IceCube Detector Operations

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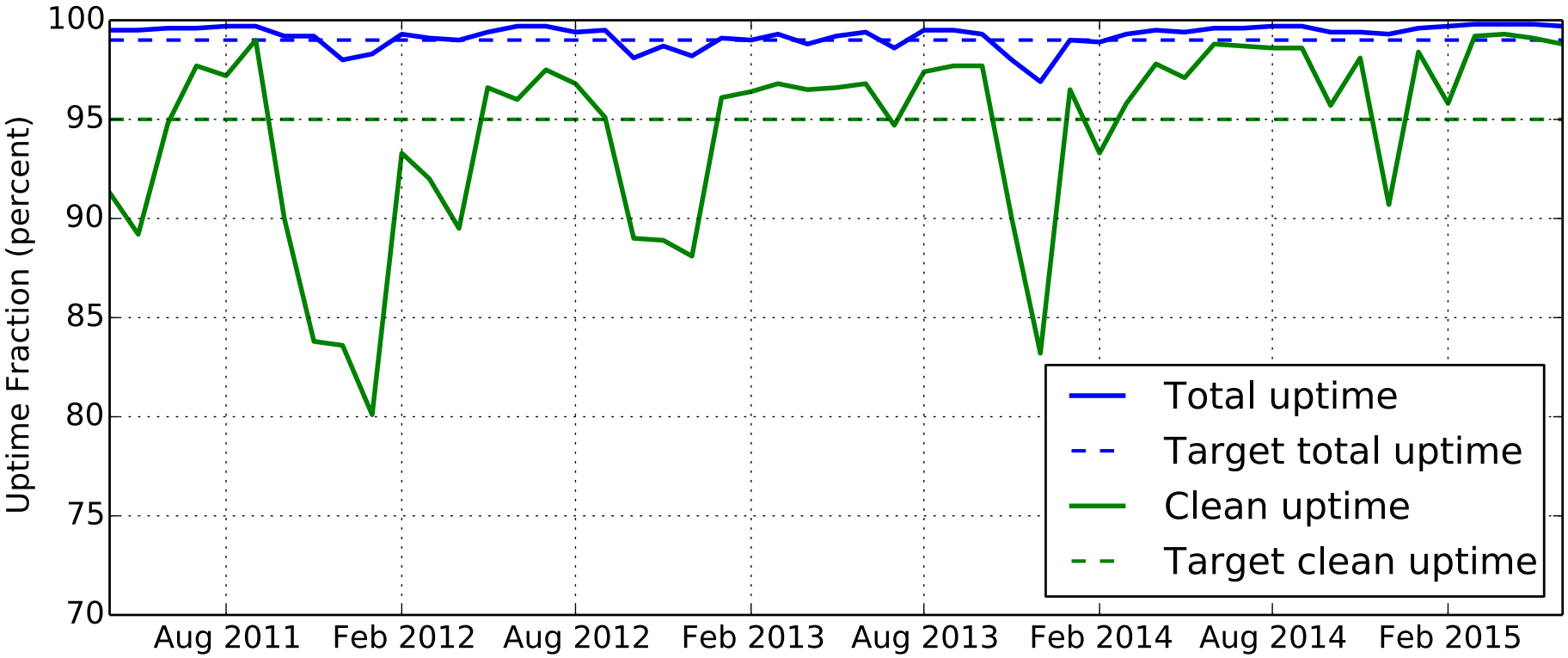
SAC Meeting
October 19, 2015

photo credit: E. Beiser / S. Richter

Operations Charge

- Keep the detector running!
  - reliable hardware and software
  - fast response time to problems (automatic paging)
  - 2 winterovers + northern support team
- Ensure high-quality data to collaboration
  - monitoring and verification of every run
  - calibration
  - good / bad run tracking
- Support continued expansion of IceCube science
  - new features in online systems
  - improvements supporting multi-messenger program

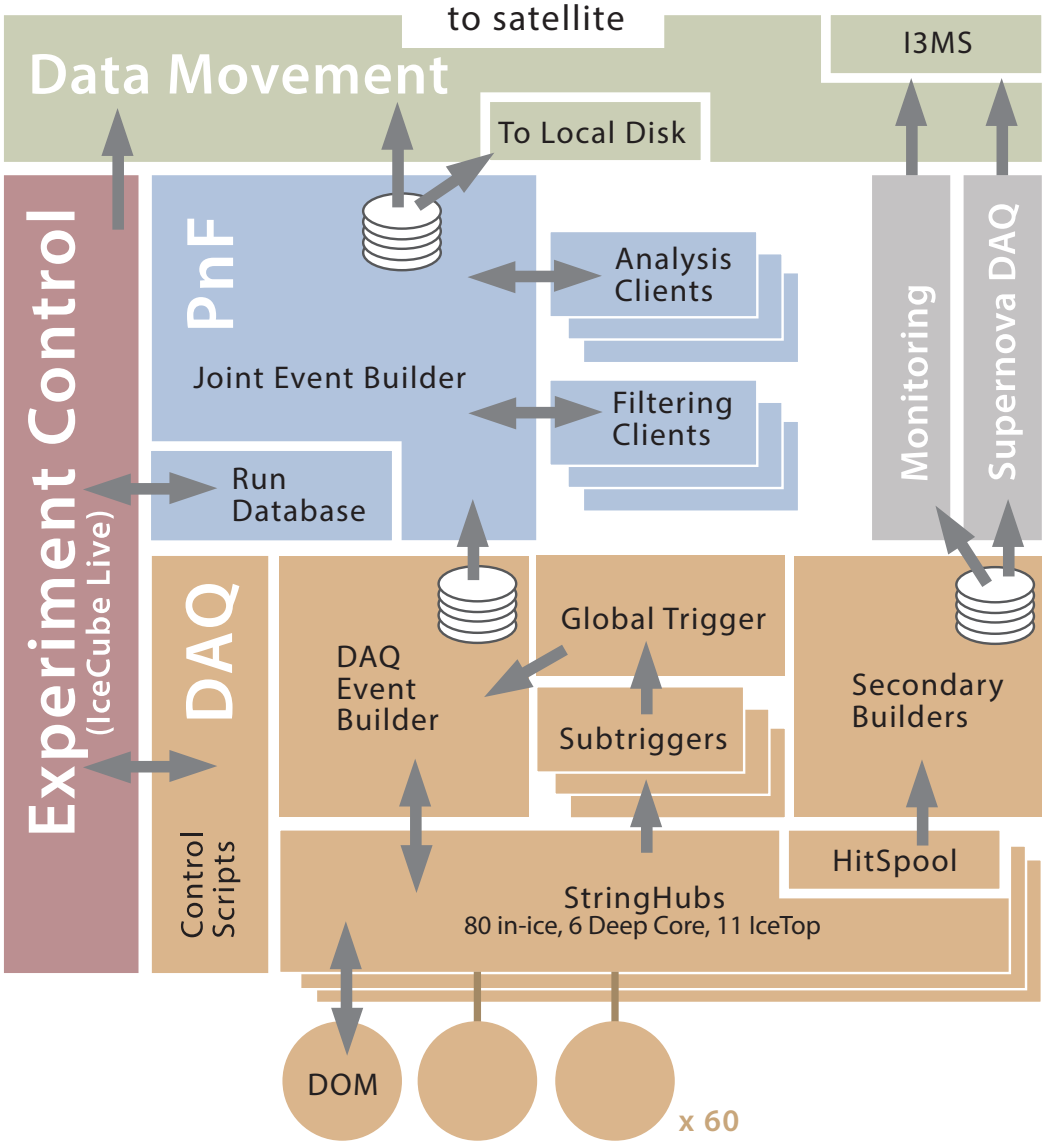
Uptime



Uptime average >99% every month since February 2014 (last week: 99.7%)

Clean uptime: successful run, no missing strings, no problems found;
regularly exceeding 95% (less during austral summer maintenance periods)

IceCube Online Systems



Hardware Stability

Failures since May 1, 2014

Component	Failures
Acopian (DOM) power supplies	6
Hub ATX power supplies	3
SBC RAM modules	2
DOMHub hard drives	1
SBCs	0
DOR cards	0
DSB cards	0
DOMs	0

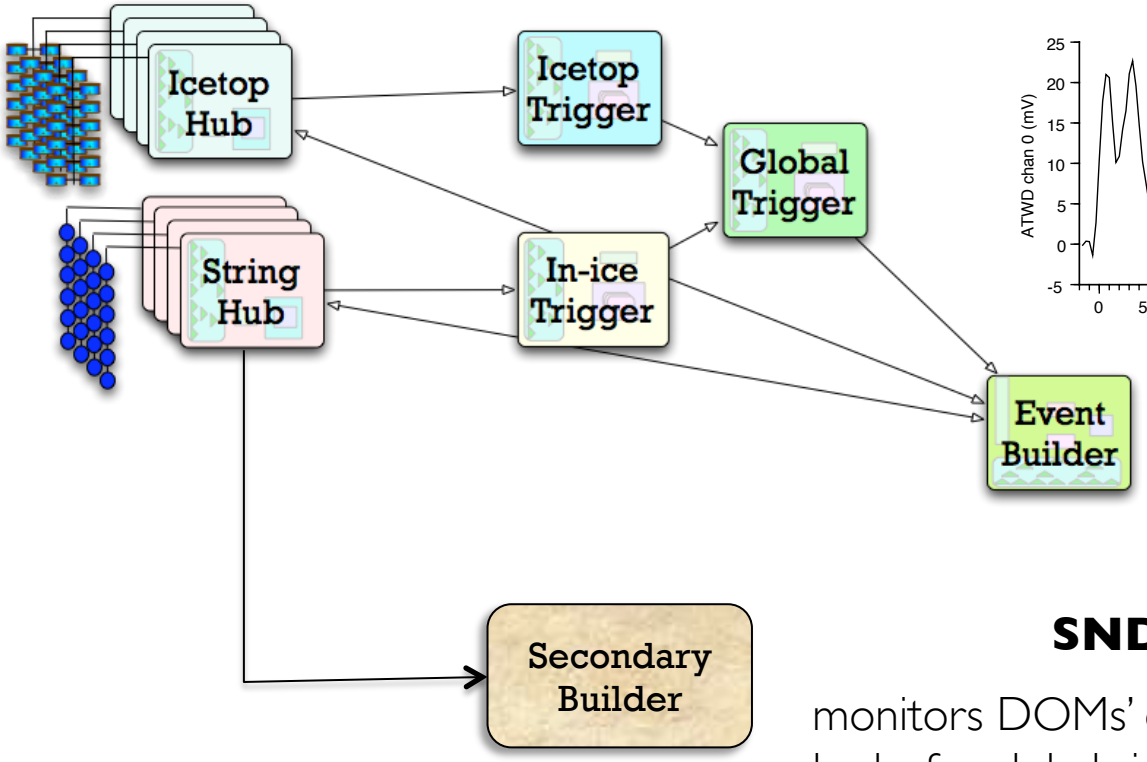
- Acopian (DOM) power supplies have the highest failure rate
  - additional spares shipped to pole last season
  - 5–6 / year average
- No DOM failures since dark sector power outage, May 2013
- No custom hub component failures (DOR/DSB cards)
  - budget for DOR repair / DSB re-spin

Computing Upgrades

- Most systems upgraded in 2013–14
  - 48 Dell PowerEdge R720 servers
  - 97 DOMHub single-board computers (Atom D525)
- Server reliability better than planned
  - no performance bottlenecks
  - replacement timeline extended to 2017–18
- No further DOMHub SBC upgrade planned
  - modest budget for additional spares
  - investigating new hub designs as contingency plan
  - Gen2 surface hardware will be backward-compatible

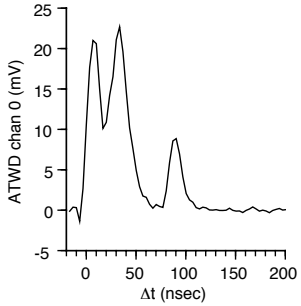
IceCube DAQ(s)

DOMs
n=5404



pDAQ

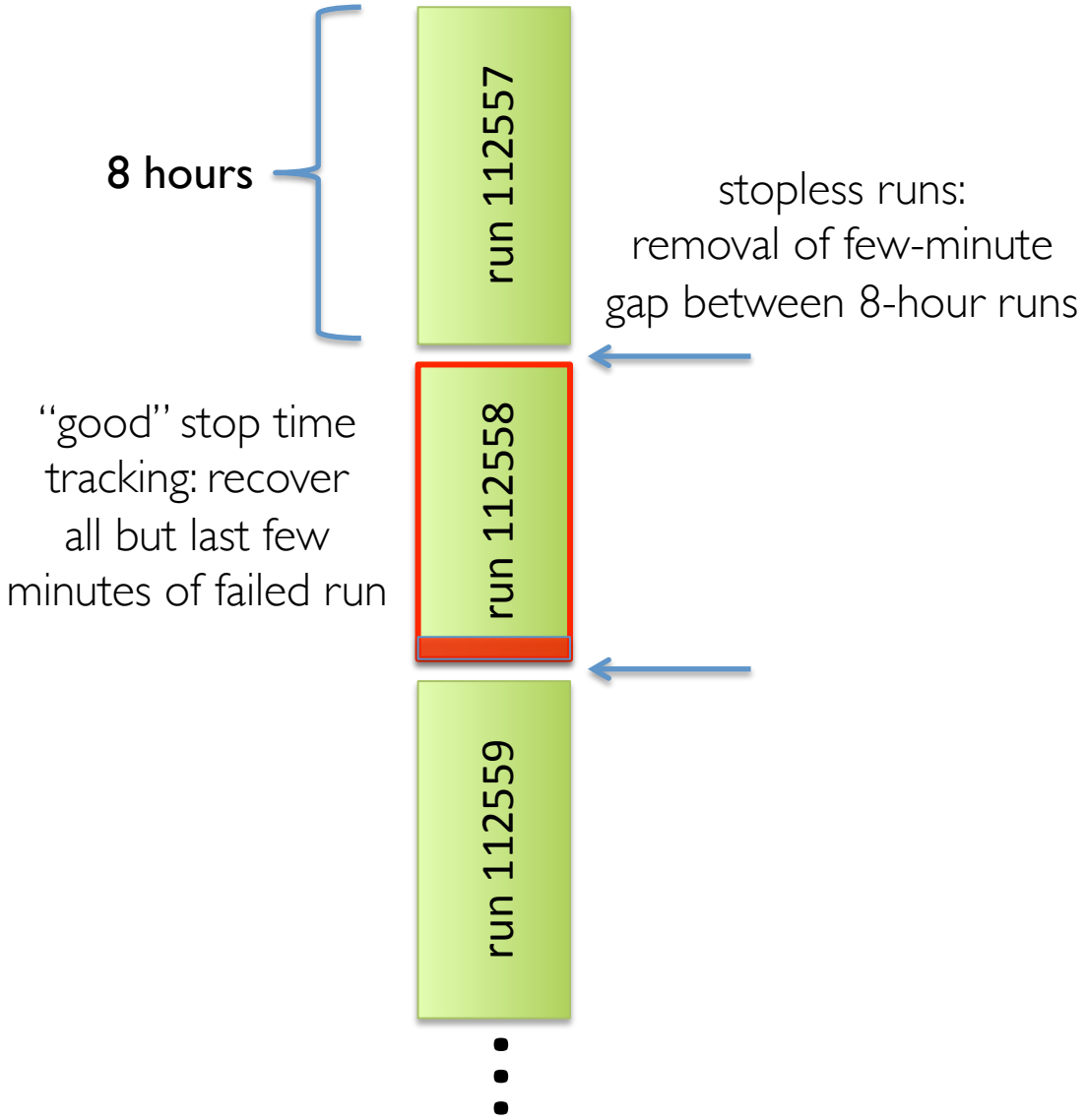
forms triggers (e.g. 8-fold multiplicity)
stores DOM waveforms + hit times



SNDAQ

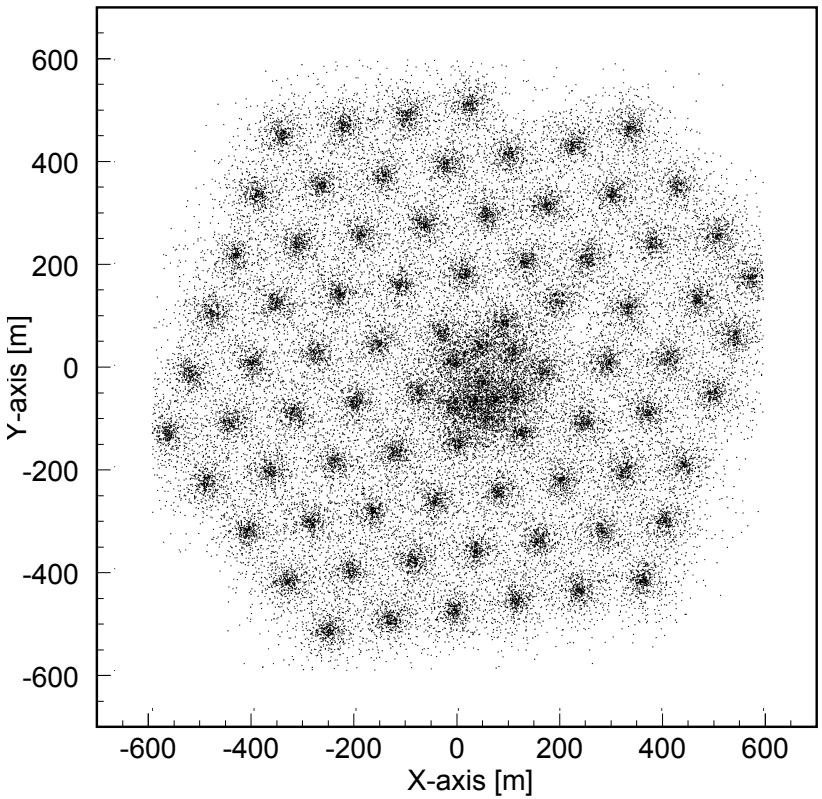
monitors DOMs' dark noise rates
looks for global rise on short time scale

Uptime improvements



- Recovery of data from failed runs
  - deployed April 2013
  - tracking in IceCube Live
  - significant increase in clean uptime gained
- Stopless run transitions
  - deployed April 2015
  - 32-hour full run restart
- Extended stopless runs
  - recovery of dropped DOMs
  - planned for 2016

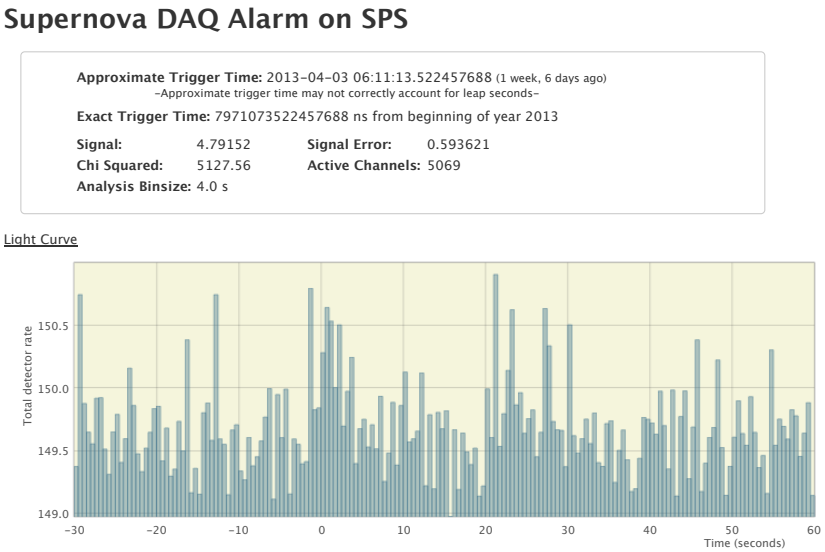
Supernova (SN)DAQ

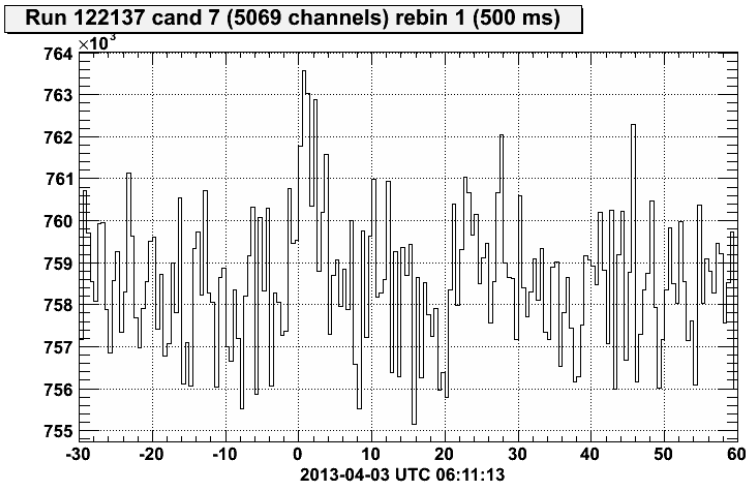


GEANT simulation of detected inverse beta decay events

- Detection principle: global noise rate increase from many ~10 MeV neutrino interactions
- Scaler dark noise counts from in-ice DOMs (4b count / 1.6 ms)
- Artificial dead-time introduced
  - reduces bursts of correlated noise hits
  - avg. rate lowered: 540 Hz to 290 Hz
- Real-time significance of any global rise estimated

Alerts + SNEWS



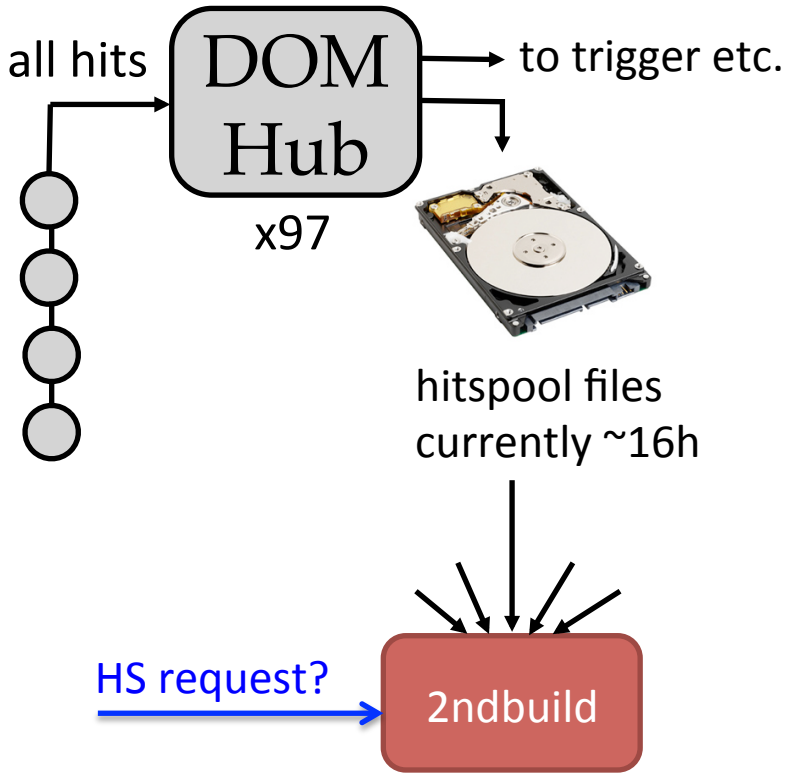


- Iridium link allows:
  - near real-time monitoring of SNDAQ light curve
  - e-mail, SMS in case of high-significance alert
  - forwarding of alarms to **S**uper**N**ova **E**arly **W**arning **S**ystem (SNEWS)

- Real-time correction of muon rate fluctuations
  - new alert thresholds (Aug. 2015)
  - for LMC supernova: probability to pass SNEWS threshold from 12% to 85%

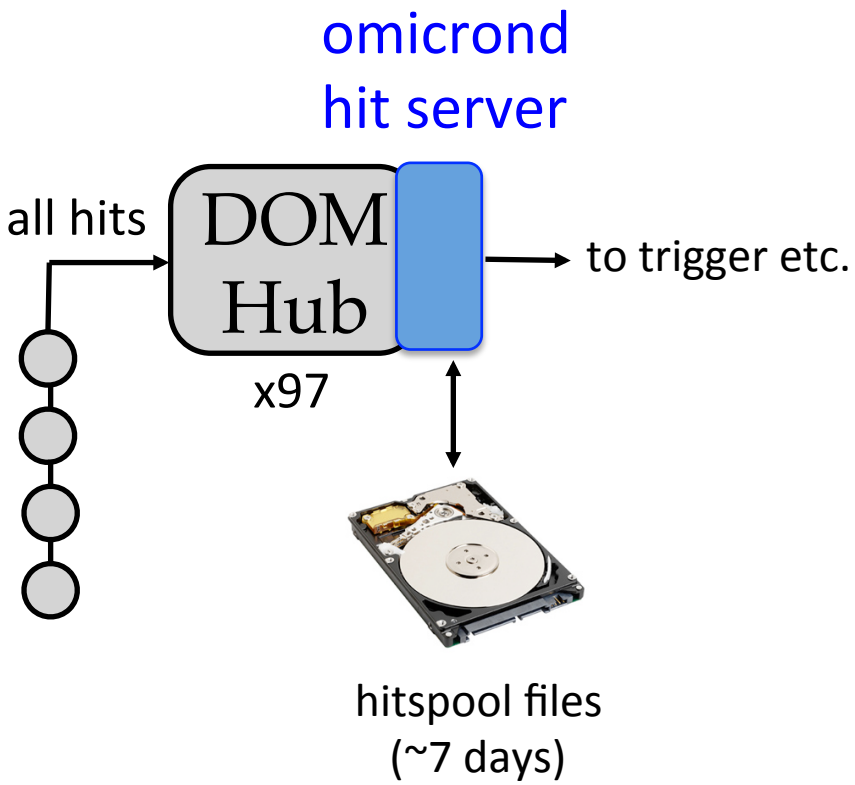
Hitspooling

- Scaler system good for triggering but limits follow-up analysis
- Hitspooling: save <u>all</u> DOM hits to hub disks
  - 2 MB/s per string
  - ring buffering in files on hubs
- Interfaced to SNDAQ
  - save files around SN trigger time
  - package and send north
  - active since 2013
- SNDAQ use case: determine mean SN neutrino energy



OmicronD

- Logical extension of hitspooling
- Decouples data-taking from trigger, event builder
- Architecture supports IceCube Gen2
  - DOMHub becomes a "DOM to Ethernet" box
  - Hits stored on servers



IceCube Live

SPS Status

Data Acquisition

Current run: **122171** (6h:32m:37s)
Run config: sps-IC86-hitspool-15sec-interval-90min-and-8h-spool-hub82-hub85-decreased-V222
DAQ release: Ale_Asylum7_13349:101968M
Total events: 62585465
Active DOMs: 5398

Light mode: **dark** Change: LID

Control Details

pdaq RUNNING

Other Components

DB	RUNNING	stop
GammaFollowUp	RUNNING	stop
I3DAQDispatch	RUNNING	stop
I3MoniDomMon	RUNNING	stop
I3MoniDomSn	RUNNING	stop
I3MoniDomTcal	RUNNING	stop
I3MoniMover	RUNNING	stop
I3MoniPhysA	RUNNING	stop
OpticalFollowUp	RUNNING	stop
PFFiltDispatch	RUNNING	stop
PFFiltWriter	RUNNING	stop

Recent Alerts from Components

Condition	Triggered
pfclient-crash	19 hours, 6 minutes ago
pfclient-crash	19 hours, 6 minutes ago

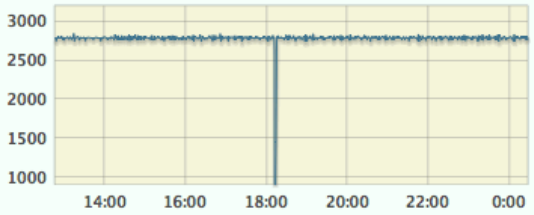
Currently Watched Alerts

multirunfail	OK
runfail	OK
ICL overtemp max2	OK
/mnt/data/pdaqlo...n.tar file count	OK
Detector not taking data	OK
ICL overtemp max1	OK
ICL overtemp min2	OK
ICL temperature too high	OK
Lots of LBM overflows	OK
Max WXGoose 3 Temp	OK
Max WXGoose 3 Temp (pages)	OK
Max WXGoose 6 Temp	OK
Min WXGoose 1 Temp	OK
Minimum Active DOMs	OK
OFU latency too high	OK
PnF latency too high	OK
PnF rate too low	OK
SERIOUS SN alert triggered!	OK

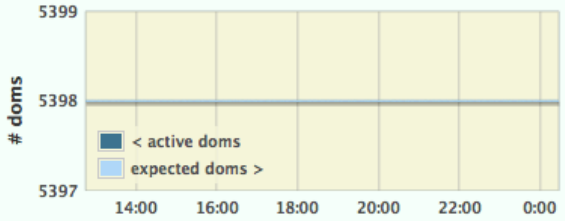
Graphs

(Detailed rates page)

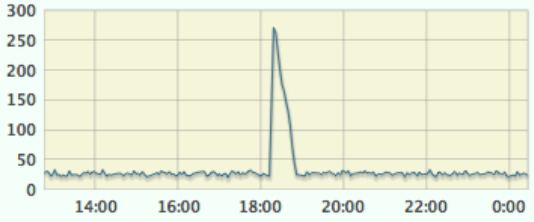
pDAQ Event Rate (Hz)



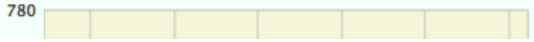
Active DOMs



PnF Latency (sec)

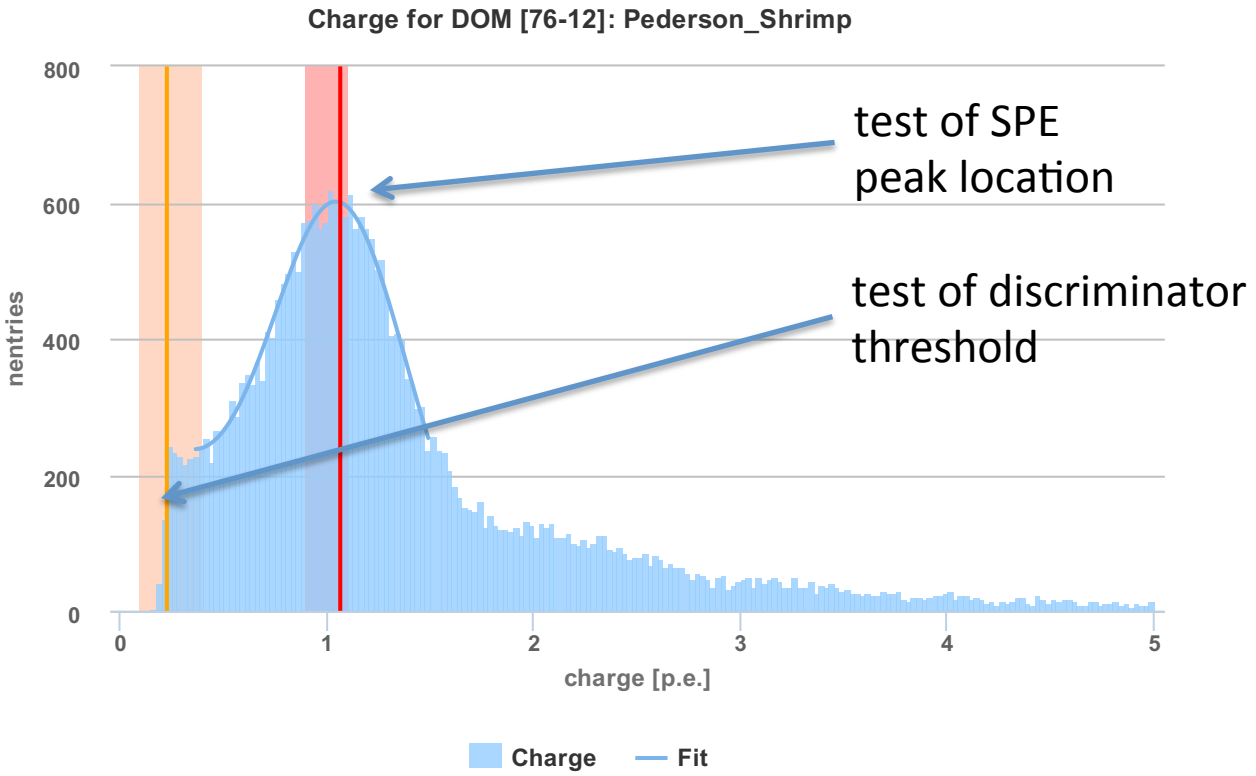


SNDAQ Processing Latency (sec)



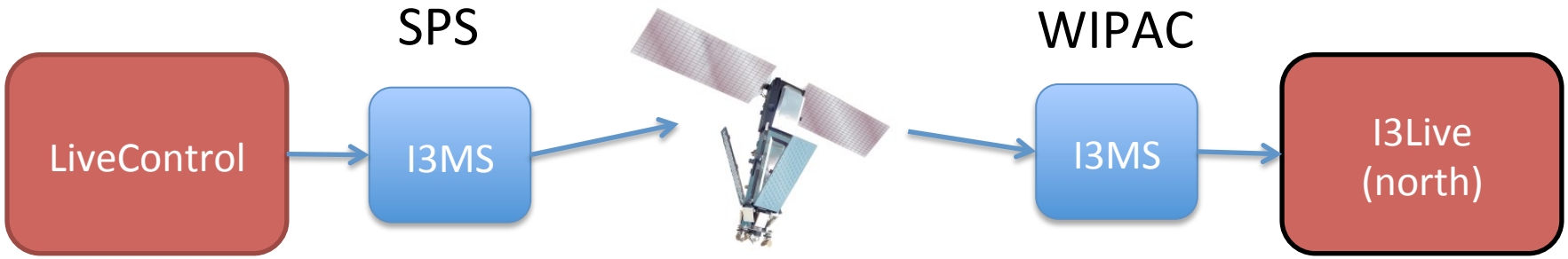
I3Moni 2.0

Charge distribution collected for all DOMs in PnF



- Monitoring data collected from DAQ, SNDAQ, PnF
- Improved accuracy and maintainability compared to current system
- Web pages in alpha release; rollout in 2016

I3MS

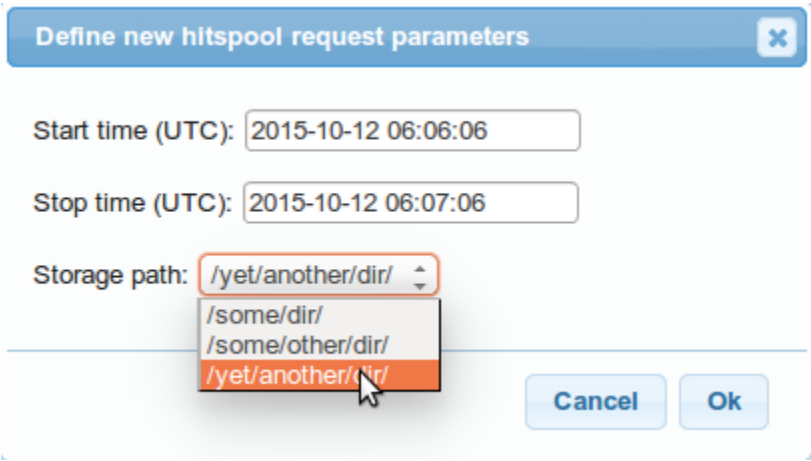


- I3MS: IceCube Messaging System
  - uses Iridium RUDICS satellite connection
  - moves IceCube Live monitoring data off of ASC Iridium modems
  - restores "thinlink" ssh capabilities
- Operating in testing mode since May 2015; rollout this pole season
- Supports expansion of real-time program
  - lower latency for alerts (~20 seconds)
  - support for large messages (e.g. compressed HESE events)

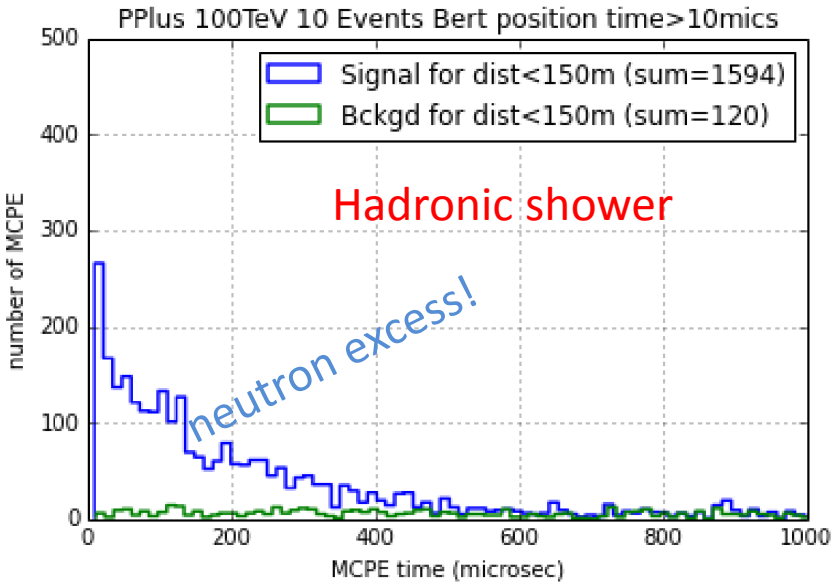
Hitspool Future Plans

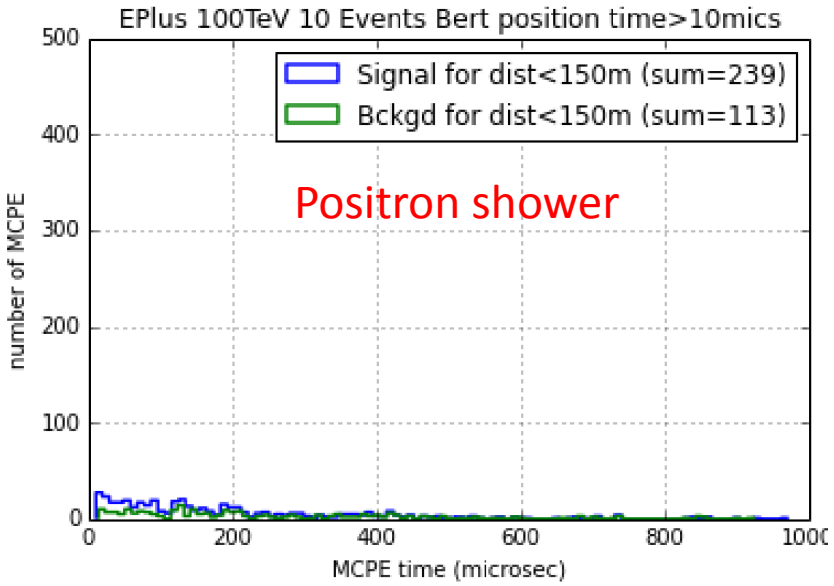
- Extend lookback time to 5–7 days
- I3Live hitspooling page
  - view requests from SNDAQ, PnF, etc.
  - user-triggered hitspool requests
- Supports creative new analyses and multi-messenger program

Hitspool Request from I3Live
(still in development)



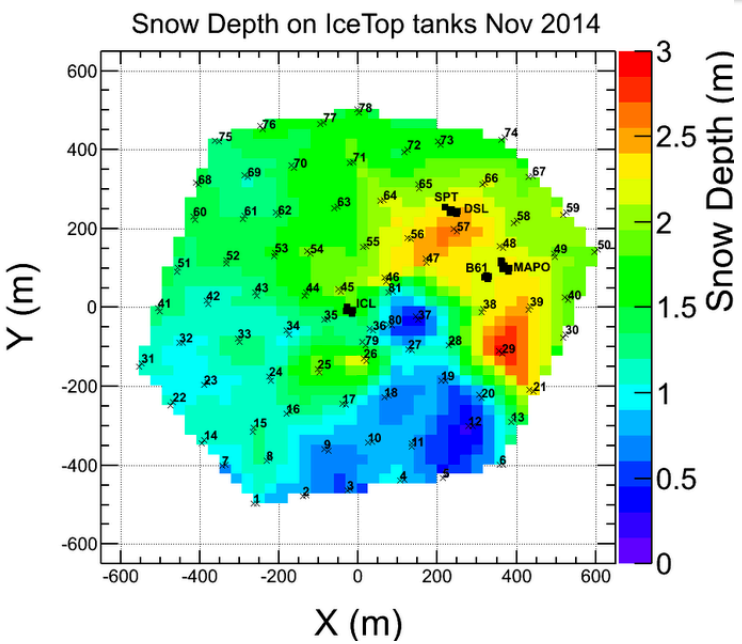
Use Case: Thermalized Neutrons



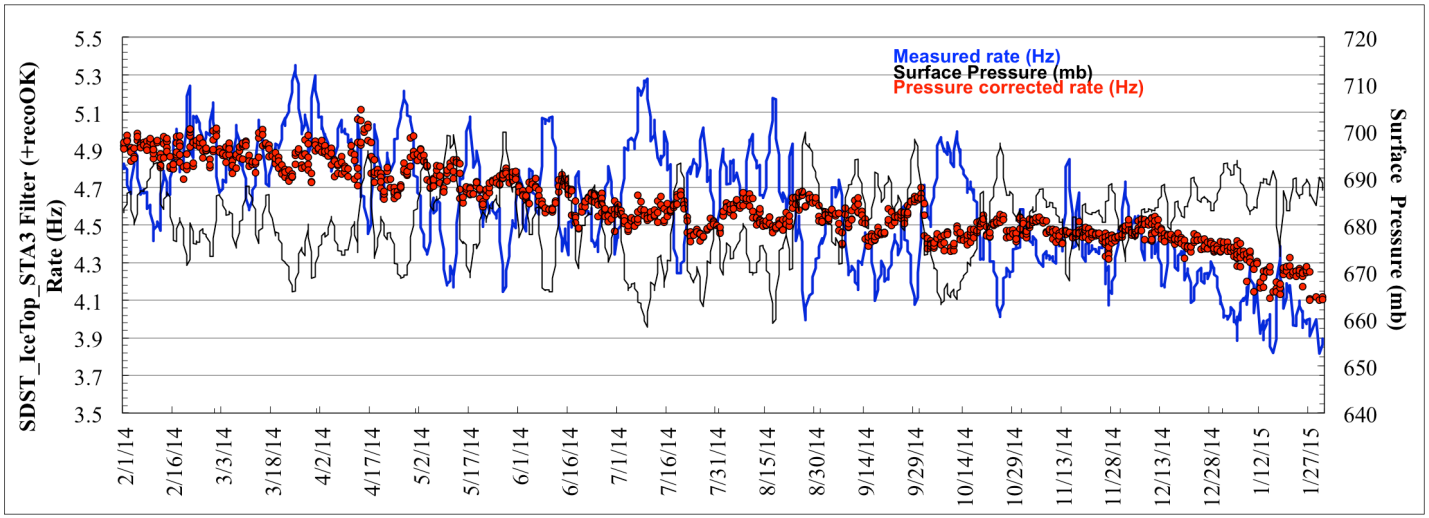


- Thermalized neutrons from neutrino-induced hadronic showers produce late hits outside of trigger readout window
- New filter selecting HESE events will trigger 1-second hitspool capture (4 events/day above 1500 PE)
- Better neutrino energy reconstruction; possible CC/NC separation?

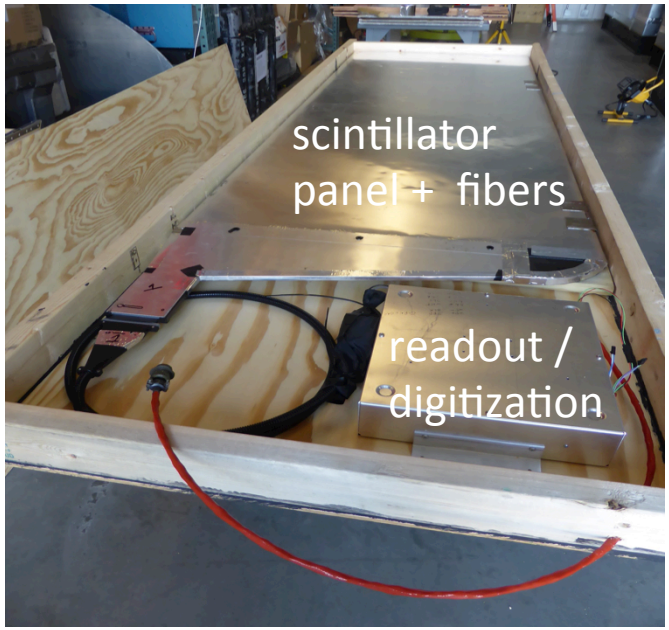
IceTop Snow Accumulation

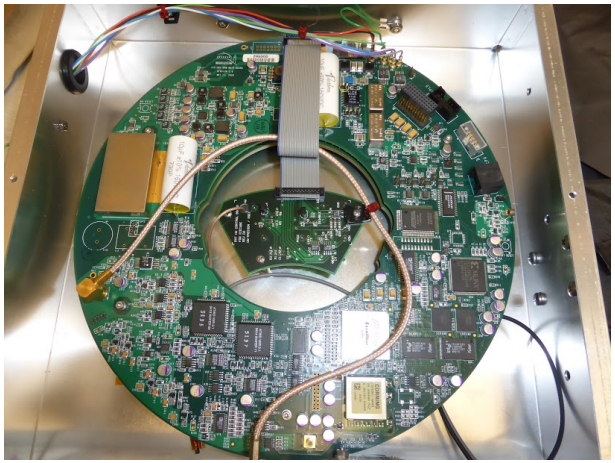


- Average snow accumulation of 20 cm/yr
- Loss of EM shower component; 12% decrease in trigger rate / year
- Contractor snow removal has ceased



Prototype Scintillators



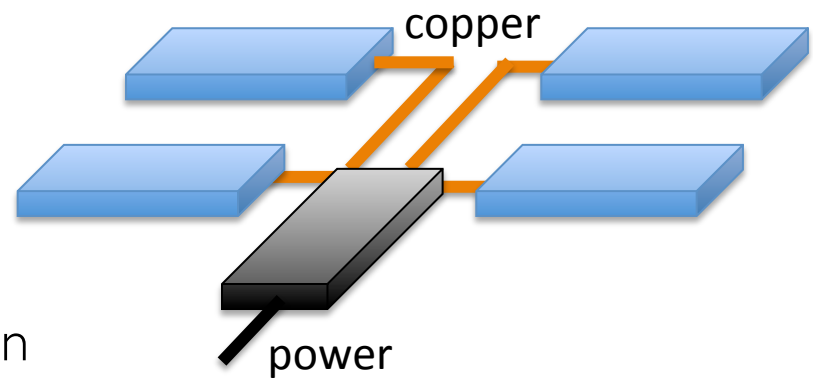


- Restore IceTop efficiency with co-located scintillators
  - also useful for veto studies
- 4 prototype panels assembled and tested in Madison
  - MINOS scintillator + 1" PMT
  - DOM mainboard for digitization and timing
  - installation using existing IceTop cabling
- Will be deployed at 2 IceTop stations in December / January
- Coincident hits will be read out into IceCube data stream

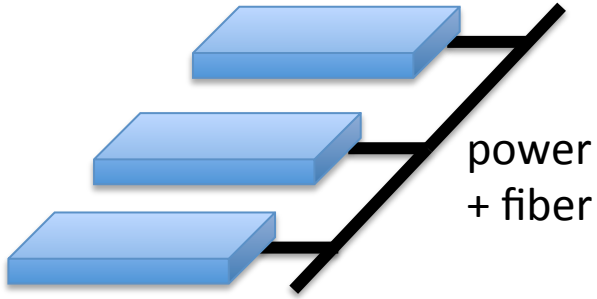
Scintillator Future Plans

- Next-generation DOM mainboard for scintillator readout
- New FieldHub fans out to scintillators
  - next-gen copper communications + White Rabbit timing to ICL
  - OR mini-fieldhub / White Rabbit node in scintillator box
- Connection to ICL via power + fiber
  - allows future veto extension beyond IceTop footprint
- Testbed for Gen2 HEA architecture

Topology 1:
separate FieldHub



Topology 2:
Gen2 mainboard + WR node



Summary + Looking Forward

- Continue improving stability and uptime
  - longer stopless runs
  - decouple data-taking and trigger (OmicronD)
  - contingency plan in case of increased surface hardware failure rate
- Improved data quality with new monitoring system (I3Moni 2.0)
  - better signal-to-noise in monitoring alerts
  - maintainable for life of experiment
- Restore IceTop efficiency + test next-gen hardware
- Support growth of science mission
  - hitspooling improvements
  - better real-time infrastructure

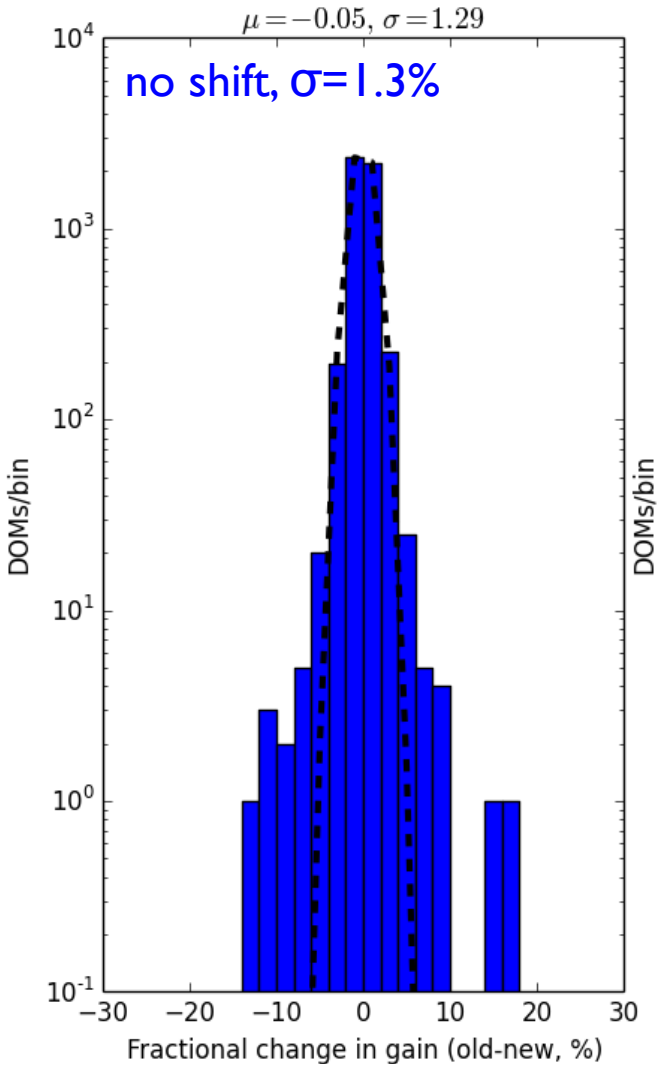
Backup

DOMs and Calibration

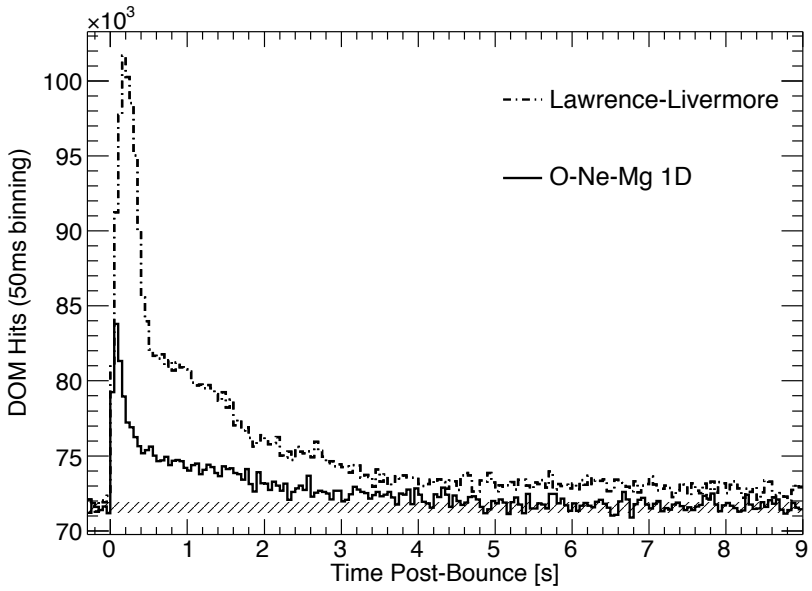
- Very low failure rate
  - 98.5% of deployed DOMs active
  - last 2 failures in 2013 (0.04%)

- DOMs "self-calibrate"
  - built-in reference circuits
  - HV/gain tuning via SPEs
  - relative gain determination to 1.3%

Gain change, 2014 to 2015

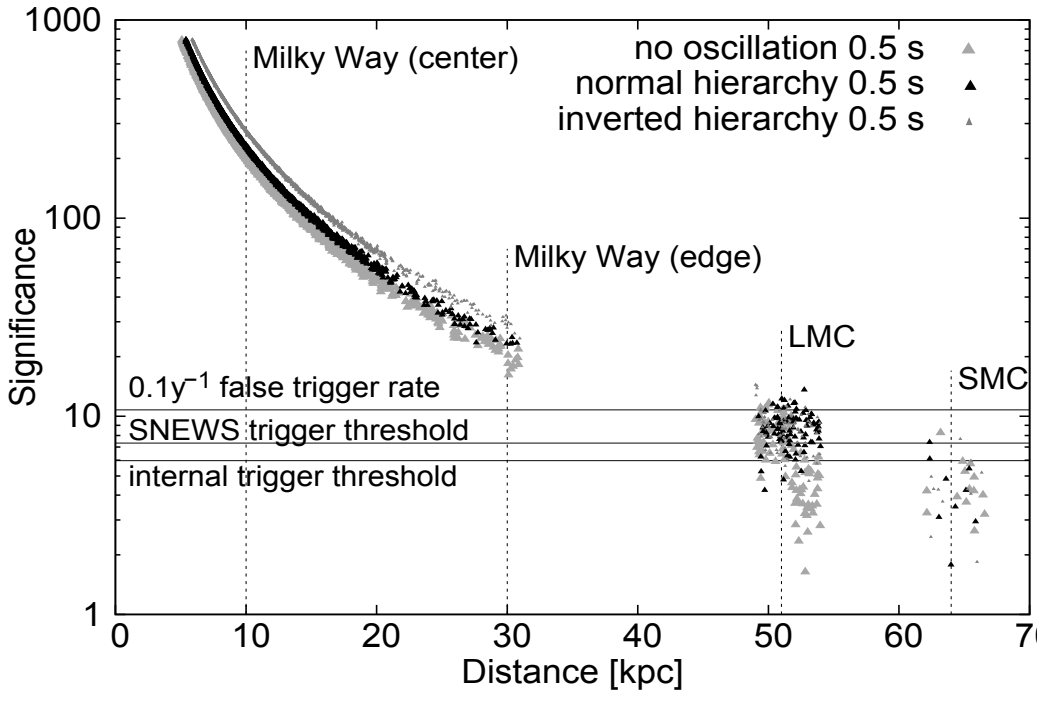


SNDAQ Sensitivity



Simulated summed signal
(10 kpc distance)

Detection significance vs. distance
(LL model)

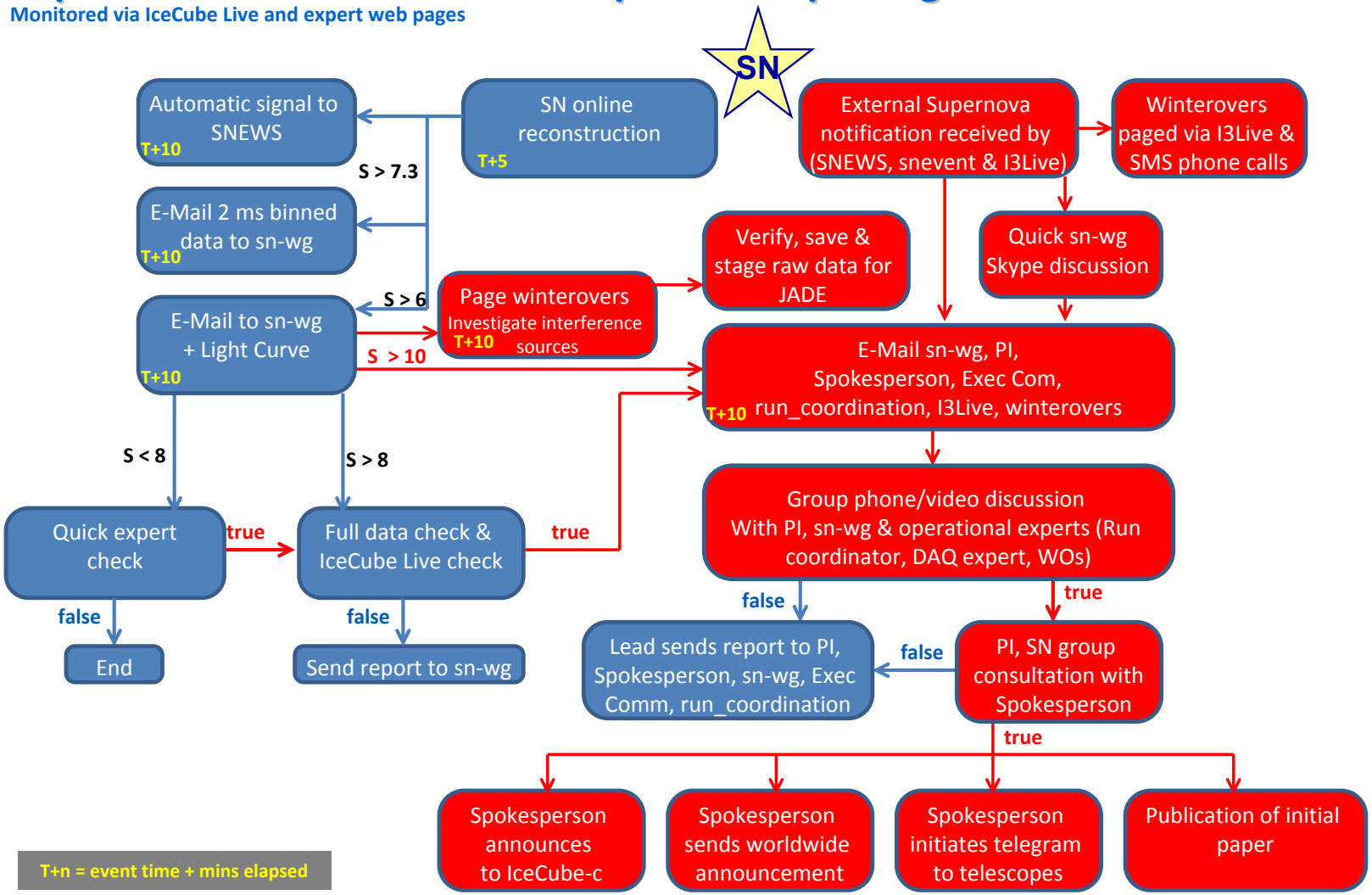


see Abbasi et al., A&A **535** A109 (2011)

Escalation Scheme

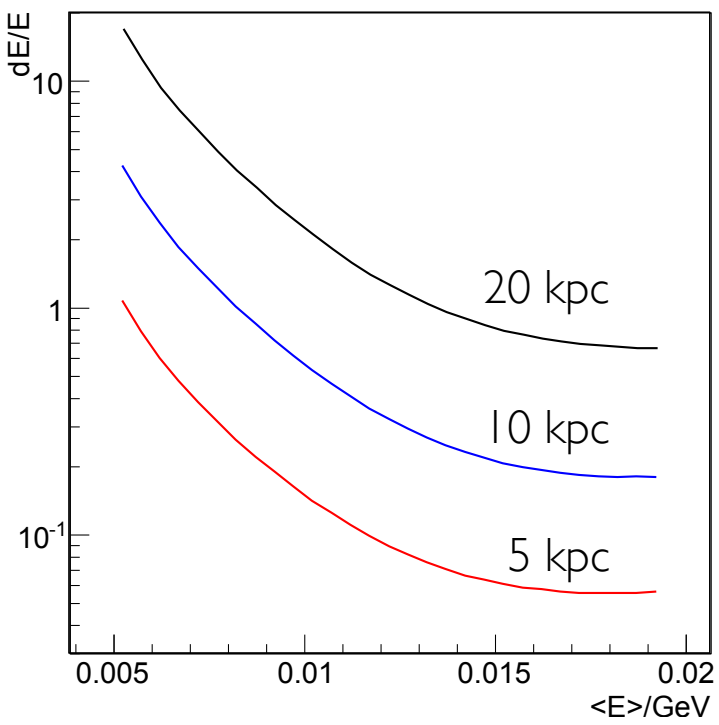
Supernova Escalation Scheme Dependent Upon Significance S

Monitored via IceCube Live and expert web pages



SN Physics via Hitspooling

mean energy determination



- Access to all detected photons allows:
  - subtraction of atmospheric muons, correlated DOM noise
  - analysis of hit multiplicity
- Ratio of single hits to double hits correlates with mean neutrino energy
- In case of nearby (0.5 kpc) supernova:
  - no worries about scaler saturation
  - data recovery in case of pDAQ failure