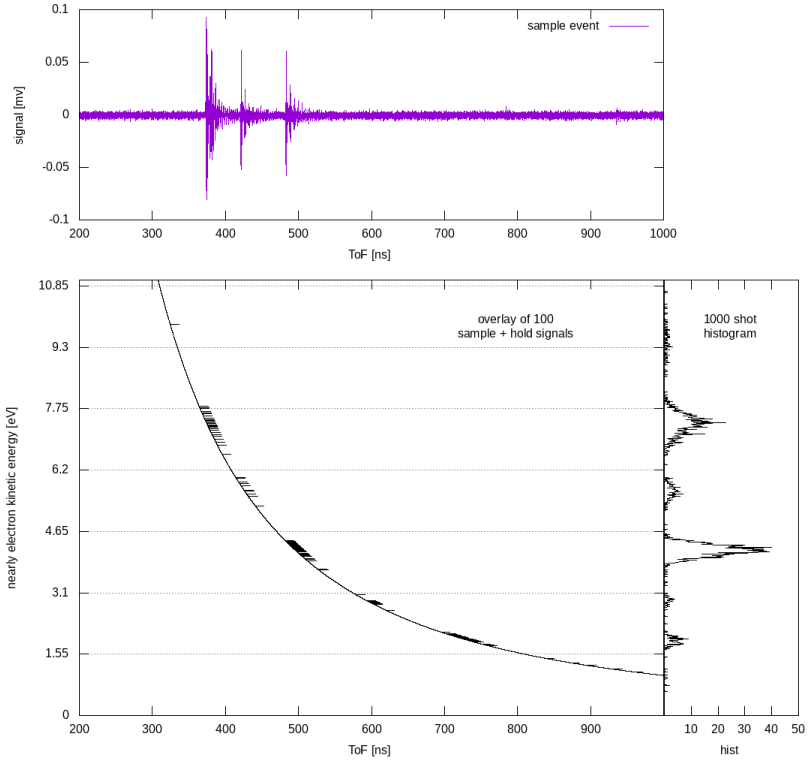
Ultrafast artificial intelligence at the Edge



Non-linear Time-to-analog conversion logic. The top panel shows a few-hit single shot, central demonstrates the non-linear voltage ramp used for the “sample and hold”, and the right panel the resulting histogram.

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Scientific Achievement

Analog signal processing that directly feeds sub-20 microsecond latency machine learned identification of desirable x-ray SASE sub-structure.

Significance and Impact

Analog signal processing transforms detector signal to ideal ML-model input.

FPGA-based inference neural network for autonomous decisions with 20 microsecond latency.

Research Details

- Initial test with surrogate HHG laser source and newly designed electron Time-of-Flight (ToF) spectrometer
- Analog signal processing that transforms raw Micro-channel plate (MCP) signals directly into the representation needed for the neural network.
- Shallow neural network for on-the-fly decision making that uses the 16-fold angular array of electron ToF spectrometers
- FPGA-based identification of the number of sub-spikes in SASE XFEL shots with decision times below 20 microseconds.

Next Steps

- Use 8-fold differential retardation to simulate angular streaking results.
- Measure linear streaking in PULSE lab with analog pre-processing circuit and on-digitizer FPGA neural network.
- Incorporate recently measured wave forms to benchmark inference fidelity in both over- and under-sampling regimes.
- Improve spike counting discrimination for high numbers of SASE sub-spikes.