The Auger Photomultiplier Tubes Calibration Facility in Lecce

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1. Introduction

The Pierre Auger Observatory is a hybrid detector to measure ultra-high energy cosmic rays[1]. The test facility built in the Lecce INFN Astroparticle Laboratory is used to test Photomultiplier Tubes (PMTs) useful for the upgrade programs and for the standard deployment of the detector.

Photomultiplier Tubes[2] are devices designed to amplify very small light signals, on the order of single photons, to levels that are detectable by conventional electronics. Such a high level of amplification, however, has to deal with the precise knowledge of the relationship between a light signal in and the current out response of the system that can be difficult to determine. For this reason the photomultiplier tubes use in scientific research requires a great deal of sensitive calibration.

The calibration setup has been built starting from the photomultiplier tubes used in the SD stations of the Auger experiment, PHOTONIS PMT (XP1805) shown in fig 1. 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 the upgrade program.

Figure 1. A picture of the PHOTONIS Photomultiplier Tube (XP1805) connected to the High Voltage electronic card.

2. Experimental Setup

The measurements for the PMT characterization follow the performance specifications required by the Pierre Auger experiment. The PMTs need to have a large dynamic range, a good linearity, a low counting rate and a low breakdown. In order to check these parameters we setup a dark box that can host more than one PMT at a time. It allows testing PMTs of different size (Photocathode diameter: 1.5-8 inch). The detector under test can be positioned looking upwards where a light source is placed. Dark tight connectors plate for signals transmission and power up 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. A blue LED (470 nm, 45 deg viewing angle) is used and in order to have a fast turn-on turn-off response an appropriate LED driver has been designed. The LED driver discharges quickly a charge stored on a reference capacitance. This charge is proportional to the number of the photon generated by the LED in a short time. The LED is 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 for non-linearity measurements. The signal from the anode is sent to a digital oscilloscope of 4 GSa/s sampling and 1 GHz bandwith (AGILENT MSO6104A) connected to

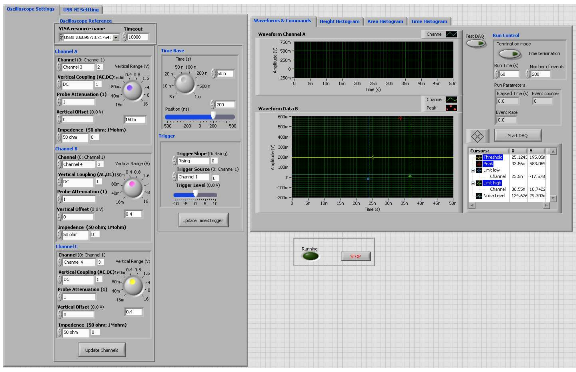

Figure 2. Front Panel of the Labview Graphical Interface.

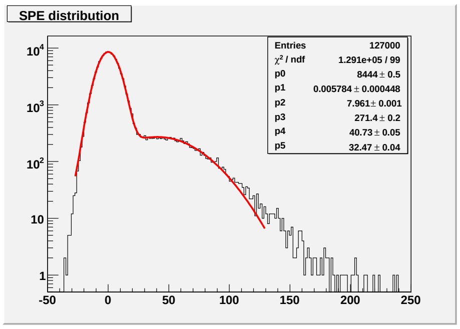

Figure 3. Single photoelectron spectrum with background. The charge is expressed in Mega-electrons.

the computer through USB. The data acquisition user interface has been developed in LabVIEW (a system-design platform and development environment for a visual programming language from National Instruments). The system parameters (such as the LED voltage and oscilloscope acquiring conditions) can be tuned in the dedicated tab of the front panel (see fig. 2.

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 in real time. The relevant quantities acquired during the run are also saved on data files for further analysis.

3. Measurements

Using the described setup and the LabView program, several measurements can be performed: dark pulse rate, single photoelectron spectrum, gain versus voltage, non-linearity, after pulse ratio and quantum efficiency curve. In this section we present the results of measurements of the single photoelectron spectra recorded with our standard setup.The SPE is the response of the system to the emission of a single photoelectron at the first dynode.

The primary challenges associated with finding the SPE of a system are related to distinguishing the SPE from higher order peaks (i.e. the response of the system to multiple photons), and distinguishing the SPE from the pedestal. Thus, its necessary to use very low light levels. To this end the pulsed light source has been tuned to have 90% pedestal, and 10% signal for Poisson distribution of average 0.1 photo electrons. The tunig is performed by mean of a transmittance filter. A Hystogram of single photoelectron spectrum is shown in fig 3. It contains two main peak. The huge peak corresponds to the ADC pedestal, corrected for the baseline level of the acquired scope. The width of the pedestal is caused by the noise of the electronics and the PMT. The small peak in the spectrum corresponds to the single emitted photoelectron. The solid line in fig. **??** shows a fit of two overlapping Gaussian functions. The statistical errors of the calculated parameters are shown in the panel in the upper part of the picture.

4. Conclusions

The calibration facility built in the Lecce INFN Astroparticle Laboratory is used to test Photomultiplier Tubes (PMTs) useful for the upgrade programs and for the standard deployment of the Auger detector. The experimental setup has been improved during the last year. The new system provides the possibilities to carry out the calibration of different photomultipliers and includes different kind of measurements. An improved data acquisition system has also been developed, allowing the calibration monitoring at run time. As an example of the measurement performed the single photoelectron spectrum has been shown.

REFERENCES

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