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Cold Krypton system for the Phase III Upgrade of the LHC

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During the Phase III Upgrade the Large Hadron Collider (LHC) will experience radiation levels extent never achieved before. The current detector cooling system operating with CO2 and the associated mechanical supports must be upgraded as the current cooling temperature is not sufficient to prevent the phenomena of the thermal runaway of the sensors. Indeed, over the years the CO2 cooling system (2PACL) has been pushed until to its limit, represented by the refrigerant triple point (≈ -55 ℃). The new temperature levels required are in the range of -60 down to -80℃. This, together with the CERN environmental policy, has further restricted the list of potential coolants for the future detector upgrade. Among them, the noble gas Krypton stands out as promising and efficient coolant. As side-effect of its thermophysical properties, the cooling starting from ambient conditions is completely different than what occurs with CO2 thus requiring a completely new cycle starting from the gas phase down to the cold region (two-phase area). A new cooling concept has been developed based on an ejector-supported cycle which differs from a traditional ejector cooling system due to the requirements in the evaporator section such as passive expansion and flooded evaporation, as well as the supercritical phase involved during the startup.
In order to emulate the Krypton cooling concept in more attainable temperature levels typical for commercial refrigeration (≈ -30 ℃), the noble gas Xenon is proposed thanks to its warmer critical temperature (≈ 17 ℃). Numerical design of the evaporator loop, as well as dynamic modelling of the cycle startup and transcritical operation is here presented and discussed. The Xenon demonstrator is currently under construction for future testing.

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