Sensitivity and Event Reconstruction with the Radio Neutrino Observatory Greenland (RNO-G).

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Sensitivity

- Aim of RNO-G is neutrinos at energies above 10PeV
- 35 stations will be built at Summit Station, Greenland, in the next 5 years
- Particle showers in ice emit radio signals via the Askaryan effect
- Large attenuation length in ice allows for large effective volumes at low cost

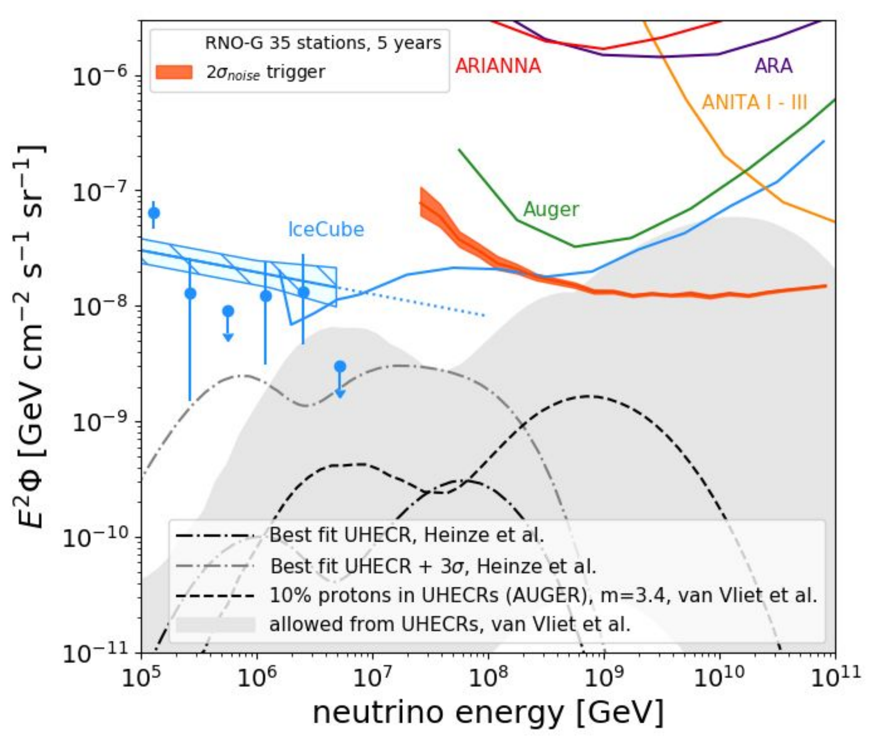


Figure 1: Expected sensitivity for RNO-G with 35 stations in 5 years.

Station Design

- 9 LPDAs at surface for cosmic ray identification
- Vertically and horizontally polarized antennas for polarization measurement
- 4-channel phased array used as trigger on main string with many antennas
- Support strings for azimuth reconstruction

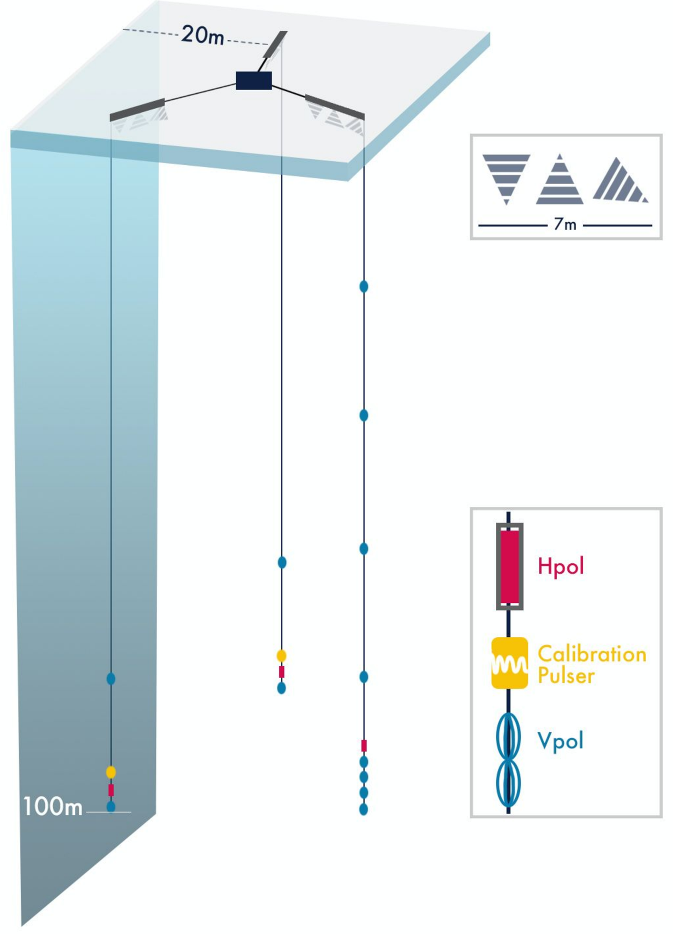
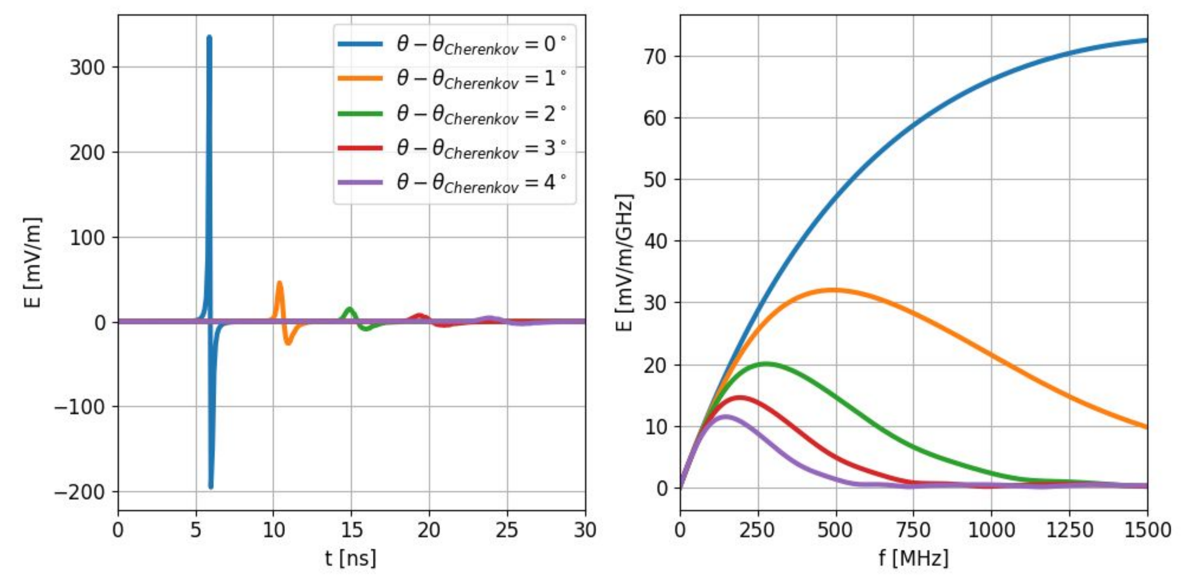


Figure 2: Lay-out for an RNO-G station.

Radio Signal Properties



To reconstruct the **neutrino energy**, we need:

- Electric field amplitude (is proportional to shower energy);
- Distance traveled by the radio signal (inferred from Vertex Position Reconstruction);
- viewing angle (inferred from Electric Field Reconstruction);
- Inelasticity (from simulations, cannot be reconstructed)

To reconstruct the **neutrino arrival direction**, we need:

- signal arrival direction (inferred from Vertex Position Reconstruction);
- viewing angle (inferred from Electric Field Reconstruction);
- polarization (points towards shower axis)

Figure 3: Waveform (left) and spectrum (right) of the radio signal emitted by a 1 EeV shower seen at different viewing angles from 1 km distance. The viewing angle is the angle the signal makes with respect to the shower axis. The radio signal is the strongest near the Cherenkov angle (56°).

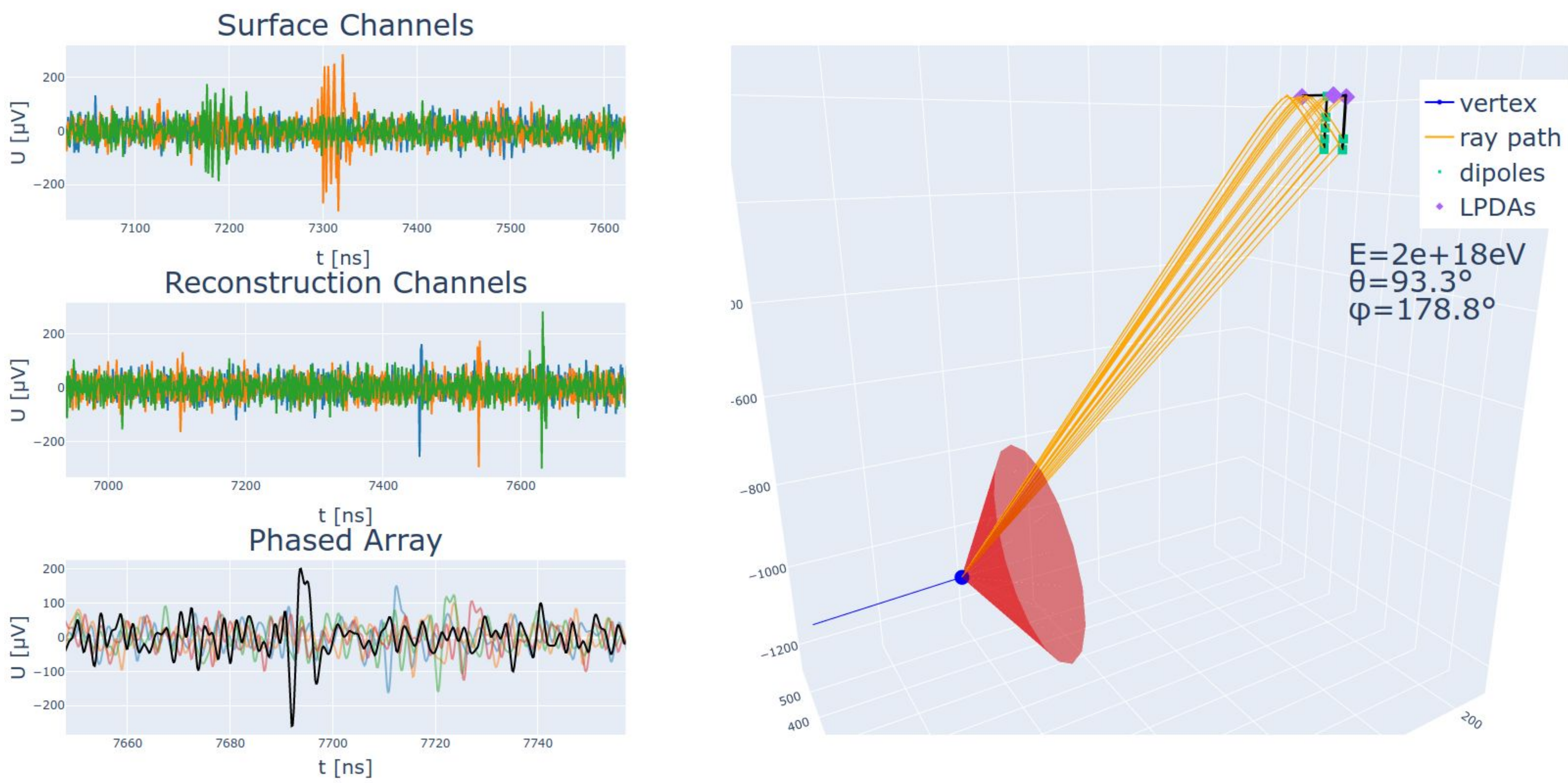
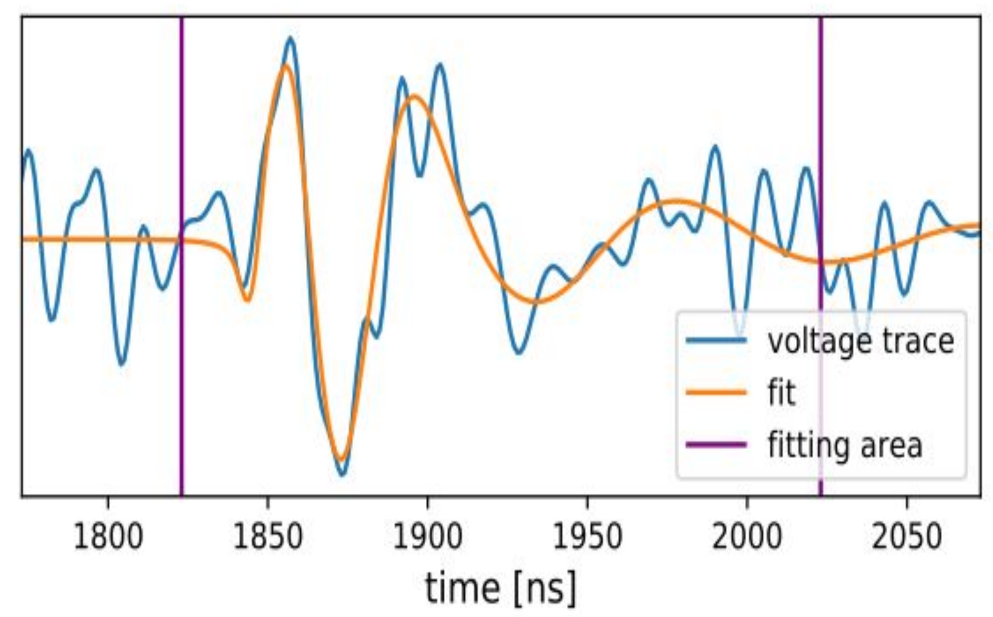


Figure 4: Example of a neutrino event to be detected by RNO-G. Left: Voltage traces from the surface LPDAs (top), signal in the deep vertically polarized antennas (middle) and the phased array (bottom). For triggering, the four channels of the phased array are combined (black curve) to enable triggering at lower thresholds. Right: Visualization of radio signal propagating towards the station. In red the Cherenkov cone is shown. Due to the inhomogeneous density profile of the ice, the signal is refracted during propagation. Note that also reflections from the ice-air boundary are detected.

Electric Field Reconstruction

Figure 5: Example event for electric-field reconstruction.



- Use parametric model for electric field spectrum
- Apply antenna response to signal model
- Fit model to measured waveform in the time-domain
- Reduces the influence of noise on signal

Vertex Position Reconstruction

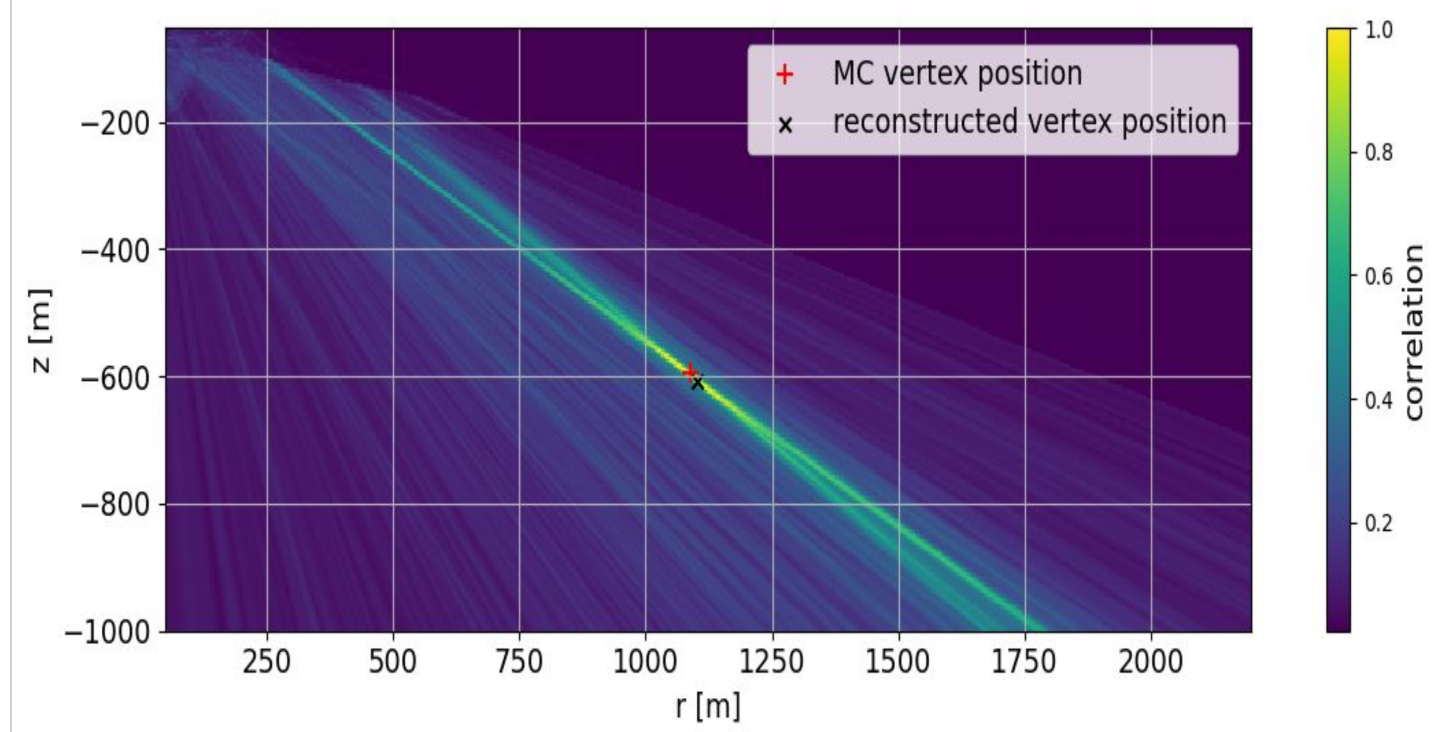


Figure 6: Correlation between channels for a given vertex position.

- Expected time differences in channels can be calculated for given vertex position
- Perform beamforming by cross-correlating channels
- Location with highest correlation is likely the vertex position

References

C. Glaser et al. "NuRadioReco: a Reconstruction Framework for Radio Neutrino Detectors." EPJ-C 79.6 (2019)

C. Glaser et al. „NuRadioMC: Simulating the radio emission of neutrinos from interaction to detector" EPJ-C 80 (2020)

All simulation and reconstruction software is available on https://github.com/nu-radio

A whitepaper on RNO-G is currently in preparation