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Whole gamma imaging: PET combined with Compton imaging

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Whole gamma imaging (WGI) is a novel concept of combined PET with Compton imaging. An additional detector ring, which is used as the scatterer, is inserted in a conventional PET ring so that single gamma rays can be detected by the Compton imaging method. In addition to a conventional PET mode, Compton imaging (single-gamma mode) is possible. Further large impact can be expected for triple gamma emitters such as 44Sc (about 4 h half-life), that emits a positron and a 1157 keV gamma ray almost at the same time (triple-gamma mode). In principle, only a few decays would be enough to localize the source position by calculating intersection points of a 511 keV line-of-response with a 1157 keV Compton cone. We developed a prototype of the WGI system [1][2]. All interaction events were recorded as list-mode data, and event selection such as coincidence detection was done in software. We measured a 137Cs point source in the single-gamma mode and a 22Na point source with convention-al coincidence detection. The 22Na point source was also used to demonstrate the triple gamma mode as it emits a 1275 keV gamma ray after a positron decay. In the single-gamma mode, spatial resolution for the 137Cs point source obtained by 3D list-mode OSEM was 4.4 mm FWHM (8 cm off-center) - 13.1 mm FWHM (center). Spatial resolution values for the 22Na point source, obtained by the absorber-absorber coincidence and the scatterer-scatterer coincidence, were almost the same (below 2 mm). In the triple gamma mode, where only simple backprojection was applied and no image reconstruction algorithm was applied, spatial resolution for the 22Na point source was 4.8 mm FWHM (8 cm off-center) - 5.7 mm FWHM (center). WGI with 44Sc can be also used to measure positronium lifetime [3], which may enable a new field of “quantum PET (Q-PET)”. One possible application of Q-PET is hypoxia imaging of tumor patients [4].

References

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