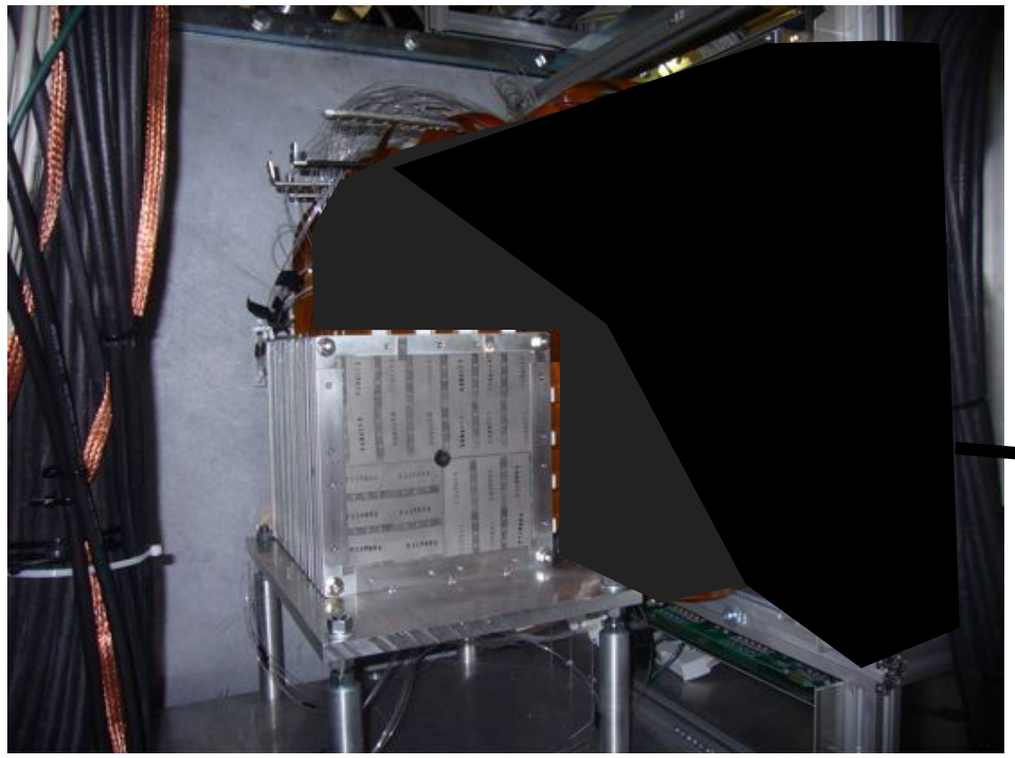
Sc-ECAL Test Beam Report

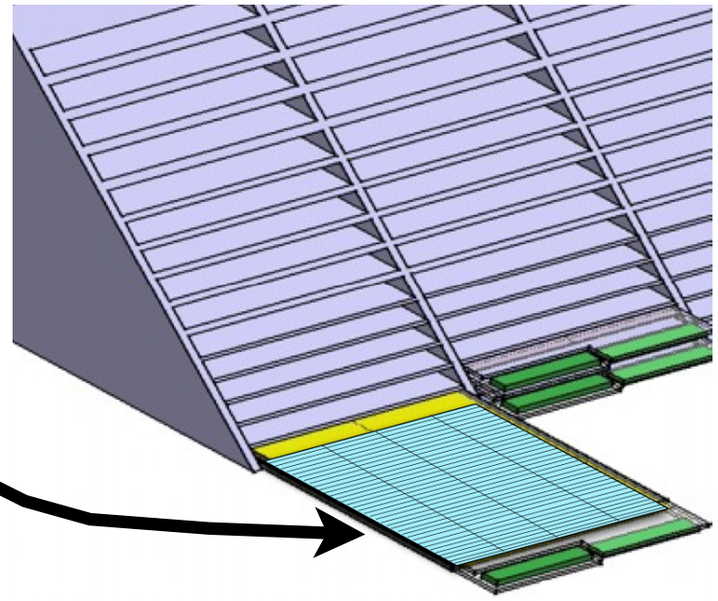
22th March 2013

K. Kotera,
Shinshu University

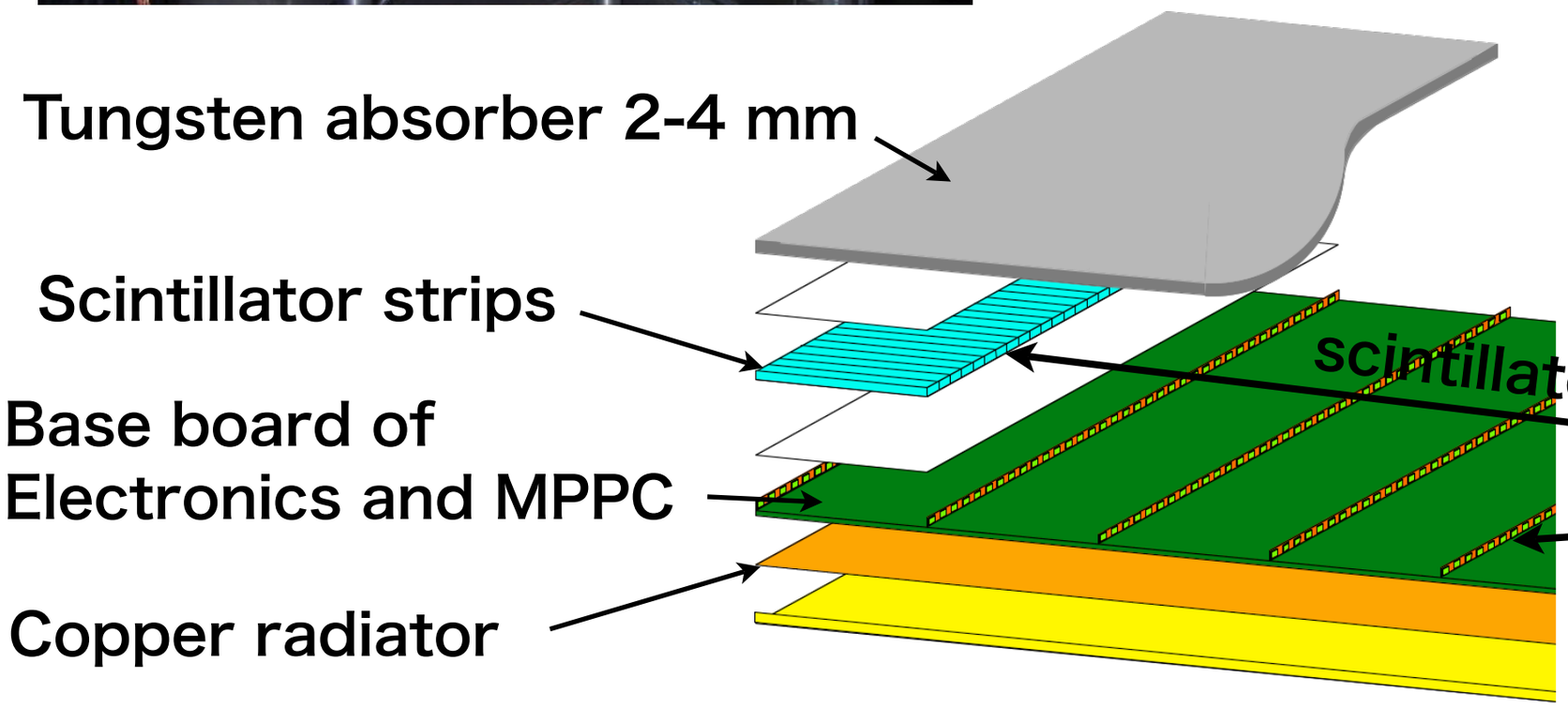
Purpose of technological ScECAL

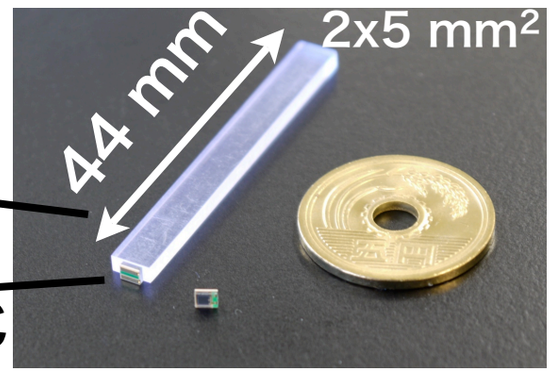


Electronics should be put in between sensor layers for ILD



this carton is not true because electronics should cover the sensor

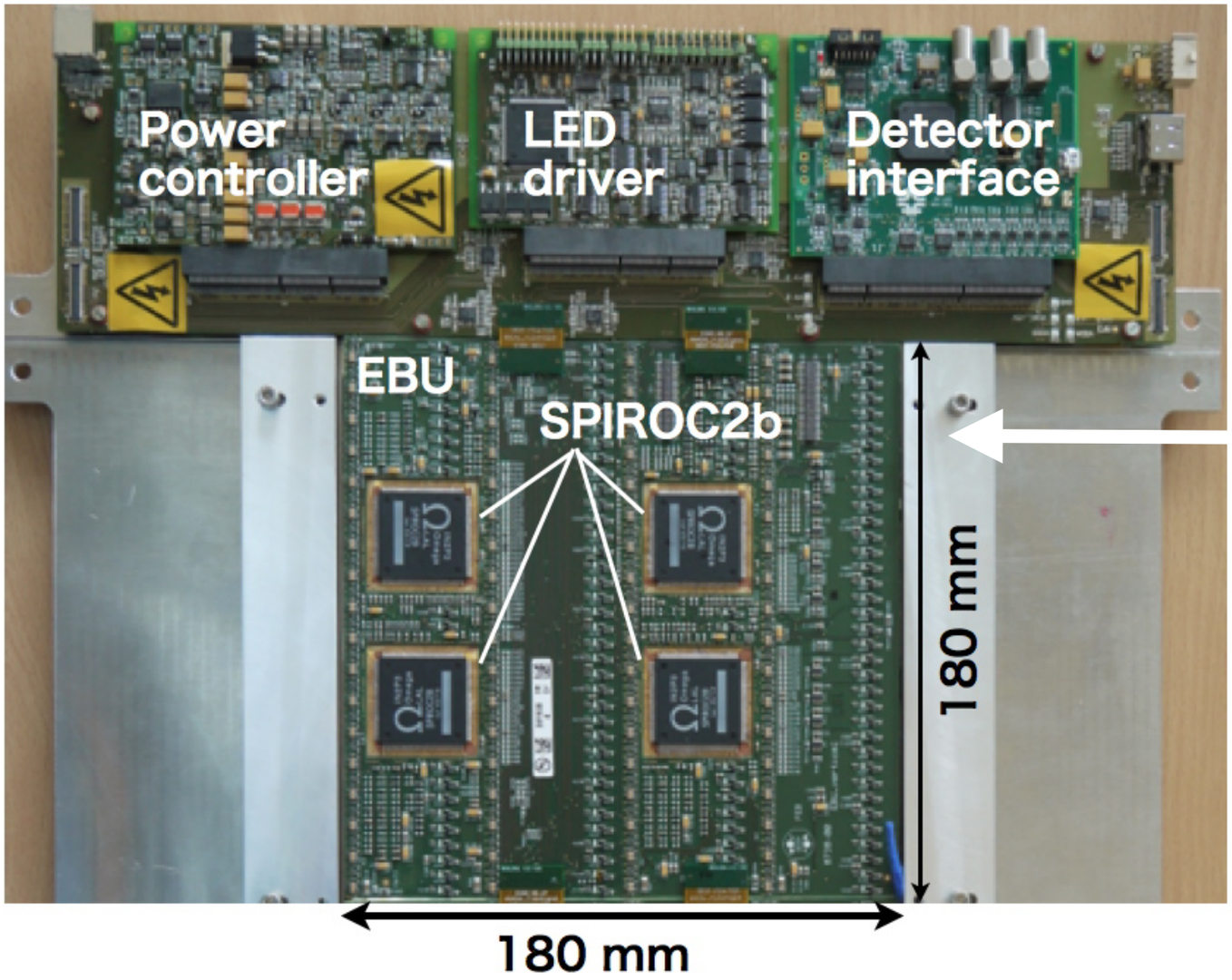




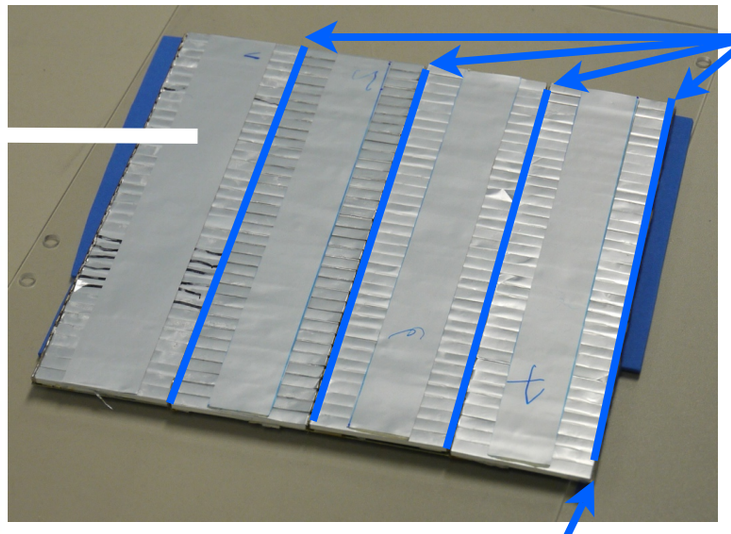
Alveolar frame was made by Si ECAL group. Thank you!

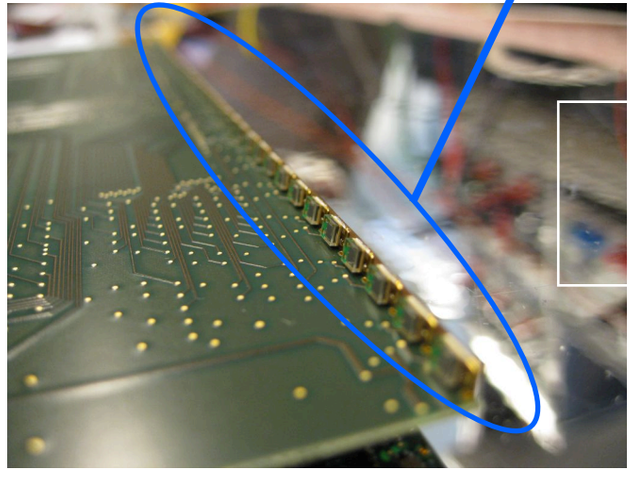
ScECAL technological prototype

- One layer one base board (EBU) prototype so far.
- Four SPIROC2b (ASIC) on an EBU control 144 MPPCs.



The other side.

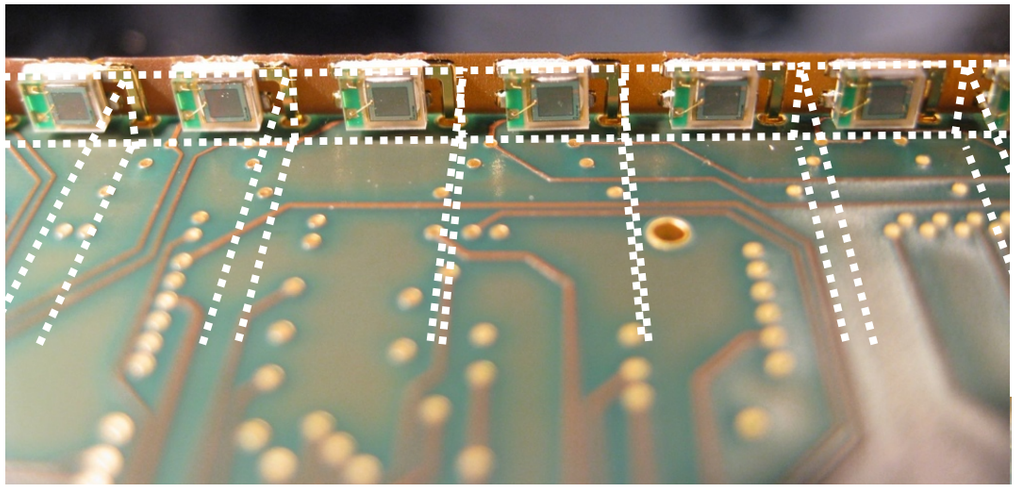


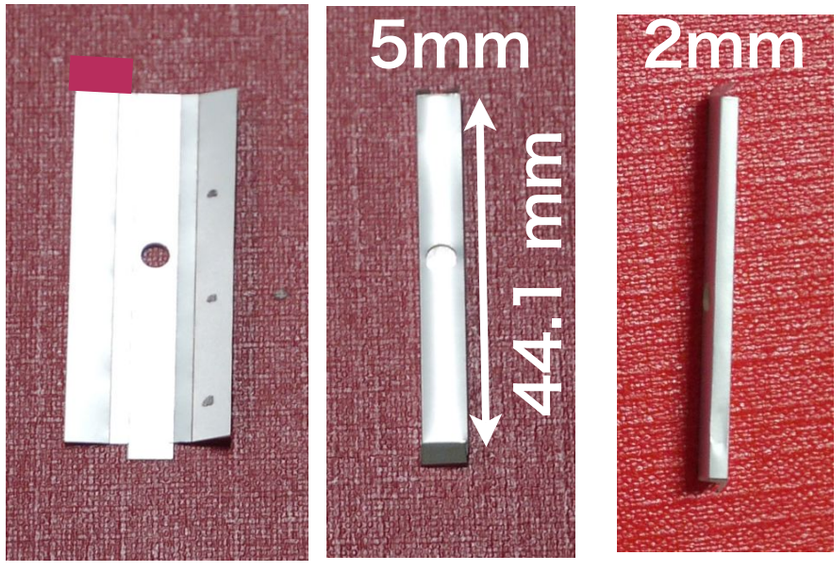


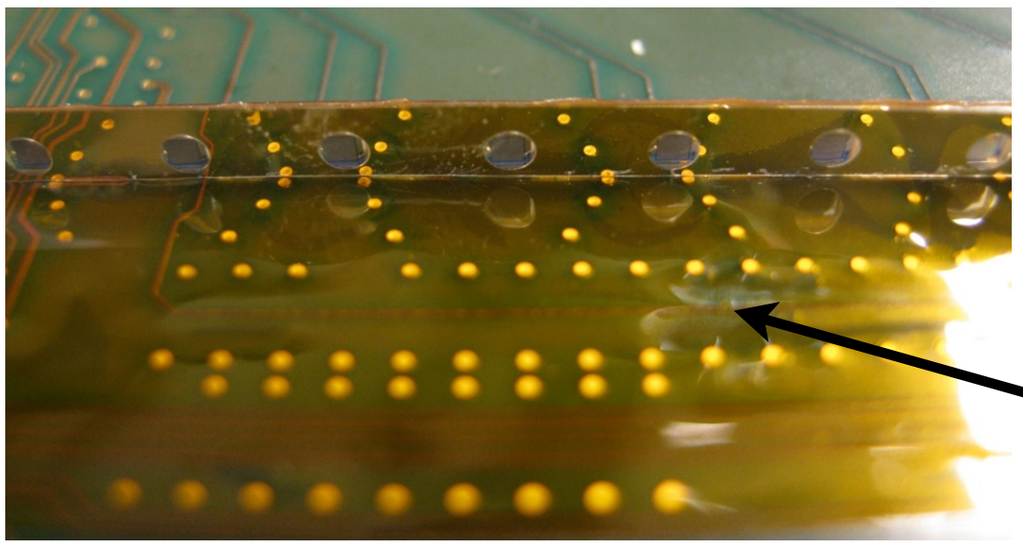
Technology is the same as AHCAL HBU
Density of channels on an EBU is x 4.
←Thank you for AHCAL grp.(Mathias)

MPPC-scintillator strip

- 36 MPPCs/row on a polyimide ribbon.
- The polyimide ribbon is for only mechanical support.



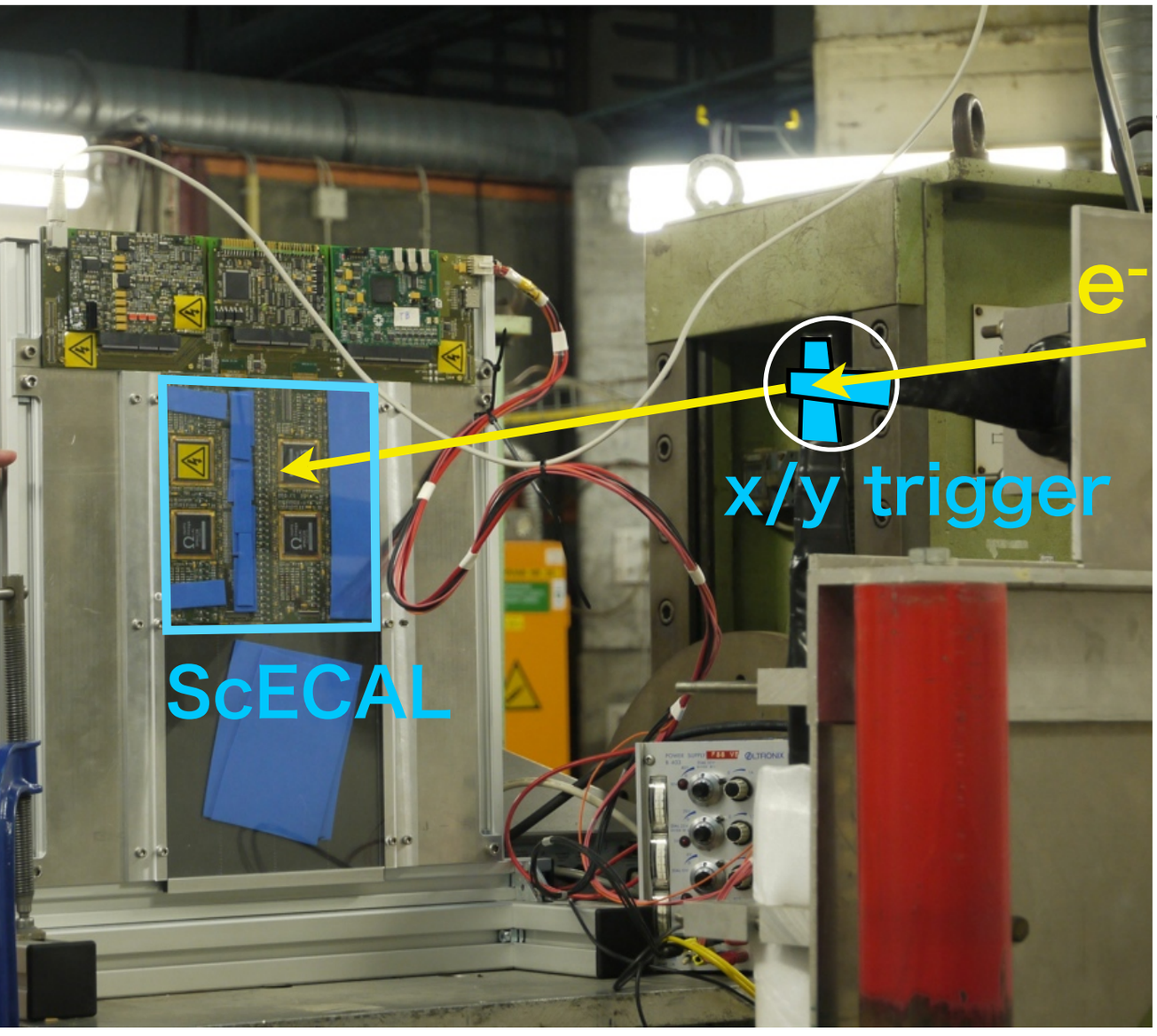


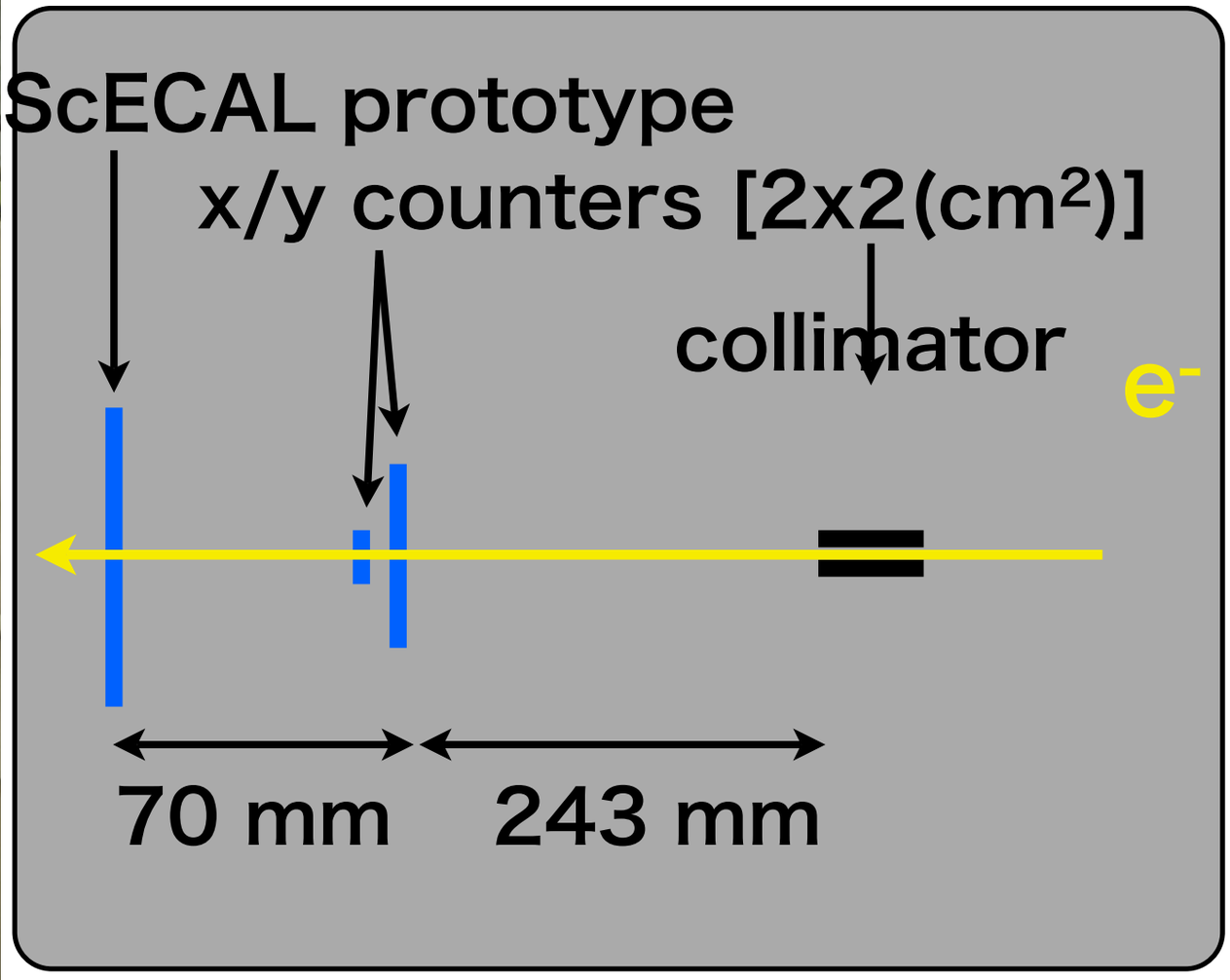


- A reflector ribbon with holes as MPPC windows is put in front of MPPCs
- A polyimide sheet is put on the EBU for each MPPC radder.

Test beam at DESY with 1-6 GeV e^-

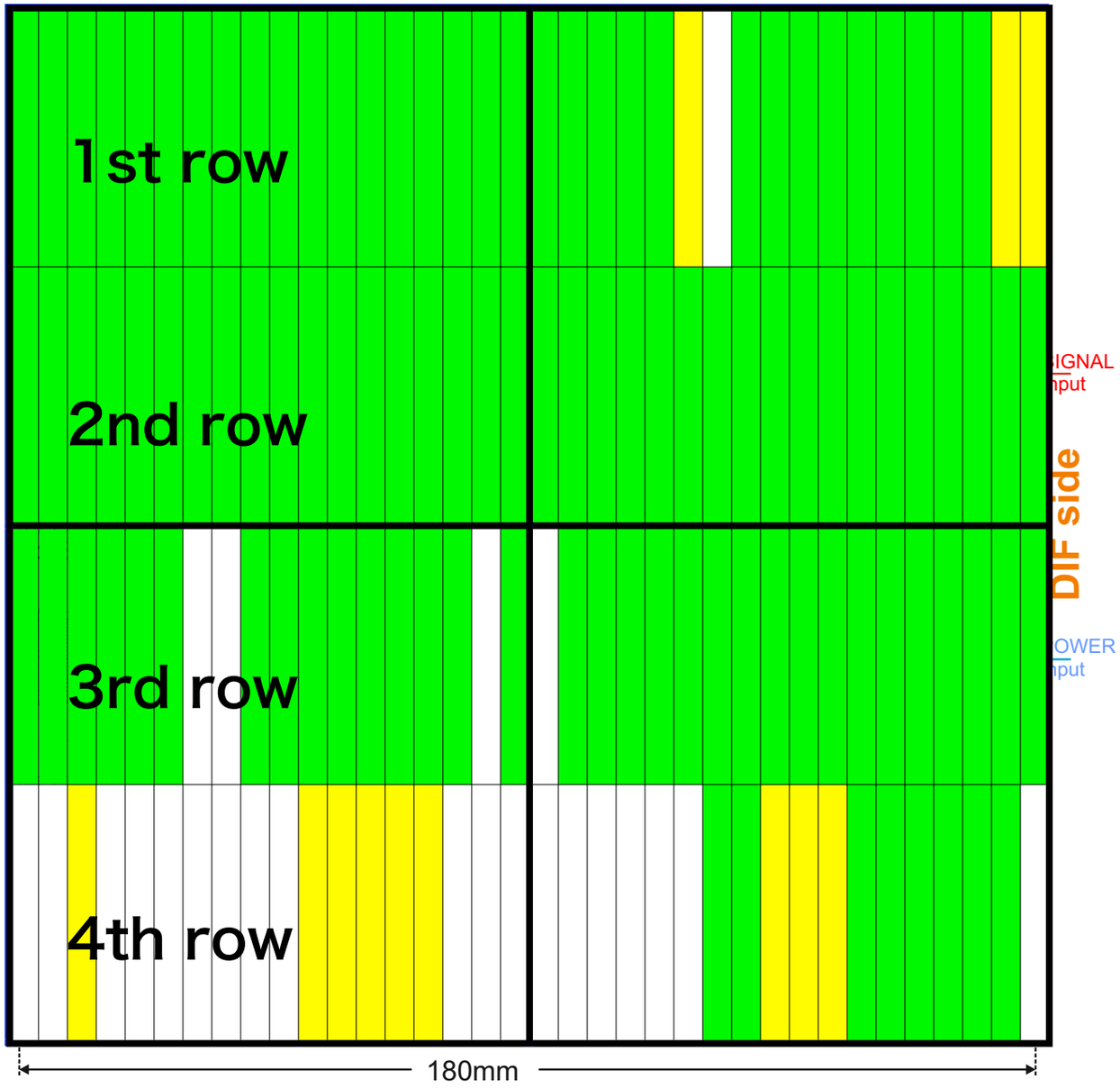
8th Oct 2012 - 26th Oct 2012



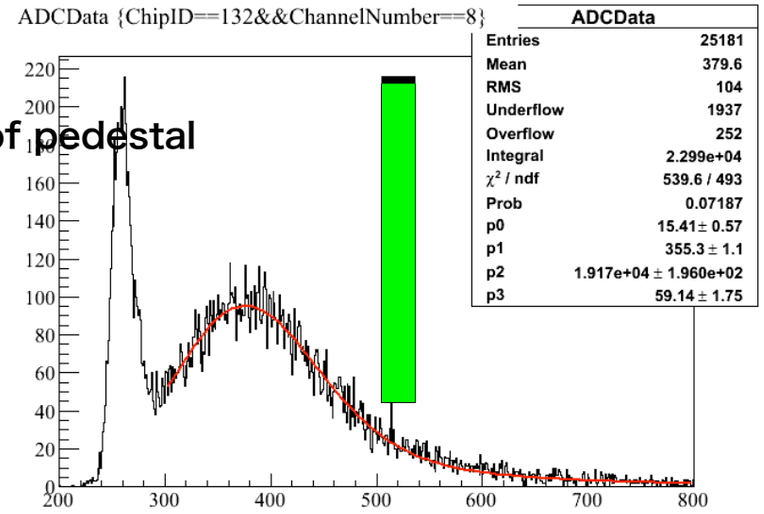


24th beam line

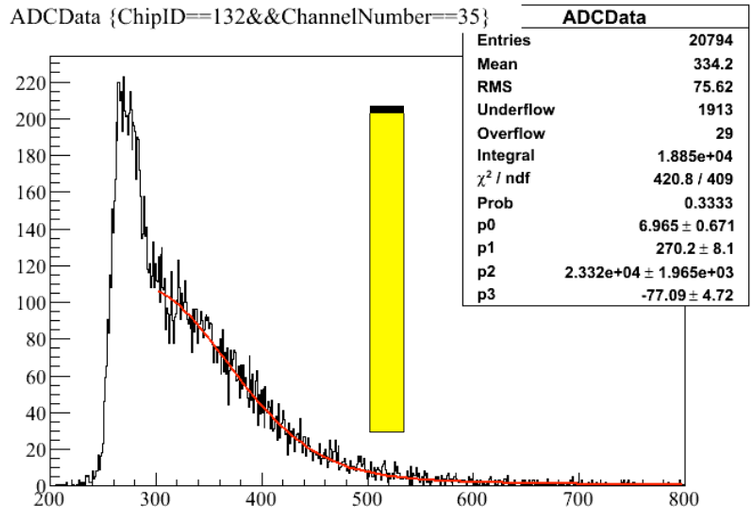
Response to MIP events



Part of pedestal



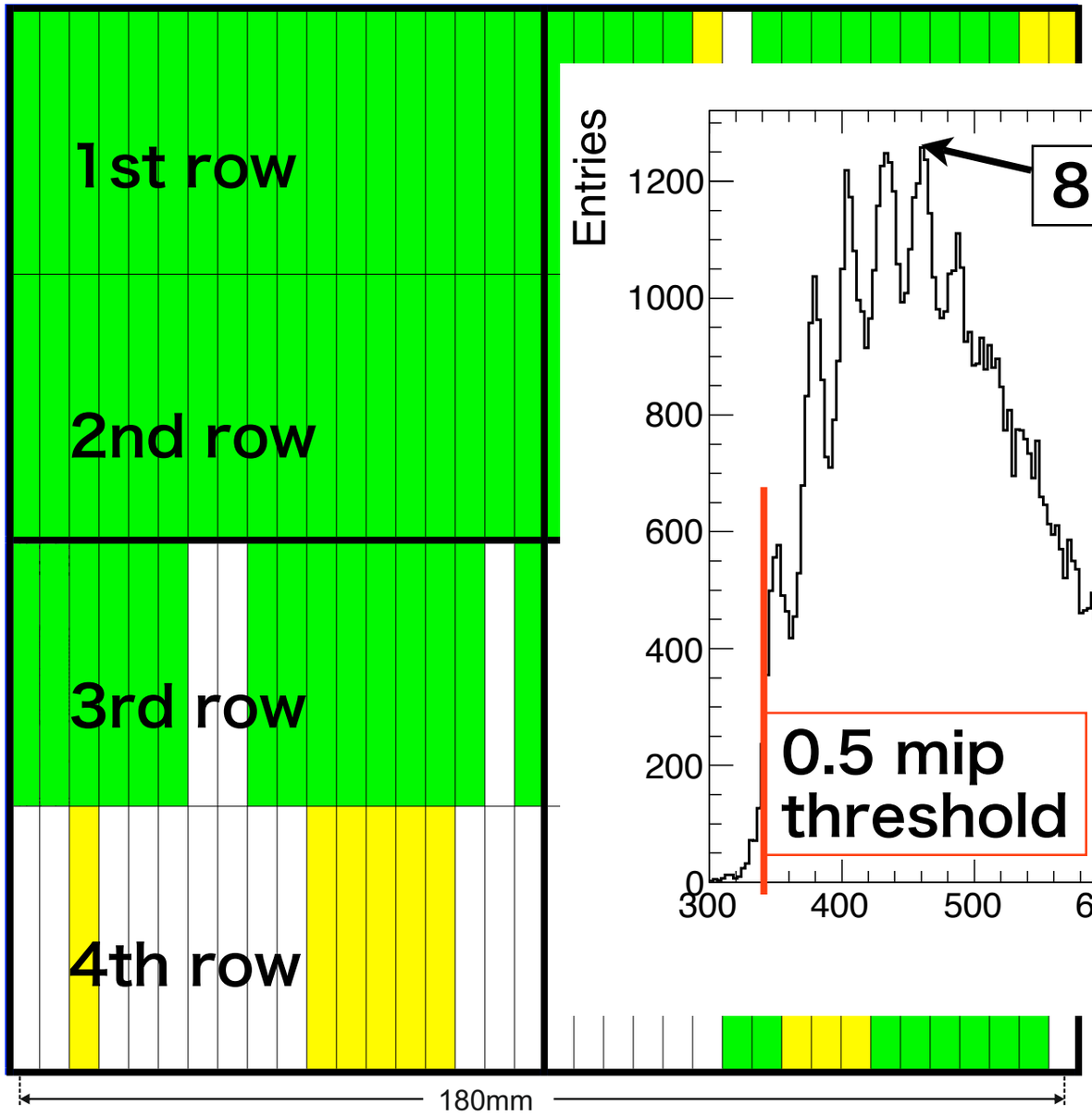
Trigger threshold << 0.5 MIP

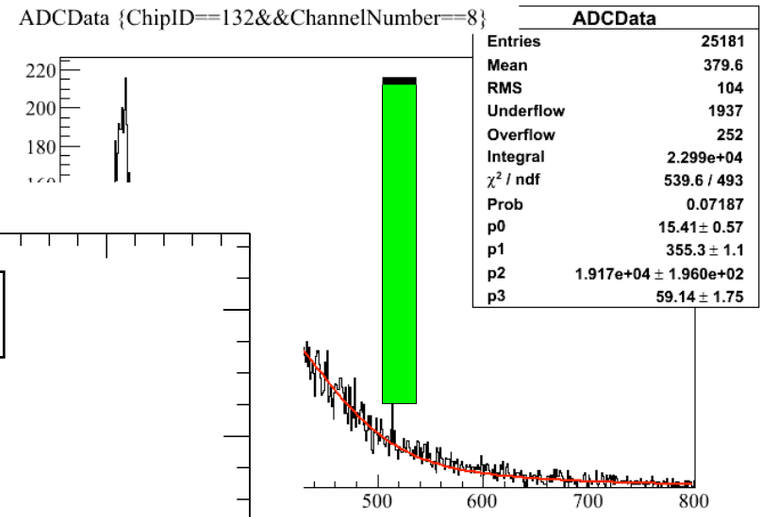


75% channels have succeeded to have good MIP distribution

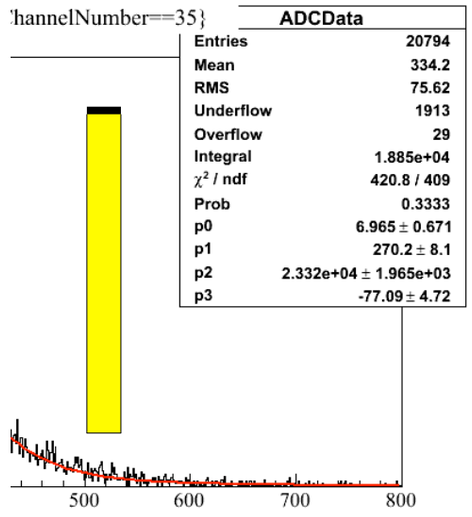
: no signal or large noise

Response to MIP events





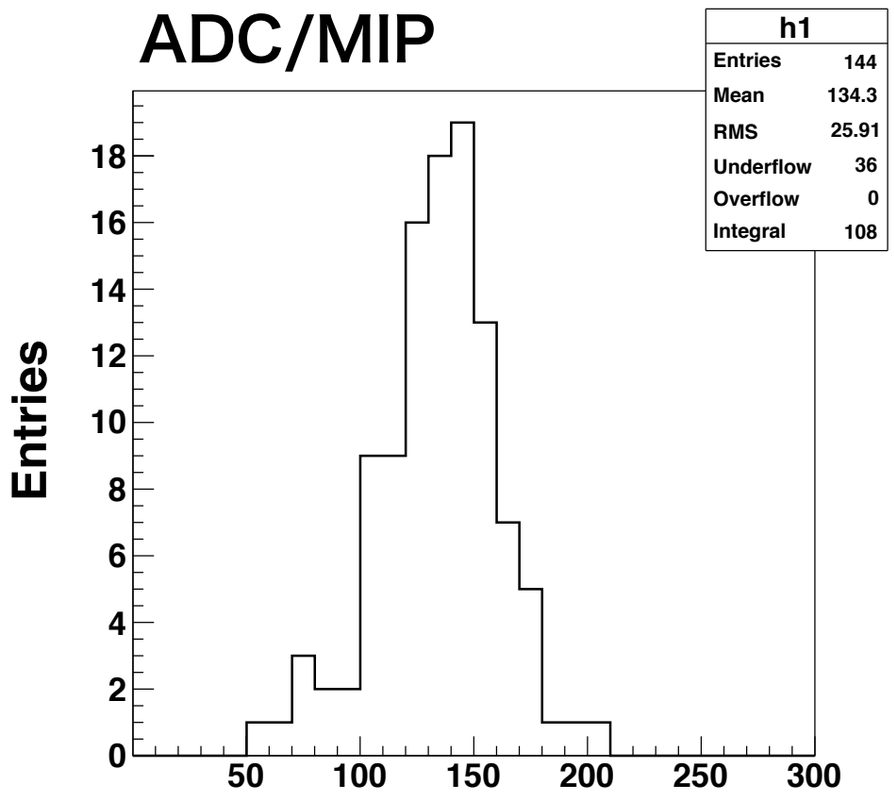
reshold << 0.5 MIP



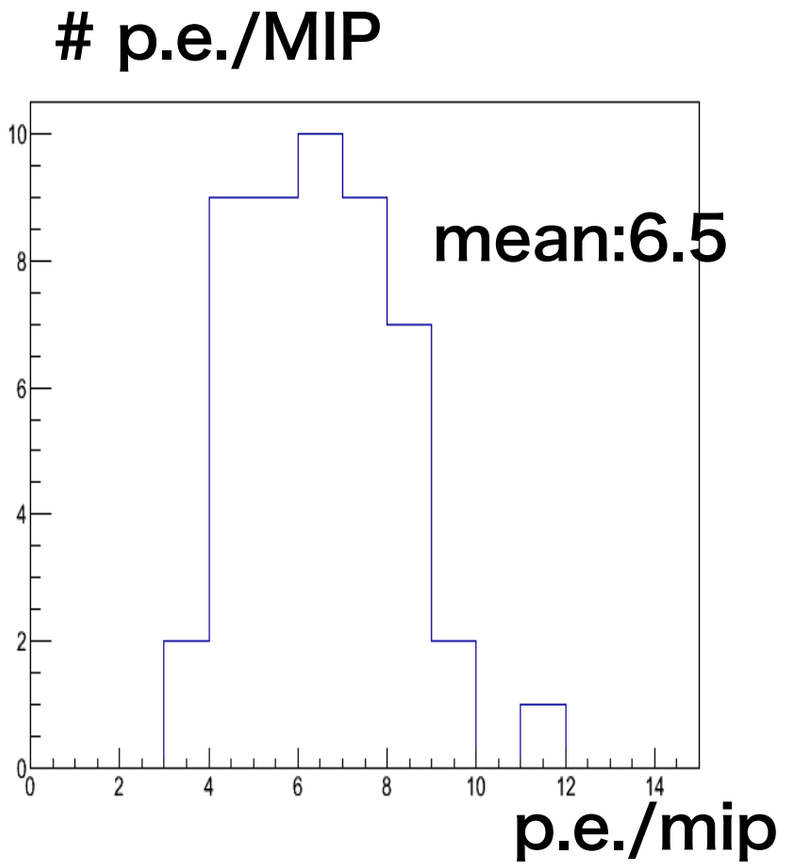
75% channels have succeeded to have good MIP distribution

: no signal or large noise

ADC/MIP and #photon/MIP

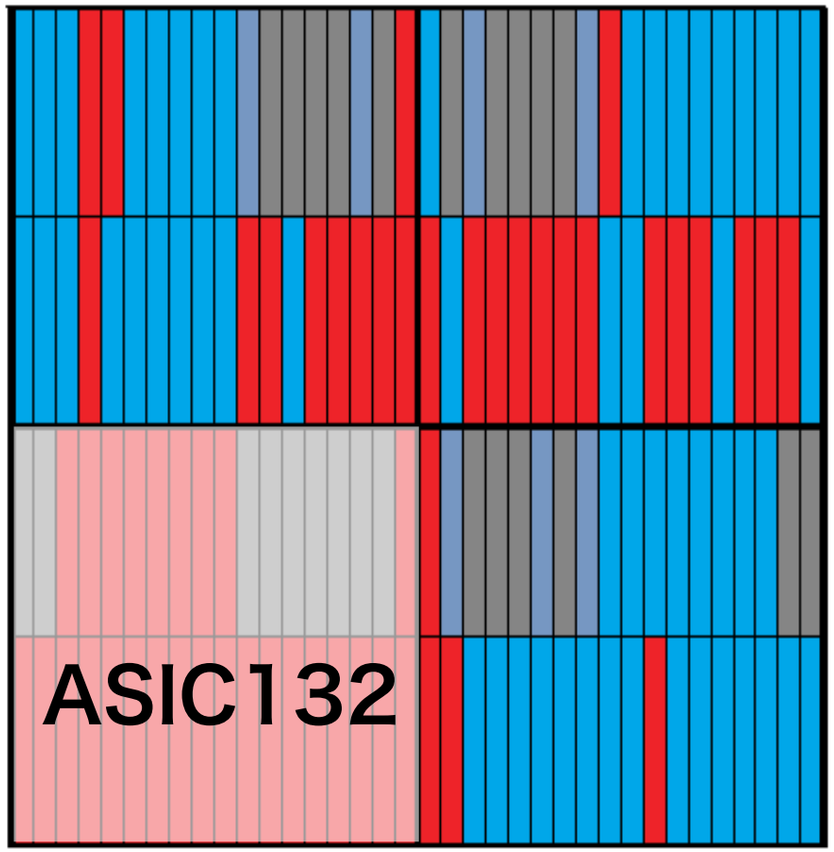


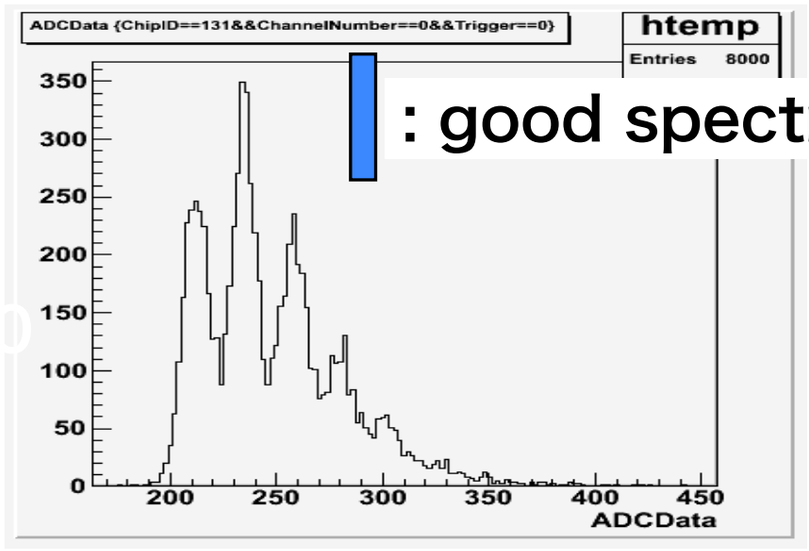
- 108 entries of available channels (75%).
- RMS/Mean = 19.3% (This is the same as in the case of FNAL physics prototype).



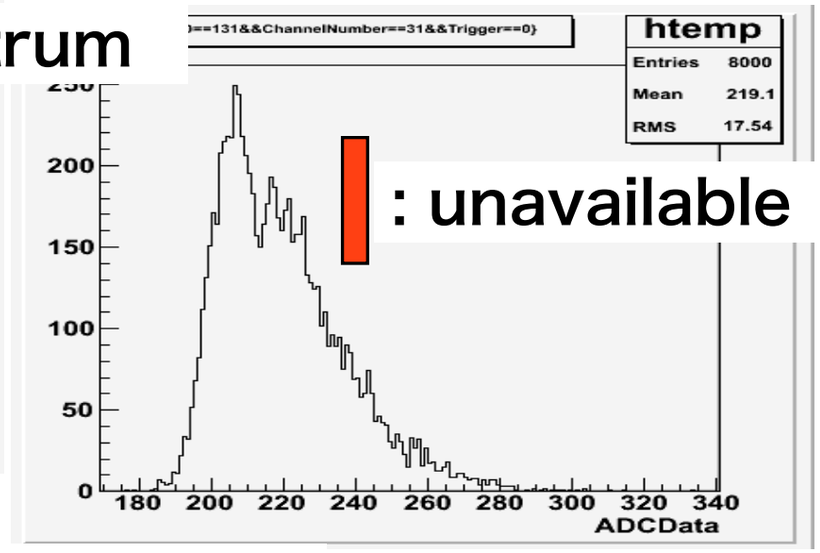
- seven photo-electron is the number of photons we need,
- mean = 6.5 is near the requirement,
- we need to reduce too small #.p.e. channels (2-5 p.e.)

LED lights for gain monitoring





: good spectrum

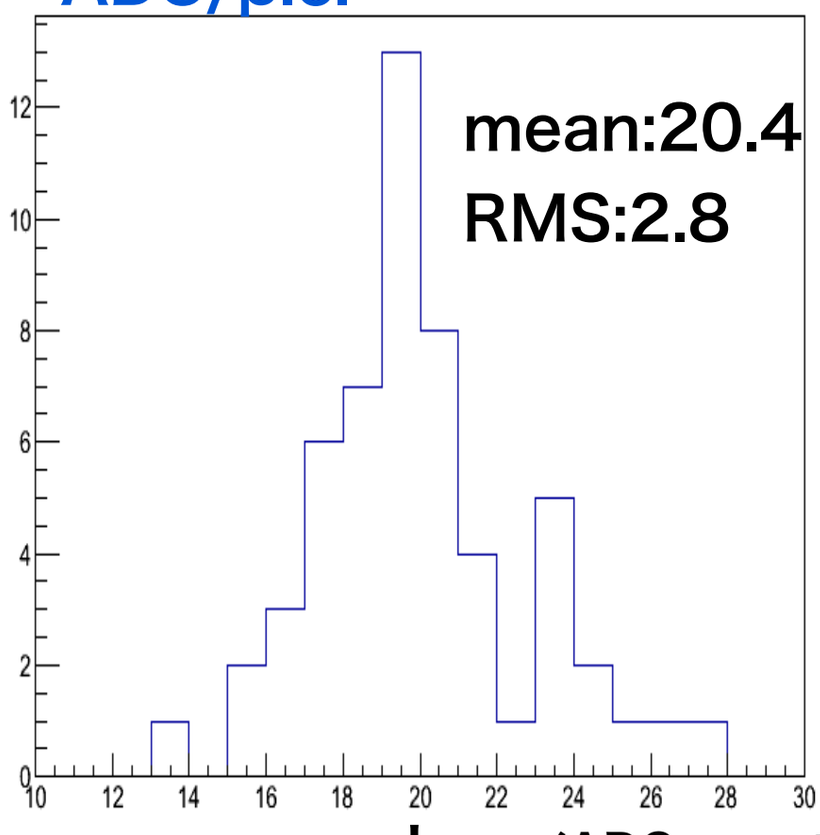


: unavailable

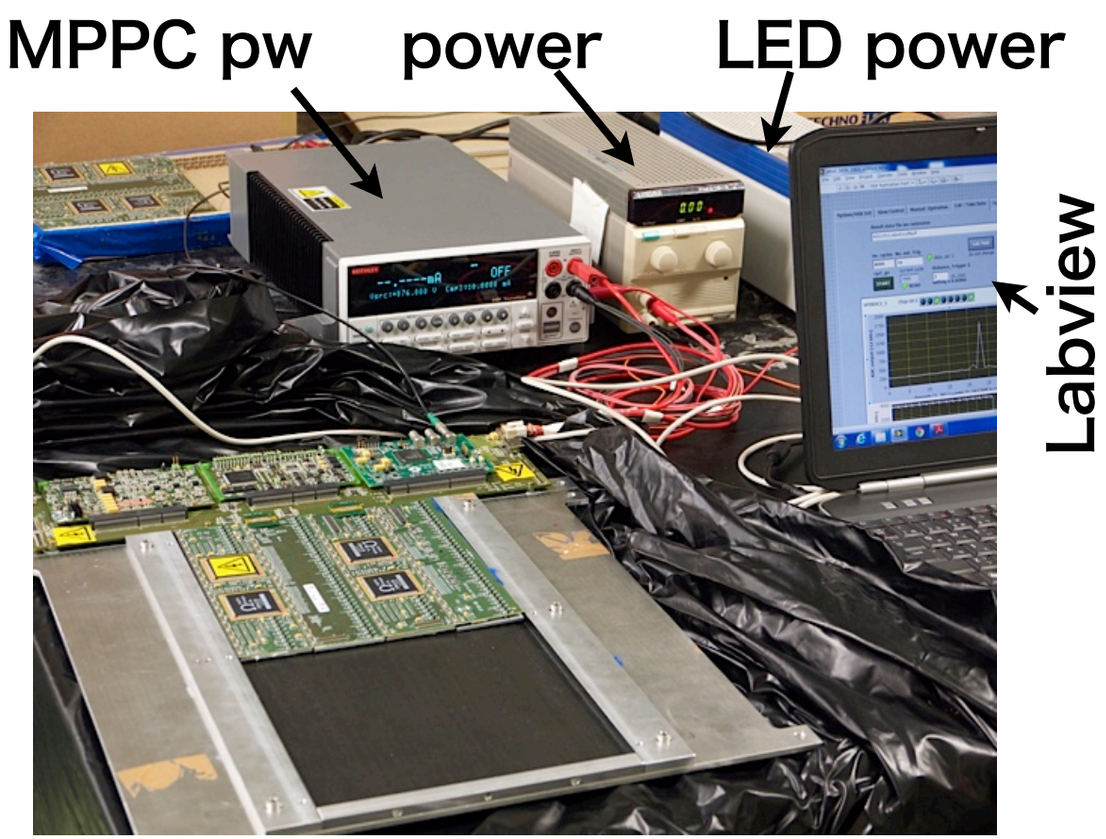
: no LED by ASIC or connector

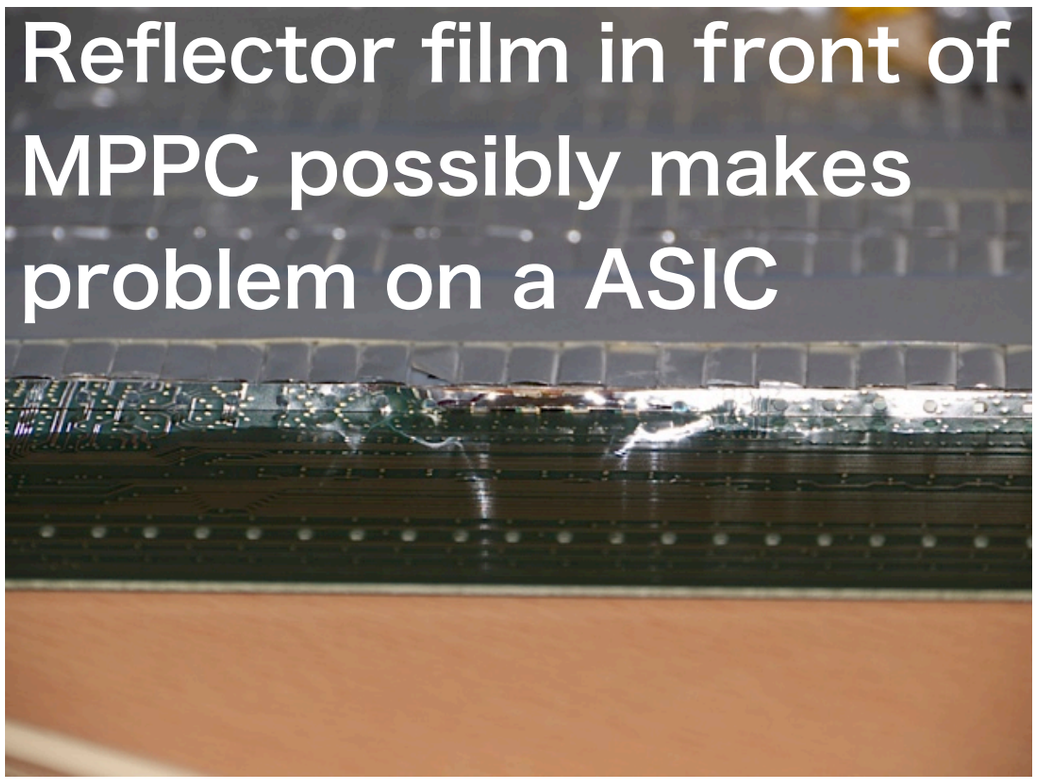
- (#good channels)/(144-32) = 50%.
- There is no any good LED channel on ASIC132.

ADC/p.e.



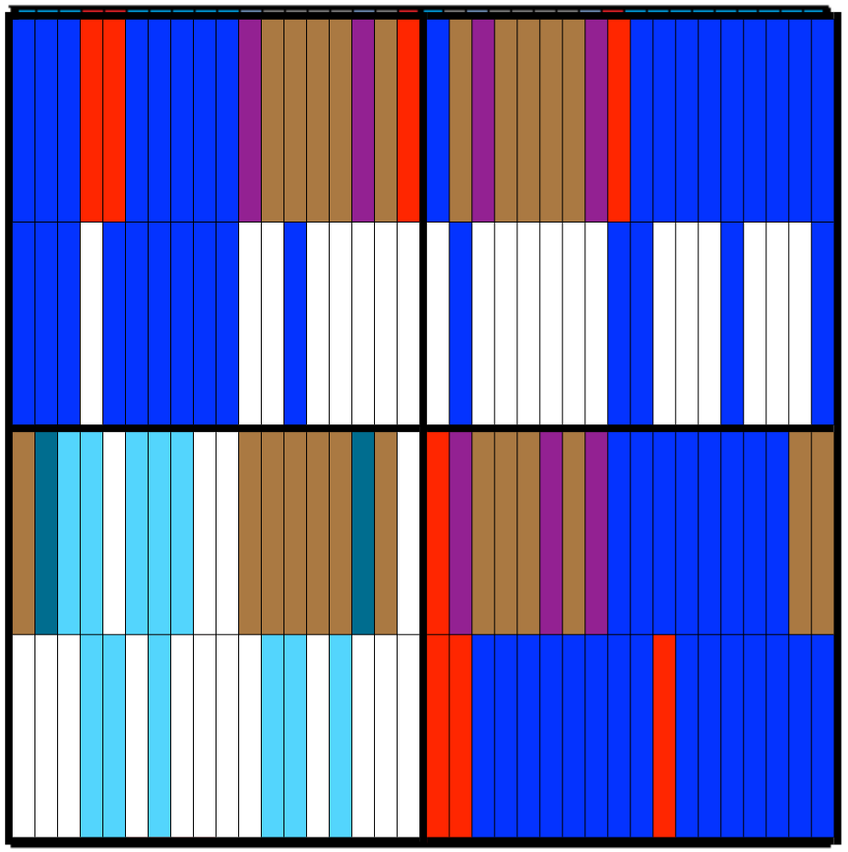
Repairing/Retuning at Shinshu

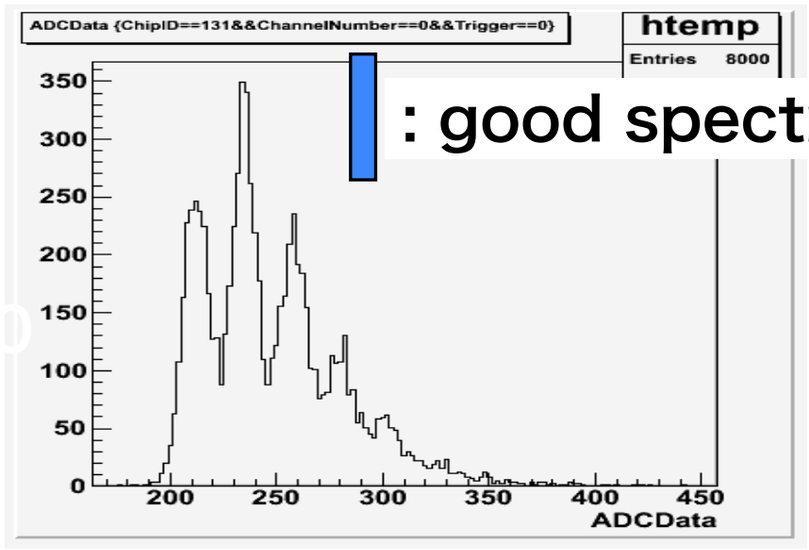




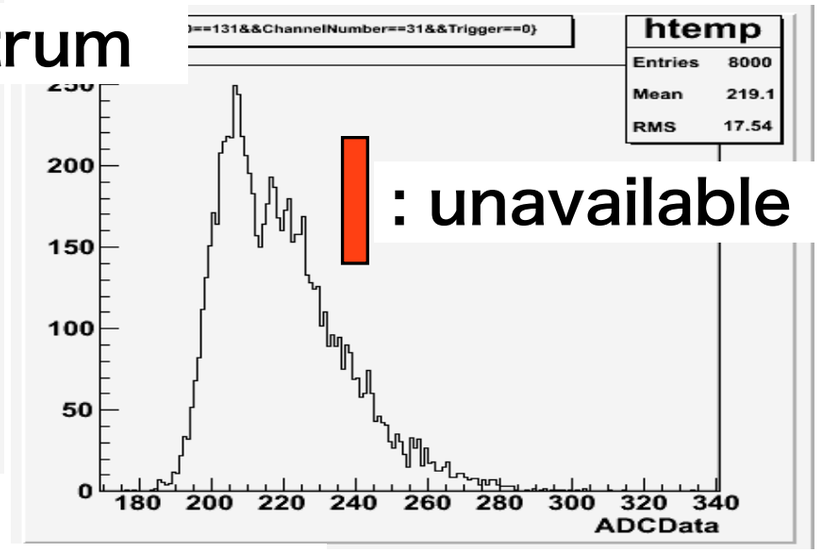
- We have set up the technological prototype at Shinshu.
- For the problematic channels, we reset the line of scintillators and removed the reflector in front of MPPC, then they seem to work well.
- For LED calibration, around half of problematic channels were already confirmed that they worked well, on going the rest.
- MIP signals were also observed by using ^{90}St RI source.

LED lights for gain monitoring





: good spectrum



: unavailable

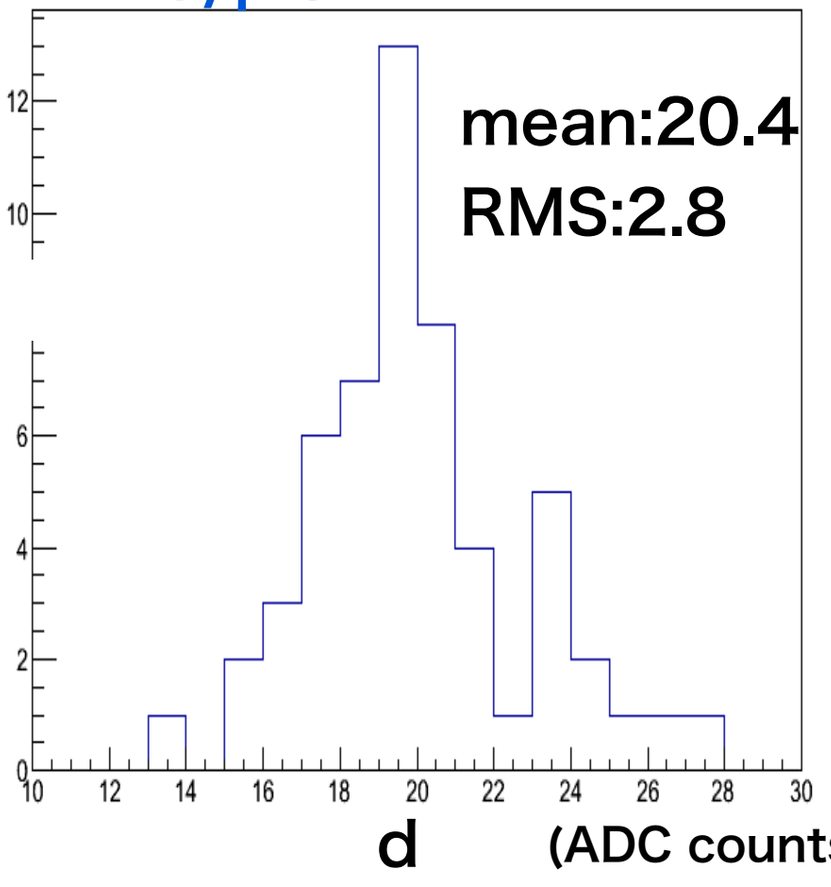
: no LED by ASIC or connector

: good spectrum after reset scintillator

: seems be good, measurement on going

- (#good channels)/(144-32)
= 50% ---> > 78% - 92%
- At Shinshu we will investigate what happens with the reflector.

ADC/p.e.



Pseudo-Multilayer ScECAL Shower events

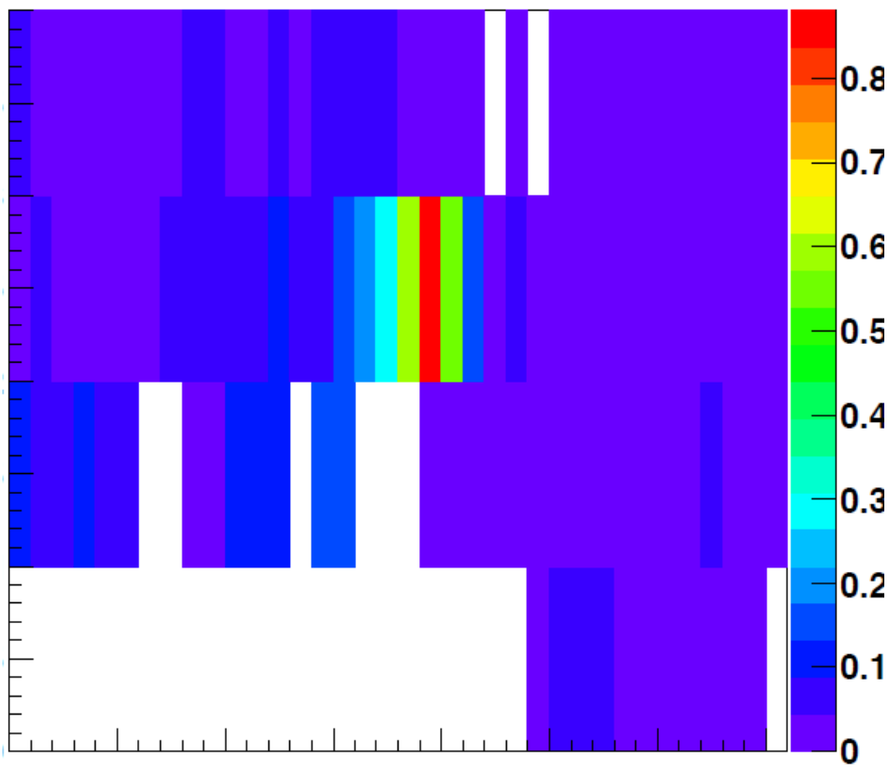
0.7 X_0 × (1 - 14) layers

Response of ScECAL behind

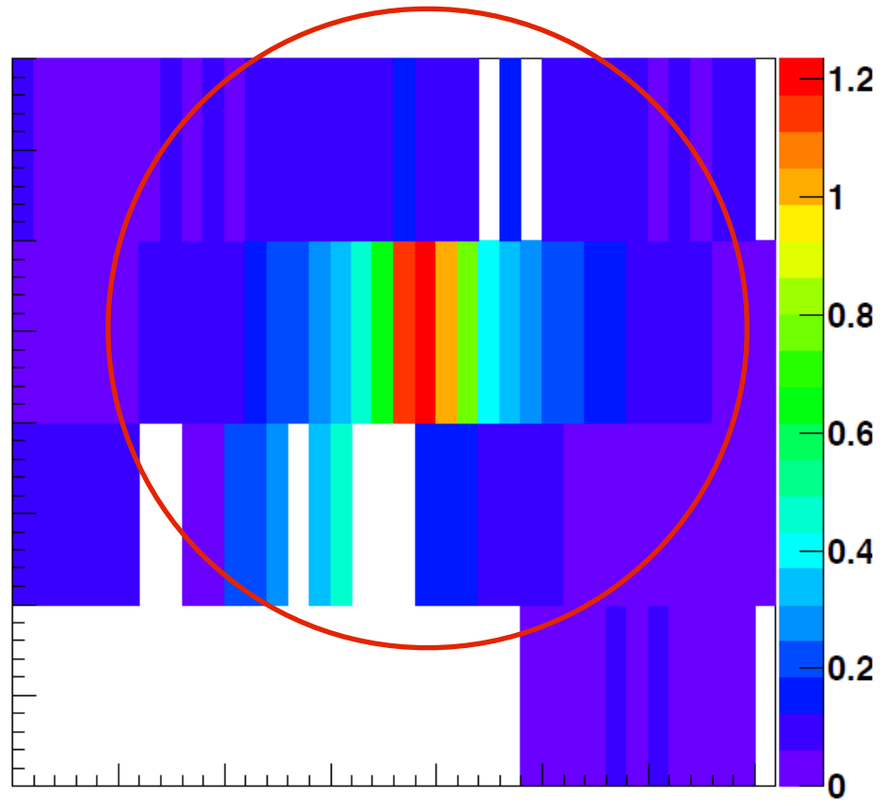
1. 0.7 X_0 tungsten absorber
2. 6.4 X_0 tungsten absorber

3 GeV e^- events

Mean of Energy deposit in each channel



3 GeV e^- w/ 0.7 X_0 absorber.



3 GeV e^- w/ 6.4 X_0 absorber .

Future version

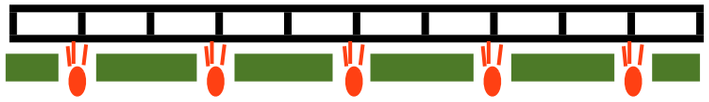
MPPC:

- HPK has established 10000 pix in 1 mm x 1mm which has similar PDE to the 1600 pix. It has no after pulse, no cross talk, and low dark noise. We will get it in April.
- Smaller package to reduce the dead volume from MPPC

1.4 x 1.4 x 0.6 mm^3 package

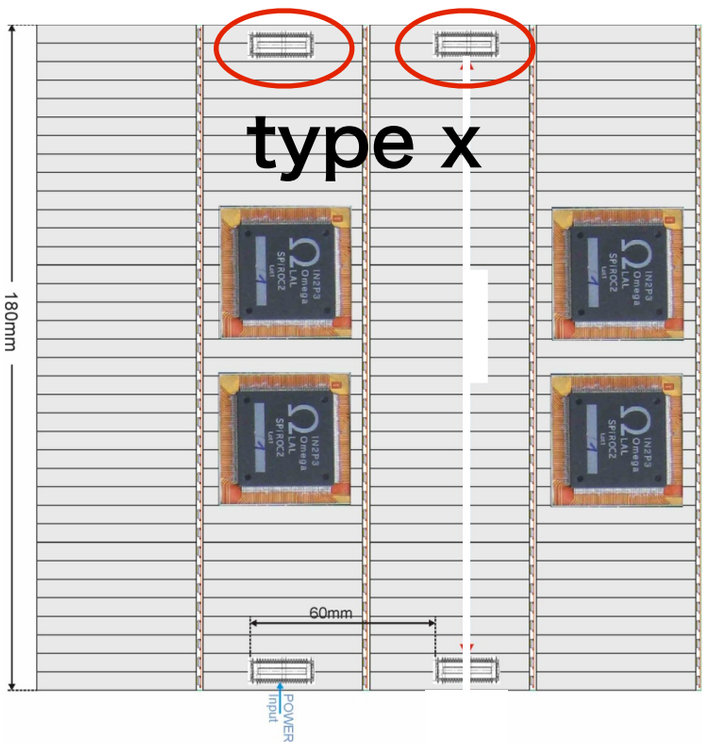
EBU:

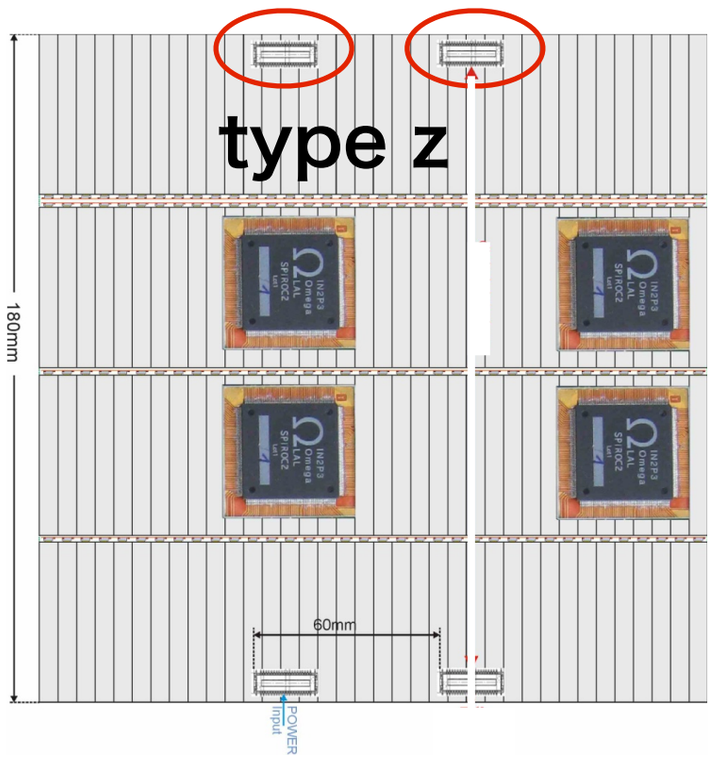
- More space for LED



We can reduce the # of LEDs.

- We need to make “type z”.



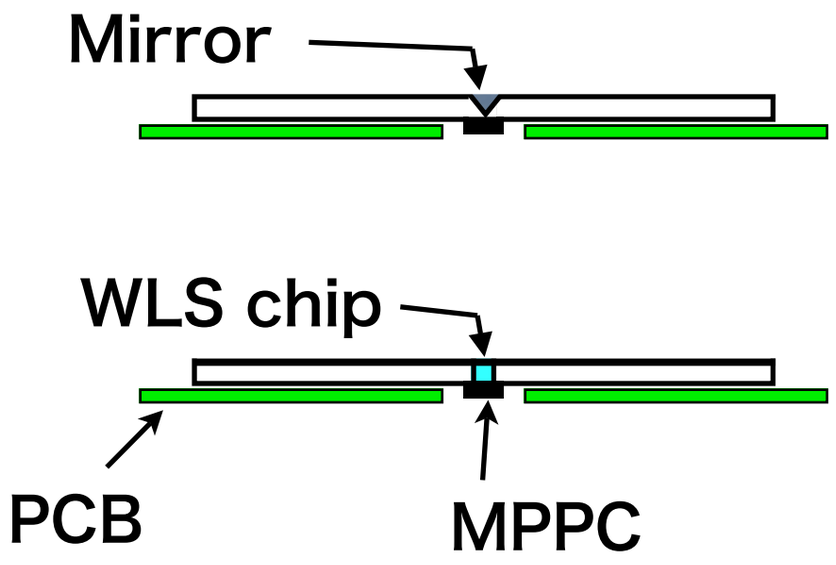


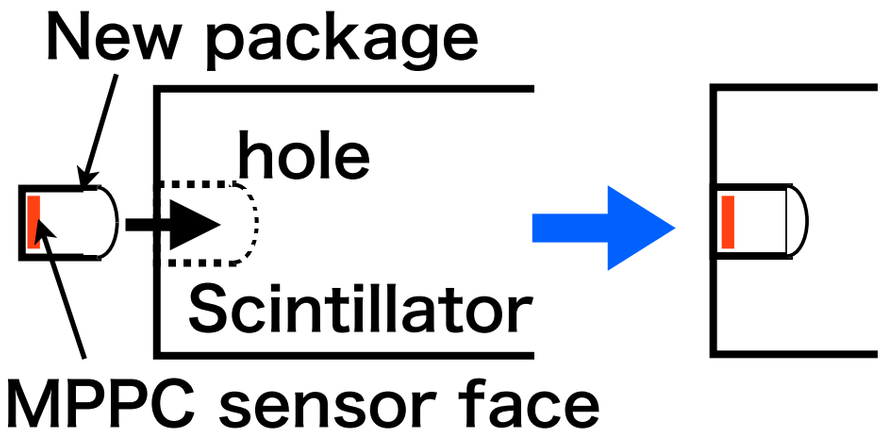
MPPC ladder and EBU-DIF connectors are conflict with each others.

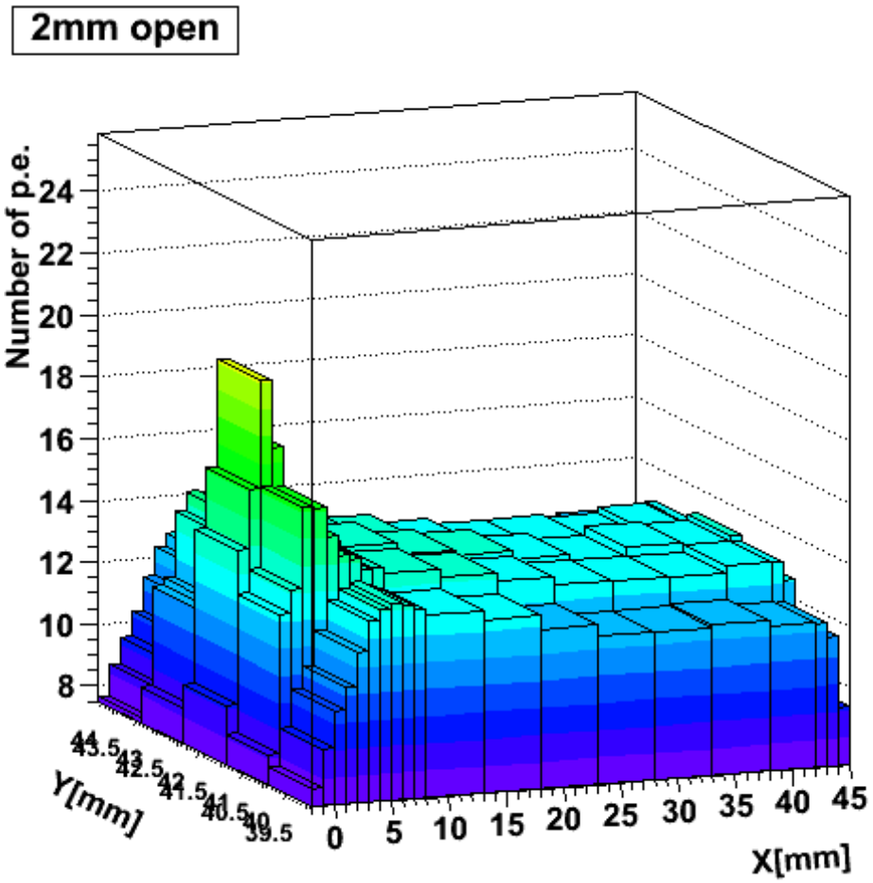
- Flip MPPC position,
- Shift connectors,

→ Test in lab.

Combination of MPPC/Scintillator







We've developed an automatic position measurement system at Shinshu

Using this system, we will study many types of MPPC/ Scintillator combinations.

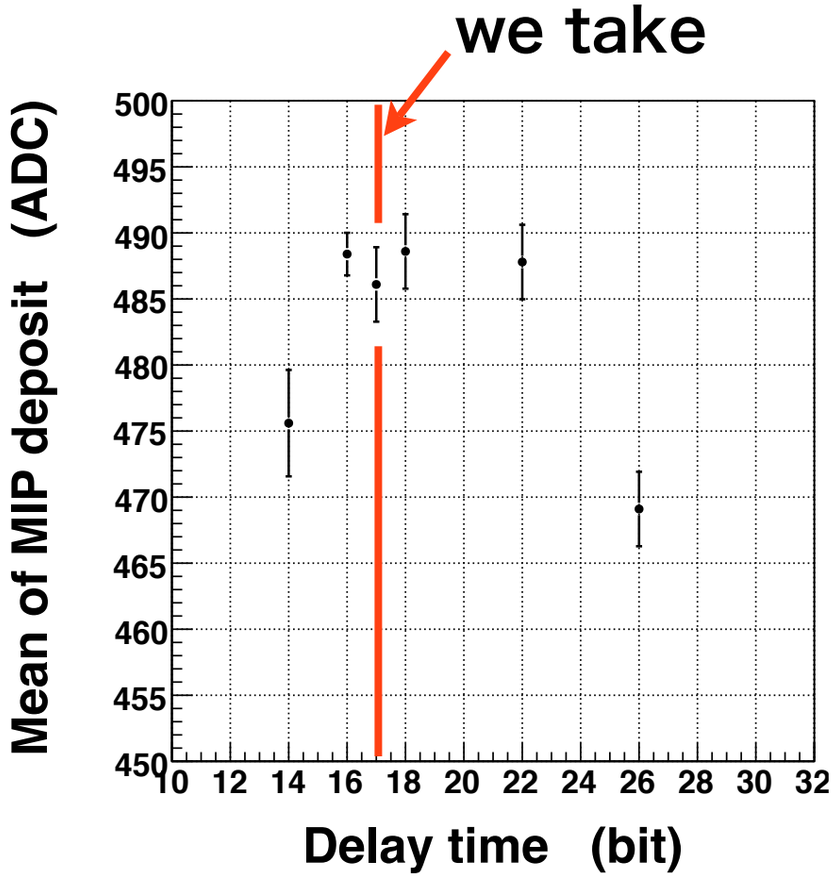
Summary

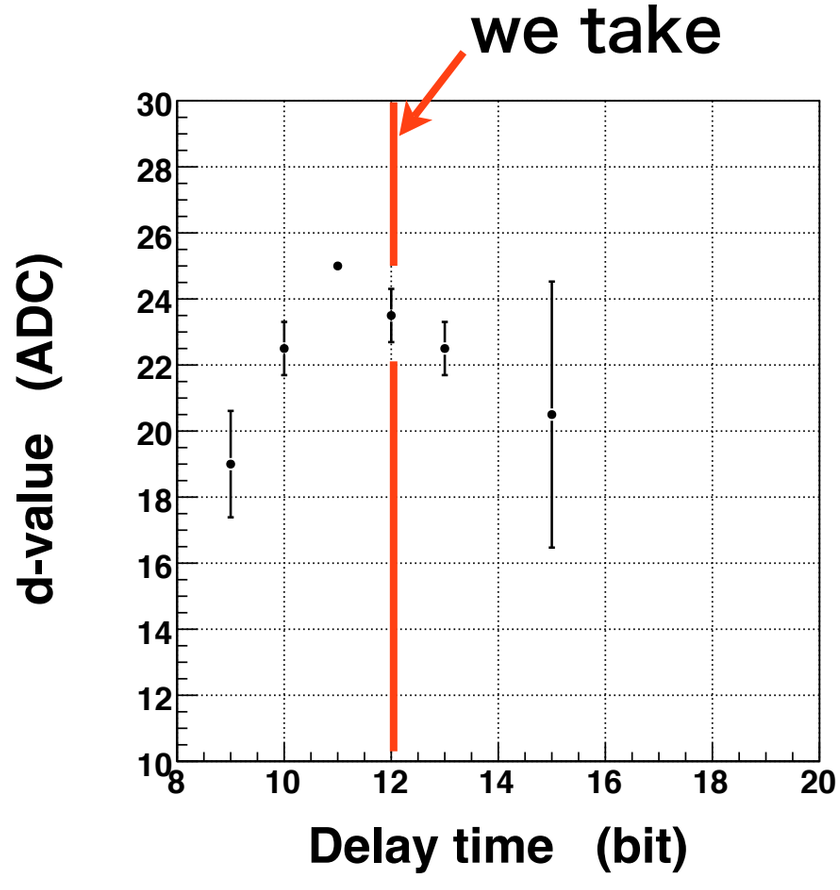
1. We have had the test beam experiment for the ScECAL 144 channel technological prototype using electron beam at DESY Oct 2012.
2. We have seen the distribution of MIP energy deposit with MPV of around 6.5 p.e. for 75% of channels.
3. The number of successful channels of gain monitor with LED system is 50% of channels which have LED light, so far.→ > 90% at Shinshu
4. We have set the ScECAL prototype up at Shinshu and started investigation what happened on the problematic channels.
5. From this TB, we've recognized many problems what we need to overcome.
6. Next test beam with more than two layers of current version at beginning of July,
7. more future, ... synchronization with AHCAL, SiECAL.

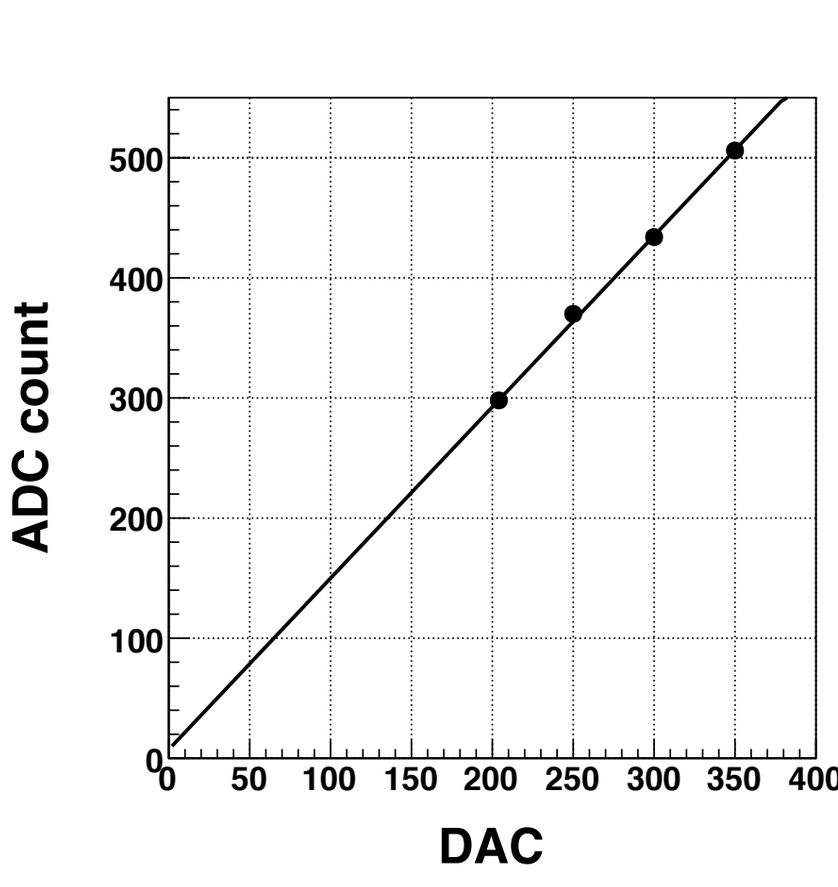
back up

Done: some tunings

9. Others
    1. large statistics of:
        1. MIP measurement with 0.5 MIP threshold
    2. delay time for TB run and LED run
    3. DAC-ADC relation

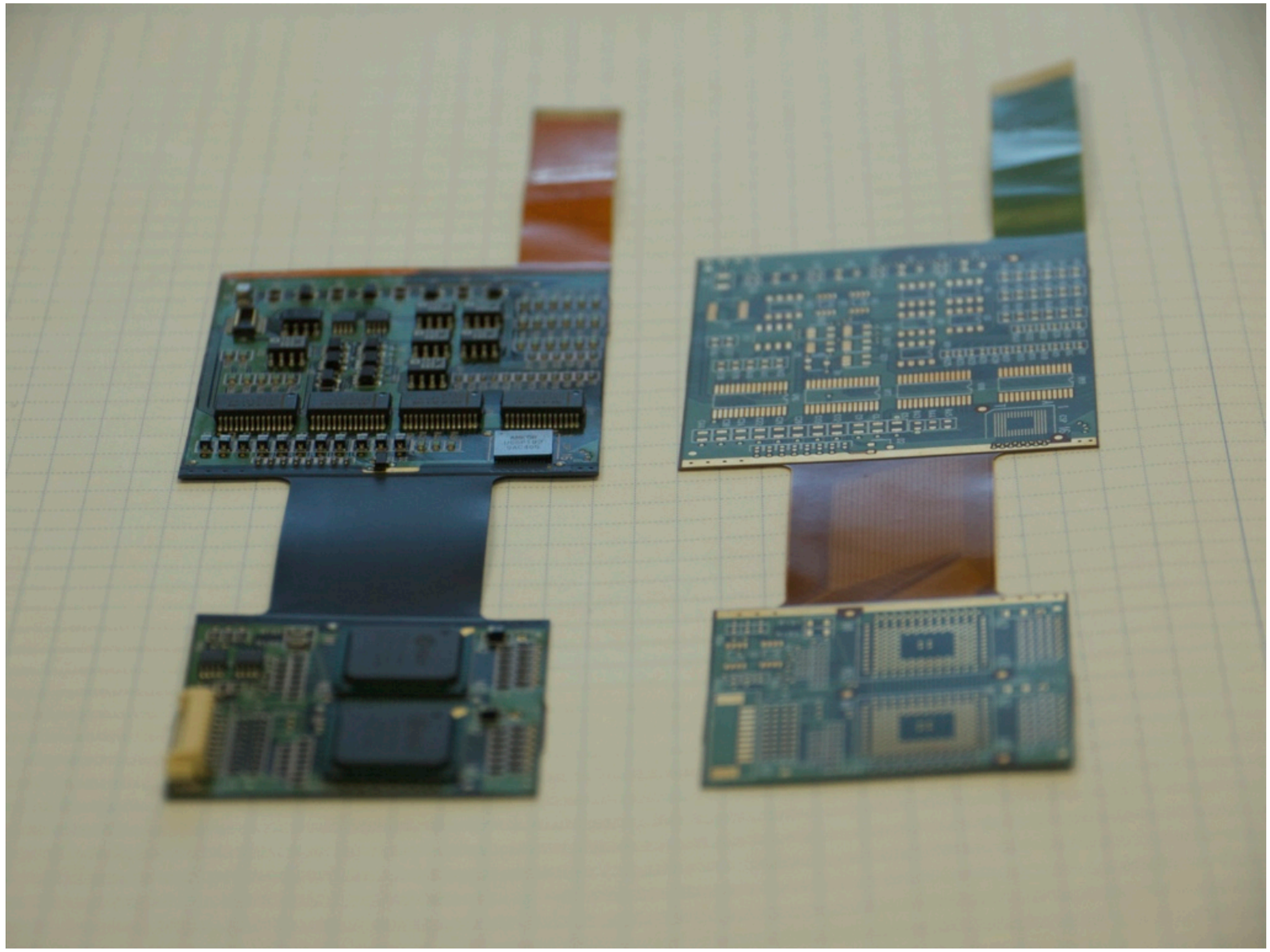




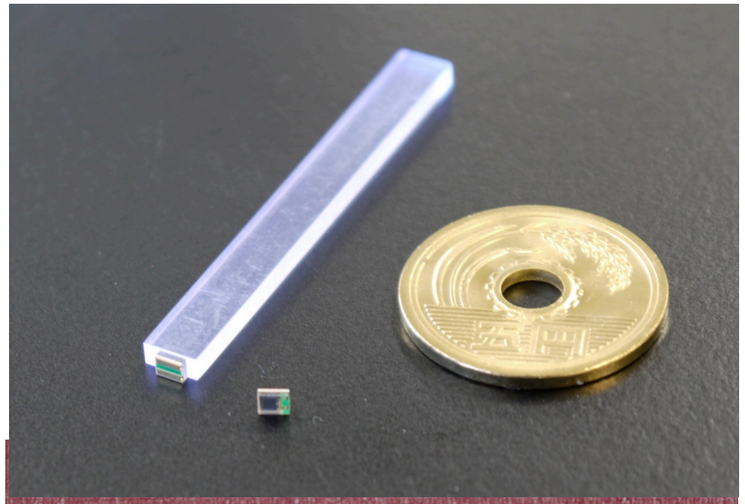


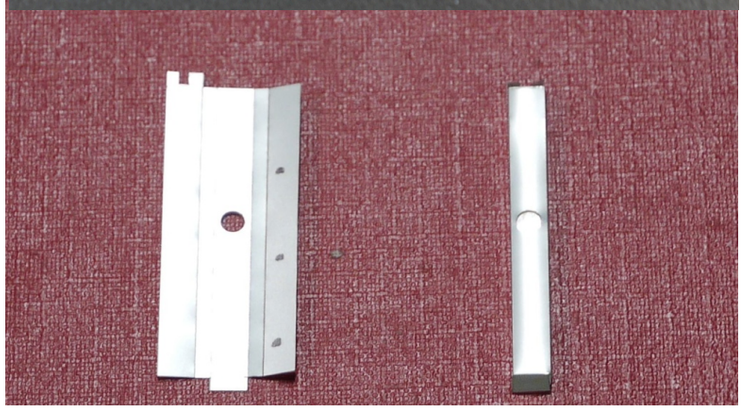
Future PCB?

- What can we do with 0.3 mm thick PCB?

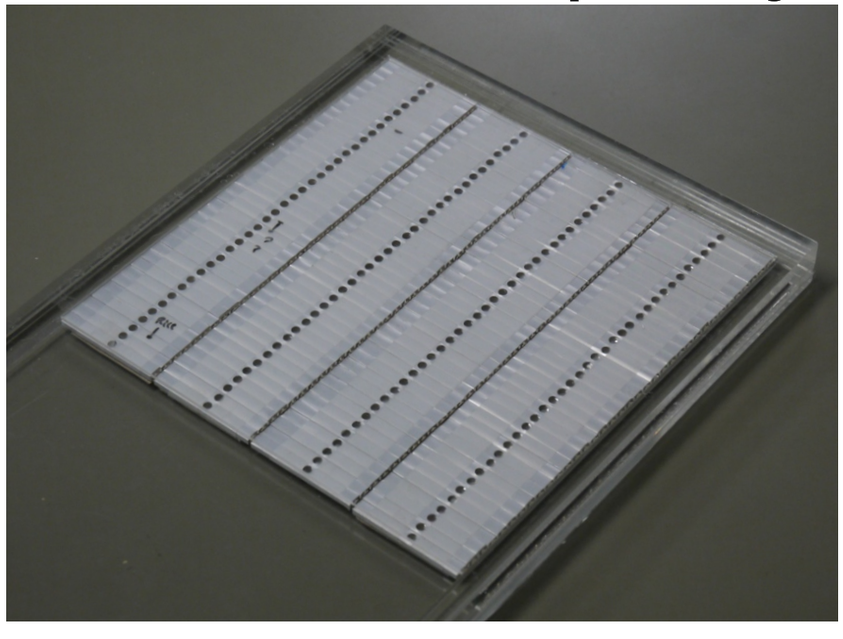


Current design of scintillator and MPPC

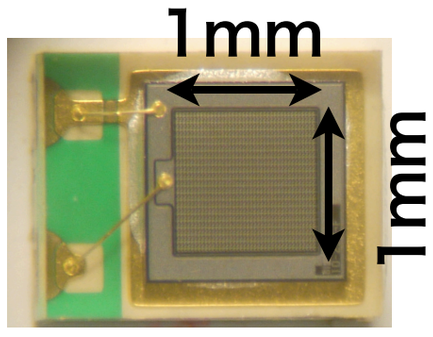


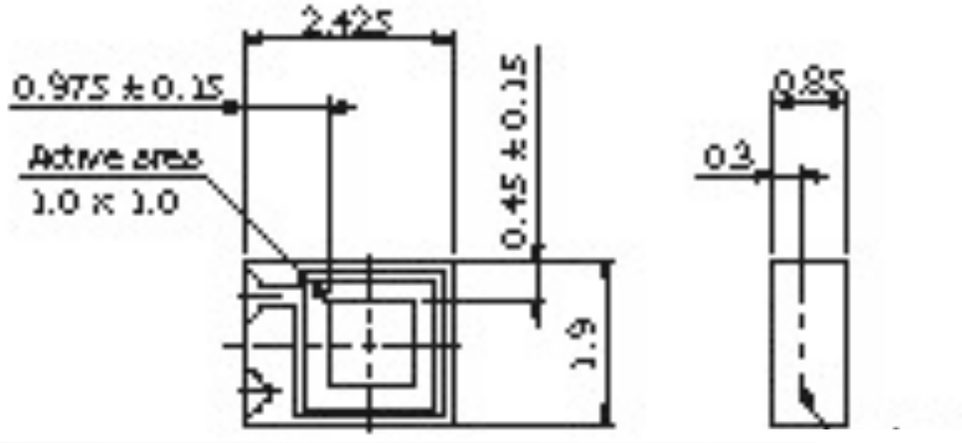


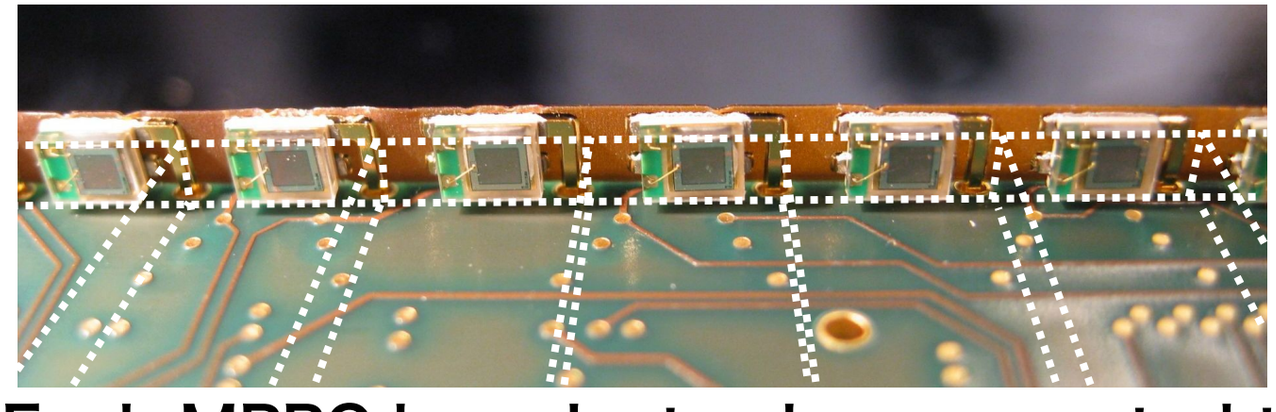
36 x 4 = 144 strip array



1. 45 mm x 5 mm x 2 mm plastic scintillator
2. with surface mounted MPPC
    1. > 1600 pixels in 1 mm x 1mm.
    2. Hamamatsu has developed 10k pixel MPPC recently --> We will test it.
    3. MPPC package: 2.4 x 1.9 x 0.85 mm^3

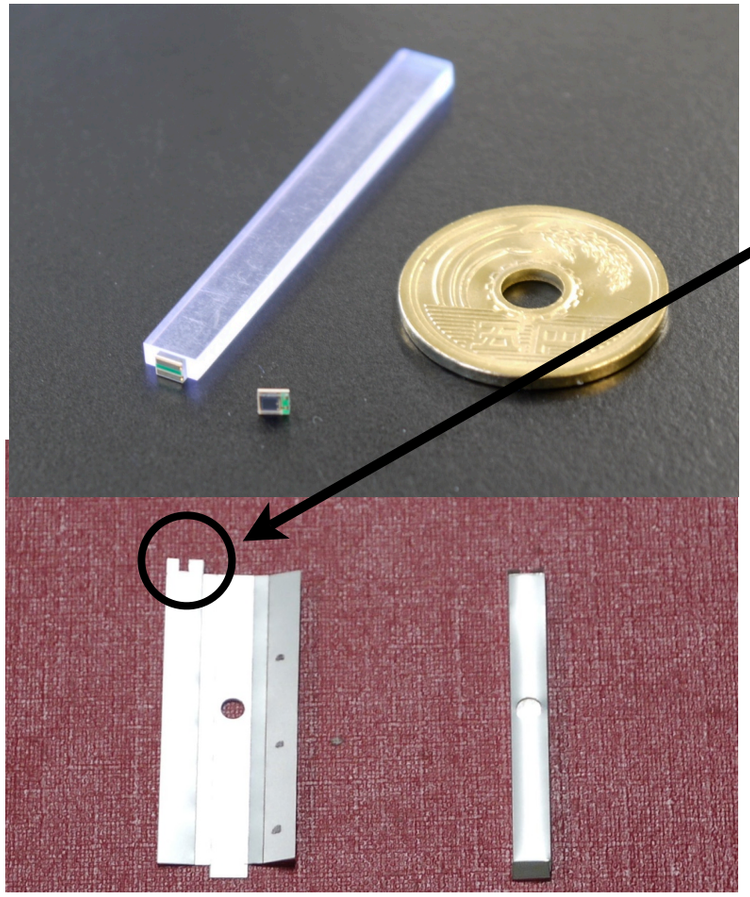






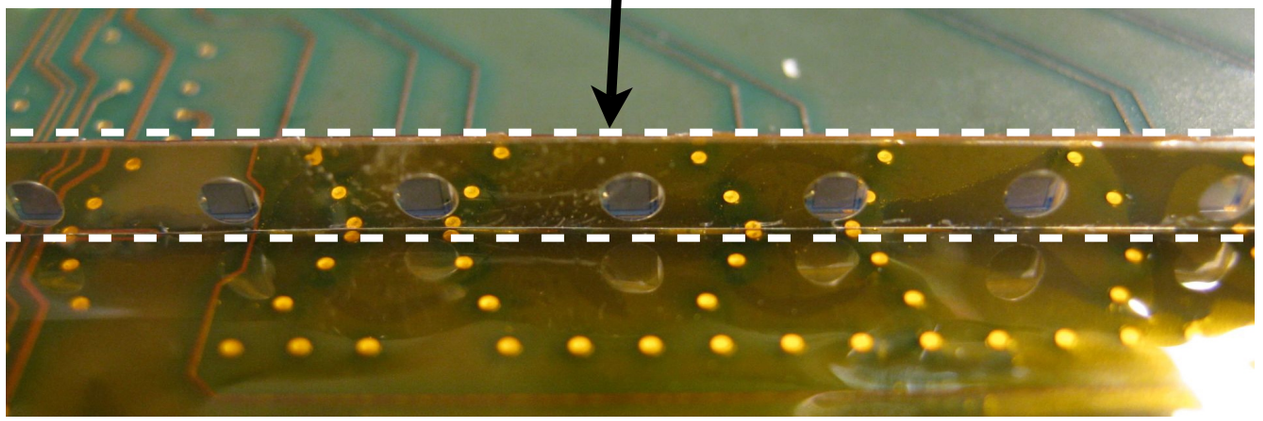
Each MPPC has electrodes connected to the baseboard directly.

Current design of scintillator and MPPC

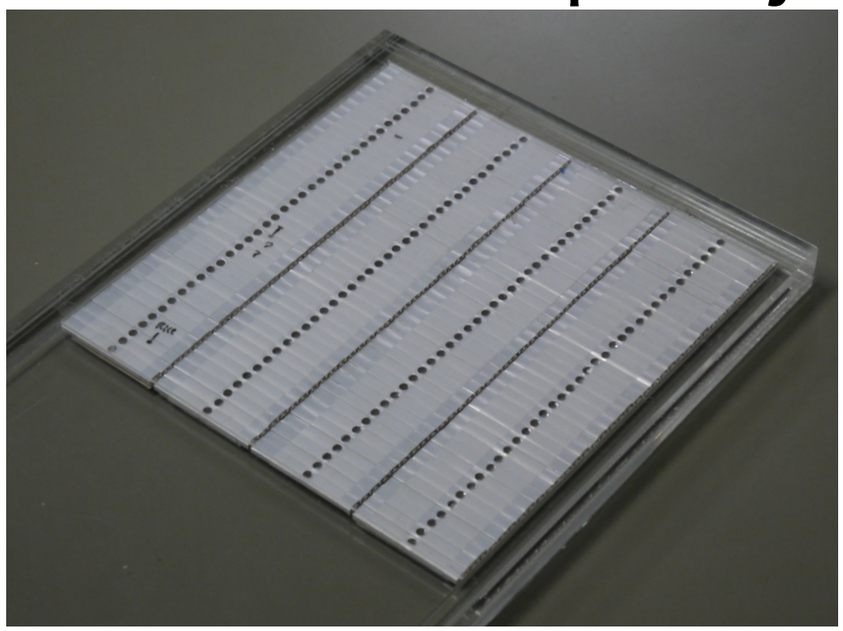


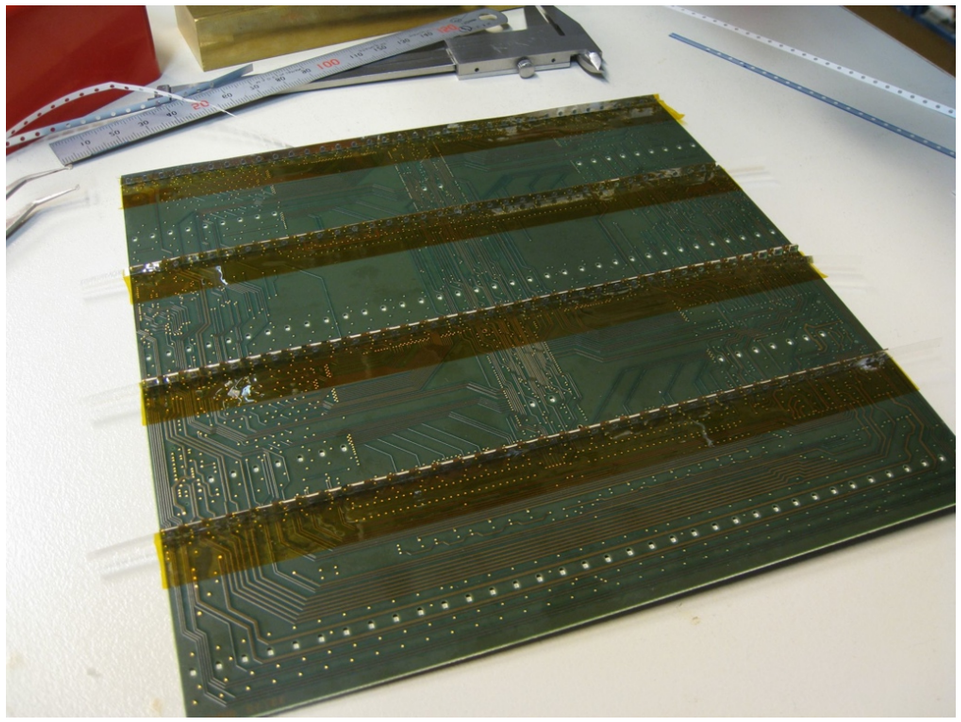
Since it was to difficult to keep the quality of the holes for MPPCs, we removed this parts and we put

a reflector tape with holes for MPPCs for an MPPC ladder.



36 x 4 = 144 strip array





Polyimide tape to avoid to touch the conductive cross-section of reflector film.

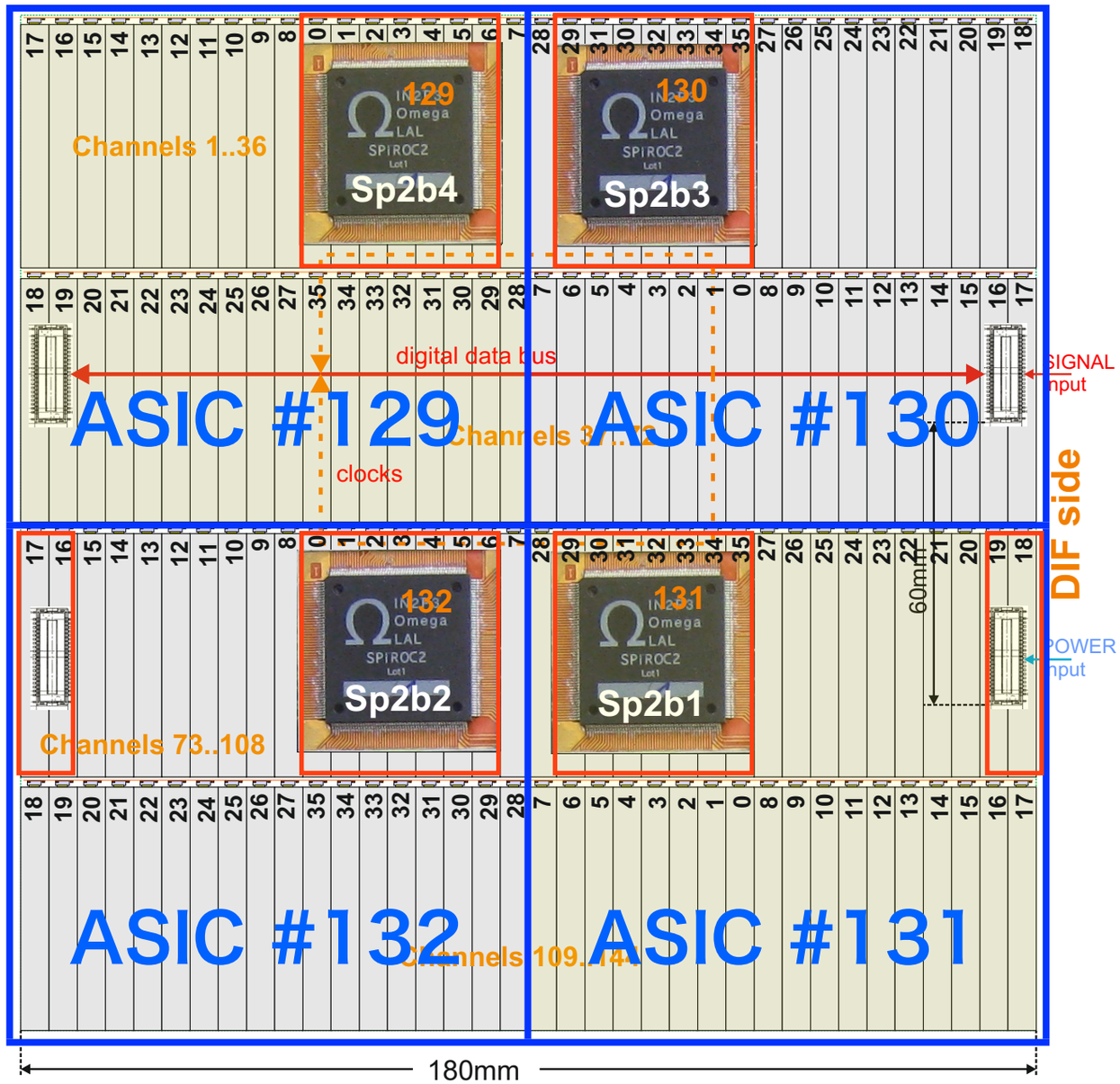
Problems we recognized

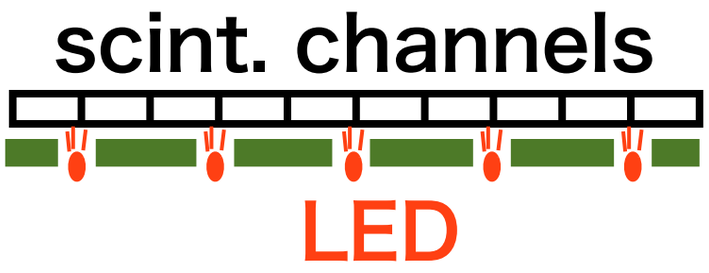
1. DIF cannot control multiple EBU for the TB mode so far.

   → Already Fixed

2. Individual threshold cannot be available so far.
3. A SPIROC2b has 16 analog memory cells. This means that 16 events can be taken for a spill and the conversion factors between the analog memory cell and ADC has difference by memory cell by memory cell.
4. Some events have a triggered channel which has small ADC counts than the true one.
5. Many unavailable LED channels.
6. LED system makes strange noise on #132.
7. We need more photon yields.
8. ・・・

LED lights for gain monitoring





No space for LED

7 x 4 for ASICs.

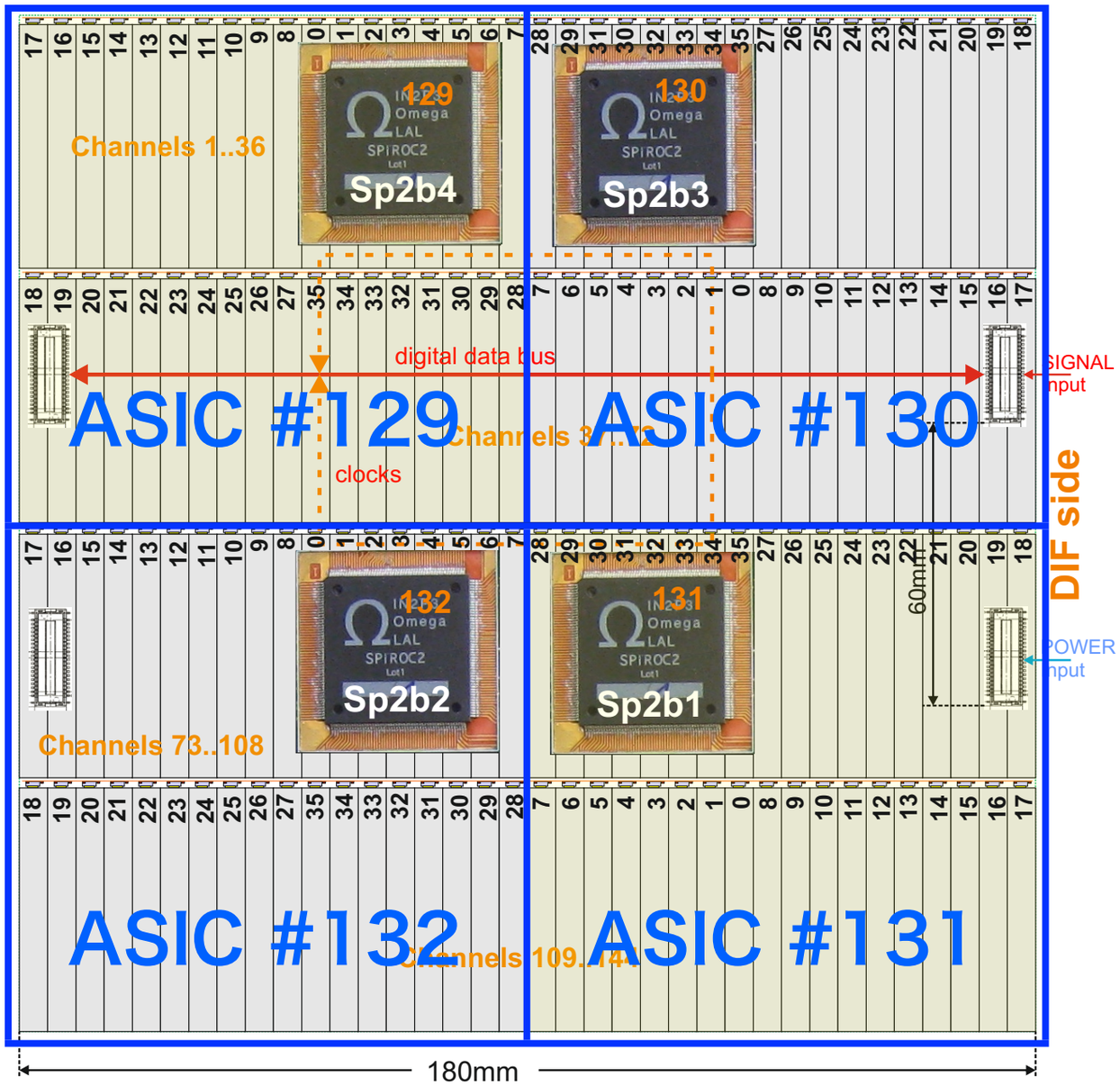
2 x 2 for power connectors.

32 channels have no LED.

We need to ask to reduce the size of SPIROC package not only in thickness but also in area by using some package technique.

Next time,we can reduce the number of LED by sharing an LED with more than two channels

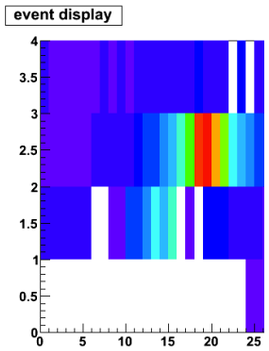
Address of channels

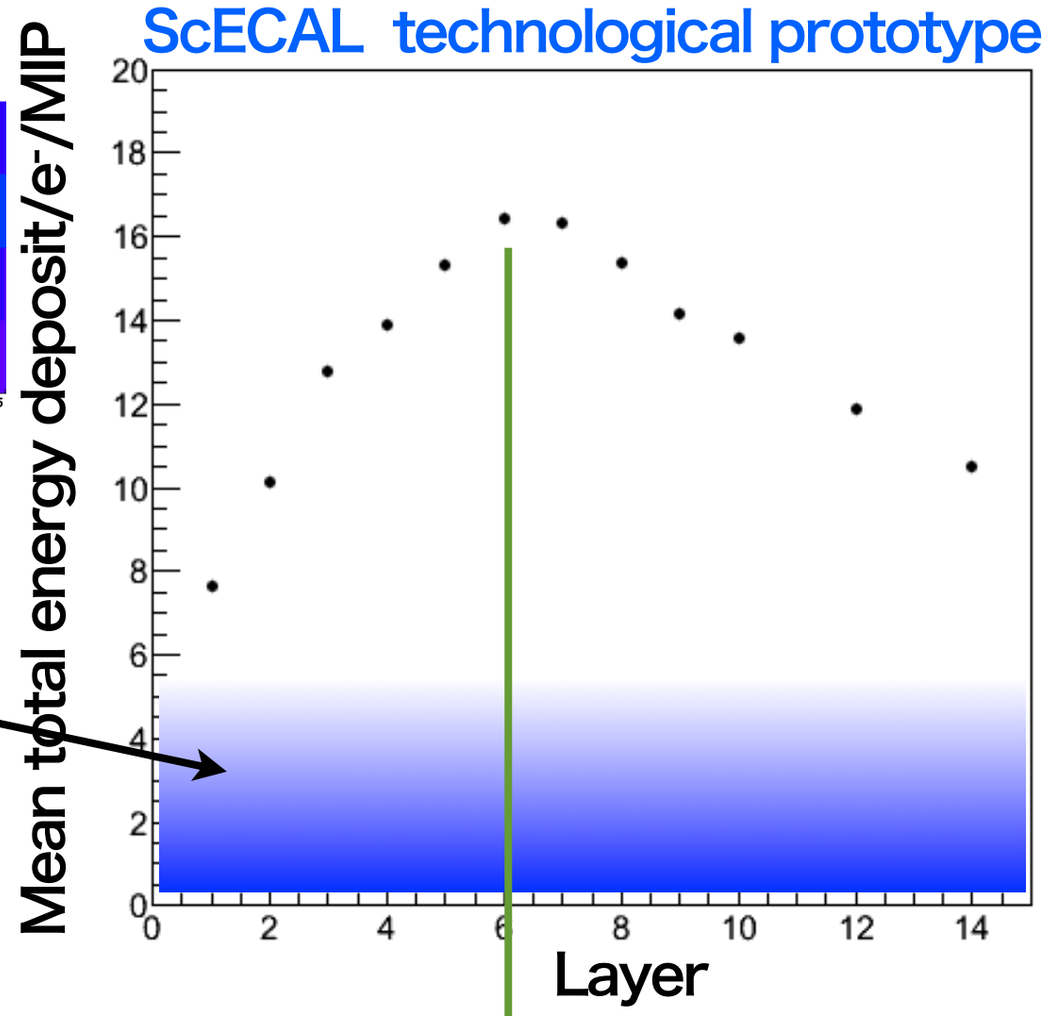


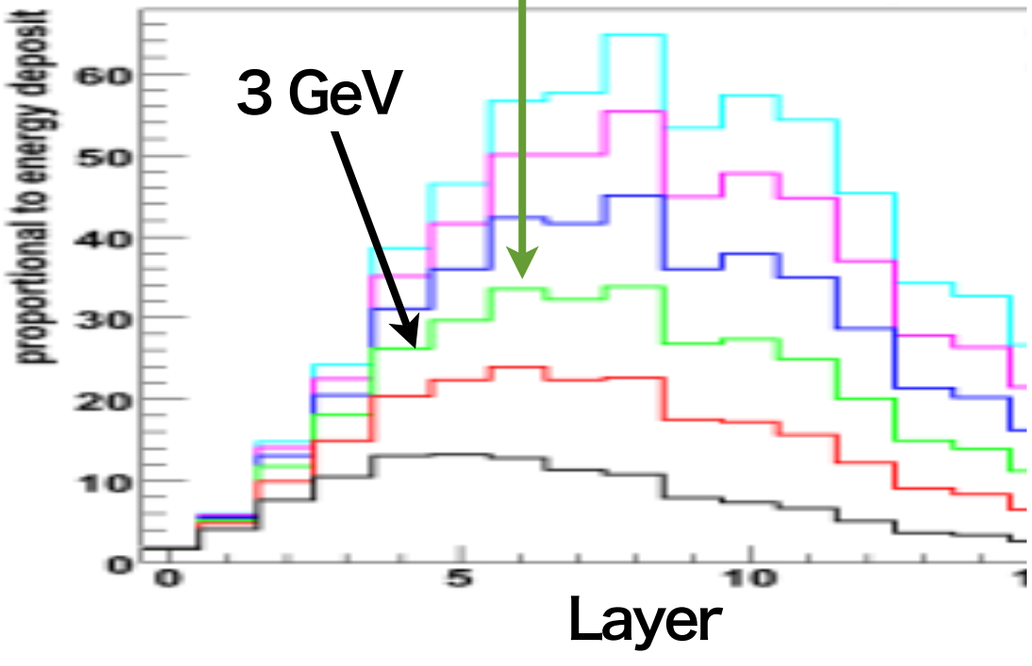
Sp2b1: Channels 91:108, 127:144
Sp2b2: Channels 73:90, 109:126
Sp2b3: Channels 19:36, 55:72
Sp2b4: Channels 1:18, 37:54

Pseudo-Multilayer ScECAL

- Longitudinal shower profile is plotted.
- Shower maximum is reasonable 6-7.
- Some amount of offset comes from noise will be estimated.
- Zero absorber data will be added from the mip measurements.

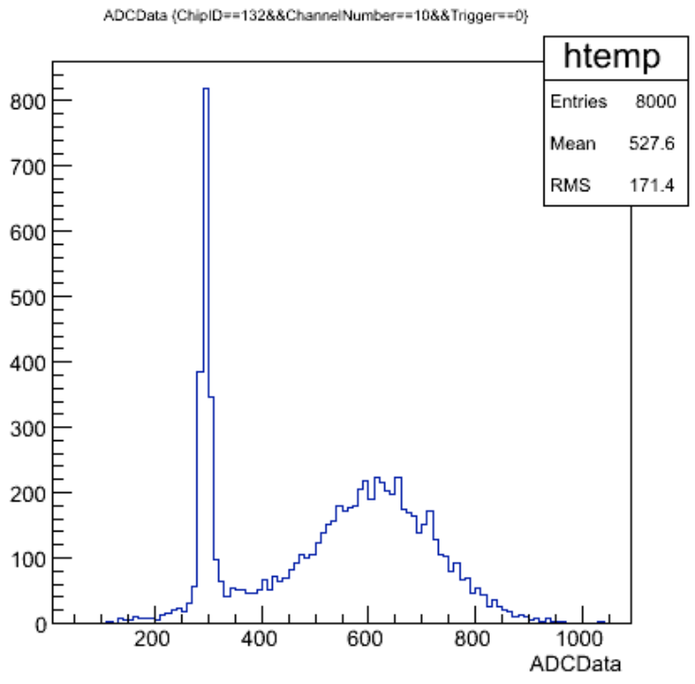


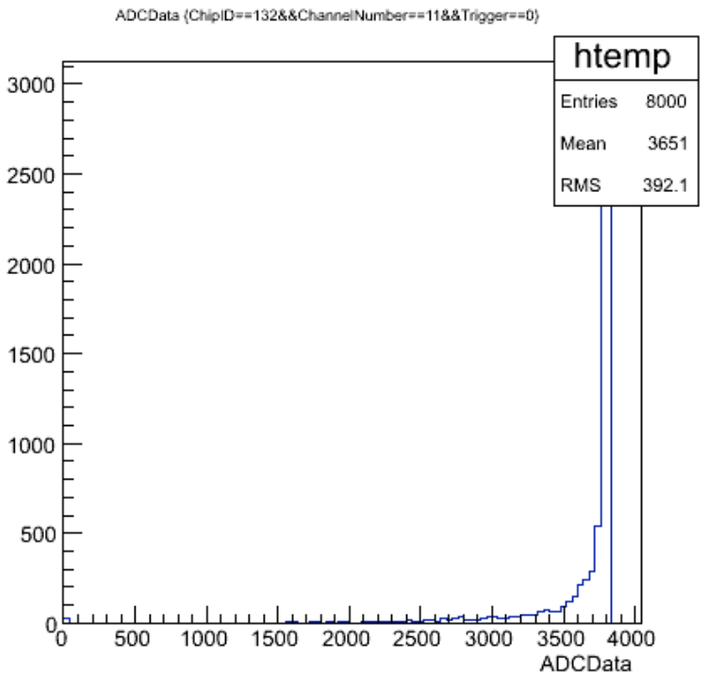




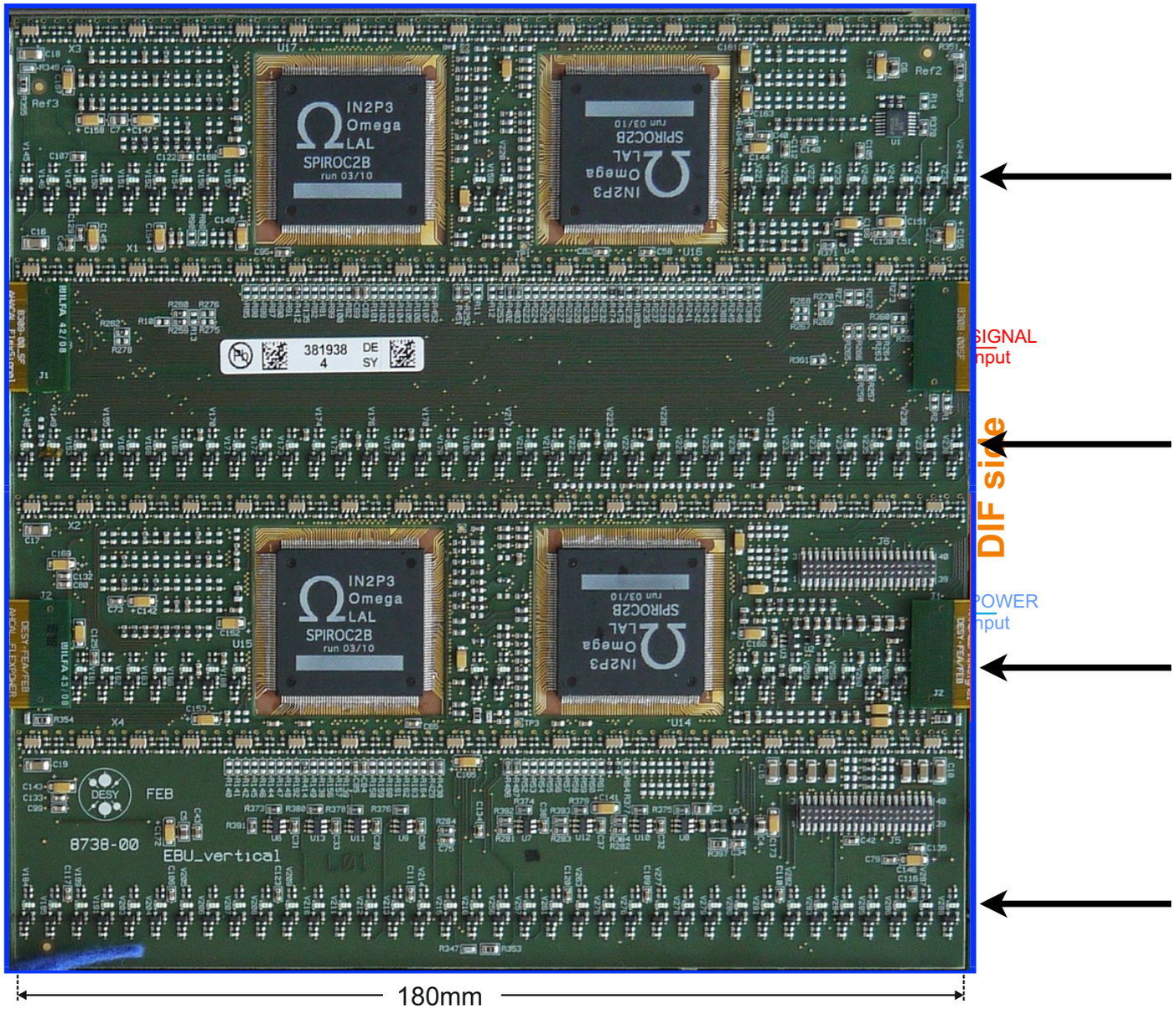
- From the result of physics prototype tested at DESY(2007)

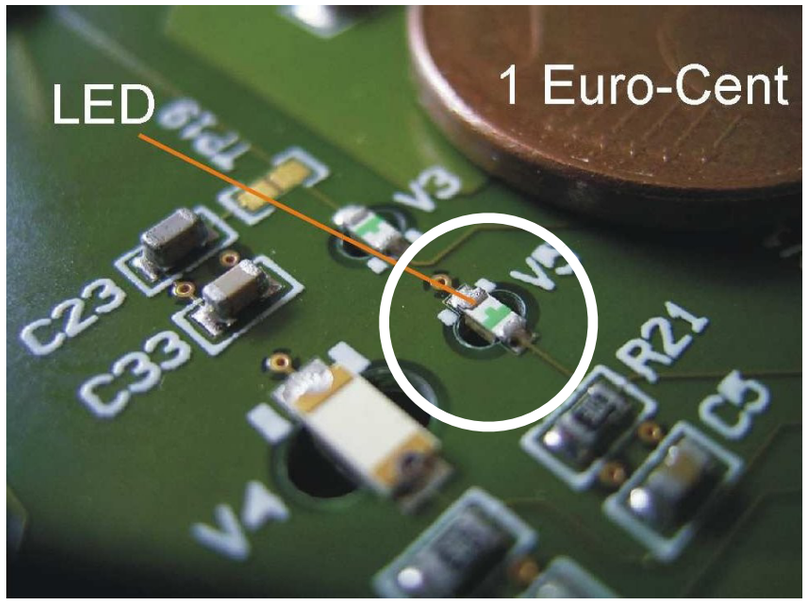
ASIC 132 LED on (but we can see normal pedestal with 0 V LED ▶ LED current makes noise?)





LED lights for gain monitoring





EBU has LEDs for each channel

Future plan

1. Near Future:
    1. Two layer (x and y type) ScECAL prototype,
    2. Combined with Si-W-ECAL prototype (Hybrid ECAL),
2. Further more,
    1. Fix the technology and design of Scintillator-MPPC unit,
    2. more compact electronics.
        1. ASIC,
        2. Central detector interface.

Plan of the analyses

1.Precise analysis of MIP and pedestal.

2.Precise analysis of gain with LED run data.

3.Study on the fluctuation of memory cells by measuring LED p.e.-ADC depending on memory cells (data has a flag).

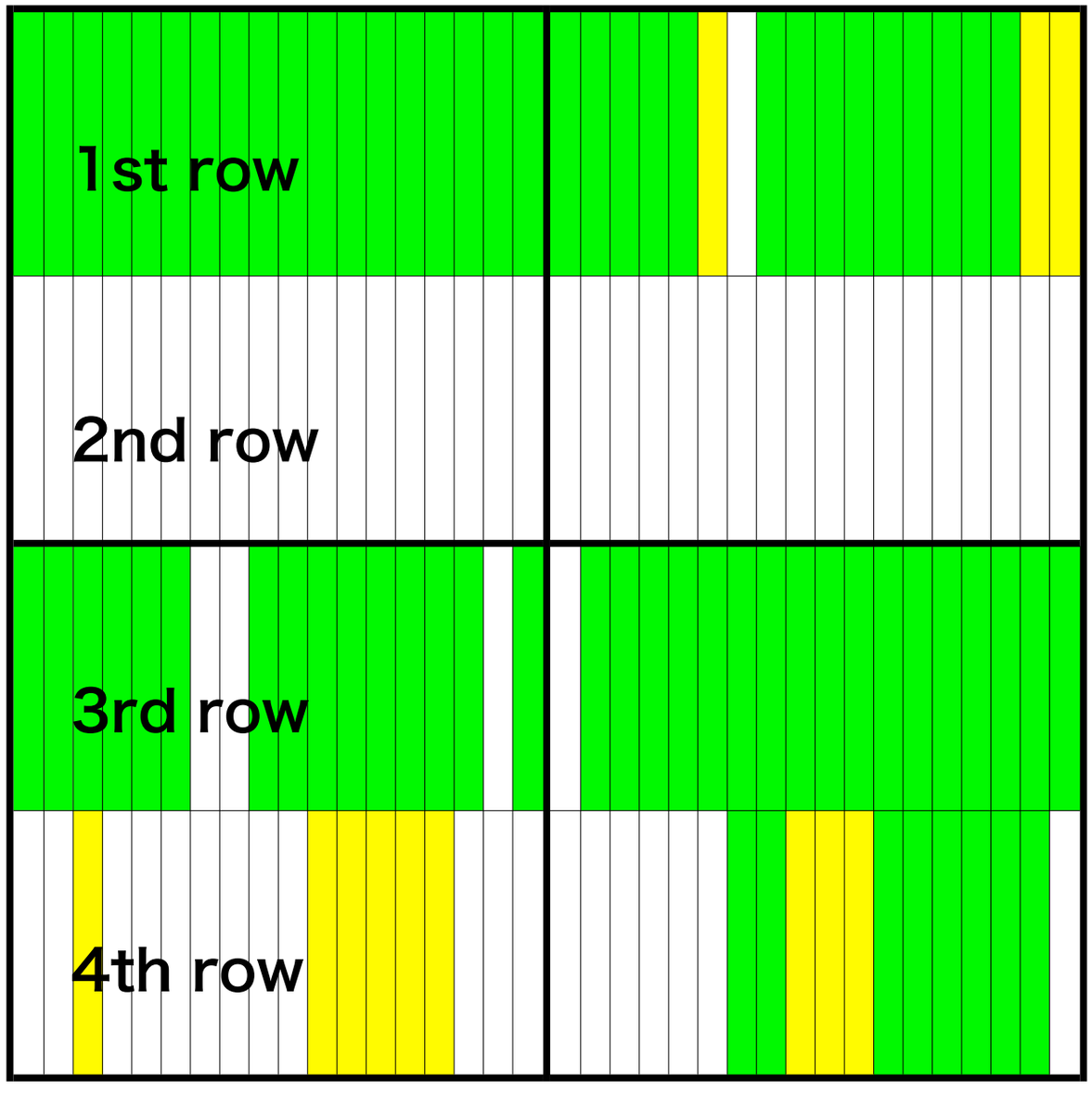
4.Study on LED system using EBU at Shinshu [We have brought two EBUs including one full equipped EBU, central interface board (DIF, LED, Power)] and its frame.

5.TDC analysis (we have data)

6.Power pulse study in our lab in shinshu and in the next TB.

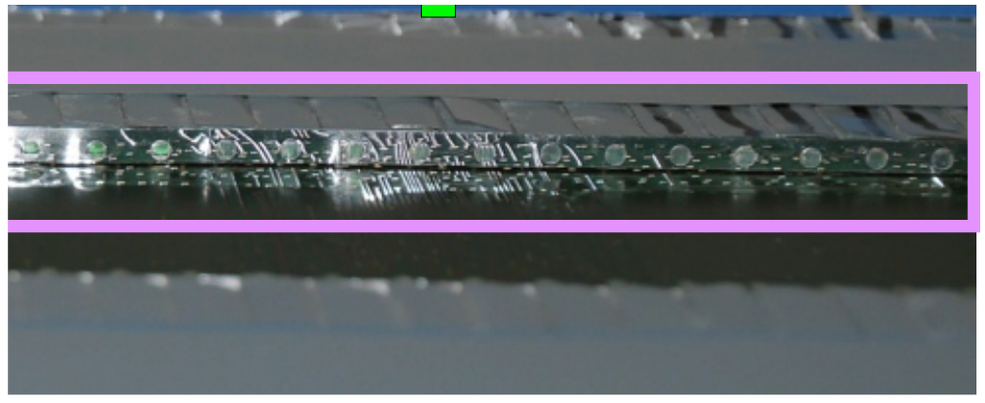
7.More EBUs, more layers, and Hybrid ECAL.

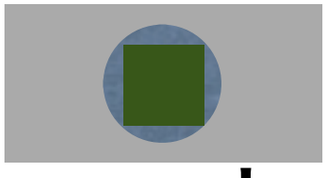
Response to MIP events



75% channels have succeeded to have good MIP distribution

We checked MPPC-Window matching

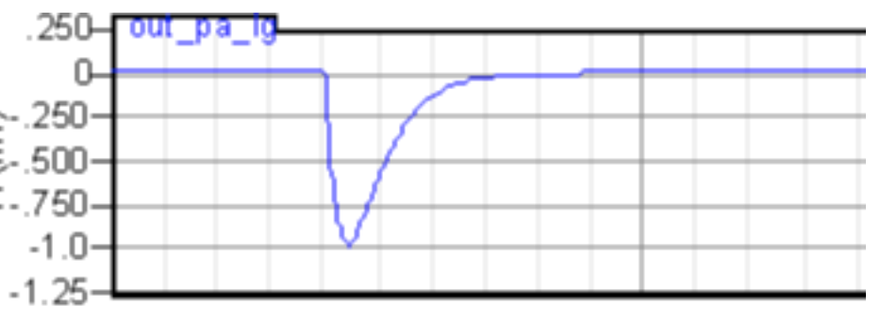




window/MPPC matchings were good

Nevertheless we removed the reflector ribbon and 2nd row came back!

SPIROC2b logic for auto trigger mode



MPPC analog signal

Slow Shaper (integrated)

IN

Slow Shaper

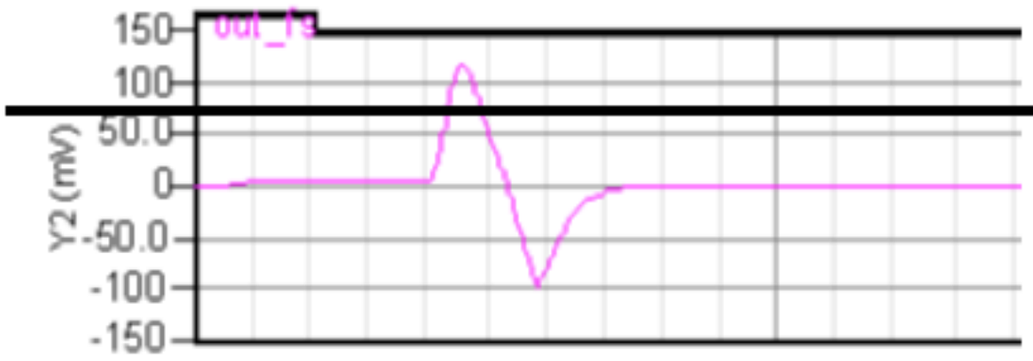
16 Analog memory

ADC

Fast Shaper

Valiable Delay

Discri



Threshold

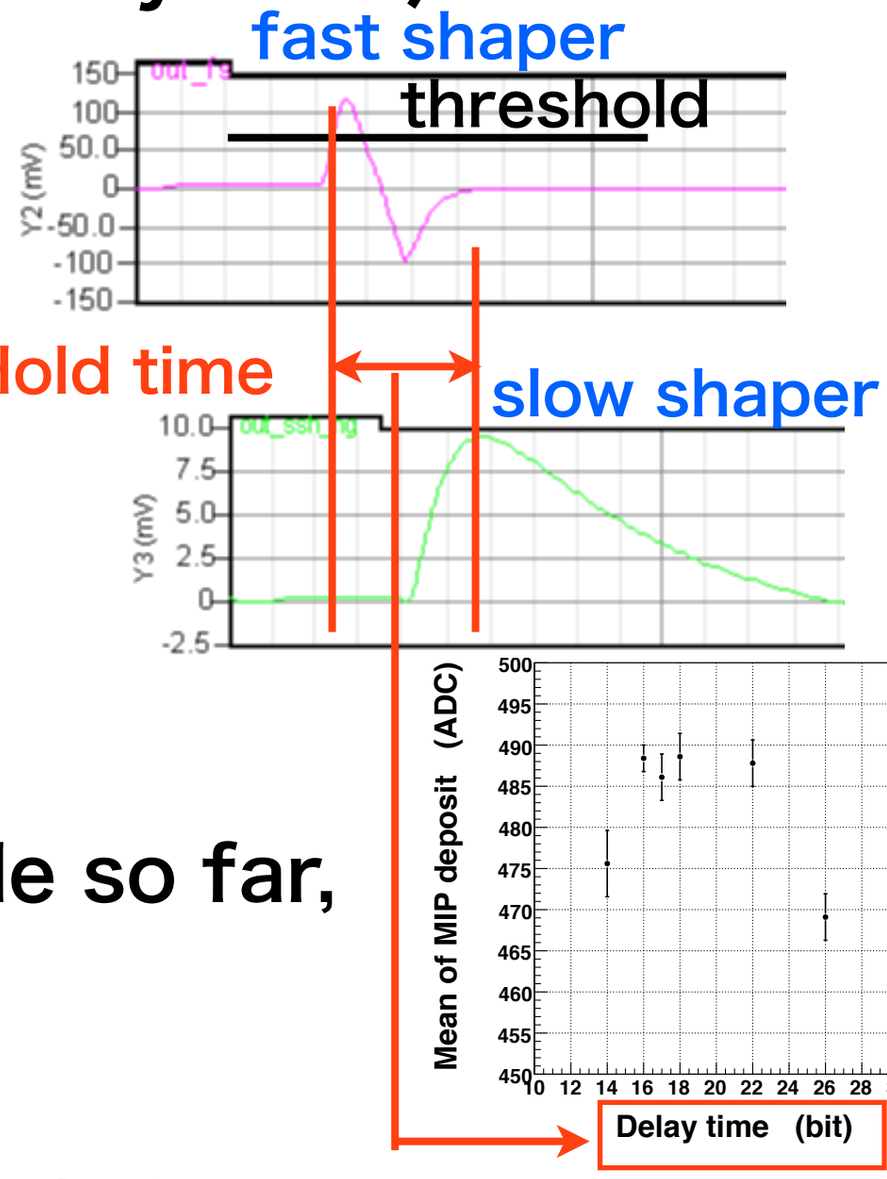
TDC

Fast Shaper for triggering (dif)

Issues should be optimized

- Shaping time (like gate length, ASIC by ASIC)
  - we tuned to 100 ns
- Delay time (ASIC by ASIC)

- Spill signal delay
- Bias voltage (channel by channel)
- Threshold for auto trigger
  - global (ASIC by ASIC) : we used
  - channel by channel : not available so far,
- Preamplifier (channel by channel)
  - maximum value in this TB
  - in future, tune this value to have 0.5 MIP threshold at the same DAC value for all channels.



Logics

spill signal

TTL to NIM

Gate Generator

40 ms

NIM to TTL

Beam

40 ms

validation mode

beam makes it

x counter

y counter

coin.

Gate Generator

10 ns

NIM to TTL

10 ns

EBU

Validation mode (like triggering)

40 ms

EBU can work

spill signal

4 μs clock

validation failed

max meas.length or16 events

delay spill sig.

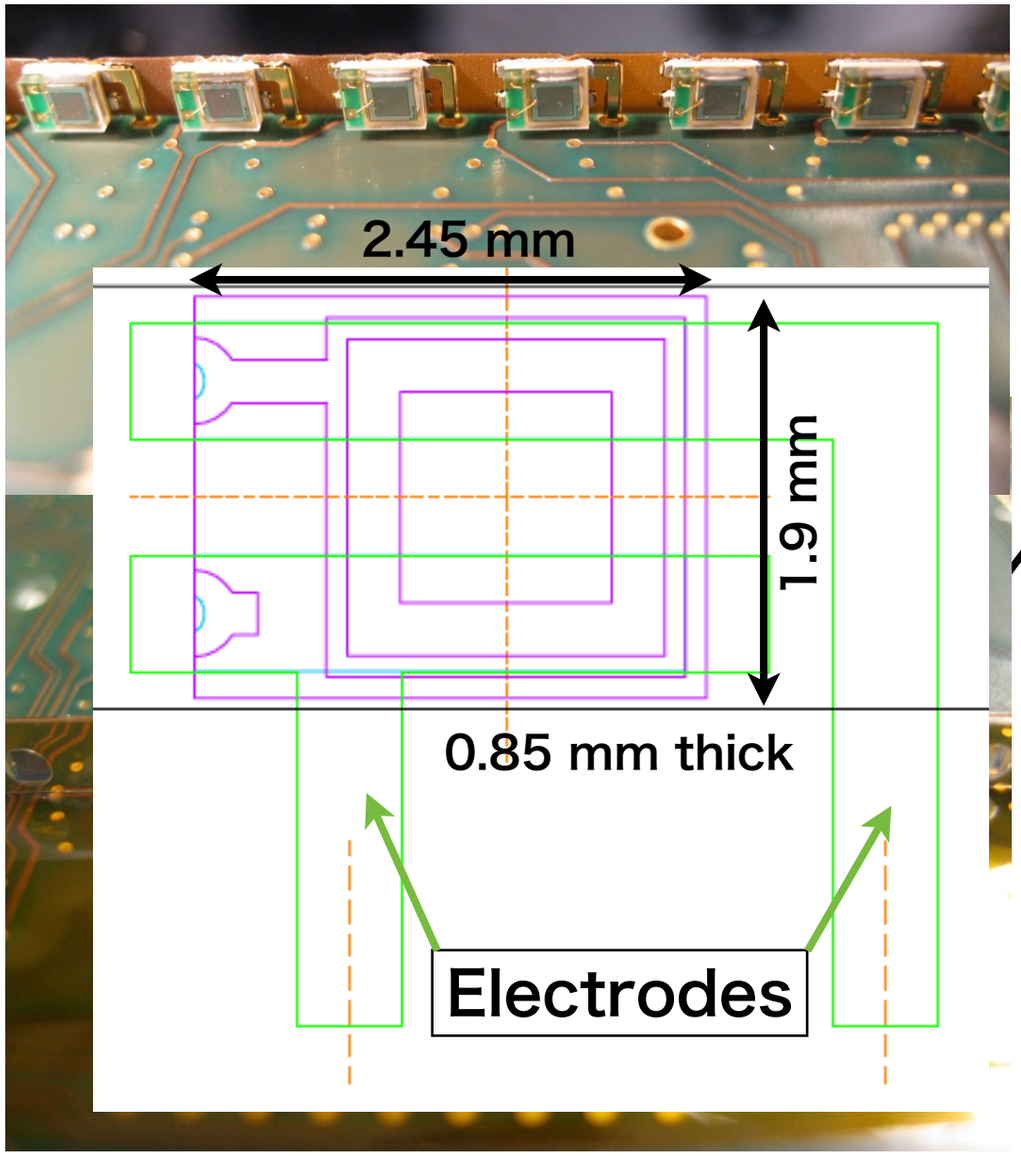
40 ms

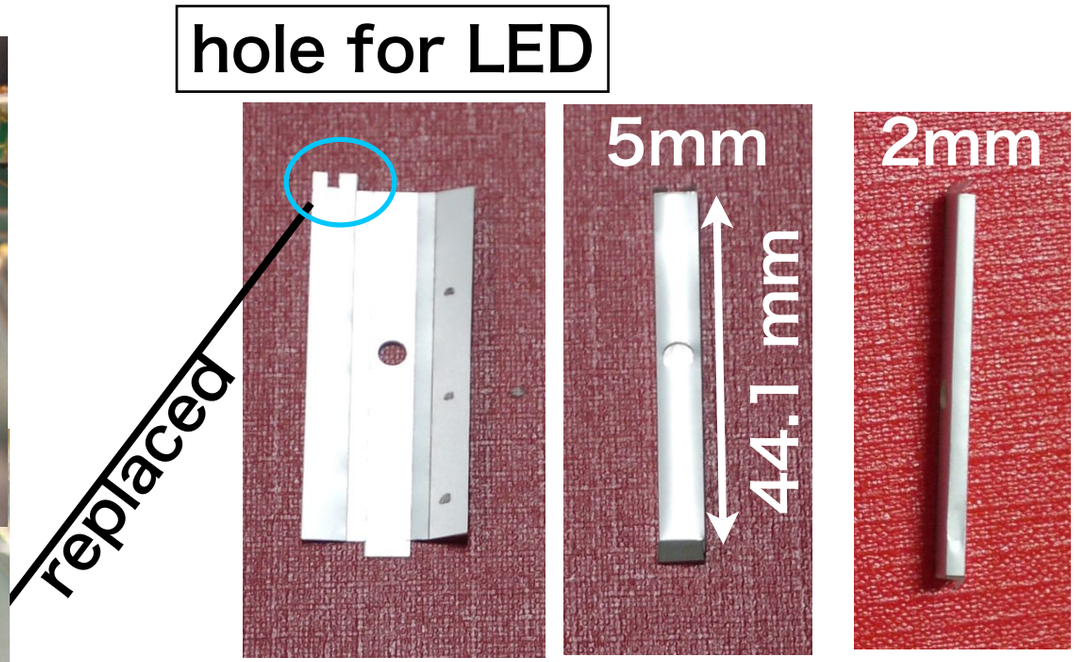
EBU can work

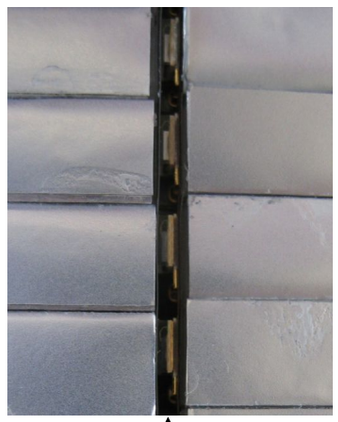
validated!

MPPC-scintillator strip

- 36 MPPCs/row on a polyimide ribbon.
- The polyimide ribbon is for only mechanical support.







Precision of alignment of scintillators is not enough. we can fix this next time.

Channels 1..36

129

Sp2b4

130

Sp2b3

digital data bus

SIGNAL input

ASIC #129

clocks

Channels 37..72

ASIC #130

DIF side

60mm

POWER input

132

Sp2b2

131

Sp2b1

Channels 73..108

ASIC #132

Channels 109..144

ASIC #131

180mm

Purpose of technological ScECAL

- To check feasibility of one layer unit and its control unit. [To check if we can control two ECAL base board unit (EBU) from one control unit.]
- Detail test issues:
  1. Performance on energy measurement.
     1. Verification of MIP measurement ability.
        1. stability of procedure,
           - scintillator-MPPC-amplifier-charge-ADC
        2. separation from noise
     2. Gain measurement with builtin LED system.
  2. Other functions.
     1. TDC,
     2. power pulsing system .... next TB...

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     2. power pulsing system .... next TB...

Purpose

in laboratory

1. System test in lab (2.5 weeks).
   - ADC, TDC, auto trigger, power pulsing
2. LED calibration in lab. including noise monitoring (0.5 weeks)

on beam line

3. installation (0.5 week)
4. noise run (2 days)
5. LED calibration (2 days)
6. 3 GeV electron run w/o absorber (2 days)
7. electron run w/ absorbers (0.5 week)
   - one absorber, two absorbers, three absorbers, ...
   - x 1 GeV, 3 GeV, 6 GeV
8. withdraw