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LHCb VELO upgrade

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 x 10ˆ33 /cmˆ2/s and probe physics beyond the Standard Model in the heavy flavour 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 55x55 umˆ2 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. The detector modules are located in a separate vacuum, separated from the beam vacuum by a thin custom made foil. The foil will be manufactured through milling and possibly thinned further by chemical etching. The detector halves are retracted when the beams are injected
and closed at stable beams, positioning the first sensitive pixel at 5.1 mm from the beams. The high data rates require development of low-mass, high-speed, flexible electrical serial links bringing the data out of the vacuum where electrical-to-optical conversion is
performed. The material budget will be minimised by the use of evaporative CO_2 coolant circulating in microchannels within 400 um thick silicon substrates. Microchannel cooling brings many advantages: very efficient 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. The 40 MHz readout will also bring significant conceptual changes to the way in which the upgrade trigger is operated. Work is in progress to incorporate momentum and impact parameter information into the trigger at the earliest possible stage, using the fast pattern recognition capabilities of the upgraded detector. The current status of the VELO upgrade will be described together with a presentation of recent test results, including operation of irradiated sensor and ASIC assemblies in testbeam and lab environments.

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