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Sensor development and characterisation for Velo Upgrade

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The upgrade of the LHCb experiment, planned for 2020, will transform the experiment to a trigger-less system reading out the full detector at the LHC collision rate and up to $2 \times 10^{33} cm^{-2} s^{-1}$ instantaneous luminosity.

As part of the LHCb Upgrade, hybrid pixel prototypes have been studied in detail at SPS testbeams using the Timepix3 Telescope. A range of prototype planar sensors, with varying thickness, type, implant size and guard rings were provided by two manufacturers. These sensor have been characterised using two different readout ASICs, the Timepix3 (analogue) and VeloPix (binary).

The evaluation programme of the prototypes also includes studies to show the effects of radiation damage. The sensors were irradiated at several facilities, including reactor neutrons at JSI in Ljubliana, mid energy (27 MeV) protons at KIT in Karlsruhe and high energy (24 GeV) protons from IRRAD at CERN

Complementary measurements without the telescope tracking have been done using only the hit information within a sensor. The grazing angle method consists of placing the device under test (DUT) almost parallel to the beam, such that tracks cross multiple adjacent pixels, where each pixel then represents a certain depth in the sensor. This is one of the few methods to perform depletion depth measurements and investigate the evolution of the charge collection profile at different depths. The high timing resolution of the Timepix3 chip also made it possible to study the charge collection time as a function of depth.

The impact of radiation damage on the charge collection and time-to-threshold is investigated at different fluences by studying non-uniformly irradiated assemblies. The spatial resolution and collected charge were studied as a function of track angle, bias voltage and threshold both before and after irradiation. In this presentation an overview of the test beam results will be shown comparing the performance against all the different parameters implemented in the prototypes.

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