HASP 2018 ~~Science~~ Failure Report

Report Month:	December 2018
Submitted by:	Peggy Norris (advisor)
Submit Date:	12/ 14 / 2018
Institution:	SDSMT/SURF
Payload Number:	2018-06
Payload Name:	Cosmic Ray Detector

The SDSMT/SURF HASP Payload (2018-06) flew with a silicon surface barrier detector designed to measure protons and alpha particles. Unfortunately, no data was recorded during flight, so this report is a failure analysis rather than a scientific data analysis.

System Overview / Redesign

The original project as proposed planned for two detectors, a 150μ transmission detector and a 1 mm stopping detector, so that particle identification could take place by correlating the energy loss of particles in the two detectors. We were not able to procure the detectors in time for the launch, so a redesign took place utilizing one used detector and relying on pulse shape discrimination for particle identification. A block diagram of the detector and signal processing is shown in Figure 1.

We had concerns that time required to record the full pulse shape of the signals would lead to too much dead time and that we would not be able to get accurate data on the flux of particles during flight. Therefore we designed the acquisition to take data in two modes: pulse shape and pulse count. The Raspberry-PI would switch back and forth between modes with a period that could be set with a command. We also did not know what the noise threshold of the detector would be, so the software was designed so that it started with a high threshold then lowered it until the computer started recording signals. The threshold could also be set manually with an uplink command.

Sequence of Events / Root Causes

The root causes of the failure of this mission mainly lie in schedule. Scheduling and resource issues that were not foreseen led to a lack of system testing ahead of integration and flight. The main issues were:

1. A budget line item was in the NASA South Dakota Space Grant Consortium (SDSGC) Solar Eclipse Balloon team grant to buy new silicon surface barrier detectors from Ortec, but the funding was set to expire in April 2018. By the time the proposal was approved in January 2018, the four month lead time for the 1 mm detector put it past the end date of the grant. Even though SDSGC was assured that a no-cost-extension (NCE) was automatic, the university purchasing department would not approve the purchase until the NCE was processed. After months of delay, the new detectors were put on hold and a used detector was found on EBAY.
2. Meanwhile, in January 2018 we put together a senior design team within the Mechanical Engineering Department at SDSMT to design and build the payload. The team was

supplemented with other students, including Zachary Christy, Pratik Sinai Kunkolienker and Dakotah Rusley, from the Electrical Engineering/Computer Engineering Department, who provided needed expertise on the power, electrical and computer systems. These students had limited time to work on the project since they were also involved with other design projects and competition teams. The Student Leader of the Project Team was Jacob Fonkert.

3. Once the used detector arrived and was tested, it was discovered that it required negative bias voltage instead of the positive voltage in the initial design. This necessitated a major redesign of the power system to add a voltage converter, which ate up more of the current budget.
4. In early May, eight members of the team graduated and dispersed. Undergraduates Zachary Christy, Pratik Sinai Kunkolienker, and Daniel Rynders continued to work on the project, augmented by high school student Dominick Oedekoven. Pratik worked on completing the power system redesign while he was working an internship in Texas. Once the power converter was built, the detector was installed in a vacuum chamber and tested with an alpha source, using the preamplifier and shaping amplifier modules, but not the full DAQ system.
5. The final system and software was finished just barely in time for the integration week in Palestine, TX, which was attended by Zachary Christy, Daniel Rynders, and faculty advisor Lowell Kolb. The payload passed integration. Within a week of returning from integration (and before Pratik returned from his internship in Texas), Zachary left for a permanent job in Colorado.
6. Between integration and flight, attempts were made to further test the system without taking everything apart. One thing that we were not able to do was to look at the output of the oscilloscope board (input of Raspberry PI). The time was also spent trying to understand the code, which was quite complicated.
7. The flight team consisted of Pratik Sinai Kunkolienker (electrical), Daniel Rynders (mechanical) and Peggy Norris (advisor). The day before leaving for Ft. Sumner, the preamplifier board stopped working. It appeared that maybe some stray voltage had shorted out a component. We ordered a new board and had it overnighted to the hotel in Ft. Sumner. Tuesday afternoon and evening of flight integration was spent in installing the new board and trying to get things working again. It turned out that the new board also didn't work, until we added a shunt resistor (thank you NASA Balloon Office support for finding us that resistor) that was recommended for detectors with high leakage currents. We don't know why we were able to run without this resistor in earlier tests, but perhaps the leakage current had been creeping up over time and finally hit some kind of threshold.
8. Once we had the detector working and showing at least noise signals through the shaping amplifier, we spent most of the rest of that night and part of the next day (until the payload had to be mounted) trying to debug why the Raspberry Pi was not recording data to the SD card. This is the failure we still have not solved. Not only did detector data not record, but it was not sent in the downlink data either, and the Raspberry Pi did not seem to be responding to status and other commands. The SD Card did record temperature and

pressure data, which bypassed the Oscilloscope Card. Therefore we are strongly suspecting that component of the electronics as the cause of our failure.

Lessons Learned

This was the first attempt by this team to build a complicated scientific balloon payload and we all – students and advisors alike – learned a tremendous amount. It is a tall order to take what in a physics lab would be a NIM Bin full of electronic modules, miniaturize it to the specifications of the HASP payload, AND stay within a stringent power budget. We definitely needed more time to do careful testing.

In our travel budget, we included funding for a run at the Berkeley Accelerator Space Effects Facility to test and calibrate the payload. Because of the issues with procuring the detector in a timely manner, we were not able to do this before they shut down for the summer.

Also, the timing of the HASP launch around Labor Day is not a very good fit with the semester schedule at a university. This project would have worked best with a senior design team working the spring/summer semesters (which we did for the Eclipse Balloon project). Unfortunately, at SDSMT, there are not a lot of students staying an extra summer. The transition from a senior design team to research interns right at finals time was rocky.

Future Plans

We plan to continue with the HASP program. It was a tremendous opportunity for the students who participated in integration and flight to experience how things are done when working with an organization such as NASA. However, we are not putting in another proposal until the 2020 launch; we feel that we need two years to get ready for a successful flight. Our planned timeline for the next 24 months are as follows:

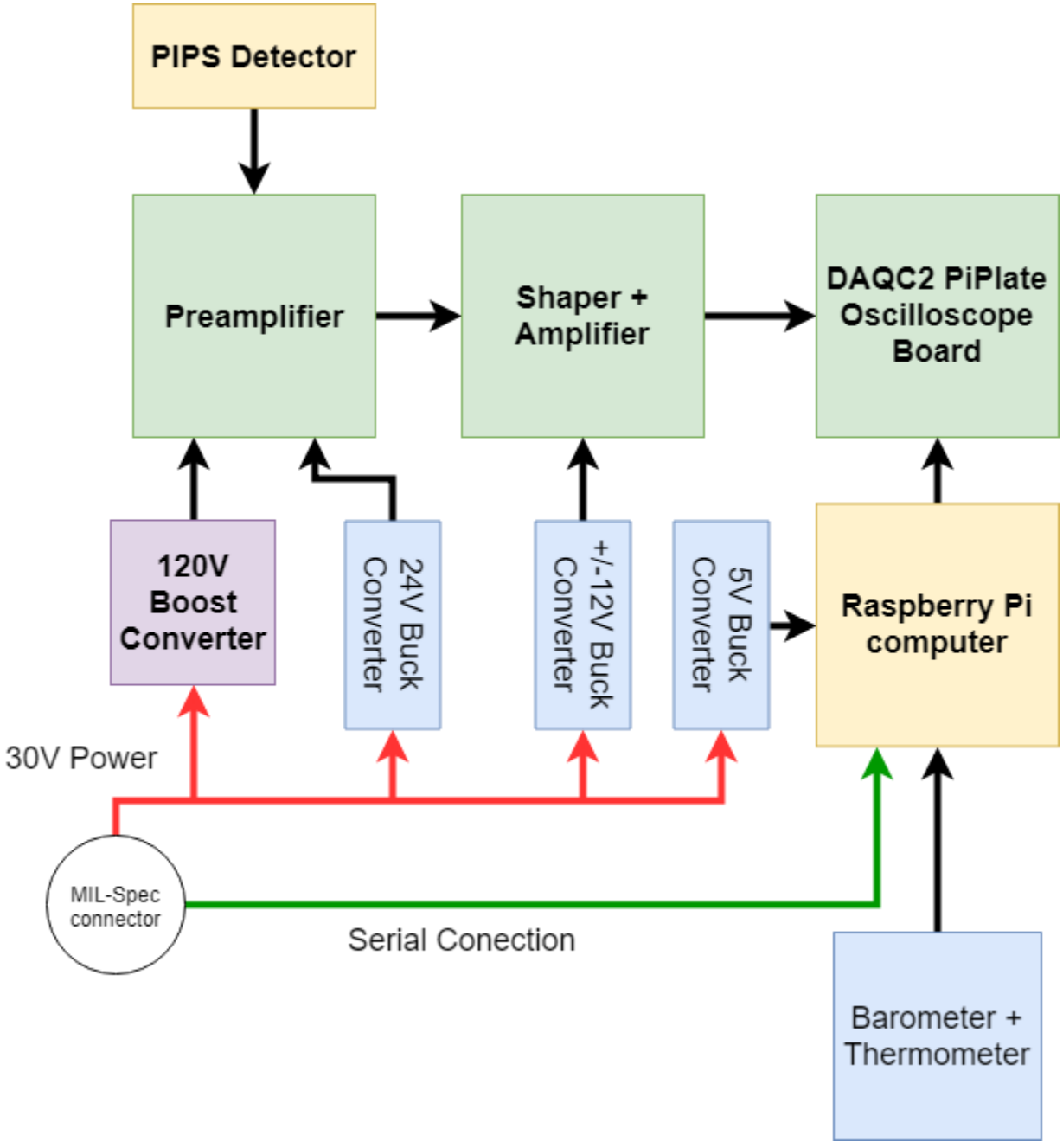
1st Quarter 2019	• Bench testing and debugging of electronics • Order a 1 mm thick detector (in progress) • Build a 'CosmicWatch' compact secondary cosmic ray detector to add to payload (in progress)
2nd Quarter 2019	• Weather balloon flight (test components of final system) • Redesign power distribution for positive bias
3rd Quarter 2019	• Weather balloon flight (test components of final system) • Bench testing of new detector and electronics components • FLUKA calculations of proton and alpha energy distributions
4th Quarter 2019	• Finalize electronics / power and layout of payload • Proposal for 2020 launch
1st Quarter 2020	• Construct payload • Test/calibration run in Berkeley
2nd Quarter 2020	• Analyze test results • Modifications as needed
3rd Quarter 2020	• Integration • Launch

4th Quarter 2020	• Analyze a SUCCESSFUL HASP flight

Bibliography

The only presentations made about the HASP 2018 project were the Preliminary and Conceptual Design Reviews by the Senior Design team as well as a poster presentation for other SDSMT students at the Senior Design Fair in April 2018.

Figure 1. Block Diagram of Electronics



APPENDIX

Student Demographics

Name	Role	Student Status	Race	Ethnicity	Gender	Disabled
Luke Bauske*	Mechanical Design	Undergraduate	White	Non-hispanic	Male	No
Zachary Christy[#,*]	DAQ/Telemetry / Integration Team	Undergraduate	White	Non-hispanic	Male	No
Jacob Fonkert*	Team Lead	Undergraduate	White	Non-hispanic	Male	No
Dalton Fox	Student Research	High School	White	Non-hispanic	Male	No
Sarah Kelly	Systems Integration	Undergraduate	White	Non-hispanic	Female	No
Noah Klamm*	Materials	Undergraduate	White	Non-hispanic	Male	No
Pratik Sinai Kunkolienker	Power Supply / Flight Team	Undergraduate	Asian	Non-hispanic	Male	No
Brandon Lind*	Flight Operations	Undergraduate	White	Non-hispanic	Male	No
Kob Meier*	CAD Design	Undergraduate	White	Non-hispanic	Male	No
Dominick Oedekoven[#]	Detector Subsystems	High School	White	Non-hispanic	Male	No
John Carlo Primo	Detector Subsystems	Undergraduate (ASU)	Pacific Island	Non-hispanic	Male	No
Dakotah Rusley*	Power Systems	Undergraduate	White	Non-hispanic	Male	No
Daniel Rynders[#]	Flight Operations / Integration Team / Flight Team	Undergraduate	White	Non-hispanic	Male	No
Isabel Schuster	Physics Analysis	High School	White	Non-hispanic	Female	No
Aaron Vogel*	Detector Subsystems	Undergraduate	White	Non-hispanic	Male	No

[#] - Summer 2018 interns through South Dakota Space Grant Consortium

* - SDSMT Graduates, May 2018

Advisors

Jason Ash	SDSMT	Faculty	White	Non-hispanic	Male	No
Steve Gabriel	Spearfish High School	Physics Teacher		Non-hispanic	Male	No
Lowell Kolb	SDSMT	Faculty Emeritus	White	Non-hispanic	Male	No
Peggy Norris	BHSU/SURF	Staff	White	Non-hispanic	Female	No
Charles Tolle	SDSMT	Faculty	White	Non-hispanic	Male	No

SDSMT Graduates, May 2018 (includes 'Catching Rays' Senior Design Team)

Name	Major	Graduation Date	Status	Company / School	Position
Luke Bauske	Mechanical Engineering	May 2018	WF	Vishay-Dale Electronics (SD)	Design Engineer
Zachary Christy	Computer Engineering	May 2018	WF	Wolf Robotics (Co)	Software Engineer
Jacob Fonkert	Mechanical Engineering	May 2018	WF		
Noah Klamm	Mechanical Engineering	May 2018			
Brandon Lind	Mechanical Engineering	May 2018	WF	Bullfrog International (UT)	Manufacturing Process Eng
Kob Meier	Mechanical Engineering	May 2018			
Dakotah Rusley	Computer Engineering	December 2018	WF	NASA Goddard	Systems Engineering
Aaron Vogel	Mechanical Engineering	May 2018			