JLab LDRD2410 Quarterly Report FY24Q2

Proposal Name:
Streaming Readout Real-Time Development and Testing Platform

Report Date:
Apr. 2, 2024

Principal Investigator:
David Lawrence PhD

1 Work-scope Highlights

Work continues with progress towards multiple milestones. Some issues encountered that slowed progress in some areas. This results in some schedule lag, but no significant schedule risk at this time.

The major highlights are:

- Poster presentation at ACAT2024
- CLAS12 Data capture data verification
- GlueX EVIO raw data files split on rocid
- EVIO stand alone event aggregator
- Continued graph visualization and configuration
- Streaming of podio ePIC data

Ayan Roy produced a poster for the RTDP project which was presented at the 22nd International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT2024)[1]. The poster received positive attention during the event.

Figures 1 and 2 show some analysis of the data from the CLAS12 packet capture exercise. Figure 1 shows the packet payload amount in 1 second time bins for one of the four ports captured. This illustrates the benefit of capturing packets as opposed to simply recording payloads. The indicated beam trip is clearly seen as well as some additional spikes in the bandwidth. These types of fluctuations may be significant in complex streaming configurations where one or more components access limited resources. Figure 2 shows the extraction of some key values from the payload of the captured data for one of the ports. The histograms show probability densities that align with expectations. For example, the ADC spectrum with a peaking distribution and a long tail. Note that since the data was read in streaming mode, the extracted TDC times are all relative to a regular clock which should lead to a flat time distribution.

Details on additional highlights are given below in the section on Milestone Progress.

[1]RTDP at ACAT2024: https://indico.cern.ch/event/1330797/contributions/5796646/

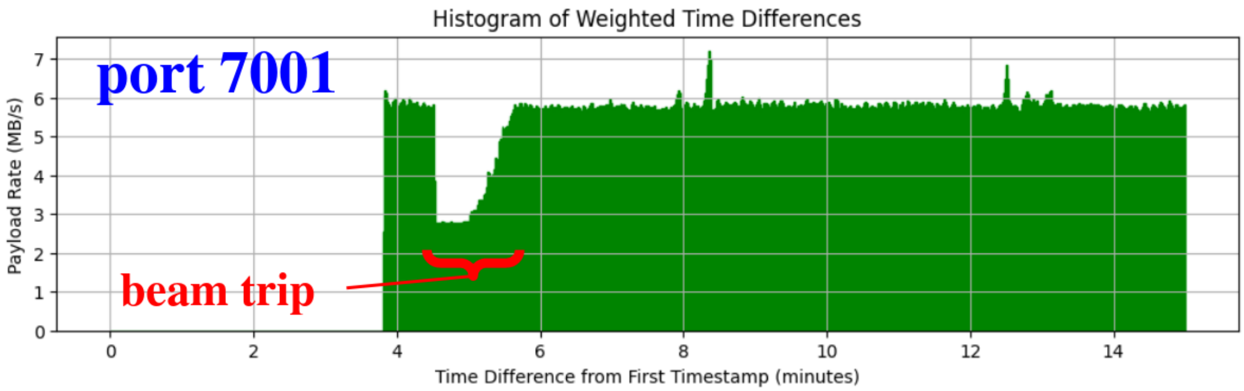

Figure 1: Histogram of data played back from packet capture exercise. Bins of 1 second were used and entries weighted by the size of the data packet. The marked location corresponds to when a beam trip occurred.

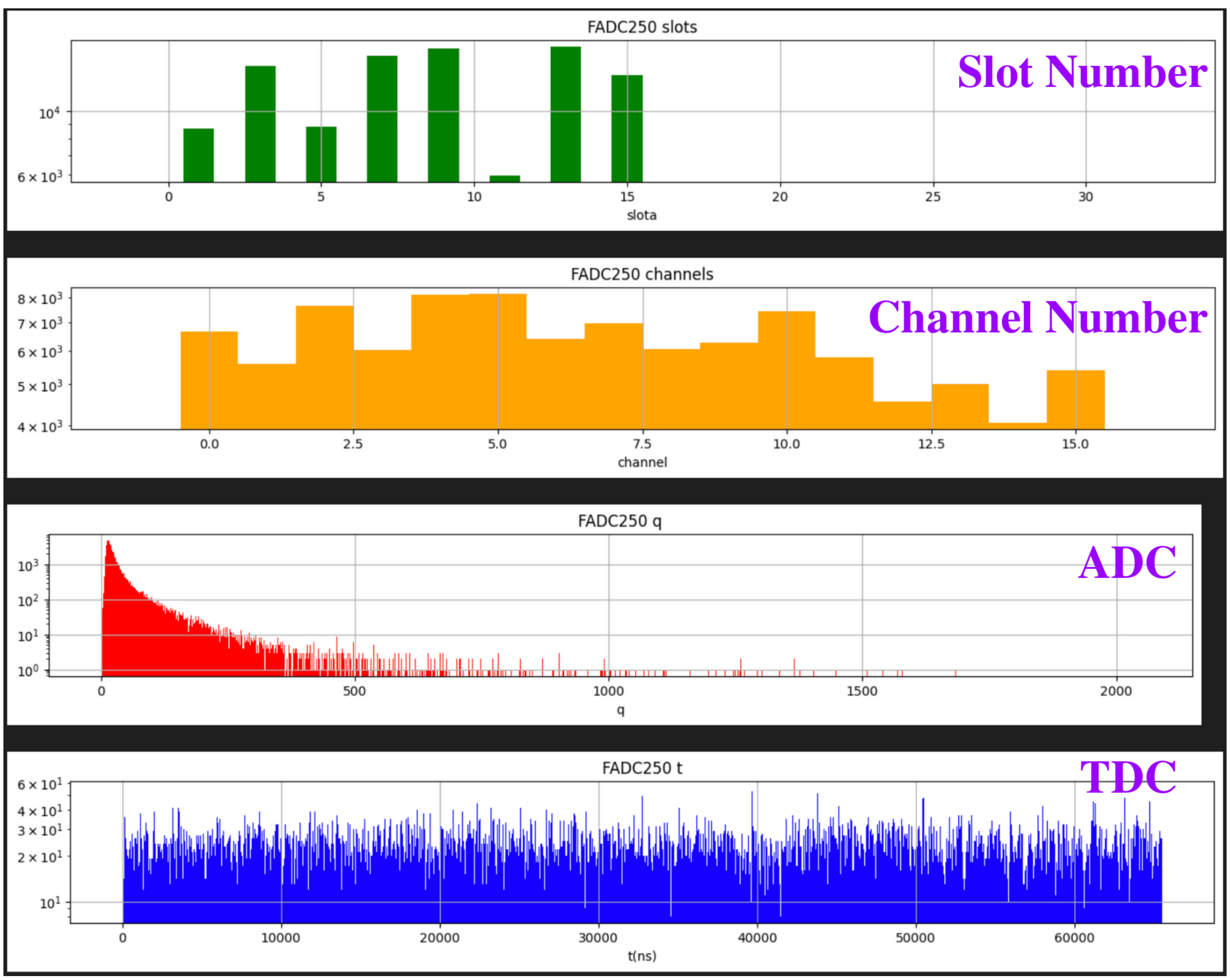

Figure 2: Histograms of values extracted from data gathered during the packet capture exercise. Population densities align with expectations for this data.

2 Milestone Progress

Table 1 shows the status of the FY24Q1-2 milestones. Five are completed, two are partially completed, and one has not been completed as originally envisioned.

For milestone M01 we have completed preliminary examples of configurations. These do not have the complexity of configurations starting at the VTP level so cannot be considered full scale. Such full scale configurations are of limited use without the corresponding software modules they describe being available to test them with. Implementation of the stand-alone aggregator has been an unexpected delay in getting these modules in place which, in turn, has propagated to delays in fully completing M01.

For milestone M02 we transferred a small amount of some data from the SAMPA setup in the INDRA to the EJFAT cluster in the Data Center. The data was generated from a pulser and is therefore of less interest than the real data already collected from CLAS12.

For milestone M05 we investigated splitting the HIPO formatted data from CLAS12 by rocid into streams corresponding to the VTP modules they originated from. It turns out that part of the conversion process to HIPO includes application of the translation table and simultaneous dropping of the DAQ coordinates (including rocid). We investigated the original EVIO raw data which still had the rocid values but ran into some issues with the format not closely adhering to the documented CODA standard[2]. Work on this was pivoted to use GlueX raw data instead which was more familiar to the PI and known to adhere to the standard. Small modifications to EVIO v4.3 were made to allow modern compilers and build tools (cmake) to be used. This was tagged as EVIO 4.3.1 and used with the evio splitter program to generate individual files for each rocid encountered in the raw data input file.

For milestone M06 a stream splitter based on DAQ hardware components is not possible at this time due to a lack of a translation table for the ePIC detector. While the DAQ and Streaming working groups collectively are making progress in the overall design, it is unlikely that such a table will become available before the end of this project. What has been done, however, is a prototype streaming system for the existing PODIO formatted ePIC simulation data. This allows a single PODIO file to be dynamically broken into blocks of events and distributed to multiple clients that are then able to process them using the ePIC reconstruction code. Thus, a single file is split into multiple streams, but they are based on event or time slice boundaries as opposed to DAQ coordinate boundaries. This will be sufficient to serve the purposes of RTDP development over the course of the LDRD project.

Milestone M07 is intended to provide a software VTP module that could feed data from a file source in a format matching what an actual VTP module would produce in a live experiment. This, coupled with M08 would provide multiple, synchronized streams in an offline software environment that mimics the streams from the hardware online environment. Actual raw data split using the tool from M05 would automatically satisfy this since it would already contain buffers exactly as they were sent from a VTP. The more complicated task is to convert simulated data using an inverse translation table into VTP format. The work has been largely completed for the raw data part but has not started for the simulated data part.

Milestone M08 simulates the functionality of various streams within the simulated VTP by simultaneously sending packets to the destination machine. As part of this milestone, an orchestrator program will initiate the different emulated VTPs mentioned in M07 at a specified target time. These emulated VTPs then proceed to read events from an EVIO file (as detailed in M05) and initiate the transmission of data to the target machine. The development work has been successfully completed and tested using example executables. An orchestration script employing parallel SSH has been utilized as the orchestrator, enabling the synchronized triggering of emulated VTPs at the designated target time.

[2]see https://coda.jlab.org/drupal/system/files/eventbuilding_7.pdf

ID	Task	status	Comments
M01	Create prototype ERSAP configurations for INDRA and CLAS12 test systems	■	A CLAS12 example and "Hello World" example have been placed in Github. INDRA has not been done yet.
M02	Identify or capture SRO formatted data from CLAS12 and INDRA test systems with data tag/filtering capability (output data ready for further offline processing)	✓	Data was captured at various beam currents from CLAS12 on Dec. 17. INDRA data capture done using pulser inputs to SAMPA setup.
M03	Evaluate existing solutions for configuring and launching remote distributed processes	✓	see evaluations in document on EPSCI wiki.
M04	Establish code repository(s), project site, and method of documentation	✓	This has been done here: https://github.com/JeffersonLab/SRO-RTDP
M05	Create stream splitter program for EVIO or HIPO data formatted files	✓	Created for GlueX. (See text for details on HIPO)
M06	Create stream splitter program for simulated data in PODIO for ePIC	■	Created podio streaming prototype. Large scale testing is pending.
M07	Create VTP emulator using files produced by stream splitter	■	Mostly done for raw data. Not started for simulated data.
M08	Create controller program to synchronize multiple VTP emulators	✓	Satisfied through alternate design using synchronized system clocks.

Table 1: FY24Q1 and FY24Q2 Milestones

3 Budget

Figure 3 shows the project spending as of the end of FY24Q2. This is considered on track with the project expectations.

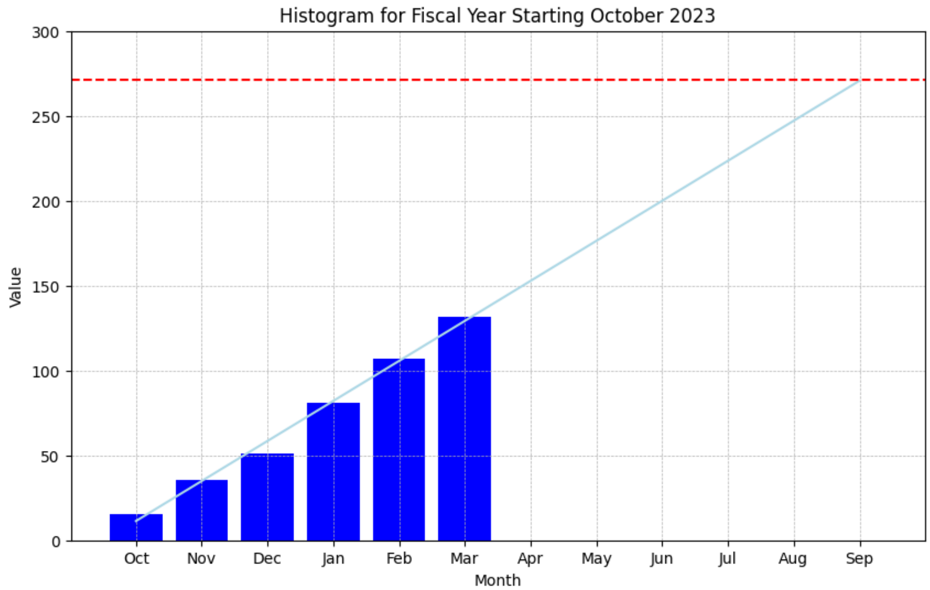

Figure 3: LD2410 Project Spending through FY24Q2. Values are in $K.

4 Concerns

Minor concern over schedule slippage due to some external software components not being available. These are being worked through but if additional,similar roadblocks are encountered, schedule adjustments may be needed.

Acknowledgements

The research described in this report was conducted under the Laboratory Directed Research and Development Program at Thomas Jefferson National Accelerator Facility for the U.S. Department of Energy.

Appendix: Full Project Milestones

- **Y1Q1**
  - M01: Create prototype ERSAP configurations for INDRA and CLAS12 test systems
  - M02: Identify or capture SRO formatted data from CLAS12 and INDRA test systems with data tag/filtering capability (output data ready for further offline processing)
  - M03: Evaluate existing solutions for configuring and launching remote distributed processes
  - M04: Establish code repository(s), project site, and method of documentation
- **Y1Q2**
  - M05: Create stream splitter program for EVIO or HIPO data formatted files
  - M06: Create stream splitter program for simulated data in PODIO for ePIC
  - M07: Create VTP emulator using files produced by stream splitter
  - M08: Create controller program to synchronize multiple VTP emulators
- **Y1Q3**
  - M09: Determine appropriate schema for all aspects of monitoring system.
  - M10: Establish databases for monitoring system using existing JLab servers.
  - M11: Integrate Hydra as monitoring component.
- **Y1Q4**
  - M12: Integrate off-line data analysis framework into platform for CLAS12 data
  - M13: Integrate off-line data analysis framework into platform for ePIC or GlueX simulated data
  - M14: Integrate example JANA2 analysis into platform
- **Y2Q1**
  - M15: Create configurable CPU proxy component
  - M16: Create configurable GPU proxy component (hardware and software)
  - M17: Create configurable FPGA proxy component (hardware and software)
  - M18: Create functioning hardware GPU component (e.g., CLAS12 L3)
  - M19: Create functioning hardware FPGA component (e.g., ML4FPGA)
- **Y2Q2**
  - M20: Impose artificial time structure on stream sources to mimic beam-like conditions
  - M21: Configure simulation of full SRO system using existing JLab hardware resources
- **Y2Q3**
  - M22: Establish working test of system that transfers ¿=100Gbps from CH to compute center
  - M23: Establish working test of system that includes GPU component for portion of the stream
  - M24: Establish working test of system that includes FPGA component for portion of the stream
  - M25: Test system with remote compute facility (e.g., BNL or NERSC) at limits of available resources
- **Y2Q4**
  - M26: Configure system that results in stream(s) being received by JLab from external source
  - M27: Collaborate with HPDF group to evaluate processing SRO data at JLab for external experiments
  - M28: Complete documentation for platform to be used by non-experts