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Dynamic Simulations of Phase 2 Detector Cooling Systems

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CO2-based 2PACL cooling systems have undergone significant design changes to meet the challenges of Phase-2 detector cooling. The introduction of the surface storage reservoir (with a 100m height difference from the cooling plants), a smaller accumulator size with respect to transfer line volumes, larger cooling loads, and the need for a back pressure regulator have all lead to non-trivial changes in the design and control of 2PACL systems. The impact of these changes in the performance and control of the new systems needs to be studied.

In this work, a simulation model of the Phase-2 2PACL CO2 cooling systems has been developed. The model is developed in the object-oriented physical modelling platform EcosimPro. It is component-based, and uses the staggered grid method to decouple the mass and energy balance equations from the momentum equation. It uses the upwind scheme to account for reverse flow and enable splitting/merging flows. It uses a slip-ratio based void fraction model to account for two-phase flow. It also incorporates the UNICOS PLC library to model the control system.

The model has been used to simulate the startup cycle for Phase 2 systems. The startup of these systems differs significantly from previous systems, in particular, due to the inability to pressurise the whole system just from the accumulator. This new startup procedure has been incorporated in the model. The model has also been used to simulate the performance of the plant in detector heat load cycling (power on / power off / power on again) in both cold and warm operating conditions. In particular, the role of the surface storage reservoir is described in handling the two scenarios. Finally, the model has been used to study the behaviour of the plant when a temperature set-point change is requested.

The simulations give insight into the performance of the forthcoming CO2 cooling systems and will enable the operation of the systems in a safe and controlled manner.

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