

Towards Unified IceCube and IceCube Upgrade Operations

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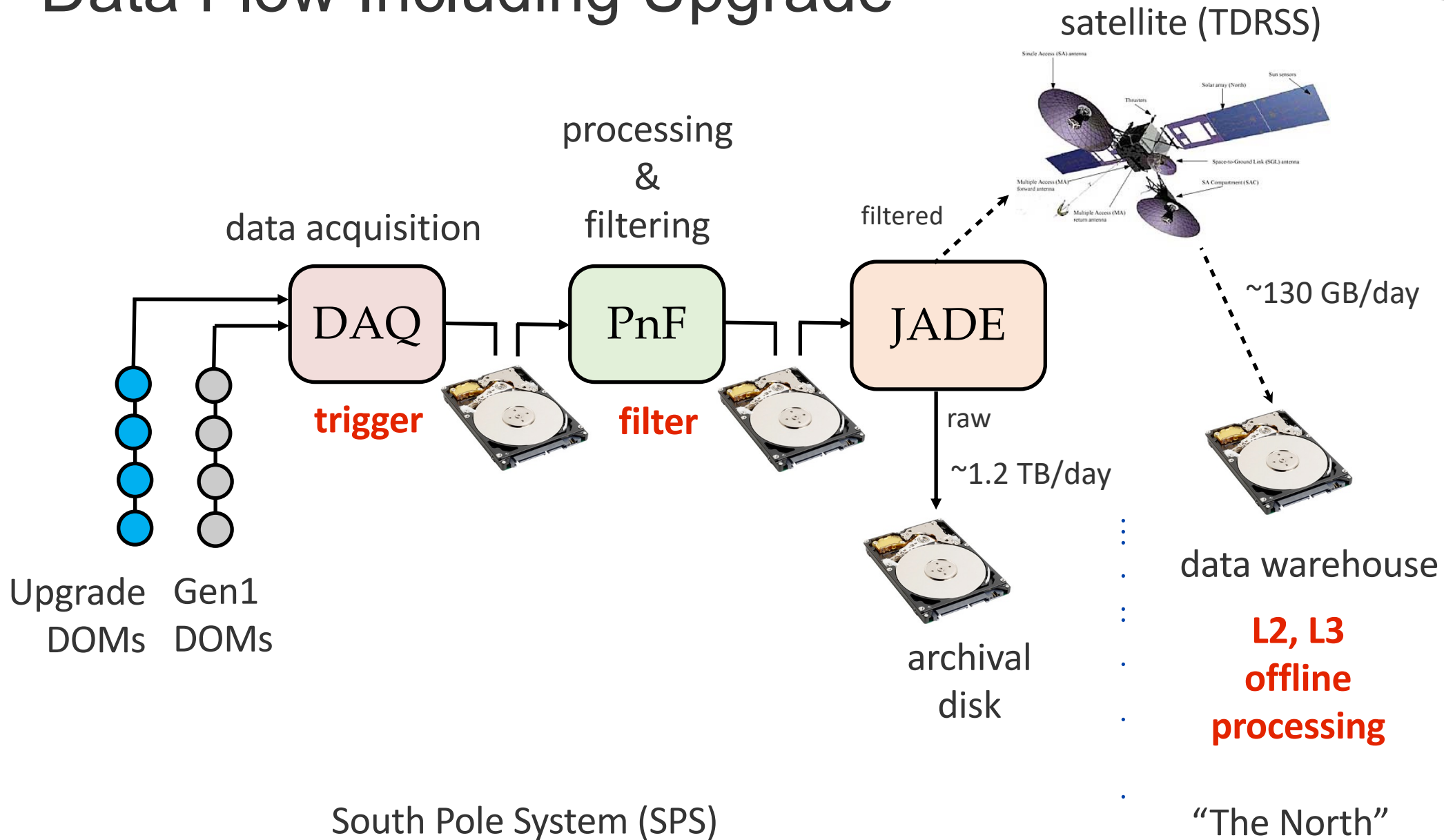
NSF Mid-Term Review
29 April 2024



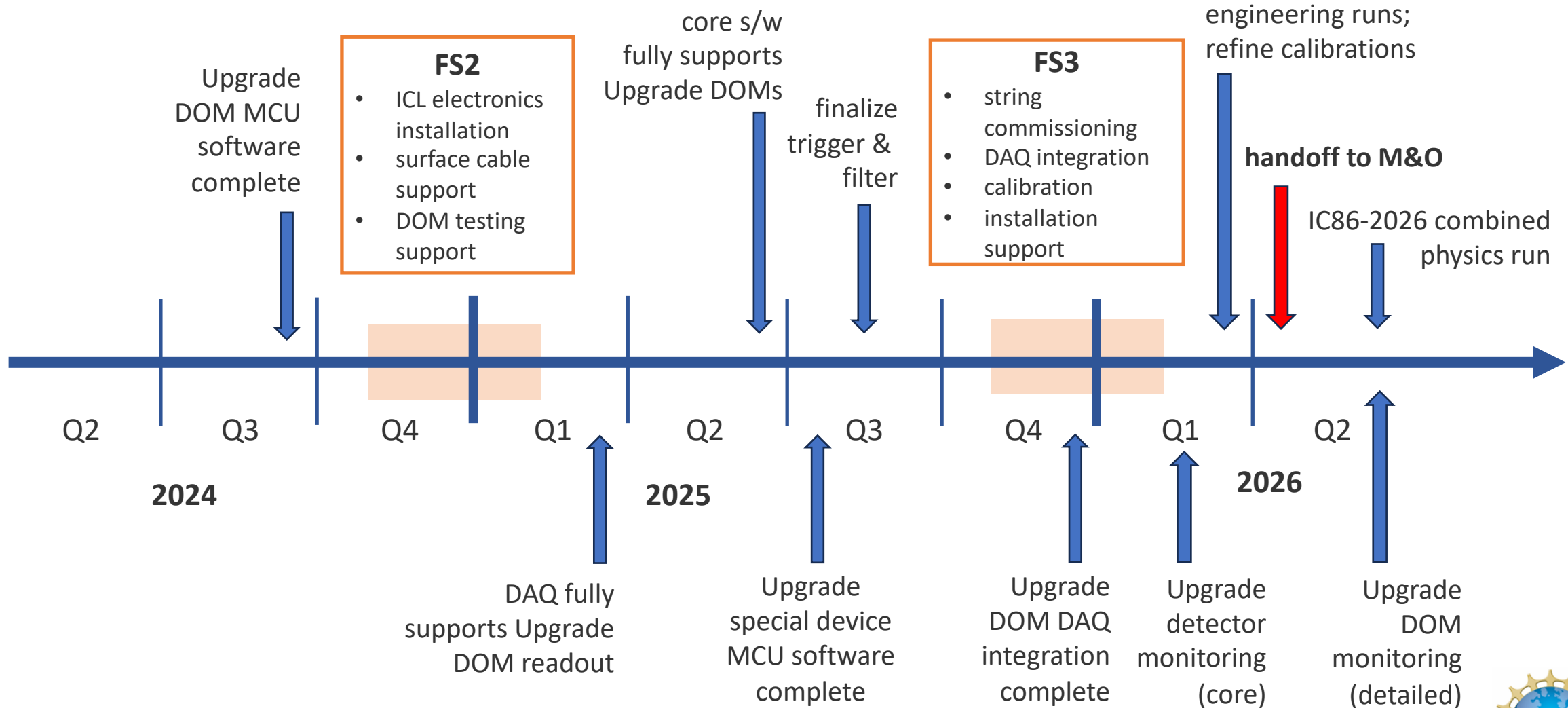
Outline

- Data flow and integration timeline
- Online hardware and software integration
- Offline software integration and computing
- View of unified operations

Data Flow Including Upgrade



M&O Integration Timeline



Upgrade ICL Electronics

ICL Rack 14 Map

U47	White Rabbit grandmaster
U46	
U45	DOM power supply 87
U44	DOM power supply 88
U43	DOM power supply 89
U42	DOM power supply 90
U41	DOM power supply 91
U40	DOM power supply 92
U39	DOM power supply 93
U38	DOM power supply spare
U37	network switch 1
U36	network switch 2
U35	
U34	
U33	fieldhub87
U32	
U31	
U30	fieldhub88
U29	
U28	
U27	fieldhub89
U26	
U25	
U24	fieldhub90
U23	
U22	
U21	fieldhub91
U20	
U19	
U18	fieldhub92
U17	
U16	
U15	fieldhub93
U14	
U13	
U12	
U11	
U10	UPS, 8kW non-redundant
U9	
U8	
U7	
U6	
U5	
U4	UPS, 8kW non-redundant
U3	
U2	
U1	

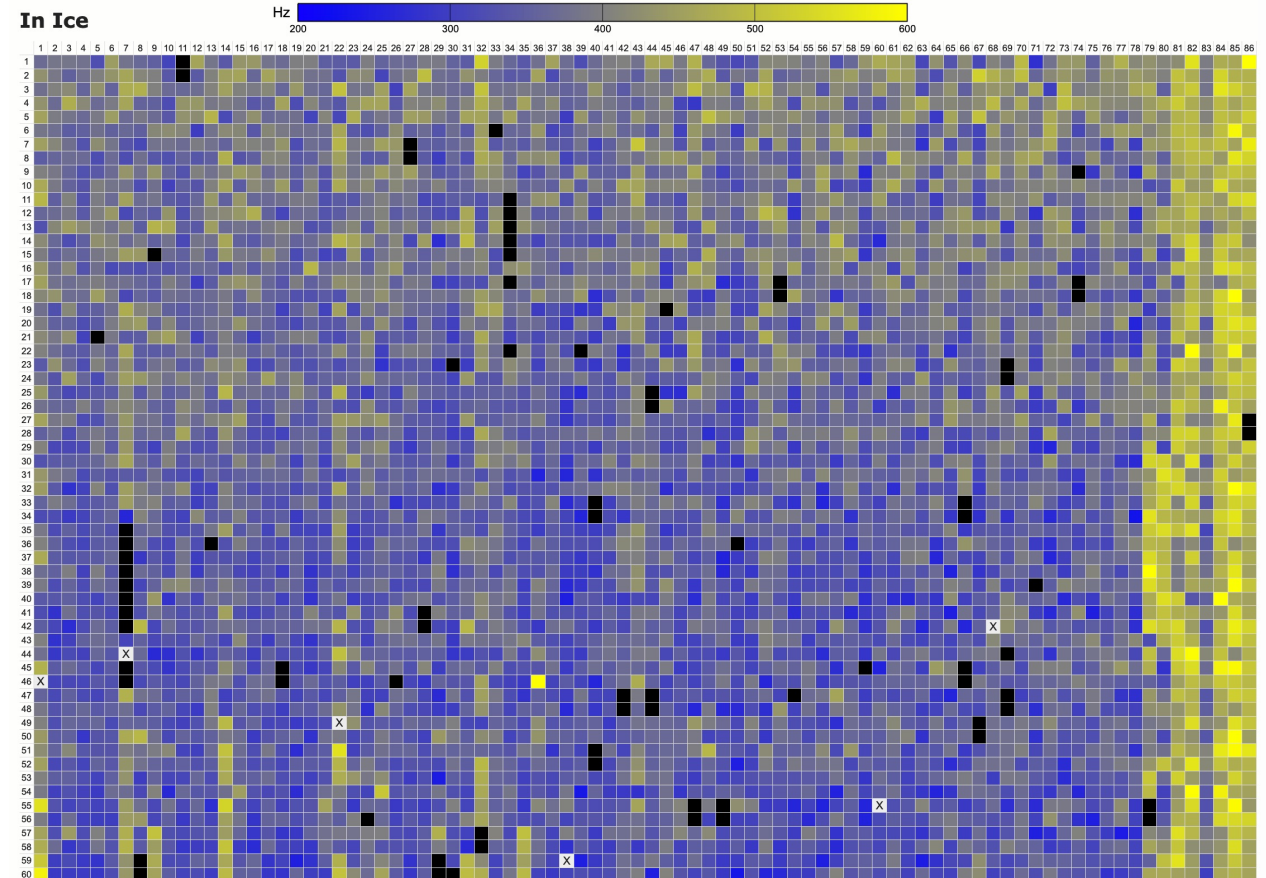
- To be installed by M&O team in 24–25 field season
- Upgrade power, communications, and timing system
- FieldHubs designed to be backward-compatible with IceCube and forward-compatible with IceCube-Gen2

FieldHub testing at DESY Zeuthen, March 2024



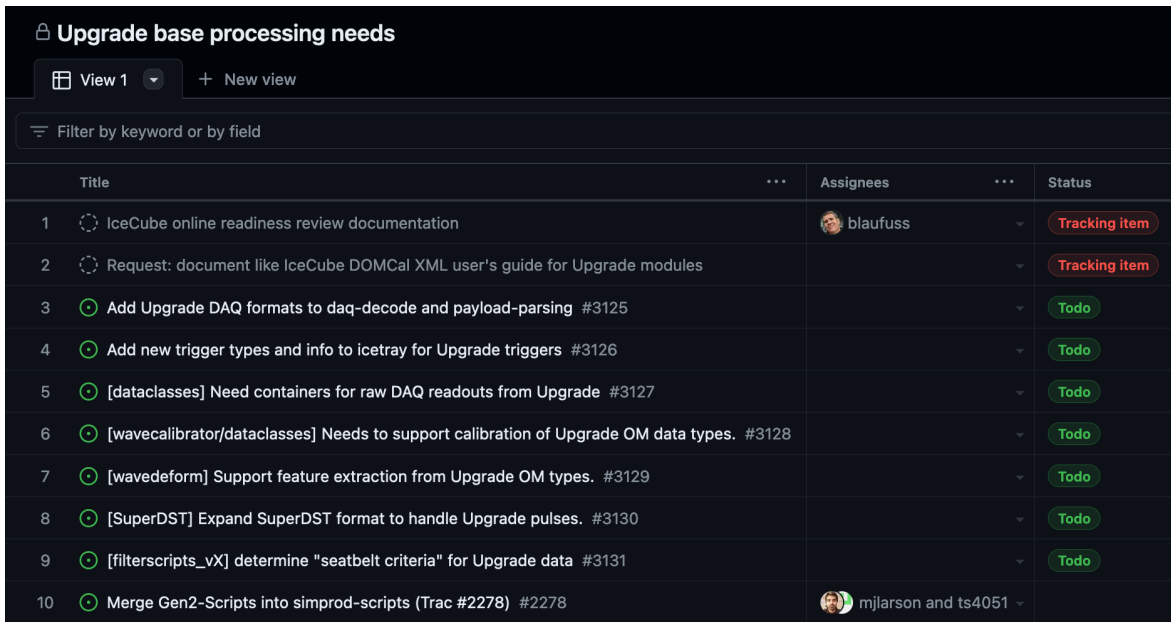
Detector Monitoring via IceCube Live

- Upgrade will be integrated into existing monitoring system
- Phase 1: detector health / stability
 - high-level monitoring of DAQ
 - trigger / filter stability
 - component health
 - straightforward extension of current capabilities
- Phase 2: Upgrade-specific extensions
 - new per-DOM quantities, tests, and plots
 - enhanced Upgrade subdetector visualizations



in-ice “DOM map” of noise rate, run 139285

IceTray, Offline Software, and Simulation

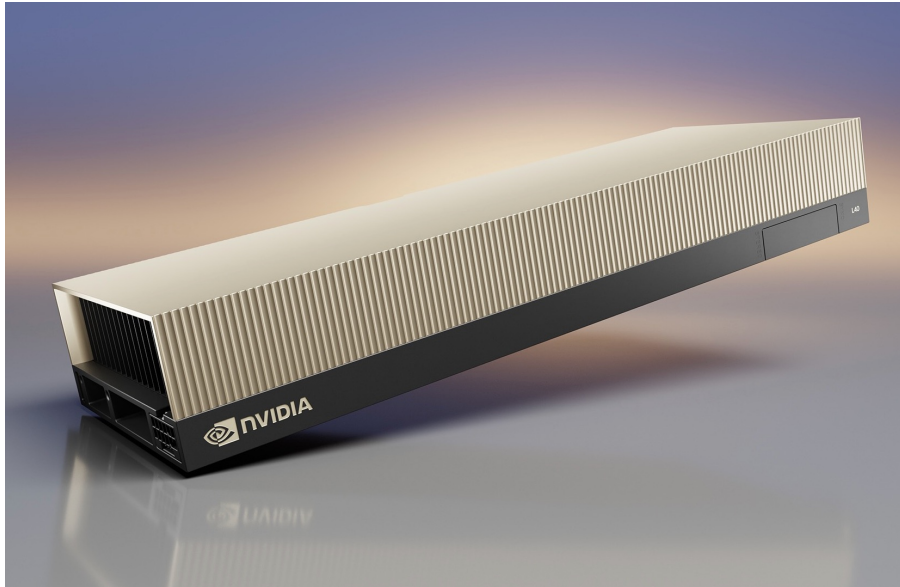


Title	Assignees	Status
1 IceCube online readiness review documentation	blaufuss	Tracking Item
2 Request: document like IceCube DOMCal XML user's guide for Upgrade modules		Tracking Item
3 Add Upgrade DAQ formats to daq-decode and payload-parsing #3125		Todo
4 Add new trigger types and info to icetray for Upgrade triggers #3126		Todo
5 [dataclasses] Need containers for raw DAQ readouts from Upgrade #3127		Todo
6 [wavecalibrator/dataclasses] Needs to support calibration of Upgrade OM data types. #3128		Todo
7 [wavedeform] Support feature extraction from Upgrade OM types. #3129		Todo
8 [SuperDST] Expand SuperDST format to handle Upgrade pulses. #3130		Todo
9 [filterscripts_vX] determine "seatbelt criteria" for Upgrade data #3131		Todo
10 Merge Gen2-Scripts into simprod-scripts (Trac #2278) #2278	mjlanson and ts4051	

base processing TODO list

- IceTray core software support for the Upgrade
 - support for new DAQ formats
 - new waveform calibrations
 - superDST for multi-PMT modules
- Full-fidelity simulation of Upgrade DOMs
- Some recent success identifying in-kind effort to assist with this

Upgrade Computing



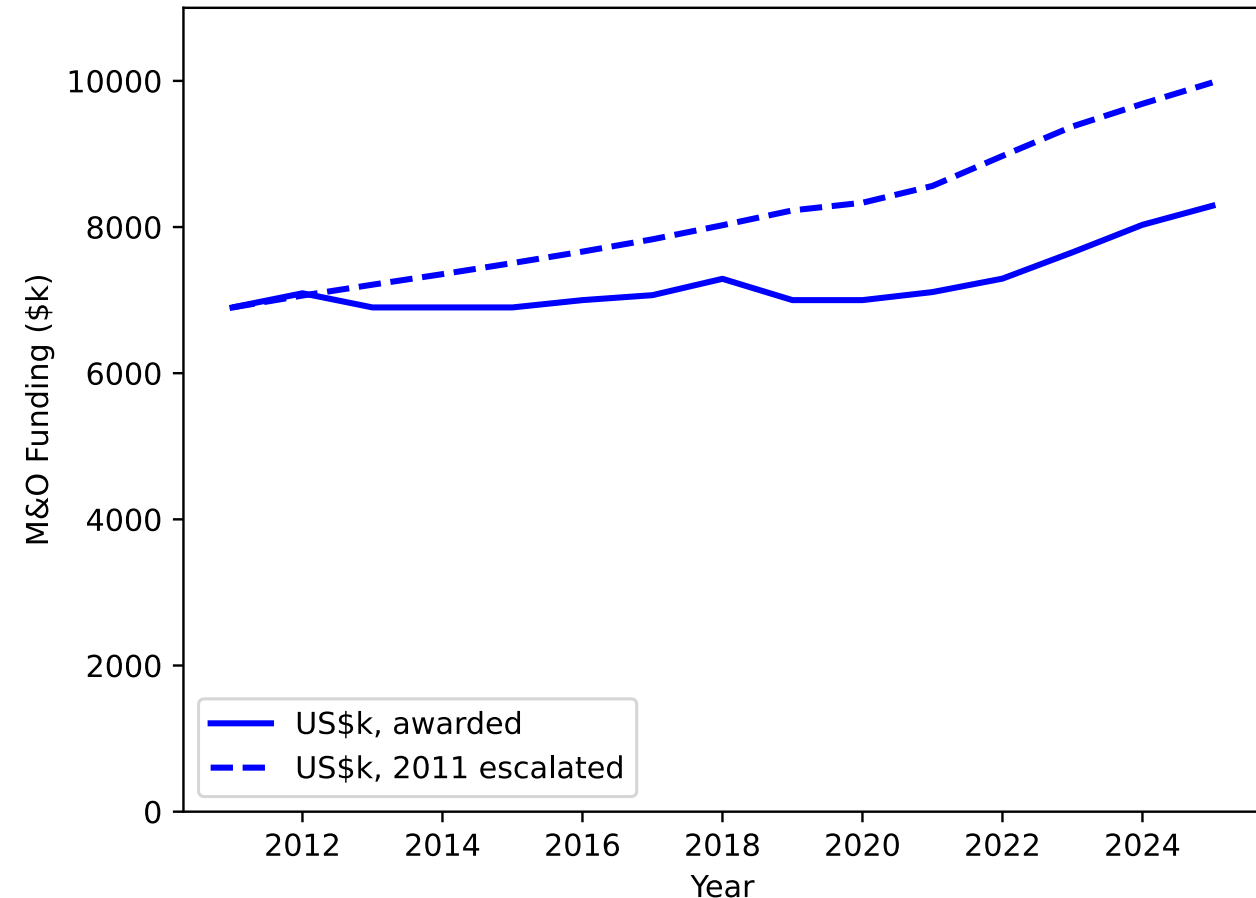
Nvidia L40S GPU

- Continue to grow data warehouse for experimental and simulated data
- Continue to leverage worldwide grid resources
 - support wide collaboration use
- Add both hardware and developer expertise to support ML / AI

Deferred Maintenance

- Successfully prioritized critical maintenance during COVID and post-COVID periods
 - South Pole logistics constraints
 - inflationary pressure
- Post-Upgrade completion priorities:
 - SPS server upgrade
 - northern CPU / GPU cluster upgrades
 - surface array enhancement

M&O funding vs. inflation



Post-Upgrade Logistics Estimates

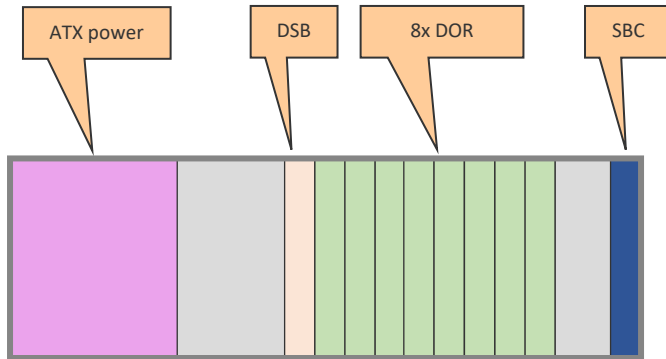
- Power: 73–75 kW (+11–13 kW)
- Satellite bandwidth: 135–155 GB/day (+30–50 GB/day)
- Winterovers: 2 (no change)
- Summer field population: same level as pre-COVID M&O
 - 7–9 beds incl. WOs
 - 14–16 deployers incl. self-tickers
 - NB: plans rely on population rotation

Nominal Upgrade power estimates

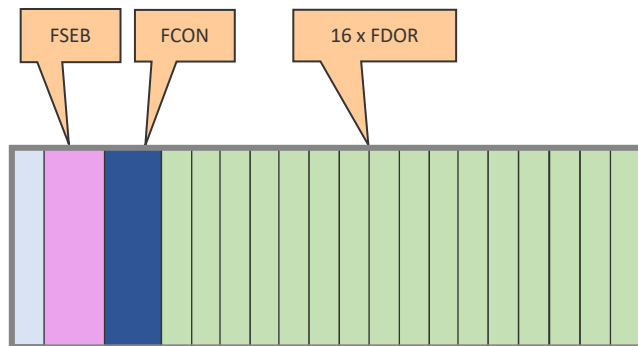
Item	Power (W)	NOMINAL	
		Quantity	Total (kW)
String power	1251	7	8.76
DOM supply AC-DC losses	963.27	1	0.96
UPS	4	2	0.01
PDU	10	2	0.02
network switch	350	2	0.70
weather goose	20	1	0.02
FieldHub	75	7	0.53
WR switch	80	1	0.08
Total			11.07



DOMHub Upgrade



Gen1 DOMHub card layout



FieldHub card layout supports two Gen1 strings

- Plan to replace Gen1 DOMHubs with Upgrade FieldHubs
 - most hardware is 20 years old (SBCs, disks upgraded)
 - have operational spares, but cannot fabricate more
 - Gen1 and Upgrade will initially be on different (but linked) clock fanout systems

- Originally planned to begin this M&O cycle
 - delay in Upgrade deployment

- Hardware is backward-compatible
 - will need firmware, software development

- Ensures long-term health of experiment

- Provides unified system for efficient maintenance

Post-Upgrade Operations Outlook

- Ensure stability of the detector, DAQ, and data processing
- Support new calibration runs
- Promptly deliver processed experimental data and simulation
 - support ML-enhanced data processing
- Deferred hardware maintenance
- Replace DOMHubs with Upgrade ICL FieldHubs
- Continue to expand IceCube science!

Summary



- Upgrade integration leverages well-maintained IceCube software
 - systems are being adapted, not re-written
- Unified DAQ output will flow naturally into existing data pipeline
 - changes needed for data formats, new devices, etc.
- Focus of M&O team in upcoming field seasons is Upgrade integration and support
- On track for unified operations in 2026