Critical Design Review

Amelia Beckwith, Hazel Betz, Aaron Groves, Ikaika McKgeague-McFadden, Nicholas Cantrell, Delphine Le Brun Colon, John Paul Molden, Christina Pack, Amos Parmerter, Brianna Sparks, Ariel Stroh, Sarah Trevisiol, Levi Willmeth, Rong Yu

2014 - 2015
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Mission Overview

Amelia Beckwith, Hazel Betz, Ikaika McKeague-McFadden, Brianna Sparks, Levi Willmeth
Mission Overview

Our teams mission is to collect readings of cosmic radiation using Geiger tubes during a rocket’s flight.

Our mission was born from a desire to have an opportunity to learn, and work as a team to achieve our mission. We hope our experiment to detect cosmic rays will enhance our education, inspire our fellow students, spark interest in the STEM disciplines, and ignite a passion for space exploration.

In addition, Oregon State University RockSat C team will utilize our data to enhance their Tardigrades research.
Particle counts are measured in flux ($m^2$ per second). The particle density decreases significantly after 30km of altitude. Our main window of data collection will be between 0 and 30 km of altitude, during ascent and descent.

- **Apogee**
  - $t = 3$ min
  - Altitude 115 km
  - We anticipate fewest low energy readings per cosmic ray

- **Bulk of data collection**
  - **ascent**
    - $t = 0$ and $t = 0.4$ min
    - Altitude 0 to 30 km

- **Altitude ~30 km**
  - Anticipate change in readings based on atmosphere density

- **Bulk of data collection**
  - **descent**
    - $t = 5$ min
    - Altitude 0 to 30 km

- **$t = 0$ min**
  - G switch activates
  - Begin data collection

- **$t = 15$ min**
  - (exact time TBD)
  - End data collection

- **Altitude = 0 m**
  - Splashdown
Expected Results

Based on the mission timeline and flight plot from RockSat-C 2014, and Geiger count flight data from RockOn 2014, we estimate detecting the following quantities of cosmic radiation data:

Particle Energy $10^{10}$ eV 0.046 particles per second

Particle Energy $10^{9}$ eV 0.46 particles per second

Particle Energy $10^{8}$ eV 4.60 particles per second

Because not all particles will have enough energy to pass through the skin of the rocket, the canister, or have the required angle to pass through more than one Geiger tube, we expect quality data in small quantities.

The effective area of 6 Geiger tubes is 0.00046 square meters, which is relatively small compared to the particle detection data measured in Flux (particles per square meter).
Expected Results Continued

We expect that using 6 tubes will allow us to record several hundred cosmic rays over the course of the flight.

As seen by graph, we anticipate a decrease quantity of cosmic radiation as we approach an altitude of 30 km. The limited time interval of our data collection will prevent any dead time of our Geiger-Müller tubes.
Design Description

Hazel Betz, Nick Cantrell, John-Paul Molden, Amos Parmenter, Brianna Sparks, Sarah Trevisiol, Levi Willmeth
Our team increased number of geiger tubes from 3 to 6. This increase of tubes will increase our detection ability. The tubes we have selected are physically smaller and cheaper than what we had previously anticipated. Our tube selection enables us to save space inside the canister while saving money.

Arduino Due was selected. We settled on the Due because this Arduino has the most processing power as well as it is the only Arduino to run two loops at once. The dual loop feature allows us to update our new code.

Removal of the coincidence gate. New code was designed allowing the Due to read data from the tubes and write data to the SD card at the same time. This allows us to remove the coincidence circuit and use code to know when we are hit with a high energy particle.

These changes will not affect the path, mission requirements, or objectives. We have remained true to the path we started on.
Our original design was meant to compare two types of cosmic ray detectors:

- Scintillation detector
- Dual-tube Geiger-Müller detector with a coincidence gate.

The team has decided a scintillation detector would add too much complexity to our project and therefore is focusing solely on the Geiger-Müller based detector.

We originally planned to use a coincidence gate to ensure we could accurately determine when a particle struck more than one tube. We have since designed a simpler and more elegant circuit which will simplify our circuit layout and code requirements.

The improved circuit design allows us to use more tubes while greatly reducing the complexity.
Off-Ramps - Mechanical

Reduce the number of Geiger Müller counters from 6 \(\rightarrow\) 3.

Benefits:
- Reduces complexity
- Reduces cost by approximately $200
- Allows us to complete our mission requirement of comparing single hits to coincidence hits during flight.

Downsides:
- Fewer geiger tubes available for redundancy in case of failures
- Reduces angle between tubes (increases space between neighboring tubes) decreasing our number of measured particle hits.
Off-Ramps Electrical

• Our electrical circuits are simple and fulfill mission requirements.
• Our coincidence gate circuit in particular has been greatly simplified to store hits in an ordered list which has reduced the need for in flight processing.
• As an additional safeguard, each geiger tube will have its own power circuit PCB. These PCBs will all be identical enabling us to interchange tubes in case a malfunction occurs.

Off-Ramps Software

• Reduce the software coding complexity
• When programming the startup sequence we can assume the SD card works without testing it or having a backup formatting procedure
• Abandon the timed shutdown on splashdown
Off-Ramps

LBCC Off Ramps
Much of our team’s unnecessary design complexity has already been reduced and we believe we have designed a solid mission with no remaining high-risk portions. All of our remaining design components are readily available at low cost, and we are preparing replacement parts in case of subsystem failure.

OSU Off Ramps
The main off ramp for the OSU team is removing one of the three tardigrade environments from the payload.
• This would result in reduced coding complexity
• Simplified logistics of maintaining the tardigrade environments
• Weight and stability of the payload only reliant on the two remaining systems
Mechanical Design Elements

Full Design in Canister

Components

- OSU Payload
- LBCC Payload
- Canister
Mechanical Design Elements

Full LBCC Payload Outside of Canister

**Dimensions**
- Outside diameter of Geiger Daughter Boards: 245.056mm
- Diameter of Disks: 235.712mm
- Radius of cut-outs on Disks: 16.891mm
- Total height: 135.683mm
Mechanical Design Elements

*All measurements in millimeters*
Mechanical Design Elements

Layer 1 Isometric

Geiger Daughter Boards
PCI-E Connectors from Molex
Geiger Tubes
Mechanical Design Elements

Layer 2 Isometric

- 9V Batteries
- Stand-offs
- Arduino Due
Mechanical Design Elements

Changes since PDR

Smaller Geiger Tubes
  - Much cheaper per tube
  - Allows us to use more tubes for higher rate of detection
  - Backups on hand and in machine stay within our budget

Expanded to 2 plates
  - Increases modularity, allows for easier replacement/swapping in case of damage during transit to launch site or change in design

Vertical layout of Geiger Tubes
  - Allows us to detect just as many particles as horizontal
  - Room for extra tubes & daughter boards attached to smaller Geiger Tubes
Each Geiger tube has its own board with voltage regulation and pulse shaping. This allows us to replace any malfunctioning Geiger tube with very little effort. It also means a problem with any single tube will not affect the others.
The team has removed the coincidence gate, while accomplishing the same purpose with a simpler design. The new logic gate that will replace the gate is known as a NAND Gate followed by a Latch.

New design elements including three additional geiger tubes and supporting voltage hardware, for a total of 6.

This does not affect our mission requirements. In fact, by removing the logic gate and modifying our circuit we were able to simplify the complexity of the entire system while increasing our detection capabilities.

With special thanks to our Mentor Jack Higginbotham and professional expertise of LND. Inc we were able to select a specific model of geiger tube with the durability required to survive the rugged conditions of flight while maintaining the sensitivity our team is looking for.
Pseudocode:
Setup():
  Create a file on the SD card.
  Initialize buffers A and B to temporarily hold data.
  Initialize interrupt(s)
Loop():
  Until splashdown, wait for an interrupt.
  Append timestamp and all tube states to buffer A
  If buffer A is full:
    Swap to buffer B
    Write buffer A to SD card.
On splashdown:
  Stop new readings, write current buffer to SD card, and power down.
By using an interrupt, we can record new events even while writing to the SD card or processing another event.

Current tests show the interrupt handler processes each event in about 3 microseconds (μs).

SD card latency is by far the biggest bottleneck at ~100-500 milliseconds (ms), so we should write to media as seldom as possible. Collecting data in a buffer means we can reduce delays and record data significantly faster.

Using 2 buffers enables us to record new events while a buffer writes to the SD card.

We’re using a buffer of 256 events to reduce the amount of data lost if we experience hardware failure.

Sample data output will look something like this:
13546459 00100100

This indicates a coincidence event occurred between tubes A and D, after 13.5 seconds of flight.
Prototyping / Analysis

Amos Parmenter, Ariel Stroh
Prototyping Results

• We are using an online electrical simulation to prototype our power cards. This allows us to better understand the electrical flow and power consumption of the system.

• Our initial electrical prototyping (and much appreciated advice from our advisor Parker Swanson) led us to redesign our circuit, removing the coincidence gate in favor of a much simpler “NAND” gate and latch combination.

• Our new design is almost ready to be produced as a printed circuit board, which will allow us to begin hardware testing. We are confident our thorough prototyping has already saved us hours of workbench testing.

Analysis Results

• By using the online simulators we have been able to simulate our pulse shaping along with testing our output voltage for our power cards that will be supplying the power to the detection tubes.
# Detailed Mass Budget

<table>
<thead>
<tr>
<th>Components</th>
<th>OSU Qty</th>
<th>LBCC Qty</th>
<th>Individual Weight</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arduino Due</td>
<td>0</td>
<td>1</td>
<td>45 grams</td>
<td>45</td>
</tr>
<tr>
<td>Arduino Mega</td>
<td>1</td>
<td>0</td>
<td>45 grams</td>
<td>45</td>
</tr>
<tr>
<td>Raspberry Pi</td>
<td>1</td>
<td>0</td>
<td>45 grams</td>
<td>45</td>
</tr>
<tr>
<td>2x 9V Battery w/ mounts</td>
<td>2</td>
<td>6</td>
<td>84.86 grams</td>
<td>678.88</td>
</tr>
<tr>
<td>18650 Lithium</td>
<td>0</td>
<td>4</td>
<td>44.5 grams</td>
<td>178</td>
</tr>
<tr>
<td>Makrolon Plate</td>
<td>2</td>
<td>2</td>
<td>300 grams</td>
<td>1200</td>
</tr>
<tr>
<td>Micro SD Card Shield</td>
<td>1</td>
<td>1</td>
<td>5 grams</td>
<td>10</td>
</tr>
<tr>
<td>USB Microscope</td>
<td>3</td>
<td>0</td>
<td>105 grams</td>
<td>315</td>
</tr>
<tr>
<td>Geiger Daughter Boards</td>
<td>0</td>
<td>3</td>
<td>47 grams</td>
<td>141</td>
</tr>
<tr>
<td>Motherboard</td>
<td>0</td>
<td>1</td>
<td>100 grams</td>
<td>100</td>
</tr>
<tr>
<td>Tube Mounting</td>
<td>0</td>
<td>1</td>
<td>180 grams</td>
<td>180</td>
</tr>
<tr>
<td>Canister</td>
<td>0.5</td>
<td>0.5</td>
<td>3356.6 grams</td>
<td>3356.6</td>
</tr>
</tbody>
</table>

| Total Weight                      | 6294.48 grams |
| Under                             | 13.87681061 pounds |
| Under                             | 6.15378268 pounds |
Currently, we anticipate using two 9V batteries in a diode isolated circuit, which should be plenty of power to run our experiment for at least 2 hours. That time estimate is based on the power needs from RockOn 2014.

As we get our first prototype board back and begin testing, we will update our power requirements and add batteries if necessary.

To ensure that our batteries will not completely run on a low voltage we are a “Death with Dignity” shut down that will turn the entire system off after fifteen minutes from launch.
# Power Budget

**Linn-Benton Community College, Space Exploration - Power Budget**

**Date**: Nov 29, 2014

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Start Time (min)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arduino Due</td>
<td>9.0</td>
<td>0.20</td>
<td>0</td>
<td>15</td>
<td>1.80</td>
<td>0.05</td>
</tr>
<tr>
<td>Detection Unit</td>
<td>5.0</td>
<td>0.40</td>
<td>0</td>
<td>15</td>
<td>2.00</td>
<td>0.10</td>
</tr>
<tr>
<td>Logic Gate</td>
<td>5.0</td>
<td>0.10</td>
<td>0</td>
<td>15</td>
<td>0.50</td>
<td>0.03</td>
</tr>
</tbody>
</table>

| Total              | 0.70        |                 |                  |               | 4.30  | 0.18|
| Total Power Capacity|             |                 |                  |               | 1.20  |     |
| Over/Under         |             |                 |                  |               | 1.03  |     |
| # of Flights Margin|             |                 |                  |               | 5.7   |     |
Manufacturing Plan

Amos Parmenter, Levi Willmeth
We are currently creating a new PCB schematic which we plan to print a prototype of over winter break. We decided to have the circuit professionally printed to save assembly time and ensure manufacturing quality.

We have a parts list which began from the RockOn! Bill of Materials, and has been adjusted for our project’s needs.

**PCB Manufacturing Schedule:**

- 12/14/14 - Revised electrical schematic completed.
- 12/21/14 - PCB schematic sent off for manufacturing.
- 01/01/15 - Turnaround time should be under 1 week.

At the same time we will be working on manufacturing acrylic plates and a canister with the same dimensions as the final canister, so that we can test integration with the OSU experiment and finalize our mounting points.
The software has been written and passed initial lab bench tests:

- Detects predicted voltage changes using an interrupt on multiple pins.
- Stores data to buffers, and swaps correctly as each buffer fills.
- Creates a file on SD card, and writes data to the file.

We anticipate making further changes as hardware testing continues:

- Add code to shut down when splashdown occurs, probably based on time after g-switch activated.
- Create a new file each time it starts up.
- Adjust pins as hardware circuit is completed.
- Solve any bugs we discover between now and launch.

The software is ahead of schedule and awaiting hardware for further testing.
Testing Plan

Hazel Betz, Amos Parmenter, Levi Willmeth
The welding department at LBCC is creating a replica of the canister using the specifications provided in the RockSat-C user guide. This will allow us to do fit checks, ensuring our payload is the correct size when placed into the canister. The canister replica will also allow us to confirm both OSU’s and LBCC’s payload fit and successfully integrate together.

After all of our subsystems have been tested and integrated into the canister, we will be performing system tests including acceleration tests, shake tests and gamma source tests on the payload to insure proper operation in flight.

Gamma source tests will confirm our payload is operational. The most frequent cosmic rays we will detect during flight are gamma rays, so we will be performing tests on the integrated payload using gamma ray sources provided by LBCC, and using the experimental nuclear reactor at OSU.

A successful test will record that a combination of single hits and coincidence hits occurred in the Geiger Müller tube array.
Electrical Testing

• “Test Plan” is designed to identify problems and resolve unanswered questions
  • What is the expected power consumption of the geiger board?
  • Does the circuit detect coincidence events as expected?
  • How many counts per second to saturate our detection capability?
  • Are the circuit interconnects adequate to resist vibration?
  • Will a canister heater and/or insulation be required for electronics to withstand the harsh environment?

• Entire “Test Plan” must be conducted by subassembly working group prior to sign-off by integration manager
**Electrical Testing - Characterization**

**Planned Test:** Our team has access to a few different suitable radiation sources that we will use to calibrate our systems. “Average current” values will be supplied to the geiger tubes at different counts per second to allow us to estimate power consumption of the system throughout the flight for each detection unit.

**Planned Test:** A second Arduino will be used to “simulate” different geiger tube detection combinations in order to validate that the software is correctly identifying coincidence events as expected.

**Planned Test:** With the radiation sources available to us, will be able to saturate the detection circuits at different exposure rates allowing us to log detection interrupts at the max Arduino Due sampling rate: we should be able to extrapolate from test data and confirm that our timing based estimates are correct and that the projected flux is appropriately matched to our instrumentations ability to record data.
Initial testing has begun using a function generator, oscilloscope, and arduino with an SD card shield.

Using these pieces of lab equipment we can simulate:

- Geiger tube readings at various timings
- Determine how quickly the arduino can record separate, and simultaneous events
- Determine if any results are being ‘dropped’ or skipped
- Measure delays caused by writing to SD card
- Troubleshoot any problems read/writing to the SD card

To fully test the software, we will need a complete circuit. A complete circuit will give us:

- Final pin layout
- Ensure the arduino is receiving the appropriate voltages and signal durations from our circuit
- Test the SD card socket integrated into the circuit board
Risks

Amelia Beckwith, Nick Cantrell, Levi Willmeth
In our PDR, the biggest risks were damage to either our microcontroller or storage media, because without those two pieces of equipment our experiment would yield no results.

We have attempted to mitigate those risks by reinforcing our design to protect all components from stress during launch. We are also exploring using a second media card to reduce risk of corrupted data.
Risk Walk-Down

Danger of the acceleration forces breaking equipment during liftoff.
- Drop tests will be conducted with housings designed for at least 25 G’s with a max of 50 G’s.

Failure of individual tubes continuously reading data.
- We will use 6 separate and redundant tubes each with their own supporting hardware.
- We have chosen smaller, sturdier tubes and oriented them vertically to reduce G forces.

Failure of removable media storage.
- Option 1: Long term experiments will be conducted to test the media storage capacity and reliability.
- Option 2: A secondary media card may be used to minimize risk, pending further experimentation.

Failure of the microcontroller or software.
- Thoroughly test the software on the ground before launch. Avoid last-minute changes.
- Run software during shake table, and drop tower testing to ensure continuous supply of power.
## Critical Risks Remaining

<table>
<thead>
<tr>
<th>Low Possibility</th>
<th>Low Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everything Goes Perfectly</td>
<td>Compromised Wire Jacket (No Damaged Electronics)</td>
</tr>
<tr>
<td>Minor Software Failure (Majority of Data Gathered)</td>
<td>Low Consequence</td>
</tr>
<tr>
<td>Major Software Failure or Material Failure (No Data Gathered)</td>
<td>SD Card Corrupted (Data Unusable)</td>
</tr>
<tr>
<td>Damaged Electronics (Some Data Gathered)</td>
<td>Software Failure (Some Data Gathered)</td>
</tr>
<tr>
<td>Battery Fire Damages OSU Experiment</td>
<td>Material Failure (Unsecured Components)</td>
</tr>
<tr>
<td>Material Failure (Some Tubes Disabled)</td>
<td>Material Failure (Components Remain Secure)</td>
</tr>
<tr>
<td>Experiment Is Successful (Temperature Damage)</td>
<td>Minor Software Failure (Majority of Data Gathered)</td>
</tr>
<tr>
<td></td>
<td>Experiment Is Successful (Temperature Damage)</td>
</tr>
<tr>
<td></td>
<td>Minor Software Failure (Majority of Data Gathered)</td>
</tr>
<tr>
<td></td>
<td>Low Consequence</td>
</tr>
<tr>
<td></td>
<td>Low Possibility</td>
</tr>
</tbody>
</table>
Critical Risk Walk-Down

We have identified several primary risks, and plan to mitigate or reduce them as follows:

Possibility of a battery fire or unsecured component damaging the OSU experiment, or escaping the canister.
- Select quality, low-risk batteries and components over cheaper alternatives.
- Our newest design adds structural stability and reduces applied G forces.

Possibility of software or storage media failure.
- Test, test, and re-test the software.
- Write our results to media storage more often to reduce risk of losing results.
- We are considering using 2 or more high storage SD cards to reduce chance of corrupted media.

Material or electrical failure in one or more tubes or supporting hardware.
- We designed redundant tubes and included 6, of which any 2 could complete the mission.
User Guide Compliance

Ariel Stroh
User Guide Compliance

Weight Compliance:
- The LBCC and OSU teams agreed to split the available space and weight equally between our experiments. Our combined weight between the two teams is 6.476 lbs. Including the canister our combined project weighs 13.876 lbs.

Center of Mass Compliance:
- Both teams have positioned the bulk of our experiments symmetrically around the center of the canister.
- As our mechanical testing progresses, we can add ballast to correct any drift in our mass caused by batteries, etc.
- The mockup canister will be an excellent resource while recentering our experiment using ballast.

High Voltage Compliance:
- We plan to use two 9v batteries and four 18650 Lithiums in our project.
- Both teams will be using a G switch to activate our payloads.
User Guide Compliance - Center of Gravity

- CG within 1"x1"x1" envelope
- Pink Triad in Green Cylinder
- Lots of empty volume and weight budget left for balancing weights
• Basic FEA study considering only the impact of 50g on the supports

• <1mm peak deflection

• Simplified model merges standoffs with part

• Actual standoffs will be made of metal and have more rigidity
• More thorough “buckling study” included the impact of the structure’s own weight on itself.

• Still <3mm peak displacement

• Simplified model merges standoffs with part

• Actual standoffs would be made of metal and have more rigidity
Shared Can Logistics

We are sharing the canister with Oregon State University. OSU is taking the top half of the canister so they can add their extremophiles to the canister as late as possible.

Each project will have its own mounting plate for stability. LBCC will use the bottom mounting plate, and plan to use additional structural standoffs to support OSU’s bottom plate.

The two teams plan to collaborate when making the makrolon plates to mount the payloads in the canister. Investigation is being done into milling them at LBCC.

LBCC and OSU will continue to meet on a weekly basis utilizing Google hangouts, phone calls, and face to face meetings to collaborate on our projects and ensure they will fit together in the canister.
Project Management Plan

Hazel Betz, Nick Cantrell, Brianna Sparks
<table>
<thead>
<tr>
<th></th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preliminary Design</td>
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<tr>
<td>23</td>
<td>Critical Design</td>
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<tr>
<td>27</td>
<td>Progress Update Teleconference</td>
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<tr>
<td>28</td>
<td>Subsystem Assembly</td>
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<td>33</td>
<td>Subsystem Testing</td>
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<td>39</td>
<td>First Payment Due</td>
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<td>40</td>
<td>Progress Updates</td>
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<td>43</td>
<td>Integrated Subsystem Testing</td>
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<td>46</td>
<td>Final payment due</td>
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<td>47</td>
<td>RockSat Payload Canisters sent to customers</td>
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<td>48</td>
<td>Progress Updates</td>
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<tr>
<td>51</td>
<td>Full Mission Simulation Test</td>
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<tr>
<td>54</td>
<td>Progress Updates</td>
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<tr>
<td>58</td>
<td>Preliminary Check-In Procedure Due</td>
</tr>
<tr>
<td>59</td>
<td>Launch Readiness Review Presentations</td>
</tr>
<tr>
<td>60</td>
<td>Travel to Wallops Flight Facility</td>
</tr>
<tr>
<td>61</td>
<td>Launch Prep &amp; Launch Day</td>
</tr>
</tbody>
</table>
12/15/2014 - 12/19/2014 - Winter break intensive build weekend:
   Assembly, prototyping, software testing, fundraising and marketing plans.
   is it to the Evergreen Museum to learn more about the Van Allen experiment on Explorer I.

01/16/2015 - Flights Awarded
01/05/2015 – PCBs sent out to be printed (first week of term)
01/26/2015 - Canister infrastructure preliminary design
01/26/2015 - Progress Update Teleconference
02/16/2015 – Full system (Geiger's, USB chip, and Arduino)
   bench tested and operational
02/16/2015 - Subsystem Testing Teleconference
03/02/2015 - Canister infrastructure design done
03/02/2015 - Progress Update Teleconference
03/16/2015 - Progress Update Teleconference
03/16/2015 – Preliminary integration of system onto internal
   structure of the mock canister

Pre flight test day over spring break

Term Goals
✓ Intensive build weekends,
   complete canister infrastructure
   and integration.
03/31/2015 - Integrated Subsystem Teleconference
04/13/2015 - Canisters Sent
04/20/2015 - LBCC/OSU System fully integrated
04/20/2015 - Progress Update Teleconference
05/04/2015 - Progress Update Teleconference
05/18/2015 - LBCC/OSU System fully tested for flight
05/18/2015 - Mission Simulation Test Teleconference
05/20/2015 - Progress Update Telecon
05/27/2015 - Progress Update Telecon
06/03/2015 - Progress Update Telecon
06/04/2015 - Preliminary Check-In Procedure Due
06/04/2015 - Launch Readiness Presentations
06/17/2015 - Travel to Wallops Flight Facility, Visual Inspection, Integration, and Presentation
06/25/2015 - Launch Day

Term Goals
✓ Send a Working Payload to Space!
## LBCC Build Budget

### Total payload build budget: $1600

<table>
<thead>
<tr>
<th>Item</th>
<th>Supplier</th>
<th>Number Needed</th>
<th>Cost per Unit</th>
<th>Shipping</th>
<th>Total Cost</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geiger tubes</td>
<td>LND</td>
<td>7</td>
<td>45</td>
<td>30</td>
<td>345</td>
<td>includes 1 spare</td>
</tr>
<tr>
<td>Arduino Microcontroller</td>
<td>Sparkfun</td>
<td>2</td>
<td>50</td>
<td>20</td>
<td>120</td>
<td>includes 1 spare</td>
</tr>
<tr>
<td>9V batteries for testing</td>
<td>Amazon</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>includes 2 spares</td>
</tr>
<tr>
<td>9V lithium batteries</td>
<td>Amazon</td>
<td>5</td>
<td>3.5</td>
<td>0</td>
<td>17.5</td>
<td>includes 2 spares</td>
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<td>SD card Shield</td>
<td>Sparkfun</td>
<td>2</td>
<td>15</td>
<td>10</td>
<td>40</td>
<td>includes 1 spare</td>
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<td>Misc electronics</td>
<td>DigiKey</td>
<td>2</td>
<td>50</td>
<td>20</td>
<td>120</td>
<td>includes spare set</td>
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<tr>
<td>Makrolon plates</td>
<td>McMaster-Carr</td>
<td>3</td>
<td>35</td>
<td>10</td>
<td>115</td>
<td>includes 1 spare</td>
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<tr>
<td>Prototype Run PCB Boards</td>
<td>ExpressPCB</td>
<td>1</td>
<td>170.6</td>
<td>included in unit price</td>
<td>170.6</td>
<td>Unit Price is for 1 full run</td>
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<td>Final Run PCB Boards</td>
<td>ExpressPCB</td>
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<td>236.8</td>
<td>included in unit price</td>
<td>236.8</td>
<td>Unit Price is for 1 full run</td>
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<td>Backup Run PCB Boards</td>
<td>ExpressPCB</td>
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<td>236.8</td>
<td>included in unit price</td>
<td>236.8</td>
<td>Only if necessary</td>
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Total $ 1406.7

With 10% margin 1547.37
# Detailed PCB Printing Budget

All Prices from ExpressPCB
Includes one prototype print and two full set prints all with regular shipping

<table>
<thead>
<tr>
<th>Prototype Run PCB Boards</th>
<th>Starting Charge</th>
<th>Qty</th>
<th>Per Sq Inch</th>
<th>Sq Inches</th>
<th>Per board cost</th>
<th>Shipping</th>
<th>Total</th>
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<tbody>
<tr>
<td>Daughter Boards</td>
<td>61</td>
<td>1</td>
<td>0.7</td>
<td>8</td>
<td>1</td>
<td>10</td>
<td>77.6</td>
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<td>Logic Boards</td>
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<td>1</td>
<td>0.7</td>
<td>30</td>
<td>1</td>
<td>10</td>
<td>93</td>
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</table>

<table>
<thead>
<tr>
<th>Full Final Run PCB Boards</th>
<th>Starting Charge</th>
<th>Qty</th>
<th>Per Sq Inch</th>
<th>Sq Inches</th>
<th>Per board cost</th>
<th>Shipping</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daughter Boards</td>
<td>61</td>
<td>8</td>
<td>0.7</td>
<td>8</td>
<td>1</td>
<td>10</td>
<td>123.8</td>
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<tr>
<td>Logic Boards</td>
<td>61</td>
<td>2</td>
<td>0.7</td>
<td>30</td>
<td>1</td>
<td>10</td>
<td>113</td>
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<table>
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<tr>
<th>Full Back Up Run PCB Boards</th>
<th>Starting Charge</th>
<th>Qty</th>
<th>Per Sq Inch</th>
<th>Sq Inches</th>
<th>Per board cost</th>
<th>Shipping</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daughter Boards</td>
<td>61</td>
<td>8</td>
<td>0.7</td>
<td>8</td>
<td>1</td>
<td>10</td>
<td>123.8</td>
</tr>
<tr>
<td>Logic Boards</td>
<td>61</td>
<td>2</td>
<td>0.7</td>
<td>30</td>
<td>1</td>
<td>10</td>
<td>113</td>
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### General Budget

<table>
<thead>
<tr>
<th>Indispensable Flight Cost</th>
<th>$12,000</th>
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</thead>
<tbody>
<tr>
<td>LBCC Estimated Hardware</td>
<td>$1,600</td>
</tr>
<tr>
<td>OSU Estimated Hardware</td>
<td>$2,000</td>
</tr>
<tr>
<td><strong>Total Cost of Flight</strong></td>
<td><strong>$15,600</strong></td>
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</tbody>
</table>

| Support from OSGC         | $8,000  |
| Support from LBCC         | $1,000  |
| Support from grant        | $1,500  |
| **Total Fundraising Needed** | **$5,100** |

- **10/13/2014**: Earnest Payment of $1,000 paid by OSGC
- **02/16/2015**: First Payment Due
- **04/06/2015**: Final Payment Due

We are collaborating with the OSU team for fundraising.

Our team is consulting with Mealoha McFadden, an event coordinator for the Presidents office at OSU for assistance in successfully selling our ideas to potential donors.

Possible sponsors include LBCC Foundation, NuScale, Wah Chang, and Hewlett-Packard.
Project Summary

Remaining Areas of Concern:

Power Budget:
• Although data is preliminary at this point, we believe that the 1200mAh sourced from 2x 9V Lithium Manganese Oxide(LMO) Energizer Batteries will be sufficient to power the entire experiment for over an hour. In addition: we have the mass and volume available to go up to 4x 9V or even an alternative power source such as a rechargeable 5V 4400mAh battery pack if necessary.

Daughter Board Connectors:
• The Hirose DF13 connectors are extremely reliable/vibration resistant connectors used in many unmanned vehicle systems. Provided the daughter boards consume a reasonable amount of current at 5Vdc: these connectors should work well for both power and signal lines to the daughter boards.
• The wires carrying 450-600Vdc to the Geiger Tubes require attention as an unresolved concern.
Remaining Areas of Concern:

Fundraising: Our team still needs to raise $5,100 to fly in addition to any further funds for travel.

Testing equipment: We need to find a shake test location and observe safety precautions when doing high voltage testing with our geiger tubes.

Payload is underweight: as testing goes forward and the design is finalised the team can add ballast.
# Team Contact Matrix

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Phone</th>
<th>US Person</th>
<th>Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazel Betz</td>
<td><a href="mailto:hazel.betz.5652@mail.linnbenton.edu">hazel.betz.5652@mail.linnbenton.edu</a></td>
<td>541-908-1487</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Aaron Groves</td>
<td><a href="mailto:aarongroves1@yahoo.com">aarongroves1@yahoo.com</a></td>
<td>541-730-1440</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Ikaika McKgeague-McFadden</td>
<td><a href="mailto:mc.ikaika@gmail.com">mc.ikaika@gmail.com</a></td>
<td>541-231-3835</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Amos Parmenter</td>
<td><a href="mailto:amos_parmenter@hotmail.com">amos_parmenter@hotmail.com</a></td>
<td>541-401-5207</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Ariel Stroh</td>
<td><a href="mailto:bassoon09@gmail.com">bassoon09@gmail.com</a></td>
<td>541-415-1040</td>
<td>Y</td>
<td></td>
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<tr>
<td>John-Paul Molden</td>
<td><a href="mailto:john.paul.molden@gmail.com">john.paul.molden@gmail.com</a></td>
<td>541-248-0612</td>
<td>Y</td>
<td></td>
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<tr>
<td>Sarah Trevisiol</td>
<td><a href="mailto:sarah.a.trevisiol@gmail.com">sarah.a.trevisiol@gmail.com</a></td>
<td>541-224-1511</td>
<td>Y</td>
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<tr>
<td>Nicholas Cantrell</td>
<td><a href="mailto:nickcantrell@gmail.com">nickcantrell@gmail.com</a></td>
<td>N/A</td>
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<tr>
<td>Brianna Sparks</td>
<td><a href="mailto:briannalsparks@gmail.com">briannalsparks@gmail.com</a></td>
<td>971-239-7910</td>
<td>Y</td>
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</tr>
<tr>
<td>Christina Pack</td>
<td><a href="mailto:chrissylee81@hotmail.com">chrissylee81@hotmail.com</a></td>
<td>541-974-6017</td>
<td>Y</td>
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<tr>
<td>Delphine Le Brun Colon</td>
<td><a href="mailto:delphine.lebruncolon.5989@mail.linnbenton.edu">delphine.lebruncolon.5989@mail.linnbenton.edu</a></td>
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<tr>
<td>Levi Willmeth</td>
<td><a href="mailto:levi.willmeth.3070@mail.linnbenton.edu">levi.willmeth.3070@mail.linnbenton.edu</a></td>
<td>541-708-2012</td>
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<tr>
<td>Amelia Beckwith</td>
<td><a href="mailto:beckwith.a@gmail.com">beckwith.a@gmail.com</a></td>
<td>907-957-5351</td>
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<tr>
<td>Rong Yu</td>
<td><a href="mailto:rongwingyu@gmail.com">rongwingyu@gmail.com</a></td>
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<tr>
<td>Alexis Shanice Hundley-Kennaday</td>
<td><a href="mailto:hundleyea@onid.oregonstate.edu">hundleyea@onid.oregonstate.edu</a></td>
<td>541-817-2995</td>
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<tr>
<td>Sophia Xin Zhang</td>
<td><a href="mailto:zhangso@onid.oregonstate.edu">zhangso@onid.oregonstate.edu</a></td>
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<tr>
<td>Cristina Martinez Galvez</td>
<td><a href="mailto:martc418@gmail.com">martc418@gmail.com</a></td>
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<tr>
<td>Parker Swanson</td>
<td><a href="mailto:swansop@linnbenton.edu">swansop@linnbenton.edu</a></td>
<td>541-760-5473</td>
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<tr>
<td>Greg Mulder</td>
<td><a href="mailto:mulderg@linnbenton.edu">mulderg@linnbenton.edu</a></td>
<td>541-908-4025</td>
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<tr>
<td>Ralph Tadday</td>
<td><a href="mailto:taddayr@linnbenton.edu">taddayr@linnbenton.edu</a></td>
<td>541-788-9009</td>
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</tr>
</tbody>
</table>
Immediate Plan of Action

Plan of Action Before Winter Break and During Winter Break Build Week

- Learn about PCB software/manufacturing process
- Design PCB circuit layout
- Send out our first PCB trial run by the end of Winter break
- Begin addressing internal canister infrastructure with OSU

- Create fundraising materials
- Consult with Mealoha McFadden to lay out a fundraising strategy
- Over winter break begin contacting potential sponsors

- Visit to the Evergreen Air and Space Museum with Jack Higginbotham as a guide to learn more about James Van Allen’s payload on Explorer 1
Conclusion

• Our goal is to design an experiment that will compare the performance of single count Geiger Müller detectors and the performance of the coincidence gates collecting cosmic radiation during space flight.

• We must design a payload capable of accurately recording high energy particles using multiple detection methods.

• Construct payload capable of withstanding forces during launch and landing.

• Test the payload, make sure it is fully compatible with all required specs.

• Log results including time and altitude for analysis on the ground.

• All aspects of our project have been cautiously planned out and our team is motivated to continue moving forward both with our own project and with OSU’s Water Bear project.

We welcome and value your feedback!