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Performance and Radiation Damage Effects in the LHCb Vertex Locator

LHCb is a dedicated experiment to study New Physics in the decays of heavy hadrons at the LHC. Heavy hadrons are identified through their flight distance in the Vertex Locator (VELO), hence the detector is critical for both the trigger and offline physics analyses.

The VELO is the retractable silicon-strip detector surrounding the LHCb interaction point. It is located only 7 mm from the LHC beam during normal LHC operation, once moved into its closed position for each LHC fill when stable beams are obtained. During insertion the detector is centred around the LHC beam by the online reconstruction of the primary vertex position. Both VELO halves comprise 21 silicon micro-strip modules each. A module is made of two n⁺-on-n 300 μm thick half-disc sensors with R-measuring and φ-measuring micro-strip geometry, mounted on a carbon fibre support paddle. The minimum pitch is approximately 40 μm. The detector is also equipped with the only n-on-p sensors operating at the LHC. The detectors are operated in vacuum and a bi-phase CO₂ cooling system is used. The signals read out with analogue front-end chips are subsequently processed by a set of algorithms in FPGA processing boards.

The VELO has been performing very successfully during the first run of the LHC in 2010-12. Possible effects of radiation damage have been monitored and studied in detail throughout this period. Indeed the VELO module sensors receive a large and non-uniform radiation dose having inner and outer radii of only 7 and 42 mm, respectively. A maximum dose of 1.2×10^{14} 1 MeV neutron equivalent /cm² was received in the innermost region of the sensors for the combined 2010-12 run I (3.4 fb⁻¹ of delivered data). Being operated in an extreme and highly non-uniform radiation environment, type-inversion of the inner part of the n-on-n sensors has already been measured.

The radiation damage in the detector is monitored and studied in three ways: (1) dependence of sensor currents on voltage and temperature; (2) measurement of the effective depletion voltage of the sensors from the charge collection efficiency and from studying the noise versus voltage behaviour; and (3) cluster finding efficiency. Results will be presented in all three areas with the most recent results from the full run I.

Summary

Overview of the performance and radiation damage studies performed on the LHCb experiment vertex locator during the first run of the LHC.

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