Test beam experience 2015 and more in HCAL

Tohru Takeshita (Shinshu University)

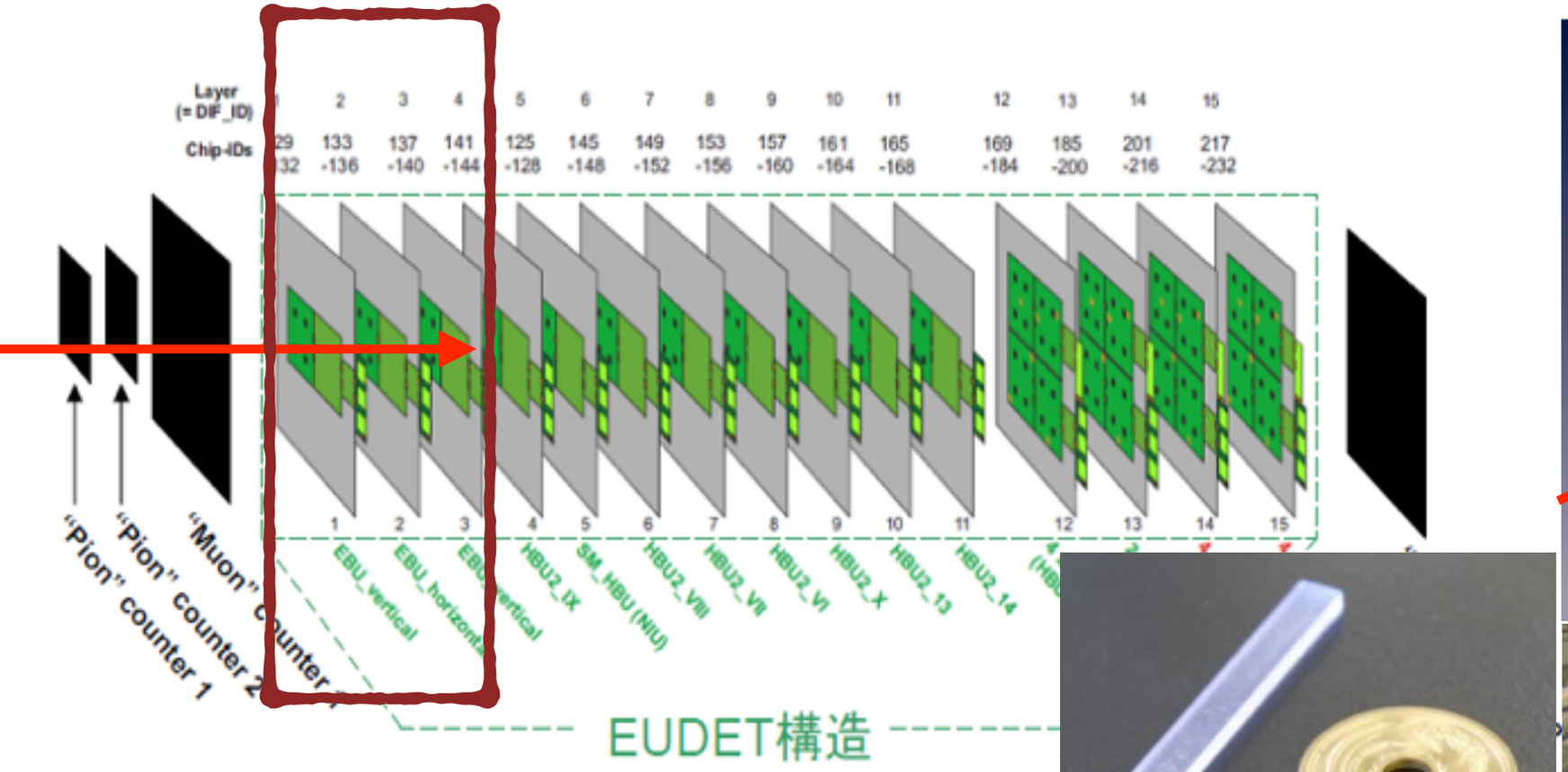
Hcal main meeting-2015 @ DESY

ECAL & strip HCAL Beam test experience

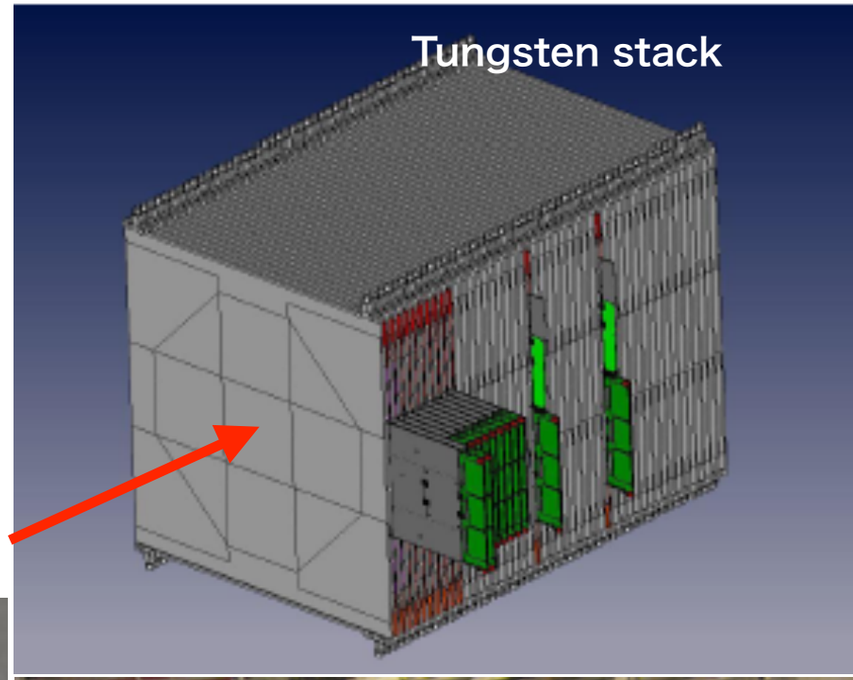
HCAL with detector

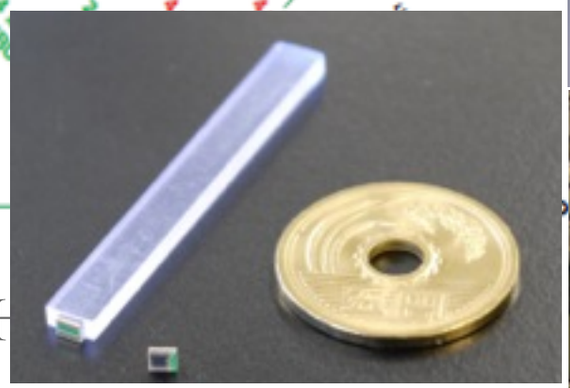
strip EBUs in AHCAL

- 3 EBUs in EUDET/tungsten absorber structure

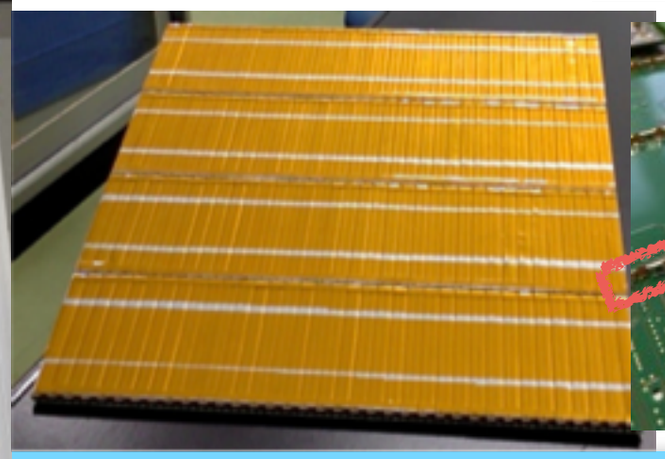


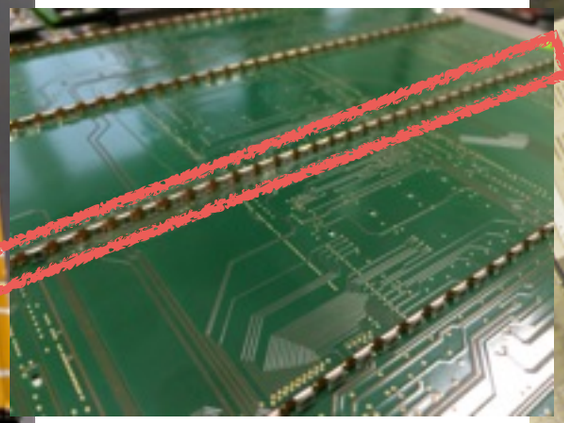
EUDET構造





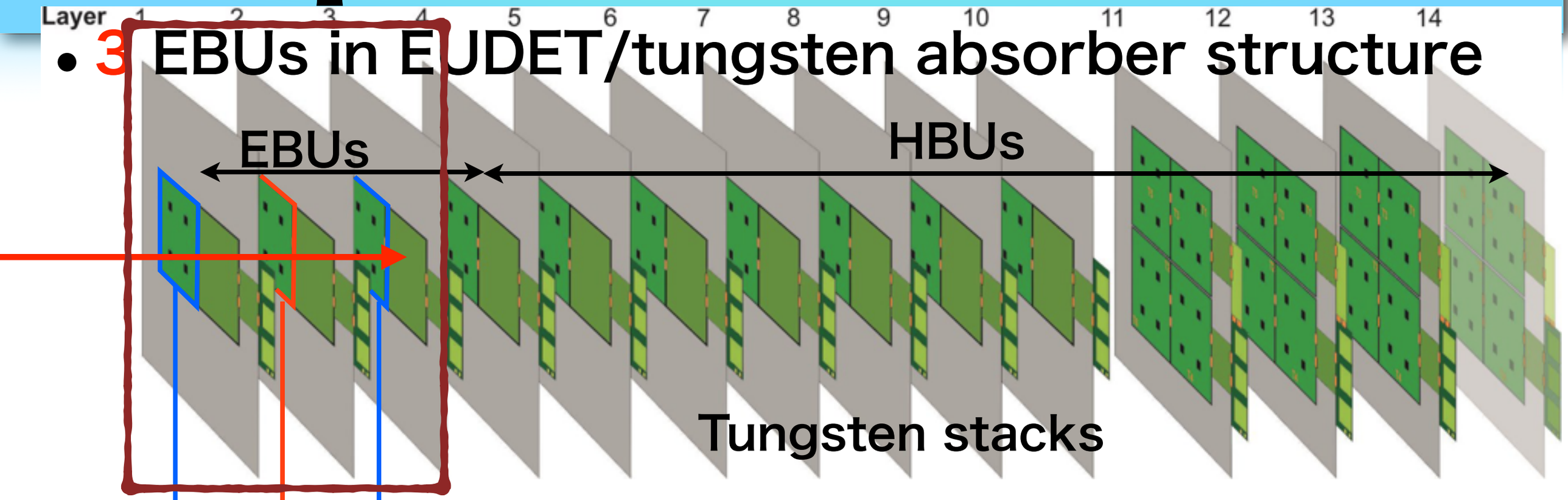
August 2015 at CERN SPS/H



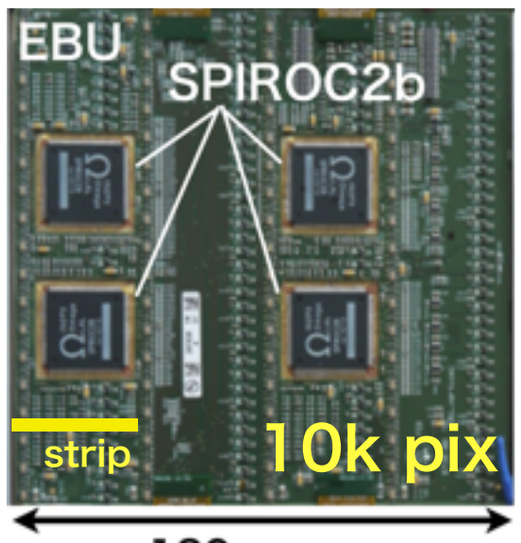


strip EBUs in AHCAL

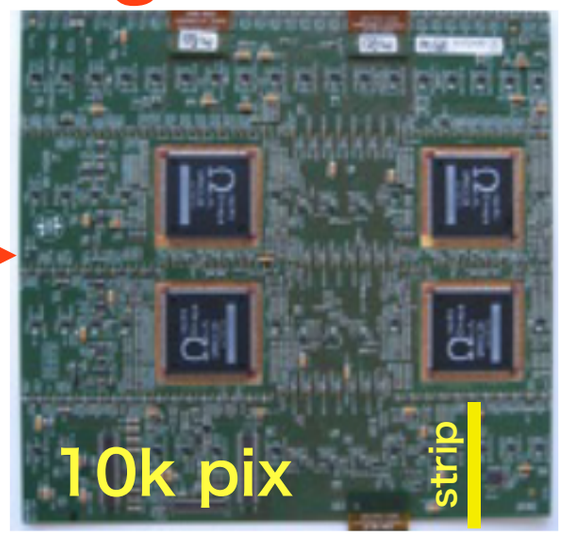
- 3 EBUs in EUDET/tungsten absorber structure



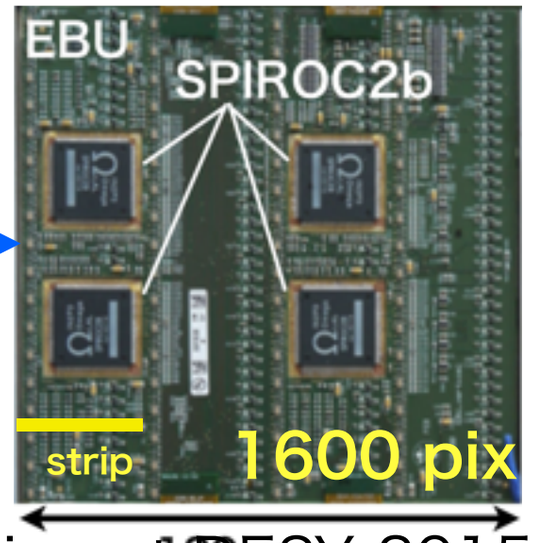
Bottom readout
Transverse EBU



end readout
Longitudinal EBU

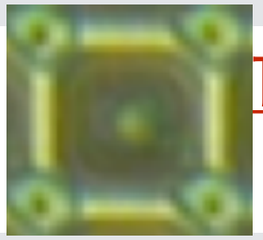
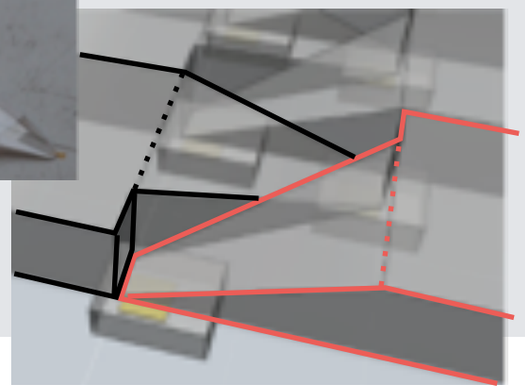
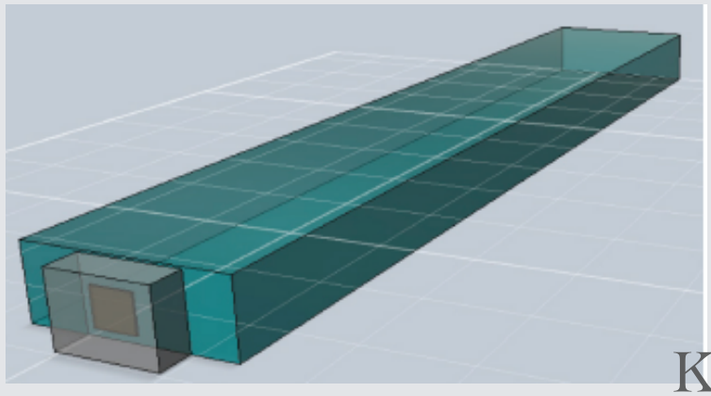


end readout
Transverse EBU



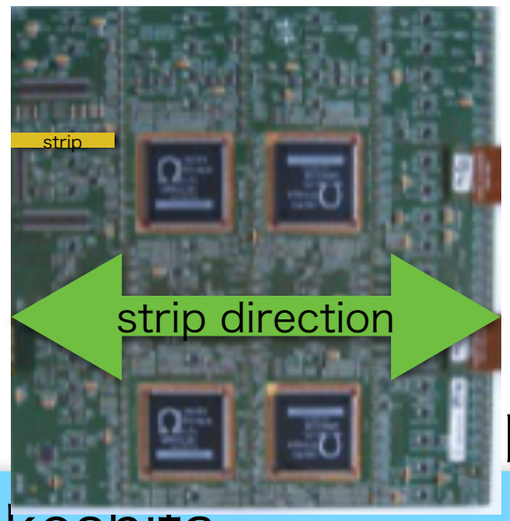
already tested

three EBUs

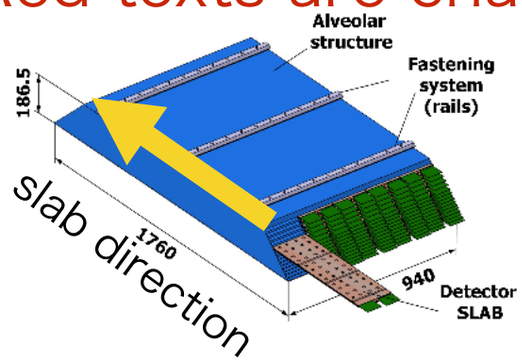
	Layer1	Layer2	Layer3
EBU type	Transverse	Longitudinal	Transverse
MPPC	10k pixel (1x1mm	 10k pixel 1x1mm	1.6k pixel (1x1mm
Scintillator	Wedge 	Default 	Default
comment	bottom readout	only August	tested @ 2013

Katsu. K

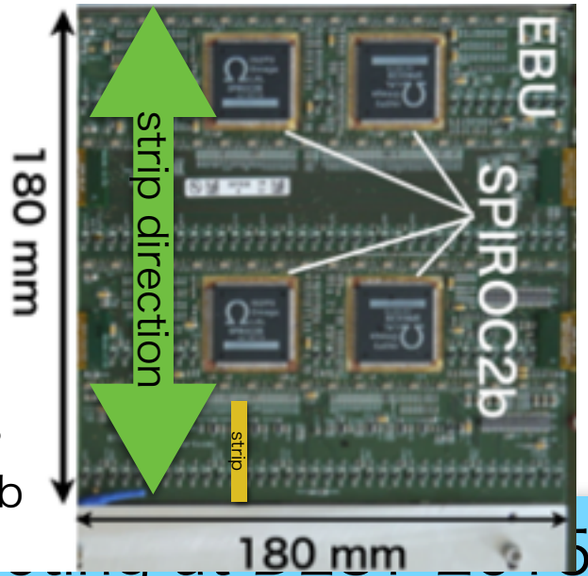
Red texts are challenging issue.



Longitudinal EBU



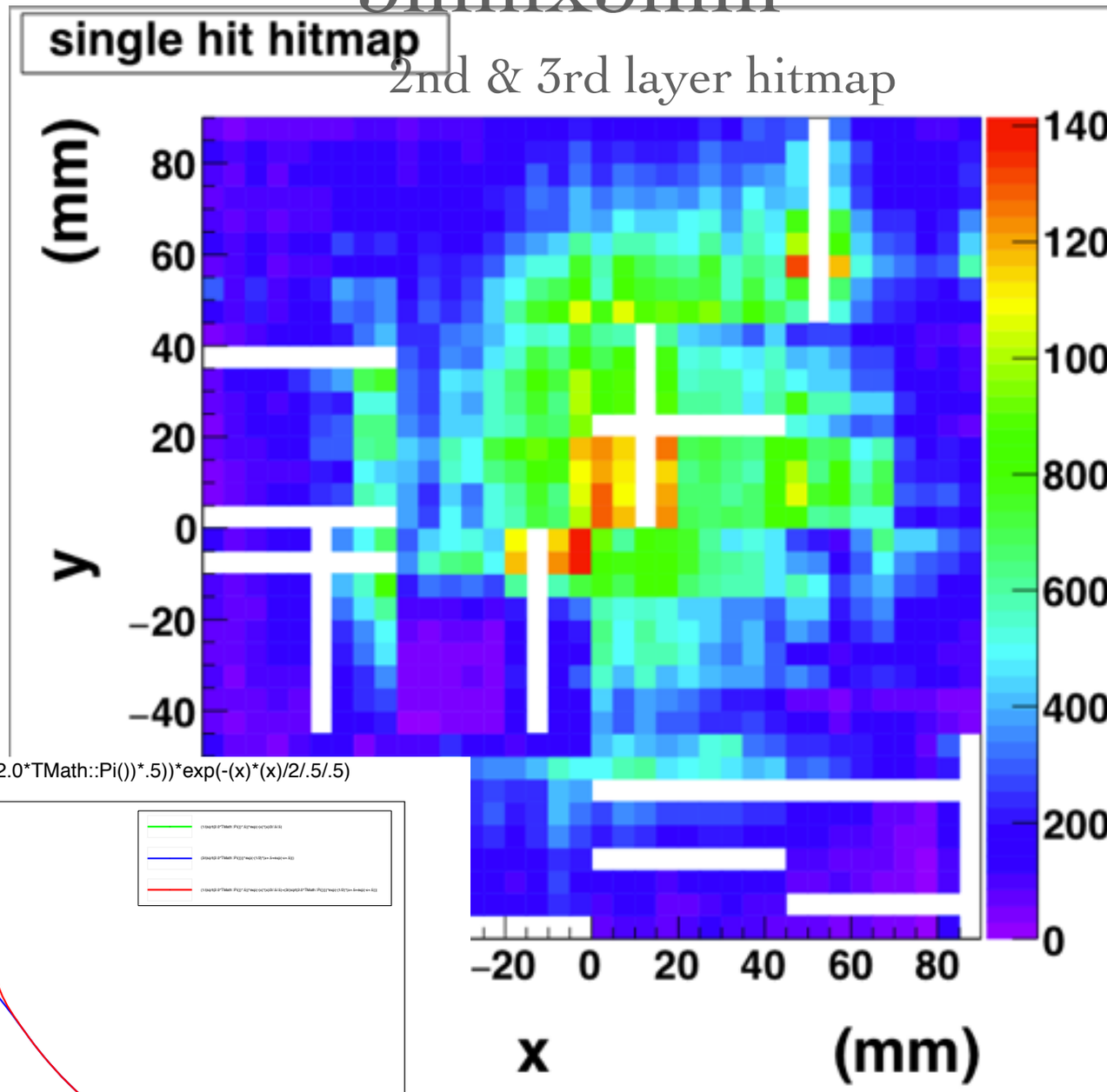
Transverse EBU



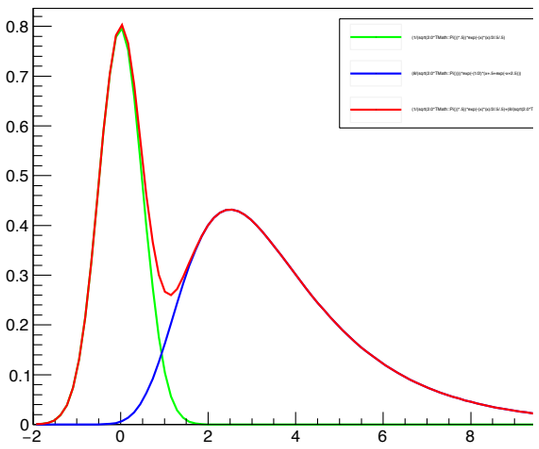
Transverse and Longitudinal mean strips direction respect the slab direction

strip EBUs in AHCAL

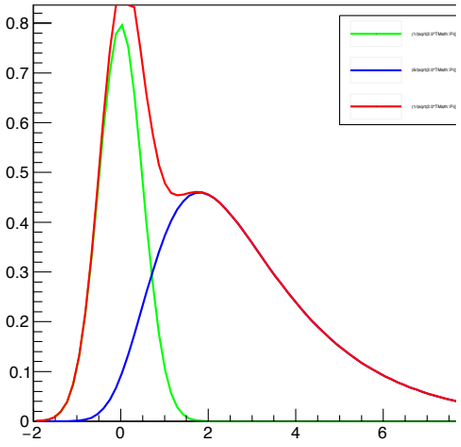
- 2nd layer EBU performance
- hit map with resolution
- of 5mmx5mm
- with 10k pix. MPPC
- small signal

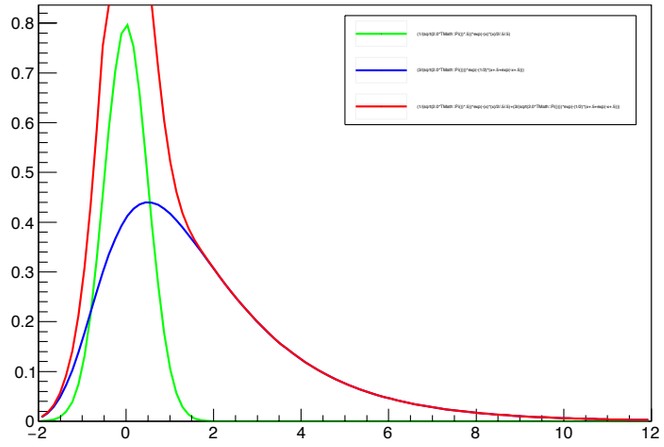


MIP Peak identify



MIP shoulder found





Yoichiro F.

strip EBUs in AHCAL

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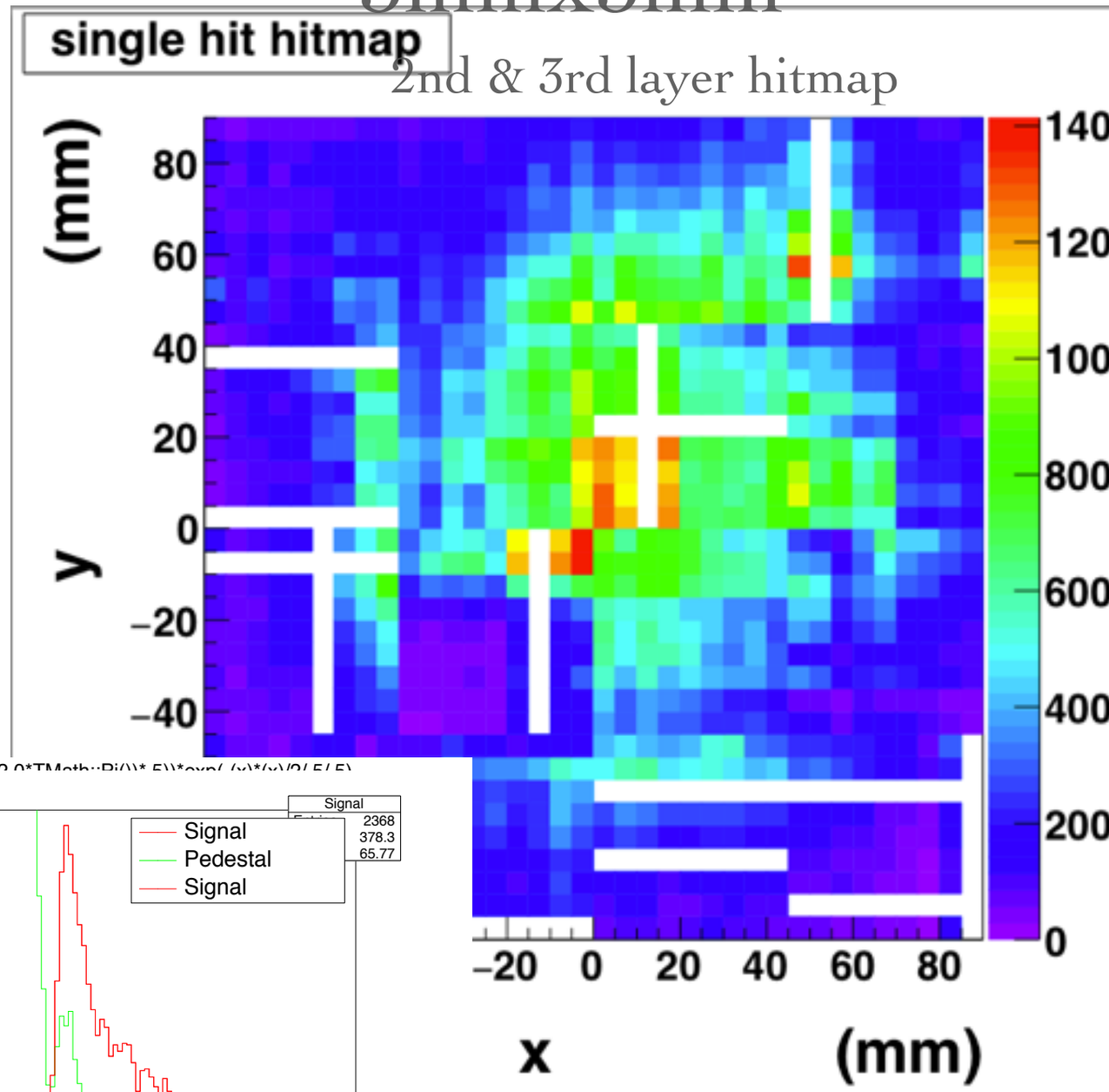
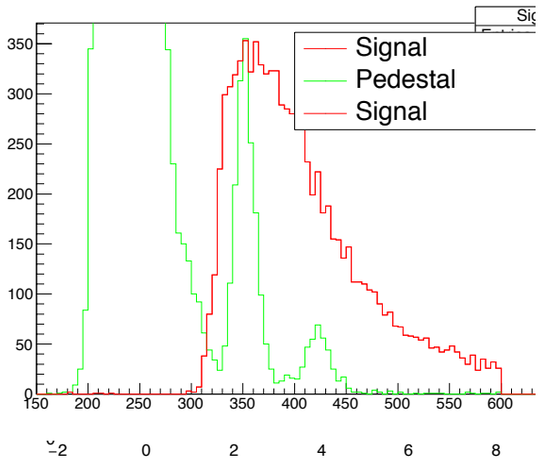
- small signal

5mmx5mm

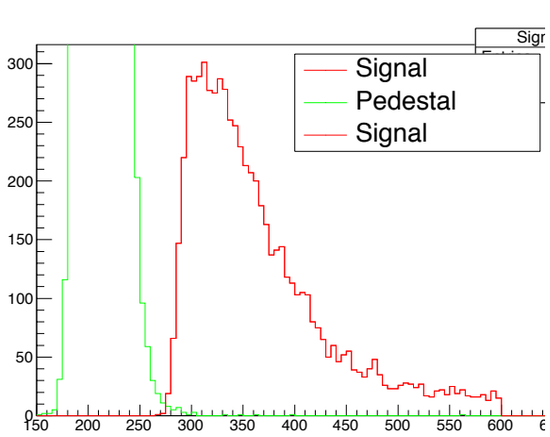


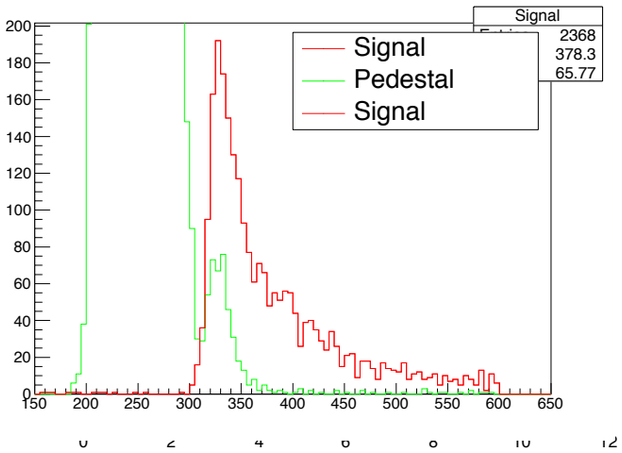
MIP Peak identify



MIP shoulder found

(1/(sqrt(2.0*TMath::Pi())*.5))*exp(-(





Yoichiro F.

2nd layer strip

- 2nd layer EBU performance
- with 10k pix. MPPC : smaller signal
- **wish better compatibility with ASIC**

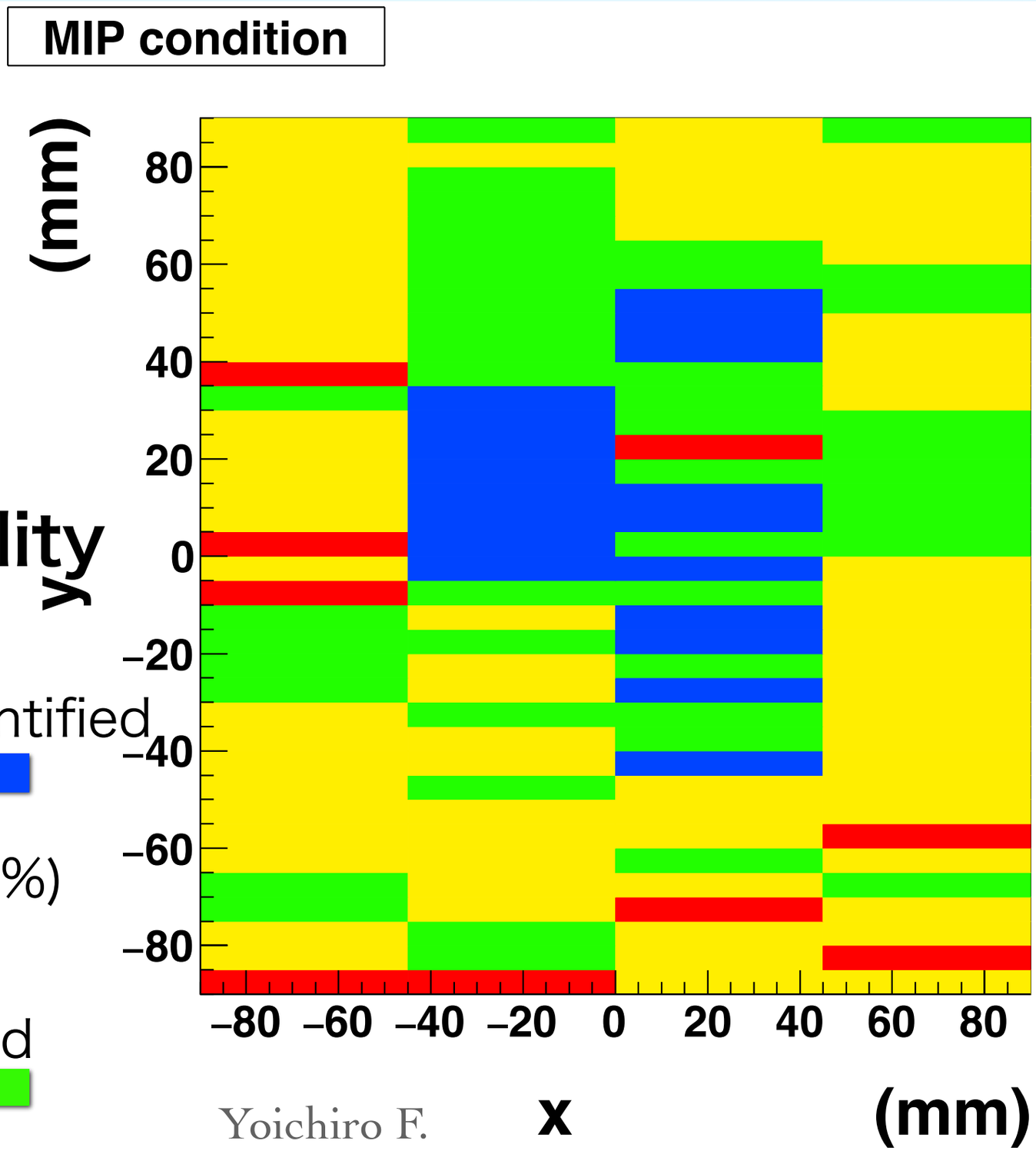
tale only · MPV peak identified

· 72 ch (50.00%) · 18 ch (12.5%)

Dead or noisy9 ch· Shoulder found

(6.25%)

· 45 ch (31.25%)



Yoichiro F.

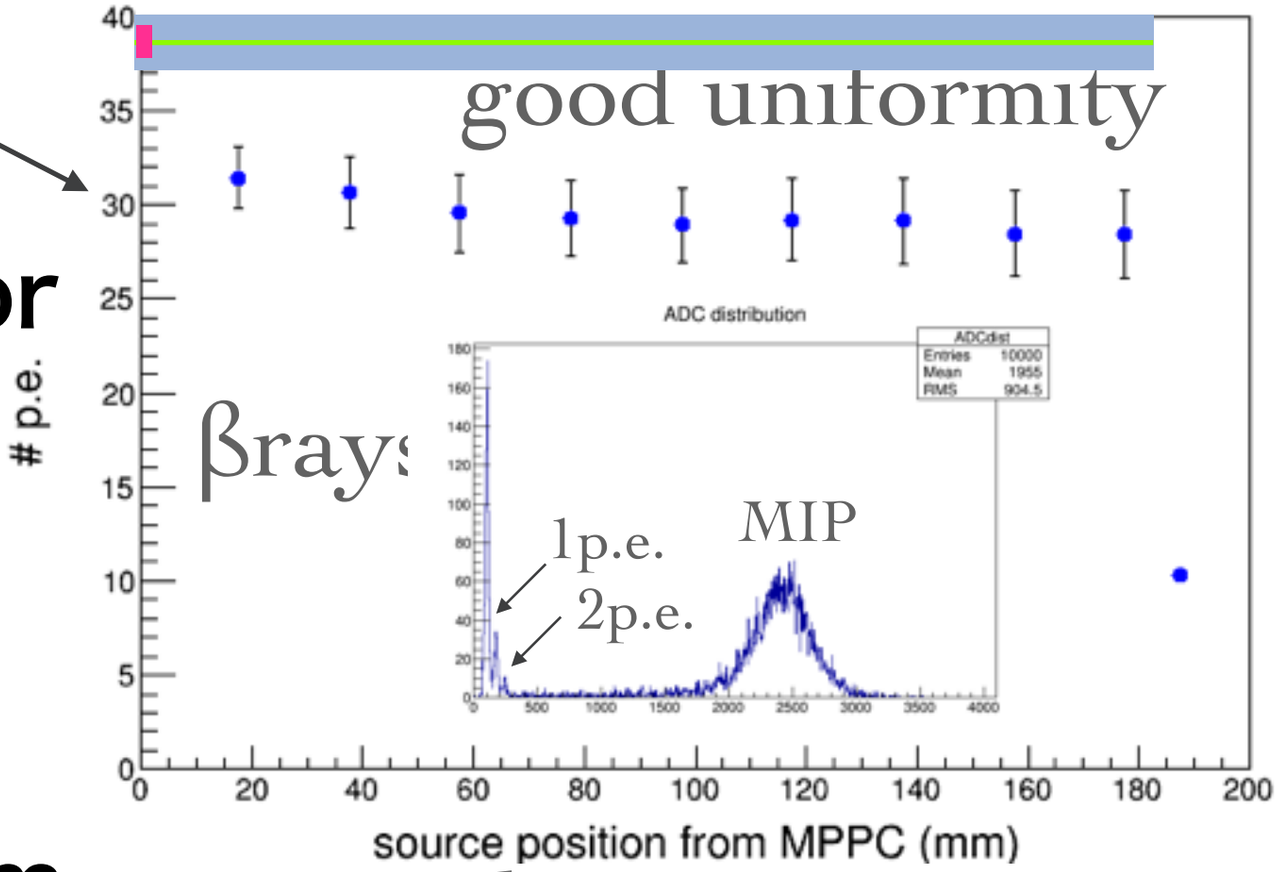
strip HCAL

- 18 cm long strip with WLSF read out
- perpendicular set up
- combination with tiles will remove ghost
- photon yield ~30p.e.
- 3mm thick scintillator
- good uniformity
- by beta rays at lab.
- 1600 pix MPPC 25um

18cm

1cm wide

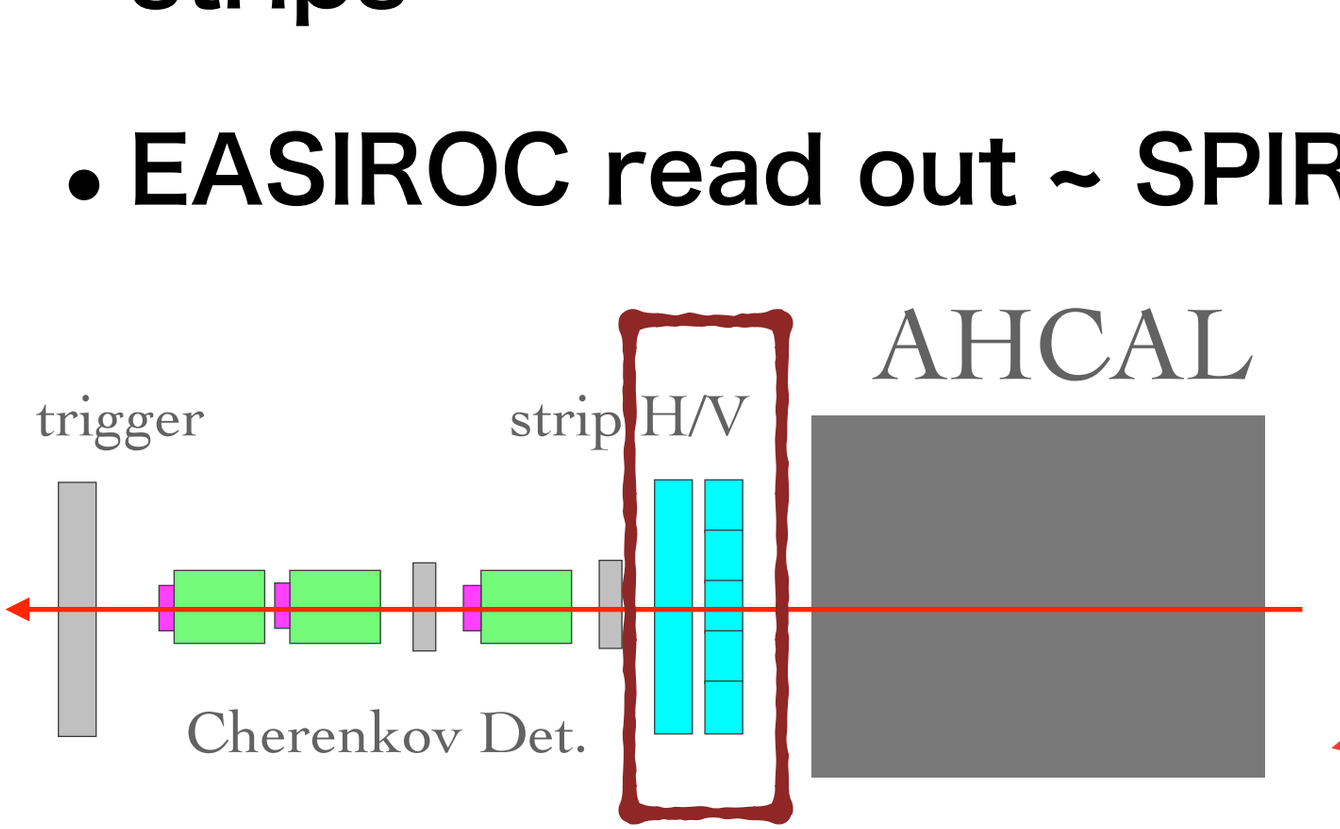
at lab.

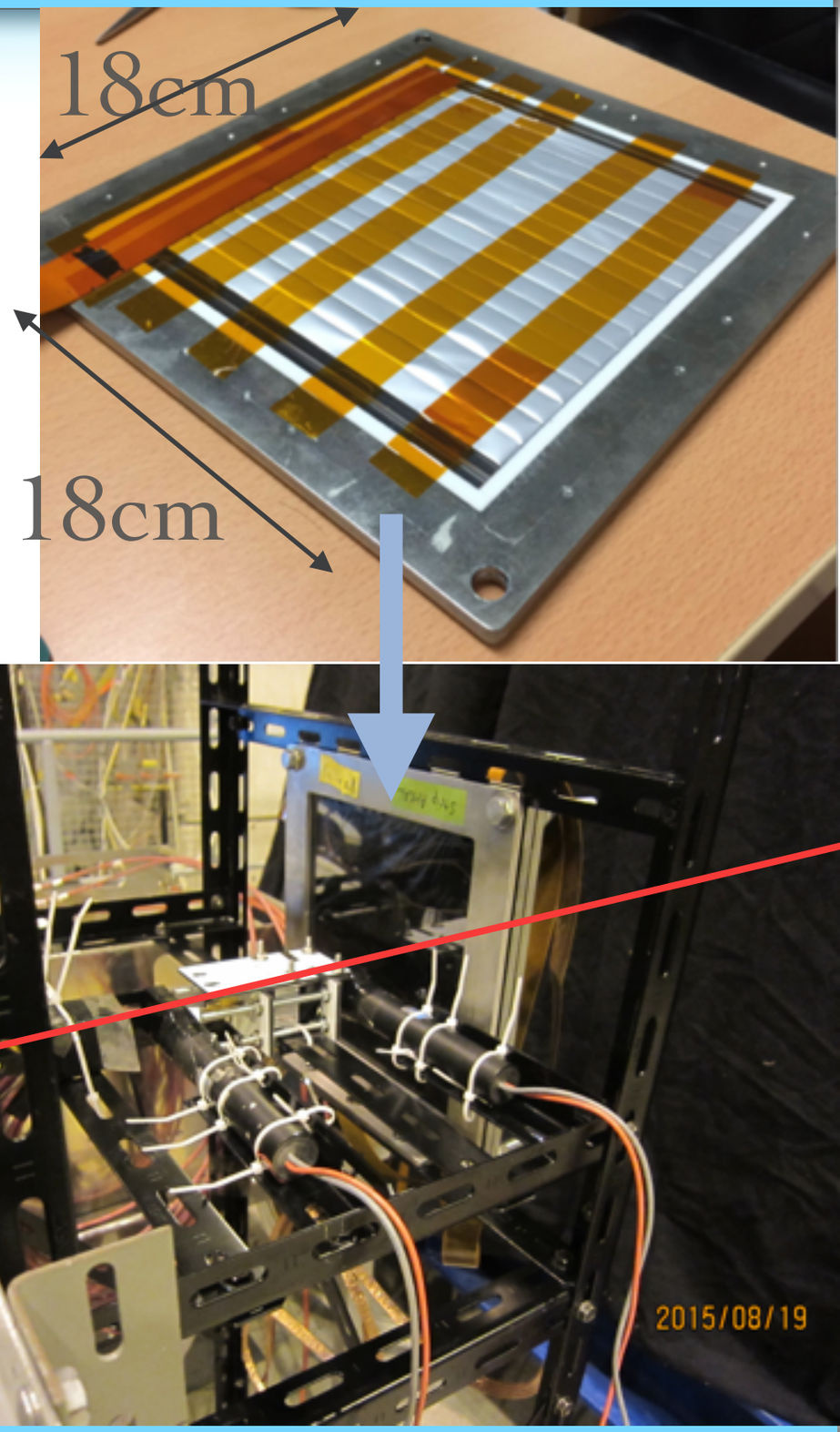


with camac ADC

strip HCAL at H6

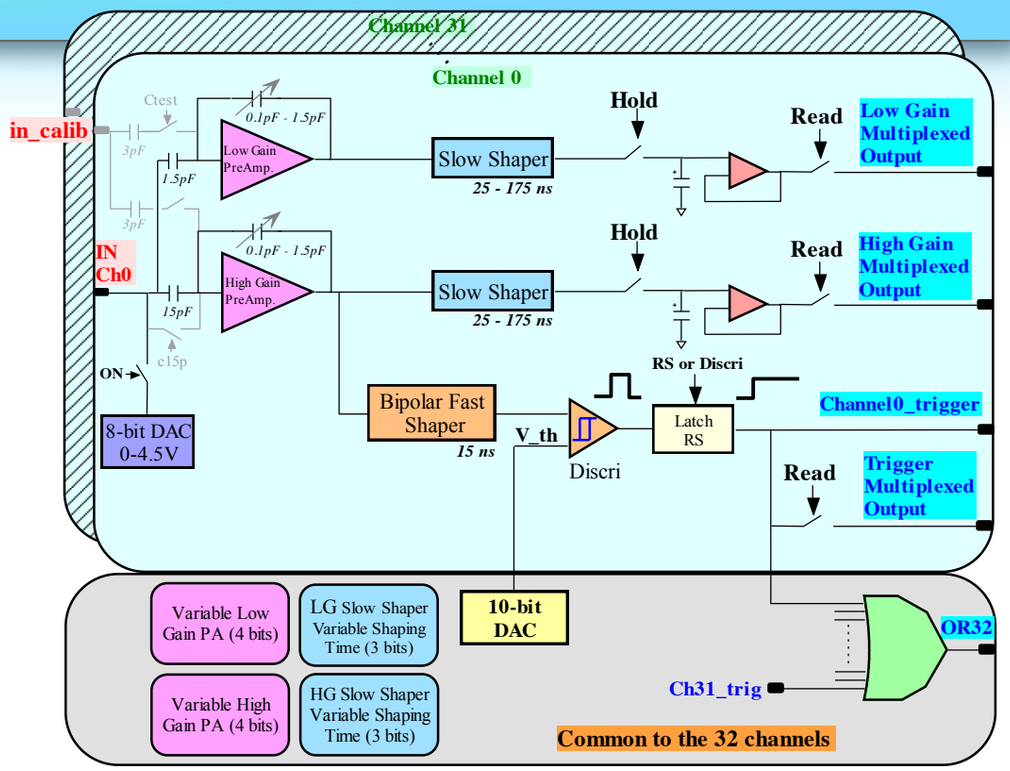
- behind AHCAL ~ muons
- 16 horizontal & vertical strips
- EASIROC read out ~ SPIROC

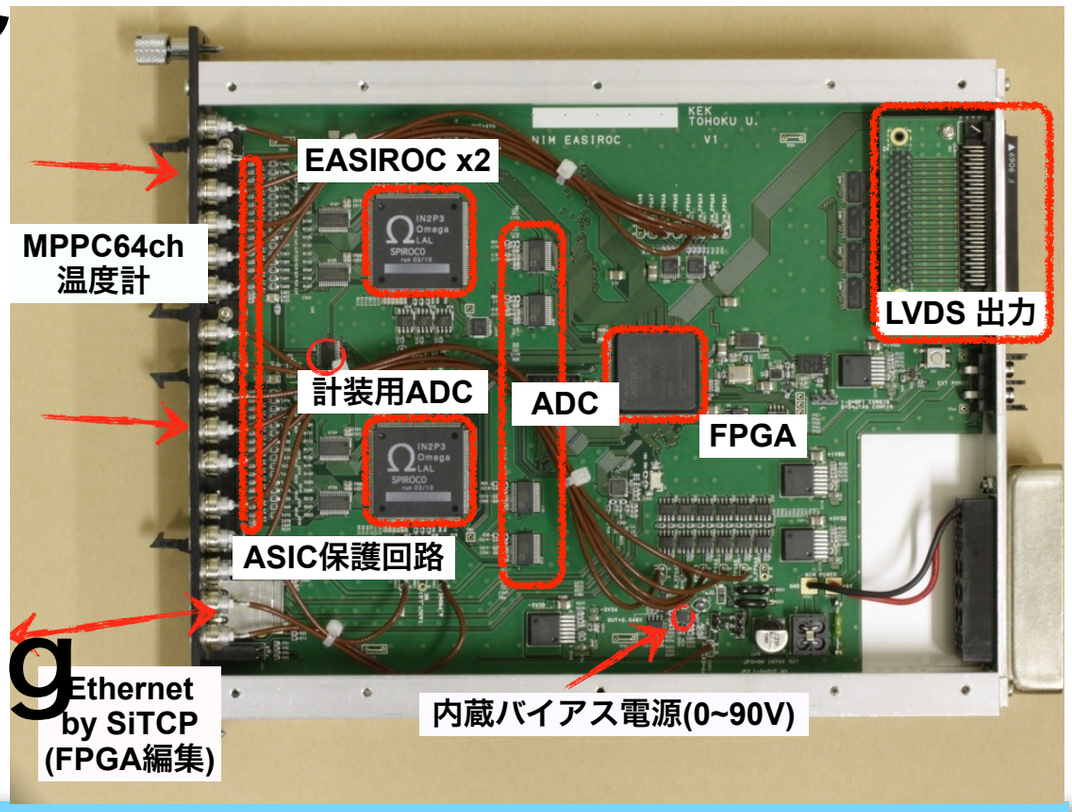




read out from PPD

- Easiroc by Omega
  32ch.
- NIM module with easiroc
- external trigger mode
- bias voltage with DC/DC
- external ADC
  64ch.
- Ethernet I/O
- DAQ & parameter setting



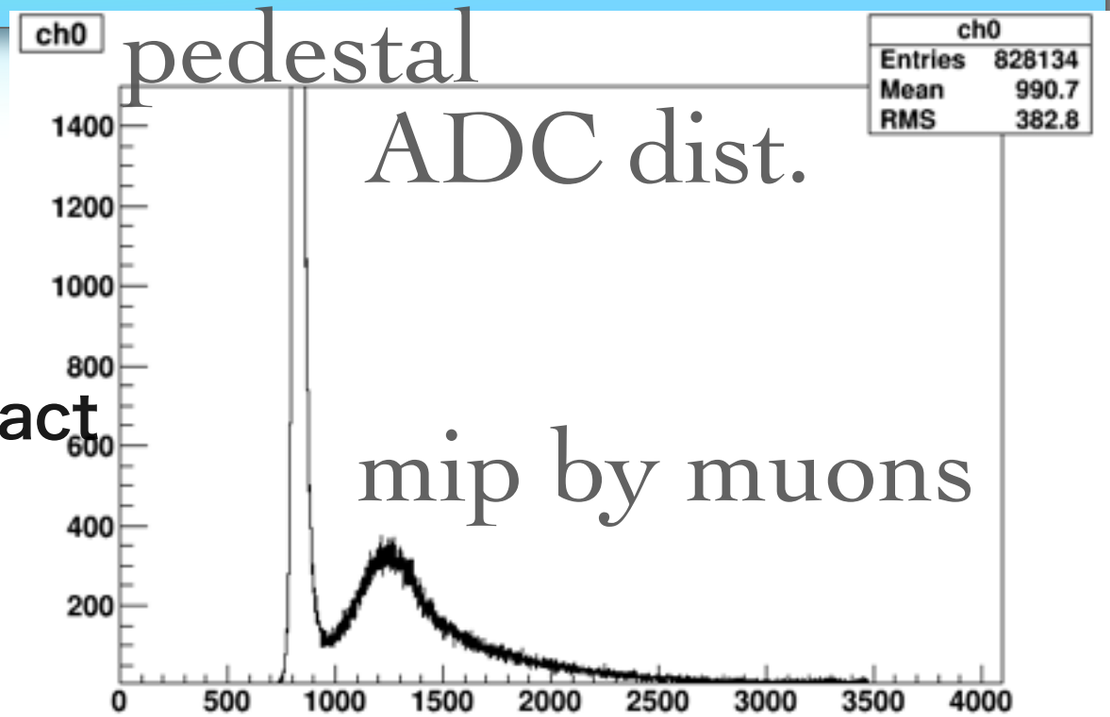


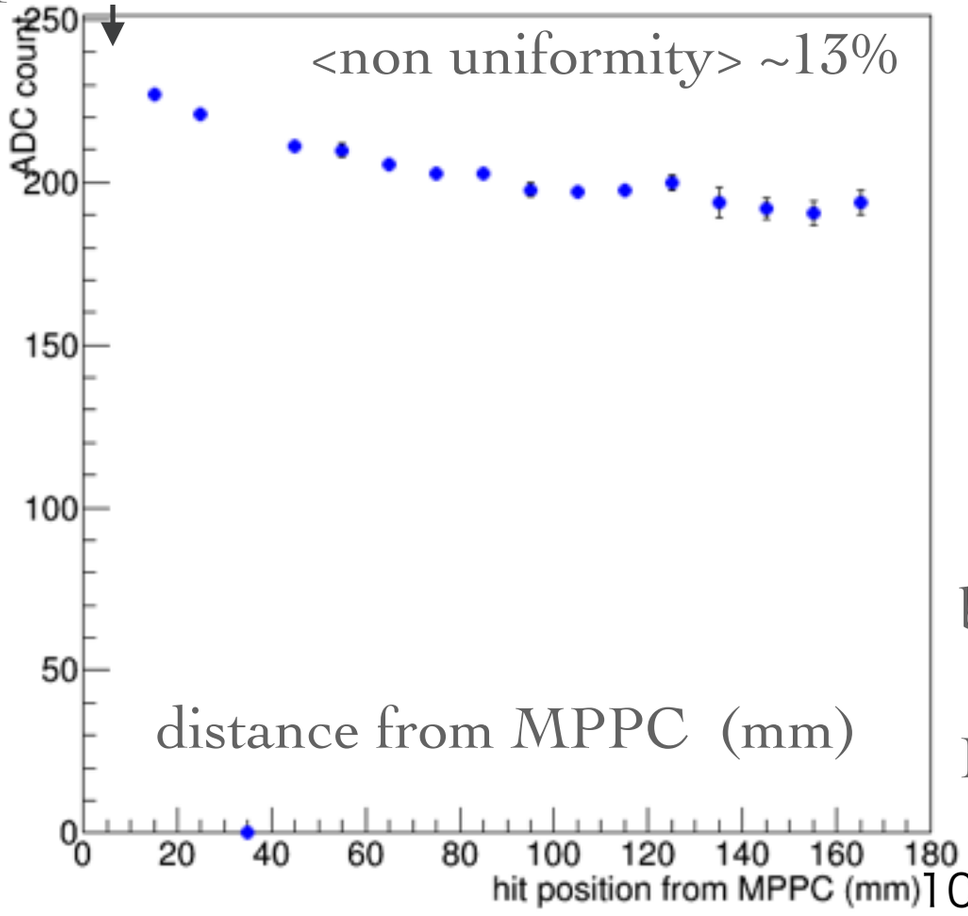
strip HCAL at beam

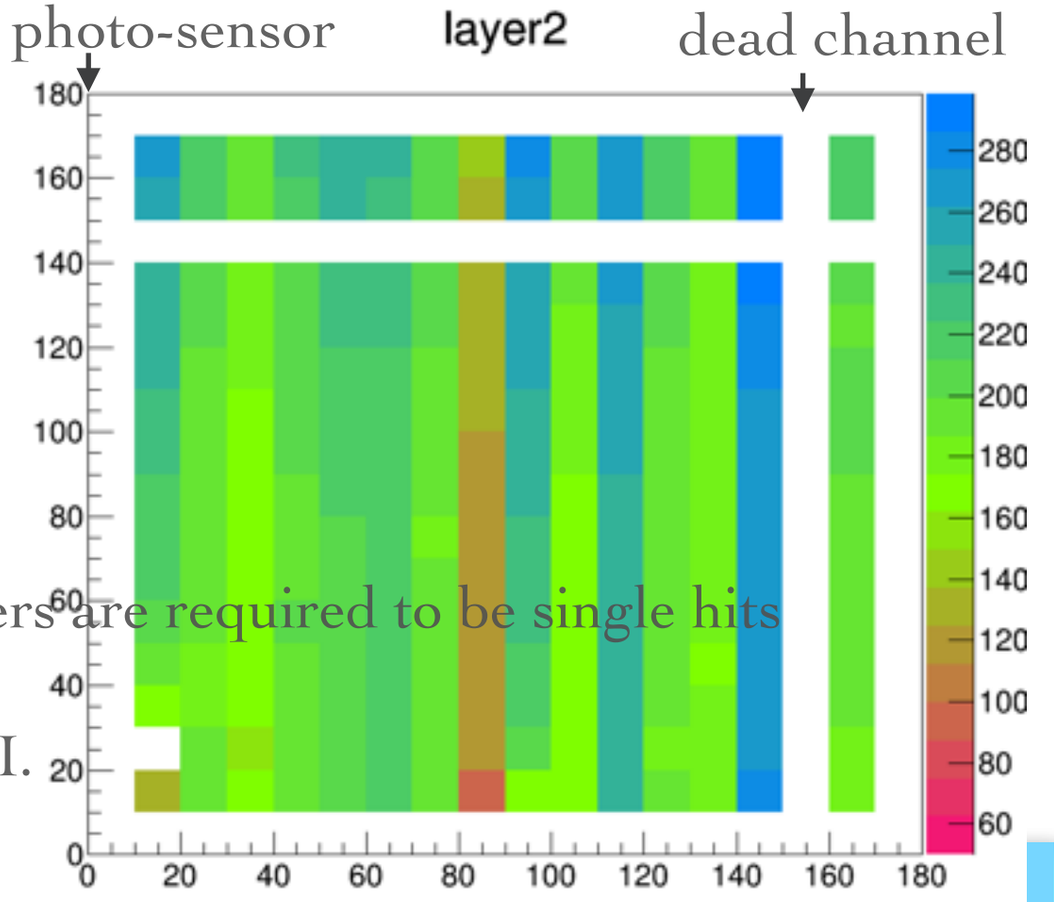
- clear MIP peaks

3mm thick EJ-strip

- no signal in two channels
  - due to poor contact
- good uniformity







both layers are required to be single hits

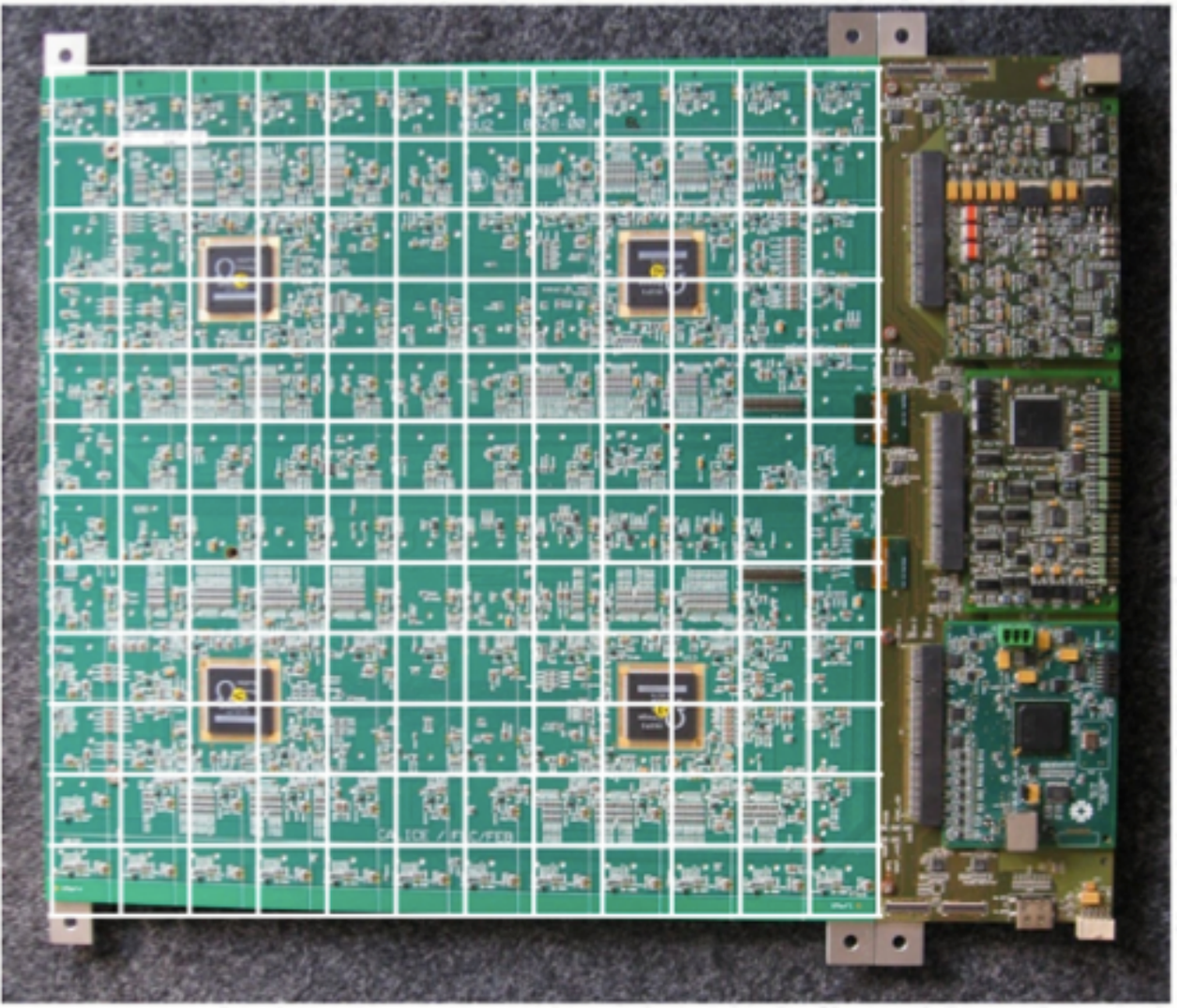
Hayato. I.

next strip HCAL

- stHBU ?

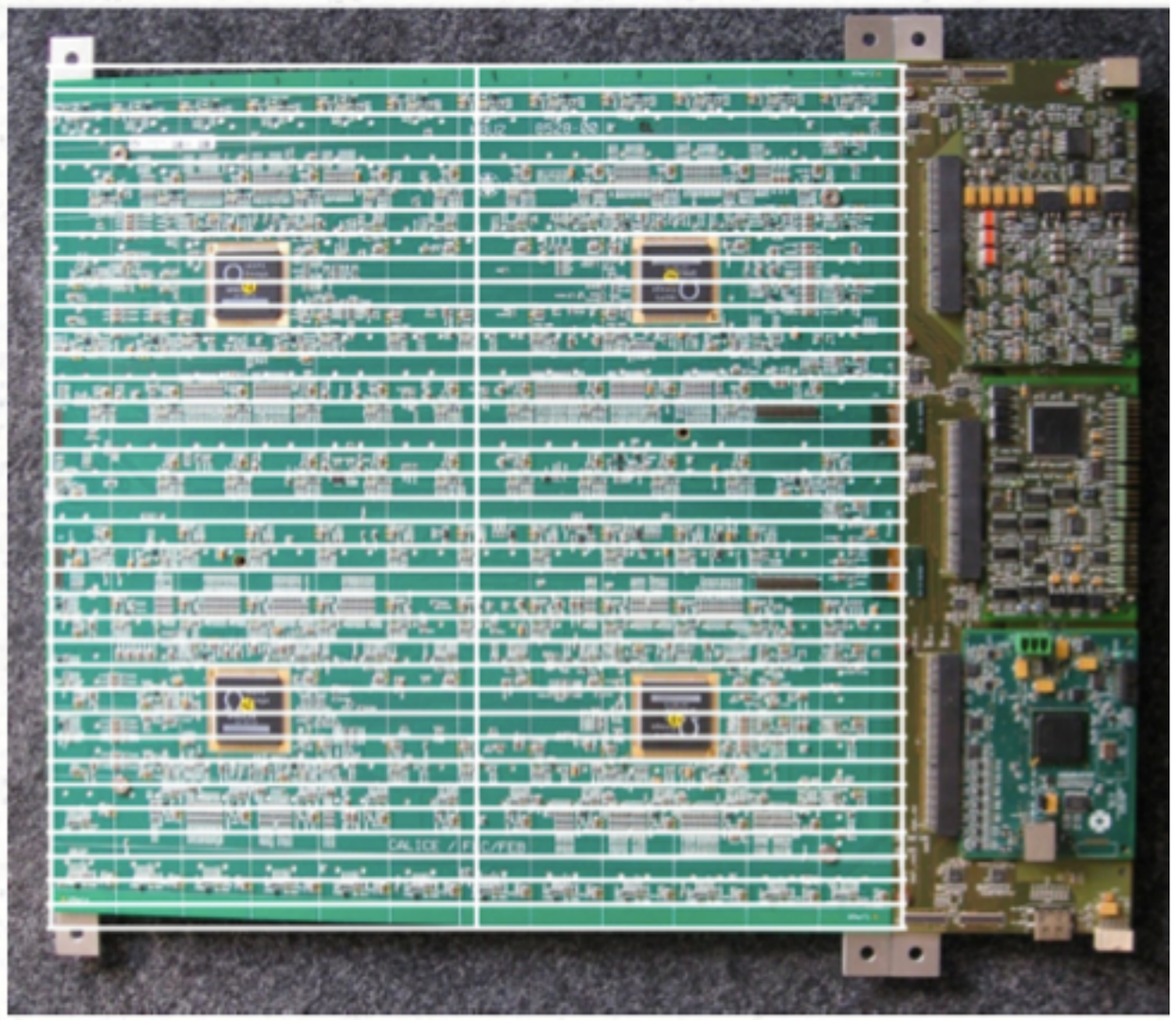
or dual read out with the same density

3cm*3cm scintillator tile



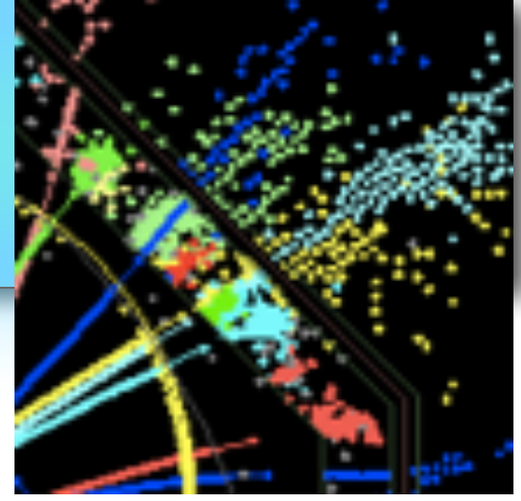
144ch
Chip *4

18cm*1cm scintillator strip



72ch
Chip *2

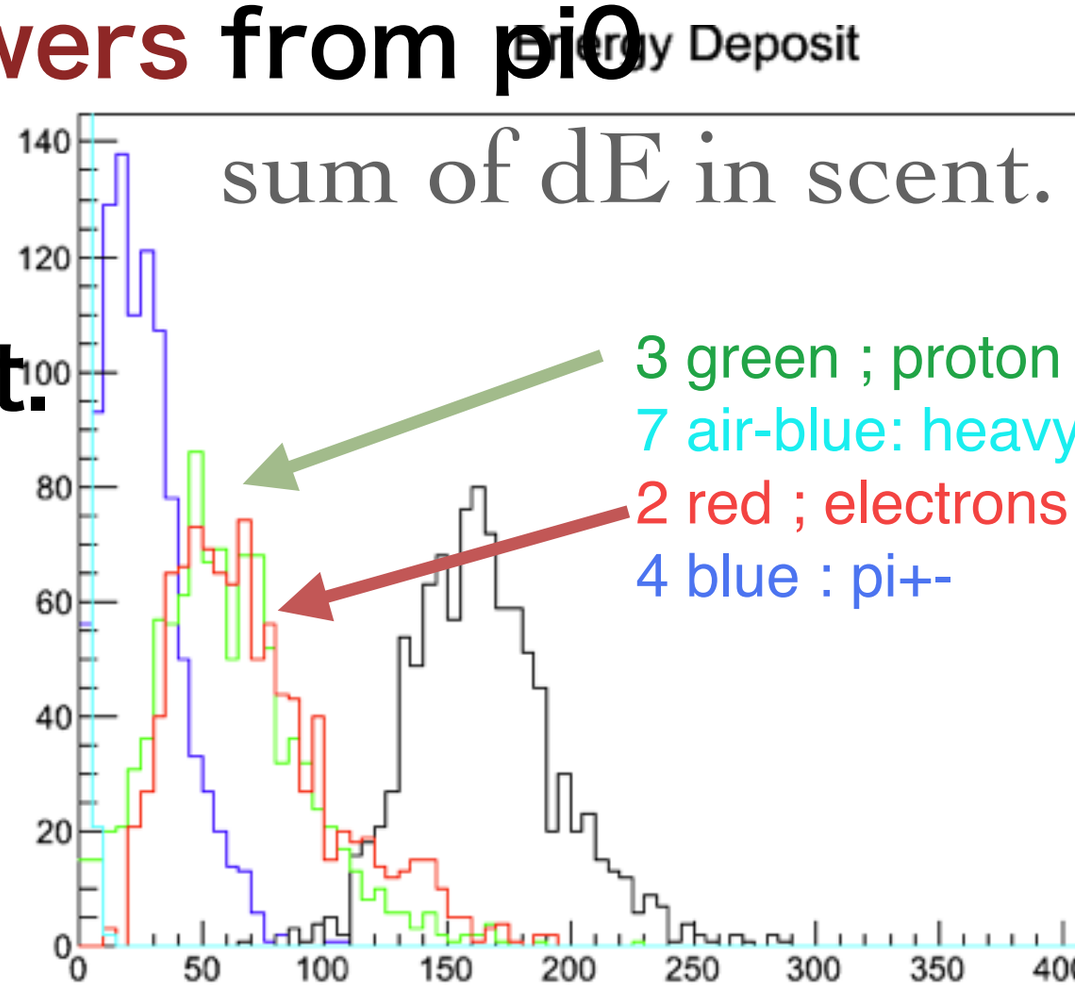
Segmented active absorber



- segmented information from the absorber will promote further improvement of PFA
- Cherenkov light in the absorber could be measured and improve hadron energy measurement
- muon Cherenkov detection is the most difficult task and for calibration

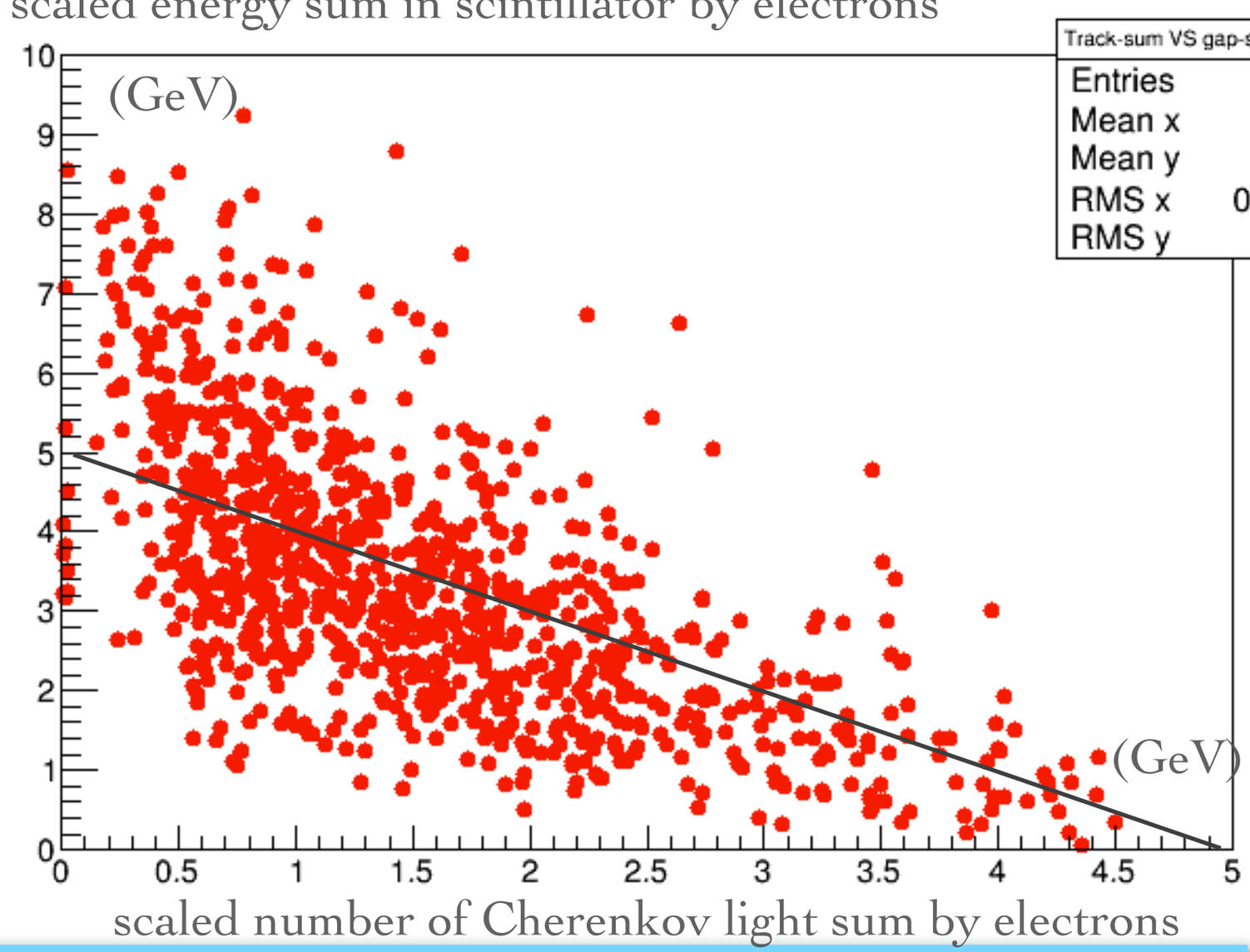
active absorber with Cherenkov

- heavy transparent absorber works as Cherenkov radiator : active
- Cherenkov light detection in absorber
- mostly produced by EM-showers from pi0 production for e+e- energy
- resolution is better than scint.
- scintillator information
  - inevitable for protons



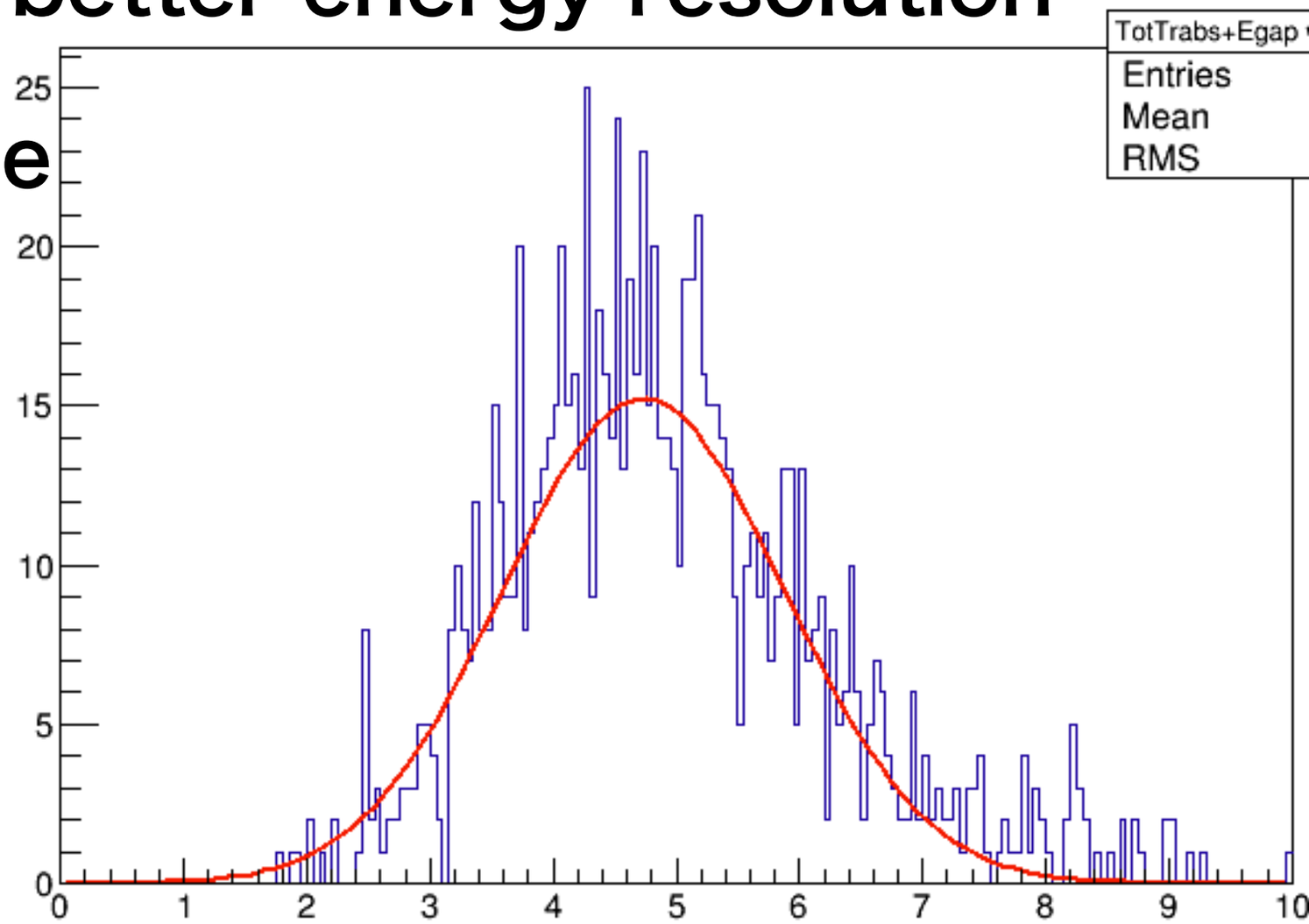
Cherenkov absorber vs scintillator

- clear correlation in number of Cherenkov light and scintillator energy



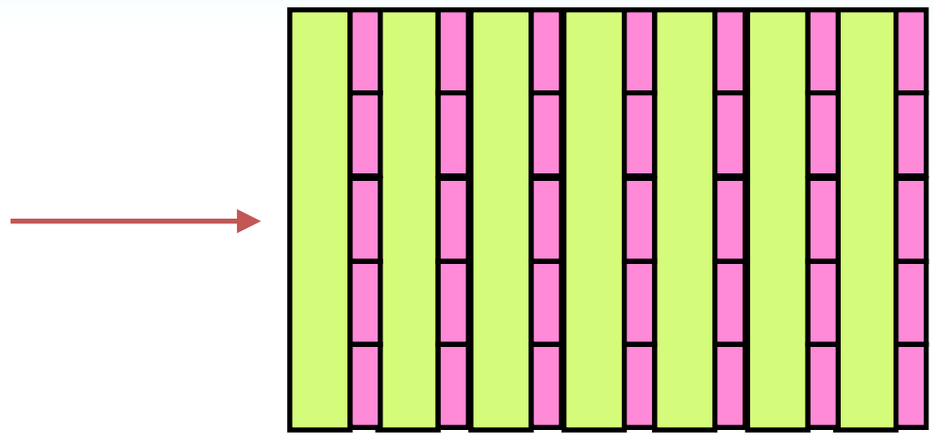
Cherenkov absorber vs scintillator

- clear correlation in number of Cherenkov light and scintillator energy
- sum of both shows better energy resolution
- still need to optimize



PFA+Cherenkov CAL

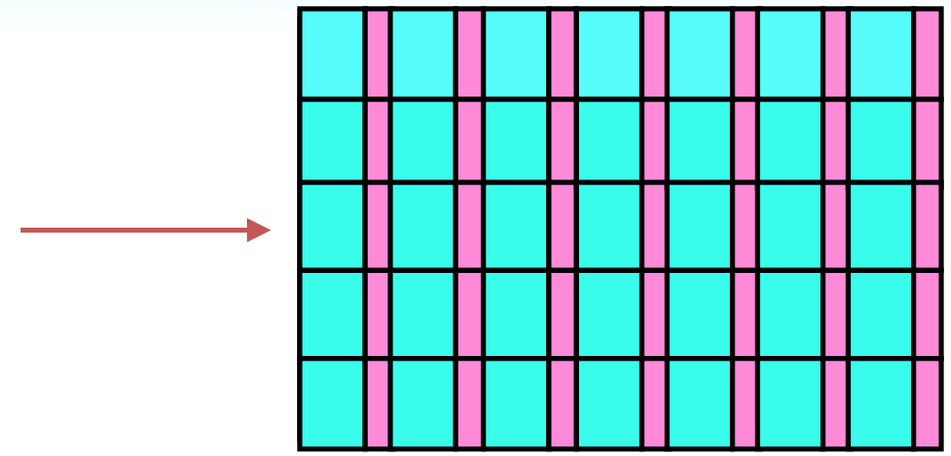
- 3D fine segmented calorimeter



- with segmented active absorber : give more info.
- for Cherenkov light detection
- transparent absorber with thin PPD

PFA+Cherenkov CAL

- 3D fine segmented calorimeter



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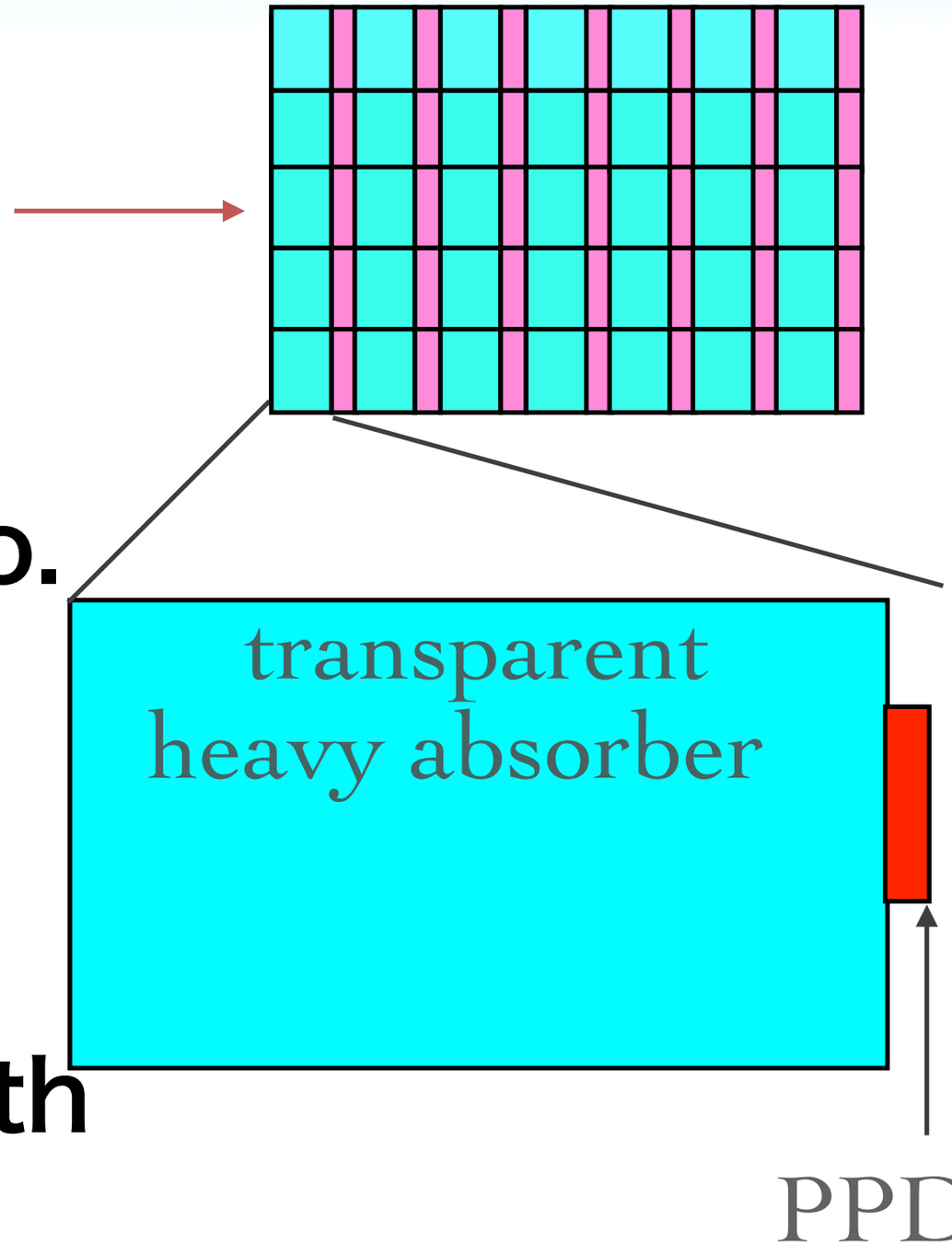
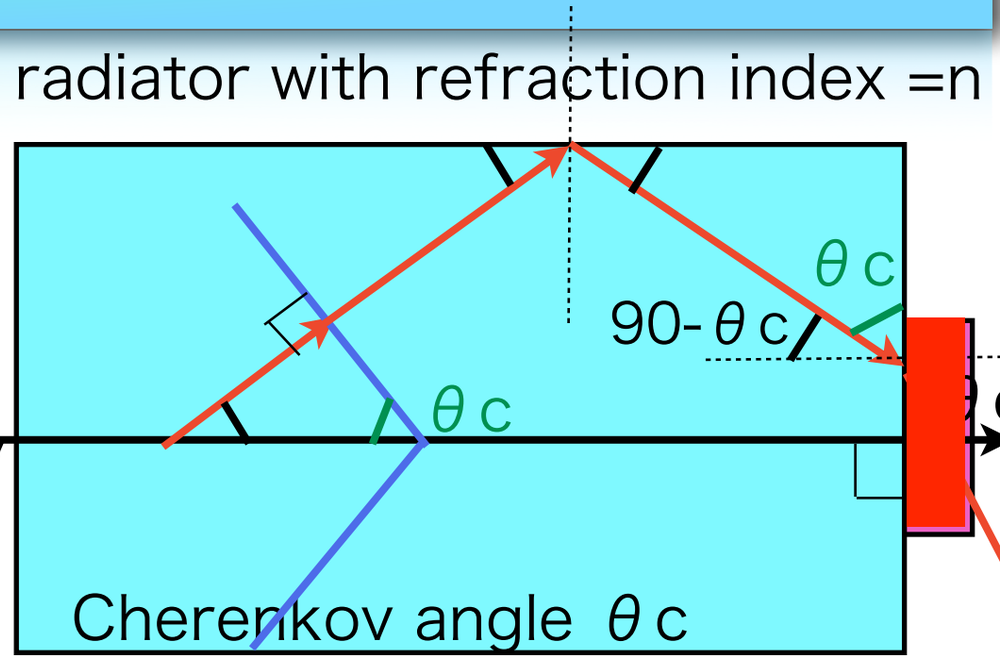
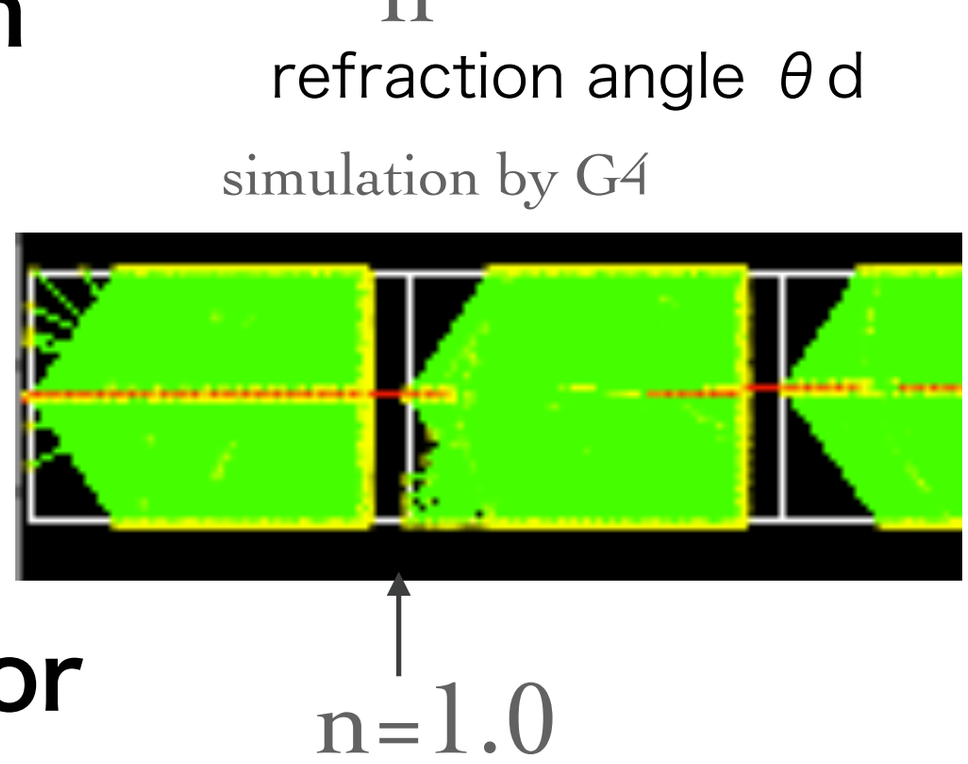


Cherenkov detection

- emitted with θc
- Cherenkov lights produced by particle perpendicular to the detector never extracted from the radiator
- as far as $n_{out}<1.414$
- crucial to have no air-gap between a PPD and the radiator



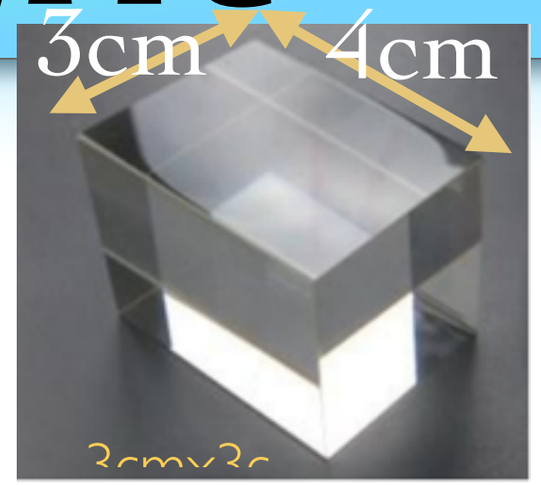


Cherenkov light

- extremely small number of photons than scintillation
- number of Cherenkov photons ~$(1-1/n^2)/\lambda^2$
- higher refraction index n
- short λ emission, however

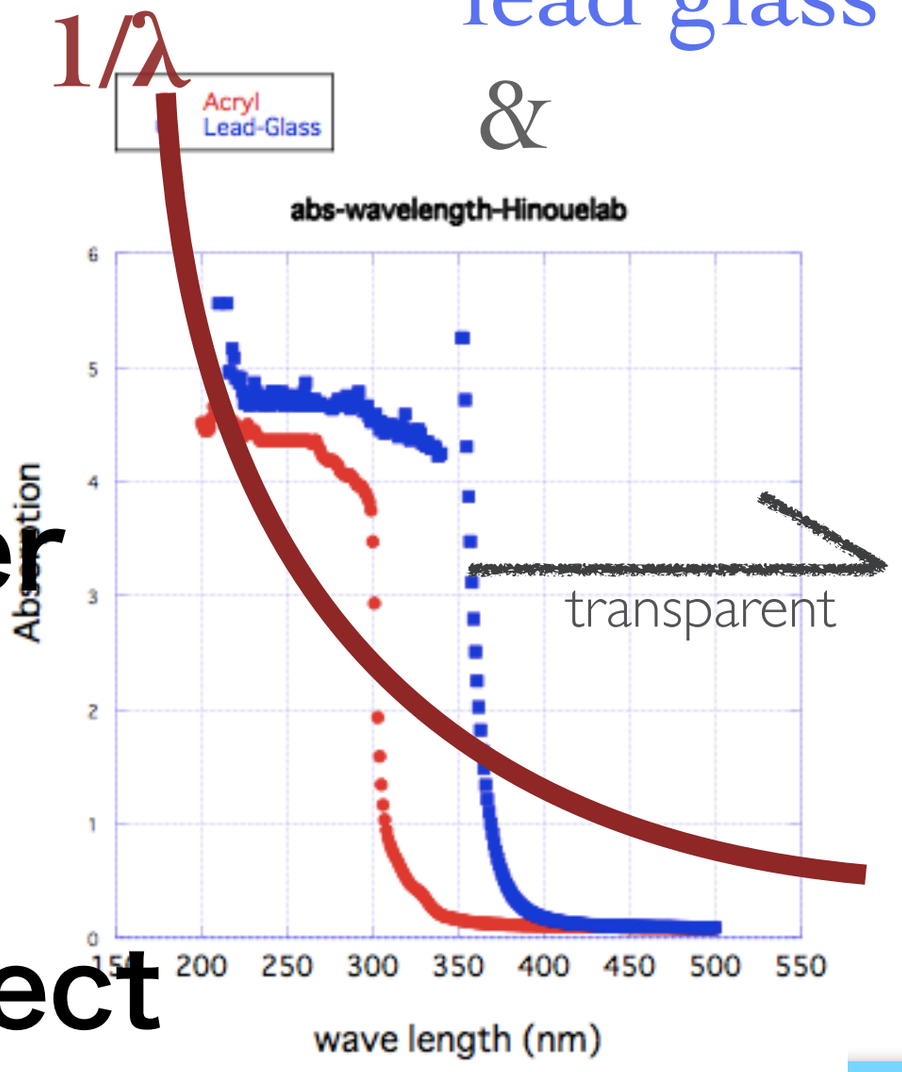
dilemma

- absorbed by radiator
- strong total reflection effect



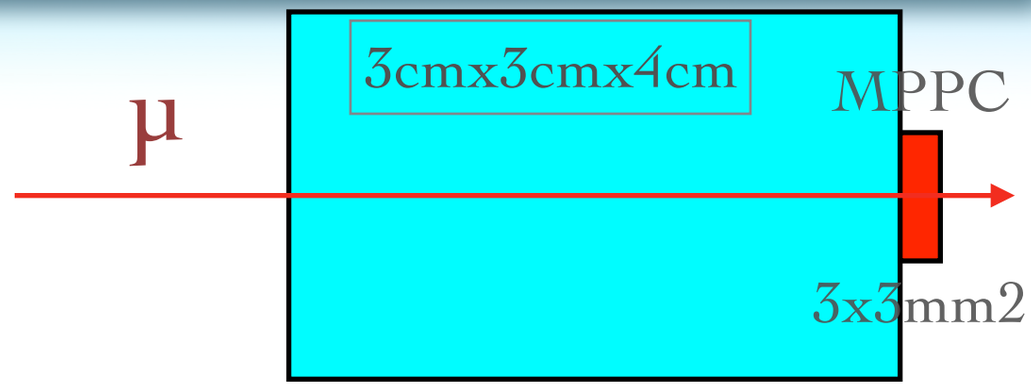
lead glass

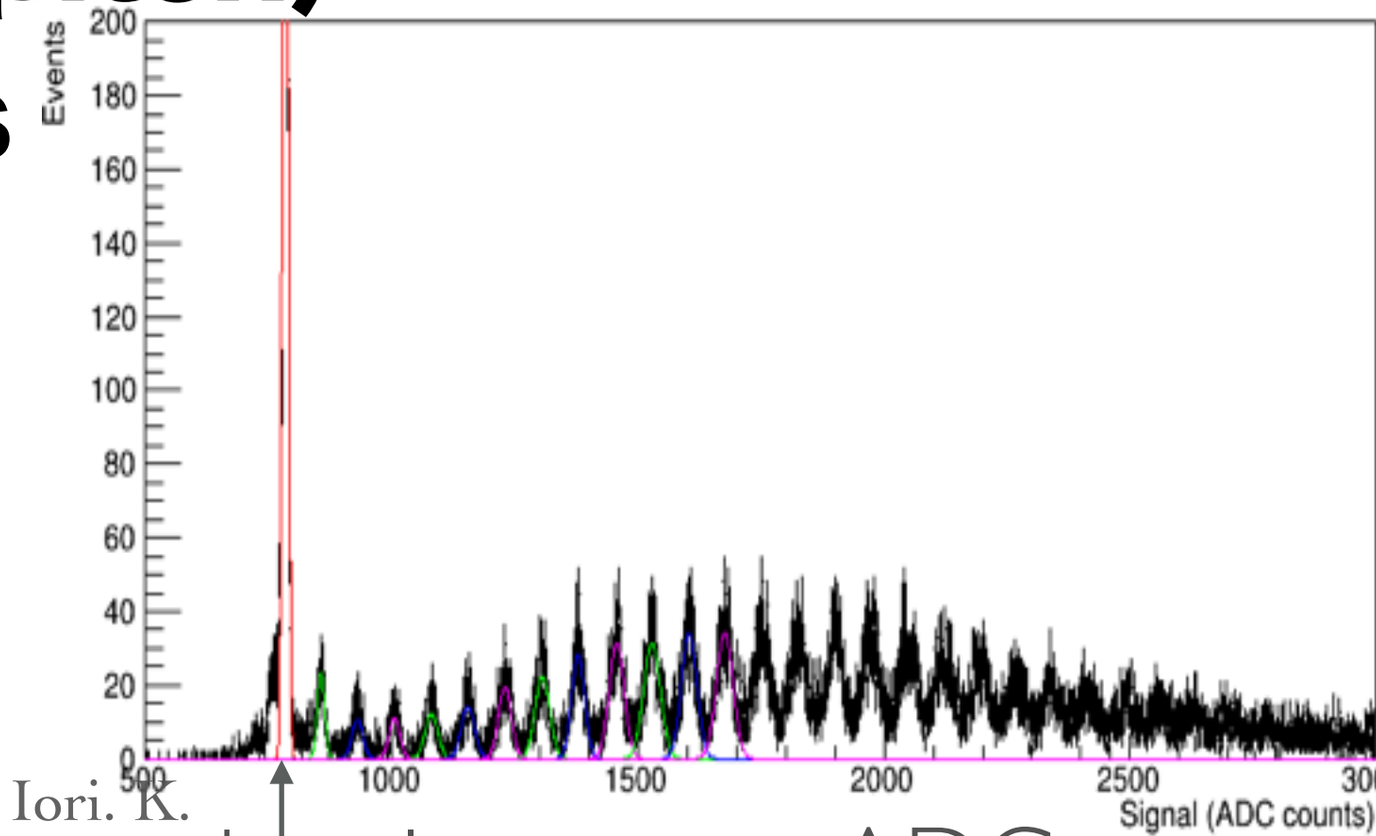
&



Lead Glass at H6

- at H6 CERN Beam
- LG : DF6 3x3x4cm³
- a MPPC (100um pitch)
  3x3 mm² detects
- ~15 p.e./MIP
- with glued





Iori. K.

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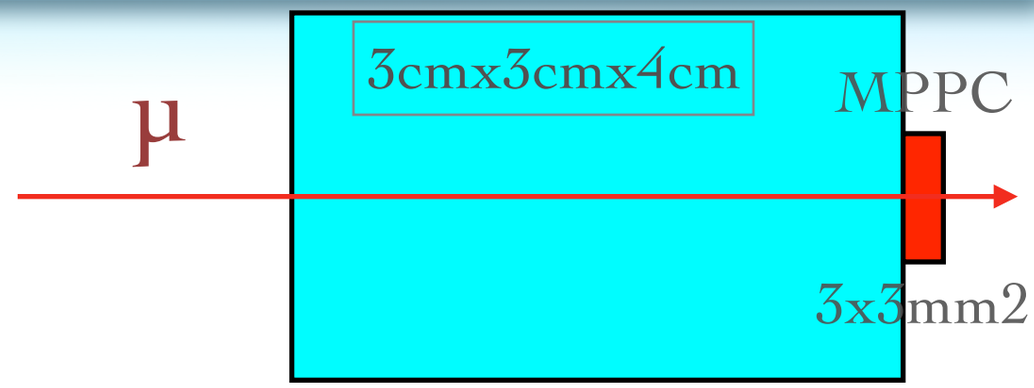
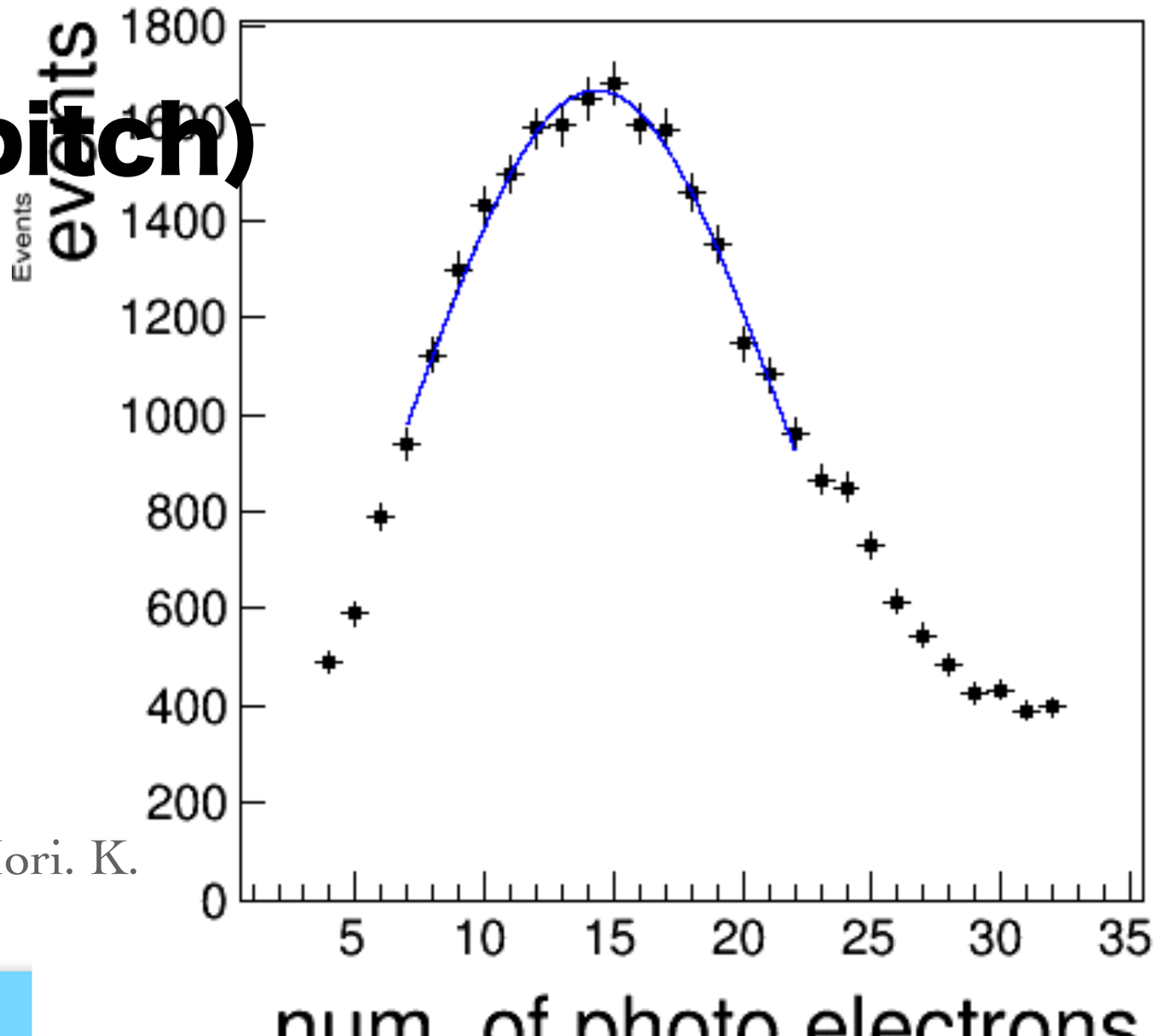
- with glued

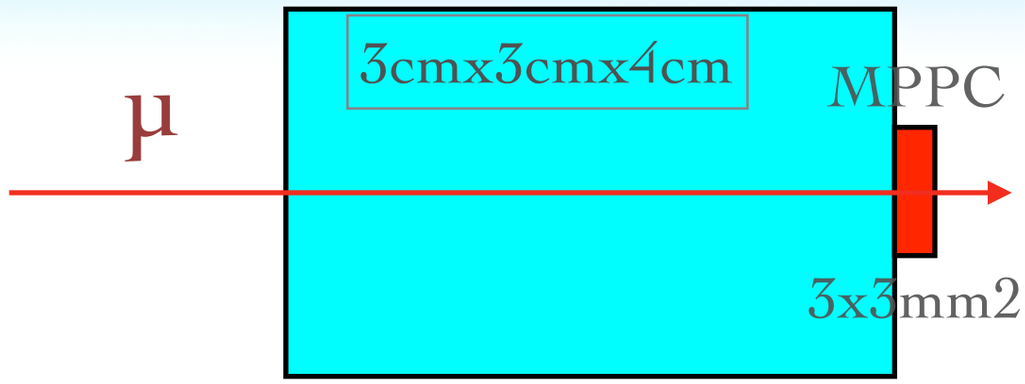




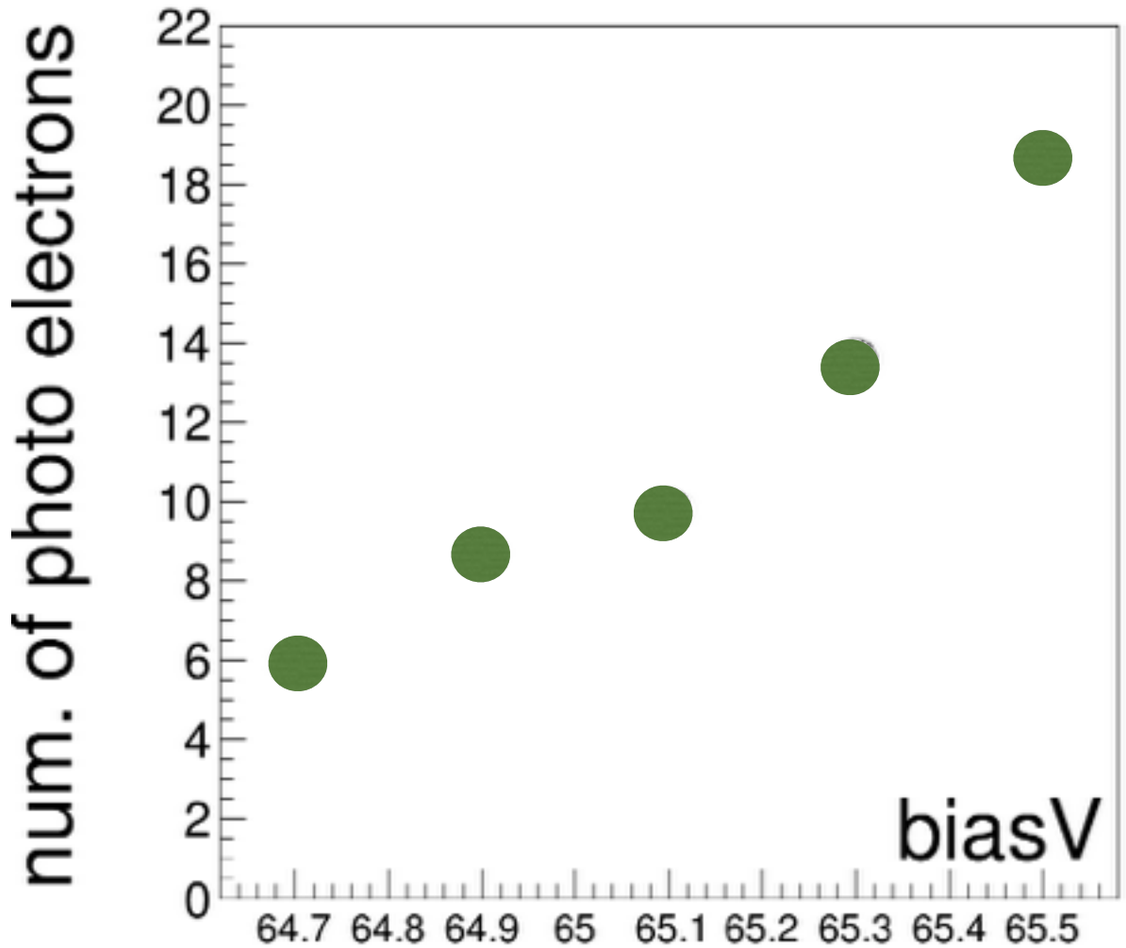
Iori. K.

Lead Glass at H6

- a MPPC (100um pitch) 3x3 mm² detects
- PDE dep. on Vbias
- we can control it

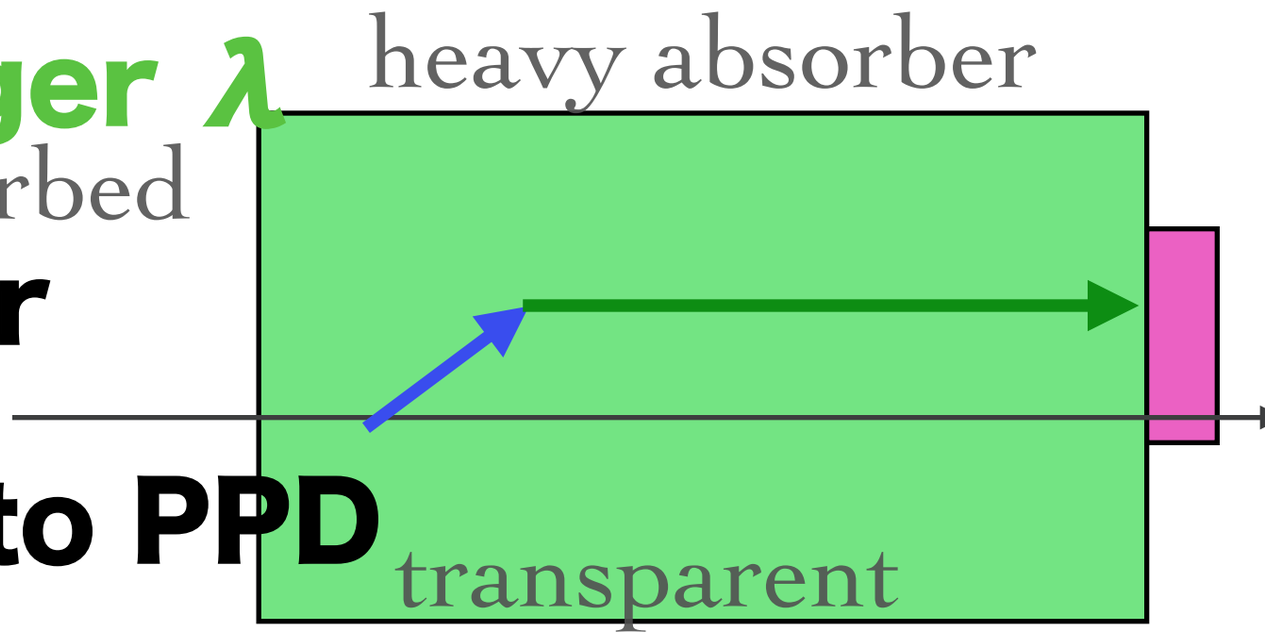


Iori. K.



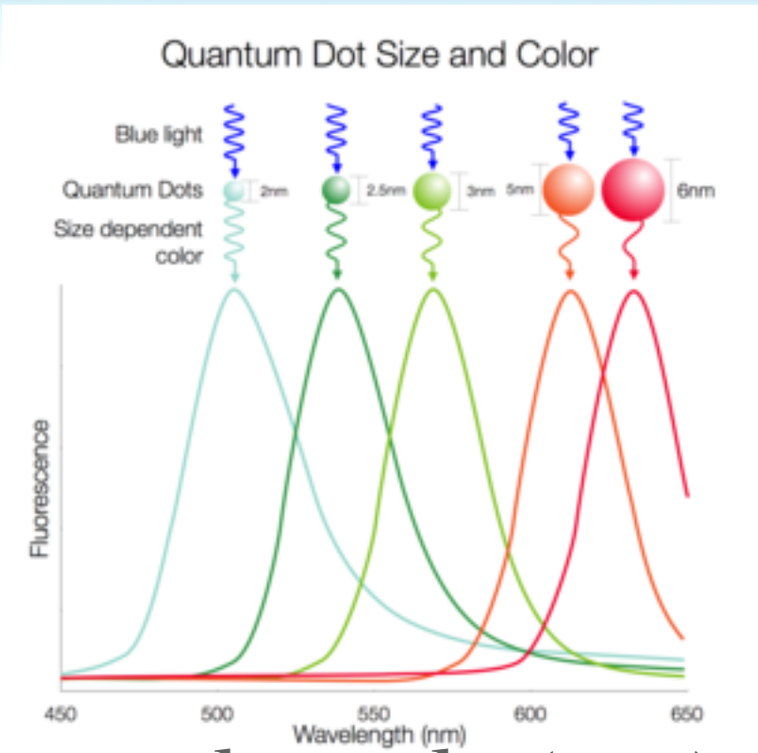
wavelength shifting

- generated Cherenkov light ~1/λ^2
- if we blend WLF material in radiator/ absorber
- short wavelength will be absorbed and
- reemitted with longer λ
- go through radiator
- extracted easily into PPD

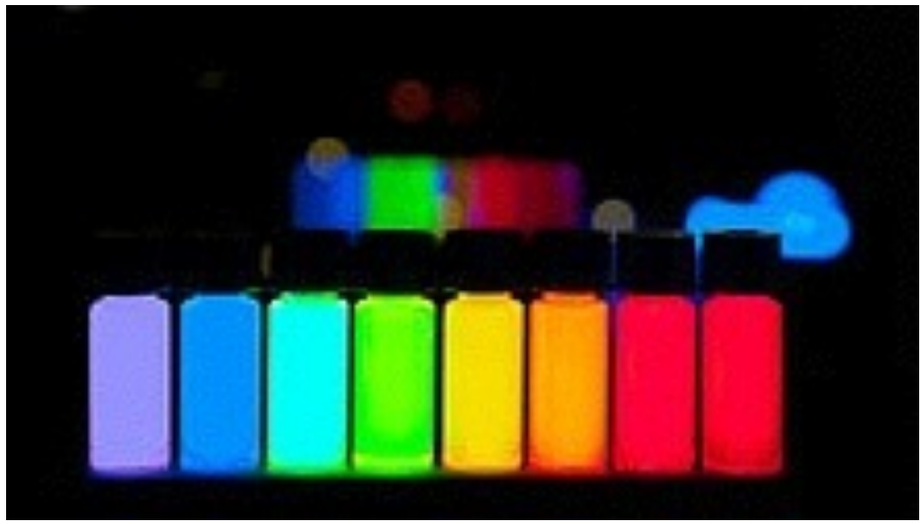


Quantum Dots:QD

- inorganic materialC CdTl/ZnS
- wave length shifting depending on the size
- shift the wave length and direction : air gap is allowed
- could be a film attached directory on the PPD-silicon



wavelength (nm)



http://www.nanosys.com/technology/quantum-dots/

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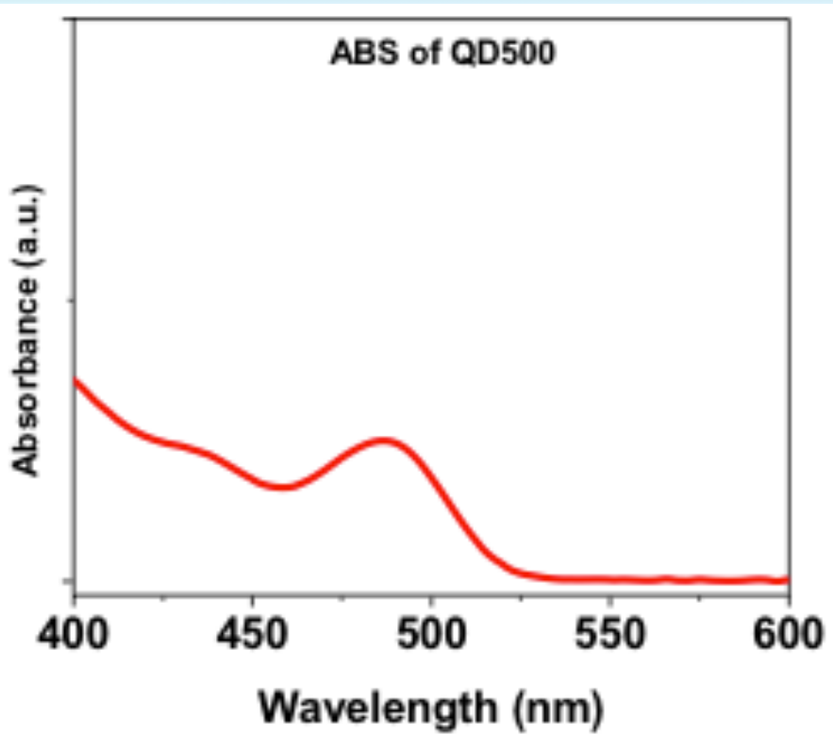

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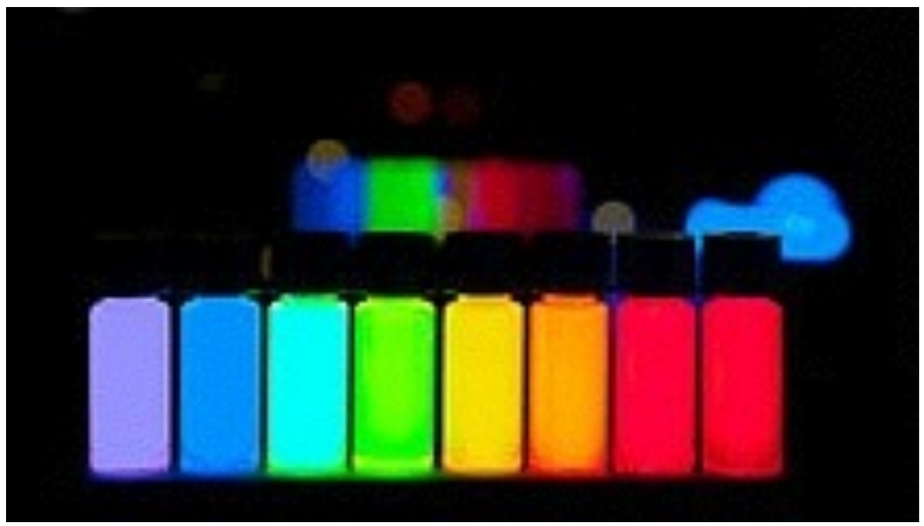
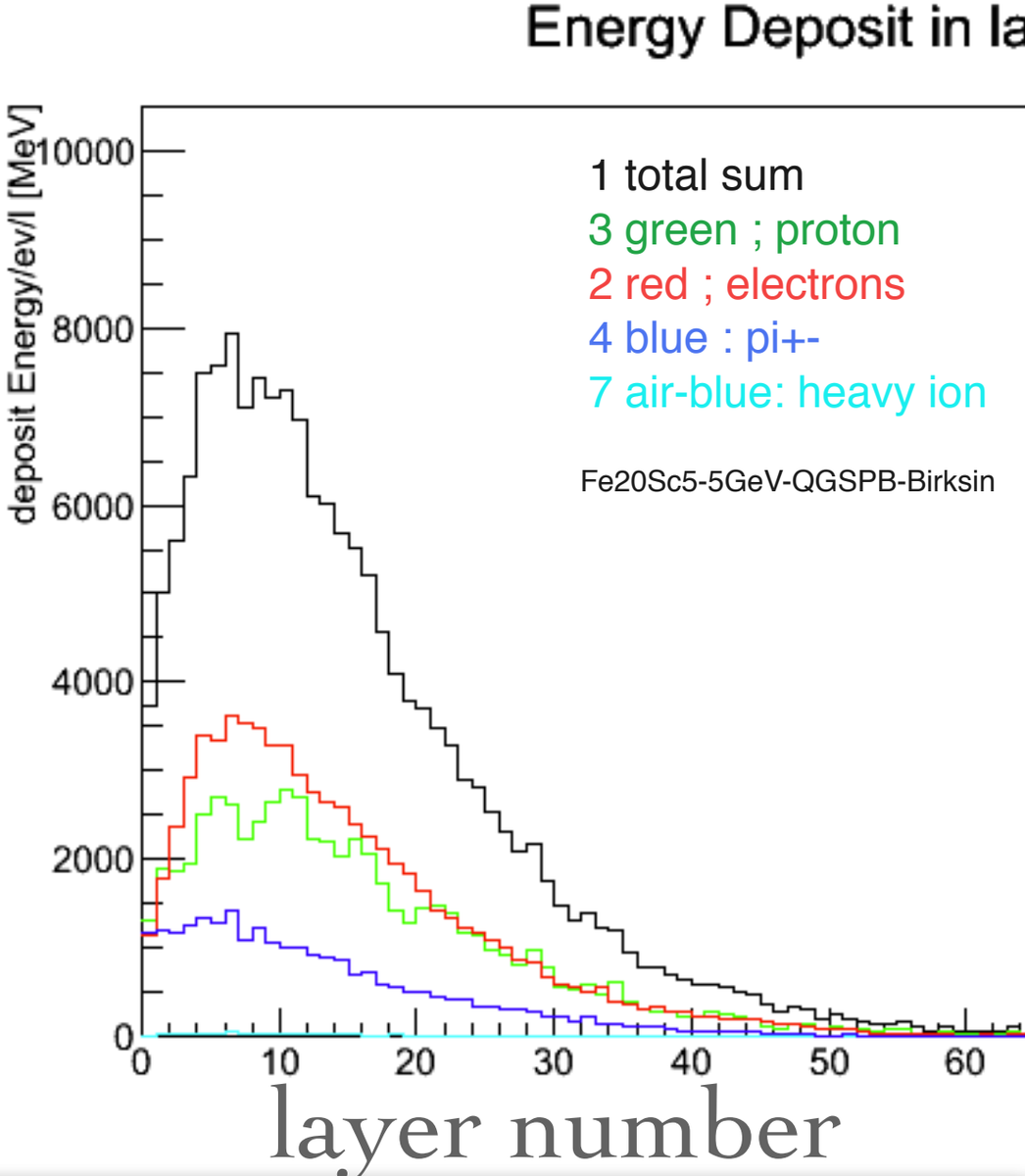


http://www.nanosys.com/technology/quantum-dots/

summery & outlook

- EBU : need more study
  - for next BT, we will prepare diff. configuration for strip & MPPC
- strip HCAL : stHBU ?
- Cherenkov absorber : single track OK
  - need to be combined in clever PFA

active absorber with Cherenkov

- charged and neutral pions
- contribute equally in HCAL