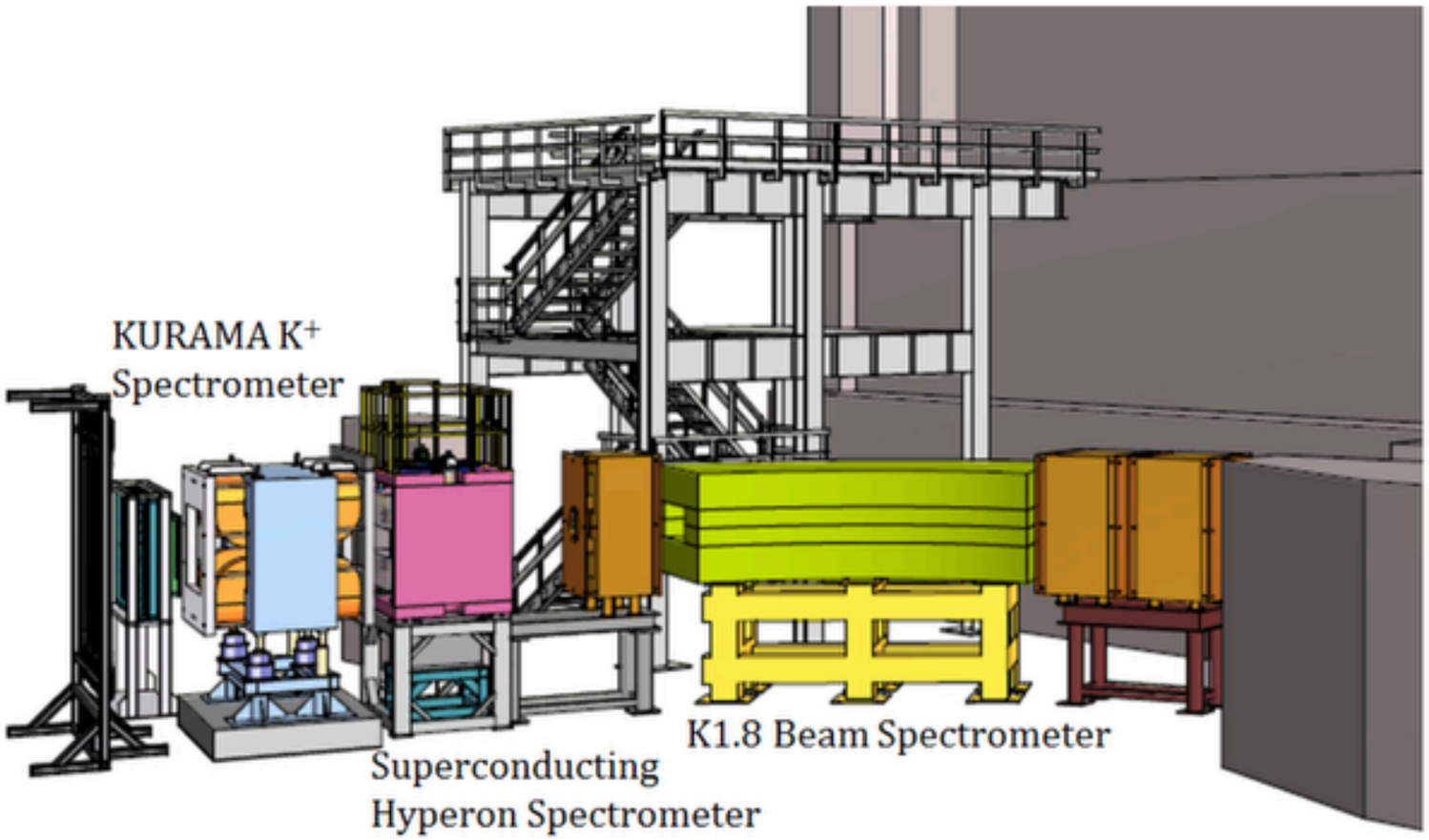
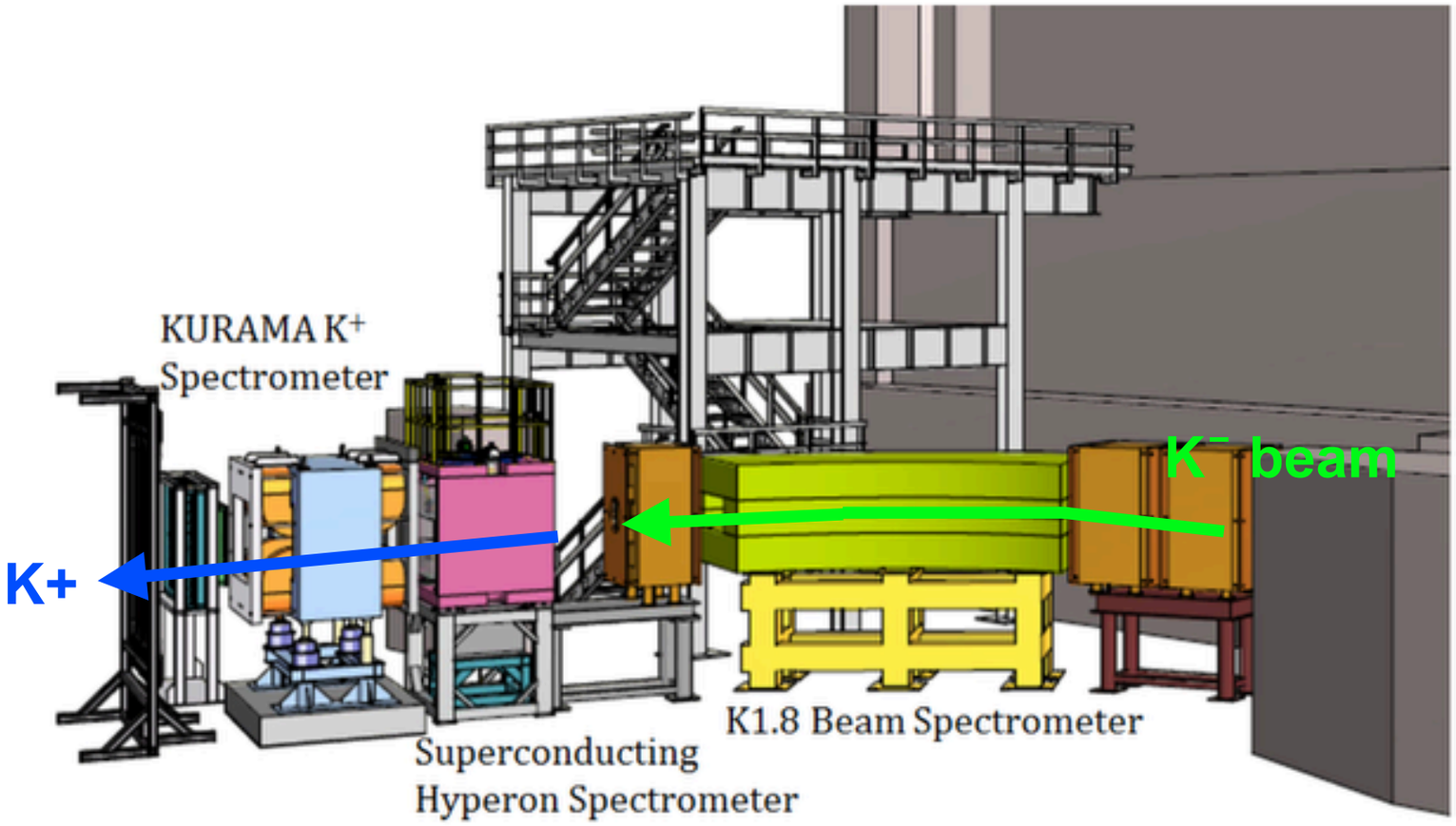
Development of a TPC Trigger Hodoscope for the H-dibaryon search experiment E42 at J-PARC

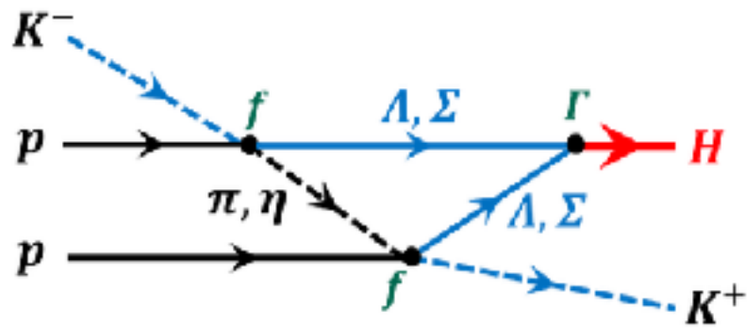


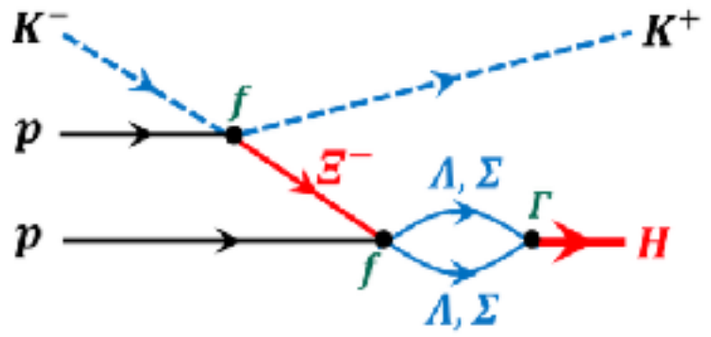
정우승
물리학과 하드론핵물리연구실

E42@J-PARC

Search for the *H*-dibaryon(*uuddss*) the near the ΛΛ mass threshold by using (K^-, K^+) reaction with diamond target at J-PARC.





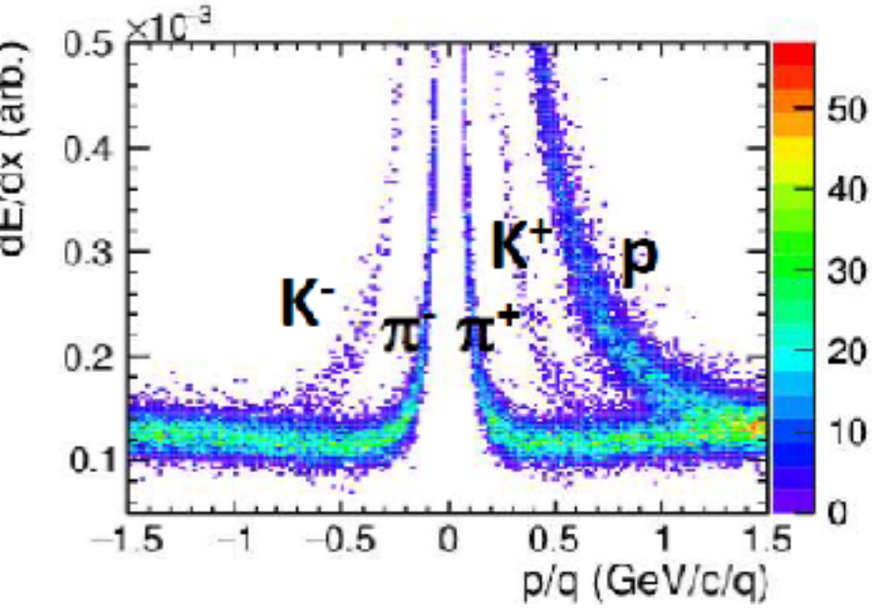


K^- beam intensity : 10^6/spill (in 5.5 s)

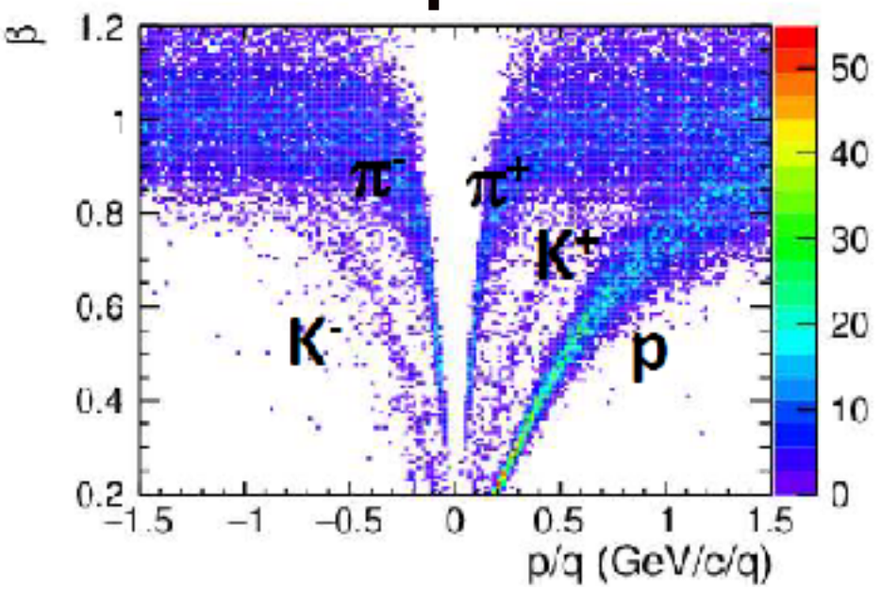
HYPTPC & TPC HODOSCOPE

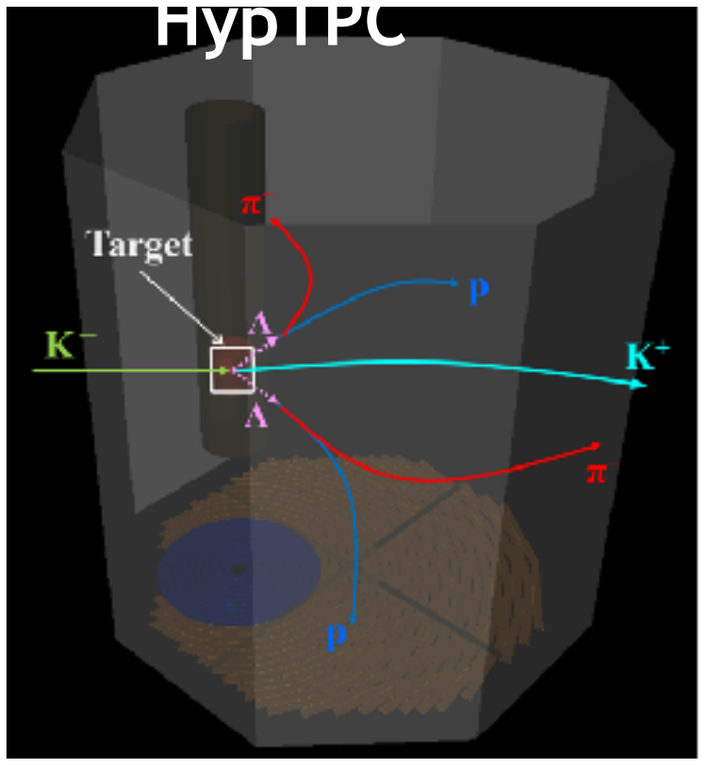
$\pi/K/p$ Particle Identification

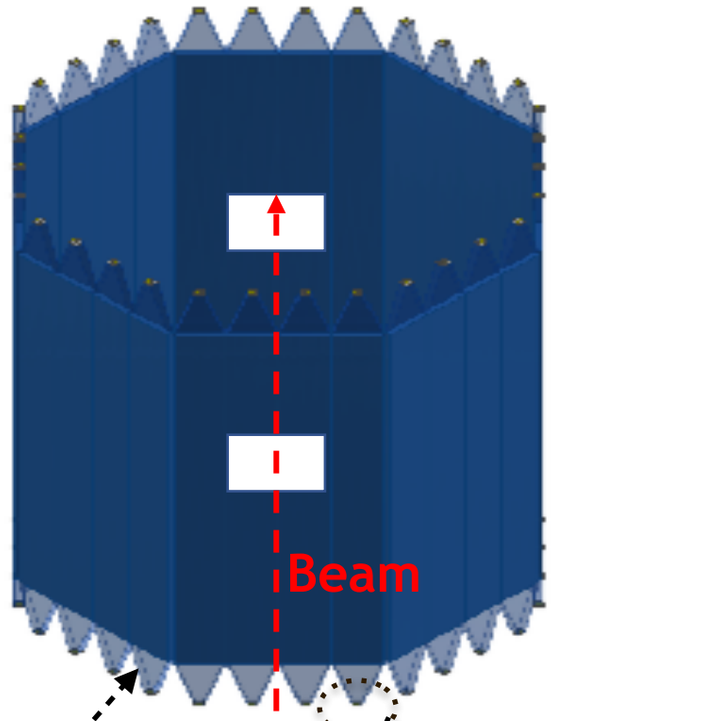
- **TPC: using dE/dx**



- **Hodoscope : TOF vs p/q**







- **Surrounding HypTPC for Trigger & PID**
- **MPPC will be used due to strong B field (~1 T)**
- **Scintillator : 32 segments (80^{L} x 7^{W} x 1^{T} cm)**

σ_T = 150 ps assumption

PROTOTYPING

Hodoscope prototype

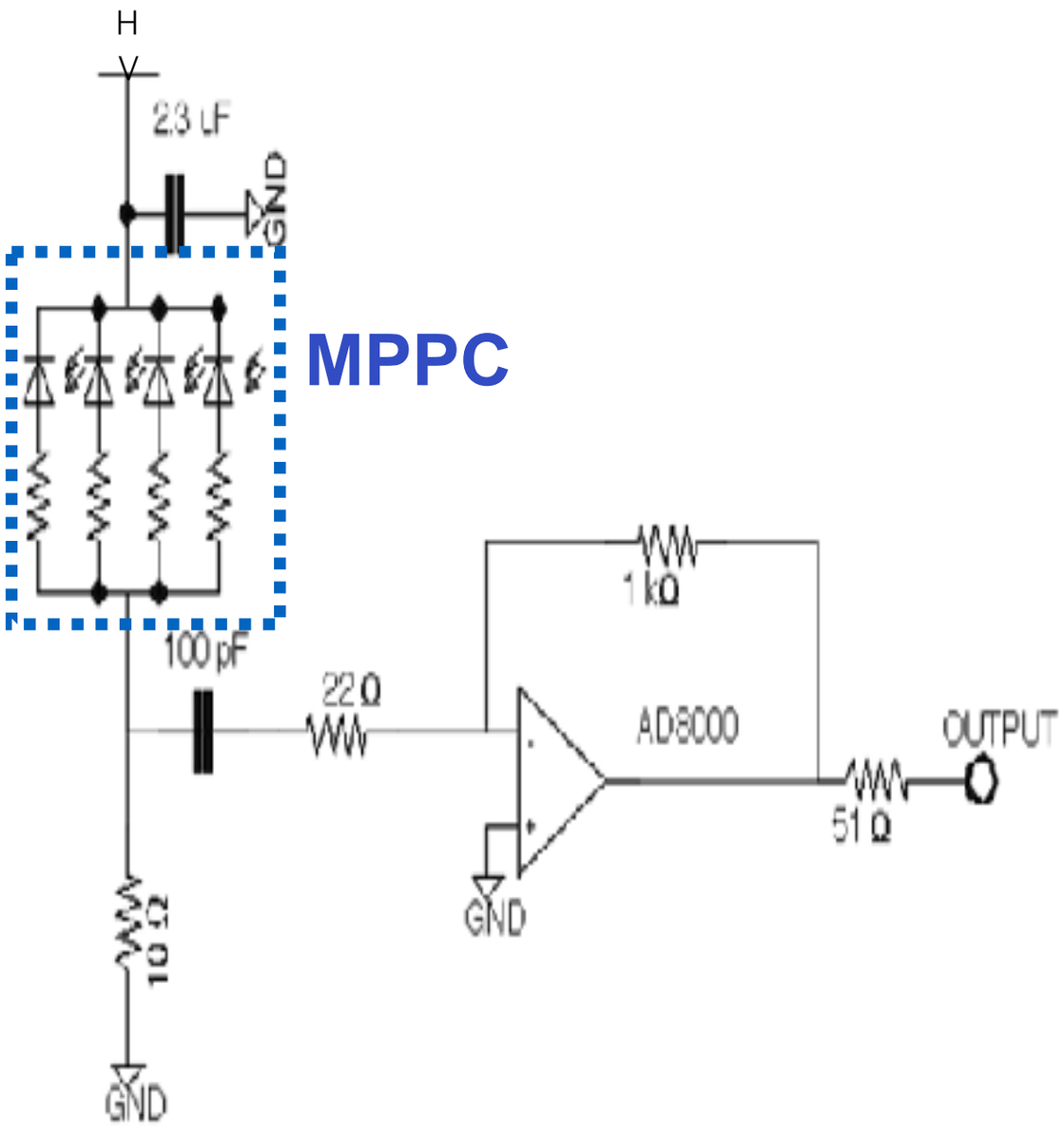
- Scintillator : 15^{L} x 7^{W} x 1^{T} cm

MPPC

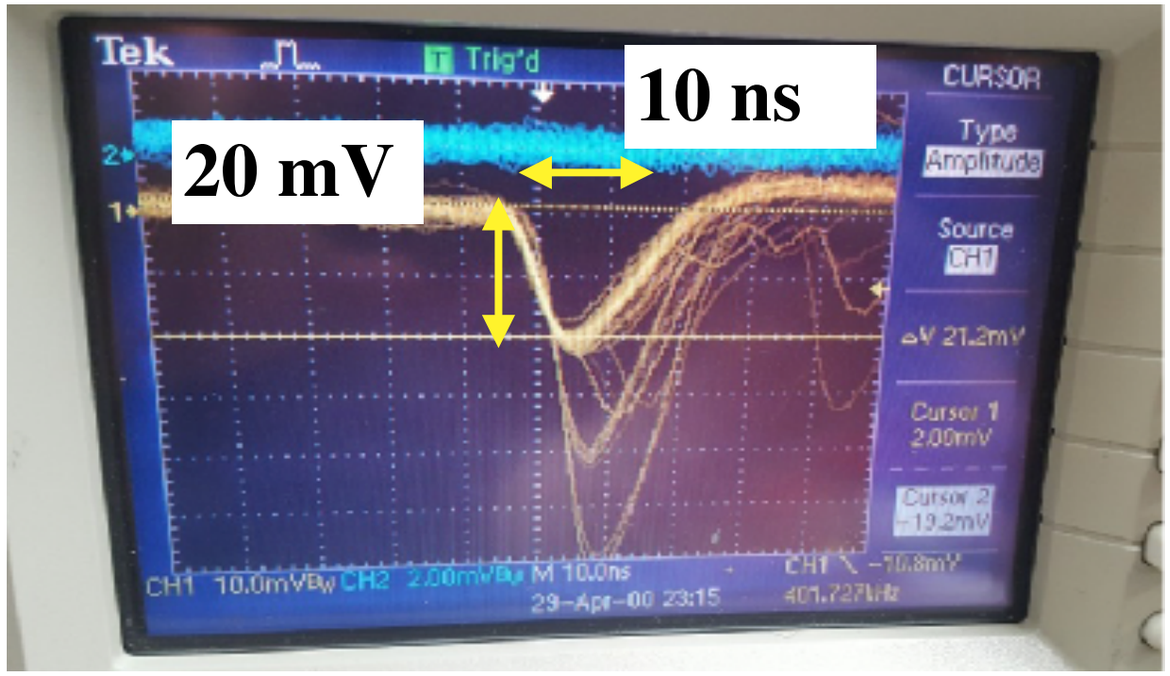
- MPPC : 3050CS (3 mm x 3 mm)
- There are four MPPCs on each side

PREAMP

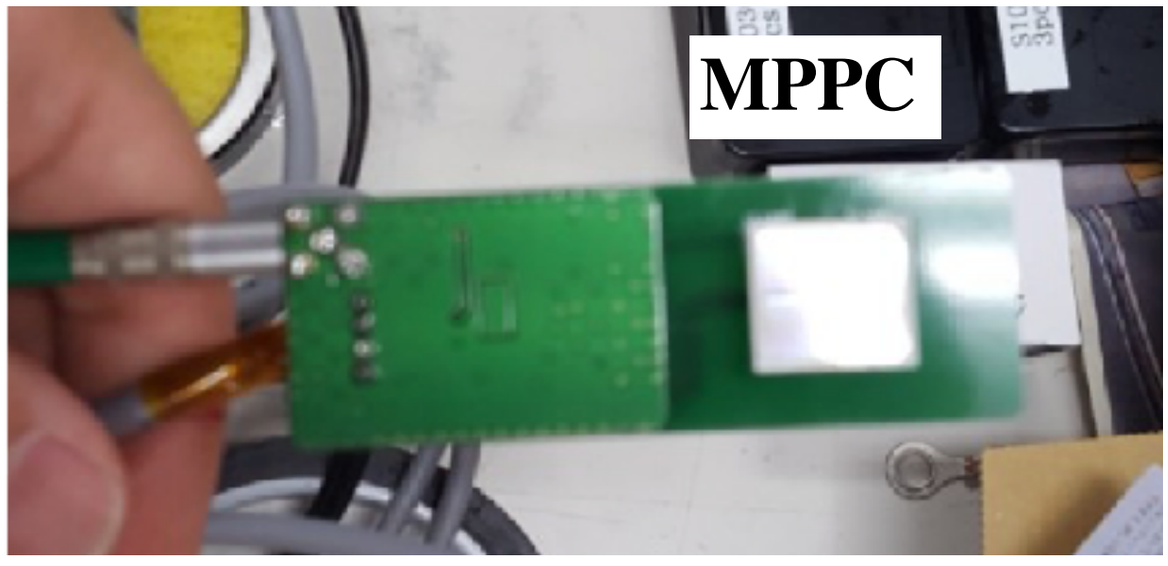
Circuit diagram



Dark current

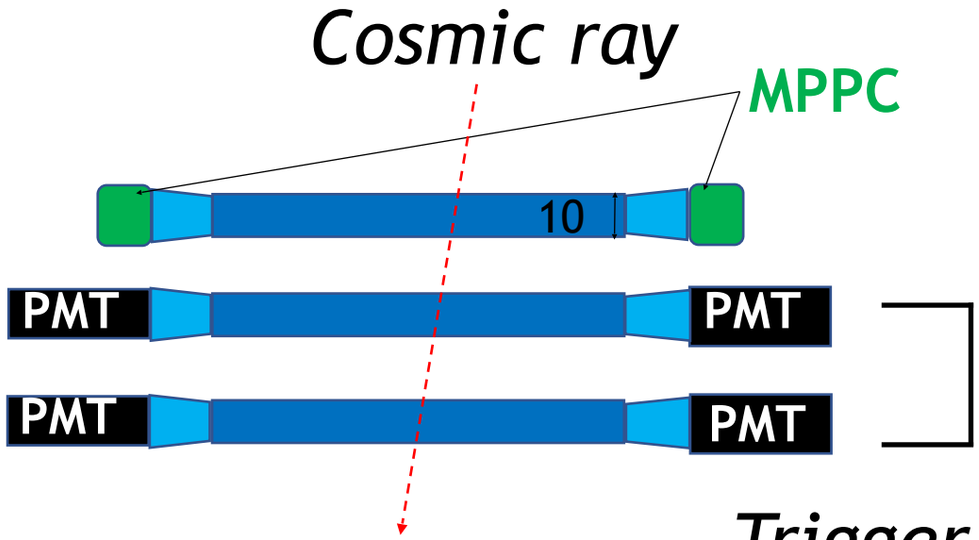


Preamp



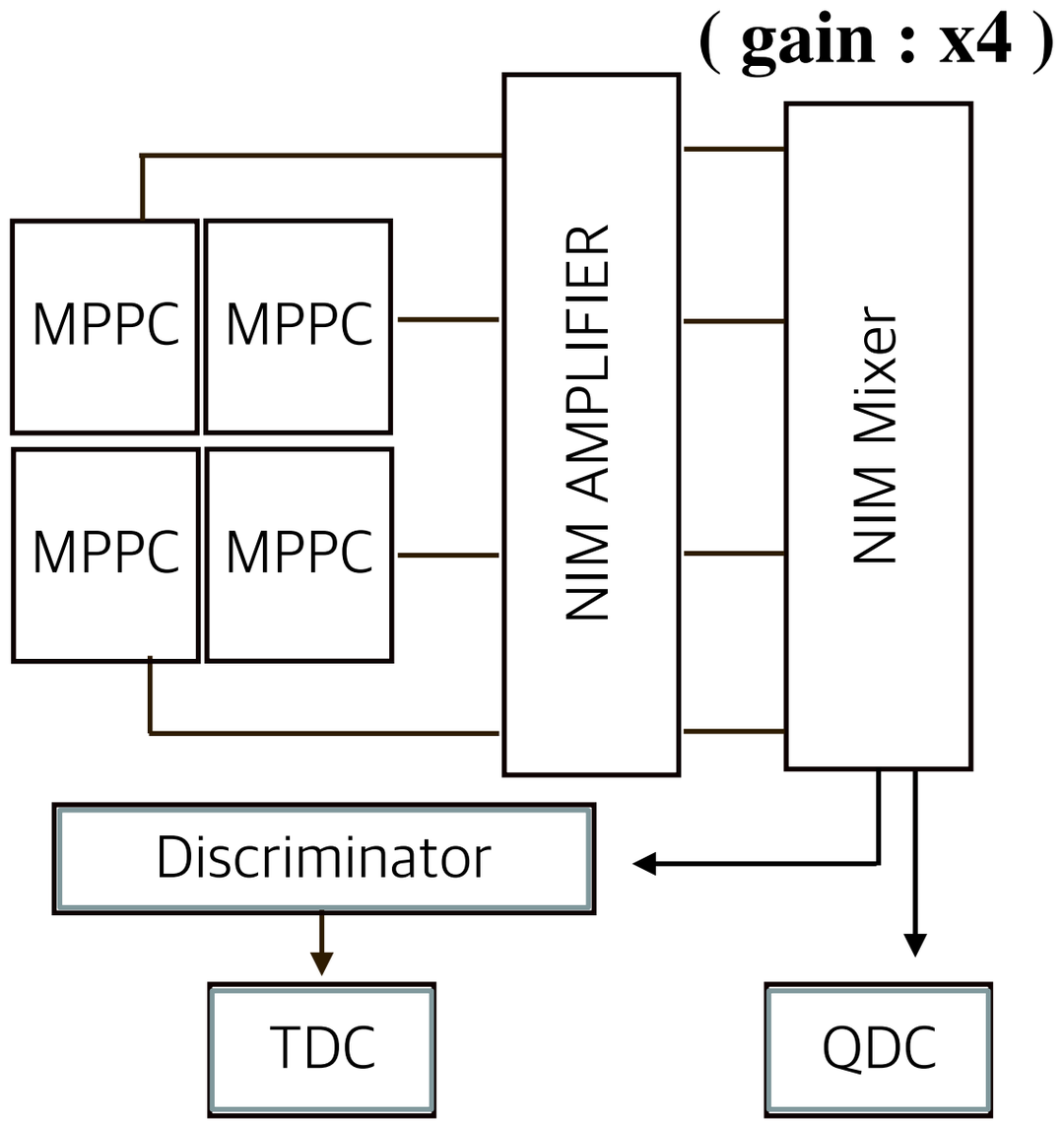
COSMIC-RAY TEST

Setup

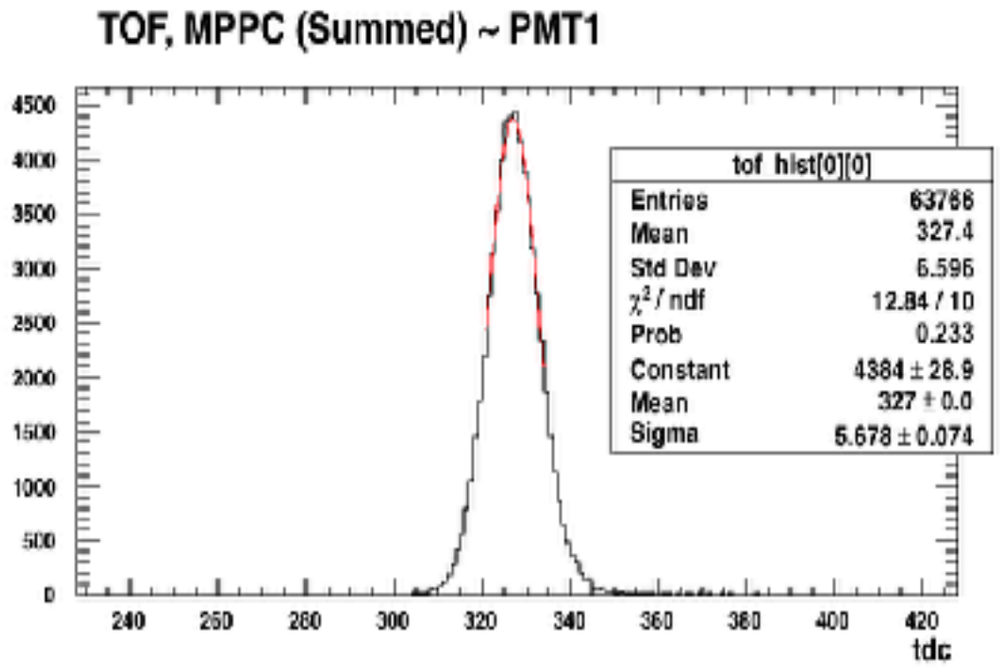


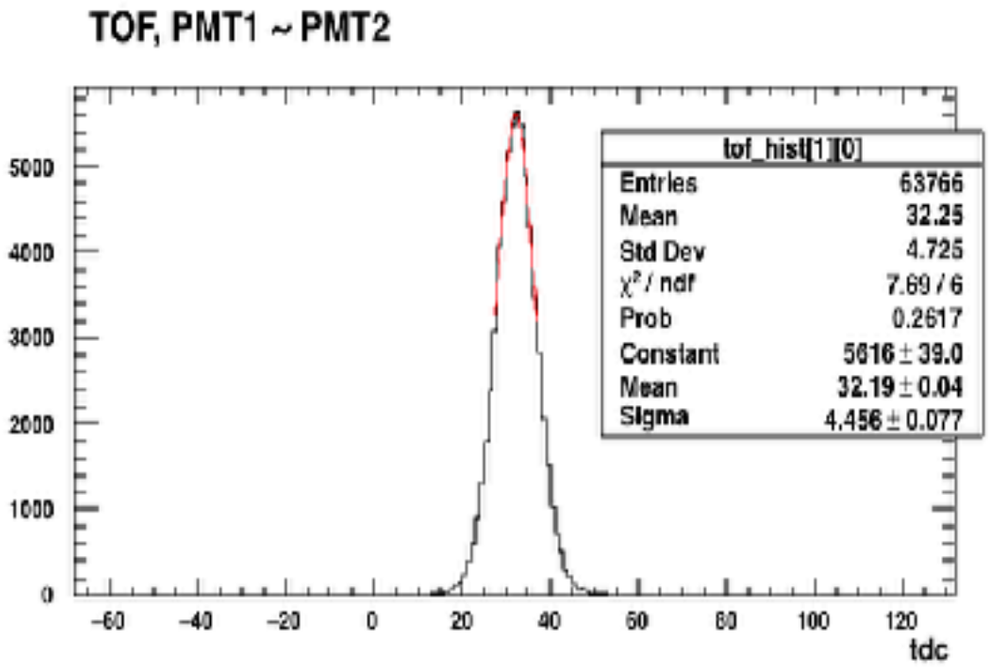
Three identical scintillators
1. Prototype with MPPCs
2 & 3. Trigger counters with PMTs

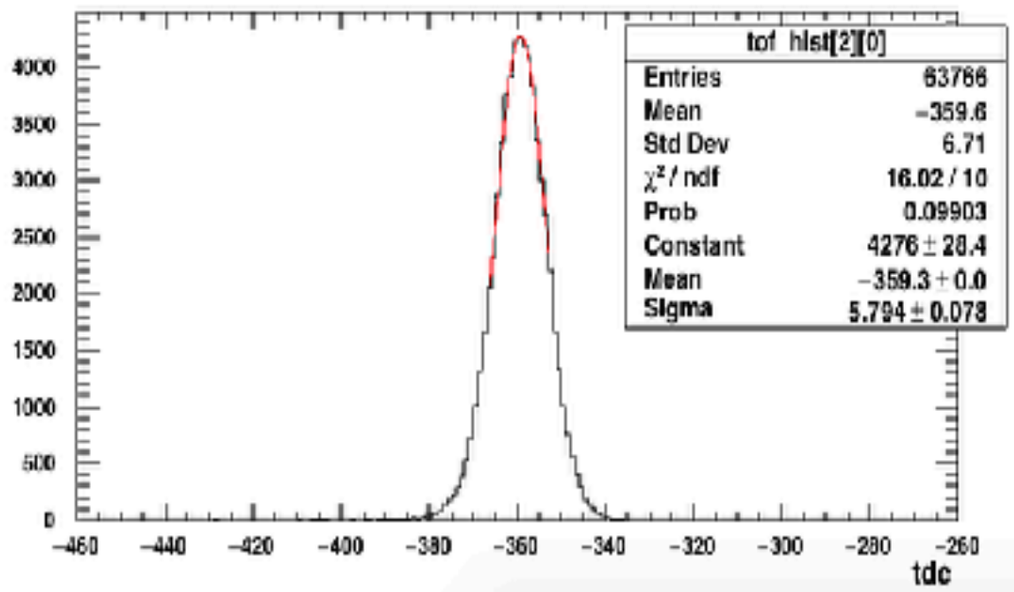
DAQ : Caen VME



ANALYSIS - TIME RESOLUTION







σ_{ij} : sigma of TOF distribution between i and j

err_{ij} : fitting error of σ_{ij}

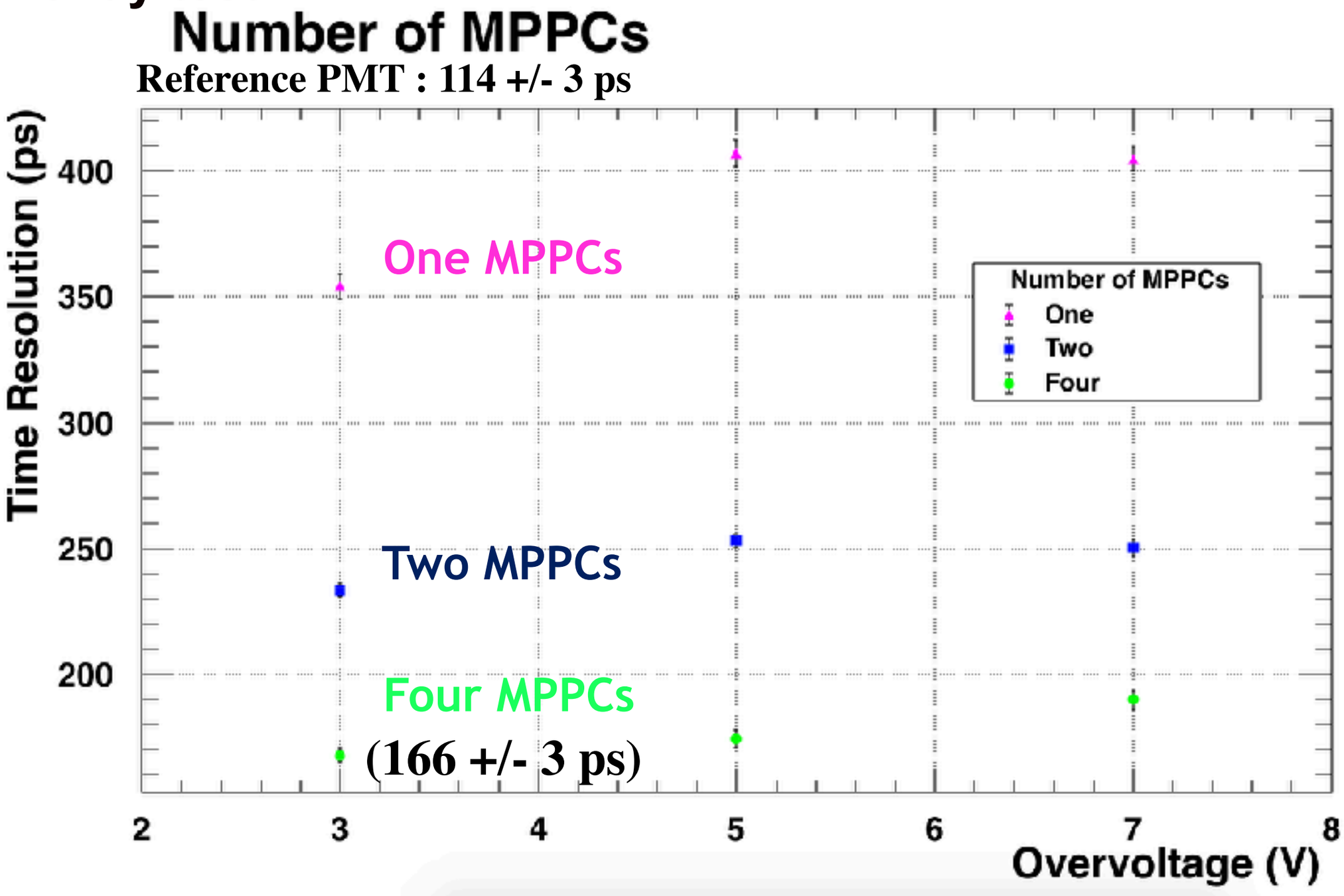
$$Resolution_1 = \sqrt{(\sigma_{12}^2 + \sigma_{31}^2 - \sigma_{23}^2)/2}$$

$$Error_{Resolution_1} = \frac{\sqrt{\sigma_{12}^2 \times err_{12}^2 + \sigma_{23}^2 \times err_{23}^2 + \sigma_{31}^2 \times err_{31}^2}}{2 \times Resolution_1}$$

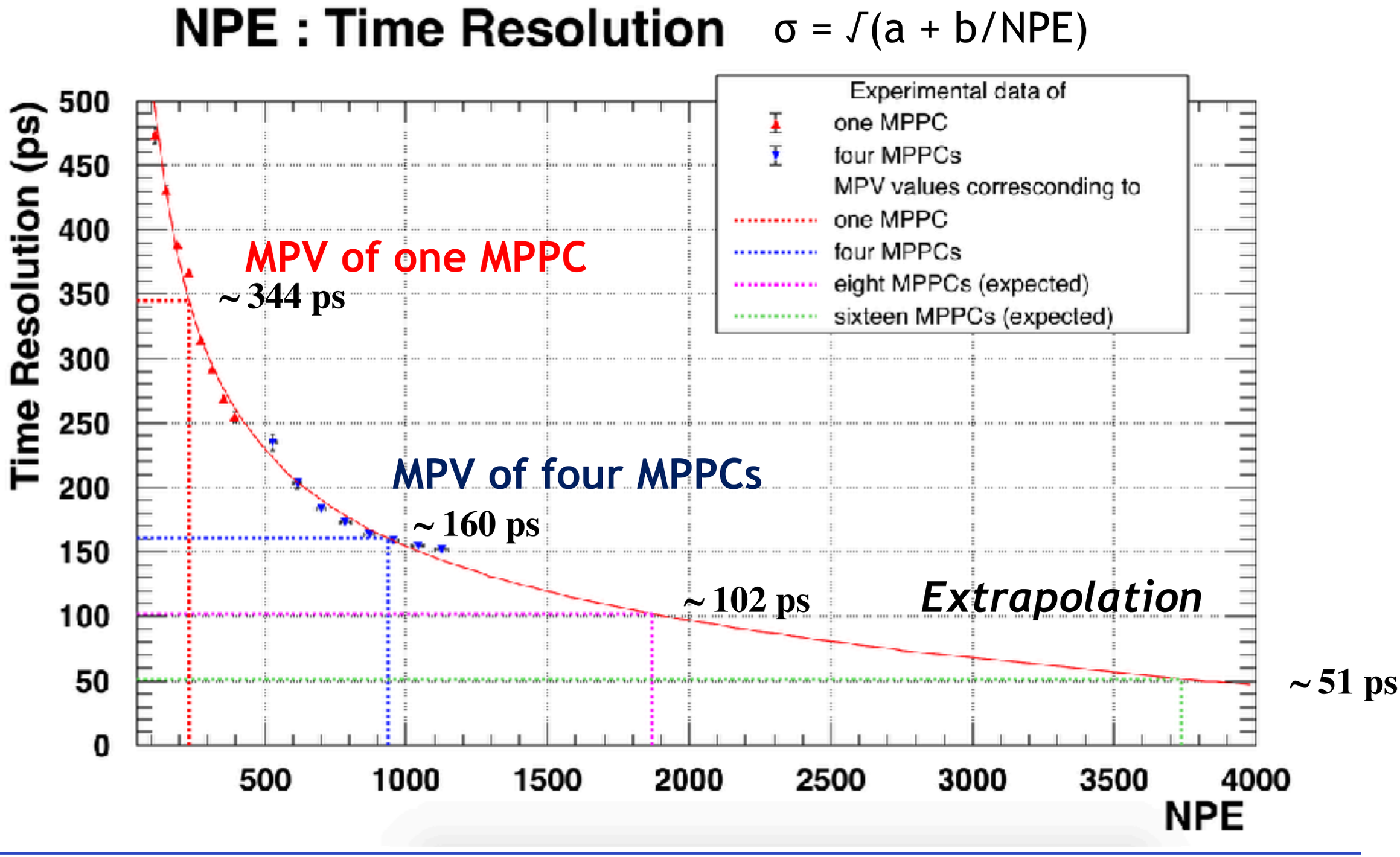
Time resolution result is <u>166 +/- 3 ps</u>

NUMBER OF MPPC STUDY

Cosmic ray test



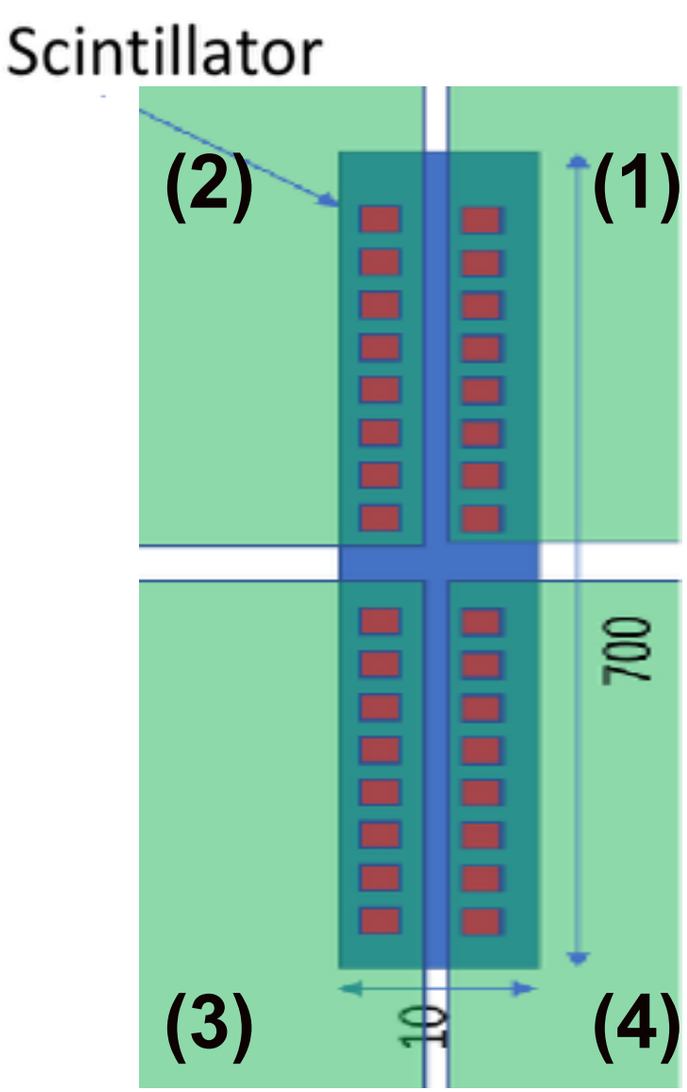
TIME RESOLUTION VS NPE

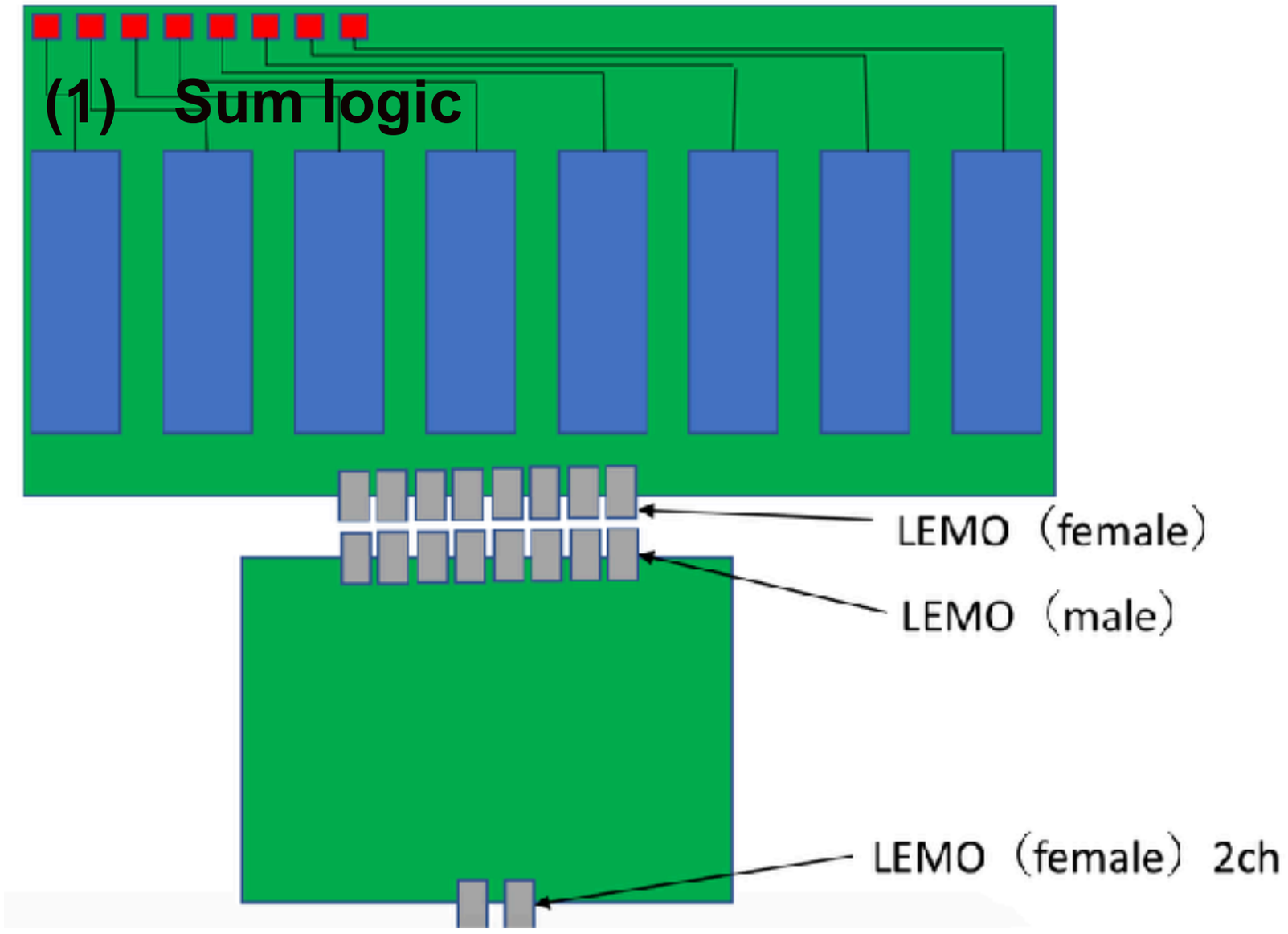


HIT PATTERN

NEW PREAMP FOR MULTIPLE MPPC READOUT

Schematic view of maximum MPPC connection (maximum 32 ch)





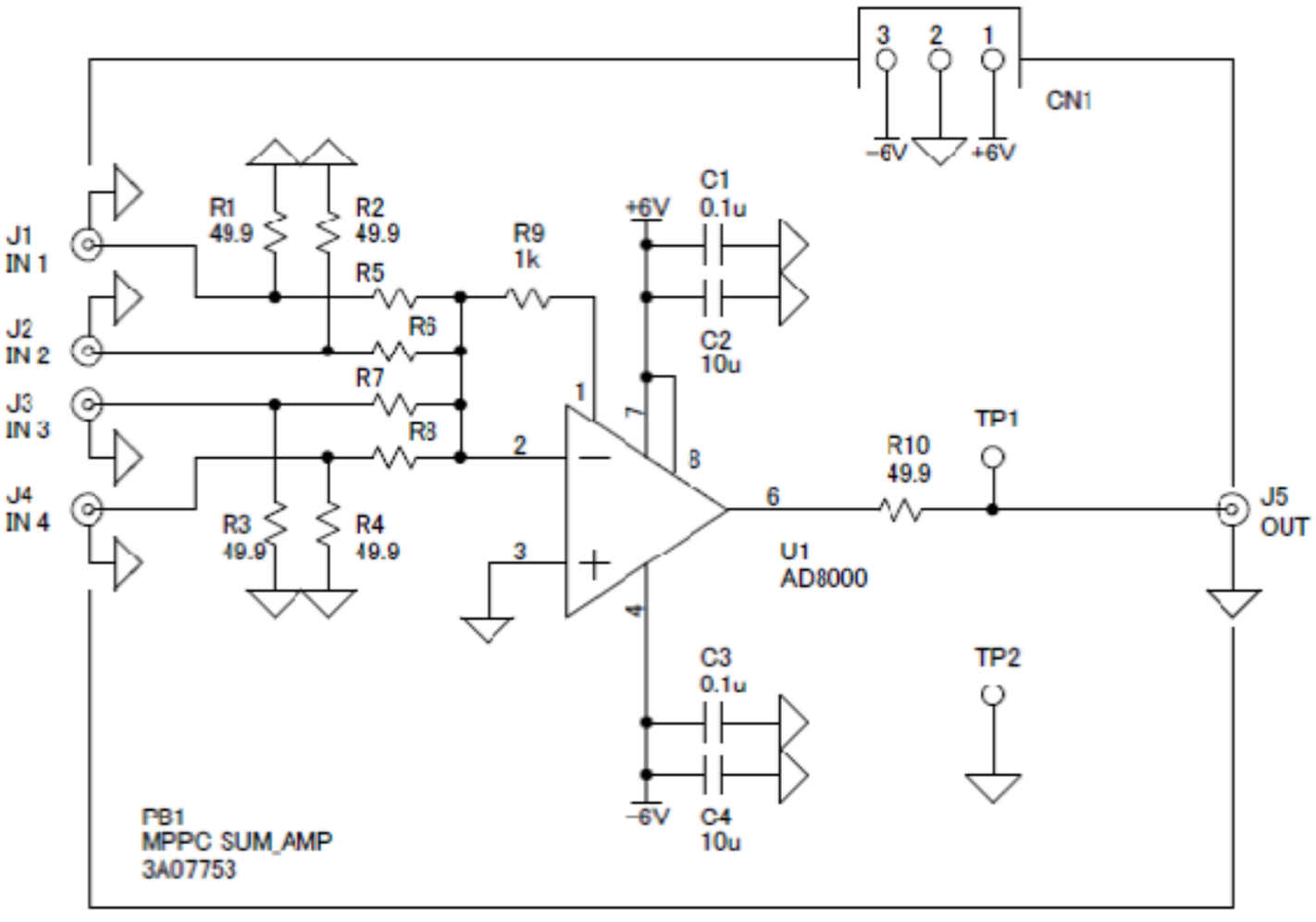
SUMMARY

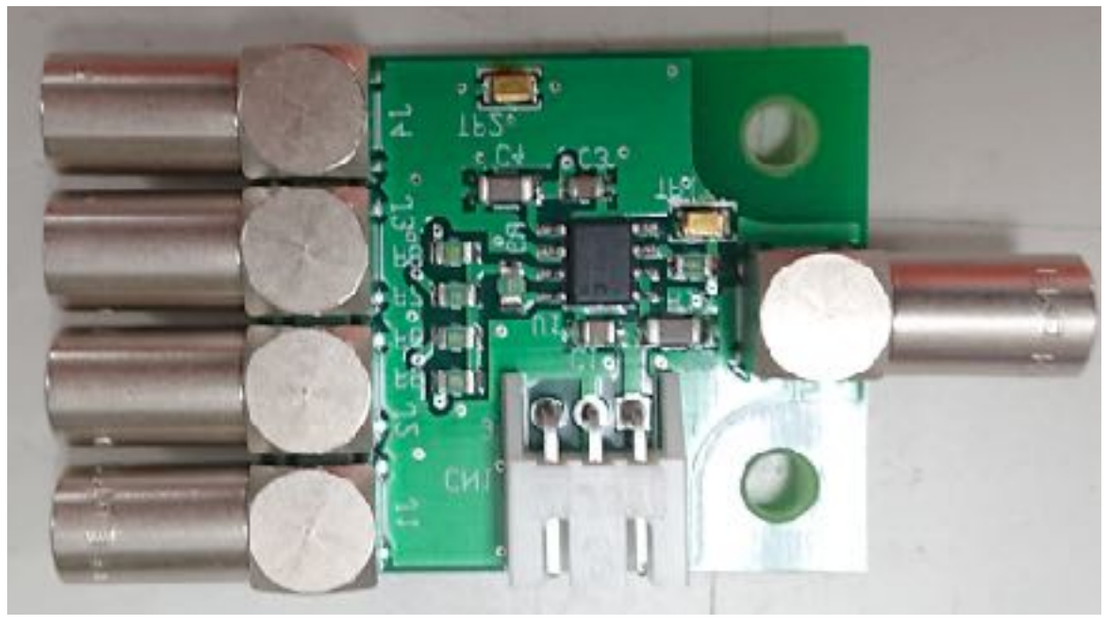
- **We are preparing Hyperon spectrometer for E42**
- **For Hodoscope, MPPC will be used due to strong magnetic field.**
- **Small size prototype's Cosmic-ray test has been done**
- **We achieved ~170 ps resolution with prototype.**
- **Real size Hodoscope with new preamp for multiple MPPC readout system be produced and tested soon.**

BACKUP

SUMMING AMP(MIXER)

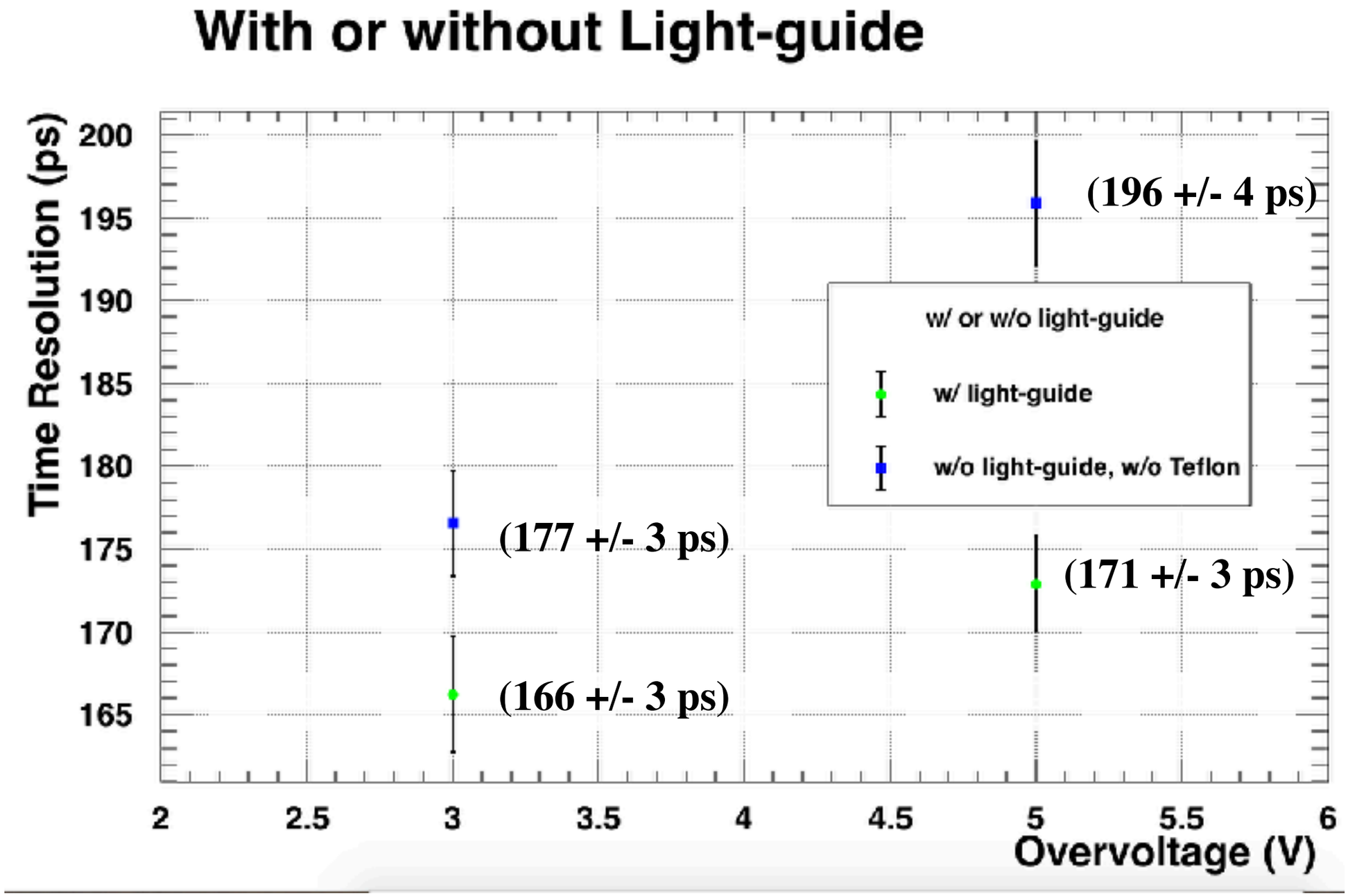
It is used to sum multi-MPPC signal(under development)





W/ OR W/O LIGHT-GUIDE

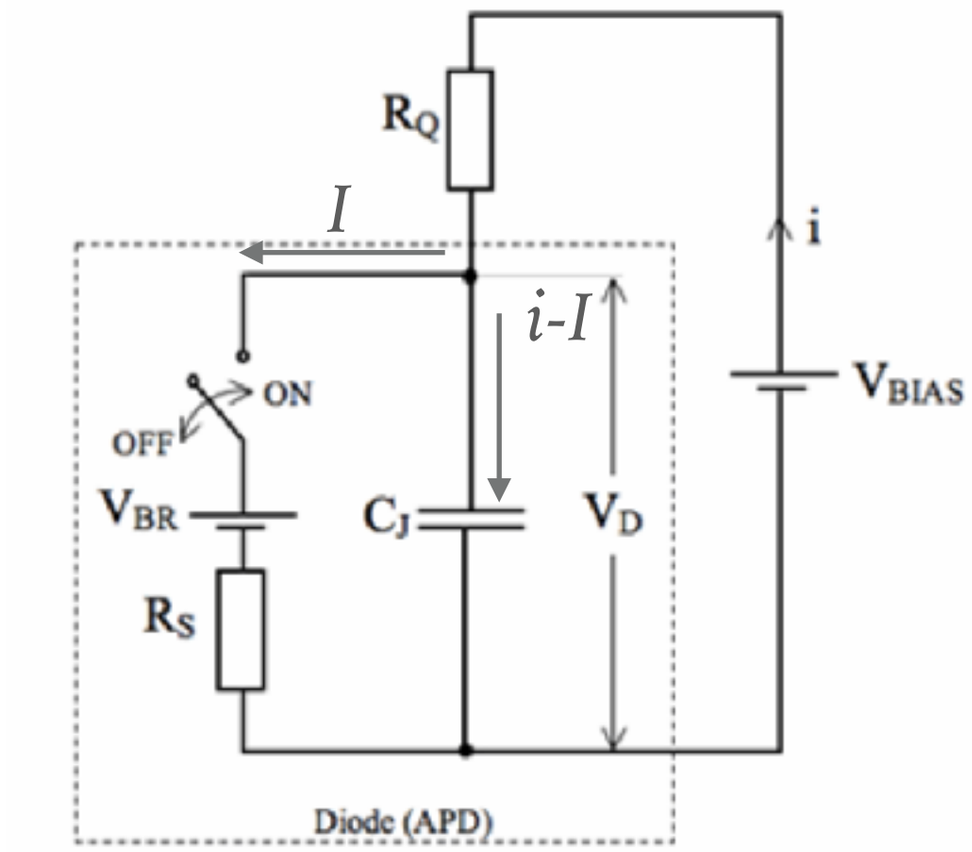
Trigger resolution: 111 +/- 2 ps



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

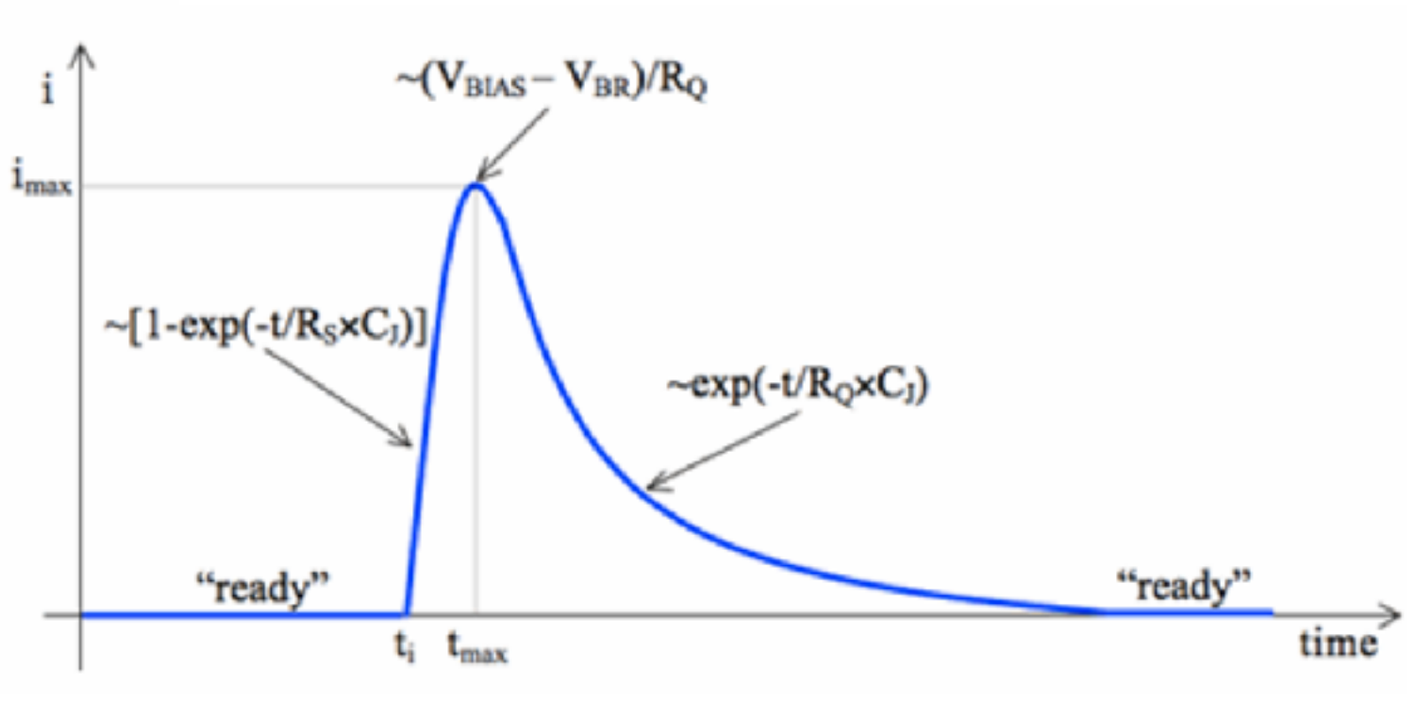
V_{BIAS}-Q/C_j-iR_Q=0

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

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

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

$\tau_r = C_j R_Q$

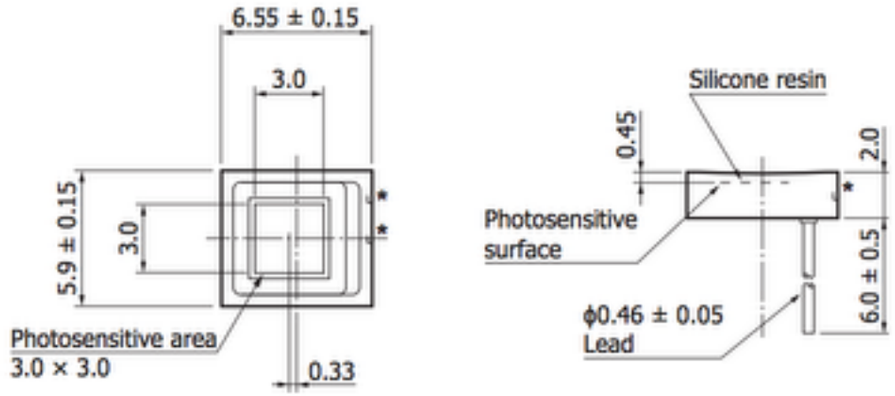


Current flowing through the APD as a function of time

MPPC

HAMAMATSU S13360-3050CS (3 x 3 mm²)

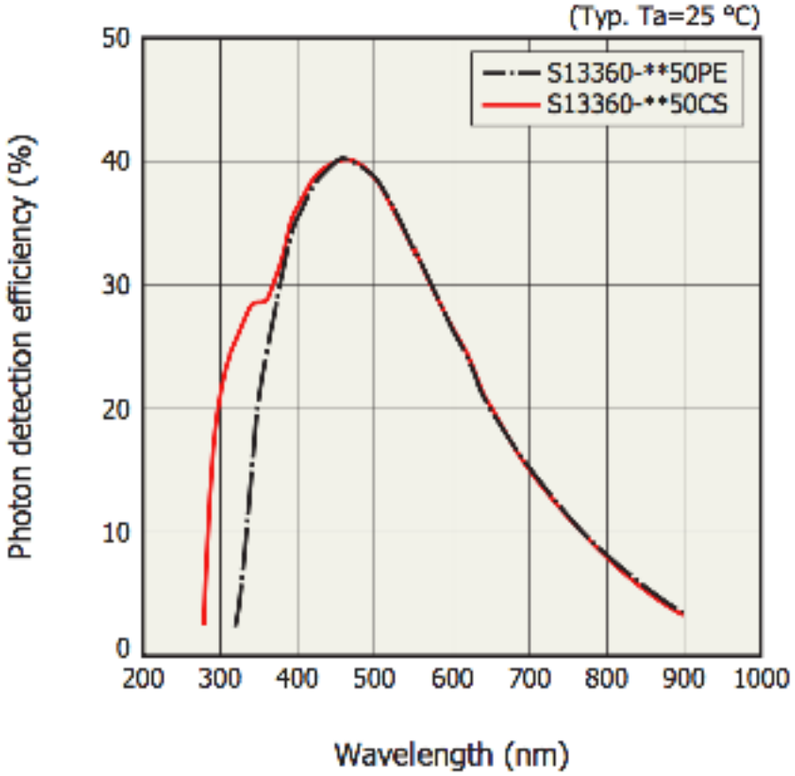
$V_{op} = V_{br}(51\ V) + 3.0\ V$ (V_{br} : breakdown voltage)



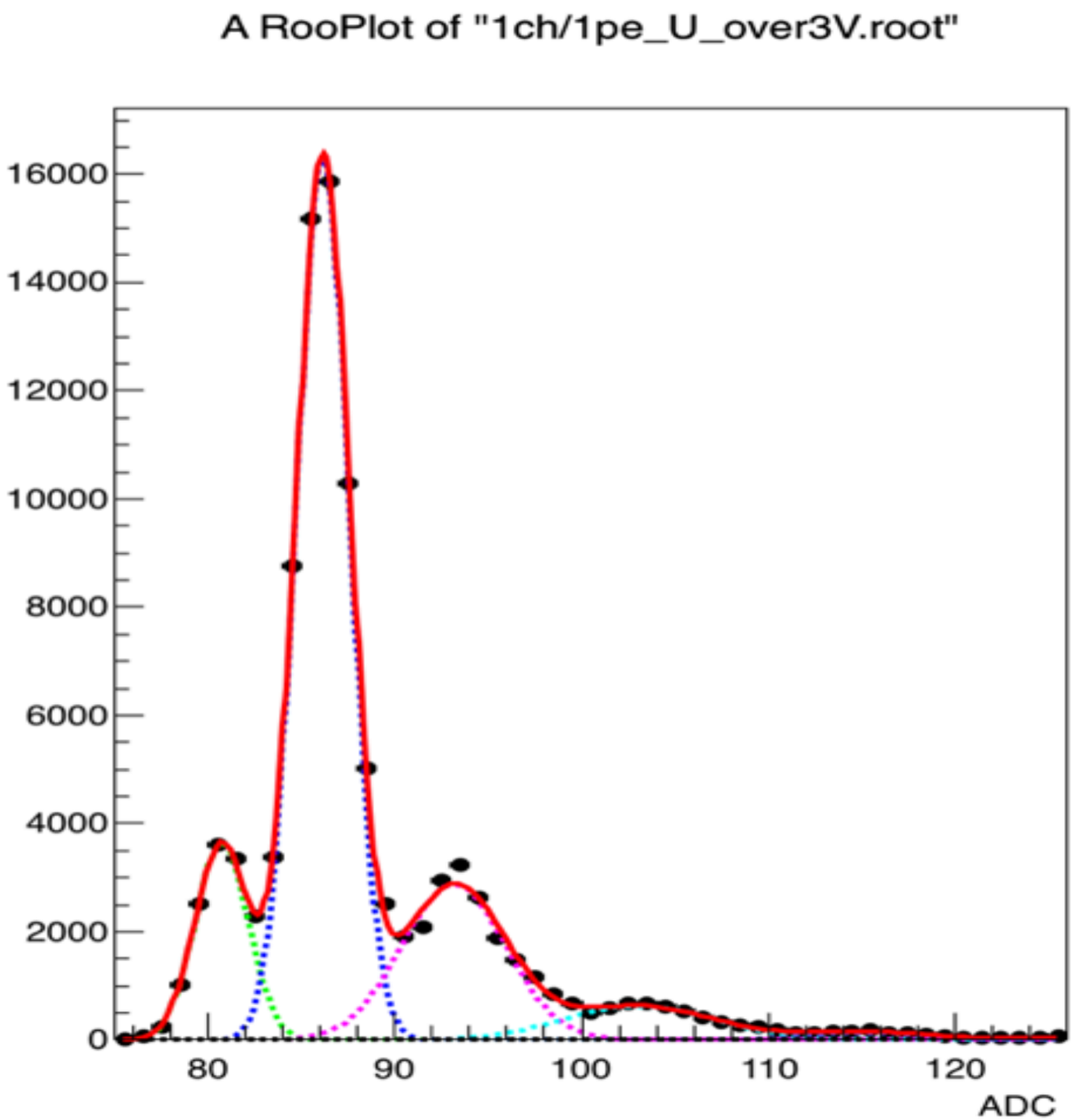
DATA SHEET

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 × 10⁶	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	



NPE

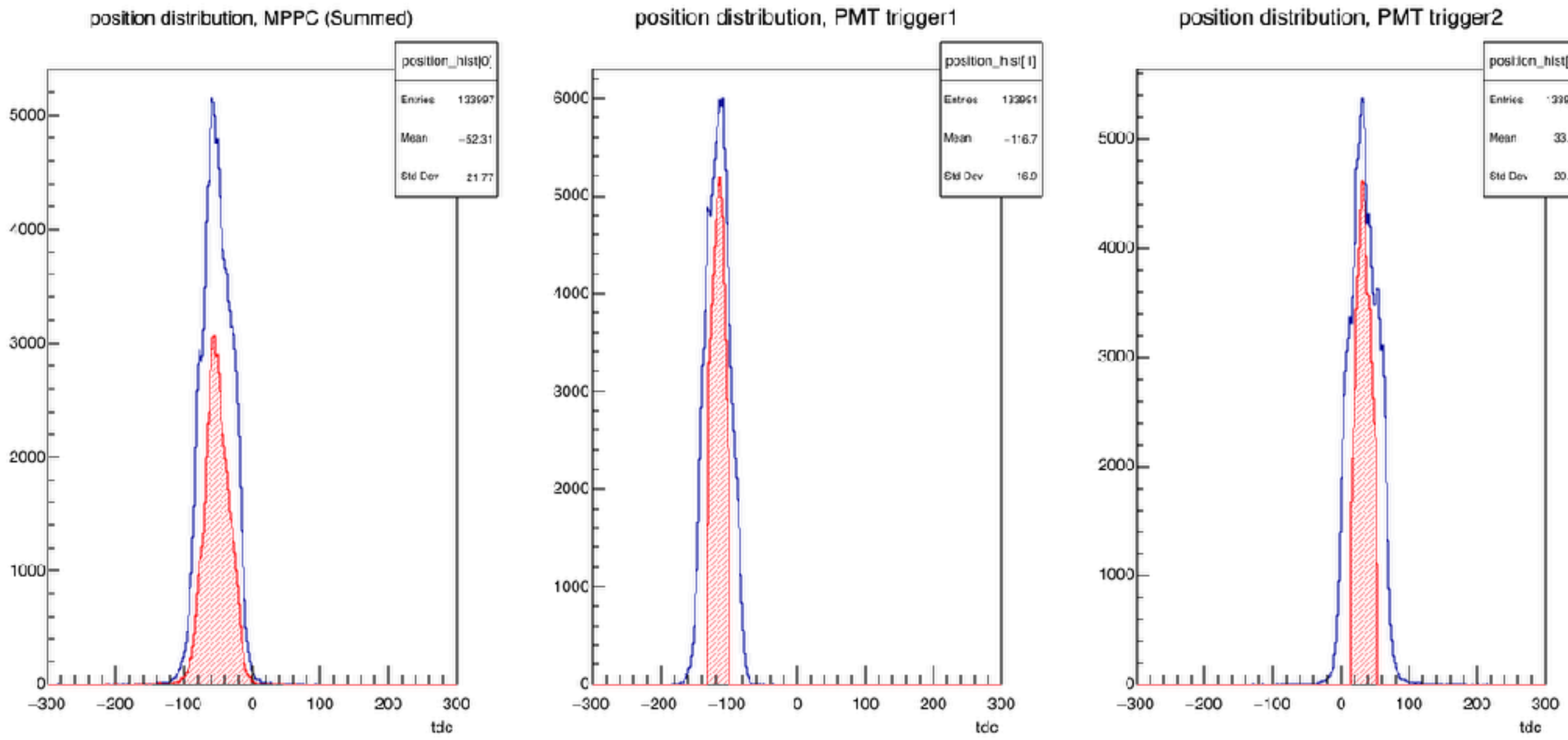


Dark current data

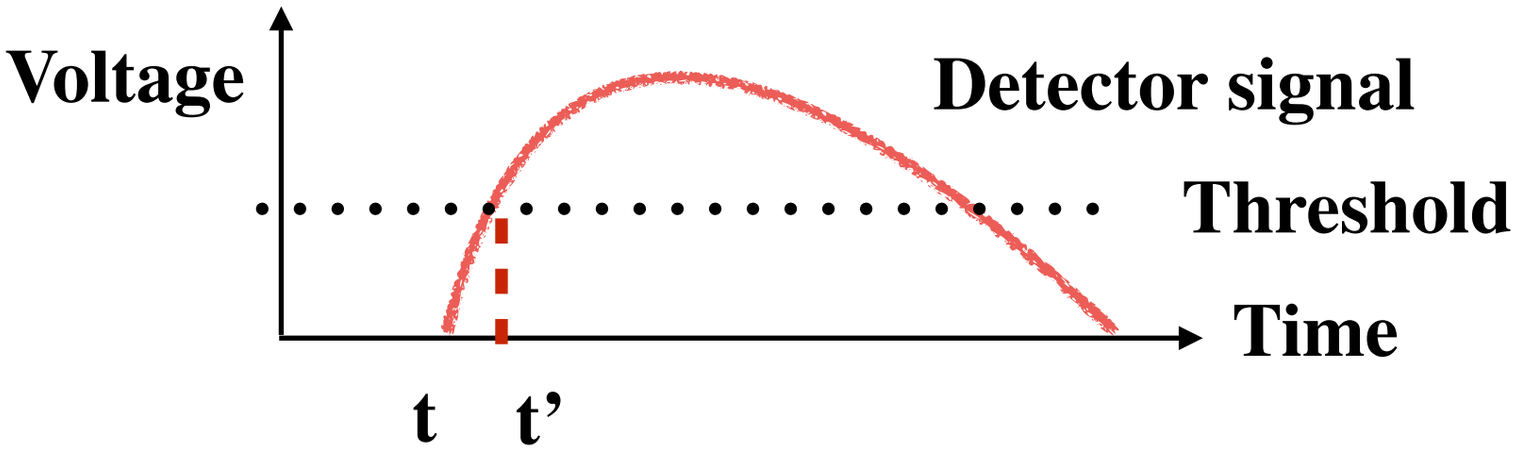
ANALYSIS - HIT POSITION CUT

Only for triggers

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

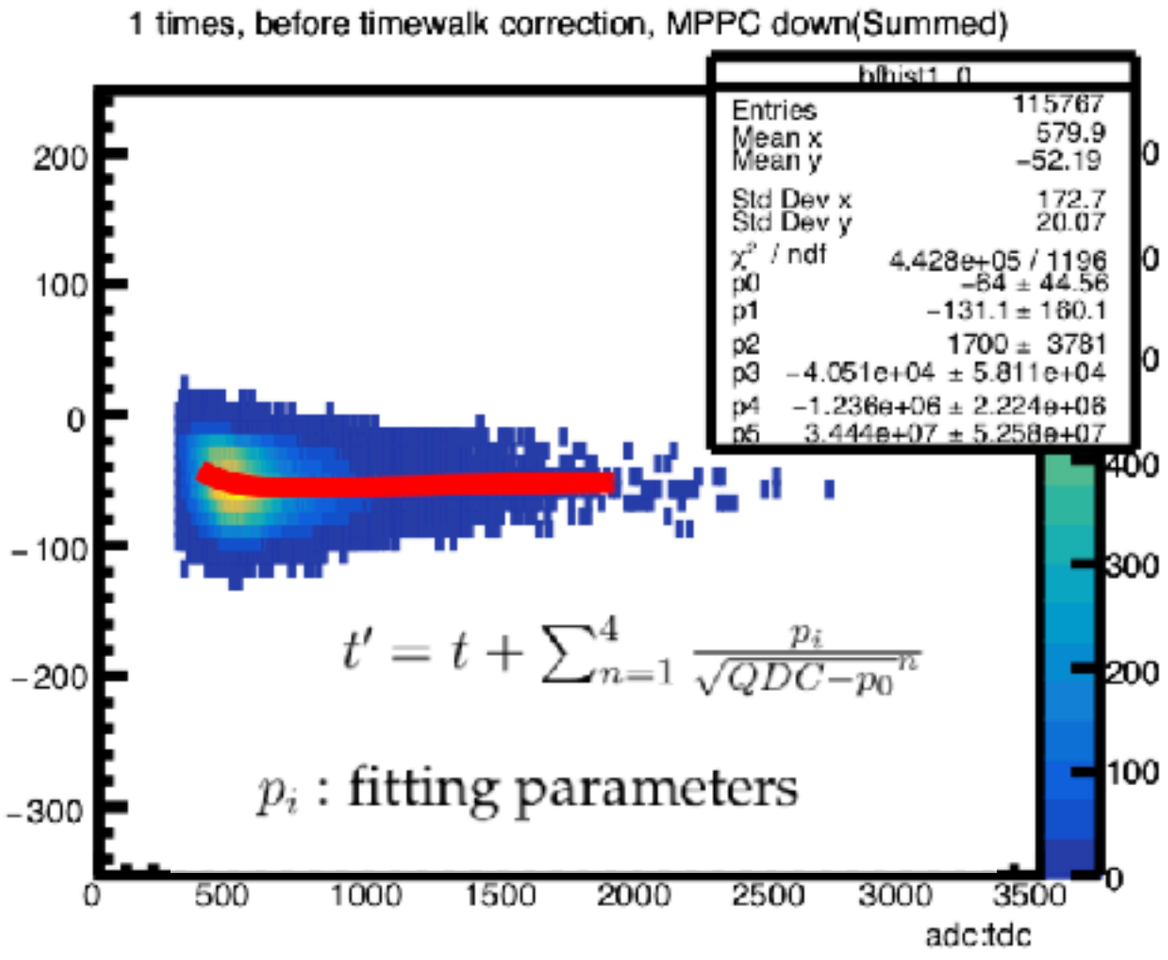


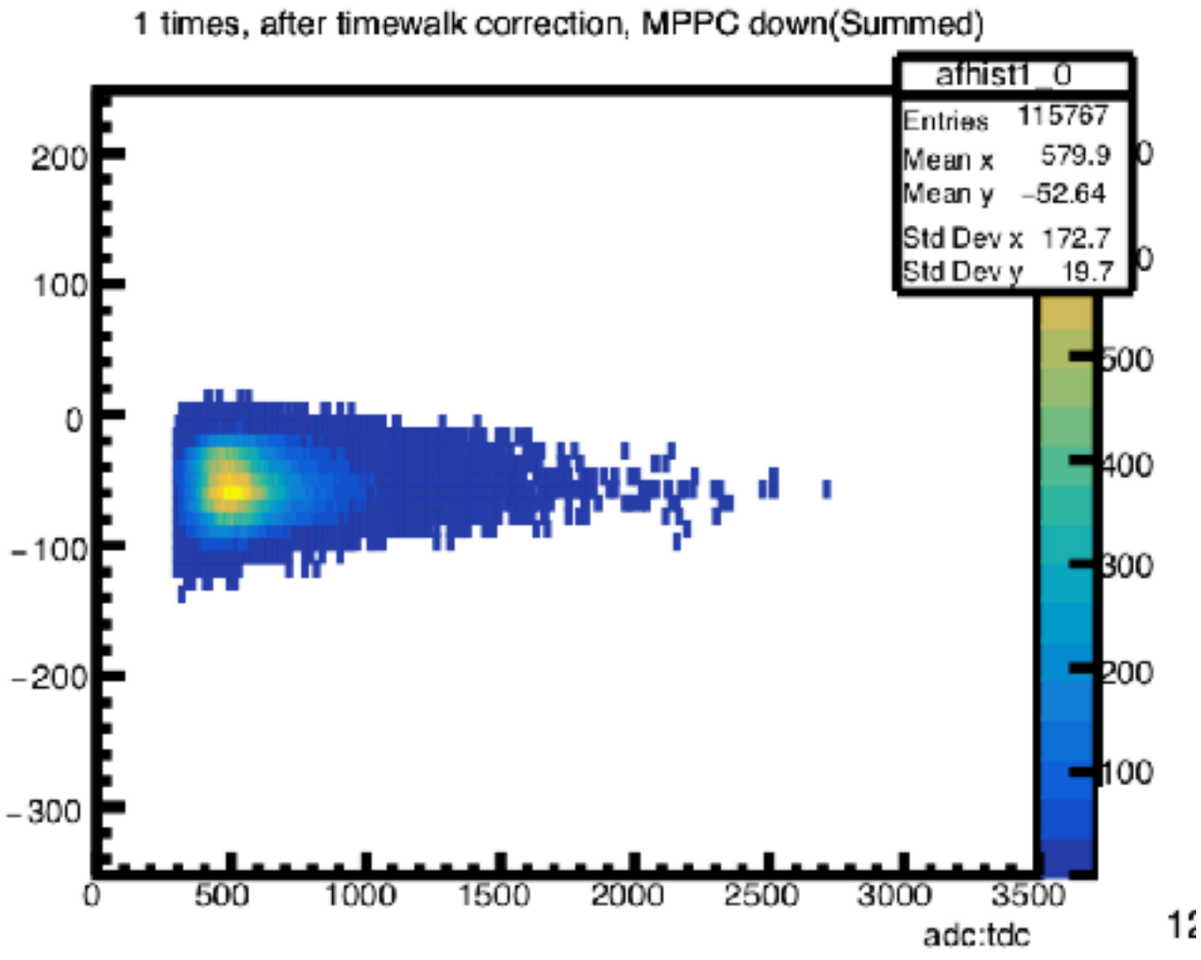
ANALYSIS - TIME WALK CORRECTION



t : real time

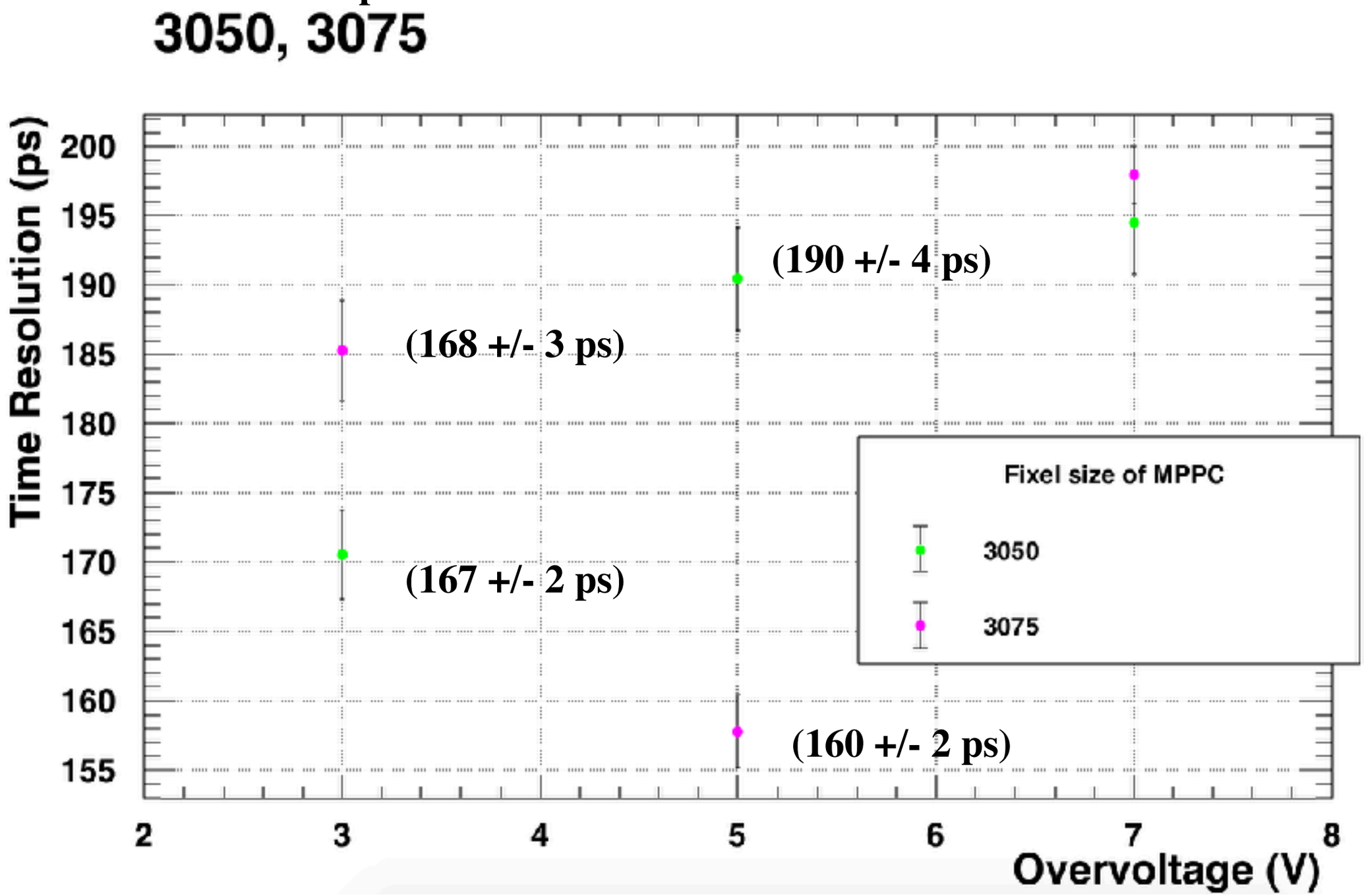
t' : measured time





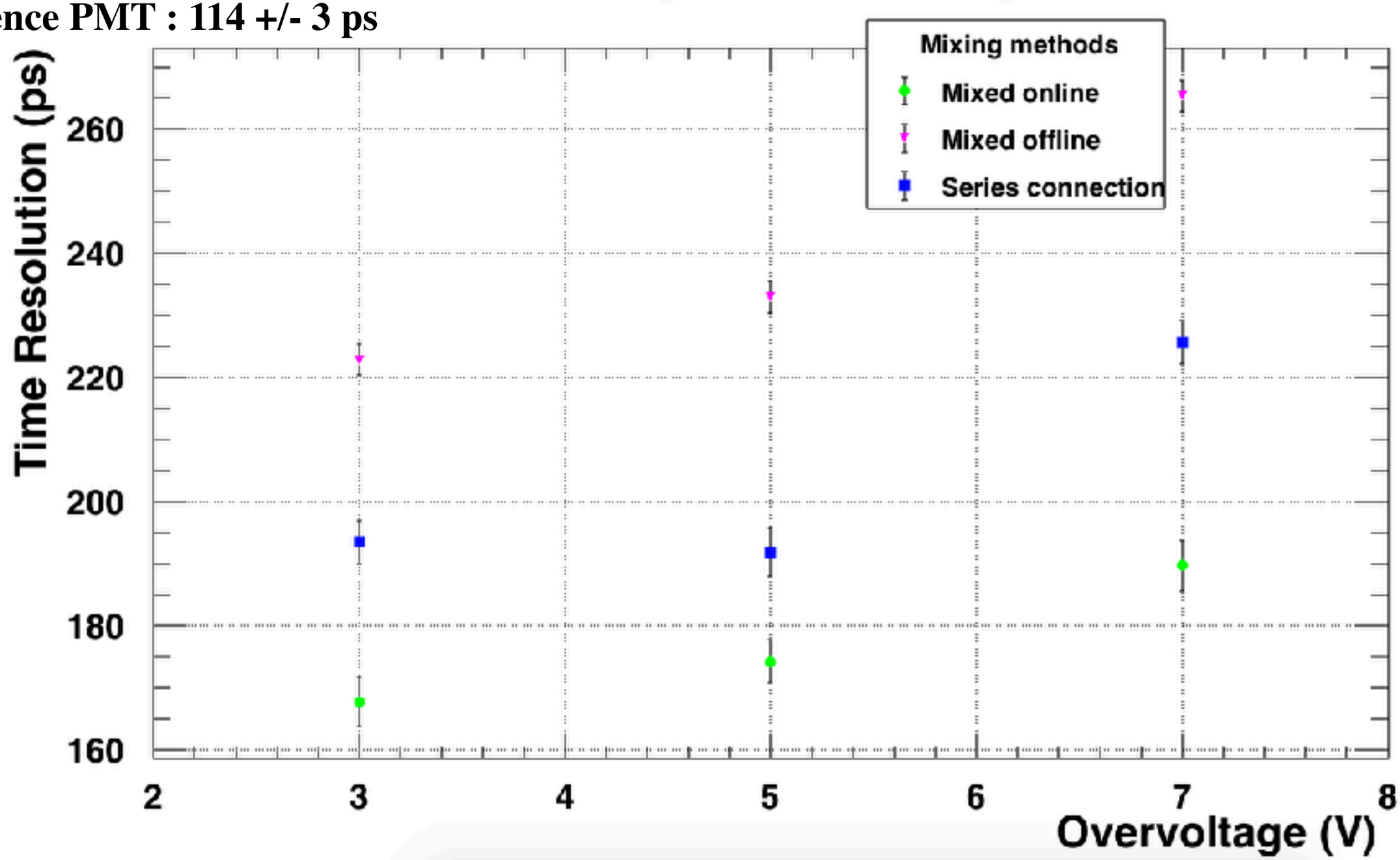
3050 VS 3075 MPPC

Trigger resolution: 120 +/- 3 ps



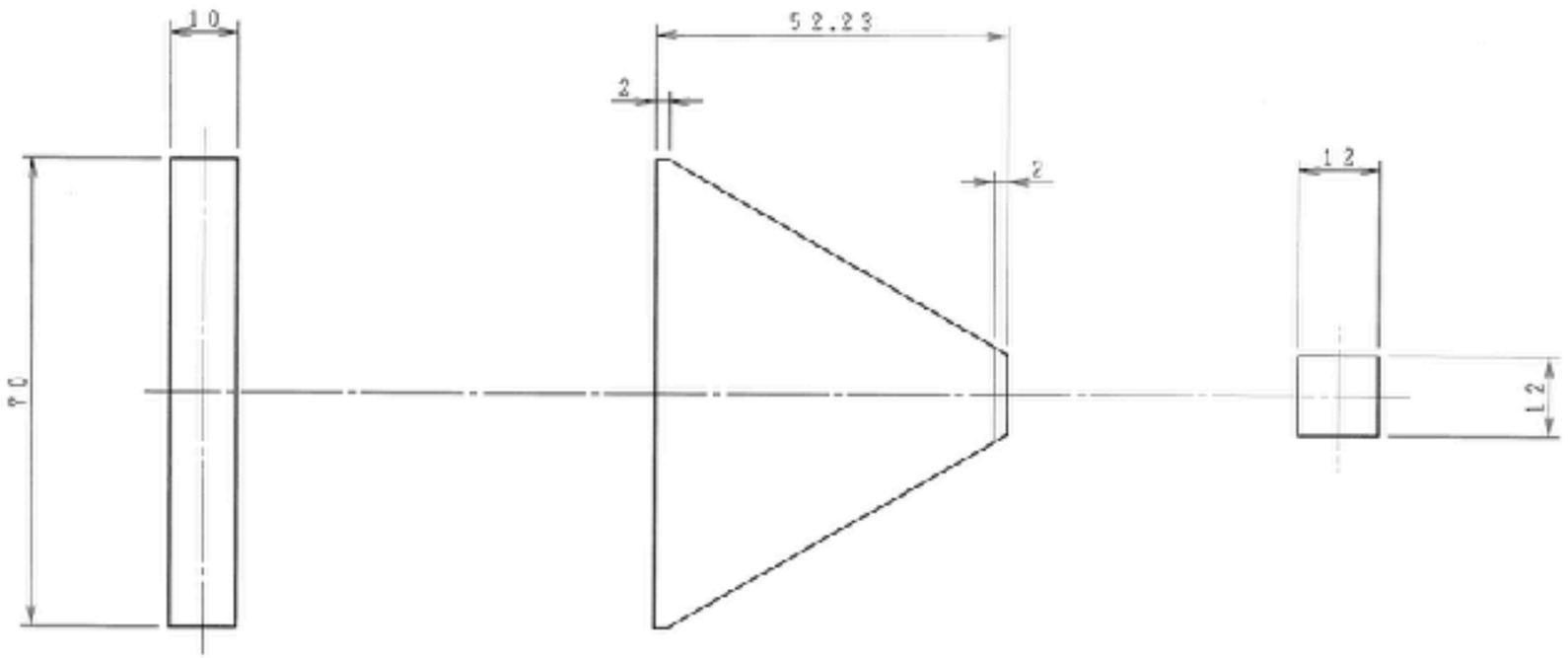
COMPARISON THE CONNECTION METHOD

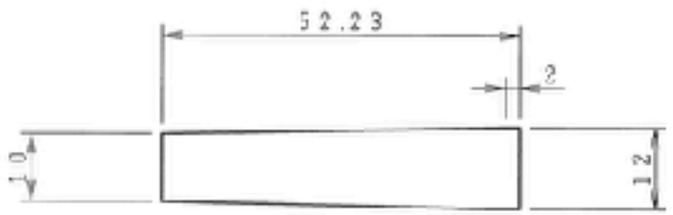
Reference PMT : 114 +/- 3 ps



LIGHT GUIDE

MPPC side is wider





Scintillator side ⟶ ⟵ **MPPC side**

TEST BOARD