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Design considerations for a low-cost PET brain scanner

Medical PET is an expensive metabolic imaging technique that has applications in cardiology, oncology and neurology and is primarily limited to high income countries. A low-cost PET detector concept would likely extend its application to middle and low income countries. This work aims to find the optimal physical parameters that minimizes the cost of the detector while still producing clinically relevant images. The detection method used by the proposed detector is a combination of pixelated scintillation material and silicon photomultipliers. The performance of said detector is described by how many of the produced photon pairs are captured (sensitivity) and how accurately it measures the photon pairs traveled path (spatial resolution). The primary factors that affect the cost are the total amount and type of scintillation material, the number and type of silicon photomultipliers and the number of electronic readout channels. The means of cost reduction for the traditional PET ring design that will be explored are reducing the ring diameter to restrict its function to brain PET, manufacturing custom SiPM arrays, reducing the total number of electronic readout channels with multiplexing schemes and utilizing larger cheaper SiPMs, strictly FPGA based DAQ hardware, sparser SiPM arrays and cheaper scintillation material. The performance reductions introduced by these design choices are to be overcome by using finer grained pixels to increase spatial resolution, integrating the scanner into a low-field MRI and using single-sided readout depth-of-interaction to reduce parallax error and maintain low-cost. Beyond the traditional detector design, novel mechanical detector designs are explored. Mathematical modeling is used to understand how the alterations in physical parameters affect cost and performance and how the proposed performance enhancing methods may combat the reduced performance. Preliminary designs for a low-cost PET detector concept that are ready for integration into a low-field MRI are presented.

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