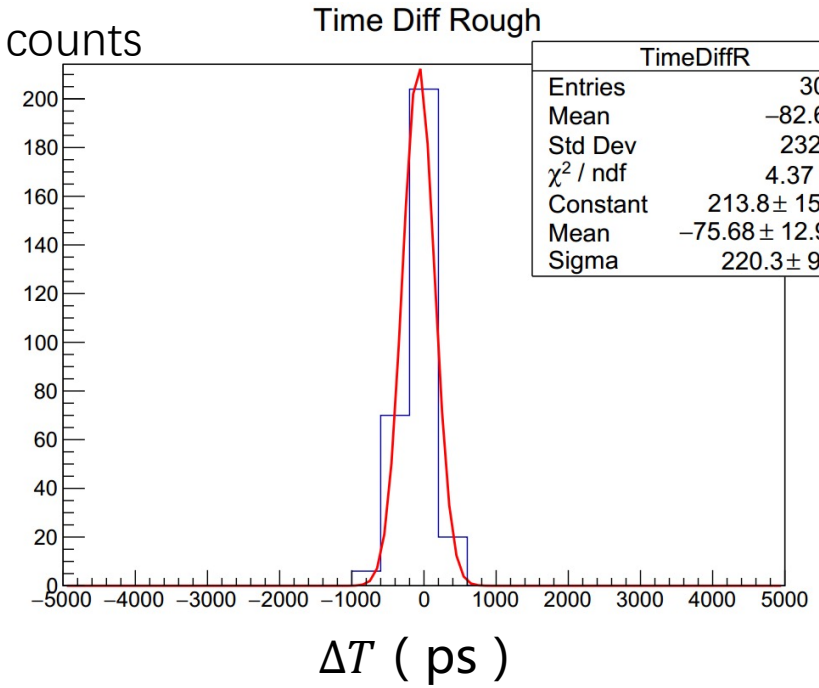
- $\mathrm{H}(CFD) = V(t - t_d) - F * V(t)$
- Poly fit : $P1 + P2 * t + P3 * t^2$
- ZCP : zero crossing point

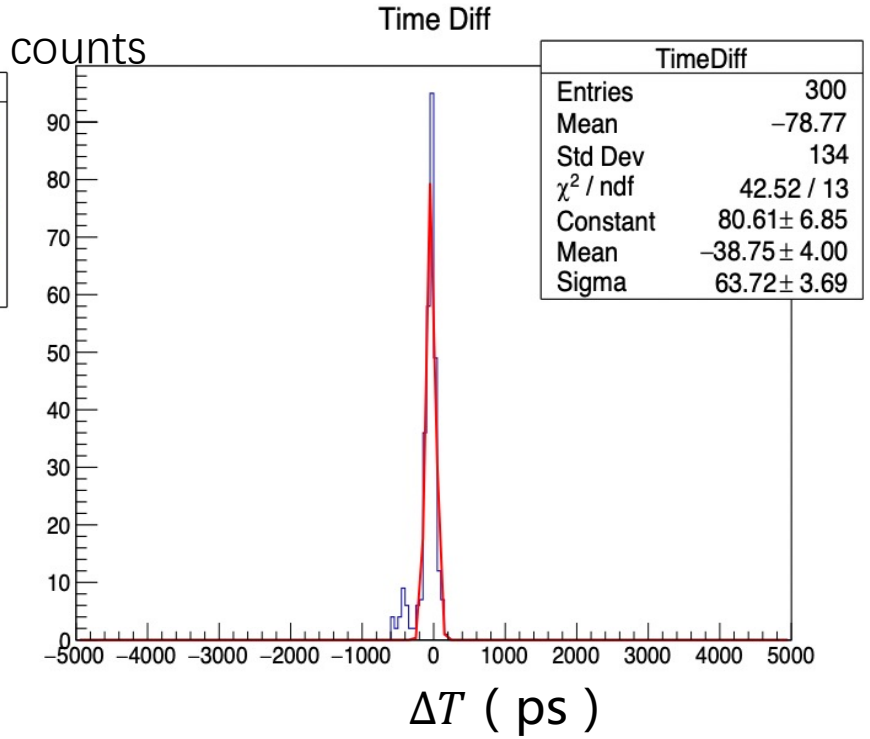
$$\Delta T = ZCP_1 - ZCP_2$$

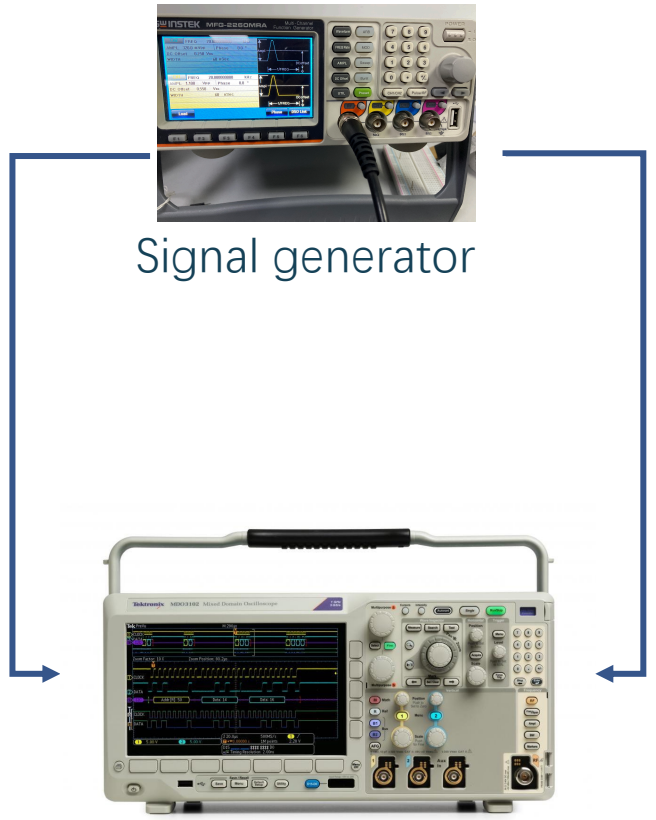
Later results are all from CFD

Result

δT of pulses from generator







Time Difference without Fitting

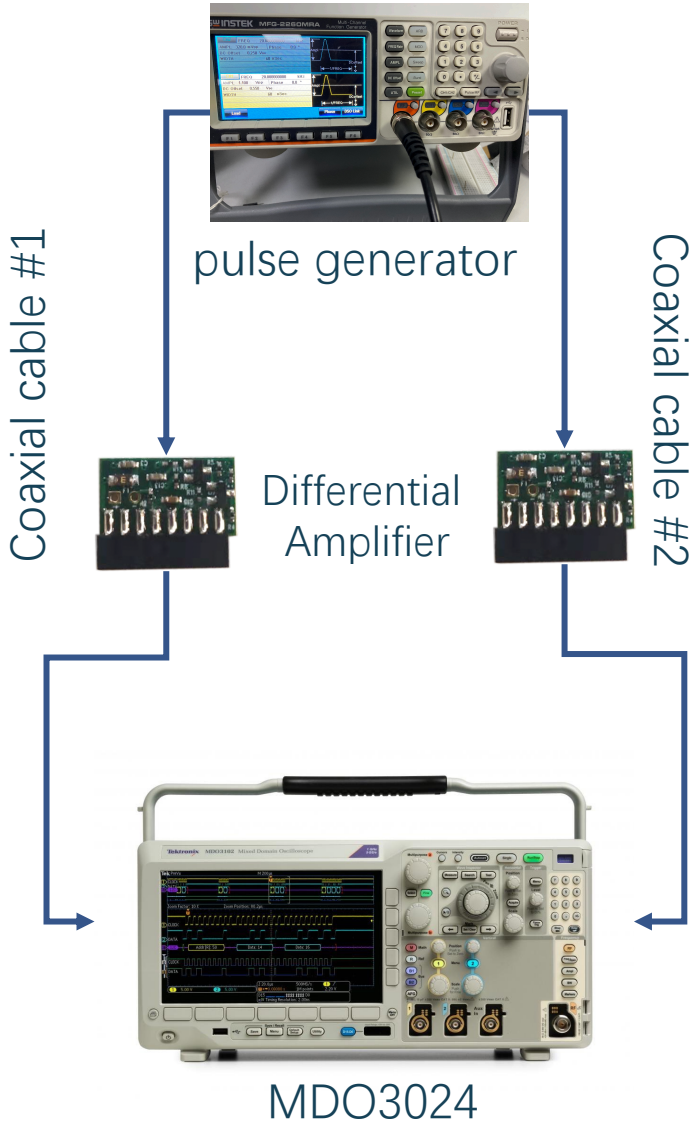
After Fitting

- Poly fit : $P1 + P2 * t + P3 * t^2$
- ZCP : zero crossing point

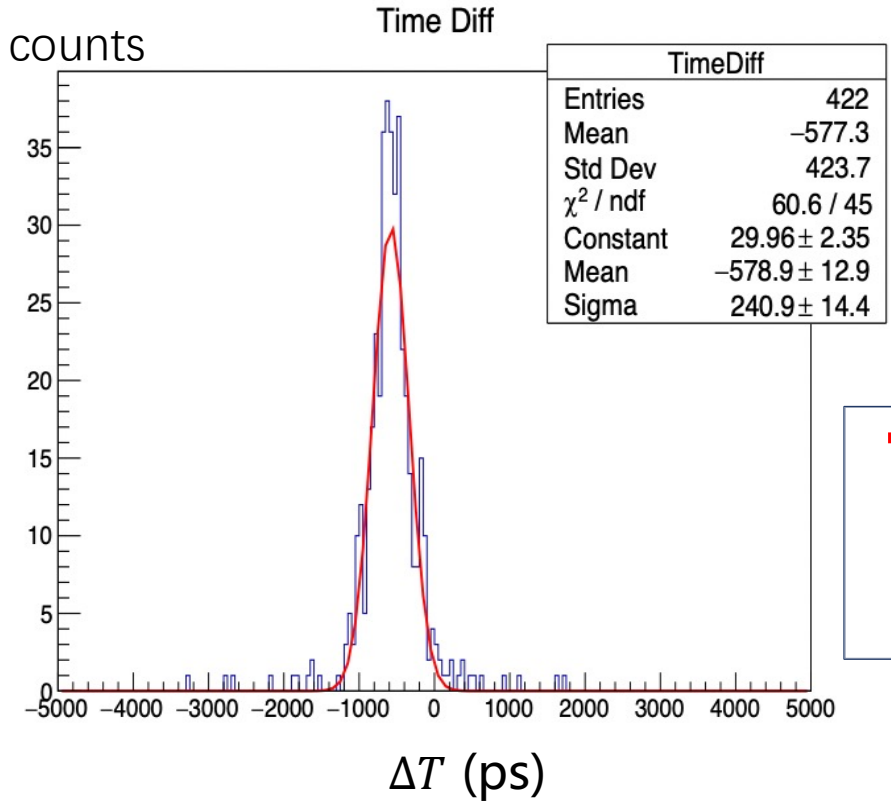
$$\sigma_T = (64 \pm 4)\ \text{ps}$$

$$\delta T = (45 \pm 3)\ \text{ps}$$

Result



δT of pulse+pream



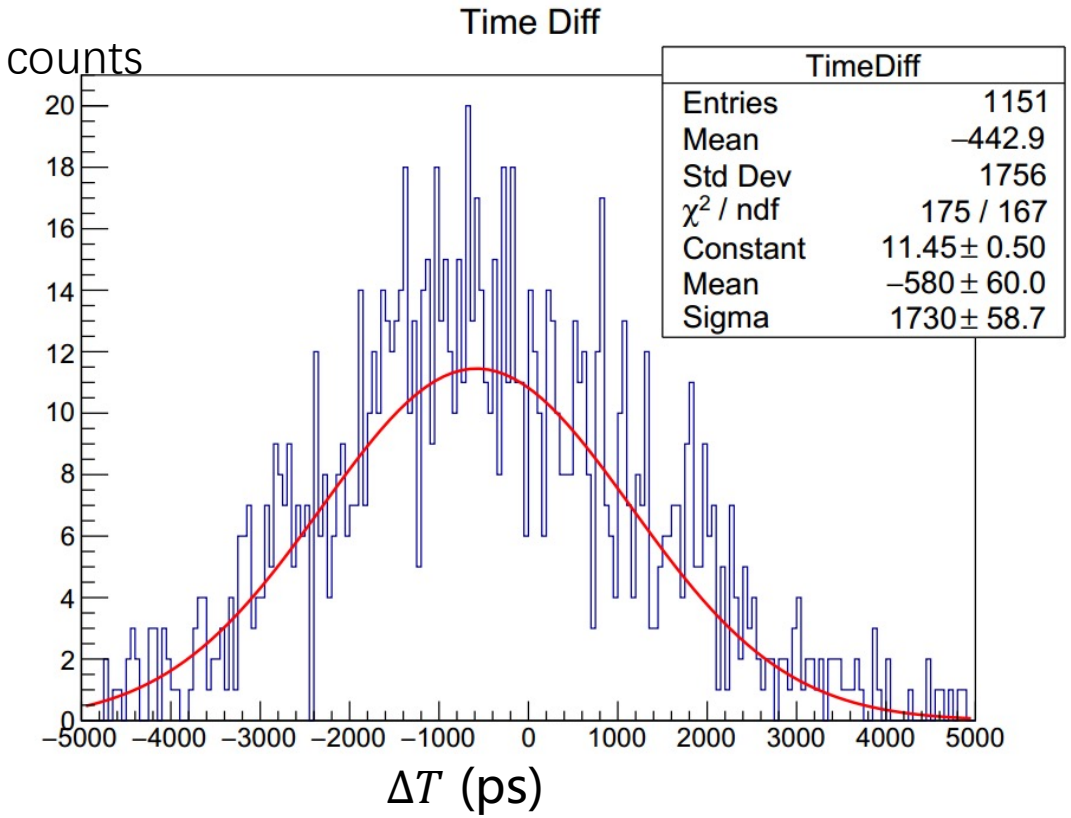
Time resolution of preamp:
$= (164 \pm 10)$ps

$\sigma_T = (241 \pm 14)$ps

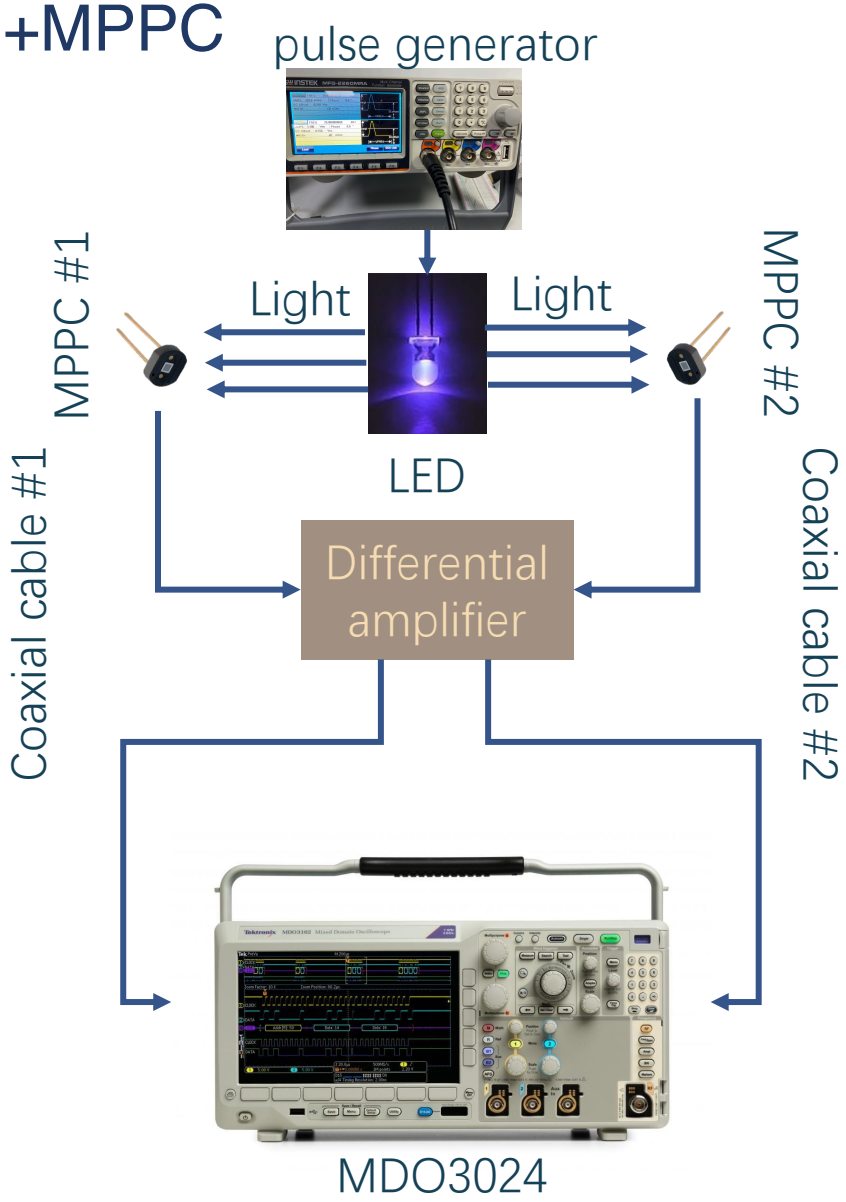
$\delta T = (170 \pm 10)$ps

Result

δT of pulse+pream+MPPC

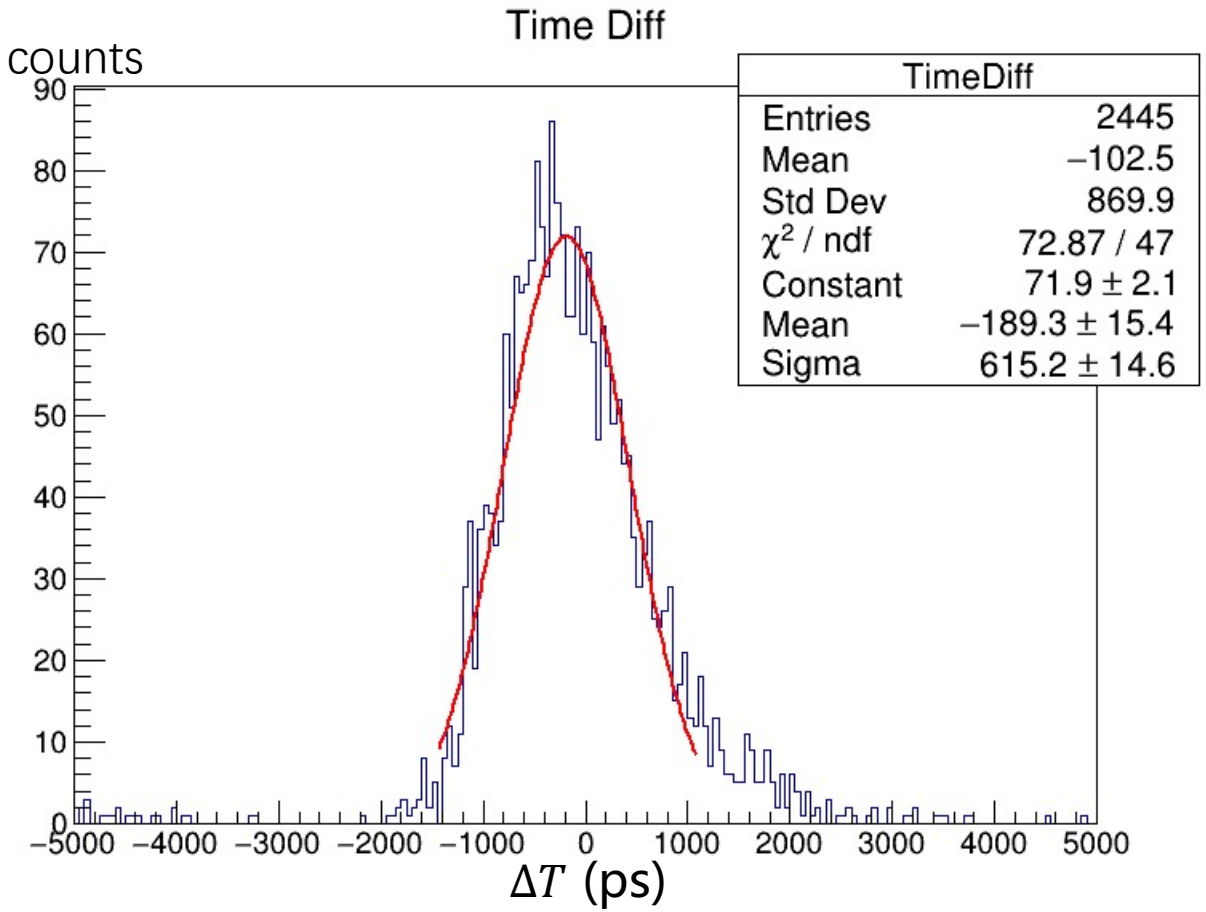


$$\sigma_T = (1730 \pm 59)\text{ps}$$
$$\delta T = (1223 \pm 42)\text{ps}$$

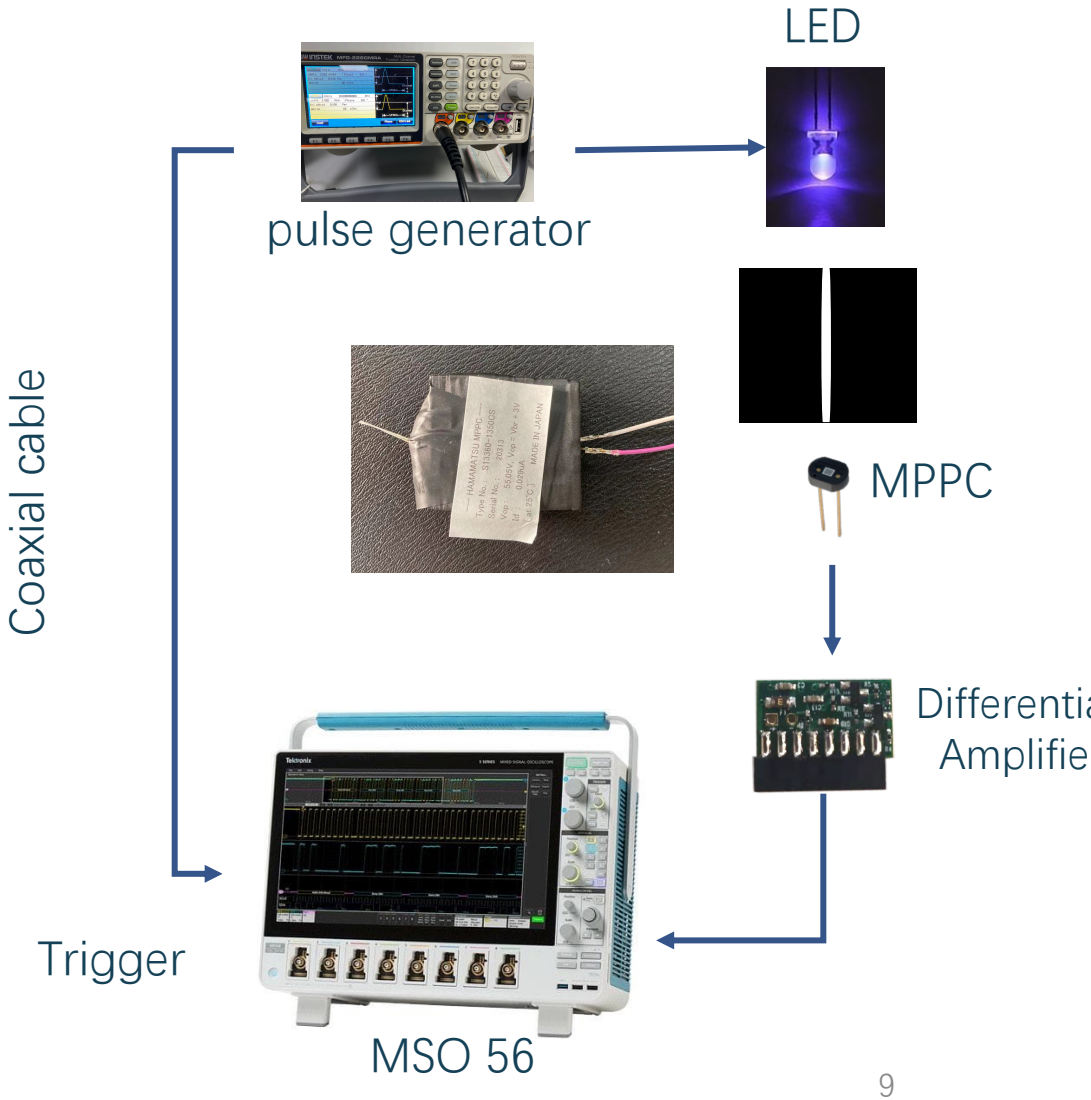


Result

δT of pulse & pream+MPPC



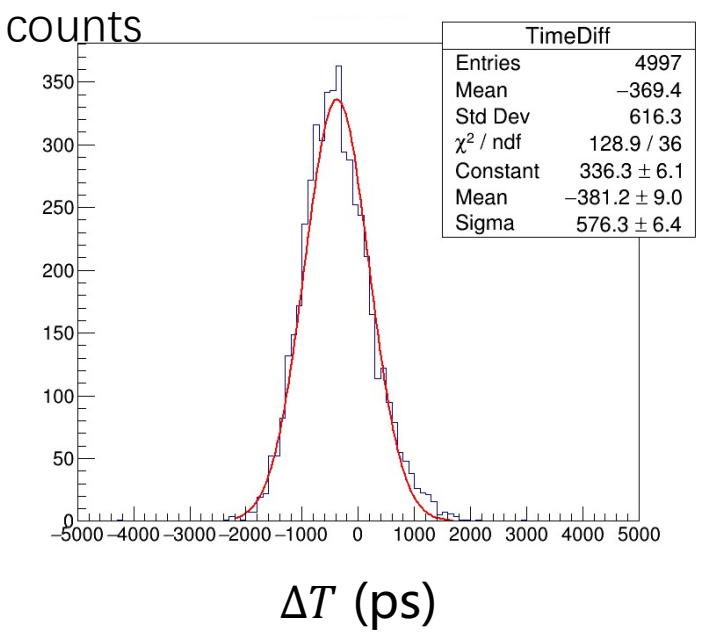
$$\delta T \approx \sigma_T = (615 \pm 14)\text{ps}$$



Result

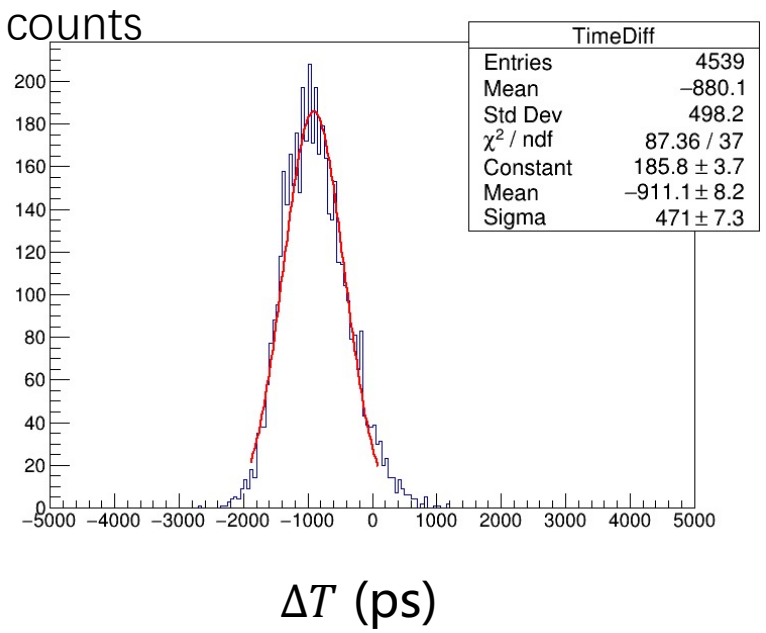
δT of pulse & pream+MPPC

LED at the end face of WLSF

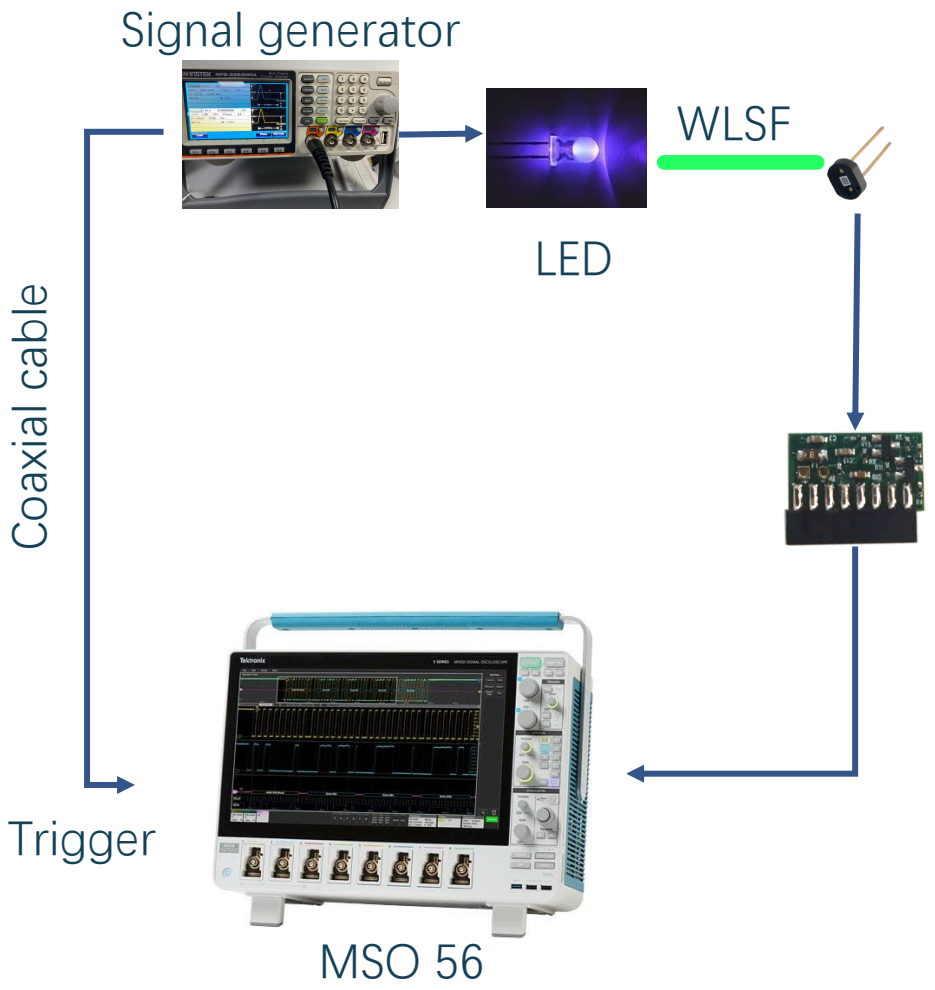


$\delta T \approx \sigma_T = (576 \pm 6)\text{ps}$

LED at the side of WLSF

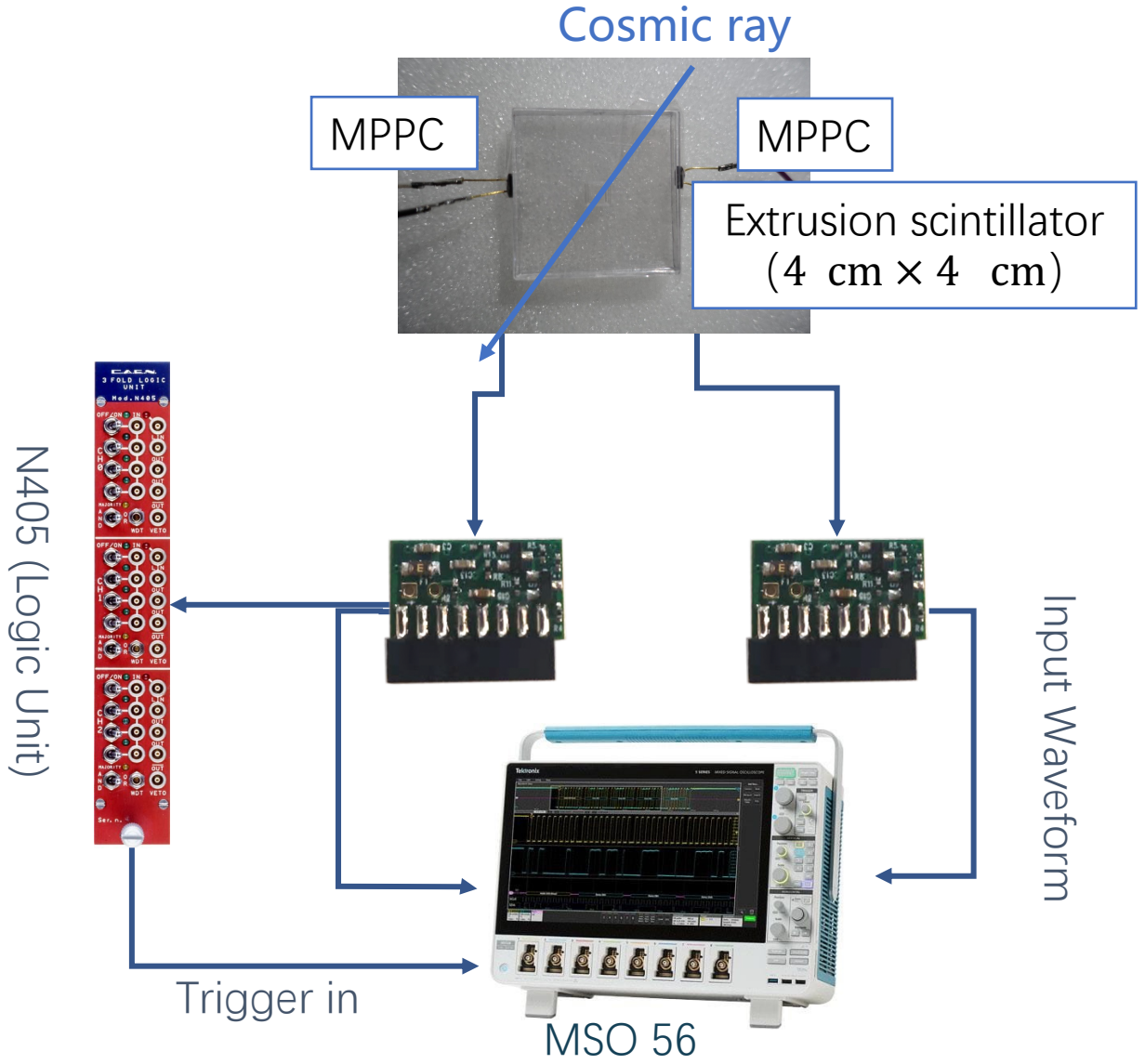


$\delta T \approx \sigma_T = (471 \pm 7)\text{ps}$



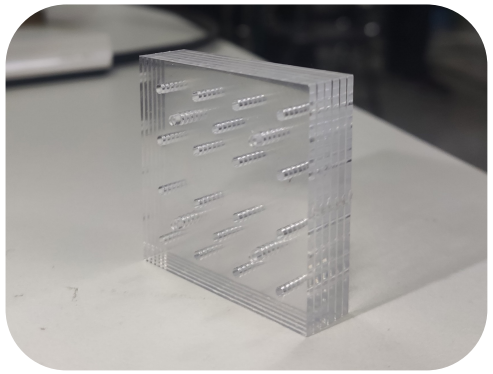
Result

δT of MPPC + scintillators



Result

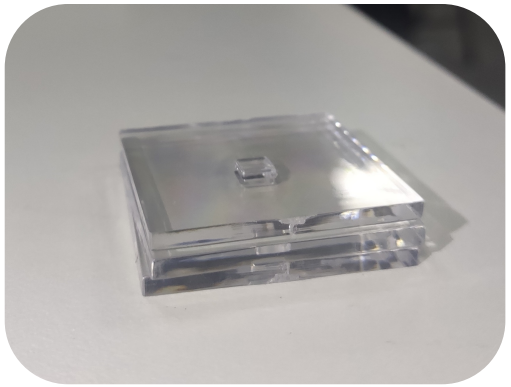
δT of MPPC + scintillators



Scintillator of NICA experiment

$\sigma_T = (789 \pm 42)\text{ps}$

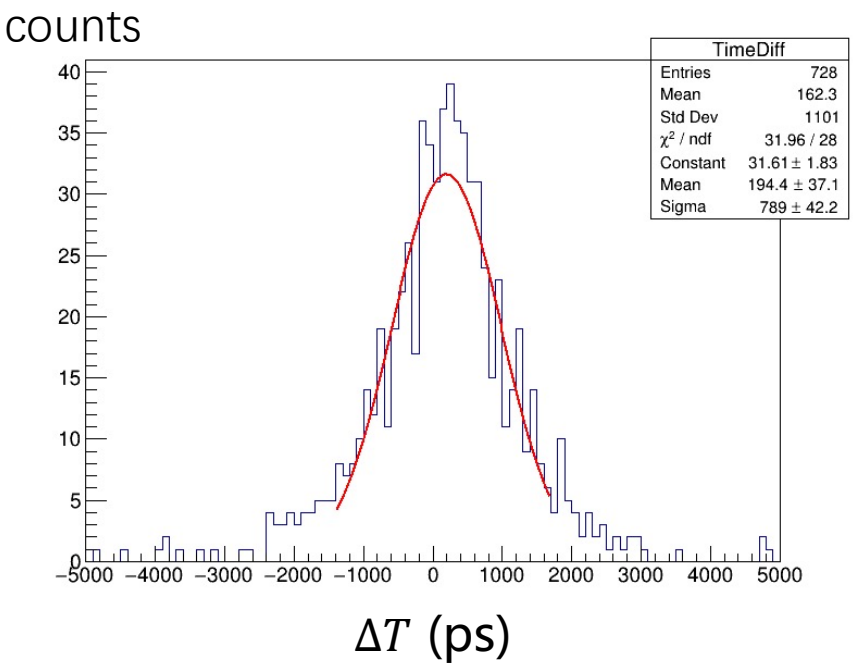
$\delta T = (558 \pm 30)\text{ps}$

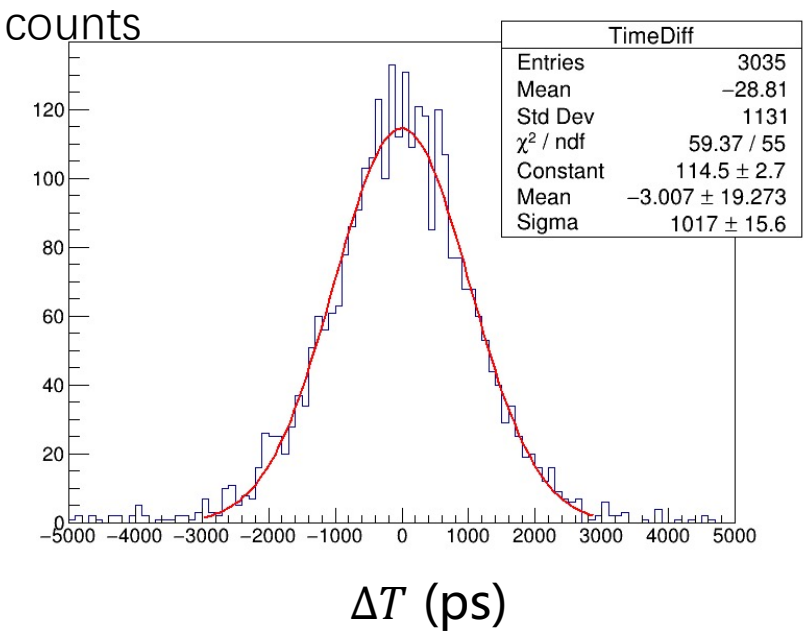


Scintillator of CEPC Hcal

$\sigma_T = (1017 \pm 16)\text{ps}$

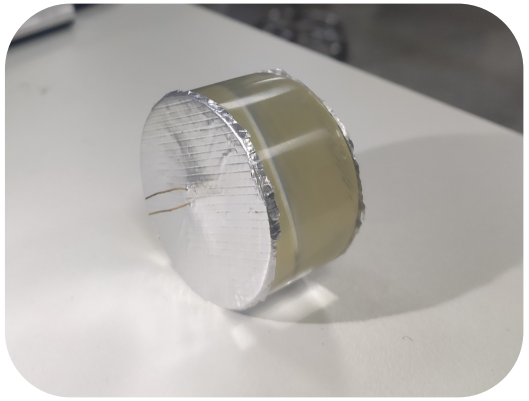
$\delta T = (719 \pm 11)\text{ps}$



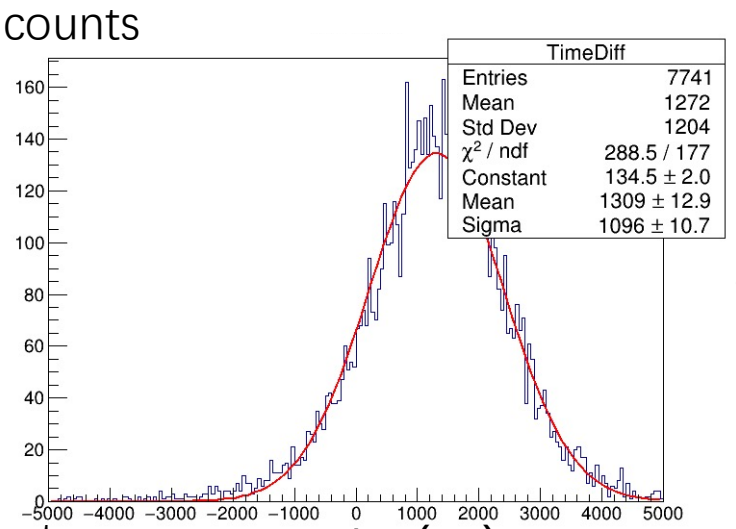


Result

δT of MPPC + scintillators

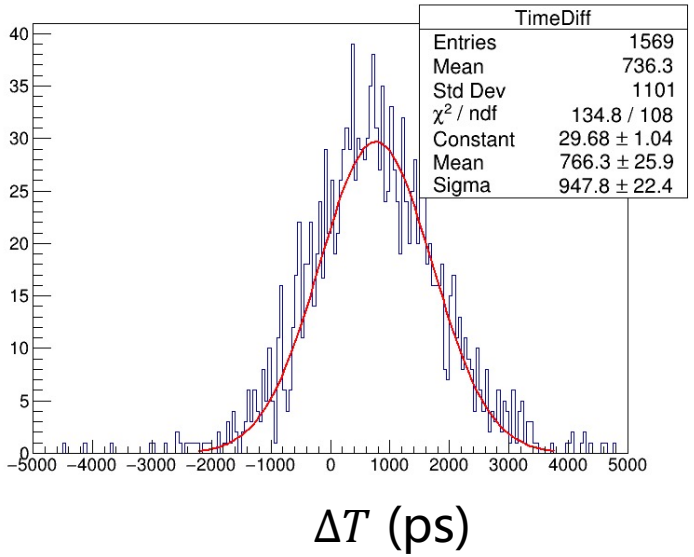


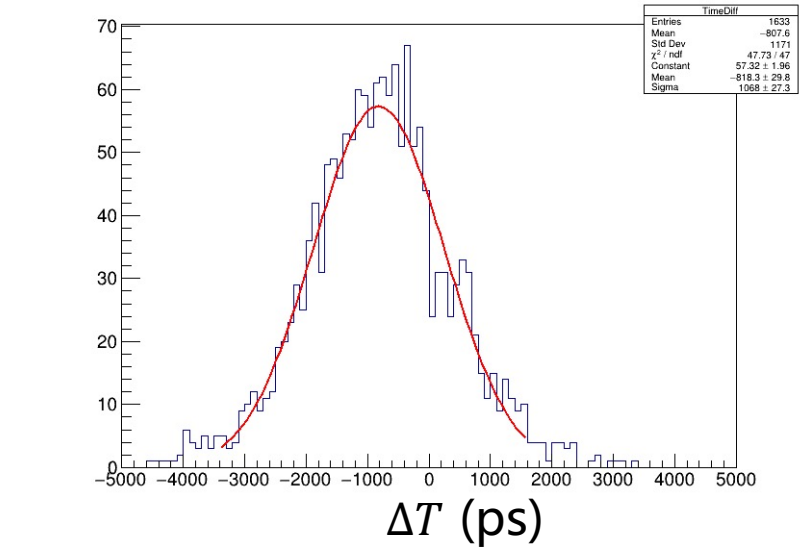
cylinder scintillators



$\sigma_T = (1069 \pm 10)\text{ps}$

$\delta T = (756 \pm 7)\text{ps}$





Summary

- Construction of two systems to measure time resolution
  - Leading edge
  - Constant fraction discriminator （CFD）
- Results of time resolution
  - Preamplifier has a good performance : (164 ± 10) ps
  - We use LED+fiber to test MPPC: (471 ± 7) ps
  - Test different scintillators

    From NICA : (558 ± 30) ps

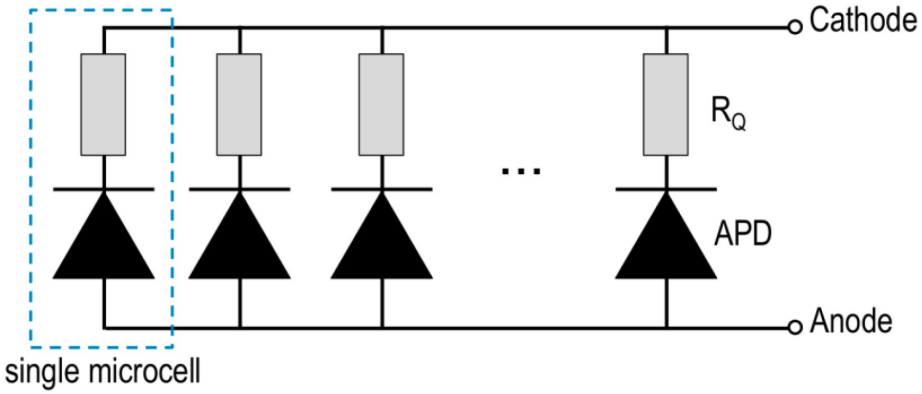
    From CEPC Hcal : (719 ± 11) ps

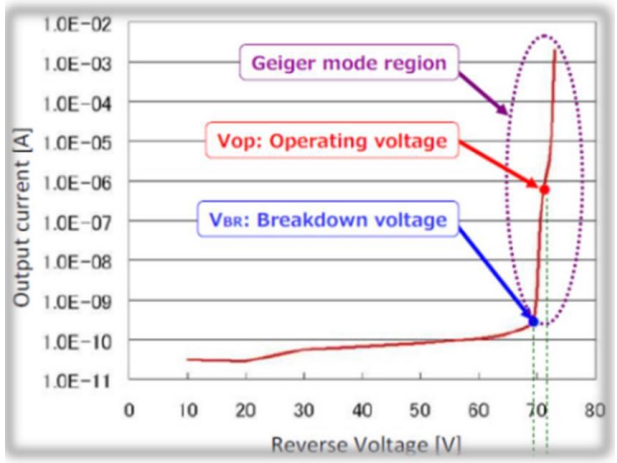
    From Gao Neng Ke Di : (756 ± 7) ps

Thanks for listening!

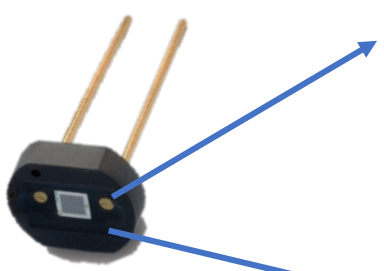
backup

Readout: SiPM

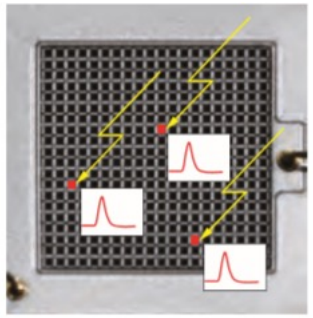




work in Geiger mode

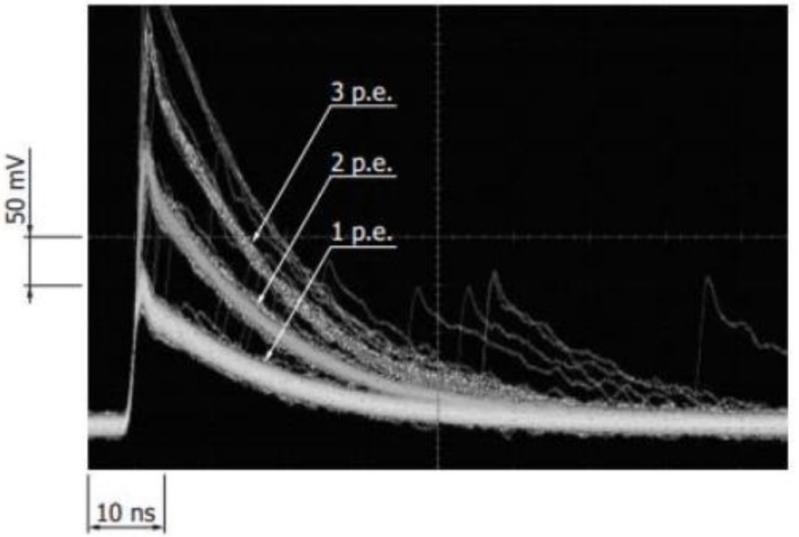


MPPC



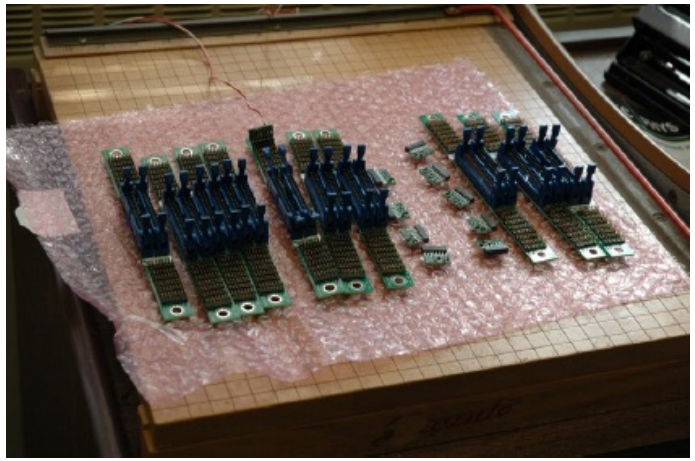
1.3×1.3mm^2

667 pixels

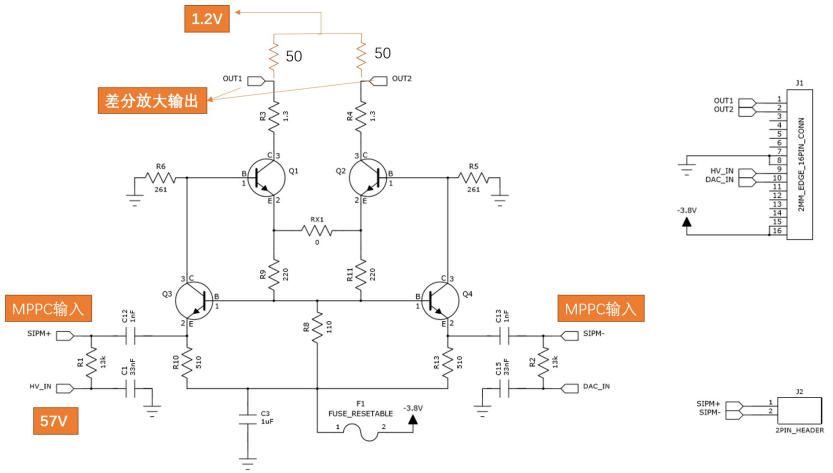


backup

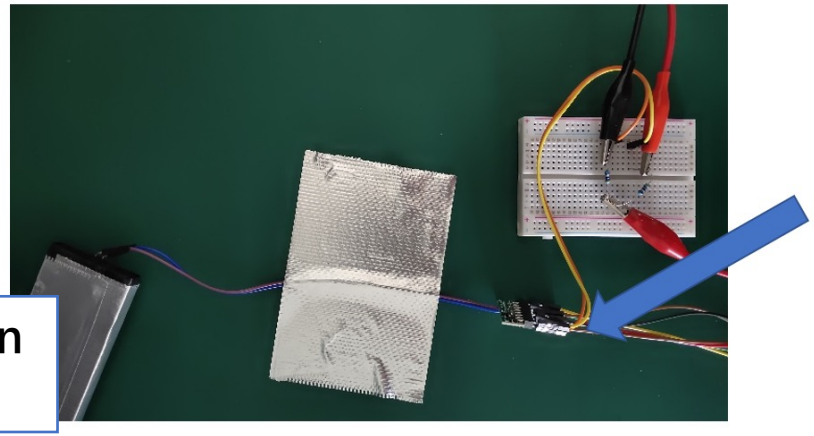
Readout: Preamplifier & carrier



Preamplifier & carrier



Circuit diagram of preamplifier



Scintillation detector

preamplifier