



# SOCIETY OF PHYSICS STUDENTS

An organization of the American Institute of Physics

## *SPS Chapter Research Award Interim Report*

Project Title	Atmospheric Muons as a Probe for the Higgs Vacuum Energy of Space and of the Lead Stopping Power
Name of School	Northern Virginia Community College
SPS Chapter Number	4963
Total Amount Awarded	\$1024.00
Project Leader	Cioli Barazandeh

### *Abstract*

Using a single scintillation detector, we will measure the muon's lifetime, atmospheric flux, energy spectra and perform calculations within the Standard Model of Particles (SM) of the Higgs field vacuum expectation value and of electric and weak charges. We will then shield the detector and find the muon stopping power in lead.

### *Statement of Activity*

### *Interim Assessment*

This is the Muon Midterm Project Report of the NVCC Chapter of the Society of Physics Students.

The muon experiment this semester alone was presented at the APS "April" Meeting in Washington, DC (2 Talks), the Virginia Academy of Science (VAS) Undergraduate Research Showcase for the Virginia Assembly (Poster and Talk) in Richmond, the VAS Annual Spring Meeting (Poster and 2 consecutive talks) at Virginia Commonwealth University, the NVCC STEM Fair (Poster and Talk), and the NVCC Joseph Windham Student Voices Conference -JWSVC (Talk).

At the VAS Showcase, the presenter, Cioli Barazandeh, spoke to the Virginia House Science and Technology Committee, and presented a poster in the antechamber. At the APS April Meeting, two talks were performed. At the NVCC STEM Fair, the presenter delivered a poster and a talk, as the sole talker. Our Muon poster has won the First Prize in the competition.

Plans are also in preparation for two talks at the MENSA Annual Gathering and Regional Gathering.

No grant money was spent yet, because we received the SPS check after the end of the Spring semester of 2017.

This section should include:

- **Research question –Does the muon lifetime depend on the amount of lead shielding?** At what rate are the low- and high-energy muons absorbed in lead? Can a simple muon experiment measure the Higgs field?
- **Brief description of project** –With one(!) detector, the NVCC SPS captures muons and electrons with the telltale twin pulses of the light. While the addition of lead shielding has been an interesting component to add into the function, it has not changed the mechanics of how the experiment functions much.
- **Progress on research goals – What has been accomplished so far?**
- Quite a bit, see Research and Results sections.
- **Any changes in the scope of project** –Issues with the equipment caused setbacks, which has led to an upgrade, courtesy of the College. This is also for security purposes, as the old computer was considered outdated.
- **Personnel**
- Cioli Barazandeh -Lead
- Walerian Majewski. -Advisor
- Previous:
- Angel Gutarra-Leon –Former Lead, but left in order to transfer to George Mason University
- Maryam Mohagheghi –Left SPS in order to prepare for exams.
- **How many participants are SPS members?** All of them!
- **SPS connection – How is the activity strengthening the objectives of the SPS program, both at the proposing school and nationally?** The NVCC chapter is an active research chapter, currently experimenting with concepts and examining physics in its directed research on muons and magnetic levitation. Through these studies, presentations are made to further enrich the populace on physics knowledge, as well as scientific activity in general.

### *Updated Background for Proposed Project*

No change here.

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

Below is an overview of the events that occurred during the past semester. In short, the lead shielding at the detector was set up, as Georgetown University has given the team a loan of lead bricks, while the Pb plates were bought from the college funds. The targets were flux and variances (as well as a few others), in which some data results were unexpected, while others were actually expected. The muon lifetime in free space was found within a few percent from the accepted value. Plans have been made for presentations, and many were given.

The data collections often crashed (and crashed and crashed and crashed once again). The reason behind all of this crashing is due to the fact that an older computer was being used, and is currently being replaced with a newer piece of hardware. This thus will likely be remedied by the second run.

### *Initial Results*

Additionally, many of the results likely would not be found directly from the raw data, but from calculations that could be made off of these and derived from the collections. As a histogram of the delay time between muon and electron signals, these are fed into the processor, and are scrutinized for the decay constant  $\lambda$  to find the lifetime ( $\tau$ ) result; a necessity of particle physics.

Even so, trial results have been found. For the low-energy muons, the flux was near-constant (increasing) with a change of lead thickness, which means that there are muons  $>140$  MeV with an almost flat spectrum, which after slowing down in lead replace muons absorbed there. As another data analysis for the low-energy muons, statistical fluctuations of the lifetime (significant, but still within the margin of error) as a function of lead amount were found, but these still proved that the lifetime is mostly absorption-independent, as expected.

Some usable data was also gained from these new results from the high-energy muons too! For the lead layers up to 25 cm, though, the results are not finalized. The end results may be presentable after a proper analysis.

### *Statement of Next Steps*

#### *Plan for Carrying Out Remainder of Project (including Timeline)*

The computer will be added in before entry into the lab after the summer break (beginning of September). Then, with the new equipment, further study and validation and precision inspections of the results may be

based upon the previously found facts (finished by the middle of November). Then, after a data analysis, the data would be presentable just in time for the report.

- Personnel -

Cioli Barazandeh

Walerian Majewski

Possible new SPS members, who may replace those who just have transferred to the College of William and Mary, University of Virginia and the Virginia Polytechnic Institute.

How many participants are likely to be SPS members? All of them. Are there SPS members or others with special expertise that will help to ensure success? The new set of members arrives in the fall semester.

## *Bibliography*

Cite all resources referenced in the interim report here.

- [1] NIST Physical Measurement Laboratory. n.d. <http://www.physics.nist.gov> (accessed 2015)
- [2] Reitner R A, Romanowski T A, Sutton R B and Chidley B G 1960 Precise measurements of the mean lives of  $\mu^+$  and  $\mu^-$  mesons in carbon. Physical Review Letters 5.1 22-3
- [3] Ye J and Coan T E n.d. Muon Physics (Report of Rutgers University)
- [4] Pierce M and Tekniska K April 2003 Measuring the Lifetime of Cosmic Ray Muons (Report, Section of Experimental Particle Physics)
- [5] L3 Collaboration et al 2004 Measurement of the atmospheric muon spectrum from 20 to 3000 GeV Physics Letters B 598 1-2; 15-32
- [6] Schwartz M D 2014 Quantum Field Theory and the Standard Model. (Cambridge: Cambridge University Press)
- [7] Griffith D 2008 Introduction to Elementary Particles. (Verlag: Wiley-VCH)
- [8] Quigg C 2013 Gauge Theories of the Strong, Weak and Electromagnetic Interactions. (Princeton: Princeton University Press)