Small PMT Test Measurements

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The Pierre Auger Observatory is a hybrid detector designed to study ultra-high energy cosmic rays[1] and it has been taking data from 2005. An upgrade program has been finalized and provides the use of a new small sized photomultiplier [2]. In the Lecce INFN Astroparticle Laboratory we performed characterization tests on a small size HAMAMATSU PMT (R6095) candidate to be employed in the upgrade program. For the performed tests we used a purely resistive divider with the progressive voltage ratio on the last stages finalized in the Lecce electronic laboratory. The calibration setup has been built starting from the photomultiplier tubes used in the SD stations of the Auger experiment, PHOTONIS PMT (XP1805). Some of these PMTs have been fully calibrated in our laboratory and they are actually used for didactical purposes and for delivering a reference signal useful for testing the front-end electronics components developed for upgrade program.
For testing this new PMT we decided to duplicate the setup using a new dedicated dark box. Dark tight connectors plate for signals transmission and power is on the box panel. The light source consists of a LED pulser controlled through a National Instruments USB-6353 Board connected to the data acquisition computer. The board has 48 digital I/O used for trigger generation, 4 digital analog converter (DAC) with 16 bit resolution and 2.8 MS/s with I_{MAX} = 5 mA/DAC. Two blue LEDs (470 nm, 45 deg viewing angle) are used and in order to have a fast turn-on turn-off response an appropriate LED driver has been designed (see [3]). The two LEDs are positioned in the center of a small box housing the driver. The LED-system can be mechanically moved to different points respect to the PMT. The signal from the anode is sent to a digital oscilloscope of 4 GSa/s sampling and 1 GHz bandwidth (AGILENT MSO6104A) connected to the computer through USB. The data acquisition user interface has been developed in LabVIEW [4]. The system parameters (such as the LED voltage and oscilloscope acquiring conditions) can be tuned in the dedicated tab of the front panel. Moreover during the data taking it is possible to have an online data analysis (peak finding, charge calculation, and spectra) in order to monitor the measurements at real time. The relevant quantities acquired during the run are also saved on data files for further analysis.
Datails on the setup and complete measurements can be found on [5].
In order to get the absolute gain of the phototube at a certain voltage, the single photoelectron spectrum is measured. This measurement is performed setting the PMT at 1200 V and setting the LED in order to get signal on the first dynode only 10% of the time. In fact, the photoelectron emission process from the photocathode follows the Poisson statistic, therefore the absence of photoelectrons 90% of the time ensures a very low contamination of event having 2 or more photoelectrons.
To avoid unexpected instability effects due to low powering, the LED was flashed at high intensity. The single photoelectron condition was reached using optical filters characterized by different transmittance. A series of preliminary measurements were performed at a fixed LED voltage and using different optical filters. The SPE condition was reached using an F30 filter with 0.01 % transmittance. Fig.1 shows the SPE spectrum for the PMT under test. The first peak is the pedestal and the second peak is due to 1 photoelectron events.

In Fig.2 we report the anode current measurement performed with fixed led voltage and varying the applied high voltage to the PMT. Moreover, in Fig.3 the anode current is shown as a function of the increasing Led voltage for a fixed high voltage of the PMT (1200 V).

Last test performed is the measurement of the afterpulses. Afterpulses are spurious pulses that appear in the wake of the true pulses. Every true

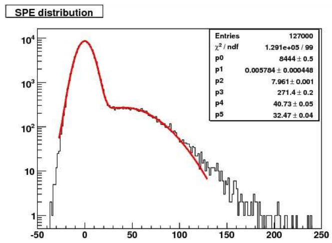

Figure 1. Single photoelectron spectrum with background. The charge on x-axis is expressed in Me.

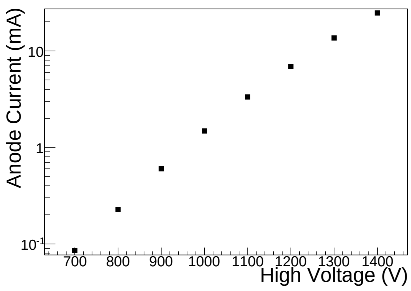

Figure 2. Anode current as a function of the PMT applied voltage.

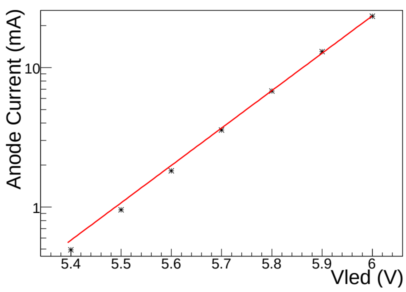

Figure 3. Anode current as a function of led voltage.

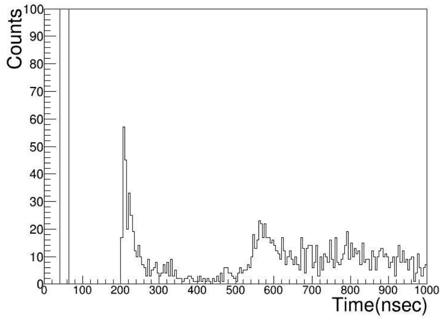

Figure 4. Time arrival distribution for peaks located in the waveform. The threshold is set to 5 mV.

pulse may be followed by one or more afterpulses. We tested the afterpulses signal respect to one incoming LED bias voltage. We have acquired the scope with a time window of 1μsec. Around 2.6% of the recorded events evidence the presence of afterpulses. Fig.4 shows the time location of the peaks considering a 5 mV threshold. At around 50 nsec we can recognize the main signal location. At least two afterpulse distributions can be evidenced at around 220 nsec and 580 nsec.

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