Development of a SiPM based camera for the Cherenkov Telescope Array

cta cherenkov telescope array

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ABSTRACT The Italian Institute of Nuclear Physics (INFN) is involved in the development of a prototype for a camera based on Silicon Photomultipliers (SiPMs) for the Cherenkov Telescope Array (CTA), a new generation of telescopes for ground-based gamma-ray astronomy. In this framework, an R&D program within the 'Progetto Premiale TElescopi CHErenkov made in Italy (TECHE.it)' for the development of SiPMs suitable for Cherenkov light detection in the Near-Ultraviolet (NUV SiPMs) has been carried out. The developed device is a High-Density (HD) NUV-SiPM based on a micro cell of 30x30 µm² and 6x6 mm² area produced by Fondazione Bruno Kessler (FBK [1]). A characterization of the single SiPM will be presented. The NUV-HD SiPM arranged in a matrix of 8x8 single units will be part of the focal plane of the Schwarzschild-Couder Telescope prototype (pSCT) for CTA. An update on recent tests of the detectors arranged in this matrix configuration and on the front-end electronics will be given.

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1. 6mm x 6mm Area SiPM

A first extensive test campaign was devoted to the study of NUV-HD SiPMs (with cell area of 30x30 µm² and 6x6 mm² pixel size) in single configuration [2]. The current signal is converted to a voltage signal by an Op-Amp based trans-impedance amplifier (Advansid [3]). All the tests are performed in a dark box at room temperature (25ºC). In order to characterize the SiPM, we illuminated it with LEDs at 300, 345, 380 and 460 nm. The interval between 4 and 10 V of OverVoltage (OV) is considered. The SiPM signal is analyzed both in terms of amplitude and charge. Two example distributions are shown in Fig.1.

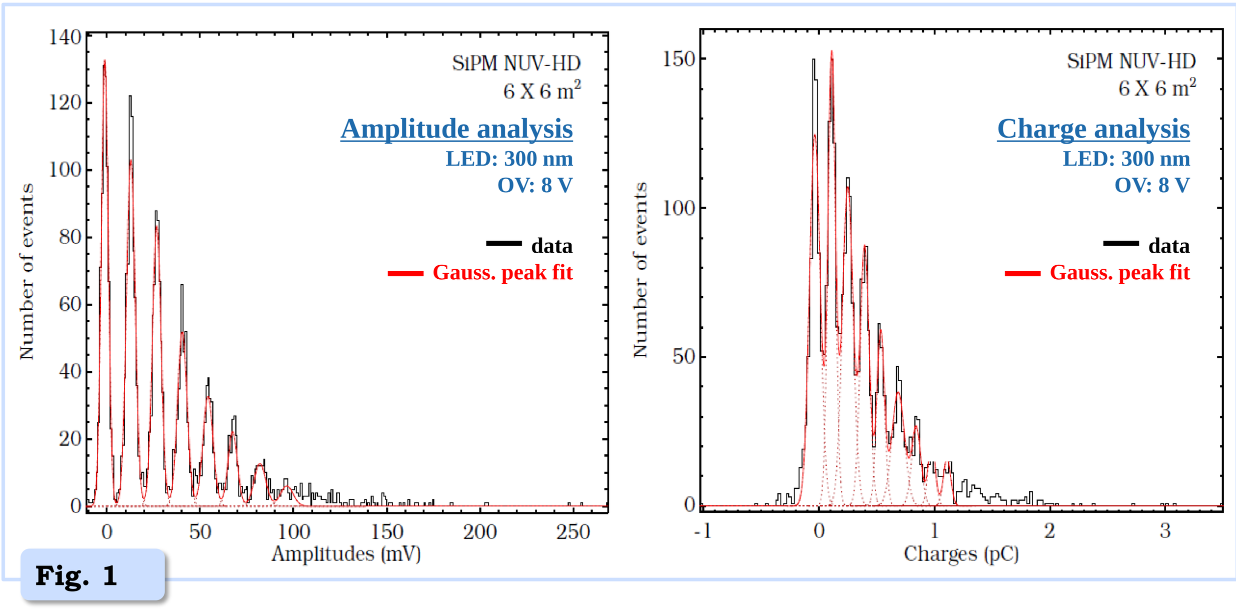

Fig. 1

A systematic study of the opposite trending curves of the SiPM gains and the 1st peak Signal-to-Noise Ratios (SNRs) allows us to choose the best integration time for future analysis (~75 ns, see Fig.2). Moreover, our tests reveal a uniformity in the behavior of the device in terms of gain. Fig.3 shows gains vs. OV, calculated considering different integration times for our 4 LEDs. Values are compatible except for high biases and long integration times due to the fluctuations in the waveform tail.

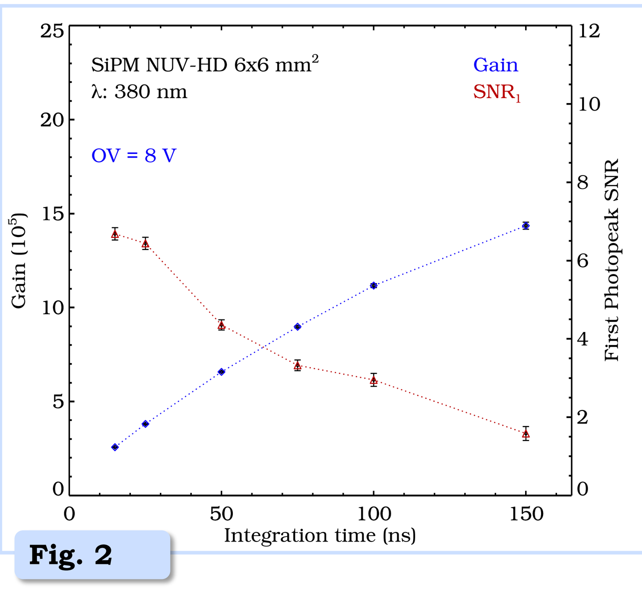

Fig. 2

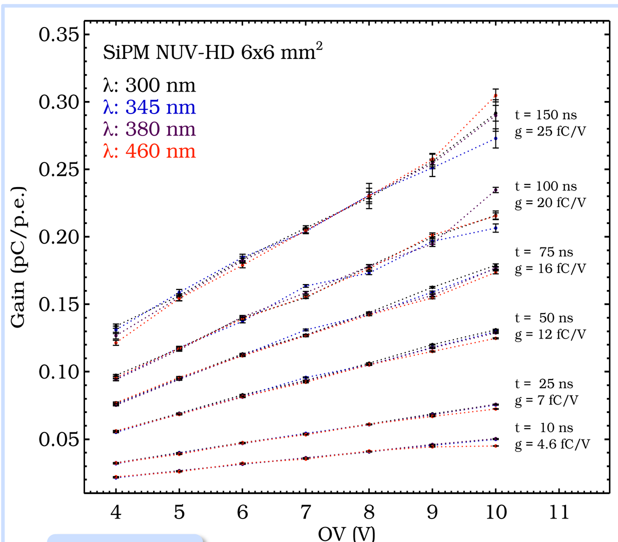

Fig. 3

2. Preliminary study towards an extensive test campaign for pSCT

NUV-HD SiPM with 30x30 µm² and 6x6 mm² pixel size will equip part of the focal plane of pSCT (see Fiandrini's poster). 1600 NUV-HD SiPMs, grouped in units of 64 detectors, will be tested before the installation on the camera in order to verify the uniformity of crucial parameters such as gain and SNR. A preliminary study on a NUV-HD SiPM with 1x1 mm² pixel size has been performed to test the reliability of the DAQ system based on a QDC module V792 that will be employed for the test campaign. First, amplitude, charge distribution and charge as a function of time have been evaluated from waveforms detected using and oscilloscope as shown in Fig.4 and Fig.5.

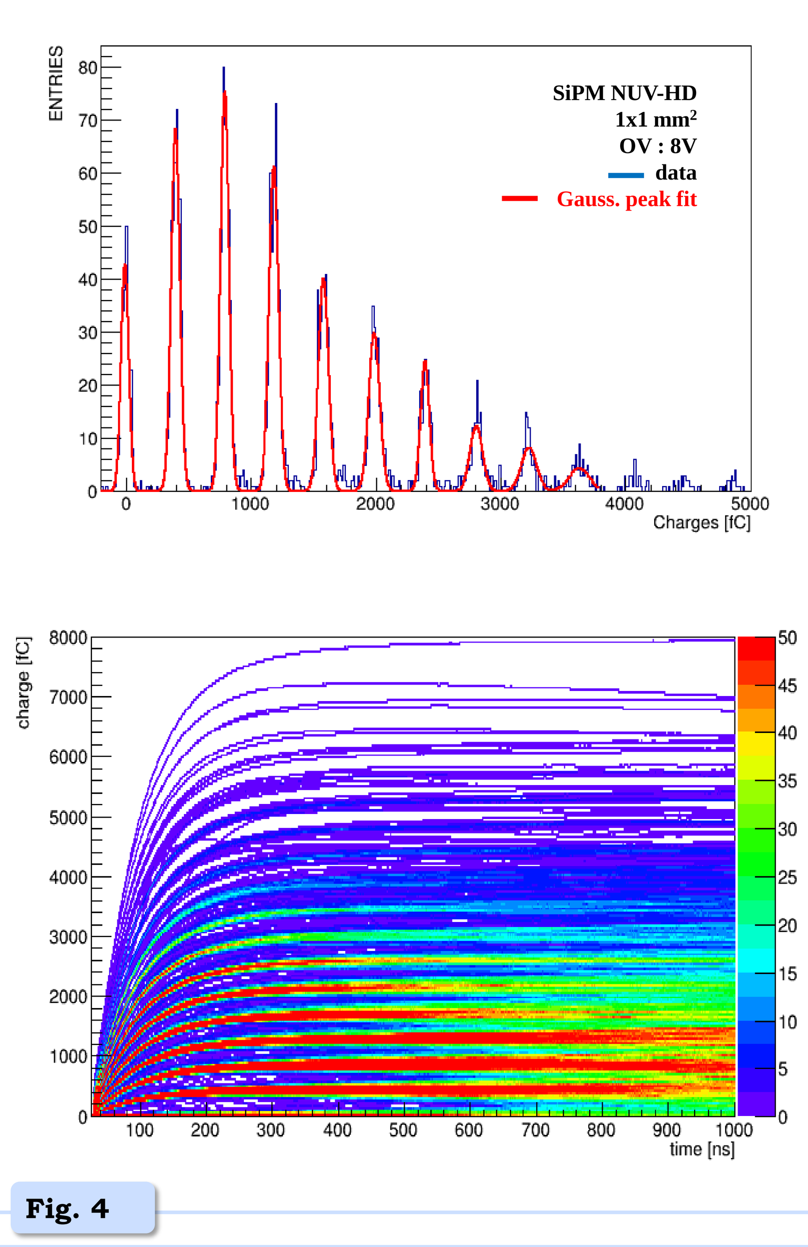

Fig. 4

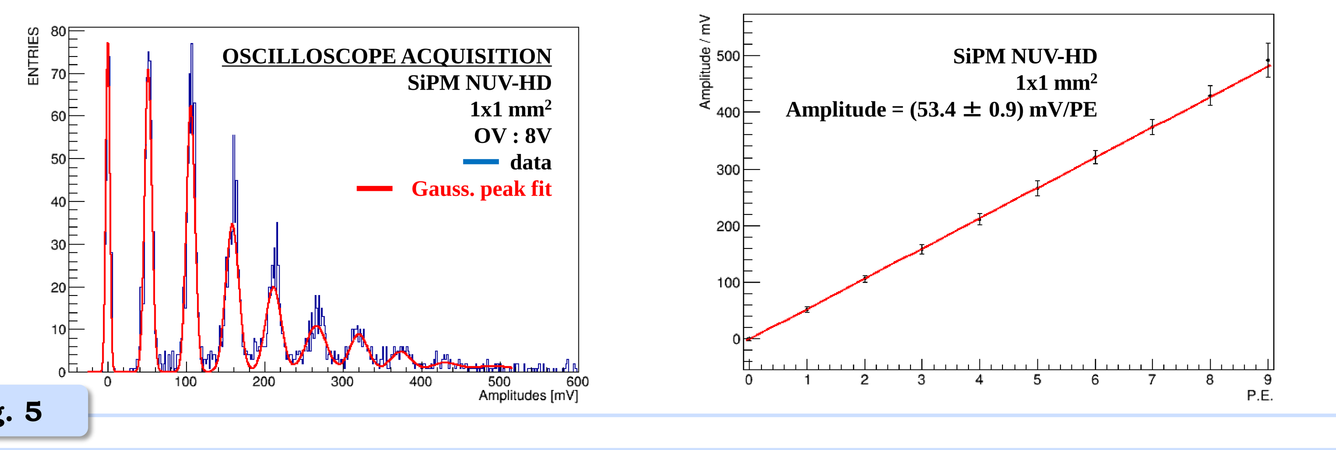

Fig. 5

Then, under the same conditions of V_{bias} and light intensity, analysis of data acquired by the QDC at several gates reveal a structure of charge histogram very similar to the one obtained from the waveform analysis and an agreement between gain and SNR calculated using the two methods.

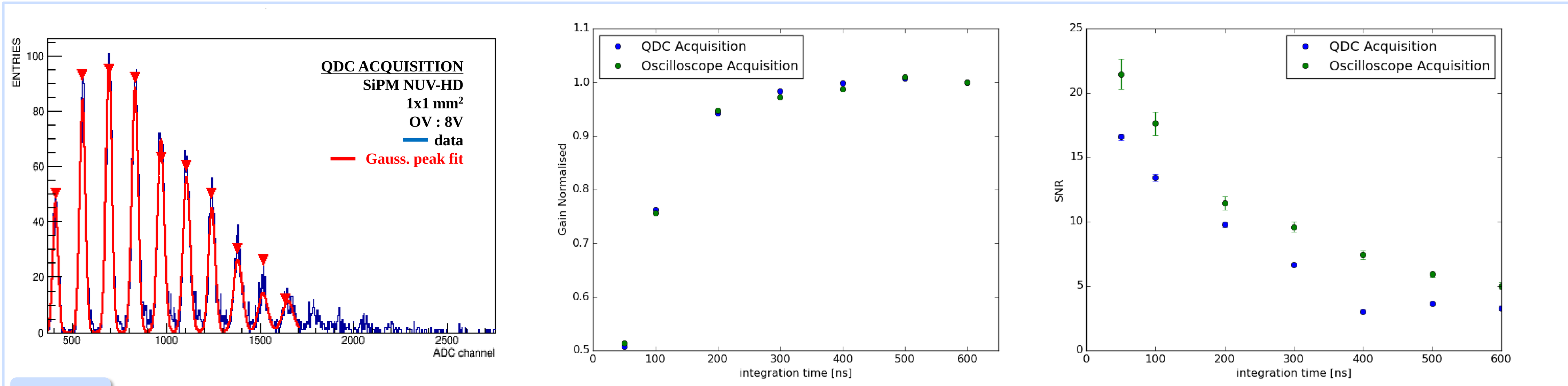

Fig. 6

3. SiPM in matrix configuration

The analysis of the reverse IV characteristic curves measured for all 16 matrix channels indicates that breakdown voltages have a uniform behavior (see Fig.7, top panel). Moreover, we measured waveforms at different OVs (6, 8 and 10 V) by covering all but one channel with a black mask. The bottom panel of Fig.7 shows that SNRs vary between 1.5 and 5.5, whereas amplitudes are characterized by a variation of a few percent. It is interesting to note that the amplitude is generally lower if compared with the previous technology of NUV SiPMs [4]. This fact makes the NUV-HD SiPMs with 6x6mm² area suitable detectors for CTA, if coupled to electronics able to detect and process positive current signals of a few mV per P.E.

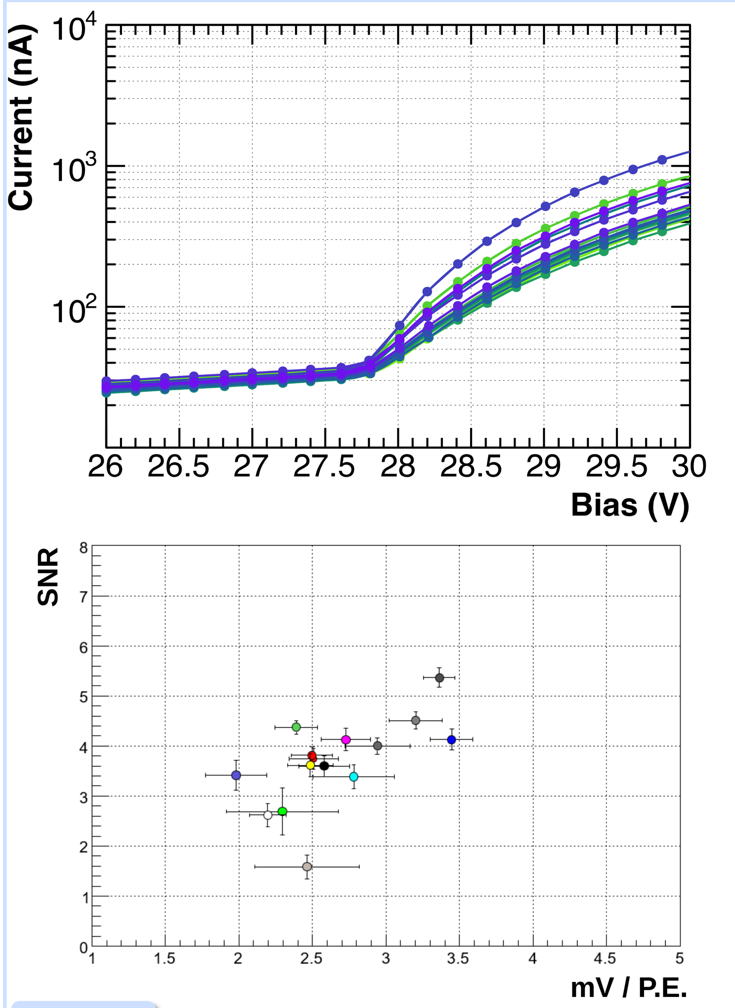

Fig. 7

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