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ASGARD X

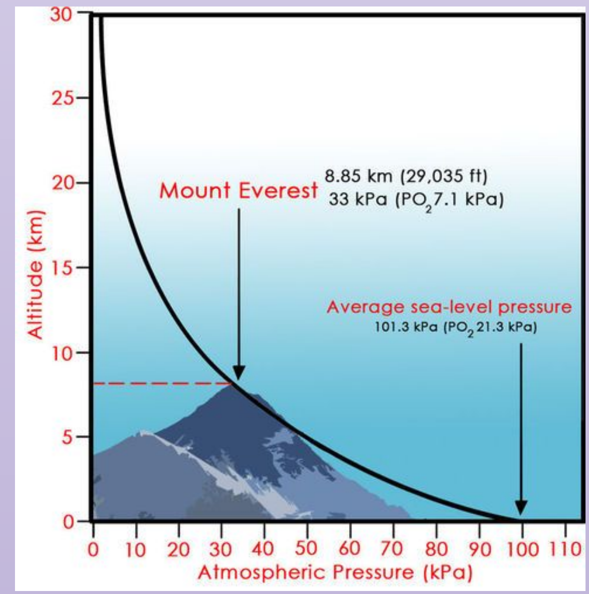
Collecting aerosols from the edges of the Stratosphere

A summary

The experiment that we conducted aimed to send an ascension balloon to the edges of Earth's atmosphere in an attempt to gather interstellar aerosols

The balloons ascend to a height of roughly 30 km; the upper region of the stratosphere. The air pressure at this altitude is very low. The diagram to the right indicates that average pressure at sea level is 101.3 kilopascals and the pressure at 30 km is roughly 1 kilopascal.

With an atmospheric pressure of this low, conventional methods of dust collection would not be effective. For example, a system using a fan would not function because it relies on creating airflow. Simply put, you cannot have airflow if there is not any air. Instead, we would have to research different ways of



Launch day

We were lucky enough to launch our experiment on two separate occasions. The first was in the annual Asgard ascension balloon launch. Unfortunately, due to travel restrictions because of the pandemic, this launch campaign had to be attended virtually, with the group photo (**below**) of all the participants being taken via zoom!

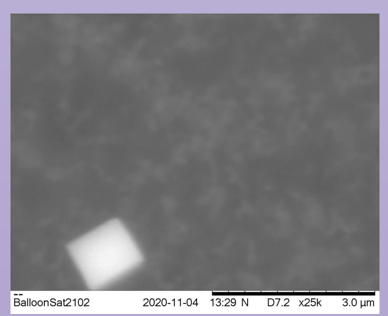
The Asgard X Launch campaign consisted of numerous talks by experts in the field, a presentation from each participating group and, of course, the livestreamed launch!

Later in the year, we also launched our experiment in the St Paul's School run Ascension launch, naturally followed by a hearty breakfast. Both launches went well, with the data gathered being in agreement with the predicted data from testing,.

Design and Testing

At first, we considered the idea of electrostatic attraction using a charged wire mesh, a piece of tinfoil and a PC fan. The basic principle was to charge the dust particles (using the wire mesh) and, with the help of the fan, attract them to the sheet of tin foil. We set the apparatus up, back in school (November 2020), and left it to run for about a week. The design was made from a crisp tin as seen in the photograph of the prototype .

After a week, we returned to and inspected the apparatus and looked at it under the school's scanning electron microscope (SEM). We saw the below images of what we suspected to be salt crystals from the crisp can that we had used in our prototype. However, unfortunately we were unable to identify obvious dust grains. This highlighted the importance of a clean preparation environment for the sample collector.



We also found what appeared to be a thread from a piece of clothing. These SEM images were taken at 1000x Magnification (left) and 25000x magnification (far left)

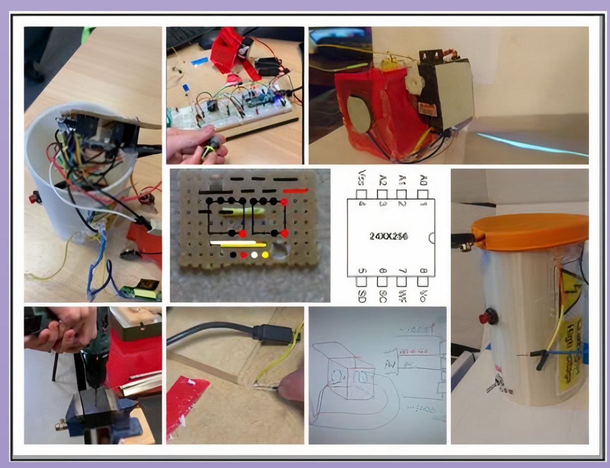
Concluding thoughts and experiences

As you may have guessed from the results, it is pretty difficult to differentiate between space dust and ordinary atmospheric aerosols based solely on the SEM images! To do this, it would be necessary to use spectroscopy, but unfortunately that functionality is not currently available to us at school. In the future therefore, it would be interesting to further investigate the dust's composition in this manner to produce more conclusive results. Our images also suggest that there is an 'impact zone' of sorts created when a particle collides at high speed with the charged SEM pad, which distorts the structure of the aerosols so it is more difficult to analyse them. To counter this, we could use slow, rather than rapid capture methods.

Due to time constraints caused by the COVID-19 Pandemic, we were lucky to have time to complete the elements of the device that we did. Given more time, we would have implemented a more elegant capture method and a better data storage solution.

Construction time! - See Technical zone for a more in depth description

After a long period of online learning and with only a week left to the deadline, during the Easter holidays, members of the team, James Platt and Victor Liu, came into school every day and worked as fast as possible. Everything had to be developed practically from scratch - hardware designed and manufactured, code written and debugged, and all components assembled. Luckily, we managed to complete it just in time!

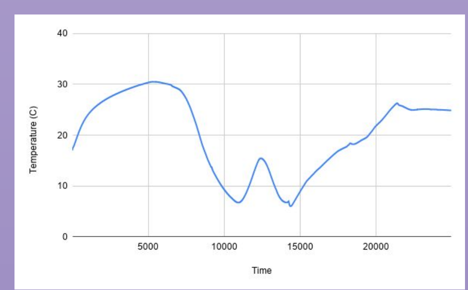


Results:

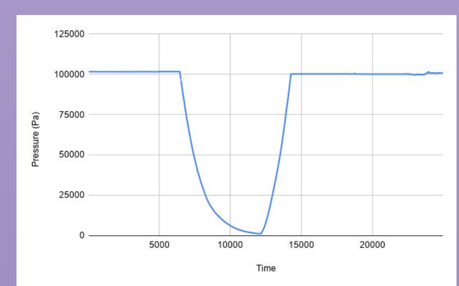
- Pressure/ temperature data suggests that our experiment worked.
- HV was turned on just after launch as expected.

Our method of logging data seemed to also be very effective at saving space.

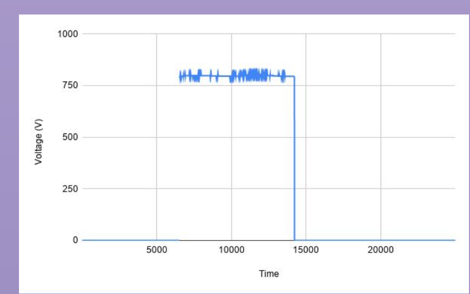
Temperature:



Pressure:



High voltage:

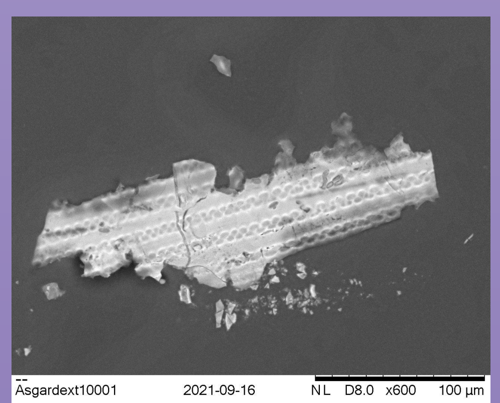


Results (continued) :

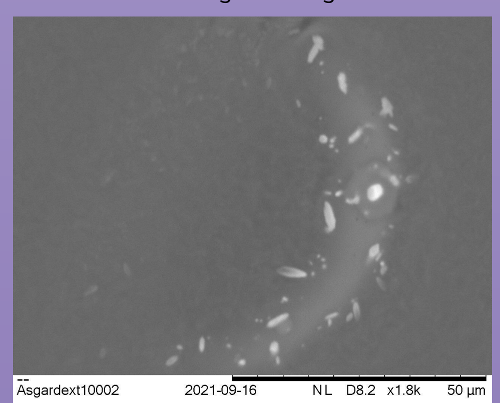
When we returned to school in the autumn, we put the sticky pads under the SEM and looked for captured aerosols

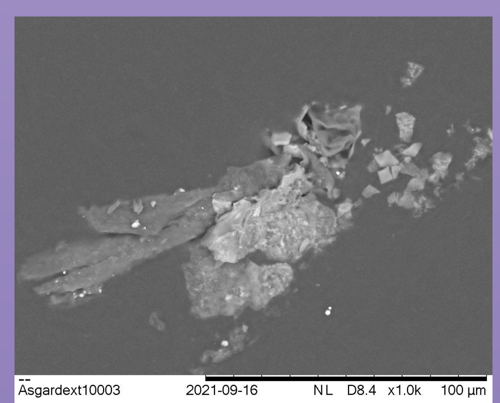
Here are some of the best ones that we captured:

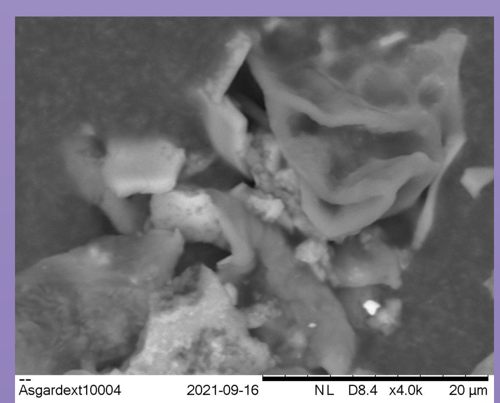
From the exterior:
We think that this is a small piece of plastic



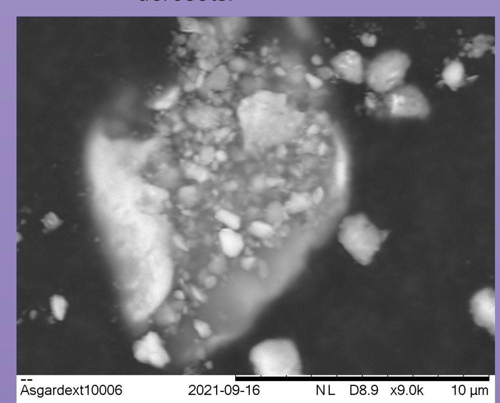
These three images were taken from the exterior, we believe that they are grass seeds. The rounded shapes resemble something more organic.

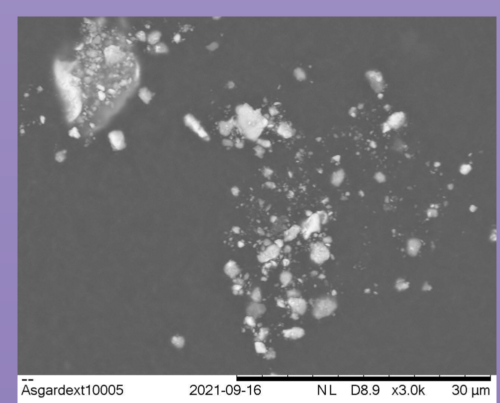






From the interior of the experiment:
These aerosols resemble dust! We believe that these are stratospheric aerosols.





Technical Zone

The main function of our circuitry would need to record data to a non-volatile memory so that we can recover the data afterwards, even in the case of power loss. We decided to use EEPROM memory, as there was already a module with 4 24LC256 EEPROM chips left over from past Asgard missions, and the 256KB of storage would be plenty for the simple numeric data we would log.

We chose the Arduino Micro to control our experiment. It is a module integrating the ATmega32u4 microcontroller and supporting circuitry, conveniently on one board. The power source would be a 9V battery, connected to the Micro's integrated 5V regulator.

The high voltage needed for electrostatic dust collection would be generated by a module with circuitry to generate AC voltage fed to a diode-capacitor ladder. This produced a total voltage differential of around 2 kilovolts across its output pins. We integrated a resistor divider with a 1000:1 ratio to create a lower voltage that we could monitor with the Arduino to confirm that the high voltage was indeed energized. We decided to include a relay (an electromechanical switch) to switch the high voltage on or off, as the experiment needed to be safe to touch before launch and after landing.

The controller would initially be mostly inactive when turned on, until a pin was pulled high by way of pressing an activation button. This started the rest of the experiment code, and initialized the launch site altitude.

Environmental data (pressure and temperature) was sensed with a BMP280 digital temperature and pressure sensor. We used pressure data to calculate the altitude above mean sea level (MSL). By subtracting from this the launch site altitude we could estimate our altitude above ground level (AGL). We would enable the dust collection part of the experiment at 1km AGL. Although we considered possible differences in launch site vs landing site altitude affecting the experiment, we decided that it was very unlikely to have a 1km difference in altitude between launch and landing.

After a significant amount of testing, bugfixing and refactoring, we had a working circuit - and it functioned perfectly on both launches.

Our Circuit Diagram