

Performance of a Miniature, Closed-Cycle Dilution Refrigerator at Tilt Angles between 0 and 30 Degrees

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Miniature, closed-cycle dilution refrigerators (DRs) are being explored as an alternative to adiabatic demagnetization refrigerators for suborbital balloon missions that require cooling of sensors to mK temperatures. These DRs do not use large, room-temperature gas handling systems; instead, the recirculating ^3He is pumped by a split condenser that is cooled by two ^4He - ^3He evaporator pairs and is returned to the mixing chamber by gravity. The two adsorption-pumped evaporator pairs run in antiphase to achieve continuous cooling of the condenser. The balloon mission requires that the DR and evaporator pairs be tipped at 20 degrees relative to gravity, which may degrade their performance. To validate performance and explore possible design improvements, we are testing a miniature DR (manufactured by Chase Cryogenics) at tilt angles from 0 to 30 degrees from vertical and at azimuthal rotations of up to 360 degrees around the tilted axis. A goal of this study is to determine the orientation of the cryostat that yields maximum performance and the performance reductions for other orientations. In addition to testing the integrated system, we plan to isolate and test each subsystem (^4He evaporator, ^3He evaporator, and split condenser) to determine their individual performance and contribution to the integrated system performance.