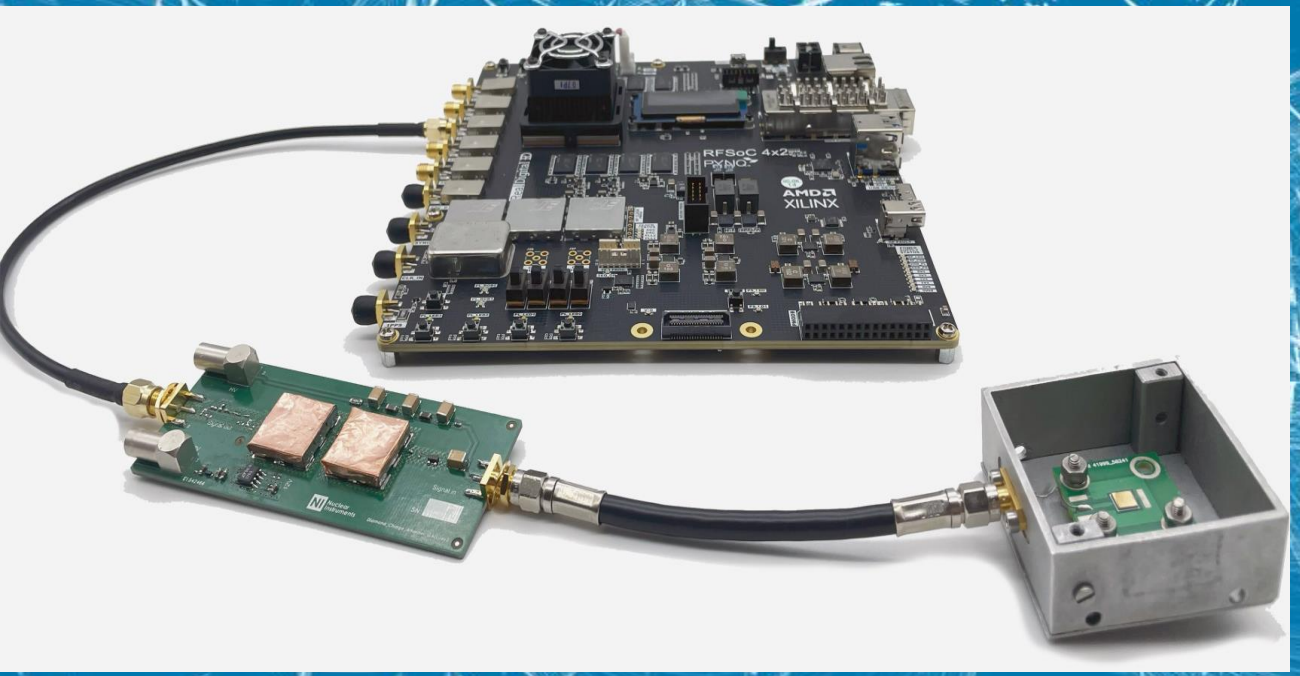
Implementation of multi-GHz digital shaper for high-rate nuclear spectroscopy



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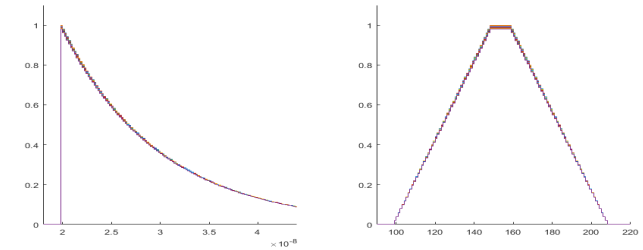
NEW 5GSPS DIGITIZERS AND DSP

New detectors, such as diamonds, demand high sampling rates.
Nuclear Instruments has developed a 5 GSPS, 14-bit digitizer. Consequently, new processing algorithms are essential for this next generation of devices.

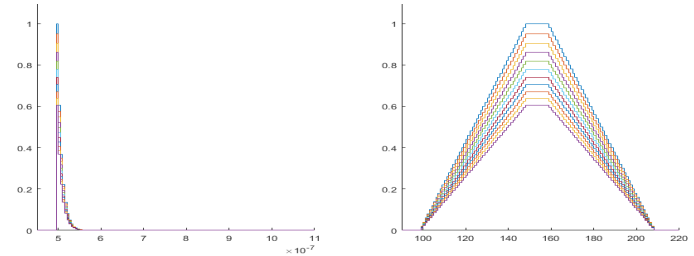
DIGITAL SIGNAL SHAPING

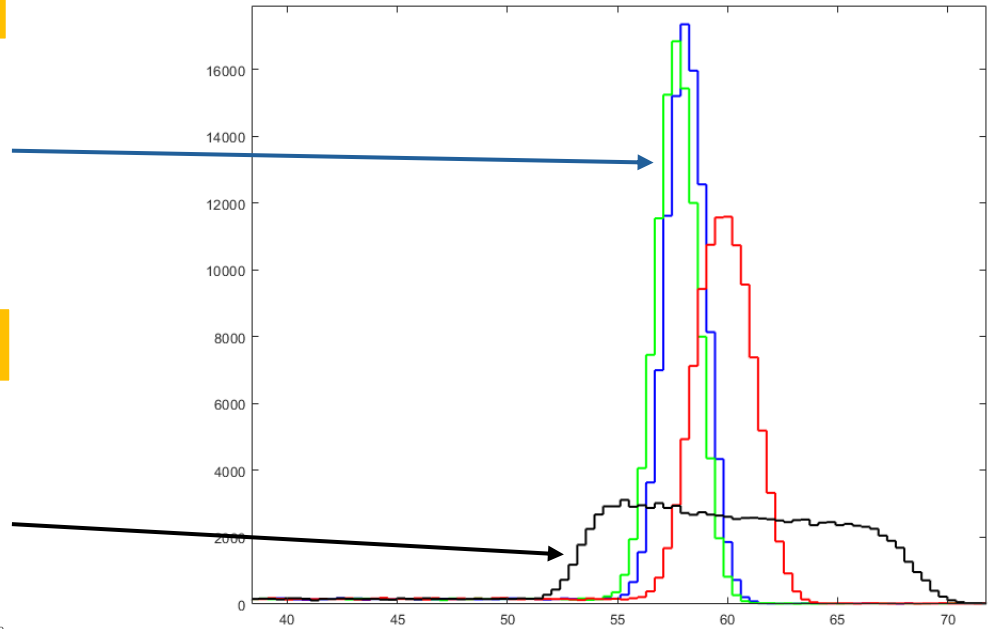
The trapezoidal shaper serves as a quasi-optimal filter for calculating pulse height and, consequently, the energy spectrum. With signal shapes of less than 10ns, diamond detectors can achieve alpha particle resolution as fine as 1%.

200MHz Sampling Clock



200MHz Sampling Clock





200Msps σ=7.5%
1Gsps σ=2.6%
2.5Gsps σ=2.3%
5Gsps σ=2.2%

* In-air Am^{241} source, 3x3mm Diamond detector

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PARALLELIZING FILTER STRUCTURE

In FPGA implementation, the algorithm must harness the parallelism of the device efficiently. For the 5 GSPS implementation, the trapezoidal filter has been unfolded into 16 parallel pipelines, each operating at 312.5 MHz.

PARALLEL ACCUMULATOR

Implementing trapezoidal filters with two large (64-bit) accumulators in a parallel architecture poses challenges due to the one-clock-cycle output-to-input data dependency.