Beamtest of ABCD2T and CAFE/ABC modules at KEK


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

- Dec99 beamtest at KEK (T450)
- Calibrations
- Threshold scans
- Bias voltage dependence of median charge
- Noise occupancy
- Summary
Dec99 beamtest at KEK (T450)

• Execution: Dec 10-21, 1999
  \( \pi^2 \) beamline in the 12 GeV PS at KEK, 4 GeV/c \( \pi^- \)

Participants:
Domestic = Y. Unno, Y. Ikegami, T. Kohriki, +6~9 students
Abroad = G. Moorhead, K. Runge, J. Ludwig, Z. Dolezal
Photo’s out of the beamtest

• DUT’s: 4 full modules + 1 irradiated det-module
  Module 0: KEK-ABCD#1, 12 chips, 285 um, trim 2 fC=200 mV
  Module 1: FR-ABCD, 12 chips, 285 um, trim 2 fC=200 mV
  Module 2: KEK-ABCD#2, 12 chips, 325 um, no trim
  Module 3: FR-irrad det-ABCD, 2 chips, 285 um, trim 2fC=200 mV
  Module 4: KEK-CAFE/ABC, 12 chips, 285 um
  Module 5: CG3, anchor

• Run conditions:
  Edge detection=ON, Mode=Any hits
  2cm x 2cm triggered region with 3 planes of scintillator
  Two temperatures: +10, and -10 °C
  +10 °C = Mod0, Mod1, Anchor
  -10 °C = All
Modules setup

• Beam defining: Three telescope planes + Anchor
  
  Two DUT’s between telescopes or anchor
  Separation: 30 mm each
  Sequence:
  Telescope1
    Mod0       KEK-ABCD#1
    Mod1       Freiburg-ABCD
  - (6 mm Al plate): accidentally left-over
  Telescope2
    Mod2       KEK-ABCD#2
    Mod3       Freiburg-irradiated detector
  Telescope3
    Mod4       KEK-CAFE/ABC
  Anchor (CG3)
  No shielding between the DUTs

• Setup drawing
  
  Setup of -10 °C
Calibration

• In-situ calibration runs:
  
  Bias 100V (irrad 350V)
  Scan points were fed into the thresholds of beamtest
  Edge detection = OFF
  Mode = X1X

  Later, a response curve and charge values are corrected
  Scan points with larger markers were those used for the fit

• Det4(Mod4):

  Threshold in (ABCD) mV
  640 (ABCD)mV~680 (CAFE)mV
  open square (nominal scale)
  filled square (KEK internal)
  Nominal charge scale: IDAR~300 μA = 10 fC
  KEK internal scale: IDAR~300 μA ~ 7 fC
Calibration (cont’d)

• Noise sigma:

<table>
<thead>
<tr>
<th>Module</th>
<th>Calibration</th>
<th>Noise [e]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mod0 - KEK-ABCD#1</td>
<td>in-situ</td>
<td>~1460</td>
</tr>
<tr>
<td>Mod1 - Freiburg ABCD</td>
<td>in-situ</td>
<td>~1470</td>
</tr>
<tr>
<td>Mod2 - KEK-ABCD#2</td>
<td>in-situ</td>
<td>~1515(1680)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mod4 - KEK CAFE/ABC</td>
<td>in-situ</td>
<td>~1600</td>
</tr>
<tr>
<td></td>
<td>Module@Fuji</td>
<td>~1690</td>
</tr>
<tr>
<td></td>
<td>Hybrid@Fuji</td>
<td>~890</td>
</tr>
</tbody>
</table>

• Notes:

- Mod2:
  <sup>a</sup> Chip6,7 were noisier than the rest
  <sup>a</sup> Chip3 was too large trim step
  No particular characteristics in wafer probed data

- Mod4:
  CAFE/ABC in nominal charge scale, IDAR ~300 uA=10fC

- Temperatures:
  In-situ: -10 °C environment air cooled
  @Fuji: +20 °C environment air cooled
Threshold scans

• In beam
  
  Scan points: typically, 0.8, 1.0, ..., 2.2, 2.5, 3.0, ..., 8.0 fC
  
  Bias voltages of 60, 80, 100, 120, 140, 160, 180, 200 V
  
  5k events per point, several points in 10k or more
  
  low threshold points being re-calibrated after the calibration curve fit

• Efficiency
  
  Tracks in 3 telescope and anchor
  
  Window (+-250 μm) from a track defined by two adjacent telescopes
  
  Any time bins

• Position resolution
  
  Residual of the nearest hit to the track defined by two adjacent telescopes
Bias voltage dependence of median charges

• Charges of 50% efficiency derived from the fits

  All 285 \( \mu \)m detector modules saturate at about 3.3 fC
  - 325 \( \mu \)m detector at about 3.8 fC, see renormalization

  Saturation above 120 V
  - Required \( \sim \)50V overdepletion to get full charge

  CAFE/ABC nominal charge scale seems correct

• Mod2(325 um) renormalization to thickness 285 um

  Bias voltage \( \propto \) (Depletion thickness\(^2\)
  Collected charge \( \propto \) Depletion thickness

  Bias voltage (285\( \mu \)) = (285\( \mu \)/325\( \mu \))\(^2\) * Bias voltage(325\( \mu \))
  factor = 0.77
  Median charge (285\( \mu \)) = (285\( \mu \)/325\( \mu \)) * Median charge (325\( \mu \))
  factor = 0.88

  Saturation at about 3.4 fC at \(~\)130 V
\[ Q = q \times \left( \frac{285}{325} \right) \]

\[ V = v \times \left( \frac{285}{325} \right)^2 \]
Noise occupancy

- Hit strip counts
  
  Outside of the efficiency window
  
  efficiency window: +- 250 \text{ \mu m} from the expected track
  
  Outside = 2 x efficiency window

- Time bin info, “100”, “010”, or “001”
  
  ABCD beam timing = mostly 010 and a fraction in 100, i.e.,

  CAFE/ABC=100

  Higher occupancy in thresholds > 1.2 fC, in time, = accidental
  coincidence with beam halo?

- Noise occupancy
  
  1.35 \times 10^{-3} @ 3\text{sigma}

  3.17 \times 10^{-5} @ 4\text{sigma}

  1 fC = 6250 e

  If 4 \text{sigma} = 0.8 \sim 1.0 \text{ fC}, then \text{sigma} = 0.2 \sim 0.25 \text{ fC}, i.e.,

  \text{sigma} = 1250 \sim 1560 \text{ e}

- Notes:

  Possible systematic uncertainty of at most 0.2 fC in the charge
  near 1fC threshold
Timebin(1.2fC, 120V)
Module 0 link 0 or 1
Timebin 010

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

Occupancy vs. Charge
Summary

• Dec 99 beamtest at KEK was carried out successfully with a new PC-based SCTDAQ 4 ABCD2T and 1 CAFE/ABC modules

• Position resolution
  Consistent with pitch/sqrt(12) ~ 23 µm

• Reasonable behaviours of median charges
  Saturation above 120 V
  Saturation at 3.3 fC for 285 µm thickness

• ASIC/hybrid/Module performance
  ABCD2T:
    noise~ 1450 e (module charge inj. calibration)

  CAFE/ABC:
    Noise ~ 1550 e (module charge inj. cal., -10 °C)