Launch Readiness Review (LRR) Document

**LBCC Space Exploration Club**

Our mission is to record measurements of cosmic radiation using an array of Geiger-Muller tubes.

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.
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1.0 Mission Statement, Requirements, and Expected Results

Our mission is to record measurements of cosmic radiation using an array of 6 Geiger tubes, while meeting all of the safety requirements and design specifications of the RockSat-C program. Our experiment uses a hexagonal array of Geiger tubes to detect cosmic radiation while filtering out low energy background particles.

We expect to see high levels of single-tube events on the ground, decreasing with altitude. Due to the short flight duration and our choice of Geiger tubes, we expect to only detect a few hundred events total, nearly all of which will probably be single-tube events.

2.0 Final Payload Design

Since the FMSR we have added ballast to the second plate. There are six main ballast locations in the form of large fishing weights arranged with radial symmetry in between the Geiger tube slots. Three ballast locations have 6oz of weight and three have 8oz of weight. In addition, six small closed cylinders have been added to hold mementos for flight. As seen in the picture below, one inch washers are being used in the cylinders for minor ballast correction and to balance the payload.

Final Assembly of the payload
LBCC’s payload integrated into canister.

Left to Right: Top view of Geiger's and Geiger boards in place, Schematics of second level and Third Level Plates.

The second and third level plates are similar in design except that the second level plate has a central hole of 1 inch diameter. This hole serves as a wire way from the Geiger boards to the logic board. There are six identical slits on the top of the second plate and the bottom of the third plate for the Geiger boards to slide into, they are 0.15 inches in depth. When fully integrated, these slits hold the Geiger boards sandwiched between the two levels. There are six holes on both plates for 2.6 inches spacers to keep the Geiger boards securely mounted. All three Makrolon plates are 9.3 inches diameter.
Bottom plate

Second level without its Geiger boards. Showing ballasts and trinket boxes.
Top view of the fully assembled payload

Side view of the fully assembled payload
The Geiger housing has not changed since the FMSR. This component was designed and 3-D printed. It holds the Geiger tubes securely and mounts them to the accompanying Geiger boards. These were designed to keep the tubes in their designated location throughout flight.

See attached Electrical Folder for Electrical Schematics, Block Diagram, Concept of Operations and Component Data sheets.
3.0 Testing Results

A. Integrated Subsystem Testing Results
As of June 4, 2015 we have fully integrated with OSU. The combined LBCC/OSU payload successfully fit within the canister. The combined payloads were 1.5 lbs under weight. The LBCC payload has been fully integrated with ballast to fulfill half the necessary total payload weight. OSU will be adding their ballast before final integration at Wallops. There is space allotted in the LBCC memento boxes for adding ballast in case slight final adjustments to total weight or payload balance are needed.

B. Full Mission Simulation Results
Out latest extended full mission test for 60 minutes had 389 hits while in the canister and experienced hits on all tubes with no coincidences recorded. However on a shorter test we had a single coincidence hit. We anticipate with the higher energy radiation at altitude we will see more coincidences. We have an excel template and python script we will be using to analyse the final data.

Full Mission Simulation Results: Power
- Completed several full mission tests with 20 min to 1 hour durations.
  - Even after an hour of flight testing, steady results still coming in.
  - Using 2 batteries for an hour, batteries showed ~6v.
- Completed battery power test using lower capacity 9v batteries.
- Will follow up with testing of the 9v lithium batteries to be used in flight.

Full Mission Simulation Results: Electrical
- The new logic boards with the delay circuits are correctly working
- G-switch and RBF activation tested
- New regulators on Geiger boards allow for steady 5v supply as batteries drop from 9V nominal.
- All Geiger boards are working

Full Mission Simulation Results: Software
We have run several full system simulations to test the software.
- Data from the SD card is parsed to look for boards which are getting unexpectedly low, or high numbers of results.
- The system correctly starts up, and shuts down on time.
- Data from the SD card is consistently readable, no corruption issues.
Flight Test with all Geiger Boards

Last Flight Test Before Final Assembly
4.0 Launch Readiness
   A. User Guide Compliance

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
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<tbody>
<tr>
<td>Center of gravity in 1&quot; mid-can</td>
<td>Yes (for LBCC payload only)</td>
</tr>
<tr>
<td>Contained in can</td>
<td>Yes</td>
</tr>
<tr>
<td>Connected to can by 4 or 5 bulkheads on top and bottom only</td>
<td>Five on Bottom and Four on top</td>
</tr>
<tr>
<td>Mass at 20±0.2lbs</td>
<td>No (LBCC is at mass, OSU is adding ballest)</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>Yes</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>Yes</td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td>Yes</td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>Yes</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td>Yes (no early activation)</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Yes (re-check)</td>
</tr>
<tr>
<td>Battery Type</td>
<td>LBCC: Four 9v lithium batteries</td>
</tr>
<tr>
<td></td>
<td>OSU: One 9v, Eight AAA batteries</td>
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B. Integration Plan and Procedure
   The full payload is composed of two separate halves: LBCC’s on the bottom and OSU’s on the top. We have attached the LBCC assembly process document to this document. The LBCC assembly starts with the bottom plate with logic board and batteries which is attached to the canister bottom bolted on with number eight screws and nuts. Our second plate carries Geiger boards, Geiger tubes, ballasts and memento boxes.

   The LBCC payload only interfaces with the OSU payload through four screws attaching the top plate of the LBCC payload to the bottom plate of the OSU payload.

C. Action Item
   1. Add mementos to memento boxes
   2. Attach lithium batteries for flight
   3. re-check current on T-0 activation wires
   4. Secure LBCC payload to bottom of canister
   5. Secure top of LBCC’s payload to bottom of OSU’s payload
   6. Do a final weight check
   7. Adjust ballast if necessary
   8. Check in payload
5.0 Conclusions

We’re feeling confident our experiment works, records data and is resistant to in-flight vibration. When we arrive at refuge inn the LBCC payload will have minimal assembly needed. The four main steps for the LBCC payload are to connect all the batteries, re-check the current on the T-0 wires, add mementos, and do a final check on the payload’s weight and balance. (The T-0 wires have been checked but not with the final battery configuration)

The main concerns we have are related to integration with OSU. We have integrated both payloads into the canister together, but OSU’s design was not quite finalized so we will not know for sure where we stand with full payload volume, weight, and balance until the final integration at Wallops. However we are bringing extra ballast, standoffs, screws, nuts, and tools to make any adjustments needed on site and easy ballast adjustment has been built into our (LBCC) payload so we remain confident we can compete the full payload in time for check in.

After flight, we have created an excel template and python script to analyse our final results.

6.0 Appendices
See attached for Assembly Instructions, Electrical Schematics & Solidworks files.