2011 HASP payload proposal
Maple Leaf Particle Detector

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HASP Student Payload Application for 2011

Payload Title: Maple Leaf Particle Detector

Payload Class: (check one) ☐ Small ☑ Large	Institution: University of Alberta	Submit Date: December 17th, 2010

Project Abstract

The Maple Leaf Particle Detector is the effort of the University of Alberta High Altitude Balloon Program team (UA-HAB), as the first Canadian Institution participating in HASP following the mandate of the Canadian Space Agency to ‘build capacity in the science and technology space sector, in particular through promoting the use of accessible and cost effective suborbital platforms’. The Maple Leaf Cosmic Ray Detector is a simple low mass solar proton and low energy cosmic ray detector that aims to measure particles with energies between 50MeV-200MeV. The detector will be constructed using Geiger tubes and absorbent material to discriminate between energy ranges on the desire energy channels. Emphasis of this project will be: to learn to run simulations (using the software SRIM/TRIM) to determine energy range absorbed by materials, to learn the electronics necessary to make measurements of solar particle precipitating into the atmosphere using the Geiger Muller counters at high altitudes (heating process, powering), to learn on data acquisition (sampling rates, detector’s sensitivity) and data analysis techniques, as well as comparison of our future measurements at high altitude in the atmosphere with available LEO satellite data corresponding to the L shell in which HASP is being launched (L=2).

Team Name: Cosmic Canucks	Team or Project Website: http://www.isset.ualberta.ca/students/HASP

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1 Introduction

The Maple Leaf Particle Detector is a University of Alberta (UofA) project, funded by the Canadian Space Agency (CSA), to participate in HASP 2011. One of the CSA's priorities is to "build capacity in the science and technology space sector, in particular through promoting the use of accessible and cost effective suborbital platforms" to contribute to training the next generation of the space workforce in Canada" [1]. This proposal to fly an undergraduate student payload on HASP represents the next step in the development of the University of Alberta student balloon program. The proposing team, initially through collaboration with the Balloon Experiment Amateur Radio (BEAR) team, have already successfully undertaken three balloon flights with a variety of payloads and using GPS tracking to altitudes of around 28km [2]. This proposal is to develop this program to the next stage through the flight of a student scientific payload on the NASA High Altitude Student Platform (HASP).

In order to present a proposal forward for UofA to participate in HASP, leaders of the University of Alberta High Altitude Program (UA-HAB) met with the Director of the CSA Space Awareness and Learning Program, Marilyn Steinberg in April 2010 during the CSA 2010 Workshop on Suborbital Platform and Nanosatellite, held at CSA Headquarters (Montreal). The Director of CSA Space Awareness and Learning Program saw great potential for the project and received a formal proposal [3] from the UA-HAB in September 2010 requesting sponsorship to participate in HASP 2011. As a result, the confirmation of funding to support the participation of the UofA team in HASP from CSA was received at the end of November. A contribution agreement was drafted by CSA and sent to UofA for its review. The contribution agreement was signed in December 27, 2010.

This is the first time that the University of Alberta has developed the infrastructure to support the flight of a science payload on a high-altitude balloon. In order to take advantage of the HASP opportunity, and to create UA-HAB, the team have had to secure agreement from the CSA for Canadian participation and to secure the funding from CSA required to fly. In addition, the Faculty Advisor further had to secure appropriate machine and electronics shop support required to enable the team to build the payload. In the last 6 months, these elements have been put in place. Since this is a new enterprise for the UofA, it is important that the team have access to the necessary technical support, and be able to design and build a payload which will operate successfully and return data from the balloon flight. To balance this development risk, the team, under advice from the Faculty Advisor, propose to utilize a baseline design for their payload based on a previously flown cosmic ray detector. This choice of payload reflects a balance between risk and the importance of being able to deliver an operating payload on the timeline required for flight on the HASP.

The baseline design for the detector will be constructed from Geiger Muller tubes shielded by Iron, or a steel alloy absorber boxes, following simulations run in the software TRIM, to discriminate three distinct energy channels of solar particles of energies larger than 50Mev and 100MeV and cosmic rays above 175 MeV.

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[1] CSA 2010 Workshop on Suborbital Platform and Nanosatellites - Report April 14-16, 2010

[2] Details for example at `http://bear.sbszoo.com/bear5/bear5.htm` and `http://www.facebook.com/pages/Institute-for-Space-Science-Exploration-and-Technology-ISSET/116217525069290`

[3] Contributions Form 2010 UAHAB see Appendix

The University of Alberta also has already completed a breadboard prototype of an electronic cosmic ray detector based on an electronic pulse count generated by cosmic rays incident upon scintillator material. However, this more simple baseline design represents the lowest risk detector during the first year of the HASP program at the UofA, with sufficient programmatic and technological learning opportunities for the Cosmic Canucks. There would be a larger scientific return from the pulse counted electronic design at the expense of increased complexity of design, including power and data interface requirements. But the Cosmic Canucks examined the feasibility of the potential flight of the more complex detector in the first few months of 2011 under guidance from the HASP administration, as well as the Faculty Advisor. These pulse counted instruments are already planned to be flown as part of a UA-HAB program utilising KCI 1200 weather balloons, and this could form the basis of a preliminary test program in advance of the HASP balloon flight. However, flying an untested and advanced instrument was deemed too large a risk by the Cosmic Canucks and their advisory team, and a baseline design using Geiger Muller tubes was chosen to represent the best compromise between risk and scientific return.

Further, a Memorandum of Understanding between the UofA and Dr. Stanislav Pospisil of the Czech Republic, with Dr. Jim Pinfold as lead contact is about to be signed (March, 2011), for a set of advanced 2cm^2 particle detectors used at CERN will be available at no cost to the UA-HAB team. Therefore, there exists the possibility to augment our revised detector design with the particle detector (medipix), but this additional detector is not essential for the successful investigation of our science goals using the revised detector design.

2 Science Justification

2.1 History of the discovery and measurement of the Radiation Belts

Figure 1: The creators of Explorer 1 holding a model of it on the press conference at launch day (pr the day before), Februray 1, 1958 (or January 31, 1958). Starting from left side: Ph. D. William Pickering, Ph. D James van Allen, Ph. D. Werner von Braun

In January 31 1958, James Van Allen and collaborators launched the Explorer 1, the first Earth satellite of the United States. Launched as part of the International Geophysical Year, celebrated in 1957 and extended to 1958, Explorer 1 was equipped with a Anton 314 omni directional Geiger-Muller tube sensitive to measure protons with energies larger than 30MeV and electrons with energies greater than 3MeV. Van Allen hoped to measure galactic cosmic rays that were not energetic enough to penetrate Earth's atmosphere [4]. The results were puzzling: the Geiger-Muller produced some expected readings at the low points of the satellite's elliptical orbit and dropped to zero in the higher points of the orbit. Further testing, done with the instrumentation at ground laboratories, after Explorer 3 produced similar results, indicated that the Geiger-Muller detector saturated when producing zero readings. The discovery revealed the existence of the now know as the Van Allen Radiation Belts, doughnut-shaped regions in Earth's magnetosphere where the electrons and protons are trapped. The outer

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[4] David P. Stern and Mauricio Peredo, **The Exploration of the Earth's Magnetosphere**

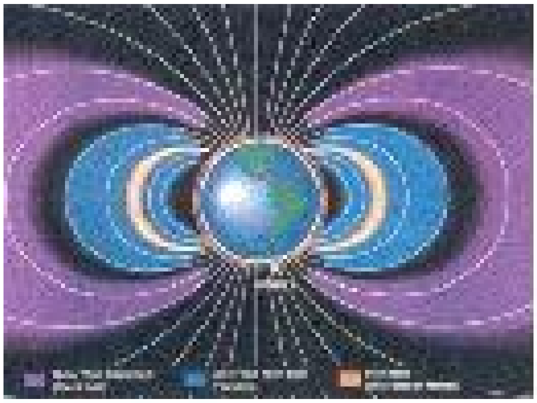

Figure 2: The Radiation Belts (Credit: Spenvis)

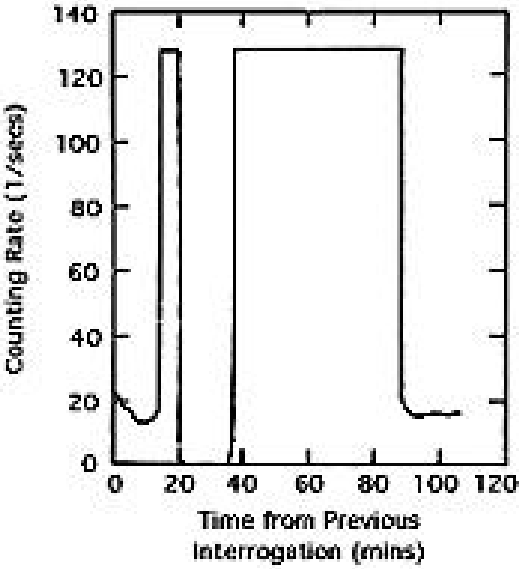

Figure 3: Trace of couting rated recorded by Explorer 3

zone was shown to be highly variable due to solar activity, and the inner zone to be less dependent on solar activity. In 1960, Van Allen published “Origin and Nature of the Geomagnetically-Trapped Radiation” [5] in which he stated that “the region around the earth out to distances of some 15 earth radii is found to be populated by high and low energy electrons and protons” and that ”the composition of the radiation in the heart of the inner zone is [. . .] protons of energy “$> 40\text{MeV}, 2 \times 10^4$“.

2.2 Theory

The Proton Radiation Belt exhibits little variation due to solar activity and it is pretty stable. The main souce of the protons in the inner belt is the Cosmic Ray Albedo Neutron Decay, CRAND [6]: Cosmic rays interact with constituents of the earth’s atmosphere produce neutrons which are emitted into the trapped region. Protons are produced by beta decay of the neutrons, that become trapped by Earth’s magnetic field. The inner proton belt exhibits high fluxes during solar minimum and low fluxes during solar maximum: solar activity during solar maximum produces a shielding effect and cosmic ray flux reaching the earth is low compared to solar minimum. Trapped charged particles follow three motions: gyration, bounce and drift [7]. Energization of either electrons or protons, these charged particles may result in an increase of their parallel velocity such that the particles mirror point lies within the ionosphere or

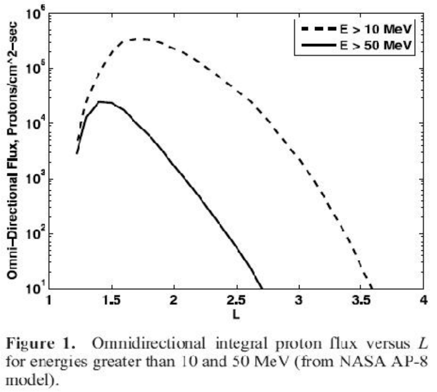

Figure 4: Figure from Shao et al

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[5] J.A. Van Allen (1960), **Origin and Nature of the Geomagnetically-Trapped Radiation**, Space Research I, Proceedings of the First International Space Science Symposium, pp 749-750

[6] P. Buhler, **Radiation Belts** (attached)

[7] W. Baumjohann and R. Treumann, Basic Space Plasma Physics

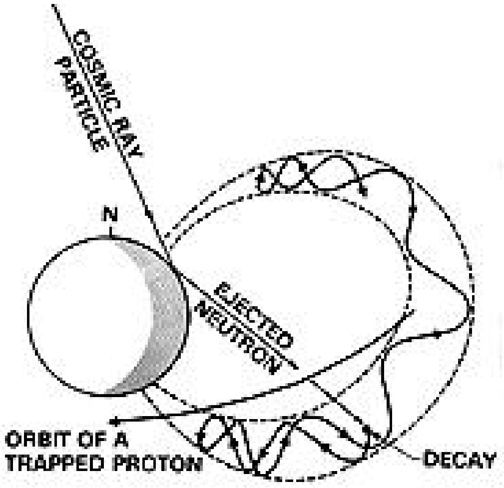

Figure 5: Cosmic Ray Albedo Neutron Decay, CRAND (Credit: Spenvis)

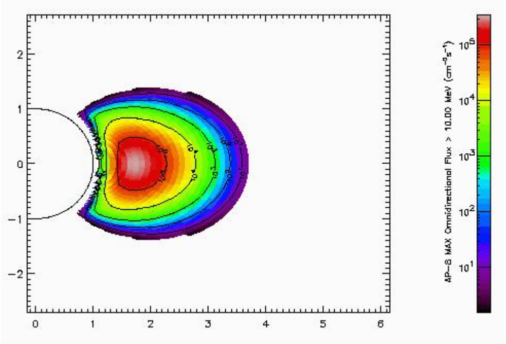

Figure 6: The Proton Radiation Belt (Credit: Spenvis)

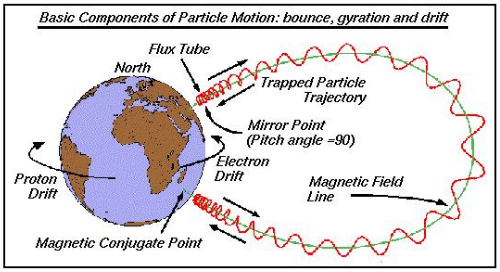

Figure 7: Motion of Trapped Particles on Earth's Magnetic Field (Credit: Spenvis)

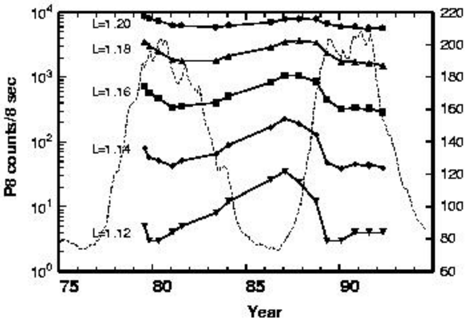

Figure 8: Flux of protons with energies > 80 MeV at the geomagnetic equator as function of time. The dotted lines shows f 10.7 during the same time period [Hudson et al, 1996]

upper atmosphere and thus precipitate into the atmosphere. will not bounce at the mirror point, but precipitate into the atmosphere. The main goal of our detector is to measure the precipitating protons of energies > 50MeV, > 100MeV, and cosmic rays with energies greater than 175MeV for comparison. The Columbia Scientific Ballon Facility is located at 34° N, which maps to L 1.90R_e [8] (see Table 1). The Proton Belt, as presented in the Spenvis figure, shows enhancement of fluxes for L greater than 1.5R_e less than 2.2R_e. During the data analysis period, data collected by the Maple Leaf Particle Detector will be compared with satellite data, available at the University of Alberta Space Physics group. The University of Alberta Space Physics group comprises a number of international experts in the analysis of radiation belt particle fluxes.

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[8] Corrected Geomagnetic Coordinate and IGRF/DGRF Model, available at `http://omniweb.gsfc.nasa.gov`

Height (km)	CGM Latitude	CGM Long	L value (R_e)
0	43.07	323.20	1.87
5	43.07	323.20	1.88
10	43.07	323.20	1.88
15	43.07	323.21	1.88
20	43.07	323.21	1.88
25	43.07	323.21	1.88
30	43.07	323.21	1.88
35	43.07	323.21	1.88
40	43.07	323.22	1.89
45	43.07	323.22	1.89
50	43.07	323.22	1.89

Table 1: Geomagnetic latitude and longitude, as well as L-value as a function of height corresponding to Fort Sumner, NM ($34°N, 104W$) calculated by the Corrected Geomagnetic Coordinate and IGRF/DGRF Model, available at `http://omniweb.gsfc.nasa.gov`

3 Principle of operation

The detector is composed of 3 Geiger counters, encased in iron, or steel alloy to provide minimum thresholds that particle energies must exceed to be observed by the detector i.e., energy ranges. The Geiger counters will be wired into a mother board where the pulses can be shaped and counted. The iron will be in the shape of a square pyramid in order to allow for there different energy ranges. Four holes will be drilled from the top of the payload through to the bottom and long metal screws will be inserted in order to mount the payload onto the platform. The electronics will be mounted alongside the iron pyramid and the entire payload will be encased in a foam shell to provide a small amount of protection for the instrumentation..

3.1 Energy Range

The boxes of iron on our detector will serve to discriminate the energies of particles detected by our 3 Geiger counters. Any count that registers in one of the Geiger counters must have a minimum energy in order to penetrate the iron shielding and reach the Geiger counter. Each successive Geiger counter is encased by a thicker amount of iron, which leads to a higher minimum energy threshold. Our successive energy minimums are 50MeV, 100MeV and 175MeV.We do understand that the energy that is detected by the detector is not the original value for the energy of the particles as some of the energy is absorbed by the upper atmosphere and the ionosphere which exists in-between the HASP platform and the mirror points. Energy deposition will occur within these regions as per the following graph (see Figure 9).

3.2 Simulations

We ran simulations using a software called SRIM to determine the penetration lengths of hydrogen ions of various energies in iron. SRIM uses probabilistic Monte Carlo methods to calculate the

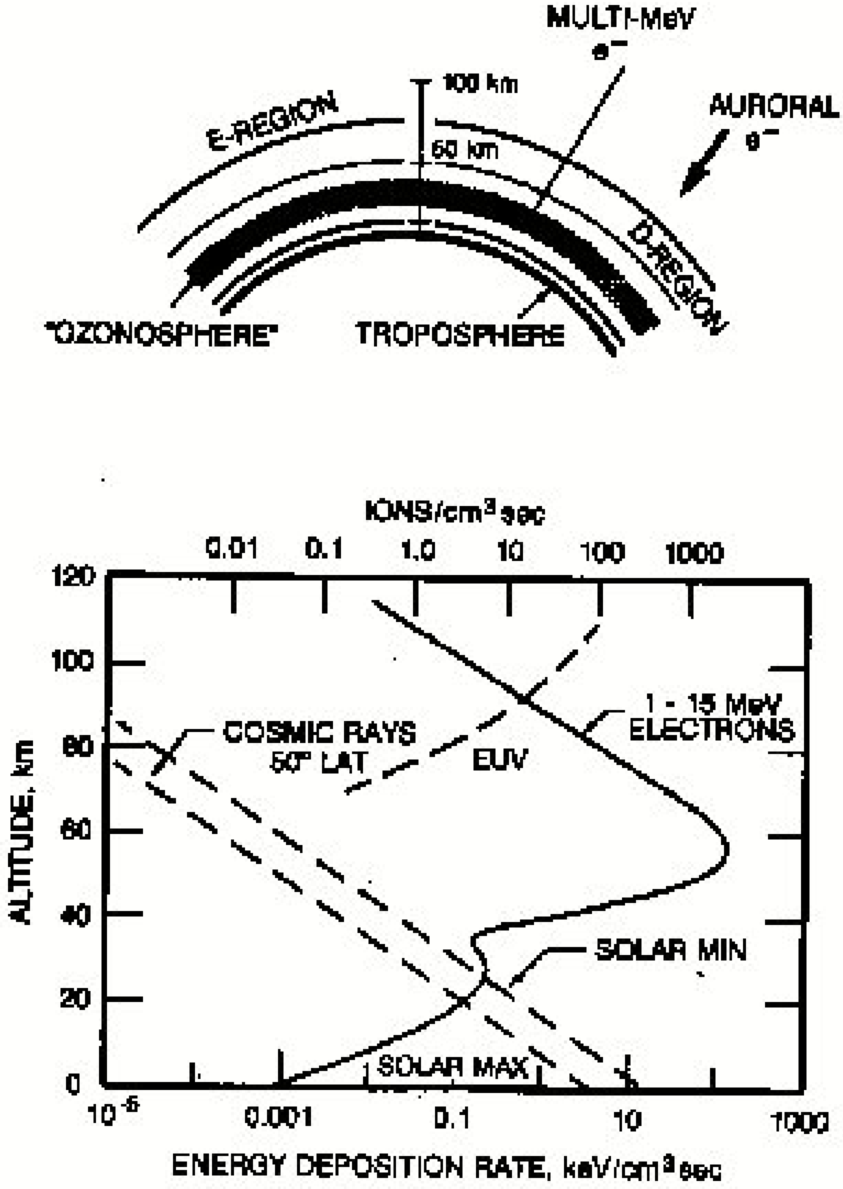
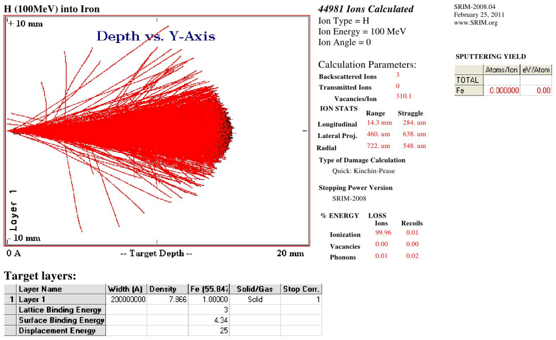


Figure 9: (Top) A diagram illustrating the much greater depth to which precipitating relativistic electrons can penetrate into the Earth's atmosphere as compared to characteristically lower-energy auroral electrons.
(Bottom) Multi-MeV electrons, when present, represent the dominant ionization source in the middle atmosphere (40-80 km altitude). The figure shows the expected energy deposition versus altitude if an energetic (1-15 MeV) electron event observed at geostationary orbit were to precipitate into the atmosphere. This is contrasted with solar extreme ultraviolet (EUV) ionization at high altitude and the effect of galactic cosmic rays at low altitude. http://www.srl.caltech.edu/sampex/pet.html

penetration distance of ions in different absorber materials. The results from our simulations for two different energies are found below. The red lines in each of the graph represents the path of a single proton within the iron sample.



44981 Ions Calculated
Ion Type = H
Ion Energy = 100 MeV
Ion Angle = 0

SRIM-2008.04
February 25, 2011
www.SRIM.org

Calculation Parameters:

Backscattered Ions	3
Transmitted Ions	0
Vacancies/Ion	310.1

ION STATS	Range	Straggle
Longitudinal	14.3 mm	284. um
Lateral Proj.	460. um	638. um
Radial	722. um	548. um

Type of Damage Calculation
Quick: Kinchin-Pease

Stopping Power Version
SRIM-2008

% ENERGY LOSS	Ions	Recoils
Ionization	99.96	0.01
Vacancies	0.00	0.00
Phonons	0.01	0.02

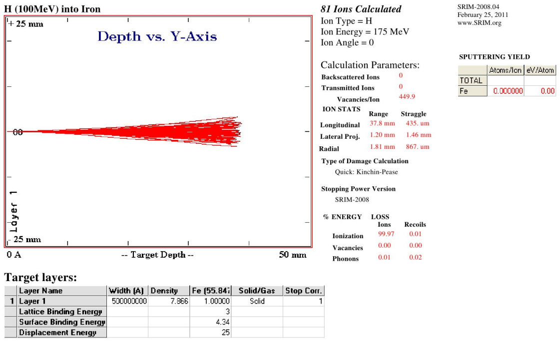
SPUTTERING YIELD

	Atoms/Ion	eV/Atom
TOTAL		
Fe	0.000000	0.00

Target layers:

	Layer Name	Width (A)	Density	Fe (55.847	Solid/Gas	Stop Corr.
1	Layer 1	200000000	7.866	1.00000	Solid	1
	Lattice Binding Energy			3		
	Surface Binding Energy			4.34		
	Displacement Energy			25		

Figure 10: 100 MeV protons in iron



81 Ions Calculated
Ion Type = H
Ion Energy = 175 MeV
Ion Angle = 0

SRIM-2008.04
February 25, 2011
www.SRIM.org

Calculation Parameters:

Backscattered Ions	0
Transmitted Ions	0
Vacancies/Ion	449.9

ION STATS	Range	Straggle
Longitudinal	37.8 mm	435. um
Lateral Proj.	1.20 mm	1.46 mm
Radial	1.81 mm	867. um

Type of Damage Calculation
Quick: Kinchin-Pease

Stopping Power Version
SRIM-2008

% ENERGY LOSS	Ions	Recoils
Ionization	99.97	0.01
Vacancies	0.00	0.00
Phonons	0.01	0.02

SPUTTERING YIELD

	Atoms/Ion	eV/Atom
TOTAL		
Fe	0.000000	0.00

Target layers:

	Layer Name	Width (A)	Density	Fe (55.847	Solid/Gas	Stop Corr.
1	Layer 1	500000000	7.866	1.00000	Solid	1
	Lattice Binding Energy			3		
	Surface Binding Energy			4.34		
	Displacement Energy			25		

Figure 11: 175 MeV protons in iron

4 Team Management

4.1 Project Organization

The Maple Leaf Particle Detector has been designed and will be built by a team of undergraduate students at the University of Alberta, led by a Graduate Student and under the advice of a Research Associate Advisor and Faculty Supervisor. There are also three further 'consultants' forming a part of the team structure, with expertise in the technical aspects of the detector available upon request.

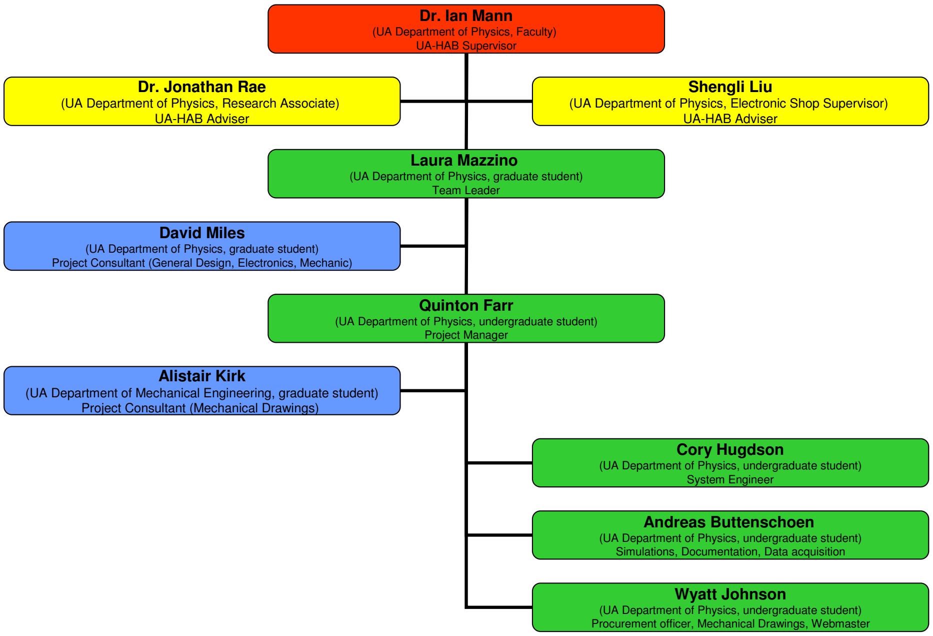


Figure 12: Team structure

There are two level of student participation: Team members will actively participate in all stages of the project, which includes writing the proposal, designing, manufacturing, testing, launching, recovering, analyzing and publishing. Team members will receive a compensating salary during the manufacturing stage. Traveling to testing/launching/conferences will be determined upon availability of funds and such that team members can at least attend one of them. The second level of participants are the volunteer participants. Volunteer participants are participants that want to participate in the project, but for personal or academic reasons cannot participate at all stages. However, they will participate in some stages of the project on a volunteer basis (i.e. will not receive any financial compensation).

The team is composed of Andreas Buttenschon, Cory Hodgson, Wyatt Johnson, Quinn Farr and team lead by Laura Mazzino; it counts with the assistance from the Project Advisor Dr. Jonathan Rae. The project is overseen by UA-HAB supervisor Dr. Ian Mann. Three consultants will be employed for various electronic and technical aspects of the design, David Miles, Shengli Lui and Alistair Kirk. The chart below illustrates the Maple Leaf Particle Detector 's team organization.

4.2 Contact Information

The following chart gives phone and email contact for the committed participants and other UA-HAB related members.

Name	*Phone*	`Email`
Laura Mazzino	*(780) 492-8179*	`mazzino@ualberta.ca`
Andreas Buttenschoen	*(780) 709-0091*	`andreas.buttenschoen@ualberta.ca`
Cory Hodgson	*(780) 668-6120*	`crhodgson@ualberta.ca`
Wyatt Johnson	*(780) 965-3962*	`wyatt.johnson@ualberta.ca`
Quinn Farr	*(780) 434 9565*	`qfarr@ualberta.ca`

Table 2: Contact Information for commited participants

Name	*Phone*	`Email`
Ian Mann	*(780) 492 6882*	`imann@ualberta.ca`
Jonathan Rae	*(780) 492 7284*	`Jonathan.Rae@ualberta.ca`
Alistar Kirk	*(780) 299 5834*	`kirk1@ualberta.ca`
Dave Miles	*(780) 492 8179*	`dmmiles@ualberta.com`
Shengli Liu	*(780) 492 5426*	`shengli@ualberta.ca`

Table 3: Contact Information for consultant and advisors contact

4.3 Timeline

Date	**Item**
2010	
October 1 or October 4	Info Session: Team recruitment
October 13	Contribution Form send to CSA
November 29	Team information
December 6-10	First team meetings
December 17	First Proposal submission to HASP
December 27	Agreement between CSA and UA formalized
2011	
January	Begin Design, Exploration of alternative designs for payload
January (Last Friday)	Monthly status report to HASP
February (First Friday)	First Teleconference with HASP
February	Second Design
February (Last Friday)	Monthly status report to HASP
February 28	Second proposal submission to HASP
March	Begin Manufacturing
March (First Friday)	Teleconference with HASP
March (Last Friday)	Monthly status report to HASP
March 31st	Second report to CSA
April (First Friday)	Teleconference with HASP
April	Completion Manufacture
April-June	Weather ballon launches (testing of components) (High schools)
April 29	Preliminary PSIP due (Payload Specification & Integration Plan)
April (Last Friday)	Monthly Status report to HASP
May (First Friday)	Teleconference to HASP
May	Testing, Calibration (David Florida Labs) Thermal/Vacuum test
May (Last Friday)	Monthly status report to HASP
June 1	Final PSIP document due (Payload Specification & Integration Plan)
June (First Friday)	Teleconference with HASP
June (Last Friday)	Monthly status report HASP
July (First Friday)	Teleconference to HASP
July (Last Friday)	Monthly status report to HASP
July	ISSET Space Academy Balloon launches

Continued on next page

Date	**Item**
August 1	Student payload integration at CSBF (USA)
August 1	Payload Integration Certification (PIC)
August 1	Final FLOP due (Flight operations plan)
August (First Friday)	Teleconference with HASP
August (Last Friday)	Monthly status report to HASP
September	Launch (Fort Summer, NM USA)
September (First Friday)	Teleconference with HASP
September	Presentation at ISSET Symposium and at the GPSA Symposium
September (Last Friday)	Monthly status report to HASP
October (First Friday)	Teleconference with HASP
October (Last Friday)	Monthly status report to HASP
October	Data Analysis
October	Third report to CSA
October	Presentation at UA Open House
November	Completion of Data Analysis
November	Publication (AGU, Phys Teacher)
November (First Friday)	Teleconference with HASP
November (Last Friday)	Monthly status report to HASP
December (First Friday)	Teleconference with HASP
December 16	Final report to HASP
December	Presentation at AGU (USA)
2012	
February	Final Report to CSA

Table 4: Timeline

5 Payload Specifications and descriptions

5.1 Payload Size

The payload will be 13.5cm tall in total, with the bottom box being 12.6cm by 14.6cm and 19.55cm tall and the top box being 9cm by 11cm and 3.95cm tall.

5.2 Weight Budget

Component	Allocation (g)	Estimation (g)	Measurement (g)
Geiger Counters (×3) + Wires	450	395	392
Iron Absorber	16000	15500	15490
Hex-Nuts (×16)	100	75	55
Threaded Rods (×4)	450	425	408.5
Electronics Board	500	400	350
Total	17500	16395	16345.5

Table 5: Weight Budget

5.3 Mechanical Interface

The payload is attached to the HASP Mounting platform via screws that are drilled through the iron/steel shielding part of the payload itself, attaching at the bottom to the platform, and then secured via steel bolts. The motherboard will likewise be attached to the mounting plate via screws through the motherboard. The three Geiger counters will be encased in a material with the best shock absorbing capability to ensure the safety of the detectors for the duration of the flight. This material will be determined during the manufacturing phase. The Geiger counters will be wired into a motherboard where the pulses can be shaped and counted.

5.4 Mechanical Drawings

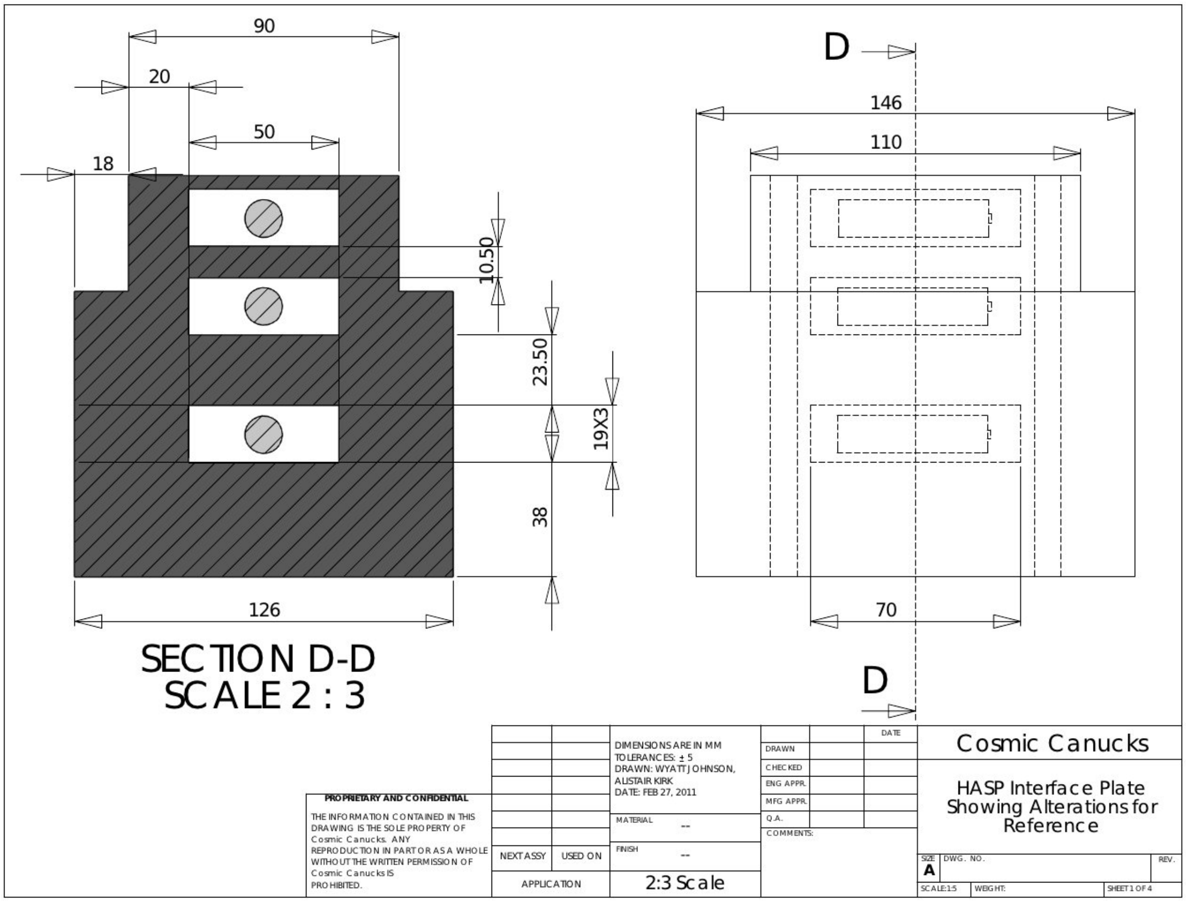


Figure 13: Mechanical Drawings

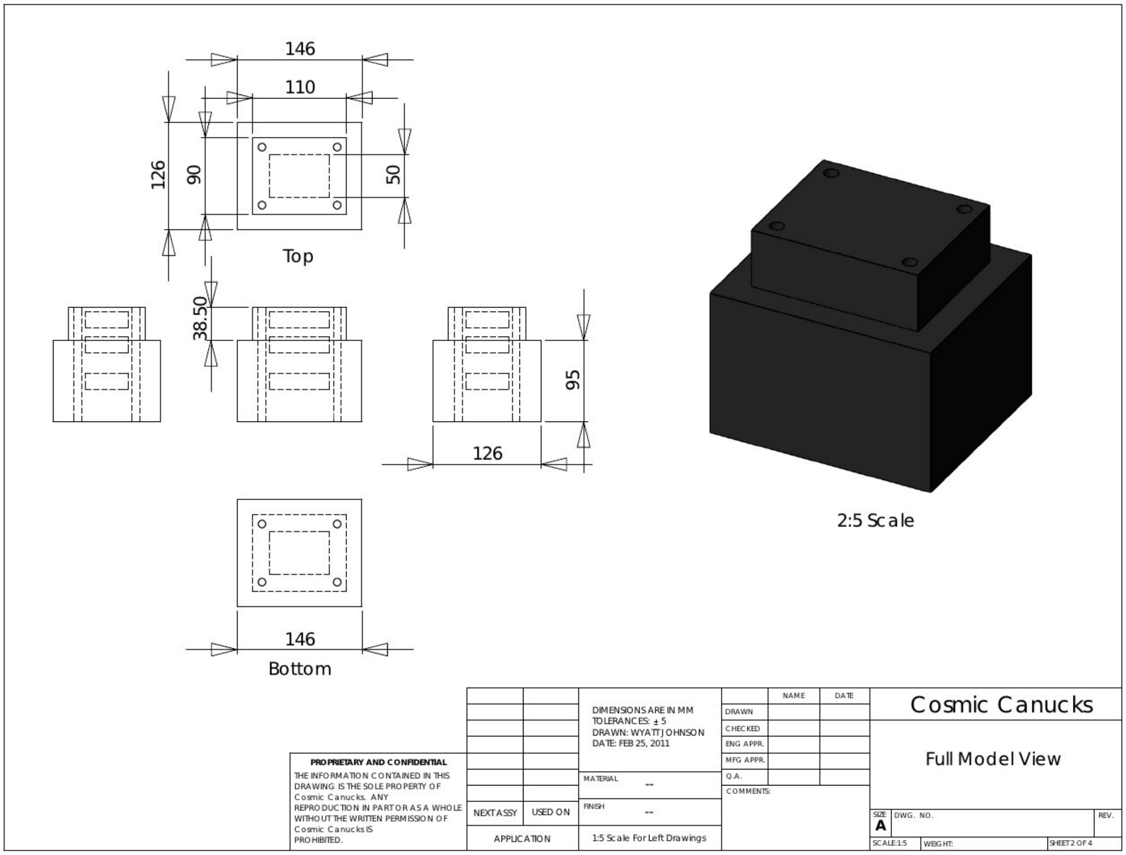


Figure 14: Mechanical Drawings

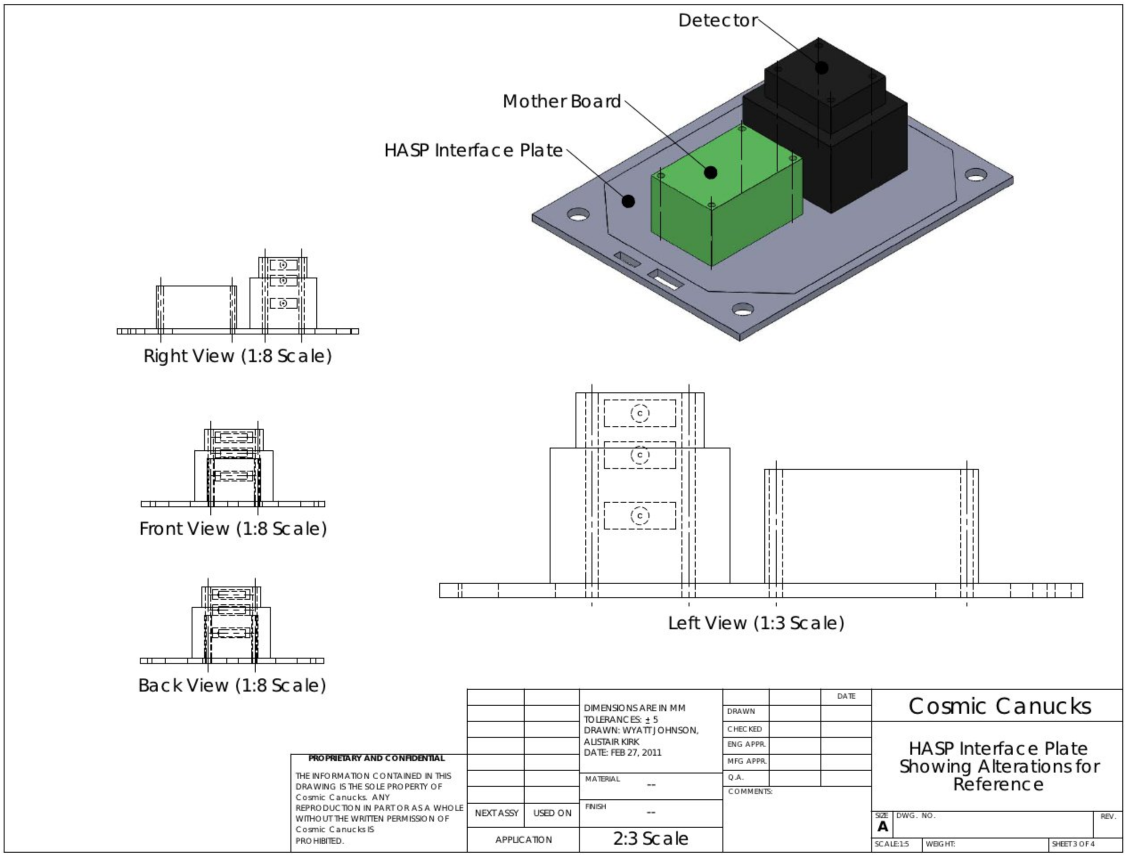


Figure 15: HASP Mounting Plate

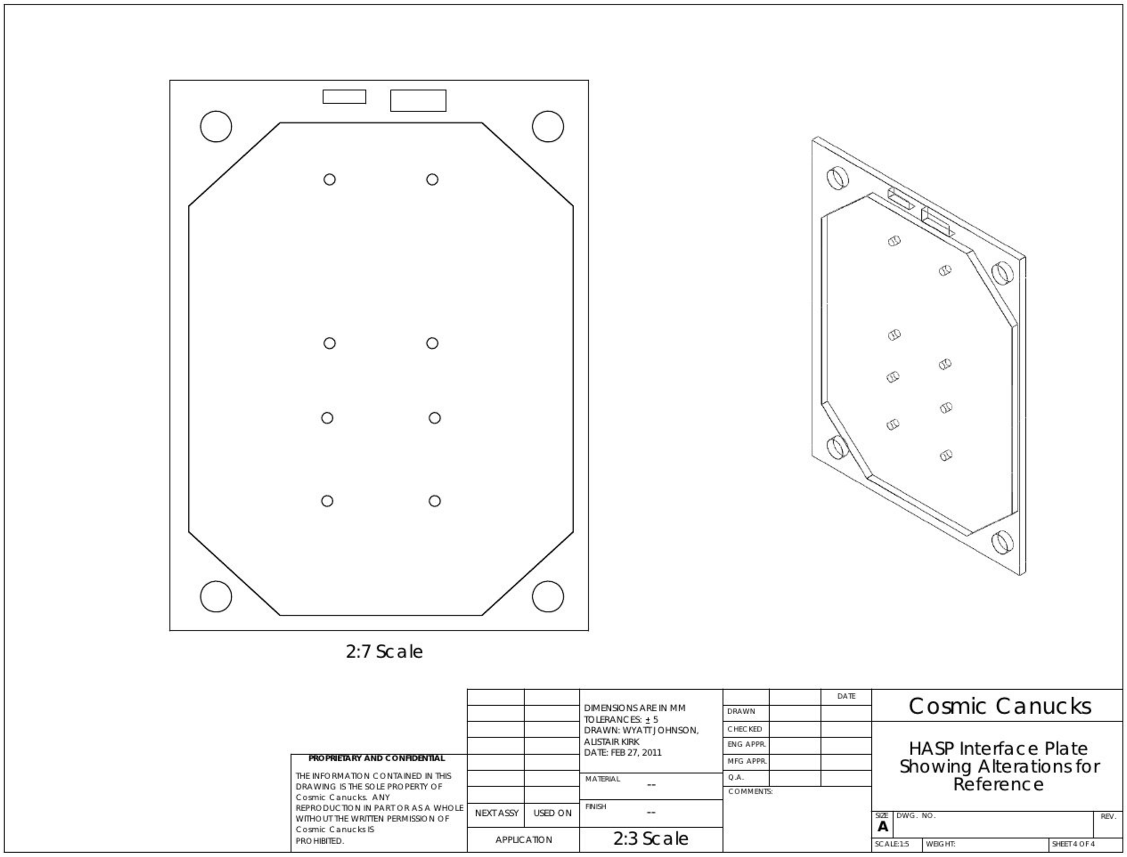
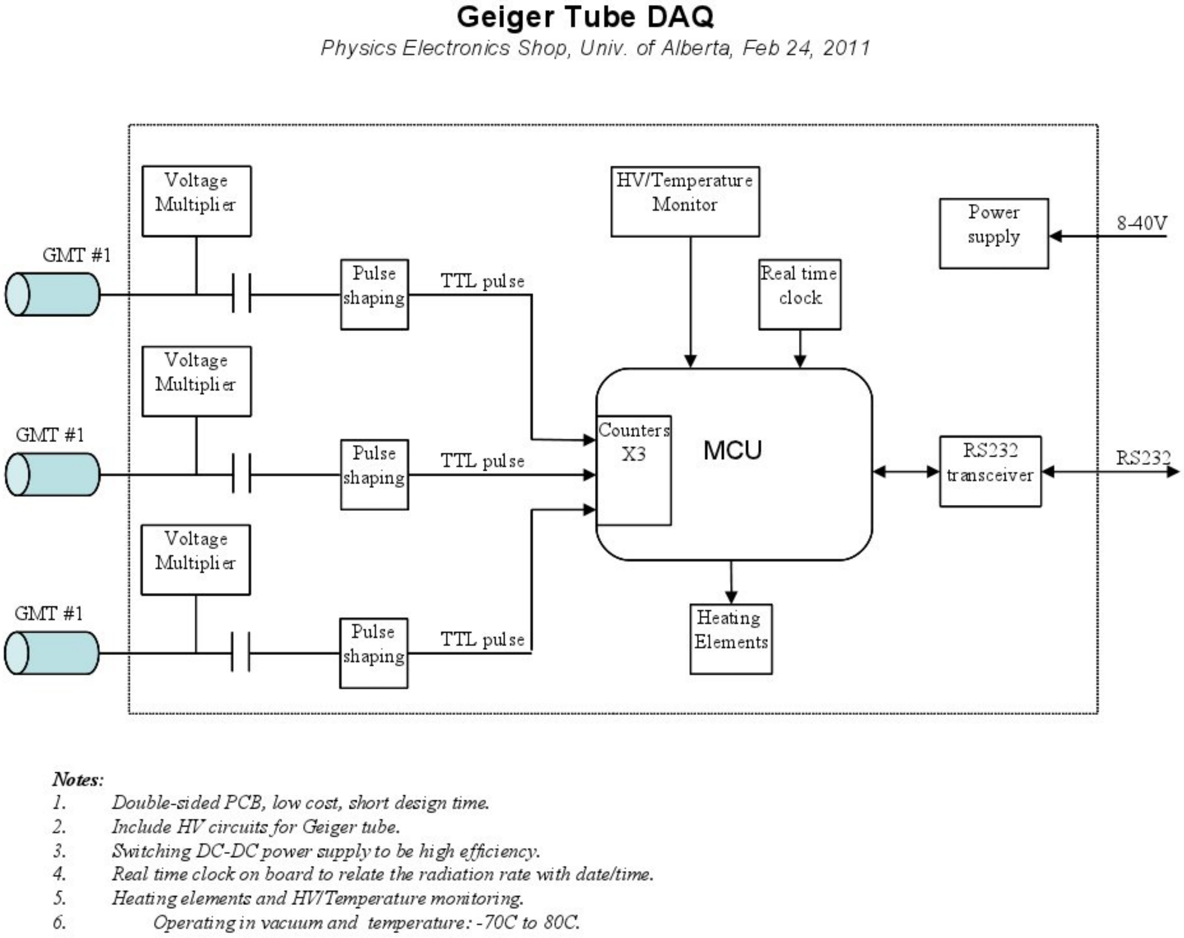


Figure 16: HASP Mounting Plate

5.5 Power Consumptions

We will consume less than 100mA on 30 V DC. This power consumption is mainly required to heat the electronics board and ensure that the electronics required to count the pulses do not display temperature dependent characteristics during the experiment. It's mainly for the possible heating resistors to consume 3W.



Geiger Tube DAQ

Physics Electronics Shop, Univ. of Alberta, Feb 24, 2011

Notes:

1. *Double-sided PCB, low cost, short design time.*
2. *Include HV circuits for Geiger tube.*
3. *Switching DC-DC power supply to be high efficiency.*
4. *Real time clock on board to relate the radiation rate with date/time.*
5. *Heating elements and HV/Temperature monitoring.*
6. *Operating in vacuum and temperature: -70C to 80C.*

Figure 17: Geiger Tube circuit diagram

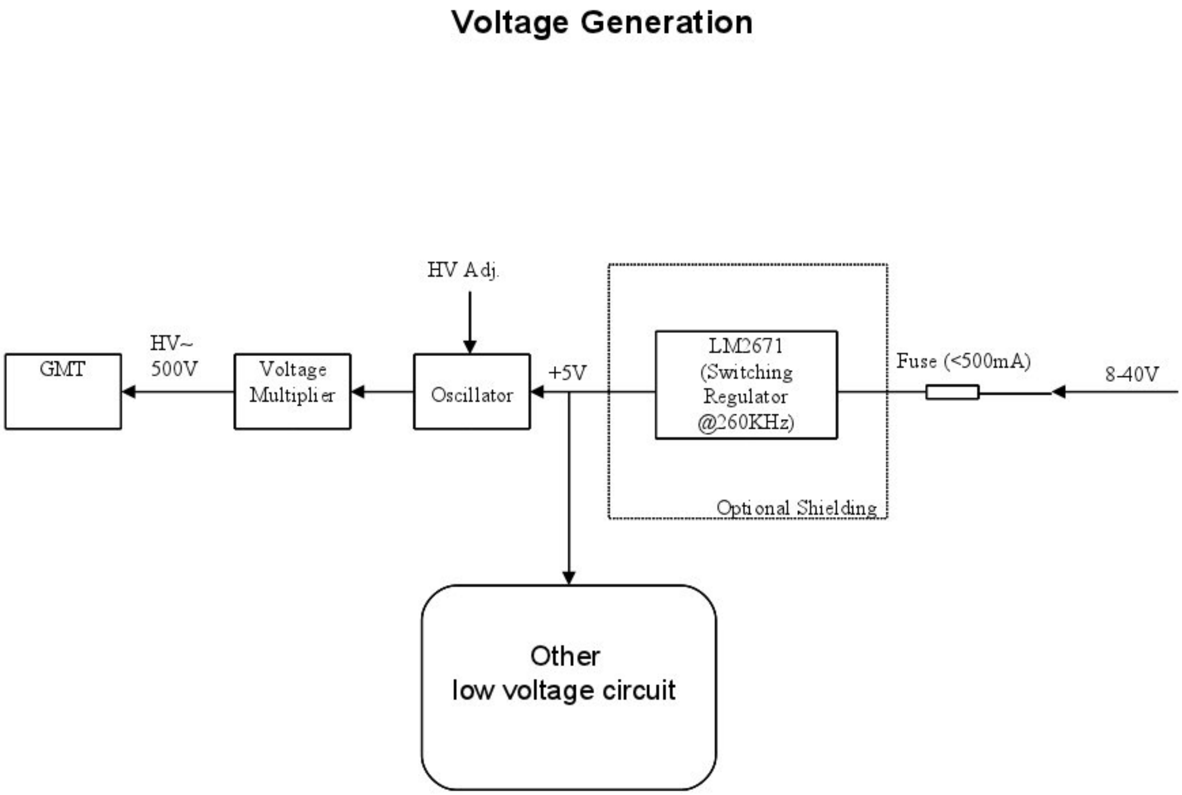


Figure 18: Geiger Tube voltage supply circuit diagram

5.6 Data Requirements

The payload will use the available 4800 baud rate. Furthermore, we will be requesting the GPS from HASP every 3 seconds. The data from the payload will be transmitted in the following format. Each second a data packet of 28 bytes will be send. In other words the the data rate is 28 bytes/s.

Byte	Bits	Description
1-2	16	Packet ID
3-6	32	Timestamp (seconds since January 1970)
7-8	16	Packet checksum
9-14	48	HV reading for each GMT
15-18	32	Low votage reading for control circuit
19-22	32	temperature reading for control circuit and enclosure
23-28	48	GMT counting number
total 28 bytes.		

Table 6: Data Format

The packets will be accumulated in the buffer for 1 minute (or less), and send out through the HASP platform every minute.

5.7 Orientation Preferences

None

6 Integration and Testing

6.1 Early planning for Integration

The Payload Specification & Integration Plan (PSIP) preliminary version will be presented by April 29 and the final version will be presented by June 1, following the deadlines directed by HASP.

Two members of the team will travel to CSBF for student payload integration with HASP on the first week of August. Additional members of the team will travel to CSBF upon available funds. Team members participating in integration will be listed in the PSIP final version on June 1.

During the integration, the team will check that the current draw at the minimum voltage does not exceed the limitations (2.5Amps), that the payload passes the thermal/vacuum test once integrated to the platform, that the serial downlink rate is between the limitations, that analog channels being used are functioning properly, etc.

6.2 Environmental and Physical Testing

Preliminary testing will be conducted at UofA. The final environmental and physical test will be done in the Canadian Space Agency (CSA) David Florida Laboratories, between April 15-May 15.

6.2.1 Vacuum Testing

Preliminary vacuum testing will be performed at the UofA: a Geiger tube plus electronic board will be placed into a small vacuum chamber available at UofA where the pressure will reach 3 Torr to model the conditions that will be experienced by the payload during the ascent of the balloon to evaluate functionality of the parts of the detector. Following the preliminary testing, the full detector will be assembled and placed inside of the vacuum chamber. Full vacuum testing will be performed at CSA David Florida Laboratories.

6.2.2 Stress, Shock and Rough Handling

Preliminary 10g vertical and 5g horizontal shock testing will be performed at UofA: the payload will undergo a series of 'drop tests' where a simulated fall at terminal velocity will occur followed by a verification of integrity of the components of the payload. Full stress and shock testing will be performed at CSA David Florida Laboratories.

6.2.3 Thermal Testing

Preliminary thermal testing will be performed at UofA by placing the detector on a cold chamber for 24 hours, to investigate the performance of the detector as a function of temperature. Full thermal testing between the ranges $-75°$C to $50°$C will be performed at CSA David Florida Laboratories.

6.3 Test, Integration and Launch Personnel

6.3.1 Test Personnel

Two members of the team and team leader will travel to CSA David Florida Laboratories to test payload. Other members of team and advisor may be able to travel as well dependent upon available funds.

6.3.2 Integration Personnel

The two members of the team not participating in the CSA David Florida Laboratories test will travel to integration and team leader will travel to CSBF for integration and final testing. Other members of team and advisor may be able to travel as well dependent upon available funds.

6.3.3 Launch Personnel

Two members of the team will be attending the launch. Other members of the team and advisor might travel upon available funds.

7 Summary

Participating in the HASP program will, present an outstanding opportunity for the UofA Cosmic Canucks to experience a high-altitude large balloon launch within a well-established program. It is not often that undergraduate students get a chance to plan, build, test and fly an experiment in a time frame that is in keeping with the undergraduate program degree length. We have already gained a better understanding of what a team project of this magnitude entails, since we have significantly revised our original proposal to incorporate a more advanced detector design. In the process, we have considered and discarded a number of different detector designs, in favour of the design outlined above. As a result, we have a vastly improved our understanding of what an effective team must accomplish together. This payload will also show us the importance of teamwork when collaborating on scientific projects.

Overall, the UA-HAB team expects to gain a number of essential skills from the completion of the HASP program in 2010-2011. Concluding, HASP will be an amazing experience for us, both undergraduate and graduate students and we are glad we have the opportunity to participate.