Study of Position Sensitive Silicon Detector (PSD)

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ILD (International Large Detector)
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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

- \( \gamma \) in jets mostly comes from \( \pi^0 \) via \( \pi^0 \rightarrow 2\gamma \) decay
- For accuracy of \( \pi^0 \) reconstruction, direction of photons (angular resolution) is important information → high position resolution sensor
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 × 7 mm²) at 500 µm intervals and get signals from electrodes at the four corners

\[
X_{rec} = \frac{(ch5 + ch6) - (ch7 + ch8)}{ch5 + ch6 + ch7 + ch8},
\]

\[
Y_{rec} = \frac{(ch6 + ch8) - (ch5 + ch7)}{ch5 + ch6 + ch7 + ch8}.
\]

- Distortion at the edge
- Range is small \( \Rightarrow \) \( x \) axis : 0.33/7000 µm \( y \) axis : 0.34/7000 µm
- Due to DAQ problem, not measured in the Test beam
New specification for PSD

• Small dynamic range $\rightarrow$ Effect of readout impedance
  $\rightarrow$ Increased resistance of the resistive layer

• Previous PSD
  - Signal charge passes through P+ layer
  - Resistance value is controlled by mesh shape $\rightarrow$ 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 × 5.5 mm²
- Sensor thickness: 650 µm
- Three resistance values are available: 10 times, 20 times, and 30 times the previous PSD, 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 × 5.5 mm²
- 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: $16 \times 16$ cells
- PSD 1 $\rightarrow$ cell size is 11mm (2 times)
- PSD 2 $\rightarrow$ cell size is 5.86mm (16/15 times)
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: $16 \times 16$ cells
PSD 1 $\rightarrow$ cell size is 11mm (2 times)
PSD 2 $\rightarrow$ cell size is 5.86mm (16/15 times)
New daughter board and connector

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

Daughter board for PSD

Test board for SKIROC

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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 (SHOTMASTER400ΩX)
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
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.

ADC count on each channel
Summary and prospect

• For $\gamma$ 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.