# Performance Enhancement of a Sub-Kelvin Adiabatic Demagnetization Refrigerator (ADR) Precooled by an Integrated Sorption Cooler

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This study presents the detailed design of the adiabatic demagnetization refrigerator (ADR) which is precooled by an integrated sorption cooler. The proposed cooler attains sub-Kelvin temperature with cooling capacity, while it rejects heat to the commercial two-stage 4 K Gifford-McMahon (G-M) cooler. The 4He sorption cooler is composed of a thermosiphon and a sorption pump. In the case of the thermosiphon, the condenser is thermally connected to the 4 K stage of the G-M cooler, while the magnetic material of the ADR is integrated as an evaporator. The integrated configuration can simplify the system by removing the active heat switches of the cooler. The sorption pump filled with activated charcoal is plate-shape to enhance the thermal and mass diffusion inside of it. When the pressure inside the thermosiphon is decreased by the sorption pump, the magnetized magnetic material is precooled by the evaporation of the liquid helium. After all the helium is adsorbed to the pump, the magnetic material is thermally separated from the heat sink. Single crystal gadolinium gallium garnet (GGG) is selected as a magnetic material and is installed inside the bore of the high-temperature superconducting (HTS) magnet which can generate a maximum center field of 4 T. After the magnetization and the sorption-precooling process, the GGG is demagnetized and achieves cooling capacity at the sub-Kelvin temperature. Detailed design, construction, and test results of the cooler are presented in the paper.