Properties of Cosmic Ray Air Showers as Measured By a Prototype Cherenkov Detector System

Elizabeth McNany with Corbin Covault
Department of Physics, Case Western Reserve University

ABSTRACT

When high energy cosmic rays interact with the upper atmosphere, a shower of particles is created that generates Cherenkov radiation as they travel towards the earth. To study this radiation, a new prototype detector has been constructed with four scintillation panels and a central photomultiplier tube to detect the visible Cherenkov light. The results from this detector will be compared in detail to a simulation designed to predict the measured properties of air showers and Cherenkov radiation. These results will ultimately be used to fabricate a larger detector system which can be used to study the astrophysical origin of the cosmic rays.

INTRODUCTION

Cosmic rays at high energy encountering the upper atmosphere will emit Cherenkov radiation and decay into other particles, which decay in turn, resulting in a particle shower throughout the atmosphere (Figure 2). These particle showers can be detected by a variety of methods. When a charged particle, such as those created by the decay of cosmic rays, strikes the scintillator, it excites the atoms and causes them to emit a photon when they return to their original, lower energy state. A photomultiplier tube (PMT) may be used to amplify this (small) signal.

A plastic scintillator may be used to detect cosmic ray air showers. When a charged particle, such as those created by the decay of cosmic rays, strikes the scintillator, it excites the atoms and causes them to emit a photon when they return to their original, lower energy state. A photomultiplier tube (PMT) may be used to amplify this (small) signal.

Material and methods

A diagram of the setup is shown in Figure 3. The key components are the four scintillator panels and central photomultiplier tube. The four scintillator panels, and attached electronics, are used as a trigger for the central PMT. The central PMT is open to the atmosphere and is used for detecting the Cherenkov radiation from the shower which triggered it. The additional electronics are used to filter the signals from the PMTs and format them for the logic units used to count the number of showers.

DATA

Some preliminary results were obtained with the prototype (Figure 4). However, the data is extremely inconsistent. Because cosmic ray events are a stochastic process, we expect them to follow a Poisson distribution and have a similar error. Instead, the measured error in average event rate for this data is far greater, indicating an issue with the equipment. After testing we found that the scintillator panels and photomultiplier tubes were not tightly coupled, which is likely the issue.

FUTURE WORK

The data from the apparatus will be compared to a Monte Carlo simulation of cosmic ray showers. This simulation is generated using CORSIKA software, which simulates atmospheric interactions of cosmic rays given initial parameters of the particle such as type, energy, and angle. Example output of a simulation run is shown in Figure 5.

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REFERENCES