A preliminary study on the characteristics of neutron and gamma ray pulse shape discrimination using EJ276G plastic scintillator

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Ⅰ. Introduction

- Organic crystal, liquid and plastic scintillators are used to detect fast neutrons
- Gamma rays are also sensitive to these detectors while measuring fast neutrons
- Pulse Shape Discrimination (PSD) is able to separate between neutrons and gamma rays
- In high flux conditions, it is difficult to perform PSD due to pile up effect
- To perform PSD like this conditions, PSD performance optimization was performed by changing the scintillator thickness

Ⅱ. Materials and Methods

□ EJ276G plastic scintillator

- In general, organic crystal (Anthracene, Stilbene) and liquid (BC 501) scintillators are known for good level of PSD performance
- However, plastic scintillators are non-toxic unlike older liquid scintillators, and strong mechanical strength and price advantage unlike Stilbene crystal
- For these reasons, EJ276G plastic scintillator was used to perform PSD

□ Pulse Shape Discrimination

- PSD is a method of using the difference in mechanism for different types of radiation
- The attenuation of light in the scintillator is different depending on the radiation
- In organic scintillators, secondary radiation is protons and electrons by neutrons and gamma rays, respectively, which cause different shape of attenuated light due to their different linear energy transfer (LET)
- To perform PSD, charge comparison method (or called charge integration method) comparing the total charge (Q_{body}) and the delayed charge (Q_{tail}) at the peak was used

□ Optimization methods

- Optimization methods for PSD include control of pulse width, delay time, threshold energy and plastic scintillator geometry
- In this study, optimization was performed in terms of count per second (CPS) and PSD performance

Ⅲ. Experiments and Results

□ Experiment conditions

- A 7.8 μCi ^{252}Cf source and scintillator thickness variations such as 1 × 1 × 1 cm, 1 × 1 × 3 cm, 1 × 1 × 5 cm, 1 × 1 × 10 cm
- A silicon photomultiplier (Hamamatsu S-13360-6025CS) was used
- Total pulse width of 800 ns and delay time of 75 ns at the pulse peak
- To perform PSD, DC power supply and NGT 400 including PSD logic were used

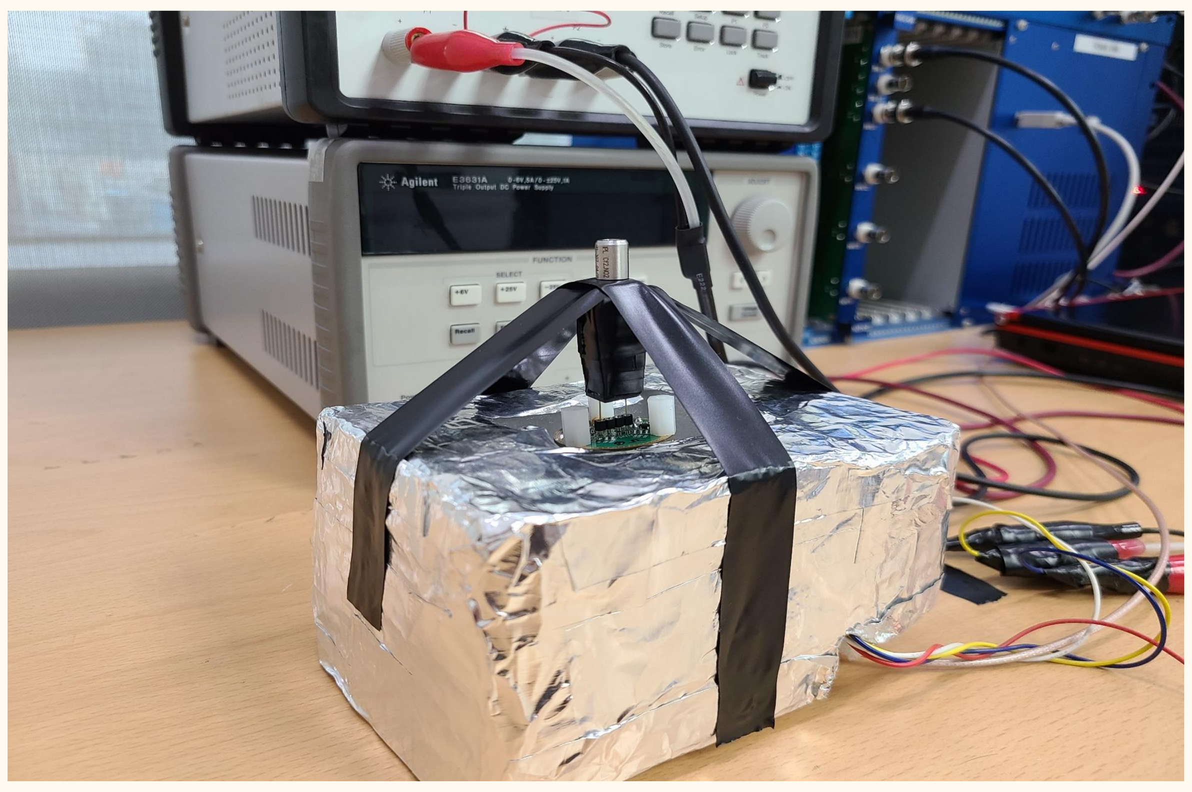

Fig. 1. Experiment setup of a ^{252}Cf source, EJ276G scintillator and SiPM

□ Results

- In terms of CPS, the highest result was 648.5 cps when the thickness of plastic scintillator is 3 cm
- In terms of PSD performance, the highest result of FoM (Figure of Merit) was 1.125 when the thickness of plastic scintillator is 1 cm
- FoM was evaluated by setting a threshold value of 1 MeVee
- Considering CPS and FoM, the plastic scinitillator 1 × 1 × 3 cm geometry showed the best results

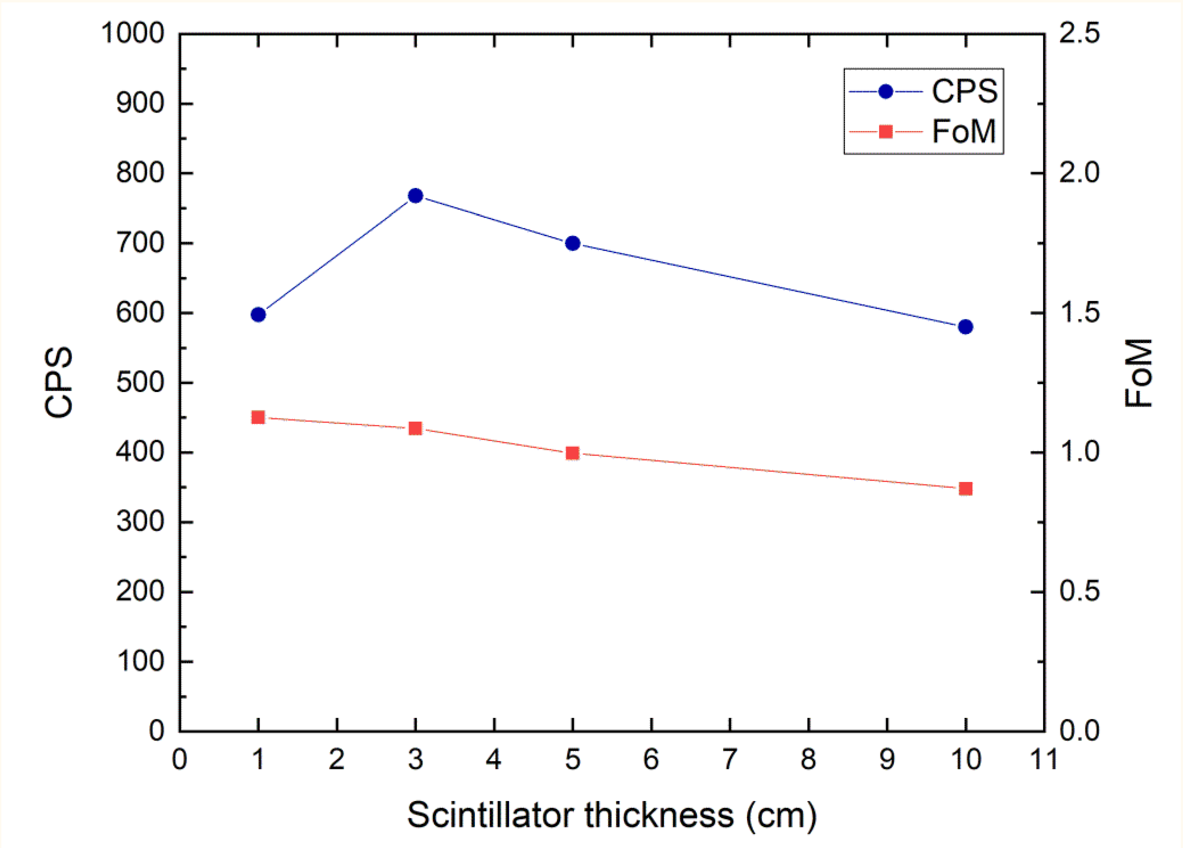

Fig. 2. Result of Count per Second (CPS) and Figure of Merit (FoM) according to the scintillator thickness using a ^{252}Cf source

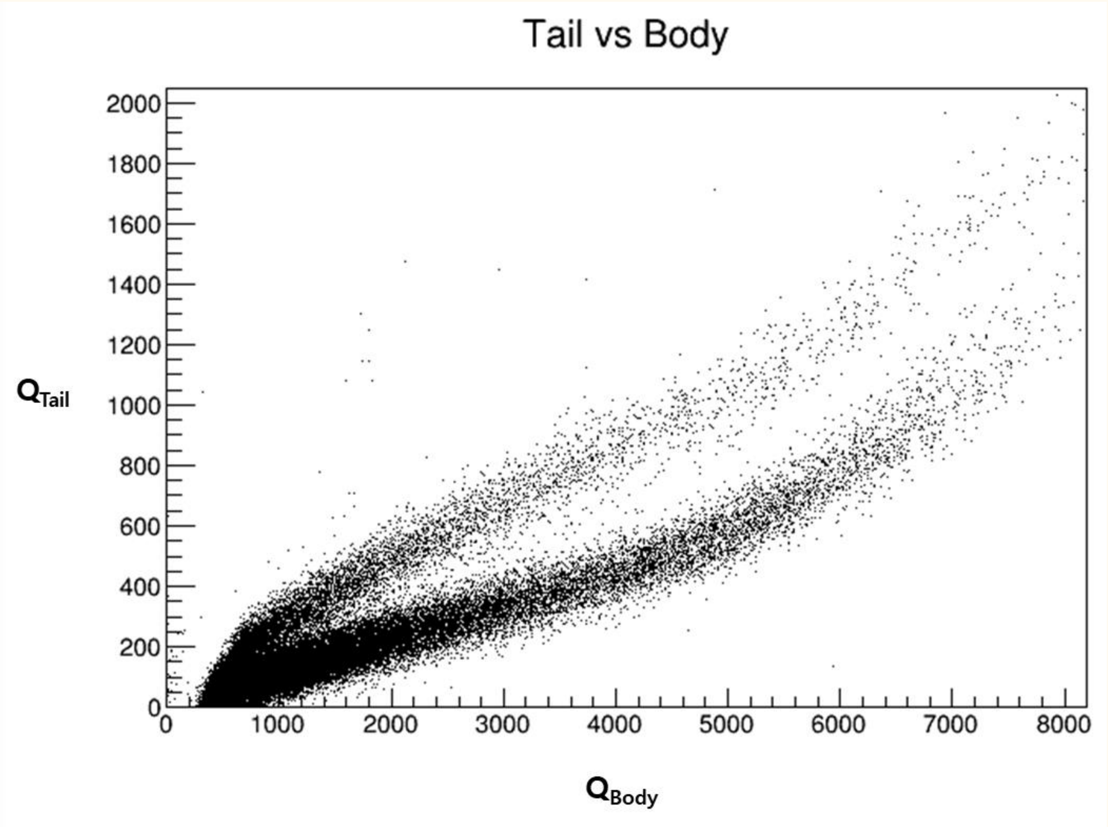

Fig. 3. Pulse shape discrimination result in 1 × 1 × 3 cm geometry x_{axis} : total charge, y_{axis} : delayed charge at the peak

□ Discussions

- It is common for detection efficiency to increase as the thickness of the scintillator increases, but in our experiments, the best result was obtained when the thickness was 3 cm
- To accurately assess the incoming light emitted by radiation into the sensor, Geant 4 Simulation will be conducted

Ⅳ. Conclusion

- This study is a preliminary optimization for distinguishing fast neutrons from gamma rays generated by D-T generator and 15 MeV electron accelerator such as high flux conditions
- At the laboratory level, the best result was obtained with the EJ276G plastic scintillator thickness of 3 cm using a ^{252}Cf source
- In further study, we will conduct experiments in 15 MeV electron acceleration whether our system can distinguish between fast neutrons and gamma rays under the high flux conditions

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