

# HIGH ALTITUDE BALLOONING DURING THE 2017 SOLAR ECLIPSE

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## INTRODUCTION

On August 21st in 2017, the day of a transcontinental total solar eclipse, the UMDBPP conducted a special flight in Greenville, South Carolina. This flight carried sun-facing cameras and instrumentation with the intent of observing and documenting the eclipse from a high altitude. The flight launched from Williamston, SC at 13:57 EDT, took 80 min to reach burst altitude, burst at ~105 000 ft (approx. 32 000 m) altitude at 15:17 EDT, then spent 35 min descending, during which it reached maximum speeds of 68 m/s. The balloon experienced totality at 14:38 - 14:41 ETC, and the payload string subsequently landed at 15:52 EDT, 24 km away from the launch site.

## FLIGHT PROCEDURE

Ground tracks close to the center of the path of totality were preferred in order to capture a longer period of totality and to guarantee that the balloon experienced totality at a reasonable altitude. Trajectory predictions run at T-2 weeks suggested the balloon would follow a generally east-west path, permitting down-selection of launch sites. The eventual launch site was selected on the evening before the launch.

The target altitude for the balloon when the eclipse reached totality at 14:37 EDT was approximately between 60 000 ft (~ 18 000m) and 80 000 ft (~ 24 000m), giving a 15 min launch window. The main goal was for totality to be before balloon burst, thus ensuring that payloads were in a stable orientation while collecting data. Lower altitude was preferable to bursting early. Although inflation started 1 h before launch, the balloon launched at 13:57 EDT, 5 min after end of the original launch window. This resulted in the balloon being slightly below targeted altitudes.

## RECOMMENDATIONS

An improvement in launch site selection would be to consider that the location of the umbra is not the same at ground level as at altitude, and can in fact vary by more than 10 km. The launch site for this flight was selected because it was near the center of the umbral path, so any deviations from the predicted trajectory were fortunately expected to keep the balloon within the umbral path. However, including this as a factor in site selection is a necessity for future flights.

Additionally, the rarity of solar eclipses warrants more thorough payload testing, ideally on a balloon flight, in order to ensure that launched payloads collect the most useful data possible. Most of the payloads on this flight collected useful data, but the quality of some of the data was significantly degraded due to issues that would have been identified during testing in an operational environment. For example, the camera settings on the PARROT payload were suboptimal for capturing clear images of the sun, and some of the sensors on LEOPARD suffered from saturation effects.



Still frame from a video taken by the Panoramic payload, showing approaching umbral shadow 97 s before totality.

## PAYLOAD OVERVIEW

### Tracking

Enables tracking of balloon flight path via [aprs.fi](http://aprs.fi) and [tracker.habhub.com](http://tracker.habhub.com). The onboard system also includes a backup cell tracker.

### SESPA

*Solar Eclipse Solar Power Analyzer*  
Designed to analyze net coronal power output in visible light and measure eclipse progress by tracking voltages generated by lightweight solar panels.

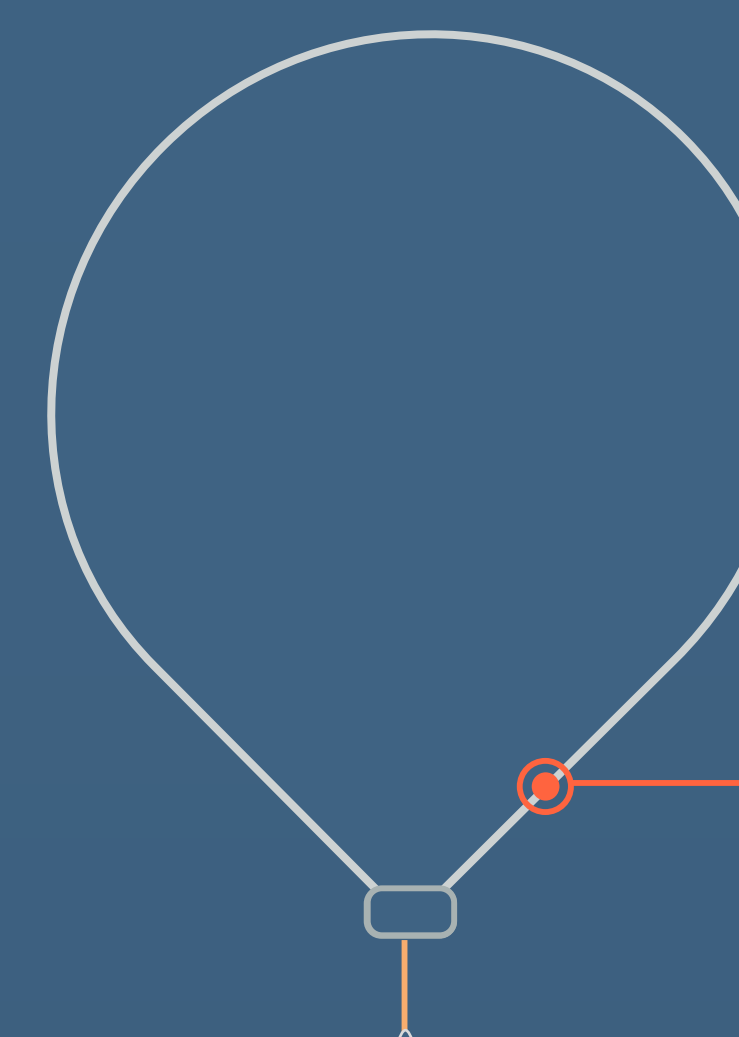
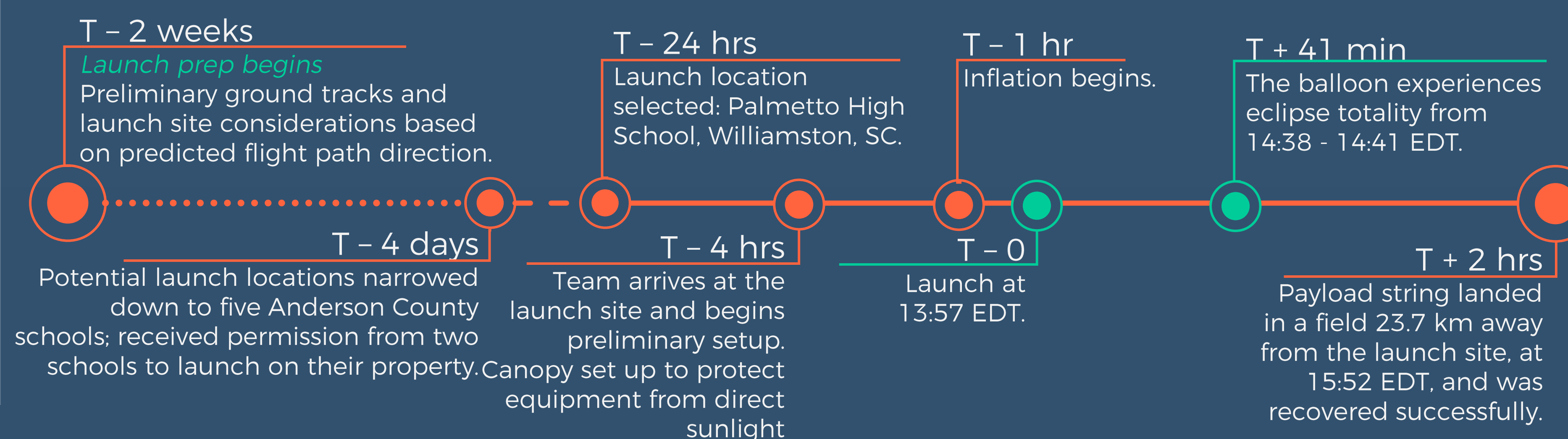
### ATOMIC

*Atmospheric Thindown Originating Mutagenesis Investigational Capsule*  
Designed to analyze the effect of atmospheric ionizing radiation on the development of mutations in micro-organisms. Carried sealed agar-plate cultures of two species of bacteria - *Bacillus subtilis* and *E. coli* - during eclipse conditions.

### Panoramic

Comprised of two Samsung Gear 360 v1 cameras housed in insulating foam that captured panoramic video of launch, ascent, totality, and balloon burst.

## TIMELINE



### 1600g balloon

Used to attain a 60 000 ft target altitude during totality. During eclipse totality, the balloon ascended between ~ 53 000 ft (approx. 16 000 m) and ~57 000ft (approx. 17 000m). Attached to an 8ft Rocketman parachute and the payload string.

### PARROT

*Payload Angled Reasonably Reclined to Observe Totality*  
A structure of four GoPro Hero3 cameras angled at 63° elevation from the horizon with a solar filter fitted to observe the eclipse during totality.

### IRENE

*Ionizing Radiation Exposure Nearspace Experiment*  
A small, cylindrical, full metal Geiger-Muller tube detector sensitive to  $\gamma/\beta$  ionization events and intended to measure the Pfozter maximum in the upper atmosphere.

### LEOPARD

*Lightweight Eclipse-Observing Payload for Ambient Radiance Determination*  
Designed to measure ambient light intensity during flight using photodiode-based sensors, specifically a TAOS TSL2561 lux sensor, TCS34725 color sensor, and SiLabs SI1145 UV index and light sensor.

## RESULTS

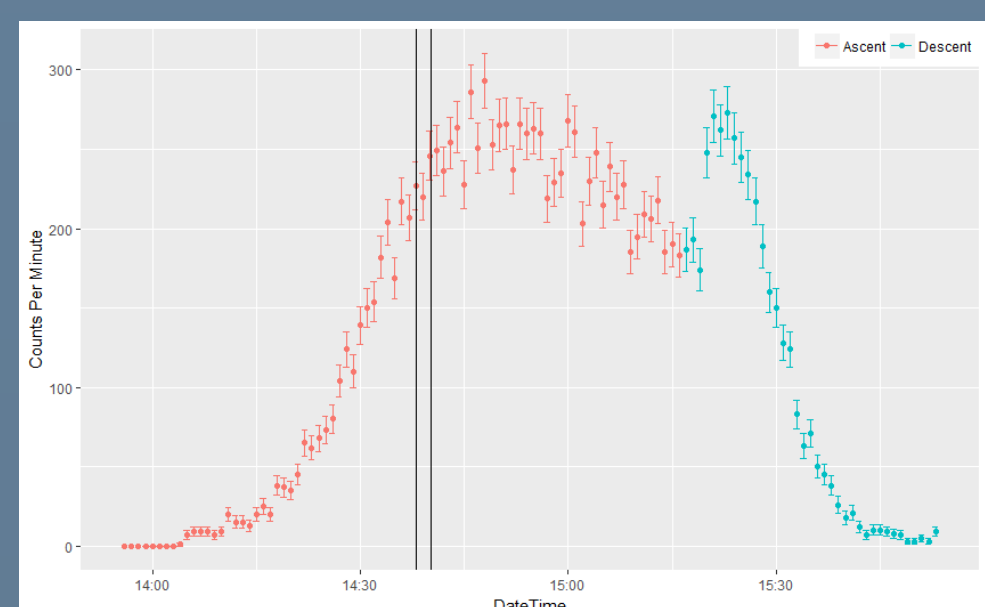
### ATOMIC

The bacteria were re-cultured in liquid media, and cryogenic stocks were prepared for later study. Qualitative observation of the bacterial morphology and colony sizes over time did not indicate any significant change from the control, although genetic sequencing will be necessary in order to ascertain the presence or absence of mutations in flight vs control samples.



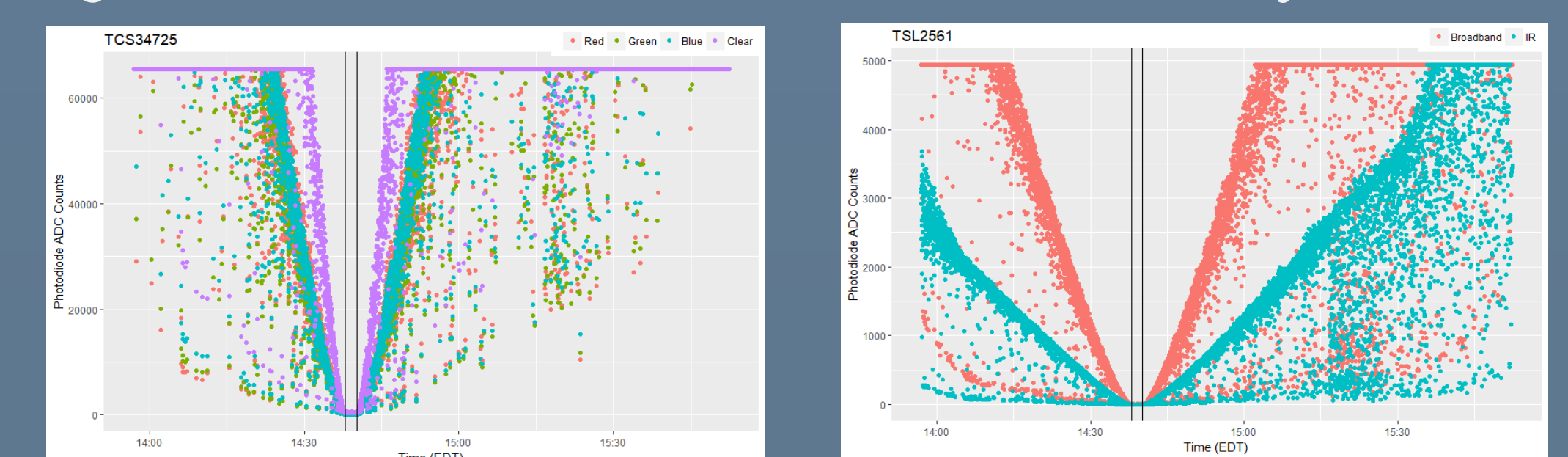
### IRENE

The results (at right, a graph of radiation event counts vs time) suggest that the eclipse did have a momentary effect on the intensity of the ionizing radiation in the high upper atmosphere, albeit small. They indicate a slight difference between totality and post-totally values at comparable altitudes, as evidenced by a portion of points' error bars not overlapping for similar altitudes.



### LEOPARD

Both the TSL and TCS saturated before the eclipse ended, and the SI1145 failed to function properly, so it is not meaningful to quantify the rates at which the available light changed. Nonetheless, the valid sensor data indicated a marked decrease in available light in throughout the visible and infrared bands near totality.



Above are the graphs with the color sensor (left) and lux sensor (right) data from LEOPARD. Vertical lines indicate totality.

### SESPA

From the collected data, it is estimated that  $1.17 \times 10^{-4} \%$  (13.72% uncertainty) of available sunlight reached the sensor. Considering that the solar cells have an efficiency rating of nearly 15%, maximum coronal irradiance reaching the sensor during totality is estimated to be  $6.249 \times 10^{-4} \text{ W}$ .

## ACKNOWLEDGEMENTS

The authors would like to thank Dr. Mary Bowden for her leadership and guidance with the UMD Balloon Payload Program. The authors would also like to thank the UMD Clark School of Engineering for funding travel and materials for this flight, the Maryland Space Grant Consortium for funding the UMD Balloon Payload Program since its inception in 2003, Xavier Jubier for his insight on calculating umbra locations and permission to use his graphics, Michael Walker for writing the section on IRENE, and Akshay Menon and Michael Schwab for writing the section on SESPA.



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