# A Multiple Payload Carrier for High Altitude Ballooning

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# A multiple payload ballooning platform

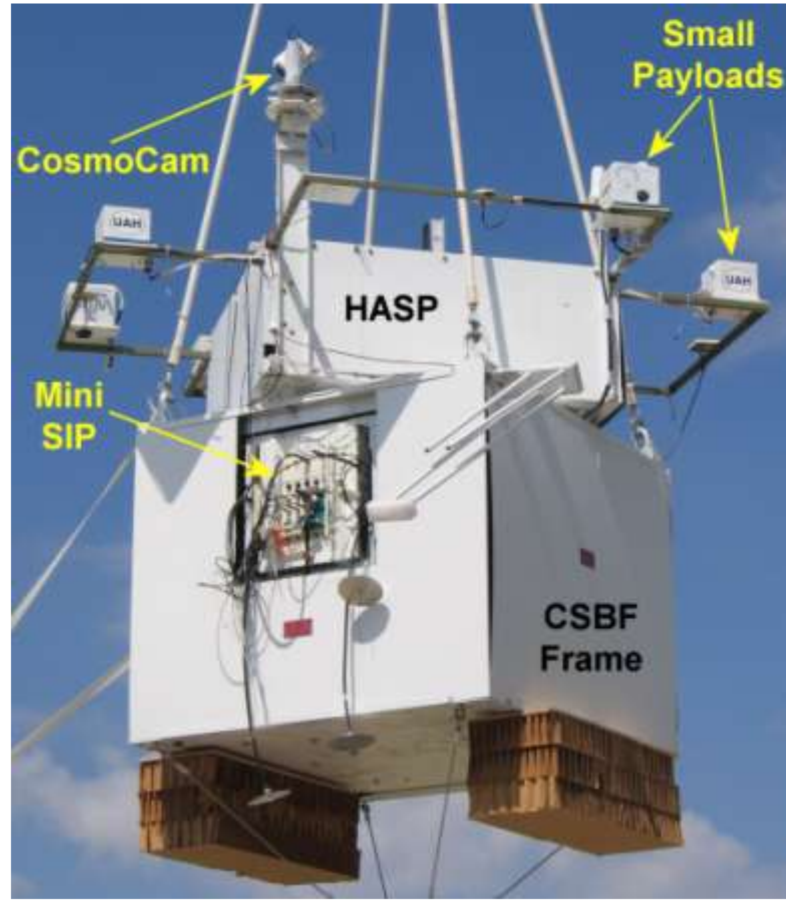
- The current scientific balloon flight model is that each experiment corresponds to a separate balloon payload.
  - This generally includes developing custom systems for the balloon payload as well as the experiment.
  - This development (or refurbishment) of balloon payload systems can add years and millions of dollars to the cost of an experiment.
- This model may need to be used for large aperture or heavy experiments.
- However, lighter, smaller packages could be clustered on the same platform and take advantage of common resources
  - A standardized power, telemetry and commanding interface enables the research group to focus on instrument development.
  - Potentially lowers overall experiment cost and improves turn-around time.

# The High Altitude Student Platform (HASP) is a model multi-payload carrier

- HASP is the first balloon carrier specifically designed with a standard interface to carry multiple experiments to high altitude for an extended period of time.
- Operates as a partnership between the **NASA Balloon Program Office** (BPO) and **Louisiana Space Consortium** (LaSPACE)
  - BPO provides balloon, launch and flight services
  - LaSPACE maintains HASP & supports the student payloads
- Developed in 2005 to address a looming crisis in training the next generation of aerospace scientists and engineers.
- Provides a regular flight opportunity for student groups across the world.
- A multiple experiment balloon platform, similar to HASP, might have application beyond student training programs.

# Major HASP Features

- Fly to an altitude > 36 km for a duration of ~20 hours
- Includes two major components
  - The upper frame (HASP) supports the multiple payloads
  - The bottom frame (CSBF frame) to support the balloon vehicle communication and support structure
- HASP includes a standard interface for each payload
  - Eight "small" experiments on booms and four "large" experiments on top
  - The HASP control electronics multiplexes and isolates the 12 experiments from the CBSF systems.



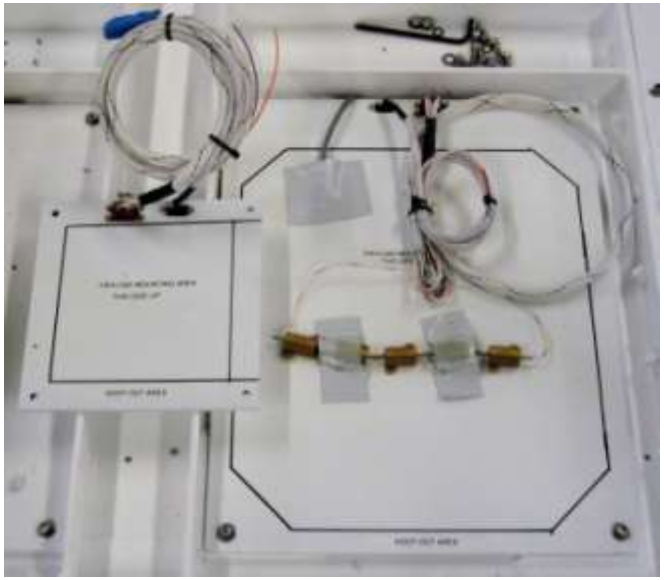

- Include CosmoCam for real time video during launch & flight

# The standard HASP payload interface

- Different resources for “small” and “large” payloads.
- Mechanical interface is a ¼” thick PVC plate, including power and communication connectors, wiring pigtail and footprint.
- Power provided at ~30 VDC plus both uplink and downlink communication.

**Table 1: Payload Interface Specifications (v2008)**

| Specification: | Small Payload | Large Payload |
|---|---|---|
| Total number of positions: | 8 | 4 |
| Maximum weight: | 3 kg | 20 kg |
| Maximum footprint: | 15 cm x 15 cm | 38 cm x 30 cm |
| Maximum height: | ~30 cm | ~30 cm |
| Supplied voltage: | 29 - 33 VDC | 29 – 33 VDC |
| Available current @ 30 VDC: | 0.5 Amps | 2.5 Amps |
| Max. serial downlink: | <1200 bps | <4800 bps |
| Serial uplink: | 2 bytes per cmd | 2 byes per cmd |
| Serial protocol | RS232 | RS232 |
| Serial interface: | DB9 | DB9 |
| Analog downlink: | Two @ 0 to 5 VDC | Two @ 0 to 5 VDC |
| Discrete commands: | 2 to 4 | 2 to 6 |
| Analog & discrete interface: | EDAC 516-020 | EDAC 516-020 |



# CosmoCam provides visual monitoring

- Real-time views of the payloads, the balloon and the Earth during launch, flight and termination.
- Provided and operated during the flight by Rocket Science, Inc. (www.cosmocam.com)
- Exciting live views showing the black of space and the curvature of Earth from the edge of space.
- Scientific value monitoring experiments that change their physical configuration.



Opening of MSU experiment
(8 times normal speed)

# Typical Payload Development Schedule

- Application process takes place in the fall
  - Release of CFP (Call for Payloads): October 1
  - Applications due: December 18
  - Selection announcement: mid-January
- Payload development takes place in the spring
  - Require monthly status reports and telecon meetings
  - Preliminary thermal / vacuum test the 3rd week of May


- Integration occurs during 1st week of August
  - Use the Columbia Scientific Balloon Facility (CSBF) in Palestine, Texas
  - Must pass a thermal / vacuum test to be flight certified
- Flight Ops take place around Labor Day
  - Use the CSBF balloon launch facility in Ft. Sumner, New Mexico

# ConUS flights launched from Ft. Sumner NM

# Typical Pre-launch Preparation







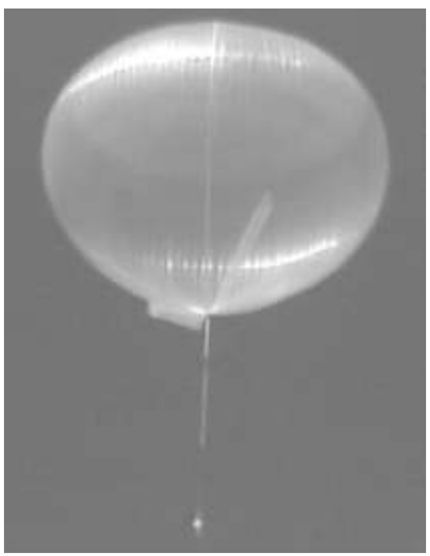


# HASP Launch Preparation

# Typical HASP Flight

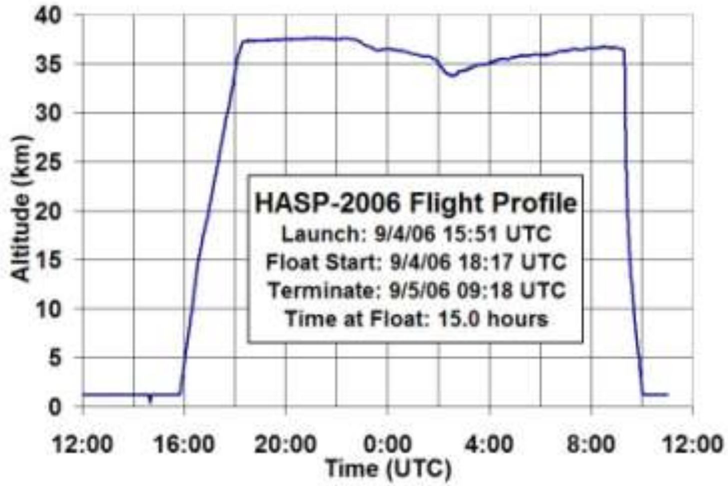
- HASP is a medium weight payload
  - Total suspended weight is 2,000 pounds
  - Use a 11 million $ft^3$ zero pressure balloon
- Usually launch just after dawn
  - Require ground, low level and high altitude winds to cooperate

speed

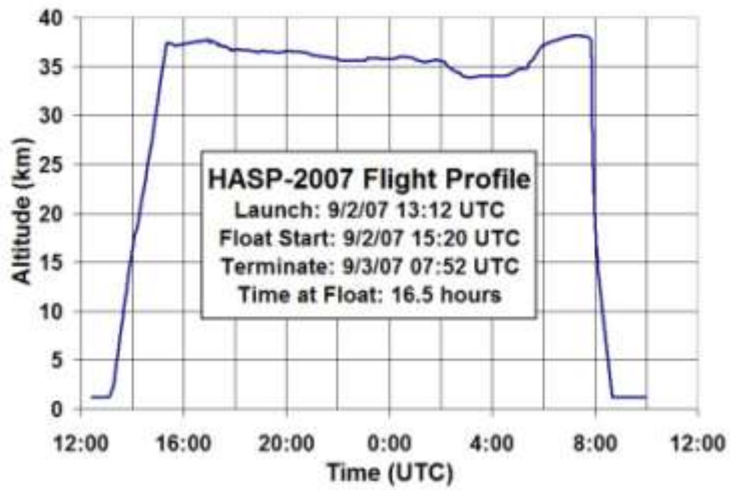


- Flight lasts about 17 hours
  - Takes about 2 hours to get to ~36 km (~120,000 feet)
  - Take about 45 minutes to come down on parachute
  - Get a day and some night in “space”
- HASP has now flown four times
  - Total time at float is more than 75 hours
  - Expect to continue flights each year

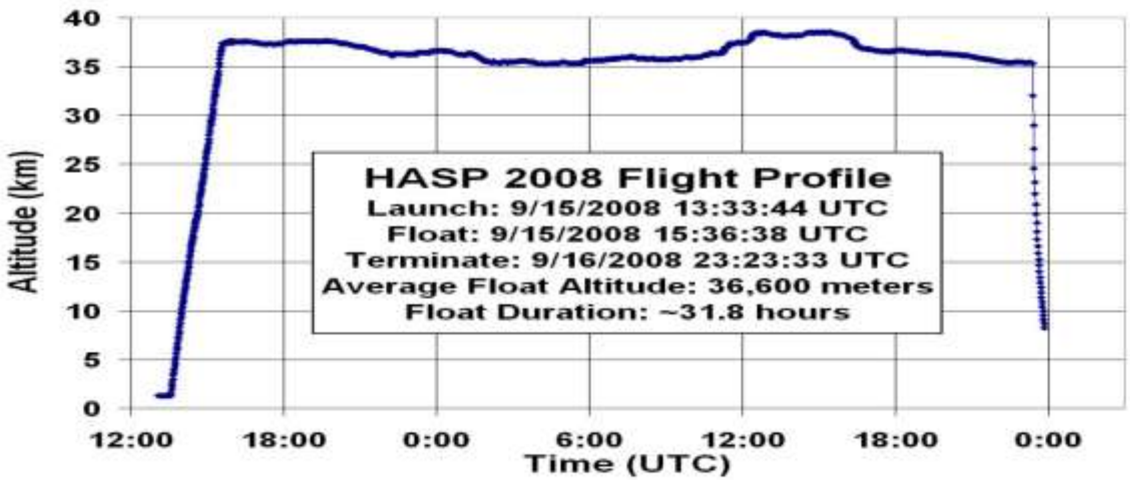
# HASP 2006 & 2007 Flights

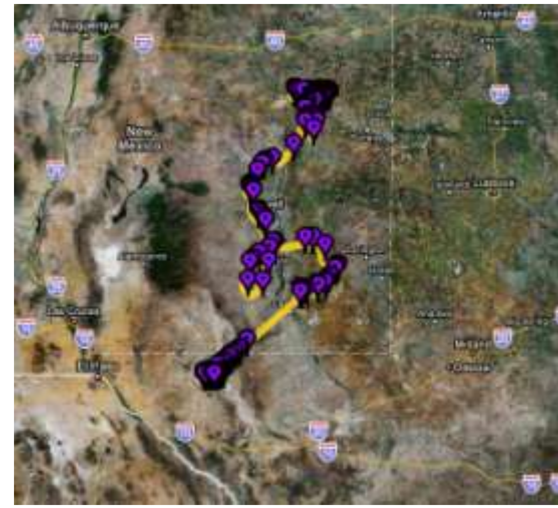


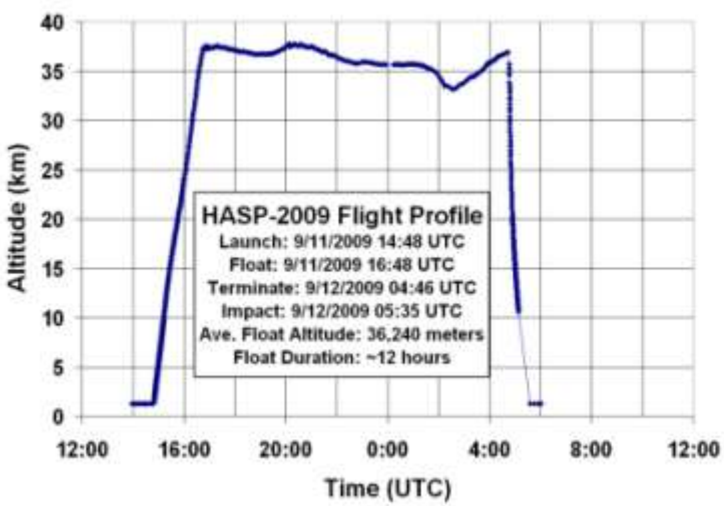





# HASP 2008 & 2009 Flights






# The HASP system is very robust

- CSBF recovery personnel are usually at the payload within hours after landing.
- Several features lessen impact damage
  - Suspension cable threaded through PVC pipe to minimize chance that the pin plate and flight train will collapse on the payloads.
  - Fiberglass booms absorb some impact on payload tip over.

- Many of the outrigger booms and payloads survive impact.
- Sometimes there is damage to a few of the solar shields.
- Internal electronics is fully functional after each flight.

# HASP has involved teams from across the U.S. and now includes international teams

# Many individual experiments have flown on HASP over the years

- HASP was flown each year from 2006 through 2009
- The 2010 flight has been delayed until August 2011
- The HASP 2011 will fly about one week after HASP 2010
- To date close to 370 students from 27 institutions across 14 states plus Puerto Rico and Alberta, Canada have been involved in developing a HASP experiment.

**Table 2: Payloads Involved with HASP Since 2006**

| Year | Launch Date | Float Duration (hours) | Students | Payloads | | |
|---|---|---|---|---|---|---|
| | | | | Accepted | Flown | Success |
| **2006** | 9/4/06 | 15 | 25 | 8 | 8 | 6 |
| **2007** | 9/2/07 | 16.5 | 70 | 11 | 10 | 8 |
| **2008** | 9/15/08 | 31.8 | 96 | 13 | 12 | 6 |
| **2009** | 9/11/09 | 12 | 50 | 10 | 6 | 6 |
| **Total 06 to 09** | | **75.3** | **241** | **42** | **36** | **26** |
| **2010** | ***8/29/11*** | 0 | 57 | 10 | 0 | 0 |
| **2011** | ***9/6/11*** | 0 | 70 | 11 | 0 | 0 |
| **Total 06 to 11** | | **75.3** | **368** | **63** | **36** | **26** |

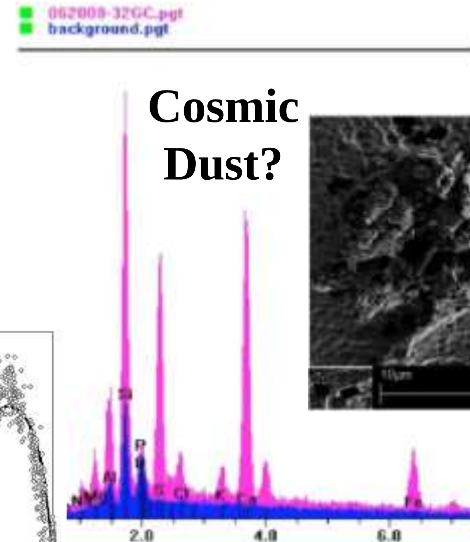
# The success rate for HASP payloads is reasonably good

- **Accepted payloads** are those that survived the initial application review and were assigned a seat on HASP
  - There are a total of 63 accepted payloads from 2006 through 2011
  - There were 42 accepted payloads from 2006 through 2009
- **Flown payloads** are those that where attached to HASP at the time it was launched
  - There were 36 flown payloads from 2006 through 2009
  - This is 86% of the accepted payloads
- A payload is defined to be **successful** if at least 50% of the proposed sensors obtain analyzable results for at least ¼ of the balloon time at float
  - There were 26 successful payloads from 2006 through 2009
  - This is 70% of the flown payloads.

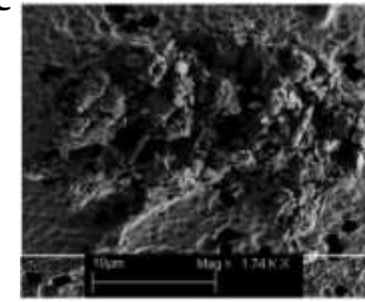
# A wide variety of topics have been investigated

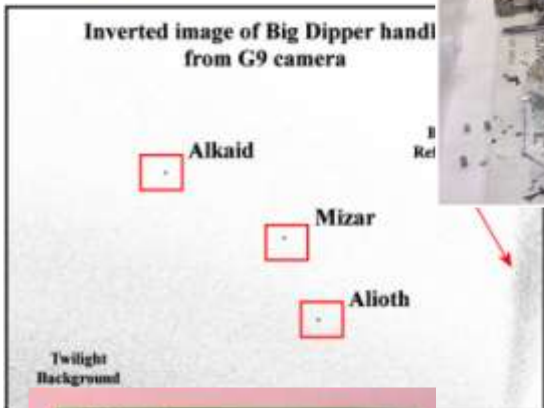
**Table 3: General Topics of Investigation by HASP Payloads**

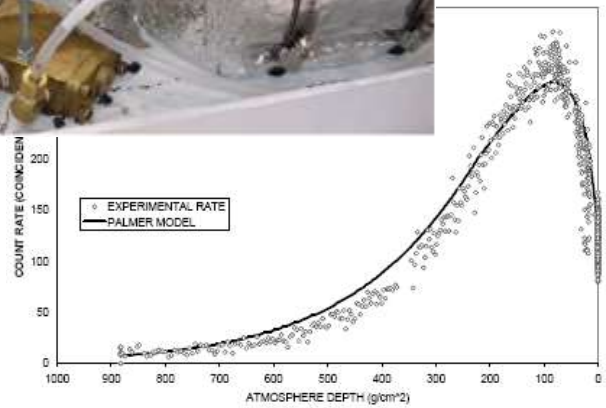
| Topic | Number |
|---|---|
| Various Investigations of Cosmic Rays | 9 |
| Testing of Various CubeSat Prototype Subsystems | 6 |
| Remote Sensing Investigations | 6 |
| Attitude Determination Prototype Systems and Components | 5 |
| Studies of Using Optical Telescopes on Balloon Platforms | 5 |
| Thermal Imaging of the Balloon | 5 |
| Solid State Ozone Sensor Prototype Testing | 4 |
| Capture and Analysis of Stratospheric Dust | 3 |
| Radiation Detector Prototype | 3 |
| Recoverable Data Capsule Prototype Test | 3 |
| Student Training | 3 |
| Biological Sampling and Testing | 2 |
| Magnetic Field Prototype Sensor Testing | 2 |
| Investigations using a Microwave Detector | 2 |
| Radio Telemetry System | 2 |
| Rocket Engine Nozzle testing | 2 |
| Development of a Gamma Ray Burst Detector | 1 |
| Testing of an Infrared Detector Prototype | 1 |

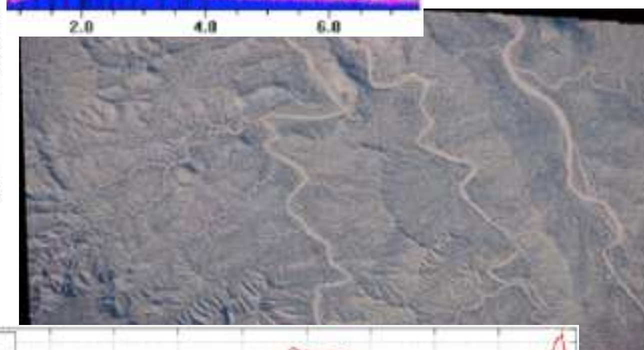



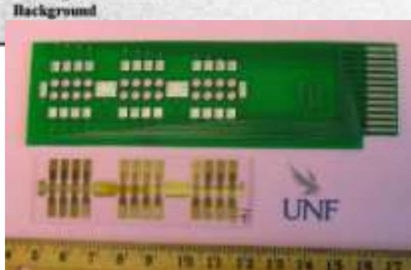

Cosmic Dust?

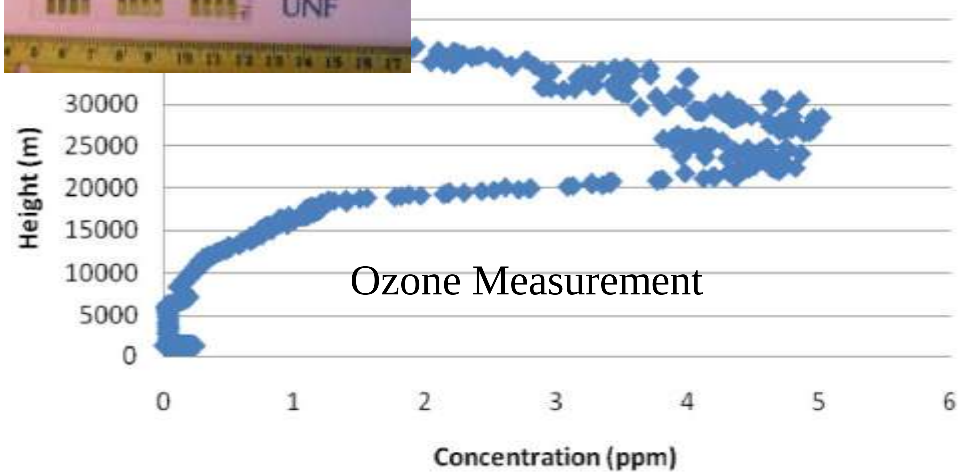




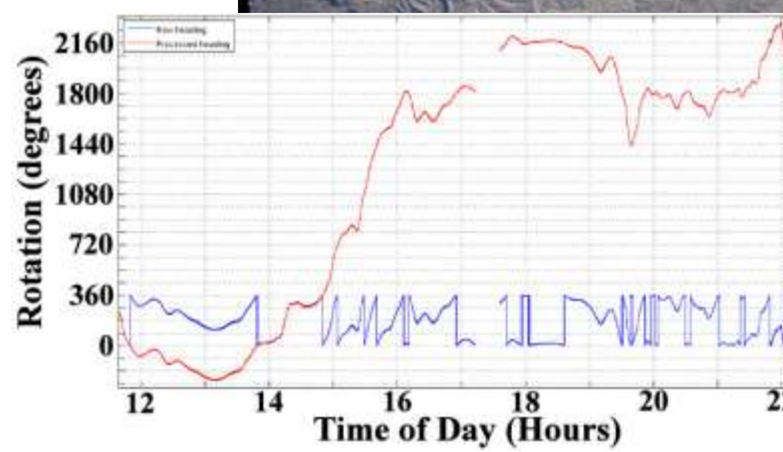






Ozone Measurement



# Conclusions

- HASP is the first balloon platform to support multiple independent experiments using a standard interface.
  - Originally developed to help address the looming crisis in aerospace workforce development
  - Four flights between 2006 through 2009 with two more scheduled for fall 2011
- The standard mechanical, power and communication interface supports payload needs.
- Modular design isolates the multiple payloads from the balloon vehicle improving flexibility.
- More than 60 payloads have been accepted for flight on HASP
  - Of these we expect about 85% will make it to flight and about 70% of flown payloads will be successful.
- HASP systems are very robust and we plan to fly twice within a period of about one week this fall
- Lessons-learned from HASP are applicable beyond student training and can be scaled to support heavier more complex instruments.