Status of strip scintillator ECAL and HCAL

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(Shinshu)

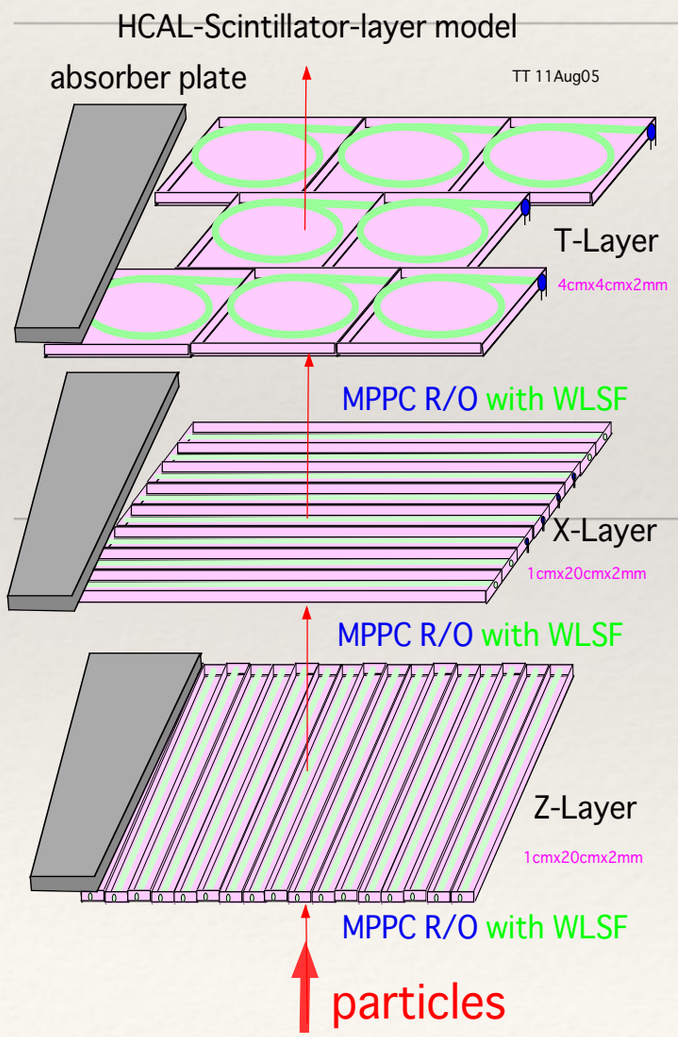
for CALICE

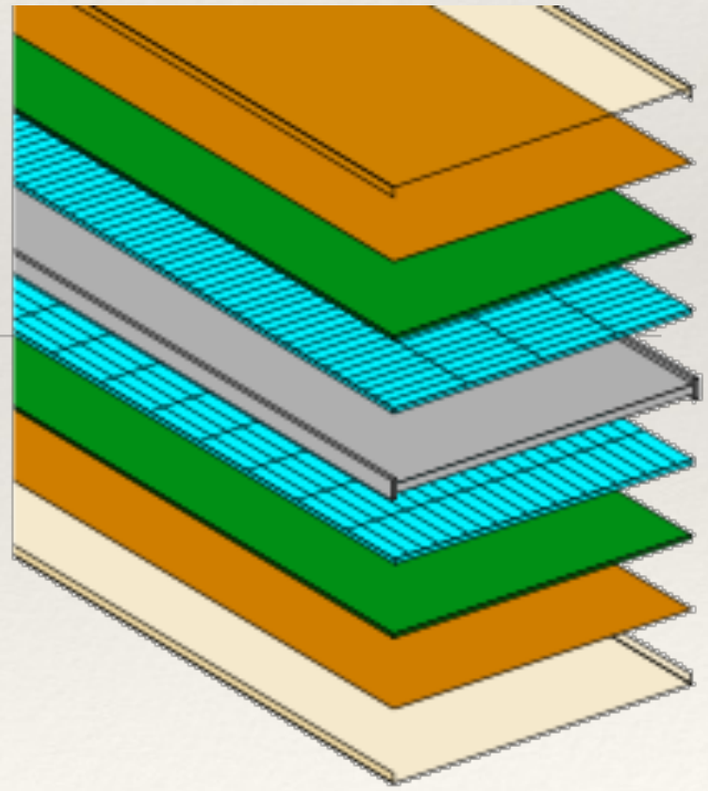
strip scintillator

scECAL progress

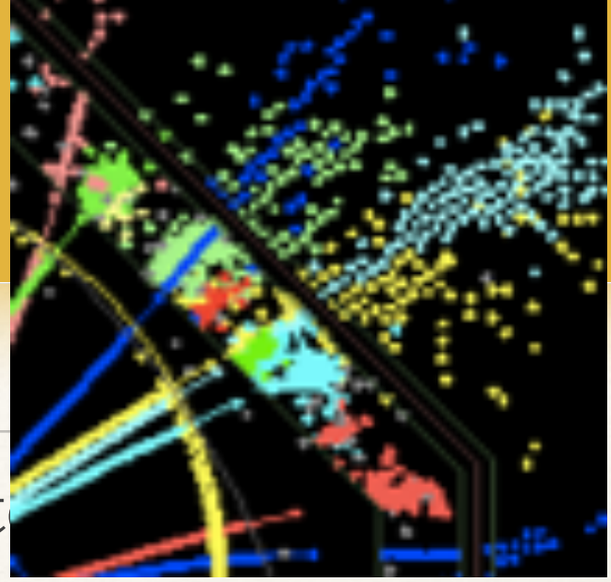
strip HCAL

more on HCAL





PFA requirements

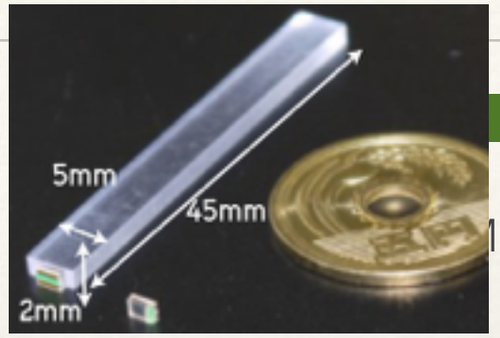


Track/ECAL/HCAL

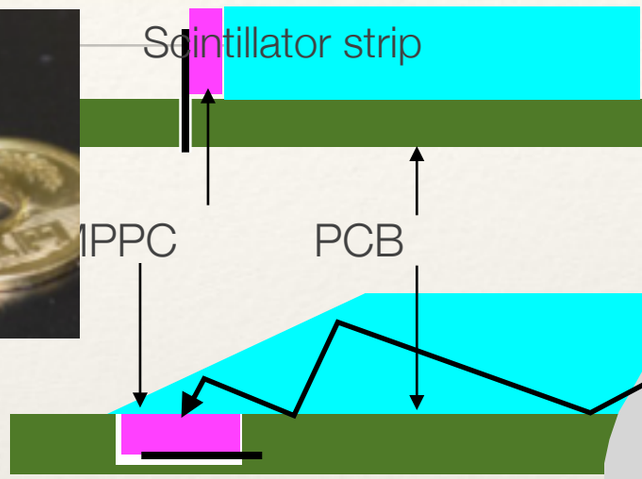
- Jet Energy resolution ~ 3%
- fine segmentation in 3D (longitudinal and lat
- for both ECAL (5mm) and HAL(3cm) : current opt.
- strip scintillator technology can achieve high granularity
- with perpendicular setup for both ECAL and HCAL
- moreover it is able reduce the number of R/O channels ~1/10
- HCAL strip would be 1cm width which is compatible (S)DHCAL
- with analog read out capability ~AHCAL

strip for scECAL

- 5mmx45mm strips direct MPPC readout
- attached at the end side or bottom
- enough light yield
- good uniformity except near sensor

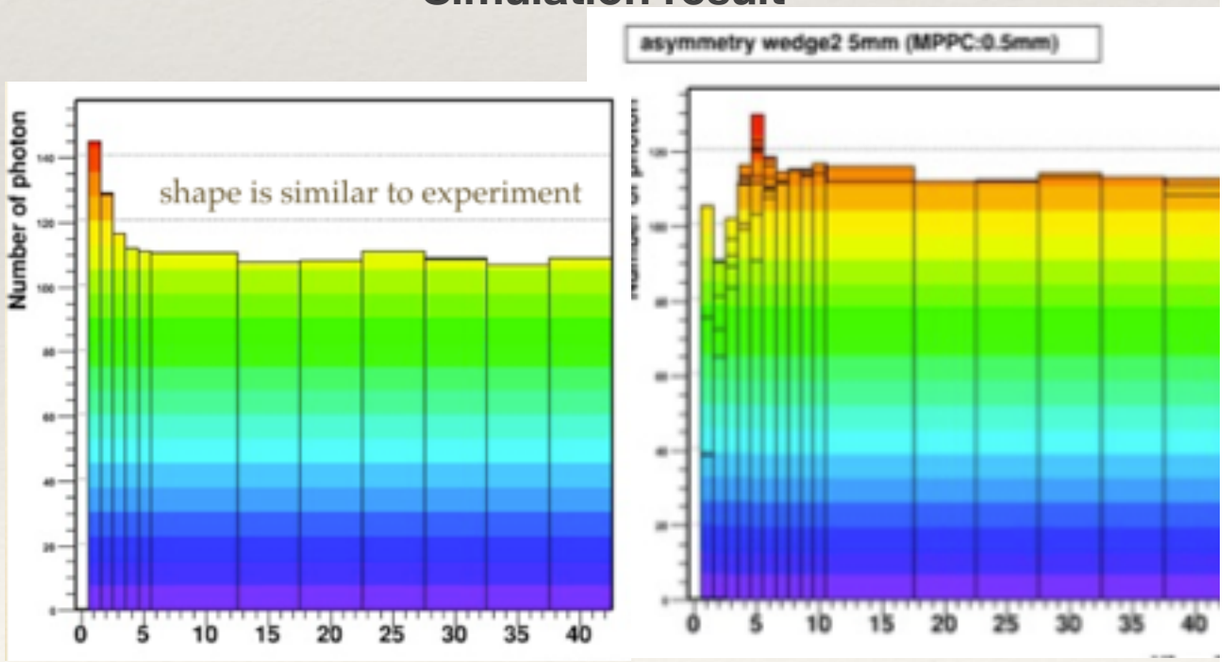


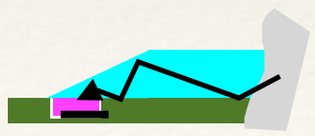
end side R/O



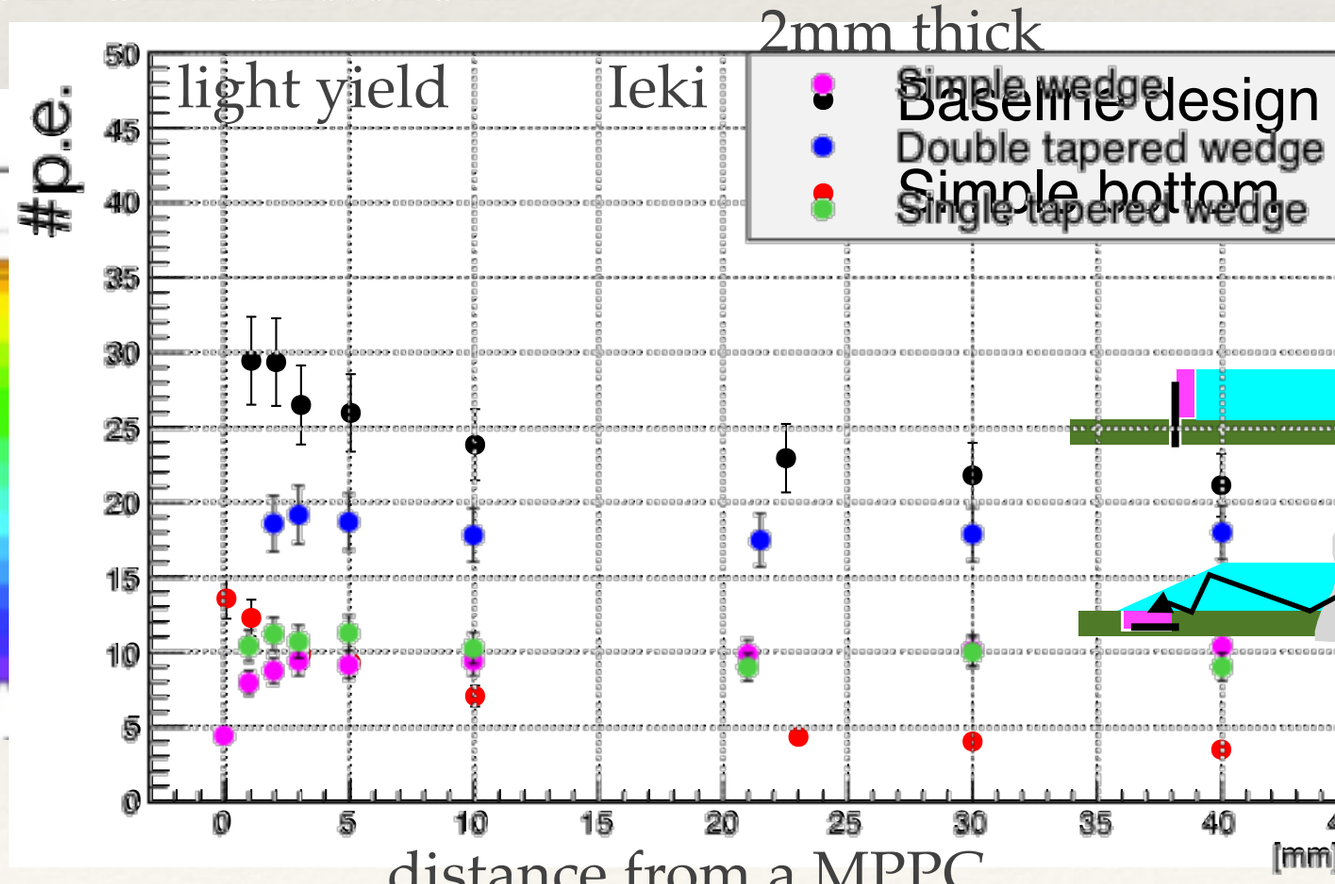
- scintillation light transmission simulation

Simulation result Tsuzuki





bottom R/O
2mm thick

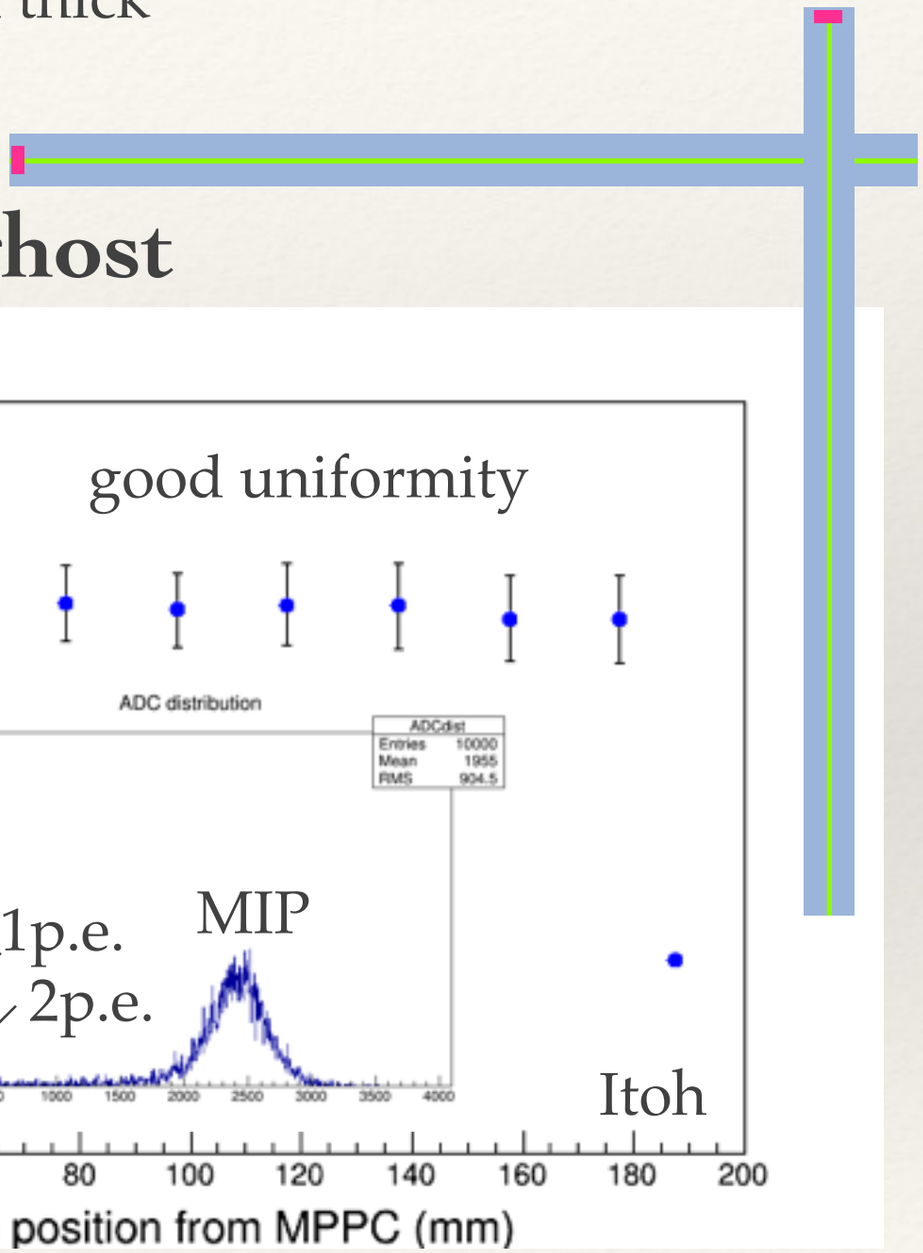


strip for HCAL

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

18cm^2

1cm wide 3mm thick



with camac ADC

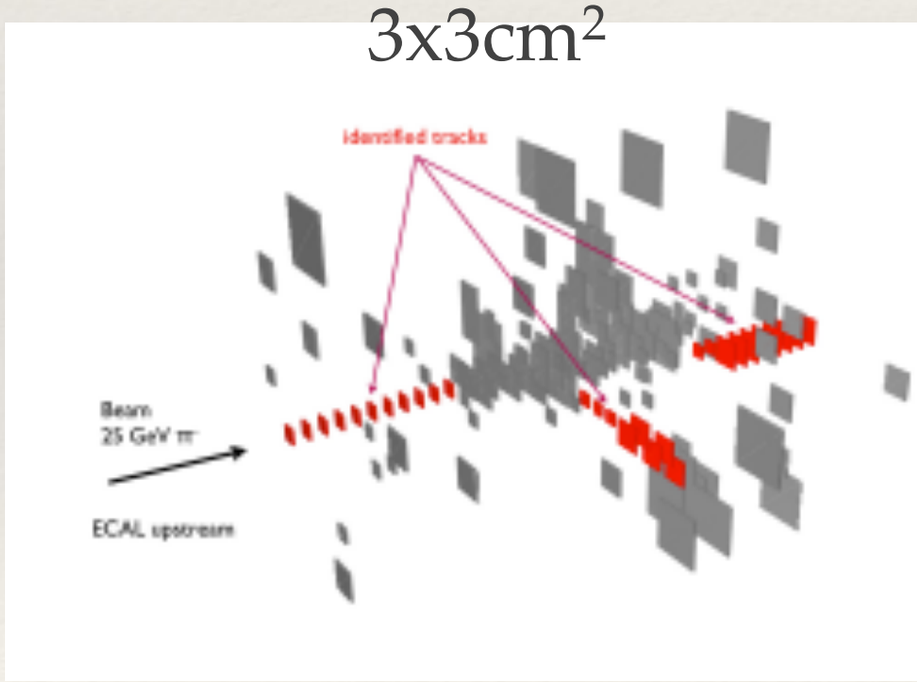
strip HCAL

- fine segmented HCAL looks better for tracking in hadron interaction

- scintillator HCAL is better for EM shower measurement

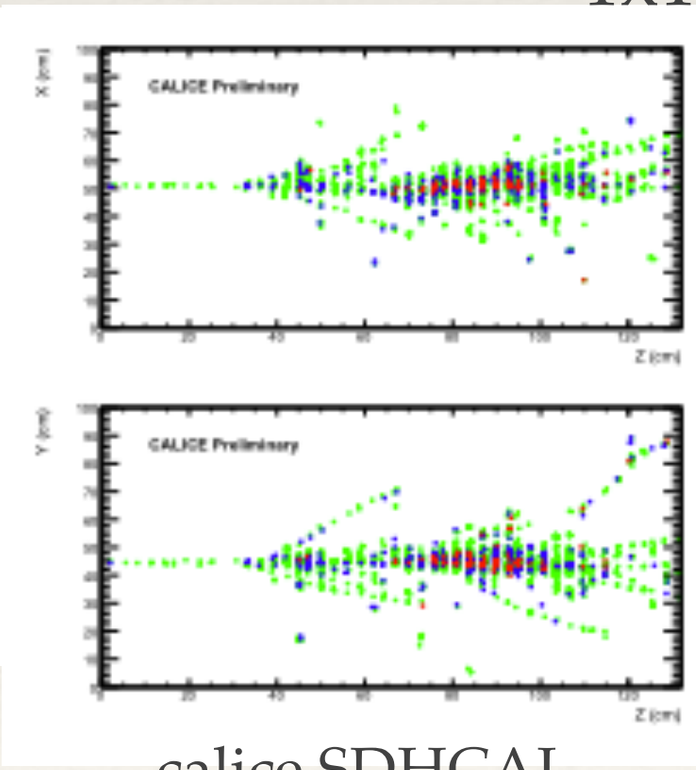
- we do “cherry picking”

3x3cm²

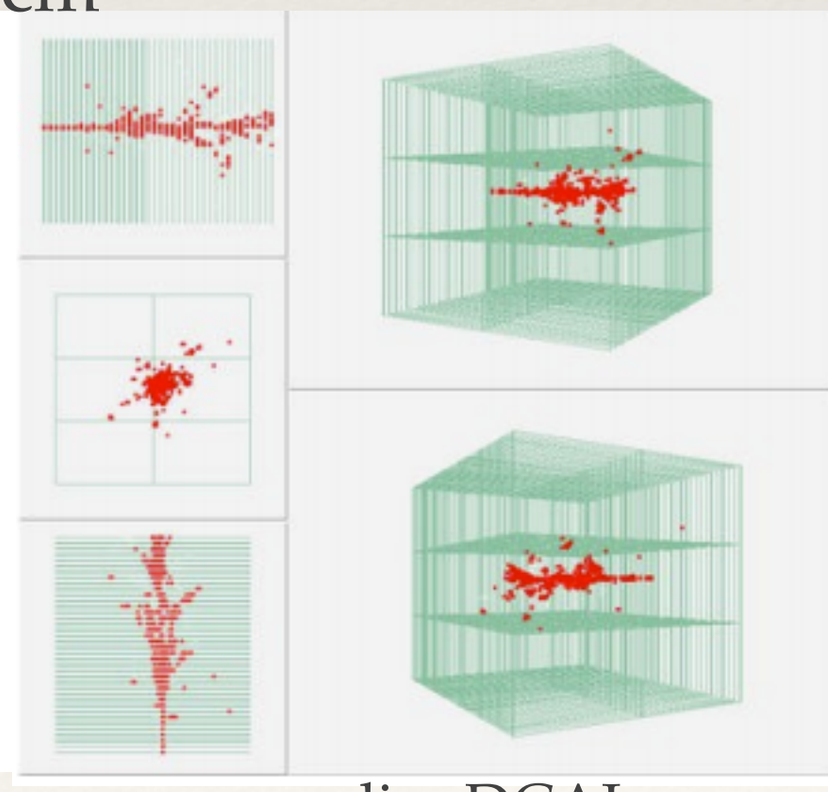


calice AHCAL
25GeV π-

1x1cm²



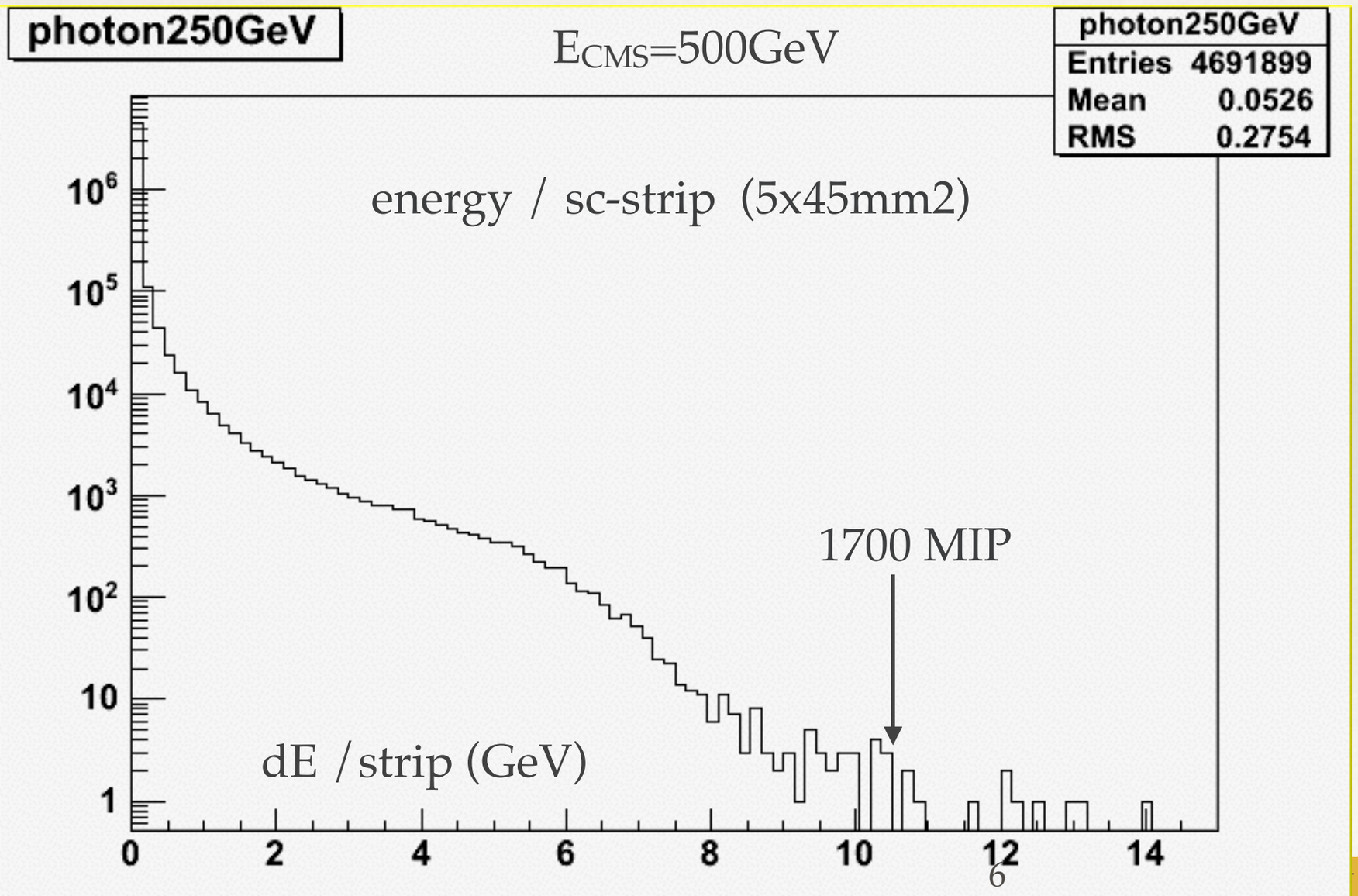
calice SDHCAL
50GeV π-



calice DCAL
16GeV π-

photo sensor for scCAL

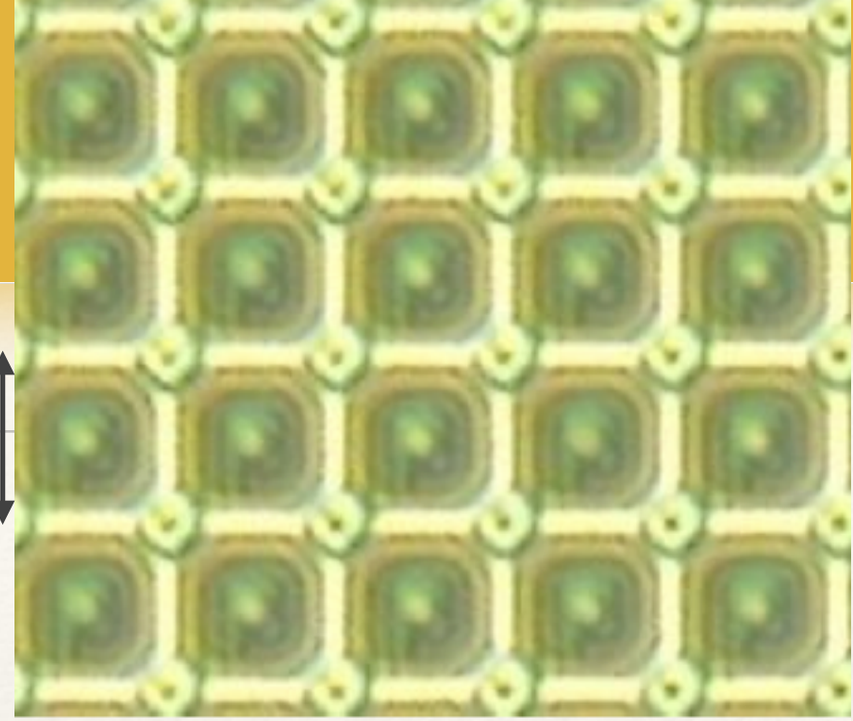
- ECAL need very large dynamic range for number of photons
- MPPC has limited number of pixels which has saturation phenomena with rapid recovery

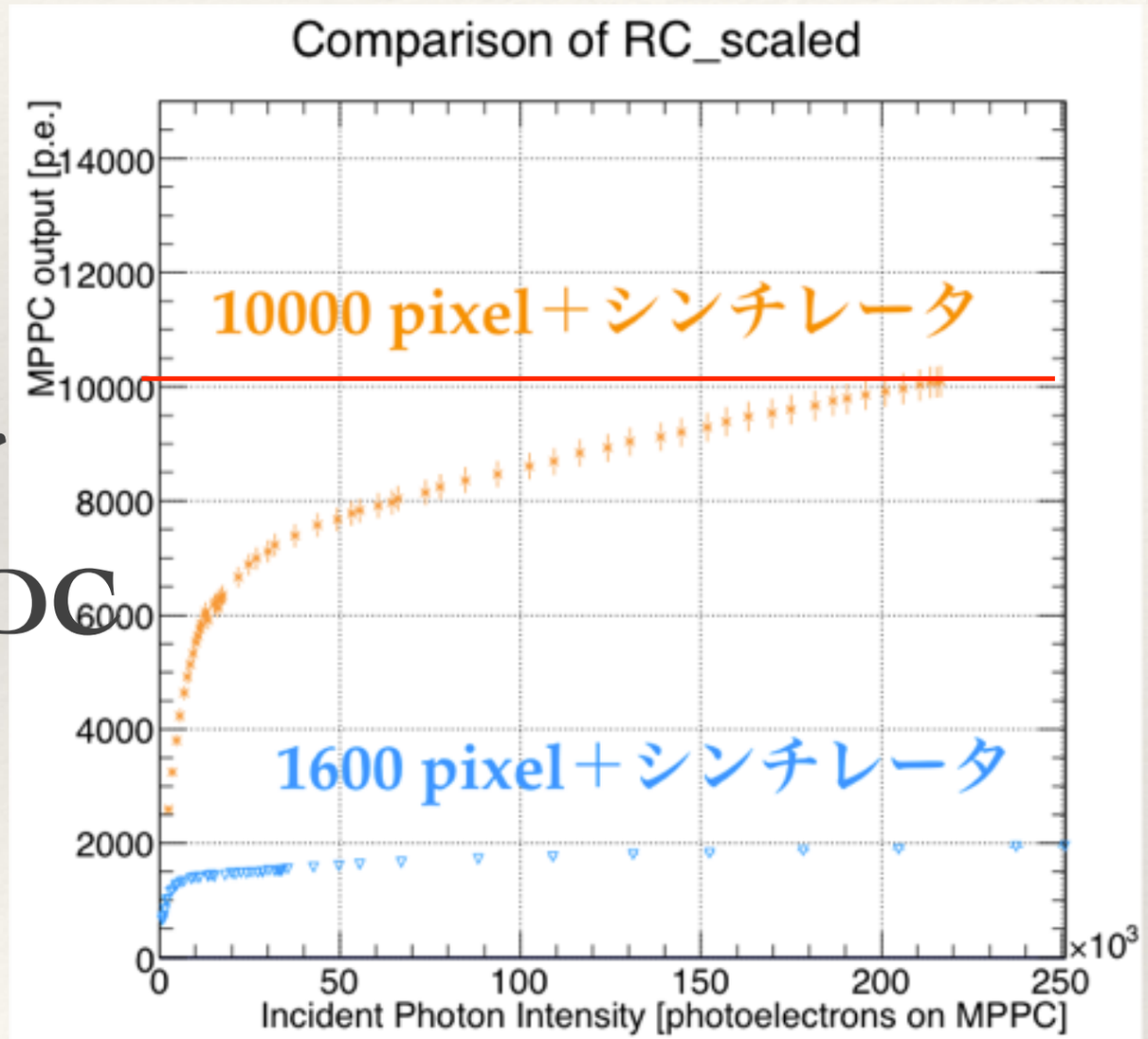


number of pixels in a MPPC should be 10k, when 7p.e./MIP

10k pixel MPPC

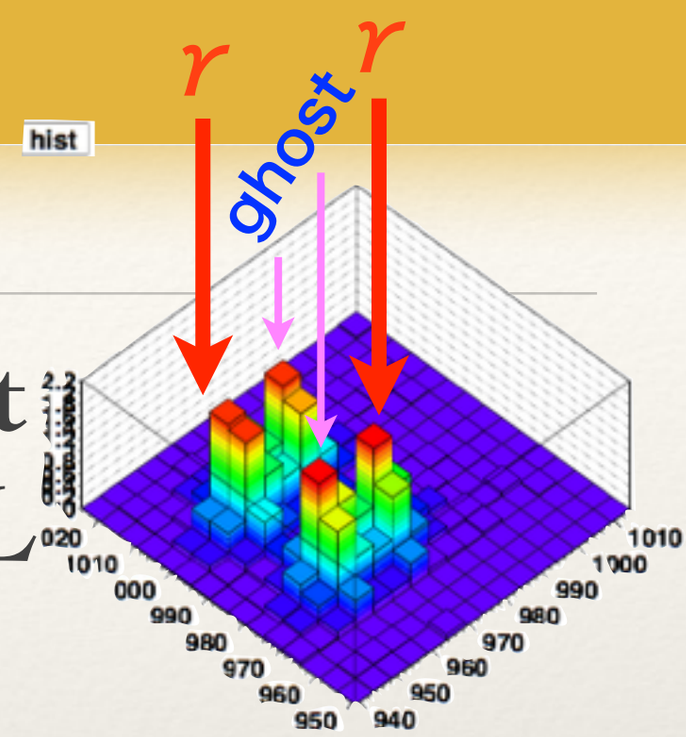
- 10um pitch MPPC in 1mmx1mm
  - =10k pixel MPPC
- response with scintillator is measured
  - reached ~ 10000 p.e.
- signal is significantly smaller
  pixel size is small, small C
  - need careful signal amp/ADC
  - current SPIROC2 facing difficulty

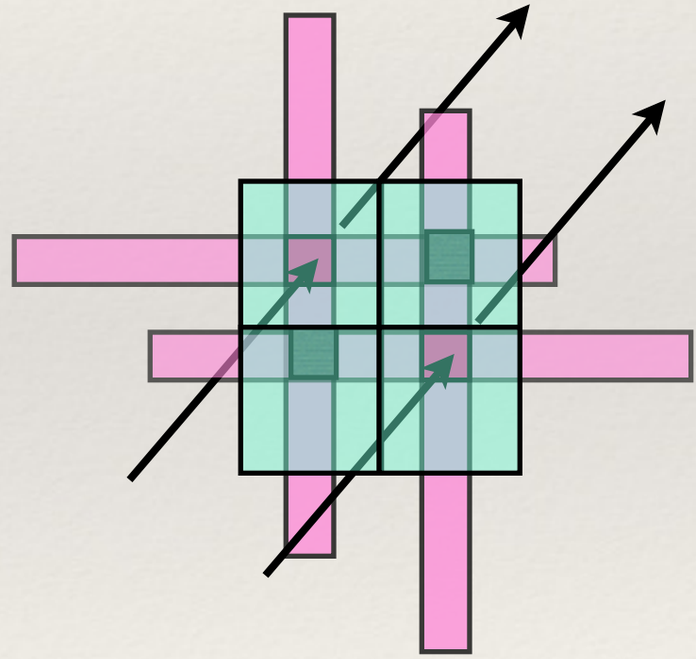




strip problem

- ghost
- strip calorimeters suffer from ghost problem for both ECAL and HCAL
- ghosts appear when multi-particle passing near by
- ghost can be avoided by introducing tile layers
  - size of the tile depends on the strip width

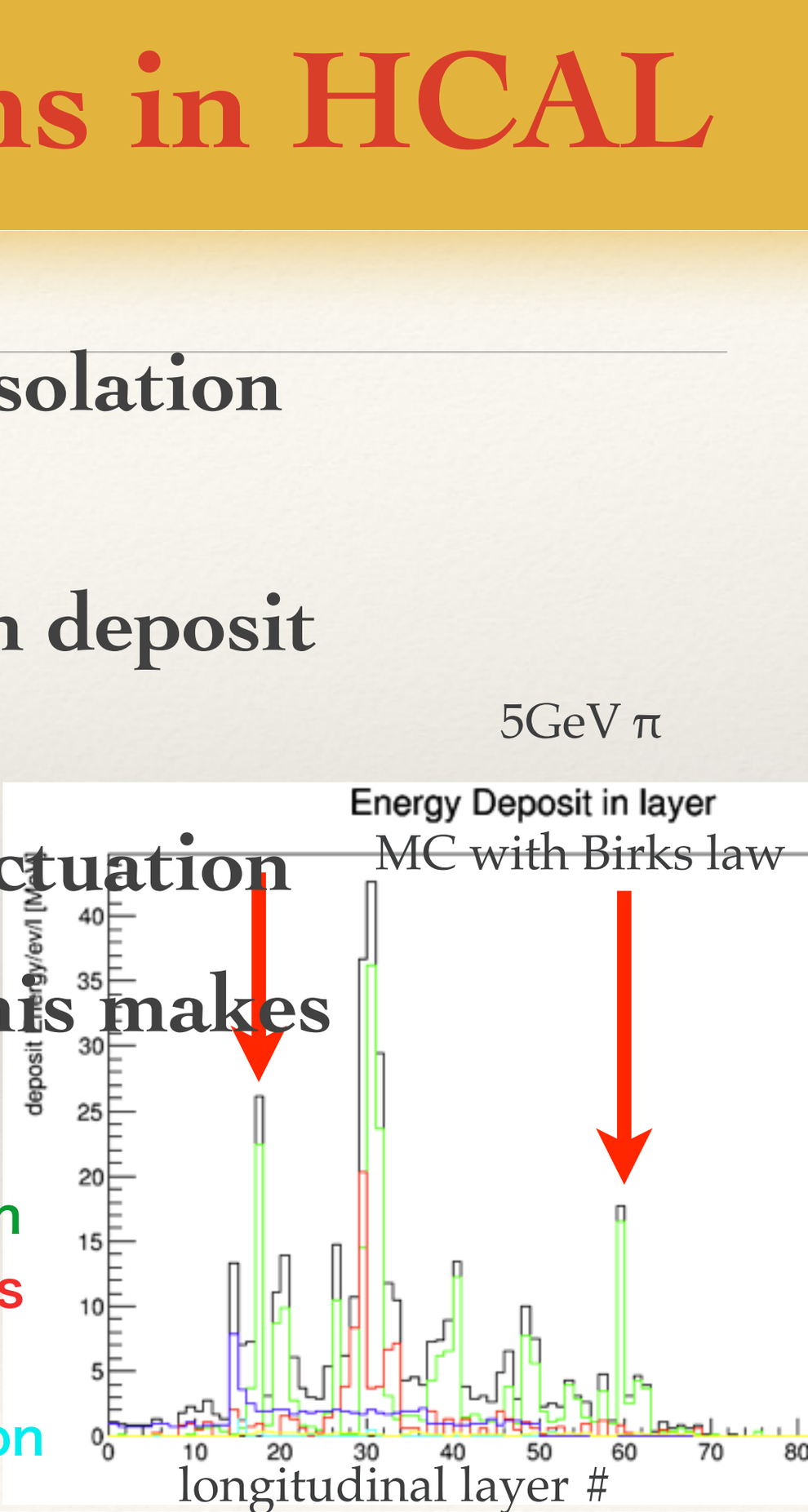




scintillator problems in HCAL

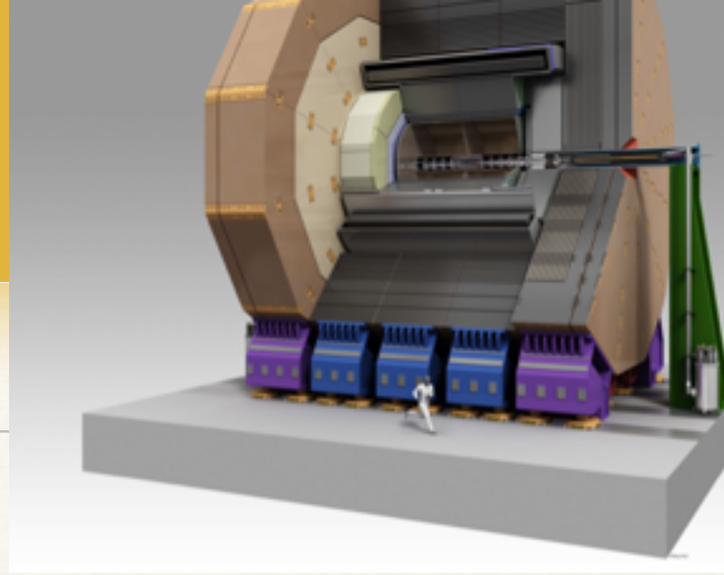
- **neutron** rich events
  - can be removed by time and isolation cuts
- low energy / slow protons which deposit **huge energy in a strip/tile**
- significant contribution to fluctuation
- must be removed, however this makes
- total energy smaller
- under study

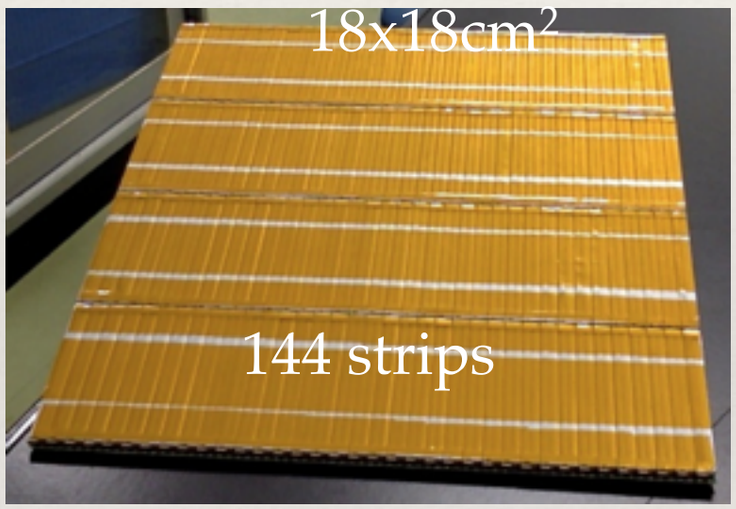
5GeV π

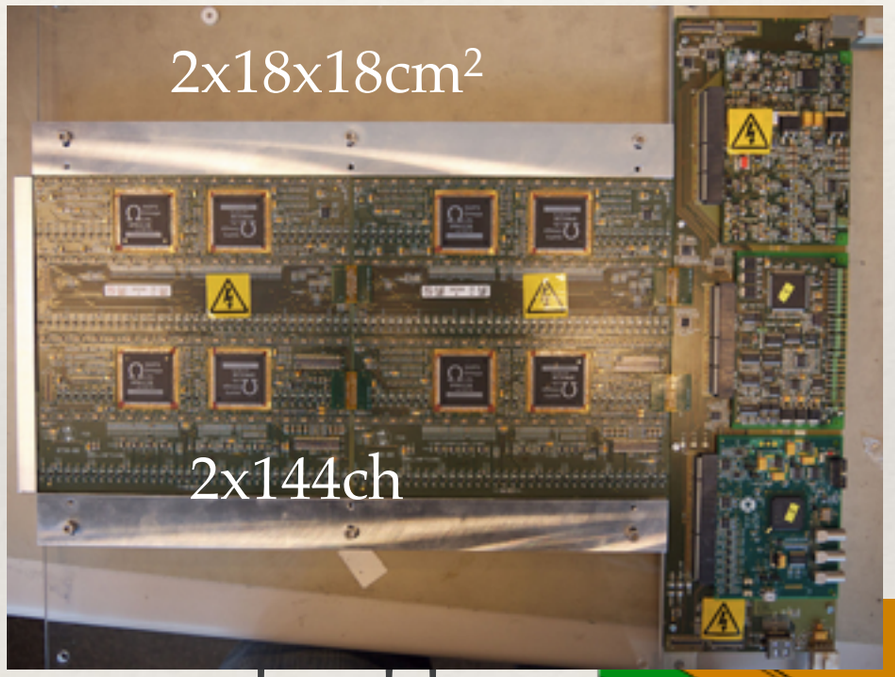


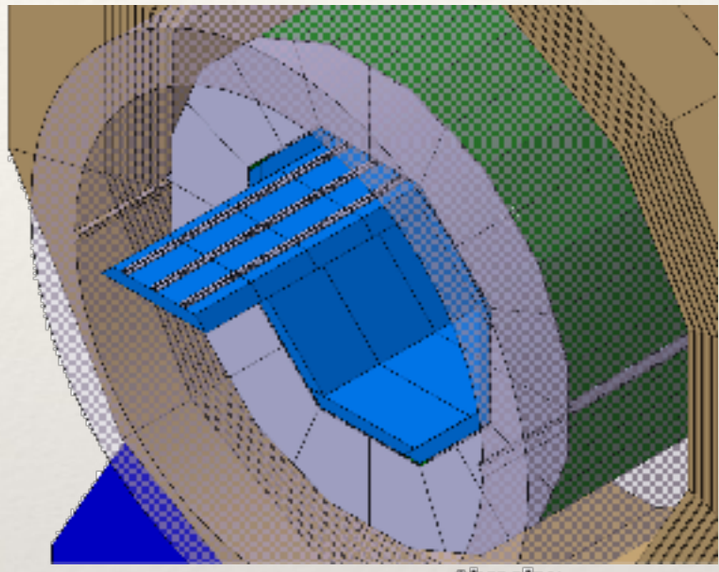
strip scECAL status

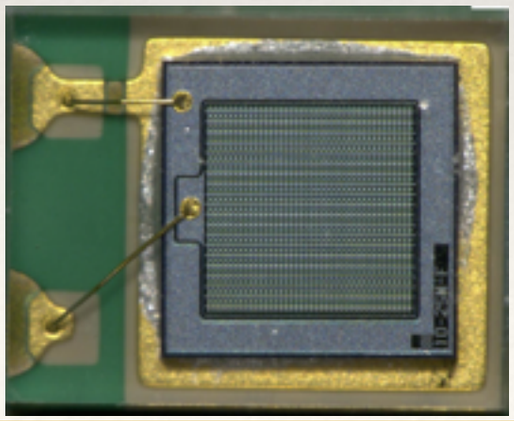
- integrated layers are being tested
- with scintillator strips and the read out electronics
- with 10k pixel MPPC of 1x1mm^2

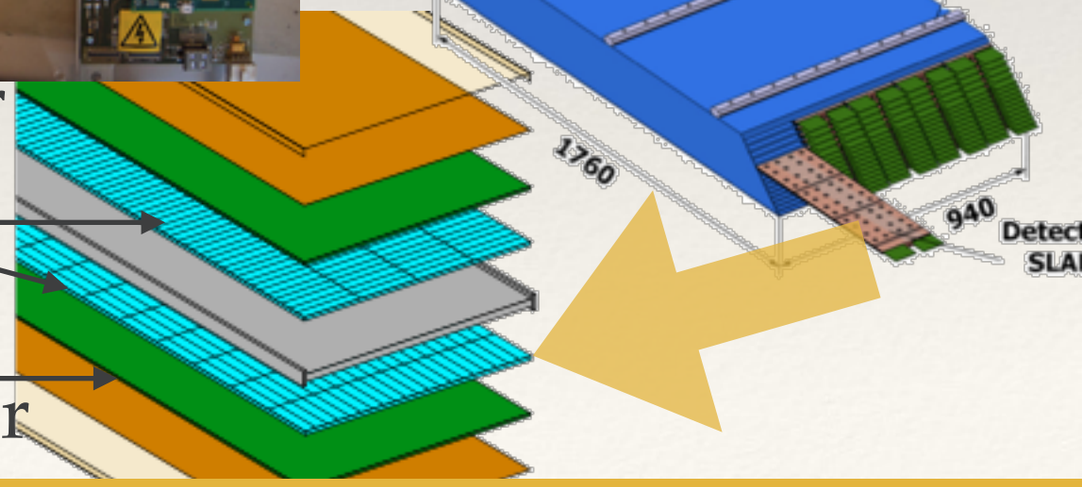






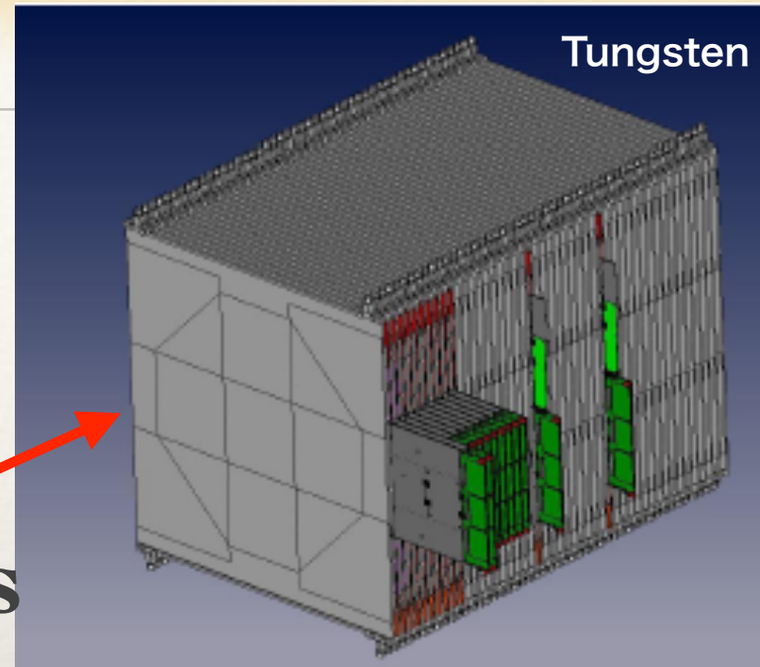


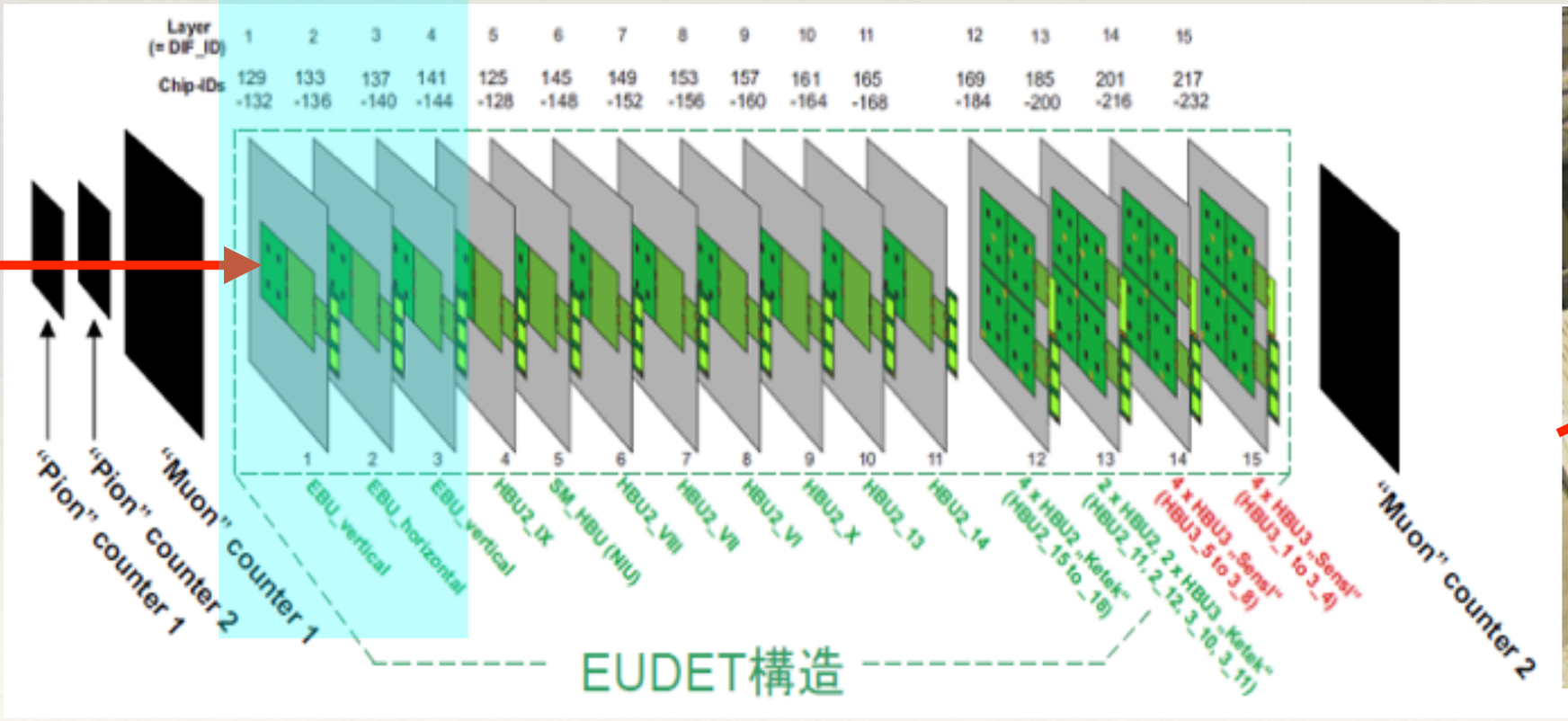




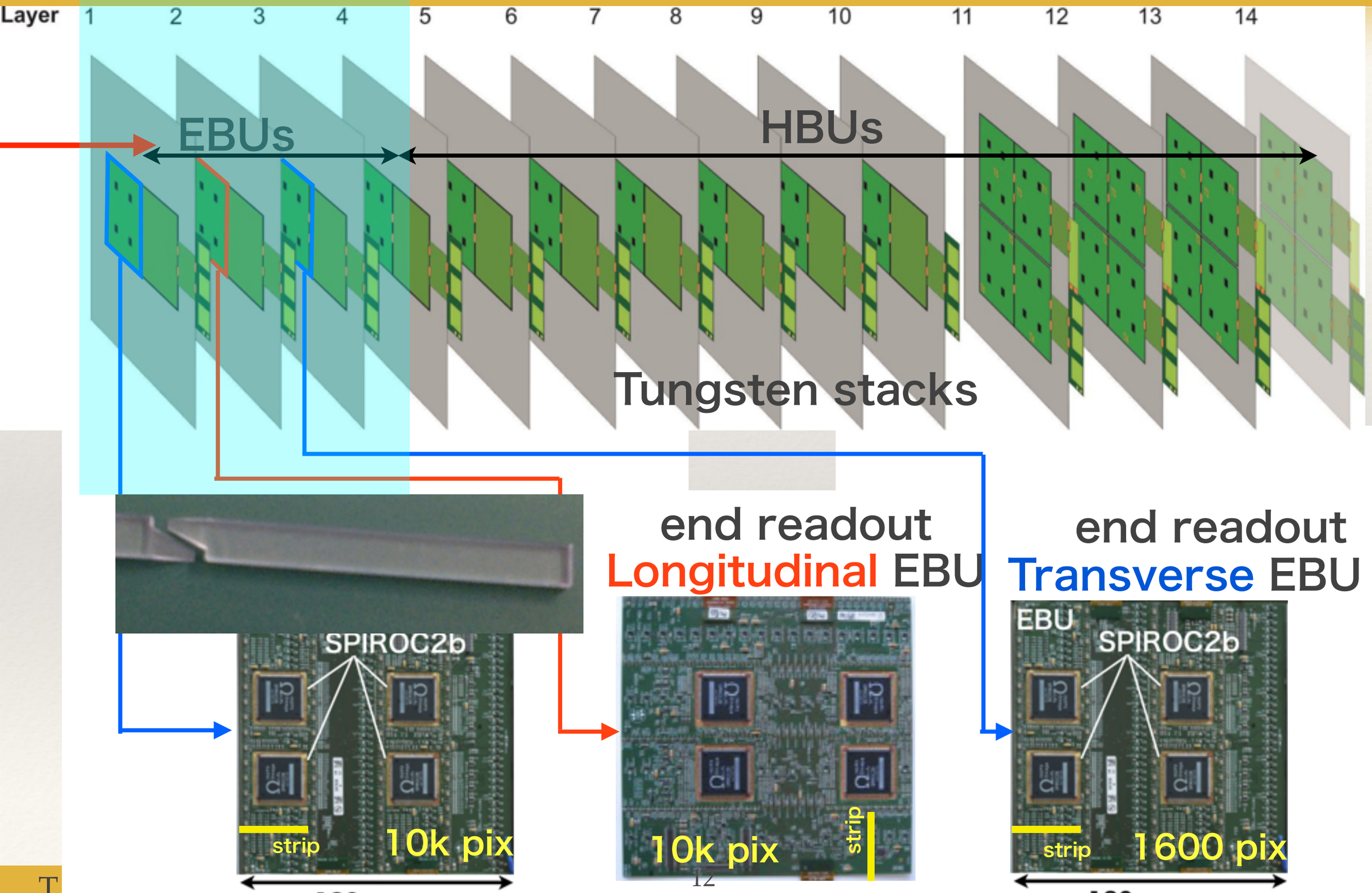
strip scECAL test at CERN

- together with AHCAL in absorbers
- 2014 at PS T20 with steel and 2015 at SPS H2/6 with tungsten
- 3 ECAL layers & 12 AHCAL layers



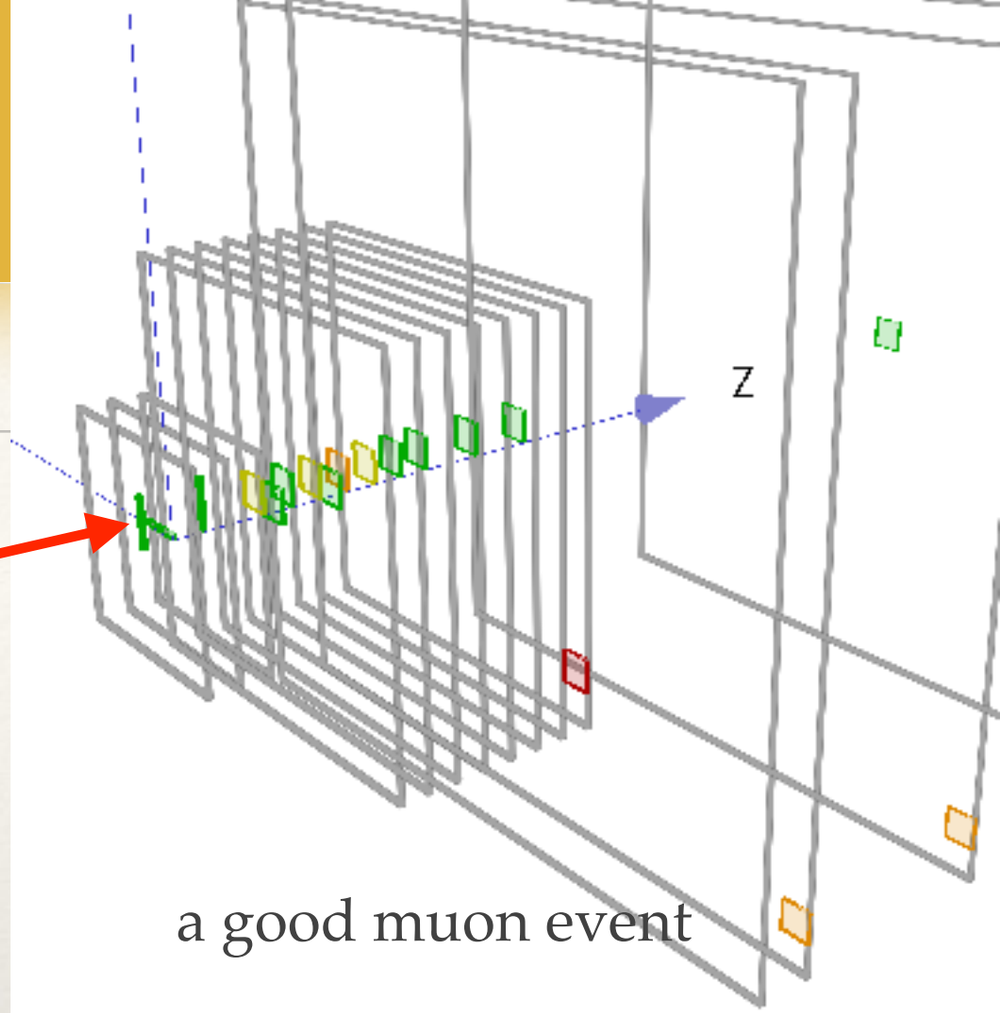


strip scECAL unit : EBU

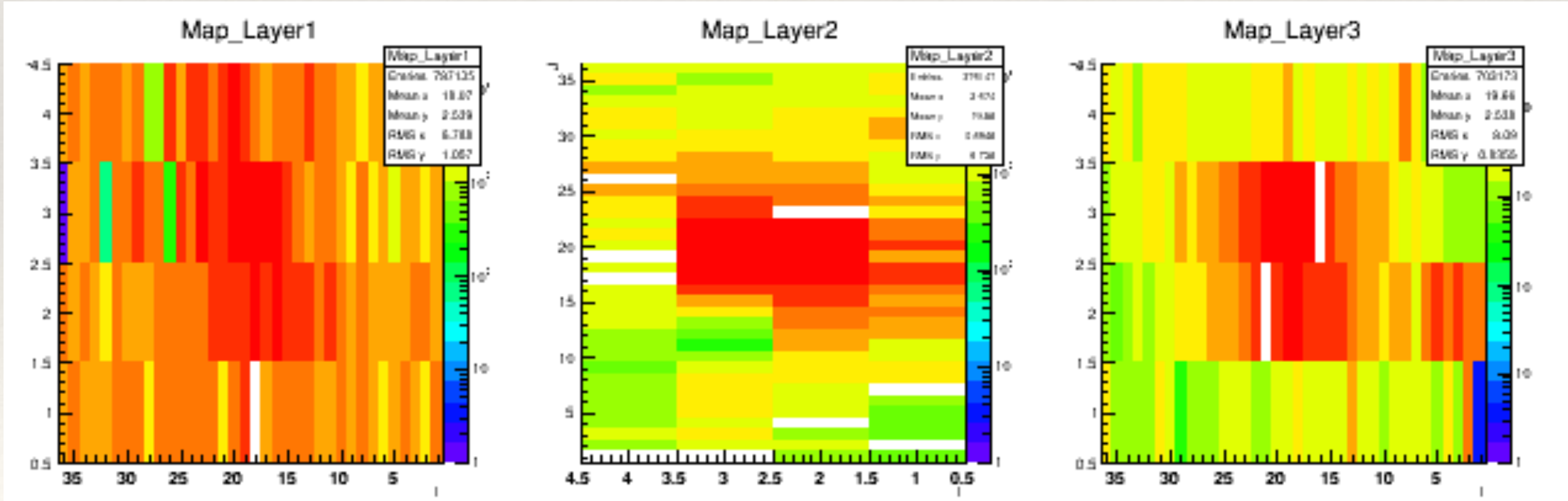


scECAL layers

- online hit maps at CERN/SPS
- for muon calibration
- layer-1 is a bit noisy due to low thresholds 144strips/layer
- further analysis is on going

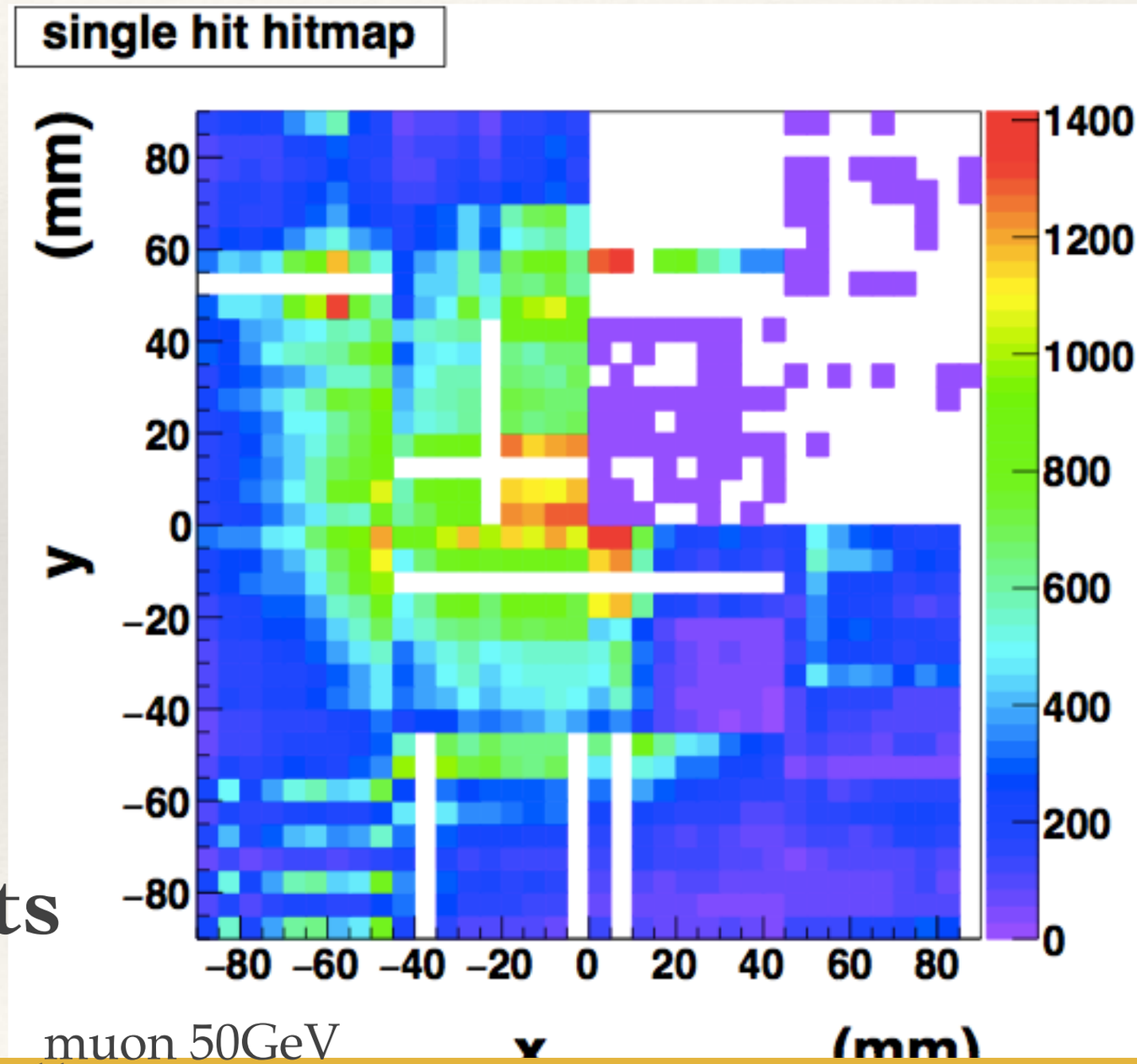


a good muon event



strip scECAL performance

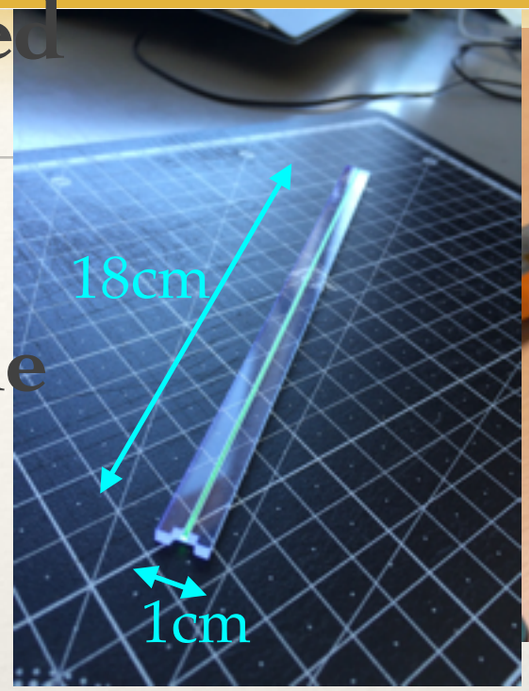
- hit information from
- second and third scECAL layers are combined
- to have matching hits
- problematic strips degrade hit map
- importance of tuning
- before the experiments

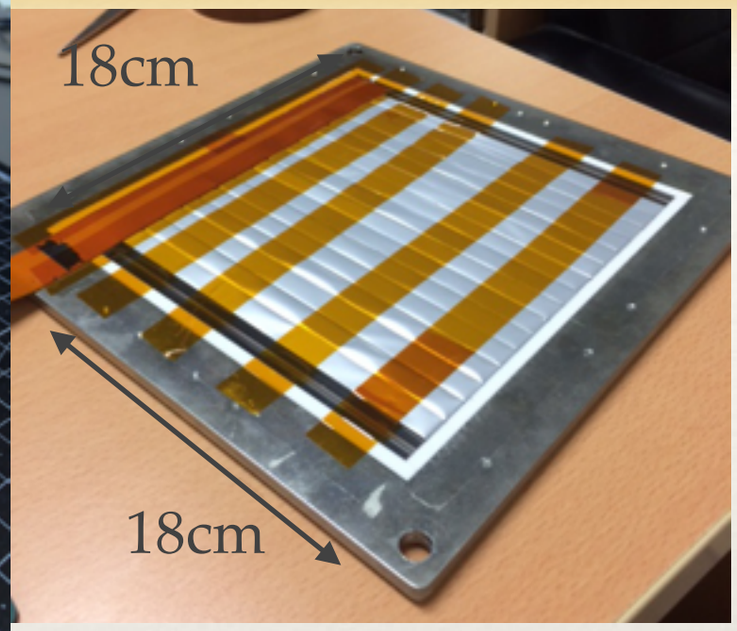


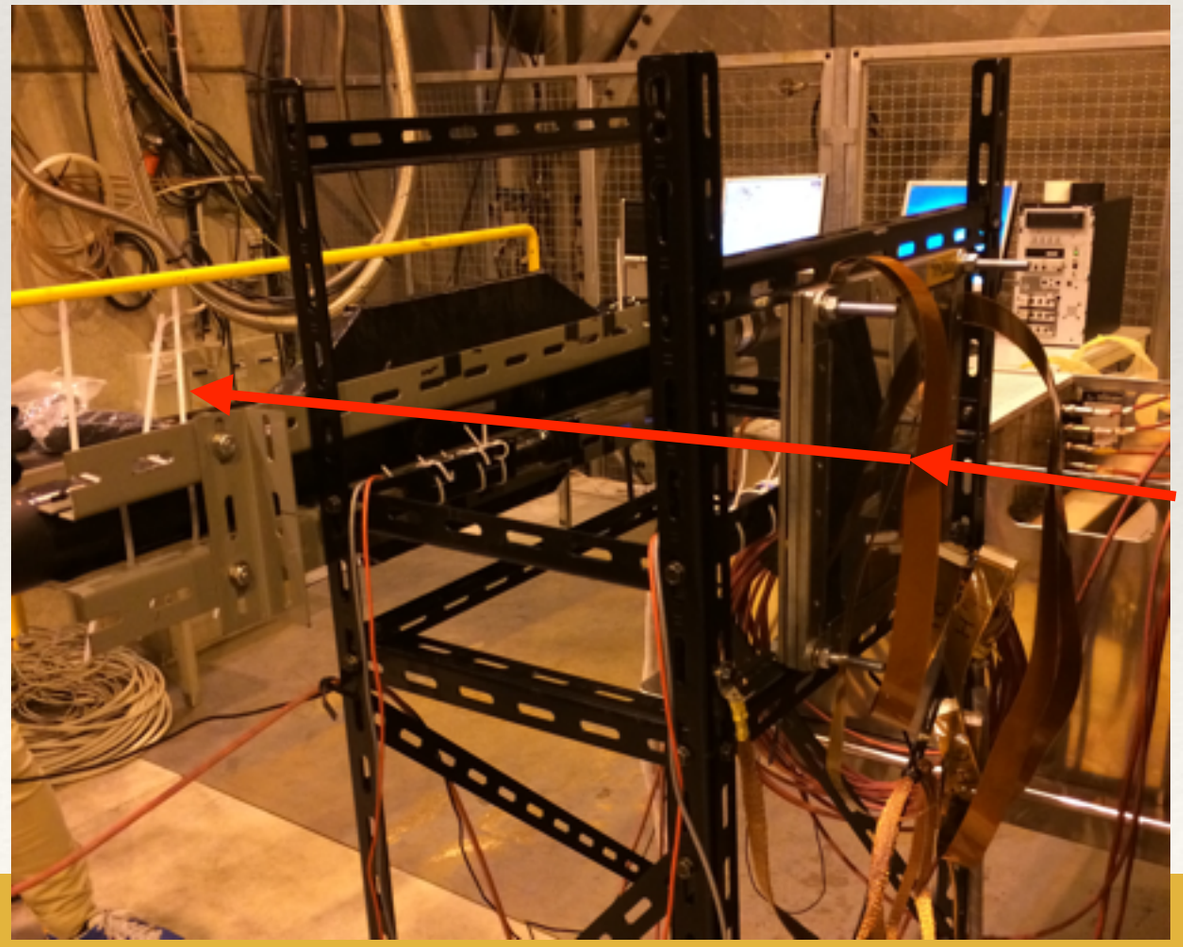
muon 50GeV

strip HCAL prototype

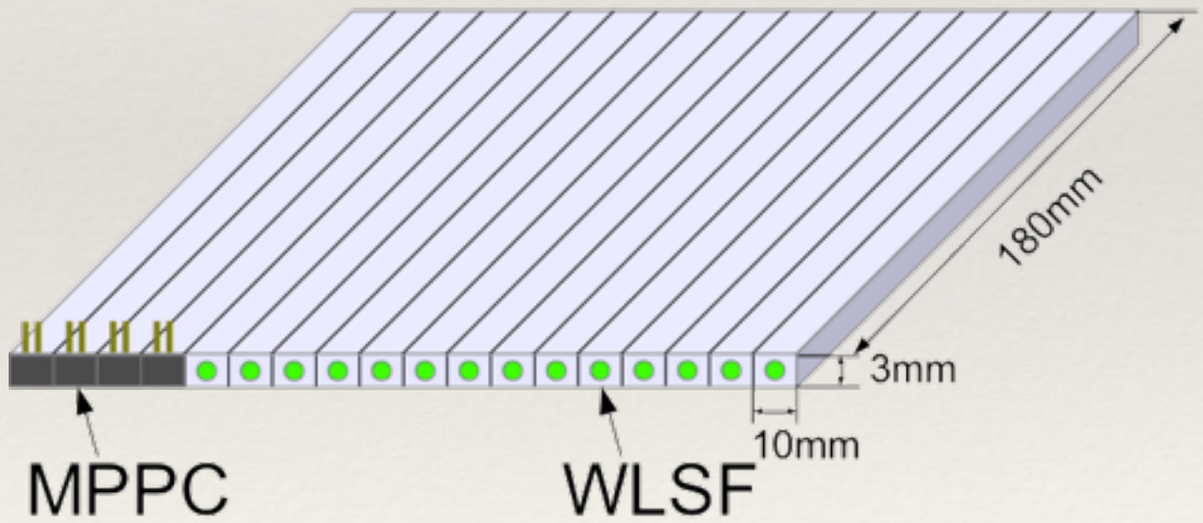
- four layers have be constructed
- stuck together at the beam
- read out by EASIROC module
- contains SPIROC, however, independent from others





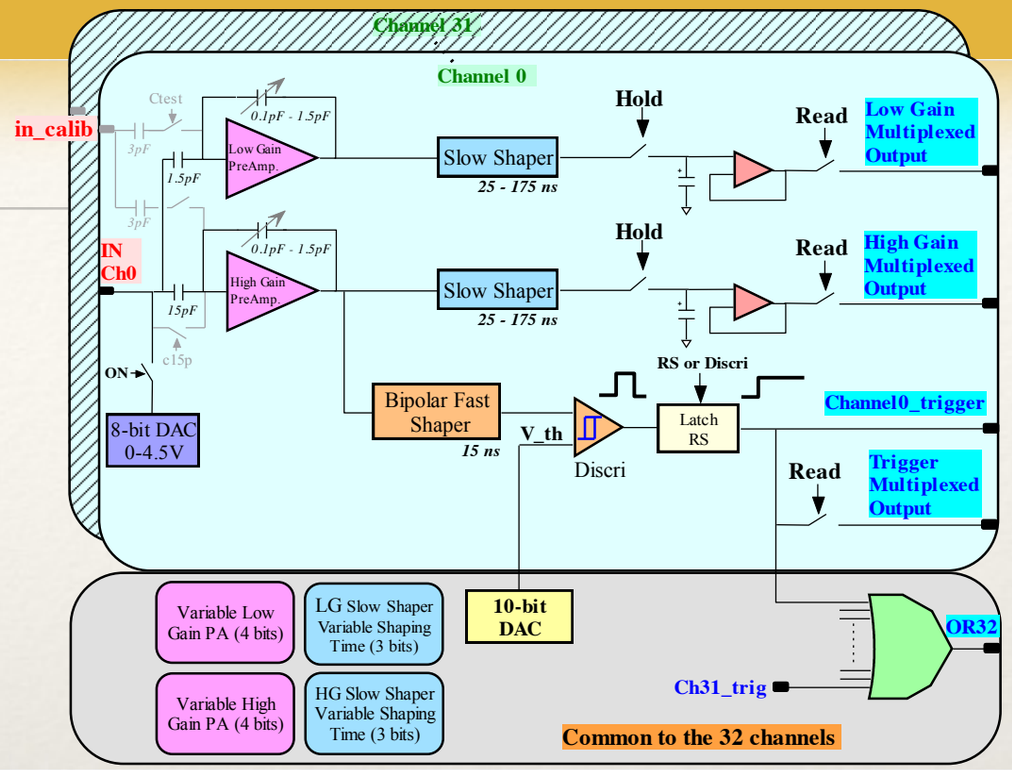


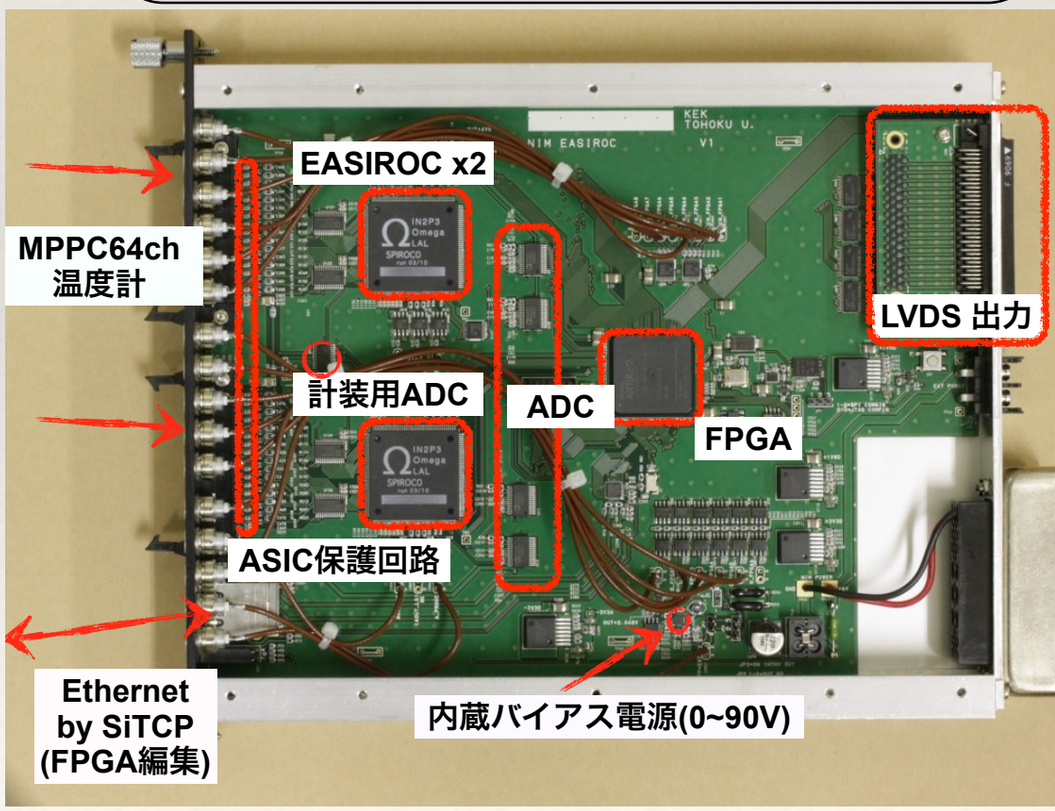
16channels



strip HCAL read out

- EASIROC NIM module 64ch.
- ASIC:easiroc by OMEGA 32ch.
- external trigger mode
- bias voltage with DC/DC
- external ADC
- temperature monitor
- Ethernet I/O
- DAQ & parameter setting





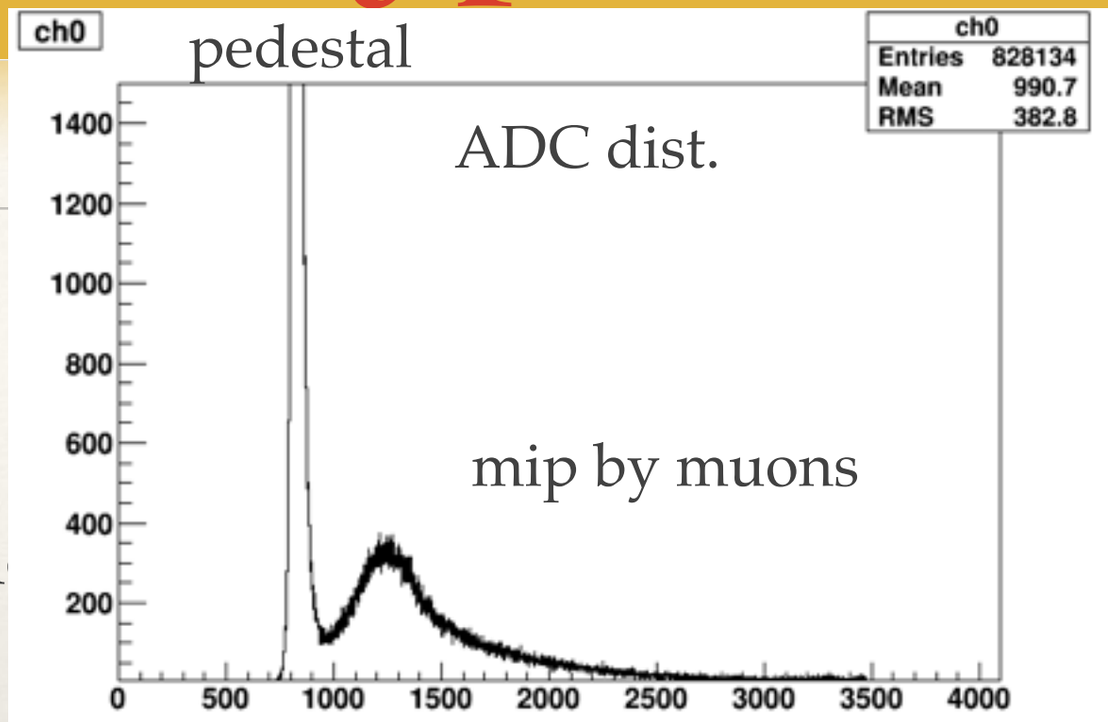
strip HCAL prototype

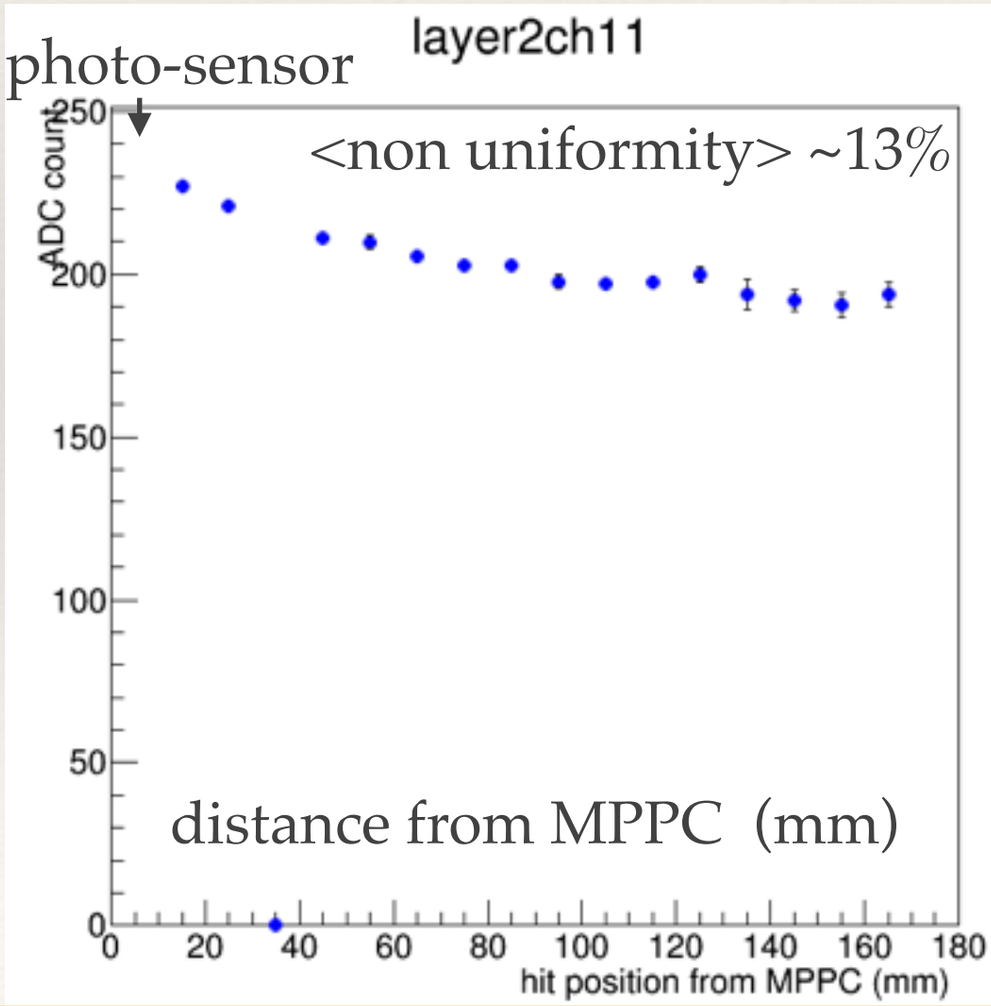
- **uniformity by muons**

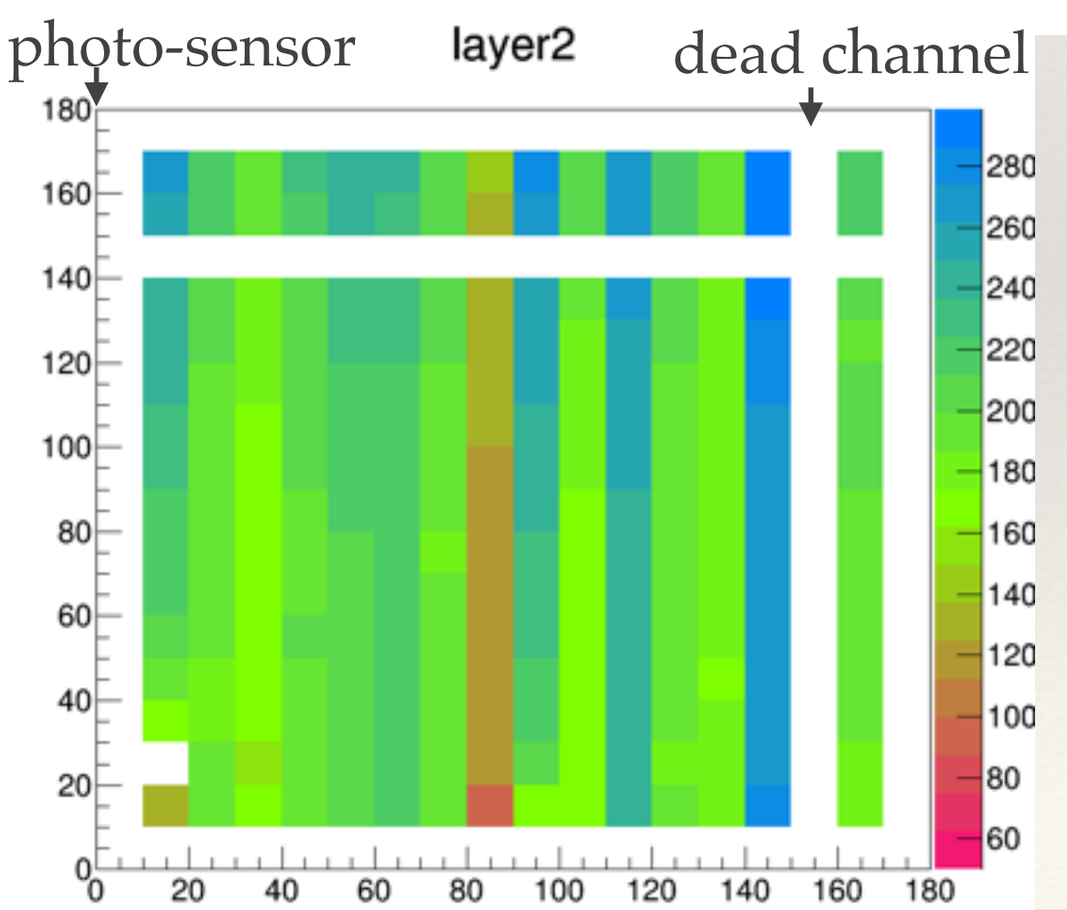
- **positions were determined by the next layer**

  both layers are required to be single hits

- **will be calibrated with photon-yiel**

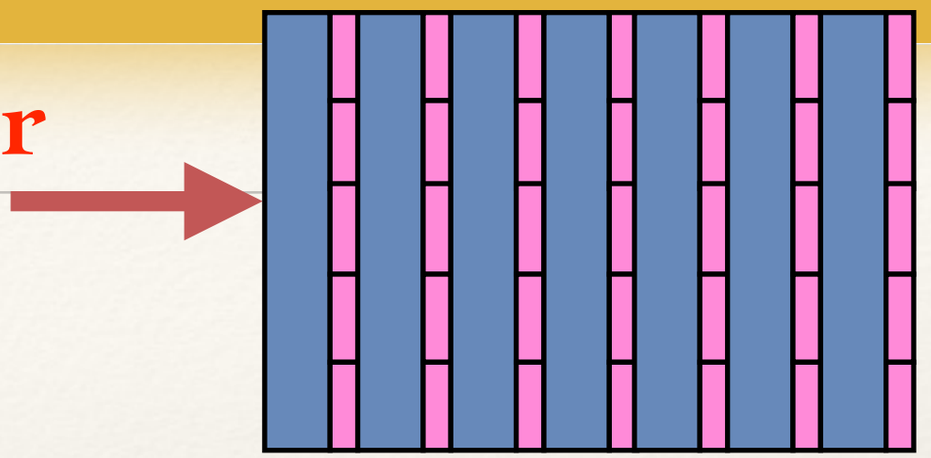






HCAL improvement

- active fine granular absorber for PFA



- by Cherenkov detection
- with very thin photo-sensor ~ MPPC
- heavy and transparent absorber
- currently testing the lead-glass
- X0~1.7cm, ρ ~ 5.5 g/cm3
- refractive index n=1.8

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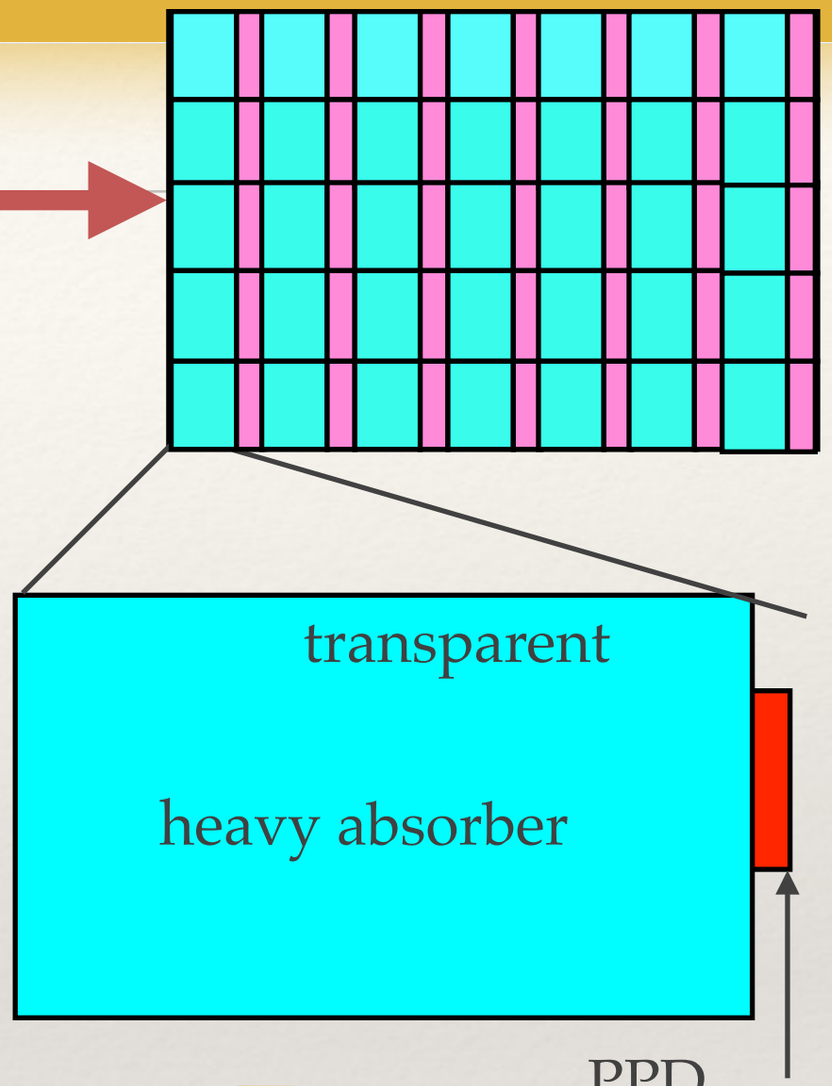
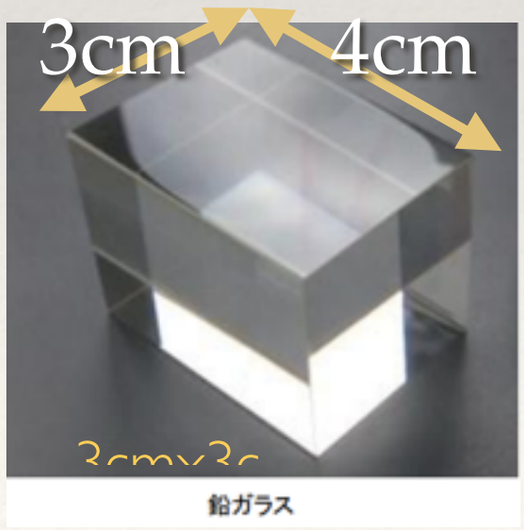
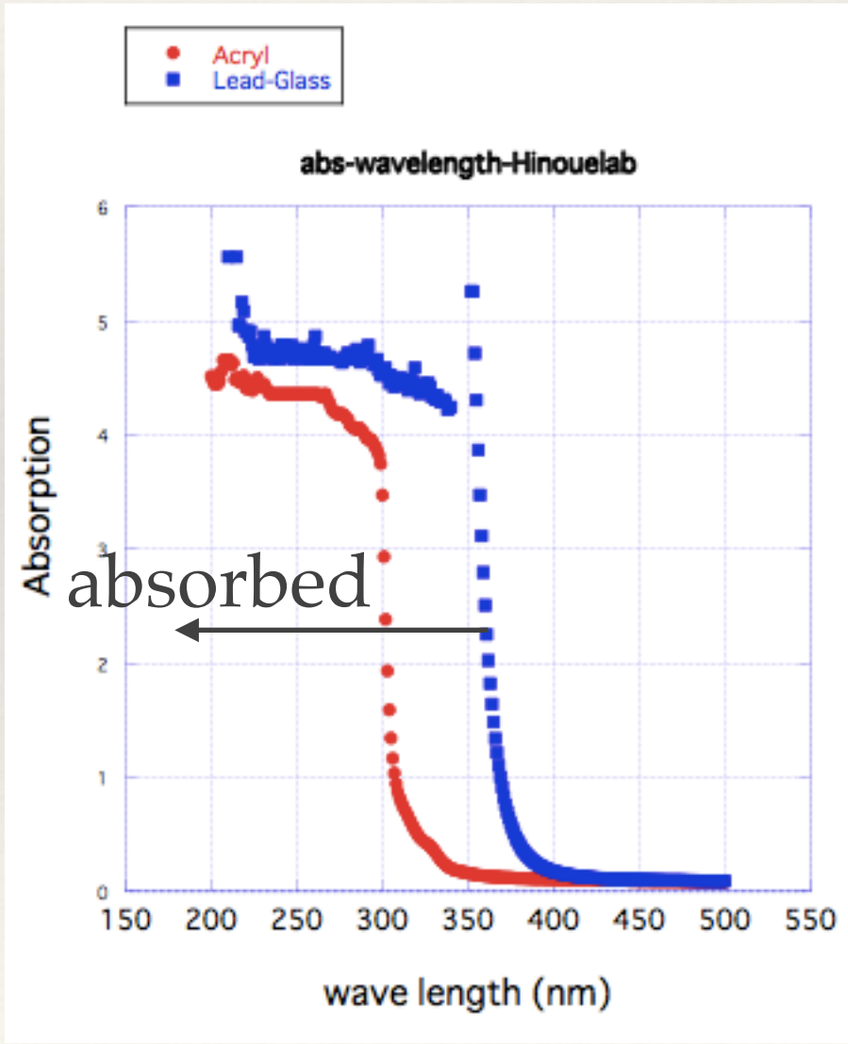




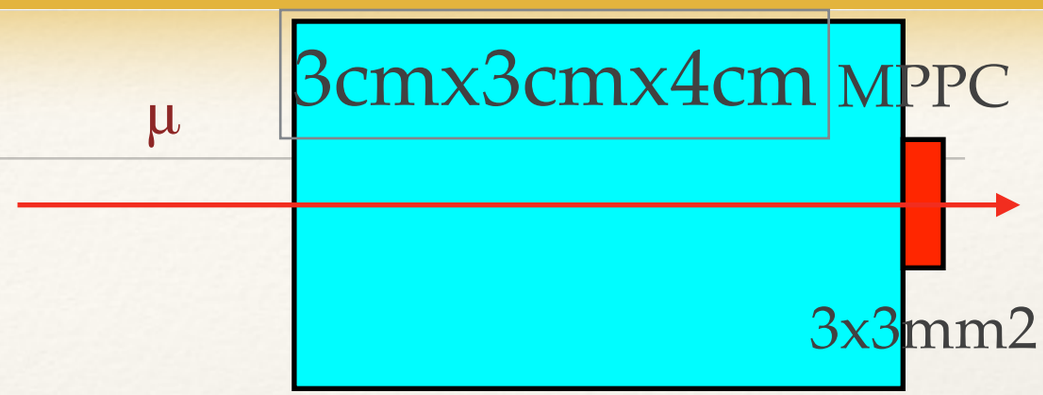
Cherenkov light detection

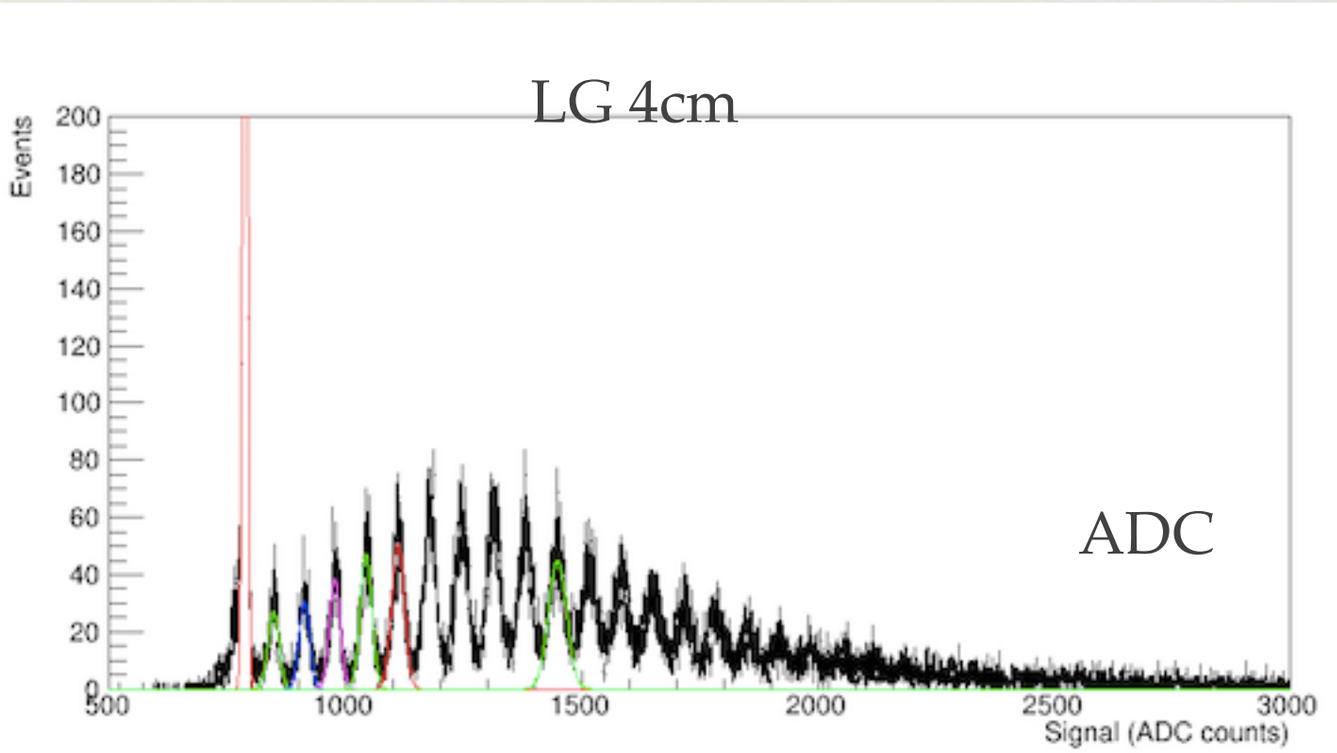
- extremely small number of photons than scintillation ~$(1-1/n^2)/\lambda^2$
- higher refraction index n is desired
- UV light detection is a key
- will be absorbed in lead glass
- photo-sensor must be glued with
- high n > 1.41, otherwise totally reflected



muon Cherenkov

- at H6 CERN Beam
- LG : DF6 3x3x4cm^3
- a MPPC (100um pitch) 3x3 mm^2 detects
- ~15 p.e./4cmLG
- with glue





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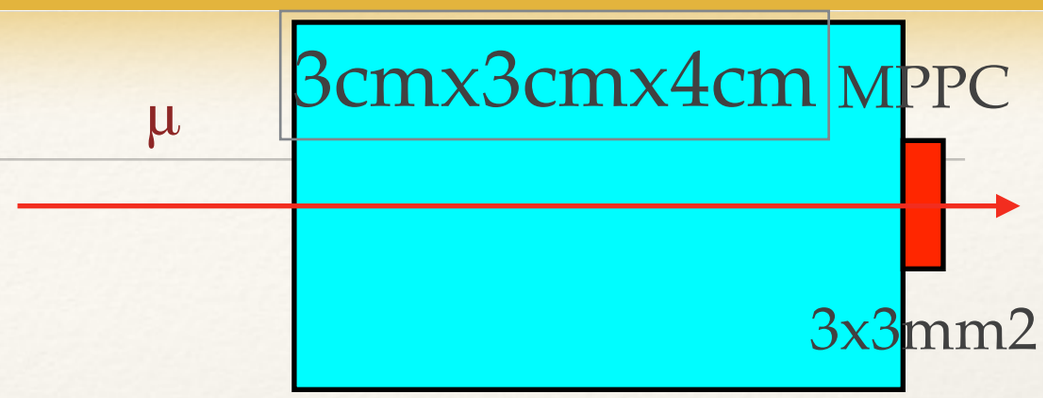
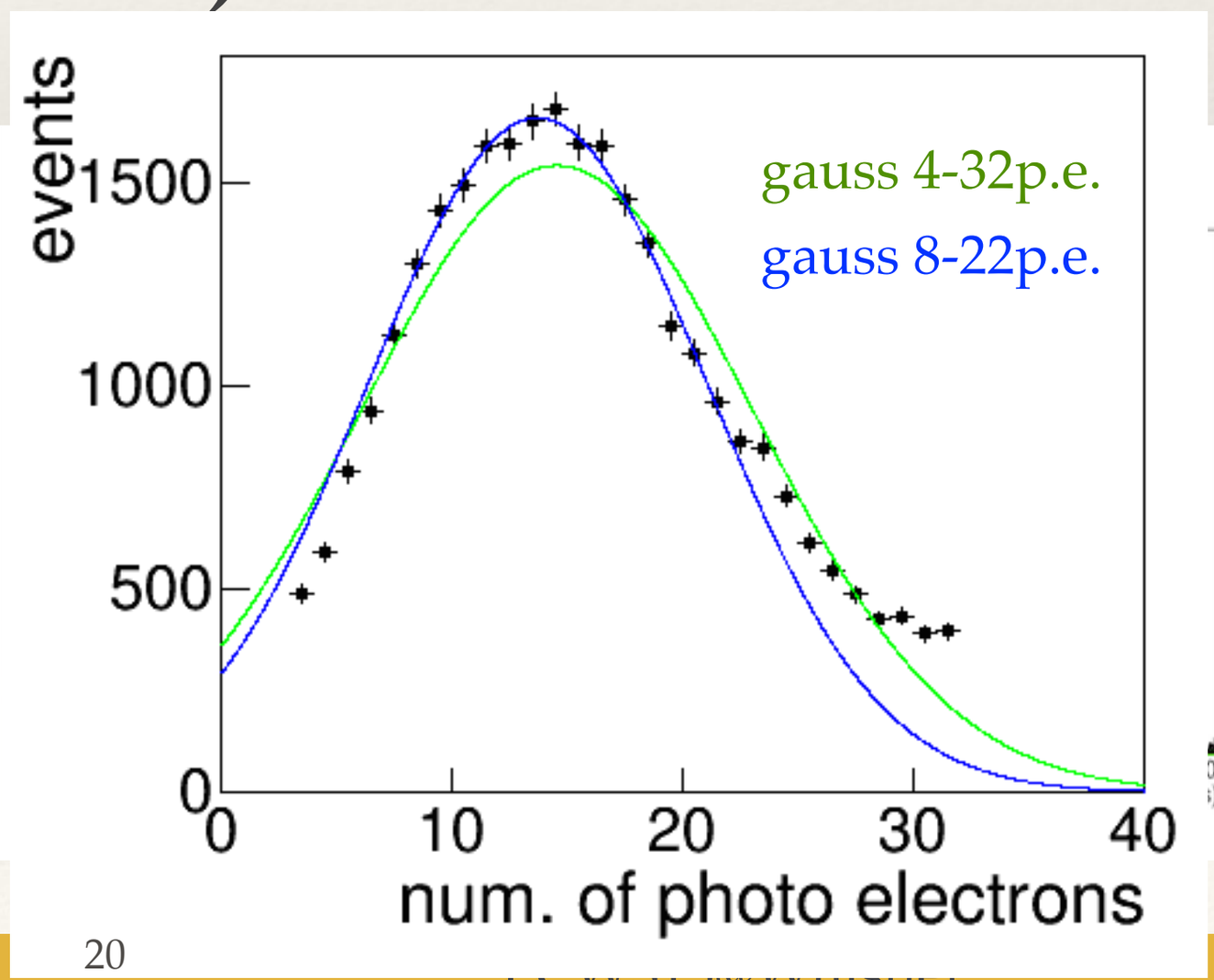




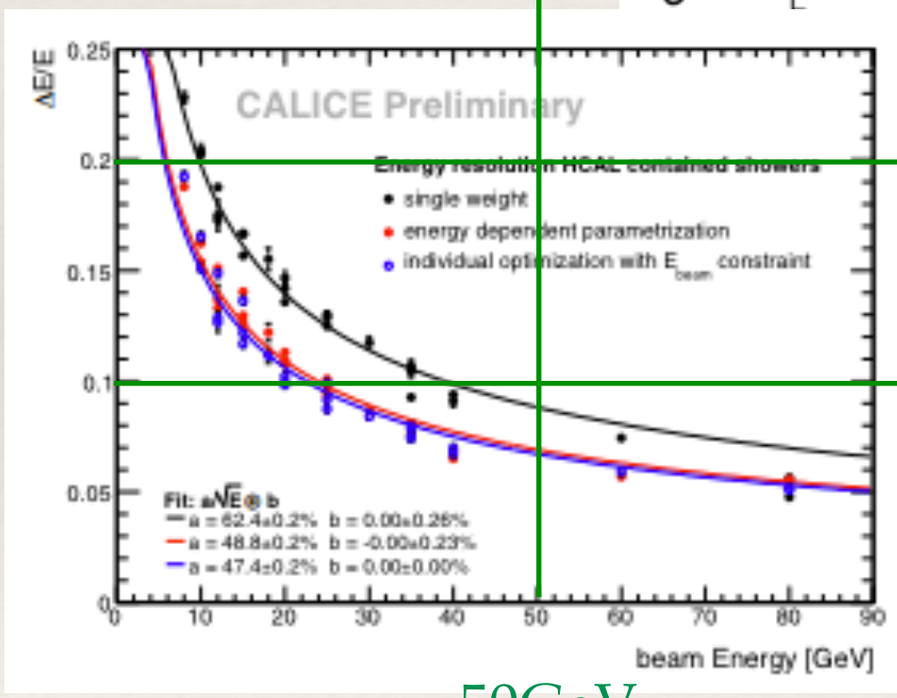
summary and outlook

- scintillator strip calorimeters

- scECAL is close to module 0 for ILC
- strip HCAL can be achieved with less R/O ch
- further possibility with active absorber
- PFA modification to fit strip technology
- take into account information from absorber

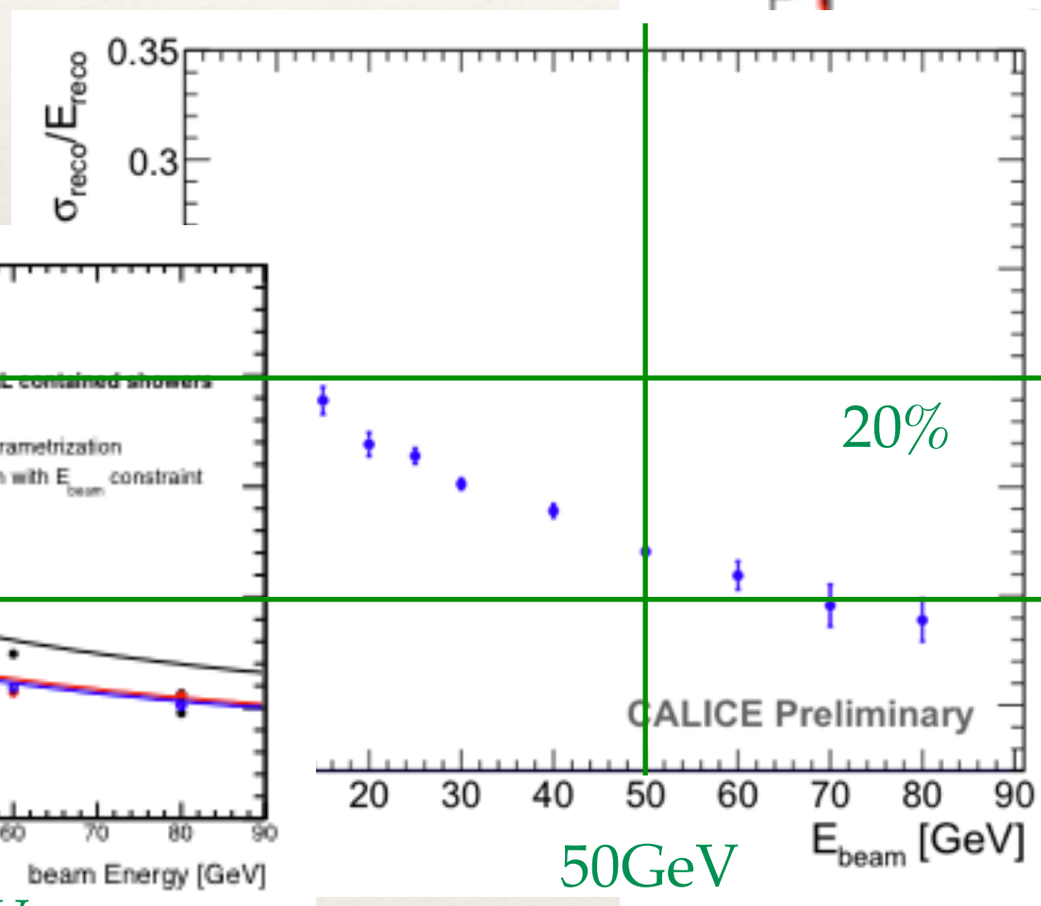
Hadron energy resolution

- energy resolutions
- AHCAL is better than S/DHCAL



calice-AHCAL

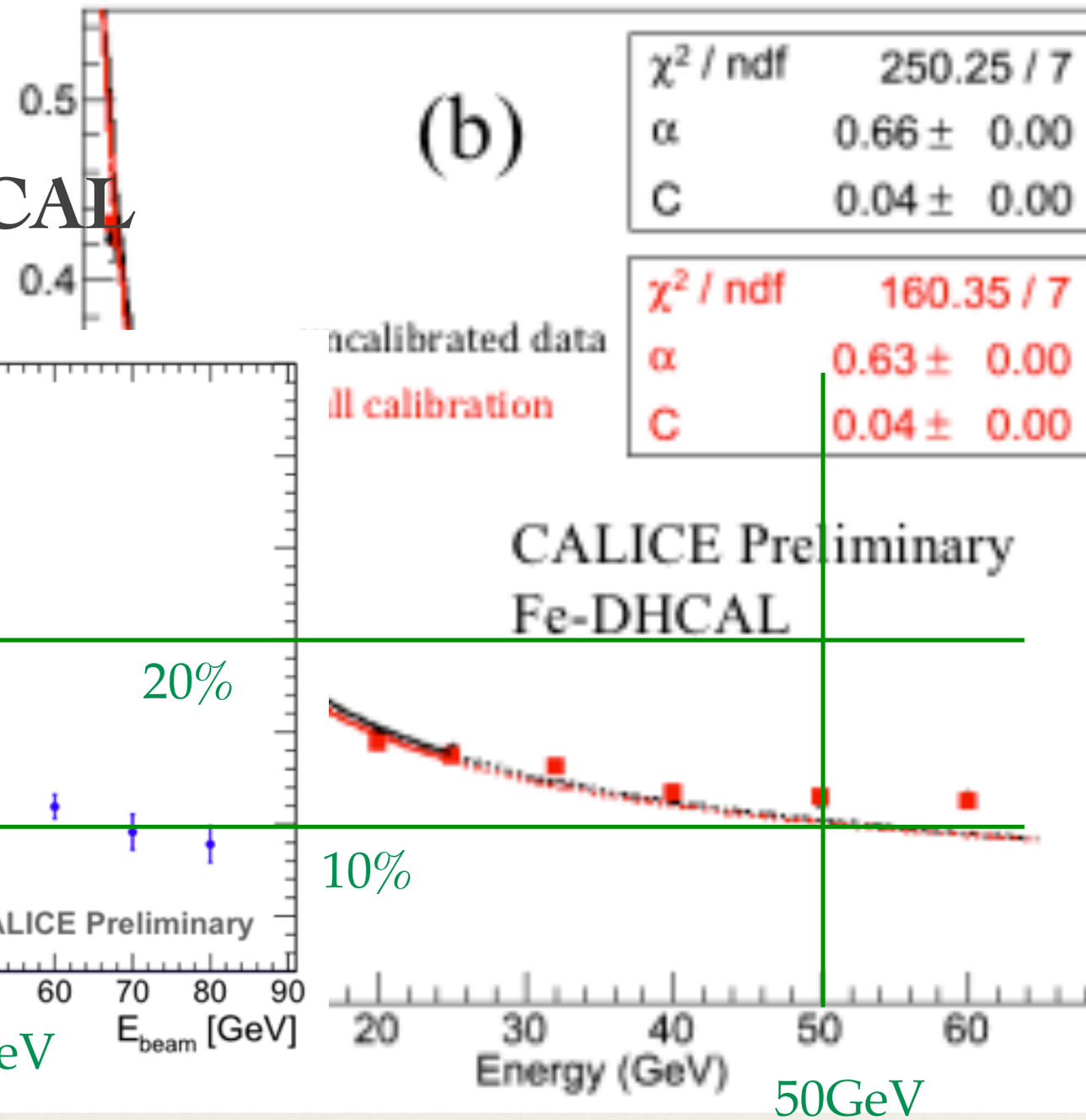
50GeV



20%

50GeV

calice-SDHCAL



10%

50GeV

calice-DHCAL