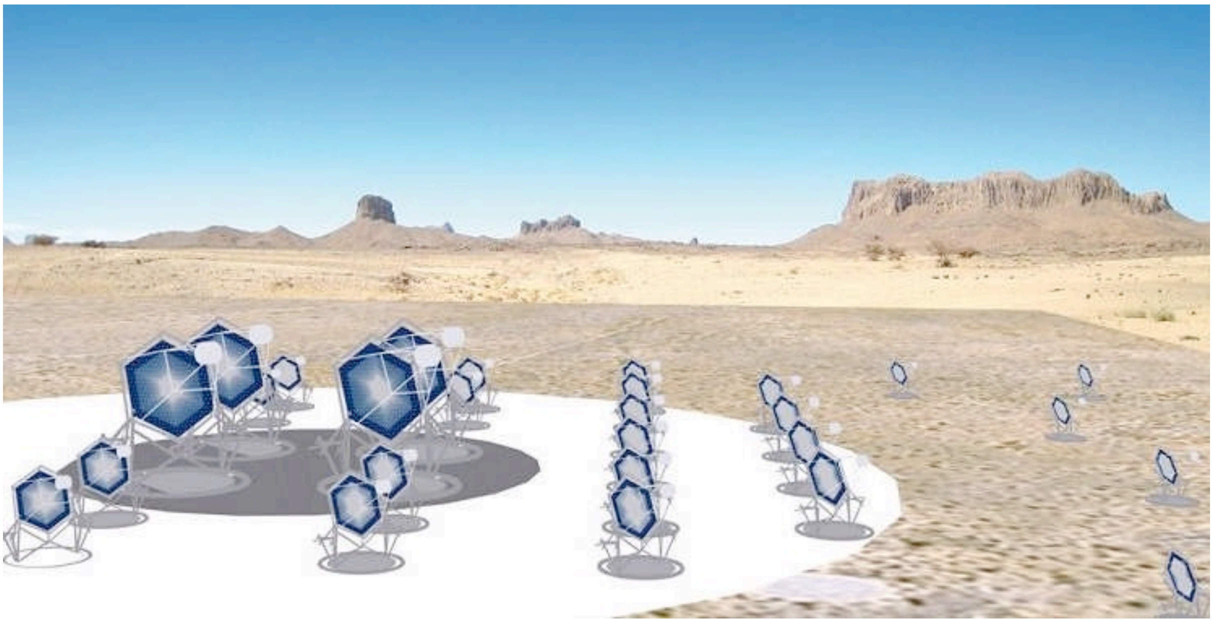
OSSERVATORIO ASTROFISICO DI CATANIA

Characterization Test of SiPM FBK

Device: NUV-HD



Osservatorio Astrofisico di Catania

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Rapporti interni e tecnici
N.08/2015

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Characterization Test of SiPM FBK NUV-HD Measures of: Dark Stairs, Dark Count Rate and Cross-Talk

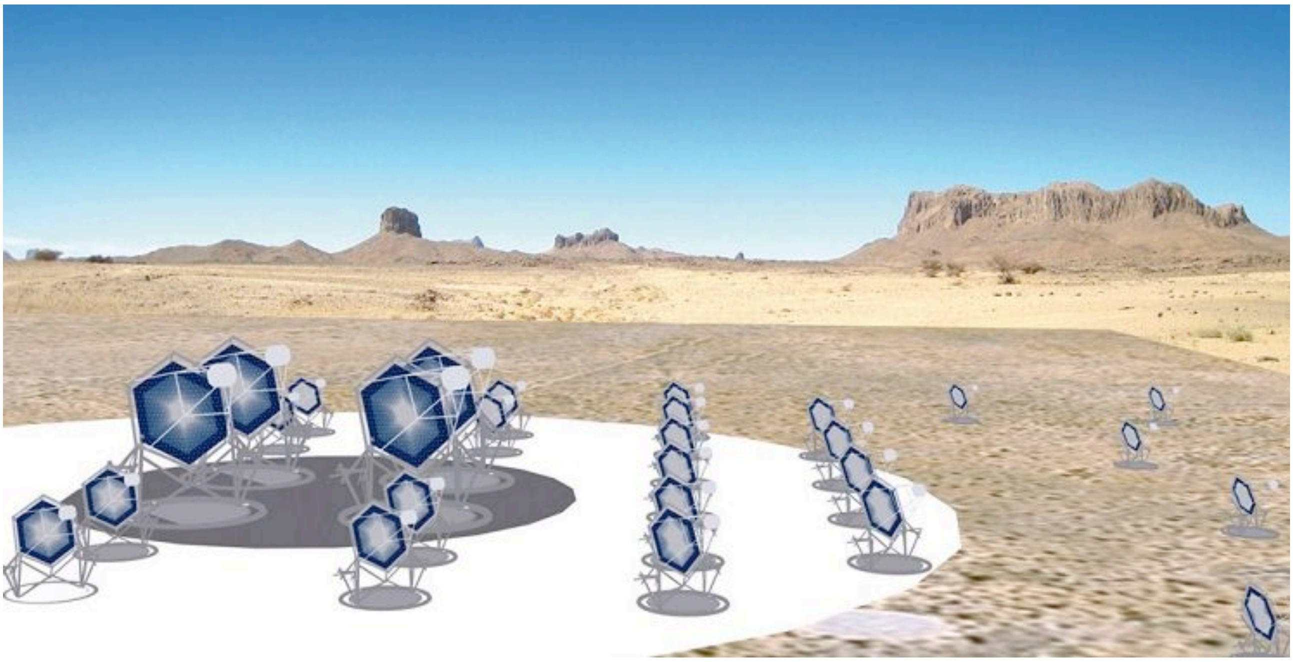

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TABLE OF CONTENTS

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LIST OF ACRONYMS

OACT	Osservatorio Astrofisico di Catania
IFC	Istituto di Astrofisica Spaziale e Fisica Cosmica di Palermo
COLD	Catania astrophysical Observatory Laboratory for Detectors
PCB	Printed Circuit Board
SiPM	Silicon Photo-Multiplier
MPPC	Multi Pixel Photon Counter
SST-2M	Small-Size Telescope Dual-Mirror
PDM	Photon Detection Module
ASIC	Application Specific Integrated Circuit
FEE	Front-End Electronics
BEE	Back-End Electronics
FPGA	Field Programmable Gate Array
EASIROC	Extended Analogue Silicon-pm Integrated Read-Out Chip
CITIROC	Cherenkov Imaging Telescope Integrated Read-Out Chip
I/F	Interface
LCT	Low Cross Talk
PSAU	Power Supply and Amplification Unit

1. INTRODUCTION

This document discusses on some measurement results of the SiPM most relevant characteristics: dark stairs, cross-talk (XTalk) and dark count rate (DCR), carried out at the Catania astrophysical Observatory Laboratory for Detectors (COLD) on a class of recently available detectors by FBK.

2. MEASUREMENT SYSTEM

A Xenon lamp is used as a radiation source; a wavelength selection system constituted by a set of band-pass filters and mirrors, and a Czerny-Turner monochromator are exploited to achieve the desired wavelength in the 130-1100nm spectral range, with a FWHM smaller than 1nm. A beam splitter is employed to direct the monochromatic radiation through an optical lens towards an integrating sphere, which hosts, in one port, a 1-cm^2 NIST-traced reference photodiode and, in a second port, the SiPM sensor to be characterized. The photon flux intensity coming into the integrating sphere can be regulated by means of neutral density filters or changing the aperture of the entrance or exit slits of the monochromator. Due to the small dimensions of the detectors to be characterized with respect to the optical beam, the integrating sphere is used to spatially integrate the radiant flux. Furthermore, appropriate mechanical structures are realized, in terms of both aperture and distance from the centre of the sphere, to illuminate the SiPM detector and the NIST-traced photodiode with the same radiant flux. The reference photodiode allows to evaluate the number of photons per unit area, and then, after a proper rescaling, the number of photons impinging on the detectors under test.

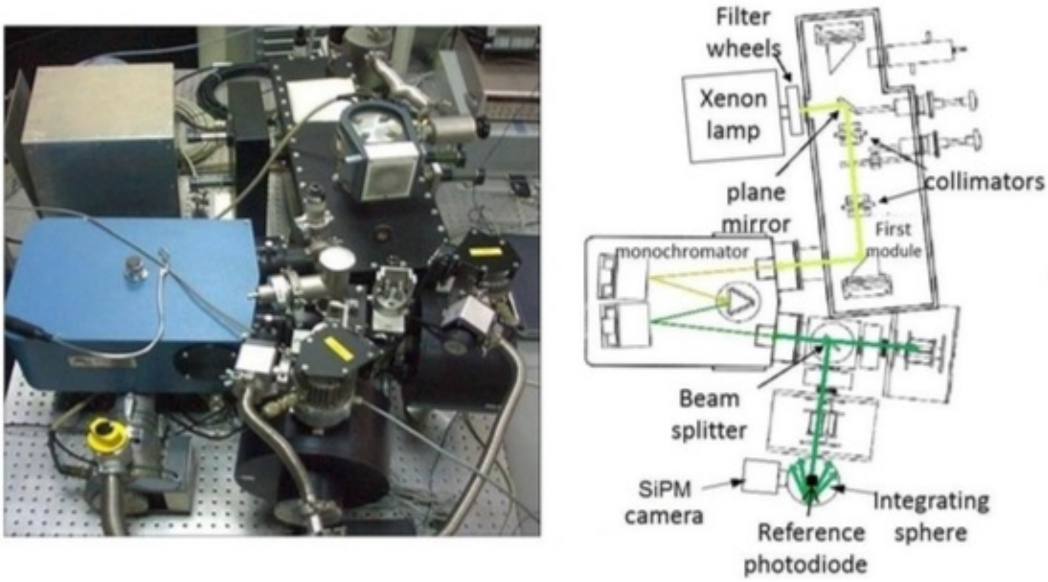


Figure 1. *Simplified schematization of the COLD optical apparatus. On the left side: photograph of the characterization equipment. On the right side: scheme of the implemented mechanical and optical parts of the apparatus, where the green line indicates the light path.*

The SiPM front-end electronics is the Integrated Read-Out Chip (CITIROC) produced by Omega. CITIROC is a 32-channel fully-analog front-end ASIC specifically designed to directly interface SiPM detectors. The Figure 2 shows a photograph of the CITIROC evaluation board with the black light-tight box that prevents accidental light exposure of the SiPM detectors and allows a thermic regulation by means of a cooling system adopting a Peltier thermoelectric cooler device.

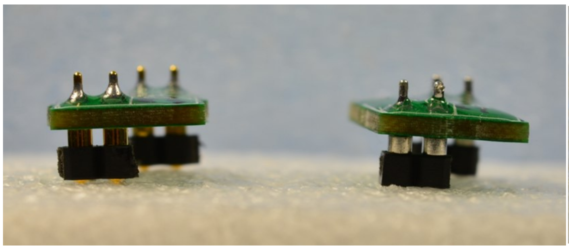
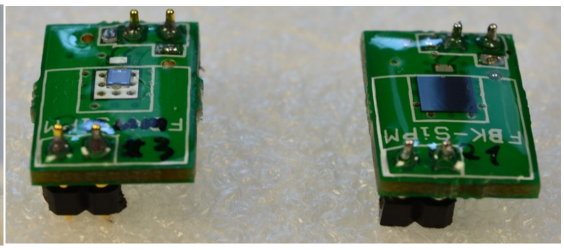
Figure 2. Citiroc evaluation board and the black light-tight box with cooling system based on Peltier TEC.

3. Electrical Characteristics and Physical from Data Sheet.

The characterized SiPM detector presented in this report is the latest device series manufactured by FBK. The following table reports the main physical features of the characterized detector.

Device Series	*NUV - HD*
device size	$1\times1mm^2$
fill factor	77%
Breakdown voltage	25,68V
Recovery Time	75ns
DCR	230KHz/mm2 @20°C@9V
cell pitch	30µm

Device Series	*NUV - HD*
device size	$4\times4mm^2$
fill factor	73%
Breakdown voltage	25,82V
Recovery Time	73ns
DCR	200KHz/mm2 @20°C@9V
cell pitch	25µm

4. Measurements Results

Staircase and Cross-Talk Measurements

Dark current and optical cross-talk are the main crucial parameters affecting the performance of SiPM detectors. The Dark Count Rate (DCR) is defined as the number of avalanche current pulses produced by thermally generated carriers simulating the detection of single photons at a certain bias voltage. Since the dark noise is comprised of a series of time pulses, its magnitude is often quoted as a pulse rate, typically expressed in kHz or MHz.

It is extremely important that the SiPM operating conditions are maintained stable versus the working temperature during the measurements. The dark signal is amplified and discriminated , generating a logic output pulse each time a dark pulse crosses a predefined voltage level, allowing to select the appropriate threshold.

Optical cross-talk occurs when optical photons that are emitted by accelerated charge carriers undergoing an avalanche propagate towards neighboring diode pixels where, depending on their energy and location, they have a certain probability to generate an additional Geiger avalanche discharge; as a consequence, since the original and neighbor avalanches may occur almost simultaneously (on the same scale of few nanoseconds), single absorbed photons may generate output signals equivalent to more than 1-pe (photoelectron) avalanche events. The experimental approach used for assessing the SiPM cross-talk probability relies on the analysis of DCR measurement results. The SiPM optical cross-talk is evaluated from the DCR data as the ratio between the first and the second event count rate.

In Figure 3 is shown the connection between FBK device and the electronics CITIROC through the use of light-tight box.

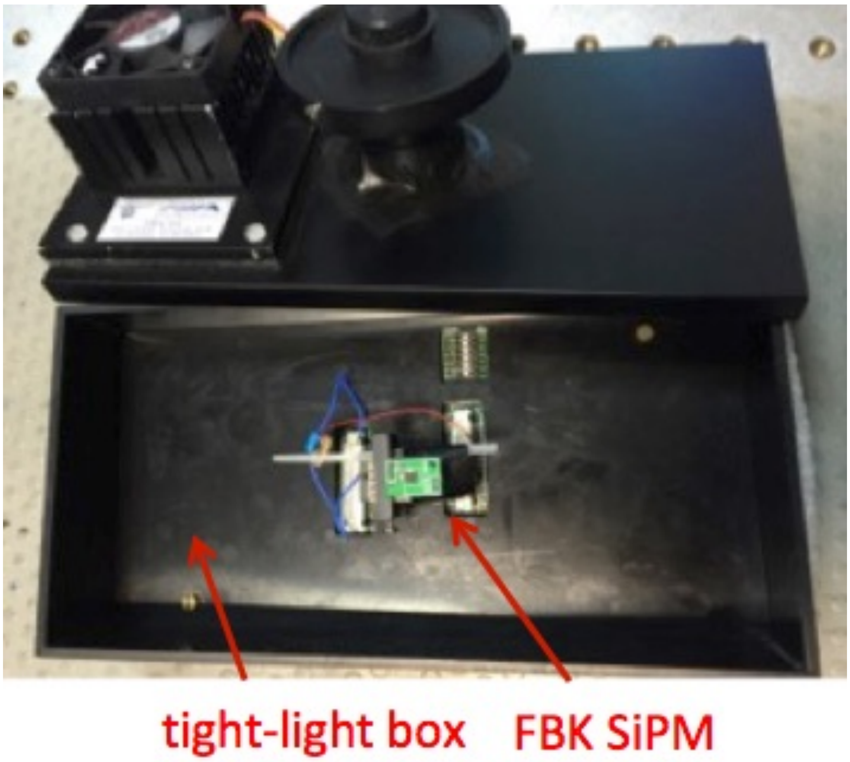


Figure 3. Connection with the CITIROC amplifier

In Figure 4, Figure 5 and Figure 6 are shown the staircase, cross-talk and DCR at 20°C and at different overvoltage with the use of the CITIROC.

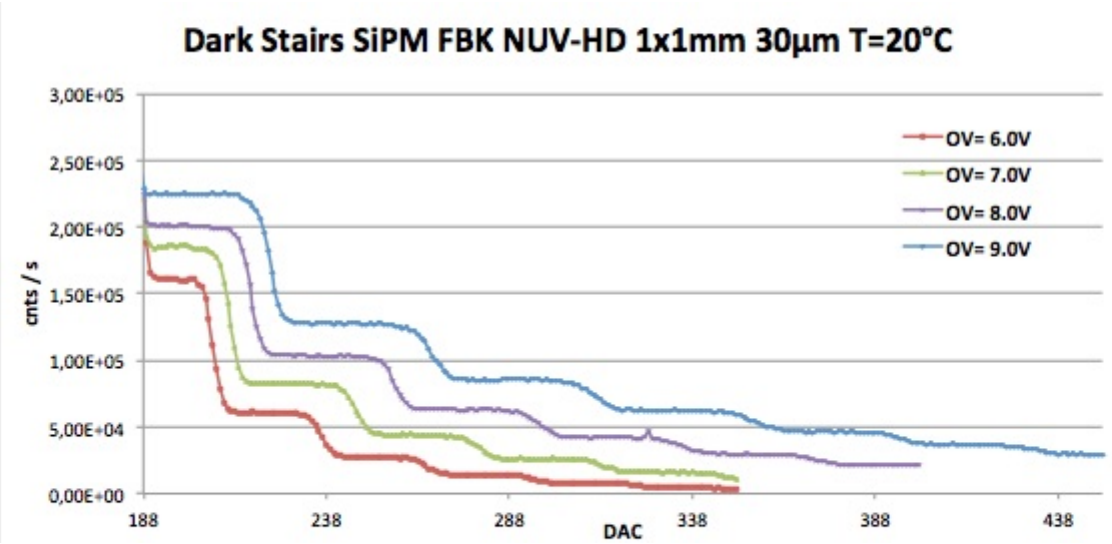


Figure 4. FBK NUV-HD 1×1mm^2 *Staircase at 20°C and at different overvoltages with the use of the CITIROC.*

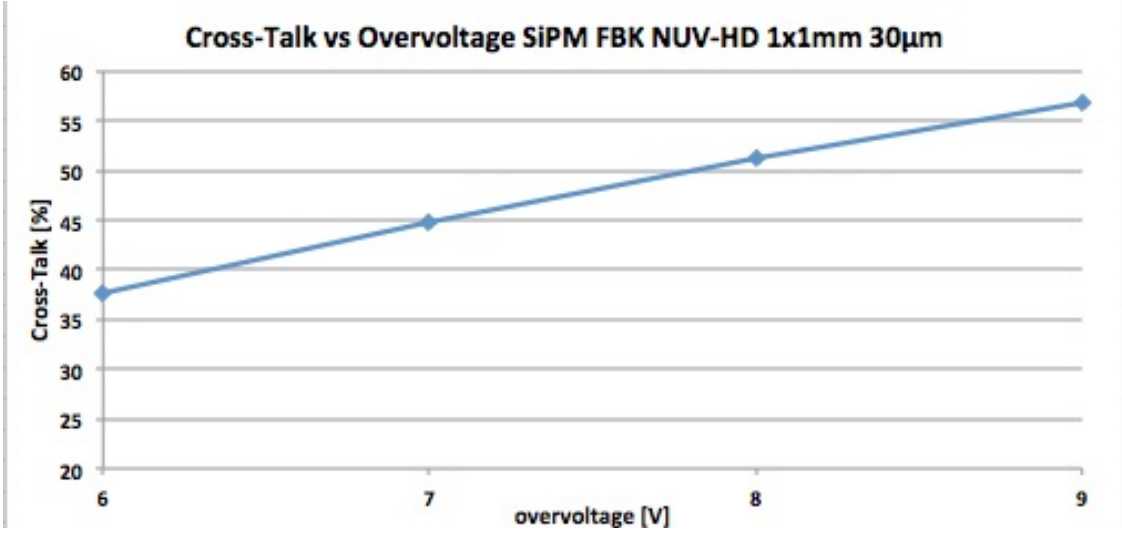


Figure 5. FBK NUV-HD 1×1mm^2 *Cross-Talk at different overvoltages with the use of the CITIROC.*

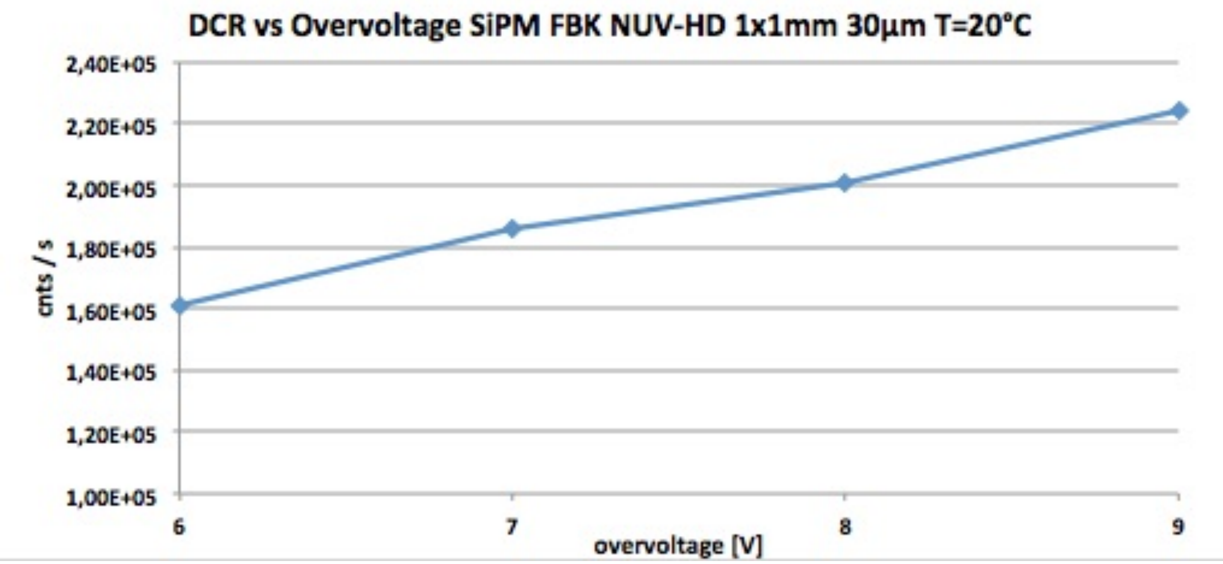


Figure 6. FBK NUV-HD 1×1mm^2 *Dark Count Rate at different overvoltages with the use of the CITIROC.*

In Figure 7, Figure 8 and Figure 9 are shown the staircase at 11.5°C and 10°C at different overvoltage with the use of the CITIROC.

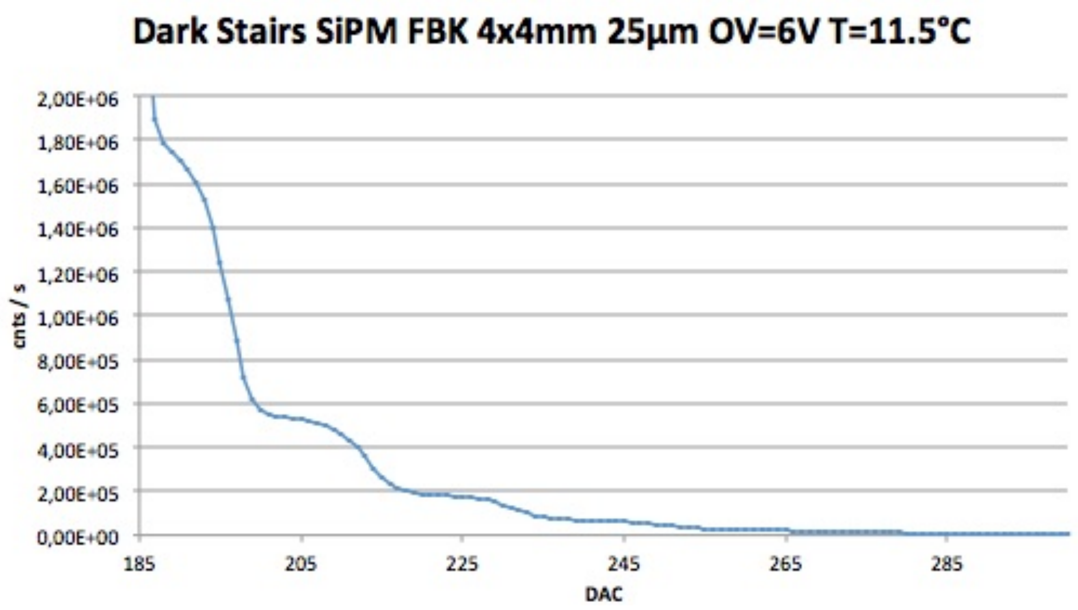


Figure 7. FBK NUV-HD 4×4mm^2 *Staircase at 11.5°C and at 6V of overvoltage*

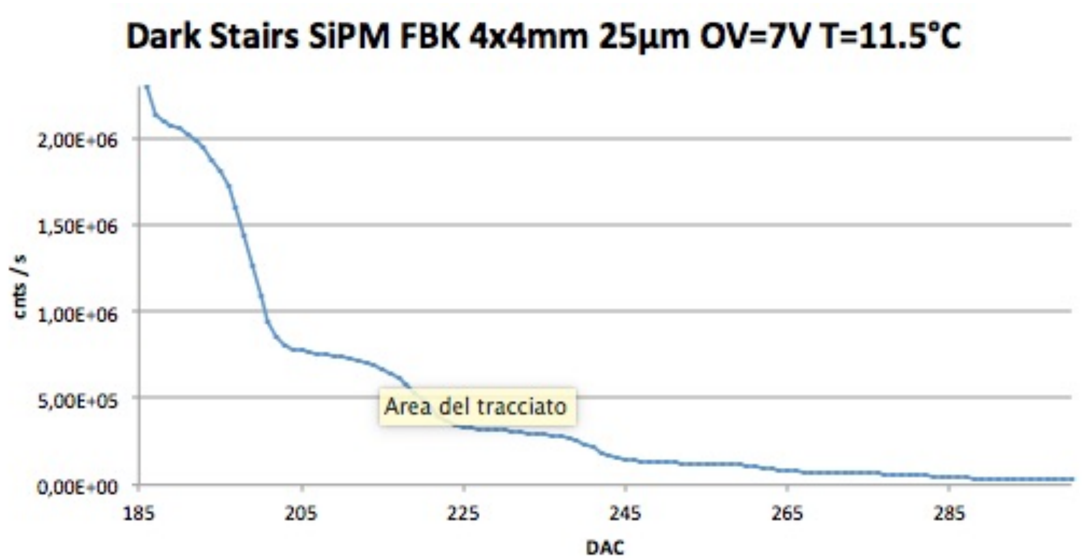


Figure 8. FBK NUV-HD 4×4mm^2 *Staircase at 11.5°C and at 7V of overvoltage*

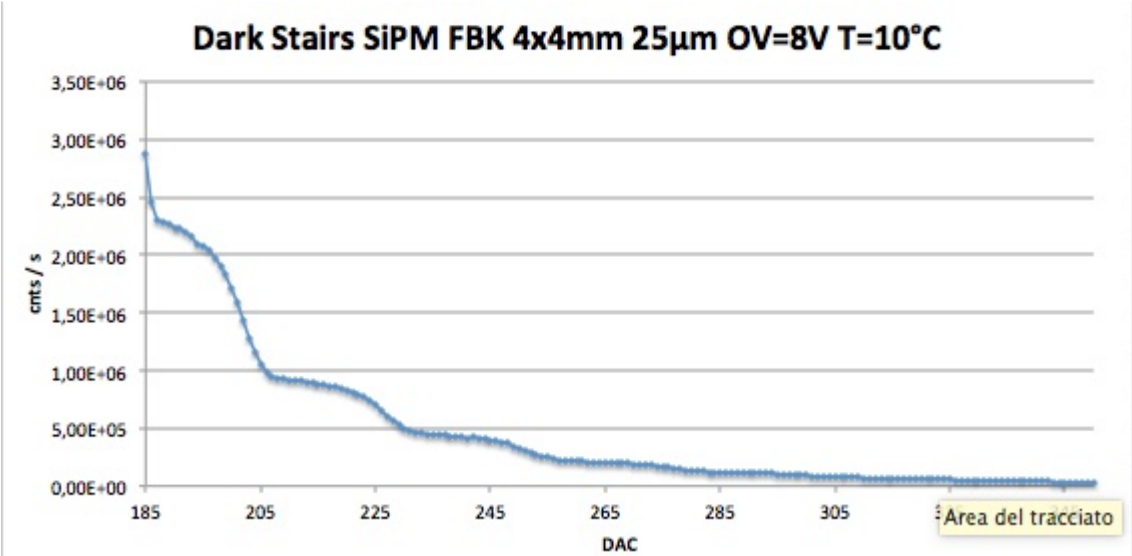


Figure 9. FBK NUV-HD 4×4mm^2 *Staircase at 10°C and at 8V of overvoltage*

In this case as you can see from Figures 7, 8 and 9, the XT can not be evaluated.

All files related to the experimental measurements presented in this report, are located in the database on the PC-LAB (COLD) site Astrophysical Observatory of Catania, path C:\Users\CCDLab1\Desktop\Romeo\Misure

5. CONTACTS

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