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Cosmic Muon Tomography at the Wylfa Reactor Site Using an Anti-Neutrino Detector

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Abstract : At the Wylfa Magnox Power Plant between 2014–2016, the VIDARR prototype anti-neutrino detector was deployed. It is comprised of extruded plastic scintillating bars measuring 4 cm × 1 cm × 152 cm and utilised wavelength shifting fibres (WLS) and multi-pixel photon counters (MPPCs) to detect and quantify radiation. During deployment, it took cosmic muon data in accidental coincidence with the anti-neutrino measurements with the power plant site buildings obscuring the muon sky. Cosmic muons have a significantly higher probability of being attenuated and/or absorbed by denser objects, and so one-sided cosmic muon tomography was utilised to image the reactor site buildings. In order to achieve clear building outlines, a control data set was taken at the University of Liverpool from 2016 – 2018, which had minimal occlusion of the cosmic muon flux by dense objects. By taking the ratio of these two data sets and using GEANT4 simulations, it is possible to perform a one-sided cosmic muon tomography analysis. This analysis can be used to discern specific buildings, building heights, and features at the Wylfa reactor site, including the reactor core/reactor core shielding using ~ 3 hours worth of cosmic-ray detector live time. This result demonstrates the feasibility of using cosmic muon analysis to determine a segmented detector's location with respect to surrounding buildings, assisted by aerial photography or satellite imagery.

Keywords : anti-neutrino, GEANT4, muon, tomography, occlusion
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