FRanconian Astronomy Neighborhood Collaboration Incentive: FRANCI 2021

RNO-G: Radio Neutrino Observatory in Greenland

Maddalena Cataldo

RNO-G Group: DESY / FAU Erlangen-Nürnberg

Anna Nelles (Faculty)

Adrian Zink (Staff, Engineering)

Robert Lahmann (Staff)

Steffen Hallmann (Postdoc)

Maddalena Cataldo (Postdoc)

Bob Oeyen (PhD)

Lilly Pyras (PhD)

Sjoerd Bouma (PhD)

Zack Meyers (PhD)

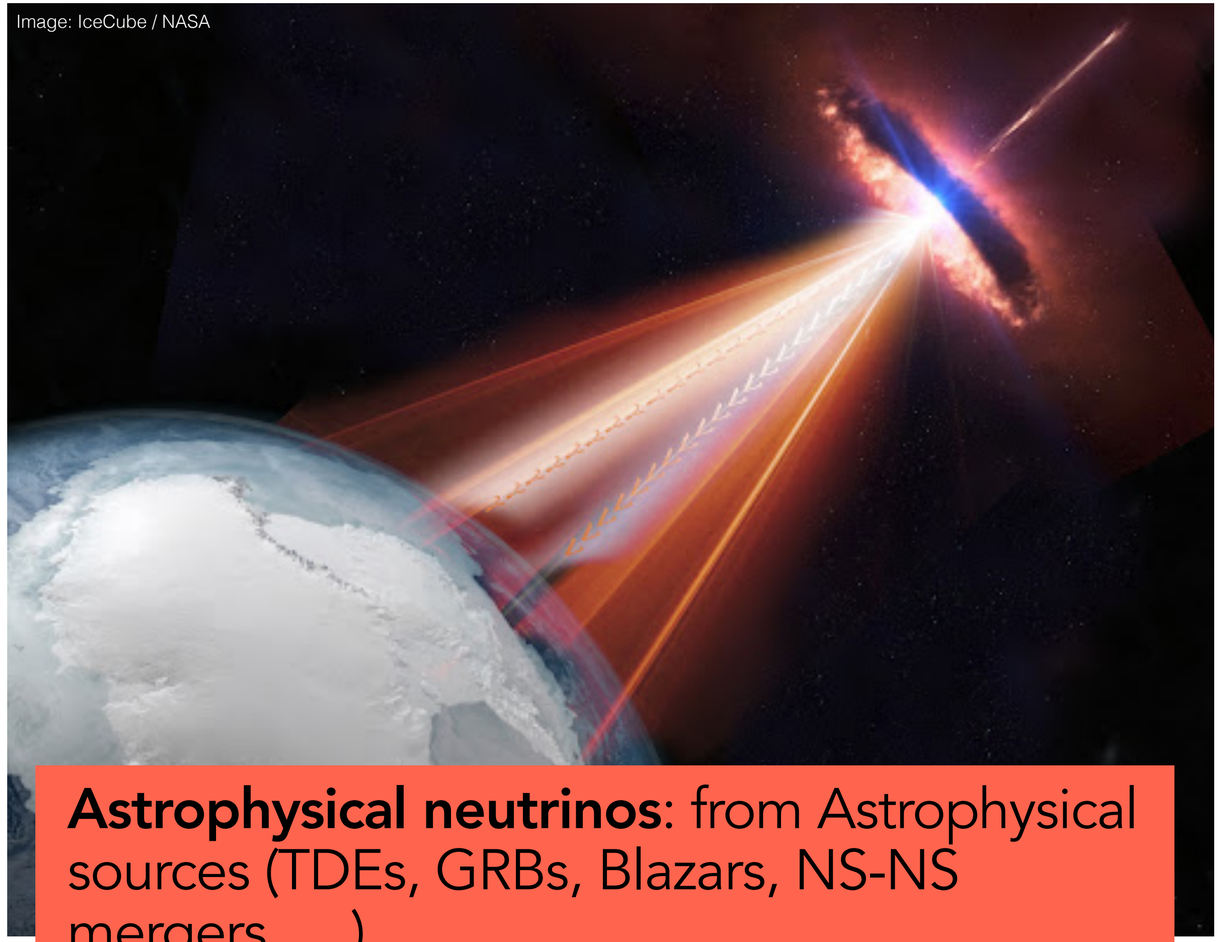
Ilse Plaisier (PhD)

Christoph Welling (PhD)

What do we do? Database Development; Software Development; Simulations; Energy/Direction Reconstruction; Sensitivity studies; Laboratory assembly and tests

Ultra High Energies Neutrinos

UHE neutrinos probe the extragalactic sky and UHECR sources



Astrophysical neutrinos: from Astrophysical sources (TDEs, GRBs, Blazars, NS-NS mergers, …)

Cosmogenic neutrinos: from interaction between **UHECR** and **CMB**

$$p + \gamma \rightarrow \Delta^{++} \rightarrow \pi^{+} + n$$

$$\pi^{+} \rightarrow \mu^{+} + \nu_{\mu}$$

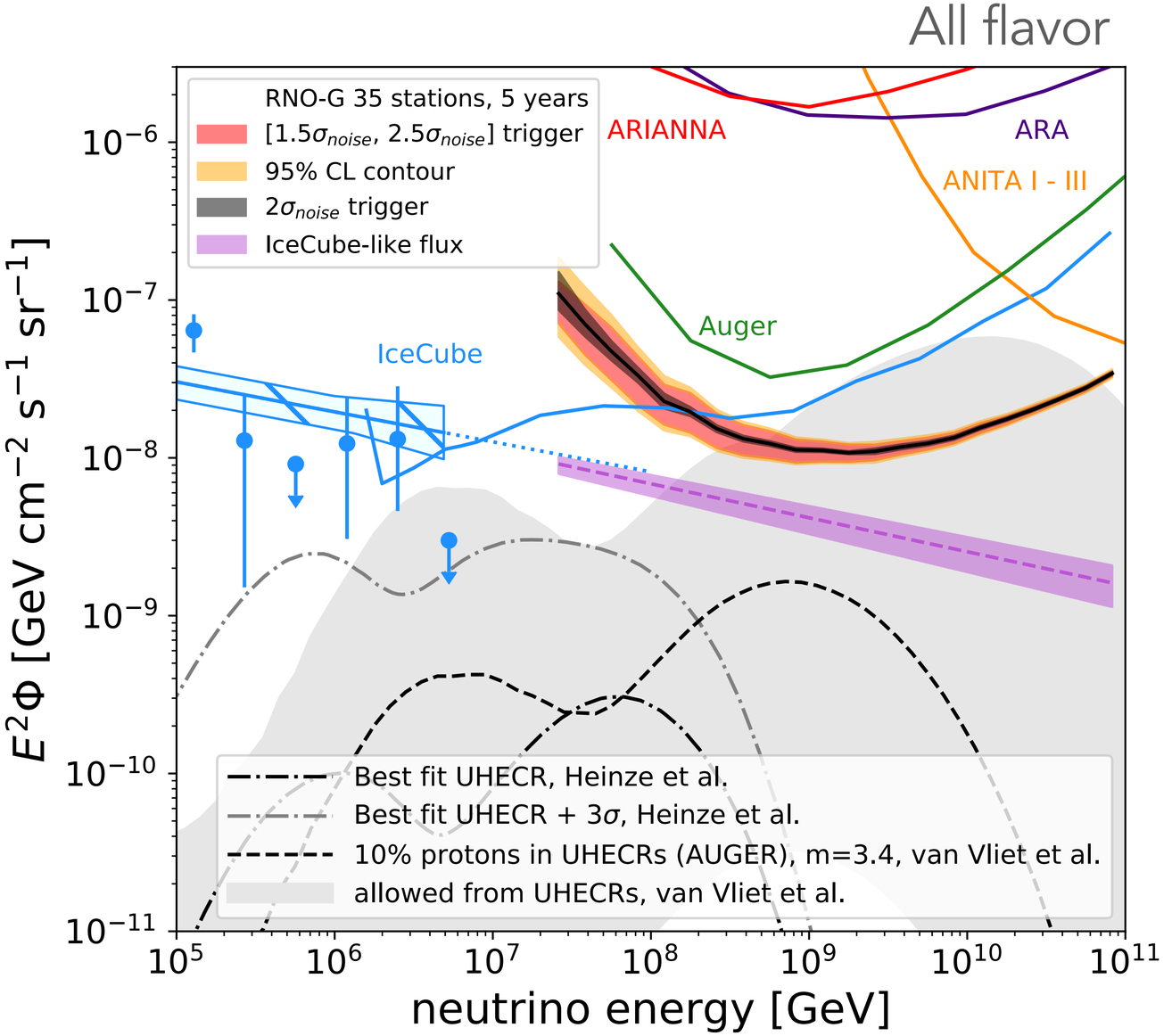
$$\mu^{+} \rightarrow e^{+} + \bar{\nu}_{\mu} + \nu_{e}$$

RNO-G addresses UHE neutrinos (> 10 PeV)

Radio detectors' scientific purpose is to observe ultra-high energy neutrinos, a regime out of reach via traditional optical methods.

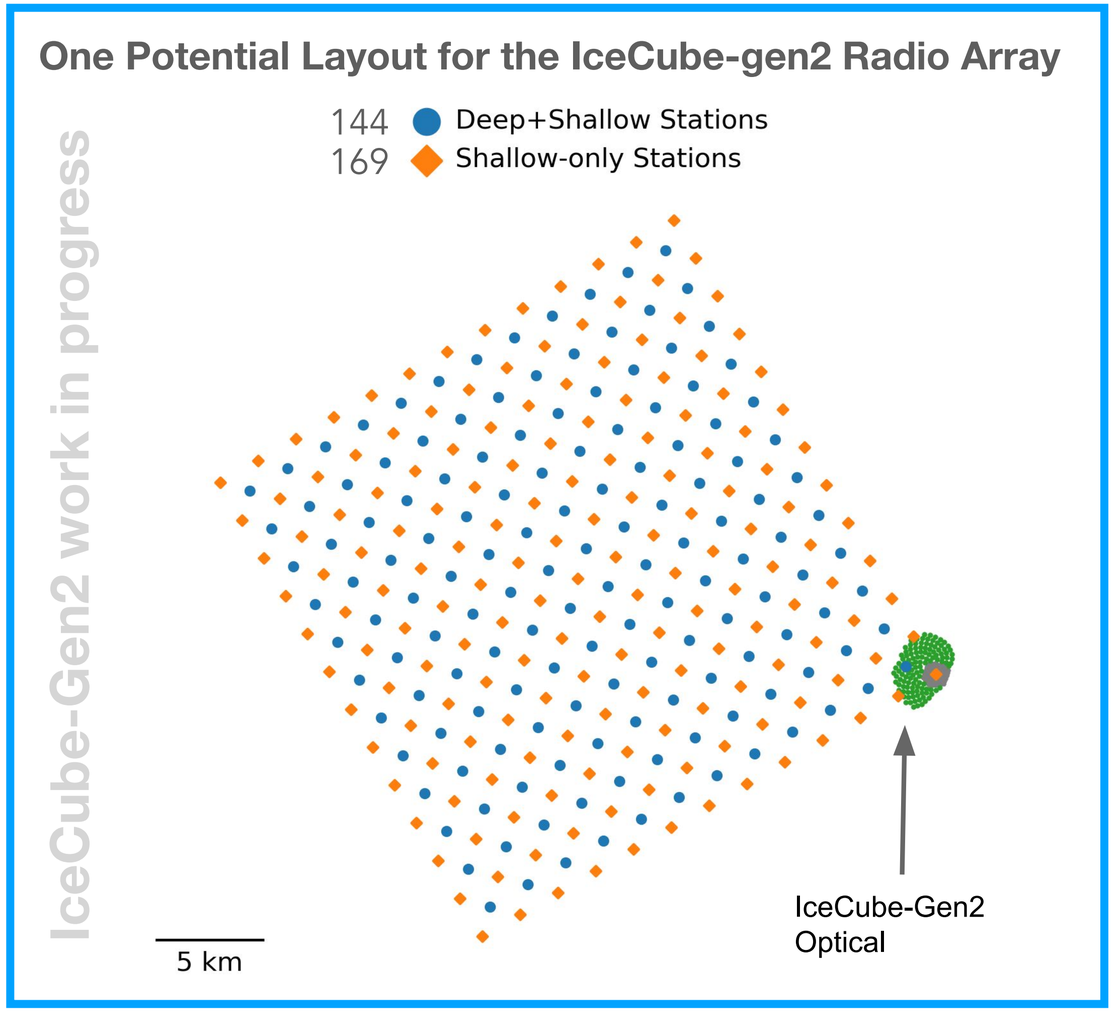
At UHE the flux decreases at best as E^{-2}

We need a larger detector to improve the sensitivity

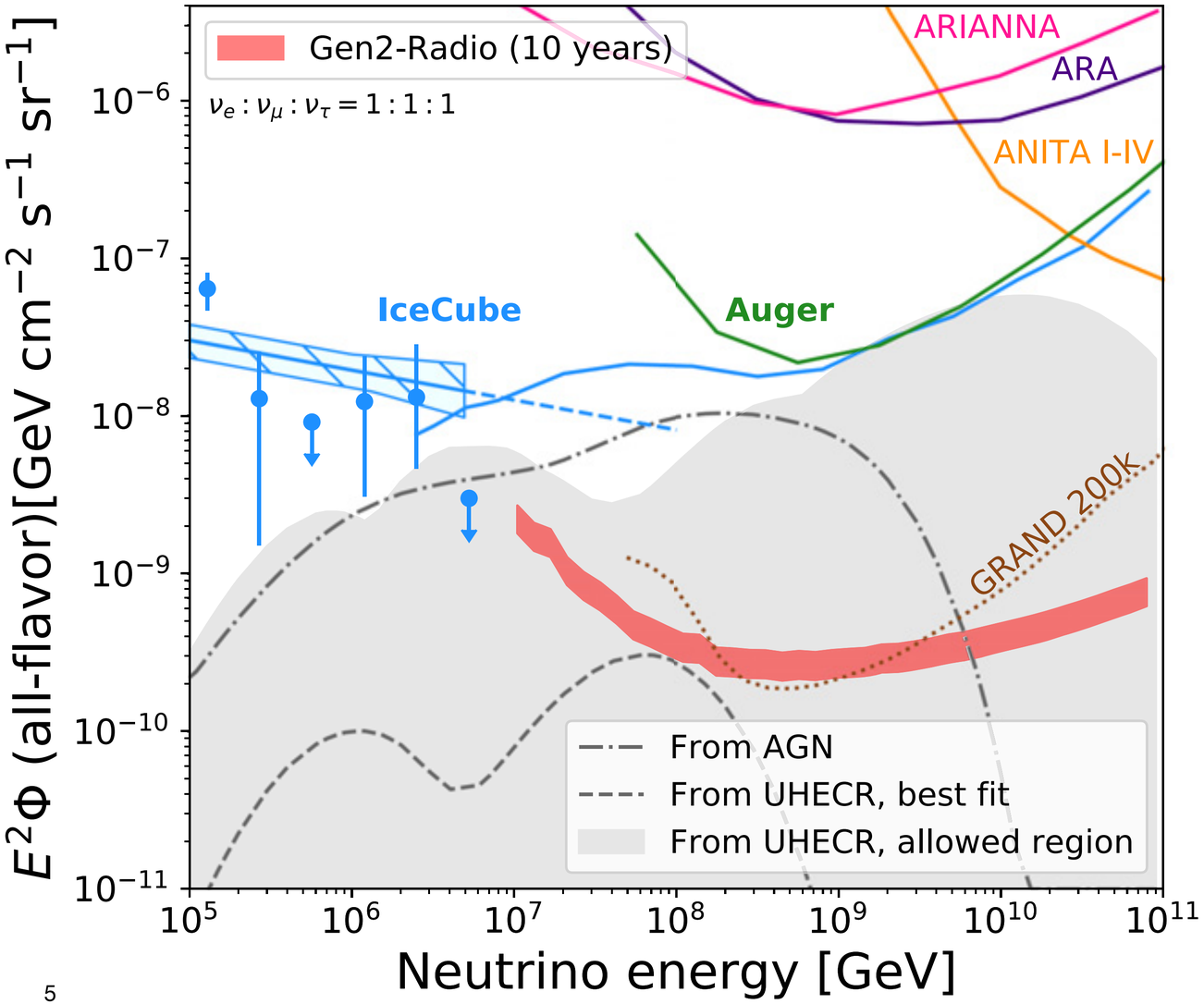


Towards the IceCube Gen2-Radio Array...

RNO-G is designed for **scalability**:
Large-scale production and deployment



J. Phys. G: Nucl. Part. Phys. 48 (2021) 060501



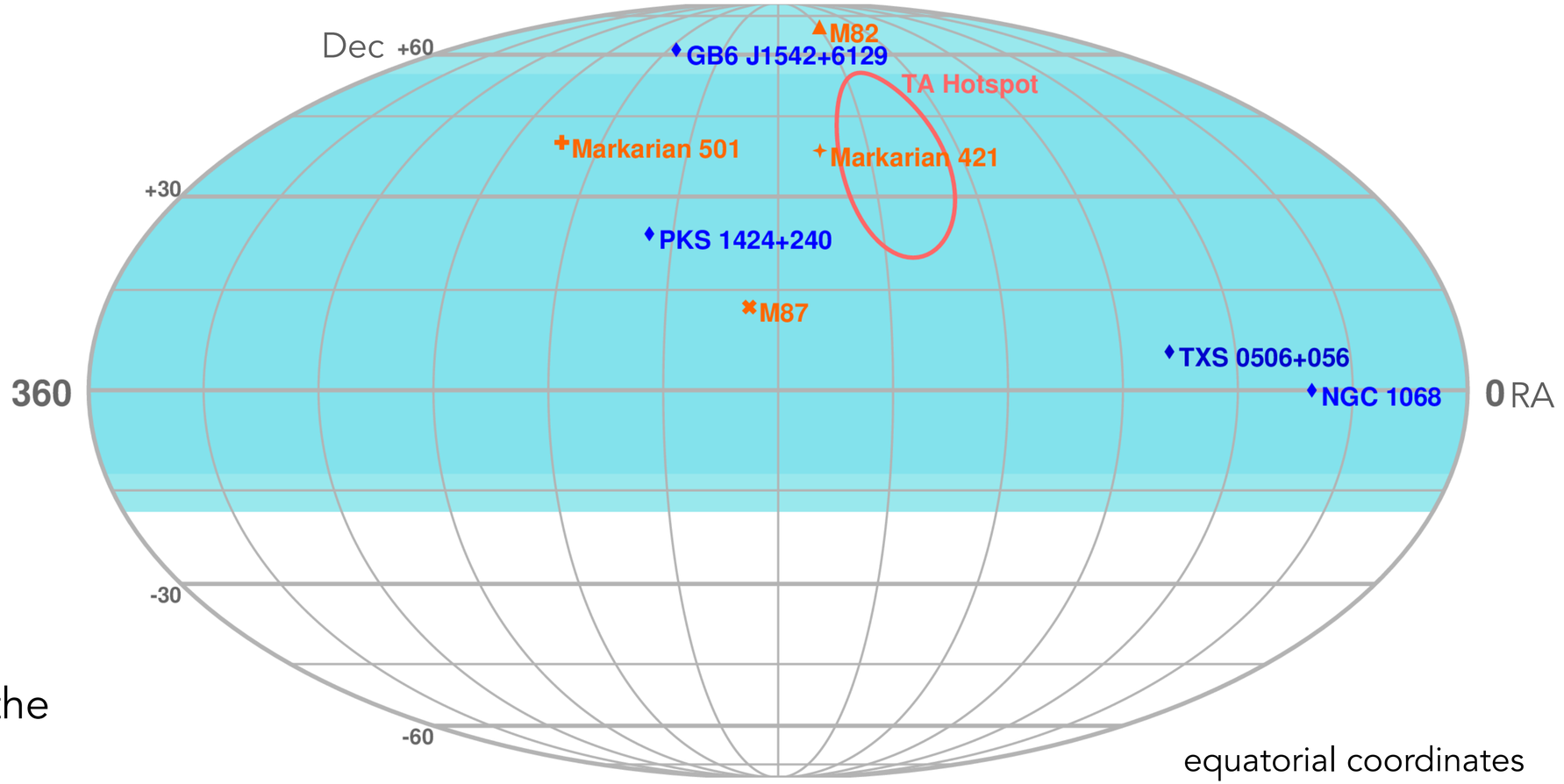
RNO-G Sky coverage

- First neutrino detector of the **Northern** sky at UHE energies above 10 PeV

- At UHE is sensible to down going neutrinos and Earth-skimming neutrinos

- In the field of view there are interesting targets, as the sources seen by IceCube as the most significant sources in a point-source search.

The diurnally-averaged total field of view of the detector



equatorial coordinates

arXiv: 2010.12279

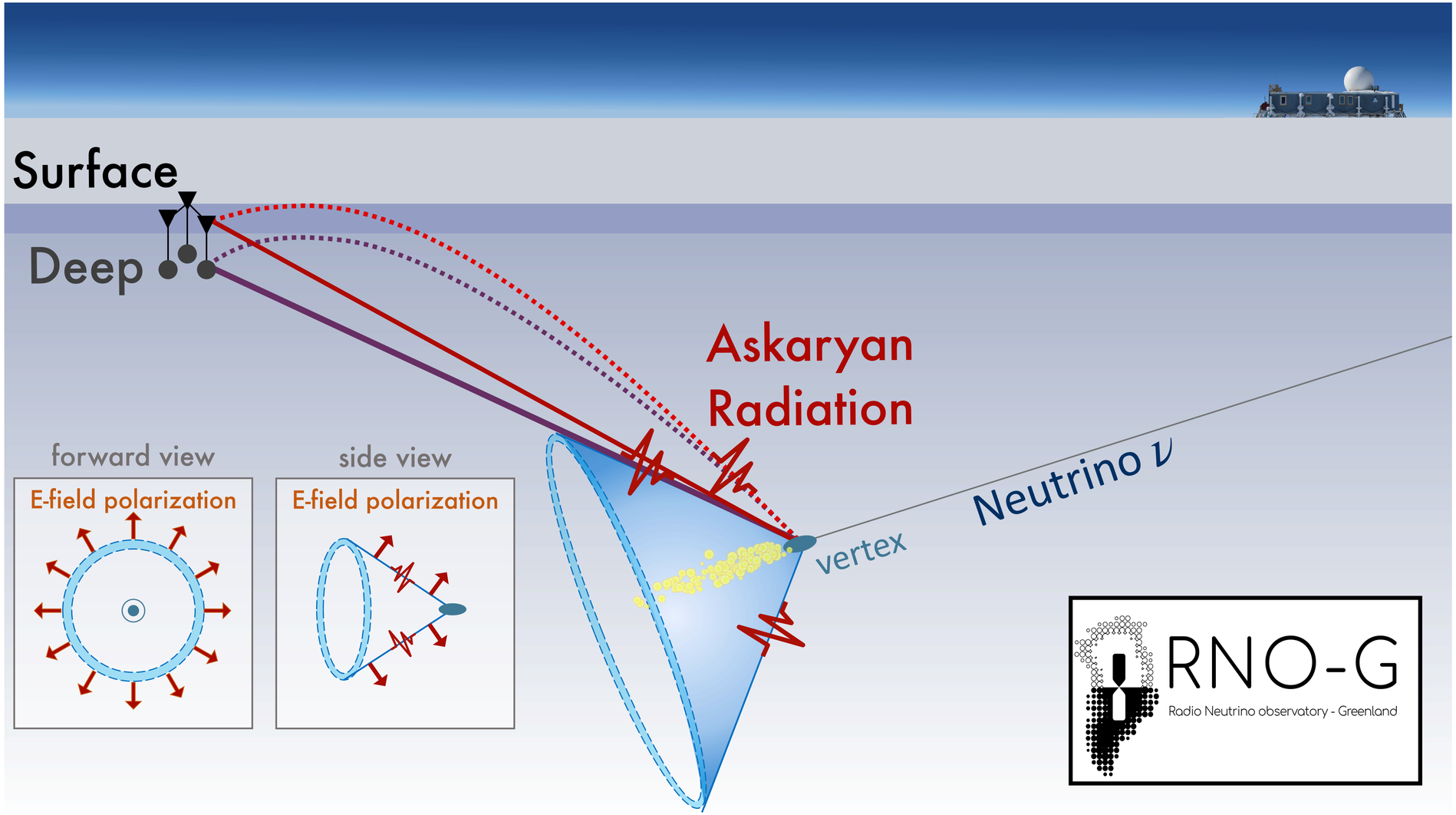
Askaryan radiation

arXiv: 2010.12279

- Askaryan emission is caused by showers developing in a (dense) medium.

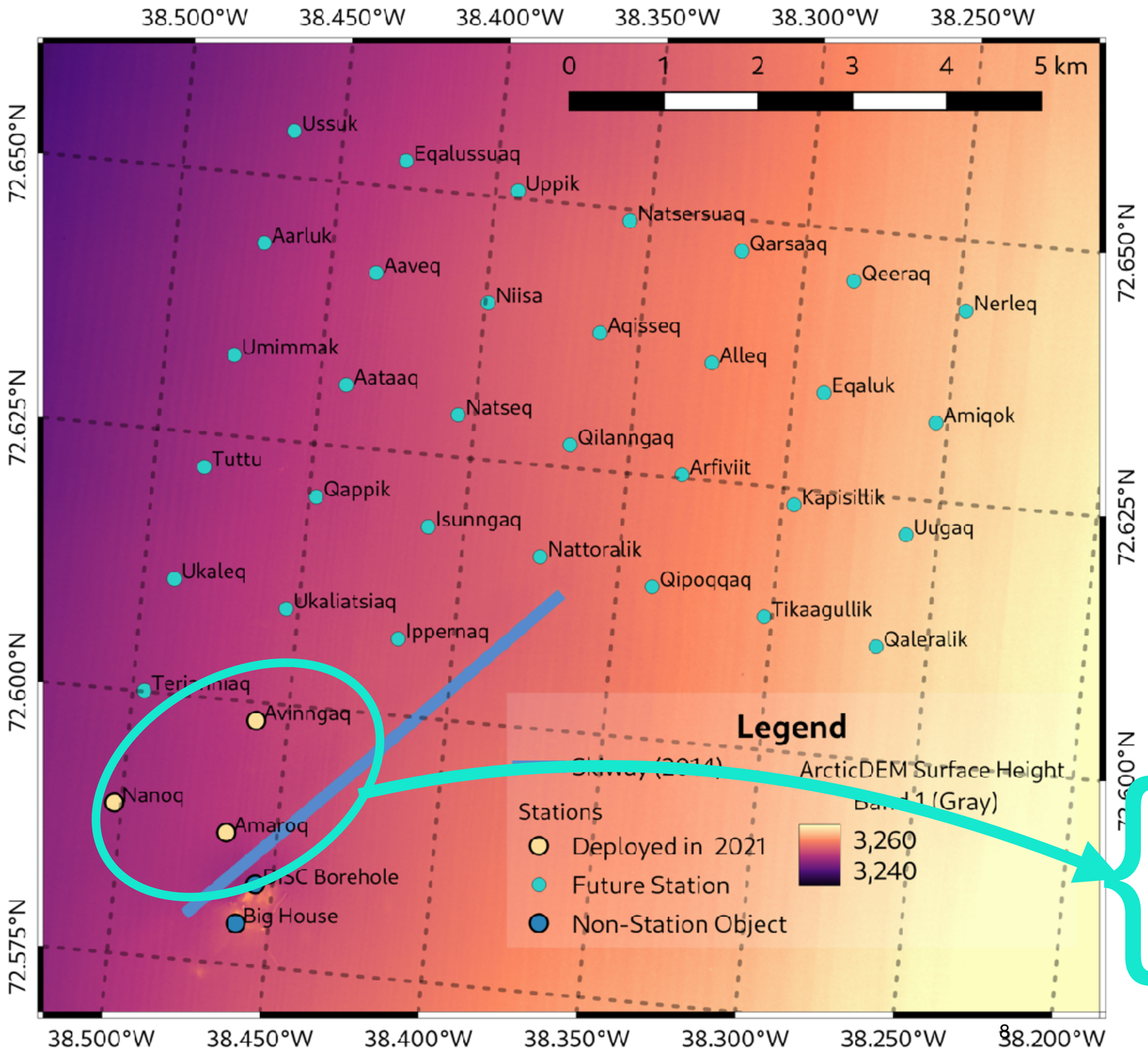
- The radiation is stronger at the Čerenkov angle but gets refracted in the ice.

- The attenuation length of radio waves in ice (order of kms) allows to detect higher energies.



RNO-G Planned Layout

https://rno-g.github.io/station-map/



https://geo-summit.org/summit-station

SUMMIT station

- 35 stations
- 1.25 km spacing
- Last deployment season: 2024
- 3 stations currently deployed

Deployed in Summer 2021:

- **Amaroq** (Arctic wolf)
- **Nanoq** (Polar bear)
- **Avinngaq** (Arctic lemming)

RNO-G station

arXiv: 2010.12279

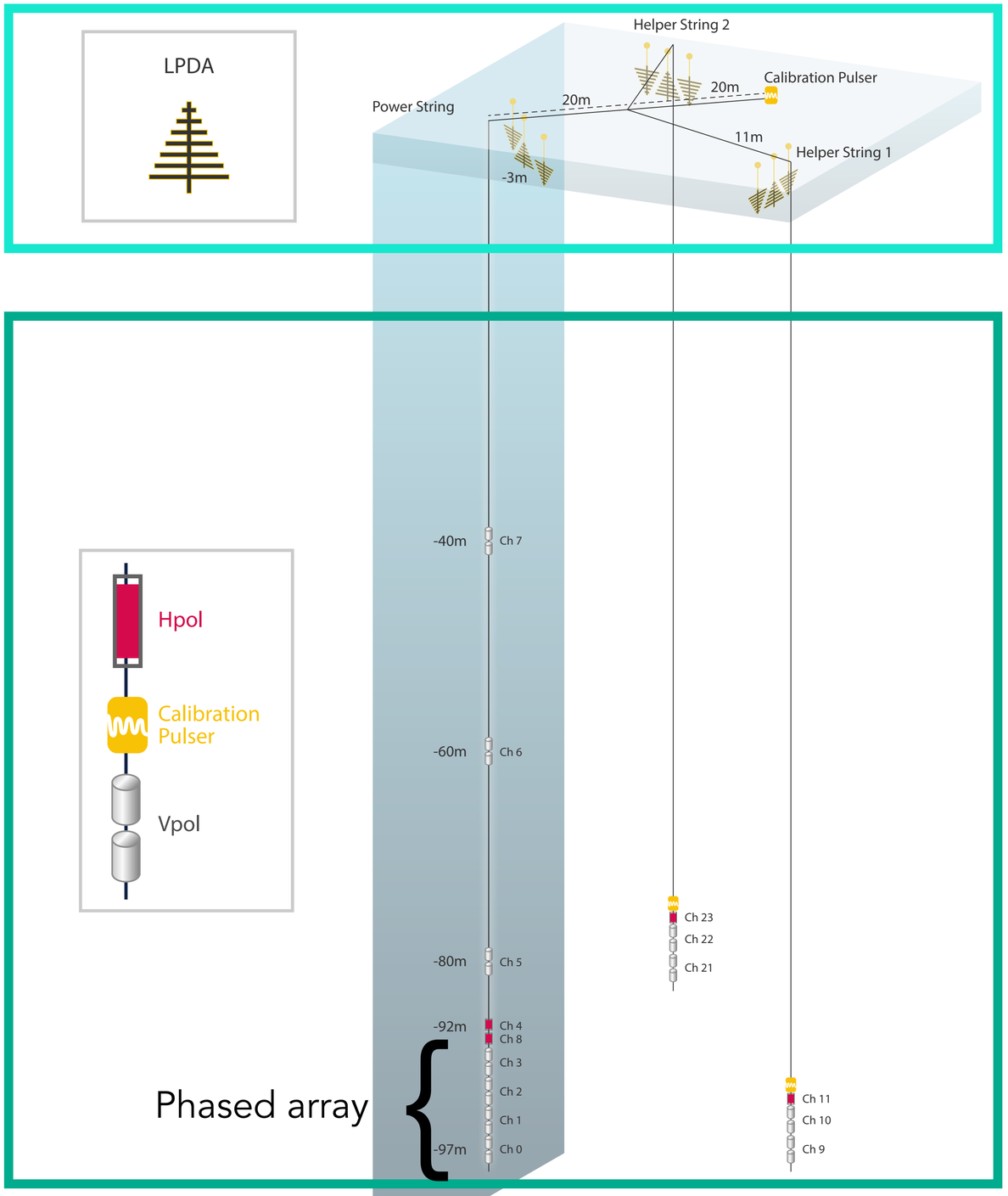
Hybrid design combines advantages of **ARA** (deep) & **ARIANNA** (shallow):

Shallow component (~3 m)

- LPDAs facing upward and downward
- Cosmic rays and RFI veto

Deep component (~100 m)

- Hpols & Vpols
- Provides large fraction of effective volume
- Event reconstruction
- Includes a low-threshold trigger system

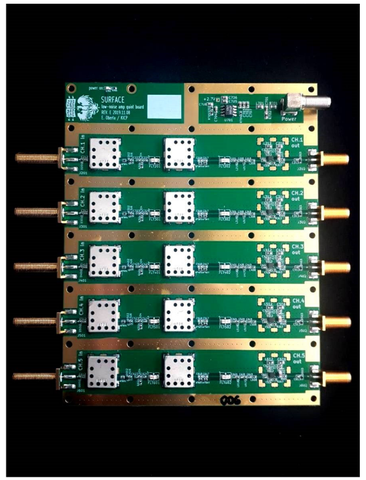


Work at ECAP

Assembly and testing of the Amplifiers

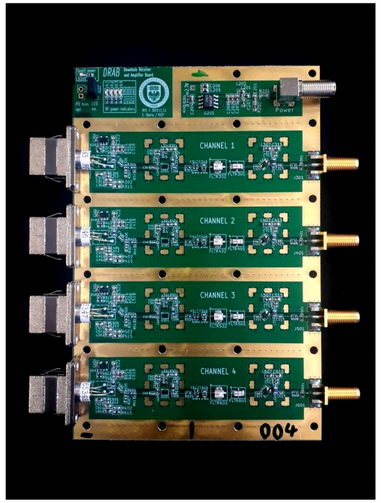
ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

Surface board



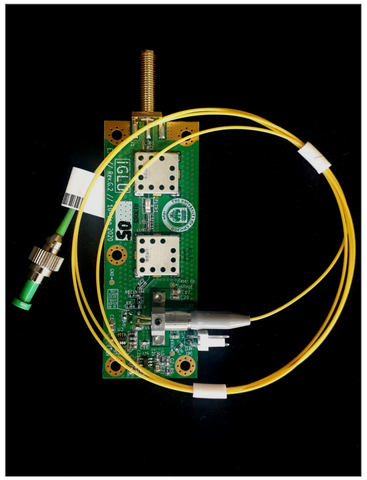
DRAB

(Downhole Receiver and Amplifier Board)



IGLU

(In-ice Gain with Low-power Unit)

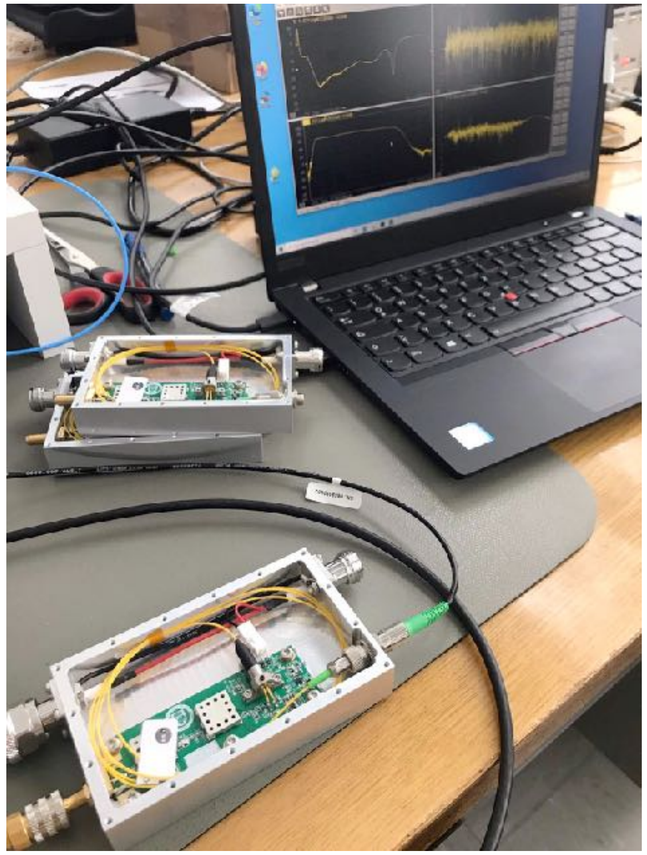


Work at ECAP

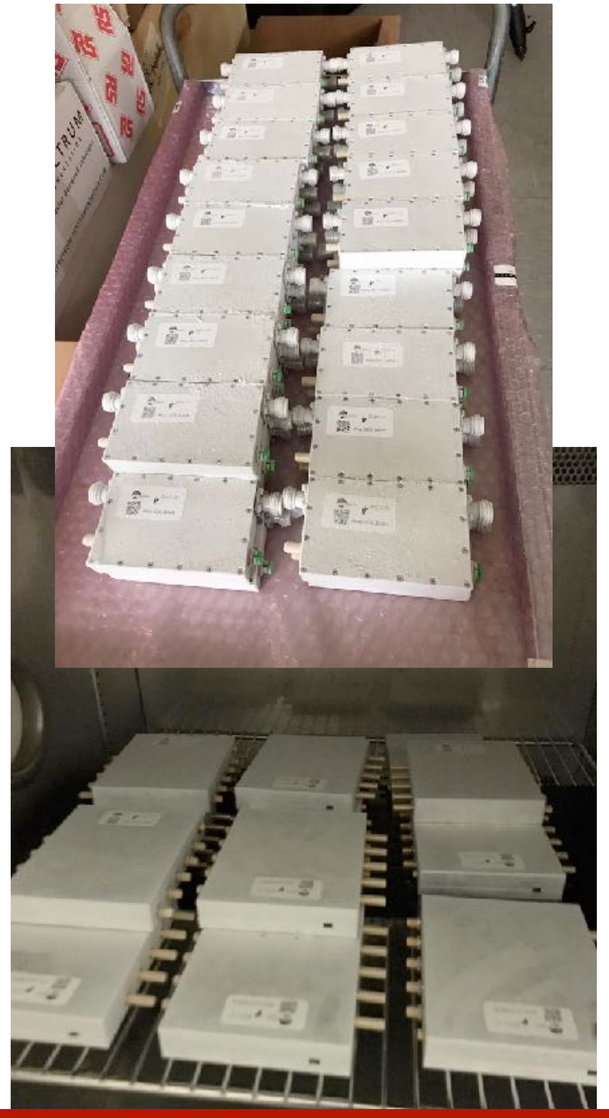
Assembly and testing of the Amplifiers:

Spring 2021

Assembly



Function test

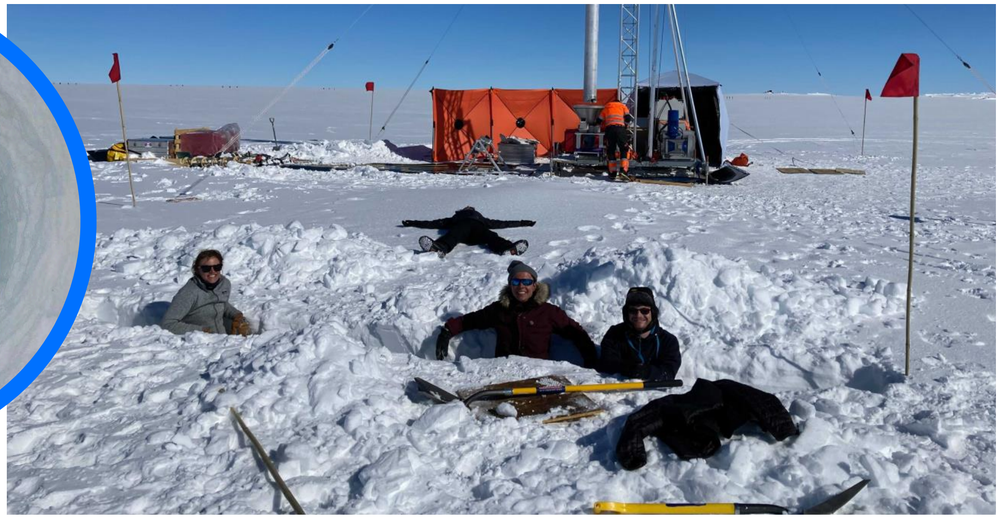


Stress test

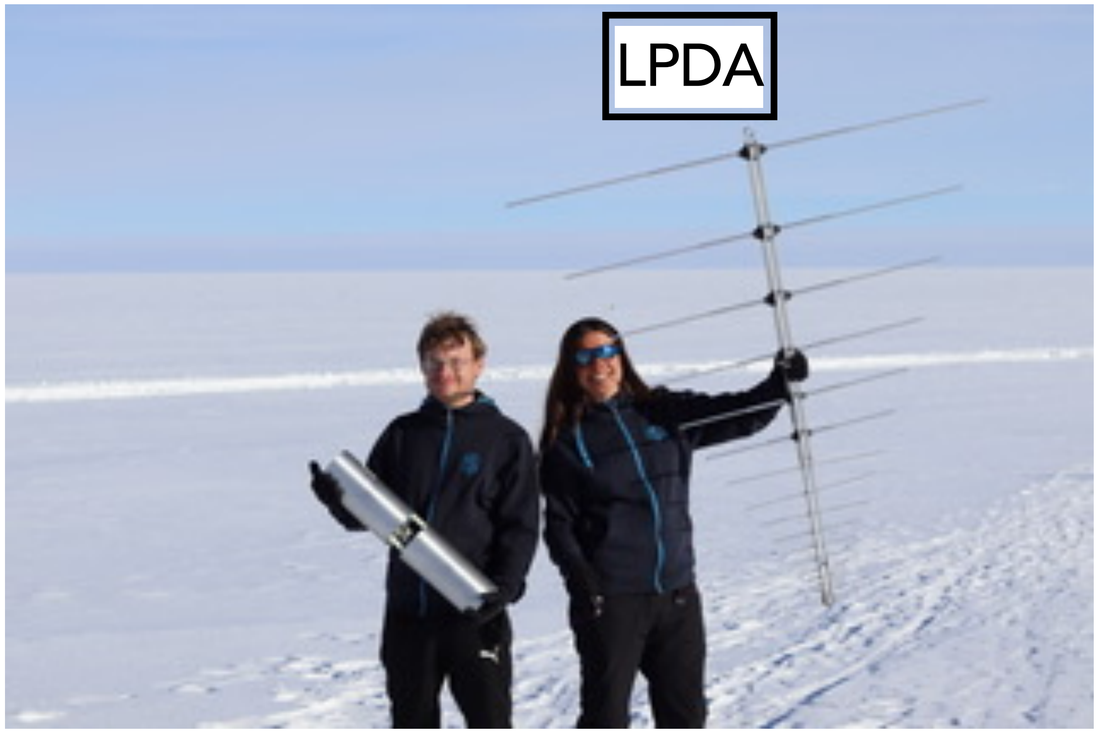
Deployment

From June to August (2021)

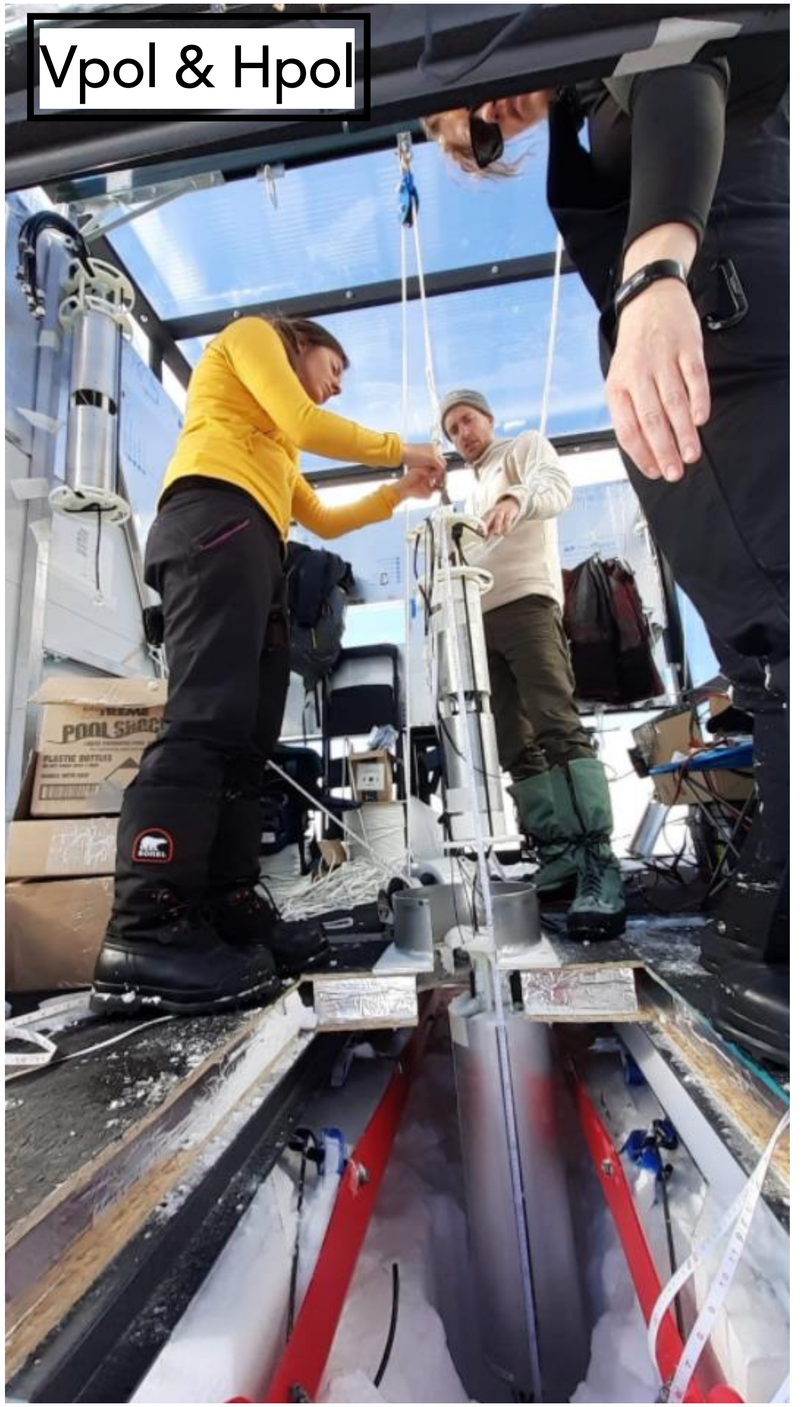
Drilling



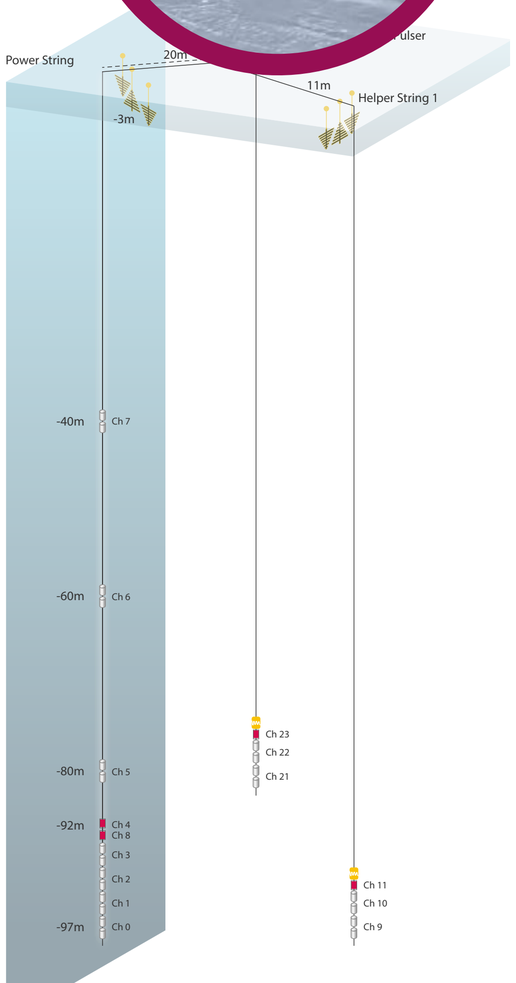
LPDA

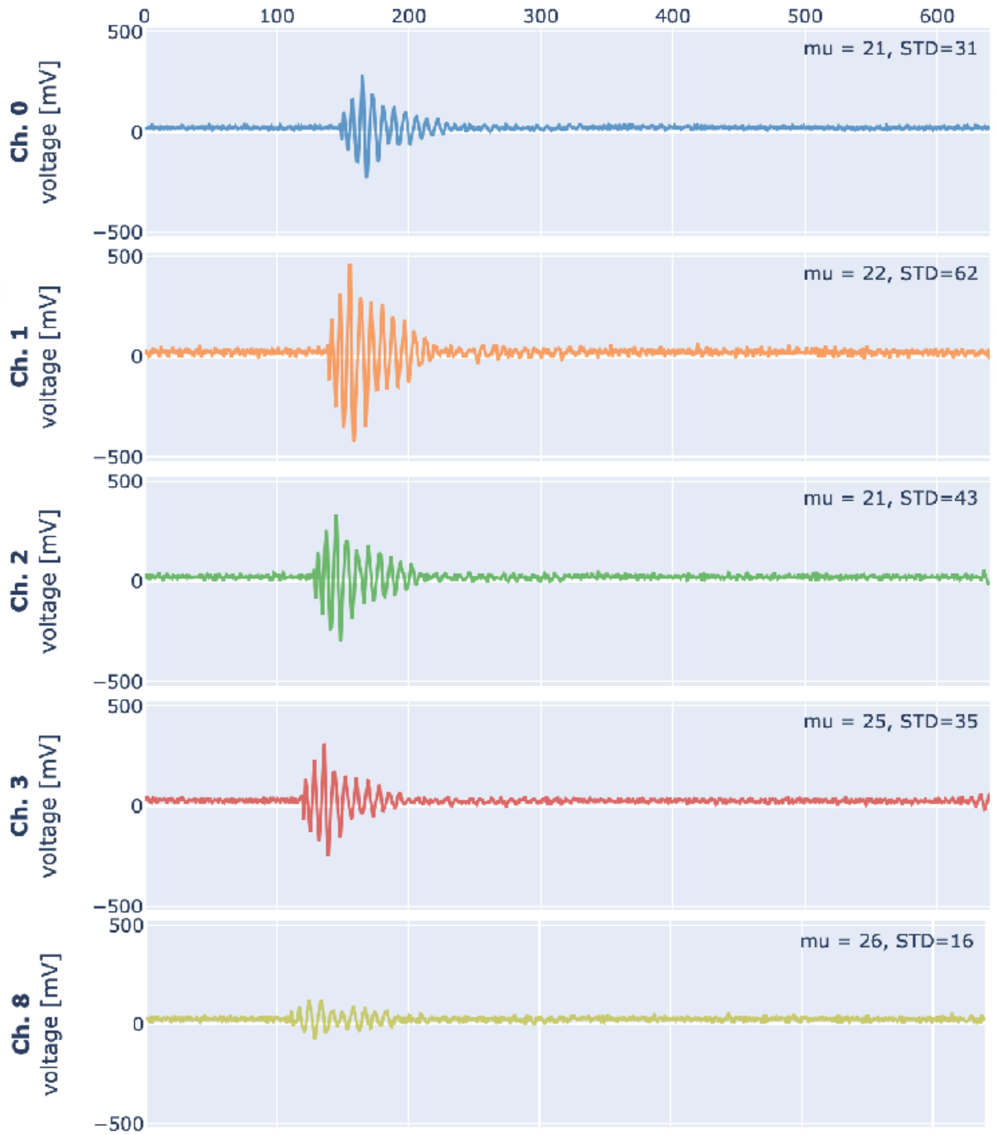


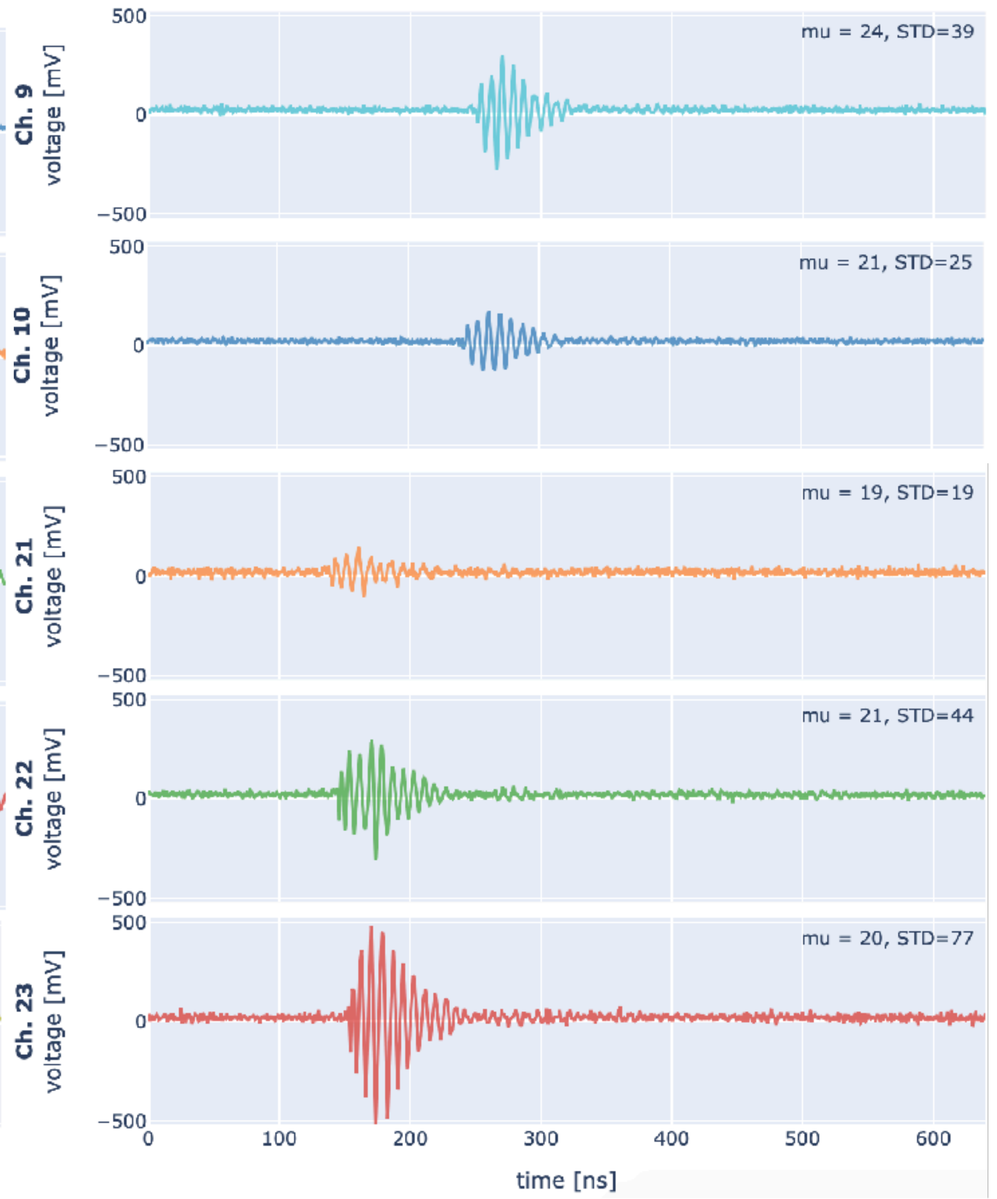
Vpol & Hpol



Events from the **deep** component: *Snowmobile*







- First UHE radio neutrino observatory in the Northern hemisphere
- Designed for scalability
- 35 station planned, 3 deployed
- Three more field seasons planned (last deployment in 2024)
- Data are coming from the first stations…

Thank you!