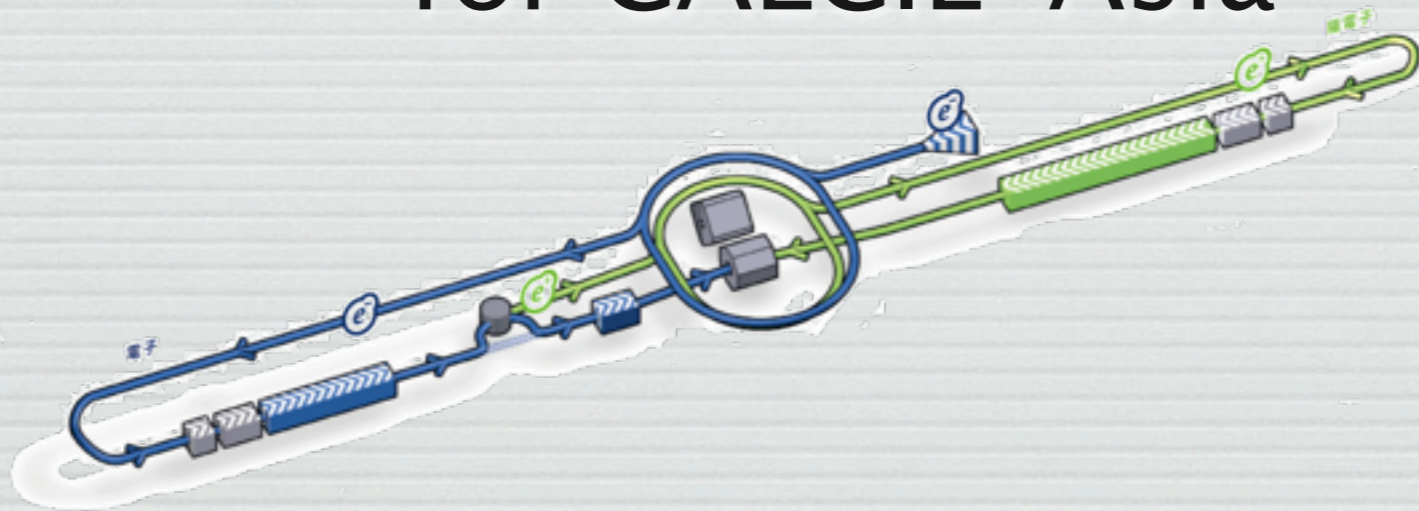


MPPPC progress

LCWS2012 @ Texas
Tohru Takeshita (Shinshu)
for CALCIE-Asia



Shinshu
University



- ▶ development of MPPC
numbers of pixels
saturation & linearity
timing resolution

scintillator ECAL

→ to satisfy 5~10mm granula

→ required by PFA

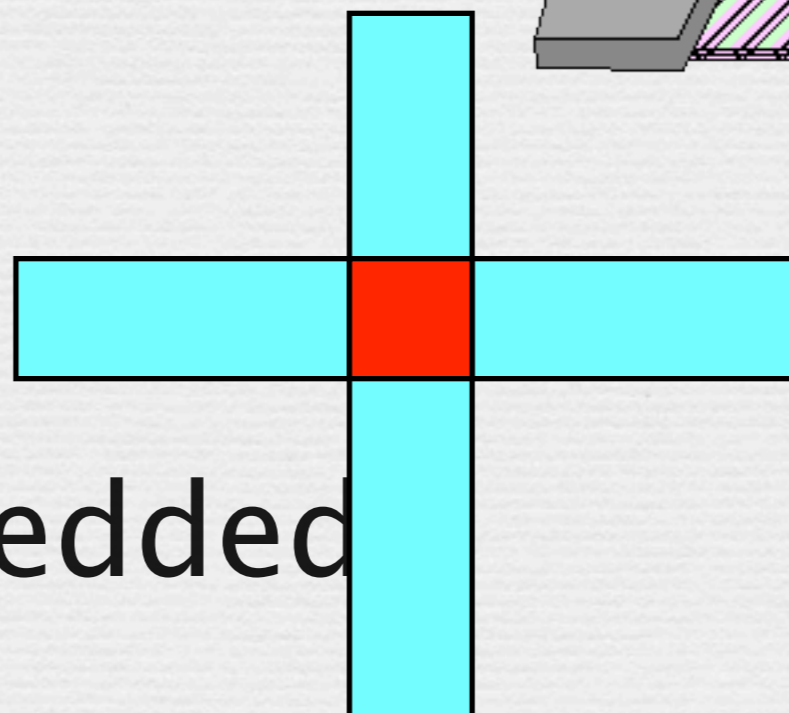
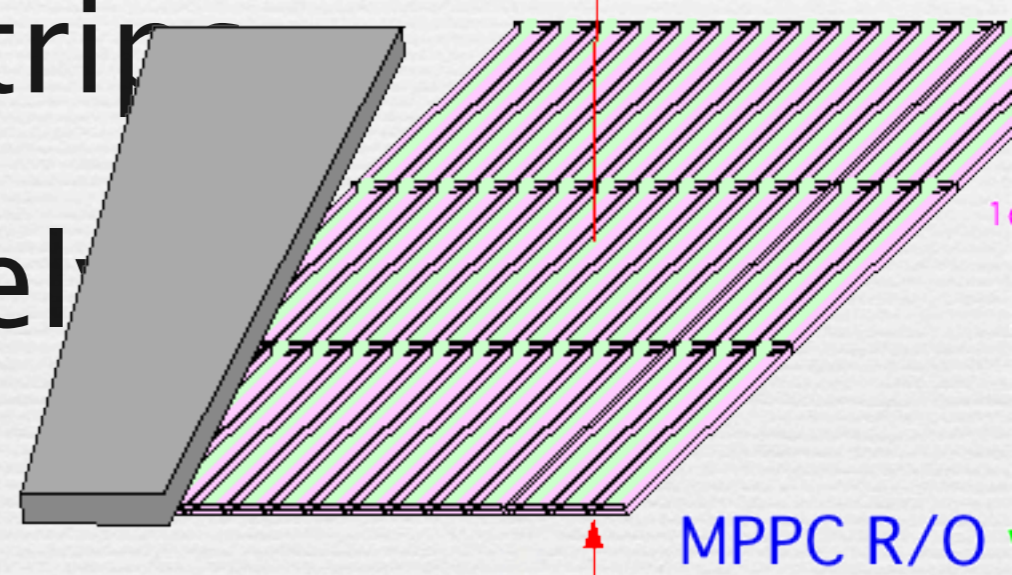
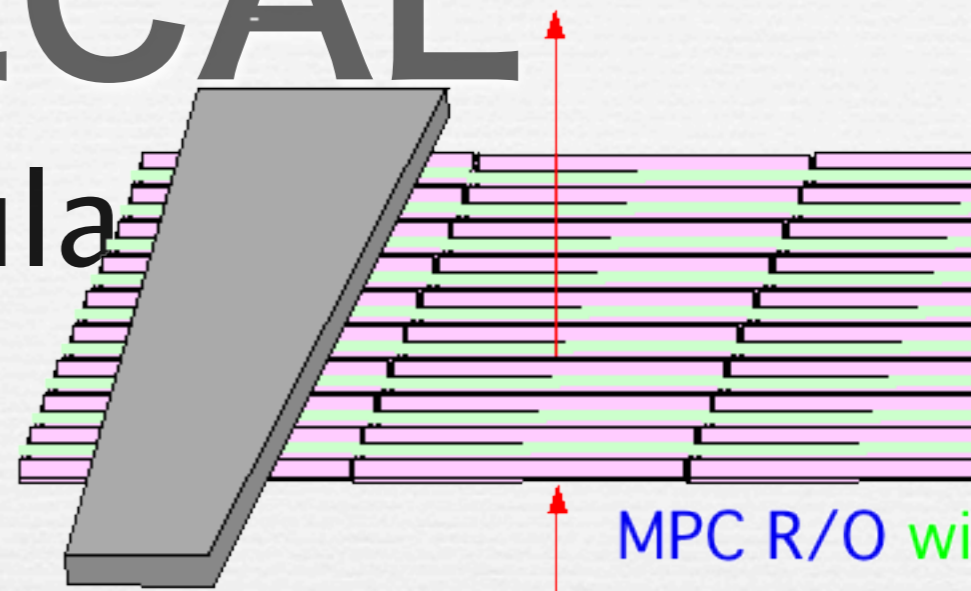
→ orthogonal scintillator strip

→ high granularity effectively

→ thinner layers

→ MPPC read out

→ electronics embedded



scintillator ECAL

→ to satisfy 5~10mm granula

→ required by PFA

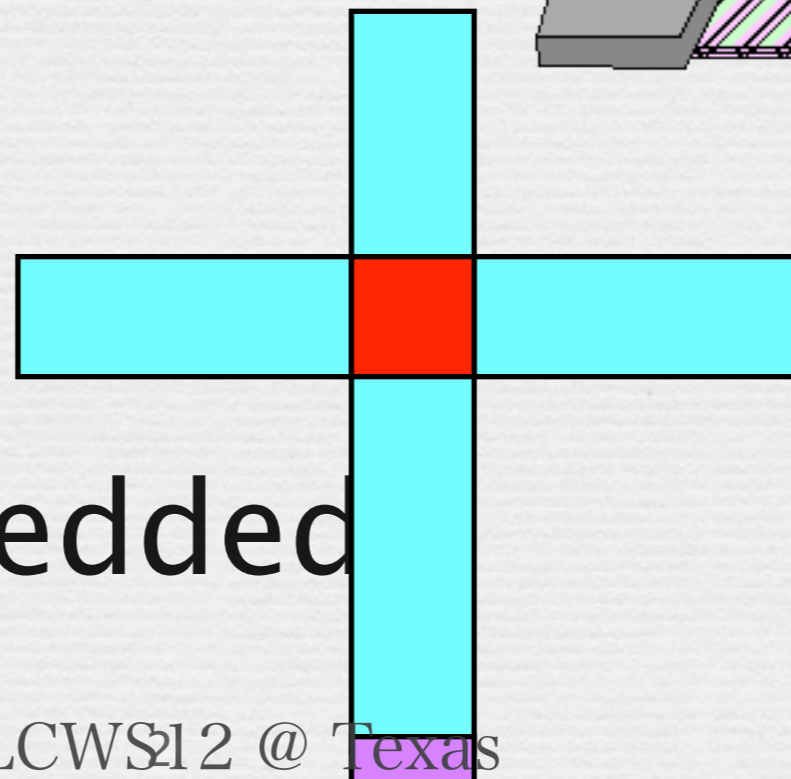
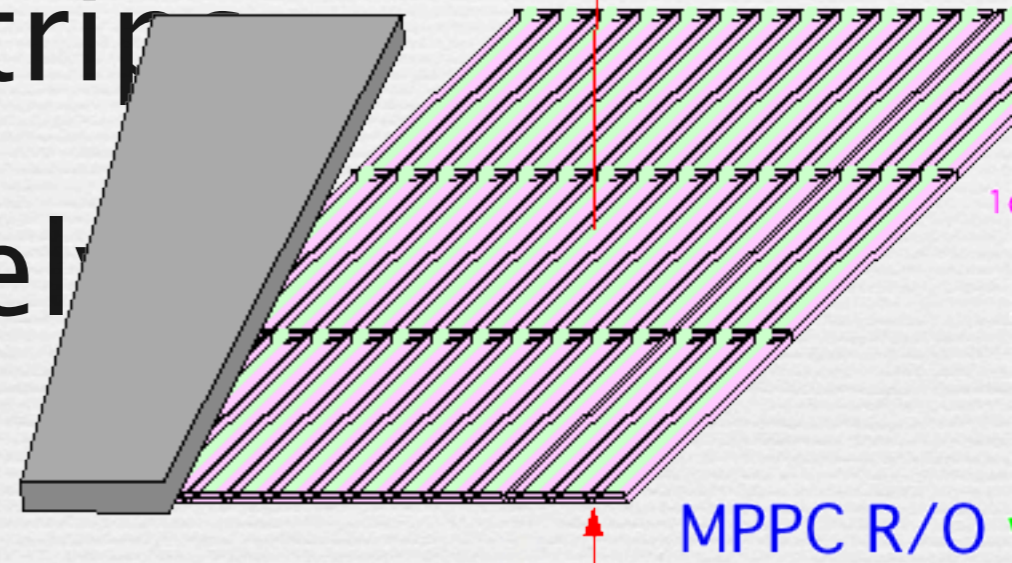
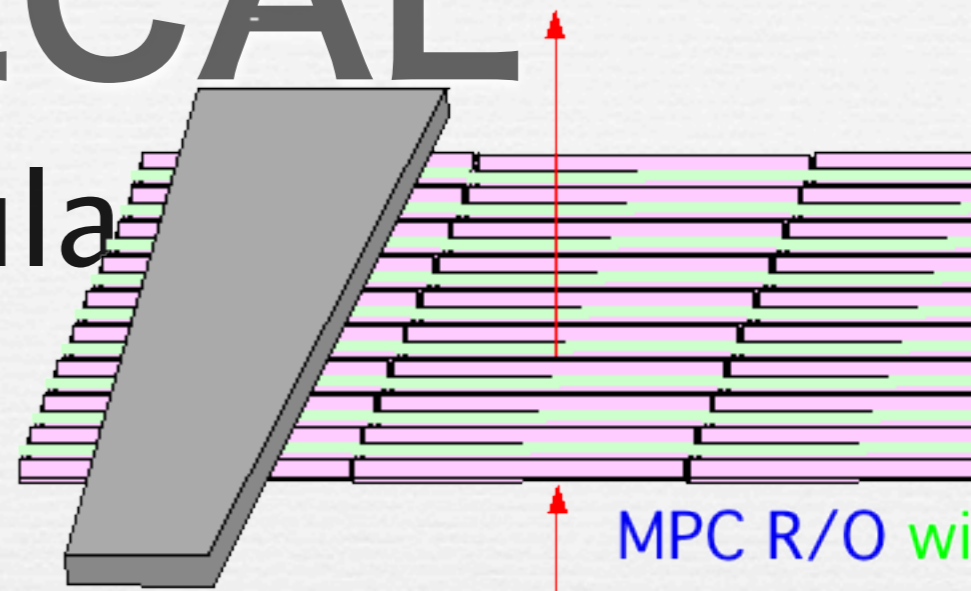
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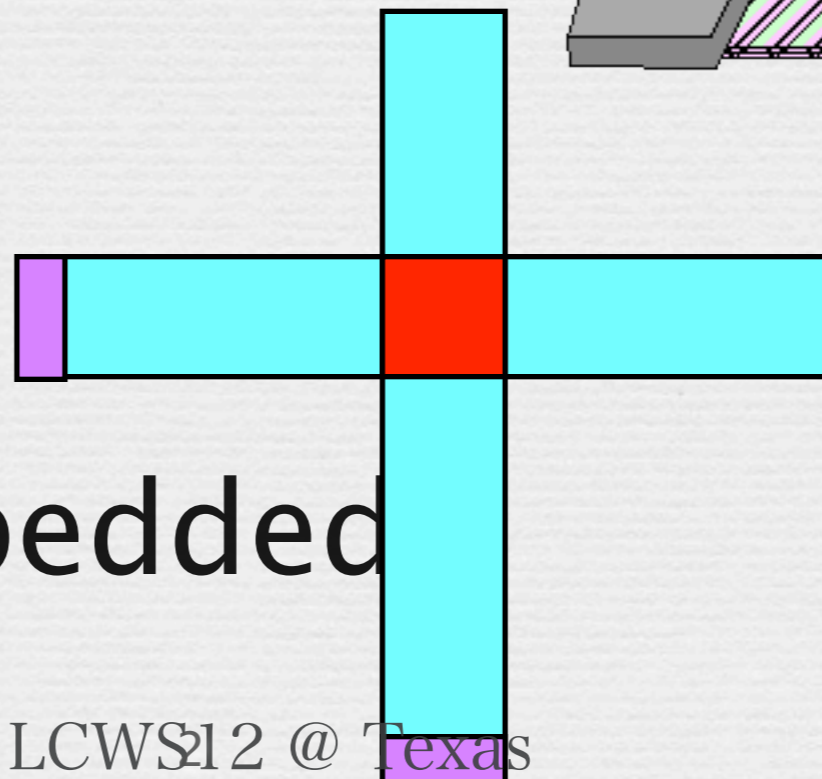
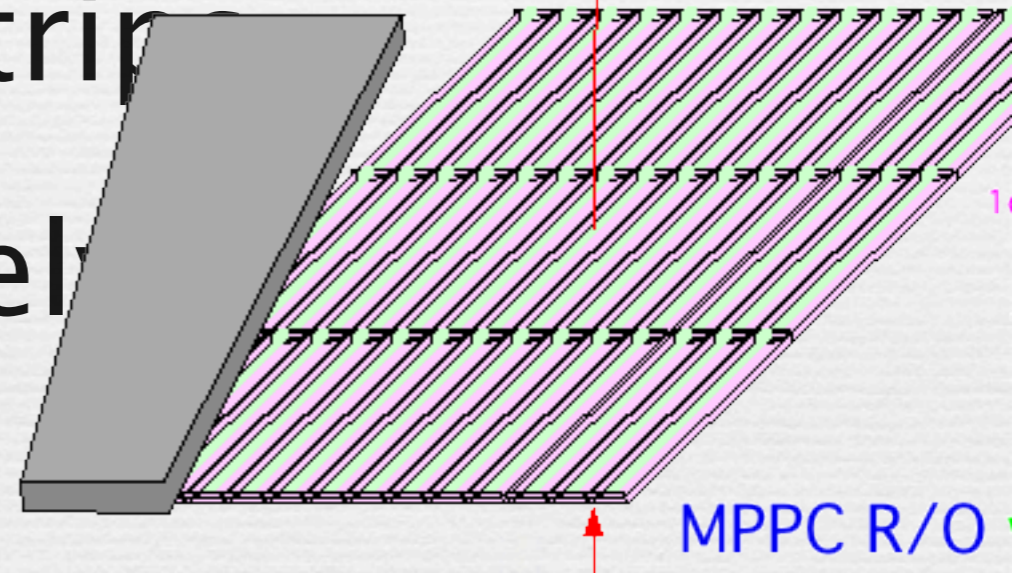
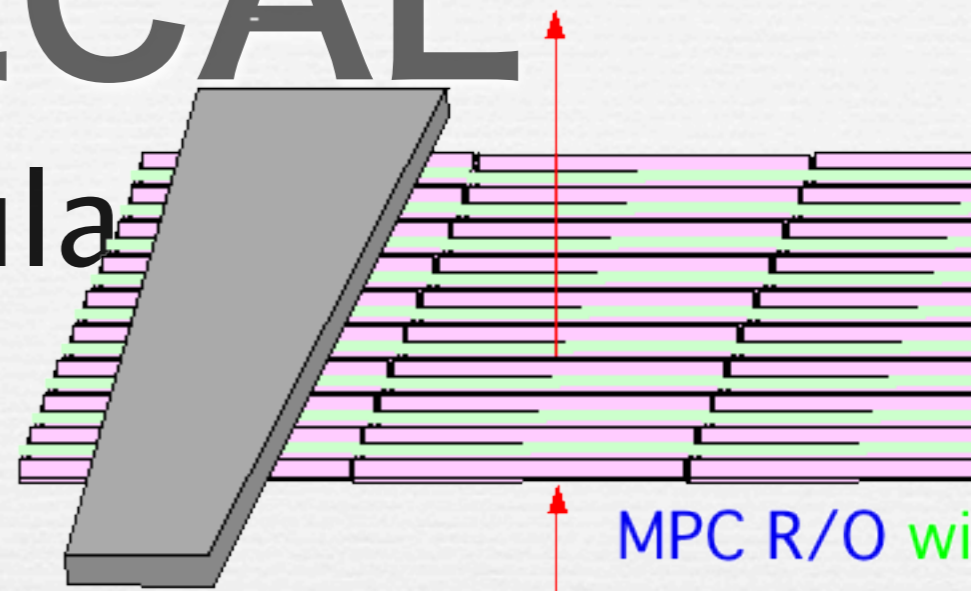
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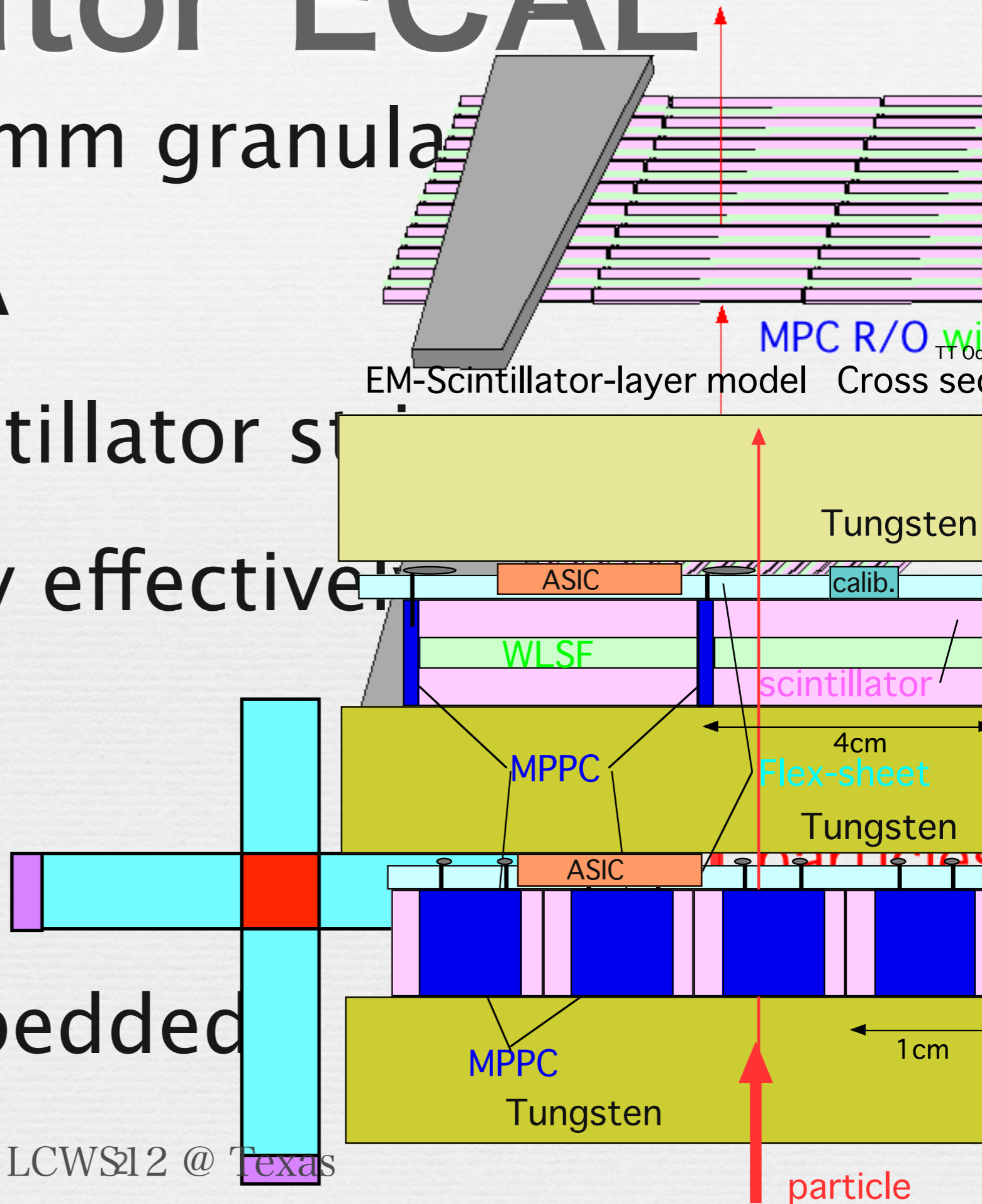
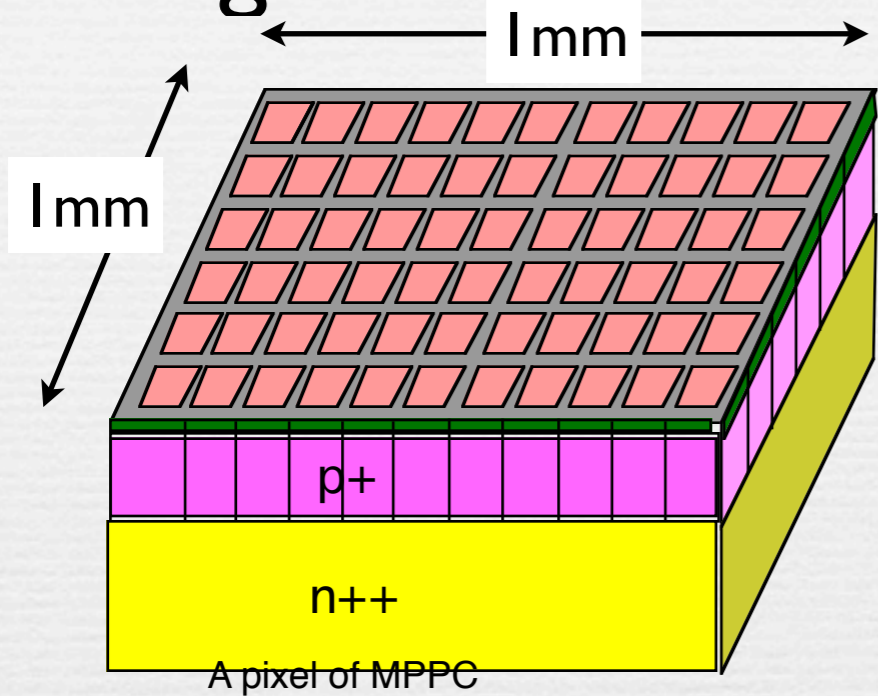


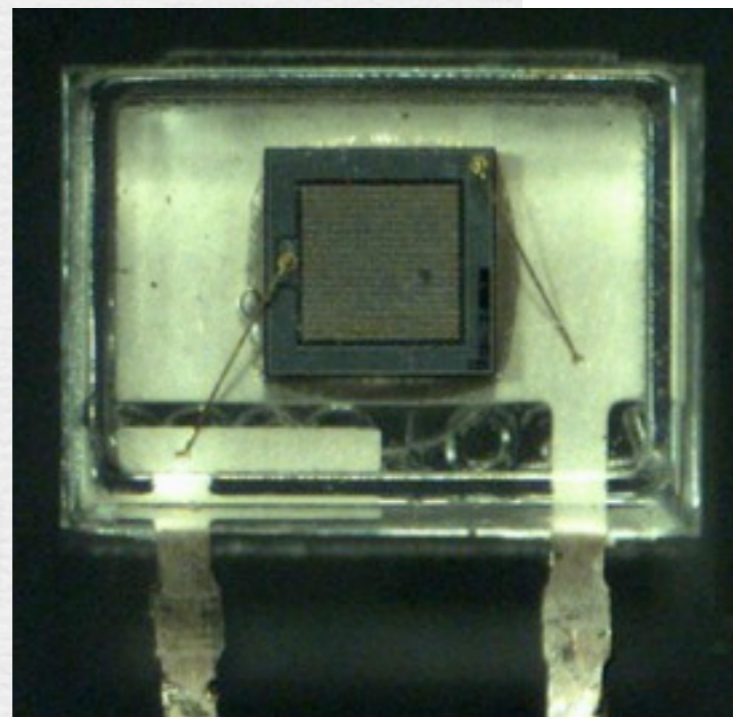
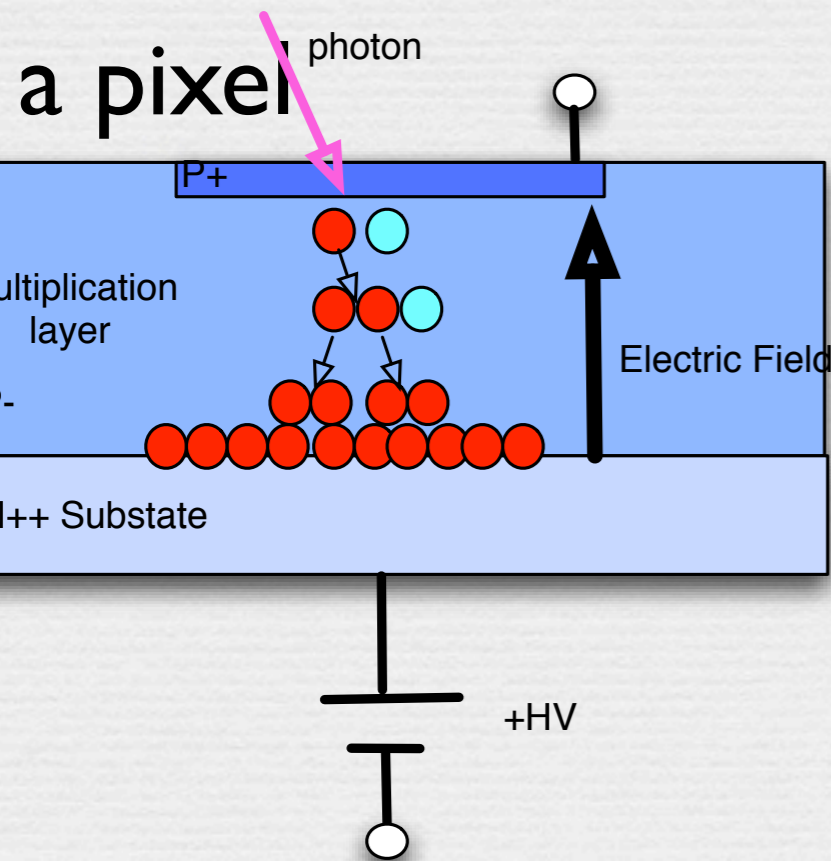
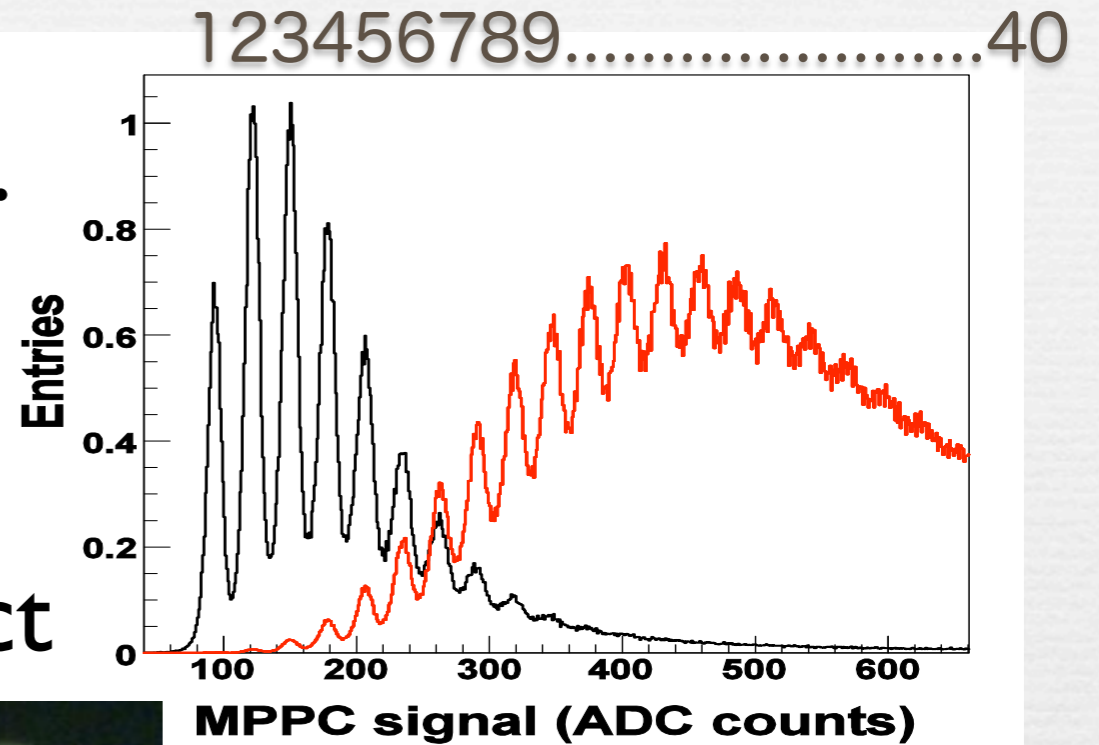
photo-sensor

- MPPC: new type of photon sensor : Pixlated Geiger Mode APD



of p. e.
= # of pix

MPPC pict



high gain $\sim 10^{5\sim 6}$
 blue sensitive
 low Voltage $\sim < 100V$
 small $\sim 1\text{mm}^2$
 insensitive to mag.

MPPCCs

→ **100,400, 1600 pixels in 1mm x 1mm**

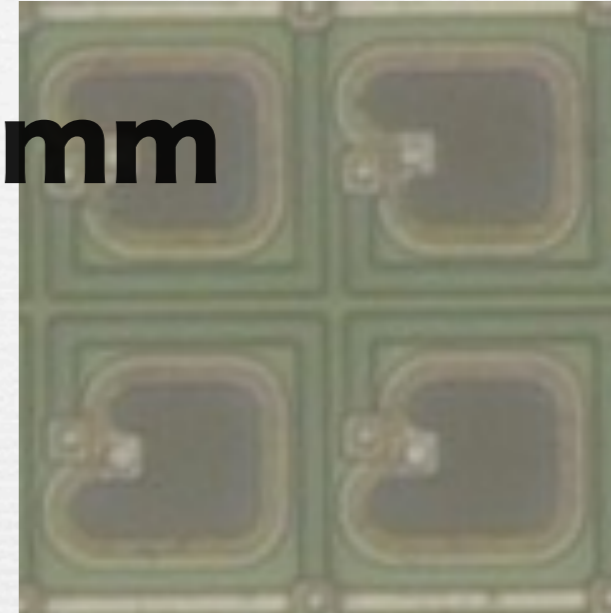
available in the market

→ **100,50, 25 μm pitches**

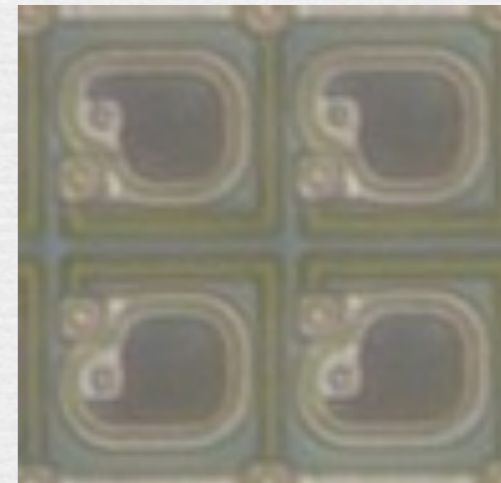
→ **2500 and 4400 pixels in 1mm x 1mm**

→ **20 & 15 μm pitches**

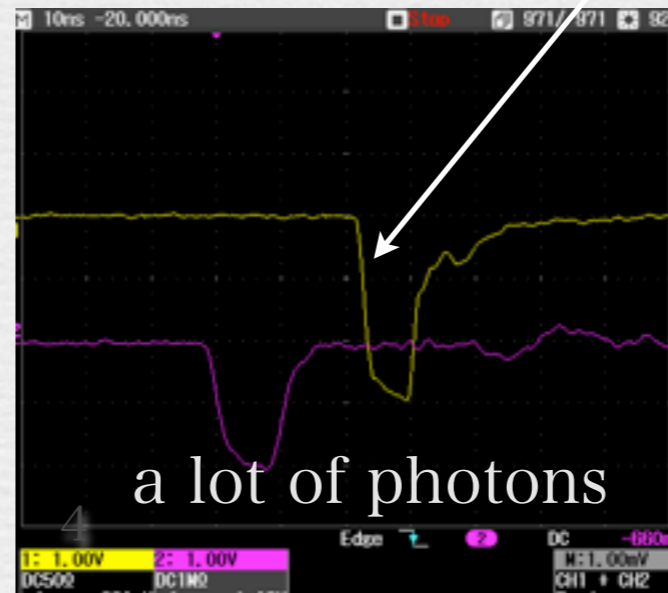
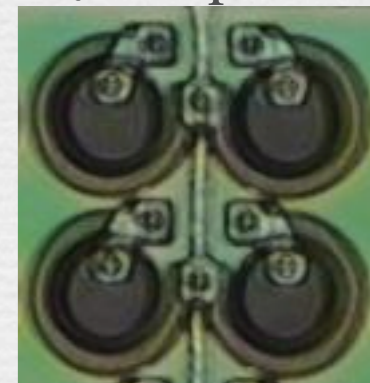
25 μm pitch



20 μm pitch



15 μm pitch



saturation in MPPPC

→ saturation occurs when lots of photons in a very **short time**

→ Bias voltage recovers in short time $\sim 4\text{ns}$

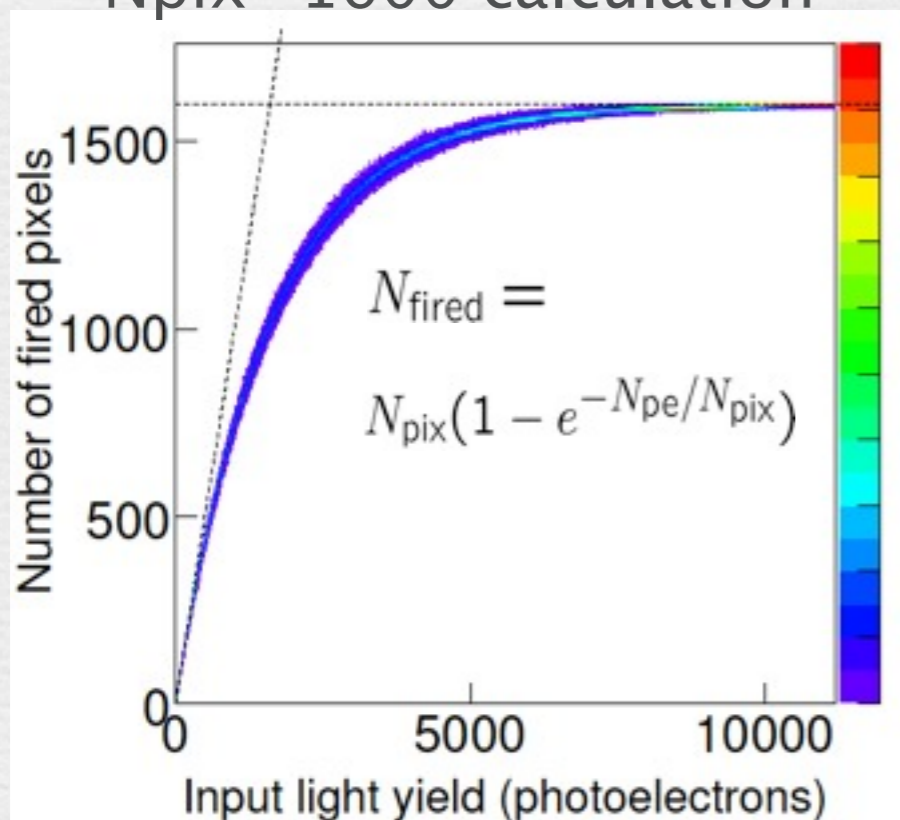
$$N_{\text{fired}} = N_{p0} \left(1 - \exp\left(-\frac{p1N_{\text{true}}}{N_{p0}}\right) \right)$$

→ more than numb. of **pix**

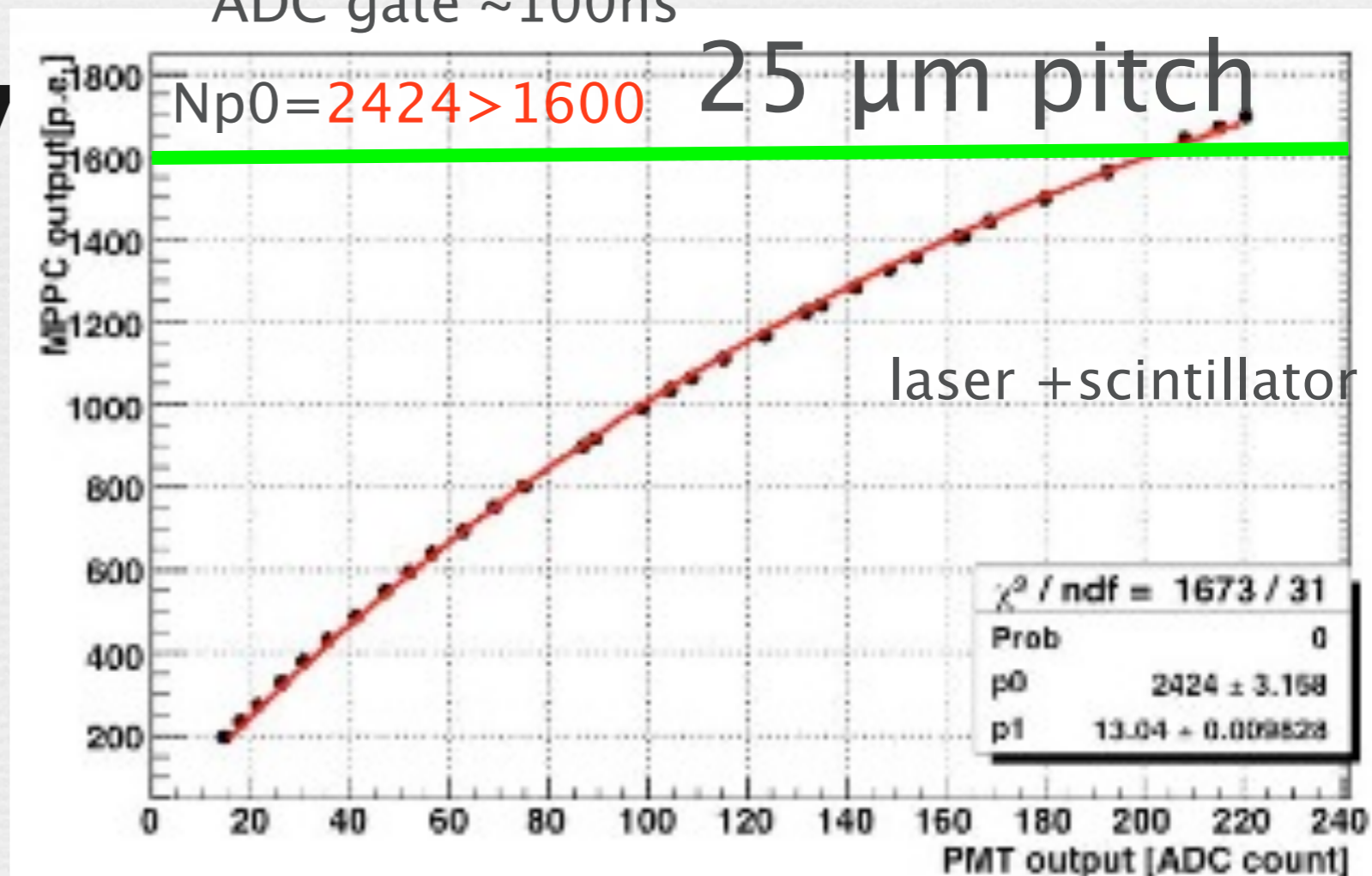
ADC gate $\sim 100\text{ns}$

→ **non-linear behavior**

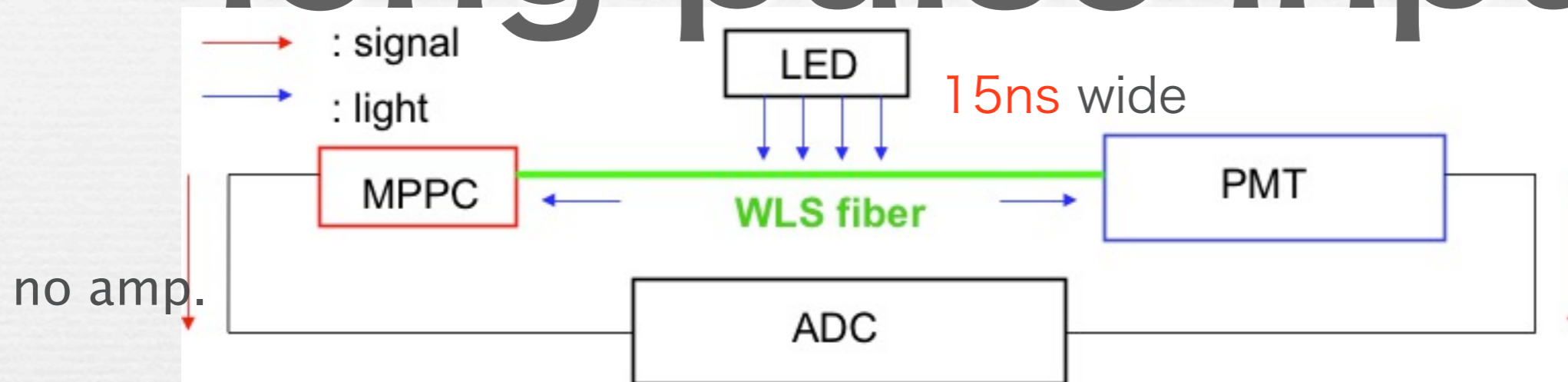
$N_{\text{pix}} = 1600$ calculation



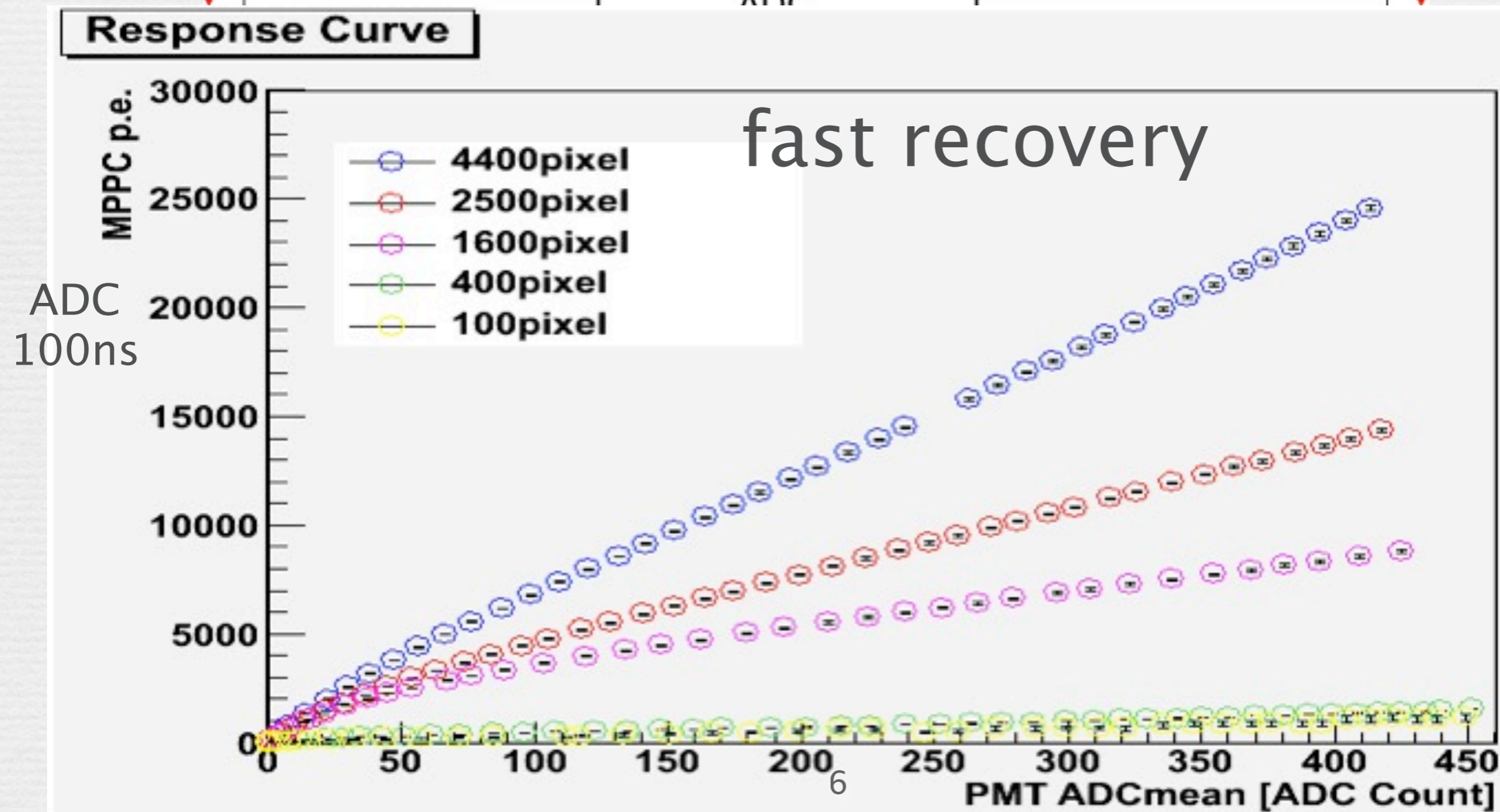
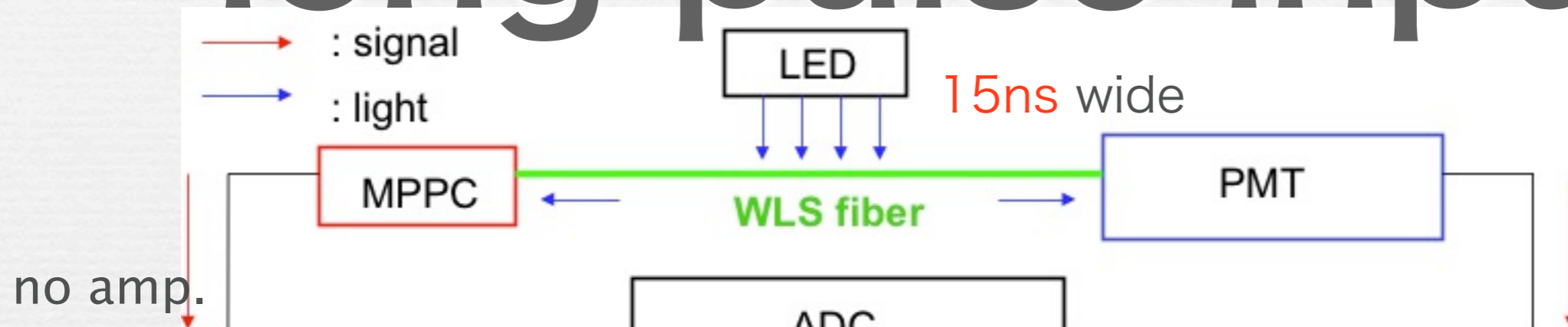
$p1N_{\text{true}}$



non-saturation when long pulse input

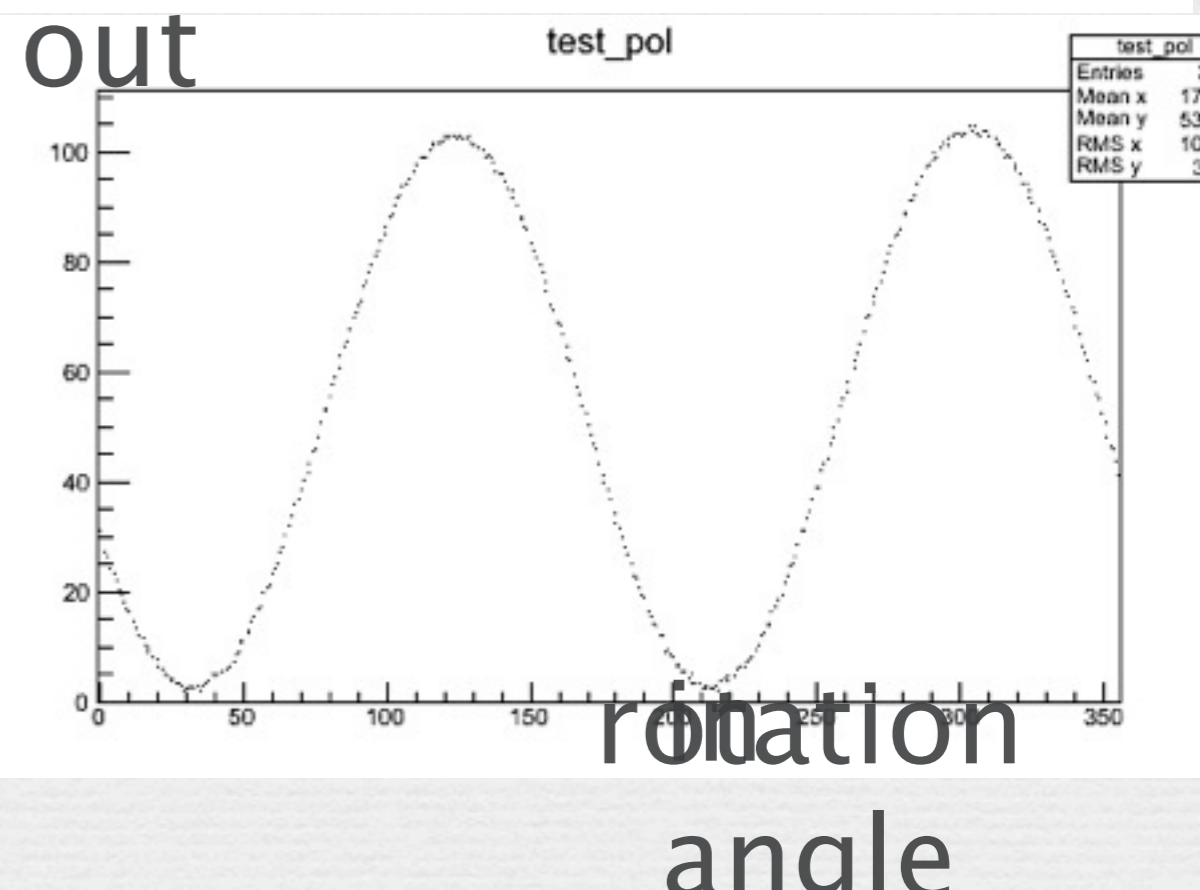
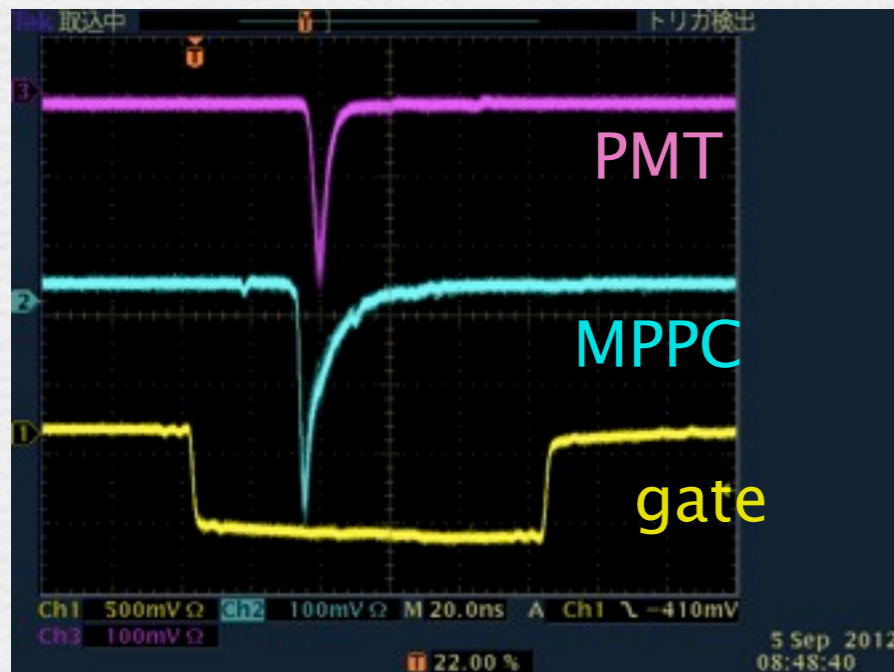
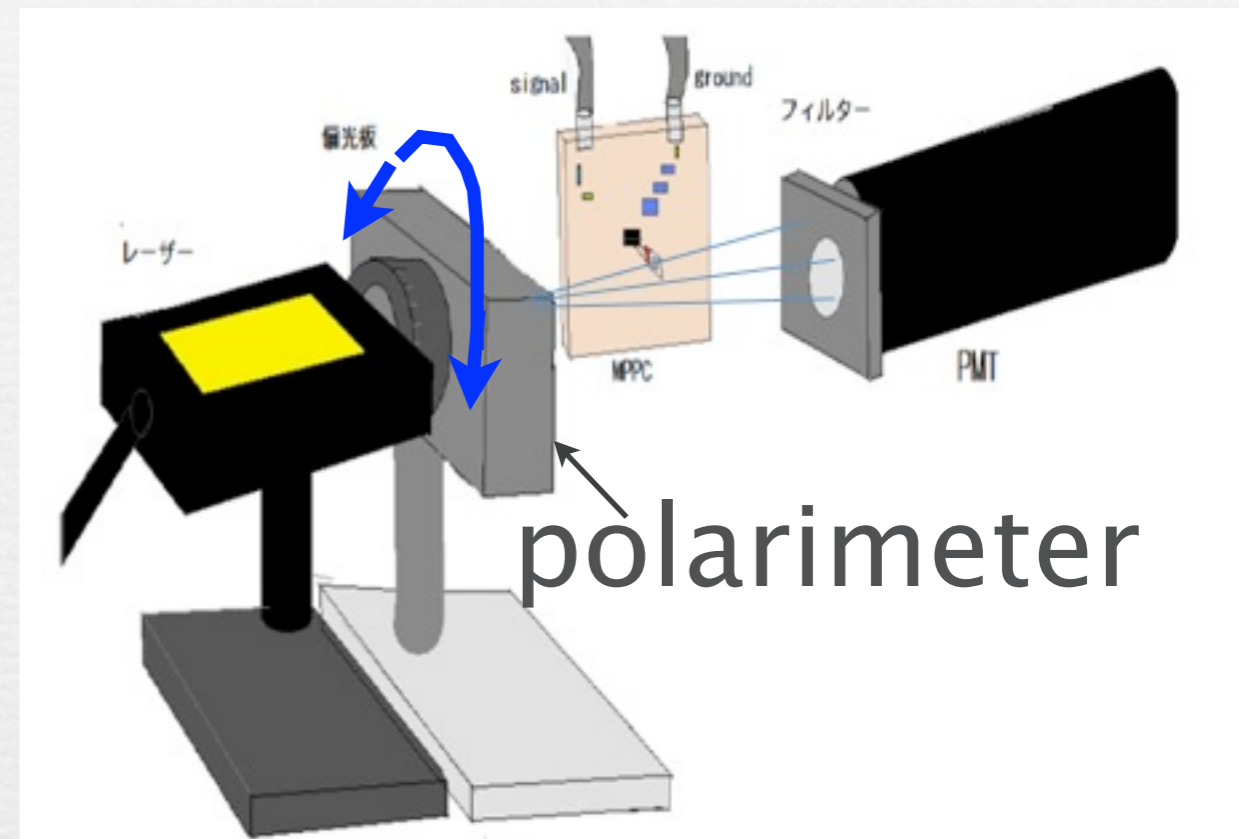


non-saturation when long pulse input



response by short

- blue laser + bare MPPC
406nm 30ps
- alter number of photons by a polarimeter, since laser is already polarized

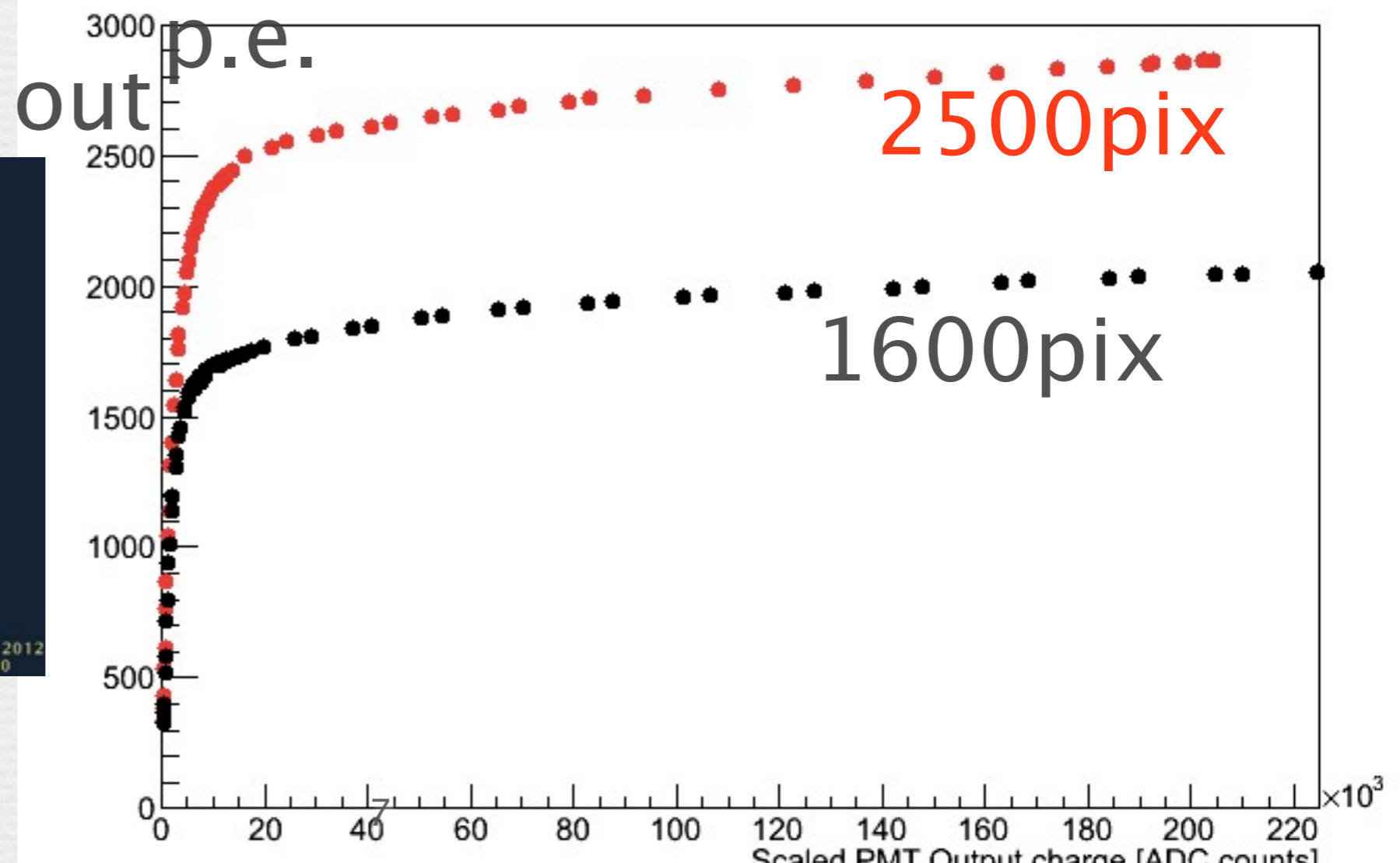
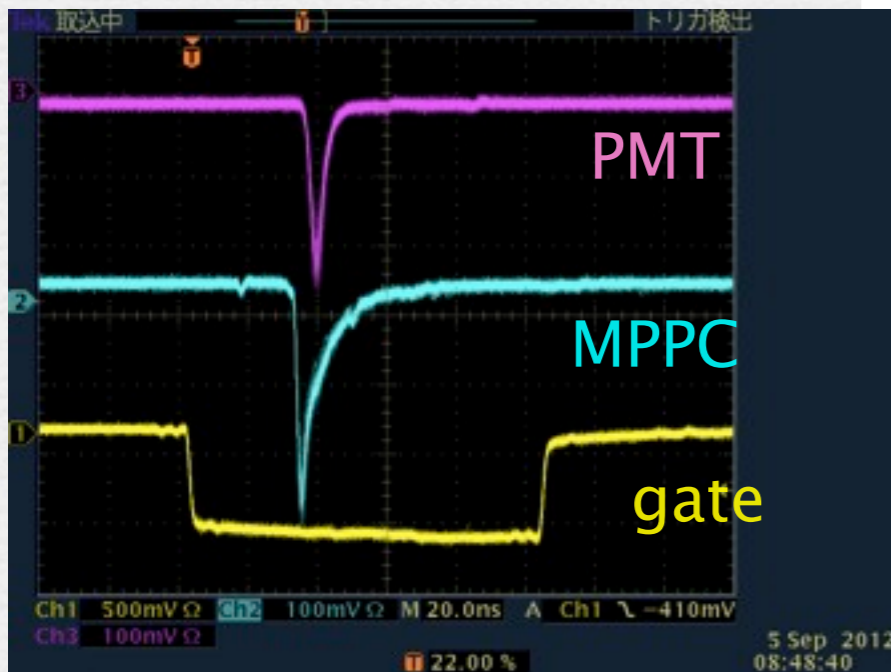
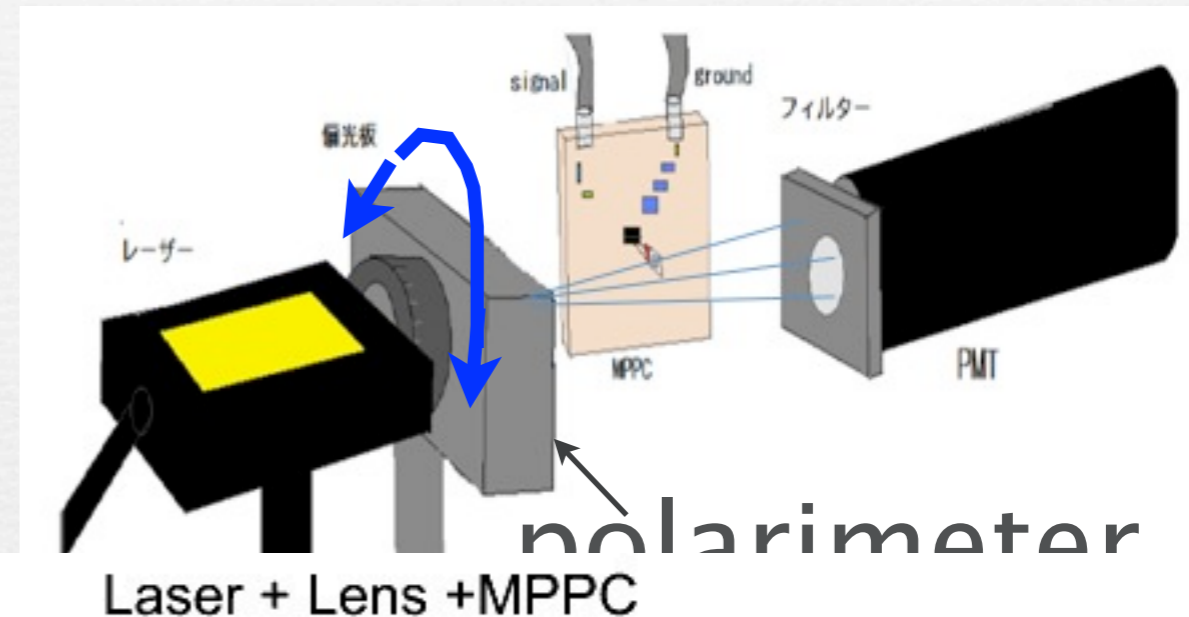


response by short

→ blue laser + bare MPPC

406nm 30ps

→ alter number of photons by a polarimeter, since laser is already polarized



response curve

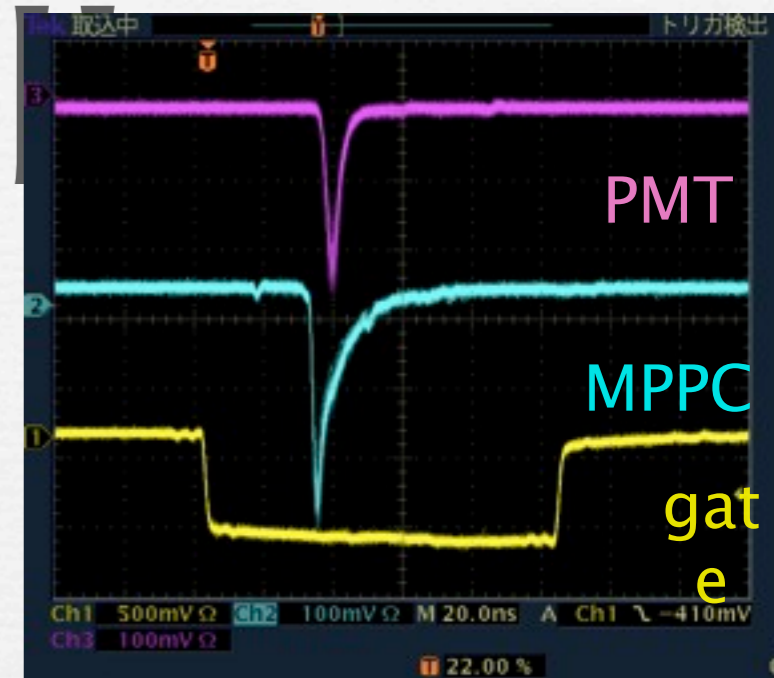
→ blue laser + MPPC from

406nm 30ps

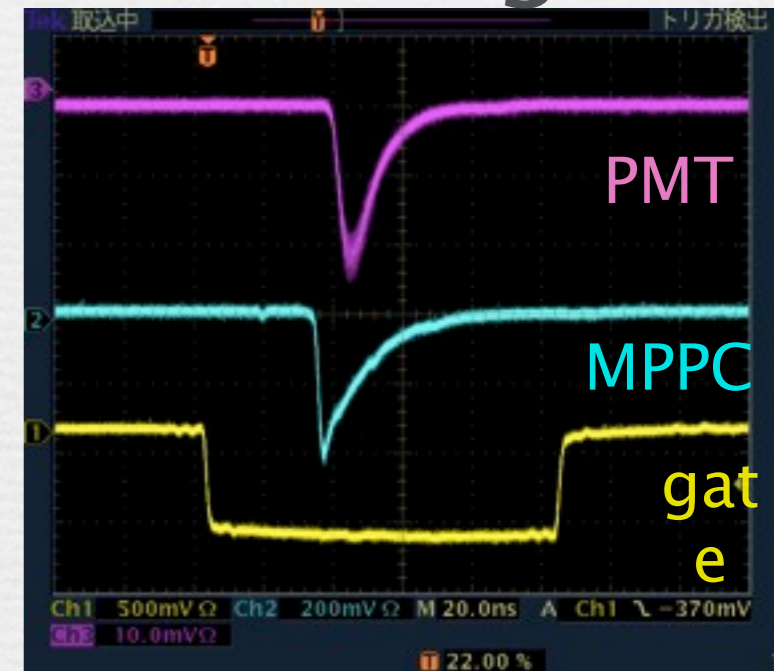
WLSF+scintillator



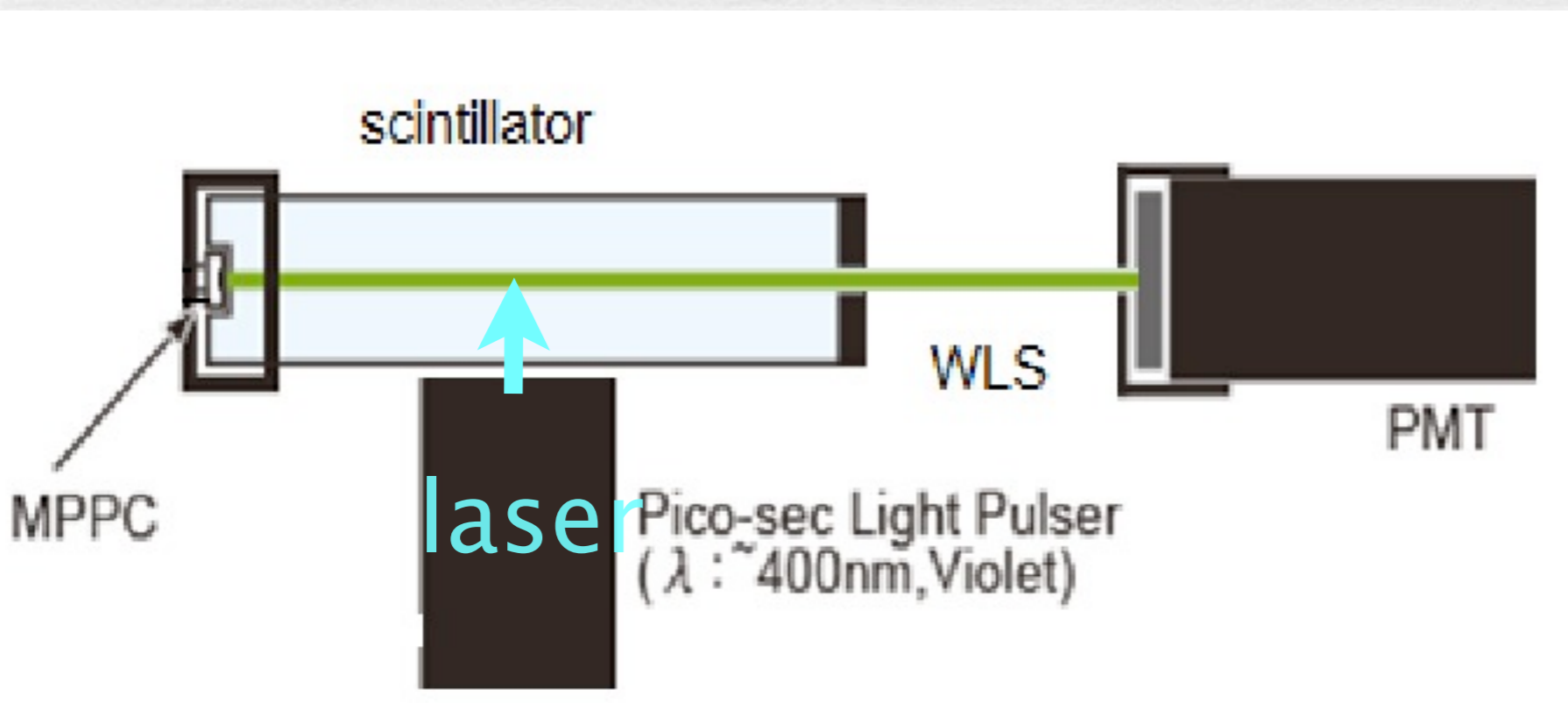
→ Npixel increases response



bare signal



+WLSF
signal

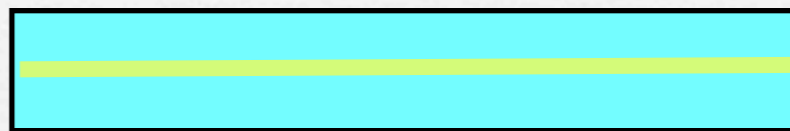


response curve

→ blue laser + MPPC from

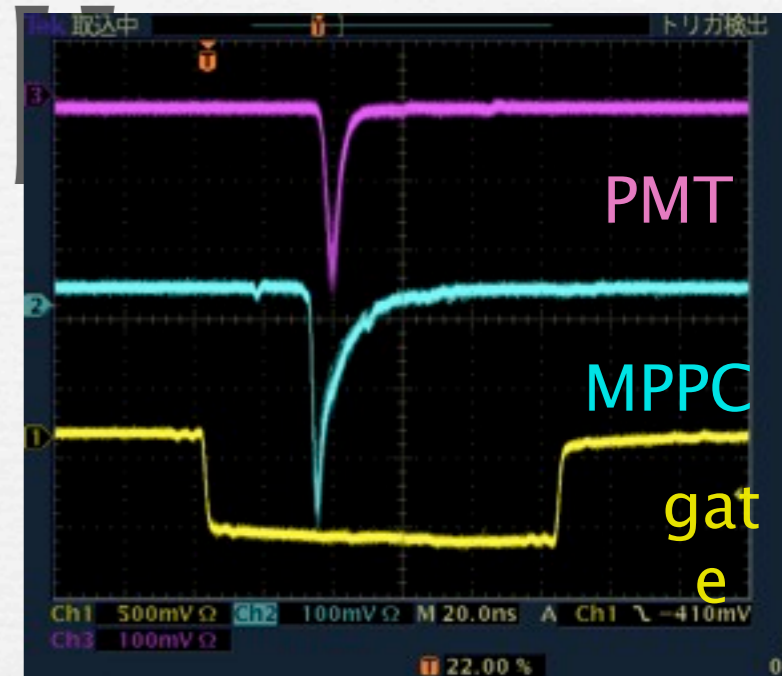
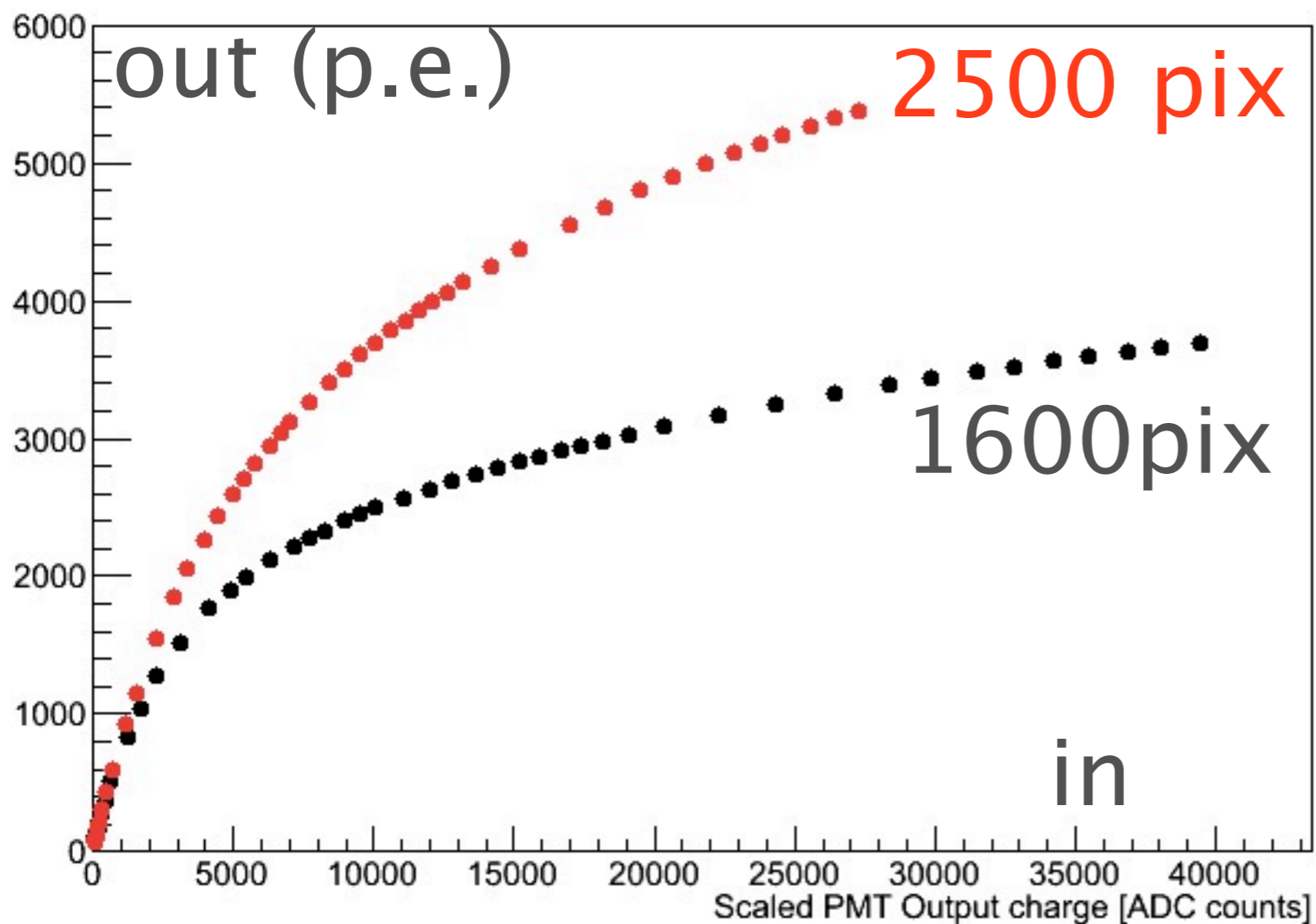
406nm 30ps

WLSF+scintillator

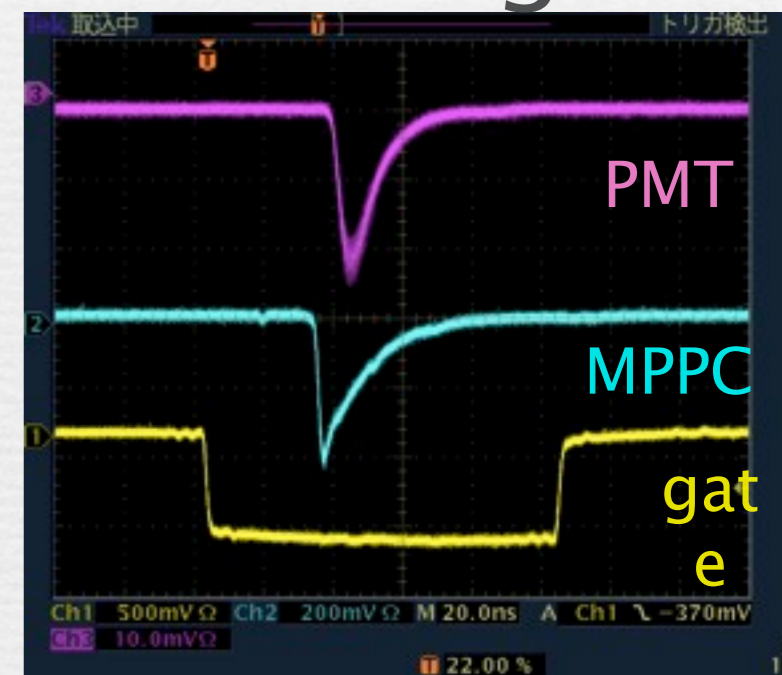


→ Npixel increases response

Laser + Scintillator + WLS + MPPC



bare signal



+WLSF
signal

response curve

→ blue laser + MPPC from

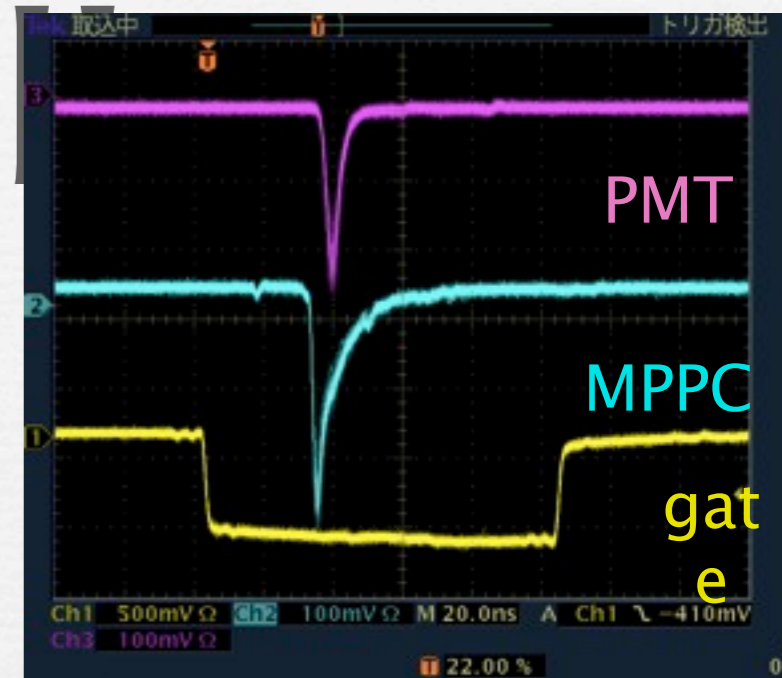
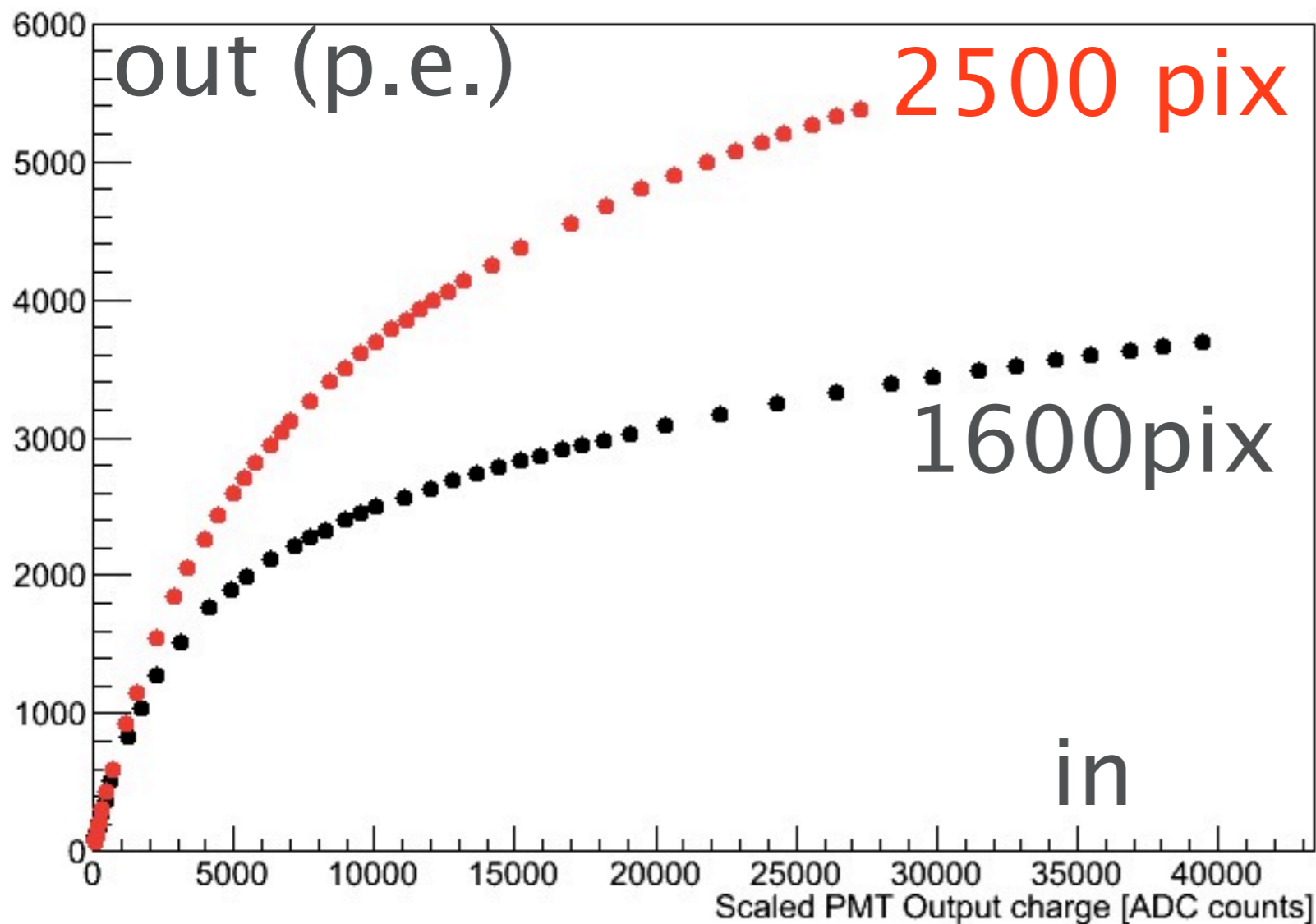
406nm 30ps

WLSF+scintillator

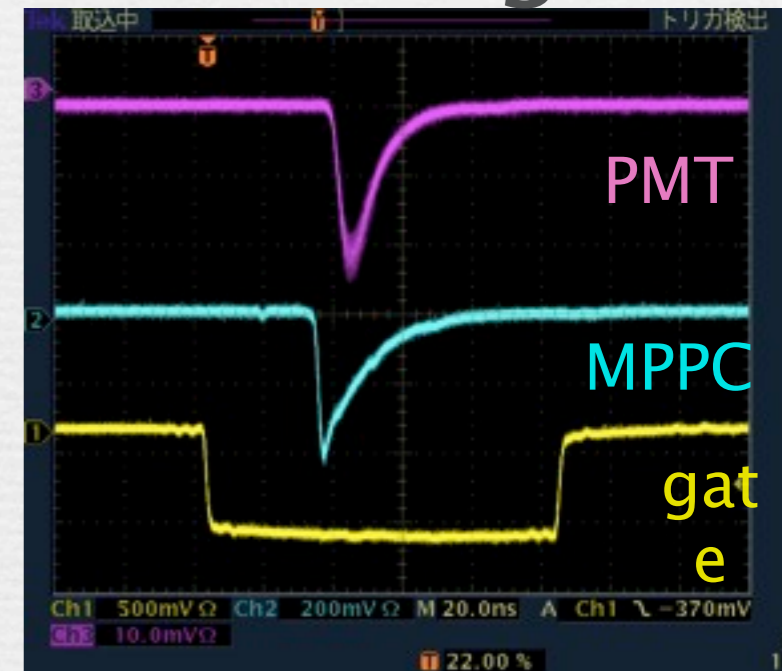


→ Npixel increases response

Laser + Scintillator + WLS + MPPC



bare signal



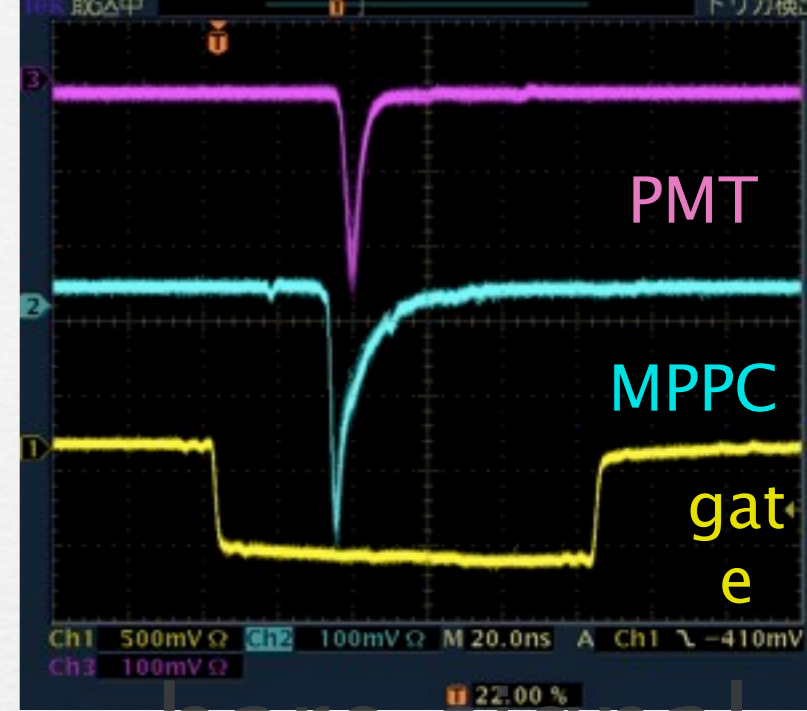
+WLSF
signal

response curve

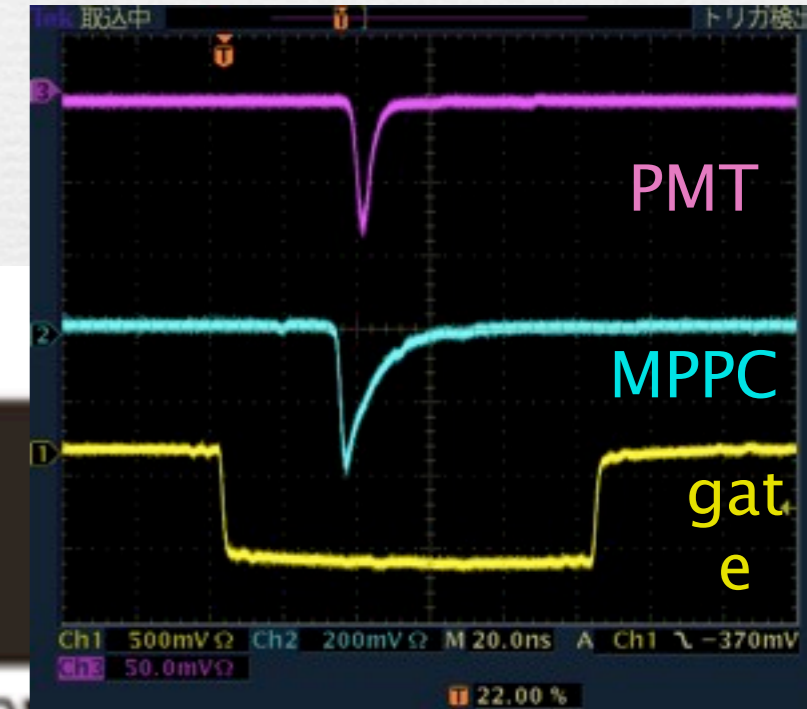
→ blue laser + MPPC
from scintillator



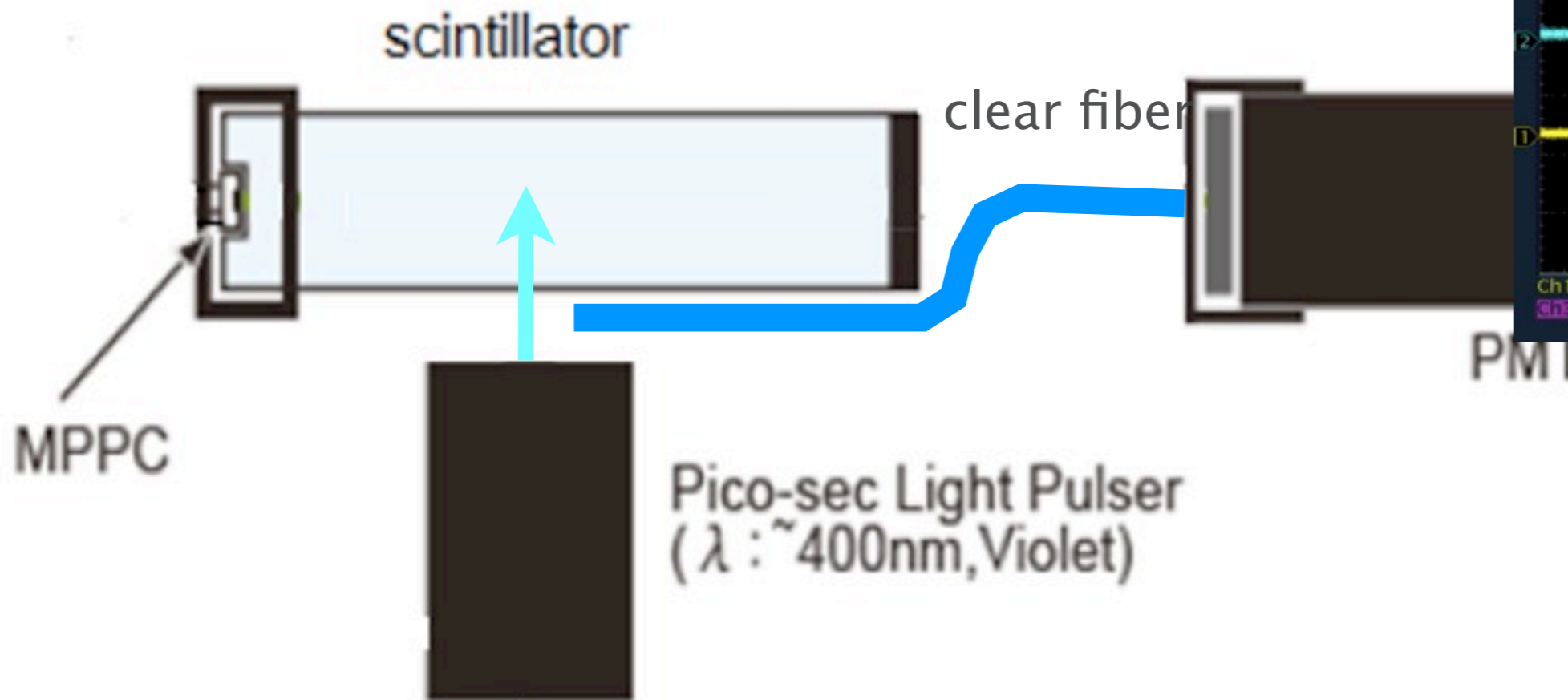
→ no WLSF



bare signal



+scintillator
or signal

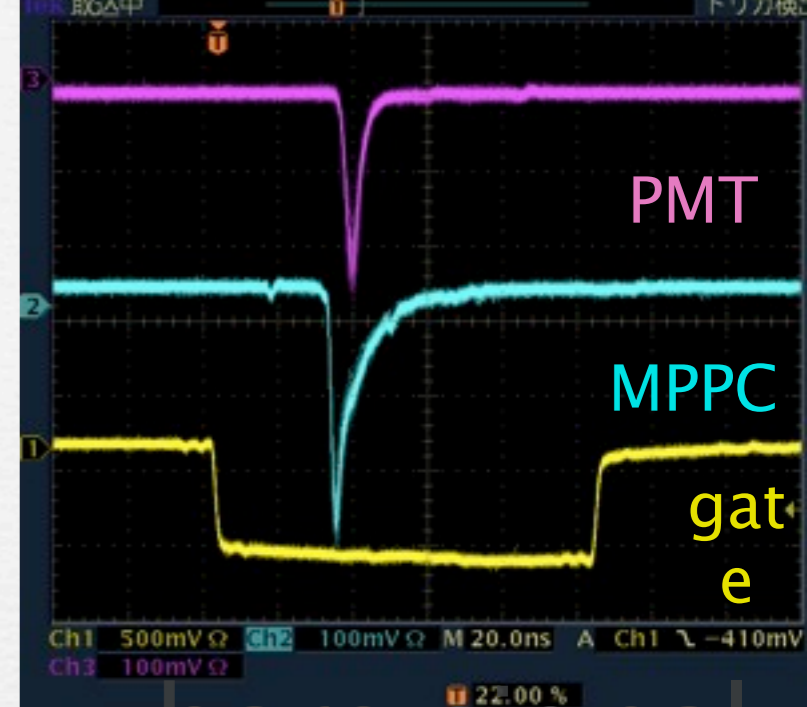


response curve

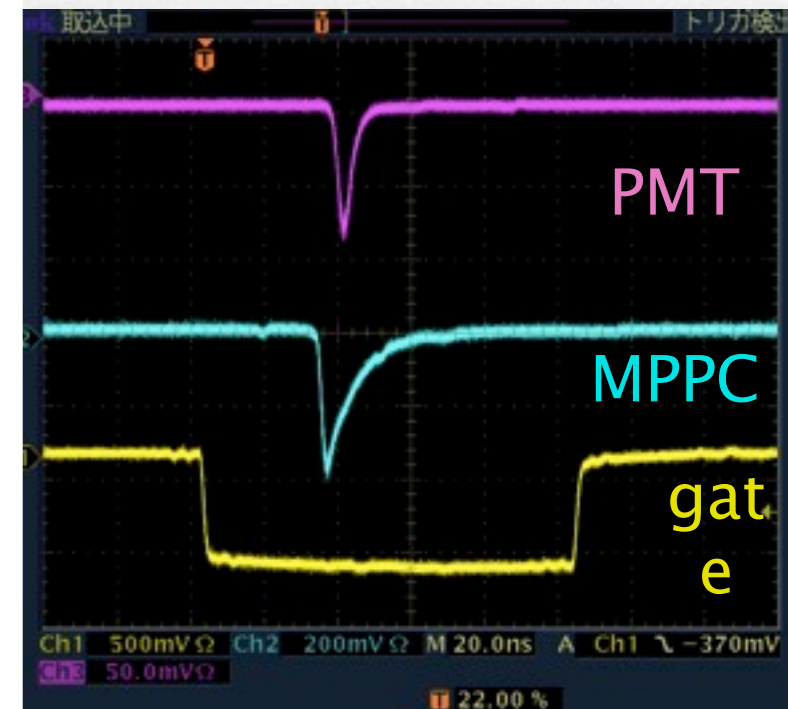
→ blue laser + MPPC
from scintillator



→ no WLSF

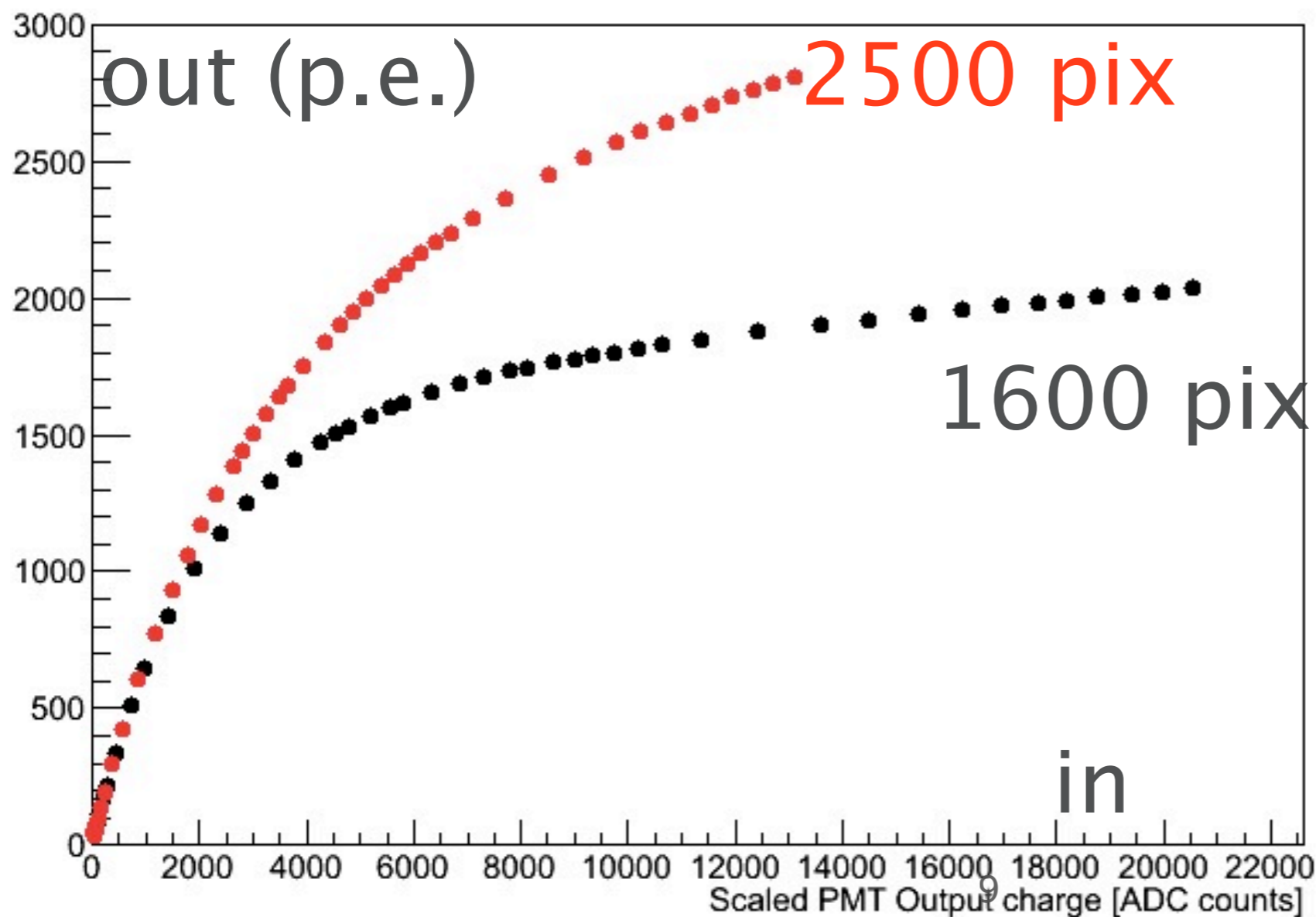


bare signal



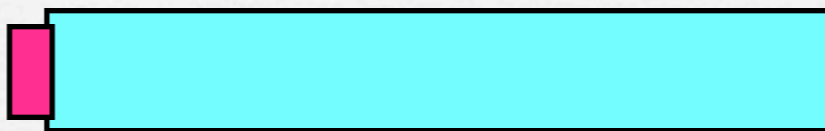
+scintillator
or signal

Laser + Scintillator + MPPC



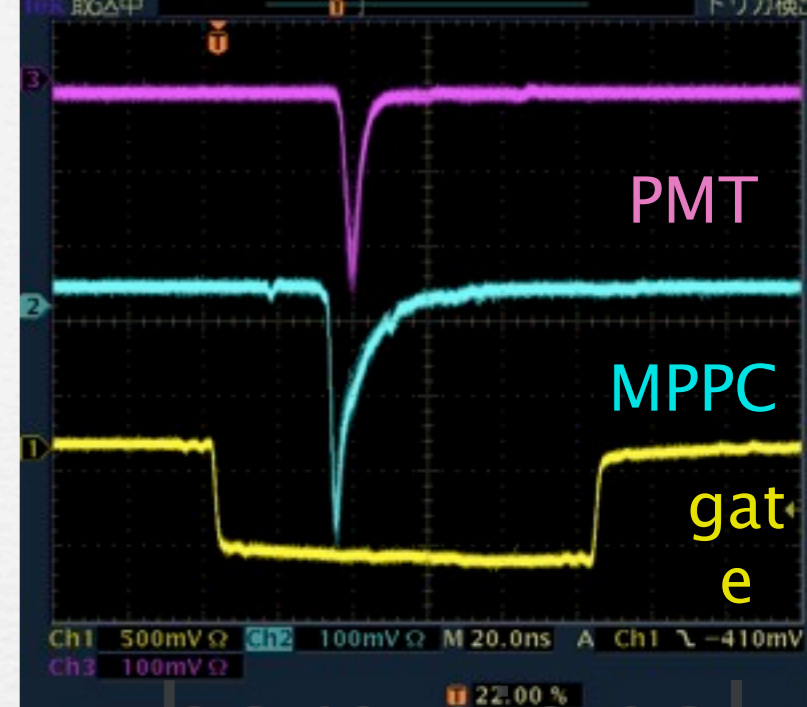
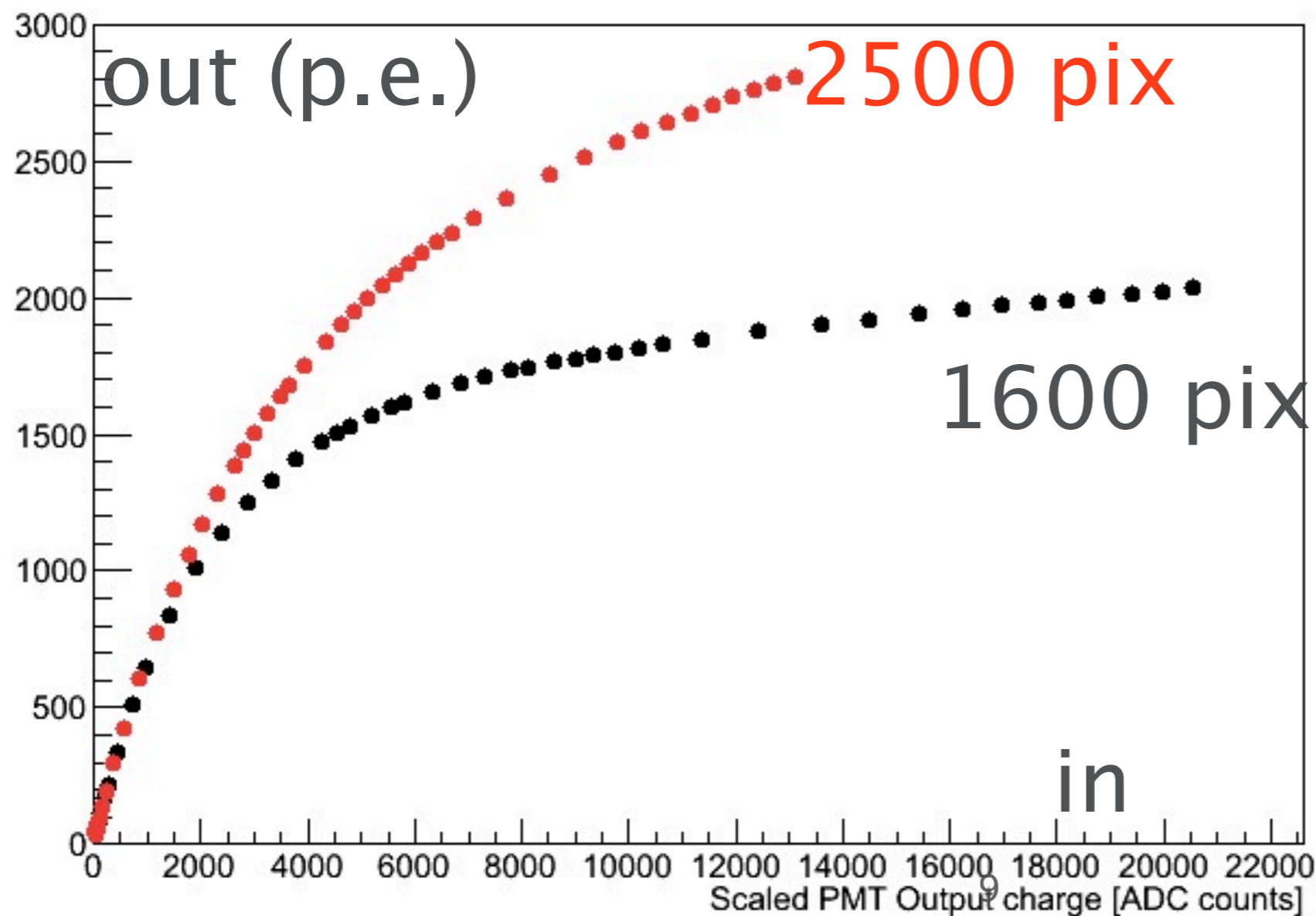
response curve

→ blue laser + MPPC
from scintillator

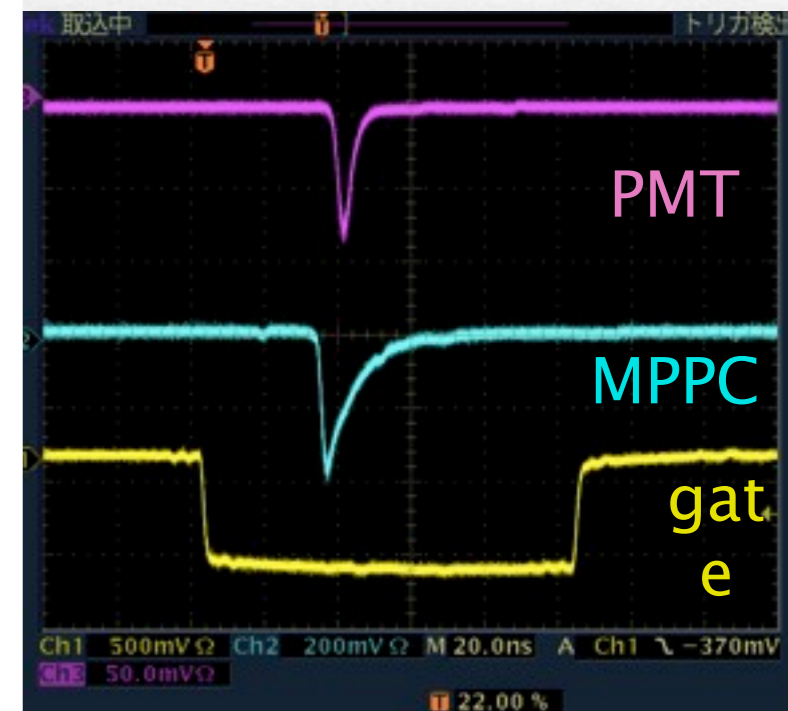


→ no WLSF

Laser + Scintillator + MPPC



bare signal



+scintillator
or signal

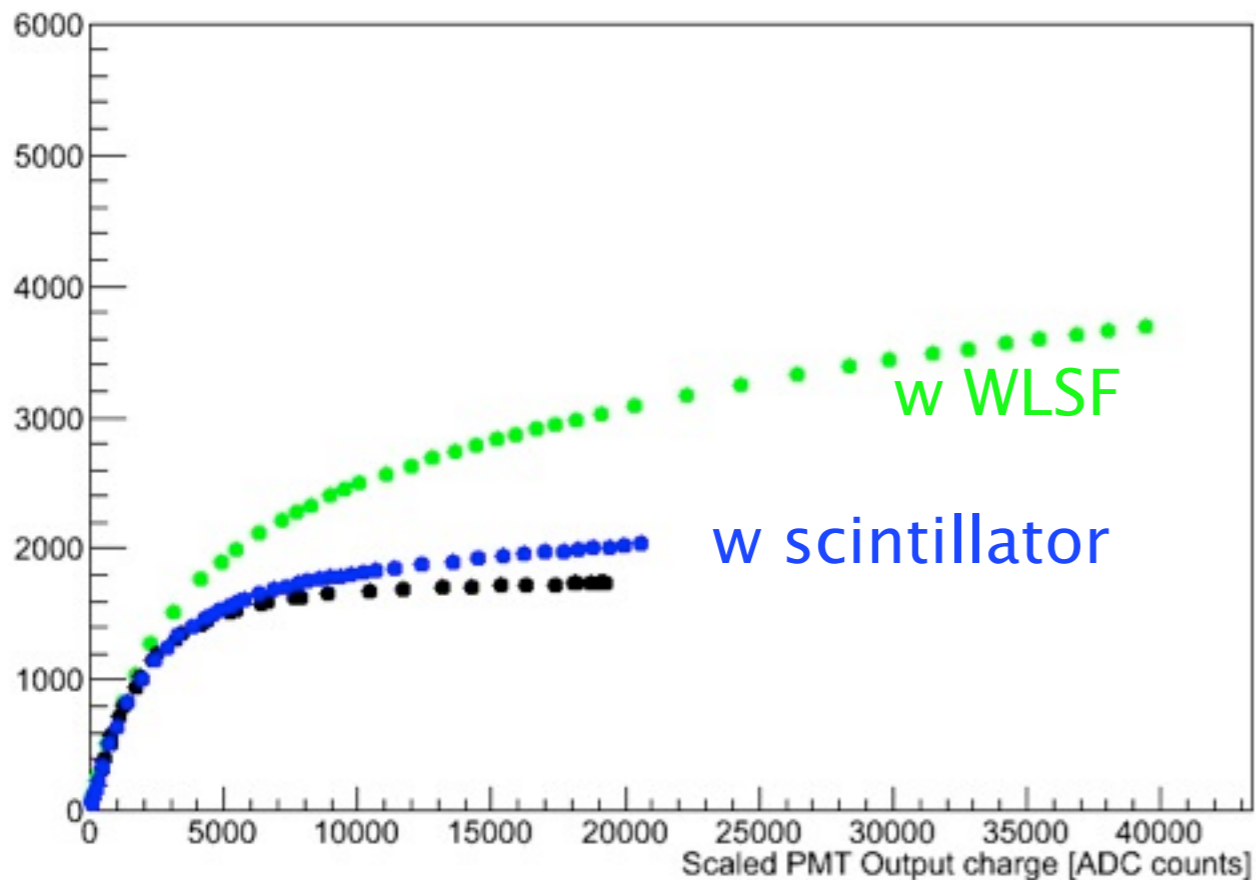
response curves

saturation is less severe for

2500pix MPPC with slow light

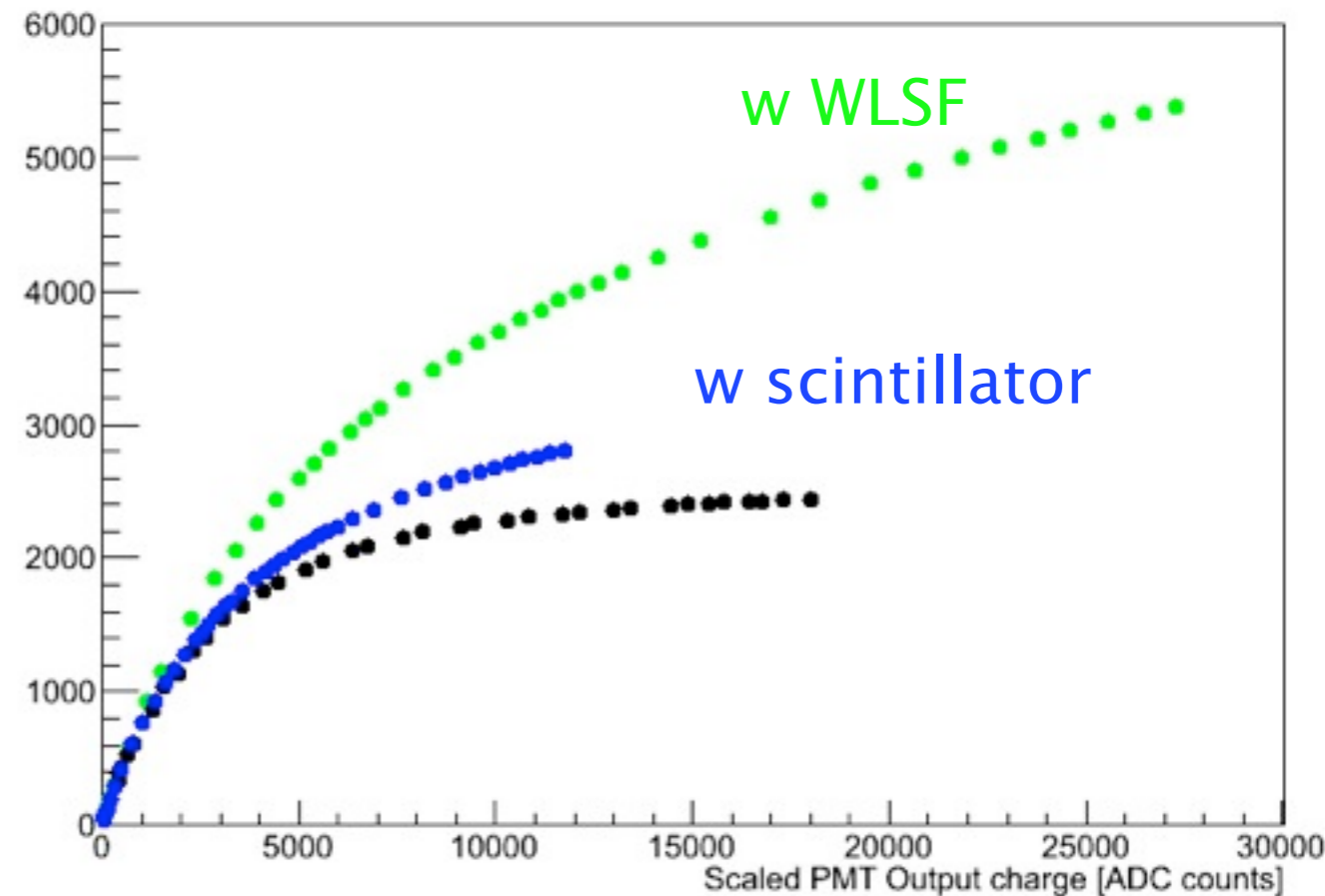
1600 pixels

Response Curve (1600pix)



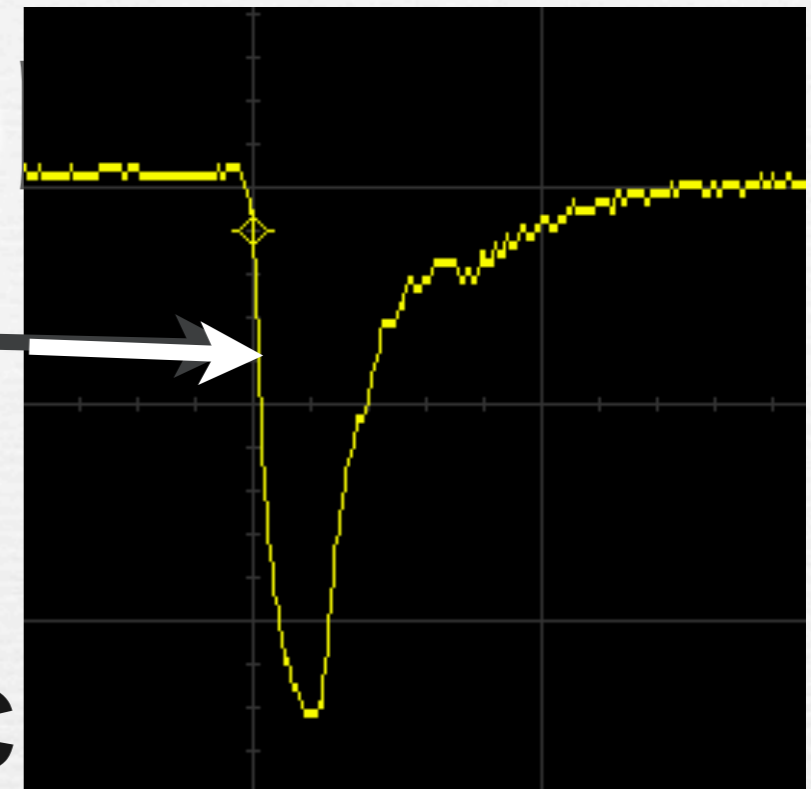
2500 pixels

Response Curve (2500pix)

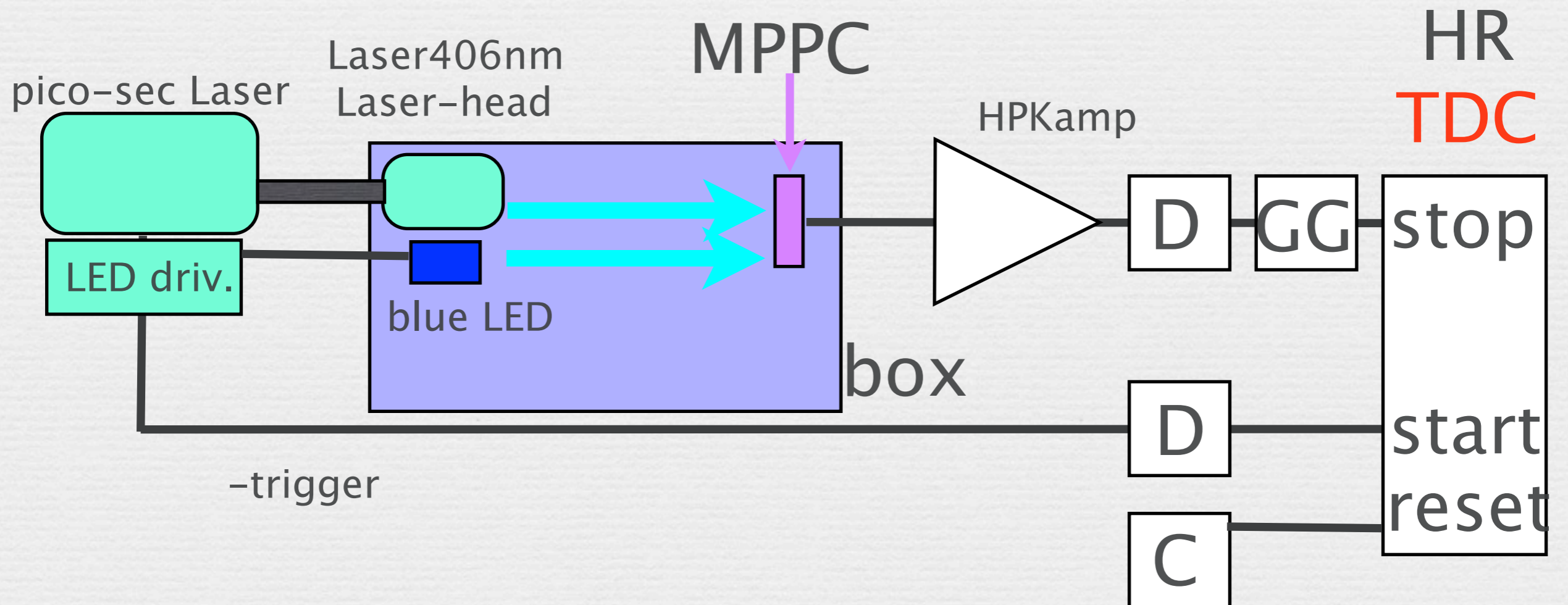


derivatives are the same at origin

timing resolution of MPPPC

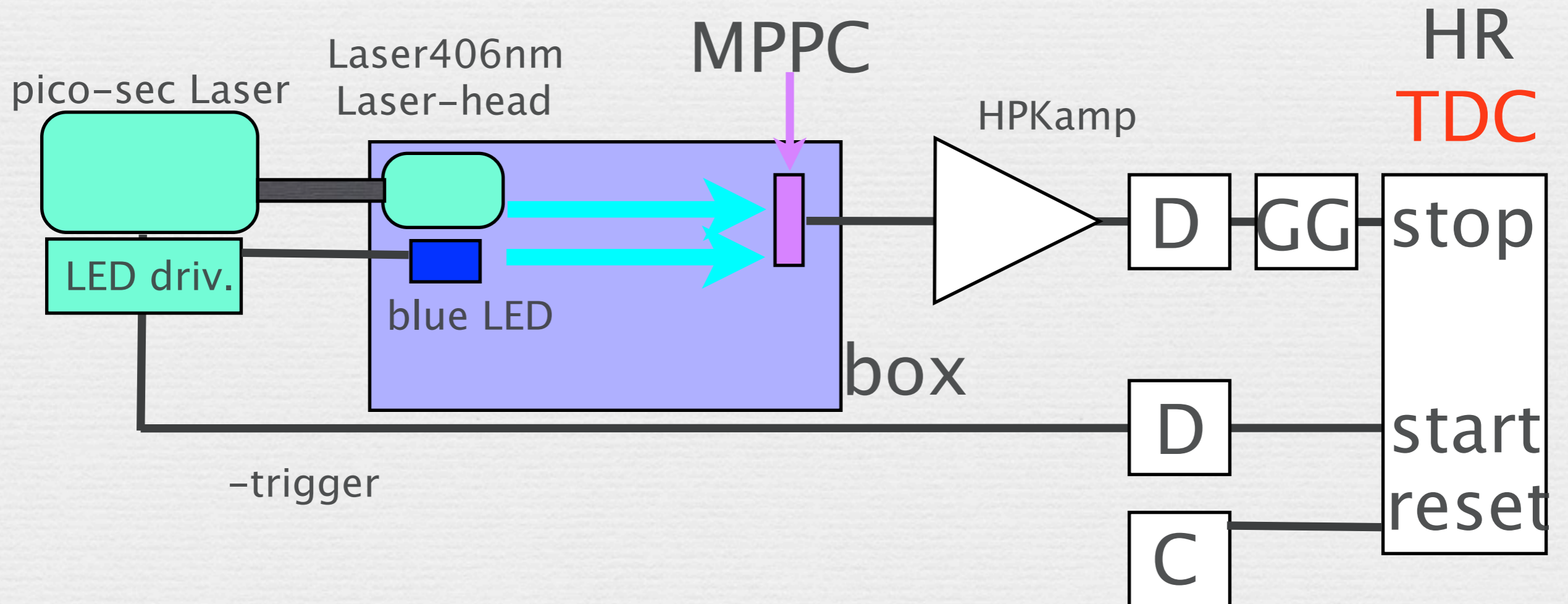


→ blue (laser or LED)+ bare MPPPC



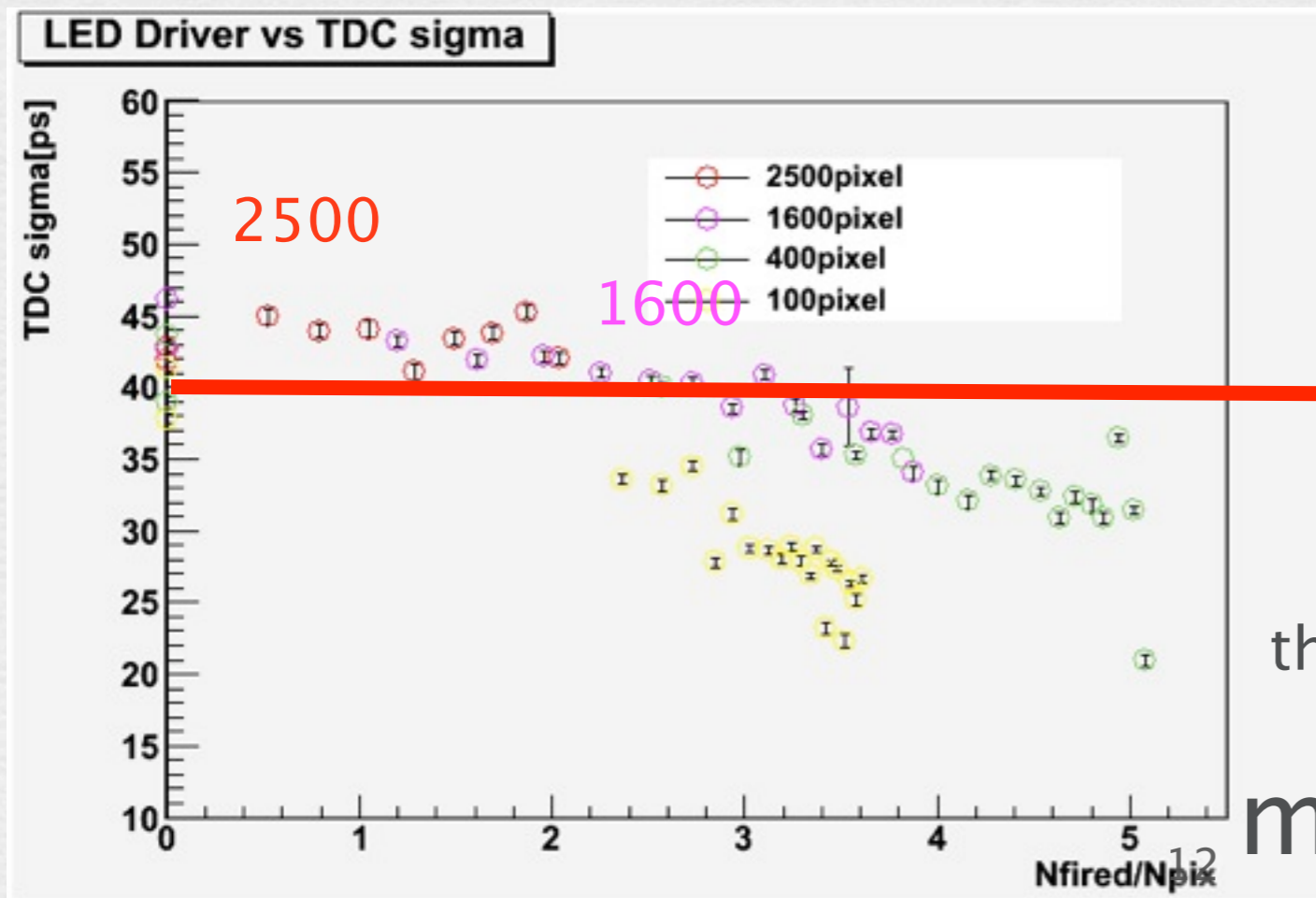
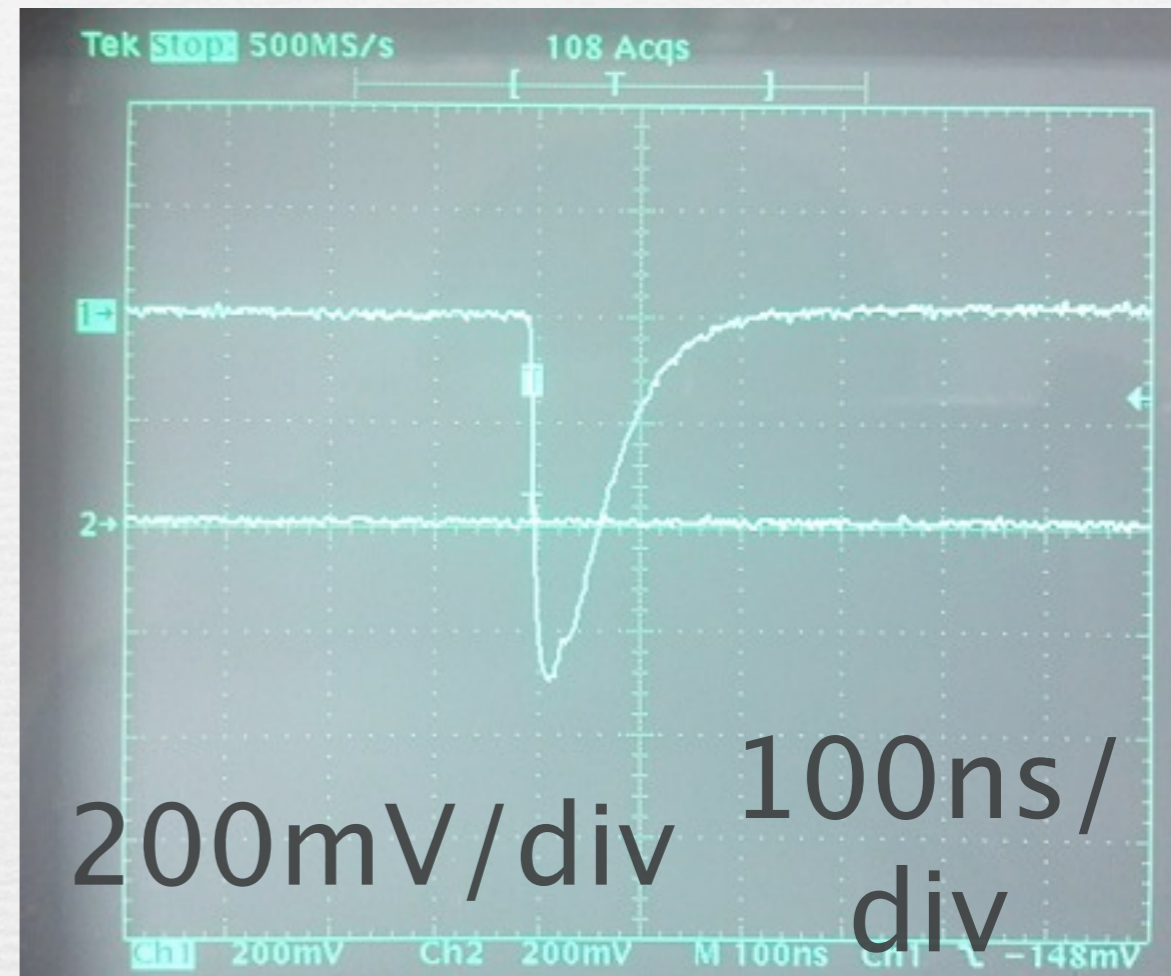
timing resolution of MPPPC

→ blue (laser or LED)+ bare MPPPC



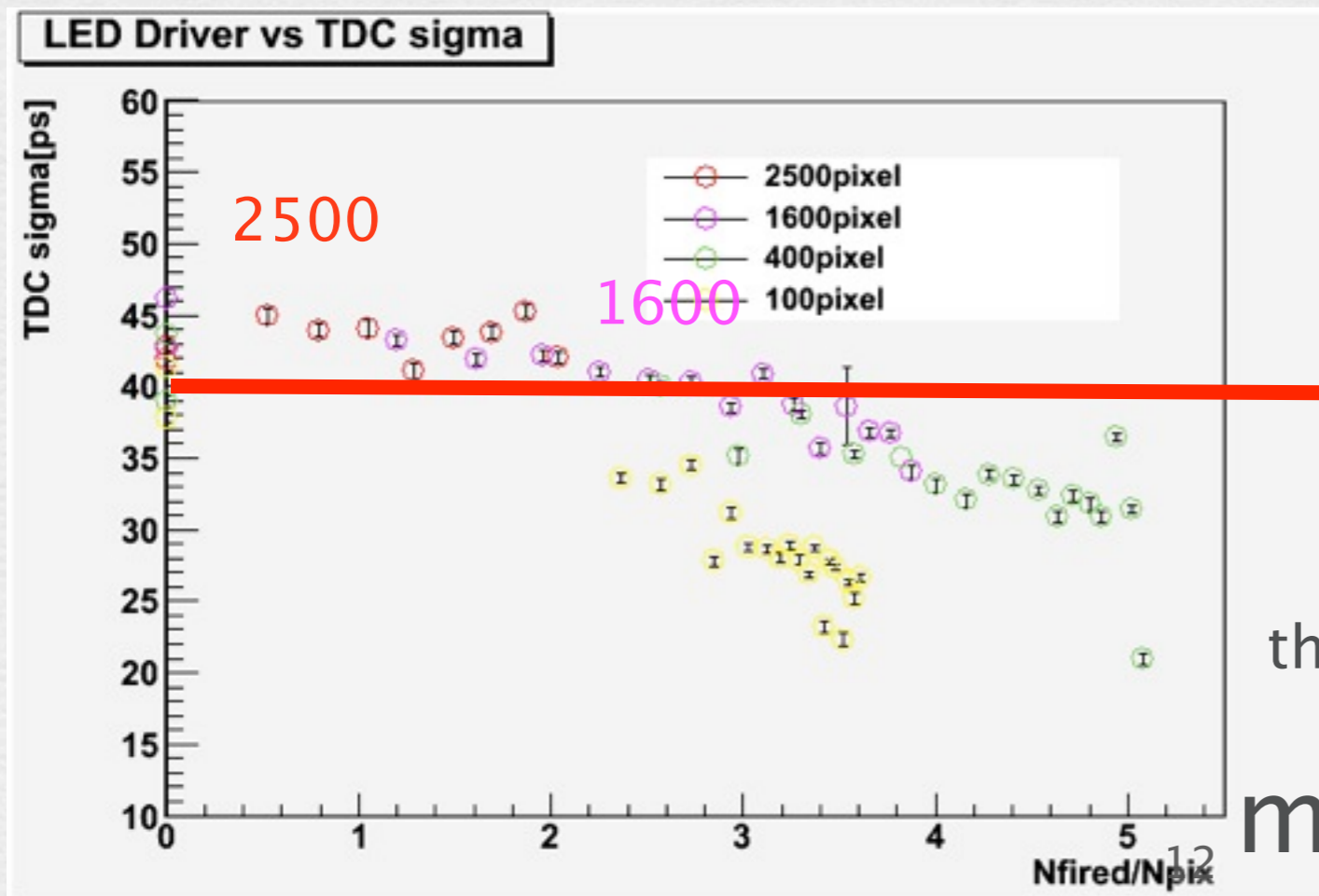
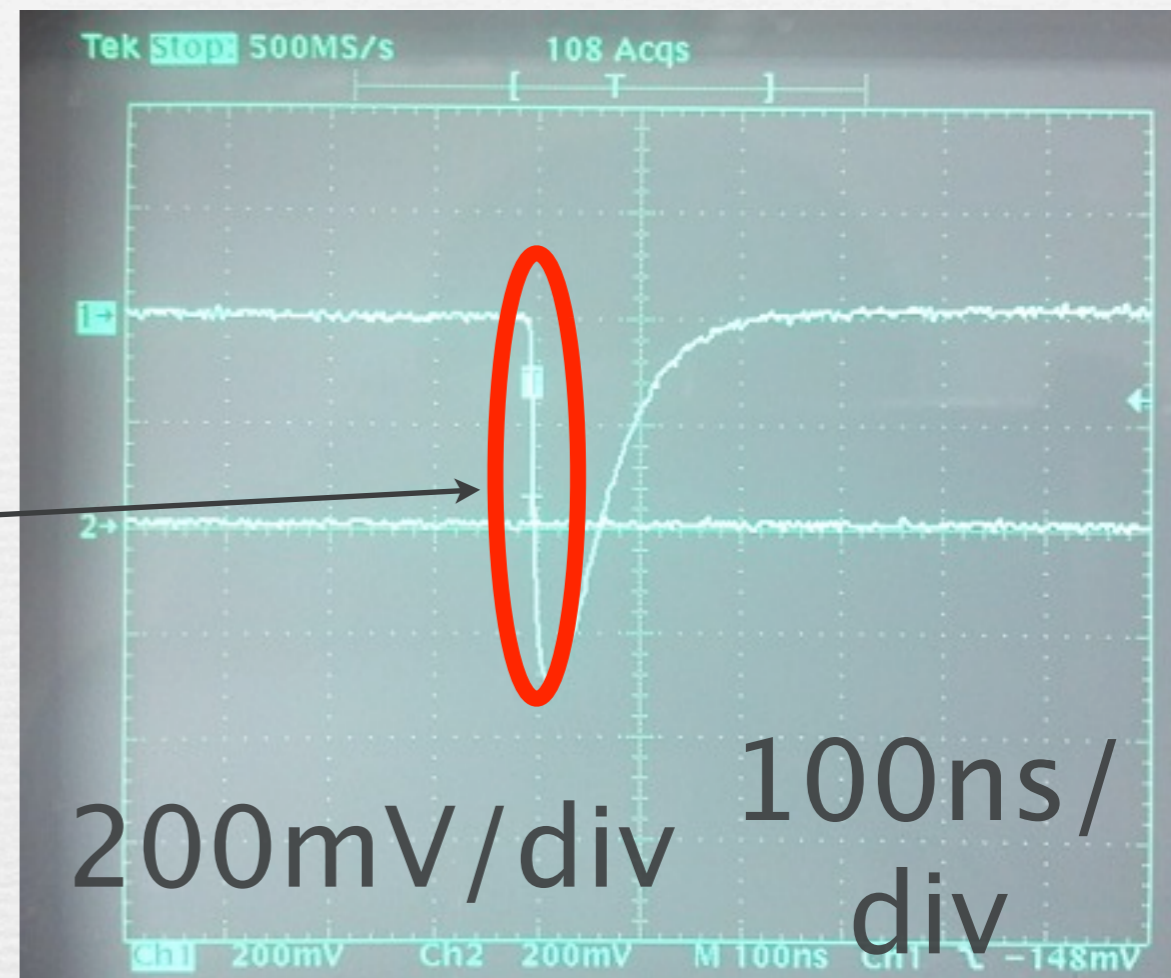
TimingR by LED

- width **15ns**, huge amount of light
- TR is sensitive at **rise** timing



TimingR by LED

- width **15ns**, huge amount of light
- TR is sensitive at **rise** timing



threshold = 100mV fixed

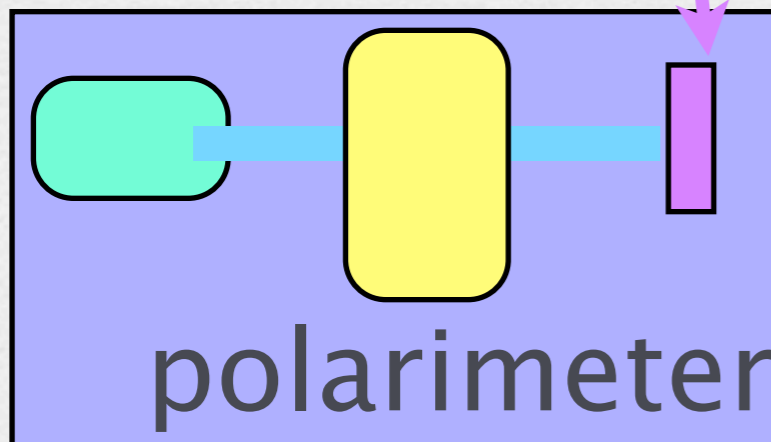
mean firing pix

timing resolution by laser II

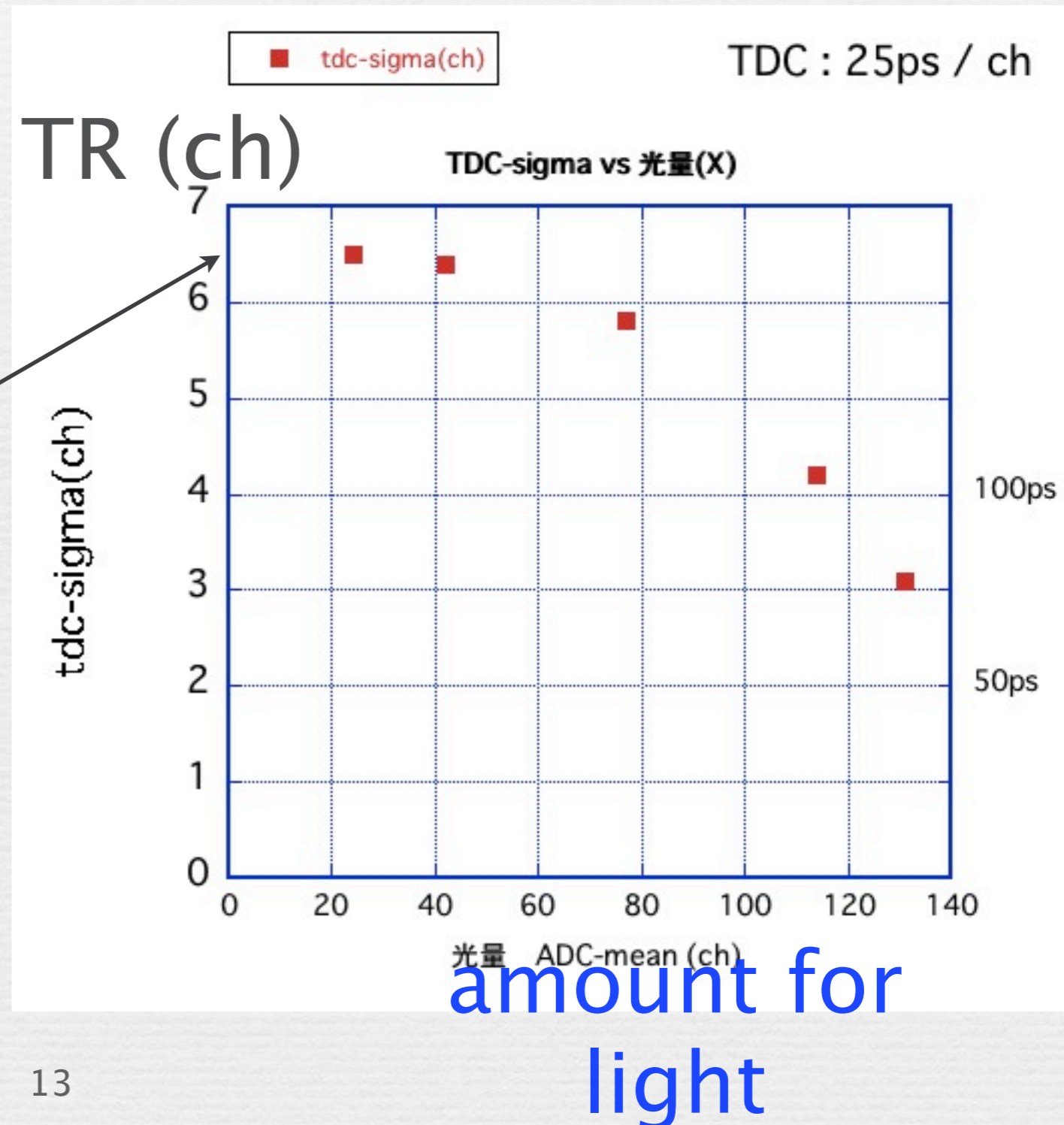
- short pulse
- amount of light
- changed by polarimeter
- timing resolution worsened $\sim 170\text{ps}$

Laser-head

MPPC



polarimeter box



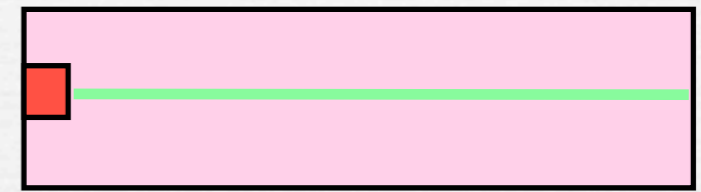
scintillator strip

→ scintillator width: 10 > 5mm

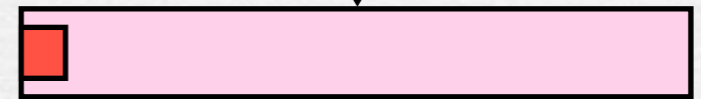
→ without WLS fiber

→ uniformity studied

→ scintillator thickness: 3 > 2 > 1 mm, 5mm wide



no precise alignment required

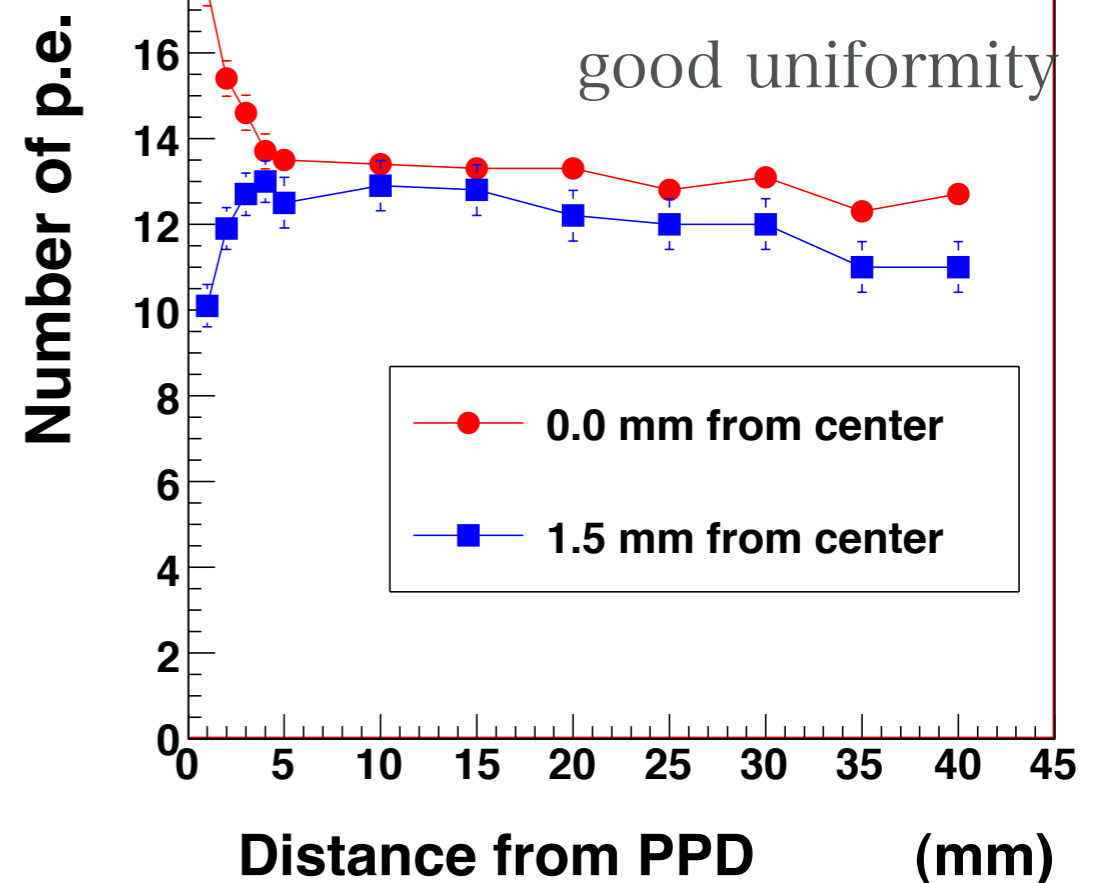
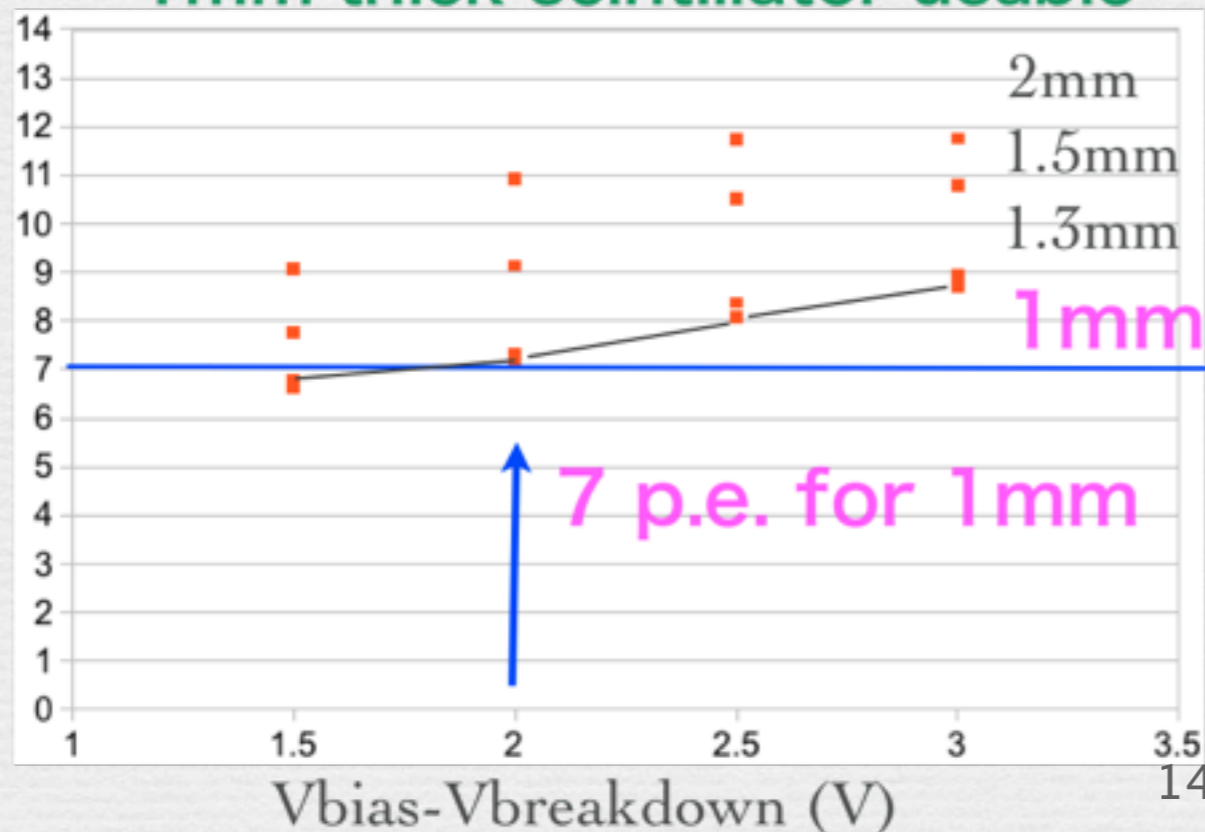


5mm wide strip bench test

MPPC 25um

scintillator strip

p.e. 1mm thick scintillator usable



MPPPC summary

- aiming for scintillator strip ECAL
- different number of pixels available up to $4400 / \text{mm}^2$
- two parts of pulse shape studied
 - response curve or saturation behavior
 - long pulse make better response
 - rising time fluctuation
 - 40ps for high intensity, 170ps for low
- we need further understanding

pulse height

