Karlsruhe Institute of Technology

Institute for Data Processing and Electronics

A heterogeneous FPGA/GPU architecture for real-time data analysis and fast feedback systems

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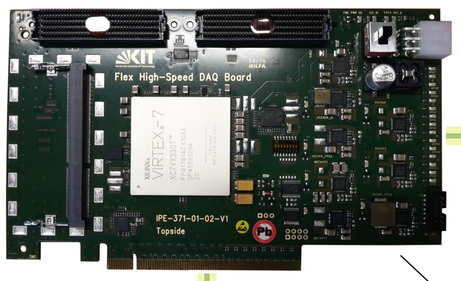
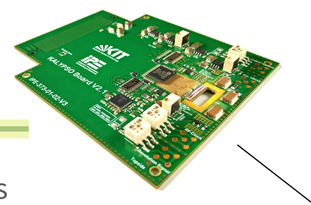
We propose a versatile and modular approach for a real-time data acquisition and evaluation system for beam diagnostic and photon science experiments. Our hybrid architecture is based on an FPGA readout card and GPUs for data processing. To increase throughput and reduce the FPGA is able to write data directly into the GPU's memory. Data analysis is handled transparently by our real-time capable processing framework which users can customize and extend.

FPGA-based data acquisition



PCIe 3.0 / 8 lanes
4 GB DDR3 RAM
Xilinx Virtex 7

"Hi-Flex" FPGA board

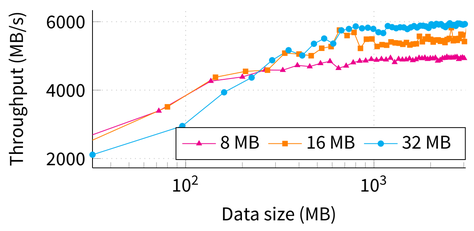


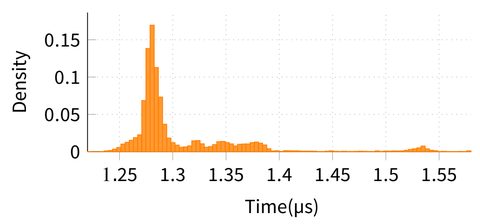
256 channels @ 2.7 MHz
1.5 GB/s throughput
Continuous acquisition

KALYPSO spectrometer

- Modern linear accelerators cause large data due to high repetition rates
- Real-time analysis is desirable but requires optimized acquisition and processing

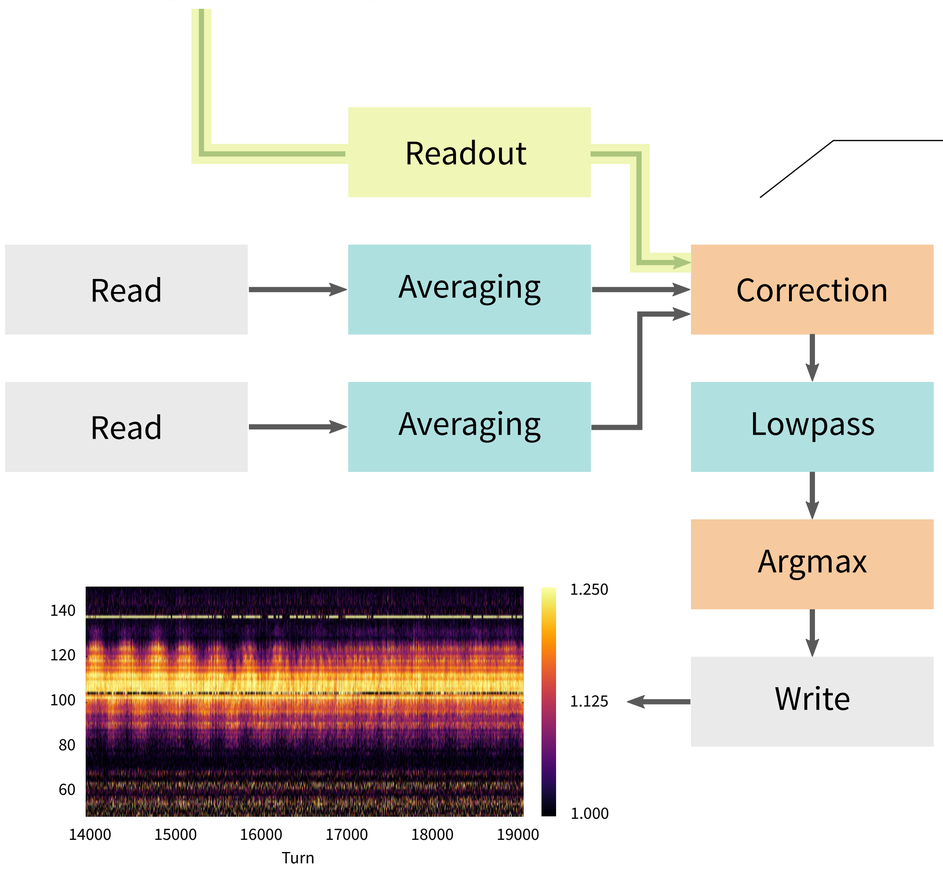
DMA data transfers using DirectGMA



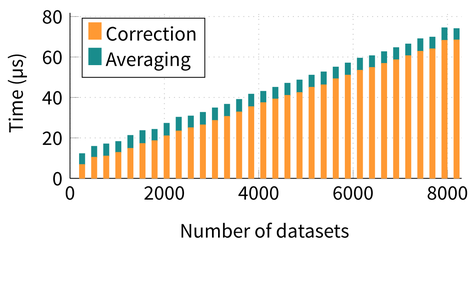


- AMD's DirectGMA technology provides mechanisms for direct writes from FPGA to GPU
- Avoiding system memory round-trips allows required latencies and fully utilizes PCIe bandwidth

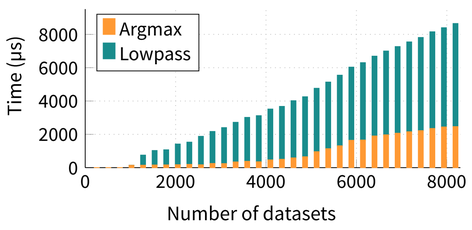
GPU data processing for KALYPSO



Real-time pre-processing



Subsequent analysis



- Heterogeneous computing using both multi-core CPUs and GPUs
- Exploits multiple levels of parallelism for high throughput
- Command line as well as programming interfaces (C, Python, …) available