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Sensor Development for the LHCb VELO Upgrade

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The upgrade of the LHCb experiment, planned for 2018, will transform the experiment to a trigger-less system reading out the full detector at 40 MHz event rate. All data reduction algorithms will be executed in a high-level software farm with access to the complete event information. This will enable the detector to run at luminosities of 2 1033cm-2s-1 and probe physics beyond the Standard Model in the heavy
avour sector
with unprecedented precision.
The Vertex Locator (VELO) is the silicon vertex detector surrounding the interaction region. The current detector will be replaced with a hybrid pixel system equipped with electronics capable of reading out at 40 MHz, designed to withstand the irradiation expected at an integrated luminosity of 50 fb�1 and beyond. The upgraded VELO will form an integral part of the software trigger, and must provide fast pattern recognition and track reconstruction while maintaining the exceptional resolution of the current detector.
The detector will be composed of silicon pixel sensors with 55 55 m2 pitch, read out by the VeloPix ASIC which is being developed based on the TimePix/MediPix family.
The hottest region will have pixel hit rates of 900 Mhits/s yielding a total data rate more than 3 Tbit/s for the upgraded VELO.

An additional challenge is the non uniform nature of the radiation damage, which results in a need for excellent high voltage control on the sensor guard ring design. The performance of the sensor-ASIC bump bonded assemblies has been investigated in a test-
beam in which the two arms are equipped with Timepix3 sensors, and the device to be tested can be mounted, rotated, and cooled in the central region. This allows tests of the speed and time tagging performance of the ASIC, together with the performance of the sensor after irradiation. Photos and gures from the testbeam setup are shown in
gure 1.
The material budget will be minimised by the use of evaporative CO2 coolant circulating in microchannels within 400 m thick silicon substrates. Microchannel cooling brings many advantages: very ecient heat transfer with almost no temperature gradients across the module, no CTE mismatch with silicon components, and low material contribution.
This is a breakthrough technology being developed for LHCb.
Results from the irradiation and testing campaign will be shown, including the calibration of the Timepix, the operation of irradiated assemblies and charge collection, and the high voltage behaviou before and after irradiation. Results will be showsn from testbeam and lab environments.

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