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LHCb VELO Upgrade

The VErtex LOcator (VELO) is the silicon detector surrounding the interaction region of the LHCb experiment. From 2019, LHCb aims to run at a luminosity of 2×10^{33}~cm$^{-2}s^{-1}$, 5 times greater than the current luminosity, and to enhance trigger efficiency. Upgrades are required to many of the LHCb sub-detectors and the experiment will transform to a system reading out the full detector at 40~MHz event rate, operating event selection in a dedicated computer form.

The VELO consists of two halves situated in a secondary vacuum inside the LHC beam pipe, separated by a thin custom-made RF foil. The two halves can be retracted when beams are injected and closed during stable beams, positioning the first sensitive pixel 5.1~mm from the beams.

Each half of the VELO will consist of 26 L shaped modules. The module is a double sided construction, with two hybrid pixel assemblies and their PCB circuits mounted on either side of the central backbone; a 400~μm thick silicon plate incorporating cooling microchannels for the circulation of evaporative CO_2. Operation is at a sufficiently low temperature to avoid thermal runaway of the irradiated sensors.

The VELO‘s proximity to the beam means that it is exposed to a harsh radiation environment, resulting in non uniform radiation damage across the sensors. The hybrid pixel system will be equipped with data driven electronics and designed to withstand a radiation dose of up to 8×10^{15} 1 MeV $n_{eq}\ cm^{-2}$. The silicon pixel sensors have a pitch of 55×55 μm^2, read out by the VeloPix ASIC which is being developed based on the TimePix/MediPix family. The performances of prototype sensors from two manufactures have been tested at testbeam before and after exposure to both uniform and non uniform irradiation. A dedicated telescope system based on the TimePix3 assemblies was created for testbeam studies at the SPS, CERN. This allows several different tests of the prototype sensors, for example, detailed analysis of the resolution, efficiency, charge sharing and radiation effects.

An overview of the LHCb VELO upgrades and the current status will be described together with a presentation of some of the analysis from testbeam using the TimePix3 telescope.

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