EPSRC CDT IN INTELLIGENT SENSING AND MEASUREMENT

28th November 2017

Detection of thermal neutrons with MAPMTs and novel glass scintillator

Laura Boyd[1], School of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ.

[1]l.boyd.4@research.gla.ac.uk

Abstract

Thermal neutron detection has significantly changed across the globe post 9/11. The increasing cost of ^{3}He, the neutron detection industry standard, has stimulated a number of alternative detection methods including: microstructured semiconductor neutron detectors (MSNDs) and thin film detectors. This research focuses on a lithium doped glass scintillator coupled with a MAPMT. Initial characterisations of the MAPMT response were conducted at the Lund University Source Testing Facility this summer using a moderated AmBe source and lead shielding to produce uniform gamma-ray and neutron fields.

Background

The European Spallation Source* (ESS) is anticipated to be the leading neutron source for materials research world wide, thus prompting the development of thermal neutron detectors capable of with-standing high rates of radiation and neutron/gamma discrimination properties. One such detector is the Solid-State Neutron Detector (SoNDe). The SoNDe module will comprise of a pixelated multi-anode photomultiplier tube (MAPMT) coupled to a Saint-Gobain GS20 lithium-glass scintillator, read out by a portable DAQ (data acquisition) system.

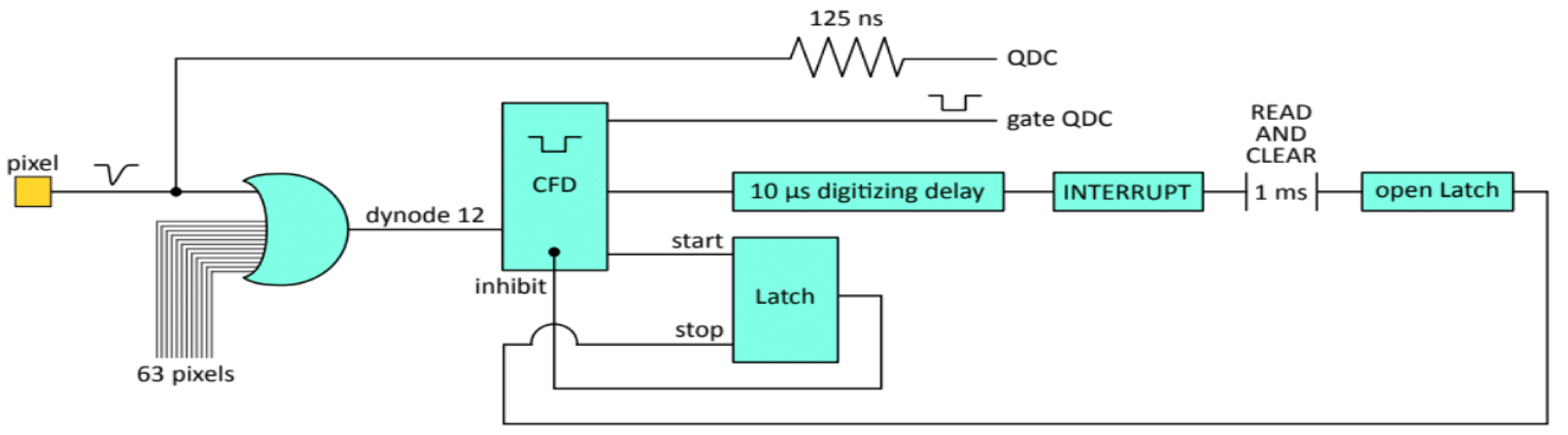

Fig.1 Diagram showing data-acquisition system. Analog signals from each pixel were passed to VME QDCs and OR'd onboard the H12700 MAPMT. The OR'd signal was then used to trigger the DAQ

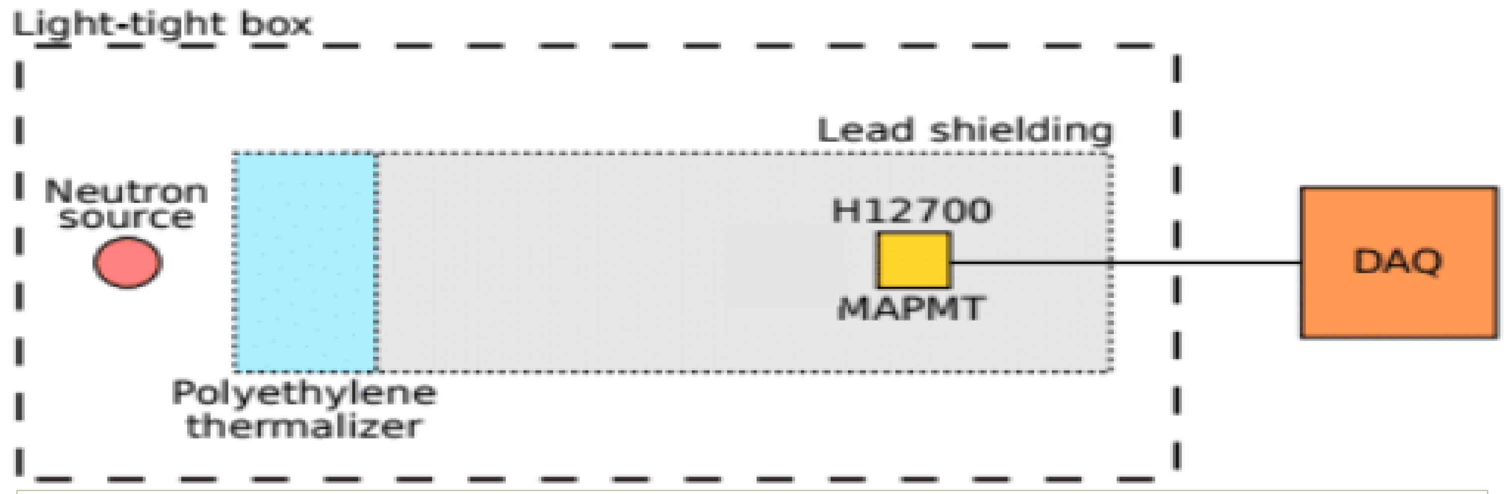

Fig.2 Schematic overview of light tight box. From the left: neutron source, layer of thermalising polyethylene, and lead castle containing the pixelated detector

Summer Project Aims:

To provide a fast, efficient, high-rate modular thermal neutron detection device with position resolution exceeding that of ^{3}He proportional counting tubes.

Objectives:

Characterise the response of an 8x8 pixelated MAPMT using a moderated AmBe source compared to a single anode PMT output (fig.6).

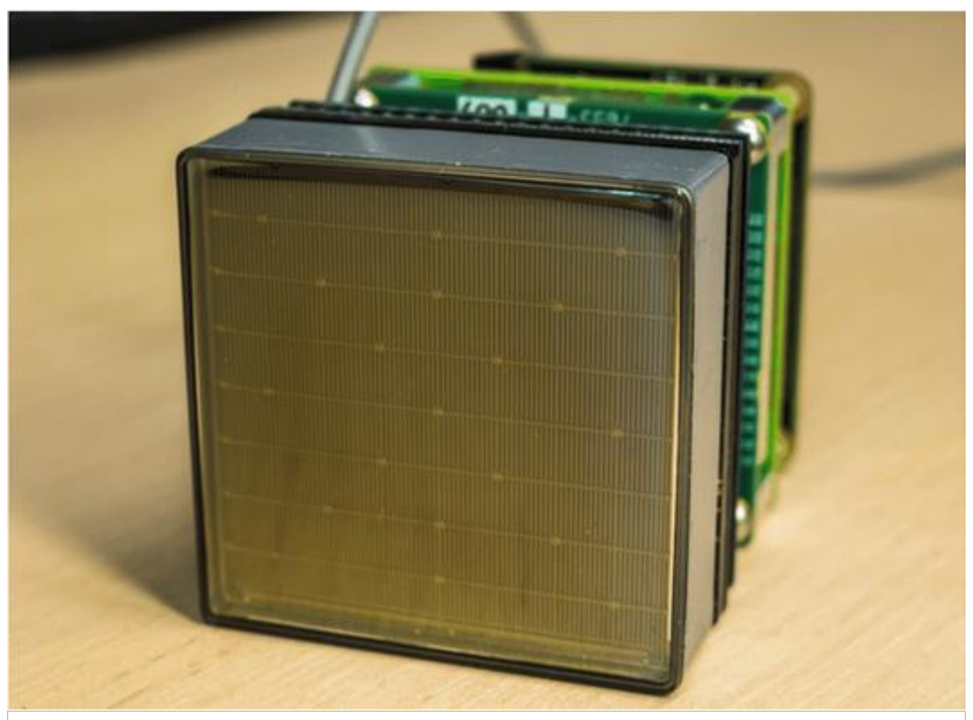

Fig.3 Hamamatsu H12700 MAPMT with GS20 lithium glass scintillator mounted using silicon rubber.

Findings:

The spread of scintillation light across the across the pixels of the MAPMT smeared the gamma/neutron signal, compared to the clean signal of the non-pixelated detector.

The optically transmitting silicone rubber unnecessarily complicated the scintillation light transmission as it introduced air pockets (fig.5).

The 'glow' effect of the scintillation light spreading across more than one pixel meant our triggering method (dynode 12) and QDC gating were not optimal.

Our trigger system did not provide any timing information, nor did it allow for patterns placed in front of the MAPMT (mirrorbor mask) to be distinguished in the output.

Future work:

This will include a comparison study of the SoNDe module DAQ to a standard VME based DAQ. Further investigations into the glow effect using a Geant4 simulation (fig.4) and possibly etching 8x8 square troughs into the GS20 scintillator glass to prevent this spreading of light. Re-running the experiment with a 'dry fit' between the GS20 and MAPMT, i.e. no silicone rubber. This should reduce Fresnel reflection at the borders and the differences in refractive indices caused by air pockets (fig.5).

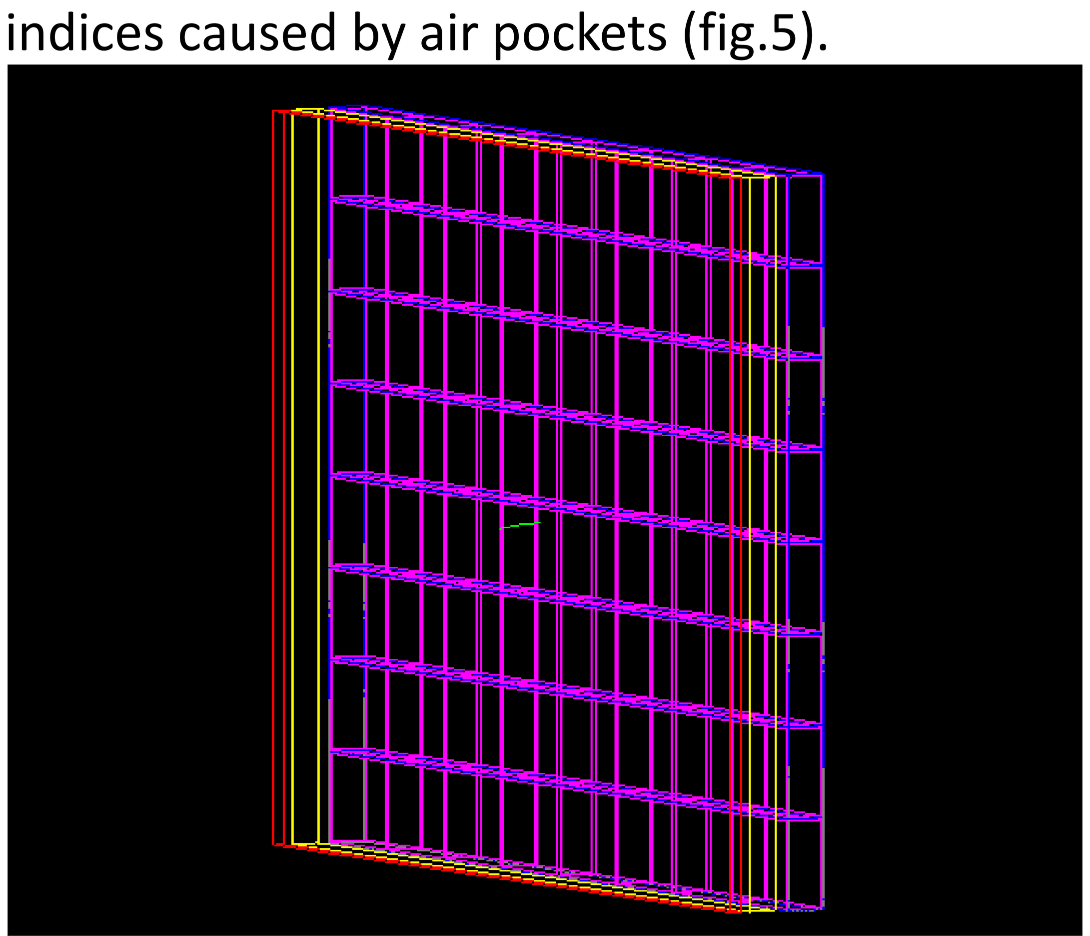

Fig. 4 Monte Carlo simulation performed using Geant4 software. The red structure indicates the GS20 ^{6}Li scintillator glass, the yellow structure represents the optical window of the MAPMT, and the purple structure represents the pixelated photocathode. The small green line represents an incident optical photon.

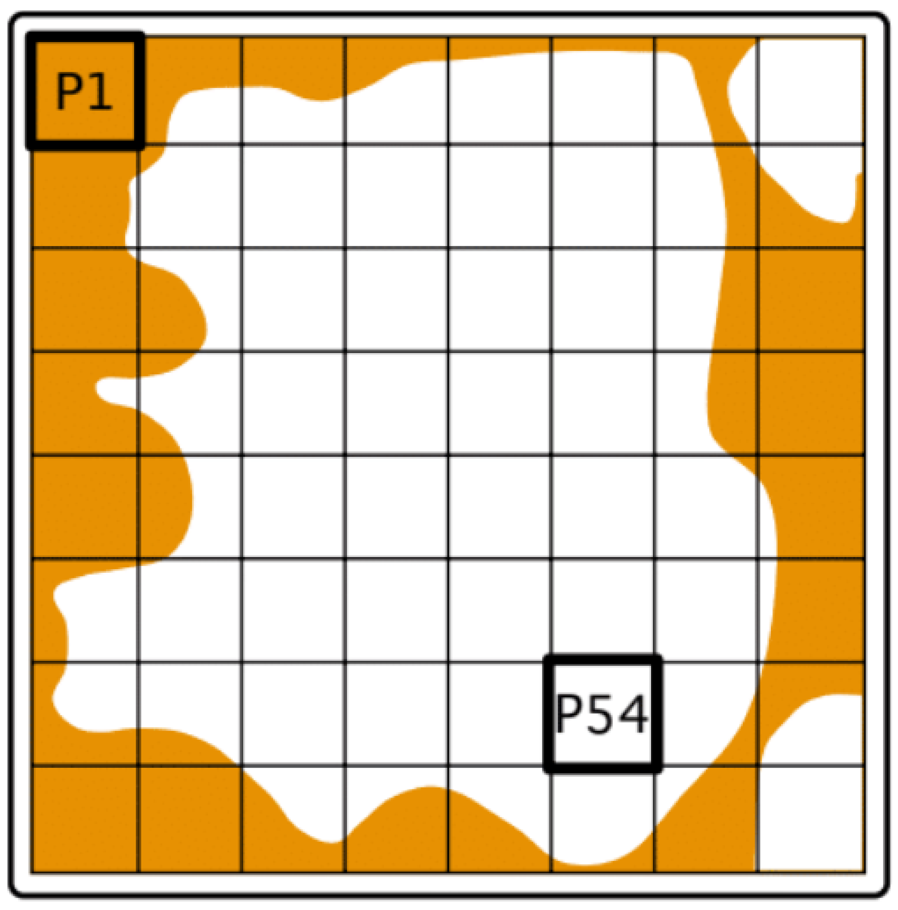

Fig.5 Map of air bubble (white) on face of MAPMT contrasted against the region of ideal optical contact (orange), caused by silicone elastomer.

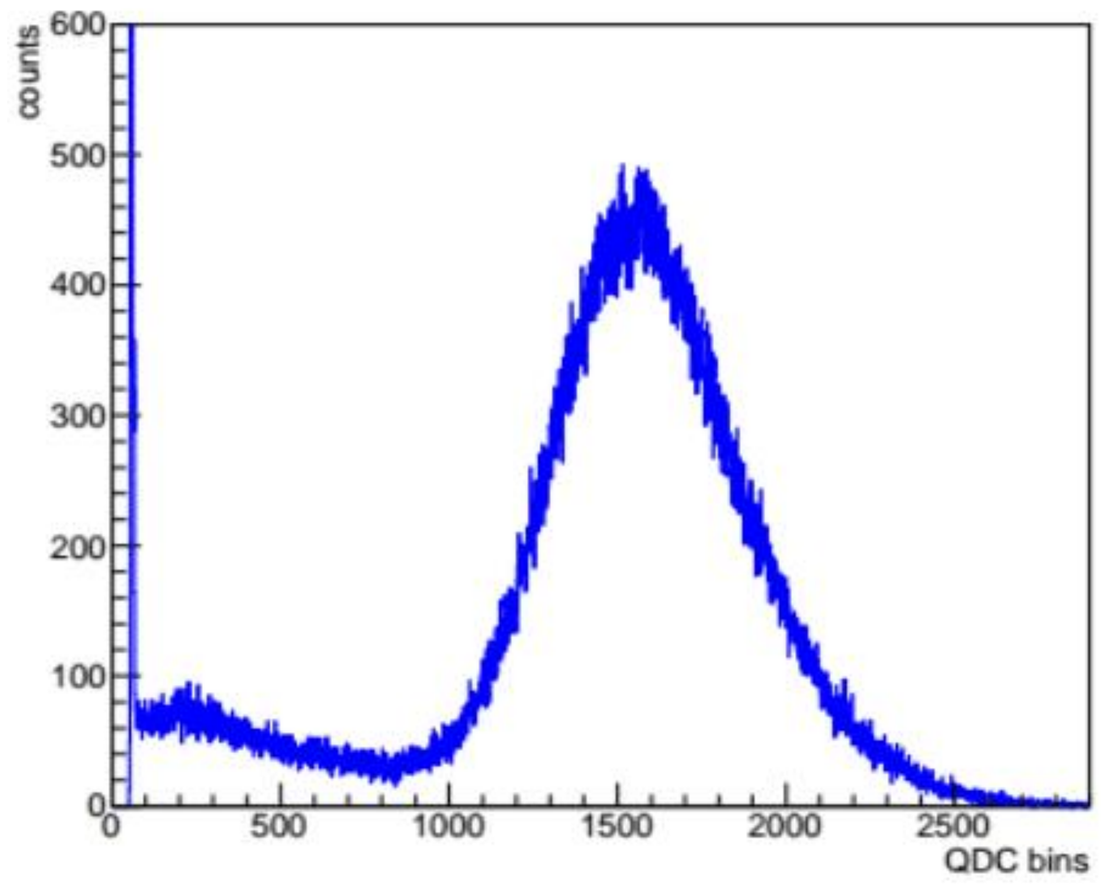

Fig.6 Response of the non-pixelated neutron detector to the uniform mixed gamma-ray and neutron fields presented by the Am/Be source. The sharp peak located at channel 50 corresponds to the QDC pedestal. The broad peak centred at channel 1550 corresponds to neutrons.

*ESS- https://europeanspallationsource.se/