Plastic scintillator
Used for Neutron-gamma discrimination

Neutron/gamma discrimination detector by PSD technique

DRS-4 board, PSI (Fast-ADC/FPGA-based)
- 0.7 GSPS – 5 GSPS
- 4 input channels
- USB 2.0 interface for data readout.

Pulse Shape Discrimination (PSD) technique

\[ Q_{\text{ratio}} = \frac{\text{Tail charge}, Q_{\text{tail}}}{\text{Total charge}, Q_{\text{total}}} \]

Mechanism of fast neutron interaction with H, C.

Cf-252 source

Conventional method

Figure of Merit (FOM)

Confidence level of neutron/gamma discrimination (unit, \( \sigma \))

Conventional method

New method
A new method of PSD technique on charge integration ratio to improve neutron/gamma discrimination in low-energy region for EJ-299-33 plastic scintillation detector

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Introduction

Charge integration ratio $Q_{int}$ method in Pulse Shape Discrimination (PSD) technique has been widely used to discriminate between fast neutrons and gammas in organic scintillation detectors.

Problem: In low-energy regime of less than hundred keV, $Q_{int}$ of scintillation detectors has highly energy dependence. This leads to Figure of Merit (FOM) is usually characterizing for neutron/gamma separation, which is low.

Solution: We introduce a new method of PSD technique on charge integration ratio to improve the FOM particularly in the low-energy regime threshold. The technique of this new method is to monitor $Q_{int}$ of neutron signals on the are constant, or independently, neutron energy. By applying the new PSD technique on C252 gamma ray, we conclude that the FOM is increased.

Experimental details

- EJ-299-33 plastic scintillation detector is placed in front of a C252 source which is fast neutron source. It is excited by fast neutron with energies from 200 keV to 1 MeV.

- Charge of the PSD is measured with a DRA3420 from the ADP44 (ion chamber) for particle discrimination.

- Voltage calibration is carried out before measurement.

- Energy calibration

Charge integration ratio method, $Q_{int}$

- To discriminate neutron and gamma is defined as:

$$Q_{int} = \frac{Q_{fast} - Q_{0}}{Q_{0}}$$

where $Q_{fast}$ is fast charge on ion chamber, $Q_{0}$ is the charge on the ion chamber of the plate, respectively.

Figure of merit (FOM)

Quantities for neutron/gamma discrimination $N_{X}$ is a number of discriminator by the figure of merit (FOM), $FOM$ is defined in the following:

$$FOM = \frac{N_{X}}{N_{X} + N_{G}}$$

where $N_{X}$ is number of neutron events, $N_{G}$ is number of gamma events.

Conventional method of $Q_{int}$

- $Q_{int}$ is calculated for neutron and gamma.

New method of $Q_{int}$

- $Q_{int}$ is calculated for neutron and gamma.

Results and discussion: Neutron/gamma discrimination

- FOM of the new method (red point) describes better performance in comparison with conventional method (blue point).

- At low energy threshold of 100 keV, with the new method, FOM reaches 1.

Conclusions

- FOM of the new introduced method of PSD technique on charge integration ratio for the EJ-299-33 plastic scintillation detector is enhanced significantly in comparison with FOM of the conventional method.

- In the new method, peaks of $Q_{int}$ distribution for neutron signals have energy independence. It promises to be a good performance for the neutron detector development by using digitizer technology.

References


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