2018 KPS SPRING MEETING

Hodoscope Prototype Test for J-PARC Experiments with HypTPC

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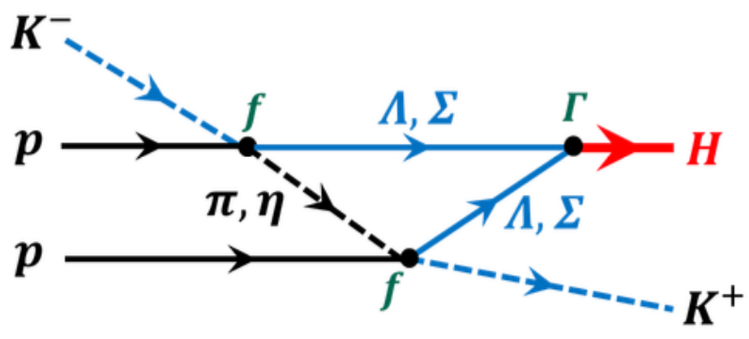
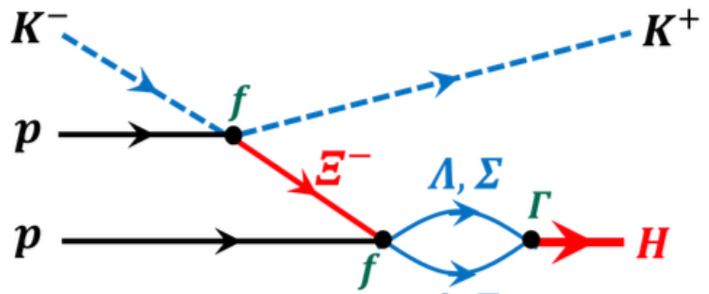
J-PARC EXPERIMENTS WITH HYPTPC

E42

Search for the *H*-dibaryon(*uuddss*) in mass region near ΛΛ threshold via $^{12}C(K^-, K^+)$ reaction

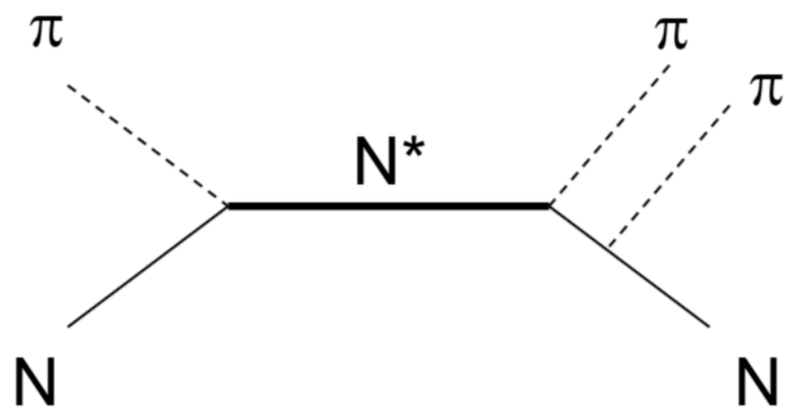




E45

Baryon spectroscopy with (π,2π) reactions at J-PARC E45

(p = 0.73 – 2.0 GeV/c , W = 1.5-2.15 GeV)



E72

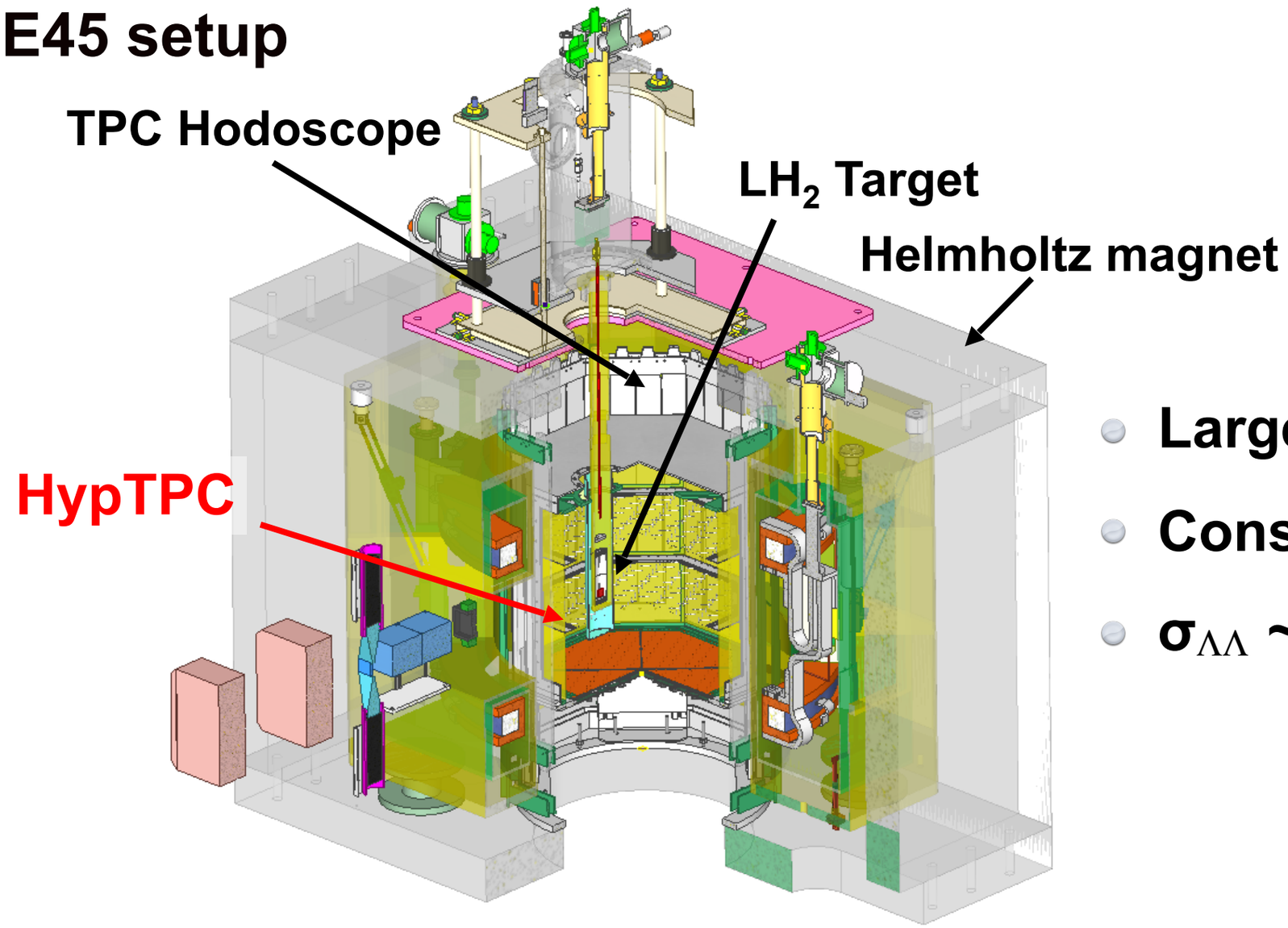
Search for a narrow Λ^* resonance using the $p(K^-,\Lambda)\eta$ reaction

HYPERON SPECTROMETER

HypTPC is located in a superconducting Helmholtz magnet

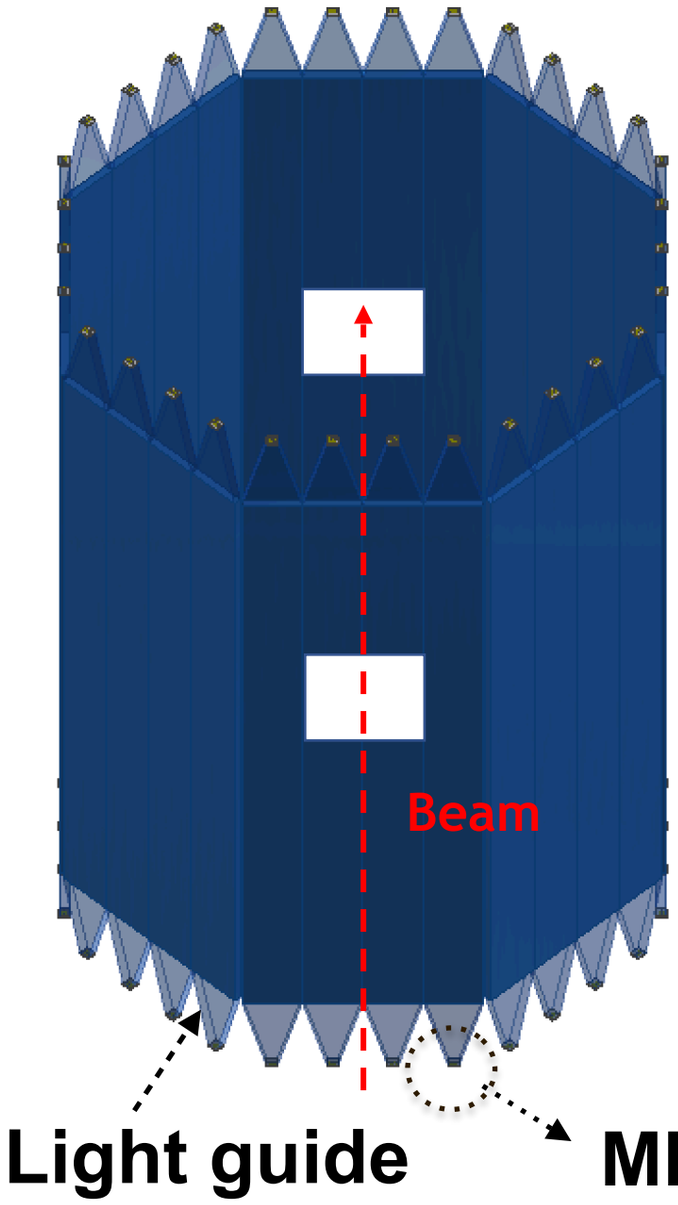
B : 1 ~ 1.5 T

E45 setup



- **Large acceptance(almost 4π)**
- **Construction complete**
- **$\sigma_{\Lambda\Lambda}$ ~ 1 MeV/c^2 (expected)**

TPC HODOSCOPE



- Surrounding HypTPC for Trigger
- Scintillator : 32 segments (80^{L} x 7^{W} x 1^{T} cm)
- Additionally TOF can be used for PID
- MPPC will be used due to strong B field (~1 T)
- For 2-charged particle trigger

2 charged particles + 1 neutral particle

→ missing mass technique

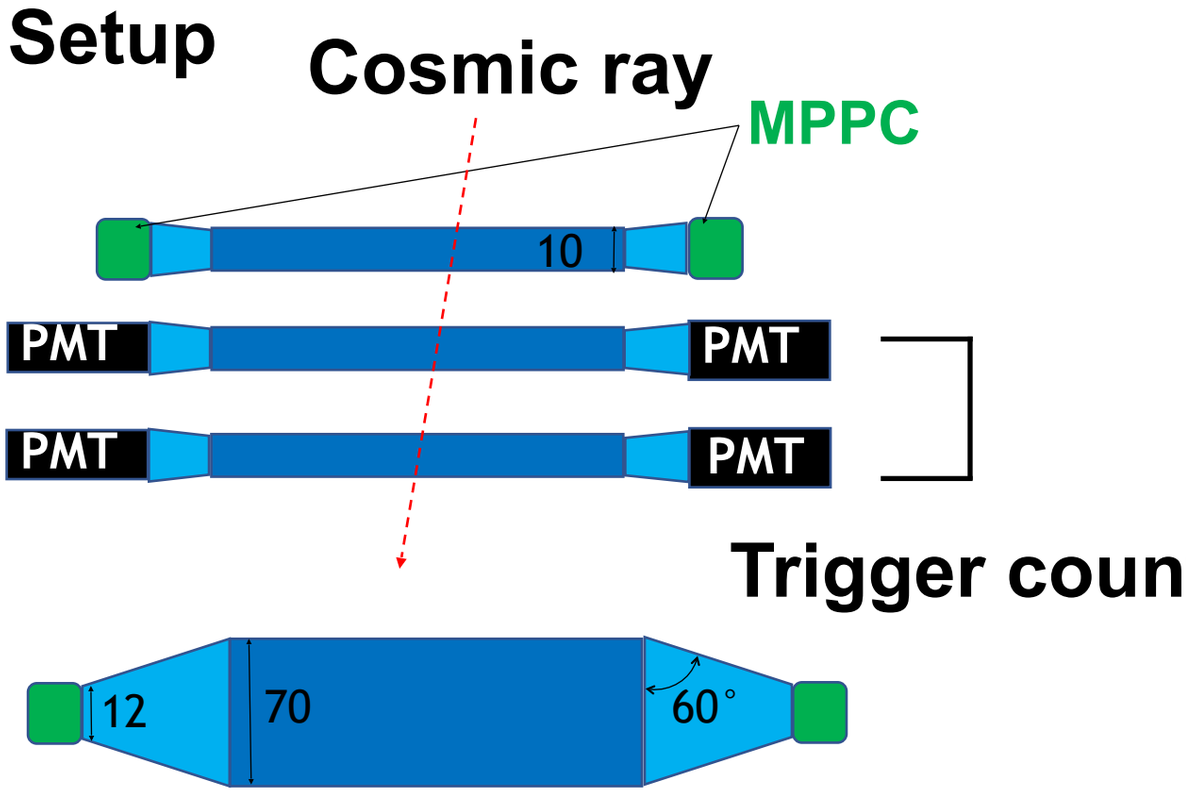
(π,2π) reaction

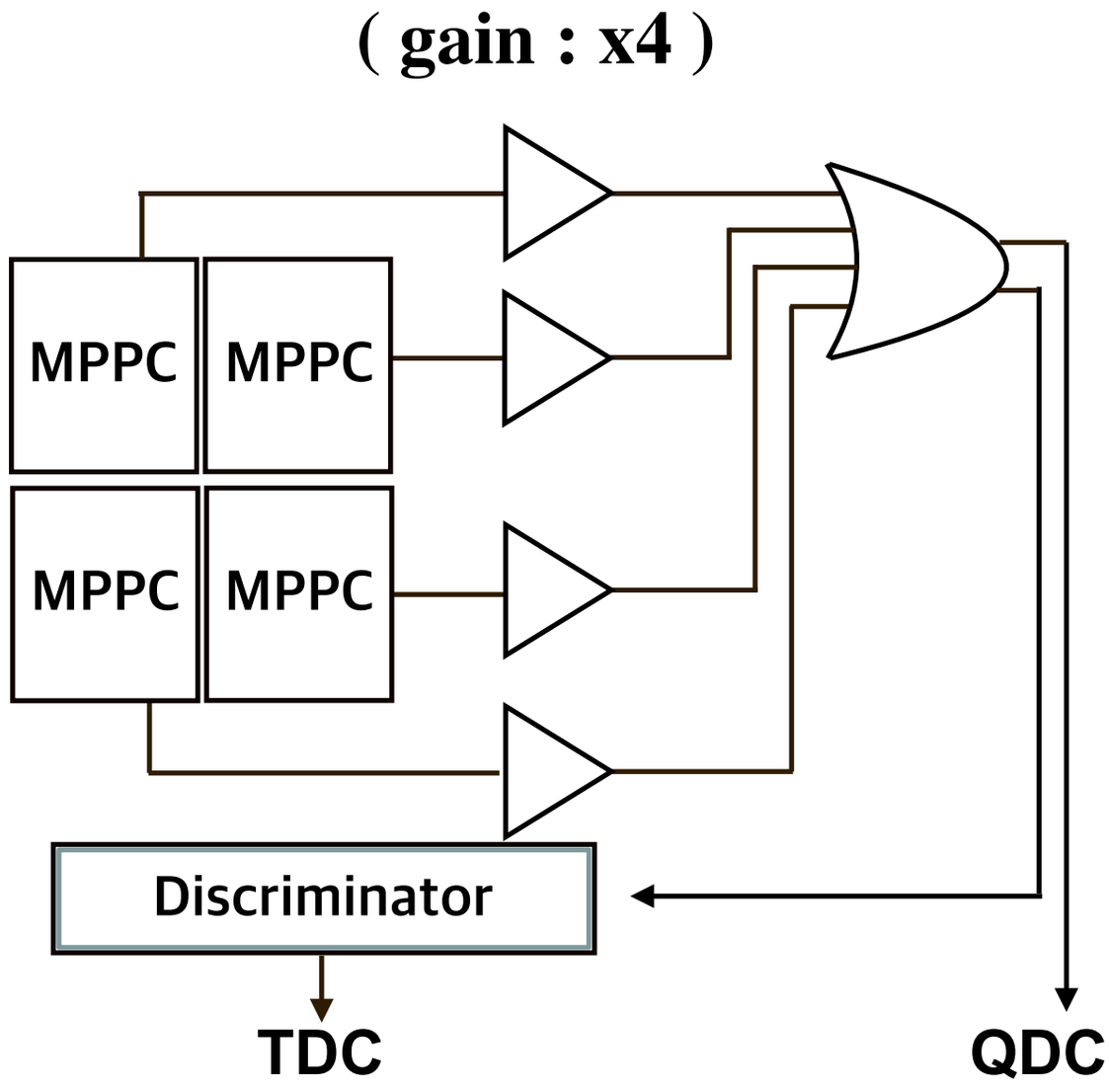
π- p→π+π-n, π0π-p

π+p→π0π+p, π+π+n

PROTOTYPE COSMIC-RAY TEST

Setup





Three identical scintillators
(15^{L} x 7^{W} x 1^{T} cm)

1. Prototype with MPPCs
2 & 3. Trigger counters with PMTs

- **Trigger's σ_T ~ 110 ps**

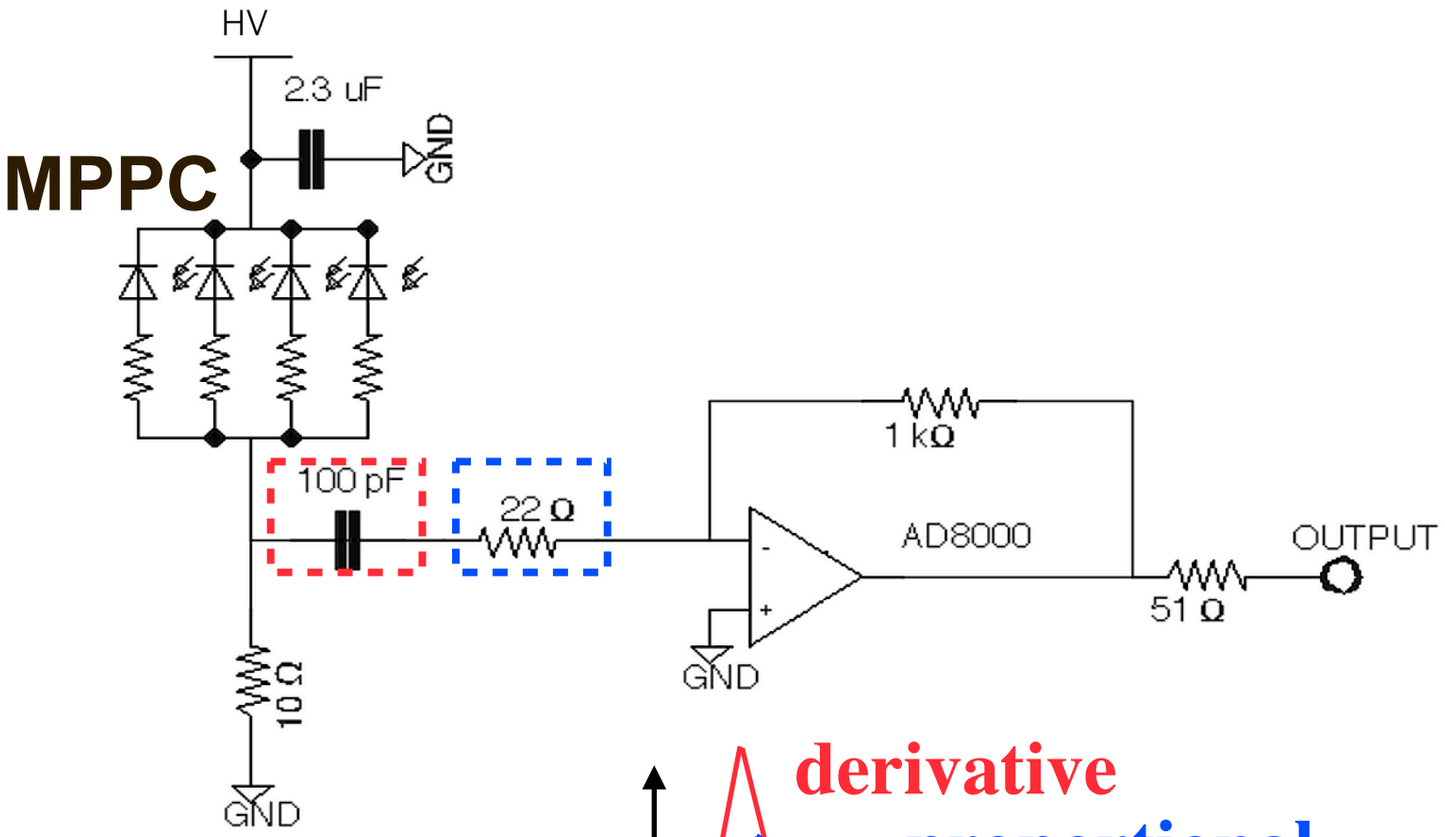
MPPC

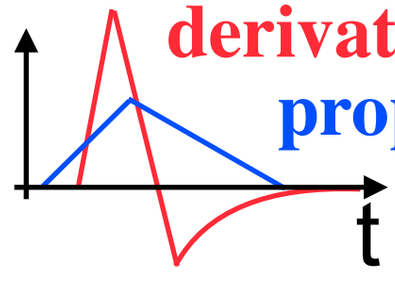
S13360-3050CS (3 x 3 mm^2)

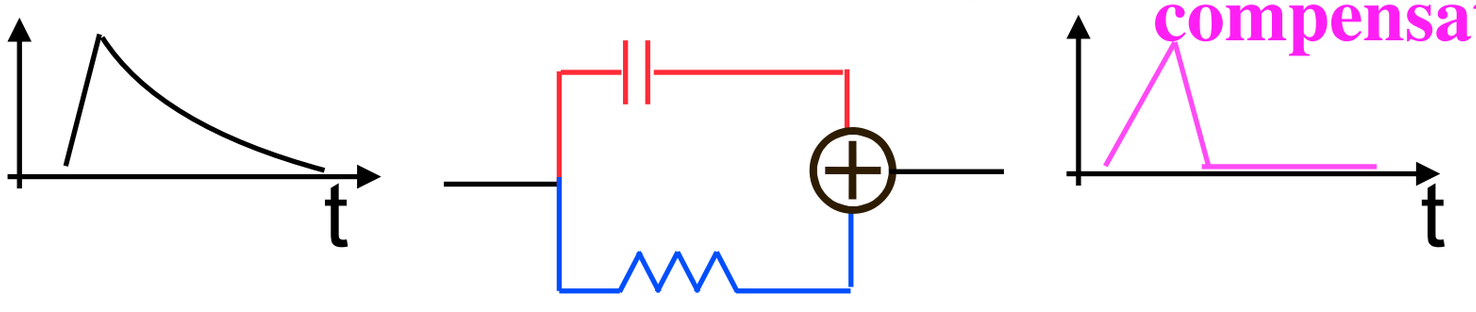
$V_{op} = V_{br}(51\ V) + 3.0\ V$

PREAMP

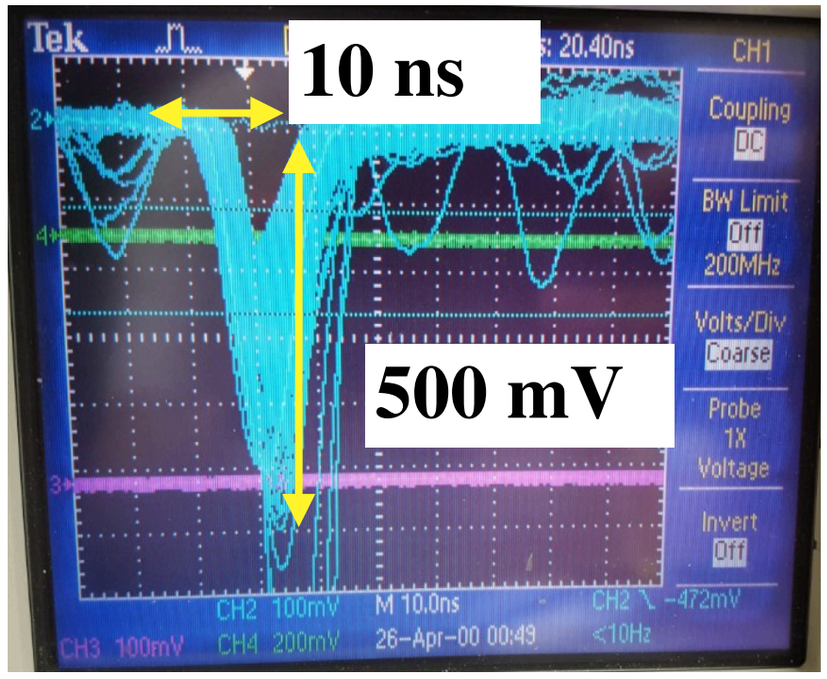
Circuit diagram

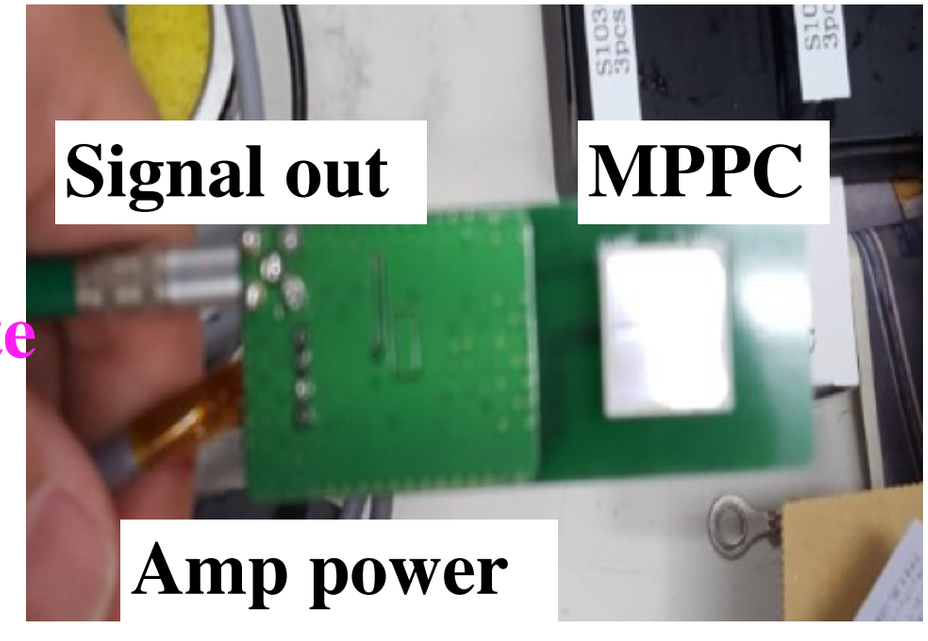




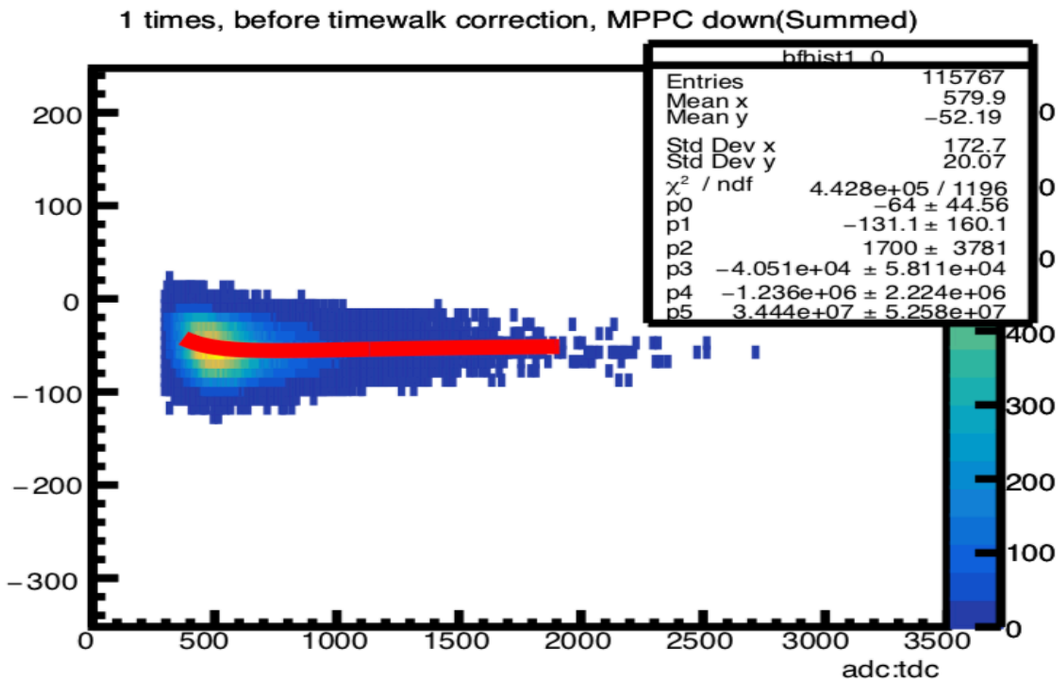


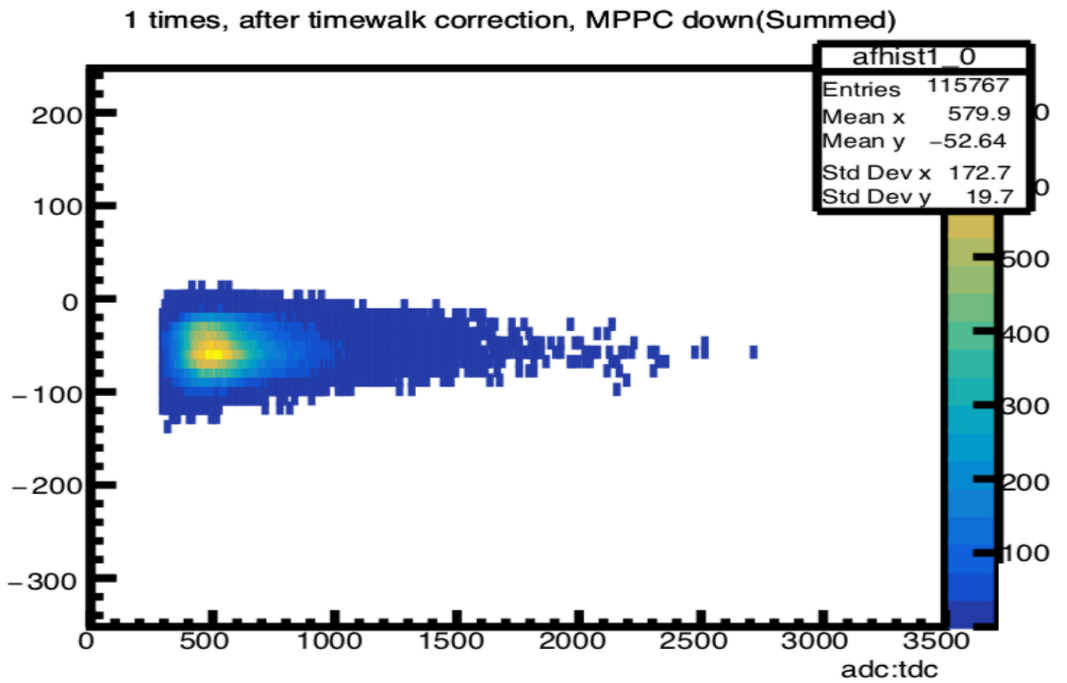
^{90}Sr output

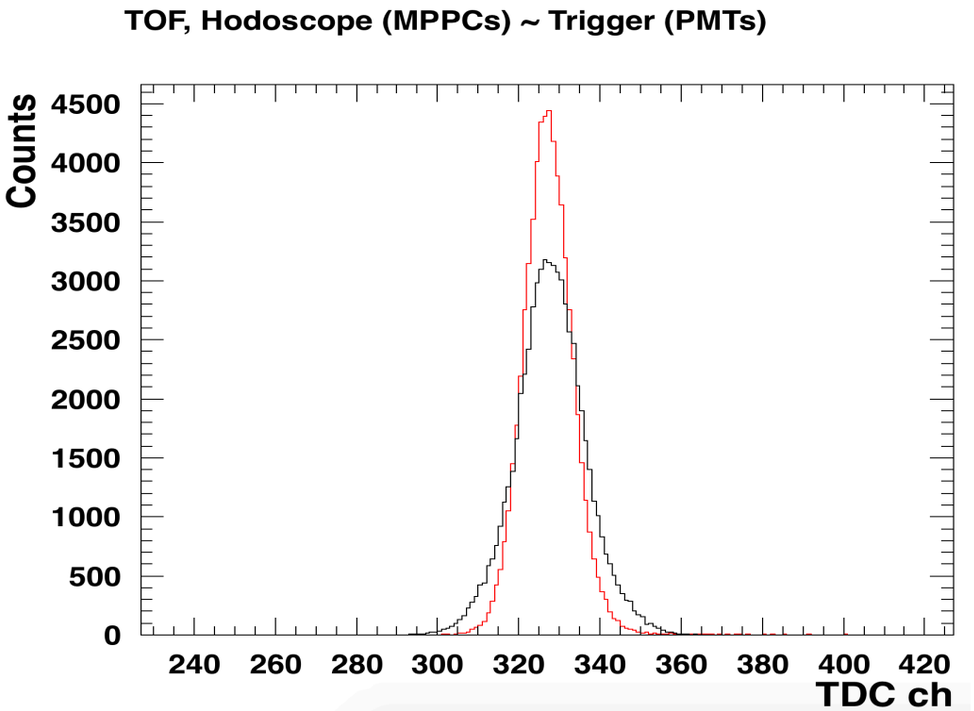




COSMIC TEST ANALYSIS







$$t' = t + \sum_{n=1}^{4} \frac{p_i}{\sqrt{QDC - p_0}^{n}}$$

p_i : fitting parameters

Red line : TOF distribution after time walk correction

- **Prototype's σ_T ~ 170 ps**

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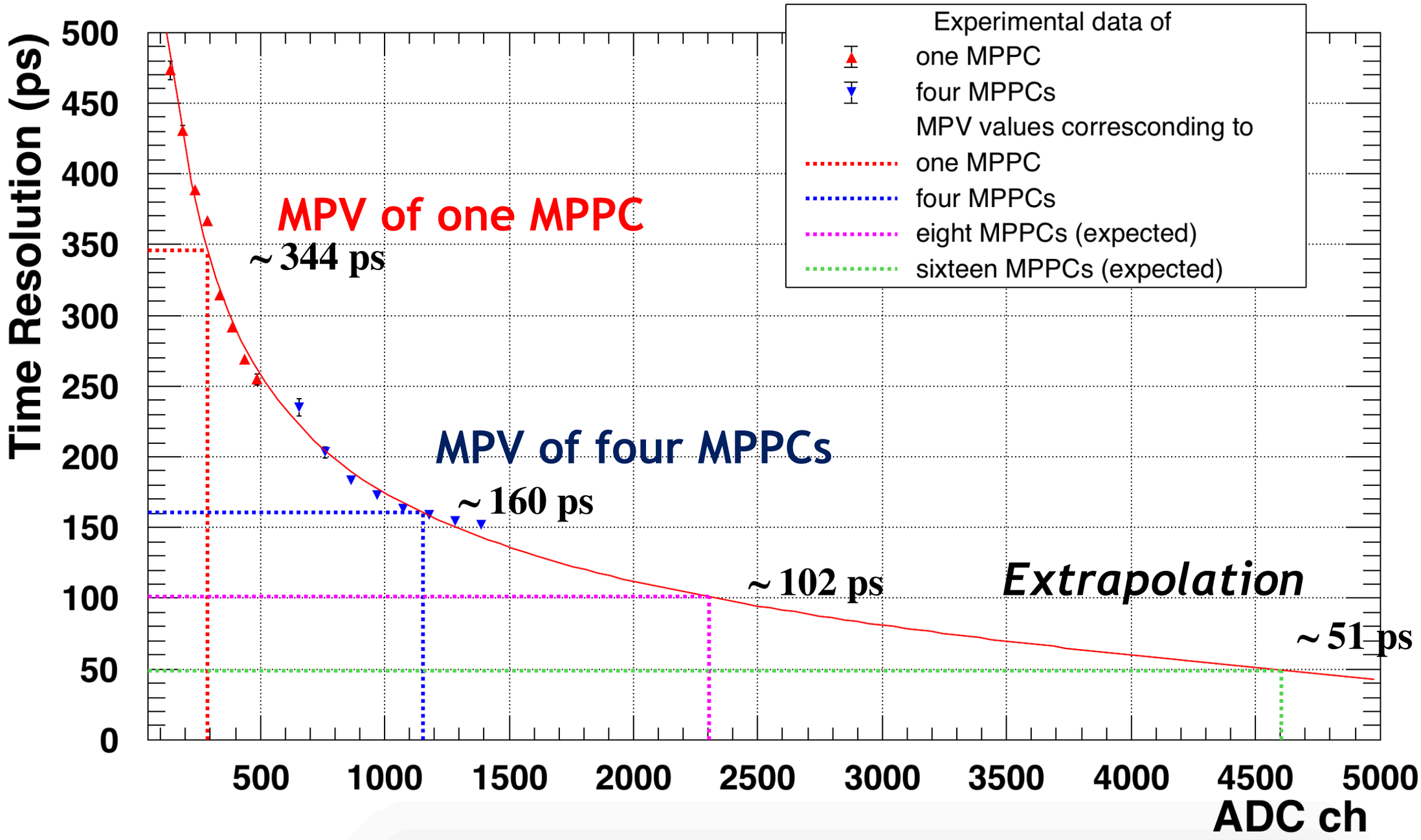
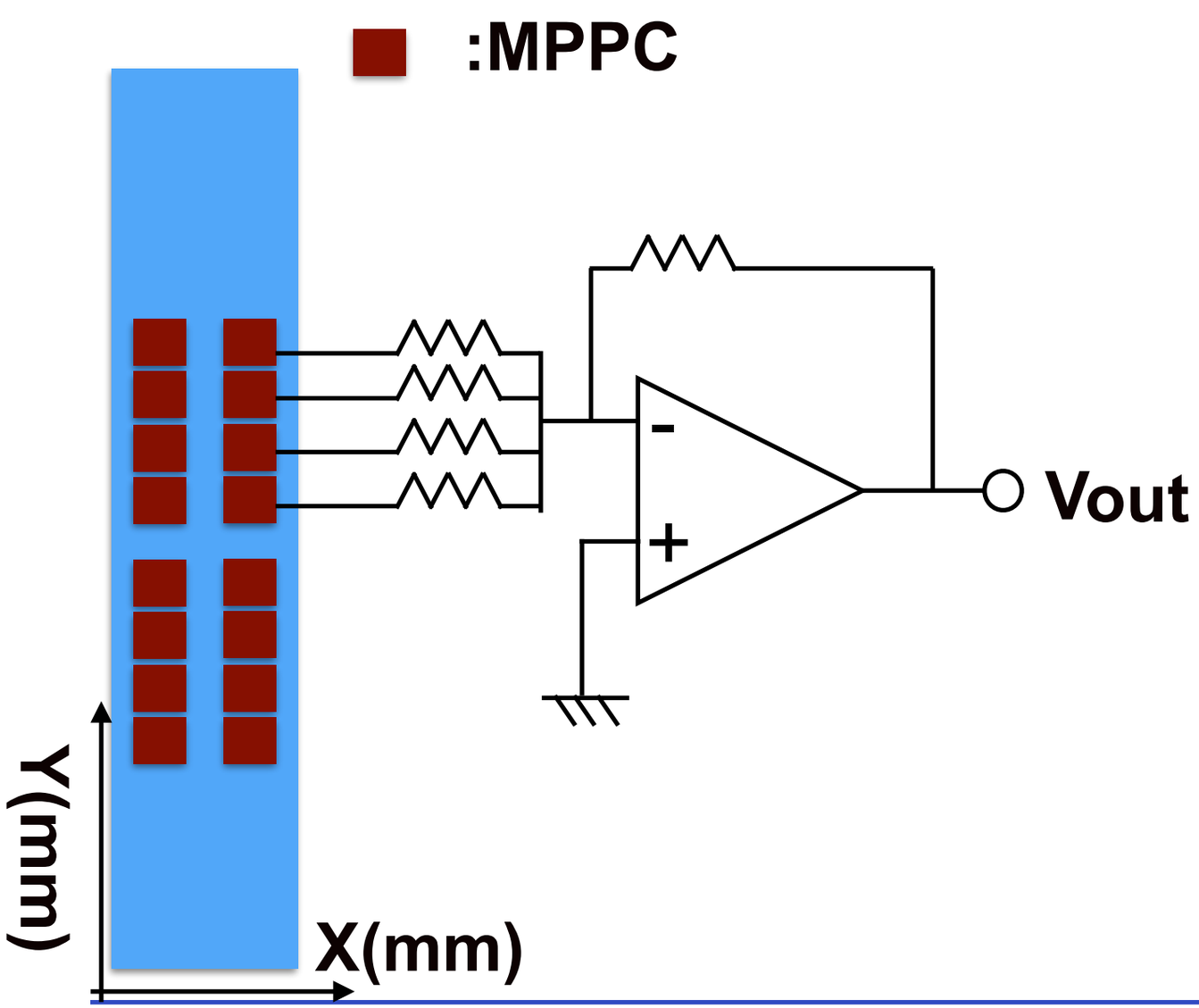
TIME RESOLUTION DEPENDENCE ON THE NUMBER OF MPPC

NPE : Time Resolution $\sigma = \sqrt{(a + b/NPE)}$

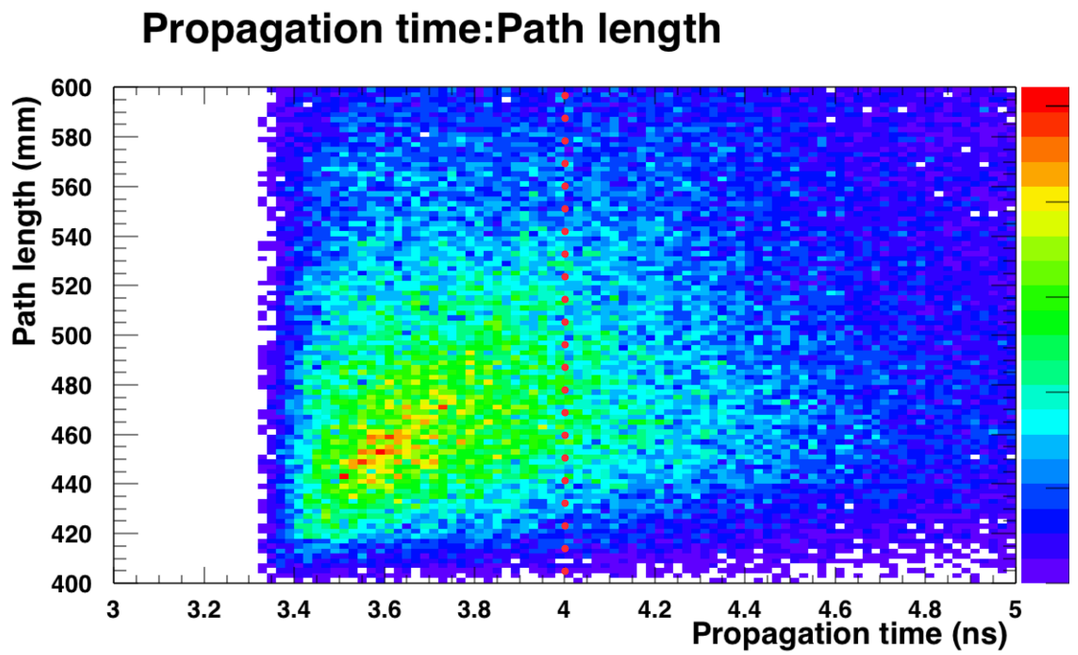


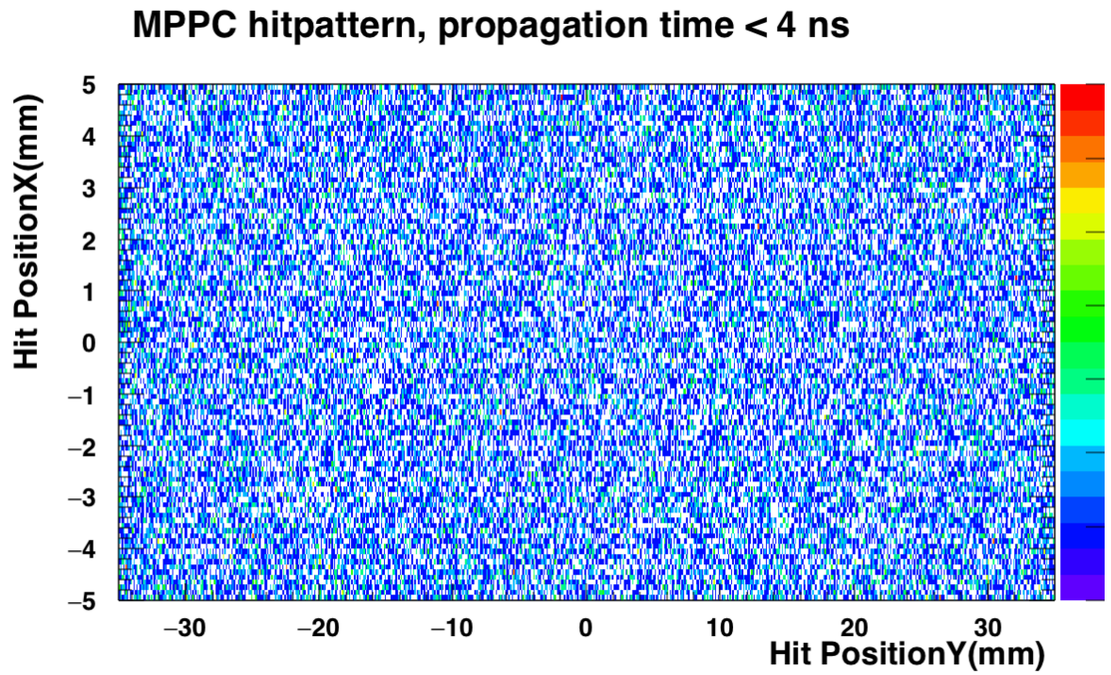
FUTURE PLAN

Schematic view of multiple MPPC connection



Position dependance study(MC)





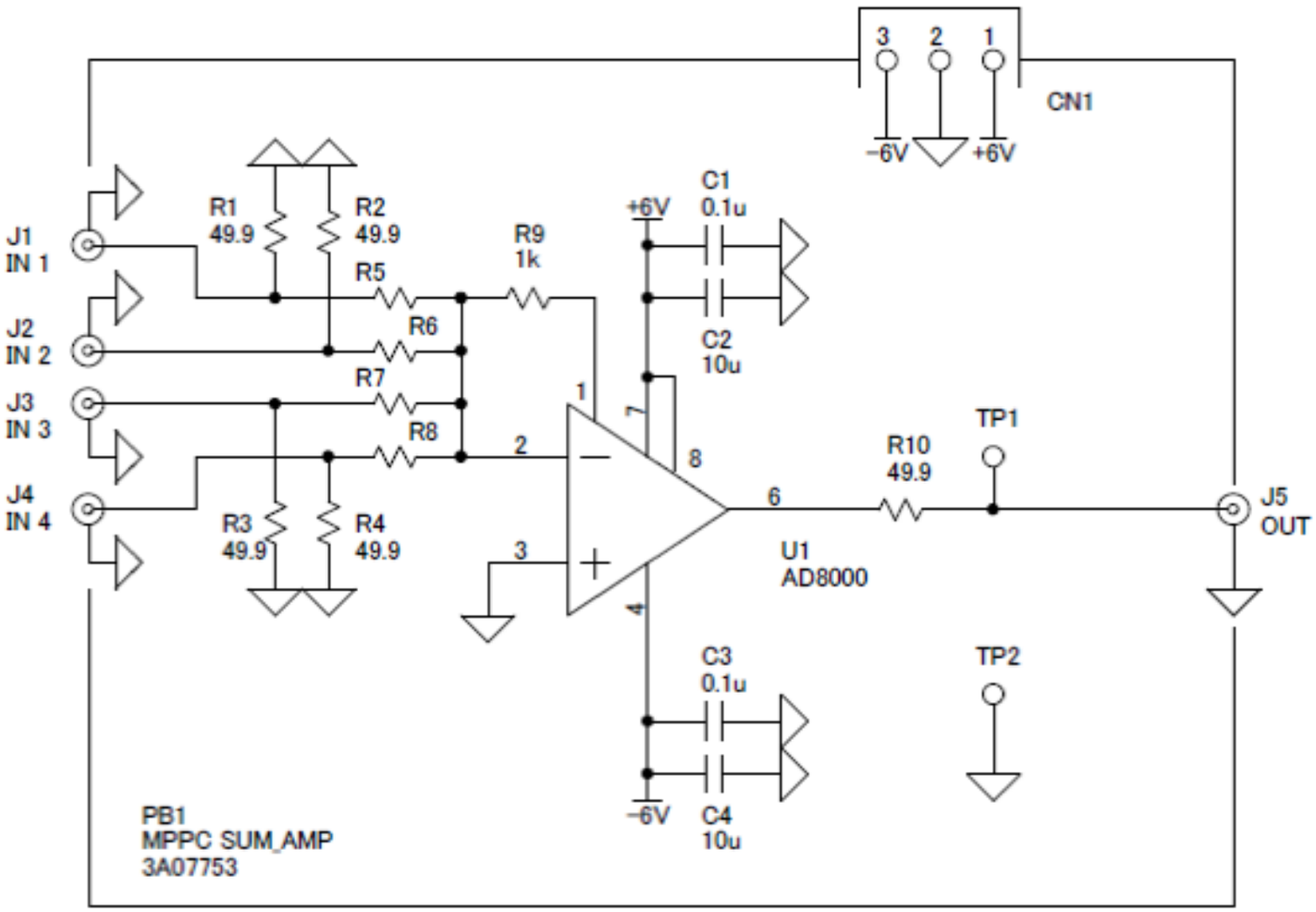
SUMMARY

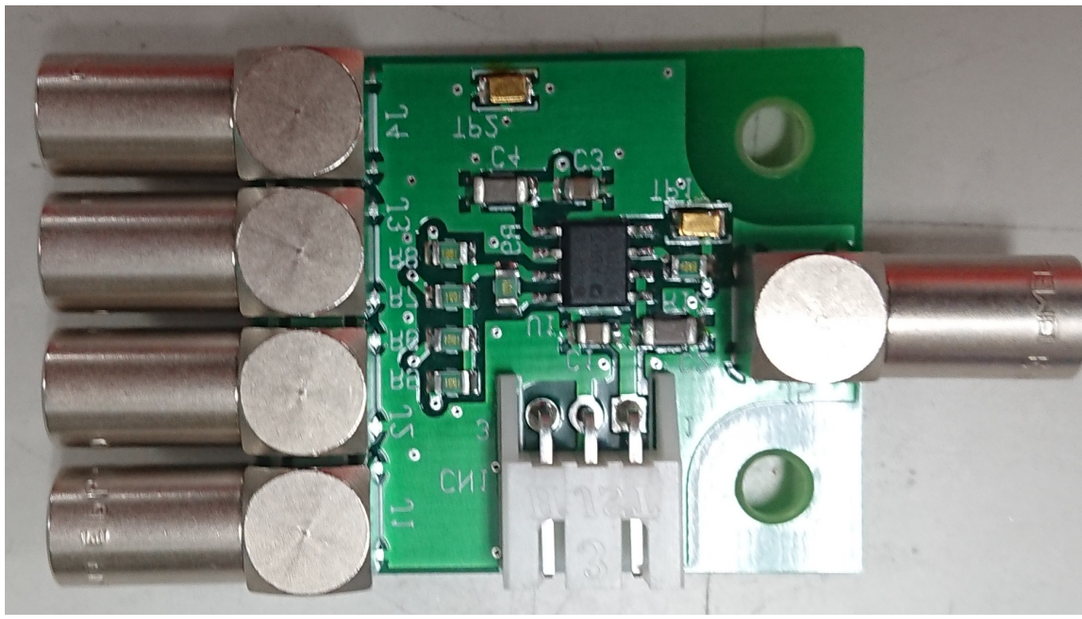
- We are preparing Hyperon spectrometer for E42/45/72 hadron experiments
- TPC Hodoscope composed with 32 scintillators is surrounding the HypTPC for Trigger
- For Hodoscope, MPPC will be used due to strong magnetic field (1~1.5 T)
- Small size prototype's Cosmic-ray test has been done. We achieved ~170 ps resolution with prototype
- Real size Hodoscope with new preamp for multiple MPPC readout system be produced and tested soon

BACKUP

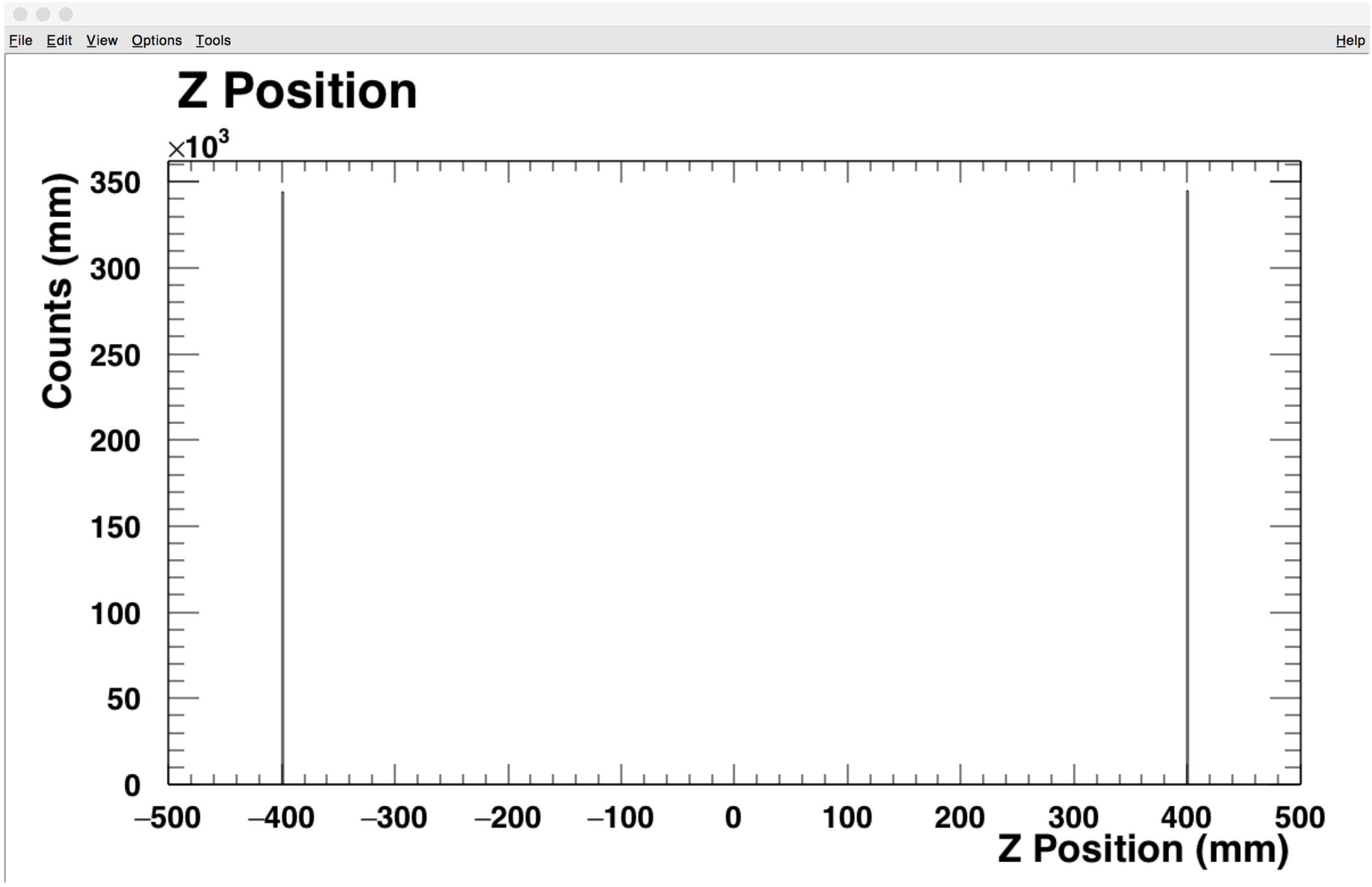
SUMMING AMP(MIXER)

It is used to sum multi-MPPC signal(under development)





MC, POSITION Z



PROTOTYPING

Hodoscope prototype

- **Scintillator : 15^{L} x 7^{W} x 1^{T} cm**

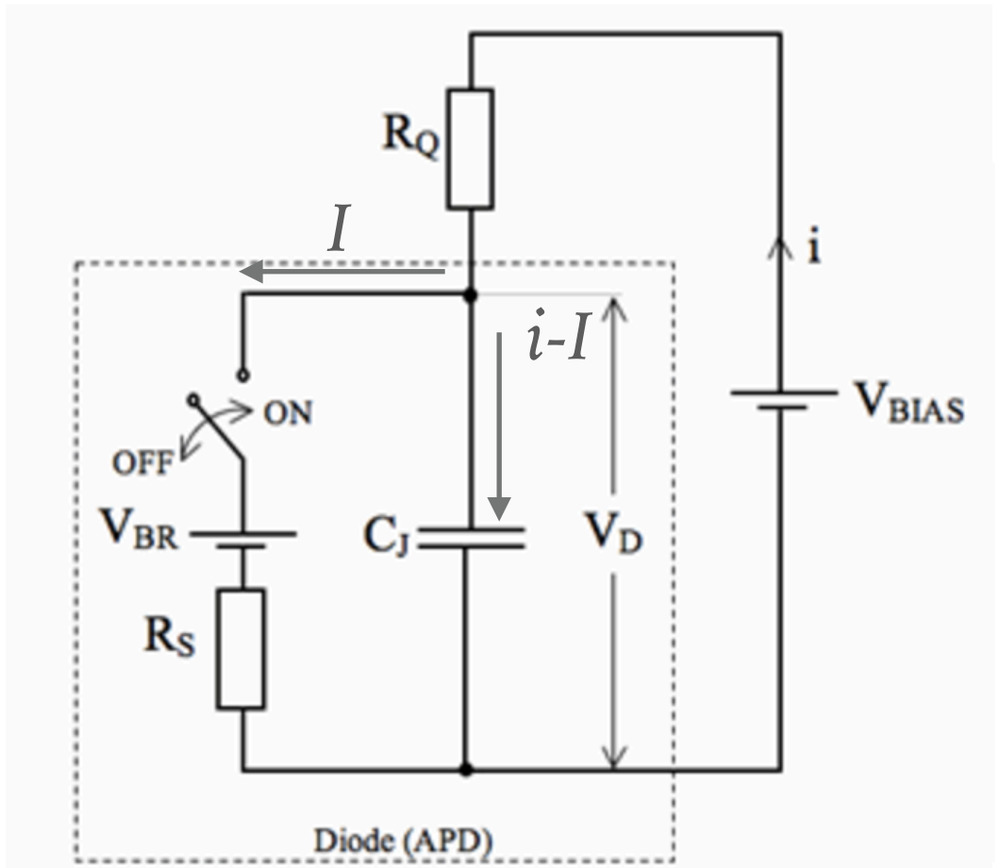
MPPC

- **MPPC : 3050CS (3 mm x 3 mm)**
- **There are four MPPCs on each side**

MPPC

R_S : Resistance of the entire APD during a discharge
R_Q :Quenching resistor
C_J : Junction capacitance

typical values
R_S ~1 k, R_Q~150 k, C_j~0.1 pf



Equivalent circuit of MPPC's single GAPD

By Kirchhof's current law

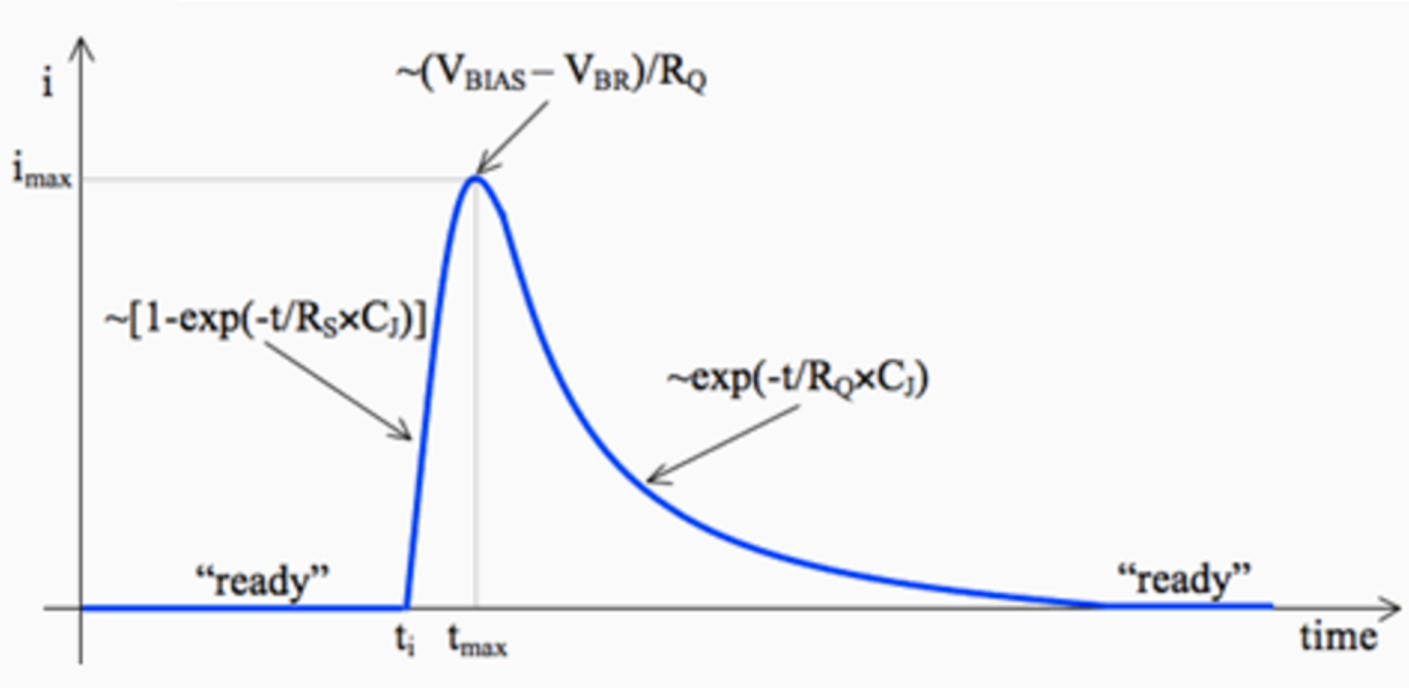
V_{BIAS}-Q/C_j-iR_Q=0

V_{BIAS}-V_{BR}-$(i-I)R_S$-iR_Q=0

$$\tau_r = C_j \frac{(R_S R_Q)}{(R_S + R_Q)} \sim C_j R_S \ (\because R_Q \gg R_S)$$

$$i = \frac{V_{BIAS} - V_{BR}}{R_S + R_Q}(1 - e^{-t/\tau_r}) \sim \frac{V_{BIAS} - V_{BR}}{R_Q}(1 - e^{-t/\tau_r})$$

$$\tau_r = C_j R_Q$$

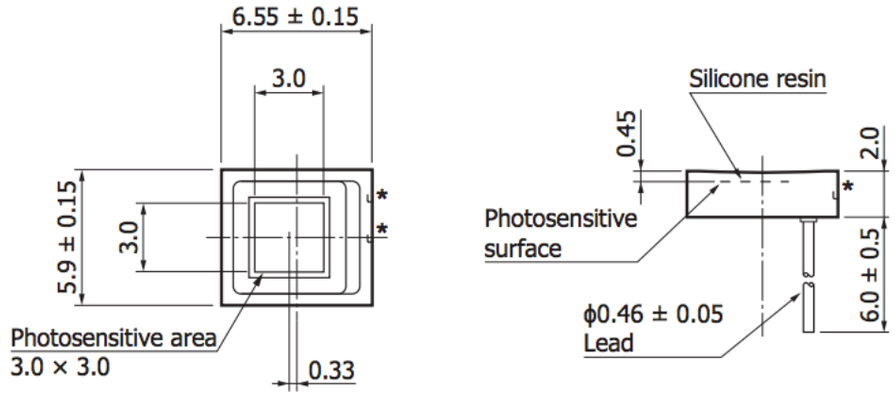


Current flowing through the APD as a function of time

MPPC

HAMAMATSU S13360-3050CS (3 x 3 mm²)

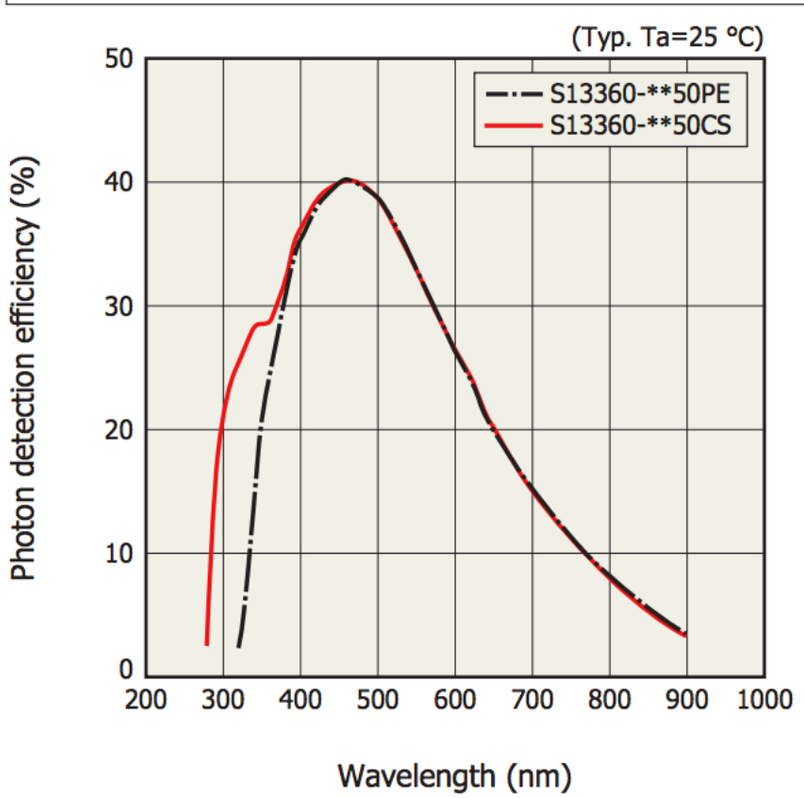
$V_{op} = V_{br}(51\ V) + 3.0\ V$ (V_{br} : breakdown voltage)



DATA SHEET

Type no.	Measure-ment conditions	Spectral response range λ (nm)	Peak sensitivity wavelength λp (nm)	Photon detection efficiency PDE*4 λ=λp (%)	Dark count*5 Typ. (kcps)	Dark count*5 Max. (kcps)	Terminal capaci-tance Ct (pF)	Gain M	Break-down voltage VBR (V)	Crosstalk probability (%)	Recom-mended operating voltage Vop (V)	Tem-perature coefficient at recom-mended operating voltage ΔTVop (mV/°C)
S13360-3050CS	Vover =3 V	270 to 900	450	40	500	1500	320	1.7×10^6	53 ± 5	3	VBR + 3	54
S13360-3050PE		320 to 900										

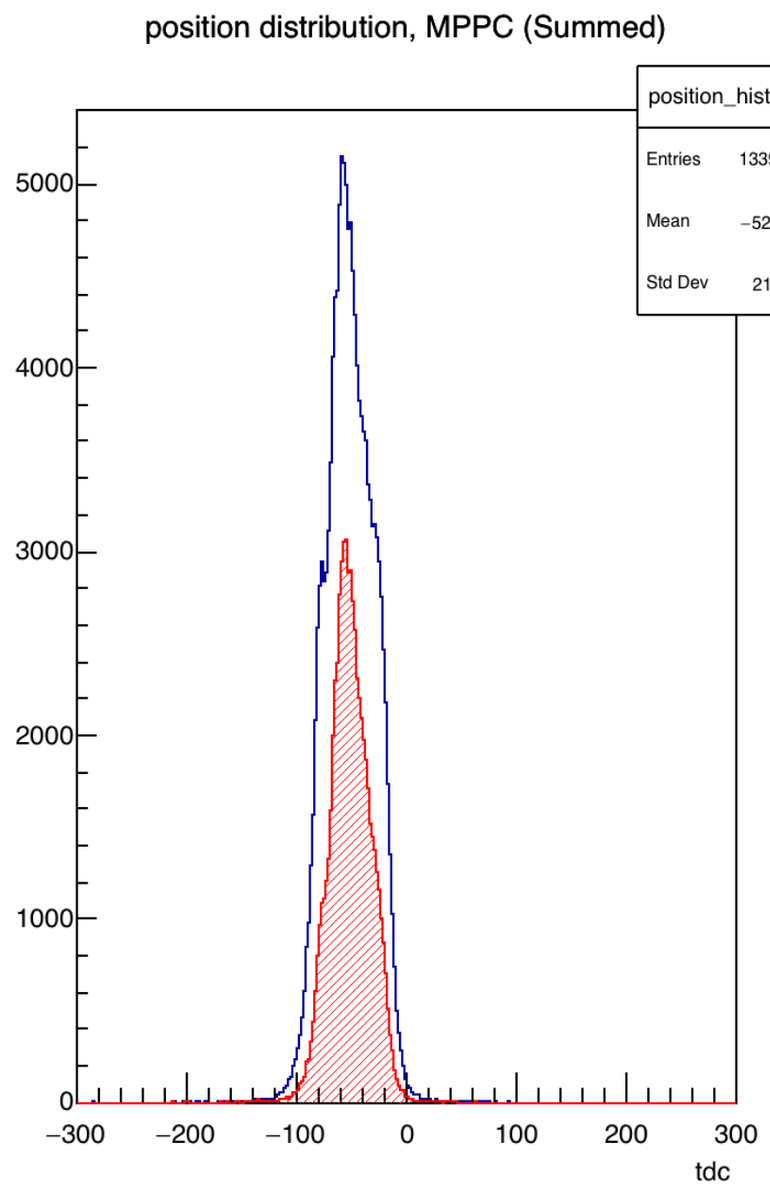
Type no.	Pixel pitch (μm)	Effective photosensitive area (mm)	Number of pixels	Package	Fill factor (%)
S13360-3050CS	50	3.0 × 3.0	3600	Ceramic	74
S13360-3050PE				Surface mount type	

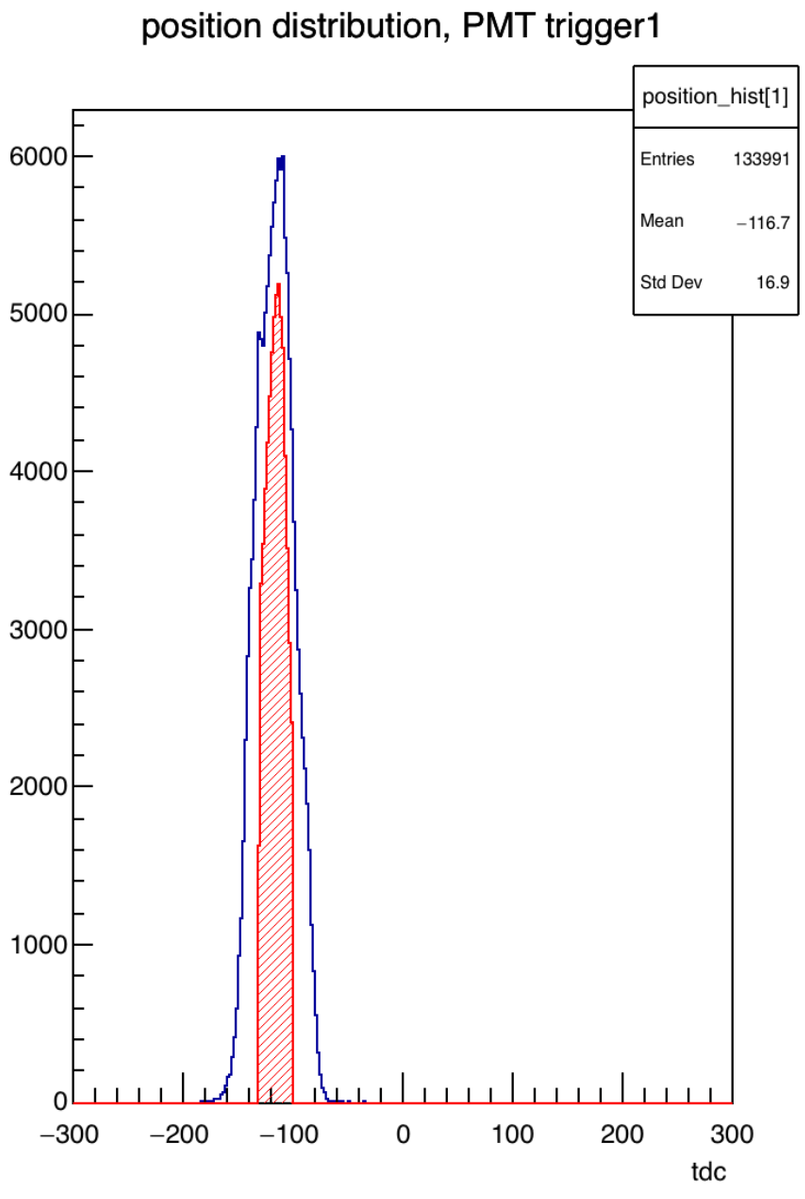


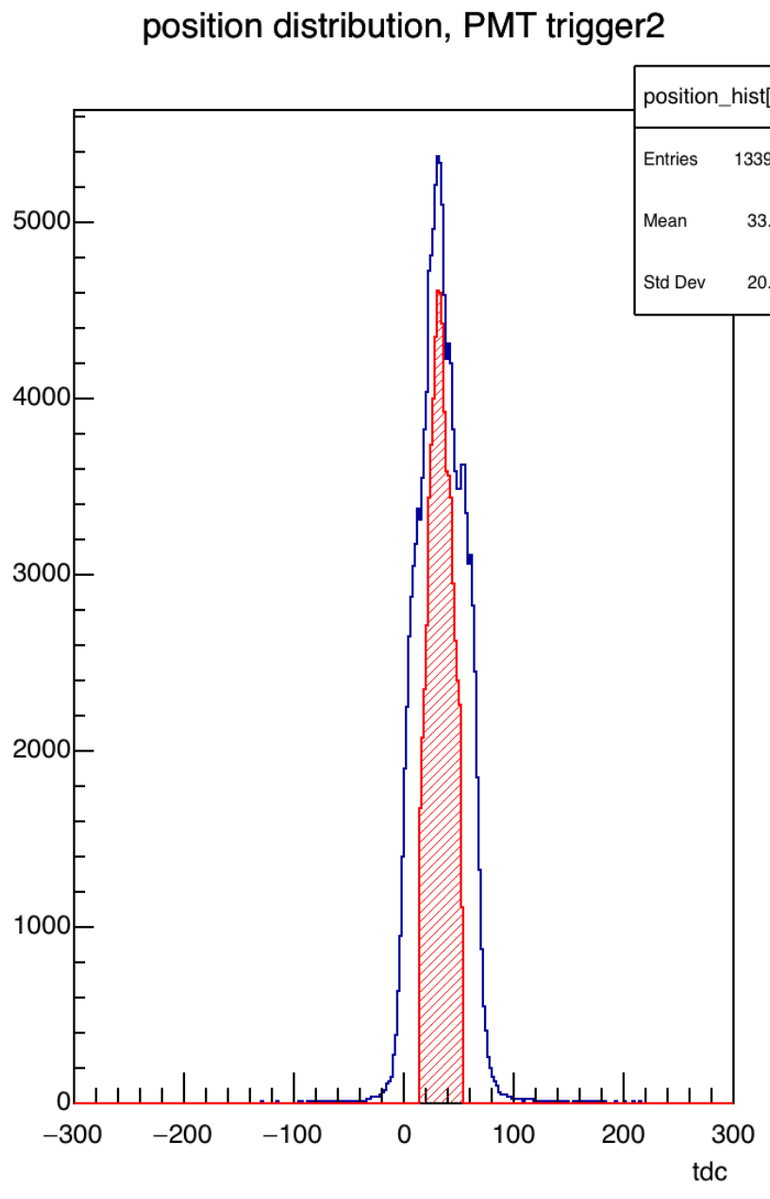
ANALYSIS - HIT POSITION CUT

Only for triggers

Cut range (mean - std < x < mean + std)

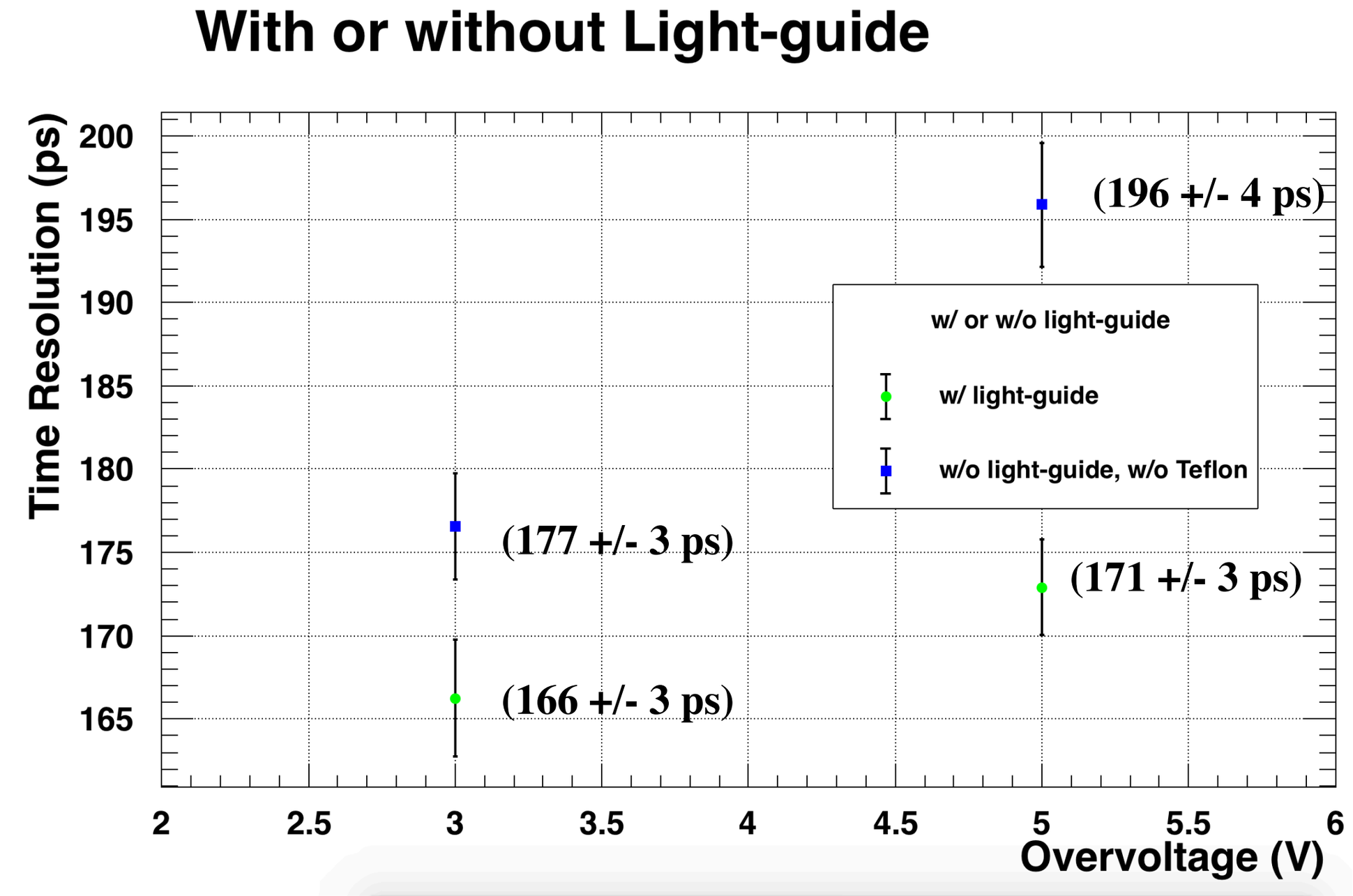






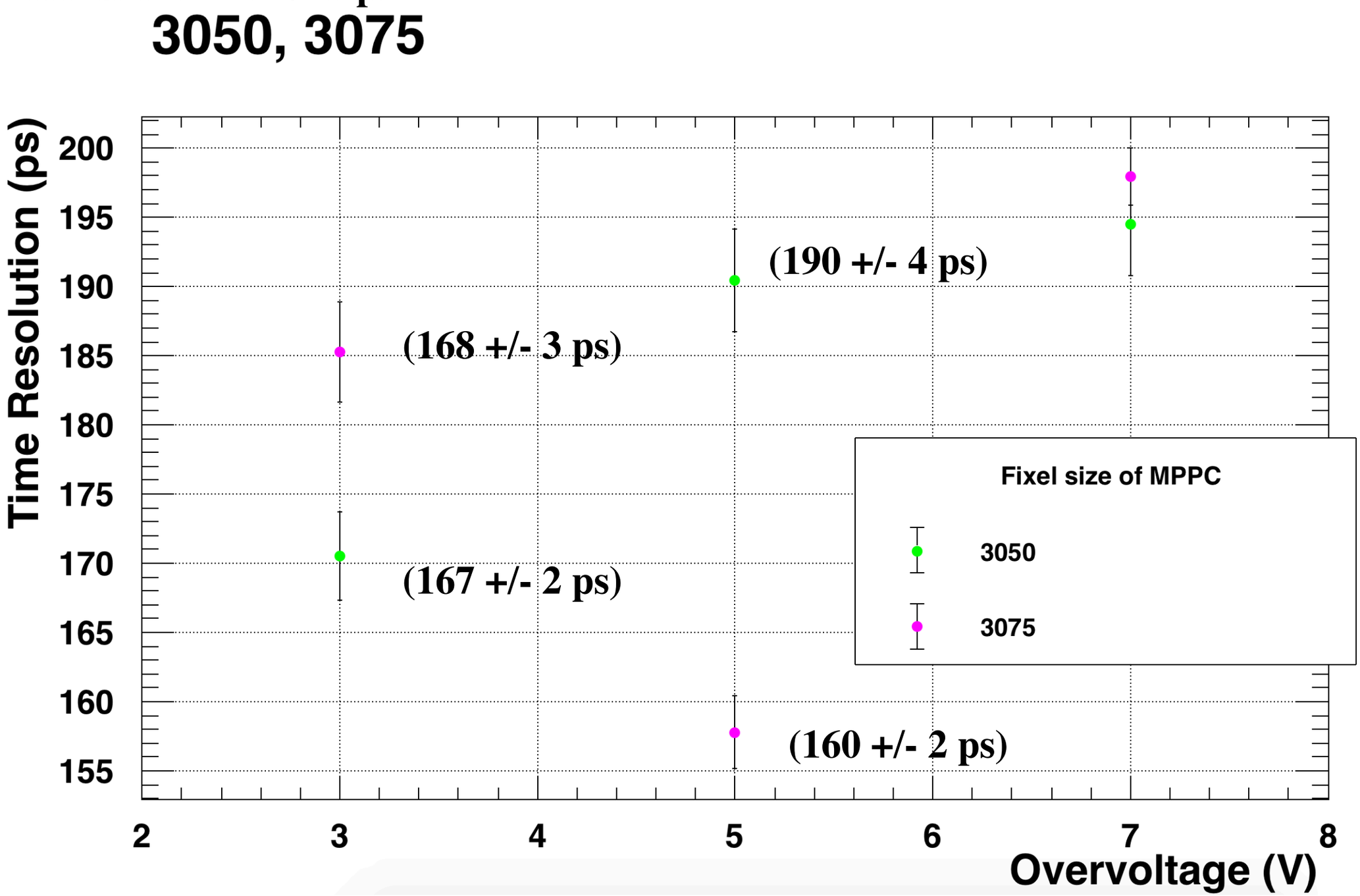
W/ OR W/O LIGHT-GUIDE

Trigger resolution: 111 +/- 2 ps



3050 VS 3075 MPPC

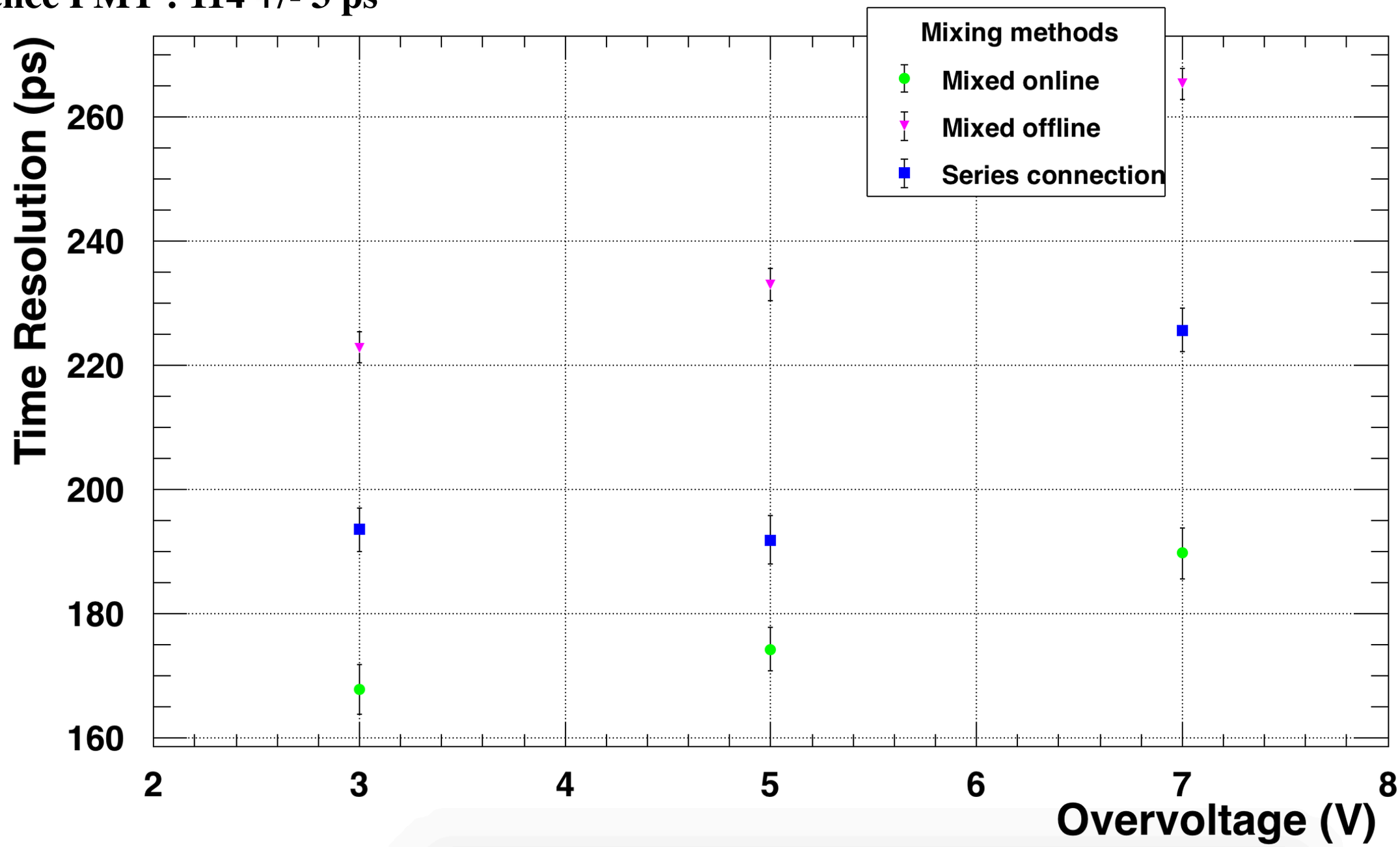
Trigger resolution: 120 +/- 3 ps



COMPARISON THE CONNECTION METHOD

Methods of Mixing MPPC's signal

Reference PMT : 114 +/- 3 ps



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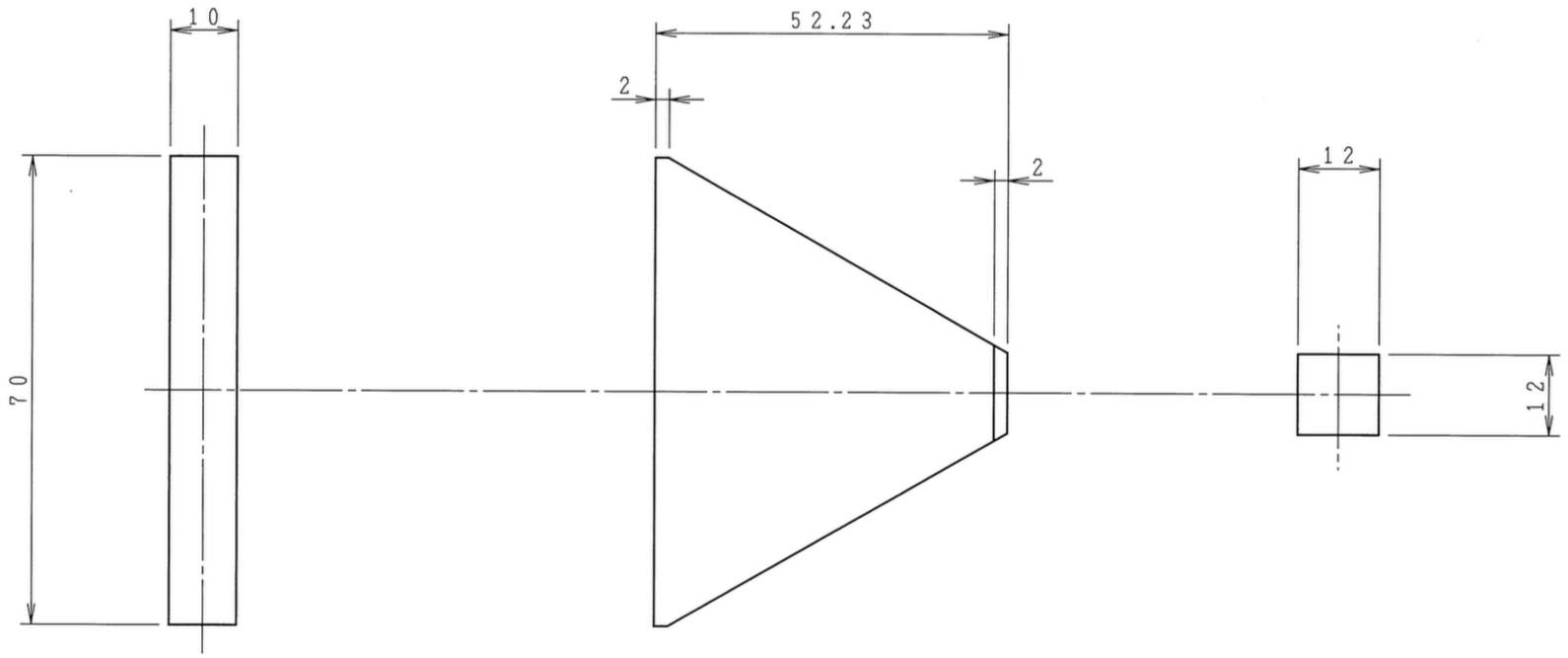
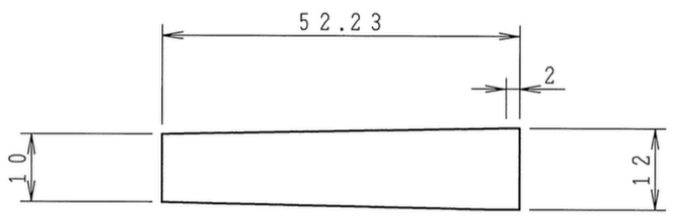
LIGHT GUIDE

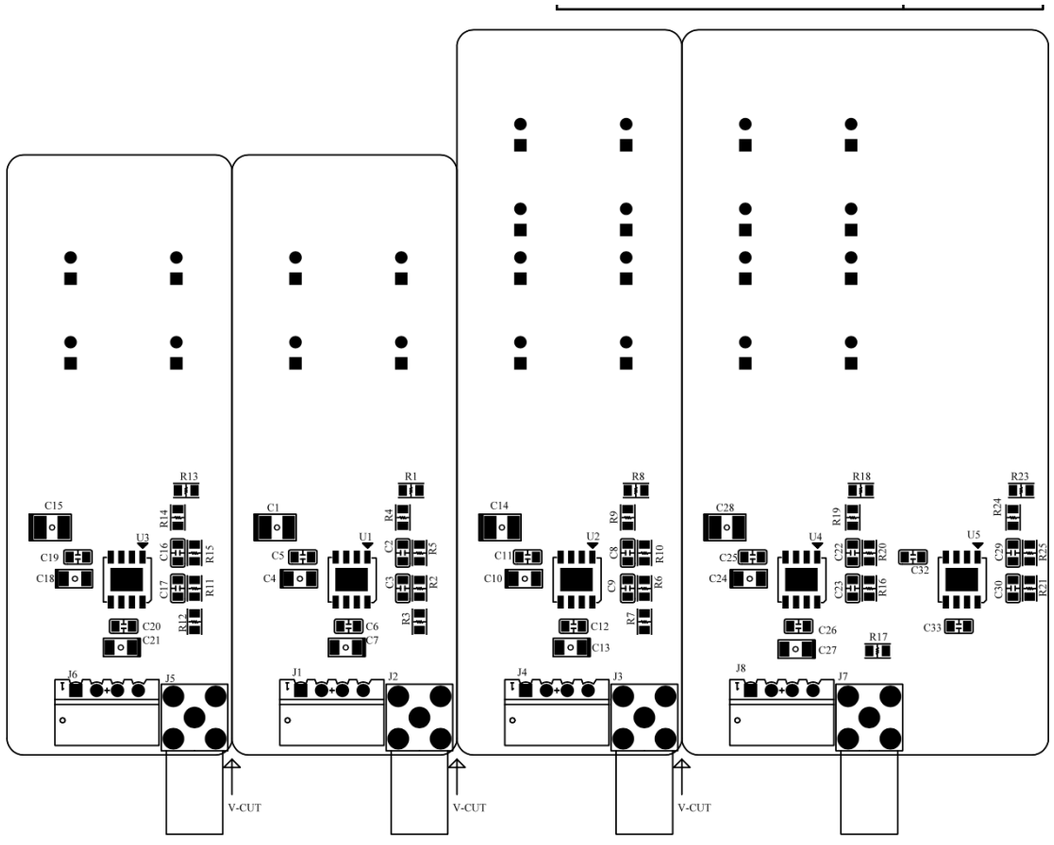
MPPC side is wider





Scintillator side ⟶ ⟵ **MPPC side**

TEST BOARD


C15
R13
R14
U3
C19
C18
C16
R15
C17
R11
C20
C21
R12
C1
R1
R4
U1
C5
C4
C2
R5
C3
R2
C6
C7
R3
C14
R8
R9
U2
C11
C10
C8
R10
C9
R6
C12
C13
R7
C28
R18
R19
U4
C25
C24
C22
R20
C23
R16
C26
C27
R17
R23
R24
U5
C32
C29
R25
C30
R21
C33
J6
J5
J1
J2
J4
J3
J8
J7
V-CUT
V-CUT
V-CUT