Numerical Analysis of Photonuclear Reaction Detection using High Energy Gamma-ray from $^{7}Li(p,\gamma)^{8}Be$ reaction Triggered by Pelletron Accelerator

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A potential of photonuclear reactions to be utilized in non-destructive assay methods for nuclear security and safeguards has been realized. A numerical study on activated photonuclear reactions by γ-rays emitted from the $^{7}Li(p,\gamma)^{8}Be$ reaction, including influences from geometrical condition and detectability analysis was performed.

Keywords: Non-Destructive Assay, Nuclear Security, Photonuclear reaction, Detectability, Pelletron Accelerator

1. Introduction High energy γ-rays from the $^{7}Li(p,\gamma)^{8}Be$ reaction can be considered an effective photon source for active interrogation of nuclear materials. An experimental demonstration on photonuclear reaction induced by γ-rays from the $^{7}Li(p,\gamma)^{8}Be$ reaction utilizing a proton beam from the Pelletron accelerator of Tokyo Tech is planned. This study aims to perform a numerical study on the current active method utilizing the $^{7}Li(p,\gamma)^{8}Be$ reaction. The study includes impacts from geometrical condition, and detectability analysis.

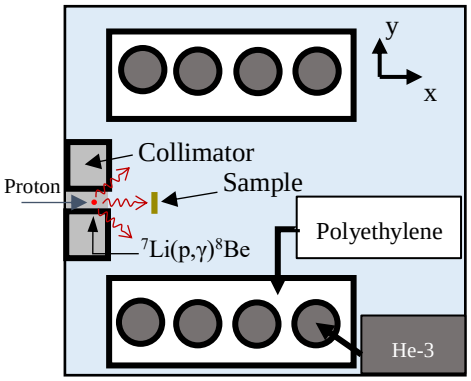

Figure 1 Simulated neutron measurement apparatus

2. Methodology Numerical analyses were carried out with the Monte Carlo simulation code MCNP. The previous experimental data of the energy distribution and yields of γ-rays from the $^{7}Li(p,\gamma)^{8}Be$ reaction [1] were used to isotropically generate photons in the calculation. Photonuclear reactions occurring in the samples were calculated from photonuclear cross section data of ENDF/B-VII.1. Investigation on detectability of photonuclear reactions changing sample materials, distance, and sample thickness was performed for the measurement setup shown in the **Figure 1**.

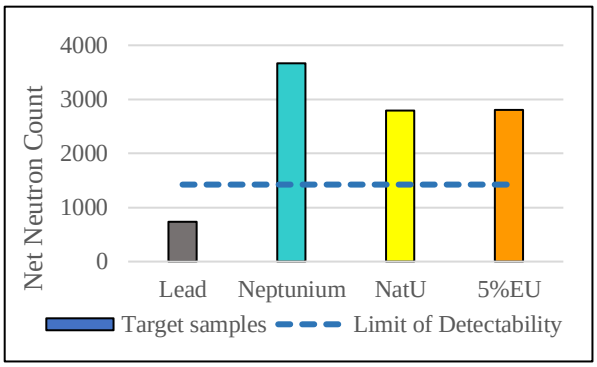

Figure 2 Net neutron counts from samples placed at 1 cm from source position

3. Result Geometrical conditions such as distance, sample thickness and surface area have an impact on photoneutron emission. The sample was placed at 1 cm from the photon source and neutrons were detected with ^{3}He proportional counters surrounded with polyethylene moderators**.** The limit of detectability was evaluated based on background neutrons from photoneutrons emitted from the lead collimator. As shown in **Figure 2**, at a sample distance of 1 cm from the photon source, given the sample size of 1 cm^2 surface area and 1 mm thick, neutrons from lead are below the detectability limit, while photonuclear events from nuclear material samples such as neptunium and uranium samples are found to be detectable.

4. Conclusion The characteristics of neutron emission by γ-rays from $^{7}Li(p,\gamma)^{8}Be$ reaction regarding sample materials and geometrical conditions have been investigated in numerical analyses. With an optimal experimental setup, photon-induced neutron events from nuclear materials can be made detectable.

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References [1] Saito, T., Katabuchi, T. et al., (2017). Journal of Nuclear Science and Technology, 54:2, 253-259