Hobart and William Smith Colleges
PDR Report

PDR

Team Members:
Frank Oplinger
Rousseau Nutter
Tyler Hanzlik
Lauren St. Peter
Bobby Hooper

Advisors:
Ileana Dumitriu, Ph.D.
Peter J. Spacher, Ph.D.
Mission Overview

• Modified Mission statement: The purpose of our experiment is to determine the flux of muons at various levels within the atmosphere and to determine if there is a muon flux in space using a solid state scintillator detector
  • Measure muon flux density during flight
  • See how acceleration of the rocket influences muon detection
  • Determine if muons are in space
  • Improve upon muon detection from 2015
Specific mission:

- Improve upon the scintillator shape to maximize detection potential from photomultipliers
- Reduce gamma ray detection from scintillator by potentially using metal foam
- Rebuild the muon detector to fit into a half canister
Muon Overview

- Muons are leptons, related to electrons
- Mass of approx. 105.6 MeV/c^2, about 200x larger than an electron
- Formed as secondary products of interactions between cosmic rays and atmospheric particles
- Atomic nuclei collide with atmospheric molecules, producing pions which decay into muons
Previous Research

Bachri et al, 2011
• Experimental data showing the flux of muons at various altitudes
• Muons were detected underwater, and increased with height

Figure 3: Flux as function of elevation. Locations tested included: Magnolia, AR (338ft), Galveston, TX (10ft), Mt. Magazine, AR (2753ft), Mt. Hamilton, CA (4200ft) and inside the Radiation Counting Laboratory (RCL) in the NASA Lyndon B. Johnson Space Center (- 60ft).
• 2015 Rocksat-c Data collected by solid state scintillator detector
Our Project: Mission

- Data collection begins at T -60 seconds seconds (Allows proper time for system boot up and baseline data collection)
  - All systems on
  - Begin data collection

$t \approx 1.3$ min
Altitude: 75 km

$Apogee$
$t \approx 2.8$ min
Altitude: $\approx 115$ km

$t \approx 4.0$ min
Altitude: 95 km

End of Orion Burn
$t \approx 0.6$ min
Altitude: 52 km

$t \approx 4.5$ min
Altitude: 75 km

Chute Deploys
$t \approx 5.5$ min

$t \approx 15$ min
Splash Down
End of data collection

$t \approx 1.7$ min
Altitude: 95 km

$t \approx 3$ min

$t = -3$ min

$t \approx 4.0$ min
Altitude: 75 km

Dash
Expected Results

- More specific muon count in comparison to 2015
- Muon flux will decrease with altitude
- Photomultipliers will have a more accurate count of muon hits due to efficiency of shape design
- Overall hits will decrease due to filtering of muons from other radiation
- Decrease in muon flux at apogee
Mission Requirements:

- Build working SiPM that is able to count muons during flight

Minimum success:

- Store data for number of muons collected at various times during flight
## Functional Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload fit within canister</td>
<td>Inspection</td>
<td>Visual confirmation and measurement</td>
</tr>
<tr>
<td>Payload will sustain 25 g and vibrational charactistic outlined by the User Guide</td>
<td>Test</td>
<td>Payload will be subjected to testing in June</td>
</tr>
<tr>
<td>Payload will weigh 10+/- .2 lbs.</td>
<td>Inspection</td>
<td>Payload will be weighed to confirm that it is within the expected range</td>
</tr>
</tbody>
</table>
# Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th># of Items</th>
<th>Weight/Item (lbs)</th>
<th>Weight (lbs)</th>
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<tr>
<td>Canister</td>
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<td>3.35000</td>
<td>3.35000</td>
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<tr>
<td>Muon Detector</td>
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<tr>
<td>Rods (0.5” Diameter)</td>
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<td>Batteries (With Plastic Mount)</td>
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<td>0.11905</td>
<td>0.83335</td>
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<td>Plastic Plate</td>
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<td>Data Logger Sheild</td>
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<td>Additional Electronics</td>
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<td><strong>Total Weight</strong></td>
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<td><strong>11.114909 (lbs)</strong></td>
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Subsystems
Mechanical Diagram
Prototype Plates

- We are still conducting tests on last year's Solid State Muon Detector to determine the best shape.

- Due to weight restrictions we are setting a cap of 4 pounds to the muon detector.
  - Our following ideas would all fit under the 4 pounds.
Original Circle Shaped Plates
(radius reduced)
Original Circle Shaped Plates
(radius reduced)

Encasement

Upper Scintillation Plate

Center Plate

Canister Size

Lower Scintillation Plate
Pentagon Shaped Plates

Encasement

Canister Size

Scintillation Plate

Center Plate

DIA 9"

DIA 8 11/16"

6 3/16" 6 13/16"

4"

5/8"
Pentagon Shaped Plates

- Encasement
- Upper Scintillation Plate
- Center Plate
- Lower Scintillation Plate
- Canister Size

Dimensions:
- DIA 8 11/16''
- 1 1/8''
- 1/2''
- DIA 9''
- 1 1/8''
- 1/4''
- 2/16''
- 3 7/16''
- 6 13/16''
Hexagon Shaped Plates
Hexagon Shaped Plates

- Encasement
- Upper Scintillation Plate
- Center Plate
- Lower Scintillation Plate
- Canister Size

Dimensions:
- DIA 9”
- 1 1/8”
- 1 1/16”
- 3 7/16”
- 6 13/16”
- 1/2”
- 1/4”
- 1/8”

RockSat-C 2016 PDR
Prototype Photo Multipliers

- We are still doing tests on last year's Solid State Muon Detector to determine the best placement of the photomultiplier(s)

- We are looking into using more than one per layer
  - This will be determined by both the results of the tests and from funding
Single Photomultiplier
(For Circular Plates)
Single Photomultiplier
(For Pentagonal Plates)
Single Photomultiplier
(For Hexagonal Plates)
Electrical Subsystem

*excessive square waving
Power Subsystem
Software Subsystem

- Arduino computers
- Programmed to count only when they get a pulse from square-wave circuits
- Program initializes with a time date stamp when power is activated
- Write data to text files, records a numerical count and the time at which the count occurs
Risk Assessment

- Activation - the experiment may not turn on and work successfully during flight
- Wiring - velocity of the payload may cause wiring to shift during flight
- Power - power may be lost as we wait for the rocket to take flight
- Payload damage - foundation of the payload may be damaged from vibrators or heat during flight
Prototype Plans

Mechanical
- Photomultipliers may not detect at all areas of the plate
- Test thickness of scintillator plates

Mechanical
- Photomultipliers may not detect at all areas of the plate
- Test scintillator plates shapes and multiplier location
Project Management Plan
Our Project: Team Organization

Advisors:
Ileana Dumitriu, Ph.D.
Peter J. Spacher, Ph.D.

Co-lead
Frank Oplinger

Co-lead
Rousseau Nutter

Mentor
Chris Demas

Mentor
Jeff Rizza

Researcher:
Bobby Hooper

Researcher:
Kemal Turksonmez

Researcher:
Tyler Hanzlik

Funding:
Lauren St. Peter
## Hobart and William Smith Colleges

### Fall 2014 RS-C Team Availability Matrix

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
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Conclusion/Overview

- **Objective:** The purpose of our experiment is to determine the flux of muons at various levels within the atmosphere and to determine if there is a muon flux in space using a solid state scintillator detector.

- **Future plans:**
  - Await testing results from previous muon detector
  - Finalize design of plates based on results
  - Access coding errors of previous Arduino code
  - Continue to look into funding sources
Questions

- Specs of half canister
- Collaborating with other teams?