Technical progress

- detector performance, challenges, interfaces

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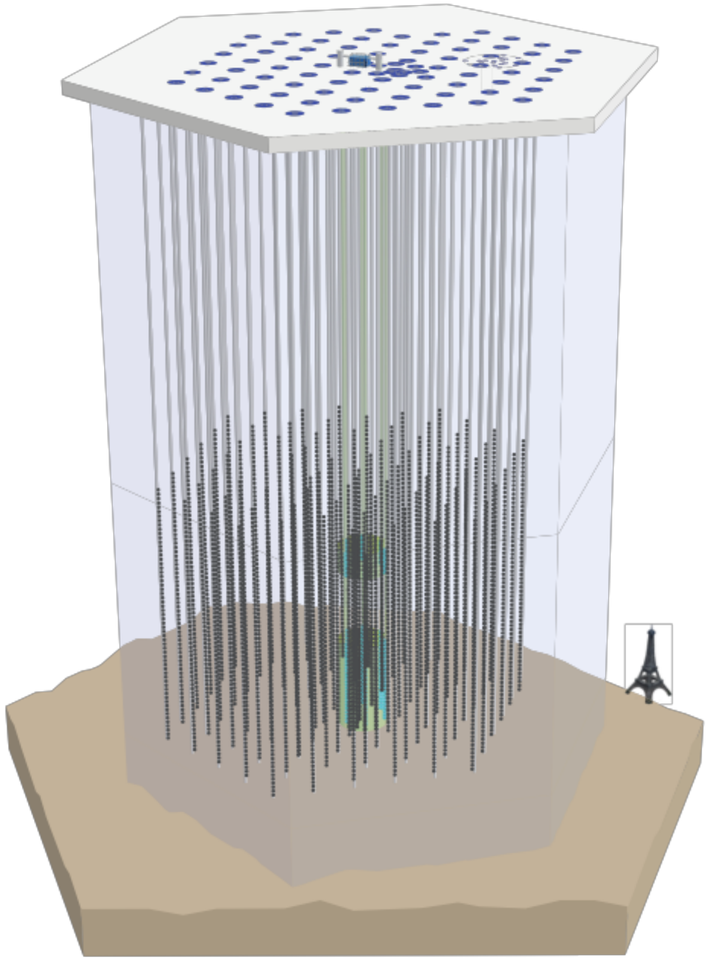
March 2019

The IceCube Neutrino Observatory



IceTop (surface array): 81 stations

IceCube: 86 strings

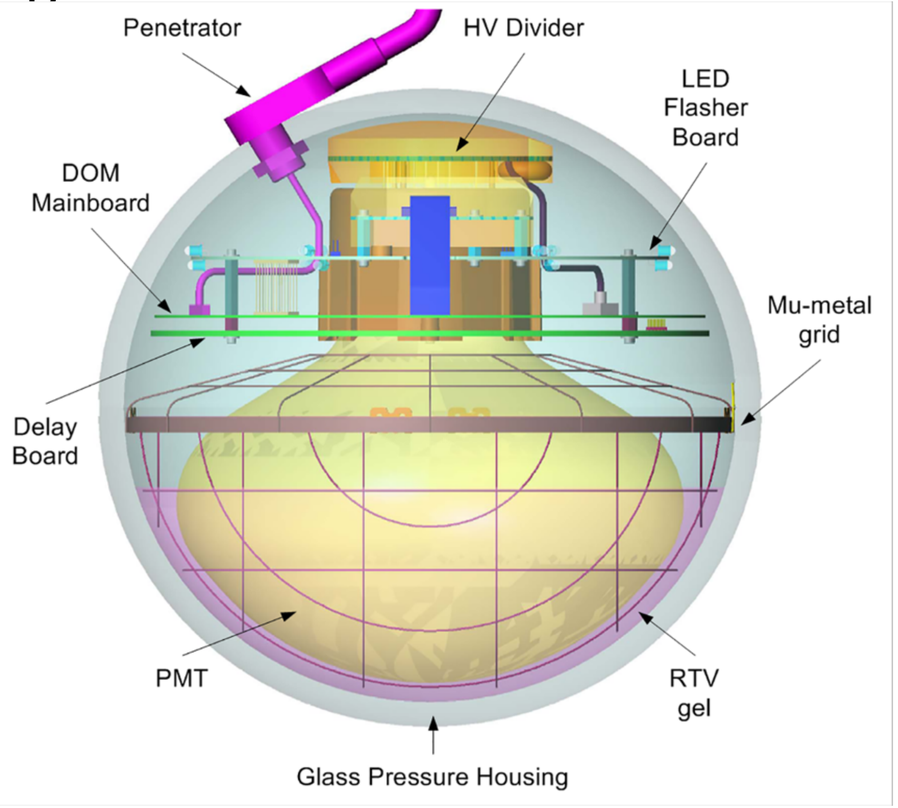
5160 optical sensors over 1 km^3 volume

17 m vertical spacing

125 m horizontal spacing

Highly stable operation.

Since 2016: livetime > 99.5%



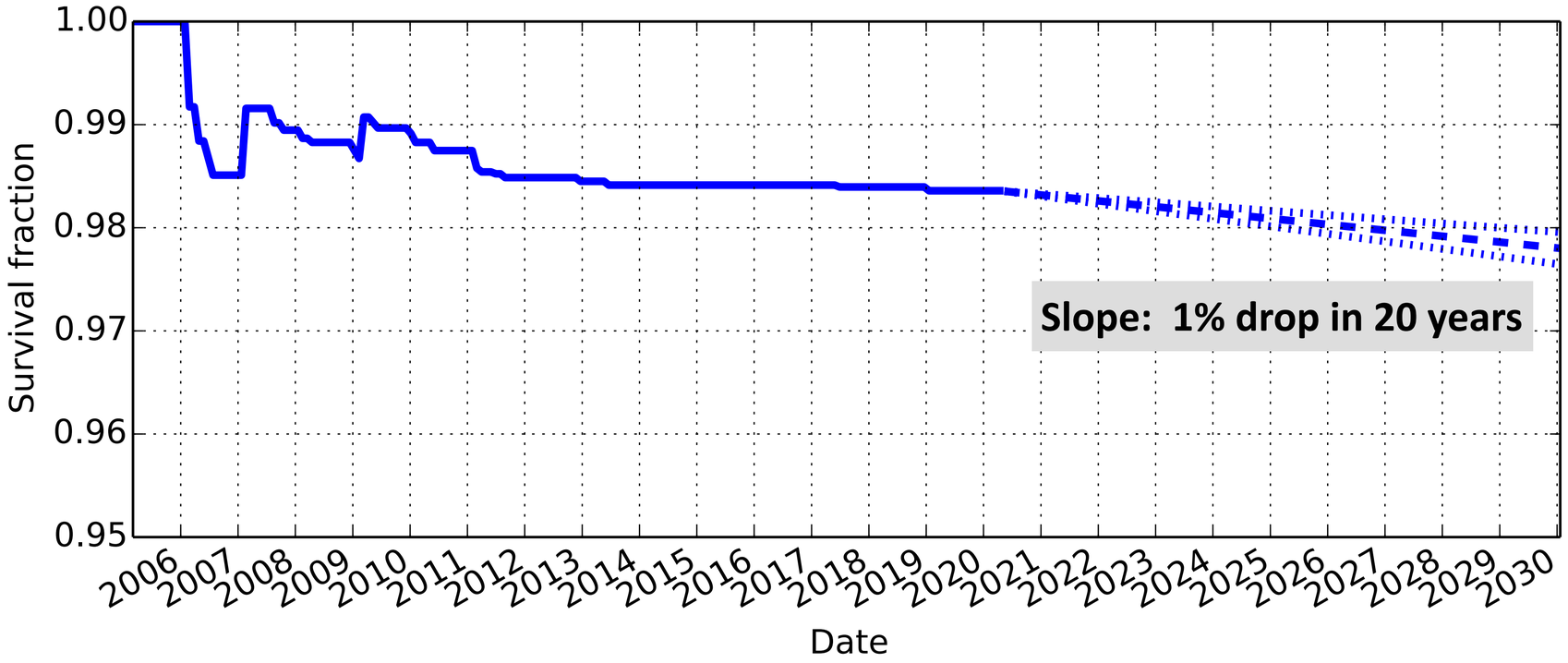
DeepCore (low energy threshold)

DOM survival rate

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

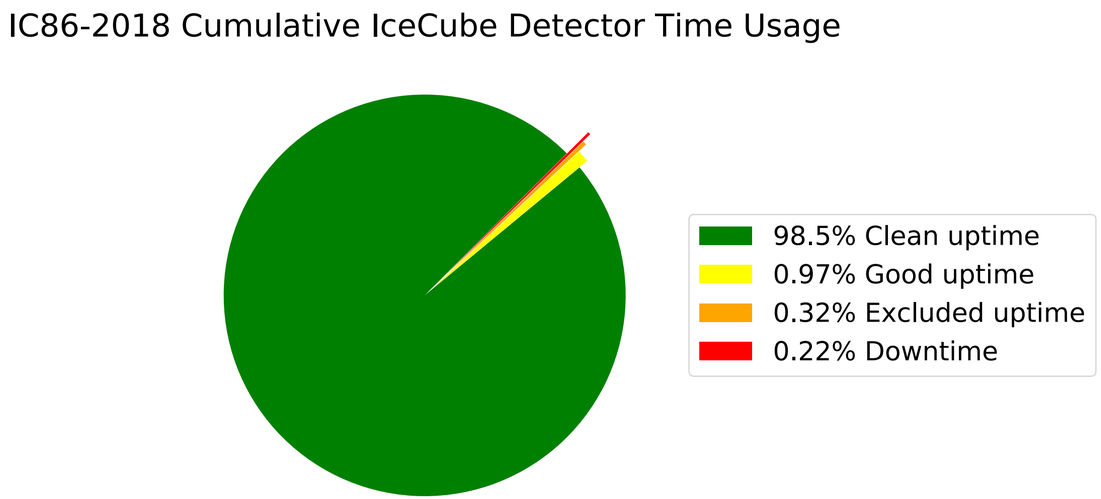


Detector Uptime

The detector uptime remains very high.

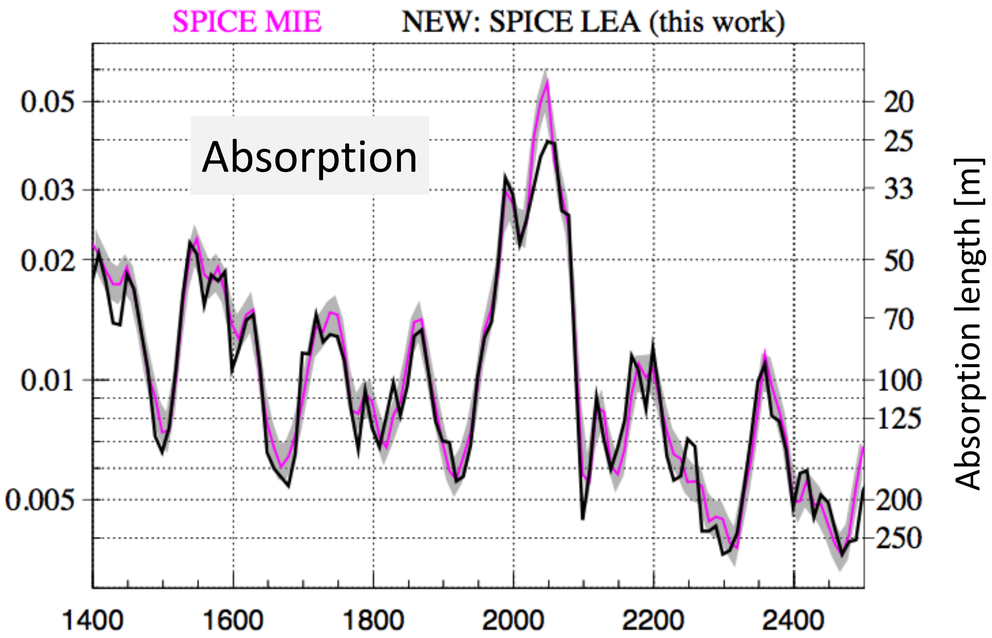
What is not visible here are many and frequent smaller
events that require the continued attention of the operations team.

—> talk by John Kelley



Understanding the ice - continued efforts

1. Vertical structure of ice parameters



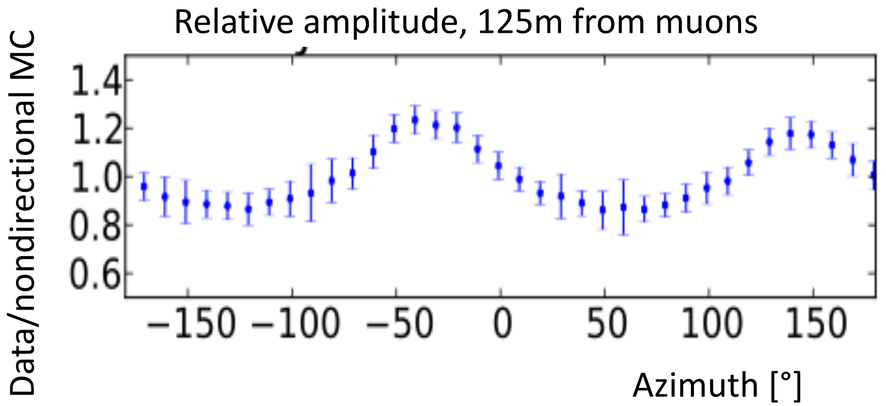
Scattering (eff.): 20 – 50 m
Absorption: 100 – 200 m

Measurement of South Pole ice transparency with the IceCube LED calibration system,

Aartsen et al., (IceCube Coll.), NIMA55353
http://arxiv.org/abs/1301.5361

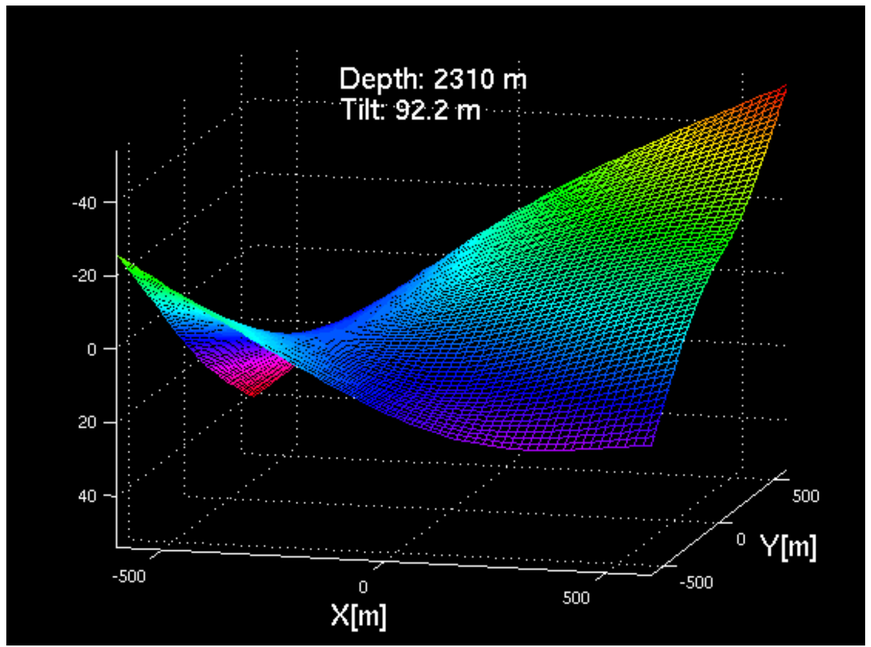
2. Azimuthal variation in of scattering

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

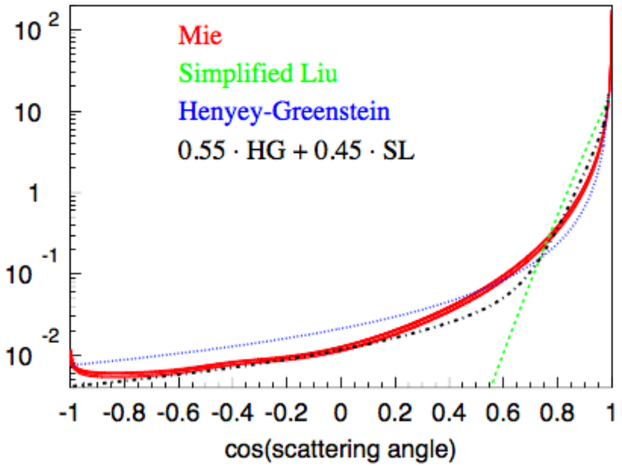


Microscopic explanation emerging.

3. Ice layers are tilted – not planar



3. Scattering function



Local effects

1. Hole ice

2. Cable Shadow

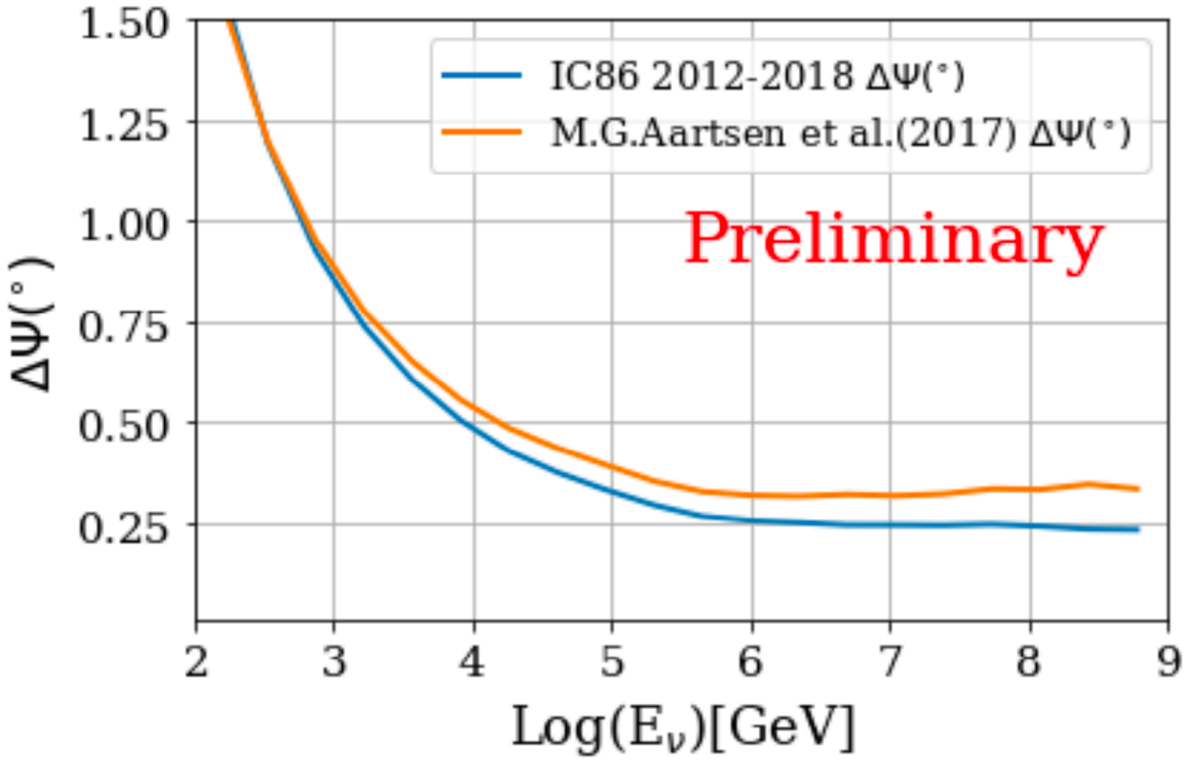
3. DOM tilt

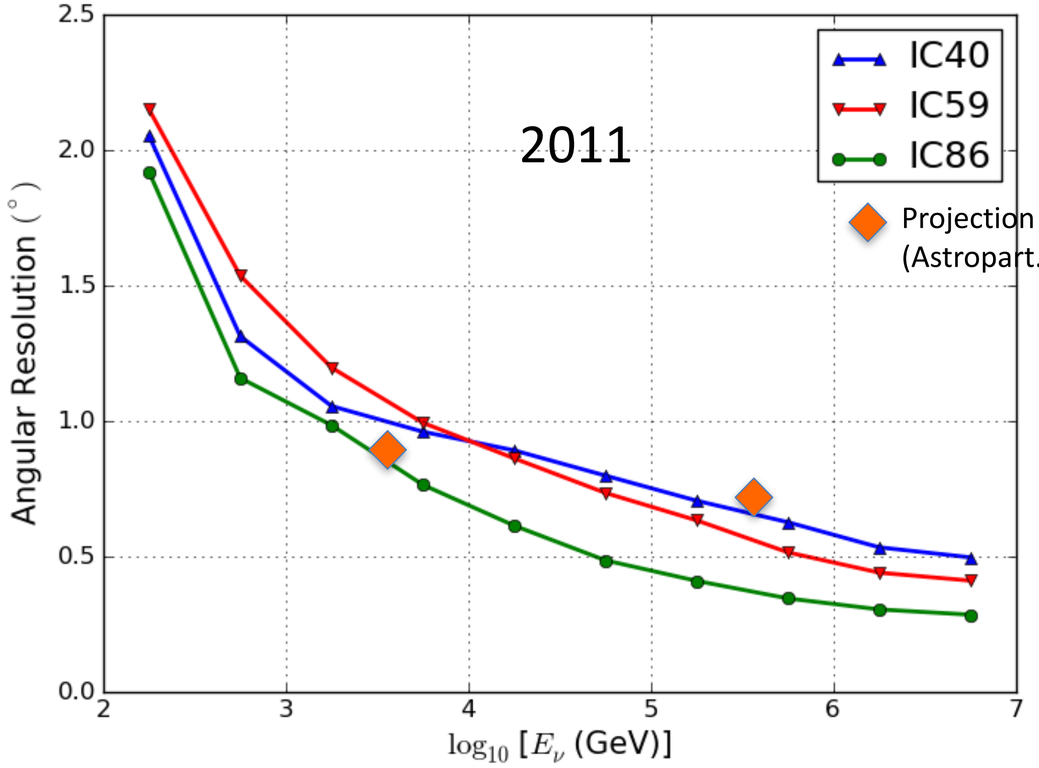
—> Talk by Summer Blot

Higher level performance parameters

Angular resolution for muon neutrinos

2019





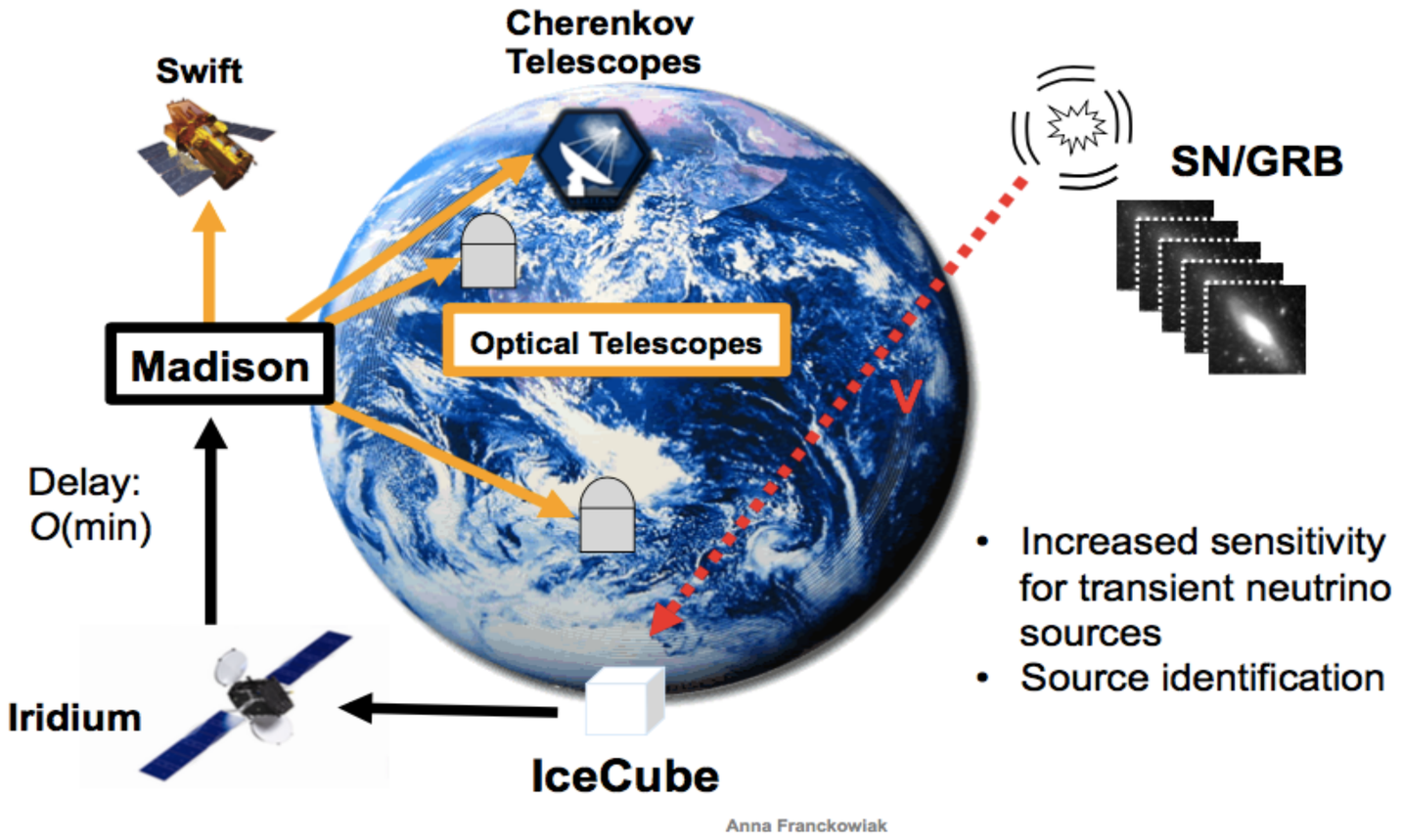
Continued improvement of reconstruction

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

ICNO software and computing

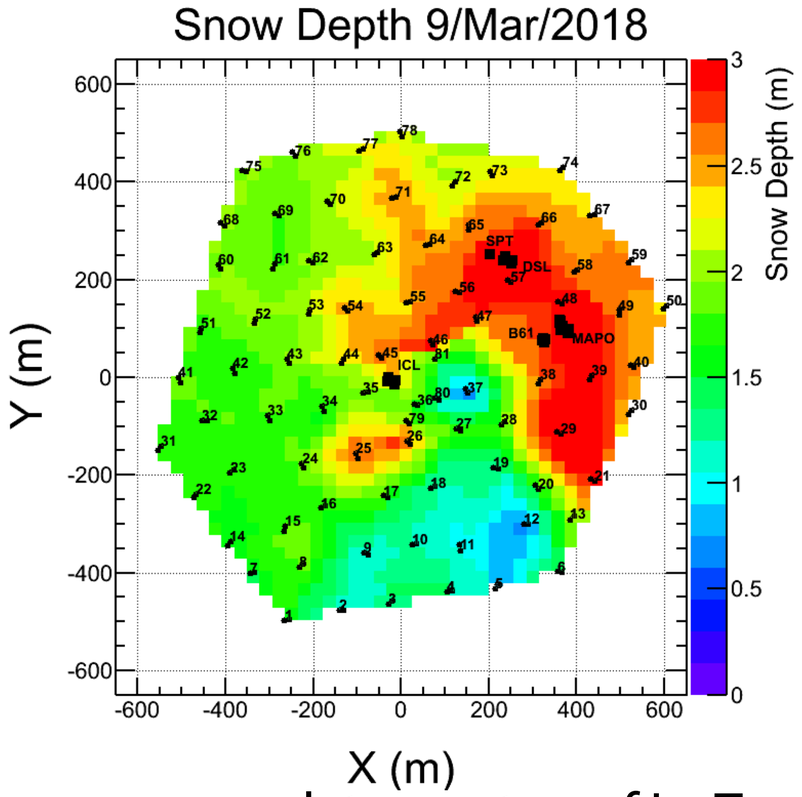
- It is continued challenge to engage young scientists, graduate students and postdocs in software.
- Reason in part, because IceCube software has become more specialized.
- Analysis and simulation require more support from core staff
- Managed in IC Coordination Committee and technical working groups.

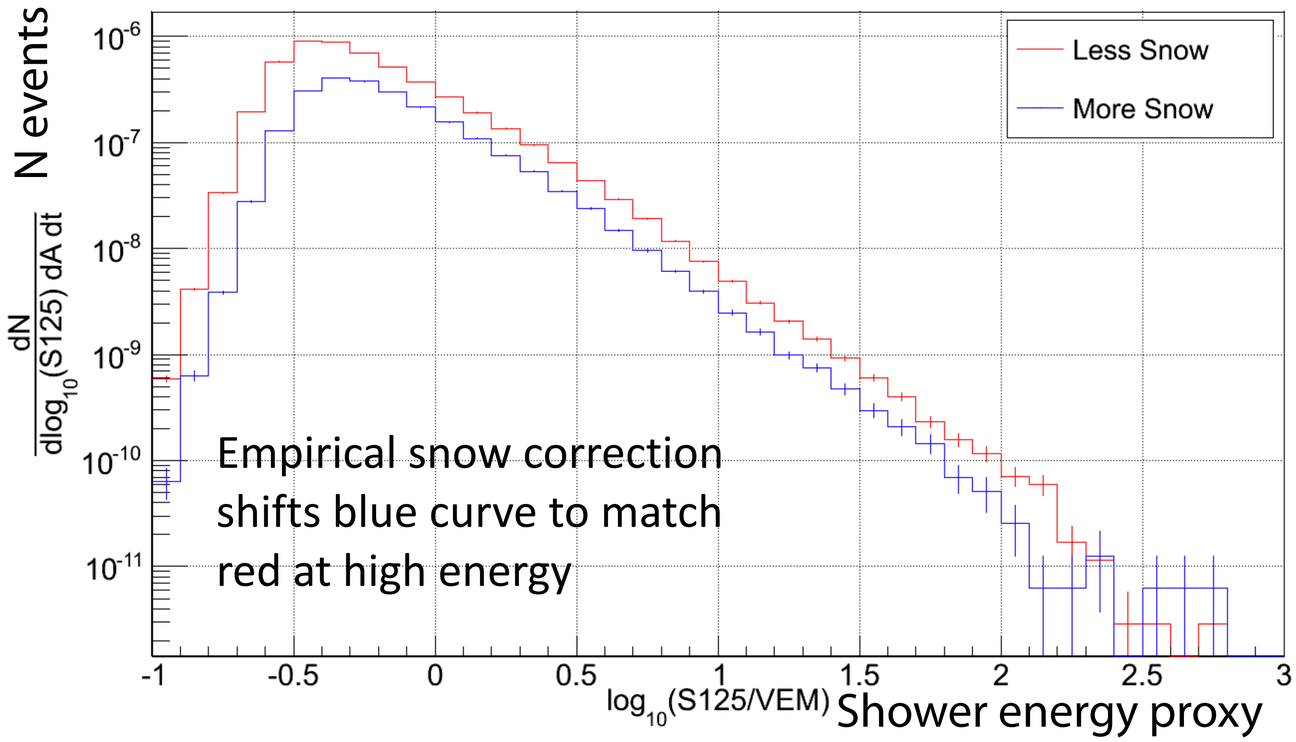
—> Talk by Benedikt Riedel

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.

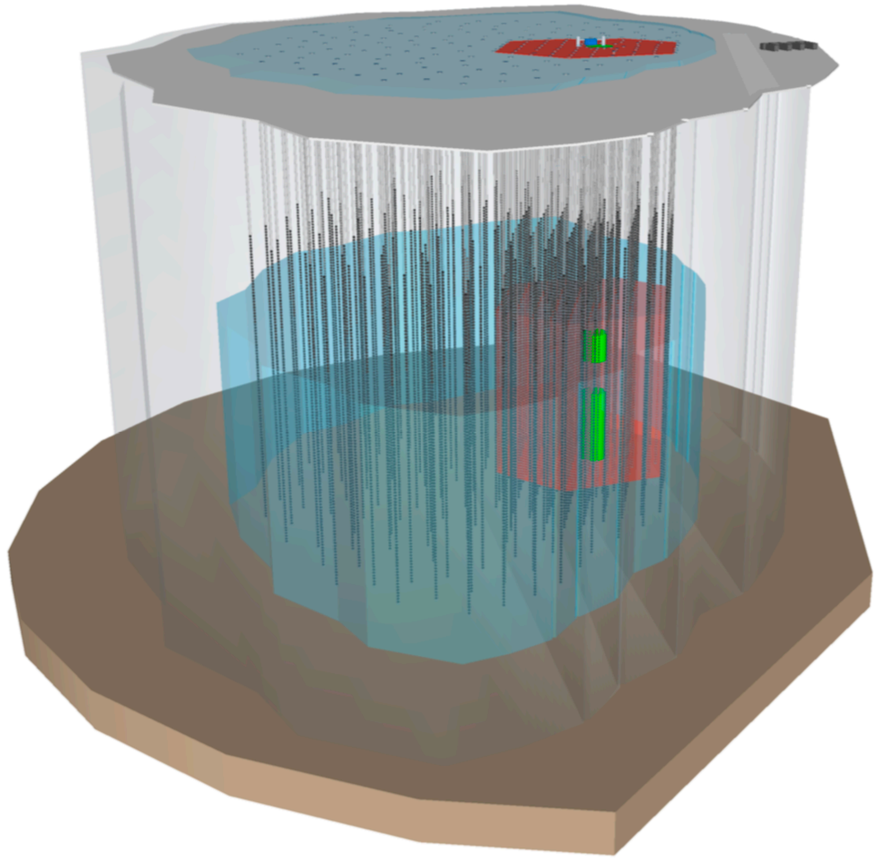
Other benefits: R&D for future detector upgrades

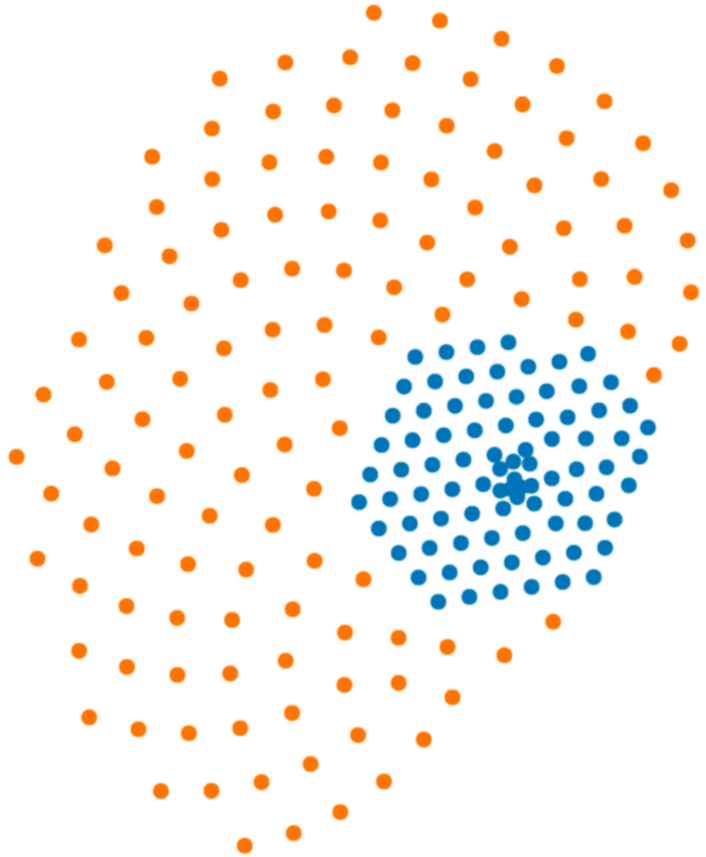
- A new, scalable precision timing and high-speed communications scheme for IceCube M&O and possible future projects.
- Efficient trenching procedures for instrumentation installation.
- Mechanical solutions to raise scintillator panels above the snow during the period of array deployment.

Technical implementation: —> talk by John Kelley

IceCube-Gen2

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





Artist's conception
120 strings at 240 m spacing

The next-generation IceCube: from discovery to astronomy

Optical sensors

IceCube
DOM

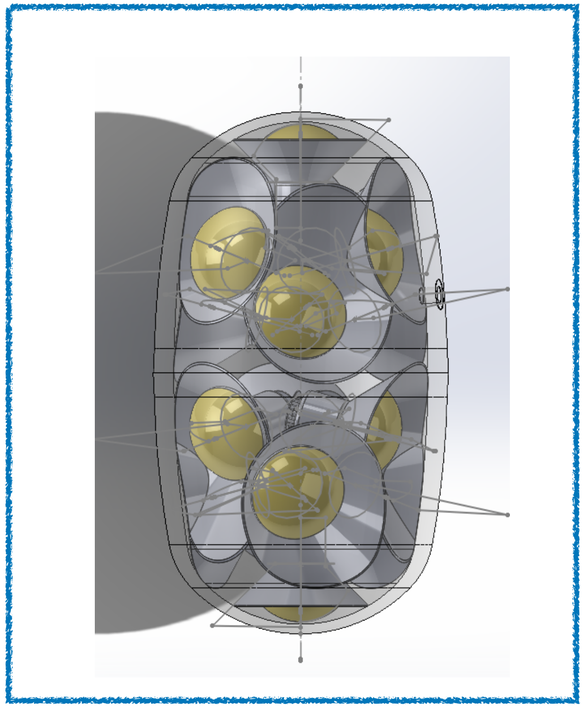
Diameter 33 cm
10 inch PMT

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.



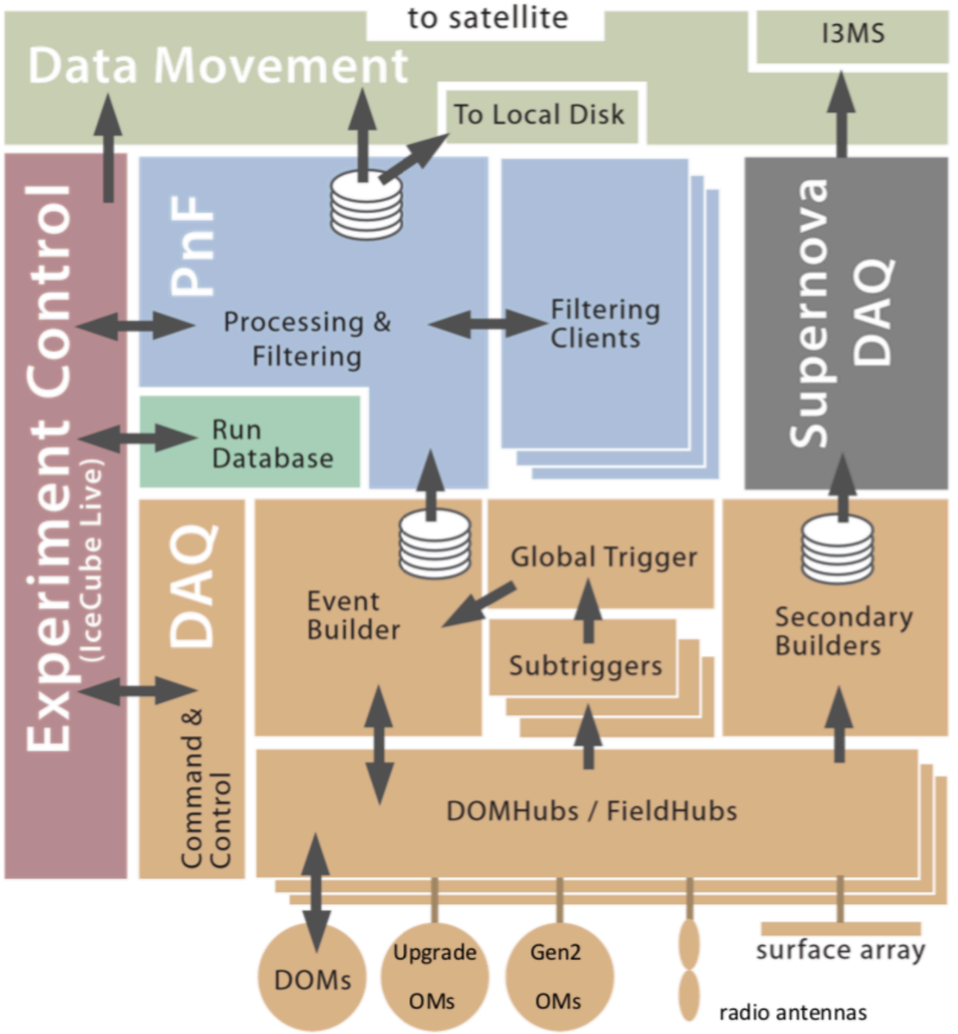
12 x 4 inch PMT
Smaller diameter 30 cm

ICECUBE
GEN2

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.

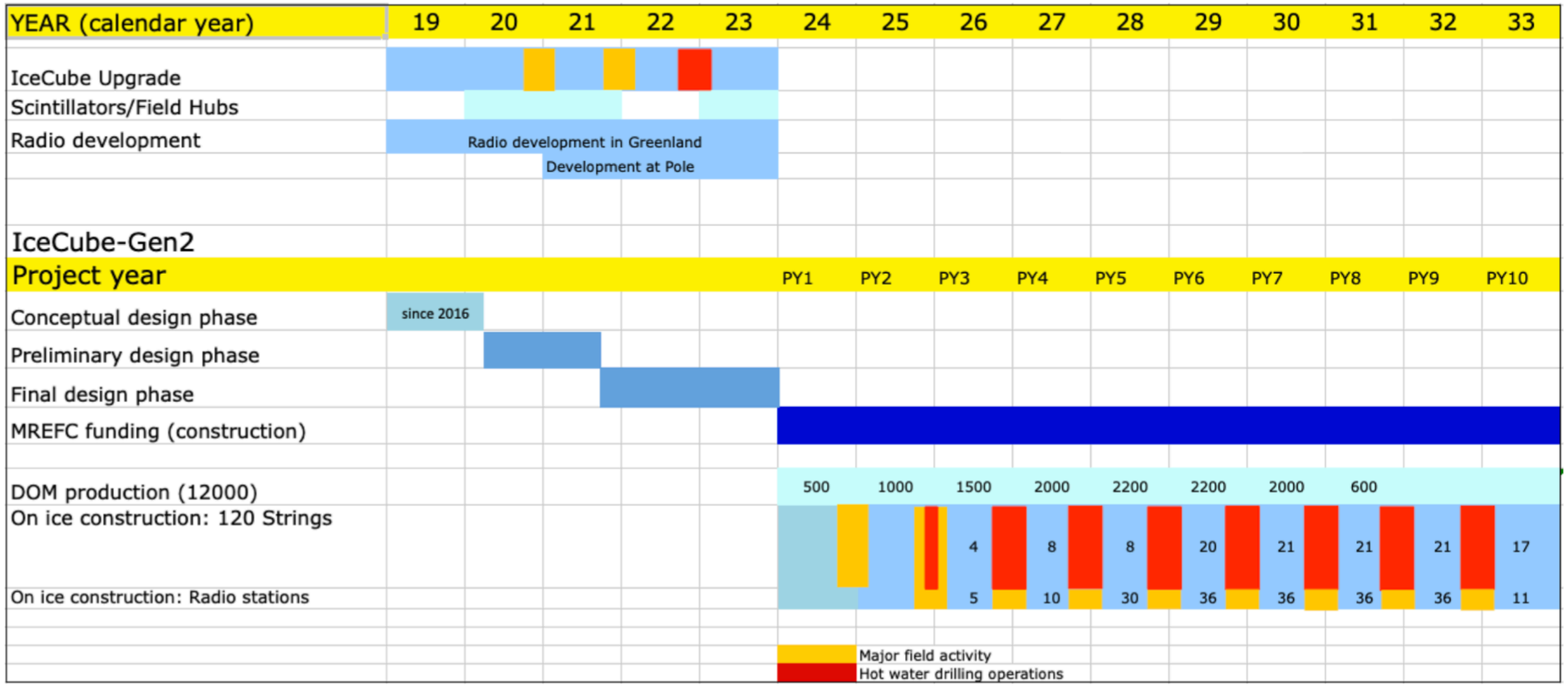


IceCube GEN2

Timeline

ICNO M&O

Significant changes to prepare for.



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.


TOSTRH
ICECUBE
DETECTOR COMPLETION

Thank you!


Grad School
is
Awesome!!