On a Three-Channel Cosmic Ray Detector based on Aluminum Blocks

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Abstract. There are many general purpose cosmic ray detectors based on plastic scintillators and electronic boards from the market. This is a new cosmic ray detector designed on three 2.54 cm X 5.08 cm X 20.32 cm Aluminum blocks in stack arrangement, and three Hamamatsu S12572-100P photodiodes. The photodiode board, the passive electronic board, and the discriminator board are own designed. The electronic signals are stored with a CompactRIO -cRIO- by National Instruments. It is presented the design, the construction, the data acquisition system algorithm, and the preliminary physical results.

1. Introduction
Currently there are many reports around the word on cosmic rays detectors [1]. The electronics has a key role in cosmic ray detection. In Mexico, particularly, the students and professors from Laboratory for elementary particles (laboratorio de partículas elementales) design, construct, and test their own cosmic ray detectors [2]. This report, focuses on the design, construction and test of electronic board to setup the avalanche Hamamatsu photodiode model S12572-100P [3] (the figure 1 display photodiode) for a cosmic ray detector based on Aluminum blocks.

2. Design and construction

Figure 1. S12572-100P photodiode.  Figure 2. Photodiode board top layer.
2.1. Photodiode board
Its function is to support mechanically the electrical connection (anode and cathode) of the photodiode to attach it to the Aluminum block on one of its polished 2.54 cm X 5.08 cm ends. The figure 2 displays the top layer. The figure 3 displays one front end 2.54 cm X 5.08 cm Aluminum block polish and finally the figure 4 displays the Aluminum block attached with a photodiode board and isolated optically with four layers of Aluminum tape 3311.

![Figure 3. Aluminum block polished.](image)

![Figure 4. Aluminum block and photodiode optically isolated.](image)

2.2. Passive electronic board
Provides high voltage to the photodiode enabling it; for the readout of the signal was implemented a RC circuit. The photodiode requires reverse polarity for working. The figure 5 displays passive electronic board diagram schematic and figure 6 displays the passive electronic board.

![Figure 5. Passive electronic board diagram.](image)

![Figure 6. Passive electronic board with photodiode connector.](image)

2.3. Discriminator board
Contains a single integrated circuit CMP401 of Analog Device [4], with 23 ns propagation delay, quad comparators and compatible with 5 volts logic. Its function is to compare analogue signal coming from the passive electronic board, with a fixed trigger voltage defined by the final user and give out the digital signal. If the input signal is higher in amplitude than the trigger, the discriminator turned on -one logical state-, otherwise, turns off -zero logical state. The figure 7 displays the four channel discriminator board.

![Figure 7. Four channel discriminator board.](image)
Each channel cosmic ray detector requires one Aluminum block with photodiode board attach and one passive electronic board, the three channels from passive electronic board are connected to the discriminator board, finally, all channels are connected to the data acquisition system, the figure 8, displays detector final assembly.

![Figure 8. Three channel detector final assembly.](image)

2.4. Data Acquisition System

The cRIO is assembled with 9025 embedded controller [5], eight NI-9402 [6] interchangeable C modules of four channels of digital input or output and one rack. The cRIO is connected to the PC HOST via Ethernet cable with one number port. The cRIO and PC-HOST required LabVIEW-FPGA and LabVIEW program, respectively.

3. Characterization

The output counts as function of applied high voltage for each channel are displayed in figures 9, 10 and 11. The recording interval began at 60 volts and finished at 100 volts in steps of 5 volts each. Nine ten minute text files were generated. In the three channels for voltages between 60 and 70 volts the result is zero counts. For 75 volts and higher the number the counts increases lineally with applied voltage.

![Figure 9. Top Aluminum block.](image)

![Figure 10. Middle Aluminum block.](image)

![Figure 11. Bottom Aluminum block.](image)
4. Results

The analogue signal noise was 50 mVpp and the configuration parameters were 75 Volts for operation voltage and 100 mV of threshold for the discriminator board.

The figure 12, 14 and 16 display the number of counts vs time for top, middle and bottom channels, respectively. The figure 13, 15 and 17 display frequency vs counts histograms for top, middle and bottom channels, respectively. The recording time length was 30 minutes for each file.

**Figure 12.** Counts vs time of top Aluminum block.

**Figure 13.** Frequency vs counts of top Aluminum block.

**Figure 14.** Counts vs time of middle Aluminum block.

**Figure 15.** Frequency vs counts of middle Aluminum block.

**Figure 16.** Counts vs time of bottom Aluminum block.

**Figure 17.** Frequency vs counts of bottom Aluminum block.
5. Conclusions
The electronic board, the data acquisition system and photodiode with Aluminum blocks work properly. It was characterized the cosmic ray detector to obtain a linear function of the counts vs applied high voltage. The distributions of counts vs time are almost flat, for the three channels of the cosmic ray detector.

6. Acknowledgments
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