Contribution ID: **79** Type: **ORAL**

Microchannel cooling for the LHCb VELO Upgrade

Thursday, 6 September 2012 16:30 (20 minutes)

Local thermal management of detector electronics through ultra-thin micro-structured silicon cooling plates is an extremely promising technique for HEP with wide potential application in other fields. It combines a very high thermal efficiency with a very low addition of mass and space, and suppresses all problems of CTE mismatch between the heat source and he heat sink.
Typical micro-fabrication techniques such as photolithography, etching, wafer bonding and thinning are all involved in the process. The technique is very suited to the LHCb VELO upgrade, where there is the challenge of constructing an efficient cooling system which is radiation hard, adds minimal material to the system, and provides an excellent CTE match to the silicon sensing elements and ASICs. The microchannel designs under development have to be specially adapated for the use of CO2 as the coolant, with the additional challenges of thinner channels, constrictions to allow an evaporative CO2 cooling process, and the higher pressures involved. The numerical simulations also have to be enhance to describe the turbulent flow within the channels. In addition to the design of the microchannels within the wafers themselves, the connectivity has also to be adapted to cope with the higher pressures, and to allow close packing of the forward silicon planes. A series of designs have already been prototyped and tested for LHCb. The challenges, current status of the measurements, and the solutions under development will be described.

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Session Classification: Session7

Track Classification: Ultra light mechanics and cooling