

## ***Cryocooler and Control Electronics for the Psyche Gamma-Ray Spectrometer***

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Gamma-ray spectrometers aboard orbiting spacecraft have successfully mapped the surface composition of planetary bodies such as the Moon, Mars, and Mercury, as well as the asteroids Eros, Ceres, and Vesta, with upcoming missions to Psyche, Phobos, and Titan. The Applied Physics Laboratory (APL) has now been responsible for three generations of gamma-ray spectrometers over the last few decades, starting with a room-temperature detector that required no cooling, a high-purity germanium (HPGe) detector cooled using a rotary tactical cooler and, most recently, an HPGe detector cooled using a miniature long-life pulse tube cooler manufactured by Lockheed Martin. HPGe detectors are particularly susceptible to microphonics, but the lower exported vibration from the pulse tube cooler has enabled the achievement in flight of record-setting energy resolution. And the much longer expected cryocooler lifetime lifts previous limitations on observing time, as this measurement technique can often require months to years of operations to map a body to high precision, especially for the rarer elemental species. The unique thermal requirements for an HPGe-based gamma-ray spectrometer along with details of cooler selection, testing, and final system performance on the ground and in flight will be presented in this paper. The cryocooler control electronics (CCE) were developed and built by APL as an integral part of the instrument Data Processing Unit (DPU). Details of the CCE, a low-distortion, high-efficiency 50-W amplifier with in-flight diagnostics such as waveform capture of voltage, current, and piston position, will also be presented.