Double photon emission nuclides for double photon coincidence imaging

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Positron emission tomography (PET) is known as a very high sensitivity imaging method. One reason for this is that it utilizes a coincidence technique, where two detectors are used to identify the event; therefore, a high signal-to-noise ratio is realized. However, PET uses only 511 keV gamma rays. Thus, it cannot be used to distinguish all positron emitters.

Some nuclides successively emit two gamma-ray photons in a very short time. The use of such gamma photons can lead a new type of coincidence imaging method.[1,2] Recently, we proposed a new concept of time/position correlation type tomography method based on a directionality sensitive gamma camera. For this, we need a nuclide that emits two photons in a relatively short period. Thus far, we have proposed the use of ^{111}In, which emits a 171 keV photon and after the life time of 85 ns, it emits a 245 keV photon. When the measurement system identifies a 171 keV photon, the system waits for a 245 keV photon for approximately 300 ns. If the system recognizes the 245 keV photon, it records two gamma photons and their incident angles, and then, it proceeds to the next measurement. To record angles, an electron tracking type Compton imager can be used for 300–600 keV gamma-ray photons; however, multi-pinhole cameras can be used for low-energy gamma rays. This enables double photon emission computed tomography (DPECT). Although ^{111}In is feasible for measurements, the advantage of the double-photon coincidence method lies in its multi-nuclide capability. Therefore, we are exploring other candidates for double-photon emission nuclides. The gamma ray energies should not be too large since the detection efficiency for high energy gamma rays is limited.

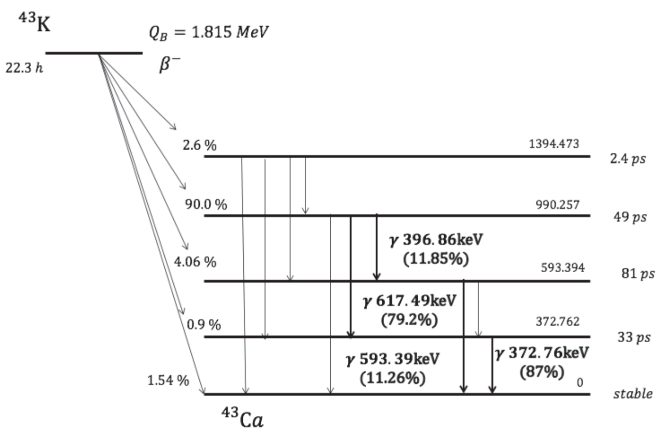

Fig. 1. Decay scheme of ^{43}K.[3]

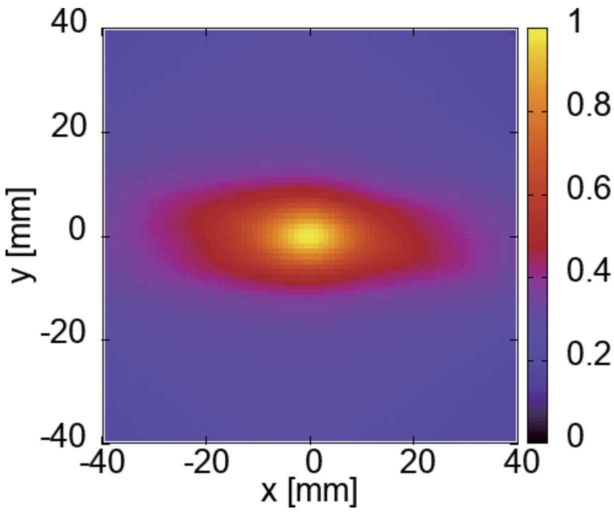

Fig. 2. Single photon Compton image of a ^{43}K source. The color bar shows relative intensity.

For nuclear medicine applications, the half-life of the nuclide should not be too short or too long. The double-photon yield should be large. The gamma-ray energies should not be too large since the detection efficiency for high-energy gamma rays is limited. Further, two photons should be emitted within a short period. Although there are various possibilities for double-photon emission nuclides. they cannot all be used owing to the above requirements. Then we successfully found the following nuclides thus far.

^{43}K is a beta minus nuclide followed by gamma photon emissions. The half-life of the nuclide ^{43}K is 22.3 h, which is a reasonable value. The decay scheme of this nuclide is shown in Fig. 1. It emits three pairs of gamma rays. The first pair is a 617 keV photon (79%) and a 372 keV photon (87%). The second pair is a 397 keV photon (11.9%) and a 593 keV photon (11.3%). Finally, the third pair is a 221 keV photon (4.8%) and a 372 keV photon. The longest life time is 81 ps. Therefore, two gamma-ray photons are observed almost simultaneously in the measurement system. The time resolution is very close to that of positron annihilation. The TOF method can be used to localize the event for this nuclide. As a first step, the single-photon Compton image was obtained as shown in Fig. 2. In this research, ^{43}K was produced at RIKEN for radioisotope imaging.

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References

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