



ICARUS DAQ: Status and Plans

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for the ICARUS DAQ Working Group

Outline

- The Data Acquisition Working Group, together with the common SBN Data Acquisition and Pre-Processing Working Group covers a broad range of responsibilities, including
 - Readout of the detector electronics, from the TPC, PMT, and CRT subsystems
 - Configuration and control of the data acquisition system
 - Interface with the Trigger and Timing systems for configuration, control, readout, and event synchronization
 - Online monitoring of data quality
 - Transfer of data to permanent storage

DAQ Software Framework

- ICARUS DAQ software uses the *artdaq* DAQ software framework developed and supported by Fermilab Scientific Computing Division
- Key improvements and feature additions in *artdaq* have been made at the request of SBN and other experiments
 - Greater flexibility in sorting the data collections in final output files to aid offline reconstruction passes
 - Full support for “BoardReader” software processes to send data collected from multiple unique hardware components
 - Control of DAQ processes without using MPI
 - Improvements in configuration database management

TPC DAQ

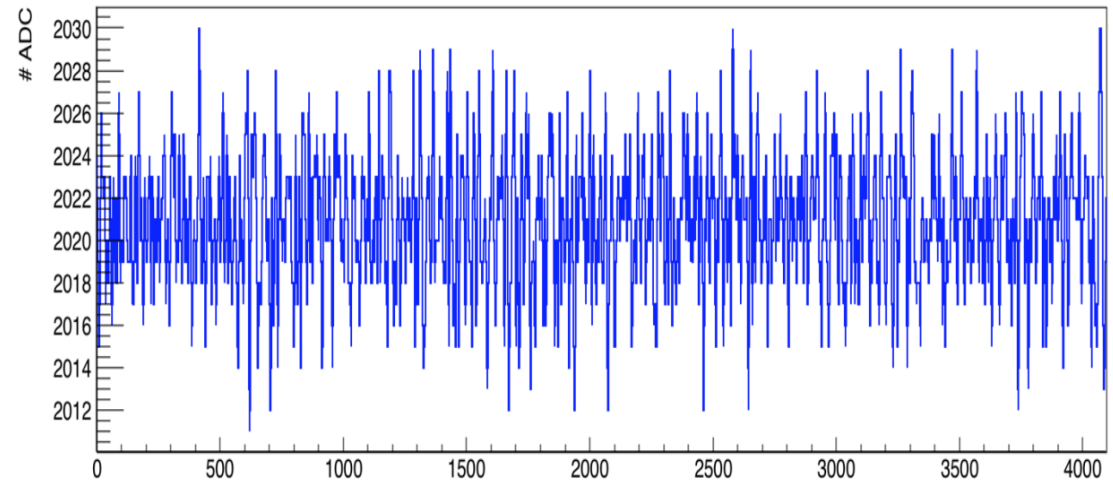
- TPC “Vertical Slice Test” of readout has been operating since this summer to support electronics testing and installation
- Running of the system has helped with improvements to the readout configuration
 - Proper extraction of front-end board number from data headers
 - Proper reset of buffers between successive runs
 - Improvements in the data handling
- DAQ handling throughput in excess of expected trigger rate (>1 Hz), even without data compression from readout boards
 - Data compression will be necessary in consideration of final network bandwidth and data storage

TPC Vertical Slice Test



Example Waveform
(*RMS ~3.1 ADC counts*)

C. Farnese, DocDB 12393



time samples (400 ns)

Y.T. Tsai, ICARUS Technical Meeting

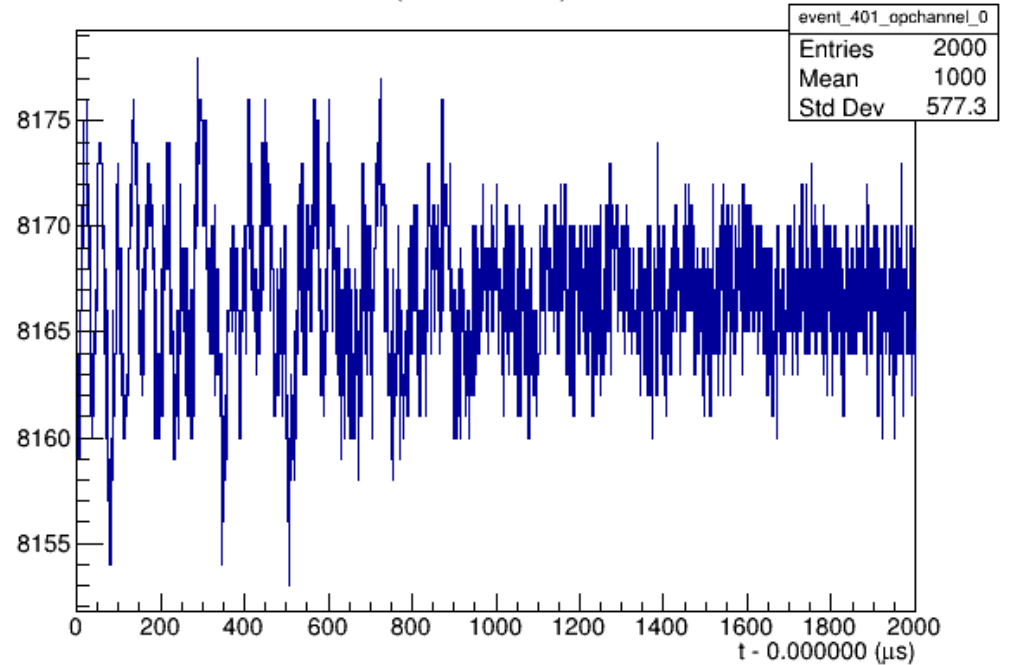
PMT DAQ

- PMT DAQ development has continued in collaboration with SBND using test-stand at DZero Assembly Building
- Recently, PMT “Vertical Slice Test” also established at ICARUS building, with first data-taking and readout in the past months
- DAQ software proven to operate at near maximum bandwidth of the CONET-2 links (80 MB/s), with detailed time synchronization tests from SBND
 - This includes simulation of the beam spill structures in readout configurations
- There are many available configurations for event-building and readout triggering conditions

PMT Vertical Slice Test



Waveform (Channel0) without LED



from A. Chatterjee

CRT DAQ

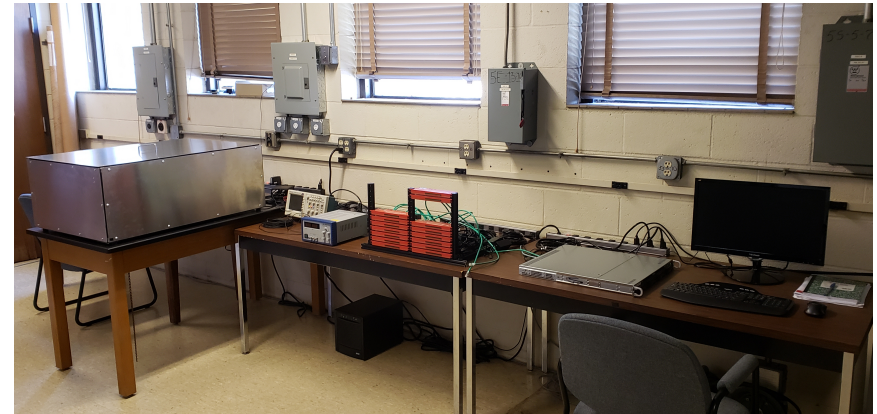
- With respect to the DAQ, the CRT has two types of readout electronics to consider:
 - Bottom panel use the “Double Chooz” electronics, also used by the ProtoDUNE Single Phase detector (R. Howell)
 - Side and top panels use the CAEN electronics originally developed by Bern, and are in common with SBND (A. Aduszkiewicz, C. Hilgenberg, T. Boone, U. Kose, ...)
- Readout strategy has been defined for both systems to collect a continuous stream of data and respond to requests for data within a window around a trigger time
 - Readout mode fully supported by *artdaq* framework
 - Development of *BoardReader* software over the summer to start simplifying the readout code continues
- Have held multiple tutorial sessions to build more involvement

CRT DAQ Teststands

- Have many operating teststands to support needs for testing and development



University of Houston



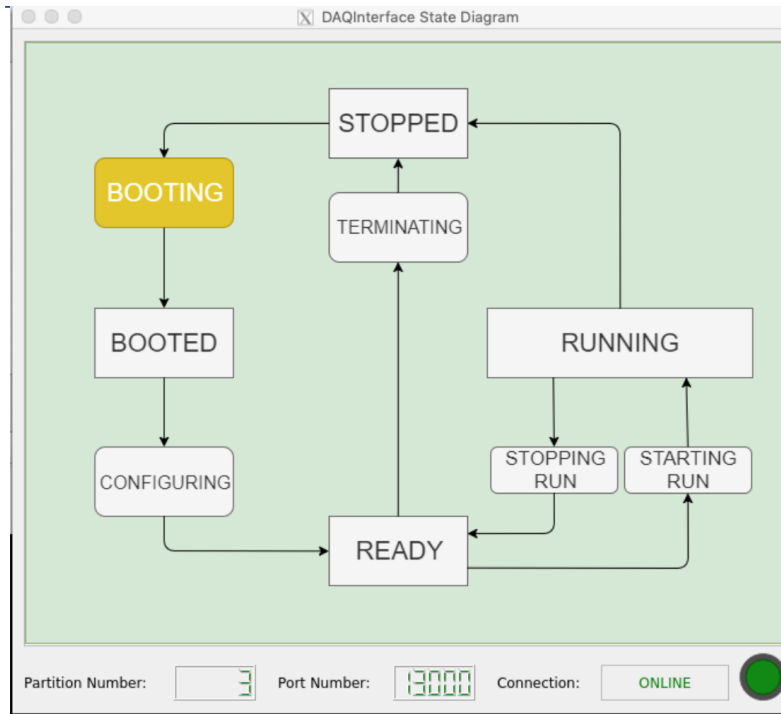
Wideband @ FNAL

Configuration and Control

- We are utilizing tools common to *artdaq* and SBN for configuration and control of the DAQ
- Configurations are managed through *FHiCL* files, and stored in an online unstructured database
 - Dedicated scripts will need to be written to transfer to offline databases
- Run control interface developed with SBND collaborators to provide a shifter-level Graphical User Interface

Run Control Interface Screenshots

Control starting processes...



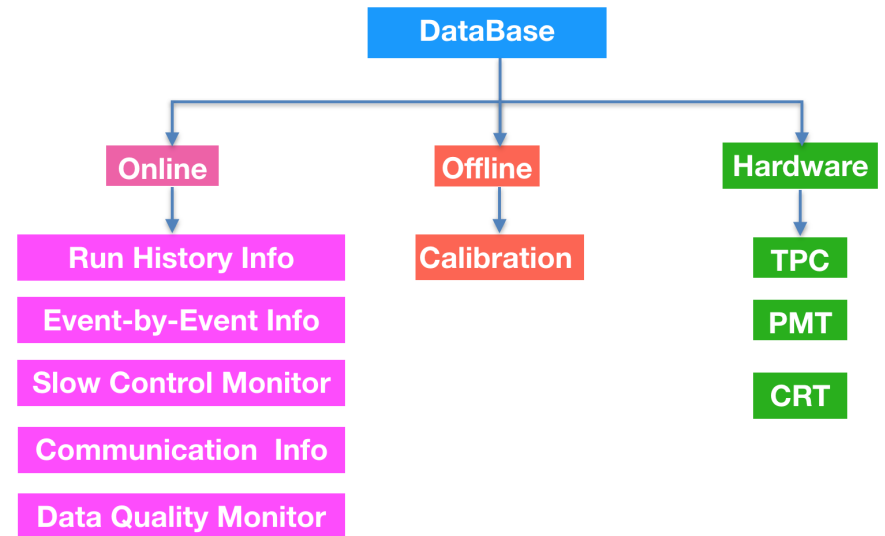
DAQ ready to begin run



I. Icaza Astiz and E. Cristaldo (SBND),
DocDB 12822

Online Databases

- Scope of needs for online databases and interactions between them defined (effort led by B. Biswaranjan)
- Recent work mostly on hardware/mapping databases:
 - TPC hardware database tables are finalized and almost ready to fill the information.
 - Top CRT schemas migrate to postgresql database in next weeks
 - Side and bottom CRT tables are being finalized
 - Please check your inbox and send your comments and suggestions!

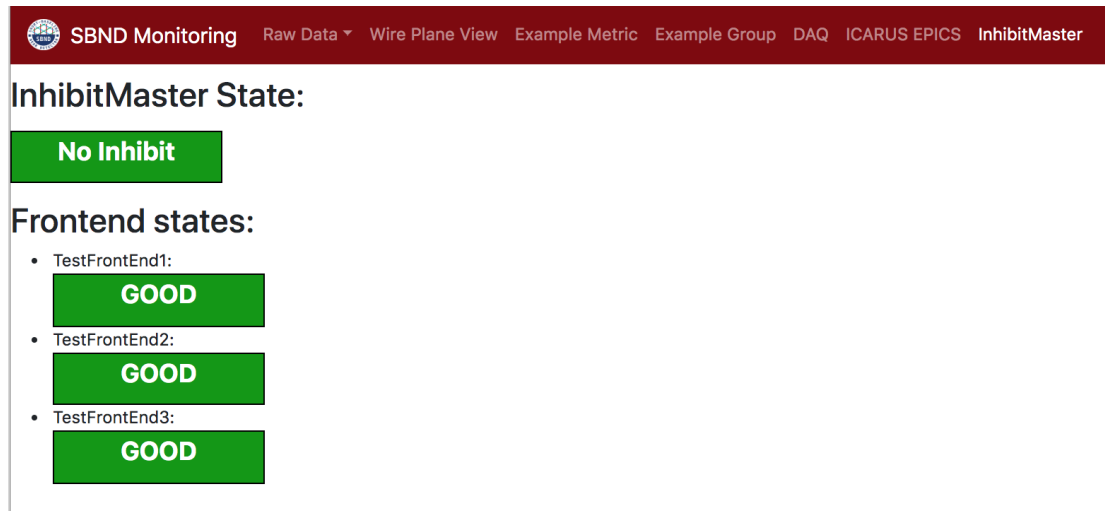


Interface to Trigger and Timing

- We will communicate with the Trigger electronics through UDP packets from a dedicated process (an *artdaq BoardReader*) in the DAQ system
 - This will allow the trigger system to be part of the larger state machine of the DAQ
 - The trigger software processes will be managed/controlled by the RunControl
 - There is sufficient flexibility to allow for modifying the necessary sequence of commands to be sent during configuration
 - This will allow data to be collected and associated with the detector data and monitoring streams
- There are existing UDP packet receivers in *artdaq* that we can modify to achieve this
- The interactions with the WhiteRabbit timing system will proceed in a similar fashion

Trigger Inhibits

- While we expect the updates to the electronics to allow for improved performance, we still would like a handshake process with the TPC readout buffers and Trigger to avoid triggering when we cannot take data
- An *InhibitMaster* process, utilized in protoDUNE SP, is being adapted for use in ICARUS and SBND
 - Status of inhibiting ready to be included in monitoring pages



The screenshot displays the SBND Monitoring web interface. The top navigation bar includes links for Raw Data, Wire Plane View, Example Metric, Example Group, DAQ, ICARUS EPICS, and InhibitMaster. The main content area shows the InhibitMaster State as 'No Inhibit' and the Frontend states for TestFrontEnd1, TestFrontEnd2, and TestFrontEnd3, all of which are 'GOOD'.

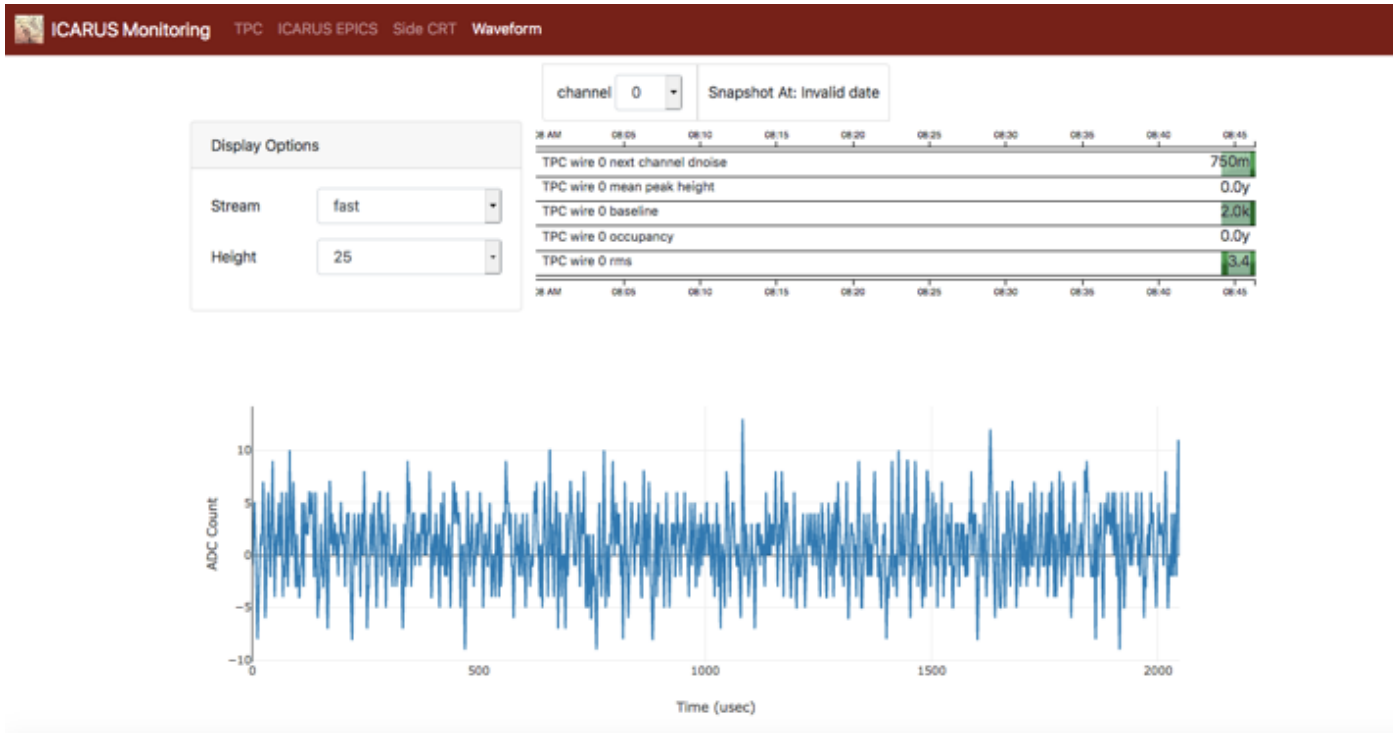
Component	Status
InhibitMaster State	No Inhibit
TestFrontEnd1	GOOD
TestFrontEnd2	GOOD
TestFrontEnd3	GOOD

Online monitoring

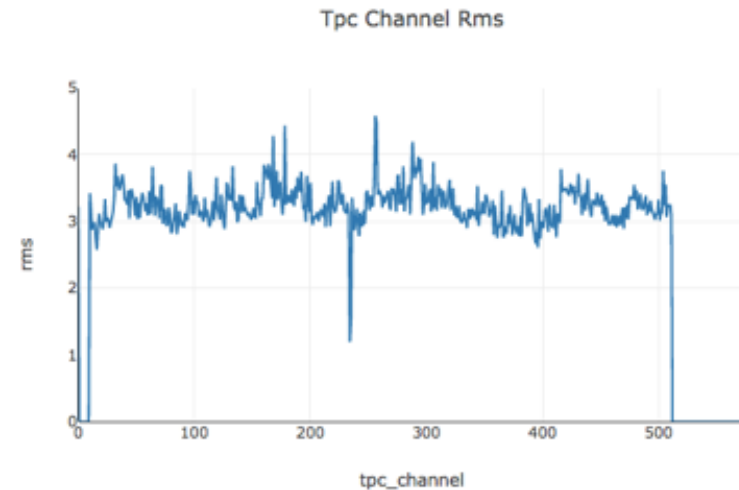
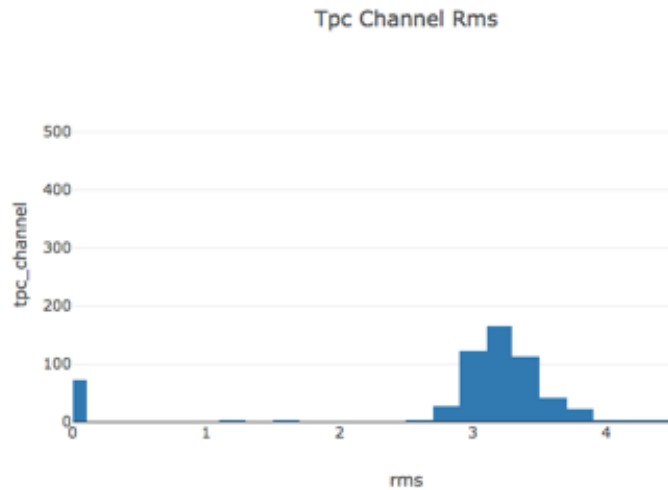
- We have made a lot of progress on filling out the online monitoring over the summer months
 - Much thanks to work from our summer interns (O. Bitter, F. Pucci), M. Betancourt, and G. Putnam from SBND
- Data is streamed to a process which can run both low and high level analysis in *LArSoft*, and then display results on webpage, via online in-memory database
 - J. Mueller working on process to archive values from that database to offline
 - K. Mistry (SBND)
 - Other common developments with SBND
- We have been using this system with the vertical slice tests to help provide immediate feedback on electronics testing

Online Monitoring: TPC

- TPC waveforms for each channel can be displayed
 - Pedestal and RMS values can update every few seconds
 - Can zoom in on parts of waveform, perform pedestal subtraction, and choose different channels to view
 - Purity information can be extracted from analysis of TPC tracks
 - Preliminary version being tested on simulated data
 - Expect an updated measurement every 5 minutes



Online Monitoring in the TPC Vertical Slice Test



Display Options

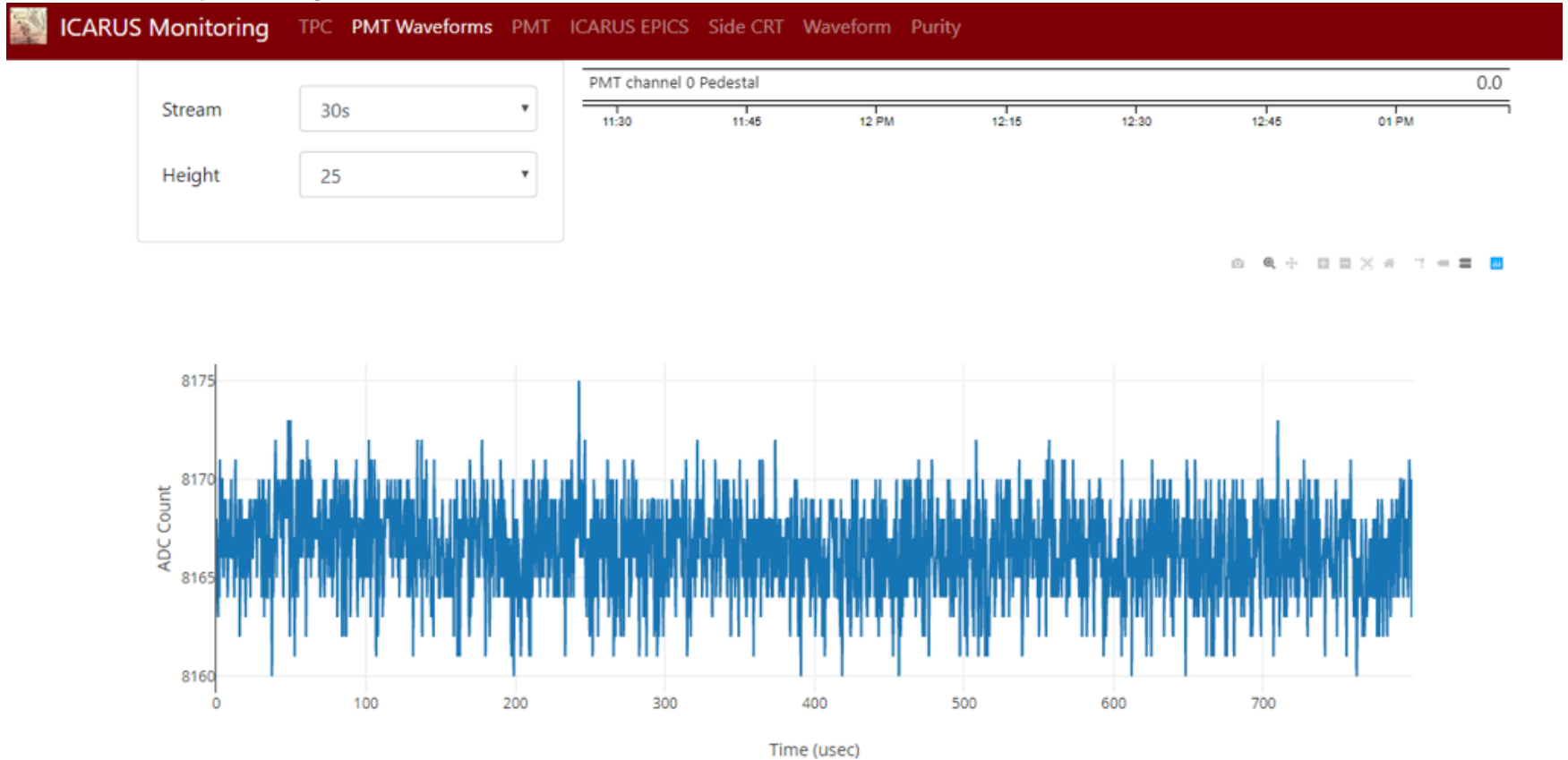
Data

Stream

Time	Value
08:05	TPC wire 0 rms 3.3
08:10	TPC wire 24 rms 3.5
08:15	TPC wire 48 rms 3.2
08:20	TPC wire 72 rms 3.3
08:25	TPC wire 96 rms 3.8
08:30	TPC wire 120 rms 3.6
08:35	TPC wire 144 rms 3.2
08:40	TPC wire 168 rms 2.9
	TPC wire 192 rms 3.3

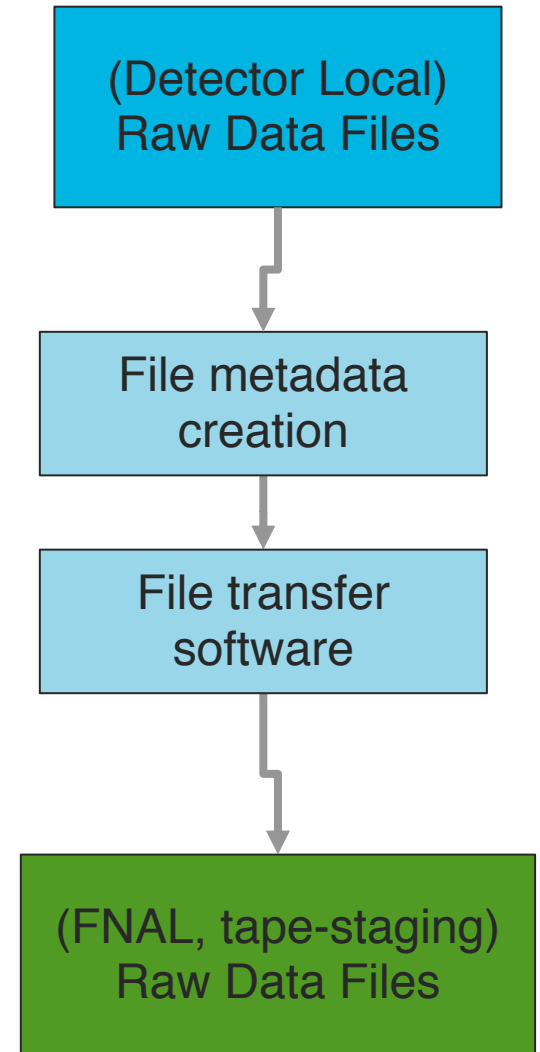
Online Monitoring: PMT Waveforms

- Many of the same tools immediately useful for the PMT monitoring
 - A. Chatterjee and C. Garces working to incorporate that more completely now: first tests below!



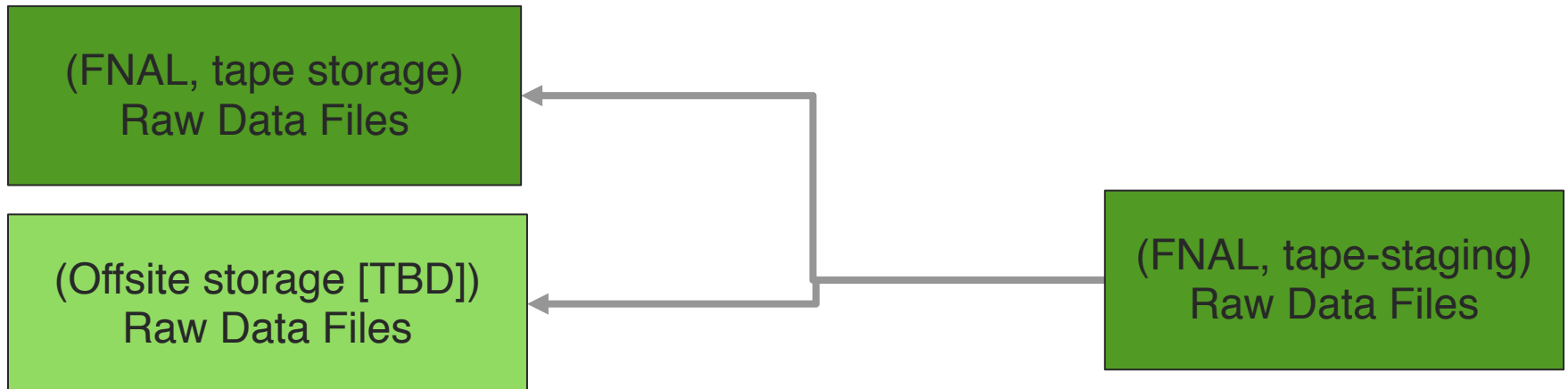
Online data file management

- Online data management will make use of standard FNAL SCD software toolkit
 - File Transfer Service (FTS) will automatically move files to off-detector computing, triggered by presence of file and metadata
- Inheriting from previous work on LArIAT and SBND, have a set of scripts to define file metadata and mark files ready for transfer
 - From there, FTS will move files automatically
 - FTS experts available to consult and help fix any issues
 - Typically: restarting a daemon



Final data storage

- Use Similar common tools for sending data to tape
 - Further consulting with SCD experts on tools for data replication (e.g. RUCIO)
- Working with experts at CAF to send data and processing jobs to Italy
 - Building from experience with CDF data and computing



Activities over the next weeks

- We are continuing work on developing the DAQ software at teststands
- We are anxiously awaiting the installation of the DAQ servers and networking to begin large-scale readout of the detector
 - Very happy to see the recent progress on power
 - Our goal is to have an integrated TPC+PMT readout at the ICARUS detector in coming weeks
- Need to work to develop the final plans for event-building and commissioning of the full DAQ and online systems

Anticipating commissioning and first data

- The online DAQ data management systems are being designed to satisfy these needs for early commissioning
 - Currently anticipate a commissioning period of ~ 3 months, with successive reduction in average trigger rate as the trigger system is commissioned
 - ~ 5 Hz ‘open trigger’ (only on beam gates/random triggers) for one month
 - ~ 3 Hz for one month
 - ~ 2 Hz for final month
 - Leading to 1 Hz final target data-taking rate
 - This will generate ~ 1.8 PB of raw data, which will be a challenge to fully process (1.7 M CPU Hours)
 - *We should not take more data than we reasonably intend to process*
- *artdaq* and DAQ software are designed implement high-level software trigger/filters that utilize offline algorithms, and filter data into appropriate streams
 - *We will work with offline analysis teams to plan specific uses of these features*

Backup slides

Online Monitoring of TPC purity

- Incorporating online analysis of argon purity into the monitoring system
 - Expect updated data point every 5 minutes
 - Preliminary test with simulation data

Purity as a function of time for each TPC

