



Contribution ID: 352

Type: Oral

## Cooling for the LHCb Upgrade Scintillating Fibre Tracker

*Monday 2 June 2014 17:10 (20 minutes)*

As part of the LHCb Phase-II upgrade programme, the existing downstream tracking systems will be replaced by a new scintillating fibre tracker read out by multi-channel silicon photomultipliers (SiPM). To ensure high tracking performance over the entire experiment's lifetime, the SiPMs will be operated at sub-zero temperatures, down to  $-40^{\circ}\text{C}$ .

This presentation outlines the proposed SiPM cooling system and describes the design considerations which led to the choice of the mono-phase liquid cooling solution. The requirements on the temperature uniformity and stability are discussed, along with the constraints which thermal considerations impose on the mechanical design of the tracker modules. The prospective refrigerants (C6F14 and 3M Novec thermal fluids) are compared with each other, including their effect on the environment.

The SiPM cooling system consists of the remote cooling plant, insulated transfer lines, the local distribution pipework and the cooling structures inside 288 read-out boxes spread over twelve  $5 \times 6 \text{ m}^2$  tracker planes. The main design challenges of this system are associated with its large extent (about 150 m of linear SiPM arrays to be cooled) and severe constraints on the geometrical envelope and, hence, insulation. Since the SiPM themselves produce very little heat, the estimated heat load of the cooling plant, 13 kW, is dominated by the heat influx through the insulation of read-out boxes, interconnection and transfer lines. Main system design parameters, as well as the latest results of the thermal mock-up tests, are summarised.

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**Session Classification:** IV.a Cooling

**Track Classification:** Emerging technologies: 4a) Cooling and cryogenics