UW Milwaukee / Sheboygan
Critical Design Review

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August Schuett, Pancho Cruz,
Kaitlin Krause, Dan Cairns
Prof. Dirienzo, Prof. Kaplan
December 13, 2016
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Subsystem Risks/Mitigation

Specimen Containment Unit
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Requirements to be verified

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Requirements to be verified

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Requirements to be verified
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Mission Overview

Ryan Kisiolek
In 2017, UW Sheboygan flew plasmid DNA samples on a sounding rocket to an altitude of 73 miles. The plasmids were mixed with Ecoli bacterial post-flight to evaluate the efficiency of gene transmission after space flight compared to control samples. Unexpectedly, the efficiency improved for samples exposed to space flight conditions.
Theory and Concepts

• DNA contains the instructions for necessary function and form of life. DNA can be damaged when subjected to environmental stresses like those found in space flight, but it has been found that it is possible for some to remain structurally sound and still be functional.
Concept of Operations

Data collection will start at T minus 3 minutes
Acceleration, Orientation and Temperature will be measured
Radiation will be measured using two types of Geiger tubes, with some Geiger tubes shielded.
Shielding will decrease radiation for some of the DNA samples.
Example ConOps

Altitude

- G switch triggered
- All systems on
- Begin data collection

High Concentration of N2
  \( t \approx 1.3 \) min
  Altitude: 75 km

Apogee
  \( t \approx 2.8 \) min
  Altitude: \( \approx 115 \) km

High Tumble Rate
  \( t \approx 4.0 \) min
  Altitude: 95 km

End of Orion Burn – Spin Rate Largest
  \( t \approx 0.6 \) min
  Altitude: 52 km

Low N2, Low spin
  \( t \approx 5.5 \) min
  Chute Deploys

\( t \approx 15 \) min
  Splash Down

RockSat-C 2018
CDR
Expected Results

It predicted there will be forces of around 20 Gs, during take off
We expect temperature to increase 15 F.
We expect to see a maximum in Beta and Gamma radiation at around 18-20 km (Pfotzer Maximum)
We expect to see a 20%+ reduction in Gamma radiation with 1/8” thickness of Silflex shielding.
It is expected that there will be a greater amount of damage to the unshielded DNA, but improved gene transmission overall.
Success Criteria

Minimum Success Criteria:
Analysis of the DNA samples will show if there was detectable damage done to the DNA during flight.

Comprehensive Success Criteria:
Data showing radiation exposure, temperature change, and acceleration.
Data from shielded and non shielded Geiger counters.
Data from total (alpha, beta and gamma) and gamma only Geiger counters.
Data from analysis of shielded and exposed specimens.
Functional & Design Requirements:

DNA samples shall be exposed to radiation during flight with half of samples shielded so that post-flight testing can determine the effect of radiation separately.

Radiation shall be measured separately to evaluate the level of gamma radiation with and without shielding. A separate measurement of radiation without shielding shall be measured to differentiate between Beta and Gamma radiation. This data will be compared to flight data, if available.

Sensors shall be included to measure acceleration, orientation, and temperature.

System will meet space and weight requirements outlined in Guidelines.
## Functional Requirements:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Verification Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The specimen containment unit will prevent liquid from leakage.</td>
<td>test</td>
<td>System will be submerged in water with an indicator inside the unit to confirm liquids will be contained.</td>
</tr>
<tr>
<td>Shielded systems will reduce radiation exposure by 20% or more</td>
<td>test</td>
<td>Measurements of known samples will be compared to shielded collectors</td>
</tr>
<tr>
<td>The full system shall fit in half of a RockSat-C container</td>
<td>Inspection</td>
<td>Visual inspection of design drawings will verify this requirement</td>
</tr>
<tr>
<td>The system shall survive the vibration characteristics prescribed by the RockSat-C program.</td>
<td>Test</td>
<td>The system will be subjected to these vibration loads in June during testing week.</td>
</tr>
<tr>
<td>The full system shall weight 6 lbs full canister shall weigh 20 lbs</td>
<td>Inspection</td>
<td>System shall be put on a scale to determine weight.</td>
</tr>
</tbody>
</table>
System Overview

Ryan Kisiolek
System Definitions

RSB: Radiation Sensor Board
EPS: Electrical and Power System
CDH: Command and Data Handling
SCU: Specimen Containment Unit
Changes Since PDR

New mechanical design is being finalized.

Prototype for second system with microcontroller, SD card, and 2 RSB / Geiger tubes.
System Design - Physical Model

Above shows the microcontroller with sd card, and associated power supply
Above shows the two ABG Geiger tubes and retainer

Below shows the microcontroller with micro sd card, w/ power
below shows the three Gamma Geiger tubes and retainer
This view shows the experiment contained in the canister. Electronics are positioned towards center of can. SCU vials are positioned near plate. The 5 RSB’s (black) are shown in the center of two retainers.
First system will utilize all same components from 2017, except for new PCB. We will be using T-3 activation, which will eliminate circuit for G-switch.
Second system will utilize same battery and power booster (not shown)
- SD shield (full size SD card)
- 2 RSB / Geiger tubes
Software Elements

Two microcontrollers will each have separate software.

Only minor modifications needed for first subsystem.

Second subsystem code is being developed for prototypes, then will be revised to include flight code elements.
If 5 Geiger counters will not fit, fewer will be used.
If funding is limited, students will divide available travel funds equally and pay remaining costs themselves.
Special Requests

• Please describe any special request for Wallops that are required for minimum and/or comprehensive mission success.

• *Examples include but are not limited to*
  – High Voltage
  – Biology Components
  – Liquids
  – Lasers
  – RF
  – Extensions outside the rocket
Subsystem Design
Shielding System

Bob Aloisi
Subsystem Design Section - Shielding

• Searched for lightweight shielding with good attenuation of radiation
• Found 2 suppliers of flexible Si or rubber with Tungsten, Tin, or Lead
• Obtained quote for Silflex ($600 cost). It was delivered on 12/6, just in time for prototype.
• 13 - 15% attenuation of background radiation for two 1/8” layer thickness. We are testing 1, 2, 3 layers.
• Alternatives are flexible lead or Tungsten from India (quote still pending)
• We found Silflex easy to cut and shape for shielding.
• Prototype confirmed 15% attenuation with two, 1/8” thick layers. This is less than 33% expected.
• Density was higher than expected, but should be manageable.
• Our plan is to use the Silflex material in 1 or 2 layers.
Shielding: Risk Matrix

Shielding, RSK.1: Loose shielding in canister causes damage.
Shielding, RSK.2: Secondary radiation unintentionally impacts results.

Other risks including availability and toxicity were eliminated through selection and purchase of Silflex.
Shielding: Risks

• Secondary Radiation – We are addressing this risk during prototyping by testing cosmic rays over extended time periods with 0, 1, 2, 3 layers of 1/8” Silflex tape.

• Initial results suggest that attenuation is less than expected, possibly due to secondary radiation.

• Need to complete additional prototype trials to understand tradeoffs when adding layers.
Subsystem Design
Radiation Sensor Board
(Geiger Counters and Tubes)

Bob Aloisi
Radiation Sensor Board / Geiger Tube:

- Identified Radiation Sensor Board (RSB) that has been tested with various Geiger tubes, including LND712 used in RockON 2016.
- Selected LND 712 (Alpha, Beta, Gamma) and LND 71217 (Gamma) as Geiger Tubes.
- Confirmed LND 71217 has improved sensitivity to Gamma rays.
- Prototype results confirm additional learning possible, comparing data from LND712 and LND 71217.
- Team plans to use RSB and Geiger tubes selected.
Geiger Tube: Risks

- Tube breaks – *mitigated by selecting LND tube proven in Rockon 2016.*
- Delays risk mitigated by selection and purchase of LND 712 and 71217 Geiger tubes.
Geiger Tubes: Risk Matrix

Geiger Tube, RSK.1: Broken tube – major failure, loss of data – **mitigated by using proven LND tubes**
Geiger Tube, RSK.2: Unable to differentiate Gamma vs. Total radiation, minor loss of data – **mitigated by prototype results**
Geiger Tube, RSK.3: Delay due to availability of tube – **No issues**
SCU (Specimen Containment Unit) Subsystem Design

Josh Janezick
Subsystem Design Section

- This is a bottom view with the aluminum mounting plate hidden.
- 3D printed retainers will hold the secondary vials.
- We are using the same secondary containment vials as last year.
Subsystem Design Section

The specimen containment unit starts with the primary specimen vials. Next there will be a secondary specimen containment unit, that will be hold (4) primary's, then stuffed with cotton balls.

- The secondary unit was tested for leakage by placing inside a dryer. After 15 minutes in dryer with tape around cap, no leakage occurred. Vial weighed before and after with no difference, and visually inspected.

This structure will be divided into four parts, 2 across from each other will be shielded with Silflex tap

- This will all be ”pinched” together by a poly plate, the pinching force will come from the (5) header bolts that will secure the structure, secured with thread lock.
**Risk Matrix – Subsystem Name**

**EPS.RSK.1**: The primary and secondary containments fail, leakage can damage electrical components.

**EPS.RSK2**: Loss of integrity of radiation shielding tape resulting in bad data from tape not wrapping specimens adequately.

**EPS.RSK.3**: Risk of structural integrity being lost from thin walled design.
We still need to communicate with the team we are paired with.
- Total Weight
- C.O.M.

Make up weight difference
- Design tweaks to add weight
- Ballast bolted to mounting plate

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Total Mass (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our System</td>
<td>5.92</td>
</tr>
<tr>
<td>Oppo. Team</td>
<td>6.57</td>
</tr>
<tr>
<td>Canister</td>
<td>6.87</td>
</tr>
<tr>
<td>Midplate</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19.35</strong></td>
</tr>
<tr>
<td><strong>Over/Under</strong></td>
<td><strong>(0.65)</strong></td>
</tr>
</tbody>
</table>
Subsystem Design – Detailed Power Budget

• Include a screenshot in your presentation and the actual excel file with your CDR package
• You should track the power need for each subsystem, and the power included for your payload (i.e. via your batteries)
• This helps ensure you have enough power for flight with a safety margin for any unexpected occurrences
# Subsystem Design – Power Budget

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Voltage (V)</th>
<th>Max Current (A)</th>
<th>Time On (min)</th>
<th>Watts</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arduino Mega 2560</td>
<td>5.0</td>
<td>0.10</td>
<td>60</td>
<td>0.50</td>
<td>0.10</td>
</tr>
<tr>
<td>Power Booster 1000</td>
<td>3.7</td>
<td>0.10</td>
<td>60</td>
<td>0.37</td>
<td>0.10</td>
</tr>
<tr>
<td>5 RSB Boards</td>
<td>5.0</td>
<td>0.25</td>
<td>60</td>
<td>1.25</td>
<td>0.25</td>
</tr>
<tr>
<td>5 Geiger Tubes</td>
<td>500.0</td>
<td>0.25</td>
<td>60</td>
<td>125.00</td>
<td>0.25</td>
</tr>
<tr>
<td>Data Logging Shield</td>
<td>3.7</td>
<td>0.10</td>
<td>60</td>
<td>0.37</td>
<td>0.10</td>
</tr>
<tr>
<td>ADXL377 Accelerometer</td>
<td>3.7</td>
<td>0.00</td>
<td>60</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>BNO055 9 DOF Sensor</td>
<td>3.7</td>
<td>0.01</td>
<td>60</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Total: 0.81 Watts

Total Power Capacity: 5.00

Over (+)/Under (-): 4.19

# of Flights Margin: 1.2
Test/Prototyping Plan

Bob A
Prototyping Plan

Risk/Concern

- Unable to differentiate between Gamma and total radiation
- The functionality of the microcontroller board needs to be verified by CDR

Action

- Prototype RSB with multiple tubes
- Prototype the micro board on a bread board to verify functionality
**Prototyping Plan**

<table>
<thead>
<tr>
<th>SCU/SSCU</th>
<th>Risk/Concern</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Able to contain liquid spill</td>
<td>3D print prototype and test find</td>
</tr>
<tr>
<td>CDH</td>
<td>Will not be able to handle data from all sensors</td>
<td>Prototype data logger with multiple digital/analog sensors</td>
</tr>
</tbody>
</table>
Testing/Prototyping Example

<table>
<thead>
<tr>
<th>Test</th>
<th>How</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>Create shaker table</td>
<td>Confirm 3D printed parts, structure and electronics can handle the forces of flight. Confirm vials don’t shake open</td>
</tr>
<tr>
<td>RSB Prototype</td>
<td>Measure background radiation</td>
<td>Confirm new RSBs have similar results to prior year tests.</td>
</tr>
</tbody>
</table>
Testing/Prototyping
### Prototyping Results

<table>
<thead>
<tr>
<th>Geiger Tube</th>
<th>Shielding (Layers)</th>
<th>Source</th>
<th>Count/Min.</th>
<th>Attenuation, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>LND 71217</td>
<td>0</td>
<td>None</td>
<td>22.4</td>
<td>---</td>
</tr>
<tr>
<td>LND 71217</td>
<td>2</td>
<td>None</td>
<td>19.8</td>
<td>13</td>
</tr>
<tr>
<td>LND 712</td>
<td>0</td>
<td>None</td>
<td>16.8</td>
<td>---</td>
</tr>
<tr>
<td>LND 712</td>
<td>2</td>
<td>None</td>
<td>14.6</td>
<td>15</td>
</tr>
<tr>
<td>LND 71217</td>
<td>0</td>
<td>Gamma</td>
<td>159</td>
<td>---</td>
</tr>
<tr>
<td>LND 71217</td>
<td>1</td>
<td>Gamma</td>
<td>141</td>
<td>11</td>
</tr>
<tr>
<td>LND 71217</td>
<td>2</td>
<td>Gamma</td>
<td>119</td>
<td>25</td>
</tr>
<tr>
<td>LND 71217</td>
<td>3</td>
<td>Gamma</td>
<td>133</td>
<td>16</td>
</tr>
<tr>
<td>LND 712</td>
<td>0</td>
<td>Gamma</td>
<td>134</td>
<td>---</td>
</tr>
<tr>
<td>LND 712</td>
<td>1</td>
<td>Gamma</td>
<td>125</td>
<td>7</td>
</tr>
<tr>
<td>LND 712</td>
<td>2</td>
<td>Gamma</td>
<td>124</td>
<td>7</td>
</tr>
<tr>
<td>LND 712</td>
<td>3</td>
<td>Gamma</td>
<td>118</td>
<td>12</td>
</tr>
</tbody>
</table>

LND 71217 confirmed more sensitive to Gamma than LND 712.

Additional testing needed to clarify attenuation with multiple layers.

Attenuation may be greater with Gamma radiation (LND 712) compared to total radiation (LND 71217).
Manufacturing Plan

Dan Cairns
Mechanical Elements

Retainer parts modified to hold additional vials (1)
Retainer parts will be 3D printed
  Timing: Early January 2018
Minor modifications will be made to eliminate bolt pattern interference
Electrical Elements

3 RSB and Geiger Tubes from 2017 payload need to be removed and reconfigured for 2018 payload.

2 additional RSB / Geiger Tubes purchased.

Need to design and order new PCB without G switch circuit. Plan on needing to revise PCB at least once.
Software Elements

Two microcontrollers will each have separate software.

Only minor modifications needed for first subsystem.

Second subsystem code is being developed for prototypes, then will be revised to include flight code elements.
Testing Plan

Bob Aloisi
Josh Janezick
Mechanical Testing

• COM test
• Vibration test.
  – Mount to plywood, strap to generator
• See schedule for timing
System Level Testing

- Integration of PCB and Battery Power
- Mechanical/Fit Testing for retainers
- Final Integration into Flight design
- Integration of software and electronics
User Guide Compliance

Josh J
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Status/Reason (if needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of gravity in 1&quot; mid-can?</td>
<td>Currently within limits</td>
</tr>
<tr>
<td>Contained in can</td>
<td>yes</td>
</tr>
<tr>
<td>Connected to can by 4/5 bulkheads on top and bottom only</td>
<td>four 8-32</td>
</tr>
<tr>
<td>Mass at 20±0.2lbs</td>
<td>Currently ok</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>Will not interfere, ½” separation between payloads</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>Not worried, will check once built</td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td>Yes, have to order</td>
</tr>
<tr>
<td>Activation wire at least 24 gauge</td>
<td>22 gauge</td>
</tr>
<tr>
<td>Early Activation: current &lt; 1 A</td>
<td>Not using</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Yes, will check once built</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Lithium Polymer (will not charge at Wallops)</td>
</tr>
</tbody>
</table>
– Special requests?
  • Liquids double contained, small quantities.
  • High voltage for RSBs only
Design Overview: Shared Can Logistics

• Who are you sharing with?
  – Unknown

• Plan for collaboration
  – TBD
  – Flexible top or bottom position
  – Mid mounting plate may not be needed
Project Management Plan

Ryan Kisiolek
Organizational Chart

- **Project Manager**: Ryan Klsiolek
- **CFO**: August Schuett
- **Faculty Advisor**: William Direnzo
- **Faculty Advisory**: David Kaplin
- **System Engineer**: Bob A, Josh J, Dan C.
- **Safety Engineer**: Ryan K
- **Testing Lead**: Bob, Josh, Katie
- **Sponsor**: David Kaplin

- **EPS**: Bob A, Katie K.
- **RSB/CDH/SSS**: Bob A, Pancho Cruz
- **SCU**: Ryan K, Josh J, Dan C.
- **BIO**: Ryan K
Schedule

Gantt Chart

<table>
<thead>
<tr>
<th>Name</th>
<th>Begin date</th>
<th>End date</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDR Teleconference</td>
<td>11/3/17</td>
<td>11/3/17</td>
</tr>
<tr>
<td>Fundraising</td>
<td>10/2/17</td>
<td>3/16/18</td>
</tr>
<tr>
<td>UWM SEDS Funding</td>
<td>2/15/18</td>
<td>2/15/18</td>
</tr>
<tr>
<td>WSGC Grant Request</td>
<td>11/1/17</td>
<td>11/13/17</td>
</tr>
<tr>
<td>WSGC Grant Decision</td>
<td>12/15/17</td>
<td>12/15/17</td>
</tr>
<tr>
<td>Seek Corporate Sponsors</td>
<td>10/2/17</td>
<td>3/16/18</td>
</tr>
<tr>
<td>CDR Teleconference</td>
<td>12/4/17</td>
<td>12/4/17</td>
</tr>
<tr>
<td>Dev RSB Prototype Code</td>
<td>10/2/17</td>
<td>10/10/17</td>
</tr>
<tr>
<td>RSB Prototype</td>
<td>10/2/17</td>
<td>10/10/17</td>
</tr>
<tr>
<td>SCU Prototype</td>
<td>10/2/17</td>
<td>10/27/17</td>
</tr>
<tr>
<td>Subsystem Tests</td>
<td>12/4/17</td>
<td>1/1/18</td>
</tr>
<tr>
<td>Progress Update</td>
<td>1/22/18</td>
<td>1/22/18</td>
</tr>
<tr>
<td>Subsystem Testing Review</td>
<td>2/13/18</td>
<td>2/13/18</td>
</tr>
<tr>
<td>Integrated Subsystem Tests</td>
<td>2/13/18</td>
<td>3/12/18</td>
</tr>
<tr>
<td>ISTR Telecon</td>
<td>3/13/18</td>
<td>3/13/18</td>
</tr>
<tr>
<td>Revise and Integrate Systems</td>
<td>3/13/18</td>
<td>4/9/18</td>
</tr>
<tr>
<td>Full Mission Testing</td>
<td>4/10/18</td>
<td>4/10/18</td>
</tr>
<tr>
<td>Full Mission Simulation Report</td>
<td>4/10/18</td>
<td>4/10/18</td>
</tr>
<tr>
<td>Final Revisions</td>
<td>4/11/18</td>
<td>4/30/18</td>
</tr>
<tr>
<td>Progress Update</td>
<td>5/21/18</td>
<td>5/21/18</td>
</tr>
<tr>
<td>Check In Document Due</td>
<td>6/4/18</td>
<td>6/4/18</td>
</tr>
<tr>
<td>Travel</td>
<td>6/13/18</td>
<td>6/13/18</td>
</tr>
<tr>
<td>Visual Inspection</td>
<td>6/14/18</td>
<td>6/14/18</td>
</tr>
<tr>
<td>Vibration Test</td>
<td>6/18/18</td>
<td>6/18/18</td>
</tr>
<tr>
<td>Launch Date</td>
<td>6/21/18</td>
<td>6/21/18</td>
</tr>
<tr>
<td>Preliminary Report</td>
<td>7/13/18</td>
<td>7/13/18</td>
</tr>
<tr>
<td>Final Report Due</td>
<td>7/20/18</td>
<td>7/20/18</td>
</tr>
</tbody>
</table>
## Budget

<table>
<thead>
<tr>
<th></th>
<th>WSGC</th>
<th>UW Sheboygan</th>
<th>UW Milwaukee</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplies and Expenses</td>
<td>$2,000</td>
<td>---</td>
<td>$1,000</td>
<td>$3,000</td>
</tr>
<tr>
<td>Travel</td>
<td>$4,000</td>
<td>$2,000</td>
<td>$6,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>Payload Fee</td>
<td>$4,000</td>
<td>$1,000</td>
<td>$2,000</td>
<td>$7,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$10,000</td>
<td>$3,000</td>
<td>$9,000</td>
<td>$20,000</td>
</tr>
</tbody>
</table>
## Team Contact Matrix

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Role/Position</th>
<th>Email Address</th>
<th>Phone Number</th>
<th>US Person? (Y/N)</th>
</tr>
</thead>
<tbody>
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<tr>
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<td>engineer</td>
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<tr>
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<td>(414) 229-6881</td>
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Monday and Wednesday at 7am have been added.

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<th>Fall 2017 RS-C Team Availability Matrix</th>
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Conclusion

- We need to raise funds to support travel of larger group.
- Order of materials
- Finalize layout of components
- Finalize design of SCU
Worries

- We need to raise funds to support travel of larger group. Funding may not be available at the beginning of the project for supplies.
Backup Slides
https://en.wikipedia.org/wiki/Air_shower_%28physics%29#/media/File:AirShower.svg
Fig. 13 Modelled CRII as a function of the atmospheric depth $h$ (or altitude—right axis) and $R_c$ (or geomagnetic latitude—upper axis) for medium CR modulation ($\phi = 500$ MV)
Fig. 2  *Left panel:* height dependence of ionising particle fluxes $J$ at latitudes with different threshold cutoff rigidities $R_c$ (LP data). *Middle panel:* similar to the *left panel* but for the ion pair production rate in the ionisation chamber ($Q$) (Neher 1967, 1971). *Right panel:* the same as at the middle panel but converted to ionisation in free ambient air ($q$)
A Muon passing through lead will create electromagnetic cascades where they are detected by Geiger–Müller tubes.