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Radiation Damage in the LHCb VELO and its Impact on Operations in LHC Run 2

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LHCb is a dedicated experiment to study New Physics in the decays of heavy hadrons at the Large Hadron Collider (LHC) at CERN. Heavy hadrons are identified through their flight distance in the Vertex Locator (VELO), which consists of two retractable silicon strip detectors surrounding the interaction point.

The VELO comprises 42 modules made of two n+-on-n 300 um thick half-disc silicon sensors with R-measuring and Phi-measuring micro-strips. One upstream module is manufactured with n+-on-p technology, which allows a direct comparison of the two technologies in real operational conditions. In order to allow retracting the detector, the VELO is installed as two movable halves containing 21 modules each. The detectors are operated in a secondary vacuum and are cooled by a bi-phase CO2 cooling system. Analogue front-end chips are reading out the sensors and feed the signal into DAQ boards where it is converted to digital and processed in FPGAs.

During data taking in 2011 and 2012 the VELO sensors have received a large and non-uniform radiation dose of up to 1.2 x 1014 1 MeV neutron equivalent /cm2.
Type-inversion has already been observed in the innermost regions close to the interaction point. The analysis of the radiation damage has been refined during the LHC shutdown. It is expected that the VELO can no longer be operated efficiently with uniform bias voltages across all sensors in Run 2 of the LHC. Results of of the radiation damage analysis will be presented based on measurements of reverse currents versus voltage and temperature, charge collection efficiency versus voltage and cluster finding efficiency. In addition, the new Run 2 operational procedures addressing the non-uniform radiation damage will be discussed.

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