Contribution ID: **33** Type: **not specified**

Ongoing R&D activities for ATLAS and CMS phase 2 upgrade CO2 cooling systems

Wednesday, 19 June 2019 09:30 (20 minutes)

The CO2 cooling systems for the phase-2 upgrade of ATLAS and CMS are an order of magnitude larger in cooling power than the CO2 cooling systems developed so-far. This enlargement of the systems brings new engineering challenges which are currently being studied in several R&D programs in the CERN EP-DT-FS cooling team. A prototype cooling unit, called DEMO, of about 100 kW is being built.
A proportional enlargement of the system would lead to very large CO2 accumulators and hence large CO2 quantities stored underground. In order to reduce the volumes, a modified control concept is under study to supply the multiple plants with a common CO2 storage on the surface. A modified control mechanism to fill and empty the system is foreseen.
The enlargement of the systems also leads to large diameter transfer lines between the cooling plants in the service caverns and the cooling loops in the detector. These transfer lines typically have 2-phase flows in both horizontal and vertical orientation. The behaviour of 2-phase CO2 flow under these novel conditions is insufficiently understood and is therefore subject to a dedicated R&D program. In the CERN cooling laboratory in B153 a set-up of 8mm ID pipes is mounted in order to understand the fundamental behaviour of 2-phase flow especially in vertical pipes. Transparent sections are present for visualization of flow patterns. Following the small-scale setup, a next R&D on a real size transfer lines up to 2" will follow using the large capacity DEMO cooling plant, while smaller scale transfer lines, with the typical size of the detector to manifold ones are being tested in real scale on the CMS experiment for vertical flow effects.
A second large R&D activity is the application of CO2 as working fluid also in the primary cooling system. When used as primary cooling fluid, CO2 is referred to as R744, the refrigeration code. A R744 primary system is able to cool the underground CO2 plants directly to the air or the primary water towers on the surface. This application makes the full detector cooling to work with natural refrigerants only, ensuring a green future for the next generation cooling systems at CERN. The primary R744 cooling R&D is done in a successful collaboration between world experts from NTNU in Norway and EP-DT and EN-CV at CERN.

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