KILC12 study of MPPC saturation

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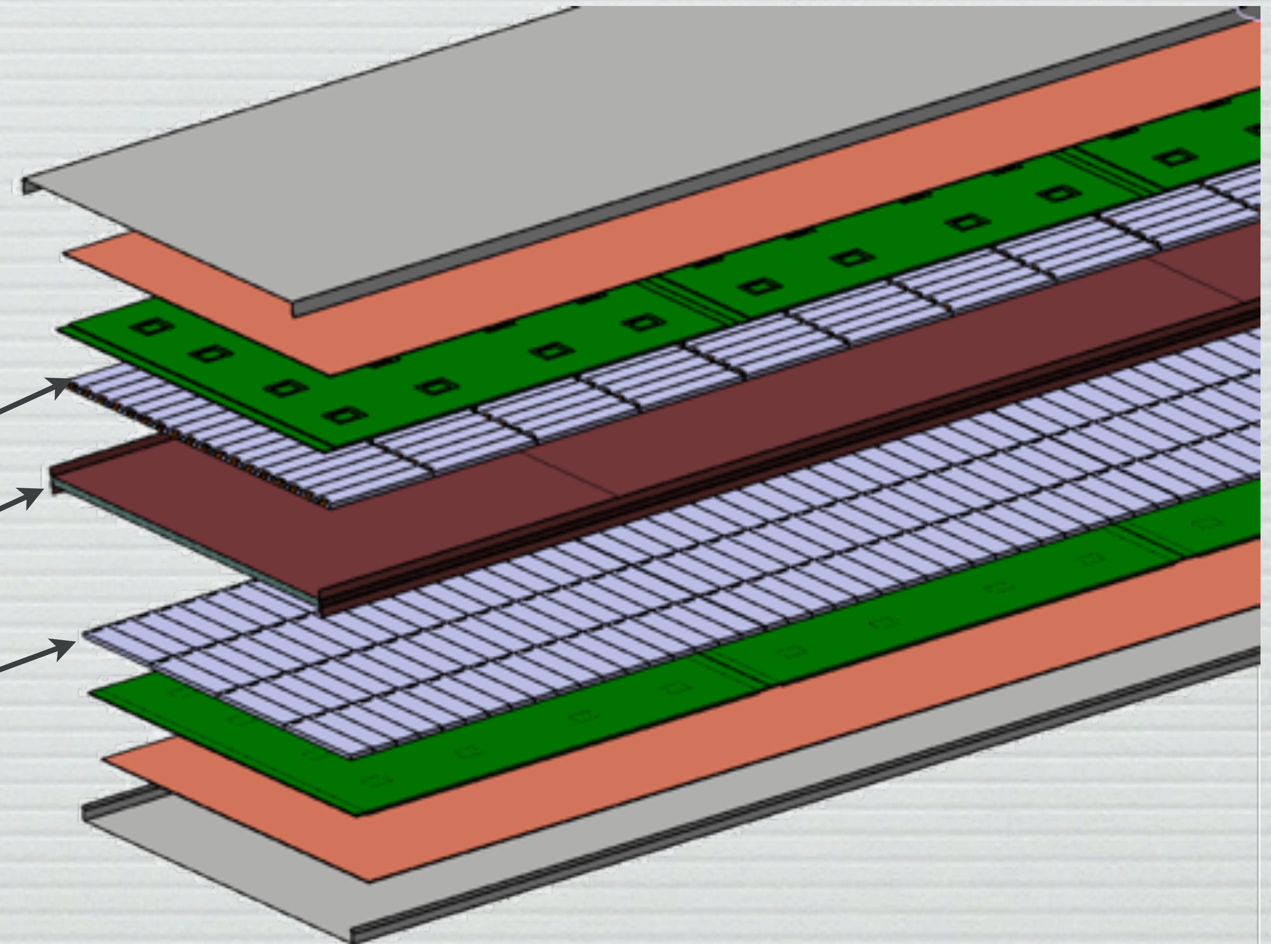
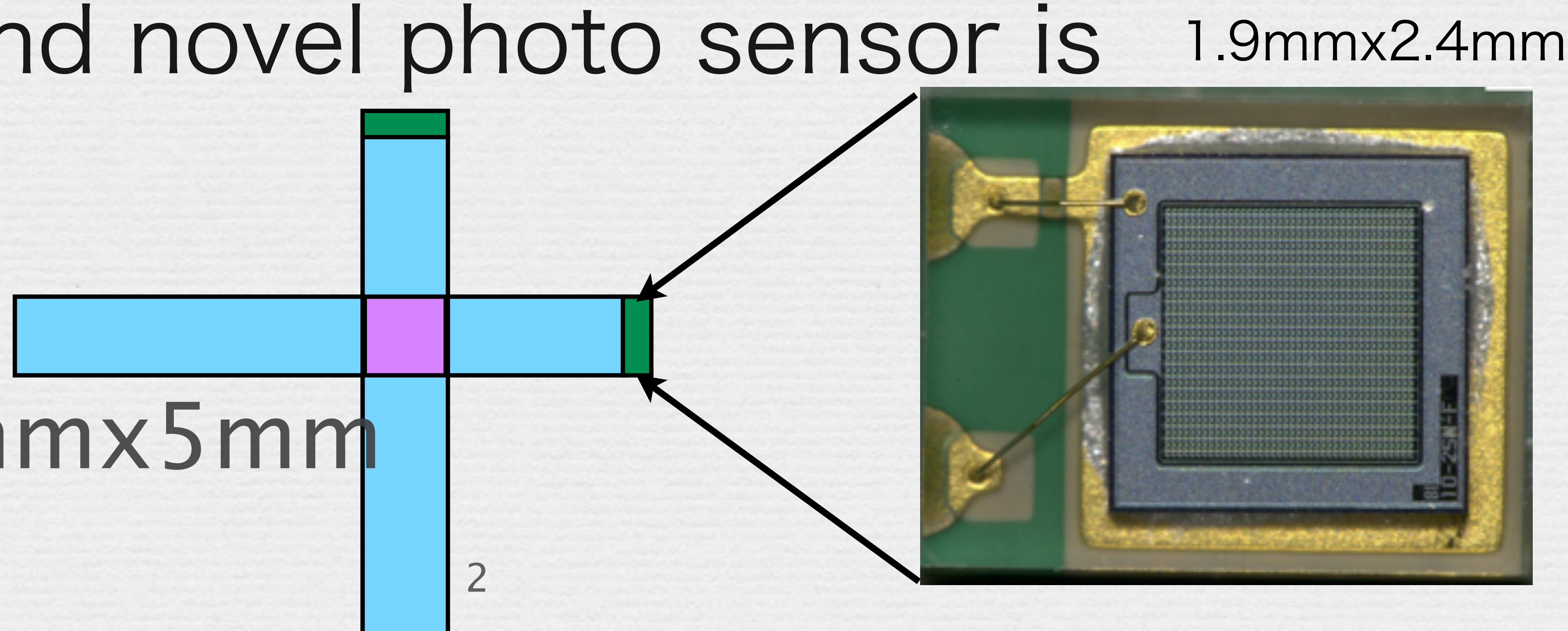
for CALICE-ASIA



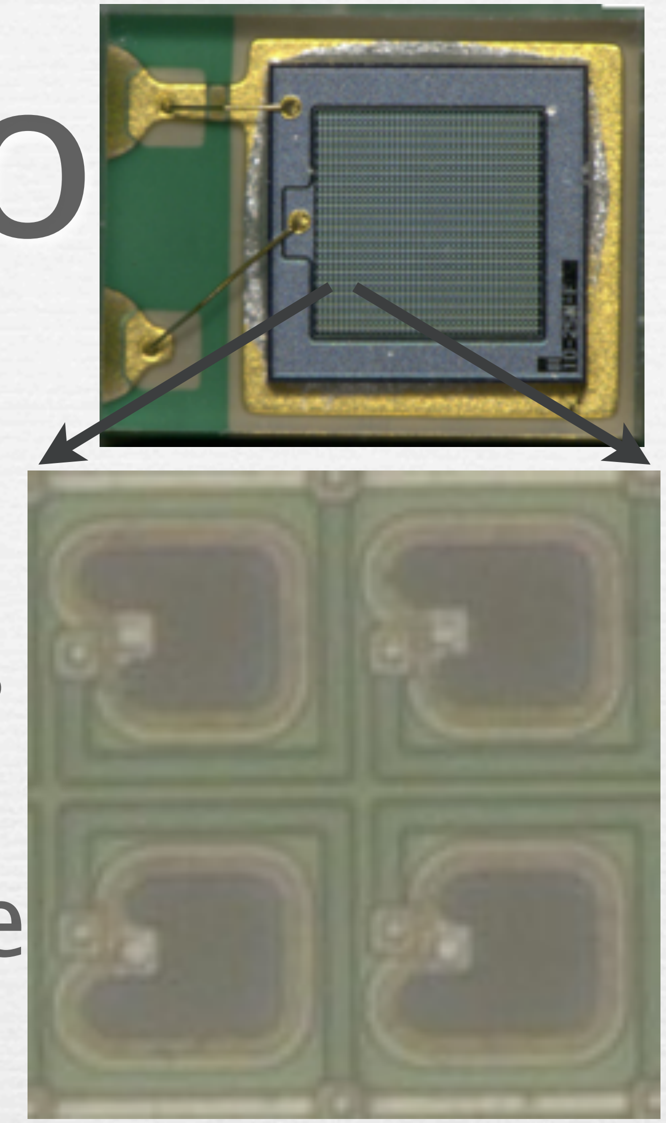
Scintillator ECAL

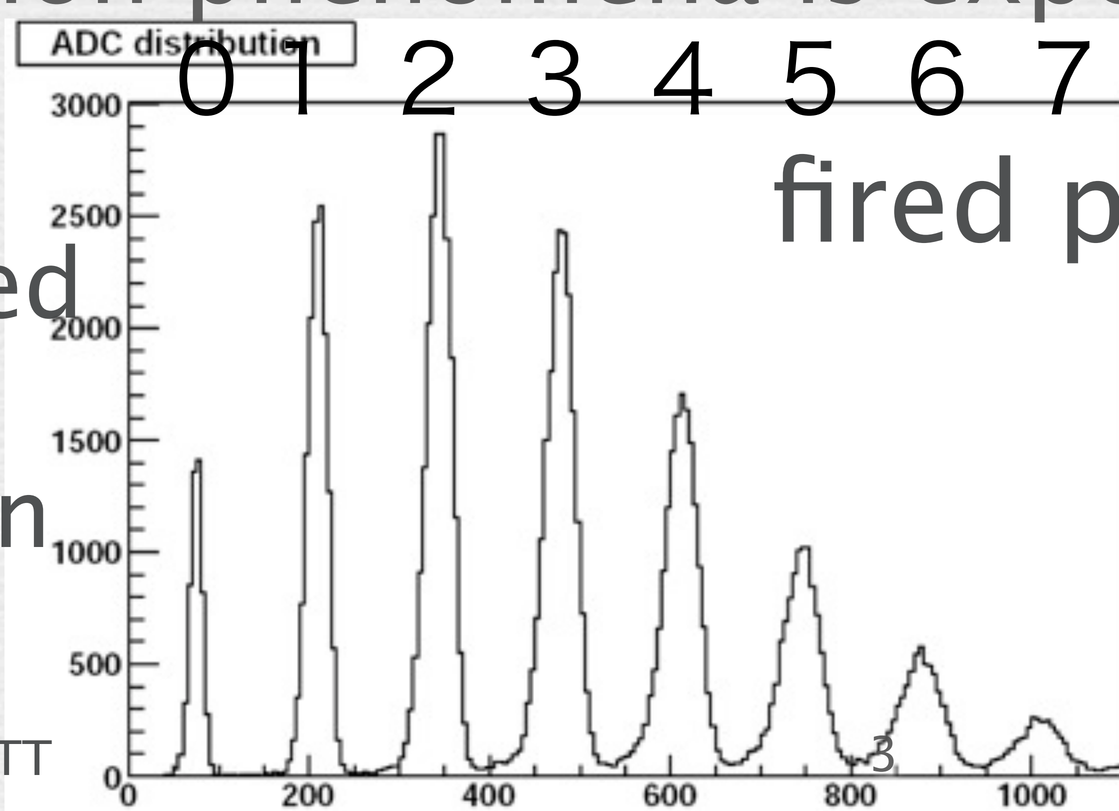
- Strip Scintillator ECAL for ILC
- PFA requires highly granular ECAL 5mm
- to accommodate within reasonable cost
- scintillator strip ECAL with orthogonal directions to achieve fine segmentation
- very thin and novel photo sensor is developed



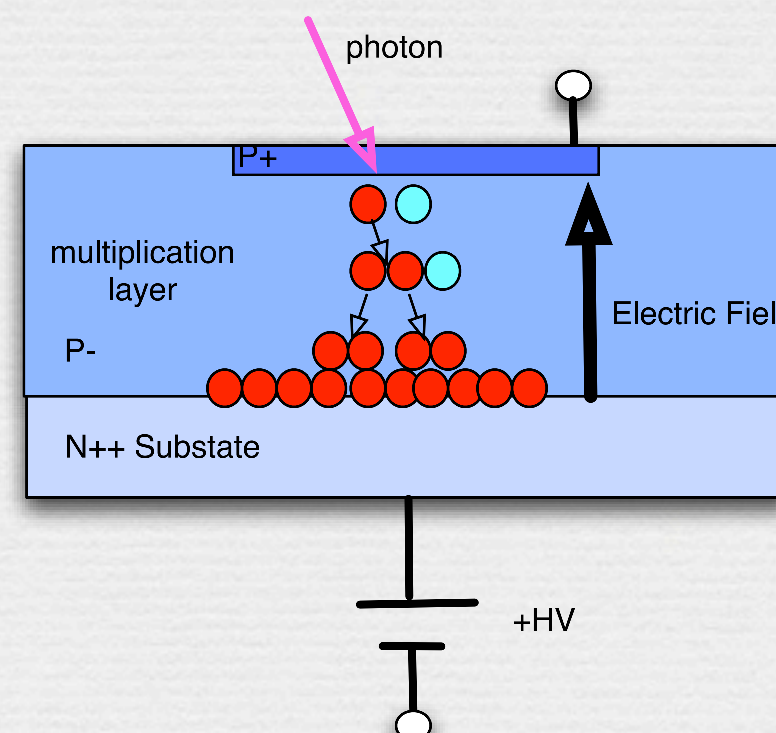
silicon photo-senso

- a lot of APD cells operated in G. Mode
- MPPC by Hamamatsu Photonics
- photon counting with number of pixels firing
- simultaneous photos in a pixel will give single firing
- saturation phenomena is expected





can be used for calibration



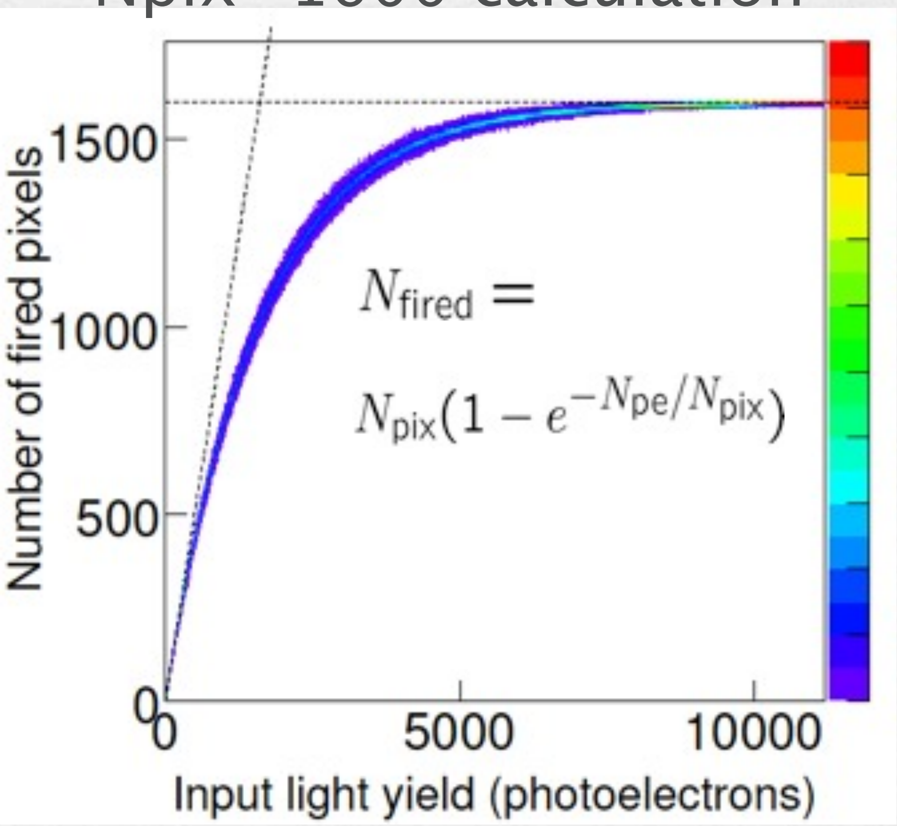
saturation in MPPC

- saturation occurs when lots of photons in a very short time

$$N_{fired} = N_{p0}(1-\exp(\frac{-p1Ntrue}{N_{p0}}))$$

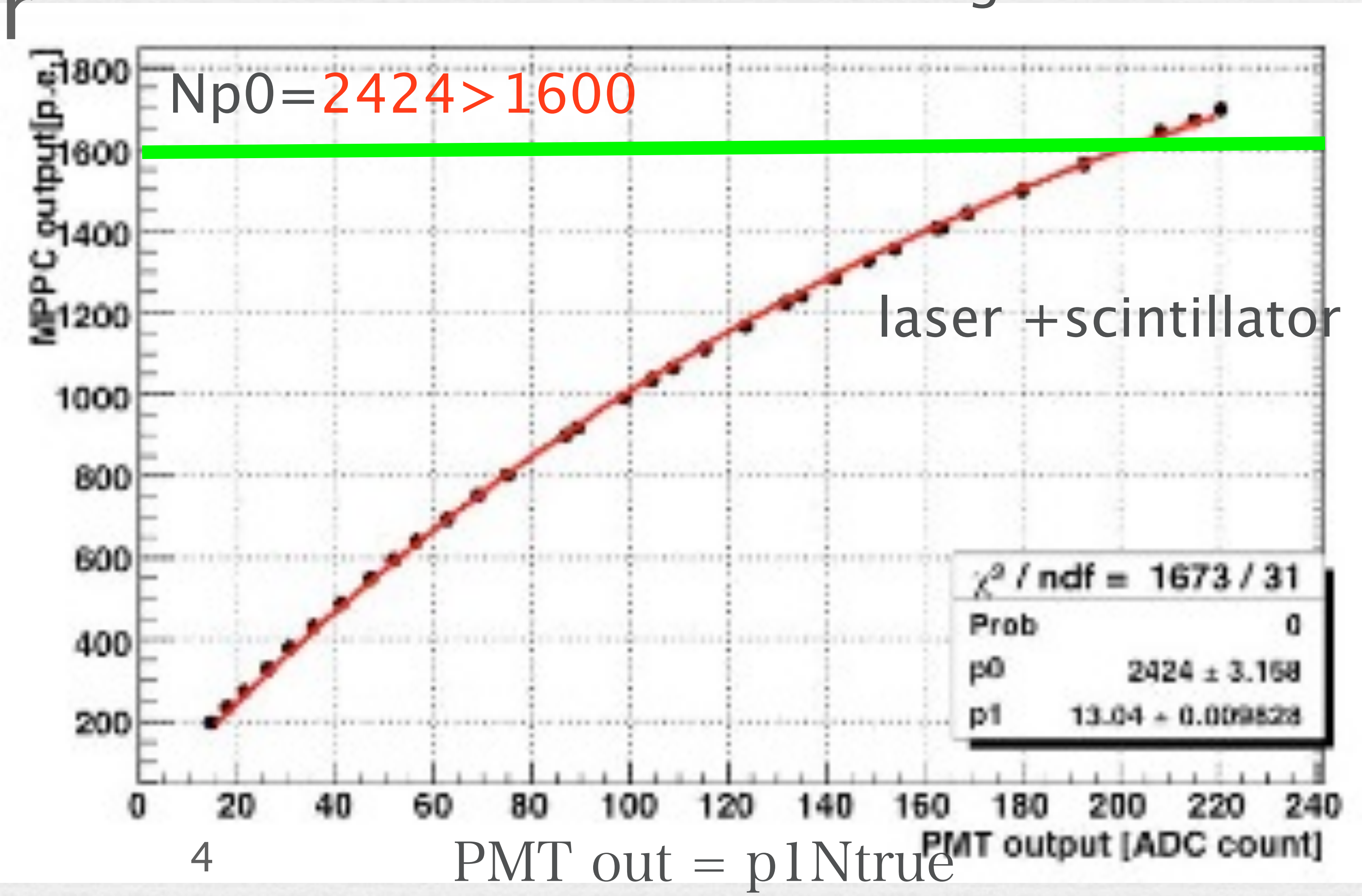
- Bias voltage recovers in short time ~ 4ns
- more than numb. of pix
- non-linear behavior

Npix=1600 calculation



p1Nture

ADC gate ~100ns

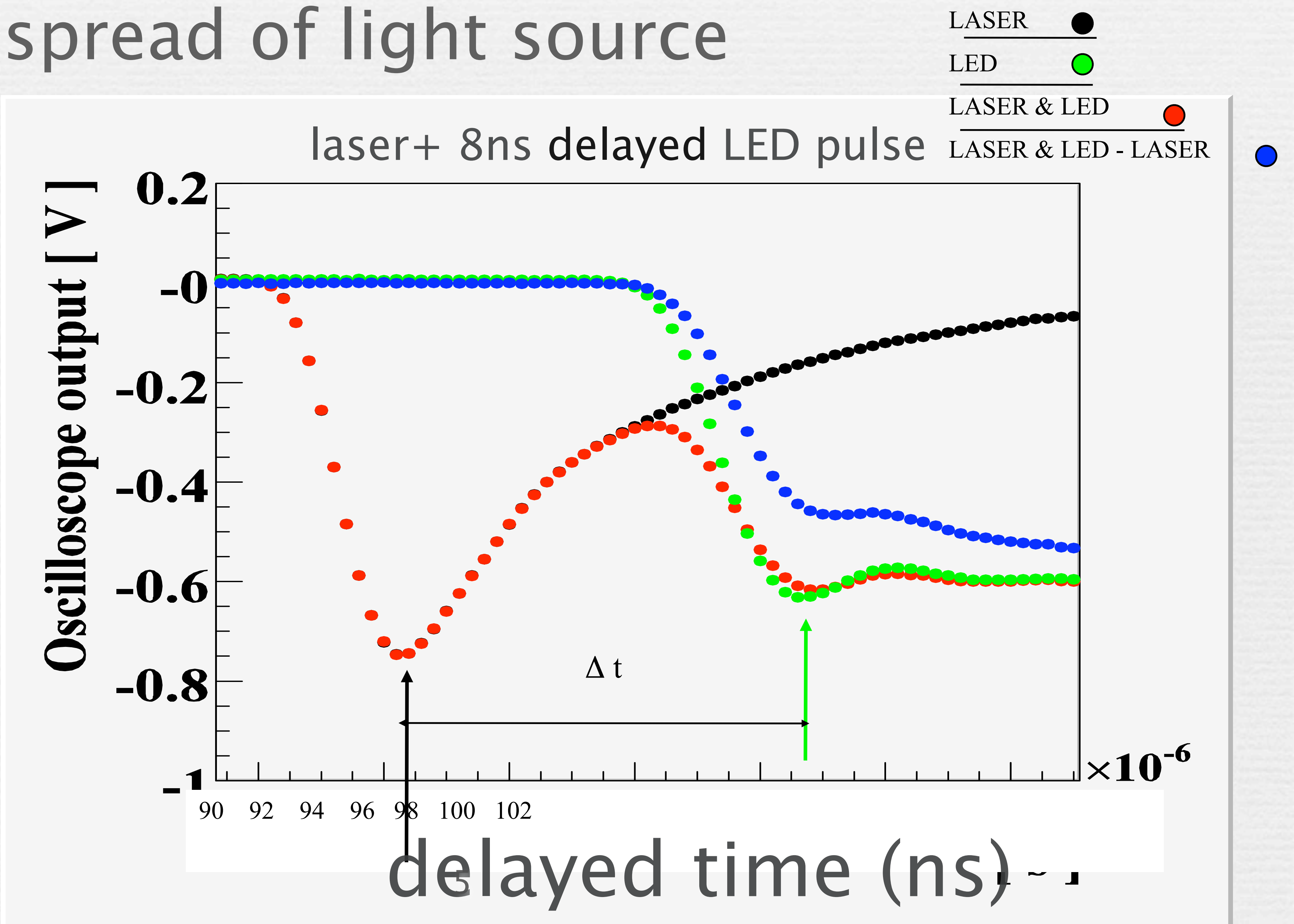


PMT out = p1Ntrue

saturation and linearity

- we expected saturation due to its operation mode
- however, somewhat different nature
- due to time spread of light source
- indeed
- calorimeter
- has linearity

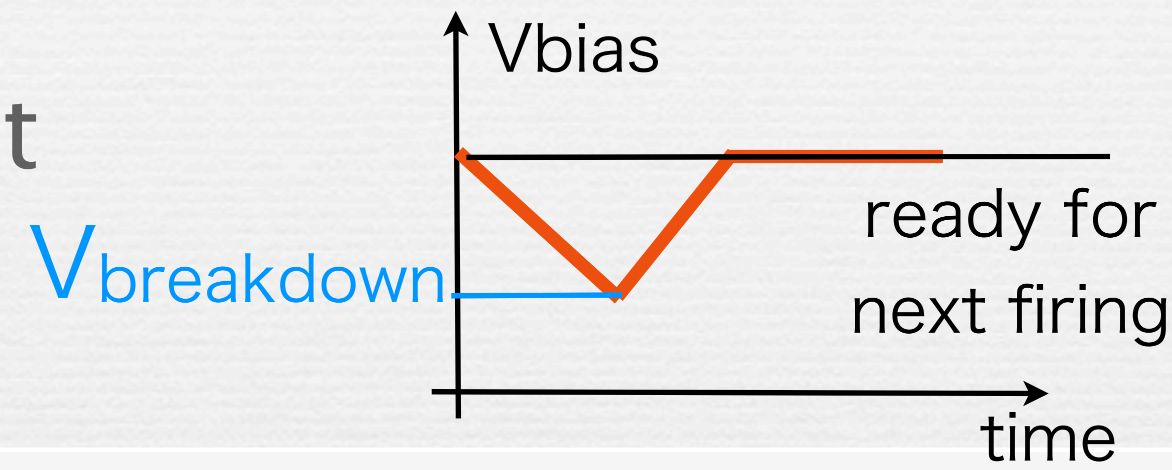
charge integra tion in gates

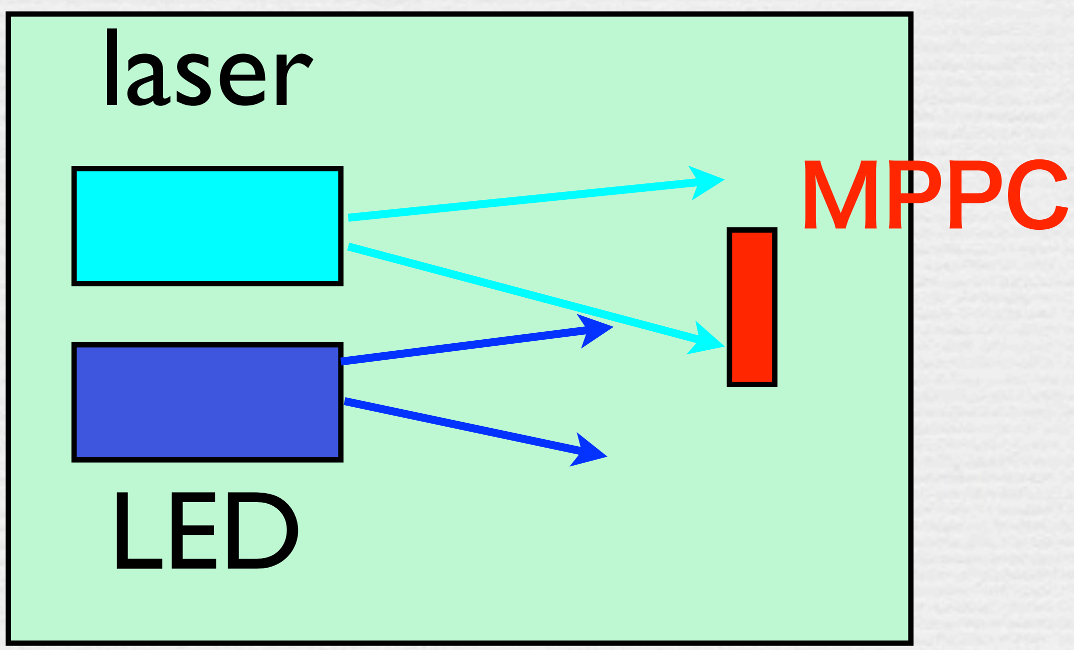


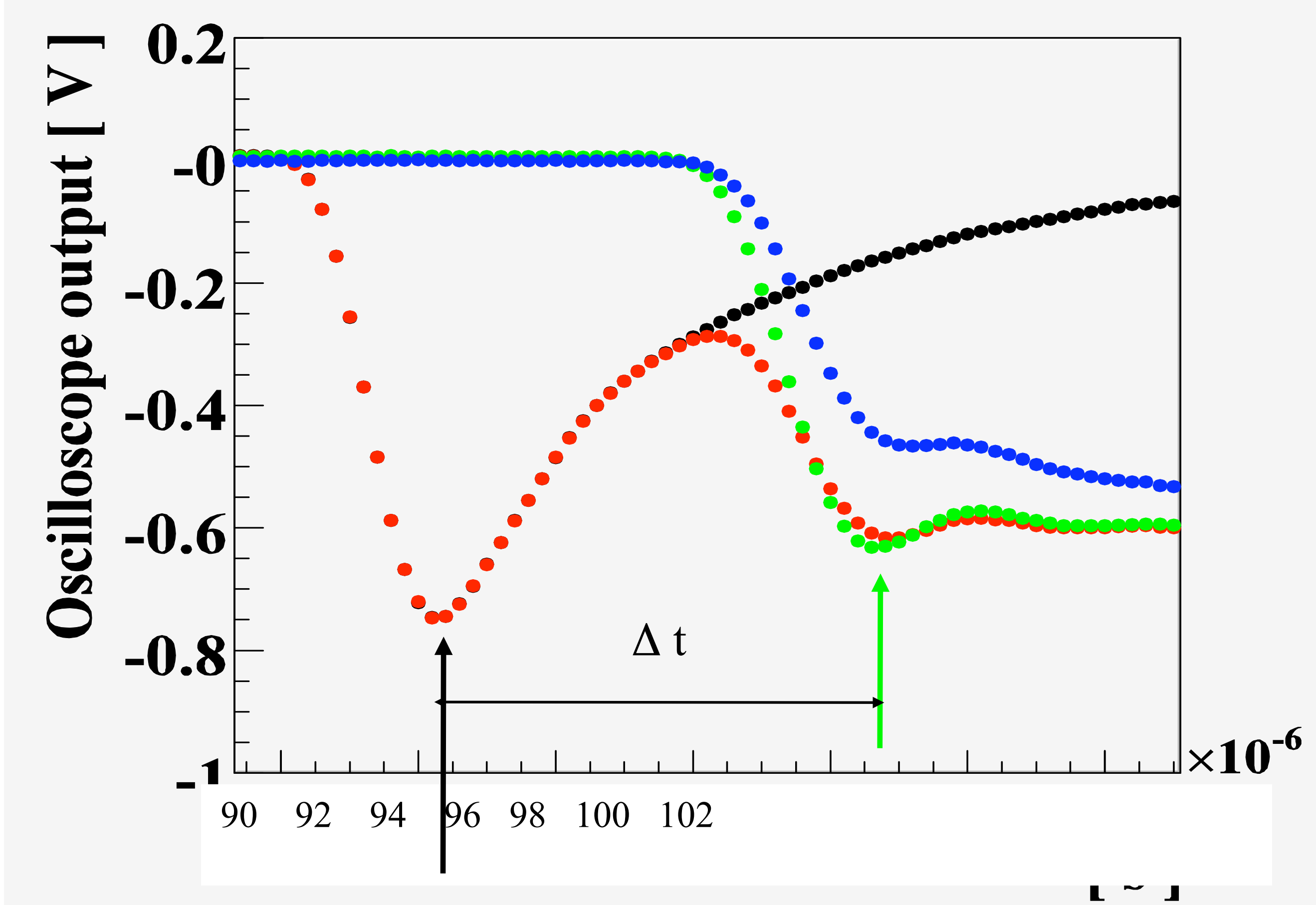
recovering of Geiger M

laser light in

- tested by blue laser light







recovering of Geiger M

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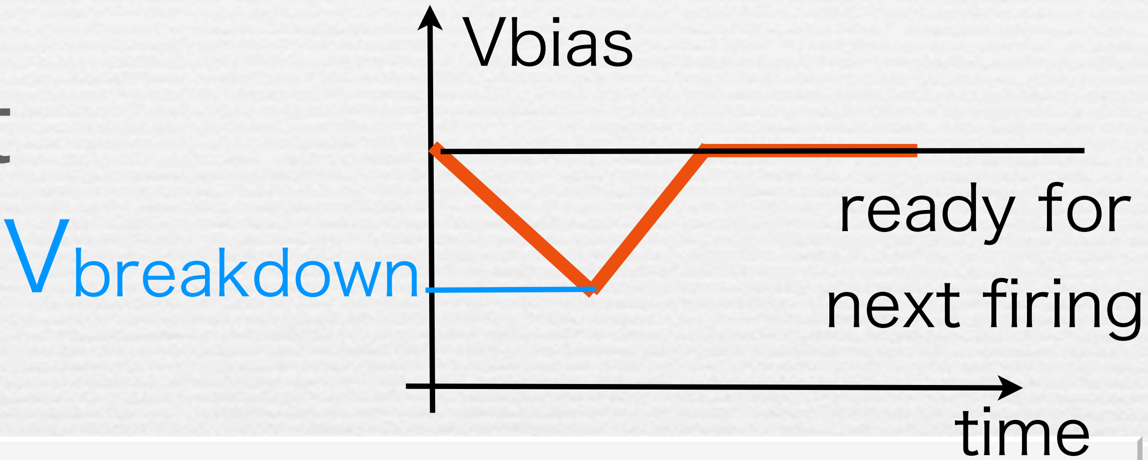

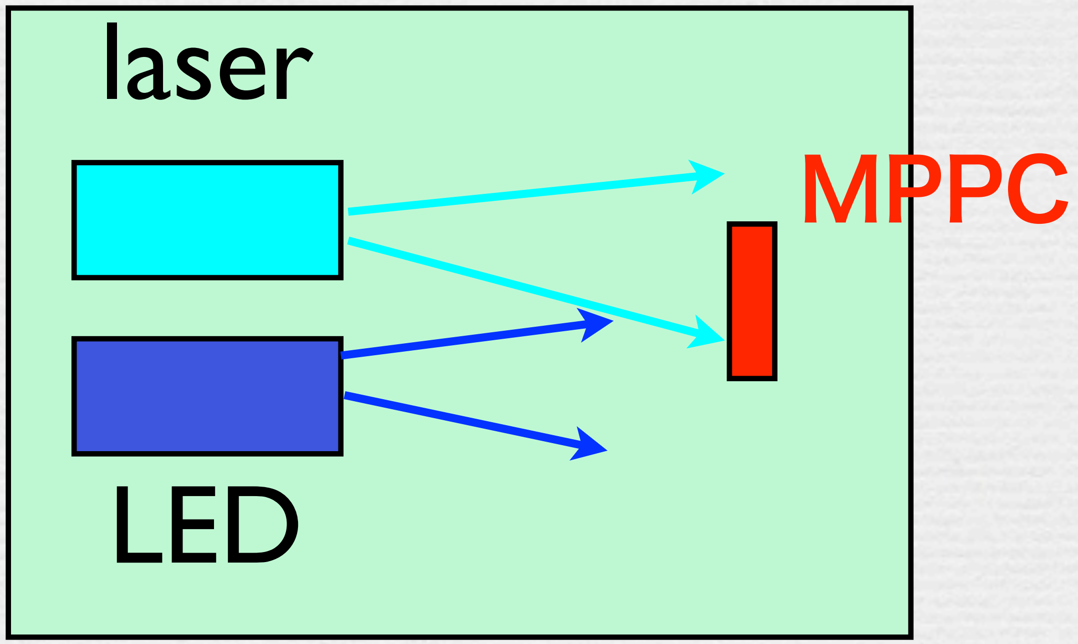

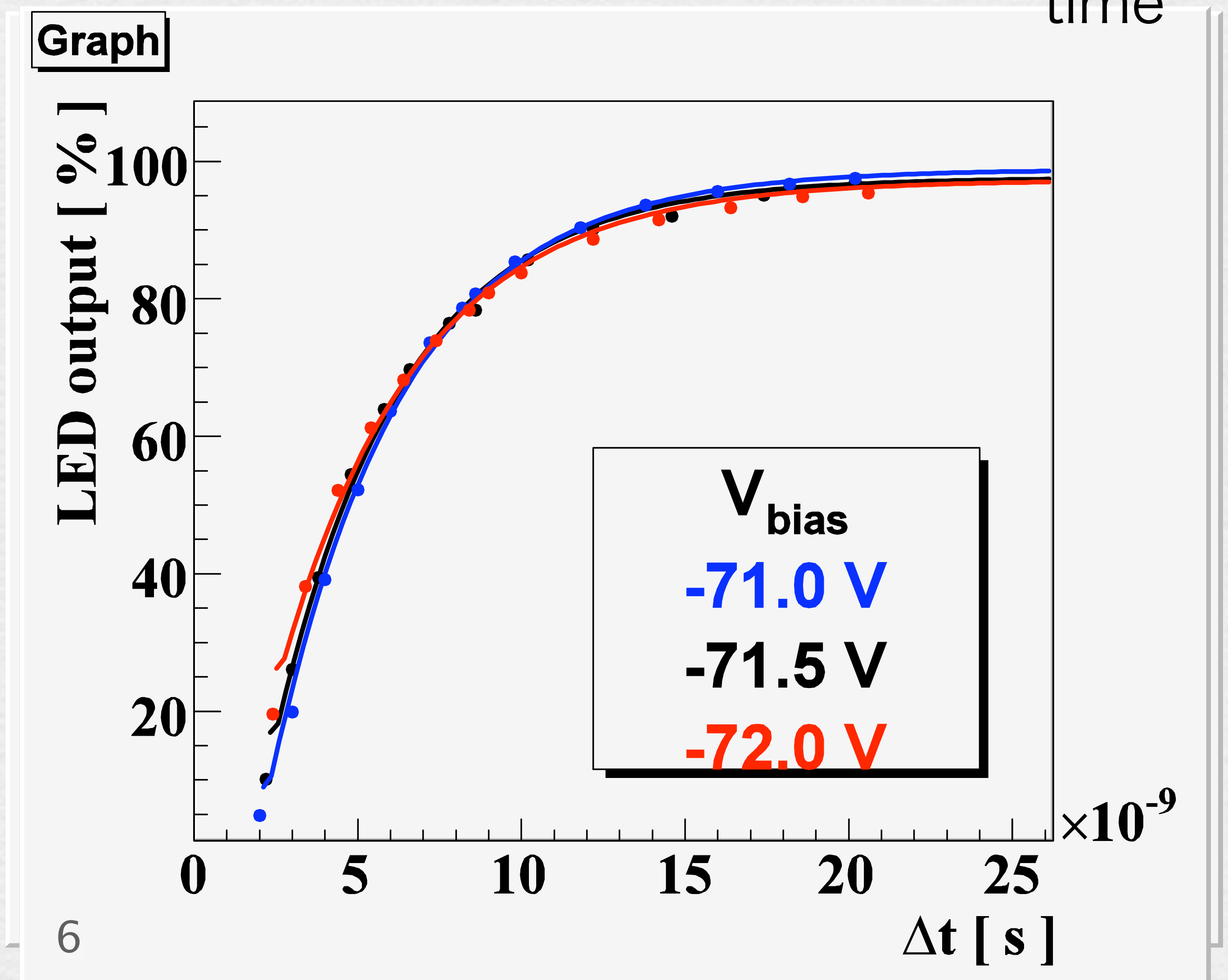

recovering of Geiger M

laser light in

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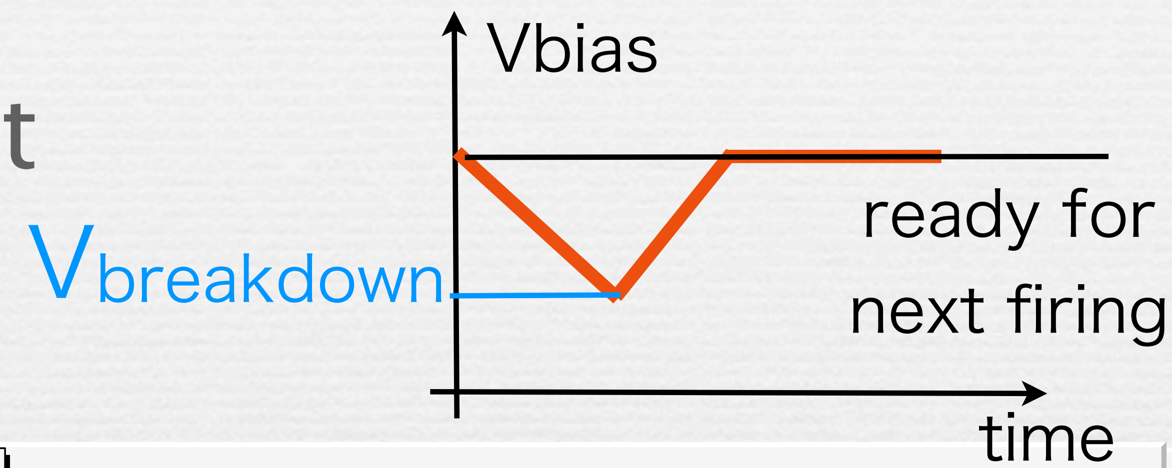
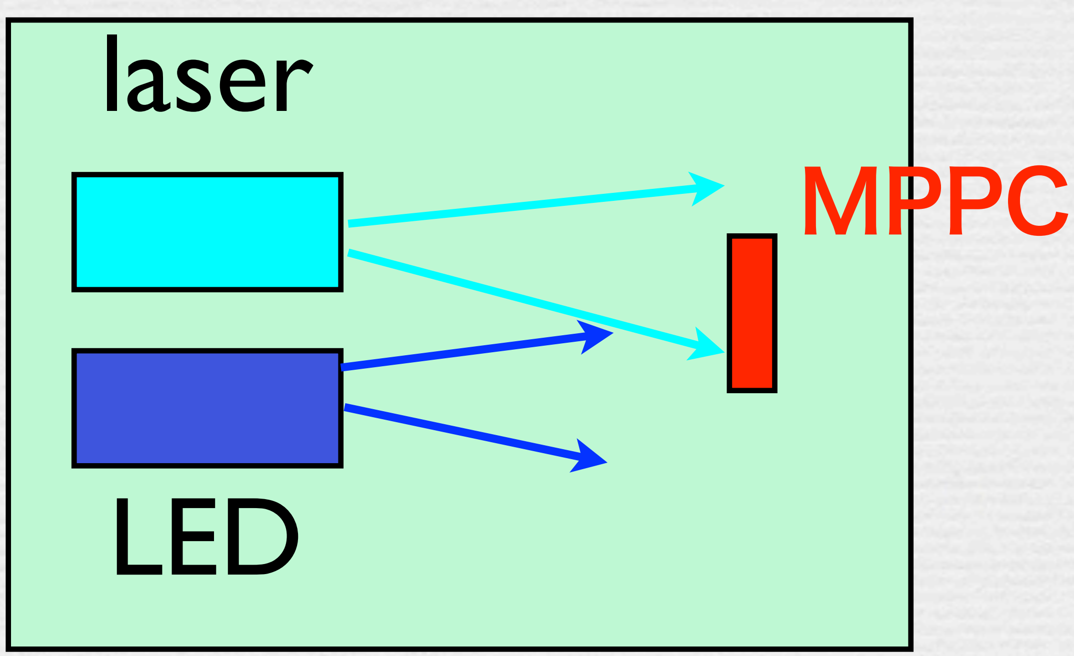
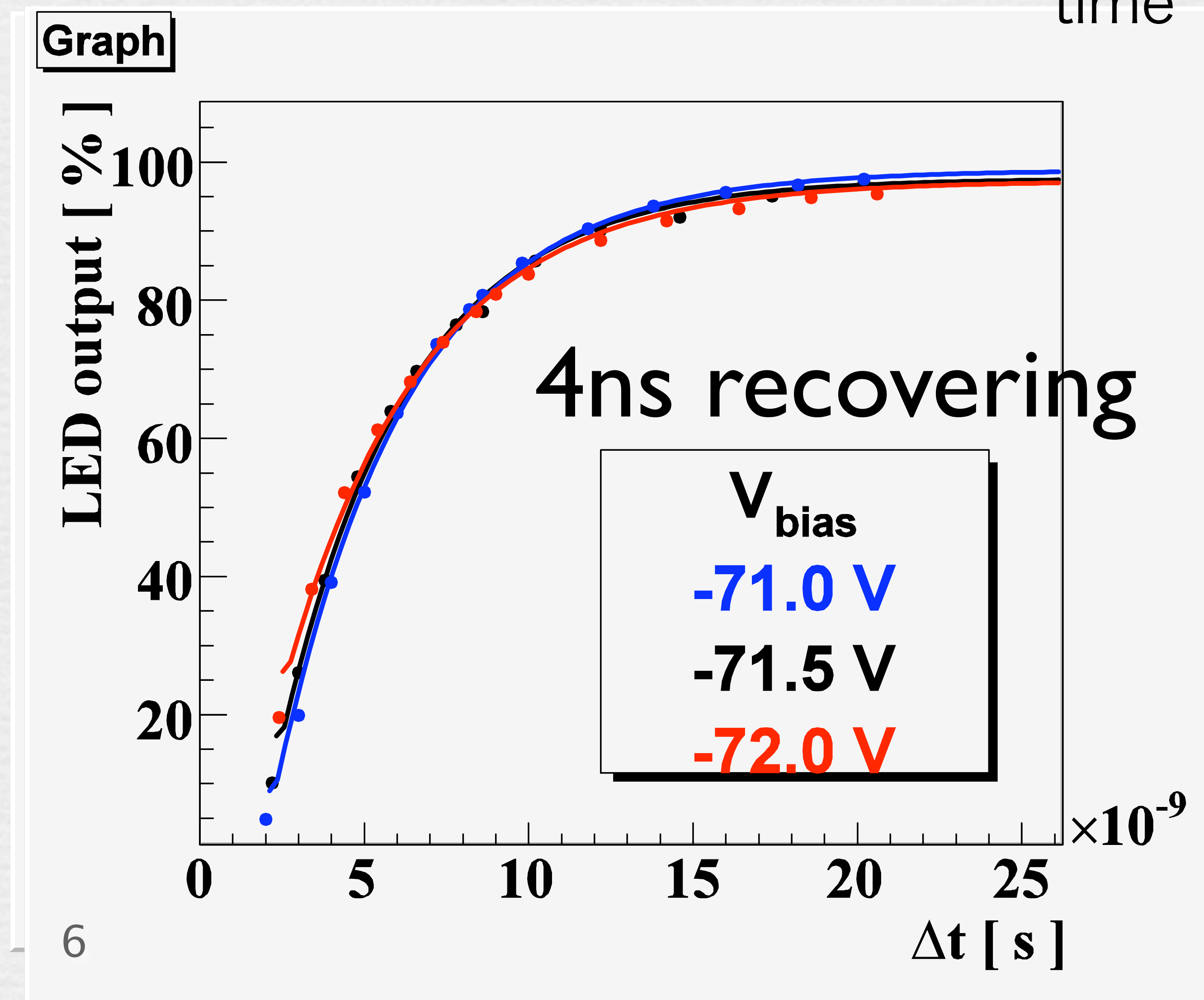


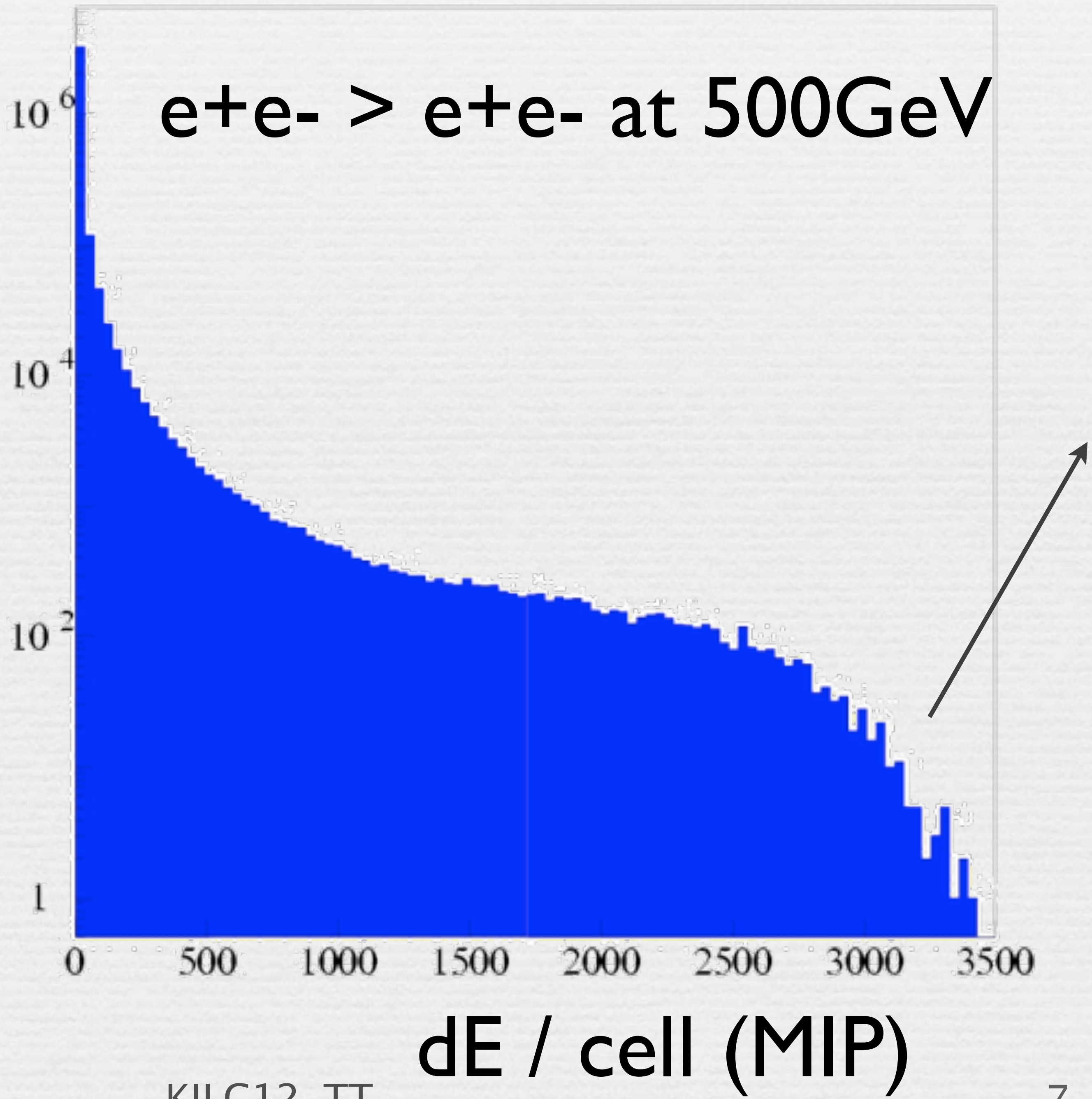




ILC ECAL

effect of saturation on the EM-Calorimeter

- Dynamic range : electronics & Photon sensor



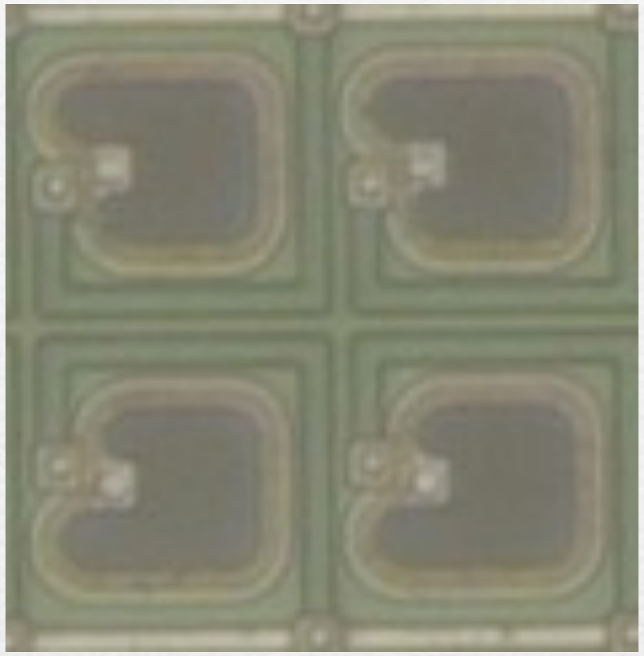
15bit ADC for electronics

3000MIPS ~ 30000 pixels at maximum

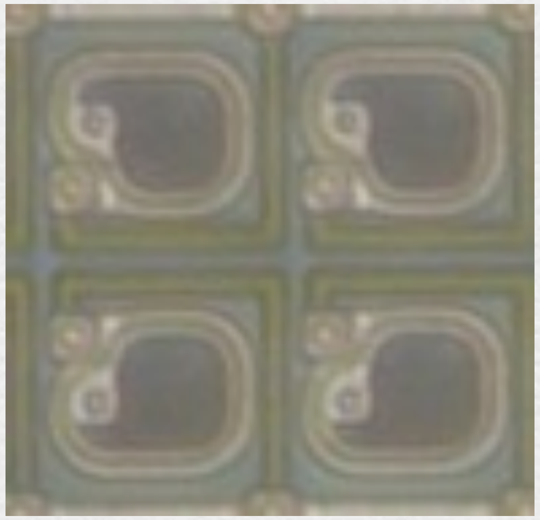
solution

- increase the number of pixels
- smaller pitch size, 25>20>15 μm
- number of pixels / mm^2
- 1600 > 2500 > 4400 pixels/mm^2
- loose acceptance

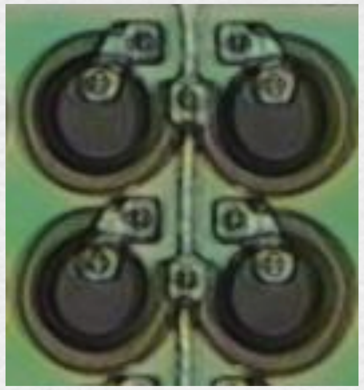
pitch
25μm
23%



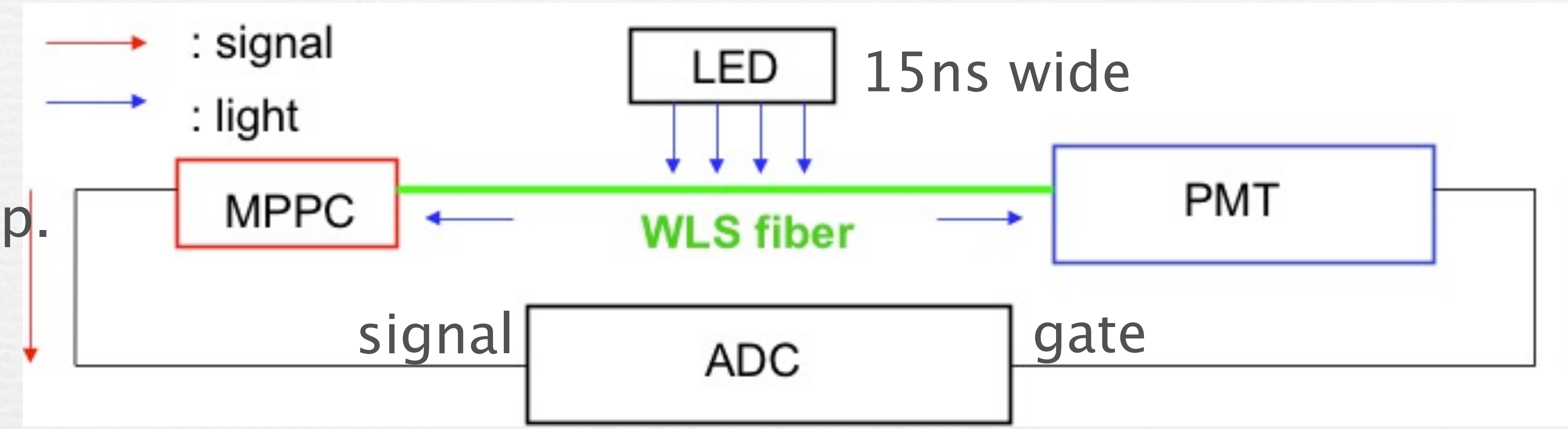
pitch
20μm
12%



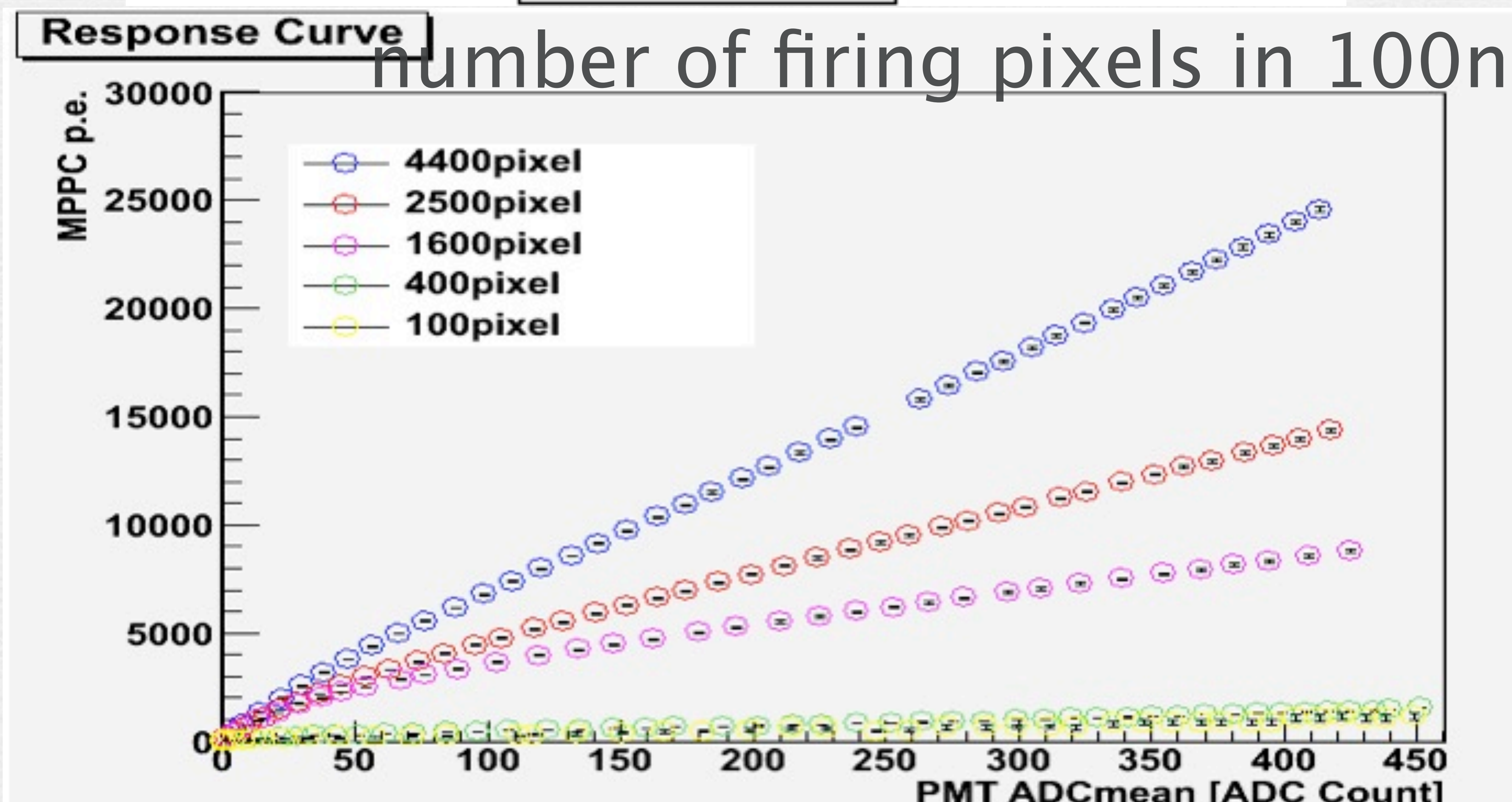
pitch
15μm
10%



linearity test by LED

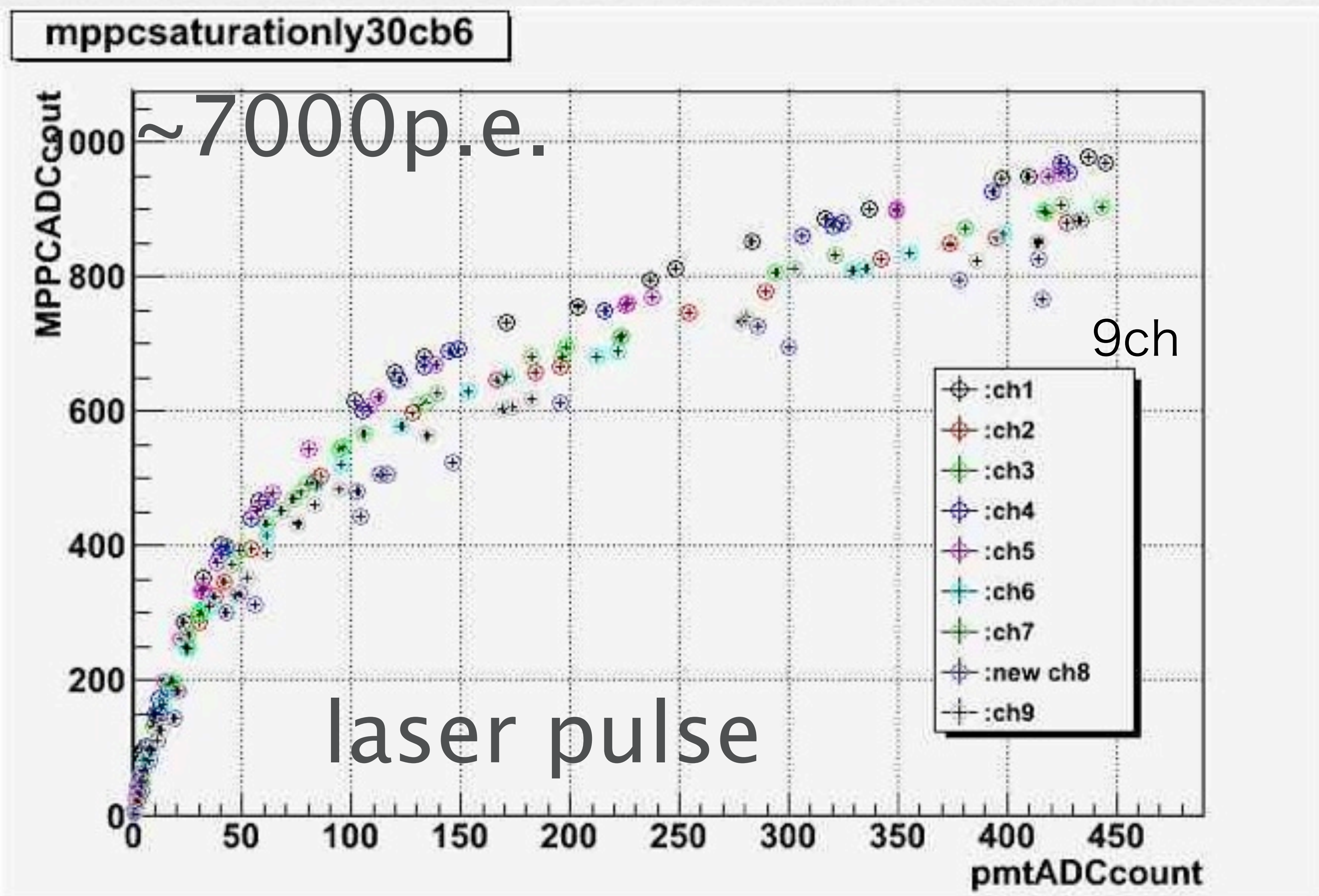


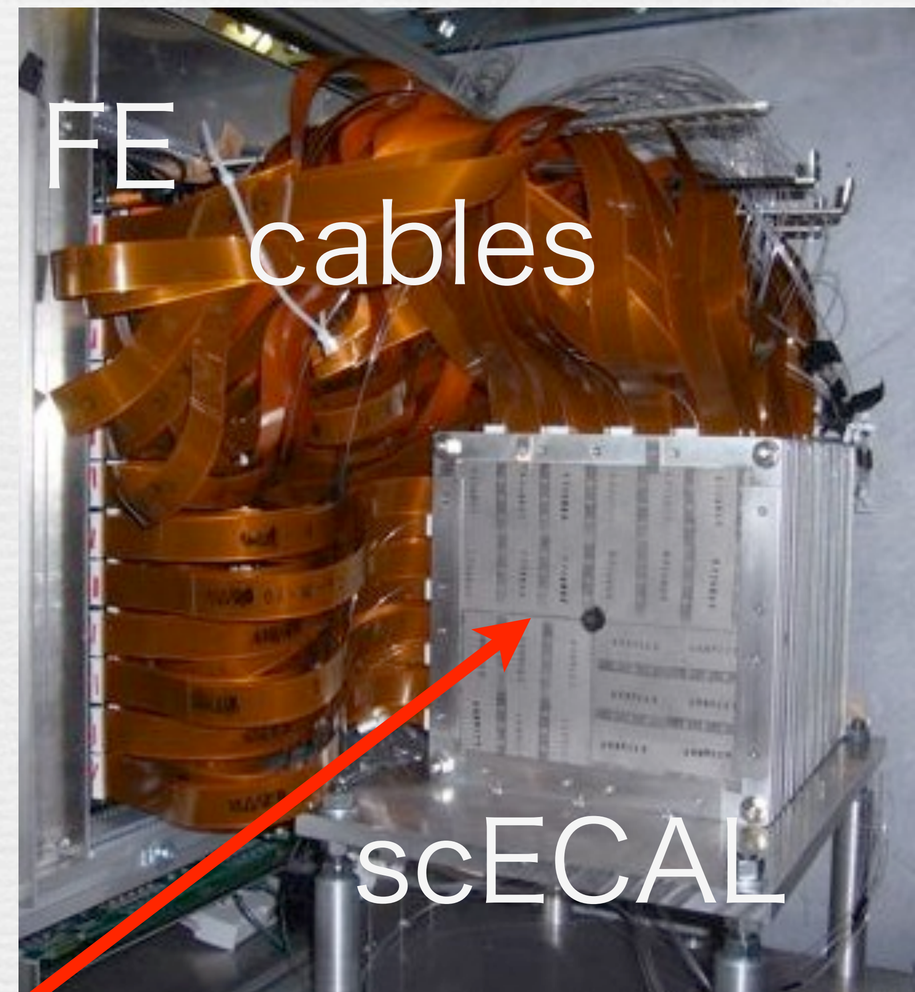
no amp.



study of non-linearity

- variation in 72 scintillator strips and MPPCs
- they are tested at the FNAL beam for scintillator ECAL





nels

saturation

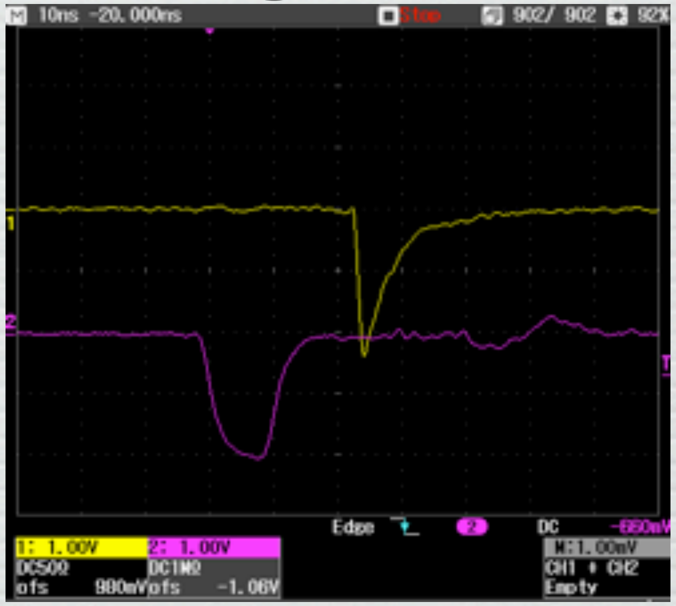
- GM photo-sensor was believed to have complete saturation phenomena

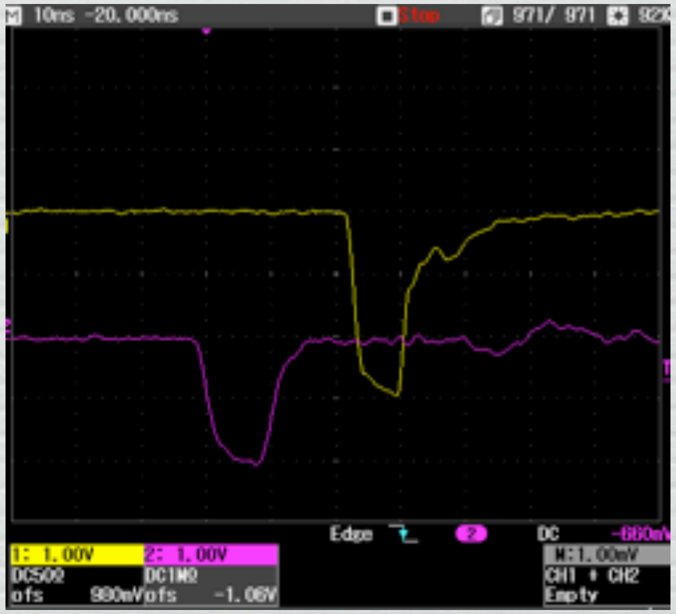
However

- having a huge amount of photons in some time span , its response looks linear
- energy measurement can be recovered as far as we control the response

we look into the leading edge of signal

normal signal



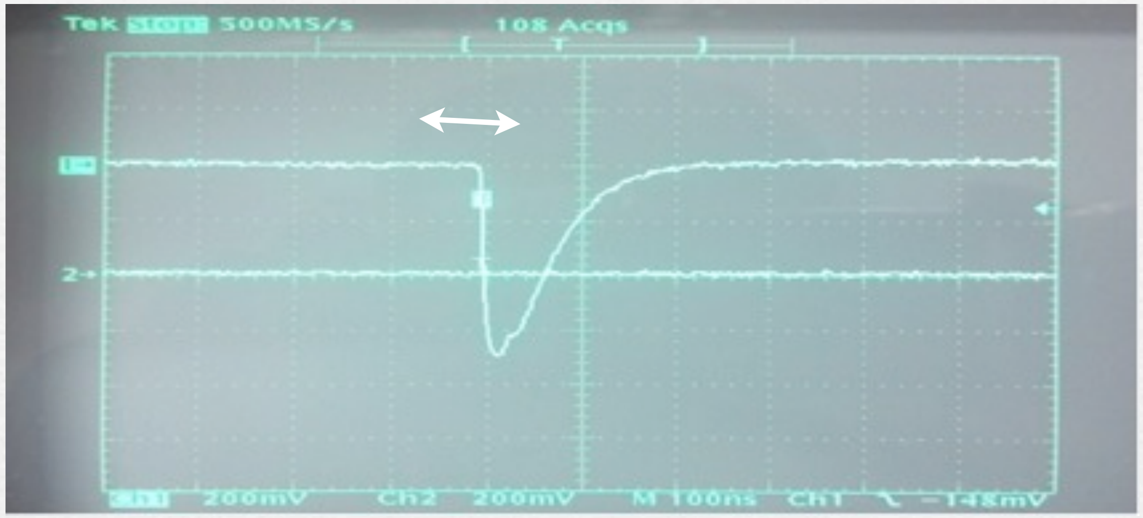


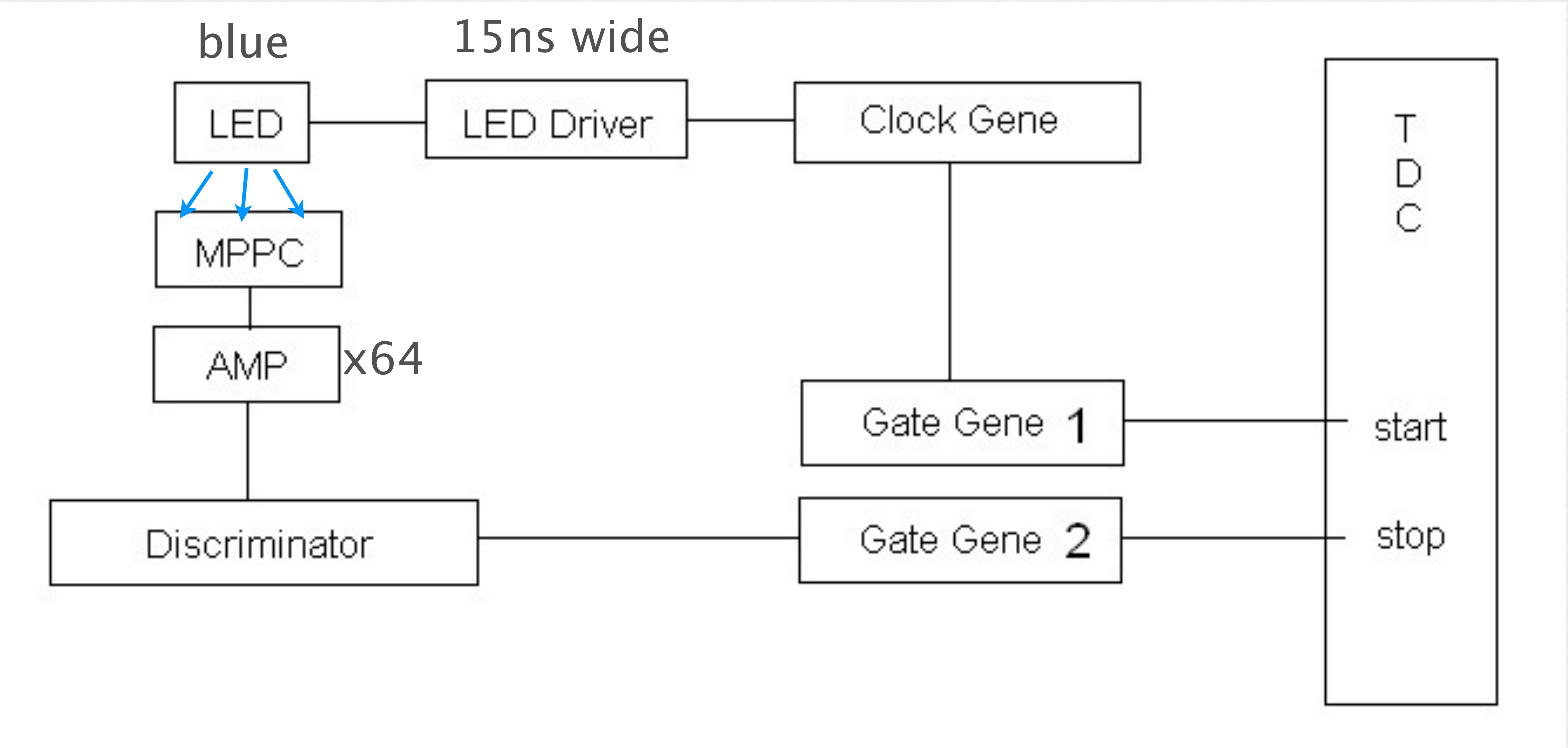
saturating signal

timing resolution

setup

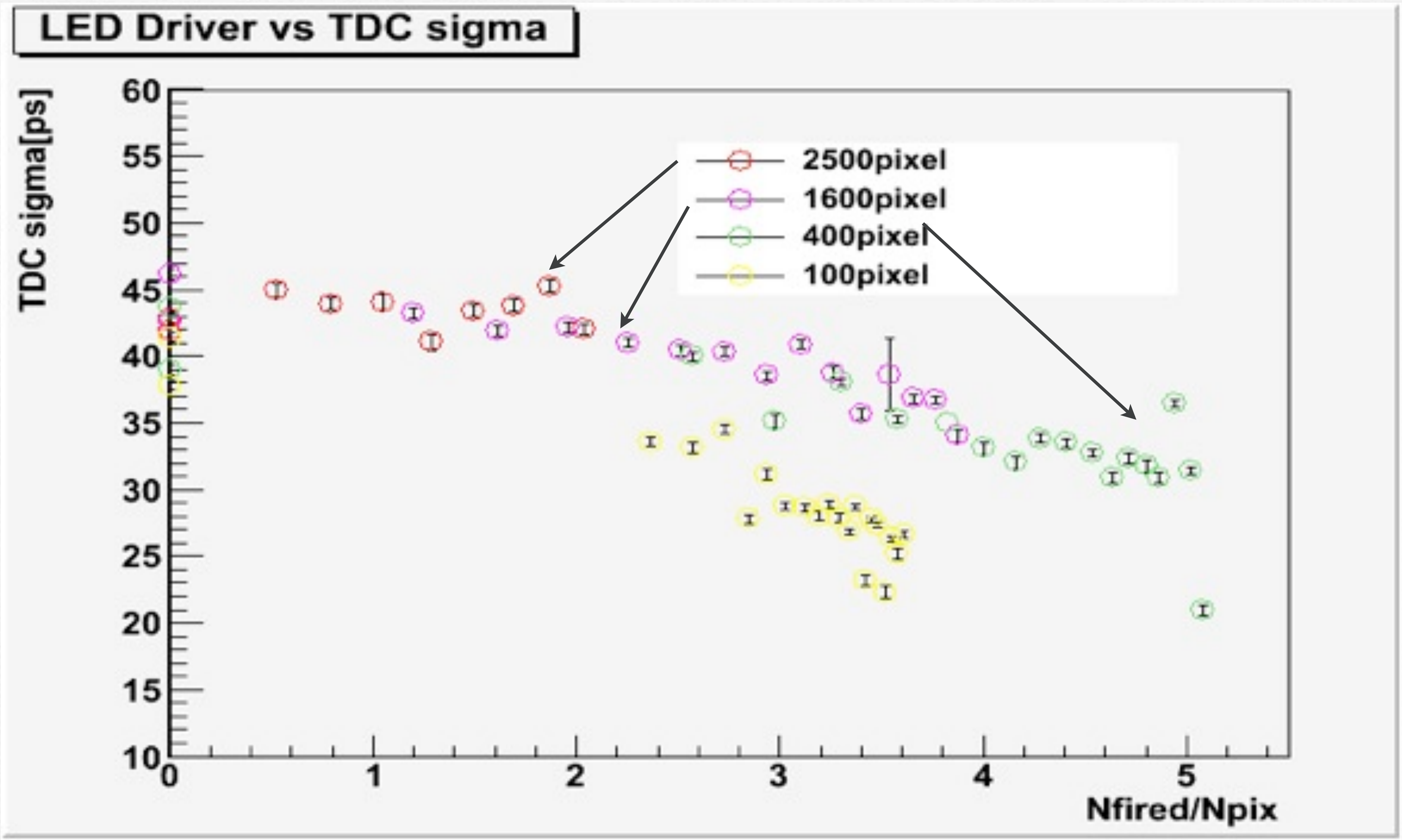
amount of light is not small





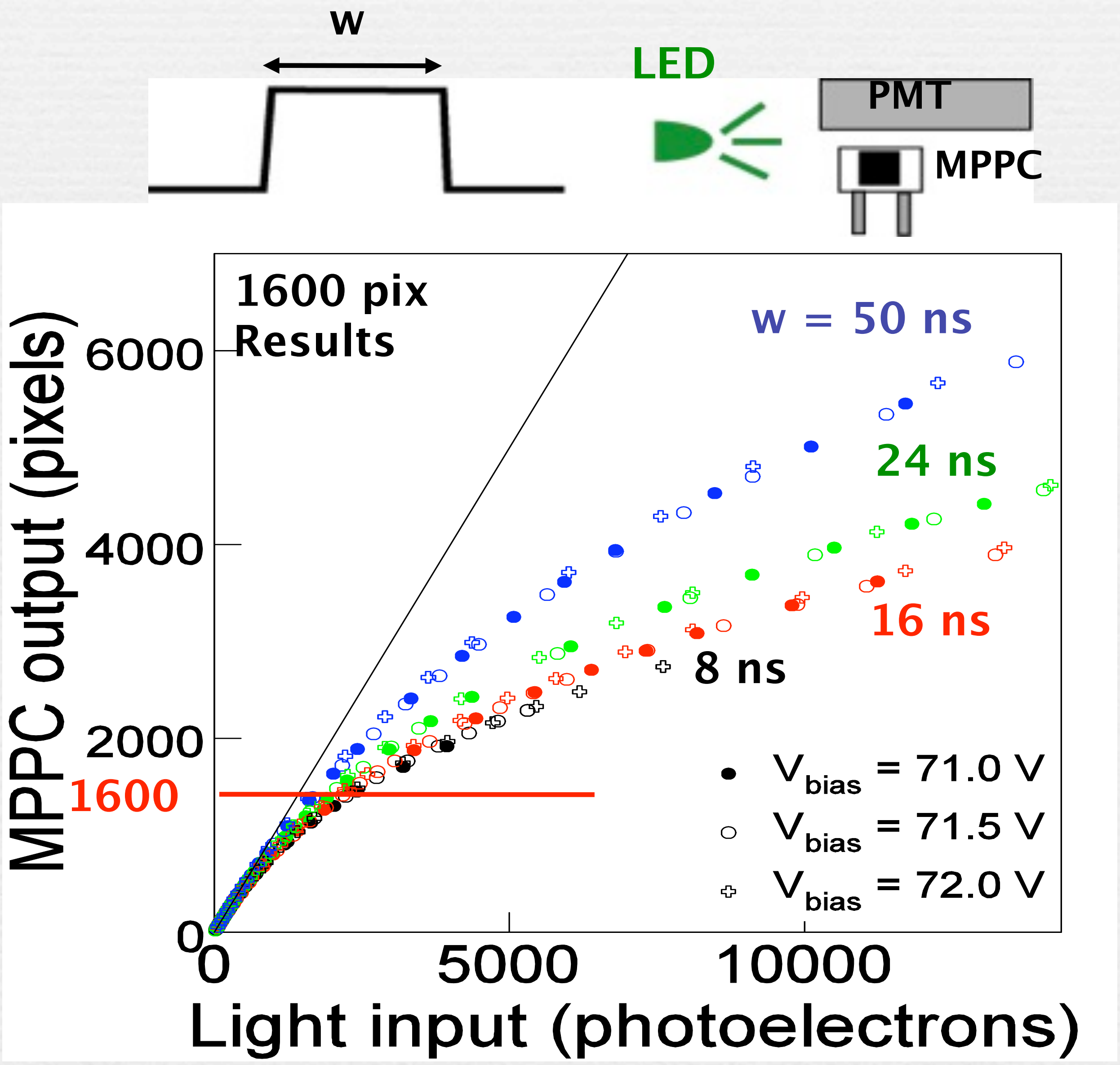
timing resolution

35 ~ 45 ps in rms

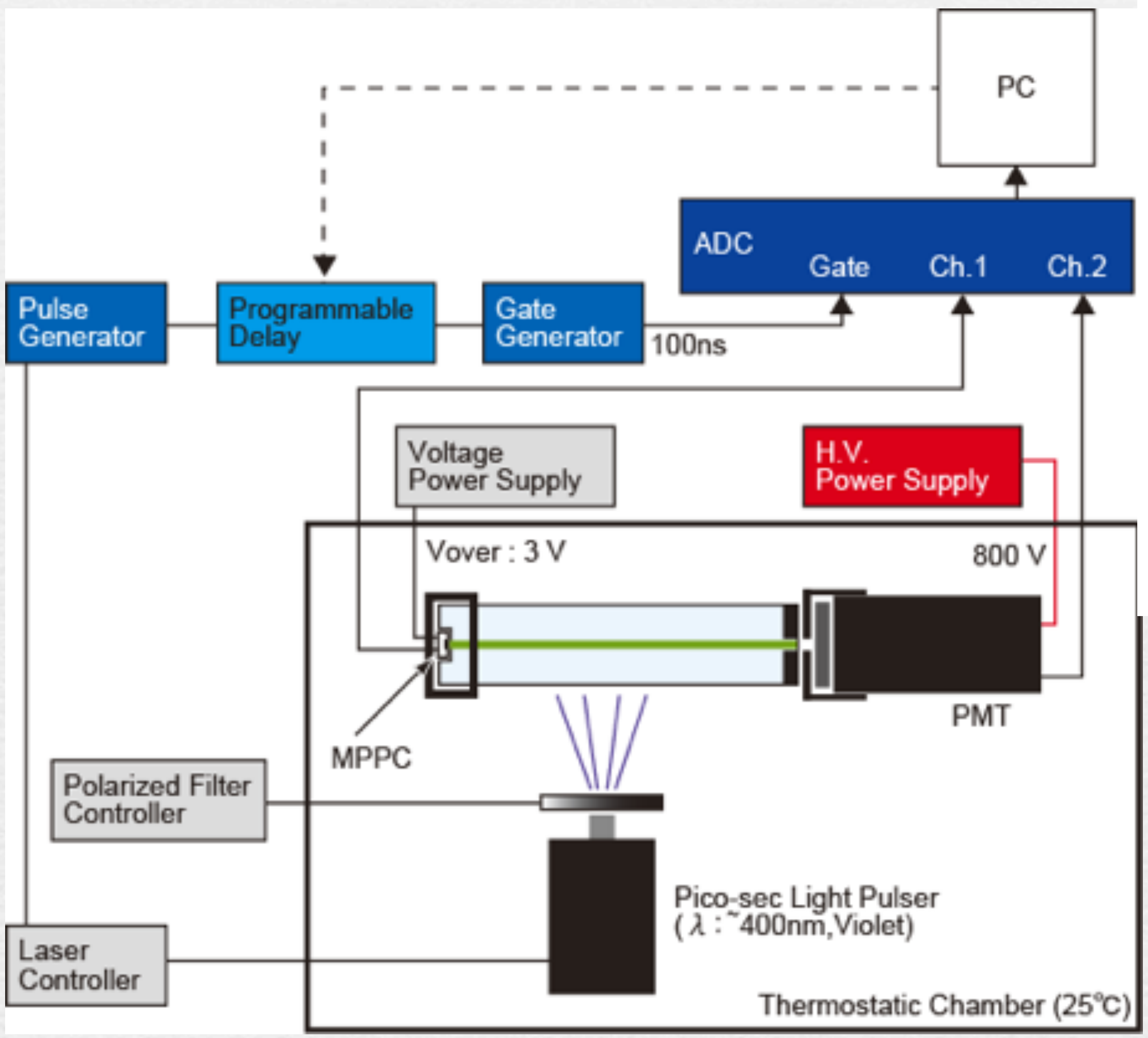


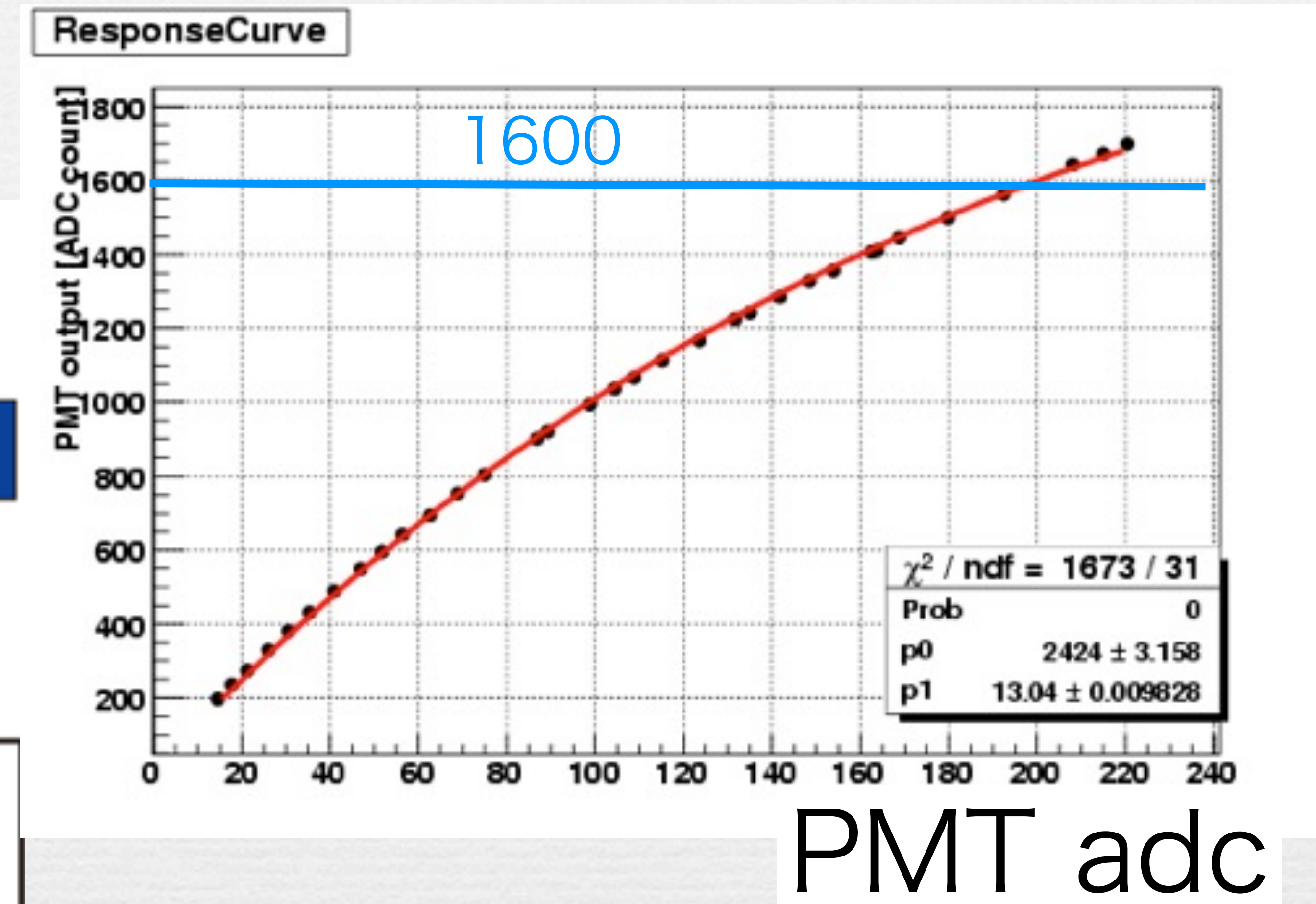
summary

- linearity up to 30000 pixels is seen ~ 500GeV Bhabha
- saturation phenomena is understudy
- fine ~40ps timing resolution is found
- good for CLIC
- test at low number of photons ~ 1 MIP is under dev.
- with a scintillator strip
- Scintillator ECAL can be a good candidate for ILC calorimeter


w
LED
PMT
MPPC
1600 pix
Results
w = 50 ns
24 ns
16 ns
8 ns
MPPC output (pixels)
6000
4000
2000
1600
0
0
5000
10000
Light input (photoelectrons)
V_{bias} = 71.0 V
V_{bias} = 71.5 V
V_{bias} = 72.0 V

saturation found





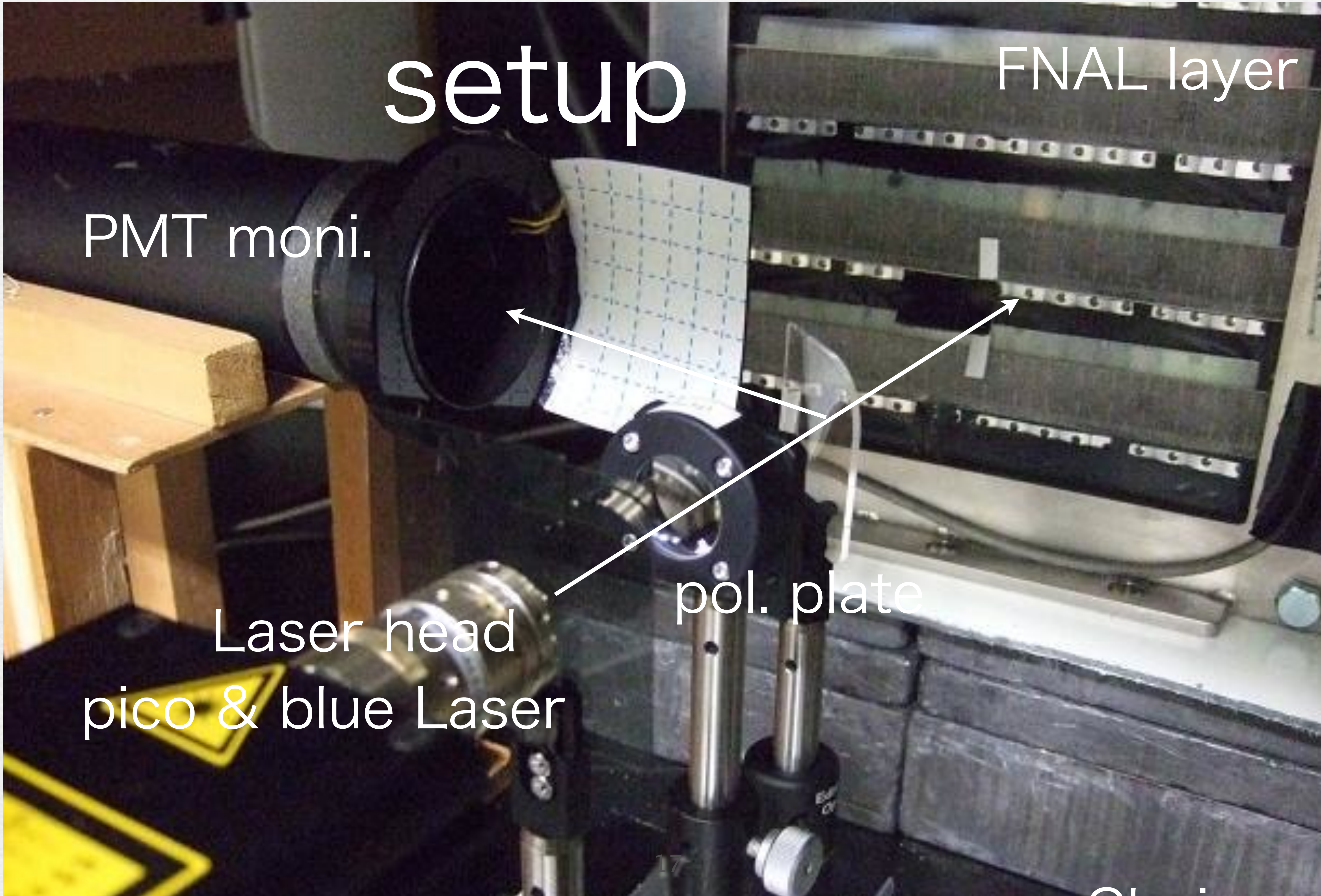
$$N_{fired} = N_{pix}\left(1 - \exp\left(\frac{N_{true}}{N_{pix}}\right)\right)$$

↓

Fit function

$$Output_{MPPC} = \mathrm{p0}\left(1 - \exp\left(\frac{\mathrm{p1} \times Output_{PMT}}{\mathrm{p0}}\right)\right)$$

saturation


setup
FNAL layer
PMT moni.
pol. plate
Laser head
pico & blue Laser