【Grant-in-Aid for Scientific Research (S)】

Study on higher-order imaging method based on double photon coincidence counting using correlation in multidimensional space

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Purpose and Background of the Research

●Outline of the Research

It is an effective way to utilize highly penetrating radiation for observing biological information in depth from outside, since we can identify a single atom through radiation. So far, people concentrate on single radiation particle detection and it just tells us about its existence. In contrast, this research focuses on the use of multiple radiation particles which are emitted from single atom and utilizes the relationship between multiple particles, such as the time between the first and the second emission, the angle formed by the two particles, etc. This higher-order measurement can provide much information about the local environment surrounding the atom.

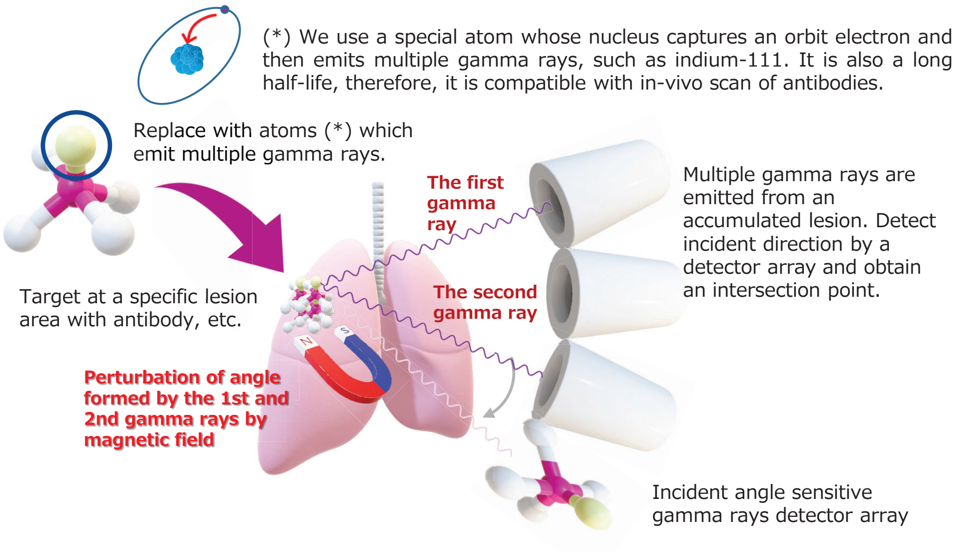

Figure 1. Overview of the research

●Higher-order imaging method

By utilizing multiple gamma ray photons, single atom could be used as an ultra-small sensor to obtain external environment (Figure 2).

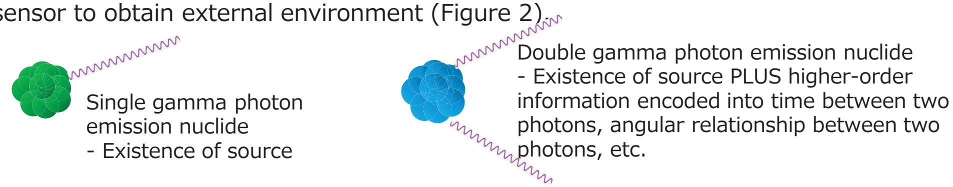

Figure 2. Comparison of single and double gamma photon emissions

●Gamma ray imaging method with planar collimators

Perpendicular incident component has been used in the conventional gamma ray imaging such as SPECT, however, we are developing a new technology with planar collimators which accept an arbitrary incident angle (Figure 3). The intersection of a plane and a line falls into one point in most of occasions. Then, we can use double photon emission nuclide to get local information on the source. Figure 4 shows an example image of neuroendocrine tumors through Octreoscan.

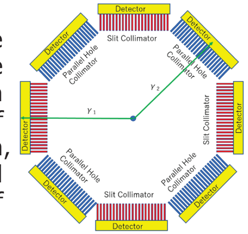

Figure 3. The use of slit collimators

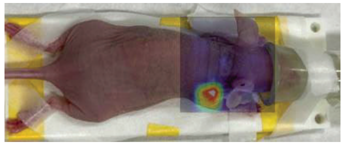

Figure 4. A neuroendocrine tumor image obtained with a double photon coincidence imaging with plane collimators

Expected Research Achievements

●Frontier of a new magnetic gamma-ray imaging

This research aims at the fusion of two independent principles – gamma-ray imaging and magnetic resonance imaging (MRI) at their native principle levels.

Conventional fusion of modalities such as PET-MRI is, in some sense, only the integration of independent instruments into a single package. However, this research integrates two principles in the signal detection scheme. We actually combine two principles in such a way shown in Figure 1. Two gamma-ray photons are used as a signal readout of local electromagnetic field, therefore a pair of gamma rays works as a signal readout line. Figure 5 shows a preparatory experiment of the use of gamma ray imaging system operated in a strong magnetic field. In conventional MRI, radio frequency signals carry the information and it strongly limits the sensitivity of this method and hydrogen nuclides are used because of their richness in the human body. In contrast, this research utilizes the gamma rays and the target atom itself emits the strong signals identifying a single atom. Therefore this research started from the production of special nuclides which emit multiple gamma photons in series, followed by the development of a system and collimator development. And we aimed at the fabrication of the first small prototype of the gamma-ray magnetic-resonance fusion imaging system that can demonstrate the cancer diagnostic and brain disease diagnostic abilities. This research contributes to the healthy long life society. Figure 6 shows a scheme of inner cell measurement with this technology in the future, where we anticipate inner cell information is effectively obtained through the fusion of the two modalities for effective diagnostics.

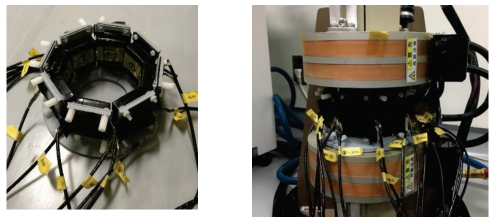

Figure 5. Gamma ray imaging system (left) and setup of the system in the magnetic field (right).

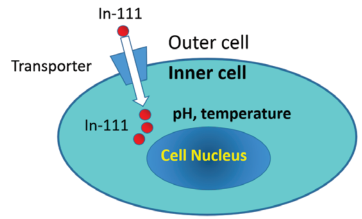

Figure 6. Future inner cell diagnostic image with peptide etc.

Homepage Address, etc.	https://spiny.t.u-tokyo.ac.jp/22H04961e.html