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

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High energy neutrinos (E>10^{17} eV) are detected cost-efficiently via the Askaryan effect in ice, where a particle cascade induced by the neutrino interaction produces coherent radio emission that can be picked up by antennas installed below the surface. A good knowledge of the firn properties is required to reconstruct the neutrino properties. In particular, a continuous monitoring of the snow accumulation (which changes the depth of the antennas) and the index-of-refraction profile are crucial for an accurate determination of the neutrino's direction and energy. We present an in-situ calibration system that extends the radio detector station with a radio emitter to continuously monitor the firn properties by measuring time differences of direct and reflected (off the surface) signals (D'n'R). We optimized the station layout in a simulation study and quantified the achievable precision. We present 14 months of data of the ARIANNA detector on the Ross Ice Shelf, Antarctica, where a prototype of this calibration system was successfully used to monitor the snow accumulation with unprecedented precision of 1mm. We explore and test several algorithms to extract the D'n'R time difference from noisy data (including deep learning). This constitutes an in-situ test of the neutrino vertex distance reconstruction using the D'n'R technique which is needed to determine the neutrino energy.

Keywords

Askaryan; UHE neutrinos; in-ice radio detection; energy reconstruction; radio; deep learning; in-situ detector calibration

Collaboration

other (fill field below)

other Collaboration

ARIANNA

Subcategory

Experimental Methods & Instrumentation

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