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Microchannel evaporative CO2 cooling for the LHCb VELO Upgrade

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The LHCb Vertex Detector (VELO) will be upgraded in 2018 to a lightweight, pixel detector capable of 40 MHz readout and operation in very close proximity to the LHC beams. The thermal management of the system will be provided by evaporative CO2 circulating in microchannels embedded within thin silicon plates. This solution has been selected due to the excellent thermal efficiency, the absence of thermal expansion mismatch with silicon ASIC's and sensors, the radiation hardness of CO2, and very low contribution to the material budget.

Although microchannel cooling is gaining considerable attention for applications related to microelectronics, it is still a novel technology for particle physics experiments, in particular when combined with evaporative CO2 cooling. The R&D effort for LHCb is focusing on the design and layout of the channels together with a fluidic connector and its attachment to withstand pressures in excess of 200 bars. This talk will describe the design and optimization of the cooling system for LHCb together with latest prototyping results.

Even distribution of the coolant is ensured by means of the use of restrictions implemented before the entrance to a race-track layout of the main cooling channels. The coolant flow and pressure drop has been simulated together with the thermal performance of the device. The results can be compared to the cooling performance of prototype plates operating in vacuum. The design of a suitable low mass connector, together with the bonding technique to the cooling plate will be described.

Long term reliability as well as resistance to extremes of pressure and temperature is of prime importance. The setup and operation of a cyclic stress test of the prototype cooling channel designs will be described.

Summary

The status and R&D for microchannel cooling for the LHCb VELO upgrade will be described, as outlined in the abstract above.

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