Quality control tests on the new front-end electronics for the Schwarzschild-Couder Telescope

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ABSTRACT: One of the proposed Medium-Sized Telescopes for the Cherenkov Telescope Array (CTA) is the dual mirror optics Schwarzschild-Couder Telescope (SCT). The prototype SCT camera [1] is currently equipped with 24 SiPM modules each one made of 64 pixels. The upgrade of the current camera is in progress, with the aim of fully equipping the 177 SiPM modules. A new front-end electronics is being developed and tested in order to improve the noise performance and match CTA requirements. In this process, 11328 SiPMs and related electronics will be tested in the laboratories before the assembly on the telescope camera. The SiPM Multichannel ASIC for high Resolutions cherenkov Telescope (SMART) has been developed by INFN to amplify the SiPM signals to be digitized and injected in the trigger logic based on the TARGET ASICs (TeV Array with GSa/s sampling and Experimental Trigger Application Specific Integrated Circuit). An experimental setup has been devised to test about 750 SMART, which will be used to equip the full camera of the prototype SCT. Each SMART was tested for proper operation in response to a laser pulse. In this contribution we present a detailed scheme of the test bench and the first results obtained on the quality control measurements.

SMART AND TEST BENCH

The SMARTs (Fig. 1) have been developed to amplify and shape the signals of 16 FBK NUV-HV Silicon PhotoMultipliers (SiPM) [2], thanks to a transimpedance amplifier and a tail suppression filter. The SMARTs to be tested were placed in a dark box and connected to the 64 SiPMs, arranging in 16-channels array configuration, illuminated with laser at 380 nm (Fig. 2). The data have been acquired with the Front End Electronic Module (FEEM), which is a device based on the TARGET-C ASIC that makes use of the switched capacitor array technology [3], and able to sample and digitize 16 signals waveform simultaneously with a sampling rates of 1 Gsample/second. Each TARGET module hosts 4 chips in order to acquire 64 channels.

A single SMART is made up by two principal parts: the analog part including the above mentioned 16 channels, a multiplexer and an ADC (Analogue to Digital Converter) to estimate the SiPMs mean current and the second part is a digital control unit that manage useful 24 programmable bits to change the device configuration in terms of gain, bandwidth and pole-zero compensation.

Fig. 1: SMART photos.

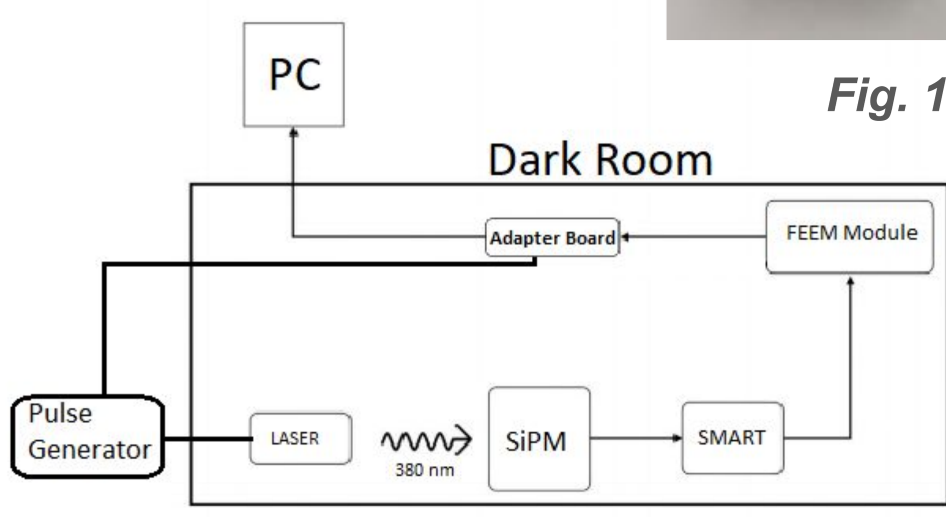

Fig. 2: Test bench for the quality control test.

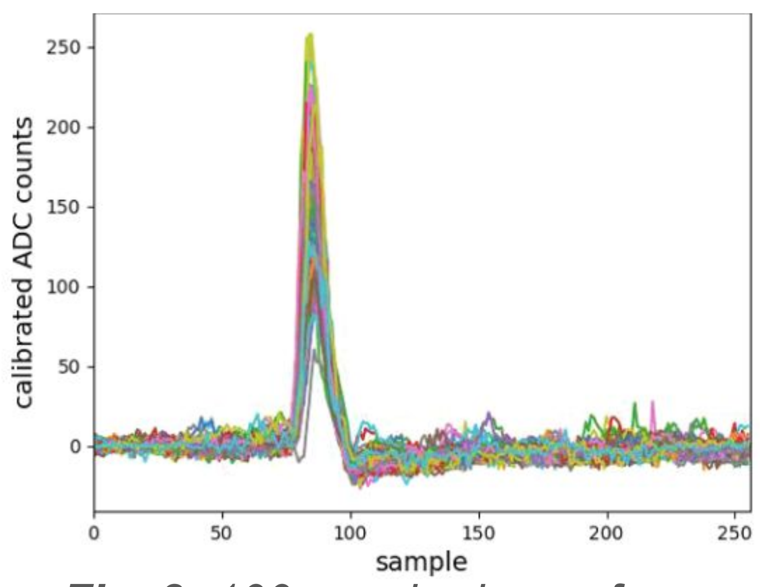

Fig. 3: 100 acquired waveforms.

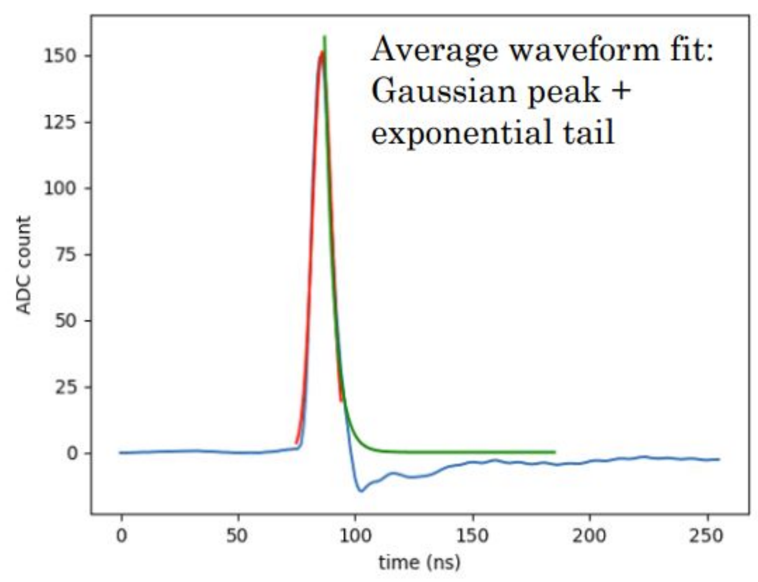

Fig. 4: Mean waveform and fits.

QUALITY CONTROL TEST

A quality control test, made up by 4 parts, has been performed for each SMART to make sure that it works as it should:

- **Signal Test:** a ten seconds acquisition with external trigger generated by a pulse generator with a rates of 1113 Hz has been performed. There are 11K generated events (100 are shown in Fig. 3) of which have been calculated, thanks to the gaussian fit and the exponential fit, the mean and standard deviation for amplitude, Full Width Half Maximum (FWHM) and tail recovery time (Fig. 4).
- **Linearity test:** the configuration of the SMART is fixed, and the bias of the SiPMs (Digital to Analogue Converter (DAC) value) are changed to study the linearity response of the device.
- **Globals test:** bias (DAC) is fixed, and the configuration of the SMART is varied and the signal run is performed to check the behavior of the device. The results for four configuration are shown in Figs. 5, 6 and 7.

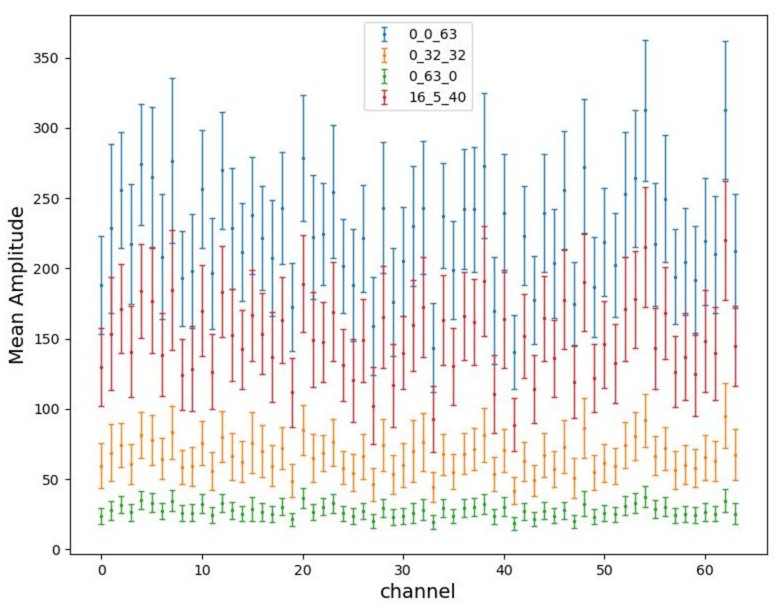

Fig. 5: Mean amplitude for 4 tested SMARTs configurations.

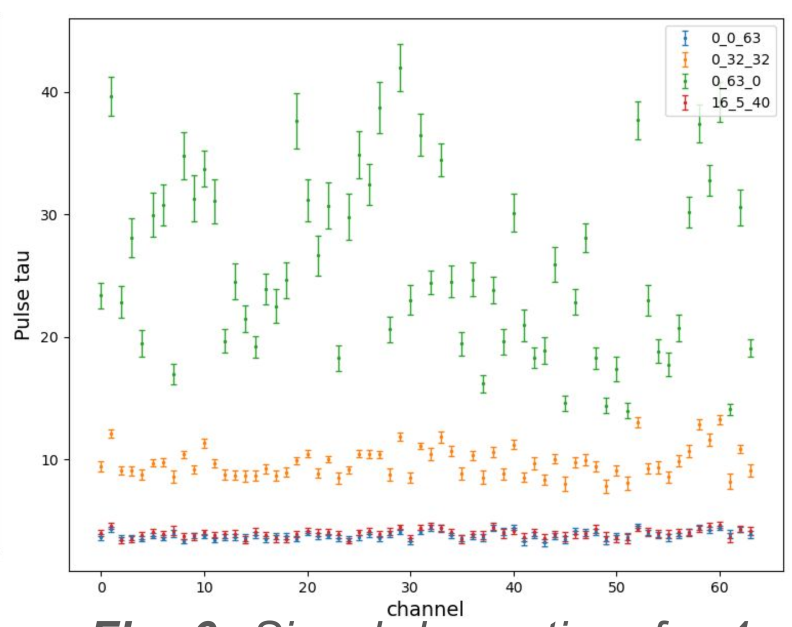

Fig. 6: Signal decay time for 4 tested SMARTs configurations.

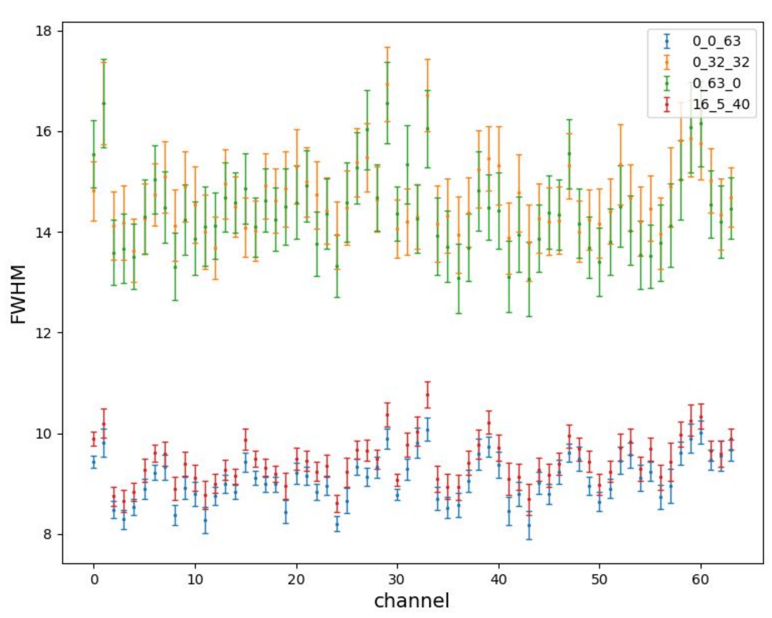

Fig. 7: FWHM of the mean waveform (see fig. 4) for 4 tested SMARTs configurations.

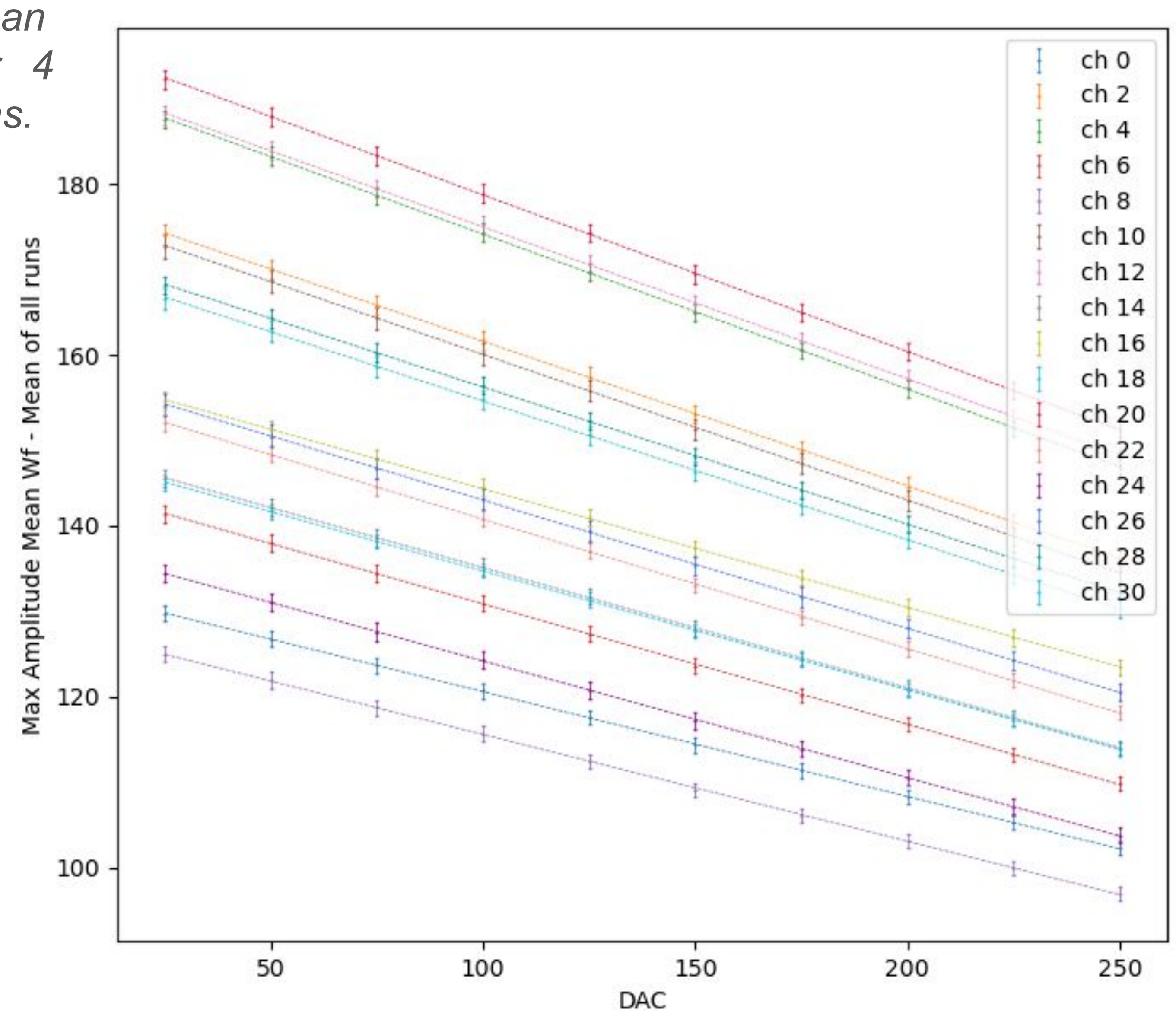

Fig. 8: Max amplitude of the mean waveform for different SiPM bias (DAC).

DISCUSSIONS, CONCLUSIONS AND FUTURE WORKS

We tested 739 SMARTs and we have found only 7 (<1%) not properly working due to one or more non-functioning channels. At the end of the test, an analysis is performed to compare the global functioning of the devices. We calculated the average maximum amplitude over all SMART ASICs tested, as a function of the input DAC valued (bias to SiPM). The figure shows a good linear trend on all channels, proving the good functionality of the SMART ASICs that are ready to be mounted in the new pSCT camera. Test on the FEEM and the SiPM matrix are now in progress.

References:

[1] C.B. Adams et al, JATIS (2022)

[2] https://www.fbk.eu/

[3] S.Funk et al., AIP Conference Proceedings (2017)

Acknowledgments:

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