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Optimization of fast neutron and gamma ray pulse shape discrimination (PSD) at high neutron to gamma ray ratio

Organic crystalline, liquid and plastic scintillators with low Z number materials are commonly used to detect fast neutrons. These detectors are also sensitive to gamma rays by Compton scattering while measuring fast neutrons. Pulse shape discrimination (PSD) is used to distinguish between neutrons and gamma rays. To perform PSD, Charge Comparison method (or called Charge Integration method) comparing the total charge (Qbody) and the delayed charge (Qtail) at peak was used in this study. Most studies have been conducted under laboratory conditions such as 252Cf or 241Am-Be sources. In our case, we will perform PSD in 15 MeV electron accelerator, where the total flux is 6.72E+14 #/sec and the ratio of neutron to gamma ray is up to 1:4071. Since PSD is difficult to perform due to the pile up effect under these conditions, PSD was optimized by changing the size of the silicon photomultiplier (SiPM) pixel pitch and thickness of the plastic scintillator before measuring high flux conditions. Optimization was performed in terms of count per second (CPS) and PSD performance. Although CPS is not related to PSD performance and PSD performance is evaluated as a figure of merit (FoM) index, it is important to conduct PSD within a limited time because our PSD system will be applied to the industry field. To distinguish neutrons from gamma rays under these conditions, it is necessary to use lead shielding to reduce neutron to gamma ray ratio. We are performing Monte Carlo N-Particle Transport Code (MCNP6) simulation to find optimized shielding thickness. In general, lead is known as a gamma ray shielding material. Fast neutrons also interact with lead due to its high density, but lead has a high Z number, which results in less neutron energy loss and changes direction by scattering. This may cause noise signals to other pixels. To verify the effect of noise, reconstruction will be performed to obtain neutron images under lead shielding conditions.

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