Development of a Charge Preamplifier to improve NUV- HD SiPM performances

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ABSTRACT The development of a new camera based on the use of Silicon Photomultipliers (SiPM) proposed for the Cherenkov Telescope Array (CTA), which represents a new generation of ground based very high energy gamma ray observatory, is one of the main items of the Italian Institute of Nuclear Physics (INFN). In the R&D framework a single channel electronic charge preamplifier has been developed to improve the performance of photon cameras equipped with High Density NUV– HD SiPM produced by Fondazione Bruno Kessler (FBK) [1] with a micro cell of 30 μm x 30 μm and 6 mm x 6 mm total area. The single channel preamplifier will be used as basic component for a 16-channel electronic board prototype to test the 8 x 8 NUV – HD SiPM modules proposed to equip a pSCT (Schwarzschild-Couder Telescope prototype) camera. In this work the results of tests on the single channel preamplifier prototype to optimize the SiPM performances will be presented.

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1. NUV-HD SiPM output signal

NUV-HD SiPMs with 30x30 μm^2 and 6x6 mm^2 pixel size will equip part of the focal plane of pSCT (see Fiandrini's poster). They will be organized in units of 16 pixels read by a front-end electronics (FEE) based on the TARGET7 digitizer. Four 16-pixels units will constitute a 64-pixel module managed by a back-end electronics (BEE) which provides power supply, slow control signals, pattern recognition trigger and data transmission. Then each 16-pixel unit must be tested and fully characterized to verify its compatibility with the existing FEE. For this purpose, an individual NUV-HD SiPM has been tested preliminarily using a commercial Advansid [2] electronic preamplifier (Fig. 1a). The signal output for 9 V of OverVoltage are reported in Fig. 1b.

2. Single channel electronic charge preamplifier

The signal obtained using the Advansid preamplifier cannot be used for data taking because of its long tail and high offset. To provide the compatibility between the SiPM output signal and the FEE it is necessary by hardware to reshape the signal according to required characteristics of zero-tile, zero offset, 20 ns duration and 4 mV amplification. The new charge preamplifier developed in Naples satisfies these characteristics (Fig. 2). The signal parameters have been optimized by means of three trimmers (variable resistance) P1, P2 and P3 (as shown in Fig 2c) which allow rectifying respectively the tail, the undershoot and the offset of the SiPM signal. The preamp performance has been tested using a light beam produced by an led flasher triggered at 1kHz with a wavelength of 400 nm and for various value of P3 (Fig. 3). The experimental set up used to test the preamplifier is reported in Fig. 4

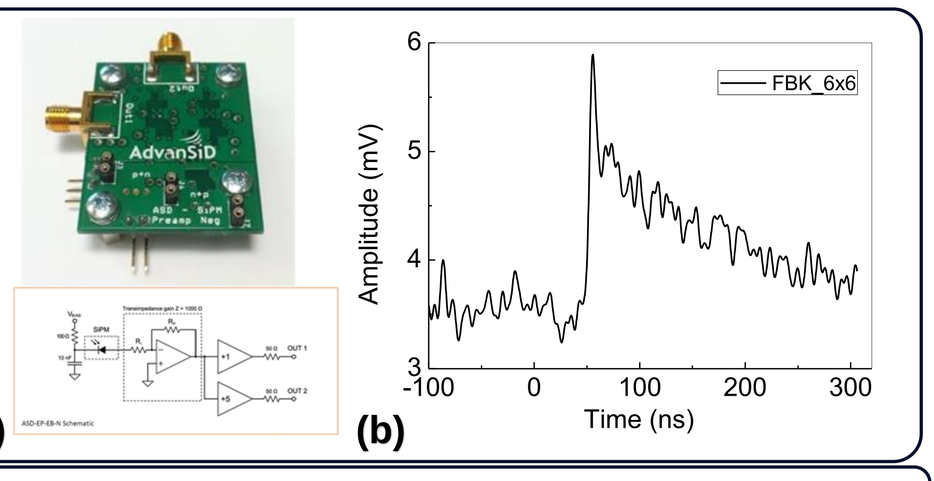

Fig. 1: (a) Advansid electronic preamplifier Advansid and its electronic layout; (b) signal output using Advansid board.

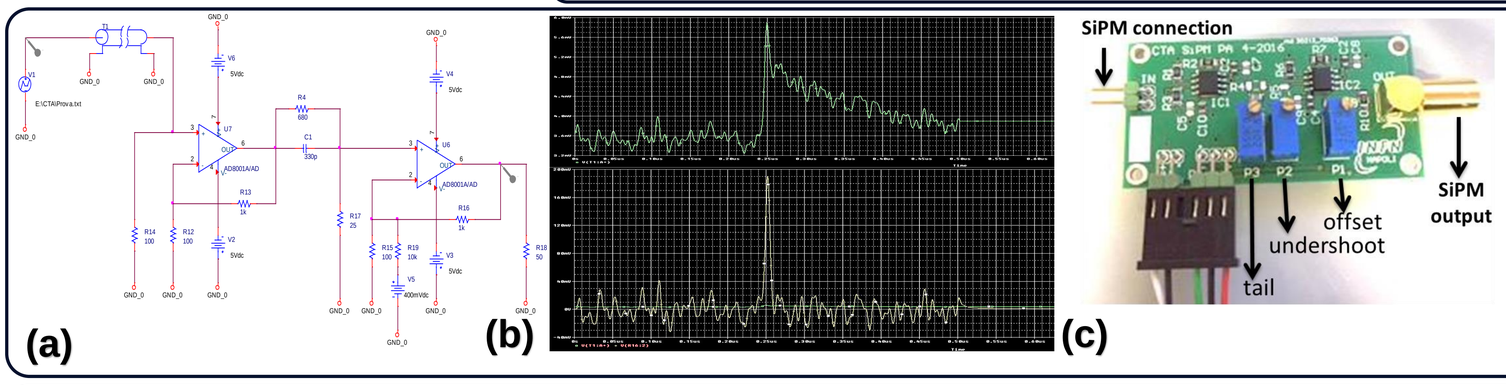

Fig. 2: (a) Orcad schematic of the preamplifier zero-pole cancellation; (b) the signal output before (up) and after (down) the tail cancellation; (c) image of the electronic board preamplifier realized at INFN Napoli.

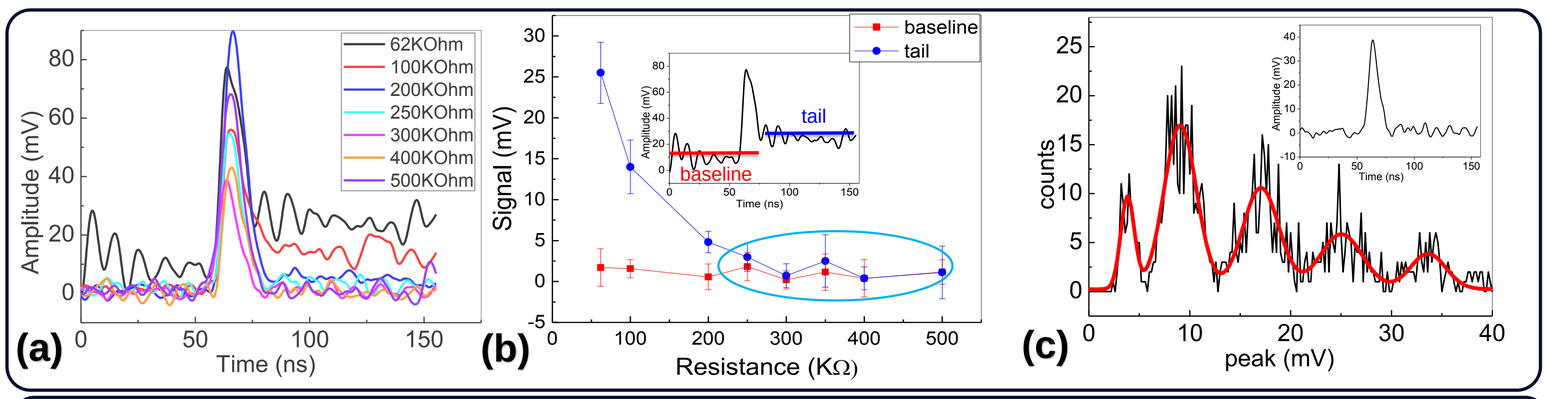

Fig. 3: (a) Output signal obtained with different P3 trimmer values; (b) the values of signal baseline and tail as function of P3 trimmer values; (c) the amplitude spectrum obtained after the zero-tail by the signal shown in the inset.

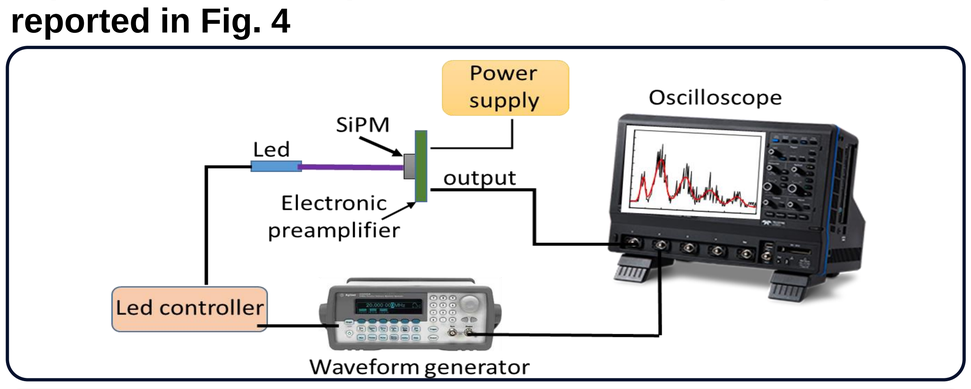

Fig. 4: The diagram of the experimental set-up used to test the single channel electronic preamplifier.

3. Test station

The charge preamplifier has to be used, in a new version of 16 channels, to test 1600 SiPMs grouped in a 16-pixel unit to build a pSCT module. A DAQ system has been developed in Bari (see Simone's poster) and it is based on a QDC module V792 and a controller 1718. The light beam produced by an led of 380 nm lights up the 6x6mm NUV-HD SiPM connected to the electronic preamplifier. The V792 QDC module records the output signal produced by the preamplifier board. Results are reported in Fig. 5.

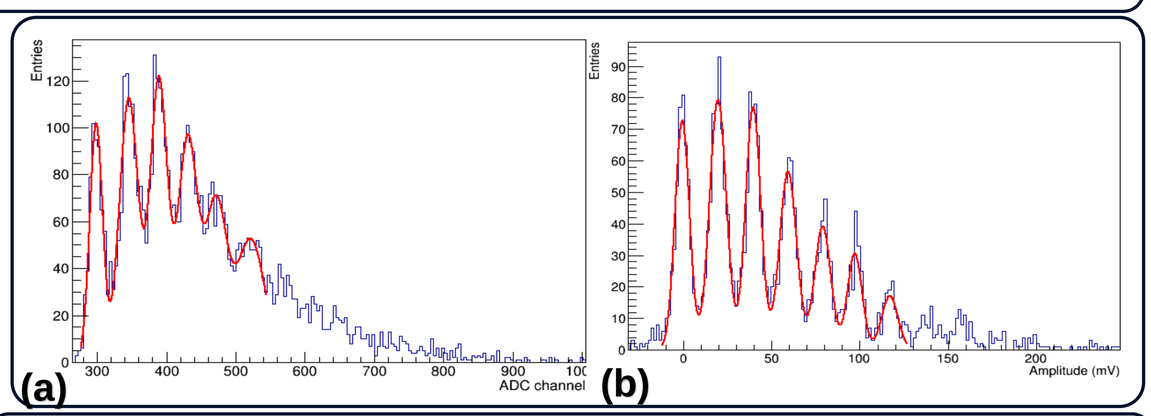

Fig. 5: SiPM (a) ADC channel spectrum measured with V792 QDC module, (b) for comparison a plot of the amplitude spectrum is shown. The distributions are obtained considering an integration gate of 50ns.

REFERENCES
[1] http://www.fbk.eu
[2] http://advansid.com/home

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