Online data quality monitoring

Notes for DQM discussion

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DQM overview and p3s tutorial, Feb 2, 2018, CERN

Origin: https://indico.fnal.gov/event/15969/contribution/33/material/slides/0.pdf

DUNE-FD DAQ "design" workshop, January 26, 2018, Oxford

Online monitoring

- The online monitor analyzes live data as it passes through the DAQ. It updates at regular intervals to ensure performance and indicate any possible problem.

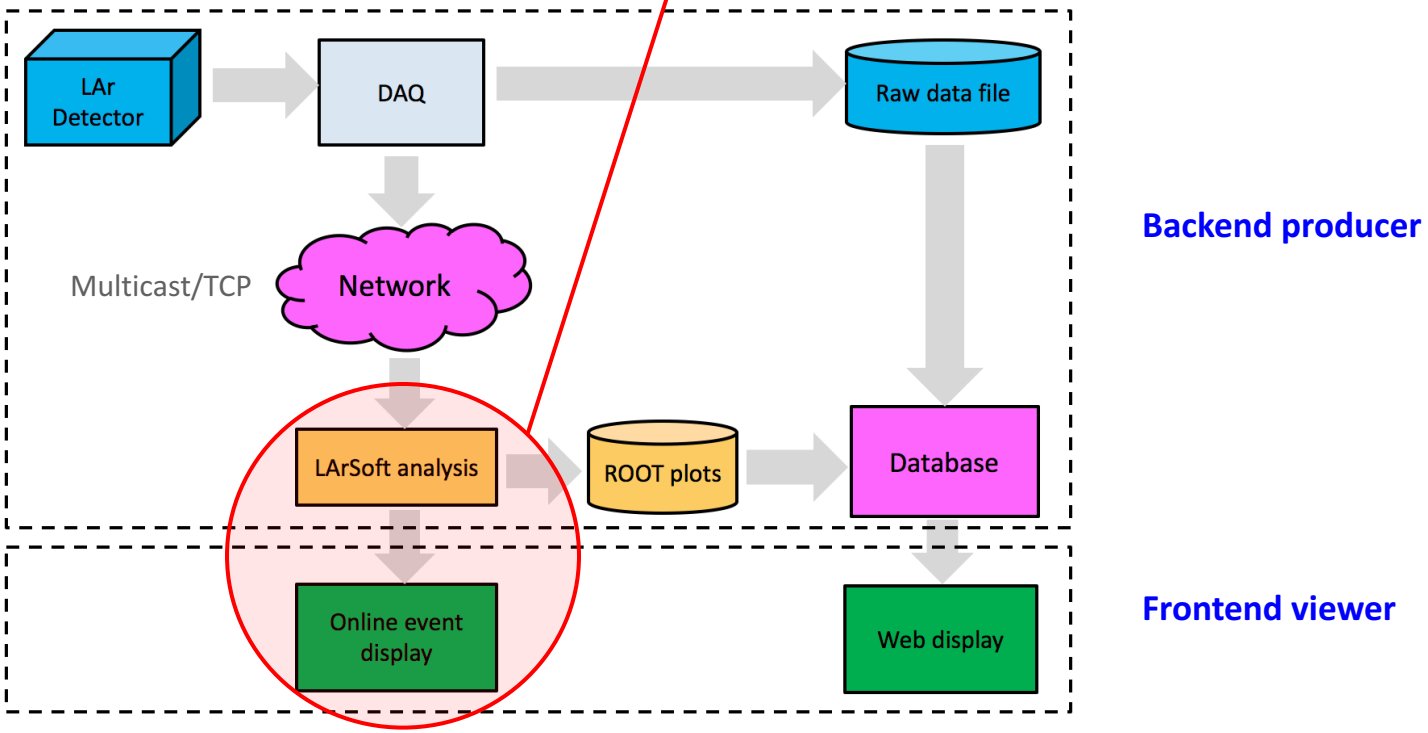
- It allows us to view a lot of low-level information, such as:
  - Pedestal and noise level of the readout electronics
  - Waveform-level performances: Mean/RMS of ADCs, FFT spectrum…

- It allows us to debug the electronics and detectors right away if there is something wrong.

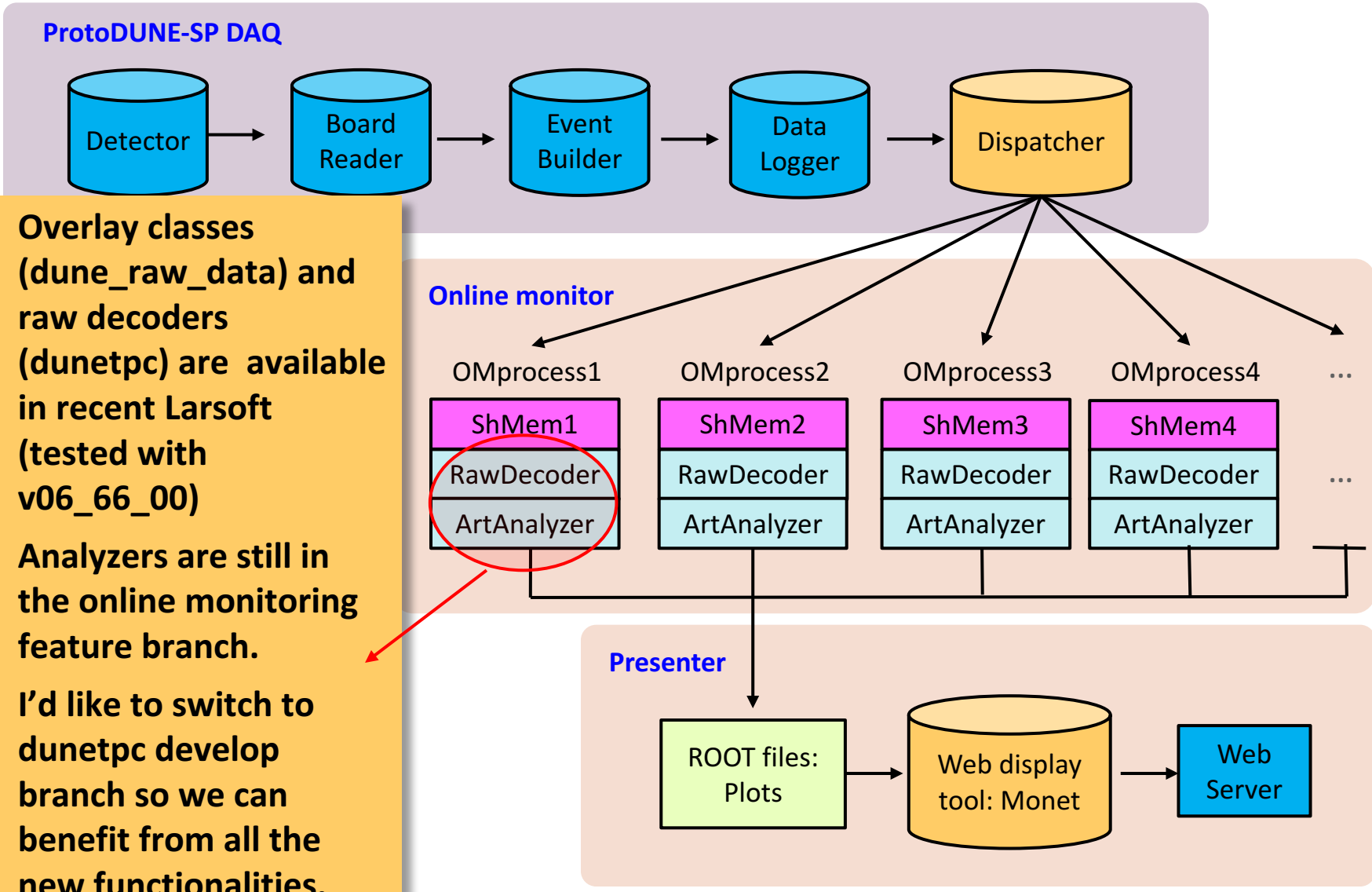
- Basic online monitoring framework has been built for ProtoDUNE-SP. Tools developed can be reused by DUNE.

General architecture

- The framework will be written in Art and will be compatible with LArSoft
- **"Larsoft analysis" can be immediately reused by offline DQM (p3s)**
- **How to implement "Online event display" is under discussion. If the event display tool is written in Larsoft using ROOT library, it can be shared by online and offline DQMs.**
- An online event display tool is beneficial for quick check of the data quality



An example: ProtoDUNE-SP framework



- **Overlay classes (dune_raw_data) and raw decoders (dunetpc) are available in recent Larsoft (tested with v06_66_00)**
- **Analyzers are still in the online monitoring feature branch.**
- **I'd like to switch to dunetpc develop branch so we can benefit from all the new functionalities.**

Candidate monitoring metrics

- **General monitoring**
  - Number of subdetectors with data
  - Event size vs “time”
  - Trigger rate vs “time”

✓ Latency: ~seconds from the trigger production

✓ Tools: Artdaq, Larsoft, ROOT

- **Event monitoring**
  - Raw event display in three views for each APA
  - ADC Mean/RMS vs channel number
  - FFT of waveforms vs channel number
  - Stuck bits fraction
  - Trigger type

- **Already available in online monitoring**
- **Can be immediately reused by p3s**

- **System diagnostic information (for electronics and detector experts)**
  - DAQ system functionality.
  - Hardware configuration (gain, peaking time, threshold
  - Front end electronics/sensor functionality (error code)

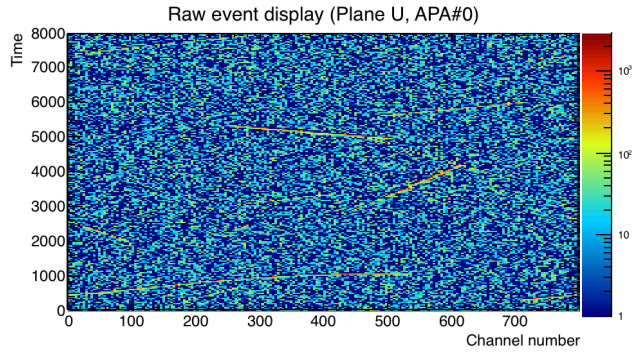
- **Very important but not ready yet**

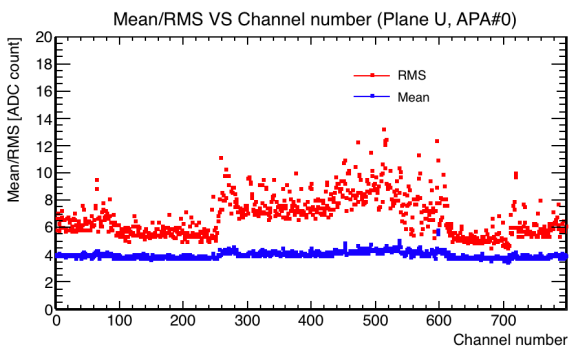
RCE/FELIX in ProtoDUNE-SP

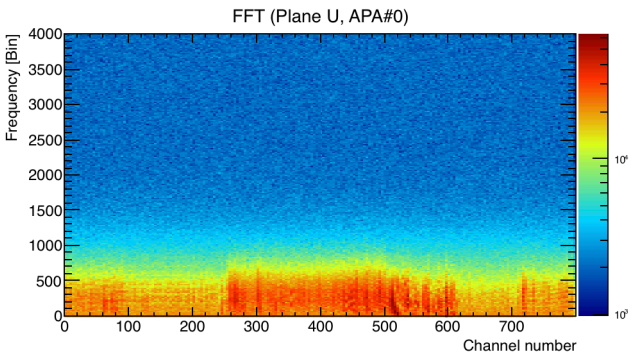
- **Raw decoder (art producer module)**
  - All ADC values
  - WIB-level numbers: crate, slot, fiber
  - Expecting more electronics diagnostic input: asic ID, asic channel

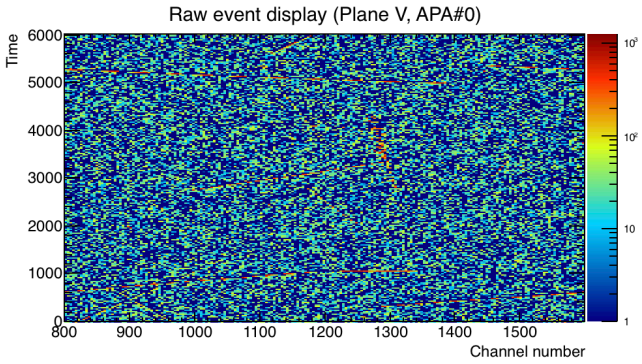
- **Analyzers (art analyzer modules)**
  - Raw event display in three views
  - ADC Mean/RMS VS channel ID for each view in each APA (2D histogram)
  - Profiled histogram of the ADC Mean/RMS
  - FFT spectrum VS channel ID (2D histogram)
  - Expecting more requests from cold electronics experts

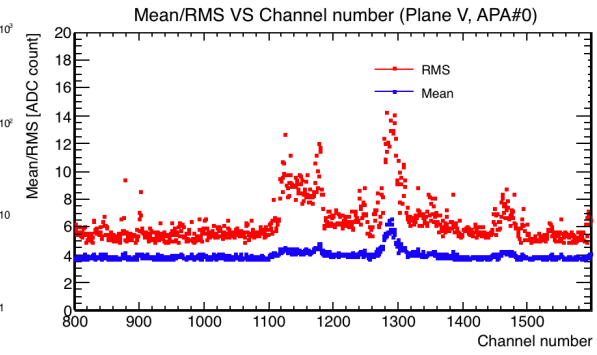
Test with exponential noise model

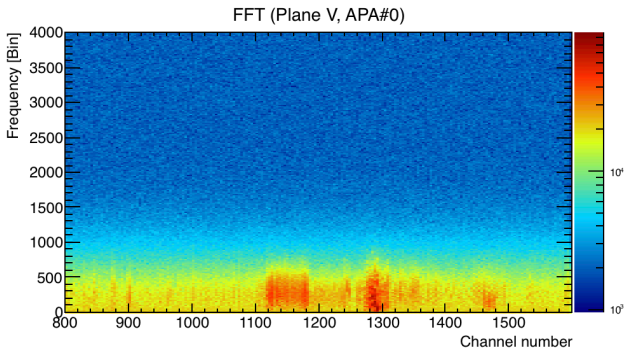


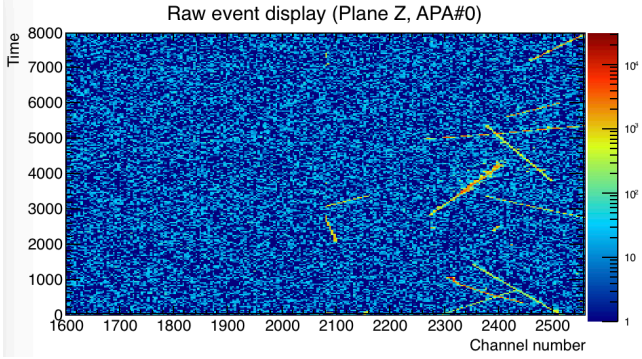


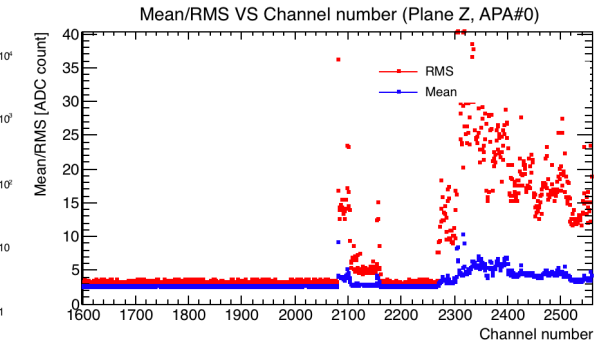


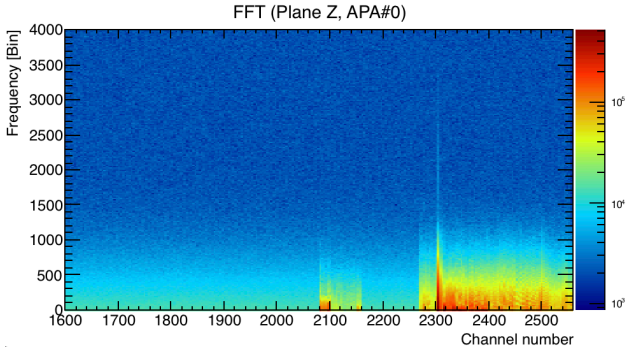




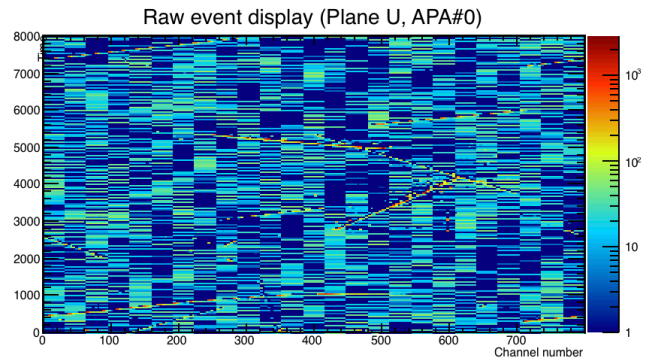


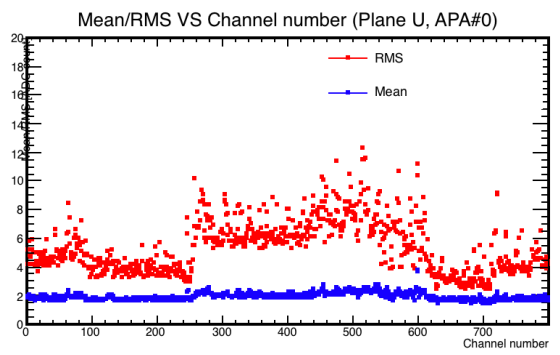


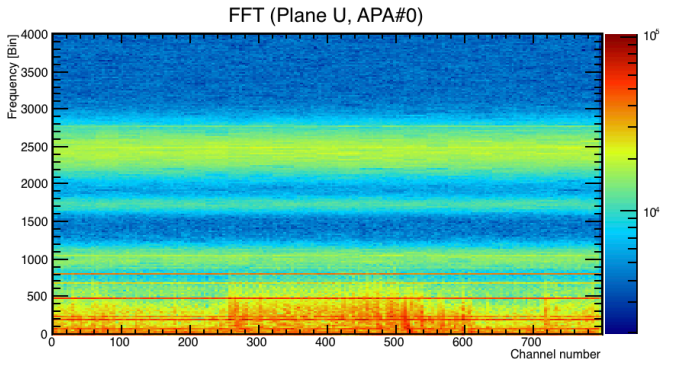


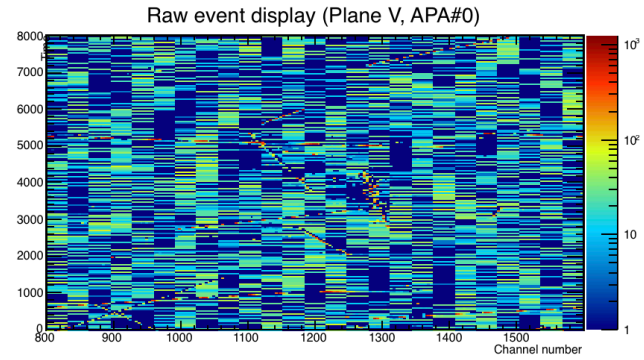


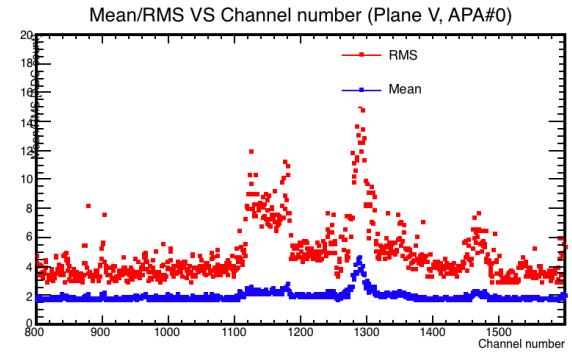
Test with coherent noise model

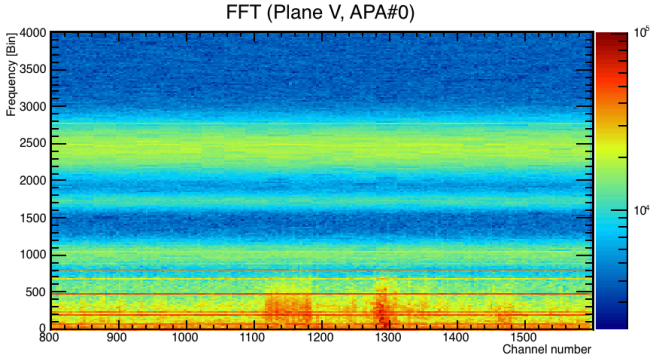


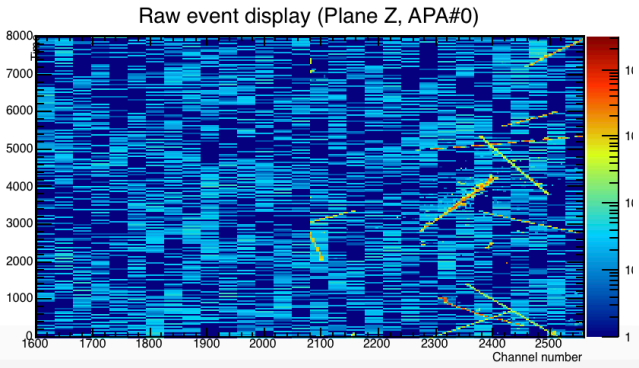


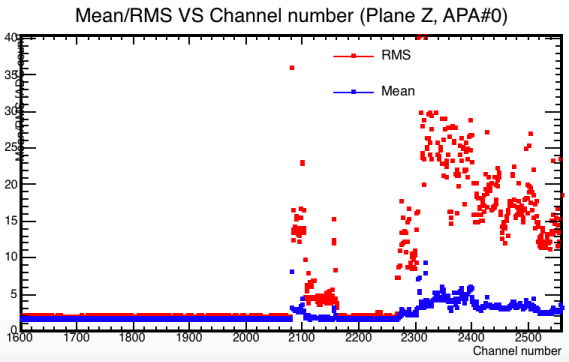


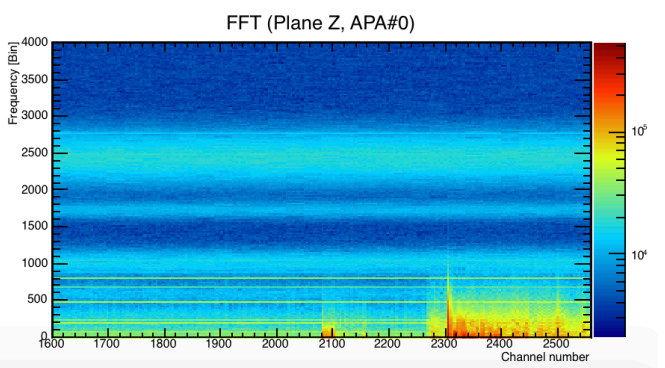




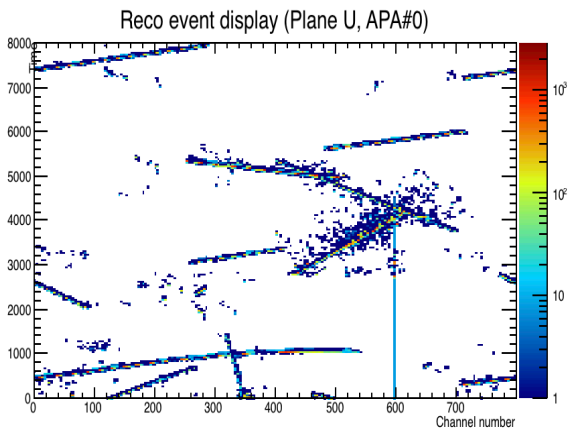


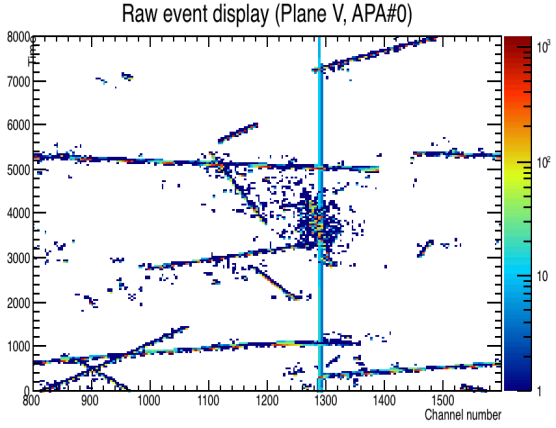


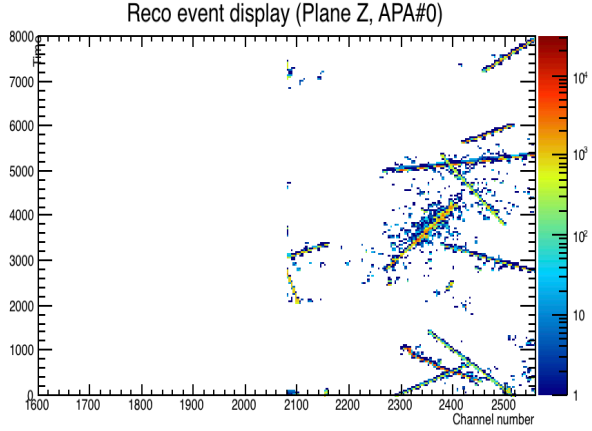


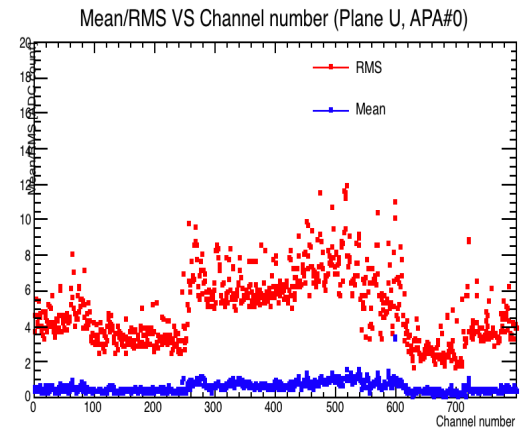


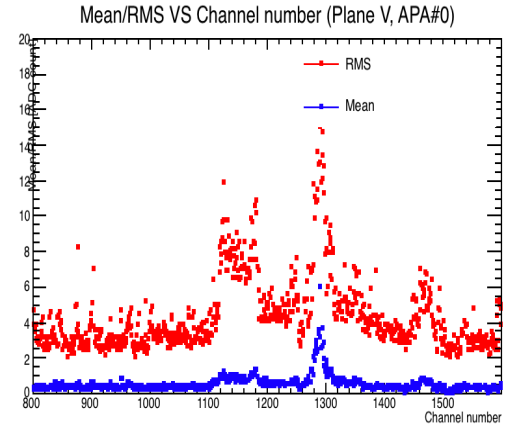
ProtoDUNE-SP noise removal

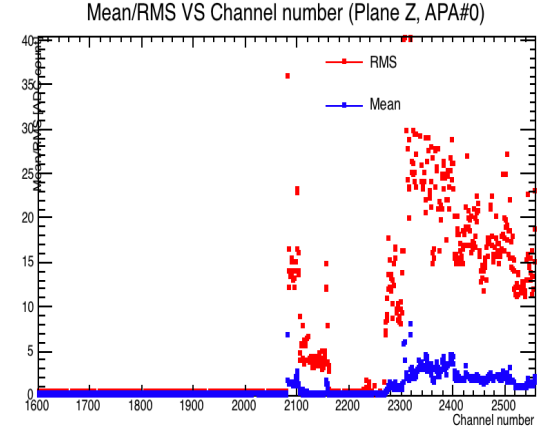












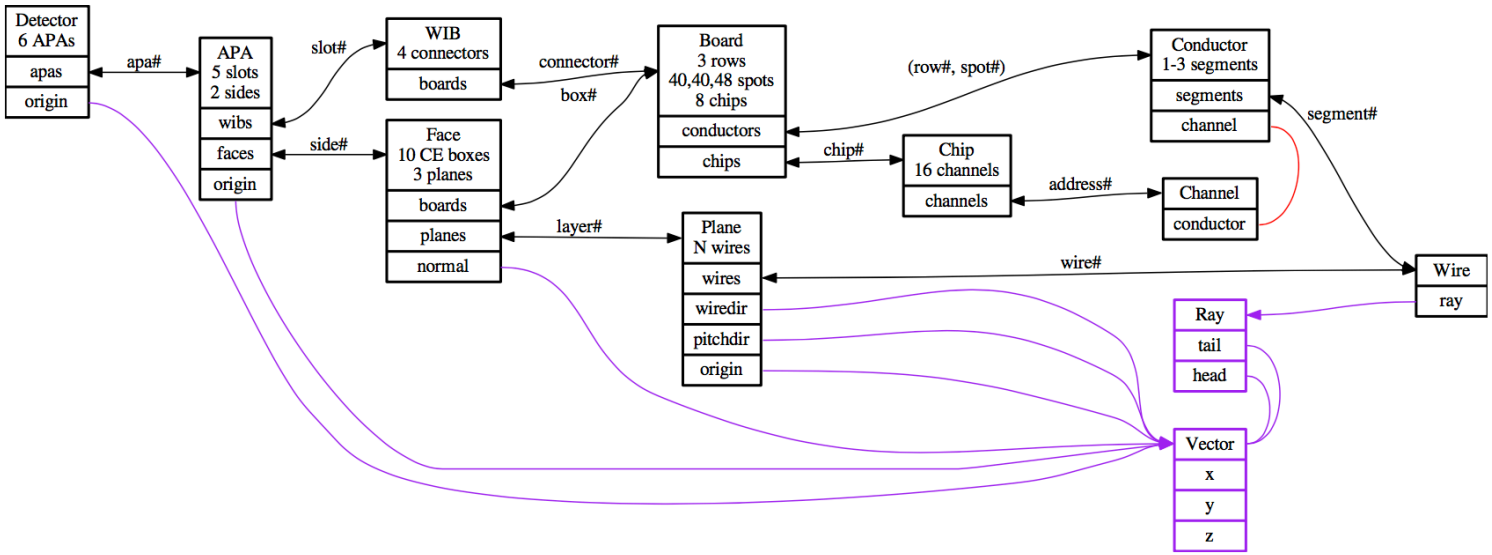
Shall we do

- **This is very useful for both online and offline**
- **We need a better event display tool (discussed with David Adams)**

Channel map

- Channel map is important for tracking the entire data flow over the electronics.
- **Offline channel number is unique for each wire.**
- **Preferred plots:**
  - **Mean/RMS vs Offline channel number**
  - **Crate/slot/fiber/FEMB/Chip/ASIC vs Offline channel number**
- The channel map service will provide functions to obtain all the channel numbers

Graph of ProtoDUNE-SP detector element connectivity



Channel map

Just a “toy” map with expected format

Crate /APA	Slot /WIB	Fiber /FEMB	FEMB Channel	Chip	Chip Channel	ASIC	ASIC Channel	Offline channel
0	1	0	118	7	6	0	6	630
0	1	0	119	7	7	0	7	631
0	1	0	120	7	8	1	0	632
0	1	0	121	7	9	1	1	633
0	1	0	122	7	10	1	2	634
0	1	0	123	7	11	1	3	635
0	1	0	124	7	12	1	4	636
0	1	0	125	7	13	1	5	637
0	1	0	126	7	14	1	6	638
0	1	0	127	7	15	1	7	639
0	1	1	0	0	0	0	0	640
0	1	1	1	0	1	0	1	641
0	1	1	2	0	2	0	2	642
0	1	1	3	0	3	0	3	643
0	1	1	4	0	4	0	4	644
0	1	1	5	0	5	0	5	645
0	1	1	6	0	6	0	6	646
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0	1	1	8	0	8	1	0	648
0	1	1	9	0	9	1	1	649
0	1	1	10	0	10	1	2	650
0	1	1	11	0	11	1	3	651
0	1	1	12	0	12	1	4	652
0	1	1	13	0	13	1	5	653
0	1	1	14	0	14	1	6	654
0	1	1	15	0	15	1	7	655
0	1	1	16	1	0	0	0	656
0	1	1	17	1	1	0	1	657
0	1	1	18	1	2	0	2	658
0	1	1	19	1	3	0	3	659
0	1	1	20	1	4	0	4	660
0	1	1	21	1	5	0	5	661
0	1	1	22	1	6	0	6	662
0	1	1	23	1	7	0	7	663

- Placeholder channel map service and map file are prepared in dune_raw_data for ProtoDUNE-SP
- Raw decoder maps the WIB-level information to the offline channel number (crate:slot:fiber:FEMB -> offline channel number)
- Offline channel number is then mapped to all the other useful numbers (for example Chip ID, ASIC ID, ASIC channel, APA, plane…)
- Need to coordinate with the detector installation team and the electronics experts.

Web-page display tool

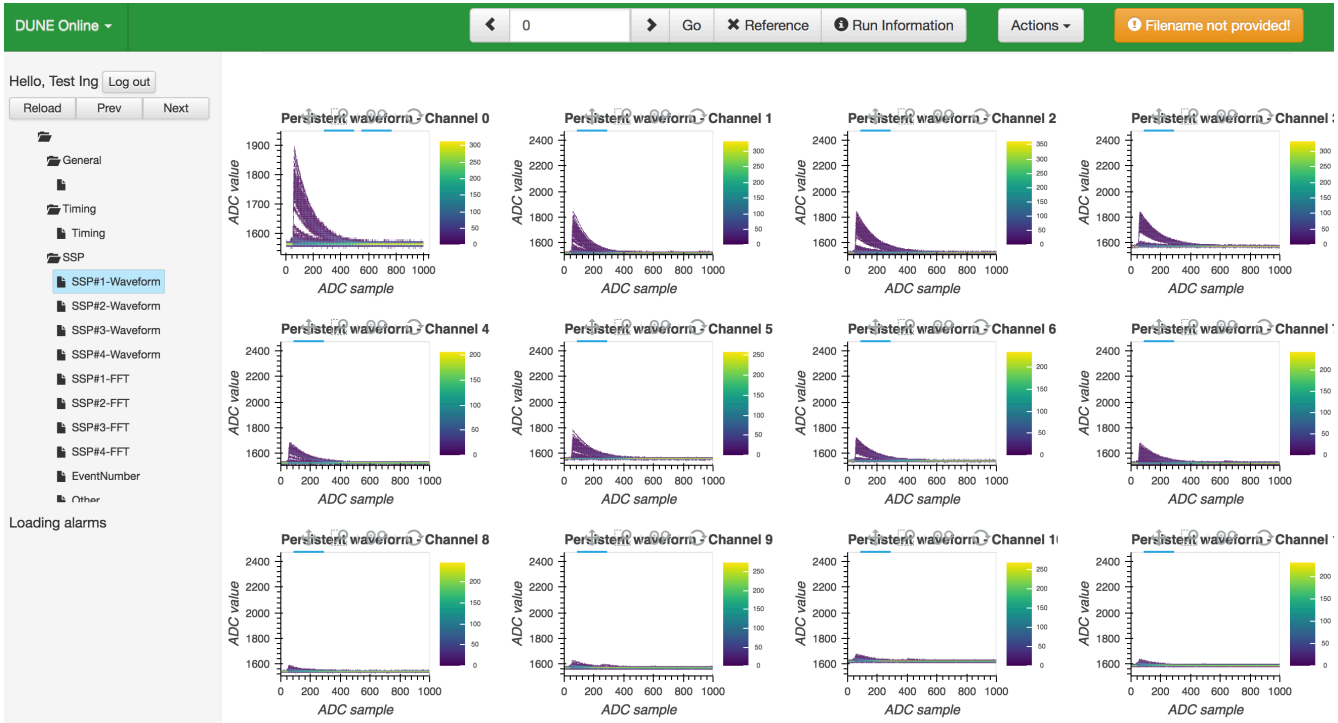
- Web-page display allows for easy monitoring from everywhere without connecting to remote machines

- **In practice, it shall:**
  - Periodically update the content that is static for some period of time
  - Provide options to display low and high resolution plots (this is user-selectable)
  - Provide a database to manage the data flow and configure the web display
  - Provide an highly interactive web-page for users to configure their request.
    - Auto refresh time
    - Run and sub-run number
    - Detector elements
    - Trigger type
    - Alarm conditions
  - Other suggestions?

Similar requirements apply to the event display tool

ProtoDUNE-SP web display: Monet

- Proto-DUNE is using a modified version of Monet developed by LHCb.
- Monet is written in python and has several user cases. Its PromptDQM case is hacked for Proto-DUNE-SP online monitoring
- Folder/page/histogram structure allows to organize plots for different categories of users: shifter, expert, special studies...
- Moving towards a simple database which manages the data (still under discussion)



Multi-process running

- The online modules must be very efficient since the monitoring needs to allow supervision of the live data
- A good design of the Multi-processing functionality allows faster running and scalability to larger systems
- Art doesn't support multi-core running. For ProtoDUNE-SP, we chose to implement the multi-process feature using shell scripts
  - Every process runs a single fcl file
  - Pre-scaler filter to assign events to different processes
  - Shell scripts to run and kill the processes

- In DUNE-SP FD, it would be beneficial to develop a more advanced multi-process task manager (progress underway for ProtoDUN-SP)
  - Decides which computer and which CPU core to use
  - Checks the status of memory cost of each process
  - Runs commands to start, pause, and terminate a process

Can we make use of p3s for online purpose?

From online to offline

- The data access library developed for the raw data in ProtoDUNE-SP has been packed as a ups product which is now included by dunetpc.
- The offline monitoring has started testing the raw decoders developed for the online monitoring.
- The offline monitoring platform “p3s” has been installed and tested in the CERN machines.
- Anything that is not affordable to the online monitoring will be moved to p3s.

Summary

- **A basic online monitoring framework has been built for ProtoDUNE-SP (still under development)**
  - Artdaq/LArSoft based raw decoders and data analyzers
  - Web-display tool to present the monito
- **Can we implement this for DUNE FD?**
  - I believe **YES**, but improvements are ne
- **Which part is useful for DUNE FD?**
  - A lot will be common: detectors, electr tools…
- **What's the requirements for DUNE FD**
  - Data transfer service to share data via network
  - Database server to organize the online monitoring configuration
  - Interactive web-page display
  - Strategy for high performance computing

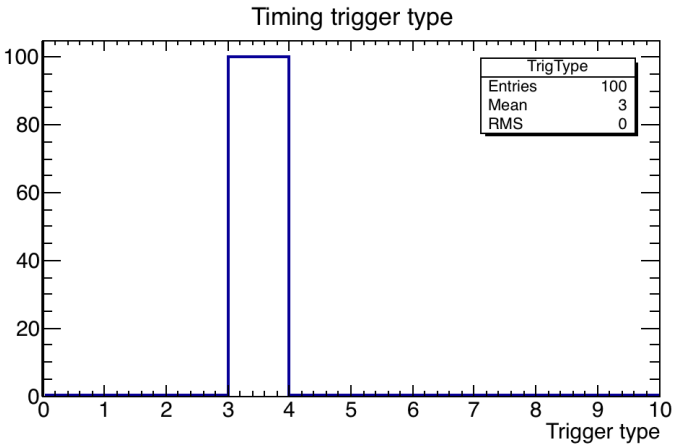
- **Data access library is available in LArSoft (tested)**
- **All the online monitoring modules can be reused by p3s**
- **Both online and offline need a better designed event display tool**

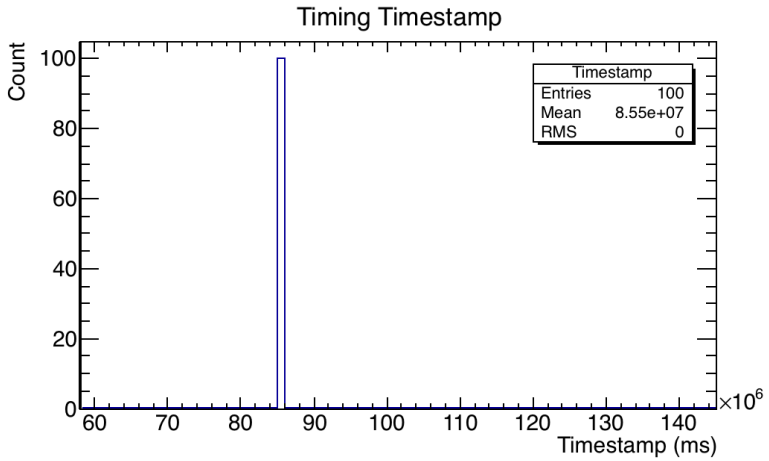
Backup

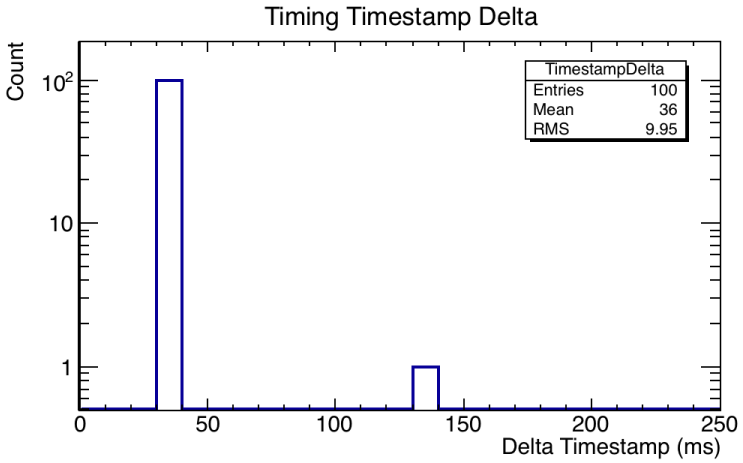
Timing Board in ProtoDUNE-SP

- Raw decoder (art producer modules)
  - Time stamp of the timing fragment
  - Time difference between two consecutive fragments
  - Trigger type
- Analyzers (art analyzer modules)
  - Suggestion?

Plots added by Philip Rodrigues

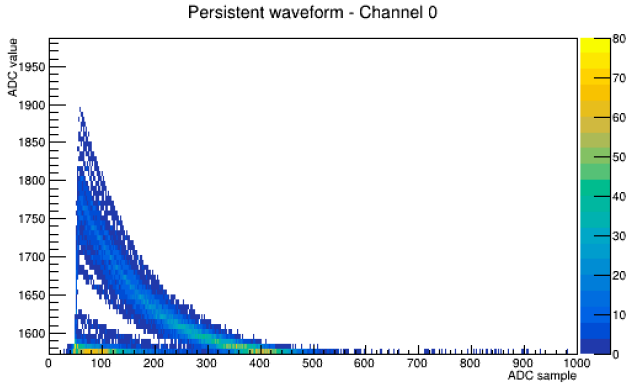


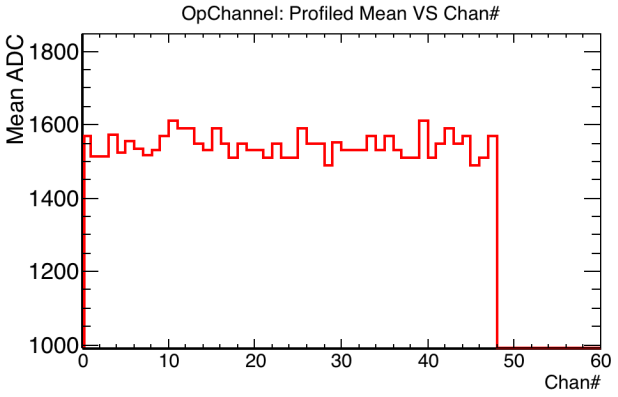


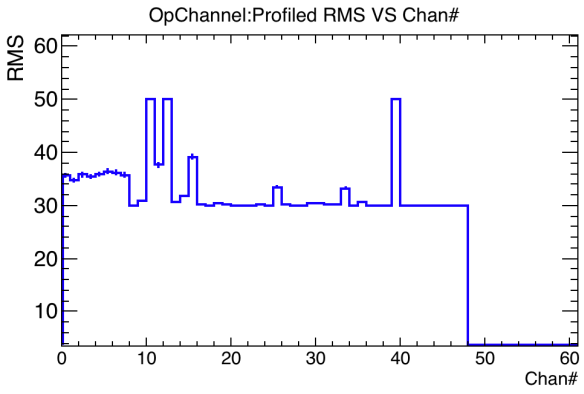


SSP in ProtoDUNE-SP

- Raw decoder (art producer module)
  - All ADC values
  - Number of packets per event
  - Peak (from metadata) spectrum per channel
  - Area (from metadata) spectrum per channel
  - Area (from metadata) spectrum per channel
  - One waveform per channel per file
  - Trigger type histogram (internal, external)
  - Persistent waveforms
  - More
- Analyzers (art analyzer modules)
  - ADC Mean/RMS VS channel ID (2D plot)
  - Profiled histogram of the ADC Mean/RMS
  - Peak time VS channel ID
  - FFT per channel

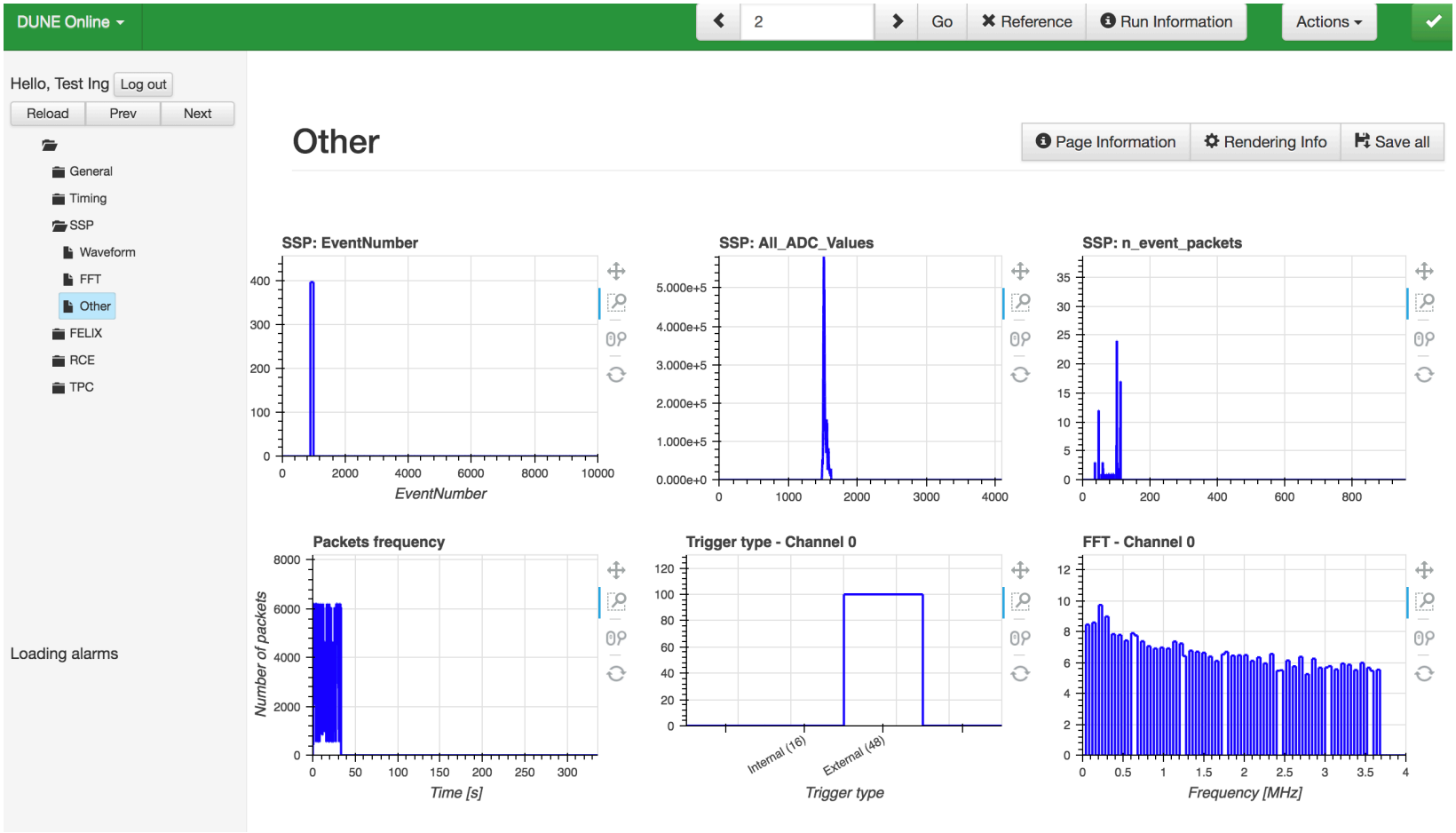






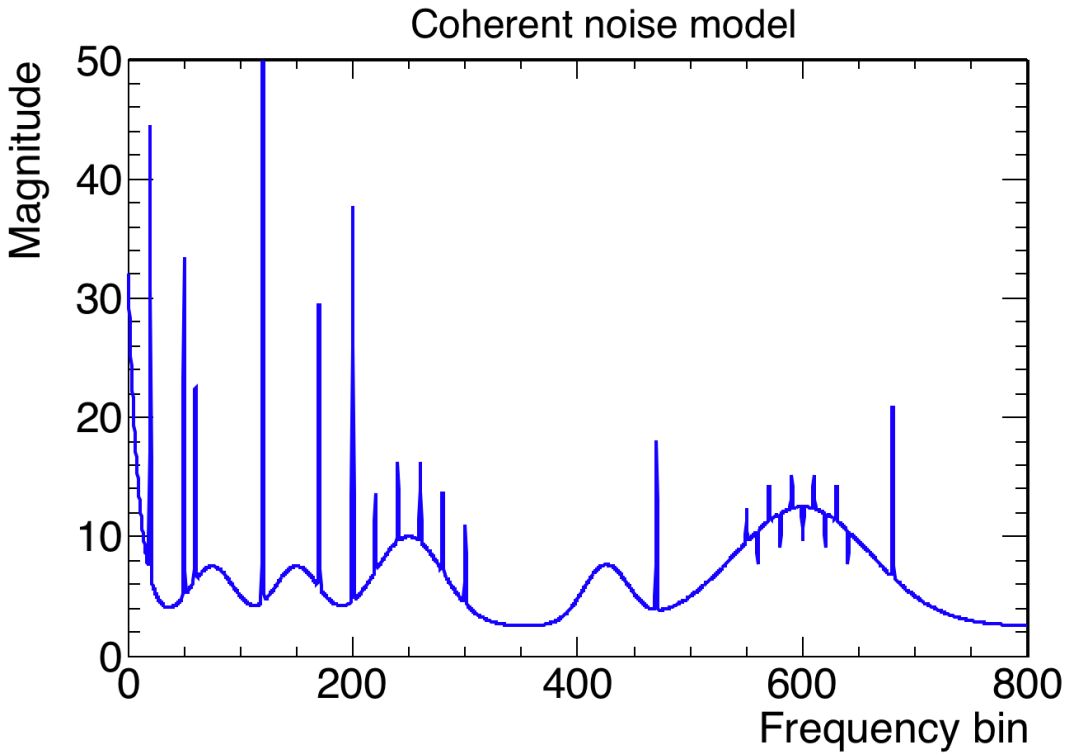
Preliminary plots in Monet: SSP

Event number, ADCs, Npackets, frequency, Trigger type, FFT



Coherent Noise Model

- An imitation of the coherent noise obtained from 3x1x1 data
- The Coherent noise model is characterized by a series of wide gaussian bumps and a number of discrete narrow lines.
- Coherent noise = exponential background + constant offset + Gaussian peaks



FFT of coherent noise