Design, construction and characterization of a three channels detector of cosmic rays

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Design, construction and characterization of a three channels detector of cosmic rays

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Abstract. Cosmic rays are particles produced by Astrophysical sources, currently they are being studied to obtain information about the sources and their properties. Cosmic rays research can be used to improve new technology in science, for instance, spectroscopy for material distinction. A three-channel detector was built using three photo-multipliers, two scintillation plastic and common materials -water, air, oil, aluminum, and others-. They were allocated in a vertical position, where materials channel is between scintillation plastics channels to validate the signal captured and study the interaction of cosmic rays with these materials. The characterization process is reported achieving positive results in the materials distinction using cosmic rays.

1. Introduction

Since Victor Hess discovered cosmic rays around 1912, measuring the dependence of air ionization with the height [1], its properties have been studied to obtain information about them, solving puzzles and therefore improving our universe understanding. In addition, new technology could be developed due to the continuous natural radiation on the Earth. The design, construction and characterization of a cosmic rays detector are presented. Complementary studies could be developed like new materials for paticle detection.

2. Desing and construction

The prototype was made in the Laboratory of Elemental Particles of the Universidad de Guanajuato. It was built with Aluminum due to his light spectrum reflectance property[2]. The photomultipliers were located inside, attached to plastic scintillators and different materials, in the figure 1 the detector structure and components are shown. The plastic scintillators were covered by mirrors and the material channel cavity was polished to mirror level.

Figure 1. Left to right: Three channel detector internal structure, aluminum tube where the photomultiplier is introduced, plastic Scintillator Saint-Gobain BC-408 [3] and Sens Tech photomultiplier P30CW5[4].

Each photomultiplier operates with two voltages, the ranges are 5 V to 8 V and 0.3 V to 1.8 V, to avoid use three dual-voltage sources, a six channels electronic plate was built, therefore only one voltage source is needed for the proper operation. Every photomultiplier output was connected to a discriminator plate to convert the analog signal into a digital signal, this is connected to a data acquisition system (Compact RIO 9025) to collect all the digital signals and to save the information in a data file through a program developed in LabView. In figures 2 and 3, these elements are shown.

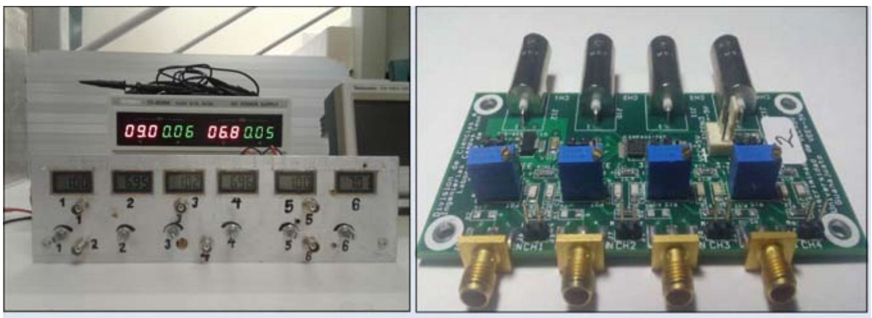

Figure 2. Left to right: Six-channel electronic plate test, four-channels discriminator plate used.

The assembled detector is shown the figure 4.

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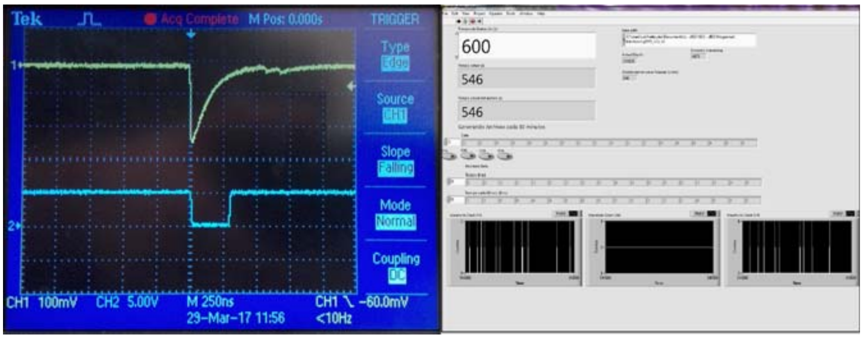

Figure 3. Left to right: analogic and digital signals observed by an oscilloscope and graphical interface of Data collected in LabView.

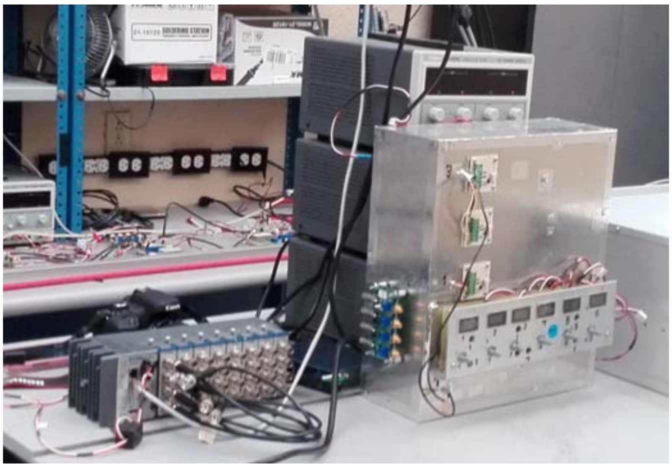

Figure 4. Detector connected to the six channel plate, discriminator plate and system data acquisition.

3. Characterization

3.1. Voltage operation

To find the plateau region [3] of each photomultiplier, the range voltage of operation was varied in a combination of (5-8) V and (0.5-1.5) V. Each sampling took ten minutes. In figure 5 the numbers of events versus voltage are shown for the three channels.

After graphs analysis the selected operation voltages are showed in Table 1.

Table 1. Voltages selected by the characterization.

Channel	V1 (V)	V2 (V)
1	6.00	0.60
2	7.00	1.05
3	6.00	0.70

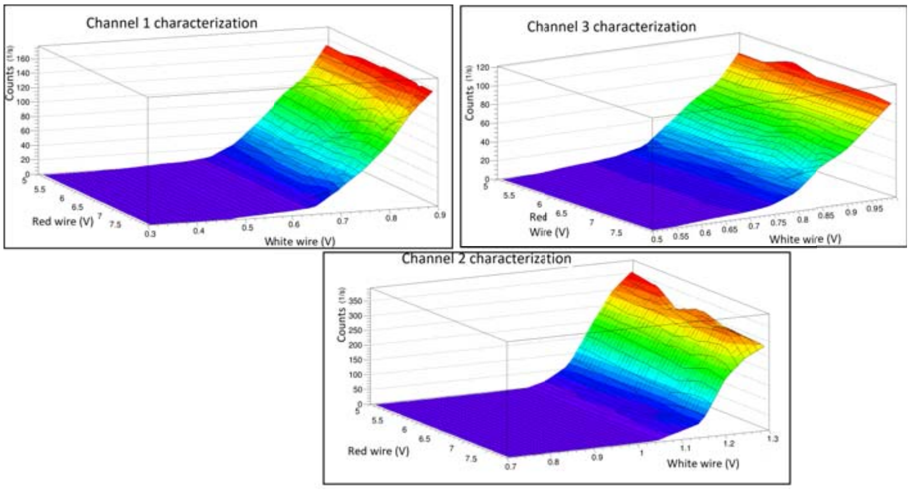

Figure 5. Characterization graphs for each photomultiplier.

3.2. Dark counts

The optical part and the tube behind were isolated from light with sticky aluminum as is showed in figure 6.

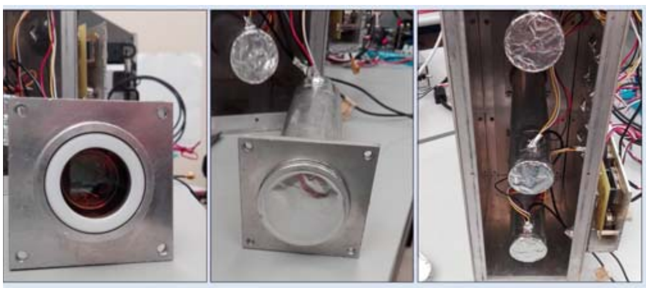

Figure 6. Left to right: Optical part of the photomultiplier, optical part isolated, tube behind isolated from light.

Data were taken during five hours to see the dark counts rate. The distribution frequencies for each photomultiplier are shown in figures 7. the dark counts rate for the channel two is greater due to the voltage selected.

4. Results and conclusions

The frequencies distribution was plotted with the dark counts rested. To compare each material, the distributions were normalized to one, in the fig. 8 the histograms are shown for every channel. Channel 1 corresponds to the lower one. The material tested was mineral oil, adhesive glue, tridistilled water, air, aluminum, asphalt, liquid detergent, quarry and marble.

The channel one and three correspond to plastic scintillators when given material was tested, for that reason it is hope see similar distributions between channel one and three.

It is possible to recognize, identify, different materials using cosmic rays. Tests should continue to collect more data, improve the statistics and observe interactions in all year seasons. Other parameters should be compared like the whether, the position on the Earth, altitude, and others.

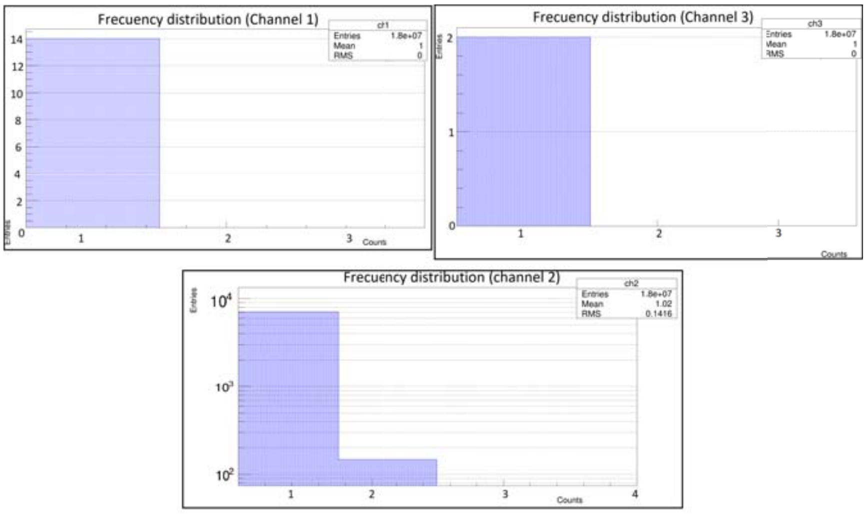

Figure 7. Frequency distribution (Dark counts).

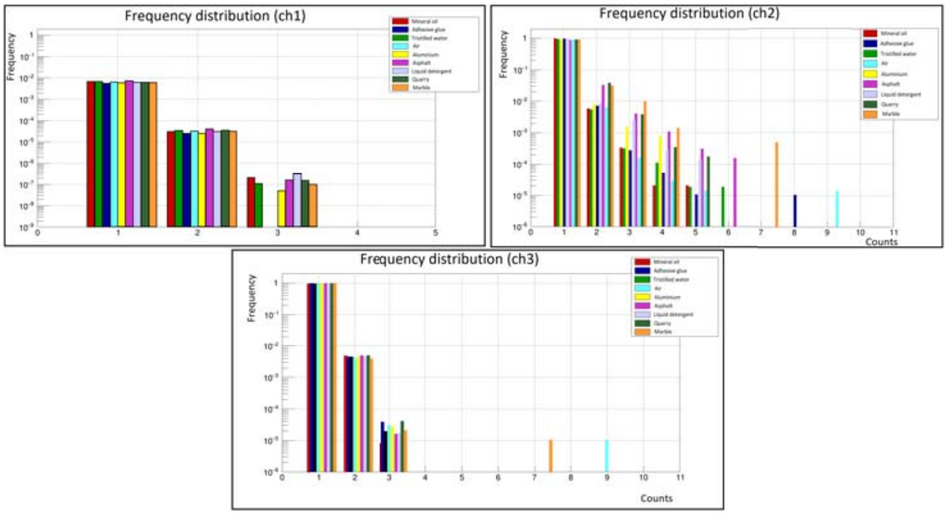

Figure 8. Frequencies distributions.

5. Acknowledgments

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6. References

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