Contribution ID: **80** Type: **Poster**

Development of Automatic Classification Algorithm of Fast Neutron from Gamma-ray in Pulse Shape Discrimination for Organic Plastic Scintillators

Monday 1 July 2024 18:17 (1 minute)

Fast neutron radiography is a promising non-destructive testing method that can be utilized in various industries. It provides different information compared to conventional radiography based on X-ray, gamma-ray, and thermal neutron, due to differences in attenuation with materials. There are two main methods for measuring fast neutrons: a thermal neutron capture detection system and a recoil proton-based neutron scattering detection system, with the latter being particularly suitable for fast neutron radiography. Among various recoil proton-based neutron scattering detectors, organic plastic scintillators are highly valued for their long-term stability, excellent hardness, and availability in various sizes. However, despite these advantages, organic plastic scintillator has poor pulse shape discrimination (PSD) performance which cannot differentiate fast neutron from background gamma-ray for the whole energy range in PSD. Given the vast amount of data generated in fast neutron radiography, automatic classification system is needed for efficiently processing large datasets, enabling accurate and quick identification of fast neutrons. In this study, we developed an automatic classification algorithm using machine learning that automatically classifies fast neutrons from gamma-ray for whole energy range in PSD result. The proposed automatic classification algorithm consists of two steps. First, data in the high energy region are clustered by Gaussian Mixture model, which is an unsupervised machine learning algorithm. Then, data in the low energy region is classified based on the clustered results by Gaussian Naïve Bayes model which is a supervised machine learning algorithm. Evaluation was conducted by applying the automatic classification algorithm to the neutron and gamma-ray signals obtained by the time of flight (TOF) measurement. The AUC of the ROC curve was 0.9390, which showed excellent classification performance.

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Session Classification: Poster Session