



Report from the DAQ and Data Pre-processing Group

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Scope of the Working Group

- Prepare the infrastructure for the efficient collection of high quality data with ICARUS and SBND
- Facilitate the adoption of common strategies whenever possible and make each other aware of the differences demanded by the peculiarities of the two detectors
- Coordinate common efforts of the two experiments and maintain the relevant interfaces to experiment-specific and common working groups

Summary of the common efforts

- PMT readout
- CRT readout
- White Rabbit timing system
- DAQ dataflow software and event-building
- DAQ hardware and infrastructure
- Run control and process management
- Operational monitoring and logging
- Online databases
- Online data management
- Online data quality monitoring

PMT Readout

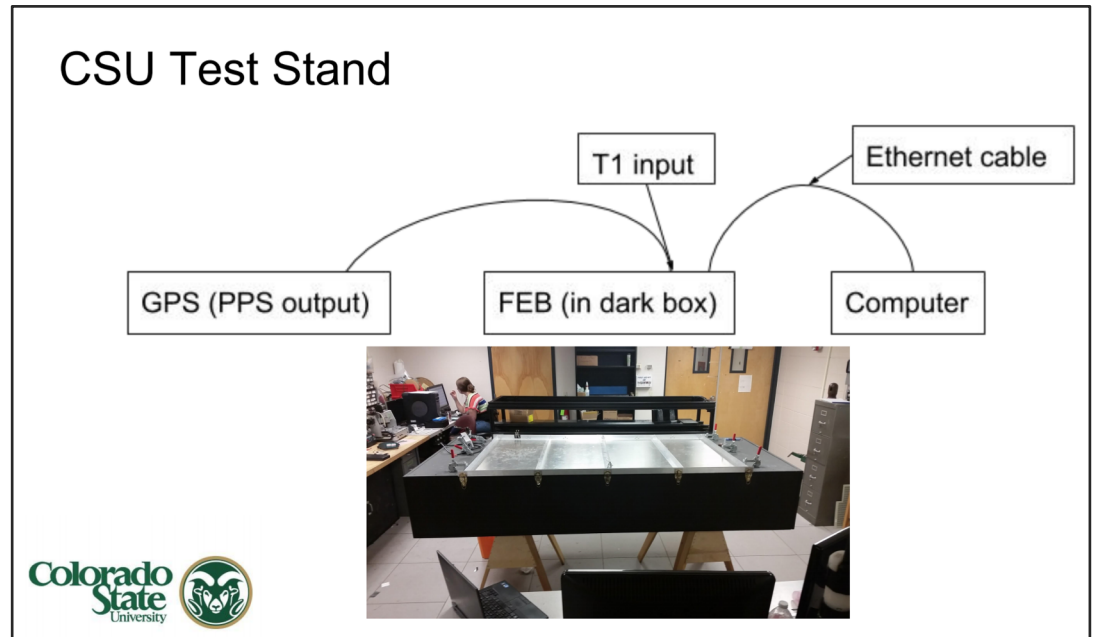
- ICARUS and SBND use common readout electronics for most of their light collection systems
- Developing common readout software to configure and collect data and interface to external trigger boards
 - Recent updates include multi-threaded readout and data packaging to reduce latency
 - Adding more configuration options extending existing interfaces
- Critical to incorporate readout in real systems!
 - CERN test stand for ICARUS
 - CAPTAIN-Mills experimental run at LANL for SBND



CAEN V1730

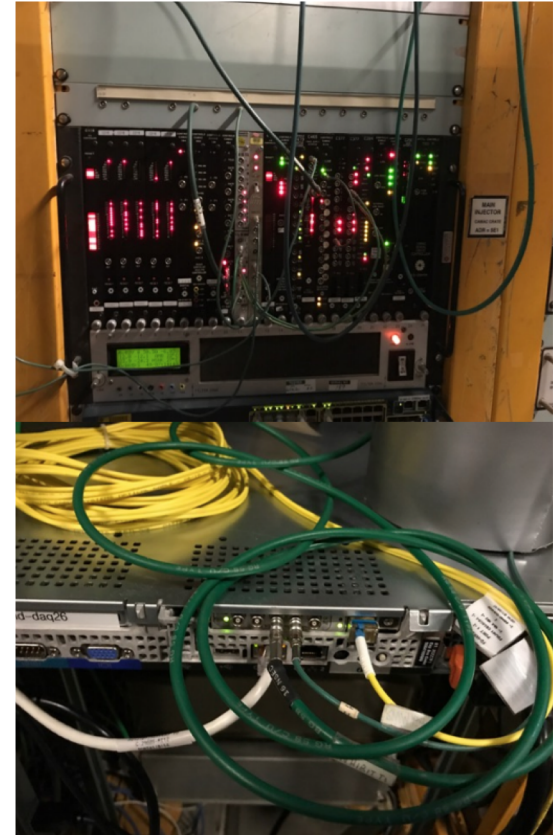
CRT Readout

- ICARUS and SBND use common readout electronics for most of their CRT systems
- The same electronics are used in MicroBooNE, which has fully developed a standalone DAQ system and software to include data with the TPC
- Common effort to further develop and incorporate the readout software with the goal of online inclusion of data
- Work ongoing at teststands at Fermilab (DAB) and CSU



Timing system

- Development of a common timing system based on "White Rabbit" to deliver timing and beam signals to the experiments
 - High precision with measurable latencies
 - Also allows synchronization of electronics to common time reference
- WR Network installed at MI-60 (NuMI), MI-12 (BNB), and detector halls with initial tests performed
- Further firmware development and design underway to provide signals with greater precision and integrate with all detector components



WR node at MI-12 (BNB)

DAQ dataflow and event-building software (1)

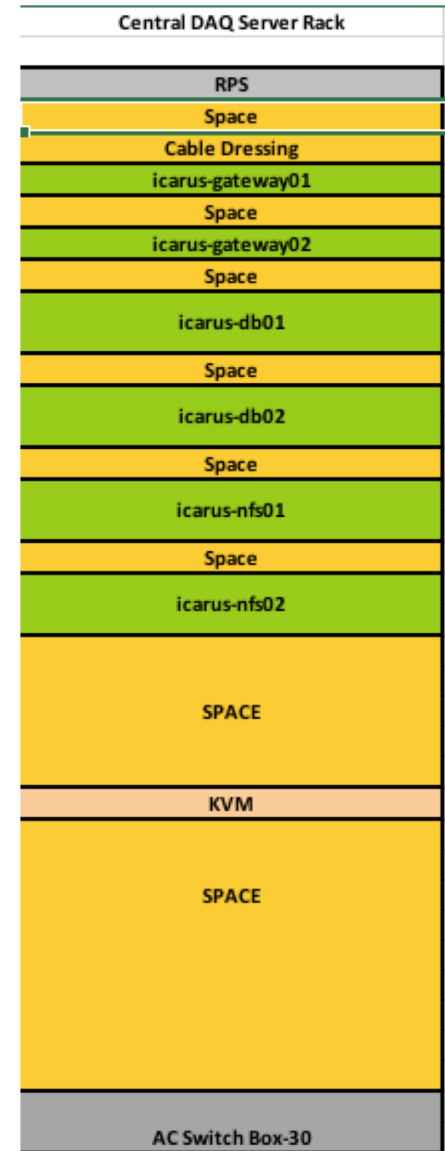
- Both experiments will use the common *artdaq* framework for DAQ software
 - Common interfaces for collecting data from hardware and transporting data to event-builder, data-logging, and online monitoring processes
 - Configurable/flexible options allow use for both experiments across all subsystems
 - Developed and supported by Fermilab SCD
- Additional software components as necessary
 - Example: common software-based trigger inhibit system

DAQ dataflow and event-building software (2)

- Infrastructure for supporting hardware interfaces is in place and allowing development of readout software
- Real tests of the entire software stack at SBND vertical slice test (VST) and protoDUNE single phase
 - SBND VST was able to run, but highlighted many limitations and issues in the software
 - Early protoDUNE testing saw similar limitations and issues
 - Prompted rapid development and debugging from the *artdaq* team that has been largely successful
 - Newer test releases of the software have achieved stable running at protoDUNE at similar or higher trigger rates and event sizes
 - Recent runs at ~40 Hz trigger rate with ~70 MB/event
 - Includes successful incorporation of software trigger-inhibits
- Release for SBN in preparation to serve as a baseline for future DAQ work

DAQ hardware and infrastructure

- Where relevant, looking to make common plans for DAQ server racks and DAQ servers
 - Common tools and considerations for rack designs
- Fermilab experts coordinating and performing stress tests of servers to determine maximum power requirements
- Disk-writing tests on Fermilab this past summer show ICARUS candidate central servers will meet specifications
 - Up to ~400 MB/s writing speeds!



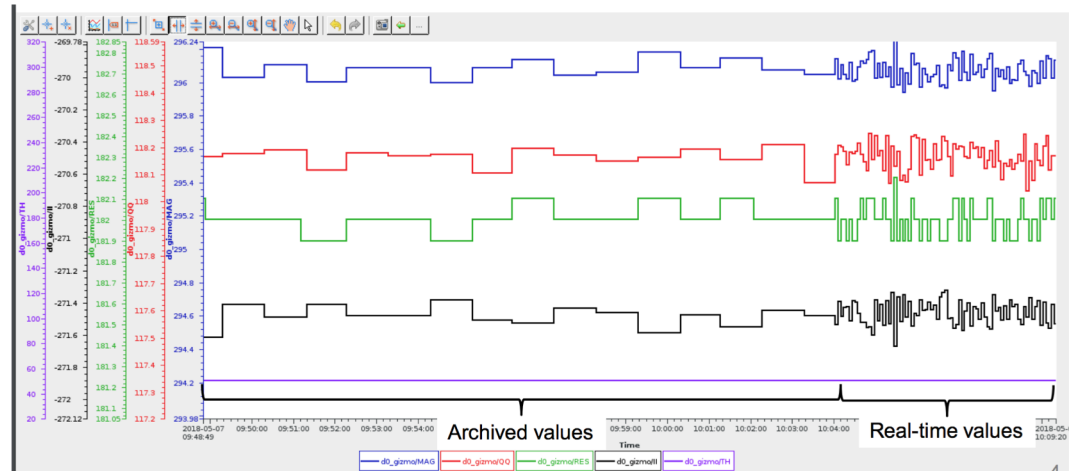
*ICARUS Central DAQ
Rack example*

Run control and process management

- Because ICARUS and SBND will use the same underlying DAQ software framework, they can use the same software for control and management of all the processes
- *artdaq* software includes low-level interface to DAQ processes, but no “pretty” run control layer exists yet
 - Experiments have typically used the low-level interface directly (like 35ton and SBND VST), or interface a high-level software package (protoDUNE SP)
- We want to design and develop a high-level interface for SBN to make the control of the detector simple and similar, with the goal to make shift-taking easy and as common as possible

Monitoring (1)

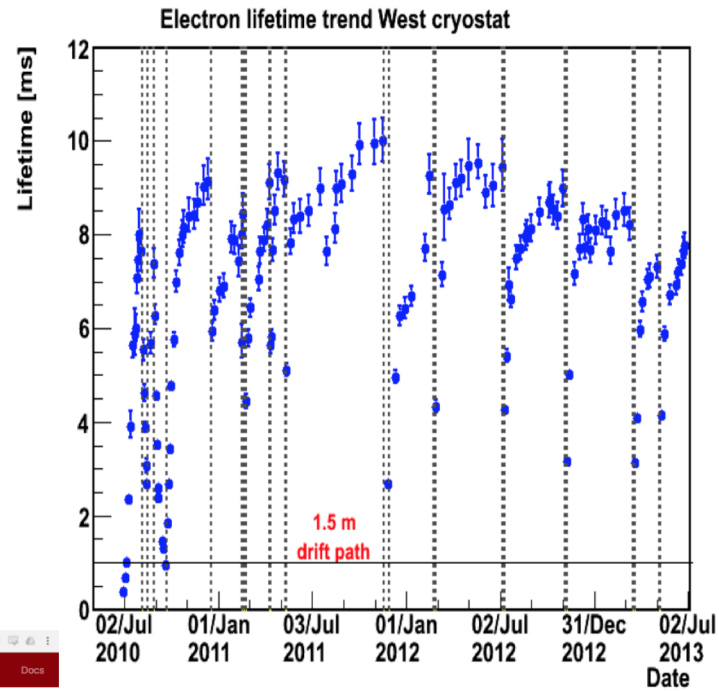
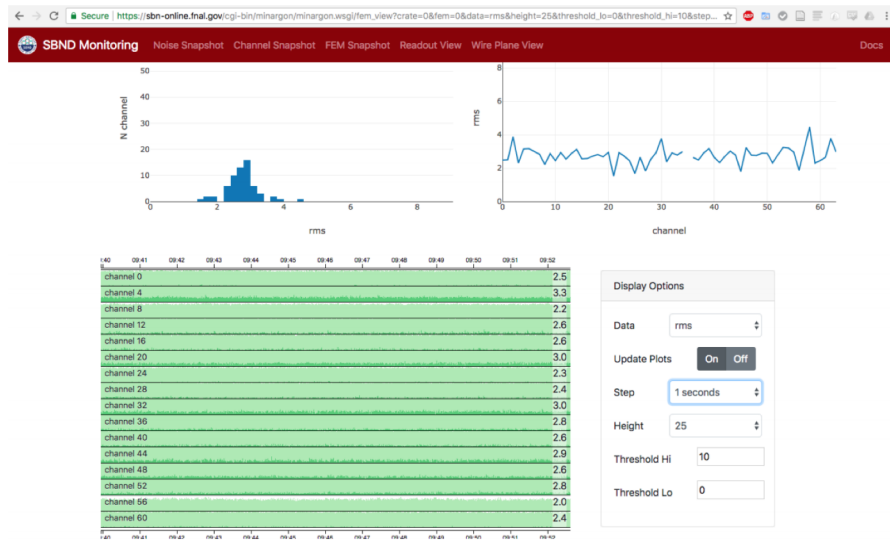
- Again, given that both experiments will use the same frameworks for DAQ and slow controls software, they can benefit from shared monitoring software
- Operational monitoring of the DAQ processes and dataflow is available from a “metric” interface in *artdaq*
 - This allows the collection and sending of monitoring information to configured receiving software
- Data can be sent directly to EPICS and integrated with the rest of the slow controls and alarming system
 - Additional needs will be studied, with a range of options already identified if needed



Example CSS display

Monitoring (2)

- Monitoring of the data quality in real/near time is essential to successful operation of the detectors
- Members of the experiments have shared their experiences to help co-develop common tools for measuring noise, purity, and other essential quantities



Purity monitoring from ICARUS, JINST 9 P12006 (2014)

- artdaq* provides for sending of data to online monitoring processes that can run *LArSoft* algorithms to analyze data
- Processing and web-based display developed and applied in SBND VST → improving that to be used for the experiments

Sample monitoring page from SBND VST

Online databases

- Working with Fermilab to coordinate the tools and infrastructure to support various online databases
 - Hardware and mapping
 - Slow controls archiving and alarming
 - Run configuration and run history databases
- An important near-term task is to design and develop an "event-by-event" database to aid in data monitoring and bookkeeping
 - Used to great extent by ICARUS on LNGS run
 - Additional tables could be of significant use for data management, monitoring, and other tasks

Online data management

- Once data is written to local disks on DAQ clusters, need processes to send data for permanent storage at Fermilab and other offsite locations
- Common Fermilab-based tools can be used to ease development and support for these processes
- First iteration of tools developed for SBND VST (inheriting also from LArIAT) to send data out → ***expect to hear about it at an upcoming SBN DAQ and data pre-processing meeting!***

Looking ahead

- The group has been very successful as a place to share ideas, software tools, and results of tests on areas of common effort
- As we rapidly near the commissioning and operation of the detectors, it will be critical to develop and improve these tools together to reduce replication of effort and produce the best possible system for the whole SBN program
- Following the model of the joint SBN analysis workshops, we are thinking to propose a similar joint workshop to be planned for the online software development
 - We hope this can occur before the end of the calendar year
 - We want to bring in new people to work on all of these items
 - *We very much would appreciate your feedback on this idea!*



Thank you!

Meeting times: every third Monday at 10:30 FNAL, 17:30 Europe

Email list: sbn-online@listserv.fnal.gov