Overall a very good proposal. Few items to improve on but I liked it.
I.1: Overview and Mission Statement

Mission Statement:

Project PePs’ mission is to determine the efficiency of polystyrene compared to polyethylene as a deterrent to gamma ray radiation. There will be two Geiger counters within the BalloonSat. One will have a polystyrene shield around it while the other will be surrounded by a polyethylene shield. The overall goal of the mission is to see whether polystyrene or polyethylene is a better deterrent against gamma radiation.

Mission Overview

Objectives:

1. Test for the absorption of gamma rays by polystyrene and polyethylene.
2. Compare these two methods to each other.

Gamma radiation has been known to be a major barrier of interplanetary travel. When exposed to gamma rays, there is a statistically elevated risk of cancer and damage to living tissue that can cause skin burns and radiation sickness. Studies have also shown that there is an increased potential for both direct damage to DNA as well as Acute Radiation Syndrome (ARS), which can result in death. The main reason for these effects is due to the harmful nature of ionizing radiation.

Ionizing radiation is energy in the form of waves or particles. However, what makes ionizing radiation so harmful is the fact that at high energies it can break chemical bonds, which then can destroy nuclei of atoms. Human tissue tends to absorb some of these rays even though gamma particles travel the speed of light and can pass through the body.

The objective is to find a cheap, effective, and lightweight shielding as a replacement for current methods of protecting against gamma radiation. Currently, the most effective attenuation of high-energy radiation is by extremely dense metals like tungsten or lead, which are far too heavy to feasibly be carried into orbit. Furthermore, even if highly dense materials had a lower mass, there would still be a large amount of secondary radiation also known as Bremsstrahlung.

Secondary radiation has been a major concern and can be even more potent than the original rays. Most of this secondary radiation occurs from the material itself because when the primary cosmic rays interact with the shield, nuclear by-products such as neutrons are produced and can pass through the material. Due to the fact that neutrons are uncharged particles, dense materials like lead do not protect against secondary radiation because the neutrons can just pass through. However, it has been shown that materials with low atomic numbers can be effective because they have a higher probability of forming cross-sections that interact with the neutrons.

There have been several studies that suggest that plastics might be a possible alternative due to their chemical composition. In 2005, NASA began experimenting with polyethylene in order to create RXF1, a material lighter and stronger than aluminum. Whether it can be used today as an efficient shield is still uncertain.

After researching several types of plastics, Team H2S decided that the two superior plastics were ones made from polystyrene and polyethylene. Both are exceptionally good for radiation absorption because of their elevated content of benzene rings which do not break upon impact from radiation, but rather dissipate the energy by moving the entire chain in a process called nucleophilic aromatic substitution.\(^7\)

The resistance of certain plastics to gamma irradiation was also analyzed and it was found that both polystyrene and polyethylene tolerated radiation.\(^8\)

The purpose of the experiment is to determine which of these plastics is a better gamma ray deterrent. Because NASA has already experimented with polyethylene and had favorable results, it would be useful to know if this property was not only limited to polyethylene, and if polystyrene is an even better alternative.

The type of polyethylene being used will most likely be high-density polyethylene because a higher density is more effective for primary radiation and the polyethylene already has a relatively low atomic number allowing it to be efficient against secondary radiation. As for the polystyrene, it will be composed of acetone and styrofoam to allow for more flexibility with the structure.

### 1.2 Mission Requirements

1. Build and equip a BalloonSat to record gamma radiation with two different types of radiation shielding.
2. Present Professor Koehler the equipment order form by Feb. 13, 2015.
3. Upon recovery and replacement of batteries, H2S’ BalloonSat will be ready for another flight.
4. The flight string will run through the center of the BalloonSat and will be secured with the provided flight string interference tube, out of the way of H2S’ experiments.
5. H2S’ BalloonSat will maintain a temperature greater than -10° C using the provided heating system.
6. H2S’ BalloonSat will not exceed 1000 grams, including the required systems.
7. Using the GPS and accelerometer, H2S will record ascent and descent of the flight string.
8. The design of H2S’ BalloonSat will allow for use of an Arduino Uno plus a microSD card shield.
9. The layout of the BalloonSat will also allow for a temperature sensor that extends an inch beyond the foam core shell of the capsule.
10. H2S’ BalloonSat schematic will account for the Canon A3400 and an additional 145 grams for the battery and SD card.
11. A heater and three 9V batteries will be accounted for in the design of the BalloonSat.
12. The BalloonSat itself will be made out of the provided foam core.
13. In H2S’ equipment request and budget outline, spare parts will be taken into consideration.
14. The outside of H2S’ BalloonSat will have H2S contact information and the flag posted on it.
15. All schematics and measurements will be done in the metric system.

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16. H2S’ BalloonSat will be prepared for the April 11, 2015 launch date in Windsor, CO.
17. The team will do its best not to injure anyone.
18. At the end of the semester, H2S will return all borrowed equipment to the Gateway to Space program in working condition.
19. All equipment will be bought with Professor Koehler’s CU Visa.
20. All of H2S’ expenses will be approved by Professor Koehler prior to purchase. Sean Grant will be in charge of purchases and expenses for H2S’ BalloonSat.
21. H2S will be having so much fun it won’t even look like the team is having fun.
22. No biological payloads will be flown on Team H2S’ BalloonSat.
23. The final report will be completed before the deadline.
24. The BalloonSat will have LEDs on the outside of foam core that will turn on when each system is functioning.
25. All of the switches will be protected by foam core covers.

II: Technical Overview

II.1: Structures, electrical, science, software, thermal, and C&DH

In order to successfully achieve the mission, it is essential that the balloon satellite protect all devices onboard the payload. To that end, the structure must be robust enough to withstand large forces of impact and torsion. For this reason, the balloon satellite will be a 20x20x15 cm box constructed with the provided foam core and held together with hot glue. Foam core is good for the task because it will remain in the shape of the box throughout the balloon satellite’s flight and impact, and it is a relatively light weight.

The electrical subsystem will be important for supplying power to other systems. The two Arduinos will be powered with separate 9 volt batteries, while yet another battery will power the heater. The required sensors: temperature sensor, accelerometer, humidity sensor, and pressure sensor, will be wired to the first Arduino. Both Geiger counters will be wired to the second Arduino. An external switch and LED indicator will be wired externally to each Arduino in order to turn it on and see if it is working without actually opening the top of the balloon satellite. The heater will also have an external switch and LED indicator.

The core of the scientific endeavors is to launch two Geiger counters; one shielded by a polystyrene cover and one shielded by a polyethylene cover. In order to make the polystyrene, a combination of acetone and styrofoam will be used. Styrofoam consists of polystyrene foam that
can dissolve in acetone and allows for the creation of a mold in a glass container. Essentially, the air trapped in the styrofoam is released and a large quantity of material can be made. Acetone is being used because it is easily available in most nail polish removers but any organic substance could be used to dissolve the polystyrene.⁹

As for the polyethylene, it will be made using plastic bottles containing high-density polyethylene (HDPE) and will be melted using oil. In order to create a mold from the polyethylene, the pot being used must reach the melting point for HDPE, which is around 120 to 180 °C. Once the plastic has melted, it can be formed into the desired shape and then cooled in a freezer. All efforts will be made to make both plastic molds relatively equal shapes and thicknesses in order to truly test which plastic performs the job better.

Each Geiger counter will be placed on a separate side of the balloon satellite with equal distances to its walls in order to allow both to be exposed to equal amounts of gamma radiation. Although it is not possible to ensure the exact same amount of exposure to gamma radiation for each Geiger counter, error can be minimized through controlling the placement and orientation of both sensors.

The first Arduino’s software will use triggered interrupt service routines to read pulses from the two Geiger counters. These triggers will guarantee that no data will be lost between the gaps using a set polling frequency. The times at which pulses are received will then be collected and periodically written to the SD card attached. After landing, the data will be collected into a readable format. The second Arduino will periodically poll the thermometers, humidity sensor, and accelerometer for values and write the data to the second SD card.

During the flight, the balloon satellite will experience extreme temperatures. To ensure that all components of the balloon satellite remain in working condition throughout the flight, a thermal subsystem is required. The primary component of this system is the provided strip heater. It will be attached to a dedicated 9V battery. There is also Mylar thermal sheeting to provide passive temperature regulation.

### II.2: Weight and Cost

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th>Quantity</th>
<th>Weight</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
<td>Water Bottle</td>
<td>$0</td>
<td>10</td>
<td>N/A</td>
<td>CU Campus</td>
</tr>
<tr>
<td>Styrofoam</td>
<td>$3.95</td>
<td>1</td>
<td>N/A</td>
<td>Safeway</td>
</tr>
<tr>
<td>Acetone</td>
<td>$0.93</td>
<td>1</td>
<td>N/A</td>
<td>Safeway</td>
</tr>
<tr>
<td>Polystyrene shielding</td>
<td>$0</td>
<td>1</td>
<td>40 g</td>
<td>Created with Acetone and styrofoam</td>
</tr>
<tr>
<td>Polyethylene Shielding</td>
<td>$0</td>
<td>1</td>
<td>40 g</td>
<td>Created with Plastic Bottles</td>
</tr>
<tr>
<td>Geiger Tube</td>
<td>$30</td>
<td>2</td>
<td>18 g</td>
<td>rhelectronics.net</td>
</tr>
<tr>
<td>Geiger Counter</td>
<td>$25</td>
<td>2</td>
<td>100 g</td>
<td>rhelectronics.net</td>
</tr>
</tbody>
</table>

### II.3: Satellite Testing

In order to make sure that the hard work is not destroyed or put to waste, multiple tests need to be administered. There are specific factors that need to be tested for such as: durability, temperature, camera functionality, and software.

**Drop Test:** The Balloon Satellite will be dropped from approximately 40 feet with an equal amount of mass as the experiment inside it. The test will decide if it will survive the harsh landing. This test will be done in a safe manner without people around.

**Stair Test:** The stair test, like the drop test, will also have conditions similar to those present during landing. The satellite, with the same amount of mass as the real payload, will be kicked and pushed from the top of a flight of stairs. This will simulate the conditions of the satellite bouncing and rolling after it has touched down. The stairs will be closed off while this test is undergoing.

**Whip Test:** For this test the satellite will be tied to a rope and spun around viciously. After launch, both wind and the balloon popping will whip it around violently. The whip test will determine if the satellite is strong enough to survive those conditions. The whip test will be conducted in an open area with no one near the person spinning it. Also, the test will be conducted in an area without windows or glass.
Temperature Test: The temperature level at the maximum altitude of the satellite will be extremely cold; so all the systems inside it need to be tested at a similar temperature. In order to test it at freezing temperatures, the satellite will be enclosed in a cooler with dry ice for two hours while all the systems are operating and recording data.

Software Test: Before sending the satellite 30 km above Earth's surface, all sensors and both Arduinos need to be working correctly. Other subsystems will ensure that the sensors are picking up data and that the Arduinos are recording that data. The camera will be tested to make sure it is taking pictures and recording them on the SD card. All the code will also be tested and perfected before launch. Bugs will be fixed during this process.

Geiger Sensor Test: Team H2S assumes there should be some sort of background radiation on Earth’s surface that the Geiger counters can pick up. It needs to be determined if the sensors can collect any sort of data and write it to the SD card.

II.3 Safety:

Safety in the construction, testing, and launch phases is very important to Team H2S. Many hours are expected to be spent soldering and flinging around the balloon satellite, so every member needs to be very careful when around the equipment. At all times, appropriate clothing will be worn and specific safety requirements, such as wearing goggles, will be strictly enforced. Because the experiment will require acetone, precautions must be made to ensure nobody gets hurt. The motto for Group H2S’s safety plan is simple: Use caution and take precautions!

II.5: Functional Block Diagram

Chris Koehler 2/11/2015 8:45 PM
Comment [16]: If you remember from class, the coldest part of the flight is not maximum altitude.

Chris Koehler 2/11/2015 8:46 PM
Comment [17]: Need to do some calibration testing with known gamma radiation source. This will take some time and needs to be started early. Hint physics department.

Chris Koehler 2/11/2015 8:48 PM
Comment [18]: Again you need approved safety procedure for making your plastic. I am your approver.

Chris Koehler 2/11/2015 8:50 PM
Comment [19]: Should have a brief intro paragraph. Also diagram is a tad too small to read easily. Geiger counters are power hogs and usually require their own batteries. May also require their own switches too. Camera has power source and switch (your finger). No compass this semester. Should also show or indicate number of batteries.
### III: Management, and Cost Overview

#### III.1: Schedule

<table>
<thead>
<tr>
<th>DAY</th>
<th>DATE</th>
<th>EVENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUN</td>
<td>2/8</td>
<td>Finish Homework 5, Review and Finish Proposal</td>
</tr>
<tr>
<td>MON</td>
<td>2/9</td>
<td>PROPOSAL DUE 8:00 AM</td>
</tr>
<tr>
<td>TUE</td>
<td>2/10</td>
<td>Shielding 1</td>
</tr>
<tr>
<td>FRI</td>
<td>2/13</td>
<td>AUTHORITY TO PROCEED by appointment with Chris, Turn in Order form</td>
</tr>
<tr>
<td>SUN</td>
<td>2/15</td>
<td>Shielding 2, Begin Coding</td>
</tr>
<tr>
<td>TUE</td>
<td>2/17</td>
<td>Begin building structure</td>
</tr>
<tr>
<td>SUN</td>
<td>2/22</td>
<td>Finish building structure, Begin PDR presentation</td>
</tr>
<tr>
<td>TUE</td>
<td>2/24</td>
<td>Structure Test (Drop, Stair, Whip), Work on PDR presentation</td>
</tr>
<tr>
<td>SUN</td>
<td>3/1</td>
<td>Finish PDR presentation</td>
</tr>
<tr>
<td>TUE</td>
<td>3/3</td>
<td>IN CLASS: Preliminary Design Review (6 min presentation)</td>
</tr>
<tr>
<td>SUN</td>
<td>3/8</td>
<td>Coding test, Geiger counter test at physics lab</td>
</tr>
<tr>
<td>TUE</td>
<td>3/10</td>
<td>Put Hardware together</td>
</tr>
<tr>
<td>SUN</td>
<td>3/15</td>
<td>Hardware Test I (Software)</td>
</tr>
<tr>
<td>TUE</td>
<td>3/17</td>
<td>Hardware Test II (Temperature Test and Software again)</td>
</tr>
<tr>
<td>THU</td>
<td>3/19</td>
<td>IN CLASS TEAM TIME</td>
</tr>
<tr>
<td>SUN TUE</td>
<td>3/22-3/29</td>
<td>SPRING BREAK:</td>
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<tr>
<td>TUE</td>
<td>3/31</td>
<td>IN CLASS MISSION SIMULATION TEST</td>
</tr>
<tr>
<td>SUN</td>
<td>4/5</td>
<td>LRR Preparation</td>
</tr>
</tbody>
</table>

Comment [20]: Should have a brief intro paragraph to this overall section and your schedule too. Would also like to see more details in your schedule. You are also missing some key dates like when final report is due.
### III.2: Organizational Chart

- **Structures**: The Structures subsystem will be led by Matt Beck who will be in charge of the design and construction of the BalloonSat housing as well as the inner layout of the components.
- **Electrical**: This will be managed by Nick Thurmes, who will be in charge of the construction of the hardware to be used on the BalloonSat. This includes both Arduinos and their respective components.
- **Science**: Guy Margalit will lead the Science sub-team in the research, design, and construction of the polystyrene and polyethylene radiation shields.
- **Software**: Software subsystem will be led by John Cutler who will work on writing the software for both Arduinos.
- **Thermal**: This system will be led by Brian Ortiz, who will manage the heating system and Mylar sheeting within and on the BalloonSat.
- **C & DH**: C & DH will be under Sean Grant’s management. He will look at and interpret the data.

### III.3: Team Members

- **Guy Margalit**
  - Address: [Guy.Margalit@colorado.edu](mailto:Guy.Margalit@colorado.edu)
  - School: CU Boulder
  - Special Skills: Extensive experience programming as well as experience using Arduino.

- **Nick Thurmes**
  - Address: [Nick.Thurmes@colorado.edu](mailto:Nick.Thurmes@colorado.edu)
  - School: CU Boulder

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<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUE 4/7</td>
<td>IN CLASS: Launch Readiness Review (4 min presentation)</td>
</tr>
<tr>
<td>FRI 4/10</td>
<td>Final BalloonSat Weigh-in and TURN IN</td>
</tr>
<tr>
<td>SAT 4/11</td>
<td>LAUNCH DAY AT 6:00 AM AT WINDSOR, COLORADO</td>
</tr>
<tr>
<td>THU 4/16</td>
<td>Quick Look Post Launch Presentation</td>
</tr>
<tr>
<td>SAT 4/25</td>
<td>ITLL Design Expo (9:00 AM - 4:00 PM)</td>
</tr>
<tr>
<td>TUE 4/28</td>
<td>Final Presentation</td>
</tr>
</tbody>
</table>
III.4: Cost Management

The team’s official budget manager is Sean Grant. His job is to complete all appropriate forms required for purchase and to ensure the team remains within the budget set by the team within this proposal. If the team goes over the $225 because of unforeseen circumstances, he will divide all the costs among team members. Sean will ensure that all purchases go through Chris Koehler’s CU credit card and will submit all receipts within 48 hours of purchase.