The LHCb Silicon Inner Tracker

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<http://lhcb-track.web.cern.ch/lhcb-track/>

Requirements for the LHCb Inner Tracker

- very good momentum resolution ($\Delta p/p \approx 3\text{‰}$)

limited by multiple scattering $\longrightarrow$ material budget

moderate spacial resolution (100 μm)

- particle rates up to $10^4 \text{ mm}^{-2} \text{ s}^{-1}$

- occupancy has to stay low (few percent)

- signal shaping time of 25 ns

silicon is adopted as technology for the LHCb Inner Tracker

Challenges

- 🚫 large pitch sensors → reduce number of readout channels (costs)
- 🚫 long sensor ladders → S/N-performance
- 🚫 small w/p → S/N-performance

full charge collection efficiency

Station Layout

station 4

- nine stations
- four layers each
- vertical strips with small stereoview
- 22 cm long ladders
- 14 m² of single sided silicon

beampipe is **conical** !

layout of every station is different

4 standard and independent boxes

Sensor Layout and Ladder Design

- sensor produced from 6" wafers
- length physical: 110 mm sensitive: 108 mm
- width physical: 78 mm sensitive: 76 mm
- strip pitch $237.5\ \mu\text{m}$ $\longrightarrow$ 320 strips

1500 sensors on 1000 ladders
300,000 readout channels

Multi-geometry prototype sensors from company SPA Detector (Kiev)

- p+ strips on n-type substrate
- pitch of 240 μm , single sided
- thickness of 300 μm
- oxygentated 4" wafers
- AC-coupled, polysilicon biased
- three different implant widths ($w/p = 0.2, 0.25, 0.3$)
- two types: over- and under metallized

64 strips 66.6 mm long

Characterization of prototype sensors

leakage current

total strip capacitance

depletion voltage 50 – 70 V
capacitance of 1.3 – 1.6 pF/cm

all measurements at room temperature

Laboratory Measurements

- readout chip HELIX128
- measurements with Laser and Ru106
- also test of irradiated sensors

η -function

S/N degrades with higher w/p

Irradiation corresponding 10 years of operation

Testbeam in May 2001

measure resolution and efficiency
& get some experience

- T7 test facility at CERN (9 GeV pions)
- used complete readout system of HERA-B Vertex detector
- two ladders and beam telescope

Preliminary Testbeam Results for Short Sensor Ladder

S/N = 20.3 / 19.9 / 19.4
for different w/p regions

efficiency ~ 98.4 %

90 V biasing voltage at
room temperature

resolution ~ 50 μm

Preliminary Testbeam Results for Long Sensor Ladder

80 V biasing voltage

100 V biasing voltage

Frontend Electronics and Link

- Beetle readout chip specifically developed for LHCb:
 - 128 channels, analogue pipeline and 40 MHz readout speed
- each ladder equipped with 3 Beetle

Next Steps

- BEETLE readout chip available now → design board
- detector specs reviewed → order 6" sensors
- station mechanics including cooling → building fullsized prototype
- optical link → build up test setup

TDR to be submitted end of this year