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# The LHCb Vertex Locator Upgrade

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The Large Hadron Collider Beauty detector is a flavour physics detector, designed to detect decays of b- and c-hadrons for the study of CP violation and rare decays. At the end of Run-II, many of the LHCb measurements will remain statistically dominated. In order to increase the trigger yield for purely hadronic channels, the hardware trigger will be removed and the detector will be read out at 40 MHz. This, in combination with the five-fold increase in luminosity requires radical changes to LHCb's electronics, and, in some cases, the replacement of entire sub-detectors with state-of-the-art detector technologies.

The Vertex Locator (VELO ) surrounding the interaction region is used to reconstruct the collision points (primary vertices) and decay vertices of long-lived particles (secondary vertices). The upgraded VELO will be composed of 52 modules placed along the beam axis divided into two retractable halves. The modules will each be equipped with 4 silicon hybrid pixel tiles, each read out with by 3 VeloPix ASICs. The silicon sensors must withstand an integrated fluence of up to $8\times10^{15}$ 1 MeV $n_{eq}/cm^2$, a roughly equivalent dose of 400 MRad. The highest occupancy ASICs will have pixel hit rates of 900 Mhit/s and produce an output data rate of over 15 Gbit/s, with a total rate of 1.6 Tbit/s anticipated for the whole detector.

The VELO upgrade modules are composed of the detector assemblies and electronics hybrid circuits mounted onto a cooling substrate, which is composed of thin silicon plates with embedded micro-channels that allow the circulation of liquid $CO_2$. This technique was selected due to the excellent thermal efficiency, the absence of thermal expansion mismatch with silicon ASICs and sensors, radiation hardness of CO2, and very low contribution to the material budget. The front-end hybrid hosts the VeloPix ASICs and a GBTx ASIC for control and communication. The hybrid is linked to the opto-and-power board (OPB) by 60 cm electrical data tapes running at 5 Gb/s. The tapes must be vacuum compatible and radiation hard and are required to have enough flexibility to allow the VELO to retract during LHC beam injection. The OPB is situated immediately outside the VELO vacuum tank and performs the opto-electrical conversion of control signals going to the front-end and of serial data going off-detector. The board is designed around the Versatile Link components developed for high-luminosity LHC applications.

The design of the complete VELO upgrade system will be presented with the results from the latest R\&D. The LHCb upgrade detector will be the first detector to read out at the full LHC rate of 40 MHz. The VELO upgrade will utilise the latest detector technologies to read out at this rate while maintaining the required radiation hard profile and minimising the detector material.

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