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High precision mapping of single-pixel Silicon Drift Detector for applications in astrophysics and advanced light source

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Abstract

A Silicon Drift Detector with 3x3 mm^2 sensitive area was designed by INFN of Trieste and built by FBK-Trento. It represents a single-pixel precursor of a monolithic matrix of multipixel Silicon Drift Detectors and, at the same time, a model of one cell Fluorescence Detector System (XAFS) for SESAME.
The point-by-point mapping tests of the detector were carried out in the X-ray facilities at INAF-IAPS in Rome, equipped with a motorized two-axis micro-

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metric positioning system. High precision characterization of this detector was done with a radioactive ^{55}Fe source and a collimated Ti X-ray tube equipped with a Bragg crystal monocromator.

The mapping in different positions and bias condition was specifically-aimed to the detailed analysis of the charge collection efficiency at the edge of the detector. The result is important to understand and verify the aspects related to the collection of the signal with respect to the position of interactions of the photons, especially in consideration of the new design and development of monolithic multipixel detectors.

Keywords: Silicon Drift Detectors, SDD, mapping

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1. Detector and experimental setup

The detector mapped is a single-pixel Silicon Drift Detector (SDD), with 3.0x3.0 mm^2 [Fig.1] sensitive area, designed by INFN of Trieste and built by FBK-Trento. The SDD has an entrance window (with bias voltages V_{WIN}) in the front side and, in the backside, the drift cathodes (bias voltage V_{OR} and V_{IR} is applied respectively to the outer and inner drift cathodes) and the central small anode, connected with the readout by the ultra-low noise SIRIO [1] charge sensitive preamplifier. The potential energy of the electrons in the SDD has the shape of a funnel [1].

The detector mapping [2, 3] were carried out in the X-ray facilities at INAF-IAPS in Rome, equipped with a motorized two-axis micrometric positioning system, a radioactive ^{55}Fe source and a collimated Ti X-ray tube with a Bragg crystal monocromator. The measurements were carried out in an air-conditioned room with an ambient temperature of 18 °C.

2. Measurments

Before performing the mapping, it is important to determine the dimension of the beam which has a oblong gaussian shape (for the X axis the FWHM of

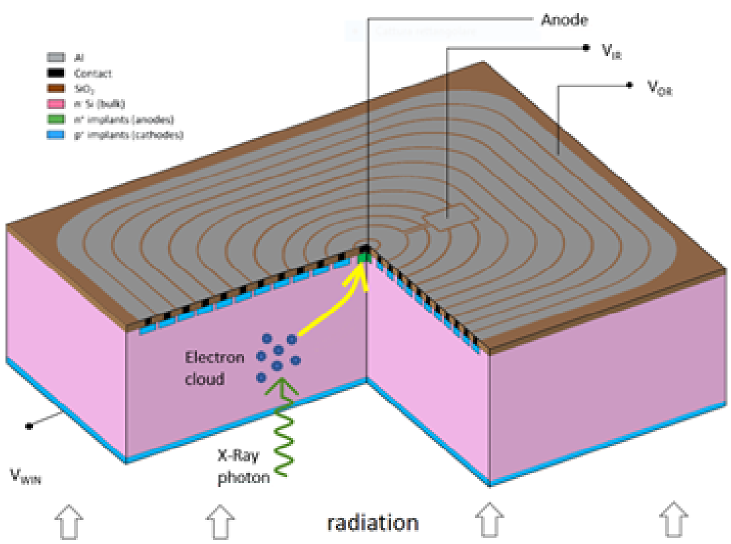


Figure 1: Working principle and structure of the detector.

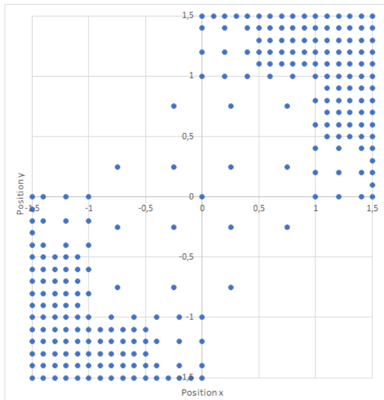
the beam is 165.48 μm and for the Y axis is 128.83 μm), to reveal the center position of the SDD, to align the detector with the X-Ray tube, and to calibrate the system with the radioactive ^{55}Fe source and Ti X-ray tube.

For the point-by-point mapping, we have used the collimated Ti X-ray tube and we have acquired data at coarse steps in the central zone (500 μm) and at finer steps (100 μm) near the edges of the detector. The measurements have been made for 4 different outer ring voltages. [Fig.2]

3. Results and conclusions

The outer ring voltage changes the efficient area of the detector. This detector has a larger effective area (2.7x2.7 mm^2) [Fig.3 and Fig.4] than the previous version tested in 2016 (2.5x2.5 mm^2) [3], but still less than the nominal 3.0x3.0 mm^2 area.

The mapping allows to verify aspects related to the charge collection to the detector's edge. Furthermore, the mapping allows the cross check of the device simulation and fosters the progress in the design and development of



Outer ring voltage (V_{OR})	Windows voltage (V_{WIN})	Inner ring voltage (V_{IR})
-144.6 V	-85.10 V	-23.8 V
-124.4 V	-80.66 V	-21.13 V
-104.06 V	-80.85 V	-19.81 V
-84.1 V	-80.97 V	-18.59 V

Figure 2: Scheme of the map used for the acquisitions with different steps for the central region and the edge of the detector, and table showing the four different bias conditions used for the measurements.

new monolithic matrix of multipixel Silicon Drift Detectors for applications in astrophysics and advanced light source.

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References

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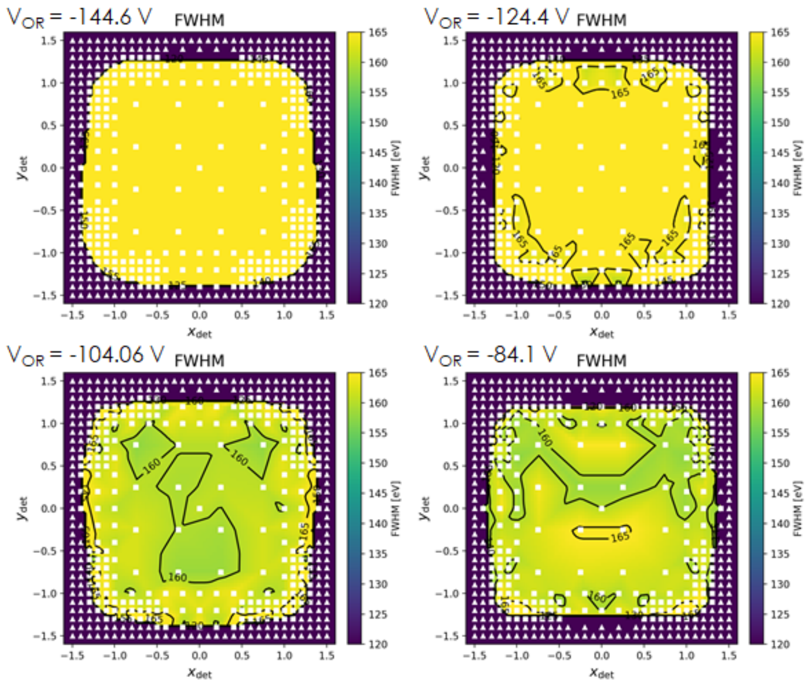

Figure 3: FWHM maps. Squares represent the points having more than 25 counts for the Ti Kα line, which were processed. Triangles correspond to measurements having less than 25 counts for the Ti Kα line and were discarded. In order to have a better view of the results, the points acquired are mirrored to represent all the detector area. Values between the experimental points were obtained through linear interpolation.

[3] F. Ceraudo, Development of space instrumentation for high throughput X-ray Astronomy, Master Degree Thesis, University of Roma Sapienza (AA 2015/16).

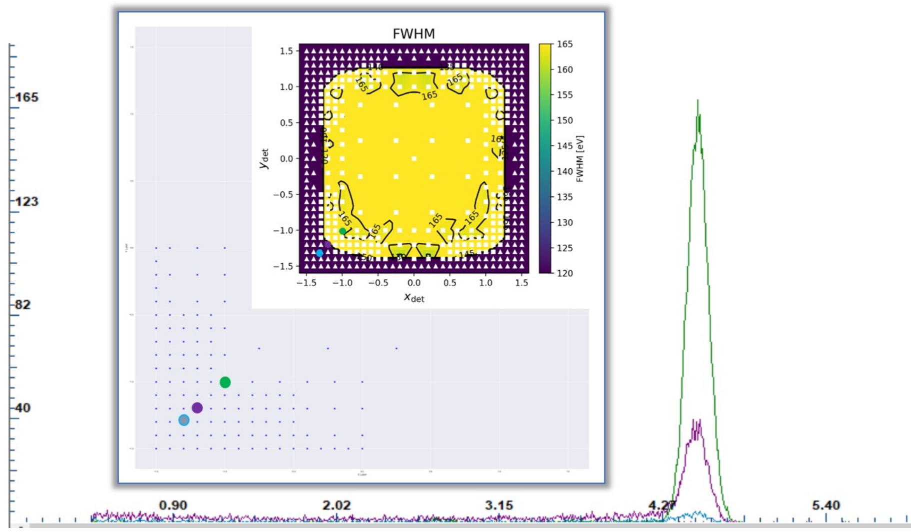

Figure 4: Spectra (Ti Kα line) at points: green (-1.0;-1.0), purple (-1.2;-1.2) and blue (-1.3;-1.3) with VOR = -124.4 V. The centroid of the peak is, respectively, at 4.51, 4.50 and 4.47 keV, the mismatch is due to the progressive growth of the left shoulder of the peak caused by truncated events where a part of the signal charge is lost to the periphery of the detector.