PERFORMANCE EVALUATION OF SIPM PHOTOSENSORS FOR PET IMAGING IN THE PRESENCE OF MAGNETIC FIELDS

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Introduction: The recently introduced [1] multi-pixel photon counters (MPPC), also known as silicon photo-multipliers (SiPM), exhibit high photon detection efficiency (PDE), are immune to magnetic fields, easy to use with simple read-outs, and have (a) small size. Therefore, they are ideal components for MRI compatible scintillator-based PET detectors. Three different 1×1 mm2 MPPCs and a 2×2 pixels MPPC array manufactured by Hamamatsu have been evaluated for their use in PET detection systems. We have studied the dependence of energy resolution and gain as a function of temperature and reverse bias voltage when coupled to LYSO scintillator crystals. The 400 and 1600 microcells 1x1 mm2 models and the 2×2 array were coupled to scintillator crystals similar in size to those used in high-resolution small animal scanners. We have evaluated the performance of these detectors in the presence of magnetic fields of 7 Tesla, and their feasibility for gamma-ray detection in the presence of fast gradient switching and intense radiofrequency pulses used on MRI [2].

Methods: Devices with 100, 400 and 1600 microcells (1x1mm2) and the 3600 microcells per element 2×2 array were coupled to 1.5mm×1.5mm×12mm LYSO crystals. The devices were placed in the static magnetic field of a 7 Tesla superconducting magnet (BIOSPEC 70/20, Bruker Corporation). The SiPM array was also tested during simultaneous MRI/PET acquisition with a RARE sequence with extreme parameters (echo and repetition times were set to 10.539 ms and 600.72 ms respectively), in order to establish a worst-case scenario. A copper shielding was used during some of the acquisitions.

Results: The FWHM energy resolution for single SiPMs was measured to be 20%@511 keV. The SiPM array showed energy resolution ranging from 12% to 22% @511 keV depending on the relative position of the crystal element. All the 4×4 crystals of the crystal matrix were perfectly resolved by the 2×2 SiPM array, yielding a 10:1 peak to valley ratio in the count profile at both 0 and 7 Tesla. The simultaneous use of the MR scanner with a heavy duty RARE sequence introduced a count loss of 20%, but otherwise the PET data acquired were fully useable.

Conclusions: We have found no significant influence of a static magnetic field of 7 Tesla. For 1x1 mm SiPM, the 400 and 1600 microcells models seem more suitable for PET purposes, exhibiting superior energy resolution and better stability. A 2×2 SiPM array coupled to a 4×4 LYSO crystal matrix has also been examined. Either shielding or a simple bandwidth limitation renders PET signals suitable for PET purposes. This shows the potential of SiPM photosensors for their use in PET/MR scanners with small scintillator crystals.

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