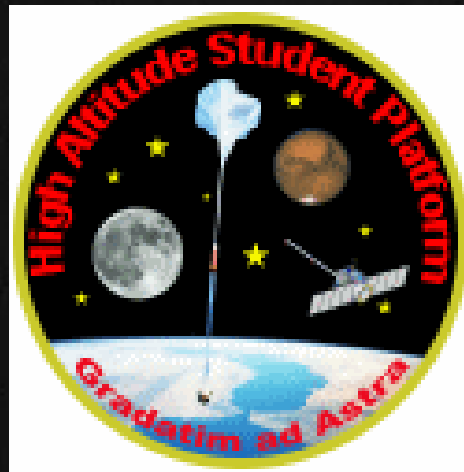


# D.I.E.H.A.R.D. Data Analysis Presentation



**Demonstrating Intensity of Electromagnetic High Altitude Radiation Determination**

# Mission Statement

The University of Colorado at Boulder student team will determine the viability of high altitude observatories by diurnal imaging of celestial bodies, measuring and recording light intensity in the stratosphere as a function of altitude, and by nocturnal imaging of celestial bodies to determine atmospheric turbulence and light intensity due to residuals in the atmosphere. The DIEHARD payload data will establish whether high altitude platforms are capable of capturing high quality images of celestial bodies at a lower cost compared to launching a space telescope like Hubble or constructing a ground based observatory.

# Introduction

- The DIEHARD payload was launched from Fort Sumner, New Mexico, on September 15, 2008.
- The approximate launch time was 7:20 AM and the first data package retrieved from the payload was timed at 7:46 AM.
- During the daytime, the payload experienced thermal problems as the computer repeatedly overheated and needed to be manually powered off. This limited the amount of data points received during the daytime.
- Once the sun set, the computer experienced no further thermal problems.
- The HASP platform ascended to approximately 36 kilometers and hovered for 32 hours.
- The CCD camera returned excellent results throughout the night, capturing stars with both the telescope and wide angle views.
- The photometer returned interesting data during the night, however, with the computer failure throughout the day, a limited amount of data was retained.
- All platform sensors returned quality data with the exception of the digital compass which experienced interference from all of the electronics onboard.

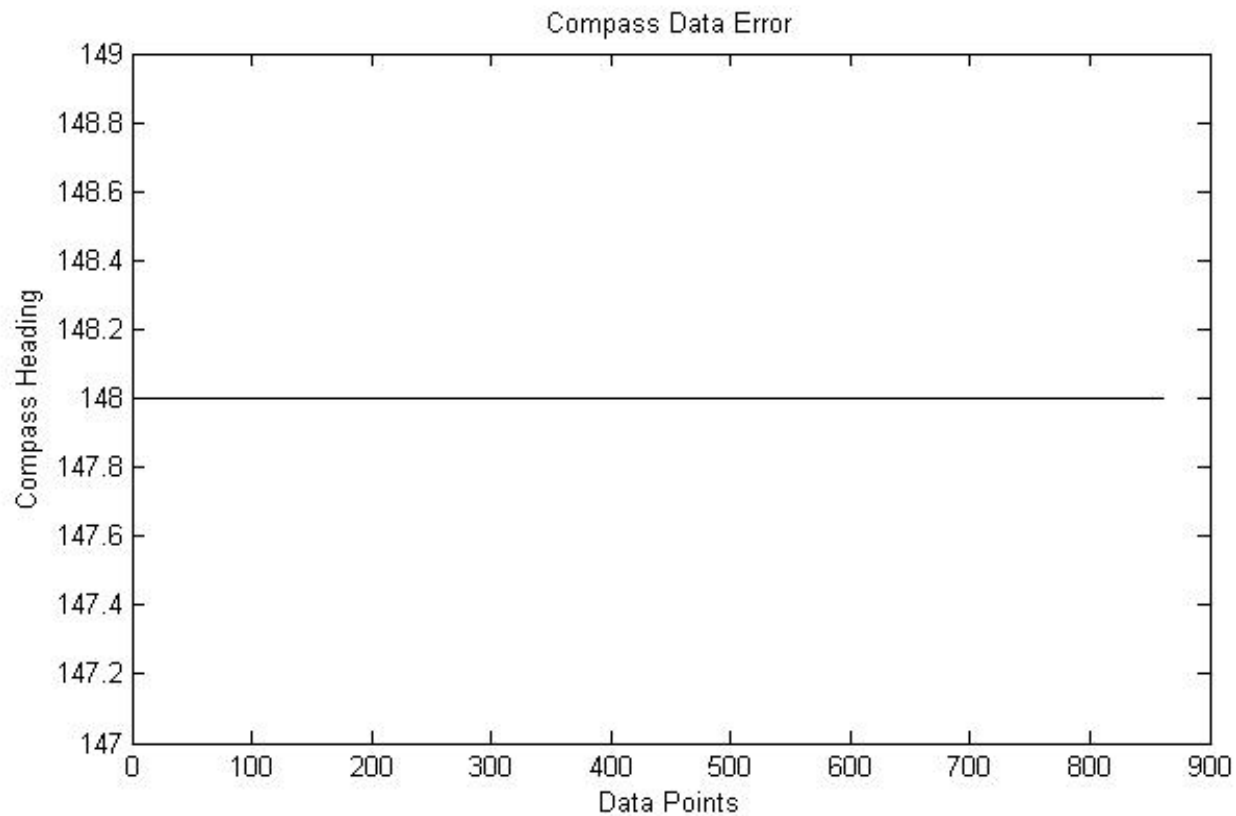
# Serial Data



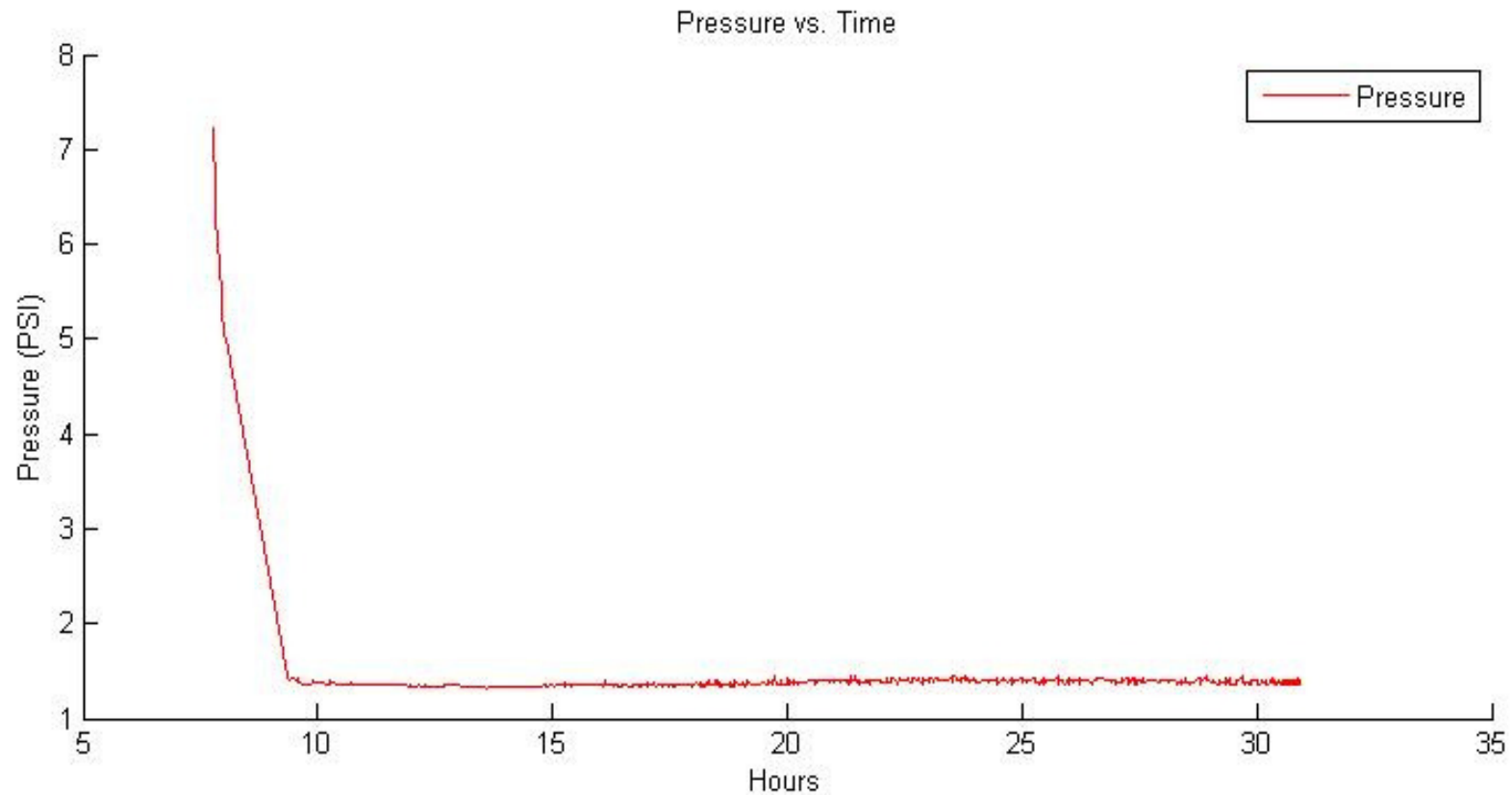
Compass, Pressure, Accelerometer,  
and Temperature Sensors

# Compass

- The compass encountered an error during flight due to electromagnetic interference from the computer and other components onboard the payload, as seen by the flat line.
- For future missions, the compass error will have to be fixed to provide accurate directional orientation to help us determine which portions of the sky are being observed at any given time.



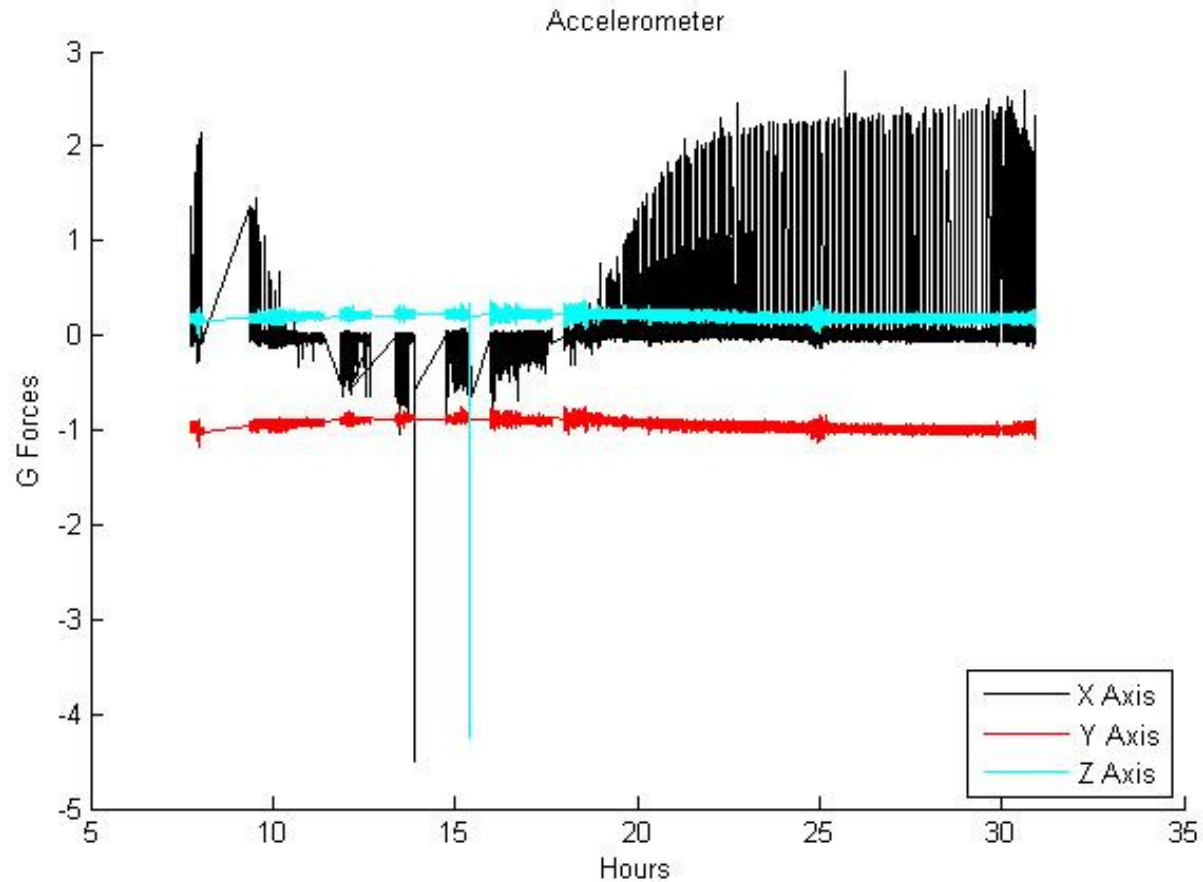
# Pressure



- A half hour into the flight, the pressure decreased to nearly half of what it is on Earth's surface, from 14 to 7 PSI.
- After reaching maximum altitude, the pressure decreased to 1.5 PSI, which is what we would expect in a near space environment.

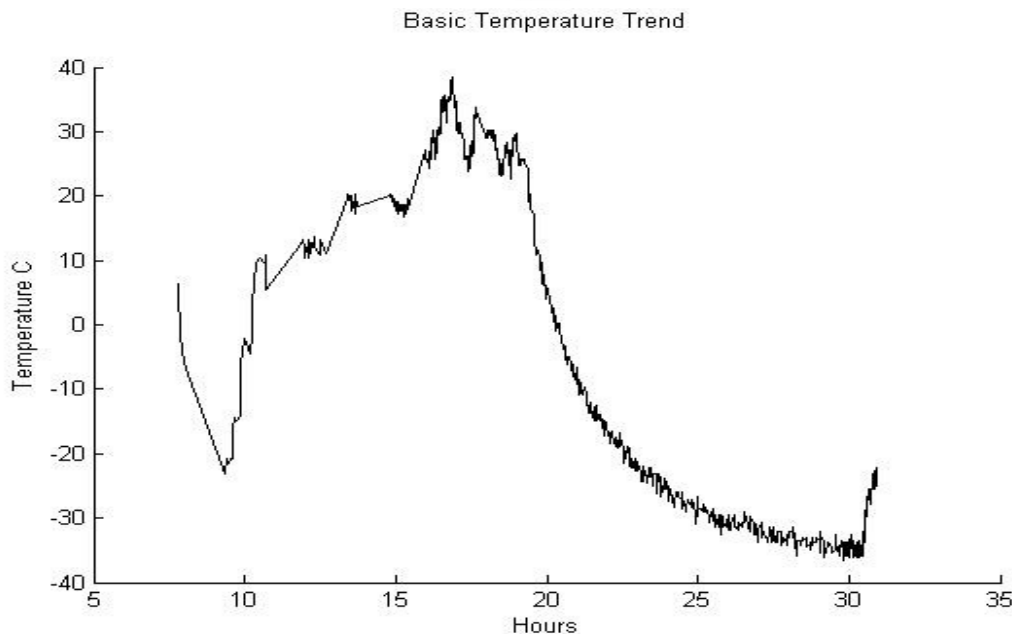
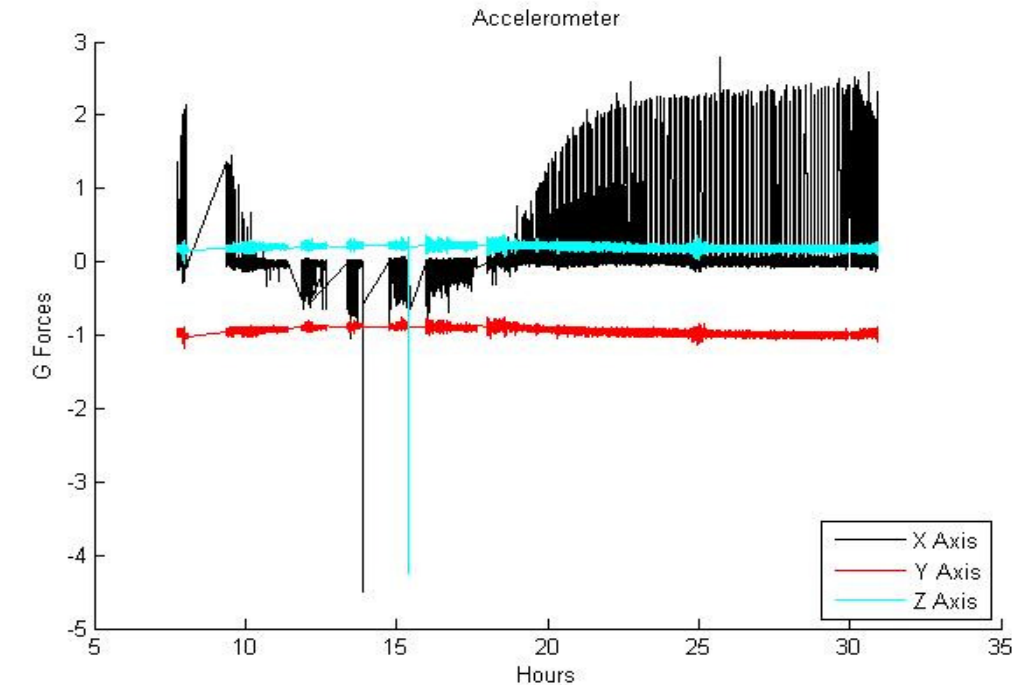
# Accelerometer

- Comparing the accelerometer findings to the altitude shall determine the approximate height at which platform stability is maximized for future high altitude observatories.



- Mild accelerometer readings were found during most of the flight, but a few more intense areas are visible.

# Accelerometer Error



Clearly visible in the accelerometer data is some interesting behavior by the X axis. While the Z axis and Y axis fluctuate within a  $\frac{1}{2}$  G value, the X data fluctuates up to  $3\frac{1}{2}$  G's.

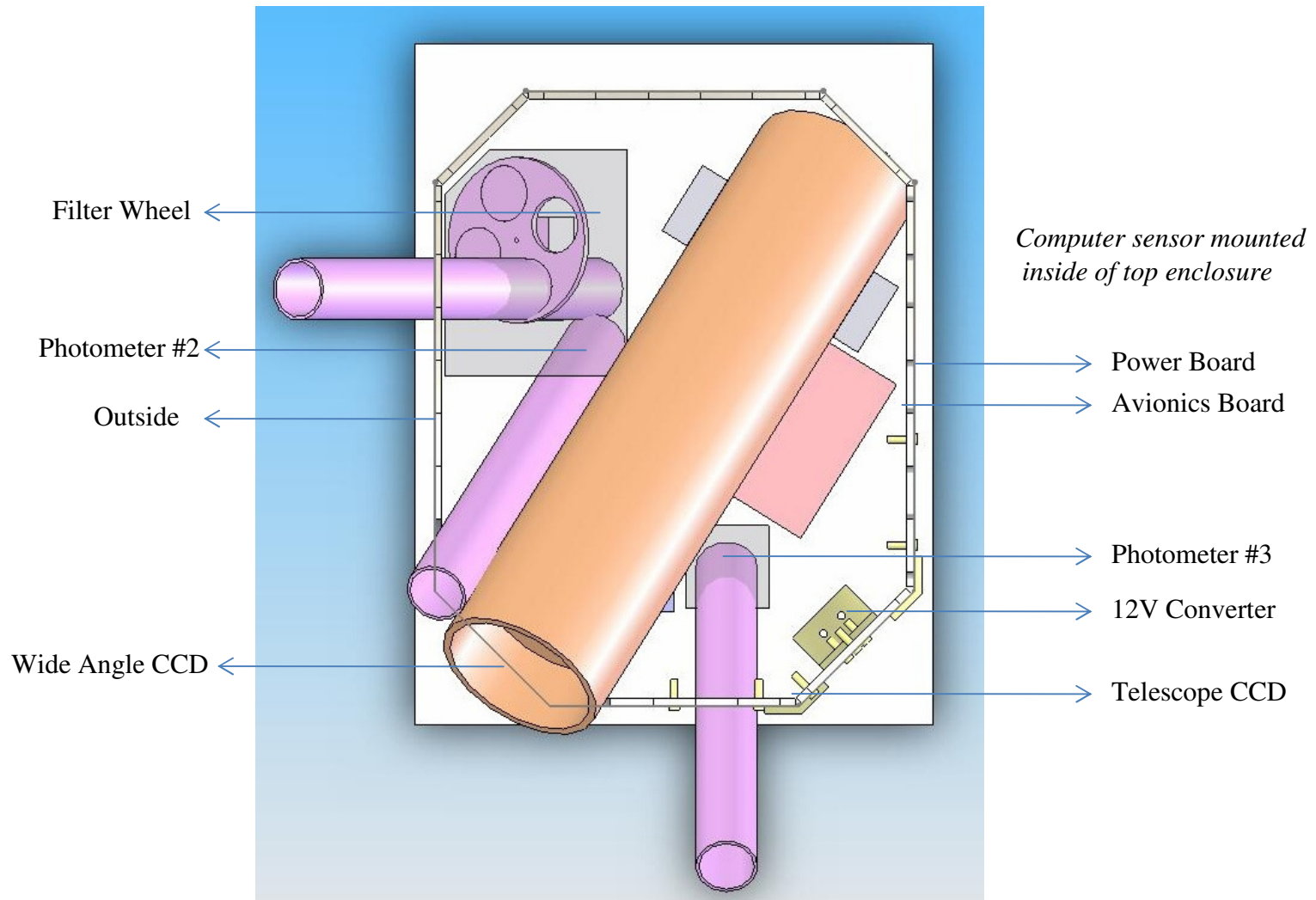
By plotting the basic temperature trend of the HASP platform next to the Accelerometer data an interesting conclusion arises. It seems plausible that the x axis of the accelerometer was getting an error reading due to the drastic decrease in temperature of the flight. The errors in the accelerometer data correspond directly to the two coldest parts of flight, launch and during the night.

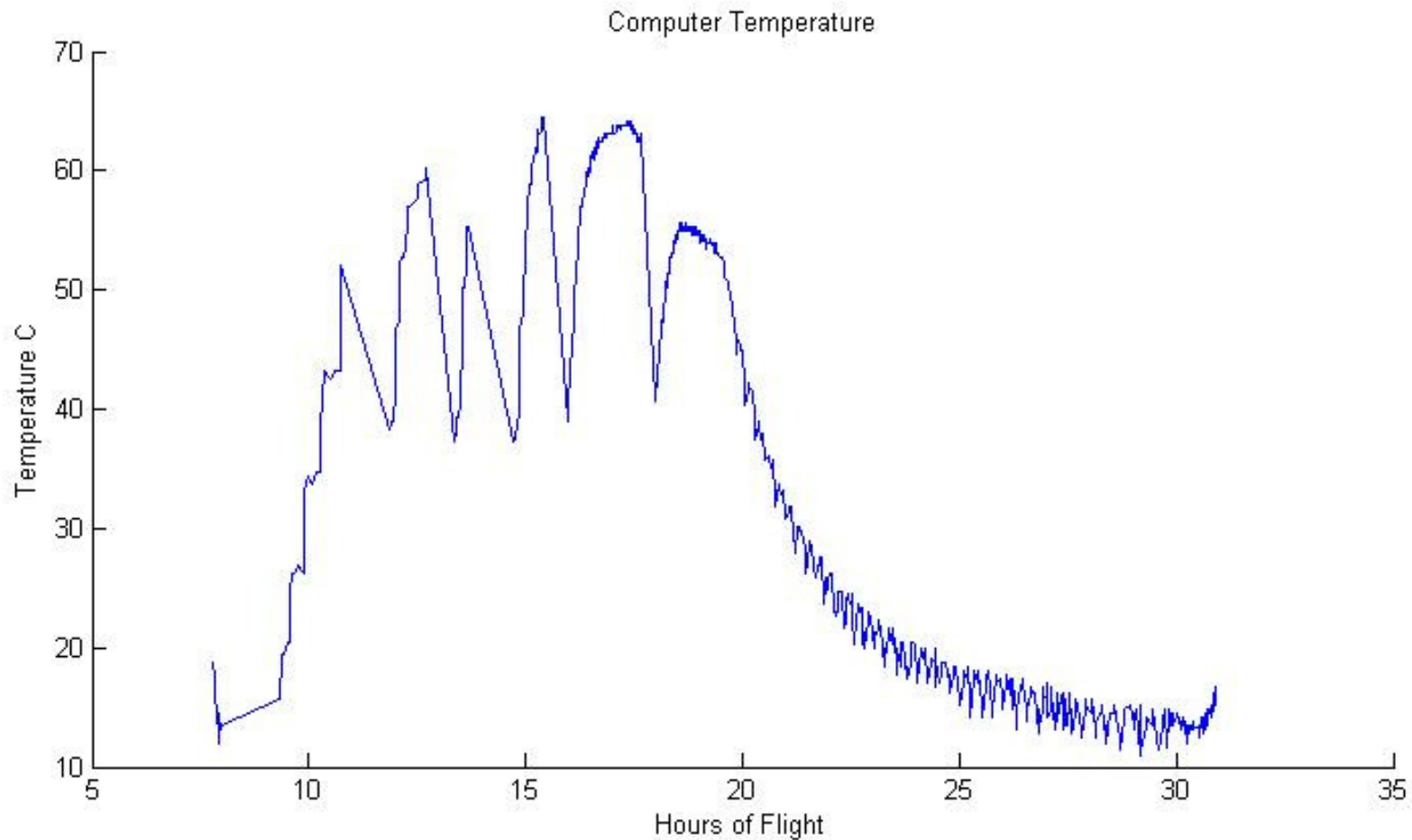


# HASP Temperature Profile

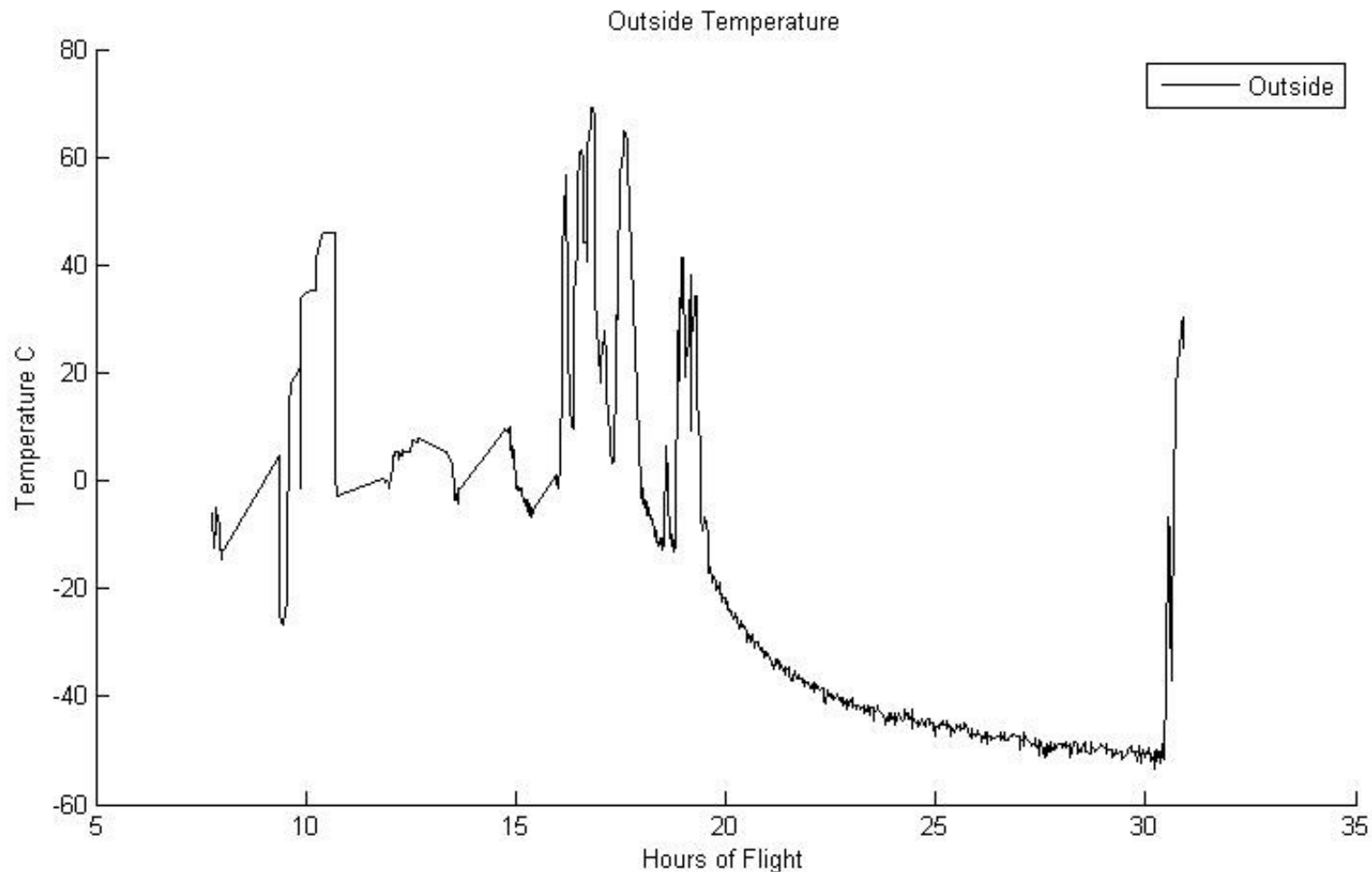


# Temperature Sensor Locations

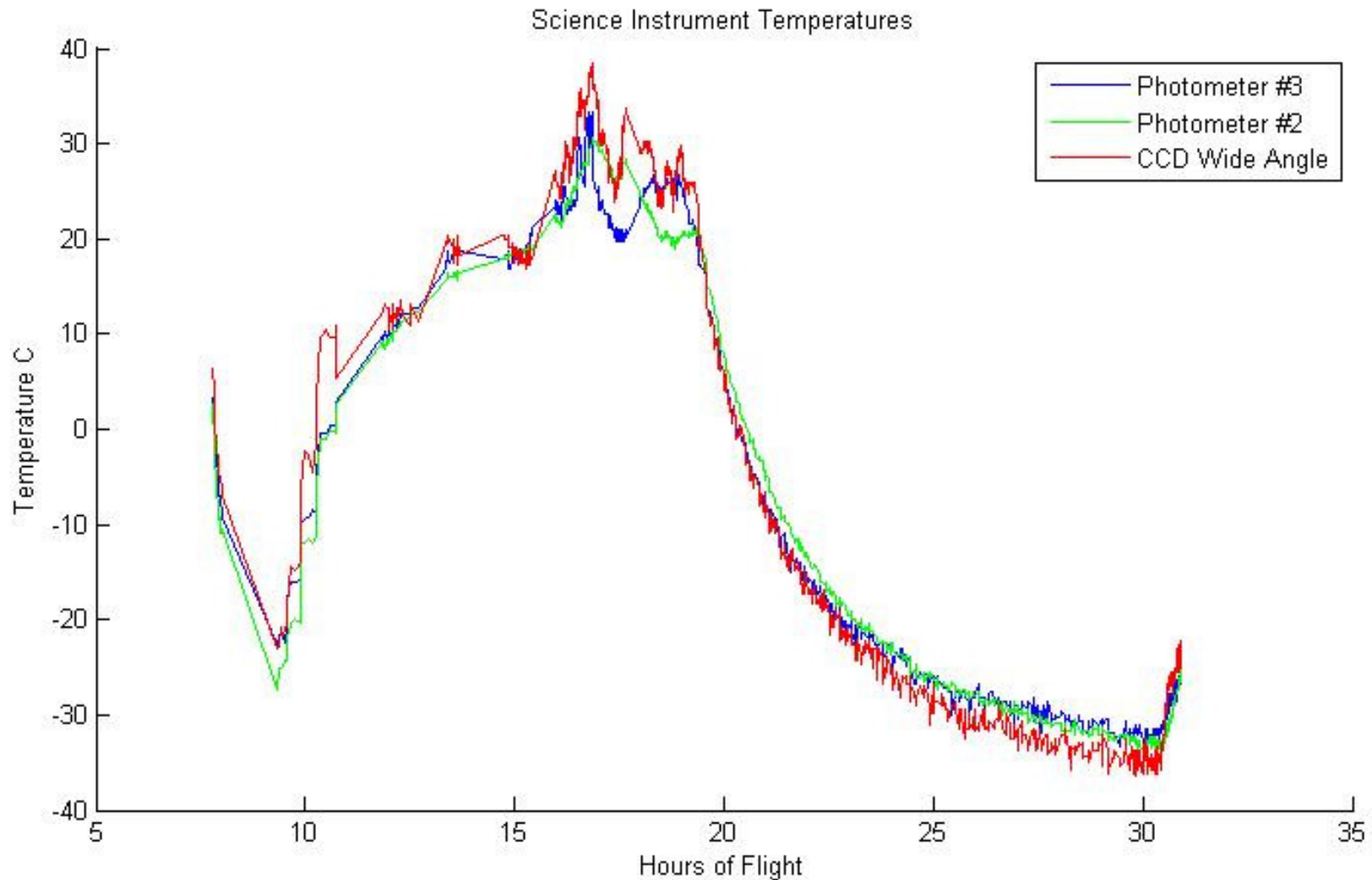




- Each abrupt diagonal line was produced when the computer was temporarily shut off during flight due to overheating.
- The computer resumed processing once cooling to about 38 degrees Celsius each time.
- This computer conflict hindered our data during the day time as it limited the amount of data recorded for all of our sensors .



- The outside temperature profile demonstrates the greatest fluctuation of any of the payload's temperature sensors. It has a minimum of -50 degrees C and a maximum of 70 degrees C.
- The maximum may be due to extreme heat from the sun during the day or the conduction of heat from the inside of the payload.
- The minimum is a result of the extremely cold nights in near space.



- These three sensors were spread evenly throughout the payload, covering three of the four corners.
- This graph demonstrates that the temperature seemed to be fairly evenly distributed throughout the payload for the duration of the flight.

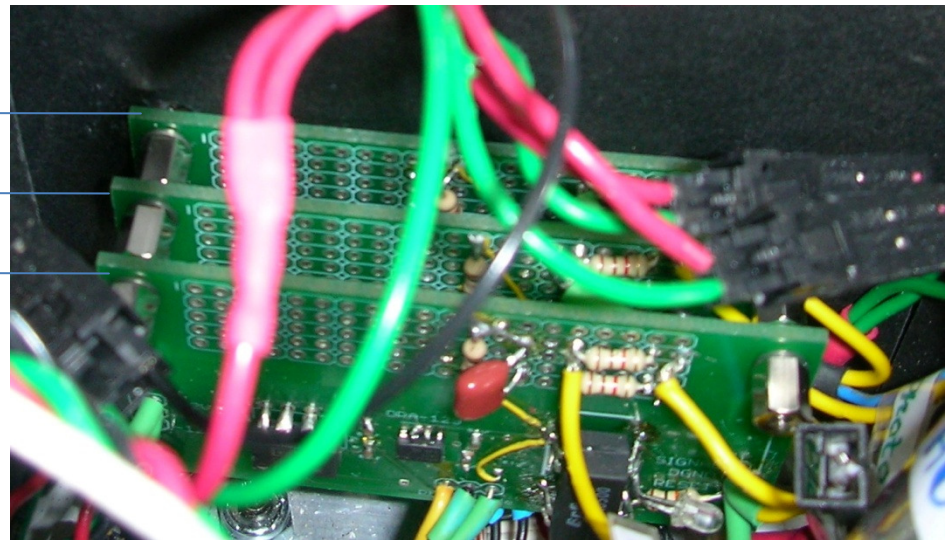
# Photometers

•The photometers on the DIEHARD payload captured sky brightness readings by calculating the time necessary to fill up a capacitor with voltages from a photodiode. The equation used to determine sky brightness in watts per square meters-steradian is  $L=(4/\pi)(n^2/a^2)(C/K)(\Delta V/\Delta t)$  as cited from Yorke J. Brown, PhD.

Photometer Board #1

Photometer Board #2

Photometer Board #3



•Photometer #1 incorporated a filter wheel, which allowed the photometer to focus on a single spectrum of light at a time. It had four filter settings: no filter, green filter, orange filter, and infrared filter.

•Photometers #2 and #3 had no filter wheel and instead captured non-filtered light.

•Each photometer was built with a 10½ inch baffling tube so that the light striking each photodiode is essentially parallel.

# Photometer Orientation

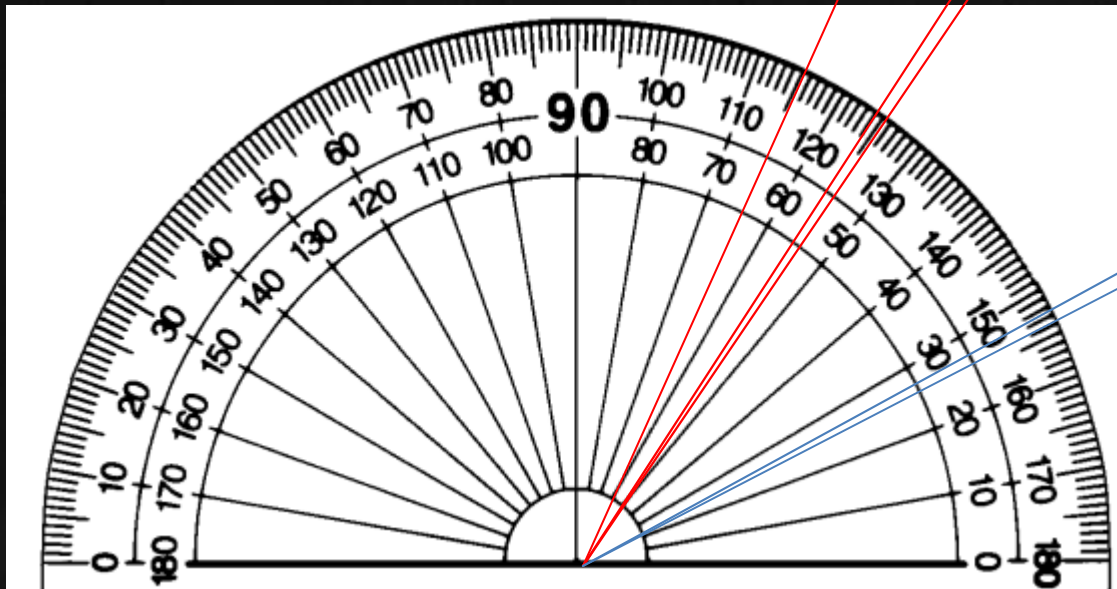
Photometer #2  
64.79 degrees

Photometer #1  
55.23 degrees

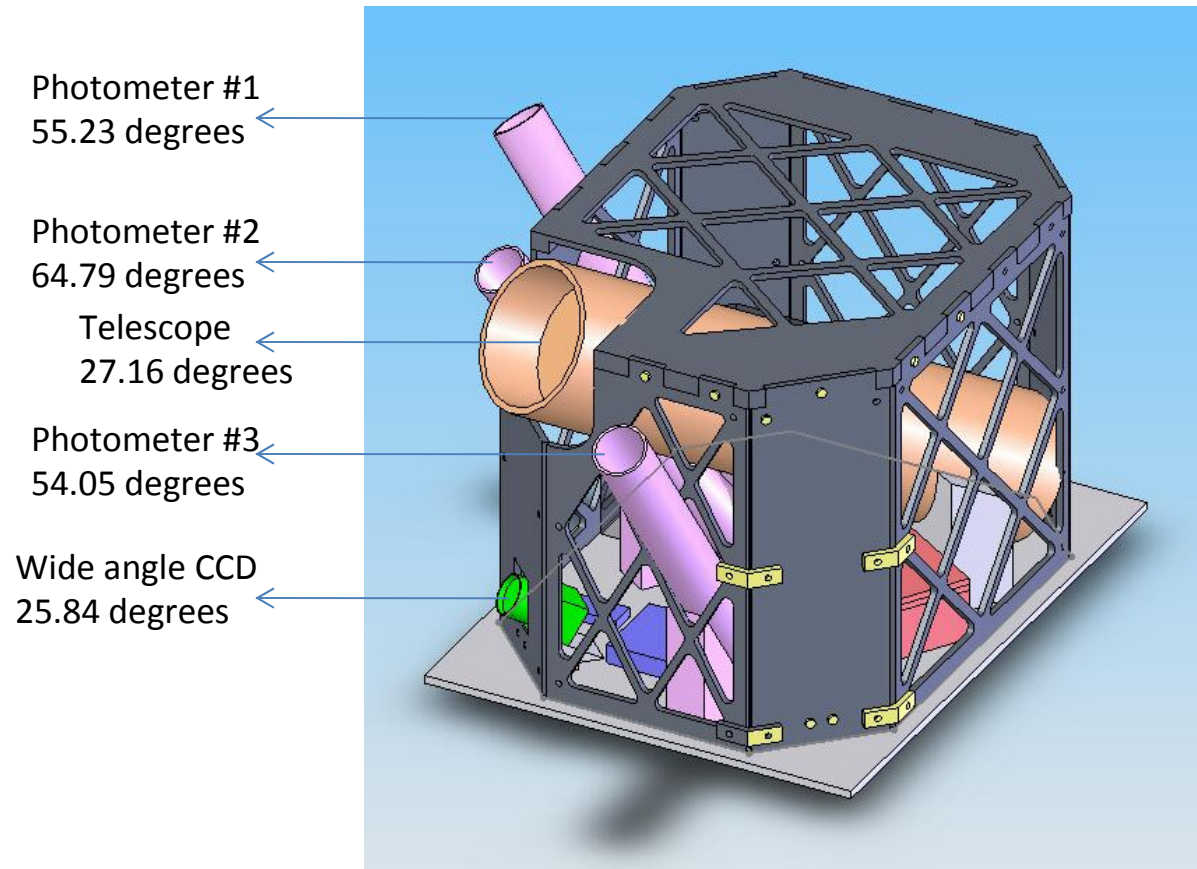
Photometer #3  
54.05 degrees

Telescope  
27.16 degrees

Wide angle CCD  
25.84 degrees

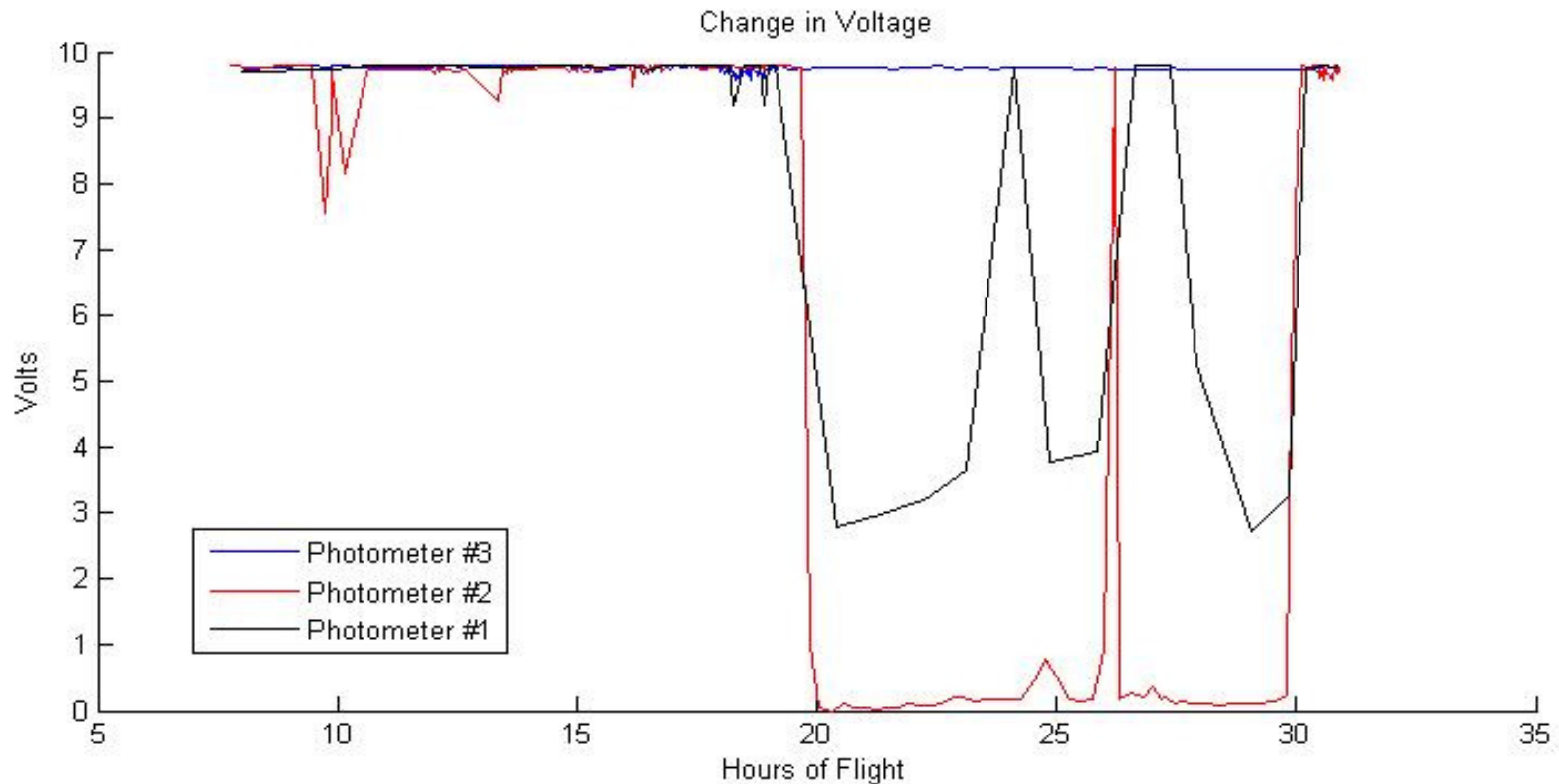


This represents the relative locations of each photometer to each other as well as the locations of the telescope and the wide angle CCD camera.



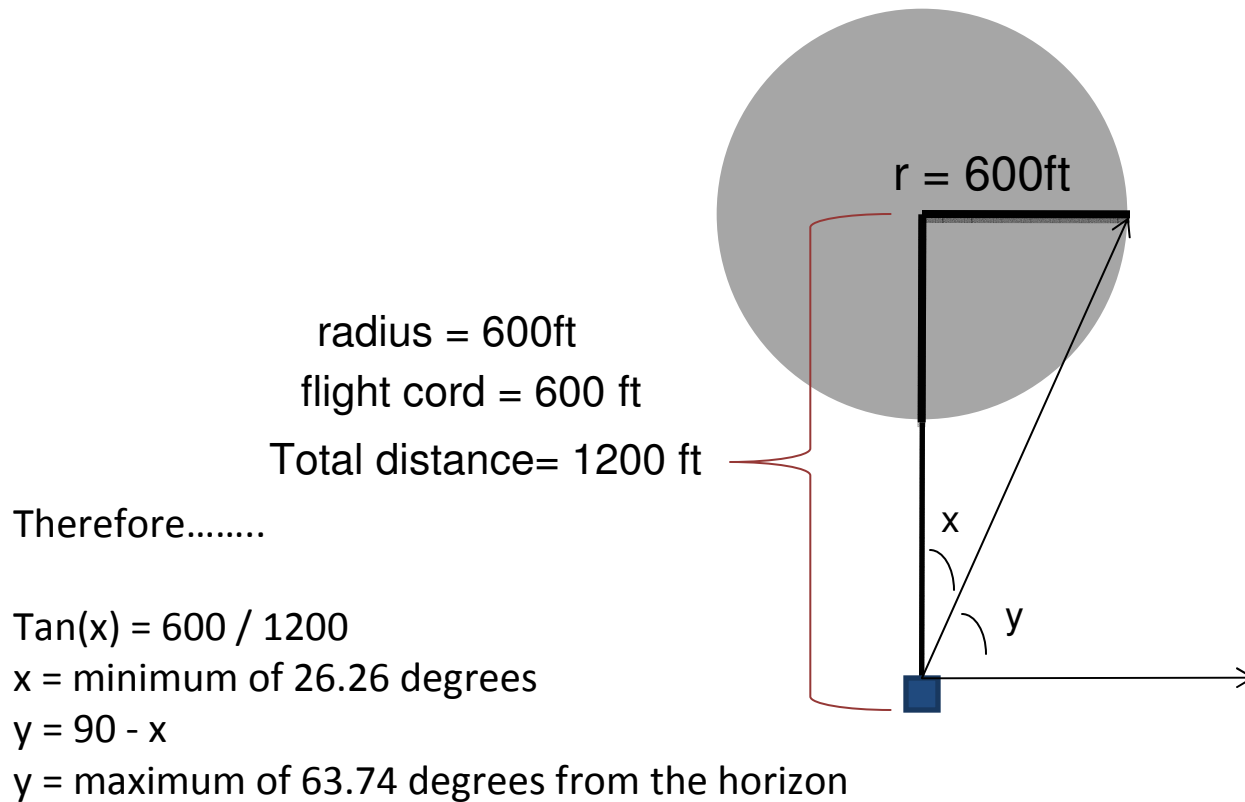


## Change in Voltage Photometers #2 #3 and #1(unfiltered)



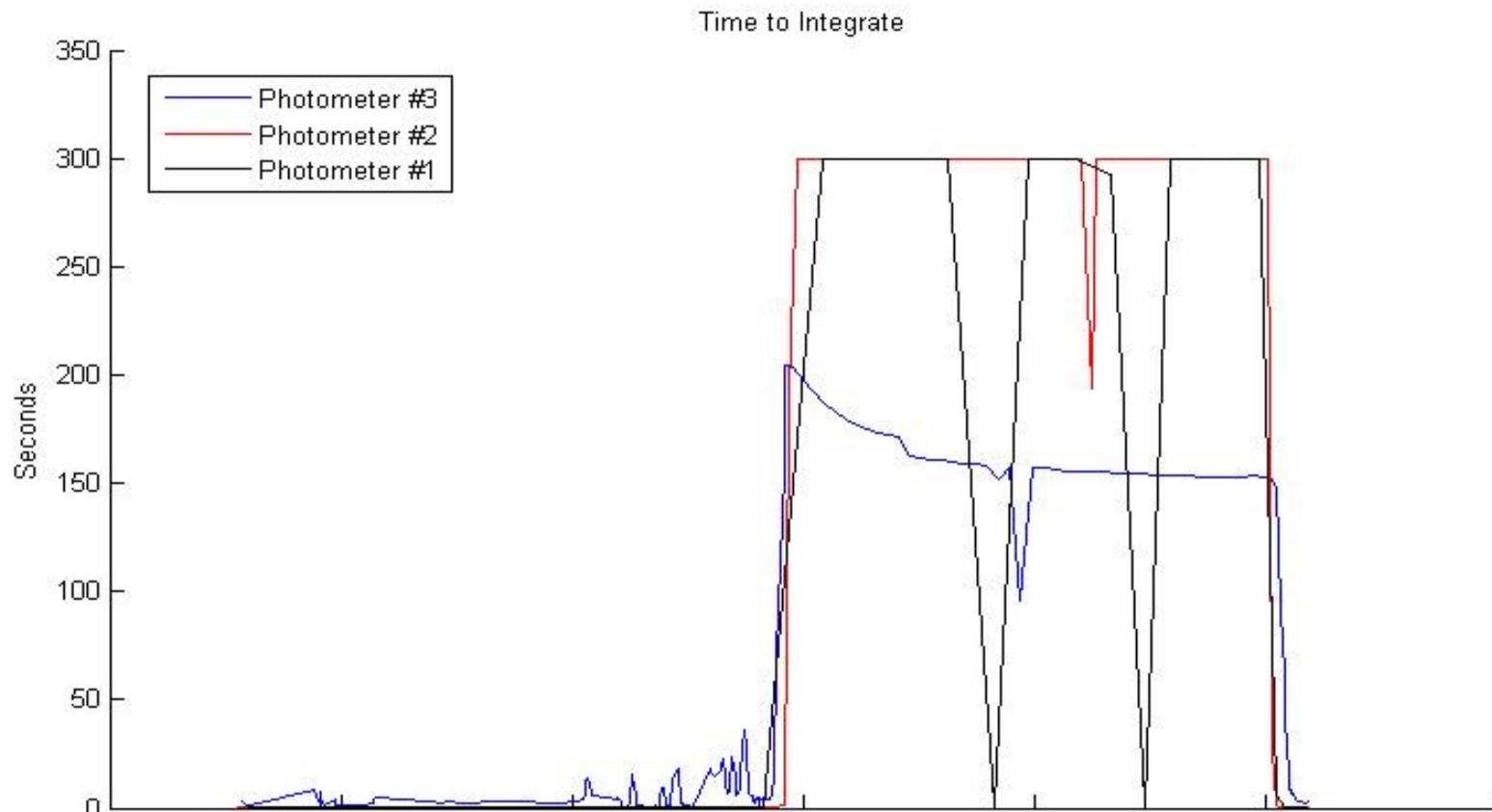
- This graph shows the final voltage value for each photometer generated at the end of every integration period.
- It is interesting that photometer #3 seemed to charge to its full capacitance for the duration of the flight, while the other photometers behaved much differently.
- Photometer #1 only seemed to charge an average of halfway during the night, while photometer #2 barely gained a charge at all.
- The upward spikes during the nighttime, as seen in all graphs, will be discussed

What could have dramatically reduced the change in voltage of photometer #2 after sunset, while the other photometers #1 and #3 were still able to charge after the absence of radiant sunlight?



Photometer #2 was mounted at approximately 64.79 degrees above the horizon. Perhaps the fully inflated balloon prohibited #2 from seeing the small amounts of light from stars. However, #2 did fully integrate at certain times. Was this light reflected off of the balloon, or from a direct light source?

# Integration Time Photometer #2 #3 and #1(unfiltered)



- This graph shows the time it took for each photometer to charge to its reset value for the duration of the flight .
- It is interesting that during the night time photometer #3 took only half the time to integrate as #2 and #3, yet took slightly longer to integrate during the daytime.
- The downward spikes, correlating directly to the upward spikes in the change in voltage graph, raise an interesting question.

# The Moon....



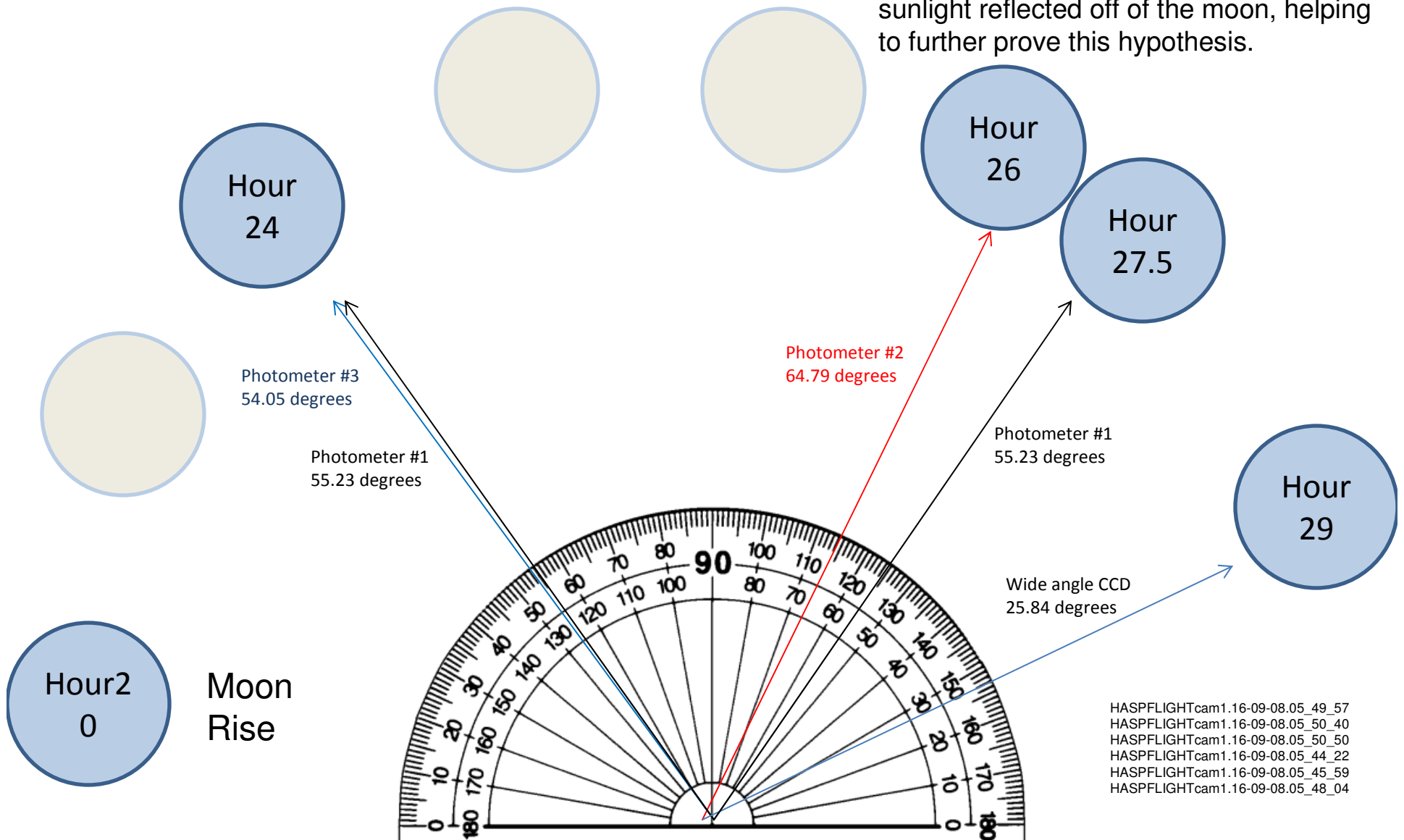
And its effects on the photometer data

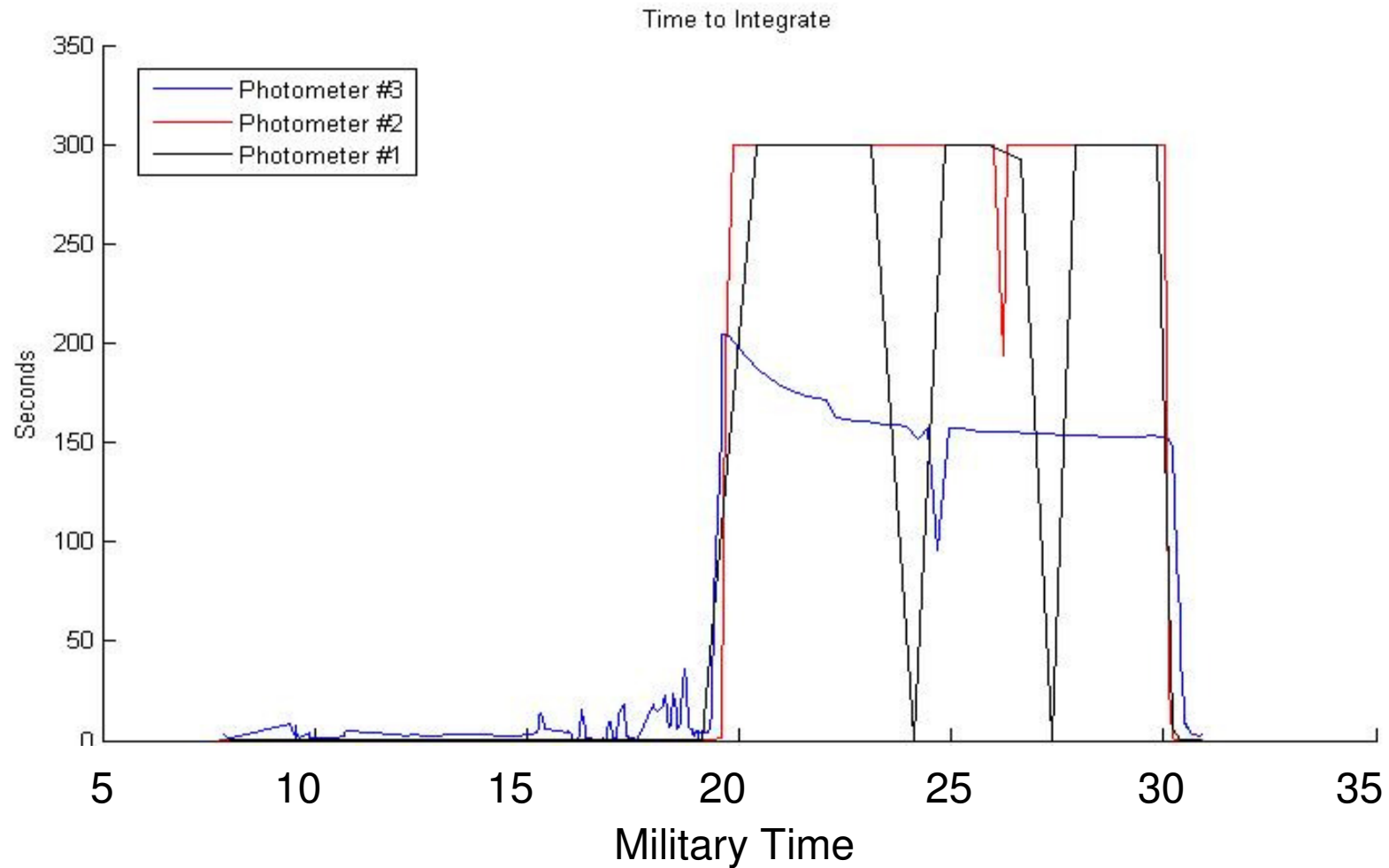
Notice the graph for the integration times for the photometers.

- The sun sets at approximately the 20<sup>th</sup> hour seen by the dramatic increase in the time of integration.
- Each photometer has an interesting spike, indicating a rapid decrease in the time that it took to integrate.
- What bright source of light could have been causing this, and would it make sense to blame the reflection of the sun off of the moon?
- YES! Here's how.....

# Moon Visual

At this point, photometer #1 sees the moon again. This can be explained by the platform rotating so that #1 is oriented toward the moonlight. Soon after this, the wide angle CCD record the intense sunlight reflected off of the moon, helping to further prove this hypothesis.

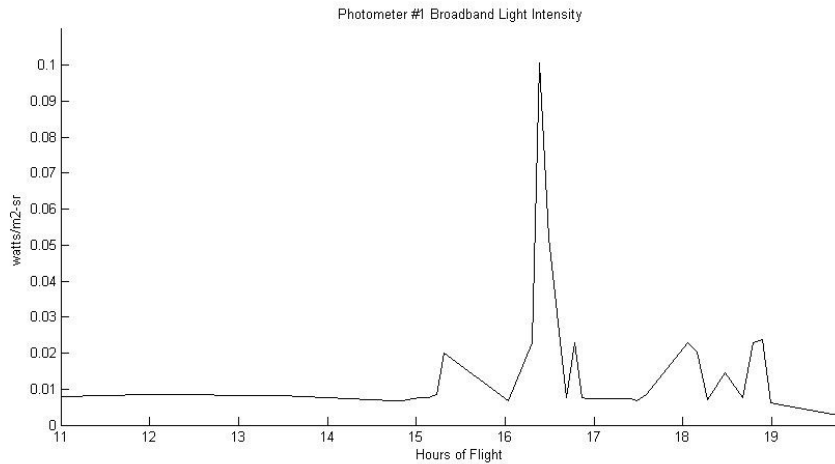




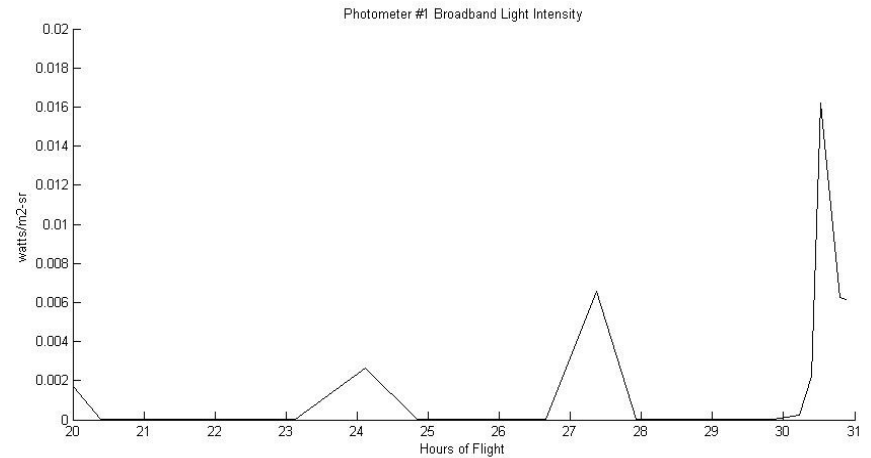
Take another close look to see how the spikes in the graph correspond to the timing of the moon in accordance with the wide angle CCD camera.

# Light Intensity Photometer #1 (unfiltered)

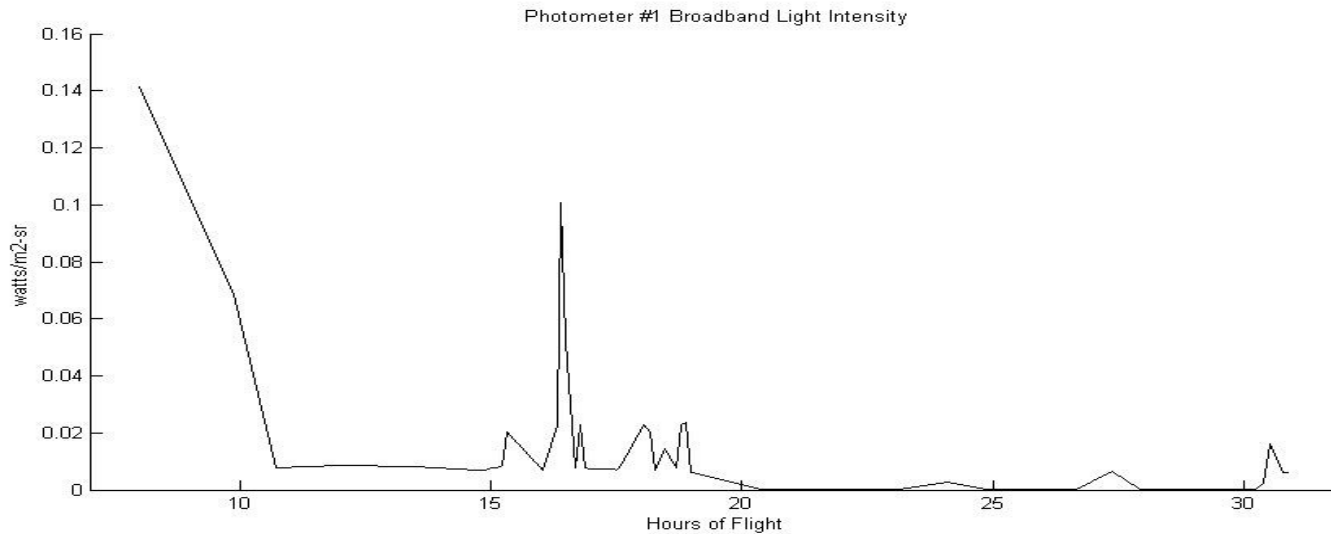
## Day Time



## Night Time



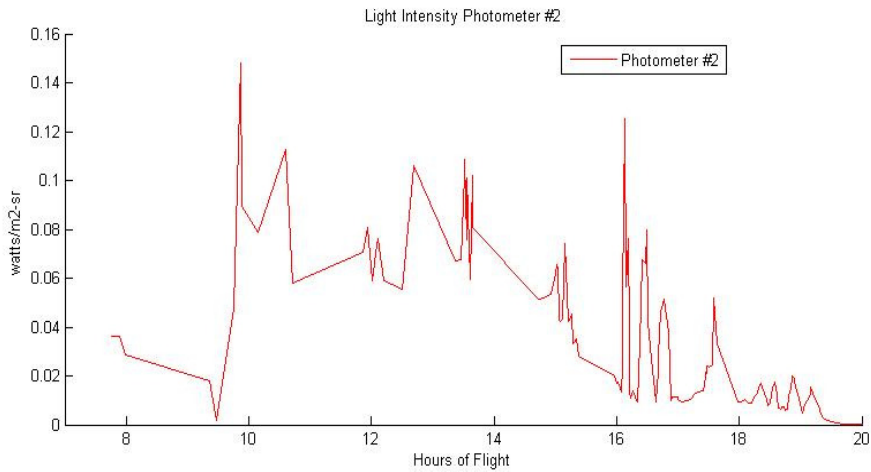
## Entire Flight



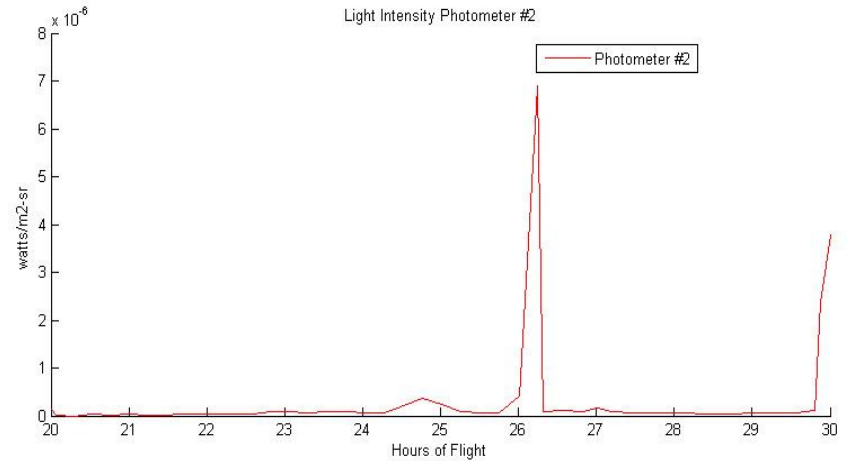
- The light was most intense during launch and around 17 hours.
- During the night, the light intensity was very minimal.

# Light Intensity Photometer #2

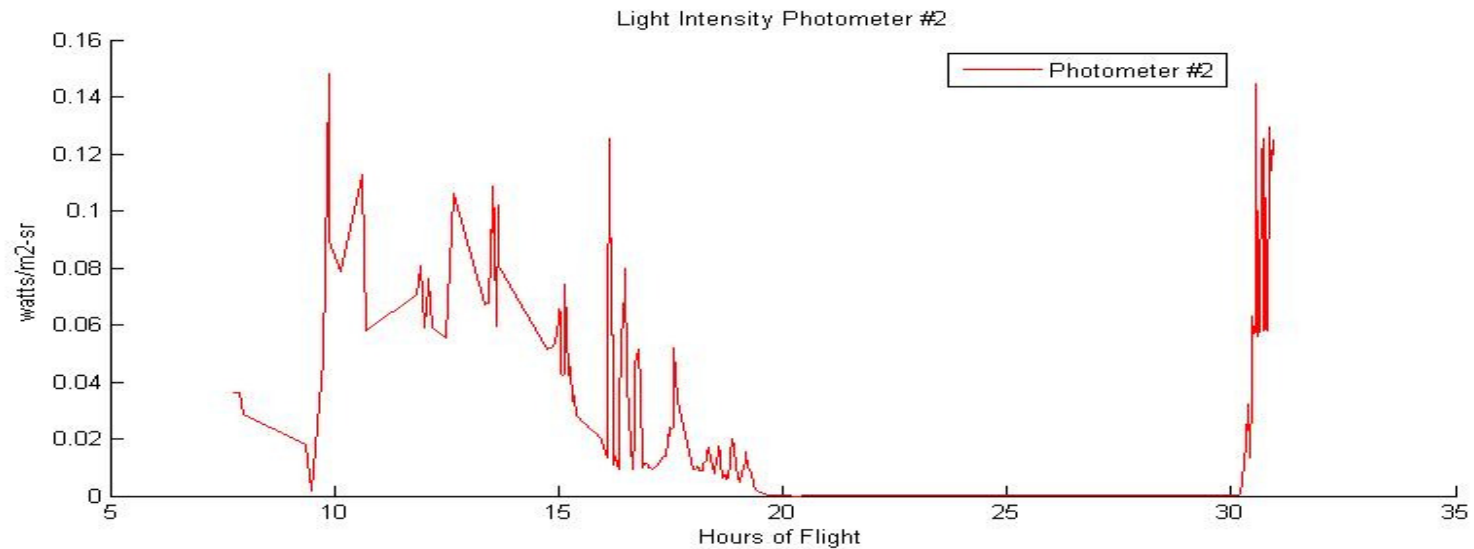
## Day Time



## Night Time



## Entire Flight



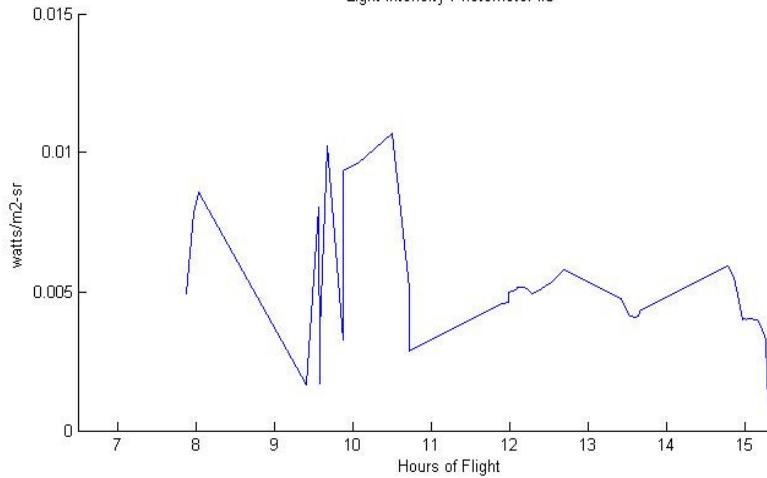
- The light intensity readings for photometer #2 are considerably higher throughout the day than the other photometers.



# Light Intensity Photometer #3

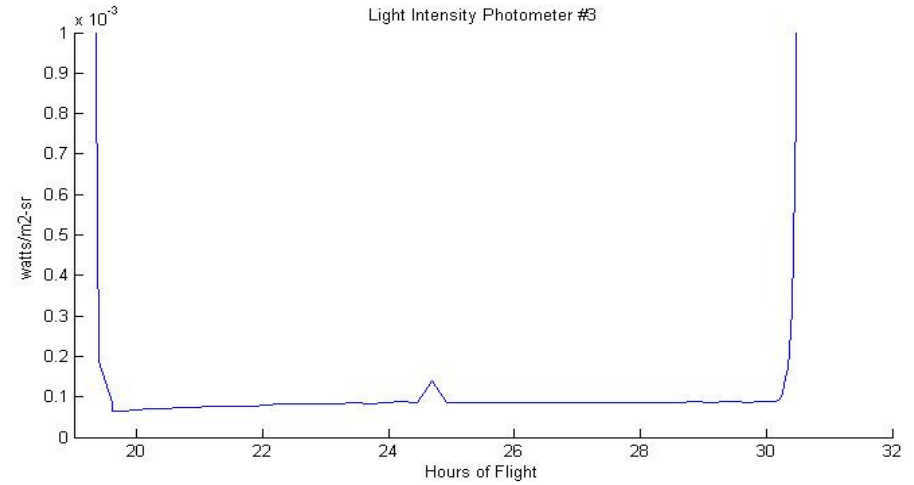
## Day Time

Light Intensity Photometer #3



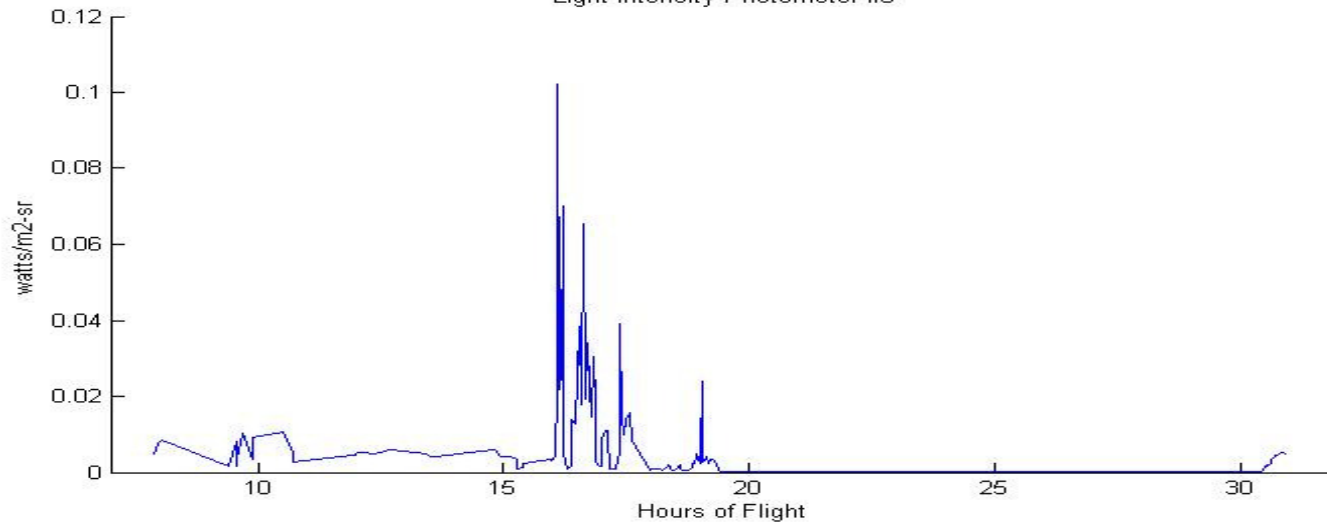
## Night Time

Light Intensity Photometer #3



## Entire Flight

Light Intensity Photometer #3

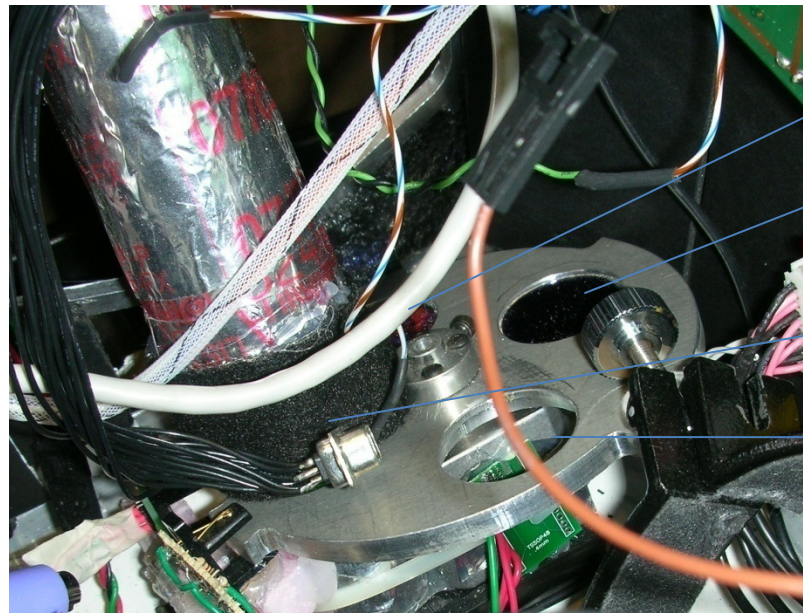


- Photometer #3 has a spike in light intensity from 15 to 20 hours of flight.

# Photometer #1 Filter Wheel

- Photometer #1 was equip with four filters connected to a stepper motor.
- The different filters were:
  - 0-No Filter: all wavelengths
  - 1-Green (visible): 495–570 nm
  - 2-Red (visible): 620-750 nm
  - 3-Infrared: 750-1000 nm

During the flight, an error was received about the functioning of the filter wheel. It is highly possible that the wheel may not have been changing filters during flight. From the data found in the sections below it is evident that there is no real difference between the light captured by the different filters.



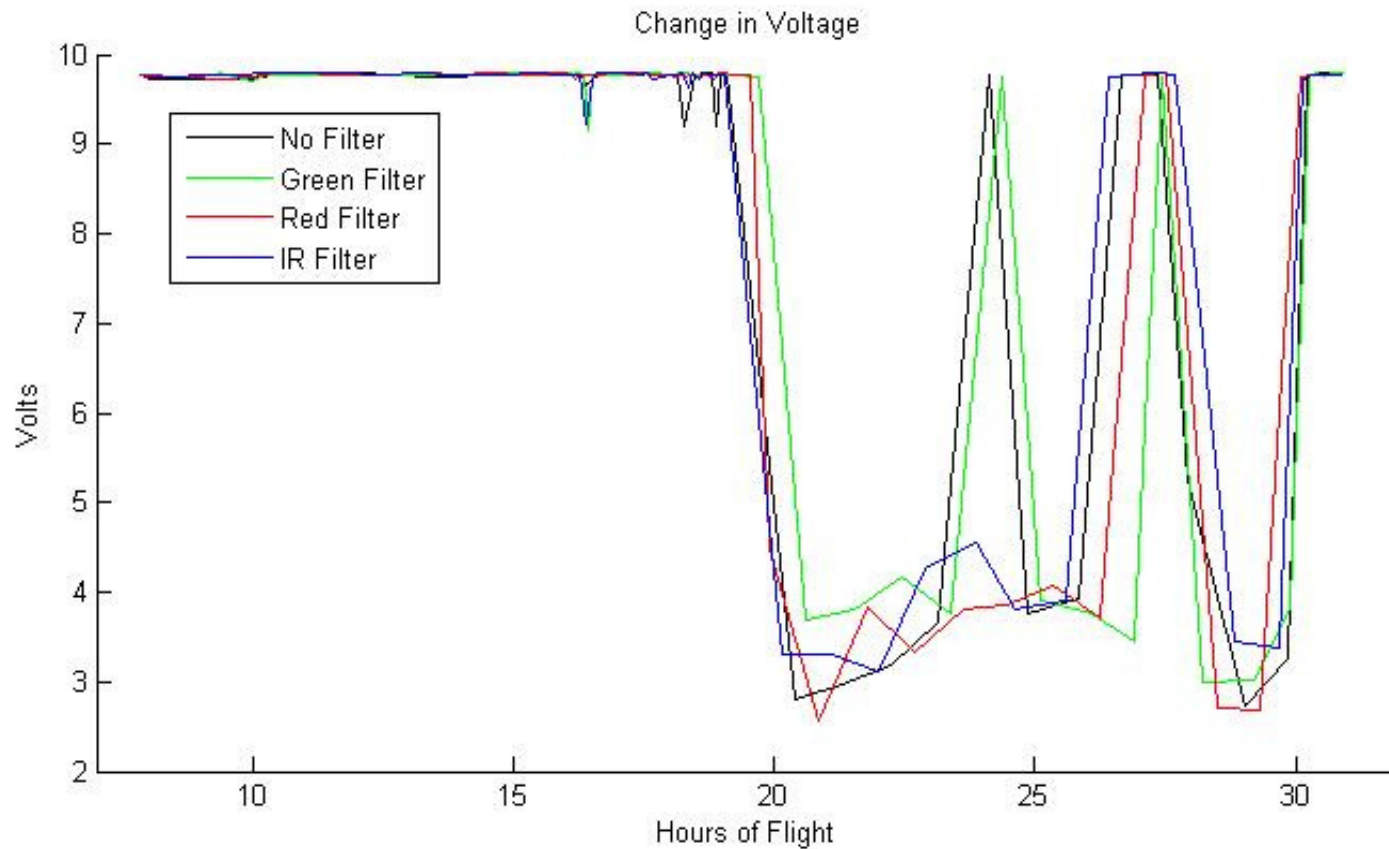
Red Filter

IR Filter

Green Filter

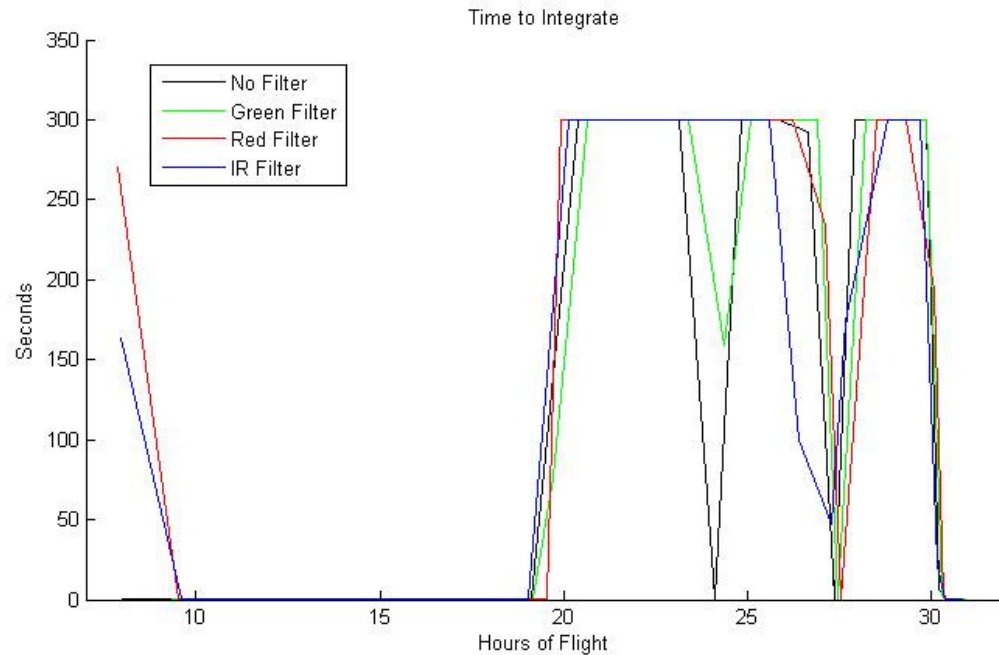
No Filter

# Change in Voltage of Filter Wheel Photometer #1



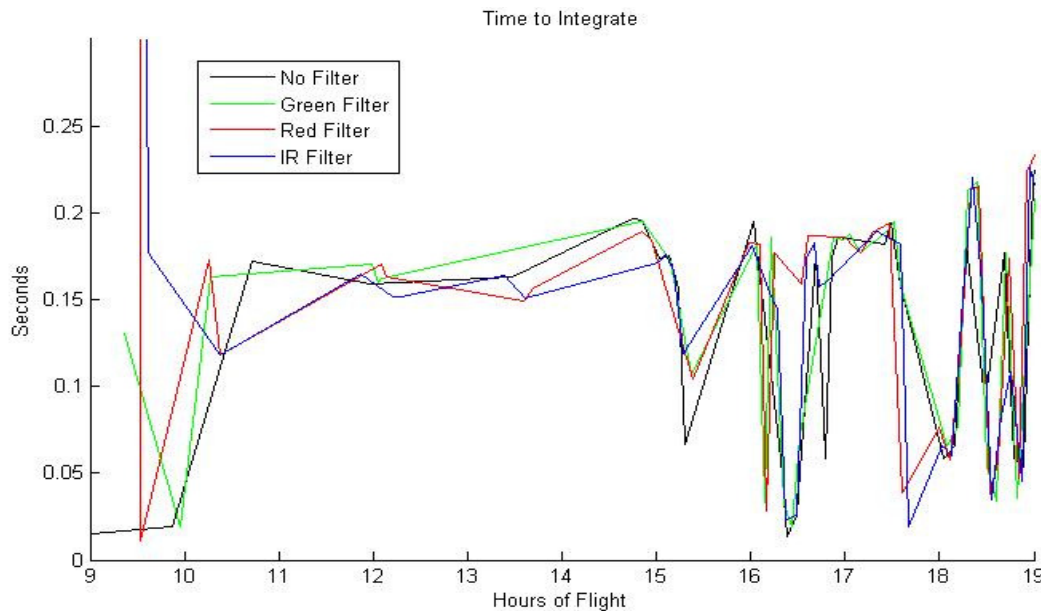
- During the day all colors seemed to charge to their full potential.
- All filters seems to follow the same basic pattern.

# Integration Time of Filter Wheel Photometer #1



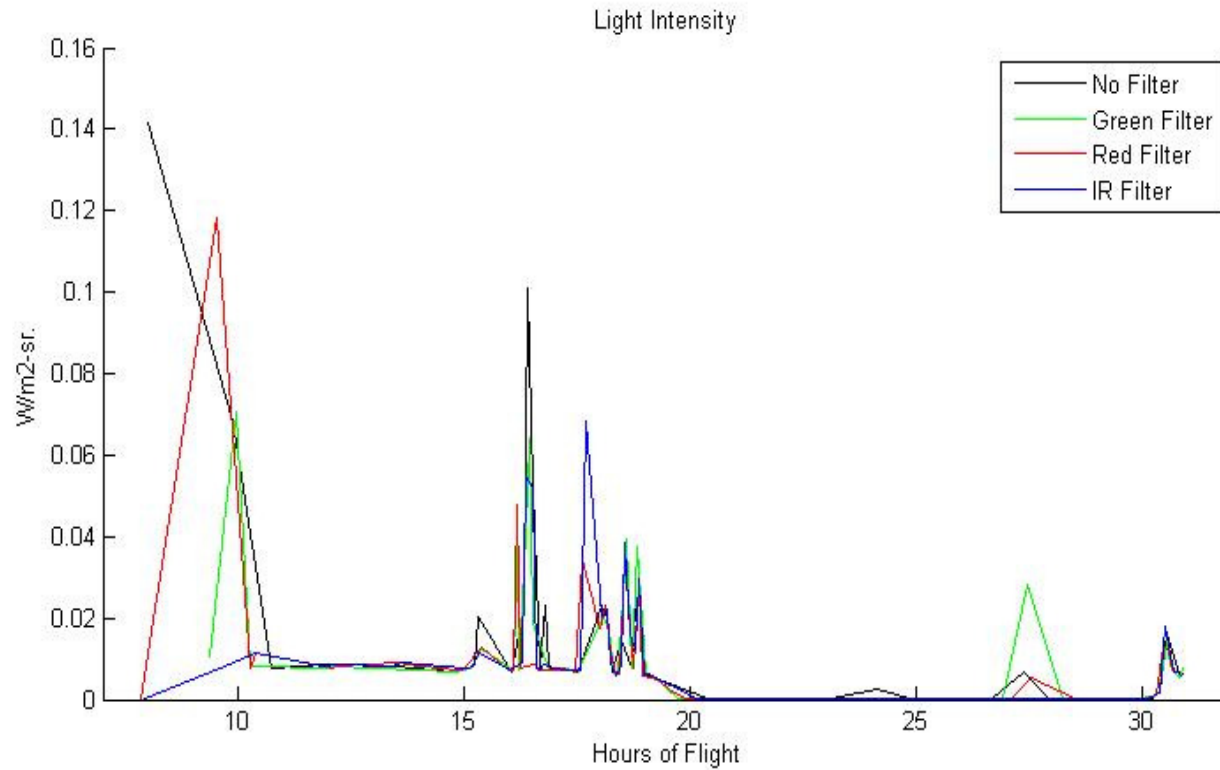
These graphs show the integration time for the filter wheel photometer for the entire flight and zoomed in to see the fluctuation during the day.

← Entire Flight



← Daytime

# Light Intensity of Filter Wheel Photometer #1

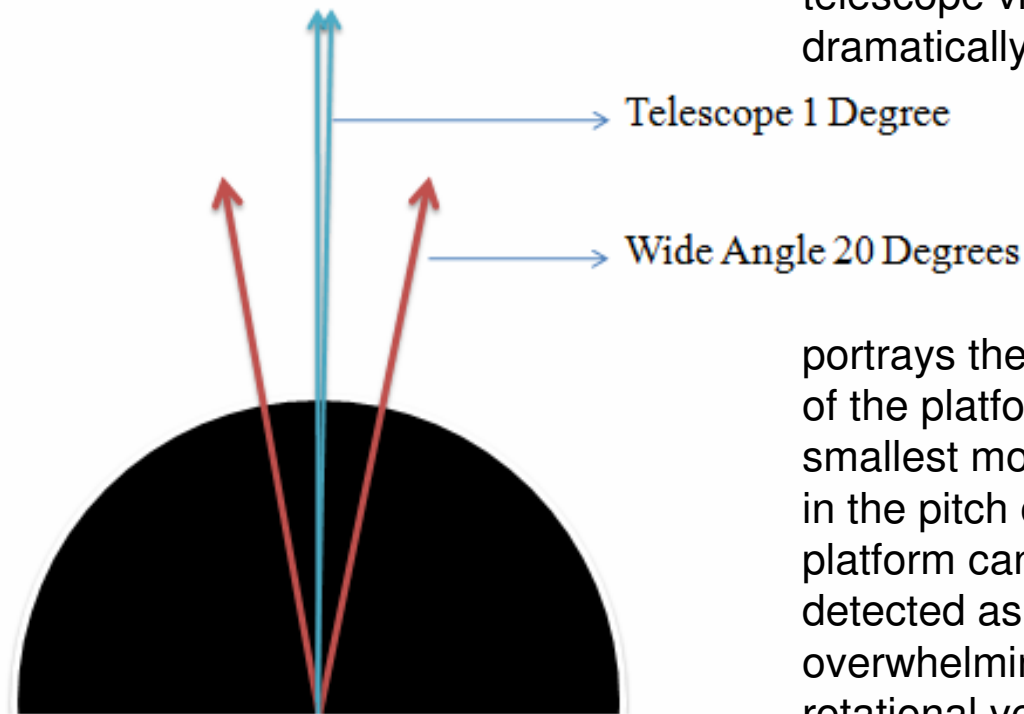


- The light intensity for each filter is also very similar.

## Telescope vs. Wide Angle Field of View

- This represents the difference in the fields of view between the telescope and the wide angle CCD camera.

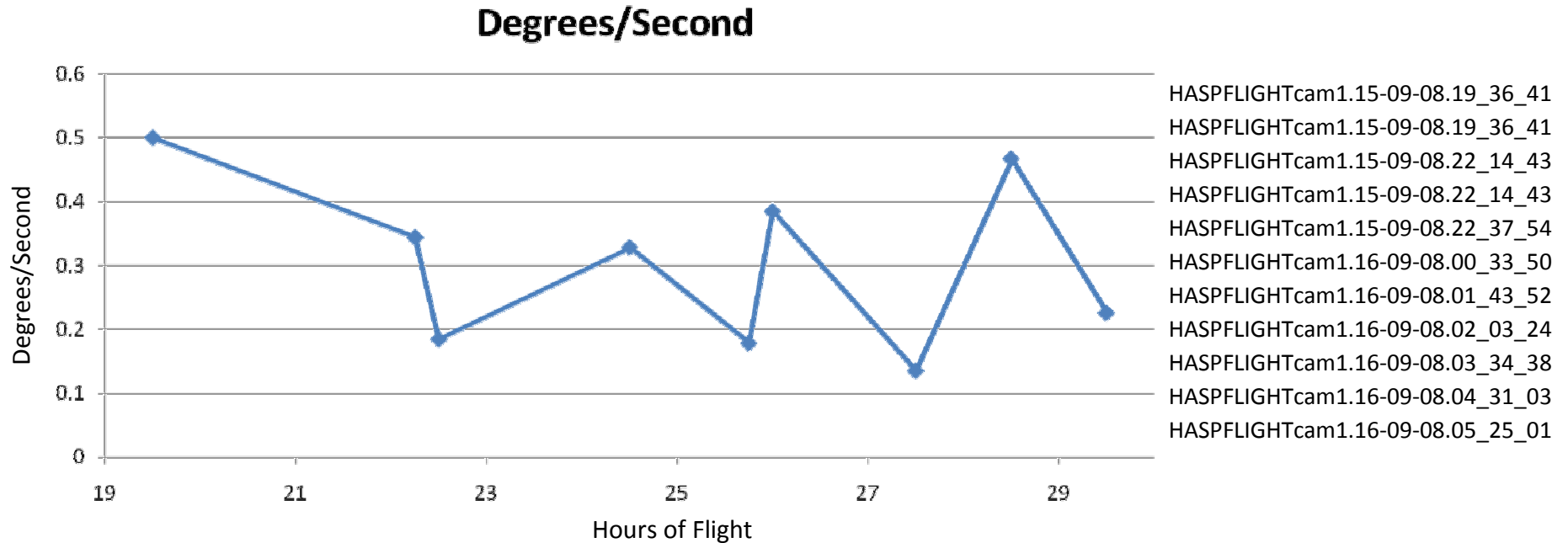
- With a field of view at **20 degrees, the wide angle video** portrays the rotational velocity of the platform as well as capturing video of larger groups of stars and occasionally recognizable constellations like Orion.



At a **1 degree field of view, telescope** is only able to capture pieces of constellations. More interestingly, the telescope video dramatically

portrays the stability of the platform. The smallest movements in the pitch of the platform can easily be detected as well as an overwhelming rotational velocity at times.

# Rotational Behavior of Platform



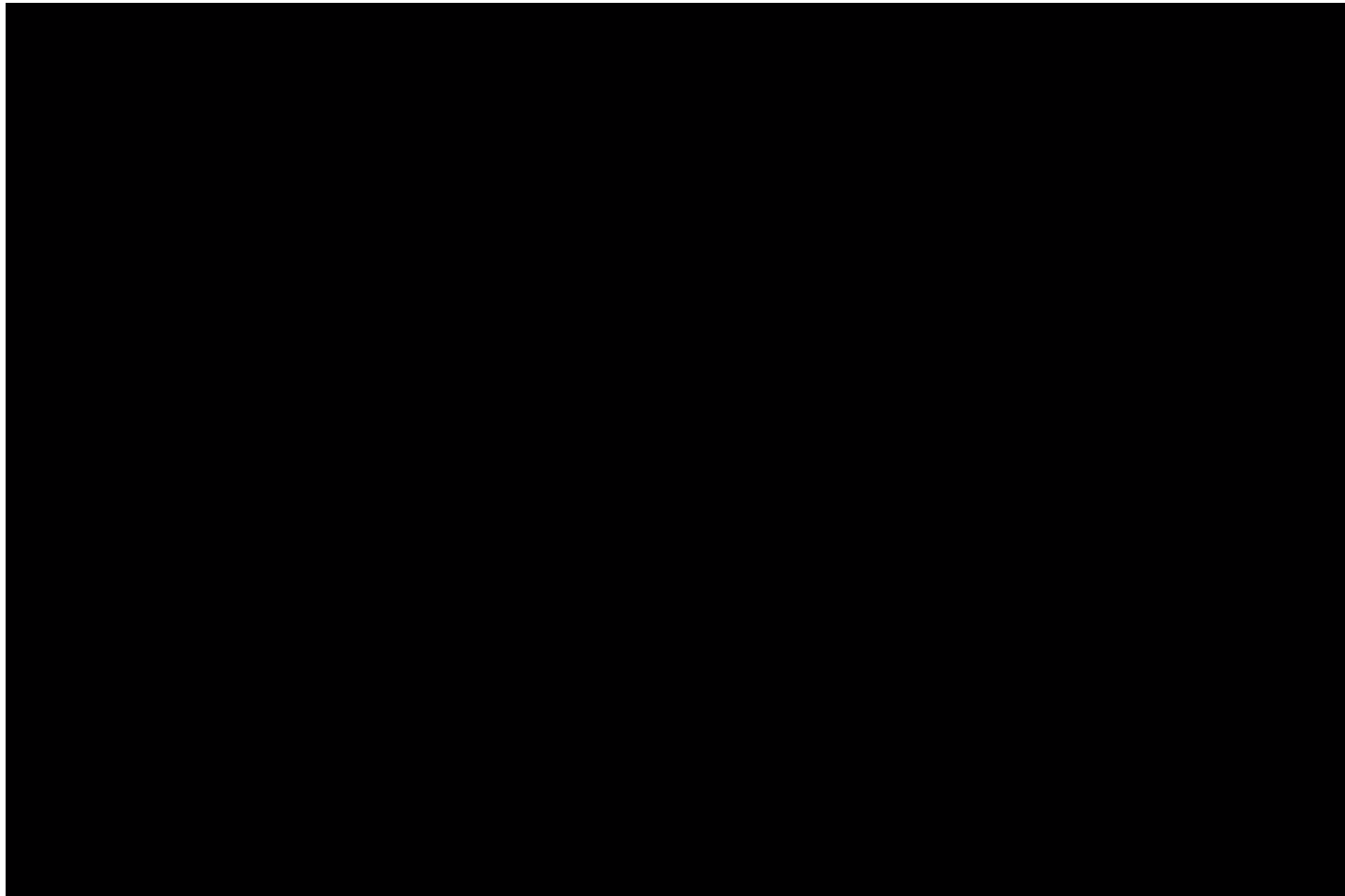
- Using the stars in the night time videos the rotational velocity in degree change per second was calculated.
- There seems to be no definite trend in the data, concluding that upper atmospheric winds may change the rotational speed sporadically.



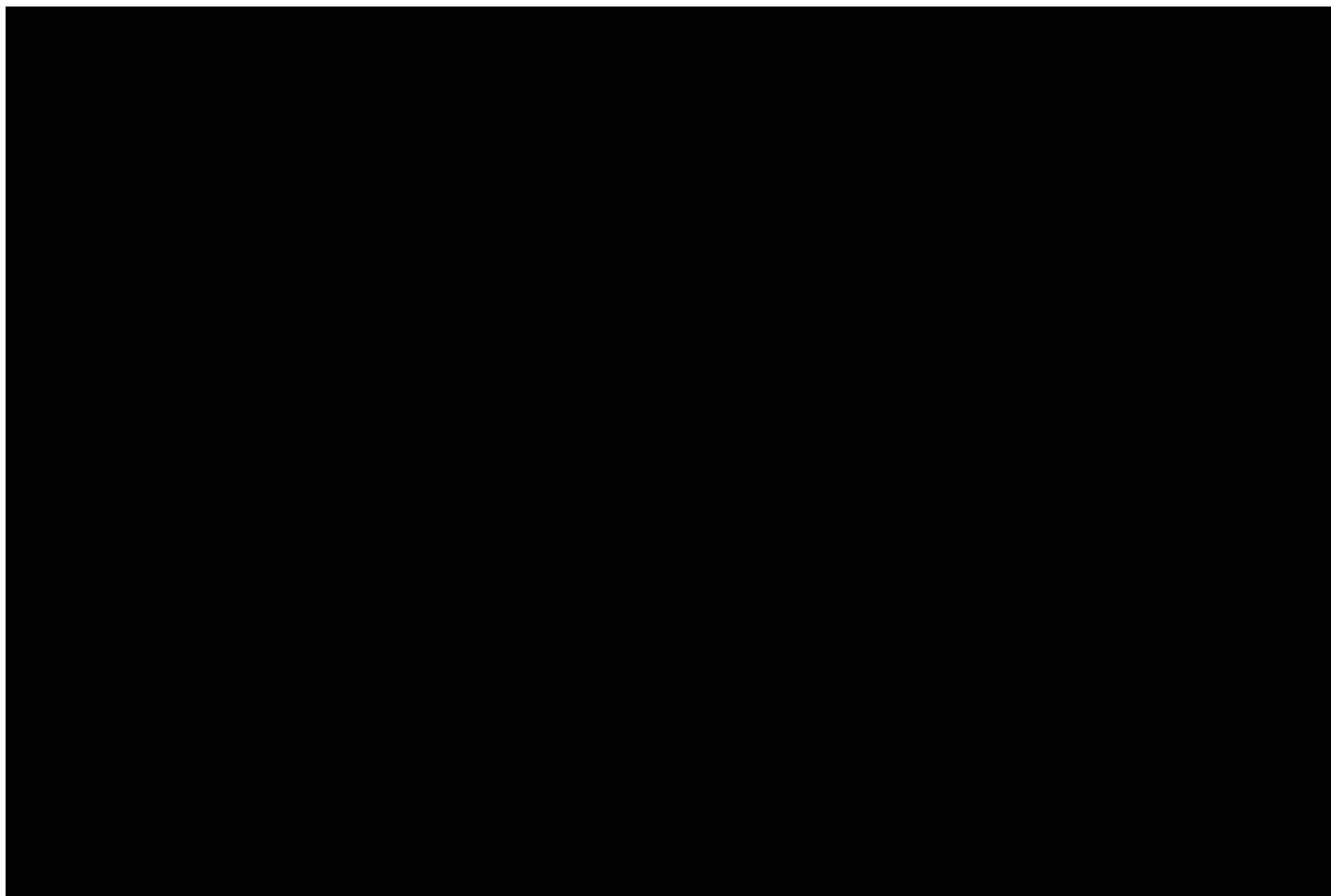
Stars seen from  
the telescope CCD  
video



HASPFLIGHTcam2.16-09-08.03\_26\_26 platform rotates one way then the other

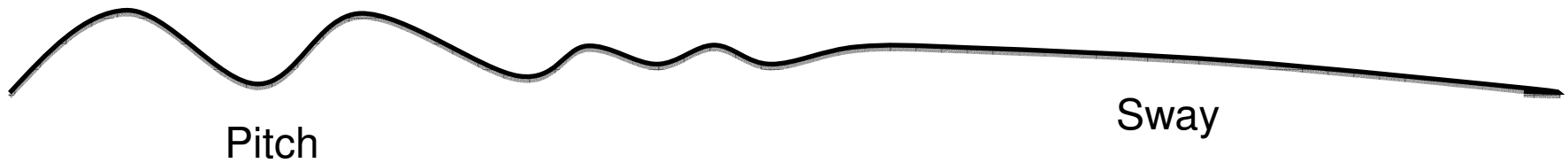



HASPFLIGHTcam2.16-09-08.01\_34\_28 great pitch movement



The pitch of the stars in the telescope video fluctuate anywhere from 0 % to 18 % of a degree. On average, the stars fluctuate in a 5 to 6 % range

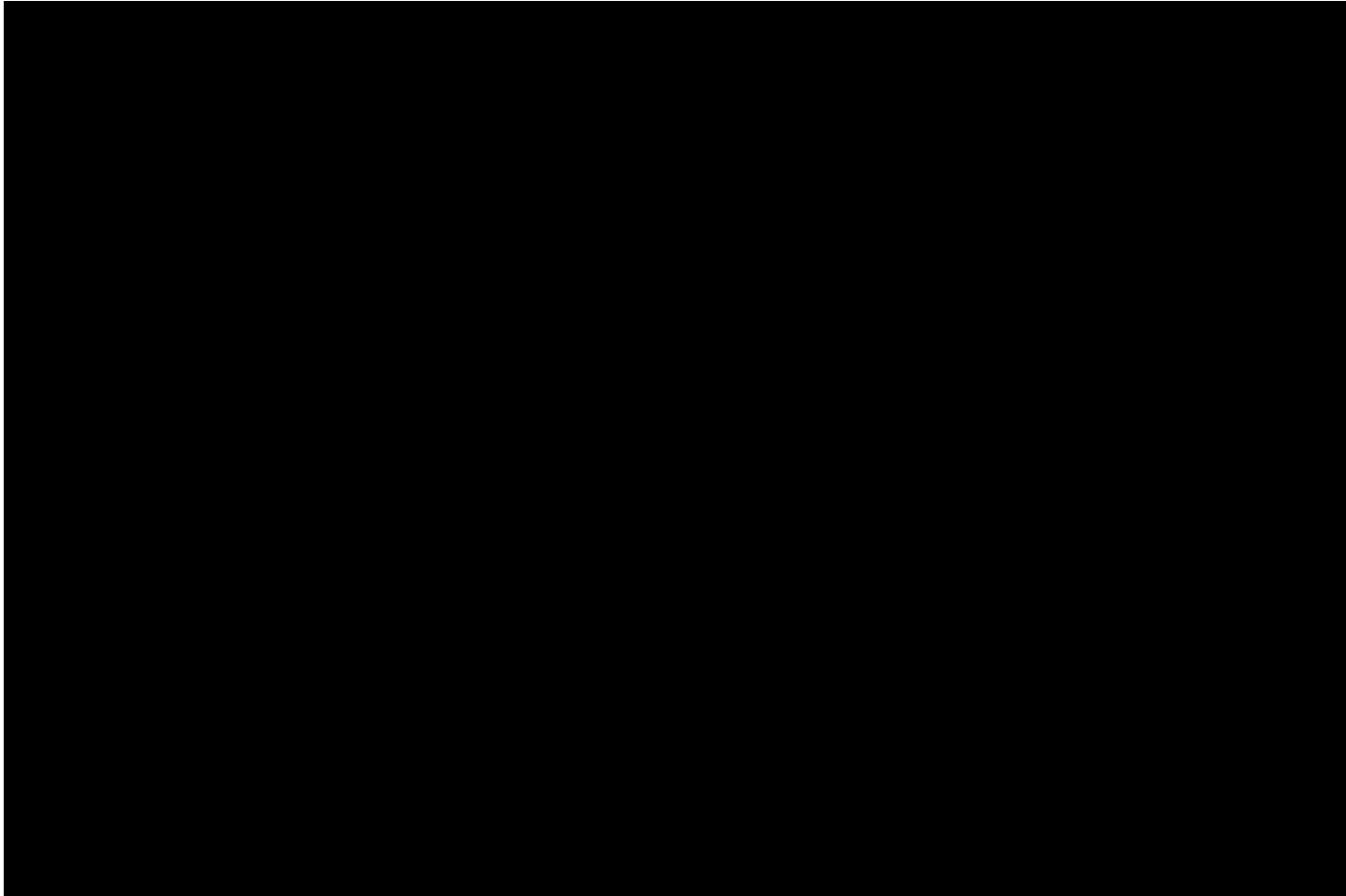
The extremely large surface area of the telescope will be affected much more dramatically by air currents, causing the platform to pitch and sway, resulting in the movements of stars across the screen shown here:



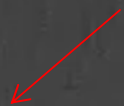


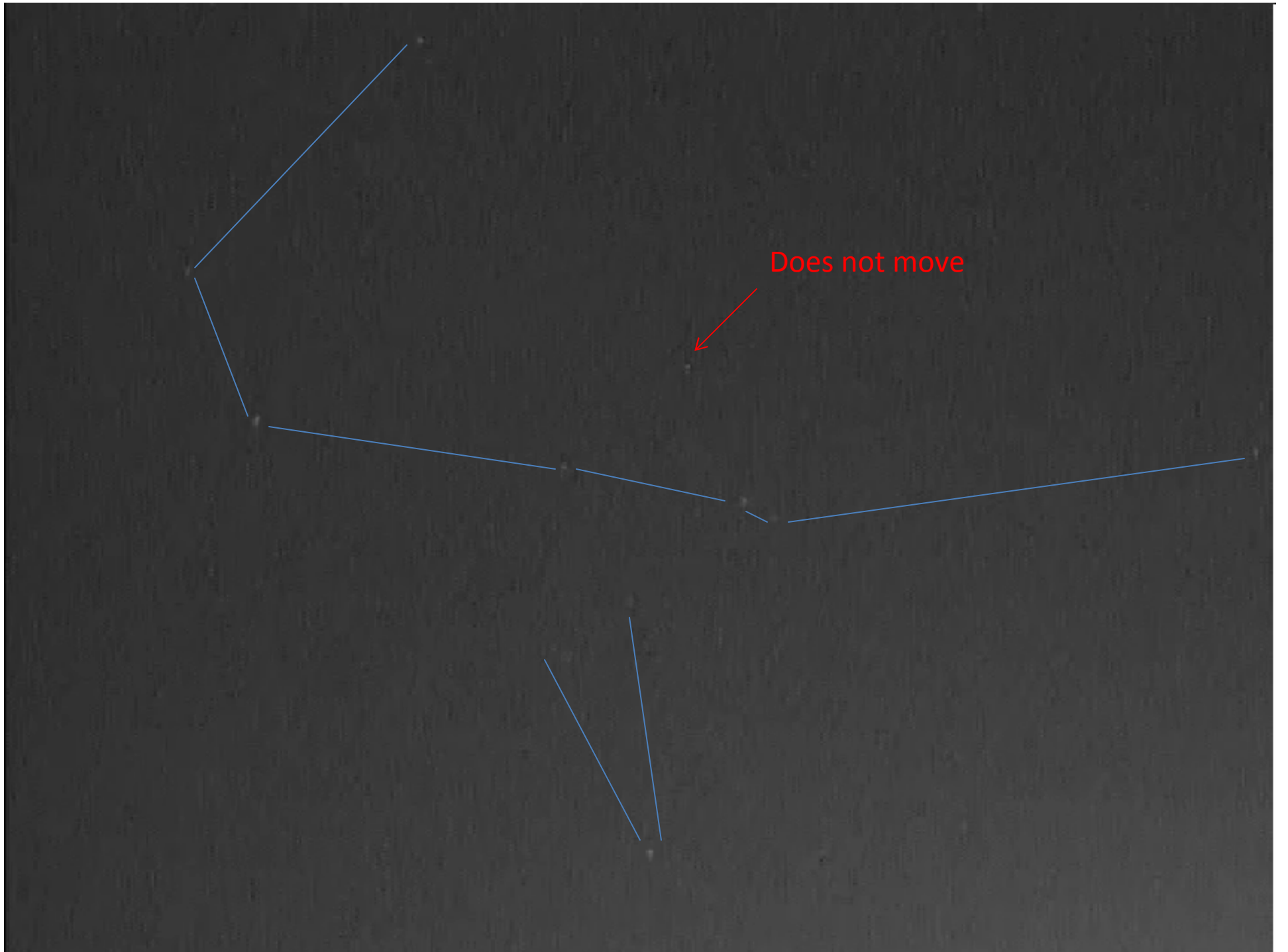
Constellations  
seen from the  
wide angle  
CCD

HASPFLIGHTcam1.15-09-08.19\_36\_41 Grey sky, visible stars

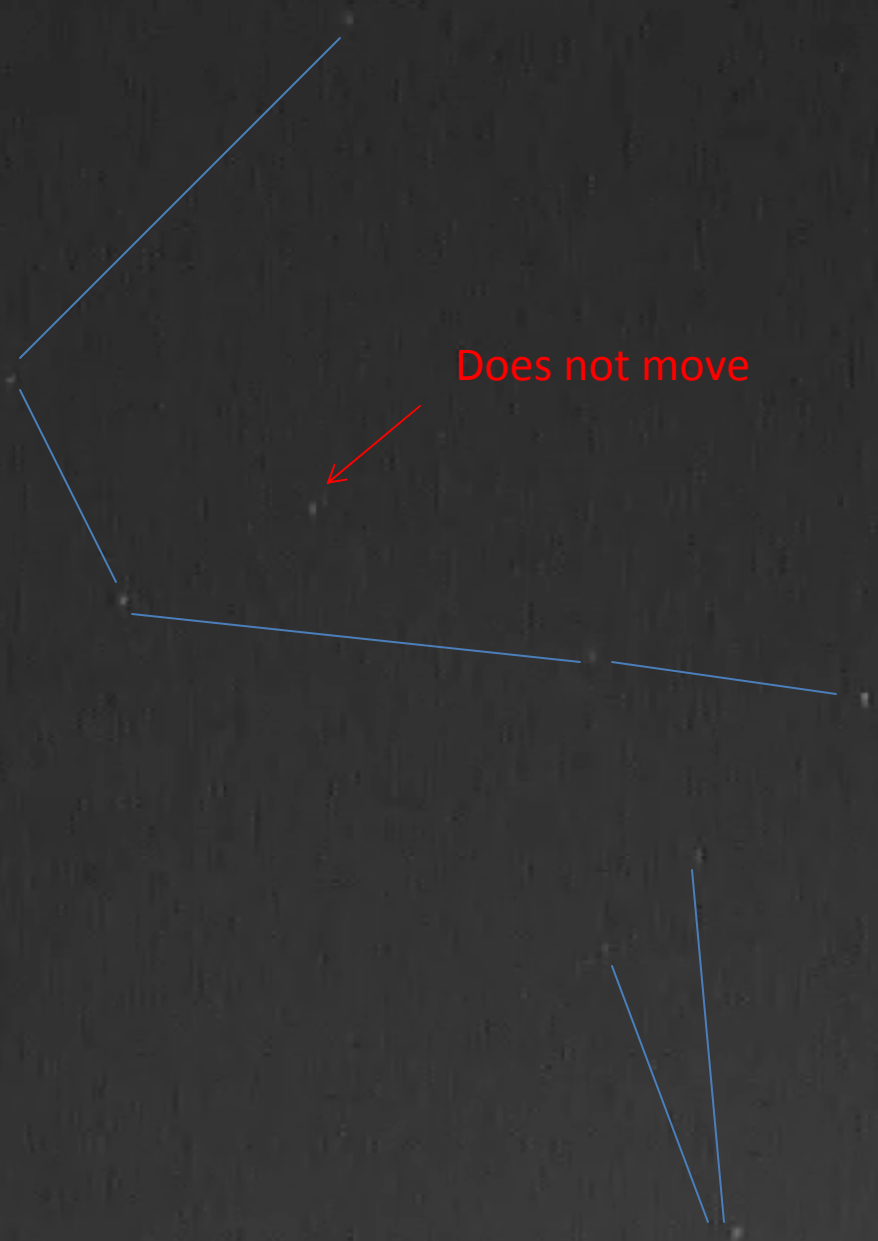


Does not move



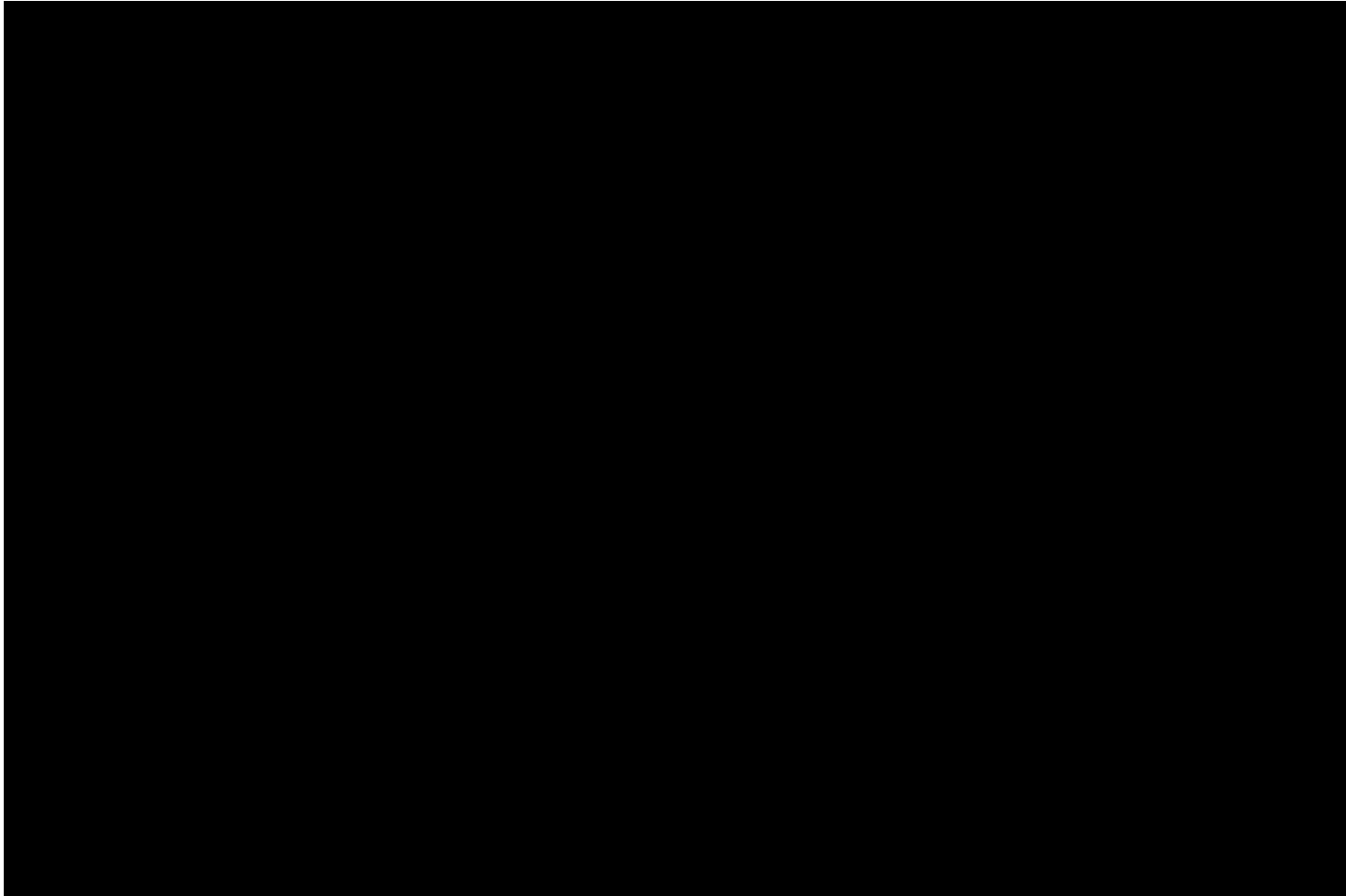


As the platform rotates, this formation of stars moves across the field of view. However, one relatively bright spec stays stationary.





HASPFLIGHTcam1.15-09-08.22\_14\_43 Group of stars

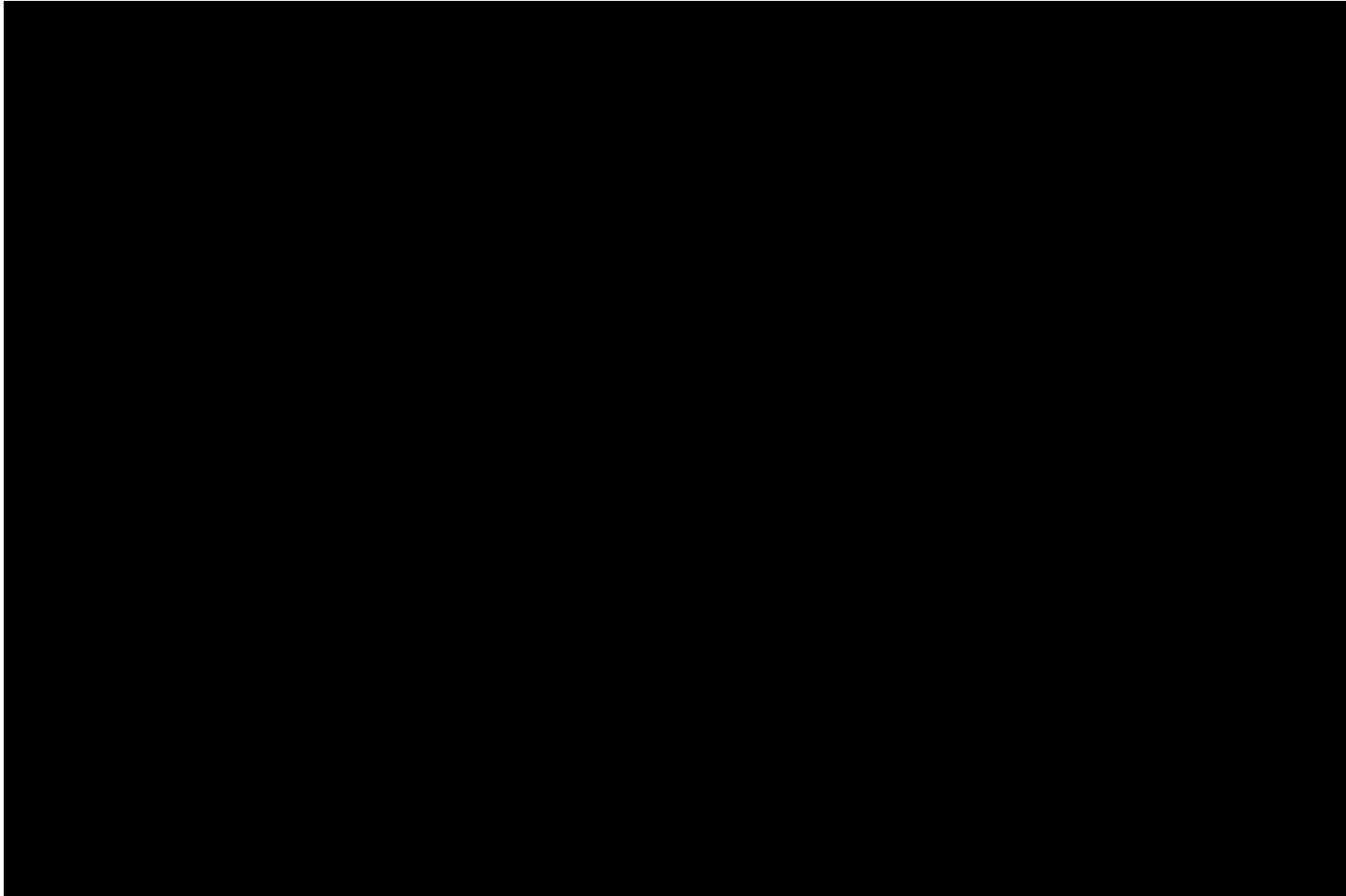


Same eleven stars as the past video, except  
the platform is oriented slightly higher in  
altitude

HASPFLIGHTcam1.15-09-08.22\_37\_54




HASPFLIGHTcam1.16-09-08.02\_03\_24 Orion



# ORION

HASPFLIGHTcam1.16-09-08.02\_03\_24





HASPFLIGHTcam1.16-09-08.03\_52\_59

This formation of stars  
may be the ladle to  
the Big Dipper or  
perhaps the little  
dipper

HASPFLIGHTcam1.16-09-08.04\_31\_03



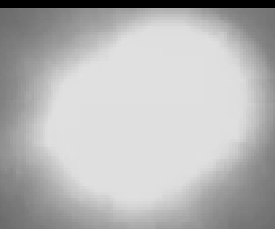
# The Moon and stars

HASPFLIGHTcam1.16-09-08.05\_48\_04



Like the grey videos, stars can still be seen with intense reflection of the sun off of the moon.

HASPFLIGHTcam1.16-09-08.05\_49\_57







Questions?