SPS Chapter Research Award Proposal

Project Proposal Title	Cosmic Ray Detector for ground and stratospheric observations
Name of School	American River College
SPS Chapter Number	0169
Total Amount Requested	$1986

Abstract

American River College students plan to assemble a Cosmic Ray Detector for observing high energy particles. Our goal is to identify the best detector for classroom and ground operations, and have it fly in the stratosphere via a high altitude balloon.

Proposal Statement

Overview of Proposed Project

The grant offered by the Society of Physics Students will greatly benefit our efforts and plans to construct a cosmic ray detector (CRD). The main goal of our project is to gain insight into the development and operation of such a device at ground level. A stage two goal will be flying the CRD in near-space conditions, ideally by earning a payload slot in the NASA financed and Louisiana State University operated High Altitude Student Platform (HASP) balloon. Also, we already have experience in the launch and retrieval of our own stratospheric balloons from previous experiments in the Mojave desert.

This process will involve designing and assembling a portable CRD with a scalable interface that will enable us to attach it as a payload to a high altitude balloon platform. Essentially, we will detect primary and secondary cosmic rays, with different particles peaking in density around an altitude of 20-25 Km, which is a region in the atmosphere where the Pfotzer maxima occur. The cosmic rays density increases in this area due to interactions of cosmic rays with atmospheric particles. We expect our data will clearly show the Pfotzer Maxima, by contrast with the detection rate at higher and lower altitudes.

Ultimately, the goal of this project is to test the efficacy of certain types of cosmic ray detectors in order to maximize data collection at different altitudes and corresponding thermal and pressure conditions. In doing this, we will provide an important detector for the Physics & Astronomy courses at ARC, identifying and testing the best CRD for educational purposes, benefiting all students. On a national scale, we hope this project may bring some useful information about the most effective methods of design for other universities that wish to detect high energy cosmic rays.

The significance of constructing a CRD for purposes of academic research is that it will enable us to examine and compare high energy particles in the upper atmosphere and sea level. Successful data collection in this project may allow other community colleges across the nation to take initiative to make an impact academically in their own Physics & Astronomy programs. The data analysis and storage *per se* will already represent a significant challenge - among others - in the CRD design. In general it will be a magnificent introduction for students to the overall experience of research in an academic setting.

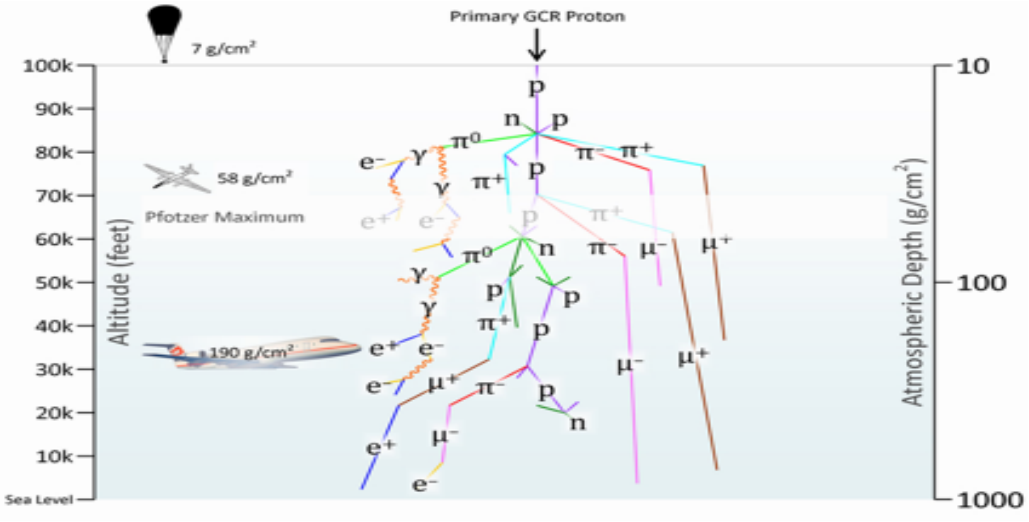

Figure #1: Depiction of the interactions of different primary and secondary in the upper atmosphere that end up decaying into other particles such as pions (labeled "π") and muons (labeled "μ") at lower altitudes.

Background for Proposed Project

CRD work in a variety of methods when it comes to identifying high energy particles. There are two designs that we will examine in our project. The first of which includes using a photomultiplier tube which will amplify the number of photoelectrons with several dynodes. This flux generated by individual photons in the scintillator is detected as a digital signal in the end electronics. The second method of identification uses fluorescent tubes. As the muons cross these tubes, the gas inside will ionize, producing a detectable electric signal. Also we expect the number of secondary cosmic ray muons to decrease significantly above an altitude of approximately 15 Km, where they typically are produced.

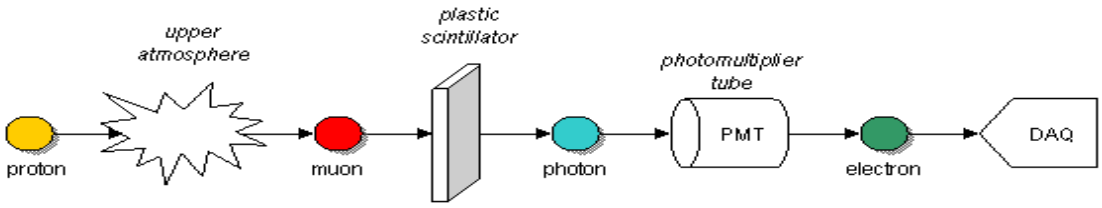

Figure #2: Depiction of a brief mechanism as to how the detection will work for identifying high energy particles.

Expected Results

Upon completion of our project, we expect to have qualitatively shown through data collection which CRD is the best for identifying high energy particles in different environmental conditions. We also expect to observe the following results:

- Increase of cosmic rays with altitude up to the Pfotzer Maxima - and subsequent decrease at higher altitudes
- Observe the East-West effect in cosmic rays above 25 Km, confirming most primary cosmic rays have positive charge.
- Observe the decrease of muons above ~ 15 Km.
- Perhaps observe a day-night effect due to the solar cosmic rays contribution.
- Systematic usage of our CRD in ARC physics and astronomy courses at ground level.

We assume that the HASP balloon will have a total flight time of approximately 20 hours where within that time frame, it will have reached a maximum altitude of ~ 36 km.

Description of Proposed Research - Methods, Design, and Procedures

The research experiment will revolve around the use of two differently designed CRD. One will consist of a NaI(Tl) scintillation crystal coupled with a multi-stage photomultiplier tube. The other will feature multiple circular or straight fluorescent lamp tubes with an electronic counter circuit. The selected CRD will be affixed to a compact, integrated platform attached to a high altitude balloon, with a data collection system working in stratospheric conditions. The custom software will capture and record live data from the CRD in addition to associated telemetry data. The data collected from the CRD will mainly come from a particle counter, energy meter, PMT module sensor, temperature and pressure sensors as well as a specialized photosensor array. Continuous operation of the entire system will be ensured through the use of a stable, uninterruptible power supply. Additionally, sensitive components and delicate circuitry will be shielded in order to minimize influence from electromagnetic interference and external noise that may be prevalent in the upper atmosphere. A possible visit to the Columbia Scientific Balloon Facility (CSBF), Palestine, Texas, for thermal and vacuum tests as early as May-June 2015 is also under consideration in the context of the HASP balloon.

After the payload returns to ground level, the collected data will be retrieved and processed. Analysis of the data may involve some calculations related to power spectral density, energy levels of primary and secondary incident cosmic rays and other calculations designed to identify the specific kinds of particles that were detected. Following this analysis, the information gathered will be disseminated through a formal report and college seminars and talks related to the CRD. This, of course, will also include a comparison between the two cosmic ray detectors in terms of quality and effectiveness in detecting high energy radiation.

Plan for Carrying Out Proposed Project

- **Personnel -** Although only a handful of our team members are actually Physics majors, our team consist of a core of 12 students who share a great passion of the Physics field. Our team is divided into specific groups based on area of expertise, interest, and needs of the group.
- **Expertise -** Our current club treasurer, Michael Zarivny has significant knowledge and background into the design and operation of PMT's in addition to electronics. Professor Paulo Afonso has background in astronomical properties of high energy particles in deep space. In the recent past we also completed a successful launch and retrieval of a small stratospheric balloon in the Mojave desert.
- **Research Space -** The HASP balloon will launch from the Columbia Scientific Balloon Facility (CSBF) base in Fort Sumner, New Mexico. Integration and tests will be done at CSBF - Palestine, Texas. We also have the Physics, Chemistry and Electronics Dpts. facilities available at ARC.
- **Contributions of Faculty advisors or the department -** Professors Paulo Afonso (currently serving as our faculty advisor), Brooke Haag and Shih-Wen Young have their doctoral areas of expertise in astronomy, particle, and nuclear physics.

Project Timeline

- **August 23**: Fall 2014 semester begins
- **September**: Study different designs for CRD
- **October**: Begin analyzing the materials needed for the two selected CRD designs
- **November 15**: Submit a detailed proposal and budget to SPS
- **December**: Define technical details for the ground & flying CRD
- **December 19**: Submit the application for the Louisiana State University HASP
- **January 17**: Spring 2015 semester begins
- **January**: Receive notification to participate in the Louisiana State University HASP.
- **February**: Ensure the quality of the materials by running different ground trials
- **March**: Construct CRD and begin testing
- **April**: Finish trials and ensure all materials are operating properly
- **May 31**: Submit an interim report to SPS
- **June**: Finish assembly of ground-operating CRD in Sacramento.
- **August: 1-10** Fly to the Columbia Scientific Balloon Facility (CSBF), Palestine, Texas, for thermal and vacuum tests & integration of the CRD in the high altitude balloon in case of selection.
- **August 23**: Fall 2015 semester begins. Start using CRD in ARC courses of astronomy and physics.
- **September:** Fly to CSBF in Fort Sumner, New Mexico, for the HASP launch
- **October-November:** Data and flight analysis
- **December** 31: Submit the final report to SPS

Budget Justification

The grant from the SPS chapter research award will serve to purchase the necessary equipment and parts needed for the two CRD. These parts include, one NaI(TI) scintillation crystal, three fluorescent tubes, one scintillation detector housing unit, and other CRD components. Any tools that will be needed in the assembly of the CRD will be provided by the ARC Physics department.

Bibliography

Figure #1
http://physics.okstate.edu/rpl/muons.htm

Figure #2
http://www2.fisica.unlp.edu.ar/~veiga/experiments.html

"Vertical Intensity of Cosmic Rays by Threefold Coincidences in the Stratosphere". Regener, Erich; George Pfotzer (November 1935). *Nature* 136 (3444): 718–719

"Cosmic Rays at Earth - Researcher's Reference Manual and Data Book", by Peter K.F. Grieder, 2001.

"On the Magnetic Deflection of Cosmic Rays", Rossi, Bruno; Physical Review, vol. 36, Issue 3, pp 606, August 1930.