Path to IceCube-Gen2

Albrecht Karle

Chiba

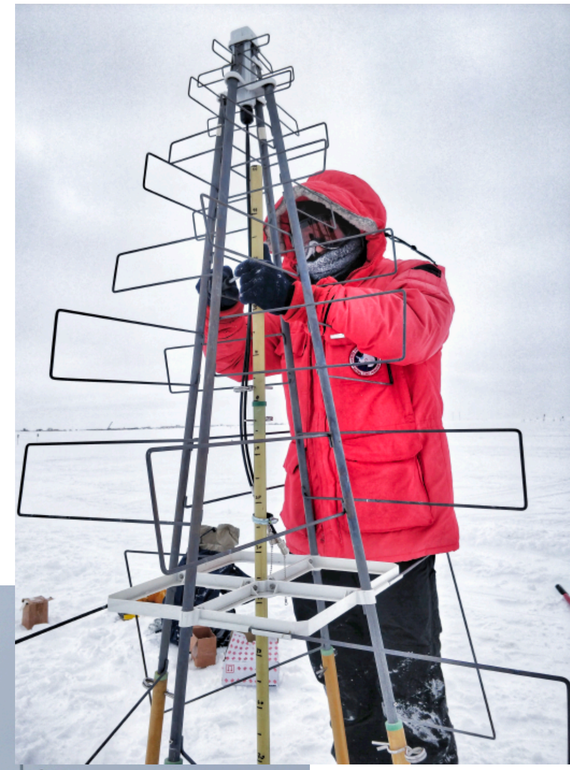
September, 2019

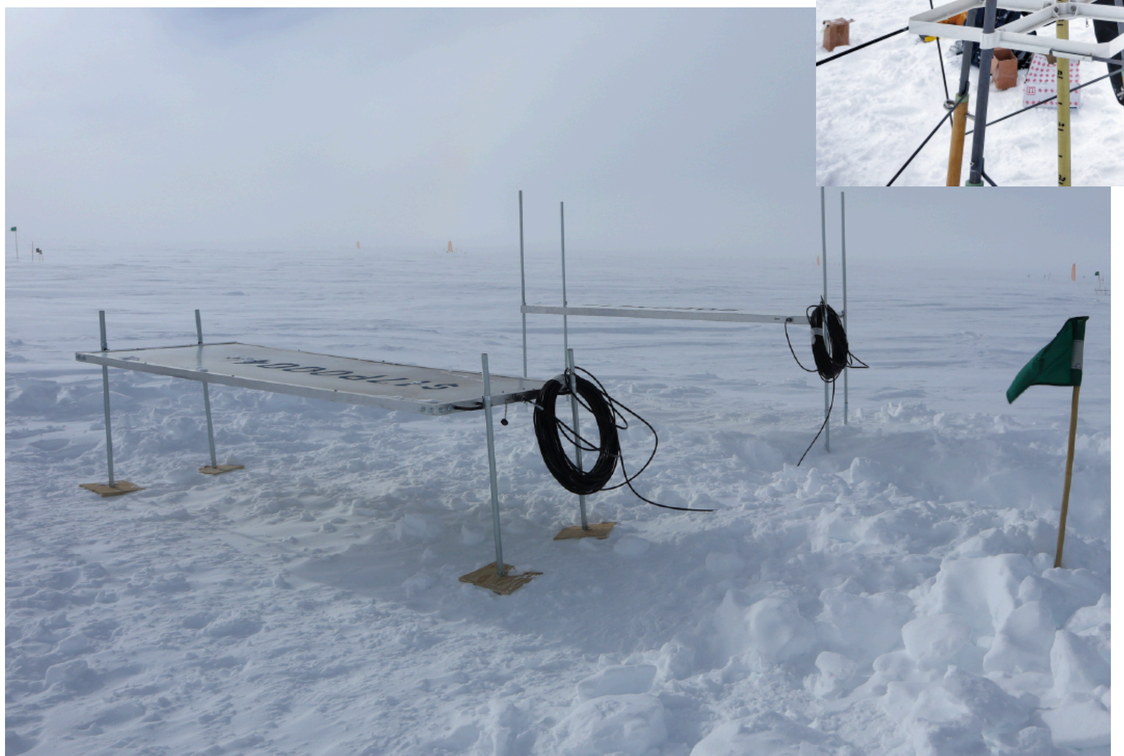
On-Ice Activities in the next few years

Icecube Upgrade (separate talk)

IceCube Maintenance and Operations

—> IceTop maintenance: scintillator upgrade



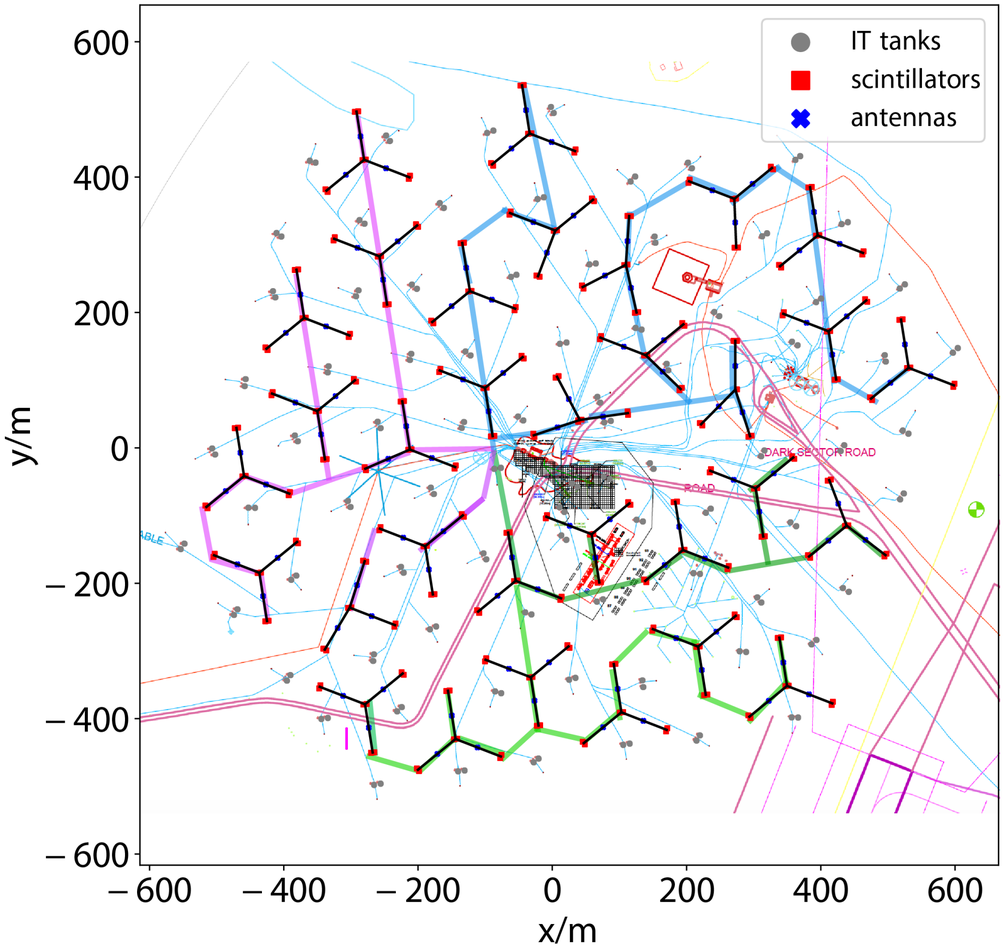


Science:

- **Enhance neutrino science (by improving understanding backgrounds)**
- **Cosmic ray science**
- **Galactic sources of gamma rays**

Scintillators stations for IceTop

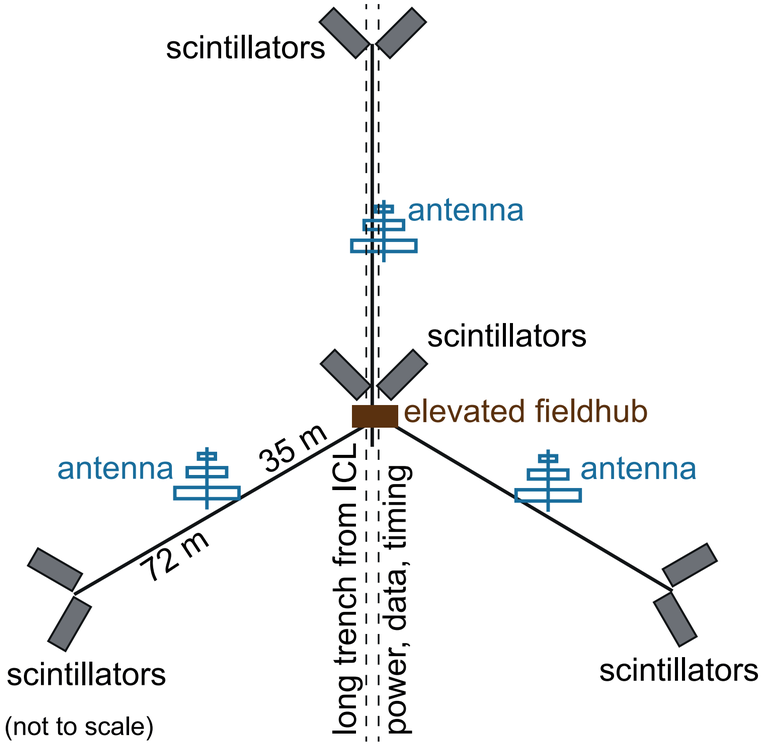
32 stations



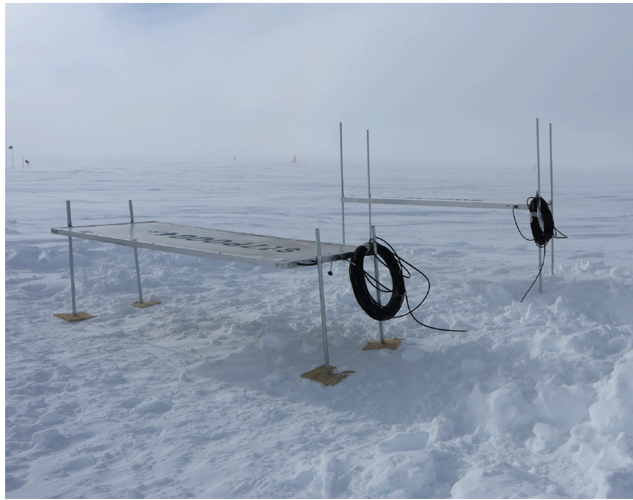
Schedule:
Deploy 11 stations before upgrade completion (before 22/23)
The remainder after.

Fits inside the nominal M&O on-ice footprint.
Subject to supportability review at NSF.
Document will be submitted.

Station



Scintillator panel

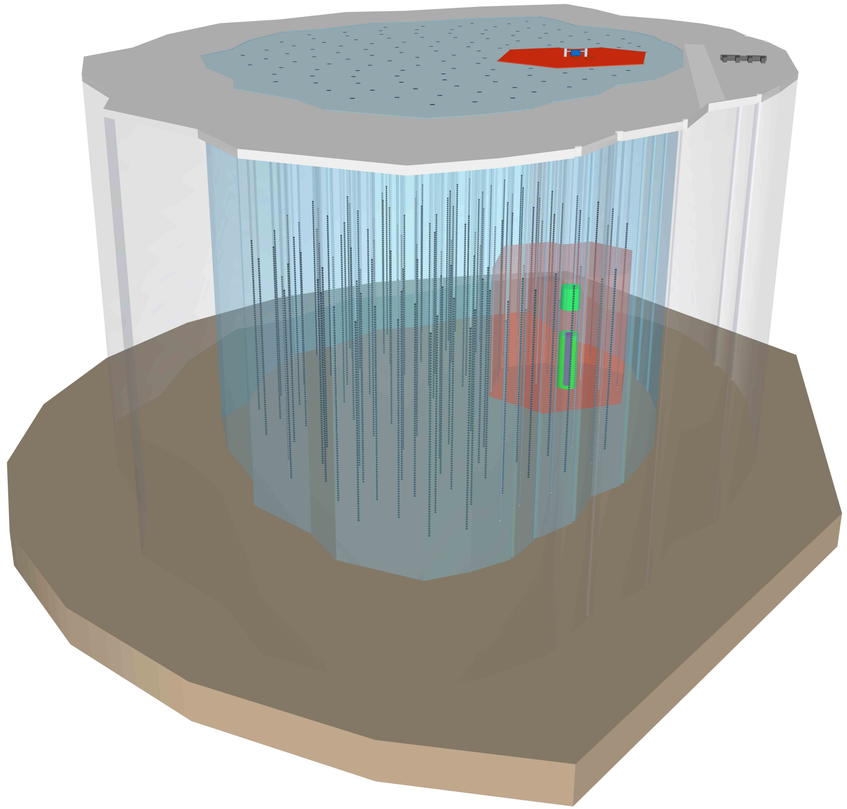


IceCube-Gen2

The next Generation IceCube: from discovery to astronomy

Multi-component observatory:

- IceCube-Gen2 High-Energy Array
  (associated cosmic ray array at surface)
- Sub-surface o(500km^2) radio array (not shown)

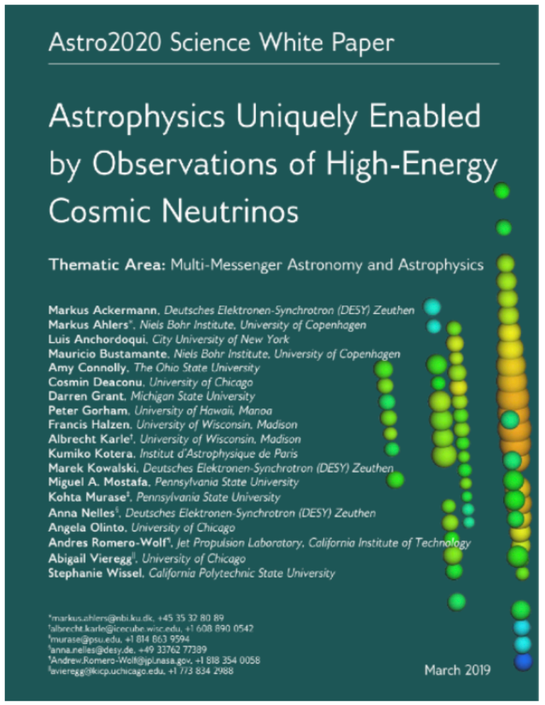


Artist conception
Here: 120 strings at 300 m spacing

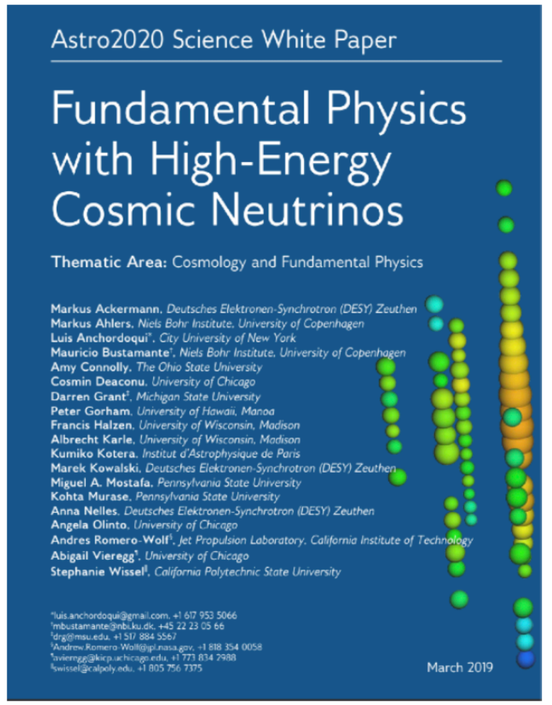
IceCube-Gen2 white papers

- Three 10-pagers for decadal survey (submitted in March and July)
  - 2 x Science
  - 1 x Instrument

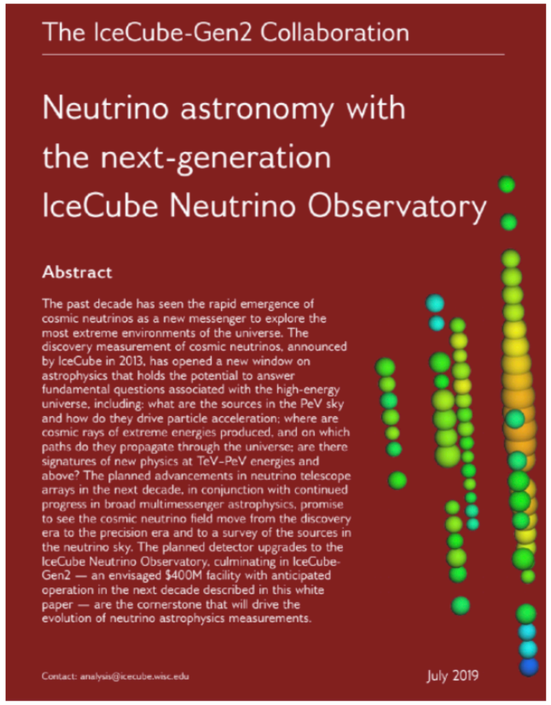
https://arxiv.org/abs/1903.04334



https://arxiv.org/abs/1903.04333

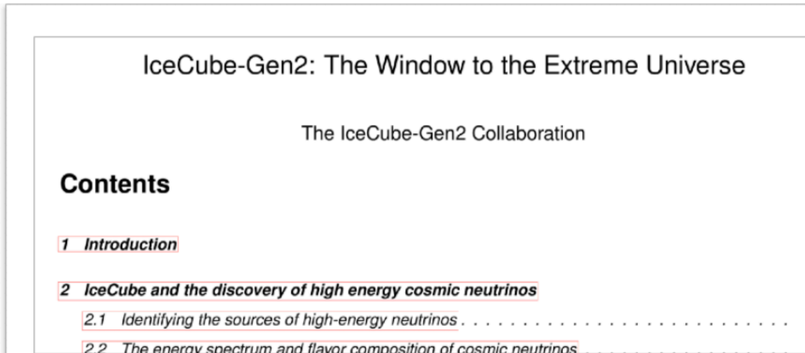


https://arxiv.org/abs/1907.12526



+

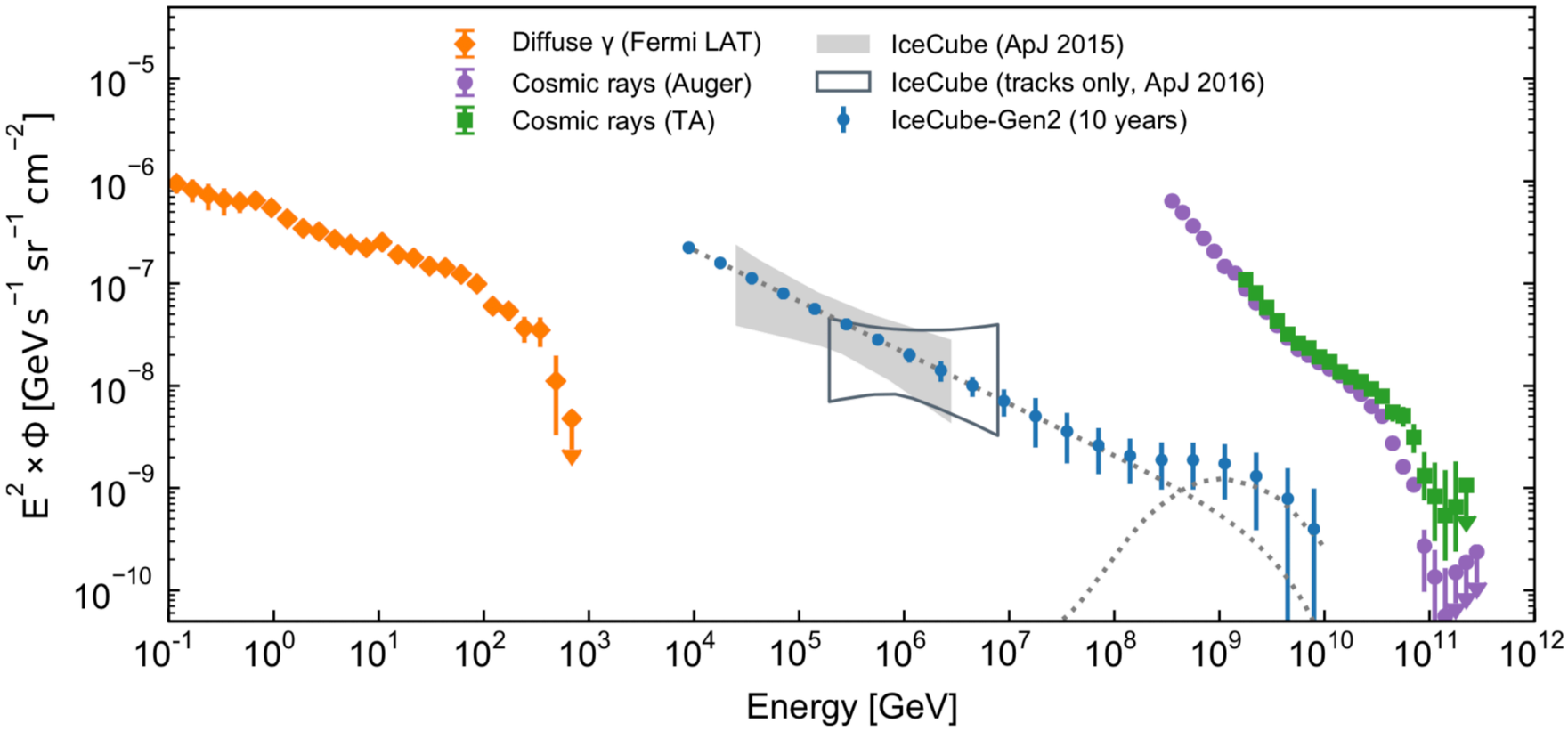
A more extensive white paper for the community (in preparation of possible invitation by NSF to submit a proposal for an MREFC)


IceCube-Gen2: The Window to the Extreme Universe

The IceCube-Gen2 Collaboration

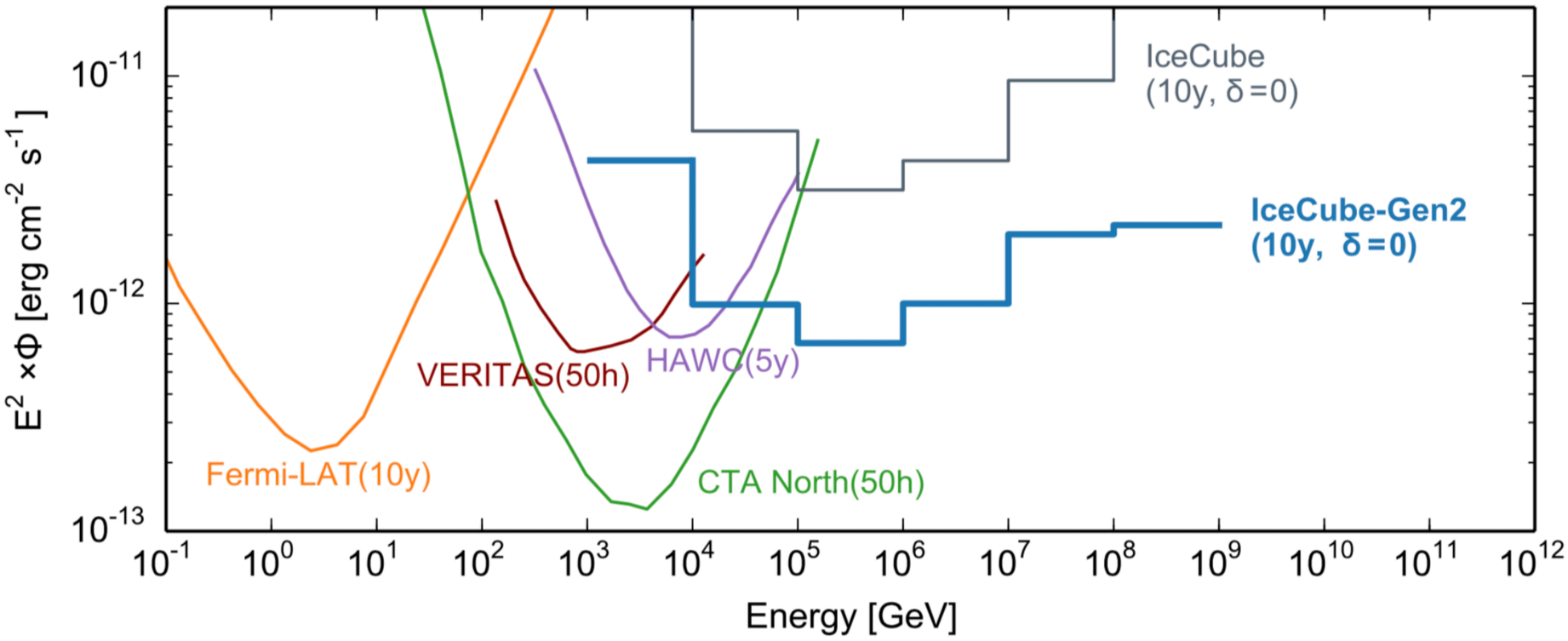
Contents

Diffuse neutrino spectrum



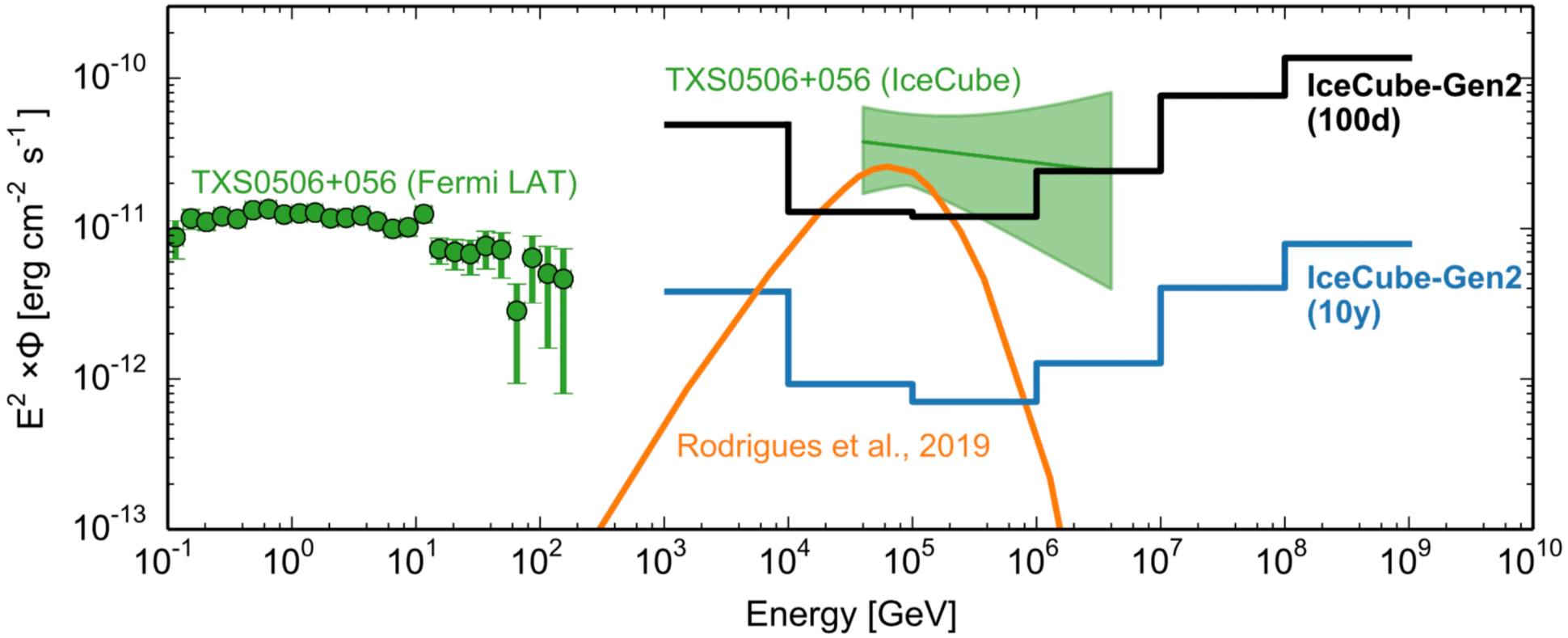
- Visualizing the energy and precision that IceCube-Gen2 can reach.
- Optical + radio array
- Astrophysical and cosmogenic contributions

Point sources - differential sensitivity



- Comparison of the differential sensitivity to current and future gamma-ray instruments

Multi-messenger astronomy: Blazars and AGN

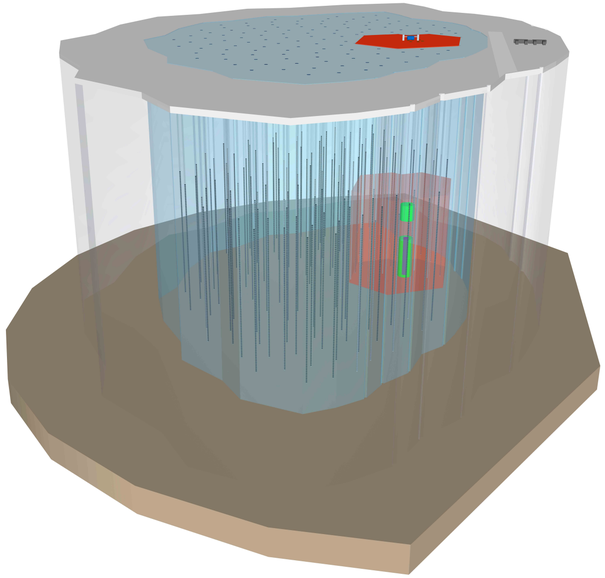


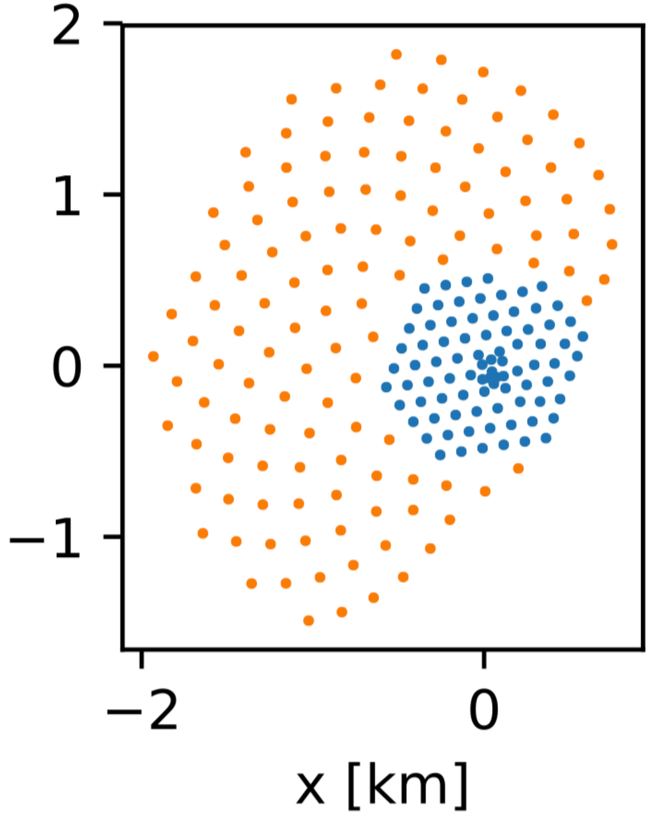
- What is Gen2's sensitivity relative to the signal observed for TXS 0506+056 ?

The Gen2 optical array

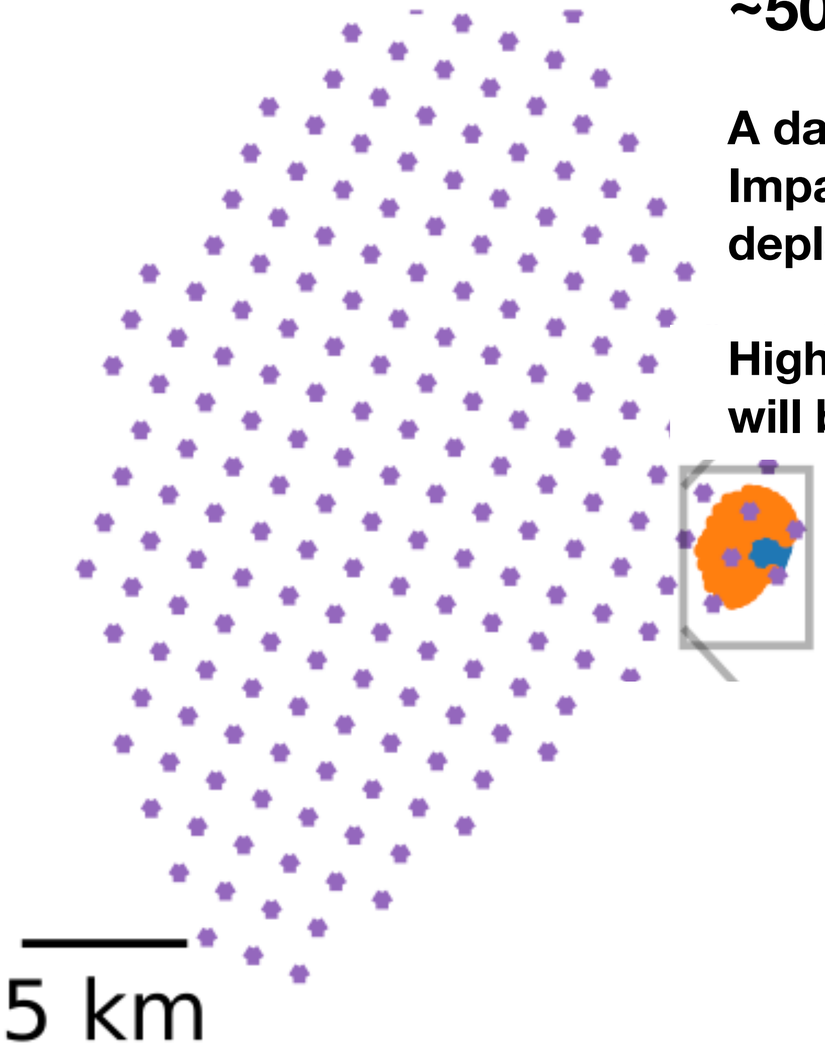
(unchanged)

- 120 strings x 80 DOMs
- DOMs ~ 3 x photodetection of IceCube DOM
- Vertical depth: 1360 m - 2610 m
- “240 m” sunflower
- Instrumented volume: 7.9 km^3
- Surface area: ~6.5 km^2





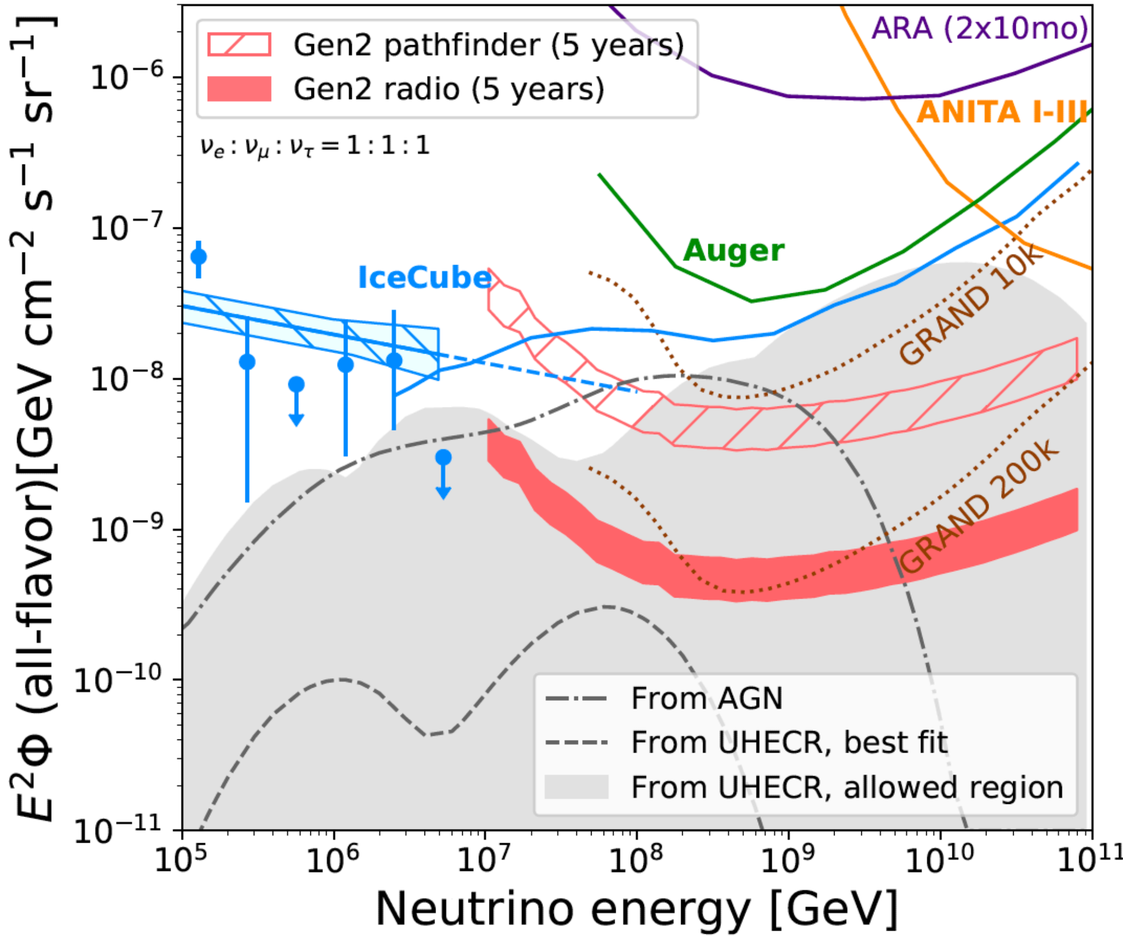
The Gen2 Radio array



200 stations
~500 km^2

A daunting scale!
Impact on Gen2 deployment.

Highly efficient deployment will be critical.



Integration of Radio

The following statement (under discussion) reflects the thinking of the collaboration:

The radio detection of neutrinos is an important technology and is planned to be part of IceCube-Gen2 as outlined in the recent decadal whitepaper. The radio technique is essential to meet IceCube's science goals at highest energies.

Therefore the IceCube collaboration welcomes members of the radio detection community, including the ARA, ARIANNA and RNO collaborations, to join the Gen2 effort as associate members of IceCube to facilitate a vigorous and concerted effort towards the major detection facility.

The Gen2 Radio array

There is a need for an **R&D** cycle before Gen2 MREFC.

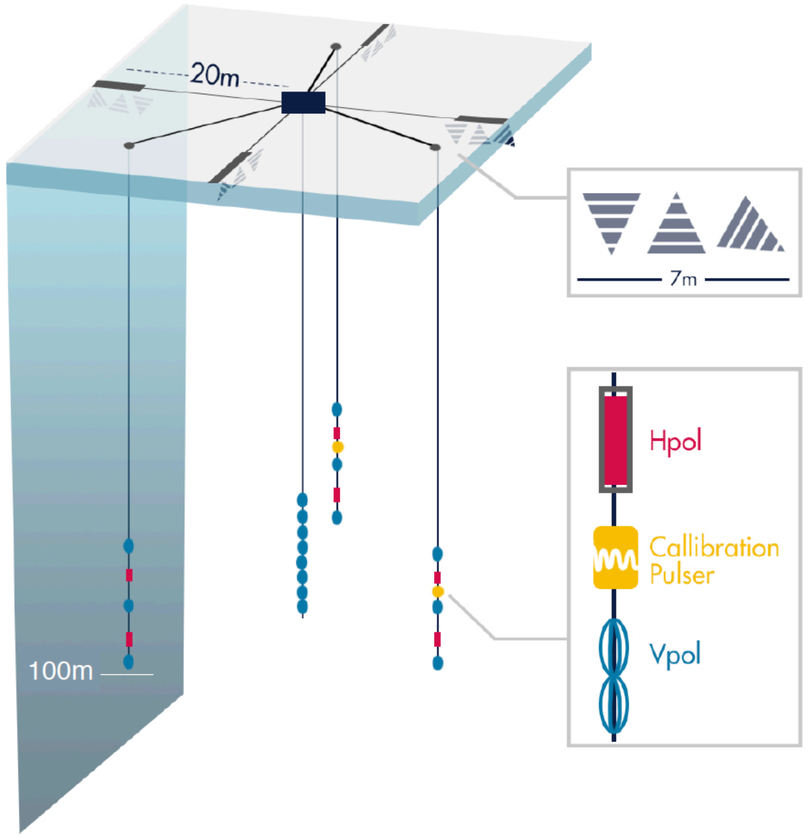
R&D in Greenland: Groups are developing plans for R&D, including a pathfinder array in Greenland. Lighter weight approach to station design, no cables, less power.

Some R&D effort planned for South Pole, inc. some effort taking advantage of ARA stations and Upgrade, also verify design at the Pole under real conditions. Analyze data, ice, radio pulser in Upgrade.

Developing a coherent R&D plan for radio detection aimed at Gen2

Station design:

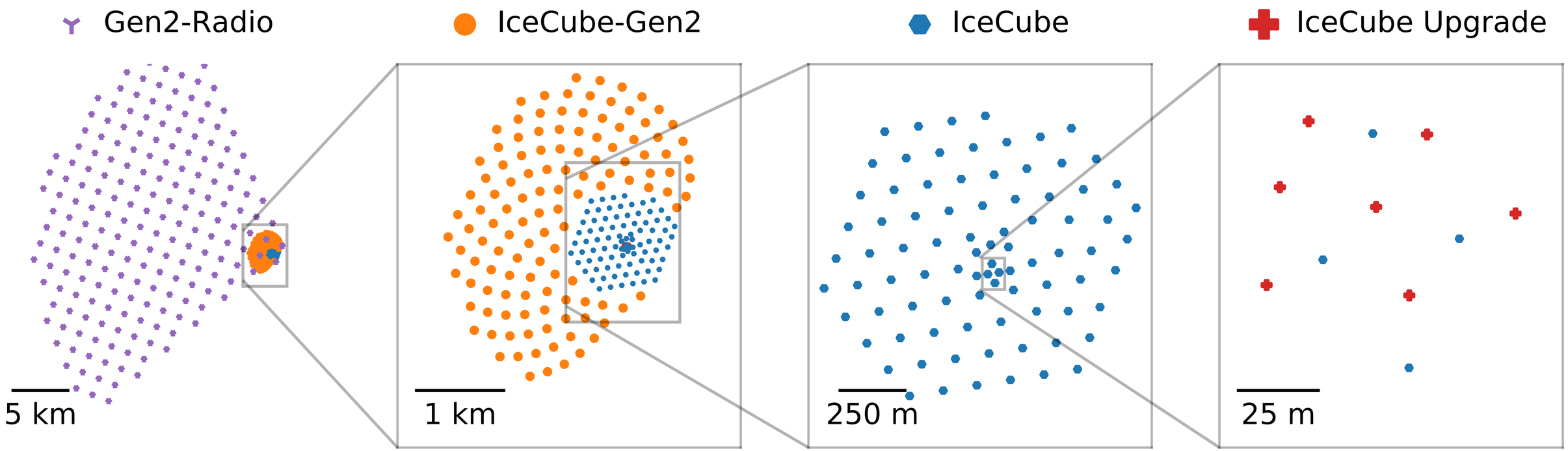
Development following ARA station 5,
Further developed by RNO collaboration.
3 strings plus one phased array trigger, depth 100 m
Surface component
Autonomous



https://arxiv.org/abs/1907.12526

IceCube Gen2 - scope

IceCube and Gen2 on different scales reflecting different energies



10 PeV **10 TeV** **1 TeV** **few GeV**

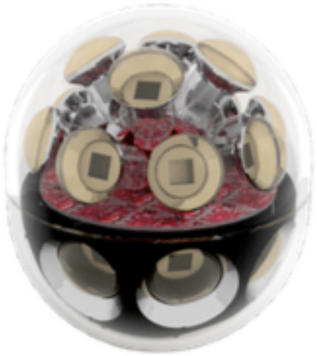
Sensor design R&D for improved performance

IceCube DOM

33 cm

Upgrade primary sensors

mDOM



36

- Directional information
- More sensitive area per module

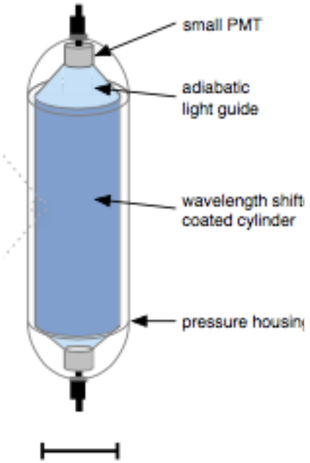
D-Egg

30

- Directional information
- More sensitive area per module
- Smaller geometry

Smaller diameter

WOM



11

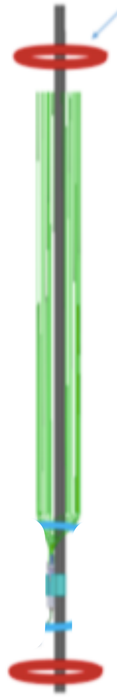
- more sensitive area per $
- Small diameter
- Lower noise rate

LOM

27

- Small diameter
- Directional info.
- More area per module

FOM



MDOM and Degg are primary sensors for Upgrade.
R&D for Gen2 for multi DOM and including other sensor concept.

Gen2 - R&D

Optical sensors (previous slide)

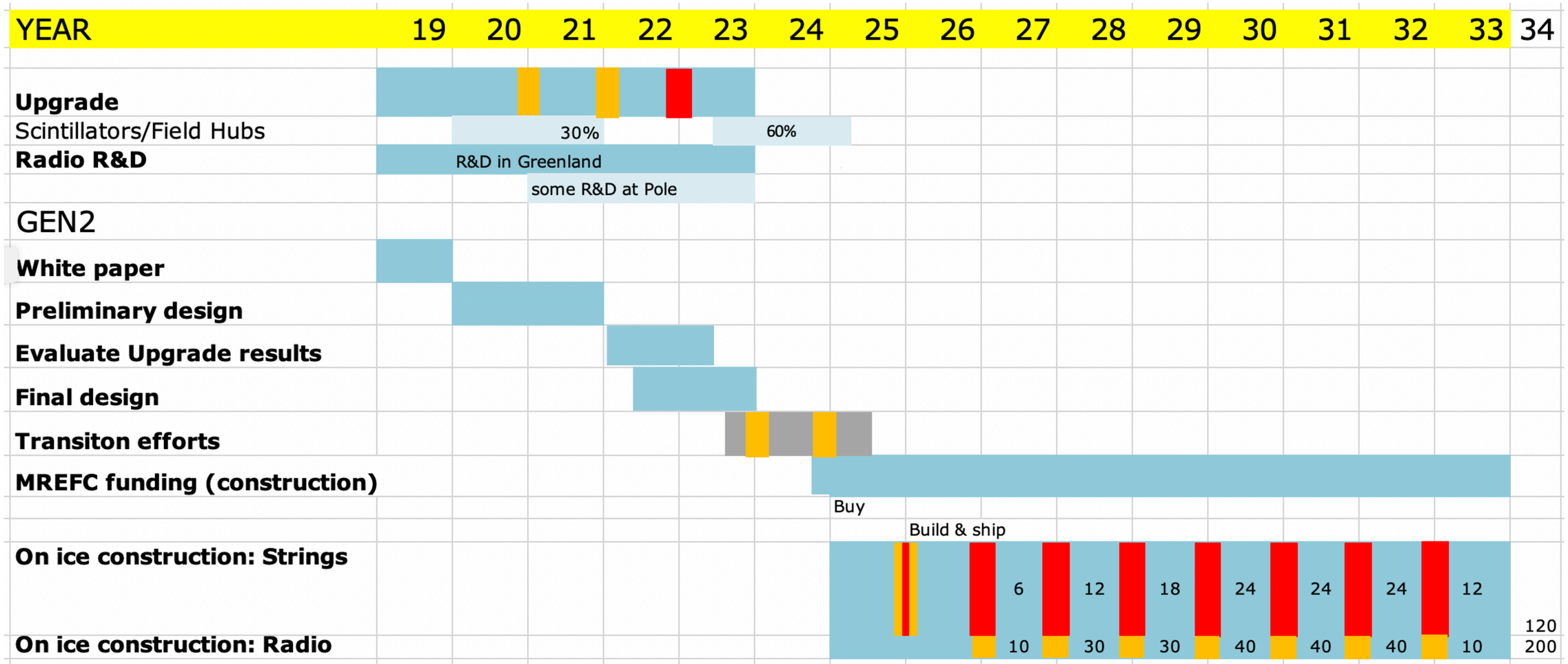
Power and communications architecture: take advantage of changing technology, possible transition to fibers, other ways to optimize communication

Surface cables - switch comms from copper to fiber. Considering deployment of a “field hub” at the top of the string on the ice. (technology partially established in scintillator project).

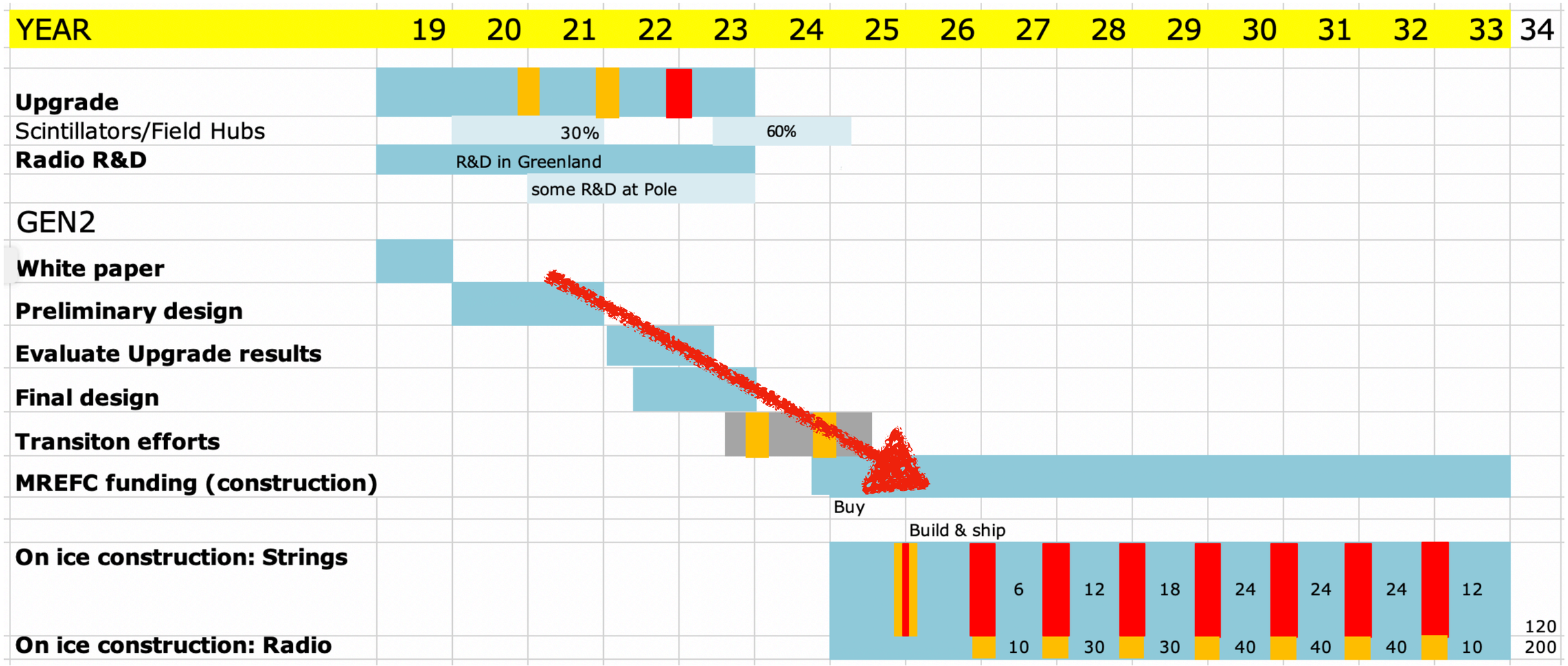
Drill: eg develop design for mobility, more efficient power generators.

Radio detection: advance design for Gen2 scale (low power, no wires, very minimal maintenance).

Developing schedule baseline for Gen2



Developing schedule baseline for Gen2



Transition period needs careful planning to enable a rapid and effective ramp-up of construction.
There will be support needs.

Summary

Progress with definition of scope.

Gen2 scope now includes radio, coherent Gen2 oriented approach important

Smooth path forward on Upgrade is important.

White papers posted, longer version available soon.

In parallel, ramp up R&D and planning for Gen2. Increasing coordination of effort.

The launch of a Gen2 MREFC by the end of 2023 or early 2024 is a real possibility.

Watch address by NSF director France A. Córdova to the ICRC in Madison this summer,
where she notes the Upgrade and makes reference to plans for IceCube Generation 2:

https://www.youtube.com/watch?v=JhjHnv526fE

Time: 1:04