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A Monte Carlo Study of Scattered and Random Coincidences for MADPET-4

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MADPET4 is a high resolution PET insert under development for use in a 7 T MR. To fully exploit the capabilities of the insert, a good understanding of the physical interactions, which take place in the active and passive components of the insert, is necessary. The goal of this study was to investigate the effects of different physical interactions in an accurate model of MADPET4 using Monte Carlo (MC) simulations. The main focus of the study was on the impact of the different active and passive components of the system on the amount of random and scattered events, including scattering in the passive components and between the crystals. The influence of low energy thresholds (50-350 keV) and different geometrical conditions in the coincidence sorting process was of particular interest. The effect of including triple coincidences was also considered in the present study. The highest sensitivity with a 3.7 MBq point source at the center of the scanner with an energy threshold of 50 keV and no geometrical condition was 3.4% with having only the crystals in the model and 3.6% with the complete model including all system components. This is expected to be a result of having scattering in the structure, which increases the probability of detecting the scattered photons in their neighbor crystals. Including triple coincidences showed no benefit for energy thresholds above 250 keV. However, low energy thresholds provided a relative gain in sensitivity, reaching 12-26% for 200 keV and a maximum of 25-71% at 50 keV.

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