Simulations of a micro-PET System based on Liquid Xenon

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The imaging performance of a high-resolution preclinical microPET system employing liquid xenon as the gamma ray detection medium was simulated. The arrangement comprises a ring of detectors consisting of trapezoidal LXe time projection ionization chambers and two arrays of large area avalanche photodiodes for the measurement of ionization charge and scintillation light. A key feature of the LXePET system is the ability to identify individual photon interactions with high energy resolution and high spatial resolution in 3 dimensions and determine the correct interaction sequence using Compton reconstruction algorithms. The simulated LXePET imaging performance was evaluated by computing the noise equivalent count rate, the sensitivity and point spread function for a point source, and by examining the image quality using a micro-Derenzo phantom according to the NEMA-NU4 standard. Results of these simulation studies included NECR peaking at 1326 kcps at 188 MBq (705 kcps at 184 MBq) for an energy window of 450 - 600 keV and a coincidence window of 1 ns for mouse (rat) phantoms. The absolute sensitivity at the center of the field of view was 12.6%. Radial, tangential, and axial resolutions of 22Na point sources reconstructed with a list-mode maximum likelihood expectation maximization algorithm were <= 0.8 mm (FWHM) throughout the field of view. Hot-rod inserts of < 0.8 mm diameter were resolvable in the transaxial image of a micro-Derenzo phantom. The simulations show that a liquid xenon system would provide new capabilities for significantly enhancing PET images.

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