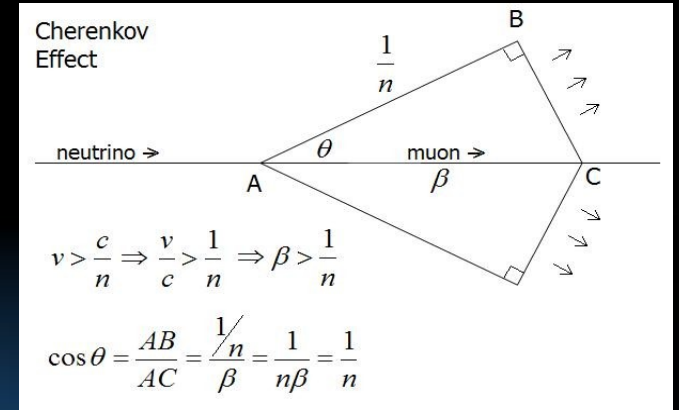
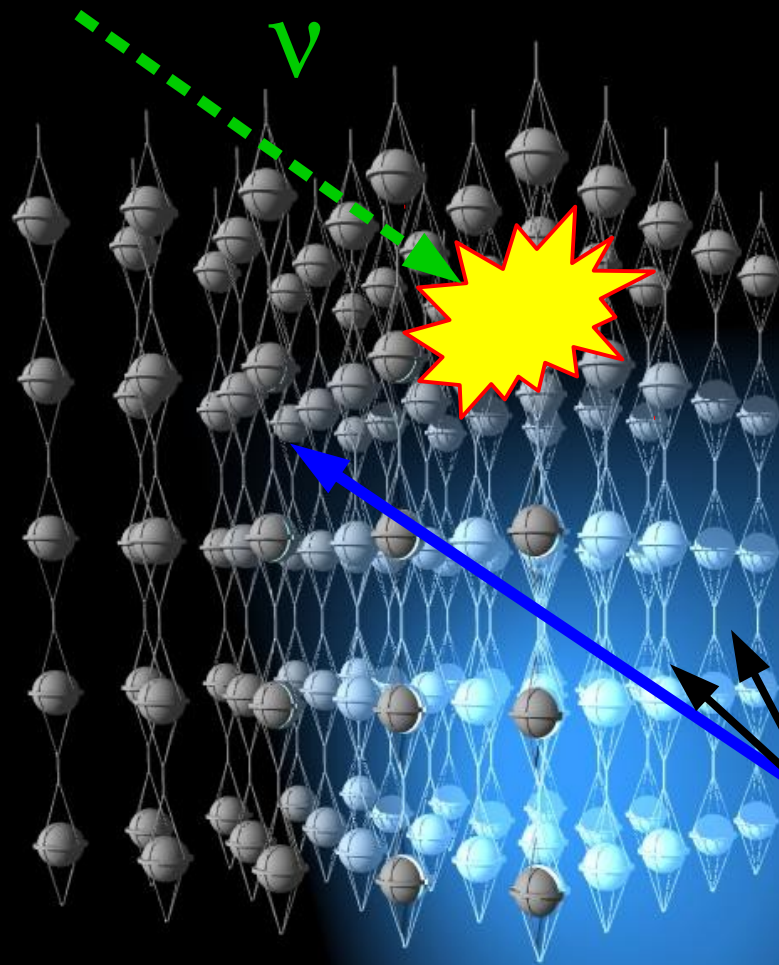


# IceCube Hardware

I: Detector

Seminar

October 22nd, 2015



Particle Shower

## Main Principle:

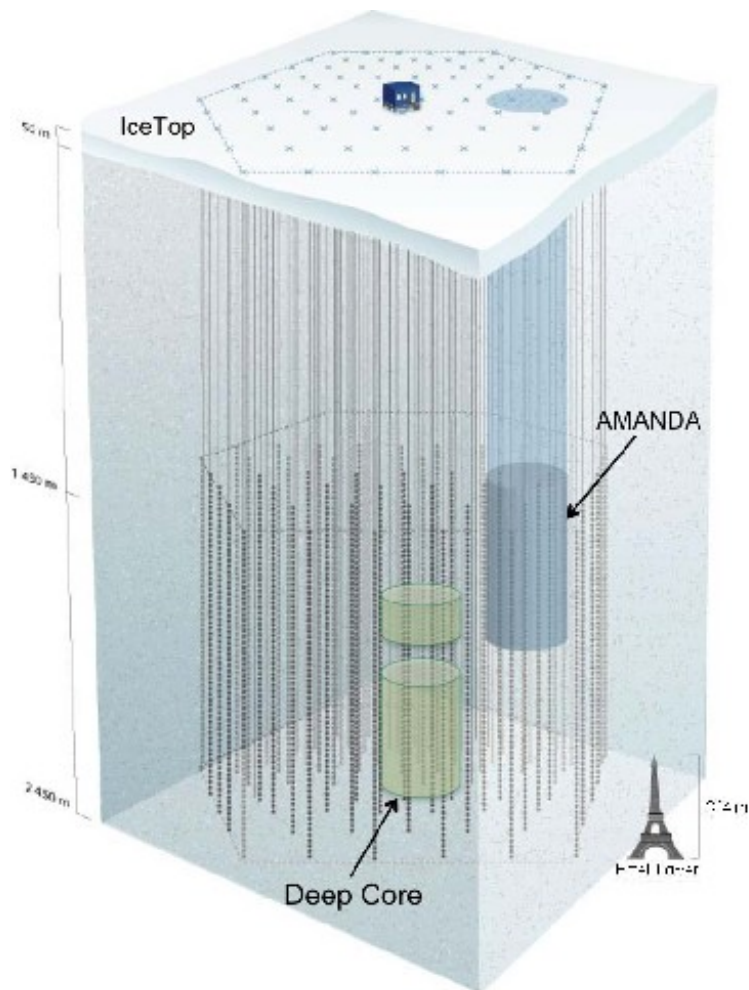
Detection of neutrino interactions through Cherenkov light emission of secondary charged particles

# IceCube

$1 \text{ km}^3$

86x60 DOMs

built between  
2004 and 2010

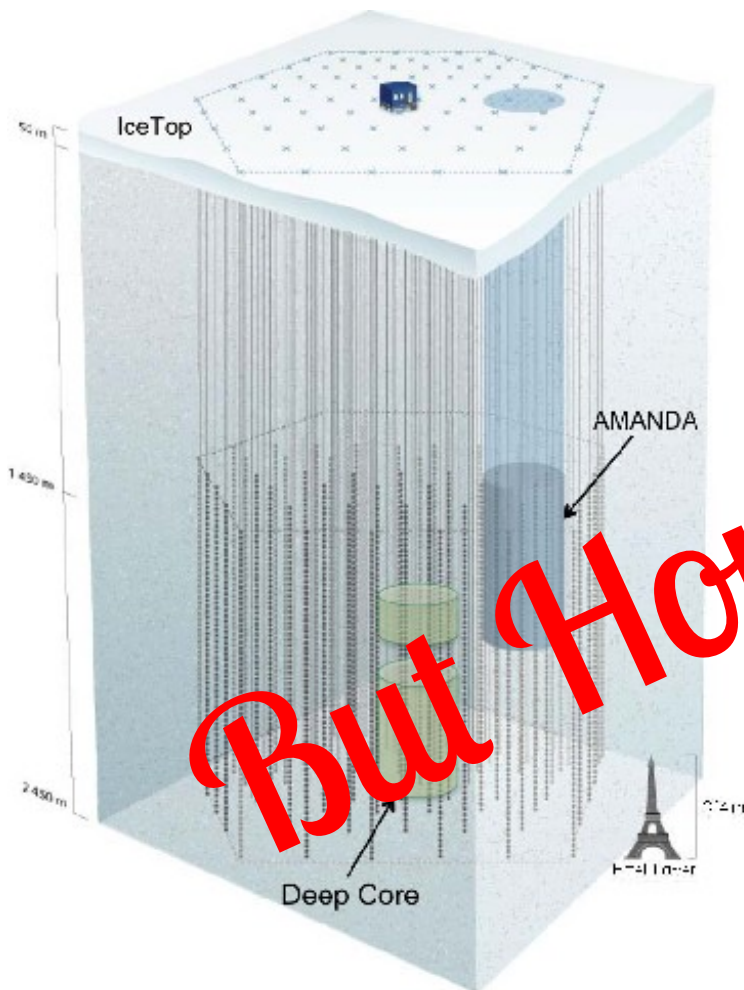


# IceCube

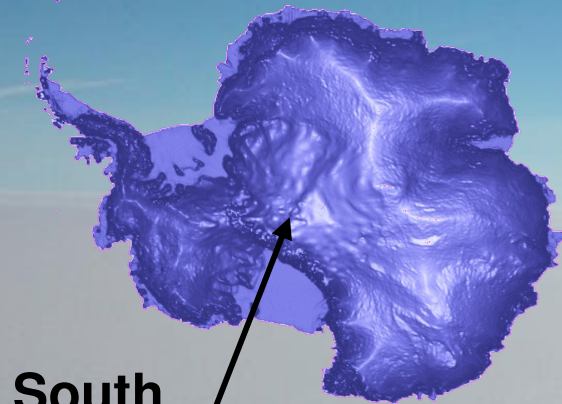
1 km<sup>3</sup>

86x60 DOMs

built between  
2004 and 2010



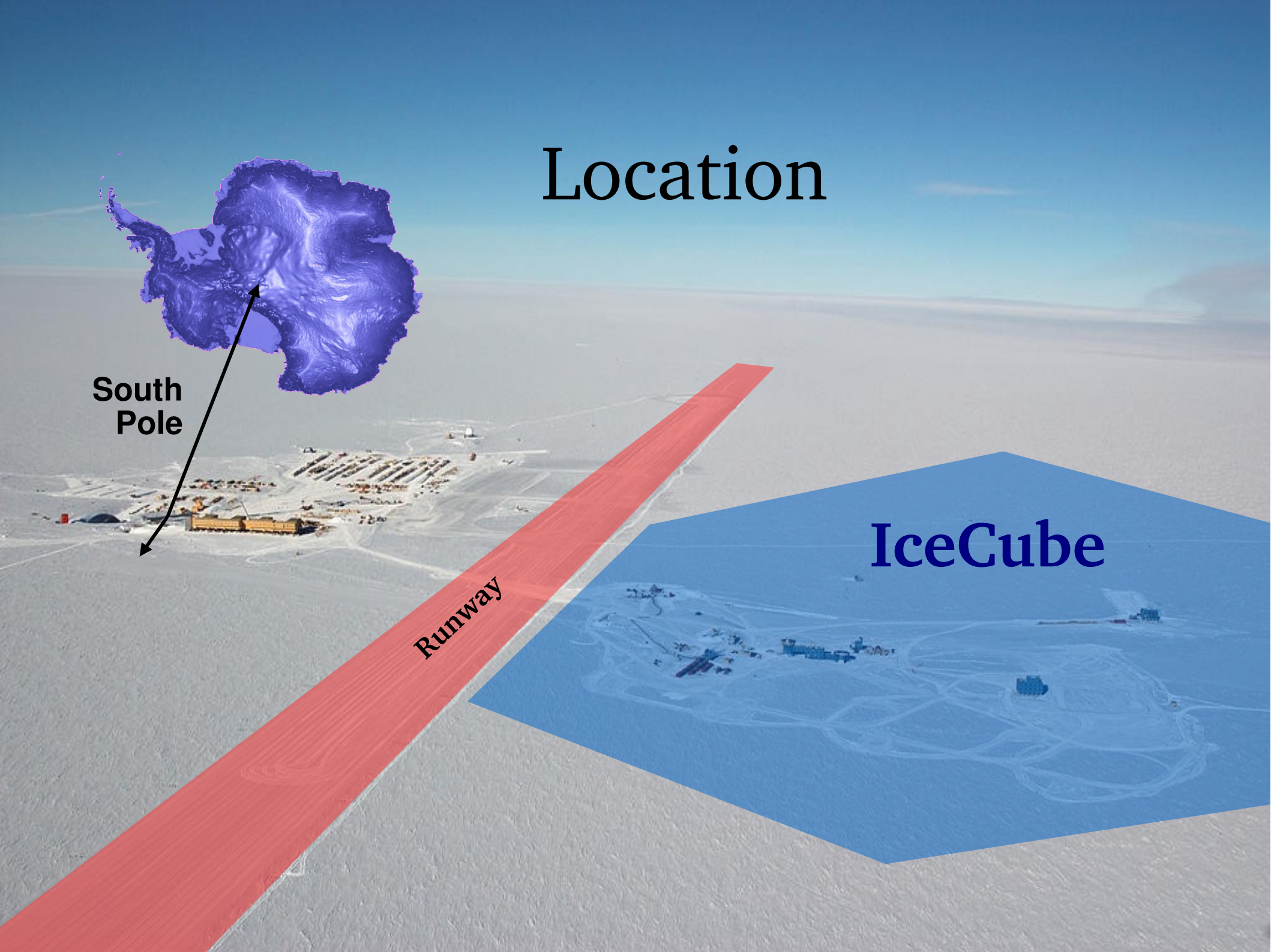
# Location



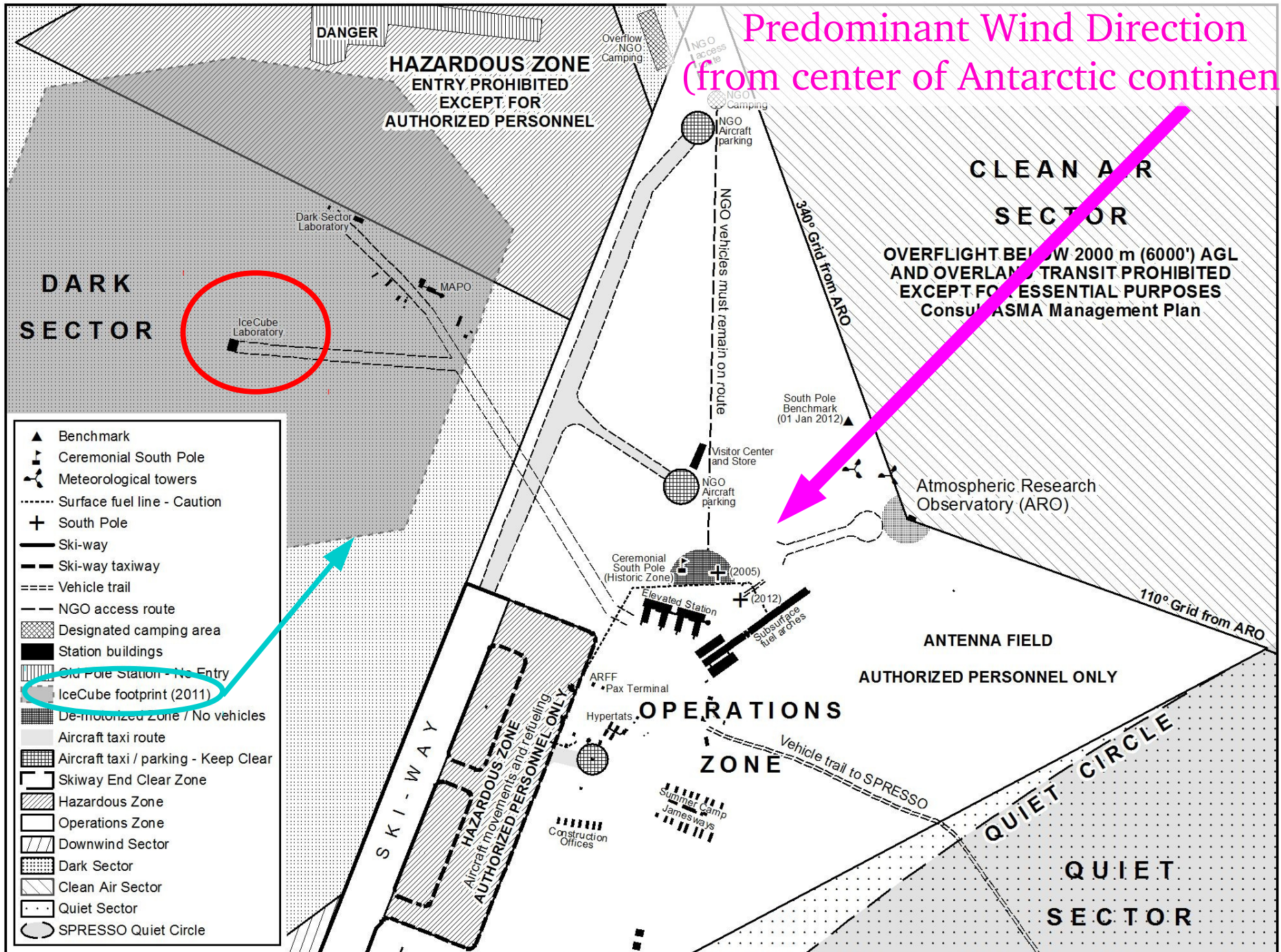
South  
Pole

Runway

IceCube



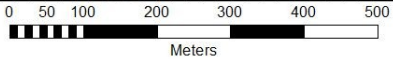
Predominant Wind Direction  
(from center of Antarctic continent)



- ▲ Benchmark
- ⚡ Ceremonial South Pole
- 🌬 Meteorological towers
- ⋯ Surface fuel line - Caution
- ⊕ South Pole
- Ski-way
- - - Ski-way taxiway
- ==== Vehicle trail
- - - NGO access route
- ▨ Designated camping area
- Station buildings
- ▨ Old Pole Station - No Entry
- ▨ IceCube footprint (2011)
- ▨ De-motorized zone / No vehicles
- ▨ Aircraft taxi route
- ▨ Aircraft taxi / parking - Keep Clear
- ▨ Skiway End Clear Zone
- ▨ Hazardous Zone
- ▨ Operations Zone
- ▨ Downwind Sector
- ▨ Dark Sector
- ▨ Clean Air Sector
- ▨ Quiet Sector
- SPRESSO Quiet Circle

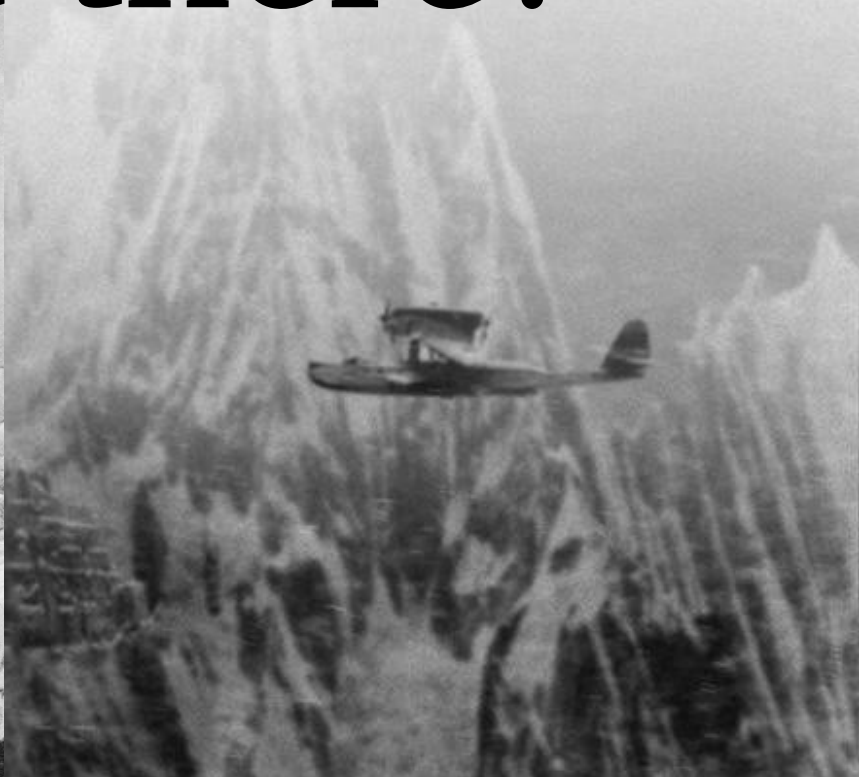
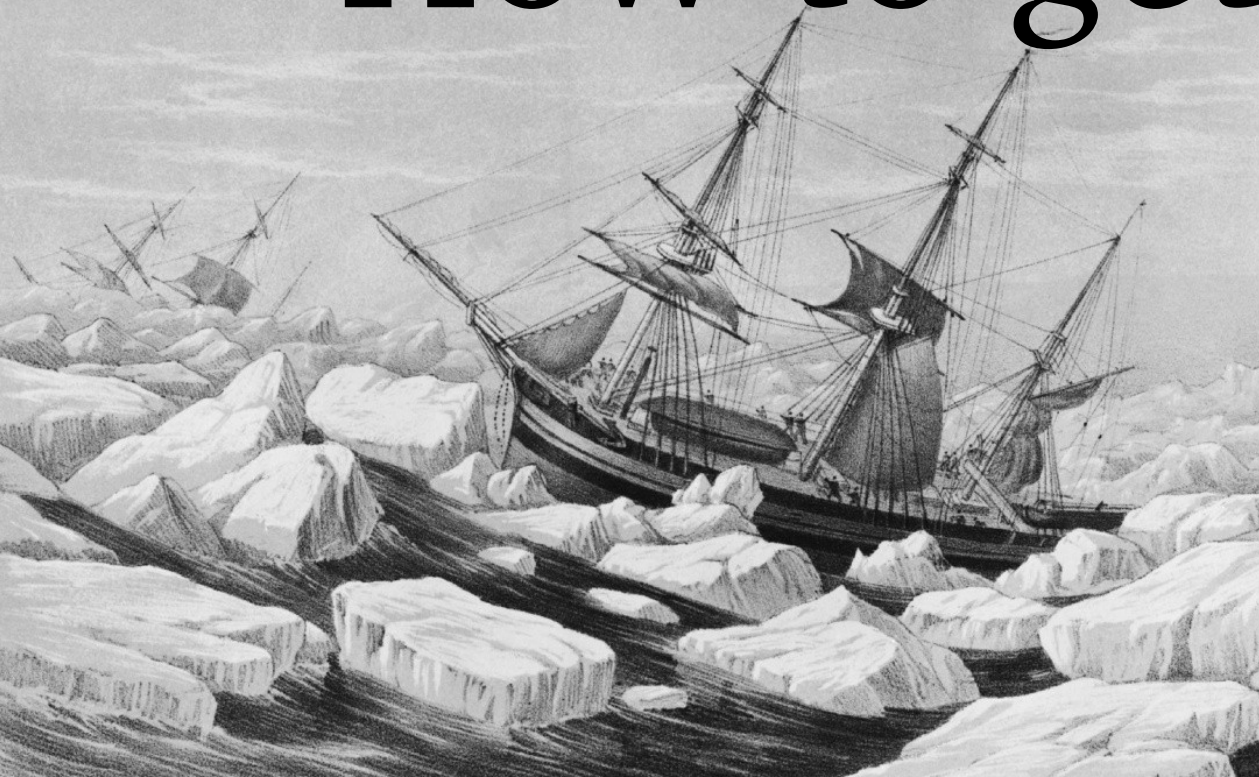
Projection: Polar Stereographic; Standard Parallel 90°S;  
Latitude of Origin 90°S; Spheroid: WGS84  
Data source: United States Antarctic Program

ASMA No. 5: South Pole  
Map 4: Amundsen-Scott Station





How to get there?





## Air Transport:

Christchurch, NZ





# C-17 "Globemaster"



## Air Transport:

Christchurch, NZ

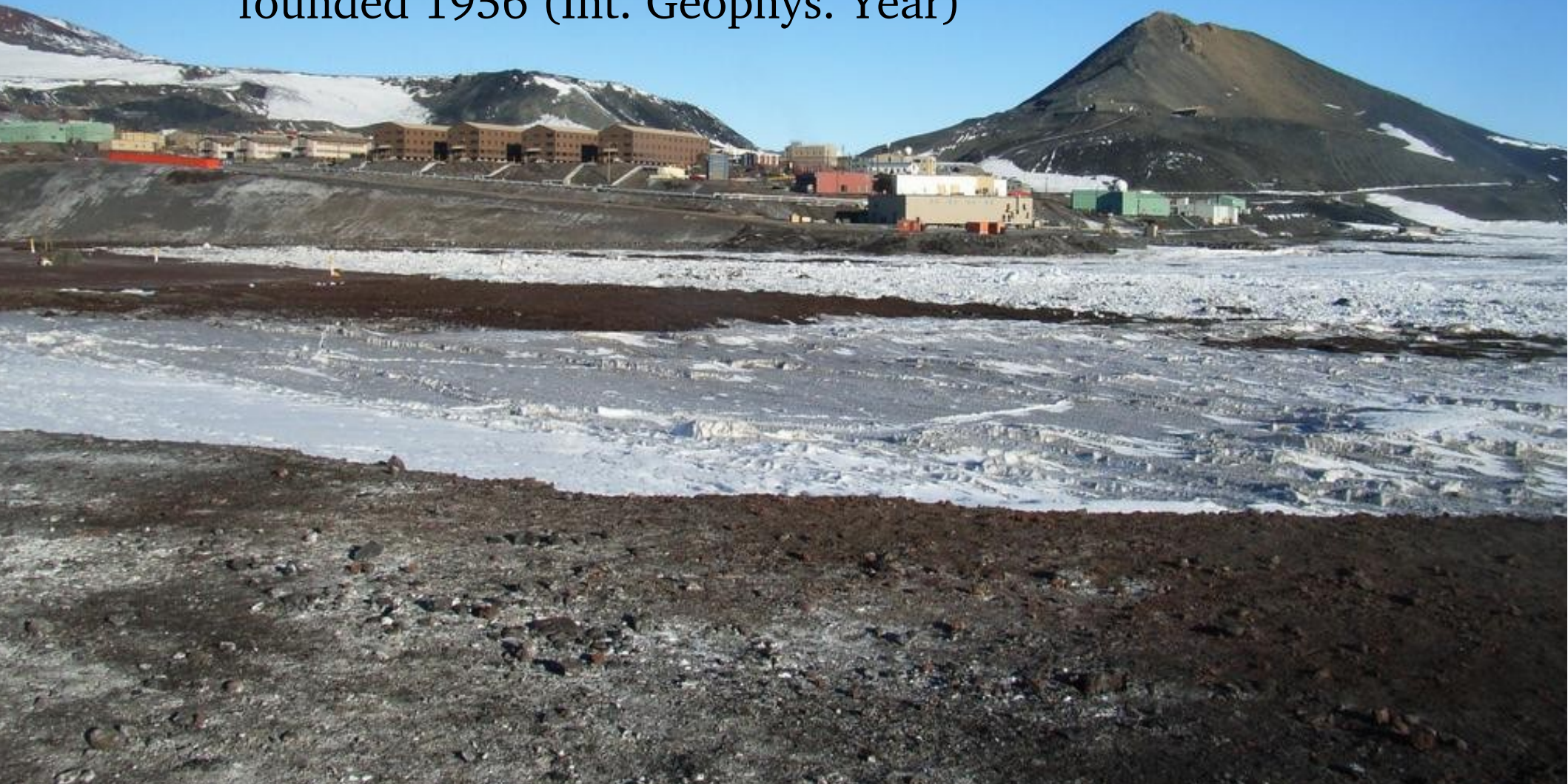
-  
McMurdo

# McMurdo

77° 51'

population: Up to 1200

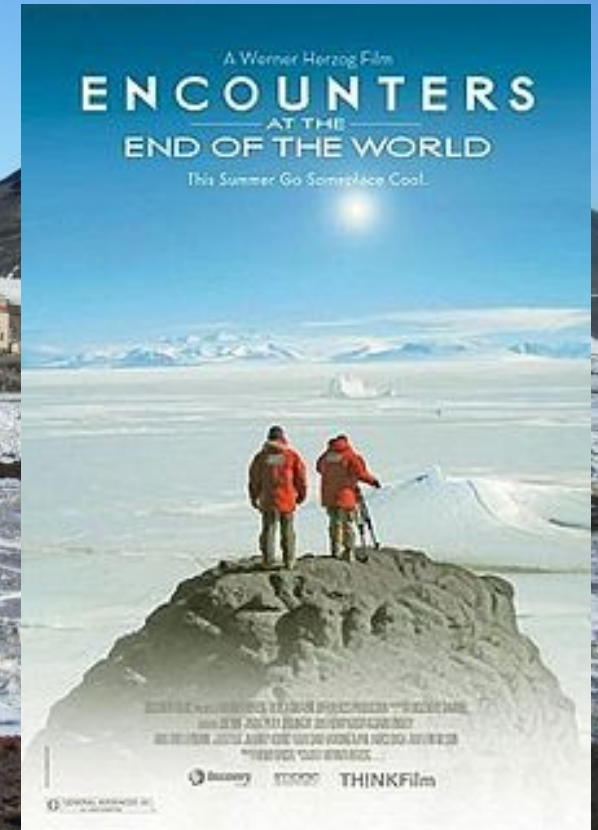
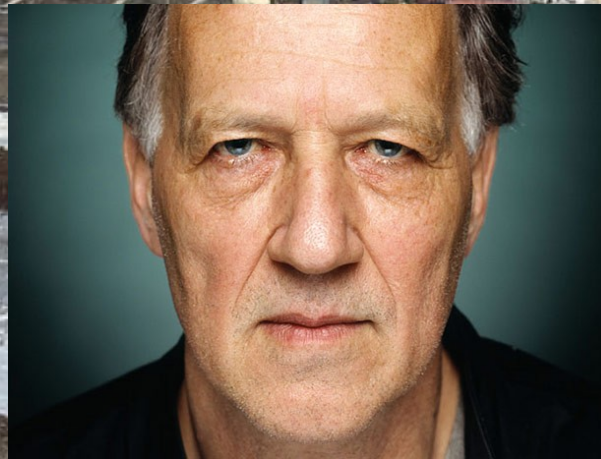
founded 1956 (Int. Geophys. Year)



# McMurdo

“The most bureaucratic place on Earth”

(W. Herzog)



# Coastal Location: Accessible by Ship!



Mt. Erebus  
(active volcano)  
3,794 m

Russian Ice Breaker  
«Krasin»



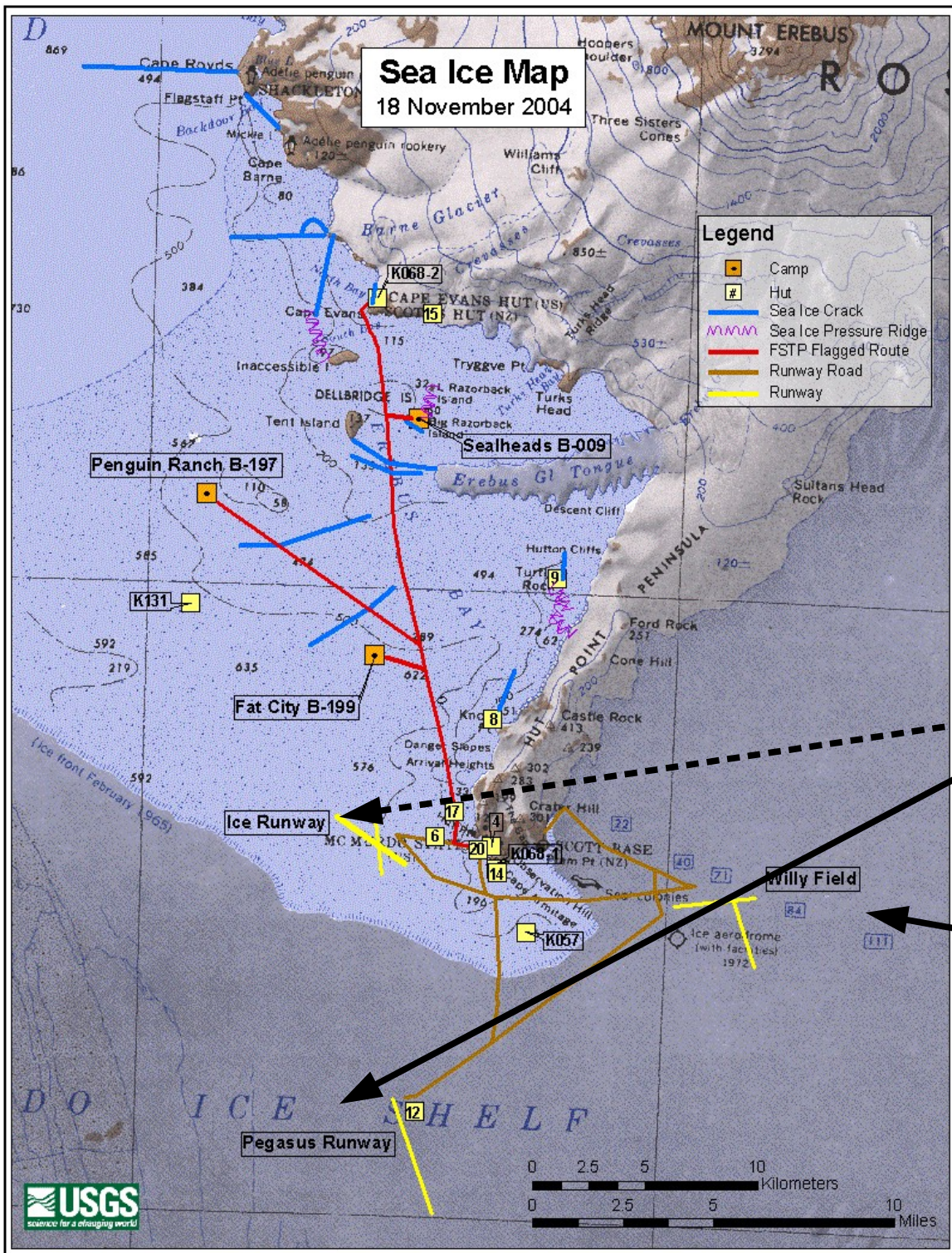
Sea Transport for Bulk Freight



# “Discovery Hut”

Built by R.F. Scott in 1902





Two (1/2)  
Runways:

Wheels  
(to outside world)

Skis  
(to Antarctic stations)





# C-130 "Hercules"



## Air Transport:

McMurdo

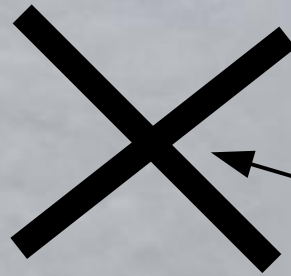
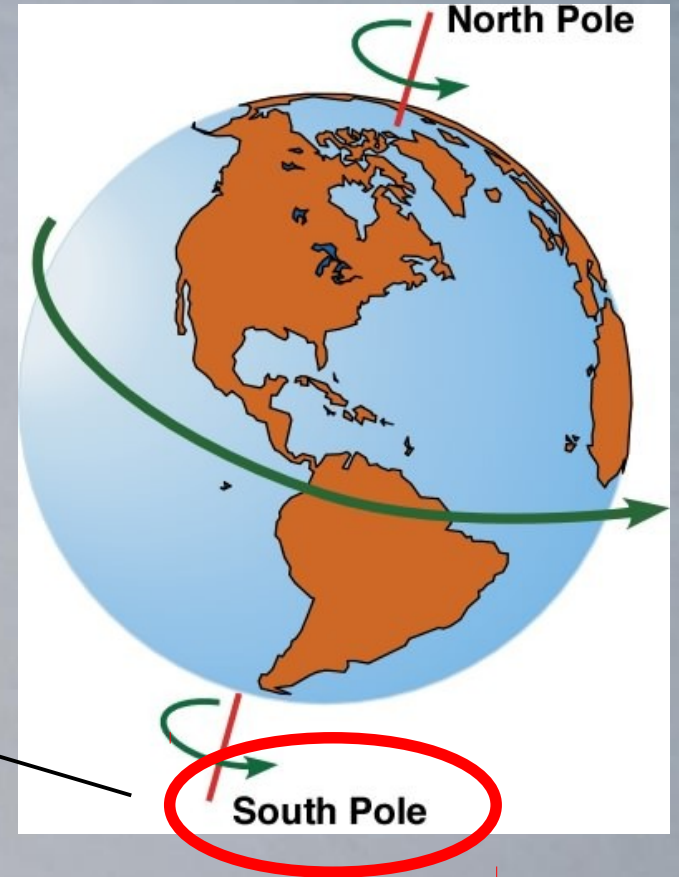
-

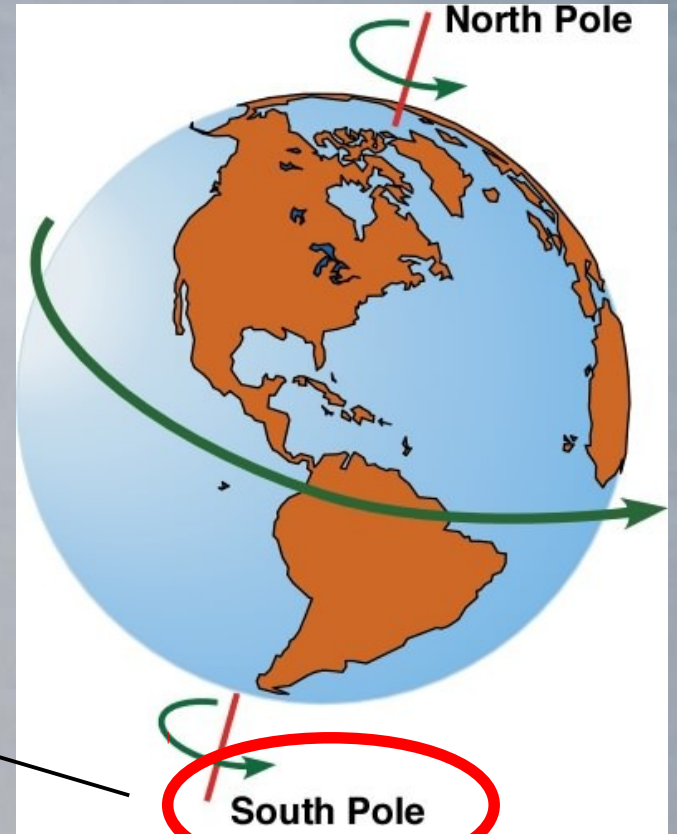
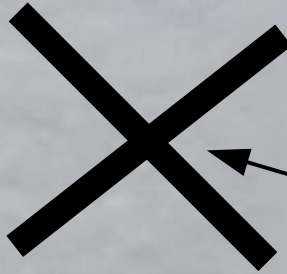
South Pole

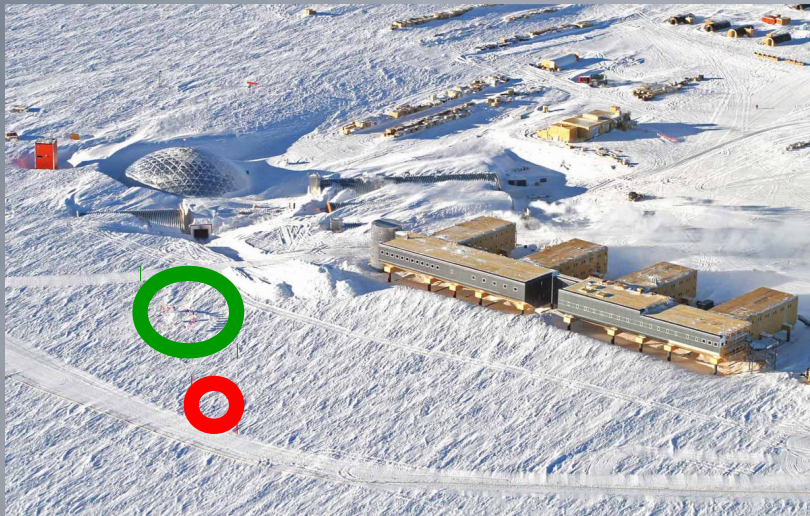
An aerial photograph of the South Pole Station in Antarctica. The station is a large, multi-story building with a grey facade and a flat roof, situated on a snow-covered slope. To the left of the station is a large, white, geodesic dome structure, which is the old dome mentioned in the text. The surrounding area is covered in snow and ice, with various tracks and structures visible. The text "Old Geodesic Dome, 1975 (demolished)" is overlaid on the image, and "South Pole Station" is also overlaid on the right side.

Old Geodesic Dome, 1975  
(demolished)

South Pole Station







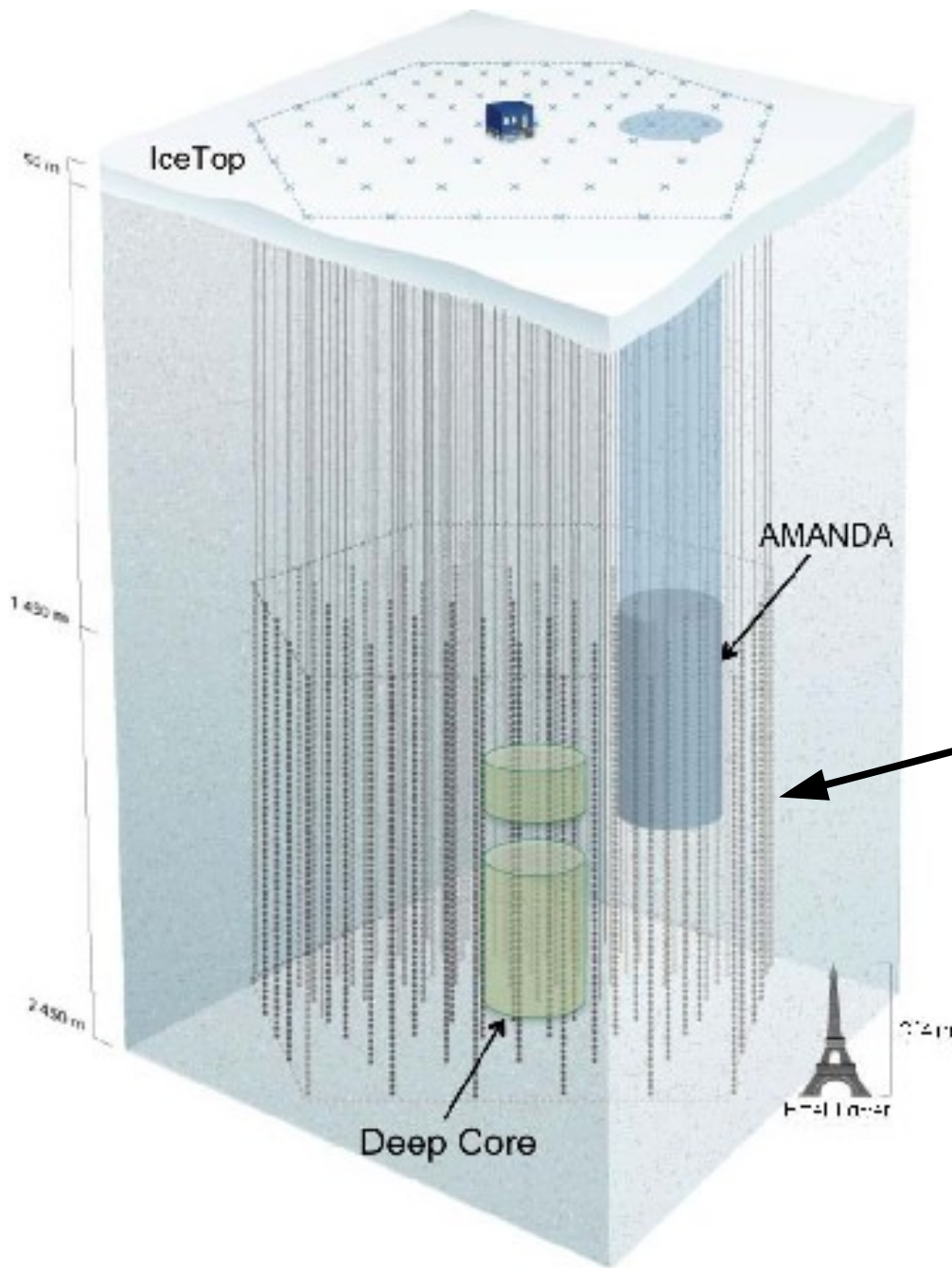
Ceremonial (“Tourist”) Pole



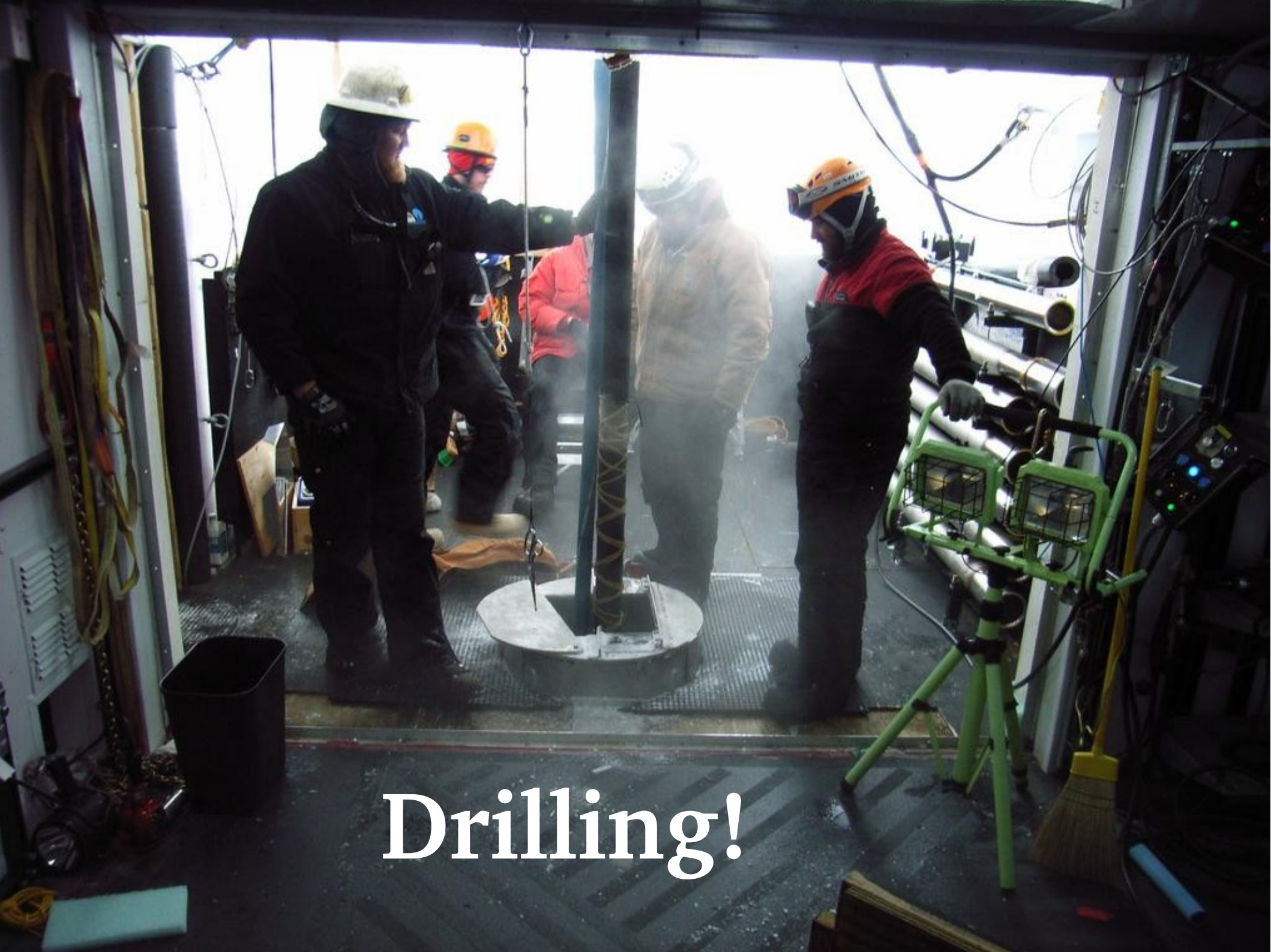
Flags of the **original 12** signatories  
of Antarctic Treaty



Ceremonial ("Tourist") Pole



How to get  
down there?



Drilling!



2100 mm

m  $\approx$  120 kg

# Drillers!



Melting ♥



~~Drilling!~~



South Pole:  
Six Months of Night!



Work Season:

End of October-Early February

Too cold for planes to land in winter=night!

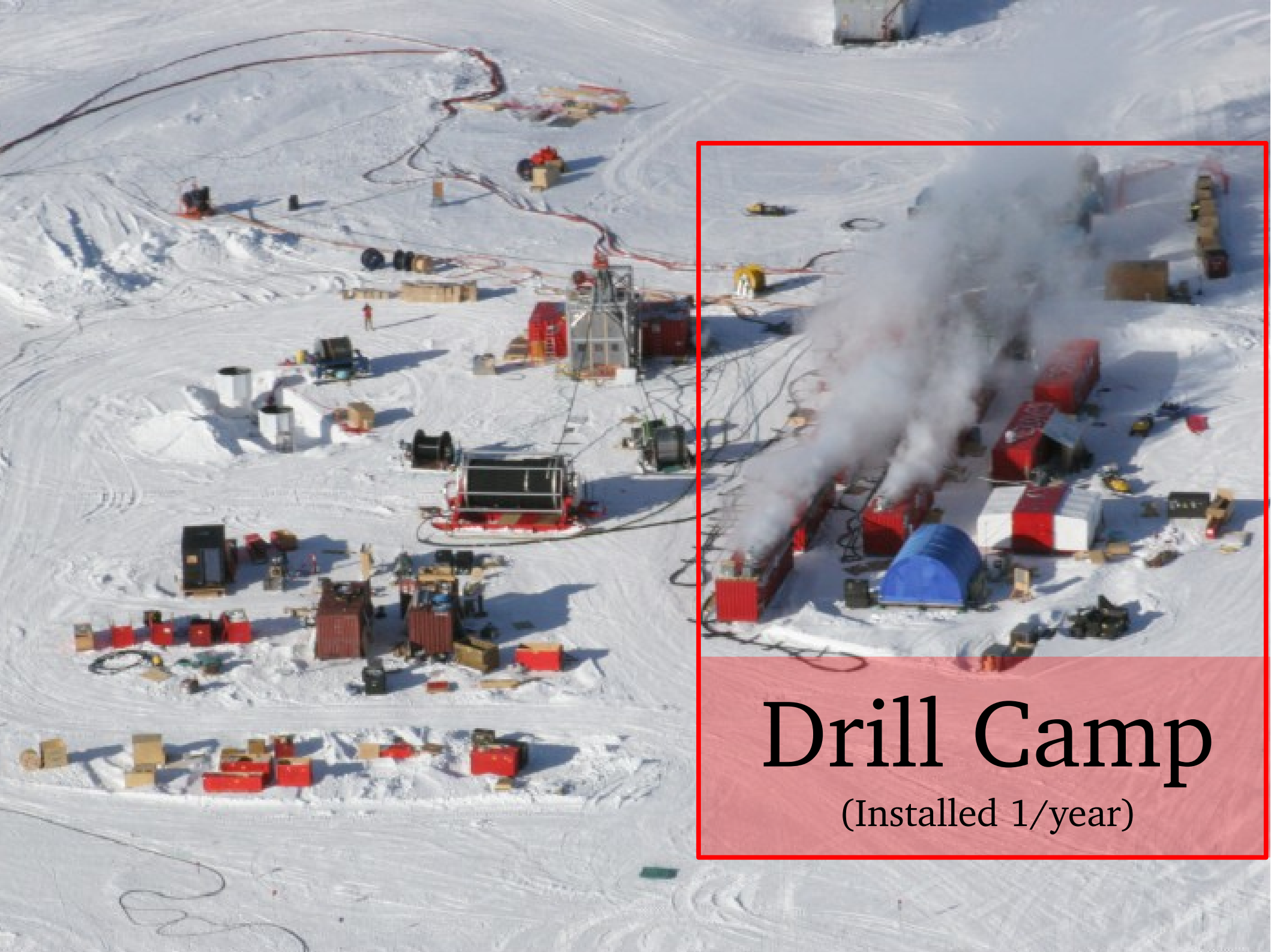
Station Population: ca. 40 (>200 in summer)



# First Plane 2015/16

## October 14th





# Drill Camp

(Installed 1/year)

# Technical Data

## Ice Volume:

60 cm diameter, 2450 m depth  $\approx 700\text{m}^3$  per hole

## Water Supply:

760 liters/minute at 70 atm and  $88^\circ\text{C}$

## Power:

4.5 MW thermal, 330 kW electrical

## Fuel oil requirement:

27,400 liters/hole (estimated average)

An aerial photograph of a snowy field. In the center, there is a complex of industrial equipment, including a tall tower structure and various containers. To the right, there is a cluster of red and white buildings, some with smoke rising from them, indicating a camp. The ground is covered in snow with tracks from vehicles and equipment. A green box highlights the central industrial area, and a red box highlights the camp area.

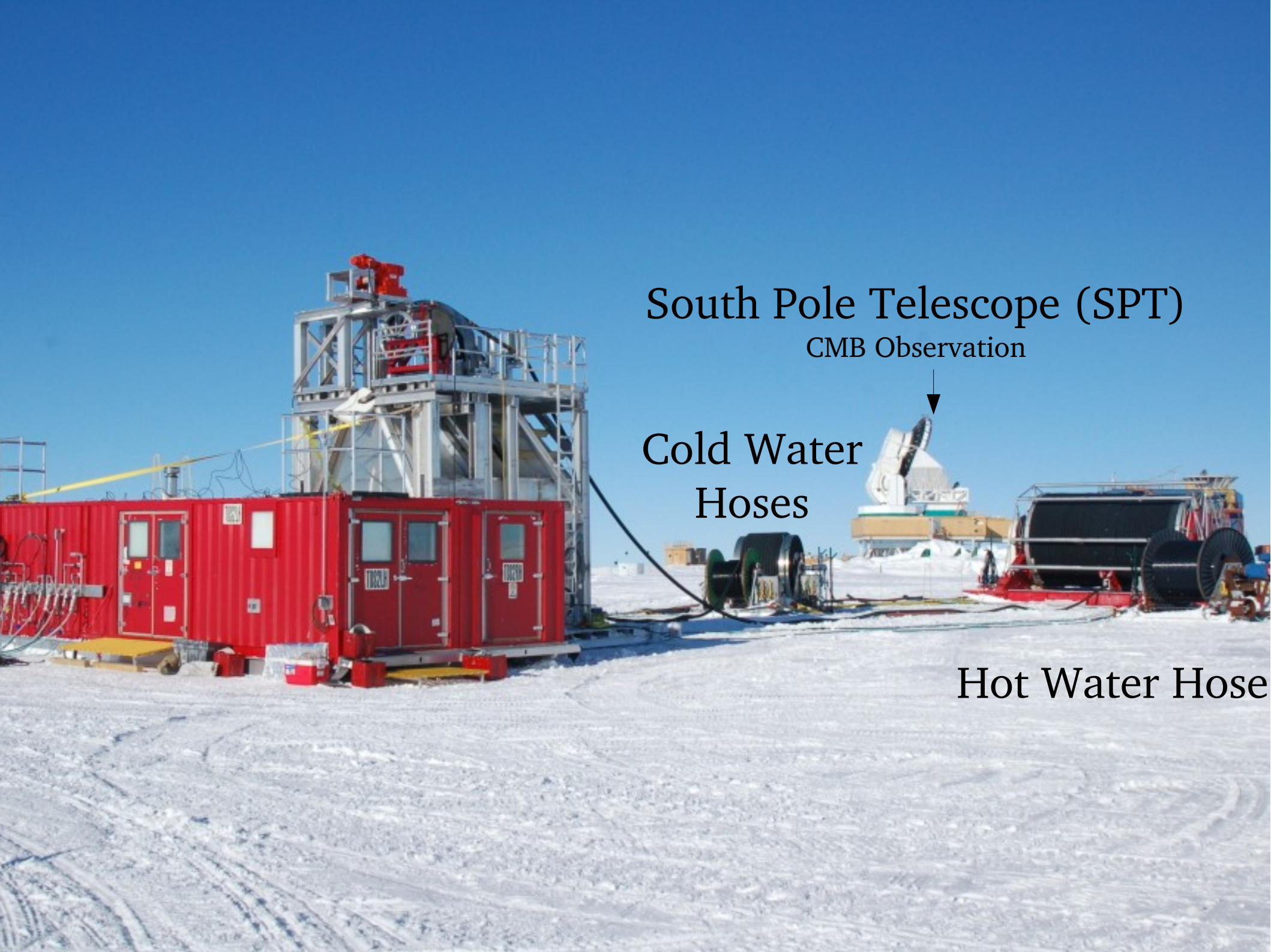
## Tower Operation Site (TOS)

Moved for String Deployment

# Drill Camp

(Installed 1/year)





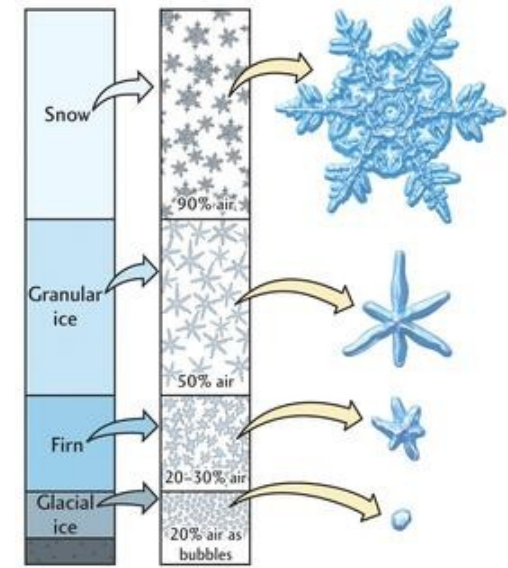
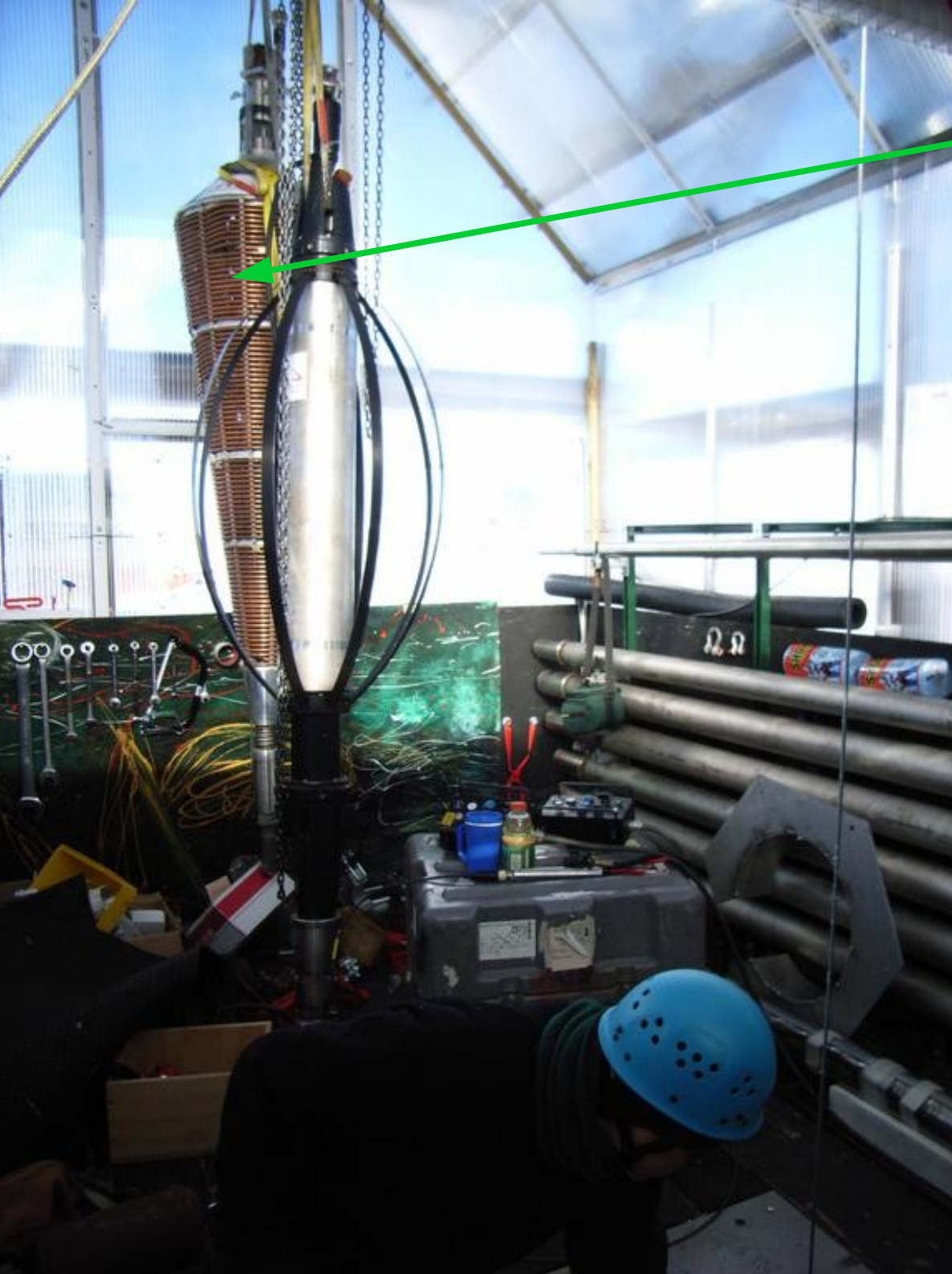
South Pole Telescope (SPT)

CMB Observation

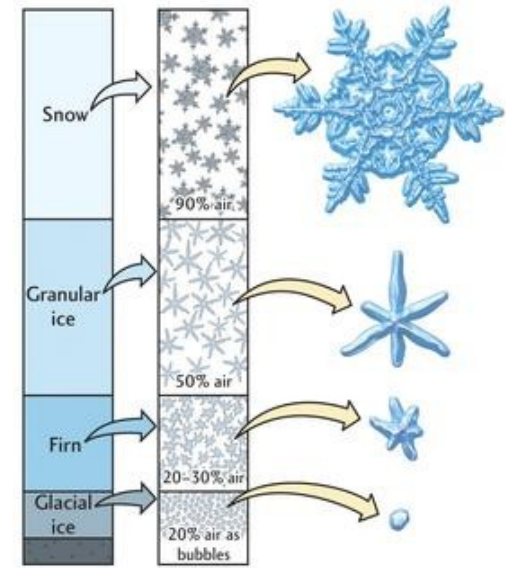
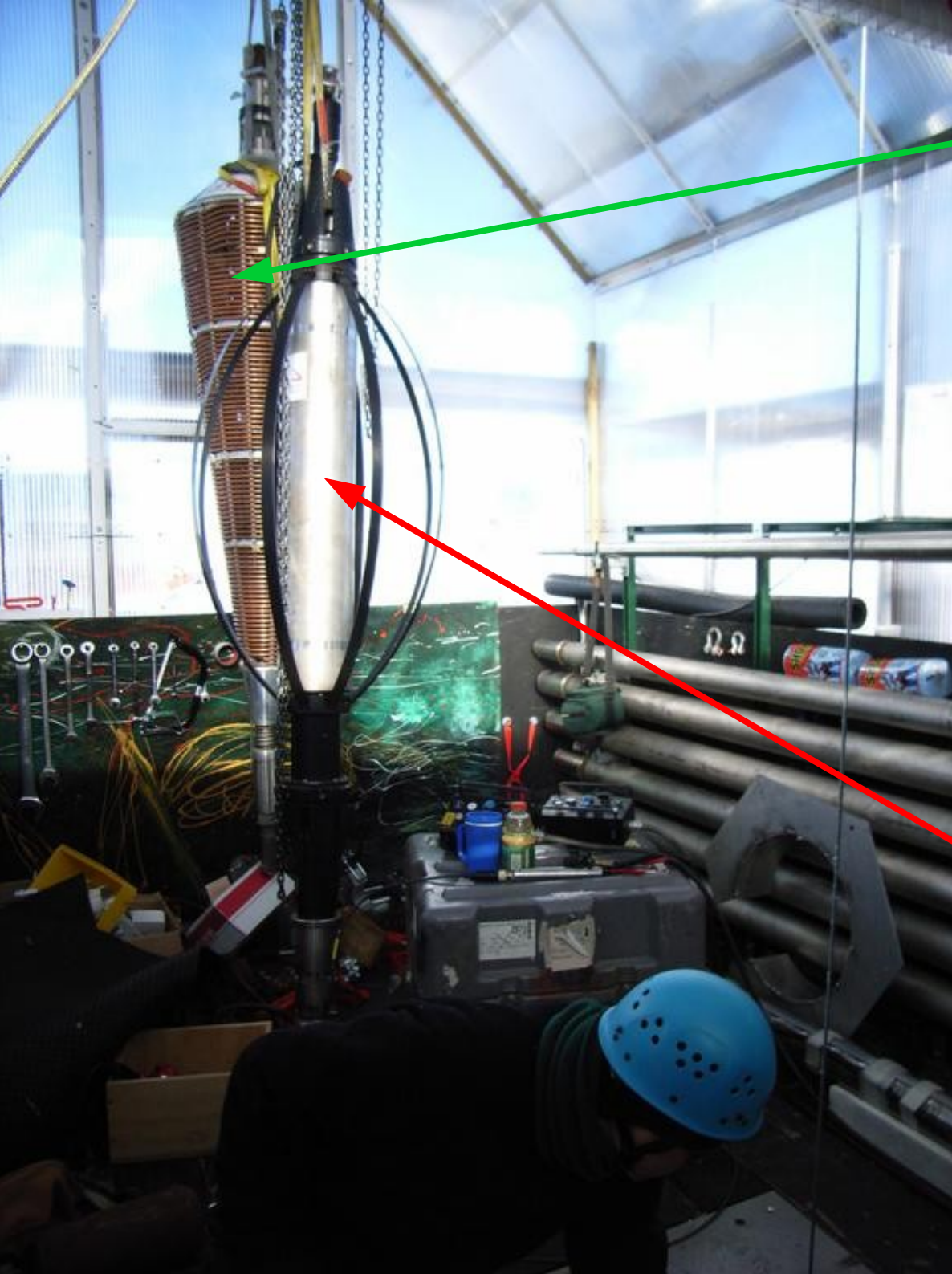


Cold Water  
Hoses

Hot Water Hose



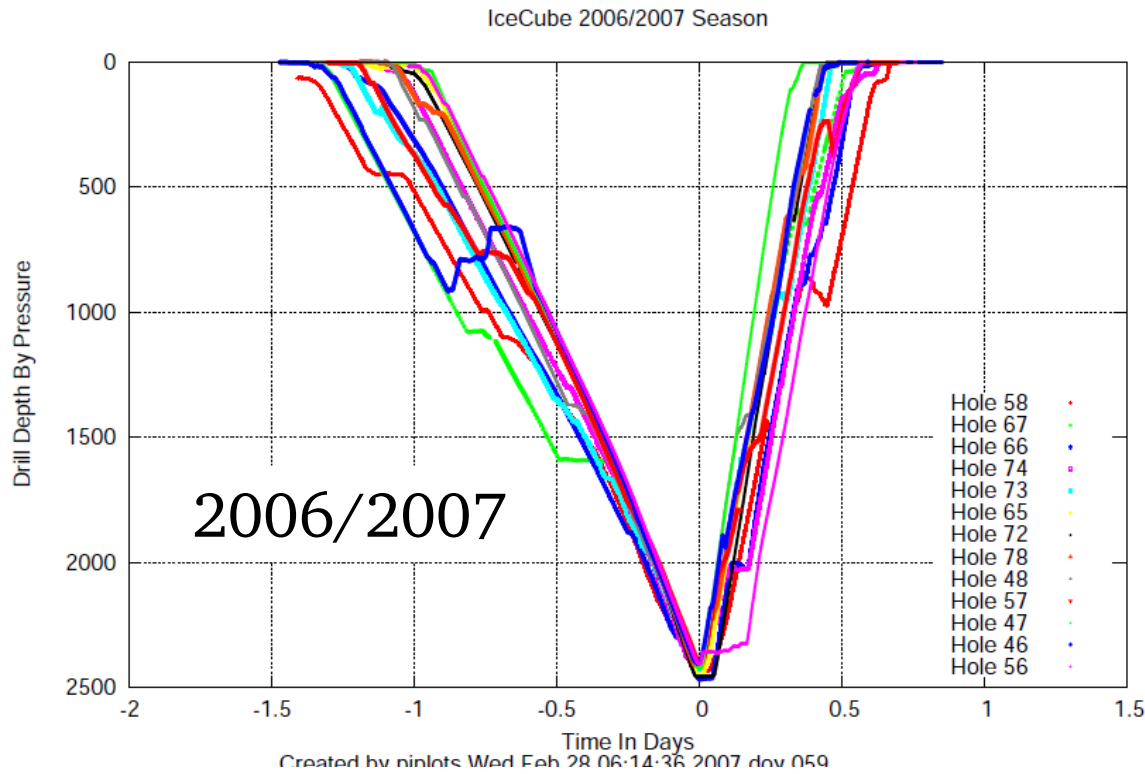
First 50 Meters:  
Closed-Circuit  
“Firn Drill”



First 50 Meters:  
Closed-Circuit  
“Firn Drill”

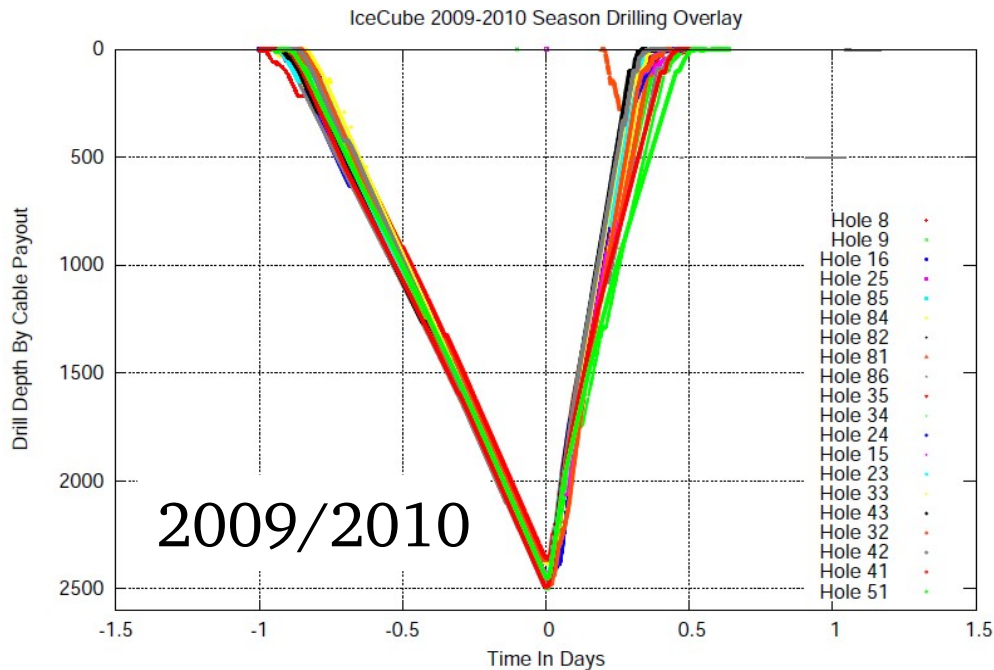
Solid Ice:  
Hot Water Drill





Drilling time:  
 $< 36$  hours/hole

Up to 20 holes per year  
 Working season:  
 End of November-  
 Early January

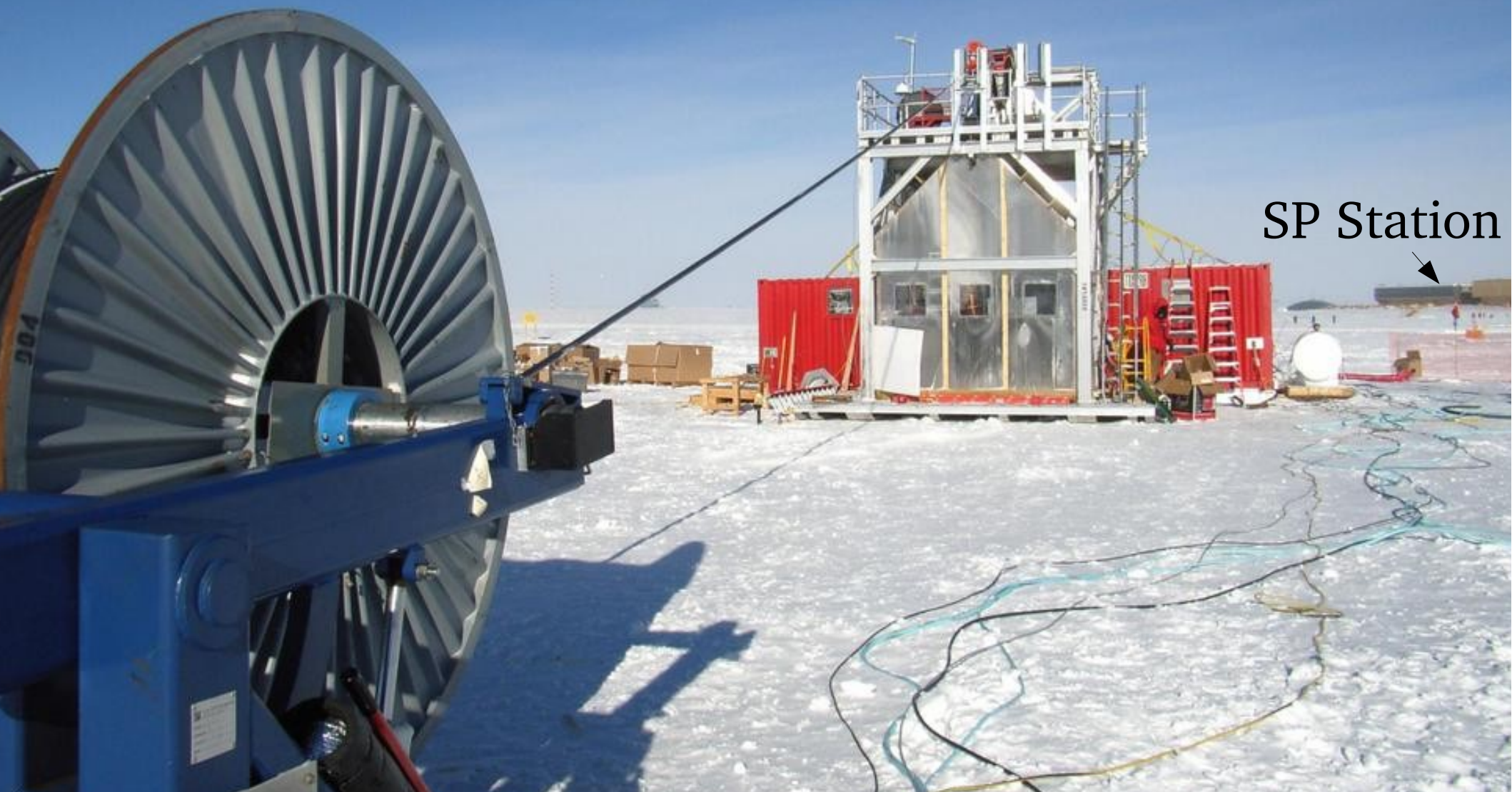


Ok. Now what?

Water Level:  
20 meters below surface



# Cable “String”



SP Station



# The (c)old days: AMANDA Deployment



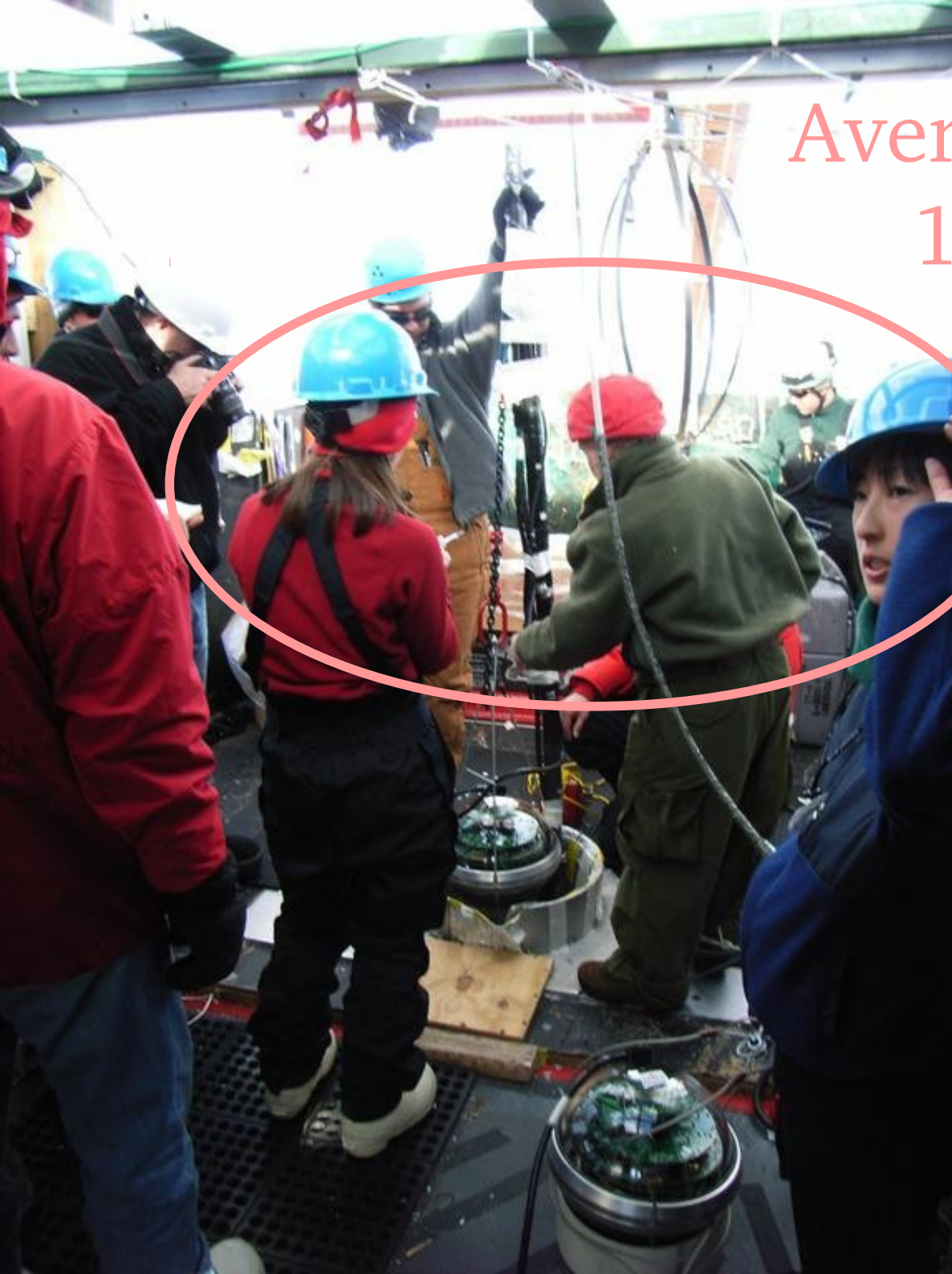


# Deployment

Time Constraint:  
Hole Freezing (48h)

Attachment of  
Digital Optical Modules  
(DOMs) to Cable





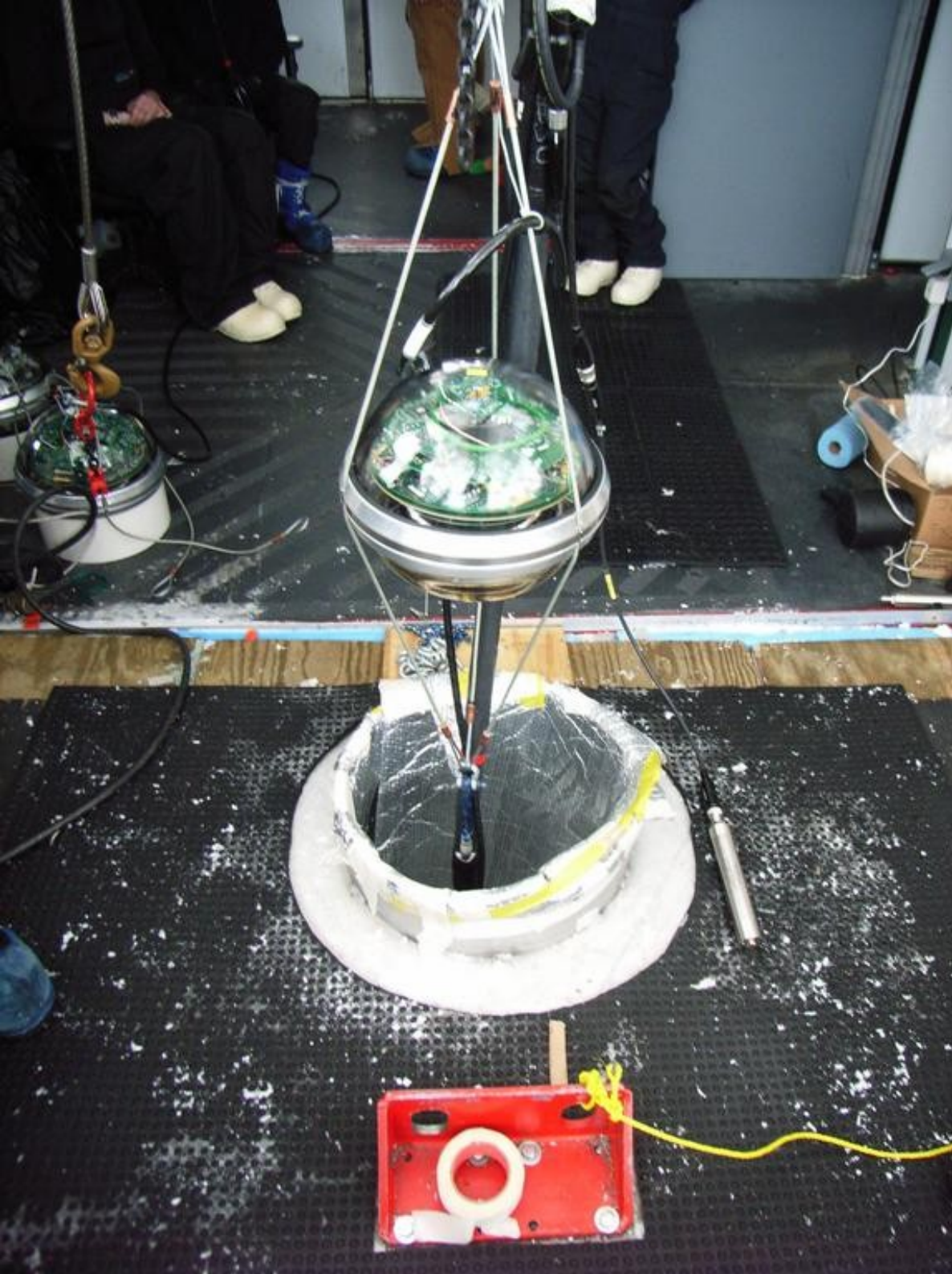
Average Height:  
1500 mm

## Deployment

Time Constraint:  
Hole Freezing (48h)

Attachment of  
Digital Optical Modules  
(DOMs) to Cable

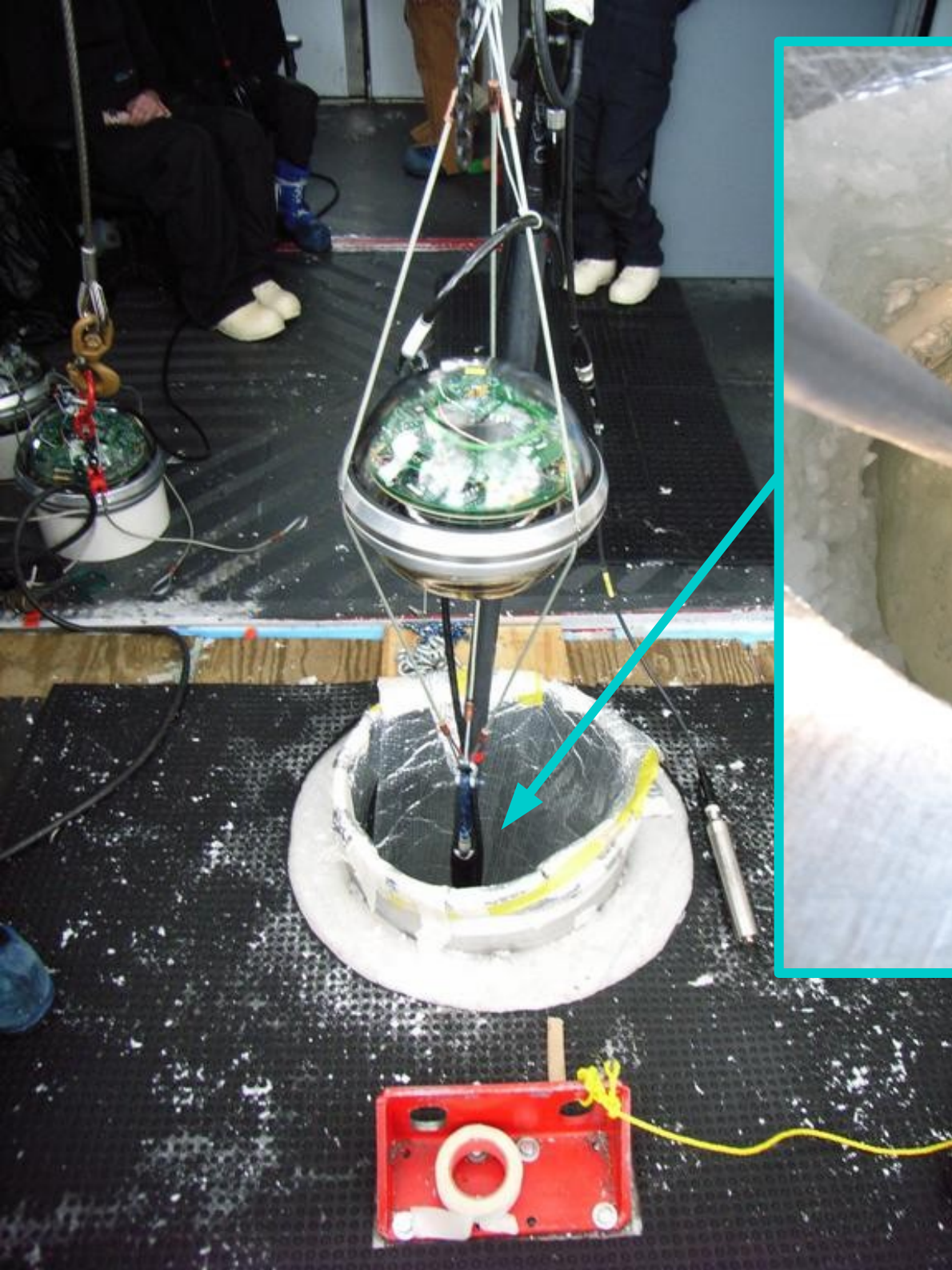
Performed (mostly)  
by Scientists



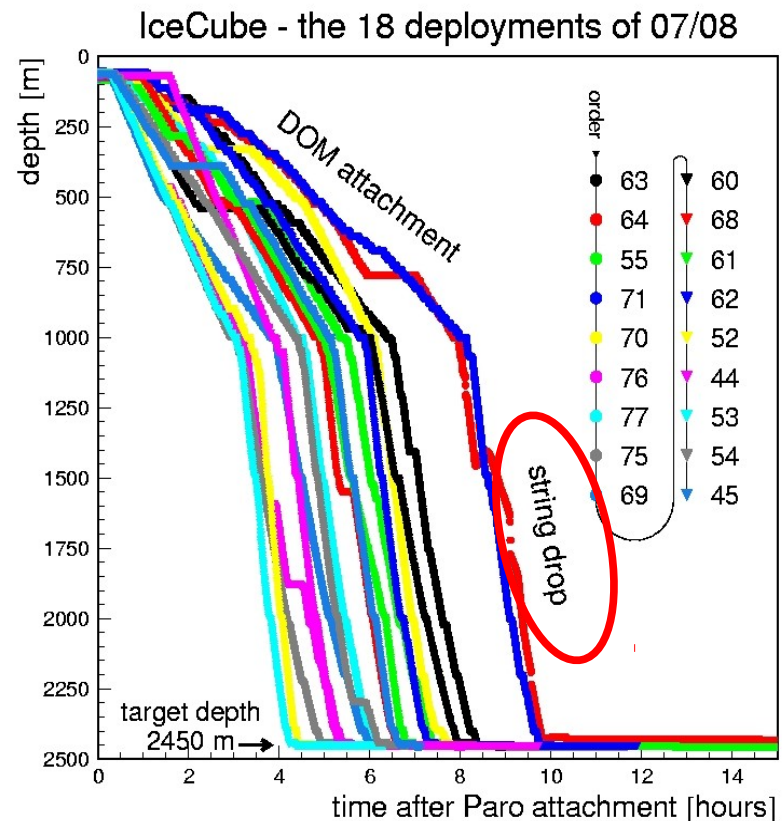
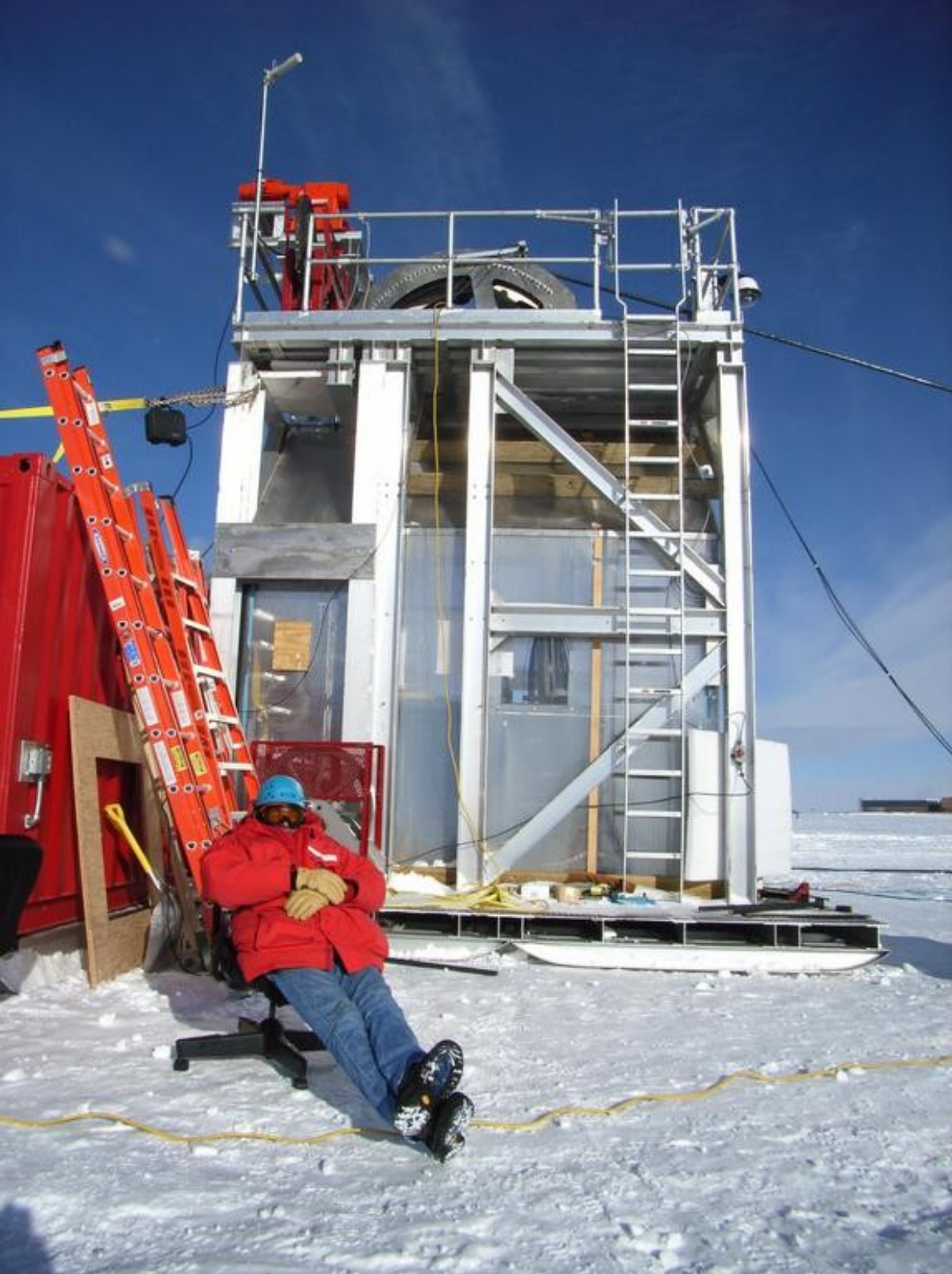
# Fully attached DOM

(picture for  
internal record)



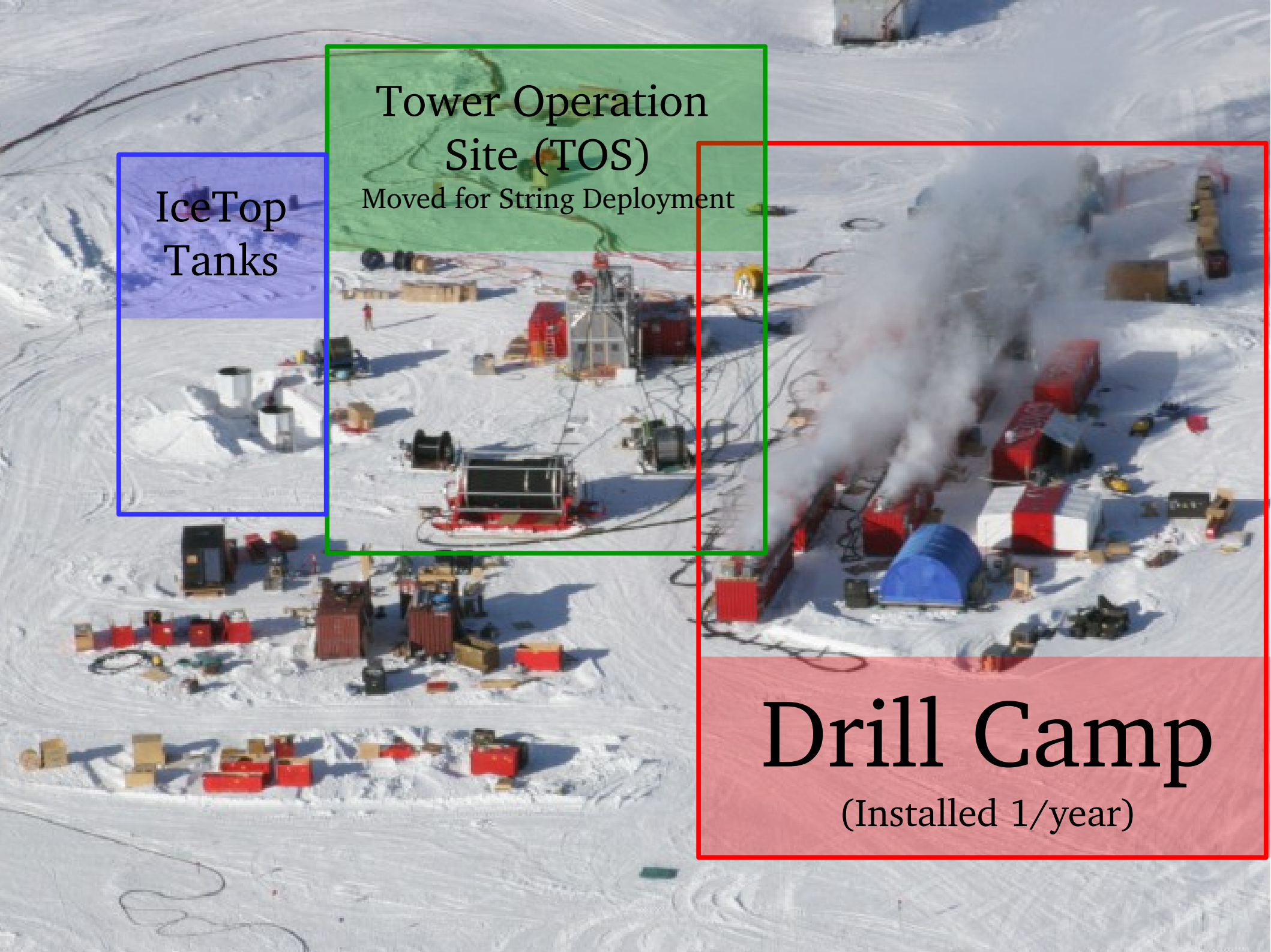


Into the Abyss!



Last Phase: “String Drop”  
(1450 m without DOMs)

Deployment can take  
all night/day!



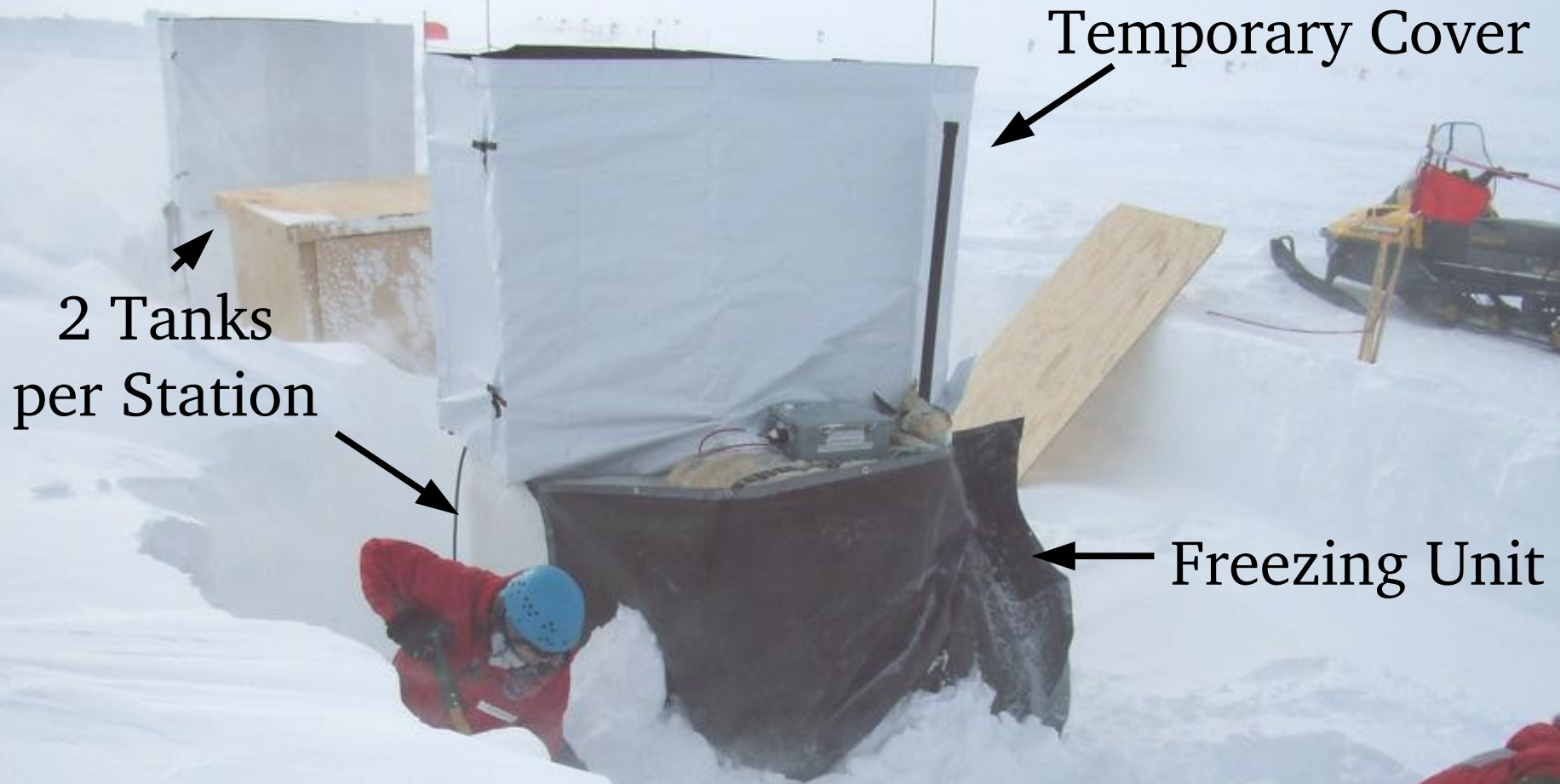
## Tower Operation Site (TOS)

Moved for String Deployment

IceTop Tanks

# Drill Camp

(Installed 1/year)



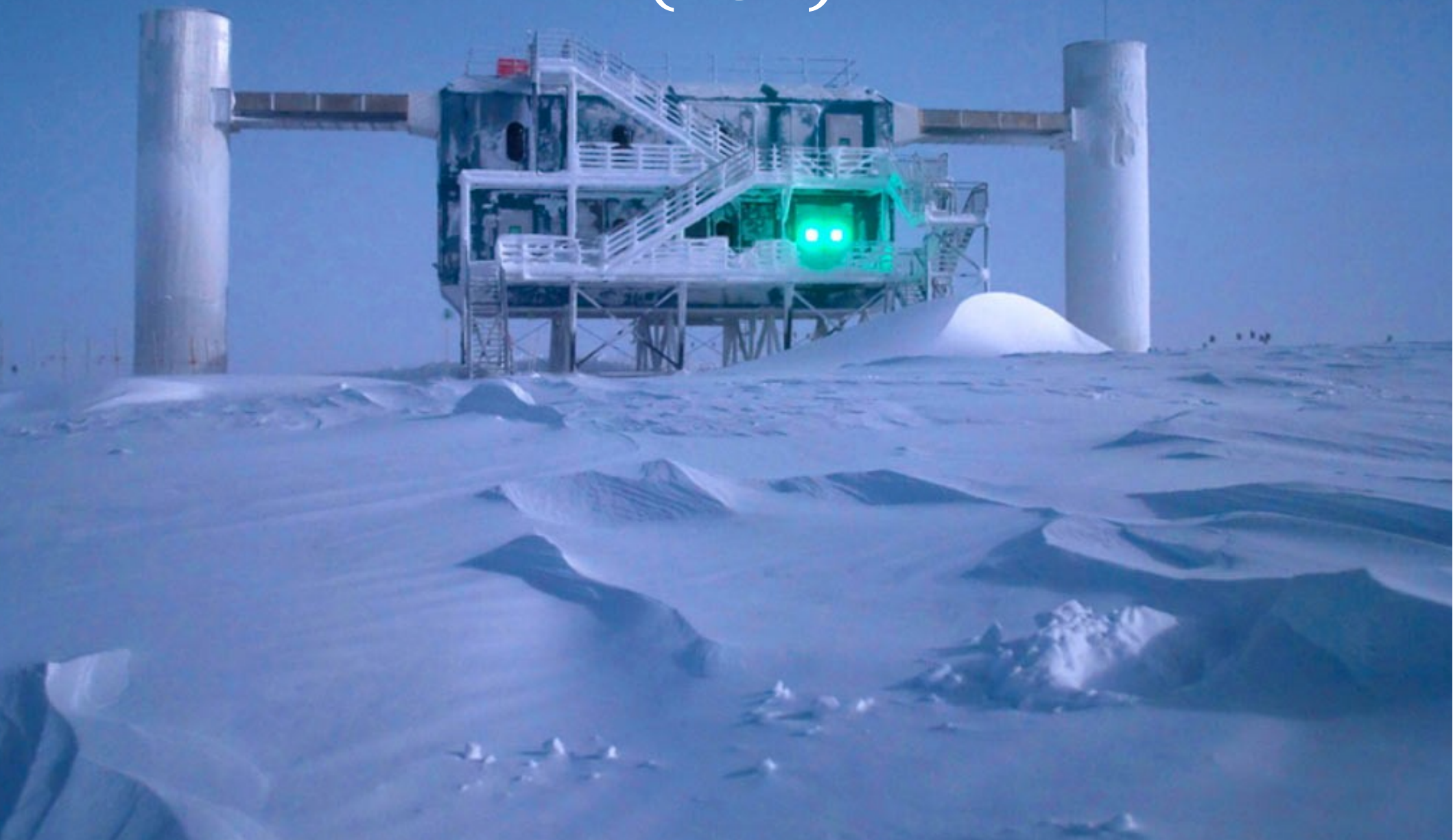
**IceTop  
Deployment**  
(1 pair of tanks next to each string)

Old AMANDA building

Warning flags to indicate sensitive equipment



# IceCube Counting Laboratory (ICL)





# IceCube Counting Laboratory (ICL)



What are the  
towers for?



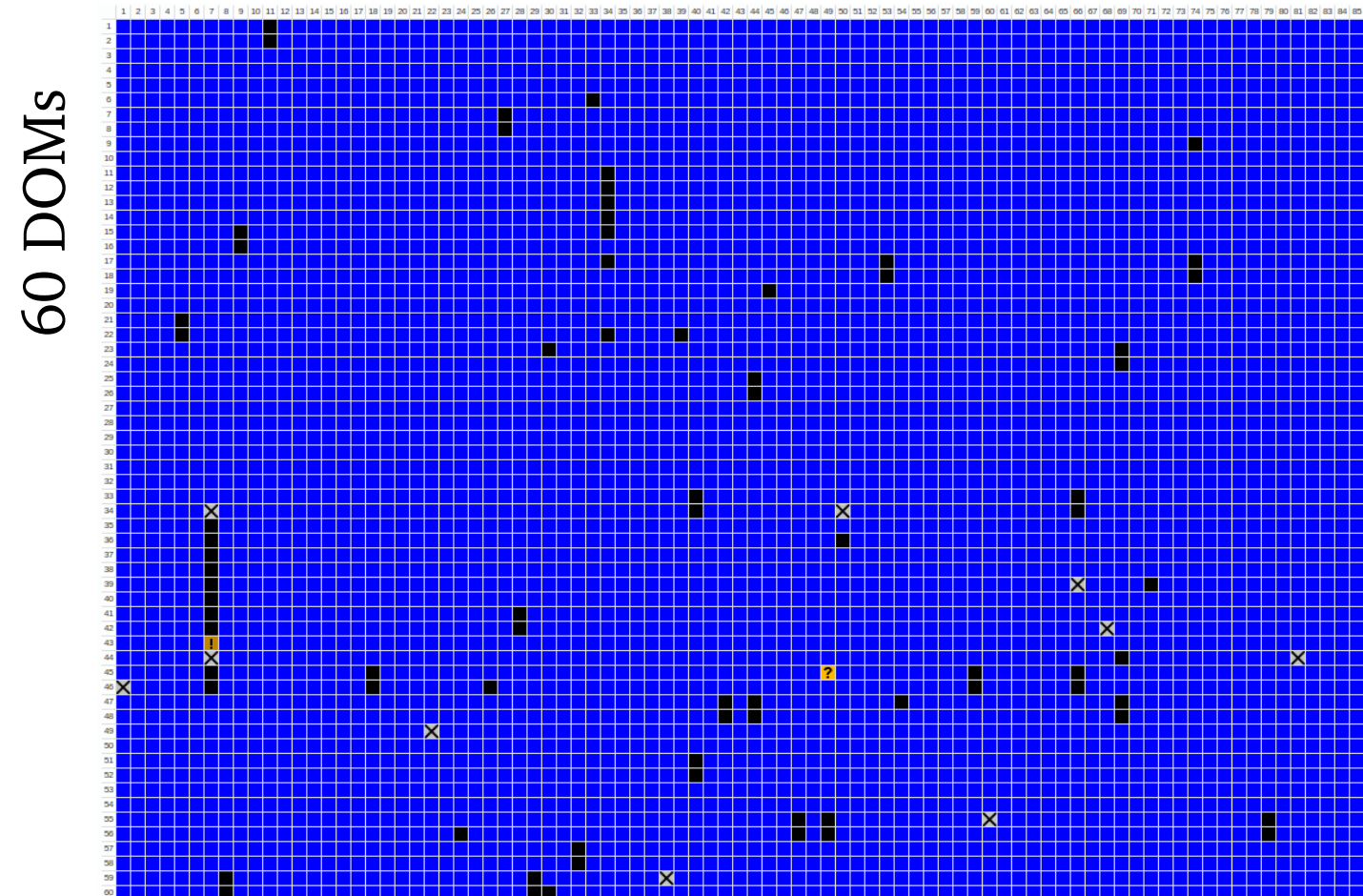
Cabling!



Connect everything...

# ...and turn it on!

86 Strings



> 98% of DOMs  
are operational

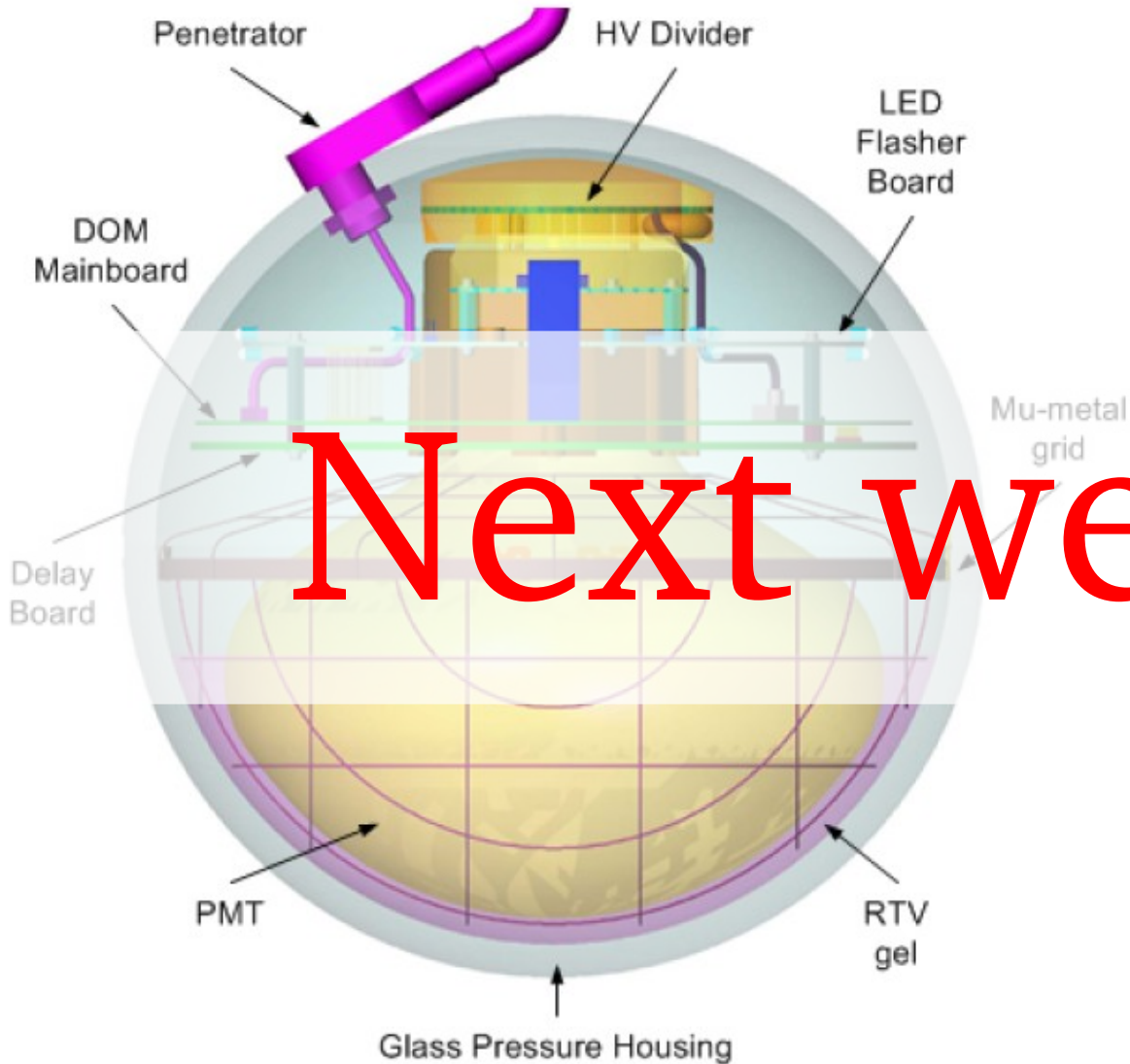
Most failures  
occur at  
deployment

No failure since  
2013!

October 16<sup>th</sup>, 2015

# DOM

(Digital Optical Module)



Next week!