An investigation of glass Cherenkov detectors in a pulsed neutron interrogation system

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Introduction

The identification of nitrogen by neutron activation has been utilized in both explosive detection and in-vivo metabolic analysis. The 10.8MeV gamma ray line emitted by thermal neutron capture provides a unique signature, however, due to its high energy its registration is non-trivial.

Conventional approaches have used large area dense inorganic scintillators. Sodium iodide (NaI:Tl) remains the scintillator of choice, but large crystals are inevitably expensive. More recent materials are even less cost-effective. Further, the decay time of NaI:Tl means that pulse pile-up in the large crystals can cause false positive registrations.

As is often the case in particle detection experiments, the problem is a signal-to-noise issue. It was decided to investigate the use of lead-glass Cherenkov detectors as an alternative. These can be relatively cheaply fabricated in large volumes. Their rapid response and energy threshold below which no signal is produced mean that pulse pile-up is much reduced. On the other hand, they have poor energy resolution at 10MeV and worse at lower energies. Despite this, it is thought that they should be capable of a threat/no-threat decision especially when the signal from a number of Cherenkov detectors is combined with that of a smaller conventional (NaI:Tl) scintillator.

Execution

Four detectors planned using available materials.

Lead glass blocks 80 x 80 x 400mm cut from larger blocks.

Blocks optically coupled to ET 9821B 3" photomultipliers with risetime 2ns.

External reflection provided with PTFE tape.

Detector housed in 3mm wall mild steel box-section tube, purchased cut-to-size.

Endcaps from off-the-shelf polythene mouldings drilled for signal and HV supply connectors.

Internal photomultiplier spring loaded mountings designed and produced by 3D printing.

Current status

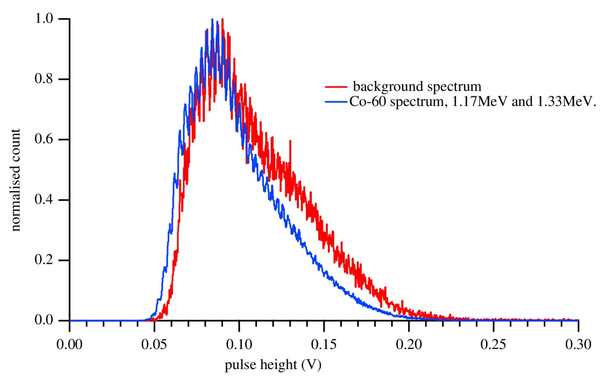
First prototype operational.

All materials procured and produced for the assembly of the remaining three detectors.

Initial spectra obtained with Co-60 gamma rays.

Remaining detectors being assembled.

Testing with higher energy gammas and in mixed neutron gamma fields proceeding.



Pulse height spectrum from Co-60 gamma rays at 1.17 and 1.33MeV is largely indistinguishable from background. As these gammas are only slightly above threshold, they are producing only single photoelectrons. Evidence for the detection of the gammas is that the rate of events increases dramatically.

Operational test with thermal neutrons on explosives surrogate samples in next few months.