# 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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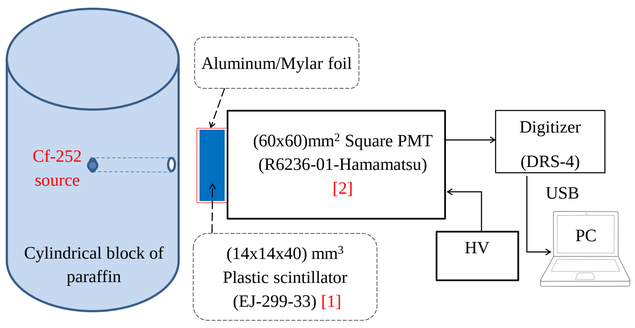
## Introduction

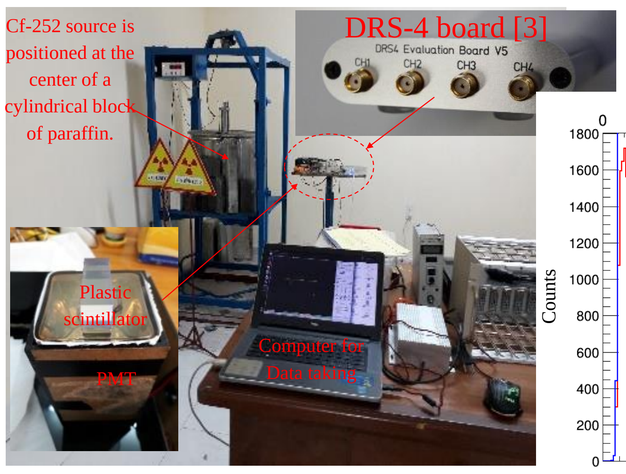
*Charge integration ratio ($Q_{ratio}$), method in Pulse Shape Discrimination (PSD) technique has been widely used to discriminate between fast neutron and gamma in organic scintillation detectors.*
***Problem**: In low-energy region of less than hundred keVee, $Q_{ratio}$ of scintillation detectors 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)mm$^3$, 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

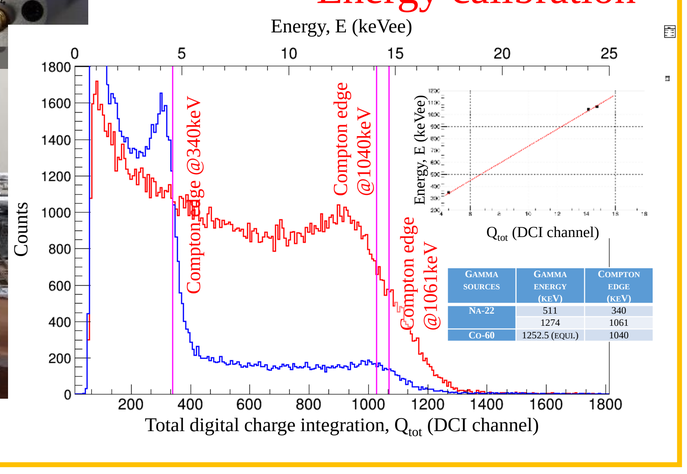



- EJ-299-33 plastic scintillation detector is placed in front of Cf-252 source which is mounted inside of a cylindrical block of paraffin with a collimator.
- Output of the PMT is directly feed into the DRS-4 board [4], a fast digitizer, for pulse digitizing.

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




## Energy calibration




| Gamma sources | Gamma energy (keV) | Compton edge (keV) |
|---|---|---|
| Na-22 | 511 | 340 |
| | 1274 | 1061 |
| Co-60 | 1252.5 (EQUL) | 1040 |

## Charge integration ratio method, $Q_{ratio}$

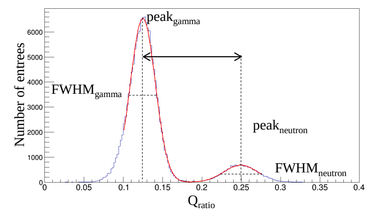
**Charge integration ratio method, $Q_{ratio}$,** to discriminate neutron and gamma is defined as:

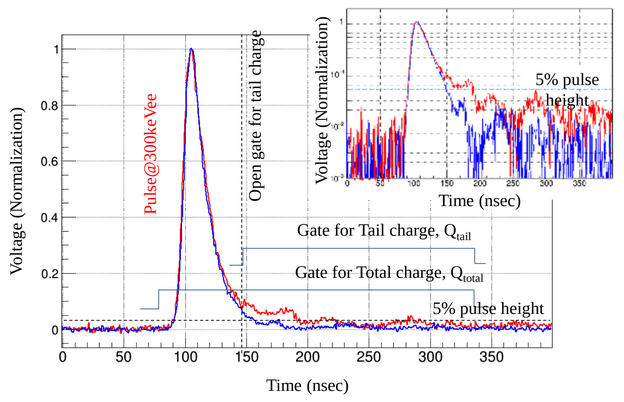
$$Q_{ratio} = \frac{Tail\ charge, Q_{tail}}{Total\ charge, Q_{total}}$$

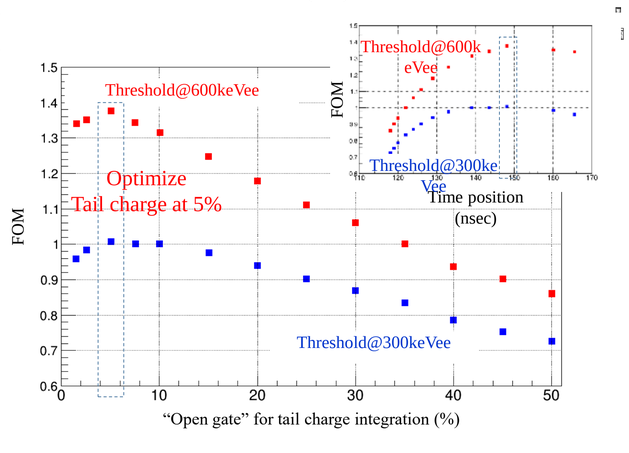
$Q_{tail}$, $Q_{total}$ the charge of tail and total of the pulse, respectively.

**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:

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

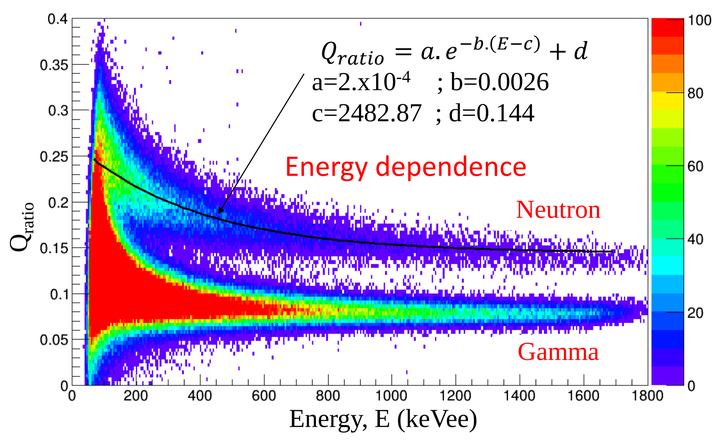


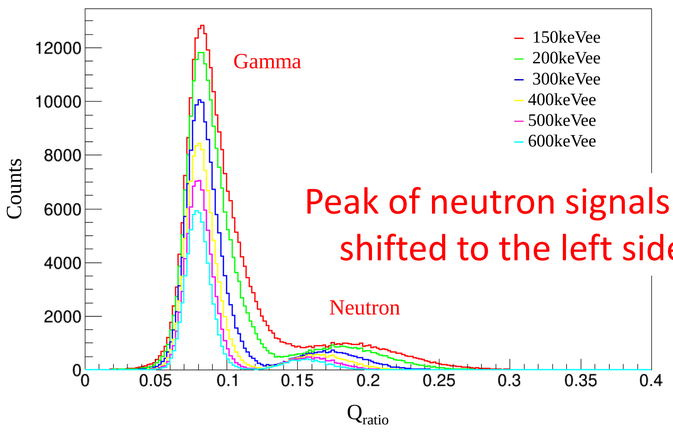



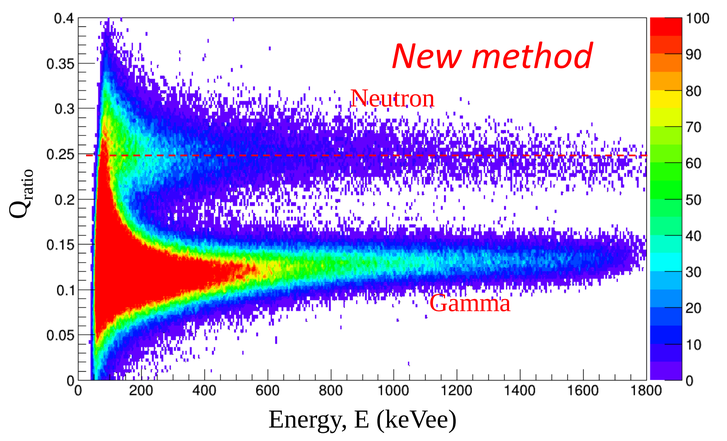

## *Results and discussion: Neutron/gamma discrimination*

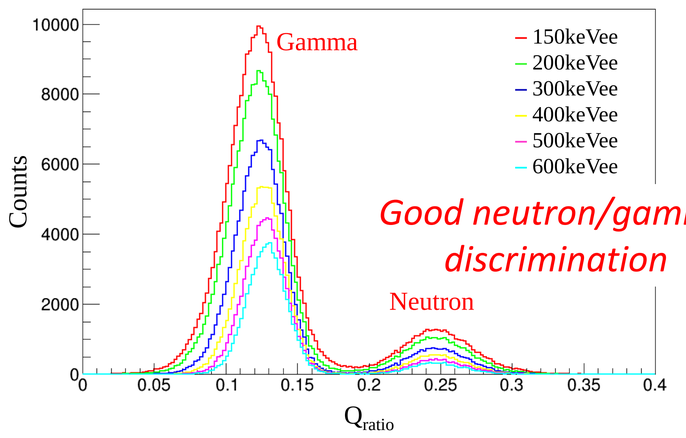
### *Conventional method of $Q_{ratio}$*



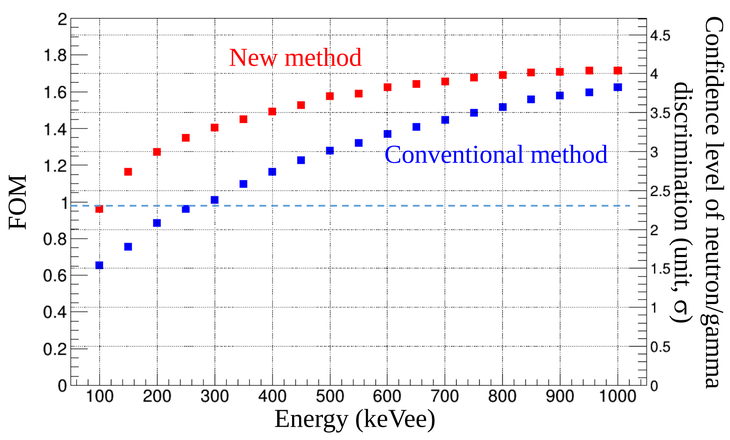




### *New method of $Q_{ratio}$*




### *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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