Shinshu University

Calorimeter for ILC

Scintillator ECAL Progress

22nd/03/2013 CALICE Collaboration Meeting@DESY.

Shinshu Univ. High Energy Physics Lab.

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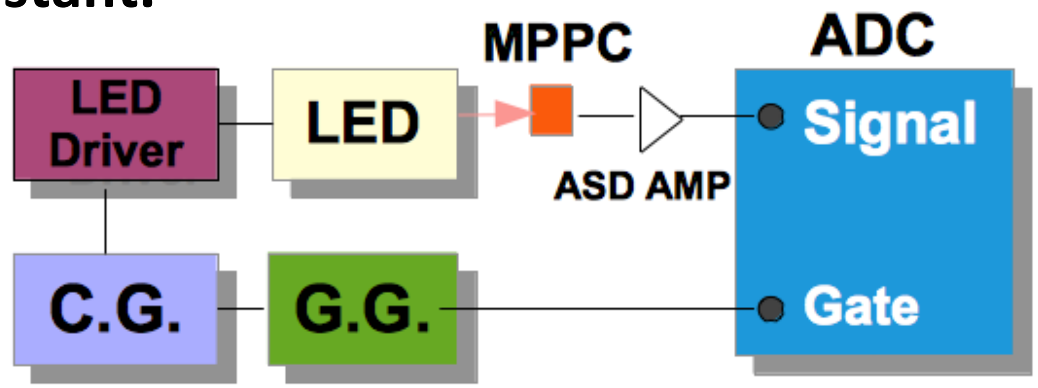
Contents

- □ Time constant of MPPC
- □ Time resolution of MPPC
- □ Time resolution of strip scintillation counter
- □ Uniformity of strip
- □ Summary

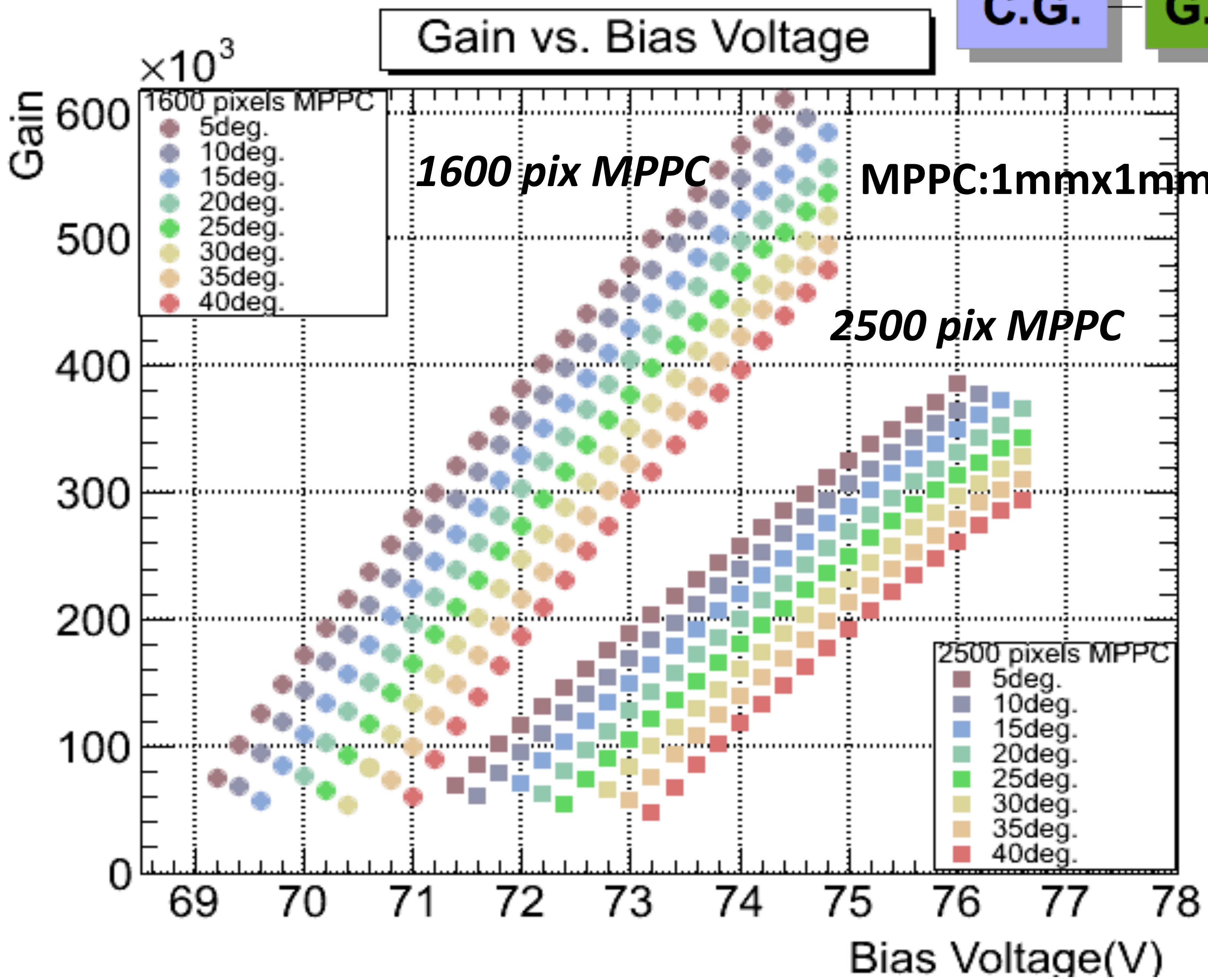
Step1. Gain measurement for C:capacity

We have measured temperature dependence of **RC time constant.**

- Step1. Gain measurement for C:capacitance
- Step2. IV curve measurement for R:resistance
- Step3. Time constant from Step1&Step2



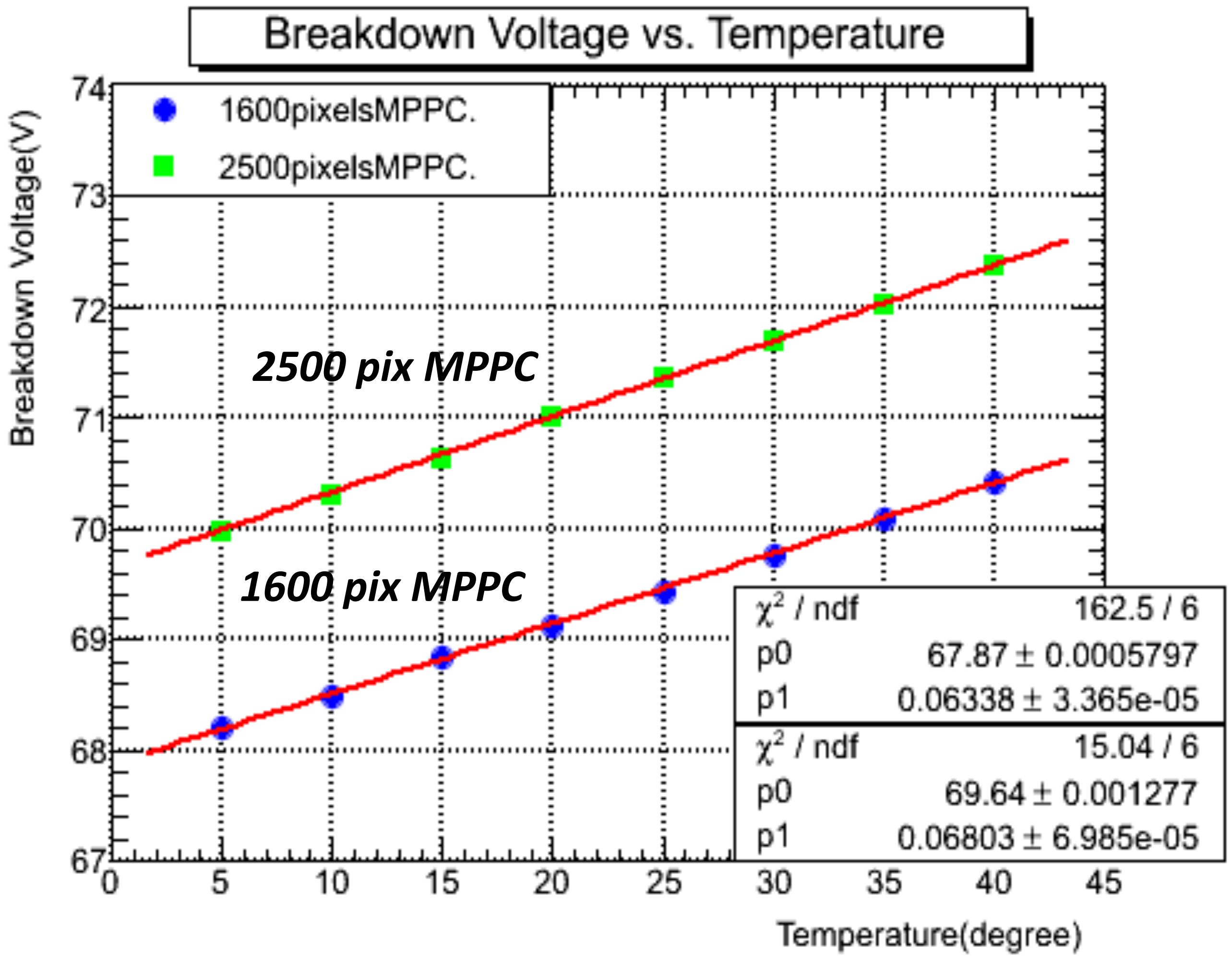
set up of gain measurement.



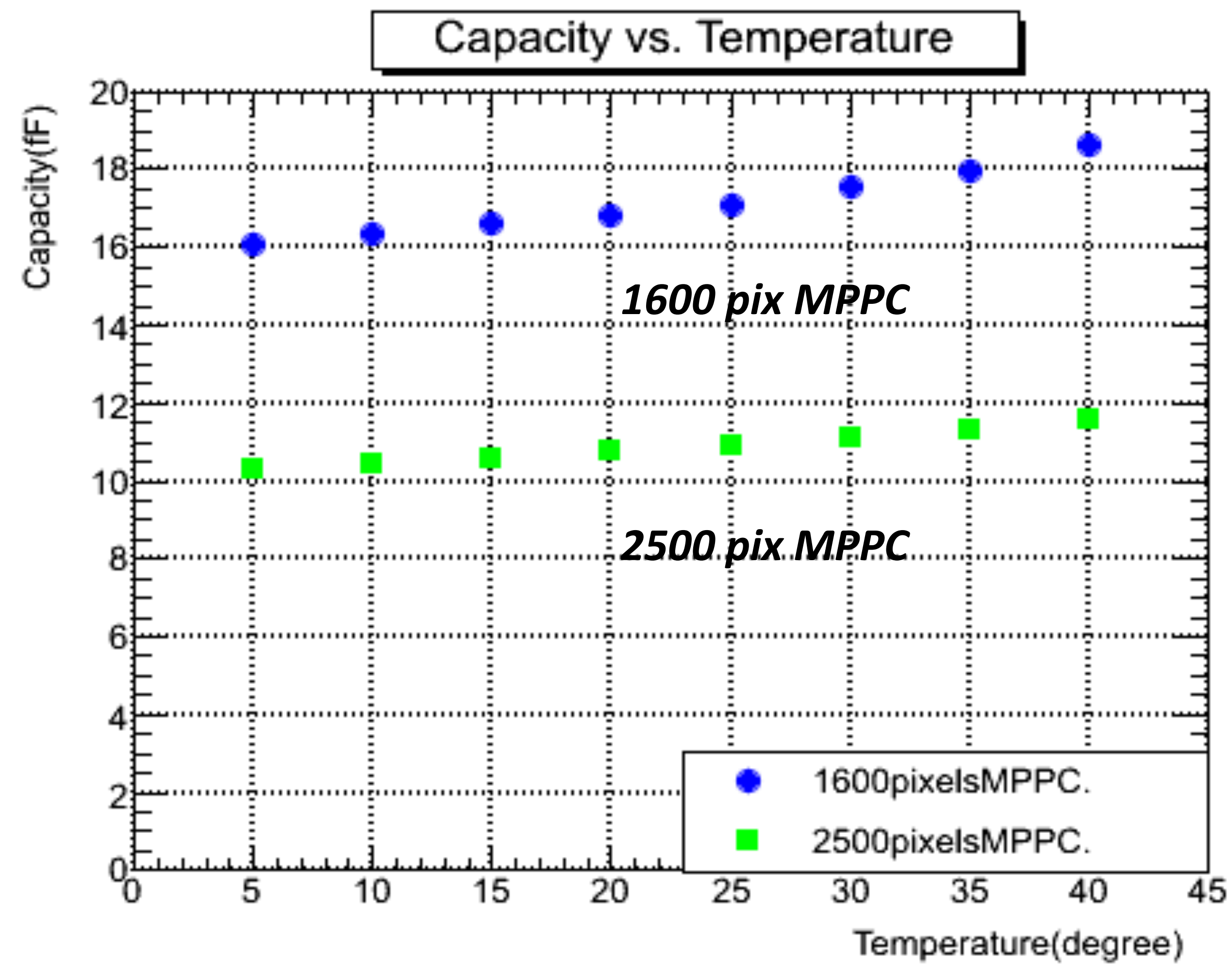
$$Gain = \frac{C}{e}\left(V_{Bias} - V_0\right) = \frac{d \times r}{A \times e}$$

C: Pixel capacitance
V_{bias}: Bias Voltage
e: Elementary charge
V_0: Breakdown Voltage

Step1. Results of gain measurement



C:Capacitance



□ The temperature dependence of breakdown voltage of 1600/2500 pixels MPPC .

□ This slope of the linear fitted line is

dV0/dT=67.87 mV/K(1600pix MPPC)

dV0/dT=69.64mV/K(2500 pix MPPC)

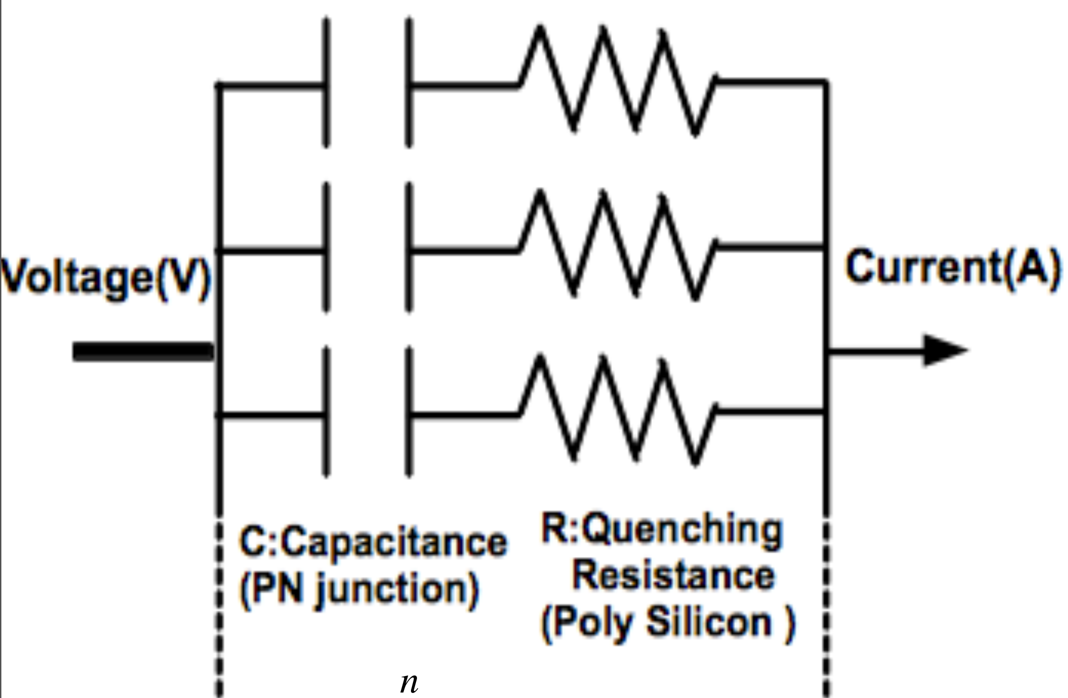
□ The temperature dependence of capacitance for 2 types of MPPC.

□ Capacitances are about

17fF(1600pix MPPC) and 11fF(2500pix MPPC)

Step2. IV curve measurement

MPPC internal circuit

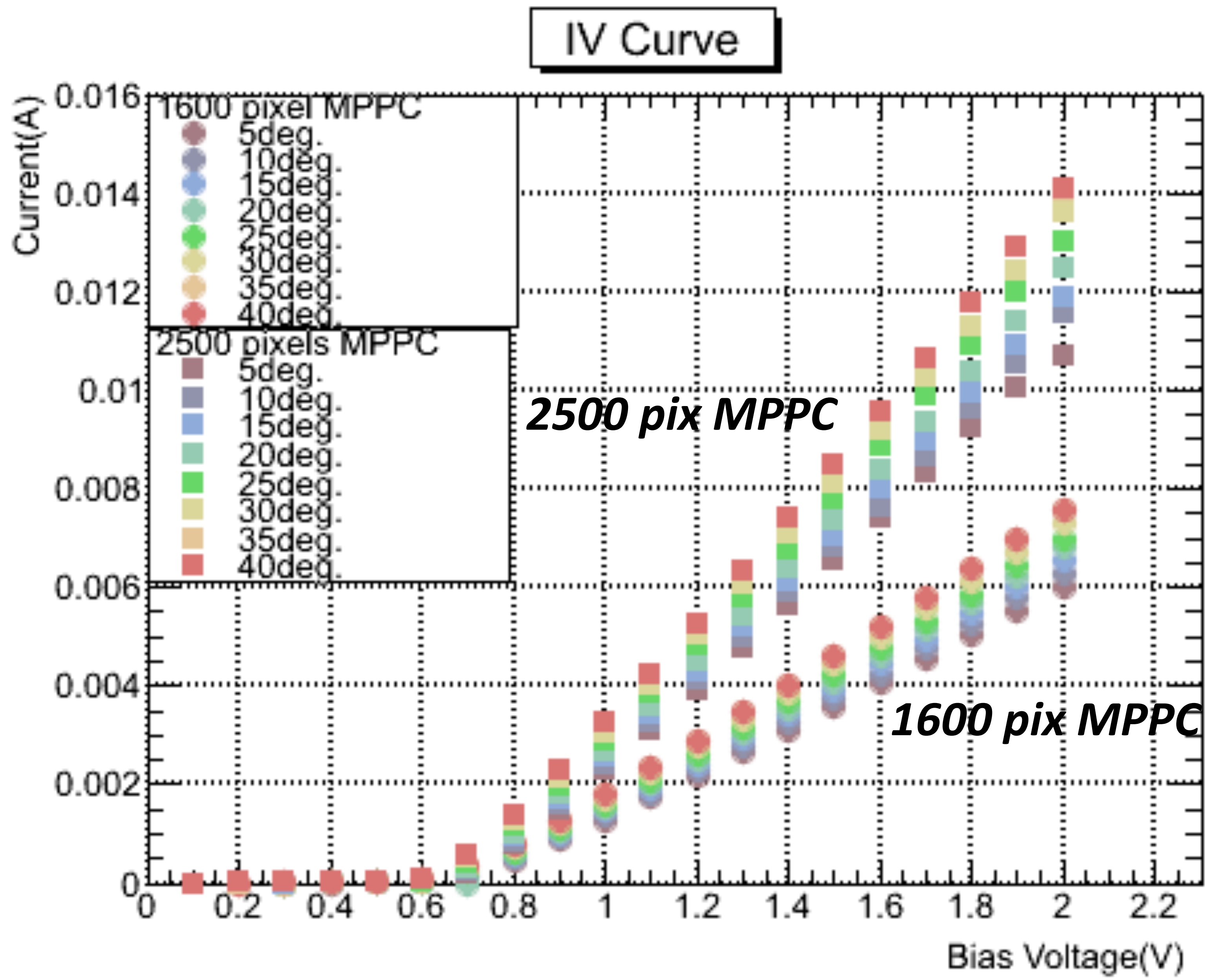


$$Q_{total} = \sum_{i}^{n} C_i V = C_{total} V$$

$$C_{total} = nC_i$$

$$C_{total} = 1600 C_i (1600\, pixels MPPC)$$

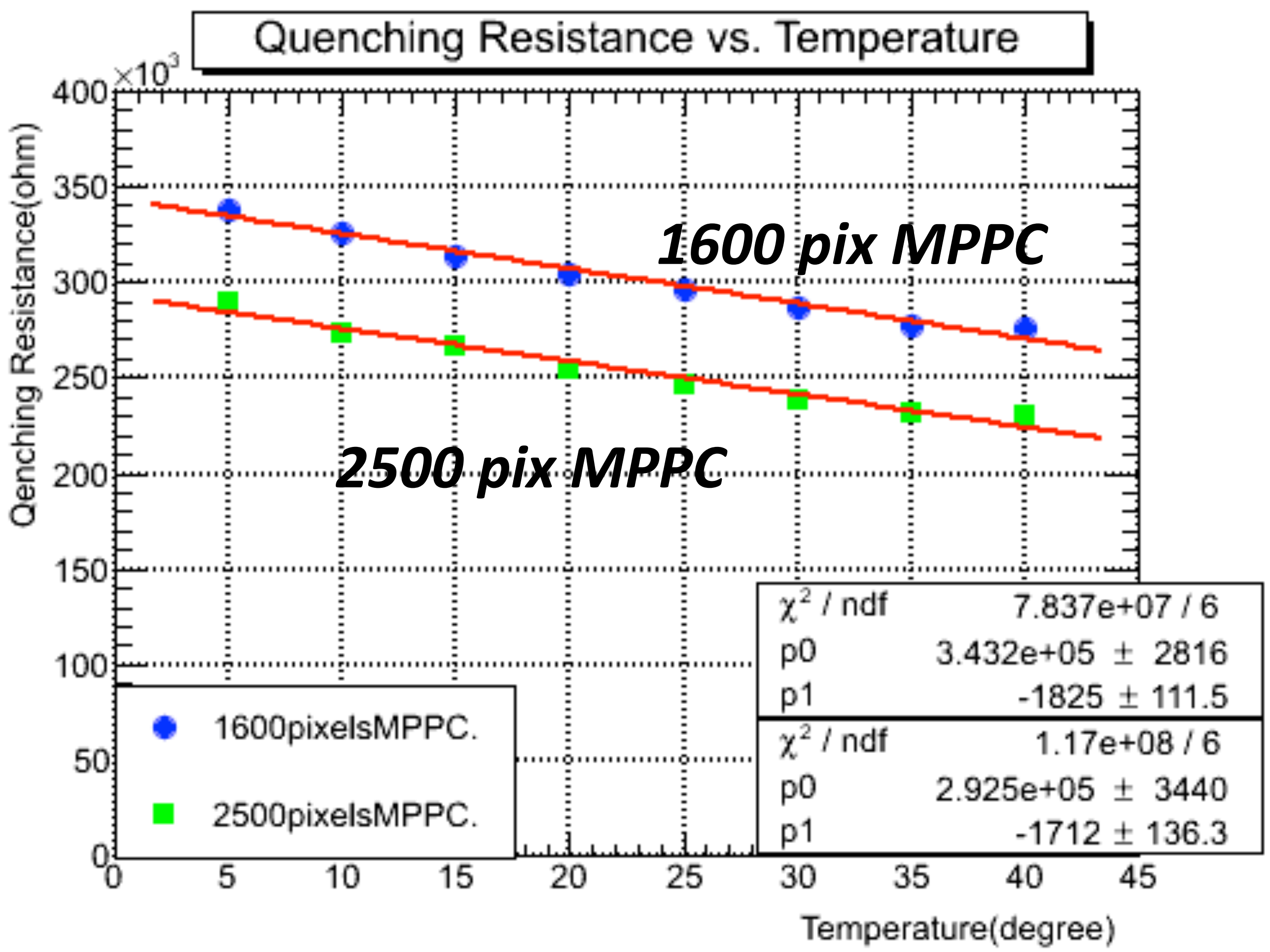
$$C_{total} = 2500 C_i (2500\, pixels MPPC)$$



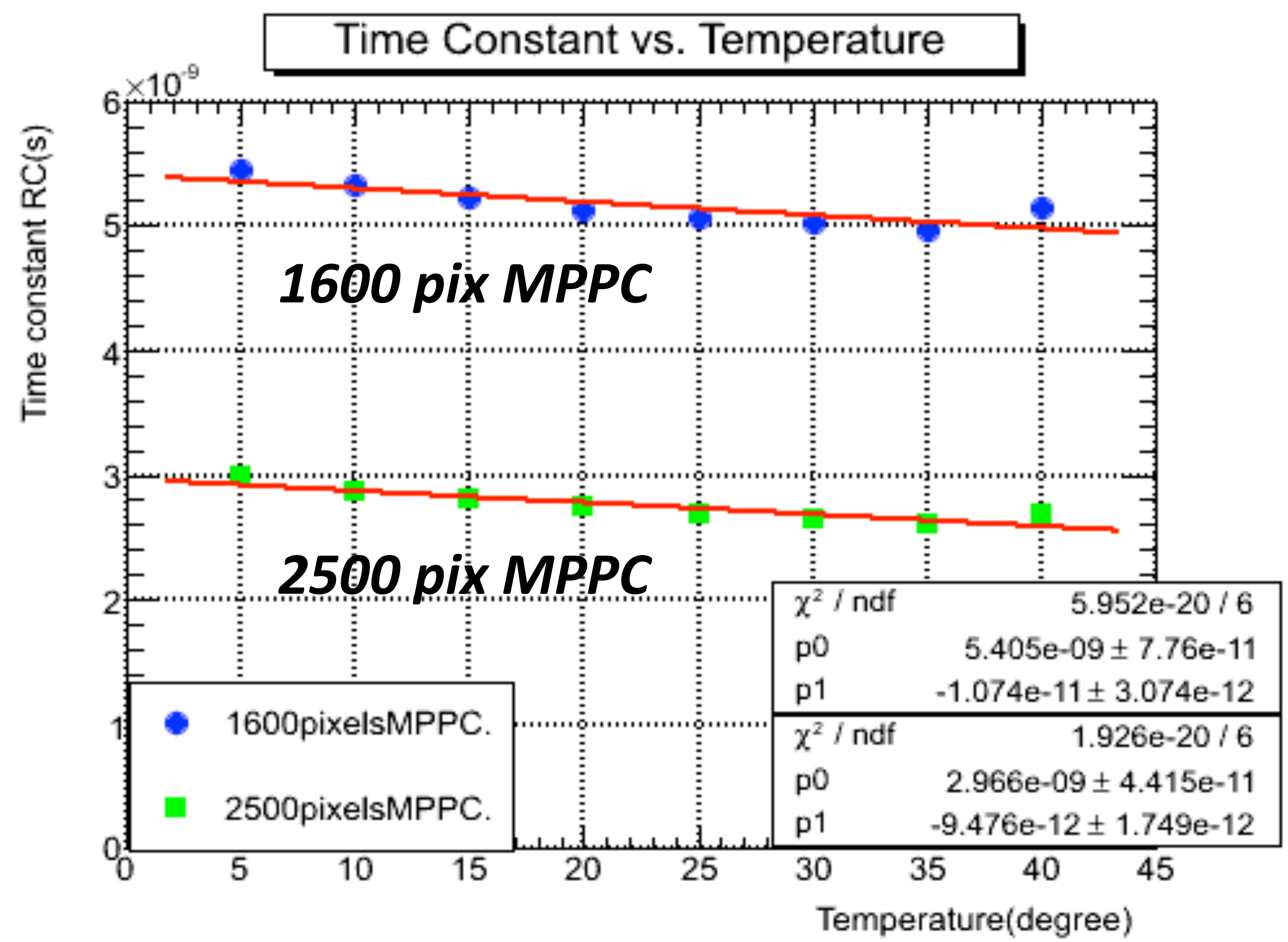
□ We measured current value as a function of the forward voltage for each temperature using 1600 /2500 pixels MPPCs .The right figure shows temperature dependence of IV curve.

Step3.Time constant RC of MPPC
from Step1&Step2 results

R:Quenching resistance



RC:Time constant

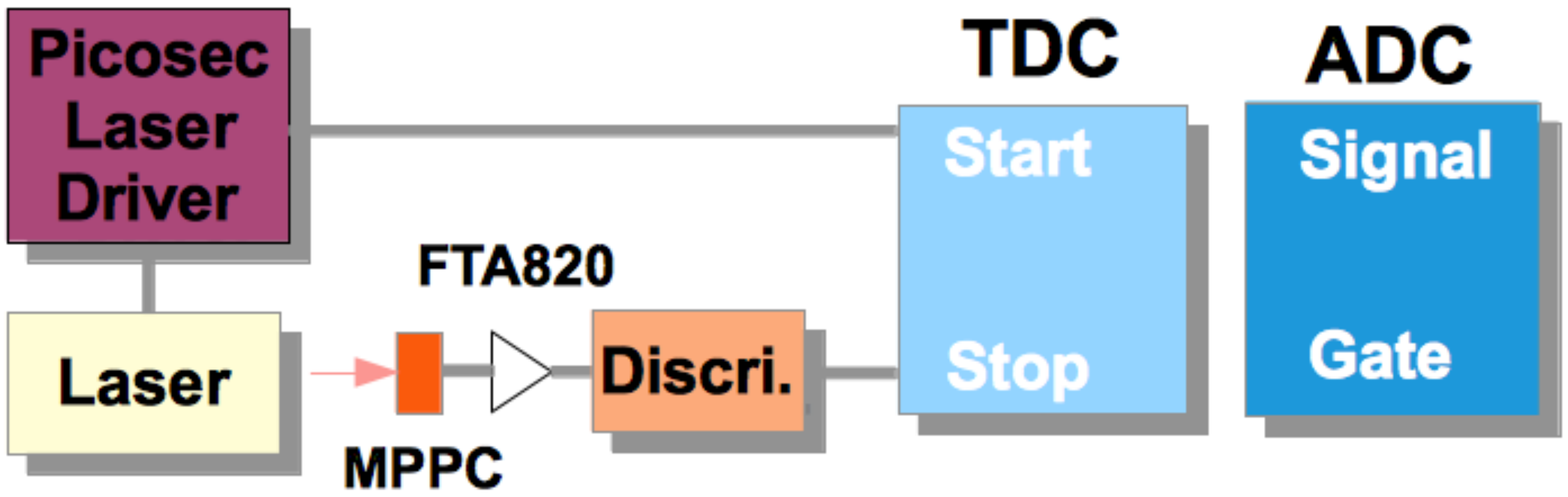


- We measured the temperature dependence of time constant for 1600/2500pixels MPPC.
- We got a linear dependence with slope for time constant.

dRC/dT= - 10.7±0.3 ps/K (1600 pixels MPPC)
dRC/dT= - 9.5±1.7 ps/K (2500 pixels MPPC)

MPPC timing resolution

setup for timing resolution measurement of MPPC.

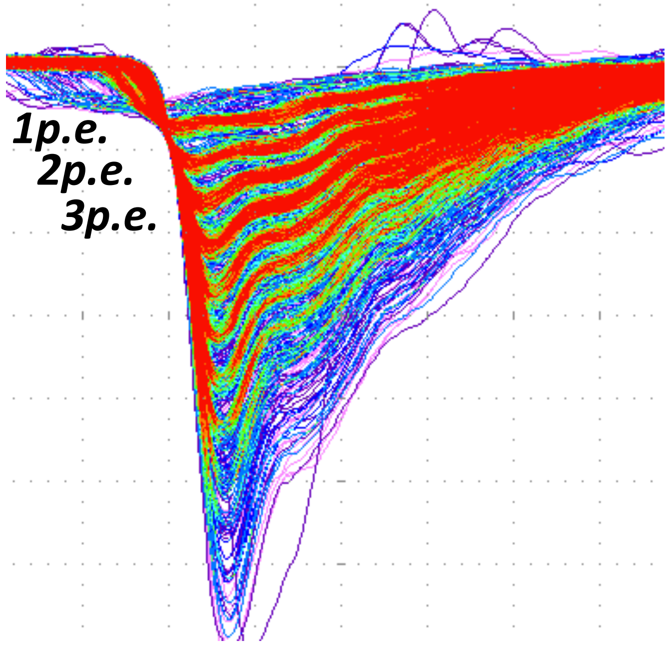


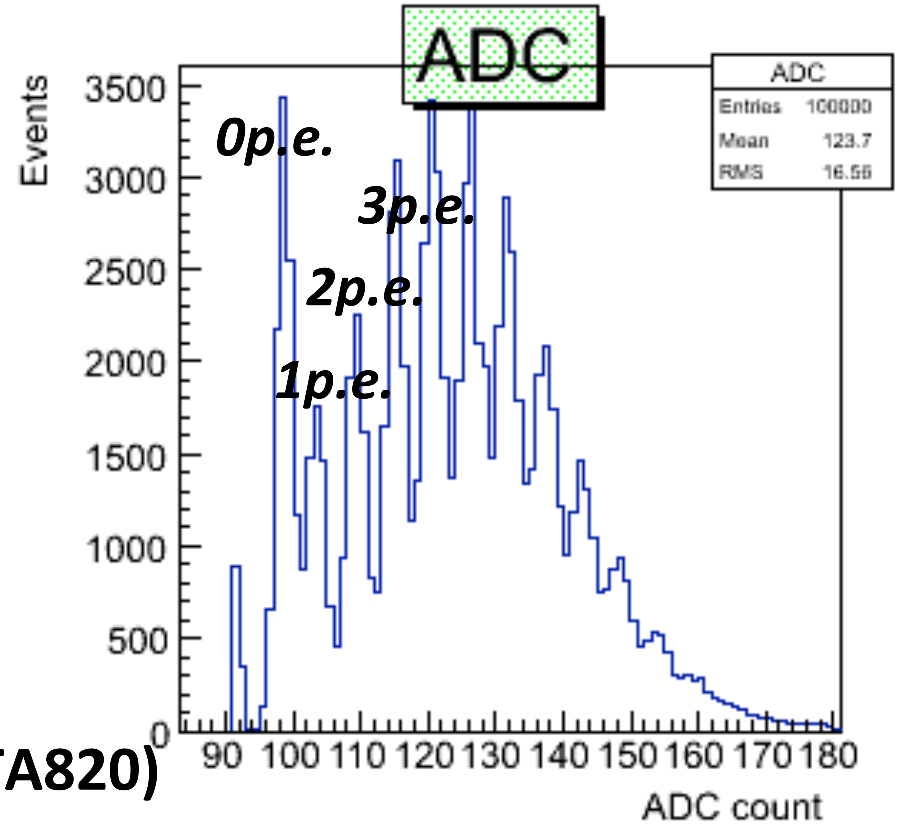
Using 1600 /2500 pixels MPPC
1mm×1mm , @25℃,
Discri=0.5p.e.th,Gate width=50[ns]

TDC →Laser trigger out makes start pulse.
ADC→ Self trigger system. ,

Wave length ：405nm jitter(：±10ps) Pulse width ：60ps～80ps

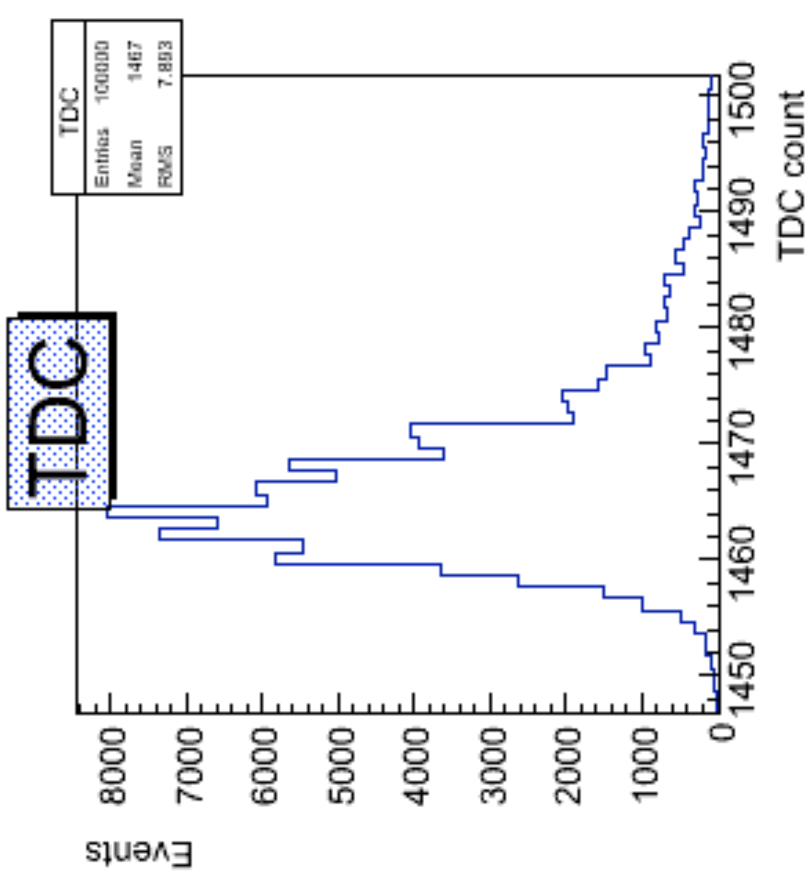
MPPC Timing resolution

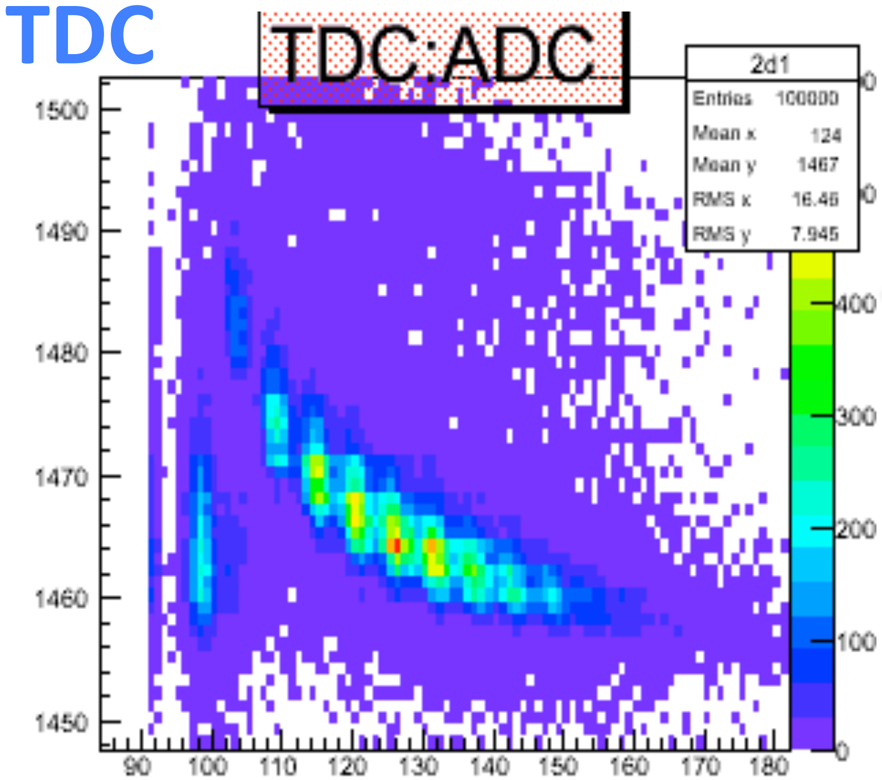




1600pix MPPC
ORTEC amp(FTA820)

TDC





ADC

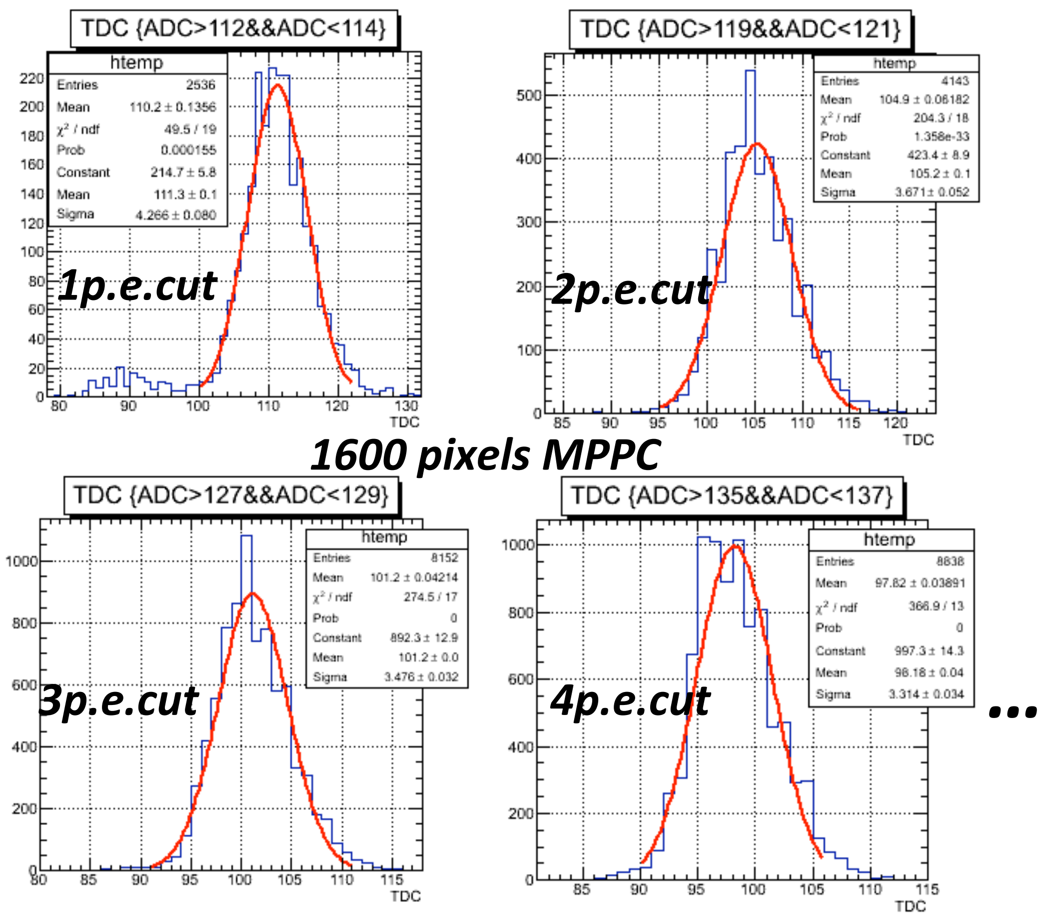
The right below figure is a distribution of scatter plot with TDC(Y):ADC(X).

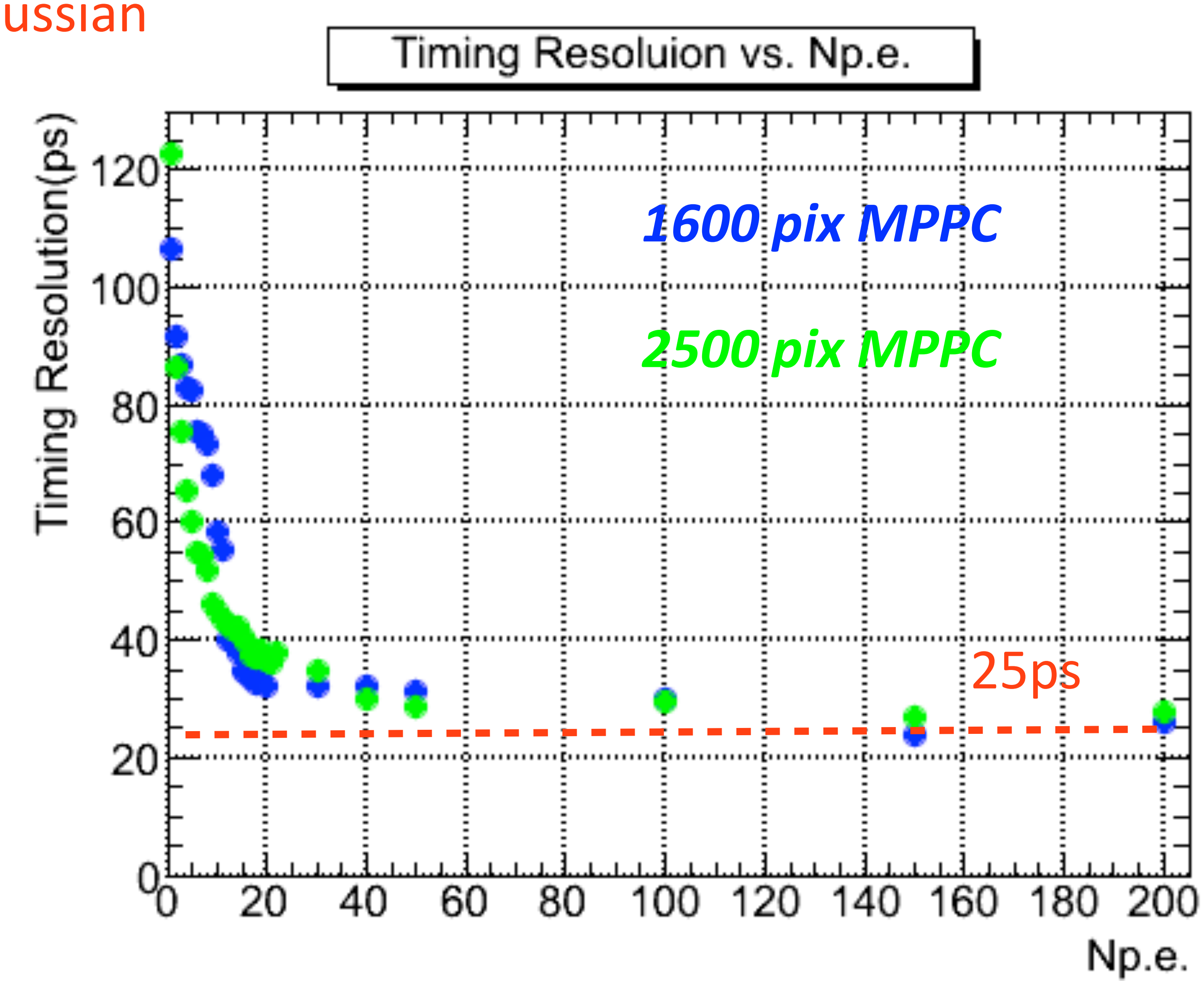
It shows timing delay depends on the number of photo electrons .

Timing resolution would depend on the number of photoelectrons .

Results: Timing resolution of MPPC

These figures show TDC distributions
after cutting the Np.e. and fitted by a gaussian

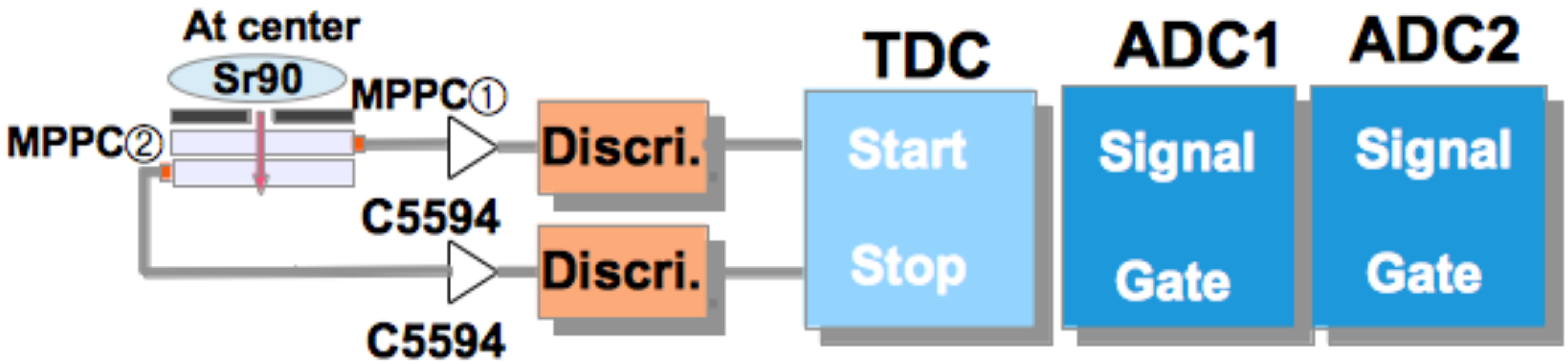




- □ This left figure shows results of timing resolution vs. Np.e using 1600/2500 pixels MPPC.
- □ We estimated the value of time resolution by each number of photoelectrons.
- □ We expected to reach 25ps at high light intensity.

Timing resolution of scintillation counter

setup for timing resolution measurement of strip scintillation counter.



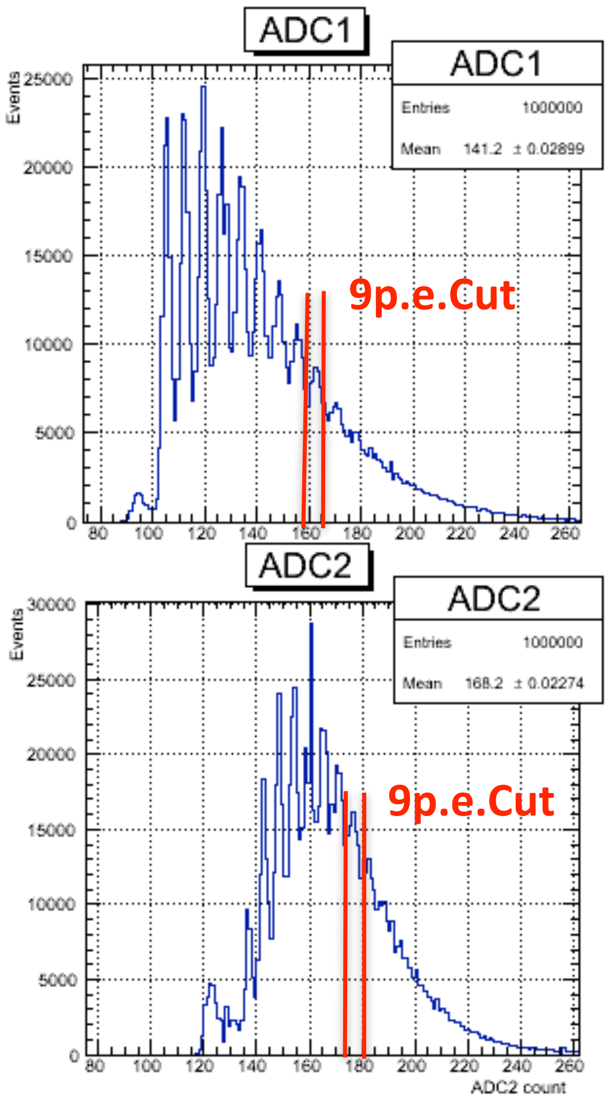
□ Both counters are 45mm x5mm x 2mm SCSN38 plastic strip scintillators and 1600pixels MPPC from HPK are used.

□ Both counters C1 and C2 should have the same time resolution, since they are identical, and are operated under the same conditions .

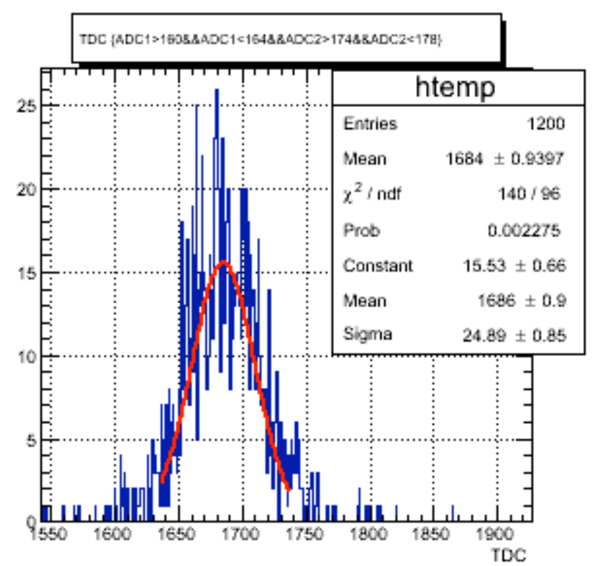
$$\sigma_{total}^2 = \sigma_{C1}^2 + \sigma_{C2}^2 \qquad \sigma_{c1} = \sigma_{c2} = \frac{1}{\sqrt{2}}\sigma_{total}$$

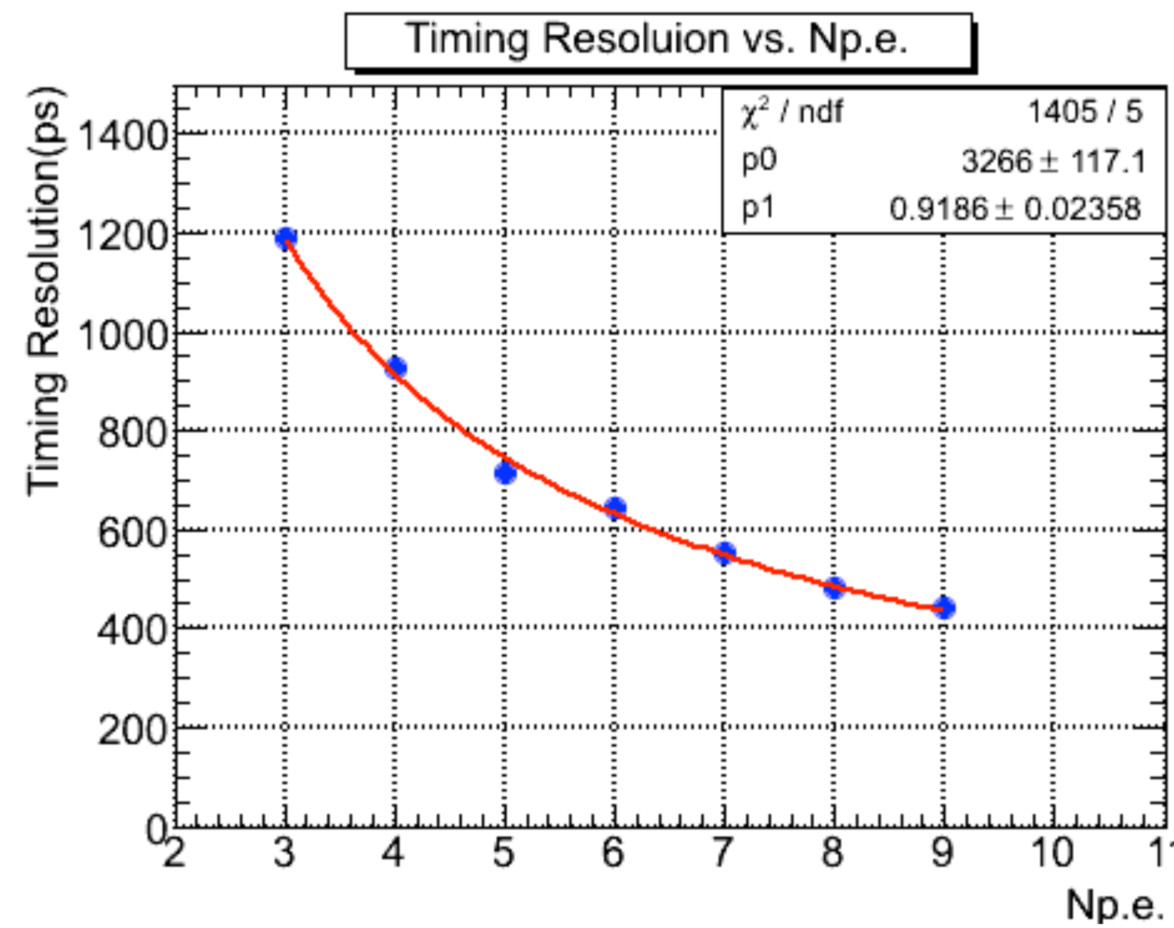
Results : Timing resolution of scintillation counter

We measured time difference between the timing signals of C1 and C2 ,light intensity of ADC1 and ADC2 .



Timing resolution depends on Np.e. so we do cut ADC ch both of same ADC1 and ADC2 Np.e.





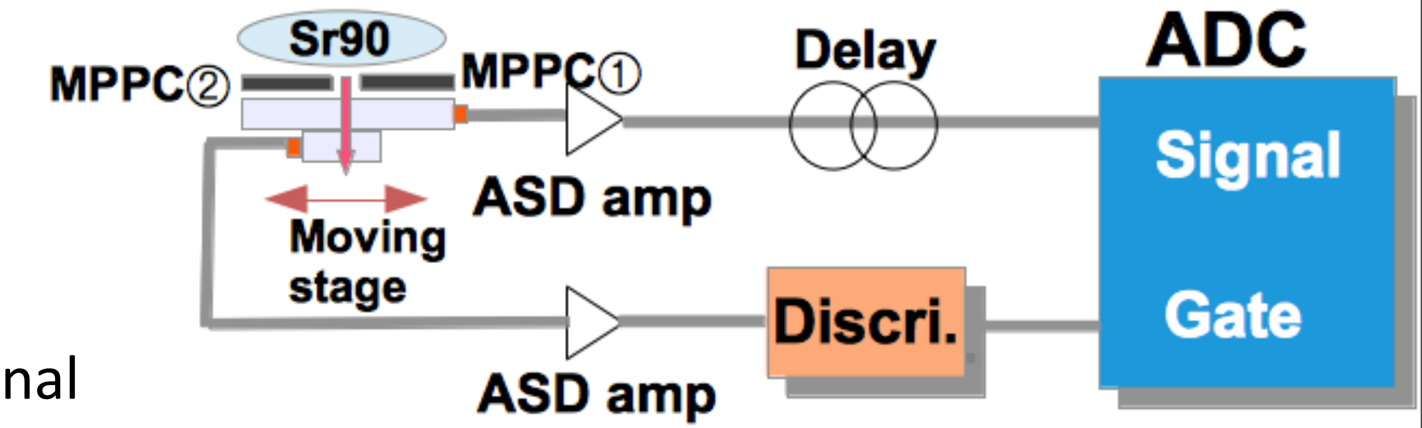
□ We measured timing resolution value of scintillation counter for 1p.e. to 9p.e. showing with blue points and fitted by f=3266x^-0.92 on light figure.

□ We expected to reach to 144ps at 30p.e by fitting.

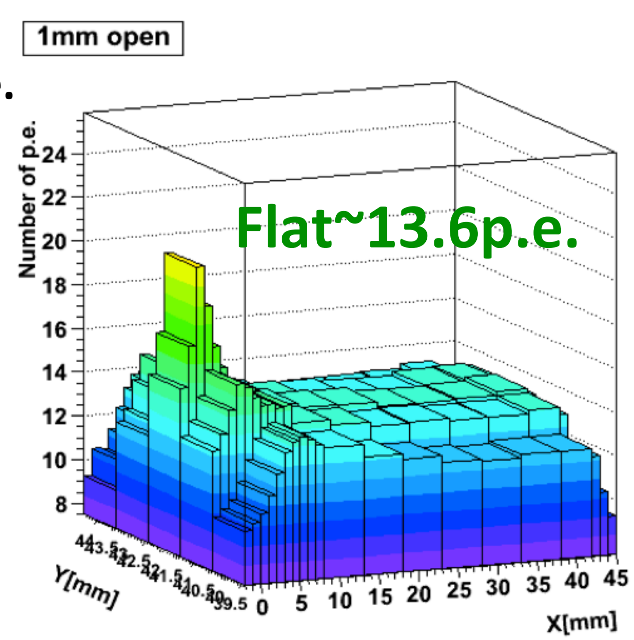
Uniformity measurement.

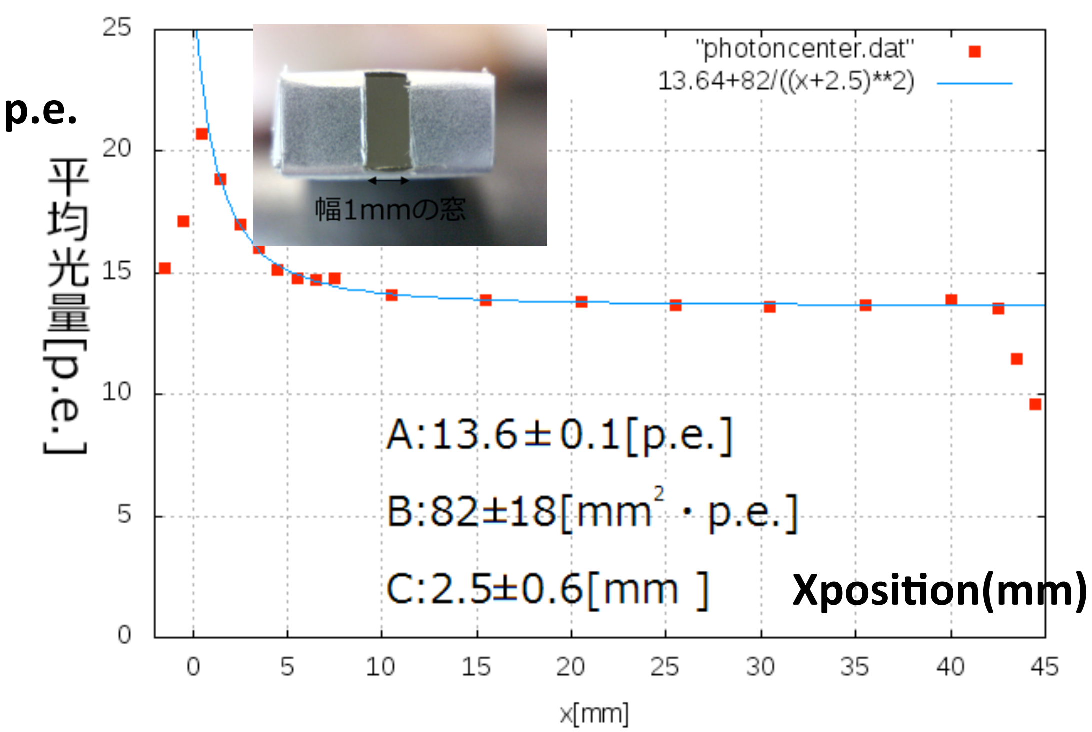
□ We made an auto measurement system using precisely xyz moving stage and we measured light intensity uniformity of plastic scintillator SCSN38(45mm×5mm×2mm) using Sr source.

□ Reference counter is small, making trigger signal (MPPC2) , fixed on the stage so that trigger condition was kept stable.



1mm window 1mm窓





□ We found good uniformity from 5 to 40mm. The results is consistent while the previous work.

Summary and Plan

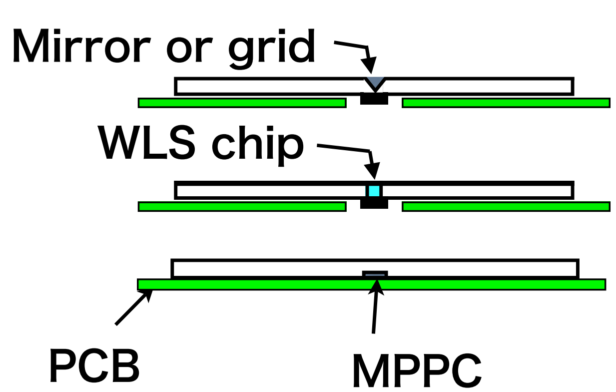
□ We measured the temperature dependence of time constant for 1600/2500pixels MPPC.
□ We got a linear dependence for the time constant.

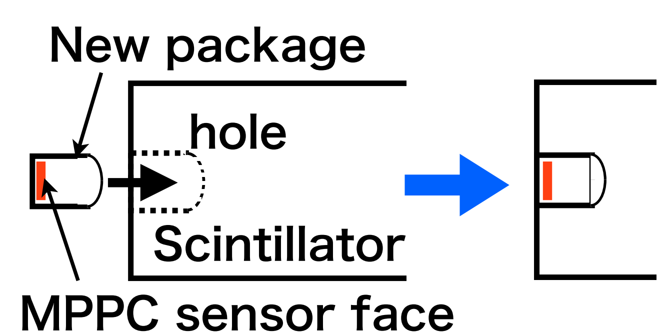
□ We measured MPPC timing resolution in low photo-electron region using pico second laser and found reaching 25ps at high light intensity both of 1600/2500 pixels MPPC.
□Plan:We check the temperature dependence of MPPC timing resolution.
□ Skip:We know the bias voltage and threshold dependence of MPPC timing resolution

□We measured timing resolution value of scintillation counter using Sr source .
□We expected to reach 144ps at 30p.e by fitting.
□ Plan : We use a bigger MPPC to get light intensity.

□ We made a precise auto measurement system using xyz moving stage so we got great progress for scintillator study.
□ We found good uniformity from 5 to 40mm, the results is consistent with the previous work.
□Plan:We will study different combinations of MPPC and strip scintillator.

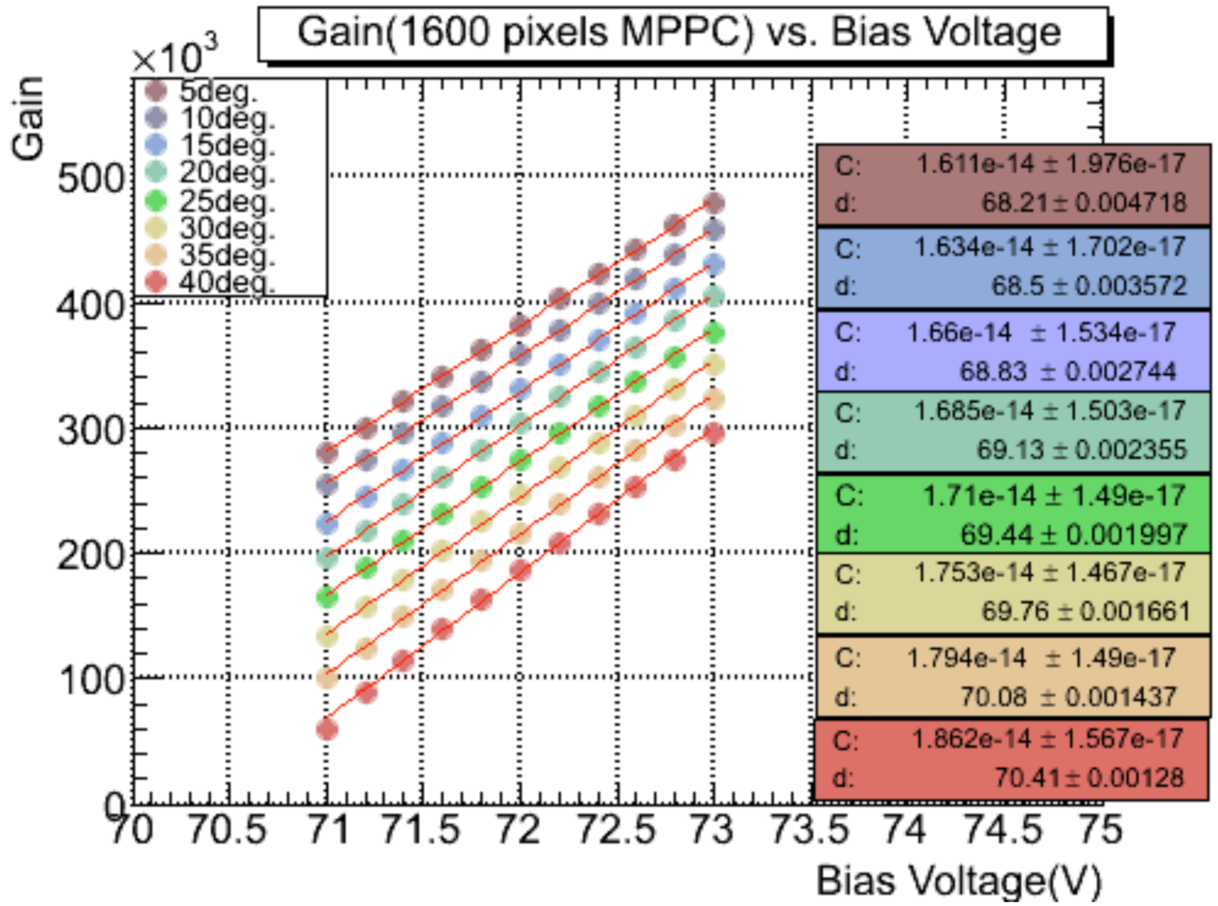
By coterra san plan



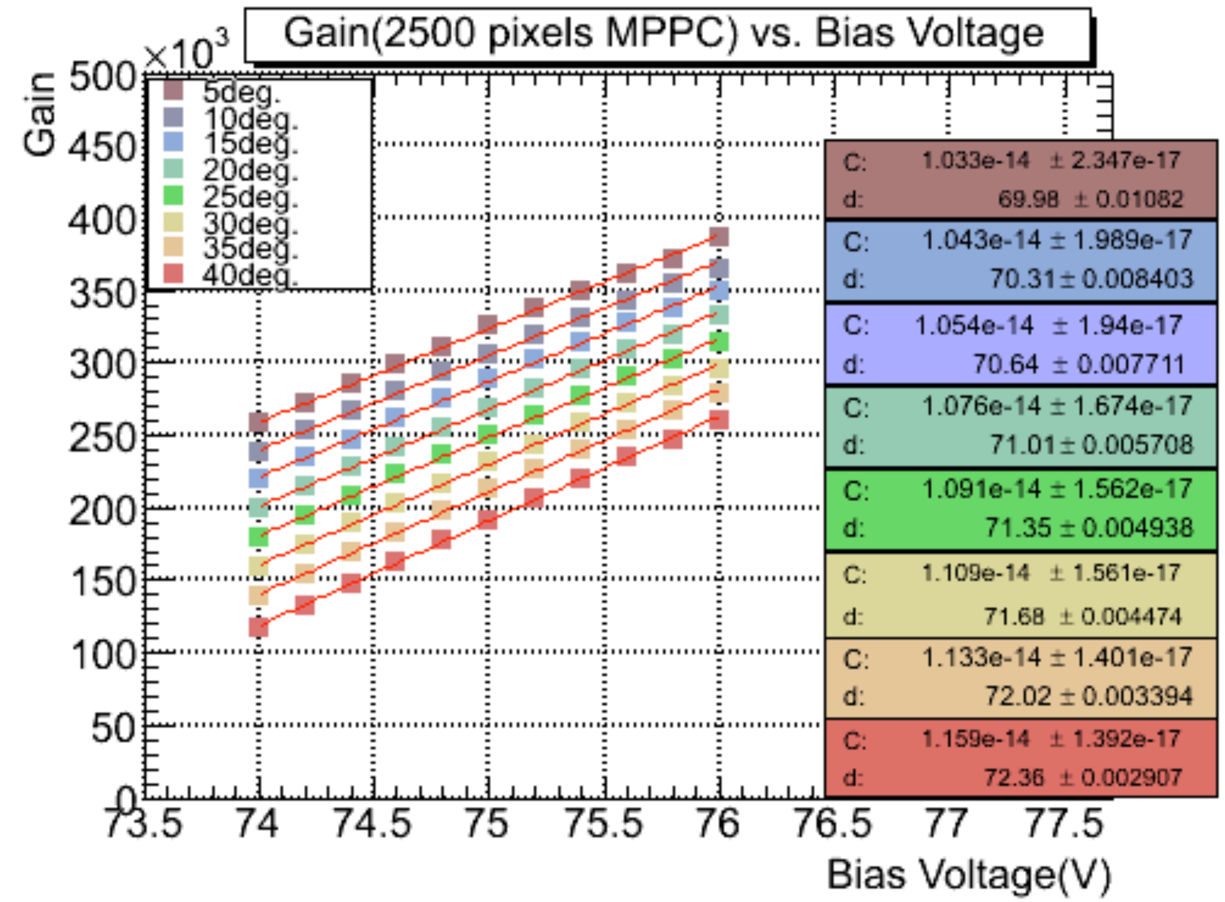


□ We will get a new types of MPPCs from HPK expecting lower noiserate ,and afterpulse rate.

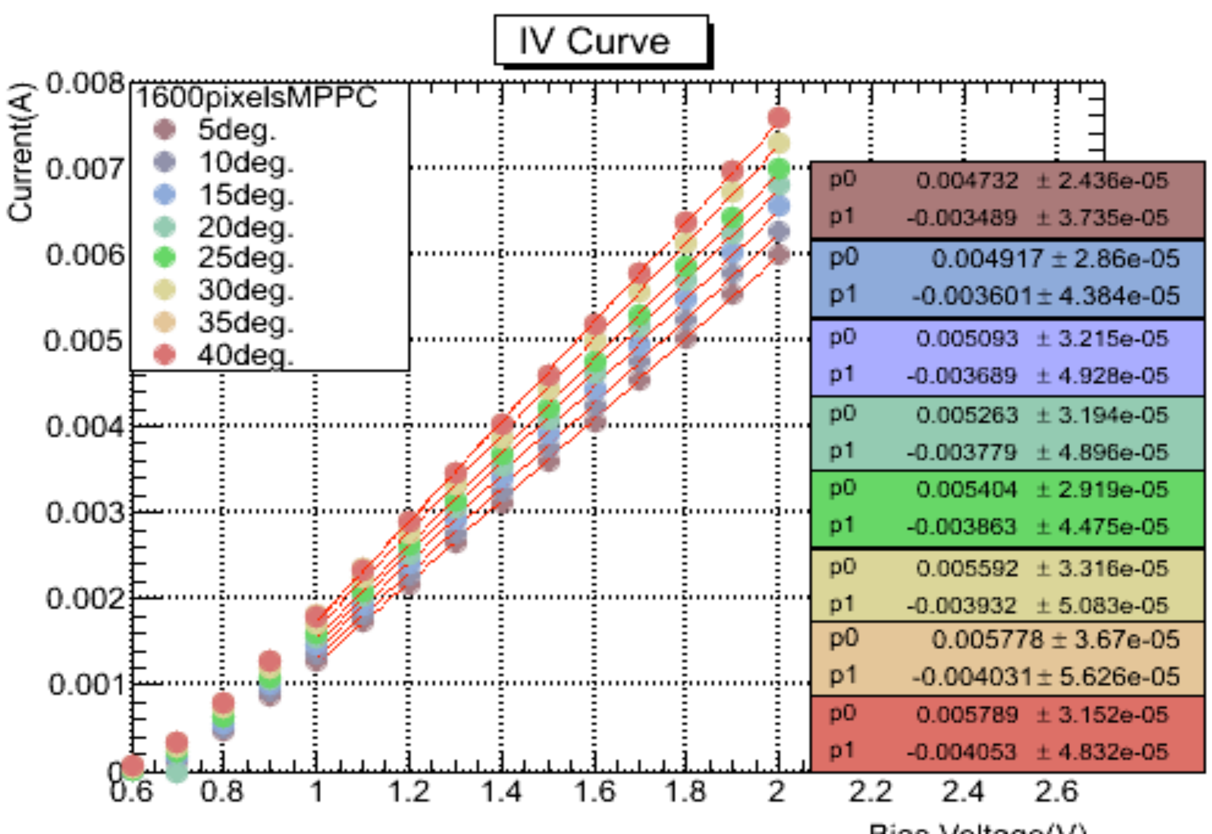
Back Up



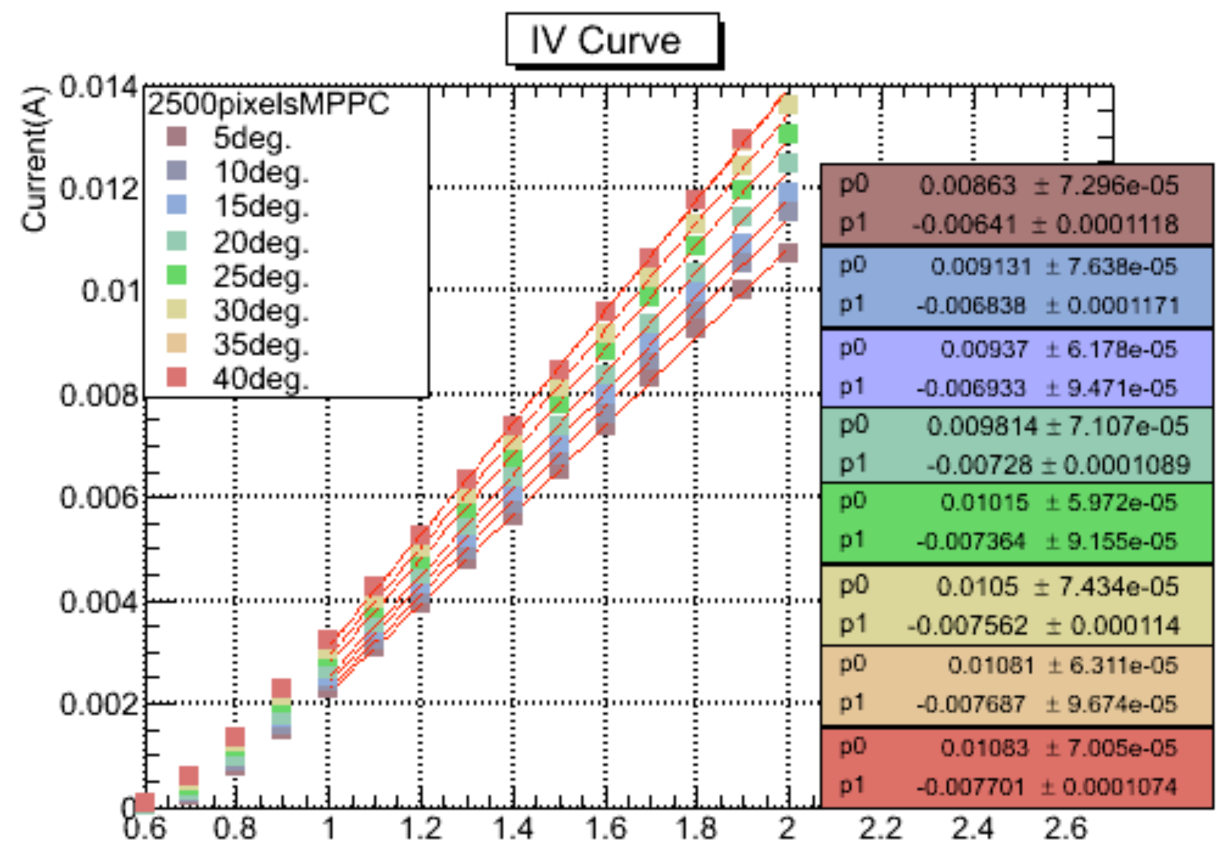
The temperature dependence of Gain vs. Bias Voltage (1600pixels MPPC)



The temperature dependence of Gain vs. Bias Voltage (2500pixels MPPC)

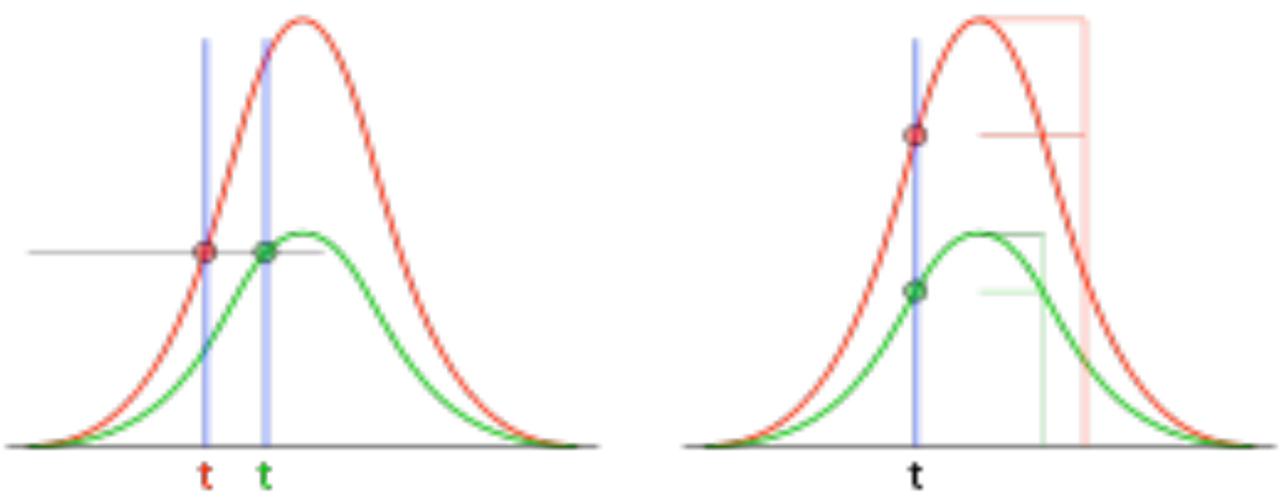


The temperature dependence of IV curve (1600pixels MPPC)



The temperature dependence of IV curve (2500pixels MPPC)

Leading edge discriminator v.s. Constant fraction discriminator

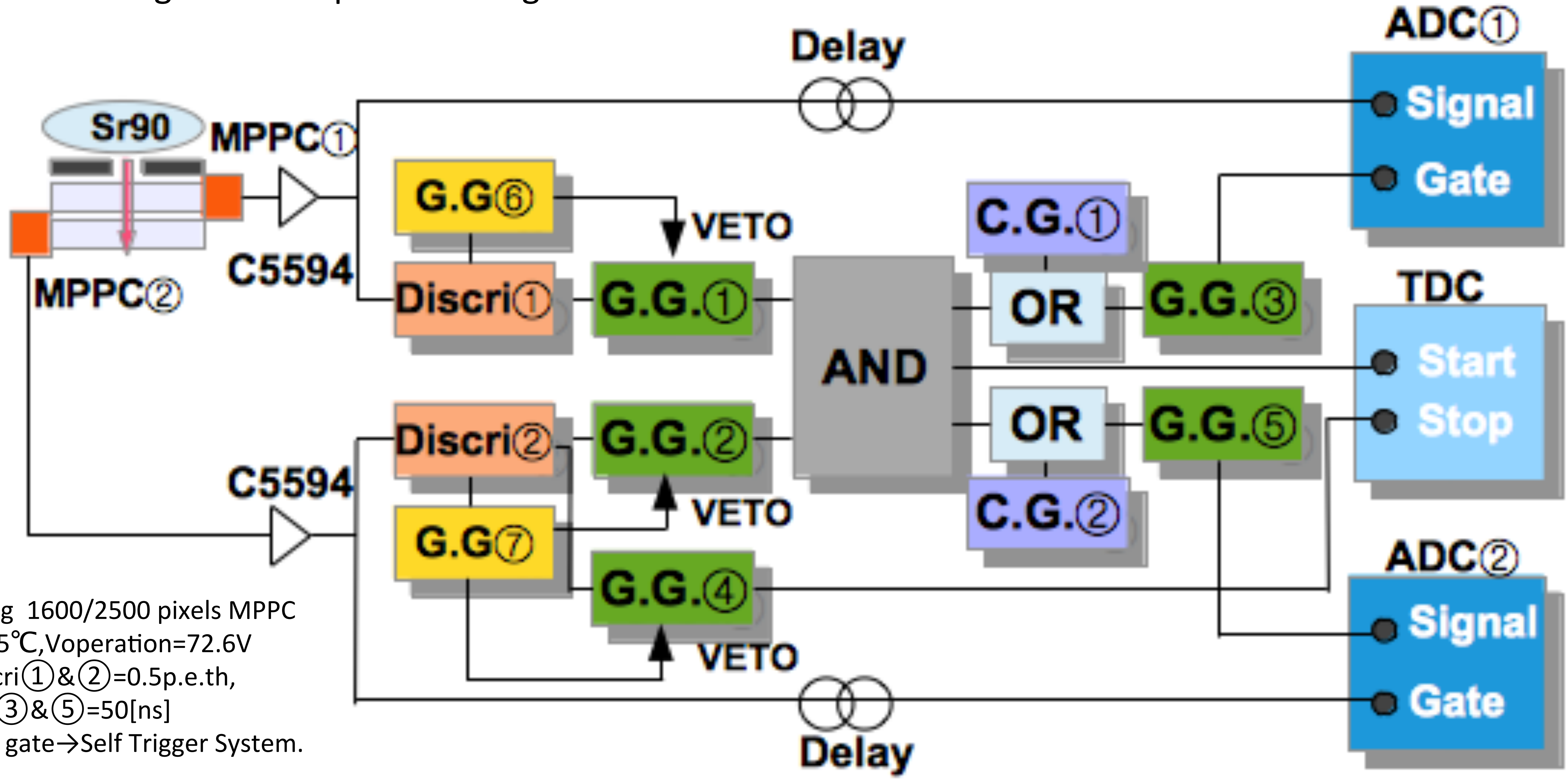


Leading edge discriminator (left) and constant fraction triggering (right)

This forbids simple threshold triggering, which causes a dependence of the trigger time on the signal's peak height, an effect called time walk (see diagram). Identical rise times and peak shapes permit triggering not on a fixed threshold but on a constant fraction of the total peak height, yielding trigger times independent from peak heights.

Timing resolution of scintillation counter

This below figure is setup with timing resolution of scintillation counter.



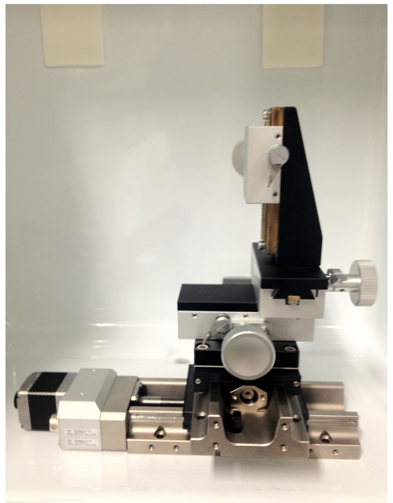
Using 1600/2500 pixels MPPC
@25℃,Voperation=72.6V
Discri①&②=0.5p.e.th,
G.G③&⑤=50[ns]
ADC gate→Self Trigger System.

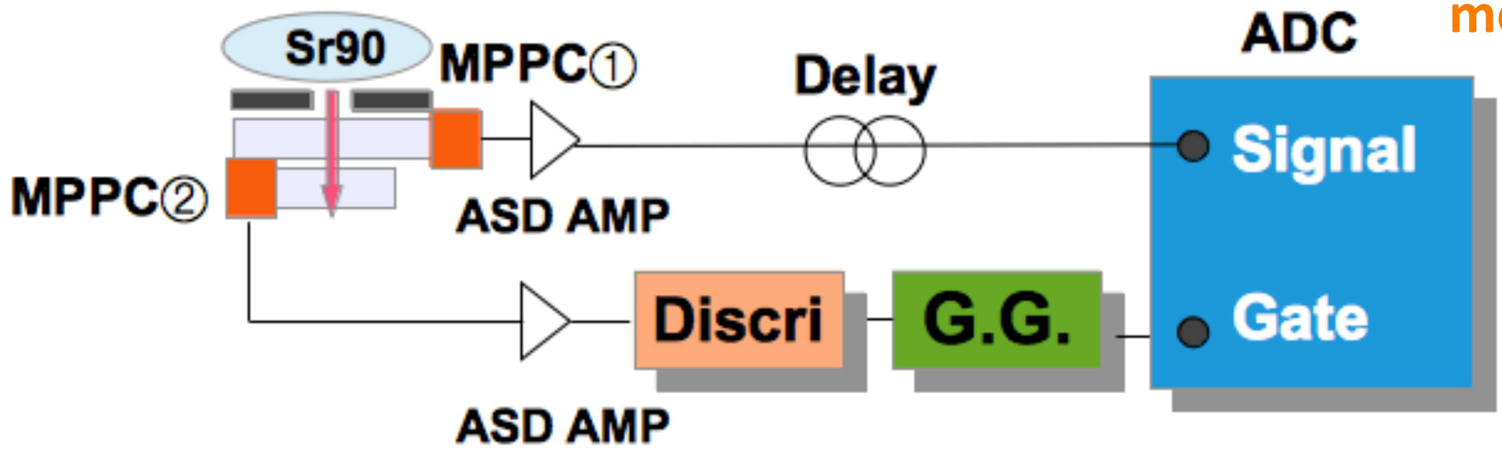
Both counters C1 and C2 should have the same time resolution, since both counters are identical, they are operated under the same conditions .

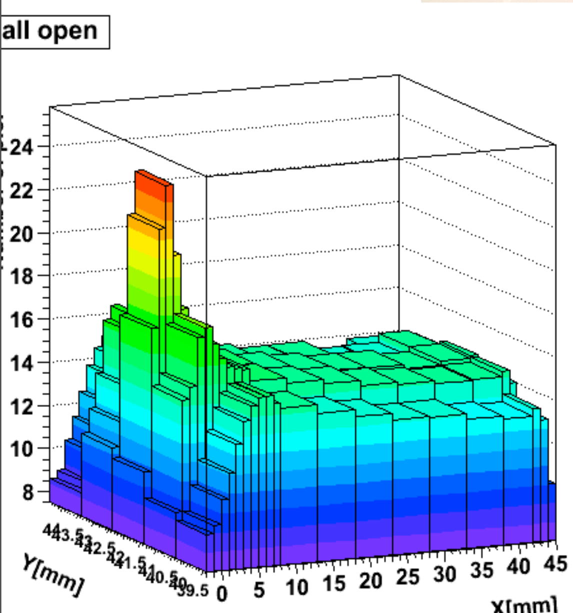
$$\sigma^2_{total} = \sigma^2_{C1} + \sigma^2_{C2} + \sum \sigma^2_{module} = \sigma^2_{MPPC1} + \sigma^2_{Sc1} + \sigma^2_{MPPC2} + \sigma^2_{Sc2} + \sum \sigma^2_{module}$$

Uniformity: Study of 4 deference types for wrapping reflector

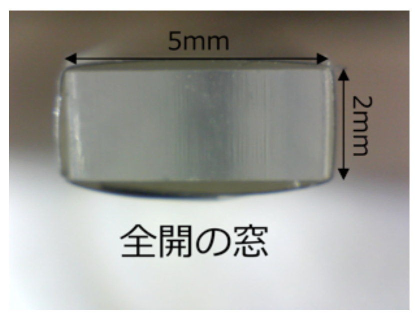
By Tsuzuki measurement







ALL open

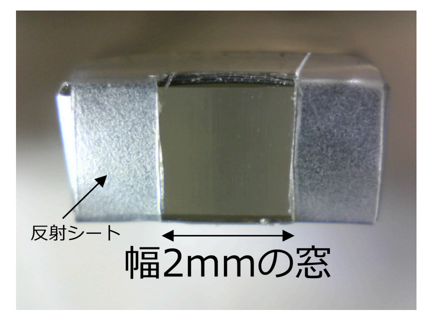


Max of Np.e.~24p.e.

Flat~15p.e.

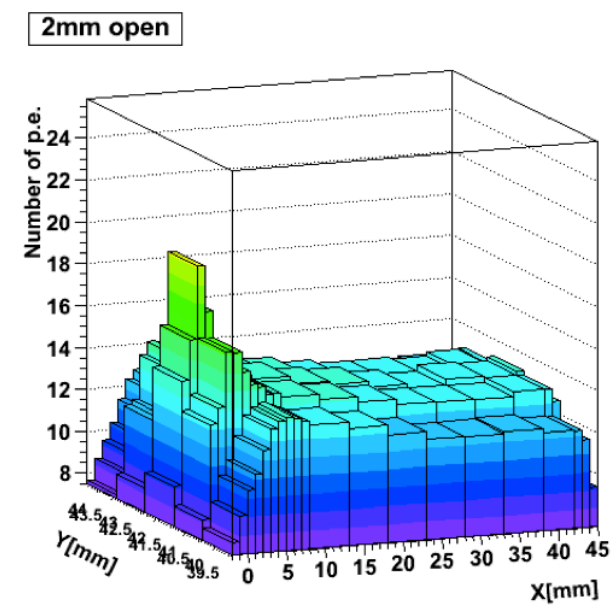
VS

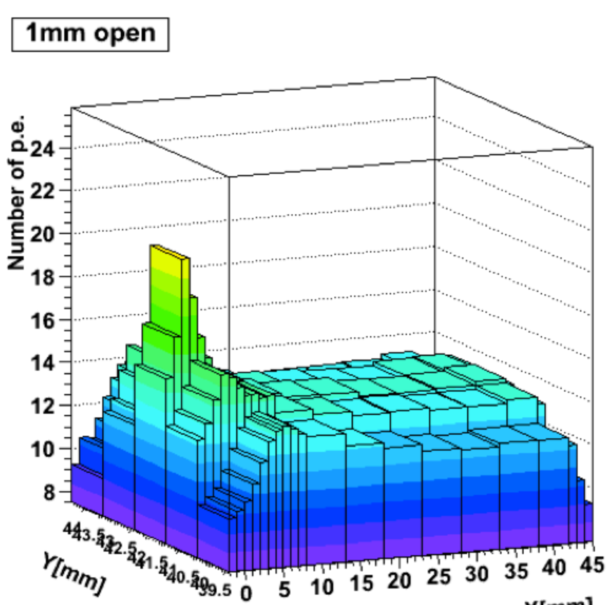
2mm window



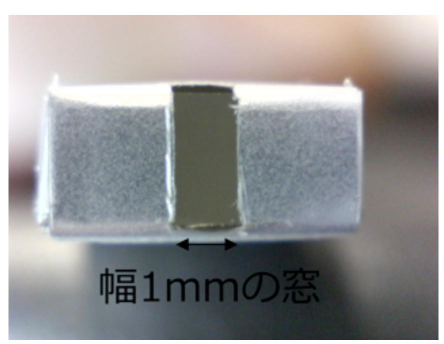
Max of Np.e.~20p.e.

Flat~14p.e.





1mm window

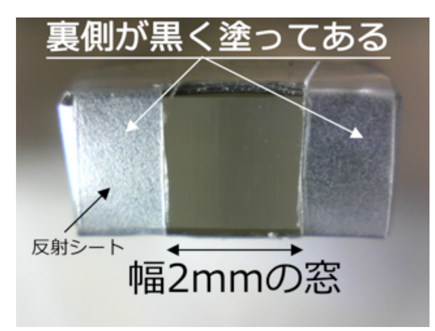


Max of Np.e.~21p.e.

Flat~14p.e.

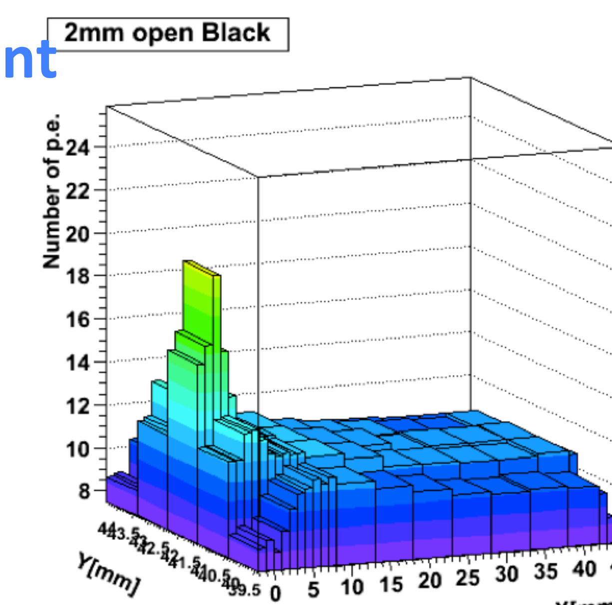
VS

1mm window w/.black paint



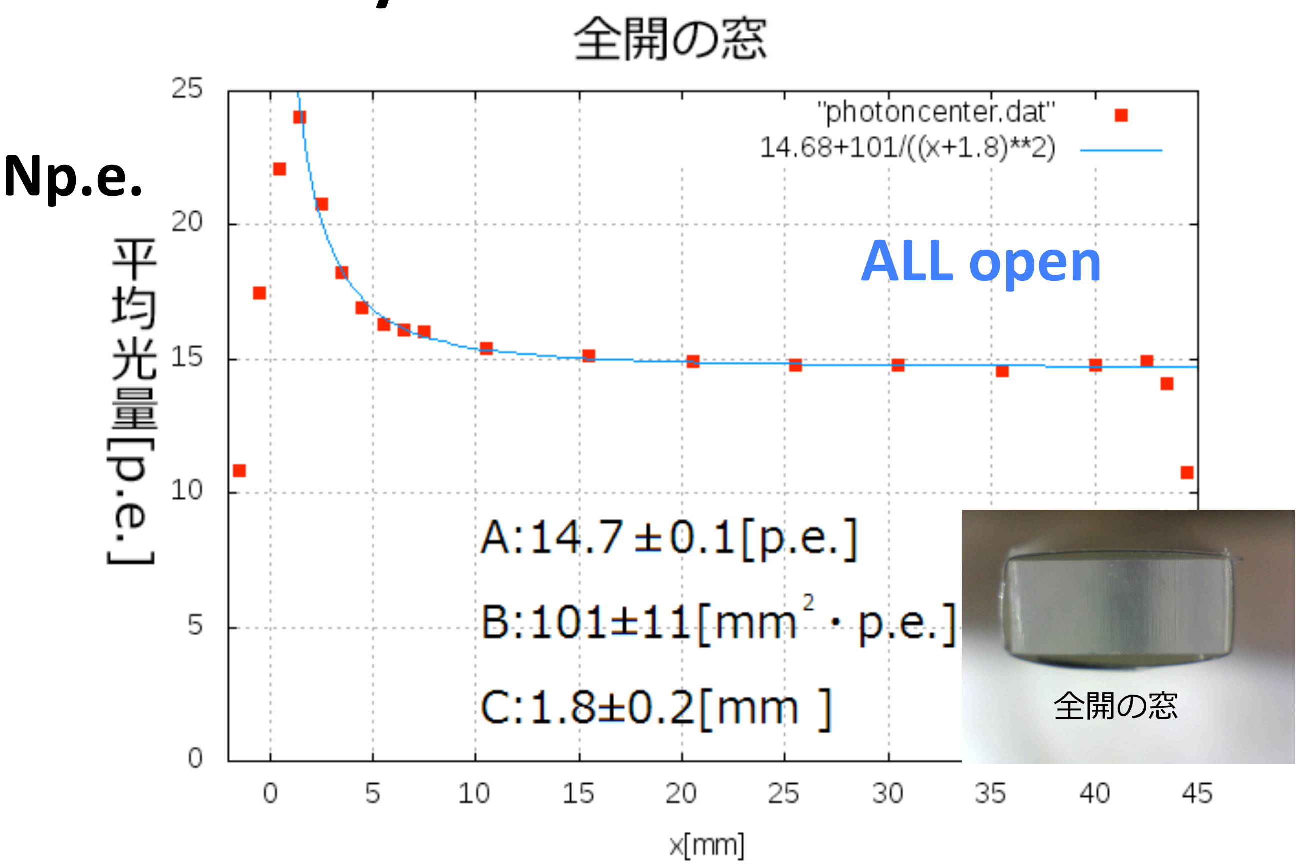
Max of Np.e.~20p.e.

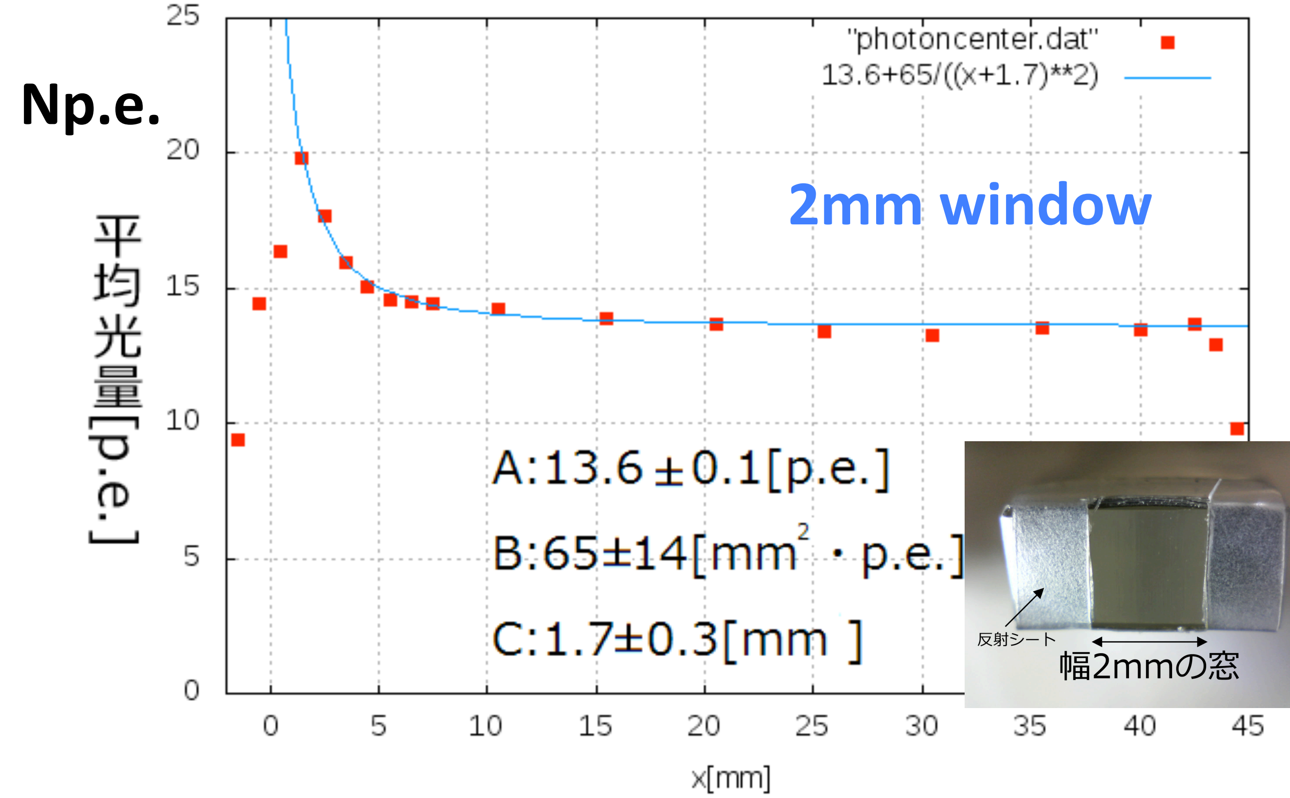
Flat~11p.e.

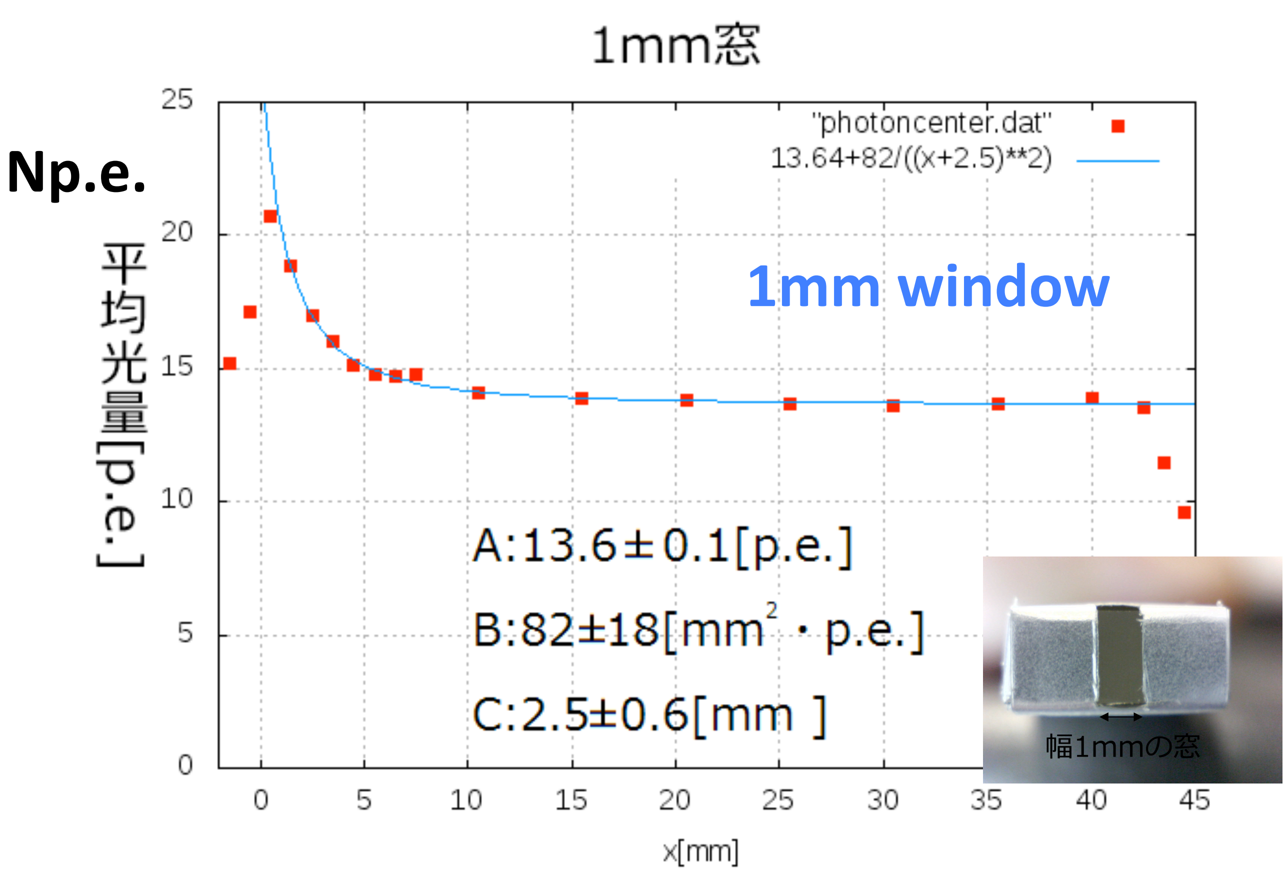


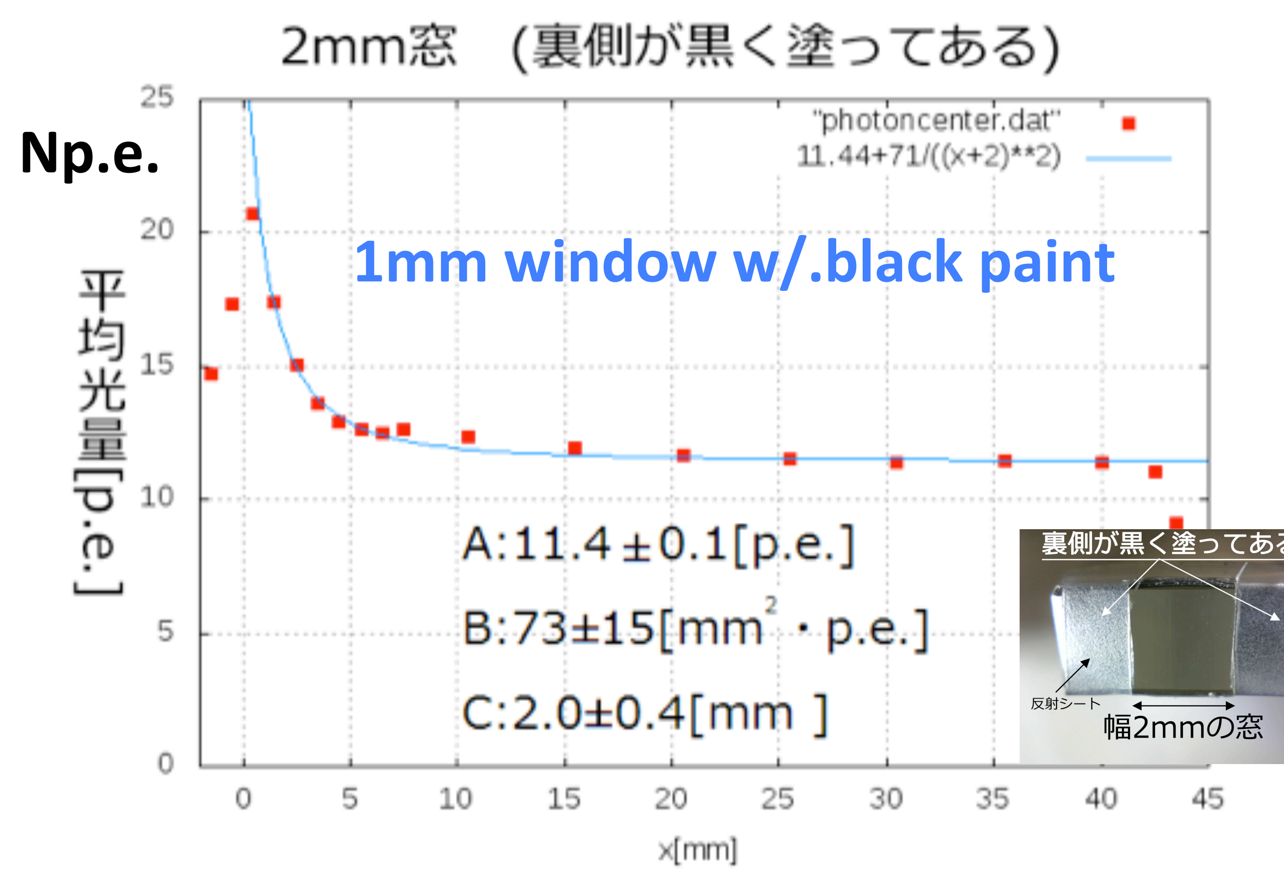
Uniformity

By Tsuzuki measurement









□ We measured light intensity uniformity of plastic scintillator(45mm×5mm×2mm) using Sr Source and studied light intensity deference with reflector condition.