Opposite Polarity Signals in Wide Pitch Sensors

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• Introduction to the R&D in LHCb
• The test-beam and the data
• Opposite polarity signals
• Other detectors
• Simulation and conclusions
Floating strip R&D has begun for the beyond the baseline VELO, which will be a replacement after 2-3 years.

Will improve resolution of the outer region of the Φ-sensor.

VELO important for tracking: will aid extrapolation to the rest of the spectrometer.

Wanted to study wide pitch n-on-n detectors read out at 40 MHz.

After irradiation needs to be studied as well.

For more LHCb details see presentation of Juan Palacios.
Detector and data-set

- Tested detector was a double-sided silicon strip manufactured by Canberra
- ALICE prototype donated by P. Kuijer at NIKHEF
- 128 n-strips with a pitch of 95 µm
- FOXFET biasing, with $V_{\text{dep}} \sim 60-70$V
- Regions bonded with and without floating strips to a SCT128A hybrid

- Operated at SPS in 120 GeV $\mu/\pi$ beam
- Track extrapolation error 24 µm
- Sample of 90k events at $V_{\text{bias}} = 100$ V
Charge sharing: I

- Measure:
  \[ \eta = \frac{Q_{\text{left}}}{Q_{\text{left}} + Q_{\text{right}}} \] from track intercept
- No clustering
- Clear charge sharing in region with floating strips compared to region with adjacent strips
- For floating strips peaks below 0 and above 1 when charge collected on a single strip
Charge sharing: II

- The charge collected on the floating strip is \(~60\%\) of that collected on a connected strip
- Corresponds to a \(\frac{C_b}{C_{\text{inter-implant}}} \sim 2.65\)
- In an LHCb design we would aim to reduce this
- Pitch is wider in ALICE prototype than LHCb scenario (20-60 \(\mu\)m)
Opposite polarity signals: I

- As noted $\eta$ biased to higher and lower values, when charge is collected mainly on left or right strip respectively
- Correlation of opposite polarity signal on neighbouring strip

- Look at relative charge on neighbouring connected strips
- Large coherent deviations over many strips, and significant distances
- Signals integrate to 0 within errors

$\eta < 0.1$ or $\eta > 0.9$
Opposite polarity signals: II

Time comparison: $\eta < 0.1$ or $\eta > 0.9$

- Looked at adjacent strip region – a hint but limited statistics
- Otherwise:
  - Looked at $\mathcal{O}(1 \, \mu s)$ integration times
  - Looked at 40 $\mu$m pitch
  - Electronics

No indication of any effect

See some dynamics as a function of sampling (TDC) time and voltage
(Asynchronous trigger used)
Other detectors: I

- LHCb testing a GLAST detector with SCT128A readout for all Si tracking station (see F. Lehner)
- 400 µm thick, p-on-n and 208 µm pitch
- Strips studied are bonded consecutively
- Approx 1 million triggers collected with tracks in the acceptance
- Results from D. Eckstein

- Analysis of neighbouring strips repeated
- Interesting results as a function of **sampling time**
Other detectors: II

- Relative signals vary between ±13%
- Near maximum sampling time effect is signal on neighbouring strips zero
- No large distance effects
Conclusions and simulation

- Significant opposite polarity signals on neighbouring strips have been observed in a wide pitch n-on-n sensor with floating strips.
- Signals around 7% and over significant distances.
- Behaviour dependent on sampling time.
- Varying capacitances at LHCb make us sensitive to these effects.
- Unique to n-on-n: in a wide pitch p-on-n detector signals on neighbouring strips vary with time. No long distance effect.
- An explanation with Ramo’s theorem (Brodbeck and Chilangarov NIM A395 (1997) 29)
- Simulation (Univ. of Glasgow) underway.
Cross-checks

- Integration time: LHCb n-on-n prototypes with ~90 µm pitch readout with VA2 electronics 2.2 µs shaping time
- Fine pitch: LHCb n-on-n prototype with 40 µm pitch readout with SCT128A
  No effect
- Electronics: across chips and between chips
- Analysis: without common-mode correction
  Effect remains