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Prototype development of a scintillator array for neutron energy measurements

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The rapid neutron-capture process (r-process) is an explosive astrophysical process thought to be responsible for producing half of the elements in the universe that are heavier than iron [1]. However, theoretical calculations have yet to reproduce the observed solar abundances of nuclei. Measuring ⍰-delayed neutron emission probabilities and neutron-capture rates of neutron-rich nuclei can help to significantly constrain theoretical r-process models. Currently, the ⍰-delayed neutron emission of very few r-process nuclei have been characterized. TRIUMF, Canada's particle accelerator centre, can synthesize many isotopes involved in the r-process. Measuring the energies of emitted neutrons can provide complementary information on neutron-capture rates, as well as unveiling the nuclear structure of these exotic species.

The DESCANT (Deuterated Scintillator Array for Neutron Tagging) array coupled to the GRIFFIN (Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei) γ-ray spectrometer can simultaneously detect γ-rays and neutrons [2]. Although DESCANT has a very high neutron detection efficiency, the array was not designed to measure neutron energies to a high degree of precision. To account for this, an ancillary neutron detector array capable of performing high resolution neutron energy measurements has been proposed. The array will be composed of thin plastic scintillation detectors and will complement the functionality of the detectors currently in use. The time-of-flight (TOF) method will be used to determine neutron energies. Prototype construction has begun in which the optimal scintillator material, thickness and geometry are being explored. We are investigating the use of silicon photomultipliers (SiPM's) for light collection as an alternative to standard photomultiplier tubes. Tests are planned to characterize neutron back-scattering that may occur from the nearby DESCANT detectors. These results and current progress on detector development will be presented.

[1] M.R. Mumpower, et al. Prog. Part. Nucl. Phys. 86 (2016) 86 –126.
[2] V. Bildstein et al. Nucl. Instrum. Meth. A 729 (2013) 188 –197.

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