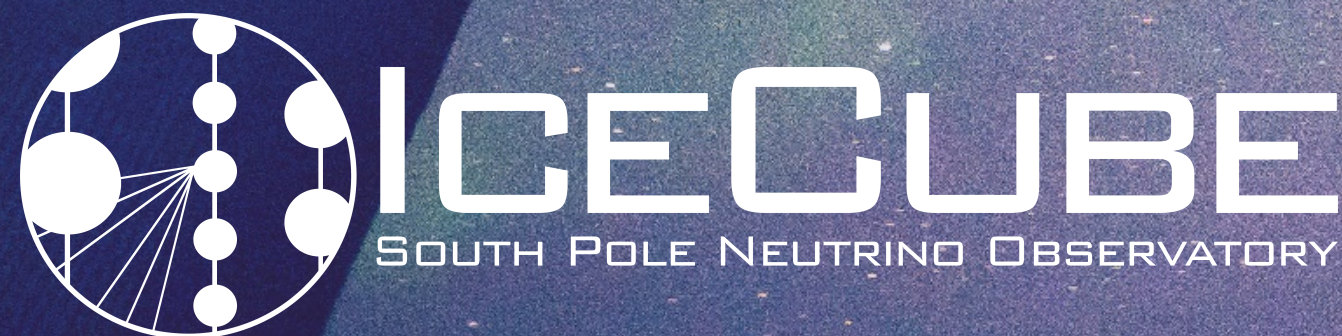
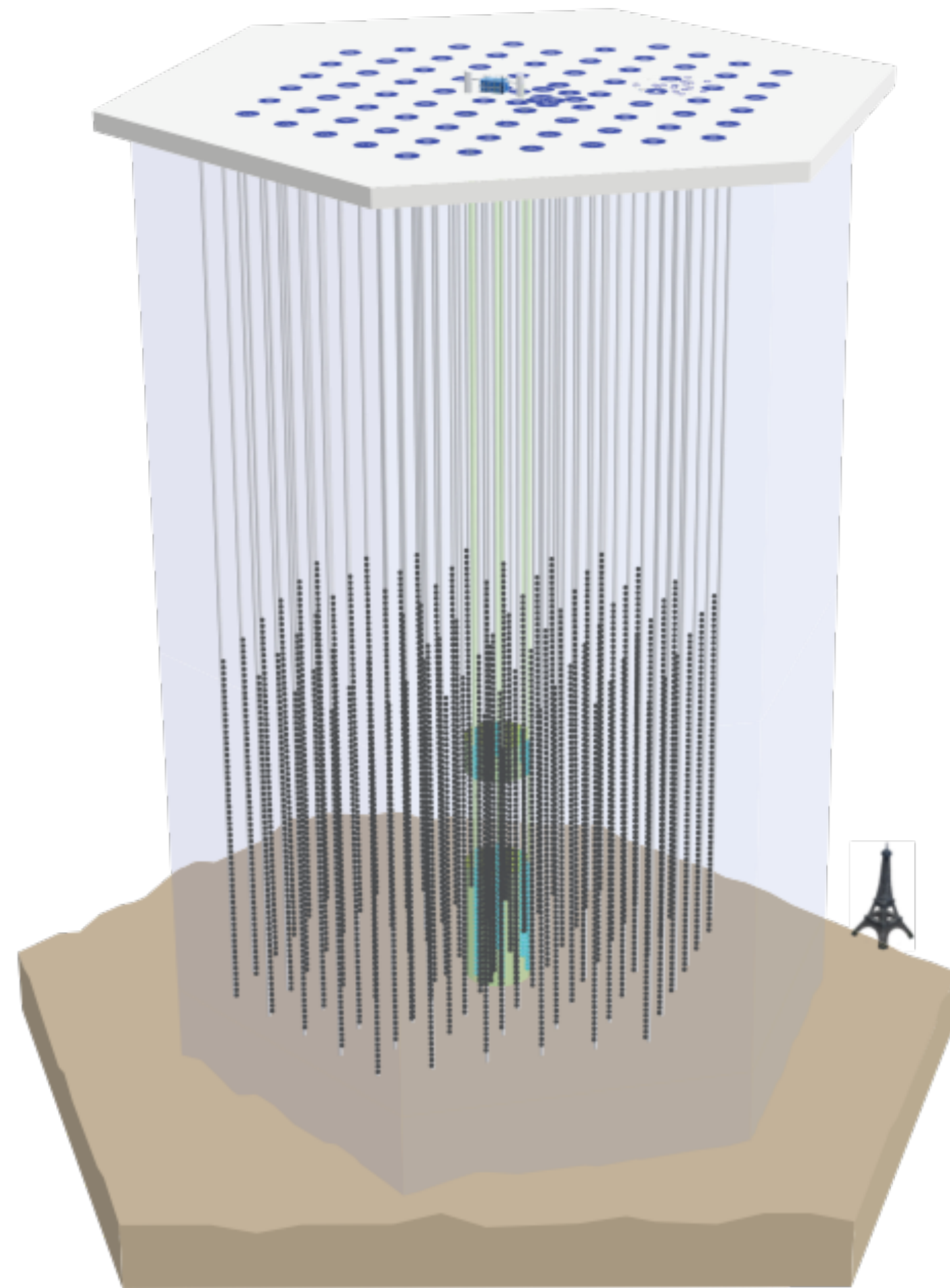


Technical Issues and Future Plans

Albrecht Karle

IceCube Management and Operations
NSF Site Visit March 16, 2020

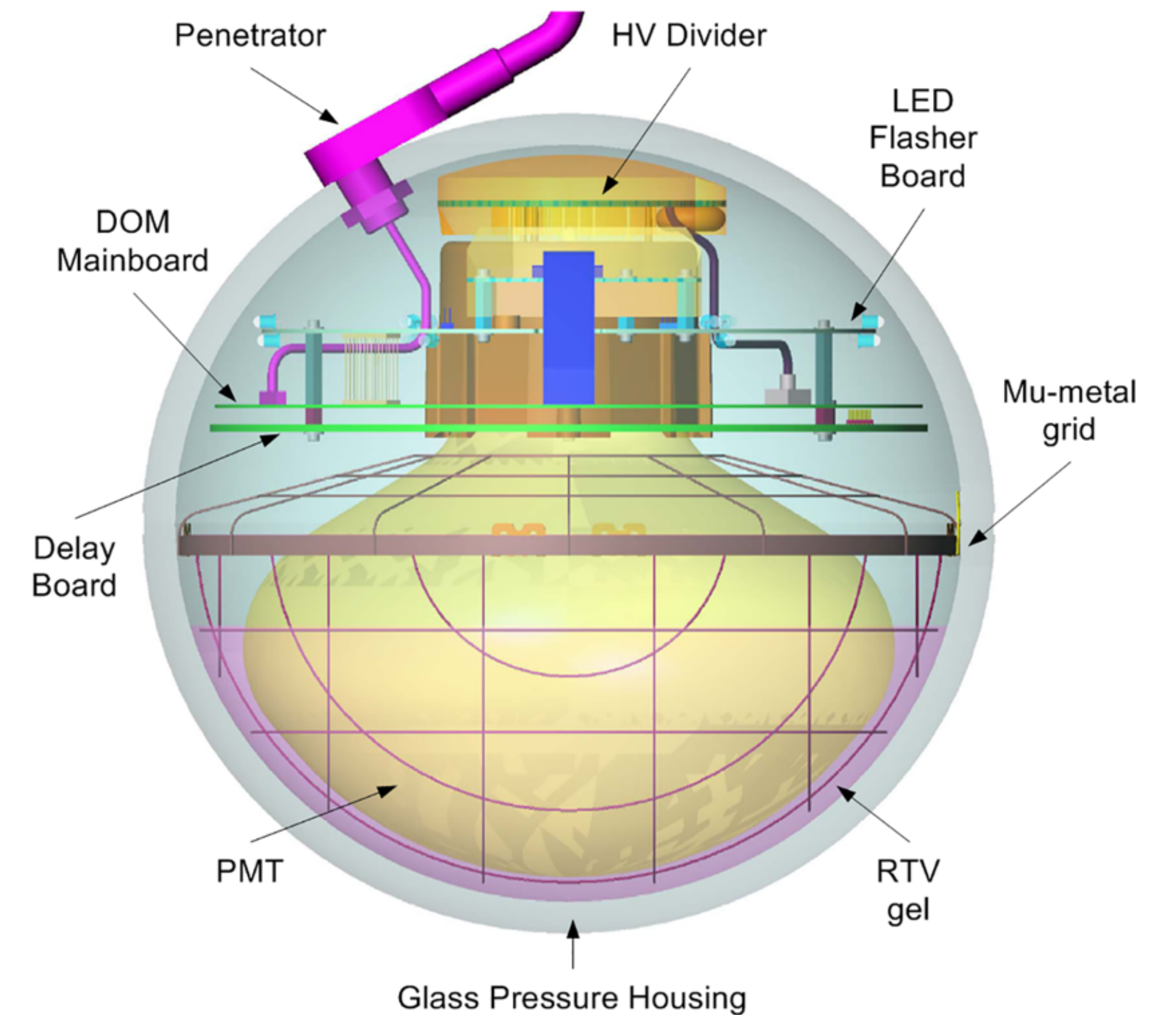




IceTop (surface array): 81 stations

IceCube: 86 strings
5160 optical sensors

Highly stable operation.
Since 2016: [liveltime > 99.5%](#)

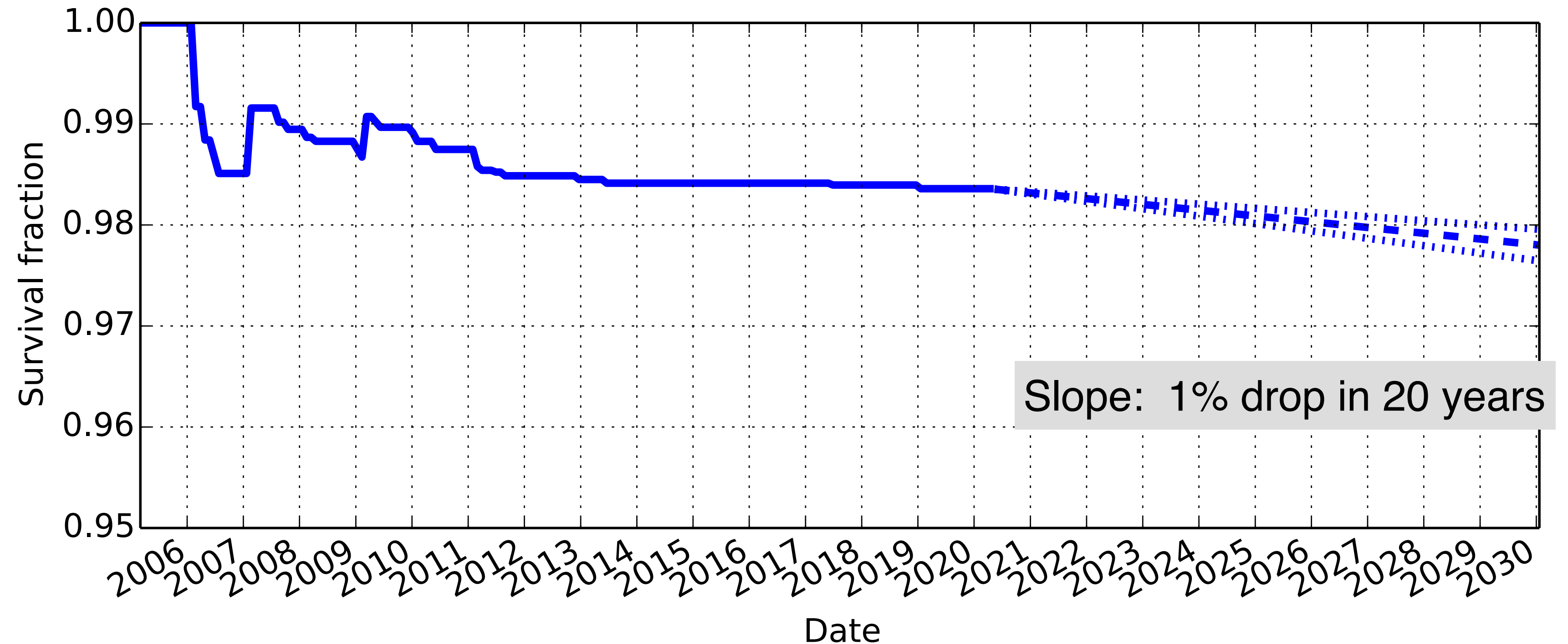


DOM reliability and detector uptime

The foundation of the detector, the frozen DOMs continue to perform very well.

3 DOMs fails in the past 5 years.

This is also the foundation for making ICNO array an integral part in Gen2 planning

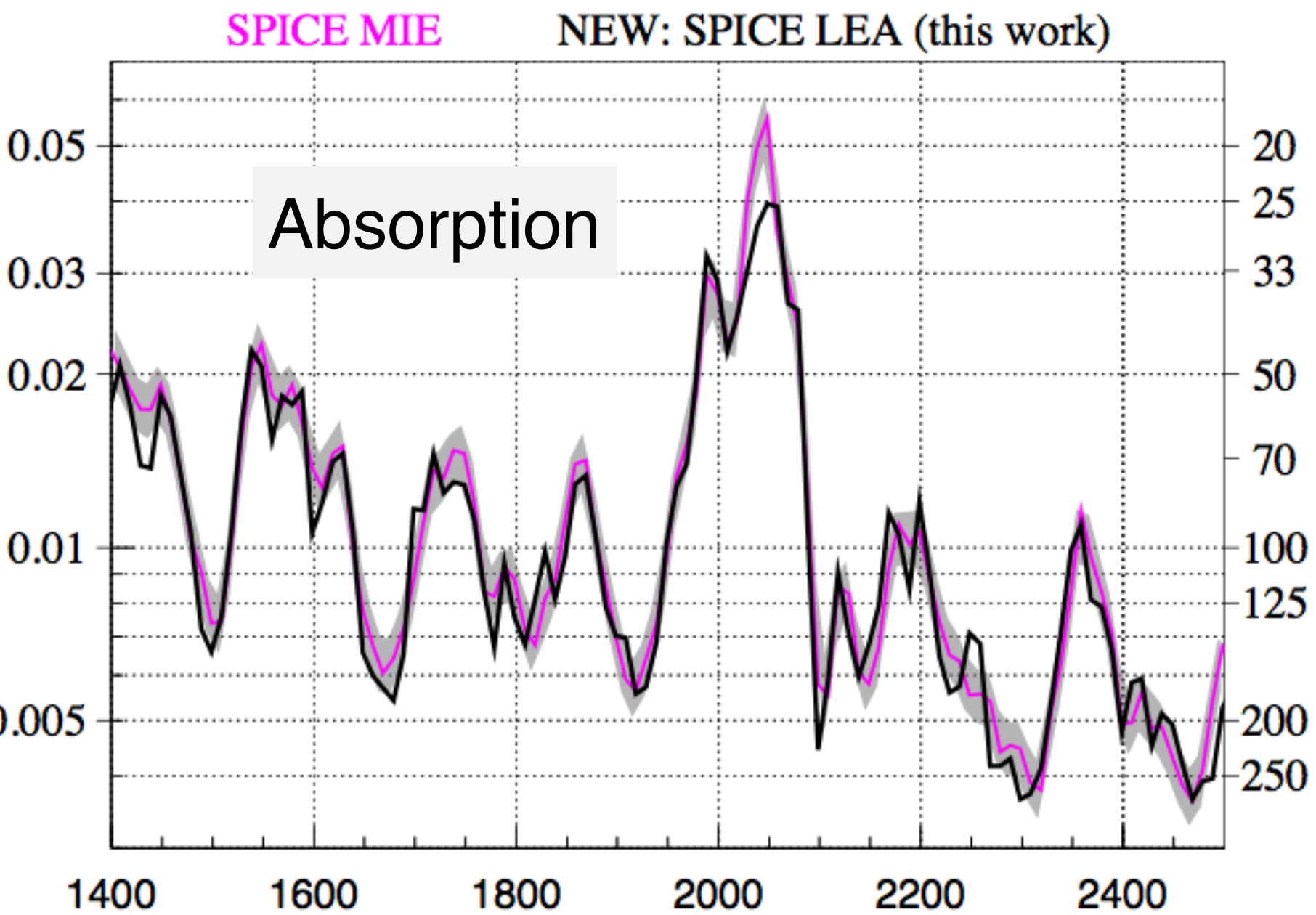


Detector Uptime remains very high.
Does require active maintenance.

—> talk by John Kelley

Global Effects

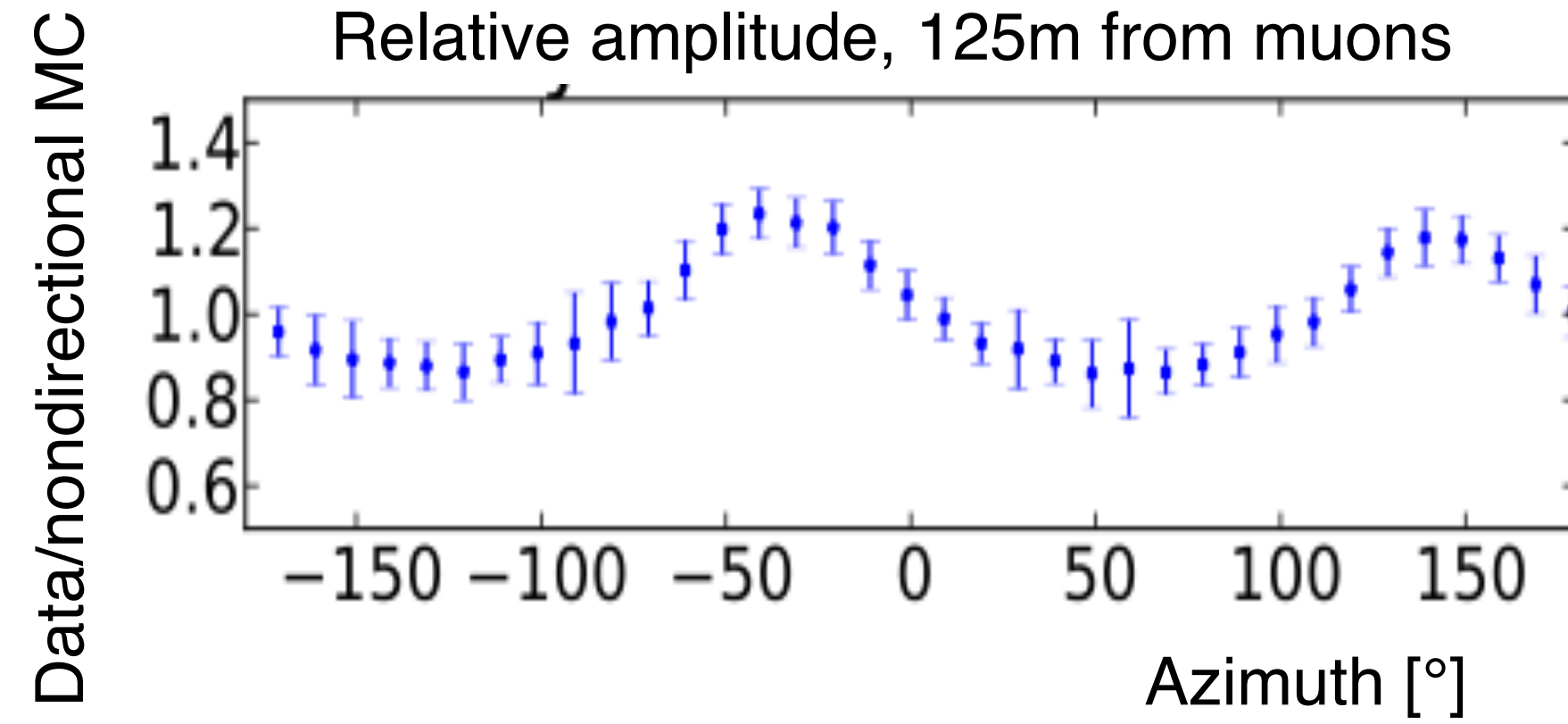
1. Vertical structure of ice parameters



Scattering (eff.): 20 – 50 m
Absorption: 100 – 200 m

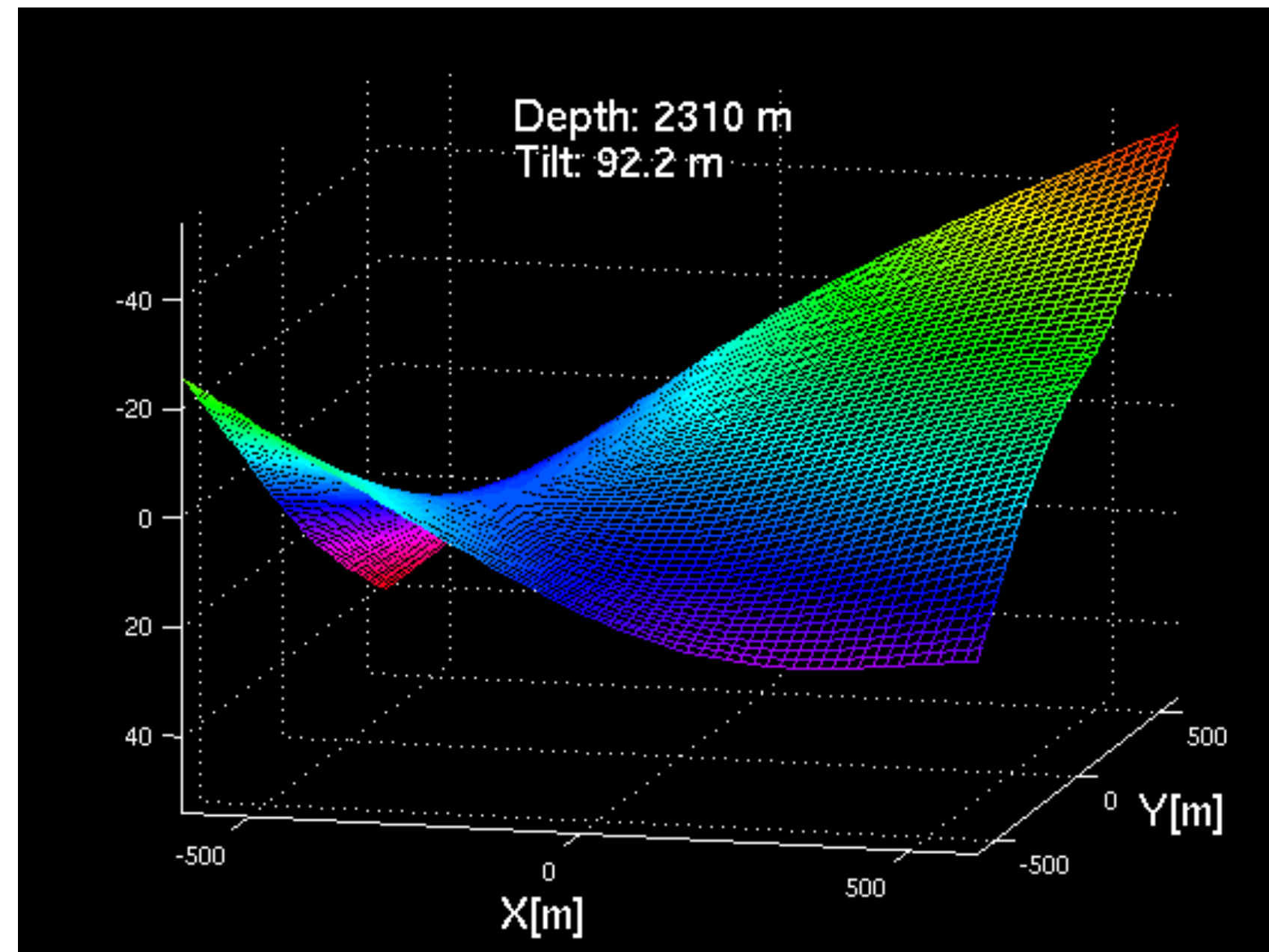
2. Azimuthal variation in of scattering

Less scattering in direction of ice flow:
→ up to ~10% /100m variation in amplitude

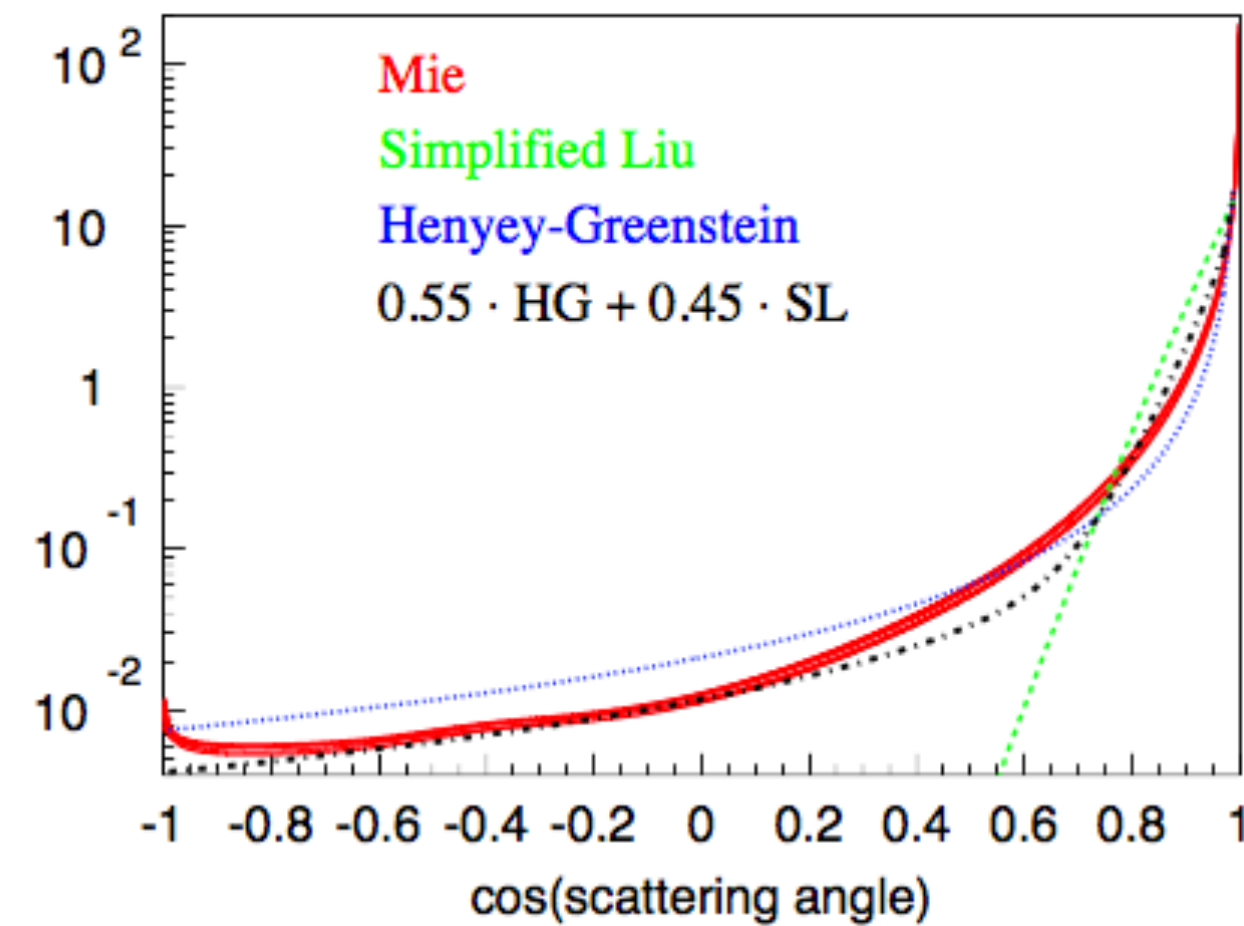


Microscopic explanation emerging.

3. Ice layers are tilted – not planar



3. Scattering function



Local Effects

1. Hole ice



2. Cable Shadow



3. DOM tilt



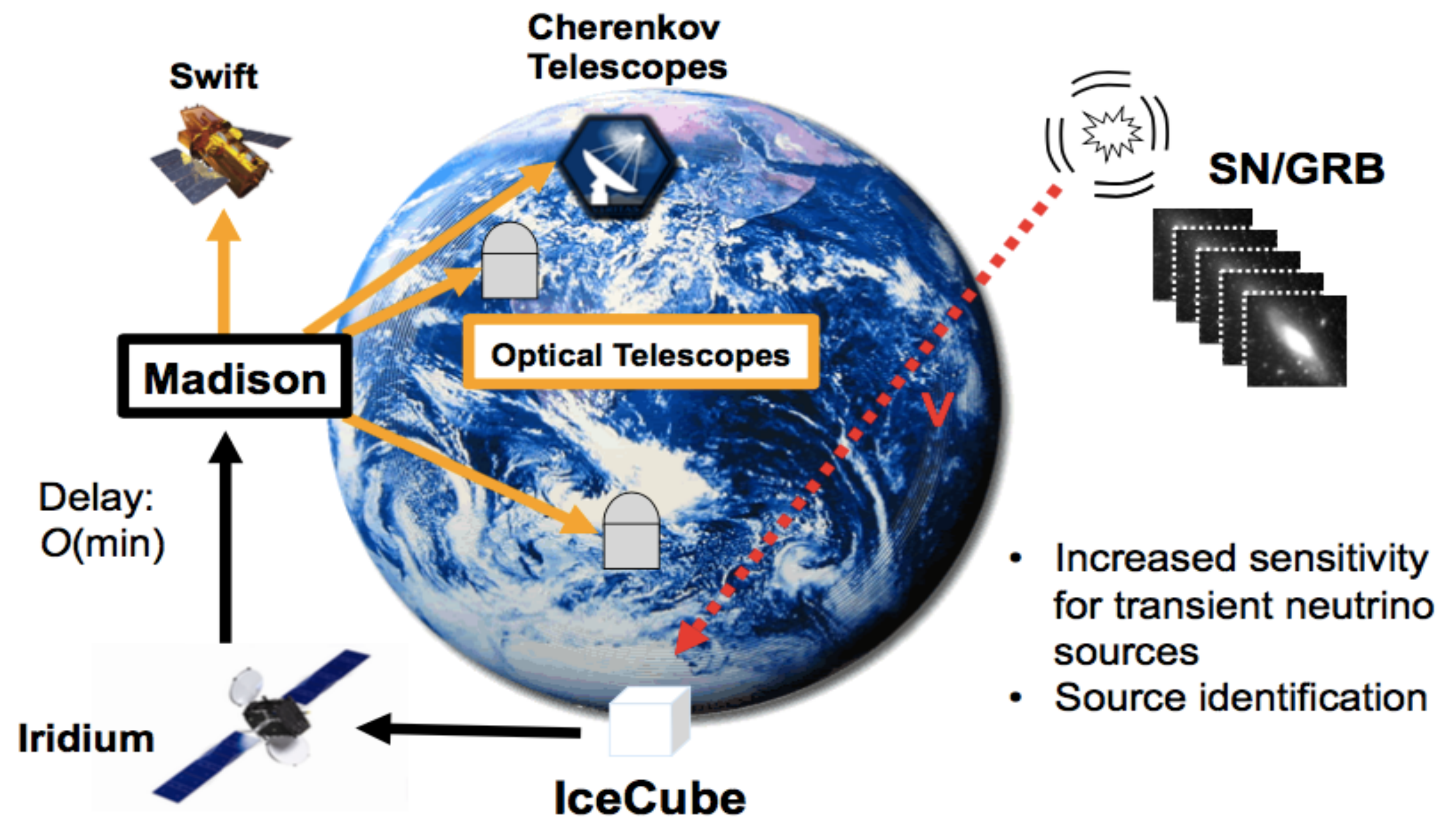
Multimessenger astronomy in real time - flares

Implementation of efficient realtime system online

Technical progress:
TXS alert published 43 seconds after interaction.

Continued development.

Real time Oversight
Committee manages
decisions and mechanisms.



ICNO software and computing

- It is a continued challenge to engage young scientists, graduate students and postdocs in software.
- Reason in part, because IceCube software has become more specialized.
- Analysis and simulation require more support from core staff
- Managed in IC Coordination Committee and technical working groups.

—> Talk by Benedikt Riedel

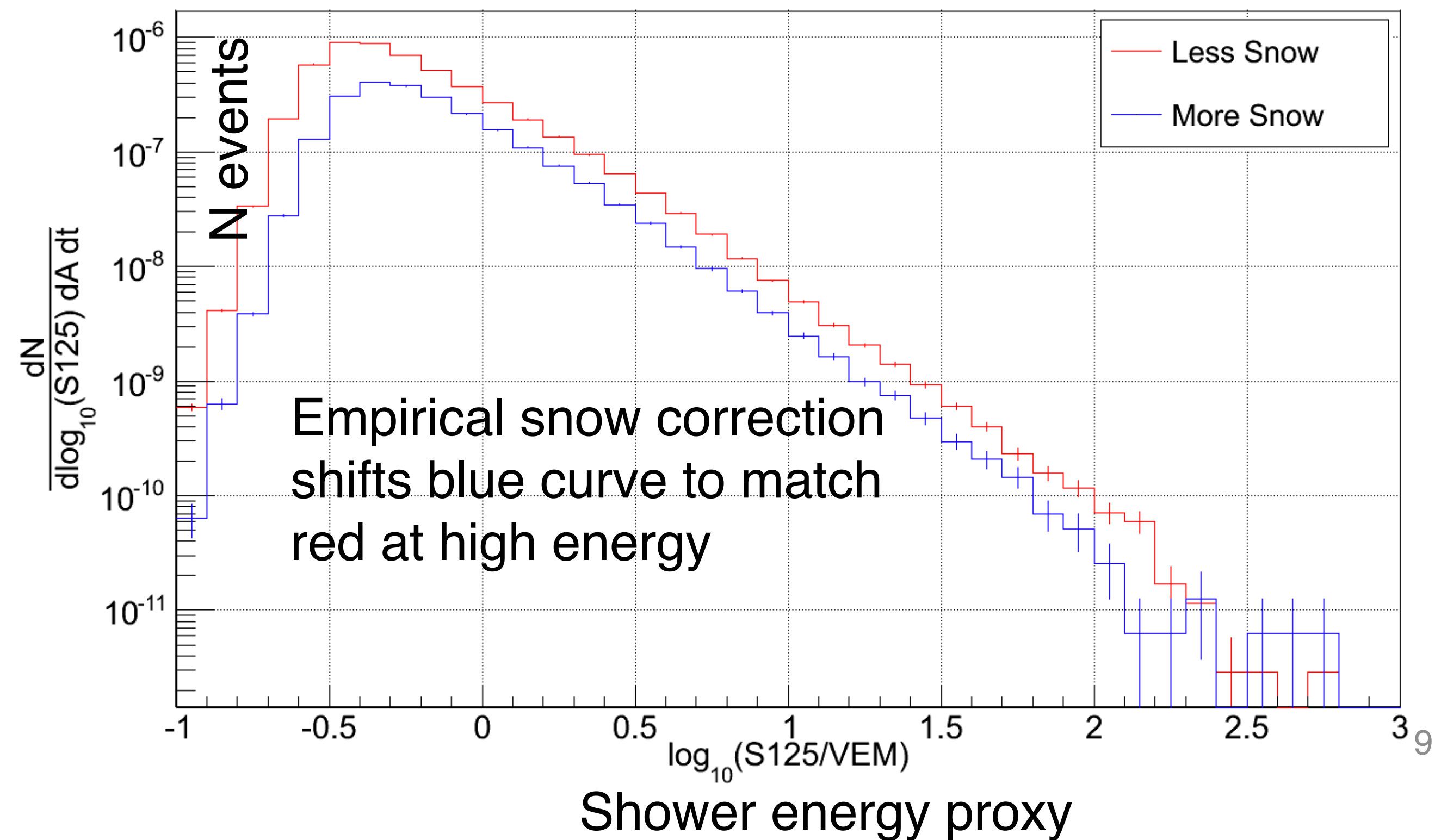
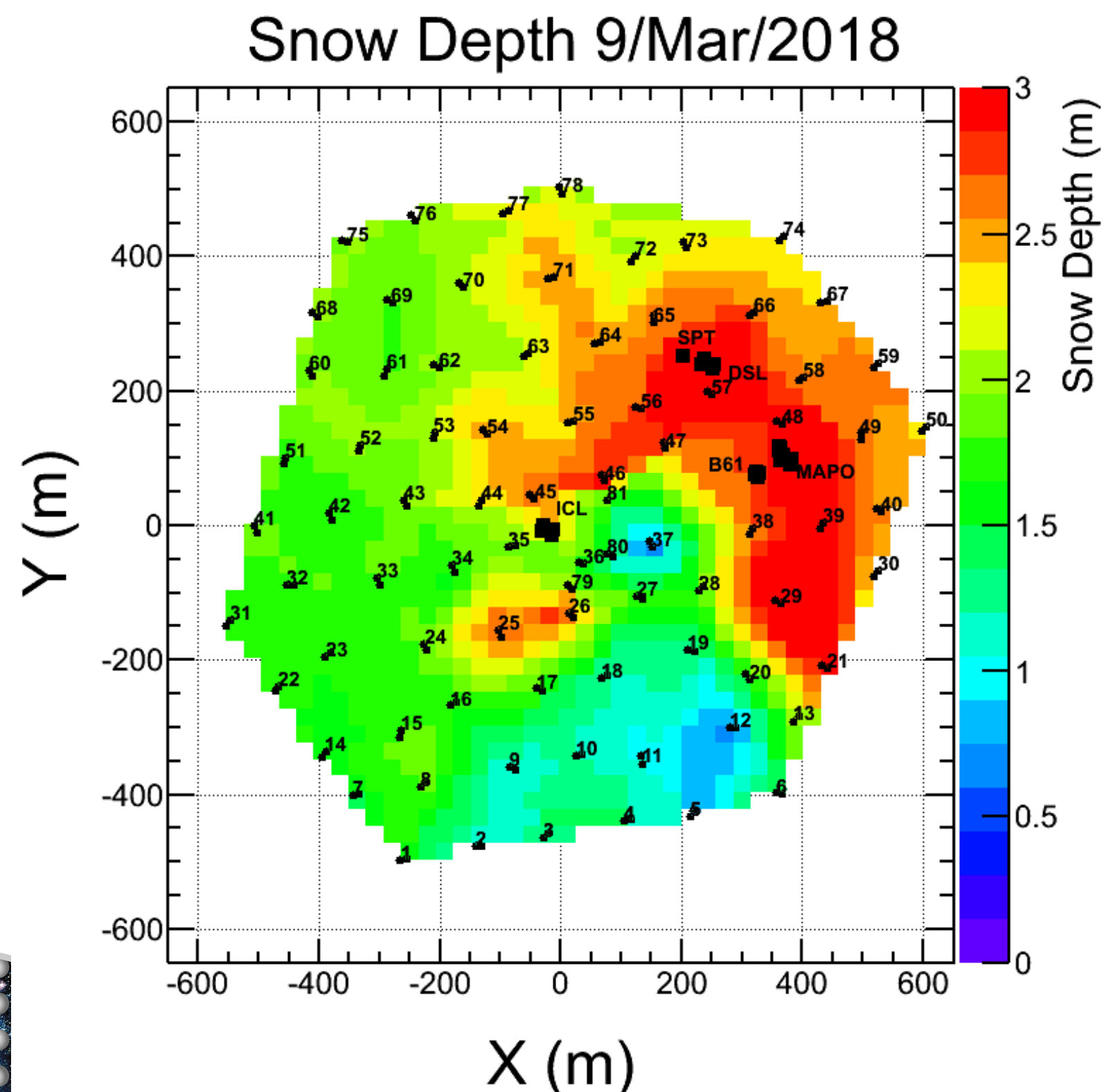
ICNO future plans

- R&D related to M&O and continued optimization of IceCube:
 - Surface instrumentation, scintillators and air shower radio
- As needed basic M&O support to ARA stations
- Prepare ICNO for integrating the Upgrade
- Provide design/interface support for IceCube-Gen2
 - Detector R&D, new optical modules

Snow depth of IceTop & effects on physics analysis

Snow accumulates on top of IceTop tanks at an average rate of 20 cm/year.

- >70% tanks are under 2 meters of snow or more.
- Sensitivity to low energy showers is reduced
- Uncertainty affects a number of physics analyses



Science case for scintillator deployment

Enhance IceCube's neutrino measurements:

- Better understanding of atmospheric backgrounds from cosmic rays.
- Improved calibration of in-ice detectors.
- More efficient veto of cosmic ray backgrounds - verification of crucial self veto method in energy range 10 to 100 TeV. The energy threshold at which the veto becomes efficient is estimated to be lower by a factor of two.

Cosmic Ray science

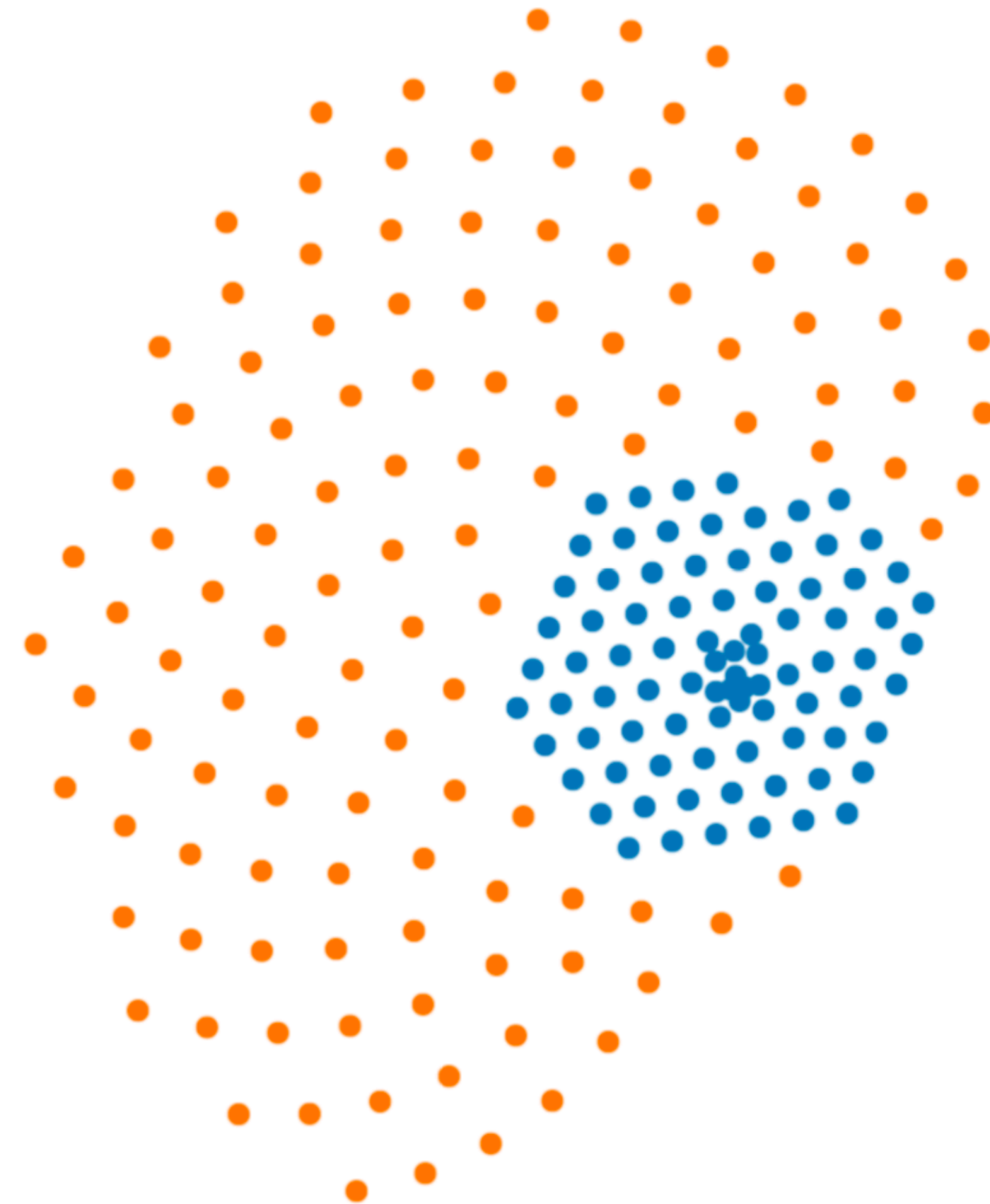
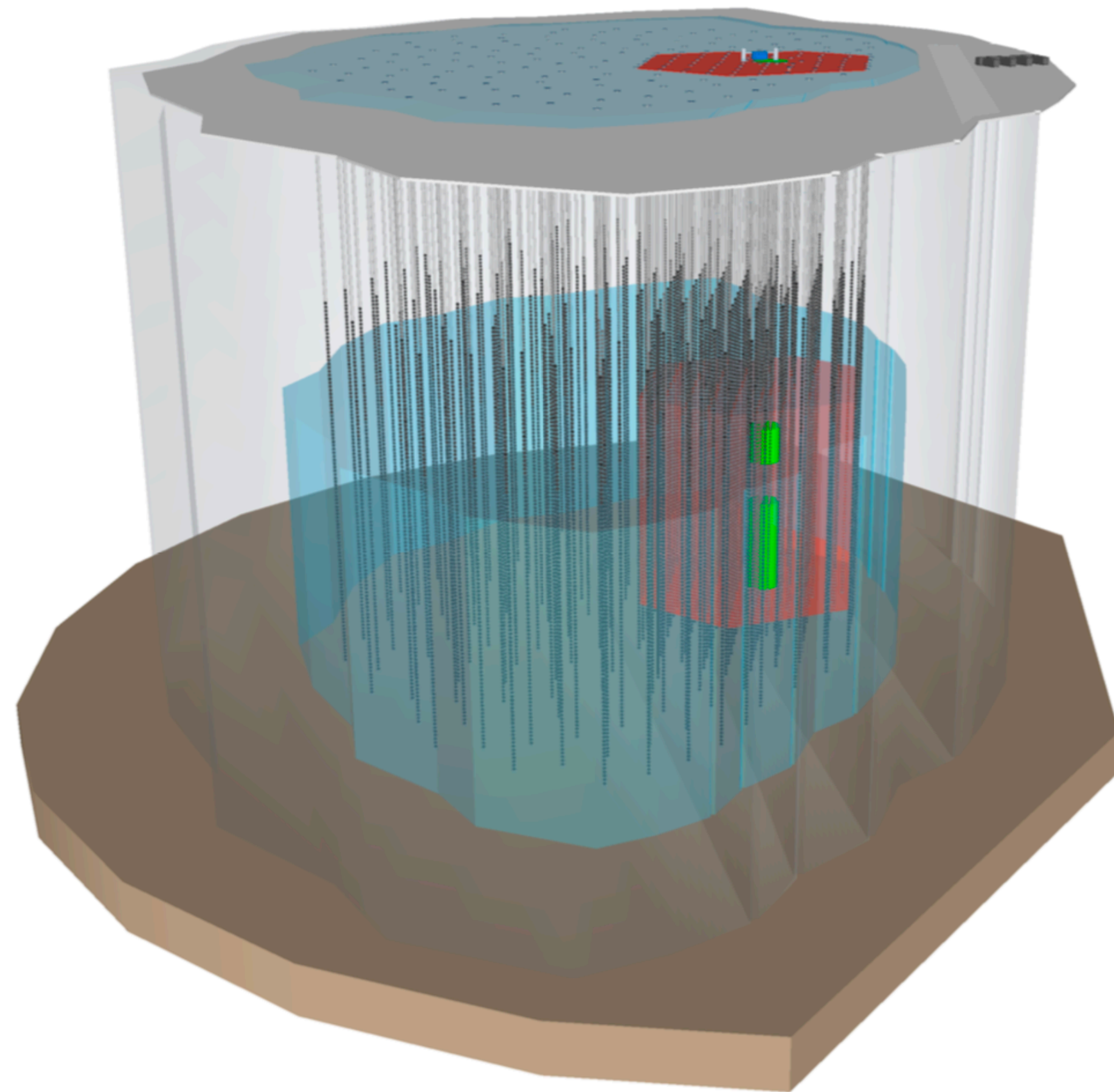
- More accurate measurements of the cosmic rays mass composition and energy spectrum above 1 PeV.

Other benefits: R&D for future detector upgrades

- A new, scalable precision timing and high-speed communications scheme for IceCube M&O and possible future projects.
- Efficient trenching procedures for instrumentation installation.
- Mechanical solutions to raise scintillator panels above the snow during the period of array deployment.

IceCube-Gen2

A Vision for the Future of Neutrino Astronomy in Antarctica (arXiv:1412.5106)



Artist's conception
120 strings at 240 m spacing

Optical sensors

IceCube Upgrade (under construction) primary sensors

IceCube DOM



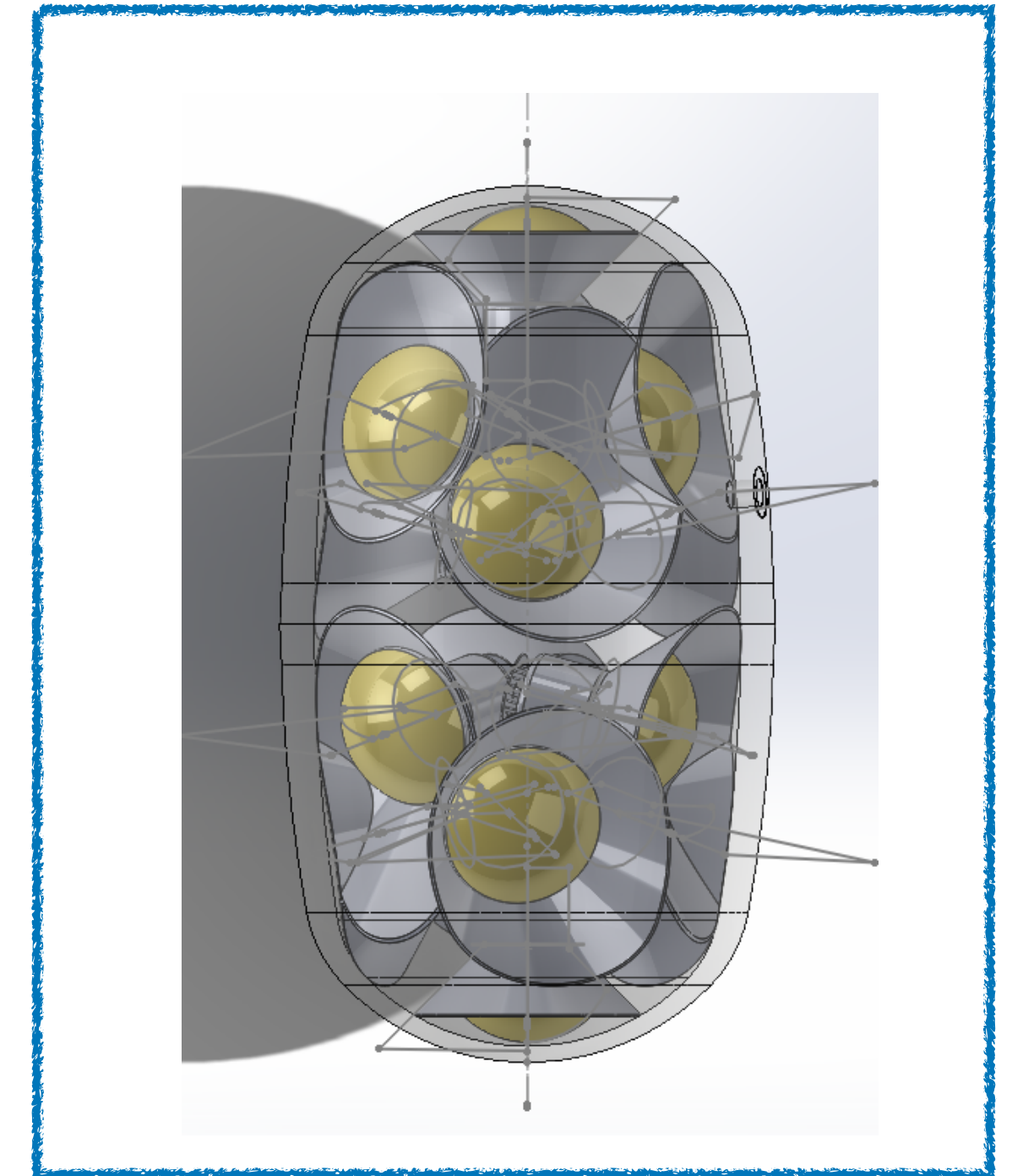
Diameter 33 cm
10 inch PMT



Directional information
24 x 3 inch PMT
Diameter 36 cm

2 x 8 inch PMT
Smaller diameter 30 cm

Gen2 sensor design studies: MDOM with smaller diameter.

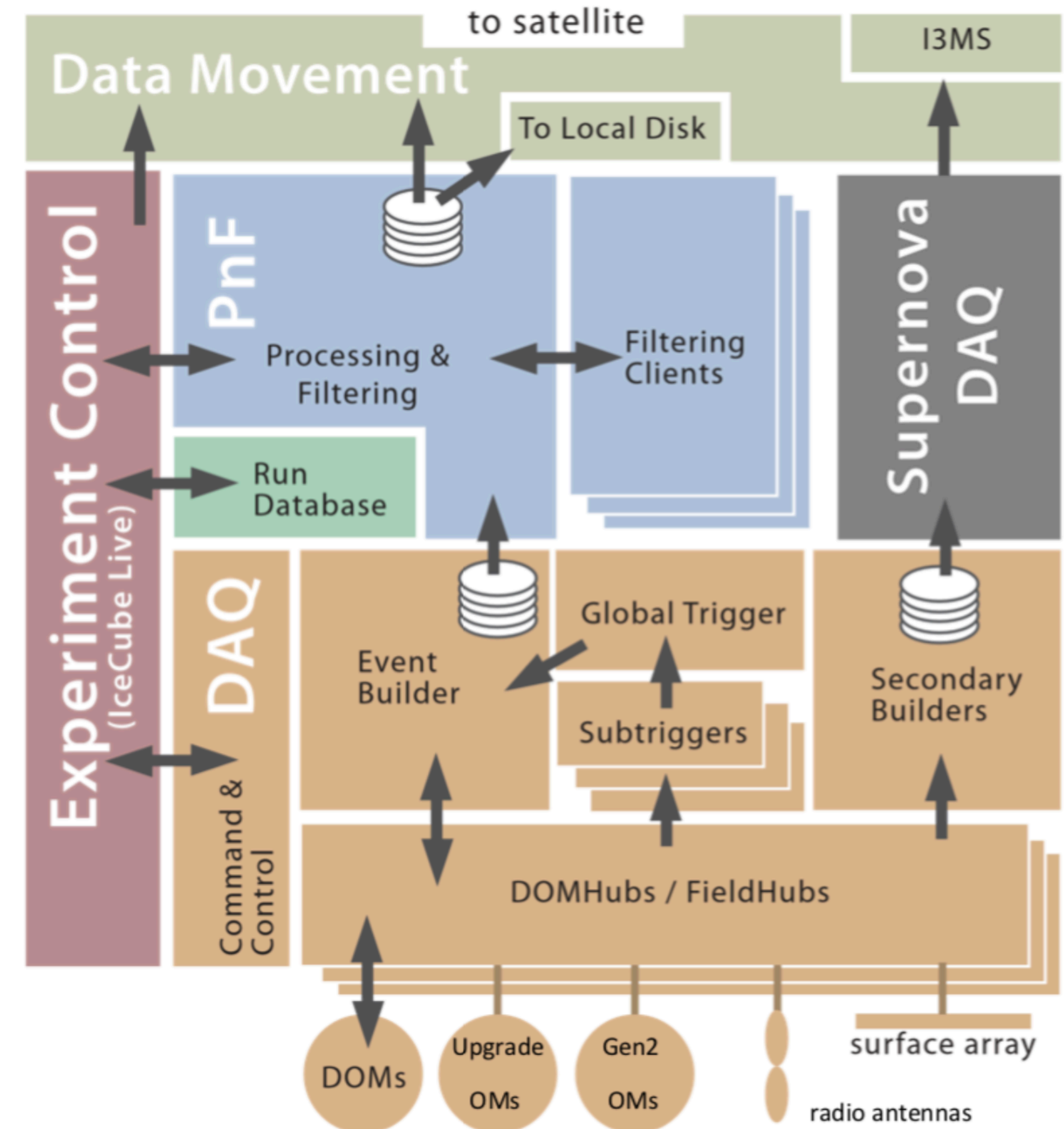


12 x 4 inch PMT
Smaller diameter 30 cm

IceCube(-Gen2) integration

IceCube will be an integral part of Gen2.

- This is possible for two reasons:
- IceCube is highly reliable: lost only a few sensors in the last 5 years.
- The fully digital architecture of IceCube allows integrating new strings/Gen2 into the system with only moderate adjustments.
- For comparison: AMANDA was turned off due to high burden of maintenance and operation, and challenges of integration.

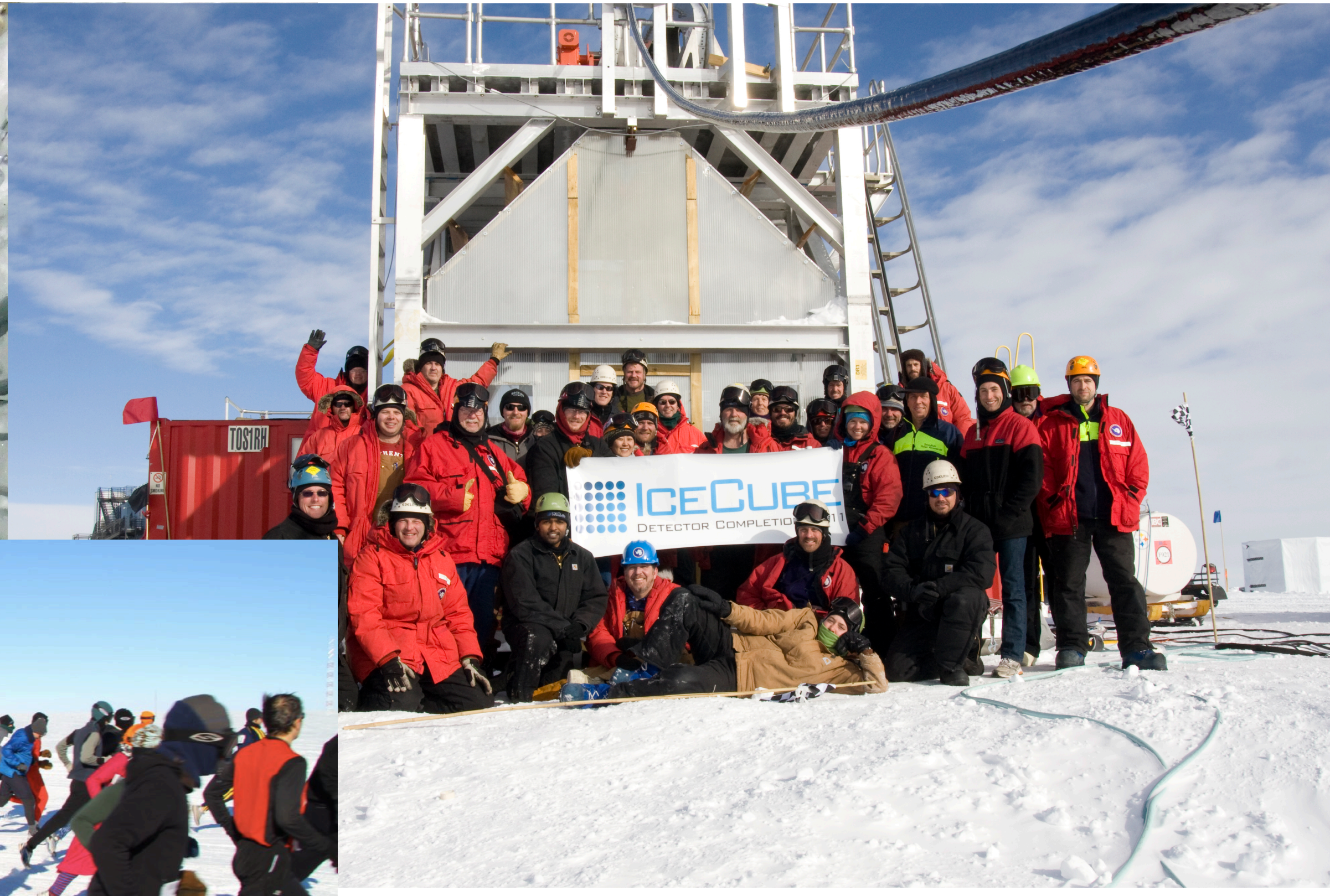
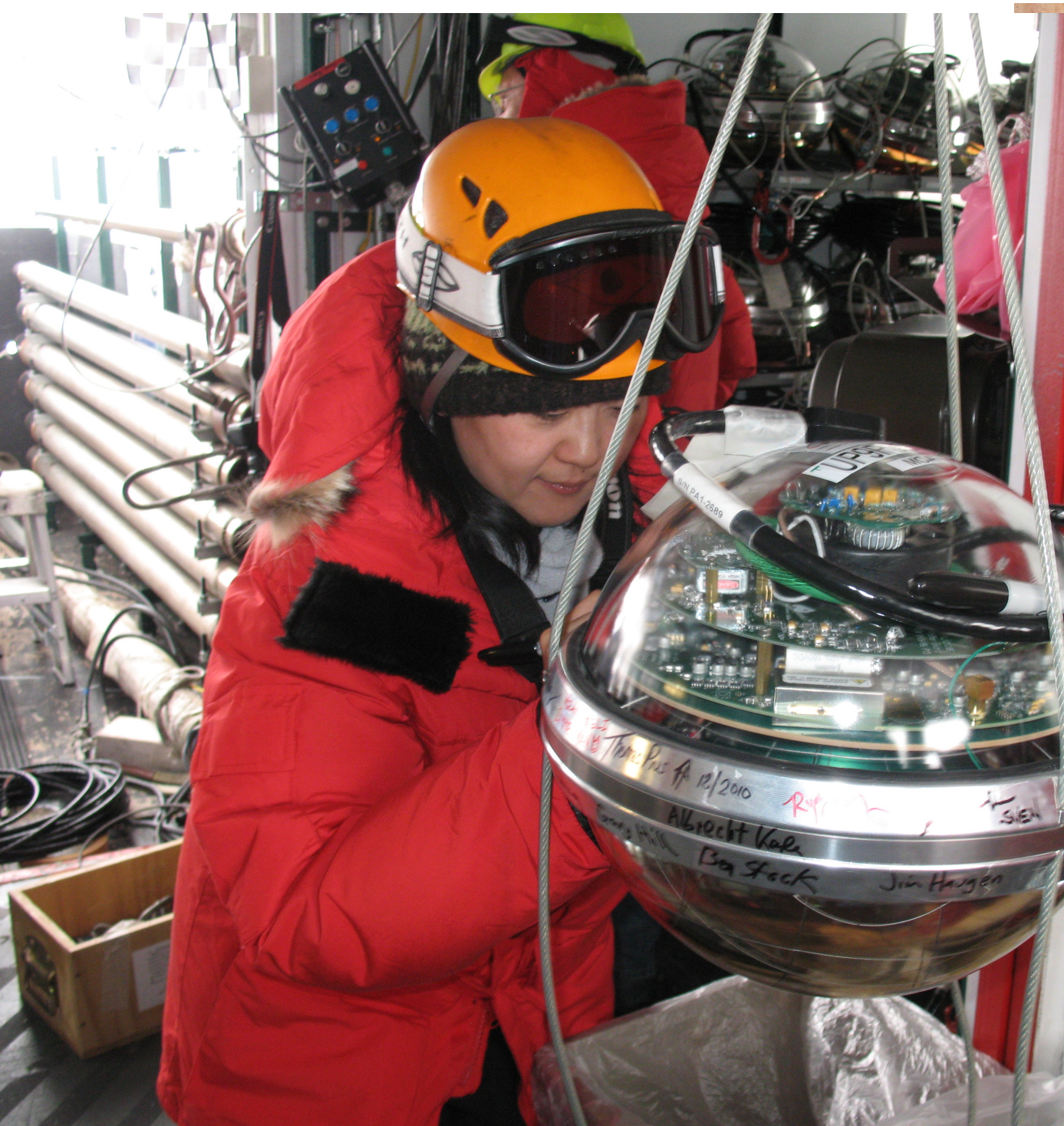


Take away messages

- IceCube continues to evolve through improvements in understanding of ice, sensors and backgrounds that far exceed those anticipated in 2004.
- This knowledge results in improvements in performance.
- Systematic errors at all levels are increasingly important and vigorous efforts are underway to reduce them.
- Maintenance and R&D efforts such as surface instrumentation will produce useful information.
- Detector R&D, sensor development, interface support is also happening to support the IceCube upgrade and maintain the ICNO facility as a support infrastructure for the future.

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Thank you!