

IceCube Systems Architecture

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NSF Mid-Term Review
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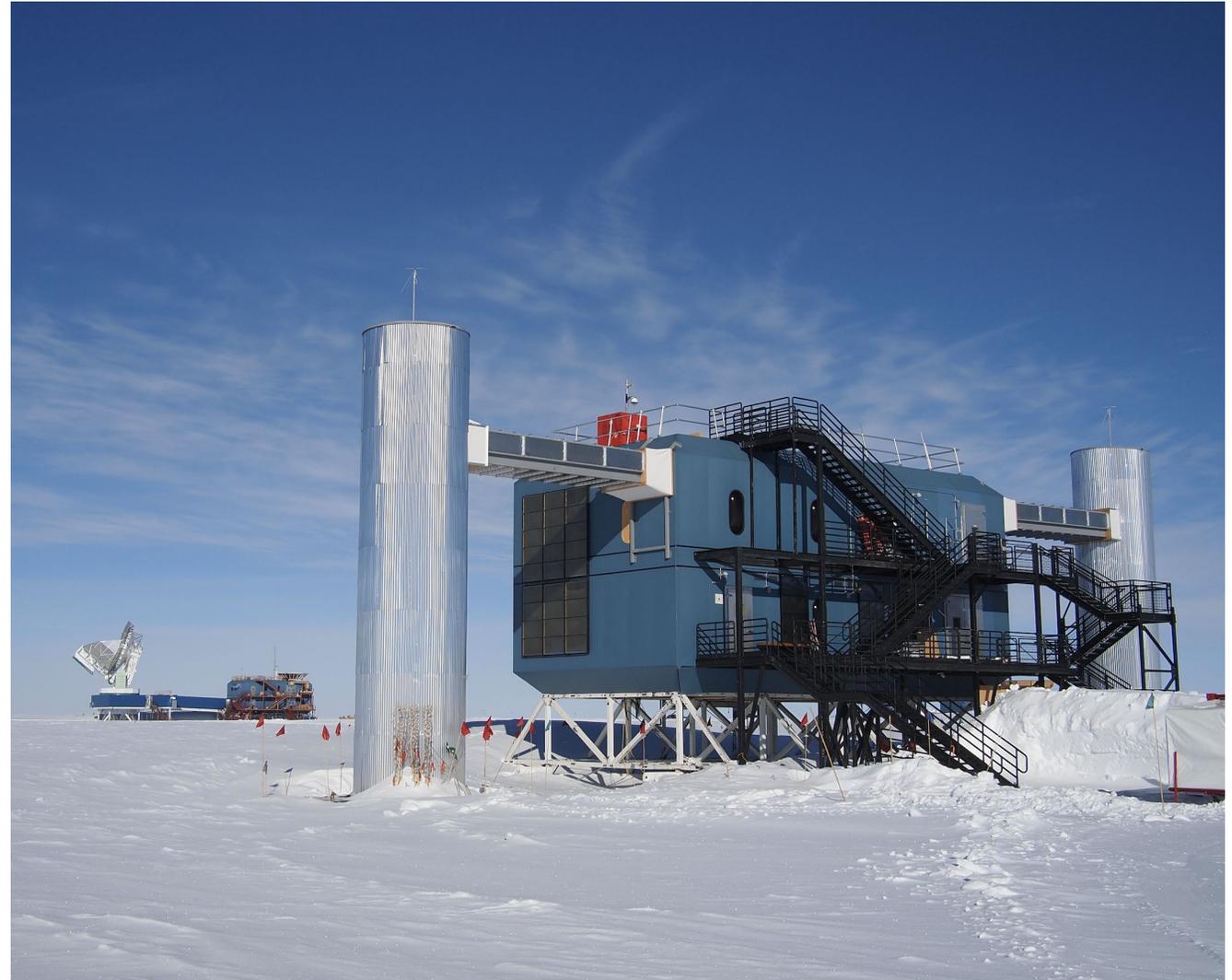
Presenter Background

- scientist at UW–Madison
- Director of Operations, 2023–present
- Detector Operations Manager, 2013–2023
- 10 polar deployments
- active in IceCube 2003–2009; 2012–present
- AMANDA / IceCube Ph.D. 2009



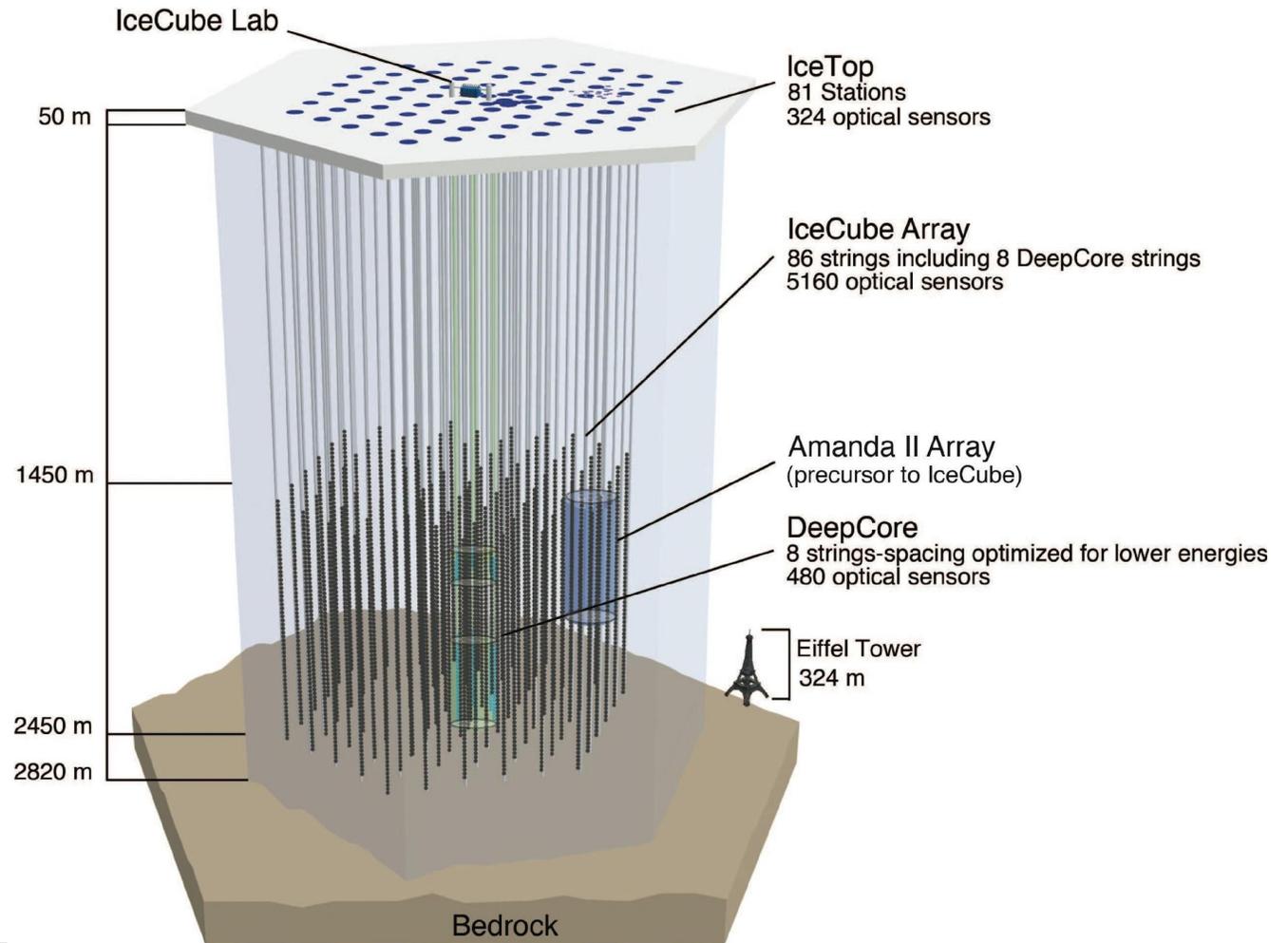
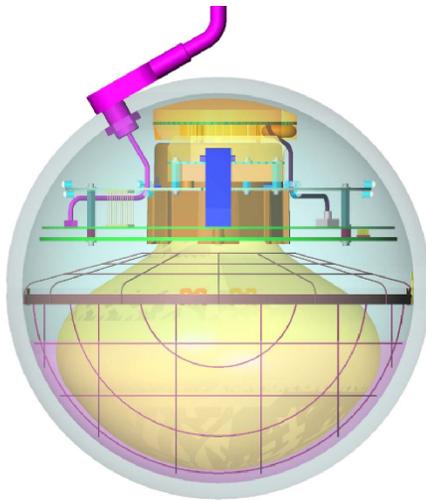
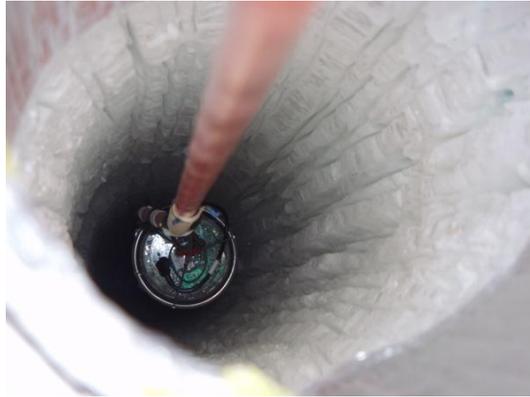
Outline

- IceCube detector
- Data flow from the ice to the collaboration
- Triggering and Filtering
- Filtering improvements and Pass 3 reprocessing



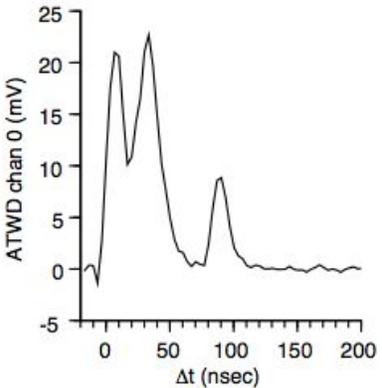
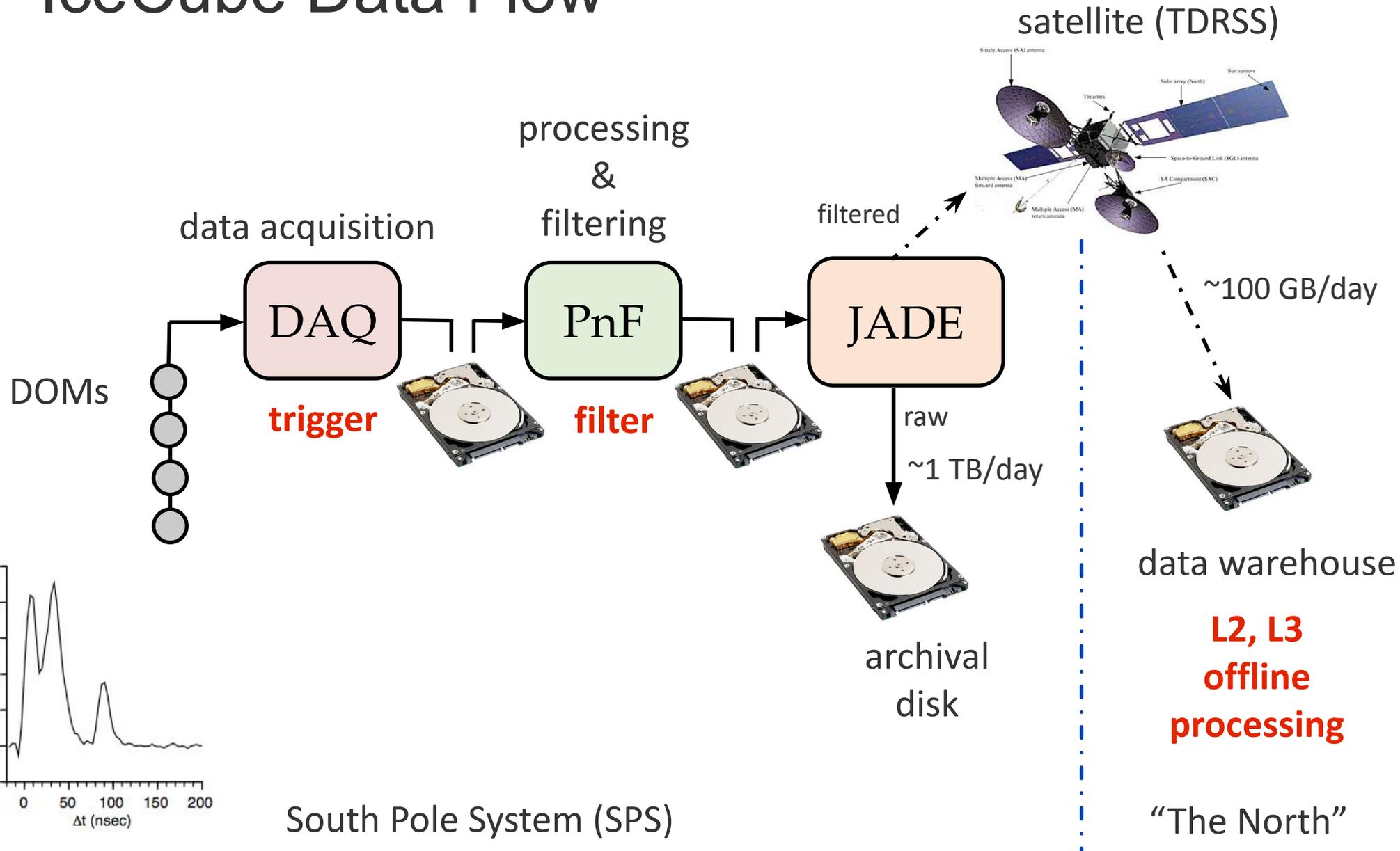
The IceCube Laboratory (ICL; 2013 photo)

The IceCube Detector

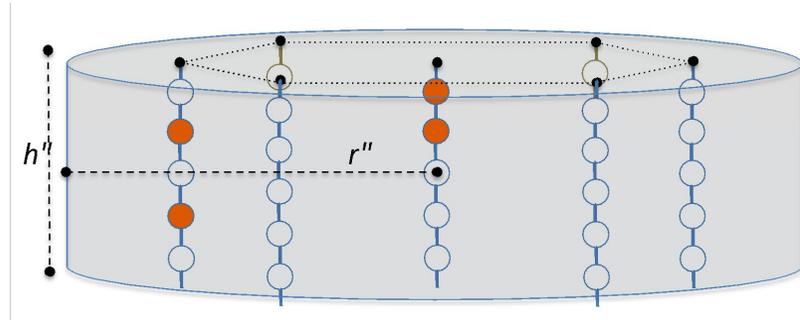


5484 digital optical modules (DOMs)

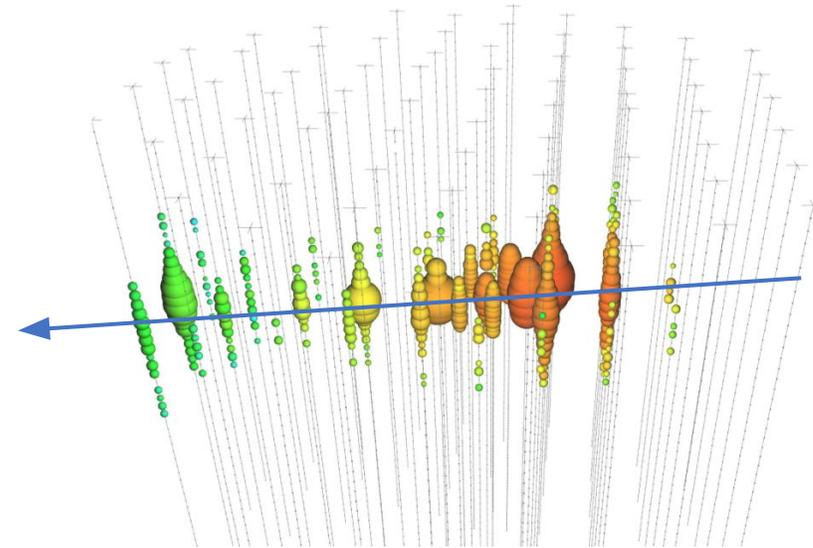
IceCube Data Flow



Triggers and Filters



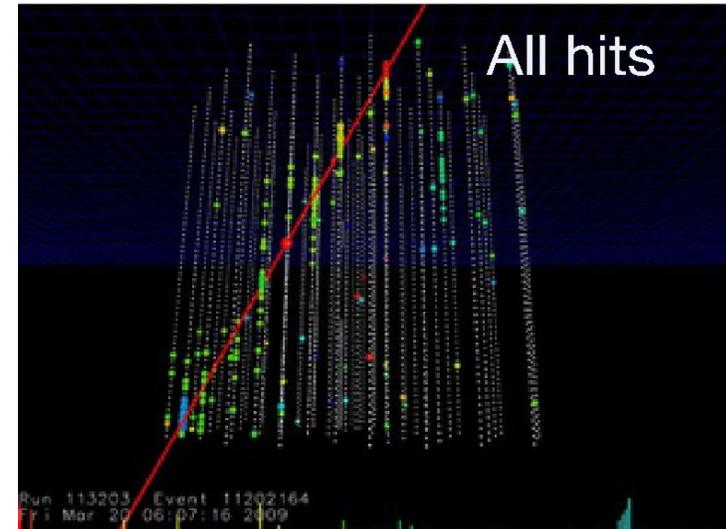
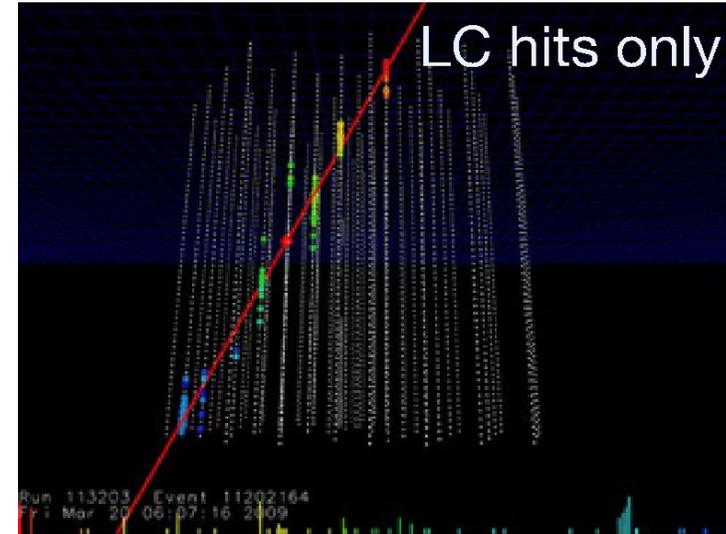
DAQ selects causal patterns of light (hits) from particle interactions



PnF performs fast reconstructions on those events, selects subsets interesting for analysis or real-time followup

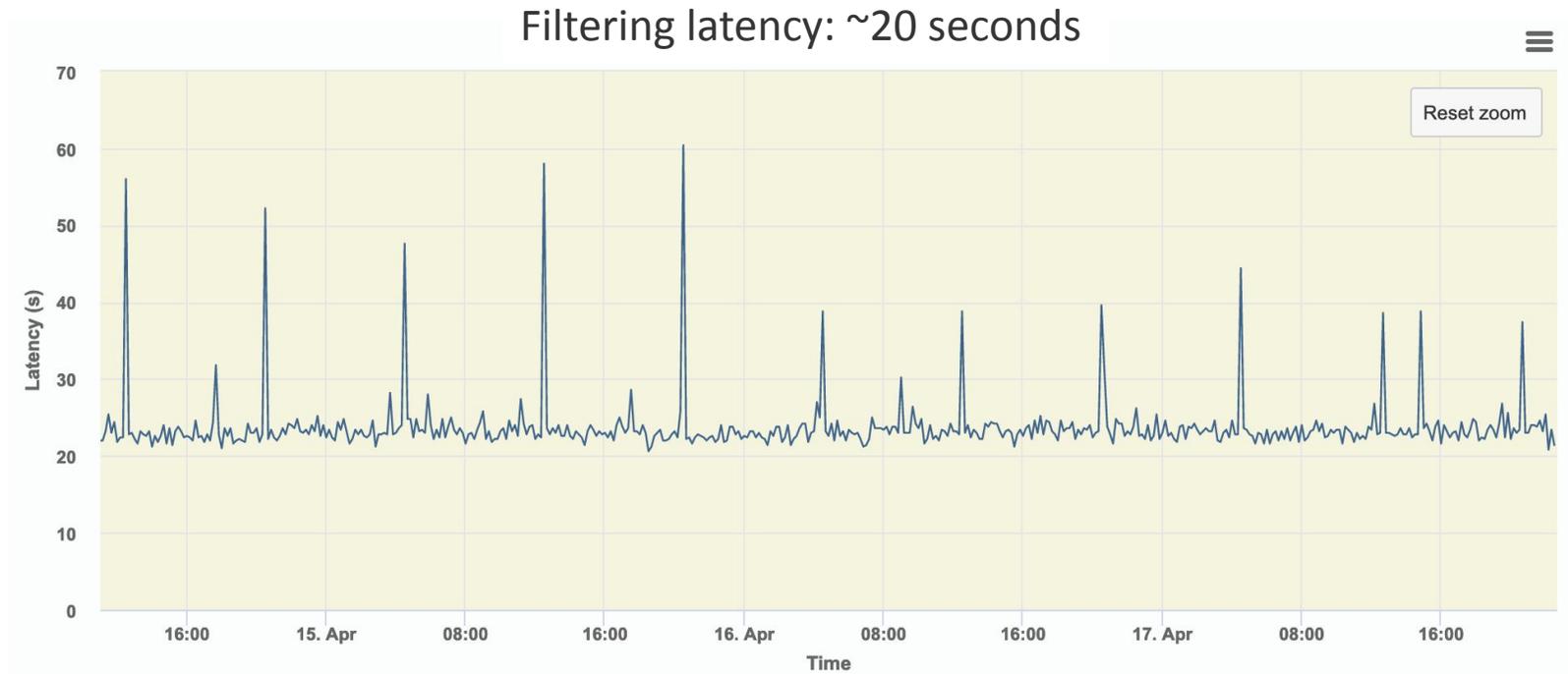
Data Acquisition System "pDAQ"

- DAQ forms events by triggering on patterns of light ("hits")
 - trigger primarily operates on hits with coincidences on neighbor DOMs ("LC")
- Core triggers are Simple Majority Triggers (SMT)
 - N LC hits in a time window
 - all trigger algorithms run in parallel
 - all hits read out and bundled into event
- Untriggered data ("hitspool") is available for 12.5 days
 - saved on request (automated or manual)
 - gravitational wave follow-up, solar flares, supernova alerts, etc.



Processing and Filtering “PnF”

- process all pDAQ events in real time
- apply calibrations, DOM waveform processing, and initial fast reconstructions
- select events for satellite transmission
 - “L1” data forms the basis of physics analyses
- select astrophysical neutrino event candidates to send to wider astrophysics community

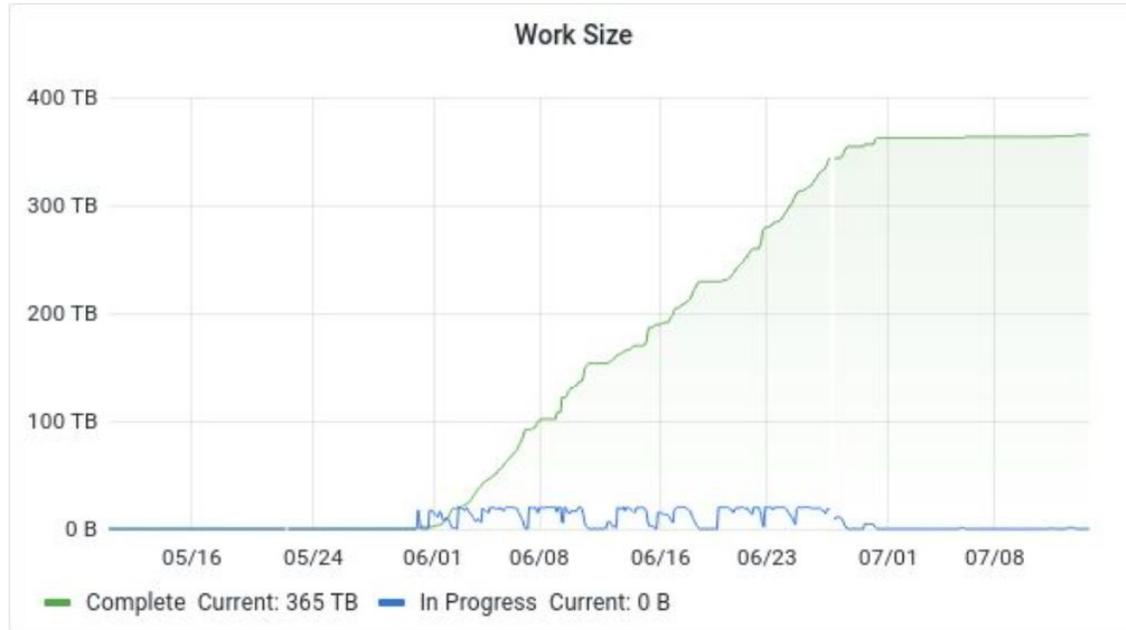


Inside the IceCube Lab (ICL)



- 18 racks
- 97 DOMHubs
 - single-board computers
 - custom DOM readout cards
 - custom clock fanout
 - in-ice: 1 hub/string
- 43 Dell PowerEdge R740 servers
 - 6 data acquisition (DAQ)
 - 17 filtering
 - 2 database
 - 4 data transfer and communications
 - 7 infrastructure
 - 3 miscellaneous (ARA, surface array, IceACT)
 - 4 spares
- GPS receivers + fanouts, network switches, uninterruptible power supplies (UPS), special devices

Data Transfer and Management



2022 raw data archival timeline

- JADE data transfer software
 - archival of raw data to disk at South Pole (2 copies)
 - handoff of filtered data to ASC for satellite transfer
 - validation of data copies and transfers to the data warehouse

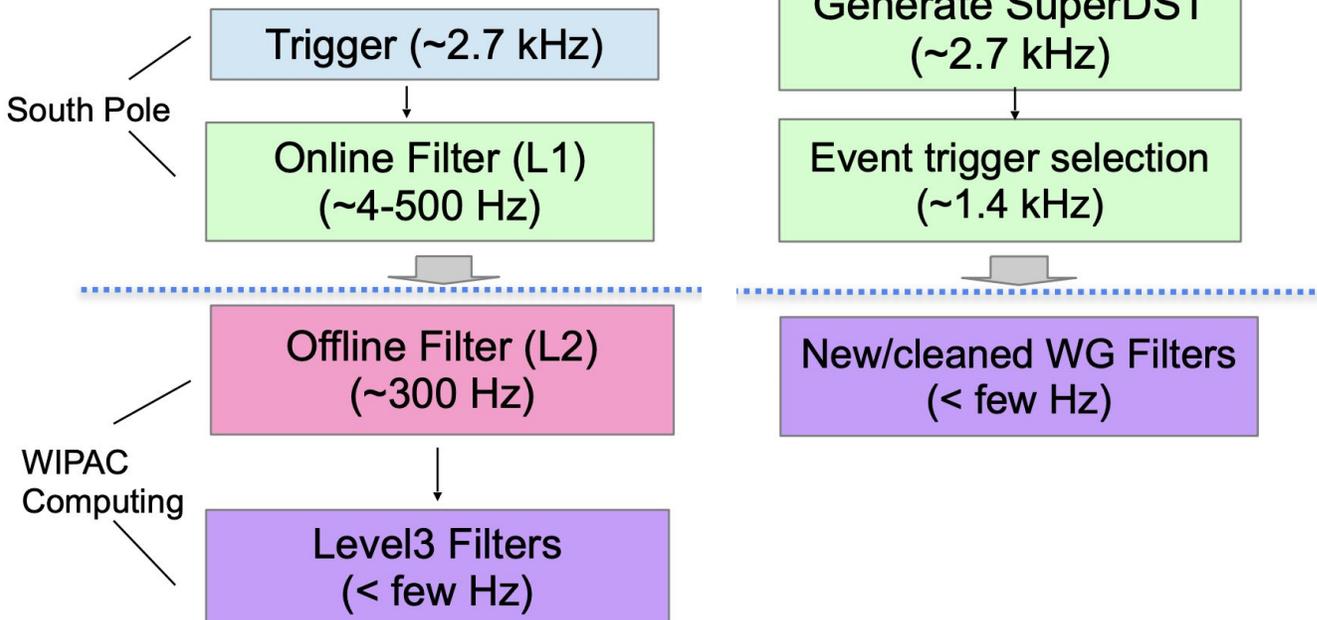
- Data warehouse at WIPAC
 - provides experimental and simulated data to collaboration
 - supports further data processing
 - large distributed filesystem (recently upgraded)
 - raw data archived to tape

- Local and grid compute resources both provide processing CPUs/GPUs

Streamlined Filtering

Pre-2023 model

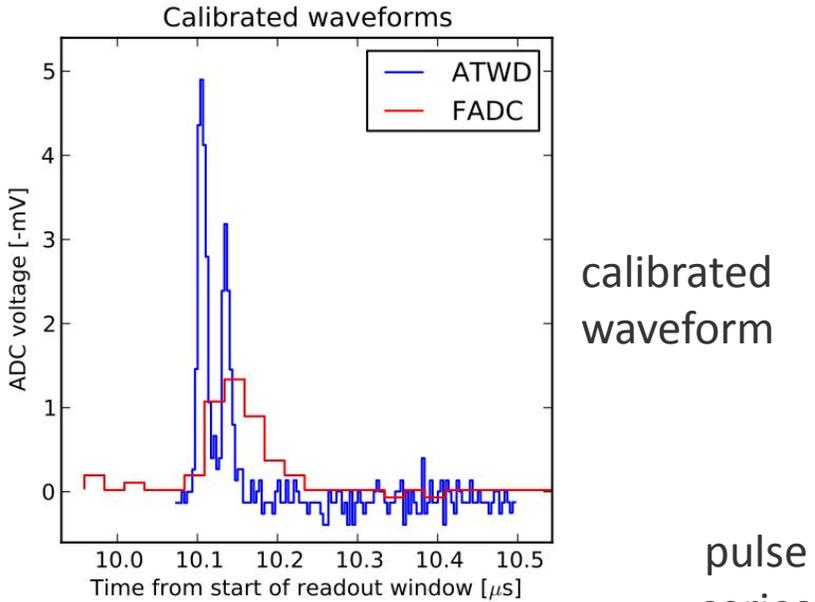
New model



see also talks by Kauer, Riedel, Díaz Vélez, and Blaufuss

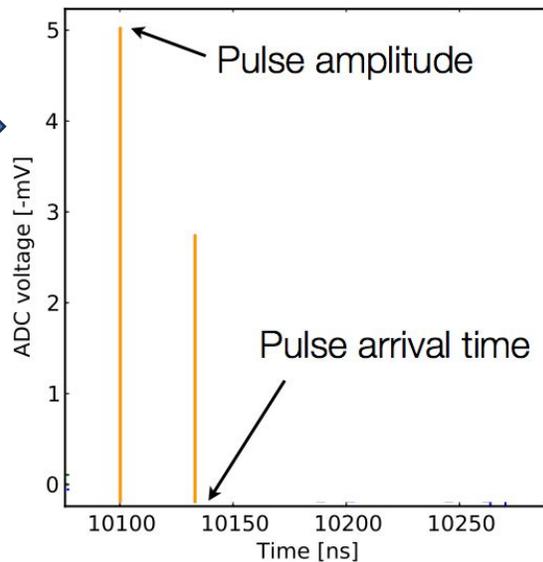
- Major effort underway to streamline online and offline processing
- New online processing implemented November 2023
 - before: 20+ separate physics filter streams
 - after: **all** events after SMT12 software retrigger and compression
 - archival not changed (all events saved in raw and superDST format)
- New offline working group filters to be deployed at 2024 physics run start
 - employ modern reconstructions
 - remove outdated/unused processing
- Improves efficiency, simplifies processing
 - solid base on which to add the Upgrade

“Pass3” Reprocessing



pulse series

waveform unfolding



- Improvements to calibration and waveform processing can also be applied to historical data
 - e.g. previous “Pass2” reprocessing
 - “Pass3” will apply streamlined data processing from IC86-2023/24 to all historical data
- Raw data to be retrieved from tape archive (NERSC, TACC) and reprocessed
 - significant computing and storage requirements to process all historical data
- Pass3 will homogenize and improve historical data set

Supplementary Material

Real-Time Alert System

