Technical Issues and Future Plans

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IceCube Management and Operations
NSF Site Visit March 16, 2020

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SOUTH POLE NEUTRINO OBSERVATORY

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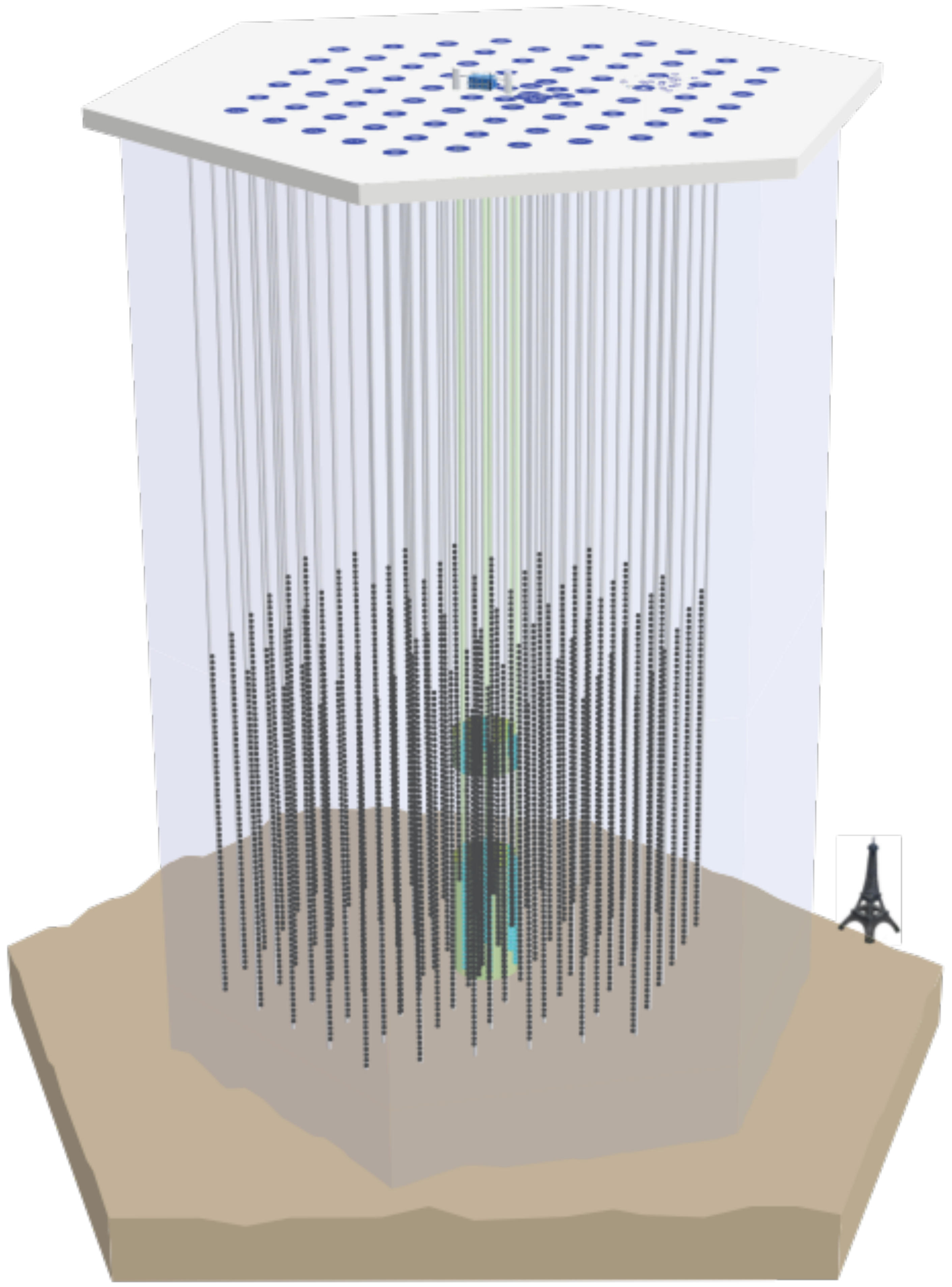
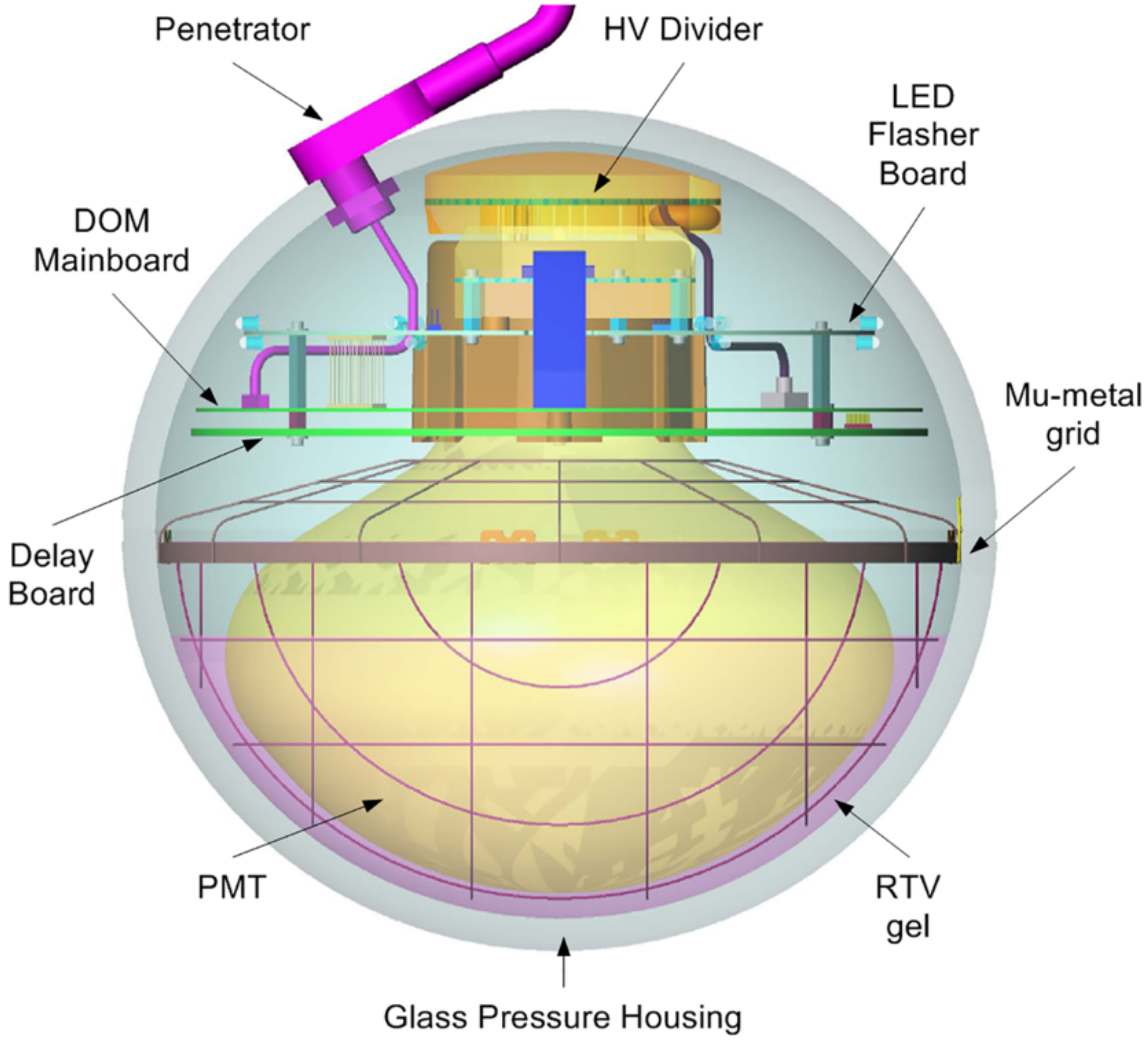


IceTop (surface array): 81 stations

IceCube: 86 strings
5160 optical sensors

Highly stable operation.

Since 2016: livetime > 99.5%



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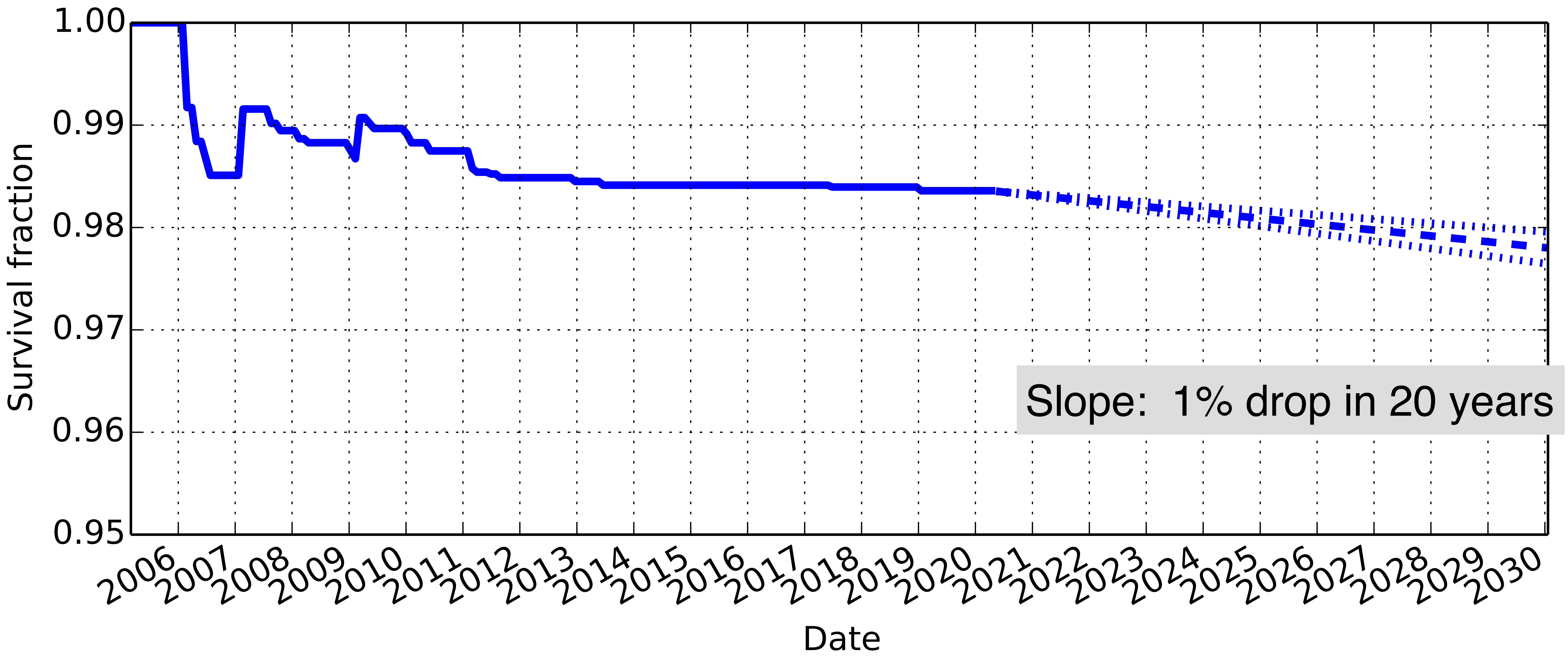
DOM reliability and detector uptime

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

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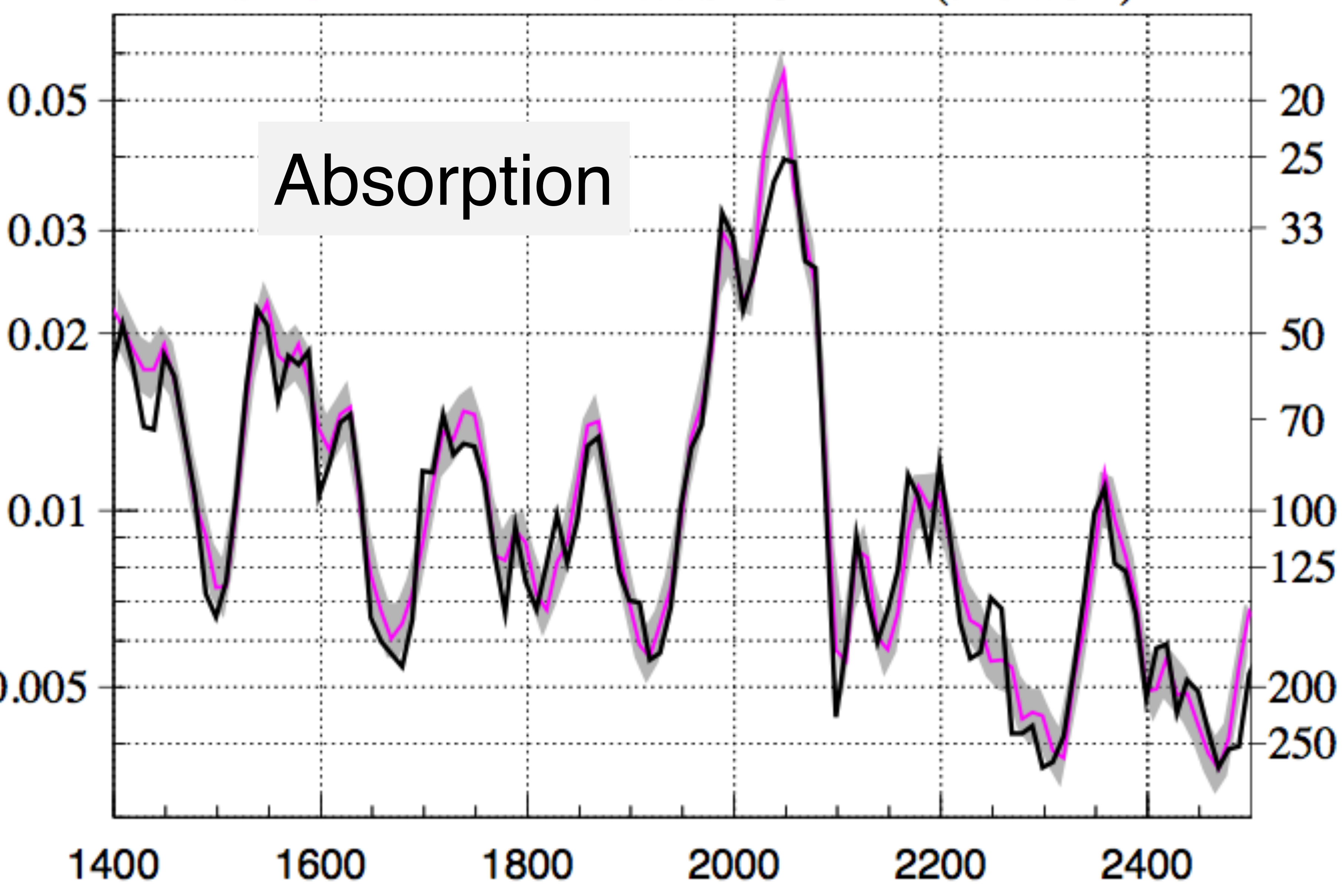
Ice: Global Effects

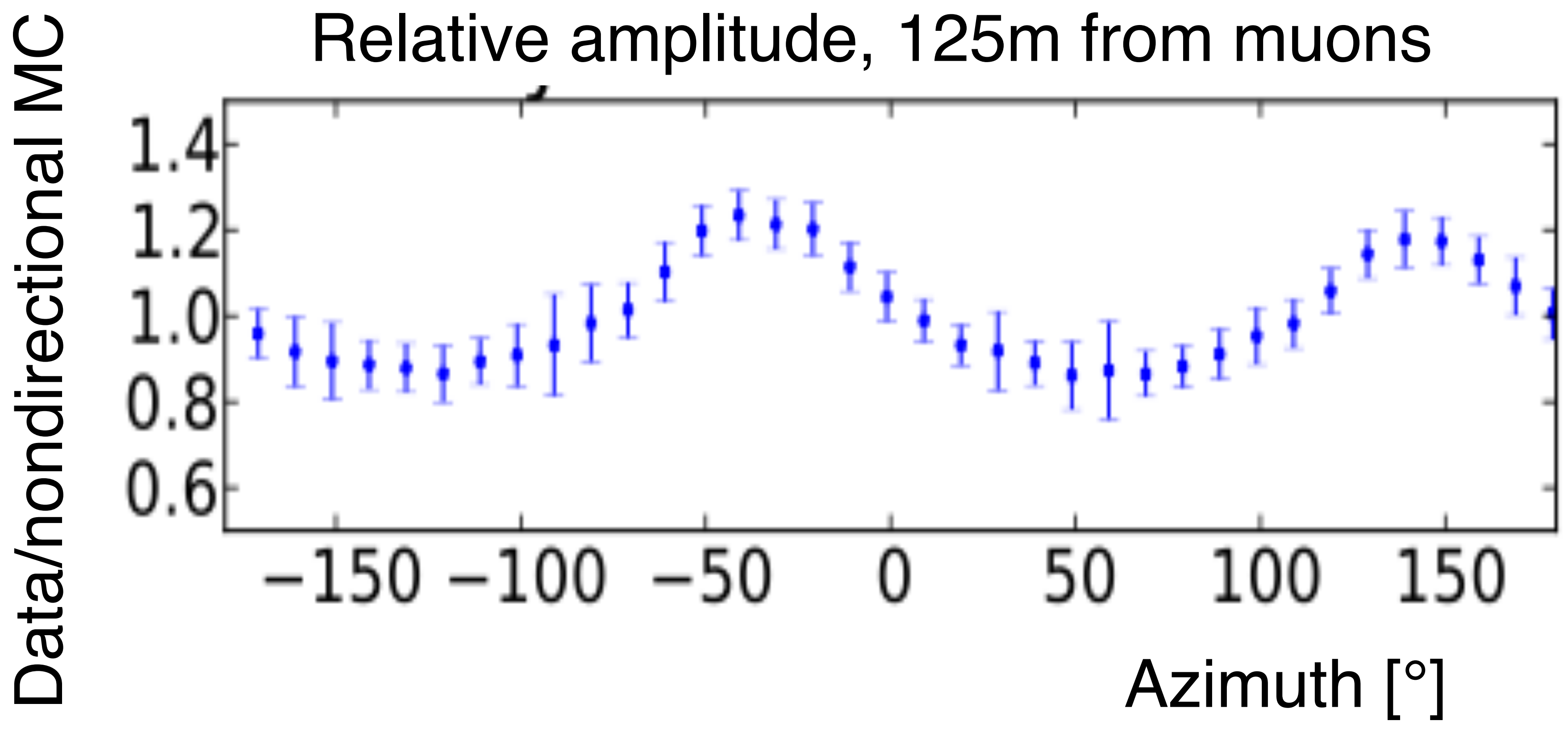
1. Vertical structure of ice parameters



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

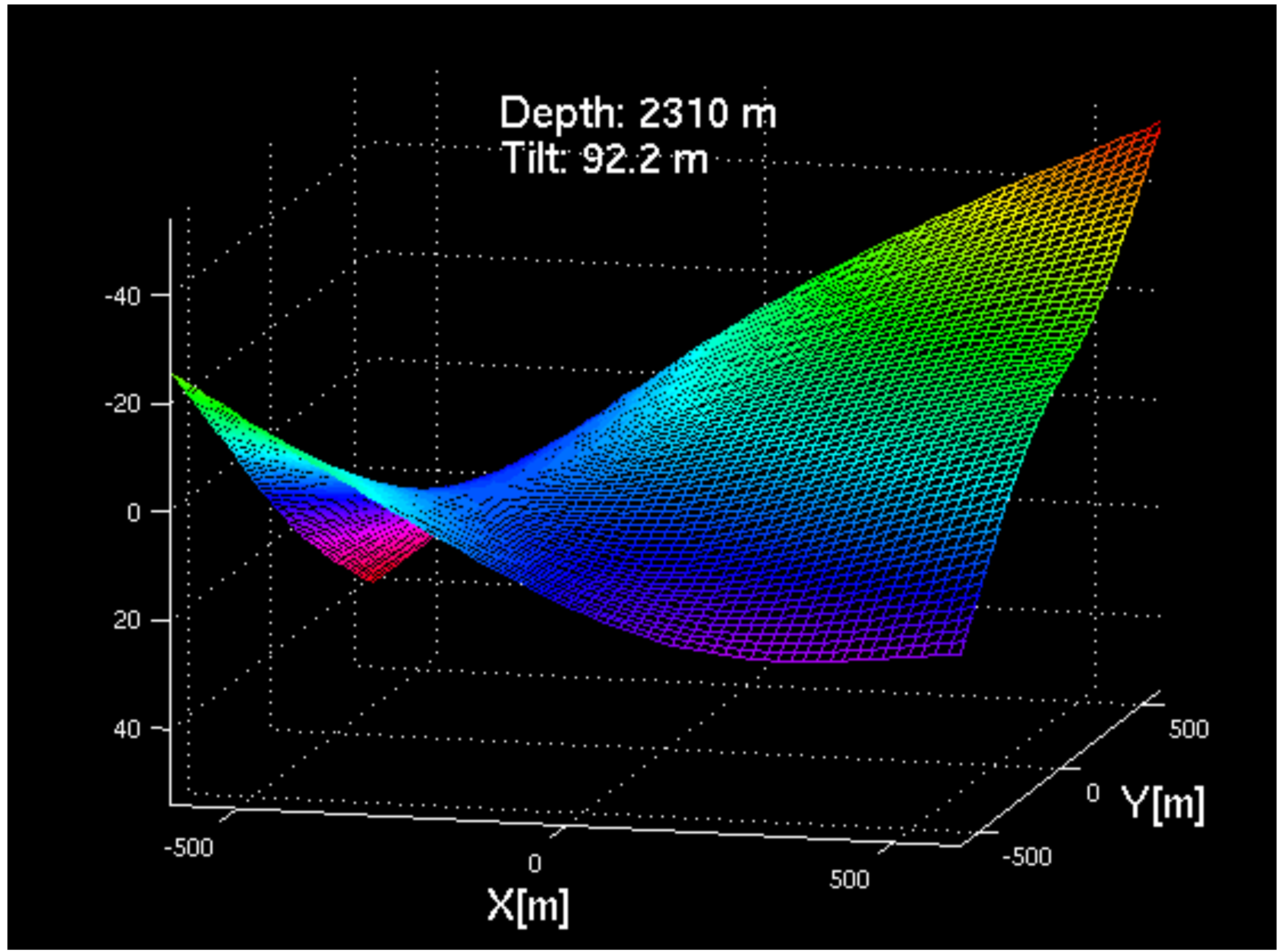
2. Azimuthal variation in of scattering

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

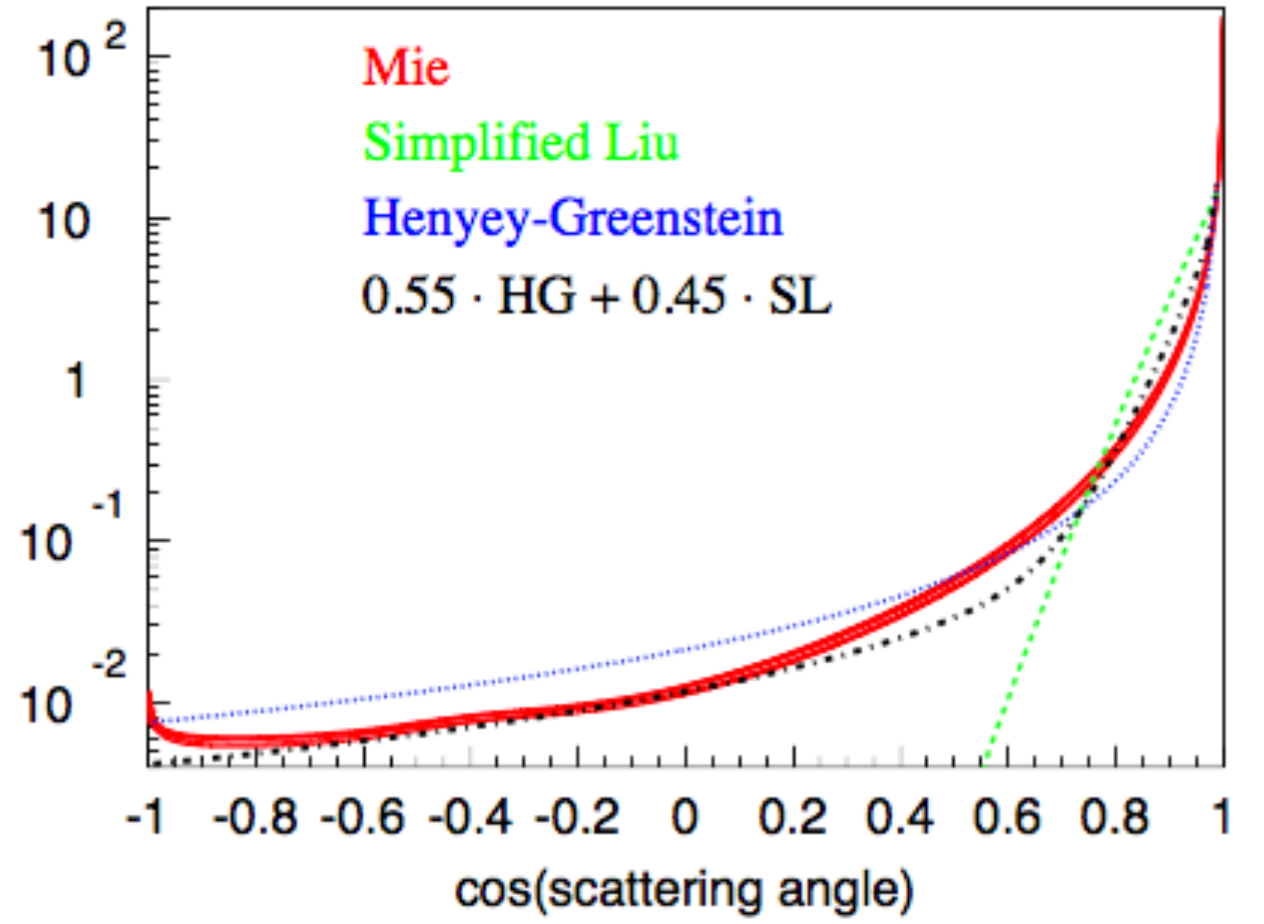


Microscopic explanation emerging.

3. Ice layers are tilted – not planar



3. Scattering function



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Ice: Local Effects

1. Hole ice

2. Cable Shadow

3. DOM tilt

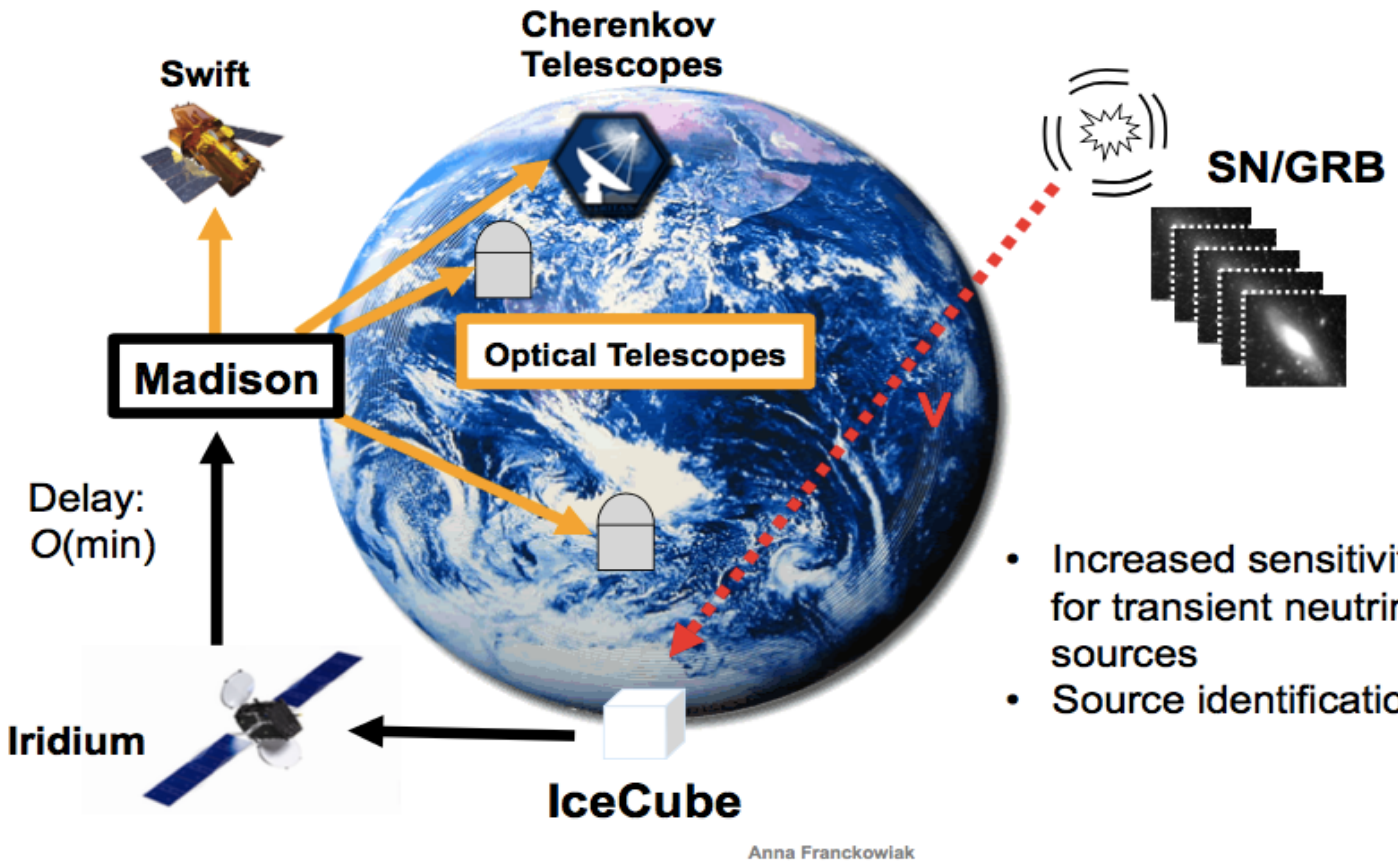
—> Talk by Summer Blot

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.



- Increased sensitivity for transient neutrino sources
- Source identification

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ICNO software and computing

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

—> Talk by Benedikt Riedel

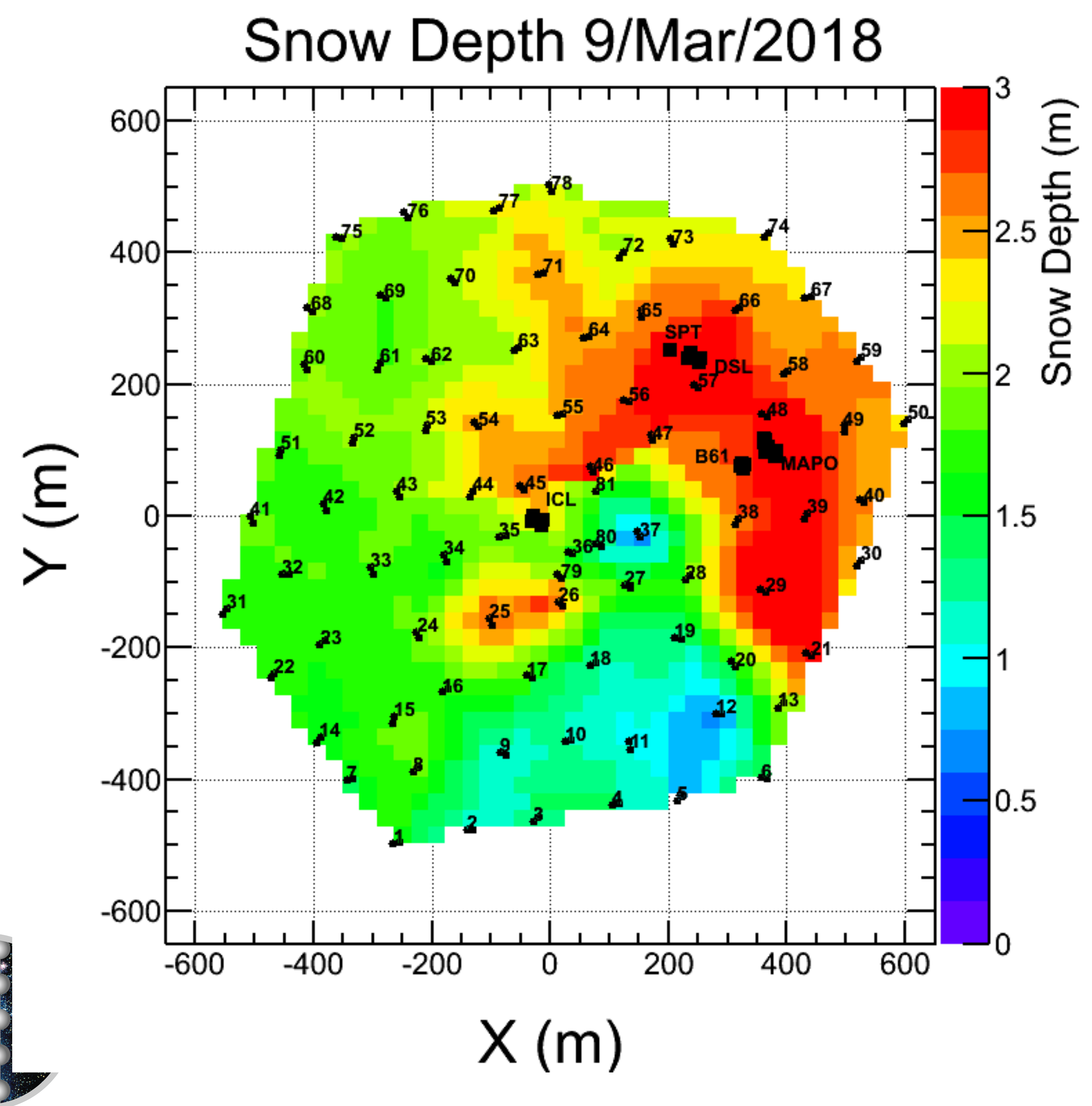
Snow depth of IceTop & effects on physics analysis

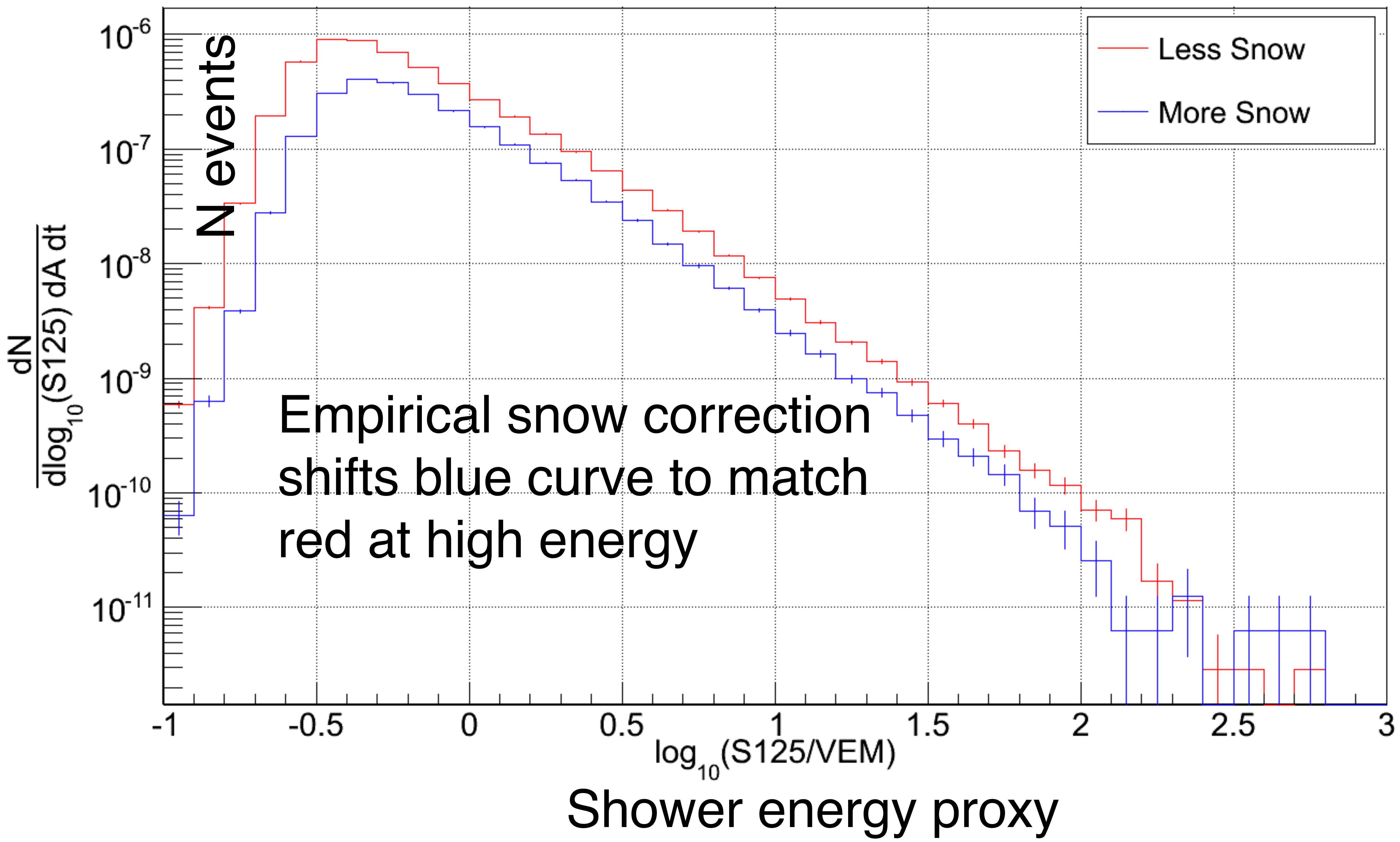
Snow accumulates on top of IceTop tanks at an average rate of 20 cm/year.

- >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.

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Technical implementation: —> talk by John Kelley

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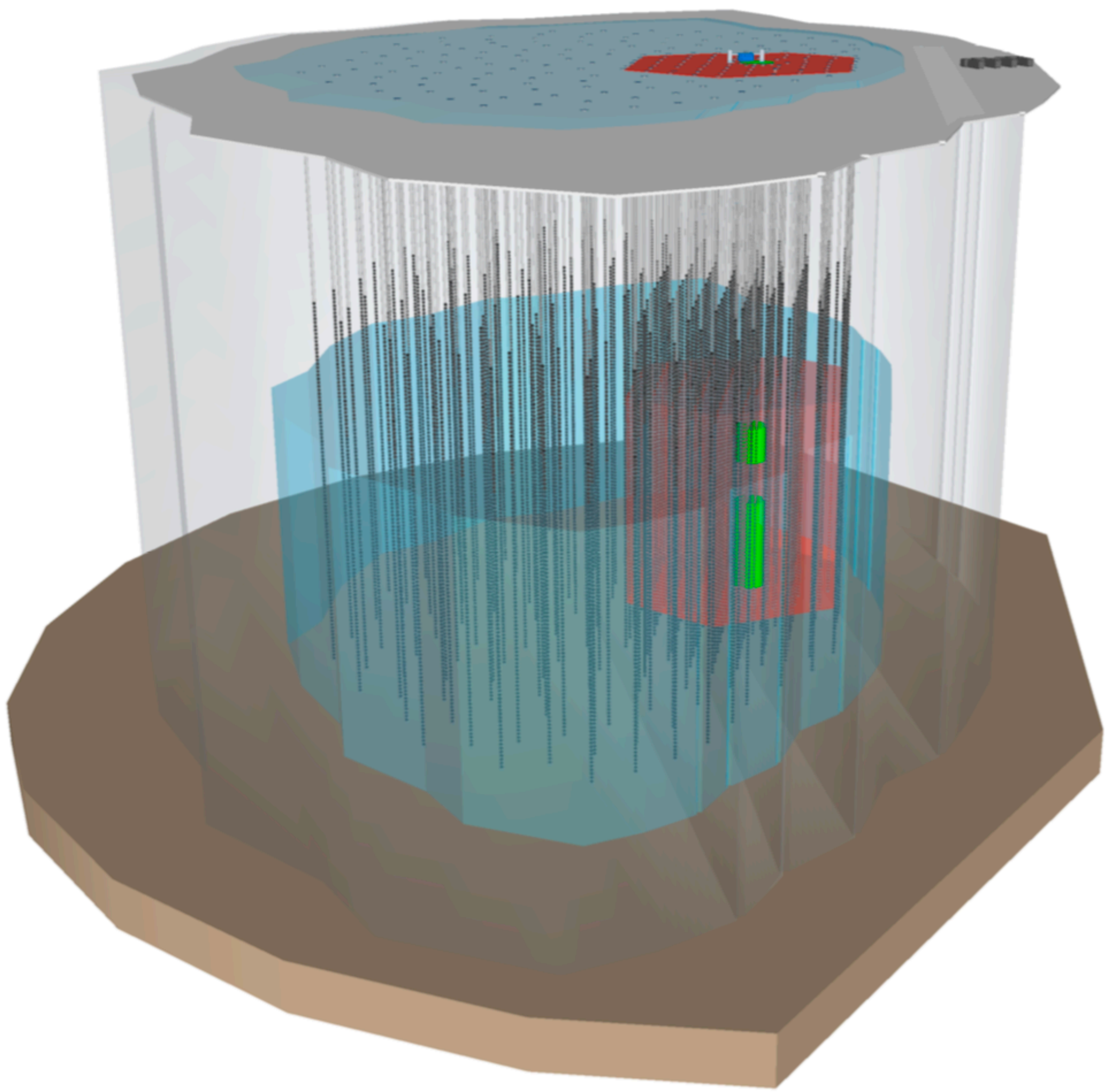
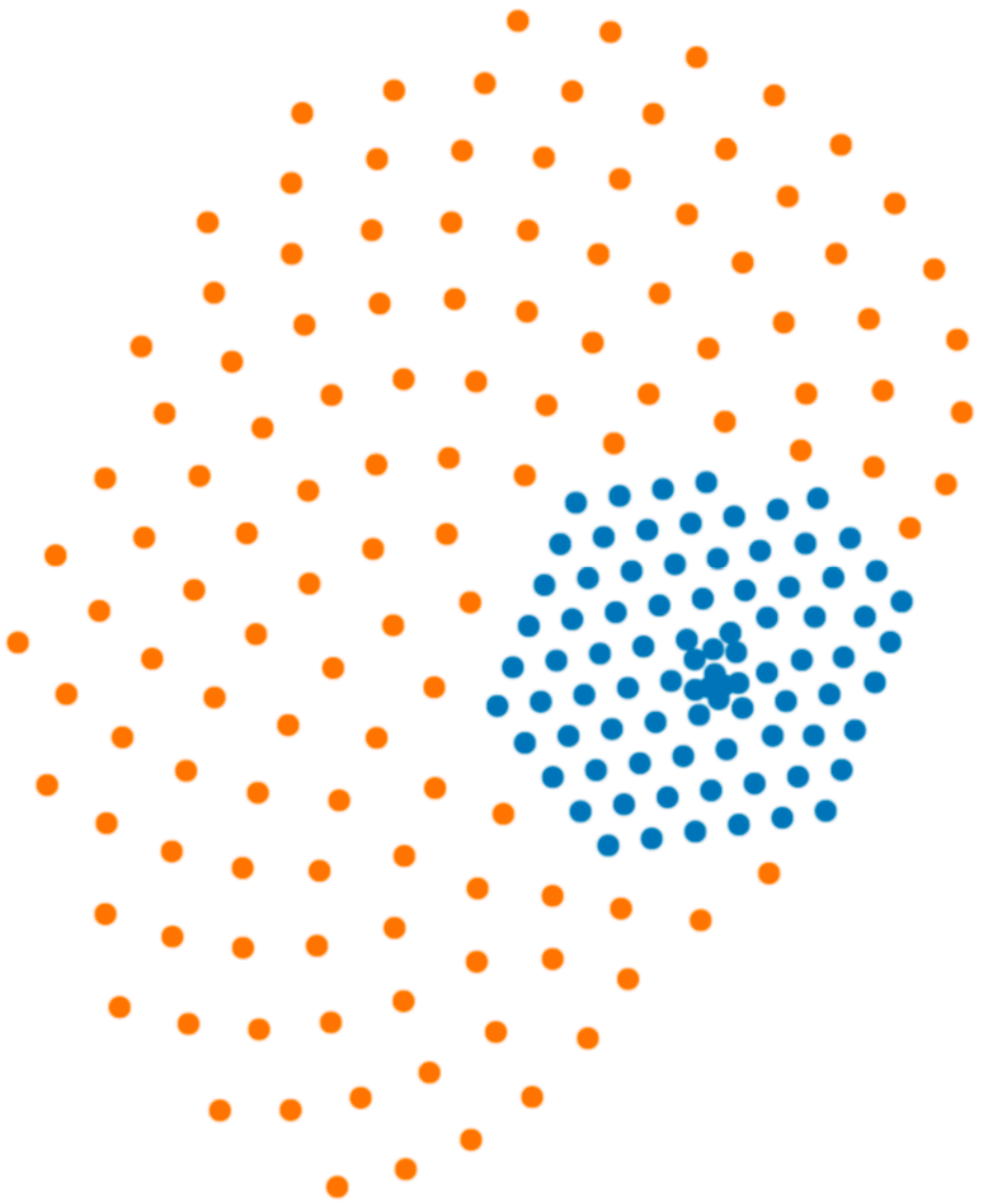
IceCube-Gen2

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





Artist's conception
120 strings at 240 m spacing

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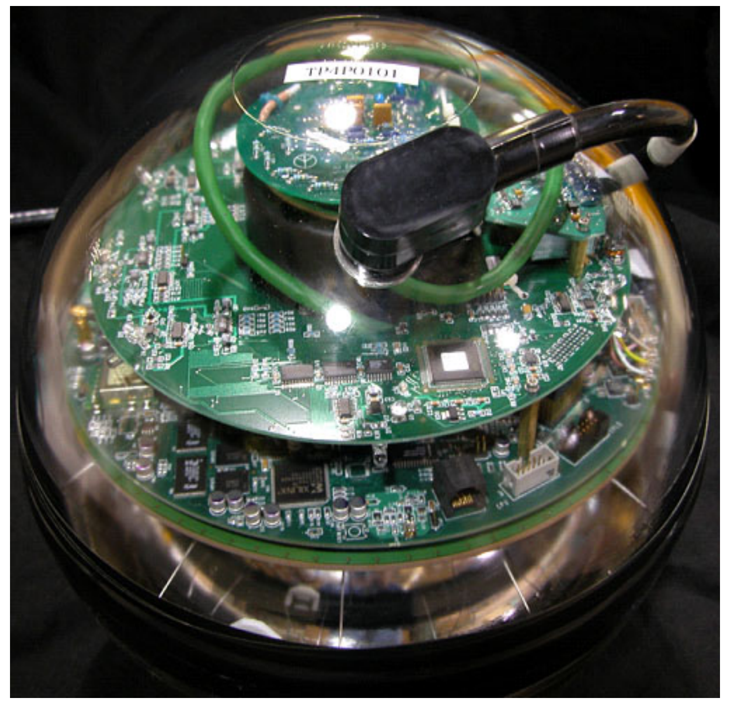
The next-generation IceCube: from discovery to astronomy

Optical sensors

IceCube DOM



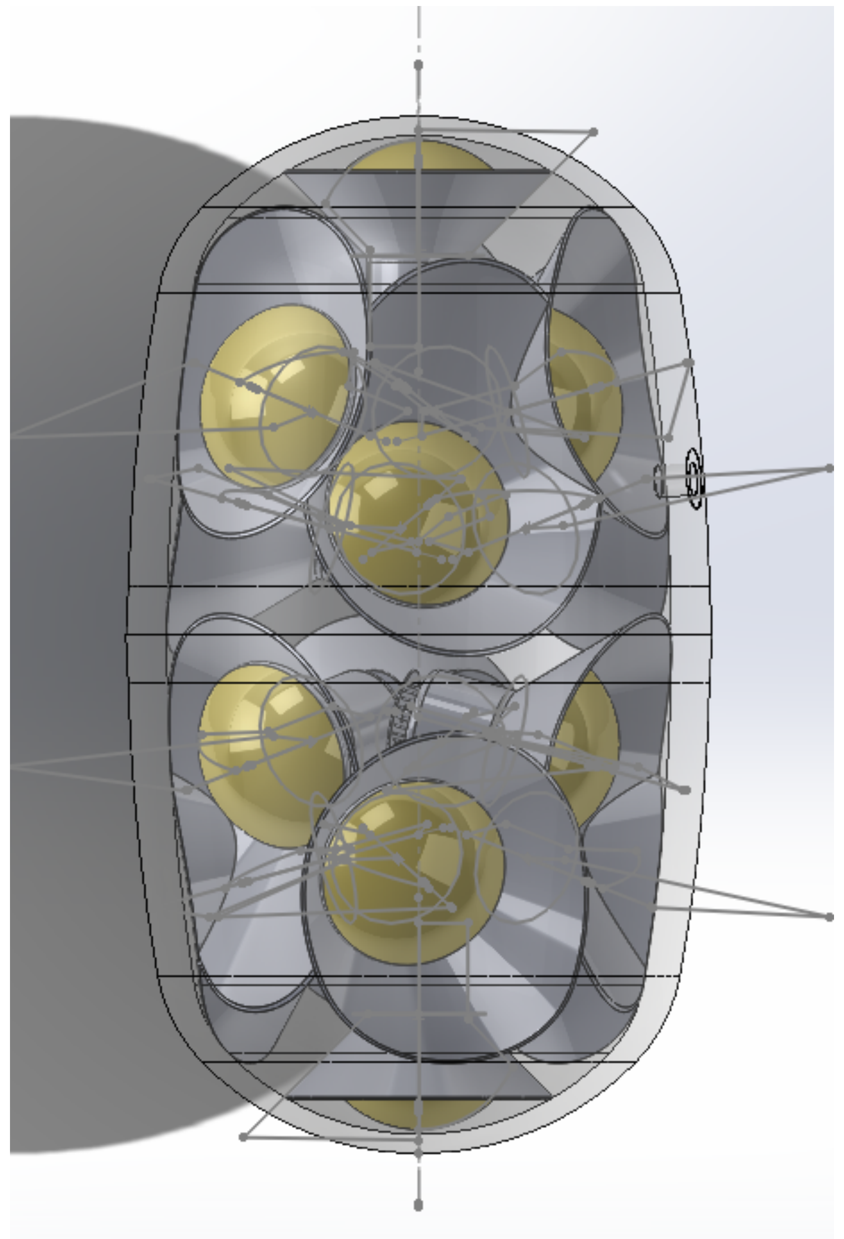
Diameter 33 cm
10 inch PMT

IceCube Upgrade (under construction) primary sensors

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.

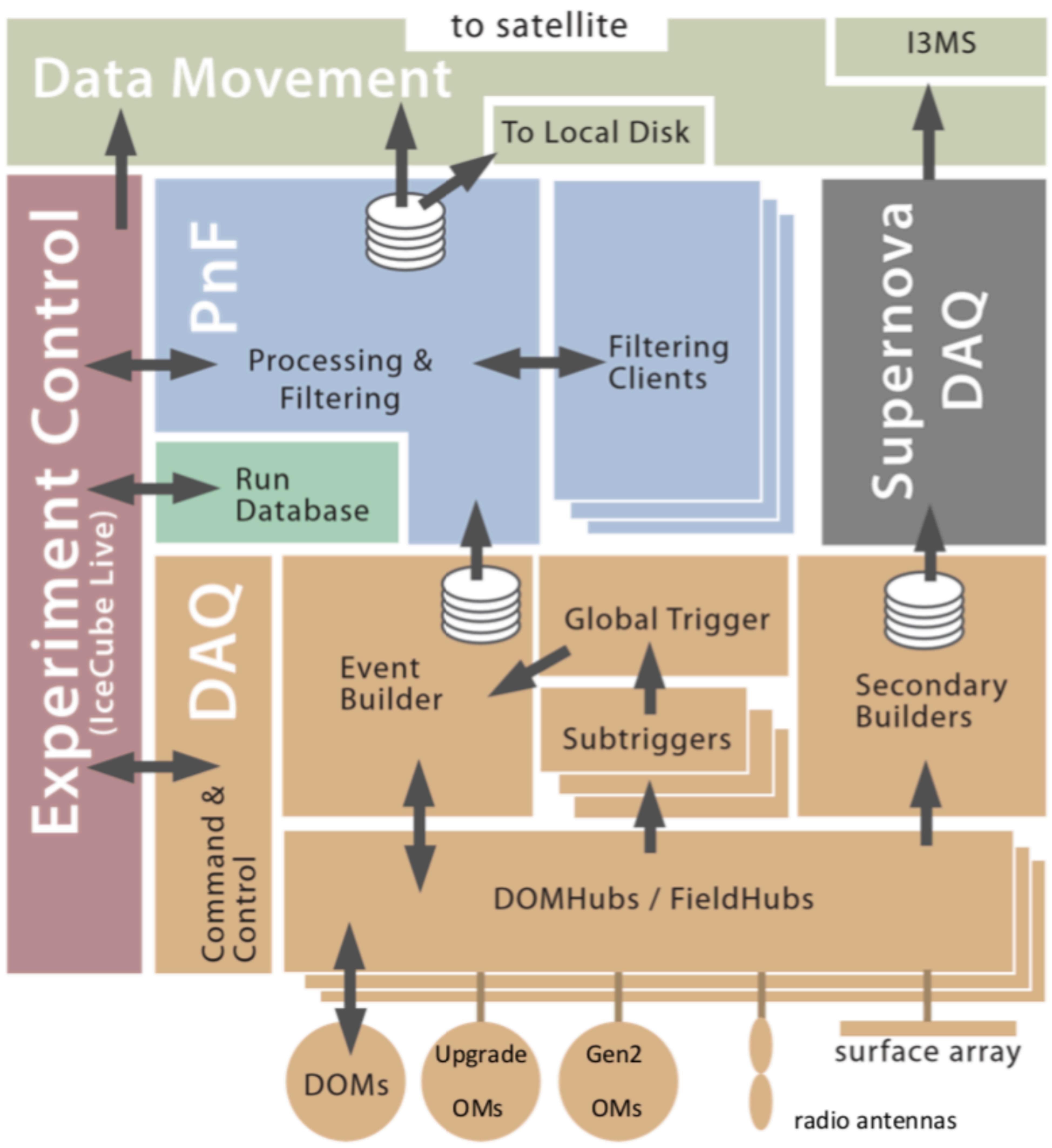


12 x 4 inch PMT
Smaller diameter 30 cm

IceCube(-Gen2) integration

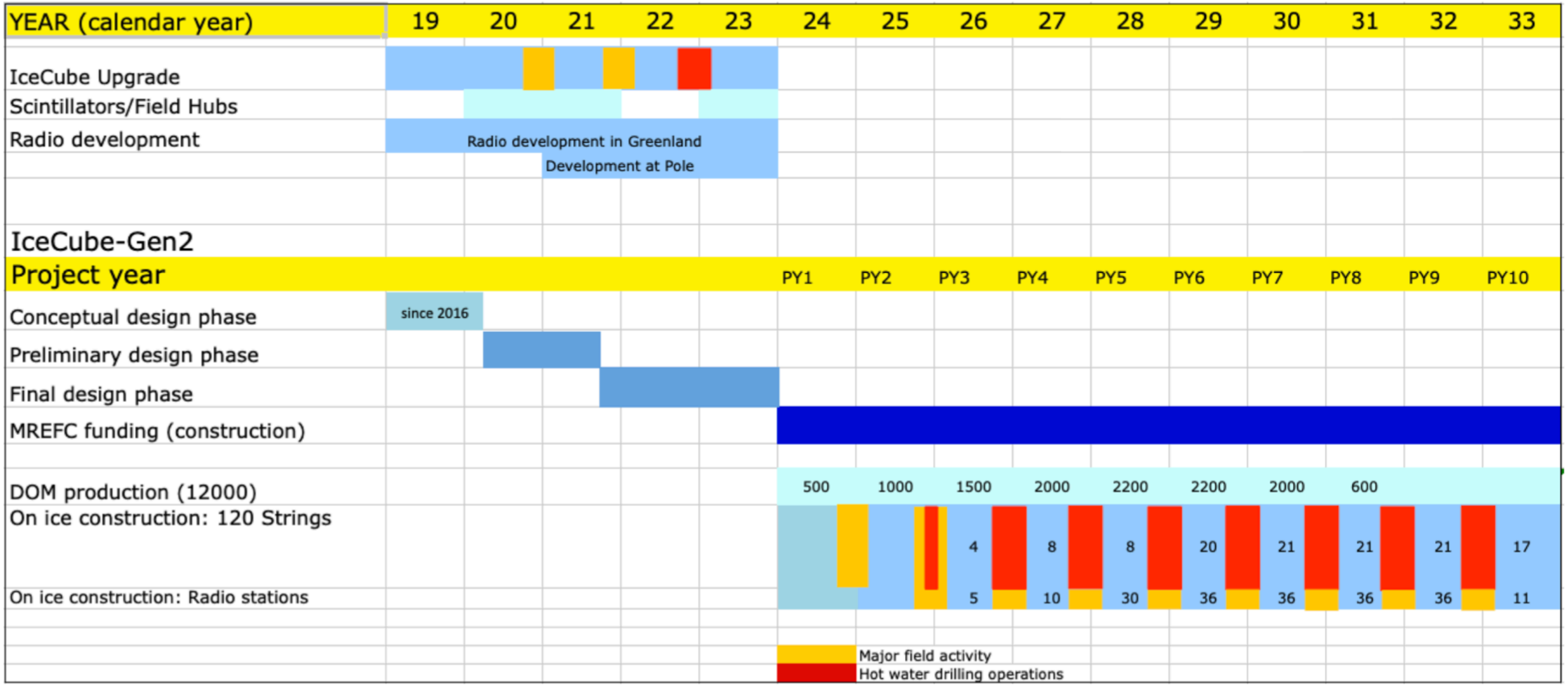
IceCube will be an integral part of Gen2.

- 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.



Timeline

Significant changes to prepare for.



ICNO future tasks and plans

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

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.

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.
- Over the past decade many new tasks and functions were added, eg.: DeepCore, direct simulation, Realtime, Calibration and Ice, scintillators and CR radio, ARA adoption.
- Maintenance and R&D efforts such as surface instrumentation will produce useful information.
- Detector R&D, sensor development, interface support for IceCube upgrade and to maintain the ICNO facility as a support infrastructure for the future, preparing for a possible Gen2.
- To complete all these tasks puts pressure on the scientists and developers, difficult to handle.

Thank you!