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LHCb Velo upgrade telescopes

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The upgrade of the LHCb experiment will transform the experiment to a trigger-less system reading out the full detector at the LHC collision rate and up to $2 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$ instantaneous luminosity. The Vertex Locator (VELO) is the silicon detector surrounding the interaction region. The upgraded VELO is based on a hybrid pixel system equipped with data driven electronics and designed to withstand a radiation dose up to 370 MRad or $8 \times 10^{15} \text{ 1 MeV n}_{eq} \text{ cm}^{-2}$. The detector will be composed of silicon pixel sensors with $55 \times 55 \mu\text{m}^2$ pitch, read out by the VeloPix ASIC which is being developed based on the TimePix/MediPix family. The VeloPix is capable of reading out up to 900 million hits per second. An additional challenge is the non uniform nature of the radiation damage, which results in requiring a guard ring design with excellent high voltage control. In addition, the n-in-p design requires the guard ring to be on the chip side making the high voltage reach the vicinity of the ground plane (about $30 \mu\text{m}$ apart).

The performance of the prototype sensors has been investigated in a test beam in which a dedicated telescope system was created with two arms each equipped with 4 Timepix3 assemblies. The device to be tested can be mounted, rotated, and cooled in the central region, with a optional vacuum setup. This allows several different tests of the performance of the sensor prototypes before and after irradiation.

The TimePix3 telescope is also used to study sensor prototypes for other LHCb upgrade sub detectors. In addition to VELO prototype sensors, the telescope has been used to study Upstream Tracker (UT), Scintillating Fibre (SciFi), Ring Imaging Cherenkov (RICH), Time-Of-Flight Ring Imaging Cherenkov (TORCH) and GasTpx3 prototypes.

A few VeloPix Assemblies were used to create a telescope in order to check the synchronization of chips in a very high intensity beam environment, as well as investigate time-walk effects. The detectors were brought to the Fermilab beam facility where data were collected with highest possible particle rates. The preliminary results on the Velopix telescope data will be presented.

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