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

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Detection of nuclear materials remains a matter of utmost importance due to potential security issues. Current detection techniques for neutrons and gammas involve using a combination of a 3He proportional counter, which allows for detection of thermal neutrons, along with a plastic scintillator, which allows for detection of gammas. This in itself creates issues as 3He is a rare and expensive material, with dwindling global supply, and as such a detector which does not rely on 3He is favourable.

Not only should a new detector meet these requirements, but it should also be low power, robust, and relatively small, which would allow the detector to be deployed in many field settings, allowing for wide and varied use that would be necessary to evaluate any potential nuclear material.

This is possible using dual mode detectors, a material that would allow for both neutrons and gammas to be detected. To accomplish this, pulse shape discrimination (PSD) algorithms would be used to analyse recorded data and determine whether a neutron or gamma was detected.

The scintillator materials selected for investigation were, CLLBC, an inorganic scintillator made of Cerium, Lanthanum, Lithium and BromoChloride. As well as EJ-276, an organic plastic scintillator. These materials will be paired with Silicon Photomultipliers (SiPM's), which were chosen to 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 their greater stability when compared to SiPM's. Results taken using CLLBC have demonstrated a 5% energy resolution at 662KeV.

Once this preliminary stage has been completed, an SiPM will replace the PMT. Firstly, a GEANT4 simulation will be developed to yield idealised results, then PSD algorithms will be developed to effectively separate neutron and gamma spectra, with final testing then taking place to ascertain whether an analog or digital form will be best to meet the initial low power criteria.

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