SLAC CPAD RDC5 Activities & Interests

SLAC TID & FPD

06 October 2023

SLAC CPAD RDC5: At the DAQ Edge

At the DAQ Boundary

- Reliable UDP (RUDP) Network offload engine to support network attached devices (NAT)

- High bandwidth synchronous (timing & trigger delivery) & asynchronous fiber protocols for front end readout (PGP2,PGP3)

- HLS data processing cores for lossless data compression, lossy data reduction & triggering (nEXO, LDMX, HPS)
  - HLS based ML inference (HLS4ML + SNL)

- SLAC Ultimate RTL Framework (SURF):
  - Open source VHDL/Verilog framework for rapid FPGA/ASIC development using common generic, extensible libraries
  - Ruckus: Open source build system

At the Hardware To Software Handoff

- Open source DMA engine & associated driver for high bandwidth & high rate DMA transfer
  - Works both in amd64 & Zynq (SOC + RFSOC) platforms
  - Zero copy user space buffer mapping
  - Direct to GPU data transfer support

- Rogue: Open source Python/C++ hardware abstraction software for rapid readout development & test stand support
  - Easily integrated into back end DAQ systems
  - Balanced python (ease of use) and C++ (high bandwidth & high event rate) implementation

Direct to GPU DMA support in open source DMA Engine & Driver
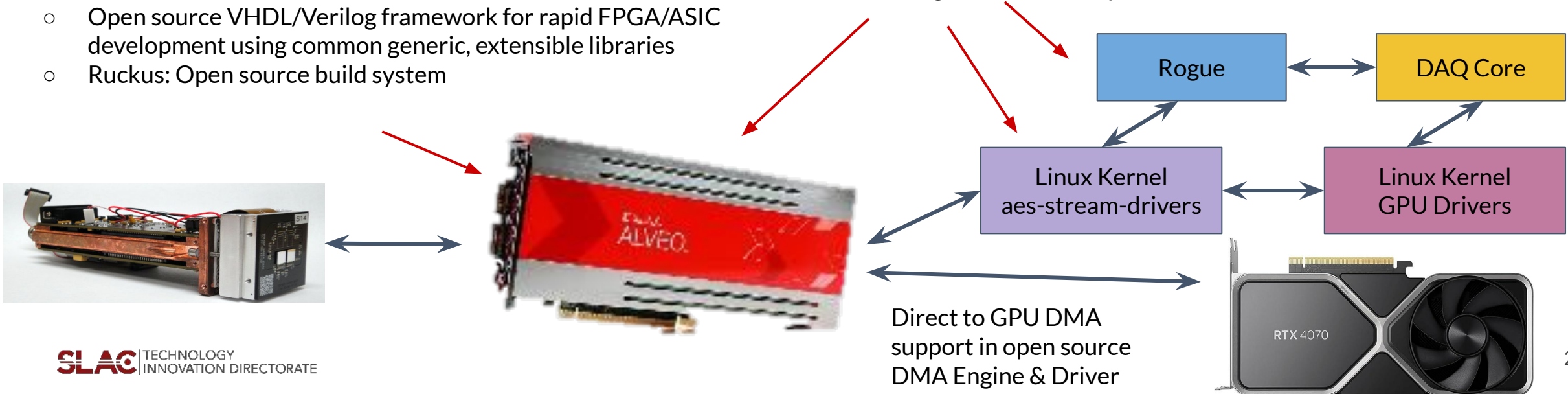
SLAC CPAD RDC5: At the DAQ Core

DAQ Core Data Processing

- Rogue can serve as a stand-alone solution for readout and data processing including event building, data reduction, online monitoring and run control
  - EPICS support currently provided via p4p library →C support under development
- LCLS provides hardware/software infrastructure for DAQ, data reduction, online monitoring, data storage that can process up to 1 TB/s of data
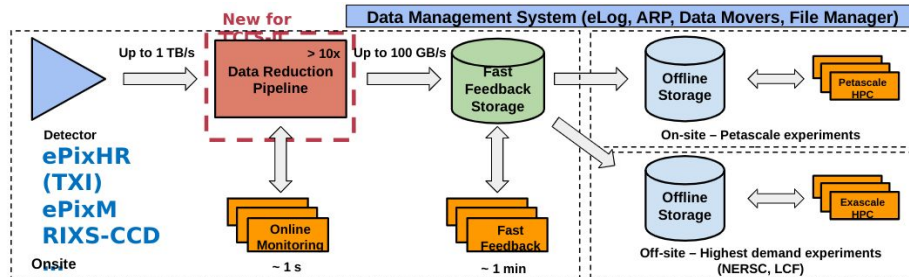
- PyDM: python based framework for control system graphical user interfaces
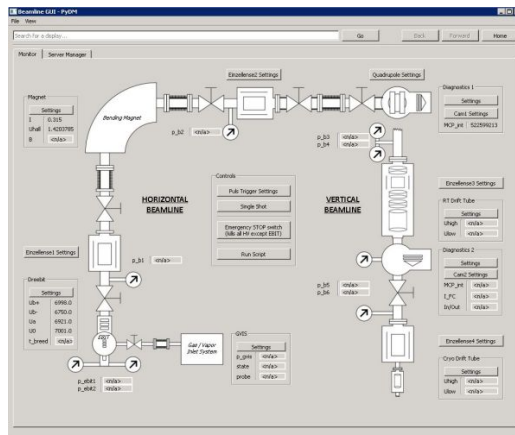
Back End DATA Processing & Data Management

- Rogue successfully integrated into several back ends including
  - CODA via readout list (HPS)
  - EUDAQ via producers (LDMX test beam)
  - OCS via agent (CMB-S4)
- Supporting data management strategies (catalog and registration development) for several projects including superCDMS, CMB-S4 and LDMX

SLAC | S3DF SLAC SHARED SCIENCE DATA FACILITY

- Data center optimized for data analytics and characterized by large, massive throughput, high concurrency storage systems that can scale to 100s of Petabytes
- Will support the large scale analytics pipelines for several programs including LCLS-II, UED, cryo-EM and Rubin.

DAQ Operation

- Exploring the use of AI to support DAQ operation including tuning of run-time configuration and using anomaly detection in data quality monitoring
  - Goal is to reduce shifter personnel and optimize efficiencies

SLAC | TECHNOLOGY INNOVATION DIRECTORATE

SLAC CPAD RDC5: Triggering

D. Rankin

Anomaly Detection Triggers: data-driven ML-based algorithms to trigger on unusual/outlier events
- Agnostic to specific BSM signatures,
- More "intelligent" algorithm could probe below current trigger thresholds
- Planned R&D ranges from software level to FPGAs and ASICs
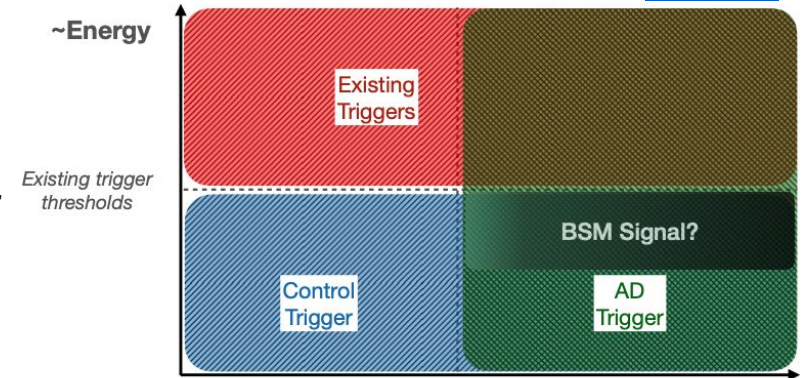
Low Latency AI algorithms in Collider Physics Hardware Triggers
- Algorithm development for collider applications, with recent / current work in jets, pileup suppression, flavour tagging, and muon reconstruction in Level 0 (HW) triggers
- Neural network implementations in HLS (recent contributions to HLS4ML: MLST 4 025004 (2023))
- Expect continued algorithm and applications development
- Interest in exploration of AI engines (e.g. Versal ACAP)