

2 K system exergetic optimisation and helium recovery system for FCC-ee

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At its tthar stage, FCC-ee is expected to require over 200 cryomodules housing 800 MHz bulk niobium superconducting radio frequency cavities operated at 2 K, and more than 60 cryomodules housing 400 MHz niobium-sputtered copper cavities operated at 4.5 K. The complexity, energy intensity, and scale of the associated cryogenic system requires a holistic design approach. Topics such as sustainability or resilience against prolonged electrical grid perturbations become integral to this process. Thus, helium preservation, energy efficiency, and integration constraints are considered in the current conceptual design phase.

This paper details the design of the very low-pressure system used to maintain the cavities at 2 K. The operational variables of its distribution line have been addressed in a parametric manner using a combination of numerical simulations and exergetic analyses. The results enable the comparison of various implementation options, directly linking them to the energy consumption of the refrigerator. Subsequent sensitivity analyses reveal that while a central heat exchanger architecture is preferred for integration aspects, it is overall less energy-efficient than a distributed one at lower heat exchanger effectiveness values. Finally, we propose a helium recovery system based on diesel-powered compressors of up to 1 MW to preserve the cryogen inventory during incidents. Initial sizing allowed to extract the additional space, cooling water and electricity requirements needed for its implementation.

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