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Metallic Magnetic Calorimeters for High-Accuracy Nuclear Decay Data

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Metallic magnetic calorimeters (MMCs) combine the very high energy resolution characteristic of cryogenic gamma detectors with a very small nonlinearity and a reproducible response function due to their all-metallic design and their thermodynamic equilibrium sensor. These attributes make MMCs well-suited for photon and particle spectroscopy applications requiring the highest accuracy. We are developing high-resolution MMC gamma-ray detectors with the goal of improving the quality of key nuclear decay data for nuclear safeguards and fundamental science. Exploratory "integrated"14-pixel MMC designs, in which the sensors and front-end SQUID amplifiers are on the same chip, have shown an energy resolution of 38 eV at 60 keV. Here we describe design and optimization strategies for MMC detectors using both "integrated"and "split"designs with SQUIDs and sensors on separate chips. The new designs include "direct"(no flux transformer) readout and reduction of critical current in the SQUID junctions by a factor of two for reduced power dissipation. The passive Nb:Ta alloy shunts developed by UNM and STARCryo are used throughout for trapping persistent magnetizing currents as well as for blocking unwanted induction of persistent currents. The combined changes yield estimated energy resolutions <5eV and <25 eV for MMCs optimized for operation up to 10 and 100 keV, respectively, with pixel counts up to 30. We will discuss the performance of our most recent MMC designs and their impact on increased accuracy of nuclear decay data for uranium assay.

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Less than 5 years of experience since completion of Ph.D

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