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Gamma ray spectroscopy for event out of phase of pulsed neutron source for short lived fission products/パルス中性子源に同期しないγ線のスペクトル測定による短寿命 FP 放射能評価

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Delayed gamma ray assay (DGA) is a promising technique for estimating fission rate ratio of uranium (U) and plutonium isotopes contained in spent nuclear fuel [1]. The accuracy of DGA relies on that of the data of fission product yield and decay (FPY & FPD). To enhance the accuracy of the FPY & FPD data, differential measurements have been conducted in the LINAC neutron source facility in KURNS. In the facility, pulsed electron beam with time width of 5 μs is periodically injected onto a tantalum target with frequency of 30 Hz. In the target, neutrons are radiated by the photo-nuclear reactions. The neutrons are moderated in a water jacket surrounding the target.

An U –aluminum sample placed 11.4 m form the target was irradiated by the moderated neutrons and γ rays generated by fission and capture reactions were measured with the HPGe detector together with time of flight (TOF) data conventionally to determine incident neutron energy. In the period of 33 ms, there is an out of phase (OOP) time region where the thermal neutrons decay away. γ rays radiated in the OOP region are not prompt ones but those from radio-isotopes with half lives. Then we decided to study the out of phase event spectroscopy (OOPS) to estimate the radio-activities of FPs. The advanced points of OOPS are 1) major discrete energy γ rays for DGA are measurable, 2) decay γ rays can be distinguished from the prompt ones with the TOF data, 3) FPs with half lives shorter than a second are measurable, and 4) the sample and the γ ray detector have never been displaced. In the OOP region, discrete energy γ rays from 1 MeV to 5.5 MeV were detected.

Radio-activities of FPs and emission rates of γ rays were calculated based on the JENDL/FPY& FPD-2011 data base [2] by solving the Bateman equation. By comparing the calculated and the measured γ ray spectra, FP nuclides with half-lives from 0.5 s to 2.6 h were identified, such as ^{95,96,97,98}Y, ^{89,90,90m,91}Rb, ^{86}Br, ^{95}Sr, etc. Estimation scheme of the detection efficiency and the estimation of radio-activity considering the time spectrum of thermal - neutron induced fission are now under development. However, even currently, OOPS is very promising to give data for validation of FPY & FPD data.

References

[1] D. C. Rodriguez, T. Bagucarska, M. Koizumi, et al., NIM-A 997, 165146, 2021.

[2] J. Katakura, JAEA-Data/Code 2011-025, 2012.

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