# Development of an in-situ calibration device of firn properties for Askaryan neutrino detectors


PRESENTER

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## BACKGROUND

- Detection of **high-energy neutrinos** most cost-efficient with **radio technique**
- ν reconstruction:

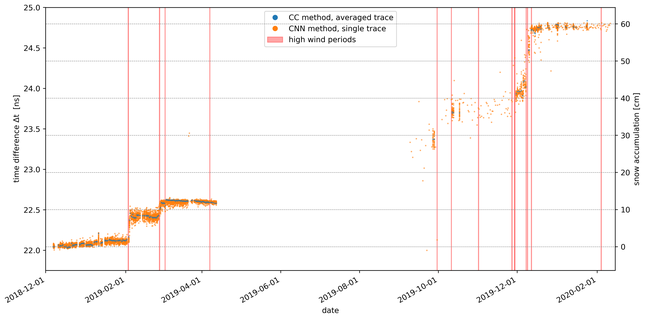
D'n'R pulse → ν-vertex distance → ν-energy

snow accumulation ***h*** & index-of-refraction profile ***n(z)*** } near surface ice (aka firn) properties

- **Monitoring** of ice properties is required for a precise direction and energy reconstruction
- What is the **optimal** calibration layout?

## SNOW ACCUMULATION MEASUREMENT

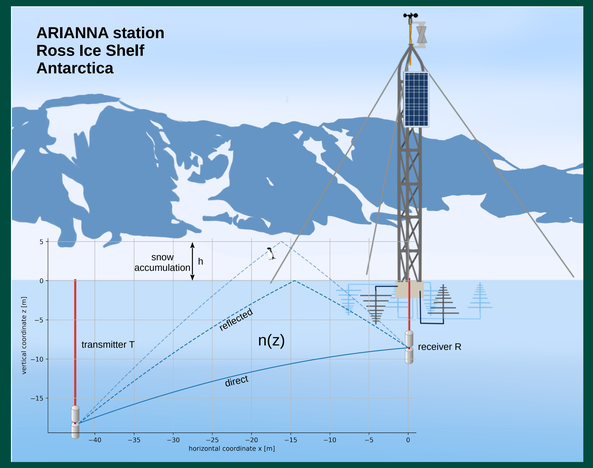
- Existing calibration device for snow accumulation comprising **transmitter-receiver** (T-R) pair
- 14 month of in-situ data from ARIANNA site analyzed with
  - **Cross correlation** (CC)
  - **Convolutional Neural network** (CNN)
- CC: 5 ps resolution for high-SNR events
- CNN: 34 ps resolution for low-SNR events



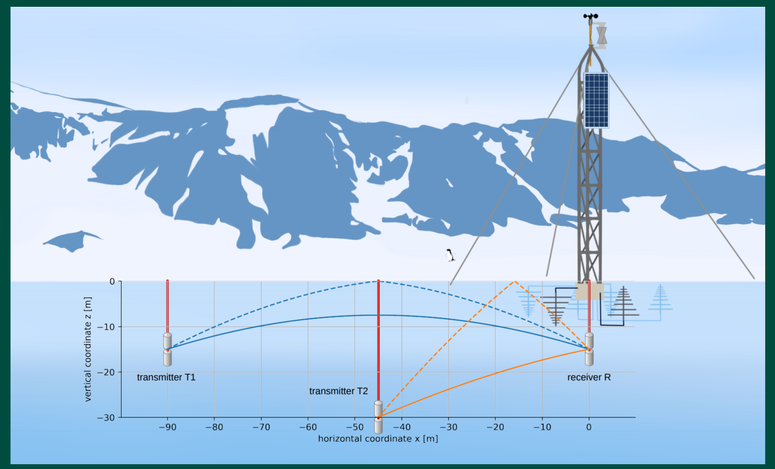

D'n'R time difference (snow accumulation) reconstruction from high-SNR traces with a cross correlation method (blue) and low-SNR events with a deep learning algorithm (orange). During the dark winter months (April 2019 to September 2019) the station shuts down. The red band indicate periods of high wind.

# *Calibration of Radio Neutrino Detectors:*

## **Transition** from **one-transmitter** …




## … to **two-transmitter** calibration device would allow for a precise measurement of the **index-of-refraction profile**

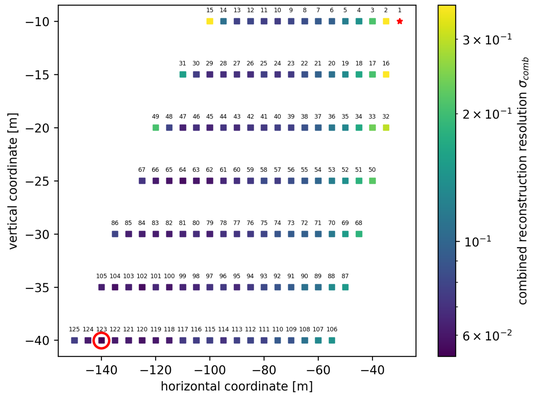



## ICE PROPERTIES MEASUREMENT

- **Additional transmitter**: (T1, T2, R)
- Allows simulatneous measurement of:
  - **snow accumulation h**
  - **index-of-refraction profile n(z)**
    - change of refractive index **Δn**
    - characteristic length $z_0$
- Optimise transmitter positions for minimal **reconstruction resolution** and **correlation**

n(z) described well by exponential function:

$$n(z) = 1.78 - \Delta n \cdot e^{-z/z_0}$$




Fixing T1 at position 1 (red star, upper right) allows for 124 positions of T2 on a 5x5 m grid in x and z. The smallest value of the reconstruction resolution (colour code) is found to be 123 (red circle, lower left). This procedure is repeated for all possible positions of T1 resulting in 15500 combinations of T1 and T2.

## RESULTS

**statistical uncertainty, correlation**

| | |
|---|---|
| $\sigma_h$ = 5 mm | $\rho_{h,\Delta n}$ = 24% |
| $\sigma_{\Delta n}/\Delta n$ = 0.04% | $\rho_{h,z0}$ = -41% |
| $\sigma_{z0}/z_0$ = 0.3% | $\rho_{\Delta n,z0}$ = -12% |

- Factor of ~50 more precise than current **density-based borehole calibrations**
- **Systematic antenna misplacement** of 1 cm during **deployment** yields: $\sigma_{\Delta n}/\Delta n$ = 0.05% and $\sigma_{z0}/z_0$ = 0.12%
- Systematic uncertainty ~ statistical uncertainty

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