CALICE-EBU
ECAL Base Unit

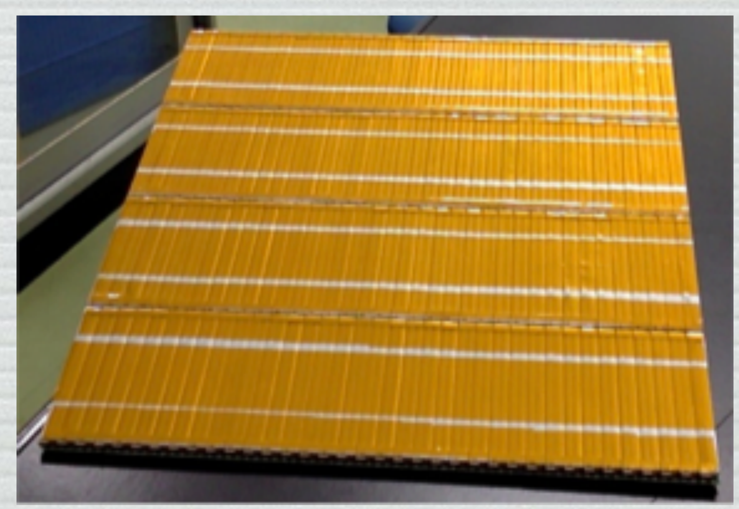
Calorimeter for ILC

Tohru Takeshita (Shinshu University)

Shinshu University

FE electronics for PFA driven scintillator strip EM calorimeter

EBU photo front/back view



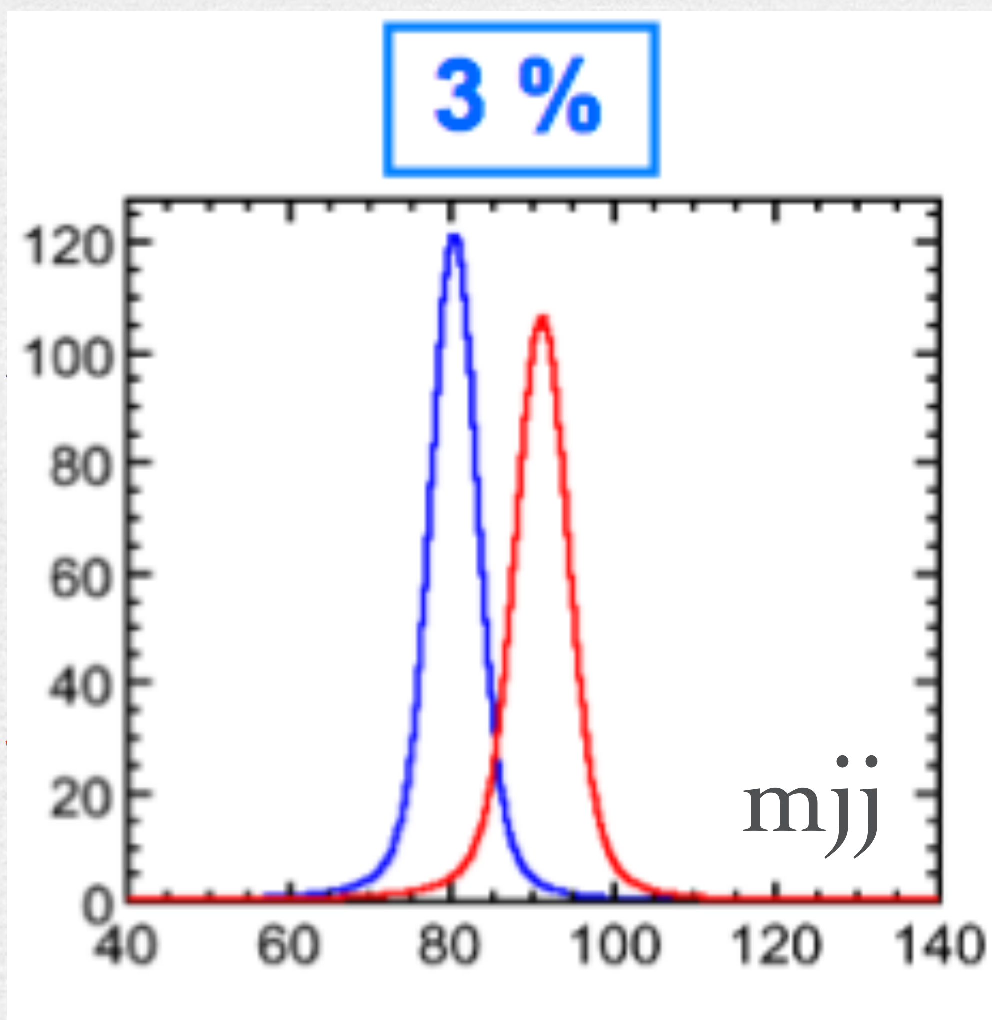
東京大学 THE UNIVERSITY OF TOKYO

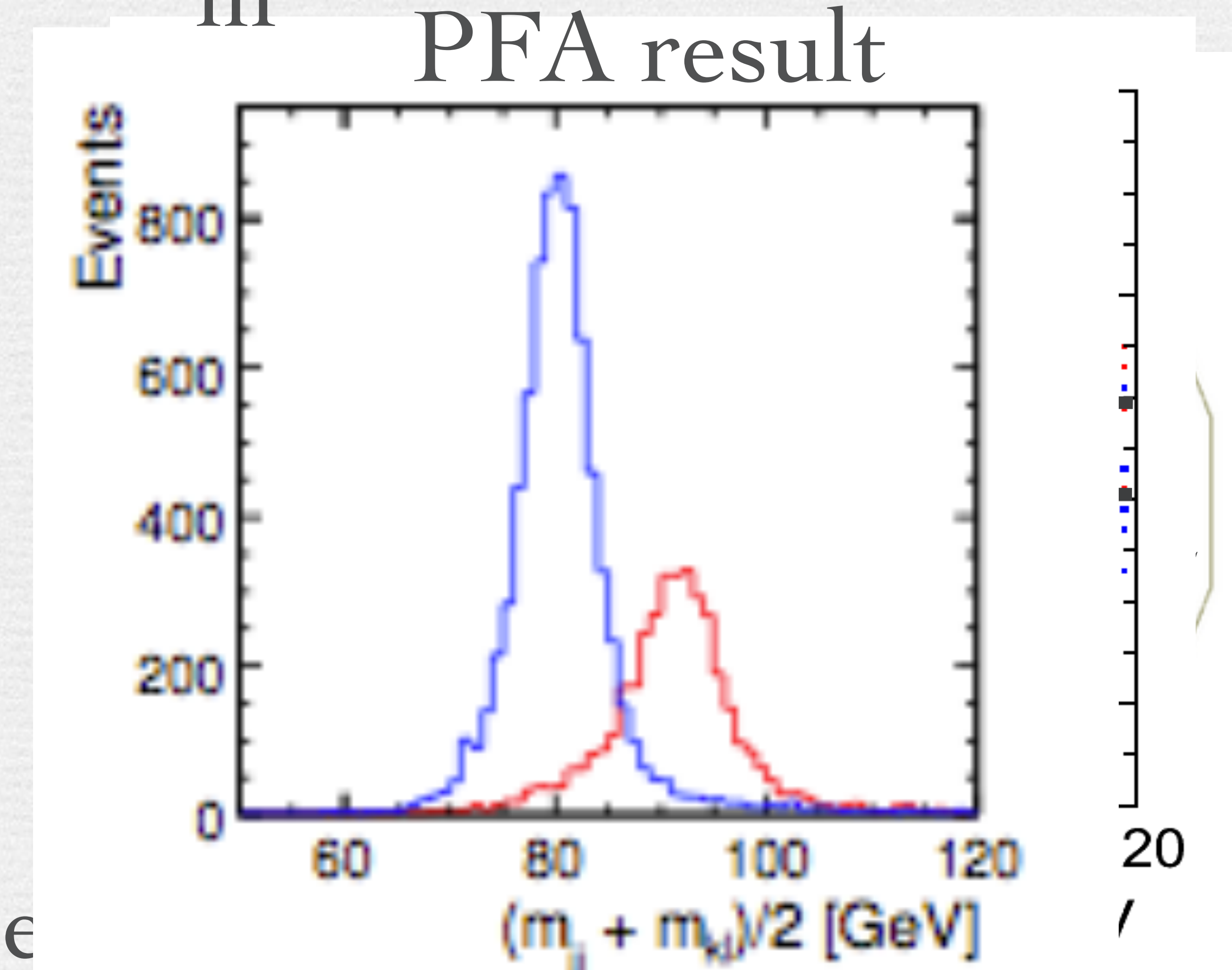
筑波大学 University of Tsukuba

DESY

e+e- collider exp.

- next generation e+e- detector is designed to match Particle Flow Algorithm (PFA)
- PFA will achieve ~3% jet energy reso. so as to separate W from Z e+e->WW/ZZνν event

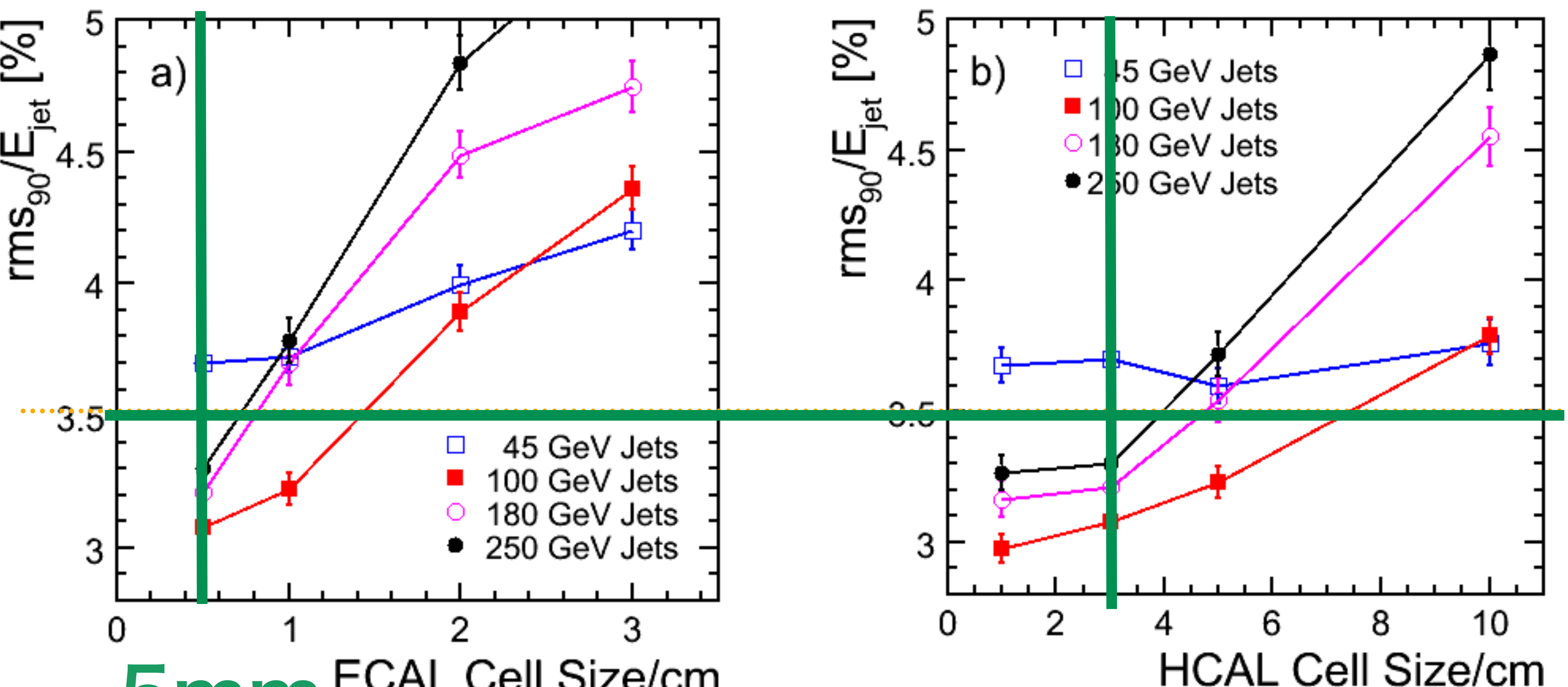




granularity

- Fine segmentation requirements for calorimeter

ECAL HCAL



3.5%

5mm

3cm

Mark Thomson

PFA-ECAL

- requirements to incorporate PFA
- fine granularity ~ 5mmx5mm (2D)
- as well as longitudinal segmentation +1D=3D)

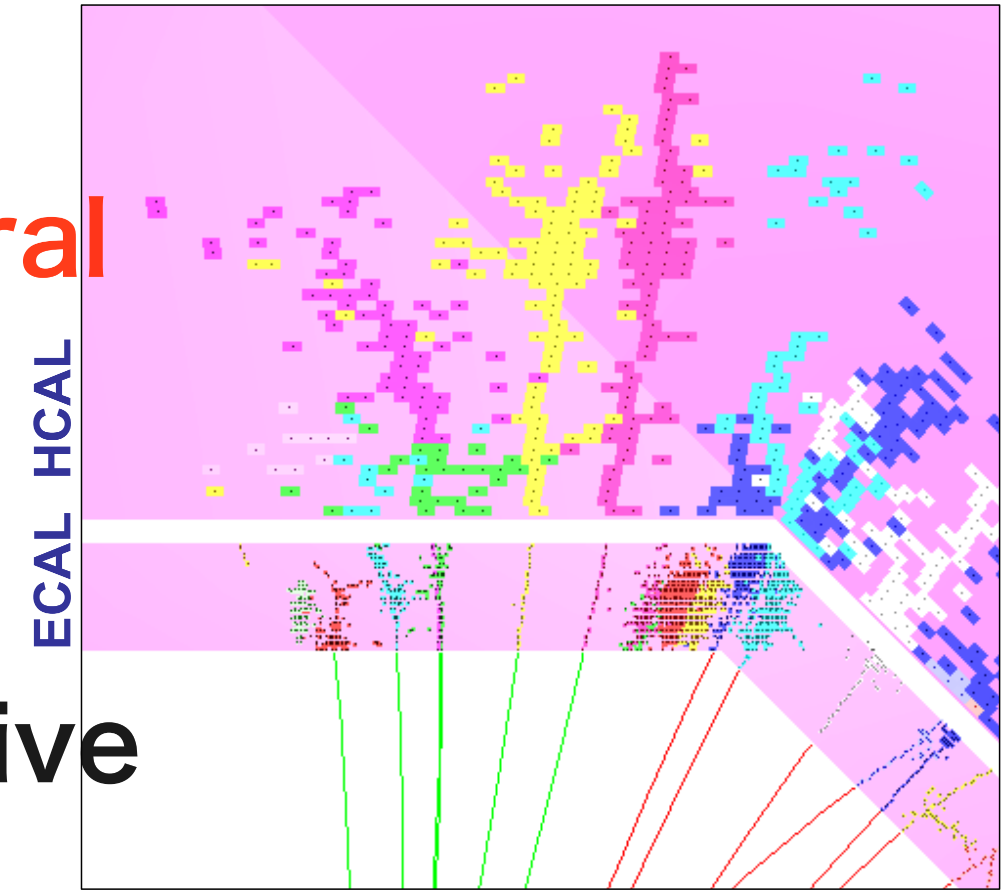
segmentaion	ECAL	HCAL	EJet resolution
LHC	5cm 10^5 ch.	20cm 10^5 ch.	60% $/\sqrt{E}$ 6% @100GeV
ILC	0.5cm 10^8 ch.	3cm 10^7 ch.	30% $/\sqrt{E}$ 3 % @100GeV

calorimeter design

- ECAL for photon separation
- smaller Moliere radius : lateral

tungsten

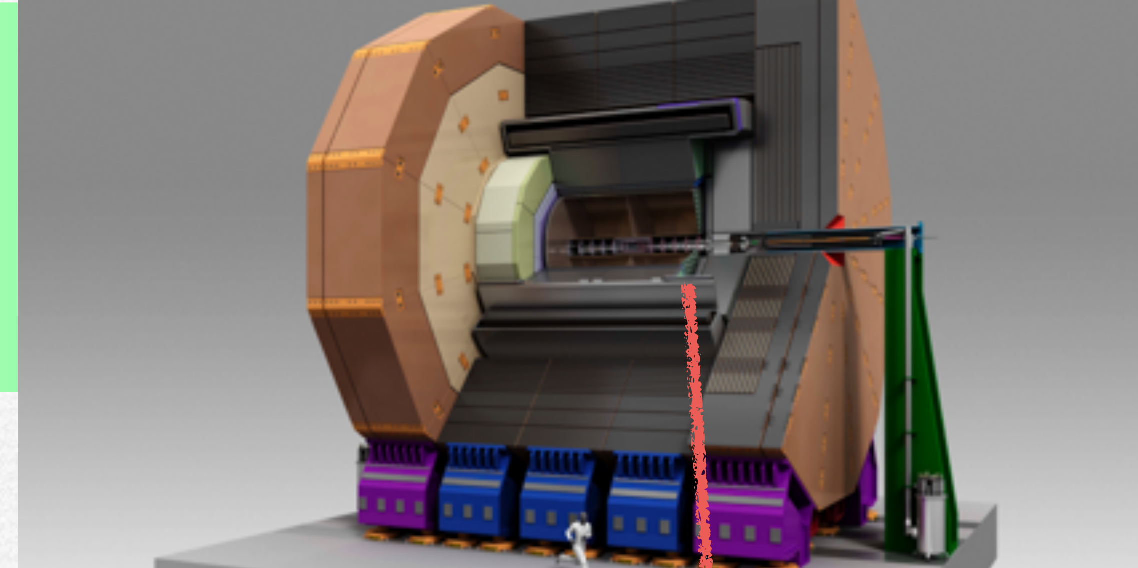
- shower containment : X0
- ECAL consists of tungsten absorber and thinner sensitive material (silicon/scintillator)

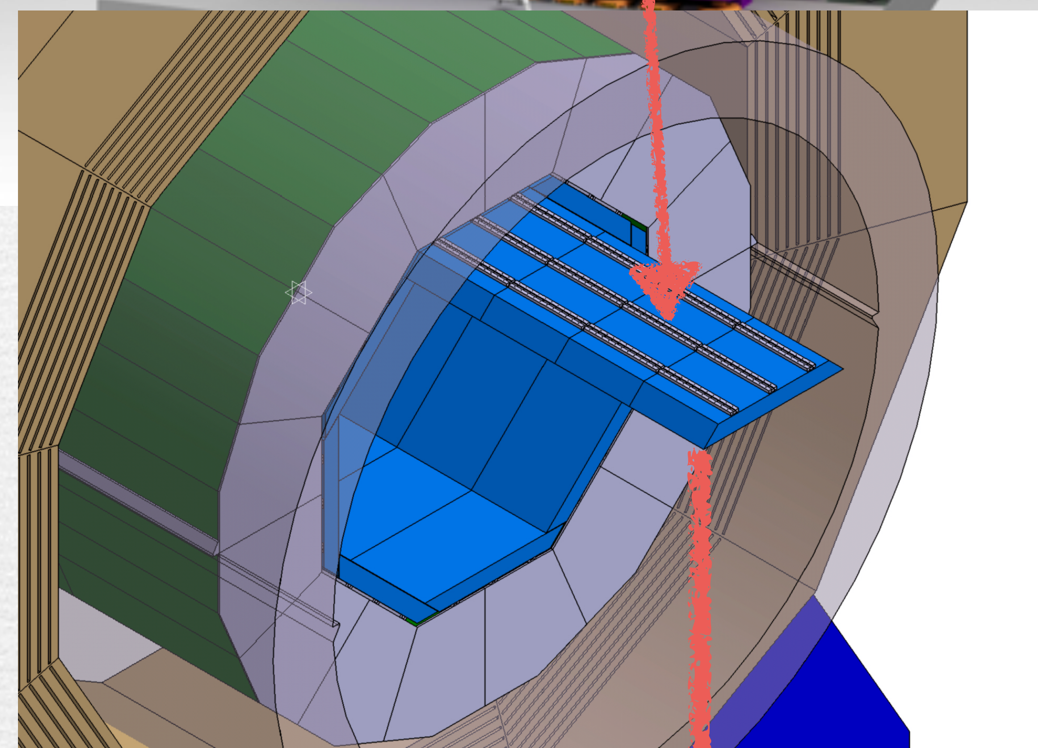


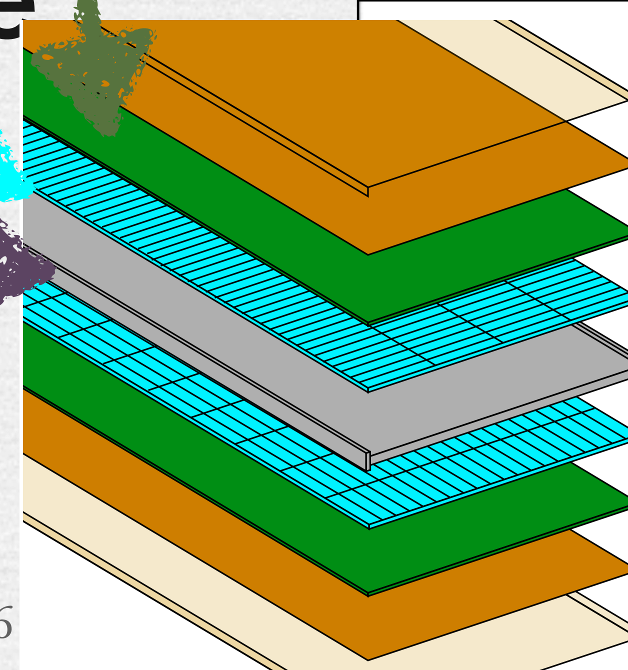
absorber	X0 (cm)	ρ (g/cm^3)	R_M (cm)	total X0=25X0 (cm)	λ_I (cm)
tungsten	0.35	19.9	~1	9	9.94

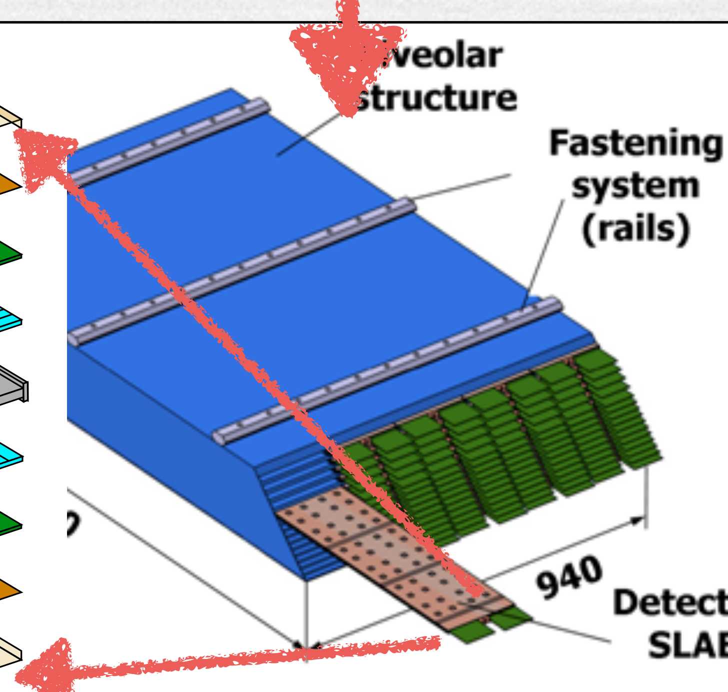
ILD ECAL

- Large Detector for PFA
- R_{ECAL} ~1.8m =R tracker
- ECAL~5x5mm^2~ 10^8ch.
- Front End read out Electronics in each layers
- together with sensitive layer in between absorber(2mm)
- 30 layers in 20cm including FE elex.



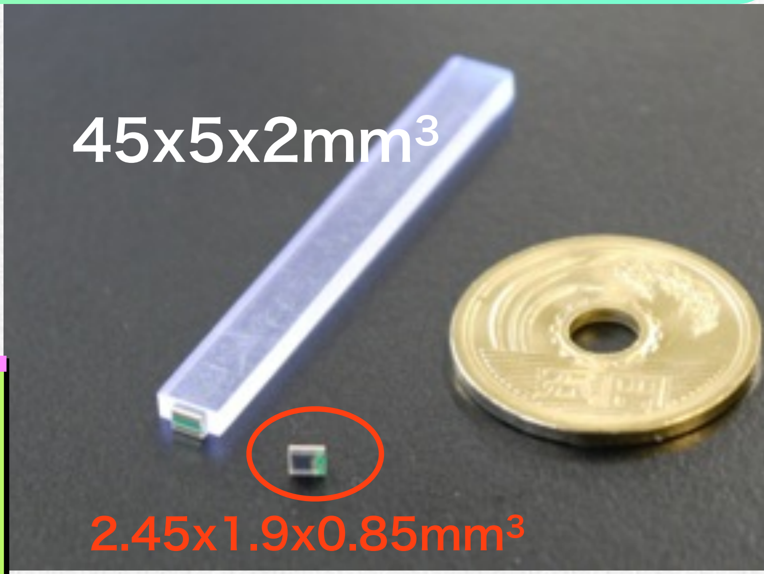


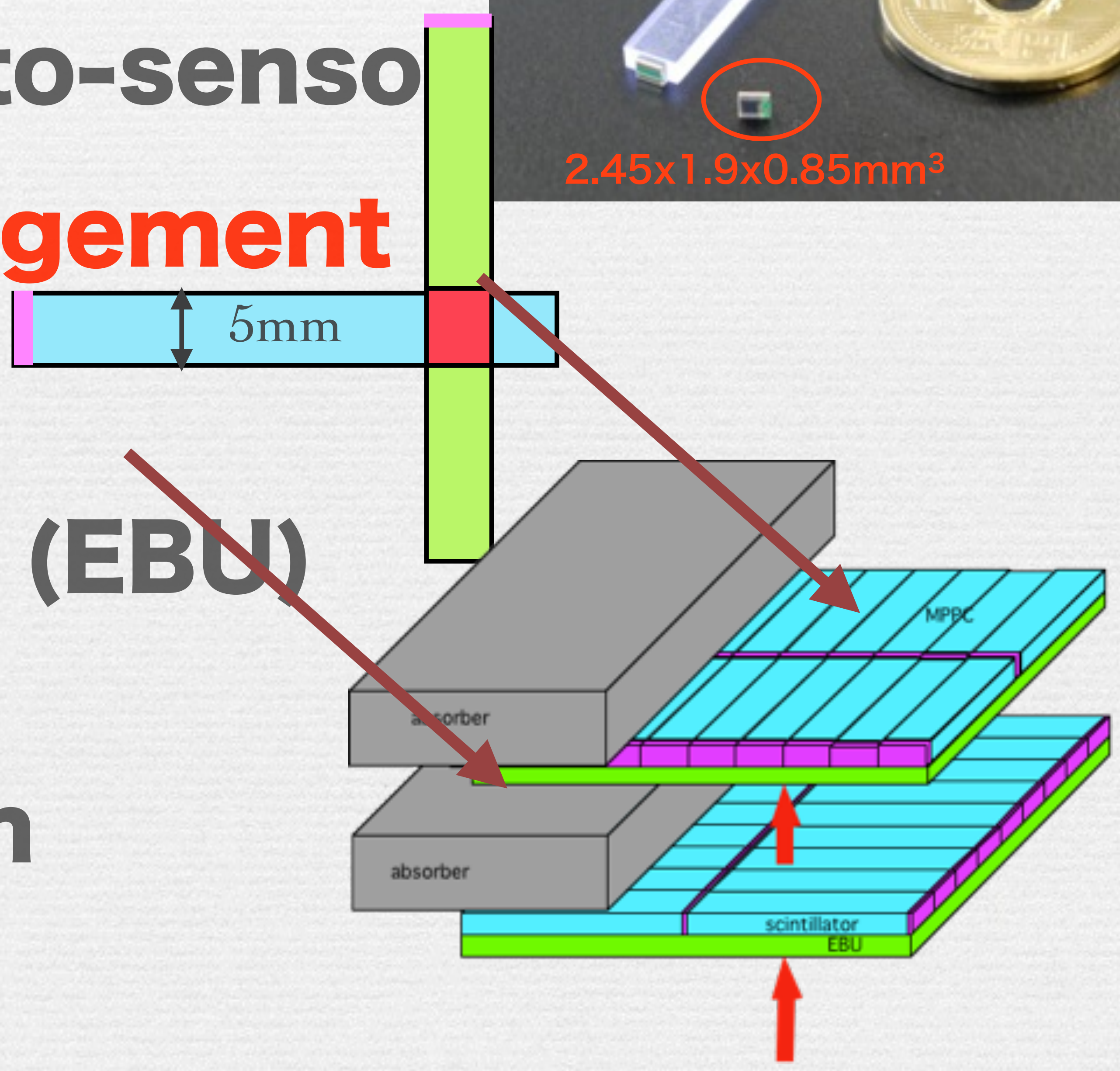




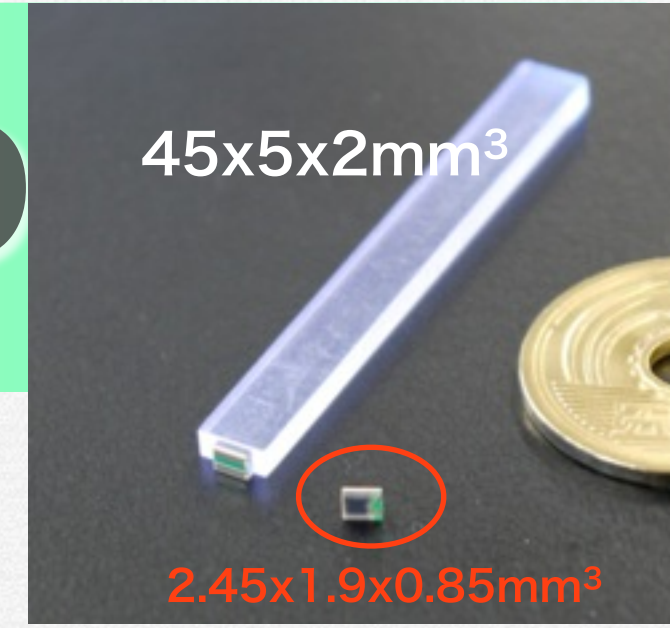
scintillator strip ECAL

- scintillator strip 5x45x2^{t}mm^{3}
  reduce number of R/O ch.
- with a very small photo-senso
- **with orthogonal arrangement**
- **to achieve 5x5mm^{2}**
- front end electronics (EBU) embedded
- good timing resolution
  <1ns.
- robust and low cost



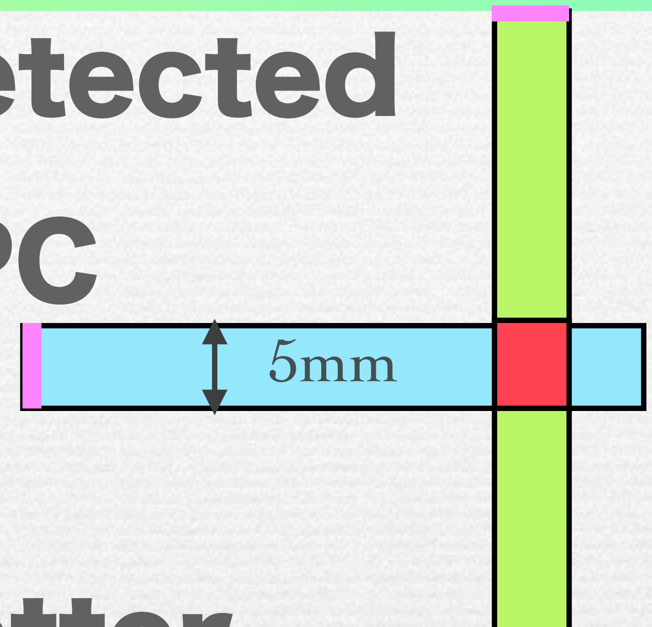


scintillator strip



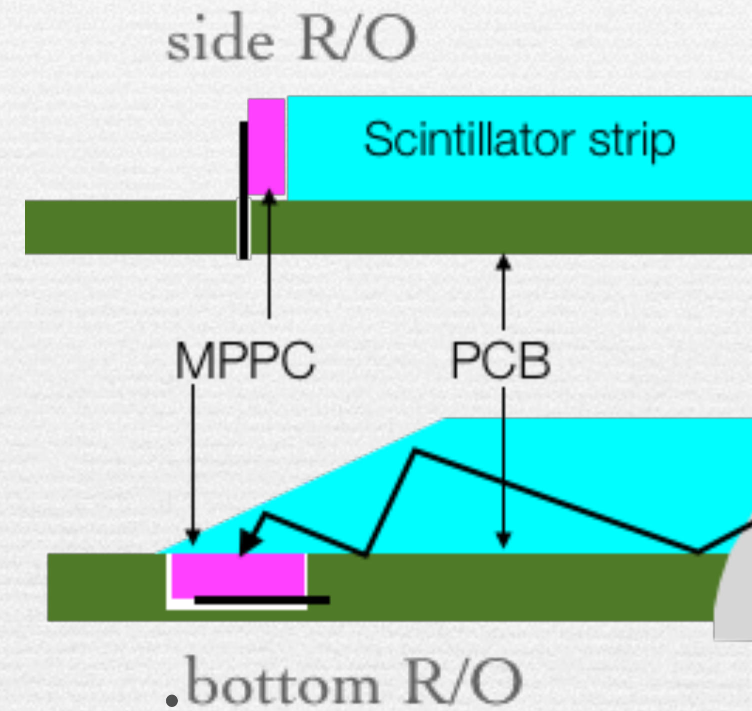
>scintillation light detected

>photo-sensor : MPPC

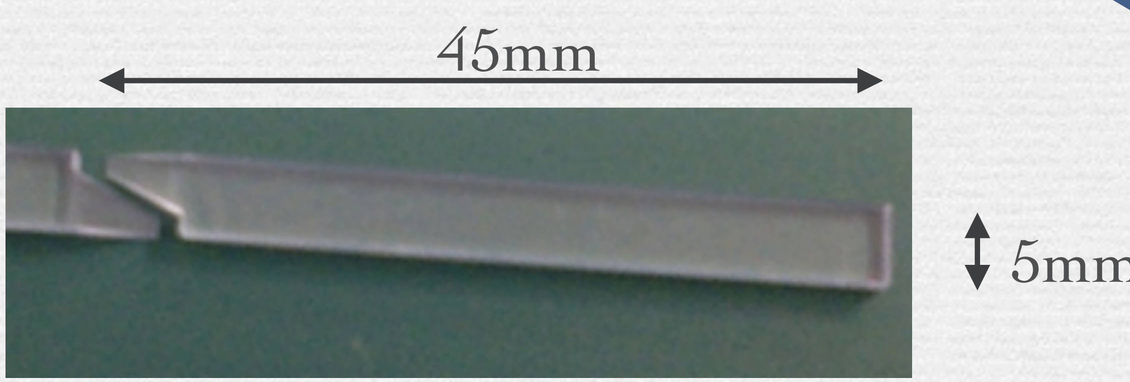


>how to read out

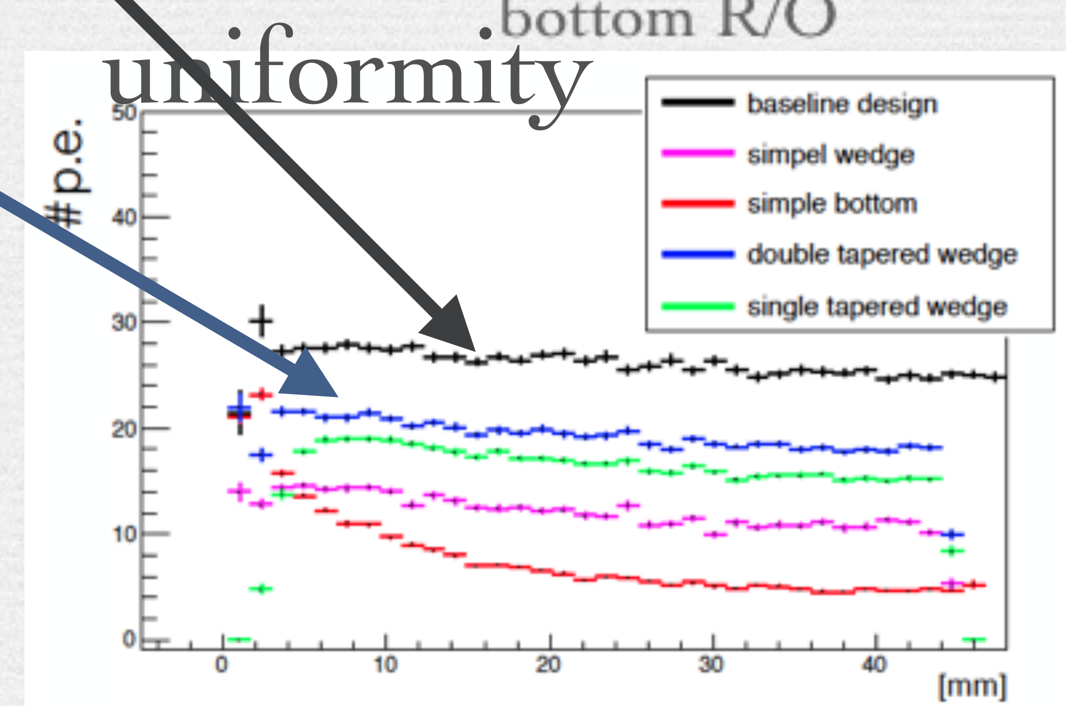
>side read out : better uniformity & Light Yield

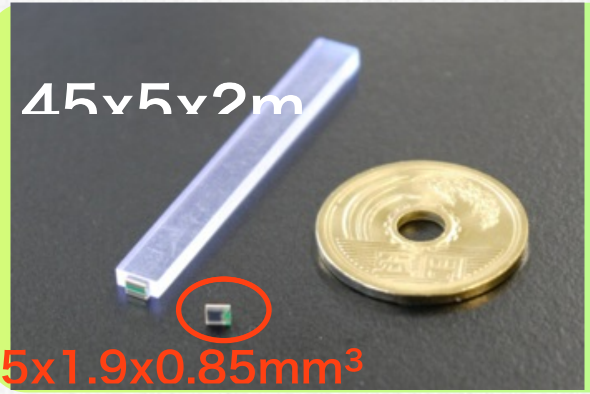


>bottom read out : easy implementation on EBU

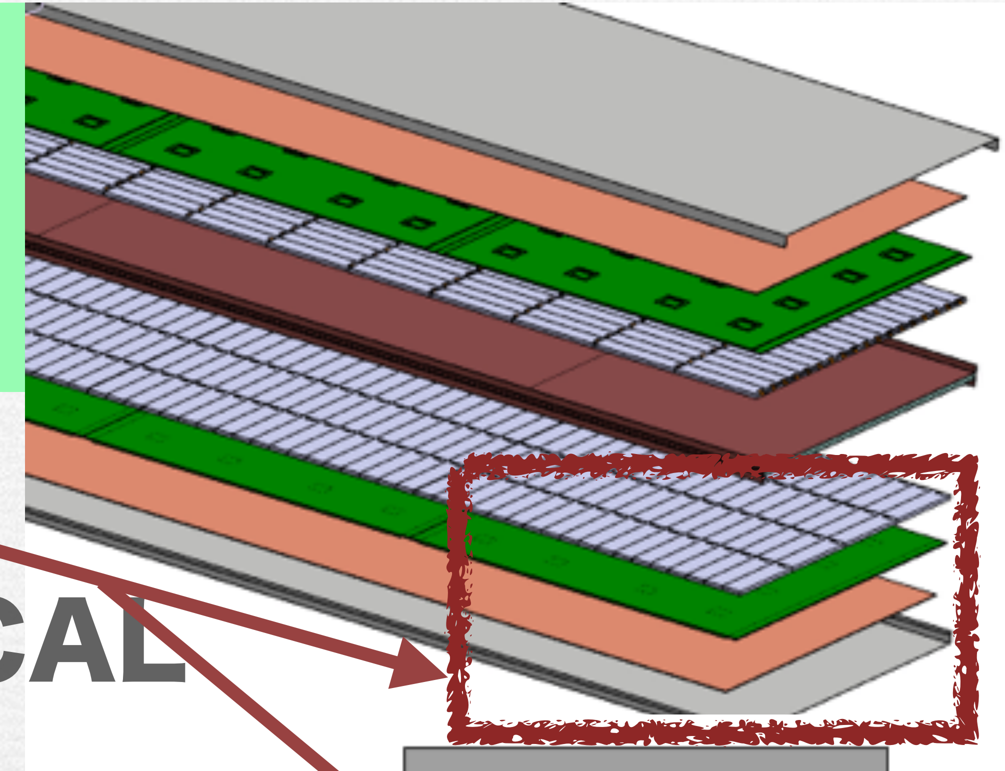


scintillator strip for bottom read out



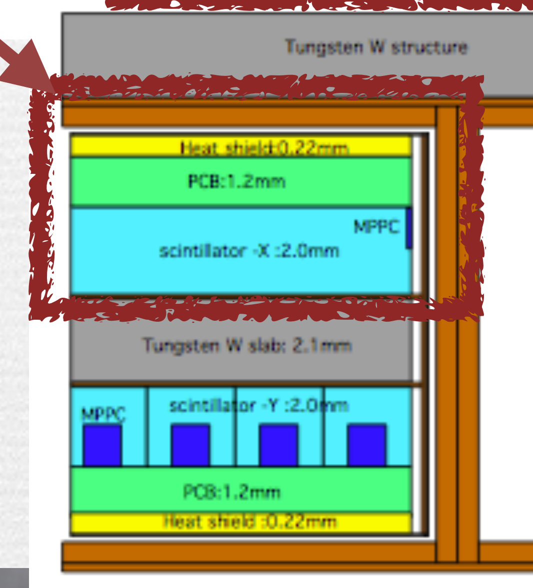


EBU

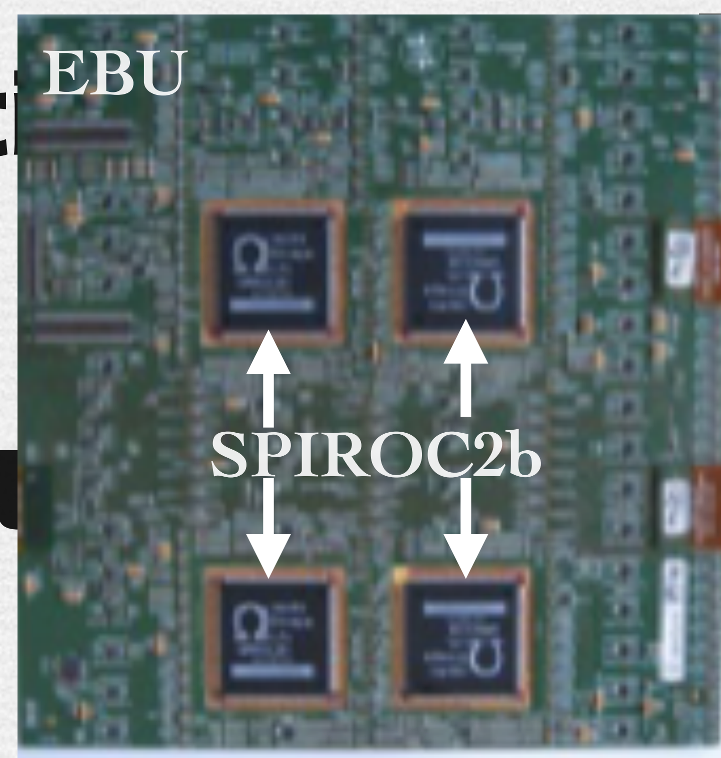


Ecal Base Unit =EBU

- minimum R/O unit of sc-ECAL
- 18cmx18cm with 144 sc-strips
- **FE electronics : 4SPIROCs ASIC + IF**
- amp,shaper,digiti
- self-trigger
- bias voltage cont



Ω



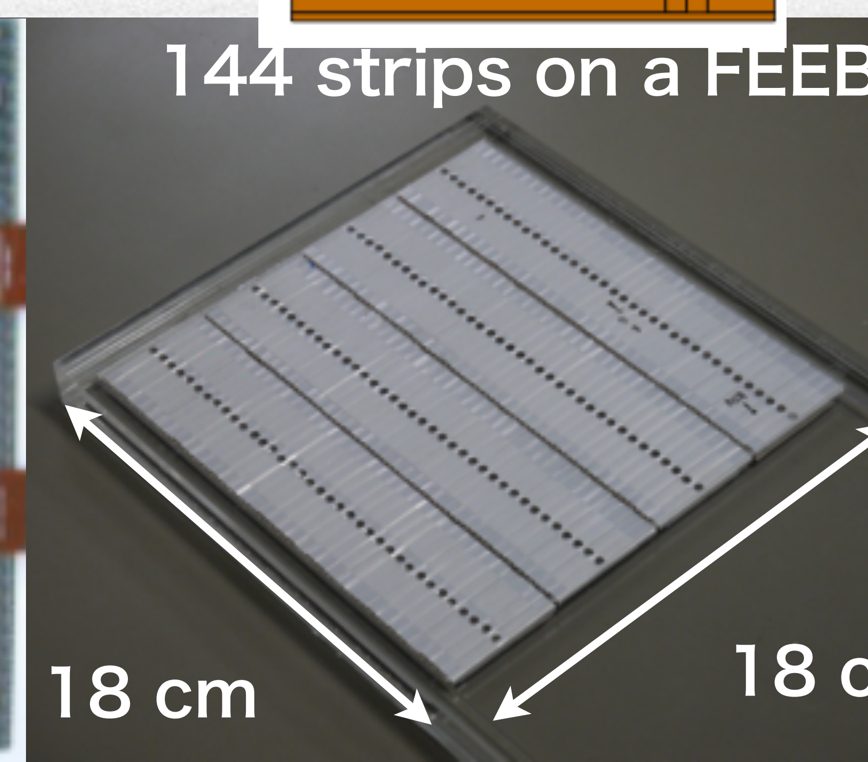
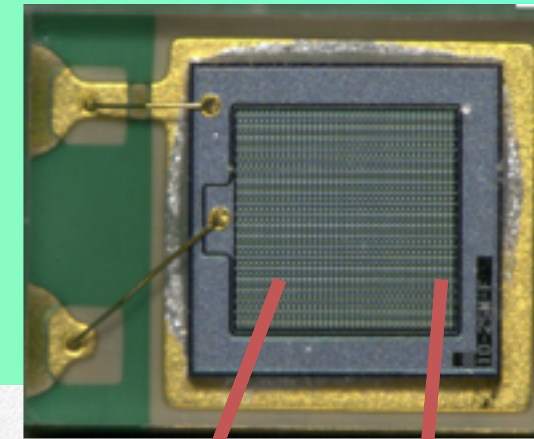


photo-sensor mppc

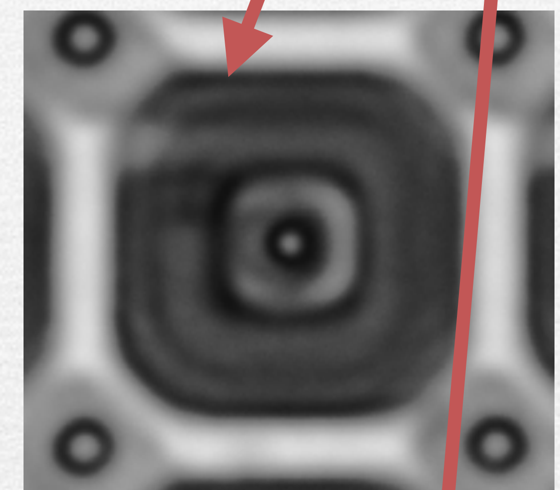
1mmx1mm



>small & low power consumption sensor : MPPC

Hamamatsu

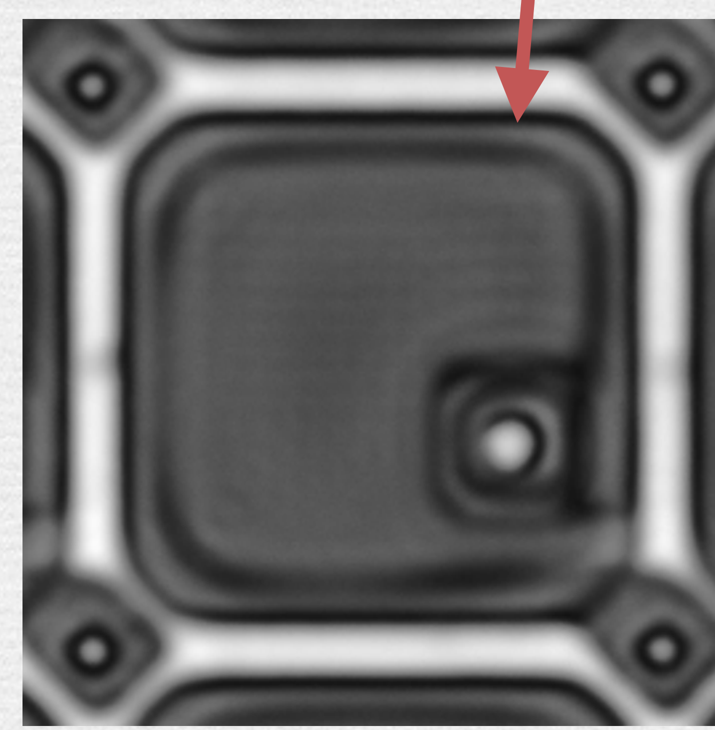
>Geiger mode device



>counts number of pixels as output

photo 10um 15um

>dynamic range must be large for EM shower



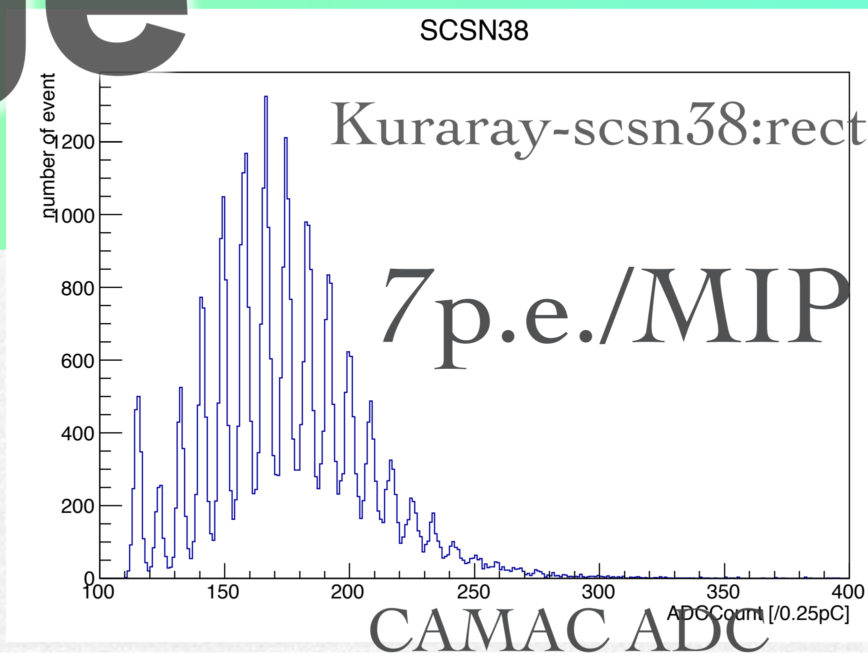
>increase # of pixel

keeping the size, smaller pixel

>10/15um pitch are available

dynamic range

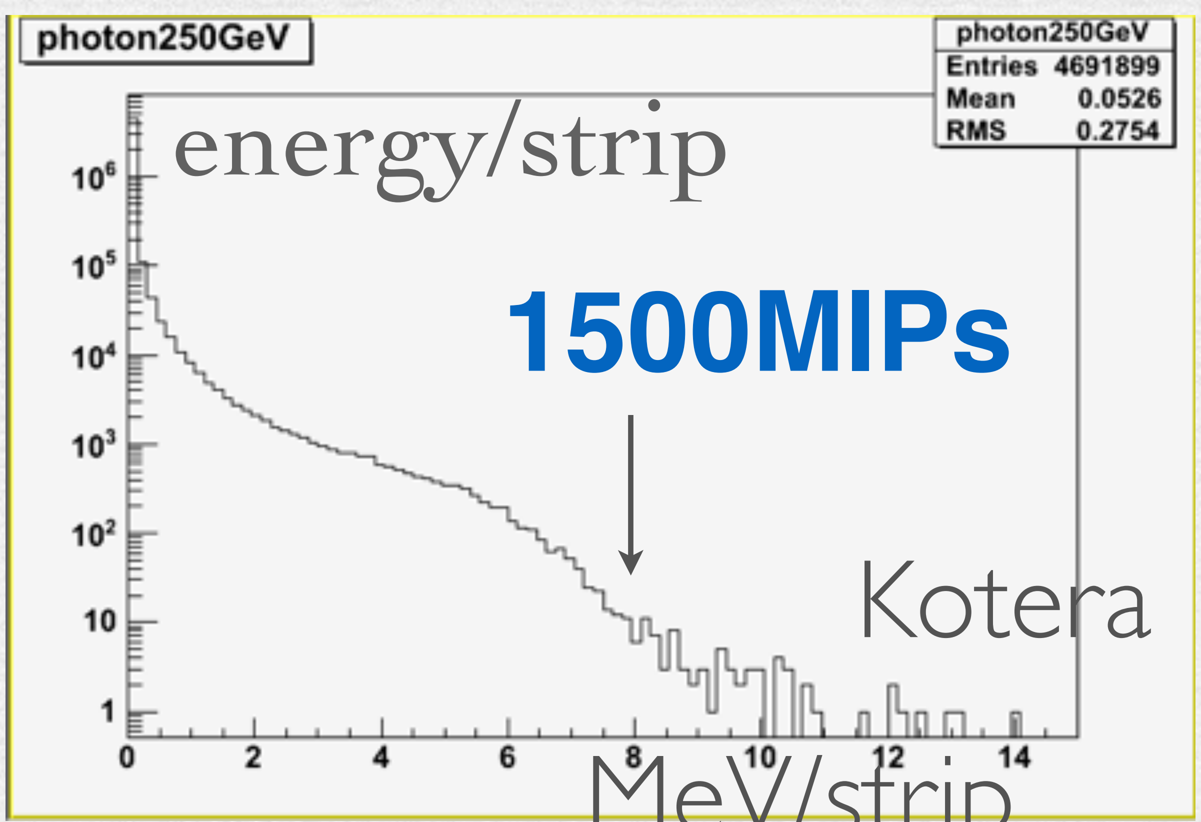
Maximum energy :Bhabha

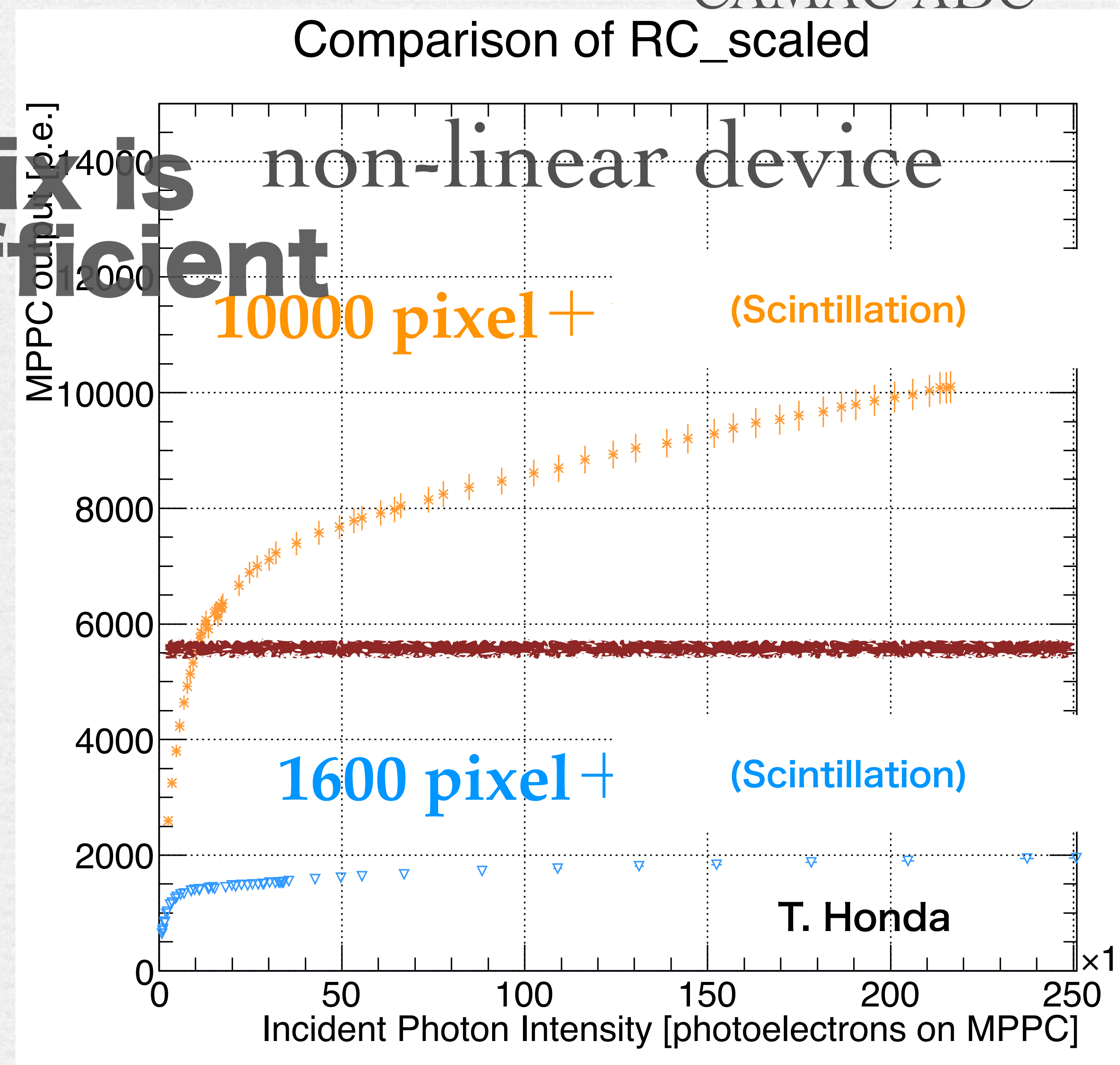


max energy/strip ~<800 MIPs

MPPC-output is limited with # of pixels

800x7=5600 pix : 10kpix is good enough, 15um sufficient





scintillator material

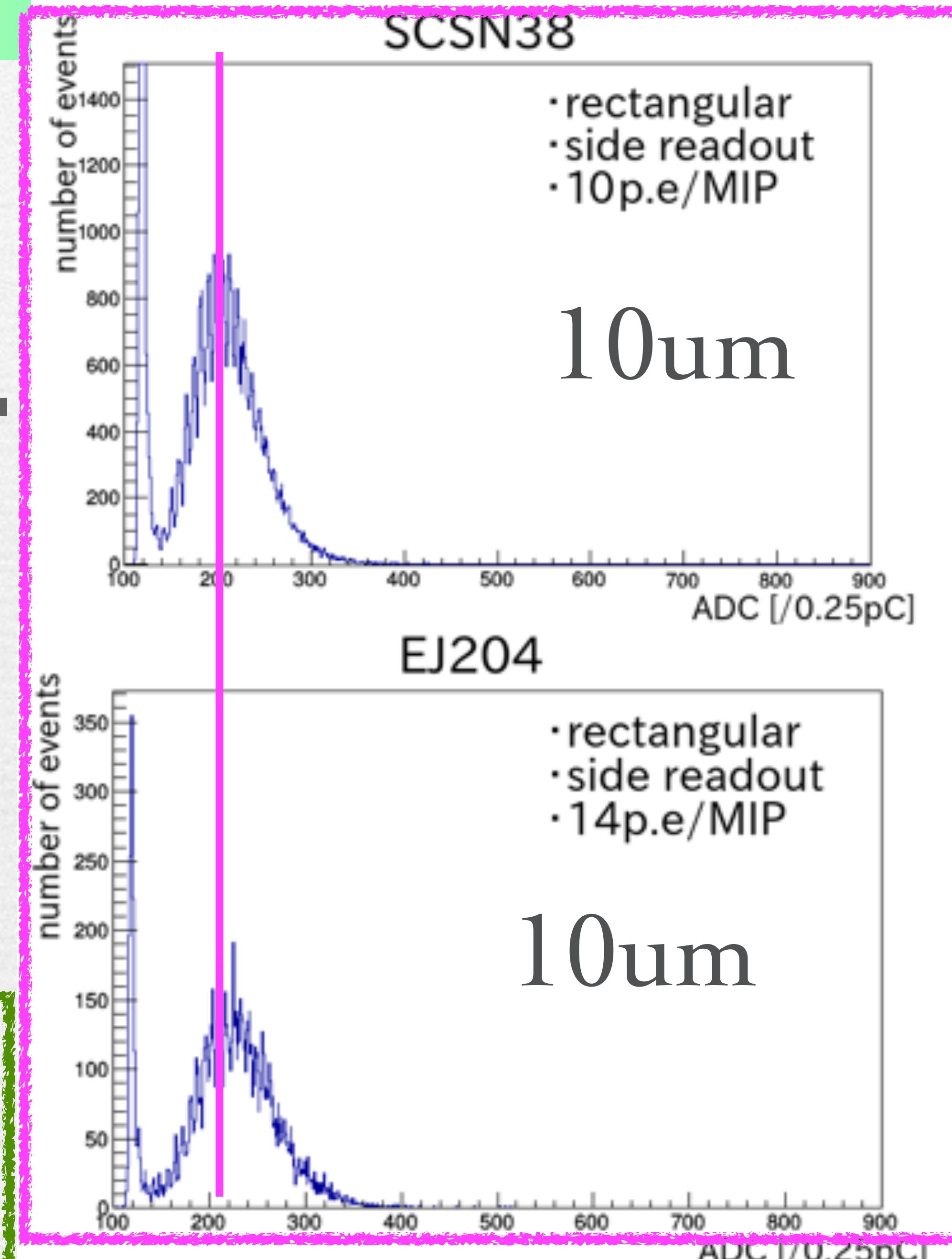
>Light yield of different producers are examined

to optimize to sc-strip ECAL

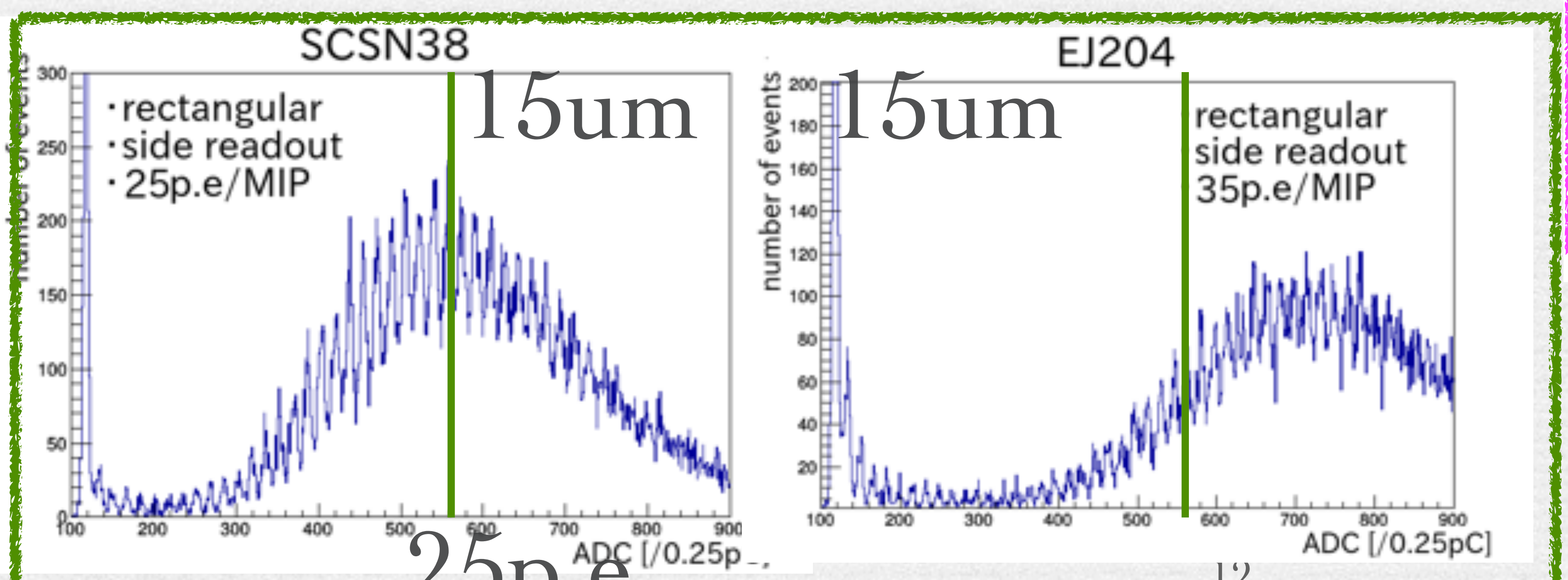
SCSN38 : Kuraray

EJ204 : ELJEN

LY (EJ) ~ LY(SCSN) * **1.4**



10p.e.



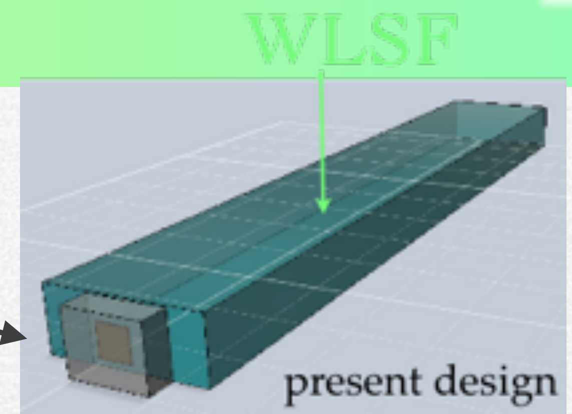
sensor coupling

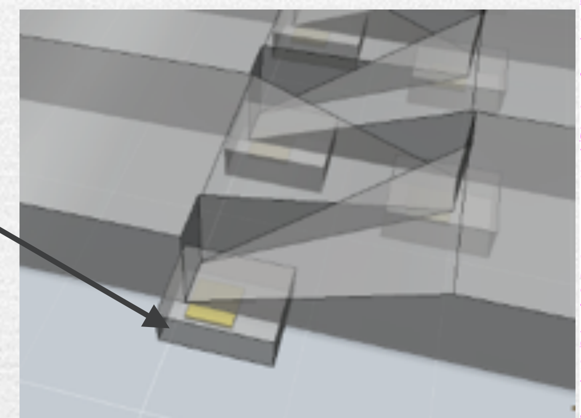
>side read out

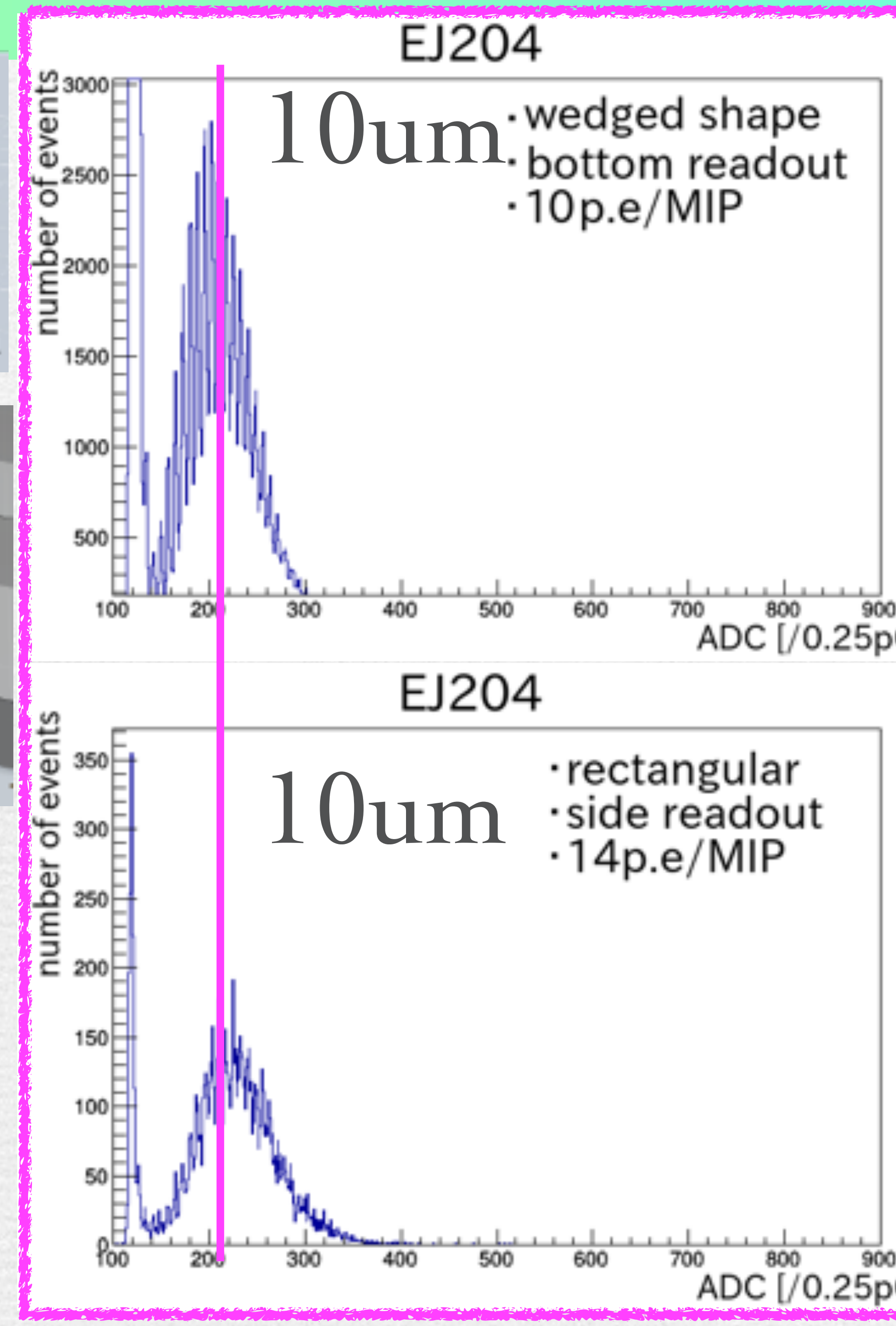
>bottom read out

LY (Side) ~

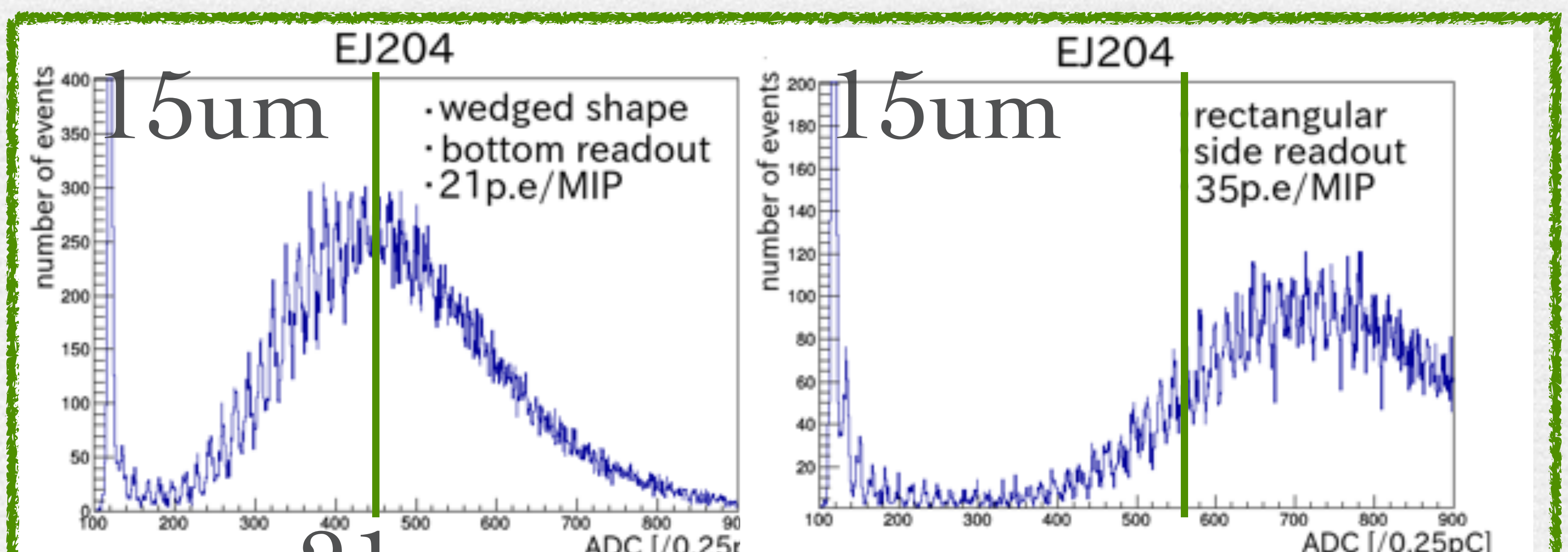
LY(Bottom) * **1.4**







10p.e.



21p.e.

another light readout

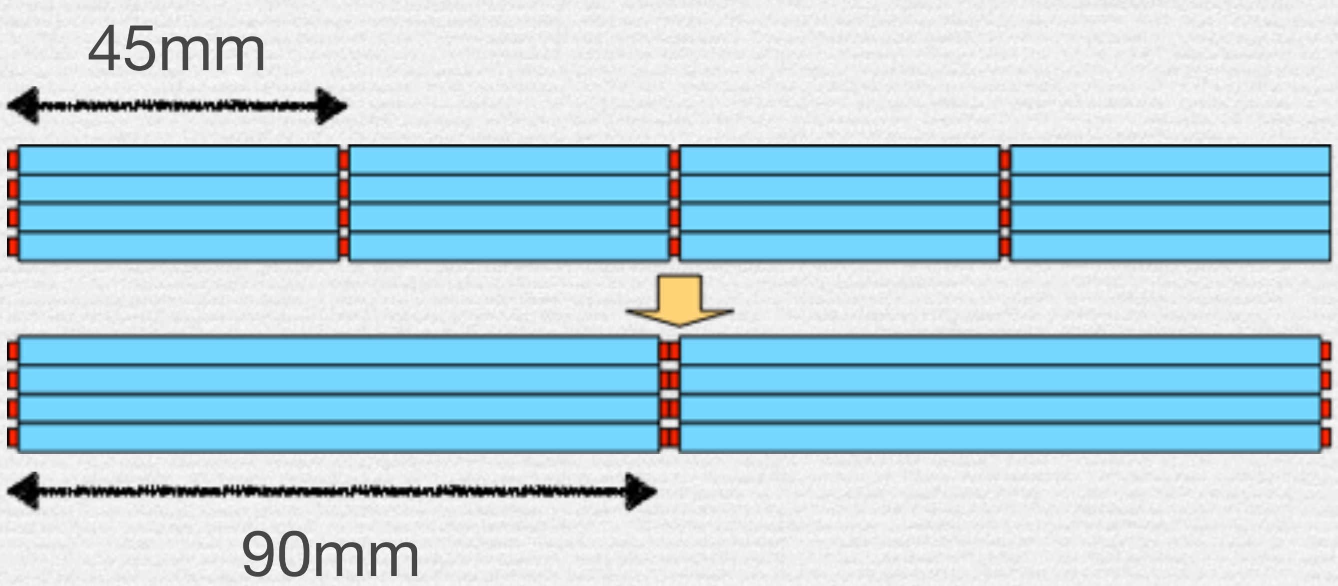
>double sided read out

>reduce noise of MPPCs

>by taking coincidence

>with position resolution

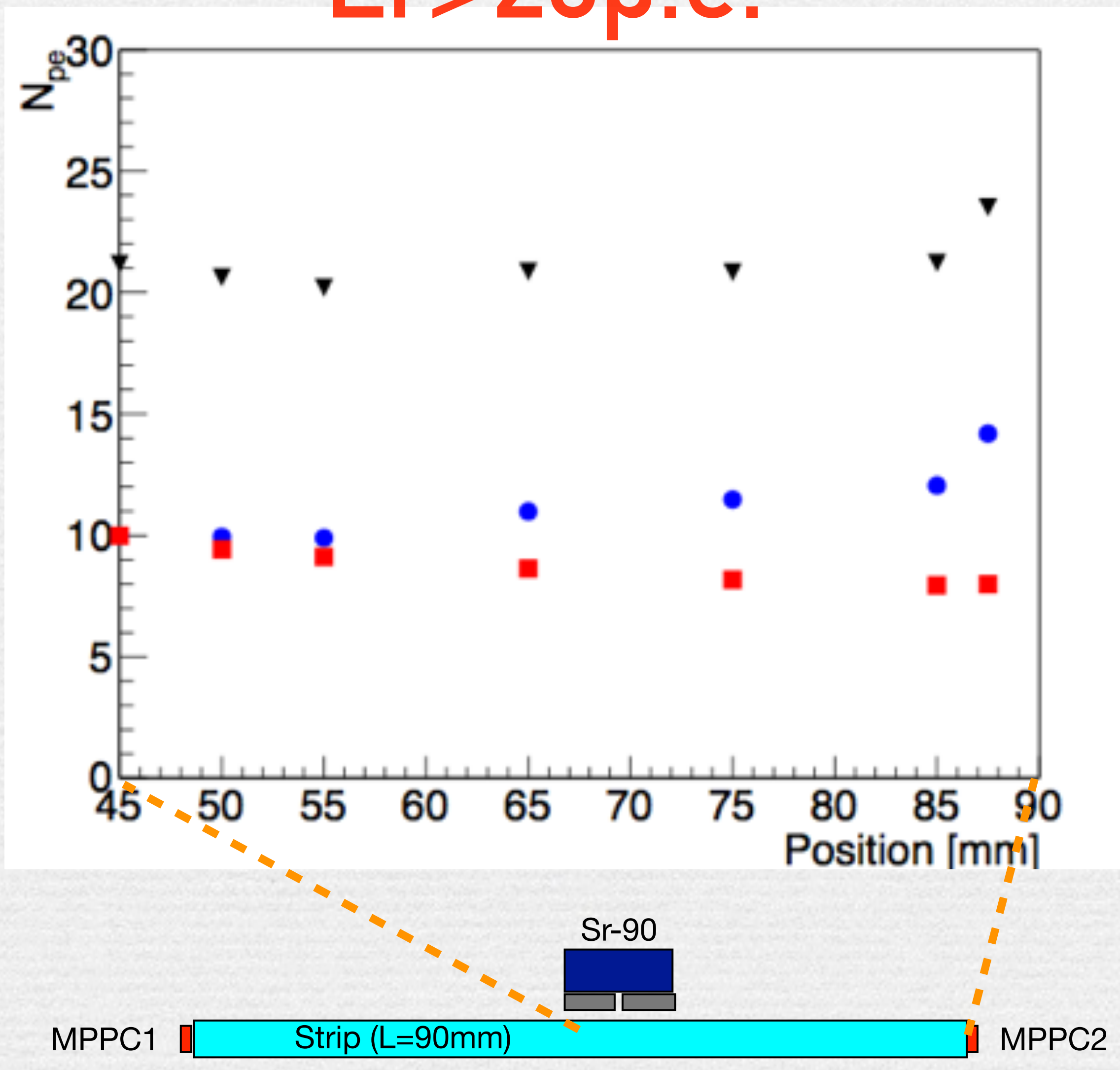
>LY sum is twice



EJ212~BC400

LY>20p.e.

dV+5.5V



EBU with 25um

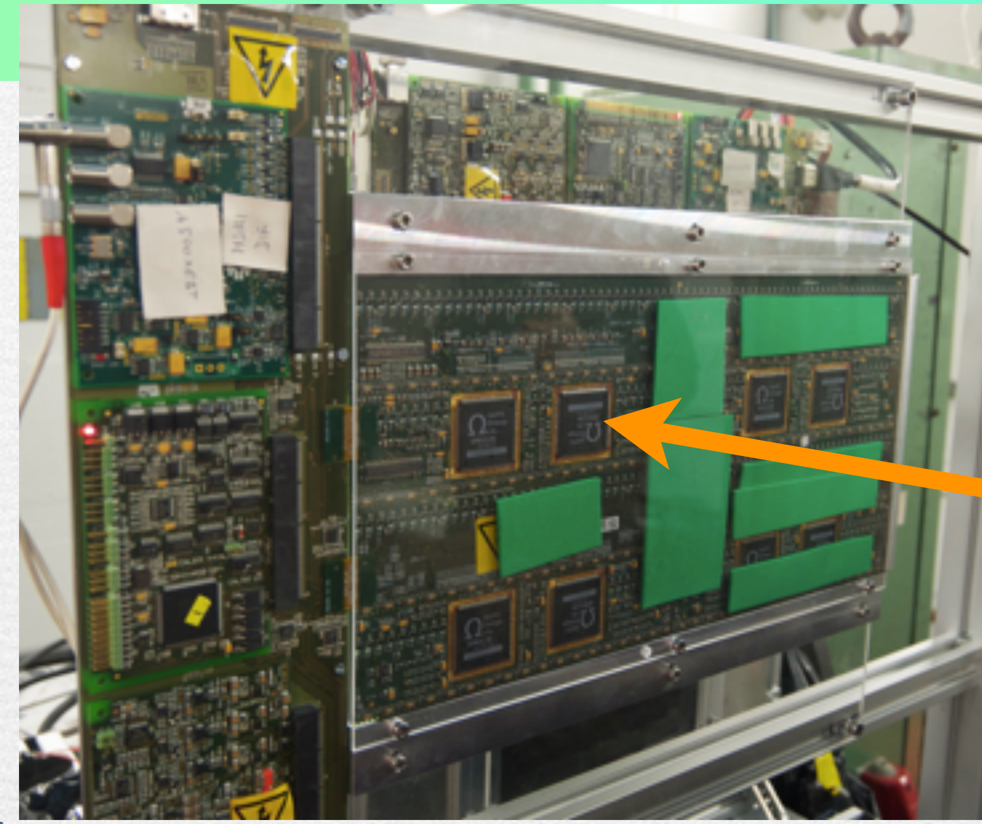
>tested at DEDY electrons

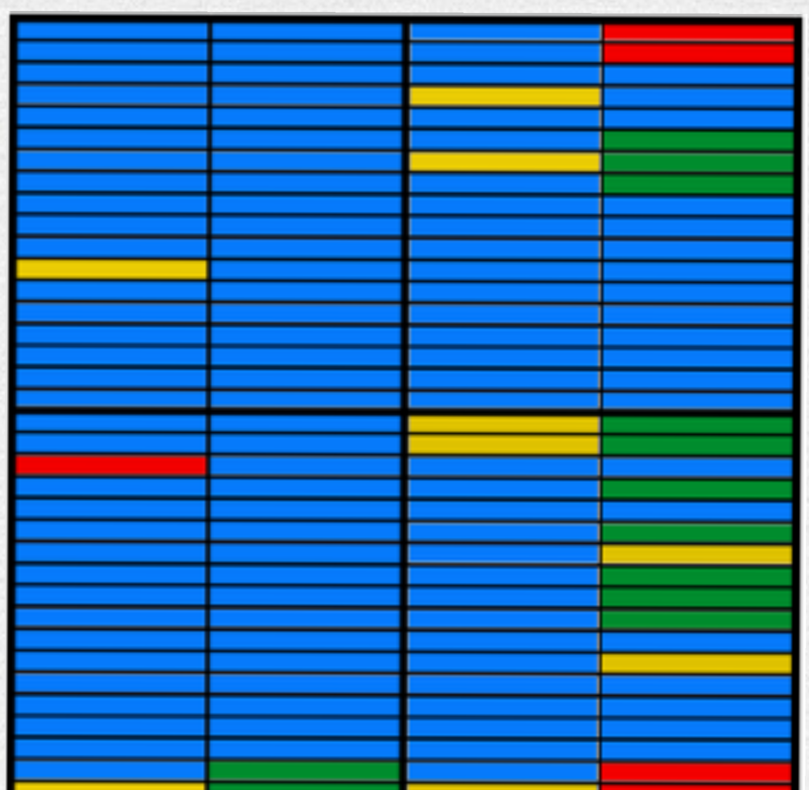
>with 25um pitch on an EBU

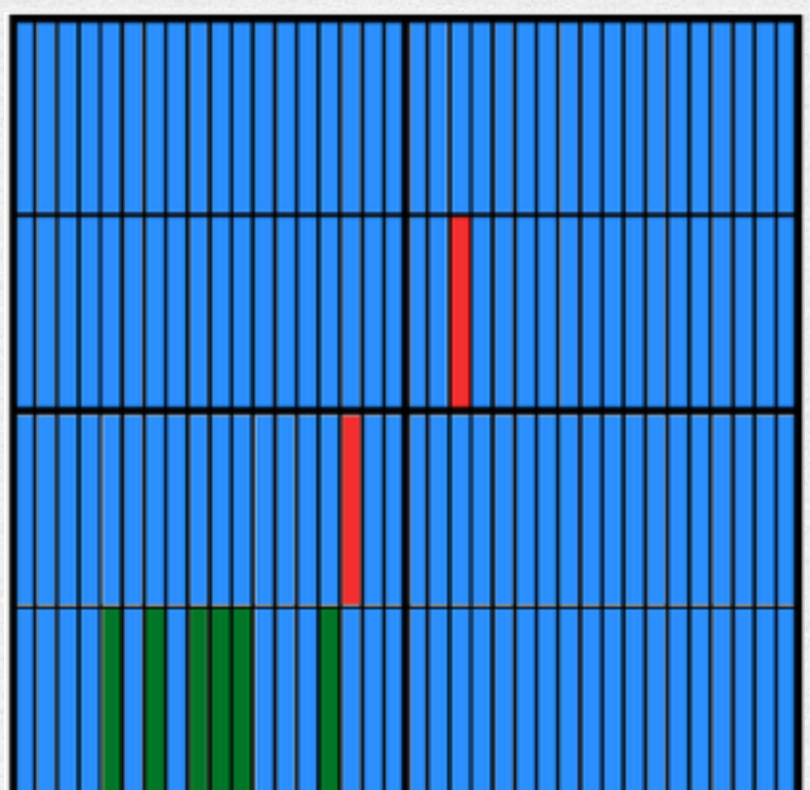
large signal

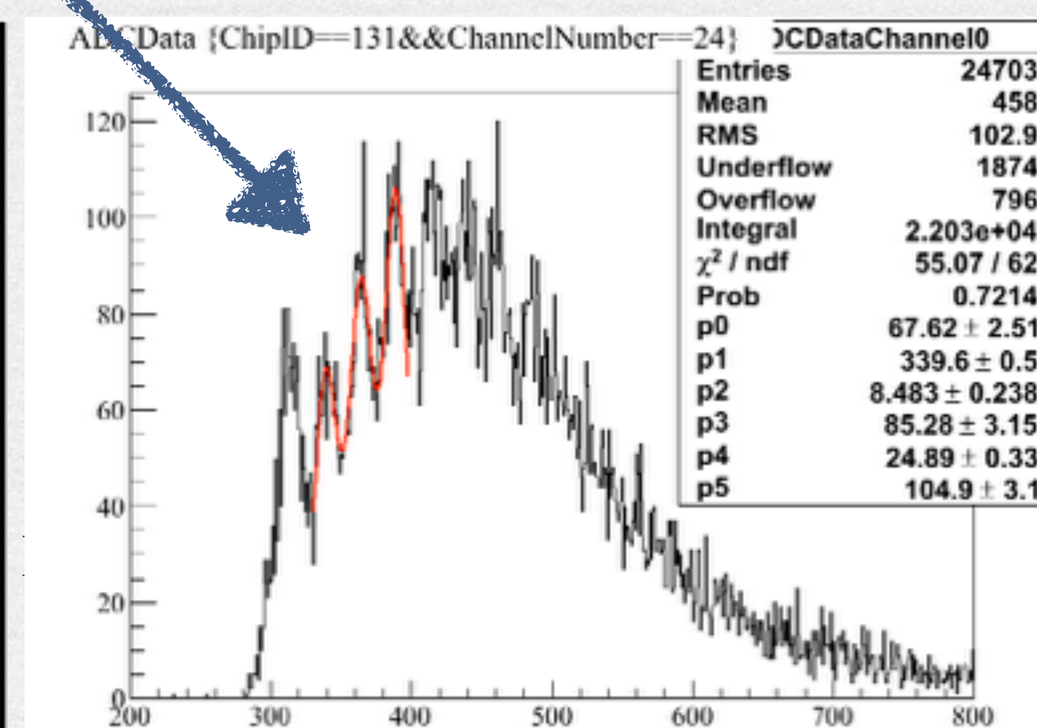
>successful

>blue indicates “good” separation of mip from ped.









ADC-EBU

EBU with 10um

>current SPIROC2b is optimized for 25um pitch MPPC

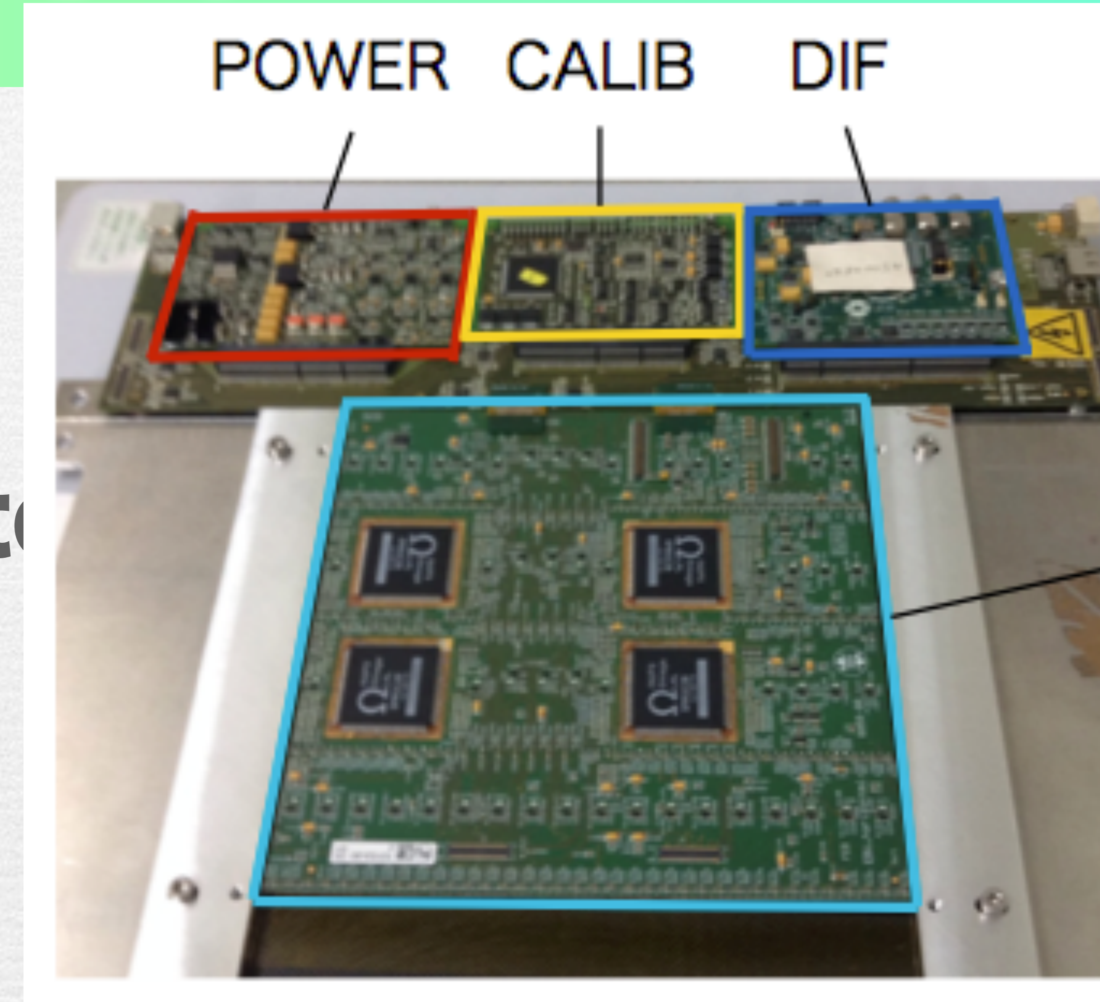
>with 10um pitch, encount difficulty   small signal

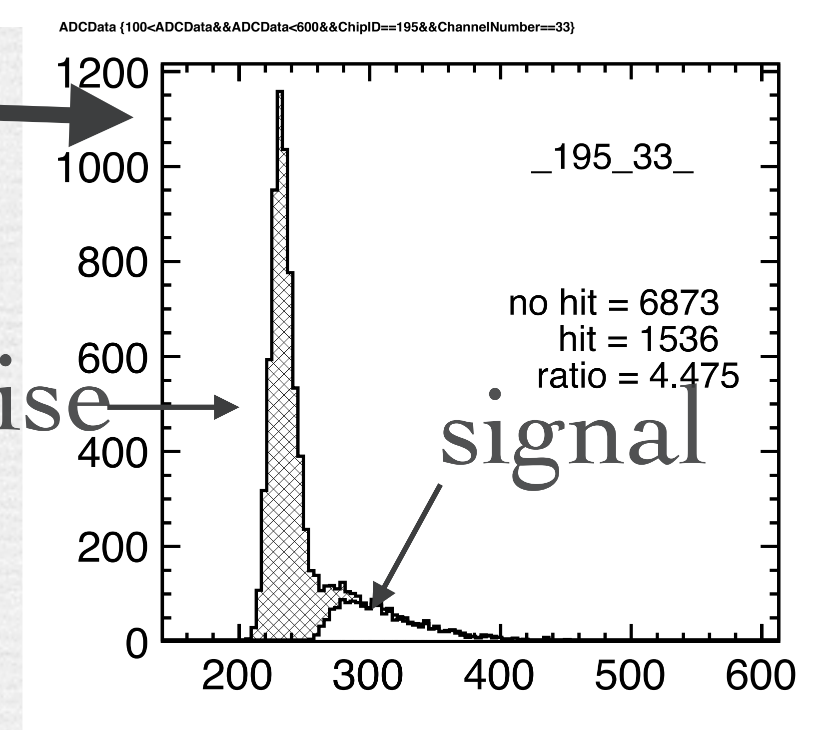
>signal is too small

>SPIROC is tuned to have max. amp and …

>ADC dist. for beta rays

>increasing gain as well as noises, separation is difficult





EBU with 15um

>15um pitch MPPC

larger than 10um

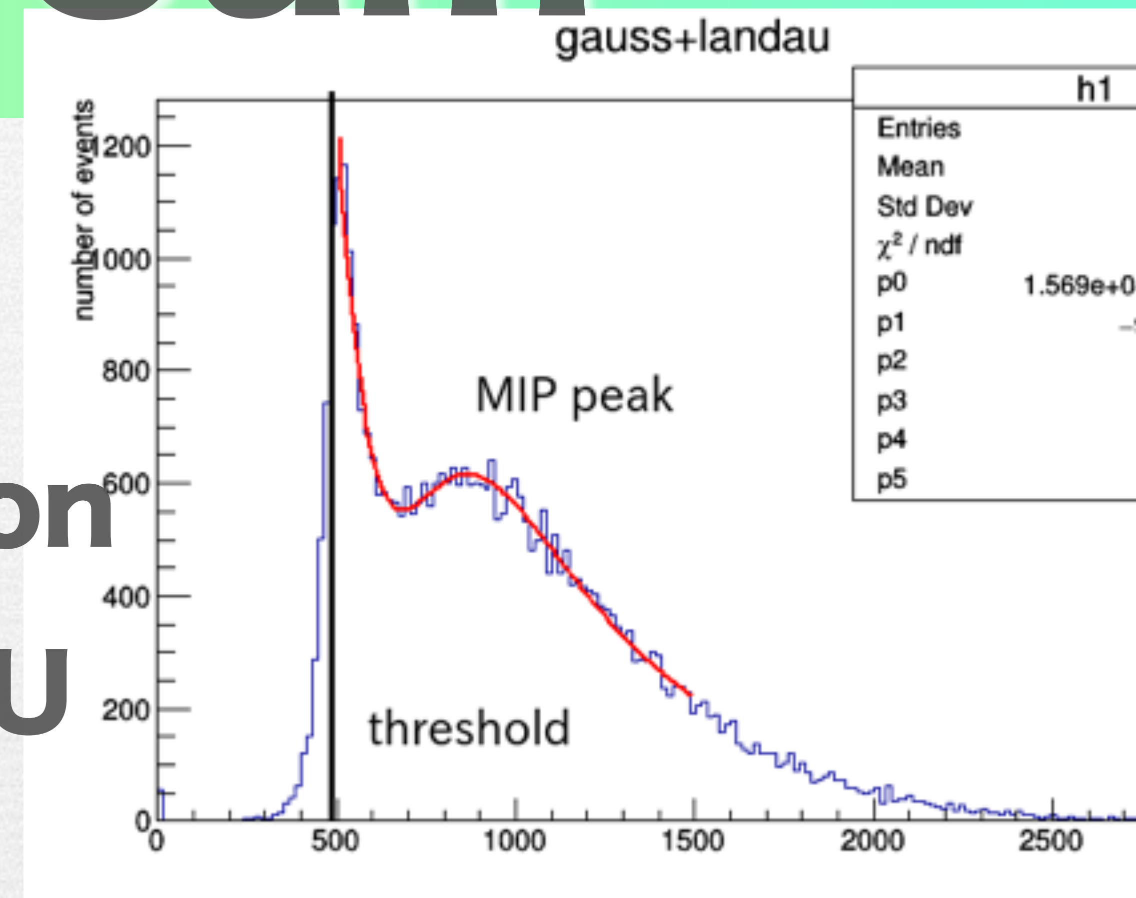
>higher gain and PDE

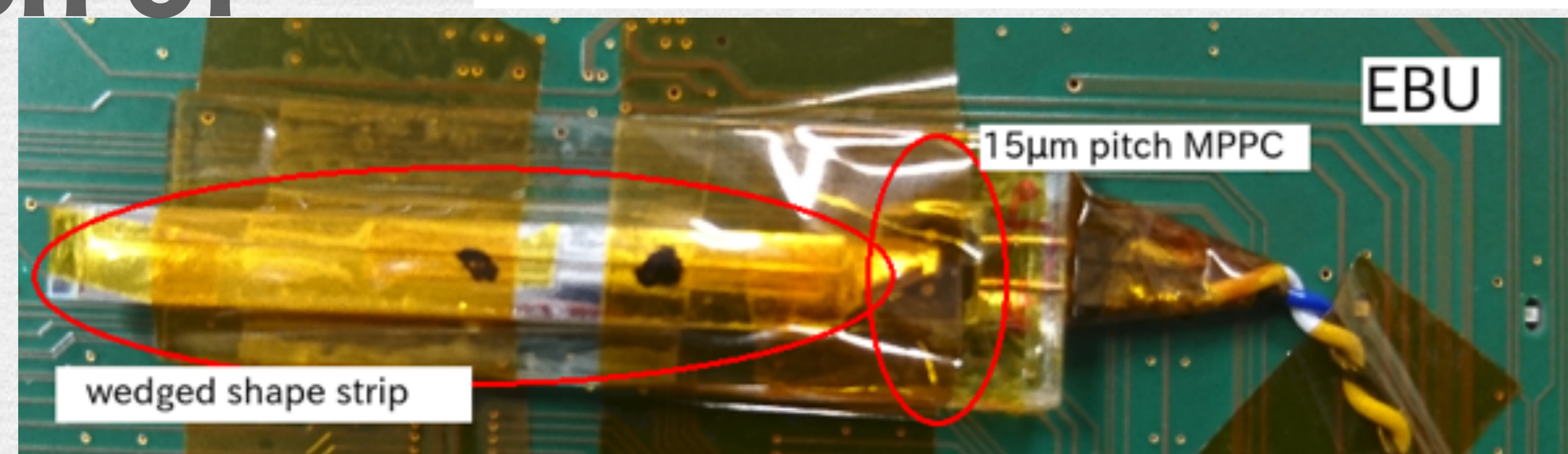
>bench test for comparison

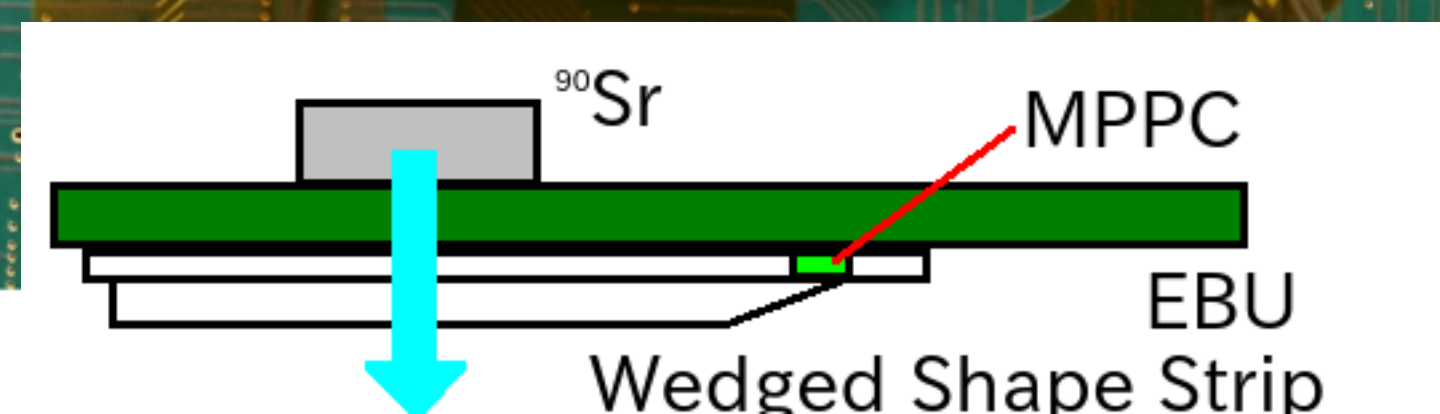
>one channel test with EBU

>possible operation of 15um pitch with EBU

>further tests







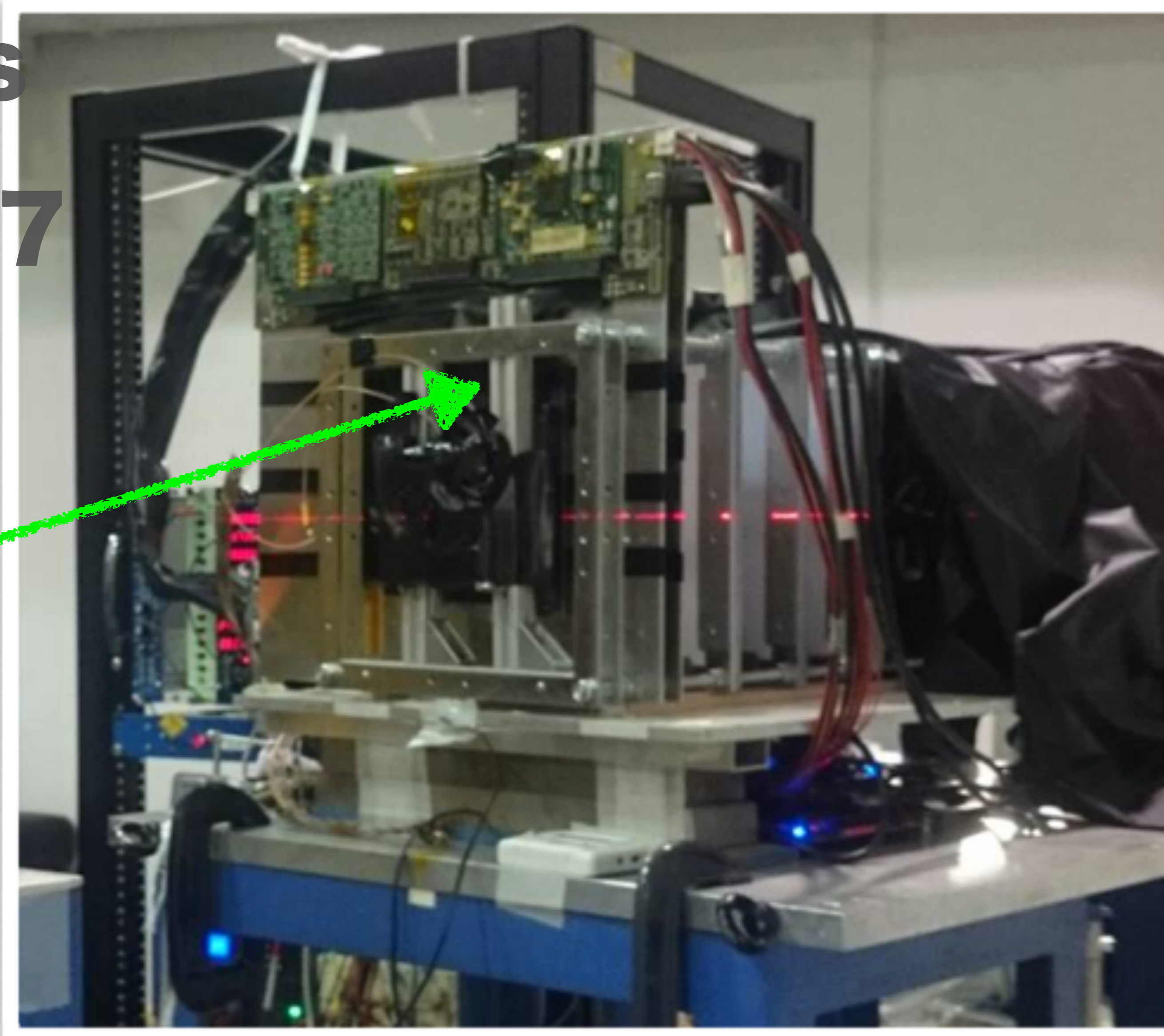
further EBU test

>EM shower test will be performed at ELPH-Tohoku university

>100-800MeV electrons

>in preparation for 2017

2016 beam test

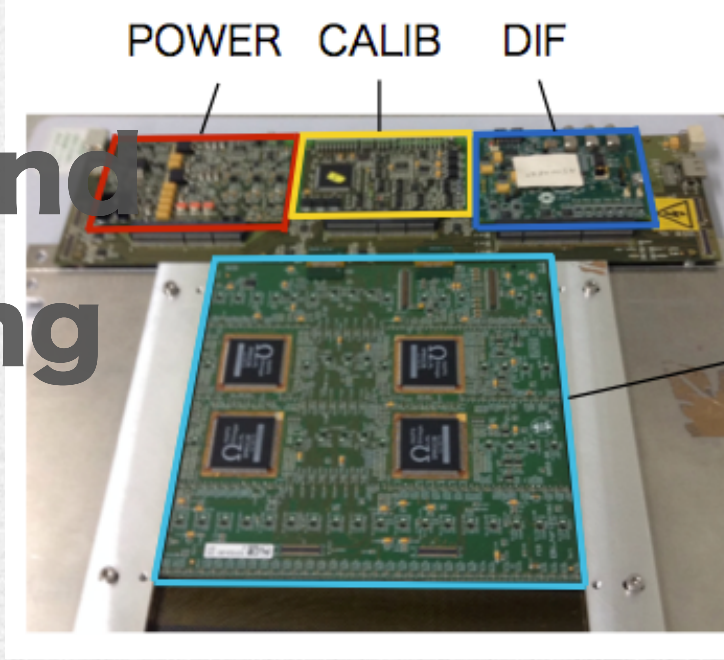


EBU with 10um pitch MPPC was tested

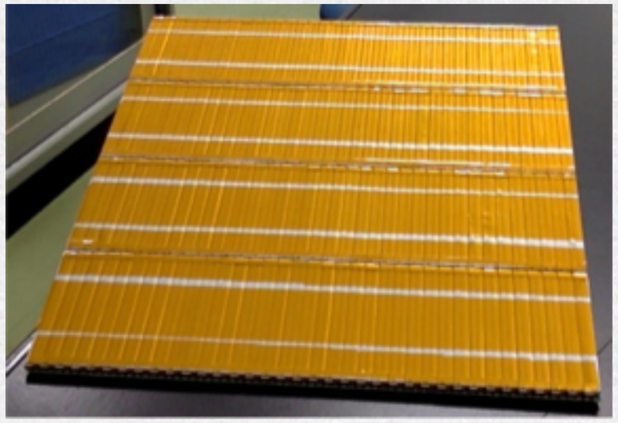
Terada's talk

summary & outlook

- Strip scintillator ECAL is under development, moving into realistic phase
- EBU: combination of sensors and embedded FE electrics including MPPC is being examined



- optimization of each parts are under investigation



- EM shower test is planed

Jet energy resolution

in terms of strip length

insensitive to the length

when SSA

Strip Splitting Algorit