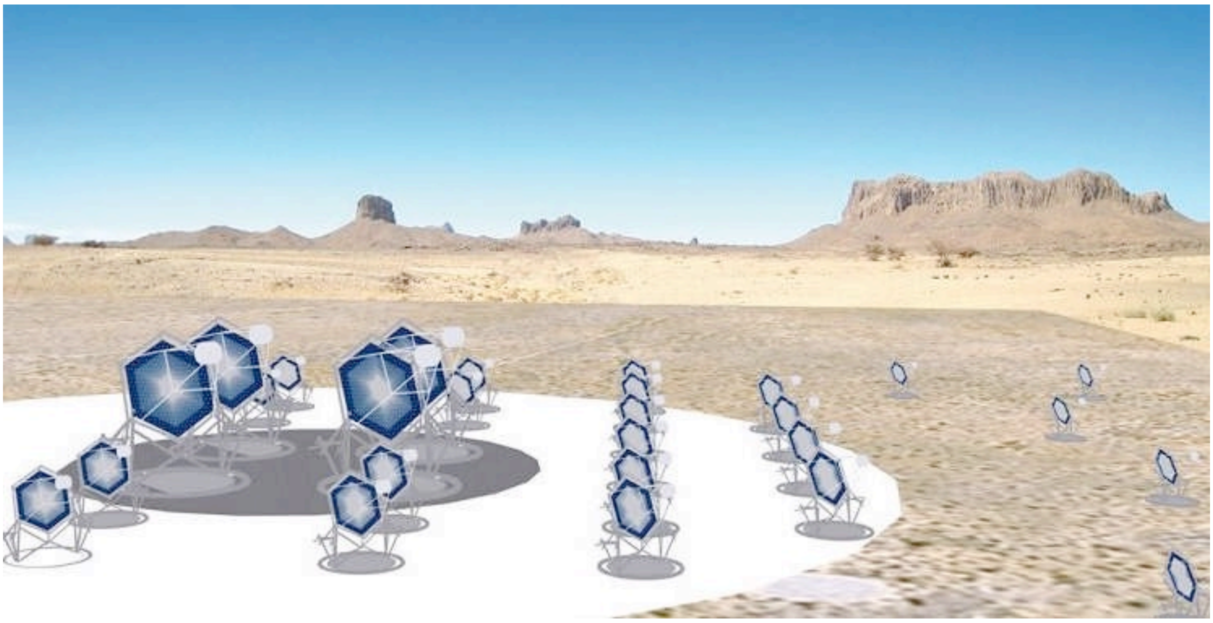
OSSERVATORIO ASTROFISICO DI CATANIA

Characterization Test of New Generation Low Cross-Talk MPPCs

Device: LCT5 with cell pitch 50μm



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Rapporti interni e tecnici
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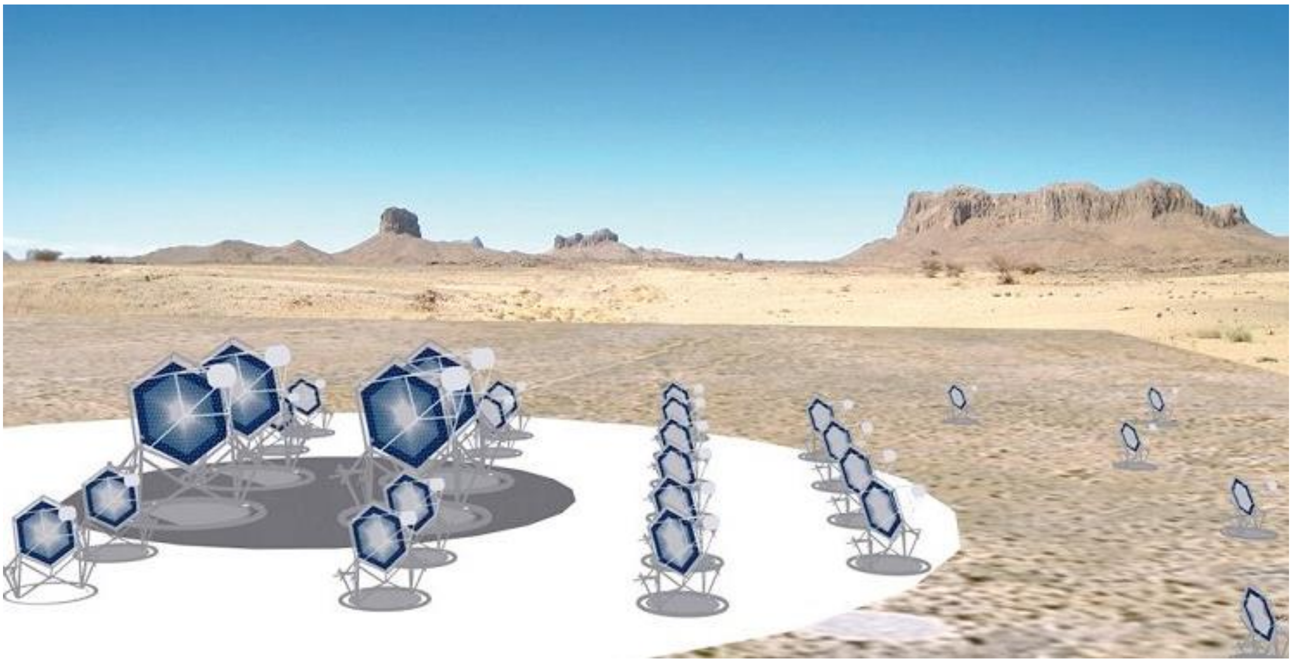
Characterization Test of New Generation Low Cross-Talk MPPCs

Series: LCT5 with cell pitch 50μm



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DOCUMENT HISTORY

Version	Date	Modification
1.0	Date	first version
		update

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

APPLICABLE DOCUMENTS

[AD1] AD1

REFERENCE DOCUMENTS

[RD1] G. Bonanno, et al., “Characterization Measurements Methodology and Instrumental Set-up Optimization for New SiPM Detectors - Part II: Optical Tests”, IEEE Sensors Journal, vol. 14, no. 10, pp. 3567-3578, 2014.

[RD2] G. Bonanno, et al., “Characterization Measurements Methodology and Instrumental Set-up Optimization for New SiPM Detectors - Part I: Electrical Tests”, IEEE Sensors Journal, vol. 14, no. 10, pp. 3557-3566, 2014.

[RD3] G. Romeo and COLD Team, “Characterization Test of New Generation Low Cross-Talk MPPCs – Series: LCT1 with cell pitch 50 µm”, ASTRI-TR-OACT-3200-020

[RD4] G. Romeo and COLD Team, “Characterization Test of New Generation Low Cross-Talk MPPCs – Series: LCT4 with cell pitch 50 µm”, ASTRI-TR-OACT-3200-021

1. INTRODUCTION

This document discusses on measurement results of the SiPM most relevant characteristics: photon detection efficiency (PDE), cross-talk (XTalk), dark count rate (DCR), and gain, carried out at the Catania astrophysical Observatory Laboratory for Detectors (COLD) on a novel class of recently available MPPC detectors by Hamamatsu.

2. SCOPE

The main goals of this work is to evaluate the best features of these new devices in order to choose the best detector for new telescopes for the mini array SST-2M.

3. 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.

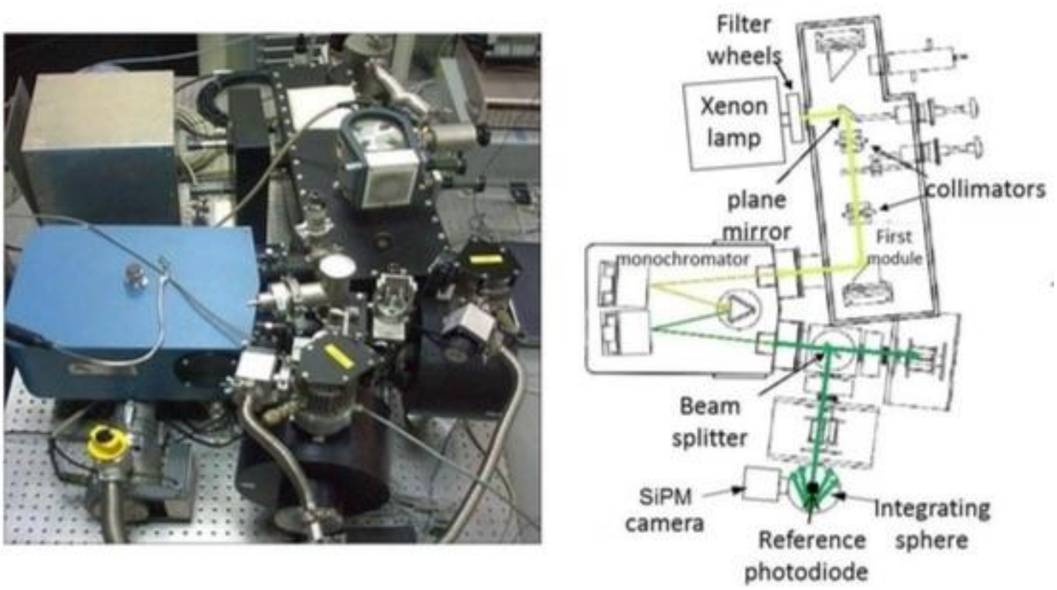

Figure 1. Simplified schematization of the COLD optical apparatus. On the left side: photograph of the characterization equipment. On the right side: scheme of the implemented mechanical and optical parts of the apparatus, where the green line indicates the light path.

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.

4. Electrical Characteristics and Physical from Data Sheet.

The characterized SiPM detector presented in this report is the latest device series manufactured by Hamamatsu and identified by the definition of Low Cross-Talk (LCT) MPPCs. The following table reports the main physical features of the characterized detector.

Device Series	*LCT5*
serial number	001
cell pitch	50 μm
device size	3×3 mm^2
micro-pixels	3600
fill factor	74%
Breakdown voltage	52.5V

5. Measurements Results

Gain Measurements

For the gain measurements we used the setup reported on **[RD2]**. As explained on the cited reference, a pulsed diode laser illuminates the SiPM detector with a photon flux of adjustable intensity and duration. A mechanical adapter connects the laser head to the SiPM detector housed in the CAEN PSAU. The obtained gain data points as a function of the applied overvoltage OV at room temperature are reported in Figure 3.

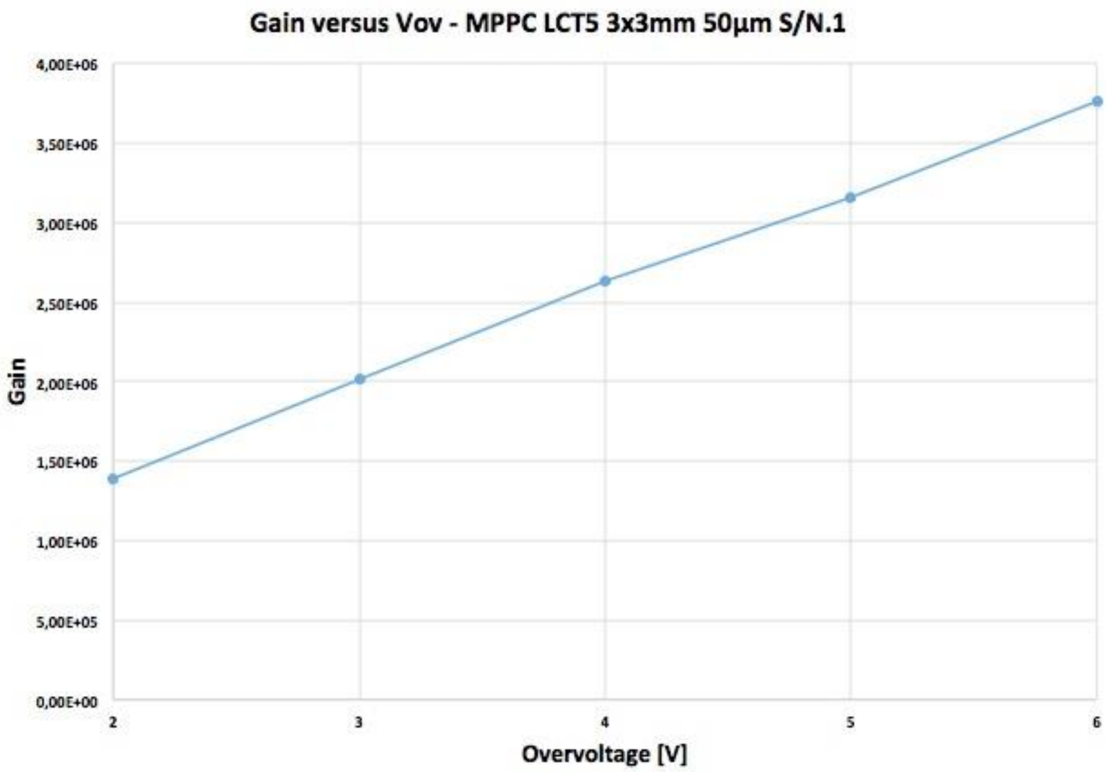

Figure 3. LCT5 Gain at room temperature and at different overvoltages.

Staircase and Cross-Talk Measurements

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. 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 4 and Figure 5 are shown the staircase and cross-talk at room temperature and at different overvoltage while in Figure 6 is shown the dark count rate.

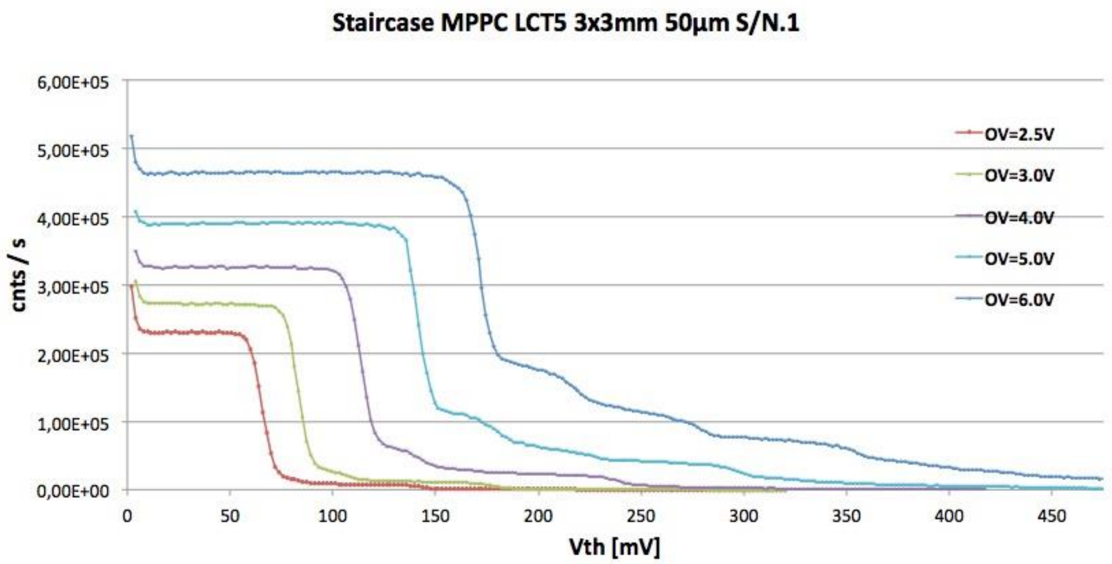

Figure 4. LCT5 Staircase at room temperature and at different overvoltages.

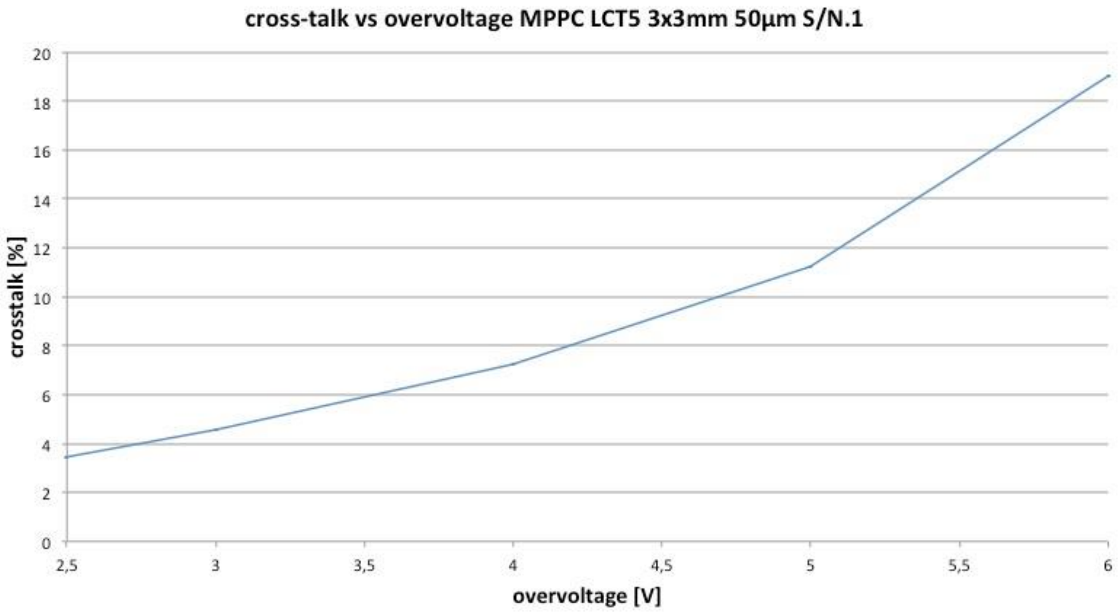

Figure 5. LCT5 the optical cross-talk probability at different overvoltages.

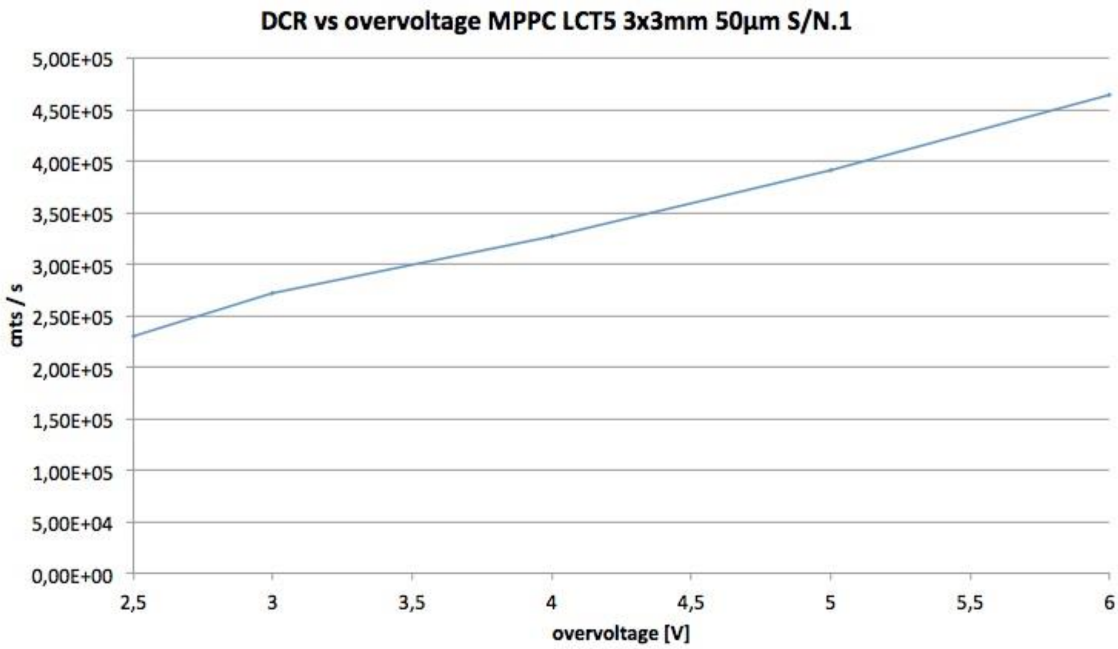

Figure 6. LCT5 Dark Count Rate at room temperature and at different overvoltages.

Photon Detection Efficiency Measurements

Measurements were performed at different overvoltage. We worked in such illuminating condition to avoid, from one side low photocurrent levels measured by the calibrated photodiode and from the other SiPM saturation. For this reason in front of the SiPM has been placed a neutral density filter calibrated at our laboratory. The introduction of the filter allows us to work with higher signals on the NIST photodiode with a consequent reduction of error bars.

In Figure 7 and Figure 8 are shown the PDE at different overvoltages and in Figure 9, the PDE versus crosstalk for two wavelengths in particular ad 320nm and 450nm.

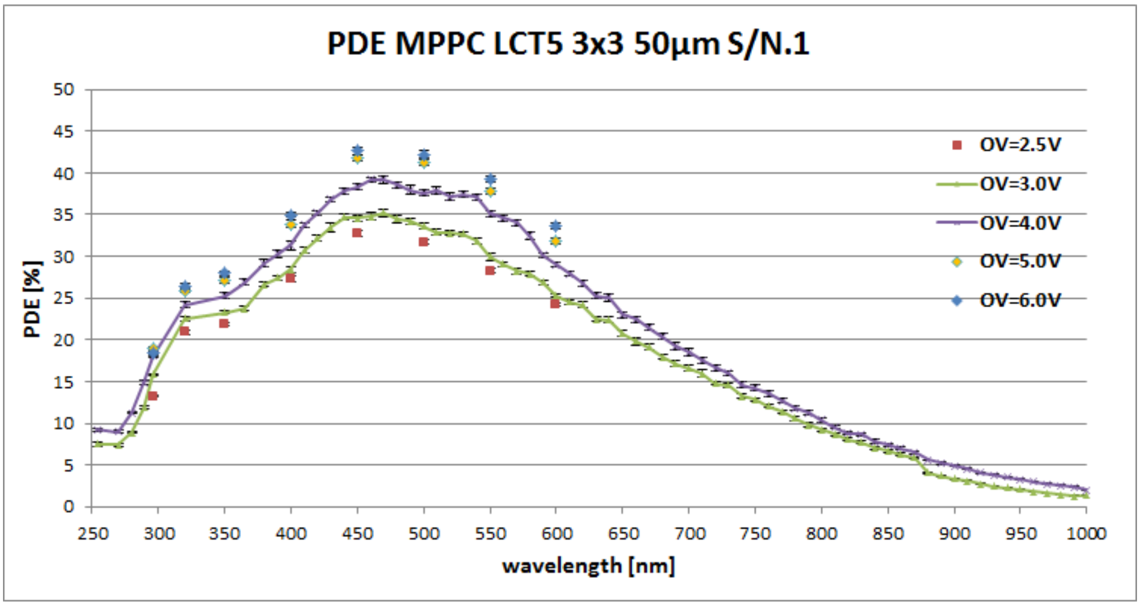

Figure 7. LCT5 Photon Detection Efficiency at different overvoltage

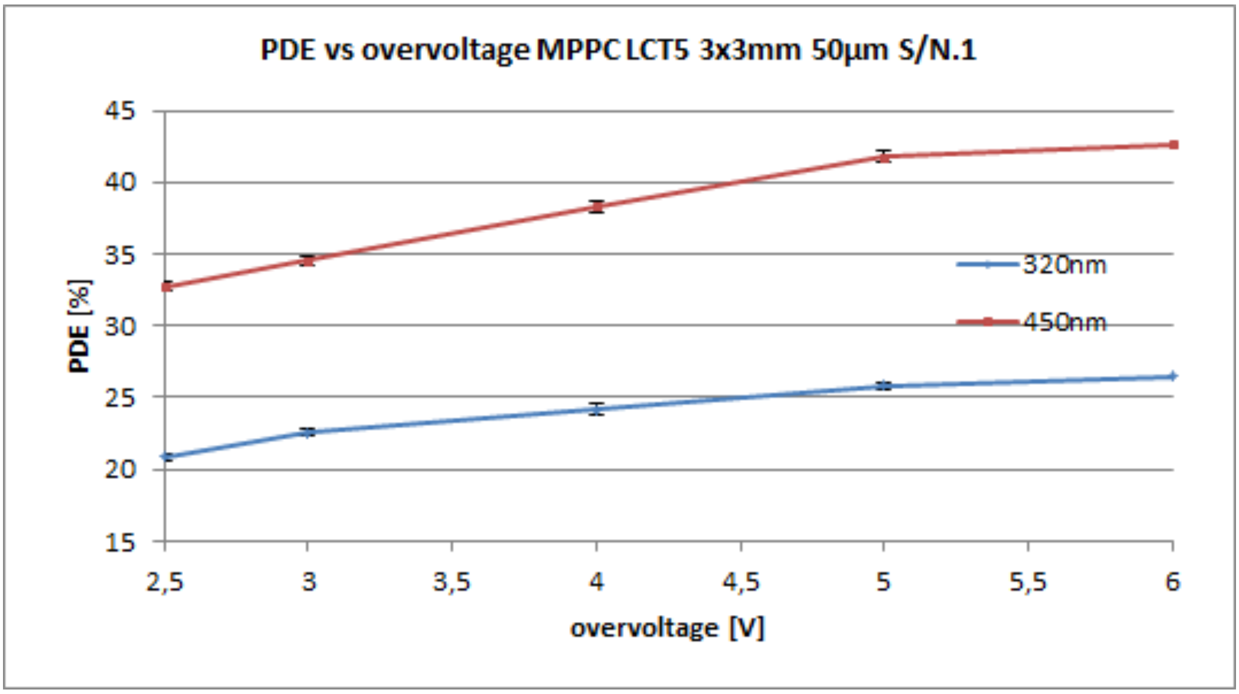

Figure 8. LCT5 PDE versus overvoltage

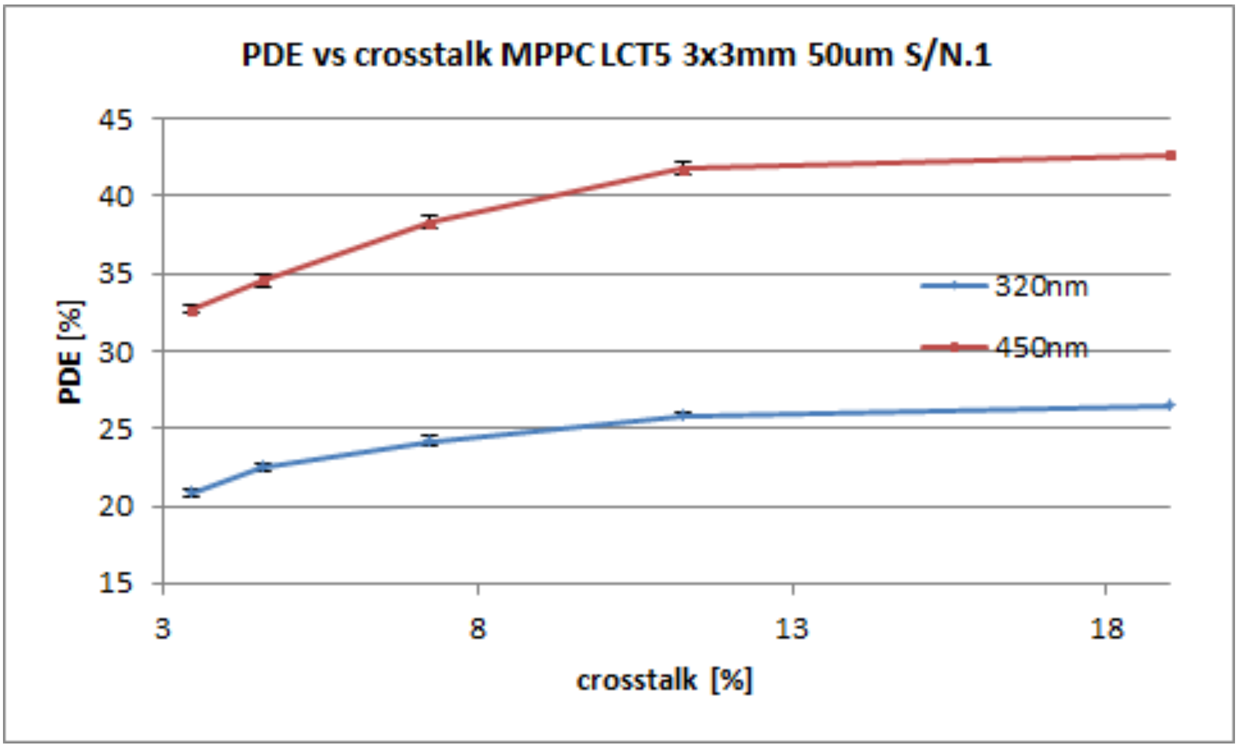

Figure 9. LCT5 PDE versus Cross-Talk

From Figure 9 it is clearly evident that the device shows less than 10% of cross-talk with PDE(450 nm) greater than 40% that is obtained at 3V of overvoltage.

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

6. CONTACTS

The team working on the electronic design of the ASTRI camera is composed by people from INAF's Catania Astrophysical Observatory and Palermo IFC. It is also referred to as the Electronics Camera Team.

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