

IceCube M&O and Upgrade

Albrecht Karle

04/02/2025

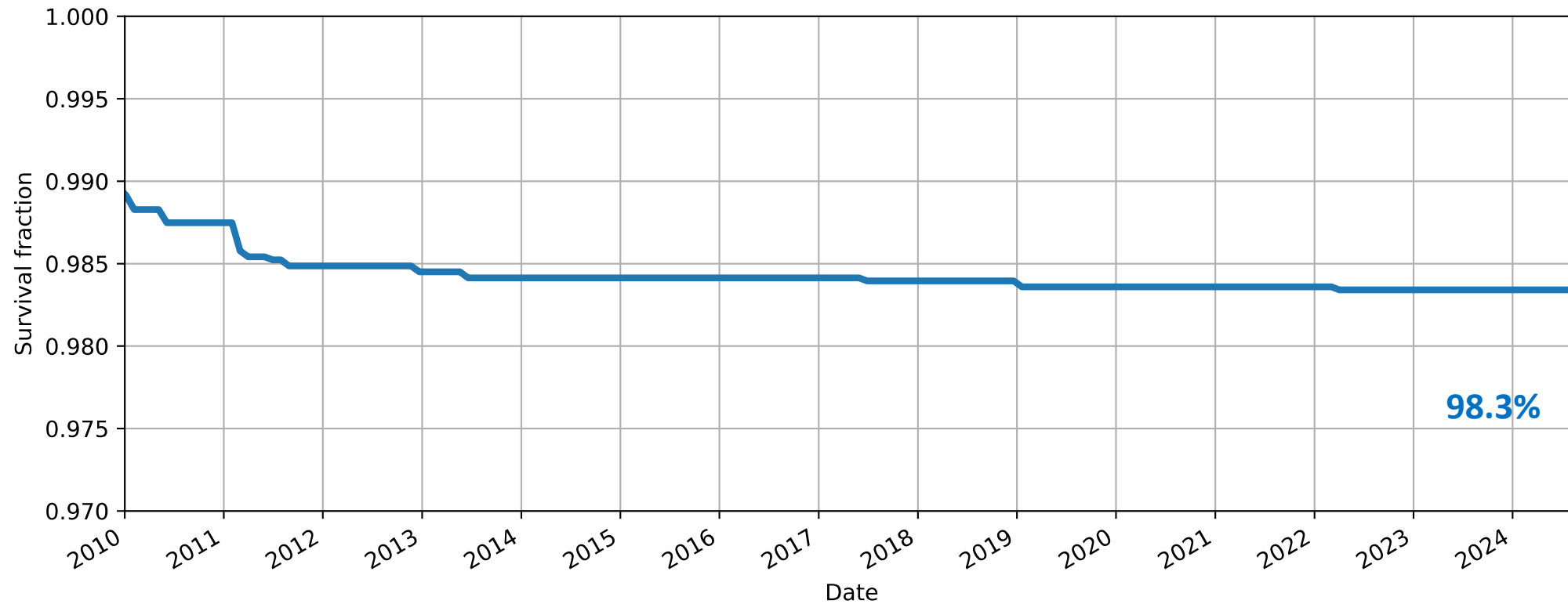


IceCube Field Team, December 31, 2024

Credit: Ilya Bodo, IceCube Winterover

IceCube DOMs continue to proof very reliable

DOM survival fraction vs. time



The hardware failure rate is very low: 4 DOM failures this past decade.

Detector Uptime

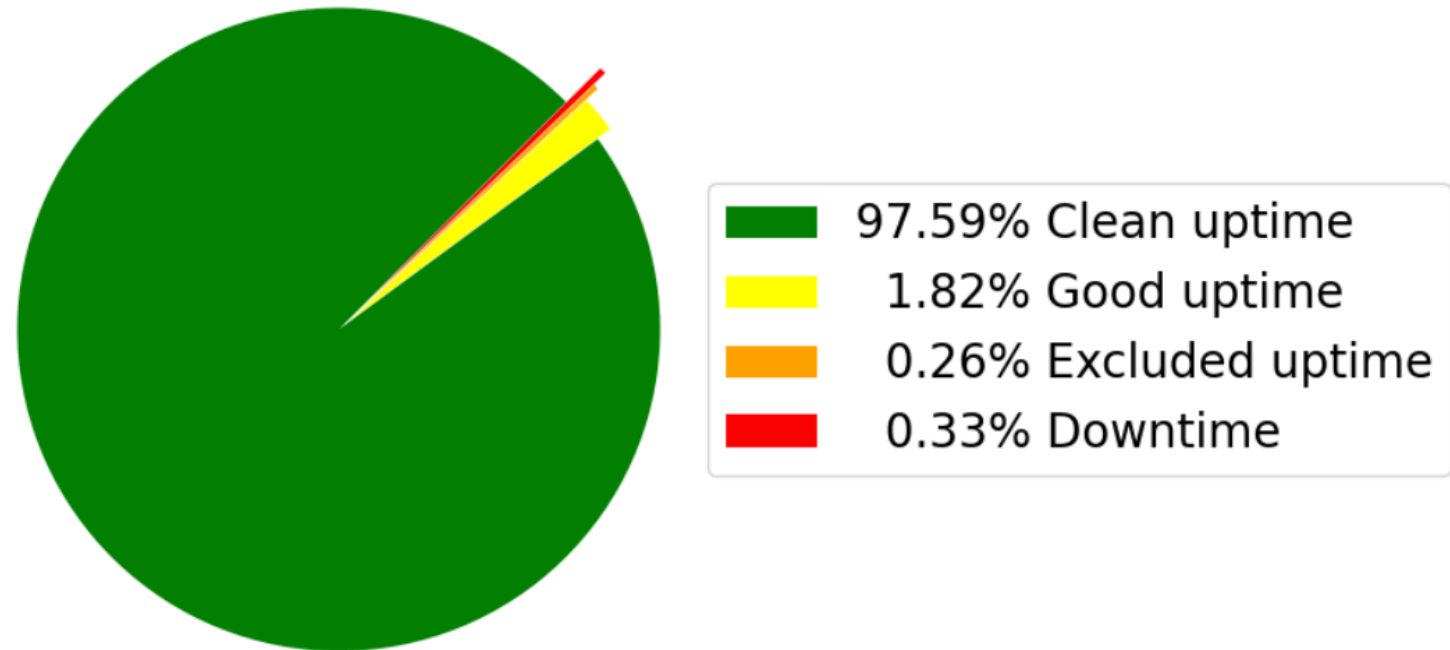
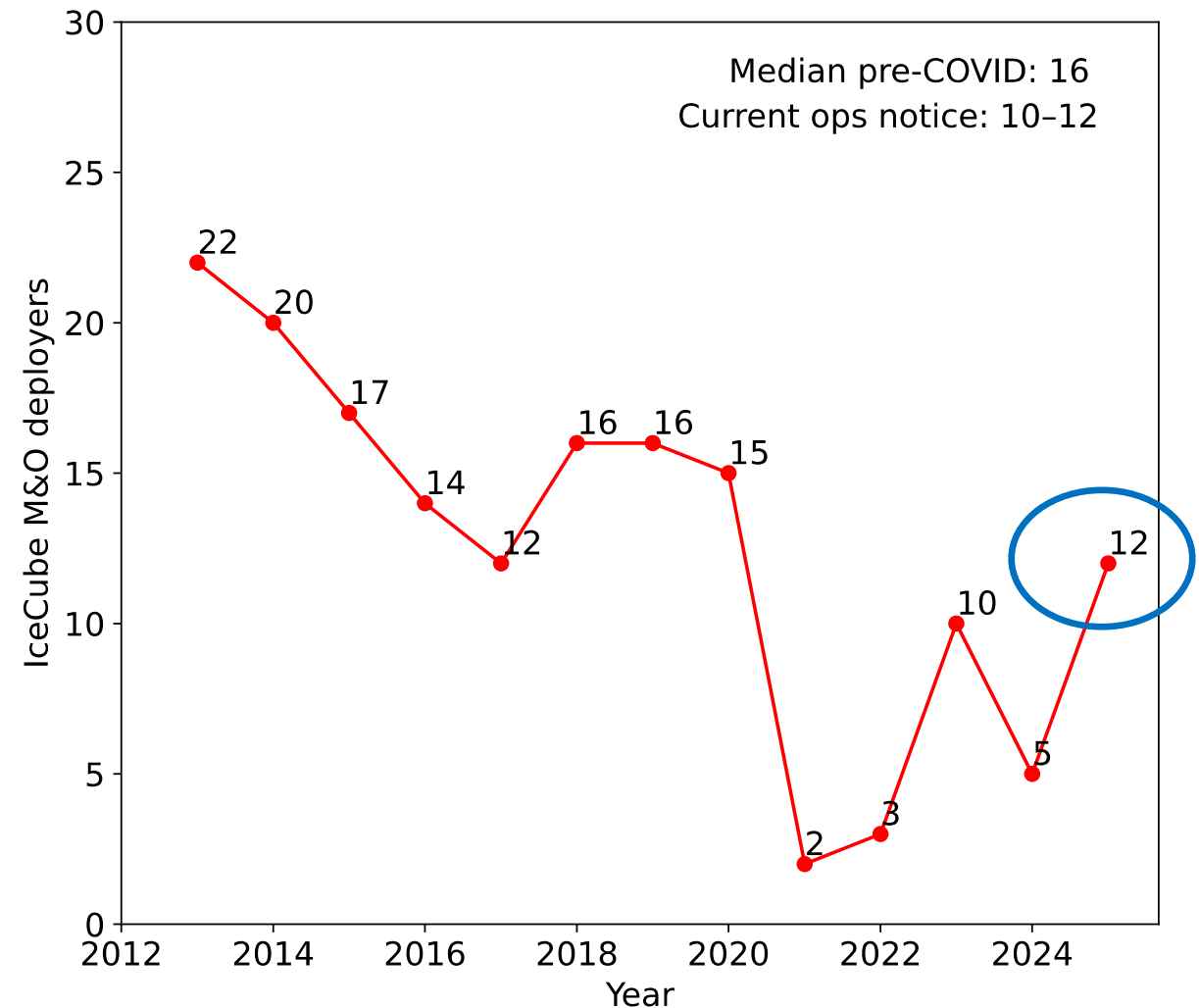


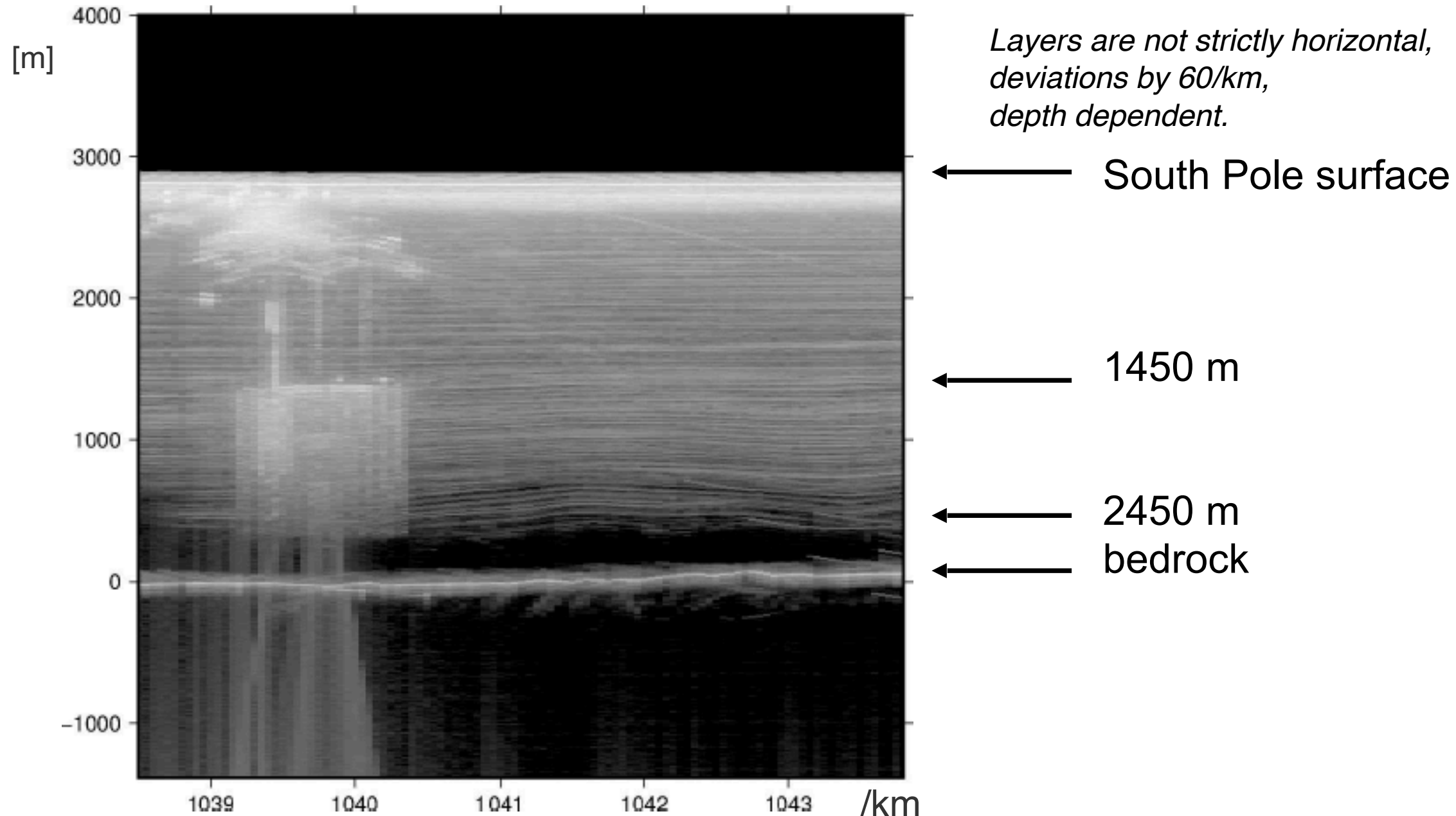
Figure 7: IceCube detector uptime for the period from April 1, 2024 to January 31, 2025.

Field effort 2024/25:

- Focus on Upgrade support, getting ICL ready to receive data from new strings.
- Support for 24–25 is significantly improved
 - 12 total deployers — resumed M&O volunteer deployer program
 - flight rotations still limited, but able to fly people in until mid-December

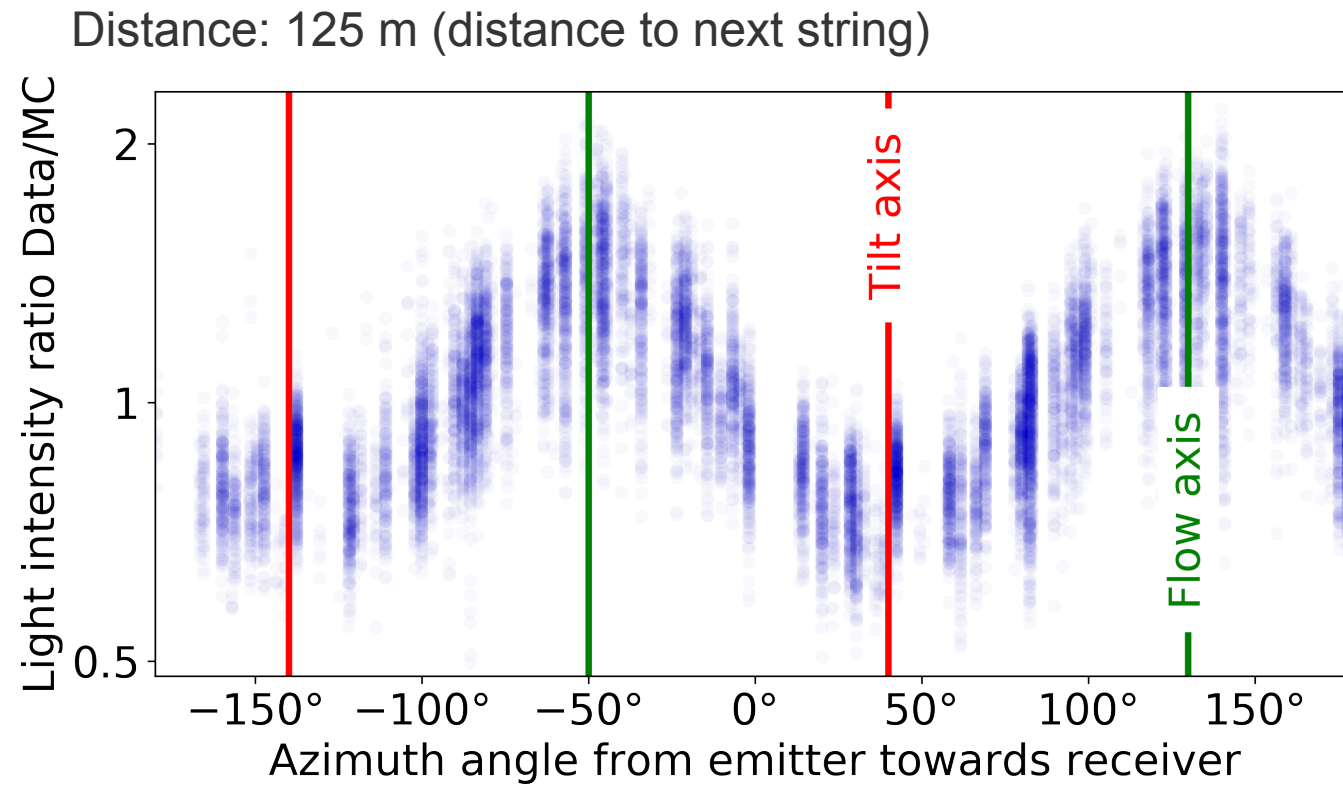


The IceCube Array seen at 60 MHz with ground penetrating radar

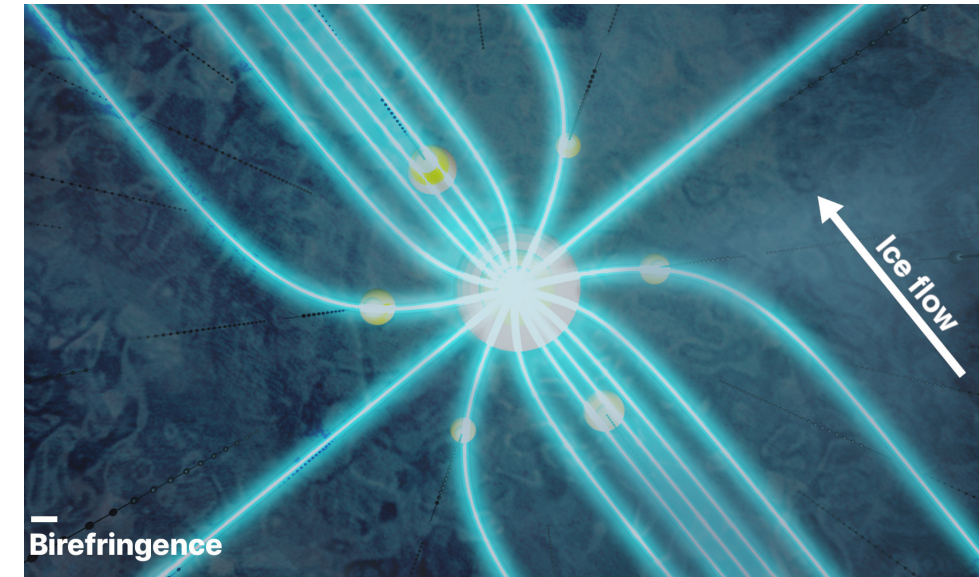


Calibration of ice

Comparison of flasher data to simulation indicated an azimuthally dependent light profile



Ref.: *The Cryosphere* 18 (2024) 1, 75-102



2024–25 Pole Activities

- Key Upgrade-supporting work this season
 - ICL Upgrade electronics installation + UPSes
 - DOM testing support
 - Upgrade surface cable installation support
- ICL maintenance
 - network firewall life-cycle replacement
 - rack remote power distribution unit (rPDU) upgrade
- Other tasks:
 - installation of two surface detector stations.
 - cable trenching not approved
 - finish IceACT field telescope upgrade
 - prototype solar panel drill camp installation
 - maintenance of ARA DAQ

A very productive field season!

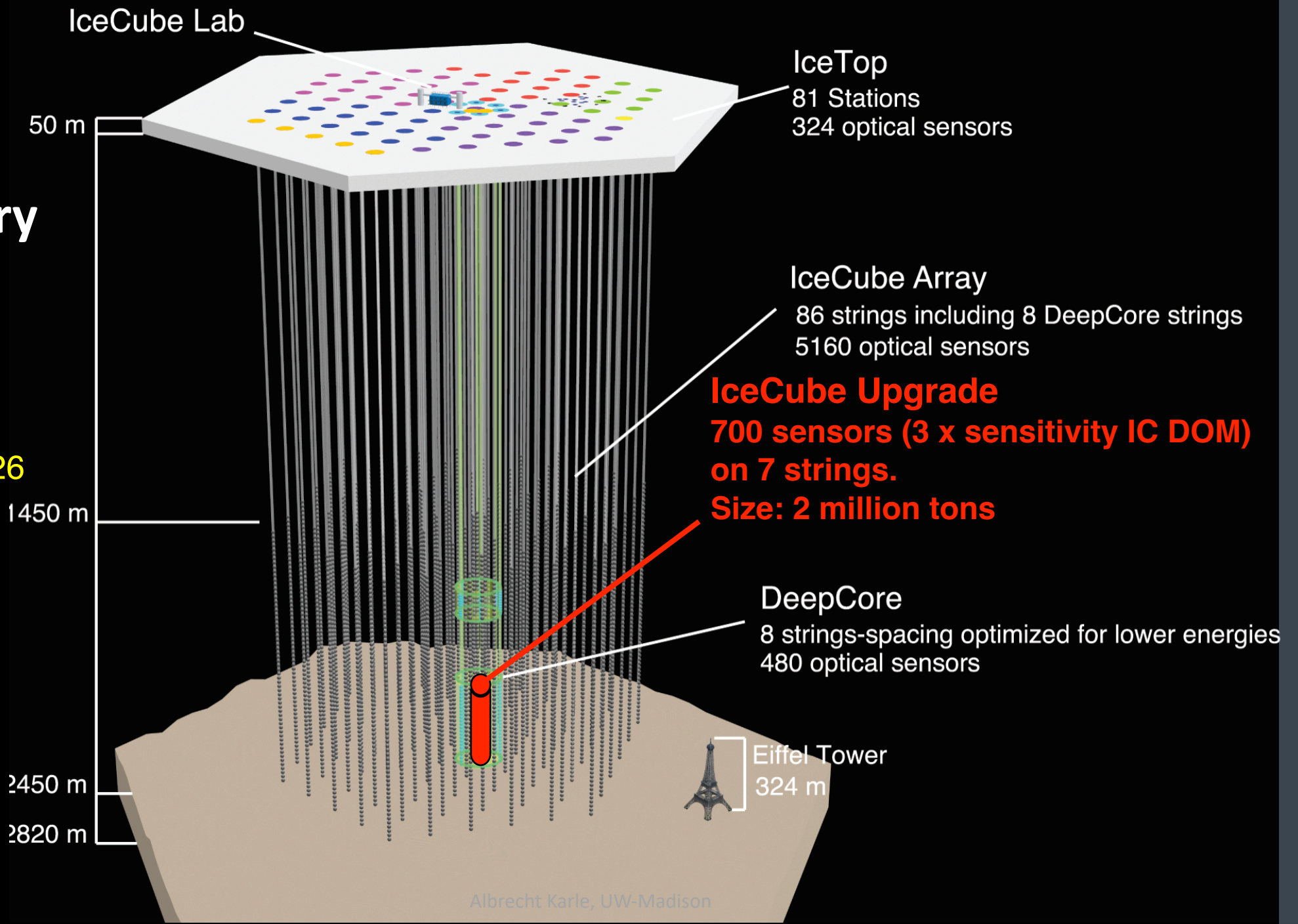
IceCube Upgrade

The IceCube Neutrino Observatory

+

IceCube Upgrade

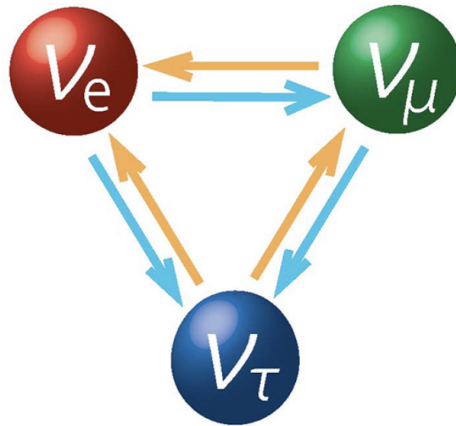
Deploy in 2025/26



IceCube Upgrade - Science goals

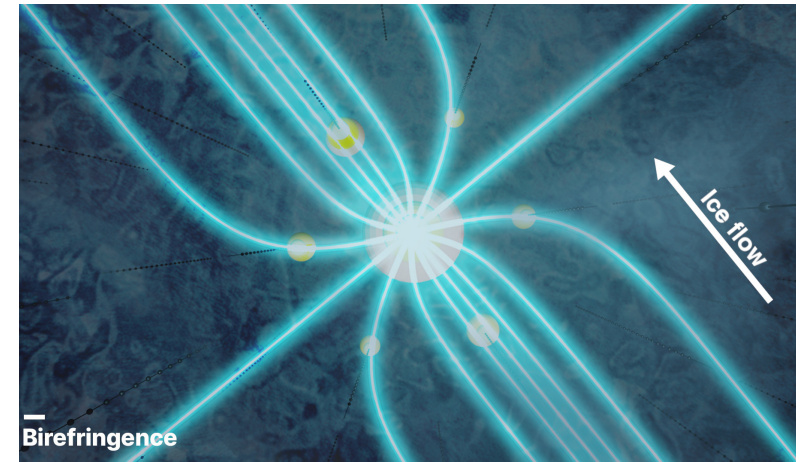
1. Neutrino properties

High statistics measurement of ($\sim 100,000/\text{yr}$) atmospheric neutrinos.
→ Measure neutrino oscillation parameters.



2. Precision Calibration of IceCube

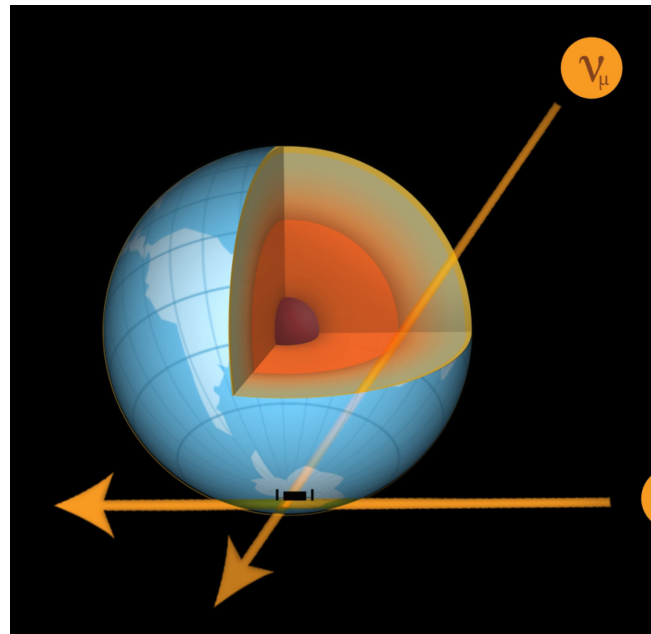
→ Improve sensitivity of IceCube for astronomy

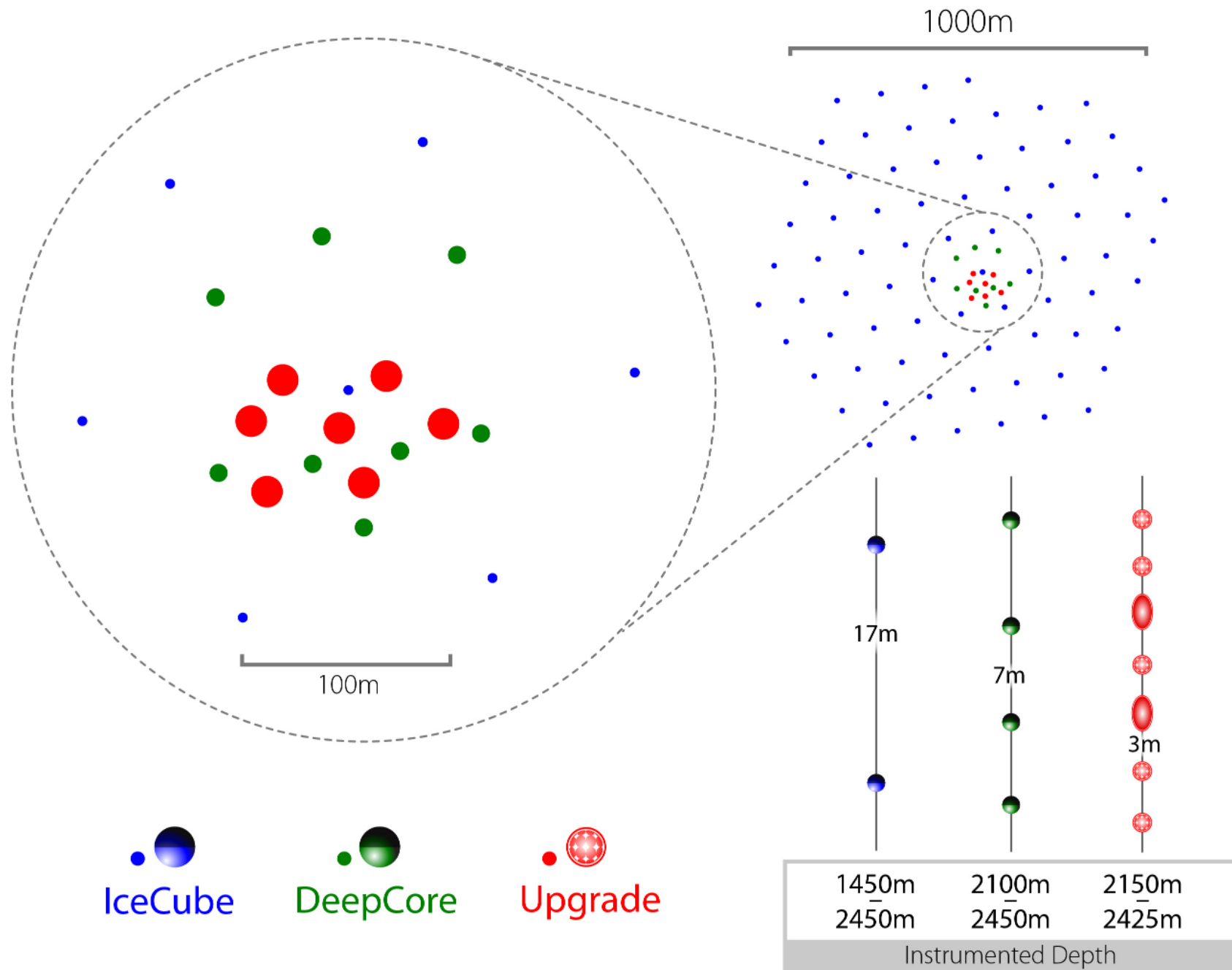


3. R&D for the future

IceCube-Gen2

4. Astrophysical Transients





IceCube Upgrade

PMT coverage:

700 new DOMs

- comparable to 2100 IceCube DOMs (almost 1/2 of IceCube)

Noise rate of MDOMs:

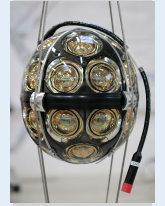
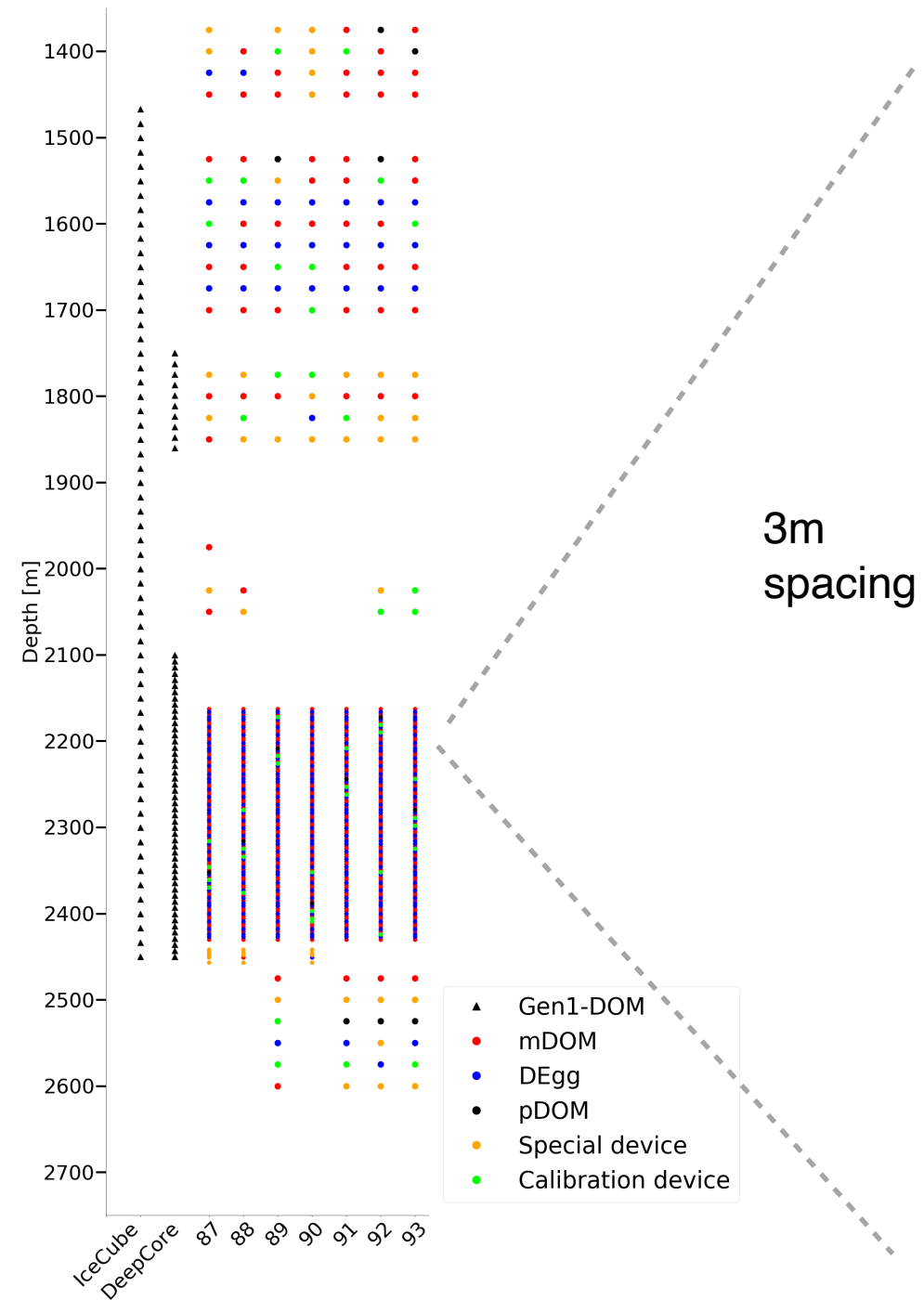
~ 10 x higher

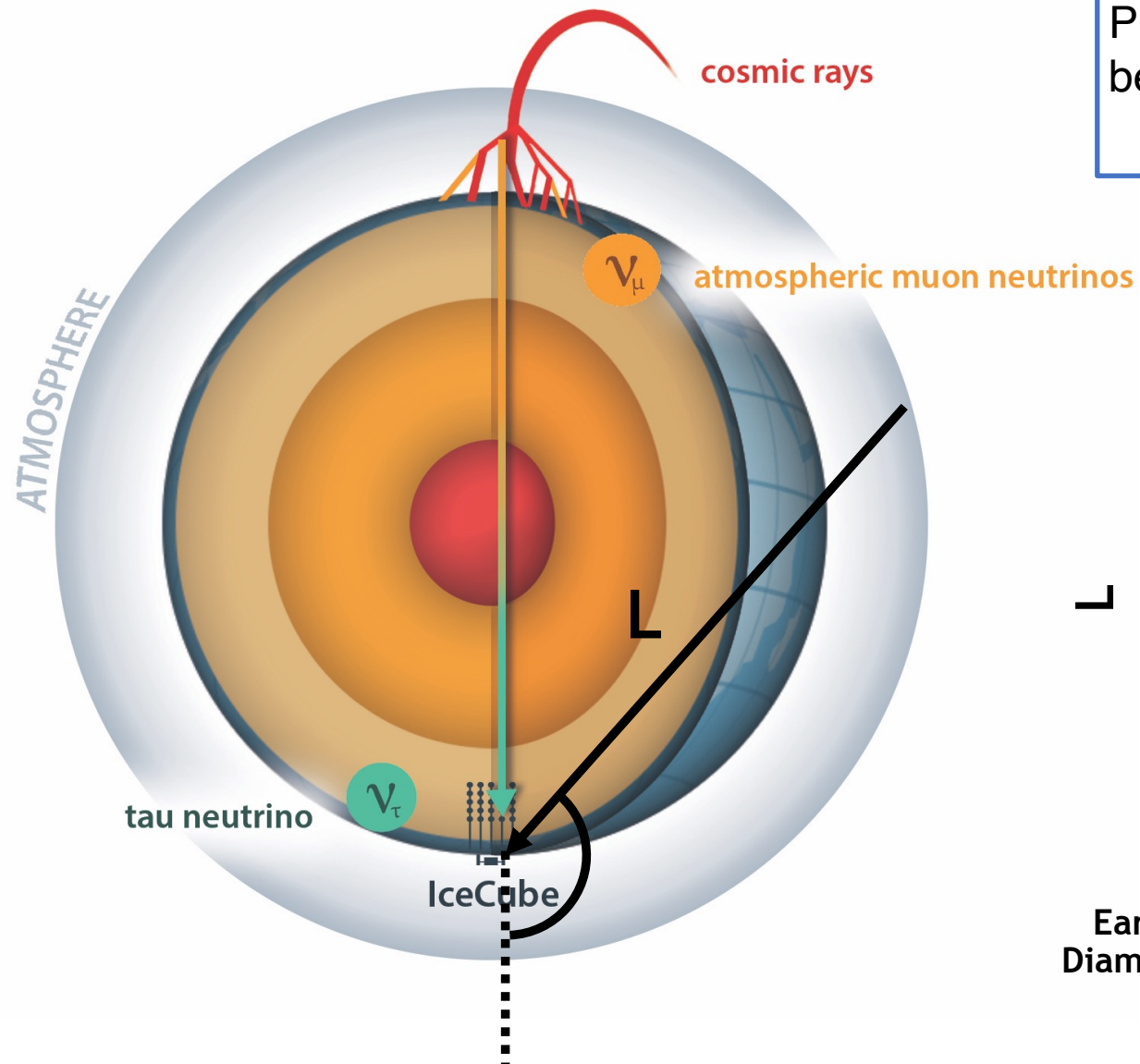
3 DOMs per wire pair are pushing the limits of cable bandwidth (~1 - 2 Mbit/s, could be different in the ice):

—>

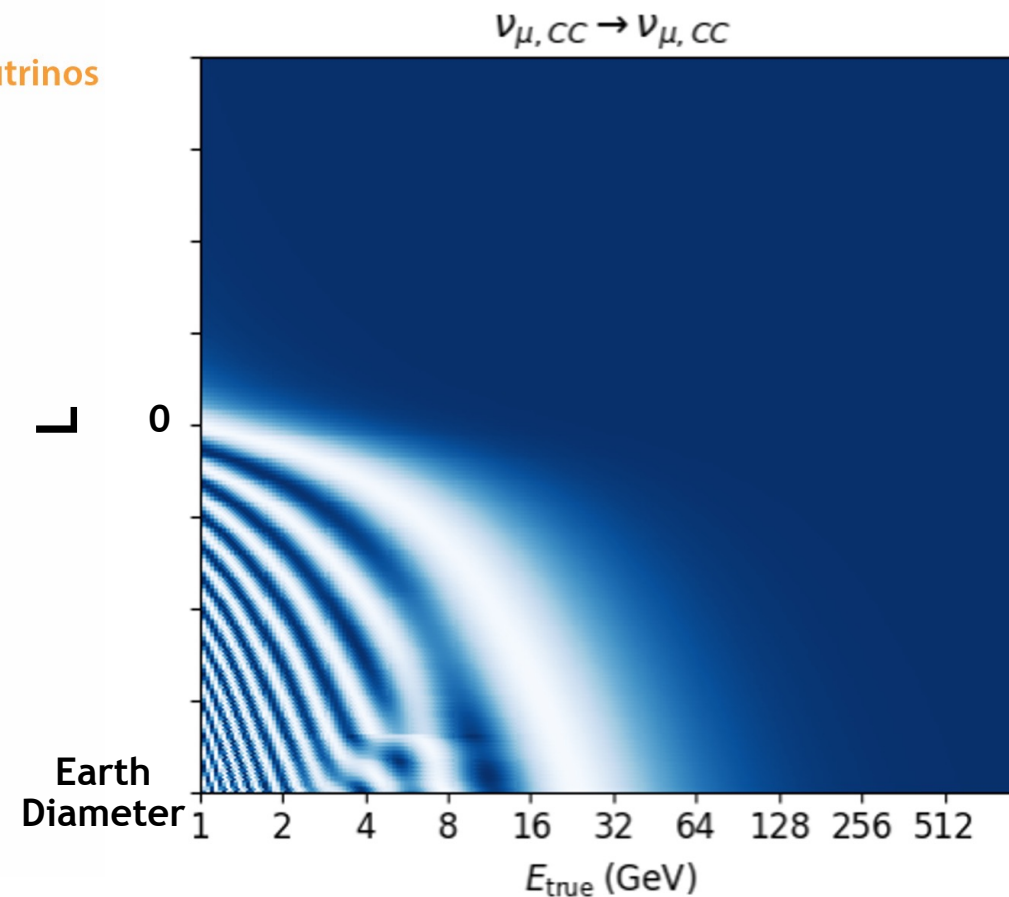
Significant effort for data transmission and triggering!

— DAQ SW effort provided almost entirely by M&O

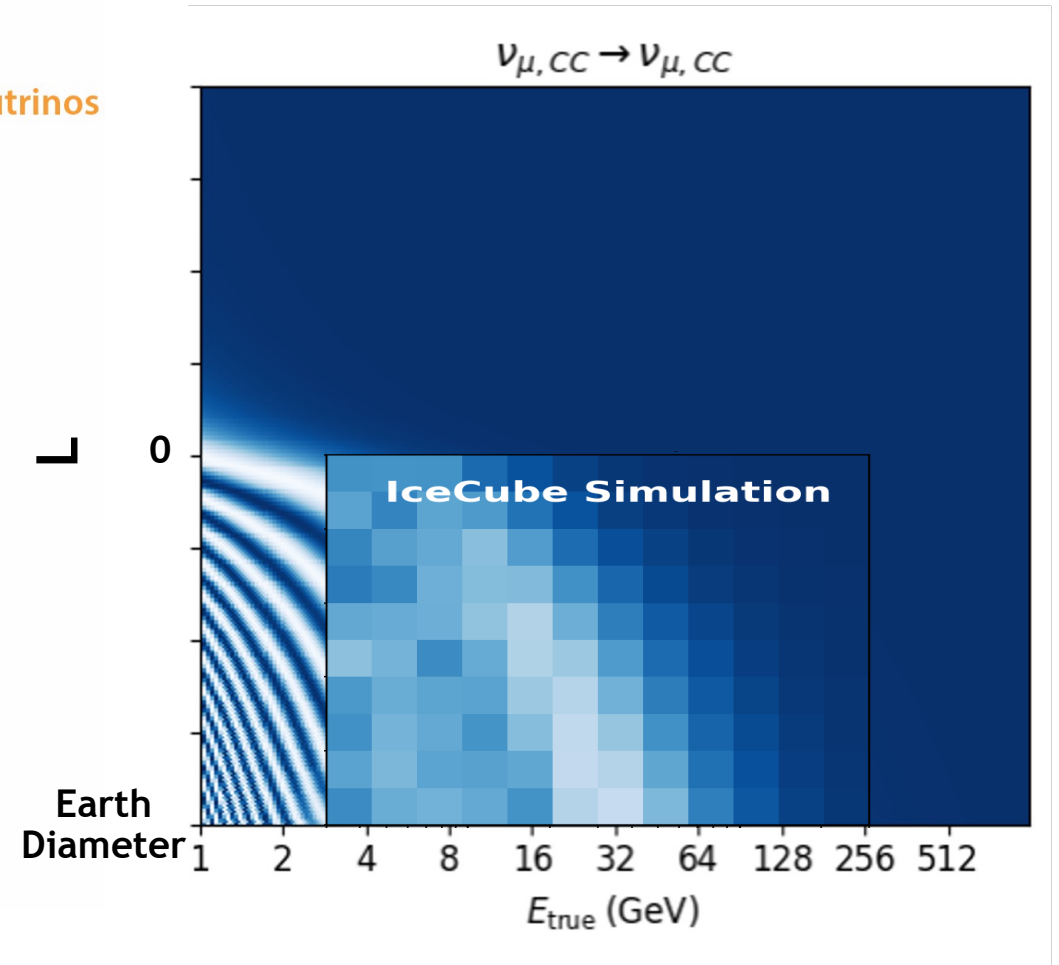
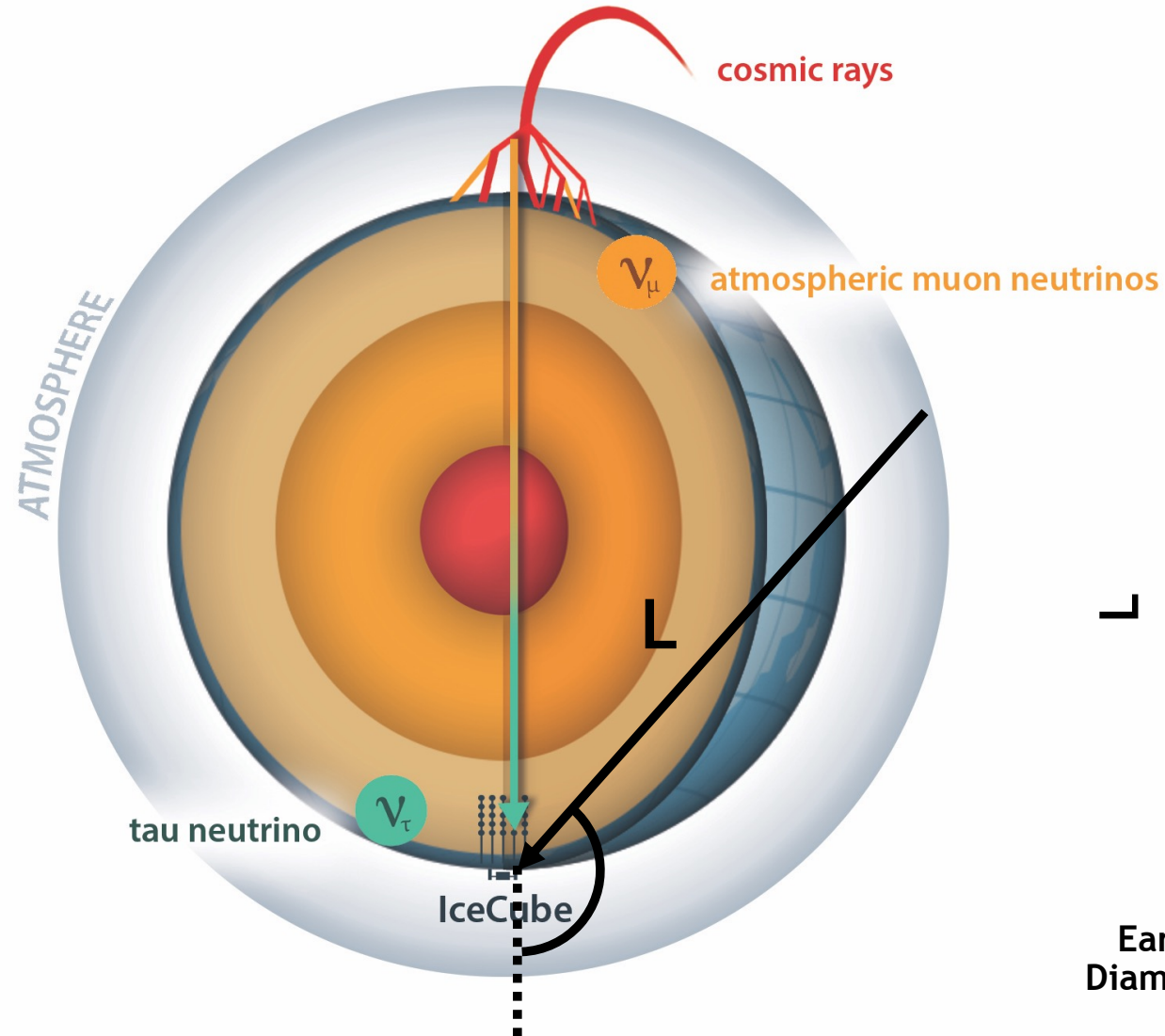




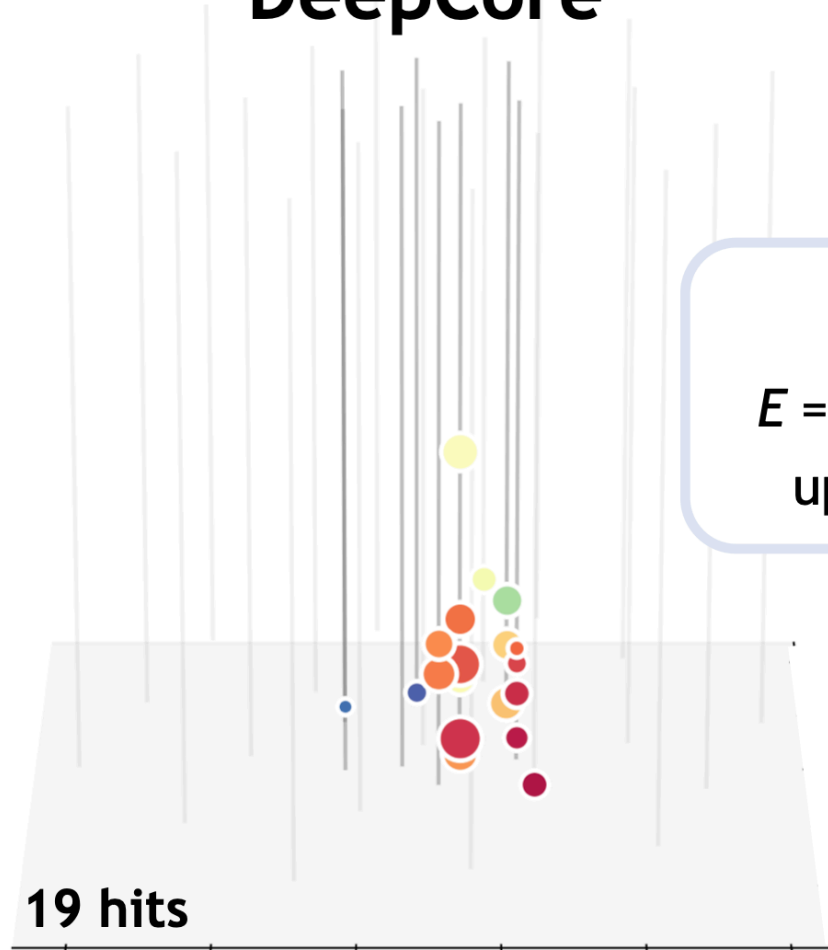
Energy threshold is critical:
PMT coverage allows access to events
below 3 GeV.



But the reality is more blurry

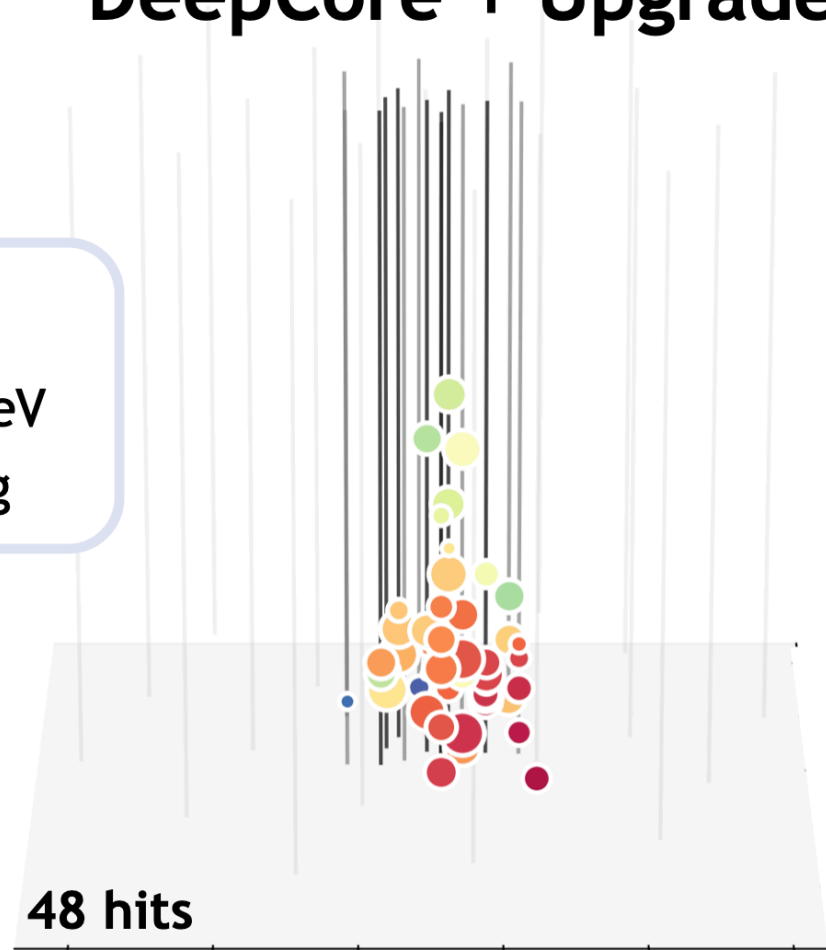


DeepCore

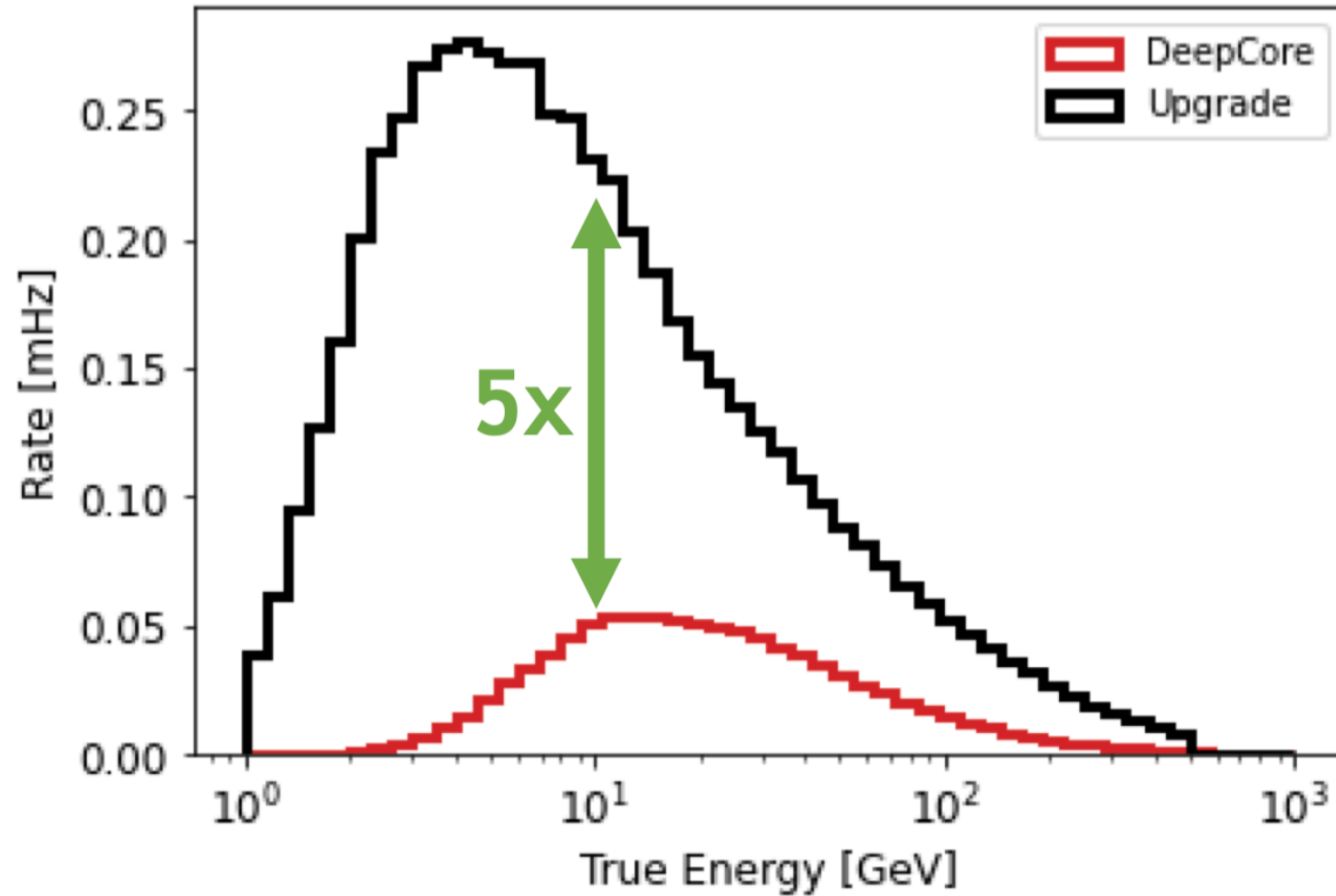


ν_{μ}^{cc}
 $E = 25 \text{ GeV}$
upgoing

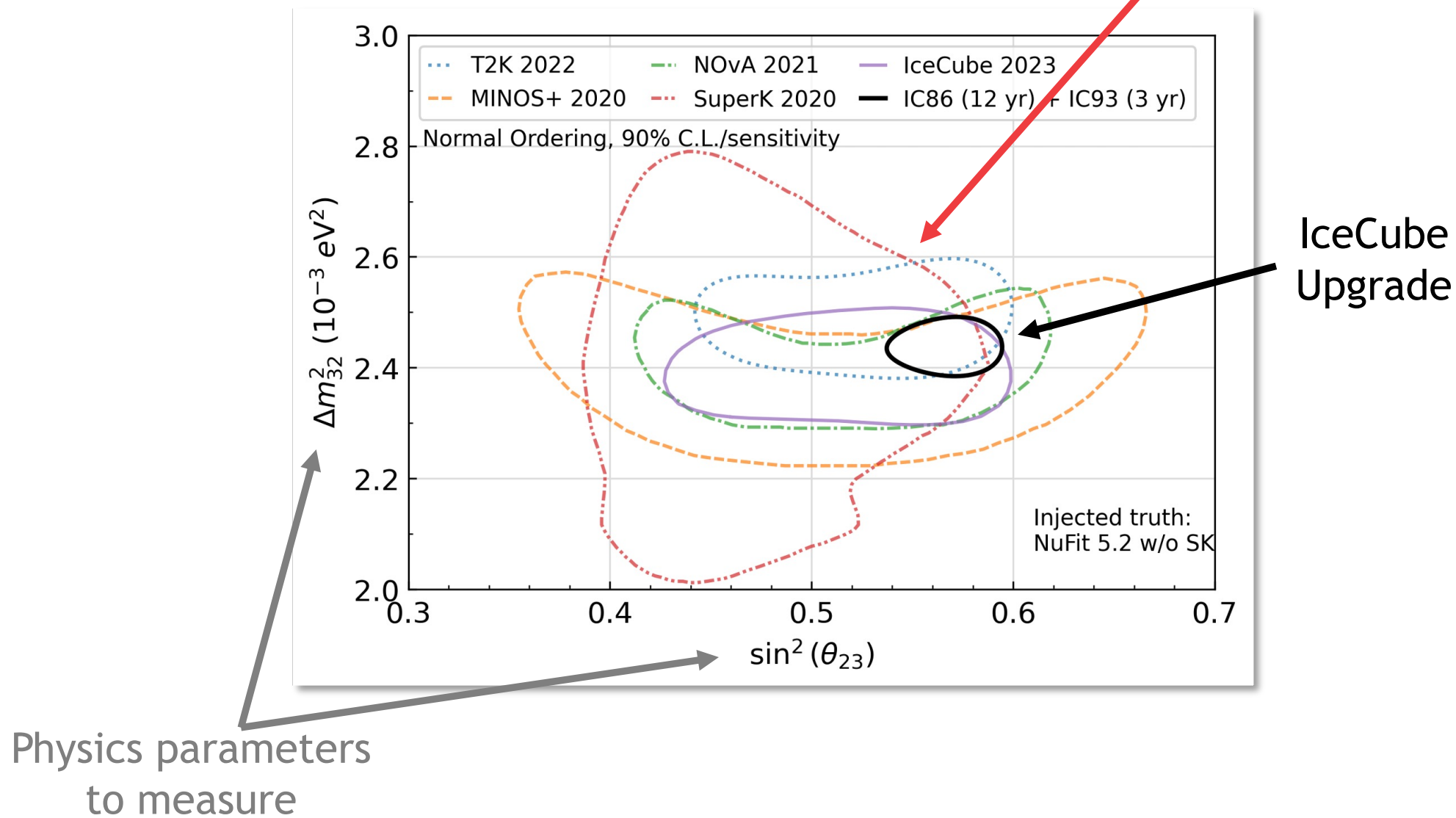
DeepCore + Upgrade



Huge increase in statistics in the oscillation region.

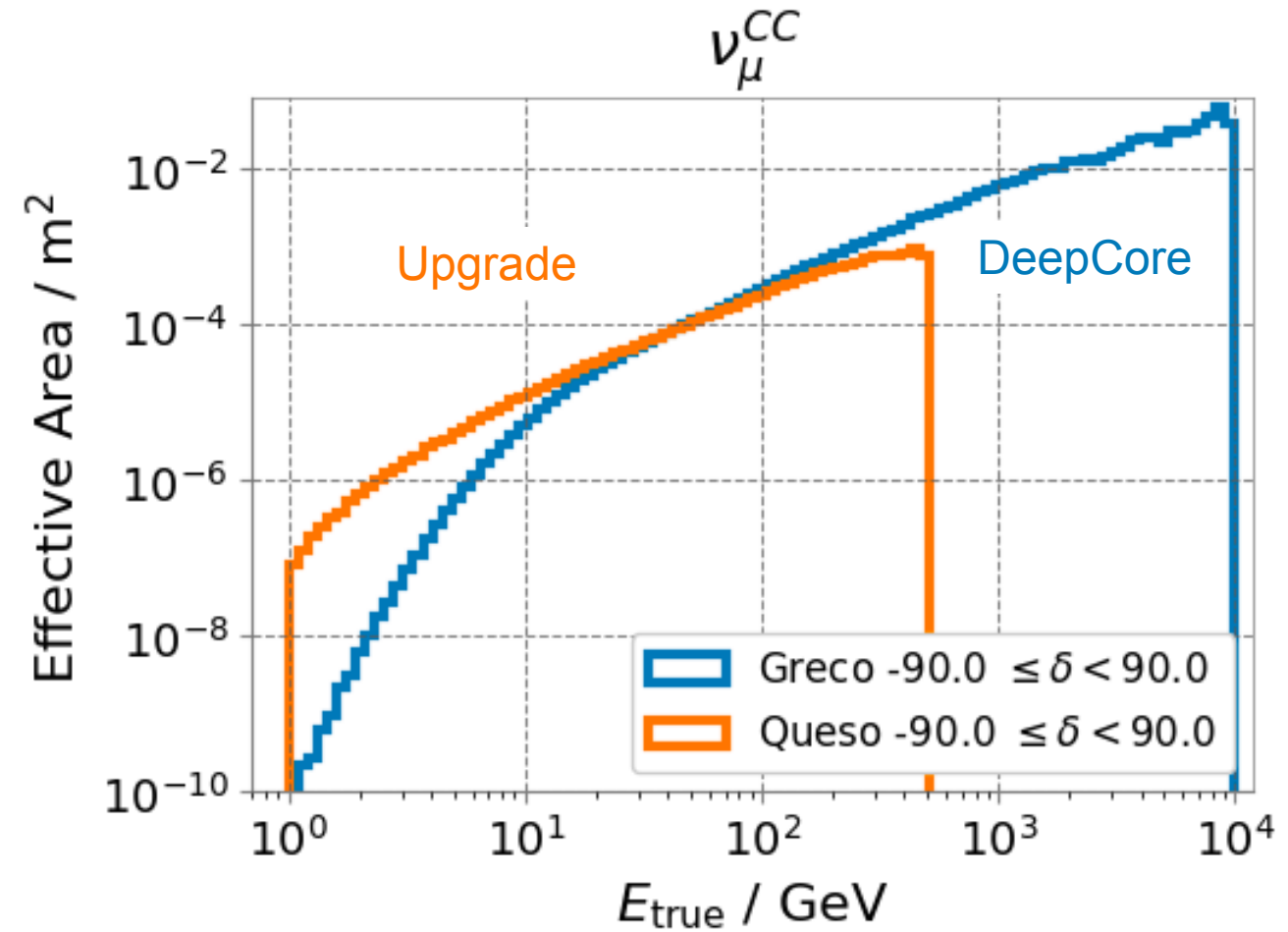


Projected sensitivity



1–1000 GeV neutrino astrophysics

- Six IceCube journal papers on 1–1000 GeV astrophysics with DeepCore
- Fermi LAT has proven the abundance and diversity of GeV sources, many of which are hadronic
- Proliferation of DeepCore and Upgrade astrophysics analyses led to a new working group, “Low Energy Astrophysics”

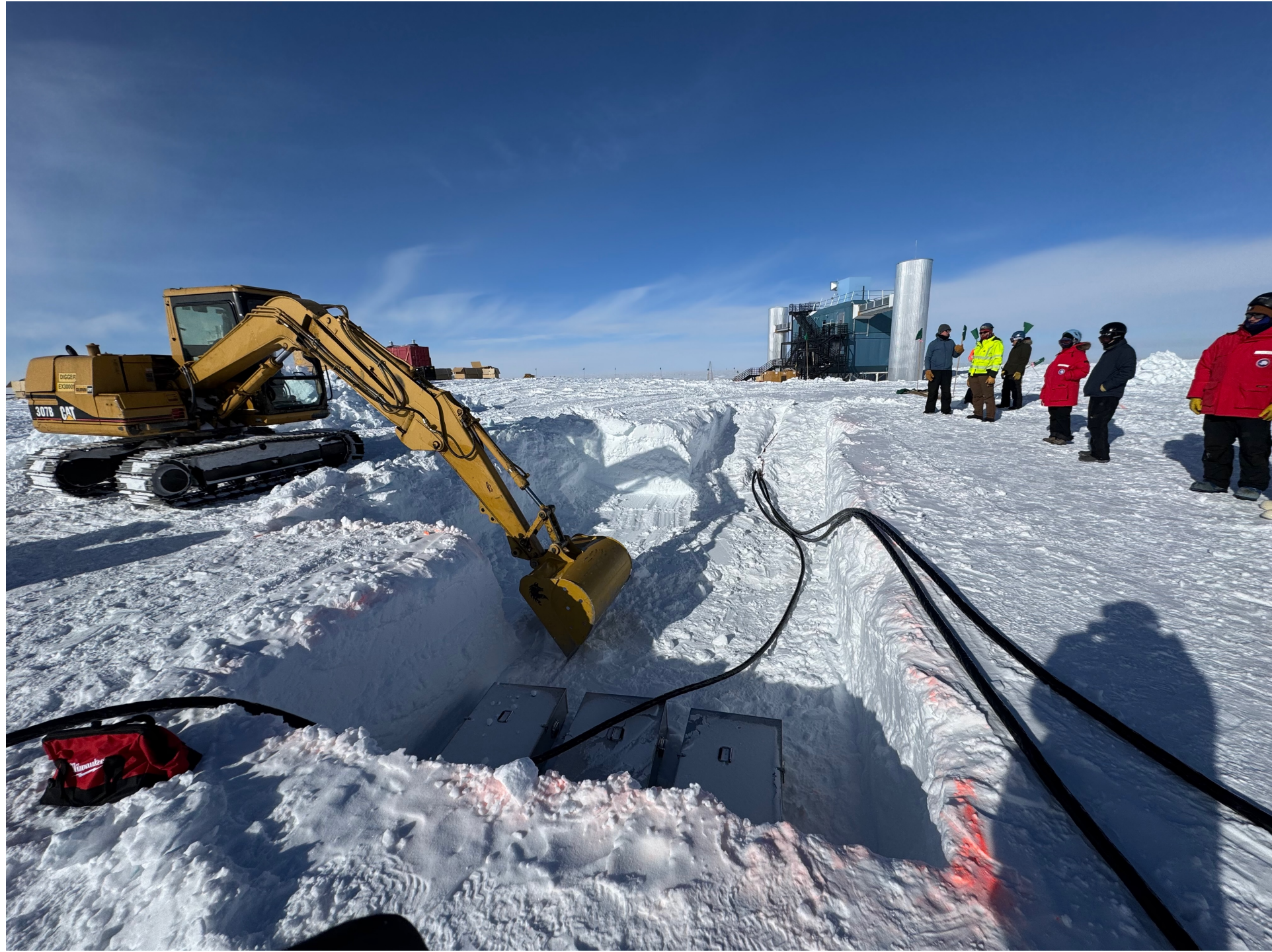


A (somewhat) predictable GeV transient: Upcoming eruption of nova T Coronae Borealis

- Novae: thermonuclear explosions on white dwarfs that somehow act as GeV–TeV particle accelerators
- T Coronae Borealis, expected to outburst between 2024 and 2028, will be $\sim 10\times$ brighter than a bright 2021 nova (RS Ophiuchi) and at a near optimal declination (+26) for IceCube DeepCore/Upgrade
- Likely to be bright in GeV and TeV gamma rays, maybe also neutrinos



Field season 2024/25



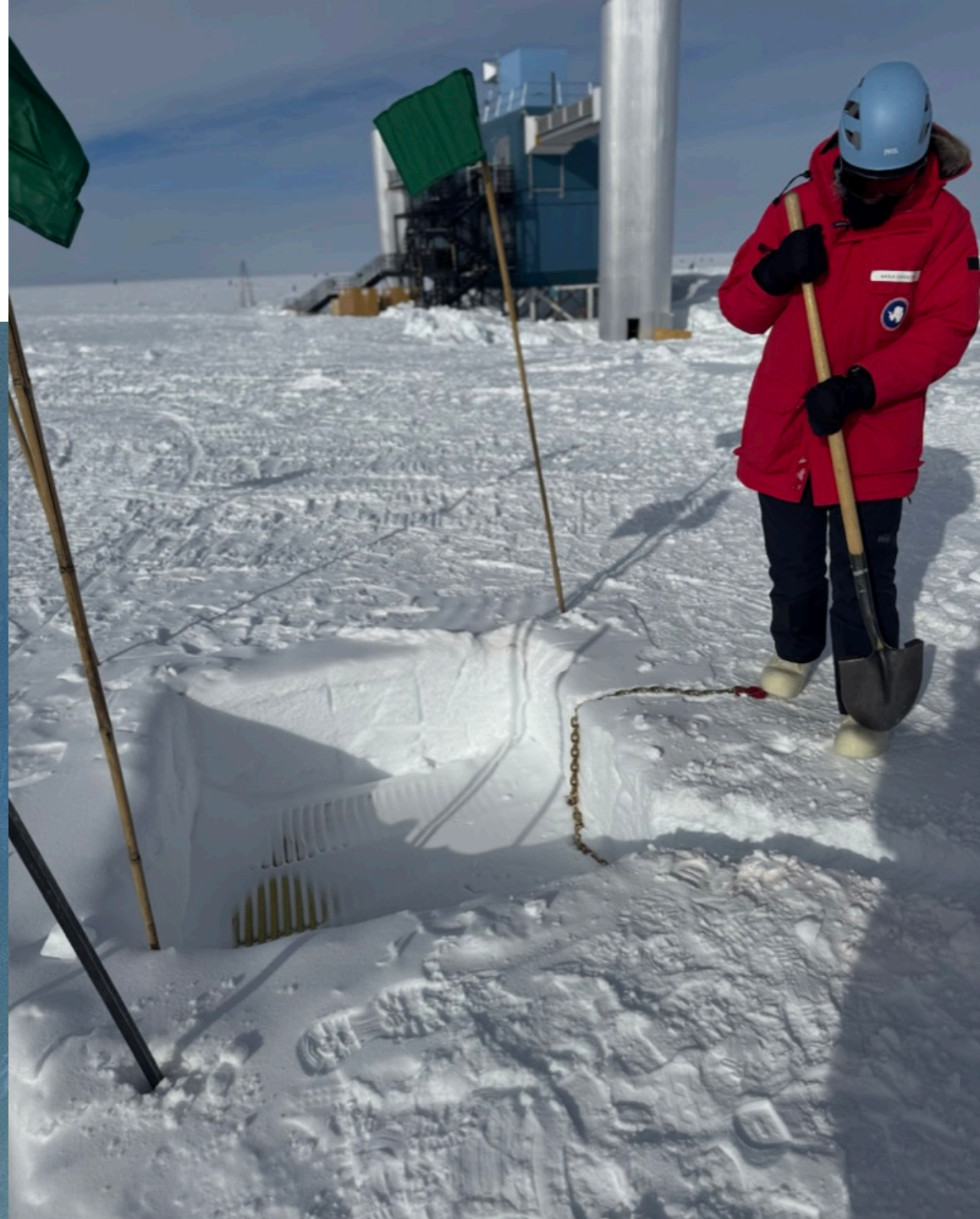
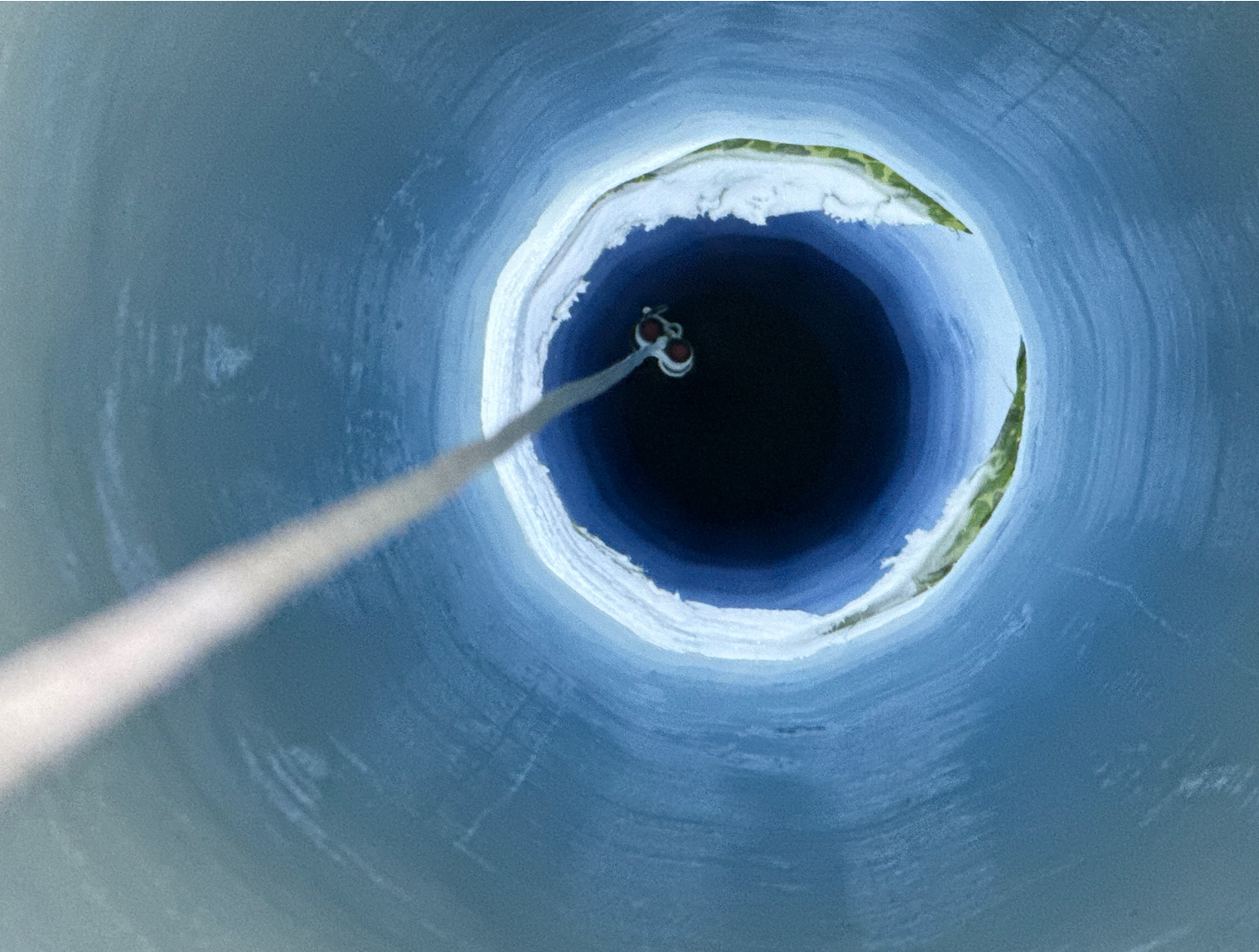
Installation

Chris Ng, MSU, inspects the cable tray in the ICL.

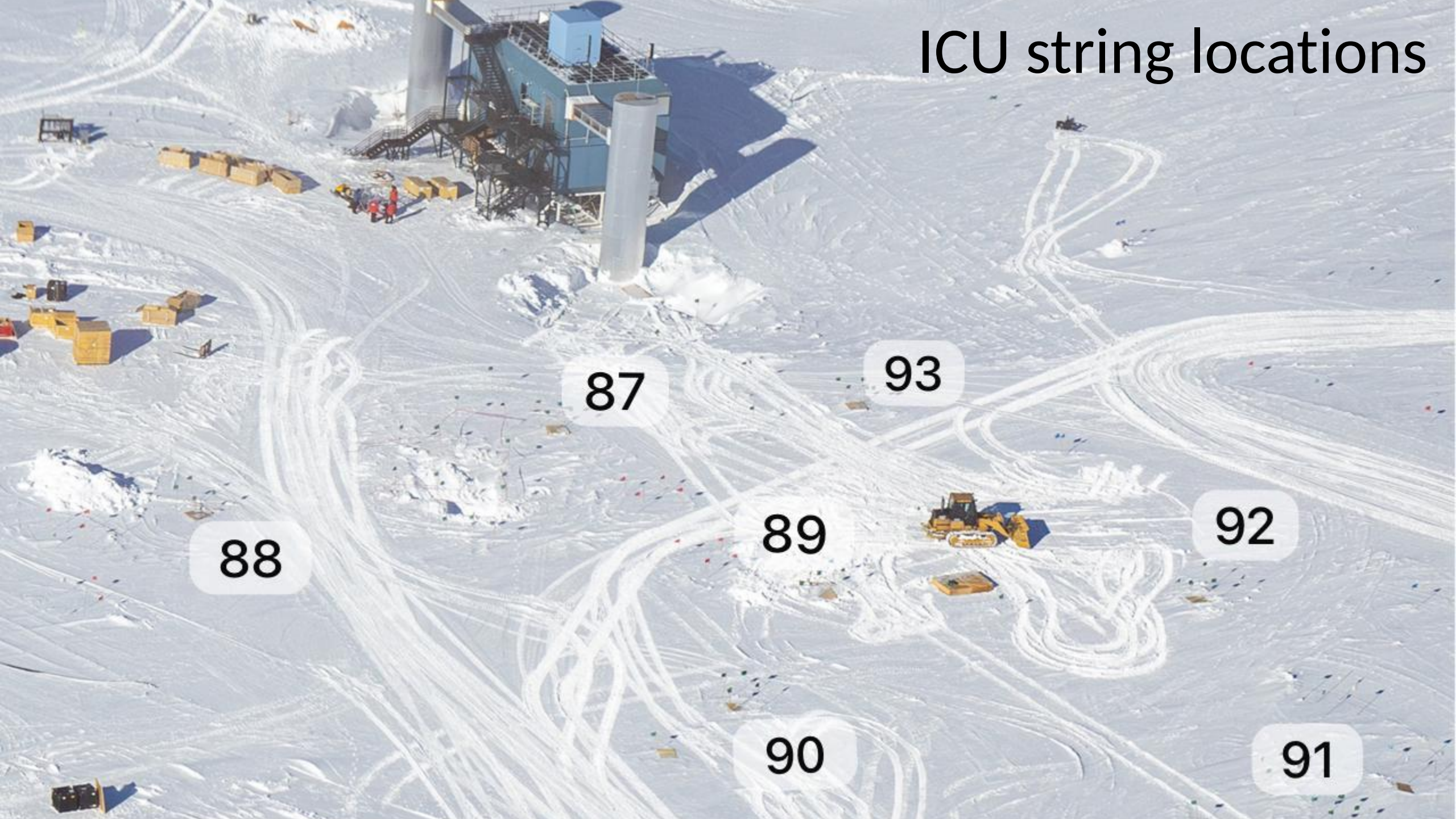


Karl-Heinz Sulanke, DESY, explains the field hub electronics.

All firn holes drilled,
anchors are prepared.



ICU string locations



87

93

88

89

92

90

91

Seasonal Equipment Site

January 16, 2025



Seasonal Equipment Site

- Water circulation successful through all major modules under pressure.



Snow ramp to one of two large hotwater tanks.

Terry Benson (from left) tours the drill camp with Dr. Jean Cottam Allen, acting director of NSF's Office of Polar Program, Sheryl Seagraves (ASC, Science Implementation Manager, Dr. Linnea Avallone, Chief Officer of Research Facilities, Office of the Director, and Albrecht Karle. (Photo: A Karle, IceCube/NSF)

IceCube Population on the Ice

Total population (ICU + M&O): 30

- Upgrade total: 20
- IceCube M&O (includes Upgrade support and winterovers): 10



Next season

Total population: ~50

The IceCube Field Team on December 31. The team is enjoying a 2-day break.

On track for deployment in 2025/25

- Many tasks are awaiting the M&O team:
 - DAQ commissioning
 - Calibration: low level (geometry, DOMs, ...), high level, new ice models, including hole ice.
 - Integration of data stream into IceCube
 - Filtering streams
 - Simulation of the detector in the initial version, advanced versions
 - Reconstruction support of new optical modules.
- Successful coordination between project Upgrade and IceCube M&O.
- Will be prepared for ICNO with $86 + 7 = 93$ strings