

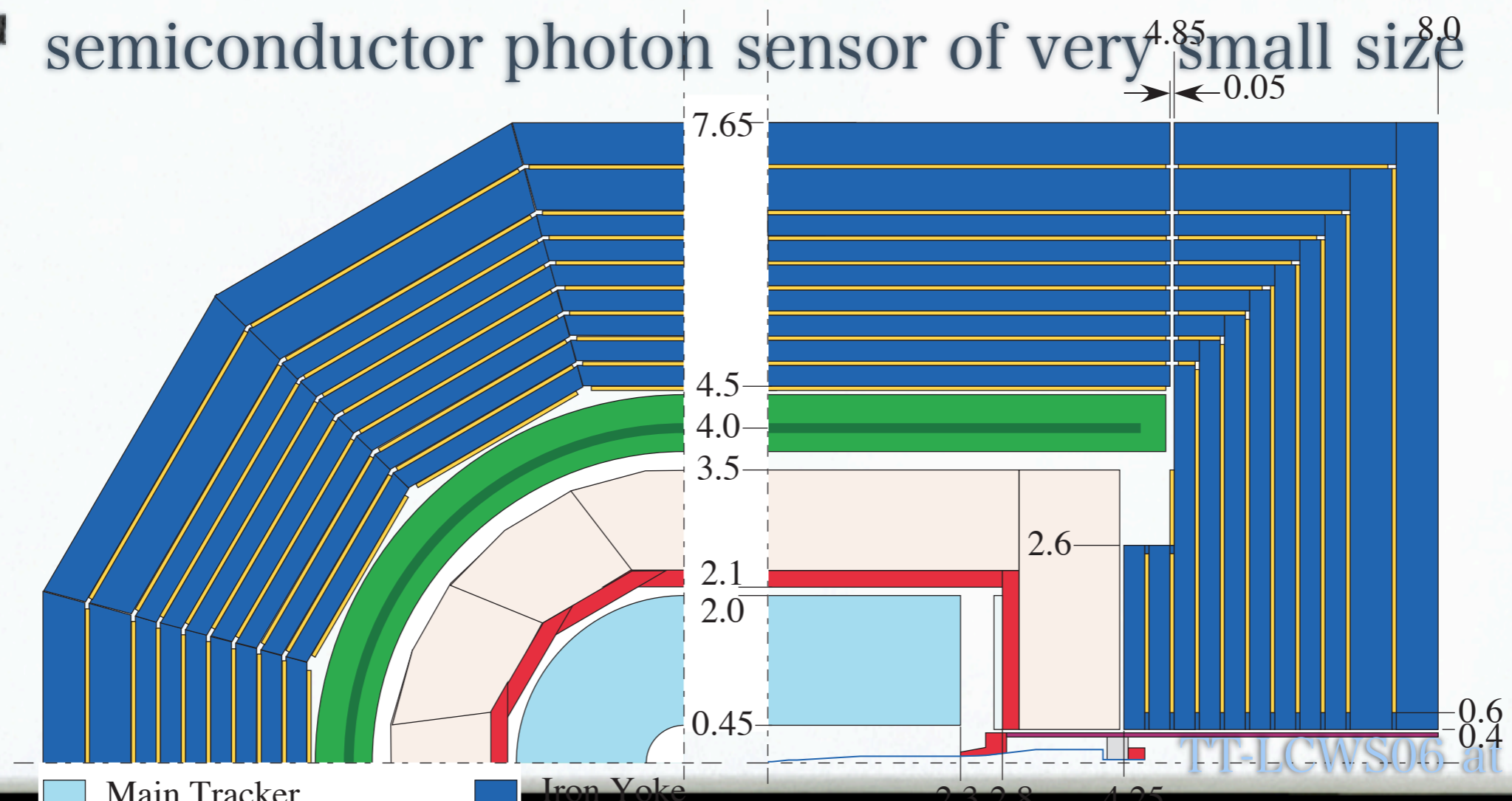
# Development of MPPC

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Tohru Takeshita  
on behalf of neutrino and GLD-CAL  
group

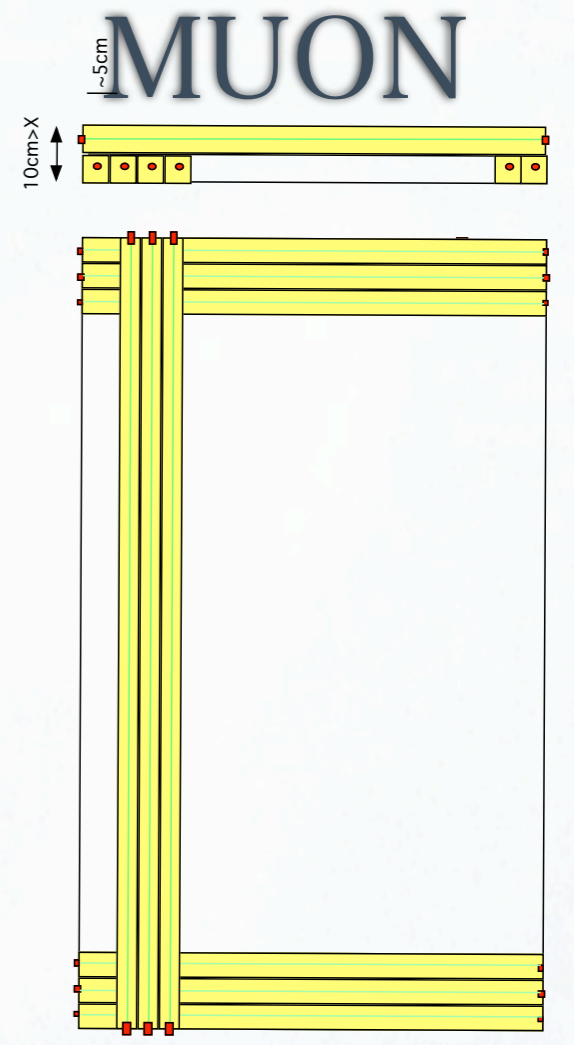
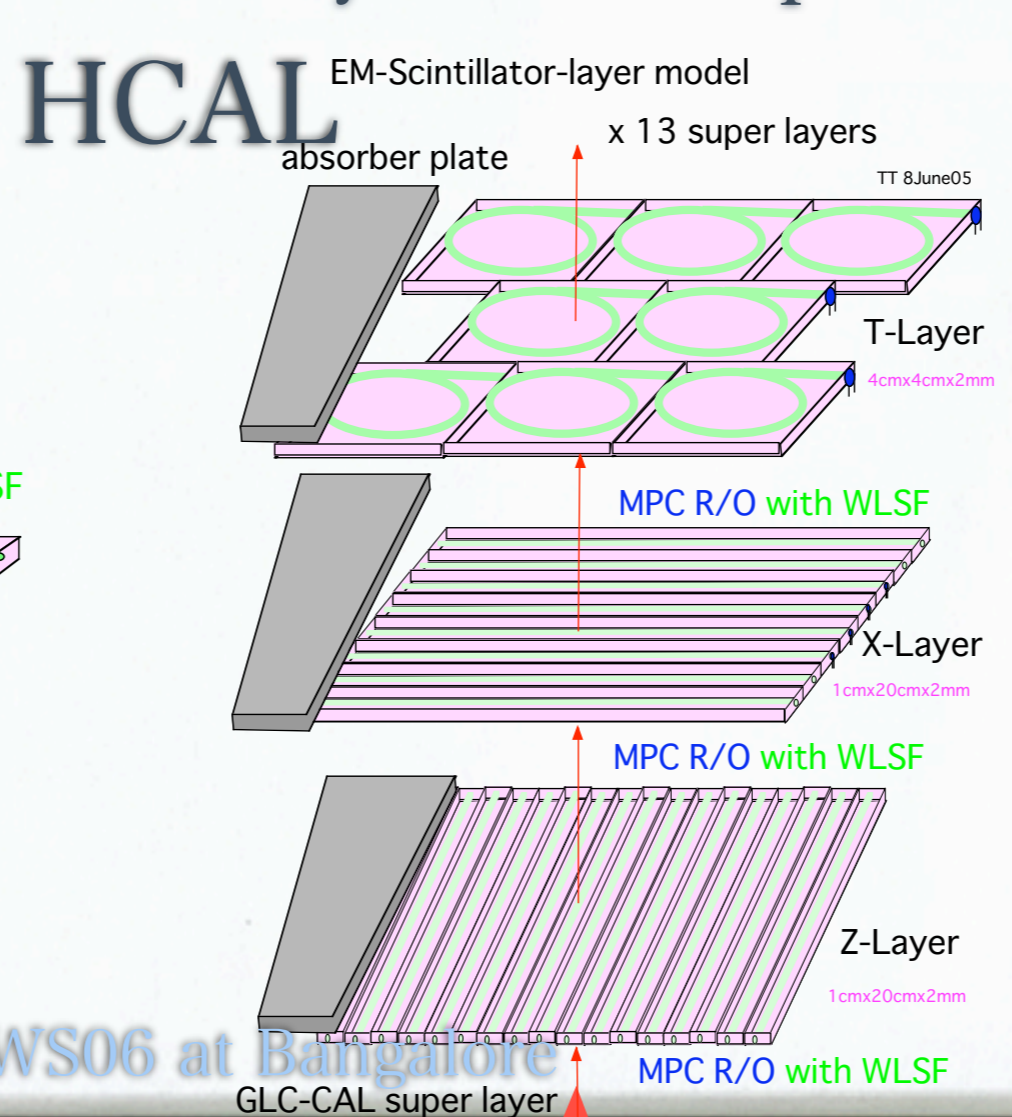
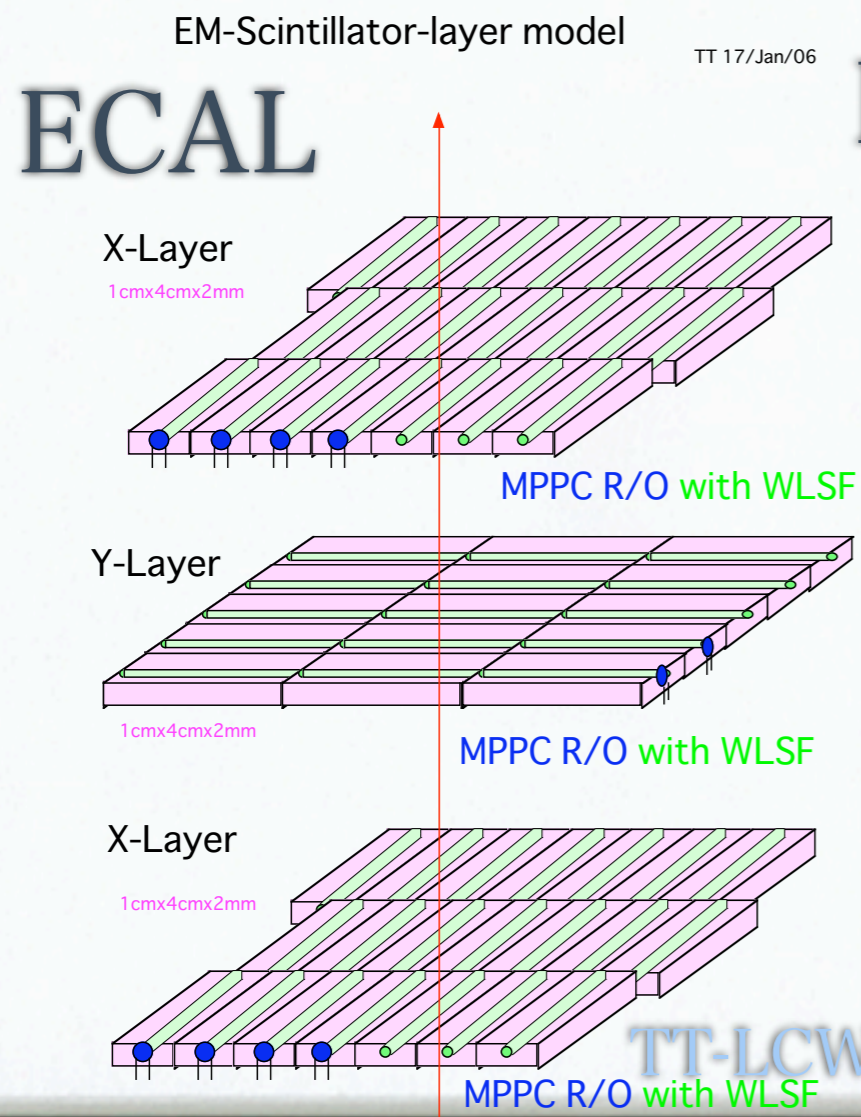
# GLD-Calorimeter and Muon

- GLD-CAL : scintillator ECAL, HCAL and MUON
- In the magnetic field of 3T
- Photon sensor and electronics on the detector
- semiconductor photon sensor of very small size



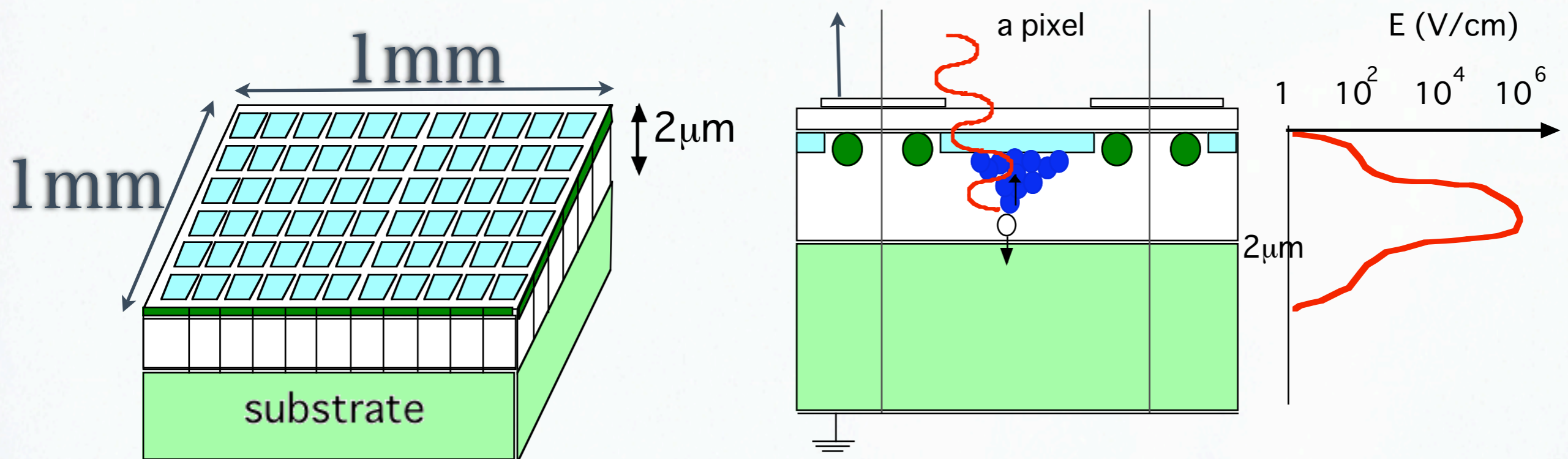
# GLD-CAL and muon

- scintillator and W/Pb sandwich calorimeter
- Wavelength shifting fiber read out
- scintillators and directly attached photon sensors



# Digital pixel Photon sensor

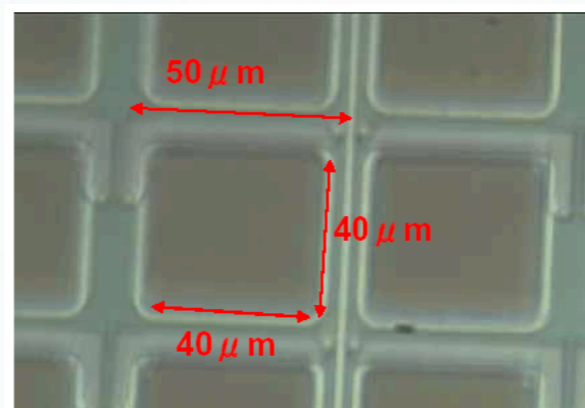
- Geiger Mode or Limited GM pixel p.s. : large gain
- Number of firing pixels  $\sim$  Number of photons
- to be operated at room temperature



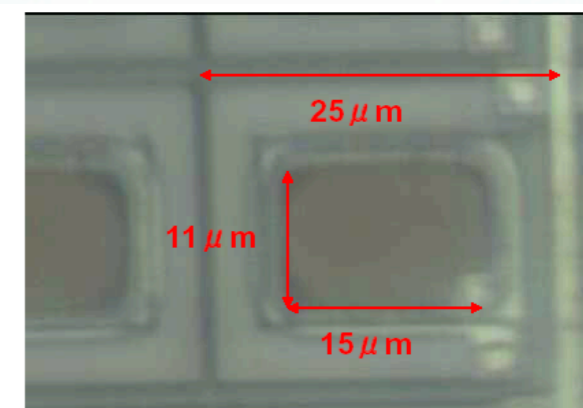
# Progress of development of MPPC

- MPPC is made in Japan by HPK
- Development underway : version 0,1,2,3(current)
- suppress noise (single pixel firing)
- higher detection efficiency
- larger surface for bigger fiber / scintillator

V3 picture



400pixel



1600pixel

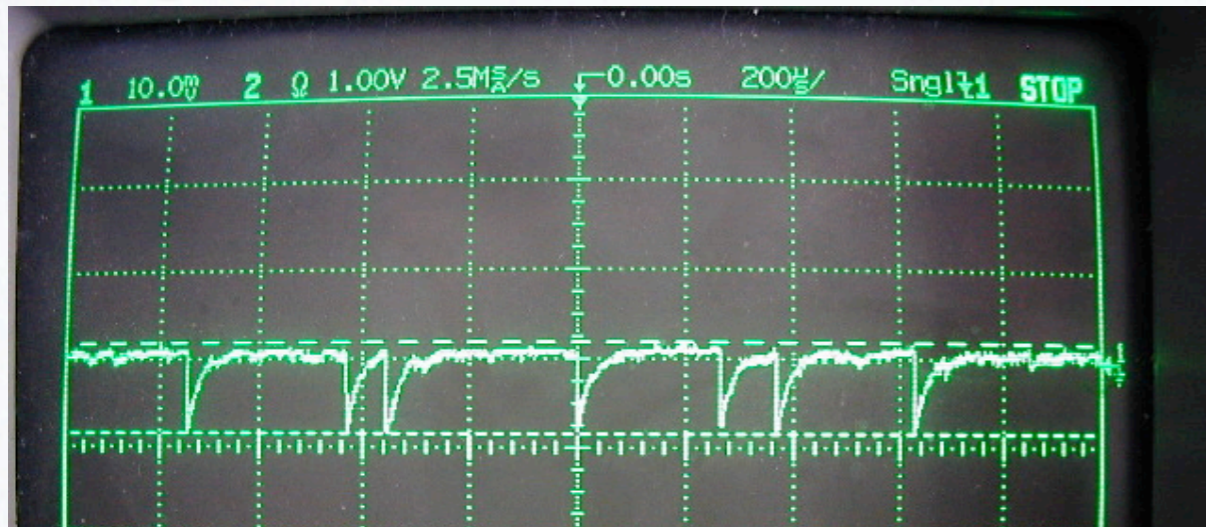
1600pix

# MPPC in GM and LGM

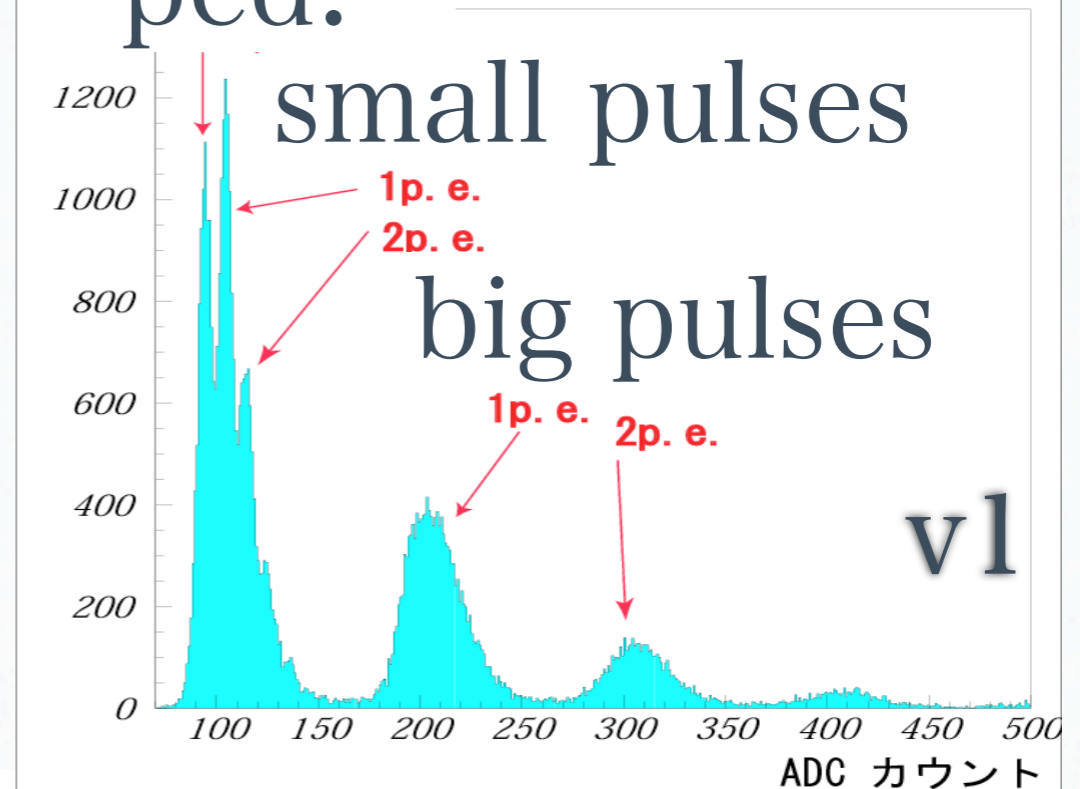
v0

■ Geiger Mode and Limited GM

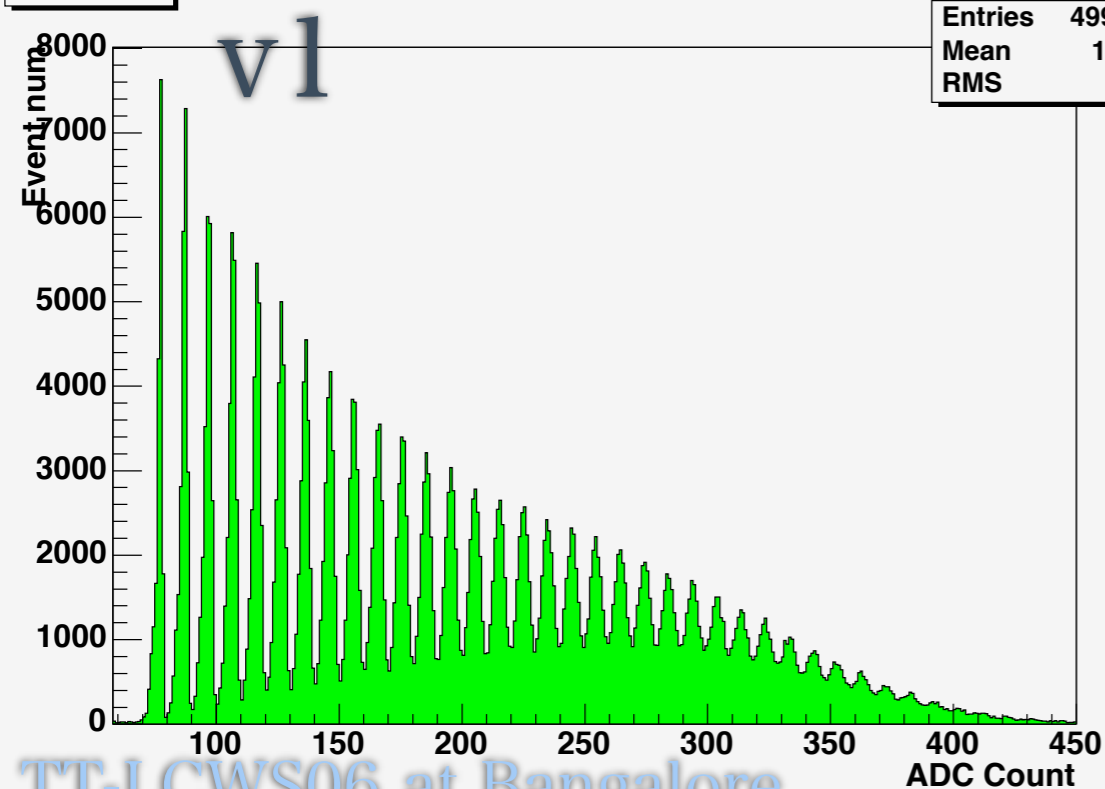
Nobuhara



ped.



run1874



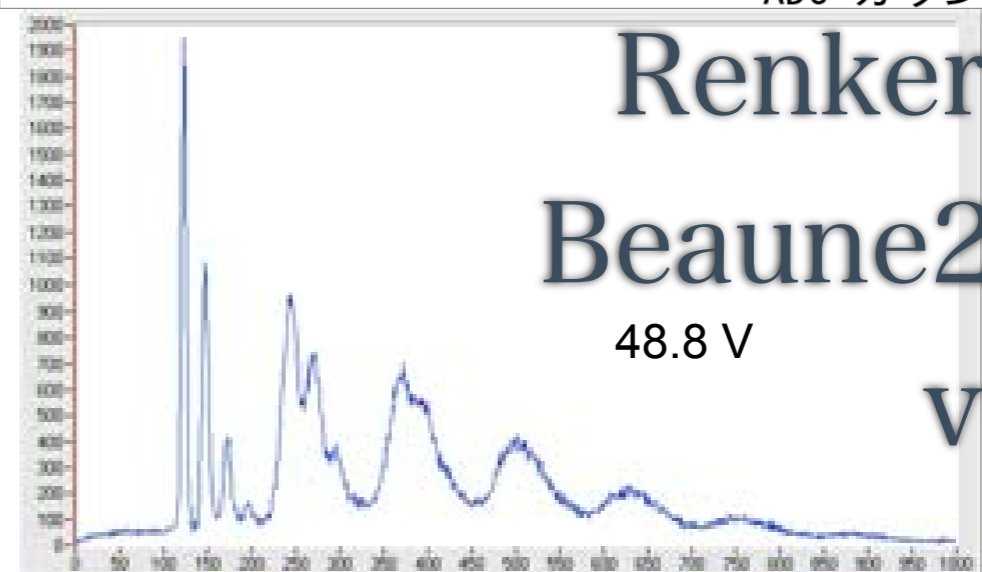
v1

Renker @

Beaune2005

48.8 V

v0

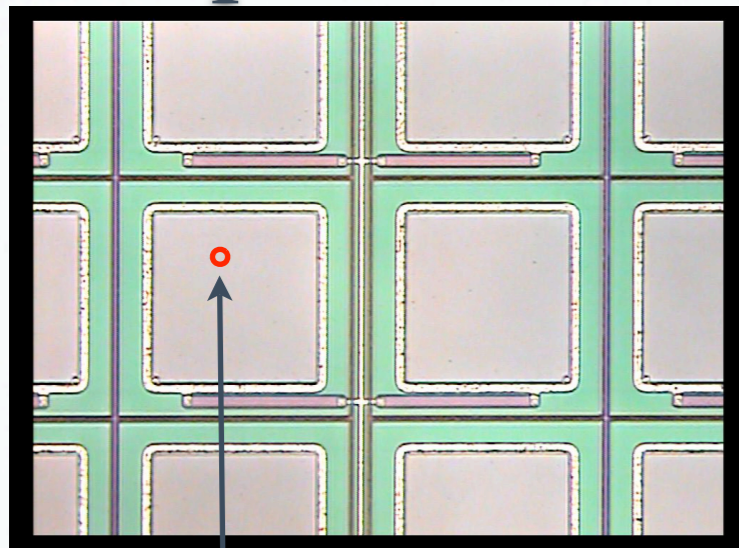


# MPPC tested by laser spot

- Laser test in a pixel in LGM

100pix v2

eff. >1p.e.

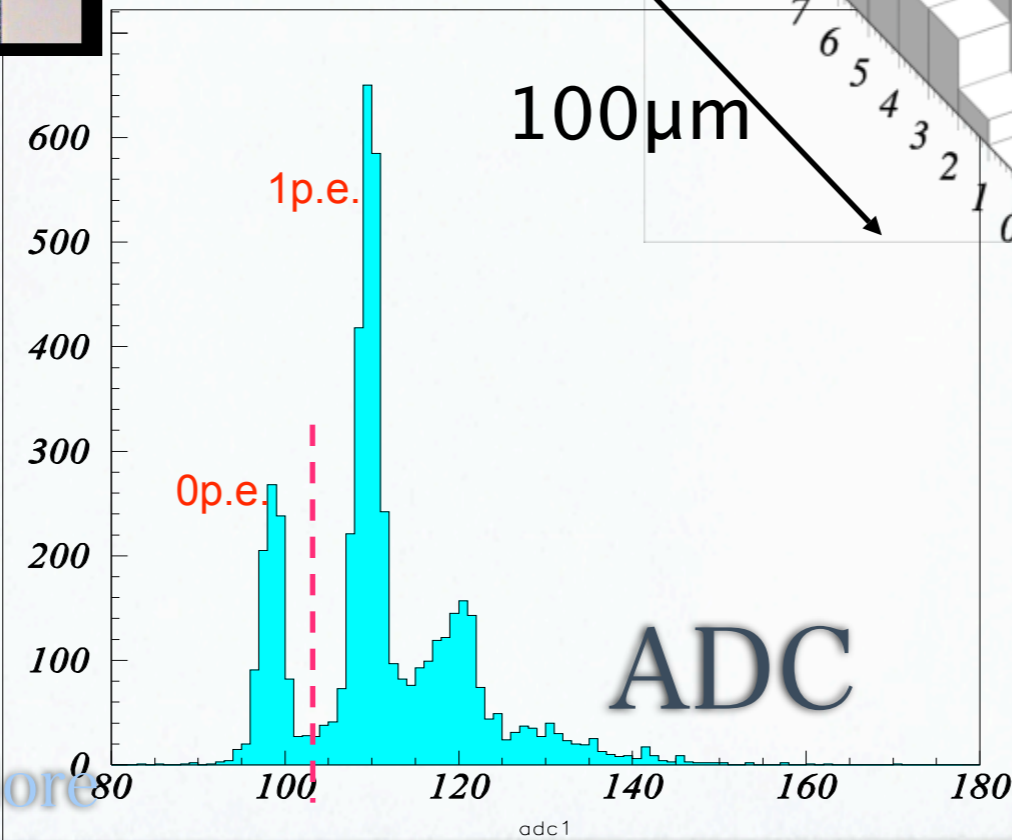
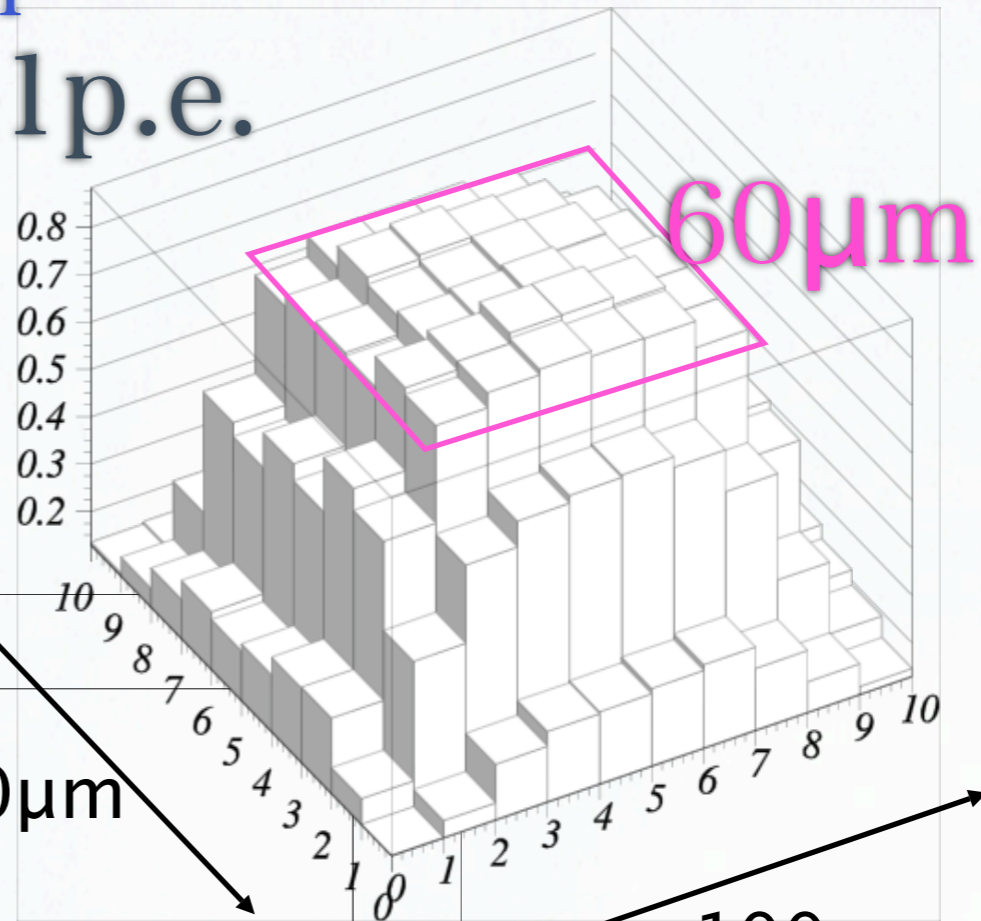


laser spot  
10 $\mu$ m

100 $\mu$ m

100 $\mu$ m

100 $\mu$ m

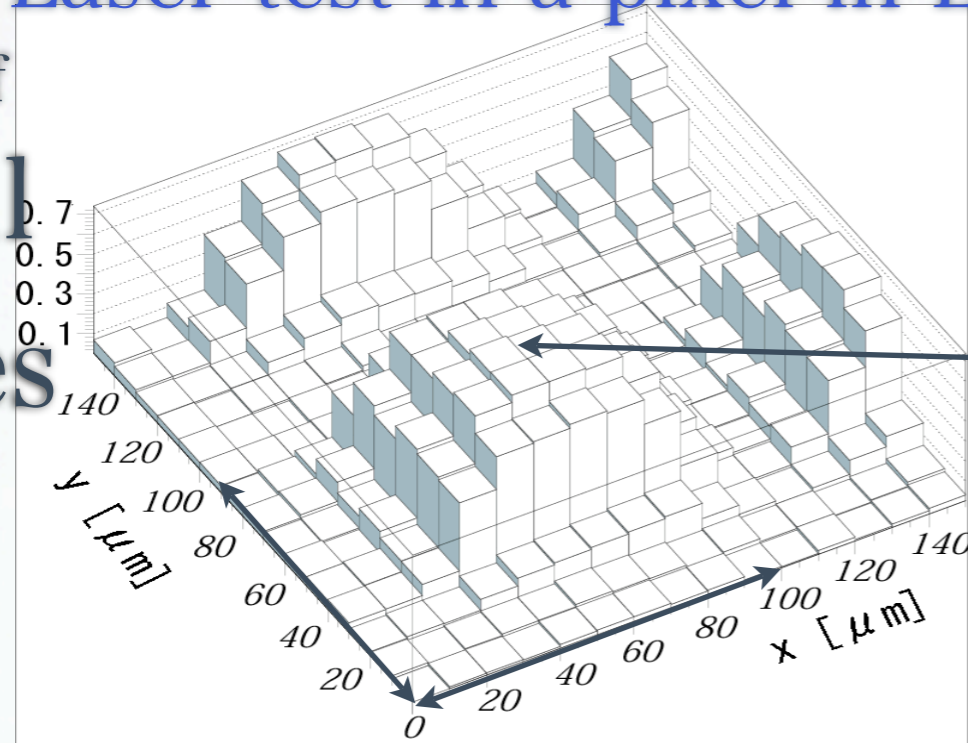


# MPPC tested by laser cont.

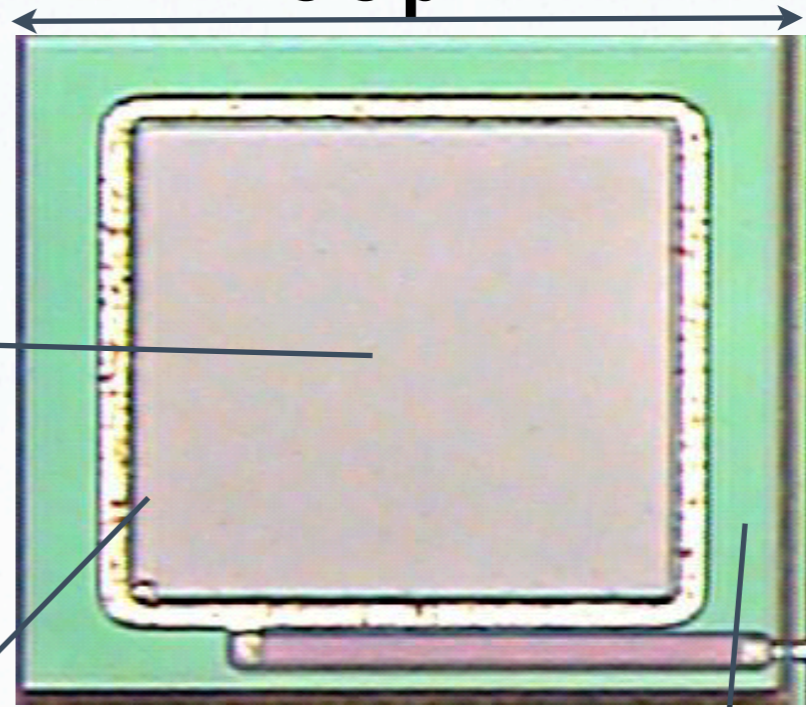
## Laser test in a pixel in LGM

100 $\mu$ m

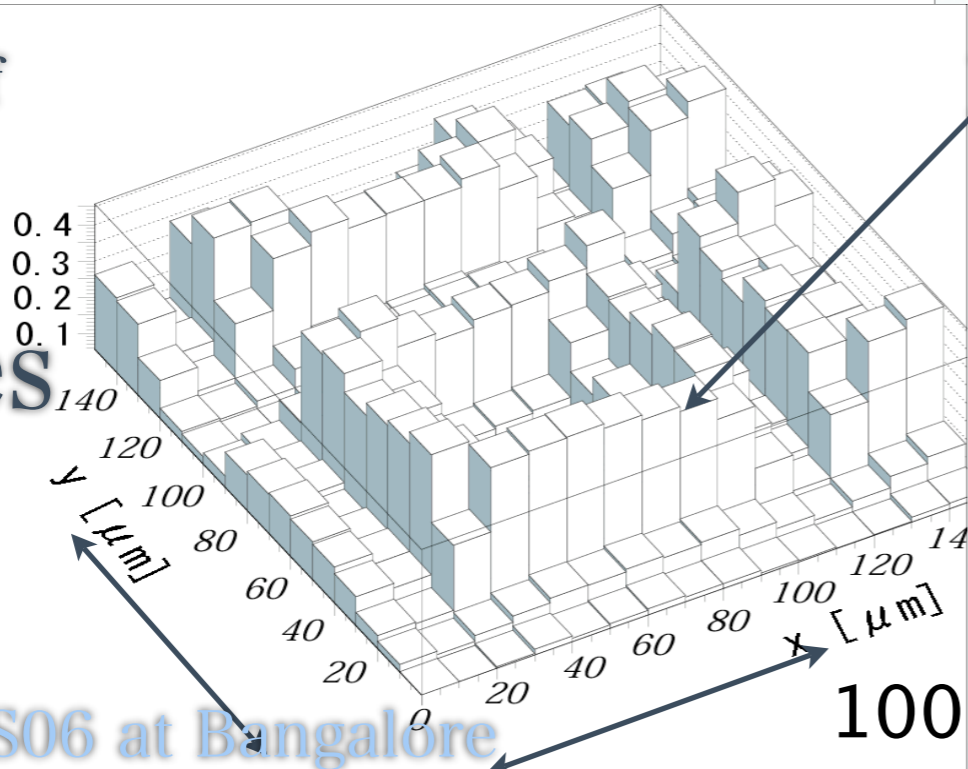
ratio of  
small  
pulses



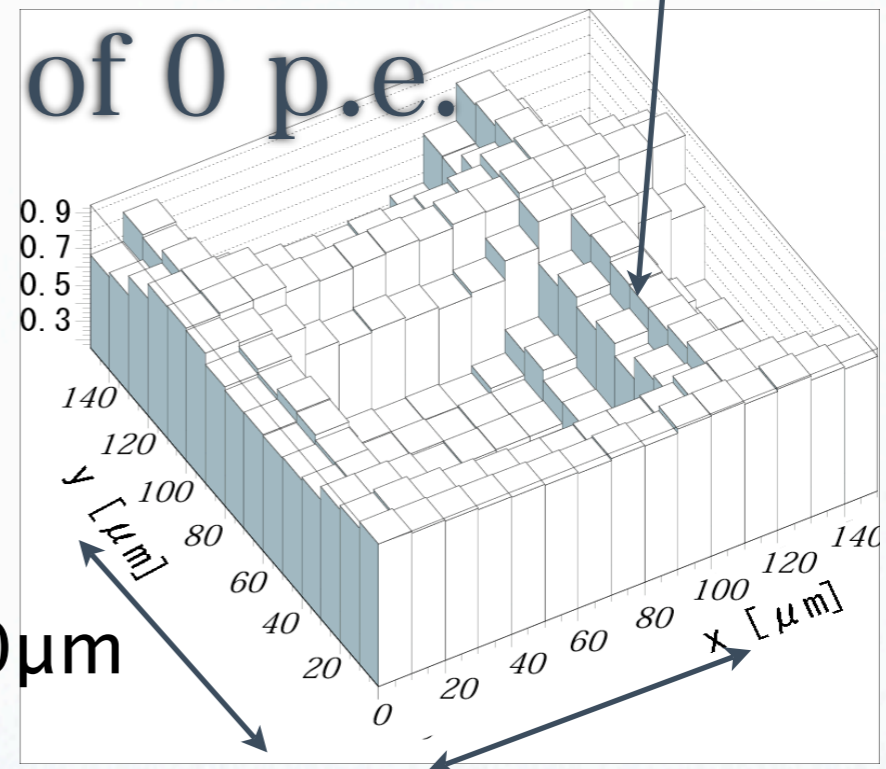
100 $\mu$ m



ratio of  
big  
pulses



ratio of 0 p.e.



100 $\mu$ m

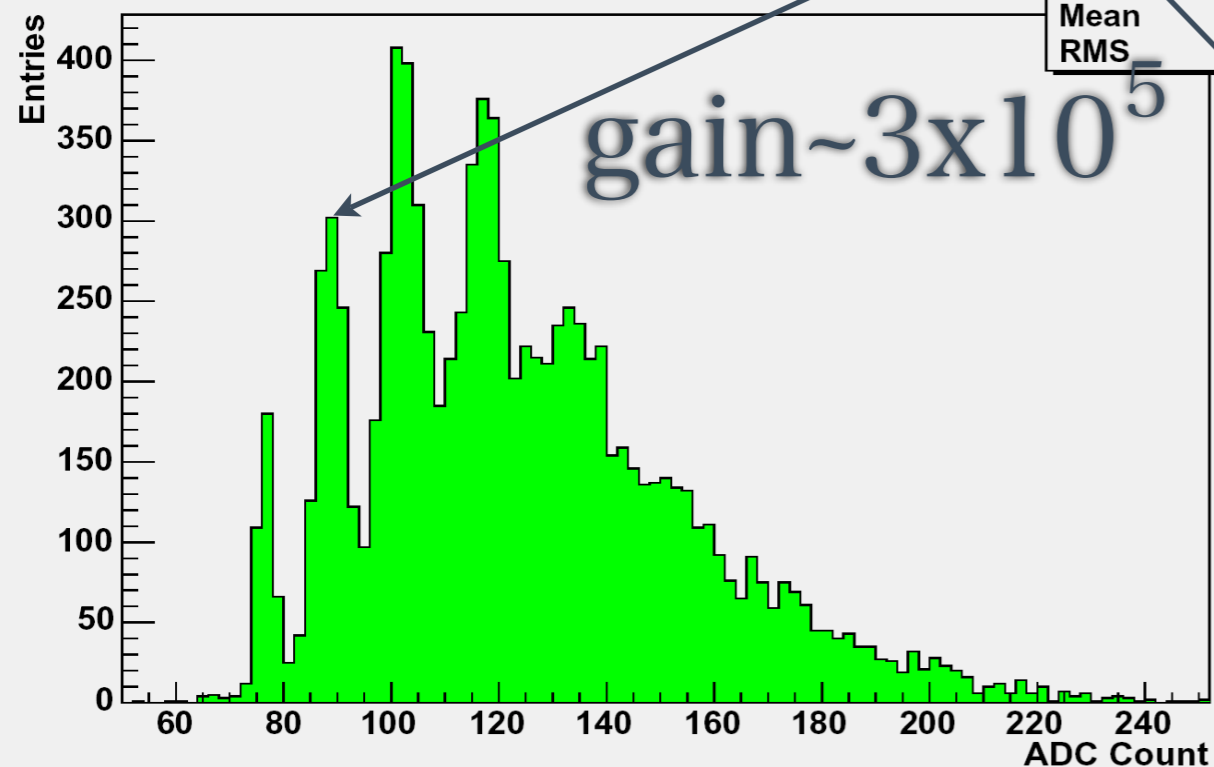
100 $\mu$ m



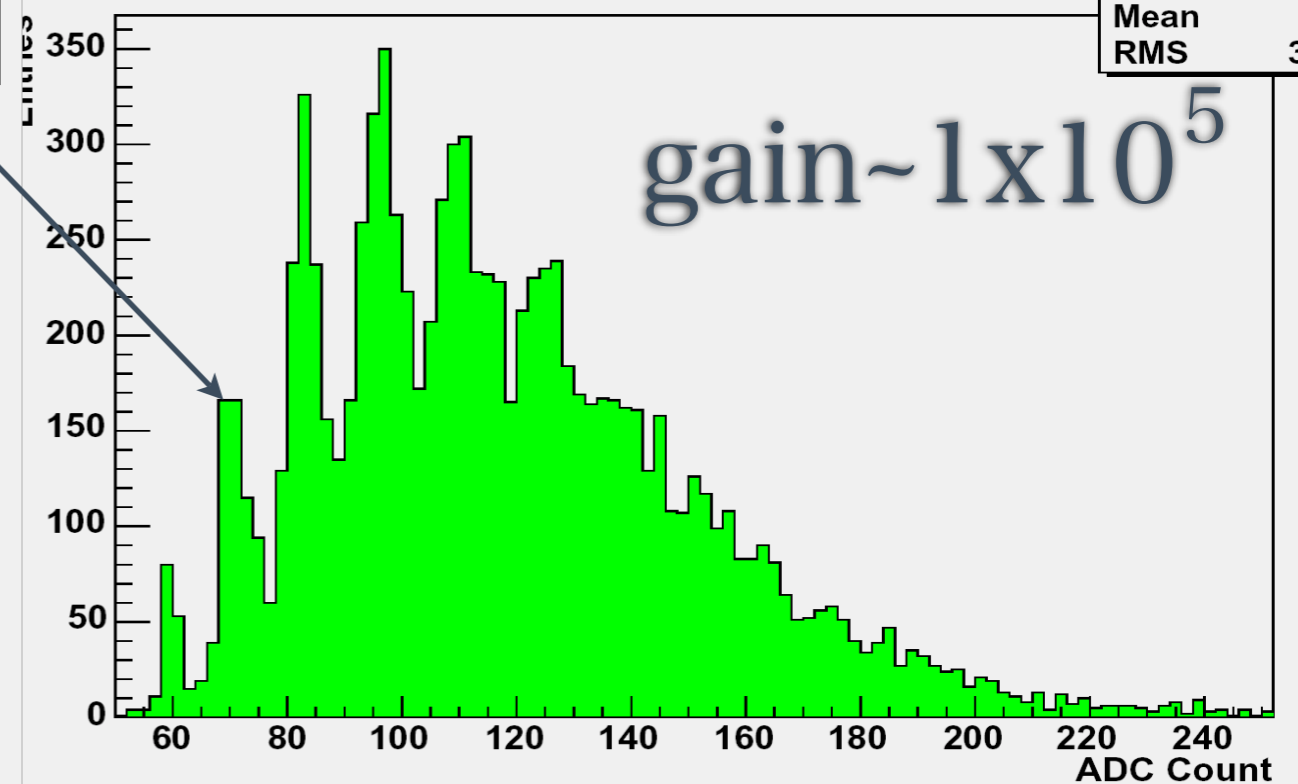
# MPPC in LGM

- operate at LGM for v3 400pix and 1600pix  
1 photon eq.

311-32A-002-6(400pixel)@68.0V DEMO



311-31A-002-1(1600pixel) DEMO

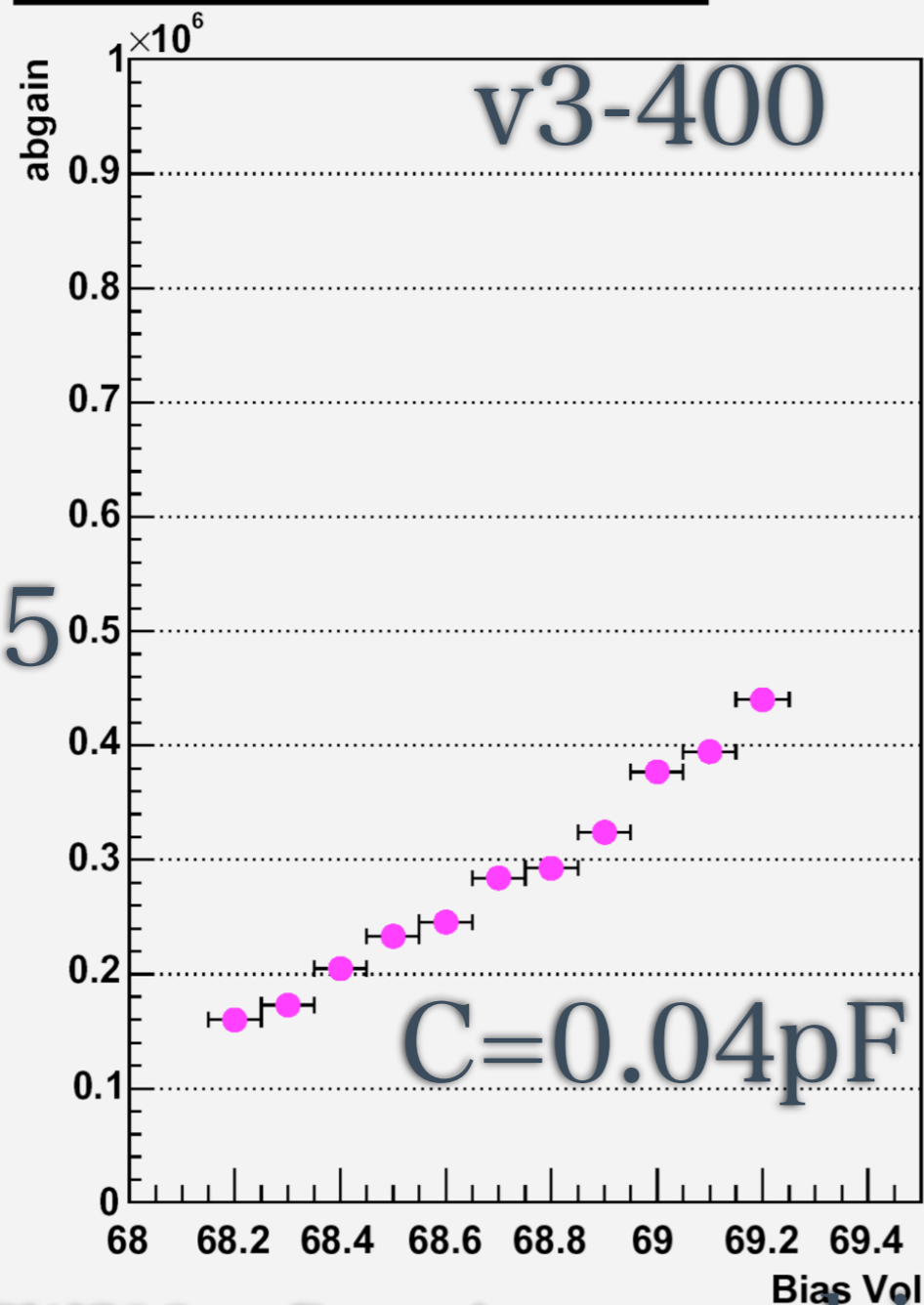


ADC dist. for 400pix

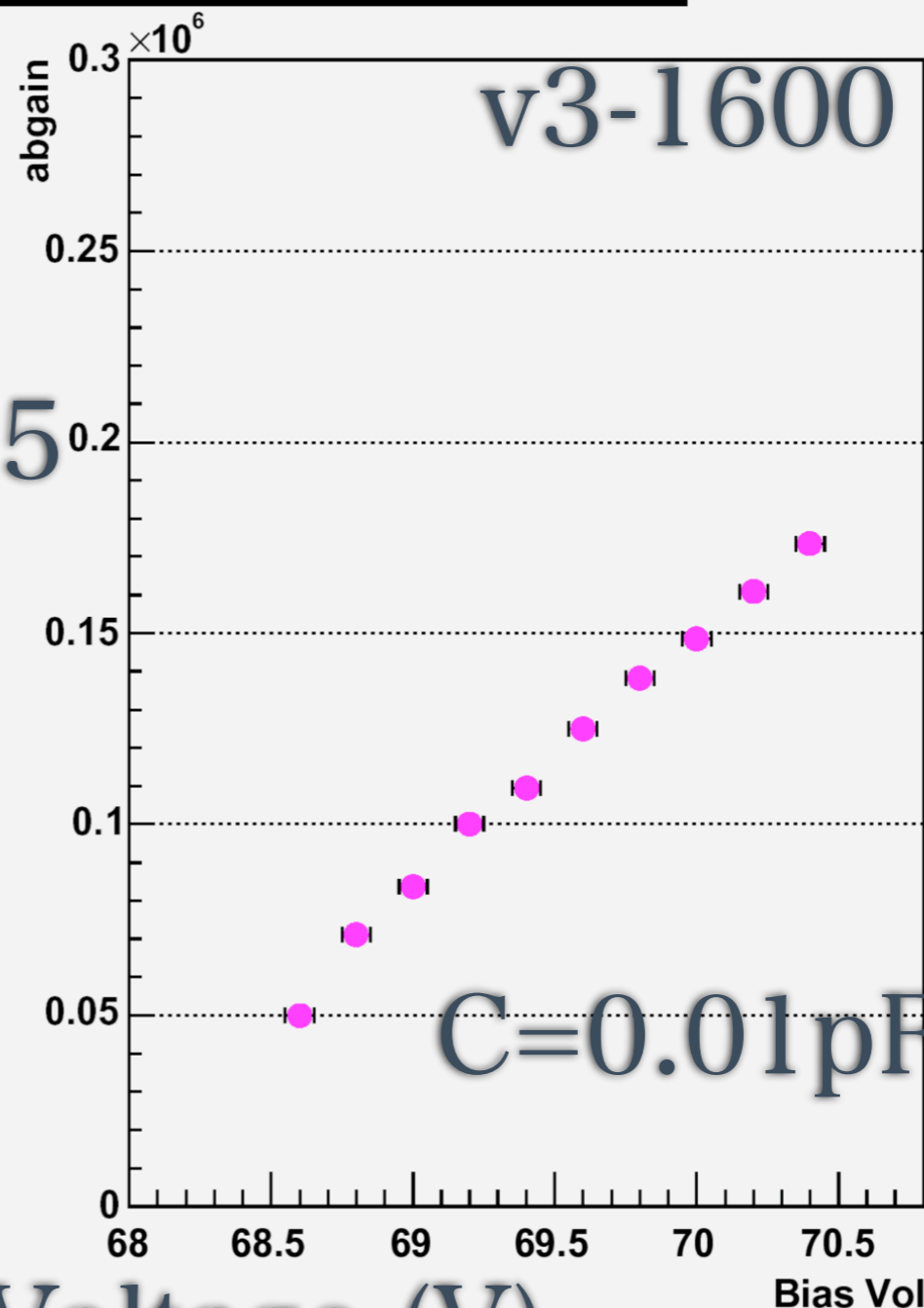
ADC dist. for 1600pix

# Absolute gain in LGM

311-32A-002-6 Bias vs Absolute Gain



311-31A-002-1 Bias vs Absolute Gain



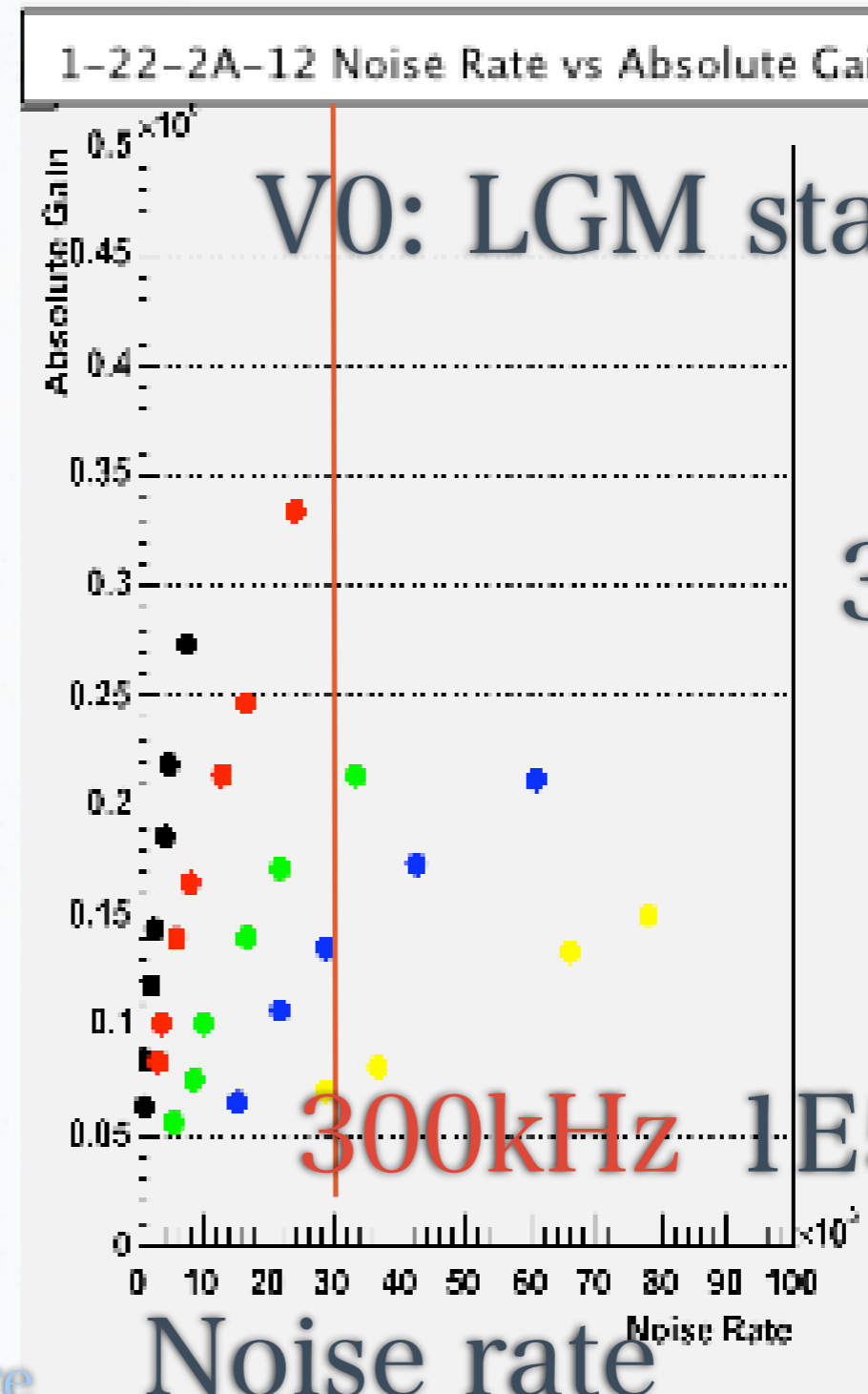
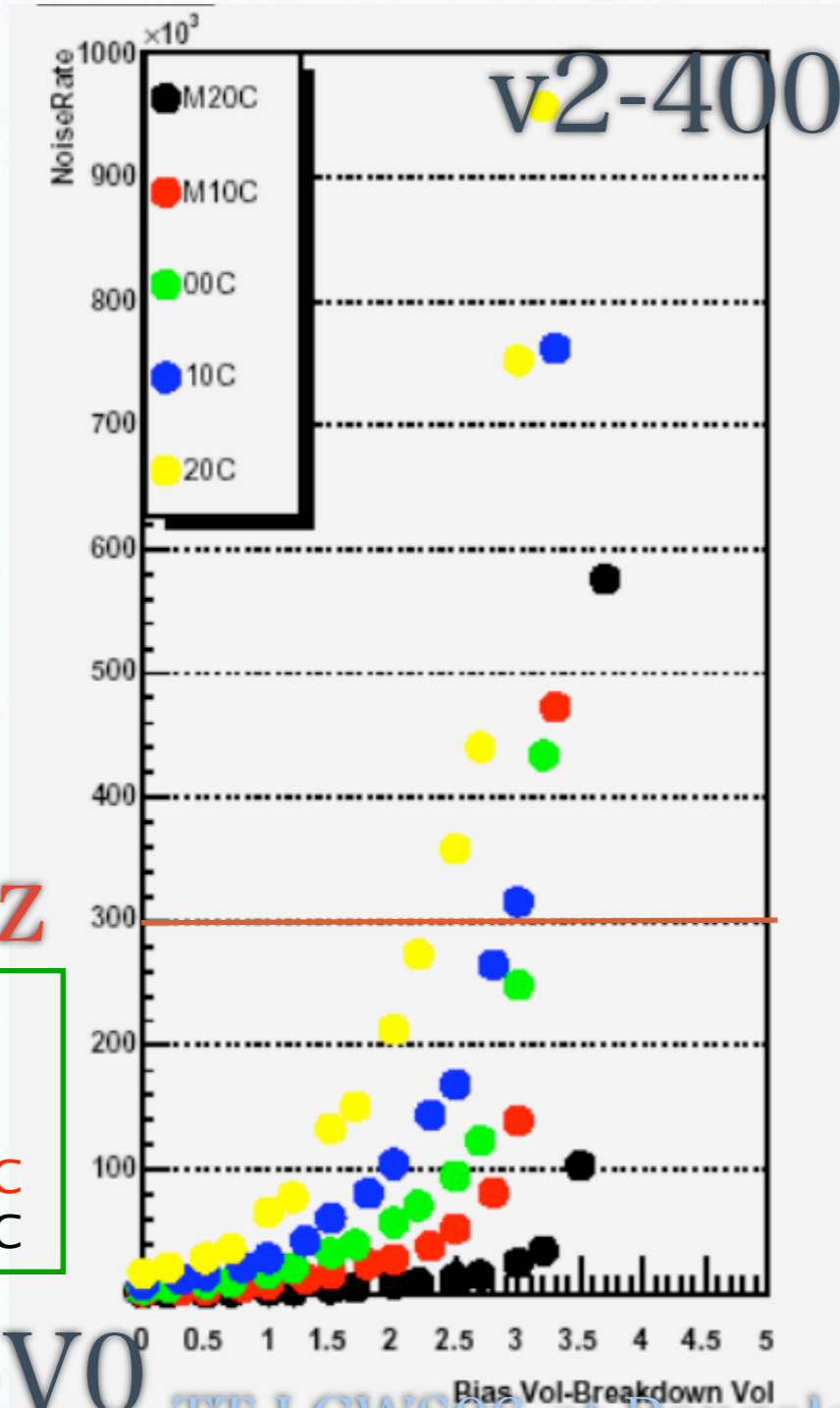
5E5

2E5

# Noise rate of MPPC

threshold = 0.5 p.e.

$$\text{gain} = C(V_{\text{bias}} - V_0) / e$$

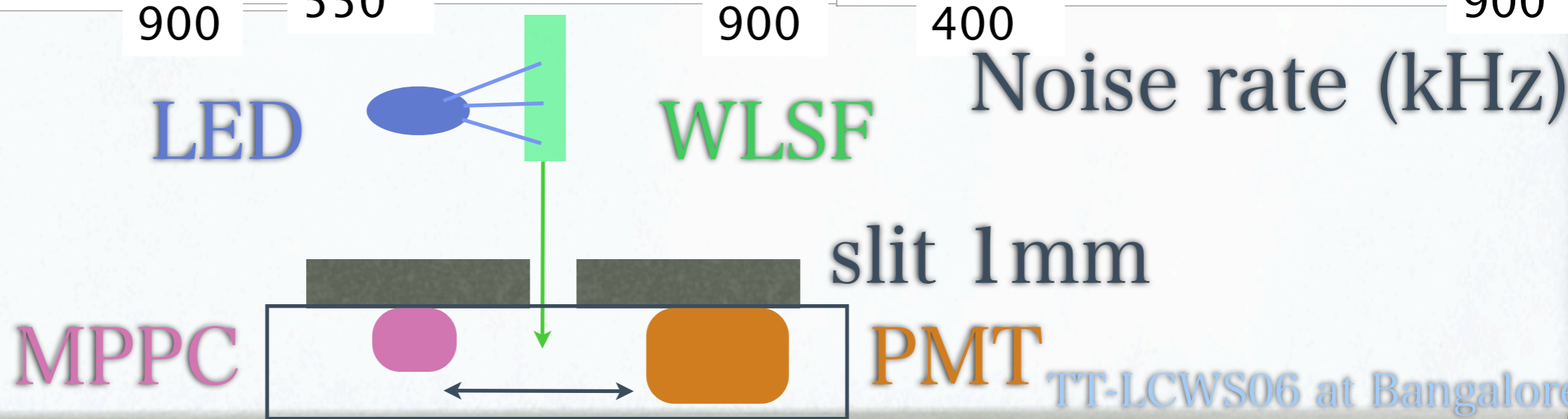
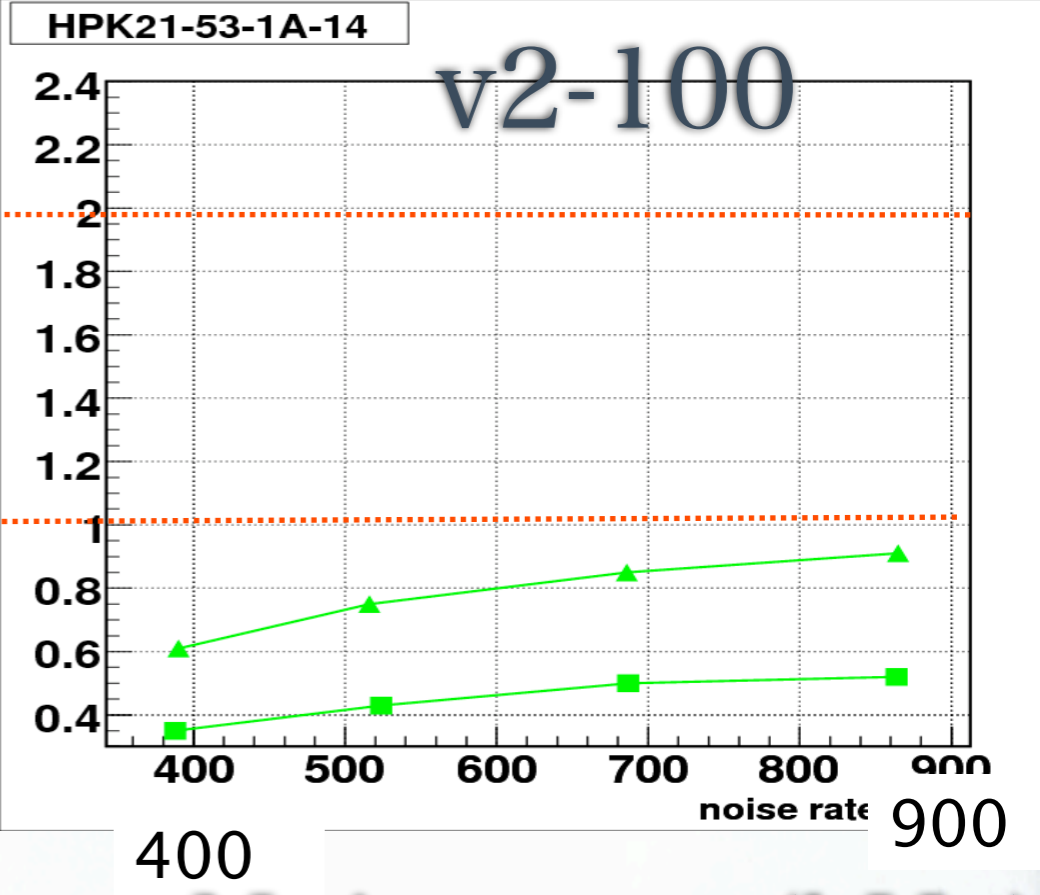
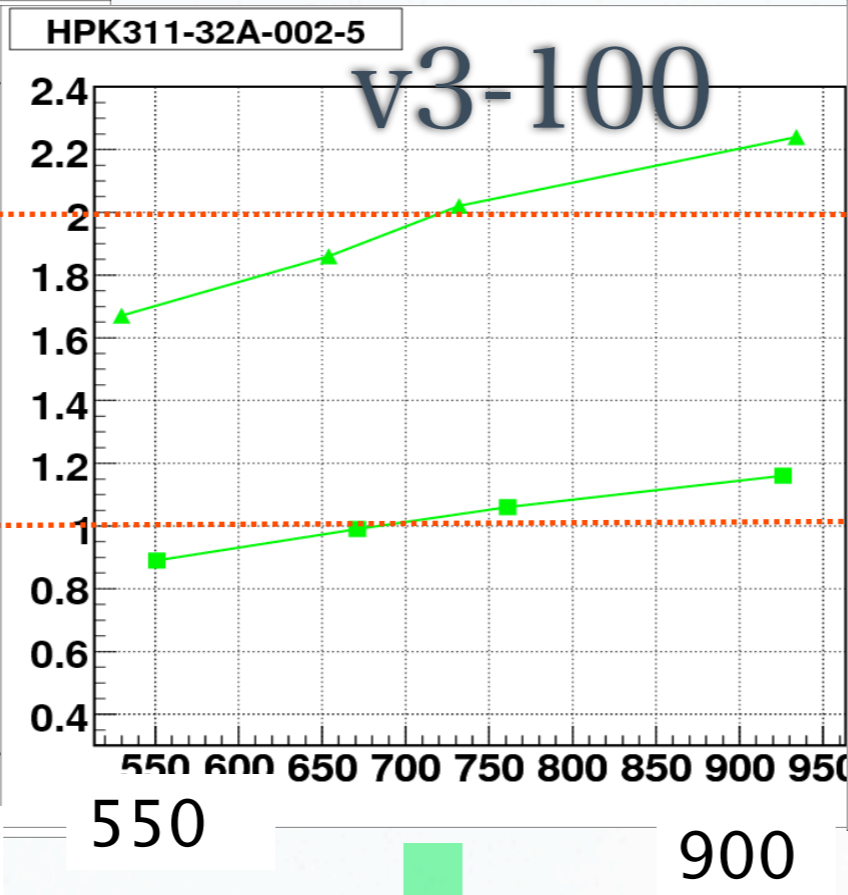
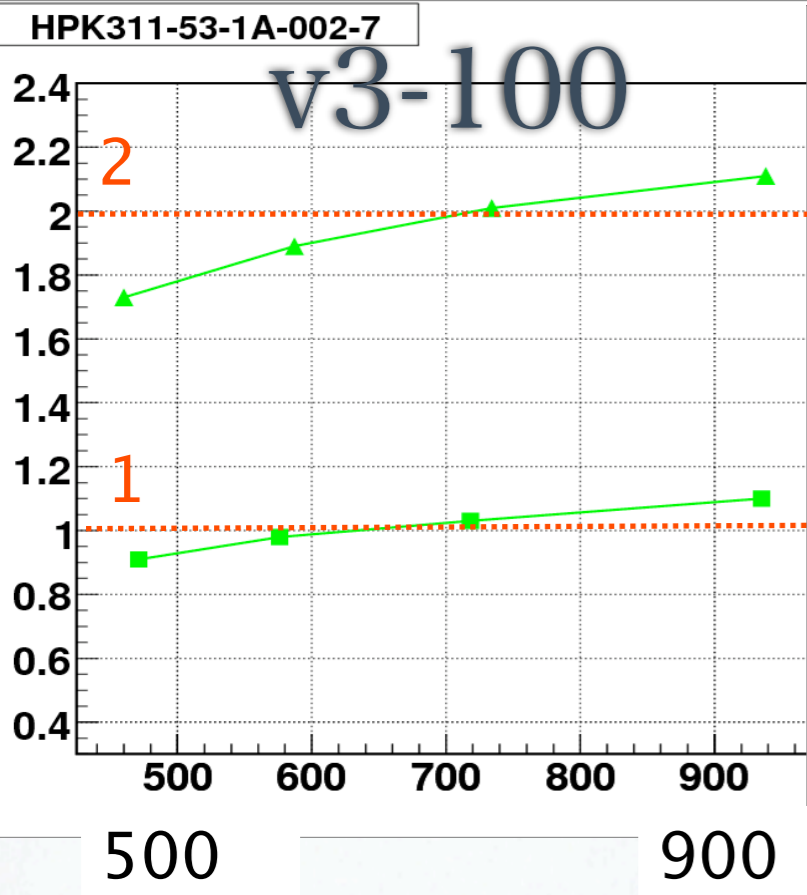


Vbias-V0

Noise rate

# PDE of MPPC

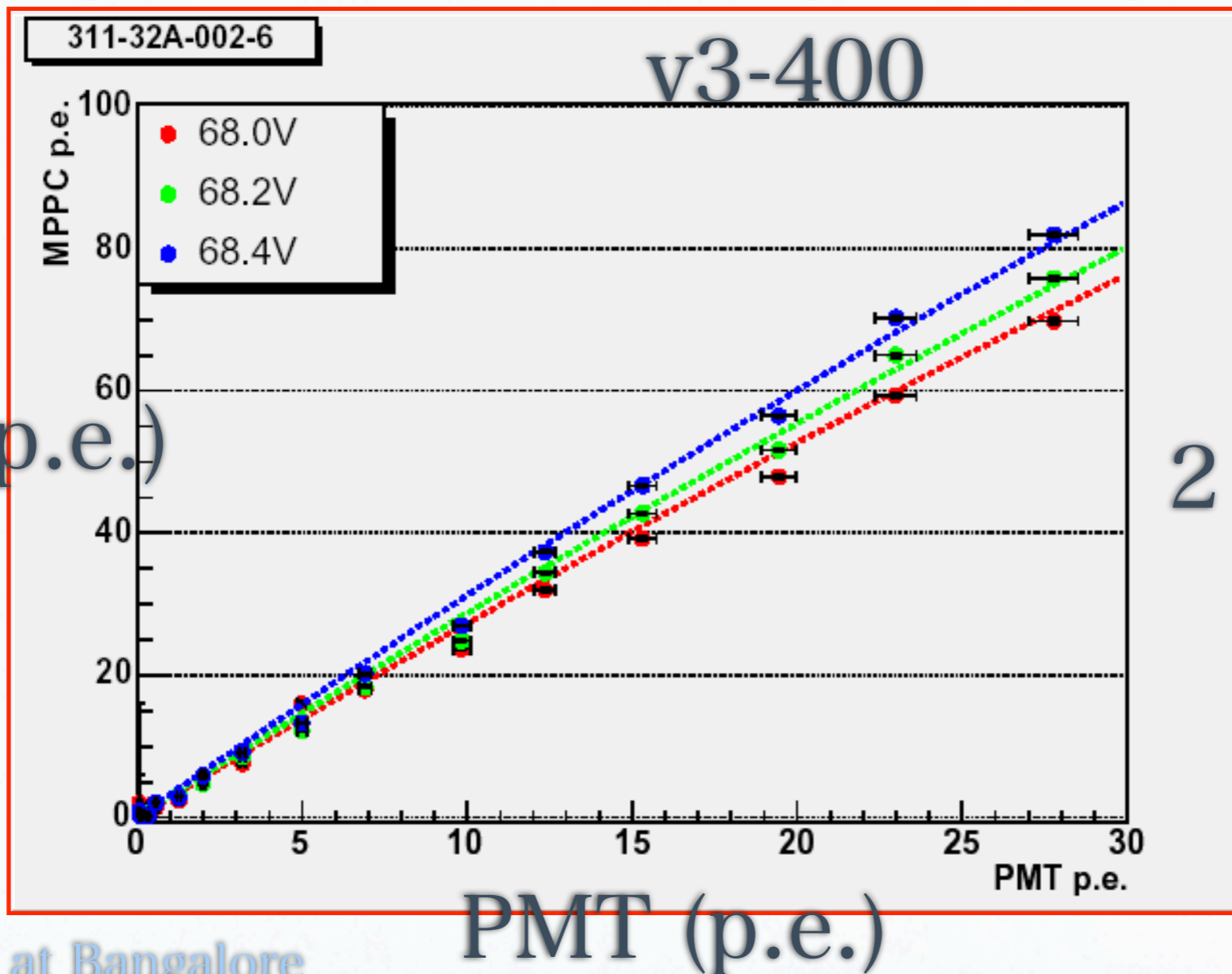
■ relative to PMT



# Linearity and PDE in LGM

- Linearity (saturated by number of pixels)

$$N_{\text{pix}} = N_{\text{max}}(1 - \exp(-\epsilon \cdot N_{\text{ph}}/N_{\text{max}}))$$



PDE

2 times better  
than PMT

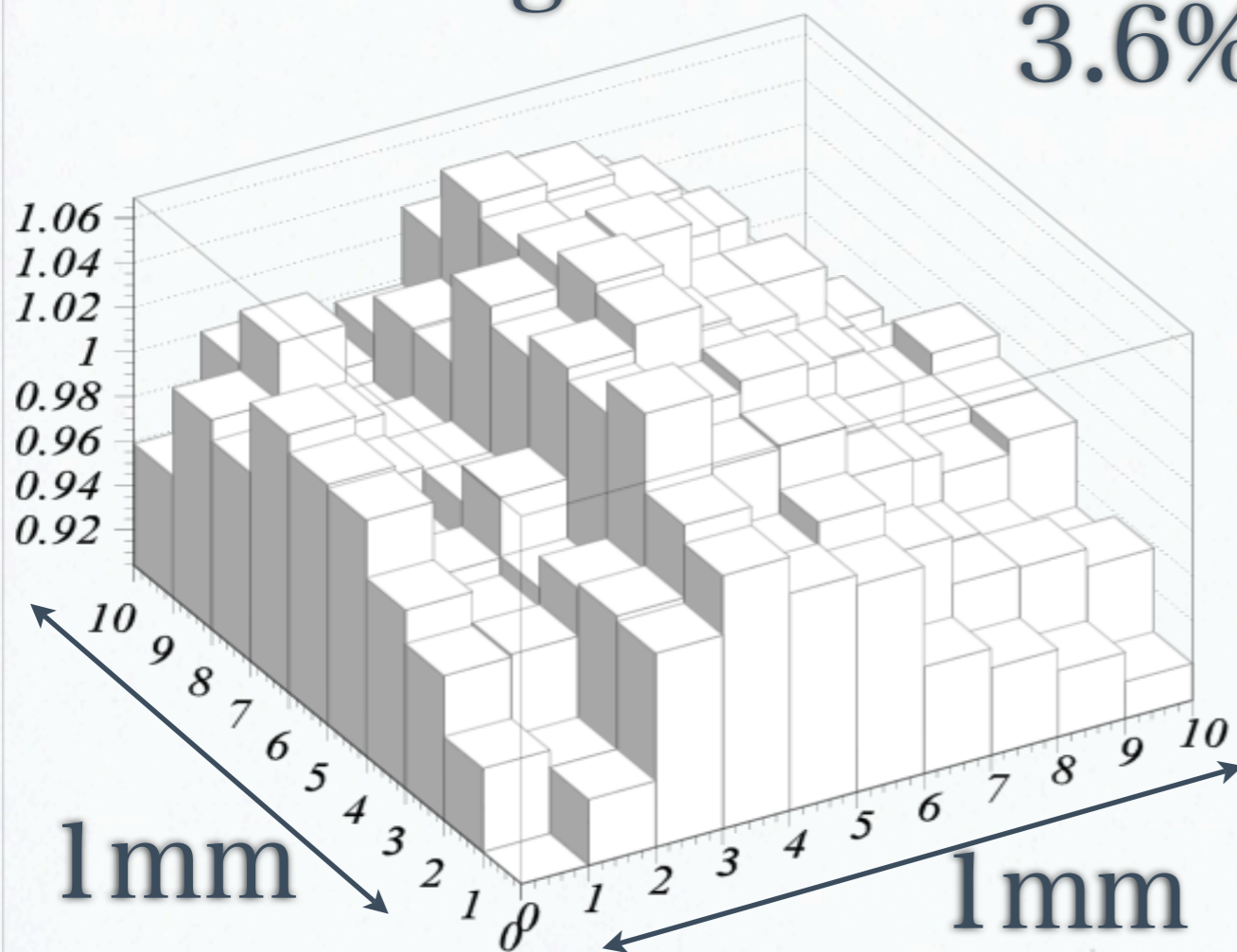
# MPPC in LGM

## homogeneity in pixels

v2 100pix

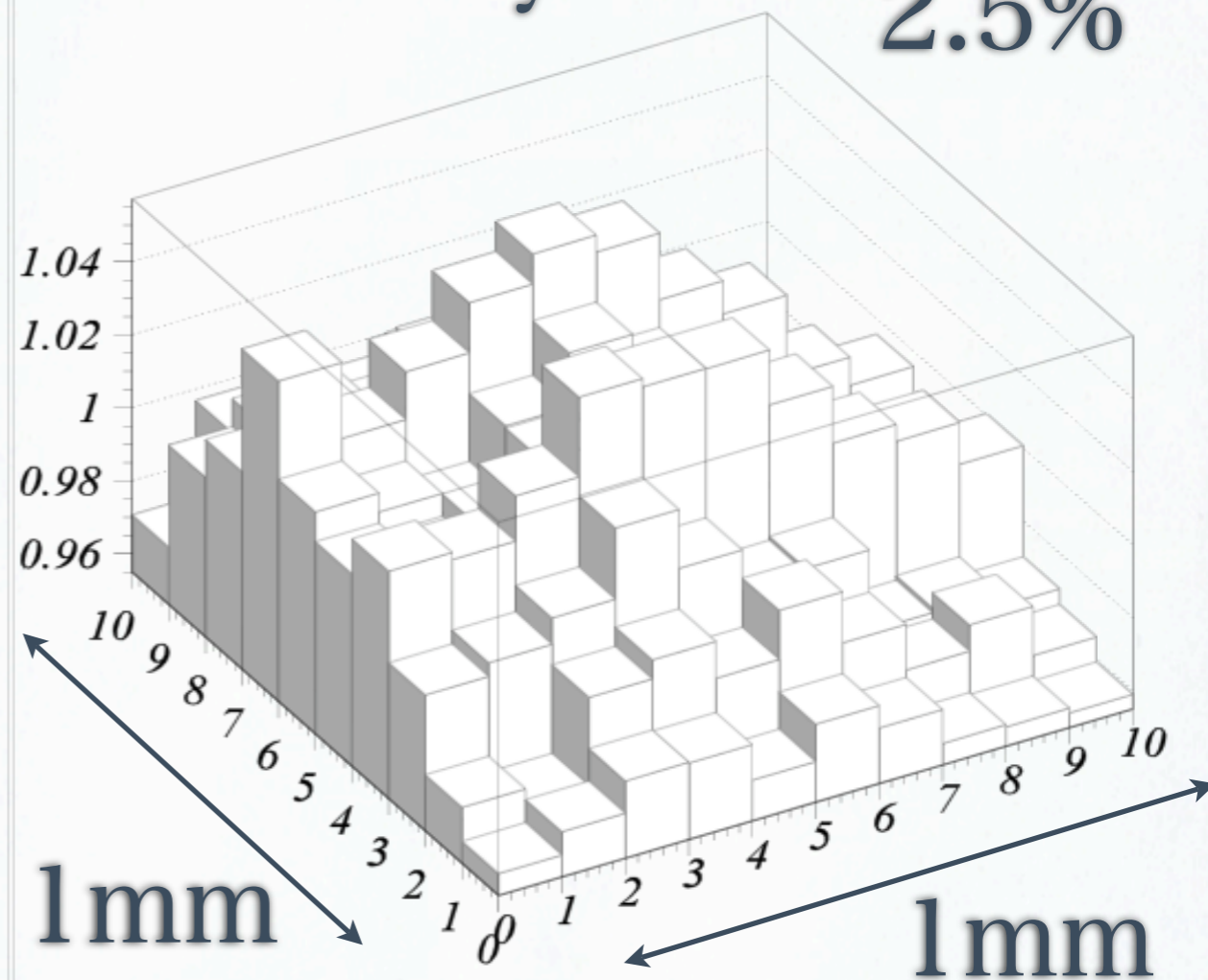
relative gain

3.6%



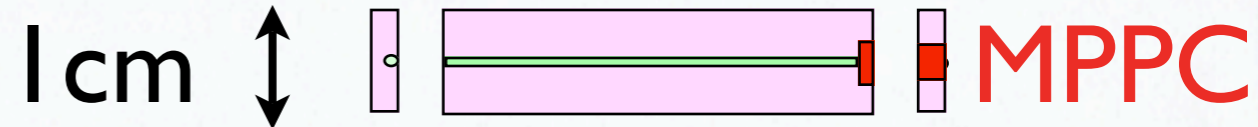
efficiency

2.5%



# Summary and outlook of MPPC

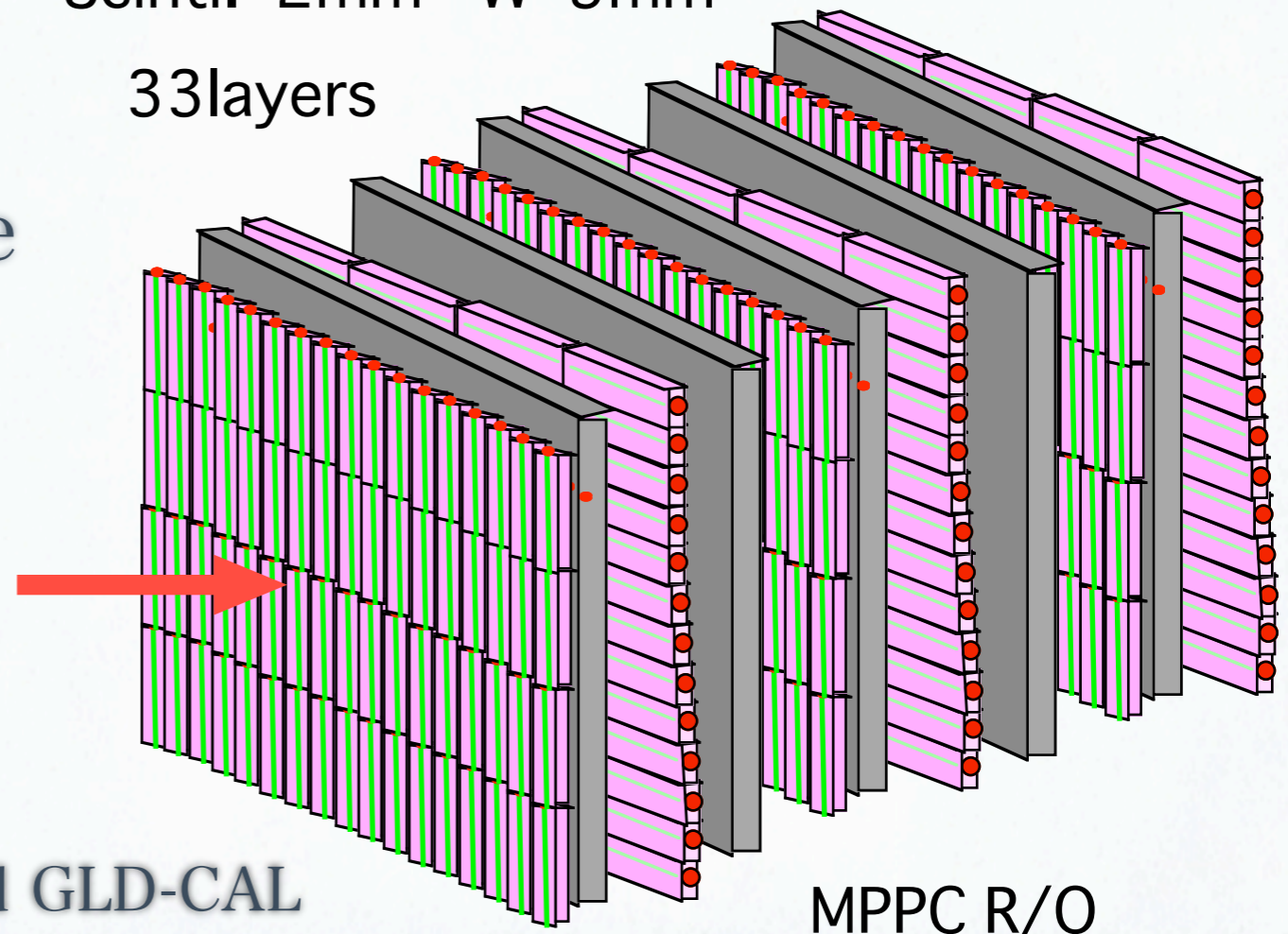
WLSF



- better understandings through development
- noise is not serious  $< 1\text{MHz}$  and dominated by 1 p.e.
- PDE is now  $\sim$ twice PMT
- need to have larger surface  
1.5mm x 1.5mm
- produce  $\sim 1000$  MPPCs  
for an ECAL test

Scinti. 2mm W 3mm

33layers



TT-LCWS06 at Bangalore

MPPC development with neutrino and GLD-CAL