# IceCube-Gen2

*Notes on construction on ice*

The IceCube-Gen2 Collaboration

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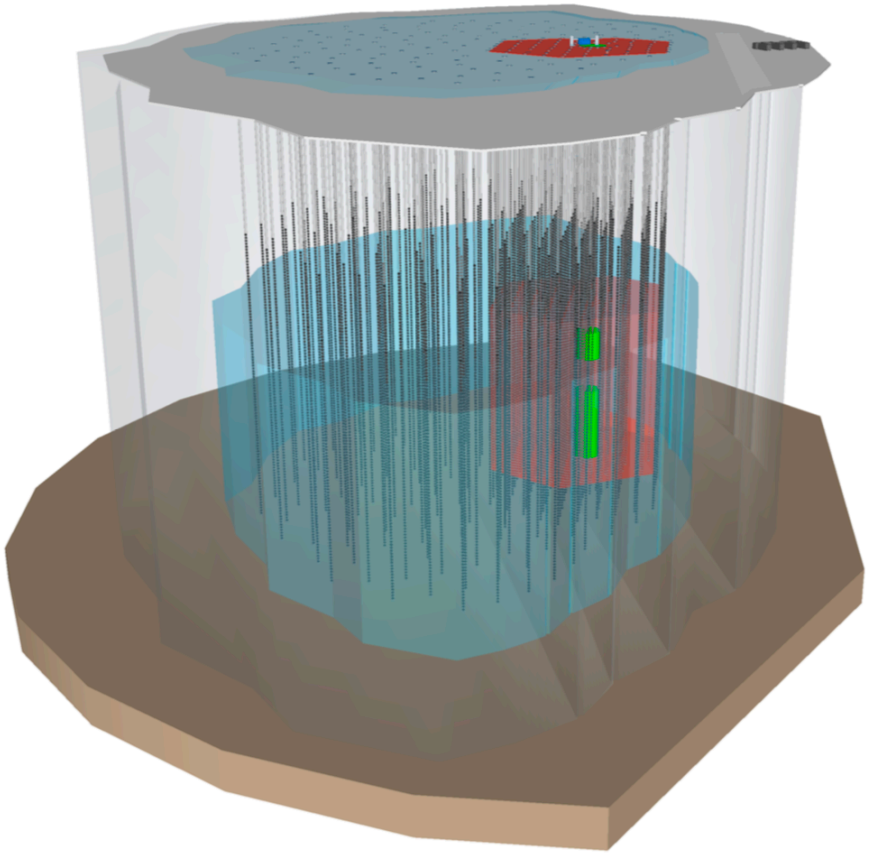
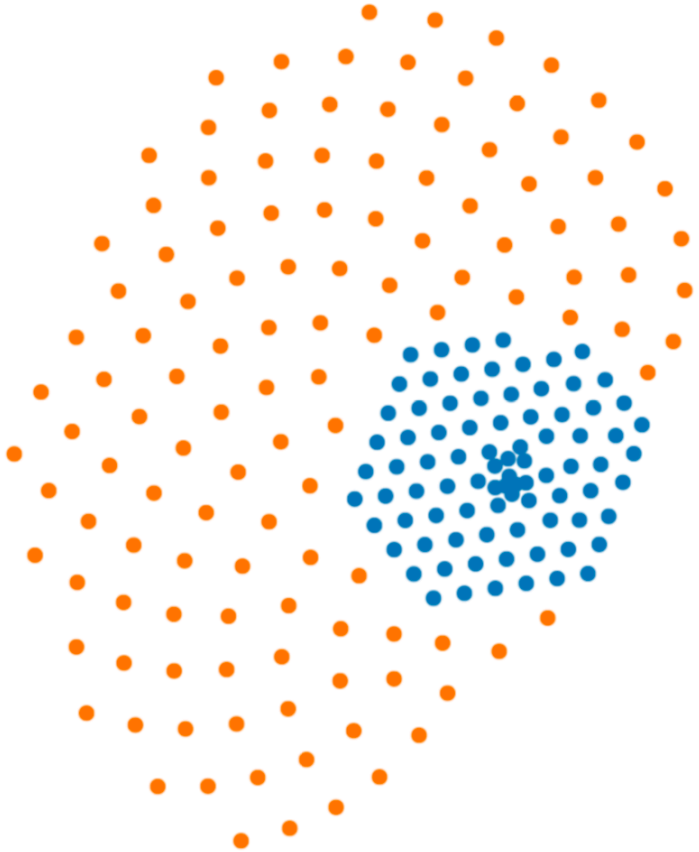
IceCube GEN2

# IceCube-Gen2



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





Artist's conception
120 strings at 240 m spacing

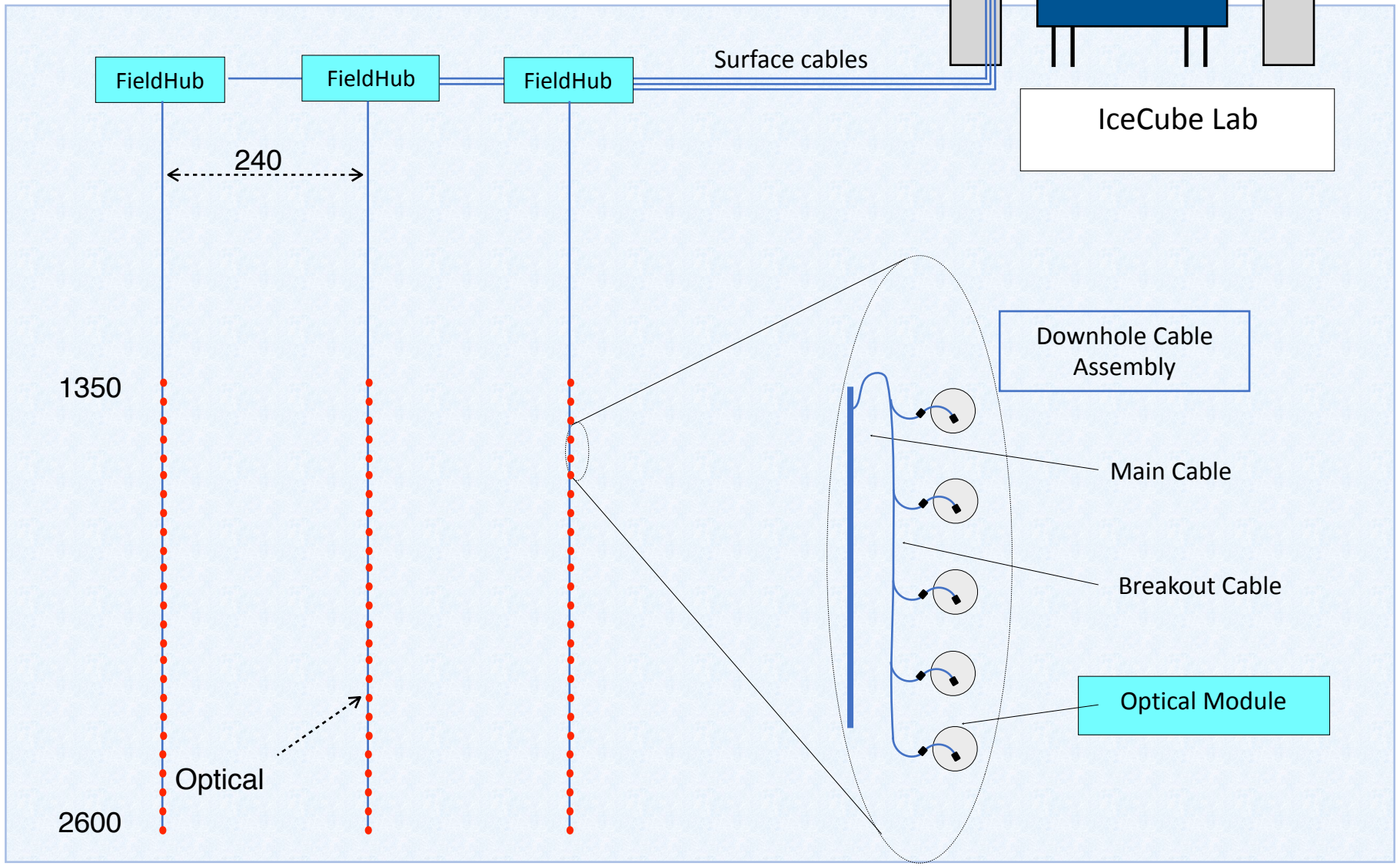
IceCube GEN2

**The next-generation IceCube: from discovery to astronomy**

# Architecture



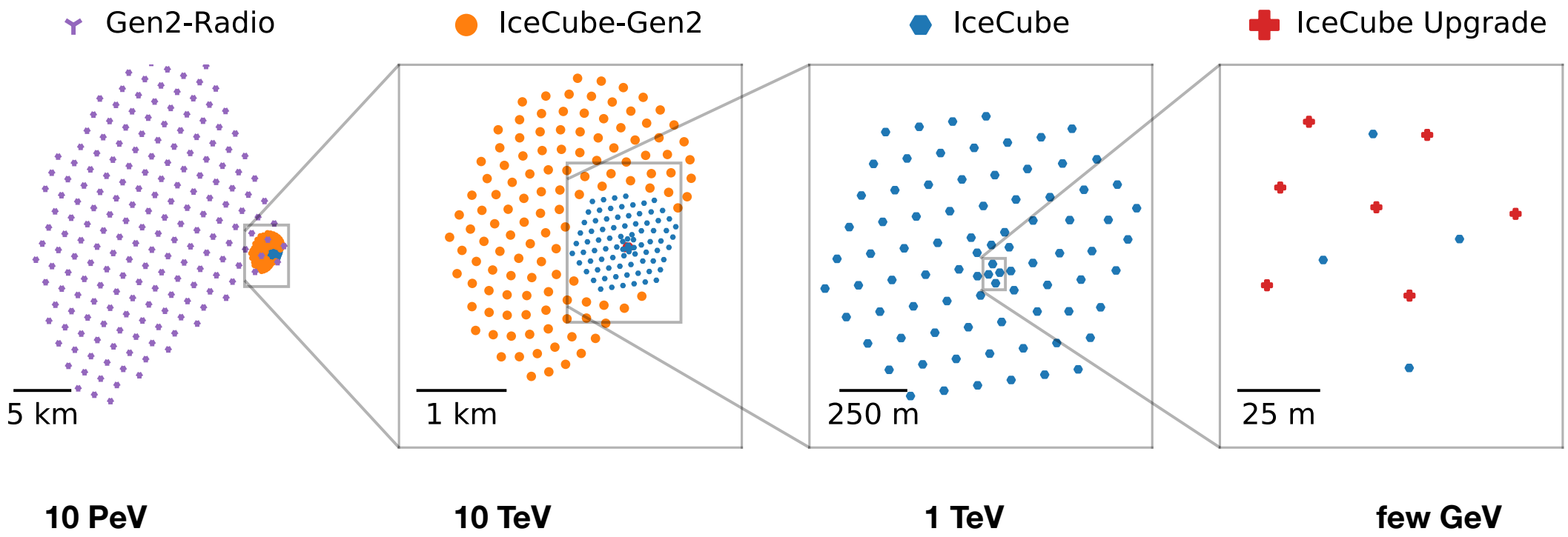
- Power and communications architecture: simplified requirements for cable hardware.



# IceCube-Gen2 — scope



**IceCube and Gen2 on different scales reflecting different energies**



# Optical sensors



IceCube DOM

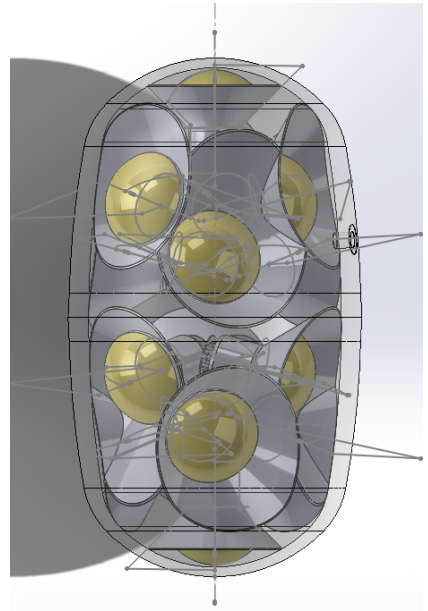
Diameter 33 cm
10 inch PMT

**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

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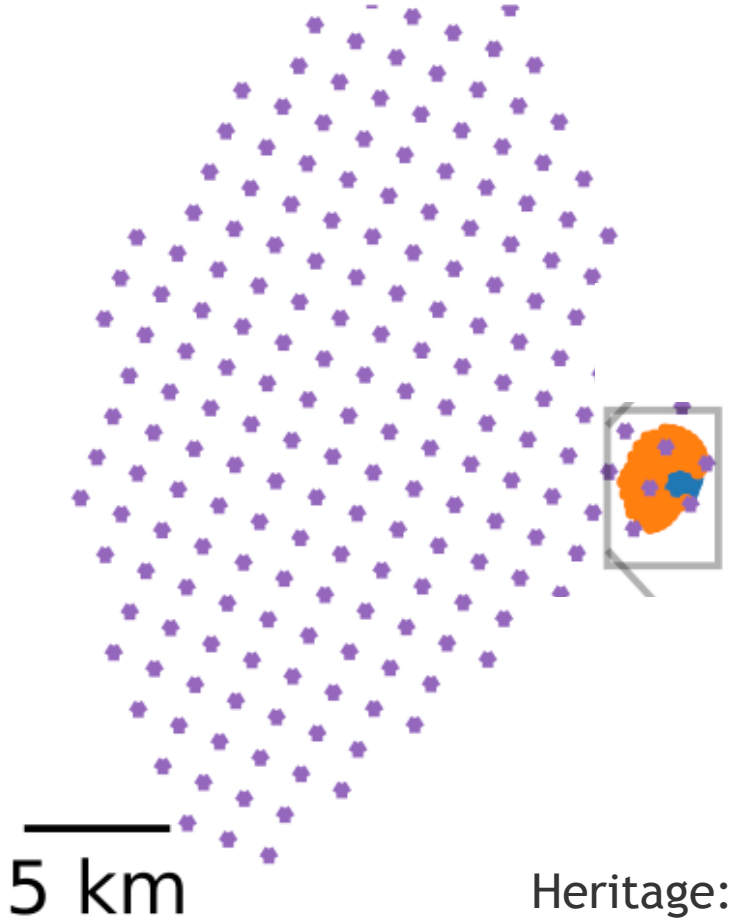
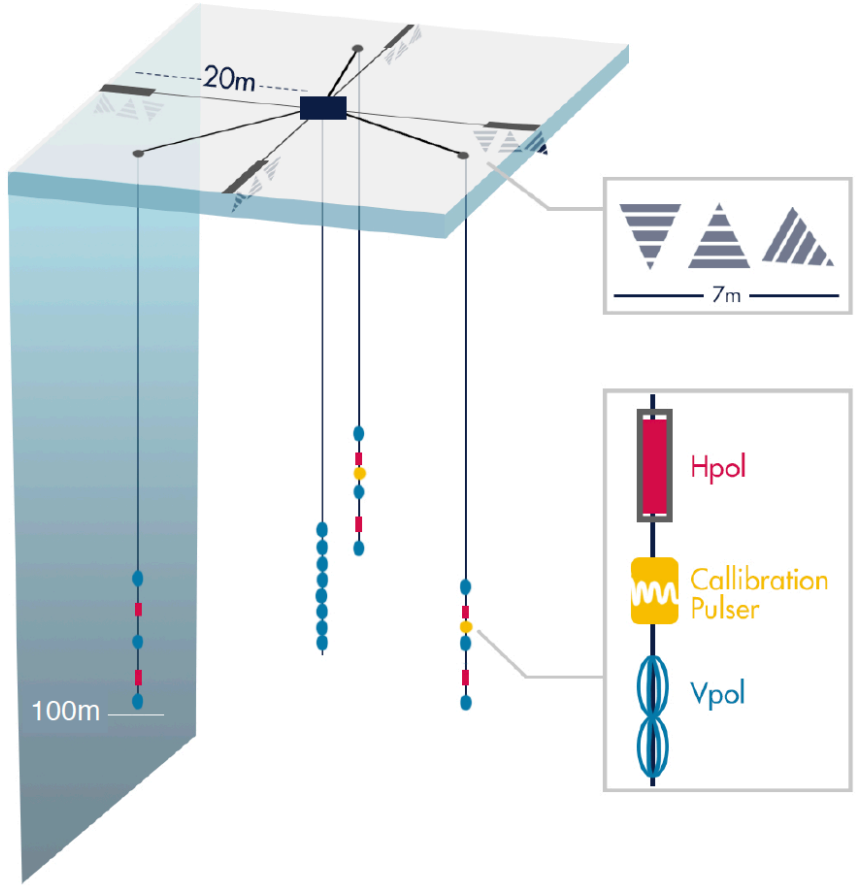
# The Gen2 radio array

**200 stations**
**~500 km^2**

- A daunting scale! Impact on Gen2 deployment.
- Highly efficient deployment will be critical.




Heritage:
RICE, ARA, ARIANNA

RNO-G (Greenland) first deployment summer 2020

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# EHWD-Gen1

Hose reel

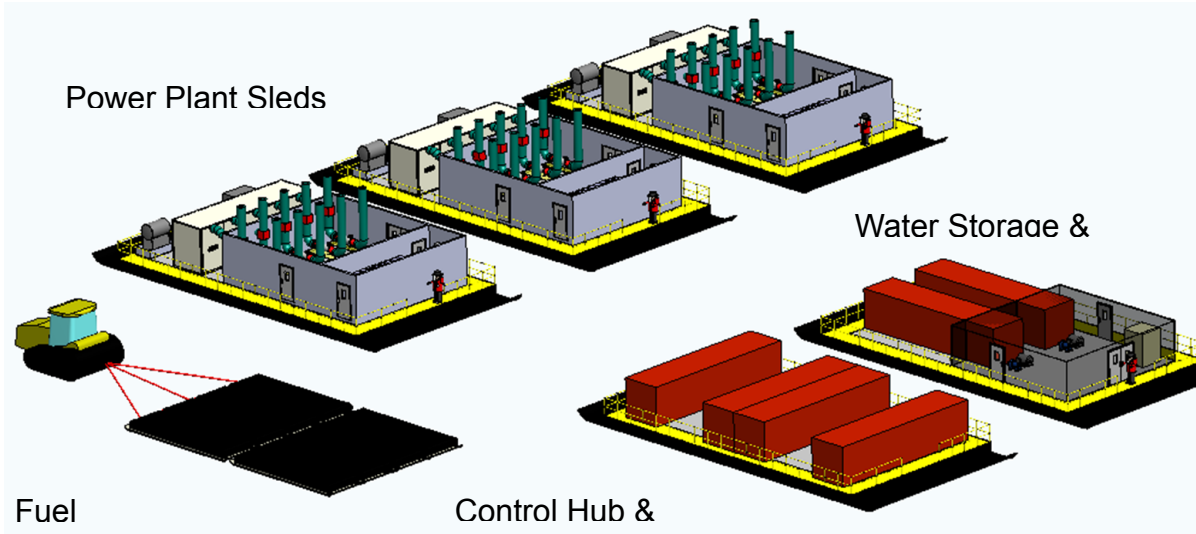
Mobile drill/deployment towers

EHWD heating plant: stationary
—> Gen2: mobile

# Gen2 hot water drill - changes in requirements



- Mobility:  IceCube drill was stationary per season. Gen2 string spacing requires a mobile drill.  WDrill will be moved multiple times per season.
- Improved efficiency and lower maintenance technology
- Aim for higher drill speed. (Gen1: 2.1 m/min, Gen2 target close to 3 m/min)


IceCube GEN2

# Logistical Support



1. Logistical Support: IceCube Gen1 had 9.5 million lb of cargo + fuel delivered by plane, more than 300 LC 130 missions. Construction took place simultaneously with South Pole station completion and SPT construction.
2. In recent years logistical support has dropped compared to 10 years ago. This is primarily funding driven. However, funding for logistical support is provided by the project.
3. Strategies for logistical support exist and have been discussed with ASC.
    1. Population of 60 people: —> separate field camp.
    2. Cargo: Traverse is scalable and can take care of fuel (2/3) and possibly cargo but this is not current practice.
4. Successful support will require high level prioritization and strategic planning at NSF's Polar Program.

—> Question 1

# IceCube, and IceCube-Gen2 - numbers

| Item | IceCube actual | IceCube-Gen2 projected |
|---|---|---|
| Deep ice strings | 86 | 120 |
| Drill and install seasons at Pole | 7 (started 2004) | 8 (start 2025) |
| Sensors/ strings | 60 | 100 |
| Hole depth (m) | 2450 | 2600 |
| Drilled hole diameter (cm) | 60 | 55 |
| Surface detector stations | 81 | 120 |
| Radio stations | none | 200 |
| Peak season total population | 50 | 60 |
| Population for radio | 0 | 10 |
| Typical total deployments | 90 | 100 |
| Typical yearly support from contractor (labor hours) | 21000 | 21000 |
| Total cargo delivered including fuel (lbs) | 9.5M | 9.5M |
| Fuel only (lbs) | 4.1M | 4.7M |
| Drill (lbs) | 1.4M | 1M |
| Instrumentation (lbs) | 4M | 2.75M |
| Instrumentation, radio (lbs) | 0 | 0.2M |
| Operating power (kW) | 70 | 150 (including Gen1) |
| 'Dedicated' Herc flights per season | 60 | ≤30 (use of traverse) |
| Total fuel used (gal) | 572k | 660k (drilling and camp) |
| Typical season length | Early November to late January | Early November to early February |
| Daily data transfer to north via satellite (GB) | 105 | 150 (including Gen1) |
| Primary method of fuel delivery to Pole | Herc LC-130 aircraft fuel tanker | South Pole Traverse (tractors with sleds) |
| Population housing method | Station, summer camp | Station, field camp |
| Field camp | N/A | Housing for up to 60 people |
| Other large projects during construction | South Pole Station, South Pole Telescope | AIMS, potentially CMB-S4 |
| Work schedule at Pole | 3 shifts, 24 hours per day, 6 days per week | 3 shifts, 24 hours per day, 6 days per week |
| Heavy equipment dedicated to project | Loader, skidsteer | Caterpillar Challenger or D8 dozer, 953 loader, skidsteer, transport van |

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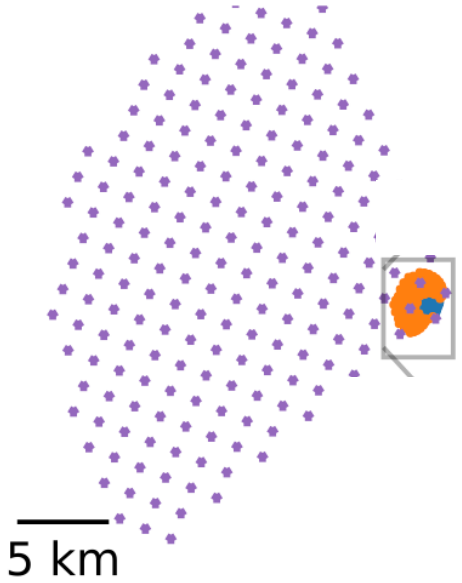
# IceCube-Gen2 Challenges: Radio array deployment

Drilling 120 holes: IceCube drilling required 7 seasons for 86 strings. Gen2 is planning 8 seasons for 120 strings.




Measures:

1. Drill speed. R&D underway to increase drill speed for Gen2. This can be achieved by increasing water pressure at the drill head from 1000 to ~1500 psi. Note that this will result in fuel savings of order 20 to 30%.
2. Investigate to increase season length by 1 or 2 weeks in February.

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# IceCube-Gen2 - Challenges: Radio array deployment

## Drilling

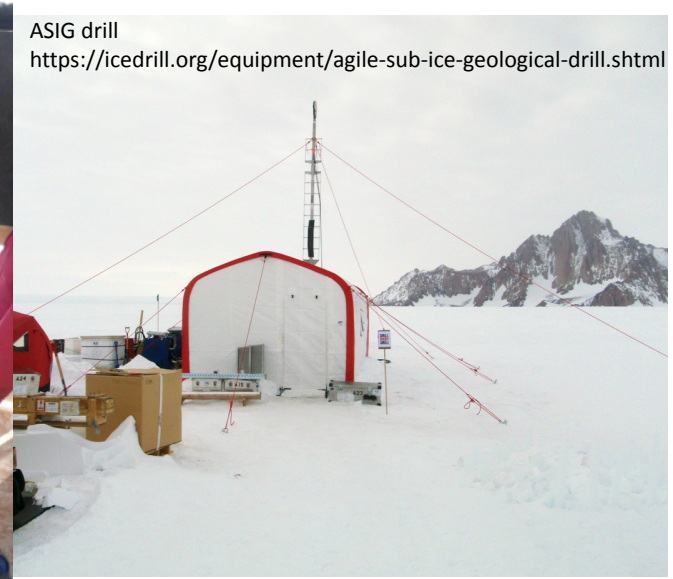
1. Drilling 600 holes for radio while a challenge, is conceptually straightforward.
2. Scalable solutions exist. ASIG drill is current reference. Requires to people to operate. can be turned on and off.
3. For production, a conceptually similar but more automated design of the British Antarctic Survey is envisioned.

Population: 2 - 3 people/hole/day

*Reminder, why drilling:*
*the same detector at 100m depth collects about 3 times more events than at the surface.*

## Deployment

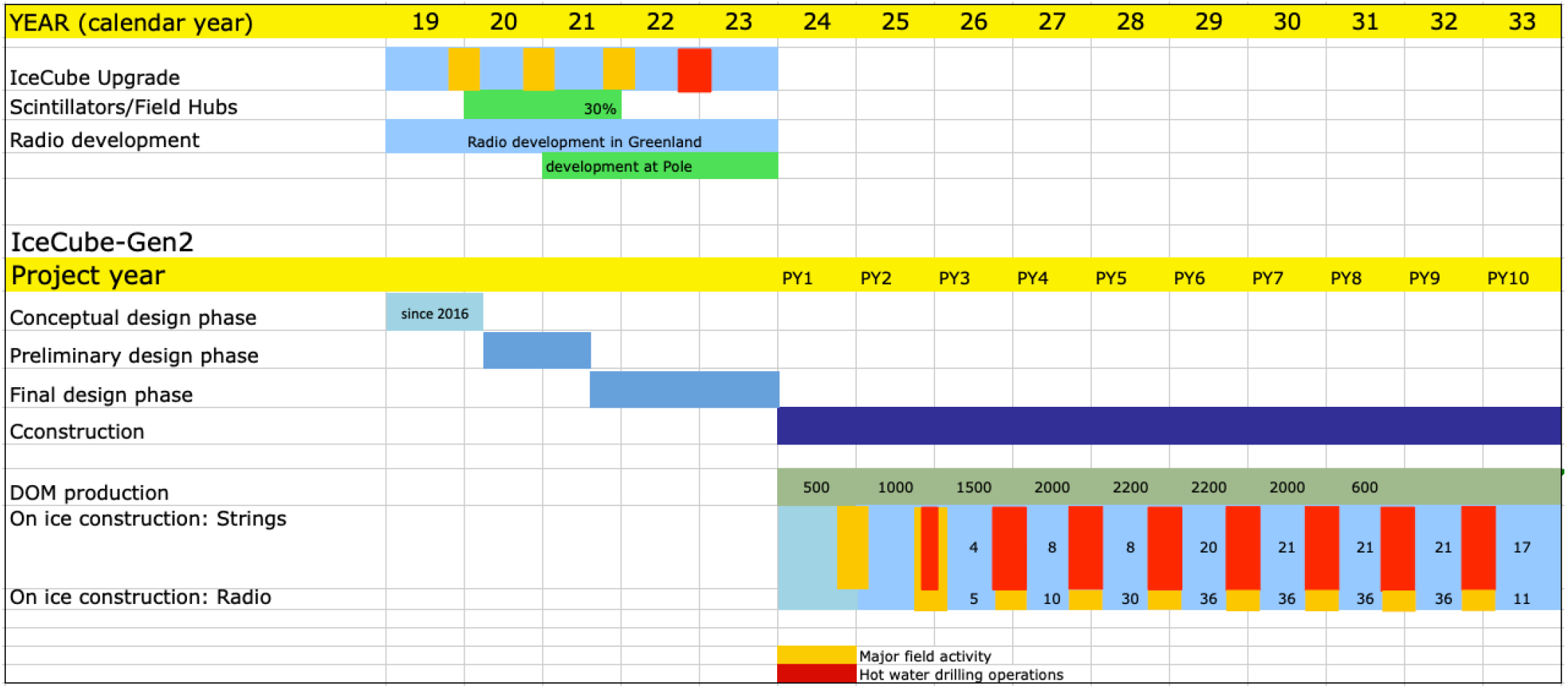
1. Deployment takes most of the labor. about 2/3 of the population will be needed for deployment.
2. Long distances require special safety considerations.
3. Good equipment for transportation: Field shelters, Arctic trucks.



ASIG drill
https://icedrill.org/equipment/agile-sub-ice-geological-drill.shtml

# Timeline







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# Gen2 — cables: surface

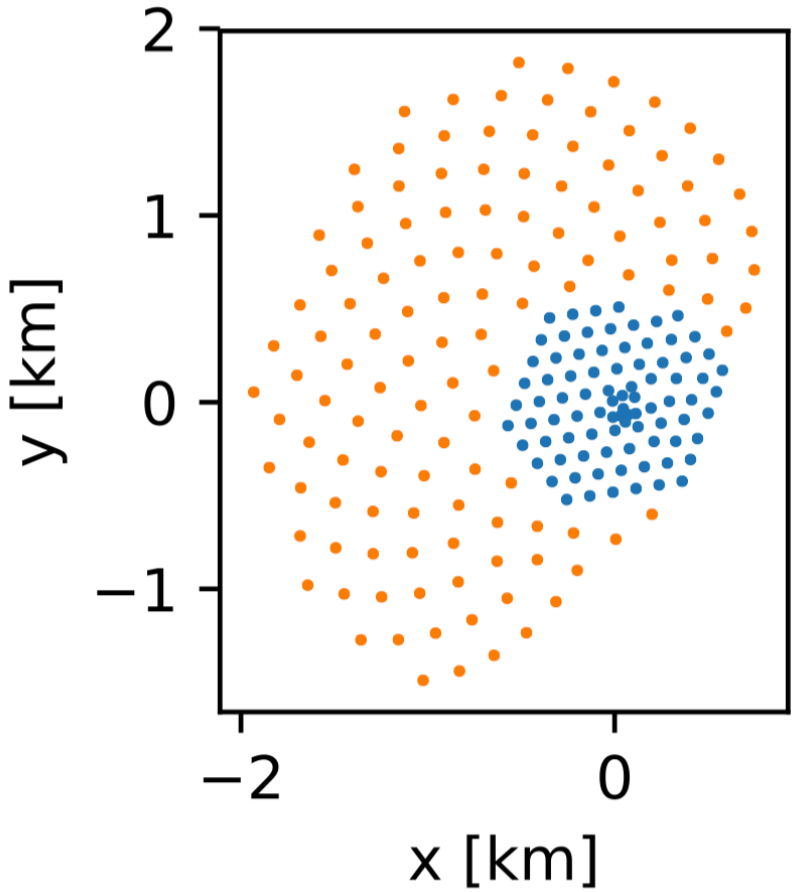


Field hub:
Deliver optical fiber and power to each string location.
Switch then to in-ice cable

R&D from scintillator array applies directly to Gen2 string architecture.

Considering taking connections and electronics above ground.

The housing approach is still at very early stage.

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# Surface detector Gen2



- Following the IceTop model, one unit per string.

- Cross calibration
- Cosmic rays at high energies
- Veto x 40