2023 IEEE Nuclear Science Symposium, Medical Imaging Conference and International Symposium on Room-Temperature Semiconductor Detectors (NSS MIC RTSD) | 979-8-3503-3866-9/23/$31.00 ©2023 IEEE | DOI: 10.1109/NSSMICRTSD49126.2023.10338414

Analytical modeling of the sensitivity of cylindrical PET systems based on bulk materials and metascintillators

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Abstract

Positron emission tomography scanners are commonly characterized by their photon sensitivity. Scanner design often requires Monte Carlo simulations to probe different geometries and materials. However, the computational load of such simulations can be significant and costly. Furthermore, the applicability of the Monte Carlo approach in optimization loops is limited as each instance, such as source position or scanner dimensions, has to be simulated independently. In this work, Monte Carlo results have been accurately replicated by an analytical model that uses characteristics of the foreseen cylindrical scanner and returns the sensitivity profile following NEMA guidelines. BGO and LYSO bulk materials and several metascintillator scenarios have been used. The mean absolute error (MAE), mean absolute percentage error (MAPE) and standard deviation of the error (SDE) are as low as 0.49%, 2.22% and 0.26% when no energy window is used, respectively. With an energy window applied, the analytical model presents the lowest values of MAE and SDE, with MAPE value being 8.19%. A normalization factor has been used to compensate for the scattered events included in the 350-650 keV window. This work facilitates significantly the development of cylindrical scanners, allowing direct probing of their axial sensitivity profiles.

Acknowledgment

This work has been in part supported by the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation program (grant agreement No 695536): 4D-PET and the Brazilian funding agencies Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq grant agreement No 202378/2020-9 and 435039/2018-0) and Financiadora de Estudos e Projetos (FINEP grant agreement No 0294/16). The metascintillator concept presented in this manuscript was based on research first developed within the TICAL: 4D total absorptionTime Imaging CALorimeter ERC (grant agreement no 338953).

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