

# scintillator ECAL

## progress & status

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March 2014 @ ANL calice

☆ sensors

scintillator strip  
(shape, material, wrapping)

MPPC

☆ combined experience at  
DESY

☆ outlook and plan



筑波大学  
*University of Tsukuba*

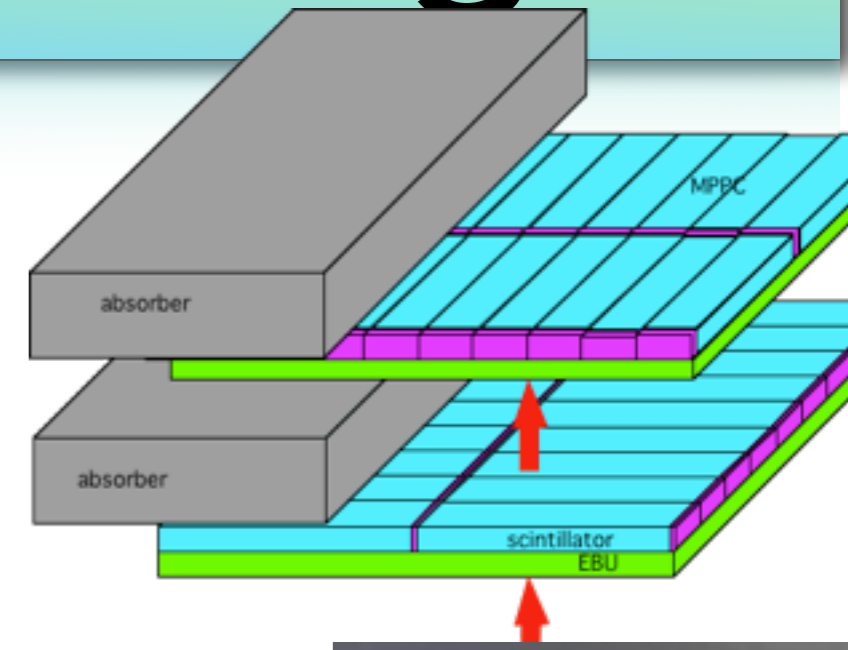


東京大学  
THE UNIVERSITY OF TOKYO



# scintillator layer design

- current design
- MPPCs are standing perpendicular to the FE PCB
- SMD is difficult to be soldered
- non-uniformity
- in front of MPPC

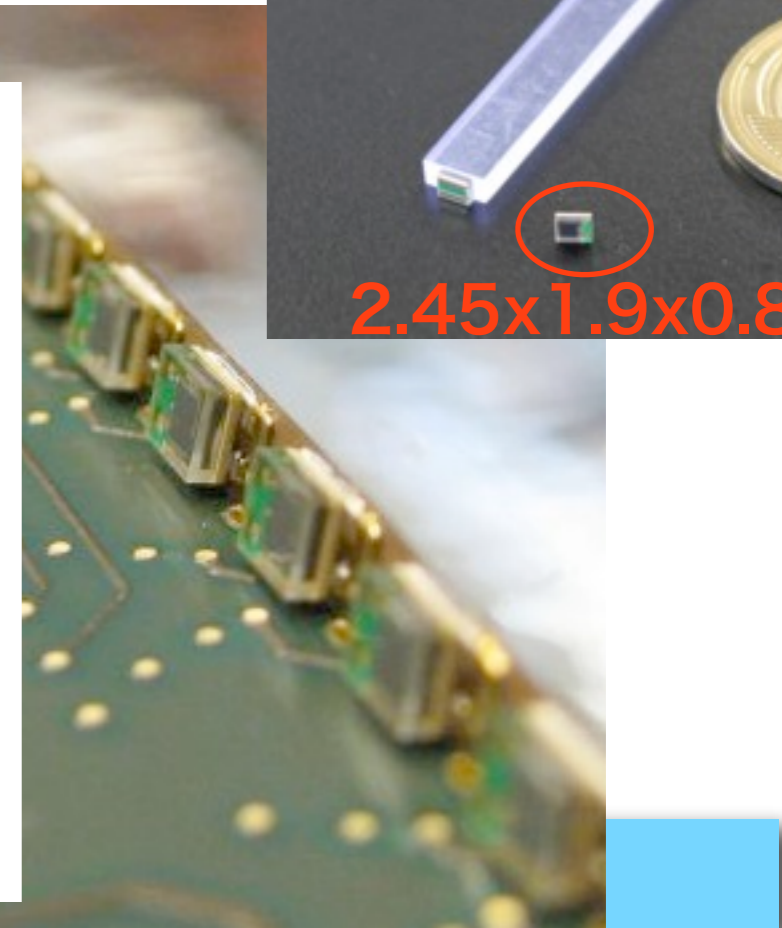
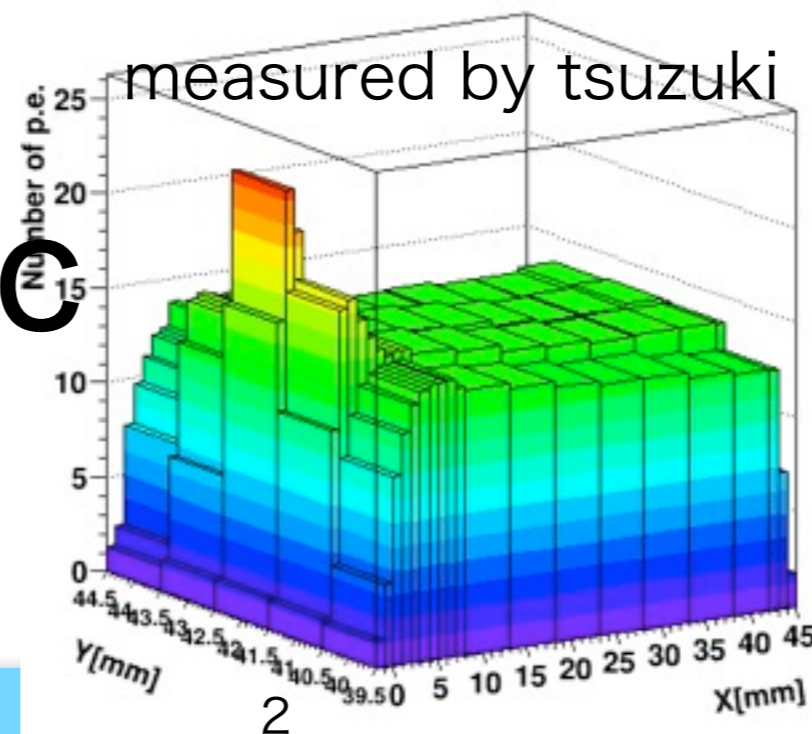


45x5x2mm<sup>3</sup>

2.45x1.9x0.8

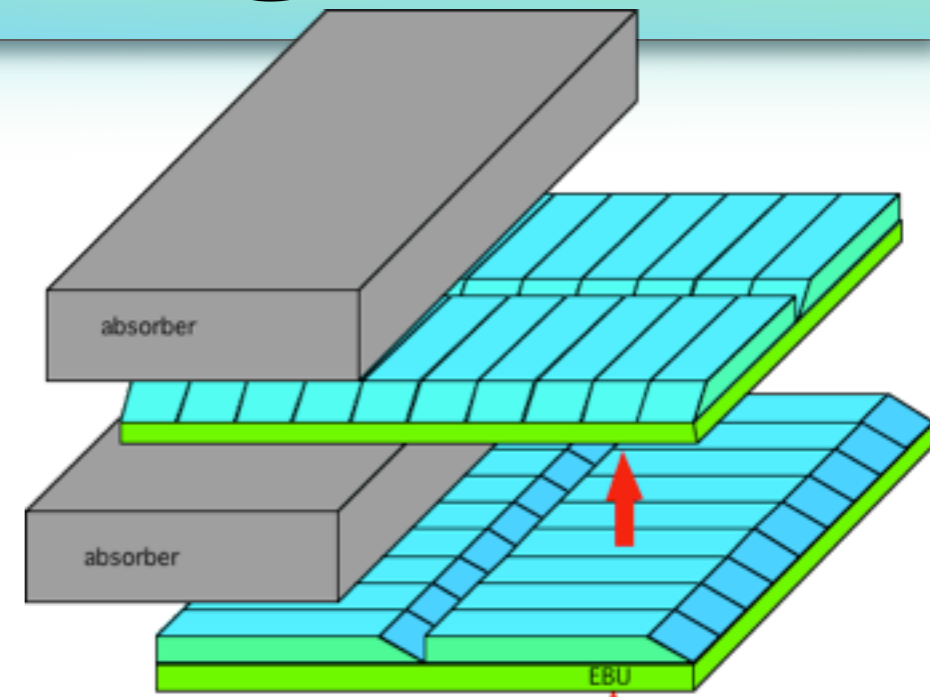
All Open, Kuraray

measured by tsuzuki

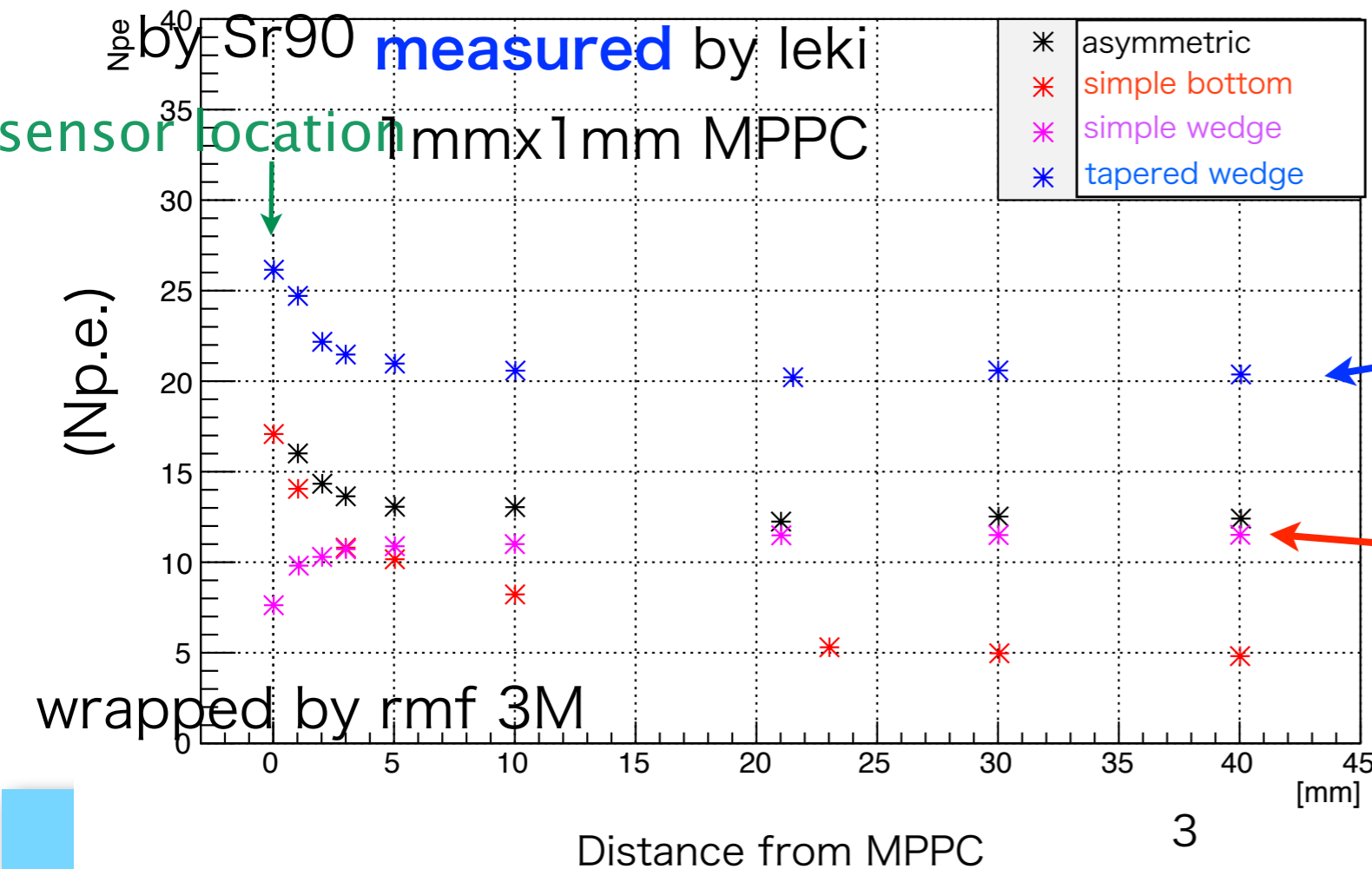


# scintillator design

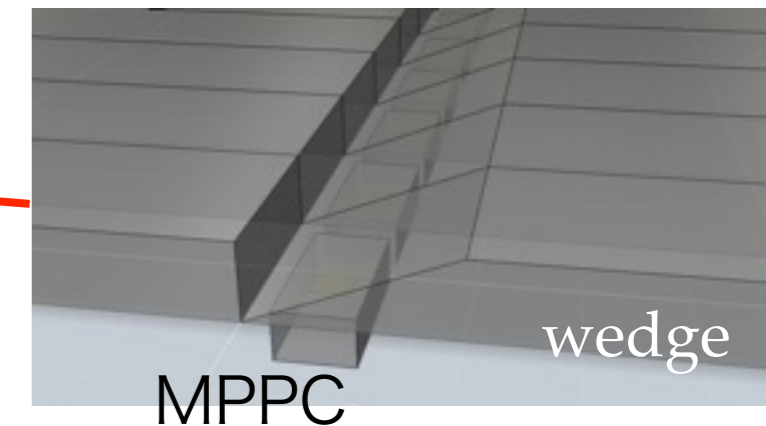
- new design
- MPPCs are soldered on the FE PCB as SMDs
- shape effect understudy



photon-yield 2mm thick scintillators

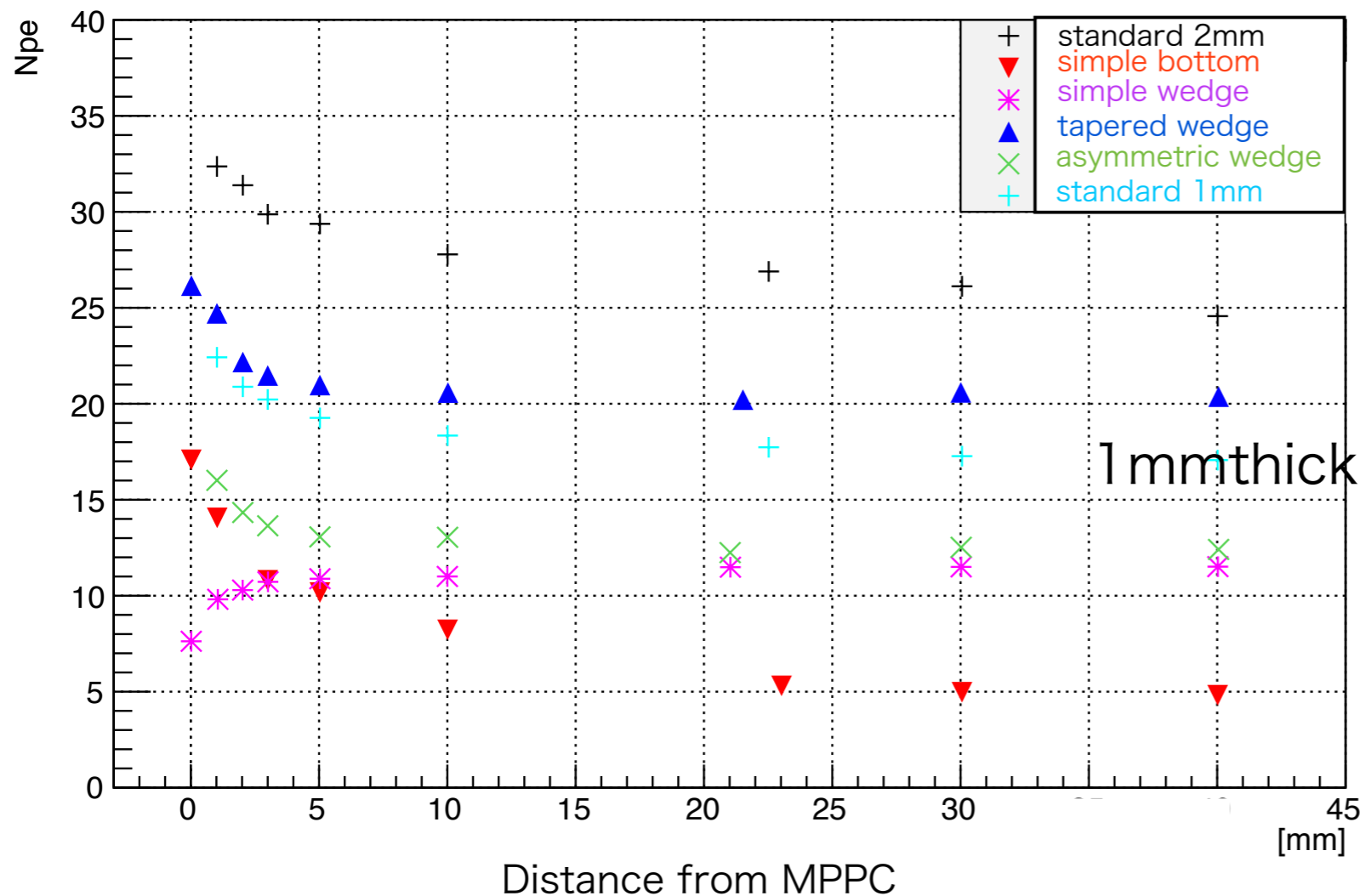
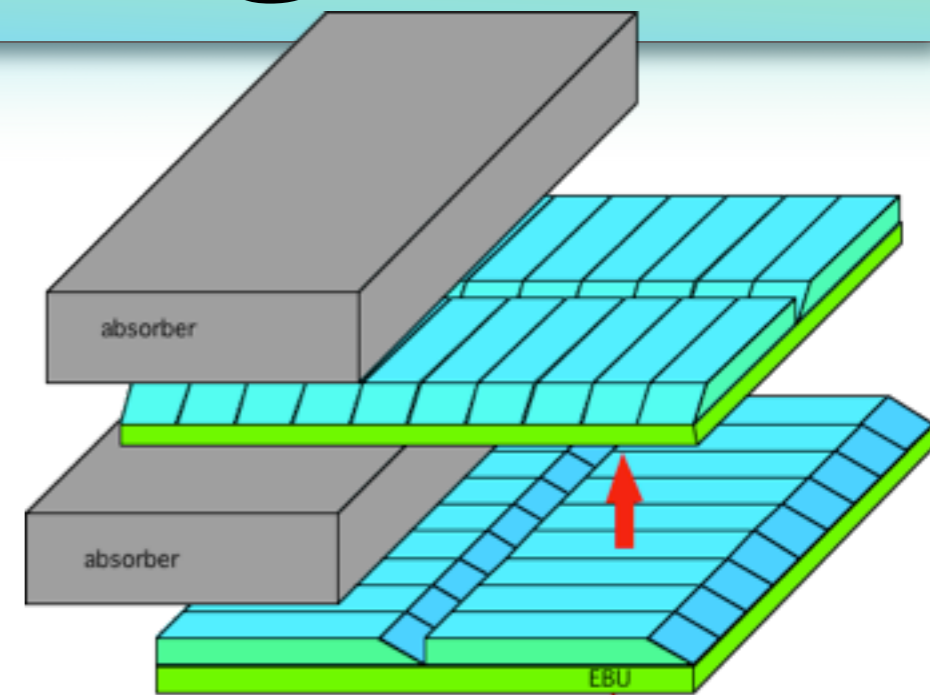


Mean value

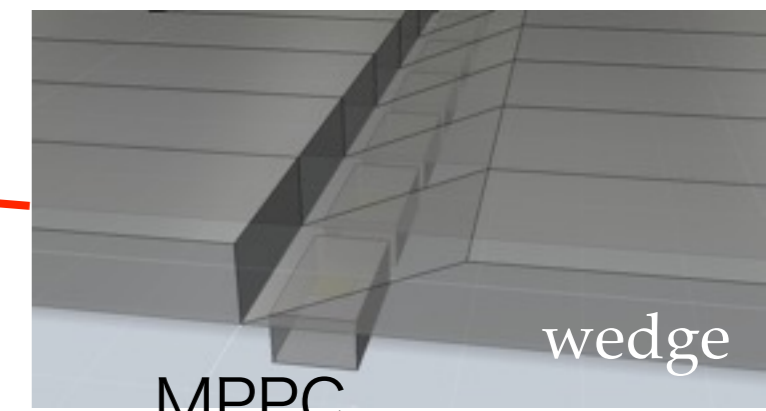


# scintillator design

- new design
- MPPCs are soldered on the FE PCB as SMDs
- shape effect understudy



all

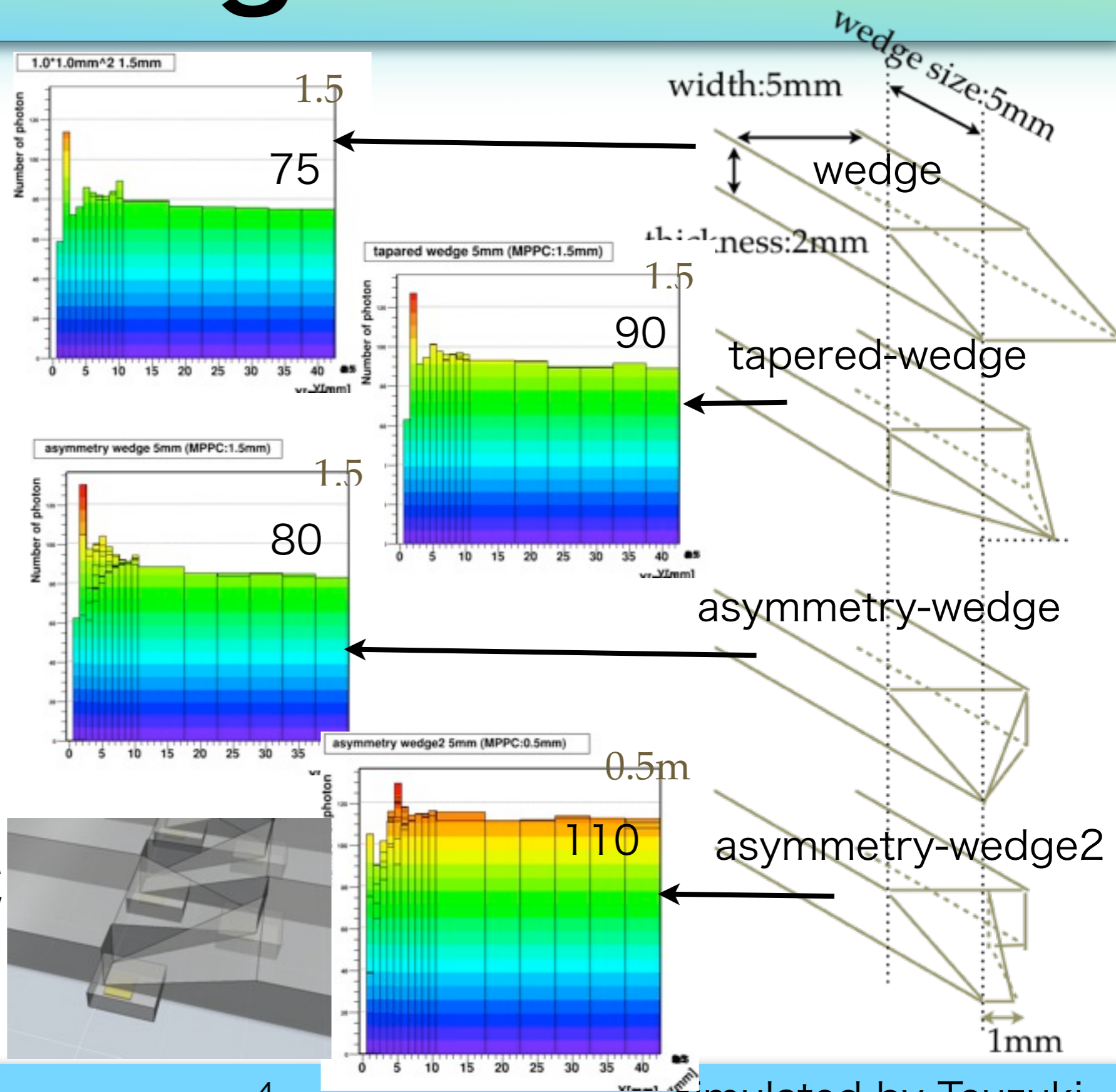


C is located 1.5mm from edge



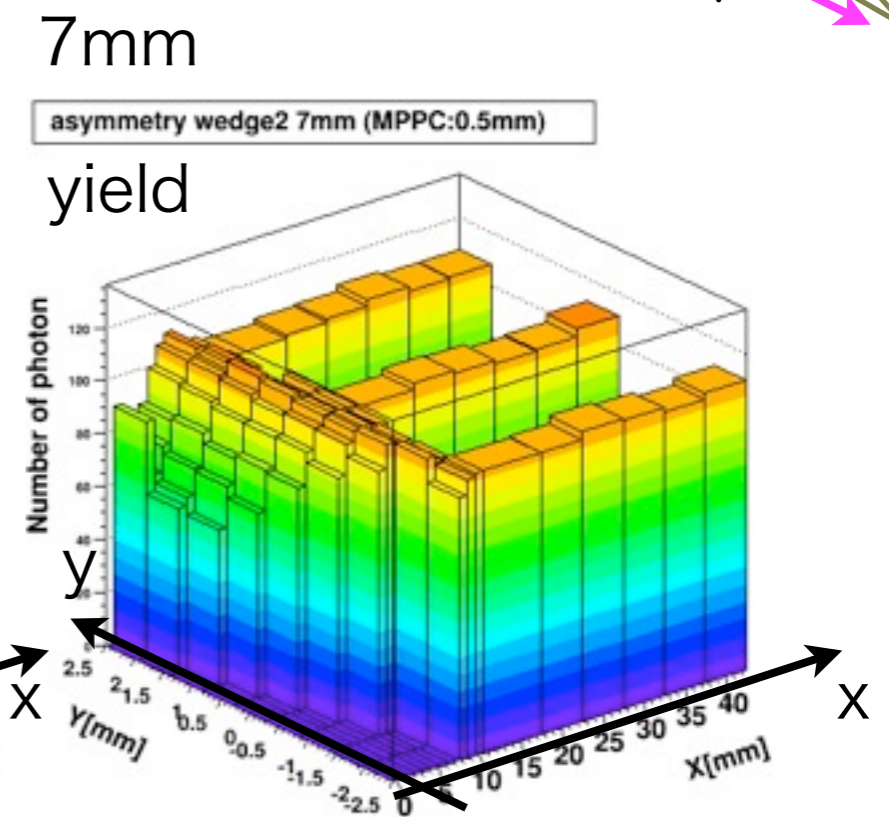
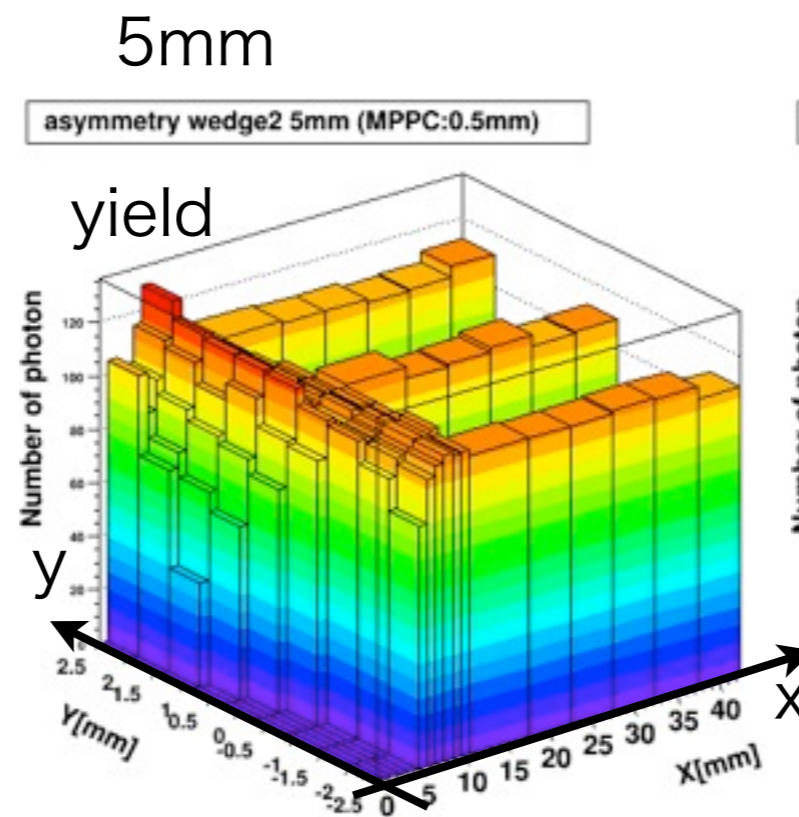
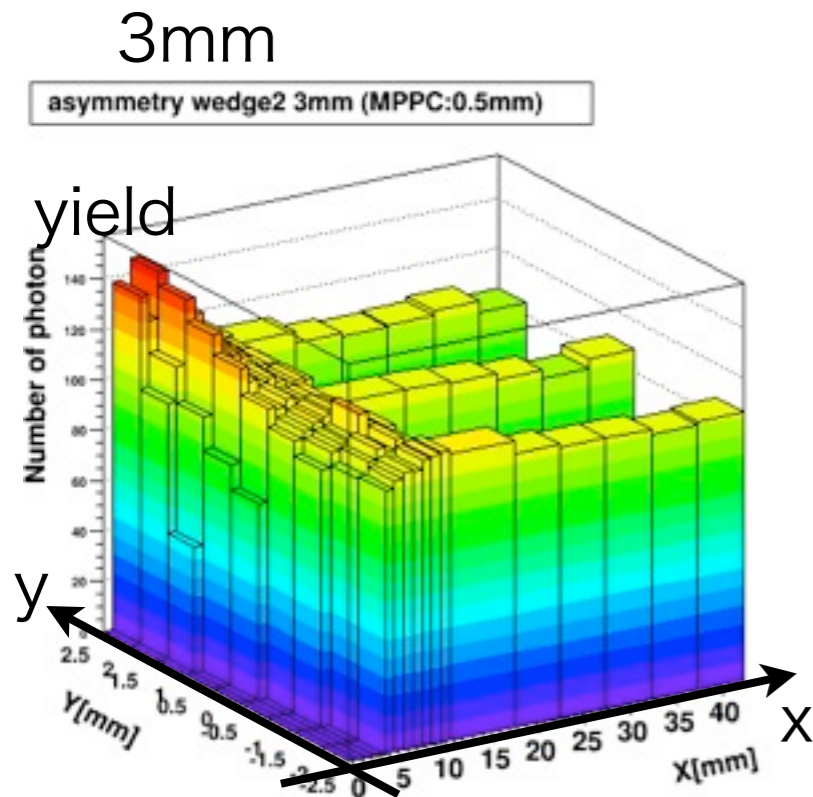
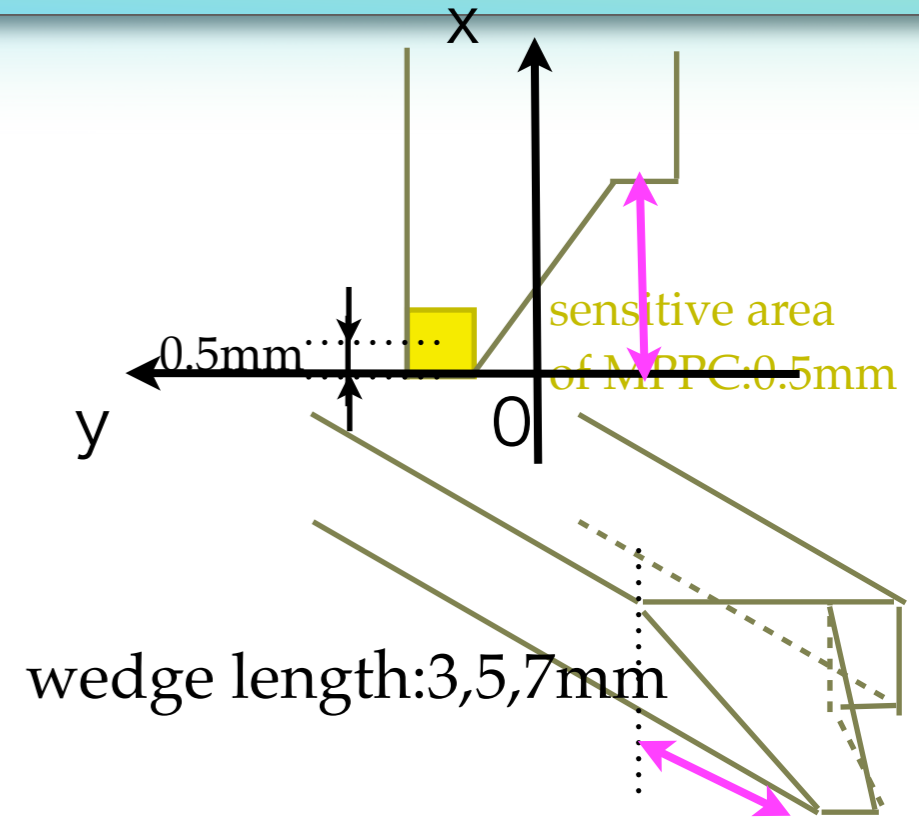
# scintillation light simulation

- $2 \times 45 \times 5 \text{ mm}^3$  strip
- simulation ~ experiment
- except light yield
- size of MPPC



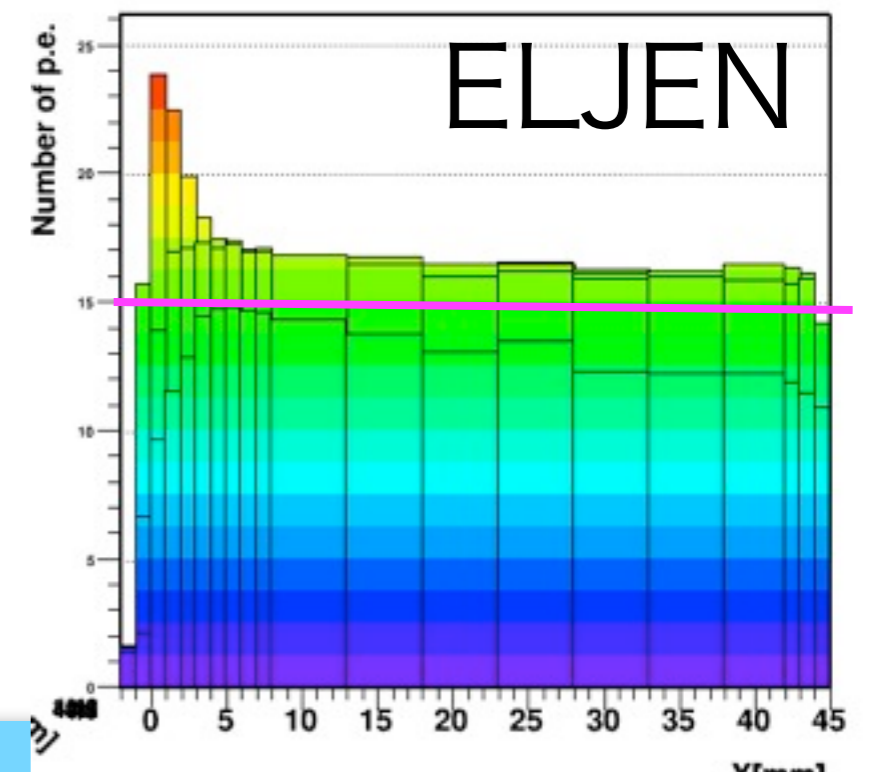
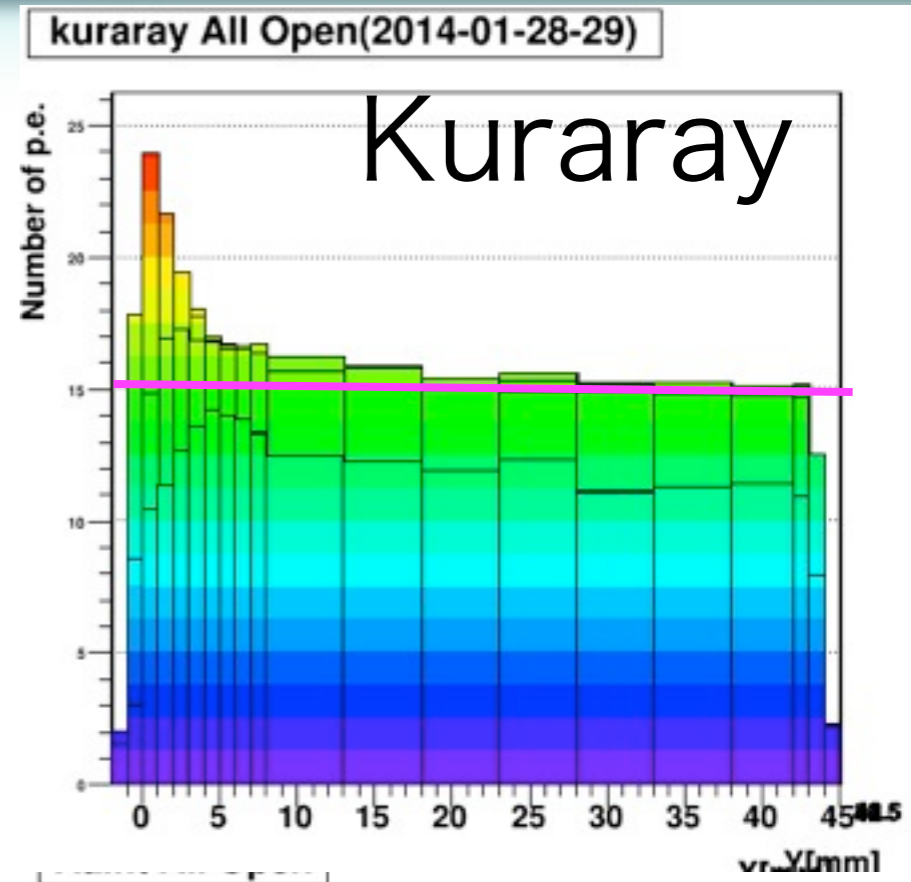
# wedge shape strip

- more **simulation** on
- wedge length 3,5,7mm
- good uniformity & yield



# scintillator material

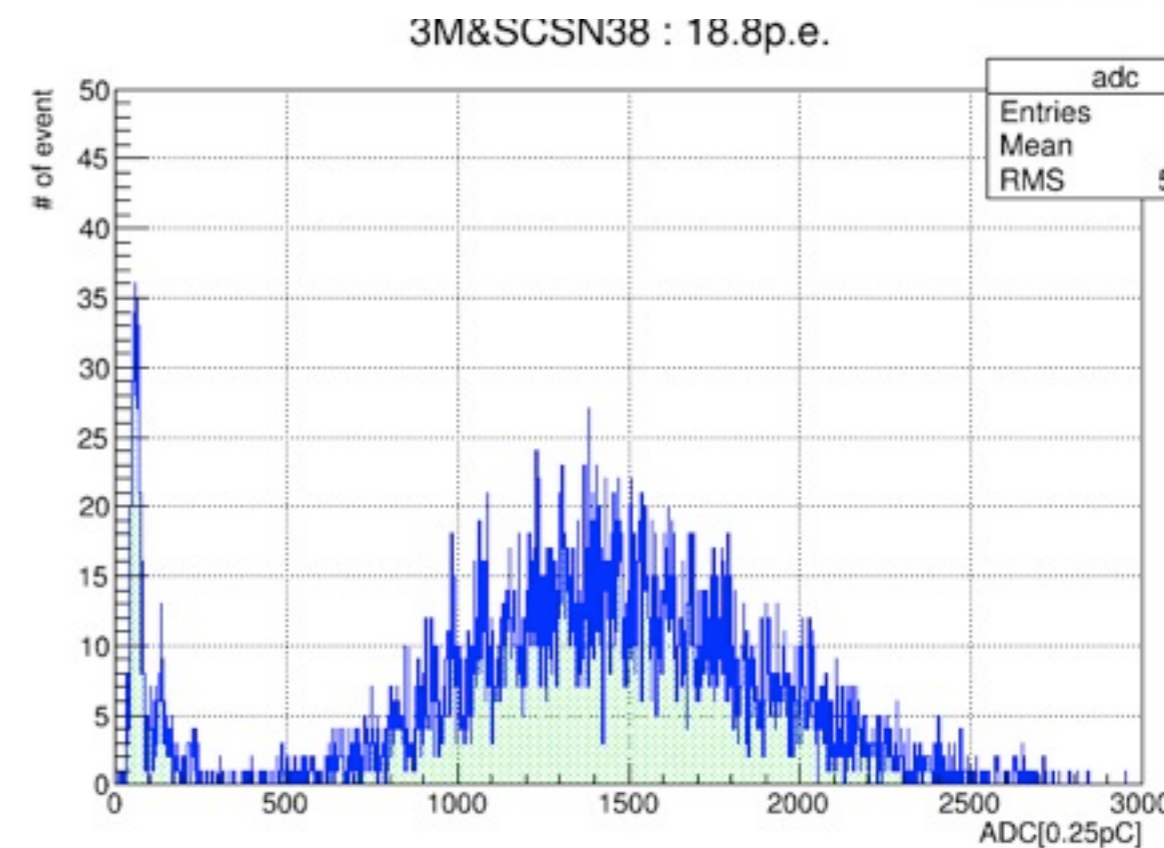
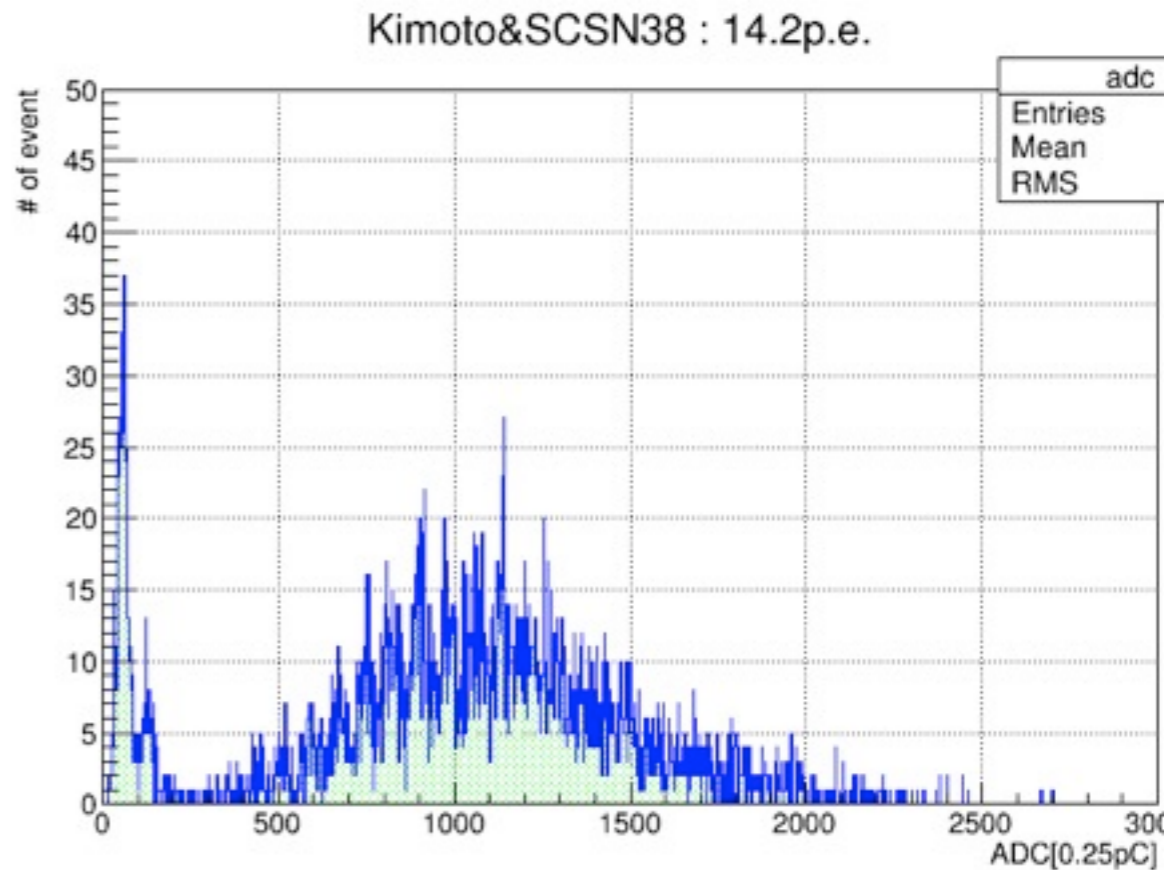
- Kuraray: SCSN-38
- ELJEN: EJ-204
- others are all the same  
PPD=MPPC 1600pix/mm<sup>2</sup> reflector film KIMOTO
- photon yield
- slight difference but not much





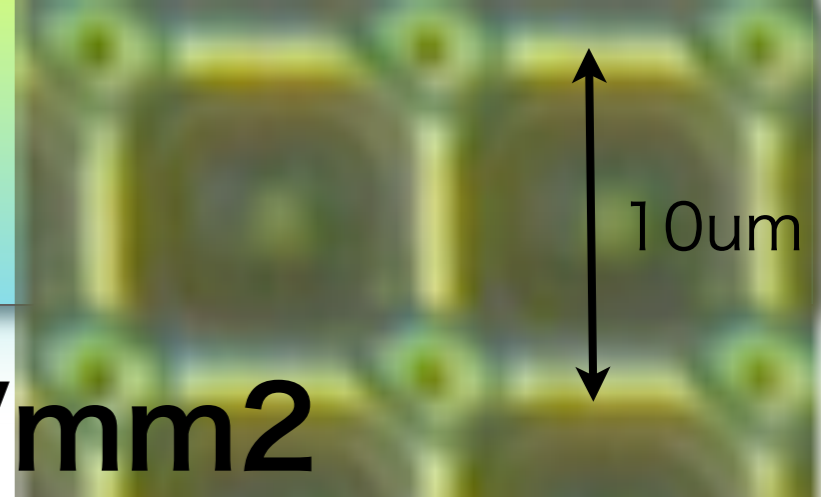
# reflector film

- we need air gap between the reflector
- better homogeneity
- KIMOTO:Ref-White  
14p.e.
- 3M: radiant mirror  
19p.e.
- 3M is better





# photo-sensor



10um

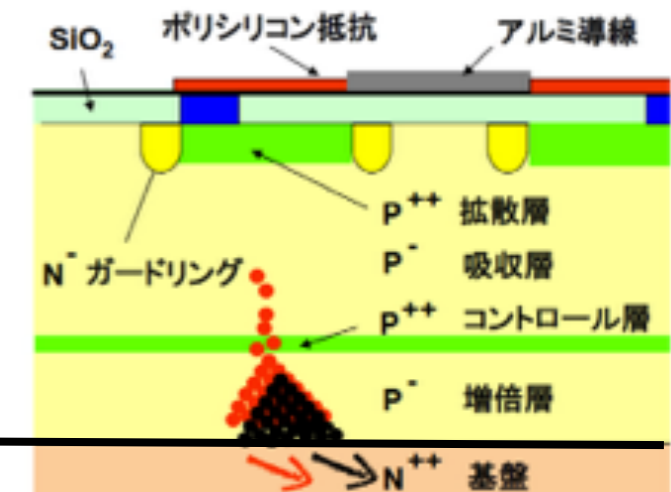
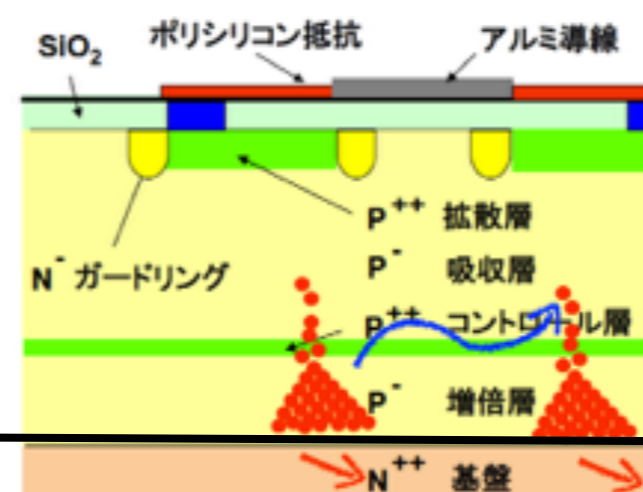
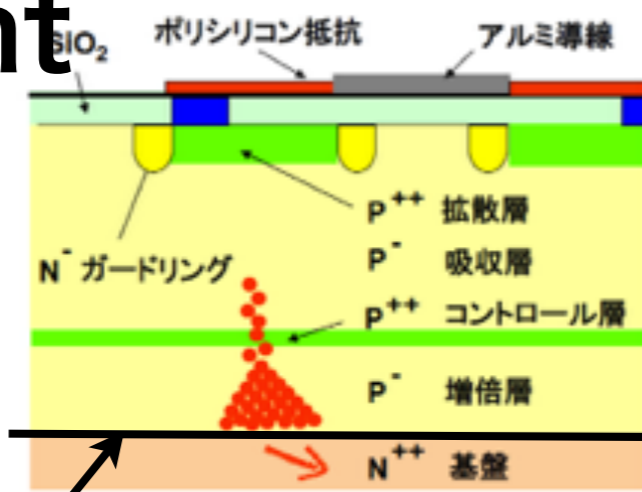
- 10um pitch with MR=10kpix /mm<sup>2</sup>

- prevent after pulse

Dark noise

Crosstalk

After pulse

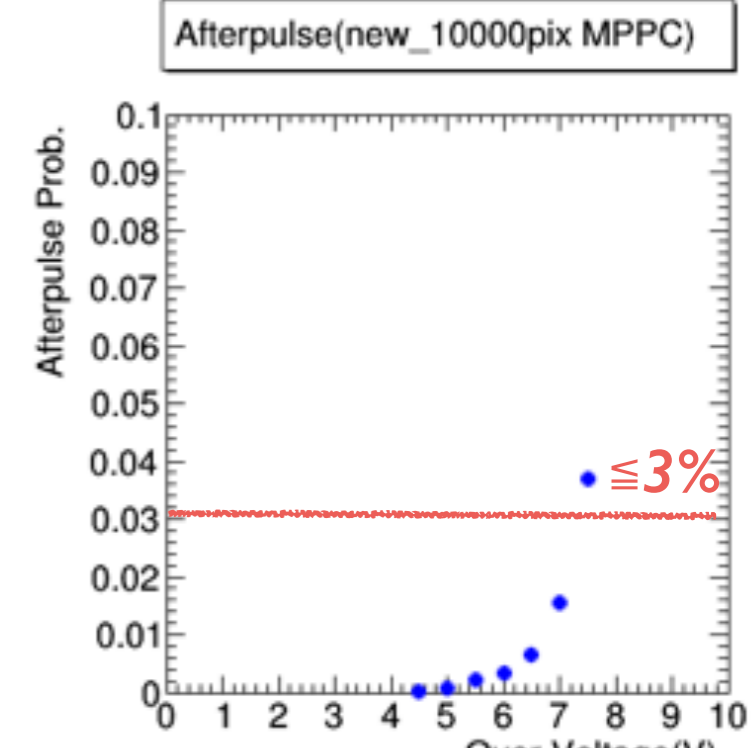
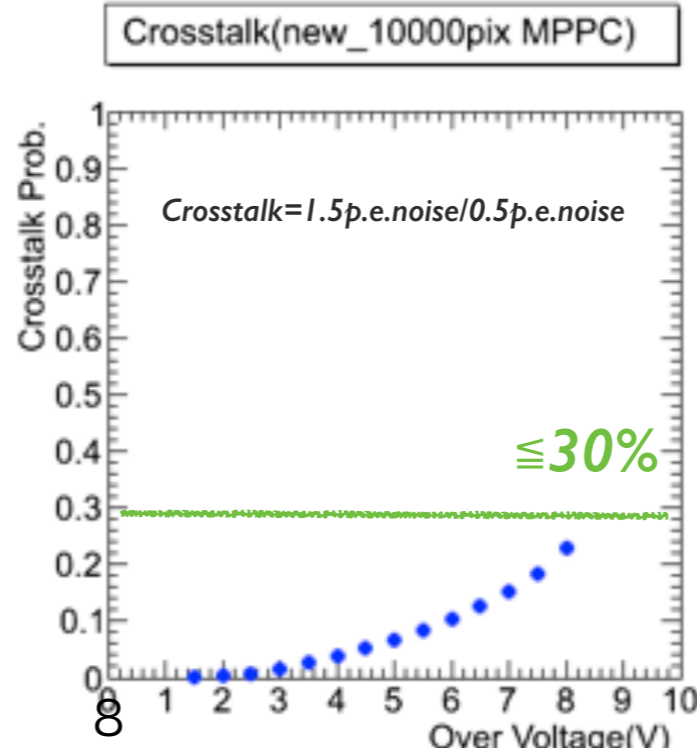
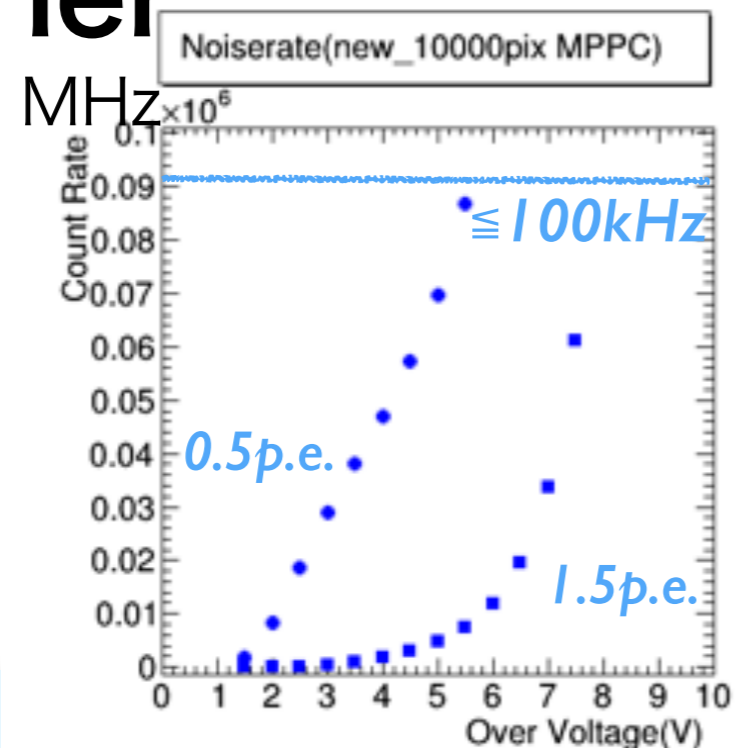


- a barrier

thermal noise

origin of thermal noise

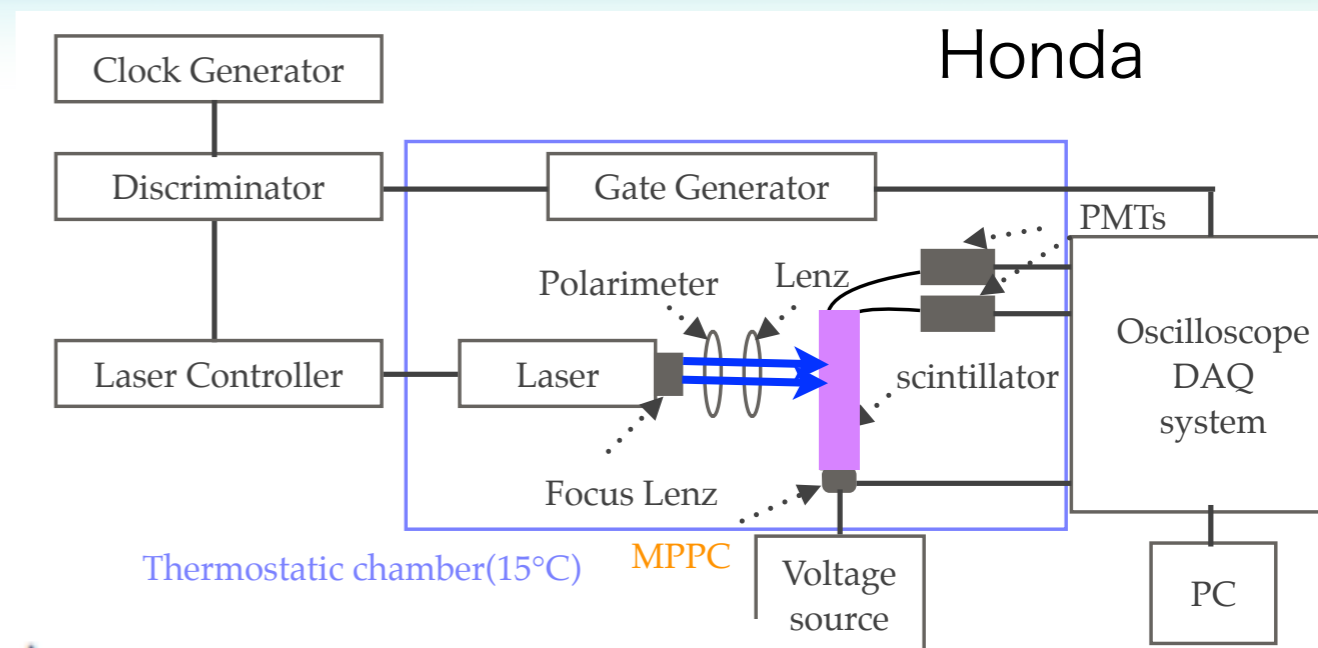
origin of thermal noise



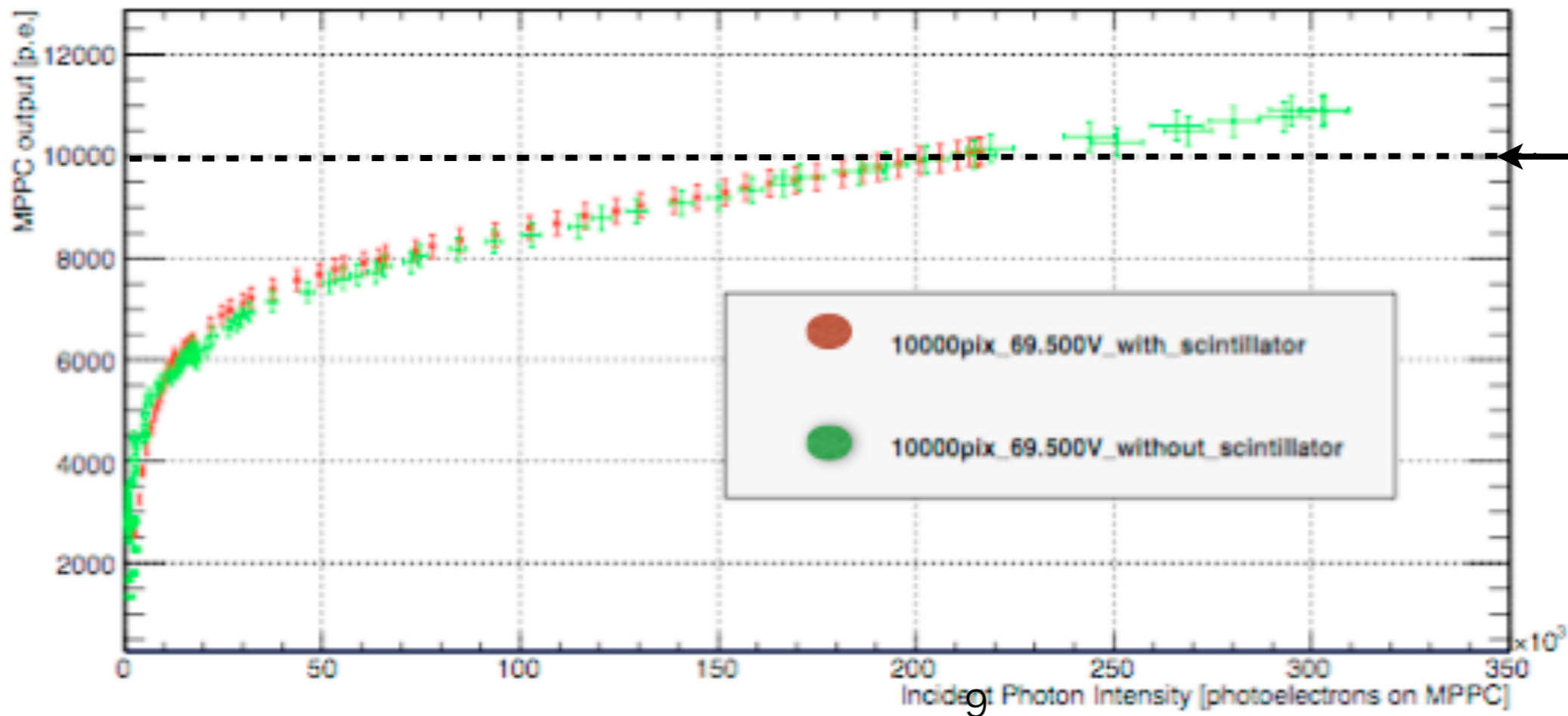
Hamasaki

# 10k pix MPPC

- response curve at high intensity
- with/wo scintillator strip



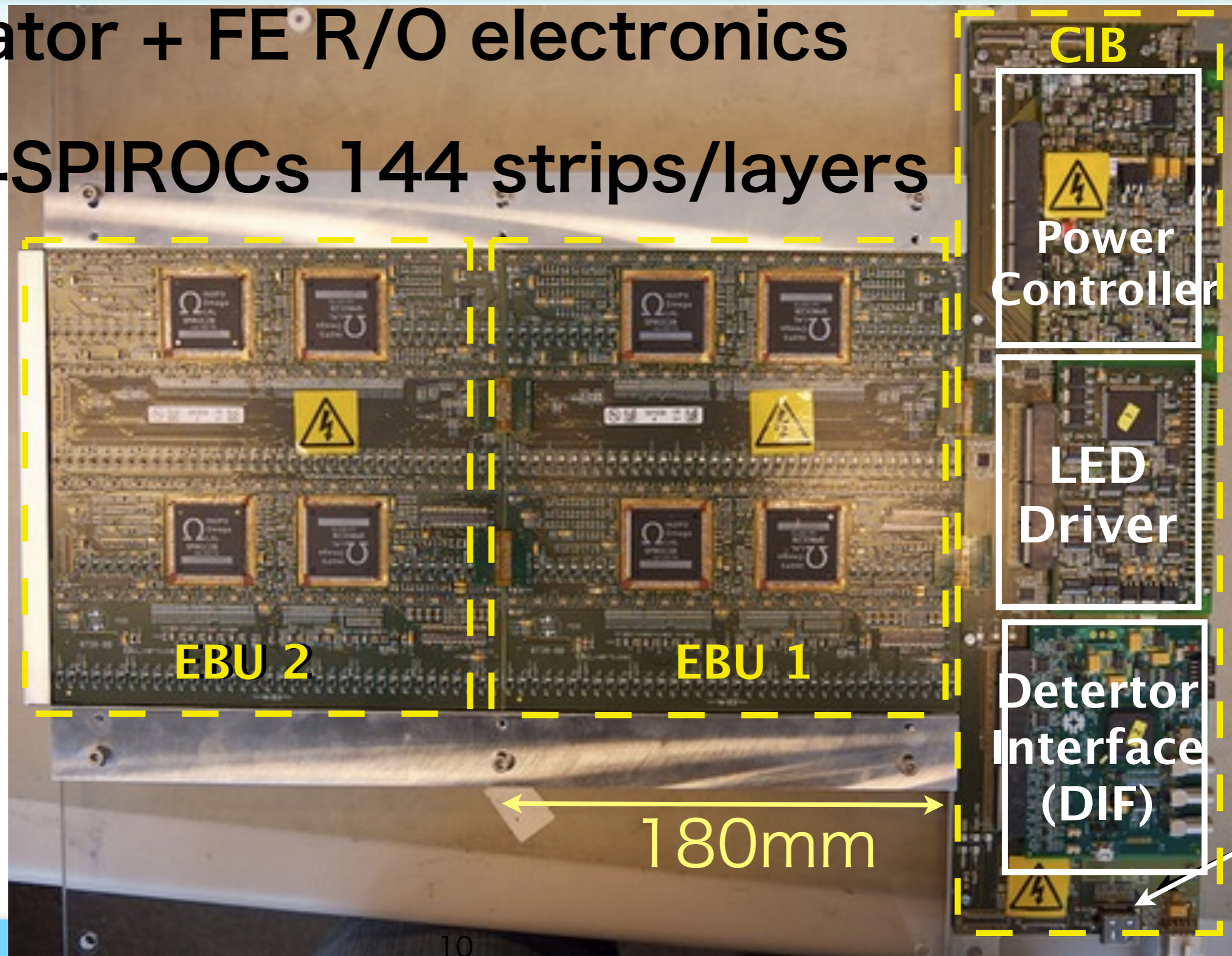
Comparison of RC\_scaled





# embedded layer

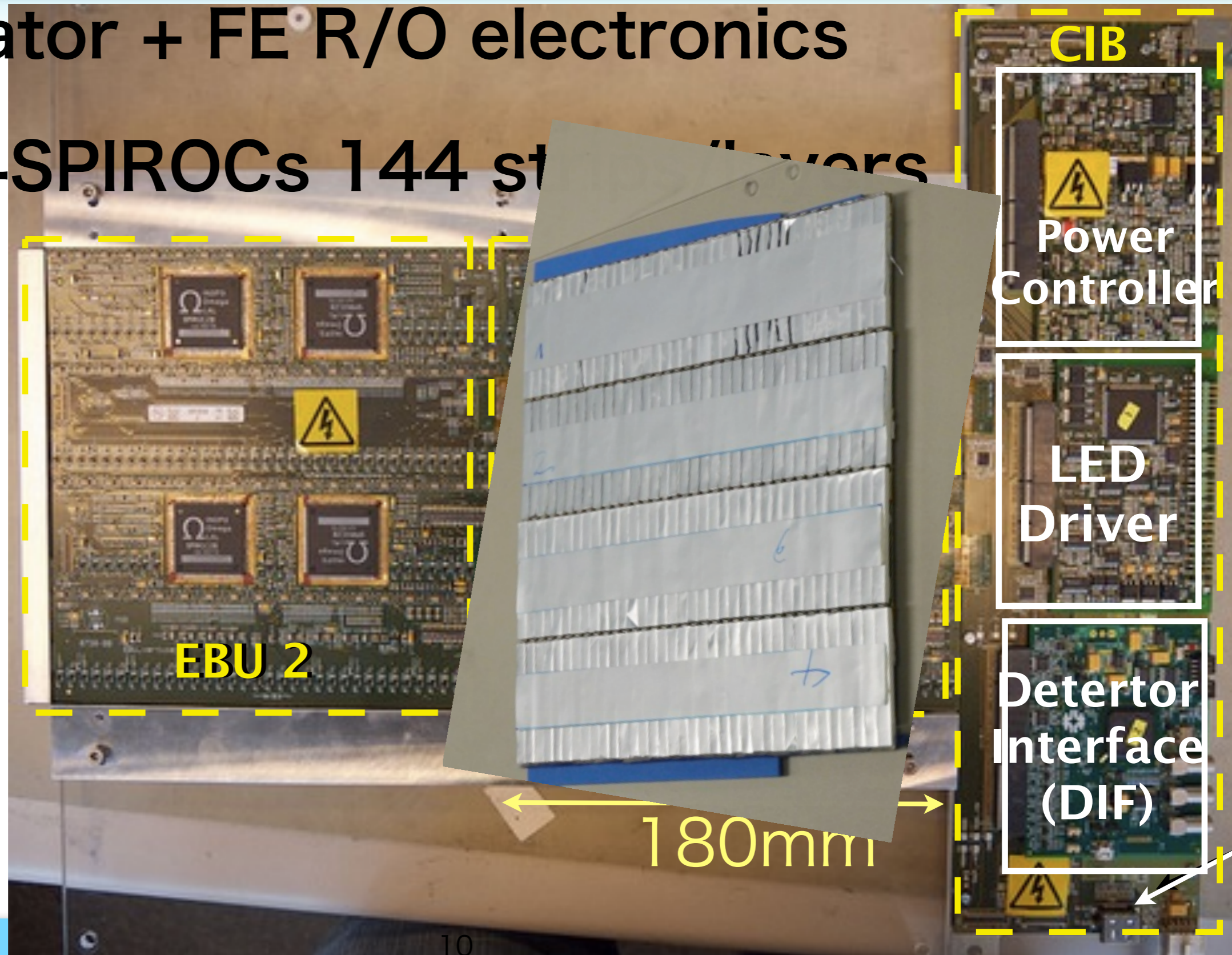
- scintillator + FE<sup>+</sup>R/O electronics
- EBU : 4SPIROCs 144 strips/layers
- tested at DESY 2012/2013





# embedded layer

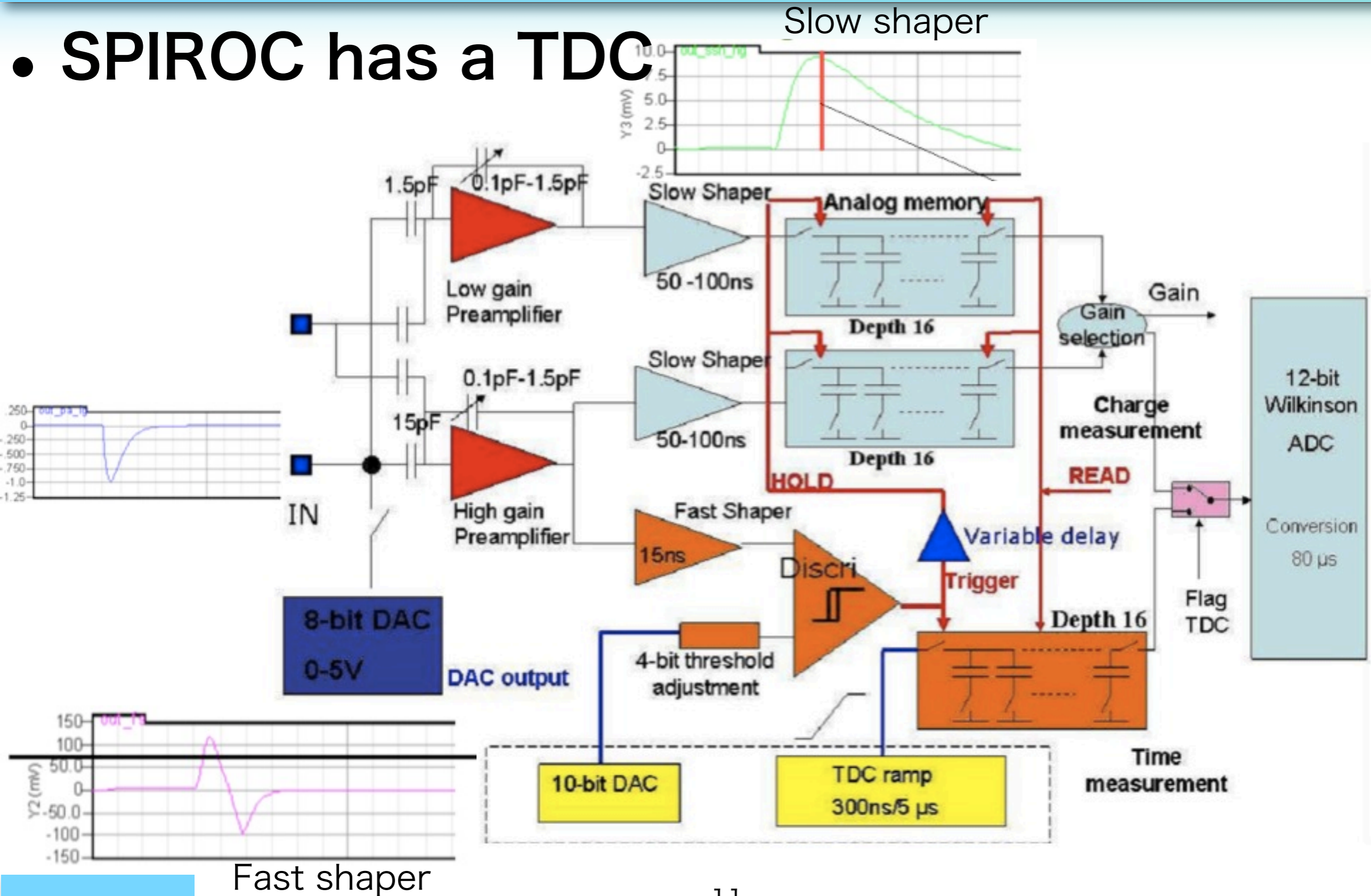
- scintillator + FE<sup>+</sup>R/O electronics
- EBU : 4 SPIROCs 144 staves
- tested at DESY 2012/2013





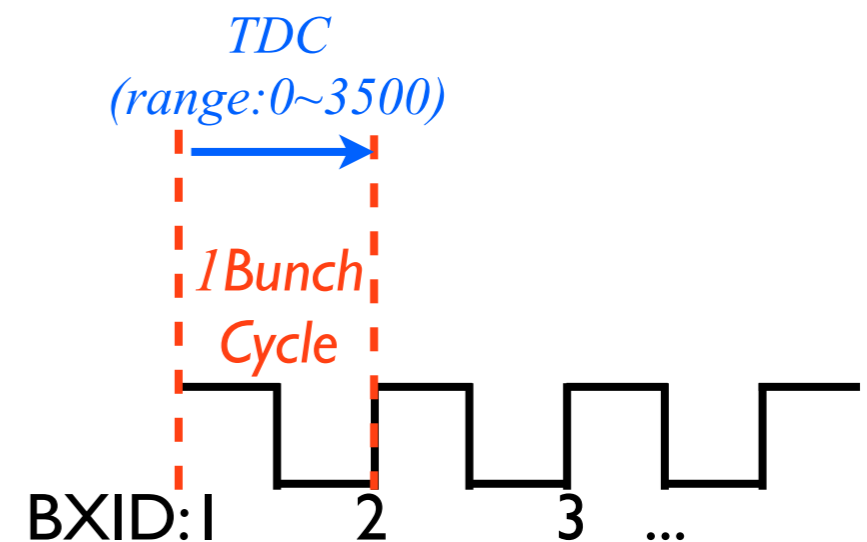
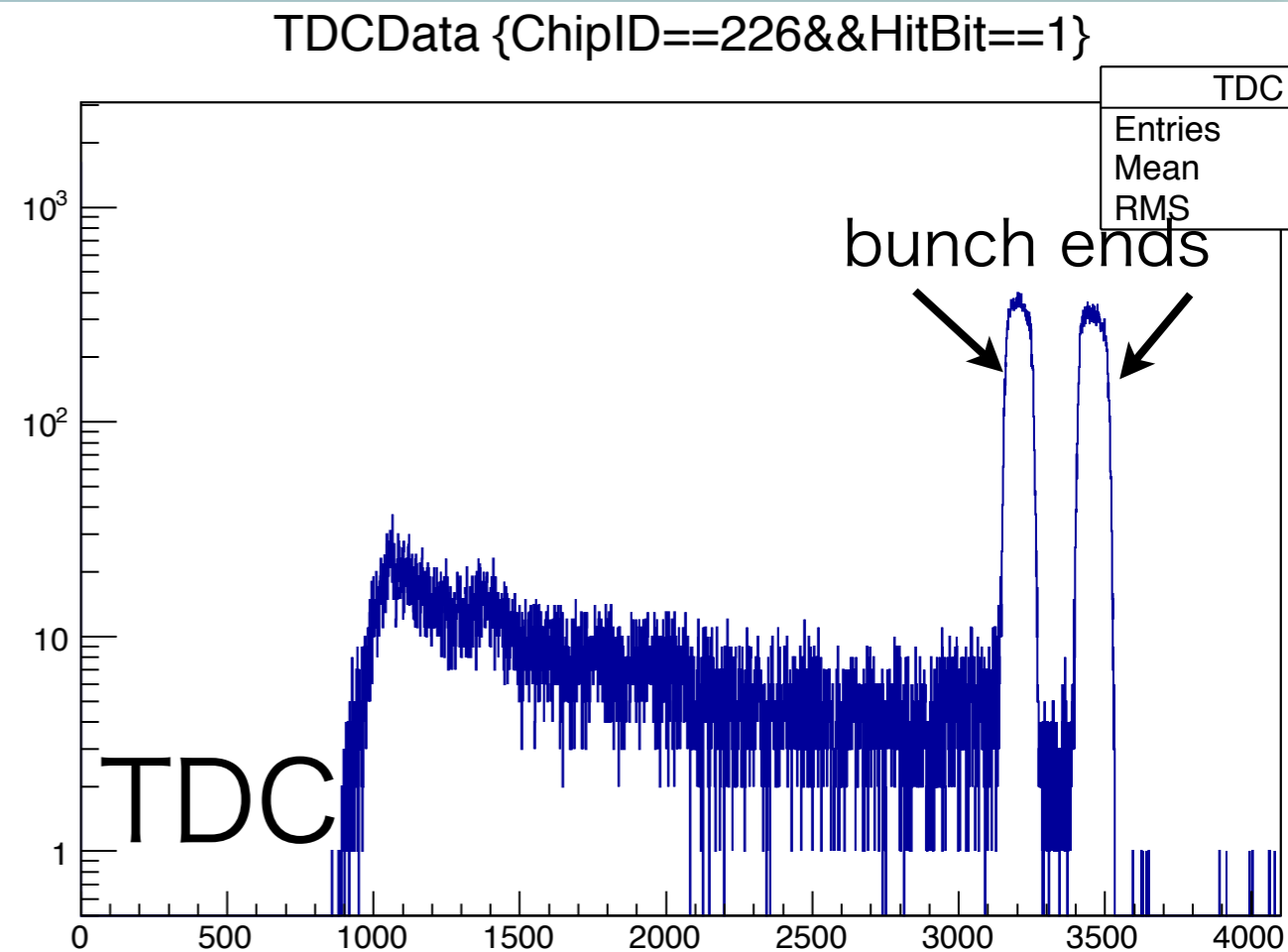
# SPIROC2b

- SPIROC has a TDC



# TDC of spiroc

- two TDC ramps
- resolution  
1.6~1.8ns/ch
- bunch end without beam trigger counter validation

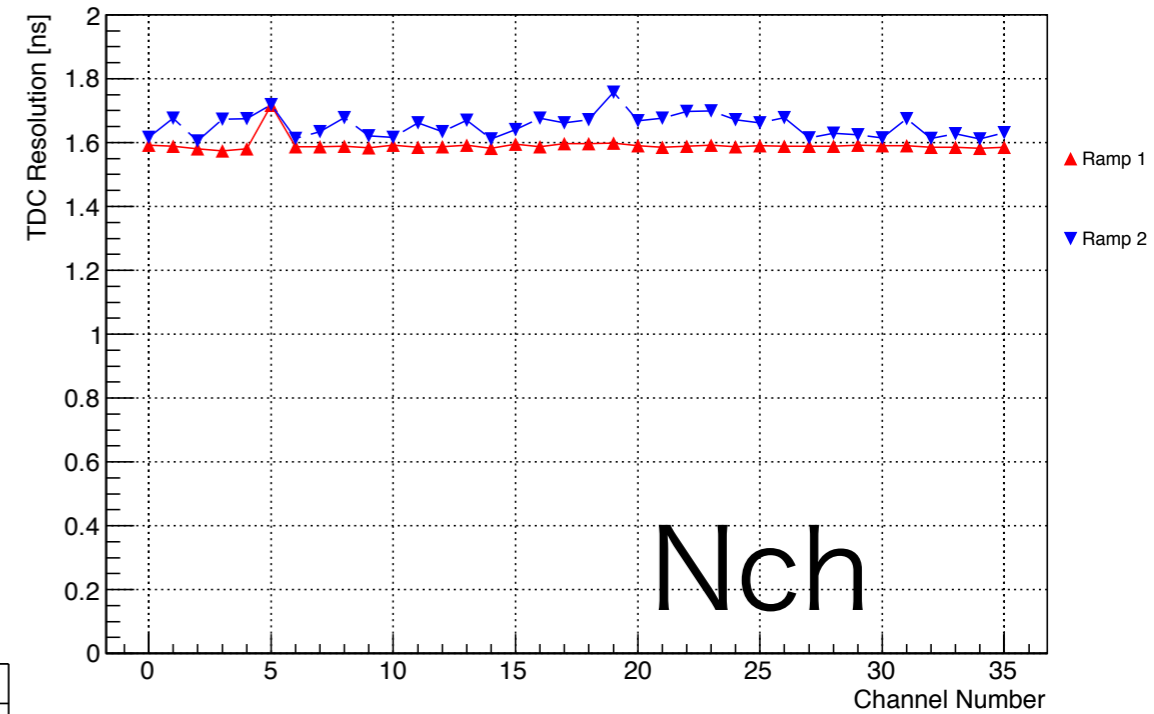




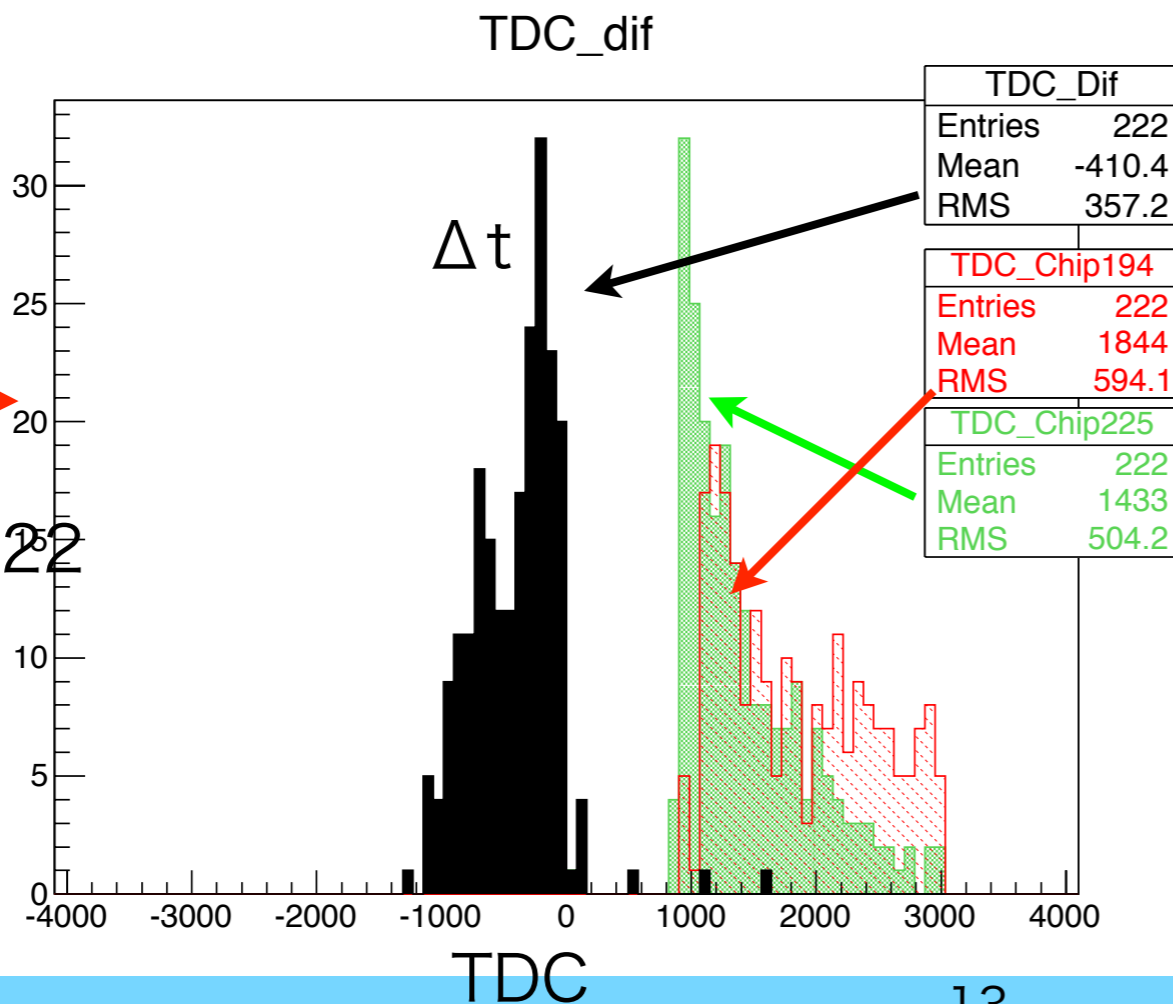
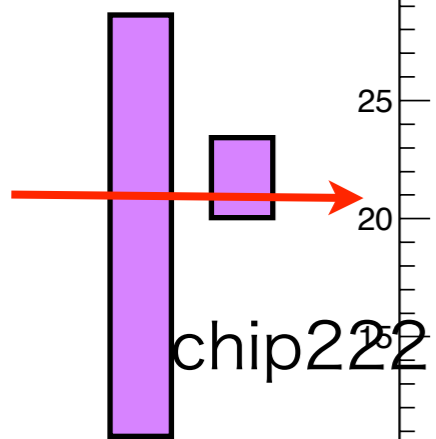
# TDC of spiroc

- two TDC ramps
- stable through runs
- beam coincidence

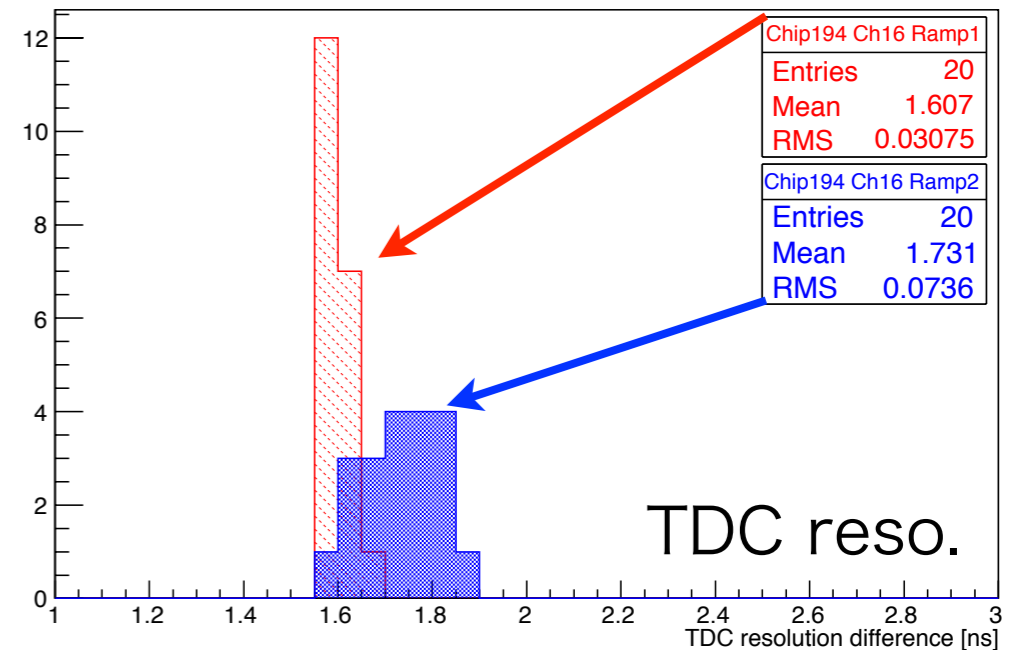
TDC reso. Chip194 TDC resolution



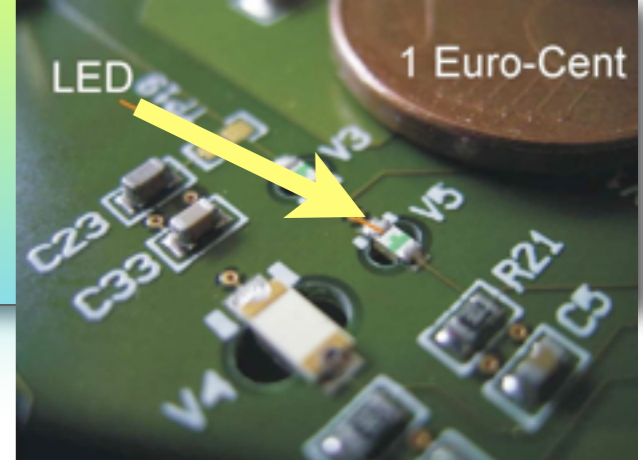
chip194



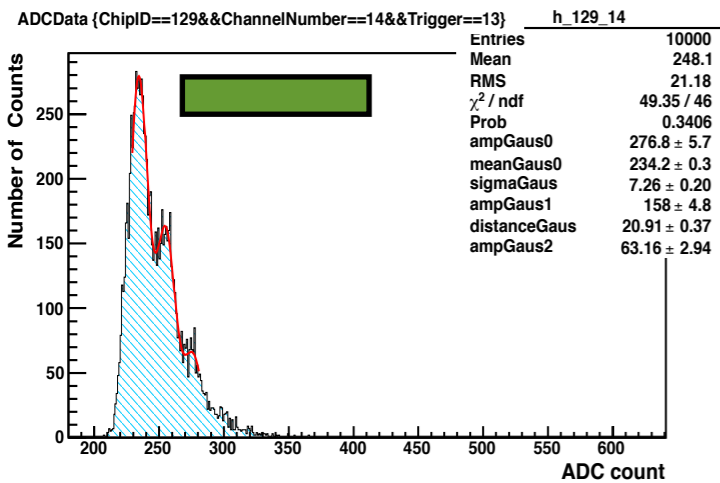
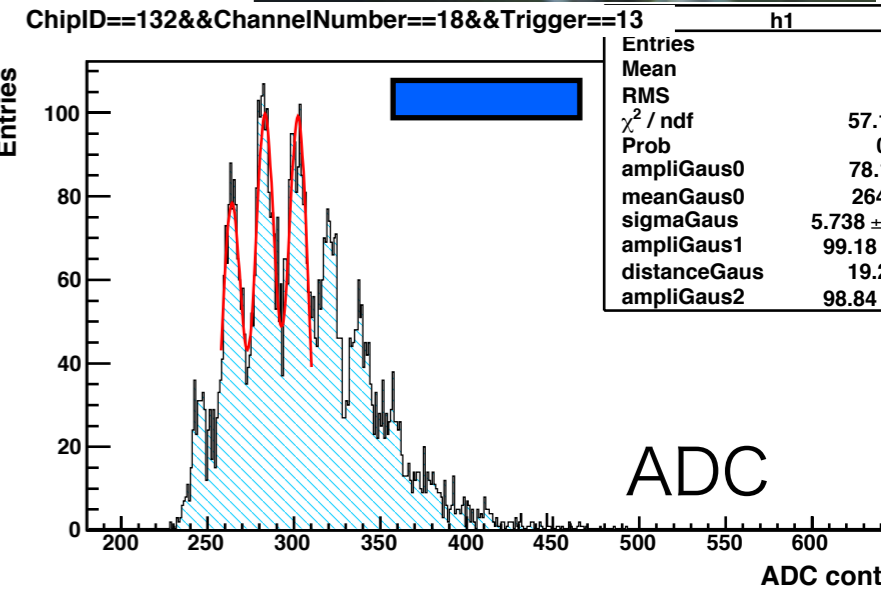
TDC resolution stability over shower runs



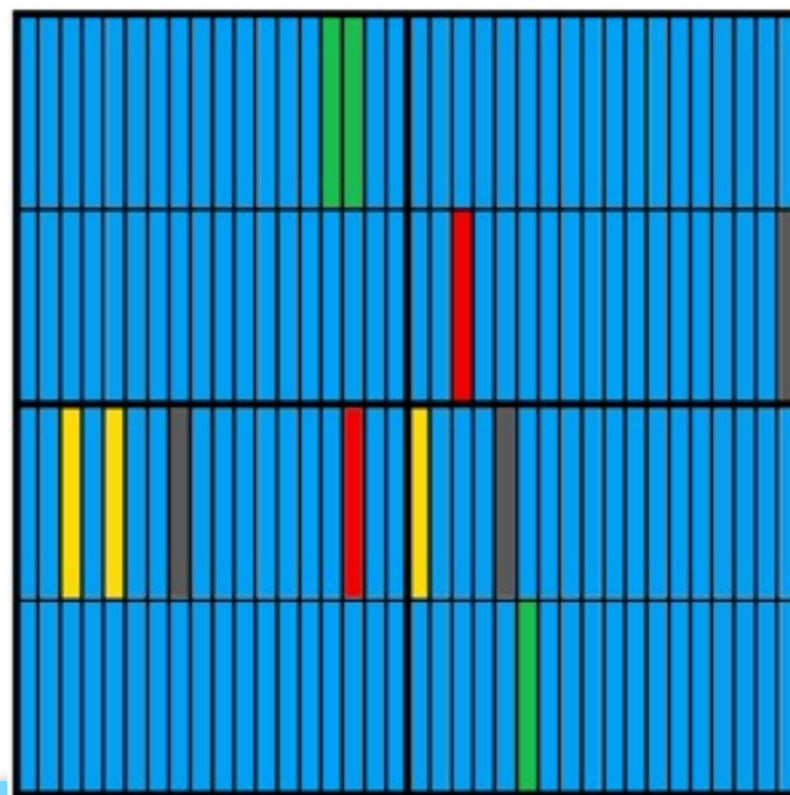
# LED calibration



- LED equipped every strip
- 2&4 dead ch. (1.4&2.8%)
- 3&8 noisy ch. in F&B-layer

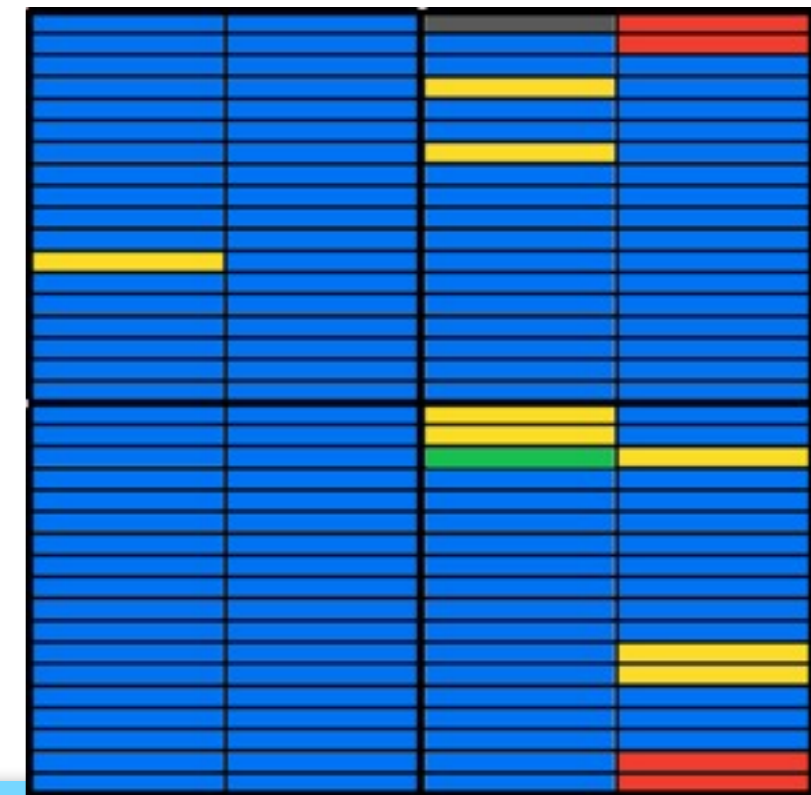


144ch  
Forward layer result

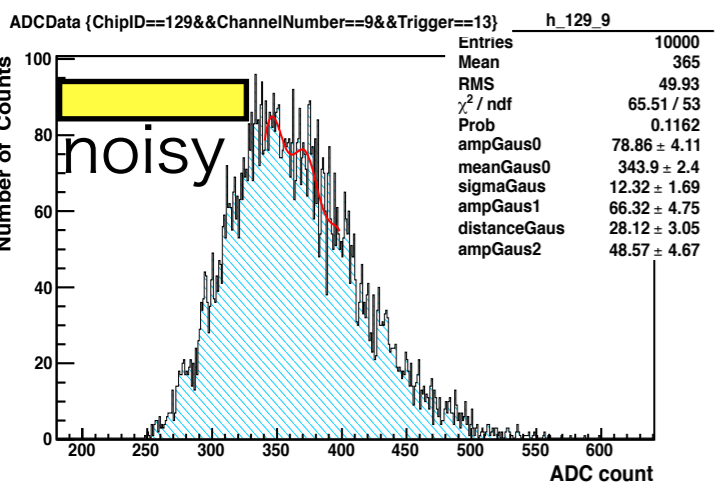


13.5%

Backward layer result



Ogawa 8.3%

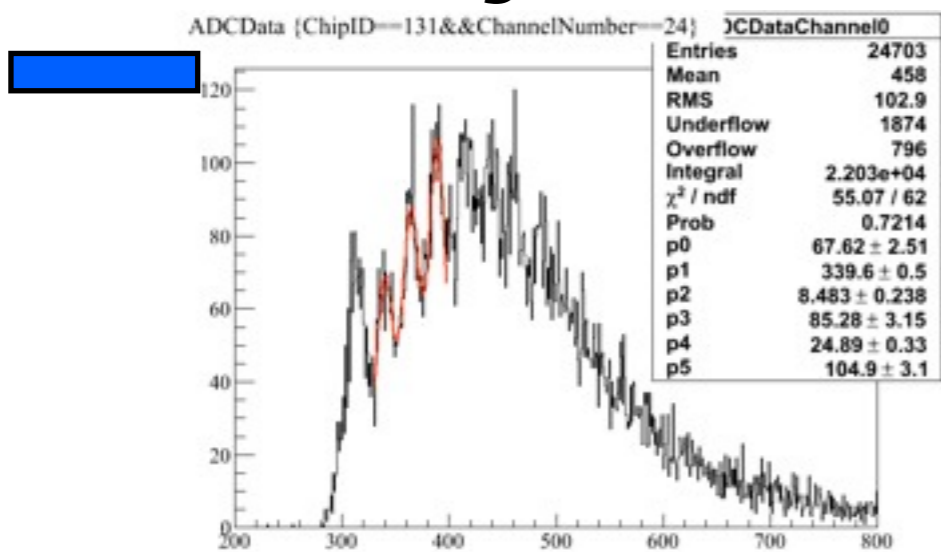
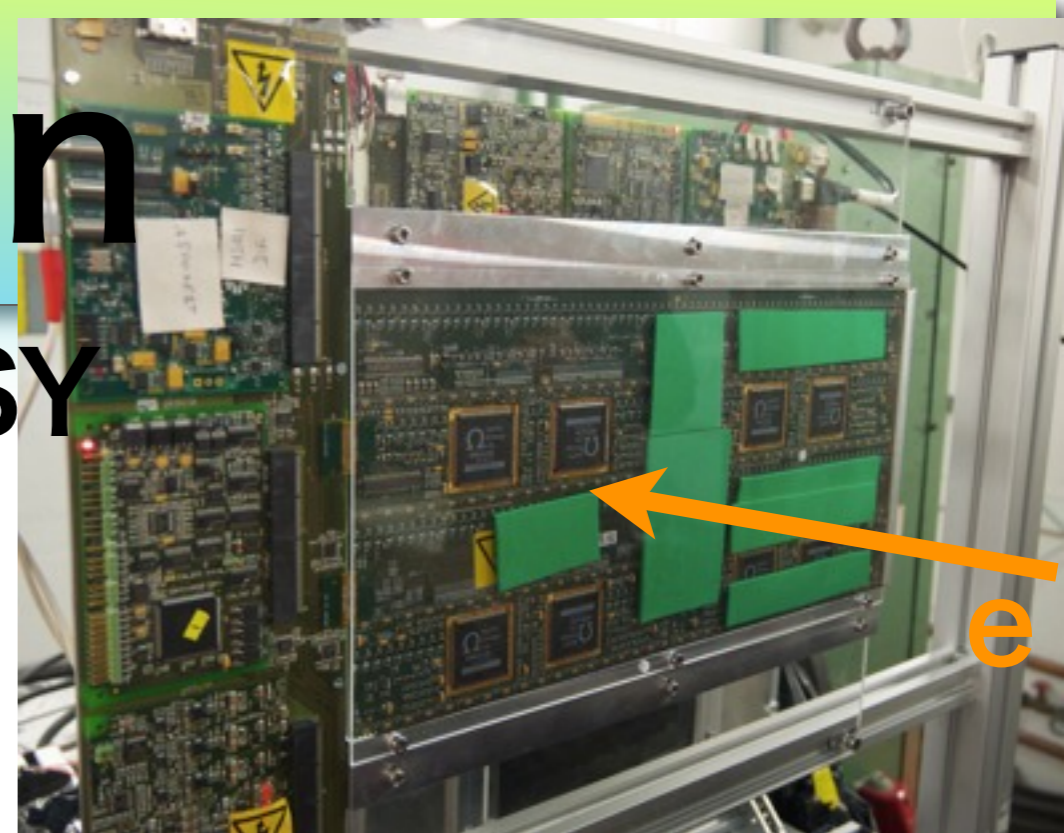


no signal



# MIP calibration

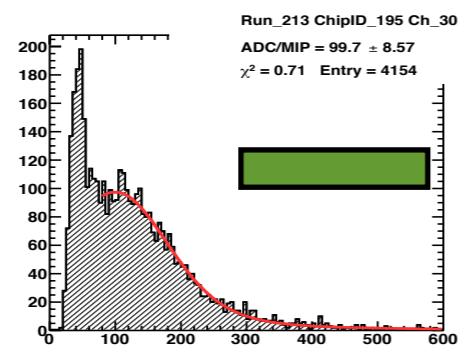
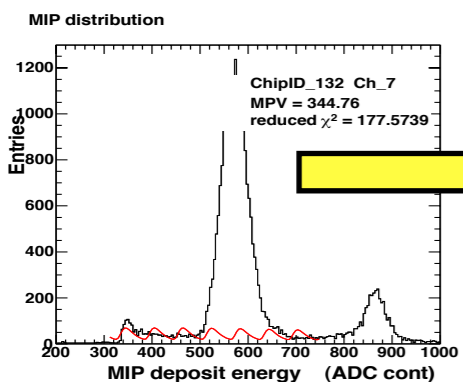
- **MIP** in the test beam DESY
- 2&5 dead ch. (1.4&3.5%)
- 9 noisy ch. in B-layer



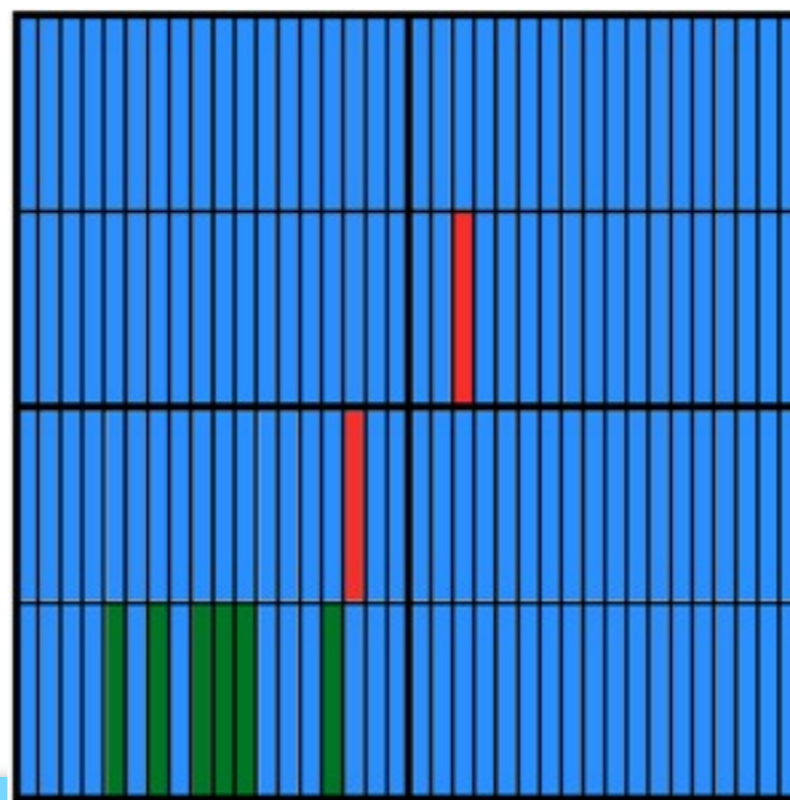
144ch

Forward layer result

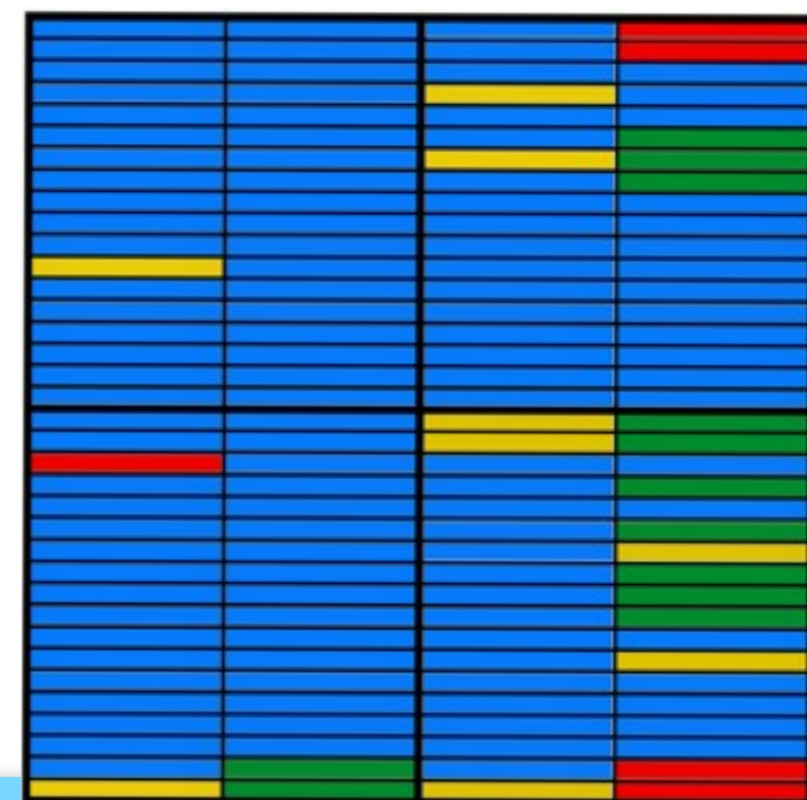
Backward layer result



no signal



1.4%



Ogawa

9.7%

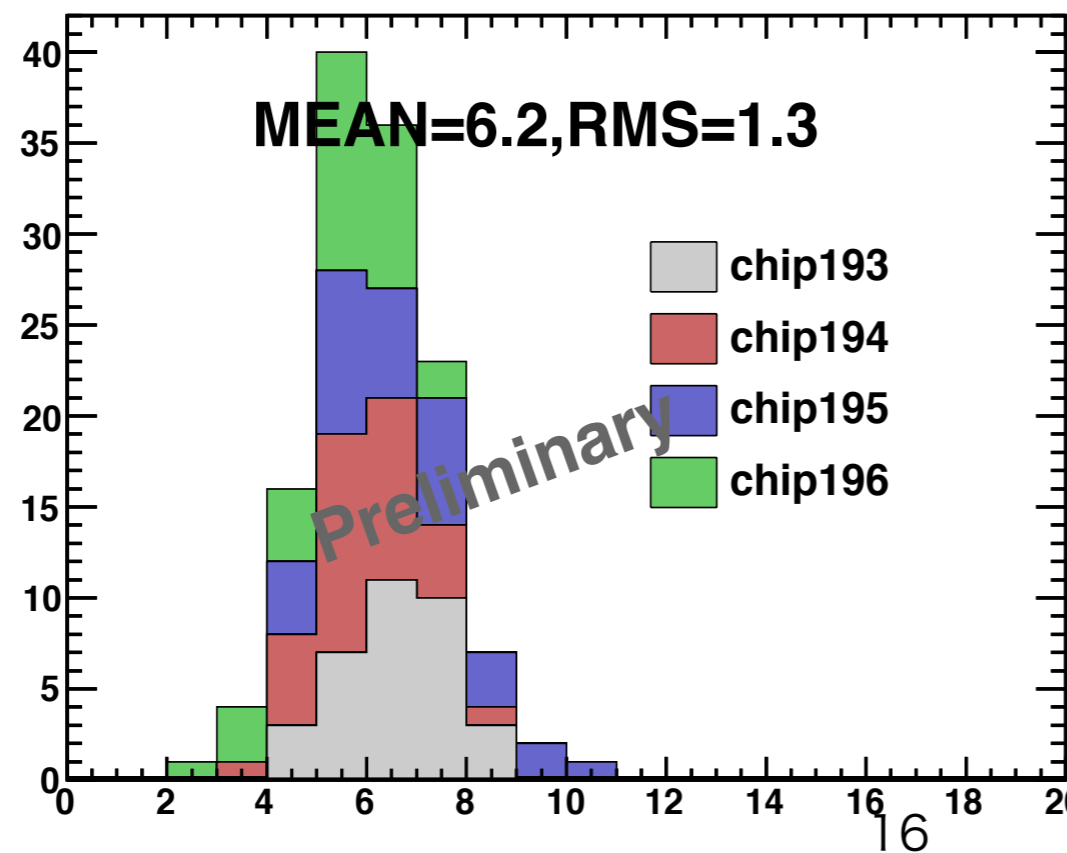
# MIP calibration

- photo-electrons / MIP
- mean: 6.2 & 7.2 p.e./MIP
- ~20% of sigma
- no apparent difference in spiroc chips

144ch

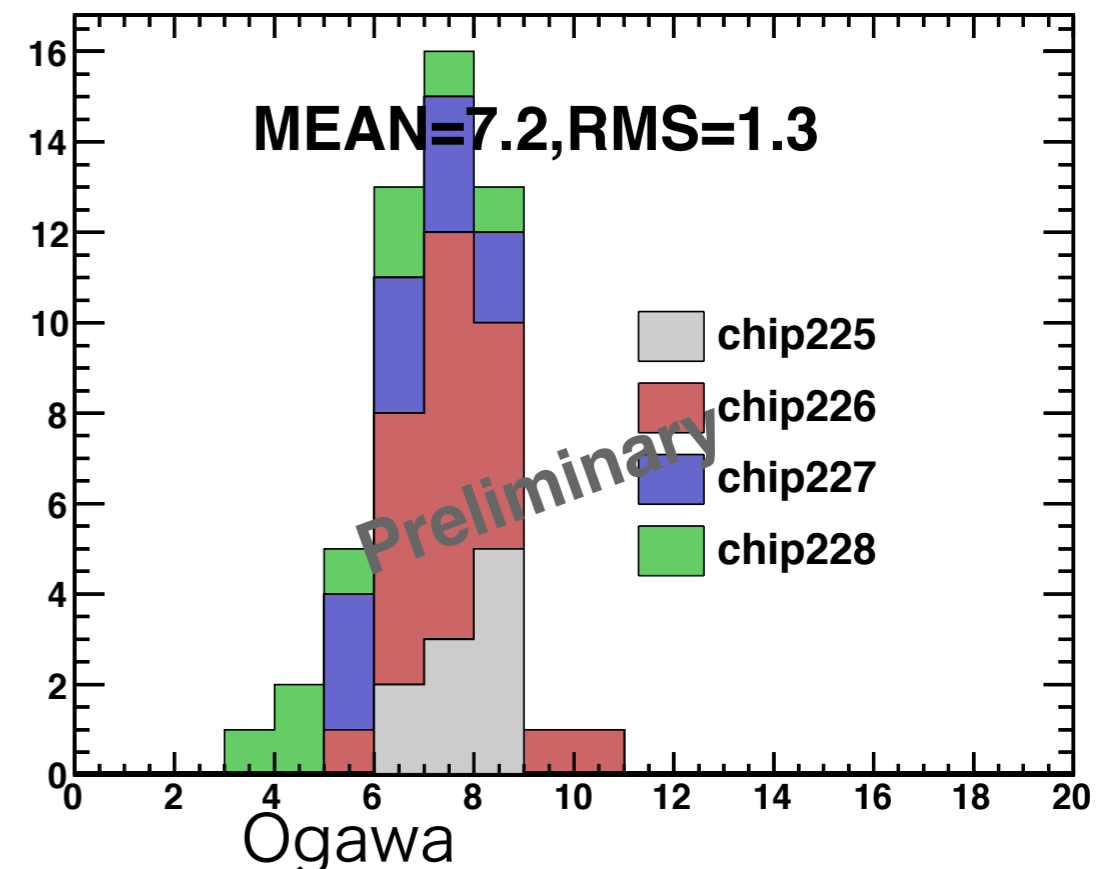
Np.e. 1stLayer

forward



Np.e. 2ndLayer

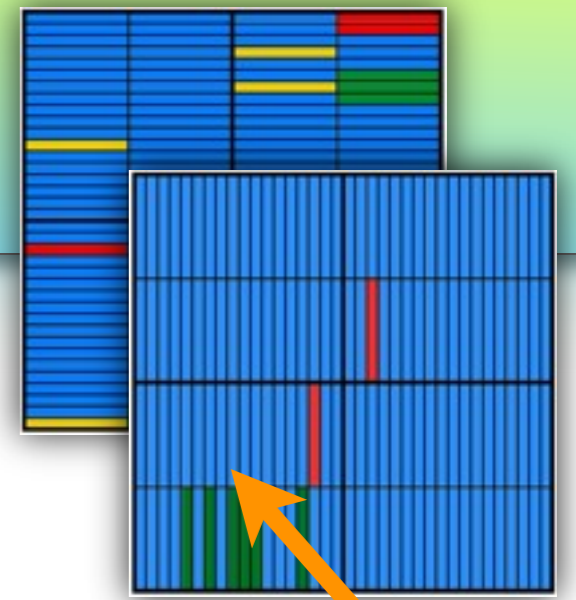
backward



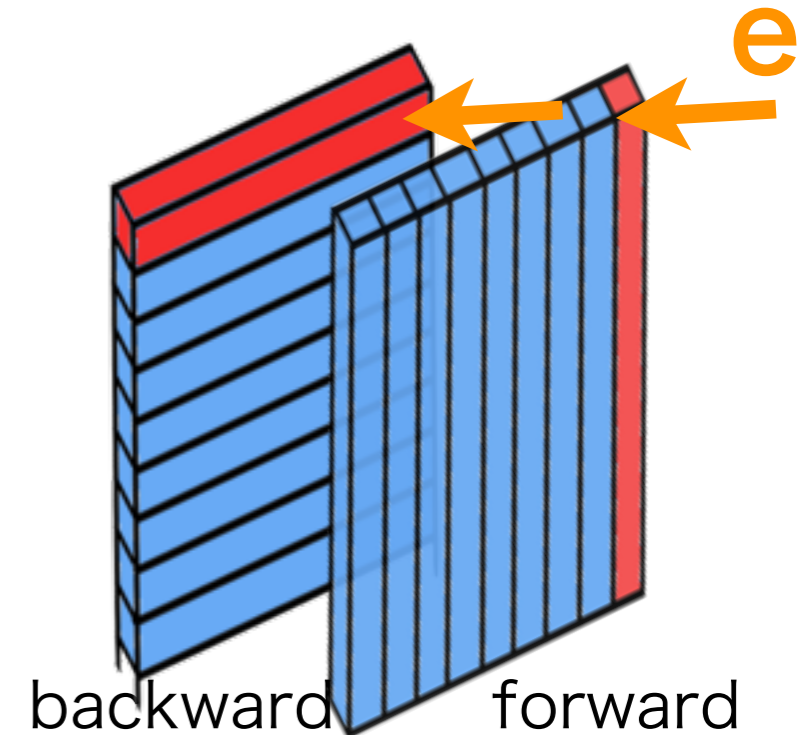
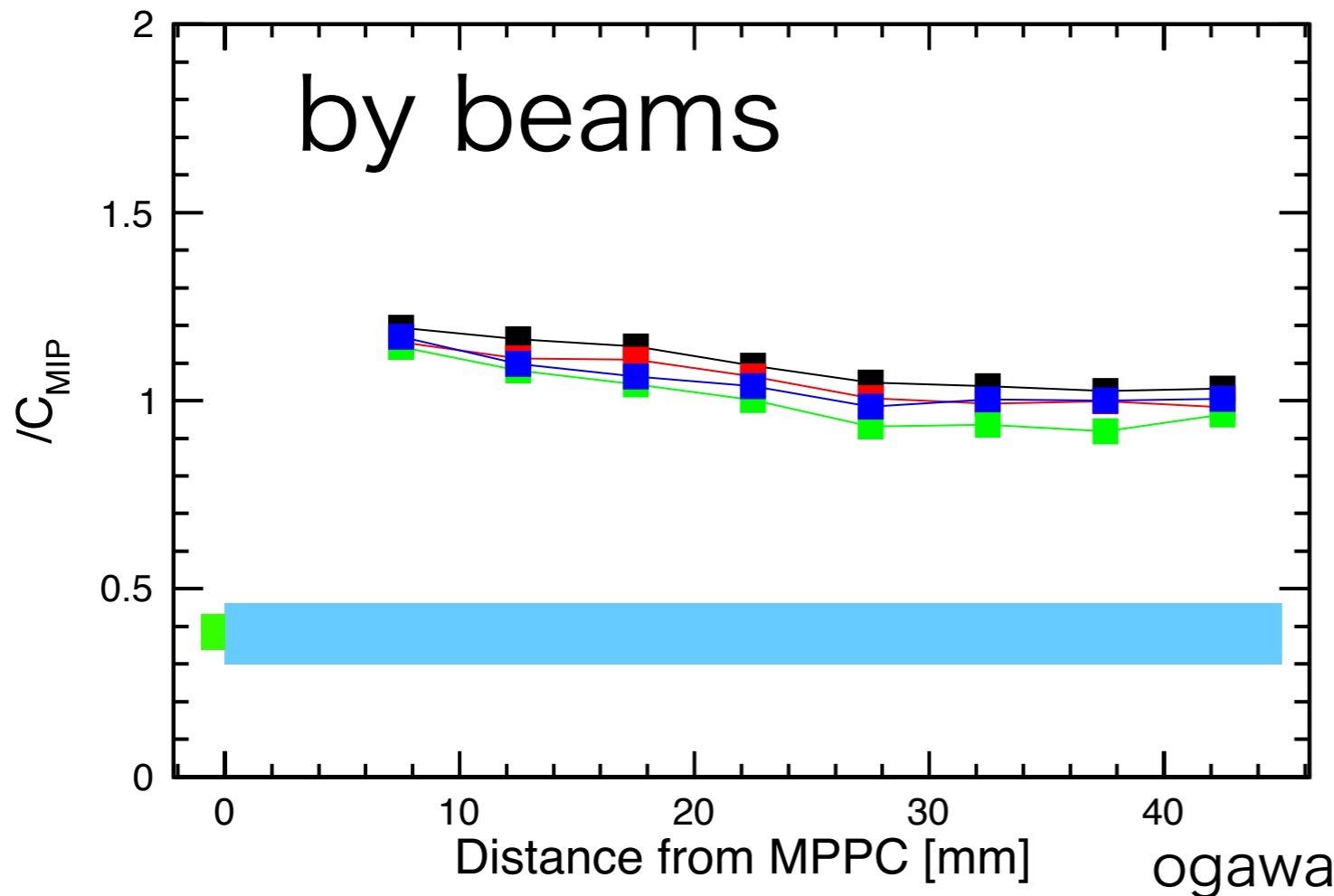


# strip uniformity

- using electron beam at DESY
- simple SSA scheme
- 5mmx5mm resolution

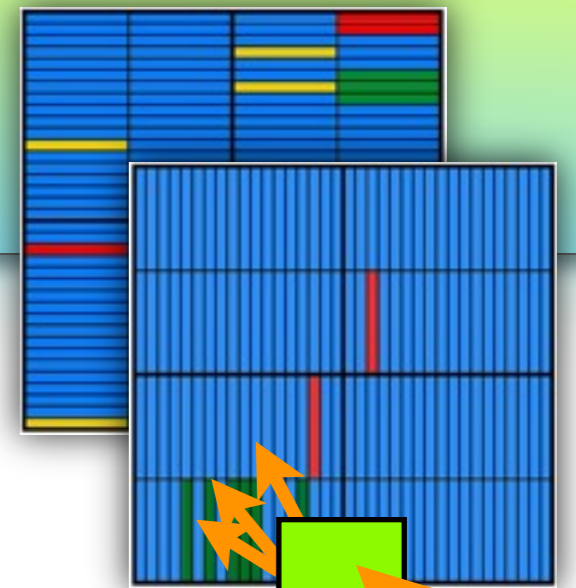


■ Chip\_194, Channel\_23 d-val=20.8    ■ Chip\_194, Channel\_24 d-val=24.9  
■ Chip\_194, Channel\_25 d-val=24.5    ■ Chip\_194, Channel\_26 d-val=21.8



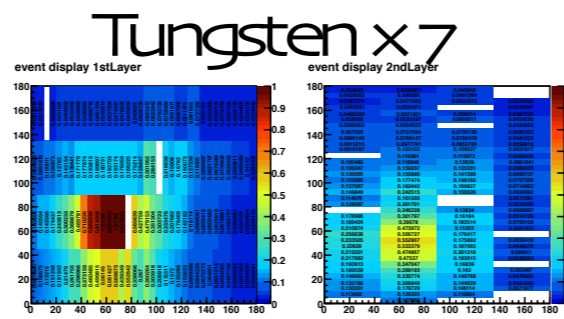
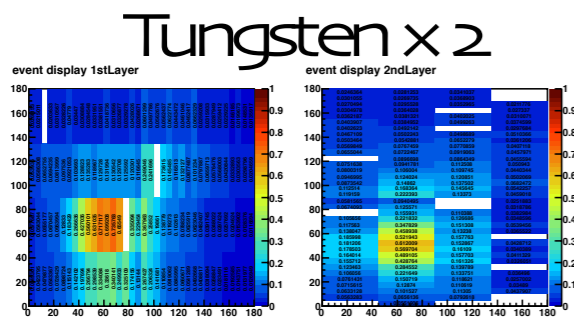
# shower profile

- using electron beam with tungsten plates
- simple SSA scheme
- 5mmx5mm resolution

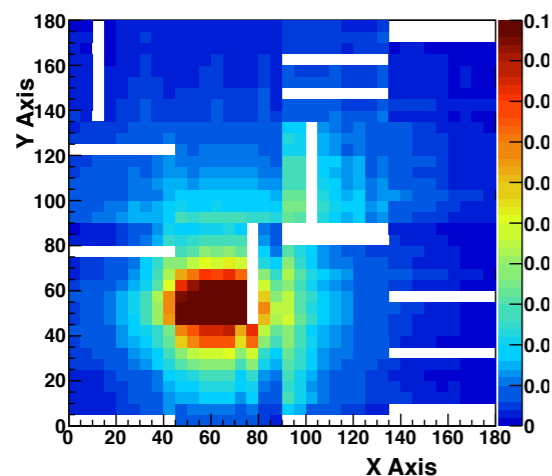


tungsten  e

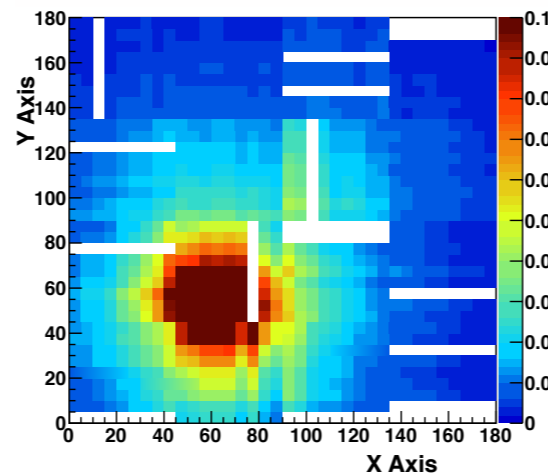
Forward layer & Backward layer Plot



SSA on 2 layers Plot



SSA on 2 layers Plot



forward

backward  
forward

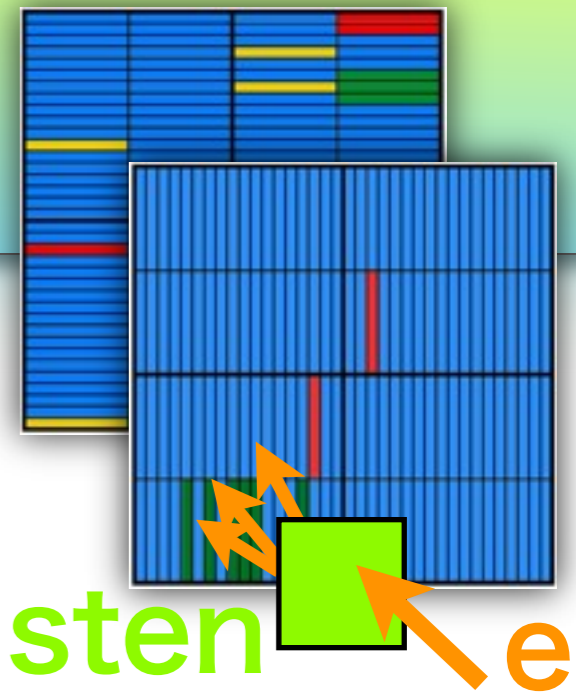
backward

forward

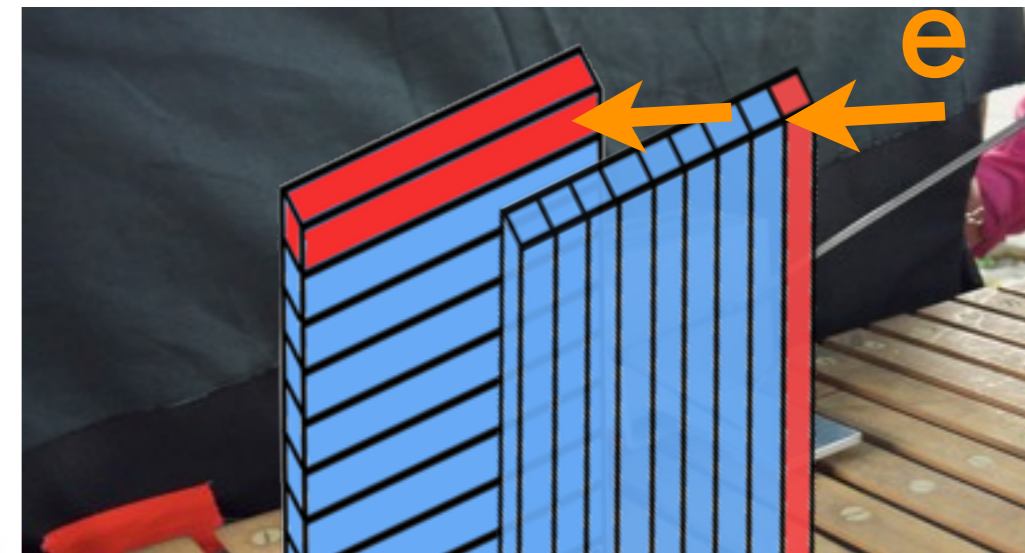


# shower profile

- using electron beam with tungsten plates
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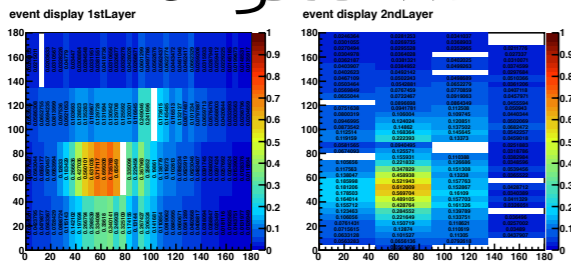
tungsten e



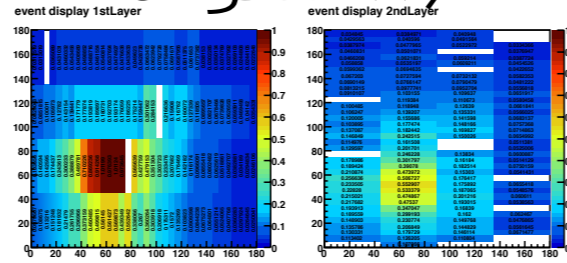
forward backward backward forward

Forward layer & Backward layer Plot

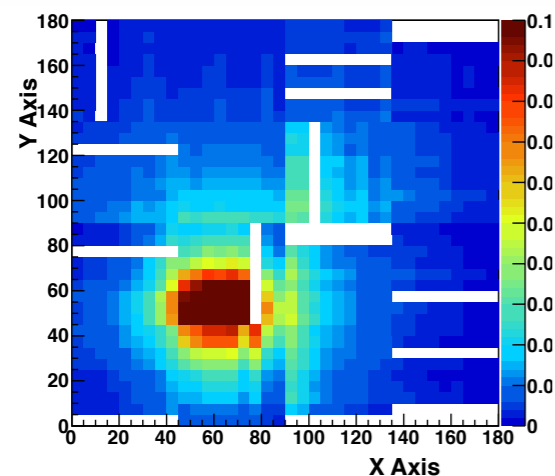
Tungsten x 2



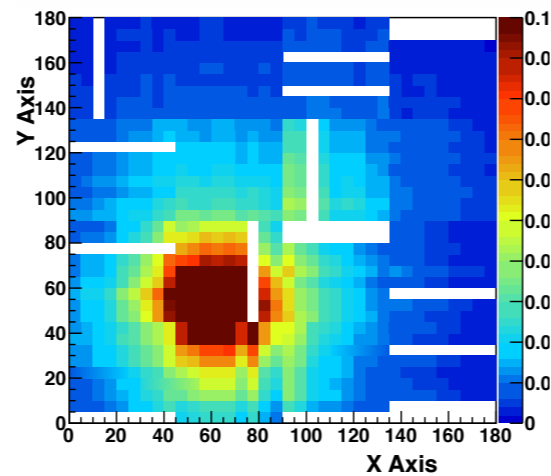
Tungsten x 7



SSA on 2 layers Plot

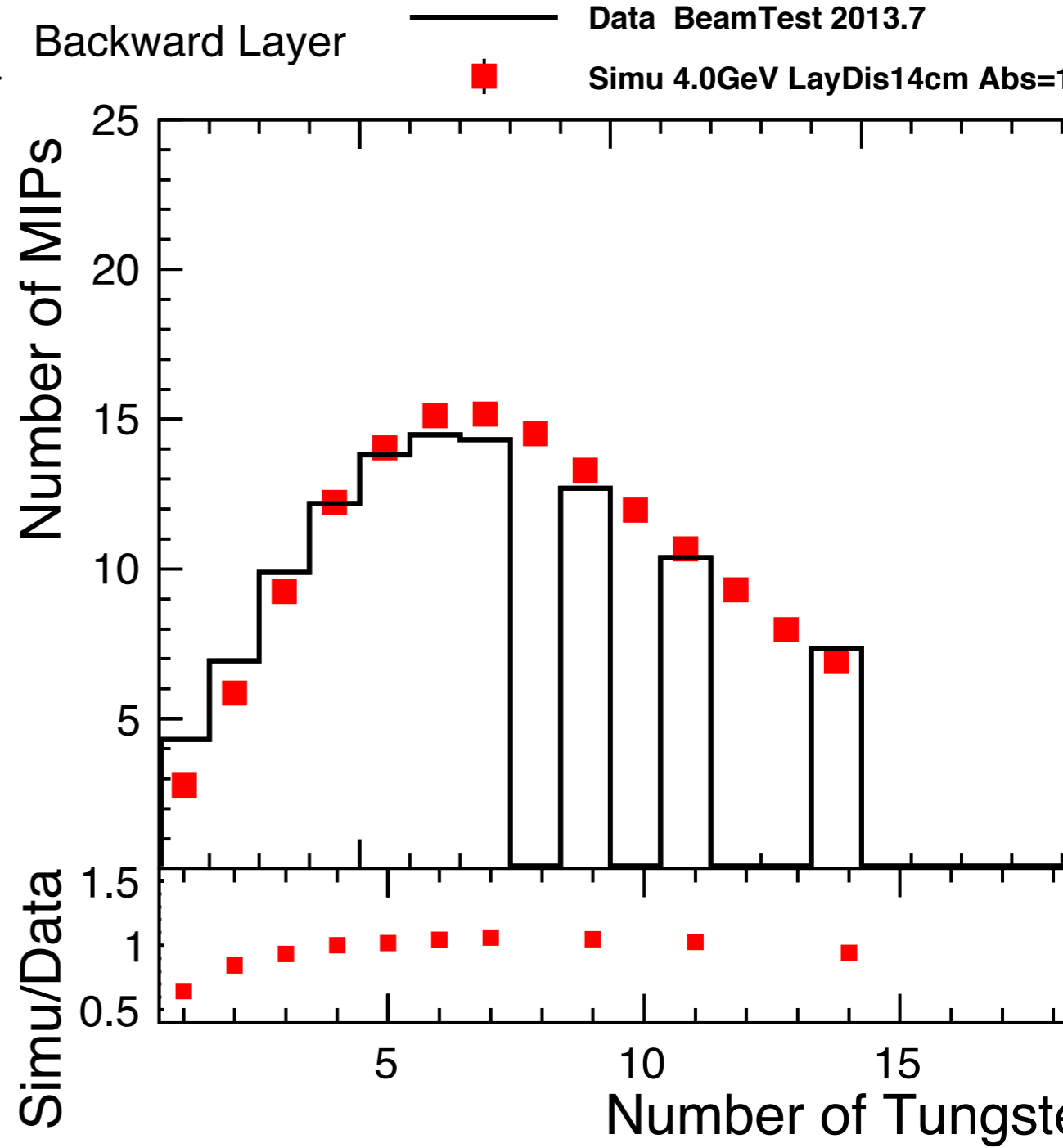
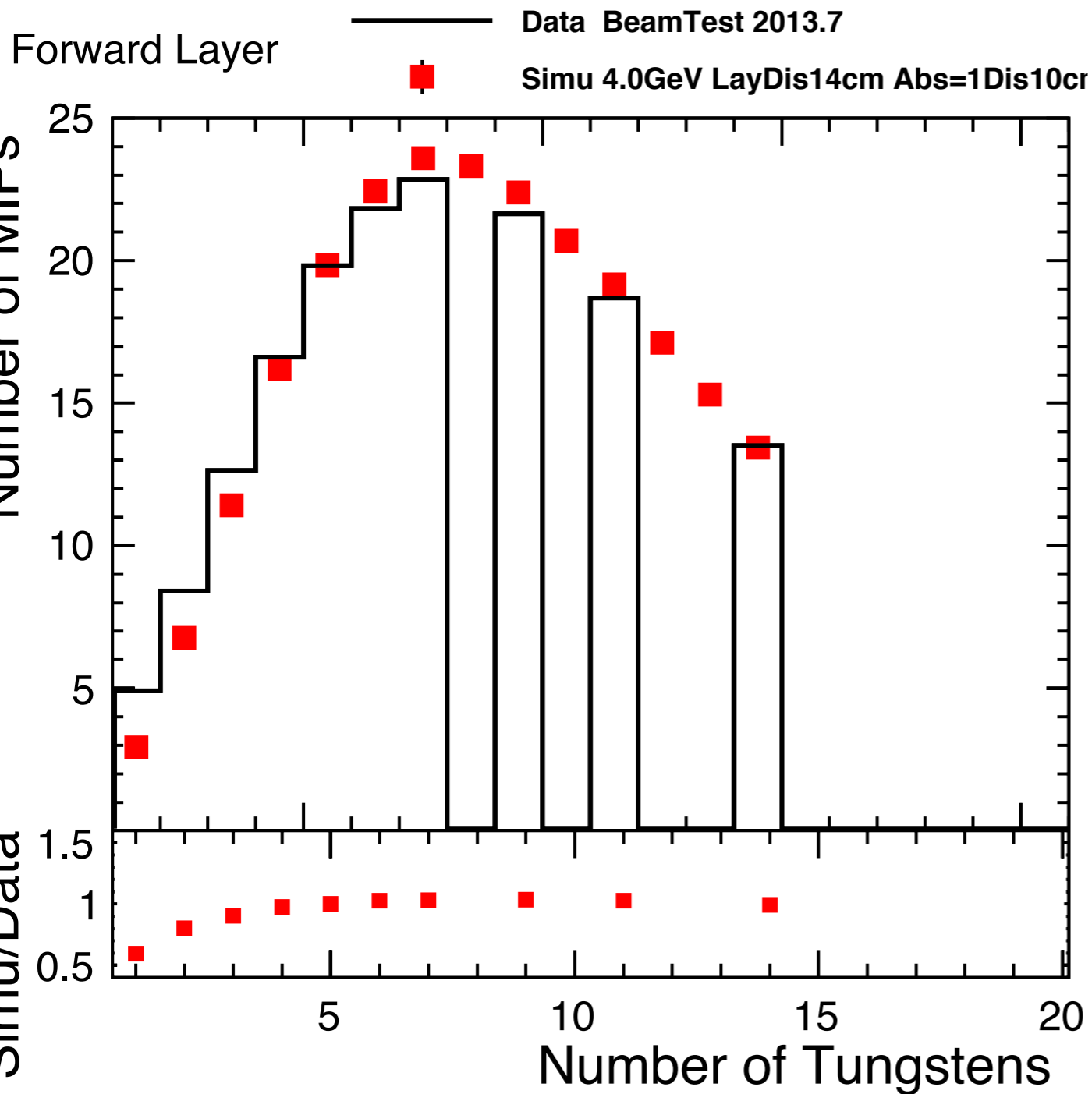
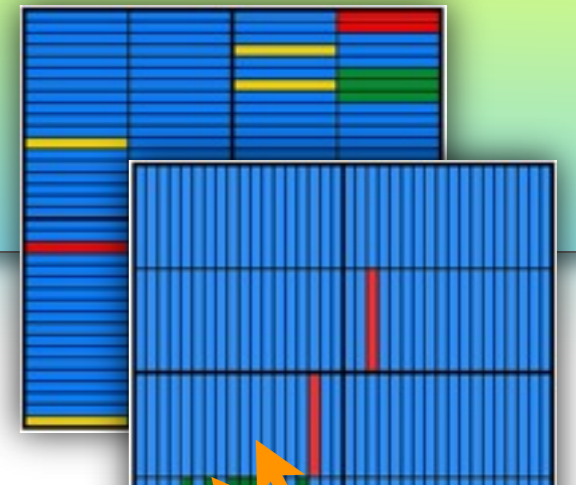


SSA on 2 layers Plot



# shower profile

- using electron beam with tungsten plates



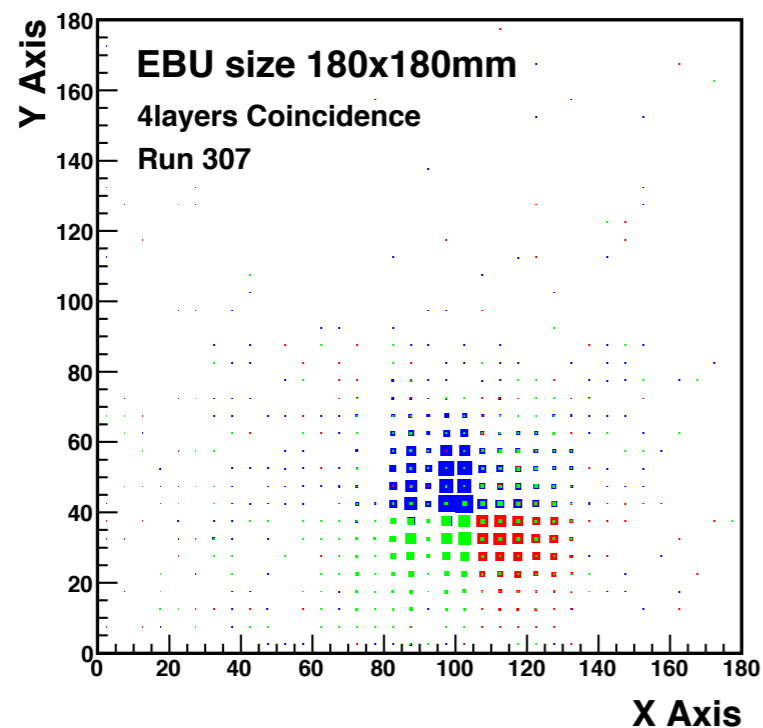


# synchro. with AHCAL

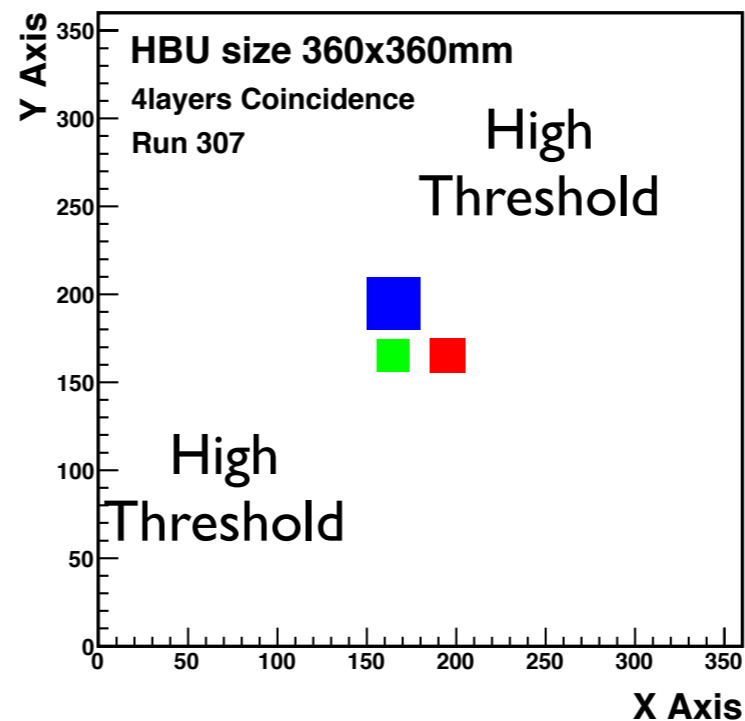
- using electron beam
- HCAL: 30mm x 30mm tile
- ECAL: 5mm x 5mm pseud-cell



ScECAL



AHCAL



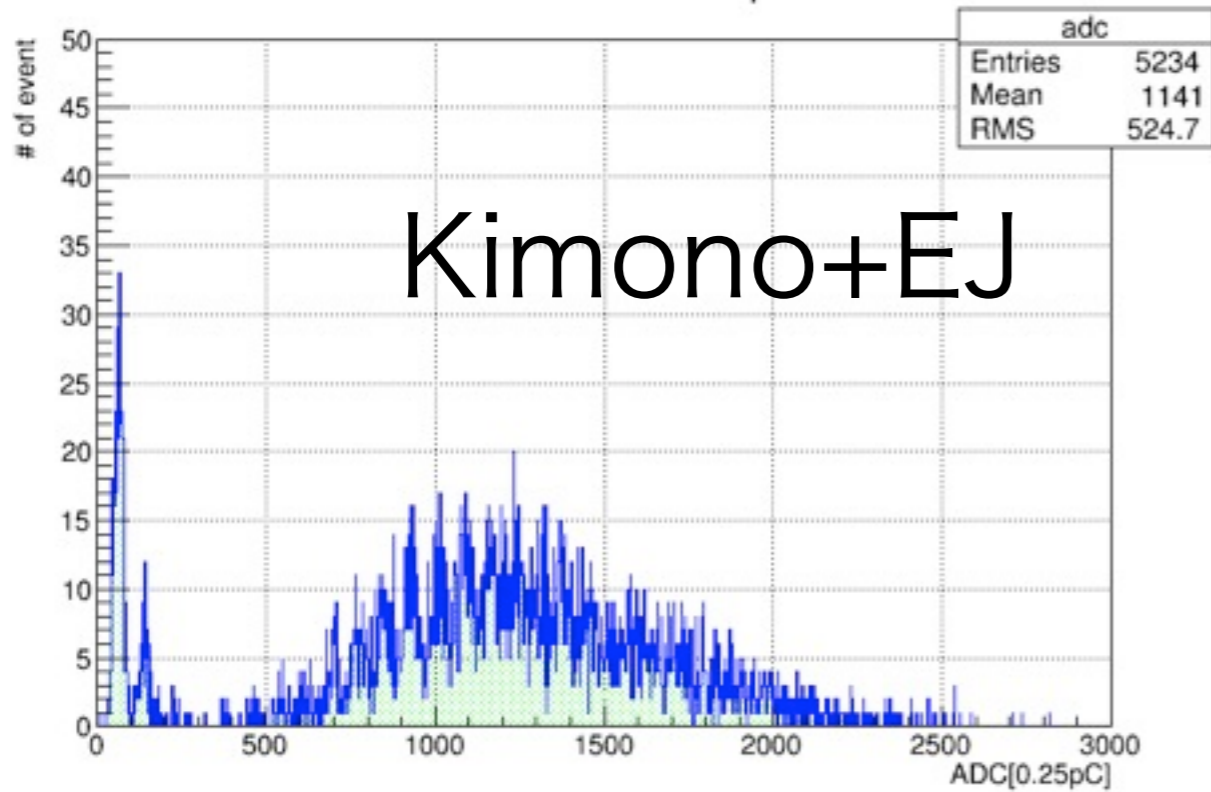
# summary & outlook

- **scintillator ECAL**
- **parts ( scintillator strip shape, material , reflector) are under optimization**
- **integration into a layer with FE ASIC (SPIROC) on going**
- **another beam test in preparation with AHCAL**

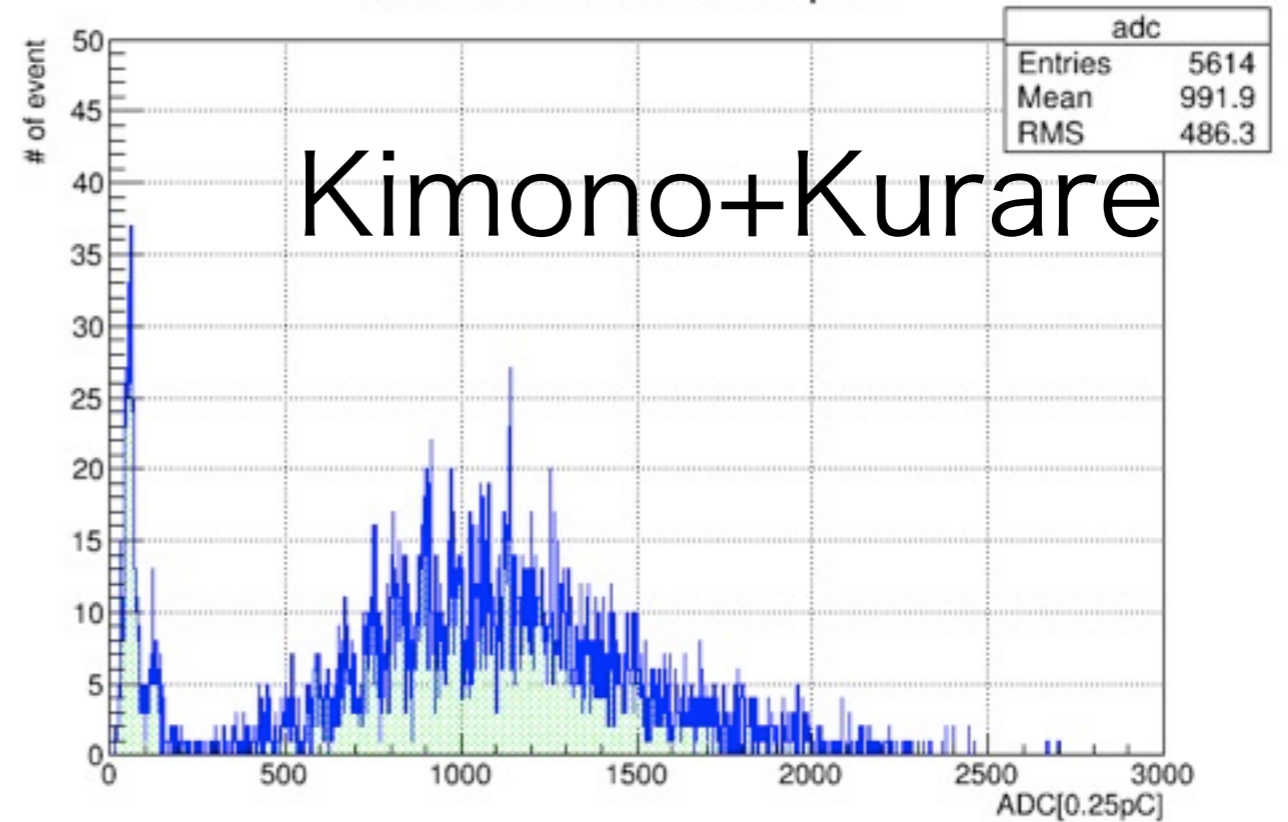


# reflector film

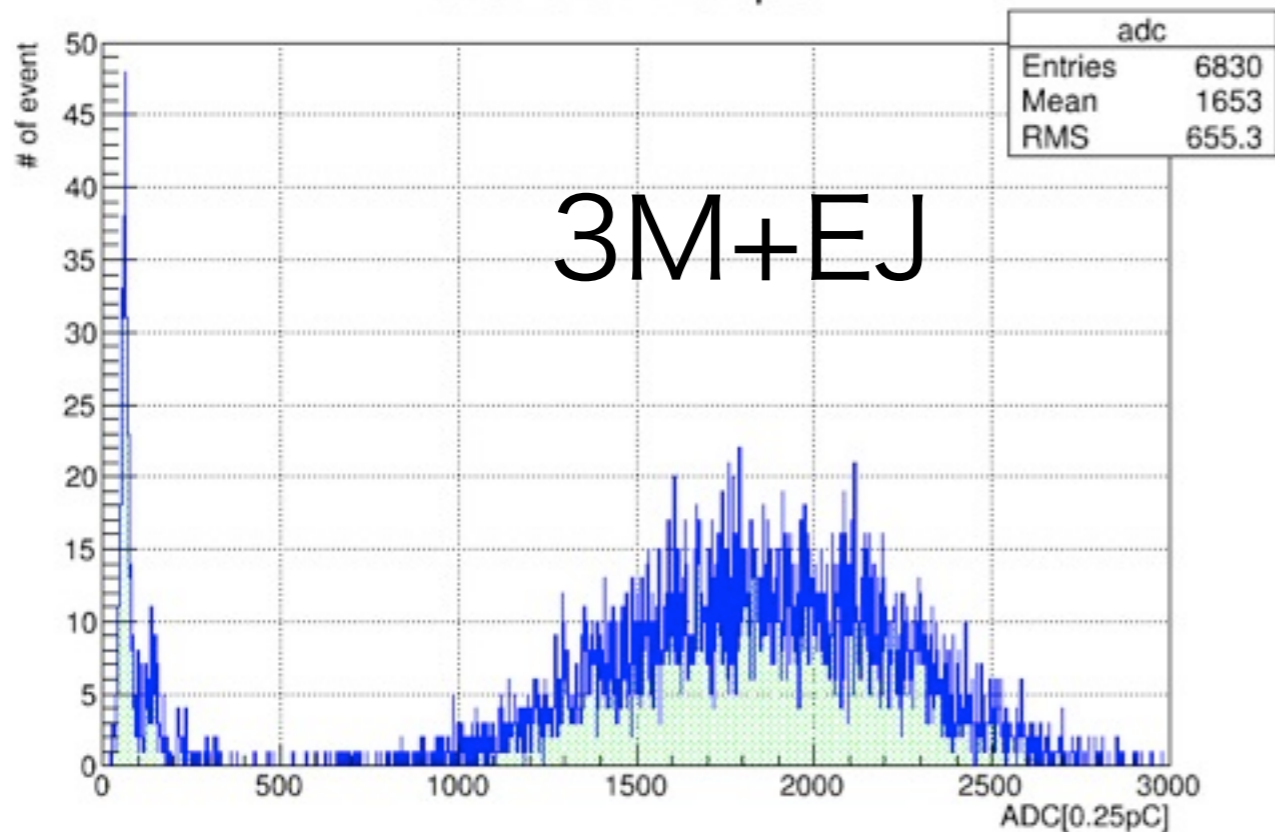
Kimoto&EJ204 : 16.2p.e.



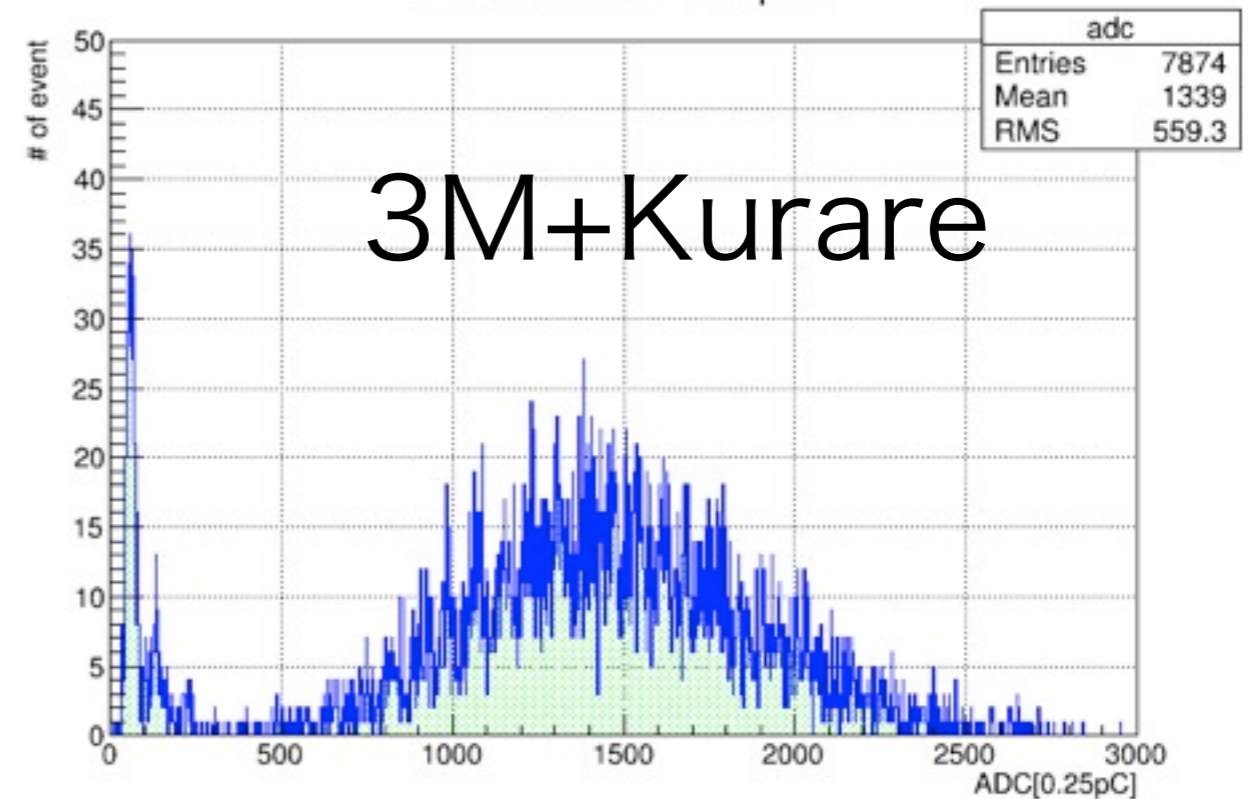
Kimoto&SCSN38 : 14.2p.e.



3M&EJ204 : 23.7p.e.



3M&SCSN38 : 18.8p.e.



# mass-fabrication

ScECAL factory 2013

