The Pierre Auger Surface Detector Led Flashers and Their Use for Monitoring and Calibration

V.M.Aynutdinov[1], C.B.Bonifazi[2,3], A.Creusot[2], D.Dornic[2], B.Genolini[2], A.N.Isaev[4], K.G.Kompaniets[1], R.P.Kokoulin[1], I.Lhenry-Yvon[2], T.Nguyen Trung[2], J.Pouthas[2], D.A.Room[1], T.Suomijärvi[2], Pierre Auger Collaboration[5]

(1) Moscow State Engineering Physics Institute, MEPhI, Moscow, 115409, Russia

(2) Institut de Physique Nucleaire, IN2P3 - CNRS, 91406 Orsay, Cedex, France

(3) Laboratorio Tandar - CNEA & CONICET, Argentina

(4) IHEP, Protvino,142284, Russia

(5) Observatorio Pierre Auger, Av. San Martín Norte 304, (5613) Malargüe, Argentina

Abstract

A Light Emitting Diode (LED) system based on two LED flashers has been designed for the Water Ĉerenkov Detectors of the Pierre Auger Observatory to monitor the performance of the photomultiplier tubes and to complement the muon calibration. In particular, LED flashers allow an easy cross calibration between the low and high gain channels and a control of the PMT linearity. The results of the first measurements using the LED flasher system in Orsay Test tank are presented.

1. Introduction

The Pierre Auger Surface Array is equiped with a monitoring and calibration system based on two LEDs. The LEDs are placed on a window located on top of the liner in the middle of the Water Ĉerenkov Detector (WCD). The light induced by shower particles or by LEDs in the WCD is detected by three 9” PMTs (Photonis XP1805) [1]. Two outputs are used: anode and amplified last dynode output. The charge ratio between the two outputs is 32. The PMT signals are filtered and digitized by 40 MHz Analog-Digital Flash Converters (FADC). The LED system can be used to measure the linearity of the PMTs and to perform a cross calibration of the two output channels. In addition, the LED flashers can be used to test the PMTs and electronics after installation and to monitor their performance.

To test the performance of the LED system and to develop monitoring and calibration methods, the LED flashers have been installed in the IPN-Orsay test tank. The Orsay tank is similar to the Auger WCD. It is equiped with Auger

pp. 825–828

liner and PMTs (Photonis XP1805) and has water quality comparable to that of the Auger WCDs. The PMT signals are recorded by an oscilloscope with a 2 GHz sampling frequency. In the following, the main characteristics of the LED flashers are described and the results obtained with the test tank on the PMT linearity and on the cross calibration of the anode and dynode channels are presented.

2. LED flasher characteristic

The LED flasher consists of a pair of LEDs with their driver boards [2]. The ensemble is mounted inside a housing filled with silicone potting to protect agains humidity. The LED system is placed on a window in the middle of the liner and views downwards in the tank. The light diodes, L-7113NBC, have a dominant wavelength of 445 nm and a viewing angle of 16 degrees. Light intensities of the two drivers can be independently regulated by control voltage ranging up to 10 V. A positive pulse with 4 V amplitude is used for driver triggering.

The LED flasher amplitude and time parameters have been systematically studied [2]. The precision of the flasher pulse adjustement is better than 10%. The maximum amplitude is about 10^8 photons and allows to study the PMT response over the whole dynamic range. The pulse width is about 6 ns. The LED light produces signals in the WCD having a rise time of the order of 10 ns and a decay time of 75 ns. These signals are similar to those produced by background muons in the detector. The relative spread of the LED pulses is about 2.5% and the cross-talk between the two LED channels was estimated to be less than 2%.

3. PMT linearity control

The PMT linearity can be measured by varying the light intensity of the two LEDs (A and B) over the full dynamic range and calculating the ratio L = (f(A+B)-f(A)-f(B))/f(A+B), where f is the integrated charge measured by the PMT. For each measurement point, intensities of A and B are equalized and the LEDs are fired 6000 times with a regular sequence A, B , and A+B. The mean value of the integrated charge at the PMT anode is calculated for the three events (A, B, A+B). The typical dispersion of the measured charge is about 15%. This dispersion is mainly due to the fluctuations of the WCD response, the dispersion due to the LED being 2.5%.

Figure 1 shows the linearity L as a function of the mean anode current for A+B. A very good linearity, better than 2%, is observed up to 60 mA anode current. The specifications for the PMTs were set to better than 5% linearity up to 50 mA and are confirmed in systematic tests performed for all PMTs by the Auger Collaboration. This study shows that the linearity of the PMTs can be controlled with good accuracy after the PMTs have been installed in the water tank by using the LED system.

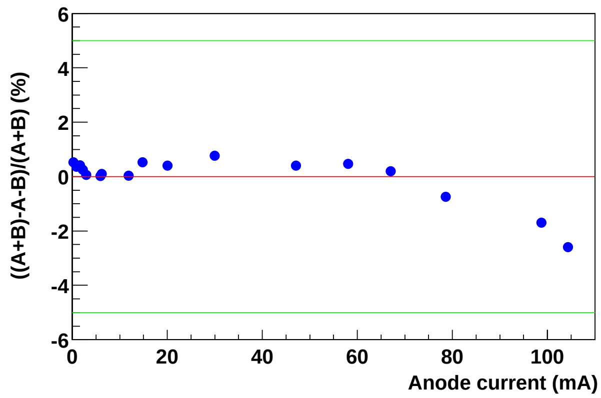

Fig. 1. Linearity L=(f(A+B)-f(A)-f(B))/f(A+B) as a function of the A+B anode current.

4. Cross calibration of dynamic ranges

The calibration of the Auger surface detectors is performed by using the background muons [3]. The muon signals can only be seen in the amplified dynode output and the anode channel needs to be cross calibrated by using the 5 bit overlap region of the two dynamic ranges. This can be done either by using shower signals or signals obtained from the LED flashers.

The cross calibration of the two channels was performed in the Orsay test tank by varying the LED intensity from low values up to the value where the dynode channel saturates. For each LED shot, the ratio between the maximum of the PMT pulse is calculated for the two channels. For each intensity values, the LED flasher is fired 6000 times. Figure 2 (left) presents the mean value of the dynode/anode ratio as a function of the PMT anode current. The dynode saturation occurs after 40 mA dynode current corresponding to an anode current of about 1.2 mA. A plateau is observed between 0.3 and 1 mA, corresponding to the overlap region between the two channels. In this region the mean value of the ratio is about 33 which is within 3% of the expected value of the dynode channel amplification.

To see the effects of the electronics, the PMT pulses were processed through the electronics simulation. The obtained ratio is plotted as a function of the anode amplitude (in ADC channels) in Fig. 2 (right). The dynode saturation occurs after channel 16. Below channel 10, anode signals are too small to obtain a reliable value. Therefore, the dynode/anode ratio can be estimated in a range from 10 to 16 ADC channels. In the case of the PMT in Fig. 2, this value is 31.7, which is close to the expected value. This method will be tested in the currently deployed pre-production tanks with the complete electronics and compared to the cross

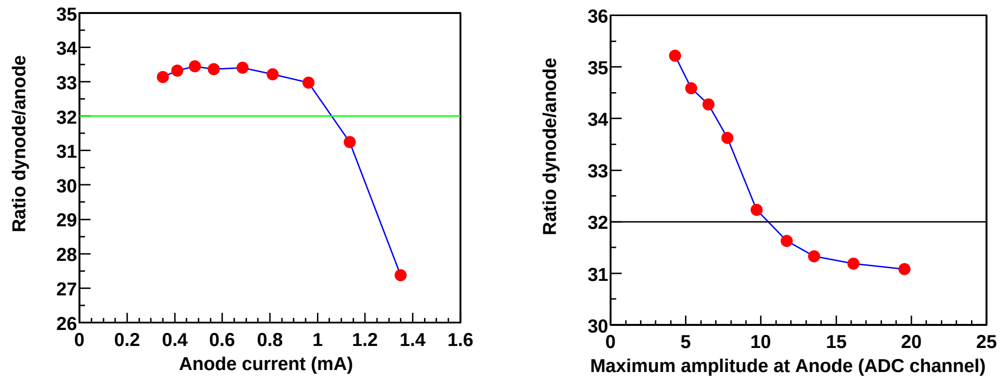

Fig. 2. Dynode/anode ratio for the average amplitude of PMT signals (see text).

calibration obtained by using shower signals.

5. Conclusions

The Pierre Auger surface detectors are equiped with a LED flasher system allowing to monitor the performance of PMTs and electronics and to perform complementary calibration of the detector. The PMT linearity and the cross calibration of the anode and dynode channels with the LEDs have been studied at the Orsay test tank. The PMT linearity can be accurately measured over the whole dynamic range by using the two LEDs. The cross calibration of the two channels is obtained by scanning with the LED flasher the overlap region of the two channels. The value obtained is close to the theoretical charge ration obtained from electronics simulations. The data from the currently deployed preproduction detectors will allow to compare the cross calibration obtained with the LED flashers to that inferred from showers signals.

6. References

1. Suomijärvi T., Pierre Auger Collaboration, Contribution to this conference.
2. Aynutdinov V. M. et al. NIM A, To be published.
3. Bertou X., Pierre Auger Collaboration, Contribution to this conference.