Study of Position Sensitive Silicon Detector (PSD)

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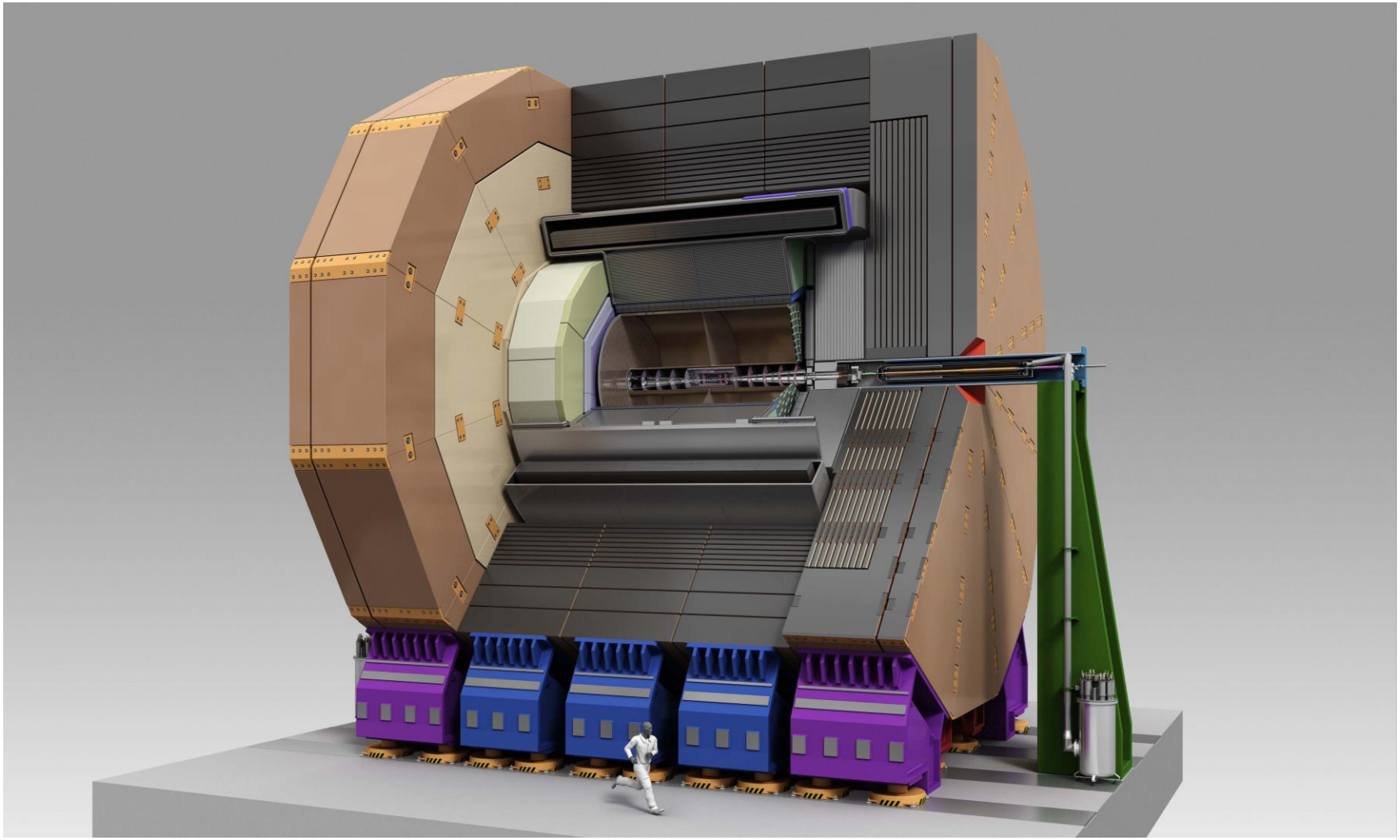
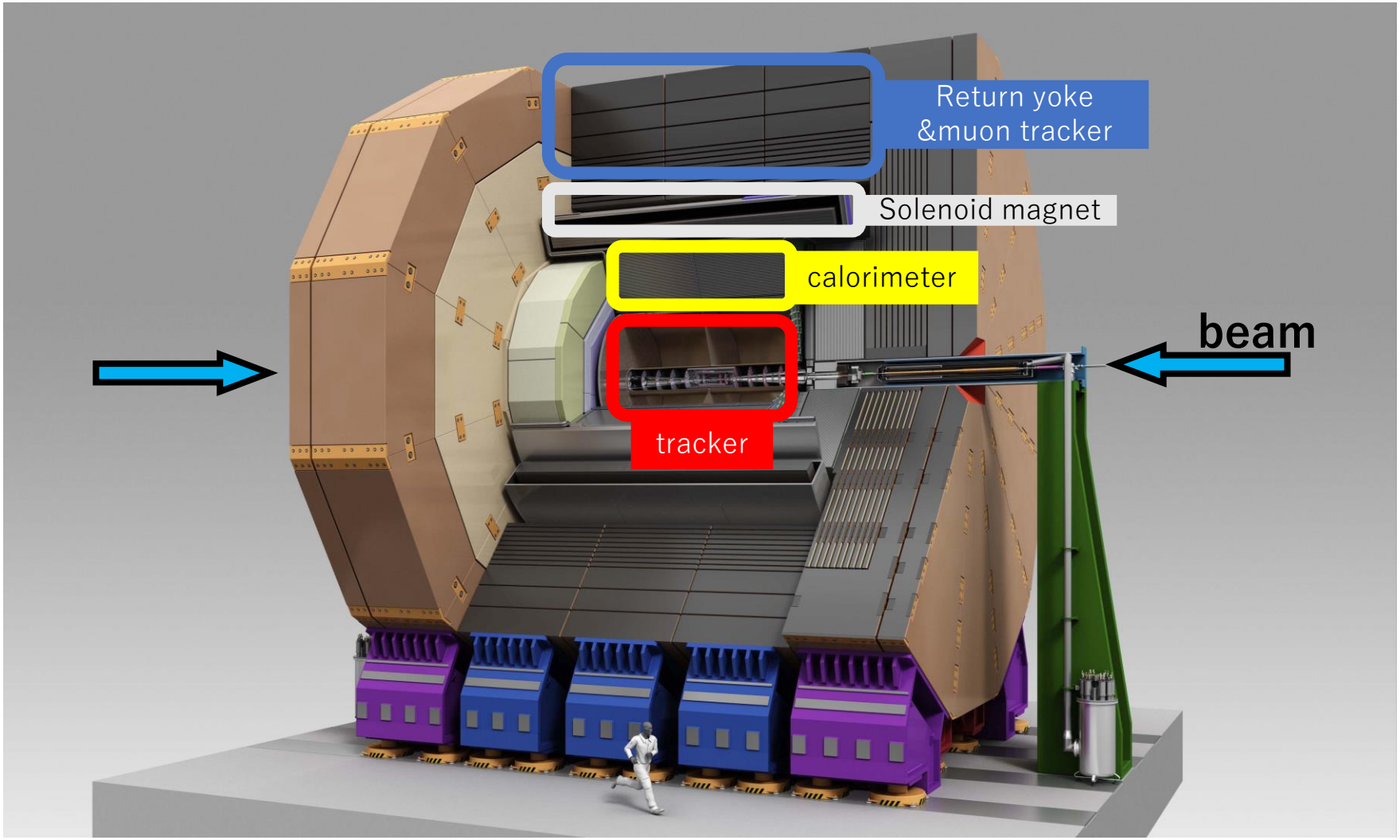
ILD (International Large Detector)

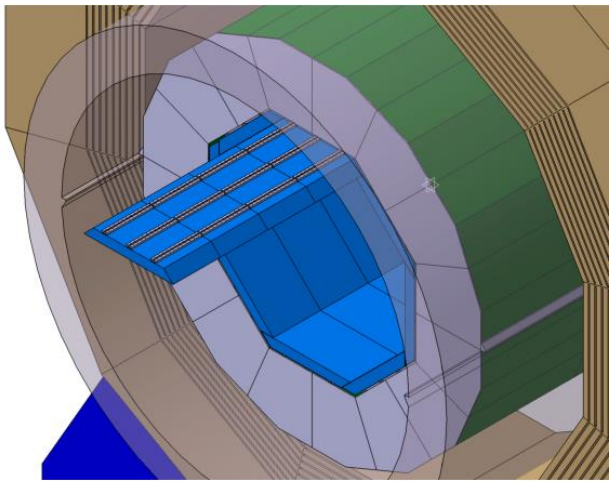


ILD (International Large Detector)



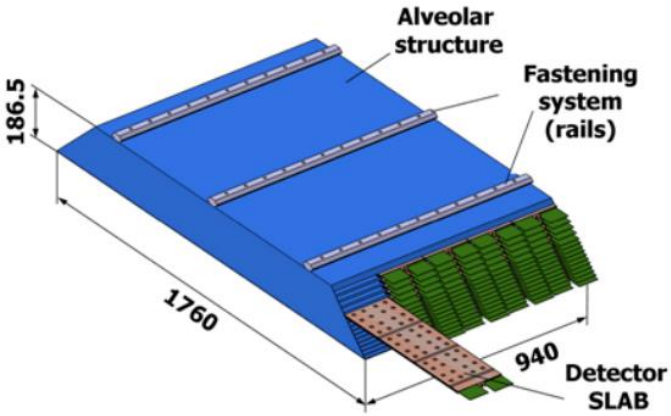
SiWECAL

- 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



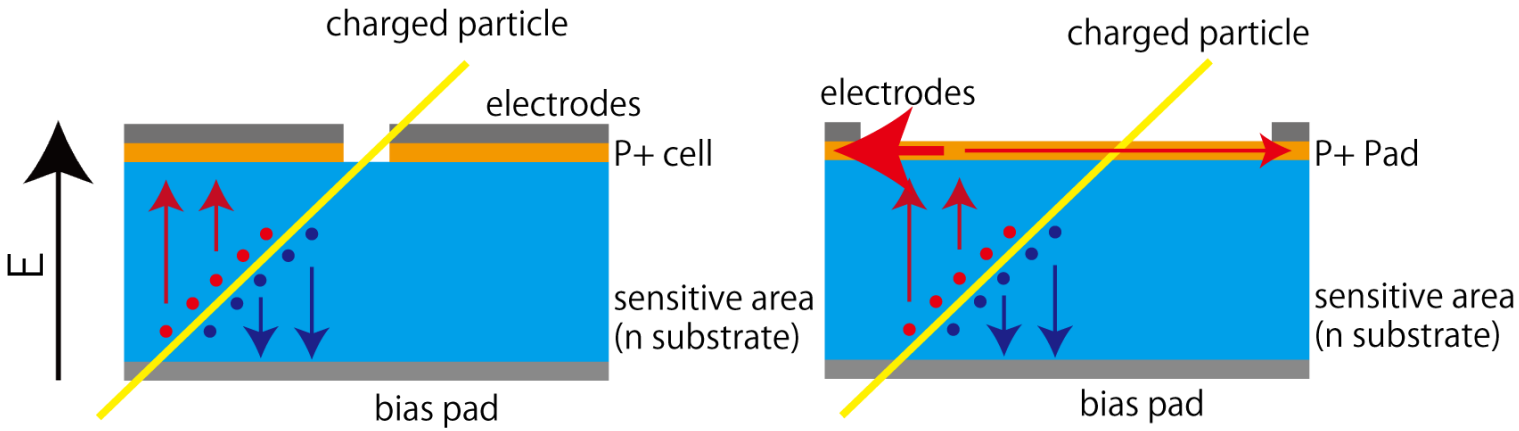
- γ in jets mostly comes from π^0 via $\pi^0 \to 2\gamma$ decay
- For accuracy of π^0 reconstruction, direction of photons (angular resolution) is important information

→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



Ordinal silicon pad:
charge drift to one pad

PSD: charge drift to P+ pad,
then resistively split to electrodes

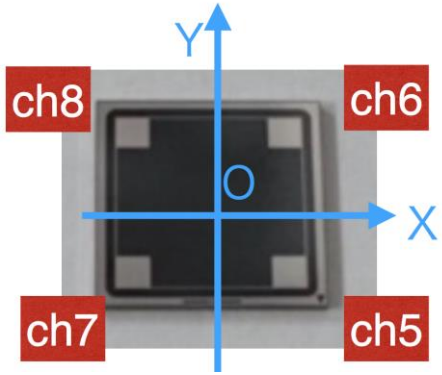
- With PSDs the position resolution can be improved with minimum increase of the acquisition channels

Previous study

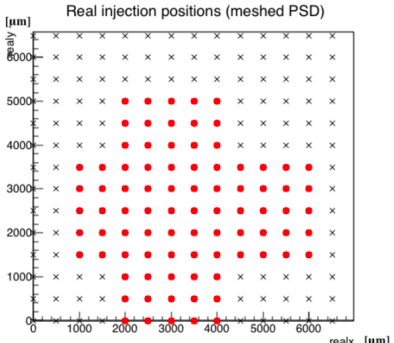
- Irradiate the laser to PSD ($7 \times 7\mathrm{mm}^2$) at 500 μm intervals and get signals from electrodes at the four corners

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

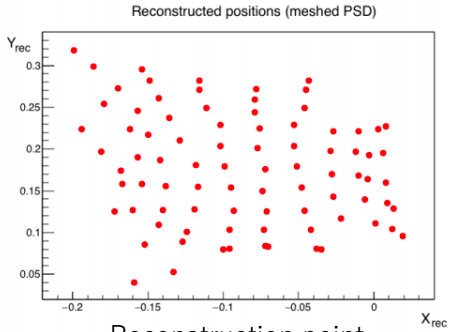
$$Y_{rec} = \frac{(\mathrm{ch6} + \mathrm{ch8}) - (\mathrm{ch5} + \mathrm{ch7})}{\mathrm{ch5} + \mathrm{ch6} + \mathrm{ch7} + \mathrm{ch8}}$$



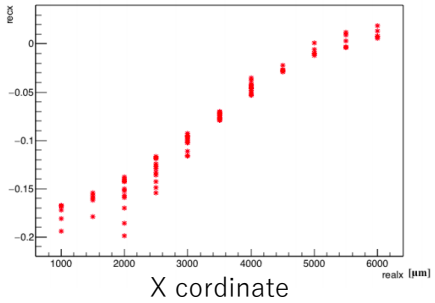
- Distortion at the edge
- Range is small → x axis : 0.33/7000μm y axis : 0.34/7000μm
- Due to DAQ problem, not measured in the Test beam



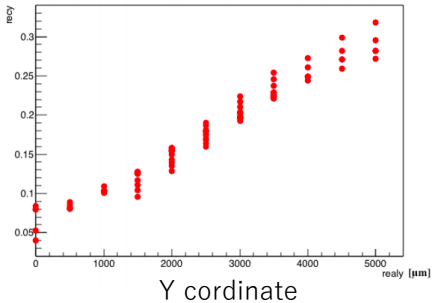
Real injection point



Reconstruction point



X cordinate

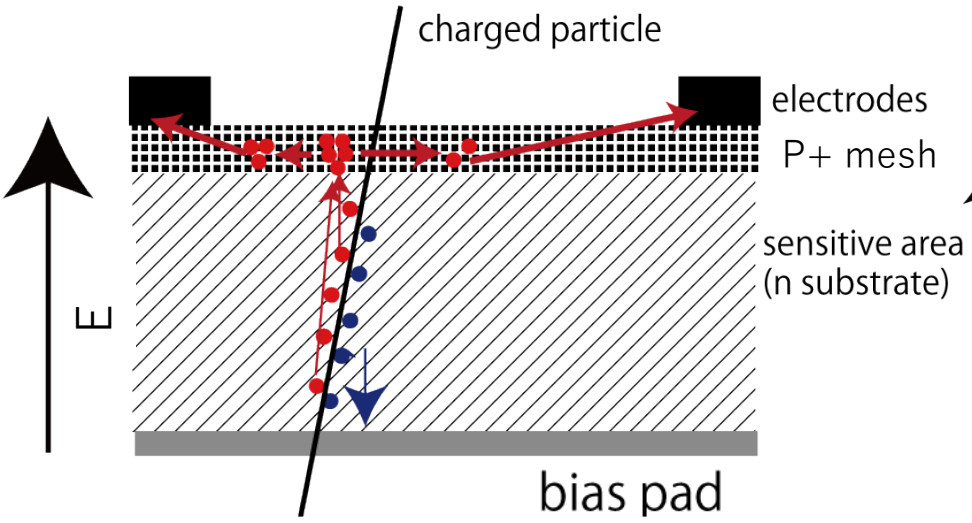


Y cordinate

New specification for PSD

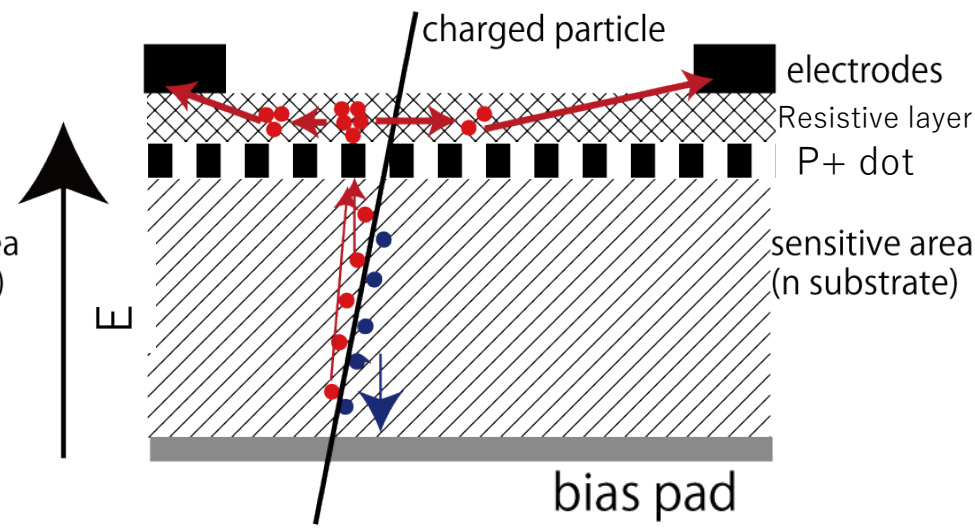
- Small dynamic range → Effect of readout impedance
  →Increased resistance of the resistive layer

- Previous PSD



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

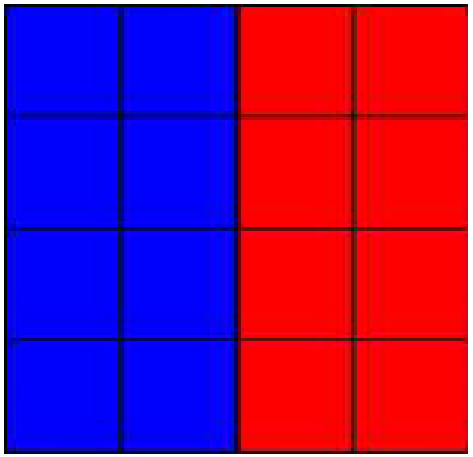
- Improved PSD

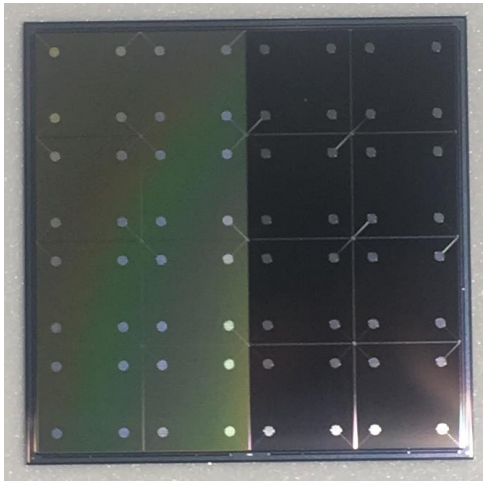


- P + is placed on the dot
- transport the signal charge through the upper resistive layer.
- The resistance value can be set higher and can be changed without changing the mask.

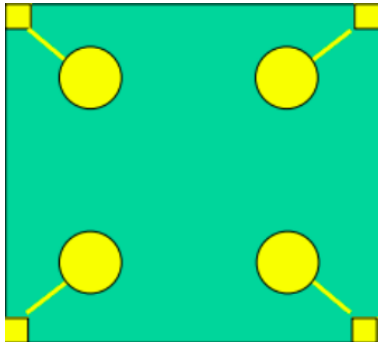
New specification for PSD 1-a

- Cell size : $5.5 \times 5.5\ \mathrm{mm}^2$
- Sensor thickness : 650 μm
- 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





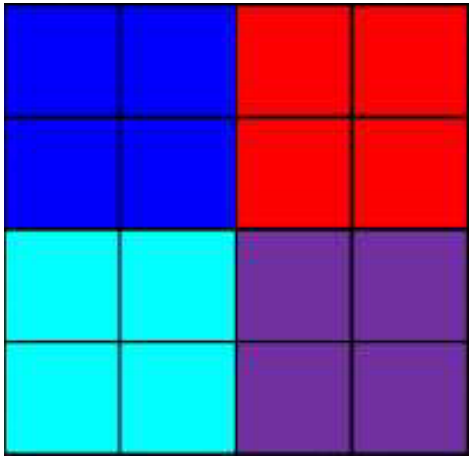
PSD 1

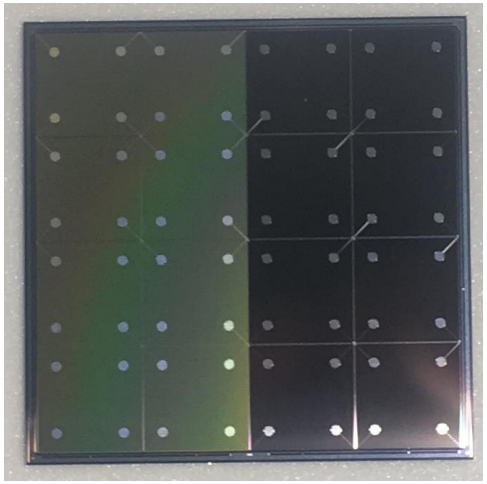


PSD 1
× 16 = 64ch

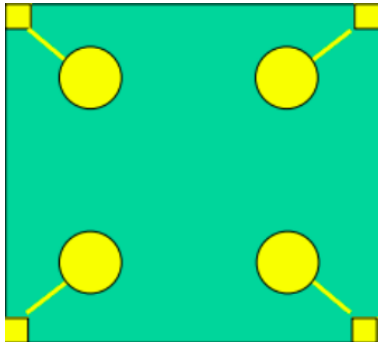
New specification for PSD 1-b

- Cell size : $5.5 \times 5.5\ \mathrm{mm}^2$
- Sensor thickness : 650 μm
- 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

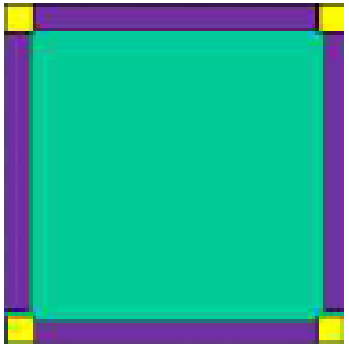




PSD 1



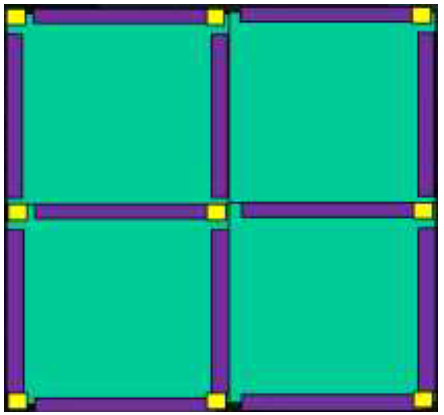
PSD 1
× 16 = 64ch

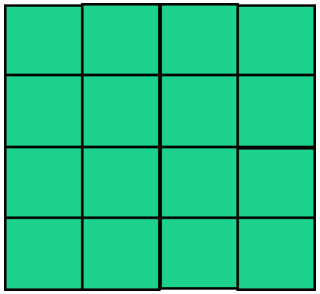


Low resistance line
→1/4 times and 1/8 times the center plane resistance

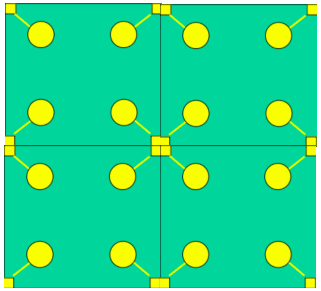
New specification for PSD 2

- 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 → cell size is 11mm (2 times)
  PSD 2→ cell size is 5.86mm(16/15 times)

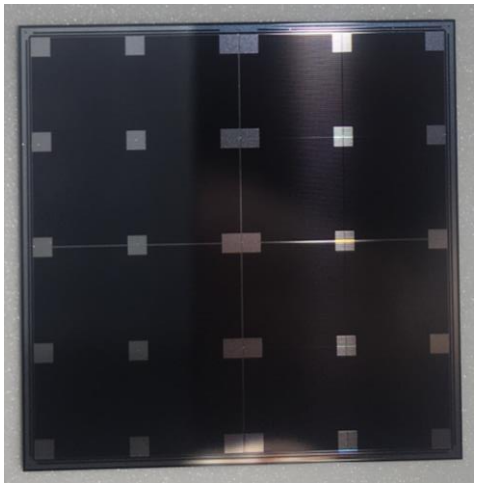




Conventional Si sensor
4×4 cell



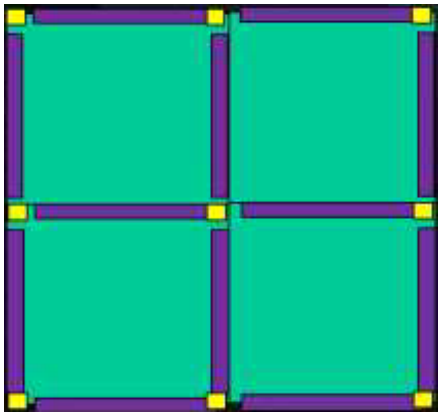
PSD 1　2×2 cell
→pixel size : 2 times

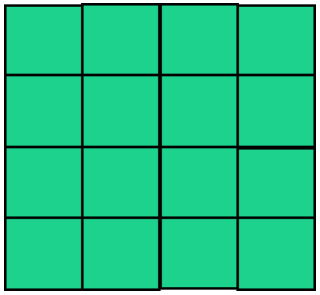


PSD 2

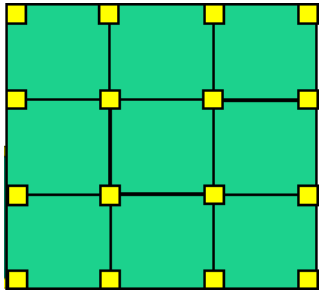
New specification for PSD 2

- 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 → cell size is 11mm (2 times)
  PSD 2→ cell size is 5.86mm(16/15 times

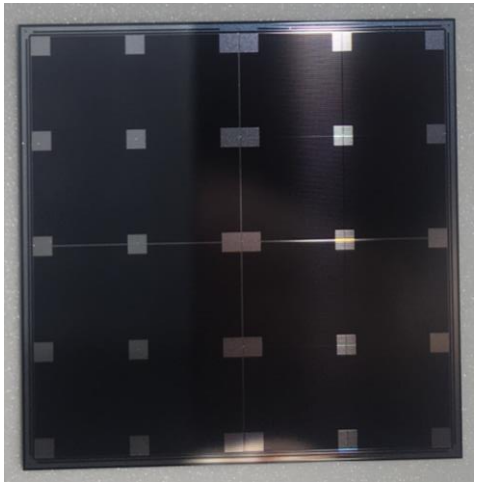




Conventional Si sensor
4×4 cell



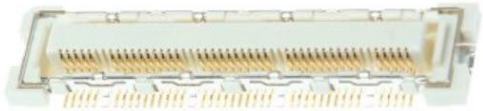
PSD 2　3×3 cell
→pixel size : 4/3 times

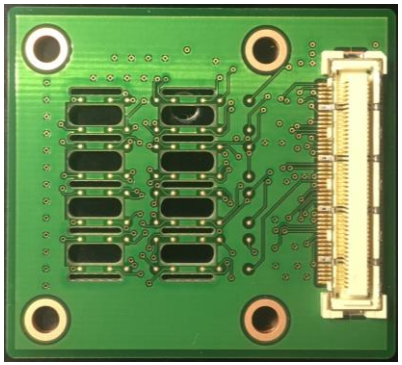


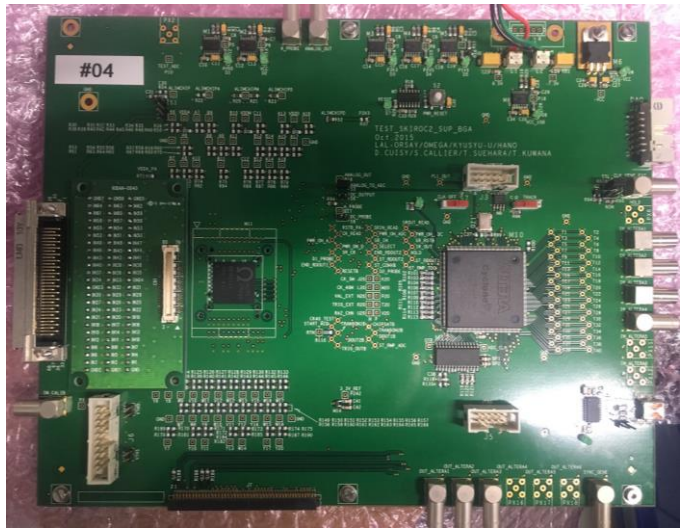
PSD 2

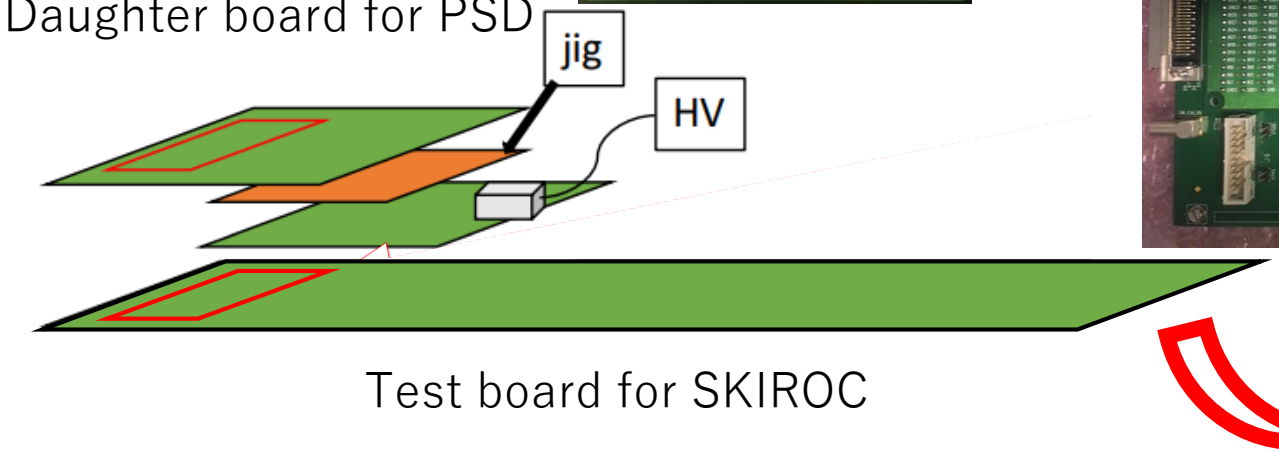
New daughter board and connector

- New connector
- PCB with 4 layer



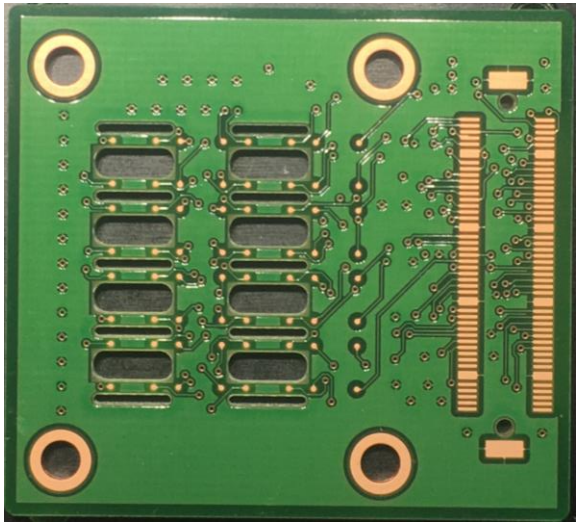


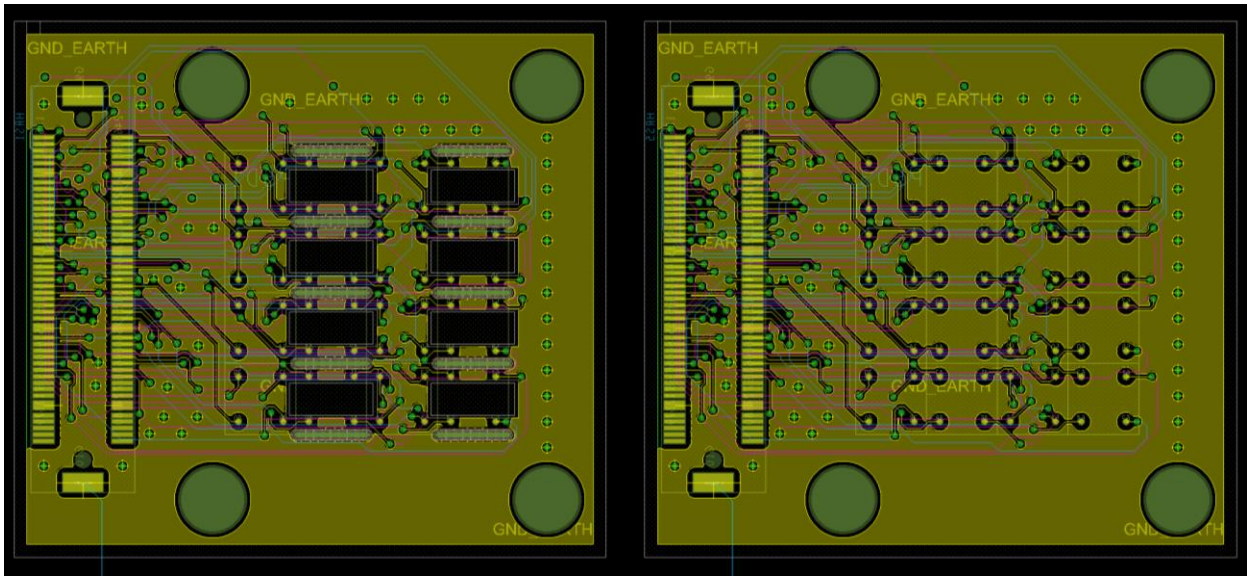




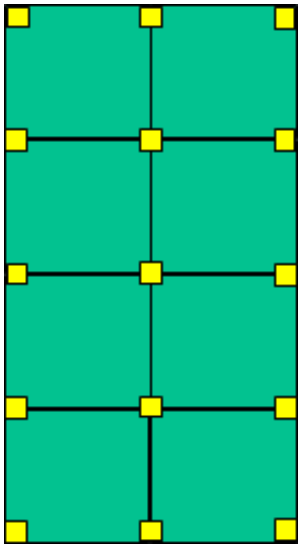
New board design of PSD 1

- New design daughter board using CADENCE allegro
  - ✓PSD 1 PCB with hole → in order to irradiate the laser to PSD
  - ✓PSD 1 without hole → to measure with radio isotope or for test beam

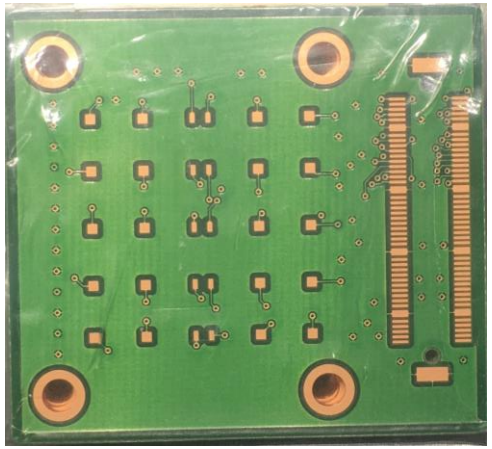




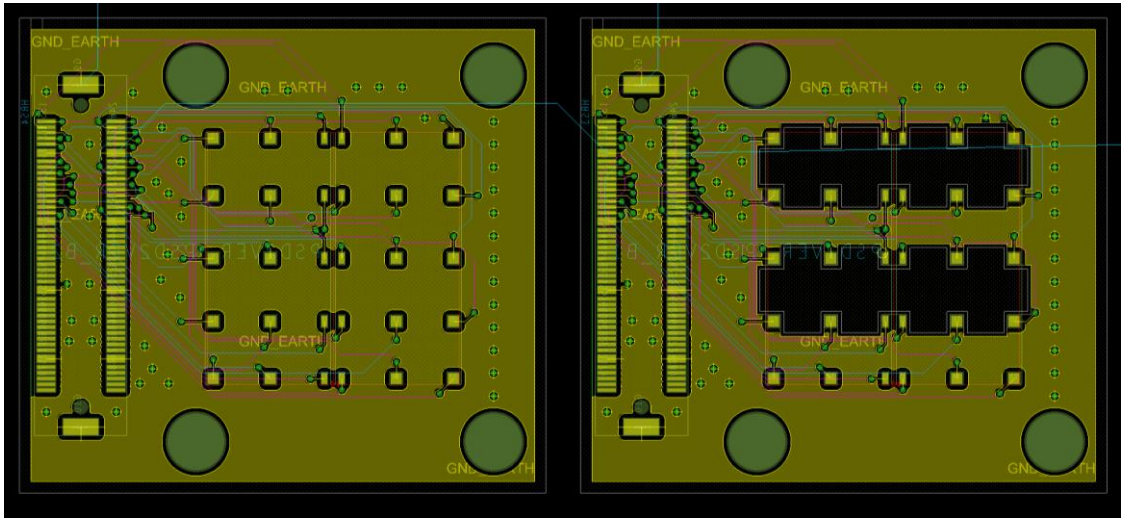
New board design of PSD 2



PSD 2
Two resistance pattern
→total 30ch

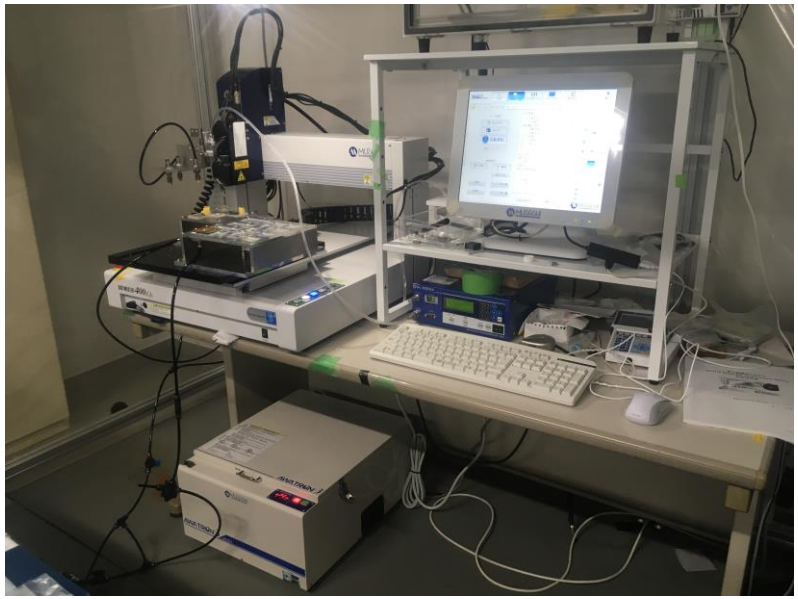


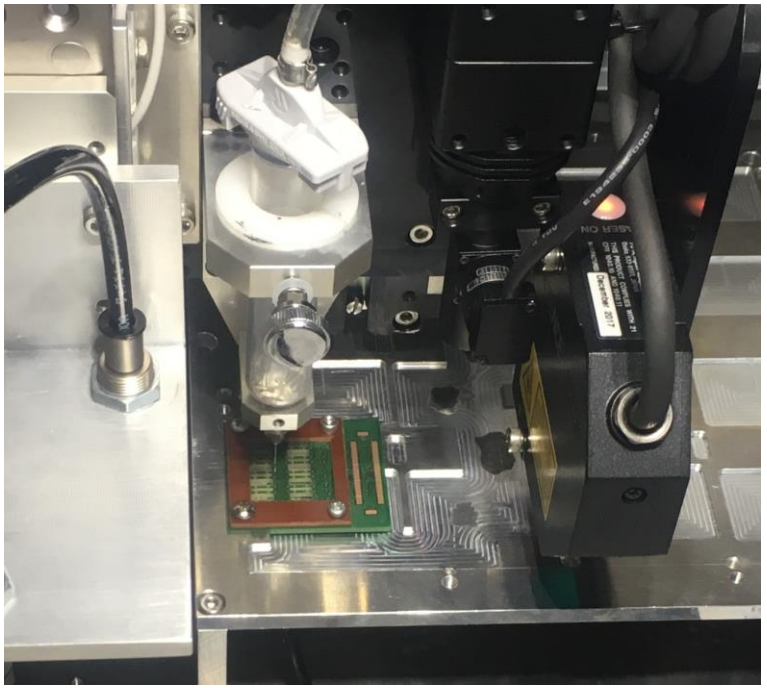
- PSD2 without hole
- PSD2 PCB with hole



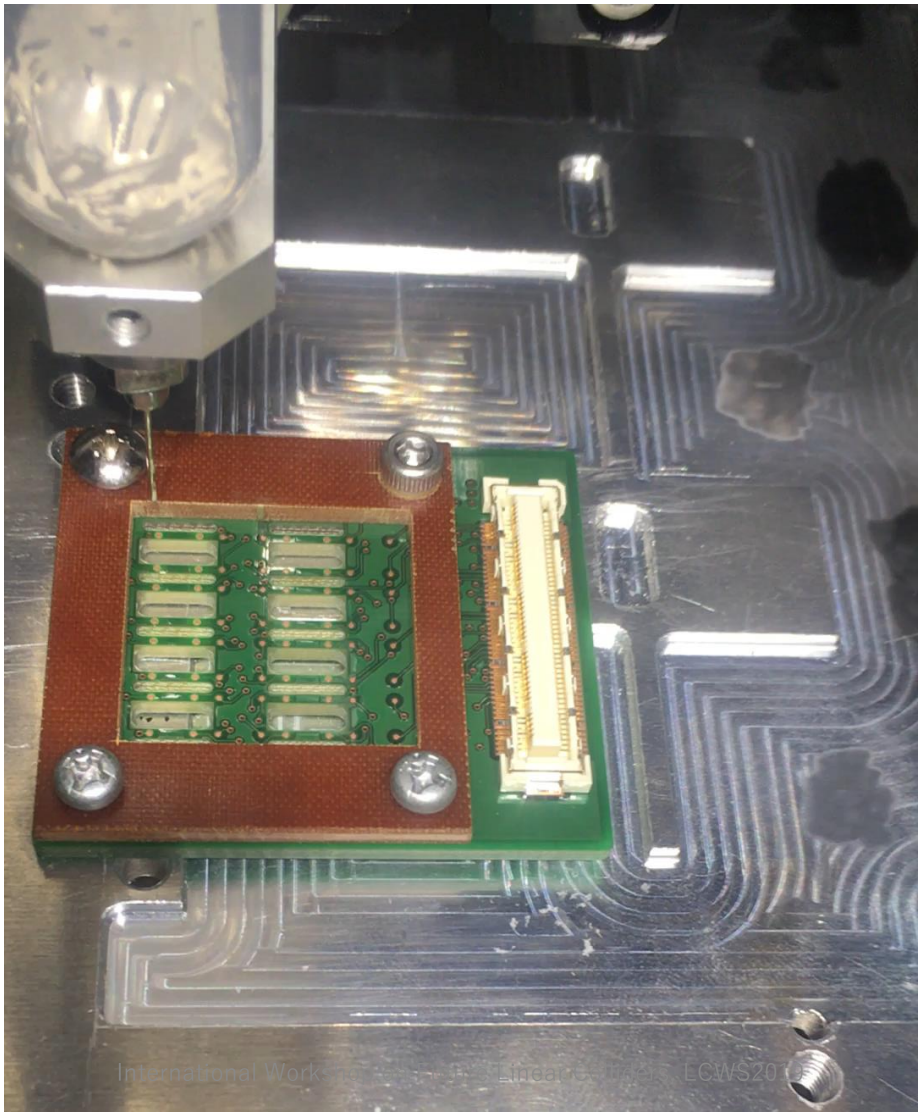
Sensor gluing

- Dispenser made by Musashi Engineering (ML-808GX)
- High precision desktop operating type robot (SHOTMASTER400ΩX)

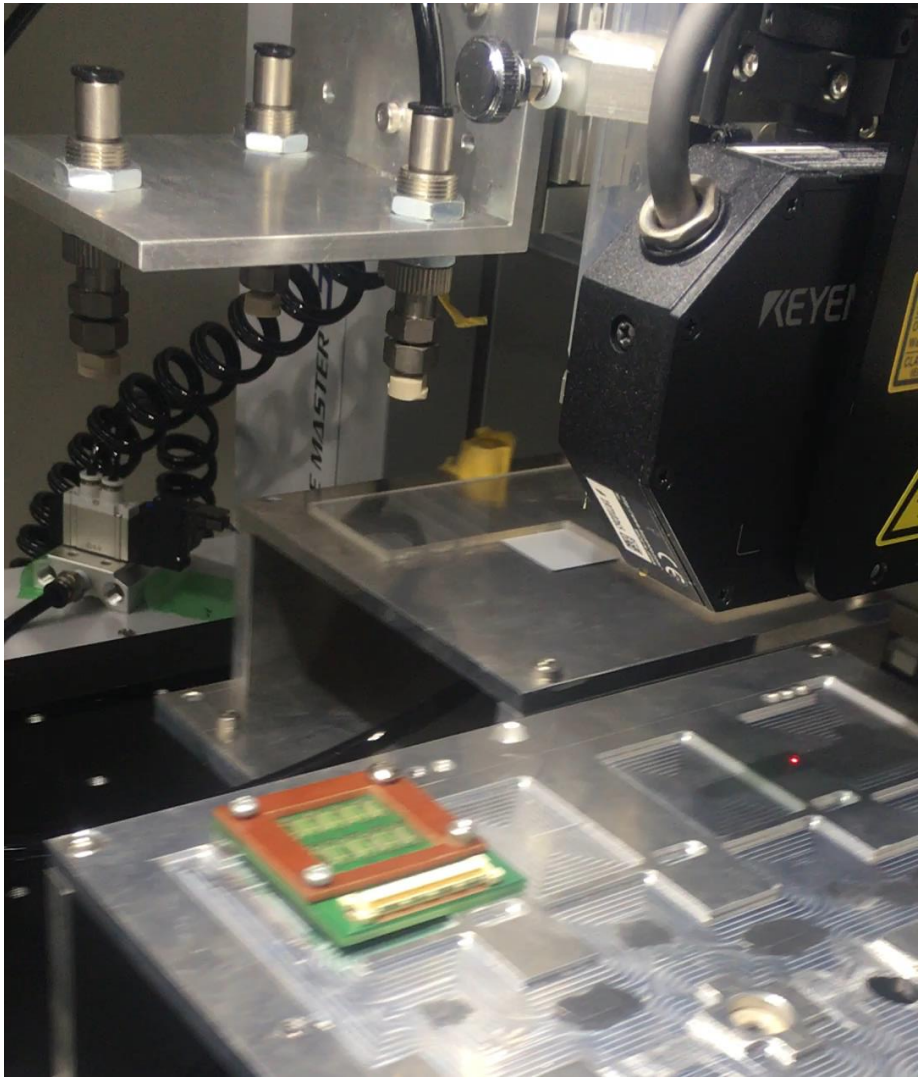




Sensor gluing

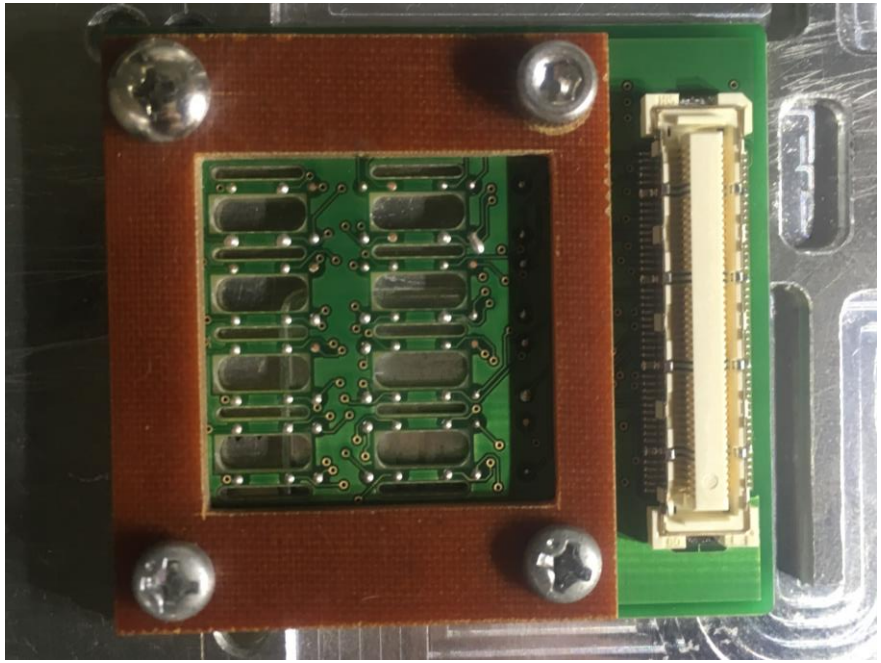


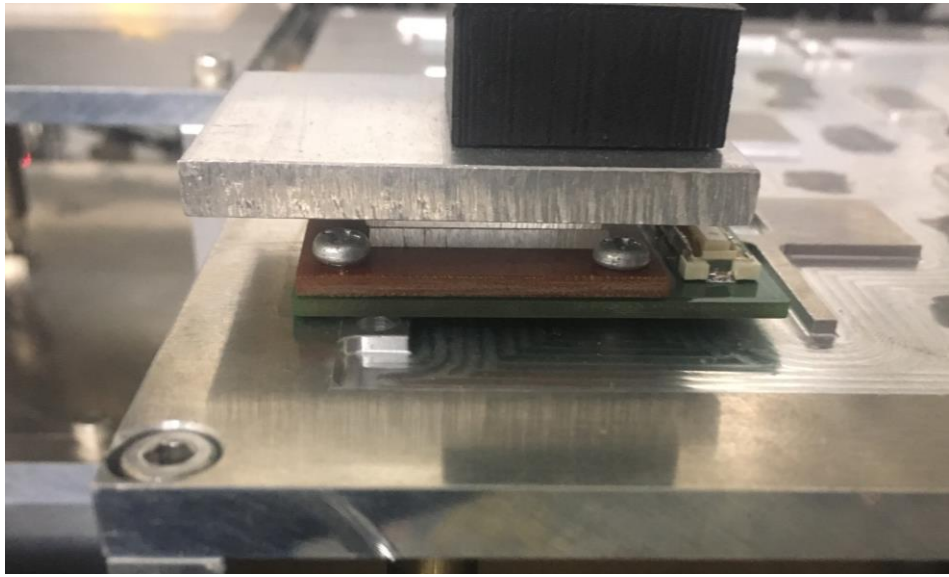
Sensor gluing



Sensor gluing

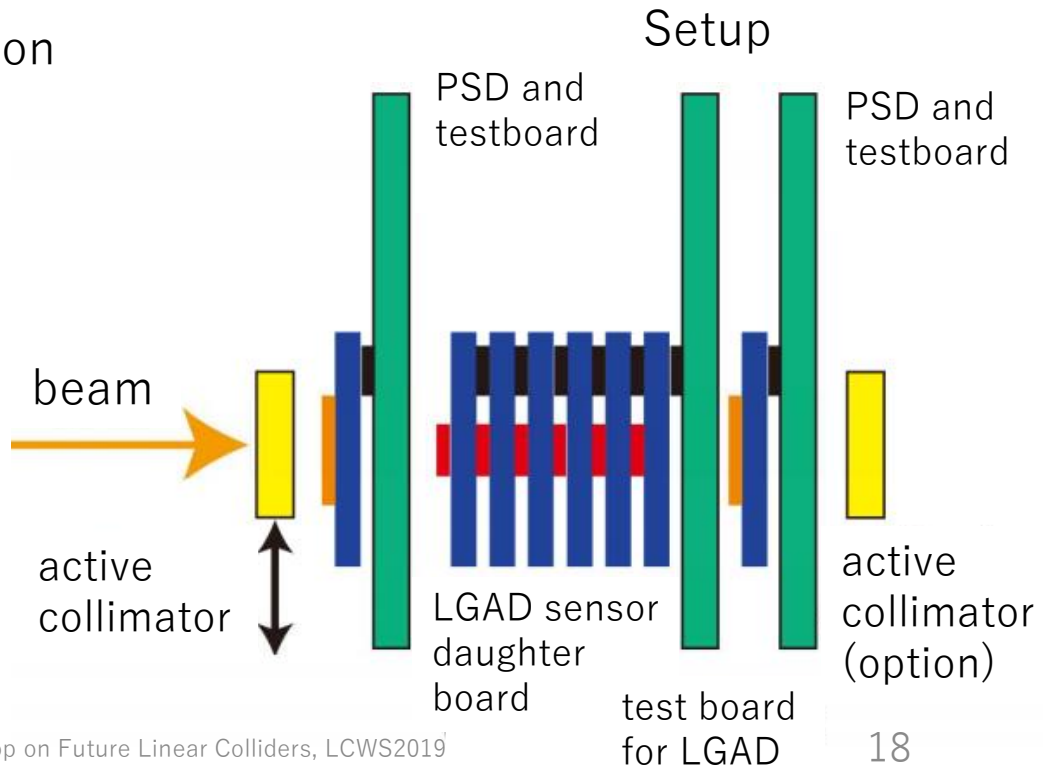
- It’s right after applying conductive bonding glue .
- I left a weight for several days.





Preparation for the Test beam

- Place: ELPH (Tohoku University)
- 560 MeV positron beam
- Use the active collimator with a plastic scintillator
- Program
  1. Measure position resolution using the collimator
  2. Measurement of position distortion without the collimator
  3. Multi-hit measurement prepare a target in front of PSD cause multiple particles to enter simultaneously by raising an electro -magnetic shower



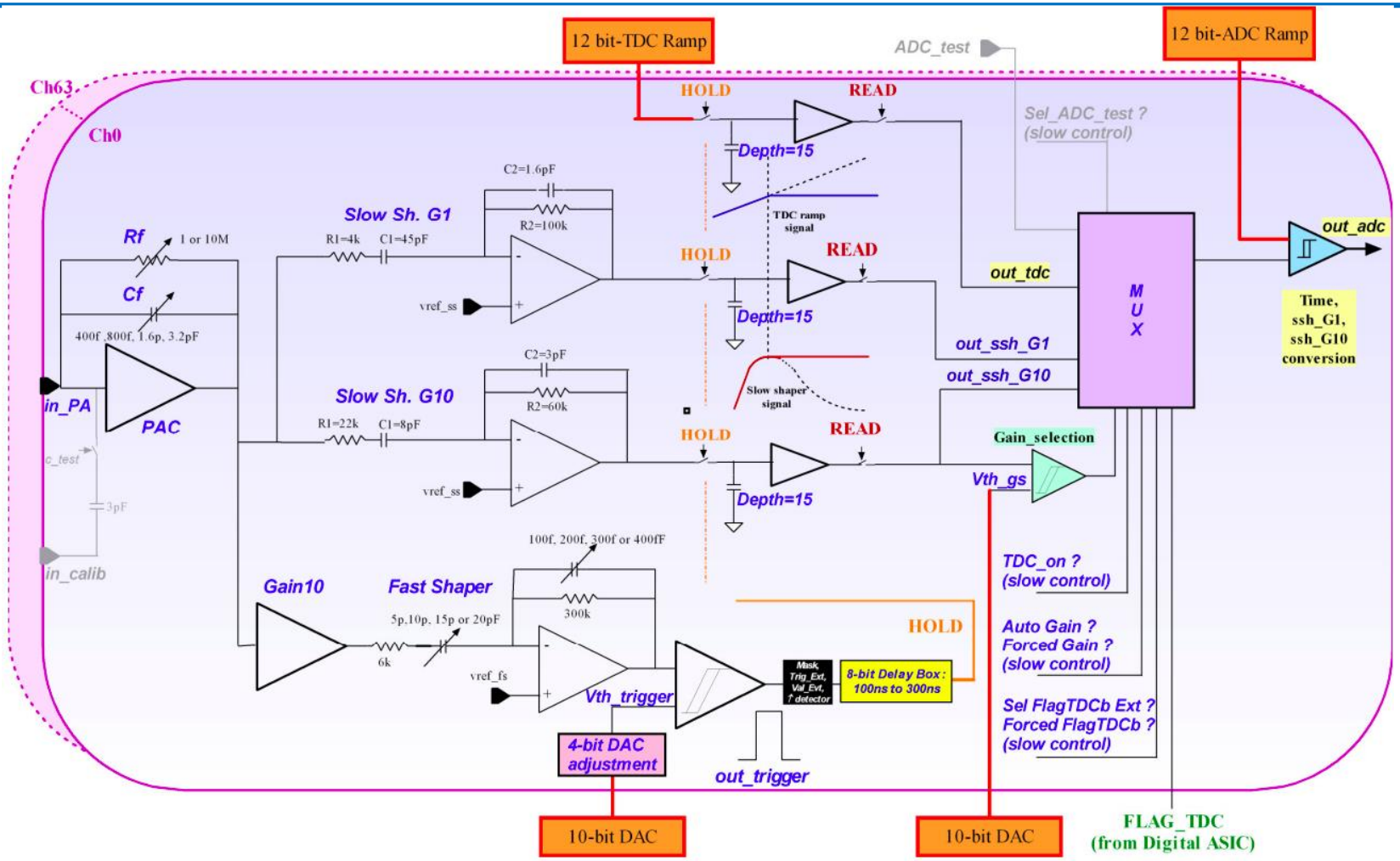
Summary and prospect

- 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
- Preparation for test beam is in progress.

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

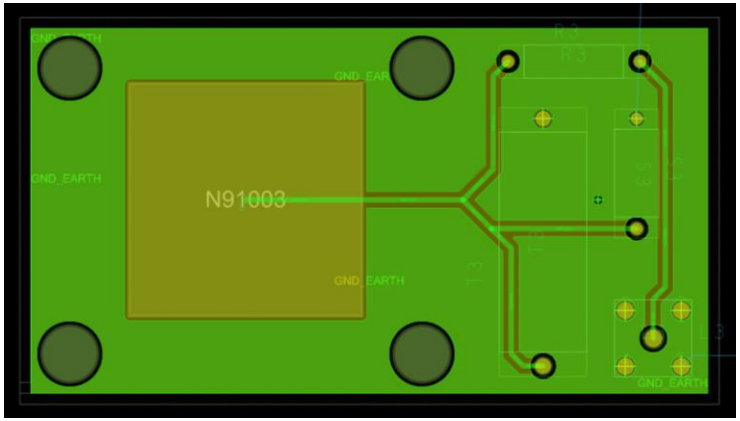
Back up

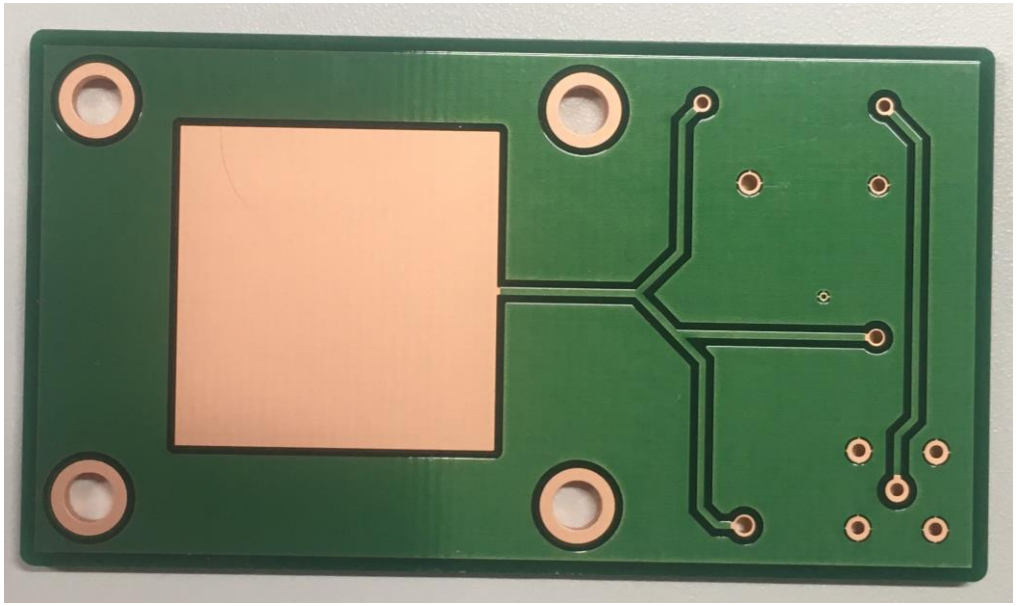
SKIROC analog



High voltage board design

- HV pad
- LEMO





Solder capacitor and LEMO connector