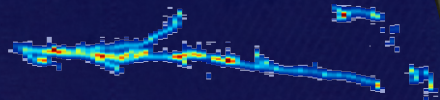


# Lessons Learned: LArIAT Diagnostic and Monitoring Tools



On behalf of the LArIAT DQM Folks

# LArIAT Diagnostic Principle

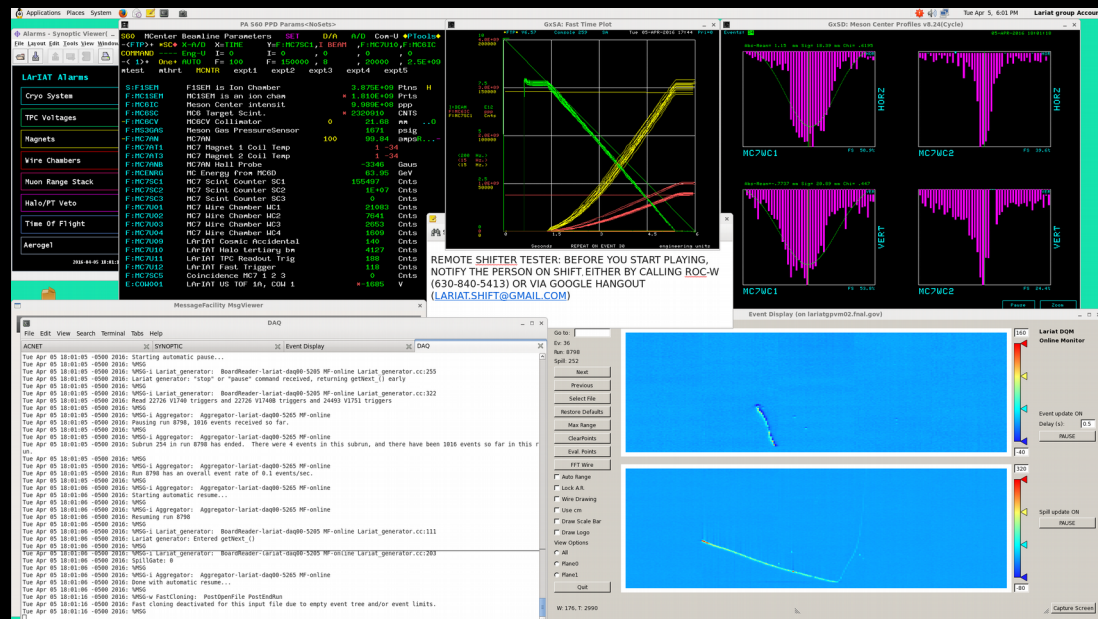
- **Keep It Simple Silly!!!!**

- LArIAT made express decisions to favor simple, robust choices for our monitoring

- LArIAT worked hard not to reinvent the wheel

- FNAL's scientific computing division already has a number of tools for just about any experimenters need!

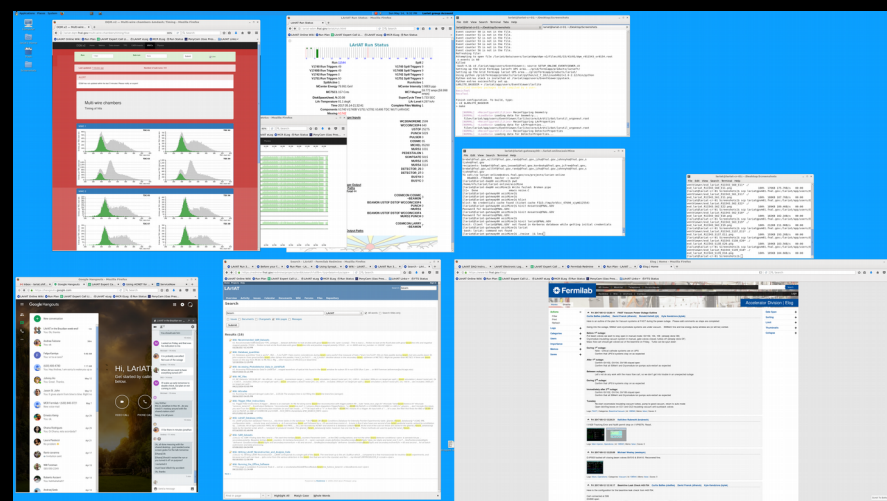
- They support these tools expertly and reliably
- Working with them IN ADVANCE has saved us 1000's of hours of effort



# LArIAT Diagnostic Principle

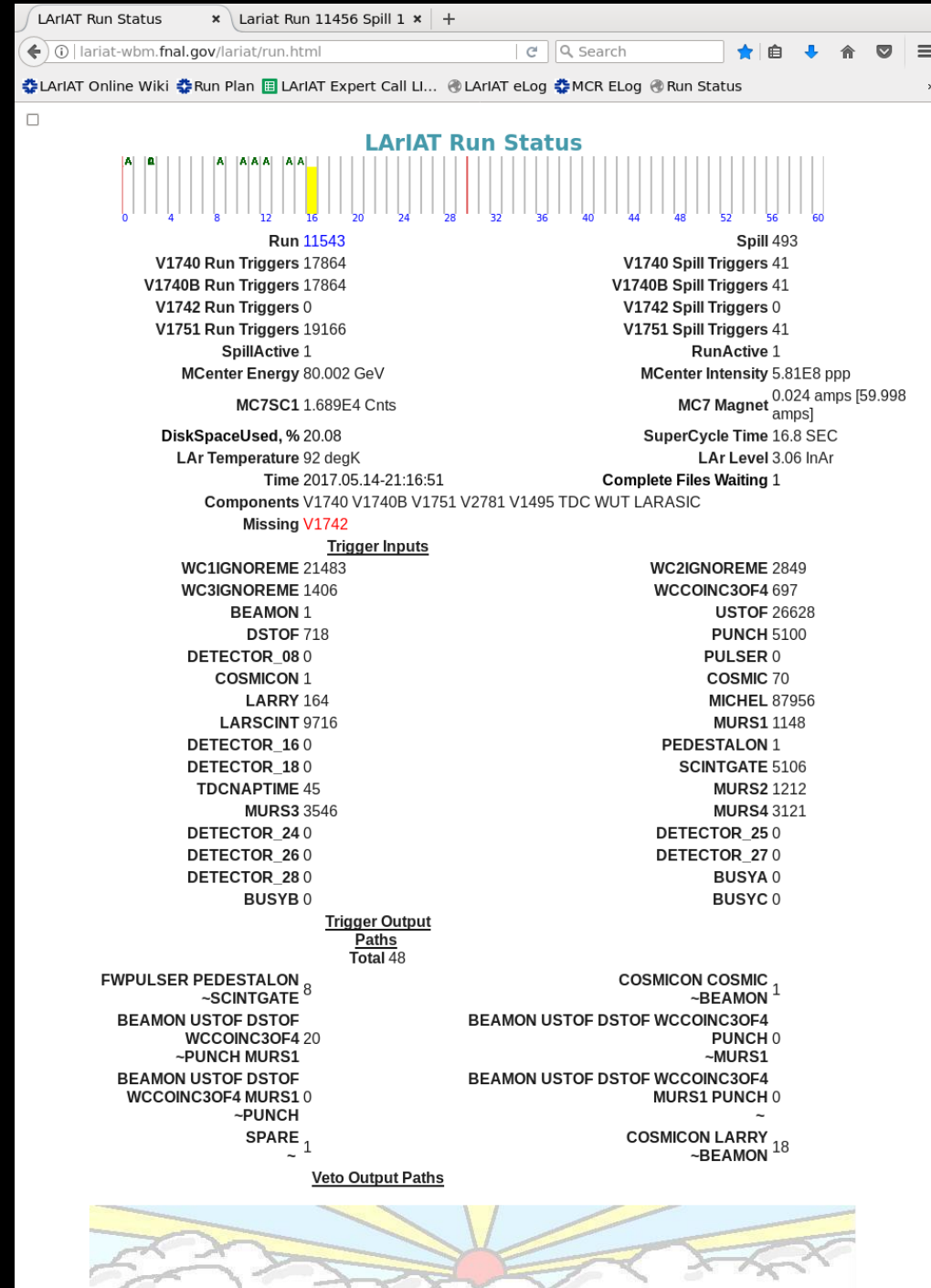
- **Keep It Simple Silly!!!!**
  - The more things that could be done via a command line interface or web site, the better!
    - Having this is ESSENTIAL for remote shifts
    - No run control, no GUI
      - Simple command line script launches the DAQ
        - “go 500” = run the DAQ for 500 spills
  - Shifters must be able to do everything essential from a remote desktop
    - VNC plays an essential role here, but can be a single point of failure

```
DAQ  x ACNET  x Synoptic  x Event Display  x lariat@lar
Unauthorized or improper use of this system may result in administrative disciplinary action and civil and criminal penalties. By continuing to use this system you indicate your awareness of and consent to these terms and conditions of use. LOG OFF IMMEDIATELY if you do not agree to the conditions stated in this warning.
Fermilab policy and rules for computing, including appropriate use, may be found at http://www.fnal.gov/cd/main/cpolicy.html
*****
** To run the LArIAT DAQ with the ArtDag framework and root output files, **
** simply type: **
** go 480 **
** where "480" here is the desired number of spills to record **
** The spills arguments is optional and default to 9999 **
** To check if someone else is using the CAEN links: **
** wholink **
** To run a quick (few seconds) pedestal check with scatter plots, type: **
** pedestal **
*****
Setting up environment, bitte warten...
[lariat@lariat-daq03 ~]$ go 500
```



# Monitoring: “Are we taking data now?”

- Above all, monitoring must do no harm, be robust, and simple
  - LArIAT deliberately avoided using ARTDAQ’s options to use an internal stream to feed a monitoring process
    - Done to avoid taking processing power or memory from DAQ processes
- LArIAT Run-Status page reads an xml file written out by the DAQ process
  - Many thanks to Bill Badgett (you rock)



# Monitoring: "Are we taking data now?"

Beam Spill Cycle

Current Run Number

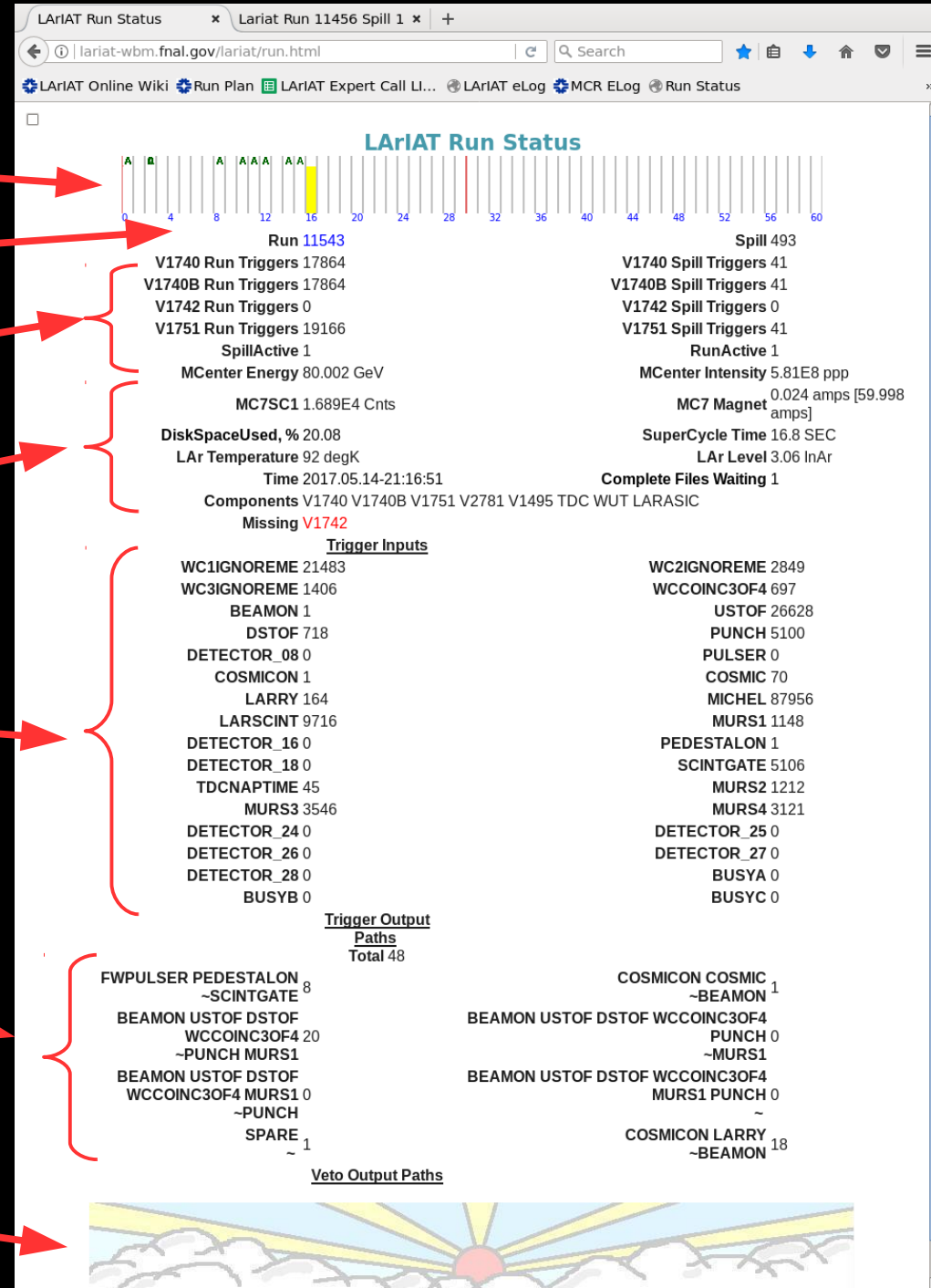
Packets from front end

Beam, Magnet and some detector information

Trigger inputs

Trigger Outputs

A pretty picture



# Monitoring: “What data were we taking?”

- This page also gives a very human readable format to look at recent data and its configurations

## Details of running conditions

Simple navigation by run number

Run	Spills	StartTime	MC7U11	MC7U12	MCENRG	MC7AN	MC7ANB	MC7SC1	Trigger
<a href="#">11512</a>	106	2017.05.10 10:30:43	0	0	0.00	0.00	0.00	0.00E00 ± 0.00E00	FWPULSER+PEDESTALON
<a href="#">11503</a>	307	2017.05.10 04:18:53	20418	14378	80.00	99.87	-3336.73	3.04E04 ± 1.43E04	FWPULSER+PEDESTALON
<a href="#">11502</a>	81	2017.05.10 02:52:57	3302	2350	80.00	99.87	-3337.41	1.52E04 ± 3.31E03	FWPULSER+PEDESTALON
<a href="#">11501</a>	261	2017.05.09 22:29:22	10772	7643	80.00	99.87	-3339.03	1.51E04 ± 3.29E03	FWPULSER+PEDESTALON
<a href="#">11500</a>	138	2017.05.09 20:05:58	4182	2947	80.00	99.86	-3343.62	1.24E04 ± 8.47E03	FWPULSER+PEDESTALON
<a href="#">11491</a>	15	2017.05.09 18:37:37	0	14	80.01	99.85	-3345.78	5.14E00 ± 2.11E00	FWPULSER+PEDESTALON
<a href="#">11485</a>	12	2017.05.09 17:24:22	0	11	80.00	99.85	-3342.91	5.73E00 ± 1.74E00	FWPULSER+PEDESTALON
<a href="#">11484</a>	8	2017.05.09 16:46:51	0	7	80.01	99.84	-3336.93	5.57E00 ± 2.76E00	FWPULSER+PEDESTALON
<a href="#">11482</a>	8	2017.05.09 16:22:20	0	0	0.00	0.00	0.00	0.00E00 ± 0.00E00	FWPULSER+PEDESTALON
<a href="#">11476</a>	12	2017.05.09 15:12:58	0	0	0.00	0.00	0.00	0.00E00 ± 0.00E00	FWPULSER+PEDESTALON
<a href="#">11468</a>	331	2017.05.09 08:55:22	25068	16264	80.00	99.87	-3336.55	2.23E04 ± 9.06E03	FWPULSER+PEDESTALON
<a href="#">11467</a>	43	2017.05.09 08:04:24	2414	1593	80.04	99.87	-3336.48	2.71E04 ± 1.20E04	FWPULSER+PEDESTALON
<a href="#">11466</a>	1	2017.05.09 07:35:38	0	0	0.00	0.00	0.00	0.00E00 ± 0.00E00	FWPULSER+PEDESTALON
<a href="#">11465</a>	253	2017.05.09 03:14:34	22126	14731	80.09	99.86	-3336.73	3.33E04 ± 5.97E03	FWPULSER+PEDESTALON
<a href="#">11464</a>	283	2017.05.08 22:22:36	20852	13650	80.09	99.86	-3337.28	2.45E04 ± 7.72E03	FWPULSER+PEDESTALON
<a href="#">11463</a>	500	2017.05.08 13:29:17	404	252	80.07	99.87	-3334.41	1.78E04 ± 1.22E04	FWPULSER+PEDESTALON
<a href="#">11461</a>	454	2017.05.08 05:42:39	0	0	80.07	99.87	-3336.09	0.00E00 ± 0.00E00	FWPULSER+PEDESTALON
<a href="#">11460</a>	500	2017.05.07 21:18:28	10248	6760	80.07	99.87	-3336.23	1.86E04 ± 1.15E04	FWPULSER+PEDESTALON
<a href="#">11459</a>	40	2017.05.07 20:30:14	2802	1865	80.09	99.87	-3336.52	2.05E04 ± 1.46E04	FWPULSER+PEDESTALON
<a href="#">11458</a>	400	2017.05.07 13:42:24	26557	17450	80.01	99.87	-3334.01	1.69E04 ± 1.09E04	FWPULSER+PEDESTALON

Spill count and start times

# Monitoring: “What data were we taking?”

- Invaluable PostgreSQL database with tables for these:

- Hardware database

History of 150+ digitizer channels NOT INCLUDING TPC.

Allowed upgrades and failures of beamline instruments to be handled smoothly in analysis offline

- All 1000+ DAQ configuration parameters

Easy to parse from xml config files through python dictionaries (in a crontabb'ed script) to database insert query

- About 60 per-spill conditions parameters

Spill intensity scalers, incident beam energy, momentum selection magnet current & sign, voltages and currents, etc.

- These were connected as “foreign tables” to SAM, the file catalog. POWERFUL!

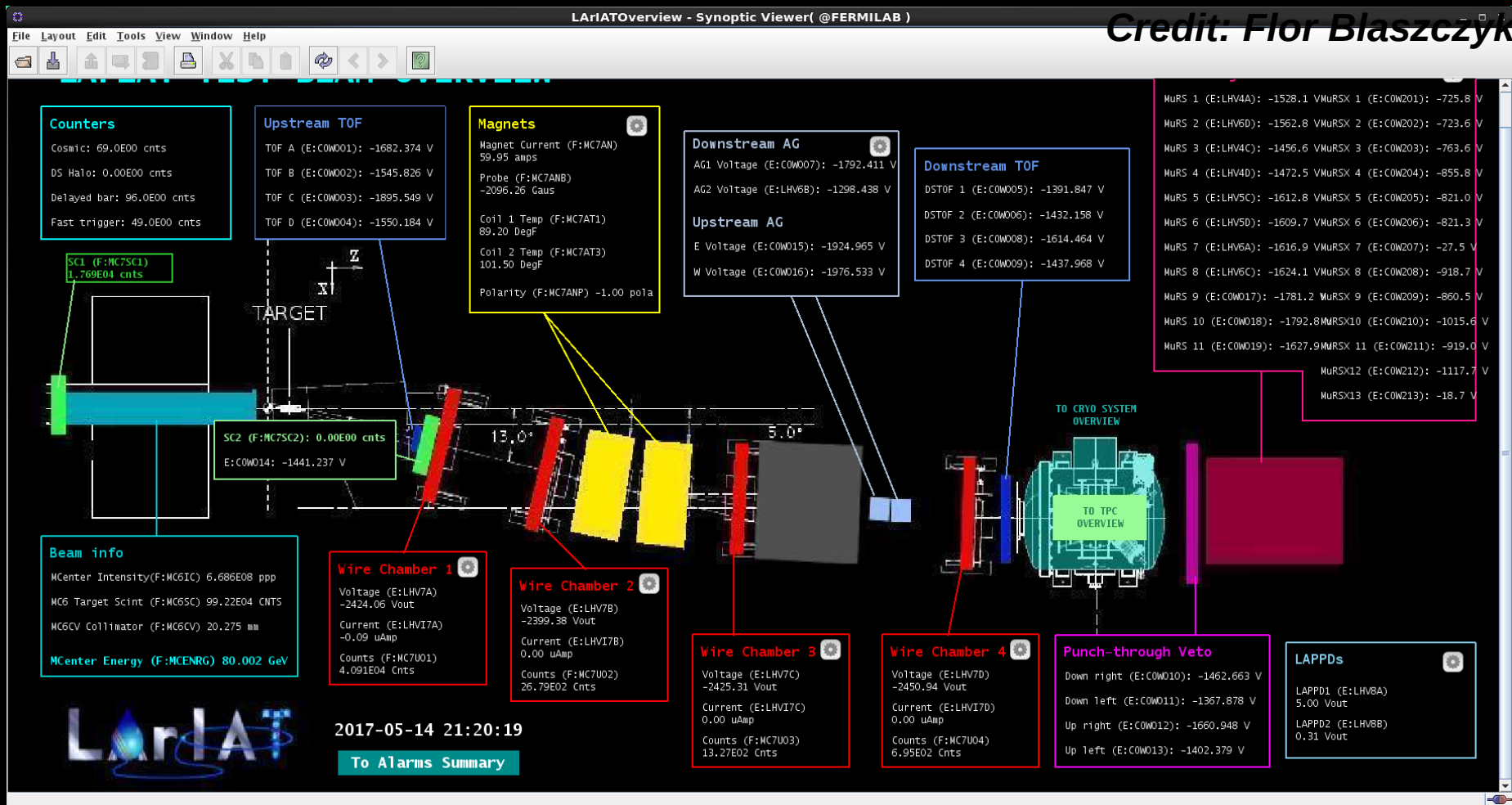
- Select data files with certain ASIC gain, TPC voltage, & beam intensity

- Assess data volumes collected in various conditions

```
lariat_v1751_config_caen_enablereadout
lariat_v1751_config_caen_eventsperinterrupt
lariat_v1751_config_caen_exttrgmode
lariat_v1751_config_caen_iolevel
lariat_v1751_config_caen_irqwaittime
lariat_v1751_config_caen_link
lariat_v1751_config_caen_maxeventspertransfer
lariat_v1751_config_caen_nboards
lariat_v1751_config_caen_nchannels
lariat_v1751_config_caen_outputsignalmode
lariat_v1751_config_caen_postpercent
lariat_v1751_config_caen_recordlength
lariat_v1751_config_caen_runsyncmode
lariat_v1751_config_caen_swtrgmode
lariat_v1751_config_caen_triggerpolarity
lariat_v1751_config_caen_usepedestals
lariat_v1751_config_v1751_chan0on
lariat_v1751_config_v1751_chan0pedcorr
lariat_v1751_config_v1751_chan0pedestal
lariat_v1751_config_v1751_chan0thresh
lariat_v1751_config_v1751_chan1on
lariat_v1751_config_v1751_chan1pedcorr
lariat_v1751_config_v1751_chan1pedestal
lariat_v1751_config_v1751_chan1thresh
lariat_v1751_config_v1751_chan2on
lariat_v1751_config_v1751_chan2pedcorr
lariat_v1751_config_v1751_chan2pedestal
lariat_v1751_config_v1751_chan2thresh
lariat_v1751_config_v1751_chan3on
lariat_v1751_config_v1751_chan3pedcorr
lariat_v1751_config_v1751_chan3pedestal
lariat_v1751_config_v1751_chan3thresh
lariat_v1751_config_v1751_chan4on
lariat_v1751_config_v1751_chan4pedcorr
lariat_v1751_config_v1751_chan4pedestal
lariat_v1751_config_v1751_chan4thresh
lariat_v1751_config_v1751_chan5on
lariat_v1751_config_v1751_chan5pedcorr
```

# Monitoring: “How’s my detector doing?”

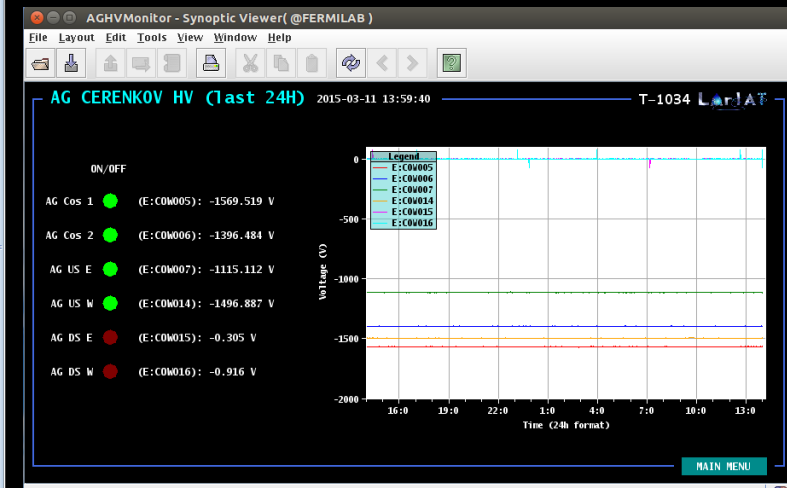
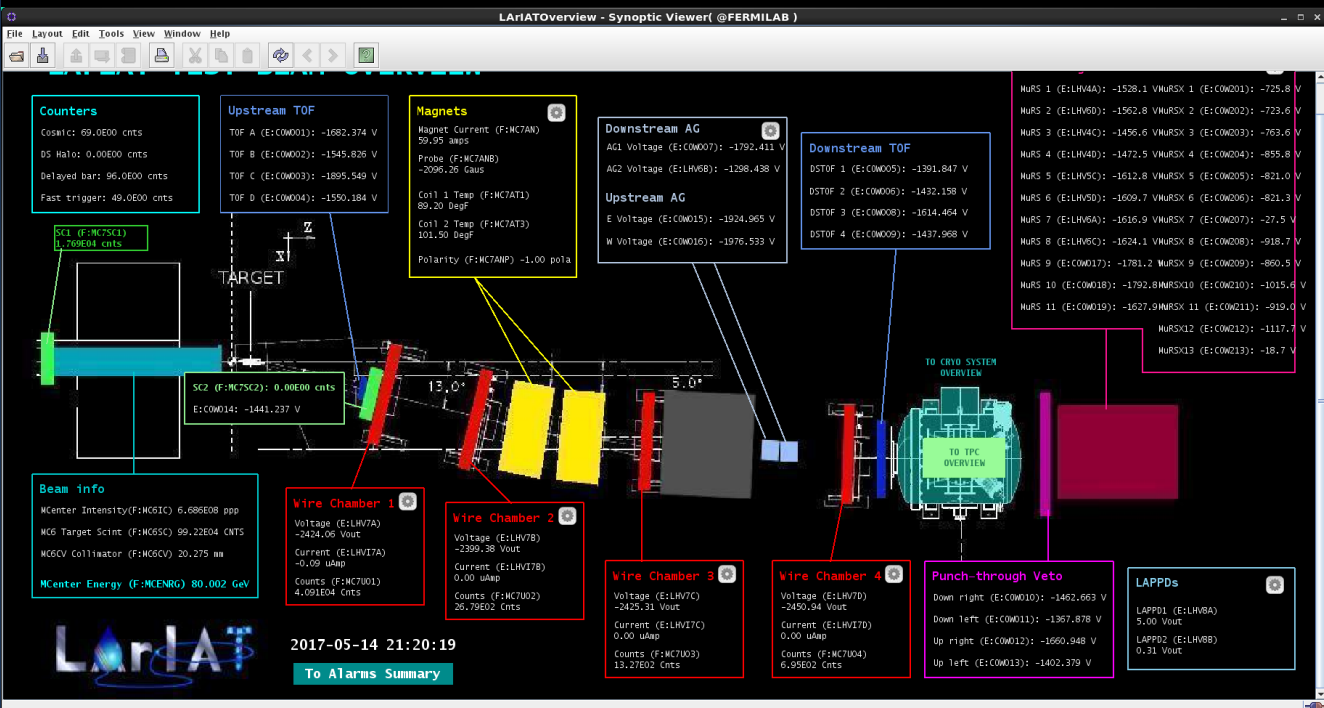
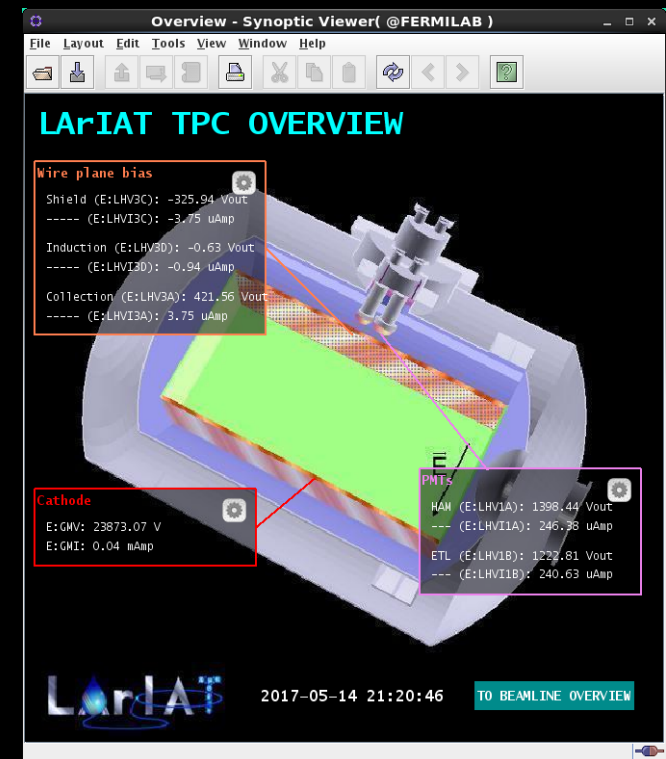
- ACNET/Synoptic monitors voltages, currents and status of many of our detectors
  - Expertly maintained by FNAL and can keep track of all kinds of hardware
- Having a human readable interface with clear easy to understand alarms allows for maximum up time as well as stable operations
  - Collaborator implemented an easy to use GUI interface





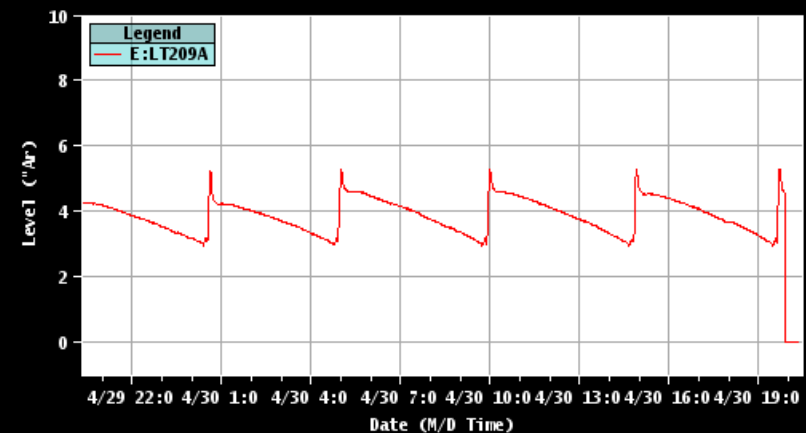
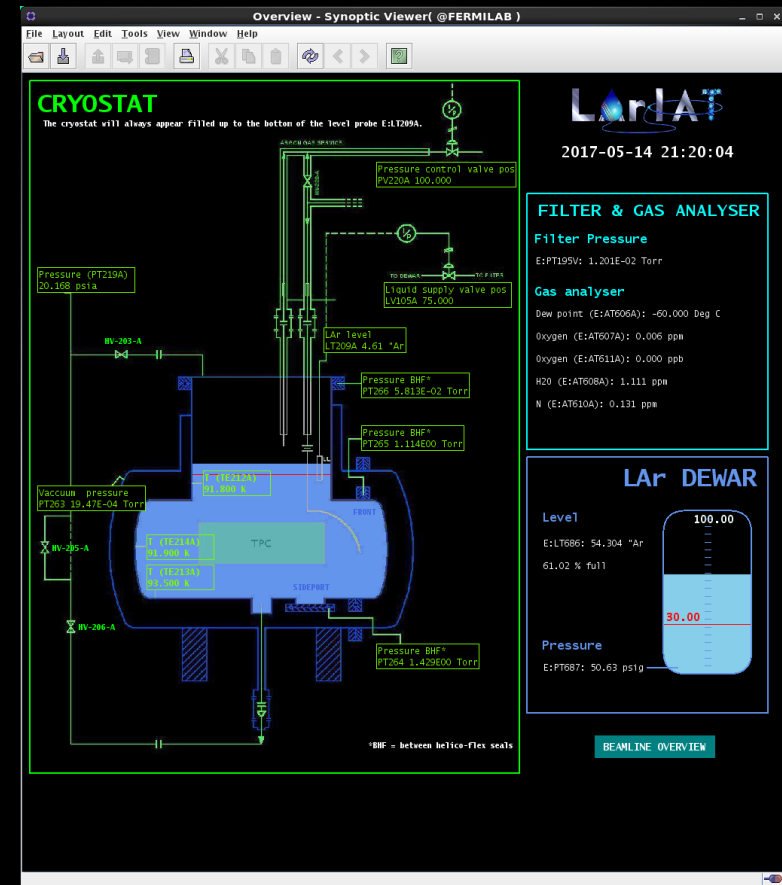
# Monitoring: “How’s my detector doing?”

- From this interface you can drill down and see individual detectors, manipulate voltages, and reset voltage trips
- Also makes plots of voltages over time and has interfaces for beam monitoring

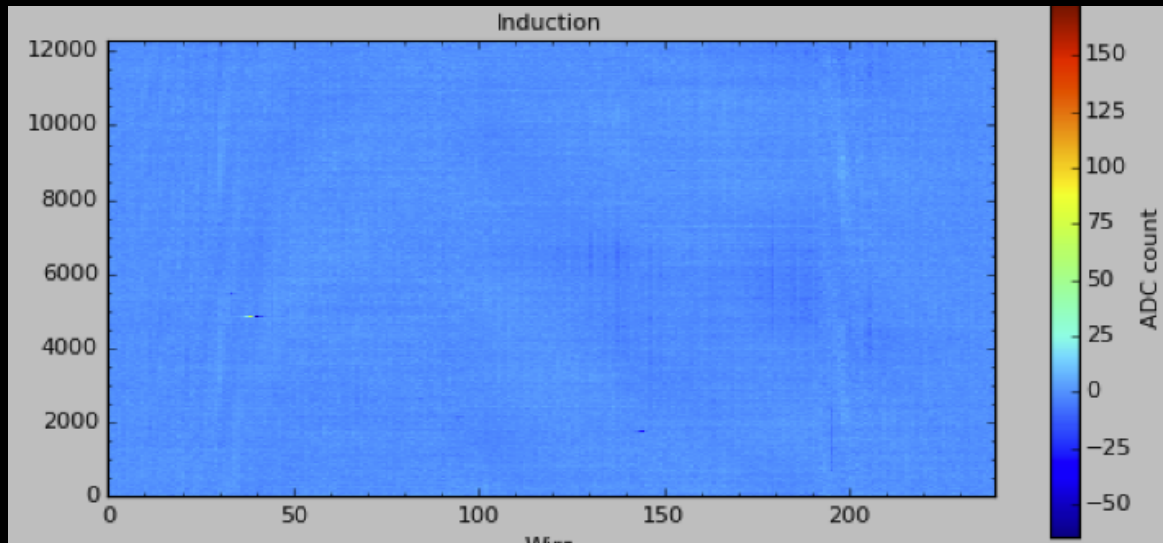


# Monitoring: “How’s my detector doing?”

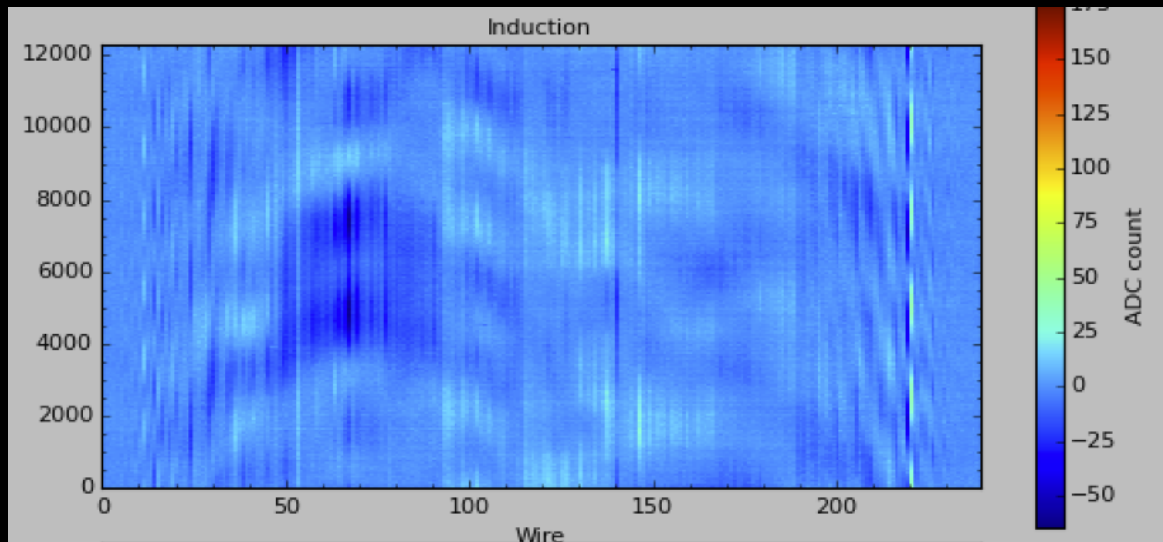
- Shifters are also a first line of defense for cryo!
  - Being able to monitor the cryo system in addition to the experts has allowed LArIAT to correlate noise in the system with when the dewar is being refilled
  - Has also allowed us to assist when there are system problems
- Essential to have good communications with the cryo-team



# Monitoring: “How’s my detector doing?”

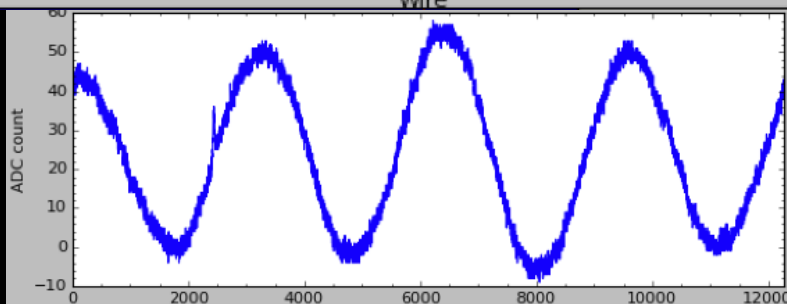


- Example of a “quiet” event in LArIAT



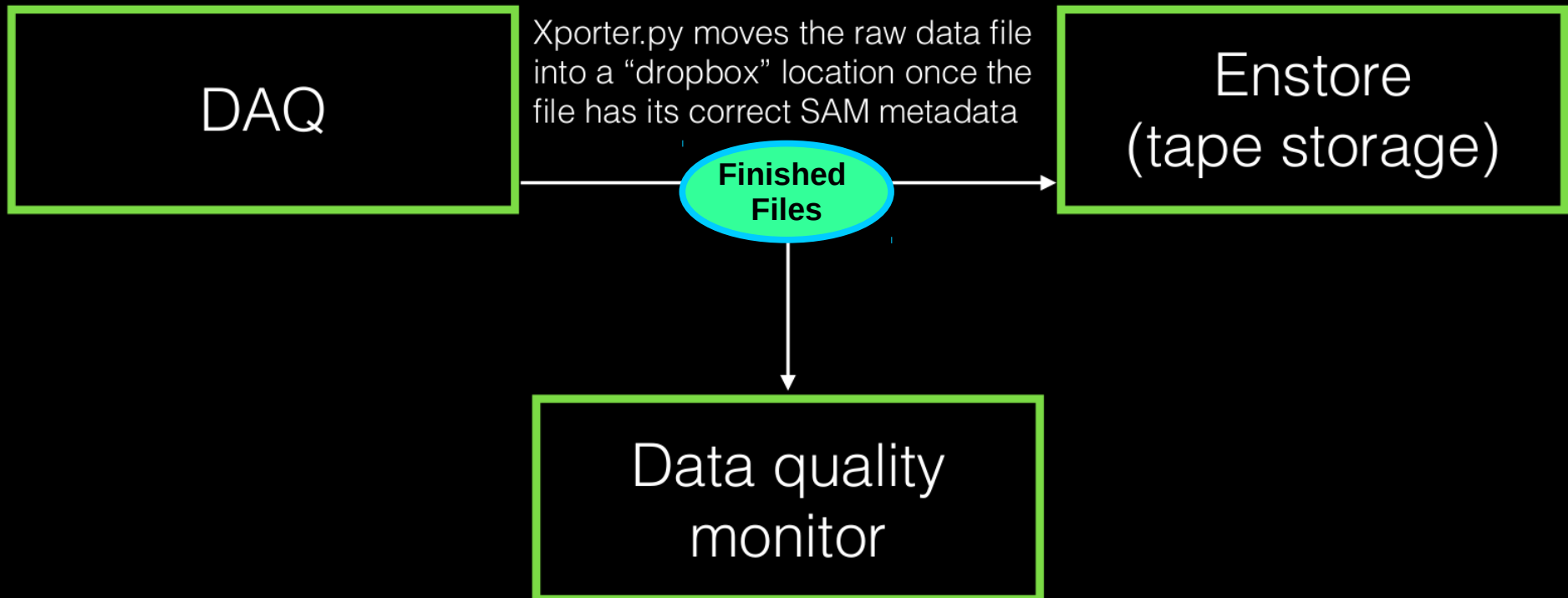
- Example of noisy event seen during LAr fill

– Looks like microphonics seen with wires pulsing due to argon motion



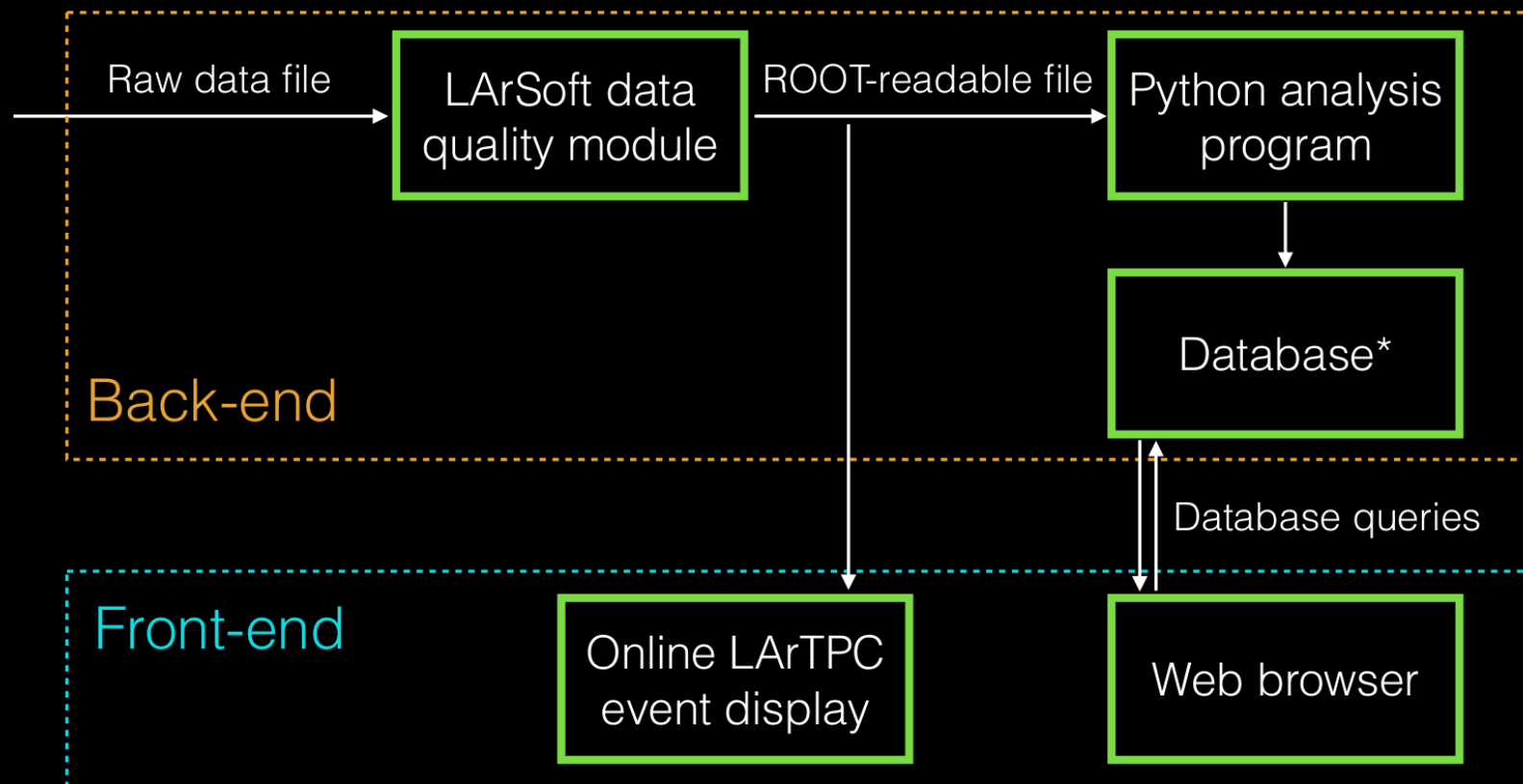
# Monitoring: “Are we taking good data?”

- Data Quality Monitoring steps between the data we’ve taken and when the data gets stored



# Monitoring: “Are we taking good data?”

- DQM has two critical components
  - Webpage based monitoring
    - Low level essential data updated ~1 min after data taken
  - Event Display
    - Near real time display of events as seen in the TPC



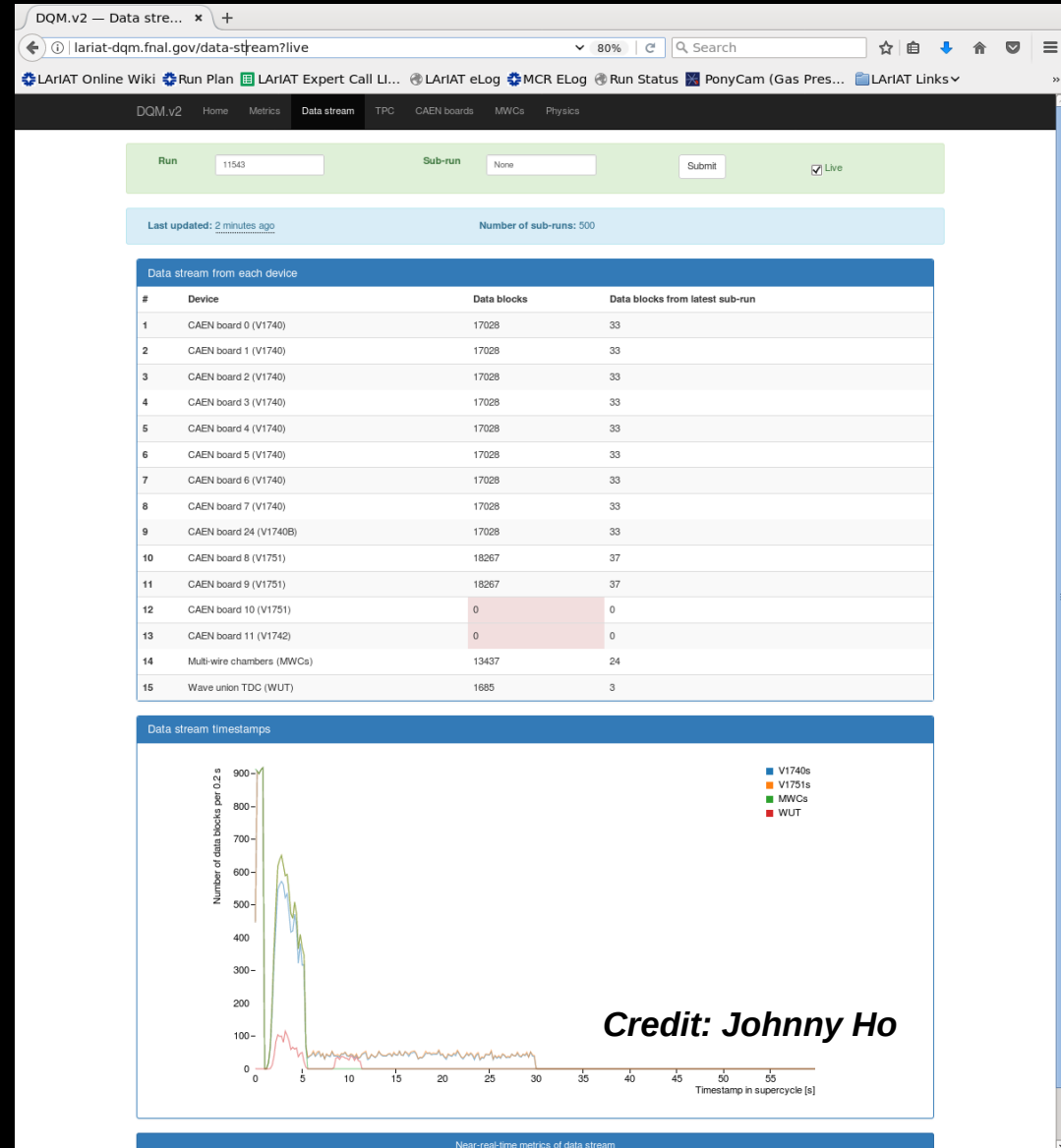
# Monitoring: “Are we taking good data?”

- **Webpage based DQM**

- Completed files (~1 min from data being taken) are processed to produce DQM plots
- Alarms when data flows are stopped from any frontend
- Can be configured to alarm on any data condition
  - TOF problems, TPC noise, missing beamline elements

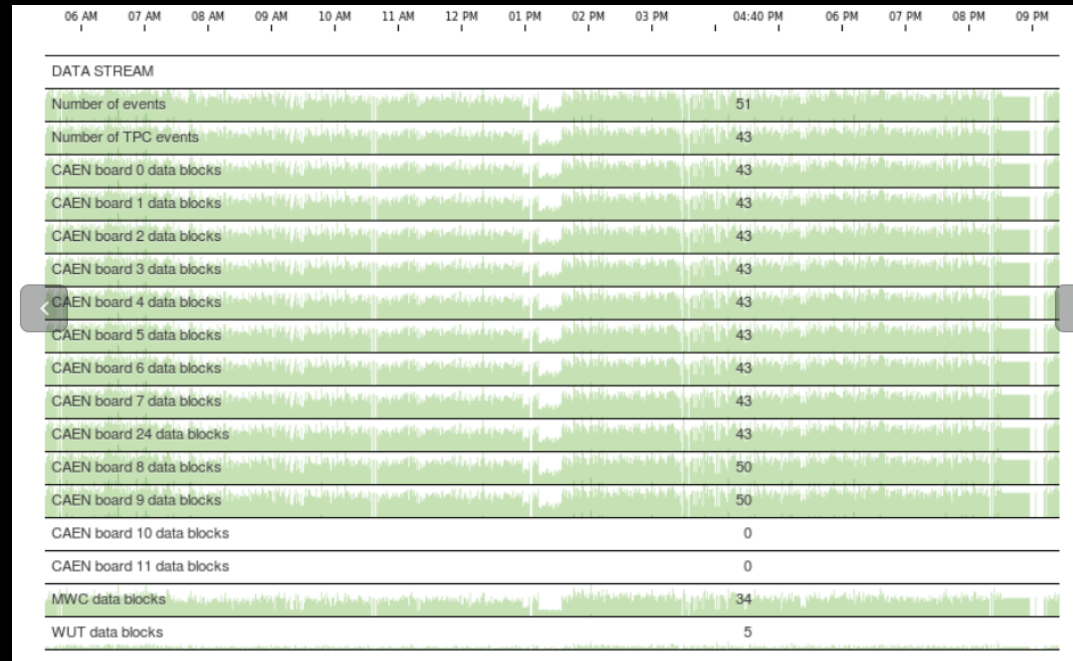
- **Can be used for ongoing run or to look back at previous runs**

- Utilizes many “off the shelf” packages to make a very slick and usable DQM
  - **Backend:** lariatsoft, python, numpy, scikit-learn, flask, sqlalchemy, watchdog, redis, rq, gunicorn
  - Frontend:** d3.js, cubism.js



# Monitoring: “Are we taking good data?”

- **Webpage based DQM**
  - Can monitor data stream individually to make sure every component is reading out
  - Can make low level plots for each system
    - TDC Hit timing from the wire chamber
    - RMS pedestal from the TPC
    - etc...
  - Can make “physics plots” to ensure we are getting good data
    - e.g. TOF for the current run

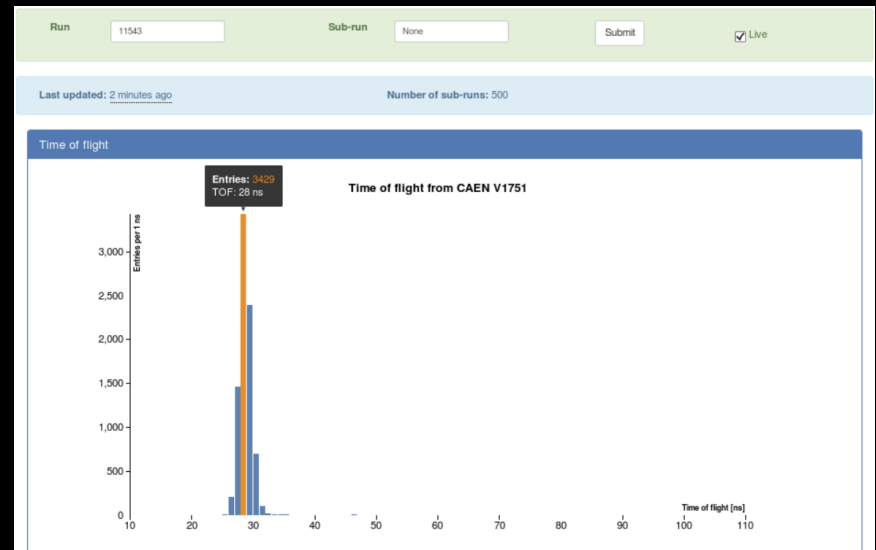
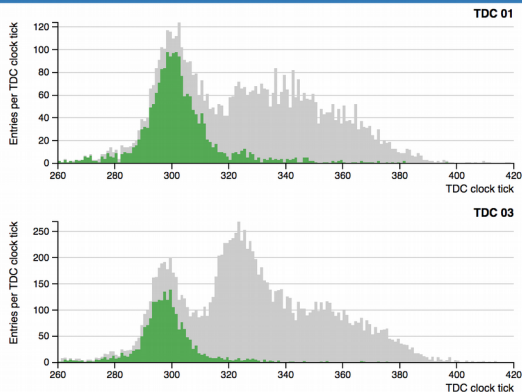


## Multi-wire chambers

Timing of hits

Credit: Johnny Ho

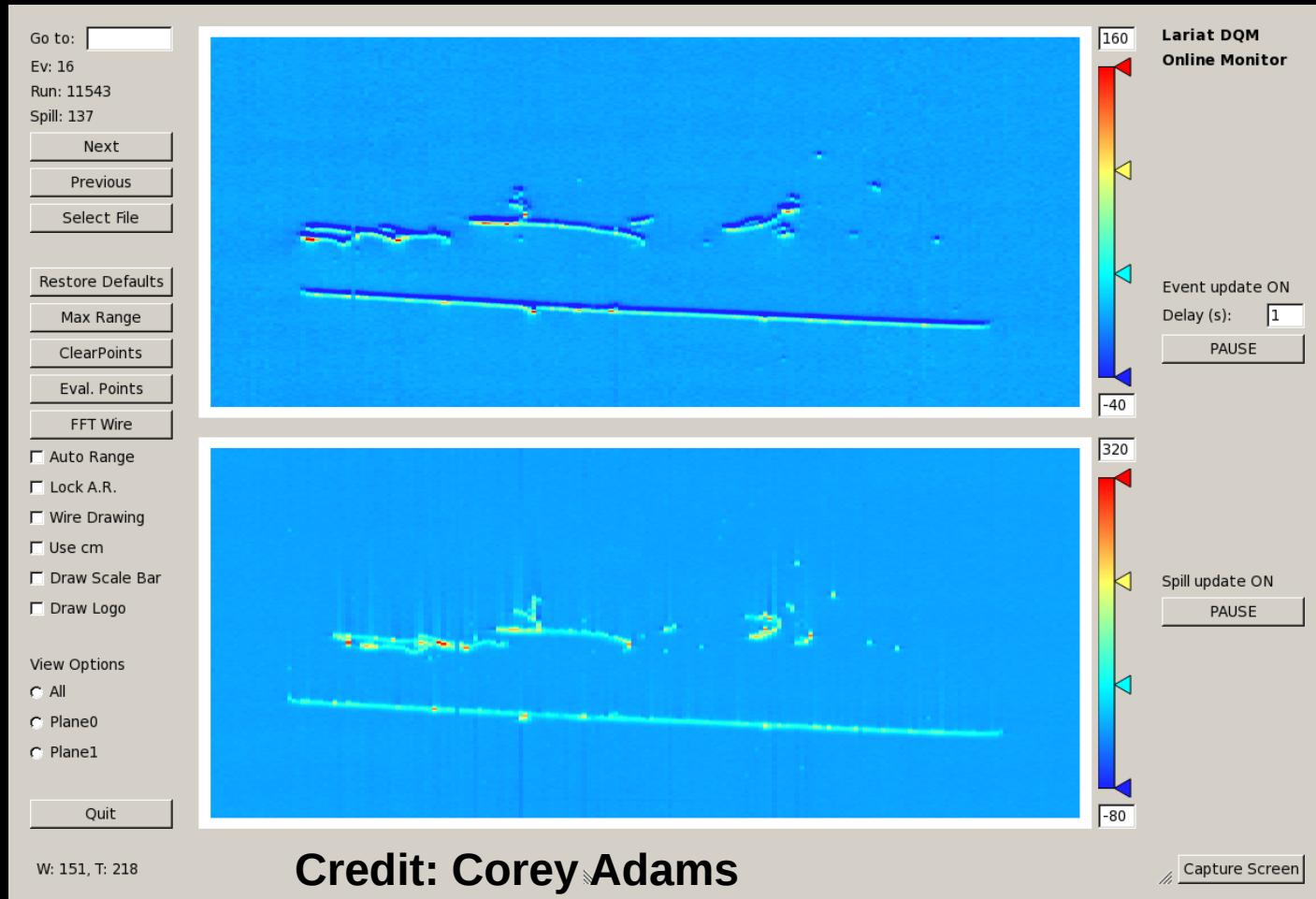
MWC 1



# Monitoring: “Are we taking good data?”

## • Online Event Display

- Having a near-line event display has helped LArIAT so much!
- LArIAT chose to use a light weight event display (LArLite)
- Events displayed made from DQM files (so only lag real time by ~ 1 min)
- Countless problems caught and solved by being able to SEE our data in near real time





# Monitoring: “How’s my data doing?”

- POMS, the Production automation system at Fermilab
  - Automates production job submission (cron, really) with web interface
  - Tracking and bookkeeping for 1000’s of jobs by software version, failure mode, with easy access to log files, etc.,
  - Perfect for re-processing with upgraded software without confusion, as well as keep-up processing for continual assessment.

Processing campaigns: unique combinations of any of

- larsoft version
- process name (Raw2Digit, eLifetime, Reco, etc)
- dataset

The screenshot shows the POMS web interface for monitoring campaign stages. The browser address bar shows the URL: [https://pomsgpvm01.fnal.gov/poms/show\\_campaigns?experiment=lariat](https://pomsgpvm01.fnal.gov/poms/show_campaigns?experiment=lariat). The page title is "Campaign Stages for lariat". The user is identified as Jason StJohn.

The main content area displays "Active Campaign Stages for lariat" with filters for "lariat" and "public". A date range is set to "2017-05-10 11:32 to 2017-05-11 11:32".

Experiment Name	Campaign Stage	Total All	Active Jobs			Jobs in 1.0 day ending 2017-05-11 11:32				Stats	
			Idle	Running	Held	Completed Total	Not Located	Located	Removed	%Efficiency	Pending
lariat	LArAT Raw2Digits	0	0	0	0	0	0	0	0	-	0
lariat	Raw2Digits_Reprocessing_5mm_v06_34_00	3	0	0	2	1	1	0	0	-	0
lariat	Raw2Digits_Reprocessing_5mm_v06_33_00	1	0	0	1	0	0	0	0	59	-
lariat	Raw2Digits_Reprocessing_v06_34_00	0	0	0	0	0	0	0	0	-	0

# Conclusions

- **LArIAT tried to follow a simple set of principles to monitor their detector and their data**
  - Keep it simple
  - Do no harm
  - Don't reinvent the wheel
  - Everything should be able to be done by a remote shifter
  - Make it fast and as near to the moment data has been taken
- **These have lead to three successful run periods and a wealth of useful data**
  - Hopefully with many physics papers coming soon