Measuring the Polarization of Gamma Radiation

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2015 - 2016
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1.1 - Mission Overview

Our mission is to build a proof of concept gamma ray polarimeter to launch on a NASA rocket and successfully identify astral gamma rays in the form of either background radiation or gamma event radiation.
1.2 - ConOps

- Early activation powers up the payload electronics.
- Both raspberry pi’s start up simultaneously and begin running their software.
- Detector Pi:
  - Creates a log file with header including date and time.
  - Listens for a signal from the IMU Pi, records timestamp to synchronize logs later.
  - Begins to record samples from all 12 detectors.
  - Each set of readings includes a timestamp with millisecond precision.
- IMU Pi:
  - Creates a log file with header including date and time.
  - Waits 30 seconds to ensure both Pi’s are ready.
  - Turns on a digital pin to signal start of log file to Detector Pi. Recorded in log.
  - Begins to record samples from the IMU, stored in log with timestamp.
  - Begins recording light levels from the viewport.
  - Begins recording video through the viewport.
2.0 - Integration Testing

Overview

- Subsystems Tested:
  - Mechanical: Successful
  - Sensor: In Progress
  - Power: Successful
  - Software: Successful

- Integration:
  - Mechanical-Electrical: Successful
  - Software-Electrical: In Progress
2.1 - Mech-Electrical Status

- **Mechanical - Electrical Integration:**
  - Mechanical tests (completed)
    - Weight needs updated w/electronics
  - Electronic fit tests (completed)
    - Status: Electronics have successfully been mounted and positions have been finalized
  - Electric insulation from payload
    - Status: Electronics assumed still insulated but with new mountings additional testing scheduled for 5/29
  - Full payload test in radiation center
    - Status: Ready and scheduled in 2 weeks

- **Open Action Items**
  - 5 holes to drill in one column to mount camera
  - Reduce height of central pillars
  - Reduce weight of ballast
2.2 - Electrical-Software Status

IMU Pi:
- Completed tests:
  - Acc/Gyro/Mag
  - Python software
  - Camera
- Incomplete tests:
  - Photoresistor through ADC
  - Comm between Pi’s

Detector Pi:
- Completed tests:
  - 6 inputs via ADC 1
  - C++ software
- Incomplete tests:
  - 6 inputs via ADC 2
  - Comm between Pi’s
We completed a mission simulation including both pi’s with the latest software, all 12 radiation sensors and the inertial measurement unit (IMU), all combined into the mechanical design.

The only components we were unable to include for this test were the optical port camera and photoresistor, but we are working to include those soon.

The test results were encouraging, but show that we still have work to do. We saw unusually steady results in our radiation sensors and noticed we could improve our logs by standardizing the timestamps and formatting between pi’s.

Our next step in testing is to use a radiation source, and the delay right now is scheduling access.

Our next full mission test with radiation is scheduled for the first week of June.

Until then, we are working on additional subsystem testing including electronics and software.
3.1 - Canister Integration Results

- We have done a fit test with the payload inside the canister and we are very close to perfect fit. We just need to grind down the central columns to make room for the washers to go between the payload and canister.

- We have tested electrical integration on the canister with success, and to provide more space we relocating pi boards to the top plate.

- Things to Do:
  ○ Drill mounting holes and install camera on integrated payload.
  ○ Grind the 4 central pillars down to fit the payload inside the canister.
  ○ Insert mechanical frame into canister and bolt in place with washers.
  ○ Final weight test to determine center of gravity and adjust ballasts as needed.
3.2 - Vibe Test Results

- Initial Vibe Test results proved successful. In our current configuration:
  - Battery holders are firm and will not relinquish their contents.
  - PCB Mounting is solid and doesn’t allow much vibration
  - Wire Management is effective if difficult
  - Connections are solid and all components retained power and data through vibration
3.3 - Electrical Test Results
Electrical system was mounted to framing system before a series of tests were conducted:

○ System process test: Detector code ran, readings from sensors captured (no gamma sources present). IMU system tested, entire payload turned to various positions and orientation data captured.

○ Shaker table test: Placed on shaker table to measure effectiveness of mounting (screws, spacers, etc) and electrical connections.

○ Heat test: Entire payload placed in heat box set at 40 degrees Celsius for 5 minutes and tested for any developing electrical faults.

○ Ground test: Electrical components will be run and framing system will be checked for any currents present.

○ See 3.4 for testing results.
3.3 Electrical Test Results: Further Tests

A series of sensor tests will be conducted in the Radiation Center over the next few weeks- tentatively schedule for first week in June.

Purpose of tests:
- Determine if sensors can successfully detect gamma hits- initially tested using Americium-241 (approx 60 keV of energy) from ionizing smoke detector, tests show “hits” that output 100+ mV from sensor).
- Determine if signal-to-noise ratio is adequate (i.e. present noise of approx. 60 mV still allows for detectable gamma hits)- initially tested as stated above, “hits” are detectable.

General purpose IMU testing for baseline data for post-flight analysis of orientation data.
- Allows us to understand “what the IMU is telling us”.
Preliminary Sensor Test
Mounting
More Mounting
Even More Mounting
Finalized Mounting/Design Expo
Electrical Integration Tests:
- Shaker Table Test: Integrated system tested at 5Hz with 0.1” displacement for 5 minutes-all mounting passed, electrical connections held.
- Ground Test: Framing system tested electrically with electrical components mounted and running, no current found in framing system- additional testing to be performed.
- Heat Test: System placed in 40 Celsius environment for 5 minutes, no electrical faults developed.
- System Process Test: Successfully passed on both detector system and IMU system- still to be done: Pi communication and camera.

Further Mechanical Integration Tests:
- Weight test after camera and photodetector are mounted, test for total weight and center of gravity.

3.4 - System Level Test Results
4.0 - Project Management

Hello

Yes, I would like to science please
4.1 - Detailed Schedule

8 sensors ETA: 5/11 (Arrived on schedule)

Latest rev of Power board ETA: 5/9 (Arrived on schedule)

New rev of system pcb connecting Detector and IMU Pi’s, ETA 5/11 (Arrived on schedule)
Finalized pcb rev ETA 6/1

Radiation center testing on sensors and system processing: ETA 6/3

Finish mech drilling and fit tests on 5/28
<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>-0.5” in Z is furthest from center</td>
</tr>
<tr>
<td>Contained in can</td>
<td>All Components 0.25” from canister wall</td>
</tr>
<tr>
<td>Connected to can by 4/5 bulkheads on top and bottom only</td>
<td>Using % on each bulkhead. Center hole excluded.</td>
</tr>
<tr>
<td>Mass at 20 lbs ±0.2 lbs</td>
<td>With electronics added need to shave down ballast</td>
</tr>
<tr>
<td>Shared canister clearance</td>
<td>N/A</td>
</tr>
<tr>
<td>No voltage on the can</td>
<td>Initial current checks show no shorting to Framing system.</td>
</tr>
<tr>
<td>Activation wires at least 4 ft</td>
<td>Will take care of it soon</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>&lt;1 A at start-up peak, 1 A fuse for protection</td>
</tr>
<tr>
<td>T-0 Activation: current &lt; .1 A</td>
<td>Not using</td>
</tr>
<tr>
<td>Battery Type</td>
<td>Lithium-Manganese Dioxide (will not charge at Wallops)</td>
</tr>
</tbody>
</table>
Our biggest challenge has been to create a working gamma sensor.

We believe we have a working design right now, but we still need to prove it works- initial tests provide good outlook.

Our biggest worry right now is that we’ll run out of time before we run out of problems.
4.4 - Conclusions

It’s been a rough ride but we have a dedicated team who is still pulling together and trying their hardest to send a working payload to Space.

The final report will be worked on by Cassandra, Justine, Levi and Delphine. We are looking ahead by meeting with Dr. Lazzati to learn how to exploit the data we expect to collect during the flight.

We will be 7 students attending the complete workshop. Cassandra will be joining us for the day of the launch taking a break from her internship at the Johnson Space Center.