

Pulse Shape Discriminating Plastic Scintillators for Neutron Detection

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Background



Why PSD Plastics?

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The ³He Supply Problem



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Background

But why PSD Plastics?

PSD capable organic liquid scintillators are not suitable for field deployment. They present a chemical, toxilogical, electrical, and flame hazard.

The alternative – a PSD plastic

- chemically stable, rugged, machineable, can be moulded to arbitrary configuration
- 56% anthracene light output
- 8600 photons/MeV
- $\rho = 1.08 \text{ g/cm}^3$







Pulse Shape Discrimination

How to Quantify a Pulse Shape?

The decay of a scintillation pulse can be described as a function of two exponentials. For most scintillators these exponentials are very similar.

Some organic scintillators exhibit the PSD phenomena where the differences in the exponentials can be exploited.

Numerous PSD algorithms

- Charge Integration
- Zero-Crossing
- Pulse Gradient Analysis
- Frequency Gradient Analysis



Charge Comparison Method





$$Q_{short} = \int_{t_0}^{t_{short}} y(t) dt \qquad \qquad Q_{long} = \int_{t_0}^{t_{long}} y(t) dt$$

 $F.o.M. = \frac{Sep.}{\sum FWHM_i}$



V1730C with C-series



Gate Optimisation





Neutron Physics in Neutrino Astronomy

Asynchronous Charge Comparison Optimisation – Close Up



Gate Start



Figure of Merit

Neutron Physics in Neutrino Astronomy

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Detector Construction

Nuclear Security – Handheld/Portal Monitors

- J- and C-series SiPM (single 6 mm and 2x2 array)
- EJ series, CLYC, UPS 113NG
- Painted with EJ-510 TiO reflective paint for increased light yield or PTFE tape wrapping
- Optically coupled with standard vacuum grease





AmBe source measurements





- 18 MBq ²⁴¹AmBe source
- Fast neutrons selected through insertion of airtube
- <1 cm water shielding between source and detector
- 5 cm lead shielding to reduce gamma signal

Ongoing – retrofitted DP2 monitor. PMT replaced with SiPM, next step neutron sensitive plastic scintillator...







Radiation Hardness



Samples of EJ200 and EJ299 were placed in the research reactor of North Carolina State University to study radiation hardness.

Sample	Flux (n _f /cm²/s)	Fluence (n _f /cm²)	Error (%)
#1 (3 min)	1.51 x 10 ¹²	1.81 x 10 ¹⁴	7.9
#2 (17 min)	2.24 x 10 ¹²	2.29 x 10 ¹⁵	5.4
#3 (3 hours)	2.16 x 10 ¹²	2.34 x 10 ¹⁶	5.6
#4 (28 hours)	1.69 x 10 ¹²	1.71 x 10 ¹⁷	5.2







Results





M.P. Taggart and P.J. Sellin, Nucl. Instr. Meth. A, 908 (2018) 148-154

Lithium loading



Itchy single J-series EJ270-PbAir





Thanks for listening! Any Questions?

Collaborators

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