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Techniques for Continuous Wave Identification and Filtering in the Askaryan Radio Array

The Askaryan Radio Array (ARA), located near the geographical South Pole, is one of the first two experiments designed to detect ultra-high energy neutrinos through the Askaryan effect. In this phenomenon, interactions of these neutrinos within dense media like ice generate coherent radio pulses. Operating within a radio frequency bandwidth of 150 to 850 MHz, ARA is deployed 100-200 m deep in the ice and low radio frequency background of the South Pole. However, experiments, like ARA, operating in the radio band must account for continuous wave (CW) signals, which can originate from anthropogenic sources, instrumental noise, and other environmental factors. These CW signals can potentially obscure the faint neutrino-induced radio pulses, complicating data analysis and event identification. Over the years, ARA has developed and refined a number of techniques for CW filtering and identification, including spectral analysis, notch filtering, and phase-variance methods. These approaches exploit the unique characteristics of CW signals, such as their narrowband nature and temporal persistence, to effectively separate noise from impulsive signal-like events. This contribution reviews these techniques and investigates improvements when applying them in adaptive and multi-stage filtering pipelines that result in higher processing speed, enhanced ease of use, more accurate CW identification and filtering, and greater reliability in performance. The efficacy of these methods is demonstrated through CW identification and filtering from all ARA stations, showcasing their critical role in reducing event misclassification and improving the experiment's overall performance. By refining these techniques, this work not only advances the capabilities of ARA but also underscores the importance of robust CW identification and filtering for current and future neutrino radio detection experiments.

Collaboration(s)

ARA

Author: SEIKH, Mohammad Ful Hossain (University of Kansas)

Co-authors: Prof. BESSON, Dave (University of Kansas); GIRI, Pawan

Presenter: SEIKH, Mohammad Ful Hossain (University of Kansas)

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