

Calibrated orifices for CO₂ cooled detectors

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Several detectors use evaporating CO₂ cooling systems. For a tracker that dissipates power and needs to maintain the sensors below a maximum temperature, i.e. -5 °C, to avoid the thermal run-away, a CO₂ cooling system integrated in the local support minimizes the total mass. This means larger radiation length.

The evaporating CO₂ coolant extracts the power, dissipated mainly by the red-out front-end ASICs, changing phase from liquid to vapour, at a nearly constant temperature; saturation temperature drops along the cooling channel in relation to the fluid pressure drop. The detector temperature uniformity, i.e. 5 °C, is controlled by its channel pressure drop. Sometime in the design small diameter pipes and non conventional geometries are used, i.e. serpentines, 2 mm inner diameter titanium cooling pipe. Analytical calculations are difficult when few or no correlations are available for these design typologies.

This is a first reason to investigate and set up experimental measurements of detector thermo-hydraulic dummies.

Another reason is that the detector cooling systems frequently have parallel evaporating channels. Attention must be paid to the stability of the cooling system. The cooling distribution needs to implement proper pressure drops at the inlet of the parallel evaporating channels. To select the correct figure the cooling channel pressure drop need to be estimated.

Finally, the inlet pressure drop to be installed has to be designed and experimentally checked. There are typically two options: distributed or concentrated pressure drops.

The first one uses capillary pipes, that could be long and need to be coiled to reduce the needed space; the second one uses calibrated orifices, less common in the actual detector design.

In Milano, investigations have been conducted, and are in progress, using a TRACI CO₂ cooling unit, focusing on the use of orifices for the CO₂ distribution.

The actual work is dedicated to both the LHCb UT tracker and the ATLAS ITk Pixel Encap, but the measurements and outcomes can be useful for any other CO₂ cooled system.

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