Simulation on the Time-of-Flight double-photon imaging with Compton camera

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Abstract

Coincidence imaging of radioactive isotopes using Compton cameras is proposed with time-of-flight (TOF) technique applied on image reconstruction. Target nuclides are those with cascade decay and a short metastable life. In this research K-43 has been used in simulation for coincidence imaging. The result shows a great improvement in image quality that results from the TOF information.

Keywords: Coincidence imaging, Compton camera, Time of Flight

1. Introduction

Coincidence imaging is a q coincidence events that results from cascade decay, the position of nuclides can be better located. Previous work has already shown superb image quality for coincidence imaging with Compton cameras[1]. However, In the 3-dimensional reconstruction, the Compton cones would have large portion of overlap, making it hard to determine the origin of incident photons in the third dimension. To suppress this effect, we propose to make use of the time of flight (TOF) information. As is the TOF-PET (Positron Emission Tomography).

2. System configuration

Manufacturers of have reported a time resolution as good as 200 ~300 ps in their TOF-PET systems. We assume the system in the simulation also have this order of magnitude. The volume for reconstruction is $20 \times 10 \times 10\ cm^3$, a typical value in practical measurement. The detector we choose for Compton camera is GAGG scintillator.

To use the TOF technique, the time interval of the origin of the coincidence photons should be as short as possible. K-43 is chosen for this simulation. It emits two photons in a cascade decay, whose energies are 617 keV and 372 keV, respectively. The half life of the metastable state is 8.1 ps, which is practical to be used with TOF in the system with timing resolution of ~300 ps.

3. Simulation and result

In addition to the original coincidence imaging reconstruction, a time factor is multiplied to the possibility distribution over the 3-D volume of reconstruction. On the cross-section of the source plane, the TOF doesn't give much improvement compared to mere coincident imaging. However, TOF information greatly suppress the interference of the signal on the third direction, so that contrast and SNR in the whole 3-D space is improved. The relative value in the image became less than 10% of what is used to be at the position 5 cm away from the simulated source position.

3 Conclusion

Simulation result shows that TOF technique has a great potential in improving image quality when coincidence imaging of multiple photons is used. Future task is to build practical systems and use TOF in measurement.

References

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