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Selection of Photodetectors in Nuclear Medical Imaging Using Multi-Criteria Decision-Making Methods

Photodetectors used in nuclear medical imaging such as single photon emission computed tomography (SPECT) and positron emission tomography (PET) are an important element of radiation detection systems. Selecting the photodetector depends on many physical criteria including quantum efficiency (QE) and gain. The aim of this study is to apply multi-criteria decision-making (MCDM) methods to determine the optimum photodetector based on the evaluation and comparison of complex and multiple criteria. The photodetectors investigated in this study are photomultiplier tube (PMT), avalanche photodiode (APD) and silicon photomultiplier (SiPM). The bias voltage, gain, rise time, and QE were selected since they are considered as the key criteria for the photodetectors. Then, the corresponding values of each criteria were defined (Table 1) and preferred weights were assigned to each criteria based on the desired outcome (Table 2 and 3). The fuzzy preference ranking organization method for enrichment of evaluations (f-PROMETHEE) and fuzzy technique for order of preference by similarity to ideal solution (f-TOPSIS) methods were used to evaluate the alternatives. The results showed that conventional PMT came first in the ranking, followed by SiPM, while APD was the least desirable photodetector according to the f-PROMETHEE and f-TOPSIS methods based on the selected criteria and assigned weights (Table 4 and 5). MCDM methods were used to select photodetectors used in PET and SPECT systems. One can incorporate as many alternatives and criteria as needed and assign the weights accordingly.

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