Characterization of ^{195}Au and ^{155}Tb for photon-pair radiotheranostics

K. Shimazoe,[*1] M. Hamdan,[*1] B. Feng,[*1] S. Ohta,[*1] Y. Shigekawa,[*2] A. Nambu,[*2] S. Mitra,[*2] H. Haba,[*2] and T. Yokokita[*2,*3]

In this study, we have been working on creating photon-pair radiotheranostics. Double photon emission nuclides (cascade nuclides) can be used to extract the chemical information in micro-environment through interaction between nuclear spin and the external electro-magnetic field by detecting the distribution of two gamma photons.[1–3] ^{155}Tb is one such cascade-gamma-rays emitting nuclides that have a relatively long intermediate live-time constant, which is useful to detect the external field. ^{155}Tb emits 180.1 and 86.6 keV with 6.5 ns intermediate live-time constant and 262.3 and 105.3 keV with 1.16 ns. Further, Tb isotopes are considered promising nuclides because they can be a positron emitter for positron emission tomography (PET), cascade gamma emitter for single photon emission CT (SPECT) or double photon emission imaging (DPEI), and an alpha emitter for therapeutics based on the neutron number.[4] ^{195}Au is a nuclide that decays into ^{195}Au with a 186 days half life. It exhibits a cascade emission of 30.9 and 98.9 keV although the intensity is low. ^{195}Au can be used for SPECT imaging. Other features of ^{195}Au is that it can used as a contrasting agent for cfFiomputed tomography (CT) and gold nanoparticle (AuNP[5]) can be used for drug delivery systems (DDSs) and fluorescence imaging because of its plasmon resonance. With these features, ^{195}Au is considered a useful multi modal imaging probe. For characterizing feasibility, the energy spectra of ^{155}Tb and ^{195}Au were measured with a cadmium zinc telluride (CZT)-based semiconductor detector. Figure 1 shows the energy spectrum of ^{155}Tb with the CZT detector in Polaris (H3D). Although the small peaks of 262.3 and 180.1 keV are visible, many other gamma-rays or Compton component are observed and found to be dominant, which makes it difficult to extract the single gamma-ray without cross-talk.

Figure 2 shows the ^{195}Au energy spectrum, where 98.9 and 129.8 keV gamma rays, and 66 and 76 keV X-ray are clearly observed as peaks. This confirms the usability of ^{195}Au for SPECT and DPEI. The energy resolution at 98.9 keV is 3.3%. Figure 3 shows the energy spectrum measured with HR-GAGG detectors combined with SiPM, which also shows a similar result and a 30.9 keV peak. The results indicate the feasibility of DPEI with a GAGG based system.

[*1] Graduate School of Engineering, University of Tokyo
[*2] RIKEN Nishina Center
[*3] Research Center for Accelerator and Radioisotope Science, Tohoku University

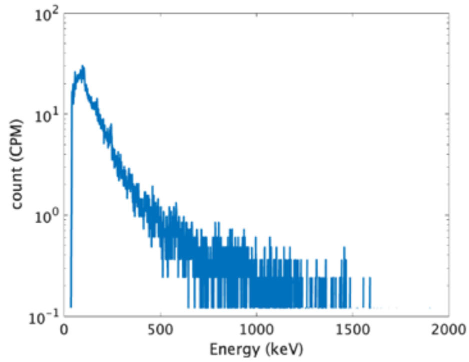

Fig. 1. Measured energy spectrum of ^{155}Tb with H3D H420 in log scale.

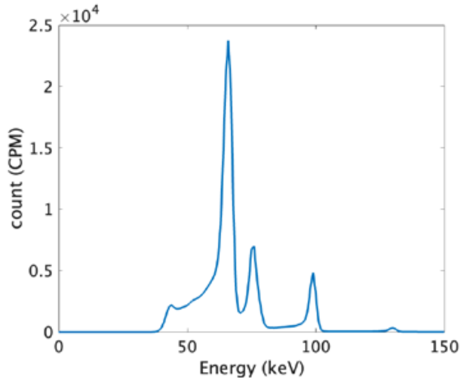

Fig. 2. Measured energy spectrum of ^{195}Au with H3D H420 in the linear scale.

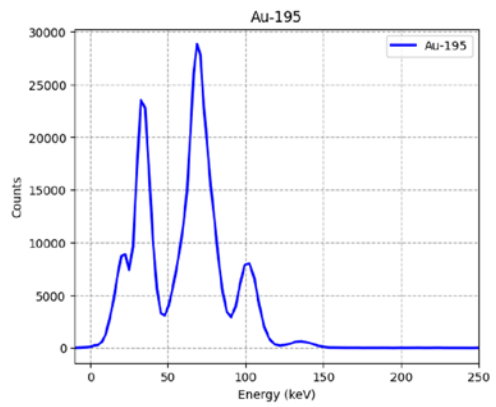

Fig. 3. Measured energy spectrum of ^{195}Au with the GAGG detector.

References
1) K. Shimazoe *et al.*, Commun. Phys. **5**, 24 (2022).
2) K. Shimazoe, M. Uenomachi, Bio-Algorithms and Med-Systems **18**, 127 (2022).
3) T. Ueki *et al.*, Nucl. Instrum. Methods Phys. Res. A **1050**, 168112 (2023).
4) H. Koniar *et al.*, EJNMMI Phys. **11**, 77 (2024).
5) S. Ohta *et al.*, Sci. Rep. **10**, 18220 (2020).

DOI:10.34448/RIKEN.APR.58-068