Performance Evaluation of SiPM Photosensors in the Presence of Magnetic Fields

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Abstract: The Multi Pixel Photon Counter (MPPC) or Silicon Photomultiplier (SiPM) consists of an array of Geiger-mode photodiodes (microcells). It is a promising device for PET thanks to its high photon detection efficiency (PDE) and immunity to high magnetic fields. It is also very easy to use, with simple electronic read-out, high gain and small size. In this work we evaluate the performance of three 1 x 1 mm^2 SiPM and one 2 x 2 SiPMs array (6 x 6 mm^2 of active area). We examine the dependence of the energy resolution and the gain of these devices on the temperature and reverse bias when coupled to MLS and LYSO scintillator crystals. The good performance of these devices up to 7 Tesla has been also confirmed.

Keywords: Positron Emission Tomography (PET), Silicon Photomultipliers (SiPM)
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INTRODUCTION, MATERIALS AND METHODS

The recently introduced [1] Multi Pixel Photon Counters (MPPC), also know as Silicon Photomultipliers (SiPM), exhibit high photon detection efficiency (PDE), are immune to magnetic fields, easy to use with simple read out electronics and have small size. Therefore, they are ideal components for PET/MRI and In-Beam PET detectors.

Devices with 100, 400 and 1600 microcells (1 x 1 mm^2) were coupled to 1.5 x 1.5 x 12 mm^3 MLS crystal. A 2 x 2 array, with elements of 3 x 3 mm and 3600 microcells each, was coupled to a 10 x 10 x 20 mm^3 LYSO crystal and to and array of 4 x 4 MLS crystals of 1.5 x 1.5 x 12 mm^3. The devices were placed in the static magnetic field of a 7 Tesla superconducting magnet (BIOSPEC 70/20, Bruker Corporation).

RESULTS

FWHM energy resolution of 20% at 511 keV was attained for the best single SiPM, the 1600 microcells one. The variation of energy resolution and relative gain of individual SiPM with the temperature and applied voltage were measured [2], (figure 1). The SiPM array showed energy resolution ranging from 12% to 22% at 511 keV and 5% to 6% at 1275 keV. All the 4 x 4 crystals of the crystal matrix were perfectly resolved by the 2 x 2 SIPM array, yielding a 10:1 peak to valley ratio (figure 2). These results were independent on the magnetic field applied.

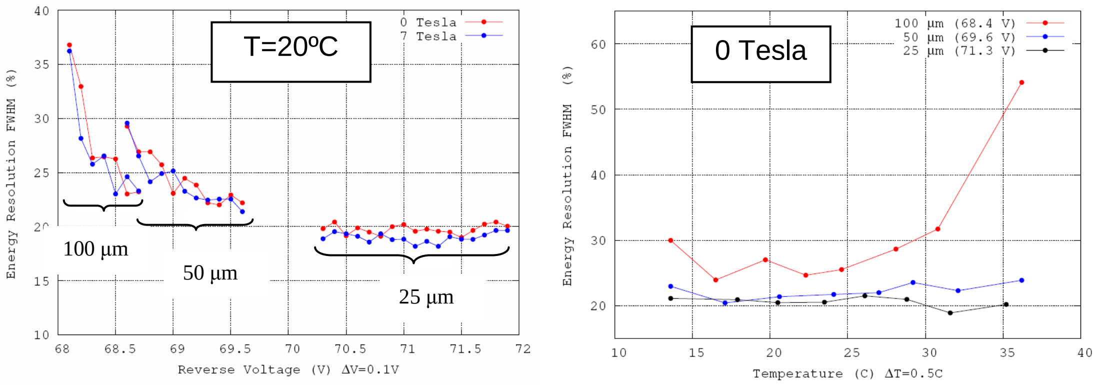

FIGURE 1. Variation of energy resolution with the reverse voltage applied at T = 20 ºC (left) and with the Temperature (right), to individual SiPMs.

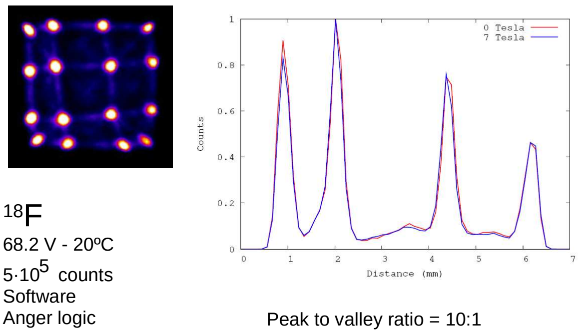

FIGURE 2. Separation of 4 x 4 MLS crystal matrix with 2 x 2 SiPMs array.

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