SOCIETY OF PHYSICS STUDENTS
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# ΣΠΣ Undergraduate Research Award Proposal

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| **Project Proposal Title** | Designing a Cloud Chamber for Academic and Outreach purposes |
| **Name of School** | Goucher College |
| **SPS Chapter Number** | #2501 |
| **Total Amount Requested** | $1230 |

## Abstract

The students of Goucher College Physics and Astronomy Department plan to design and construct a working cloud chamber. Through the project, they will develop valuable scientific skills while creating a permanent piece of equipment to be used in the classroom as well as for outreach programs.

# Proposal Statement

## Overview of Proposed Project

The purpose of this project is to design and build a usable cloud chamber, which is a piece of equipment that allows viewers to see the tracks made by subatomic particles. By measuring these tracks, viewers can use physics principles to determine what particles made the tracks, as well as other properties such as the particle's mass and momentum. We will design our cloud chamber to be compact, and will optimize viewing conditions for proper particle track study and measurement. Our ultimate goal is for the cloud chamber to be put to academic use in our Modern Physics classroom, as well as in demonstrations and scientific outreach programs.

We plan to both lead and involve multiple Goucher students, including freshmen and sophomores, in the design and building process. Our hope is to give them the experience of collaborating on a long-term scientific research project, develop hands-on skills in equipment design and testing, and practice scientific communication skills. Once completed, the cloud chamber will remain a permanent piece of equipment for use in Goucher's Physics and Astronomy classes.

## Background for Proposed Project

Developed in the early 1900s by Charles Thomson Rees Wilson, the cloud chamber was one of the first devices used to view the tracks of subatomic particles. The chamber is filled with condensed, supercooled vapor. When charged particles enter the chamber, the vapor is ionized, leaving behind visible tracks that can be seen by the naked eye. A magnetic field applied within the chamber will cause the tracks to curve, and this curvature can be used to determine the mass, charge and identity of the particle. Numerous particles have been tracked and discovered in this way – including the positron, the first experimentally discovered antimatter particle. The cloud chamber is therefore both scientifically and historically significant, and we would like to construct one as a permanent piece of scientific equipment for Goucher College.

Our Department of Physics and Astronomy is expanding at an impressive rate. Not only have we recently moved into an entirely new building, the majority of our department is made up of freshman and sophomore physics students. Because of this, we want to initiate long term projects for these students and involve them in scientific work as early as possible. A major goal of this project is for students to be able to design a quality cloud chamber, and to gain hands-on experience conducting self-guided research with the apparatus.

## Expected Results

Through the cloud chamber design and building process, we will lead underclassmen to gain hands-on experience in designing and building an intricate and usable piece of physics equipment. Additionally, we want to hone valuable professional skills, such as the ability to collaborate as a team on a long-term project and the ability to output precise scientific writing when preparing reports for SPS as well as documentation for the equipment.

Our project will not only be an informative experience for those who take part in the design and building process, but will continue to excite future physics students at Goucher College. Once built, the cloud chamber will serve as a permanent fixture of the modern physics lab, which is a sophomore level course and is meant to help students to decide whether or not they will continue on in the physics major. Though particle physics is covered in the course, we currently do not have any particle physics labs that allow students to directly measure and work with particles. The cloud chamber would allow these students to learn about particle physics in a tangible way and hopefully incite further interest in this fascinating area.

Finally, we intend to use the cloud chamber as a tool to garner public interest in physics. A major aspect of our cloud chamber design will be to make it portable. This will allow us to transport it to local schools or around campus for our prospective student visiting days, and give historical presentations as well as hands-on demonstrations. The chamber will showcase an area of physics beyond classical mechanics and electromagnetism, which is the extent to which physics is most commonly taught in high schools. This will hopefully attract more students to consider pursuing a major in physics, or if not, to at least appreciate the beauty of visible particle tracks and the exciting history of the cloud chamber.

## Description of Proposed Research - Methods, Design, and Procedures

As we plan to use our cloud chamber for academic and outreach purposes, we will design and optimize it with two aims in mind. The first will be ease of use – our cloud chamber and its supporting equipment must be compact, somewhat portable, easily started up and simple to maintain. This will be accomplished by cooling the chamber electrically, as opposed to using dry ice, and designing the chamber setup appropriately. Secondly, we wish to optimize the viewing conditions for the cloud chamber, as these will be crucial for studying and identifying low-energy particles.

Our cloud chamber will be built with the following major components:

- A permanent rare earth magnet will supply a magnetic field, which will be crucial for proper measurement and identification of particle tracks.

- Thermoelectric coolers will pump ice water from a basin to cool the chamber. They will draw electricity from a unit composed of stacked power supplies. We chose to use this cooling method because regular ice is much more easily obtained than dry ice, another common cloud chamber coolant.
- A small thermometer within the chamber will help us determine when it has reached a temperature optimal for viewing. We will also make sure that it will not interfere with the magnetic field.
- A viewing tank constructed of Lexan will allow us to observe particles from all angles. It will also be lightweight, contributing to our goal of making the chamber as portable as possible.
- An aniodized aluminum plate will serve as the base of the cloud chamber. Aniodization will make it permanently dark, making it easier to view the particles.

## Plan for Carrying Out Proposed Project

- **Personnel** - Our core team is comprised of 3 seniors, 1 junior, 1 sophomore and 1 freshman, all of whom are physics majors and will be involved in all stages of the project. Half of the team is female, which we hope will serve as encouragement to other female science majors. We expect more students to become involved in various stages of the building and testing process, following the graduation of the seniors and the entrance of incoming freshmen.
- **Expertise** - Alissa Murray, our chapter co-president, initiated interest in the project, and due to the extent of her background knowledge concerning cloud chambers she will serve as student overseer of the project. Following Alissa's graduation, Phoebe Yeoh, the other co-president, will lead the project.
- **Research space** - We will complete the project in the physics department's new workshop, where all the equipment is stored with supervision by faculty. We have just moved the department to a newly renovated building, and the workshop is spacious and ready to use.
- **Contributions of faculty advisers or the department** - Dr. Rodney Yoder, experimental physicist, will serve as our faculty adviser for the project. Our current SPS chapter adviser, theoretical physicist Dr. Sasha Dukan, has also confirmed that the Physics and Astronomy Department will cover any additional costs that may arise after we begin our project.

## Project Timeline

January 26: Spring 2014 Semester commences.
February: Finish ordering necessary parts; finalize calculations and cloud chamber design.
March: Construct and test the viewing chamber, power supply, and base of the equipment.
April: Construct and test the thermoelectric cooling system.
May: Assemble the cloud chamber and perform preliminary testing. Write and submit interim report to SPS by May 31.

August 26: Fall 2014 Semester commences.
September: Make adjustments to the apparatus as necessary; measure and map the magnetic field.
October: Optimize cloud formation and chamber viewing conditions.
November: Continue optimization of viewing conditions; begin measuring and identifying particles.

December: Create appropriate documentation for cloud chamber setup and use. Write and submit final report to SPS by December 31st.

## Budget Justification

The grant money from SPS will be used primarily for buying the components needed to build the cloud chamber. This includes the thermoelectric coolers, rare earth magnet, power supply and other chamber components, including the estimated cost for aniodizing the aluminum plate. All of the necessary equipment and tools will come from our department workshop. The Goucher Physics and Astronomy Department has also agreed to cover any additional incidental costs that may arise and which are not covered in the budget.

## Bibliography

Cosmic Imagery: Key Images In The History of Science by John D. Barrow
The Harvest of a Century: Discoveries of Modern Physics in 100 Episodes by Siegmund Brandt
M. Longair, C.T.R. Wilson and the cloud chamber, Astropart. Phys. (2013), http://dx.doi.org/10.1016/j.astropartphys.2013.01.010