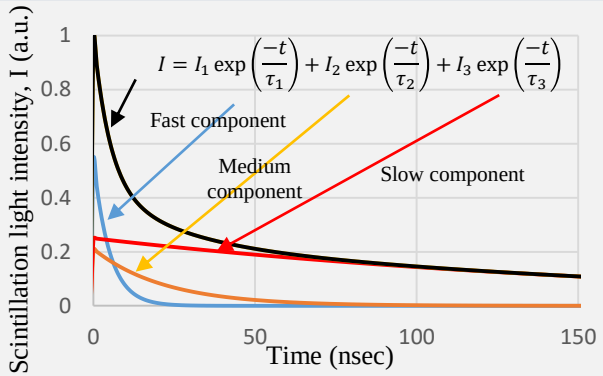
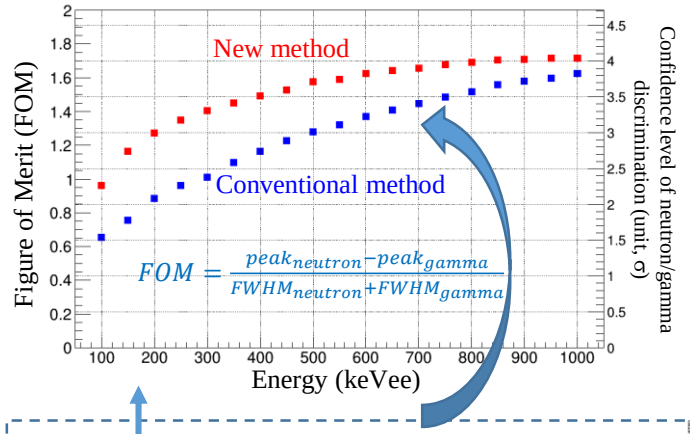
Plastic scintillator

Used for Neutron-gamma discrimination

require



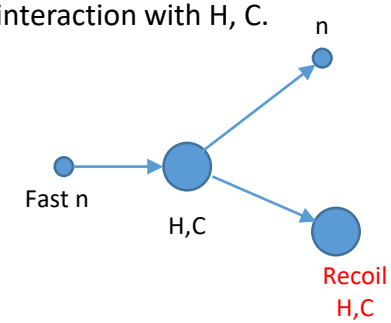
Neutron/gamma discrimination detector by PSD technique

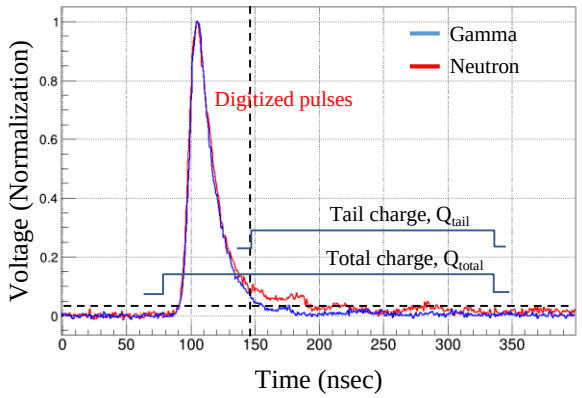


DRS-4 board, PSI (Fast-ADC/FPGA-based)

- 0.7GSPS – 5GSPS
- 4 input channels
- USB 2.0 interface for data readout.

Mechanism of fast neutron interaction with H, C.

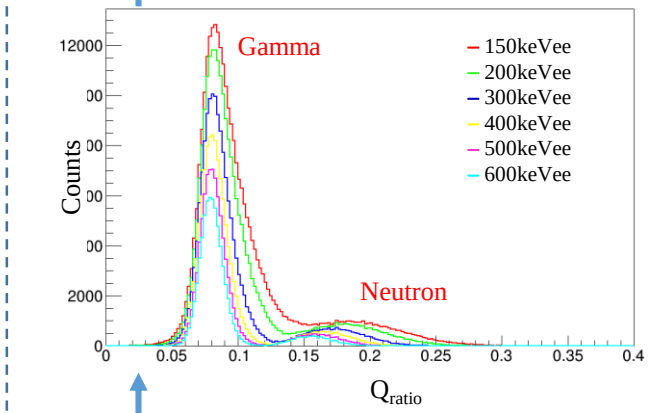


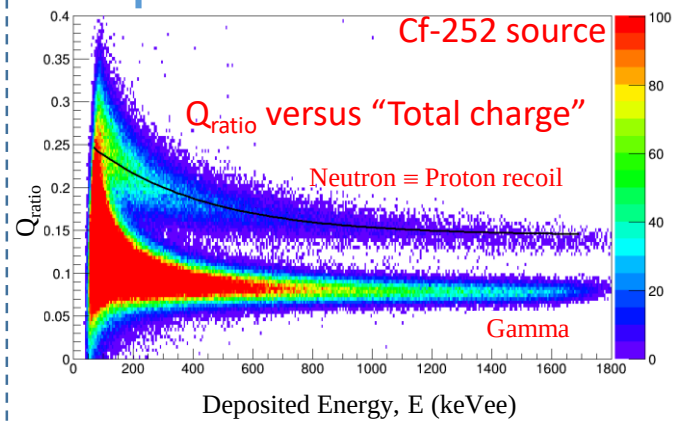


Pulse Shape Discrimination (PSD) technique

(Charge integration ratio method, Q_{ratio})

$$Q_{ratio} = \frac{Tail\ charge, Q_{tail}}{Total\ charge, Q_{total}}$$





Conventional 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

717

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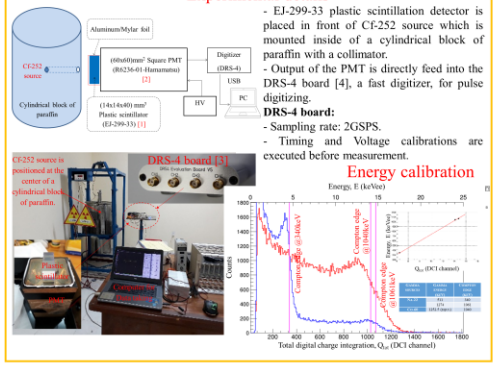
Introduction

Charge integration ratio (Q_{ratio}), method in Pulse Shape Discrimination (PSD) technique has been widely used to discriminate between fast neutron and gamma in organic scintillation detectors.
***Problem**: In low-energy region of less than hundred keVee, Q_{ratio} of scintillation detectors has highly energy dependence. This leads to Figure of Merit (FOM), a quantity characterizing for neutron/gamma separation, worse.*
In this work, we introduce a new method of PSD technique on the charge integration ratio to improve the FOM quantity in the low-energy region threshold. The technique of this new method is to normalize Q_{ratio} of neutron signals to be as a constant, or independently, versus energy.
We study for an EJ-299-33A plastic scintillator of (14x40x14)mm³, a commercial product of ELJEN technology.
- Conduct an experiment on Cf-252 radioisotope source.
- A comparison of conventional method and new method of charge integration ratio in energy thresholds from 100keVee to 1000keVee.

Experimental details



- EJ-299-33 plastic scintillation detector is placed in front of Cf-252 source which is mounted inside of a cylindrical block of paraffin with a collimator.
- Output of the PMT is directly feed into the DRS-4 board [4], a fast digitizer, for pulse digitizing.

DRS-4 board:
- Sampling rate: 2GSPS.
- Timing and Voltage calibrations are executed before measurement.

Charge integration ratio method, Q_{ratio}

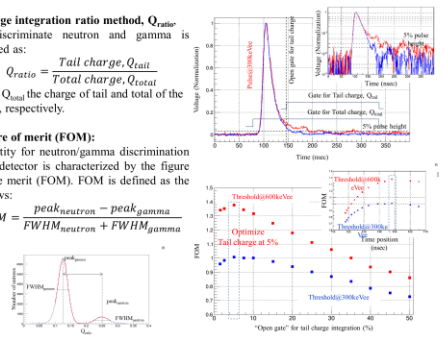
Charge integration ratio method, Q_{ratio}: to discriminate neutron and gamma is defined as:

$$Q_{ratio} = \frac{Tail\ charge, Q_{tail}}{Total\ charge, Q_{total}}$$

Q_{tail}, Q_{total} the charge of tail and total of the pulse, respectively.

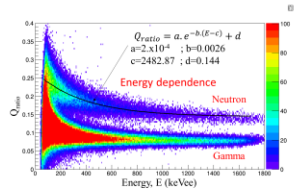
Figure of merit (FOM):
Quantity for neutron/gamma discrimination of a detector is characterized by the figure of the merit (FOM). FOM is defined as the follows:

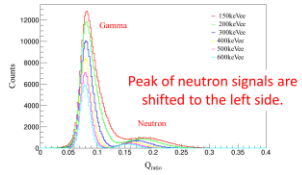
$$FOM = \frac{peak_{neutron} - peak_{gamma}}{FWHM_{neutron} + FWHM_{gamma}}$$



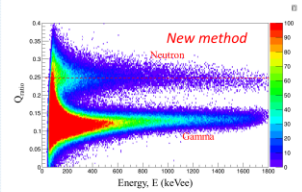
Results and discussion: Neutron/gamma discrimination

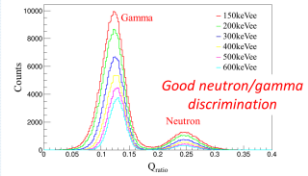
Conventional method of Q_{ratio}



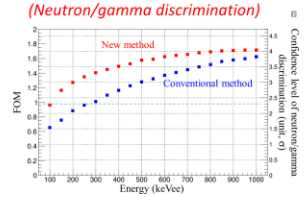


New method of Q_{ratio}





FOM (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 100keV, with the new method, FOM reaches to 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_{ratio} distribution for neutron signals has energy independence. It promises to be a good performance for the neutron detector development by using digitizer technology.

References

[1] EJ-299-33 Specification, ELJEN Technology. [Online]. Available: https://eljentechnology.com/
[2] Photo-Multiplier Tube R6236-01 Specifications, Hamamatsu Corp. [Online]. Available: http://jp.hamamatsu.com
[3] DRS-4 board, Paul Scherrer Institute. [Online]: https://www.psi.ch/drs/evaluation-board

Acknowledge

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