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(G*) Development of a digital data acquisition system capable of pulse-pileup recovery for HPGe detectors

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The versatility of gamma-ray spectroscopy has given rise to its many applications, from quantification of trace elements in a sample to maintaining nuclear material safeguards. Depending on the application and gamma-ray detector, there is often a compromise made between detection efficiency and energy resolution. While characterizing or quantifying trace radionuclide concentrations in an unknown sample, energy resolution is often the more important property. In these situations, high-purity germanium (HPGe) detectors are the detector of choice as they have a superior energy resolution which significantly reduce measurement uncertainties and improve minimum detection limits.

Applications using HPGe detectors are limited to counting rates on the order of a few tens of thousands of counts per second (cps) before the performance of the detector is severely diminished. The limiting factor for high counting rate measurements comes from the need to shape signals with a relatively long shaping time, on the order of 1-6 μs, to maintain good energy resolution. At higher counting rates however, if a signal is received while a previous signal is still being shaped, pulse-pileup occurs. Pulse-pileup distorts the energy measurement of the previous signal and entirely drops the measurement of the second signal. Traditionally, this situation is usually handled with a pileup rejection method. At ultra high counting rates, on the order of a million cps, the percentage of the pileup rejection is so high that the spectroscopy system suffers from extremely high deadtimes.

In order to solve this critical problem, the present study aims to develop a data acquisition system capable of deconvoluting pileup signals into two or more recovered signals in real-time. This technique has been applied for NaI(Tl) and silicon drift detectors, which showed very promising results. However, applications of this technique for HPGe detectors have been unsuccessful as it relies on a fixed signal rising edge shape, a feature which cannot applied for HPGe detectors due to the variation in the rising shape. Our study has been focused on developing a deconvolution algorithm to identify and recover piled-up signals using a planar HPGe. During this development stage, signal waveforms are analyzed offline, optimizing the algorithm over a range of counting rates while building a library of the rising edge shapes. Once completed, the deconvolution algorithm will be benchmarked for various high-rate measurements. The preliminary result of the pile-up deconvolution performance will be presented.

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