The Analysis of Cosmic Ray Detector Data at Chicago State University

Interim Report

Chicago State University SPS Chapter

9501 South King Drive, Chicago, IL 60628

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Investigative Researchers

Melissa Rangel

Marianela Perales

Macario Cervantes

Chapter Advisor

Dr. Edmundo Garcia

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Abstract

The Chicago State University SPS chapter seeks to promote physics and encourage students to pursue careers in STEM disciplines. We are currently working with 2 high schools, under QuarkNet, with the ultimate aim of making cosmic ray data accessible for the study of high energy particle showers over large areas in Illinois.

The funding for this project allowed us to expand our data analysis capabilities with the purchase of LabView, which is instrumental to us completing the design of the muon tracker prototype. This project will also serve as training for SPS students and high school students in the experimental techniques of high energy physics.

Introduction

The research of our SPS chapter is part of the experimental high-energy nuclear physics program at CSU. The primary goal of our current research is to obtain experimental benchmarks towards our goal of finalizing the design of a muon tracker prototype. This includes optimizing the configuration that will give us the optimal light output. In order to achieve this end, we have built a data acquisition system (DAQ) using CAMAC modules such as a TDC and ADC. The data analysis will be an integral portion of our work and is now feasible with the purchase of LabView and components required to make more high voltage and signal cables. These purchases were made possible by the SPS Undergraduate Research Award.

The tracker prototype will consist of eight scintillators in an arrangement consisting of two 4-slat planes. The tracker will allow us to develop a three-dimensional picture of the tracks of the incoming muons. We will conduct a series of experiments using different combinations of scintillators (different size, shape, and color); we will combine some with a fiber, and vary the placement of the scintillators.

Methods

As muons, electrically charged particles, traverse the scintillating crystal they produce luminescence. This light then travels to the phototube, where the signal is amplified via a series of dynodes. The result is an electrical pulse that is proportional to the number of muons detected. The electrical pulse is finally converted to a digital signal by the CAMAC components. The TDC gives an output of time interval of an event. The ADC digitizes the area of the pulse, which is related to the number of events.

ARRAYS

In order to test different arrays, we began by first testing the light output of two slats of different widths. For our first measurement we used a slat of 1cm width and a second slat of 2 cm width which we placed in coincidence with a smaller scintillator (finger scintillator). The set up is shown in figure 1.

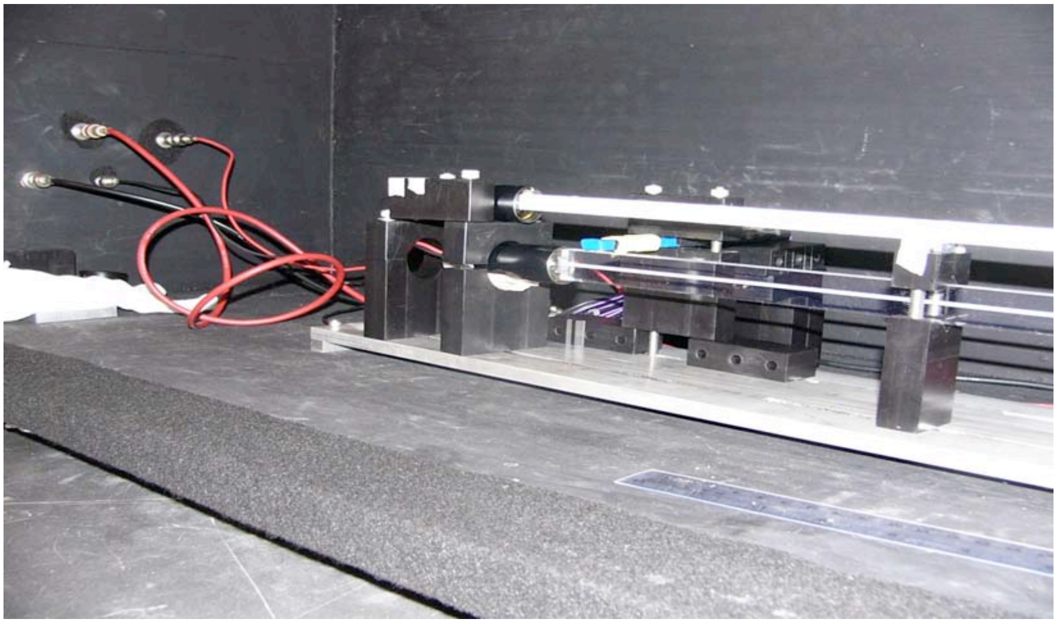

Figure 1 Triple coincidence for testing arrays

The data (ADC) for both scintillators was recorded only for particles that crossed the two slats and the finger scintillator. This formed a coincidence to minimize noise and to capture data from muons traveling vertically through the slats. Figure 2 shows the histograms of the results

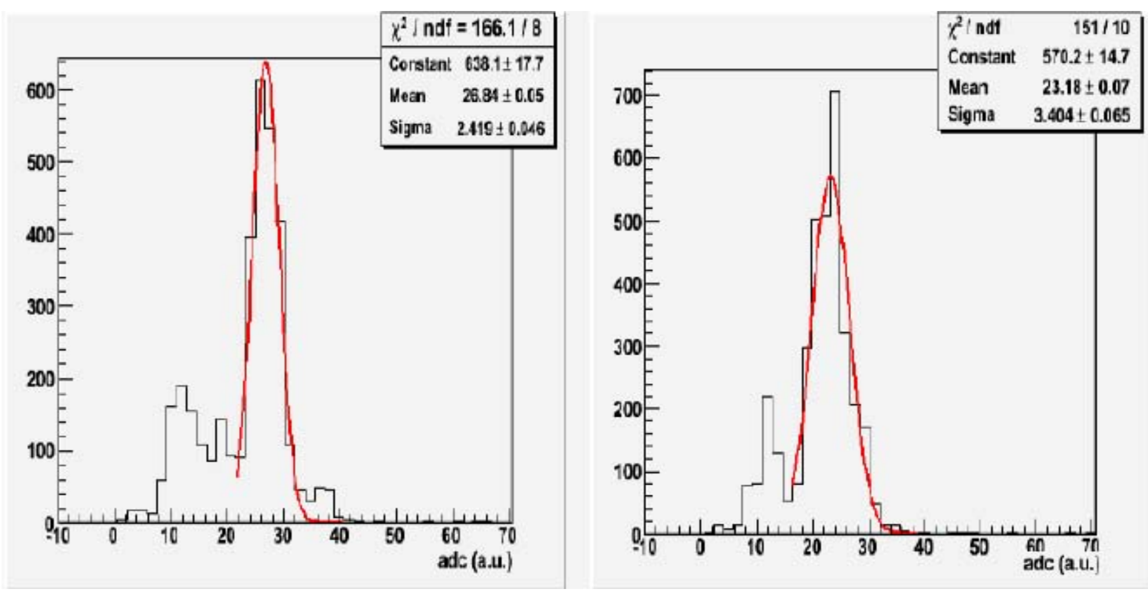

Figure 2 Histograms of ADC measurements for 2cm wide (left) and 1cm wide (right) scintillator

To our surprise, the difference in the amount of light output measured from the two scintillators was very similar. We expected to see a difference because the light produced by the charged particles when they interact with the scintillators should be proportional to the width of the scintillator. One reason may be that although the phototubes used were produced by the same manufacturer, they may not have been operating at a different gain.

Future Work

Our most recent work has been presented at the Washington D.C. AAPT meeting in February. Our research will continue, using what we have learned so far and expanding upon it. Our plans are to use a CAMAC system as a DAQ and use LabView to manage the CAMAC components and to also retrieve and store data from the controller.

We have written a program, using LabVIEW, which will allow us to control different electronic devices in order to produce benchmarks for our testing needs, but would like to expand it to allow the control of a greater number of detectors. Upon further analysis of ADC measurements, we will continue towards our goal of finalizing the design of the tracker prototype by using different combinations of fibers and scintillators. In addition, we will calibrate the phototubes so that they are operating at the same gain and provide valid results. We hope to accomplish this by spring 2011. This future work will be possible with the recent support of the 2010 Undergraduate Research award from SPS.

Budget

The funds requested were used to cover the elements needed to continue the optimization of the design parameters needed to construct a tracker device for the detection of cosmic rays. The output provided by our CAMAC modules (TDC and ADC) are read and controlled via the license that we purchased for LabView. However, the program required that we upgrade the capabilities of our lab computers and so we purchased RAM memory for all of them. The remainder was used to purchase elements to make more signal cables and connectors in order to have this prototype tracker coupled to the DAQ. Our purchased totaled over $2000.00, so the remainder was provided by the Chemistry and Physics department.

Qty.	Materials	Unit Price	Price
1	LabVIEW Full Development System, Windows one sit. National Instruments	$649.75	$649.75
NA	RAM memory upgrade for lab computers. Crucial Technologies	$340.98	$340.98
2 10 10 1	Flat Ribbon signal cable Wire Headers Wire Connectors S&H Newark Electronics	$176.13 $29.35 $4.91 $20.00	$352.26 $146.15 $49.10 $20.00
20 5 6 5 1	Coaxial connectors Coaxial adapters R/F Coaxial connectors R/F coaxial adapters S&H Newark Electronics	$6.79 $1.60 $15.95 $5.48 $20.00	$135.80 $16.00 $95.70 $27.40 $20.00
1 1	Crimp Tool 500 ft RG58 coaxial cable	$19.95 $187.95	$19.95 $187.95
		Total:	$2061.04
	SPS Funds used towards the project Chemistry and physics matching funds		$2000.00 $61.04