Cosmic Ray Project
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# 1 Background

Cosmic rays are extremely high-energy charged particles which can travel close to the speed of light with energies ranging from 1GeV to beyond $10^{20}$eV. The number of particles reaching the Earth's surface is somewhat related to the energy of the cosmic ray that struck the upper atmosphere. The lower energy particles are believed to originate in solar flares, and the higher energy particles are suspected to be of extra-galactic origin. Large distance correlations among detected cosmic rays indicate a high energy primary. One interest in this project is to explore possible anomalies at high energies.

It is believed that some cosmic rays receive their energy from the explosion of supernovas or from he collision of two supernovas, or two black holes. There are two basic divisions of cosmic rays: primaries, which consist of electrons, protons, helium, and the nuclei of carbon, oxygen, and iron. When high-energy primary particles undergo collisions with atoms in the atmosphere, they produce a cascade of secondary particles that shower down through the atmosphere to the Earth's surface. Secondary particles consist of the nuclei of lithium, beryllium and boron, as well as mesons, muons, neutrinos, photons, antiprotons, and pions, which quickly decay to produce muons, neutrinos, and gamma rays, as well as electrons and positrons produced by muon decay and gamma ray interaction with atmosphere atoms.

In 1912, Victor F. Hess discovered cosmic rays. He found that as he traveled higher into the sky in a balloon, an electroscope discharged more rapidly. He credited this to some source of radiation entering the atmosphere from above, which caused ionization in the air. In the mid 1900's, before advanced particle accelerators, cosmic rays served as the source for high-energy physics investigation. This led to the discovery of many other sub-atomic particles; such as the muon. Today, the focus of cosmic ray research has been directed toward the origins of cosmic rays, how their makeup can help us understand matter beyond our solar system, and how they get accelerated to very high velocities.

Because cosmic rays are electrically charged, they are deflected by magnetic fields, too complicated to trace exactly, making it extremely difficult to tell where they originated. Cosmic rays are studied with an array of detectors distributed over many square kilometers that sample the particles produced. Detectors used in studying cosmic rays range from Cerenkov detectors, to scintillators. The purpose of this project is to continue the work begun by researchers in finding an economical way to bring cosmic ray detection systems to high schools. In a sense, many small detectors will become one big detector.

## 2 Individual Contributions

Drew Thomas' individual contribution to the cosmic ray project is to detect the high-energy particles by setting up a coincidence procedure. The procedure will consist of particles passing through two scintillators. Light is produced as the particles pass through the scintillators. Photomultipliers will then be used to increase the number of chances one has at detecting a signal from the scintillators. The photons move inside the photomultiplier and hit a photocathode, and, through the photo-electric effect, an electron is produced. The electrons then bounce off of specially aligned plates (dynodes), which are designed to create (and multiply) new electrons. Thus, more electrons mean a better chance of getting a clear signal. Roughly, a PMT gain is estimated at $2^n$, where n is the number of stages of multiplication, or dynodes. Initially, the scintillators will overlap one another; if a specific particle has enough energy when it reaches one detector, it will pass through it and into the next detector. When this occurs, both detectors register in coincidence. A special timing module connected to the computer will initially be used to measure the time differences of particle detection. Eventually, for separated counter stations, a G.P.S. (Global Positioning System) will monitor the detection. Time monitoring, in each case, is important to tell something about the direction (and origin) of the showers. For each sequence, we will compare data received with expected data from previous and other current experiments.

We must understand the response of our detectors, and how uniform that response is. Femi Osidipe will work with Mr. Cliff Parker, visiting high school teacher, on measuring the response of our different detectors and organizing the information obtained into computer data. He will also be studying possible digitization methods for the data acquisition system, with a particular focus on the waveform digitizer.

Elizabeth Weber will work with comparing observed data with expectations. The program written to analyze the data will itself need to be analyzed for accuracy of assumptions made in performing calculations. It will be necessary to ascertain the validity of the data achieved using the current camac system. Running various tests with the detector system and comparing the data to results acquired at University of Pittsburgh and other institutions will accomplish this. The data collected will also be compared to expected results obtained by using a cosmic ray simulator. This knowledge base will be used to test the functionality of the newly developed system before its implementation in high schools.

## 3 Goal

This cosmic ray project is a development that hopes to detect such high-energy rays with the usage of simple detection devices. It is the hope of this project, that through the collection of data more can be learned about cosmic rays, specifically the higher energy particles and their potential origins outside our galaxy. The ultimate goal of this project is to create a cost-effective detection system, in order to gather the appropriate data, for use in high schools with analytical capabilities and gps time stamping to involve high school students more heavily in hands on scientific research, experimentation, and learning.