Greenland Neutrino Observatory (GNO): Radio Detection of Ultra-high Energy Neutrinos at Apex Station in Greenland

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Ultra-high energy (UHE) neutrino astrophysics is a rapidly evolving field that sits at the crossroads of particle physics, astronomy, and astrophysics. Neutrinos travel virtually unimpeded through the universe, making them unique messenger particles for cosmic sources, carrying information about very distant sources that would otherwise be unavailable. Detection of UHE neutrinos ($E > 10^{18}$ eV) could also reveal the origin of the highest energy cosmic rays. Observation of UHE neutrinos would also allow a measurement of weak interaction couplings at center of mass energies well beyond that of the LHC.

Current and recent efforts to detect UHE neutrinos (the balloon-borne ANITA experiment [1], the ARA effort at the South Pole [2], and ARIANNA on the Ross Ice Shelf [3]) have utilized radio detection techniques, searching for coherent, impulsive radio signals that are emitted as electromagnetic particle cascades are induced by neutrinos interacting with ice. UHE neutrino detection requires enormous volumes of a naturally-occurring dielectric material that allows radio signals to pass through without significant attenuation. Current experimental efforts monitor enormous volumes of Antarctic ice, whose radio attenuation properties have been directly measured at multiple locations in Antarctica [4].

We are planning a site characterization visit to NSF's Apex Station site in Greenland in the summer of 2013, which has a 3 km ice sheet beneath it. The Apex Station site is approximately 5 km from the existing NSF Summit Station, at the peak of the Greenland ice cap, and plans for a new station at the Apex site are under development. We will directly measure the radio attenuation length and birefringence of the ice at the Apex site between 100-1000 MHz, as well as make measurements of the radio noise environment at the site. Previous radio measurements of ice properties at Summit Station have been made by geologists [5] as a by product of measurements that characterize the rock interface at the bottom of the ice sheet, and hint at very long attenuation lengths (> 500 m), rivaling those measured in the Antarctic. We will perform a direct measurement of ice properties to compare directly with measurements made in the Antarctic using the same techniques.

It may turn out that the Apex Station site in Greenland is a world-class location for radio-detection of UHE neutrinos. There are many potential advantages of this site compared to the Antarctic. Greenland is more accessible with shorter travel times from the United States, a longer summer season in which to deploy and install instrumentation, and more days of sunlight to for solar power generation. The Apex site also has thicker ice (more potential detector volume) than the South Pole, and probably benefits from a lower radio-noise environment.

If the ice properties in Greenland turn out to be good after our direct measurement this summer, there would certainly be motivation to build Greenland Neutrino Observatory (GNO), a ground-based radio array for the detection of ultra-high energy neutrinos in Greenland, given the logistical and site advantages of the site in Greenland compared to the Antarctic. The scale would be similar to the proposed scale for the ARA experiment at the South Pole - tens of stations of radio antennas spread over a few square kilometers of the ice surface. If the radio detectors that are currently being proposed and developed in Antarctica are successful, the natural sister experiment would be a similar detector installed in the Northern hemisphere to view the Northern sky.

References

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