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Low Power, Compact, Dual Mode Detectors for Nuclear Security Applications

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The detection of special nuclear material remains a matter of utmost importance due to potential security issues. Current neutron detection relies upon a combination of a 3He detector and a plastic scintillator. 3He is a rare material with decreasing global supply, so an alternative solution needs to be developed. This solution should be both low power and robust, in order to be deployed in field situations.

This is possible using dual mode scintillators, which can use pulse shape discrimination (PSD) methods to separate between neutron and gamma species present due to their different timing characteristics. The scintillator materials selected for investigation are, CLLBC, an inorganic scintillator made of Cerium, Lanthanum, Lithium and BromoChloride. As well as EJ-276, an organic plastic scintillator.

These materials are paired with Silicon Photomultipliers (SiPM's), which meet the requirements of being robust and having a low operating voltage, along with single photon sensitivity. Initial tests have taken place with these materials and photomultiplier tubes (PMT's), which were chosen to begin with due to a lower room temperature dark count than SiPM's.

Results taken using CLLBC have demonstrated a 5% gamma energy resolution and 17.6% intrinsic efficiency, both at 662keV. The investigation has now transitioned towards using SiPMs due to their robust and low power characteristics when compared to PMTs. Simulation work is ongoing with both GEANT4 and LTSpice simulations being developed to test designs and provide idealised results.

This work has further led to the design and construction of bespoke printed circuit boards (PCBs) with analog electronics to meet initial low power requirements. Work is currently underway to replicate accurate gamma and neutron species separation using PSD algorithms replicated in hardware, with the goal of creating a robust analog system that can perform as well as a digital PSD system at a fraction of the power requirements.

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