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Characteristic Evaluation of Intrinsic Radiation of 176Lu in Scintillation Crystal

Inorganic scintillators contain lutetium such as lutetium oxyorthosilicate (LSO), lutetium yttrium oxyorthosilicate (LYSO) widely used today in nuclear medicine and other fields because of their convenient physical properties of high detection efficiency, fast decay time, and high light yield. Despite its advantages, lutetium-based scintillators issue in single transmission measurement, low sensitivity imaging, or wide energy windows scanning due to natural occurring radioisotope 176Lu contained in natural lutetium. 176Lu undergoes decay and emits a beta particle with mean and maximum energy of 182 keV and 593 keV and a cascade of gamma rays of energies 307 keV, 202 keV, and 88 keV.

Those radiations from 176Lu are an annoyance that makes a background noise of apparatus as a uniformly distributed radiation source in scintillation crystal. Furthermore, its noise signal is not easy to define in a spectrum as independent radiation because it is complicated that the designation of degree which radiations from 176Lu attribute to spectrum signal when the performance of spectroscopy is not guaranteed for a wide energy range. On the other hand, it is possible to quantitatively evaluate the attribution degree of each radiation to the spectrum even the performance of spectroscopy is not fully satisfying on a wide energy range, 176Lu will be of sufficient value as it suggests the possibility to conduct the energy calibration of the detector or evaluate the characteristics of the detector structure without external radiation sources.

In order to quantitatively evaluate the performance of the spectroscopy system, experiments using a detector consisting of silicon photomultiplier (SiPM) and LYSO were conducted with a data acquisition system of PETSYS Inc. With this experiment, we define the performance according to the energy as the full-width half maximum (FWHM) and reflect it in the Monte Carlo simulation code as Gaussian Energy Broadening (GEB) function. Based on the above code setting, simulations were conducted with 7 interaction cases that can occur from the cascade of gamma rays, and the results were used for making base spectrums by convolving with the beta spectrum. Through the linear combination of base spectrums and optimization algorithm, simulation data will be optimized with the experimental data. This study may serve as useful data to assess detector performance and calibrate spectrum.

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