HWS ISTR

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Mission Overview

- Mission statement remains unchanged
- Finalized Mission Statement: The purpose of our experiment is to determine the flux of muons at various levels within the atmosphere using a plastic scintillator detector with a solid state SiPM
Mission Overview cont.

- Four main specific mission components:
  - Measure muon flux density during flight
  - Determine how acceleration of rocket influences muon detection
  - Determine how temperature influences muon count
  - Improve upon detection from 2015
Operations During Flight

- Data collection begins at \( T - 180 \) seconds (Allows proper time for system boot up and baseline data collection)  
  - All systems on  
  - Begin data collection

- End of Orion Burn  
  \( t \approx 0.6 \, \text{min} \)  
  Altitude: 52 km

- Apogee  
  \( t \approx 2.8 \, \text{min} \)  
  Altitude: \( \approx 115 \) km

- Chute Deploys  
  \( t \approx 5.5 \, \text{min} \)

- Splash Down - end of data collection  
  \( t \approx 15 \, \text{min} \)  
  Altitude: 75 km

- Altitude: 95 km

- Altitude: 95 km

- Altitude: 75 km

- Altitude: 75 km

- Altitude: 95 km

- Altitude: 75 km
Changes Since STR

- Currently no changes have been made to our payload design since the STR
Subsystem Status
Electrical

- Eagle Cad Schematic designed and ready to be built
Electrical Cont.
PCB Design

- Last year’s Berkley circuit is too large
- This year’s board must fit on top of an Arduino shield (7 x 5 cm)
Electrical cont.

- Protoboard:
  - One half of the Berkley circuit is converting sine waves to square waves at a readable voltage level
  - Input voltage: 4.5 Vpp
  - Output voltage: 3.84 Vpp
Electrical cont.

- Second half of Berkley circuit is not producing a readable voltage for the Arduino
  - Input voltage: 4.5 Vpp
  - Output voltage: 960 mV

- In process of building another protoboard for further testing (specifically the photomultipliers)
Building Experimental Stand for Testing the Si Photomultiplier

- Built LED flickering circuit to test photomultipliers
- PMs to be connected to Berkeley circuit
- PMs will be placed in a dark box with the LED blinking at a known frequency to test the accuracy of the PMs light detection
- Test awaiting arrival of pre-amps
Mechanical

- Aluminum machining almost completed
- Hollowing the center of the aluminum casing
Mechanical cont.
Mechanical cont.

- Designing 3D printed plastic electronic mounting board to keep our electronics in place without drilling more holes into the aluminum casing
Next step: cut a notch in the plastic scintillation plate where to place the photo multipliers
Software

- Obtain a running Arduino test code to count pulses for a given time interval
- Tested four different square waves (four different frequencies) directly from the signal generator
- In each case, the error in the average frequency value was less than 1% off of the expected value
Software cont.

- Full results/raw data/calculations included in the Dropbox

- Frequency testing results:

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<th>Trial #</th>
<th>Seconds</th>
<th>Hertz</th>
<th>Expected</th>
<th>Actual</th>
<th>Average</th>
<th>Error in each measurement:</th>
<th>Statistical error:</th>
<th>Sum(i)^2</th>
<th>In each measurement</th>
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Integrated Subsystem Testing Status
Ideal World vs Real World Test Overview

- Integrated two main subsystems: electrical and software

- Tested to see the accuracy of the pulses converted by the Berkeley circuit
  - Input a square wave, of various frequencies, directly from the pulse generator to the Arduino and count the pulses
  - Input a sine wave, of various frequencies, into the Berkeley circuit; connect the output of the Berkeley circuit to the Arduino and count the pulses

- Compare the above two sets of measurements
Ideal world (input from signal generator) vs. Real world (input from Berkeley circuit) Results

- 50 Hertz comparison:
  - Ideal:
    - **Expected** average counts over 30 seconds: 1500 counts
    - **Measured** average counts over 30 seconds: 1499.4 ± 0.8 counts
  - Environment:
    - **Expected** average counts over 30 seconds: 1500 counts
    - **Measured** average counts over 30 seconds: 1493.4 ± 19 counts
Ideal World vs Real World Results cont.

- Raw data included in Dropbox
- As expected, the uncertainties in the counts in the real world (Arduino input signal coming from the Berkeley circuit) are larger than the uncertainties in the ideal world (when the Arduino input signal was coming directly from the function generator)
Ideal World vs. Real World

Conclusion

- As expected, the standard deviation of the real world testing was larger than the standard deviation of the mean counts of the ideal world.
- The signal generator produces identical, perfect square wave pulses at a very steady frequency.
- The Arduino when counting in an ideal scenario (perfect square pulses) is very accurate.
- Our real world average was only 6 counts off of the expected value in the ideal scenario (.4%).
- Conclusion: design the Berkeley circuit such that we will have almost “perfect” square waves at the output (minimize electronic noise).
Photomultiplier Testing Plan

- Test the integration of the photomultipliers and the Berkley circuit
- Already built LED pulsing circuitry
- Plan to run tests to check the accuracy of the number of sine waves generated by the photo multipliers

- We will know the frequency of the flickering light (the signal generator controls the frequency of the flickering LED); the light will interact with the scintillator plates and generate photons; the photons will be detected by the SiPM; the output of the SiPM will be connected to the Arduino which will count the electric pulses; the number of the pulses from the signal generator must be equal with the counts from Arduino; Thus we will know that the counting system works properly.

- Testing will start when the pre-amps for the SiPM arrive from Germany (expected April 11th)
Full Systems Testing Plan
Canister Integration

- Majority of subsystem functionality testing will be completed before full system integration
- Mechanical will happen after full system integration
Vibe Test

- Largest concern of the vibe test:
  - will be disconnection of electrical components
  - SD card popping out of Arduino
- Mechanical structure will be heavily tested before Wallops in vibration tests designed to be conducted at HWS
System Level Testing

- Test light exposure to photomultipliers
- Mechanical subsystem must be durable and light tight
  - Seal the canister with black tape
  - Count using artificial radio active source
Electrical Testing

- Our testing must ensure that there is no voltage on the canister
- Once full system integration is complete, we plan on letting the experiment run until the batteries drain out
- This will test the maximum lifetime of data collection
Integrating the System at Wallops

- We currently obtain all spare electrical components for our circuit board and plan to bring those to Wallops
  - We have kept an updated list of all electronic components to bring with us
  - Kept a list of the content of our RockSat toolbox
  - Kept clear, updated notes on common problems and solutions in our Logbook

- Ordered two extra Arduinos
4.0 Project Management Update
### Summery of Progress and Tentative Schedule

<table>
<thead>
<tr>
<th>Manager</th>
<th>Task</th>
<th>Progress</th>
<th>Future plans</th>
<th>Expected Completion</th>
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<tbody>
<tr>
<td>Frank Oplinger</td>
<td>Testing Berkeley Circuit</td>
<td>Test the wave shaping Berkeley circuit and Arduino code using the signal generator</td>
<td>Build the 2\textsuperscript{nd} wave shaping Berkeley circuit and test it. Add the AND gate on the circuit and test it.</td>
<td>04/14/2016</td>
</tr>
<tr>
<td>Roue Nutter</td>
<td>3D Printed Plastic Plate</td>
<td>Design/draw the plate sketch to send to the 3D printer</td>
<td>Refine the model for the plate then print it on the 3D printer.</td>
<td>Sketch Print 04/15/2016</td>
</tr>
<tr>
<td>Bobby Hooper</td>
<td>Electrical Circuits Design</td>
<td>Draw the electrical diagram of the coincidence Berkeley circuit in EagleCAD</td>
<td>Design the PCB layout for the coincidence circuit. Send the EagleCad file for printing out the PCB. Soldering</td>
<td>PBB layout Print PCB 04/20/2016 Soldering 04/25/2016</td>
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### Summary of Progress and Tentative Schedule

<table>
<thead>
<tr>
<th>Kemal Turksomez</th>
<th>Arduino</th>
<th>Write the counting code such that all collected data are stored on the SD card. Modify the code such that we can control a time interval for collecting data.</th>
<th>Test the Arduino count. Add the temperature probe and write the code to read temperature.</th>
<th>Test 04/12/2016 Temperature Probe 04/14/2016</th>
</tr>
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<tbody>
<tr>
<td>Lauren St. Peter</td>
<td>Fund Raising. Travel Logistics. Build the experimental test stand for the Si Photomultipliers.</td>
<td>Fund Raising. Travel arrangements (lodging). Design the electrical circuit for the flickering LED.</td>
<td>Build the experimental stand for testing the Si Photomultipliers. Test the SiPM.</td>
<td>Build 04/15/2016 Test SiPM 04/22/2016</td>
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<tr>
<td></td>
<td>Machining the Al for the case of the muon detector.</td>
<td>Top and Bottom Al plate. Scintillator plates.</td>
<td>Center Plate. Make a cut in the plastic scintillator for the SiPM</td>
<td>Metal Plate 04/12/2016 Plastic Scintillator cut 04/15/2016</td>
</tr>
</tbody>
</table>
Problems and Solutions

Problems Encountered:
  • Arduino over count
  • Berkeley Circuit malfunction

Strategy for Problem-Solving:
  • Rebuild the Berkeley Circuit
Budget Update

- HWS has agreed to fund us fully for the HWS RockSat-C project
Conclusion

- Testing has given us an indication that our wave-shaping Berkeley circuit design is working correctly.
- Arduino counting system gives us an approximation of how many counts we may be over or underestimating in our data collection.

Next steps:
- Build the coincidence circuit again
- Design the PCB board/solder the electronic components on it
- Integrate the SI photomultipliers with the Berkeley circuit