Montana Space Grant Consortium

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Dr. T. Gregory Guzik
Department of Physics & Astronomy
Louisiana State University
Baton Rouge, LA 70803-4001

December 14, 2006

Dear Dr. Gusik,

Please accept the enclosed proposal "Passive High Altitude Particle Capture Experiment" for consideration for a seat on your 2007 High Altitude Student Platform. We are excited about this opportunity and hope that we have conveyed our dedication and enthusiasm to designing and deploying our cosmic dust collection experiment. I look forward to hearing from you the good news that our proposal has been selected.

Sincerely yours,

Jayson Nissen
BOREALIS Team Leader

HASP Student Payload Application for 2007

Payload Title: Passive High Altitude Particle Capture Experiment

Payload Class: (circle one) Small [✓ Large]	Institution: Montana State University / Montana Space Grant Consortium	Submit Date: December 15, 2006

Project Abstract

The purpose of our experiment is to collect particles, especially those of extraterrestrial origins, from the stratosphere and return them to earth for analysis. Our collection method will be a ~$900 cm^2$ collection plate that will passively collect dust particles as they fall through the atmosphere. The collection plate will be housed within a pneumatically operated box that can be opened at a specified altitude allowing a silicone oil-covered collection plate to be exposed. Particles striking the collection plate will be trapped within the silicone oil coating. The box will be sealed prior to descent and will be pressurized with nitrogen to provide a constant positive pressure inside the box to prevent any in-flow of contamination. The particles will be recovered from the silicone oil matrix and subjected to imaging and elemental analysis using a scanning electron microscope. Authentic cosmic dust particles will be requested from NASA's Cosmic Dust Laboratory and analyzed for comparison.

Team Name: BOREALIS	Team or Project Website: http://spacegrant.montana.edu/borealis/

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Passive High Altitude Particle Capture Experiment

Project Overview

The purpose of our experiment is to collect particles, especially those of extraterrestrial origins, from the stratosphere and return them to earth for analysis. Our collection method will be a ~900cm^2 collection plate that will passively collect dust particles as they fall through the atmosphere. The collection plate will be housed within a pneumatically operated box which can be opened at a specified altitude allowing a silicone oil-covered collection plate to be exposed. Particles striking the collection plate will be trapped within the silicone oil coating. The box will be sealed prior to descent and will be pressurized with nitrogen to provide a constant positive pressure inside the box to prevent any in-flow of contamination. The particles will be recovered from the silicone oil matrix and subjected to imaging and elemental analysis using a scanning electron microscope. Authentic cosmic dust particles will be requested from NASA's Cosmic Dust Laboratory and analyzed for comparison[1].

Cosmic dust particle densities are known to be low. Considering the NASA cosmic dust collection flights done in previous years using collection surfaces of 30cm^2 that yielded 0-3 particles over a 30-40 hour collection period, we can expect to get several cosmic dust particles on our collection plate [2]. Having a launch that will occur shortly after the Perseid meteor shower may make our chance of capturing a larger number of cosmic particles greater than these estimates. The Perseid meteor shower is expected to hit in approximately mid August.

In addition to extraterrestrial particles, we are likely to capture volcanic dust and particles from man-made space debris and rocket fuel. The first part of our analysis will involve categorizing the particles and determining the relative abundances of the various types of particles we recover from the stratosphere. The particles which we suspect to be extraterrestrial will be subjected to further analysis of their shape and composition[3]. Since the experiment will be flying a relatively short time after the Perseid meteor shower, we plan to compare the cosmic dust particles we recover to sample collections of cosmic dust particles from previous Perseid and non-Perseid meteor showers. Specifically, we want to identify characteristics that distinguish Perseid particles from all others. The sample particles will be requested from NASA's Cosmic Dust Laboratory.

Particle Collection Device

Two major design considerations have been taken into account for the design of the particle collection device. The first major consideration is to ensure that the maximum number of particles are captured. The second important consideration is to protect the sample collection plate from terrestrial particle contamination. Design criteria that address these considerations are discussed below.

Utilizing the large payload footprint we intend to expose a 900 cm^2 collection plate that has been covered with a matrix that will capture any particles that impact the surface. We believe that the optimal matrix for this purpose is optic clear DowCorning 200 fluid at 250,000 centistokes. This substance turns to a wax at 60,000 feet and the particles should adhere to it. When the device returns to the surface the wax will liquefy and entrap the particles. The silicone matrix can then be dissolved in hexane and filtered to remove the particles.

The particle collection plate needs to be housed within a box that will open and close to prevent contamination from substances that occur below the target altitude (see attached drawing). A pneumatic or servo operated arm will open and close the lid of the box and form a seal against the sides with silicone or rubber stripping around the edge. The box closing and opening mechanism will operate based on logic signals from our on-board microcontroller. It will be triggered by commands sent through the HASP platform, or by a pressure and time-based backup, to open at a specified altitude (most likely around 90-100,000ft) and then triggered to close again when the balloon is on its way back down. If the mechanical seal were used alone, it would have to withstand significant pressure differentials. To combat this problem, we will use a tank pressurized with a “clean” gas (most likely nitrogen) that would be slowly released in the box to provide a constant positive pressure in the box versus the outside, preventing any in-flow of contamination. This method would allow for some flaws in the seal on the box and therefore prevent contamination even if the mechanical seal is not completely air tight. We intend to test this device by flying it on our own balloons. The BOREALIS team has extensive experience flying scientific payloads on high altitude weather balloons to altitudes exceeding 100,000 ft. As a result we will be able to test our device in a flight environment to verify its functionality and thermal control.

References

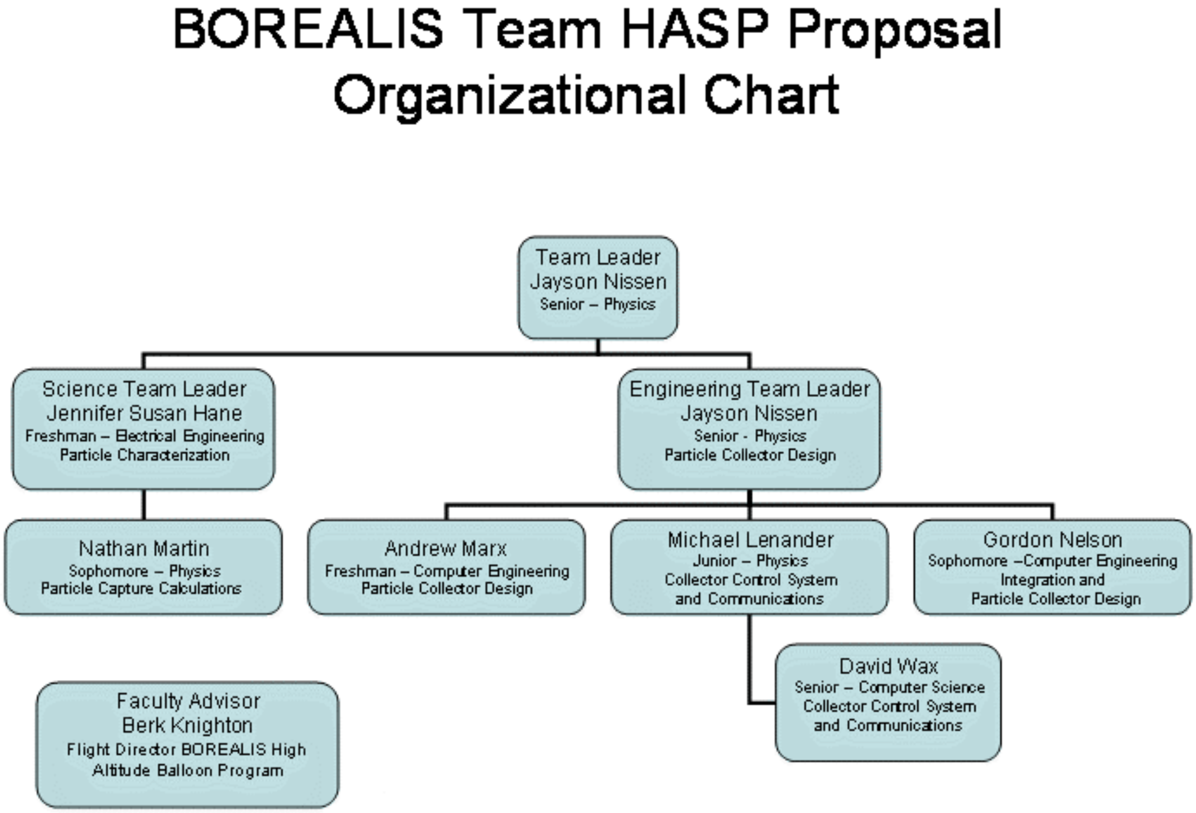
[1] Cosmic Dust Catalog web edition http://www-curator.jsc.nasa.gov/dust/cdccat16/contents.pdf

[2] Love S. G. and D. E. Brownlee, A Direct Measurement of the Terrestrial Mass Accretion Rate of Cosmic Dust, *Science*, **262**, 550-553, 1993.

[3] Rietmeijer J. M. and P. Jenniskens, Recognizing Leonid Meteoroids among Collected Stratospheric Dust, *Earth, Moon and Planets*, **82-83**, 505-524, 2000.

Borealis Team

The Borealis team currently has seven student team members and a faculty advisor. The organizational chart shown below reflects the team organization for the preparation of the proposal. In the event that our proposal is selected for a seat on the 2007 HASP flight the team will be restructured to address the design, construction and testing of the particle collector. Jayson Nissen will remain the team leader for the duration of this project. All of the students are expected to participate in the design, construction and testing of the particle collector as well as analysis of any collected particles.



BOREALIS Team Contact Information

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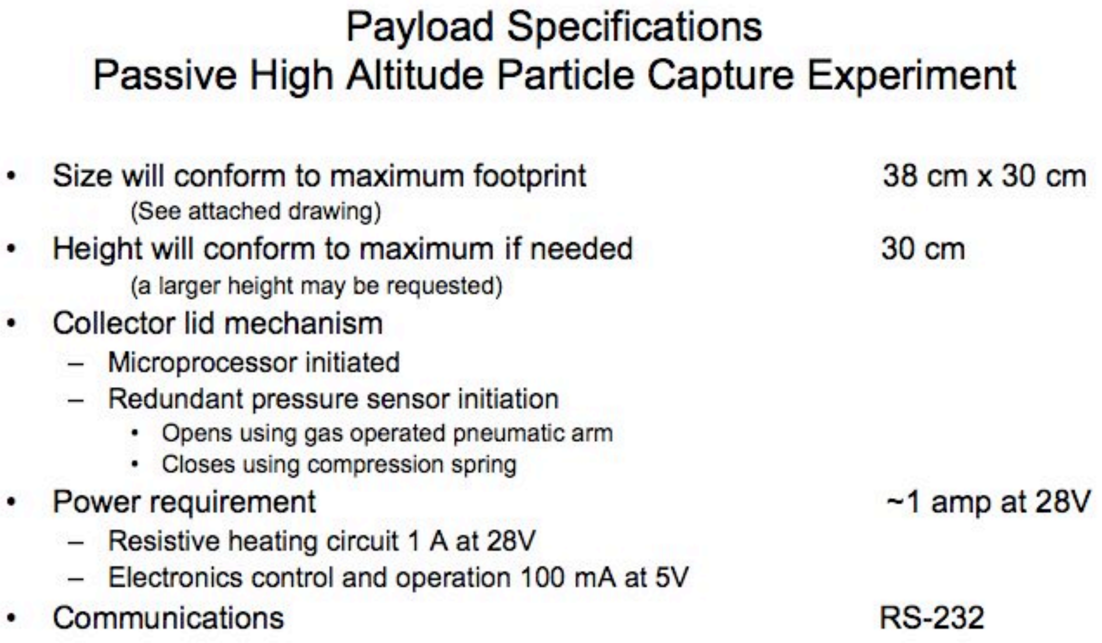


Payload Specifications
Passive High Altitude Particle Capture Experiment

Size will conform to maximum footprint (See attached drawing)	38 cm x 30 cm
Height will conform to maximum if needed (a larger height may be requested)	30 cm
Collector lid mechanism – Microprocessor initiated – Redundant pressure sensor initiation • Opens using gas operated pneumatic arm • Closes using compression spring	
Power requirement – Resistive heating circuit 1 A at 28V – Electronics control and operation 100 mA at 5V	~1 amp at 28V
Communications	RS-232

Interfacing with HASP platform

The collection box must be sealed at all times on the ground, but be able to open at altitude and then reseal on the descent. To accomplish this, the sealing mechanism will be controlled by a Parallax Basic Stamp 2 microprocessor module. These microprocessors are designed with built in RS232 communications commands which will allow the Basic Stamp 2 to receive commands via the HASP Serial Command Uplink interface. Alternatively, the Basic Stamp 2 can receive logic inputs from the HASP Student Payload Discrete Command Interface. This type of communication will allow the sealing or unsealing process to be initiated from the ground based upon altitude data. A redundant pressure sensor system will be designed and constructed to open the box at 100 mbar if no command has been sent and then initiate its closure when the pressure rises above 100 mb.

Thermal Management

The Basic Stamp 2 can only operate in temperatures above -40°C, so heating is necessary to ensure the temperature remains within operating parameters. An insulated enclosure heated using several power resistors should be sufficient for this purpose. The enclosure will be large to accommodate the solenoid switches used to pressurize and depressurize the lid opening pneumatics.

Project Timeline

January 20: Begin materials research and selection, i.e. select motors, pressure sensor, etc.
February 1: Finalize design and begin construction
February 1- April 1: Construction of the following:

1. System Housing & Platform
2. Opening/Sealing Device/Positive Pressure Controller
3. Command Based Sealing Interface
4. Redundant Pressure-based Sealing Failsafe
5. Thermal Control System and Enclosure

April 1: Finish construction and integration of subsystems; begin rigorous ground testing.
April 15-May 30: Flight test hardware, dependent on weather.
July 15-30: Integrate with HASP

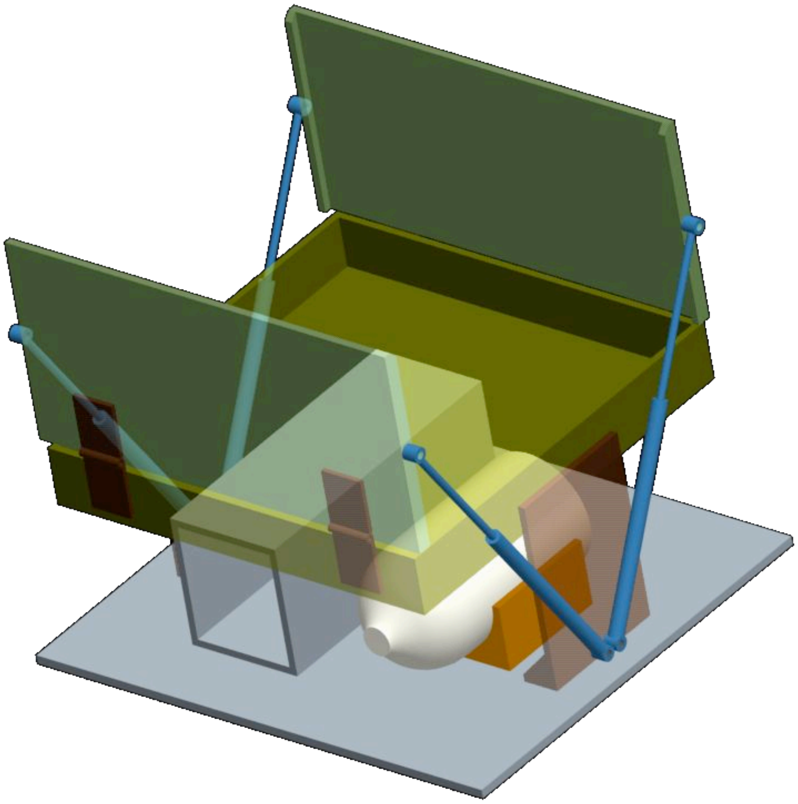
Integration Procedures

The entire experiment will be mounted to the base plate and needs only to be connected to HASP. A test command to verify proper communications should be done at integration, although communications tests are easily reproducible from the HASP specifications, so no problems are anticipated. Only an uplink command is required for the payload, so telemetry testing is not necessary.

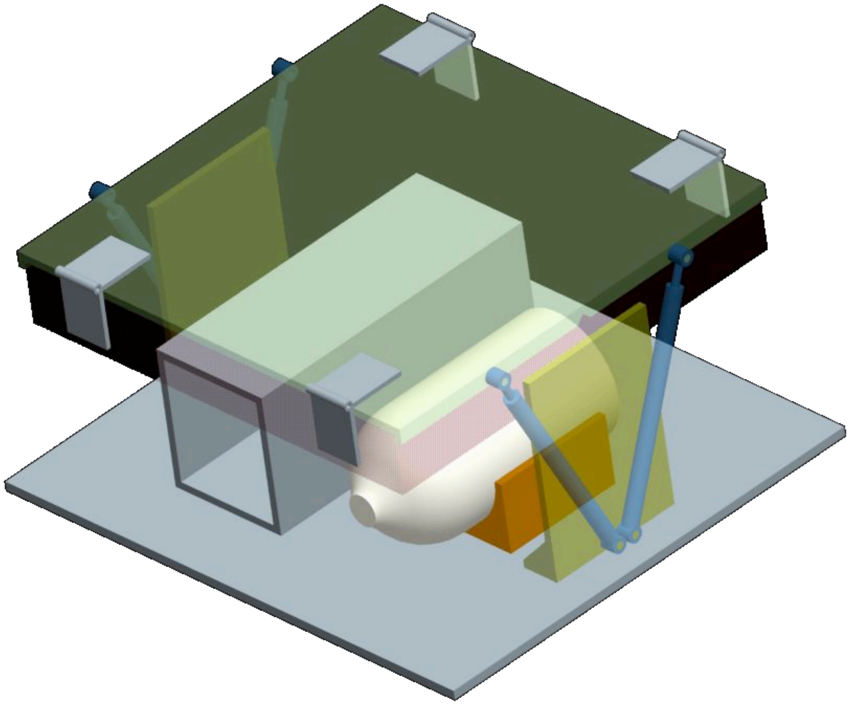
Integration and Flight Personnel

Presently all of the BOREALIS team members are planning to attend the integration and flight campaigns. The group will include the seven team members and their faculty advisor.

Preliminary drawings of the particle collector box

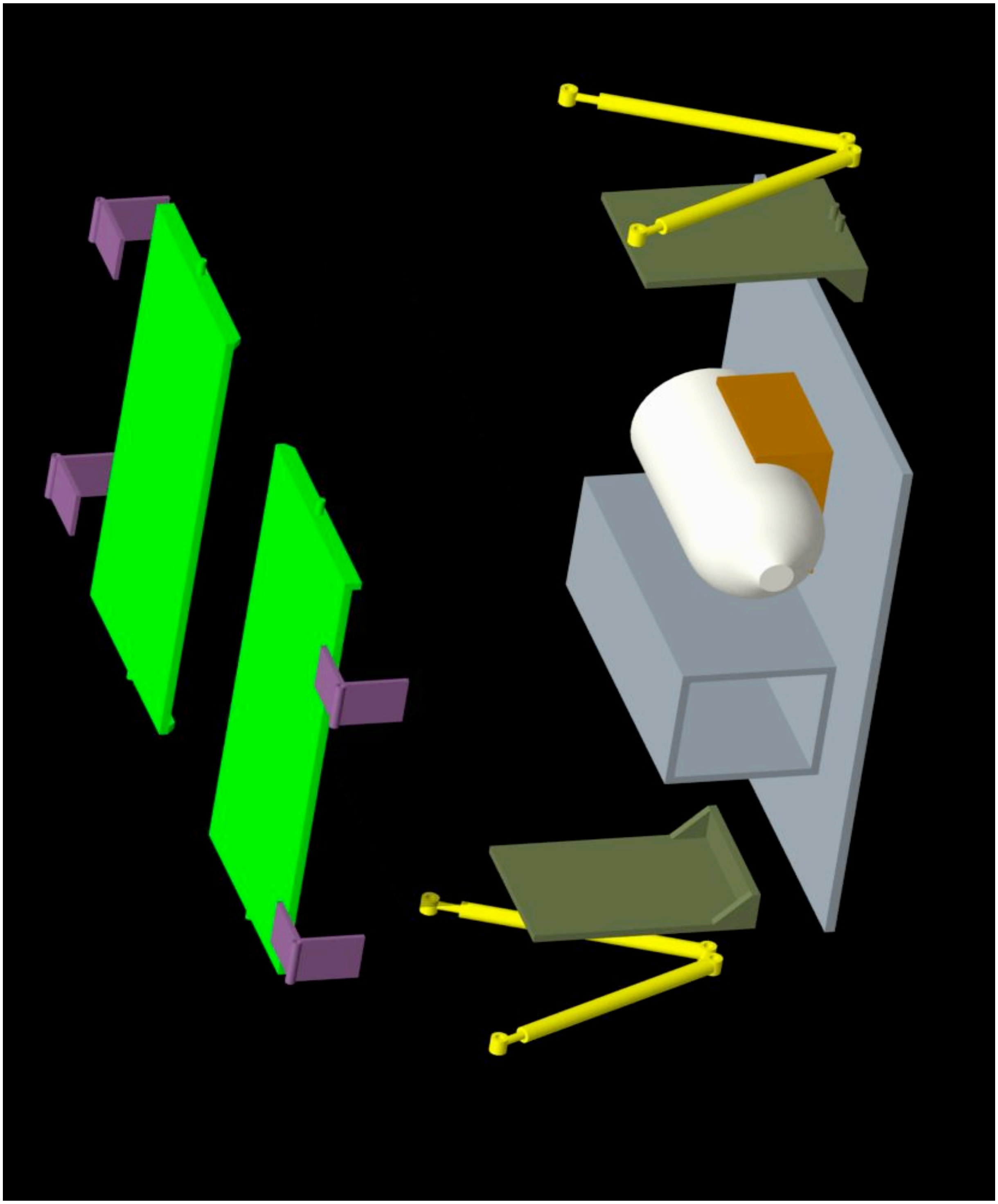


Particle collector box shown with lid opened.

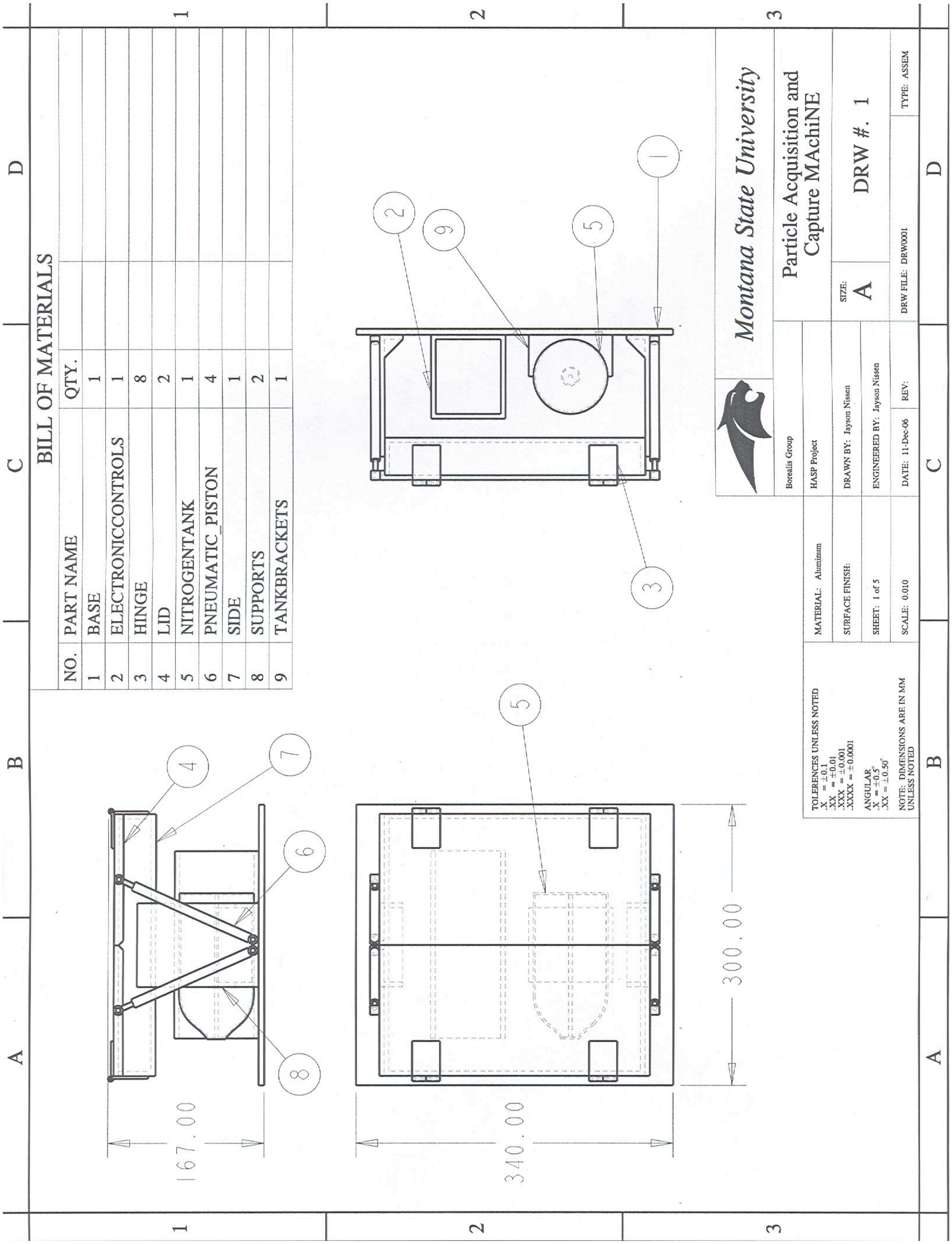


Particle collector box shown with the lid closed.

Expanded view of the particle collection box showing the individual components.



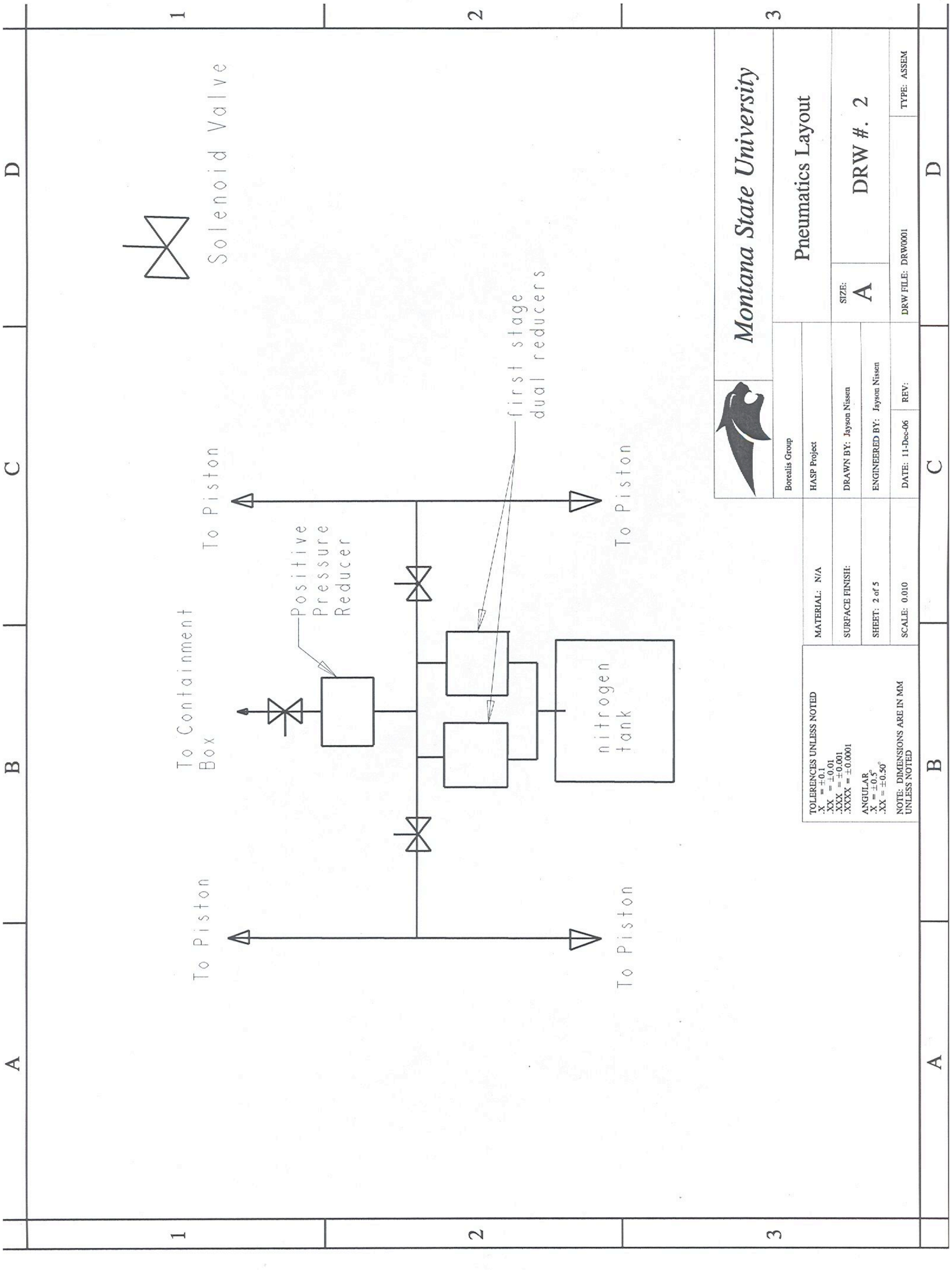
Schematic Particle Collection Box – Drawing 1



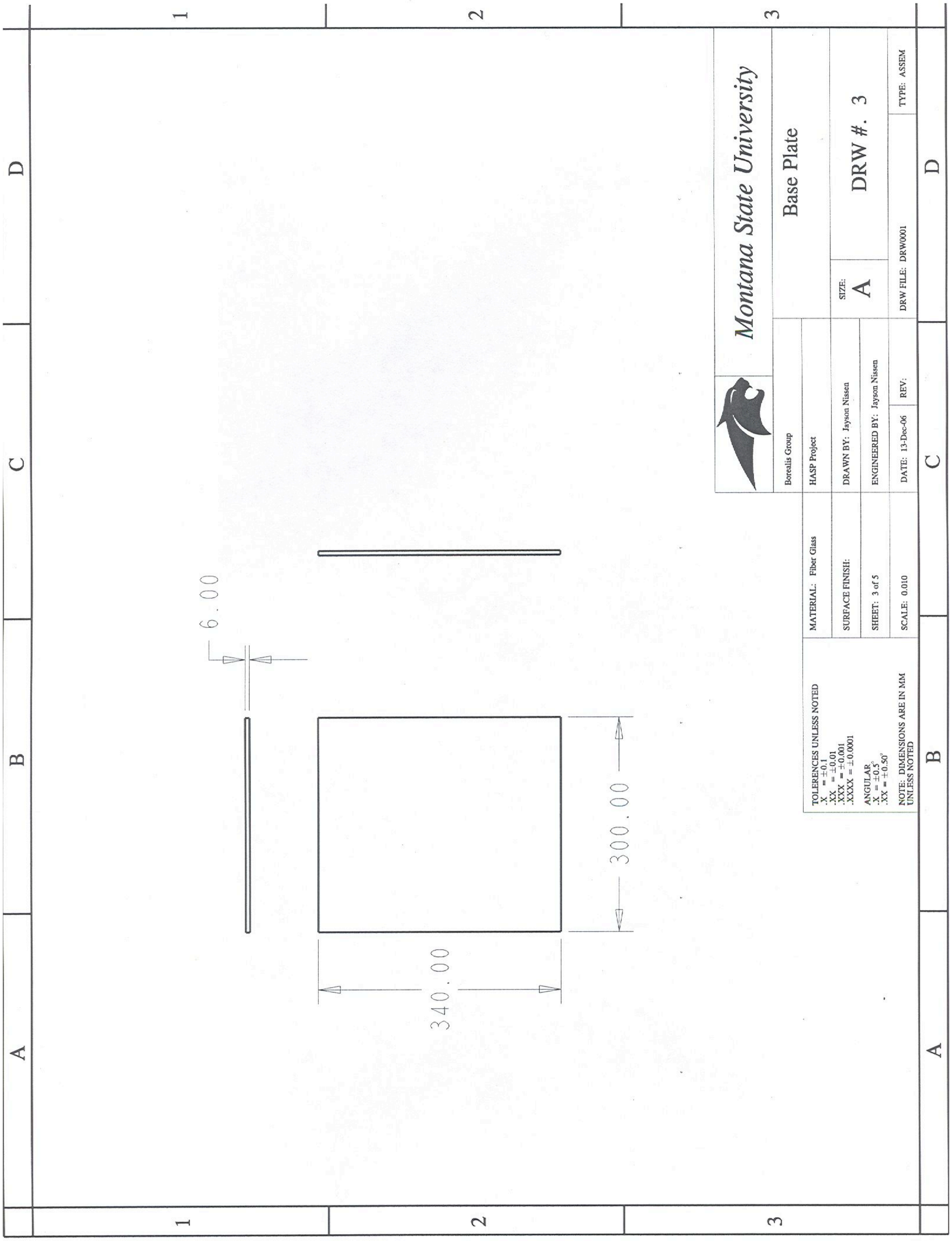
BILL OF MATERIALS

NO.	PART NAME	QTY.
1	BASE	1
2	ELECTRONICCONTROLS	1
3	HINGE	8
4	LID	2
5	NITROGENTANK	1
6	PNEUMATIC_PISTON	4
7	SIDE	1
8	SUPPORTS	2
9	TANKBRACKETS	1

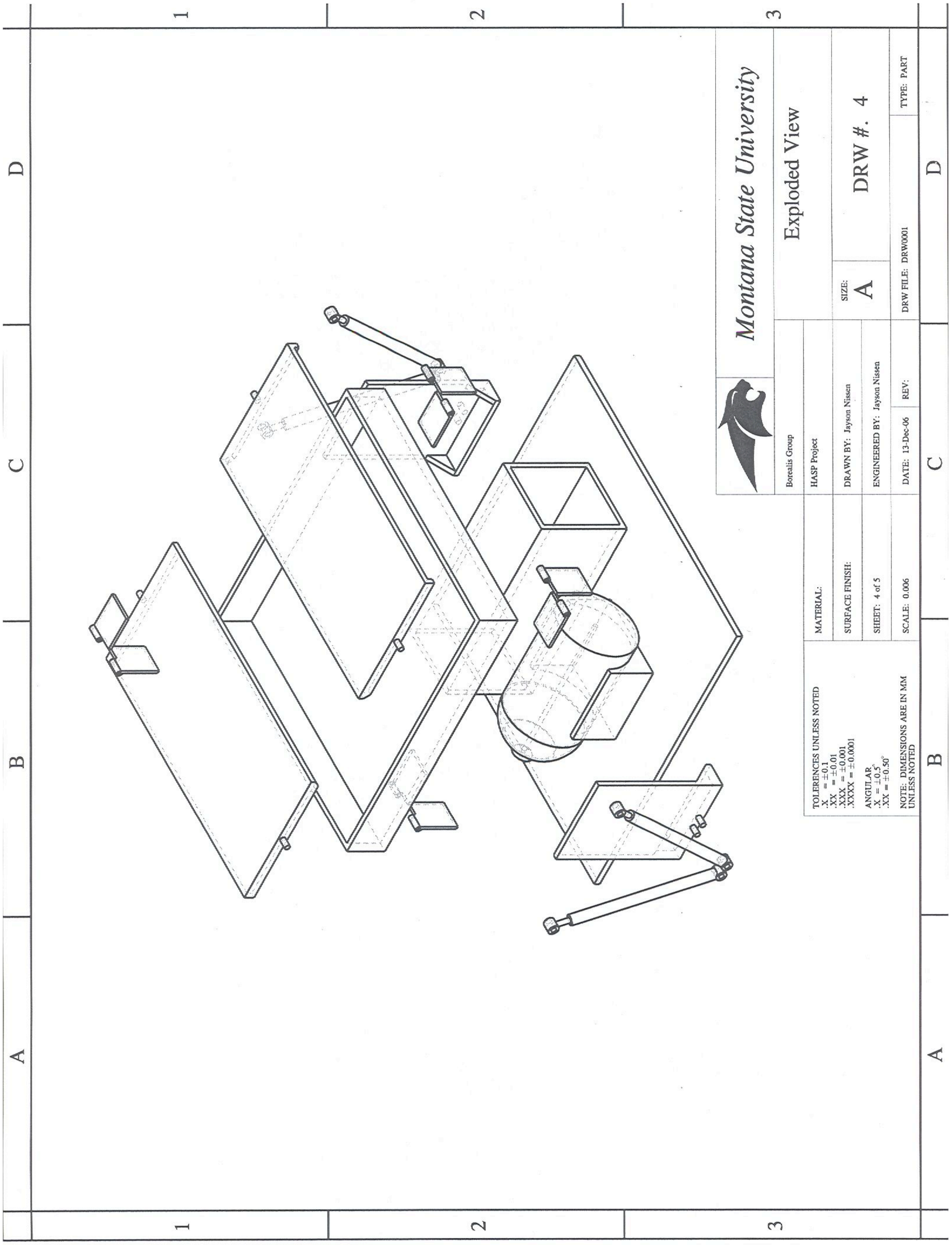
Schematic Particle Collection Box – Drawing 2



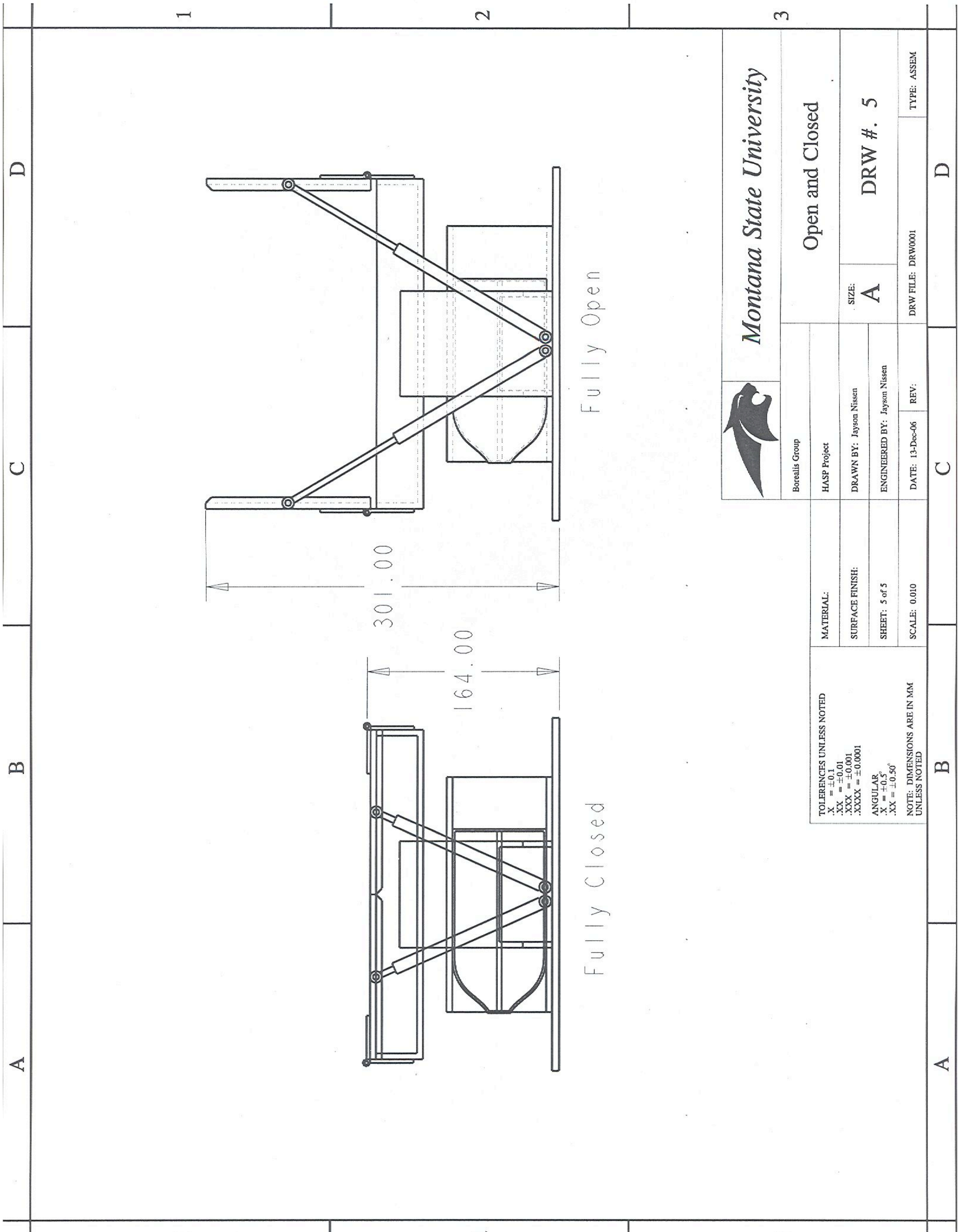
Schematic Particle Collection Box – Drawing 3



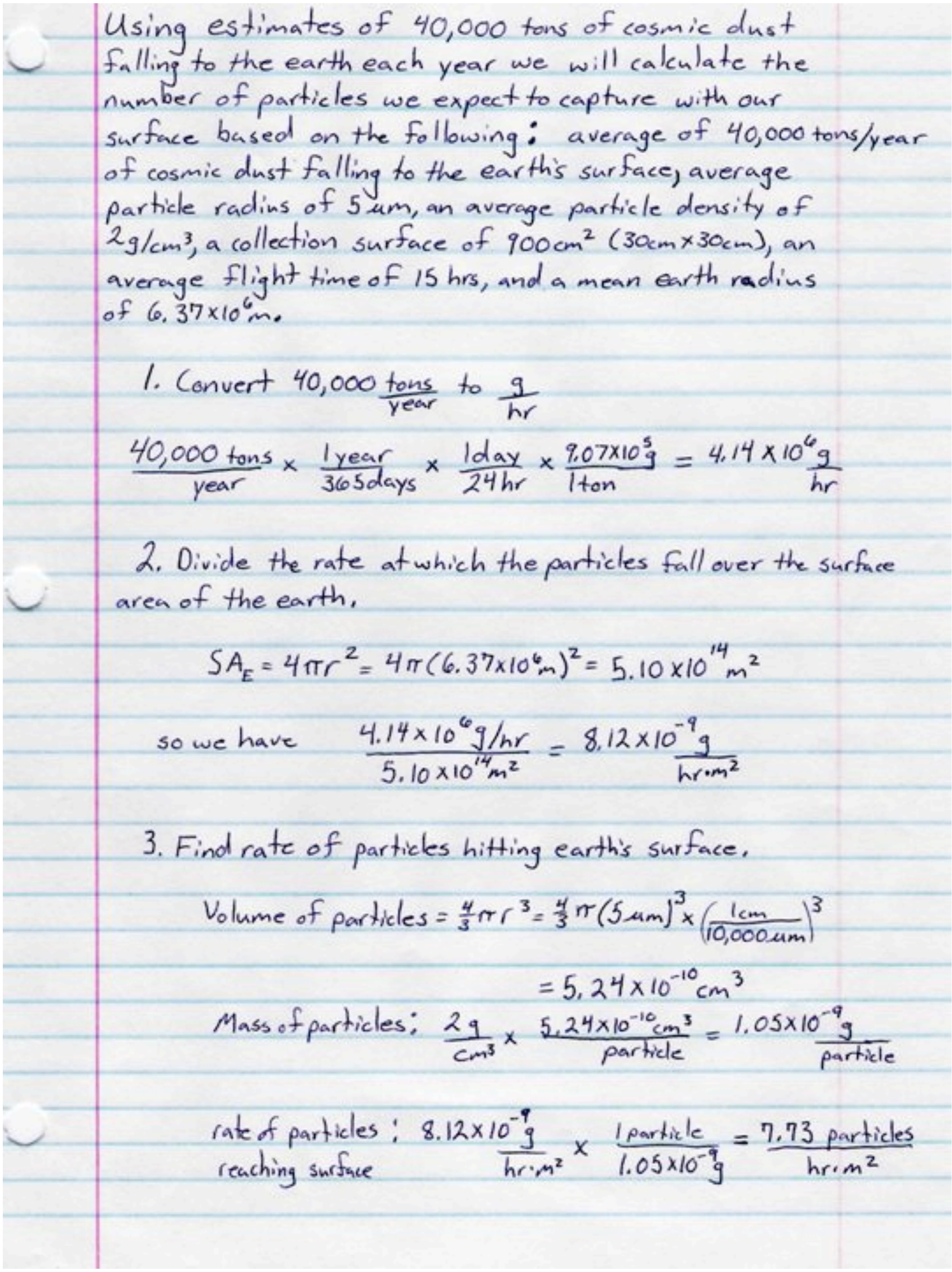
Schematic Particle Collection Box – Drawing 4



Schematic Particle Collection Box – Drawing 5



Estimated cosmic dust capture rate calculations



Using estimates of 40,000 tons of cosmic dust falling to the earth each year we will calculate the number of particles we expect to capture with our surface based on the following: average of 40,000 tons/year of cosmic dust falling to the earth's surface, average particle radius of 5 μm, an average particle density of 2 g/cm^3, a collection surface of 900 cm^2 (30 cm × 30 cm), an average flight time of 15 hrs, and a mean earth radius of 6.37×10^6 m.

1. Convert 40,000 $\frac{\text{tons}}{\text{year}}$ to $\frac{\text{g}}{\text{hr}}$

$$\frac{40{,}000\text{ tons}}{\text{year}} \times \frac{1\text{ year}}{365\text{ days}} \times \frac{1\text{ day}}{24\text{ hr}} \times \frac{9.07\times10^5\text{ g}}{1\text{ ton}} = 4.14\times10^6\frac{\text{g}}{\text{hr}}$$

2. Divide the rate at which the particles fall over the surface area of the earth.

$$SA_E = 4\pi r^2 = 4\pi(6.37\times10^6\text{ m})^2 = 5.10\times10^{14}\text{ m}^2$$

so we have $$\frac{4.14\times10^6\text{ g/hr}}{5.10\times10^{14}\text{ m}^2} = 8.12\times10^{-9}\frac{\text{g}}{\text{hr}\cdot\text{m}^2}$$

3. Find rate of particles hitting earth's surface.

$$\text{Volume of particles} = \tfrac{4}{3}\pi r^3 = \tfrac{4}{3}\pi(5\,\mu\text{m})^3 \times \left(\frac{1\text{ cm}}{10{,}000\,\mu\text{m}}\right)^3$$

$$= 5.24\times10^{-10}\text{ cm}^3$$

Mass of particles: $$\frac{2\text{ g}}{\text{cm}^3} \times \frac{5.24\times10^{-10}\text{ cm}^3}{\text{particle}} = 1.05\times10^{-9}\frac{\text{g}}{\text{particle}}$$

rate of particles reaching surface: $$8.12\times10^{-9}\frac{\text{g}}{\text{hr}\cdot\text{m}^2} \times \frac{1\text{ particle}}{1.05\times10^{-9}\text{ g}} = \frac{7.73\text{ particles}}{\text{hr}\cdot\text{m}^2}$$

4. Find total number of particles in one flight.

$$\text{Total particles} = \frac{7.73\ \text{particles}}{\text{hr}\cdot\text{m}^2} \times \frac{15\ \text{hr}}{\text{flight}} \times \frac{1\text{m}^2}{(100)^2\text{cm}^2} \times 900\text{cm}^2\ \text{collection surface}$$

$$= 10.4\ \frac{\text{particles}}{\text{flight}}\ \text{for a}\ 900\text{cm}^2\ \text{collection surface}$$

This calculation shows that our 900cm² collection surface over an average flight time of 15 hrs should yeild roughly 10 ~~pa~~ cosmic Dust particles.

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Dr. T. Gregory Guzik December 12, 2006
Department of Physics & Astronomy
Louisiana State University
Baton Rouge, LA 70803-4001

Dear Dr. Gusik,

This letter is in support of the Montana State University student proposal entitled "Passive High Altitude Particle Capture Experiment" that has been submitted as a project to be flown on your 2007 High Altitude Student Platform. It is a pleasure to offer our personnel, equipment and expertise to this exciting student proposal on the capture and analysis of cosmic dust particles.

The ICAL facility has a comprehensive list of complementary analytical techniques, and a wide range of multidisciplinary experience and expertise that can be readily used for the proposed research. These techniques and their function are given on the ICAL webpage www.physics.montana.edu/ical/ical.html. In particular, our experience in surface characterization techniques such as x-ray photoelectron spectroscopy, scanning Auger and electron microscopy will be very valuable in characterizing your cosmic dust particles. We will be willing to train and guide the students that will be participating in the proposed research and help them with the acquisition, analysis, characterization and interpretation of the data in these areas. ICAL has wide experience in working with multidisciplinary groups and has trained hundreds of users, including undergraduate and graduate students, postdocs and faculty in the use of the equipment as well as in interpreting the data.

I wish you my best and I am looking forward to hearing from you the good news that your proposal has been selected.

Sincerely Yours,

Recep Avci

Prof. Recep Avci, Director of ICAL

Montana Space Grant Consortium

NATIONAL SPACE GRANT COLLEGE AND FELLOWSHIP PROGRAM
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Dear Greg:

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As Director of the Montana Space Grant Consortium I offer my support to this proposal and have agreed to financially support this project. I also offer the use of our personnel (Space Grant and Physics Department), equipment and facilities to this exciting student proposal on the capture and analysis of cosmic dust particles.

Sincerely yours,

William A. Hiscock

William A. Hiscock
Professor and Head, Department of Physics
Director, Montana Space Grant Consortium