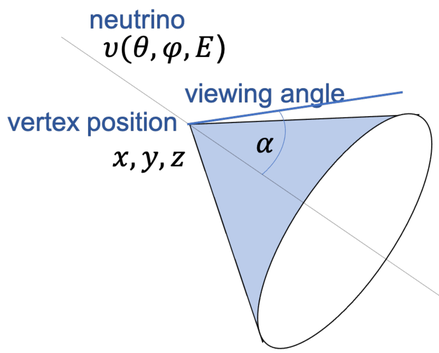
Direction Reconstruction for the Radio Neutrino Observatory Greenland (RNO-G).

Ilse Plaisier for the RNO-G collaboration

RNO-G will be the first large-scale (35 stations) implementation of the in-ice radio detection technique. The target neutrino energies are beyond the ones thus far measured. The first ten stations are currently under deployment at Summit Station Greenland.

Theory

To determine the neutrino arrival direction (θ, φ) the signal arrival direction, viewing angle α and polarization are needed.



Signal arrival direction

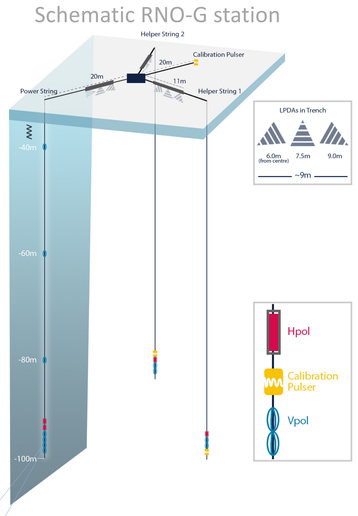
Due to the density gradient the radio signal bends in the ice while propagating towards the antennas.

Viewing angle

The radio emission is strongest on the Cherenkov cone (56° in ice). For off-cone events, the frequency content decreases rapidly for the higher frequencies. Therefore the slope of the frequency spectrum can be used to determine the viewing angle α (angle between signal and shower axis).

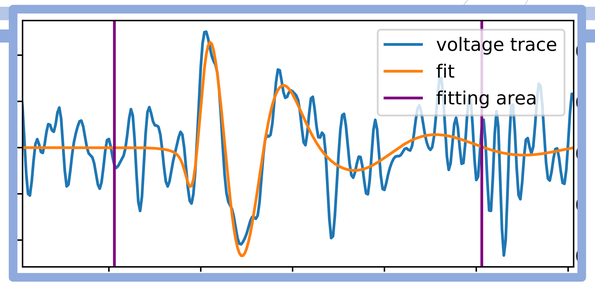
Polarization

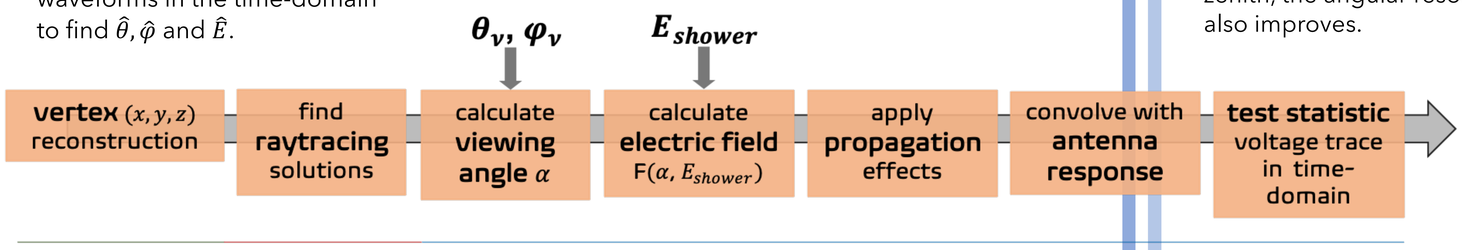
The Askaryan emission results in a polarization towards the shower axis. An RNO-G station [1] contains antennas that measure horizontal- (H-pol) and vertical (V-pol) polarization.



Methods

Step 1. Timing of the arriving pulses at antennas is used to reconstruct the vertex position
Step 2. Electric field model $F(\alpha, E)$ is used to fit the waveforms in the time-domain to find $\hat{\theta}, \hat{\varphi}$ and $\hat{E}$.

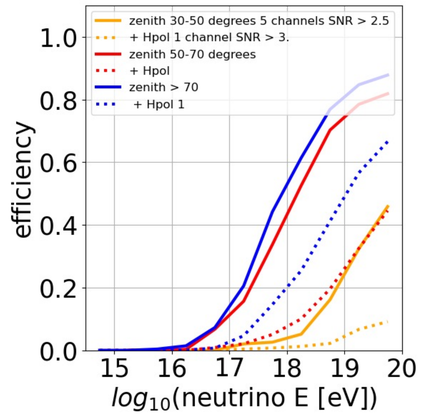


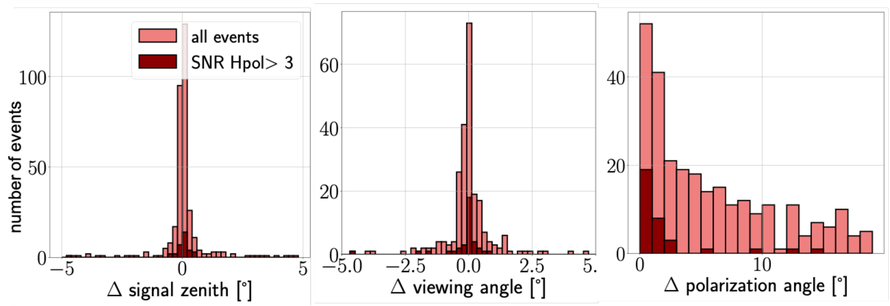


Results

Analysis Efficiency

Reconstruction efficiency for the low-threshold phased array trigger. Selection cut on SNR > 2.5 in 5 channels (for vertex reconstruction) and for Hpol SNR > 3 (for polarization reconstruction), for different zenith bands (90° is horizontal).



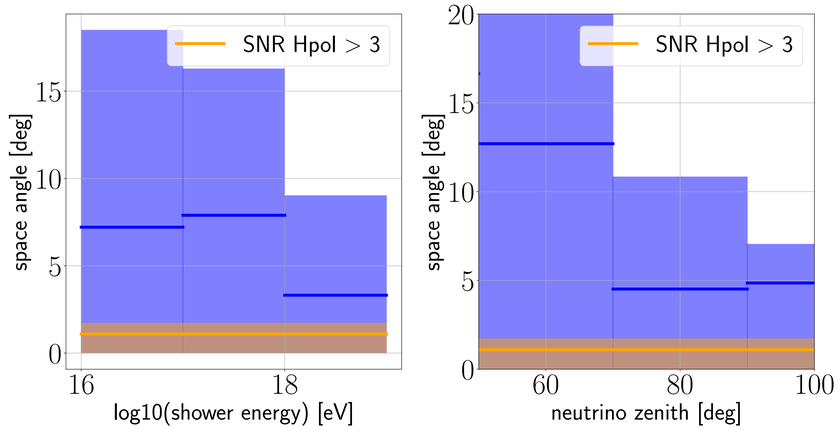


Signal Direction, Viewing angle and Polarization Resolution

The signal direction can be obtained at sub-degree level and the viewing angle at ≈ 0.5°. The polarization resolution is highly dependent on whether the Hpol records any signal.

Neutrino Direction Resolution

For all events with SNR Hpol > 3 an angular resolution of $\sigma_{68\%} = 1.7°$ is obtained. Because of the better analysis efficiency for increasing energy, as well as source zenith, the angular resolution also improves.



References [1] whitepaper on RNO-G at https://arxiv.org/abs/2010.12279