

Study of Position Sensitive Silicon Detector (PSD)



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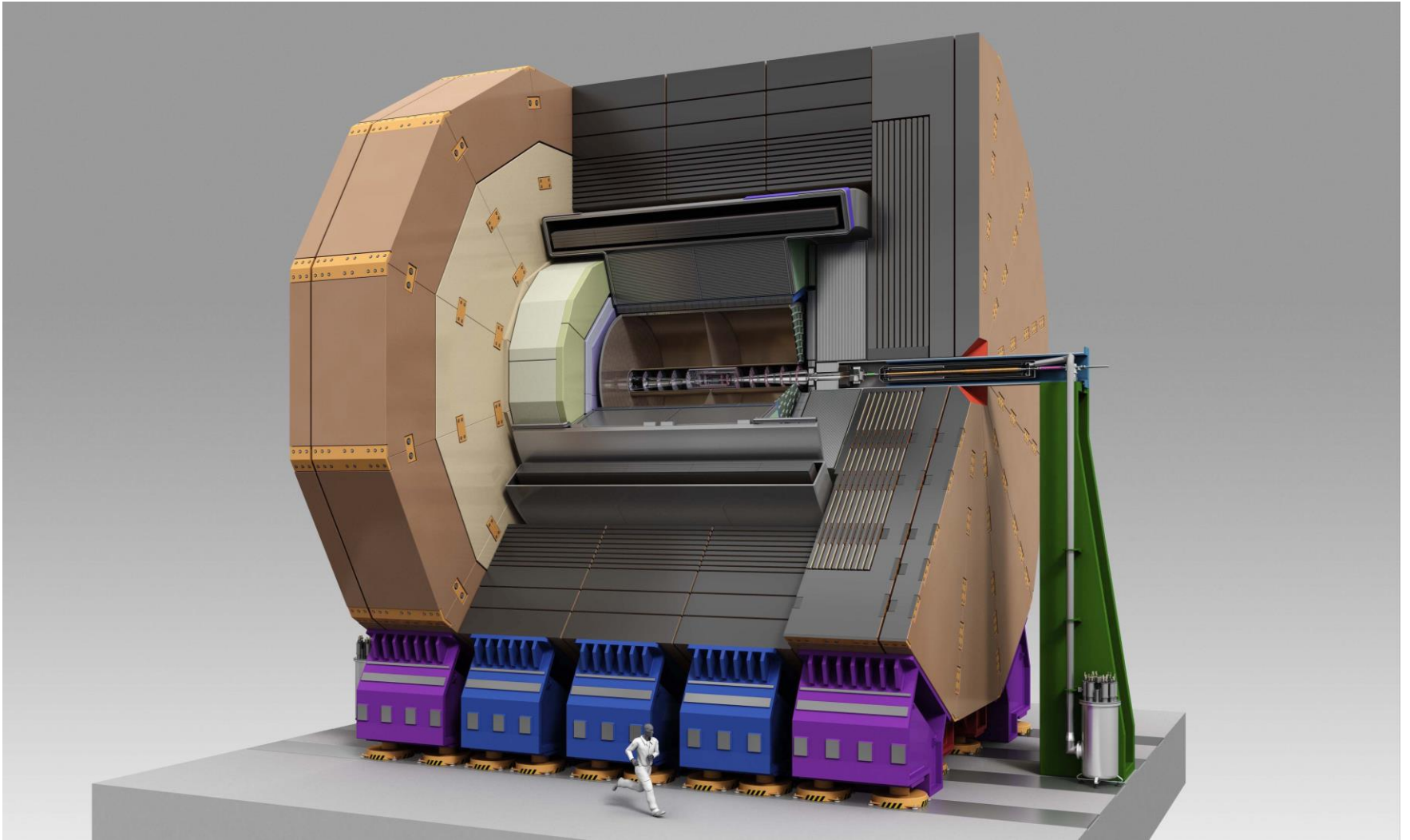
Tamaki Yoshioka , Kiyotomo Kawagoe

Kyushu University

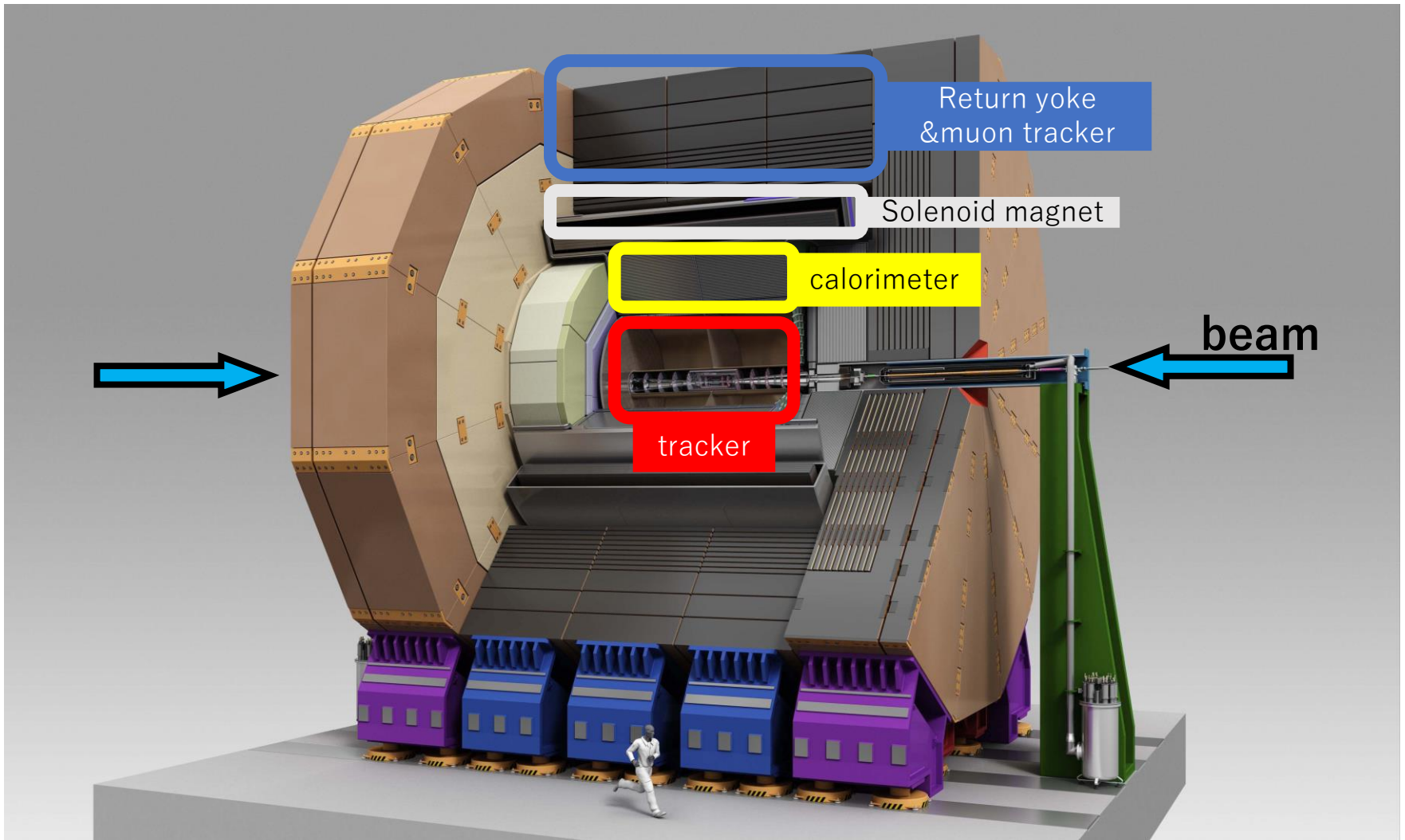
2019/11/26

CHEF2019, Calorimetry for the High Energy Frontier 2019

ILD (International Large Detector)

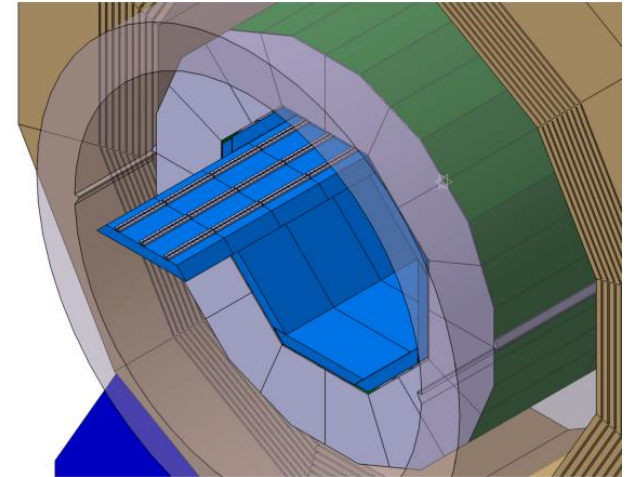


ILD (International Large Detector)



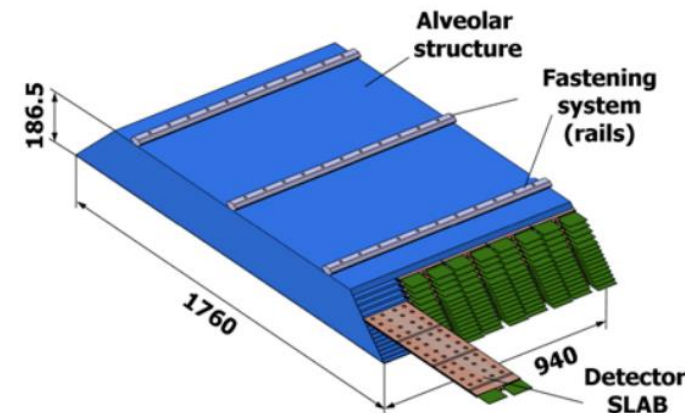
SiWECAL

- Si detection layer + W absorption layer
→ multilayer structure (20~30 layer)
- Sandwich ASIC and PCB between detection and absorption layer
- W → Electromagnetic shower
- Measure the energy of photons



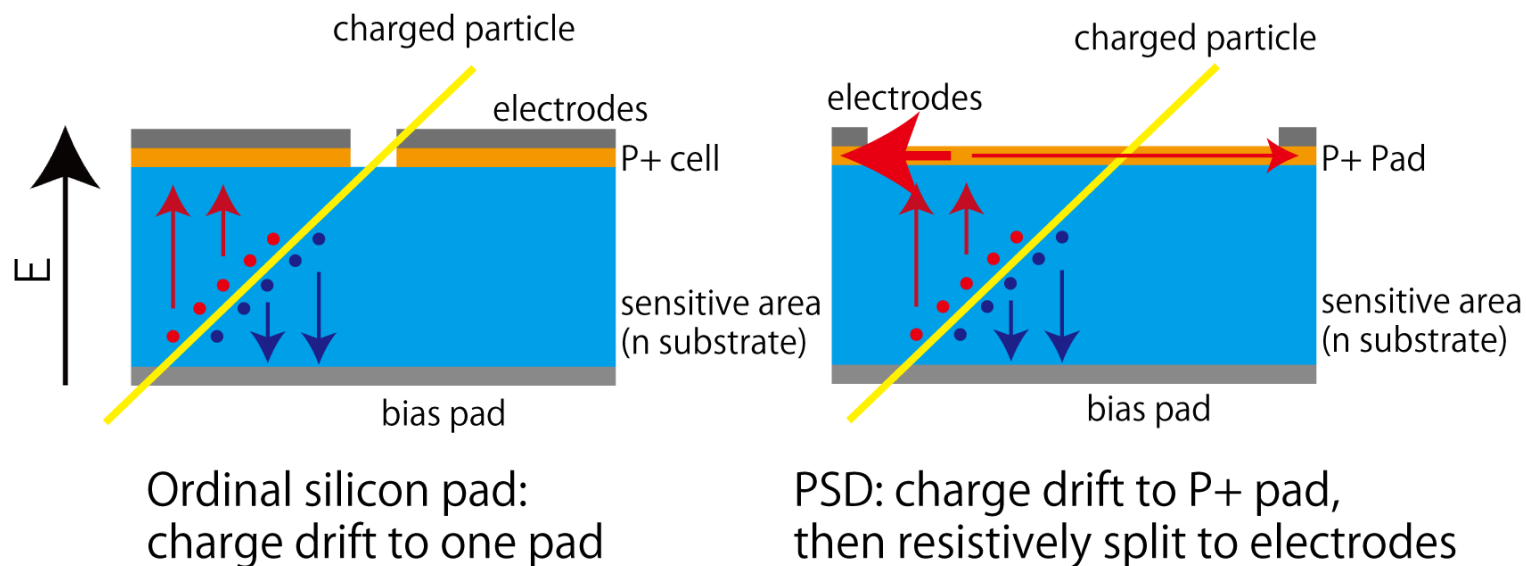
- γ in jets mostly comes from π^0 via $\pi^0 \rightarrow 2\gamma$ decay
- For accuracy of π^0 reconstruction, direction of photons (angular resolution) is important information

→ high position resolution sensor



PSD (Position Sensitive Silicon Detector)

- Divide the signal in the resistive surface layer
- Hit position can be obtained as the gravity center of signal strengths of the electrodes



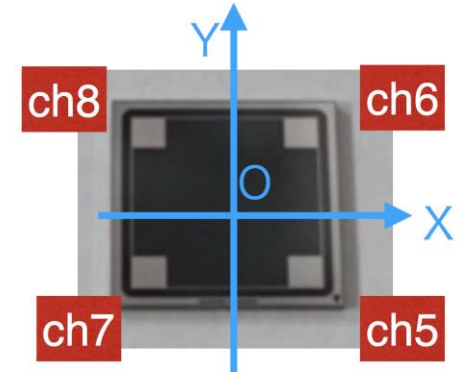
- With PSDs the position resolution can be improved with minimum increase in the acquisition channels

Previous study

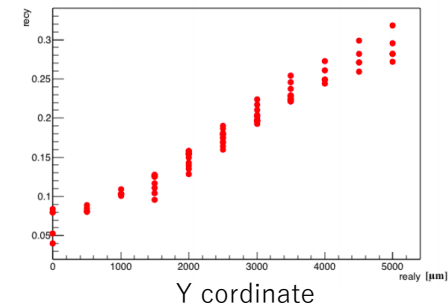
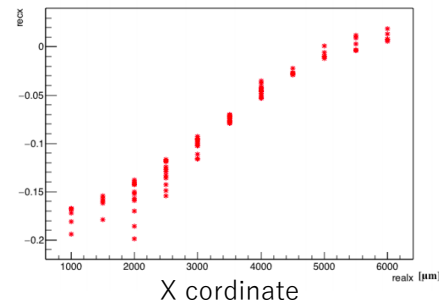
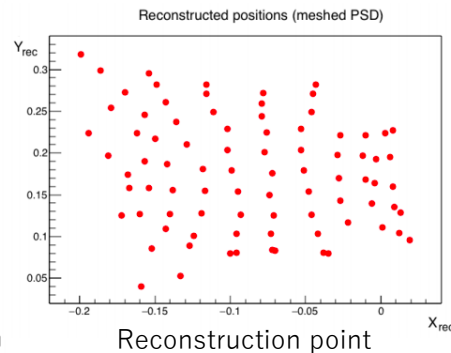
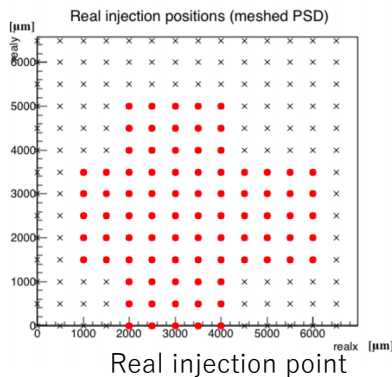
- Irradiate the laser to PSD ($7 \times 7 \text{mm}^2$) at $500 \mu\text{m}$ intervals and get signals from electrodes at the four corners

$$X_{rec} = \frac{(\text{ch5} + \text{ch6}) - (\text{ch7} + \text{ch8})}{\text{ch5} + \text{ch6} + \text{ch7} + \text{ch8}}$$

$$Y_{rec} = \frac{(\text{ch6} + \text{ch8}) - (\text{ch5} + \text{ch7})}{\text{ch5} + \text{ch6} + \text{ch7} + \text{ch8}}$$



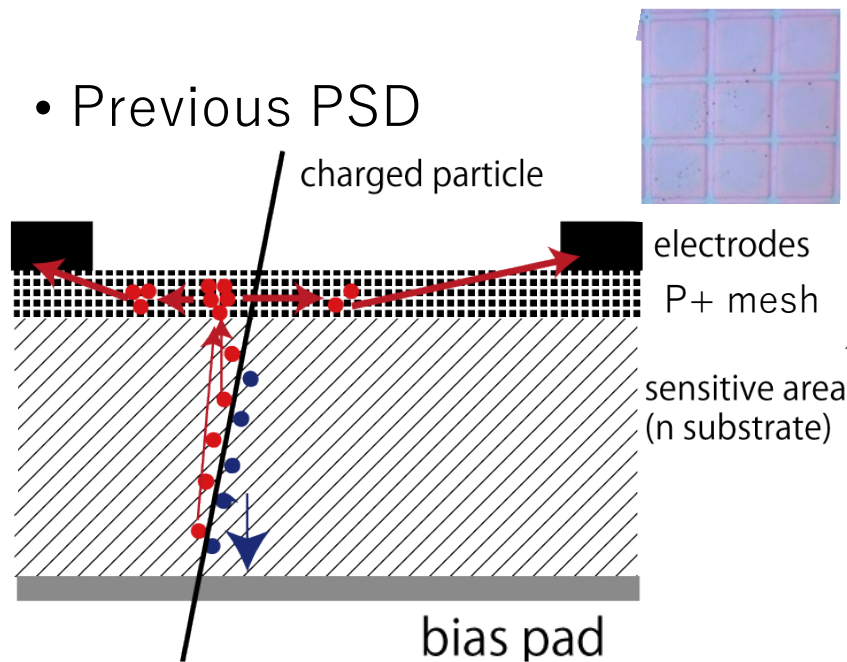
- Distortion at the edge
- Range is small \rightarrow x axis : $0.33/7000\mu\text{m}$ y axis : $0.34/7000\mu\text{m}$
- Due to DAQ problem, not measured in the Test beam



New specification for PSD

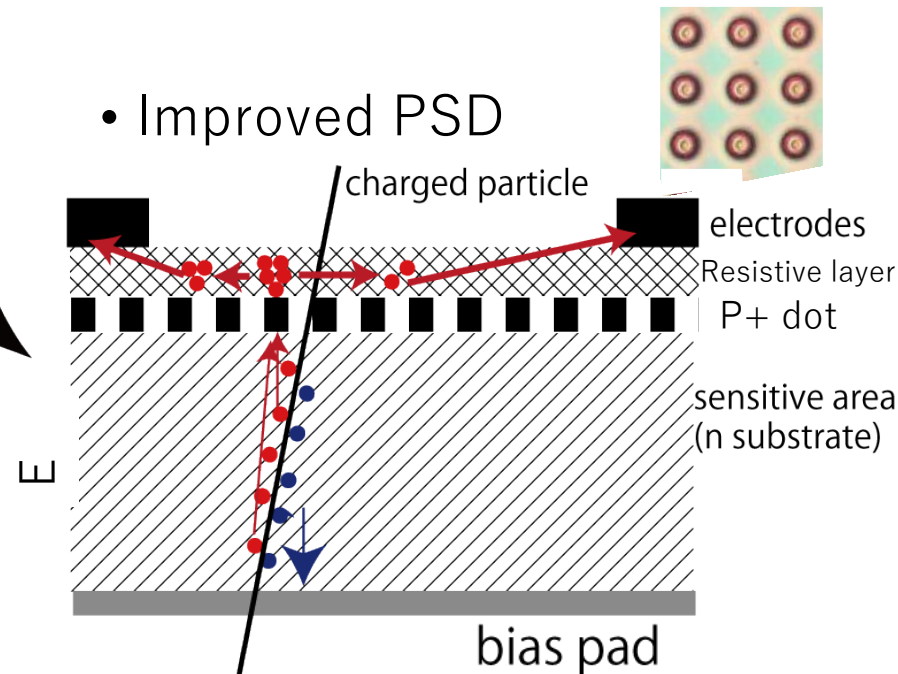
- Small dynamic range → Effect of readout impedance
→ Increased resistance of the resistive layer

• Previous PSD



- Signal charge passes through P+ layer
- Resistance value is controlled by mesh shape → it is necessary to remake mask to change it

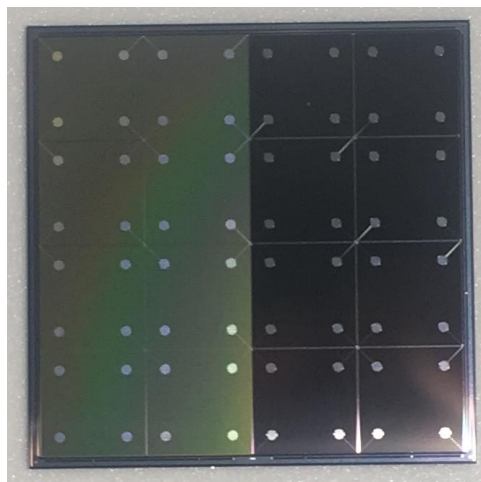
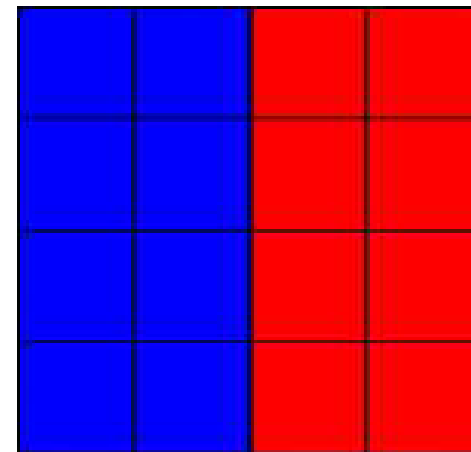
• Improved PSD



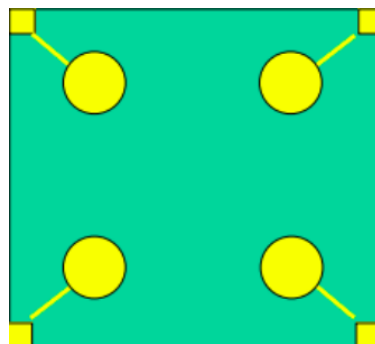
- P + is placed on the dot
- transport the signal charge through the upper resistive layer.
- The resistance value can be set higher and can be changed without changing the mask.

New specification for PSD 1-a

- Cell size : $5.5 \times 5.5 \text{ mm}^2$
- Sensor thickness : $650 \text{ }\mu\text{m}$
- Three resistance values are available:
10 times, 20 times, and 30 times the previous PSD
→ in order to optimize the resistance value of the resistance layer



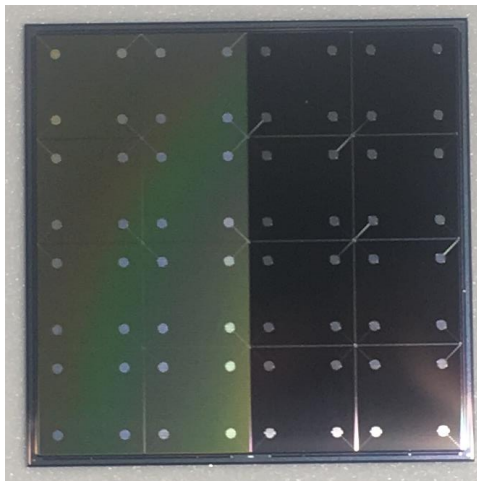
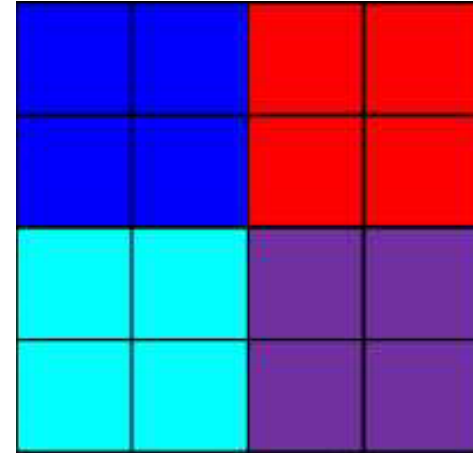
PSD 1



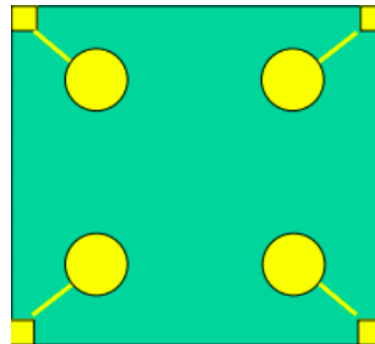
PSD 1
 $\times 16 = 64\text{ch}$

New specification for PSD 1-b

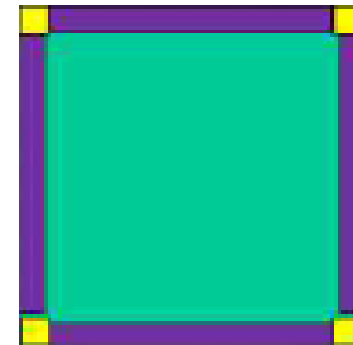
- Cell size : $5.5 \times 5.5 \text{ mm}^2$
- Sensor thickness : $650 \text{ }\mu\text{m}$
- Three resistance values are available:
10 times, 20 times, and 30 times the previous PSD
- Arrange low resistance lines at the cell edges to reduce distortion



PSD 1



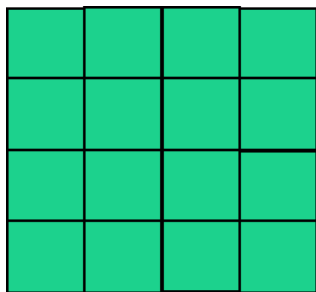
PSD 1
 $\times 16 = 64\text{ch}$



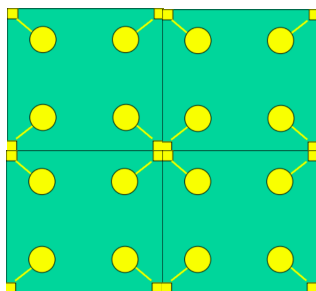
Low resistance line
 $\rightarrow 1/4$ times and $1/8$
times the center
plane resistance

New specification for PSD 2

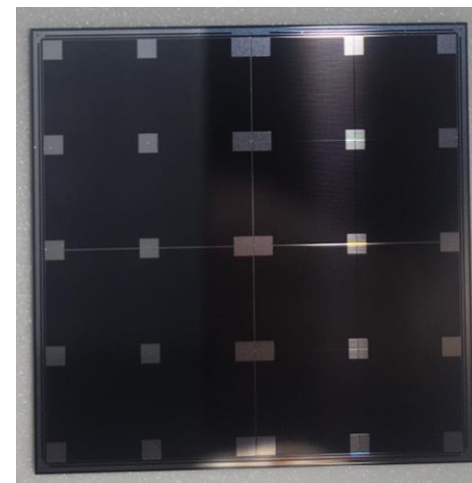
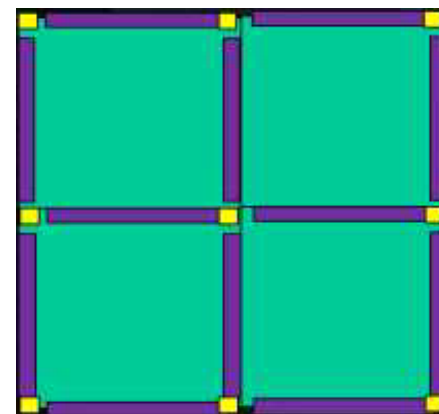
- Share adjacent cell pads
- Suppress increase in readout channel
- Multiple resistance values available
- If the number of read channels is the same, the pixel size can be reduced.
- Example : 16×16 cells
PSD 1 \rightarrow cell size is 11mm (2 times)
PSD 2 \rightarrow cell size is 5.86mm (16/15 times)



usual Si sensor
 4×4 cell



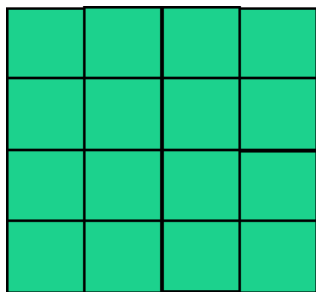
PSD 1 2×2 cell
 \rightarrow pixel size : 2 times



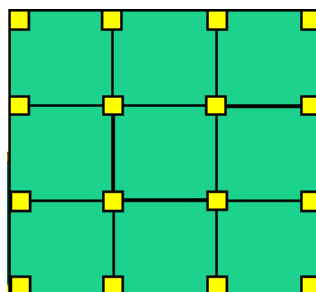
PSD 2

New specification for PSD 2

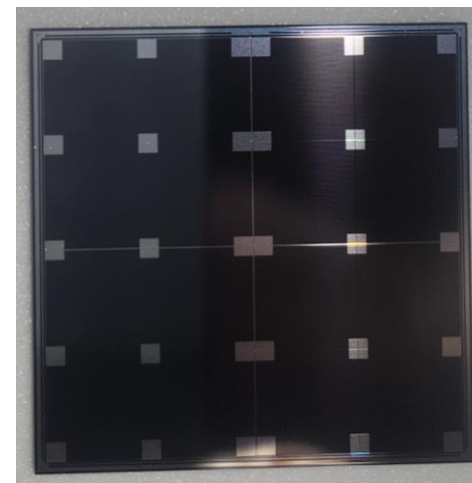
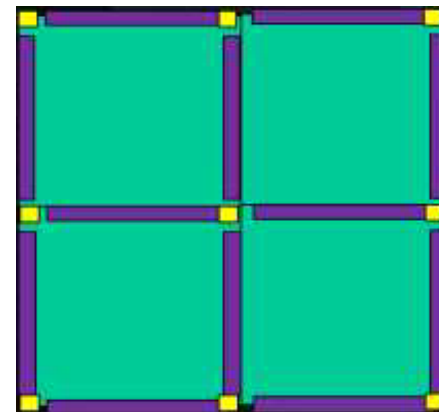
- Share adjacent cell pads
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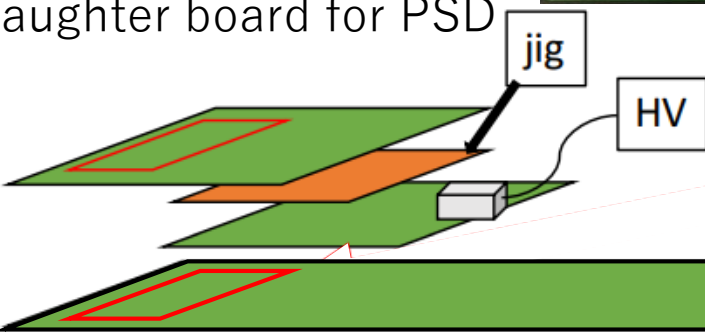
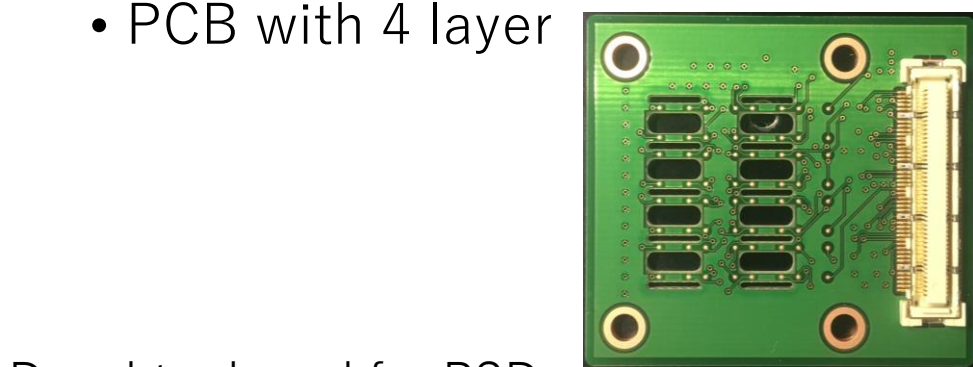
PSD 2 3×3 cell
 \rightarrow pixel size : 4/3 times



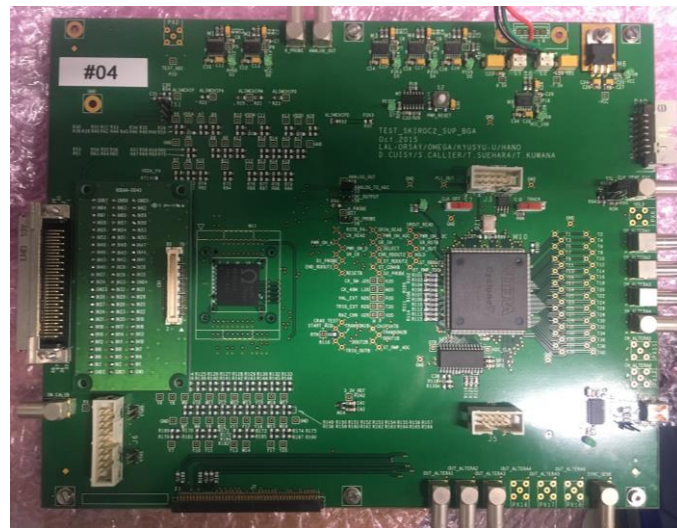
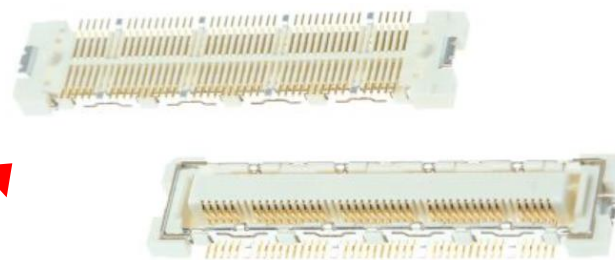
PSD 2

New daughter board and connector

- designed for connecting to the ASIC evaluation board through new connector
- PCB with 4 layer

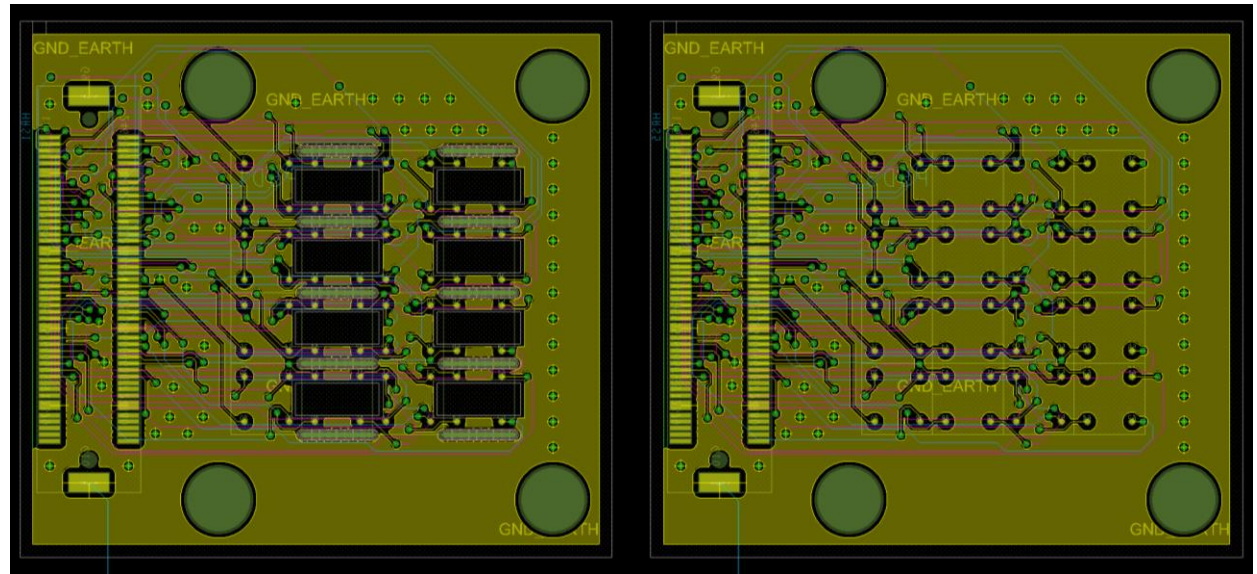
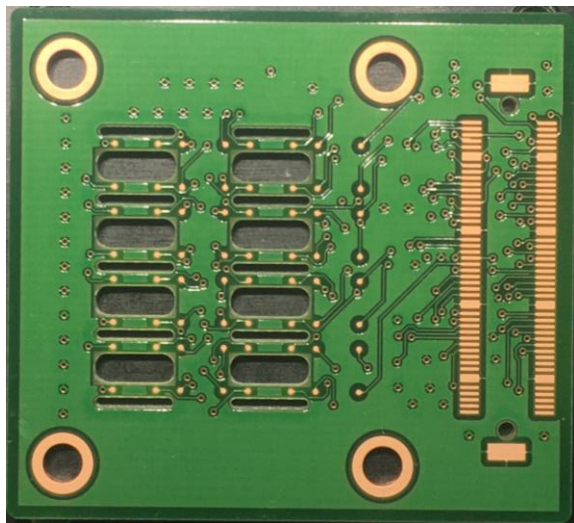


Test board for SKIROC



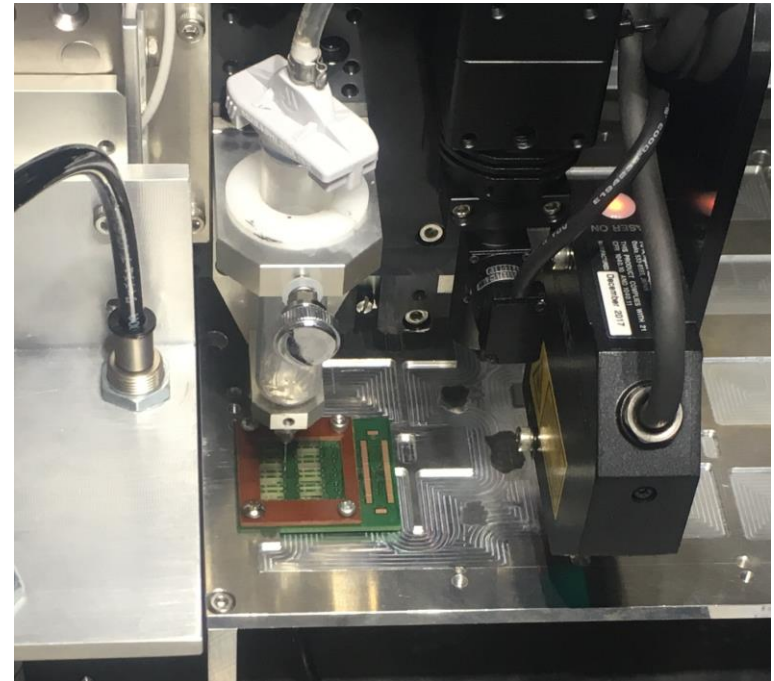
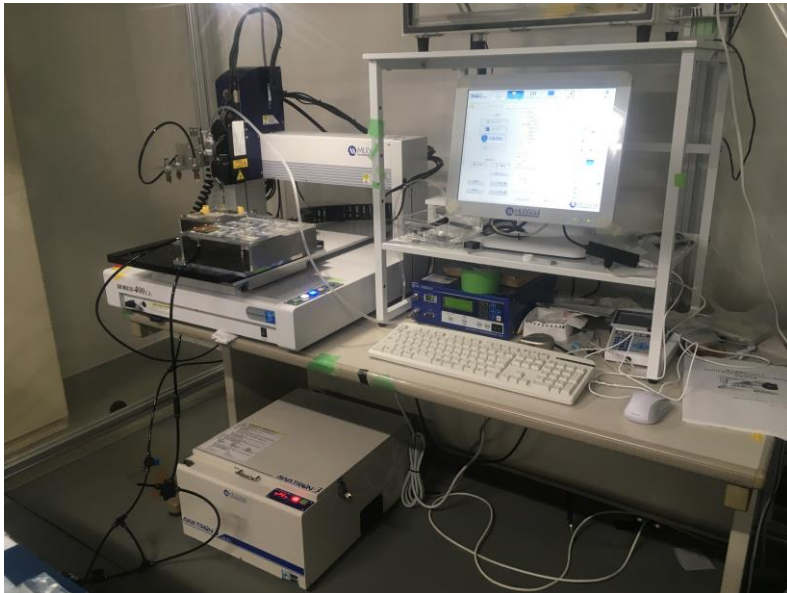
New board design of PSD 1

- New design daughter board using CADENCE allegro
 - ✓ PSD 1 PCB with hole → for irradiating the PSD with laser
 - ✓ PSD 1 without hole → for measurement with radio isotope or for test beam

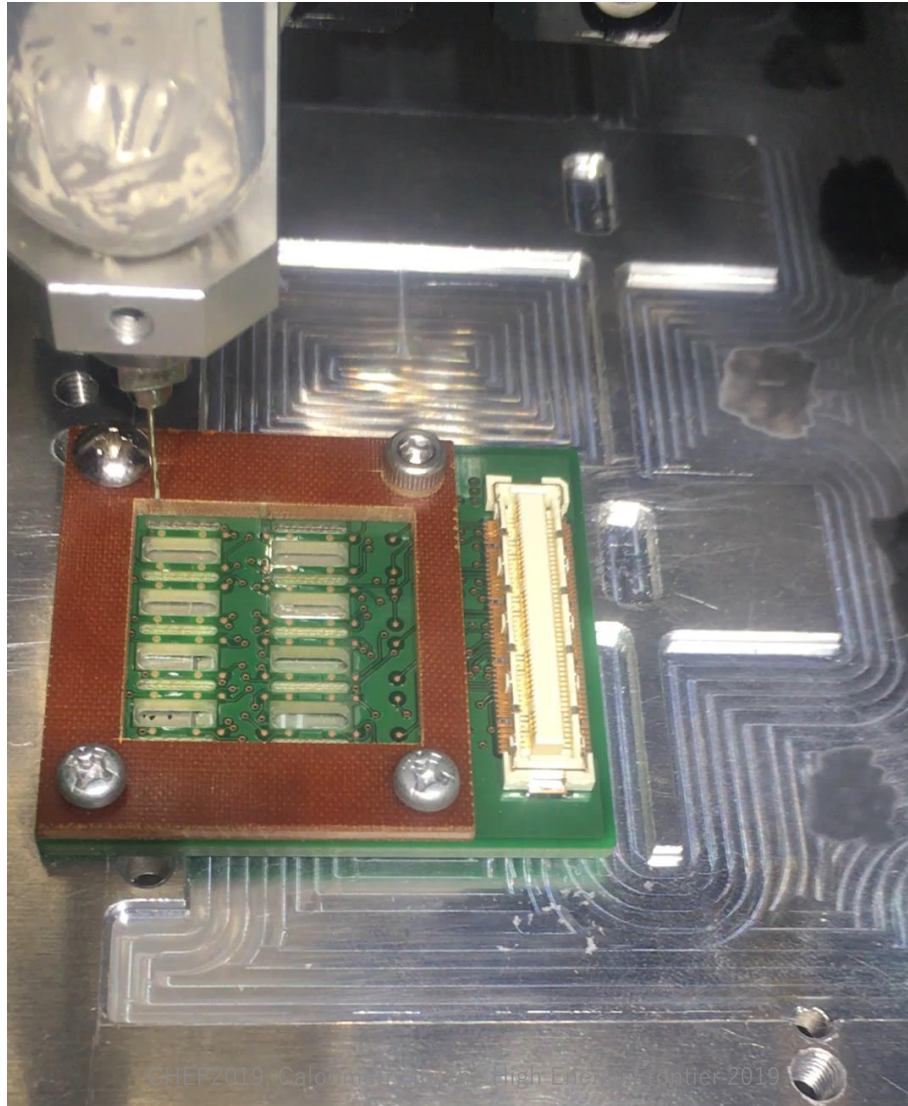


Sensor gluing

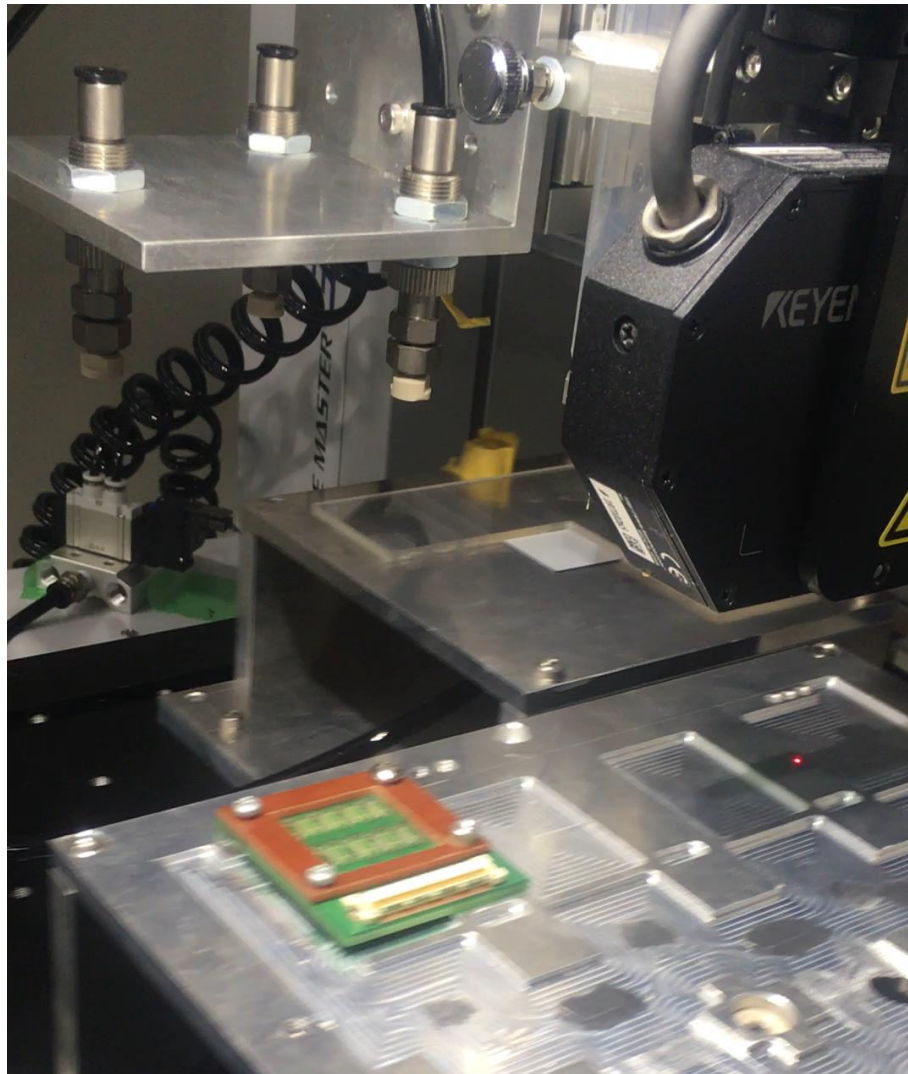
- Conductive bonding glue
- Dispenser made by Musashi Engineering (ML-808GX)
- High precision desktop operating type robot (SHOTMASTER400 Ω X)



Sensor gluing

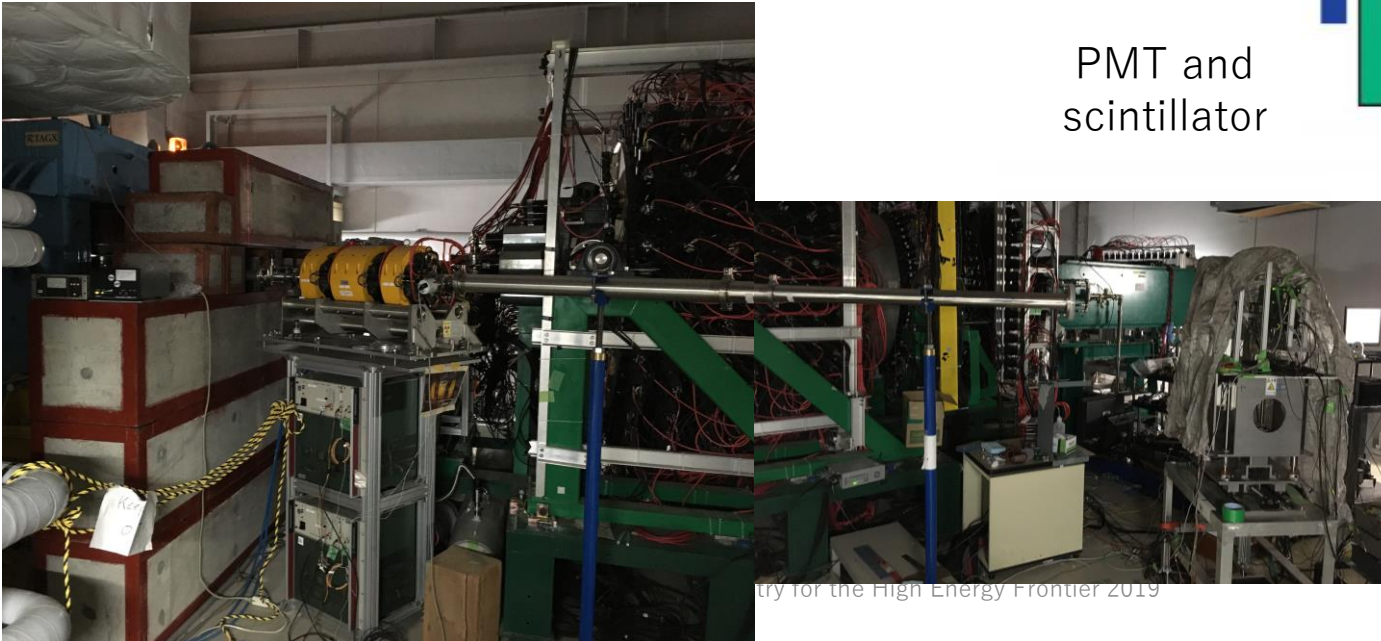
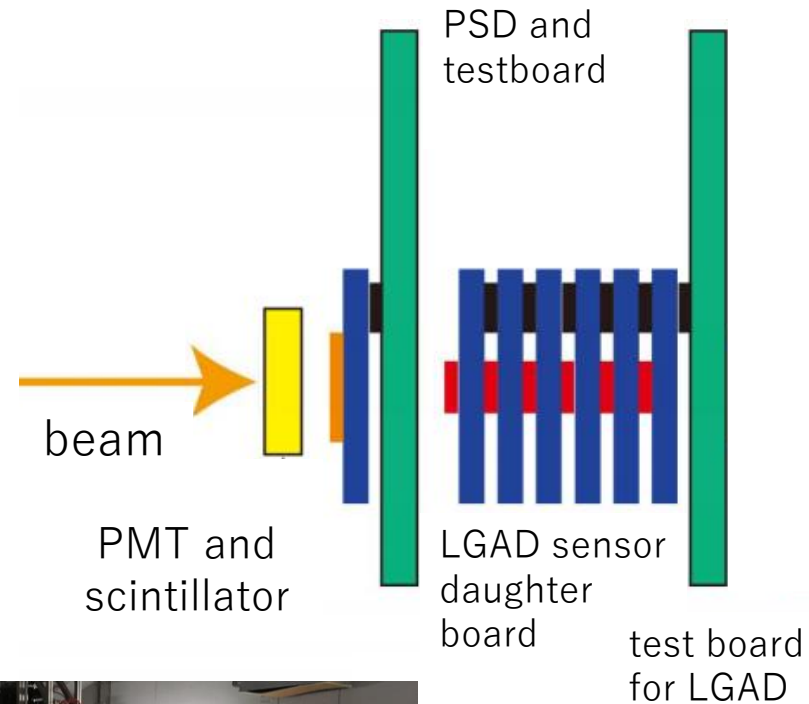


Sensor gluing



Test beam measurement

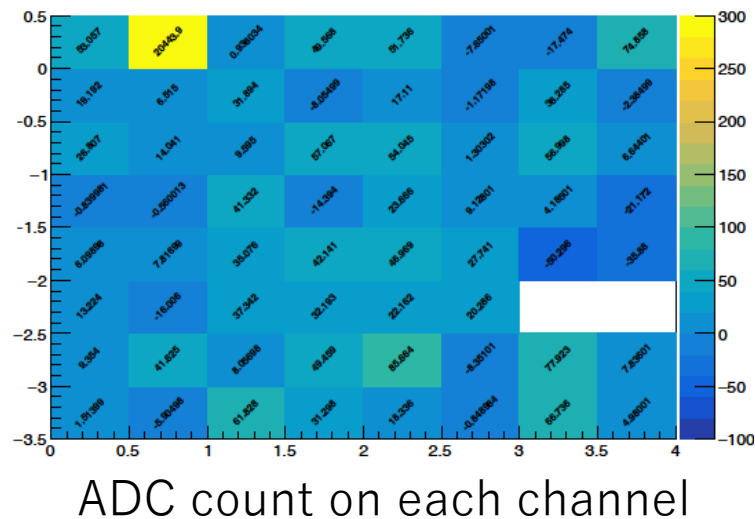
- Place: ELPH (Tohoku University)
- 560 MeV positron beam
- Program
 1. Measure position resolution
 2. Measurement of position distortion



Setup

Test beam measurement

- So far, the noise was so loud that I couldn't see the signal with the self-trigger.
- Measured by triggering with PMT and scintillator
- The signal is probably visible.
- We will analyze from now on.



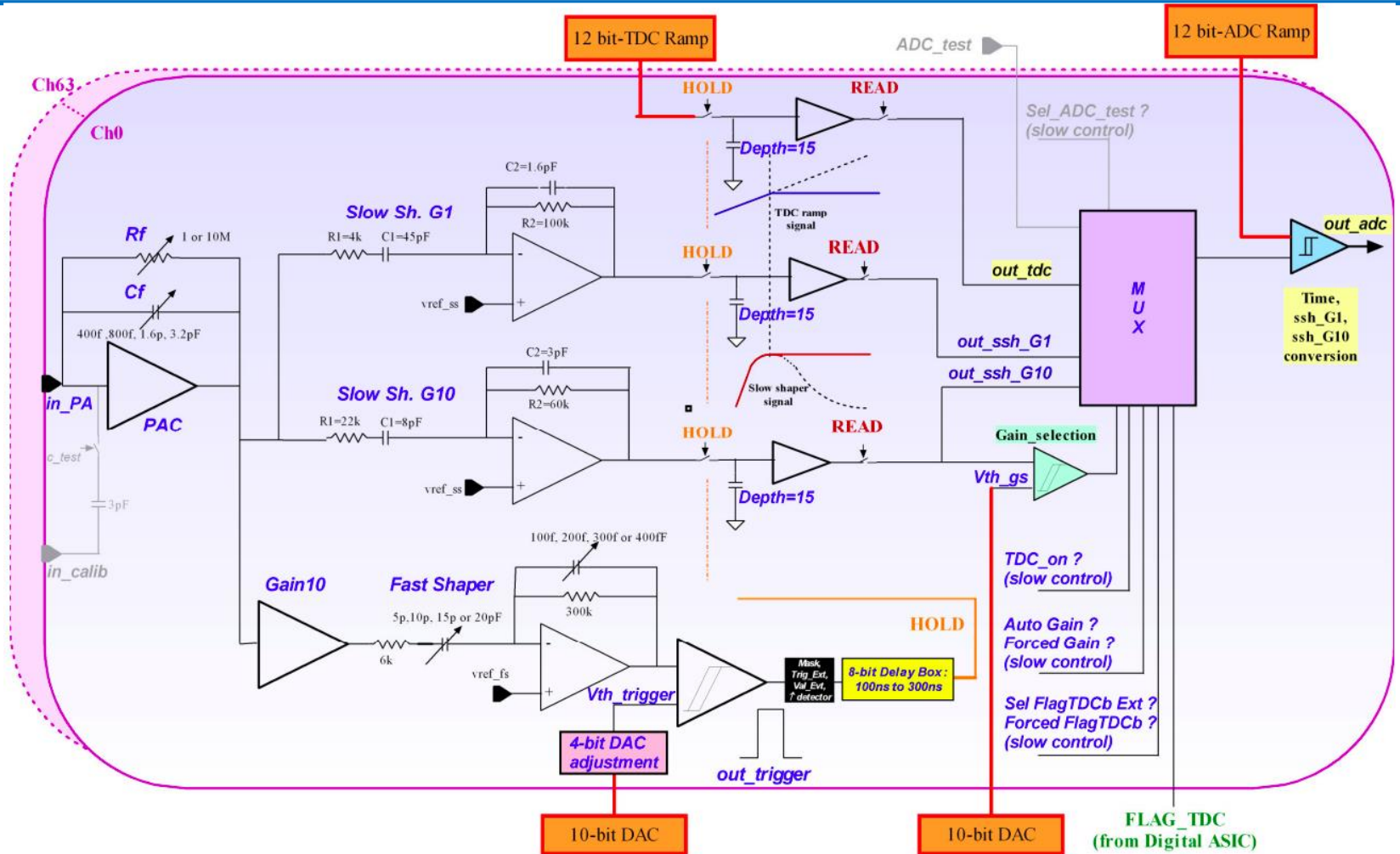
Summary and prospect

- For γ reconstruction, it is important for sensor to have high position resolution.
- PSD methods avoids an increase in the number of readout channels.
- Glued the sensor to the PCB
- Test beam measurement was performed at ELPH.

- To be done
 - ✓ Laser measurement
 - ✓ Analysis of test beam data
 - ✓ Production of PSDs designed to be mounted on ILC prototype

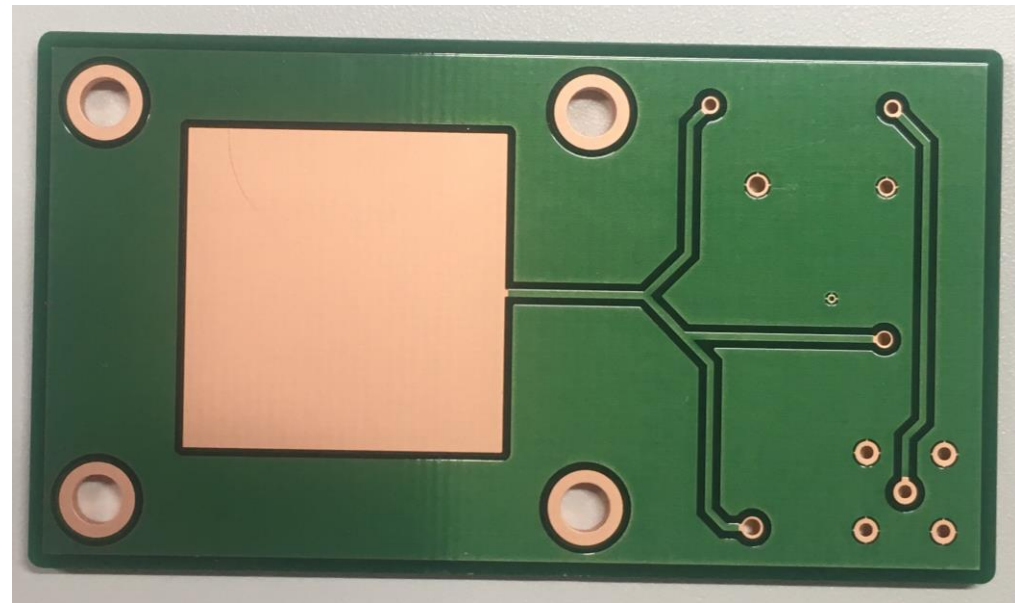
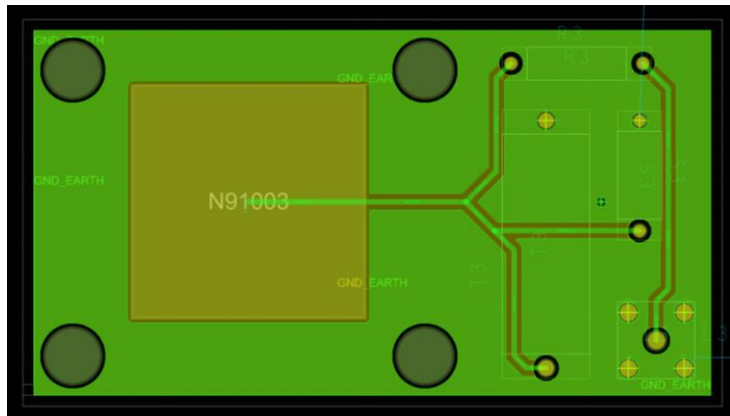
Back up

SKIROC analog



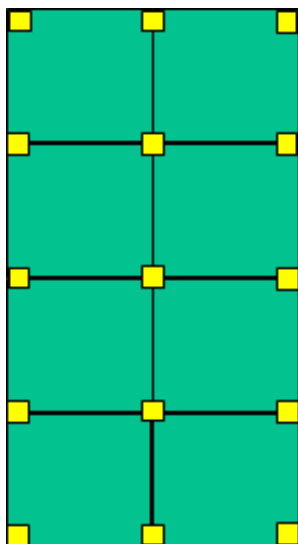
High voltage board design

- HV pad
- LEMO

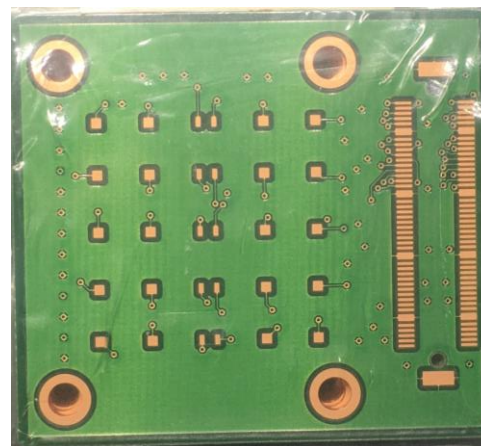


Solder capacitor and LEMO connector

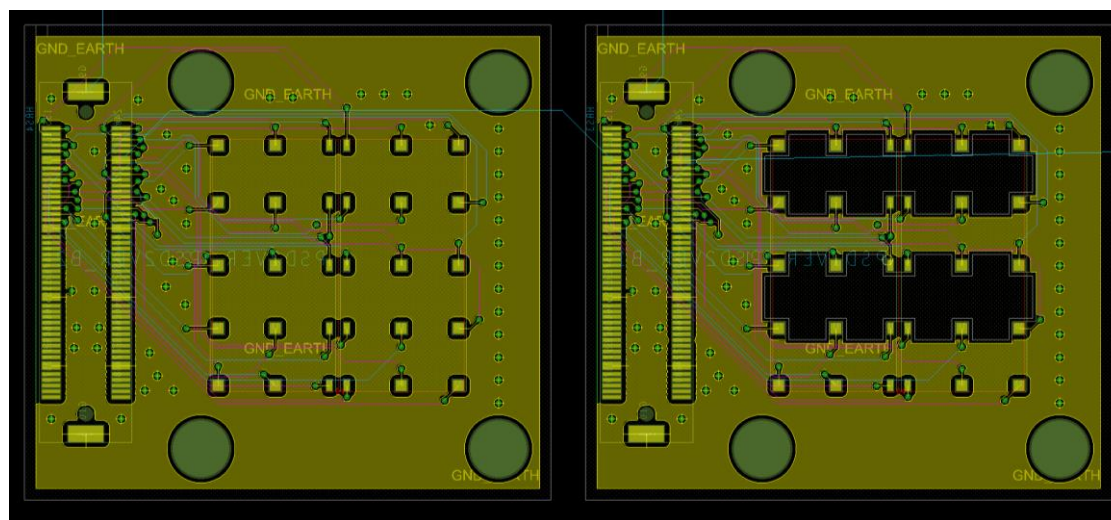
New board design of PSD 2



PSD 2
Two resistance
pattern
→ total 30ch



- PSD2 without hole
- PSD2 PCB with hole



Sensor gluing

- It's right after applying conductive bonding glue .
- I left a weight for several days.

