DemoSat: Modular Payload Design and Radiation Flux with Altitude
Veronica Buchanan, Ryan Fabian, Josh Fender, Thanabordin Lausatianragit, Bryan Lopez, and Tre Tellez
UNIVERSITY OF NORTHERN COLORADO, DEPARTMENT OF PHYSICS AND ASTRONOMY
FACULTY ADVISORS: DR. C. GALOVICH, DR. M. SEMAK, AND DR. R. WALCH

ABSTRACT
Muons are created when high energy cosmic particles like protons collide with atmospheric molecules, such as diatomic oxygen or nitrogen. These collisions create new molecules and decay products such as muons. It is known that there is a relationship between muon production and increasing altitude. For this project, we will measure the number of muons as a function of altitude. To gather these data, we will attach a payload containing an altimeter and a Geiger counter to a weather balloon. An internal frame has been constructed to protect the payload components, and the frame and components must be able to endure harsh conditions including:
- Temperatures ranging from -80 °C to 25 °C
- Accelerations up to 8 G's
The payload will be launched Saturday, April 9, 2016 and is expected to reach an altitude of between 15 and 20 miles.

EXPECTED DATA
The payload will experience a change in radiation flux as it ascends. For most of the flight, we expect the muon count to increase with altitude. However, there will be a point at which the count will decrease with altitude (Fig. 1). This is due to less atmosphere being present, and thus fewer radiation scattering events taking place. Given the wide ranges in temperature and pressure that our payload will experience, we will collect internal temperature data in an effort to evaluate any failures that occur during the flight.

STRUCTURAL DESIGN
One of our objectives is to develop a modular payload design that can withstand the extreme conditions that exist during flight. In addition, the payload should be easily modifiable for future missions. To achieve this, we designed a payload frame that includes 16 internal mounting points. We used CAD software to evaluate the frame’s ability to accommodate a variety of sensor packages and components. We then 3D printed a full scale version with ABS plastic and conducted further testing of the frame’s modular capabilities. In addition to the internal mounting points, the frame has 8 external mounts. These mounts allow for additional frames to be stacked on top of each other to create a larger payload if needed. Utilizing these internal and external mounting points allows for greater flexibility in future missions without the need to redesign the main structure.

ELECTRONIC COMPONENTS
Inside of the payload, we have:
- Three 2000mAh Li-ion batteries
- Two 7.5 ohm resistors
- Arduino Uno
- MicroSD shield
Two batteries will power each of the 7.5 ohm resistors to heat the payload. The third battery powers the Arduino. The Arduino is programmed to collect measurements from each of the sensors every second (temperature sensor, altitude/pressure sensor, and Geiger counter) and save these to a text file on the MicroSD shield mounted to the Arduino. Power from the batteries is controlled by individual switches.

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CONCEPT OF OPERATION

TESTING
In order to ensure our payload’s readiness, we rigorously tested the electronic and structural components.

Electronics tests
- all sensors and the program code were run for a duration of 4 hours (approximately the length of the launch)
- all data collected during this period were compared with known values to ensure each sensor's accuracy

Physical tests
- dropping the payload from a height of approximately 40 feet to simulate a hard landing
- whip testing to simulate large accelerations
- cold testing to simulate conditions in the upper atmosphere

Post Flight
Post flight, we will analyze the data and compare the results to those of a past experiment. This comparison will be used to determine whether our data collection process was consistent or not. Also, we will analyze our modular payload structure by checking for stress fractures, and we will review the internal temperature data to verify that the heating technique was effective.