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Title: Development of Magnetic Microcalorimeters for Decay Energy Spectroscopy

Abstract

Novel technologies for nuclear forensics and determination of the isotopic composition of nuclear samples is of high interest to the IAEA and other nuclear regulatory agencies. Magnetic microcalorimeters (MMCs) are sub-Kelvin cryogenic detectors capable of measuring the entire decay energy, alpha, beta, and nuclear recoil, from a nuclear disintegration with 100% efficiency. The noise of MMC detectors is proportional to their temperature and heat capacity, thus allowing for excellent resolution (< 1 keV) on energy scales from eV to MeV. We present initial measurements conducted with Am-241 and Cm-244 sources as well as a study of Pu-240 nuclear recoils. The gamma rays emitted in the decay of Am-241 are not measured with the decay energy. This produces two peaks 40 keV apart, a useful testbed for development of algorithms to identify Pu-239 and Pu-240 whose decay energies differ by 12 keV. We have also tested several physical detector configurations with various detector materials (metals and inorganic crystals), different magnetic sensors, and commercially available SQUIDs. Energy resolutions of order 10 – 20 keV (~0.25%) have been achieved, comparable to modern semiconductor detectors. Because MMCs are slow detectors, with response times of order milliseconds, considerable effort has been placed on modelling the effect of pileup and methods for correcting the pileup signal. These methodologies are compared against the data and inform ongoing improvement to the signal processing of data. Current work involves design of a new detector, more robust at shielding RF and microphonic noise. The promising development of MMCs offers the potential for a cost-effective and efficient method to identify the isotopic makeup of composite nuclear samples.