Gamma-ray imaging detectors based on SDDs coupled to scintillators

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Abstract

Silicon Drift Detectors (SDDs) have been recently employed succesfully in scintillation detection. Thanks to the low value of output capacitance, a SDD is in fact characterized by a lower electronics noise with respect to a conventional silicon photodiode. This feature could allow a detector based on a CsI(Tl)-SDD assembly to reach high energy and position resolution in gamma detection. In this work we present a small prototype of gamma detector for 2-D position measurements, based on a single scintillator coupled to an array of SDDs. The first experimental results are reported.

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1. Introduction

Gamma-ray imaging detectors based on Silicon Drift Detectors (SDDs) coupled to scintillators represent an attractive solution for some news applications like, for instance, breast tumor imaging using ^{99m}Tc tracers [1] where more compact detectors with better position resolution are required. With respect to conventional PMTs, SDDs offer the higher quantum efficiency to the scintillation light typical of a silicon detector. Moreover, with respect to a conventional silicon photodiode, a SDD is characterized by a lower electronics noise, thanks to the low value of output capacitance. Excellent performances of CsI(Tl)-SDD detectors have been already verified in energy measurements [2] and in 1-D position measurements [3]. In this work, we present a small prototype of a γ-ray detector for 2-D position measurements, based on a single scintillator coupled to an array of SDDs. The first experimental results obtained with this detector are reported.

2. The γ-ray CsI(Tl)-SDD detector

A first prototype of γ-ray detector for 2-D position measurements has been realized by coupling a single CsI(Tl) scintillator (1.4 mm thick) to an array of seven hexagonal SDDs, arranged in a honeycomb configuration, each one with on-chip JFET [4]. The total active area of the array is rather small (7×5 mm^2) but nevertheless it is already significant to achieve preliminary results in view of the realization of gamma cameras with a larger sensitive area based on the same architecture. Each SDD unit is characterized by an electronics noise of about 77 and 30 electrons r.m.s., at 20 °C and 0°C respectively. The typical quantum efficiency at 565 nm, wavelenght of the emission peak of the CsI(Tl) crystal, is of the order of 70 % (anti-reflecting coatings have not been implemented).

A photograph of the CsI(Tl)-SDD assembly is shown in Fig. 1. The crystal has been coupled to the SDD array by means of a 0.5 mm thick layer of Bicron BC-637 optical coupling. In order to enhance the position resolution capabilities, no light reflector was applied to the crystal surfaces. An equivalent gain of about 8 e^-/keV was measured for the present detector configuration.

3. Experimental results

In order to verify the capability of the detection system to identify different positions of interaction, a collimated ^{57}Co source (circular aperture of 0.3 mm) was moved in three different points separated by 0.6 mm. In Fig. 2 the 2-D position distribution corresponding to the three irradiations points is reported, showing the capability of the detector to distinguish the three source locations. The measured energy resolution is of about 24 % FWHM at 122 keV.

In Fig. 3, a test pattern opened on a lead layer (2 mm thick) is shown. A first gamma image has been obtained by irradiating the detector with a ^{57}Co source through the patterned layer (Fig. 4). Although not yet corrected from non-linearities, this raw image already shows the detector capability to identify the main details of the small drawing.

Aknowledgments

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References

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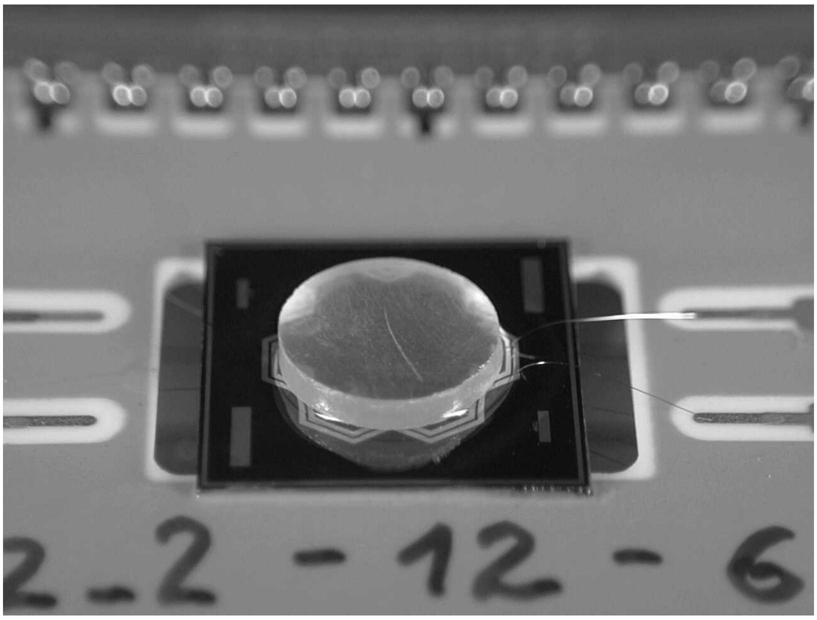
Figure captions

Figure 1. The SDDs array assembled to a single CsI(Tl) scintillator for γ-ray detection.

Figure 2. 2-D position distributions of three points of irradiation (122 keV, 0.3 mm collimator diameter) separated by 0.6 mm.

Figure 3. Test pattern realized on a lead collimator.

Figure 4. Gamma image measured with the detector, obtained by a ^{57}Co irradiation through the pattern shown in Fig. 3.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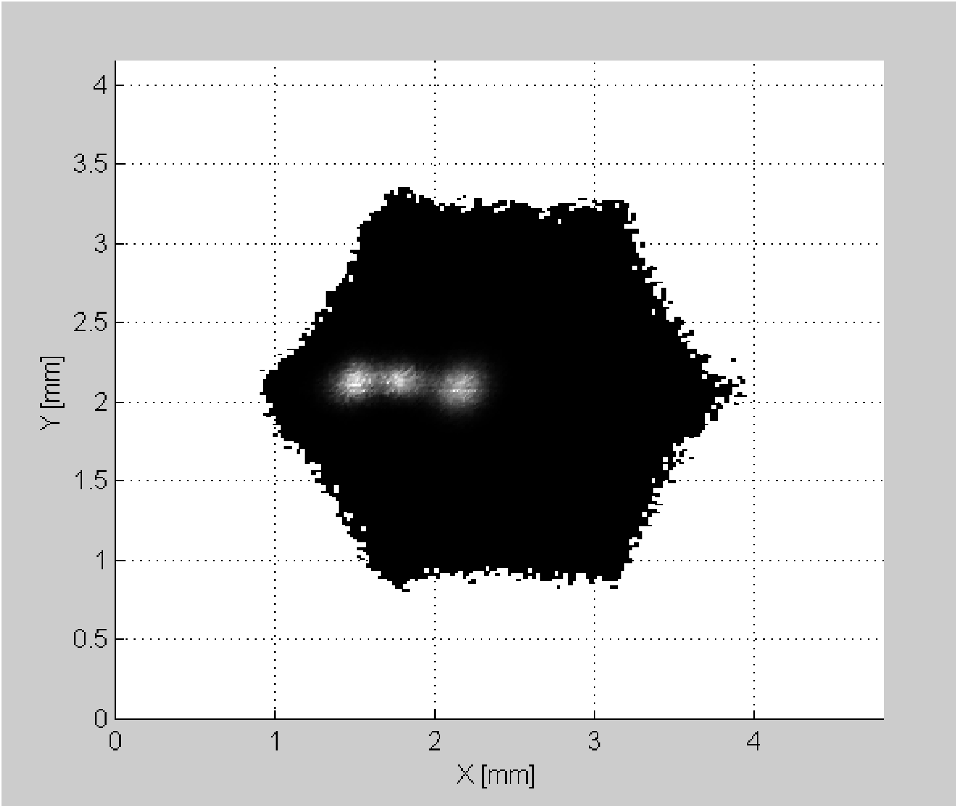
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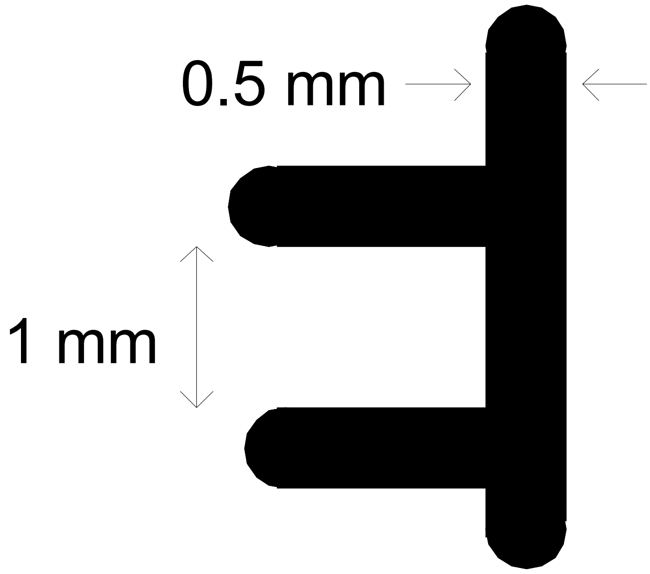
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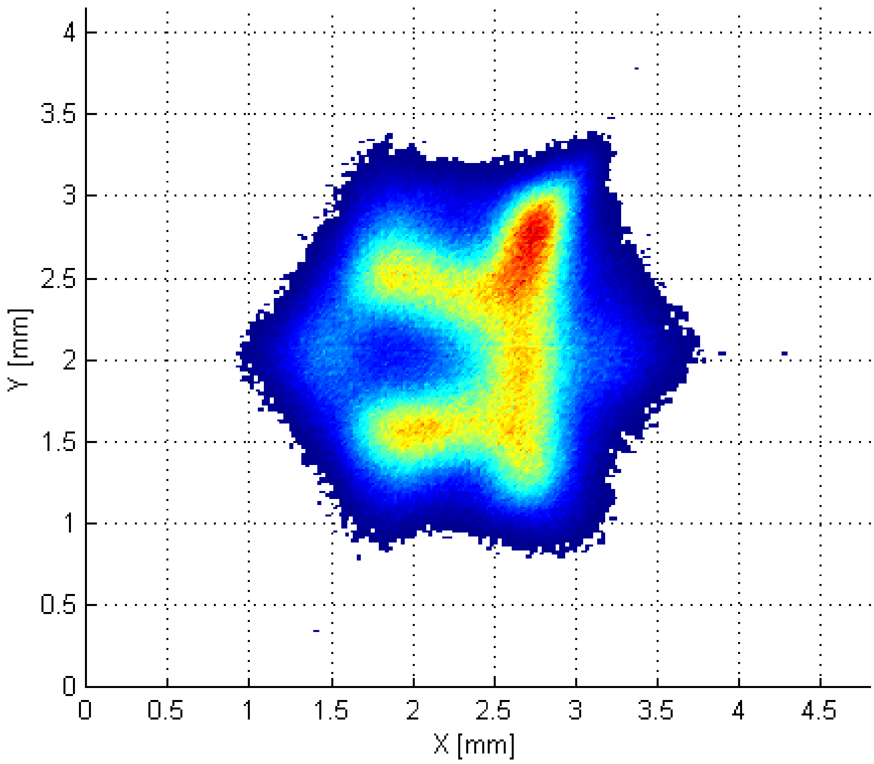

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