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Minimum Requirements for a low-Z-medium detector for low-dose high-resolution TOF-PET

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Two major drawbacks to time-of-flight positron emission tomography (TOF-PET) are low spatial resolution and high radioactive dose to the patient, both of which result from limitations in detection technology rather than fundamental physics. To address these, a new type of TOF-PET detector employing low-atomic number (low-Z) scintillation media recording Compton scattering locations and energies in the detector has been proposed [1]. Here we present a preliminary comparison of the low-Z detector performance to conventional TOF-PET using high-Z scintillation crystals, and the minimum technical requirements for such a system. We have performed a simulation study using a customized TOPAS simulation [2] to evaluate the potential of a proposed low-Z detection medium, linear alkylbenzene (LAB) doped with a switchable molecular recorder. By quantifying contributions and tradeoffs for energy, spatial, and timing resolution of the low-Z detector, we show that a reasonable combination of detector specifications improves the TOF-PET sensitivity by more than 5x, with comparable or better spatial resolution and 40-50% enhanced contrast-to-noise as compared to state-of-the-art photoelectric based high-Z TOF-PET. These improvements enable imaging of a brain phantom simulated at less than 1% of a standard radiotracer dose. This would enable expanded access and new clinical applications for TOF-PET.

Early Career

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