Commissioning of the LHCb Scintillating Fibre Tracker

The LHCb Detector

Single-arm forward spectrometer designed for the search of new physics in decays of beauty and charm hadrons.

Upgrade for LHC Run 3 to operate at five times higher luminosity
- Triggerless 40 MHz readout
- New frontend & backend electronics

The LHCb Scintillating Fibre Tracker

Three stations with four layers each
- 340 m² total active area
- 250 µm diameter scintillating fibres
- 11,000 km of fibre are used in total
- 2.5 m long 6-layer fibre mats
- Eight fibre mats per module

Readout by silicon photomultiplier (SiPM) arrays
- 524,288 readout channels in total
- Cooled to ~40°C to mitigate radiation damage

40 MHz readout electronics
- ~20 Tb/s data rate

Excellent tracking performance
- Hit detection efficiency > 99%
- Hit resolution < 80 µm

Working Principle

Frontend Electronics

SiPM Array
- 128 channels, 250 µm pitch
- 104 pixels per channel

PACIFIC ASIC
- Analogue signal processing
- Digitisation with three comparators at 40 MHz

Cluster FPGA
- Hit clustering & zero-suppression at 40 MHz

Master Board
- Data encoding transmission via 4.8 Gb/s optical links
- Distribution of power, slow & fast control, and clock

Threshold Calibration

The threshold of each PACIFIC comparator has to be calibrated with respect to the spectrum of the connected SiPM channel
- Convert from signals measured in units of DAC to photoelectrons (pe)
- Threshold scan with pulsed light for each comparator

Time Alignment

Cluster distribution in the TAE window

The time alignment of the detector is done by recording several consecutive bunch crossings (Time Aligned Events, TAE).
- Coarse time alignment: Shift in units of bunch crossing (25 ns)
- Fine time alignment: Adjust clocks in the frontend electronics (~49 ps granularity)

Cluster Occupancy

The cluster occupancy strongly depends on the location in the detector.
- From module M0 to M5, the distance from the beam pipe increases
- First Mat in M0 is shorter and therefore has a lower occupancy
- Module M5 only exists on station T3 and therefore has a lower occupancy
- Dips in the occupancy are observed at the fibre mat edges