

Online Systems and Detector Operations



John Kelley

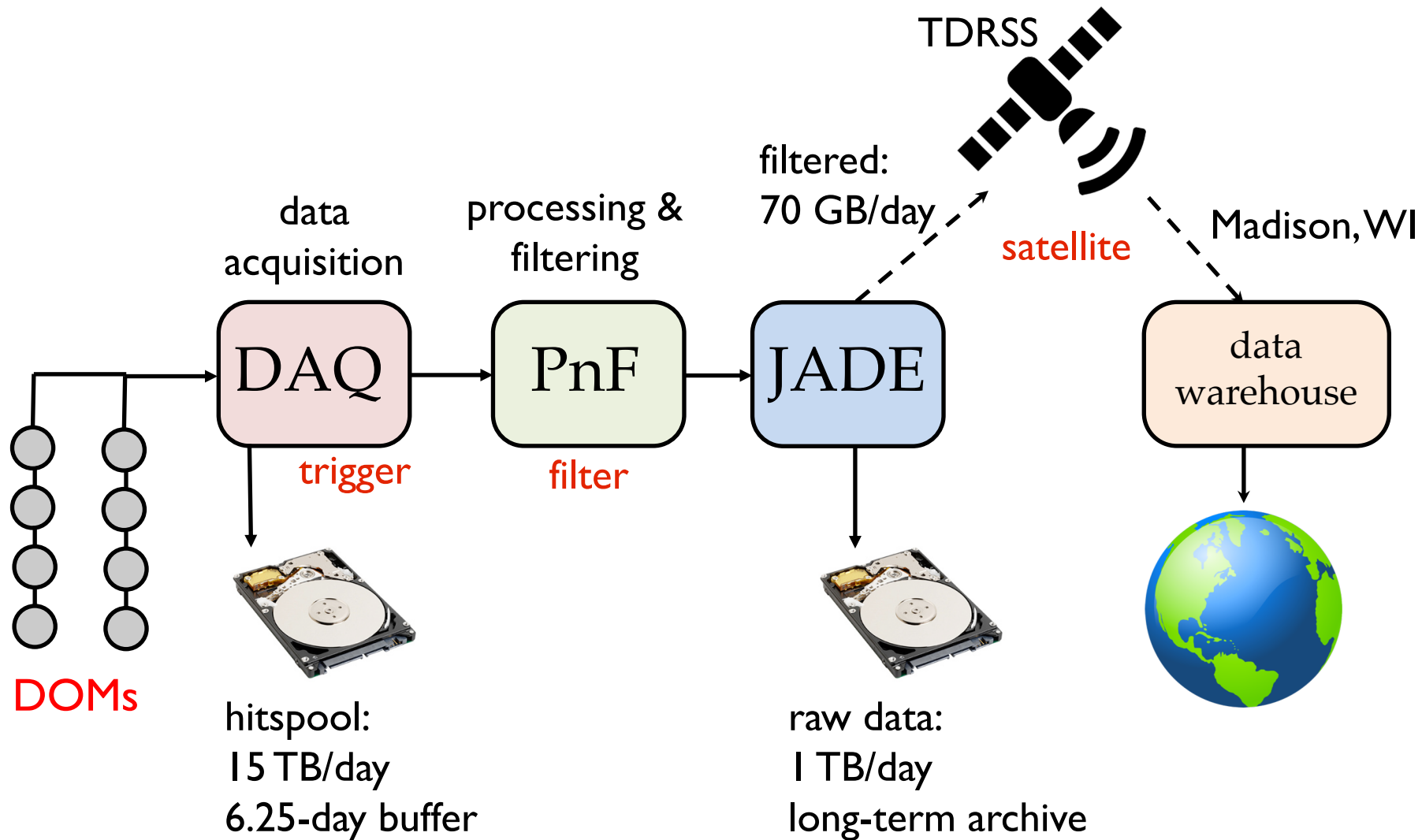
March 11, 2019

IceCube M&O Mid-Term Review

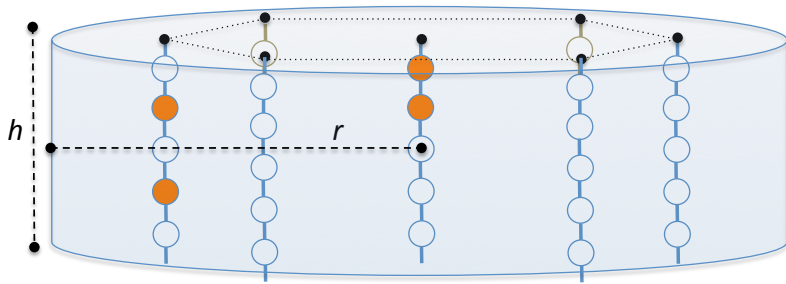
Operations Deliverables

- Keep the detector running!
 - reliable hardware and software
 - fast response time to problems
 - maintenance during austral summer at pole
- Ensure high-quality data to collaboration
 - monitoring and verification of every run
 - good / bad run tracking
- Support continued expansion of IceCube science
 - new features in software systems (e.g. multi-messenger)
 - design for integration of future detector expansions

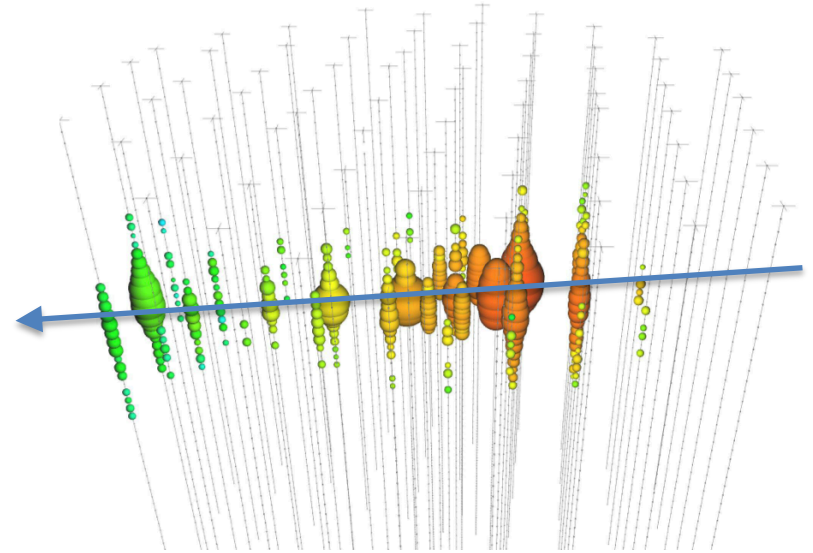
IceCube Online Overview



Triggers and Filters



DAQ selects causal patterns of light (hits) from particle interactions



PnF performs fast reconstructions on those events, selects subsets interesting for analysis

Hardware Maintenance and Pole Operations

Inside the IceCube Lab (ICL)

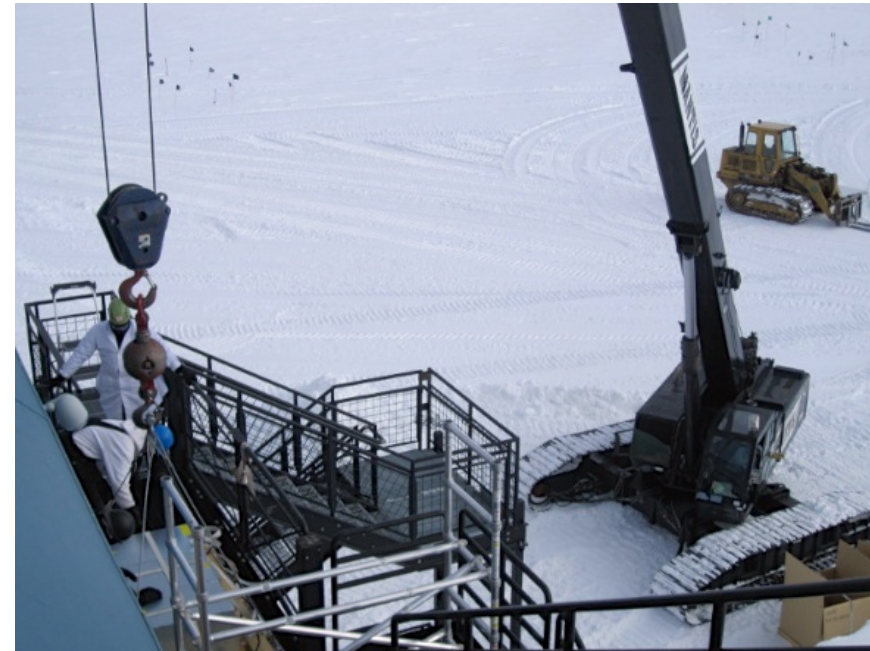


photo credit: F. Pedreros

- 18 racks of equipment
- 97 DOMHubs (1 / string + IceTop)
 - low-power single-board computers
 - custom DOM readout cards
 - DOM power supplies
- ~40 Dell PowerEdge servers
 - DAQ, PnF, infrastructure
- GPS receivers + fanouts, network switches, UPS, special devices

Computing Maintenance

- Regular server replacements
 - life cycle extended from 4 (M&O plan) to 5 years
 - 100% replacement in 2013–14
 - 50% replacement in 2018–19 + 50% in 2019–20
- UPS battery replacements
- Standard security software patches



Hardware Stability

Failures since May 1, 2017

Component	Failures
DOM power supplies (Acopian)	24
Hub power supplies	6
Hub memory	1
Hub hard drives	4
Hub single-board computers	1
DOM readout cards	0
Clock fanout cards	2
DOMs	3
master clock	1

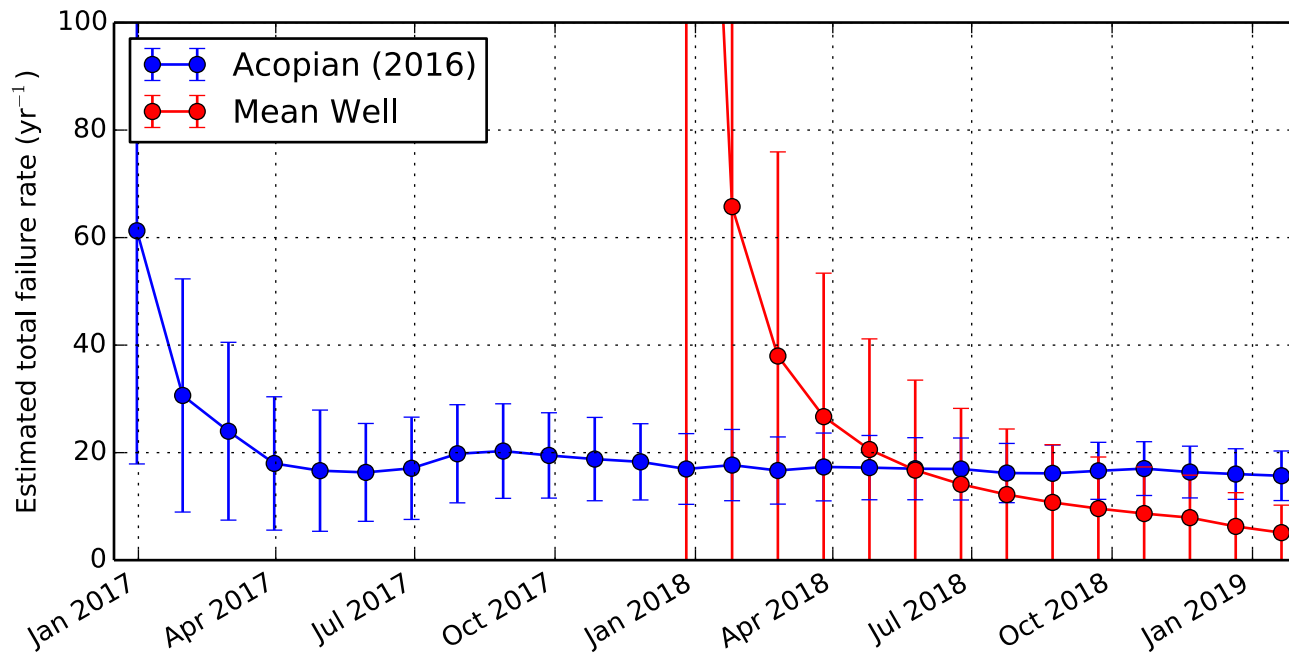
- DOM power supply failure rate unacceptably high
 - full replacement 2016–17 pole season
 - failure rate stabilized but did not decrease
- Custom electronics (including DOMs) highly reliable
- Hub hard drive failure rate being monitored
 - increase since March
 - life cycle replacement planned 2019–20

DOM Power Supply

- 16 strings running on new Mean Well power supplies since December 2017
- Additional 36 strings swapped in November 2018
- No failures yet; more stable than Acopians



Mean Well MSP-200-48



Pole Operations

- Pole Operations: planning and execution of on-site M&O activities
 - on-site winterover training
 - computing and hardware maintenance
 - calibration activities (e.g. SPICEcore)
 - new instrumentation (e.g. scintillator prototypes)
- Population evaluated based on tasking and priorities
 - approx. 15 people / season
- Combination of expert personnel and student / postdoc first-timers
 - training at WIPAC when needed
- Logistics support from contractor managed by Jim Haugen



Data Quality

Data Acquisition

131654 **RUNNING** 2h 09m
Current run pDAQ rate Duration

Tyrarena4 20,829,441 dark
pDAQ release Event count LID mode

Full Start 5409 / 5409
Transition Active DOMs

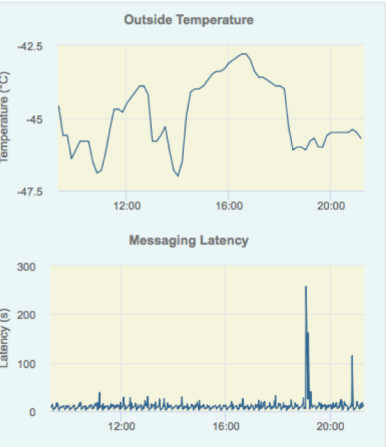
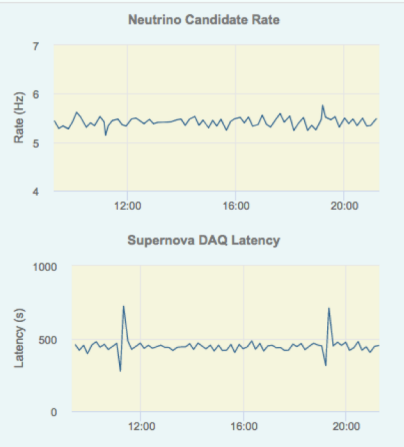
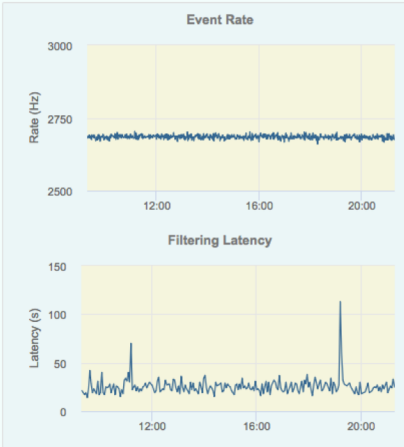
sps-IC86-2018-tweak-Grilled-Cheese-V279
Run configuration

Live Alerts

- multirunfail
- runfail
- FPMaster disk usage too high
- PnF file backlog too large
- Too much time betw...DAQ latency messages
- Detector not taking data
- Excessive run failure rate
- I3DAQDispatch is not RUNNING
- I3MS link is not UP
- Lots of LBM overflows
- Modem ttyS1 is unable to connect
- Modem ttyS4 is unable to connect
- Modem ttyS5 is unable to connect
- Modem ttyS6 is unable to connect
- PFDSTWriter is not RUNNING
- PFFiltWriter is not RUNNING
- PFRawWriter is not RUNNING
- PFServer1 is not RUNNING
- PFServer2 is not RUNNING
- PFServer3 is not RUNNING
- PFServer4 is not RUNNING
- PFServer5 is not RUNNING
- PFServer6 is not RUNNING
- PFServer7 is not RUNNING
- PFServer8 is not RUNNING
- PnF latency too high
- PnF rate too low
- PPP link is not UP
- SERIOUS SN alert triggered!
- SNDAQ is not RUNNING
- SNDAQ latency too high
- Throttling messages from noisy service
- Too many *.dat file...local/pdaq/sndaq/tmp
- Too many *sn.tar fi.../mnt/data/pdaq/local
- Too many missing DOMs
- Too much time between...I3MS monitoring msgs
- Too much time between SNDAQ alerts

Components

I3DAQDispatch RUNNING	PFDSTWriter RUNNING
PFFiltWriter RUNNING	PFMoniWriter1 RUNNING
PFMoniWriter2 RUNNING	PFMoniWriter3 RUNNING
PFMoniWriter4 RUNNING	PFOneWriter RUNNING
PFRawWriter RUNNING	PFServer1 RUNNING
PFServer2 RUNNING	PFServer3 RUNNING
PFServer4 RUNNING	PFServer5 RUNNING
PFServer6 RUNNING	PFServer7 RUNNING
PFServer8 RUNNING	sndaq RUNNING
uptimer RUNNING	



Component Alerts

No alerts in past 24h

- PFFiltWriter 2d 5h 58m ago missing events
- I3DAQDispatch 12d 6h 39m ago missing or invalid run summary! waiting for a valid one...
- hubmoni 15d 23h 9m ago ichub29: unexpected number of DOMs
- hubmoni 15d 23h 15m ago lthub07: unexpected number of DOMs
- hubmoni 16d 2h 3m ago lthub08: unexpected number of DOMs
- hubmoni 17d 17h 52m ago ichub35: unexpected number of DOMs
- hubmoni 18d 2h 16m ago ichub29: unexpected number of DOMs
- PFServer server-crash 19d 8h 14m ago
- I3DAQDispatch 20d 10h 13m ago missing or invalid run summary! waiting for a valid one...
- hubmoni 21d 8h 29m ago ichub33: unexpected number of DOMs
- hubmoni 21d 8h 29m ago ichub33: DOM power check failure
- pdaq 22d 3h 7m ago Master Clock is out of agreement with the NTP reference

Recent Log Msgs

```

2018-10-23 19:09:29 Watchdog reports starved components: stringHub#203->IceTopTrigger icetopBit.RecordsReceived not changing from [16261,
2018-10-23 19:07:33 Using system time for initial event counts (no event times available)
2018-10-23 19:07:15 Starting run 131654...
2018-10-23 19:07:14 Cluster: sps-cluster
2018-10-23 19:07:14 Run configuration: sps-IC86-2018-tweak-Grilled-Cheese-V279
2018-10-23 19:07:14 Version info: Tyrarena4 14222:143282 2018-08-10 20:20:07
2018-10-23 19:06:48 pdaq: STOPPED -> start {'runNumber': 131654, 'subRunNumber': 0, 'runConfig': 'u'sps-IC86-2018-tweak-Grilled-Cheese-V279
2018-10-23 19:06:32 Wrote combined log for run 131653
2018-10-23 19:06:31 Writing combined log for run 131653
2018-10-23 19:06:29 Run terminated SUCCESSFULLY.
2018-10-23 19:06:29 77380238 physics events collected in 28820 seconds (2684.95 Hz)
2018-10-23 19:06:23 pdaq: RUNNING -> stop
2018-10-23 19:05:35 Watchdog reports starved components: stringHub#210->IceTopTrigger icetopBit.RecordsReceived not changing from [1956673
2018-10-23 19:05:26 Watchdog reports hanging components: stringHub#84
2018-10-23 17:43:20 Watchdog reports starved components: stringHub#210->IceTopTrigger icetopBit.RecordsReceived not changing from [1873574
2018-10-23 16:54:30 Watchdog reports starved components: stringHub#210->IceTopTrigger icetopBit.RecordsReceived not changing from [1824024
2018-10-23 16:49:28 Watchdog reports starved components: stringHub#210->IceTopTrigger icetopBit.RecordsReceived not changing from [1818865
2018-10-23 16:47:46 Watchdog reports starved components: stringHub#210->IceTopTrigger icetopBit.RecordsReceived not changing from [1817186
2018-10-23 14:20:00 Watchdog reports starved components: stringHub#210->IceTopTrigger icetopBit.RecordsReceived not changing from [1667354
2018-10-23 13:36:22 Sending Alert 4.82454 (# 57 in run 131653 )
2018-10-23 13:35:18 Sending Alert 5.09722 (# 56 in run 131653 )
2018-10-23 13:33:37 Sending Alert 4.26094 (# 55 in run 131653 )
2018-10-23 13:31:20 Sending Alert 4.80873 (# 54 in run 131653 )
2018-10-23 13:27:18 Sending Alert 4.75233 (# 53 in run 131653 )
2018-10-23 13:25:23 Sending Alert 4.51294 (# 52 in run 131653 )
2018-10-23 13:23:07 Sending Alert 4.66859 (# 51 in run 131653 )
2018-10-23 13:21:23 Sending Alert 4.53084 (# 50 in run 131653 )
2018-10-23 13:19:24 Sending Alert 4.18529 (# 49 in run 131653 )
2018-10-23 13:17:21 Sending Alert 4.29741 (# 48 in run 131653 )
2018-10-23 13:13:18 Sending Alert 4.15197 (# 47 in run 131653 )
2018-10-23 13:11:22 Sending Alert 4.02718 (# 46 in run 131653 )
2018-10-23 13:11:10 Watchdog reports starved components: stringHub#210->IceTopTrigger icetopBit.RecordsReceived not changing from [1597214
2018-10-23 13:10:14 Sending Alert 4.16611 (# 45 in run 131653 )
2018-10-23 13:06:11 Sending Alert 4.44682 (# 44 in run 131653 )
    
```

IceCube Live: experiment control, detector status, and data monitoring

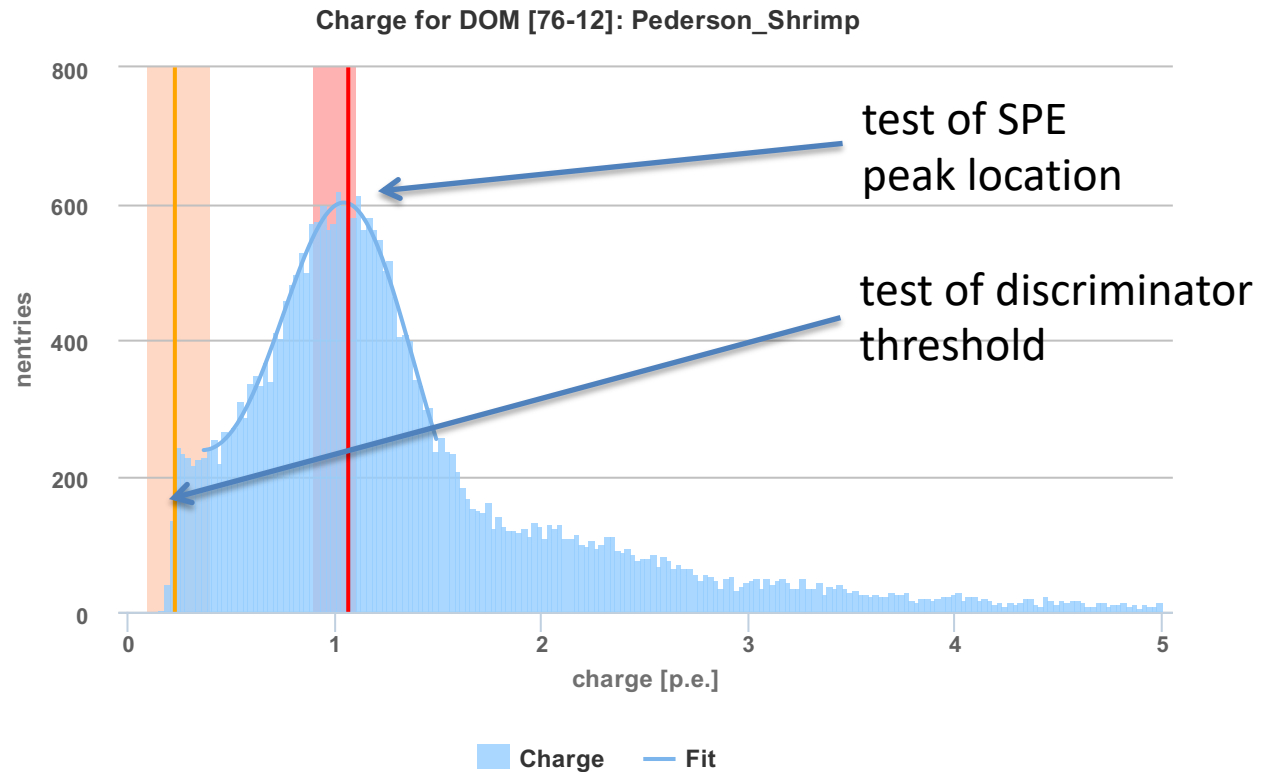
IceCube Live Good Run List

Run	Started	Duration	Rate	Drop	Configuration	DAQ release	LID	Trans	PnF	Moni	Shift	InIce	IceTop	Comments
131930	2018-12-17 14:30:19	in progress	-	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	FS	PP	-	walt	BAD	BAD	±
131929	2018-12-17 06:28:50	8:00:12	2907.92	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	☆☆☆☆☆	walt	GOOD	GOOD	±
131928	2018-12-16 22:28:36	8:00:14	2905.18	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	dpankova	GOOD	GOOD	±
131927	2018-12-16 14:28:19	8:00:17	2902.15	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	dpankova	GOOD	GOOD	±
131926	2018-12-16 06:28:15	8:00:04	2899.41	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	FS	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131925	2018-12-15 22:26:49	8:00:18	2898.06	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	PnF crash restarted PnF Issues with PFMoniWrit... ±
131924	2018-12-15 14:26:33	8:00:16	2899.37	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131923	2018-12-15 06:26:24	8:00:09	2901.57	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131922	2018-12-14 22:26:22	8:00:02	2901.82	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	FS	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131921	2018-12-14 14:25:04	8:00:11	2902.45	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131920	2018-12-14 06:24:49	8:00:15	2903.32	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131919	2018-12-13 22:24:33	8:00:16	2905.22	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131918	2018-12-13 14:24:31	8:00:02	2906.58	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	FS	PP	★★★★★	jdelaunay	GOOD	GOOD	fplave07 crashed ±
131917	2018-12-13 06:23:16	8:00:10	2907.27	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131916	2018-12-12 22:23:00	8:00:16	2908.08	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131915	2018-12-12 14:22:48	8:00:12	2909.69	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131914	2018-12-12 06:22:45	8:00:03	2912.45	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	FS	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131913	2018-12-11 22:21:14	8:00:11	2913.55	2	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131912	2018-12-11 14:20:58	8:00:16	2913.07	2	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131911	2018-12-11 06:20:44	8:00:14	2915.98	2	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	SR	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131910	2018-12-10 22:20:41	8:00:03	2919.95	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	FS	PP	★★★★★	jdelaunay	GOOD	GOOD	±
131909	2018-12-10 22:07:22	0:12:19	2923.43	-	sps-IC86-2018-tw...lled-Cheese-V279	Urban_Harvest2	dark	FS	PP	★★★★★	jdelaunay	GOOD	GOOD	baseline settling run ±
131908	2018-12-10 20:41:28	1:24:12	2863.61	-	sps-IC86-2018-tw...e-V279-no01-no22	Urban_Harvest2	dark	FS	PP	★★★★★	mkauer	GOOD	GOOD	blessed ARA pulsing on 01 and 22 manually set to physic... partial 13 ±

- Central database of run quality information
- Interfaces for both humans and software

IceCube Live Moni 2.0

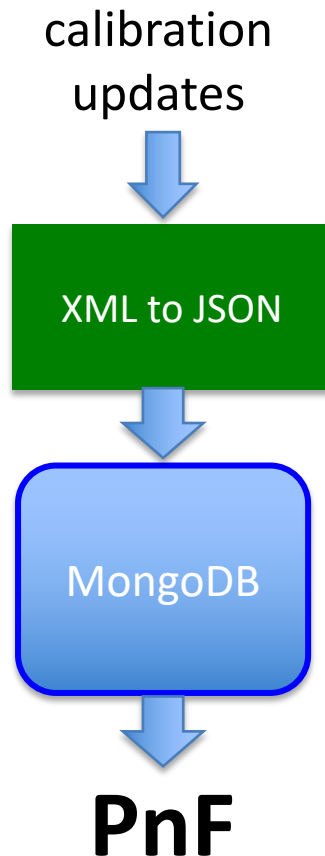
Charge distribution collected for all DOMs in PnF



- Rewrite of data monitoring system released in 2017
- Monitoring data collected from subsystems and analyzed
- Improved accuracy, maintainability, and expandability compared to old system

Additional Operational Upgrades

GCD Server



- Rewrite of **Geometry / Calibration / Detector status (GCD)** metadata framework
 - legacy system difficult to maintain / expand
- New database is very flexible
- Deployed May 2017 for physics run start
 - PnF, offline data processing updated to use new system

Master Clock Upgrade

- Issues with legacy Symmetricom ET6000
 - buggy, unsupported firmware
 - potentially severe issues after [April 2019 GPS week rollover](#)
 - instability with one unit at pole

ET6000 after erroneous leap second

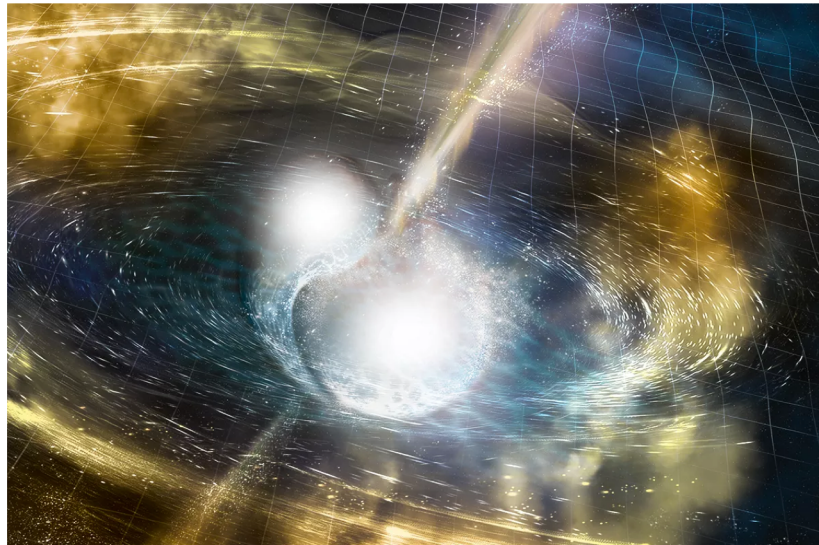


- Identified replacement: Spectracom SecureSync
 - running at pole as White Rabbit master clock since December 2017
 - validation at South Pole Test System in summer 2018
 - final testing at South Pole underway

Spectracom SecureSync 1200



External Hitspool Alerts

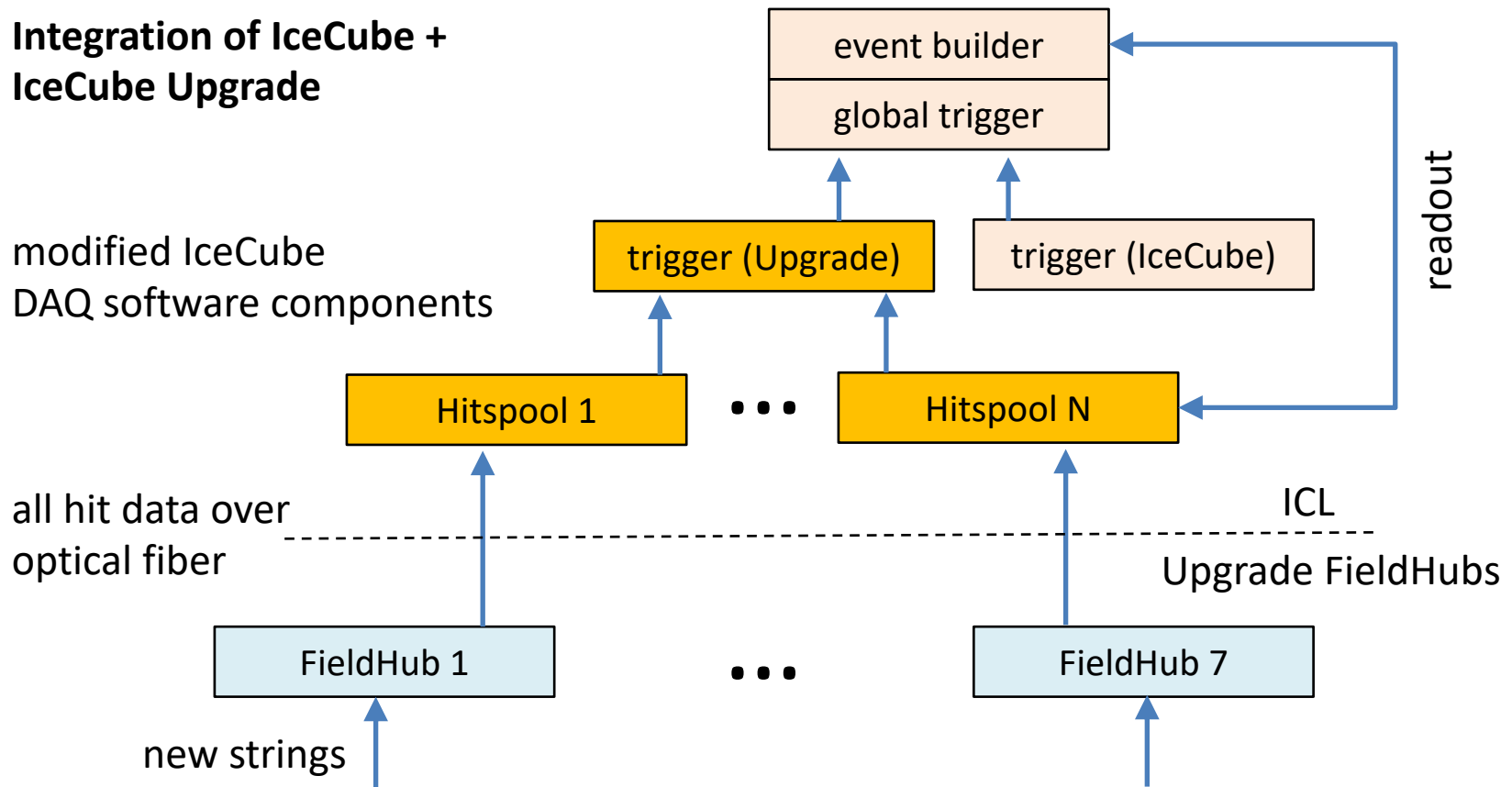


binary neutron star merger
(artist's conception)

- Receive external multi-messenger alerts for gravitational wave (LIGO/VIRGO) and supernova (SNEWS) event
- Automatically save hitspool data for subthreshold analyses
 - archive to disk and/or transfer via satellite
- Will be active March 2019
 - in time for LIGO O3 run

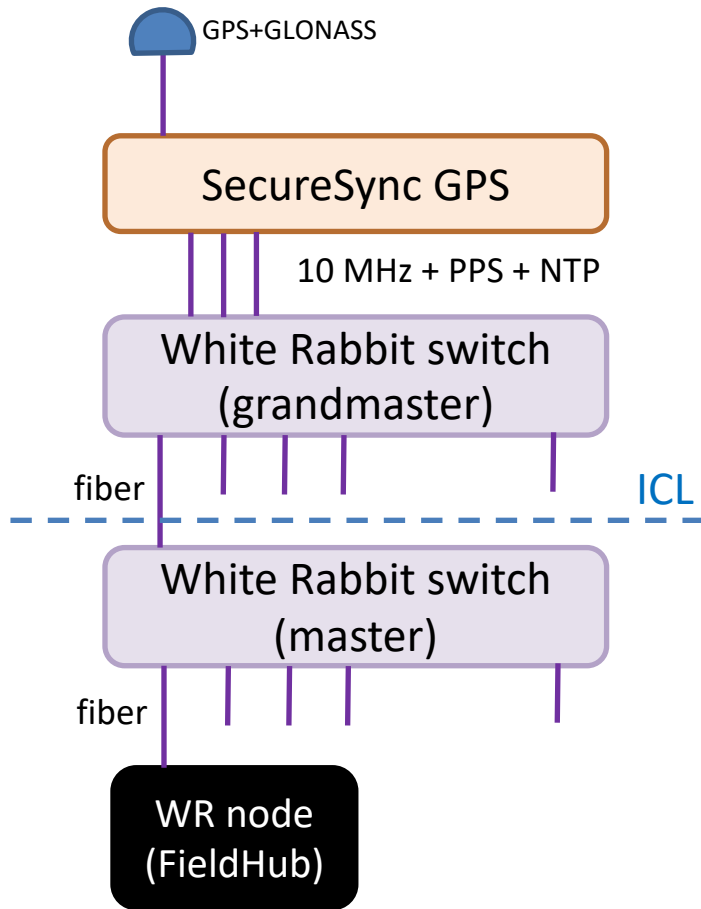
DAQ Improvements

Integration of IceCube + IceCube Upgrade



- Decouple DOM readout and hitspool / trigger
- Support expansion of detector (scintillator, Upgrade, and beyond)

IceCube Upgrade and Beyond



all elements synchronized
to TAI +/- 1ns

- Scintillator installation validates Upgrade technical strategies
 - White Rabbit precision timing over optical fiber
 - moving DOMHubs out of ICL
- Legacy software retooled to be more expandable and maintainable
 - Moni2.0, GCD Server
- DAQ software improvements lay the groundwork for expansion

Thank you!



Realtime Event Page

IceCube Realtime **BETA**

Latest Events

neutrino

2018-12-17 20:45:39.738
8 minutes ago

EHE

2018-10-23 16:37:32.652
2 months ago

ESTRES

2018-12-17 19:29:14.102
an hour ago

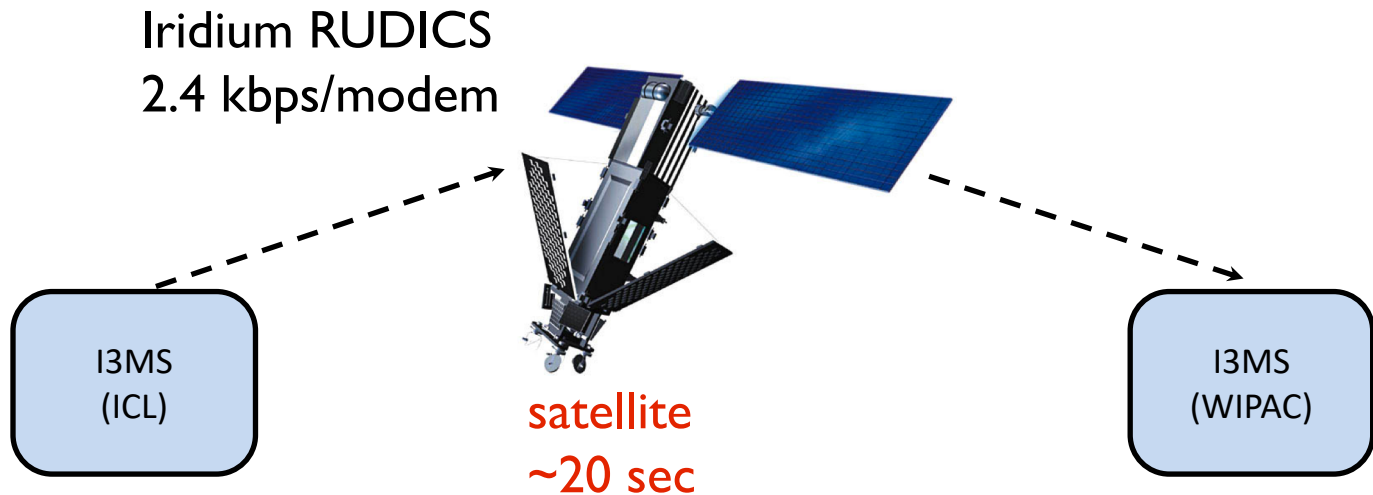
HESE

2018-12-17 20:19:24.760
35 minutes ago

Run	Evt #	Event Time	Streams
131930	60936106	2018-12-17 20:19:24.760436	HESE
131930	52178458	2018-12-17 19:29:14.102660	ESTRES
131930	27948805	2018-12-17 17:10:26.587923	HESE
131930	13414151	2018-12-17 15:47:08.813584	ESTRES
131930	8760113	2018-12-17 15:20:29.672987	ESTRES
131930	693711	2018-12-17 14:34:17.122959	ESTRES
131929	75762014	2018-12-17 13:43:04.857337	ESTRES
131929	75242460	2018-12-17 13:40:06.471208	ESTRES
131929	70800470	2018-12-17 13:14:38.555655	HESE
131929	56913754	2018-12-17 11:55:04.679999	HESE

- Beta release in 2018; production in 2019
- Support continued expansion of multi-messenger program

IceCube Messaging System (I3MS)



- I3MS messaging software supports all IceCube real-time data transfer to/from pole
 - detector status to IceCube Live
 - real-time alerts and event data
 - operations chat
- Dedicated bank of Iridium modems in IceCube Lab