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Developments on a Microchannel CO2 cooling system for the LHCb VELO Upgrade.

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Content

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 micro channels 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 micro channel 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 which must withstand pressures up to 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 design of a suitable low mass connector, together with the soldering 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.

In parallel to the development of the micro-channel substrate, the VELO group is also working on the development of an alternative cooling substrate. This design foresees a network of parallel stainless steel capillaries embedded within an aluminimum nitride cooling plate which forms the backbone of the module. A dedicated manifold supplies the CO2 via tiny orifices of 0.16 mm diameter which serve as an expansion point and control the resistance of the parallel channels. The design of the manifold and pipes and the thermal performance of full scale prototypes will be described.

The efficiency of CO2 cooling in extracting the heat from the module will be shown for both implementations, as well as the potential integration into the module construction.

Summary

Micro-channel cooling is gaining considerable attention for applications related to microelectronics. Despite this, it is still a novel technology for particle physics experiments, in particular when combined with evaporative CO2 cooling. The R&D effort for LHCb Vertex Locator (VELO) is focusing on the design and layout of the channels together with a fluidic connector and its attachment which must withstand pressures up to 200 bars. This talk will describe the design and optimization of the cooling system for LHCb together with latest prototyping results.

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