Timing resolution of MPPCs

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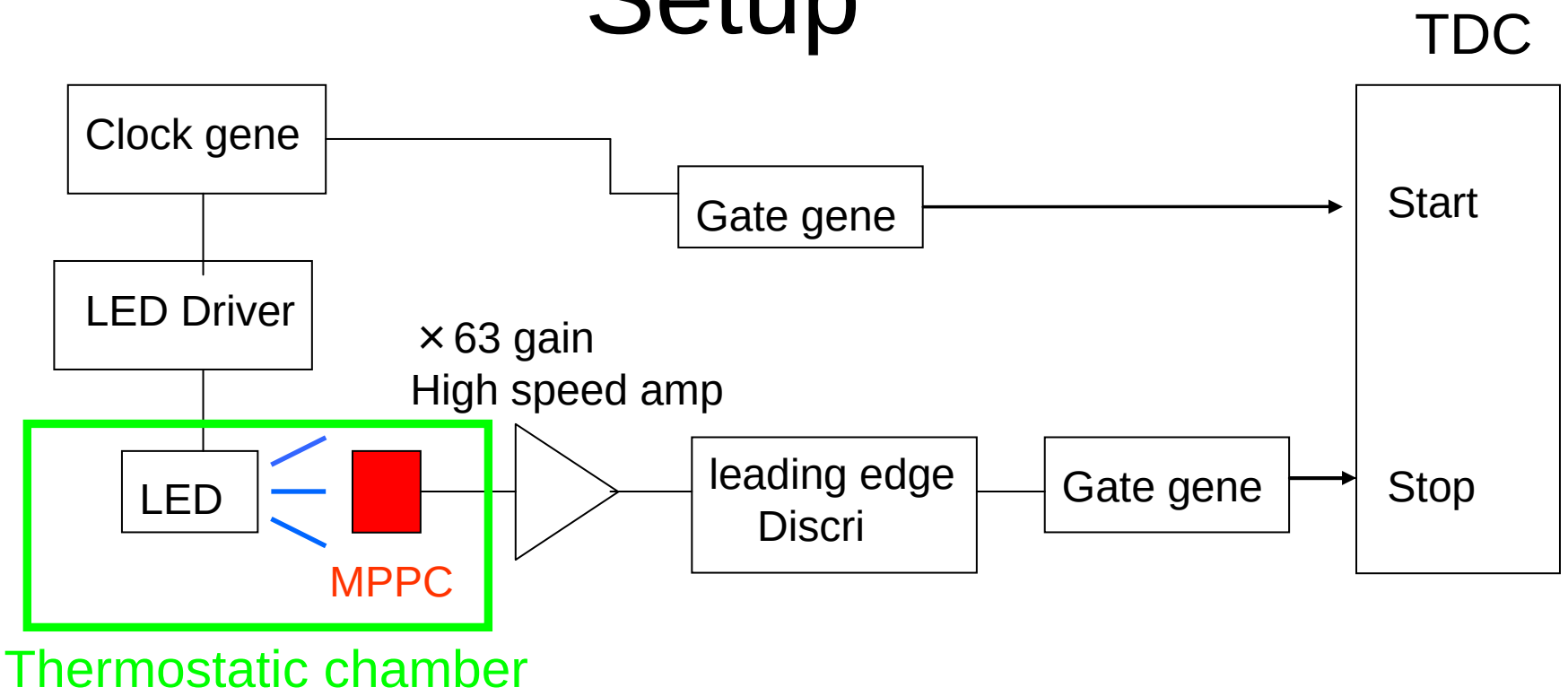
Motivation

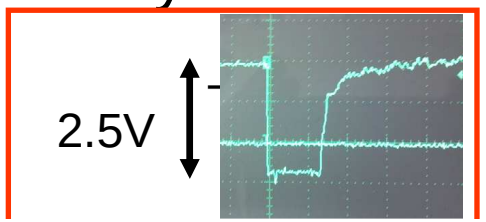
- MPPC would be a great photon sensor for scintillation counter.
- We are studying MPPC performances at high light intensity for ILC Calorimeter.
- Timing resolution is important in particular to CLIC detector.

- We measured Timing resolution of MPPC using blue LED of 15ns width at very big amount of photons where saturation phenomena is expected on the MPPCs.

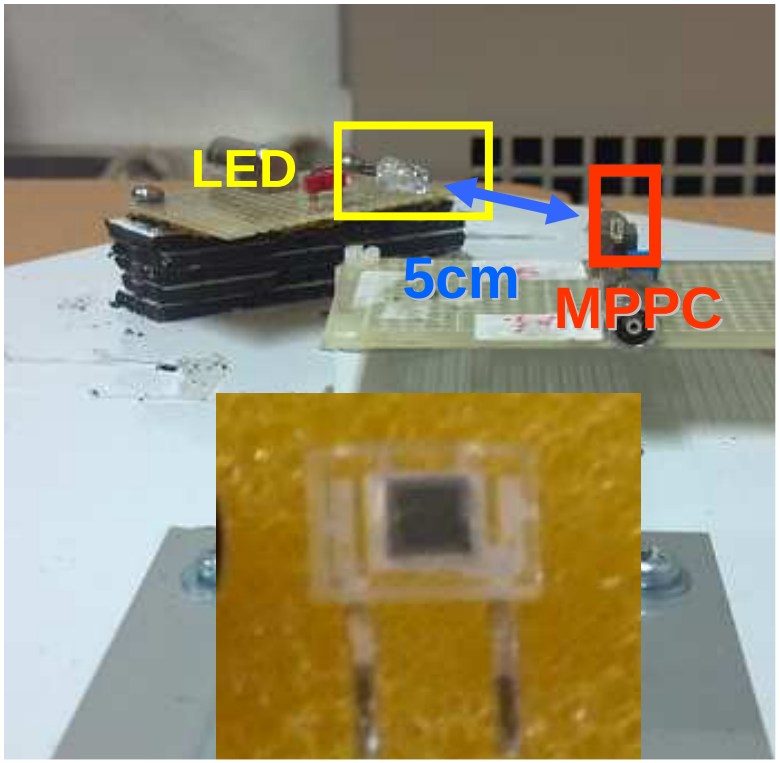
Setup



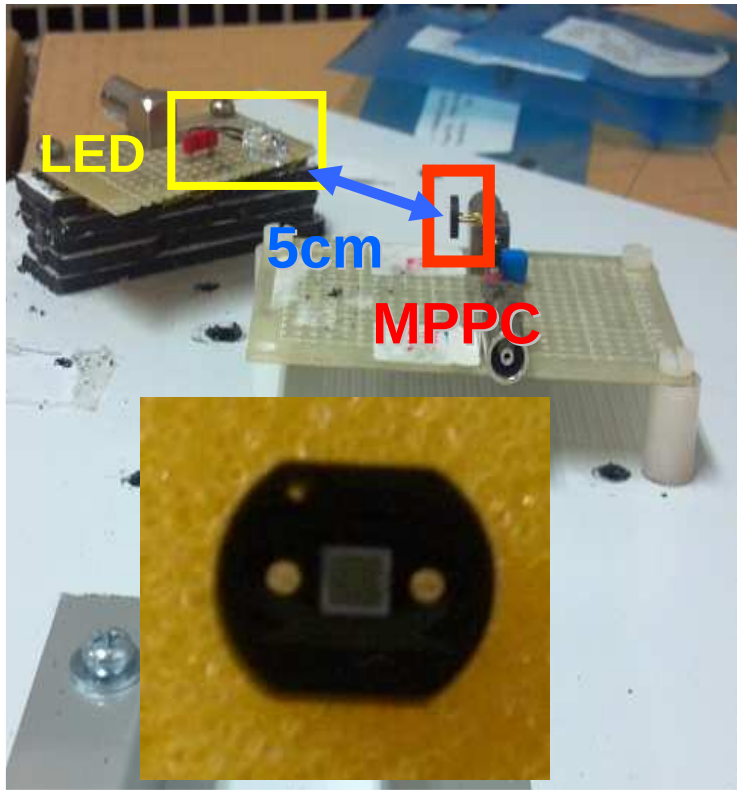
- We can control drive pulse height for the LED by keeping the width of 15ns.
- We have tested four different pixel sizes of the MPPC.
- Signal shape into the discriminator is degraded by amplifier response at high intensity light.



Setup view



For the plastic package



For the ceramic package

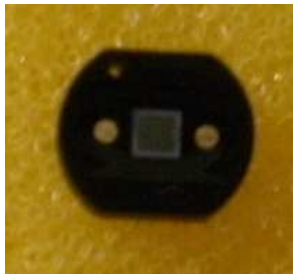
- LED located from MPPC about 5cm.
- MPPC sensor positions is the same for two kinds of packages.

MPPC parameters

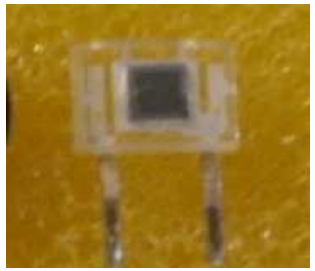
MPPC types 1mm × 1mm.

Pixel size[um]	100	50	25	20
Npix	100	400	1600	2500
over voltage[dV]	1.0	1.0	1.0	1.0
Gain[10^5]	22	6.1	1.2	0.8
Threshold[mV]	300	100	100	100

To compensate gain deference

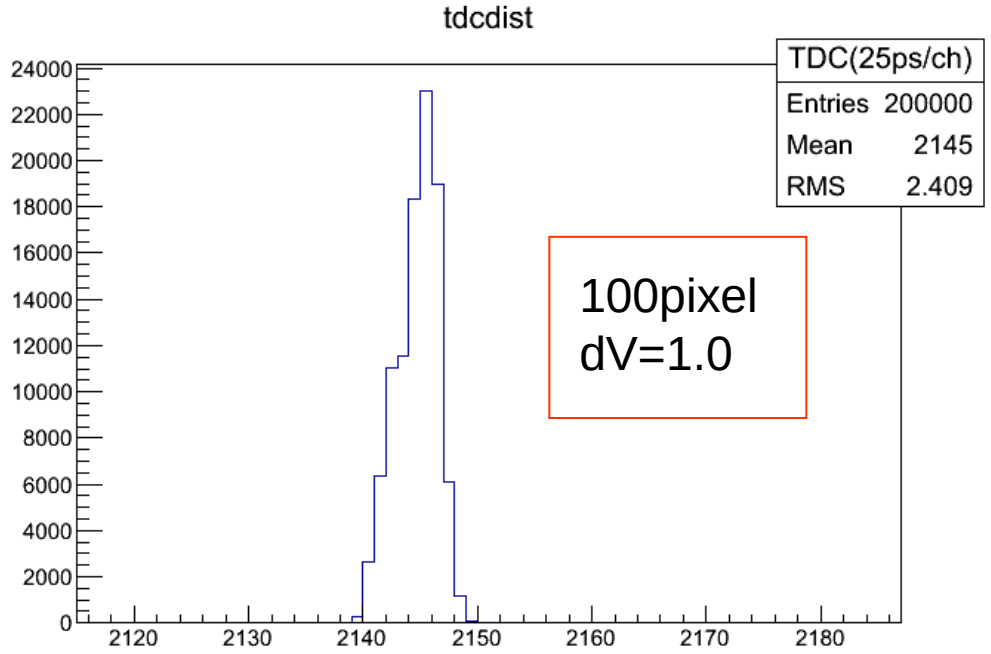


100um , 50um



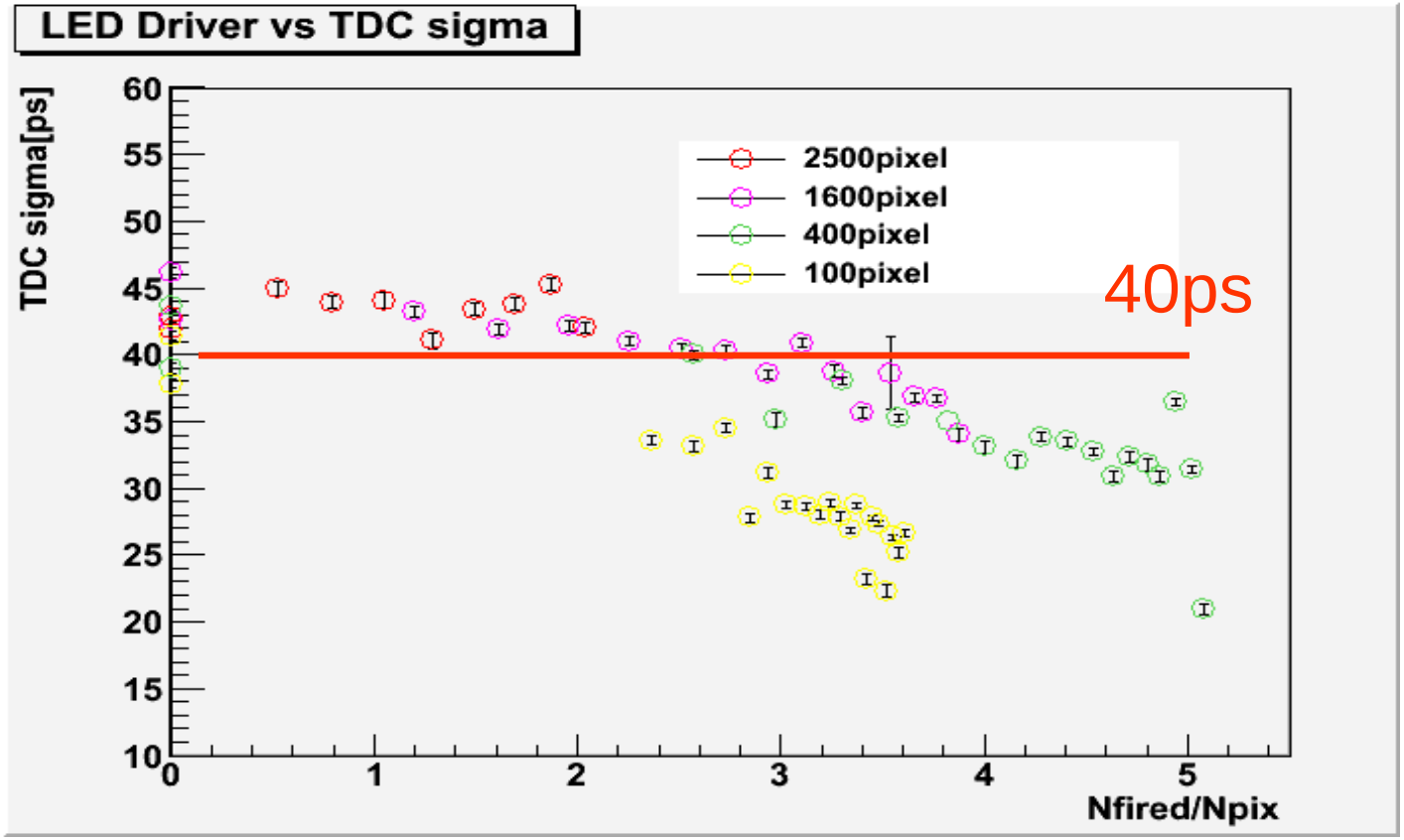
25um , 20um

Timing resolution result



- TDC resolution is 25ps/ch
- Used Gaussian fitting for TDC histogram.
- Used sigma of TDC distribution for evaluation of timing resolution.

Timing resolution

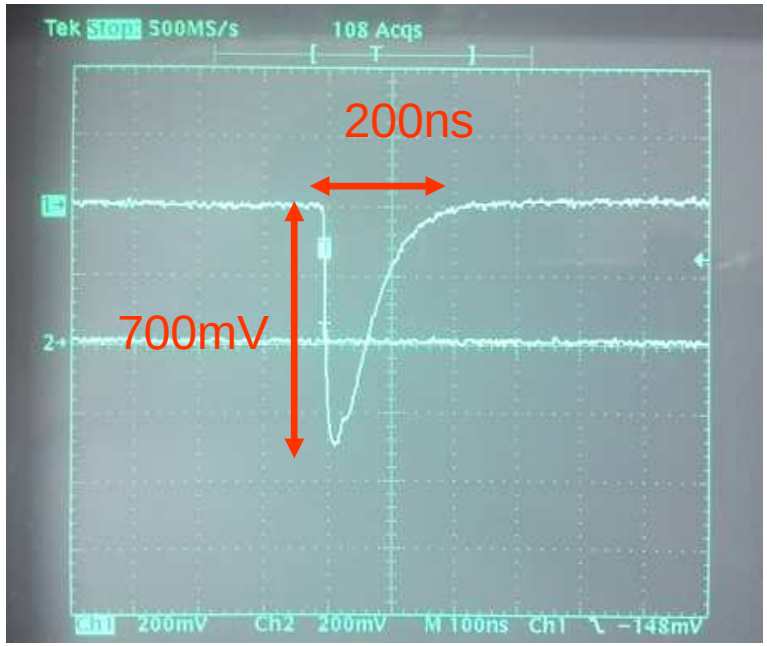


- Timing resolutions are around 40 ps.
- Resolution becomes slightly better with increasing amount of light.
- Data points of 400pixel , 1600pixel , 2500pixel aligned except 100pixel.

Threshold dependence

<Test parameter>

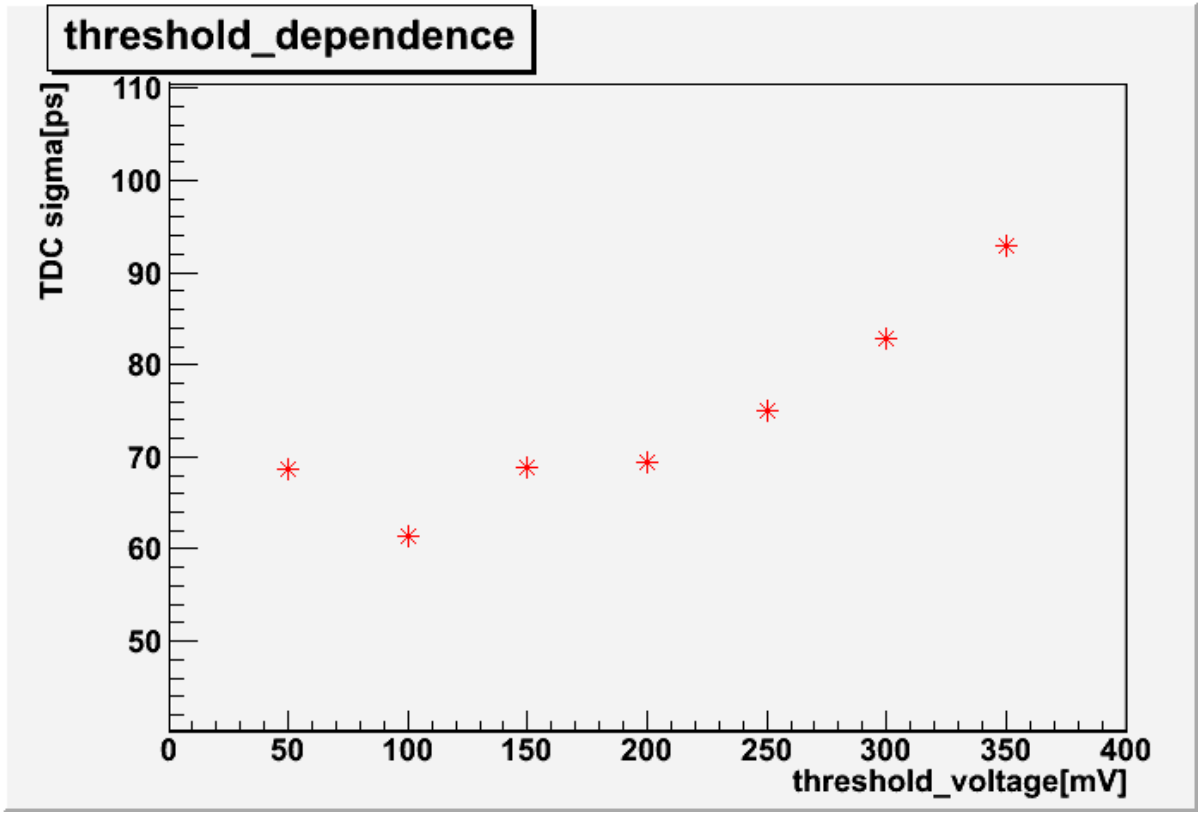
- 100pixel MPPC
- Over Voltage = 0.1V
- Gain = 2.2×10^5
- with AMP (gain = 63)



MPPC signal at test condition

We measured TDC sigma with changing threshold voltage.
We used only 100pixel.

Threshold dependence result



- Timing resolution was bitter at lower threhsold.

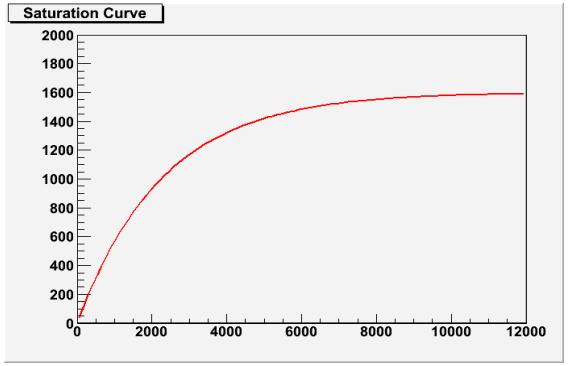
Saturation study

- A pixel can detect only one photon in a short time (~ns).

→MPPC can't detect more photons than number of pixels at once.

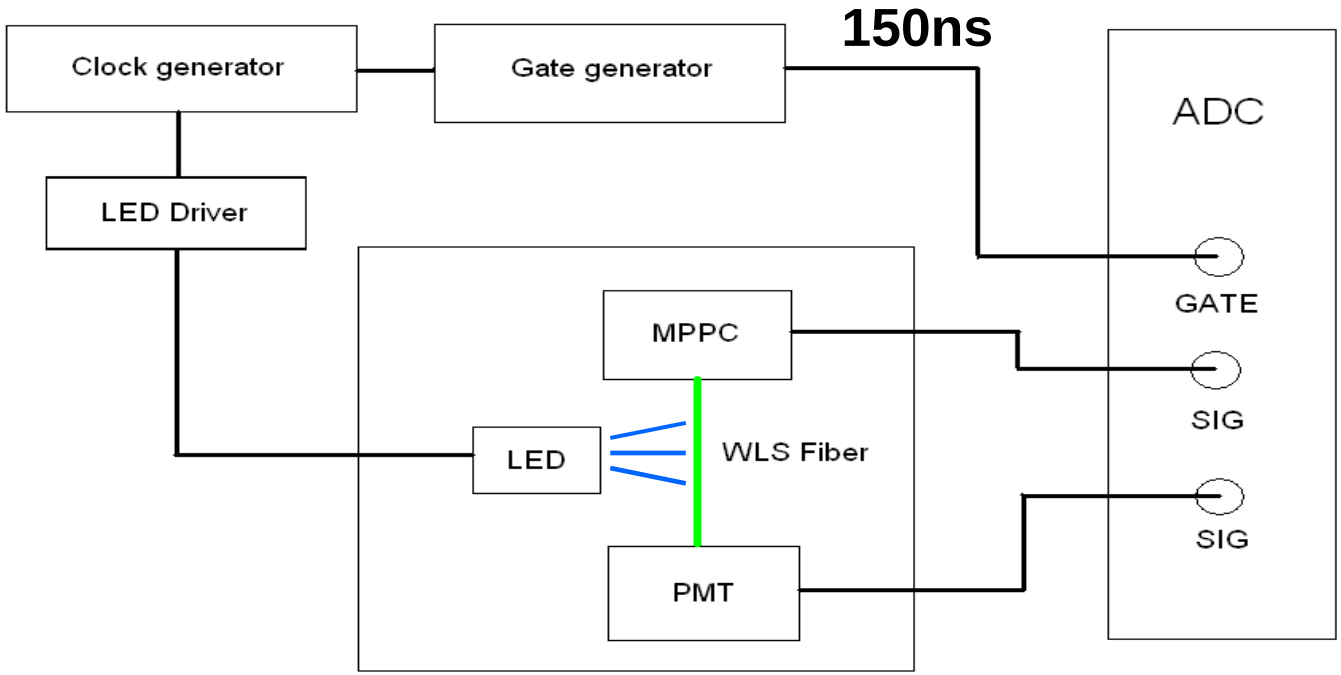
- Number of pixels fired (N_{fired}) and photons entered (N_{in}) are related in the formula if it happens less than 1ns.

$$N_{fired} = N_{pix}\left(1-\exp\left(\frac{-\varepsilon \times N_{in}}{N_{pix}}\right)\right)$$



- Measured saturation curve using LED light of 15ns width.

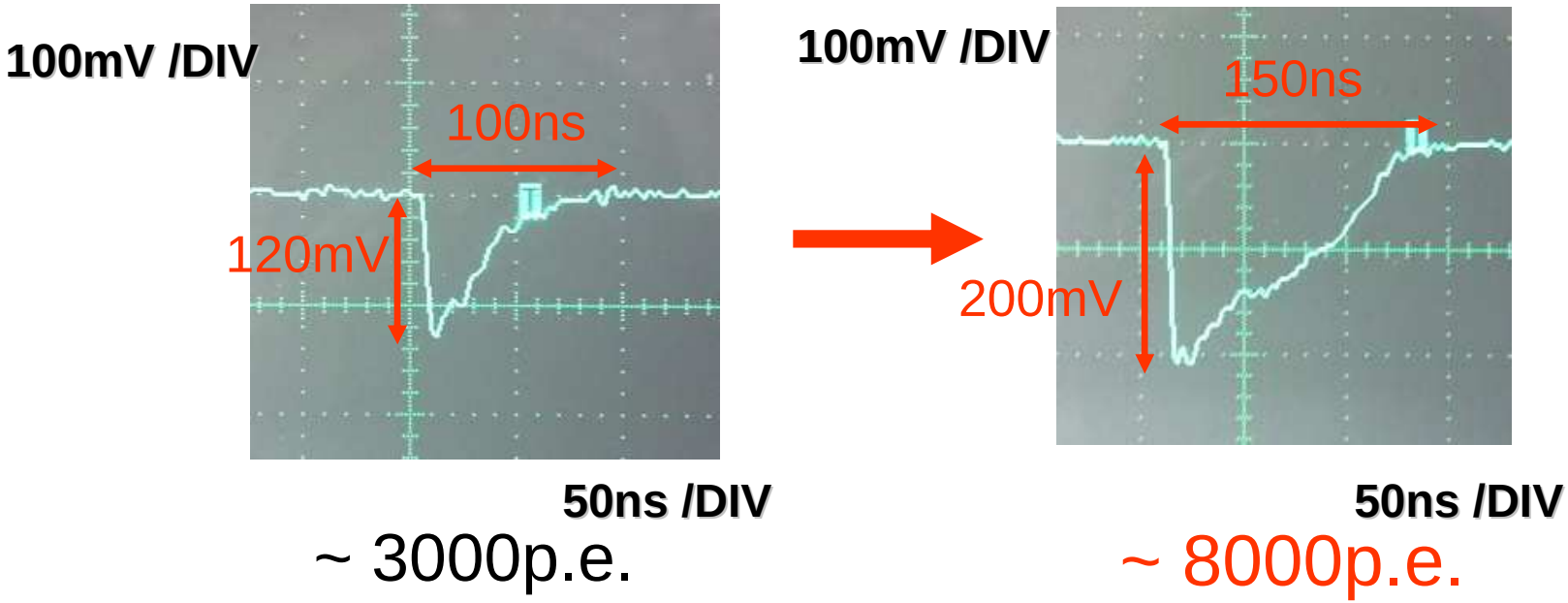
Saturation Setup



- Used blue LED of 15ns width
- MPPCs have 100 , 50 , 25 , 20 , 15 um pixels
- Gain = 1.5×10^5 for all MPPC.

pulse shape w/o AMP

1600pixel MPPC , gain = 1.5×10^5 , dV = 1.25V , w/o AMP



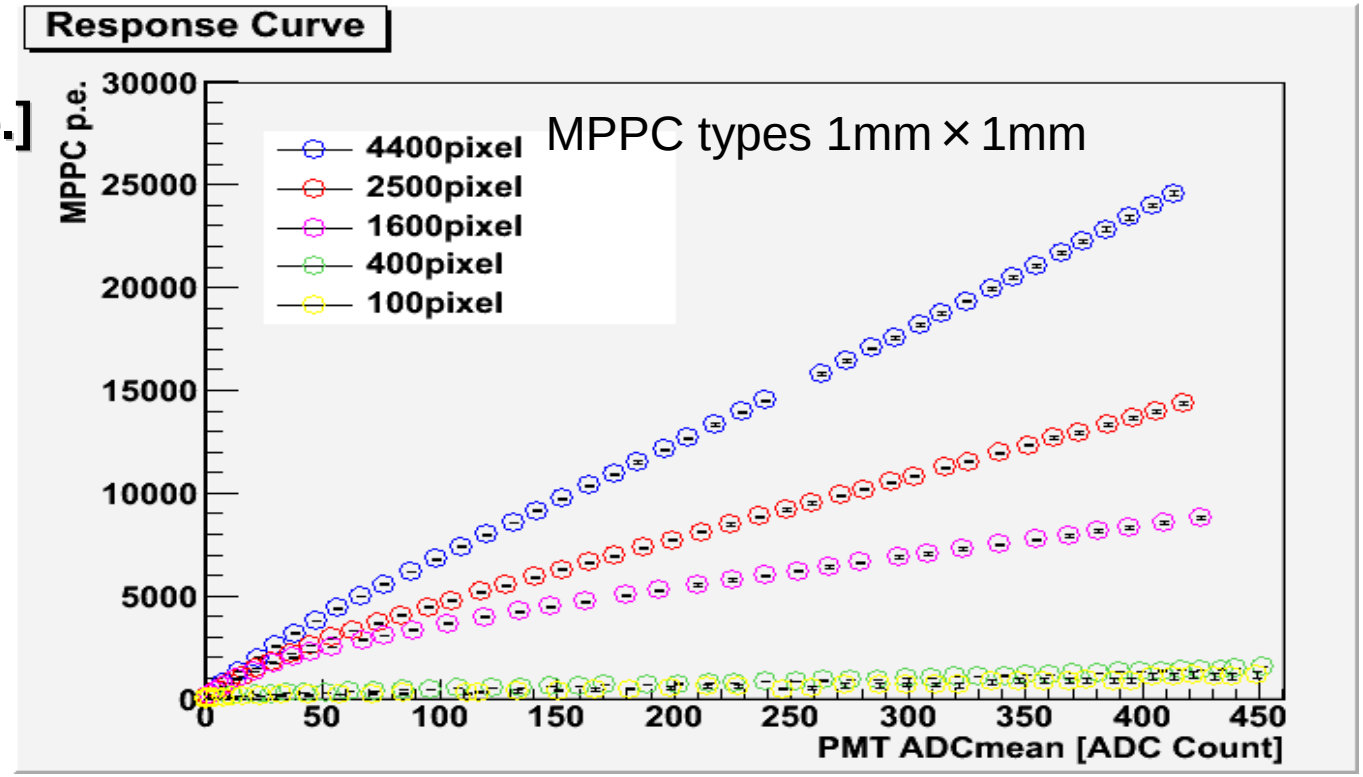
~ 3000p.e.

~ 8000p.e.

- Pulse shape was degraded at high light intensity.
- This phenomena happened to 50um, 25um, 20um MPPC.

Saturation result

Nfired[p.e.]



PMT ADCpeak[0.25pC]

- Nfired reached 25000 p.e. with 15um MPPC.
- Almost linear behavior was seen.

Summary

- Measured timing resolution of MPPCs (100,400,1600,2500pixel in 1mm × 1mm) using LED.
- resolutions of 3 MPPCs are about 40ps, and 100pixel is about 30ps.

- threshold dependence of timing resolution using only 100pixel.
- Timing resolution is bitter at lower threshold as expected.

- Measured saturation curve using blue LED of 15ns width.
- Nfired increased linearly with large amount of photons.

Prospect

- Measure timing resolution and saturation without changing LED driver bias.
- Measure timing resolution and saturation in other condition.
- Measure threshold dependence using other MPPC.

Thank you for your kind attention.