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New insights on boiling carbon dioxide flow in mini- and micro-channels for optimal silicon detector cooling

Whilst the thermal management needs of future silicon detectors are increasing, the mass and volume minimization of all ancillaries gets more demanding. This requires highly effective active cooling in very small channels. Due to its favourable thermo-physical properties, evaporative CO2 is used as refrigerant for the future generations of silicon detectors at LHC. However, available data on CO2 boiling in channels of small hydraulic diameter (< 3 mm) are too limited, often affected by large uncertainties, to allow for developing reliable predictive models for heat transfer coefficient and pressure drop. This raises the need for long iterative phases of experimental tests, which will be reduced by the availability of reliable models. In the context of the AIDA-2020 project, a new test stand has been developed to characterize, with unprecedented level of accuracy, boiling flows of CO2 in mini- and micro-channels with hydraulic diameter ranging from 2 down to 0.1 mm. Results from this long term campaign will be presented and discussed. We will show the heat transfer coefficient and pressure drop behaviour in stainless steel tubular evaporators for saturation temperatures from +20 to -25 ℃, mass fluxes from 1200 to 100 kgm-2s-1 and heat fluxes from 5 to 35 kWm-2. High speed camera observations of CO2 flow patterns recorded on micro-structured silicon cold plates are used to help with the interpretation of the heat transfer coefficient and pressure drop trends reported.

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