

The Radio Neutrino Observatory in Greenland

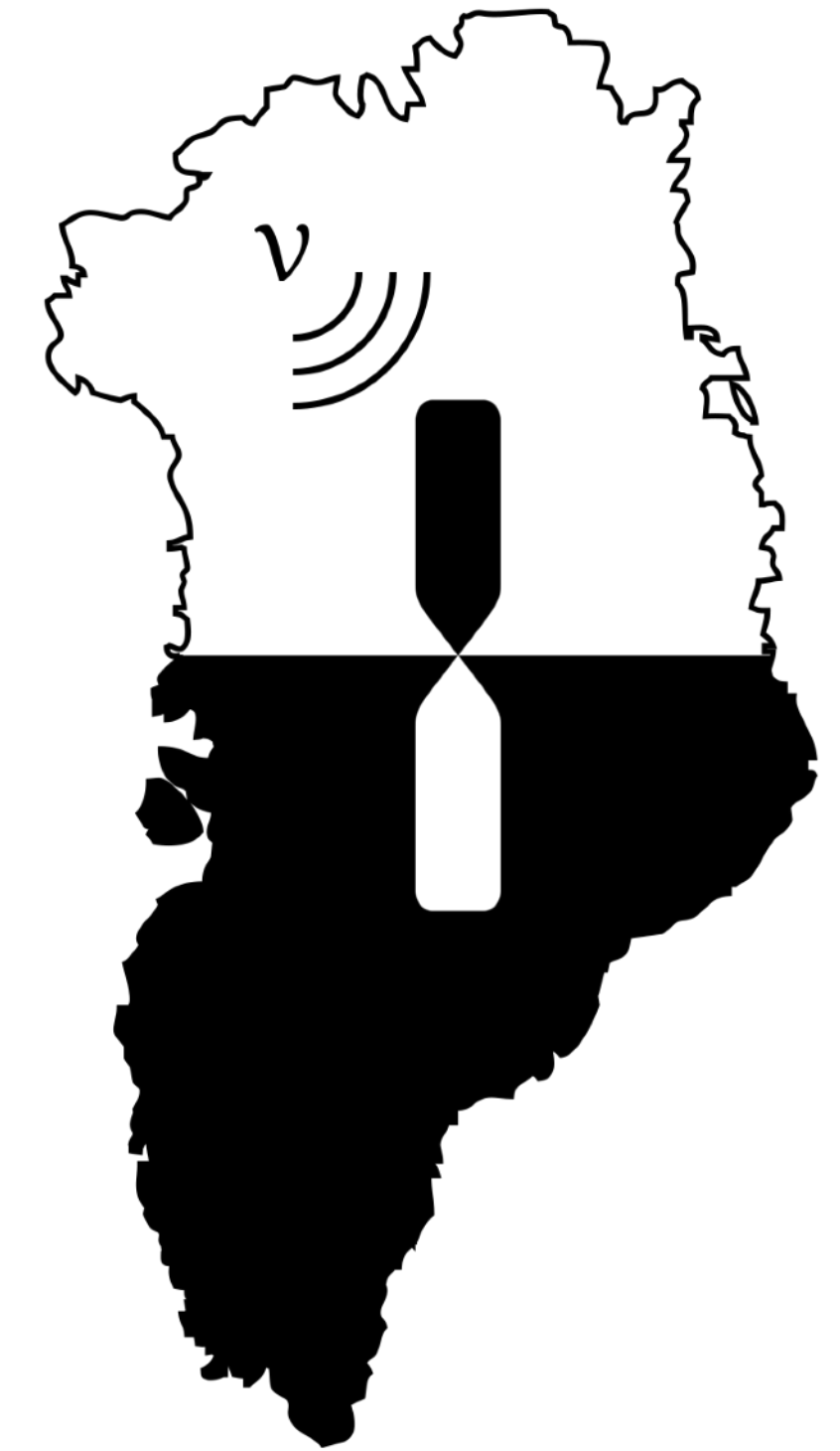
Status and Perspectives

TeV Particle Astrophysics (TeVPA) 2024

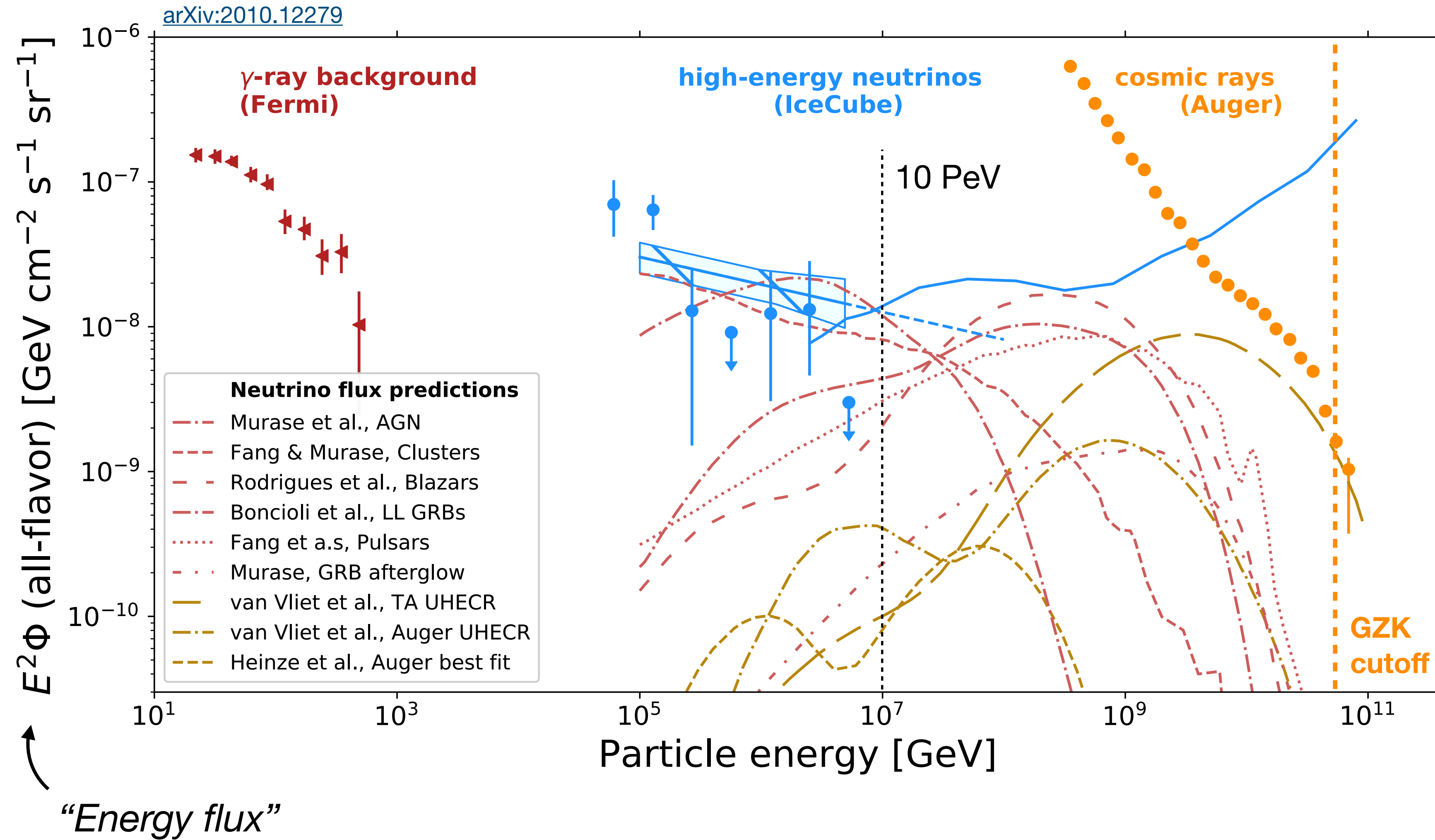
August 26, 2024

Philipp Windischhofer on behalf of the RNO-G Collaboration

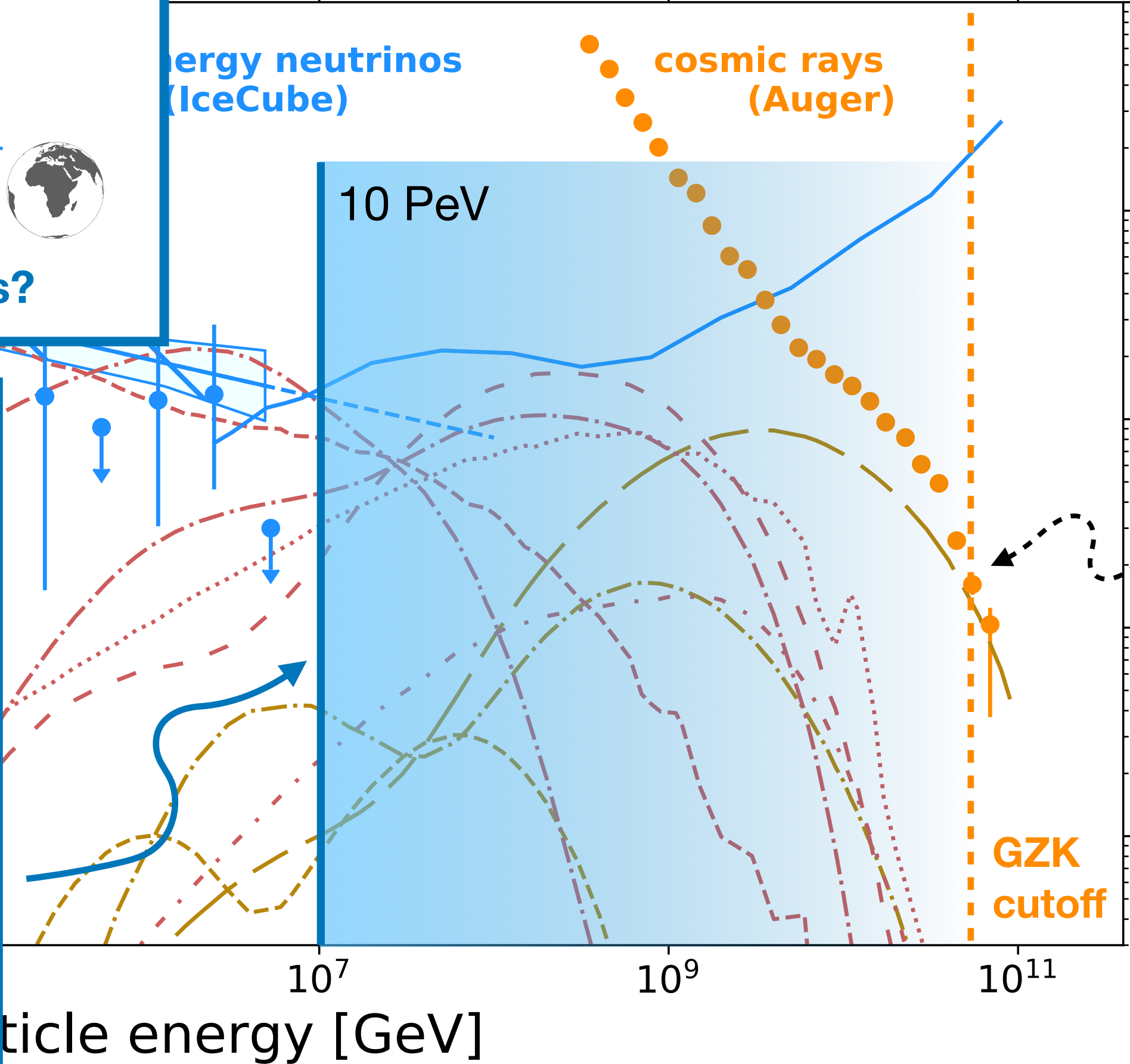
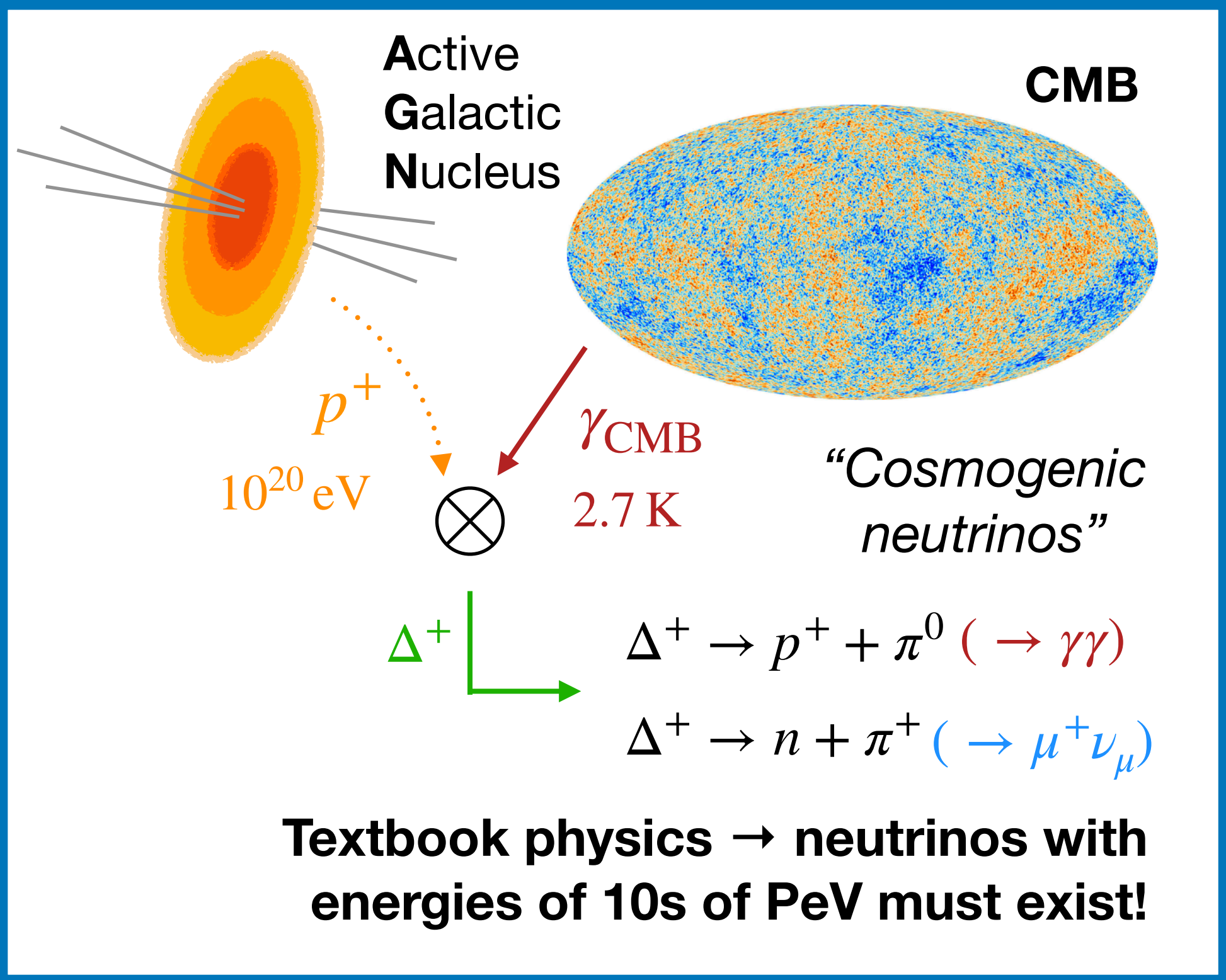
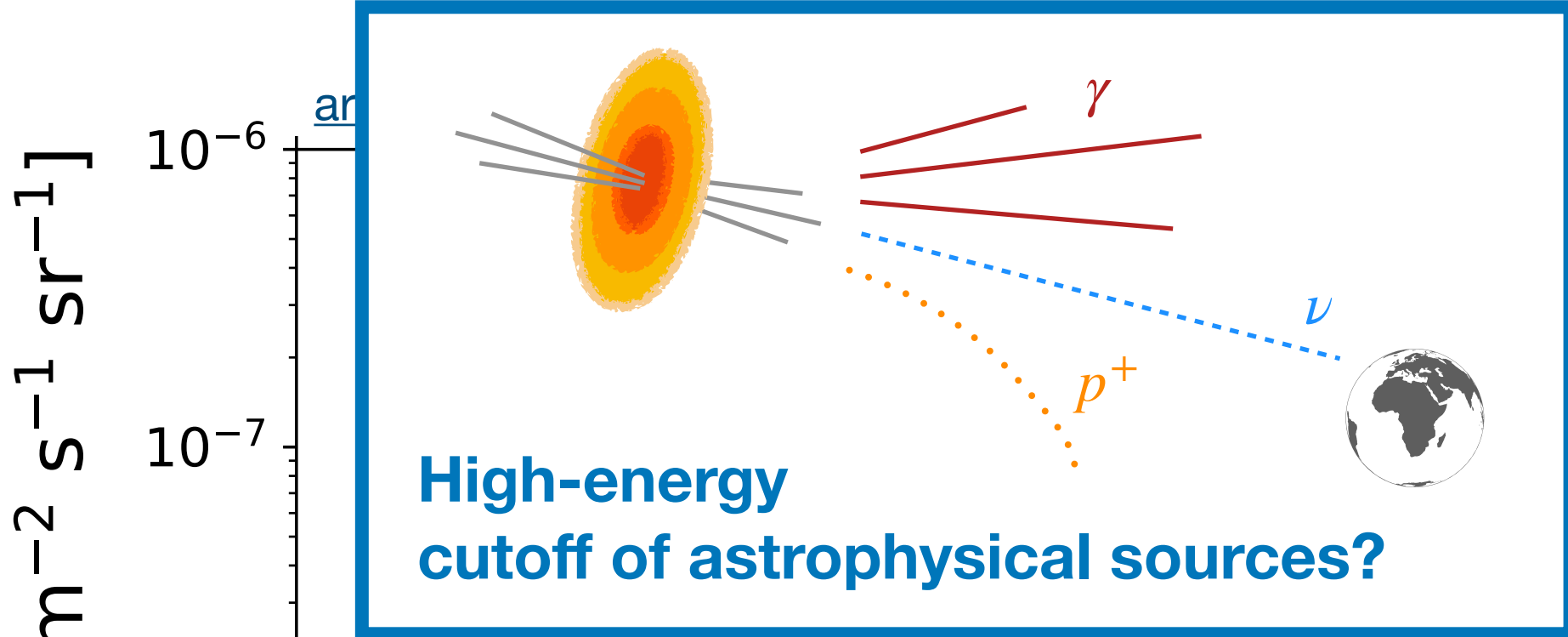
University of Chicago



The high-energy landscape of our universe



The high-energy landscape of our universe



Expect **0.01** interactions / km³ / year of GZK-scale neutrinos

Requires instrumented volume of **O(100) km³!**

Radio Neutrino Observatory in Greenland (RNO-G)
 First science-scale radio array targeting ≥ 10 PeV neutrinos in the northern hemisphere

Radio neutrino detection

Use Greenlandic ice as detector medium

Ice is dense!

Good target material for weakly-interacting particles

Charged particles in shower → **electric current**

Shower front smaller than wavelength

→ **Coherent emission**

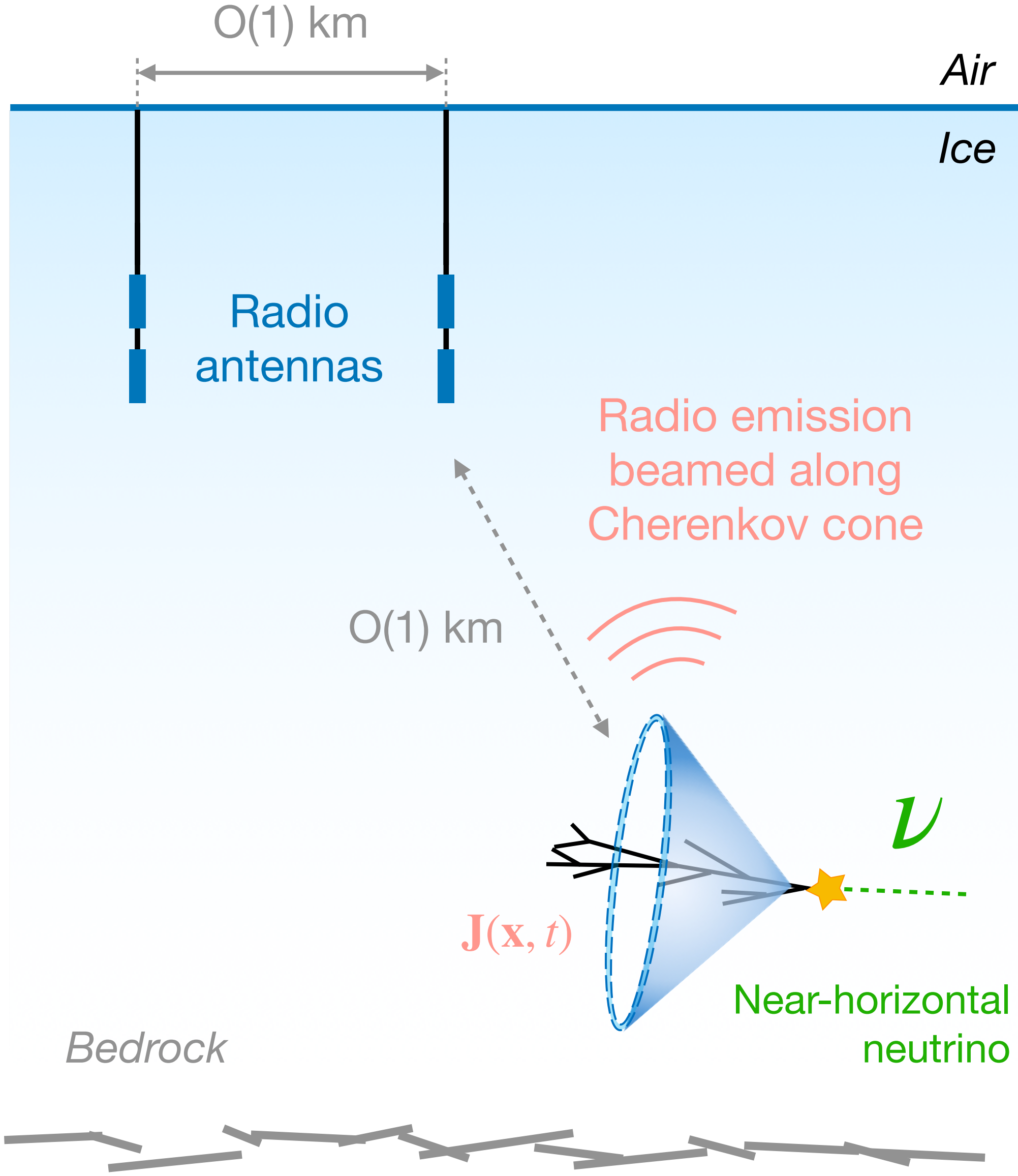
Ice is clean and cold!

Very transparent to electromagnetic radiation in the MHz - GHz band!

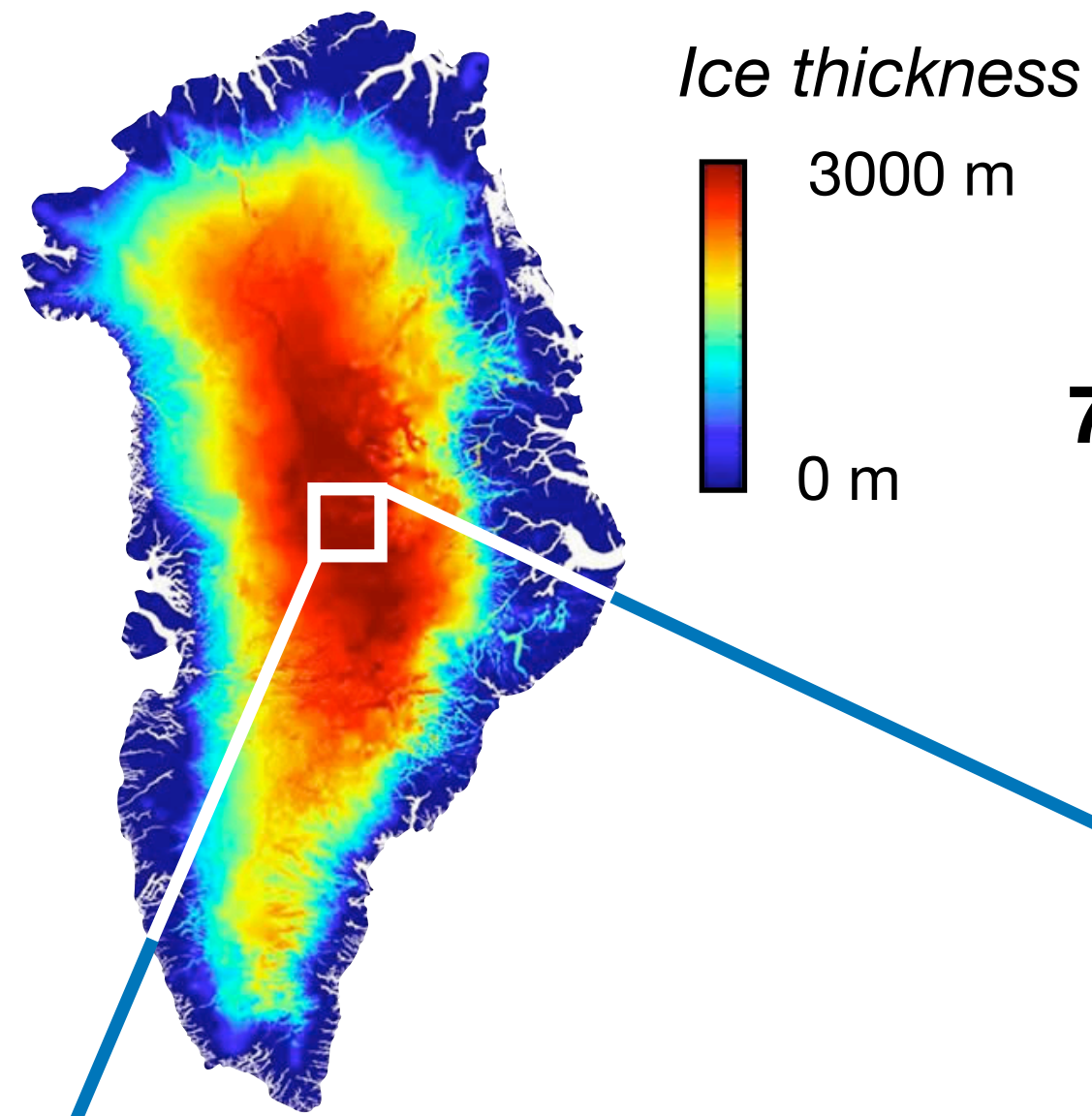
→ **Attenuation length $O(1 \text{ km})$**

$$f \sim 500 \text{ MHz} \leftrightarrow \lambda \sim 0.4 \text{ m}$$

Expect strong signals at high energies, detectable over long distances

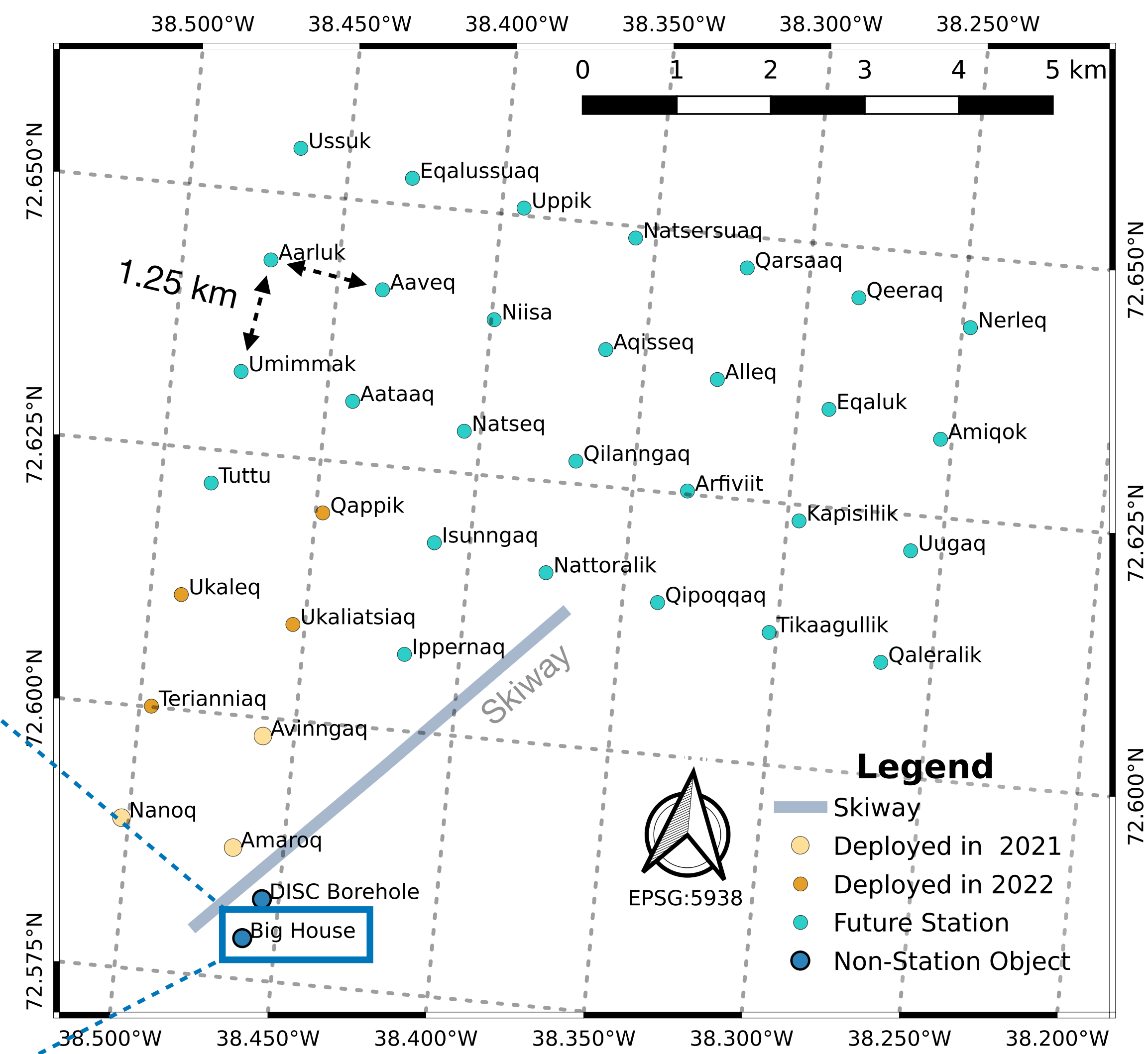


RNO-G: array design



7 stations already deployed and taking data;
35-station array fully funded!

Summit station, Greenland (NSF-operated) ↓



RNO-G: station design

Triangular station layout with downhole and surface antennas

Downhole: Horizontally- (*Hpol*) and vertically-polarized (*Vpol*) antennas

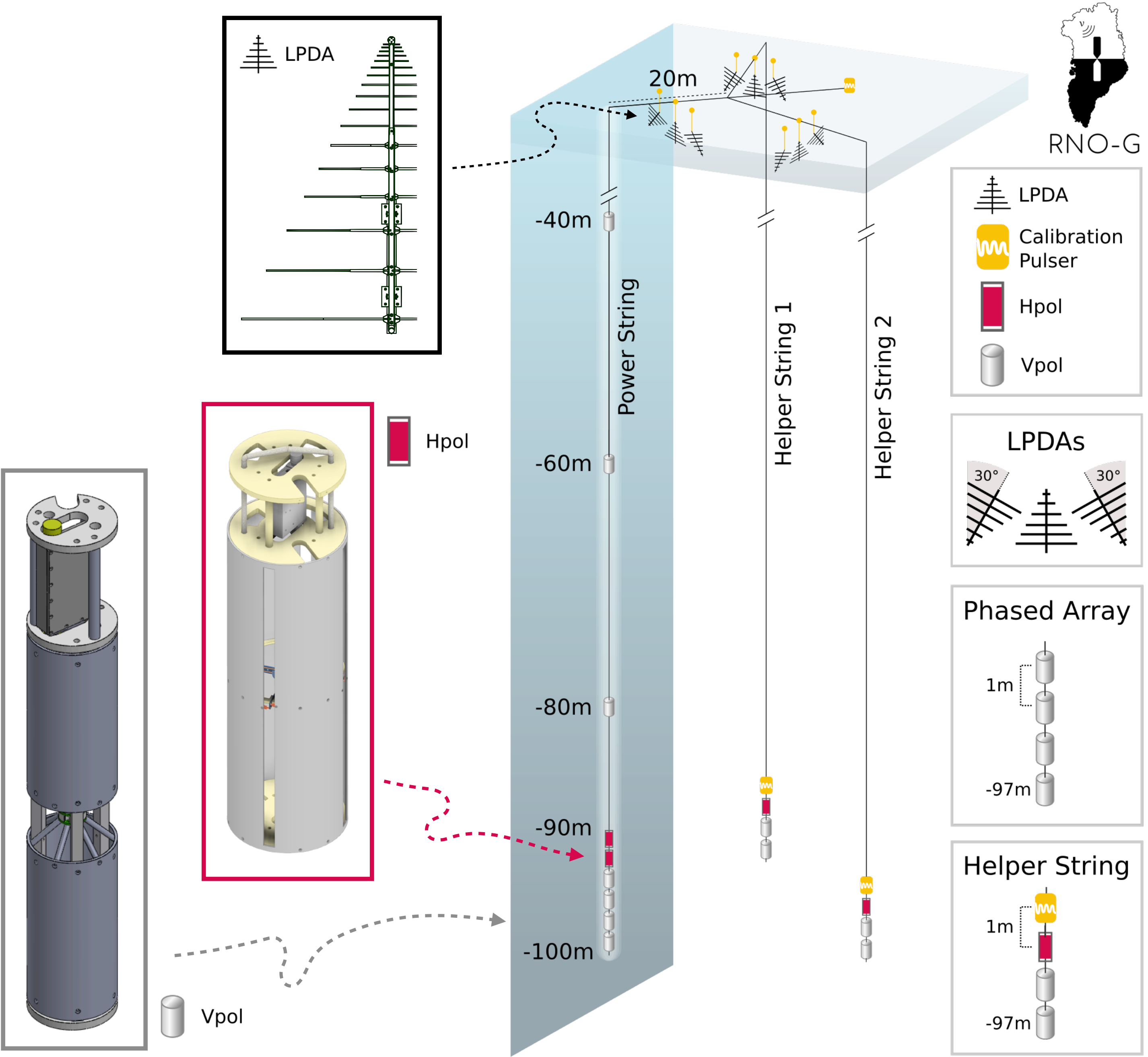
Polarization-sensitivity improves direction-finding

Surface: Upward- and downward-looking (*directional!*) log-periodic dipole antennas (*LPDAs*)

Sensitivity to (down-going) cosmic rays
→ **veto**

More details on hardware and instrument performance:
Aishwarya Vijai, Wednesday, ERC 401 [[indico](#)]

See also: “Instrument Design and performance of the first seven stations of RNO-G”, JINST (to appear)

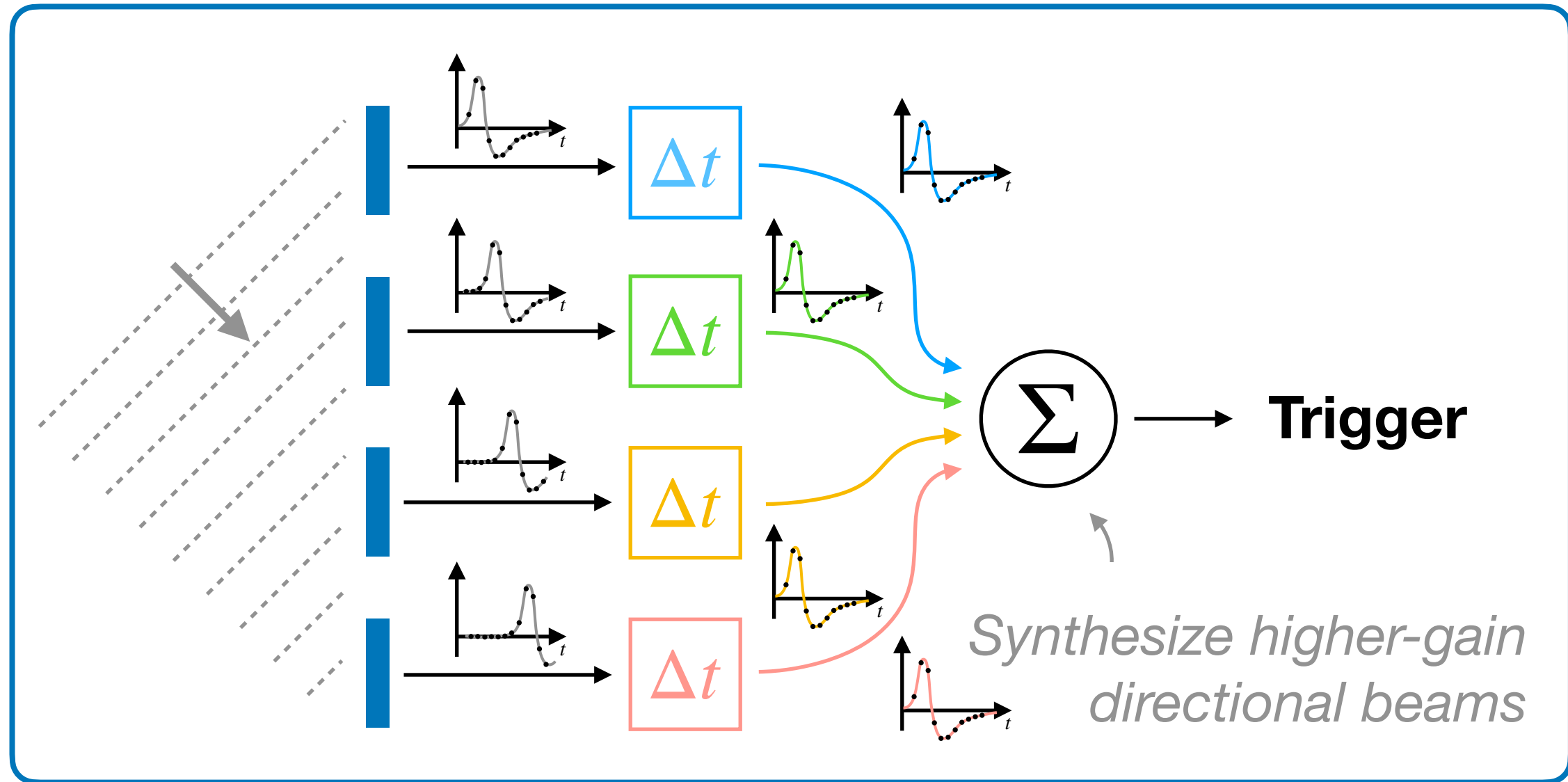


RNO-G: station design



Triangular station layout with downhole and surface antennas

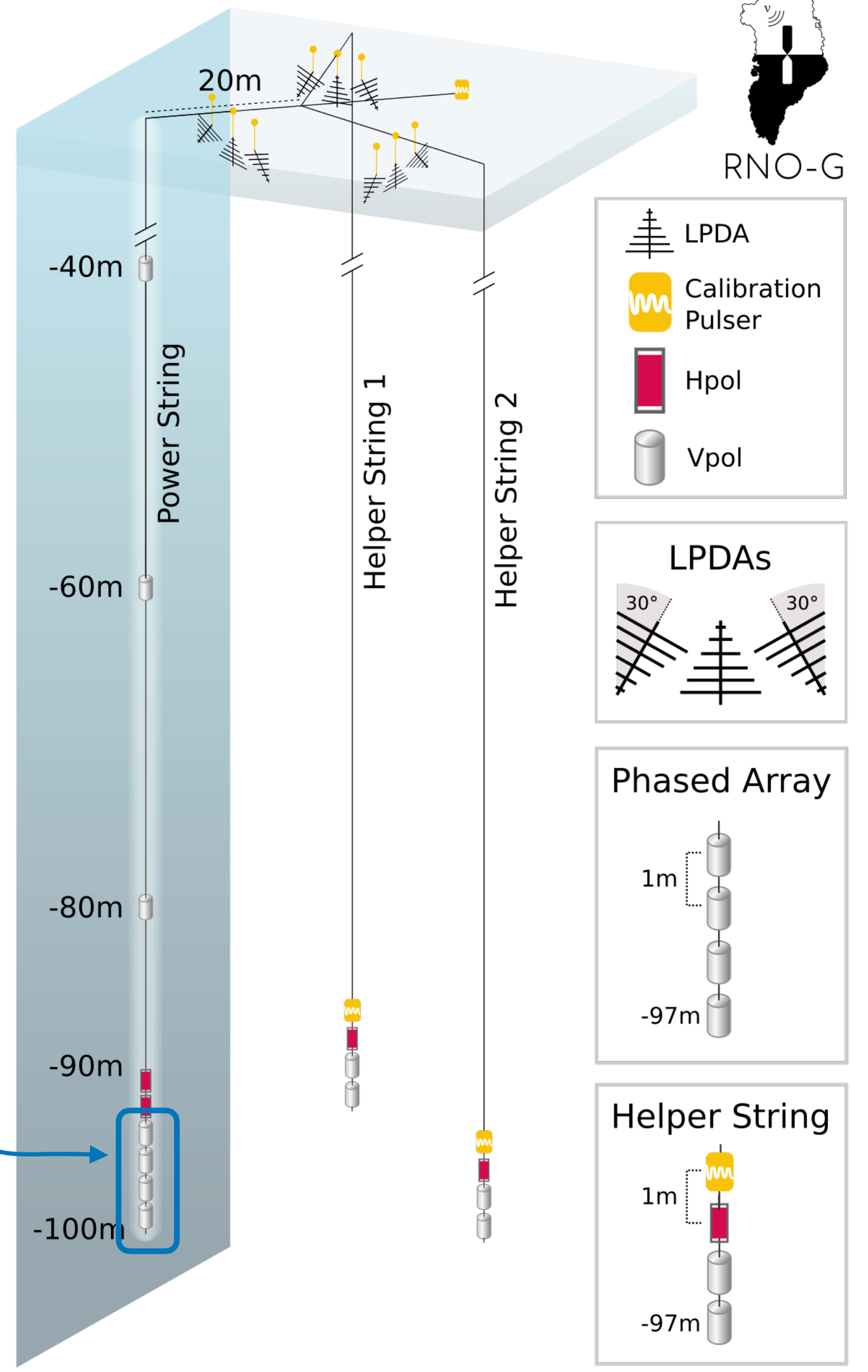
Deep channels equipped with beam-forming trigger to lower thresholds (to be activated in deployed stations soon!)



More details on hardware and instrument performance:

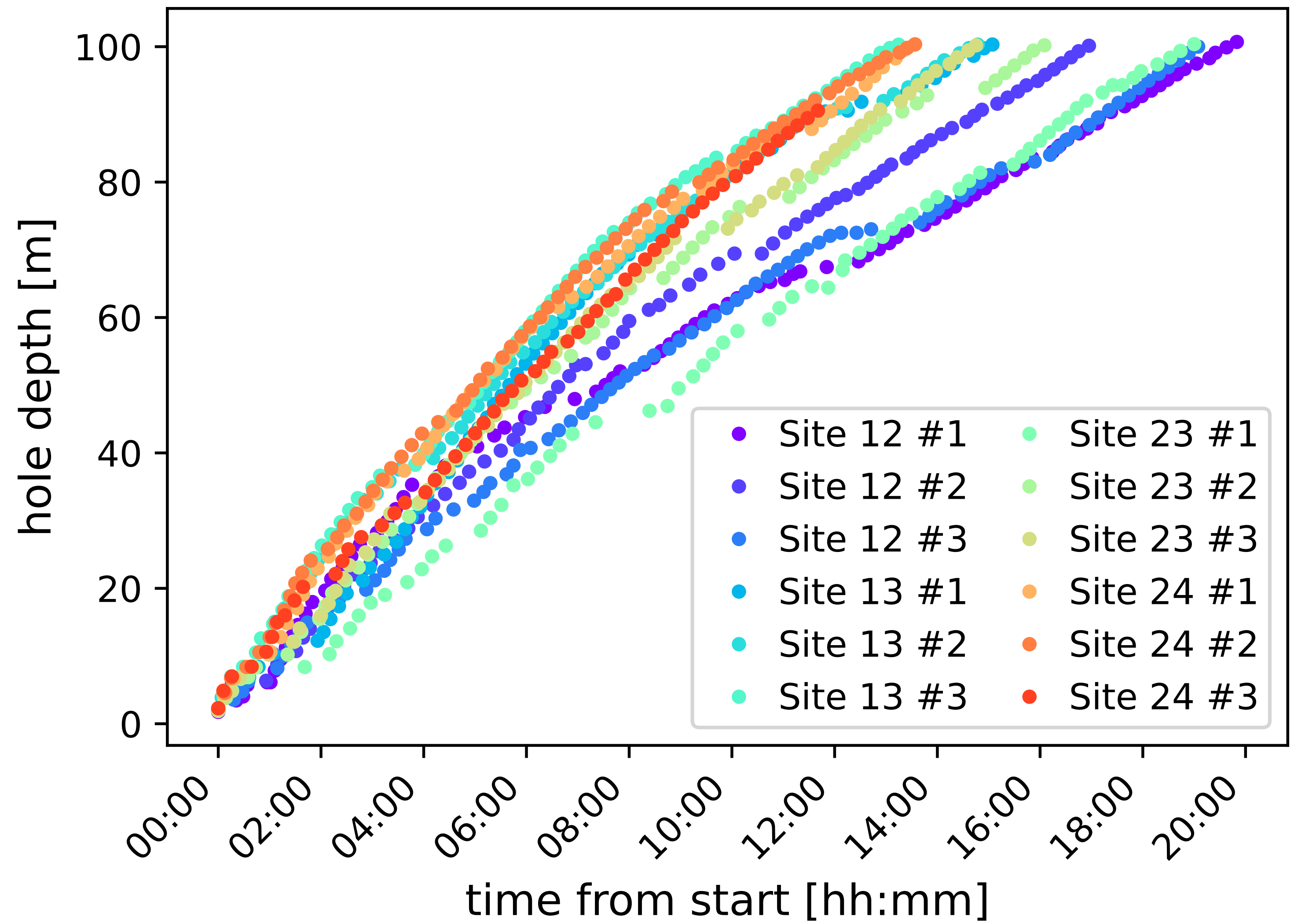
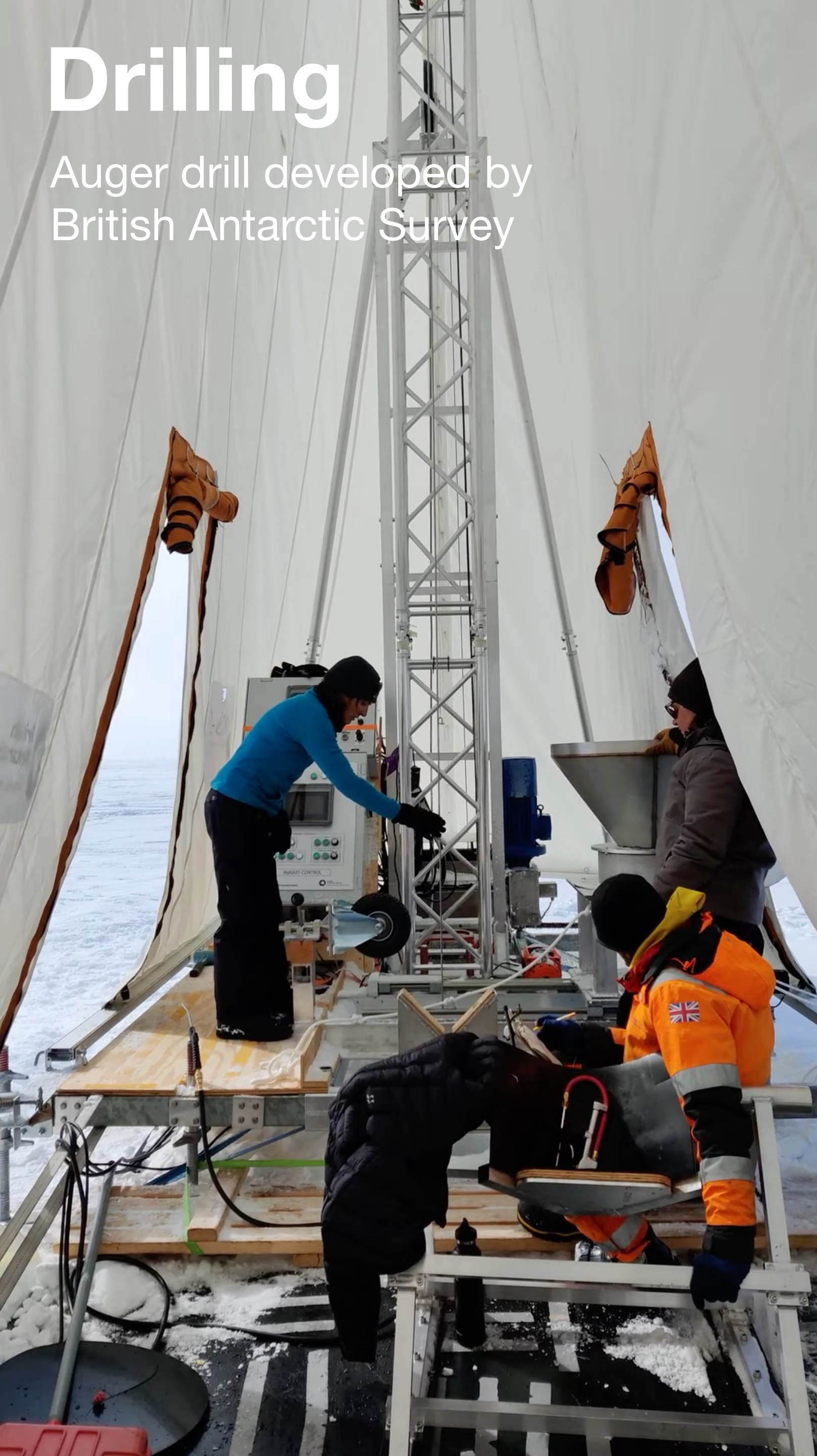
Aishwarya Vijai, Wednesday, ERC 401 [indico]

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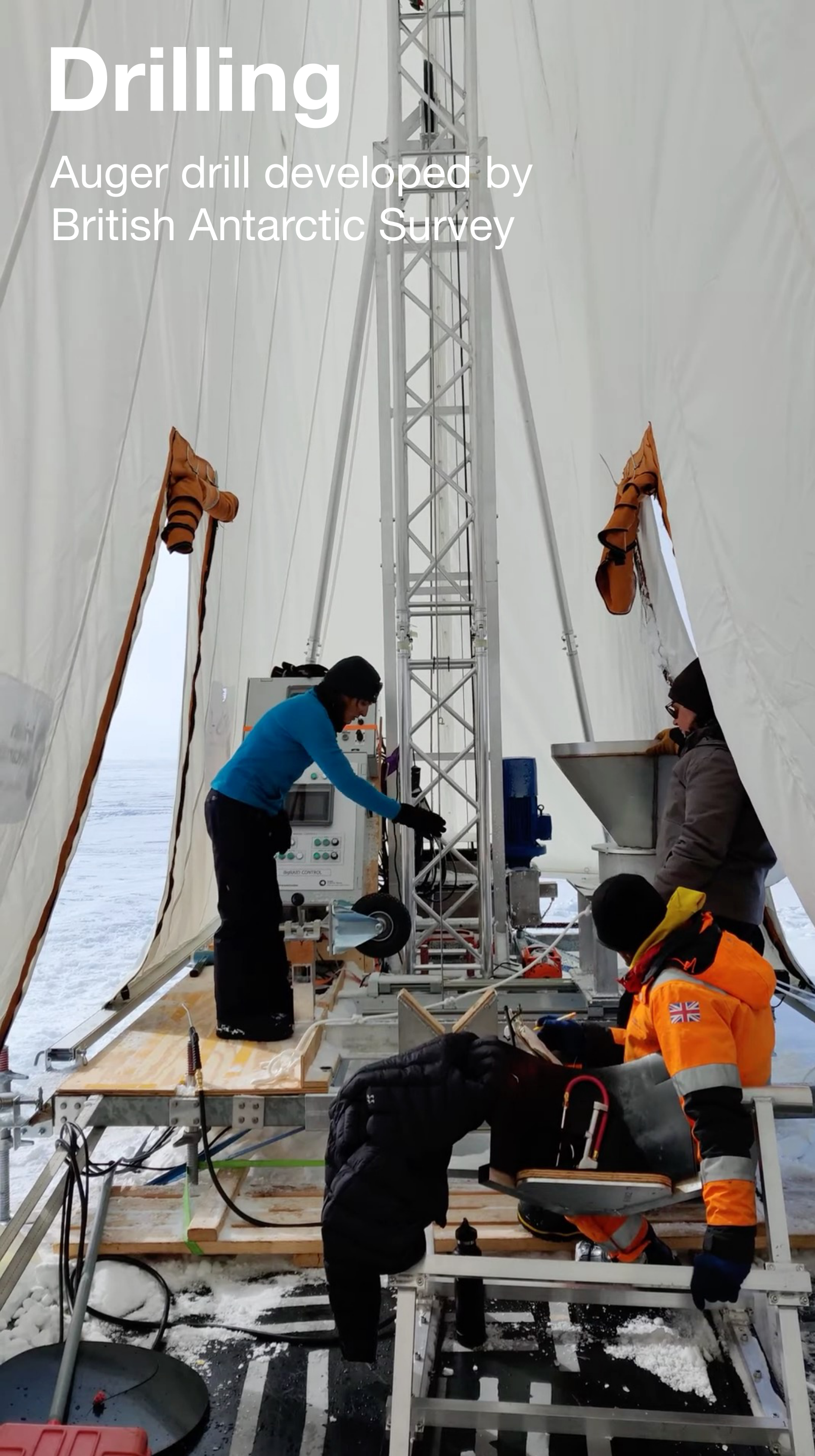
Drilling

Auger drill developed by
British Antarctic Survey



Drilling

Auger drill developed by
British Antarctic Survey



Antenna
deployment



DAQ installation



Wind turbine
installation

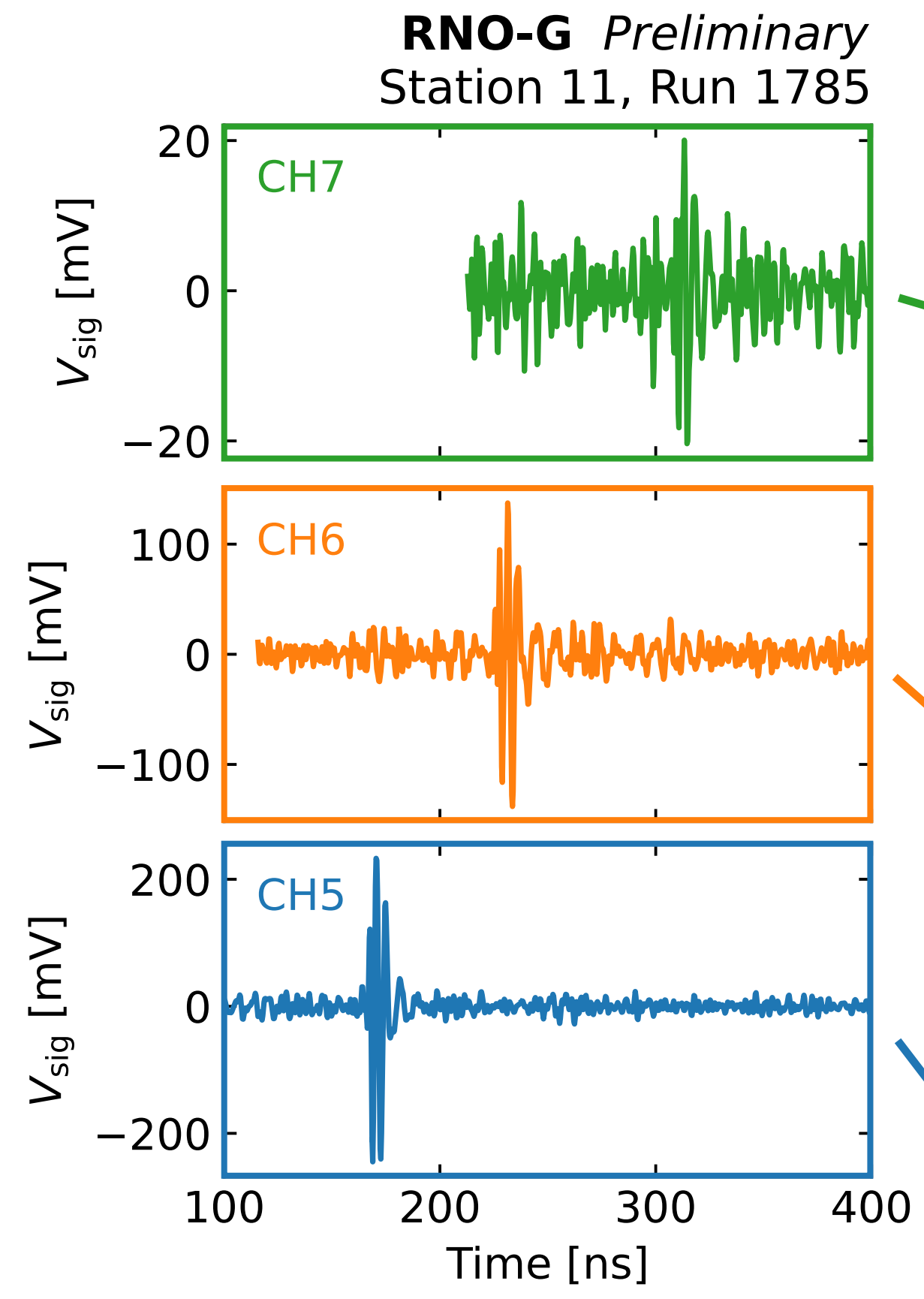
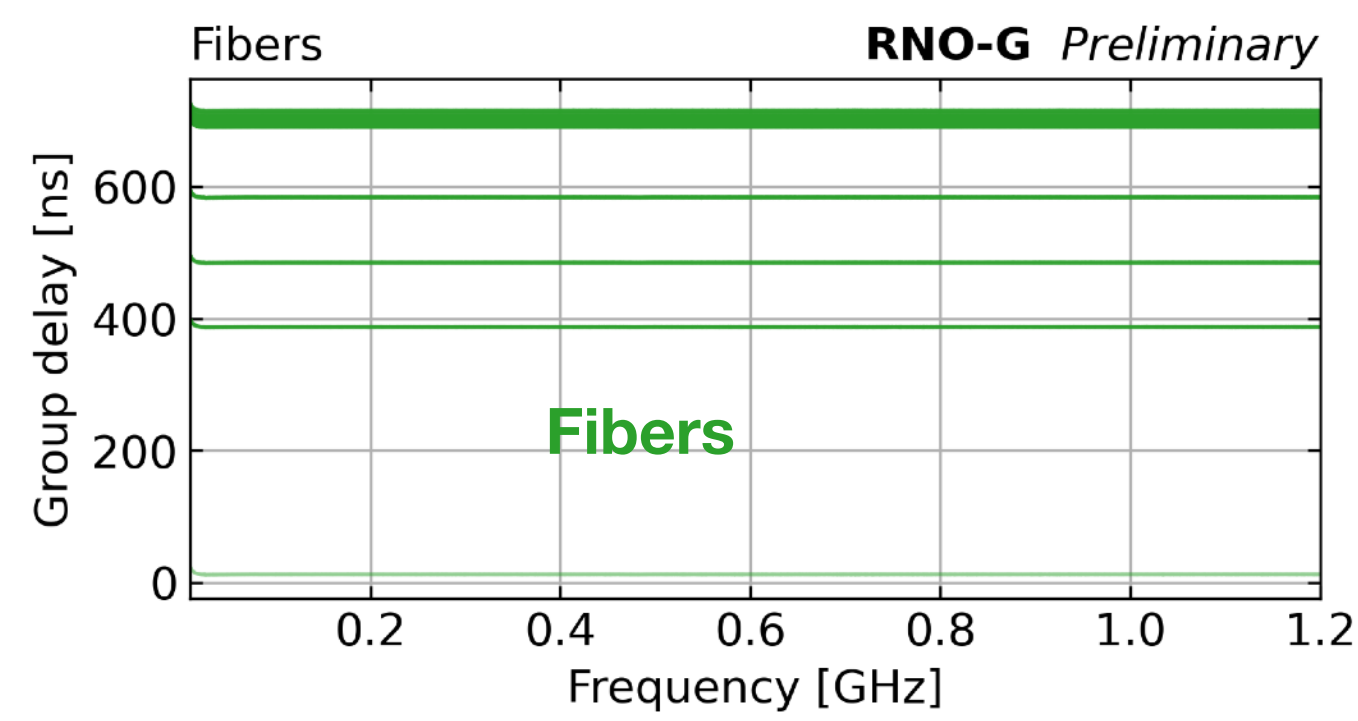
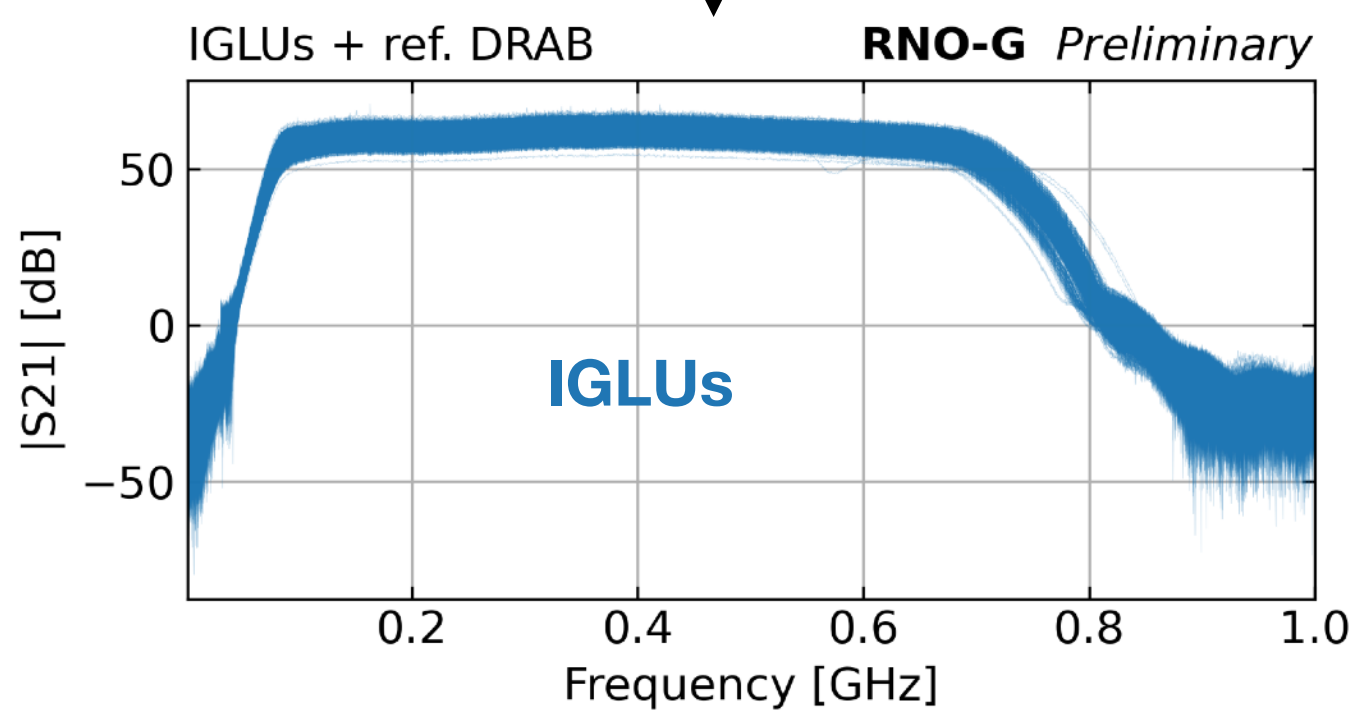
Calibration



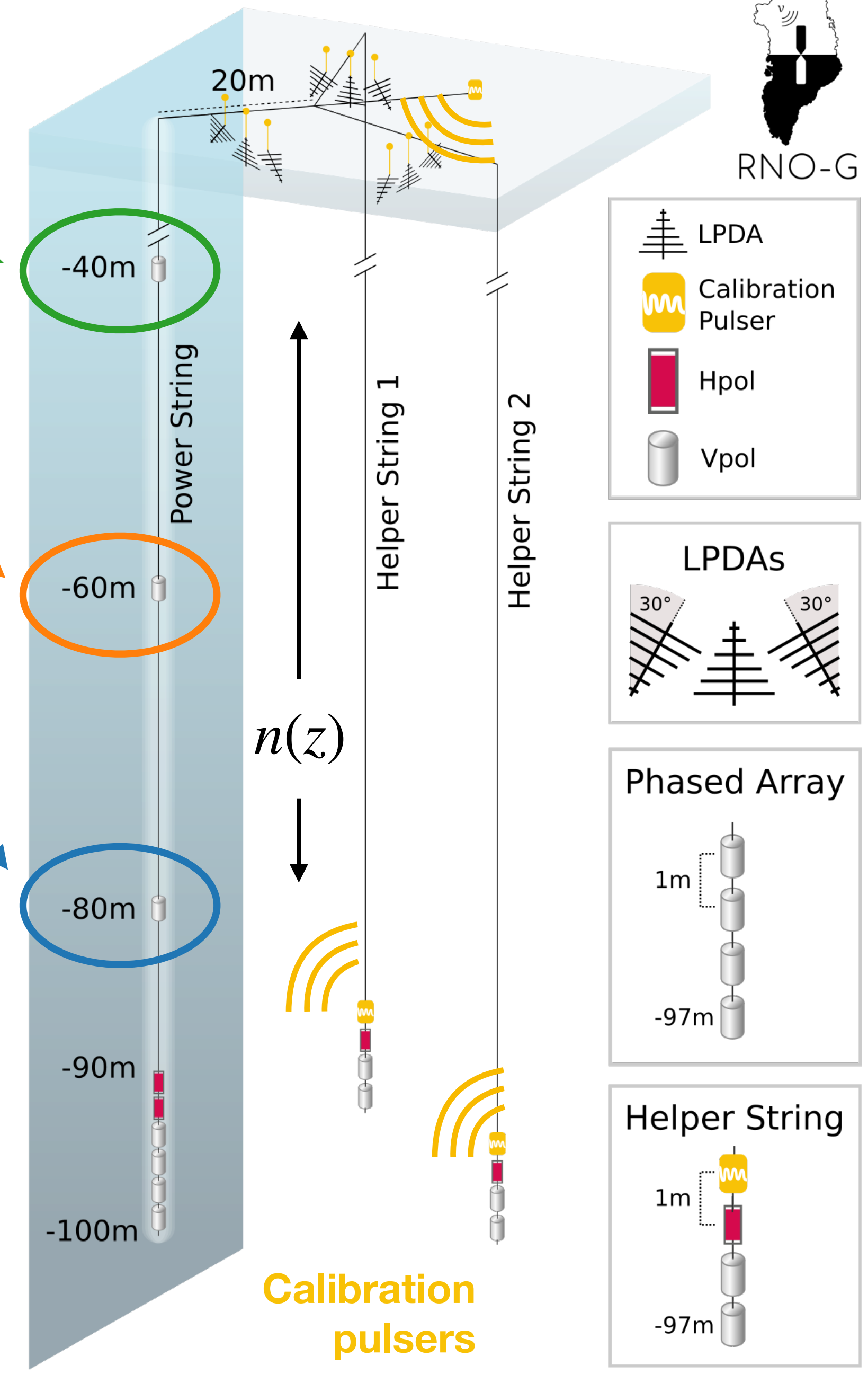
RNO-G

Multi-component signal path:
Forward gain ↔ event energy scale
Group delay ↔ event localization

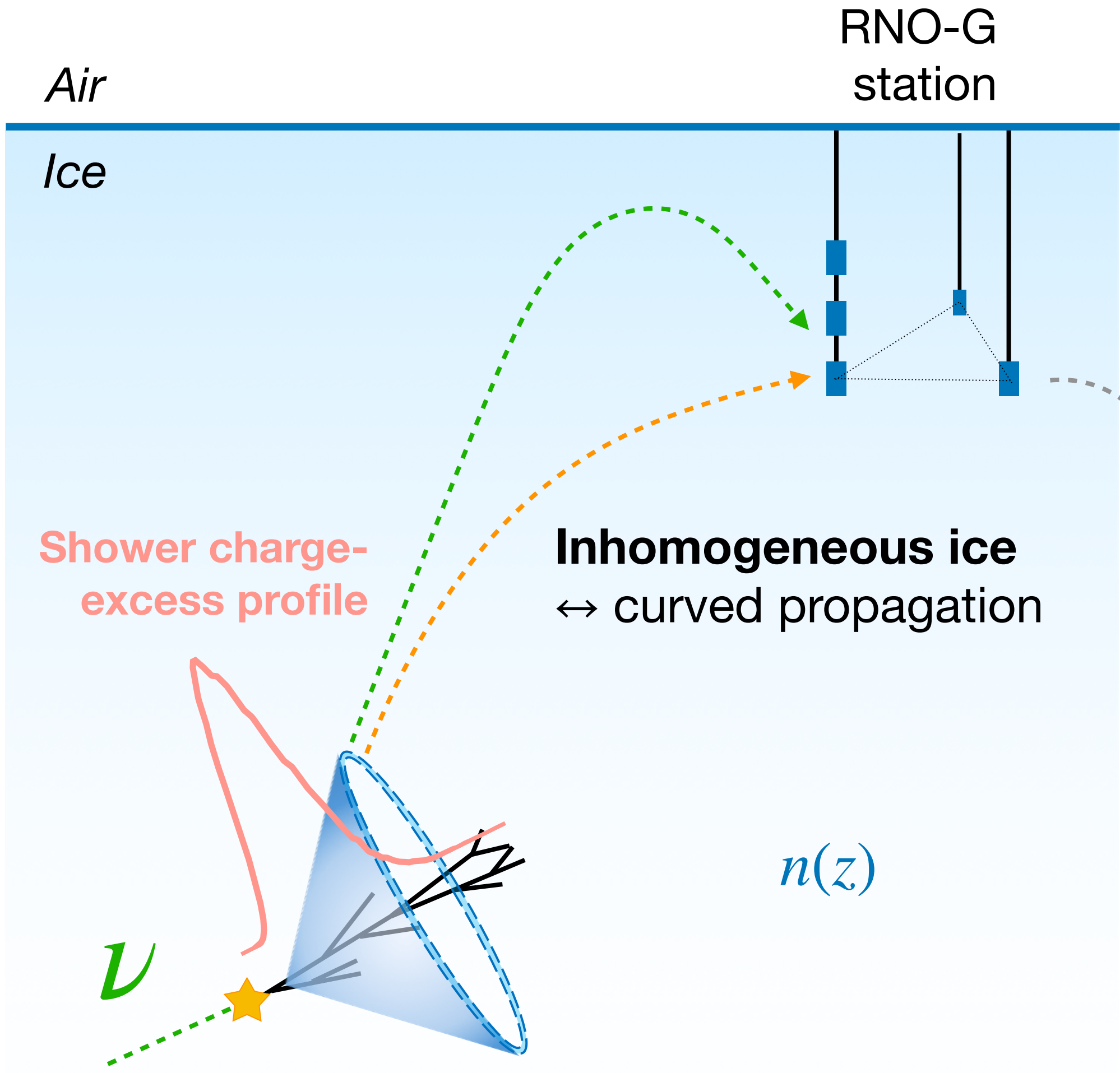
S-parameter characterization of all deployed components



In-situ calibration pulsers:
 Impulsive signals in receiving channels from source with known relative position
 In-situ correction to station geometry and local ice refractive index $n(z)$

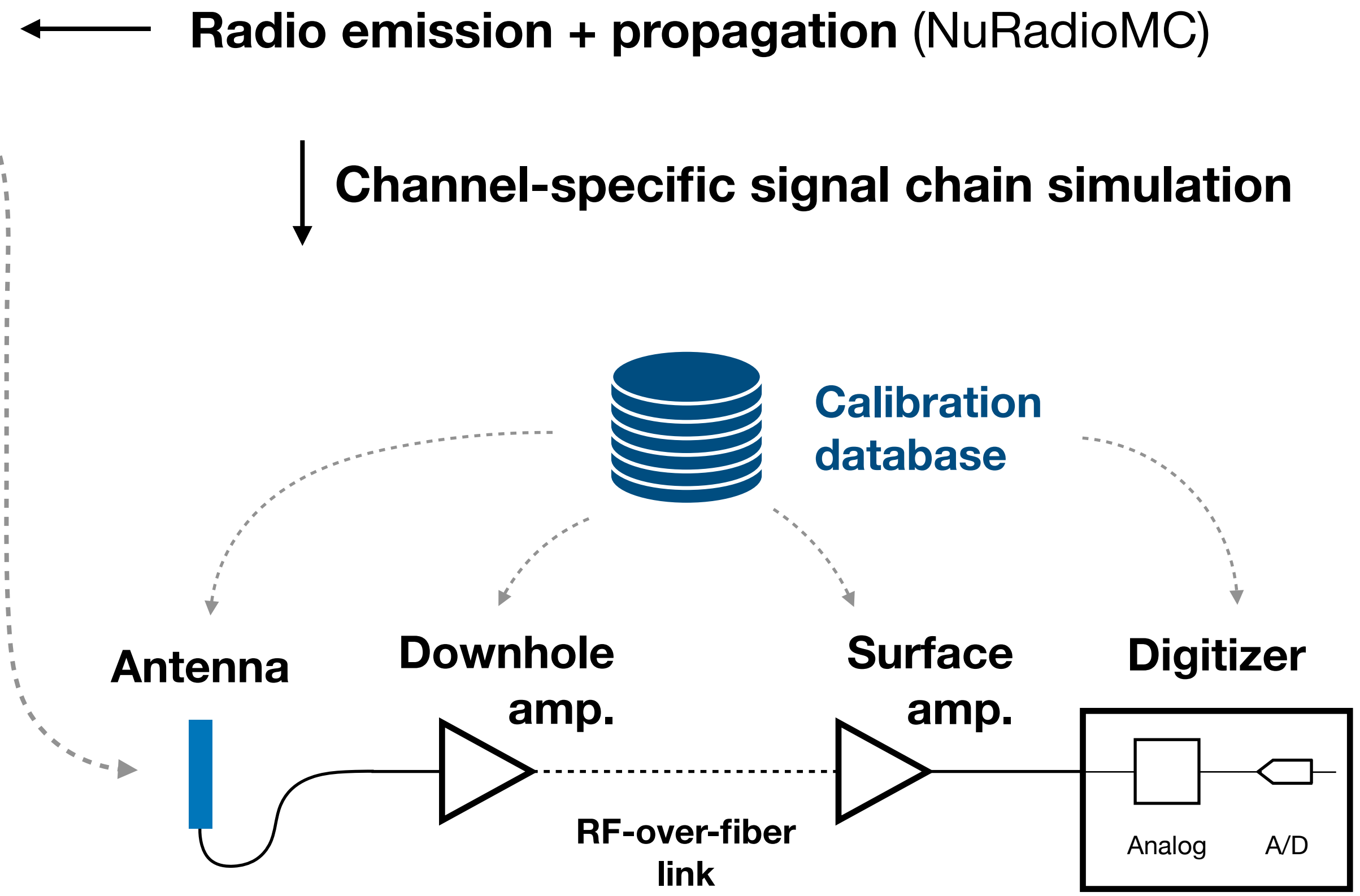


Simulation



RNO-G is an array built from autonomous stations

Calibration and simulation work hand-in-hand to analyze and interpret data

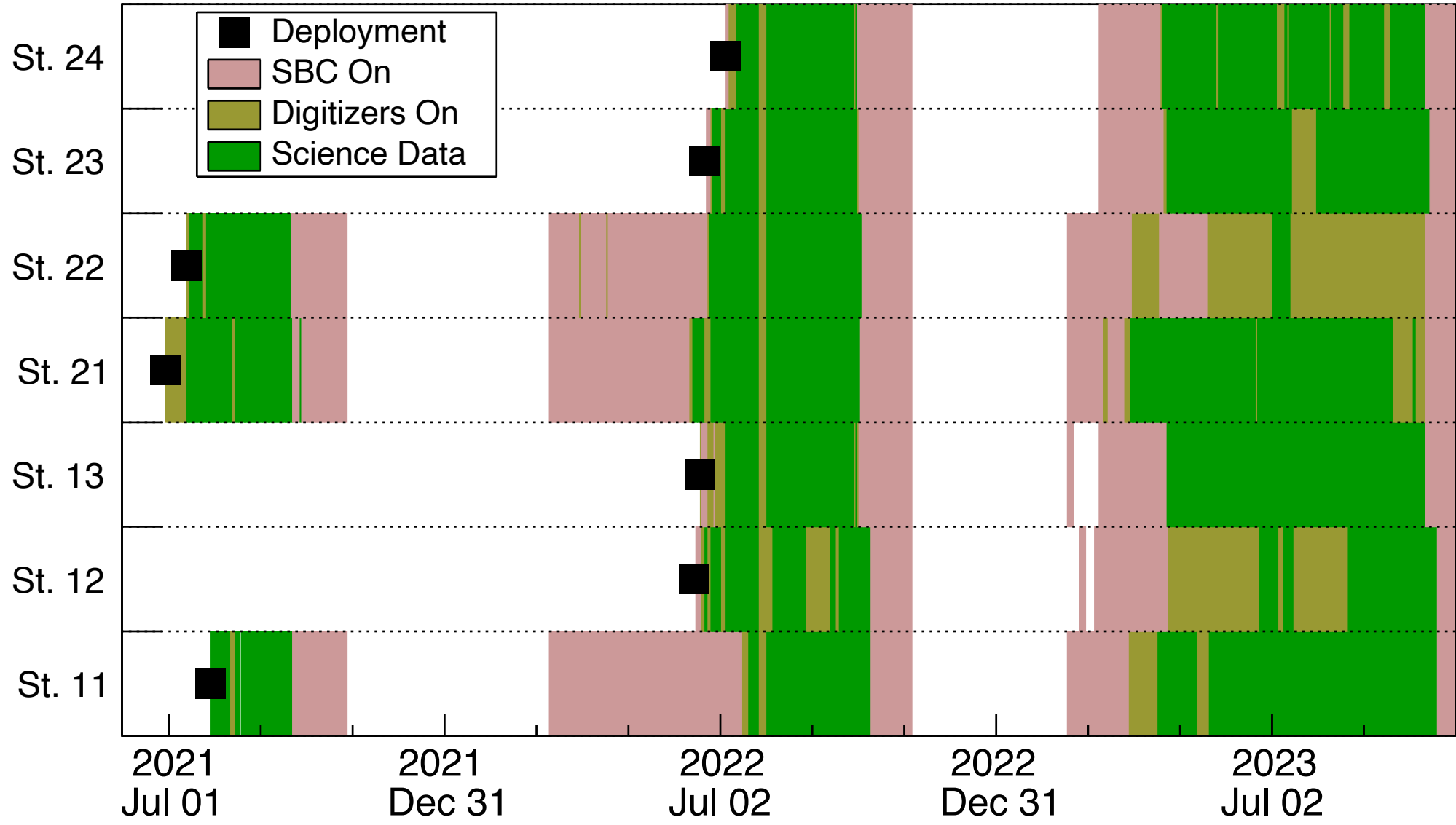


Data-taking status and first results

First deployment in summer 2021;
seven stations currently integrating data

Data set for first neutrino search still blinded

*A broadband radio array is a
very versatile detector!*



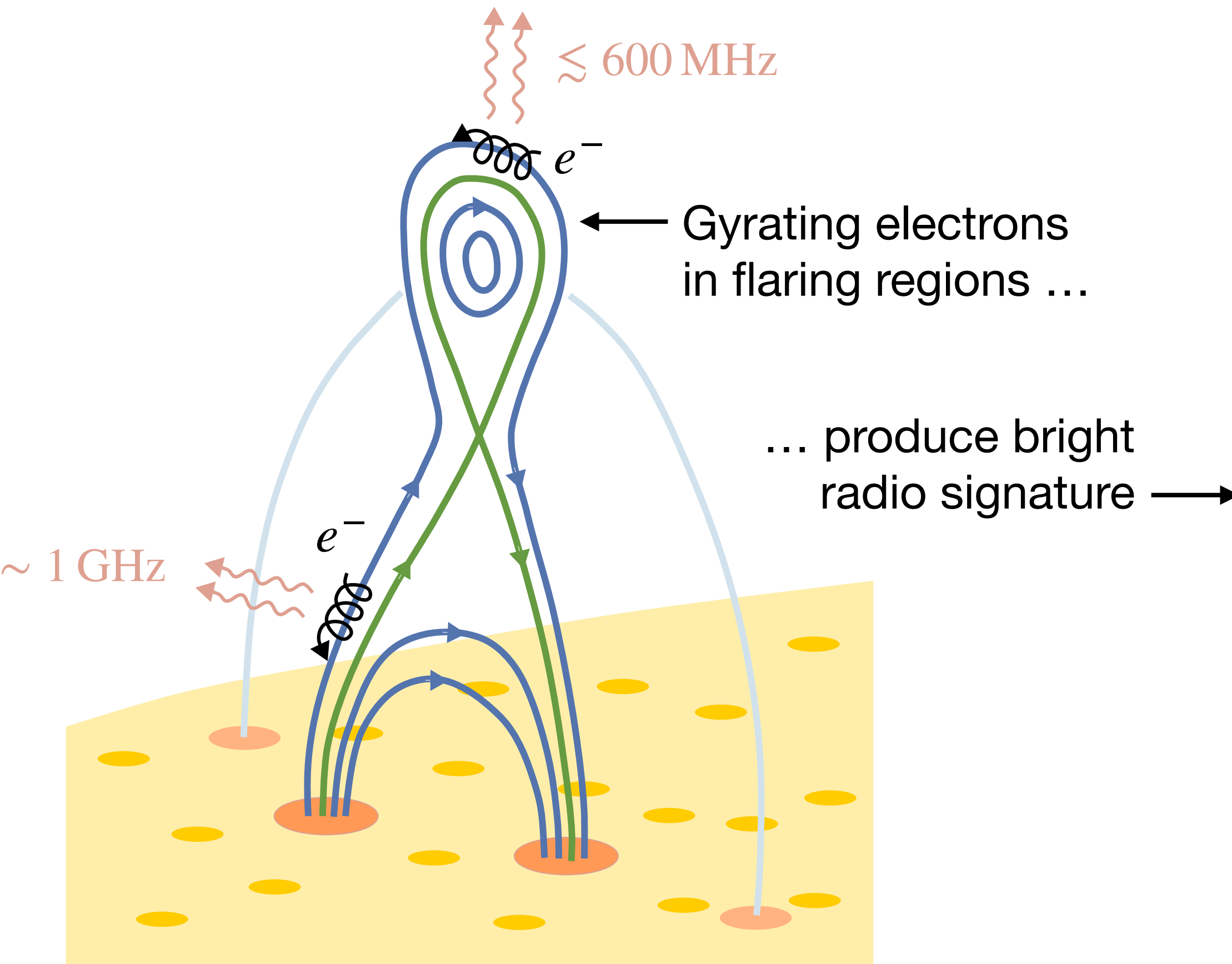
Data-taking status and first results

S. Hallmann, M. Mikhailova

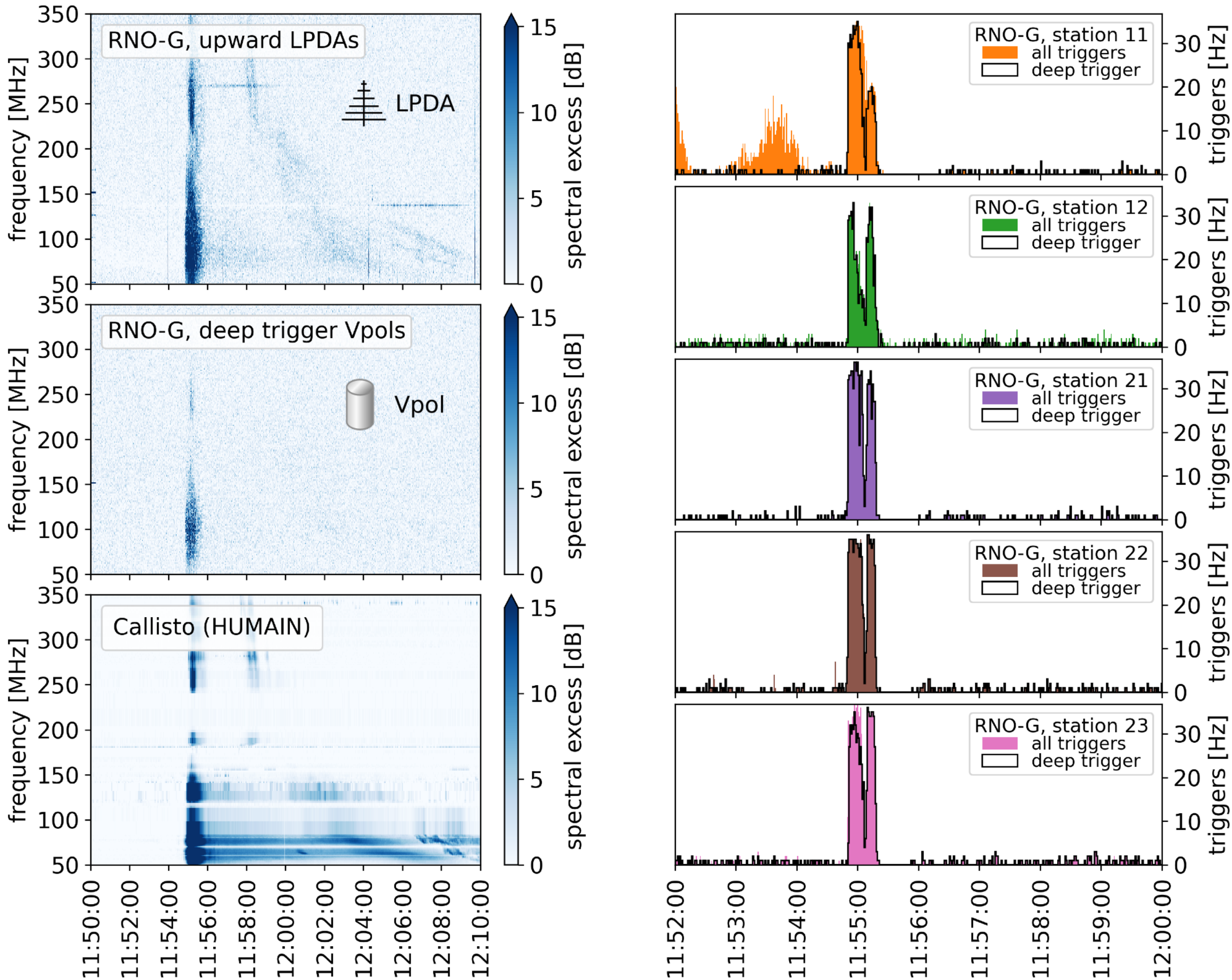
[[arXiv:2404.14995](https://arxiv.org/abs/2404.14995)]

First deployment in summer 2021;
seven stations currently integrating data

Observation of solar radio bursts in RNO-G



solar flare on 2022-09-29 (RNO-G Sun zenith angle: 78.8 deg)

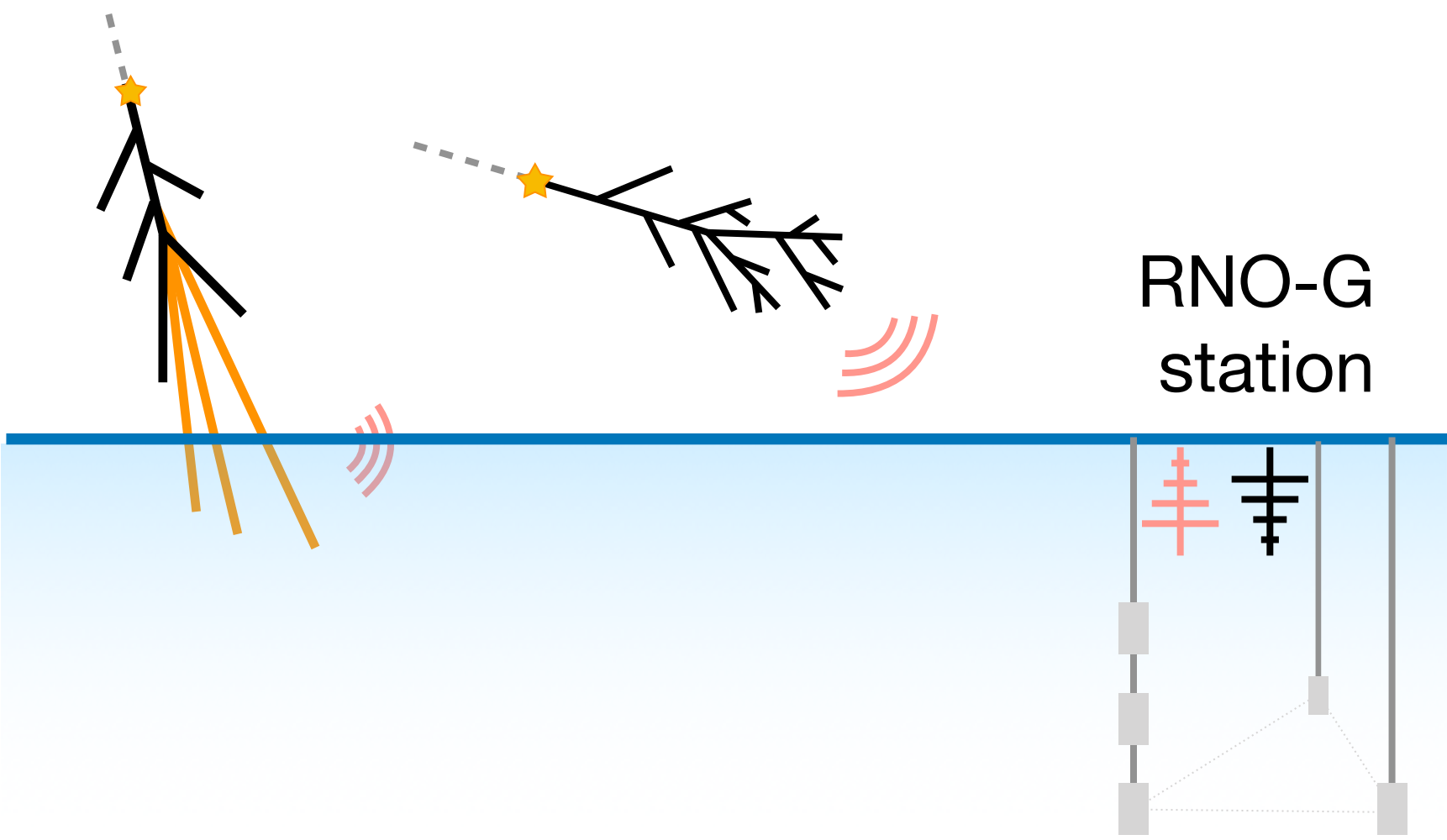


Data-taking status and first results

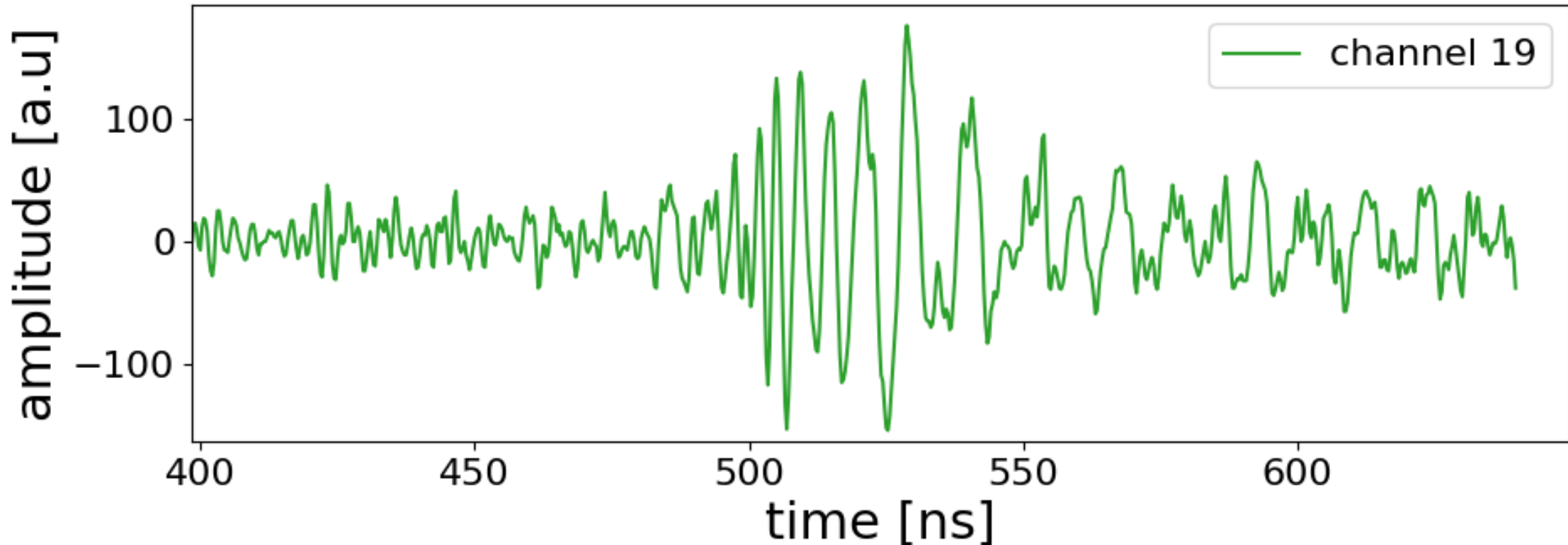
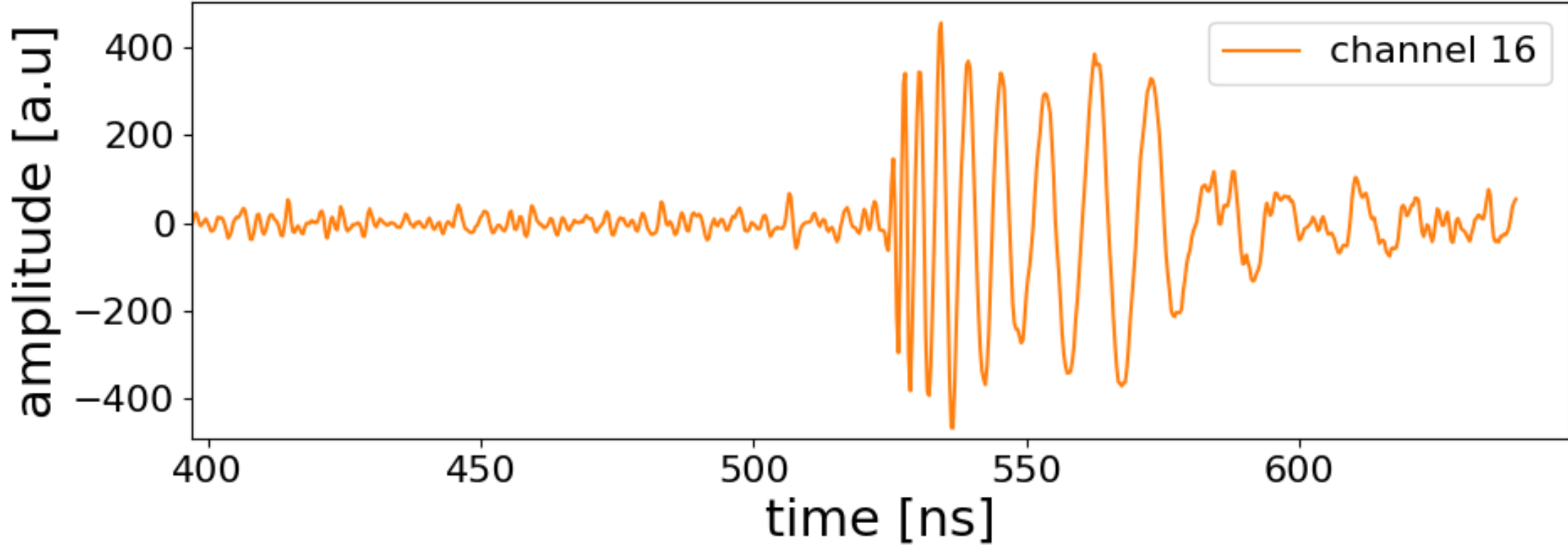
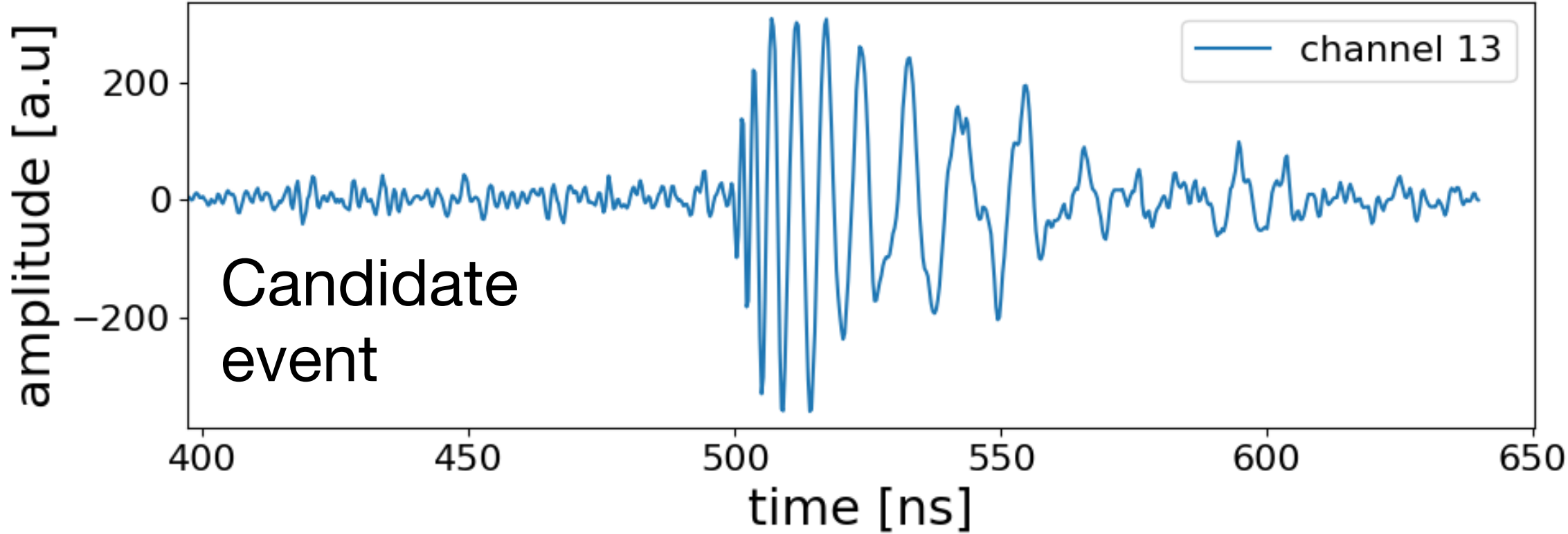
**First deployment in summer 2021;
seven stations currently integrating data**

Cosmic ray air showers

*Search for down-going signals in
surface antennas*



Full analysis / detector modeling work in progress



Building for the future

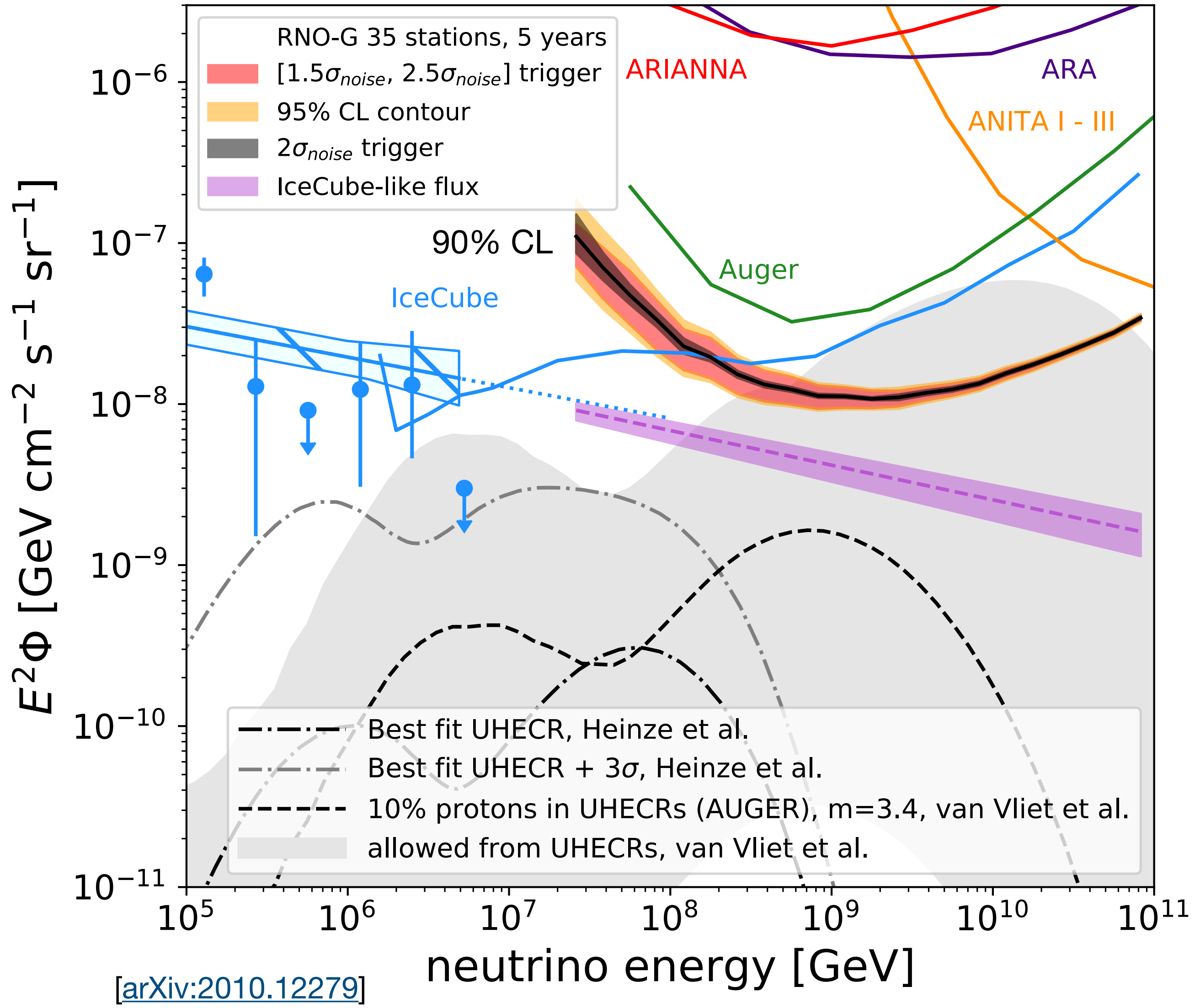
RNO-G array currently undergoing deployment at Summit Station, Greenland

Seven stations already taking data, **28 more** firmly planned (*and fully funded*)

World-leading sensitivity to neutrinos around 1 EeV

35-station array starts probing optimistic **cosmogenic neutrino models** and hard **astrophysical component**

Exciting times ahead!

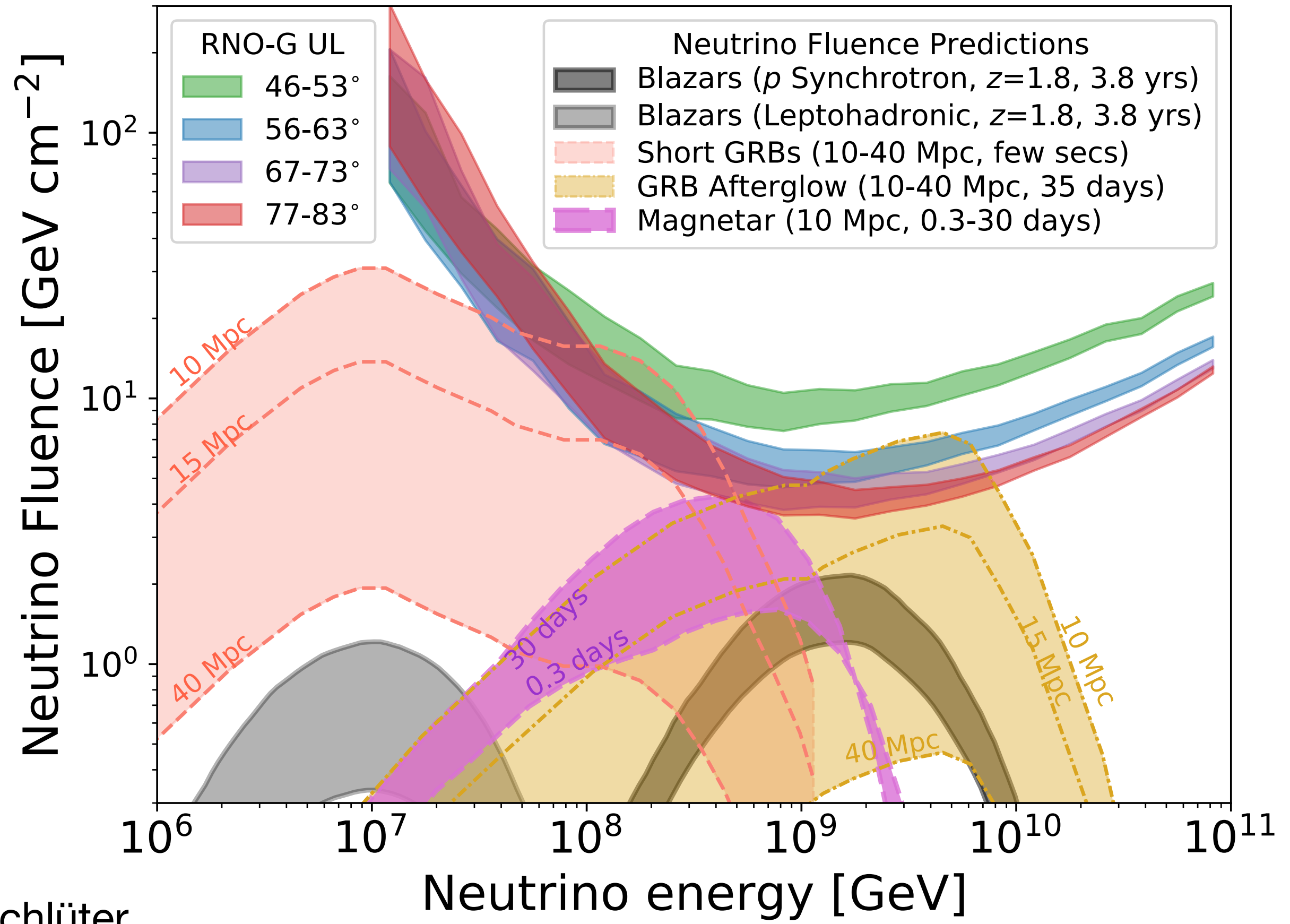
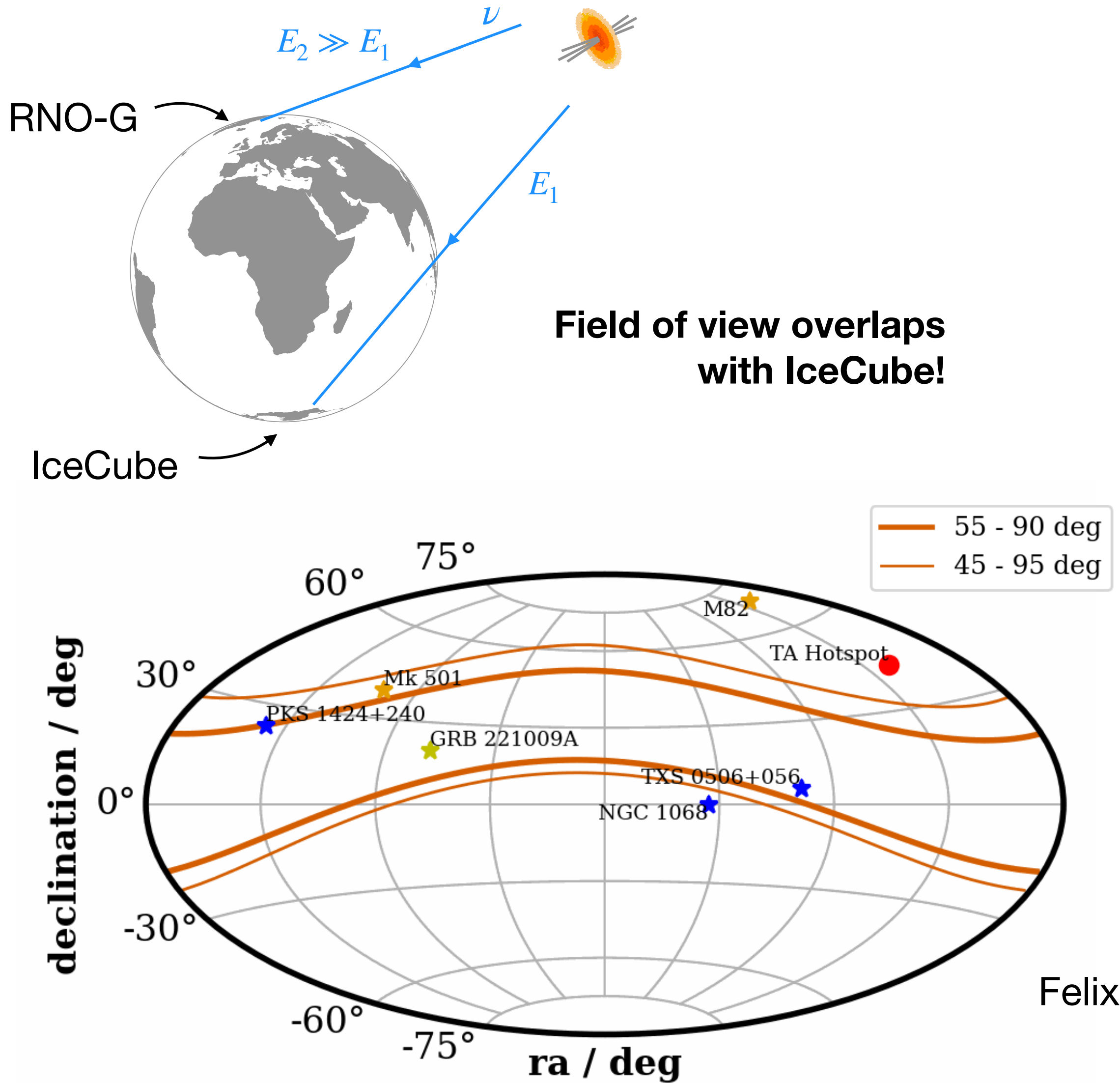




RNO-G
Collaboration
April 2024

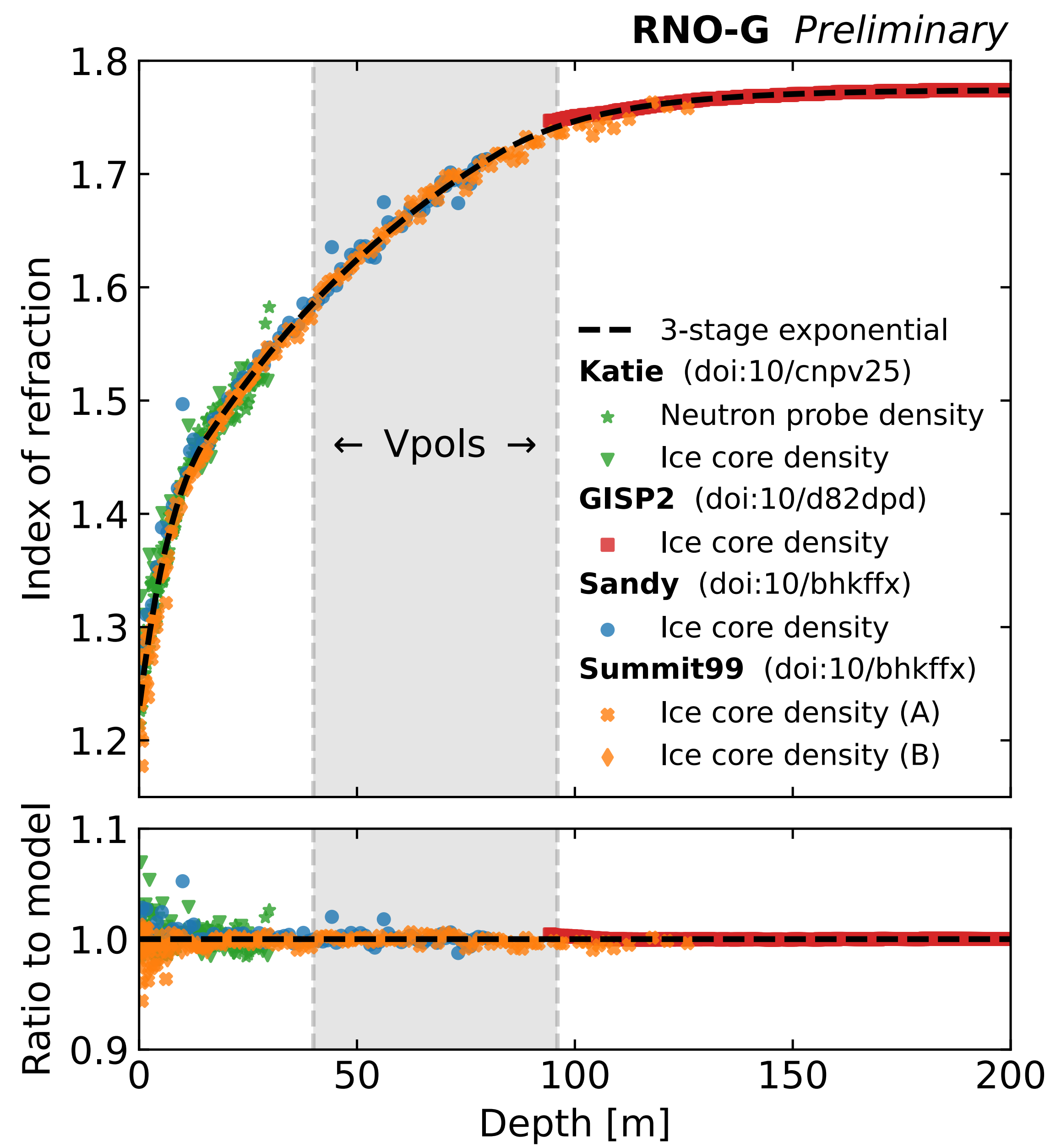
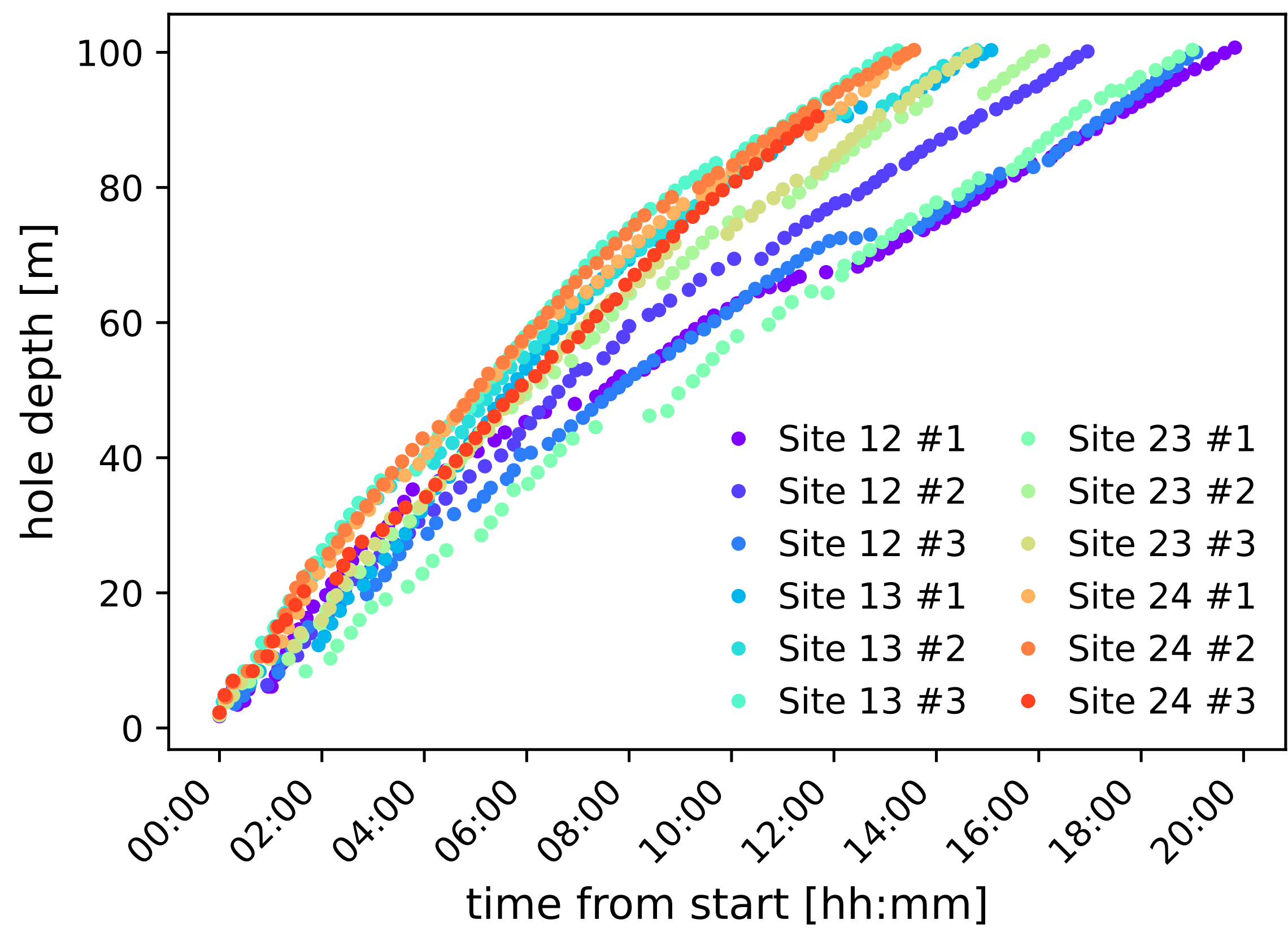
Backup

RNO-G sensitivity to flaring sources



Felix Schlüter

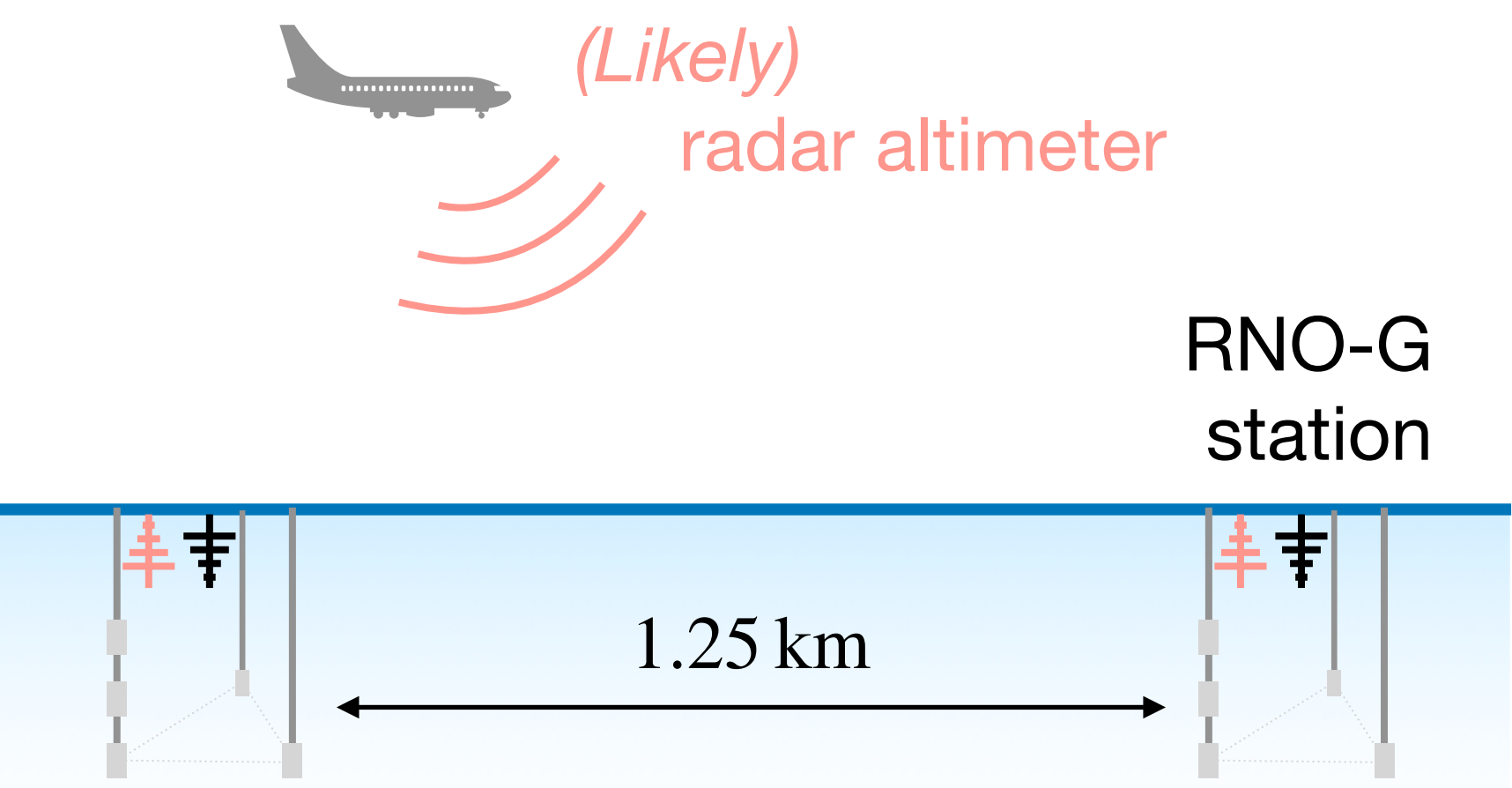
Ice at Summit



Data-taking status and first results

First deployment in summer 2021;
seven stations currently integrating data

Anthropogenic radio sources:
Satellites, weather balloons, airplanes, ...



Being explored as calibration source

