J-PARC 별난바리온 실험을 위한 TPC Trigger Hodoscope 개발

KURAMA K$^+$ Spectrometer

Superconducting Hyperon Spectrometer

K1.8 Beam Spectrometer
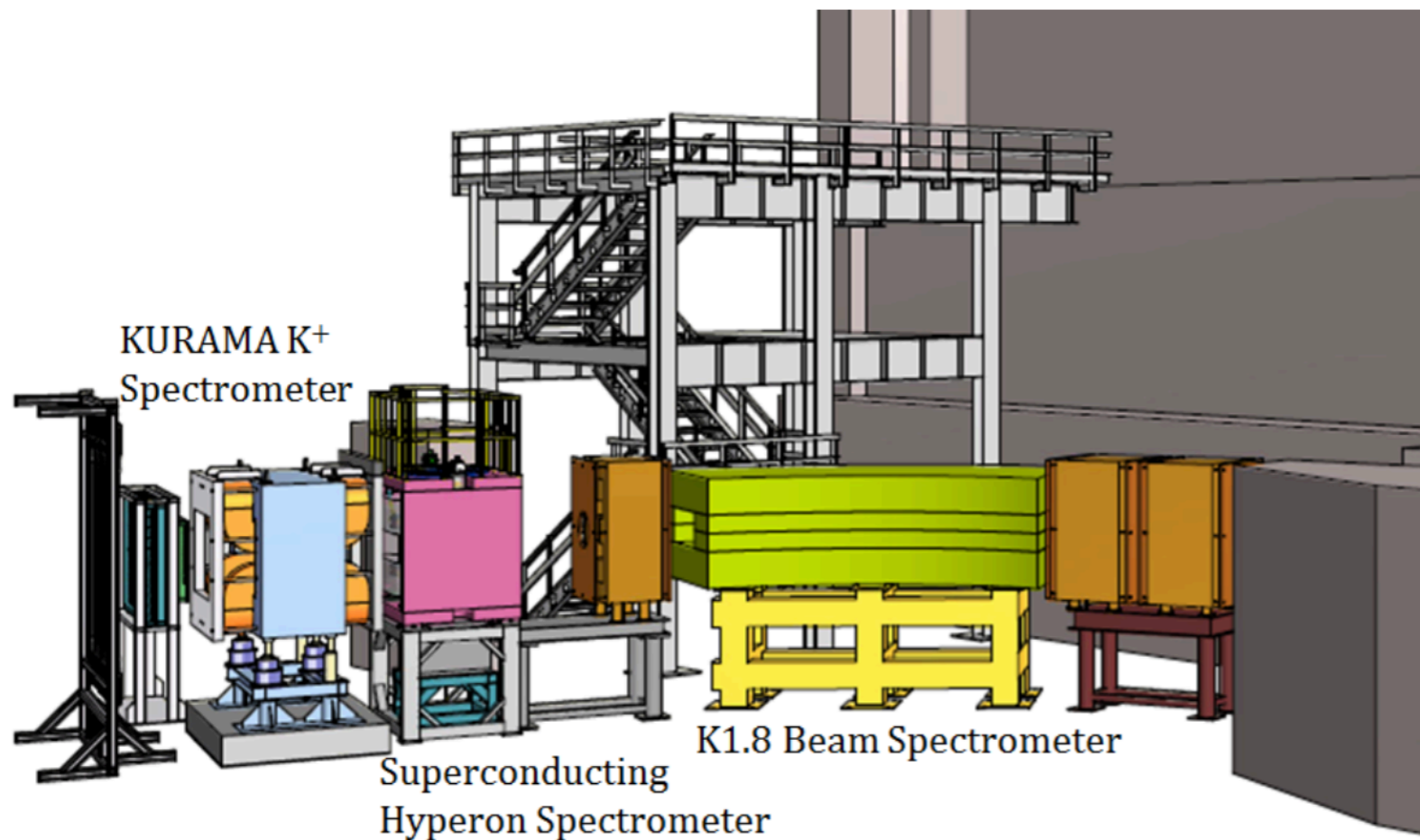
정우승
물리학과 하드론핵물리연구실

E42@J-PARC

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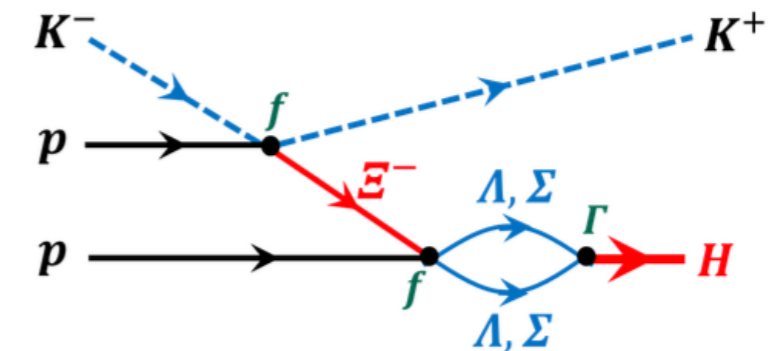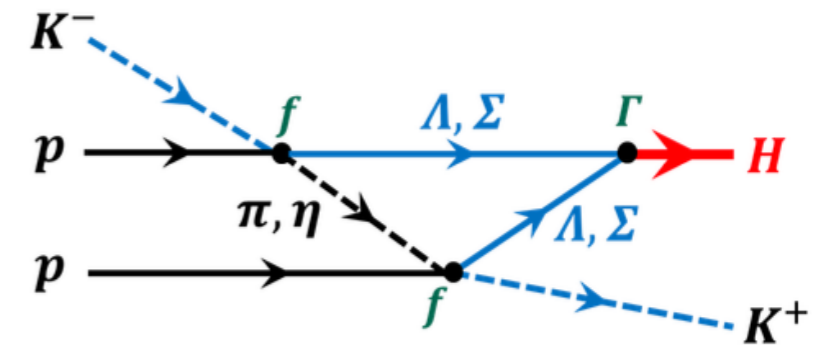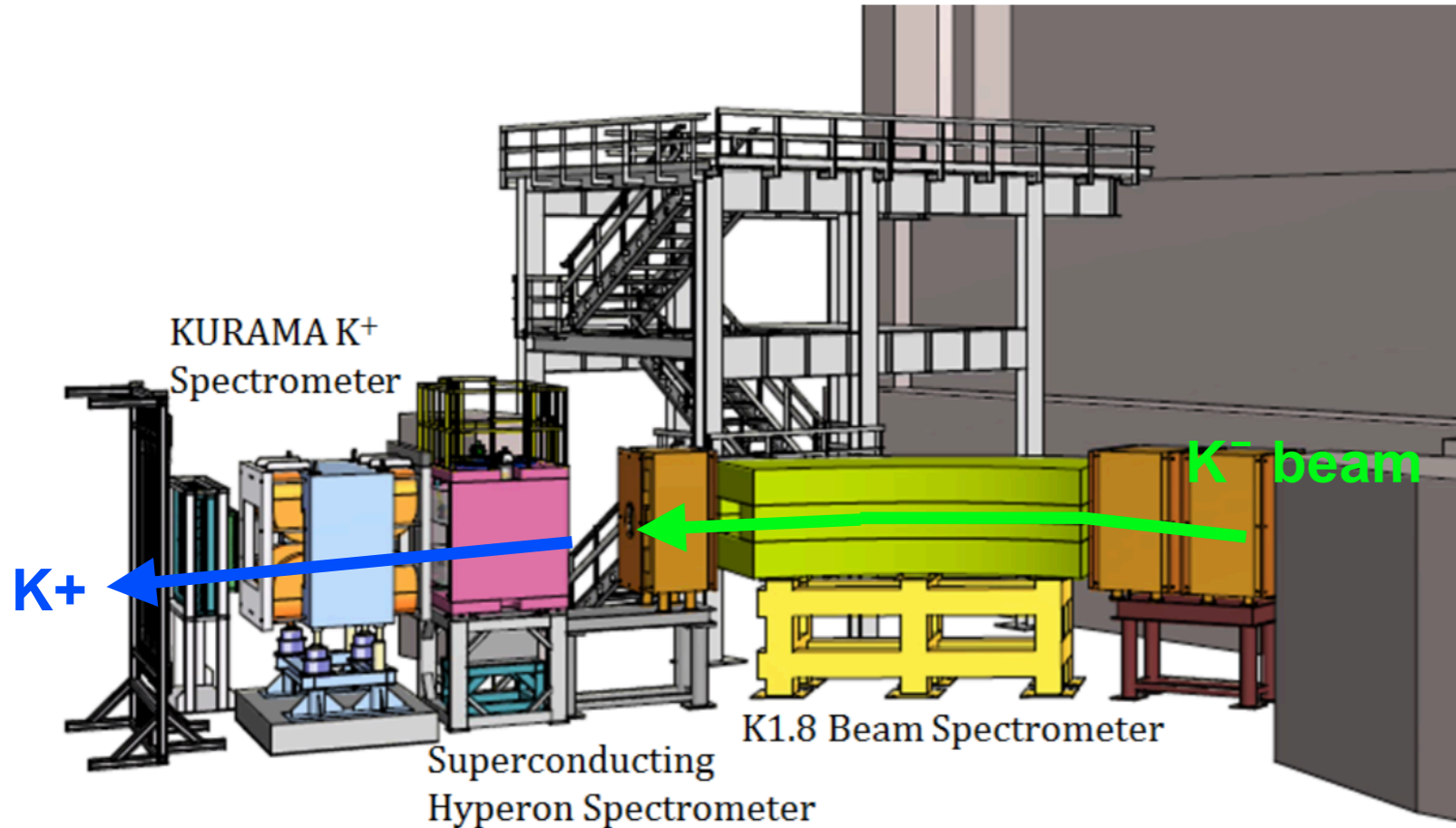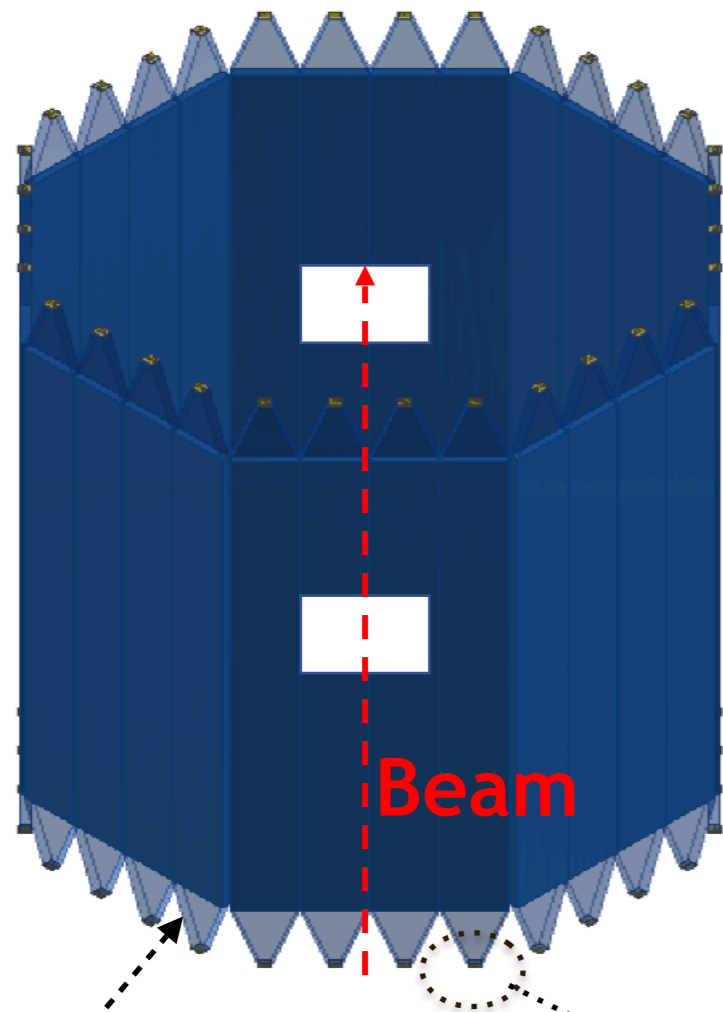

K⁻ beam intensity : 10⁶/spill (in 5.5 s)

TPC HODOSCOPE

Surrounding HypTPC for PID and Trigger

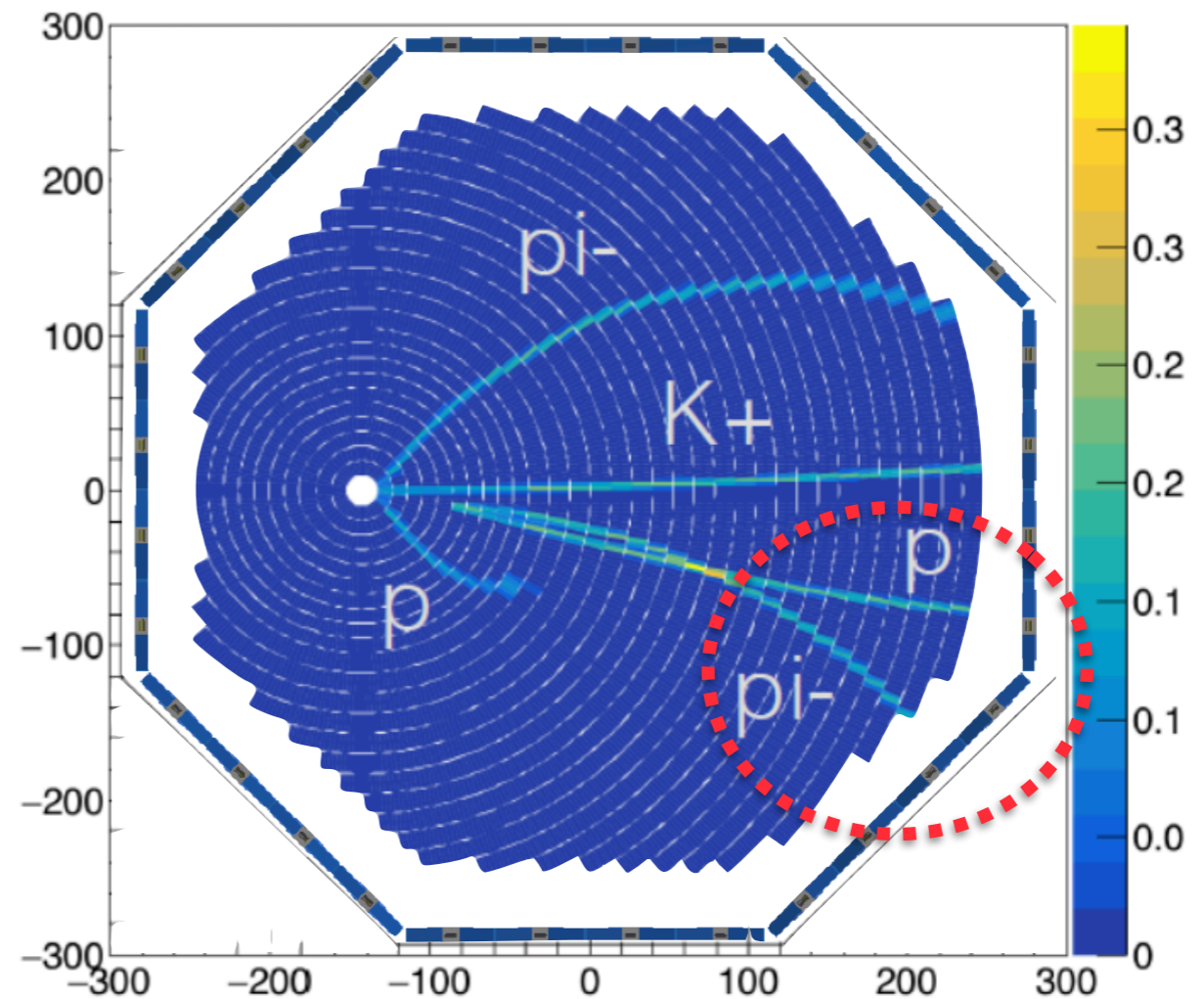**MPPC will be used due to strong magnetic field**
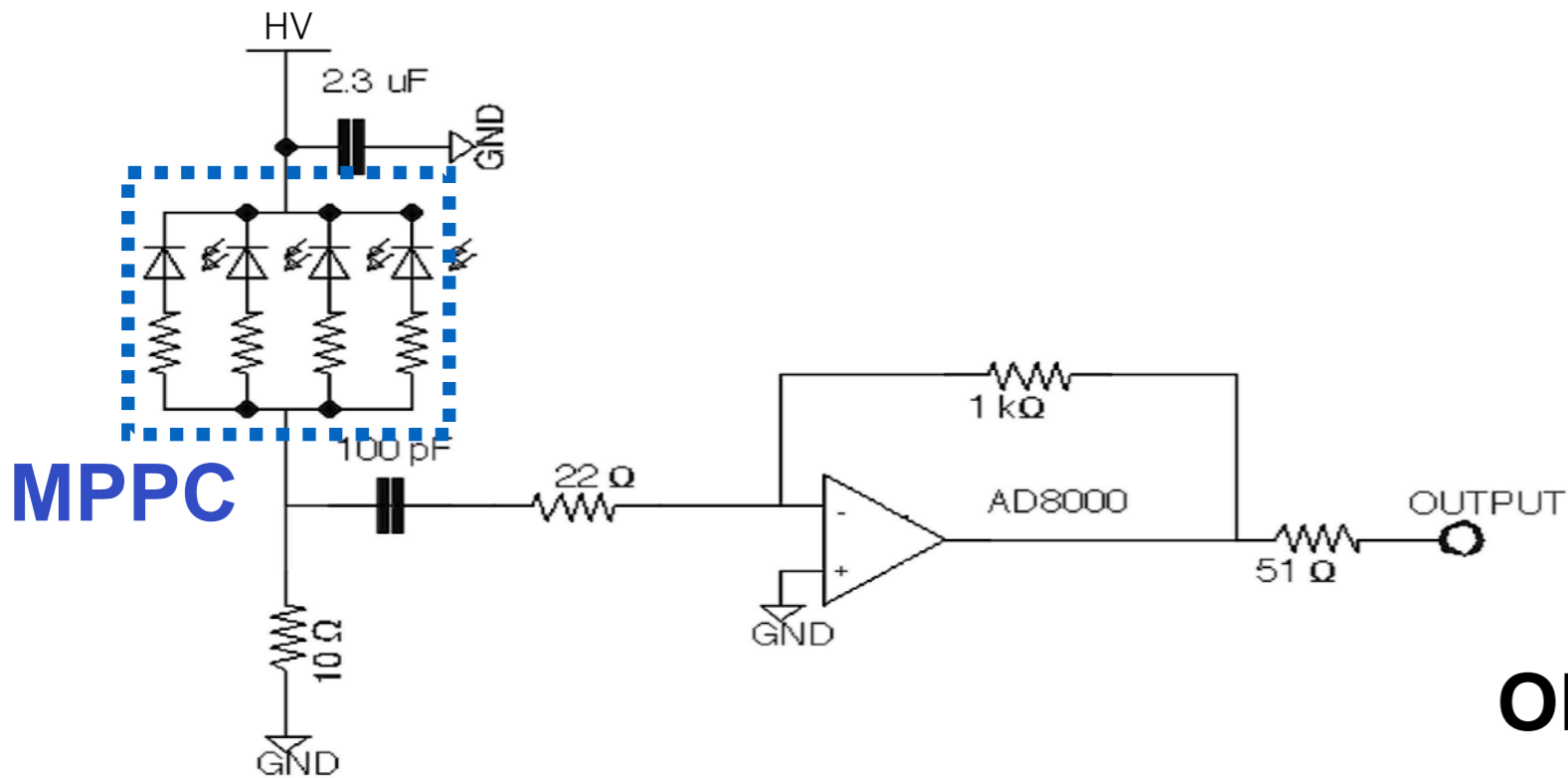

Light guide **MPPC**

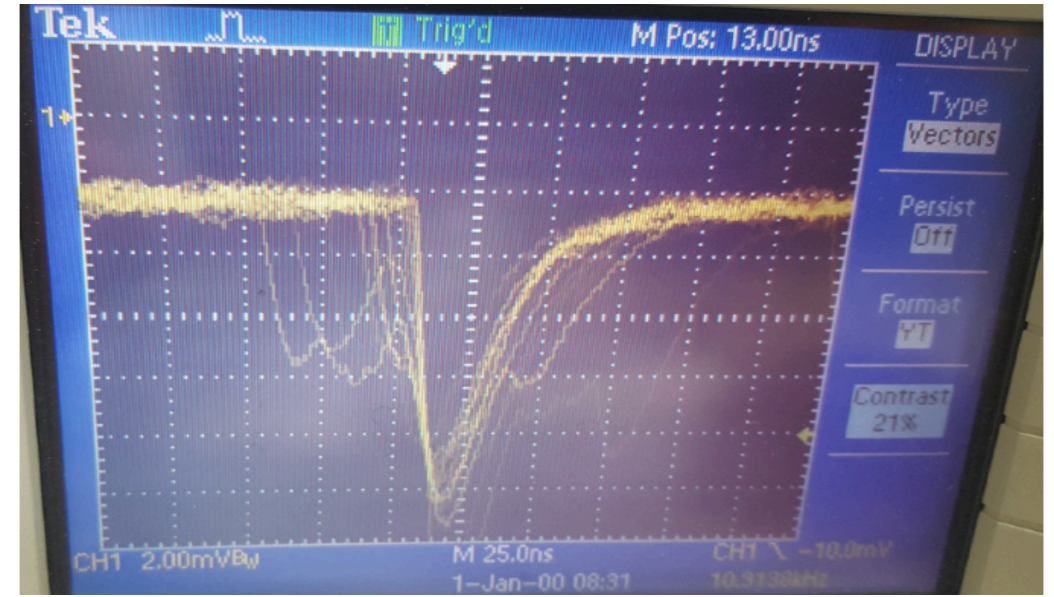**Scintillator : 80^L x 7^W x 1^T cm**

PID: using dE/dx(TPC), TOF vs p/q
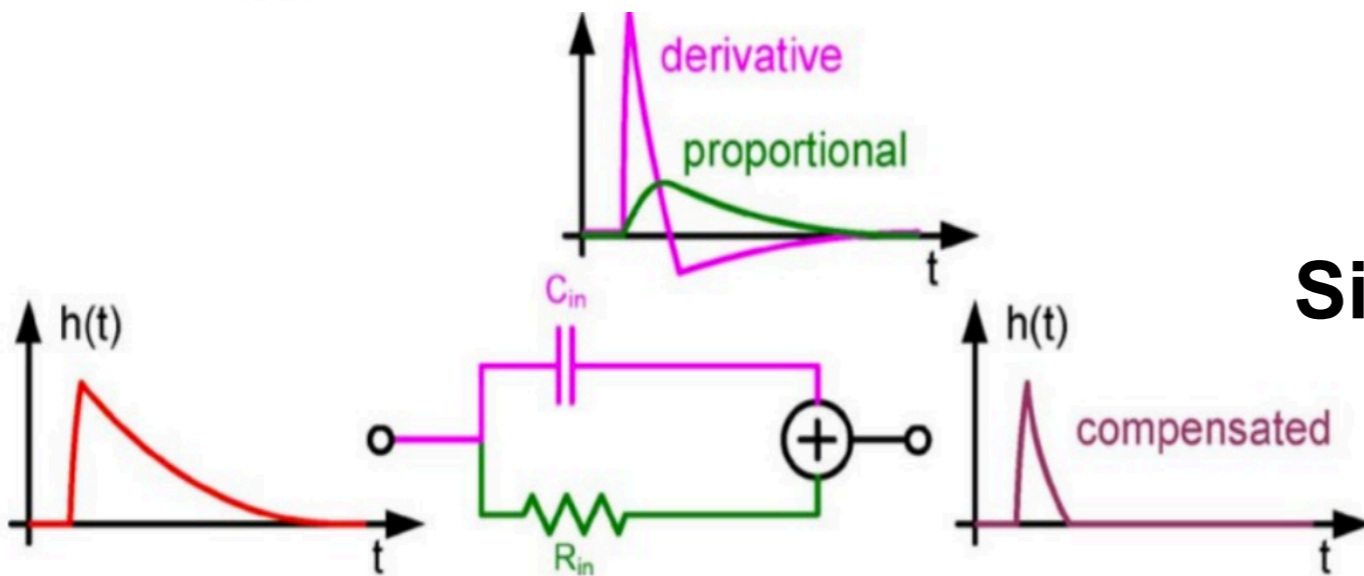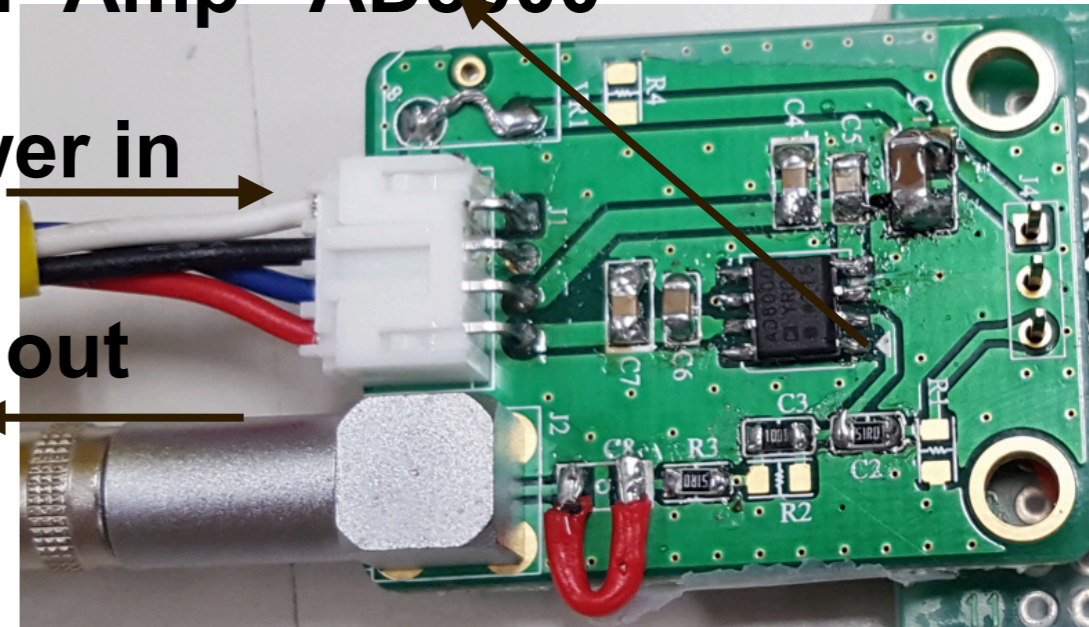
PREAMP

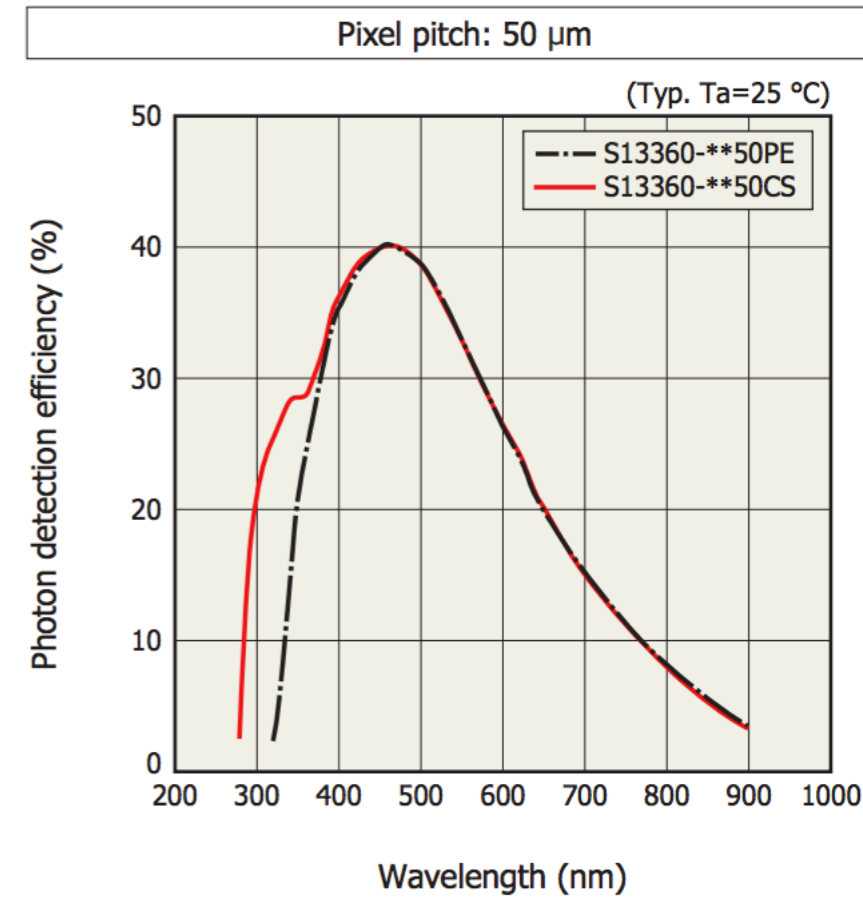## Circuit diagram

MPPC

OP Amp - AD8000

Power in

Signal out

MPPC

HAMAMATSU S13360-3050CS (3×3 mm^2)

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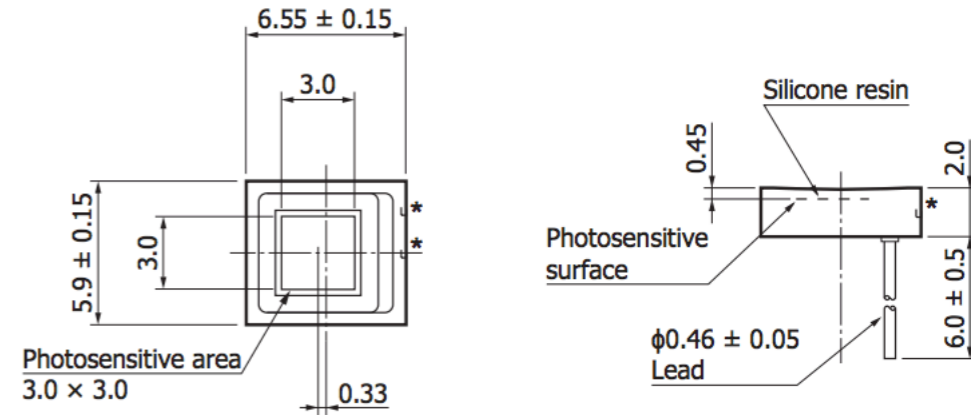
DATA SHEET

Type no.	Measurement conditions	Spectral response range λ (nm)	Peak sensitivity wavelength λp (nm)	Photon detection efficiency PDE*4 $\lambda = \lambda p$ (%)	Dark count*5 Typ. (kcps)	Dark count*5 Max. (kcps)	Terminal capacitance Ct (pF)	Gain M	Breakdown voltage V_{BR} (V)	Crosstalk probability (%)	Recommended operating voltage Vop (V)	Temperature coefficient at recommended operating voltage $\Delta T Vop$ (mV/°C)
S13360-3050CS	Vover =3 V	270 to 900	450	40	500	1500	320	1.7×10^6	53 ± 5	3	V_{BR} + 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	

SUMMING AMP(MIXER)

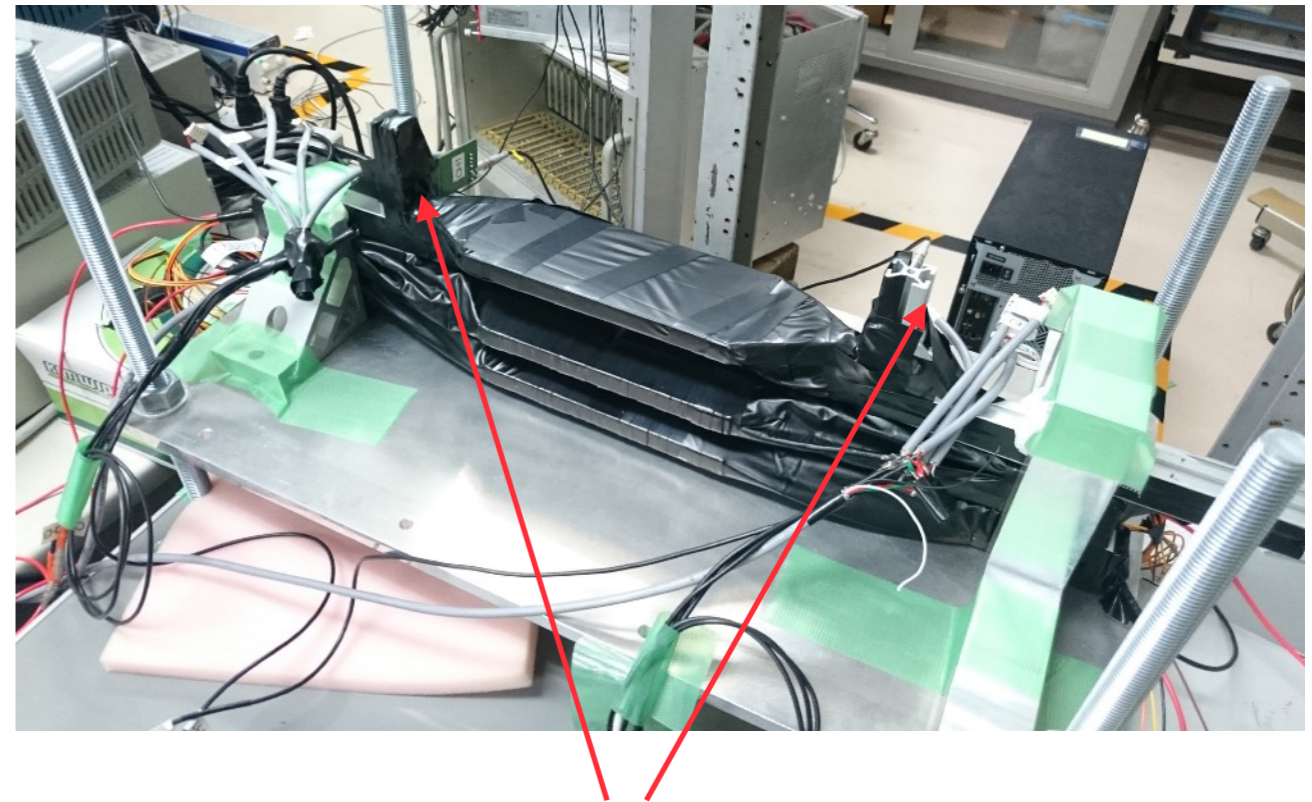**It is used to sum multi-MPPC signal(under development)**
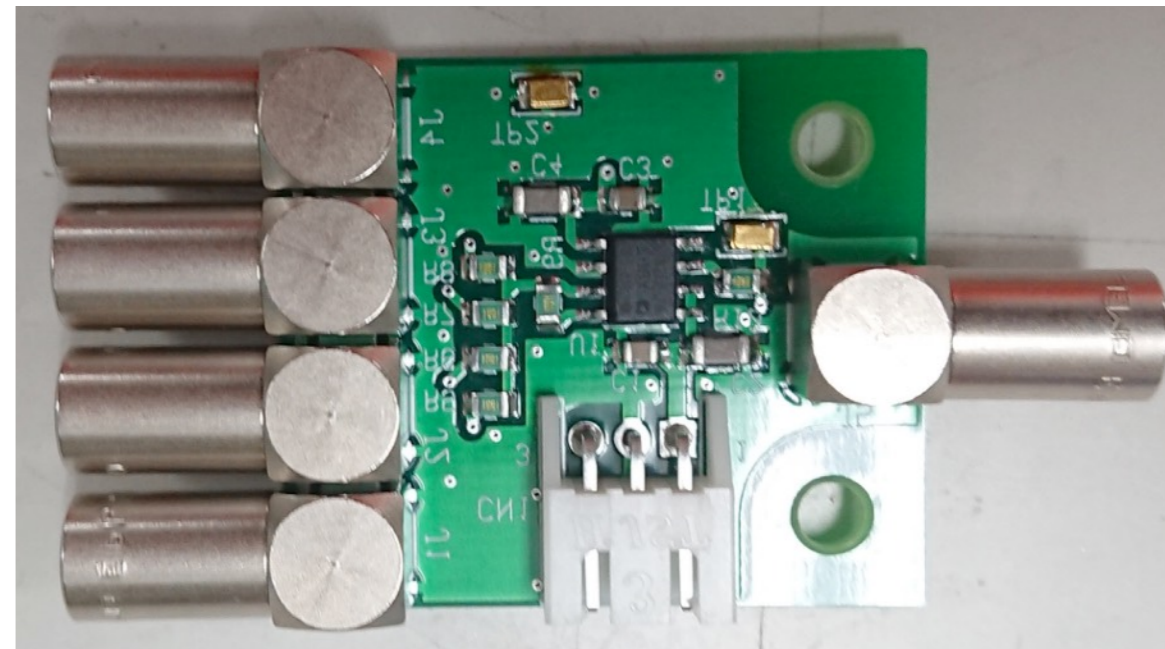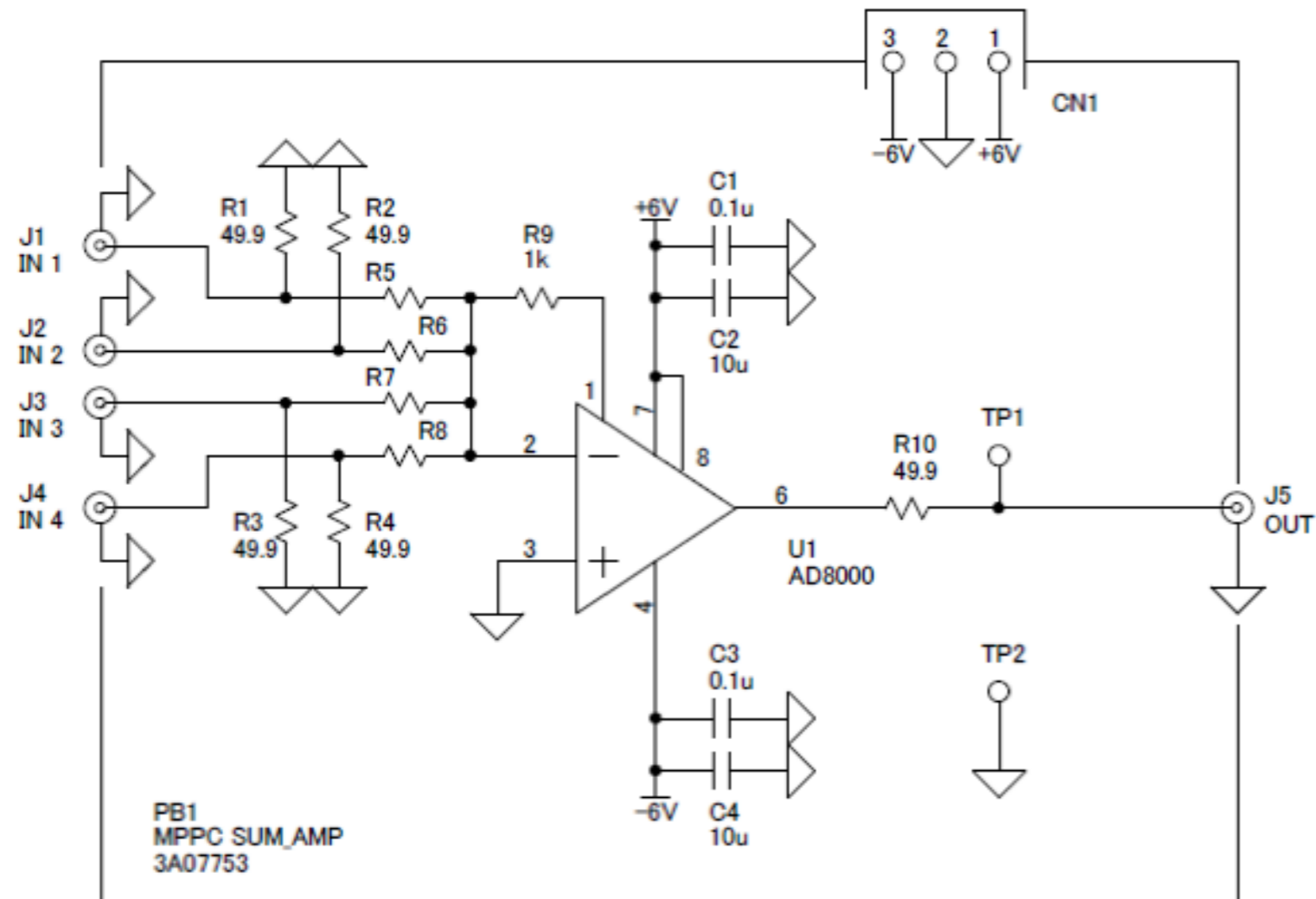
PROTOTYPING

Hodoscope prototype

- **Both-ends readout by MPPCs**
- **Scintillator : 15^L x 7^W x 1^T cm**
- **MPPC : 3050CS (3 mm x 3 mm)**
- **There are four MPPCs on each side**
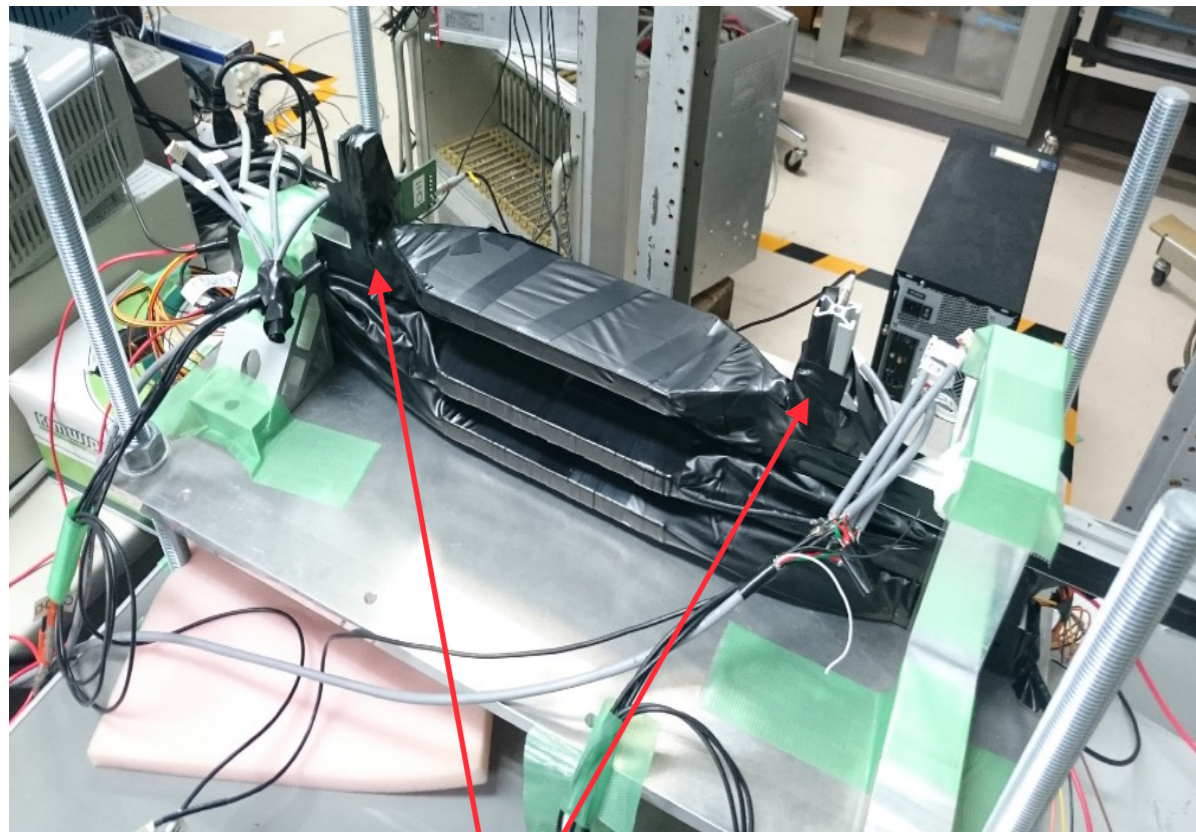

MPPC & Preamp

Comic ray bench test of prototype

-At JAEA, optimization for higher resolution is on-going.
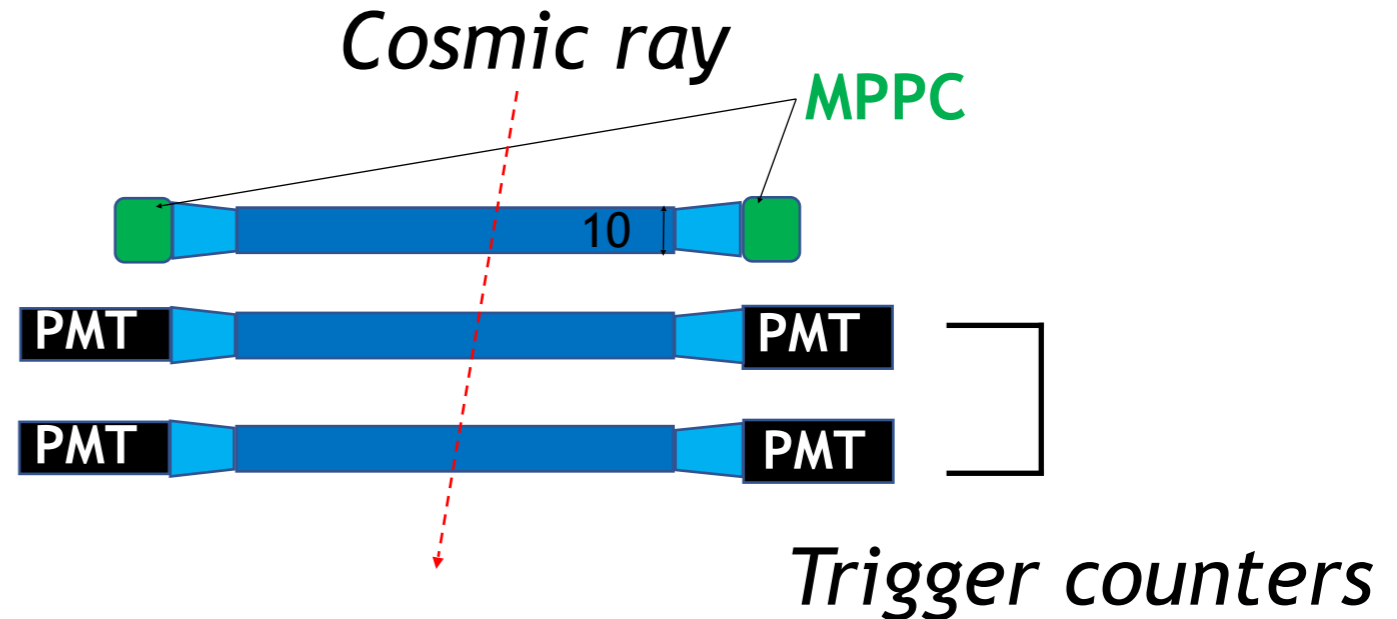
Best time resolution result is <u>174 +/- 2 ps</u>

COSMIC-RAY TEST

Set up

MPPC & Preamp

PMT - H6612 (rising time 1.3 ns)

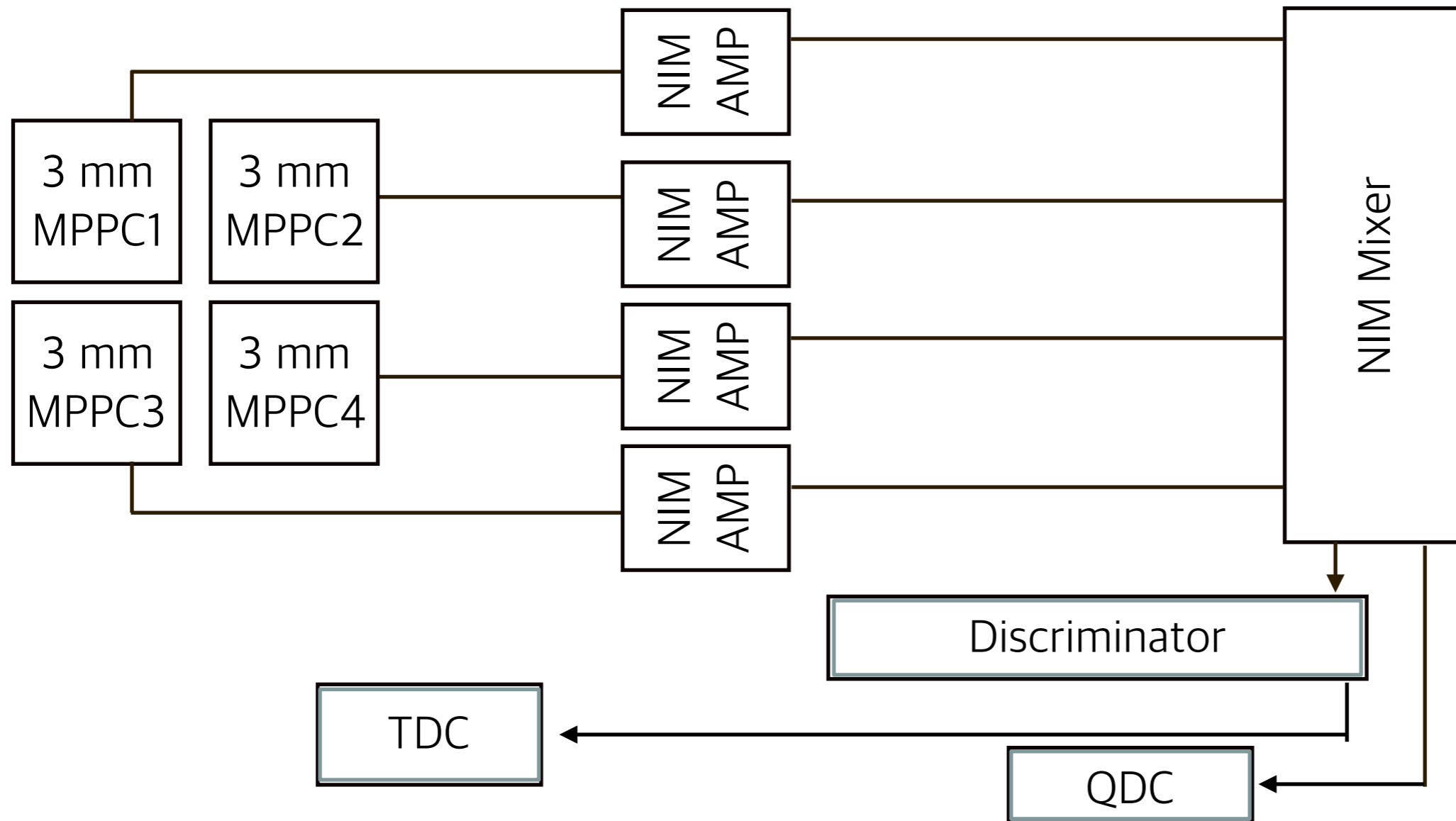**Trigger condition - All coincidence (PMTs & MPPCs)**
Trigger rate ~ 0.85 Hz

COSMIC-RAY TEST

NIM electronics   **(gain : x4)**

Caen V775n : LSB=35 ps   Caen V792n : 12bit, FSR=400 pC

TIME RESOLUTION

Three Tof distributions : Hodo (MPPC) ~ Trigger1 (PMT)
                          Trigger1 (PMT) ~ Trigger2 (PMT2)
                          Trigger2 (PMT2) ~ Hodo (MPPC)

Time resolution calculation

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

err_{ij} : fitting error of σ_{ij}

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

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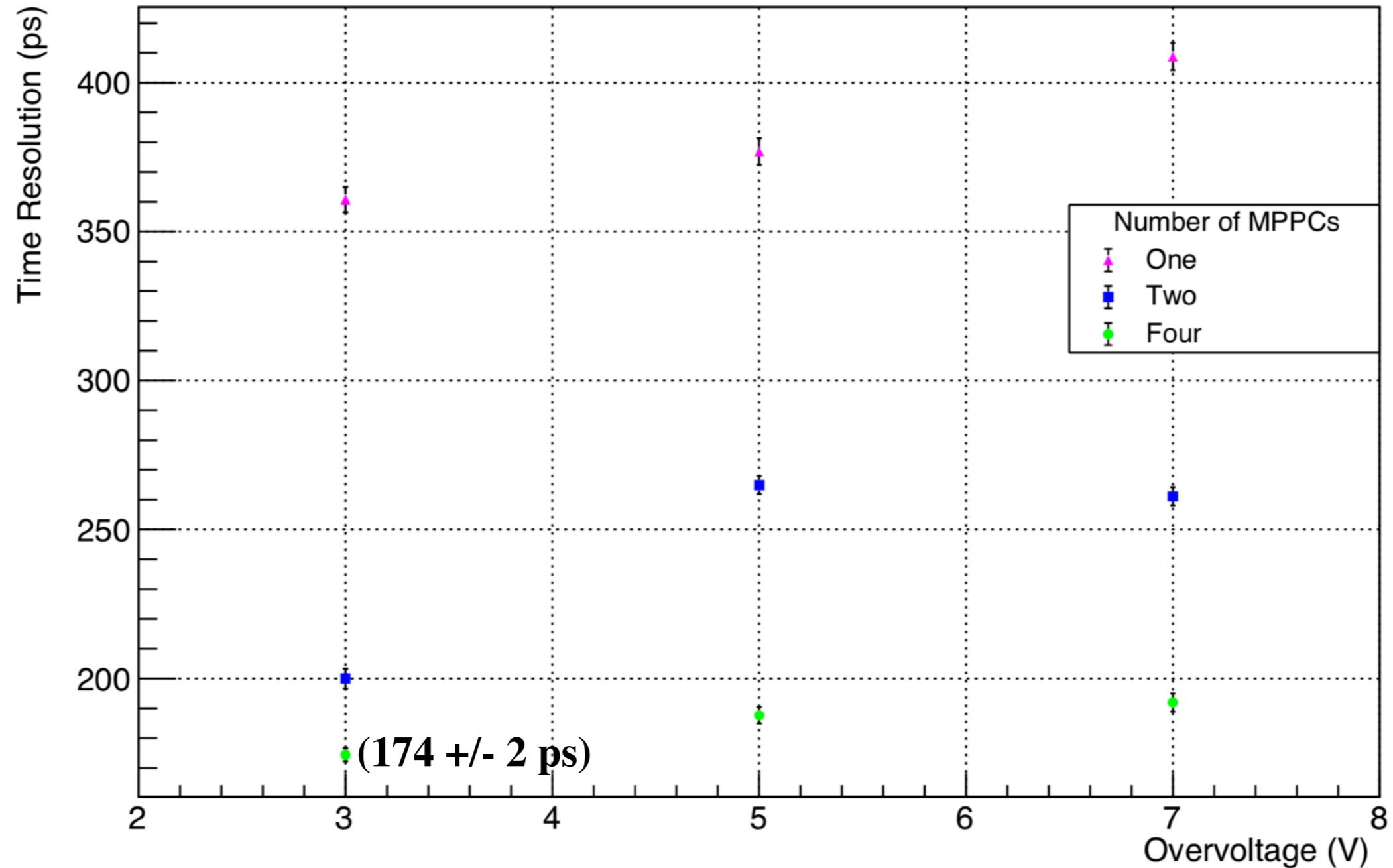
TEST LIST

Tests for optimization

1. The number of MPPCs from 1 to 4

2. Readout methods
   A. Mixed online by NIM mixer module

   B. Mixed offline in analysis

   C. Biasing MPPCs in series connection

3. The size of MPPC

4. The light-guide

5. The fixes size of MPPC (on-going)

NUMBER OF MPPCS

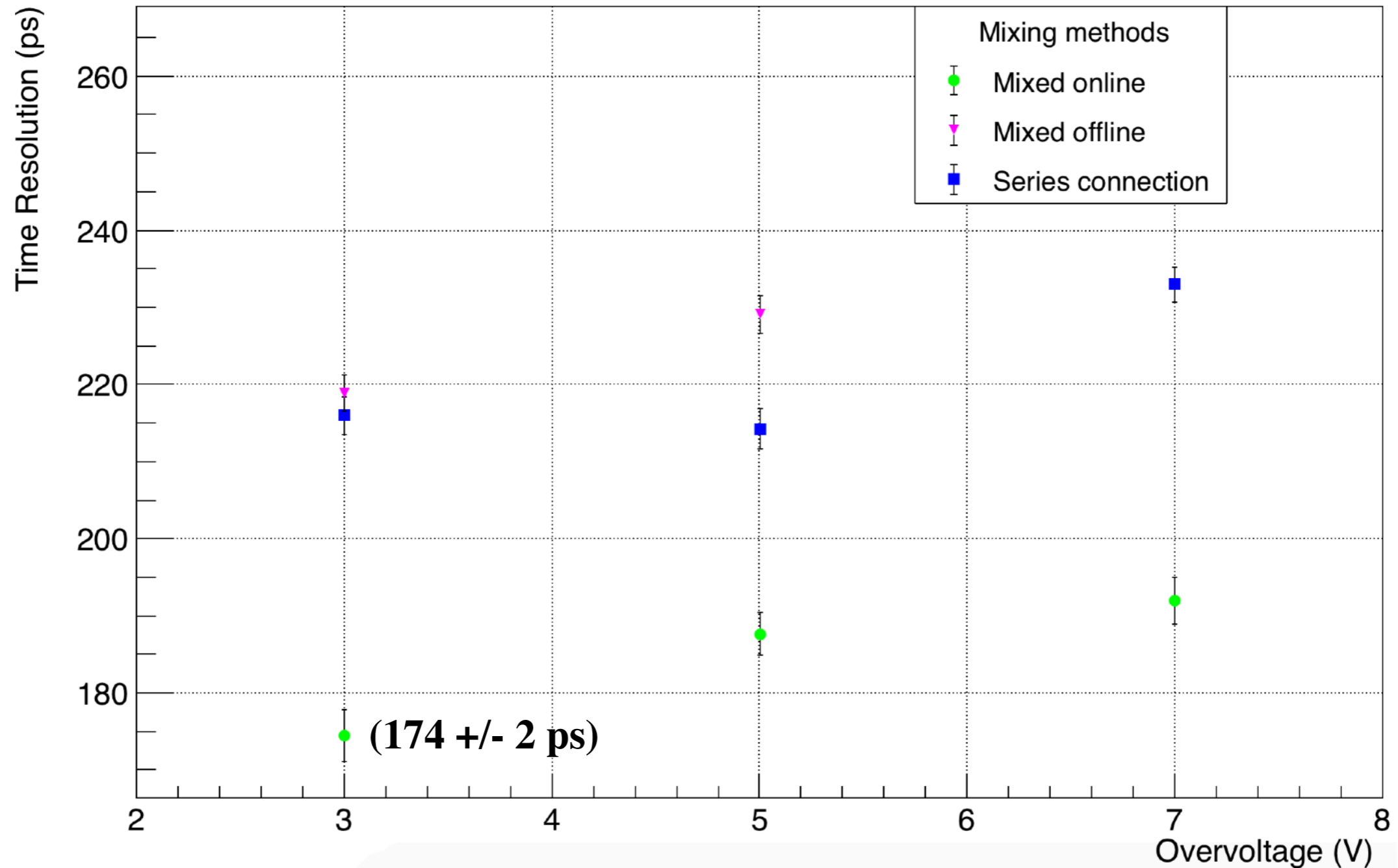**Reference PMT : 114 +/- 3 ps**

Number of MPPCs

(174 +/- 2 ps)

COMPARISON THE CONNECTION METHOD

Reference PMT : 114 +/- 3 ps

Methods for Mixing MPPC's signal

SIZE OF MPPC : 3050×4 VS 6050

Covered area is same
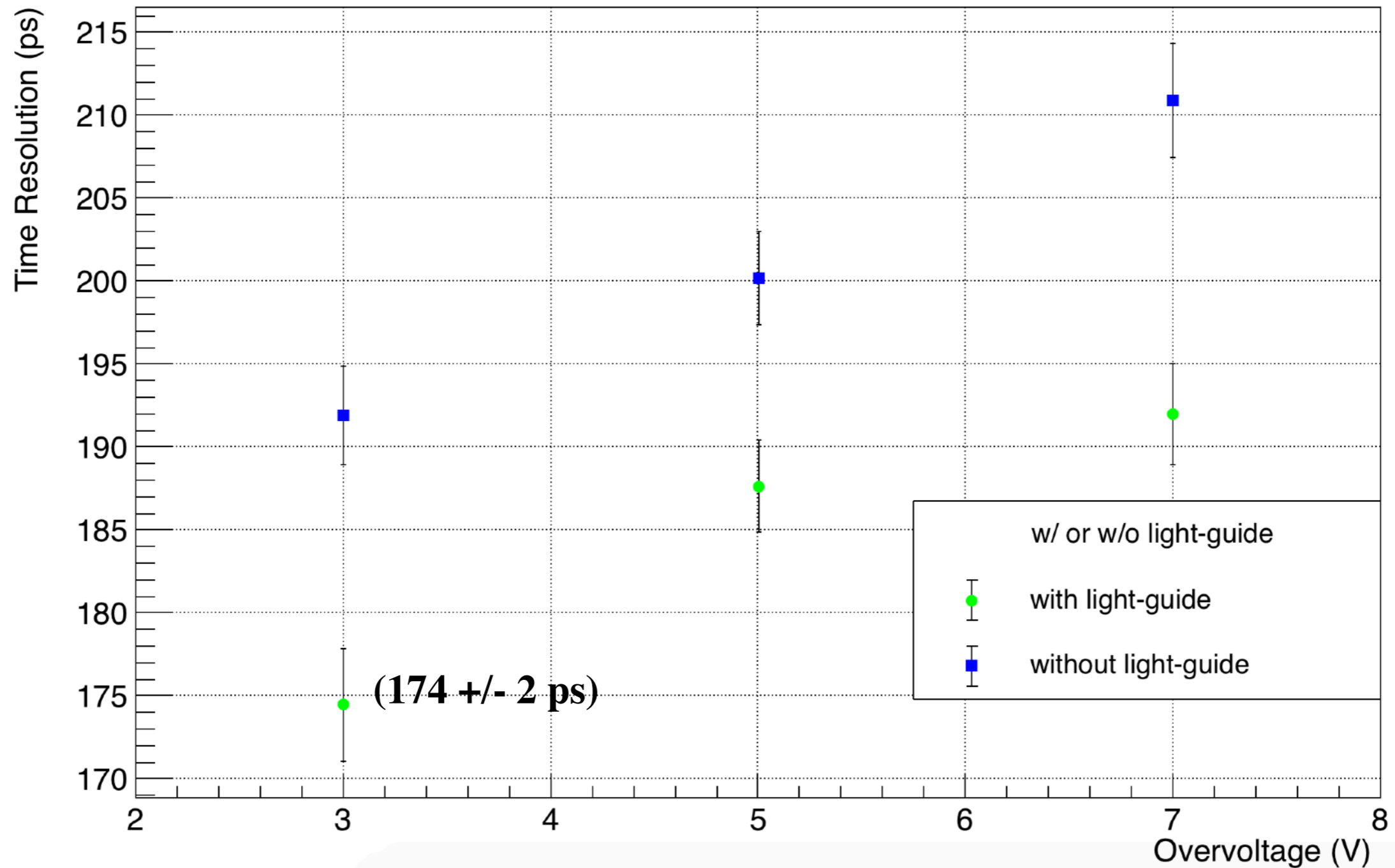
Reference PMT : 114 +/- 3 ps

MPPCs of different sizes

(174 +/- 2 ps)
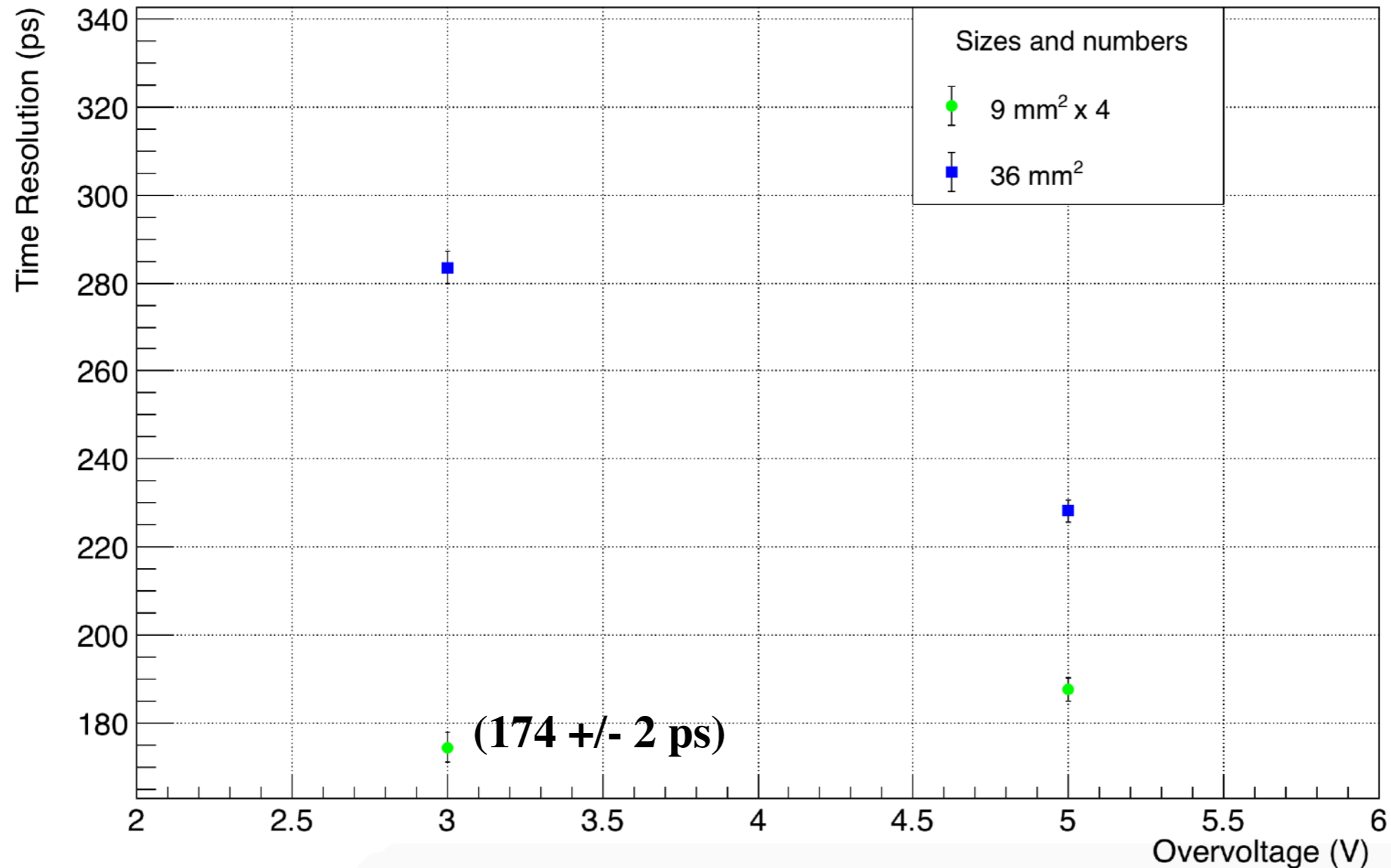
LIGHT-GUIDE

Reference PMT : 114 +/- 3 ps

With or without Light-guide

(174 +/- 2 ps)

SUMMARY

- **We are preparing Hyperon spectrometer for E42**

- **For Hodoscope, MPPC will be used due to strong magnetic field.**

- **Cosmic-ray test with small counter is ongoing.**

- **For readout of multi-MPPCs, online mixing is better than off-line sum and series one.**

- **MPPC 3050 seems to be suitable.**

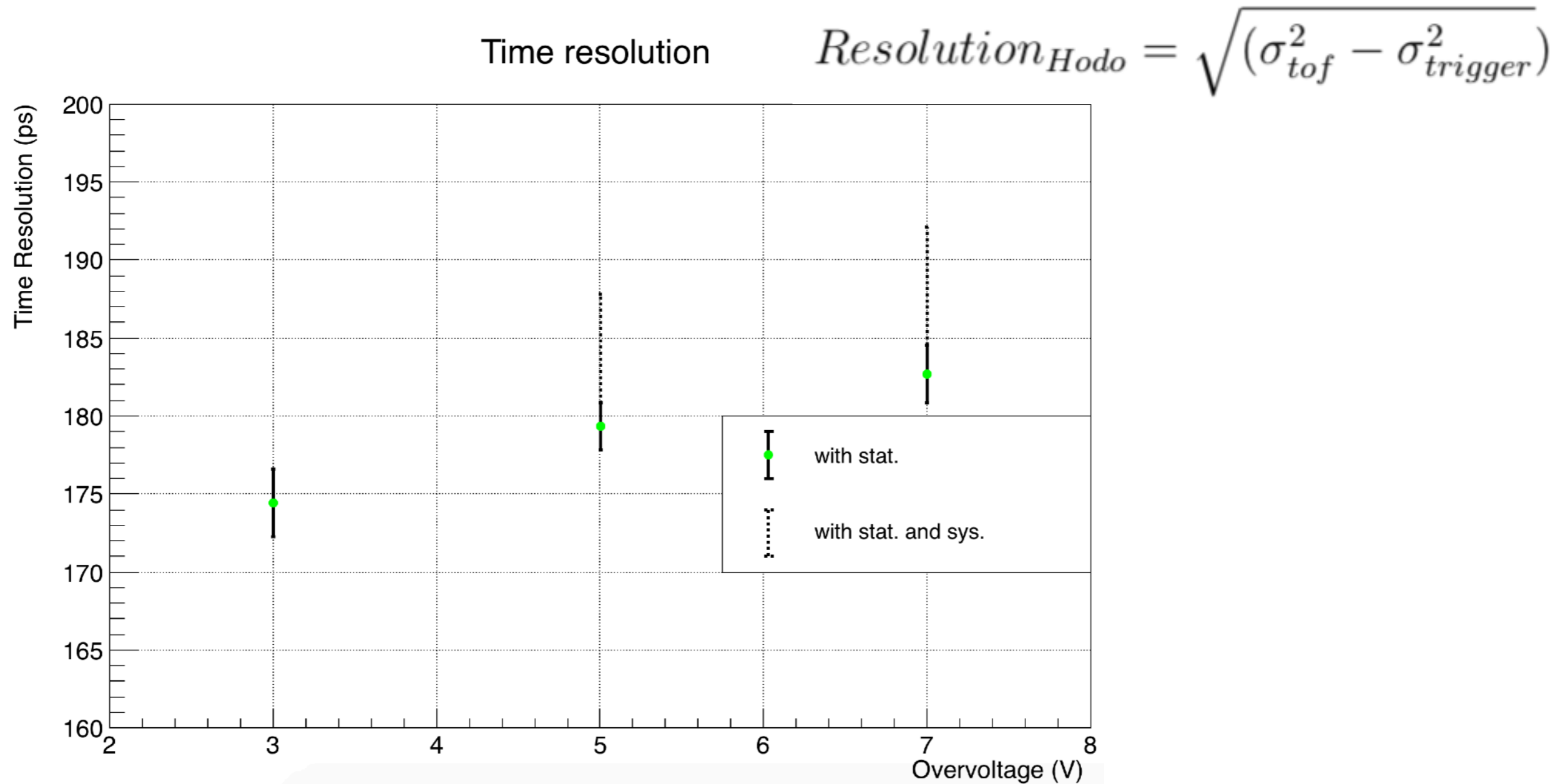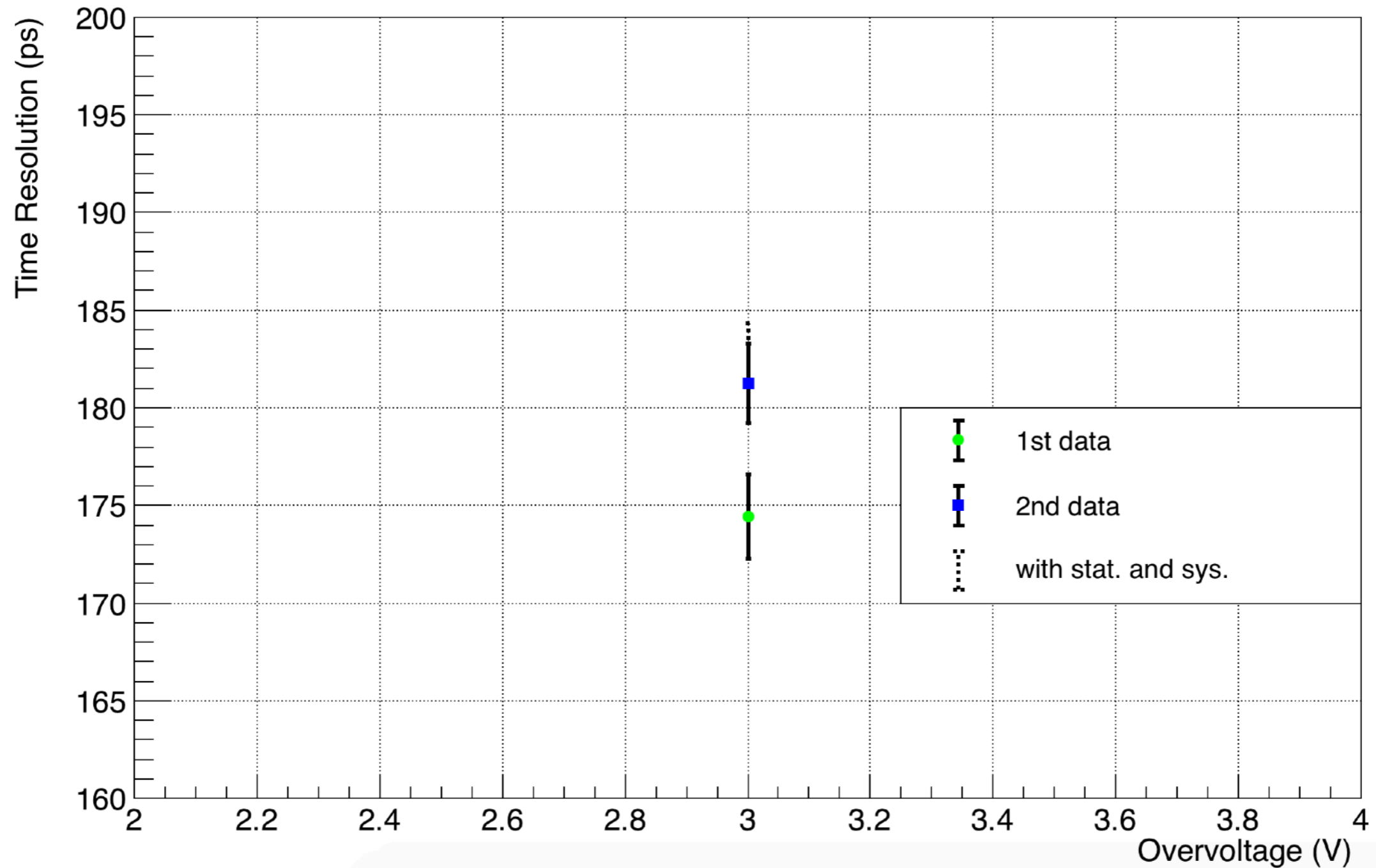- **We achieved ~180 ps resolution with prototype.**

BACKUP

SYSTEMATIC UNCERTAINTY

**How to estimate: Changing the estimation method
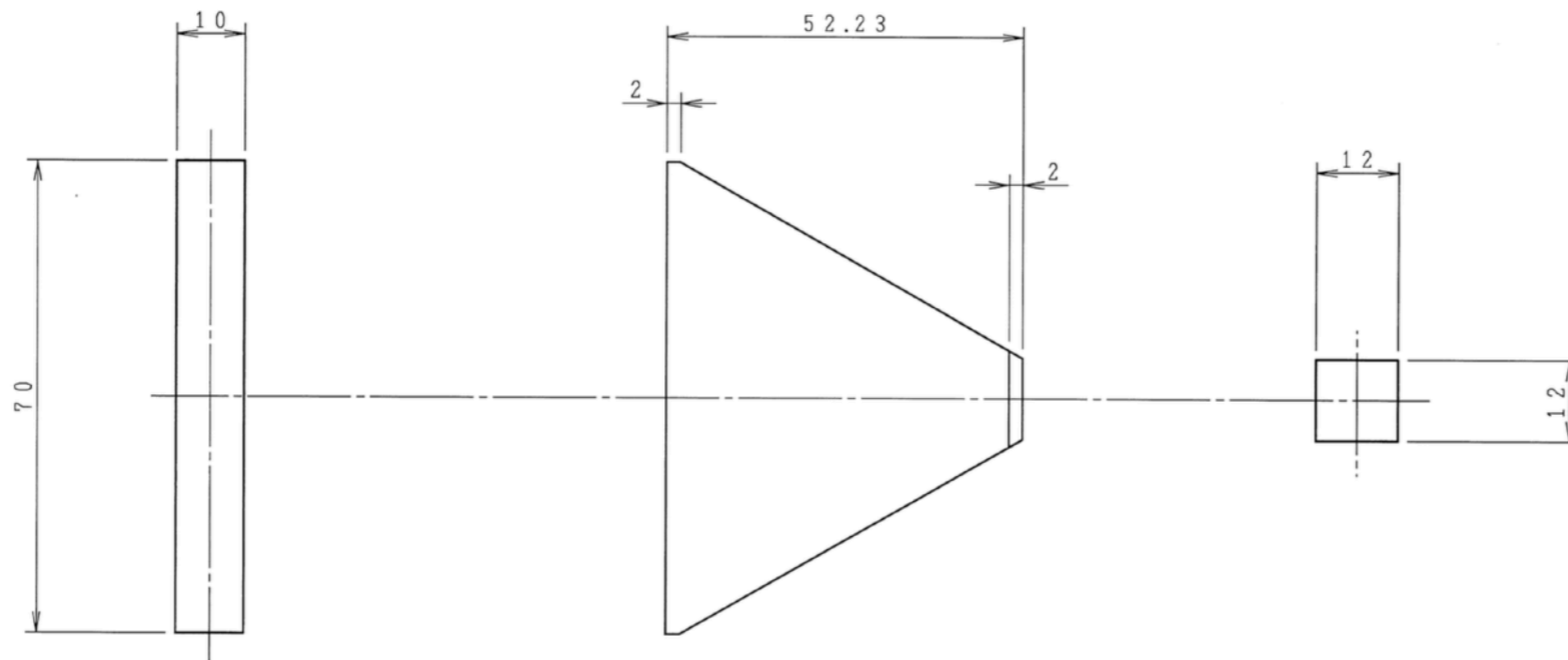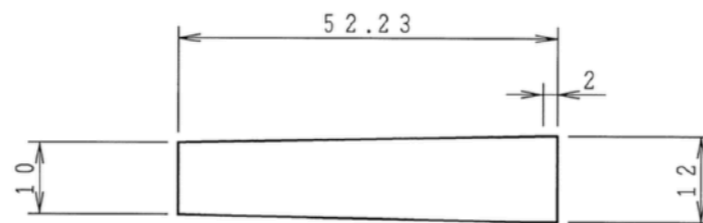fixed or not fixed reference PMT resolution.**

Time resolution

$$Resolution_{Hodo} = \sqrt{(\sigma_{tof}^2 - \sigma_{trigger}^2)}$$

REPRODUCING THE REFERENCE

Time resolution
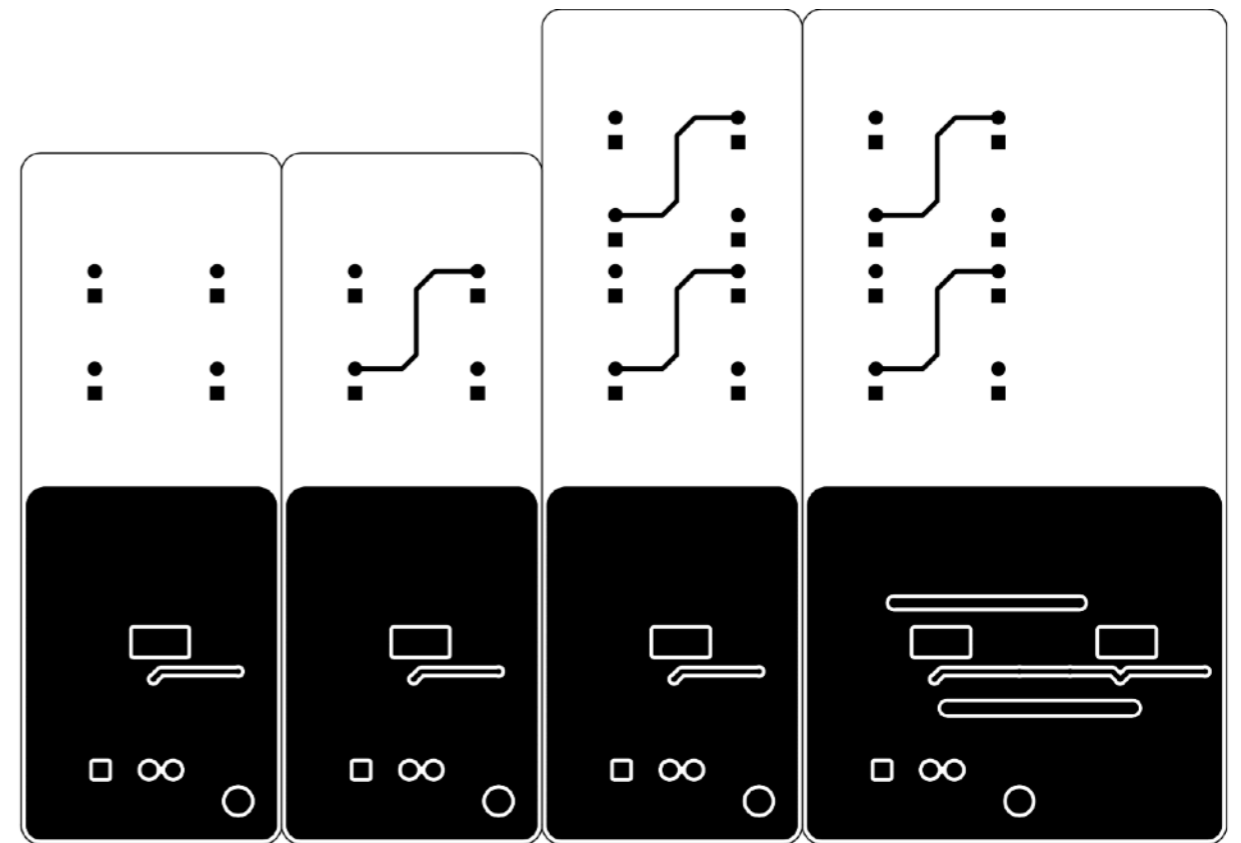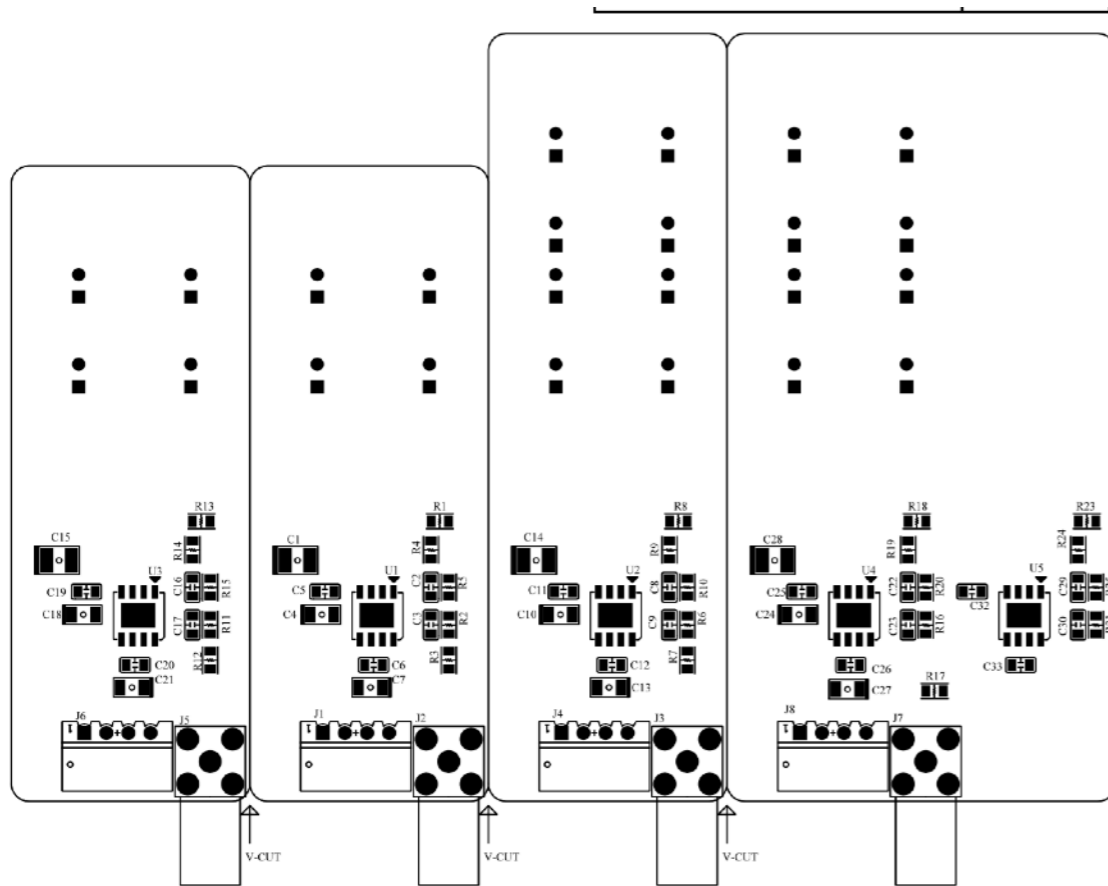
MPPC side is wider

Scintillator side ⟶   ⟵ **MPPC side**
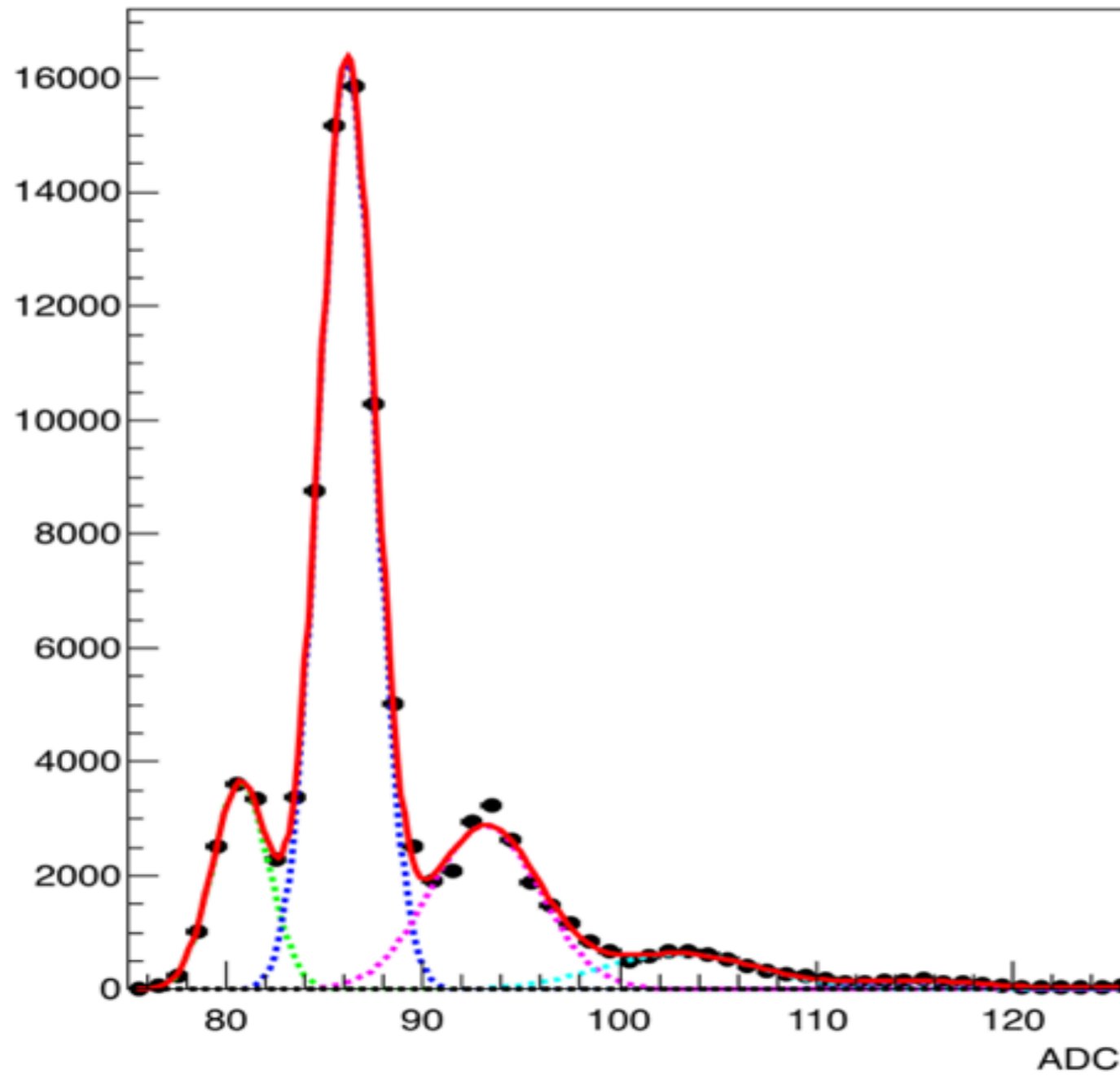
TEST BOARD

NPE

A RooPlot of "1ch/1pe_U_over3V.root"

NPE:TIME RESOLUTION

NPE : Time Resolution

Time resolution : sqrt[const.^2 + statistical.^2]

Time resolution^2 -> fit function : [0] + [1]/n

[1] : The square of the standard deviation
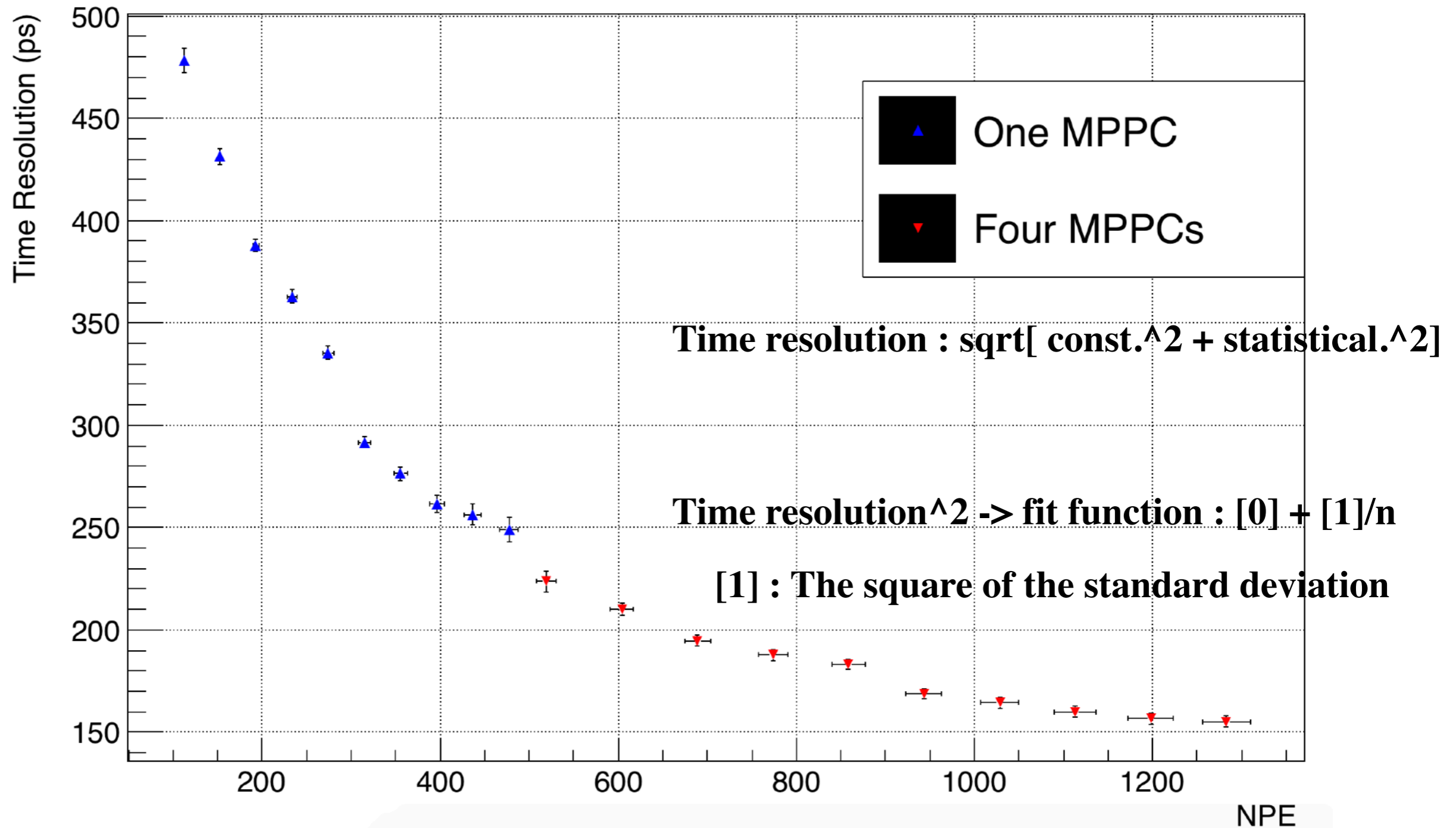
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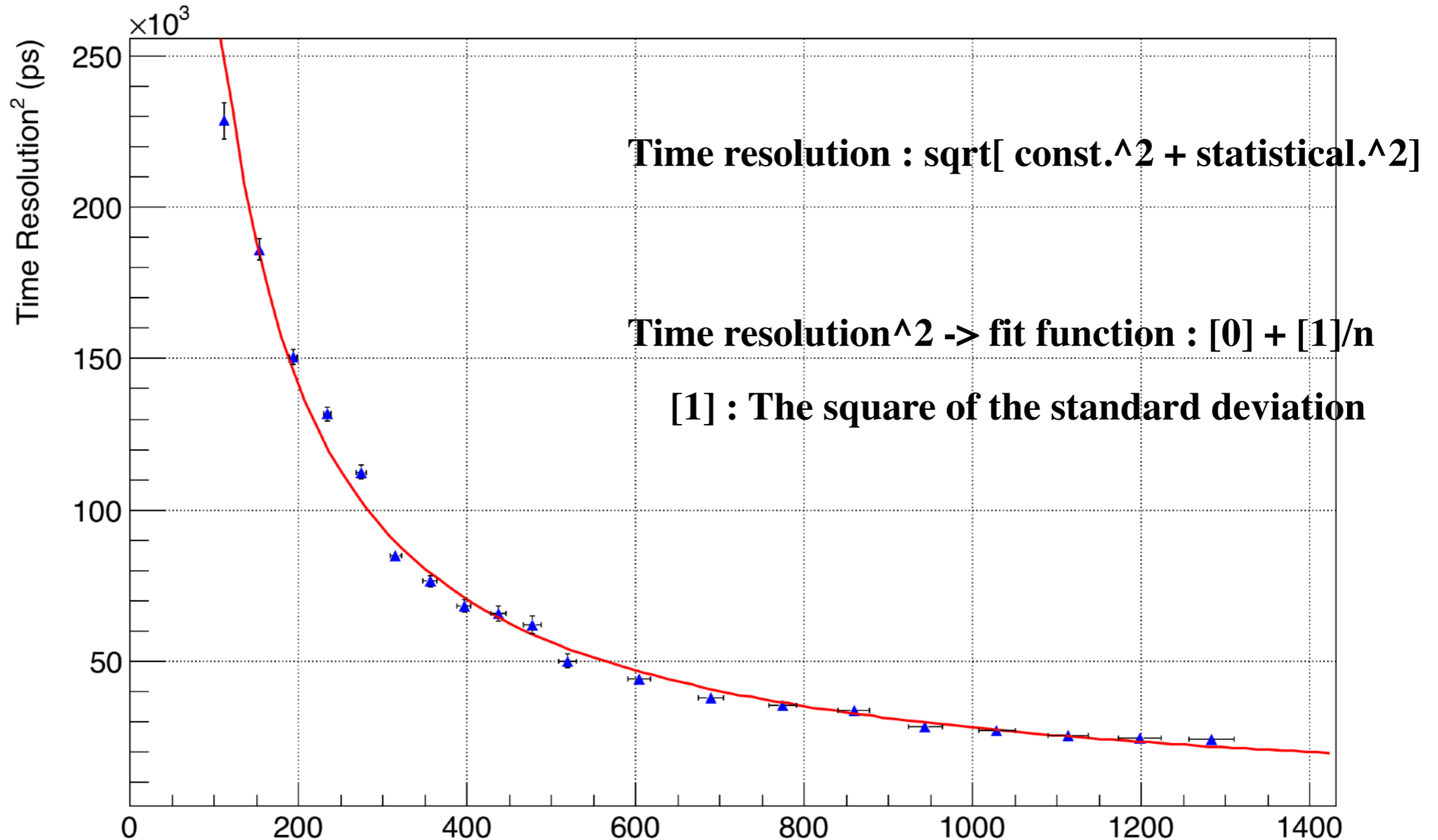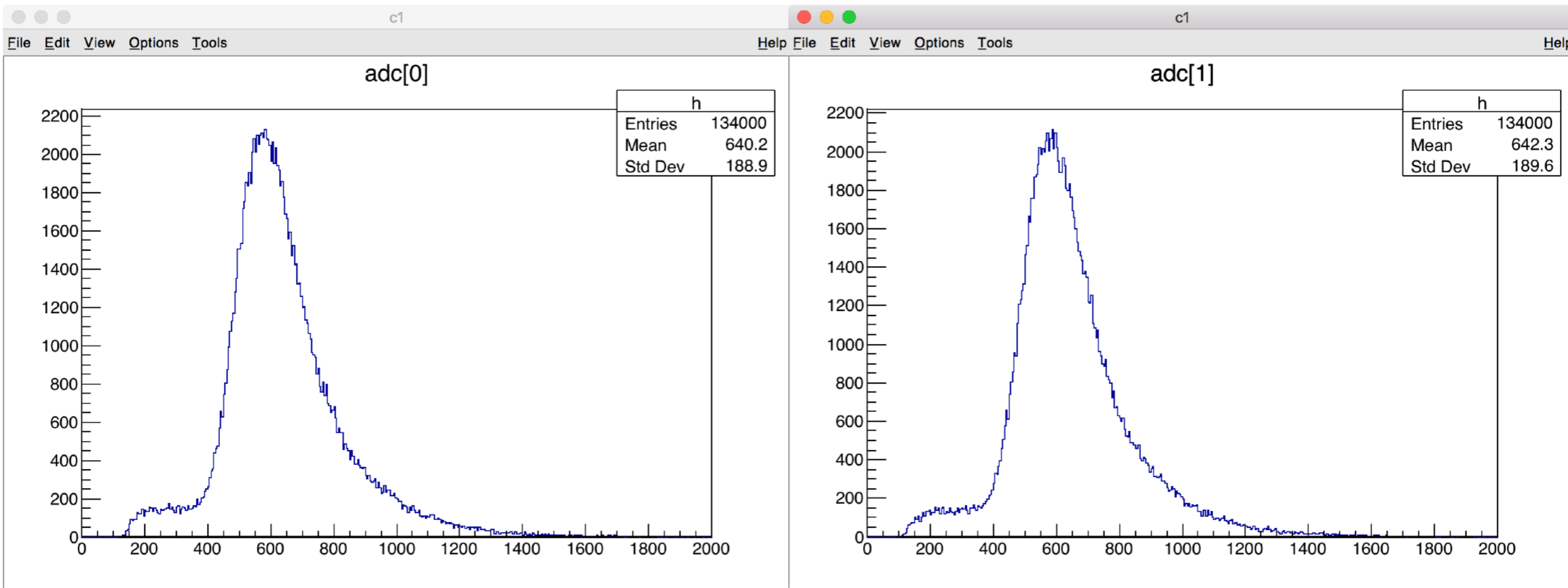
When npe is doubled, the time resolution is expected to be ~ 120 ps.
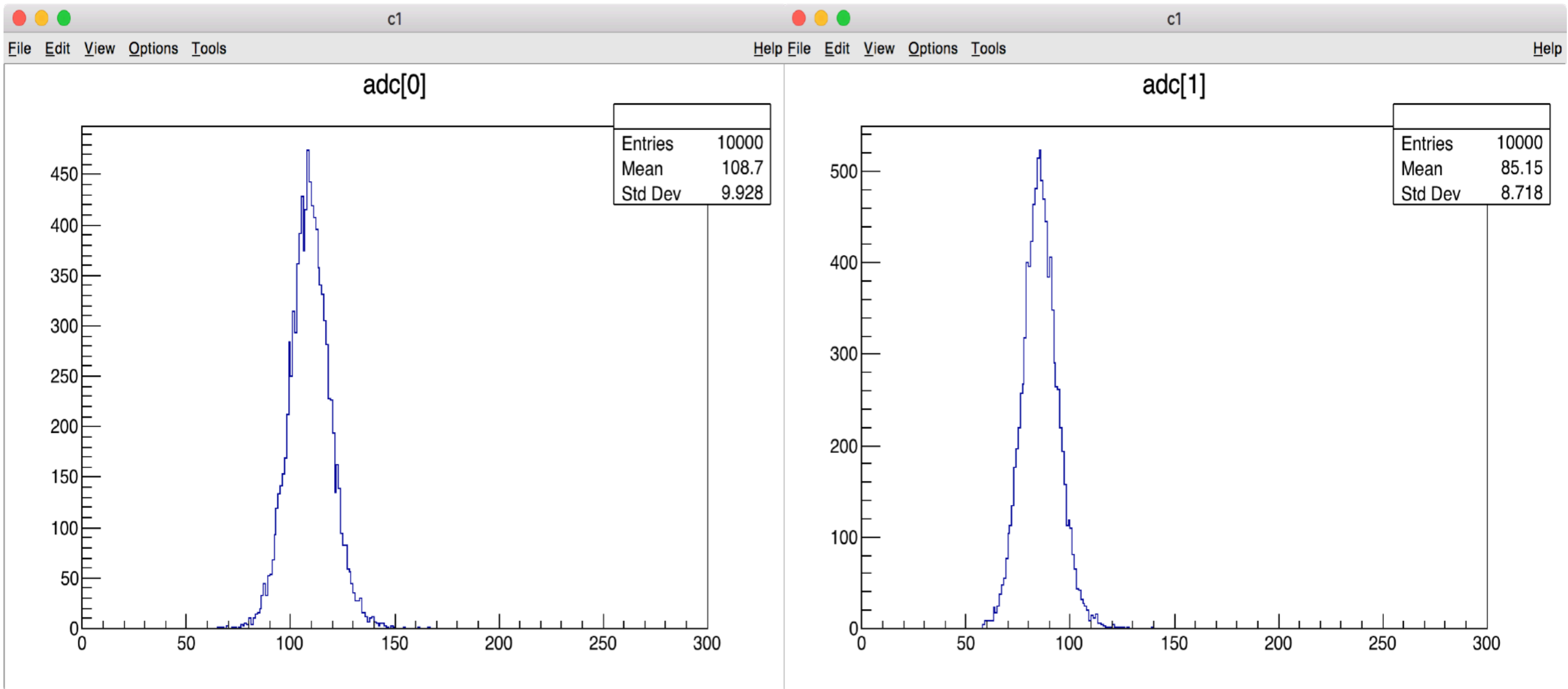
CONDITION #1-RAW ADC

Condition #1 - With Light guide

(reference)

CONDITION #1-PEDESTAL

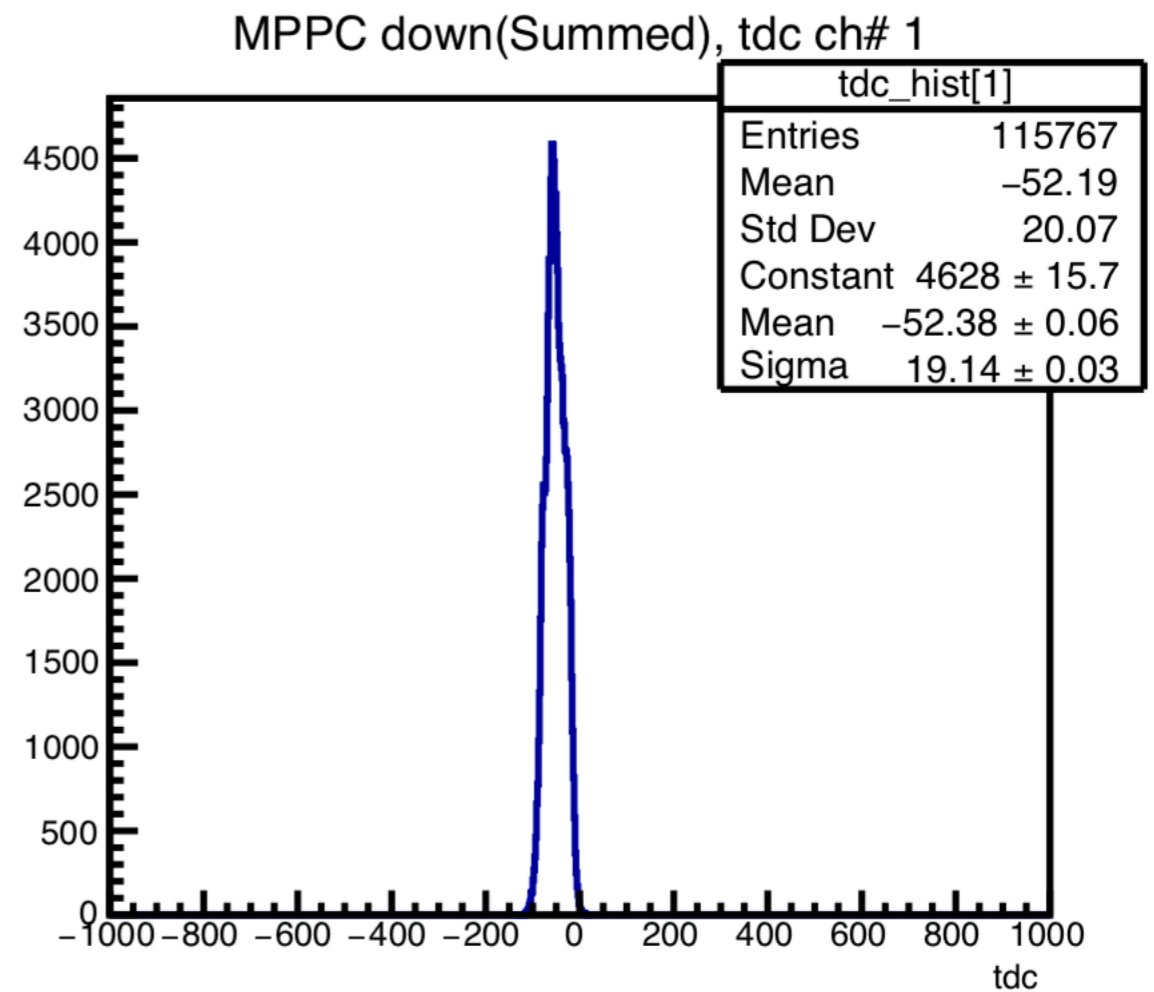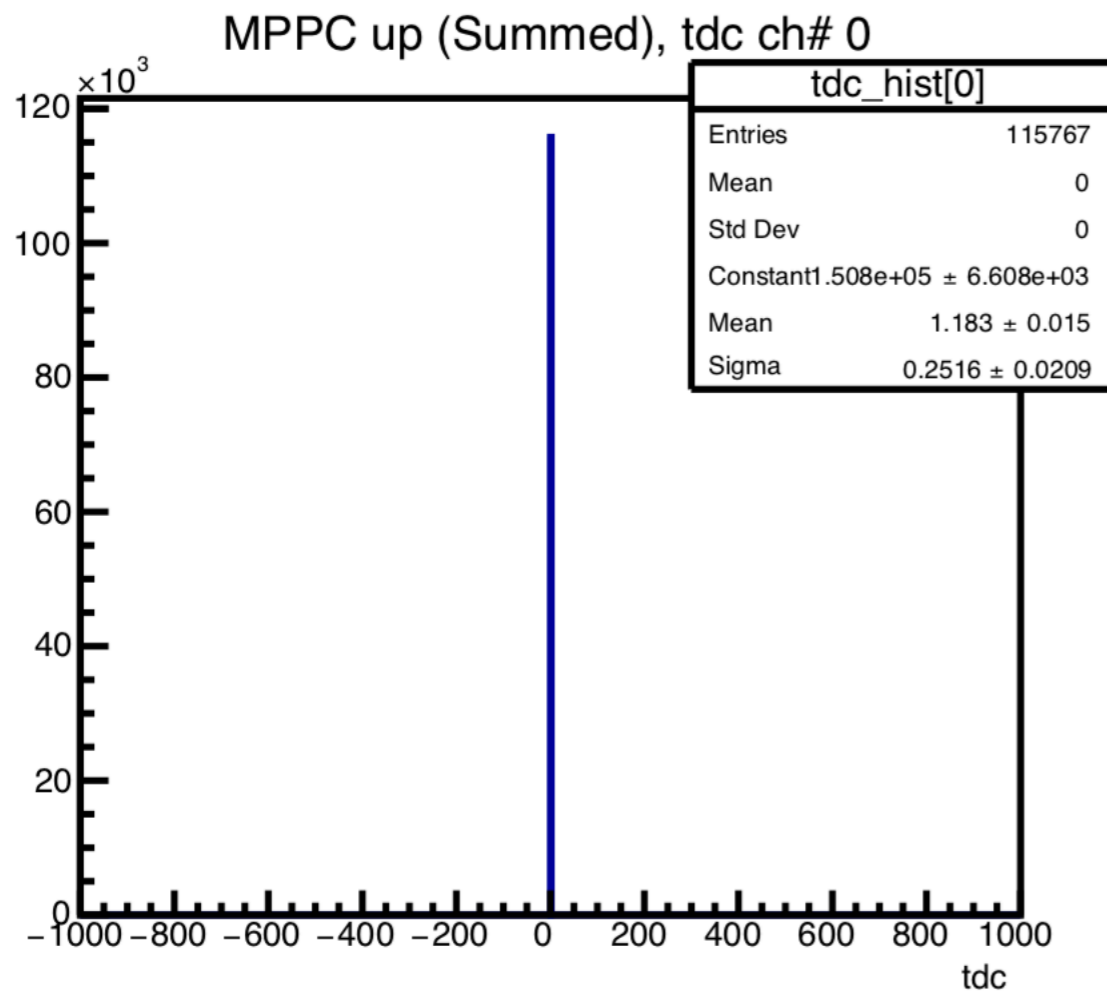**Condition #1 - With Light guide**

(reference)

CONDITION #1-RAW TDC

Condition #1 - With Light guide
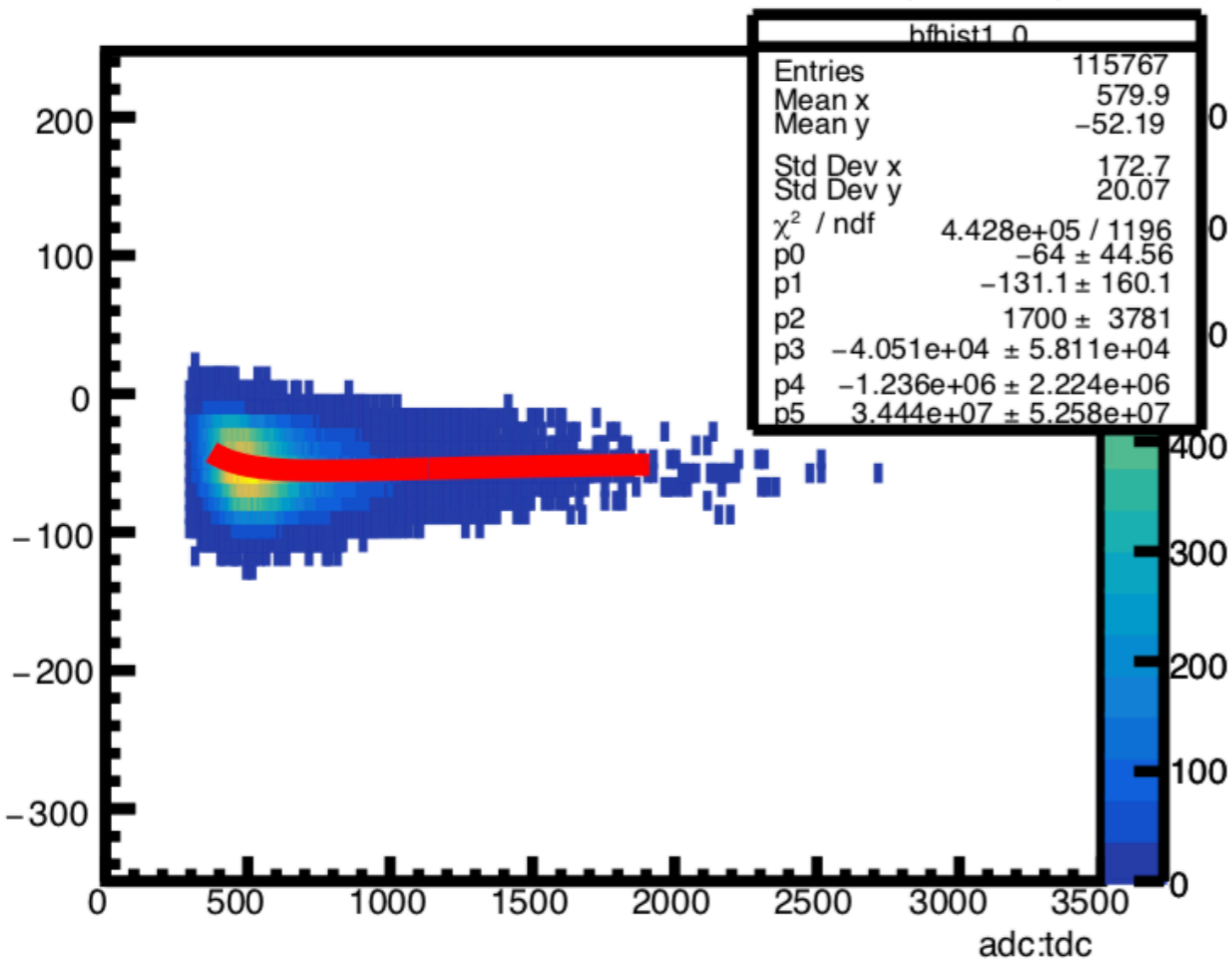
(reference)

T0 is subtracted for all TDC channels

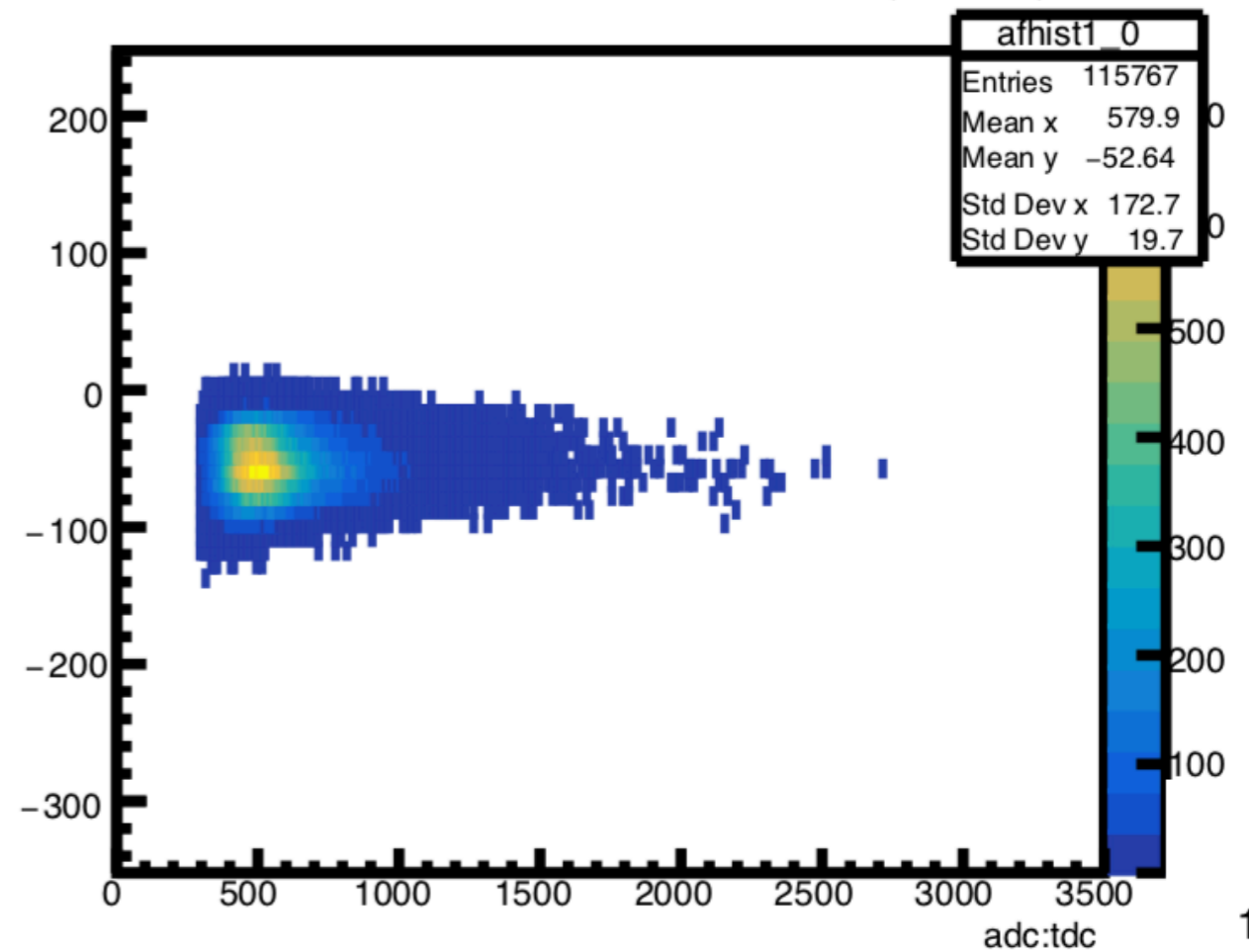# CONDITION #1-SLEWING CORRECTION

Condition #1 - With light guide

(reference)

First slewing correction

CONDITION #1-SLEWING CORRECTION

Condition #1 - With light guide

(reference)

Slewing correction with reference counter's adc
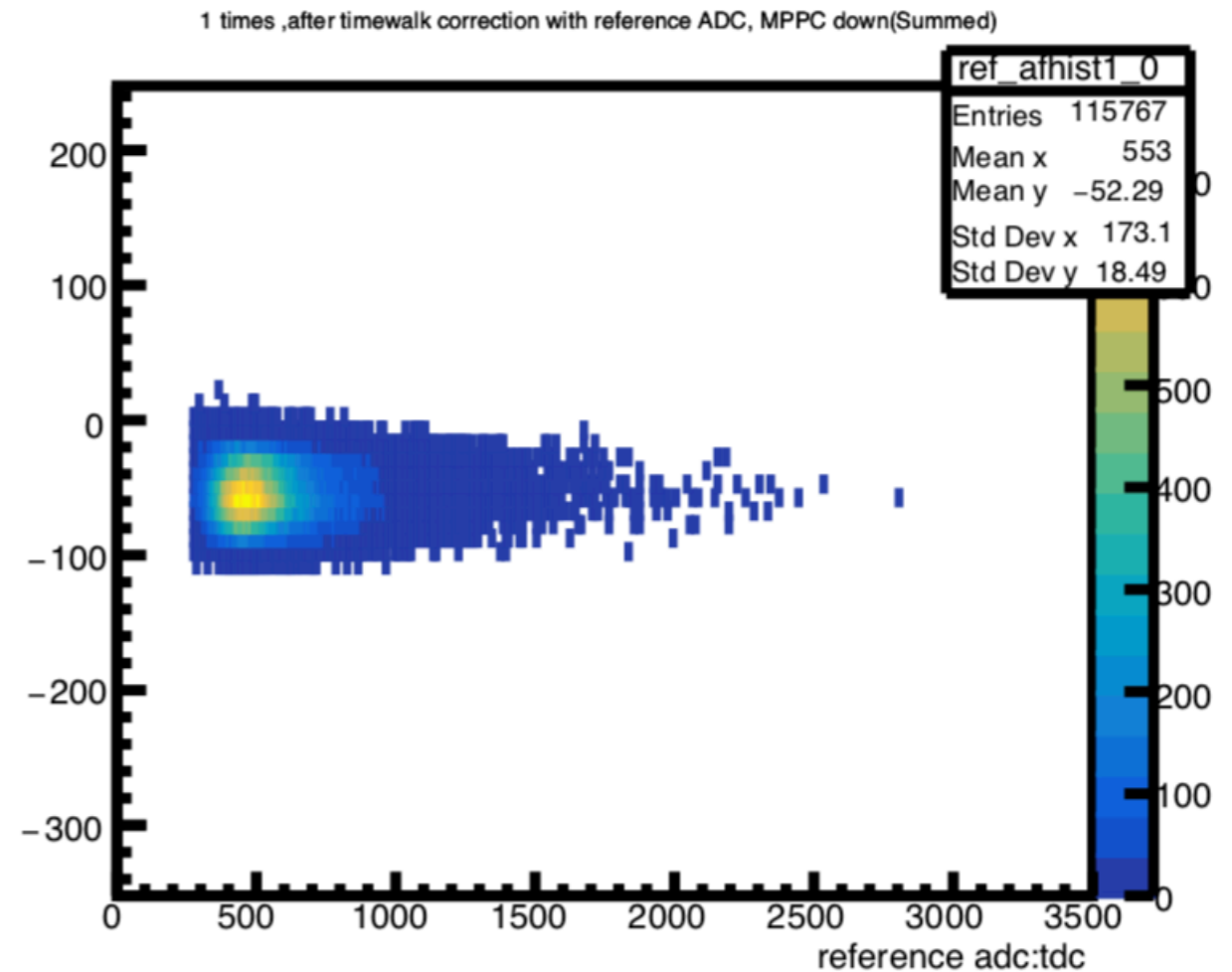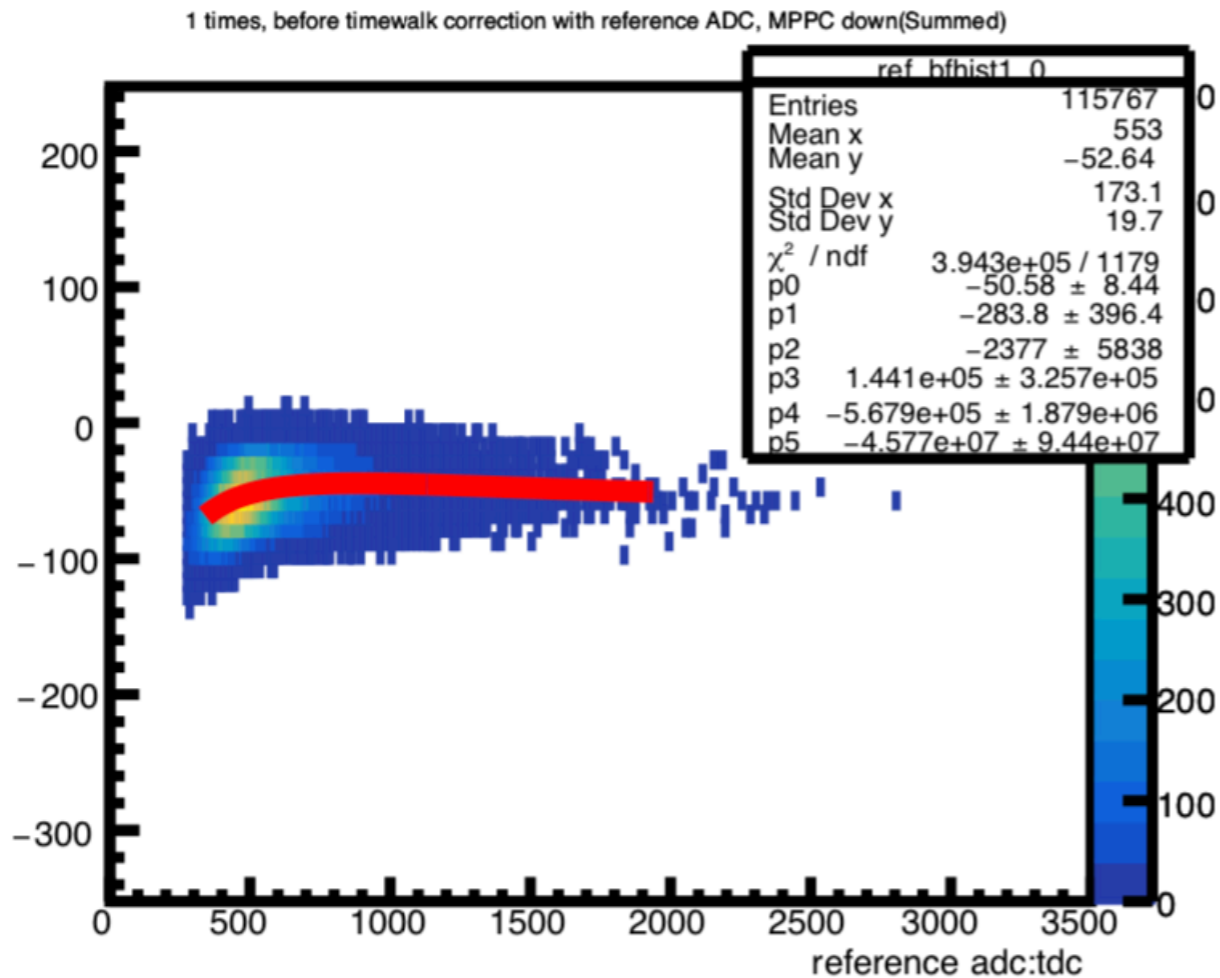
Condition #1 - With light guide

(reference)

Slewing correction again

2 times, before timewalk correction, MPPC down(Summed)

bfhist1_1	
Entries	115767
Mean x	579.9
Mean y	−52.29
Std Dev x	172.7
Std Dev y	18.49
χ^2 / ndf	3.746e+05 / 1166
p0	−52.42 ± 1.726
p1	161 ± 110.8
p2	−426.4 ± 552.2
p3	−1.118e+04 ± 3.095e+04
p4	7.229e+05 ± 8.074e+05
p5	−6.599e+06 ± 7.125e+06

2 times, after timewalk correction, MPPC down(Summed)

afhist1_1	
Entries	115767
Mean x	579.9
Mean y	−52.24
Std Dev x	172.7
Std Dev y	18.1
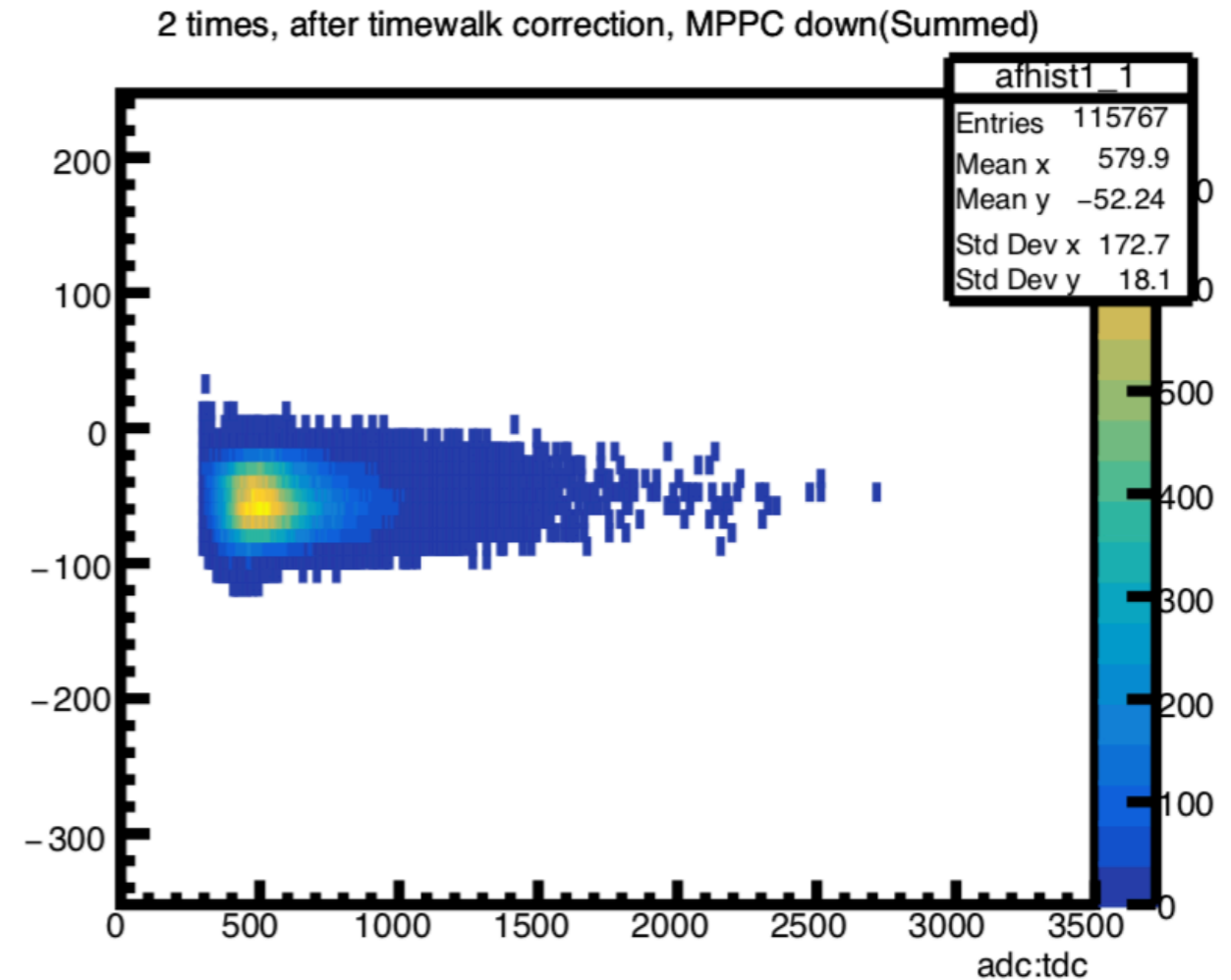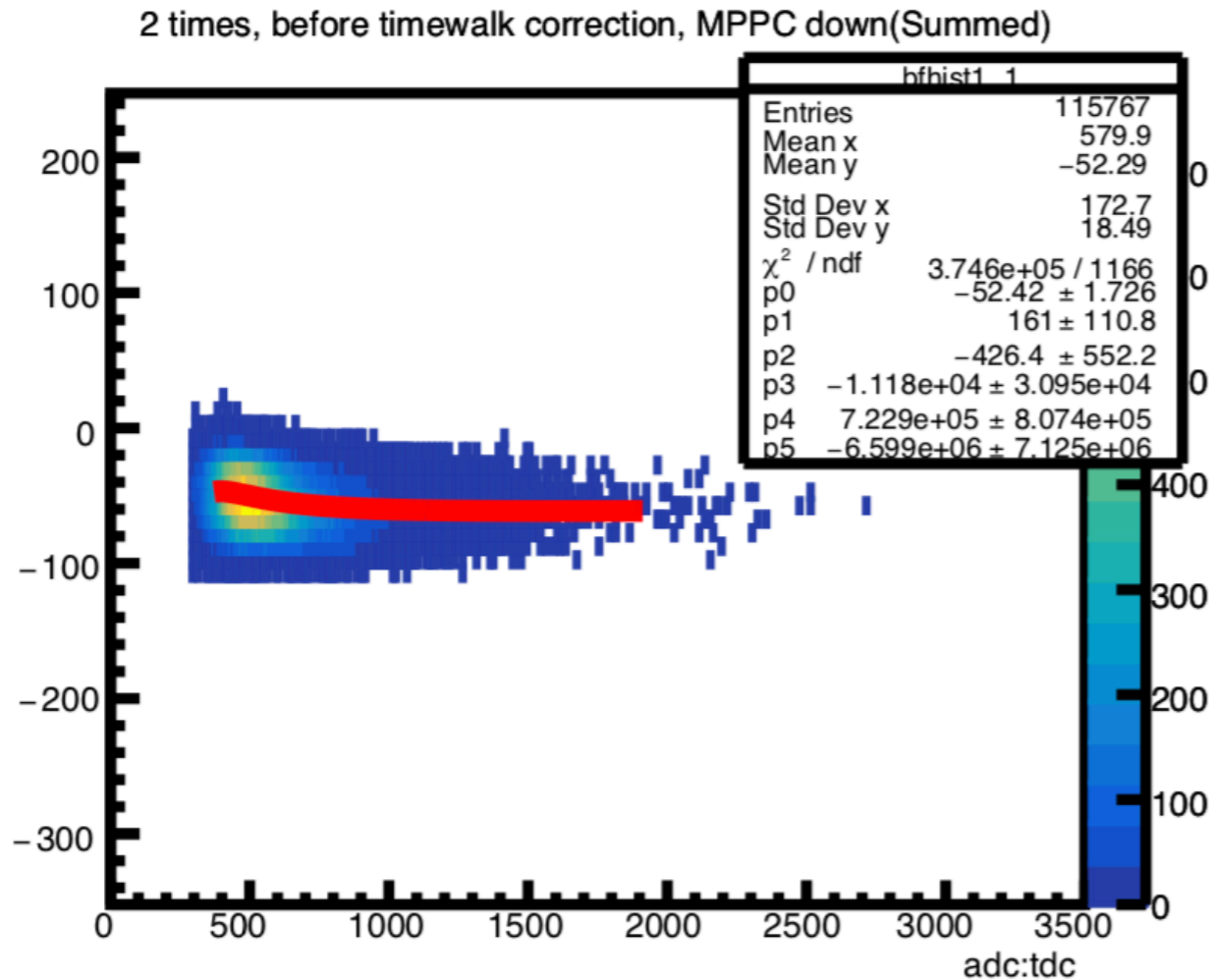
CONDITION #1-CORRECTED TDC

Condition #1 - With Light guide

(reference)

Std value : 20.7 (before) -> 18.1 (after)

MPPC up (Summed), TDC

cuttdc_hist[0]
Entries   115767
Mean   0
Std Dev   0

MPPC down (Summed), TDC

cuttdc_hist[1]
Entries   115767
Mean   −52.24
Std Dev   18.1
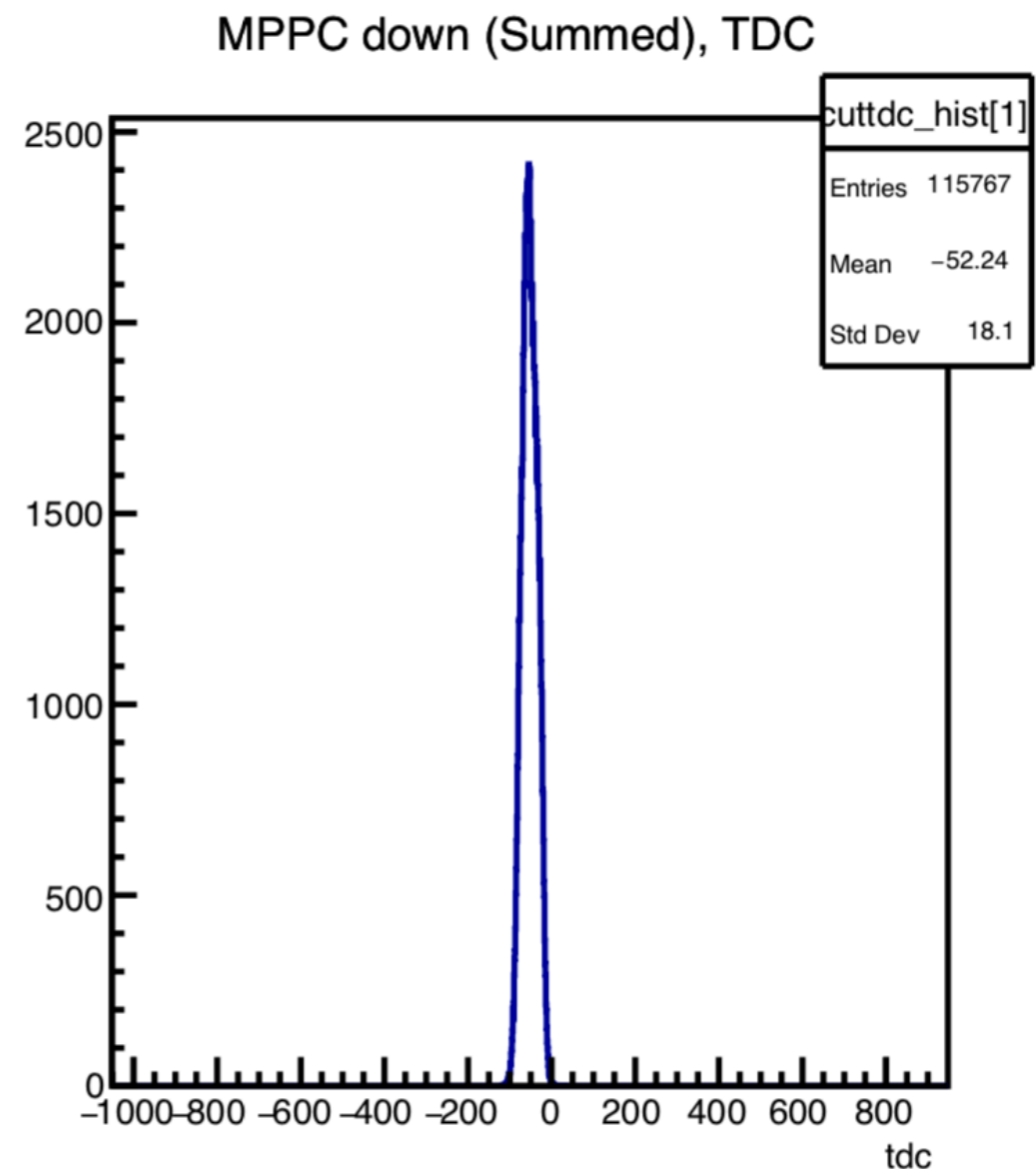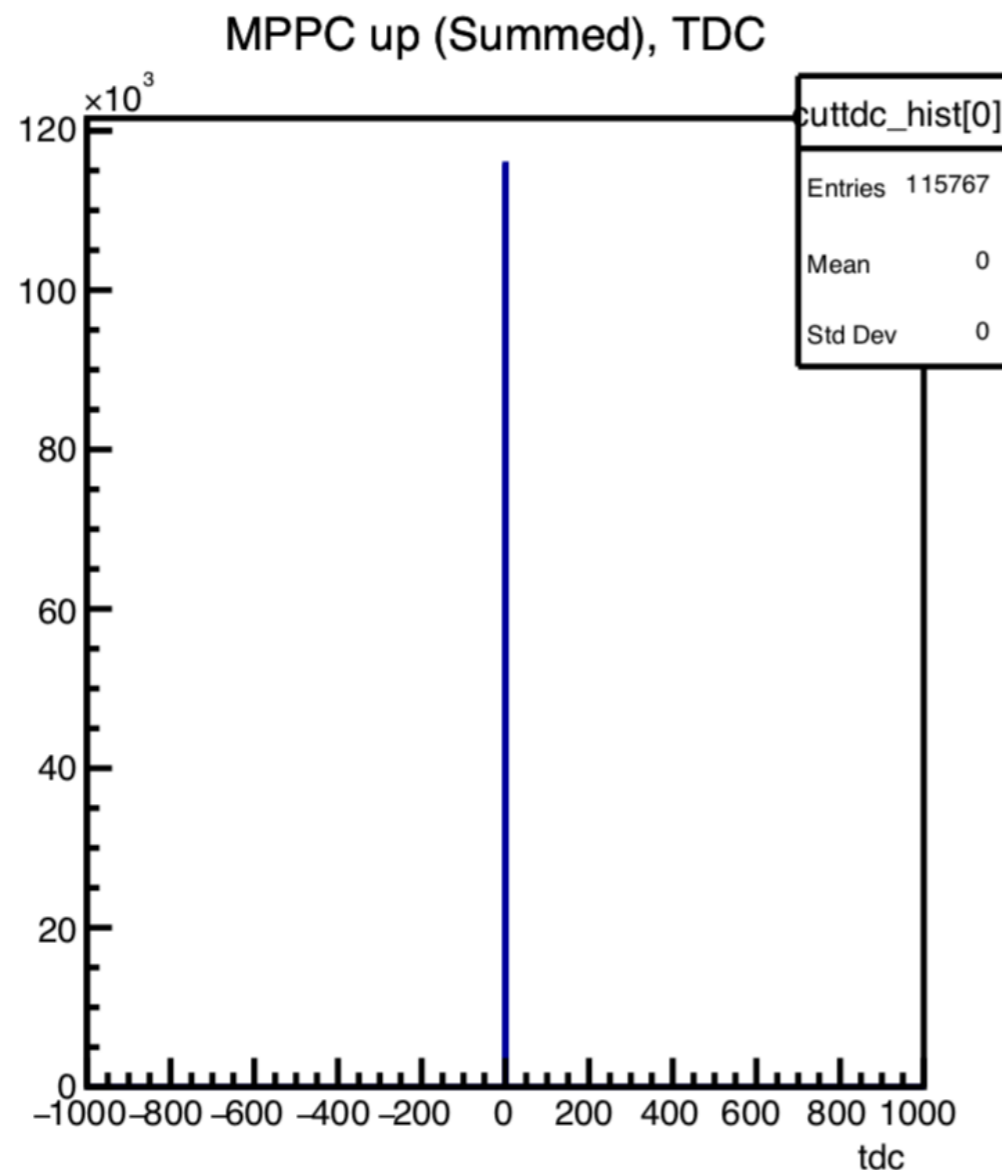
POSITION CUT

Different cut condition