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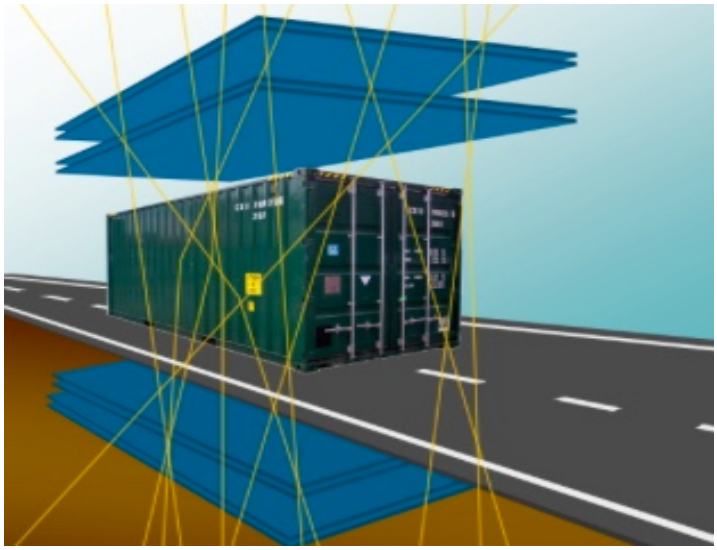
SiPM characterization report for the Muon Portal Project

Electro-optical results of the SiPM chosen for the initial configuration of the Muon Portal



Osservatorio Astrofisico di Catania

G.ROMEO(1)

(1) INAF – Osservatorio Astrofisico di Catania

Rapporti interni e tecnici
N.09/2013

Progetto "Muon Portal"

Giuseppe Romeo

SiPM CHARACTERIZATION REPORT

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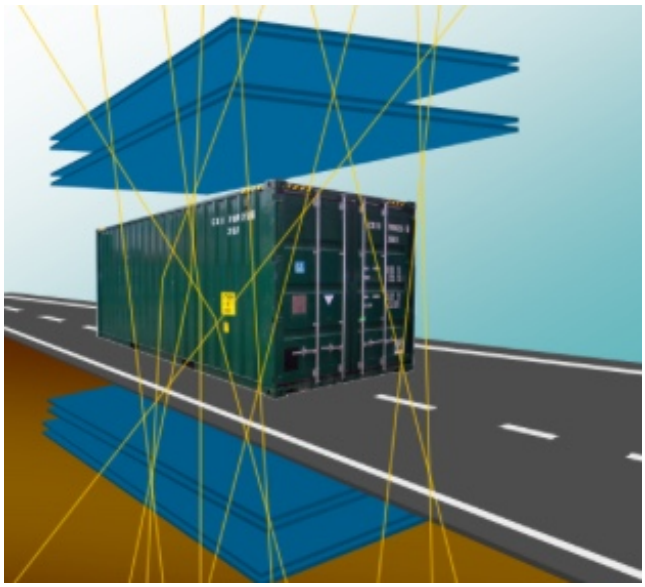


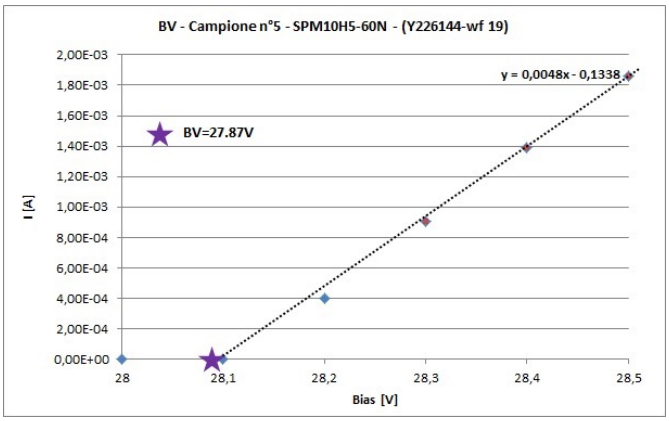
Introduction

In this report are presented (in summary) the characterization results of the SiPMs used in the project muon portal.
Among the various technologies was chosen the N on P type SiPM with substrate medium doping. The selection has been based on the optical characteristics in terms of PDE, dark counts rate and cross-talk.
The following table reports the SiPM specifications:

Parameter	*Unit*	*Value*
Sensitive area size	μm^2	**1080 × 1080**
Cells matrix dimension		**18 × 18**
Number of cells		**324**
Cell fill factor	%	**67.4**
Cell size	μm^2	**60 × 60**
Quenching resistor squares number		**28**
Quenching capacitor area	μm^2	**26**
Cell active area	μm^2	**2427**
Cell perimetral area	μm^2	**844**
Bonding pad area	μm^2	**150 × 150**
Metal grid area (2 pads included)	**μm^2**	**161802**

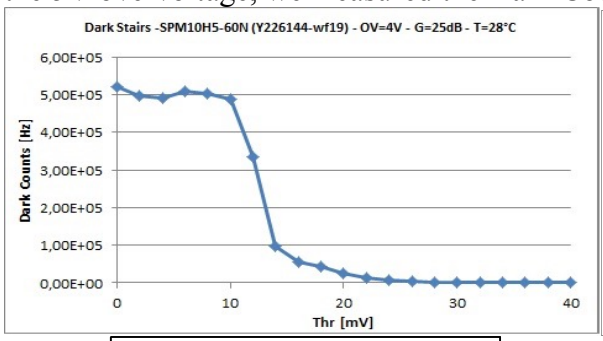
-Breakdown Voltage

The V_{BD} was measured from the voltage-current measurements and tracing the intercept between the line of best fit (range from 1mA to 2mA) and the x-axis.
Here follows the plot of the I-V characteristic and the break-down voltage for this SiPM is 27.87 V.

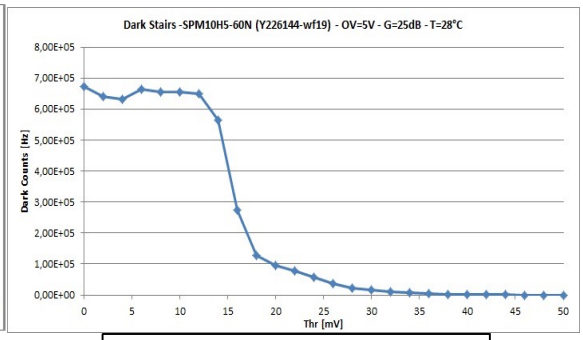


-Staircase and Cross-talk at OV=4V and 5V

By varying the threshold from 0mV to 48mV (corresponding to 0pe ÷ 4pe) for the 4V overvoltage and by varying the threshold from 0mV to 80mV (corresponding to 0pe ÷ 4pe) for the 5V overvoltage, we measured the Dark Count Rate.



From the data we derive:
Xtalk=0.46%
Dark= 500 KHz @0.5 pe



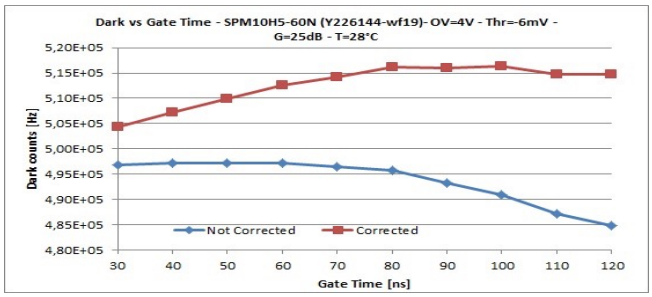
From the data we derive:
Xtalk=0.95%
Dark= 650 KHz @0.5 pe

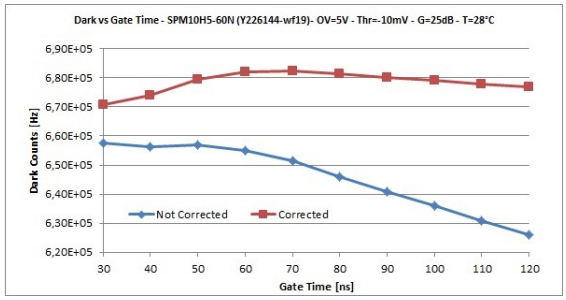
-Electro-optical characterization

The characterization includes the following steps:

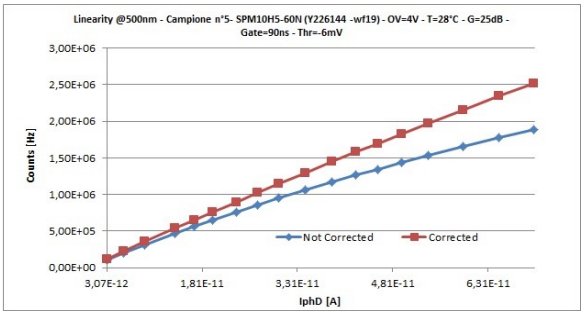
1. The Staircase to select the appropriate threshold,
2. The Dark Count Rate (DCR) at different gate time in order to select the best hold-off time
3. The system linearity to evaluate the best illumination conditions (to avoid the saturation)
4. PDE measurements taking into account the results of the previous steps.

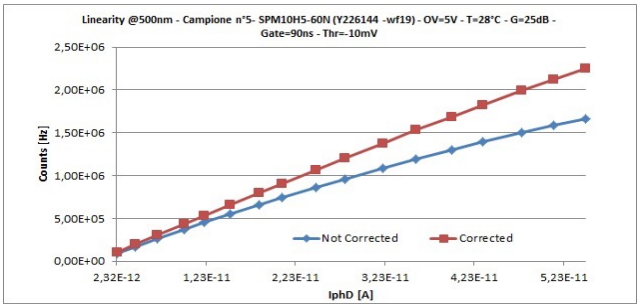
From the two plots of the staircase we derived a Vthr at 0.5pe of -6 mV and -10mV respectively for overvoltage 4V and 5V.
Below are shown the plots of the DCR at different values of gate-time to choose the best time to hold-off





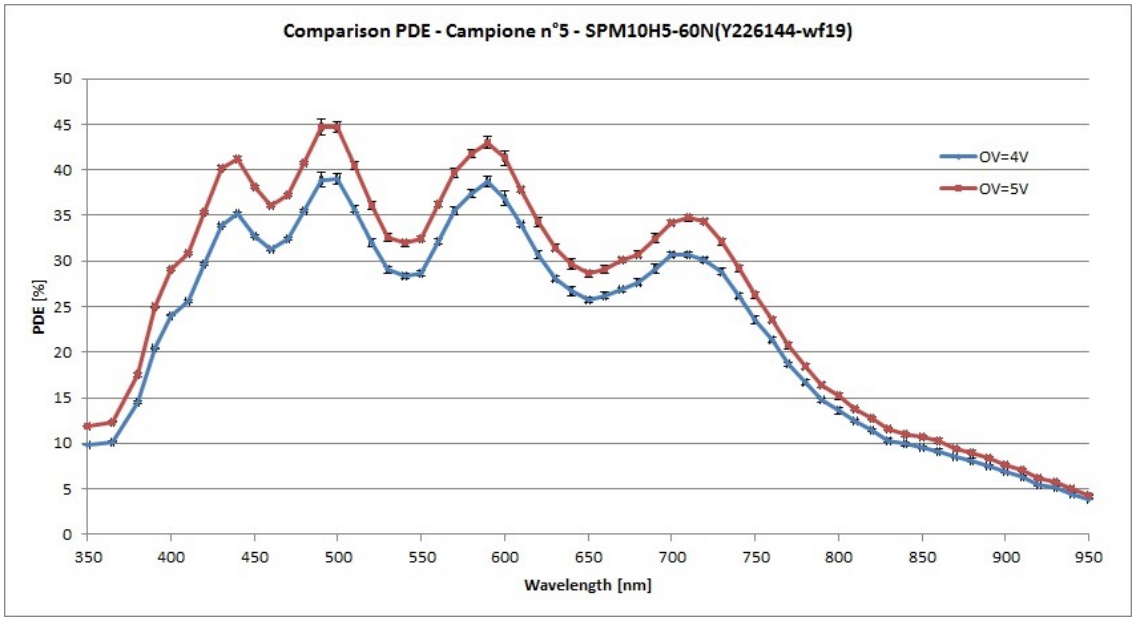
We select as optimal Gate Time $\tau = 90$ ns. The SiPMs have been characterized by using the characterization facility available at the INAF [1] - [2] and taking care of having the best illumination conditions, that means avoiding the system saturation and maintaining a sufficient signal on the NIST calibrated photodiode.
Here will follow the obtained plots of the signal count rate versus the photodiode current at 500 nm and the PDE versus the signal count rate at 500 nm, they show the linearity at 500 nm with and without the dead time correction.





-PDE measurements at over voltages 4V and 5V

The plot reports the PDE with values corrected for the dead time and whitout cross-talk.



- REFERENCES

[1] G.Bonnano, D.Marano, M.Belluso, S.Billotta, A.Grillo, S.Garozzo,G.Romeo, and M.C. Timpanaro, "Characterization Measurements Methodology and Instrumental Set-up Optimization for new SiPM Detectors - Part I: Electrical Tests", *IEEE Sensors Journal,* vol. 14, no. 10, October 2014.

[2] G.Bonnano, D.Marano, M.Belluso, S.Billotta, A.Grillo, S.Garozzo,G.Romeo, and M.C. Timpanaro, "Characterization Measurements Methodology and Instrumental Set-up Optimization for new SiPM Detectors - Part I: Optical Tests", *IEEE Sensors Journal,* vol. 14, no. 10, October 2014.