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The First Frontier: High altitude ballooning and access to near space

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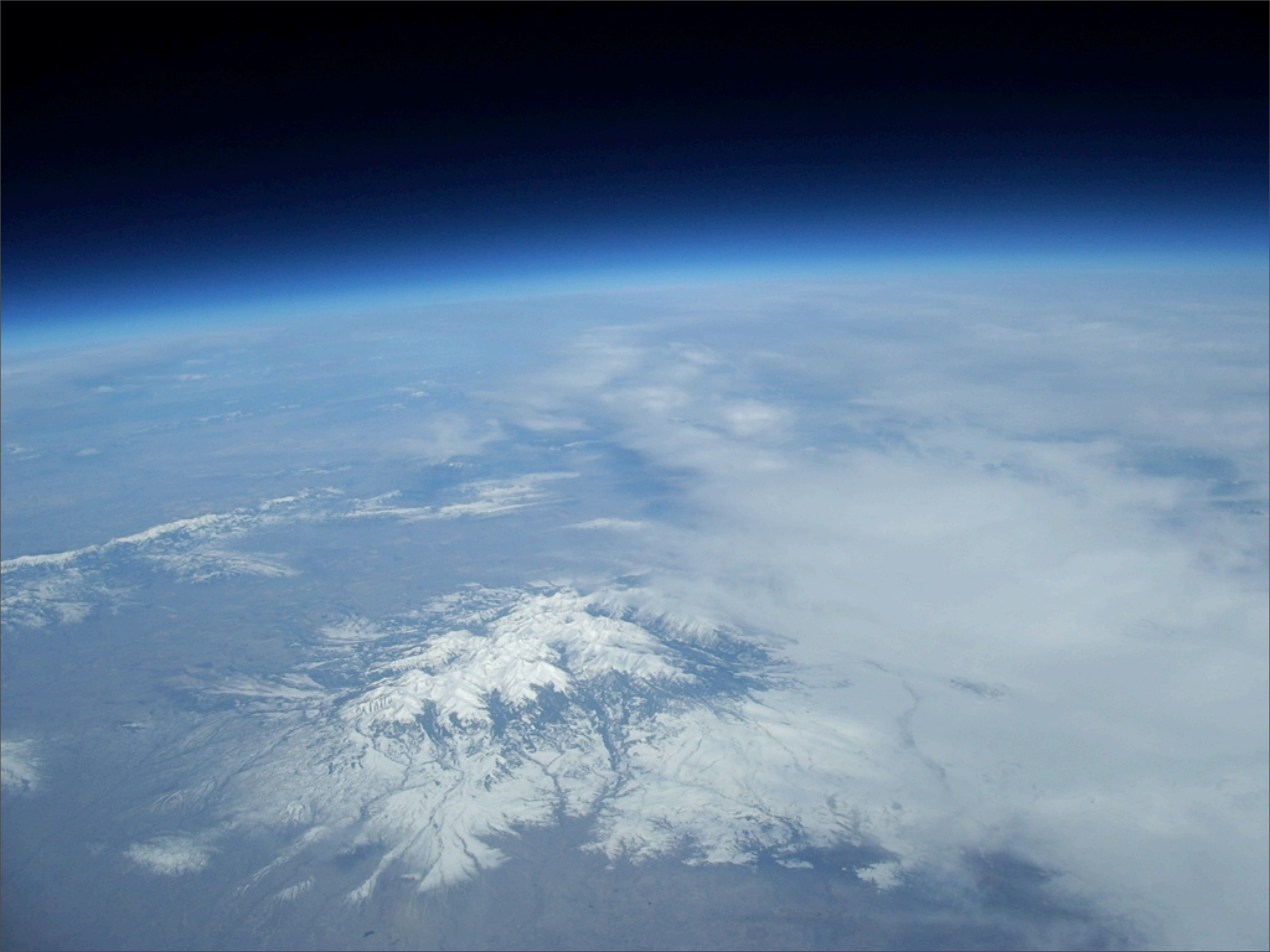


THE FIRST FRONTIER: HIGH ALTITUDE BALLOONING & ACCESS TO NEAR SPACE



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19 SEPTEMBER 2007



NEAR SPACE

- We can reach altitudes between 100,000 and 150,000 feet easily with balloon technology
- Above 99% of the Earth's atmosphere
 - At 105,000 feet, atmospheric pressure ~0.009 atm, temperature ~ -44.5° C
 - Roughly the conditions on the surface of Mars
- Technology needed is readily available; implementation trains students in the engineering of robust, remote operated/ autonomous equipment in harsh environments
- Skills and training is readily applicable in the aerospace workforce (**workforce development**)
- Flying to the edge of space is **exciting** – attracts students to science, technology, engineering and mathematics (**STEM pipeline**)

STORYLINE FOR OUR TALK

- Dry stuff: **Space Grant Consortia**
- Exciting stuff: Use **BOREALIS** to illustrate how it works and what is possible
- Ballooning in Utah – how do we get started?
 - **Student driven**
 - **Multi-departmental & Multi-institutional**
 - **Non-University partners** (high schools, companies)

SPACE GRANT CONSORTIA

- The **National Space Grant College and Fellowship** program is analogous to Land Grant and Sea Grant Programs.
- Created by an Act of Congress in 1988; there are 52 Space Grants in the United States (50 states + Washington DC + Puerto Rico)
- Organized as consortia between many universities, industrial partners. There is a “lead institution”, but no single university is “the Space Grant university” (a la Land Grant)
- The Space Grant program is NASA’s primary higher education program, and is responsible for science and engineering fellowships, seed grants for space research, and other space related activities.
- Utah is home of the **Rocky Mountain Space Grant Consortium**

RMSGC



- The Rocky Mountain Space Grant Consortium is comprised of:

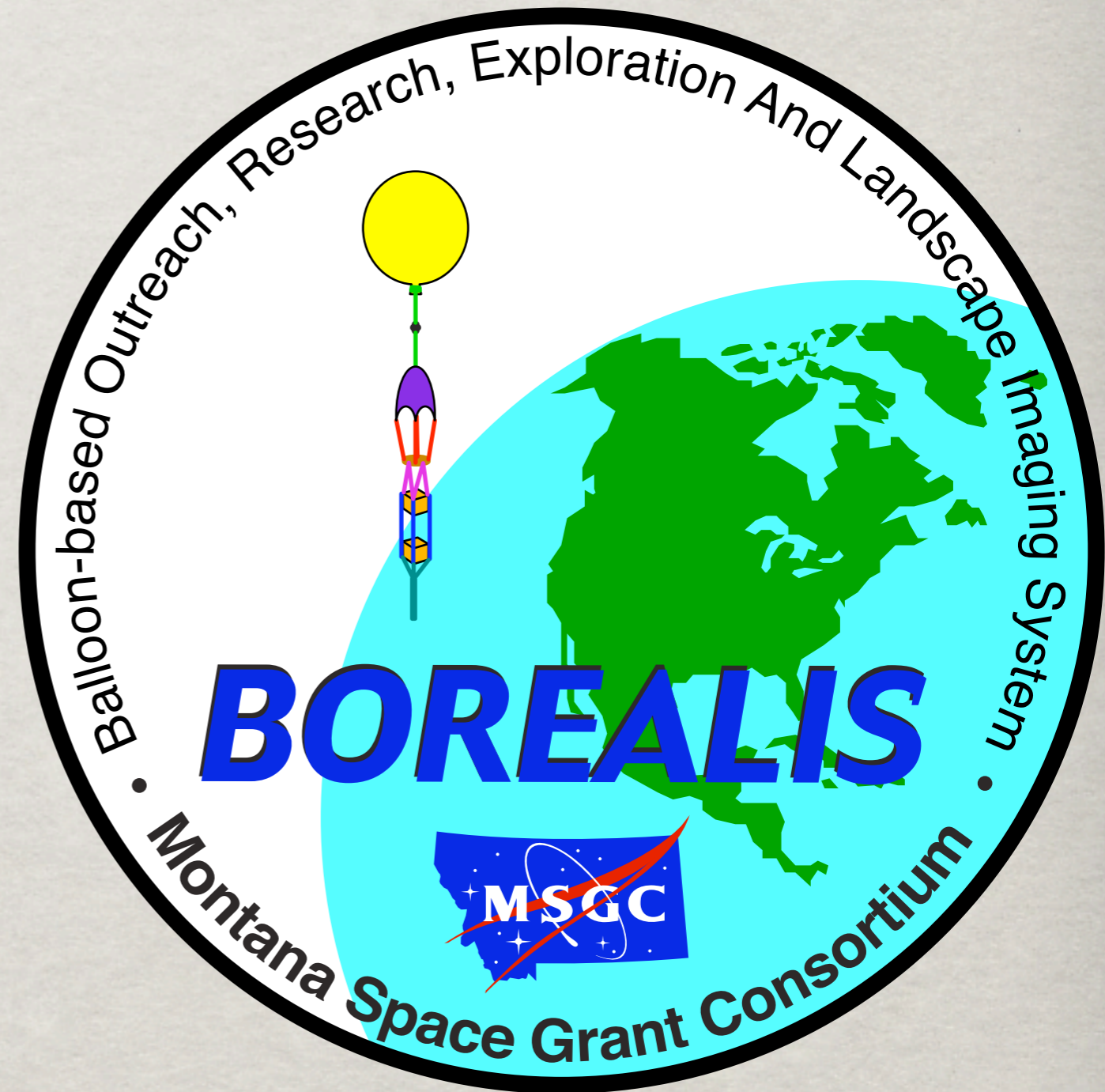
Utah State University	University of Utah	University of Denver
<i>Weber State University</i>	Thiokol	BYU
Southern Utah University	Clark Planetarium	Snow College
North American Native Research & Education Foundation	Idaho National Lab	Utah College of Applied Technology
Dixie State College	Space Dynamics Laboratory	Salt Lake Community College
Utah Science Center	Westminster College	Rocky Mountain NASA Fellows Association
Bridgerland Applied Technical College	Hill Aerospace Museum	Shoshone-Bannock School

- Co-directed by Doran Baker (USU) and Dwayne Westenskow (Univ. Utah)
- RMSGC is unique in that it has affiliates from multiple states
- Student fellowships in space-related career paths, partnerships with NASA centers, space related research experiences for students, develop industry ties
- <http://spacegrant.usu.edu/>

BOREALIS

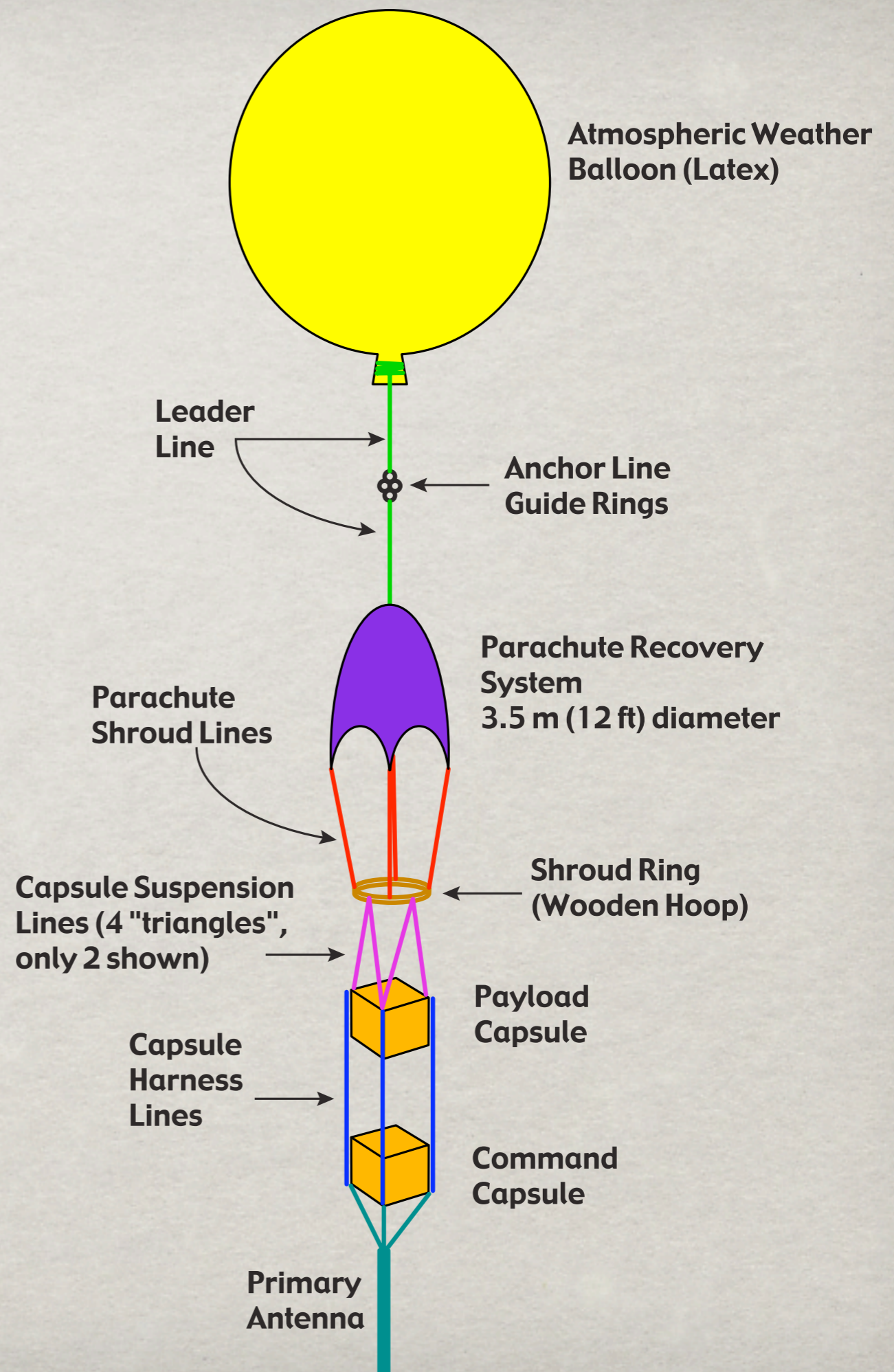
- First flight in 2001
- Provide a cheap and reliable platform for student based space hardware projects and experiments
- Low cost and quick turn around allows multiple student flights in a student lifetime
- Since 2001, had 50+ flights, all recovered; two launch systems at MSU and UM, experiments from many schools
- Some prominent Utahans got their start with BOREALIS:

Shane Larson (Weber), Mike Murray (Clark Planetarium),
John Belz (U. Utah), Michelle Larson (USU)



BALLOON FLIGHT SYSTEM

- Design is variable, but the basic elements are:
 - Balloon
 - Recovery System
 - Payloads
 - Comm System
- 12 lb mass limit



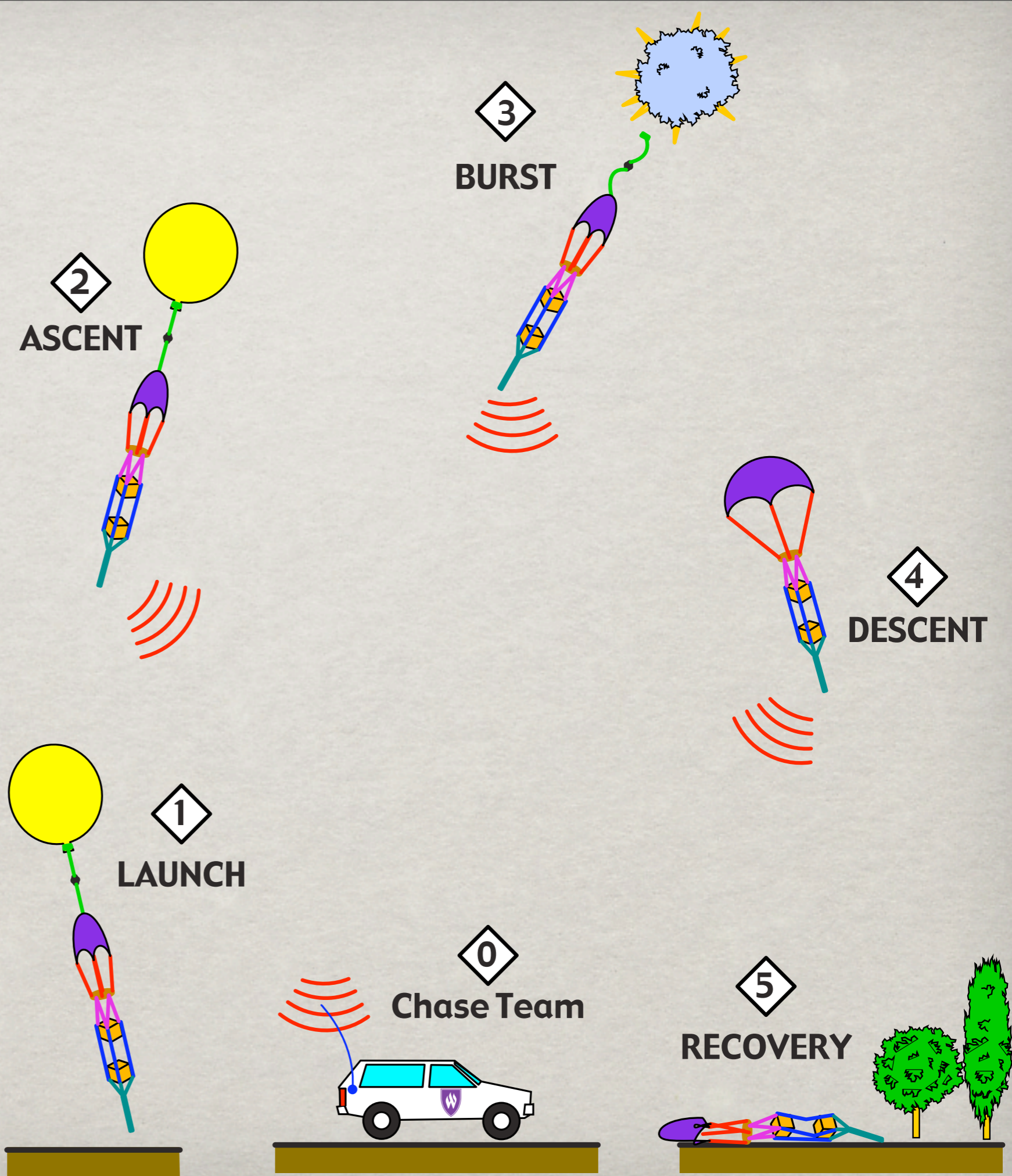
BALLOON FLIGHT PROFILE

- A high altitude balloon flight consists of:

- Launch

- Flight & Chase

- Recovery



A FLIGHT IN PICTURES: LAUNCH PREP



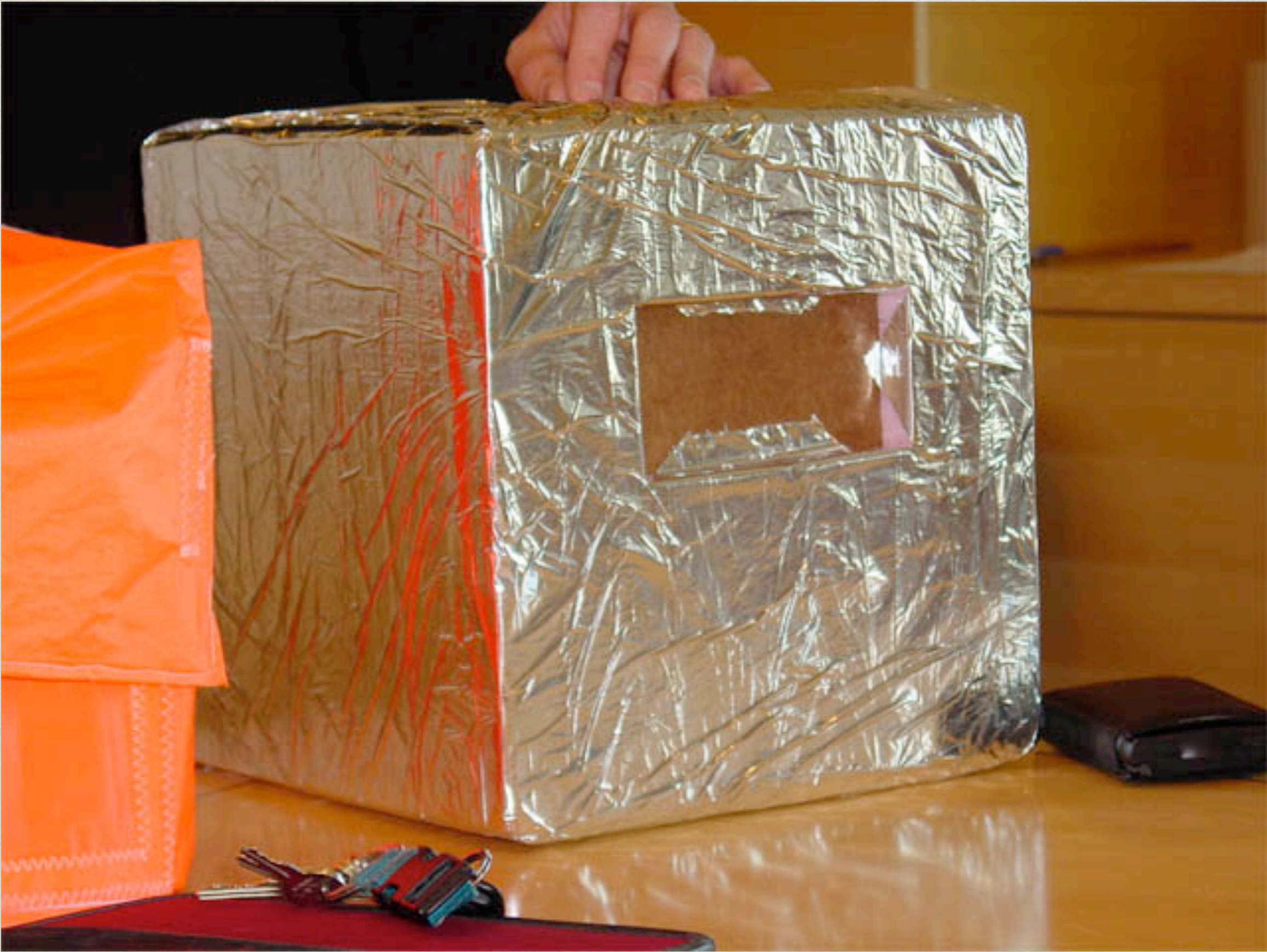
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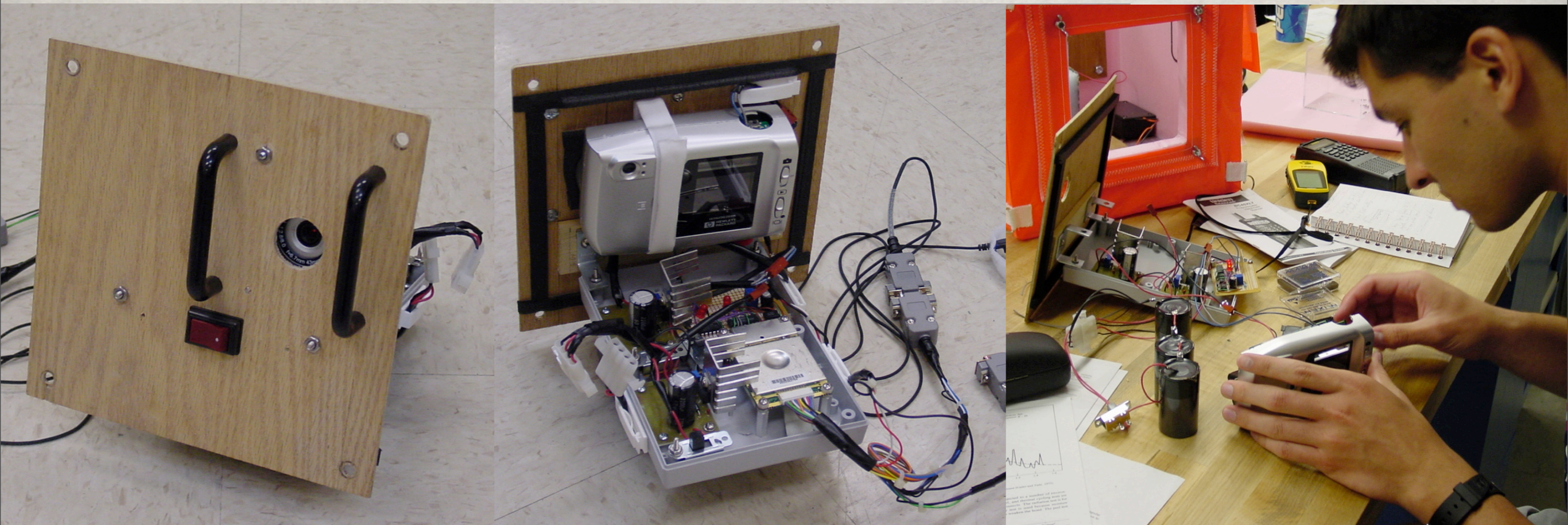
A FLIGHT IN PICTURES: LAUNCH PREP





FLIGHT EQUIPMENT: IBIS

- We *always* fly a camera on the balloon
- **IBIS: Integrated Balloon Imaging System**
 - Built by Sean Kirn (EE undergrad) and Shane Larson, HP215c, \$95 @ Walmart in 2001.
 - Replace shutter button with leads to timer circuit adapted from model rocketry



A FLIGHT IN PICTURES: BALLOON VIEW



A FLIGHT IN PICTURES: BALLOON VIEW



A FLIGHT IN PICTURES: BALLOON VIEW



A FLIGHT IN PICTURES: BALLOON VIEW



A FLIGHT IN PICTURES: BALLOON VIEW



A FLIGHT IN PICTURES: BALLOON VIEW



A FLIGHT IN PICTURES: BALLOON VIEW



A FLIGHT IN PICTURES: BALLOON VIEW





Grand Tetons are about 275 km
away from balloon flight track!

Grand Tetons



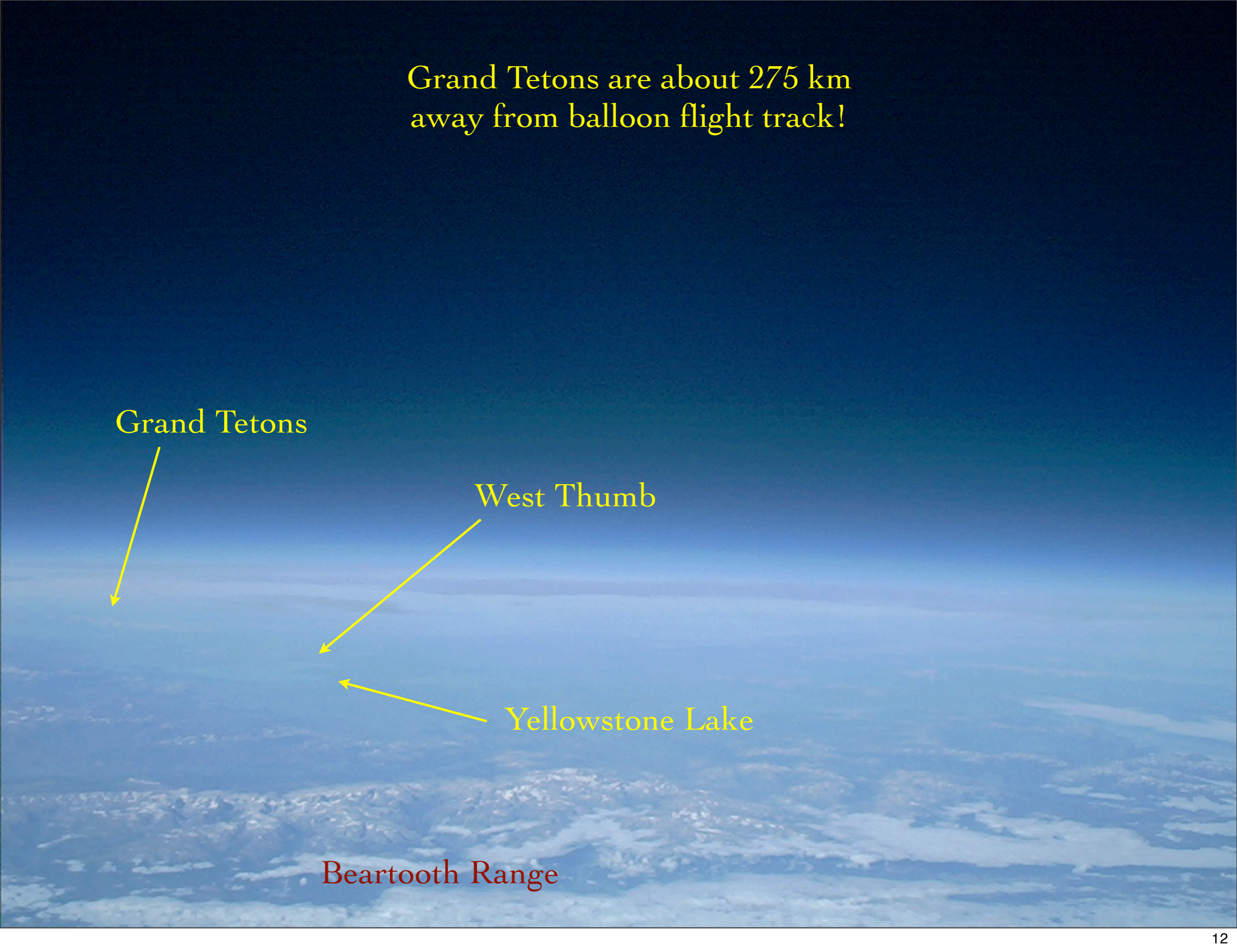
West Thumb



Yellowstone Lake



Beartooth Range





















A FLIGHT IN PICTURES: RECOVERY



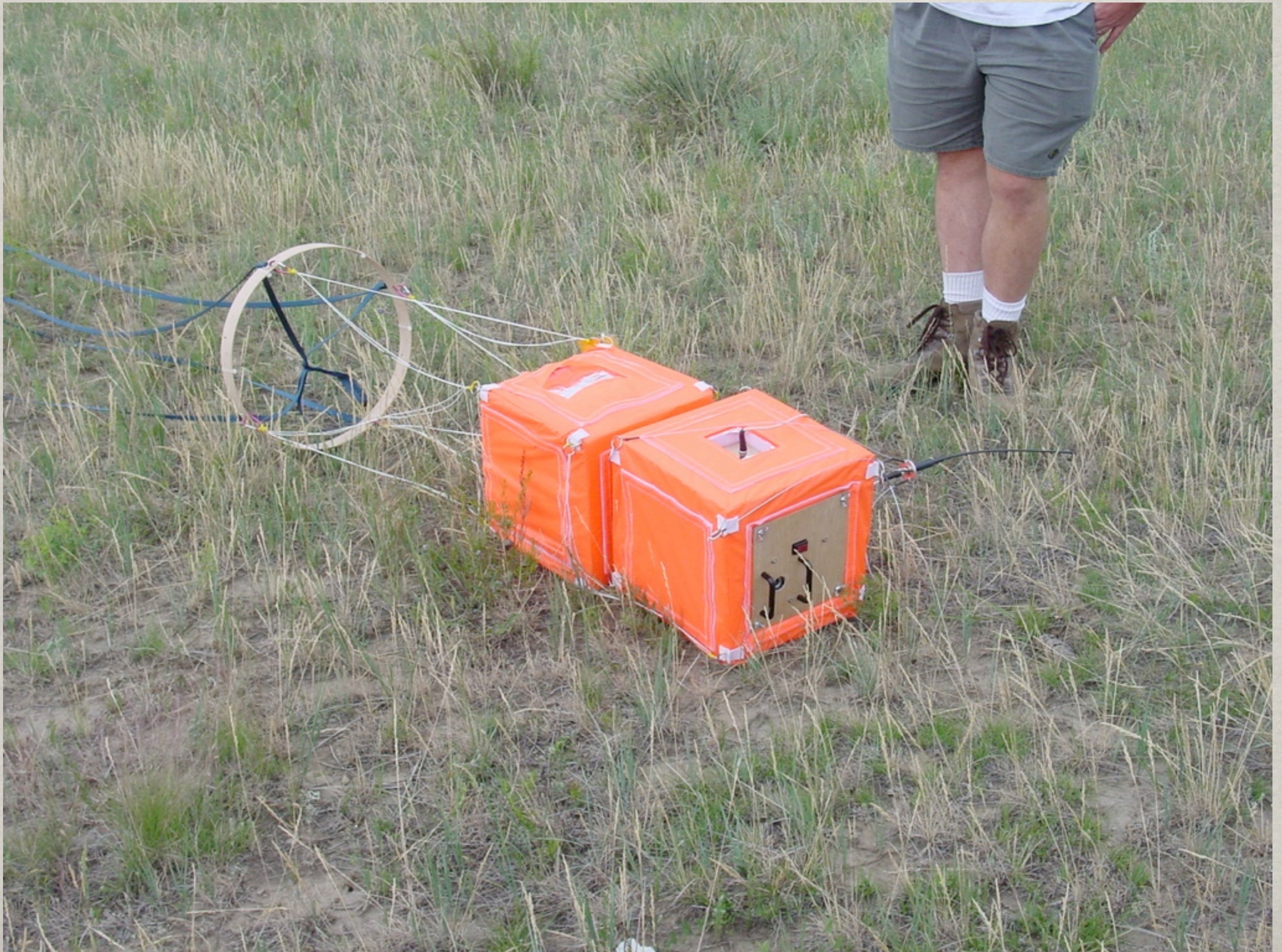
A FLIGHT IN PICTURES: RECOVERY



A FLIGHT IN PICTURES: RECOVERY



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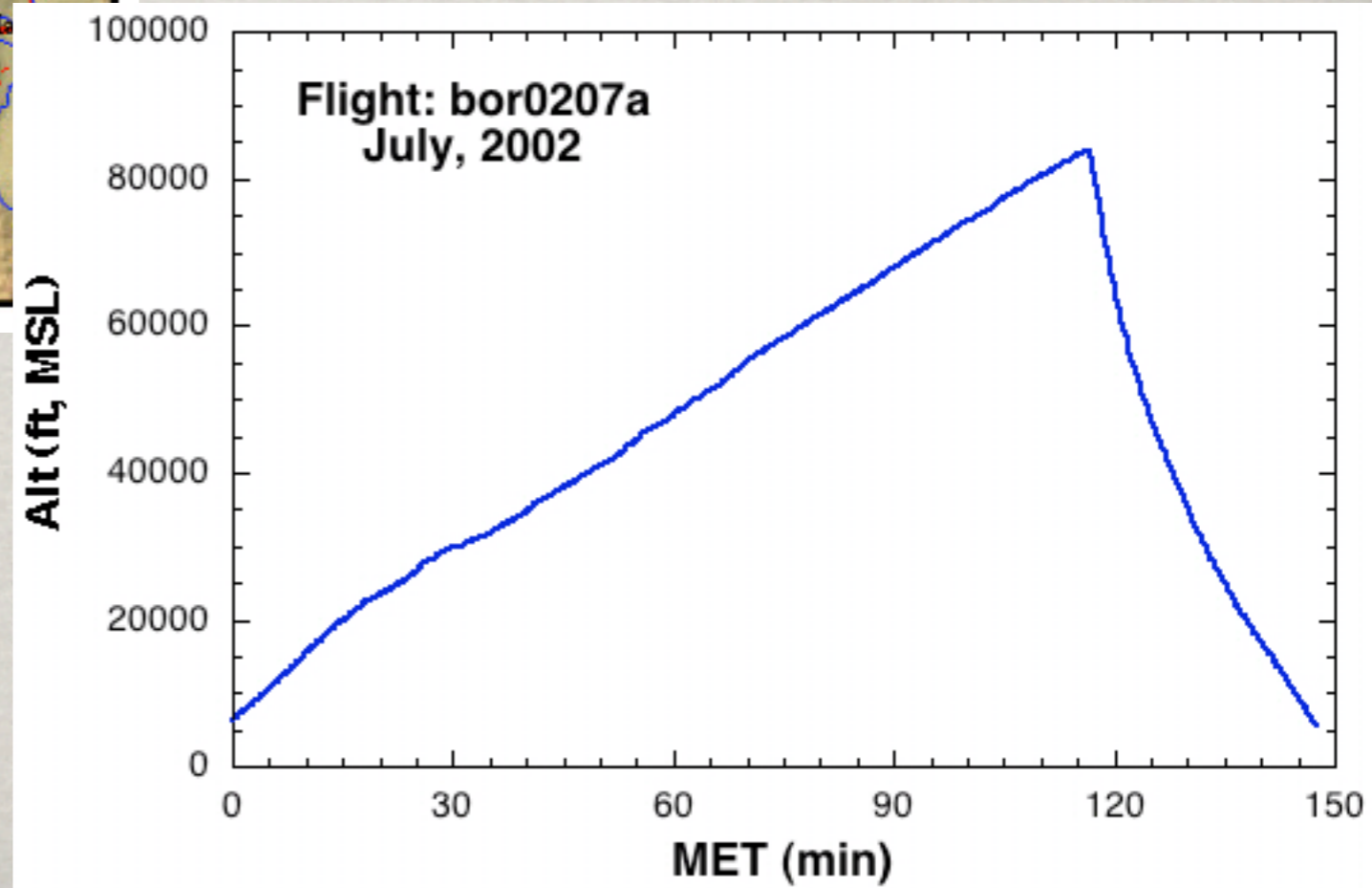
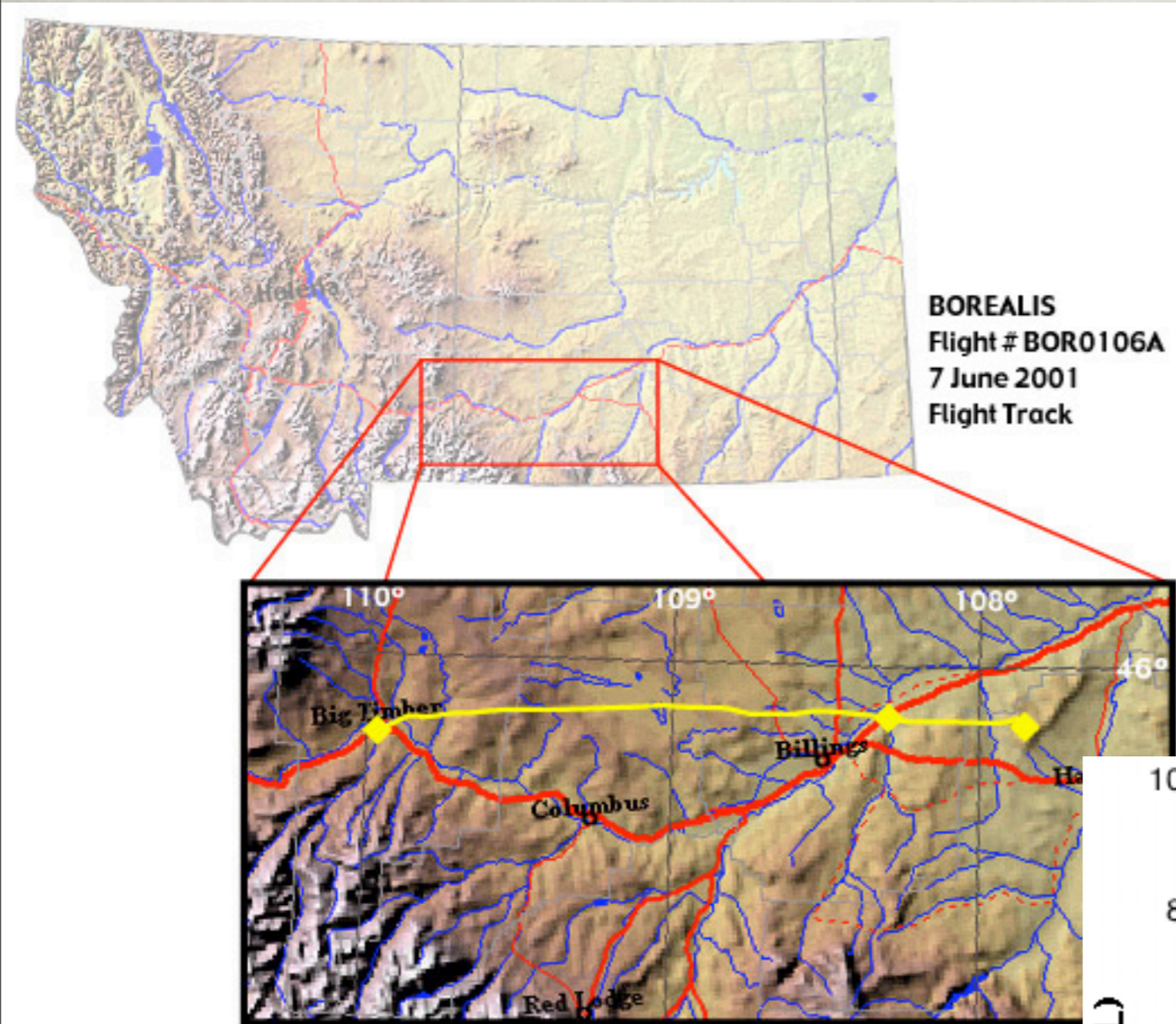
FLIGHT DATA: APRS

- The most important bit of flight data is the GPS tracking data, which gives balloons LAT, LONG, and ALT.
- Transmitted over HAM frequencies in a format known as APRS – “Automatic Position Reporting System”
- Balloon carries a transmitter, set to a licensed user (typically one of the Chase Team) that auto-broadcasts the GPS position at regular intervals

```
AE0SS-11>BEACON:T#087,086,101,046,136,135,00111000  
AE0SS-11>APRS:$PRWIZCH,30,7,05,7,02,7,04,6,10,7,06,7,29,2,21,7,00,0,13,6,00,0,00,0*42  
AE0SS-11>APRS:$GPRMC,151447,A,4034.5189,N,10424.4955,W,6.474,132.5,220406,10.1,E*58  
AE0SS-11>APRS:$GPGGA,151449,4034.5163,N,10424.4937,W,1,06,1.41,21475.8,M,-21.8,M,,*4D
```

KD7MFJ-11	45.862	-107.87583	28	112	11818	2001.0607	14	01	49	4U5QWR,RELAY,WIDE
KD7MFJ-11	45.863	-107.8795	26	111	12431	2001.0607	14	01	23	4U5QWX,RELAY,WIDE
KD7MFJ-11	45.8635	-107.881	26	111	12628	2001.0607	14	01	10	4U5QXQ,RELAY,WIDE
KD7MFJ-11	45.864	-107.88317	25	99	12831	2001.0607	14	00	57	4U5QXT,RELAY,WIDE
KD7MFJ-11	45.8645	-107.88533	20	112	13235	2001.0607	14	00	43	4U5QXW,RELAY,WIDE

FLIGHT DATA: APRS TRACK

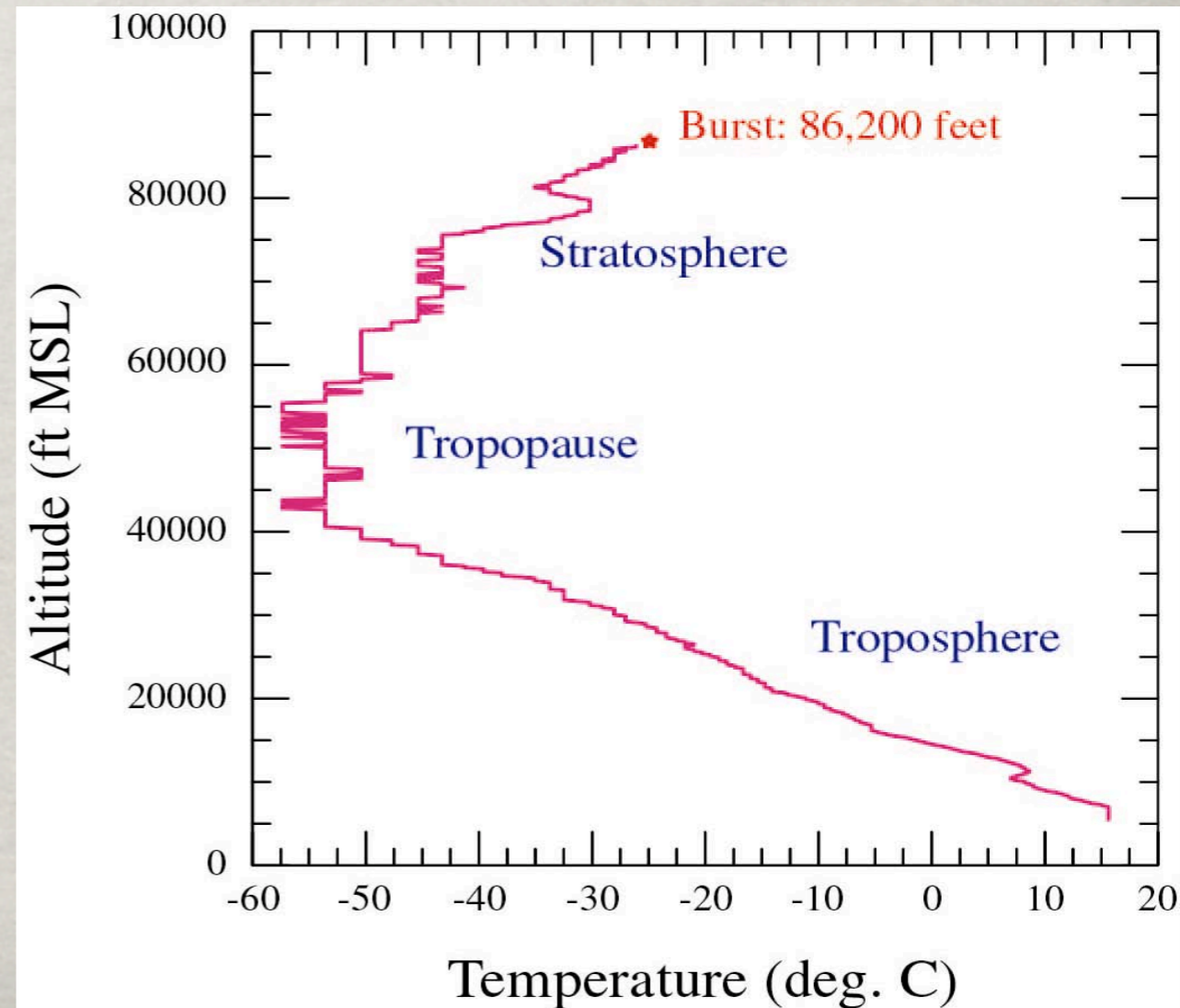
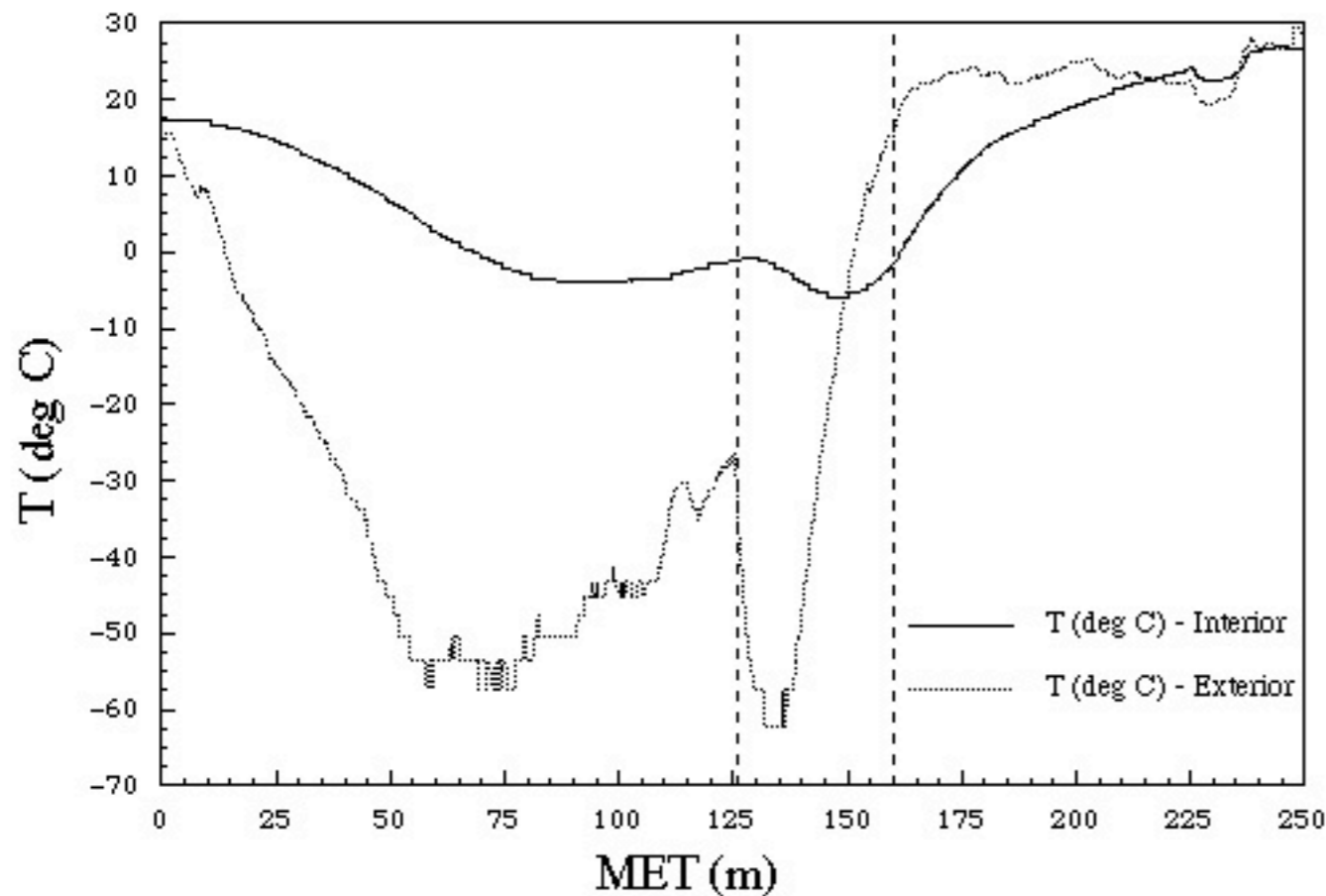


FLIGHT EQUIPMENT: HOBO

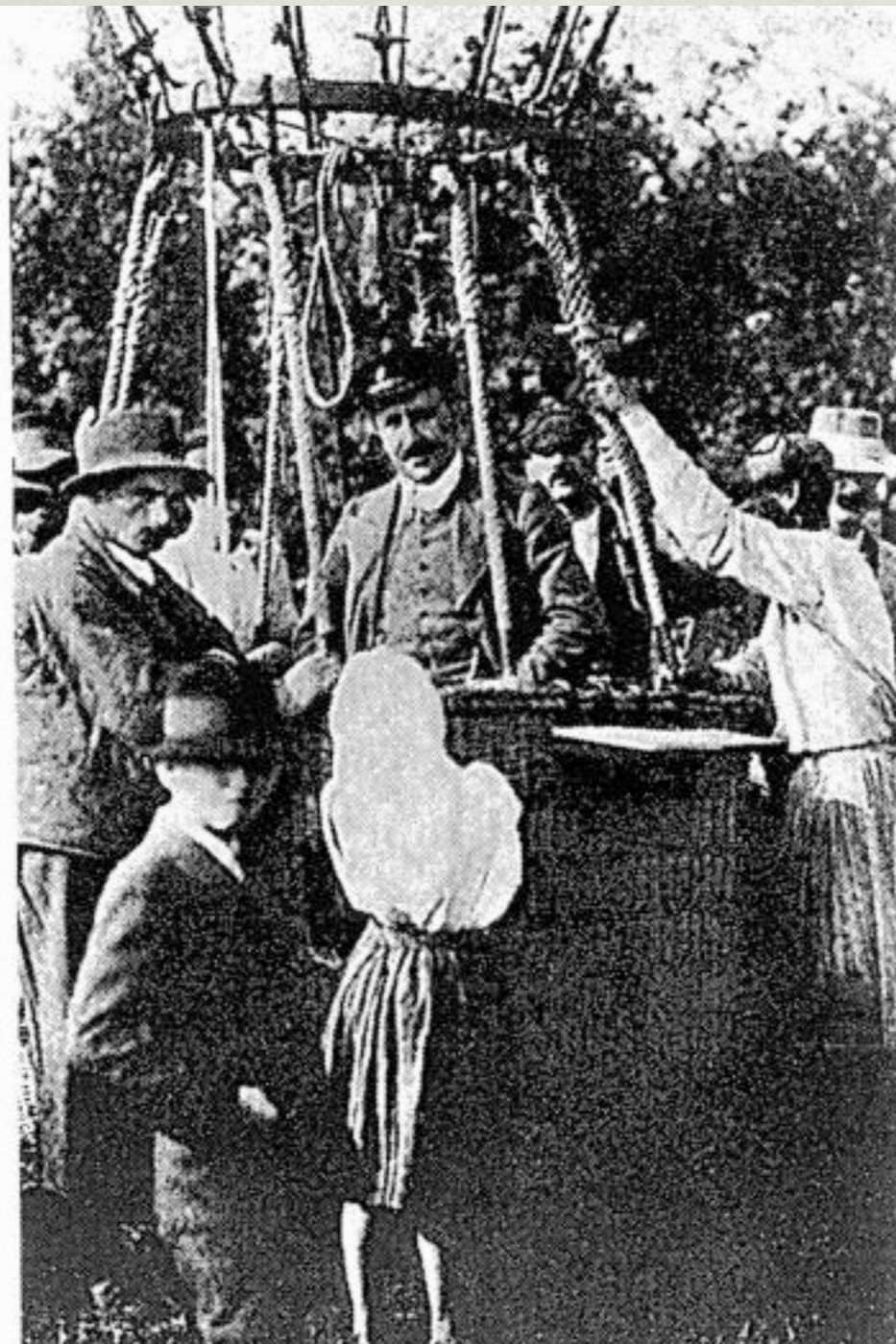
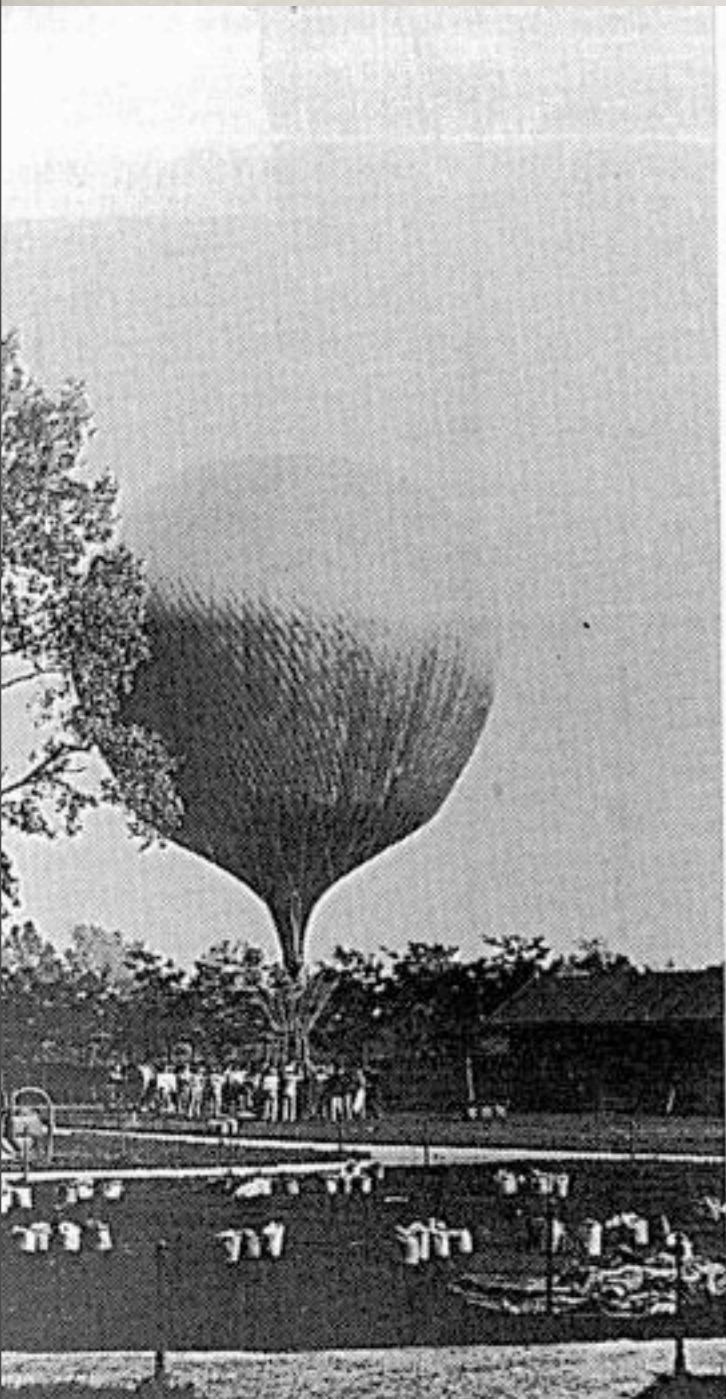
- HOBO data logger from Onset



Thermal Profile (H8 Hobo w/ External Probe)
BOREALIS: Flight# BOR0106B
30 June 2001, Command Module



THE HESS EXPERIMENT



- In 1912, Victor Hess flew a balloon to **17,500 ft**
- Discovered background radiation **increased** with altitude
- Deduced the existence of **cosmic rays**

FLIGHT EQUIPMENT: GEIGER TUBE

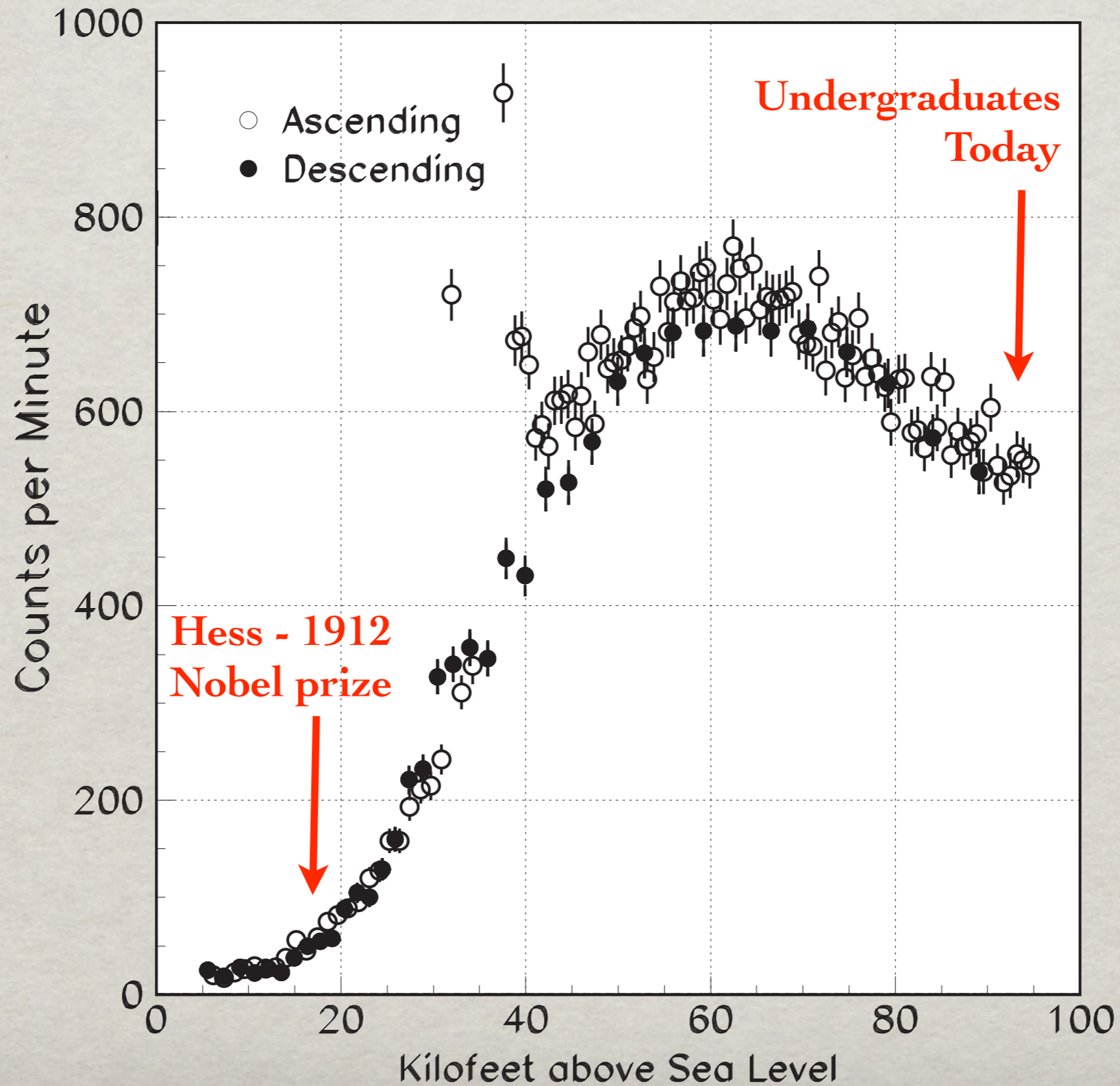
- A geiger counter, attached to a palm sized data logging PC can be flown



FLIGHT EQUIPMENT: GEIGER TUBE

- A geiger counter, attached to a palm sized data logging PC can be flown

Geiger Counter Data, Flight BOR0109A



FLIGHT EXPERIMENTS: THE FUTURE

Balloon Technology

- Mass reduction strategies*
- Power reduction strategies*
- Volume reduction strategies*
- Accelerometers*
- Communications experiments (EBBE)
- Tracking experiments (GPS, DF, ...)*
- Attitude sensing & control
- Microcontroller development*
- Cutdown system*
- Tethered Balloon (blimp!) systems*

Remote Sensing

- IBIS digital still camera system*
- Synthetic aperture
- LIDAR
- FLIR

Space Science

- Cosmic Ray experiments*
- UV solar radiance *
- Solar observations
- Cosmic Background Radiation (?)

There are no limits to
balloon payloads with
creative and excited
students

So what about Utah?

Space Hardware

- CubeSat payload test*
- CubeSat communications test
- Satellite Ground station testing

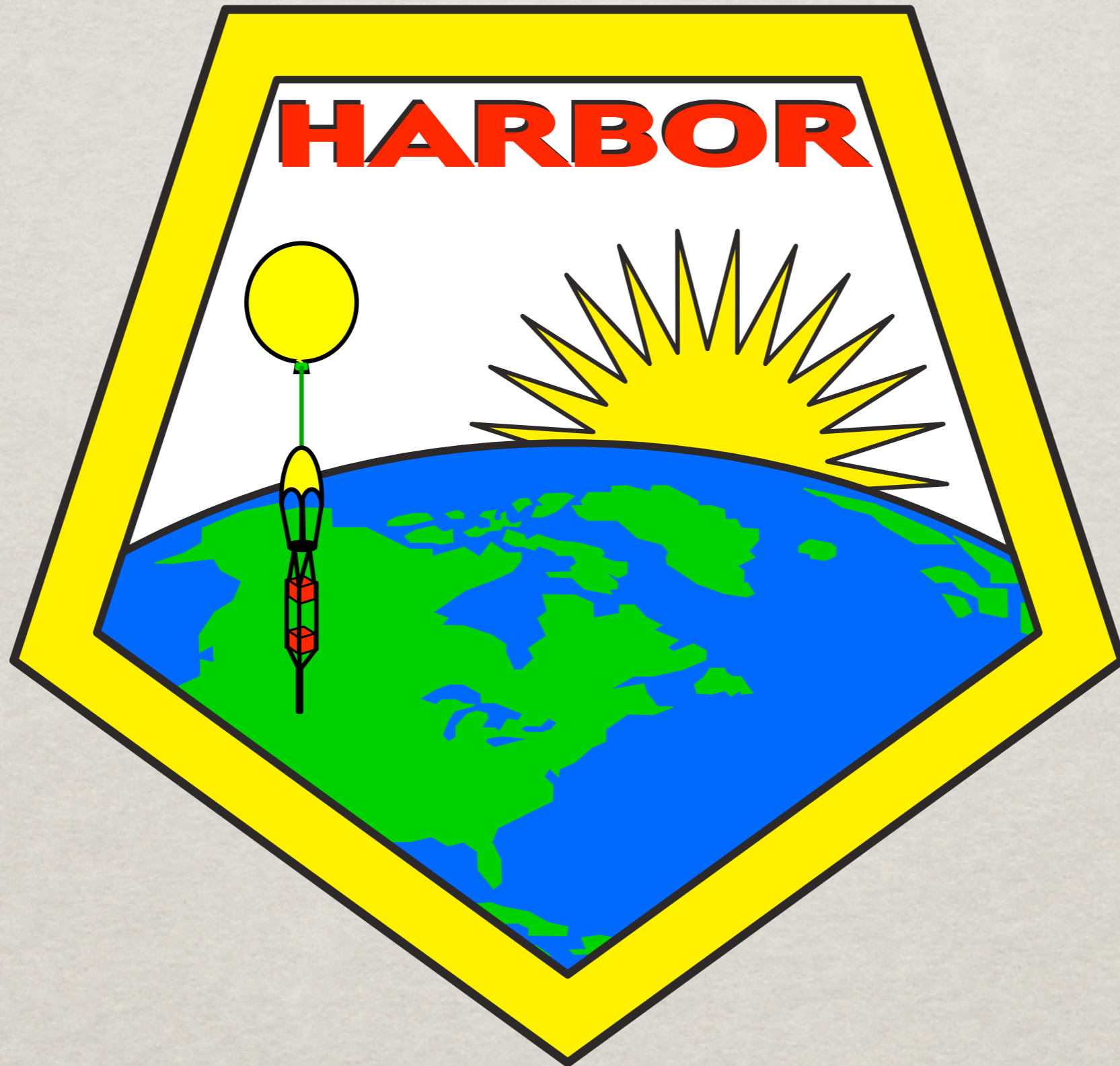
Earth & Atmospheric Sciences

- IBIS digital still camera system*
- Video camera system*
- Amateur TV system
- 2π horizon camera system
- Hyperspectral imaging
- Ozone altitude profiles *
- UV solar radiance *
- IR photometry*
- Atmospheric temperature* & pressure* profiles
- Smoke & particulate sampling
- Trace gas sampling from upper atmosphere
- Measure diameter of Earth

Aeronautics

- Glider platforms (Mars glider)
- Balloon flight modeling*

HARBOR



- High Altitude Reconnaissance Balloon for Outreach and Research

STARTING HERE IN UTAH

- Small group makes an **observation trip** for a BOREALIS flight this fall
- Construction of a “**guest experiment**” for flight on BOREALIS
- Participation in **summer workshop** on student space hardware projects, built around ballooning platforms (Colorado, summer 2008)
- Establishing **HARBOR** program for development
 - Secure **seed funding** (~\$2000; few x \$100 in expendables per flight)
 - **Student design team**, initial experiments, statewide partners
 - Identify **suitable flight range** in Utah (far from HAFB and SLC); flight simulation to determine expected ranges
 - Construction
 - Flight

LAST THOUGHTS

- High altitude ballooning provides **easy access to near space** with small payloads and experiments
- Flight turn-around is quick, so experiments can be repeated and/or upgraded many times
- **Real engineering and science experience!**
- Future flight observation trip & summer workshop

- **Let's go flying!**

RESOURCES

- BOREALIS Flight Handbook
 - <http://spacegrant.montana.edu/borealis/resources/Handbook/>
- Edge of Space Sciences (EOSS)
 - <http://www.eoss.org/>
- TVNSP (Treasure Valley Near Space Project)
 - <http://www.tvnsp.org/>
- Ralph Wallio's comprehensive listing of balloon programs:
 - <http://showcase.netins.net/web/wallio/ARHABlinks.htm>