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Low-Dose TOF-PET Based on Surface Electron Production in Dielectric Laminar MCPs

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We present simulations of whole-body low-dose time-of-flight positron emission tomo\-graphy (TOF-PET) based on laminar microchannel plates (LMCP^{TM}) packaged into High-Resolution Gamma Multiplier Tubes (HGMTs^{TM}) [1]. 511 keV gamma rays interact in the LMCP via the photoelectric and Compton effects to create an electron through surface direction conversion [2], eliminating the scintillator and photodetector sub-systems in PET scanners. The absence of a photocathode allows assembly of large arrays at atmospheric pressure and less stringent vacuum requirements. The laminae surfaces are micro-patterned to form channels, which can then be functionalized to support secondary electron emission in the manner of conventional MCPs.

We have simulated surface direct conversion using modifications to the TOPAS Ge\-ant4-based tool kit. A $20 \times 20 \times 2.54$ cm^3 LMCP composed of 150-micron thick lead-glass laminae is predicted to have a $\geq 30\%$ conversion efficiency to a primary electron that penetrates an interior wall of a pore. The subsequent secondary electron shower is largely confined to one pore and can provide high space and time resolutions.

TOPAS simulations of the Derenzo and XCAT-brain phantoms are presented with dose reductions of factors of 100 and 1000 from literature benchmarks. New applications of PET at orders of magnitude lower radiation dose include routine screening for early detection of pathologies and the use in previously unserved patient populations.

[1] K. Domurat-Sousa, C. Poe, H. J. Frisch, B. W. Adams, C. Ertley, N. Sullivan; *Low-Dose TOF-PET Based on Surface Electron Production in Dielectric Laminar MCPs*; To be published in Nucl. Instr. and Meth. A, arXiv:2307.02708.

[2] K. Domurat-Sousa, C. Poe, H. J. Frisch, B. W. Adams, C. Ertley, N. Sullivan; *Surface Direct Conversion of 511 keV Gamma Rays in Large-Area Laminated Multichannel-Plate Electron Multipliers*; Nucl. Instr. and Meth. A, v. 1055, Oct. 2023, 168538.

Early Career

No

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