

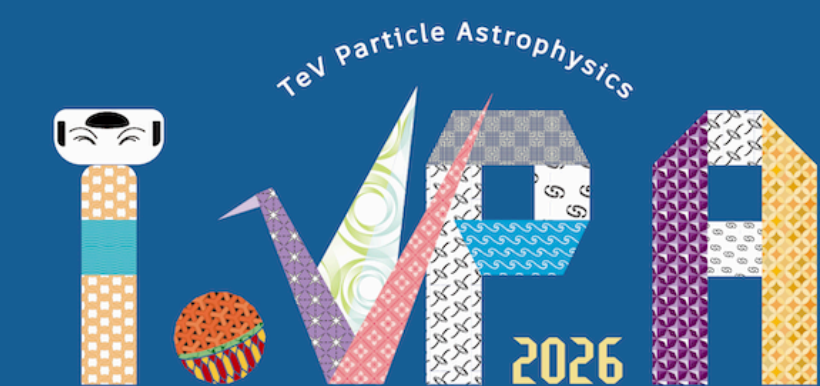


RNO-G

Radio Neutrino Observatory - Greenland

STATUS AND SCIENCE OF THE RADIO NEUTRINO OBSERVATORY IN GREENLAND

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Tendo
Japan

August 30 - September 4, 2026

September 2, 2026

fnds
LA LIBERTÉ DE CHERCHER

iihe
BRUXELLES BRUSSEL



UNIVERSITÉ
LIBRE
DE BRUXELLES

18 Institutes in 5 countries
~80 scientists



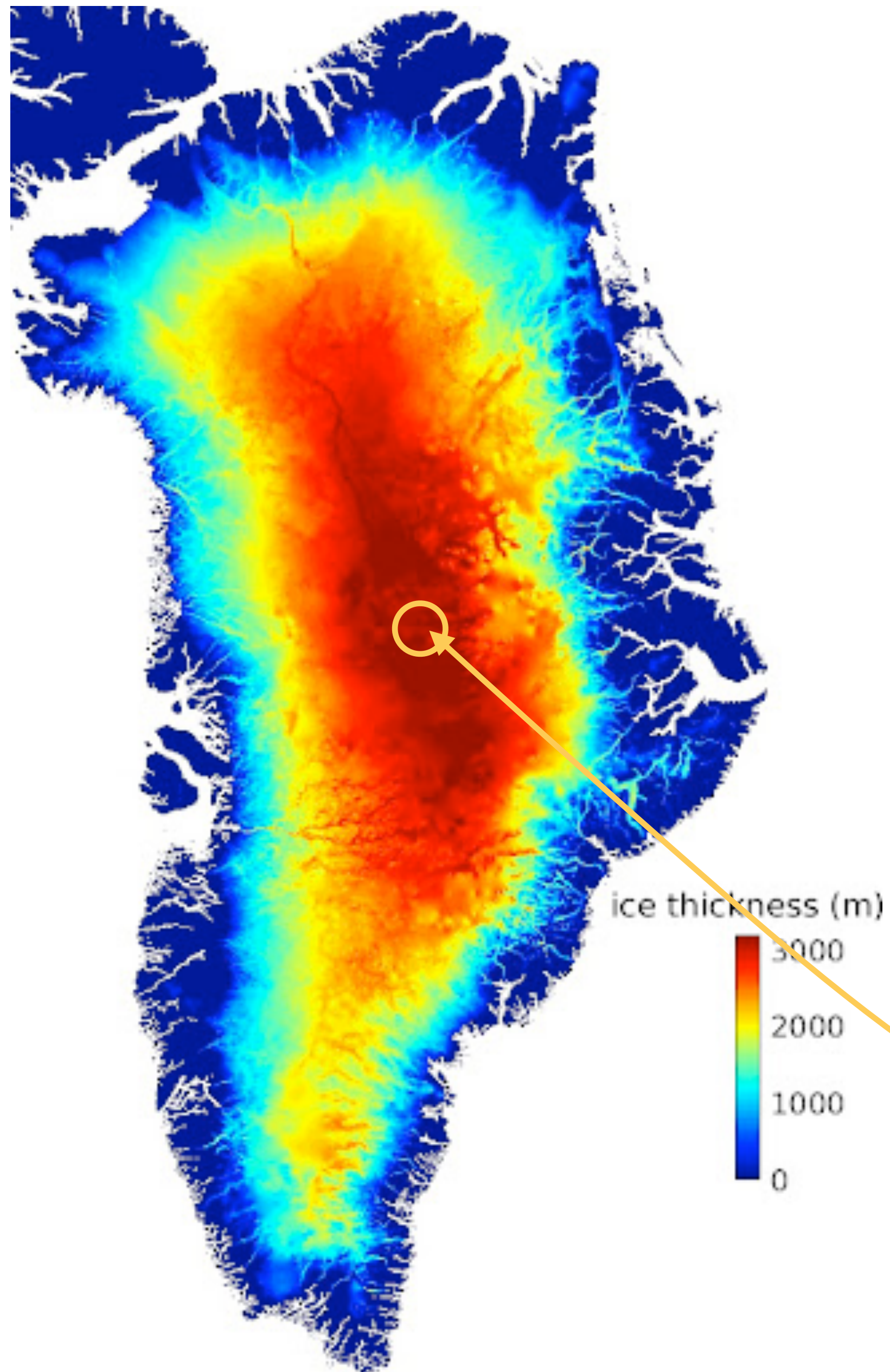
RNO-G Collaboration meeting Fall 2025



RNO-G
Collaboration
April 2024

The Radio Neutrino Observatory in Greenland

3



One of the biggest volume of transparent medium on Earth

- 3km thick ice at Summit Station.

Good infrastructure

- Summit station NSF-operated.

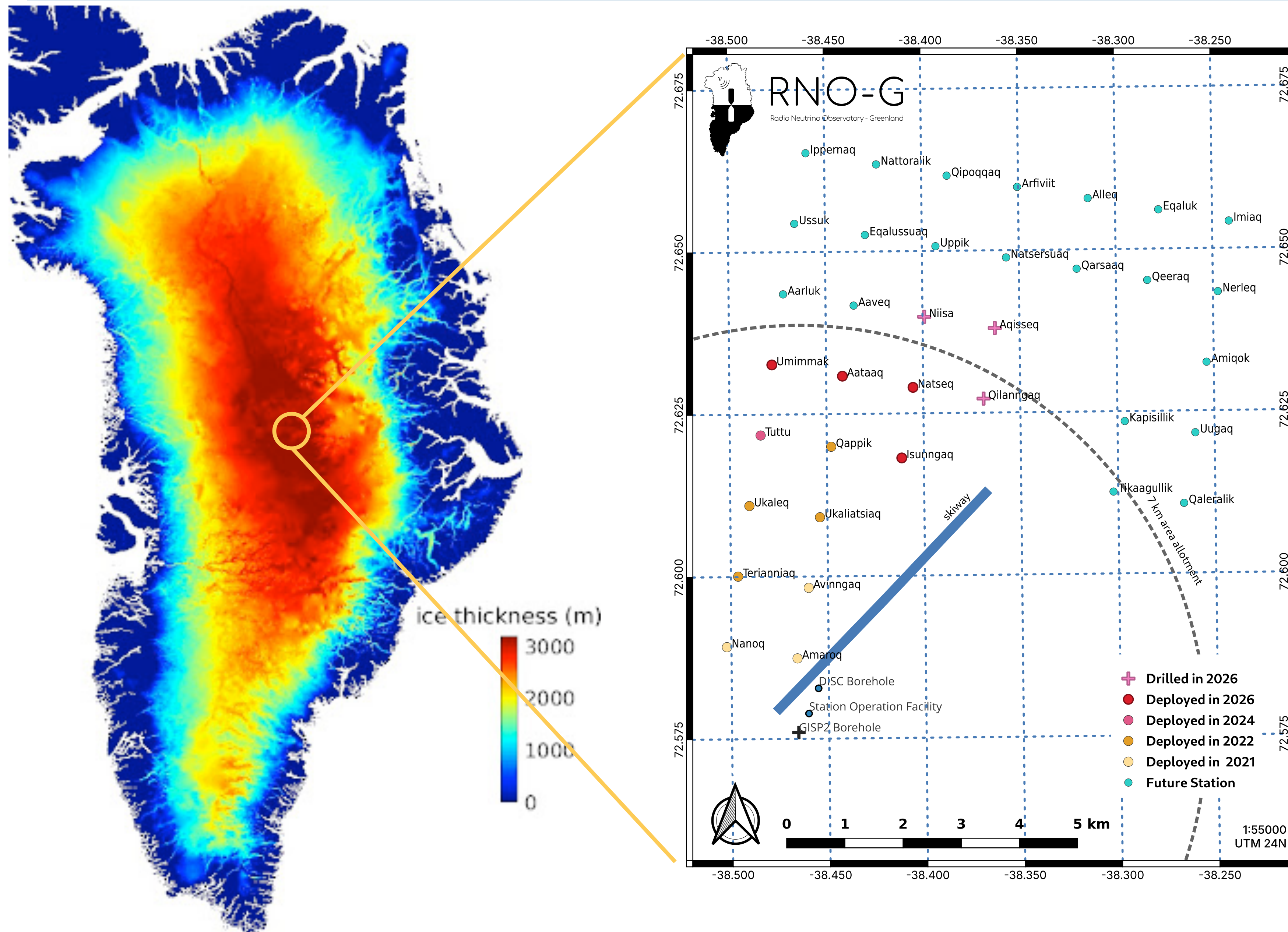
Sunlight 10 months/year

- Solar power.



The Radio Neutrino Observatory in Greenland

4

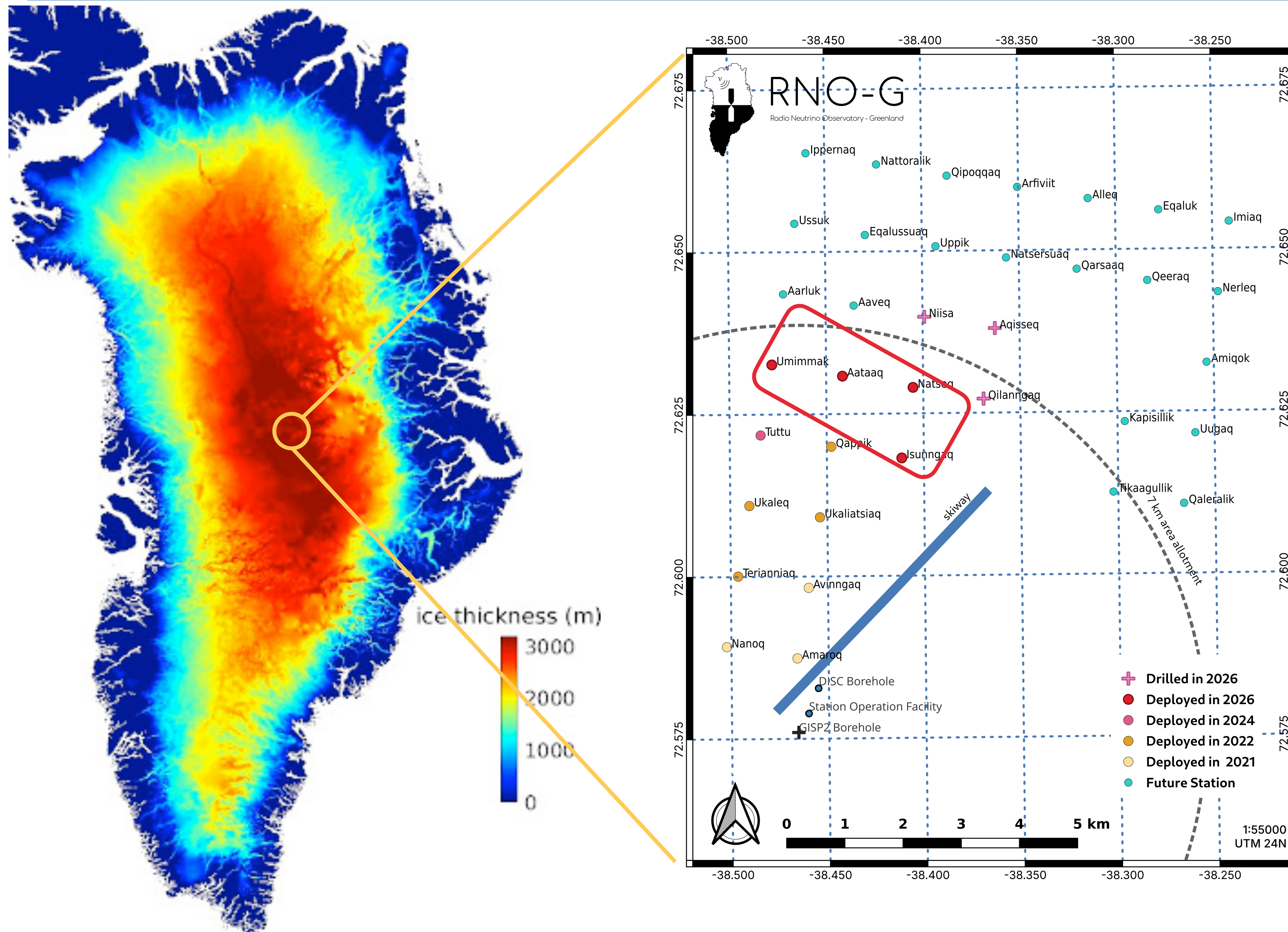


35 stations on 1.25 km grid

- **12** stations already in operation
- Fully funded (23 more to go)
- Stations are all solar powered and send data over LTE
- Each station acts as independent detector

The Radio Neutrino Observatory in Greenland

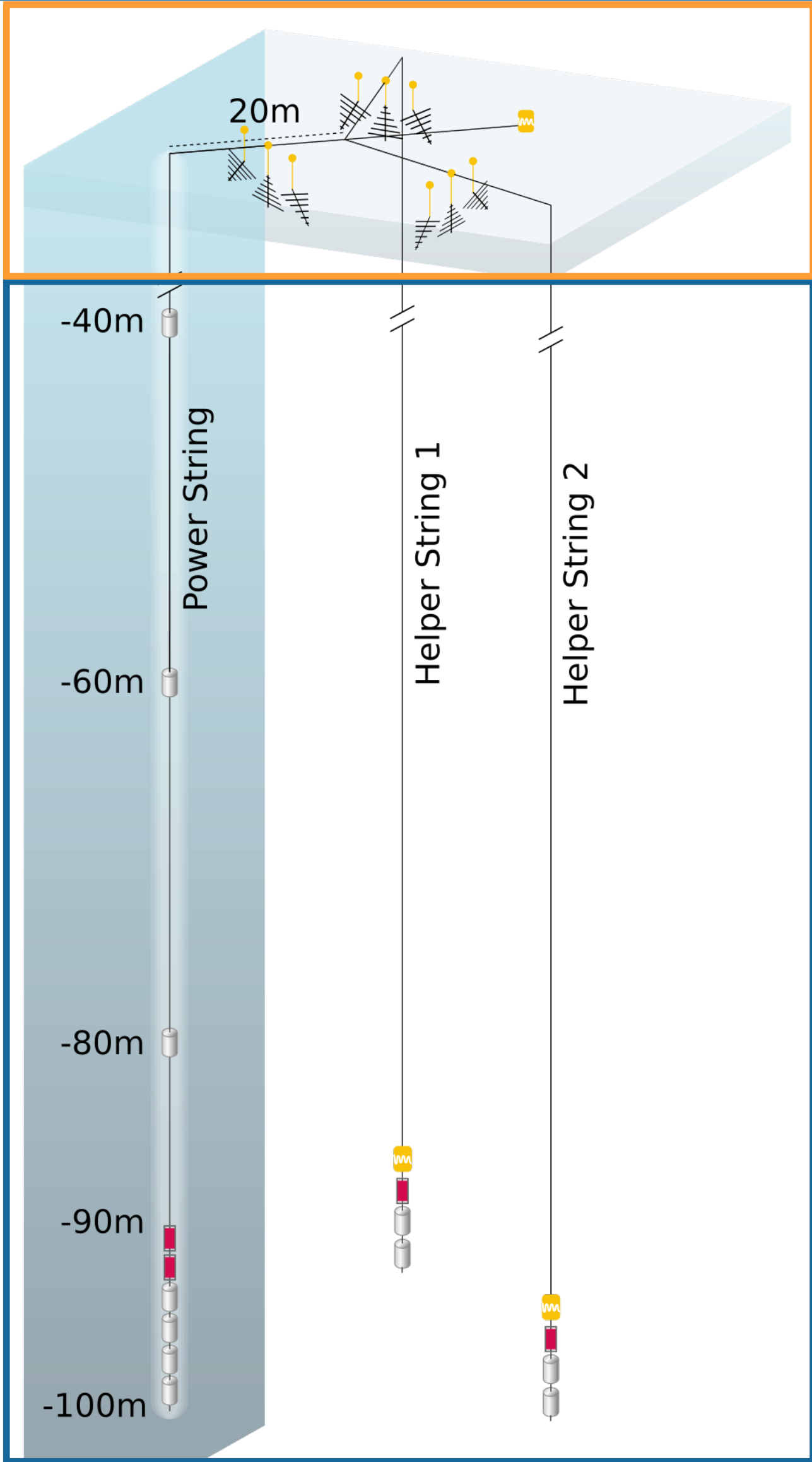
5



35 stations on 1.25 km grid

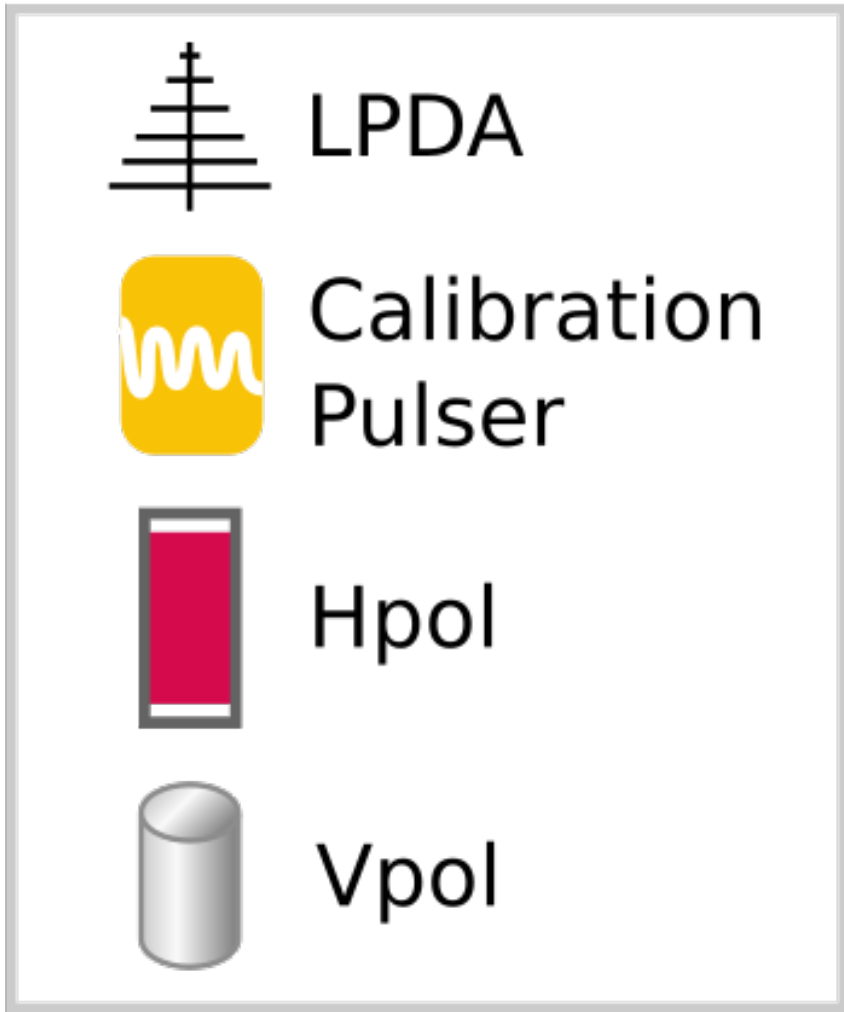
- **12** stations already in operation
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- Stations are all solar powered and send data over LTE
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A single RNO-G Station it's a Hybrid design



Surface component

Deep component

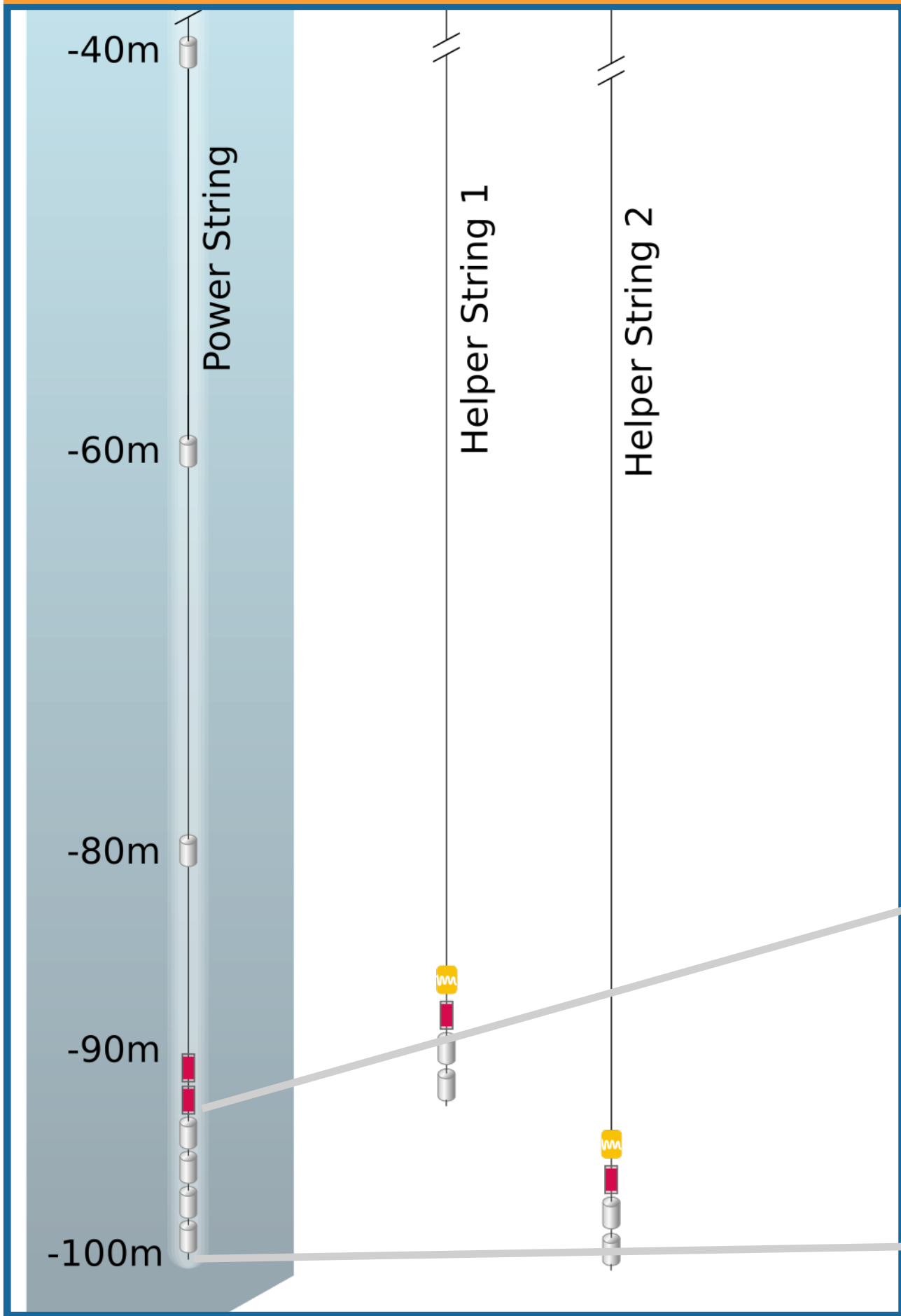
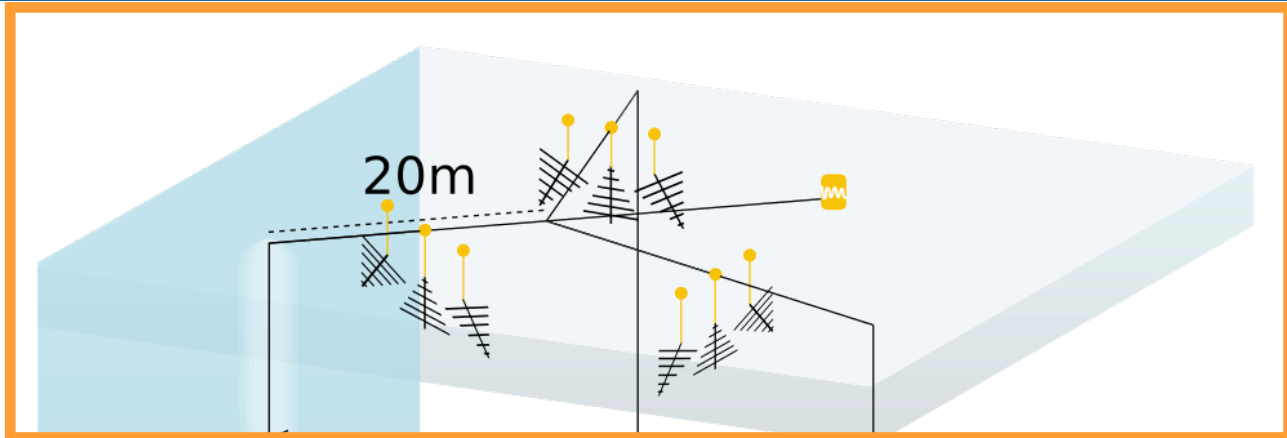


Three different antenna type:

- Log-Periodic Dipole Antenna (LPDA)
- Vertically-polarized (Vpol)
- Horizontally-Polarized (Hpol)

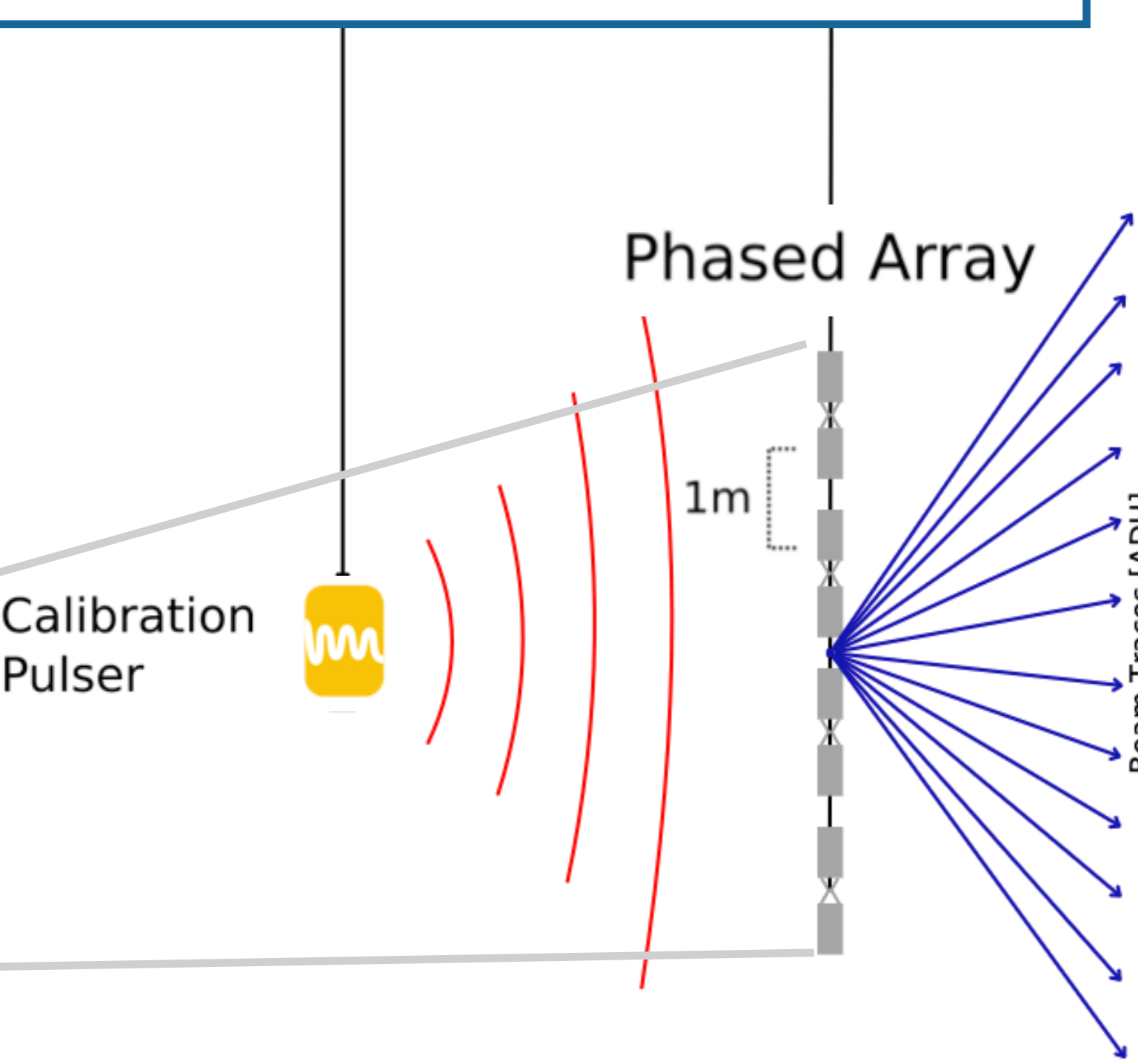


A single RNO-G Station it's a hybrid design

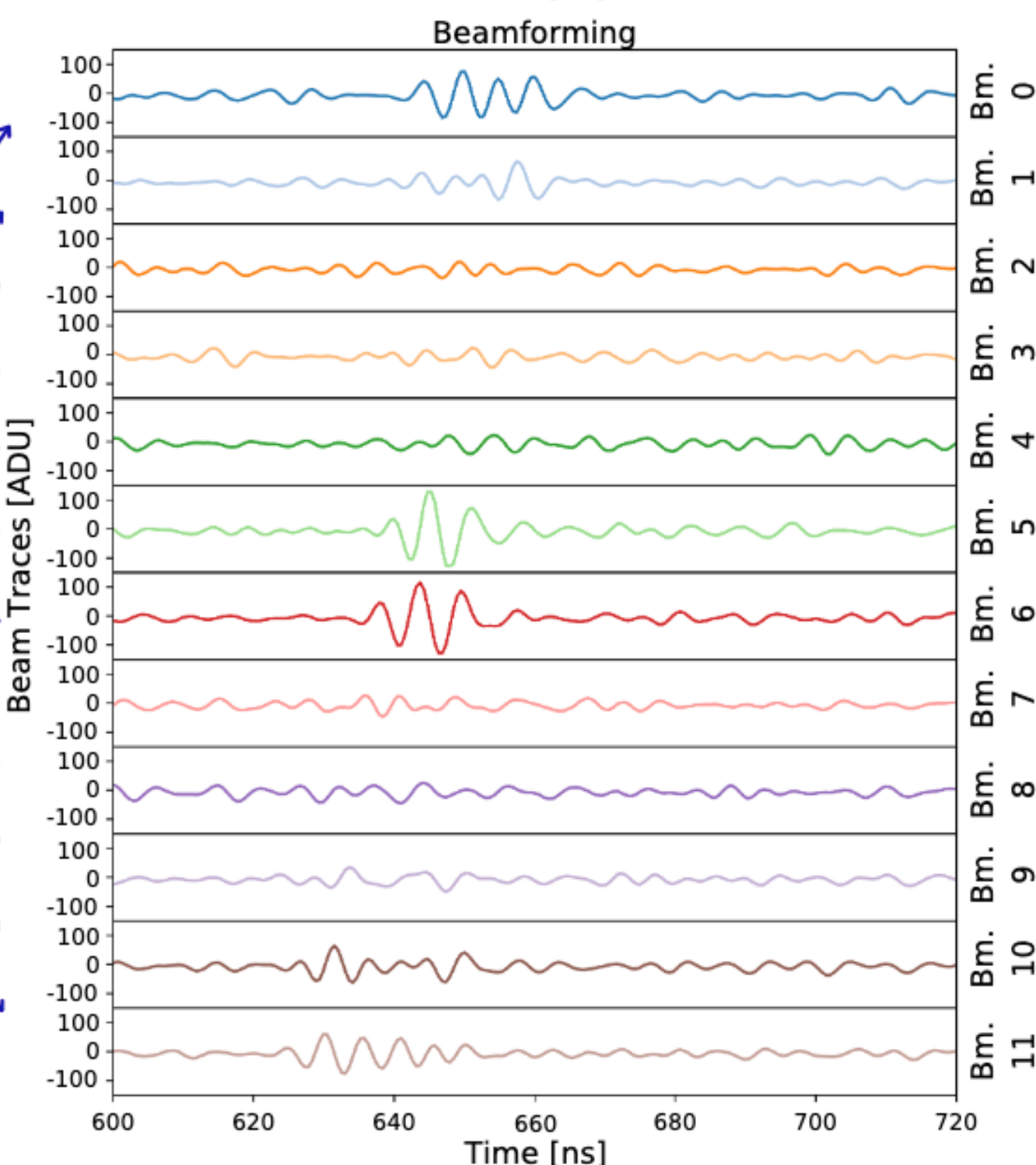
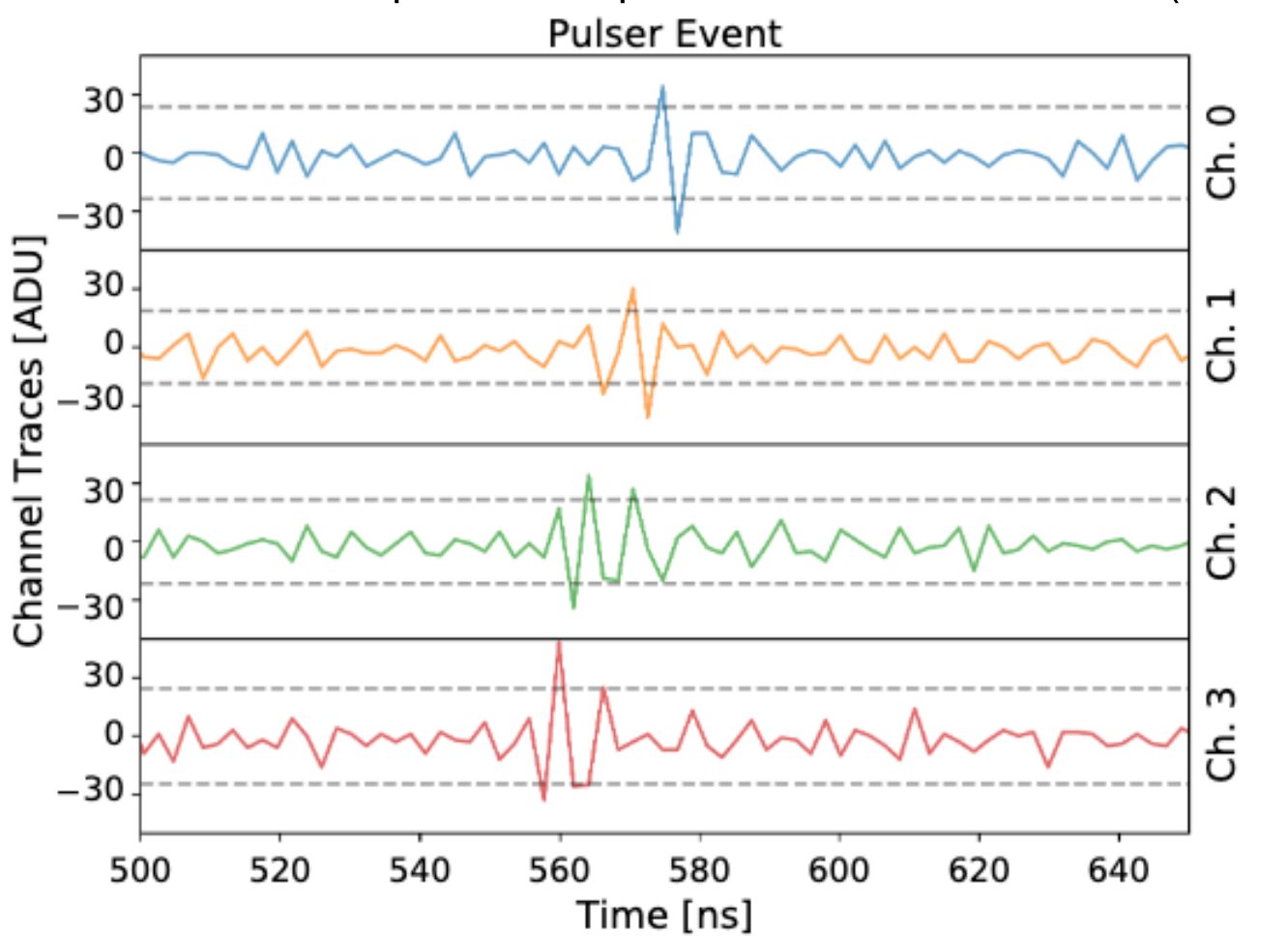


Low threshold trigger:
Densely packed Phased-Array of Vpols

- digital interferometer forms 12 beams over the full volume
- trigger runs on each beamformed trace

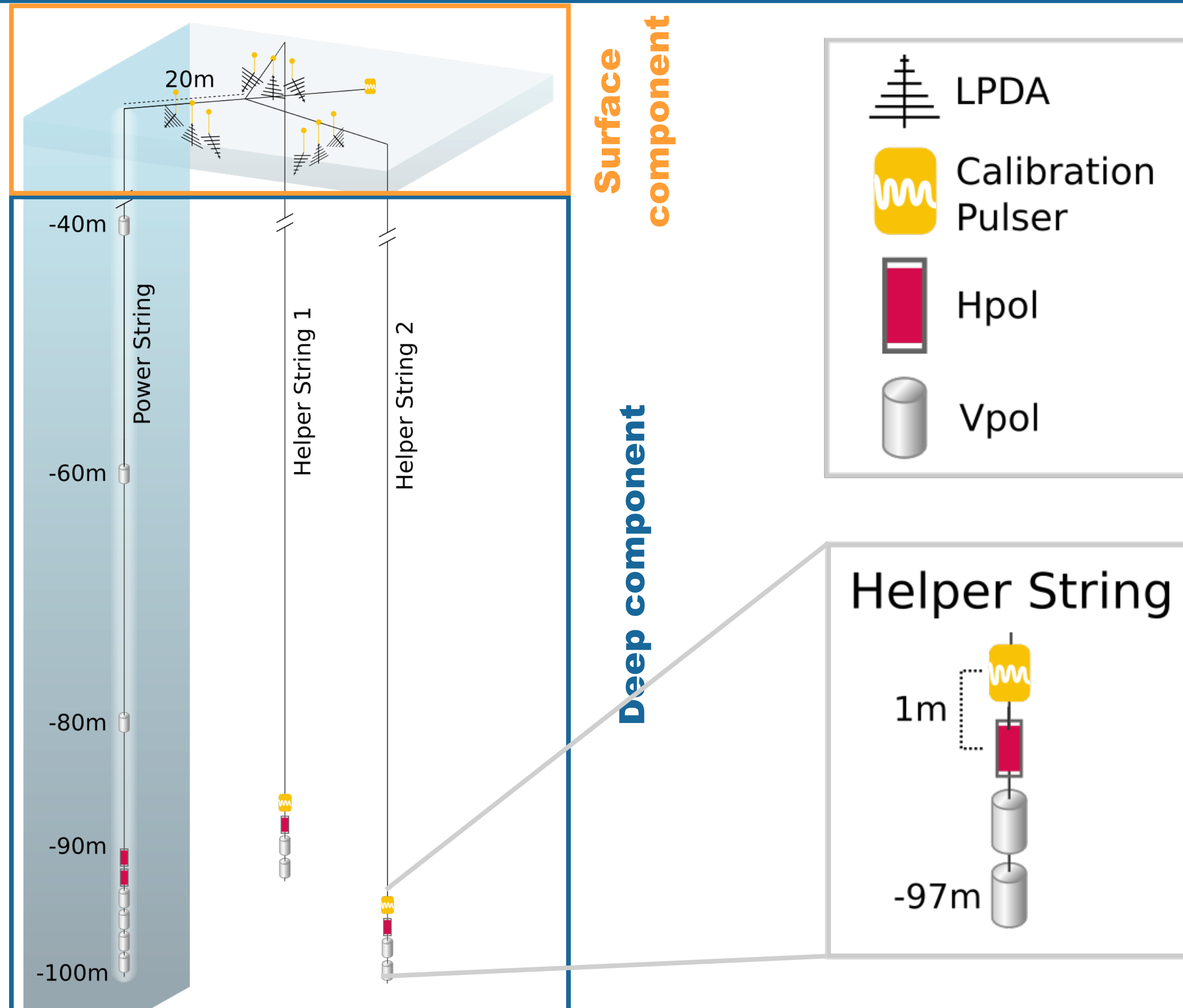


Work accepted for publication in JINST (R. Krebs, PSU)



A single RNO-G Station it's a hybrid design

8



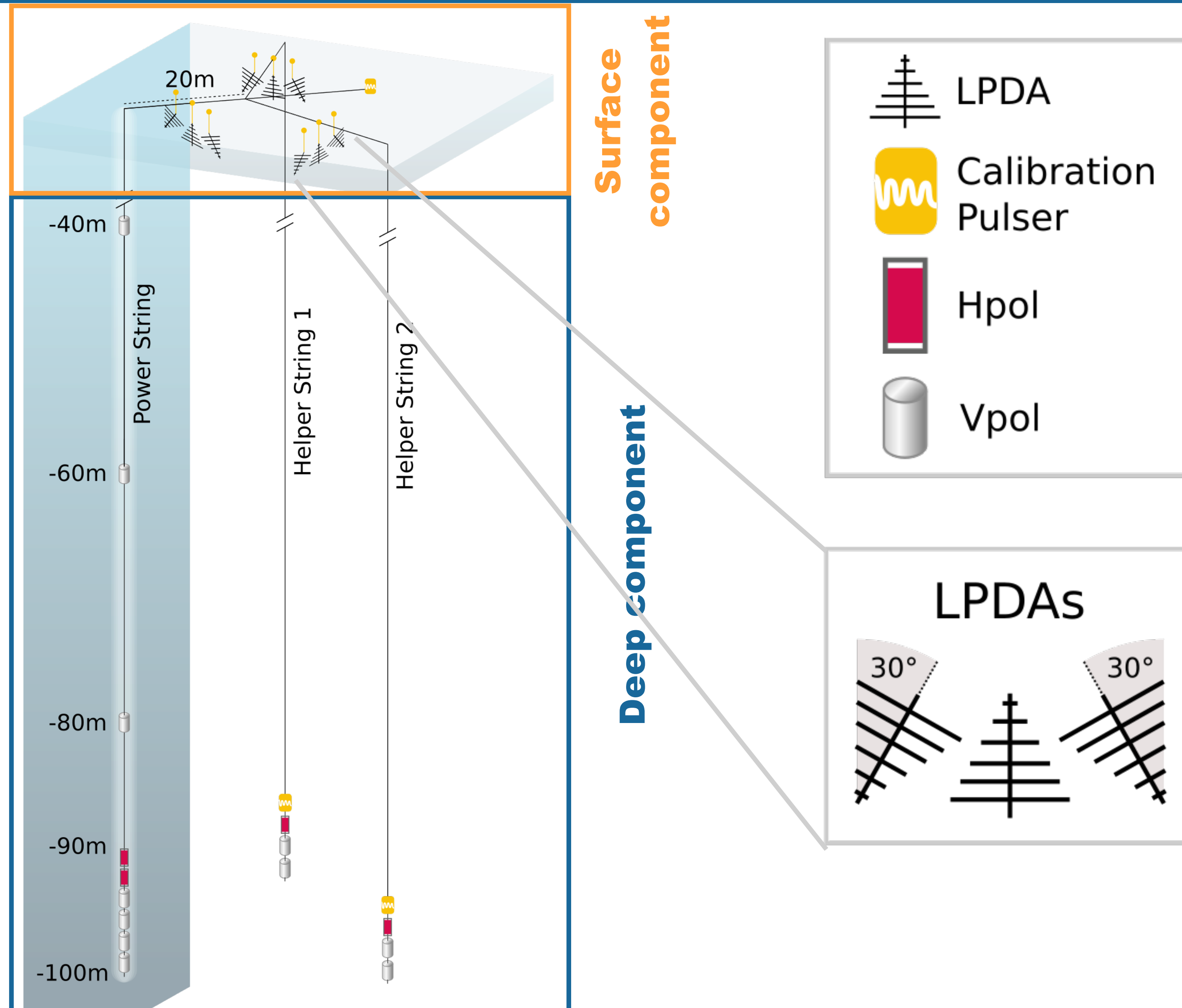
Three different antenna type:

- Log-Periodic Dipole Antenna (LPDA)
- Vertically-polarized (Vpol)
- Horizontally-Polarized (Hpol)

Helper strings include Vpol and Hpol antennas for signal reconstruction, as well as calibration pulsers that transmit signals as needed.

A single RNO-G Station it's a hybrid design

9



Three different antenna type:

- Log-Periodic Dipole Antenna (LPDA)
- Vertically-polarized (Vpol)
- Horizontally-Polarized (Hpol)

LPDAs at the surface help with signal reconstruction and act as a surface veto.

They also contribute a small amount to neutrino effective volume.

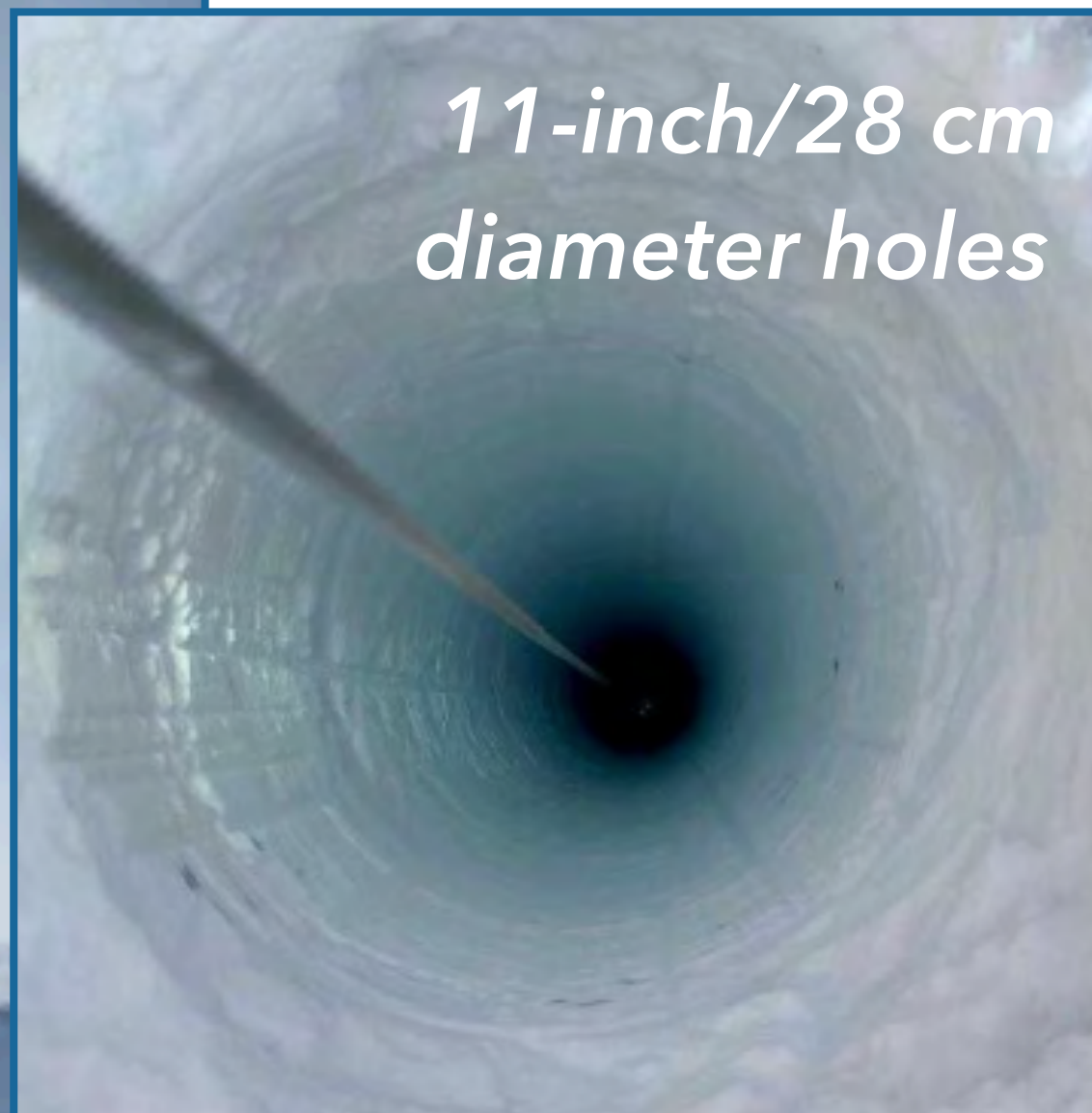
Drilling

10

*drilling speed: 12 hr / hole
demonstrated*



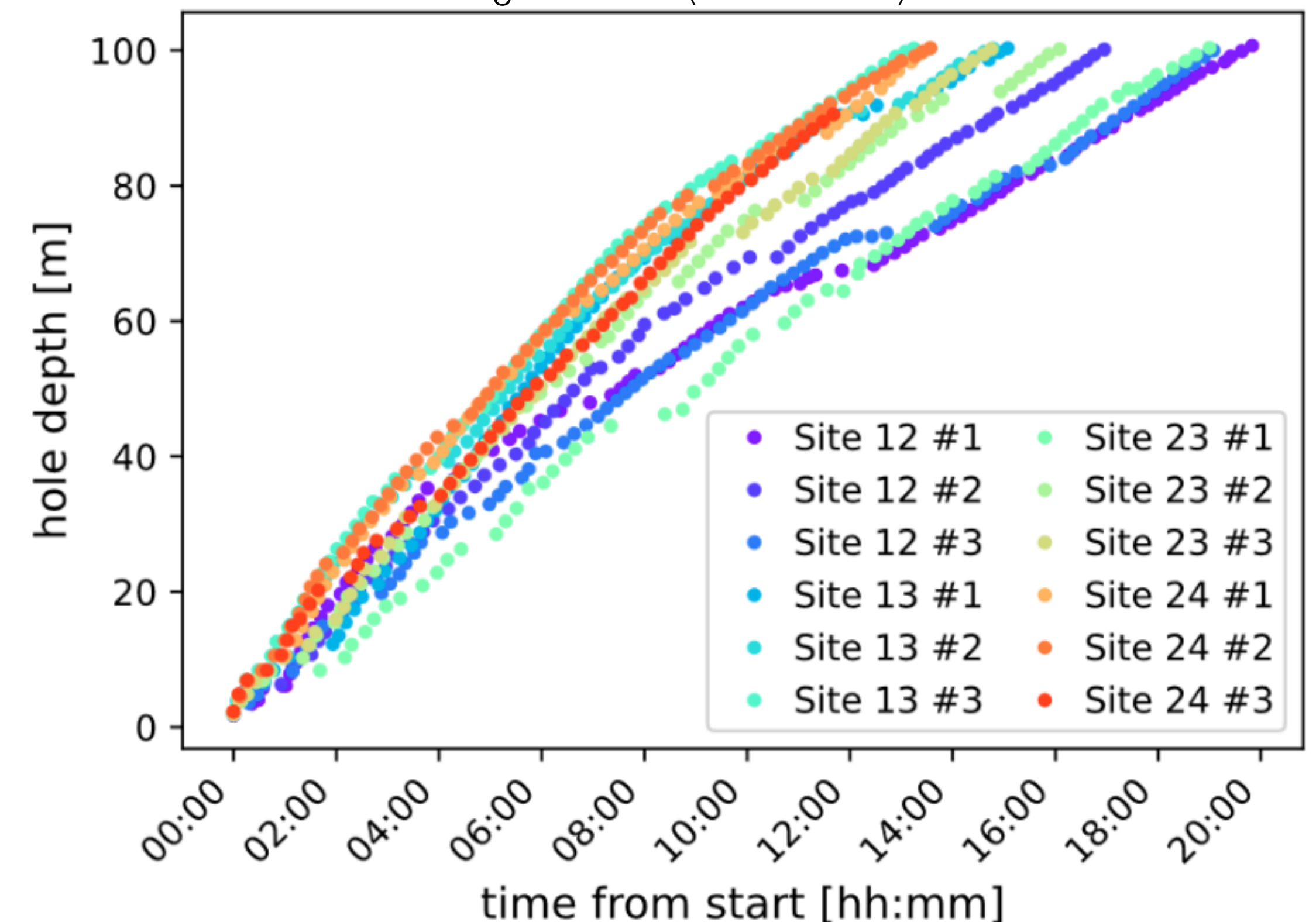
*11-inch/28 cm
diameter holes*



Station design relies on **3 holes of a depth of 100m** per stations

- World's largest mechanical drill from British Arctic Survey
- Drill underperformed in the past limiting installation in 2023 and 2024
- **Drill performance much improved in 2025**

S. Agarwal et al (RNO-G Coll.) 2025 JINST 20 P04015



Drilling

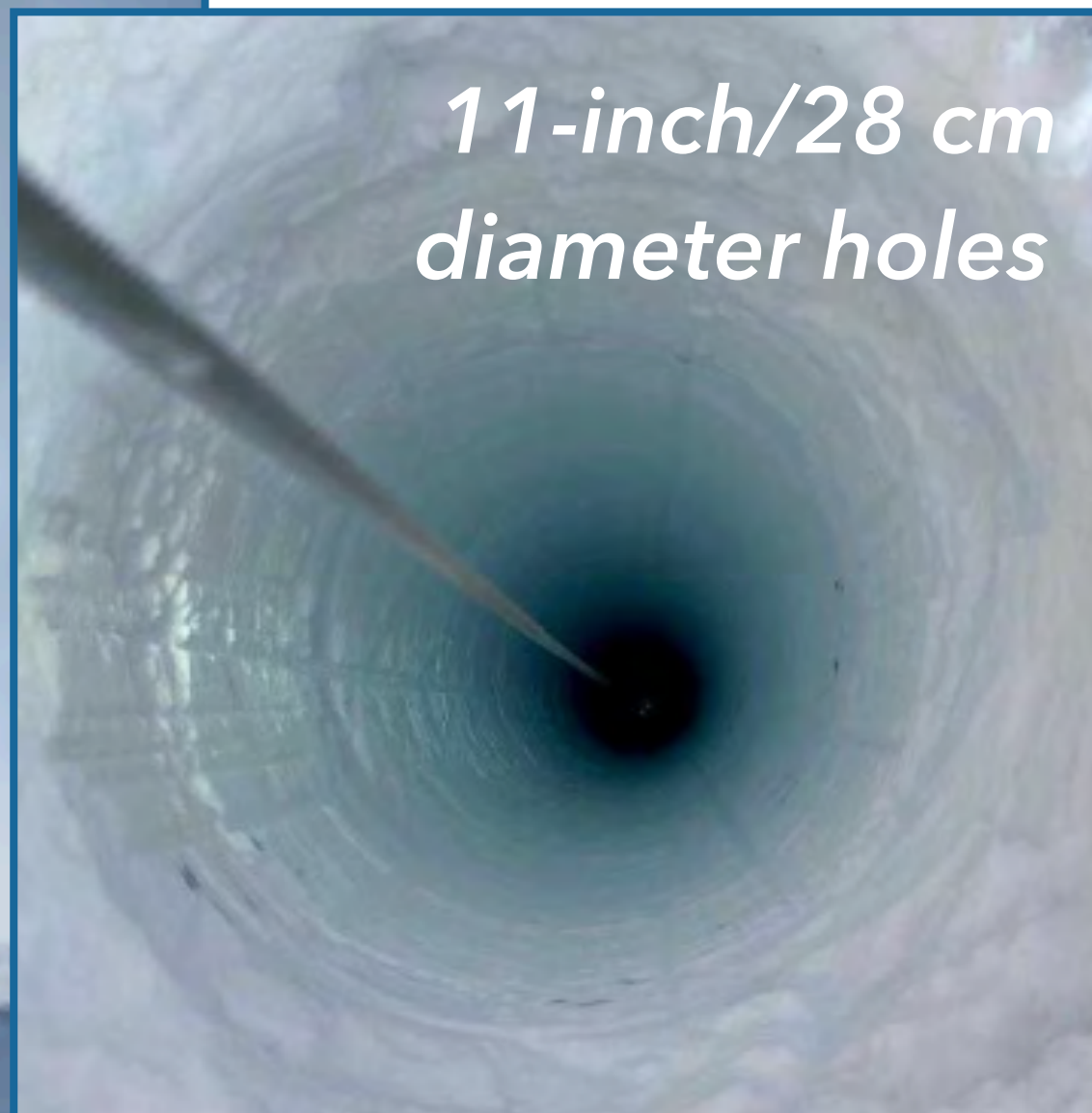
Installation

11

drilling speed: 12 hr / hole
demonstrated



11-inch/28 cm
diameter holes



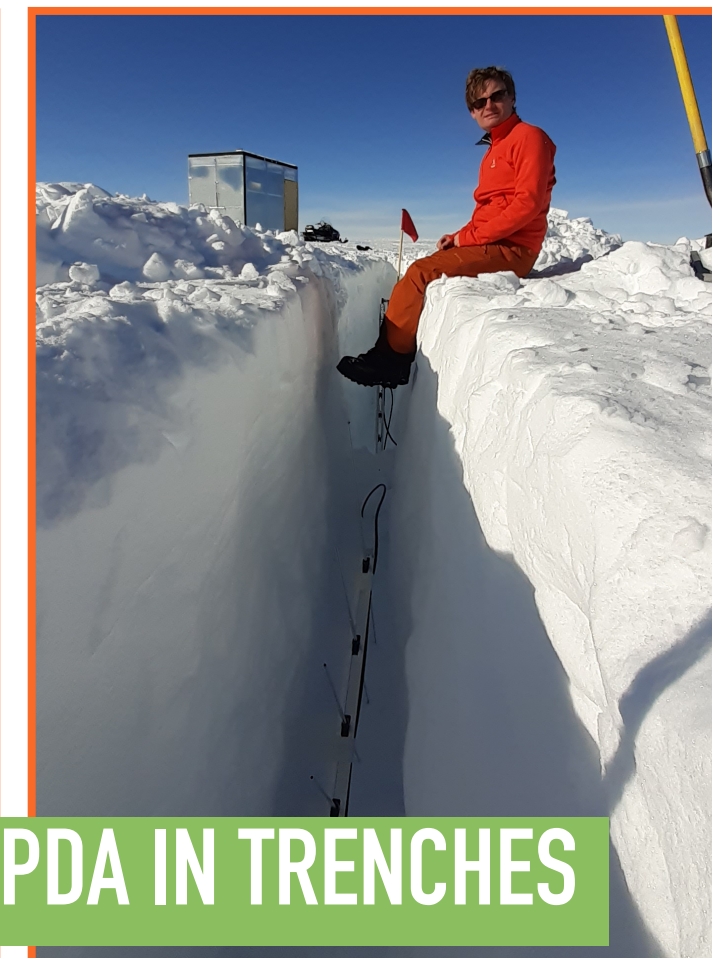
STATION AMAROQ



DEPLOYMENT HUT



SURFACE LPDA IN TRENCHES



DEEP CHANNELS: LOWERED
BY HAND



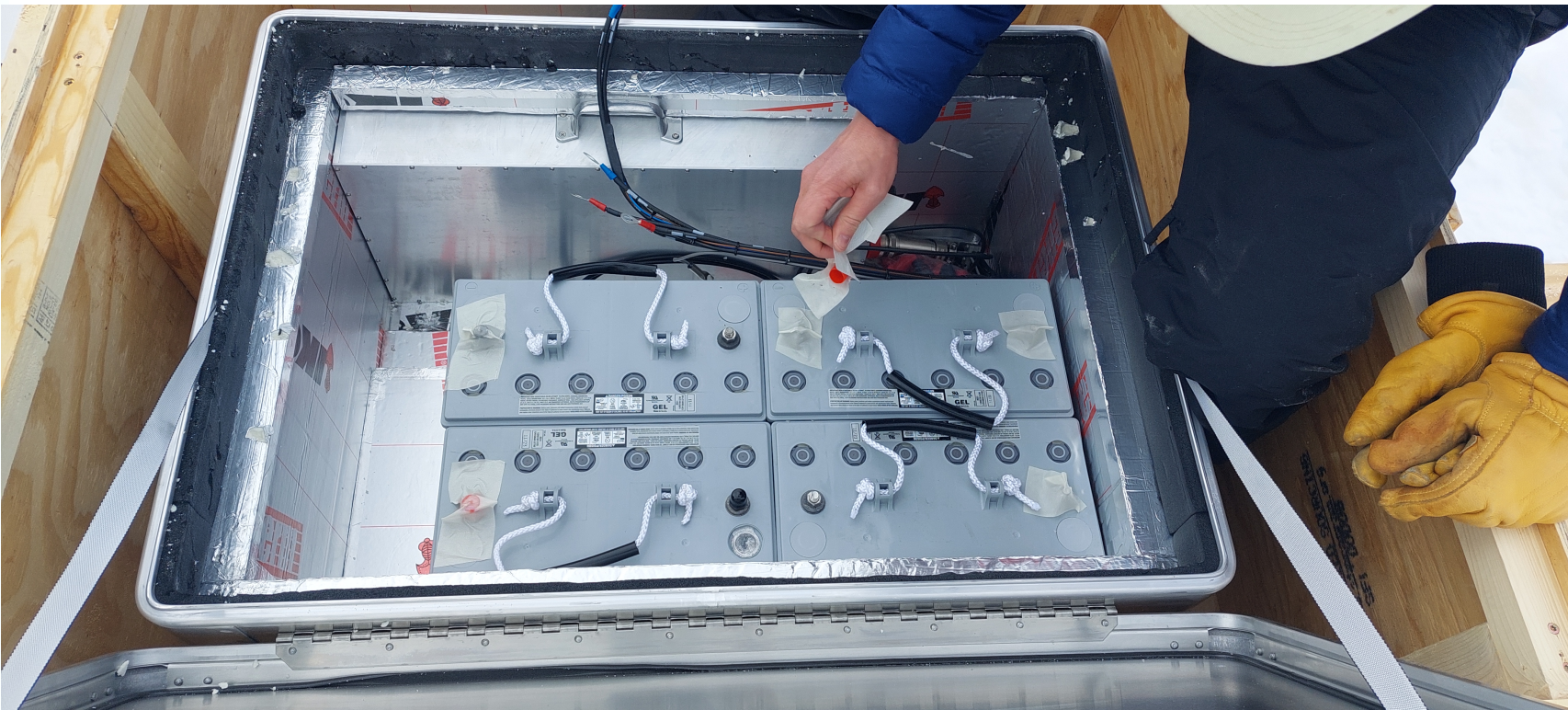
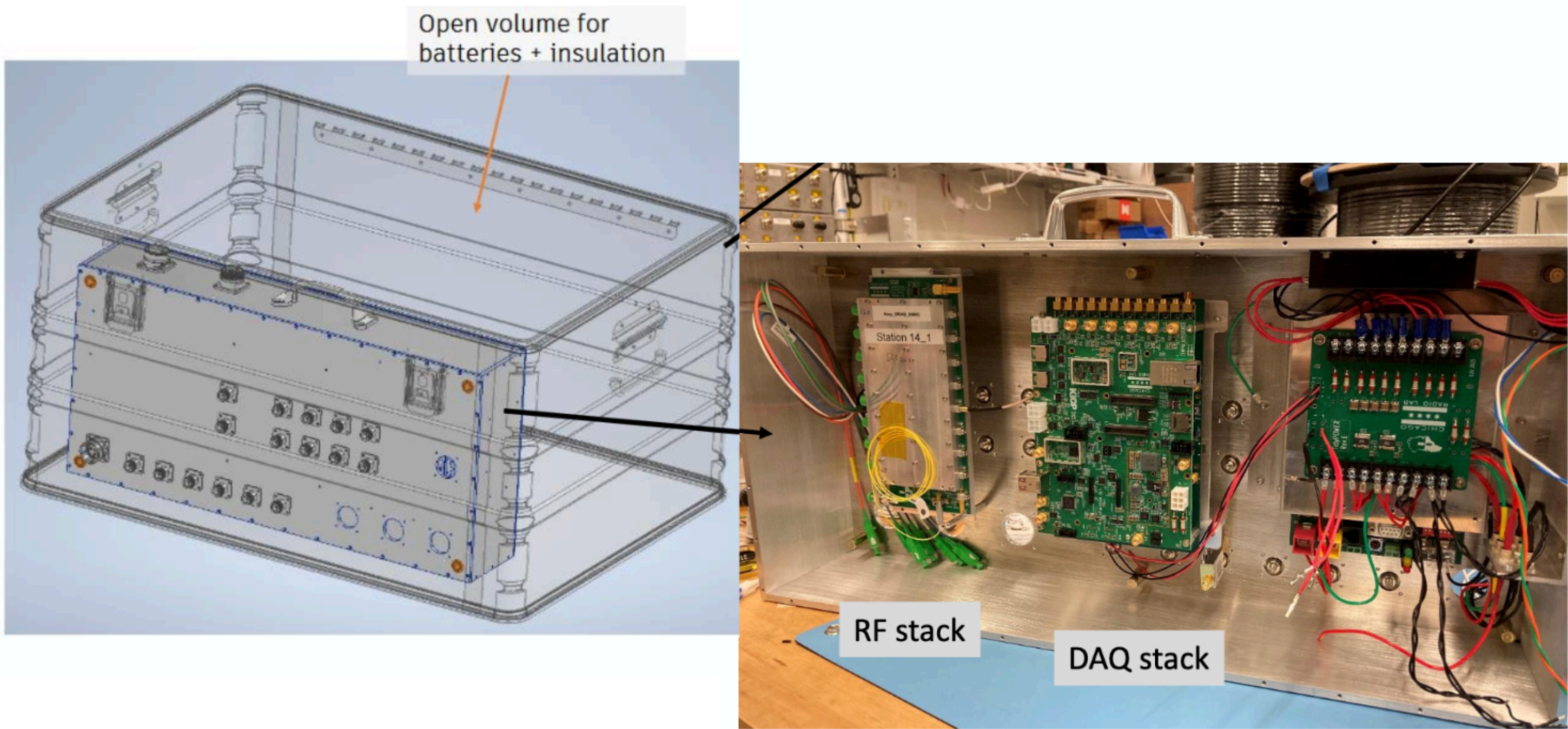
GPS SURVEY



ASSEMBLING

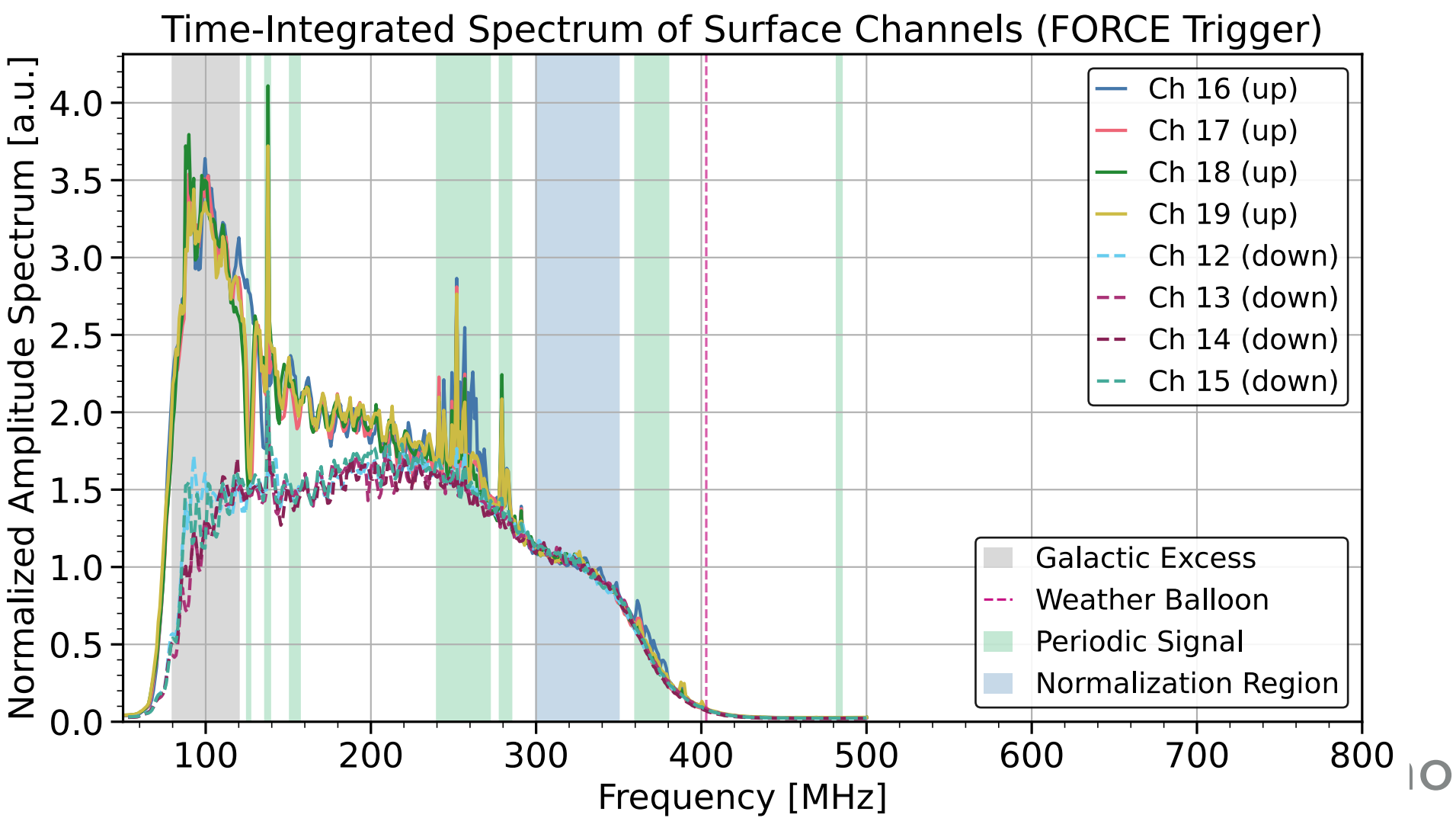
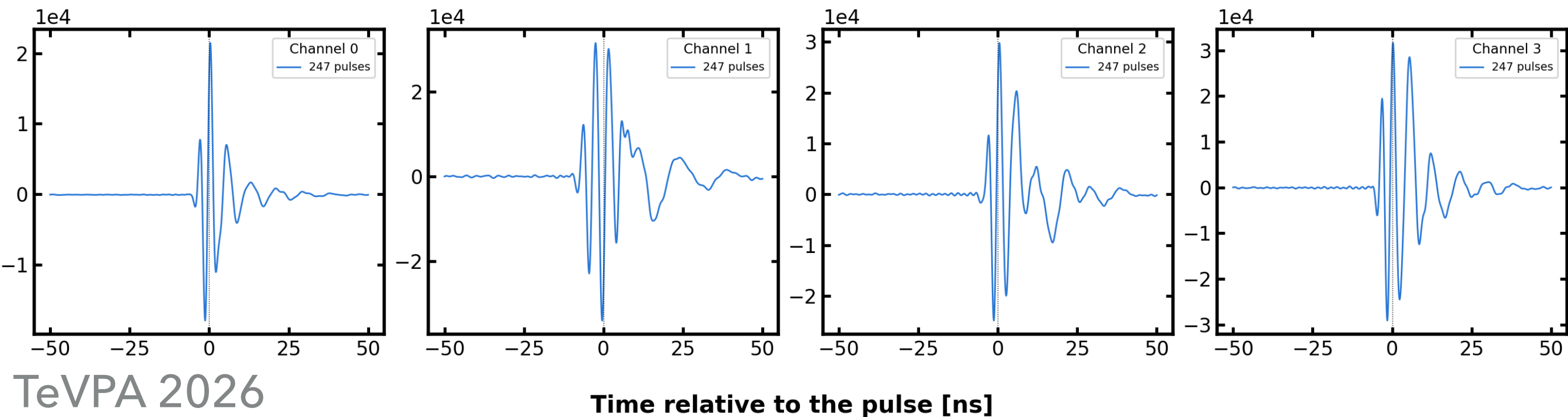


Season 2026 - Major upgrade with new DAQ

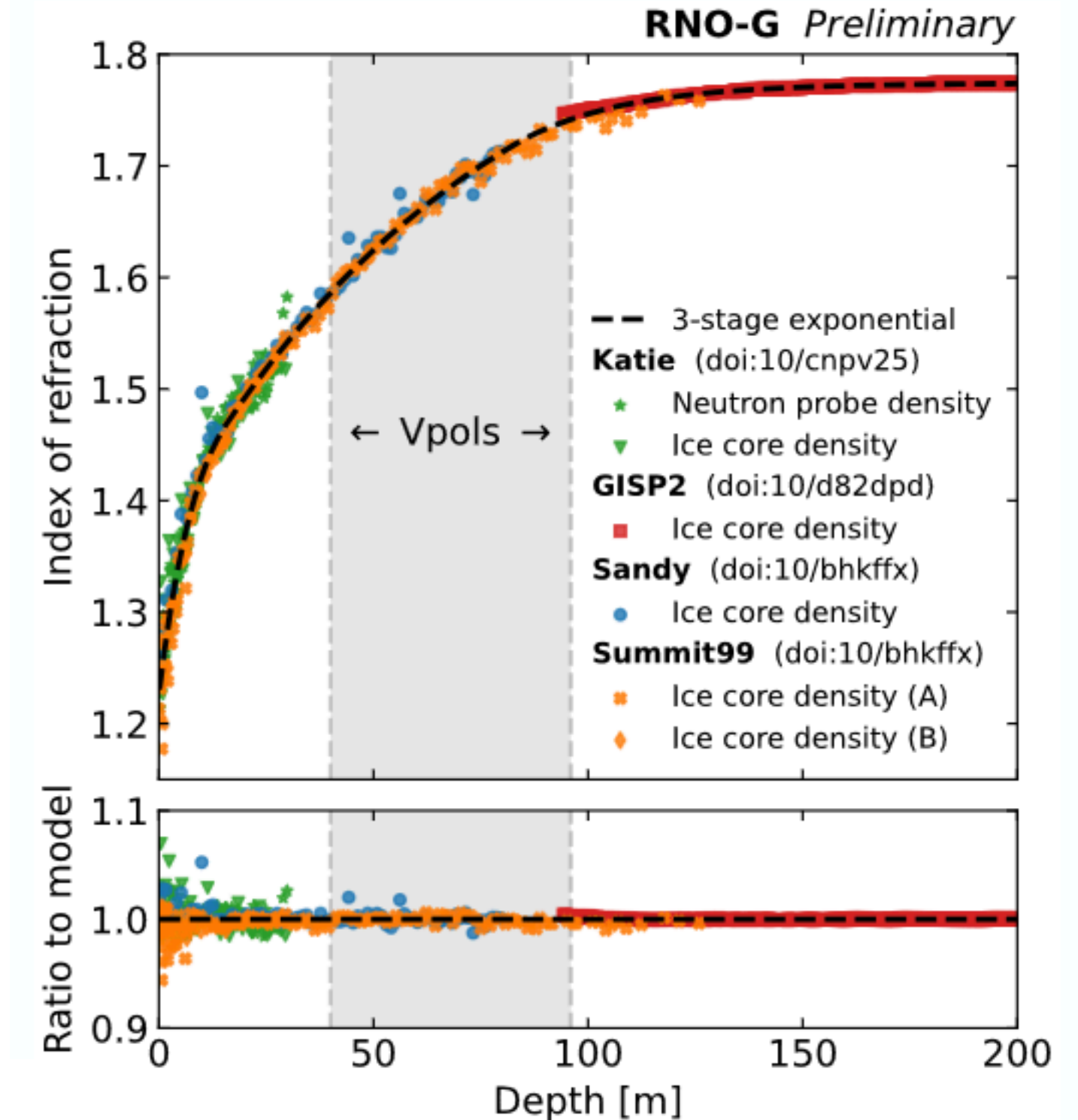
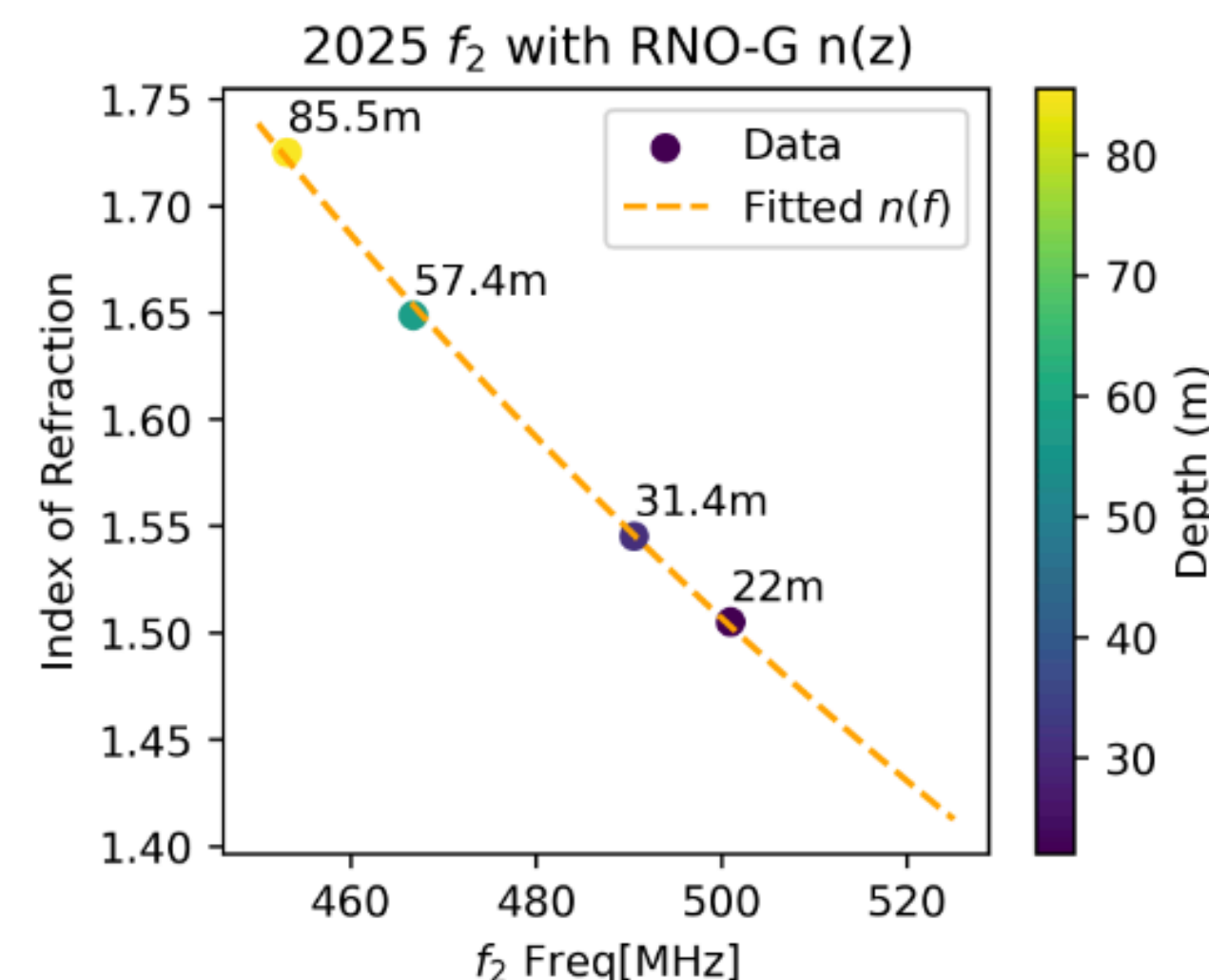
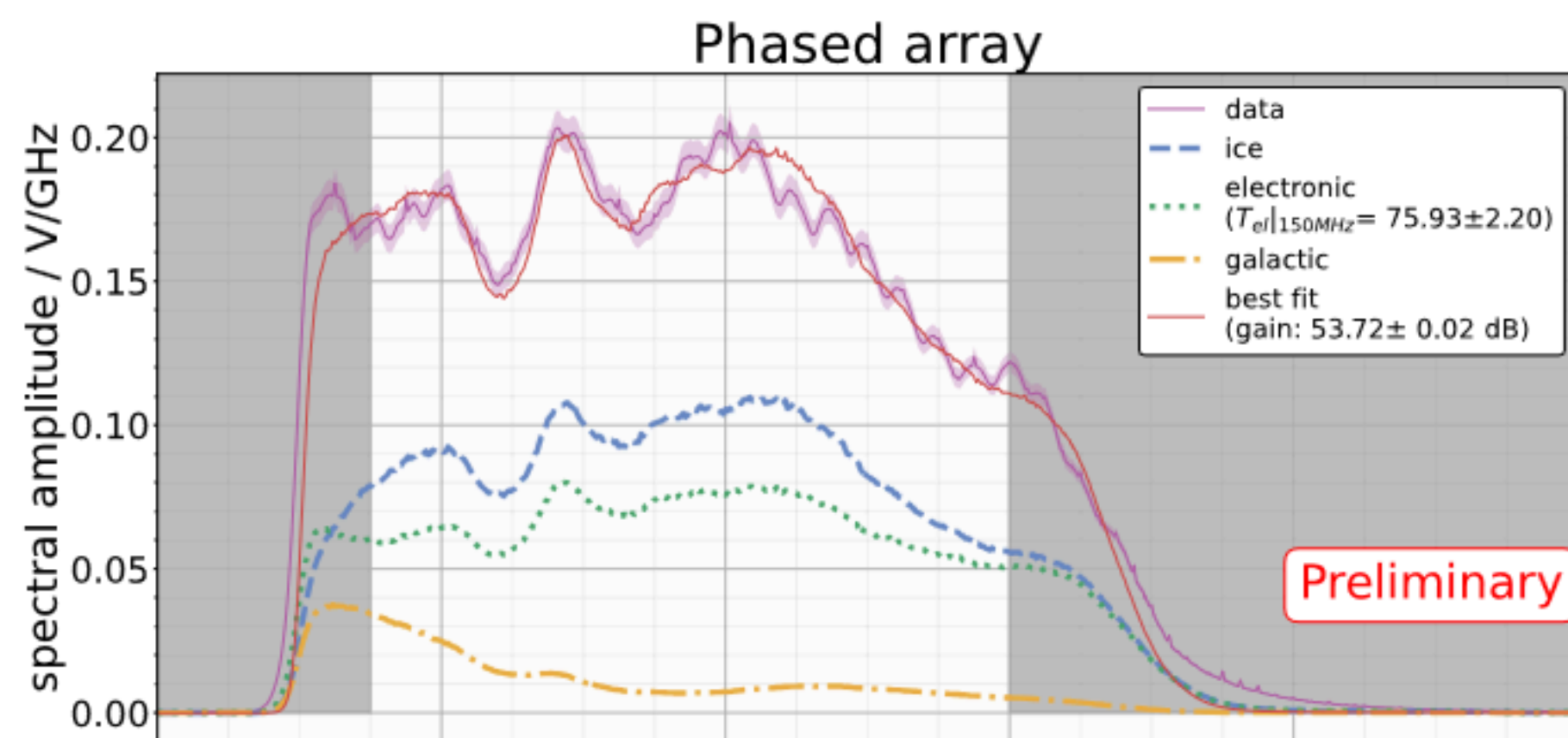


DiDAQ in commissioning phase

Calpulser run on Phased Array channels



- **Signal amplitude calibration:** for event energy estimation
- **Absolute positioning of antennas:** for direction estimation
- **Antenna alignment and relative calibration:** for signal polarization, needed for neutrino identification and reconstruction
- **In-situ ice properties:** for accurate description of signal propagation.

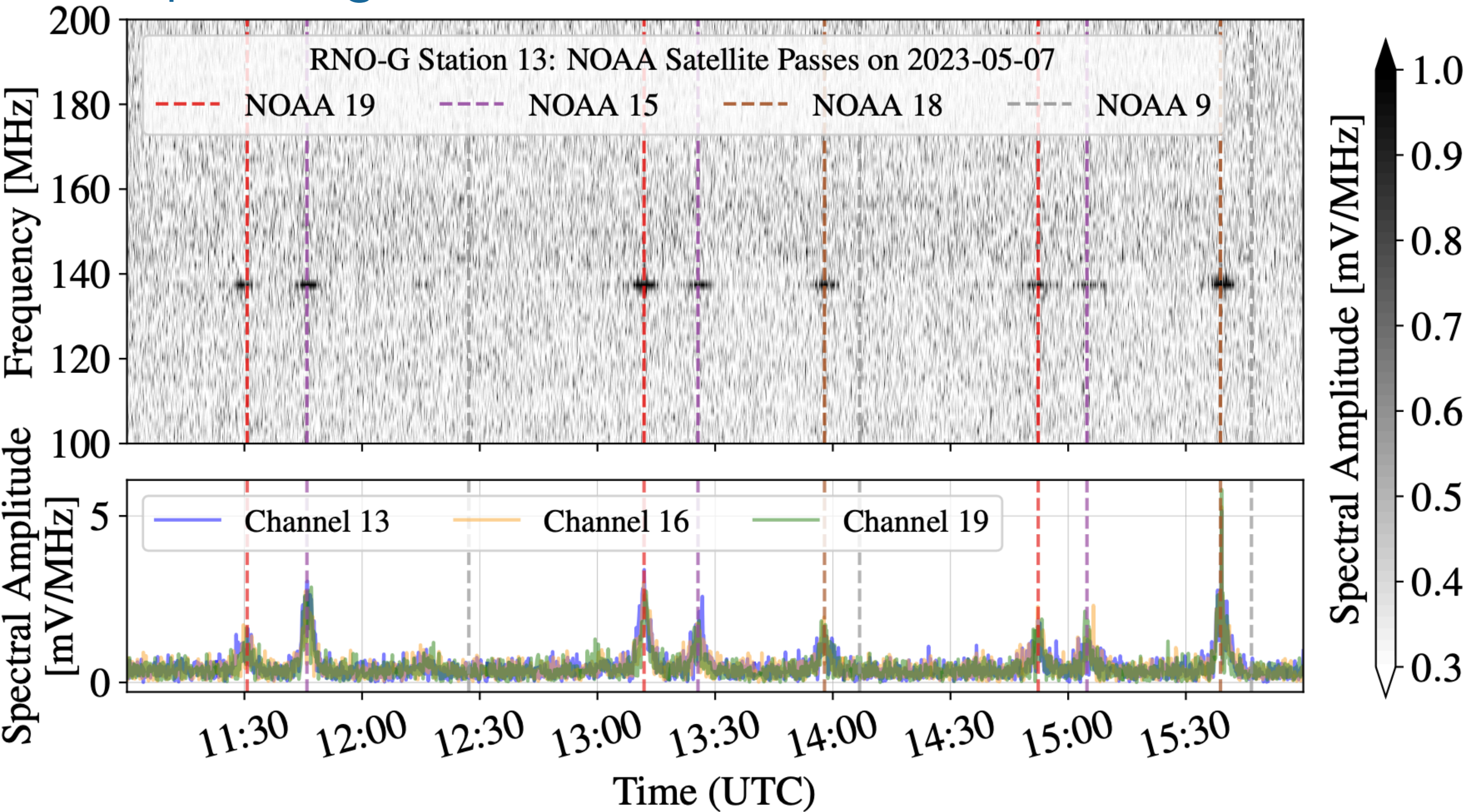


Refractive index: via dedicated measurements in-situ

Full simulation chain for prediction of absolute signal amplitude

Work presented at ARENA 2026 (A. Jaitly, DESY)

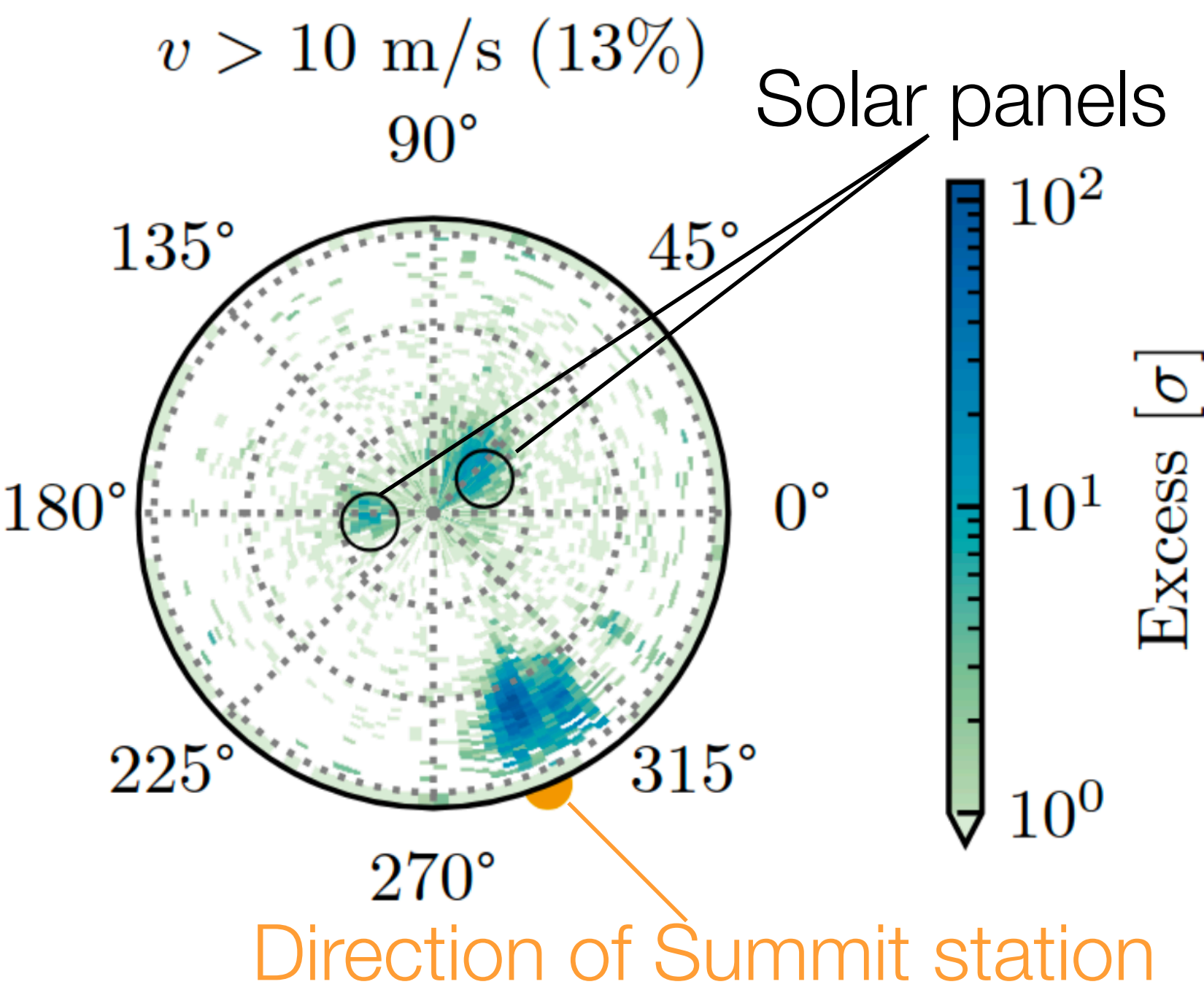
Continuous wave background from satellites:
Spectrogram of a few hours of RNO-G data.



NOAA satellites passes are vertical lines

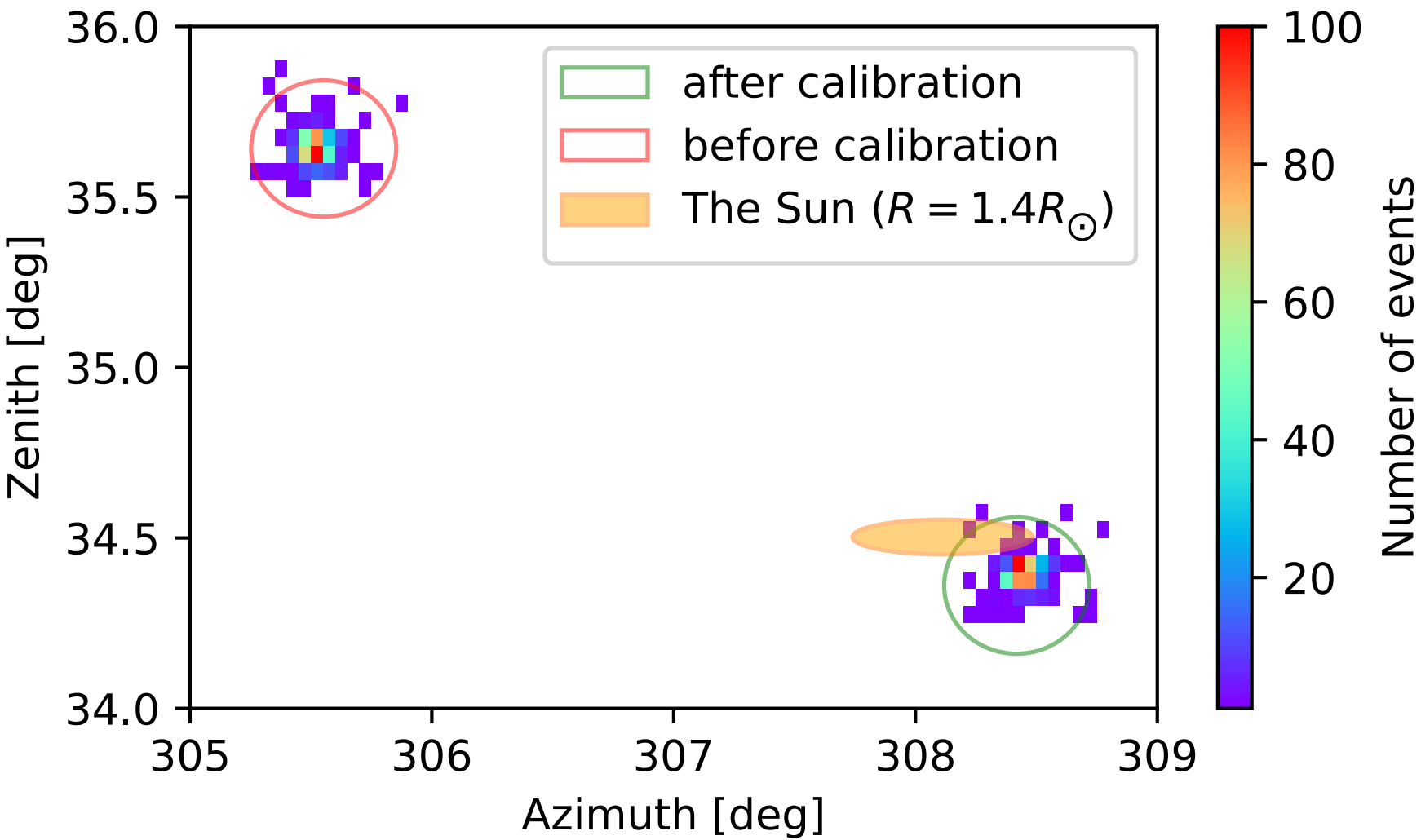
Work presented at ARENA 2026 (P. Schriefer, ECAP)

Wind noise from
electrostatic discharge
at surface



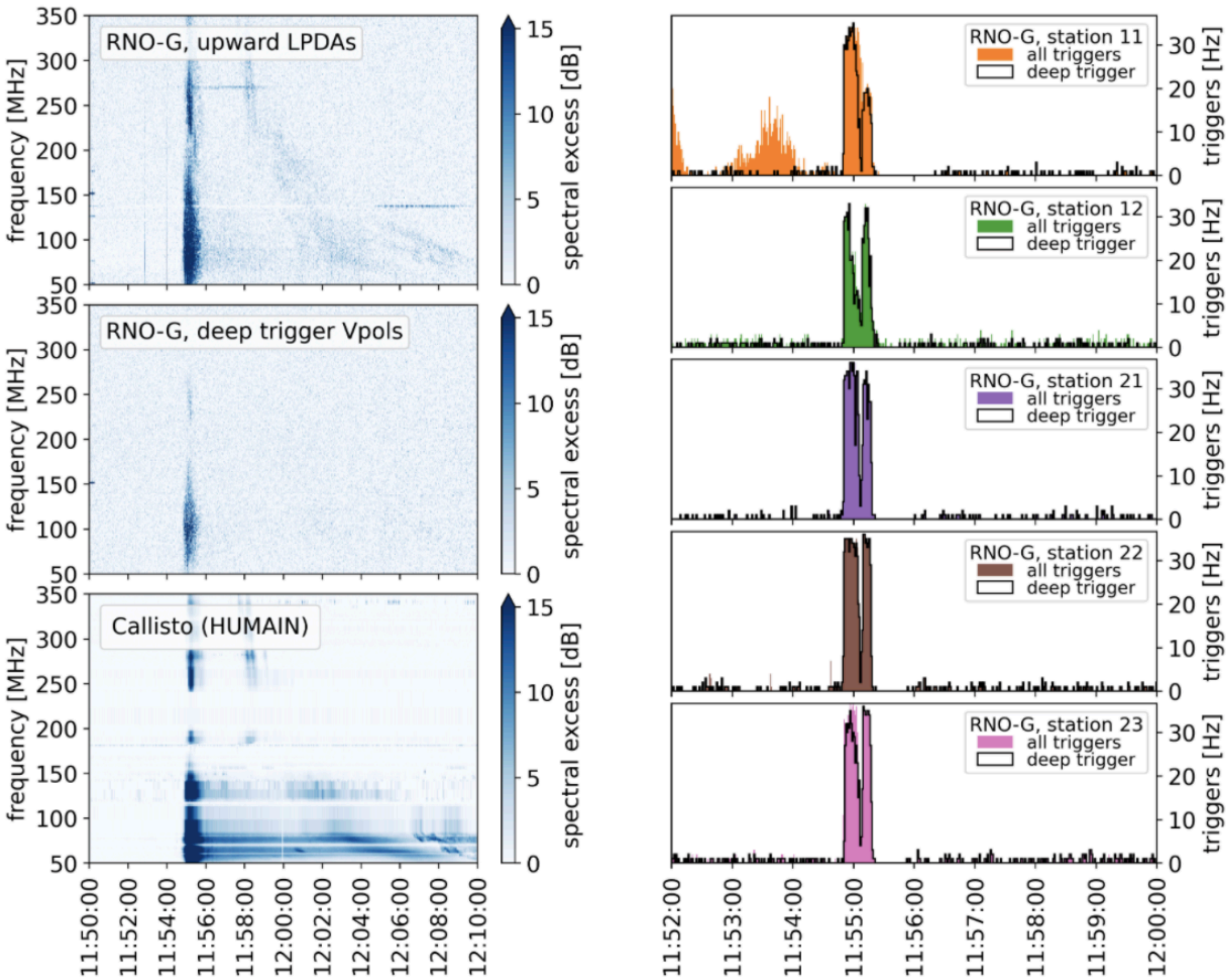
Wind reconstructs
to large metal
structures

- RNO-G detects “for free” all solar flares in the 100 - 500 MHz range
- Opportunity for solar science.
- Distant source for **absolute pointing calibration**



Pointing: degree accuracy
excellent calibration source

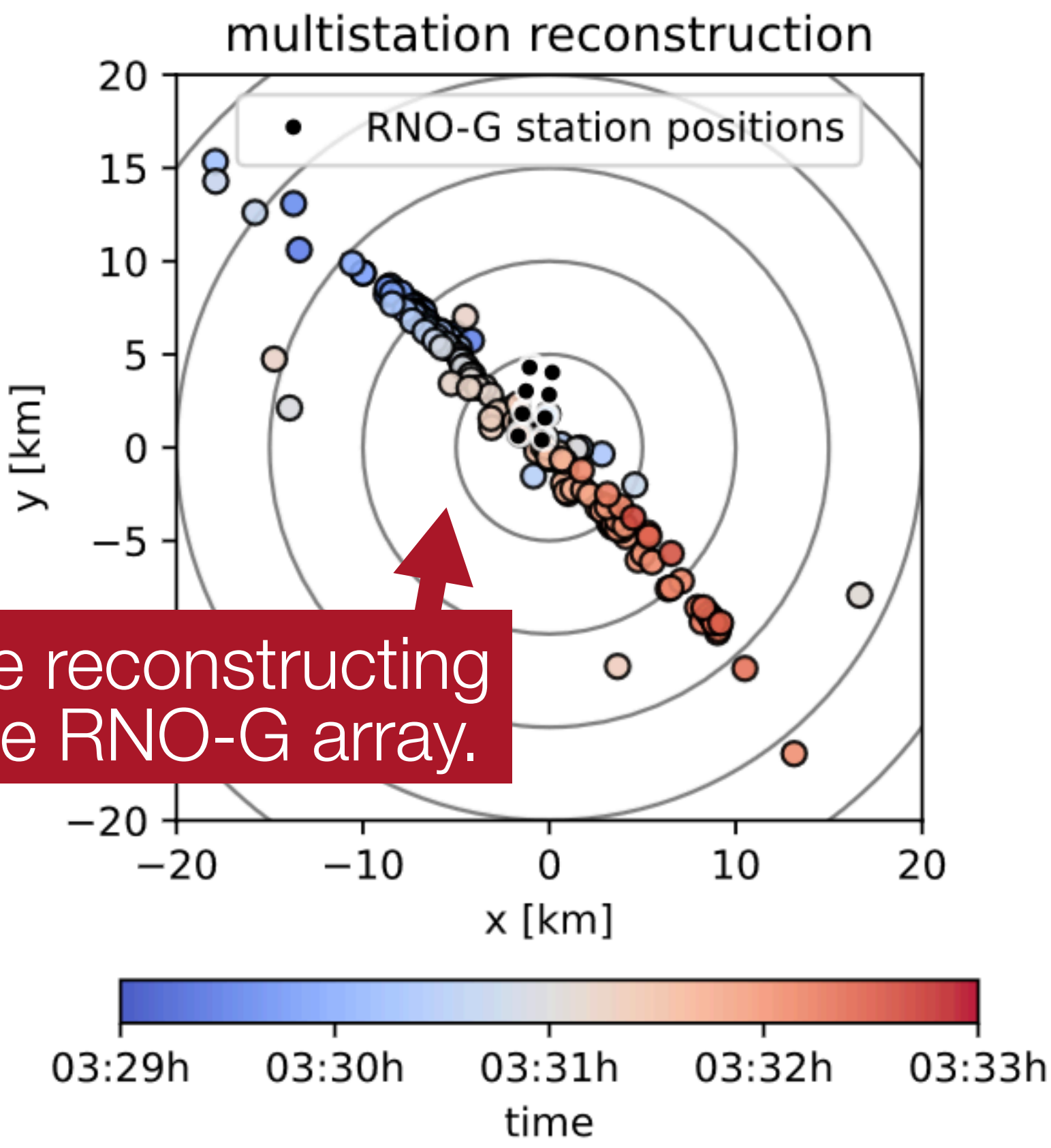
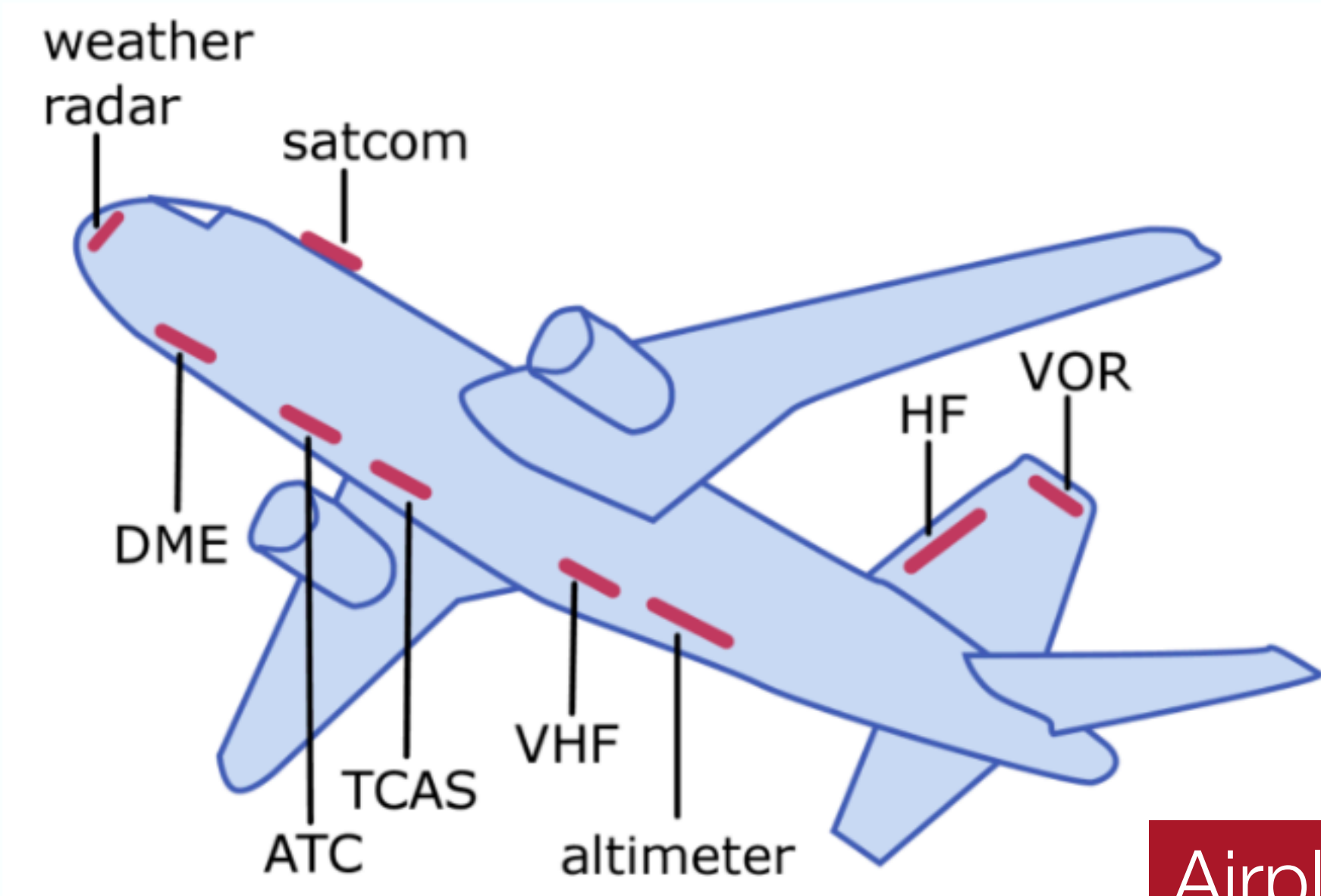
solar flare on 2022-09-29 (RNO-G Sun zenith angle: 78.8 deg)



Calibration from background sources: Signals from Airplanes 16

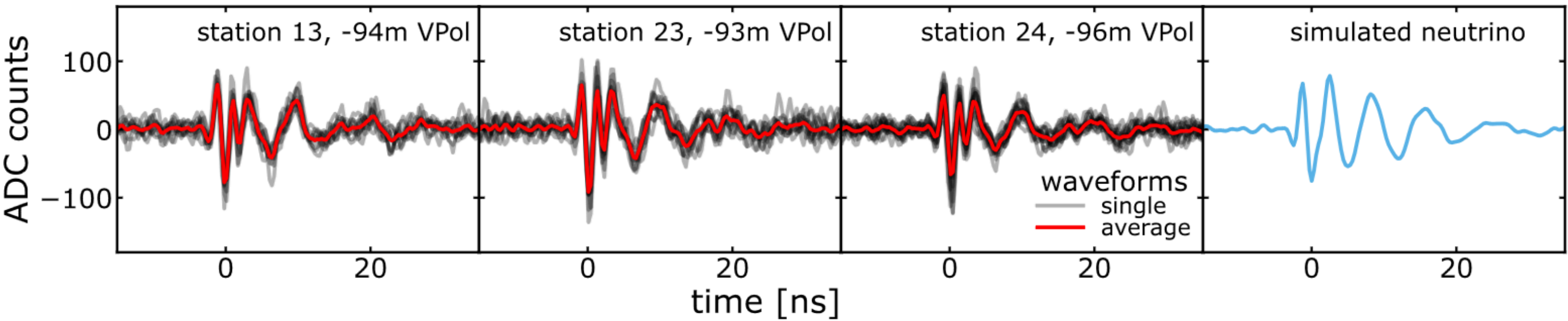
- Several flights per day above RNO-G
- Excellent calibration signal in far field, visible with many stations.
- Probes timing and direction accuracy of stations

S. Agarwal et al (RNO-G Coll.) 2025 JINST 20 P11015

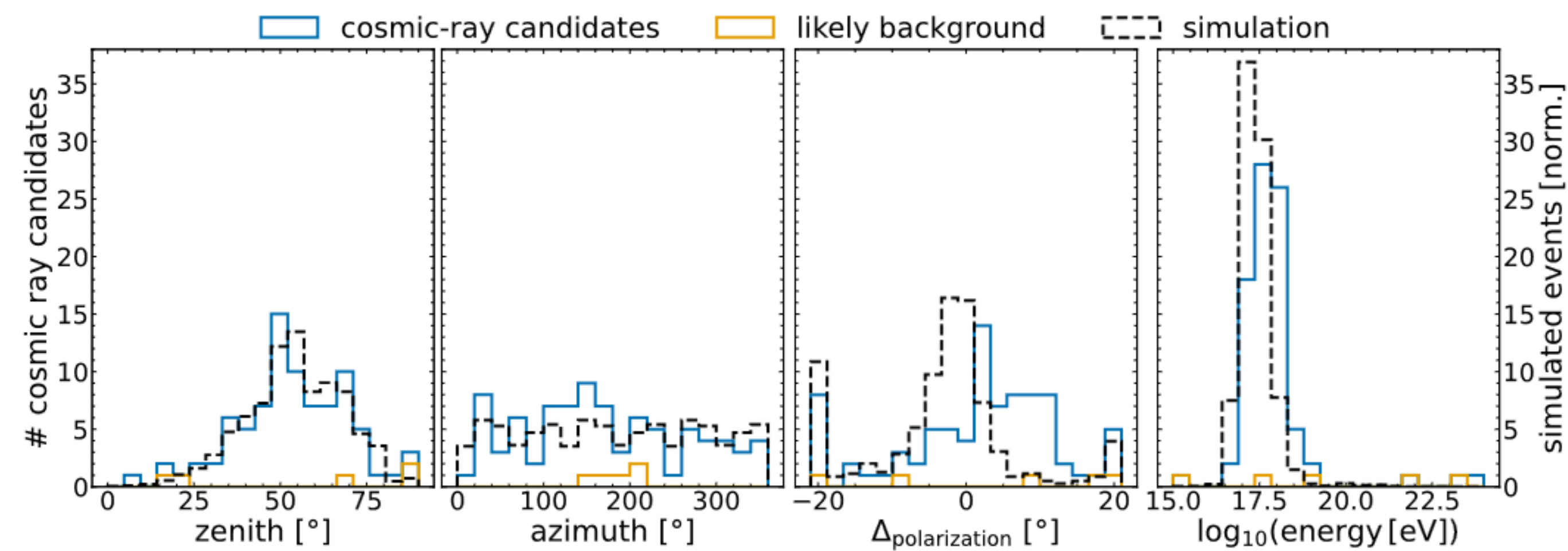


Airplane reconstructing over the RNO-G array.

Signal from airplane similar to neutrino

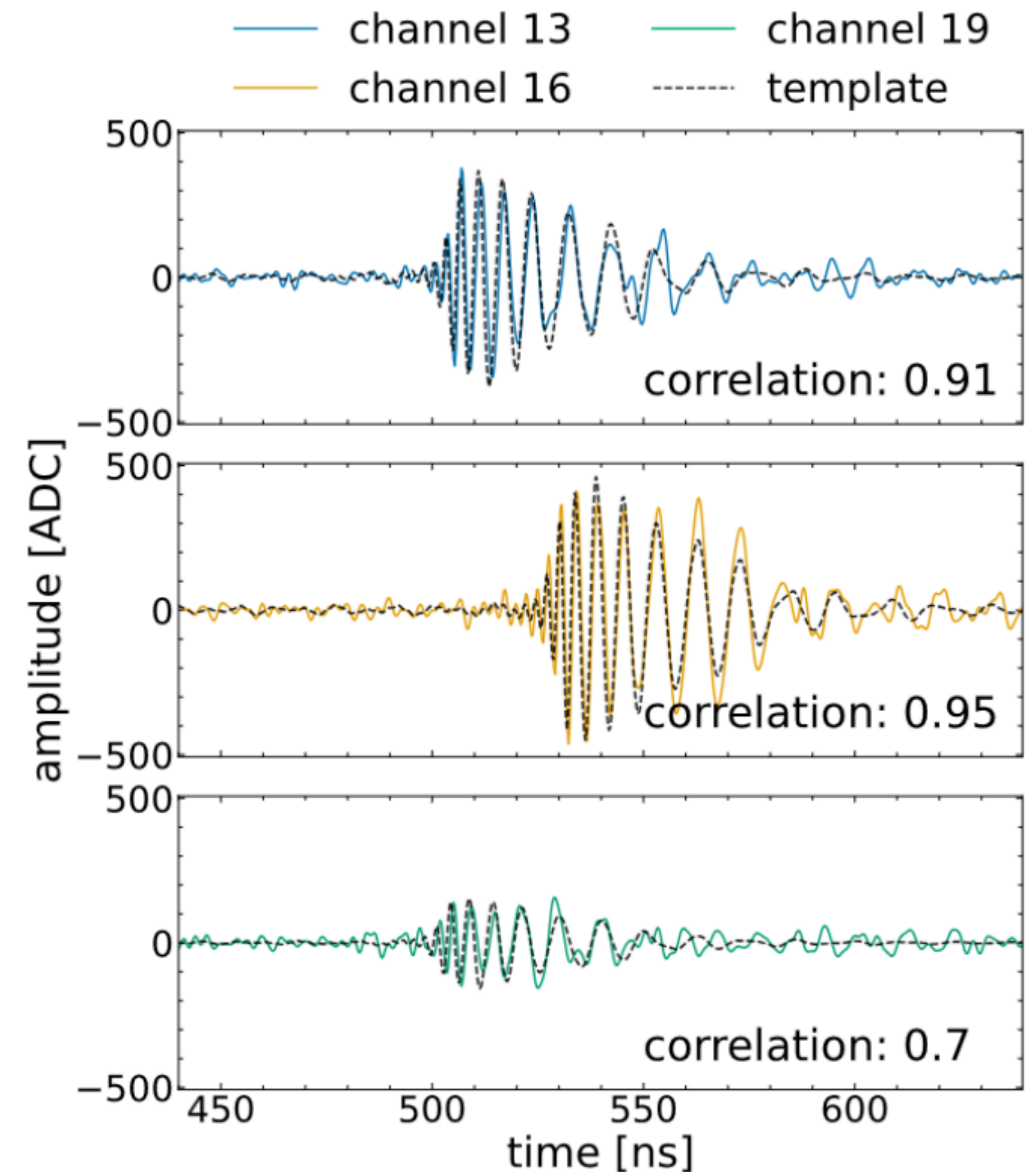


- Using our **surface channels**: Several CR candidates identified in two years of data.
- Important to understand detector response and systematics
- Number and reconstructed properties consistent with expectation.

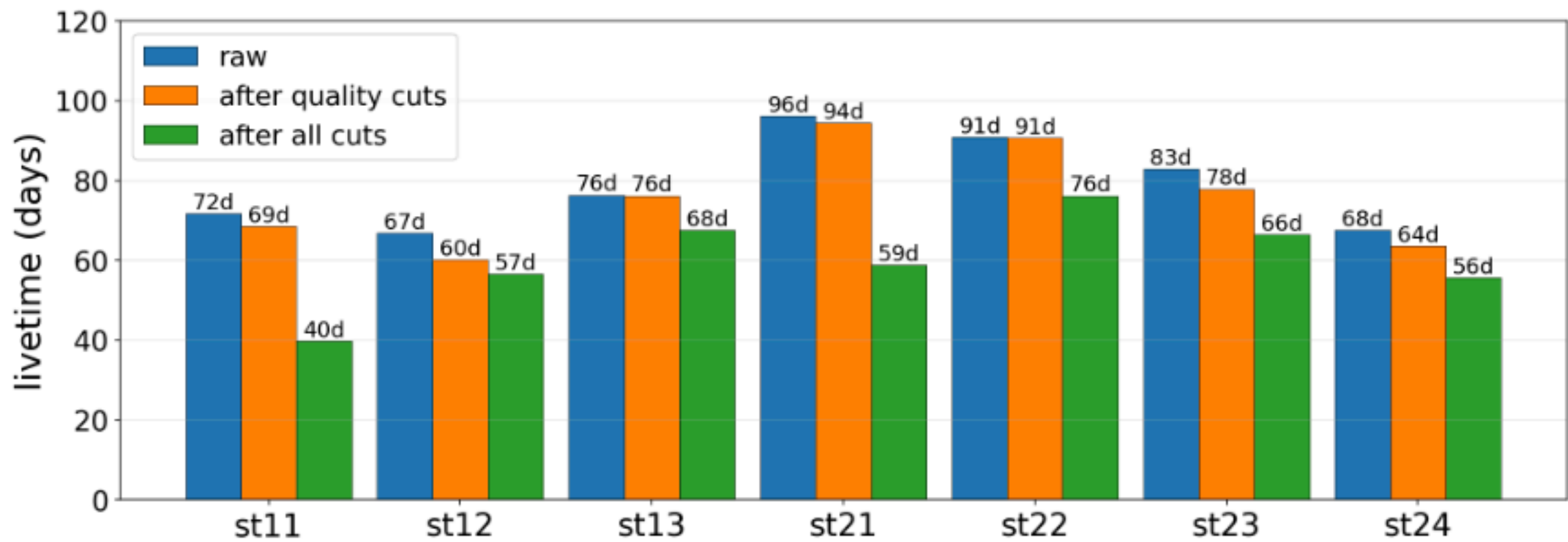


Cosmic ray candidates similar to expected simulation

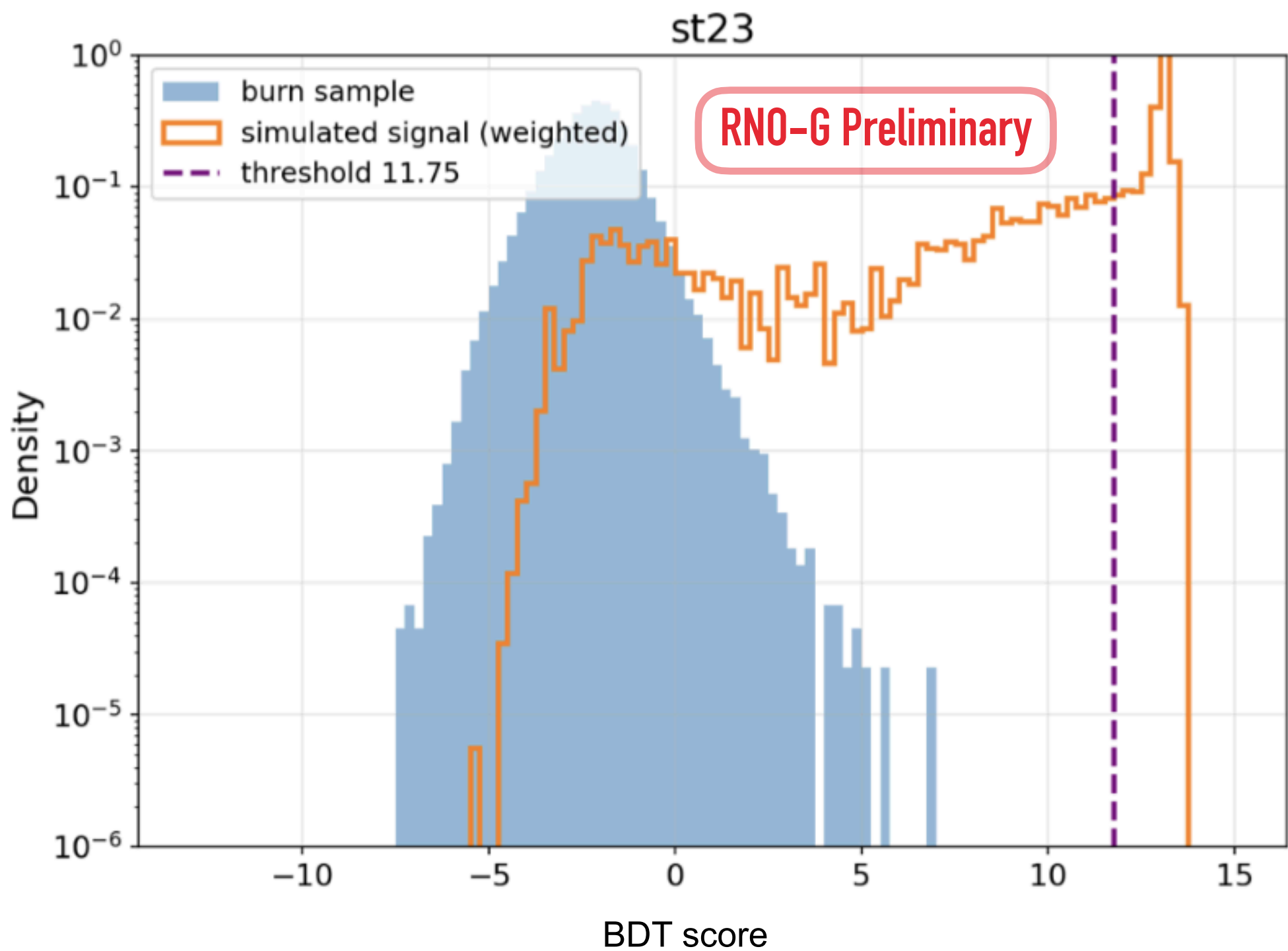
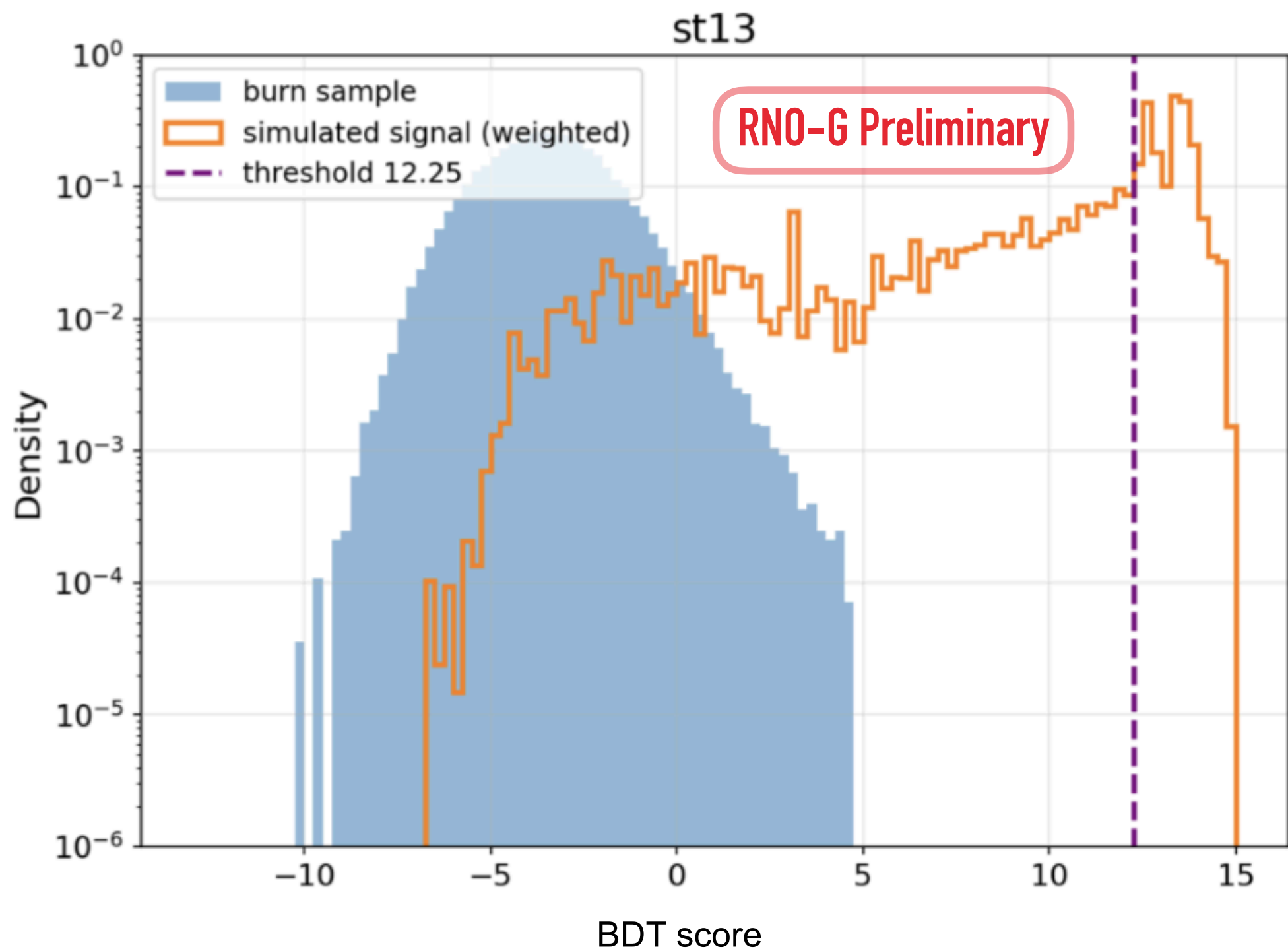
Work submitted to EPJ-C (J. Henrichs, DESY)



Work presented at ARENA 2026 (B. Hendricks, PSU)



- Searching cosmic rays in the **deep channels** in early data.
- Background estimation refinement
- Validation methods in development

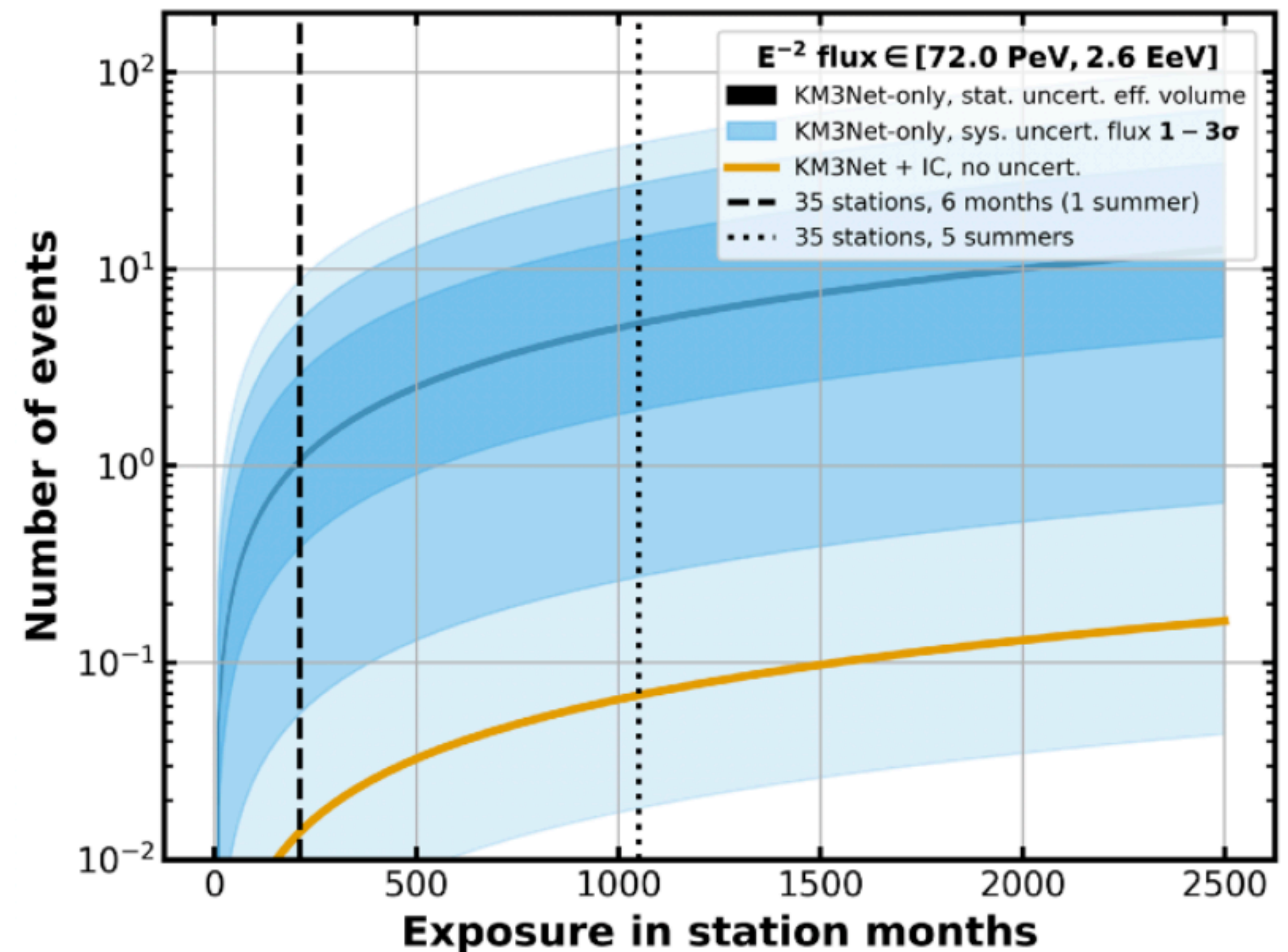




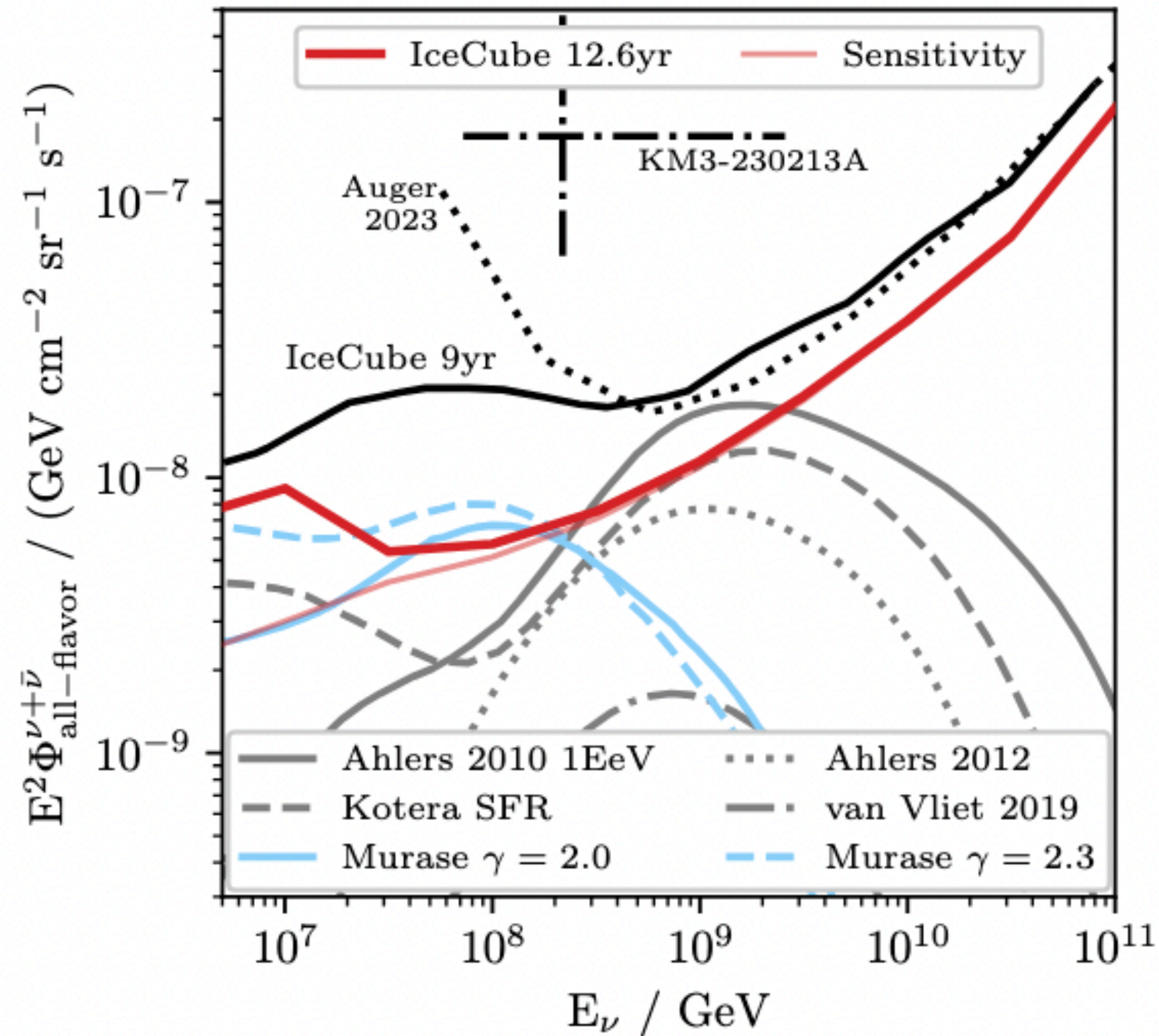
SUMMARY

- RNO-G Construction continues at Summit Station.
- Continued support and funding from Europe and US: **35-station array fully funded.**
- Early science data used for calibration and background studies.
- Ongoing efforts to improve scalability, reliable data taking, and uptime.
- Gearing up for the first diffuse UHE neutrino search.
- **RNO-G is important R&D for IceCube-Gen2.**

- Highest-energy neutrino detected by KM3NeT
- In the energy range of radio detectors:
 - potentially very interesting for RNO-G
 - RNO-G offline
- Neutrino effective areas incorporating in-situ trigger performance
- Expected 1 neutrino from nominal KM3NeT flux in one summer of RNO-G 35.



IceCube Collab. PRL 2025, 2502.01963



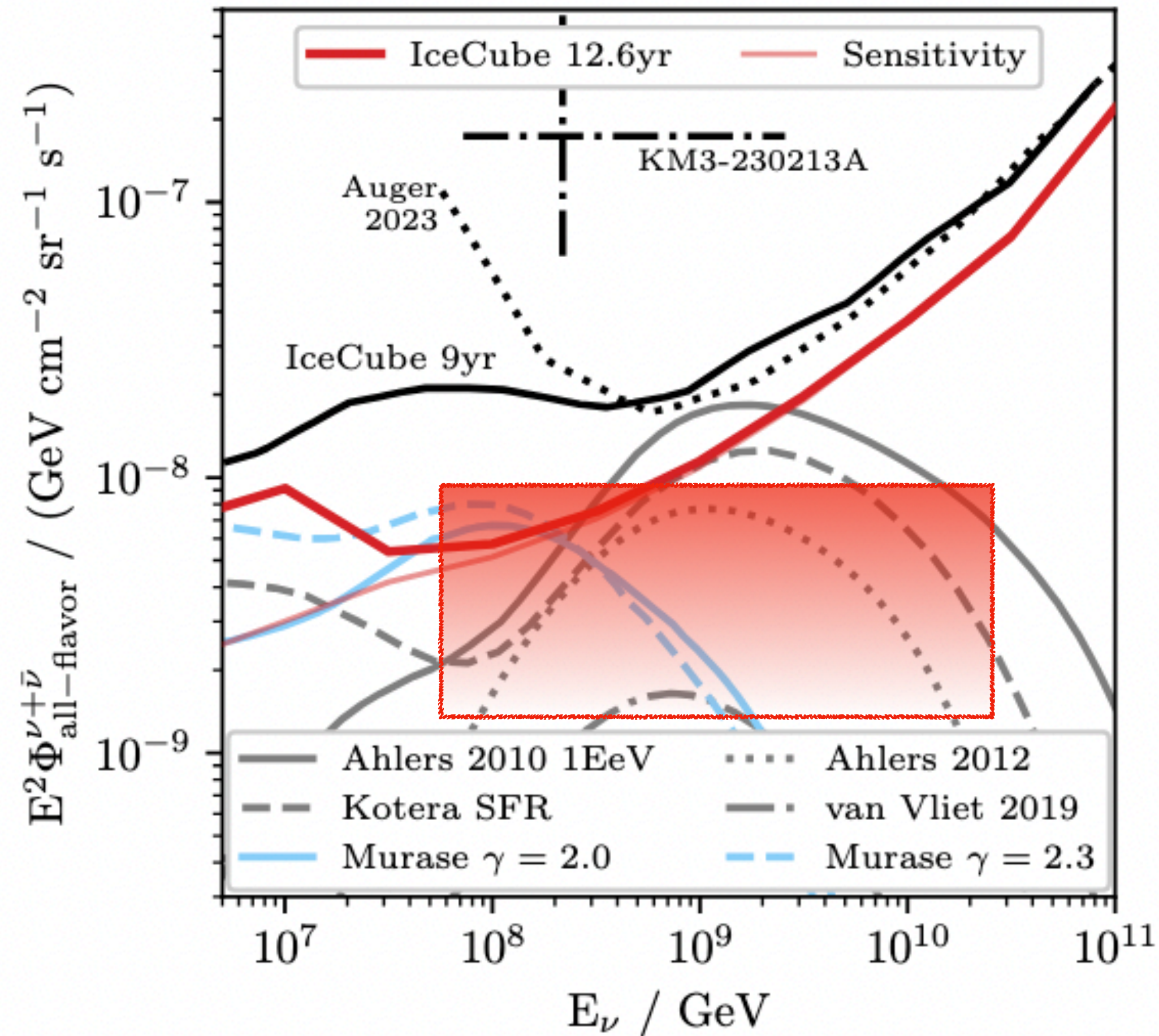
Search for UHE neutrinos in 12 years of IceCube data:

- **No observation yet!**
- **Strongest upper limits today**

KM3-230213A - A muon neutrino of astrophysical origin with record energy:

- **challenging limits from IceCube and Pierre Auger**

IceCube Collab. PRL 2025, 2502.01963



Discover ultra-high-energy neutrinos

-100 PeV - 10 EeV, or place limits on the diffuse flux at the highest energies.

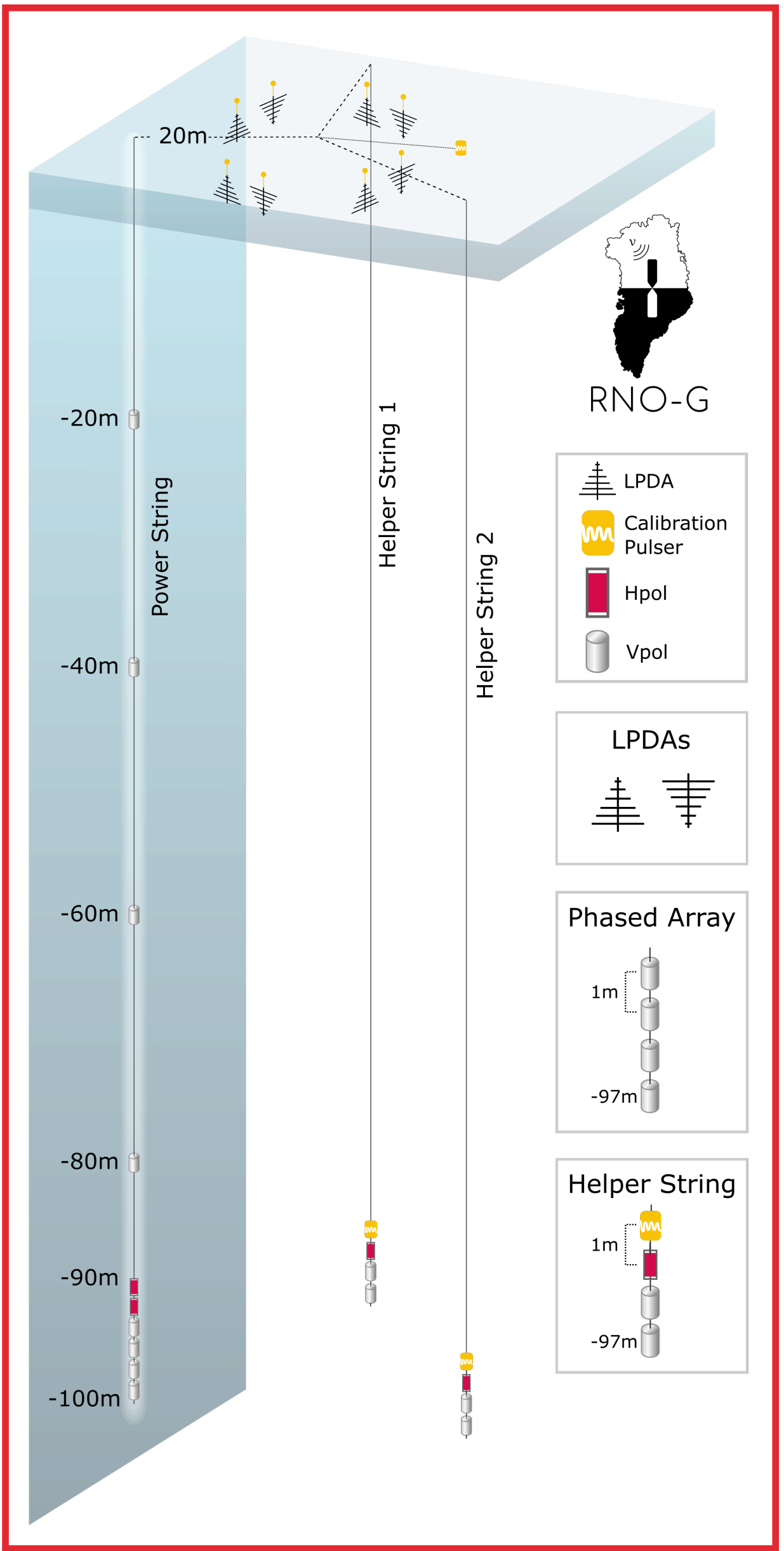
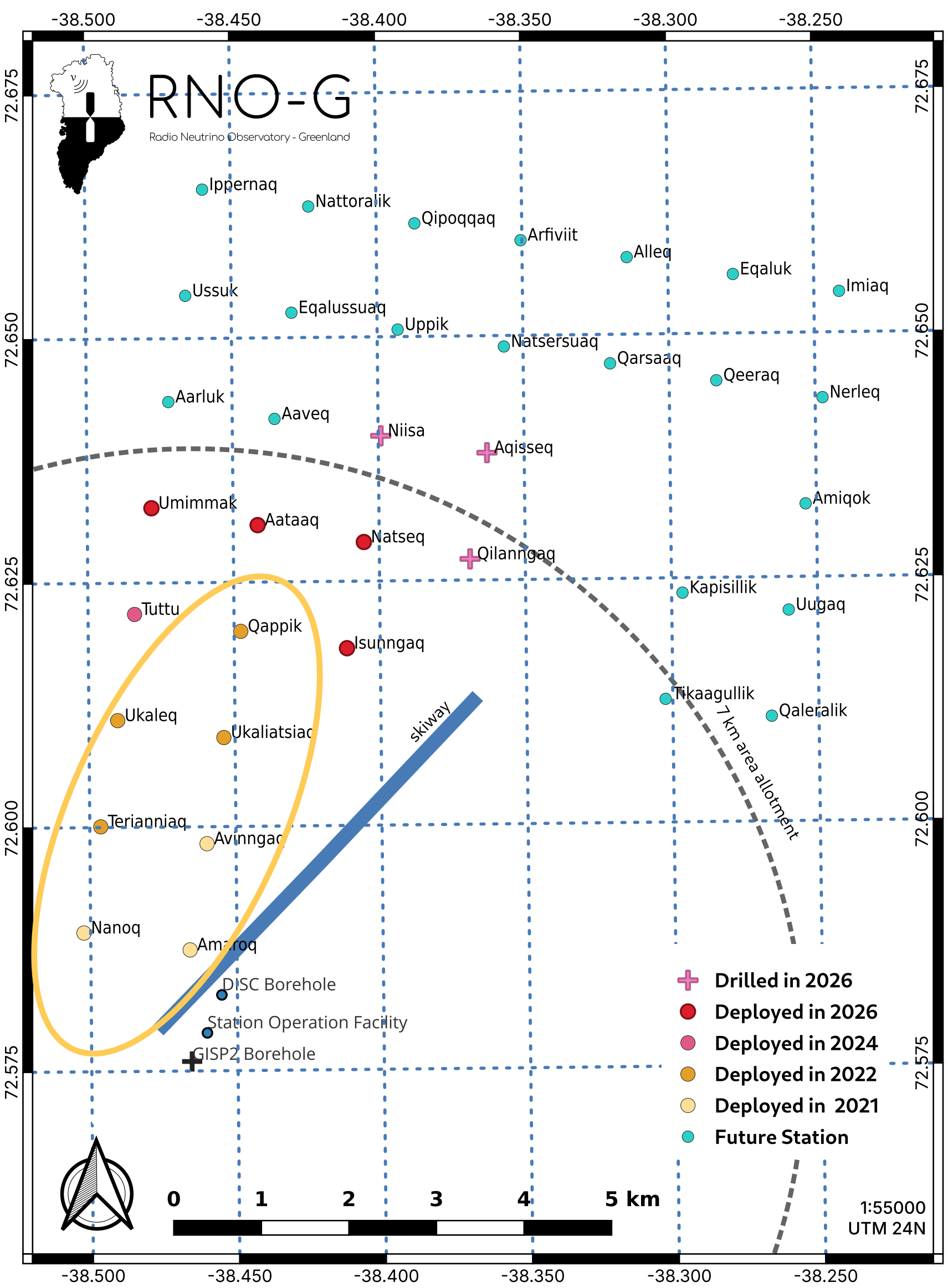
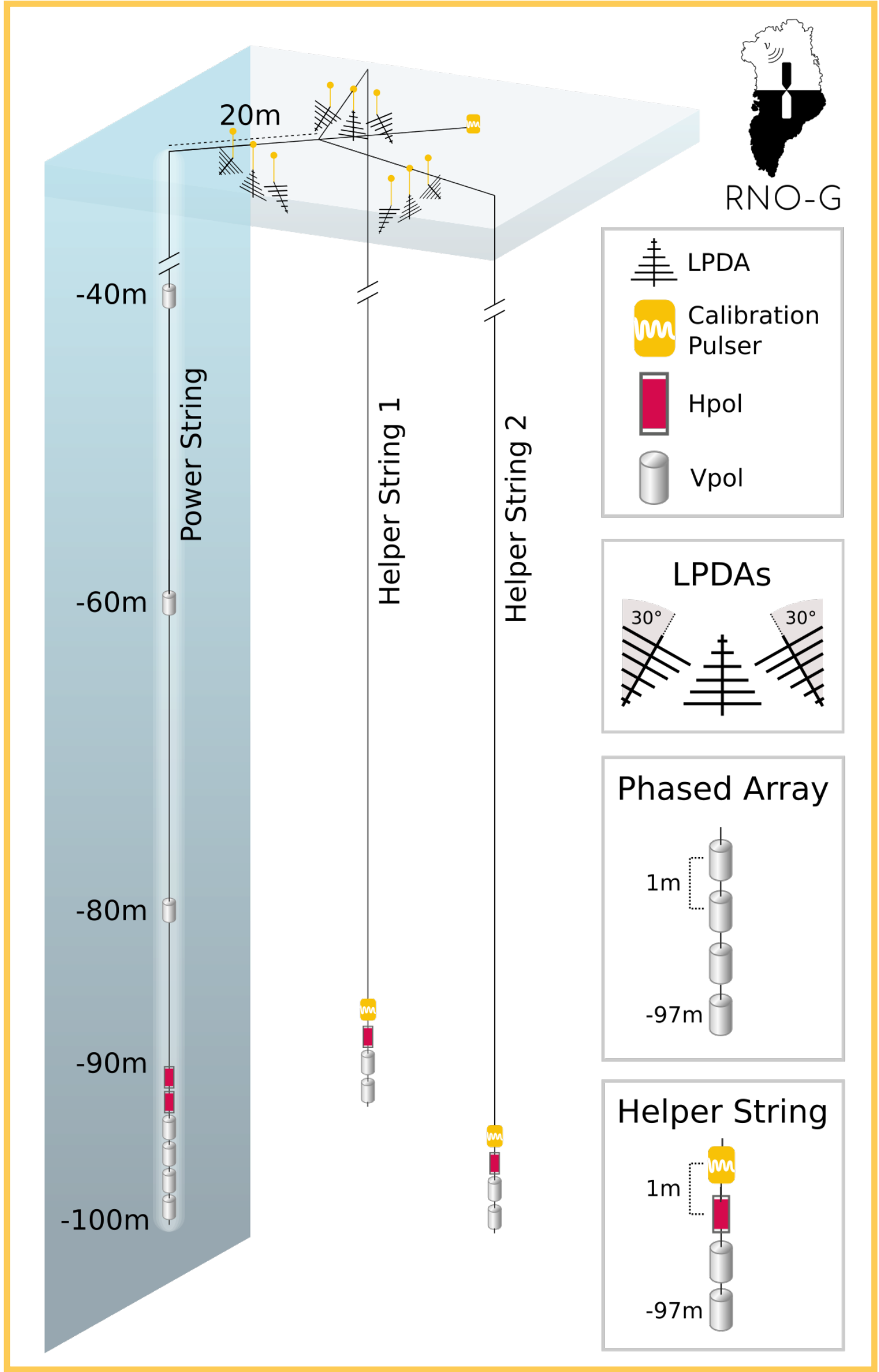
Steady and transient sources

-Searches and followup observations.

Inform design of IceCube-Gen2.

We need to go 100x bigger than IceCube

The two RNO-G Station layouts



In-ice Radio Detection: Askaryan Emission

24



Surface

We are looking for impulsive nanosecond-scale broadband (10 MHz – 1 GHz) signal

Deep

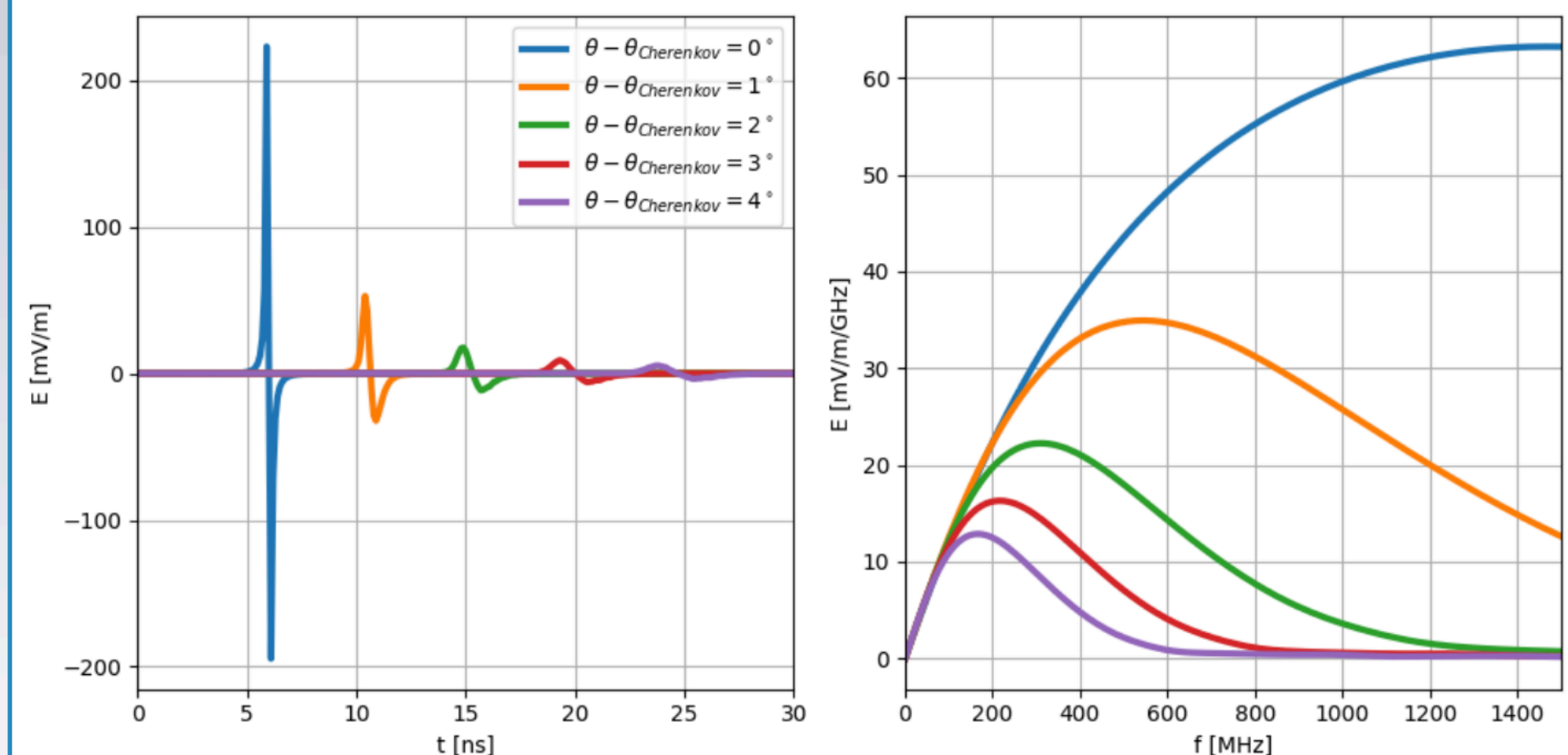
Emission strongest and higher frequency at Cherenkov angle

Askaryan Radiation

Neutrino ν

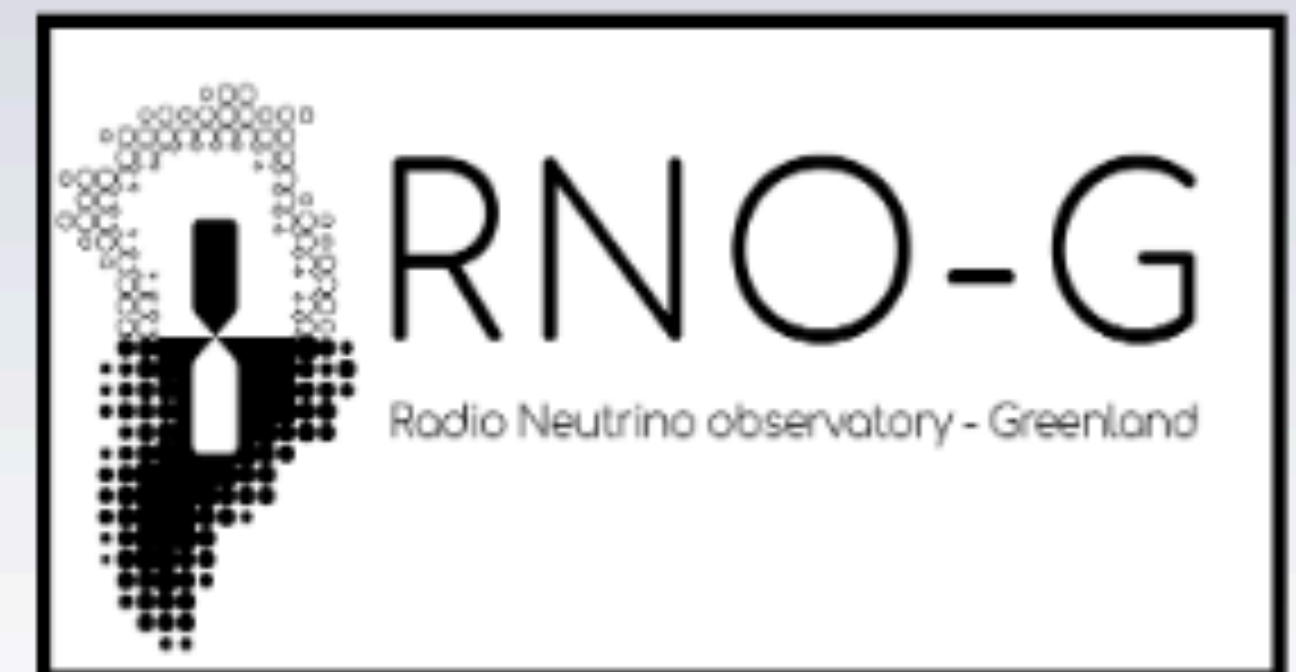
vertex

J. A. Aguilar et al. (RNO-G Collaboration), JINST 16 P03025 2021.

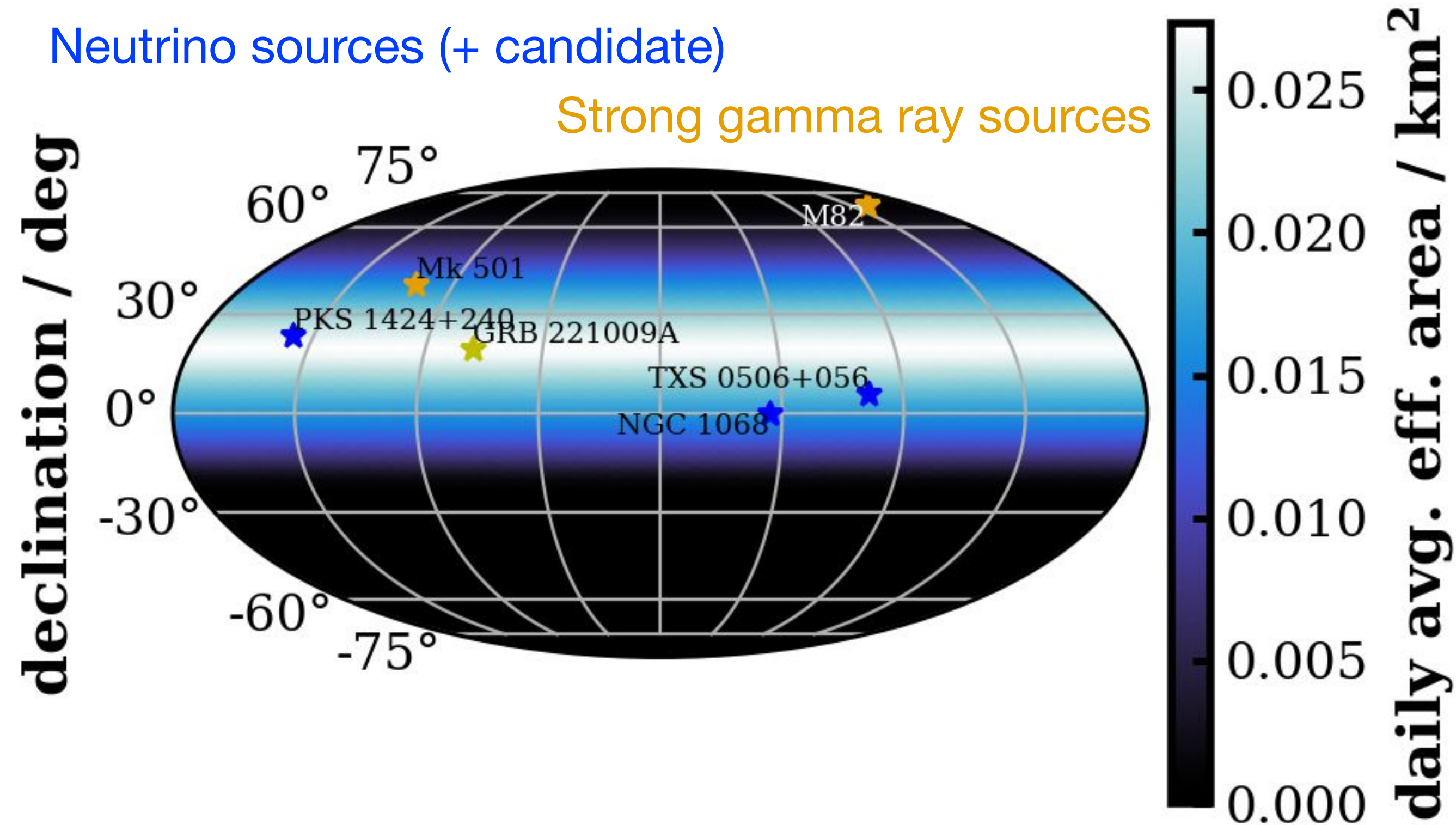


IMPULSIVE RADIO SIGNAL

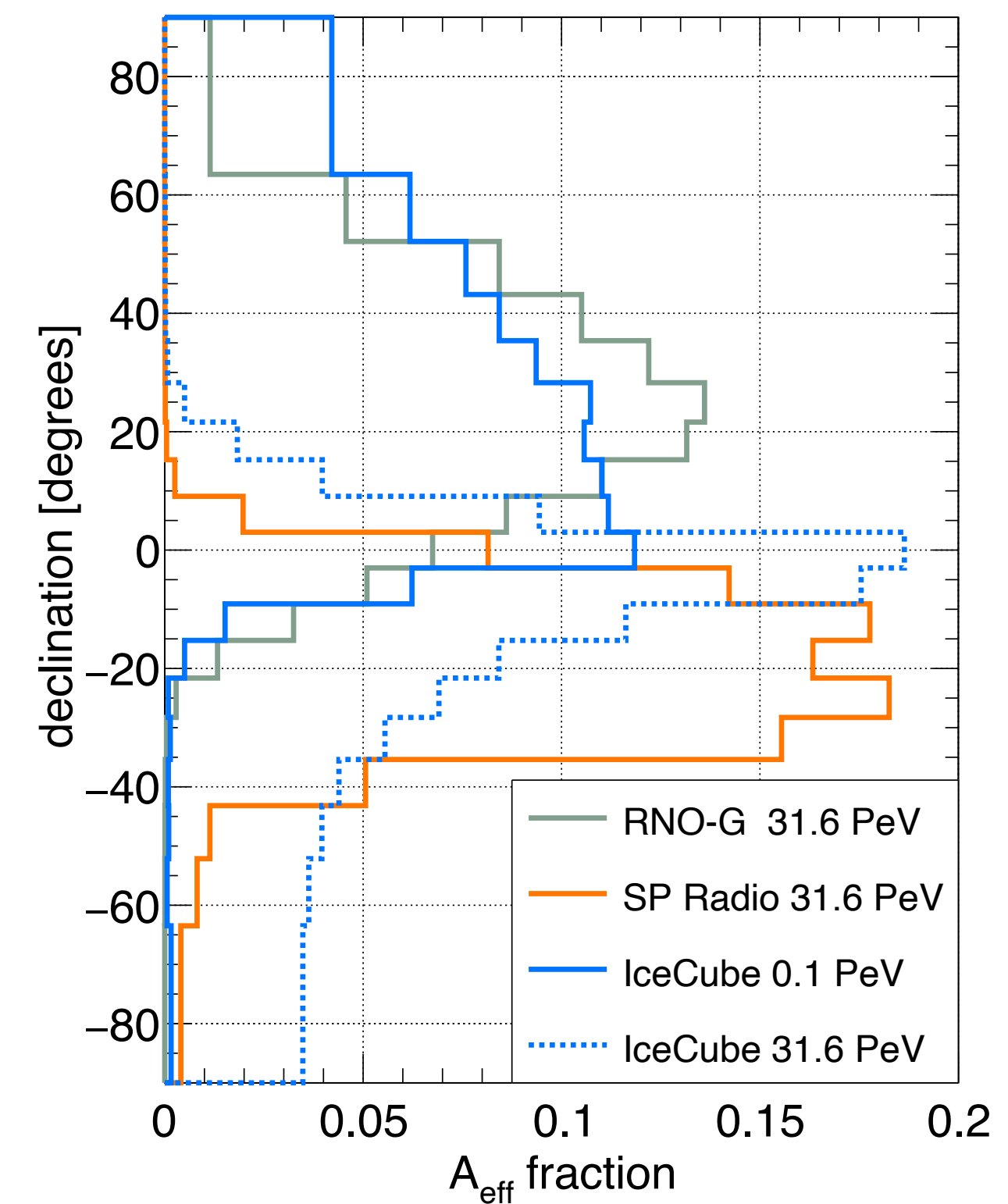
BROADBAND PULSE



At UHE energies, primarily sensitive to down-going or Earth-skimming neutrinos



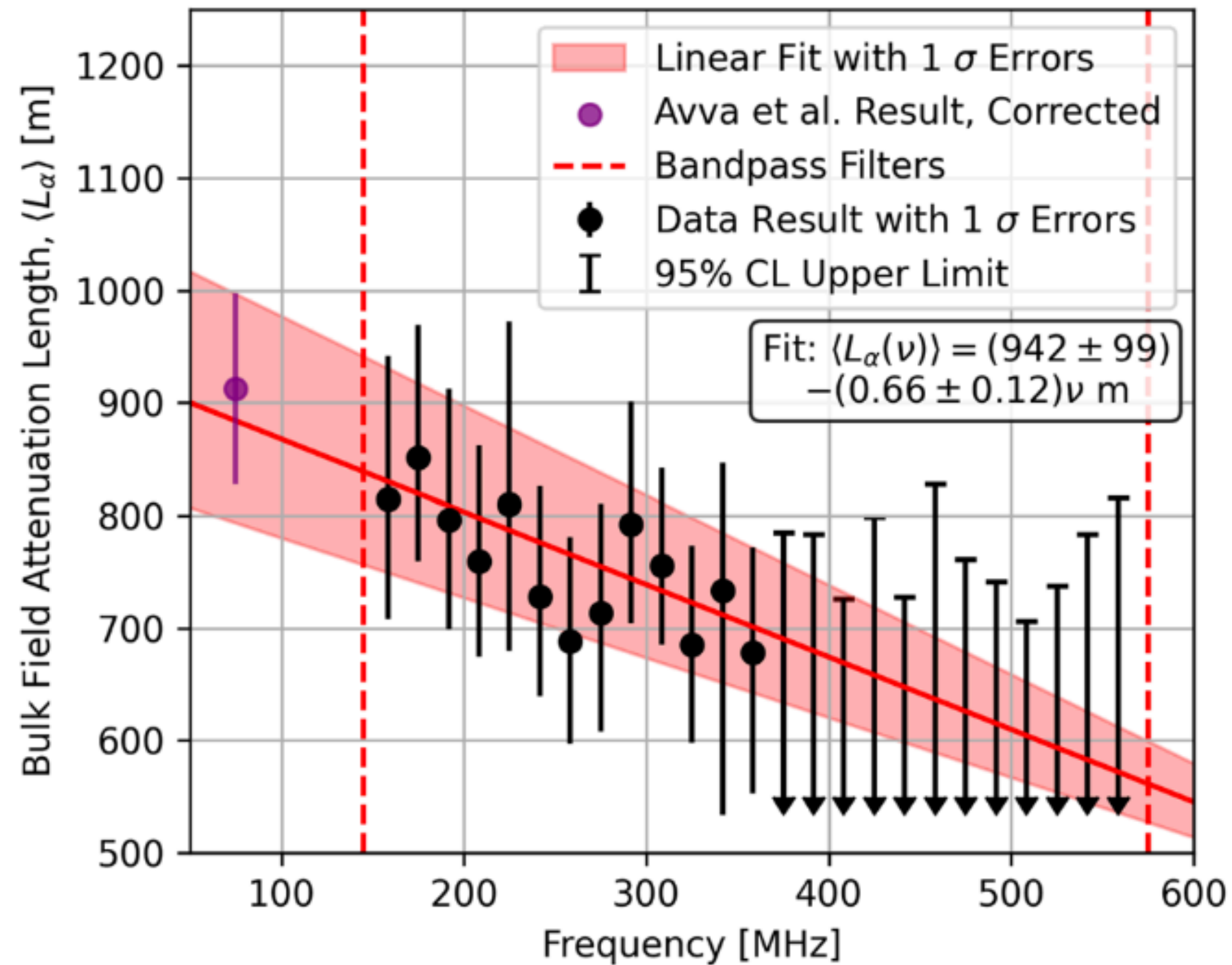
RNO-G overlaps with IceCube
at higher energies



- Strong science case:

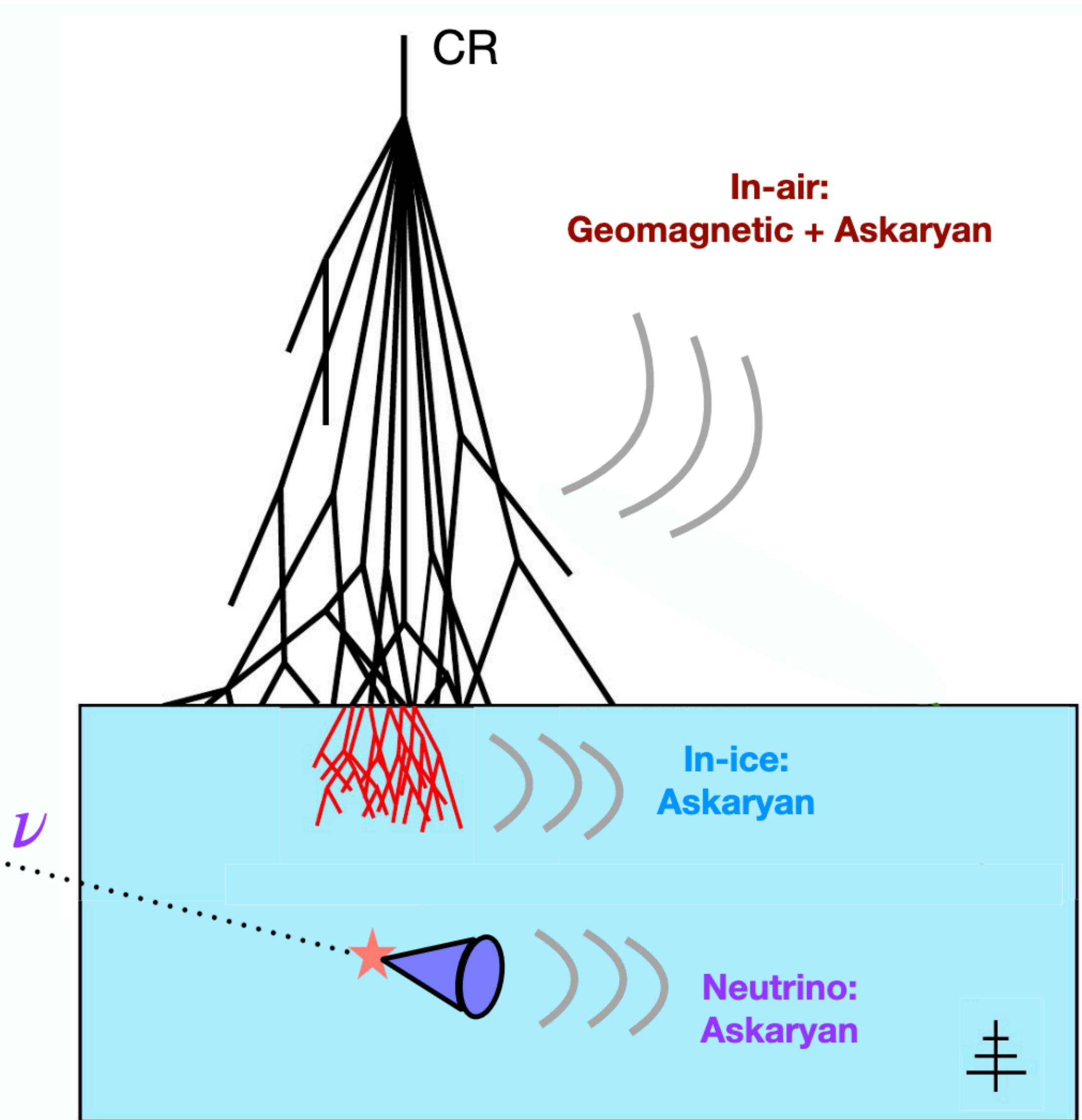
- observing the same sky as IceCube but at higher energies allowing for **multi-energy (TeV to PeV)**
- complementary to any Southern radio array in terms of FoV allowing for better sky coverage at PeV energy.
- observations of (steady and transient) sources: synergy for **multimessenger neutrino alerts**.

Aguilar et al. (RNO-G Collaboration), Journal of Glaciology, 68(272), 1234-1242.



Big effective volume with small number of detection units ($\lambda_{\text{att}} \sim 1$ km)

One radio station can typically monitor 1 km³ of ice (= the size of IceCube)



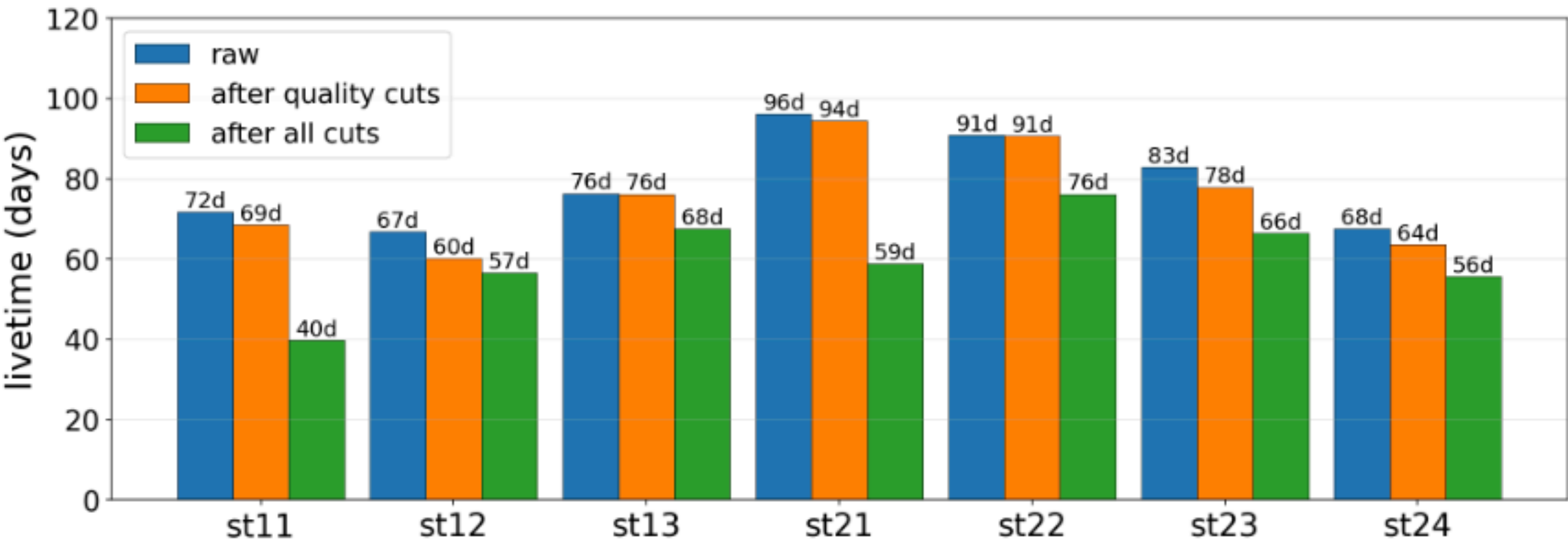
CRs more abundant than neutrinos:

- Validation of Askaryan detection technique (unique “test-beam”)
- Validation of detector performance: trigger, energy threshold, reconstruction.
- Intercalibration between surface and deep triggers (if hybrid detection).
- Background in neutrino search (veto).

Two emissions (in-air/in-ice) can be observed with the two components (shallow and deep) in RNO-G stations

Work presented at ARENA 2026 (B. Hendricks, PSU)

- Searching cosmic rays in the **deep channels** in early data.
- Few candidates identified in the cleanest stations.
- Validation ongoing.



RENA2026

