ScECAL Technological Prototype

25th May 2012
ILD meeting @ Kyushu University

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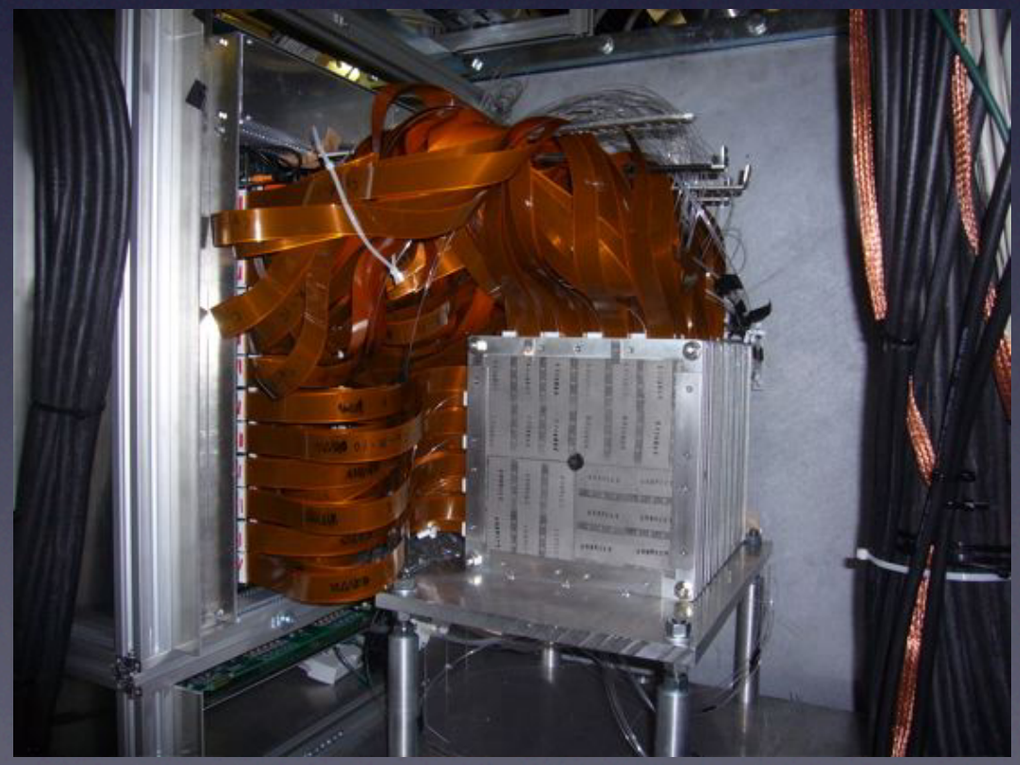
Shinshu University
on behalf of :
CALICE Group, CALICE-ASIA Group

Physics prototype → Technological prototype

- Physics Prototype has shown good performance of Scintillator based ECAL method for ILD:
  - Deviation from linear fitting to energy response plot
    - < 1.5% (e^- 2 - 32 GeV)
  - Energy resolution (e^- 2 - 32 GeV)
    - $\delta E/E = 13\%/\sqrt{E} + 1.2\%$(w/o beam momentum spread)
- Physics Prototype cannot be implemented into ILD, since:
  - Signal readout is outside of detector
  - Scintillator strip
    - to achieve 5 x lateral segme



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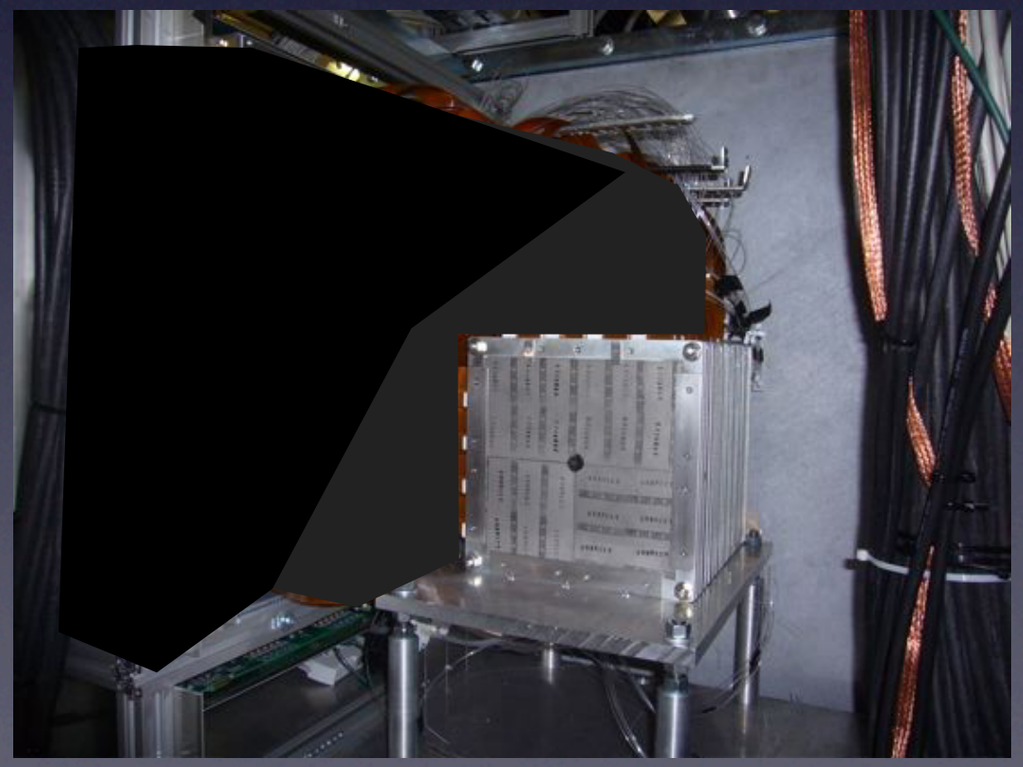

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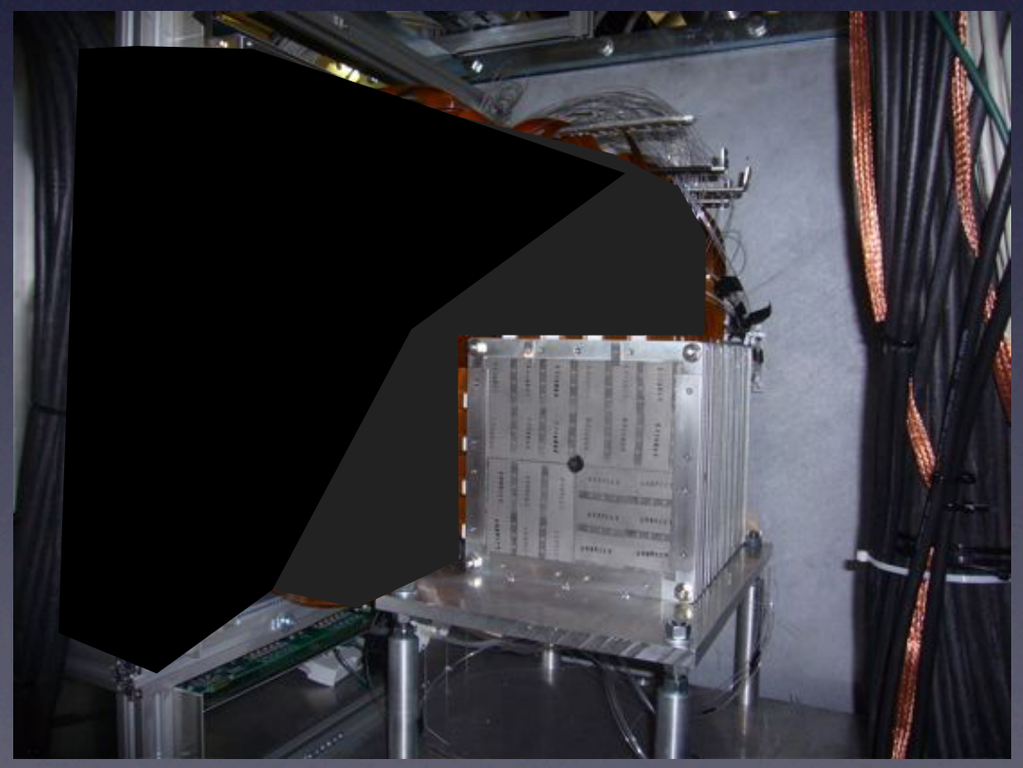
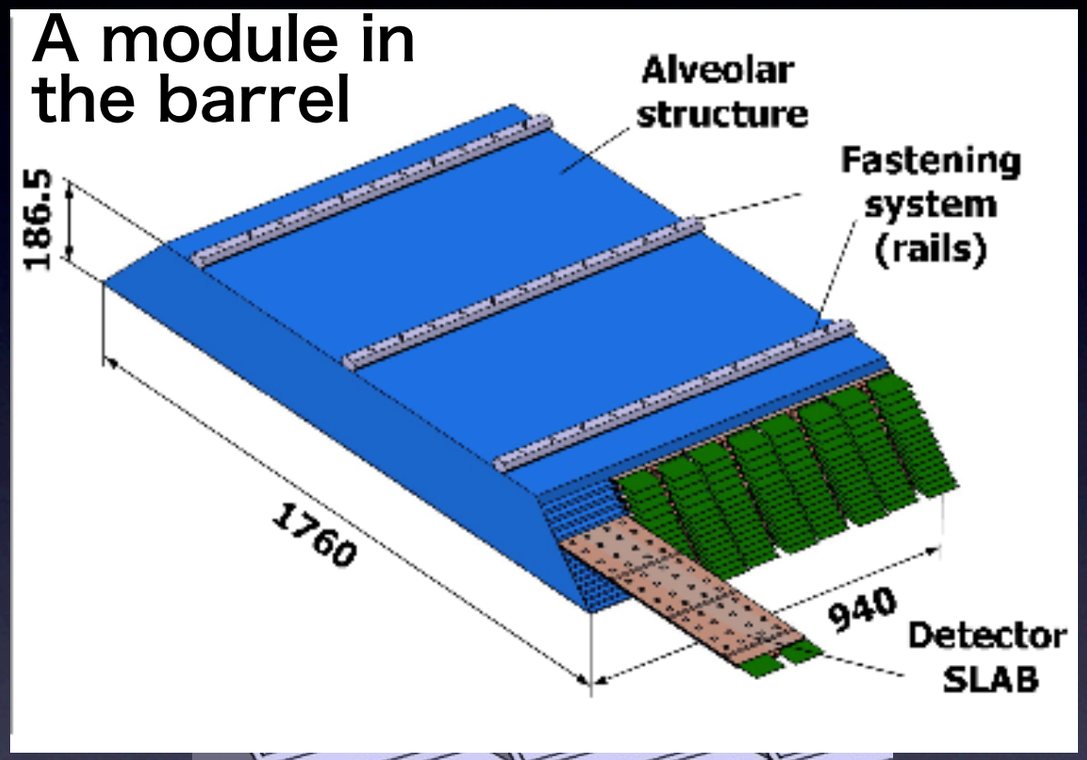
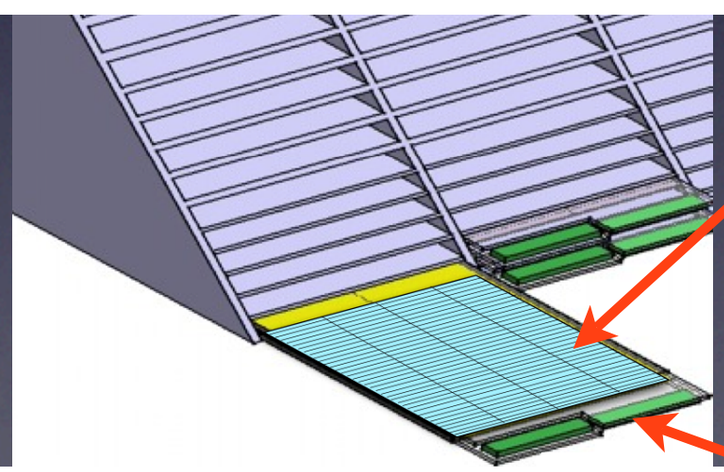


Going to Technological prototype

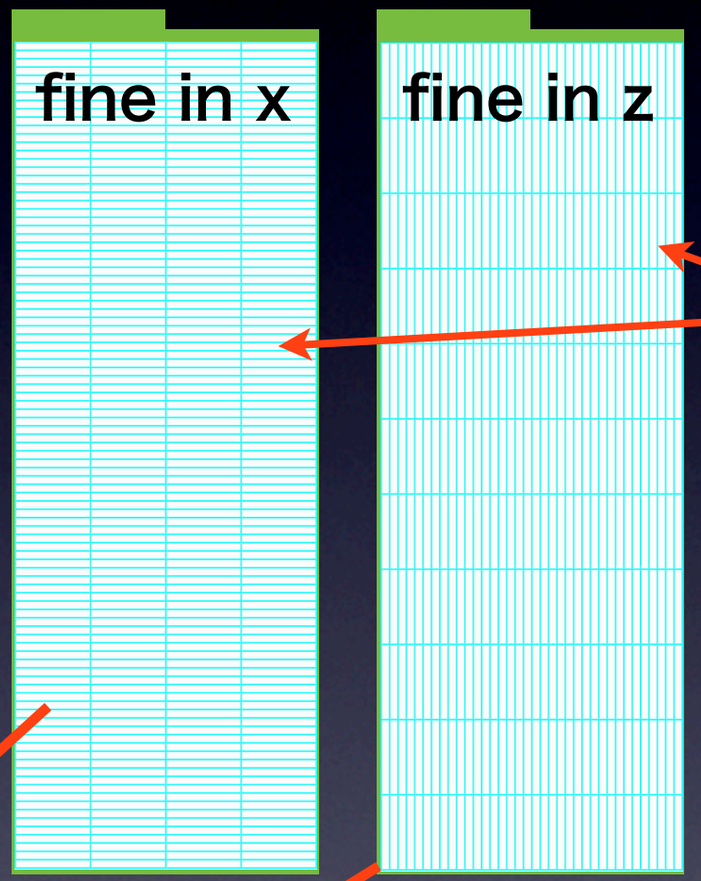
- sensor layers should be on PCB
- scintillator: lateral size of 5 x 45 mm^2, thickness of < 2 mm.

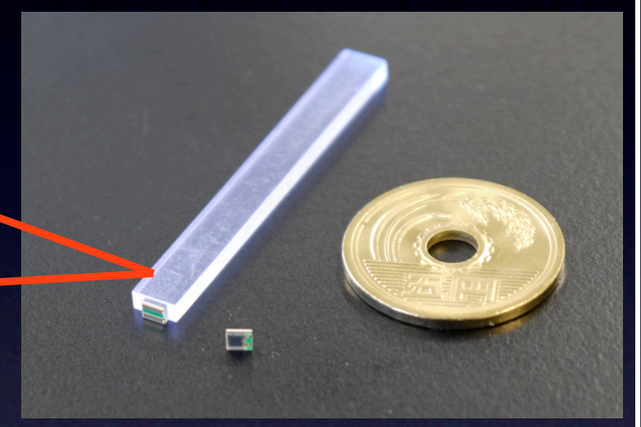
Design of ScECAL in ILD



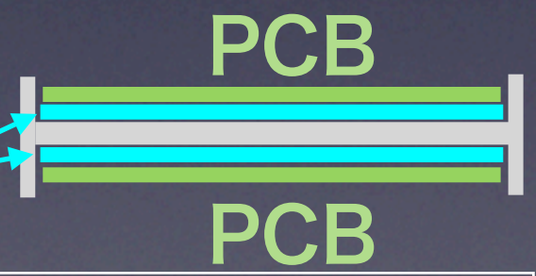


a pair of layers is inserted into the alveolar structure





H-structure
Sensor layers

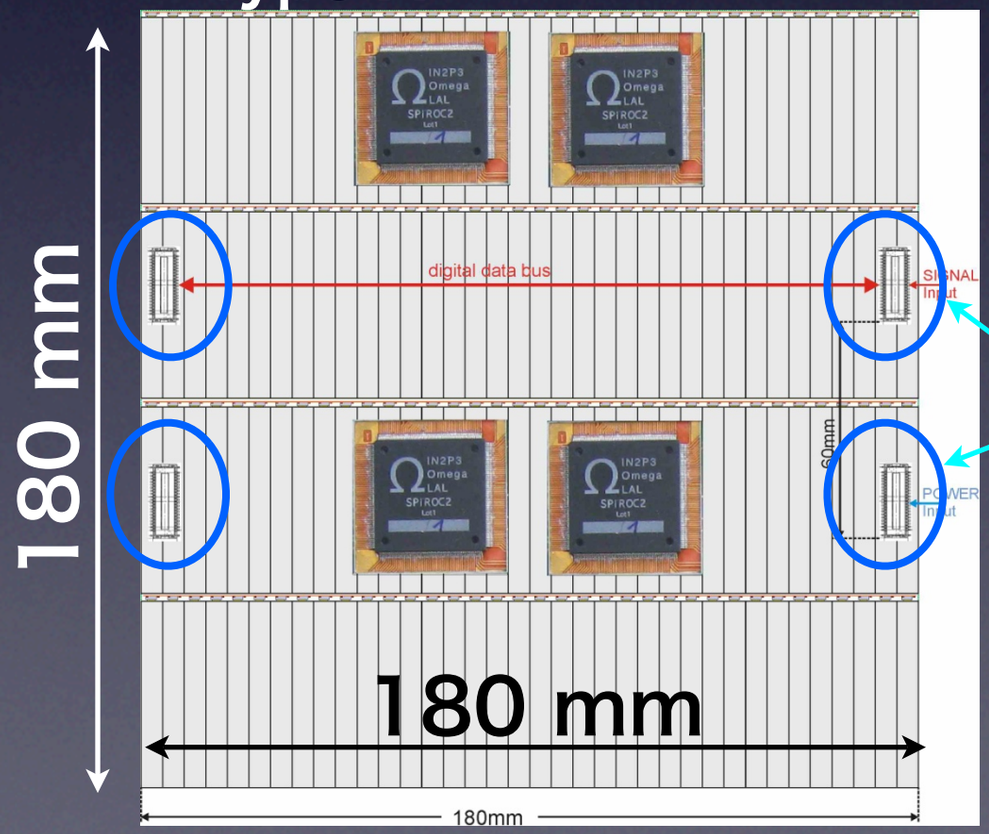


an x layer and a z layer are put back to back on the H structure of a W layer

Scintillators on PCB in the technological prototype

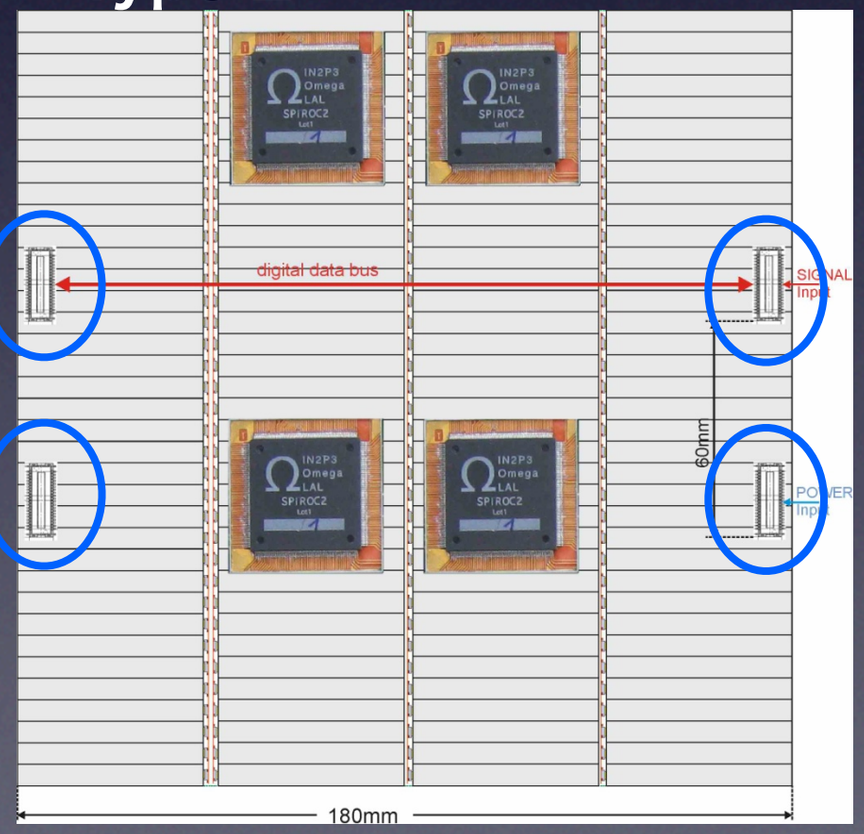
- EBU using HBU (PCB for AHCAL) technology is being developed by strong support of AHCAL group.
- An EBU has four SPIROC2s.
- 36 x 5 mm strips in a row ▶ 180 mm lateral size,
- 4 rows are on one unit of EBU ▶ 180 mm lateral size,
- Two types of EBU for the type x and type z,
- LED light for gain monitoring for each strip

Type X



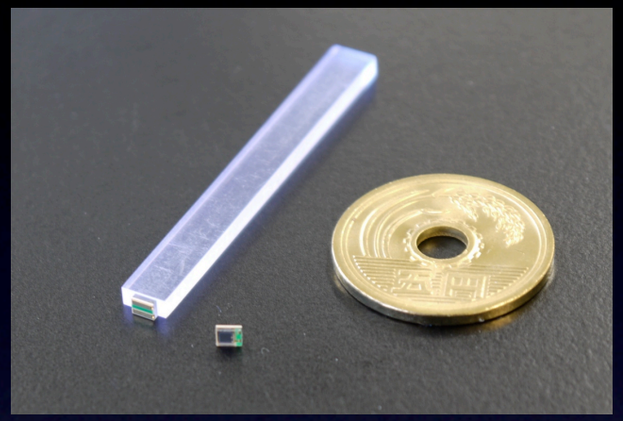
Connector : EBU/EBU, EBU/DIF

Type Z

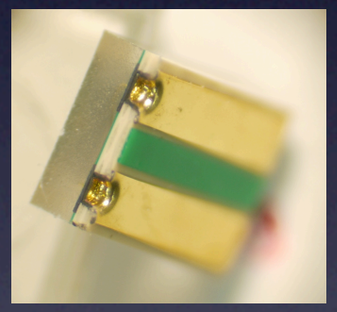


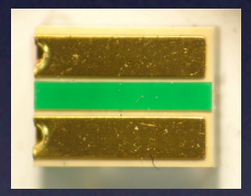
Scintillator-MPPC unit on PCB

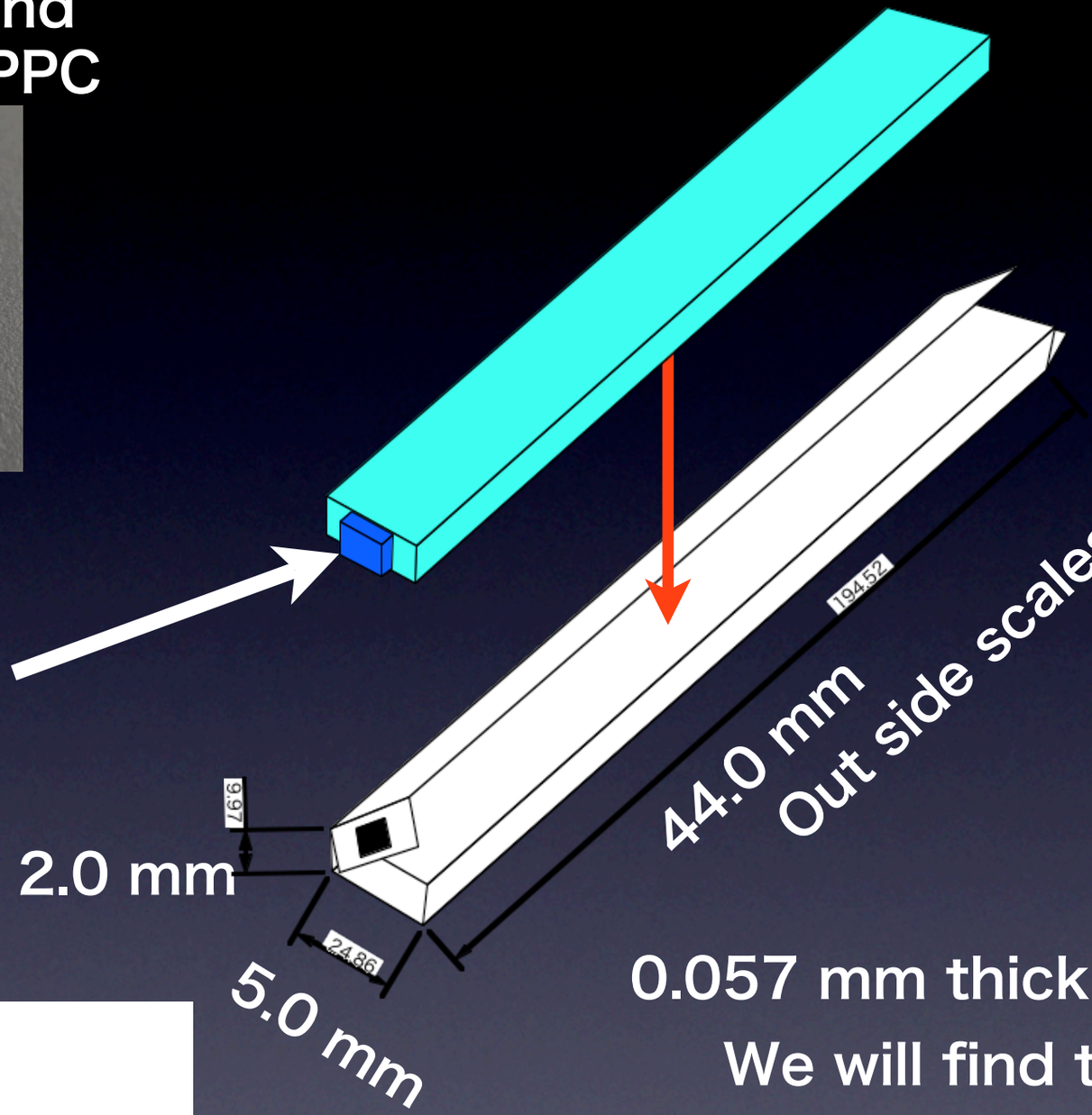
Scintillator strip and
Surface Mount MPPC



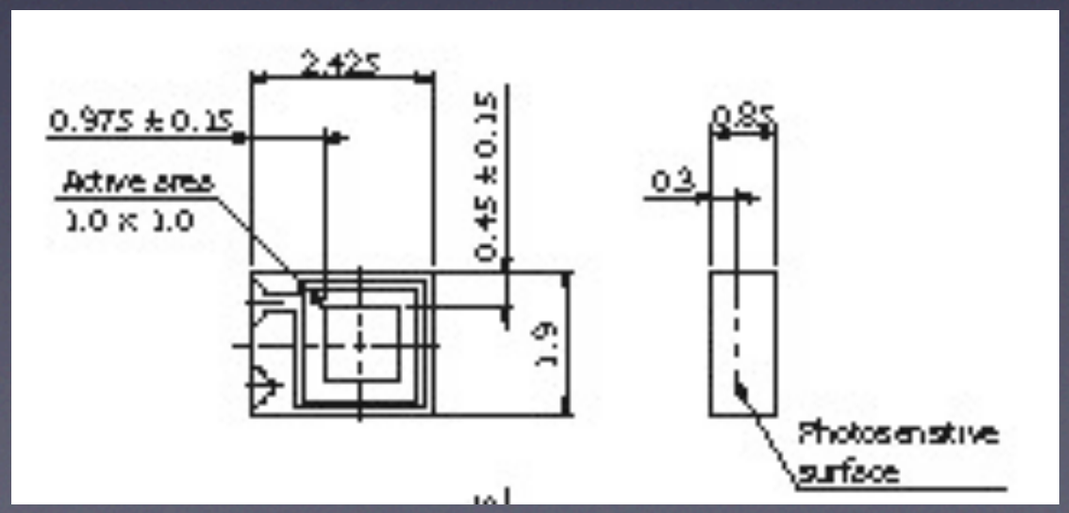
Backside of MPPC







0.057 mm thick reflector
We will find thinner film

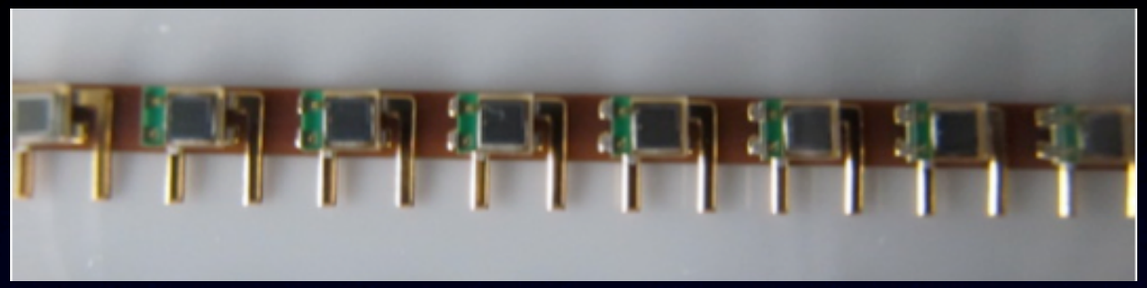


Hamamatsu is developing
smaller package now

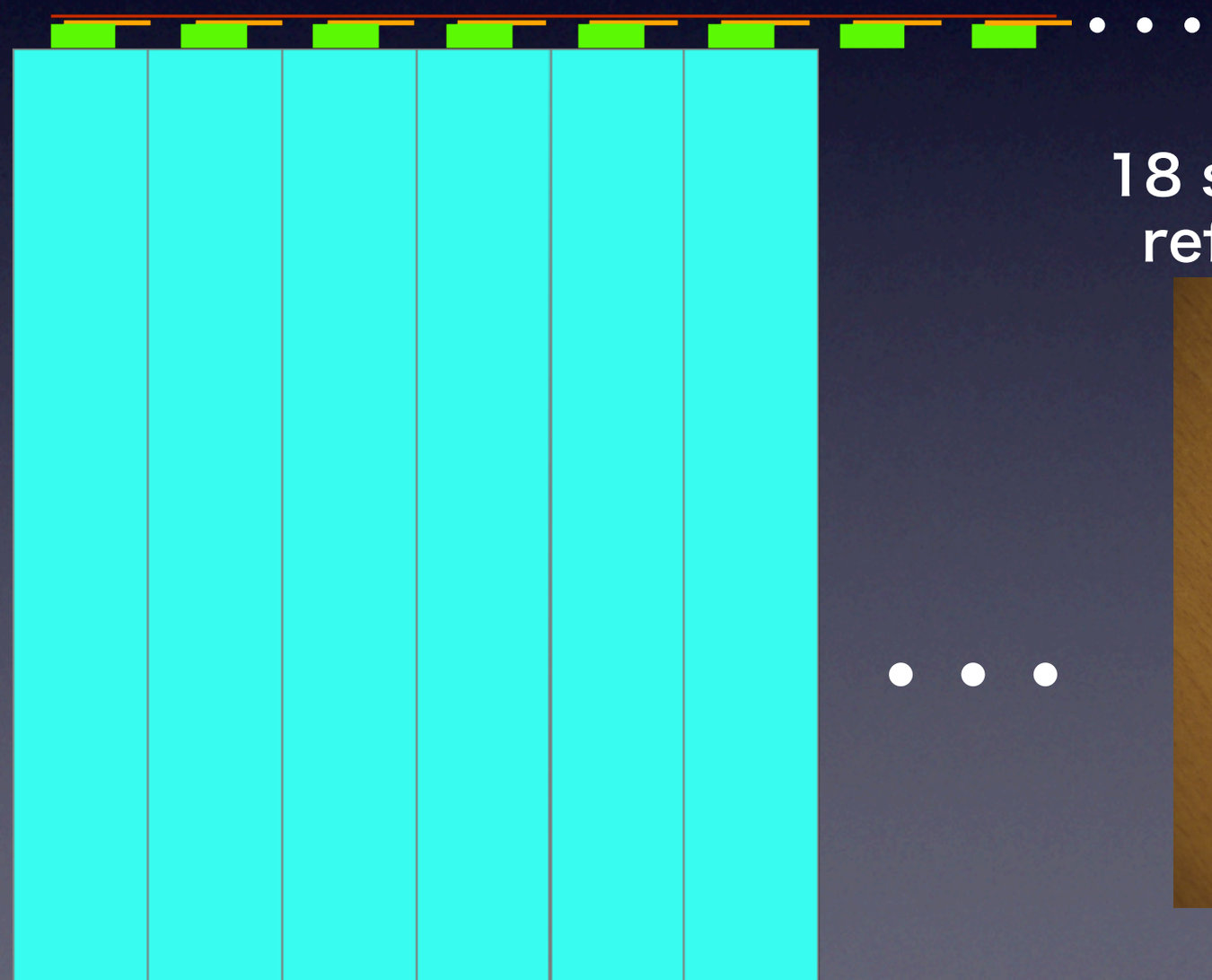
1.4 x 1.4 x 0.6 mm^3

Stacked strips

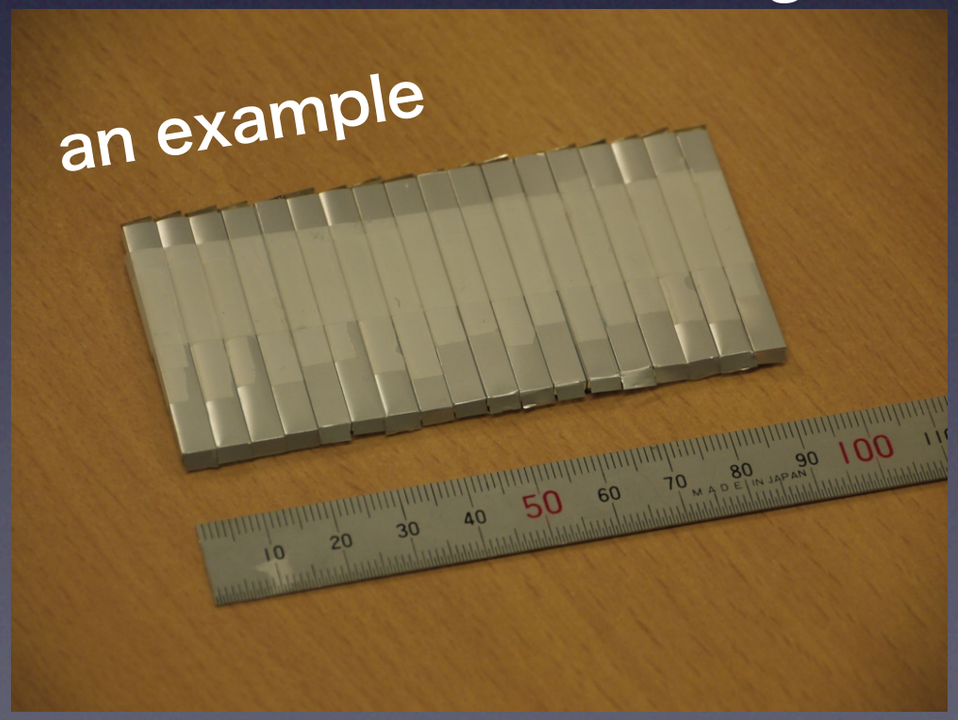
36 MPPCs soldered on electrodes
on a polyimide ribbon



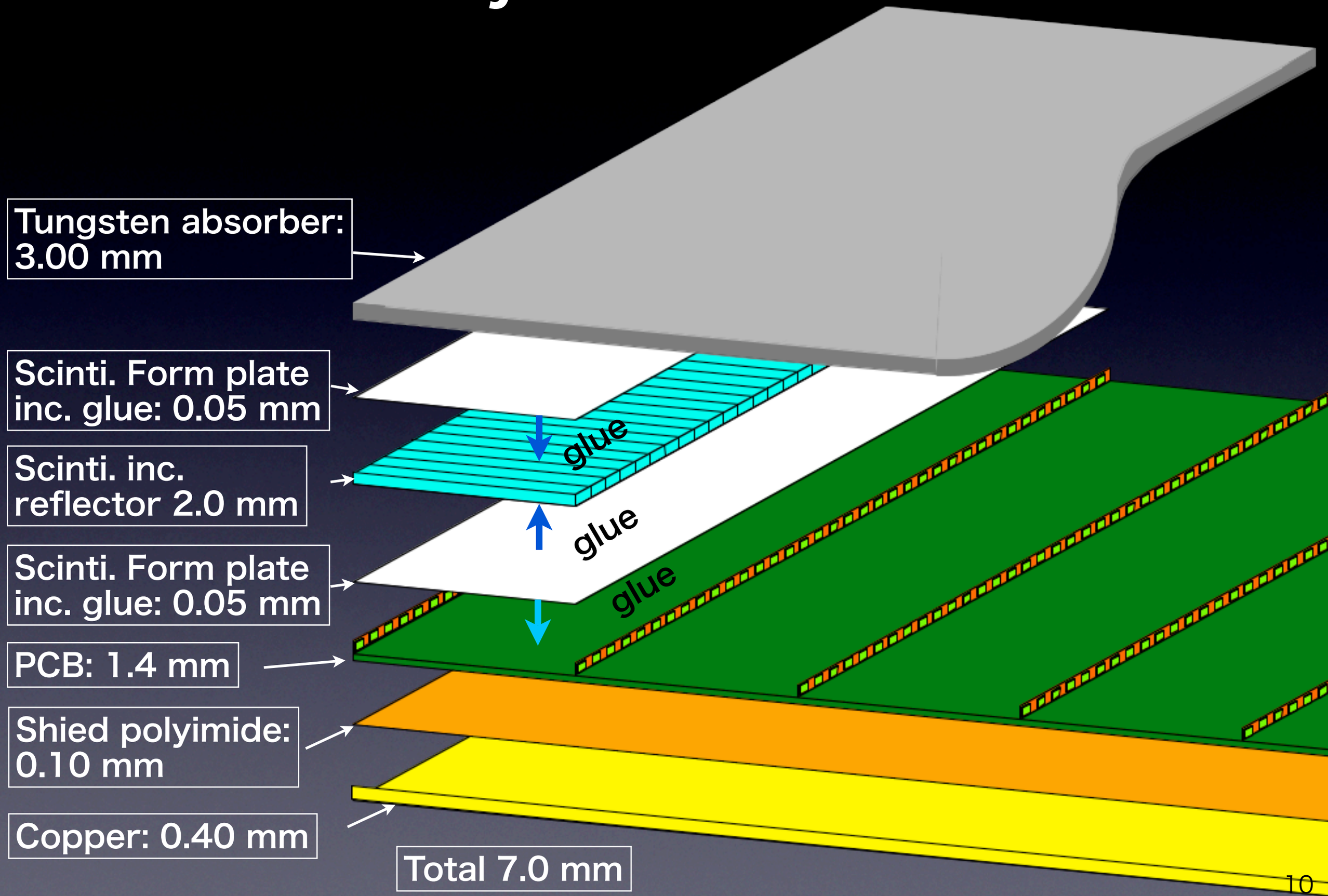
Coupled with stacked 36 strips



18 scintillator strips enveloped in
reflector film stacked together

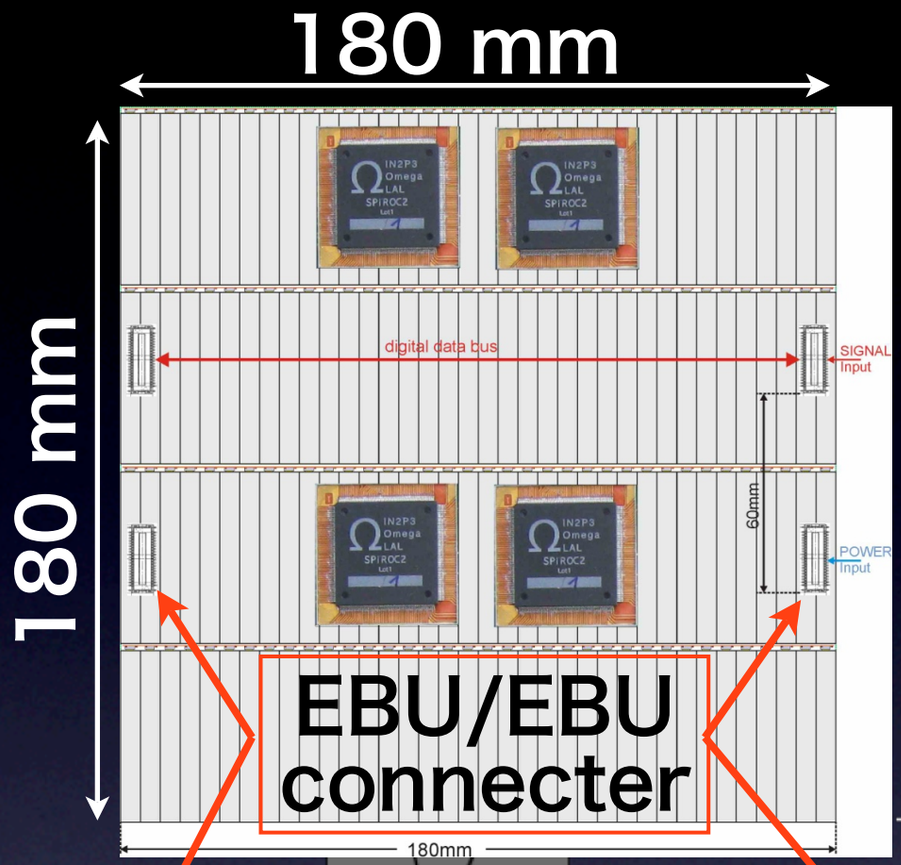


A layer in an alveolar



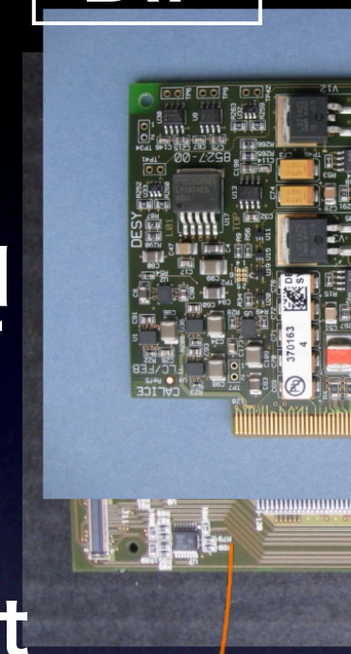
Test beam at DESY Sep. 2012

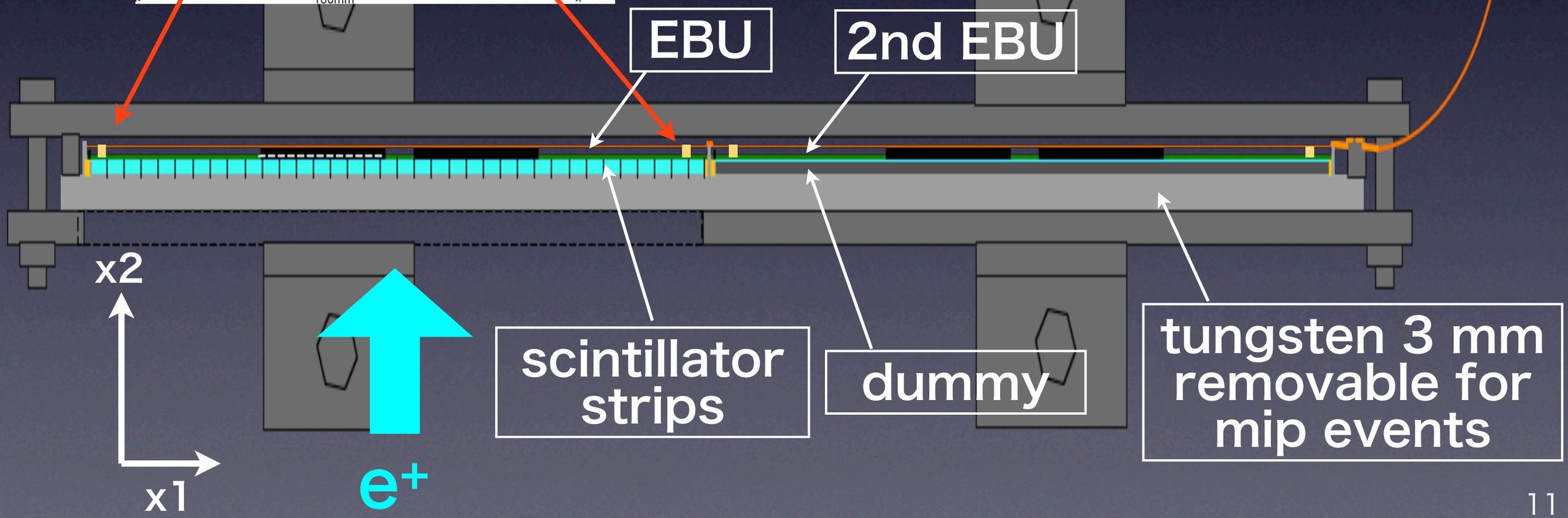
U structure in Iron frame



- Only one x type of scintillator layer will be implemented
- One more EBU will be used for relay between EBU/DIF to test tandem connection of EBU/EBU
- Temperature measurement

DIF





Goal of TB

- Establish:
  - Practical technique to integrate 144 scintillator/MPPC, units on the PCB (EBU) and its feasibility.
- Measure:
  - noise, signal (S/N) with MIP/shower events,
  - ratio of amplification of 2 modes,
  - current consumption (w/ and w/o signal),
  - temperature. → To estimate power/heat control
- Check the functions:
  - auto trigger,
  - linearity of TDC,
  - LED gain monitoring system,
  - power pulsing.

Summary

- ScECAL group is developing the technological prototype to establish :
  - Practical technique to integrate 144 scintillator/MPPC units on the PCB (EBU) and its feasibility,
  - measure the basic performance of scintillator/MPPC/PCB units.

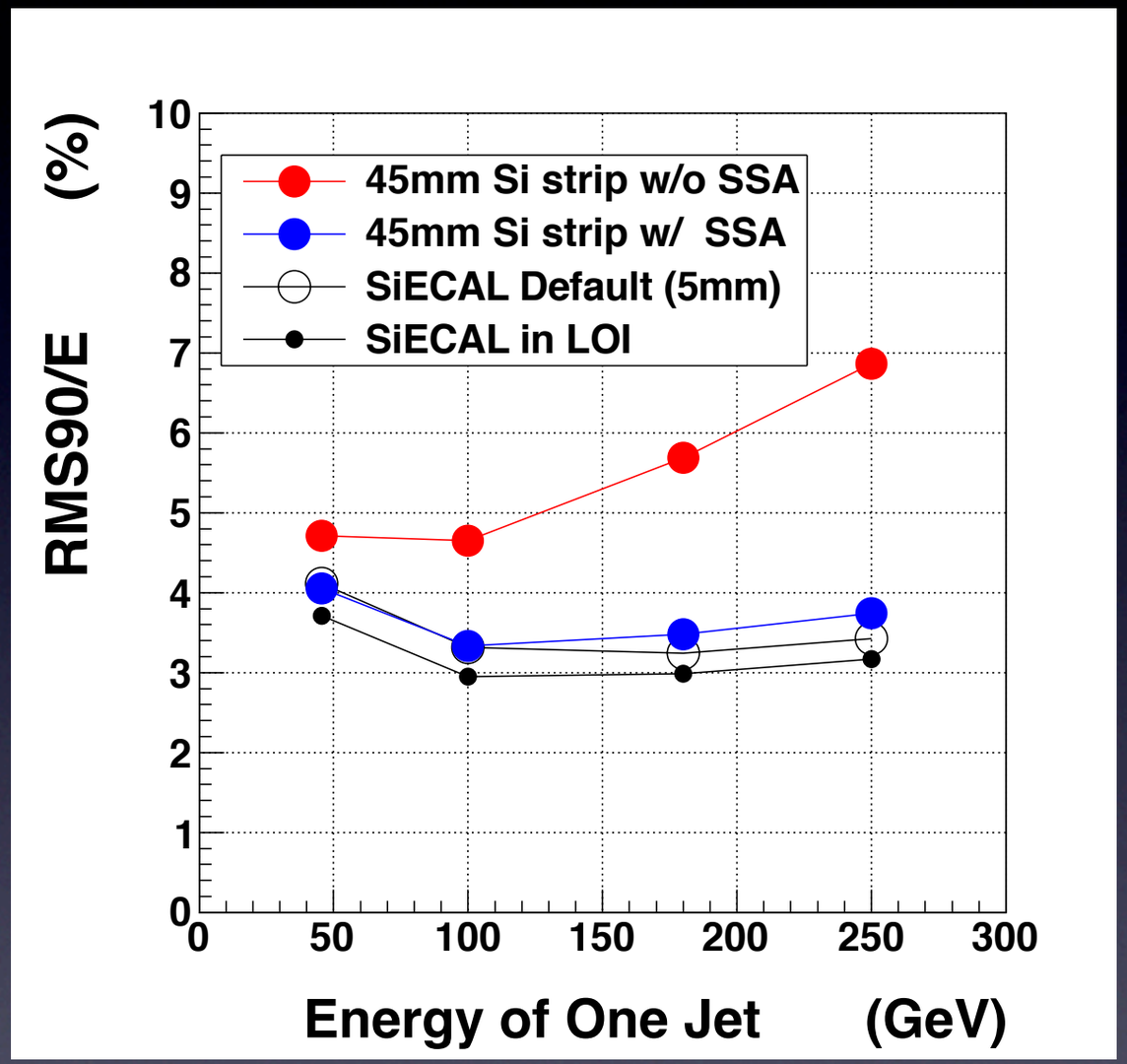
In September 2012

- 1st TB at DESY with the technological prototype,
  - show the basic performance of signal and noise.

Next step

- Construct z-type layer,
- with established technologies of
  - industrialization procedure of integration,
  - thinner PCB,
  - non-dead volume scintillator/MPPC unit,
  - Feed back issues from the first TB results.

Introduction (Idea of Technology)



- In order to minimize effects of calibration in PandoraPFA, Strip Splitting Algorithm was tested by a special ECAL model with si strip readout.
- JER improved significantly by SSA especially at H.E.

(● → ●)

- A little bit degradation of strip ECAL is seen at H.E.

(● → ○)

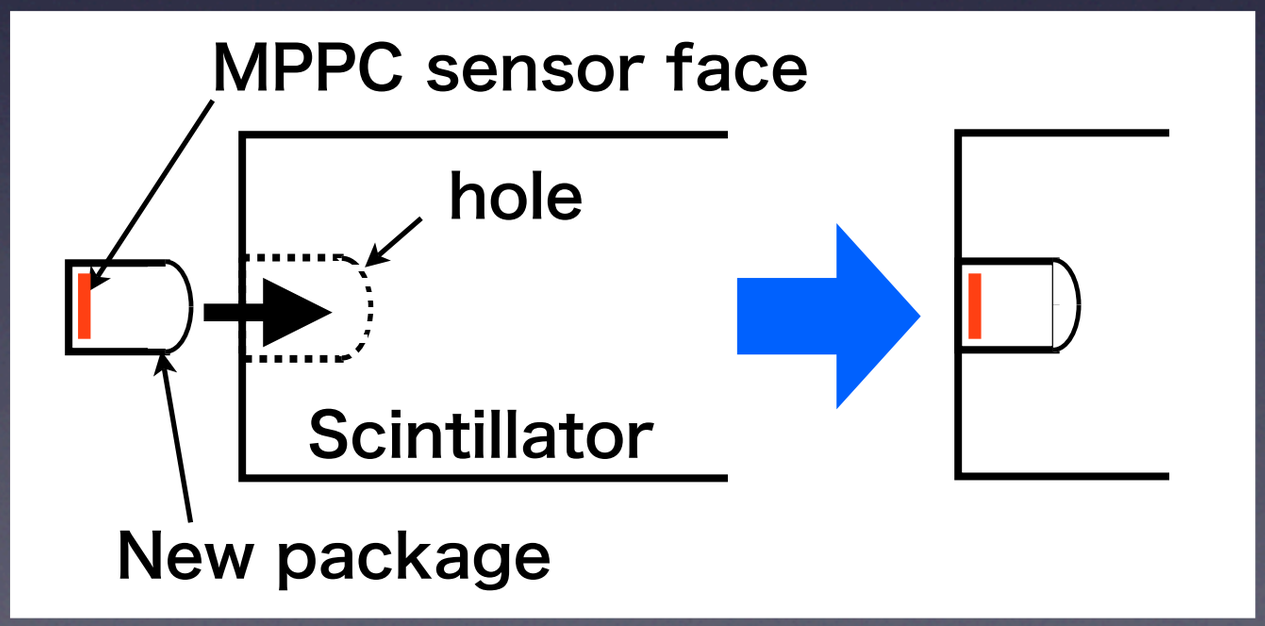
  - Square cell layers between strip layers will help to improve this
  - On of the candidate ▶ Hybrid ECAL (H. Ueno)

Backup

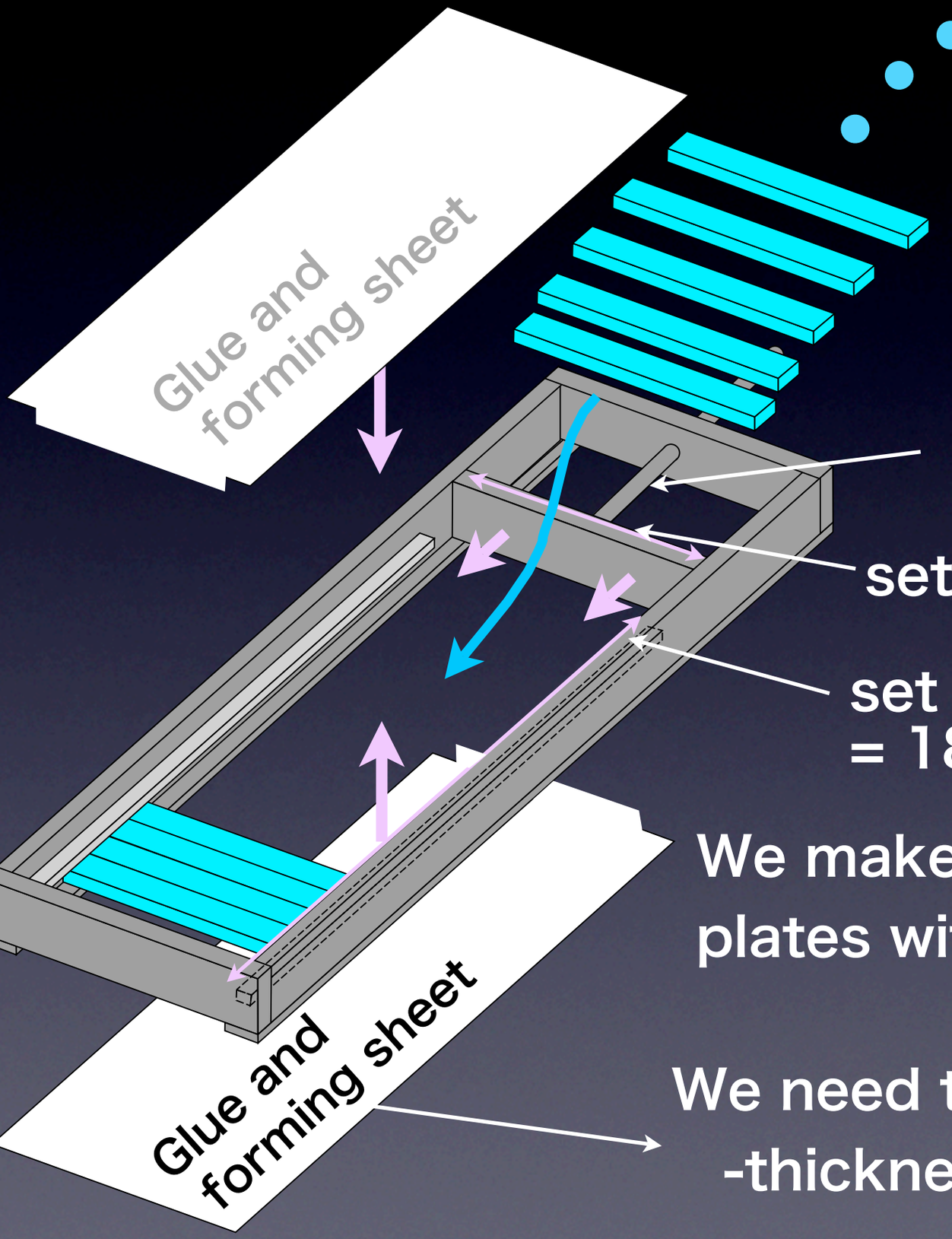
Next step

- More than two layers with both x layer and z layer.
- with alveoli structure.
- Non dead volume scintillator/MPPC system.

MPPC package-WLS plate unification



How to make them be rigid together in a plate with precise dimension



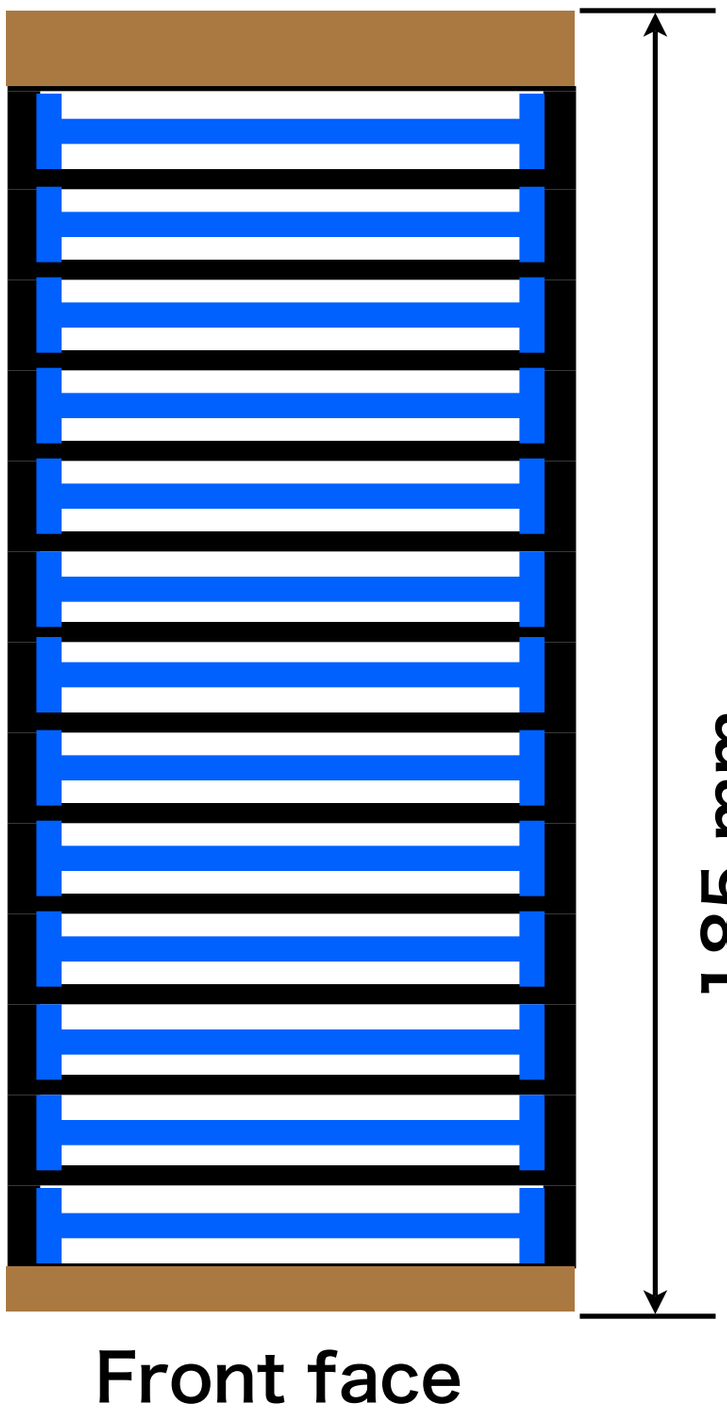
set exactly to strip length, 44 mm

set exactly to strip width x 36 = 180 mm

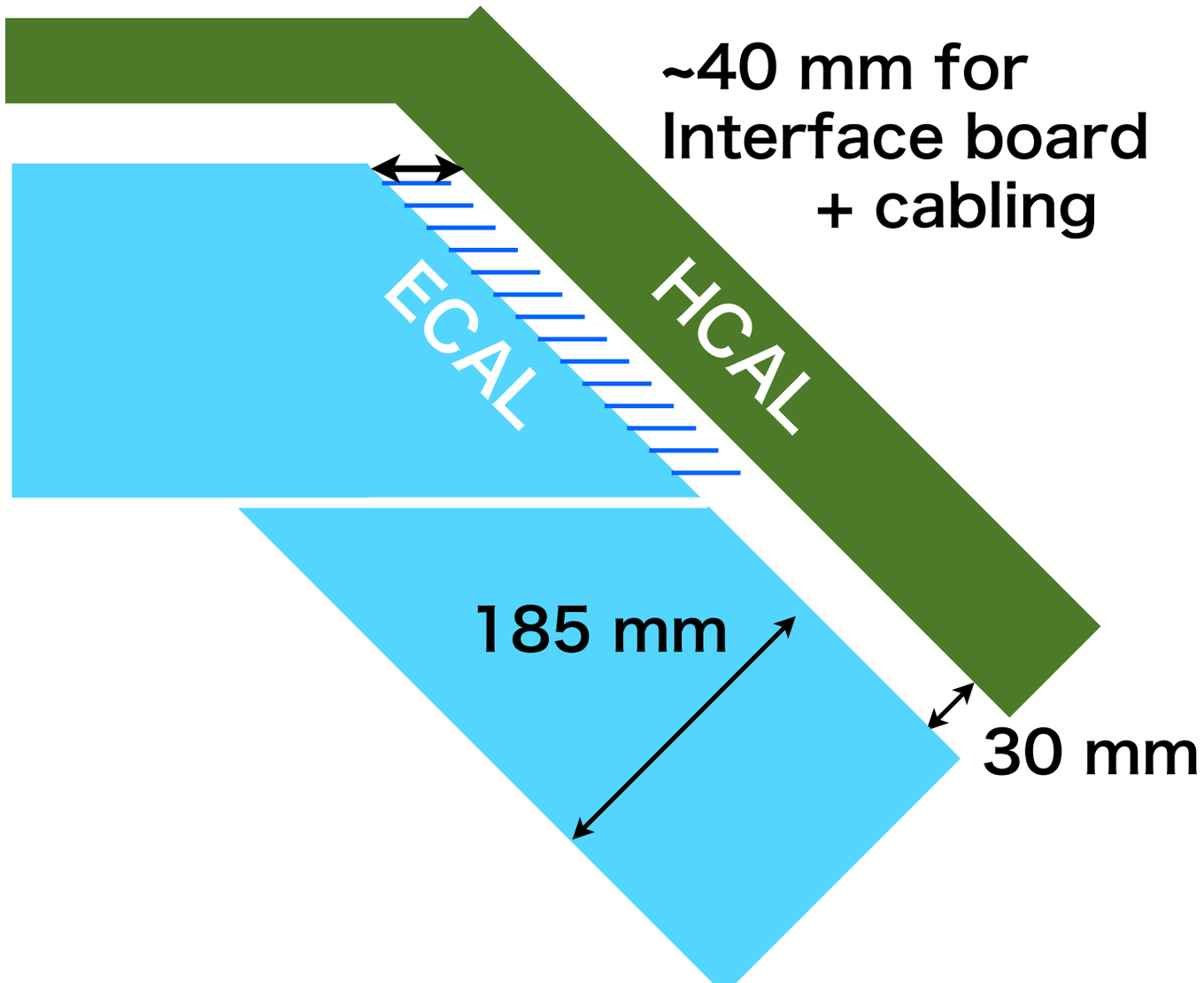
We make 44 mm x 180 mm scintillator plates with 36 strips in each.

We need to study the material
-thickness, tolerance, glue also ...

Module thickness and Gap in ILD



- 25 tungsten layers, 13 alveolars,
- 21.5 X_0,
- total ~185 mm Module thickness allows 30 mm between HCAL inner most surface,



Technological prototype TB July. 2012 @ DESY

Power control

LED system

Detector-DAQ interface

Carrier board

360 mm

(Type X)

180mm

180 mm

60mm

digital data bus

POWER Input

SIGNAL Input

TB Sep 2012 @DESY

Alveolar structure by LLR

One Sc. layer

One more EBU or connector BD

DIF of Sc

Si. layer

Short detector slabs (×14)

Technological prototype TB July. 2012 @ DESY

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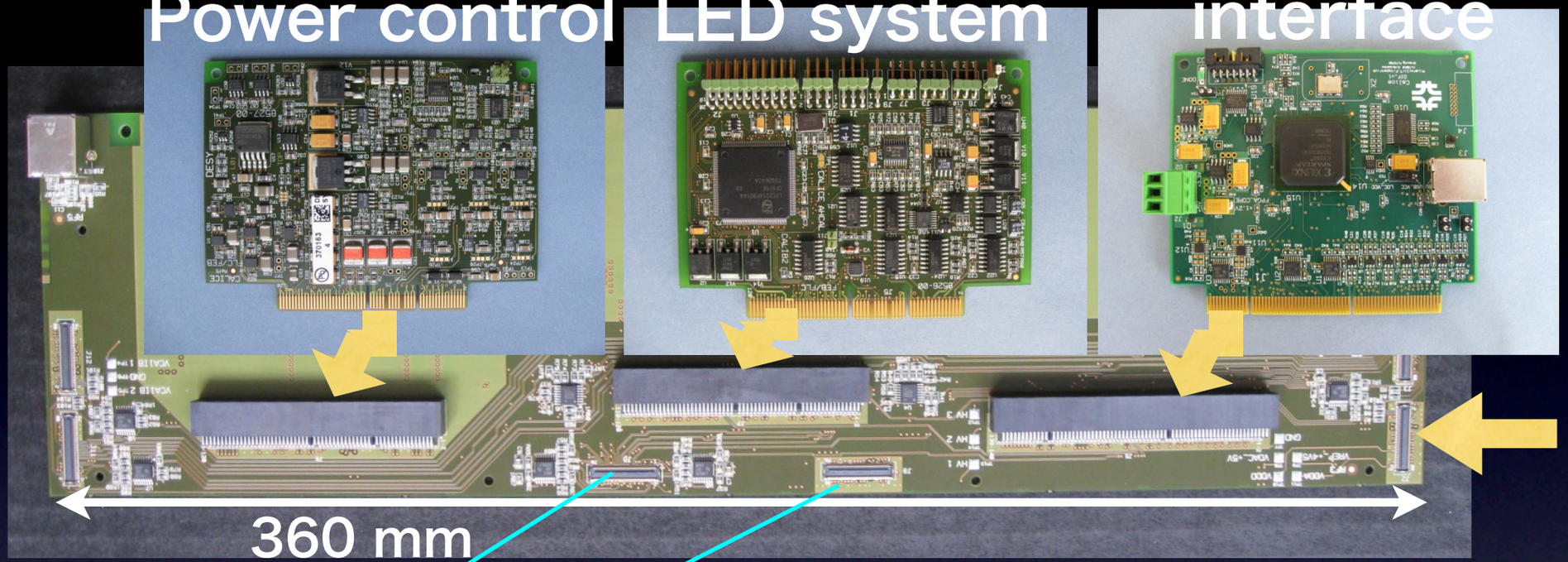
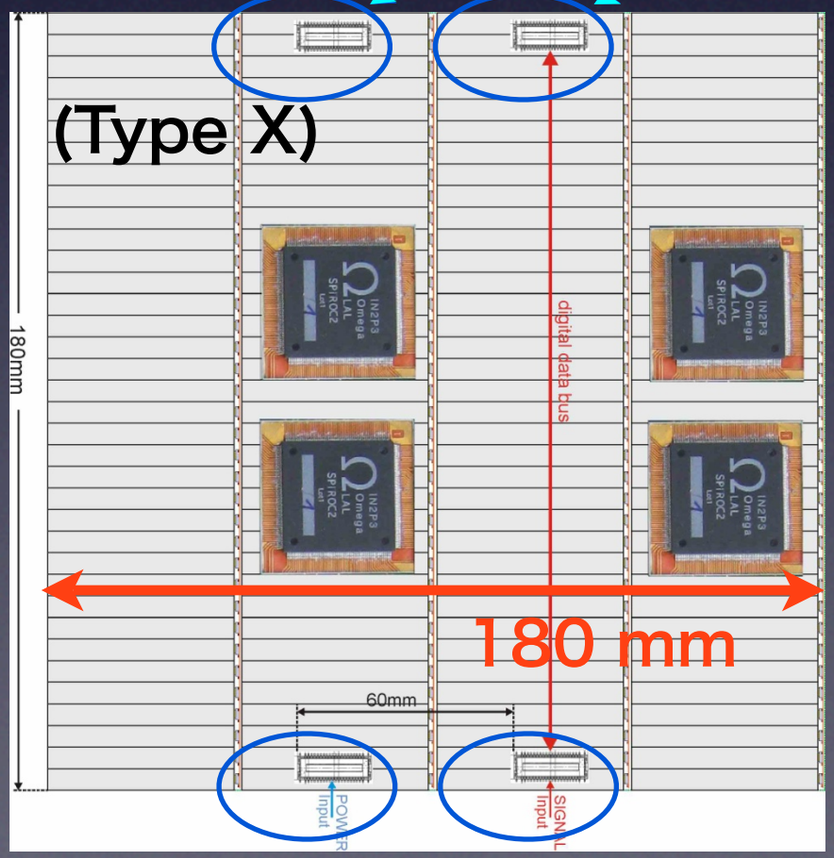
LED system

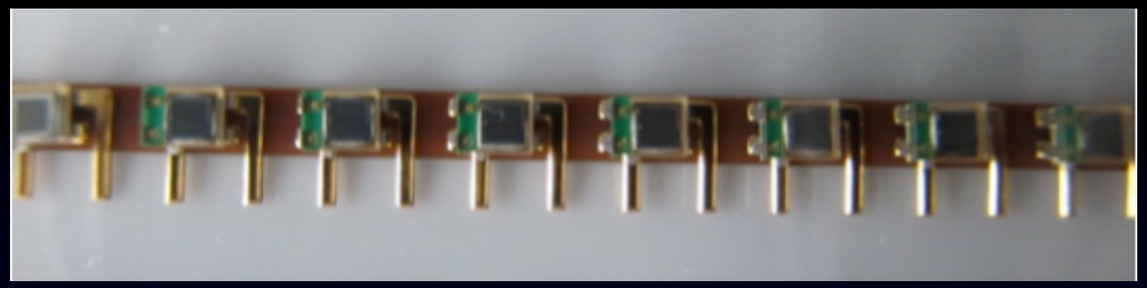
Detector-DAQ interface



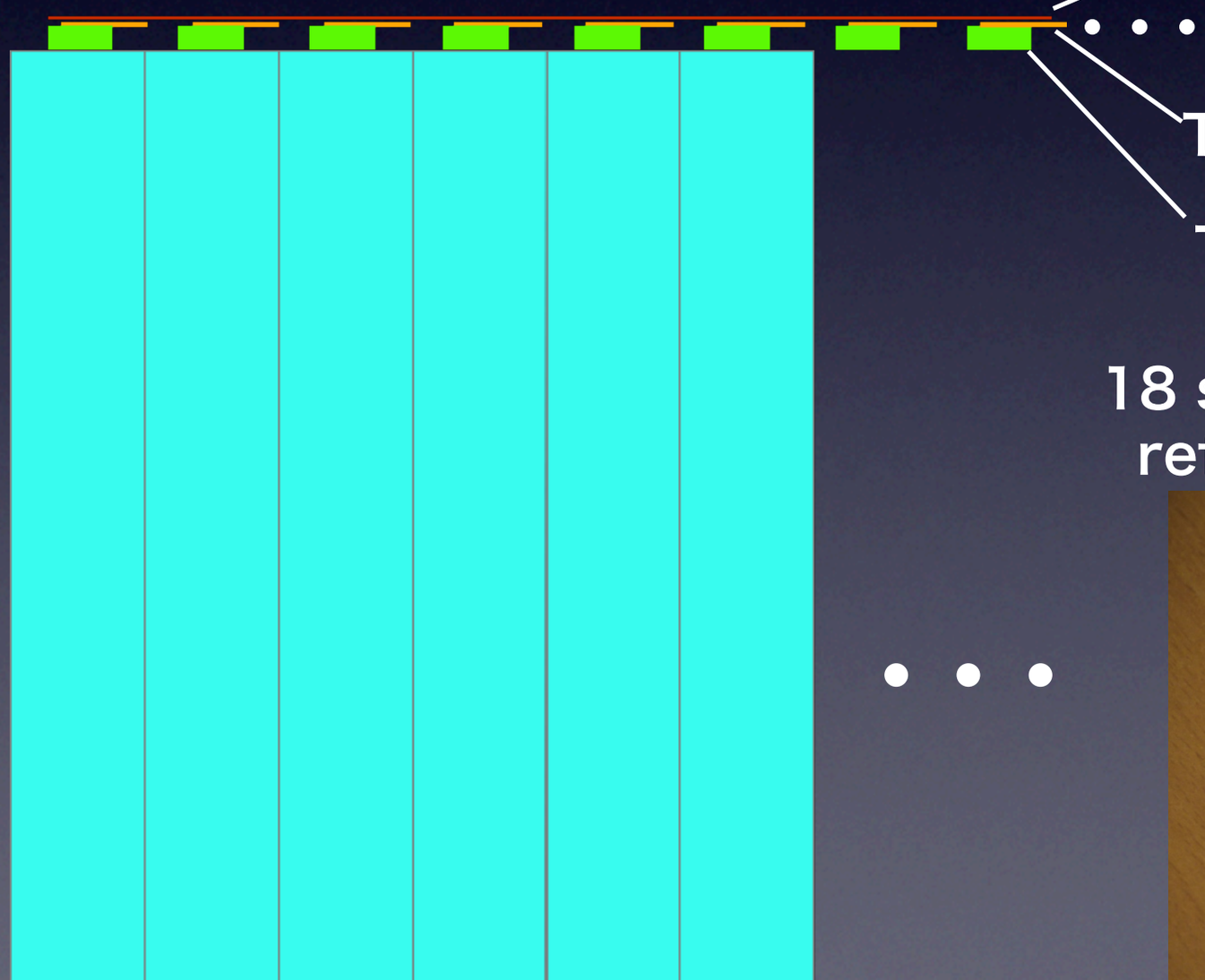


Stacked strips

36 MPPCs soldered on electrodes
on a polyimide ribbon



Coupled with stacked Strips

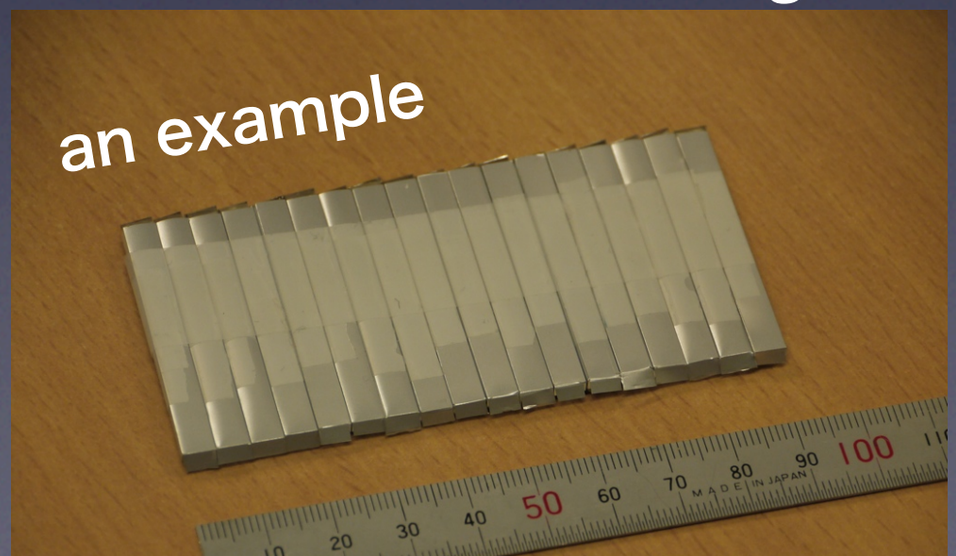


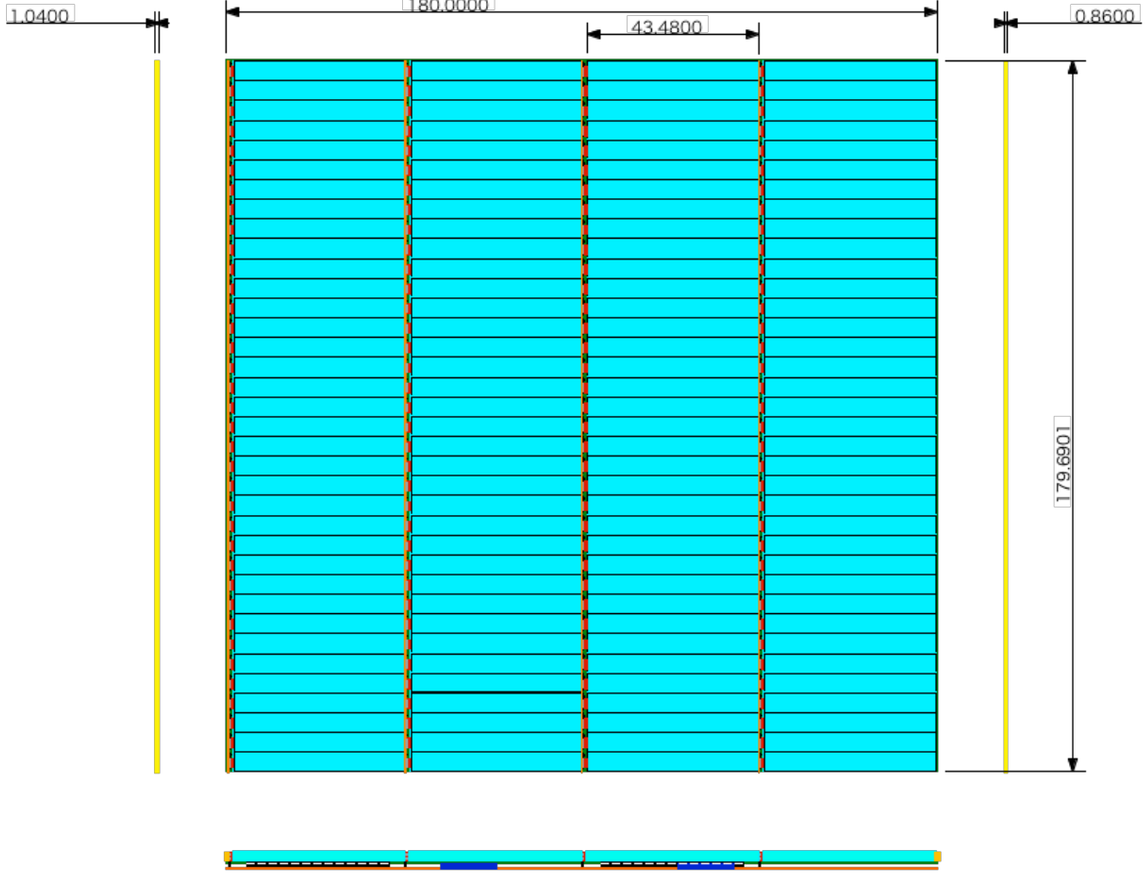
Thickness of ribbon: 0.06 mm

Thickness of electrode: 0.05 mm

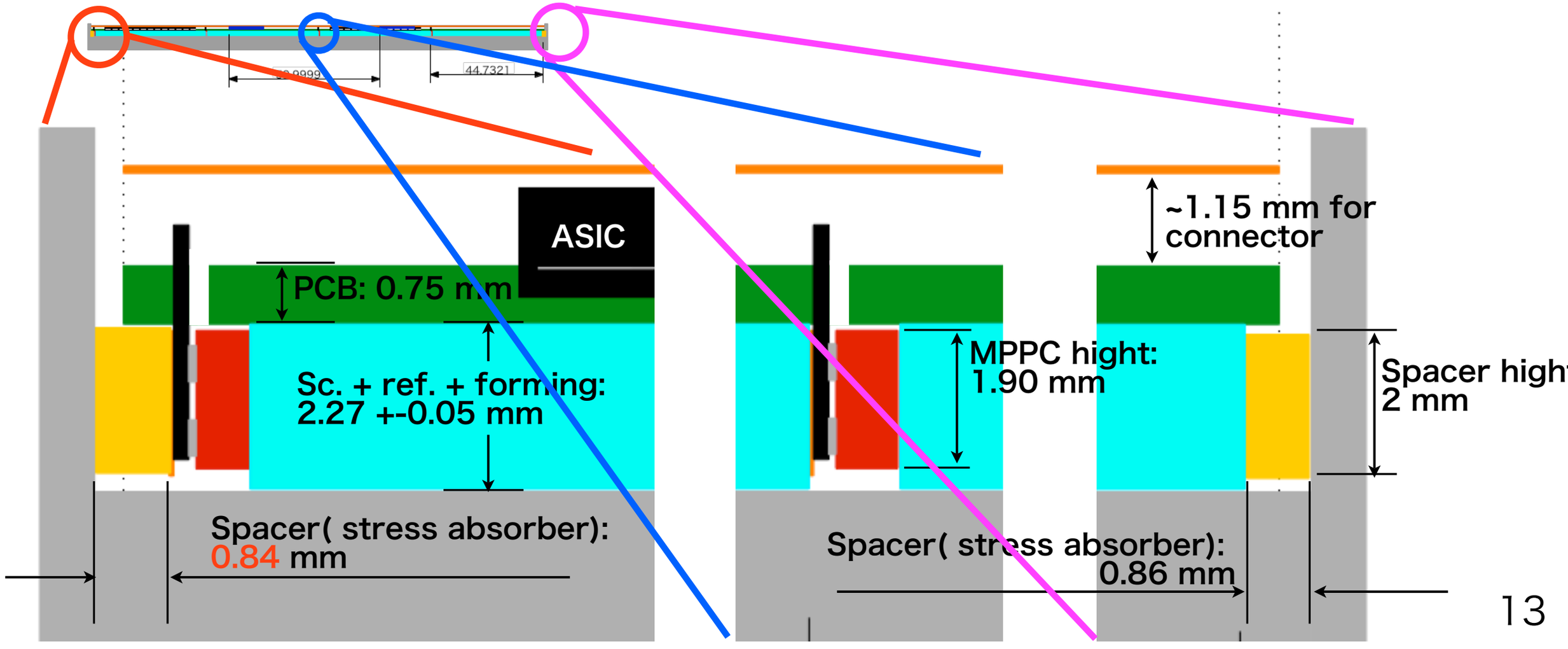
Thickness of MPPC: 0.85 mm

18 scintillator strips enveloped in
reflector film stacked together

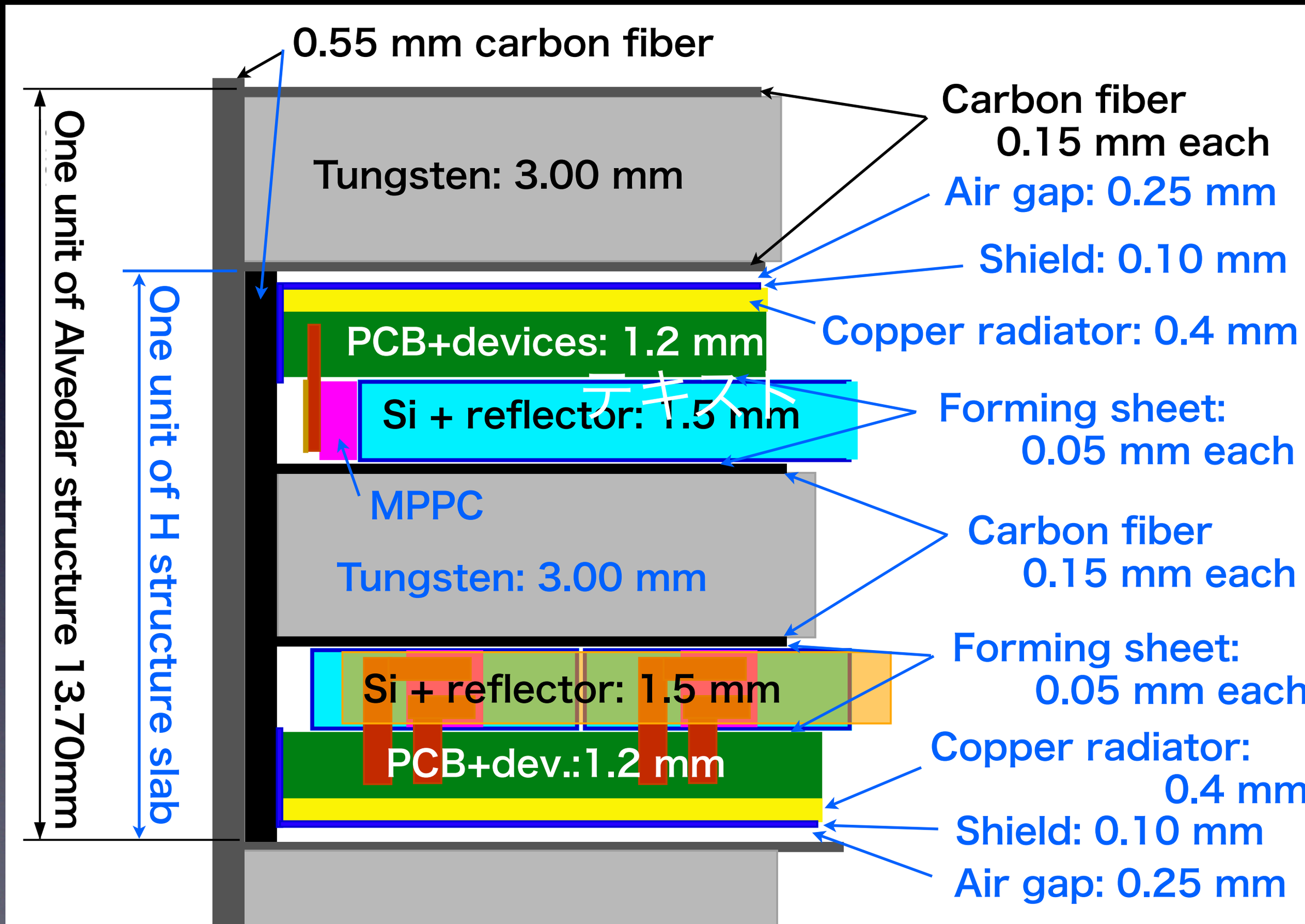


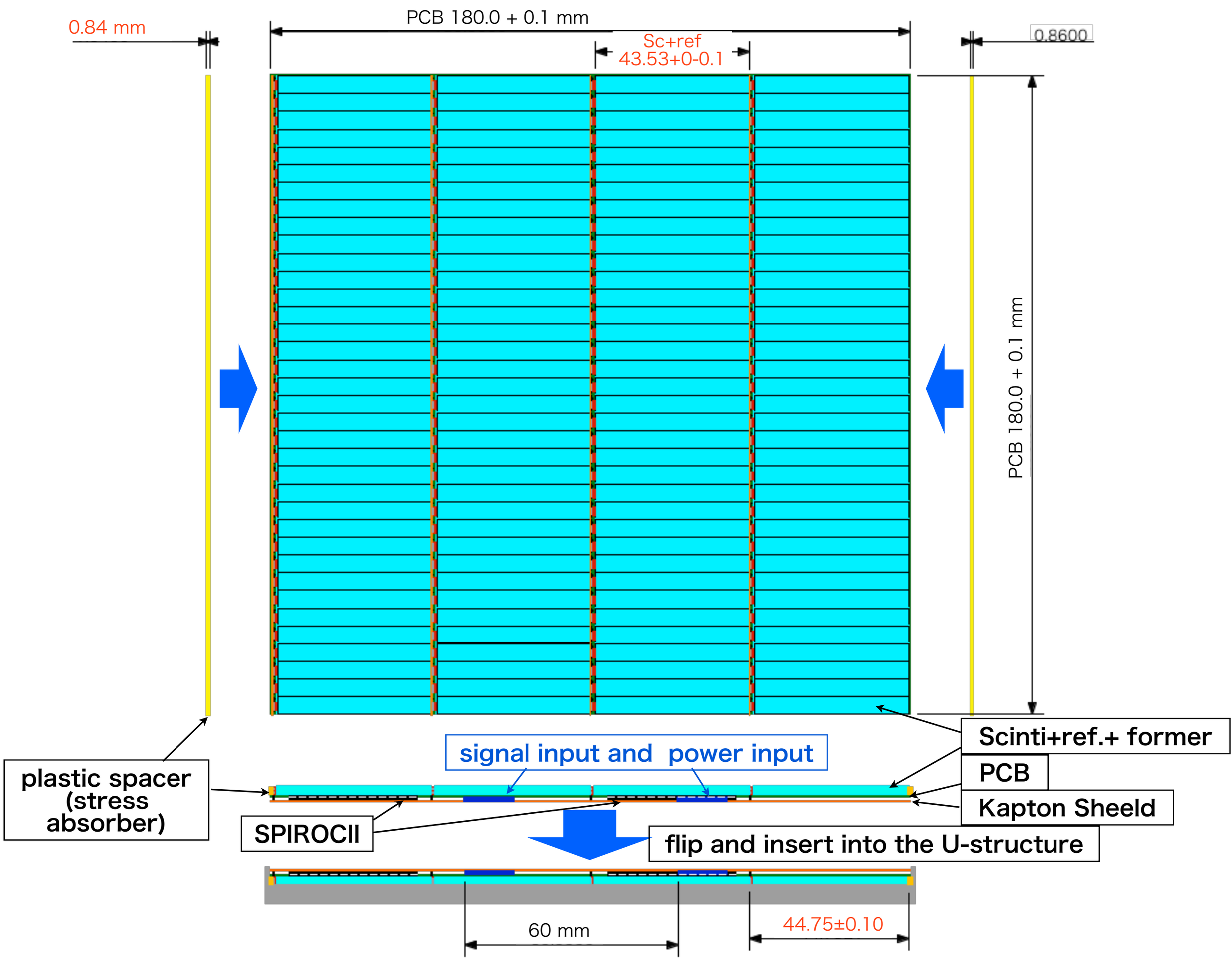


PCB and sensors are fixed on U-stracter using plastic spacers



One unit of alveolar (a pair of Sc)




0.84 mm
PCB 180.0 + 0.1 mm
Sc+ref
43.53+0-0.1
0.8600
PCB 180.0 + 0.1 mm
plastic spacer
(stress
absorber)
signal input and power input
SPIROCII
Scinti+ref.+ former
PCB
Kapton Sheeld
flip and insert into the U-structure
60 mm
44.75±0.10

MPPC thickness: 0.85 mm

Soldering thickness: 0.10 m

Electrode thickness: 0.21 mm

Flat cable thickness: 0.06 mm

PCB edge to flat cable: 0.44+(0.19-0.00)mm

tolerance of solder of MPPC pins in the holes

PCB edge to hole edge: 0.5 mm

Hole to hole (next MPPC): 5.00 mm

HV pin to readout pin: 25.40 mm

PCB edge to hole edge: 0.5 mm

MPPC width 2.425 mm

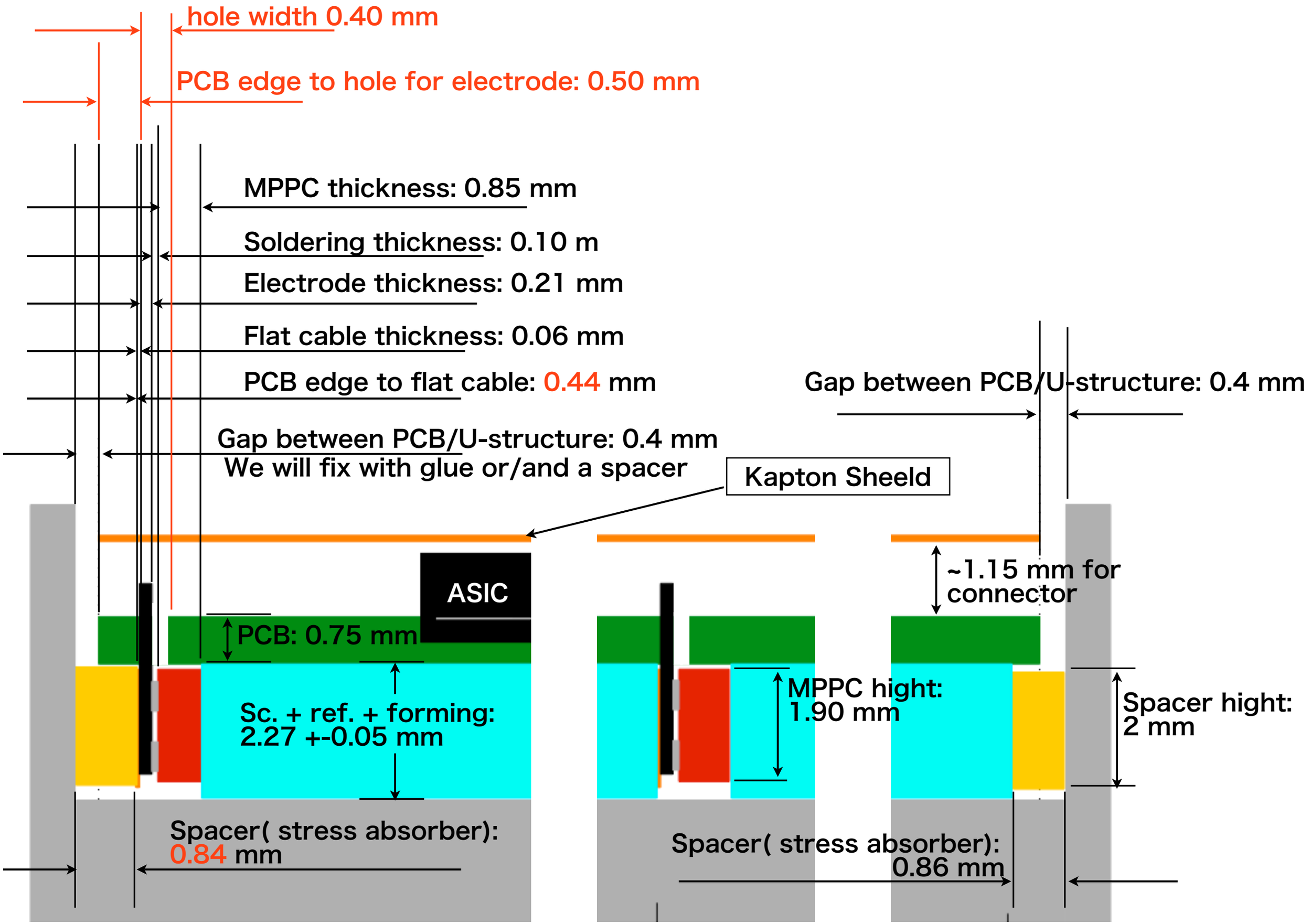
Sc.+ref: 5.00±0.1mm

**Total, 36 x 5.00 mm tolerance also±0.1mm

Distance between hole center and the hole center of the next column is 44.75 ± 0.05 mm

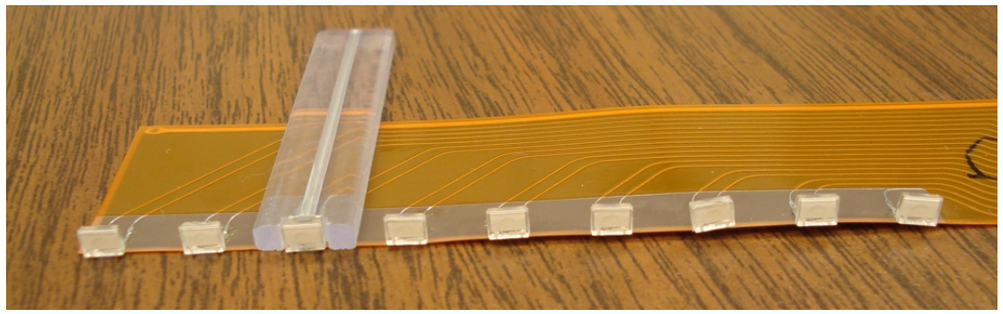
Readout electrode

HV electrode

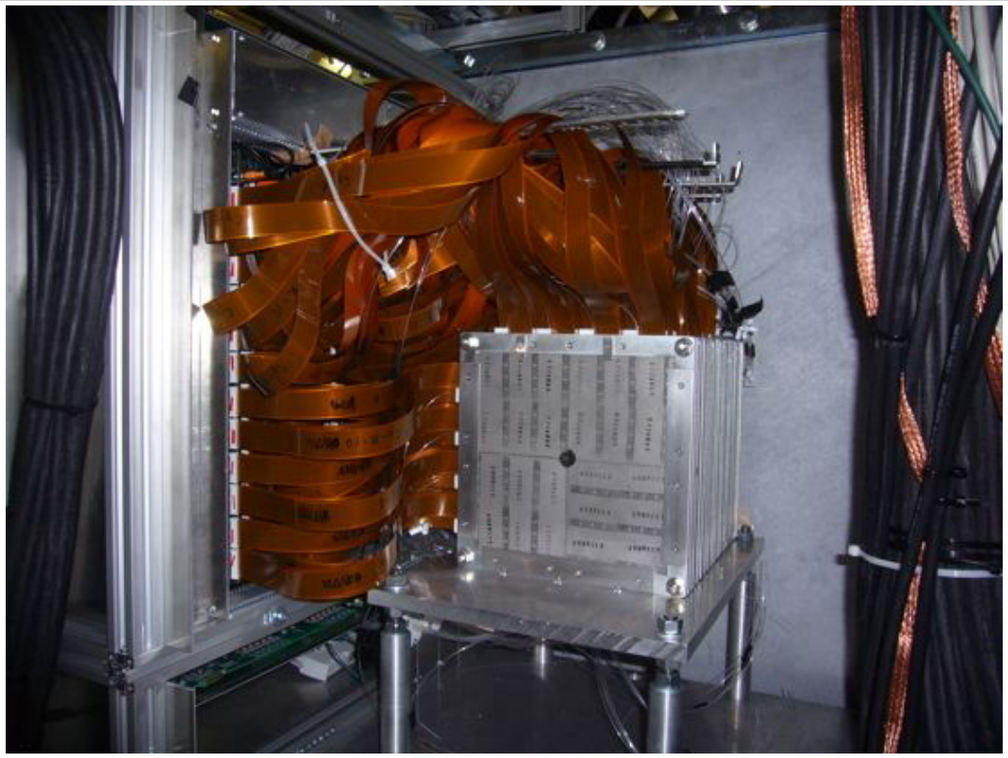

hole width 0.40 mm
PCB edge to hole for electrode: 0.50 mm
MPPC thickness: 0.85 mm
Soldering thickness: 0.10 m
Electrode thickness: 0.21 mm
Flat cable thickness: 0.06 mm
PCB edge to flat cable: 0.44 mm
Gap between PCB/U-structure: 0.4 mm
We will fix with glue or/and a spacer
Kapton Sheeld
ASIC
PCB: 0.75 mm
Sc. + ref. + forming:
2.27 +-0.05 mm
Spacer(stress absorber):
0.84 mm
Gap between PCB/U-structure: 0.4 mm
~1.15 mm for
connector
MPPC hight:
1.90 mm
Spacer hight:
2 mm
Spacer(stress absorber):
0.86 mm

Physics prototype → Thechnical prototype

9 channel MPPC on a flat cable and a scintillator strip



72 channels on a layer



Physics prototype of 30 layers =2160 channels

ScEcal Thickness Calculation

Thickness (mm)

				Default (Mokka) SiECAL				ScECAL 25 W, PCB: 1.2 mm				SeECAL 25 W, PCB:1.4 mm			
	The number of alveolar:			15				13				13			
		X0/Unit	Dens.												
				#	Unit	Total	#X0	#	Unit	Total	#X0	#	Unit	Total	#X0
for Alveolar structure	Front surface (G10)			1	2.00	2.00		1	2.00	2.00		1	2.00	2.00	
	Tungsten absorber (structure-1)	6.76	19.3	10	2.10	21.00	6.00	12	3.00	36.00	10.28	12	3.00	36.00	10.28
	Tungsten absorber (structure-2)	6.76	19.3	4	4.20	16.80	4.80								
	Support (G10)			1	9.30	9.30		1	9.30	9.30		1	9.30	9.30	
	Carbon fiber frame layer			56	0.15	8.40		24	0.15	3.60		24	0.15	3.60	
for H structure	Tungsten absorber(in alveolar-1)	6.76	19.3	10	2.10	21.00	6.00	13	3.00	39.00	11.13	13	3.00	39.00	11.13
	Tungsten absorber(in alveolar-2)	6.76	19.3	5	4.20	21.00	6.00								
	Carbon fiber frame layer			120	0.15	18.00		26	0.15	3.90		26	0.15	3.90	
	glue gap			30	0.10	3.00									
	Scintillator forming film + glue							52	0.05	2.60		52	0.05	2.60	
	Silicon Sensor	21.82	2.329	30	0.50	15.00	0.16								
	Scintillator + reflector	43.79	1.06					26	1.50	39.00	0.09	26	1.30	33.80	0.08
	ground			30	0.10	3.00		26	0.00	0.00		26	0.00	0.00	
	PCB			30	0.80	24.00		26	1.20	31.20		26	1.40	36.40	
	Copper radiator			30	0.40	12.00		26	0.40	10.40		26	0.40	10.40	
	Shielding film			30	0.10	3.00		26	0.10	2.60		26	0.10	2.60	
	Alveolar air gap			30	0.25	7.50		26	0.25	6.50		26	0.25	6.50	
Module Total thickness						185.00				186.10				186.10	
Total number of tungsten absorber 1				20				25				25			
Total number of tungsten absorber 2				9											
ECAL-HCAL gap						30.00				28.90				28.90	
ECAL inner surface - HCAL inner surface						215				215.00				215.00	
Total number of X0							22.94				21.507				21.49

G

ScEcal Thickness Calculation

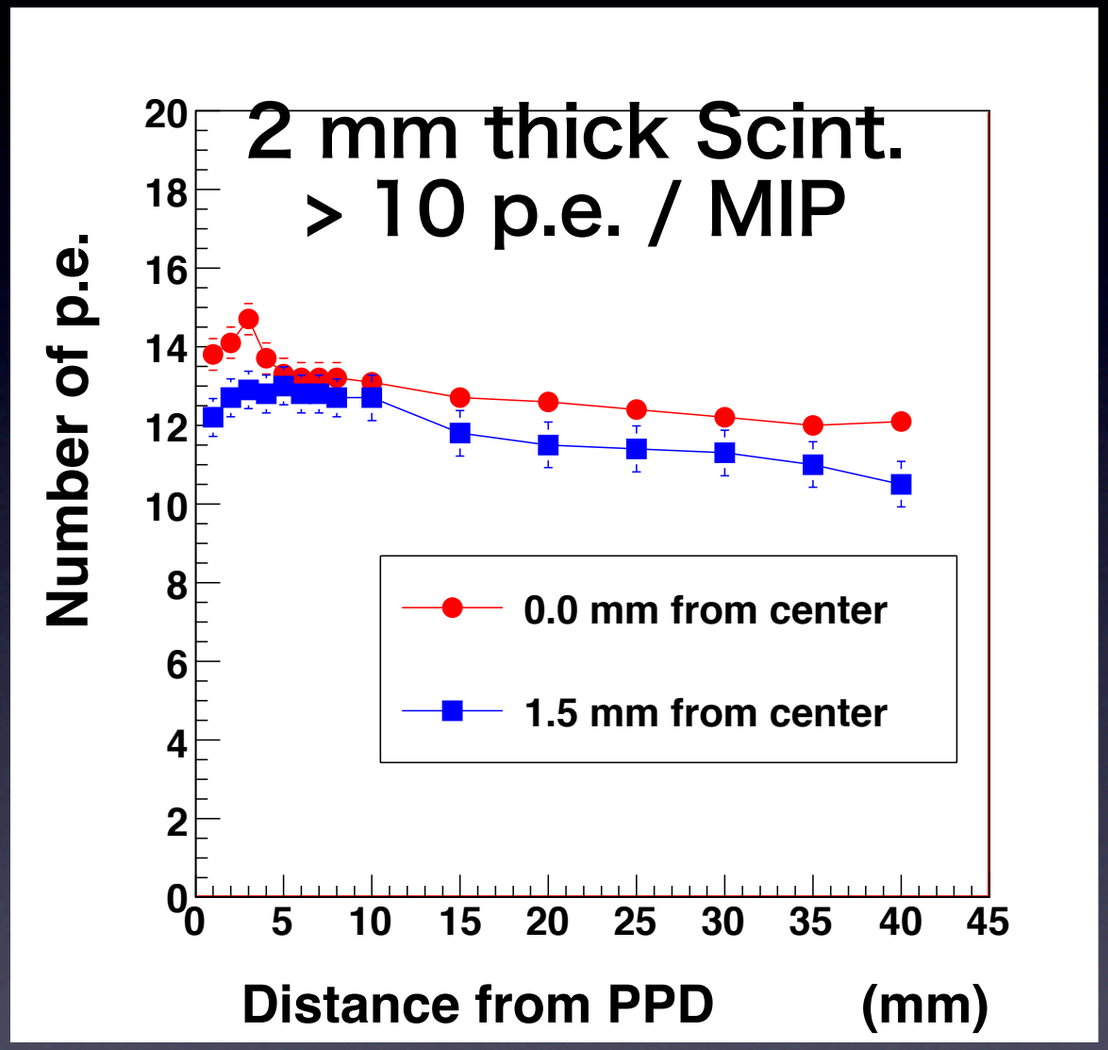
Thickness (mm)

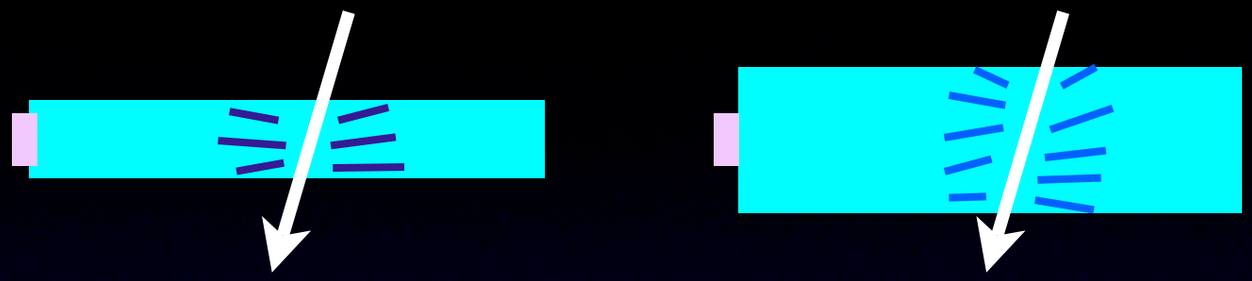
				Default (Mokka) SiECAL				ScECAL 25 W, PCB: 0.8 mm				SeECAL 23 W, PCB: 1.2 mm			
	The number of alveolar:			15				13				12			
		X0/Unit	Dens.												
				#	Unit	Total	#X0	#	Unit	Total	#X0	#	Unit	Total	#X0
for Alveolar structure	Front surface (G10)			1	2.00	2.00		1	2.00	2.00		1	2.00	2.00	
	Tungsten absorber (structure-1)	6.76	19.3	10	2.10	21.00	6.00	12	3.00	36.00	10.28	11	3.00	33.00	9.42
	Tungsten absorber (structure-2)	6.76	19.3	4	4.20	16.80	4.80								
	Support (G10)			1	9.30	9.30		1	9.30	9.30		1	9.30	9.30	
	Carbon fiber frame layer			56	0.15	8.40		48	0.15	7.20		44	0.15	6.60	
for H structure	Tungsten absorber(in alveolar-1)	6.76	19.3	10	2.10	21.00	6.00	13	3.00	39.00	11.13	12	3.00	36.00	10.28
	Tungsten absorber(in alveolar-2)	6.76	19.3	5	4.20	21.00	6.00								
	Carbon fiber frame layer			120	0.15	18.00		104	0.15	15.60		96	0.15	14.40	
	glue gap			30	0.10	3.00									
	Scintillator forming film + glue							52	0.05	2.60		48	0.05	2.40	
	Silicon Sensor	21.82	2.329	30	0.50	15.00	0.16								
	Scintillator + reflector	43.79	1.06					26	1.30	33.80	0.08	24	1.50	36.00	0.09
	ground			30	0.10	3.00		26	0.00	0.00		24	0.00	0.00	
	PCB			30	0.80	24.00		26	0.80	20.80		24	1.20	28.80	
	Copper radiator			30	0.40	12.00		26	0.40	10.40		24	0.40	9.60	
	Shielding film			30	0.10	3.00		26	0.10	2.60		24	0.10	2.40	
	Alveolar air gap			30	0.25	7.50		26	0.25	6.50		24	0.25	6.00	
Module Total thickness						185.00				185.80				186.50	
Total number of tungsten absorber 1				20				25				23			
Total number of tungsten absorber 2				9											
ECAL-HCAL gap						30.00				29.20				28.50	
ECAL inner surface - HCAL inner surface						215				215.00				215.00	
Total number of X0							22.94				21.495				✓19.79

H

Scintillator thickness

Position dependence of #p.e.





Scintillation is proportional
to thickness of scintillator

but acceptance is proportional
to the ratio MPPC hight/scinti.
hight(thickness)

We expect that also 1.3 mm thick scintillator
can make enough photon yield.

➡ we will make confirmation in the near future.

A