Beamtest of ABCD2T and CAFE/ABC modules at KEK

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KEK, Okayama Univ., Univ. Tsukuba, Univ. Melbourne, Univ. Freiburg, Acad. Scie. Czech Republic-Prague

- Proper fiducial volume definition
- Position resolutions
- Efficiencies (overall) and Median charges
- Responses between the strips
  - Strip and Midway regions
- Discussion of responses
- Summary
Proper fiducial volume definition

- Excluding strips ±250 μm from
  - dead,
  - hot,
  - sick channels

- Tracks in 3 telescope planes, ±250 μm each other

- Track hit in the anchor plane
  - Same ABCD frontend chips
  - Preventing mis-timing of telescope readout
Position resolutions

• Tracks defined by two telescopes sandwiching the DUT’s
  - Exception: CAFE/ABC module has only one telescope in upstream
  - Beam particles were scattered at the telescopes noticeably with respect to the DUT position resolution

• Fan geometry correction
  - Hits were scaled on a virtual x-axis

• Dependence on thresholds and bias voltages
  - Resolution of 25~27 μm
  - Must consider contributions of telescope resolution of about 5 μm
  - Statistical fluctuation near the end of “box”
  - Gaussian fit to the “box” distribution
  - Dependence was weak
Module 0, link 0

Resolution vs Qth(fC)

Bias 500 V
Bias 400 V
Bias 350 V
Bias 300 V
Bias 250 V
Bias 200 V
Bias 180 V
Bias 160 V
Bias 140 V
Bias 120 V
Bias 100 V
Bias 80 V
Bias 60 V

Module 0, link 1

Resolution vs Qth(fC)

Bias 500 V
Bias 400 V
Bias 350 V
Bias 300 V
Bias 250 V
Bias 200 V
Bias 180 V
Bias 160 V
Bias 140 V
Bias 120 V
Bias 100 V
Bias 80 V
Bias 60 V
Efficiencies (overall) and Median charges

- New efficiency derived with the fiducial volume cuts

- “Modified” Error function fit
  - Simulating energy deposition in a thin material
  - Integrated landau distribution by varying sigma

- Irradiated sensor
  - Reasonable efficiency saturation toward 100%
  - Median charge at about 2.5 fC toward 500V

- Comparison with previous results of irradiated n-strip and p-strip sensors
Efficiencey vs thresholds
Efficiency Curve (Mod0 Link0)
Efficiency Curve (Mod2 Link0)

- Bias 60V
- Bias 80V
- Bias 100V
- Bias 120V
- Bias 140V
- Bias 160V
- Bias 180V
- Bias 200V
Efficiency Curve (Mod3 Link0)

Efficiency

Threshold [FC]

Bias 500V
Bias 400V
Bias 350V
Bias 300V
Bias 250V
Bias 200V
Bias voltage dependence of median charges
\[ Q = q \times \left( \frac{285}{325} \right) \]
\[ V = \left( \frac{285}{325} \right)^2 \]

Bias [V]

Median Charge [FC]
Response between the strips

• Efficiency plots
  - Thresholds around median charge in each bias voltage
  
  - Strip region: \( \pm 20 \, \mu m \) around the strip
  
  - Midway region: \( \pm 10 \, \mu m \) around the centre between the strips, i.e., 25% of region

• Bias voltage dependence of median charges
  
  - Strip region
  
  - Midway region
Efficiency vs threshold, Strip region
Efficiency Curve (Mod0 Link0)

- Bias 60V
- Bias 80V
- Bias 100V
- Bias 120V
- Bias 140V
- Bias 160V
- Bias 180V
- Bias 200V
Efficiency Curve (Mod1 Link0)

Efficiency vs. Threshold [FC]

- Bias 200V
- Bias 180V
- Bias 160V
- Bias 140V
- Bias 120V
- Bias 100V
- Bias 80V
- Bias 60V
Efficiency Curve (Mod3 Link0)

![Efficiency Curve Diagram](image-url)
Efficiency Curve (Mod4 Link0)

- Bias 60V
- Bias 80V
- Bias 100V
- Bias 120V
- Bias 140V
- Bias 160V
- Bias 180V
- Bias 200V

Efficiency vs. Threshold [FC]
Efficiency vs threshold, Midway region
Efficiency Curve (Mod1 Link0)

- Efficiency vs. Threshold [FC]
- Key labels: Bias 60V, Bias 80V, Bias 100V, Bias 120V, Bias 140V, Bias 160V, Bias 180V, Bias 200V
Efficiency Curve (Mod2 Link1)

- Efficiency vs. Threshold
- Curves for different bias voltages:
  - Bias 60V
  - Bias 80V
  - Bias 100V
  - Bias 120V
  - Bias 140V
  - Bias 160V
  - Bias 180V
  - Bias 200V

Graph showing efficiency on the y-axis and threshold on the x-axis.
Efficiency Curve (Mod3 Link0)

Efficiency vs Threshold [FC]

- Bias 500V
- Bias 400V
- Bias 350V
- Bias 300V
- Bias 250V
- Bias 200V
Efficiency Curve (Mod4 Link0)

Efficiency

Threshold [FC]

Efficiency vs. Threshold

Bias 200V
Bias 180V
Bias 160V
Bias 140V
Bias 120V
Bias 100V
Bias 80V
Bias 60V
Efficiency Curve (Mod4 Link1)

Efficiency vs. Threshold

Bias 60V
Threshold [FC]
Efficiency

Bias 80V

Bias 100V

Bias 120V

Bias 140V

Bias 160V

Bias 180V

Bias 200V

Threshold [FC]
Efficiency vs. Threshold

0 1 2 3 4 5 6 7
Efficiency

0.2

0.4

0.6

0.8

1
Bias voltage dependence of median charges of strip and midway regions
\[ Q = q \times \left(\frac{285}{325}\right) \]

\[ V = v \times \left(\frac{285}{325}\right)^2 \]
\[ Q = q \times (\frac{285}{325}) \]
\[ V = V \times (\frac{285}{325})^2 \]
Discussion of responses

• Ratios of median charges of “Strip” and “Midway” regions
  - About 0.9 in non-irradiated
  - From 0.7 to 0.9 in irradiated

• Comparison with the previous result
  - Good coincidence
Figure 7: Median charges of the irradiated detectors as a function of bias voltages. The “ideal diode” is the theoretical expectation of the collected charges which scales as $\sqrt{V}$ and saturates at 300 V.
Figure 8: Ratios of the median charges in the inter-strip and the strip regions as a function of the bias voltage, of the irradiated p-in-n (circle and cross) and the irradiated n-in-n detectors (square). The inter-strip region was defined as an area midway between the strips with a width of 20 μm, and the strip region as being around the strips with a width of 40 μm.
Summary

- Results became clean after the fiducial volume cuts

- Position resolutions were reasonable, weak dependence on threshold and bias voltage

- Non-irradiated sensor saturate at about 3.3 fC and “irradiated” at about 2.5 fC

- Loss of efficiency in the midway region was confirmed
  - About 80% response in average in 25% region

- Confirmation of the response of the irradiated sensors in proper modules is urgently needed