

COSPAR 2018

42ND ASSEMBLY | 60TH ANNIVERSARY

July 14-22, 2018 – Pasadena, California

Overview of the NASA Scientific Balloon Activities

Debora Fairbrother and David Gregory

NASA Balloon Program Office

Suborbital and Special Orbital Projects Directorate

Wallops Flight Facility



Mission of the NASA Balloon Program

Wallops Flight Facility

- The NASA Balloon Program provides low-cost, quick response, near space access to NASA's science Community for conducting Cutting Edge Science Investigations
- Serve as a technology development platform
- Excellent training for NASA scientists and engineers



NASA Launch Locations

Wallops Flight Facility



FY14 Flight Manifest

Principal Investigator (PI) / Institution / Instrument	Discipline	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Fort Sumner, New Mexico	Spring 14												
Fairbrother / GSFC/WFF / LDB Test	Test Flight									⊗			
PMRF, Hawaii	Summer 14												
Adler / JPL / LDSO	Reimbursable/Special Projects									◆			
Fort Sumner, New Mexico	Fall 14												
Stuchlik / GSFC-WFF / WASP & Kopp / LASP / HySICS	Heliospheric Physics											◆	
Guzik / LSU / HASP	Student Flight Project											◆	
Fairbrother / GSFC-WFF / Test *	Test Flight											◆	
Margitan / JPL / Remote	Atmospheric												◆
Krawczynski / WUSL / X-Calibur	Gamma Ray/X-Ray												◆
McConnell / UNH / GRAPE	Gamma Ray/X-Ray												◆
Cheng / APL / BOPPS	Planetary												◆
Stuchlik / GSFC-WFF / WASP & Hurford / GSFC/ OPIS	Test / Planetary												◇

Notes:

- * = The Fairbrother/WFF Test Flight will include MoO's: EMIST/Dawkins (KSC); USIP instruments; and SolCompT/Bloser (UNH)
- = The campaign was conducted but shutdown prior to the mission being launched.



649N Dr. Guzik/ LSU launch of the HASP payload occurred Aug 9. This was the 9th HASP student outreach mission. Ten student instruments were flown. Flight time 8 hrs 54 mins.



650N Mr. Stuchik/ Dr. Drake - WASP/HySICS launch of the HASP payload occurred Aug 18. This was the second flight of HySICS. Flight time 8 hrs 54 mins.



651NT Fairbrother/ LDB Test launch of the Long Duration Balloon test flight occurred Aug 9. This mission included flying the DeVries HGA and 2 USIP payloads. Flight time 6 hrs 38 mins.

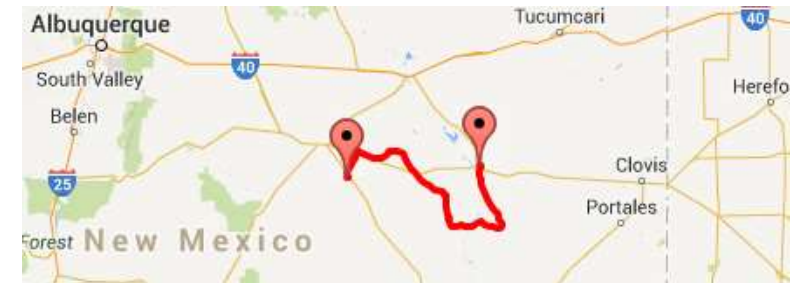




652N Dr. Margitan/ JPL launch of the JPL Remote payload occurred September 13, at 14:58Z . This was a suite of instruments to measure profiles of over 40 chemical species in the stratosphere. Flight time 23 hrs 14 mins.



653N Dr. Krawczynski/ Washington University launch of the X-CALIBUR payload occurred **September 24**, at 14:16Z . This was a test flight of pointing system and hard X-Ray Polarimeter for future LDB flight. Flight time 7 hrs 40 mins.



654N Dr. Cheng / JHU-APL-GSFC launch of the BOPPS payload occurred **September 25**, at 14:27Z . BOPPS measured the amounts and ratios of water and carbon dioxide in comets and asteroids. Flight time 18 hrs 53 mins.





655N Dr. McConnell / University of New Hampshire launch of the GRAPE payload occurred **September 26**, at 14:47Z . GRAPE will study the nature of gamma-ray bursts. It will measure the polarization of X-Rays and Gamma-Rays. Flight time 18 hrs 51 min.



656N Mr. Stuchlik/ Dr Hurford / WFF/ GSFC launch of the WASP/ OPIS payload occurred October 8. WASP/OPIS is intended to validate the reliability and capability of the WASP system to track planetary targets. Flight time 11 hrs 2 min.



Second WASP mission during campaign.



FY15 Flight Manifest

Principal Investigator (PI) / Institution / Instrument	Discipline	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Fort Sumner, New Mexico	Fall 14													
Stuchlik / GSFC-WFF / WASP & Hurford / GSFC / OPIS -CO	Test / Planetary	◆	SUCCESS											
McMurdo, Antarctica	Winter 14													
Gorham / UH / ANITA	Particle Astrophysics			←	SUCCESS									
Besson / UK / ANITA HiCAL (HL)	Particle Astrophysics			←	←	SUCCESS								
Boggs / UCB / COSI / Fairbrother / GSFC/WFF / SPB	SPB Test Flight			◆	ANOMALY									
Jones / PU / SPIDER	IR-Submillimeter			←	SUCCESS									
Wanaka, New Zealand	Spring 15													
Fairbrother / GSFC/WFF / ULDB Test	Test Flight							←	→	SUCCESS / ANOMALY				
PMRF, Hawaii	Summer 15													
Adler / JPL / LDSD	Reimbursable/Special Projects									◆	SUCCESS			
Esrangle, Sweden	Summer 15													
Millan / DC / BARREL [7 PI-Hand Launched]	Heliophysics									SUCCESS	◆◆◆◆			
Fort Sumner, New Mexico	Fall 15													
Salter / CSBF / Test*	Test Flight										SUCCESS		◆	
Guzik / LSU / HASP	Student Flight Project										SUCCESS		◆	
Mertens / LaRC / Rad-X	Upper Atmosphere										SUCCESS		◆	
Stilwell / CSBF / Test*	Test Flight												→	◆

Notes:

- CO – Carryover flight from FY14
- The CSBF Test flights included MoO's: EMIST/Smith (KSC); EUSO IR/Adams (UAH); ANGEL/Stevenson (GRC); JefferSat/Goynes (UVA); ANS/Christl (MSFC); CubeSat/Altunc (GSFC); FAA/Demidovich (FAA); LBRSP/Walker (UA); RLAGS/Fullmer (USU); Rotator2.0/Hall (GSFC); LCT2/Bundick (GSFC); MIRCA/Esper (GSFC)
- Turnaround Flights

FY15 Antarctica

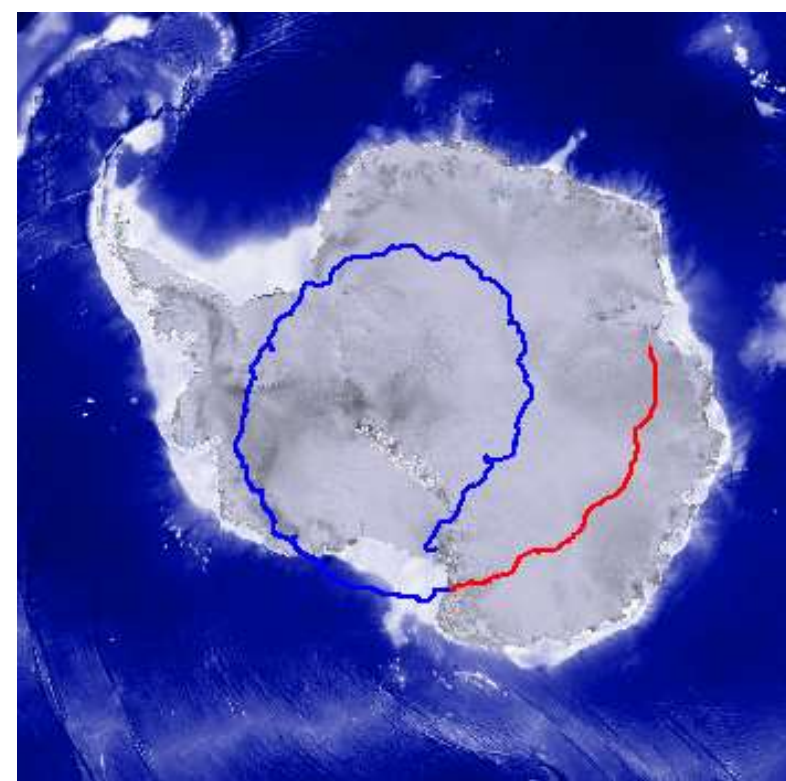
Wallops Flight Facility



ANITA

December 17, 2014

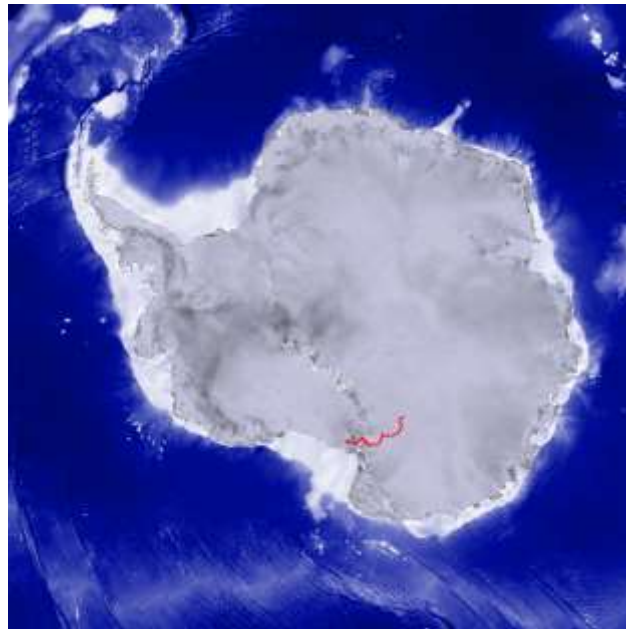
22 Days 9 Hours



SPB/ COSI

December 28, 2014

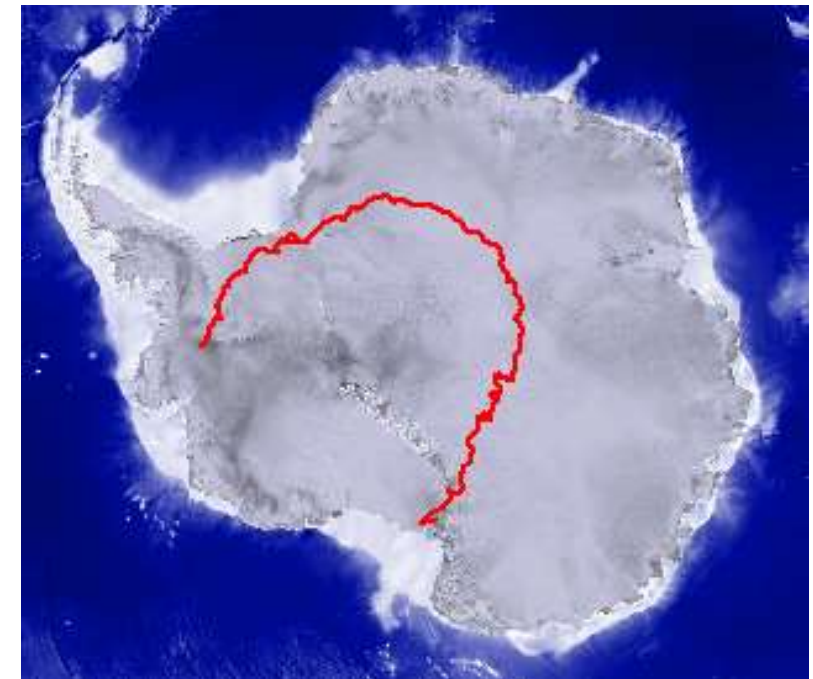
43 Hours - Leak



SPIDER

January 1, 2015

16 Days 13 Hours

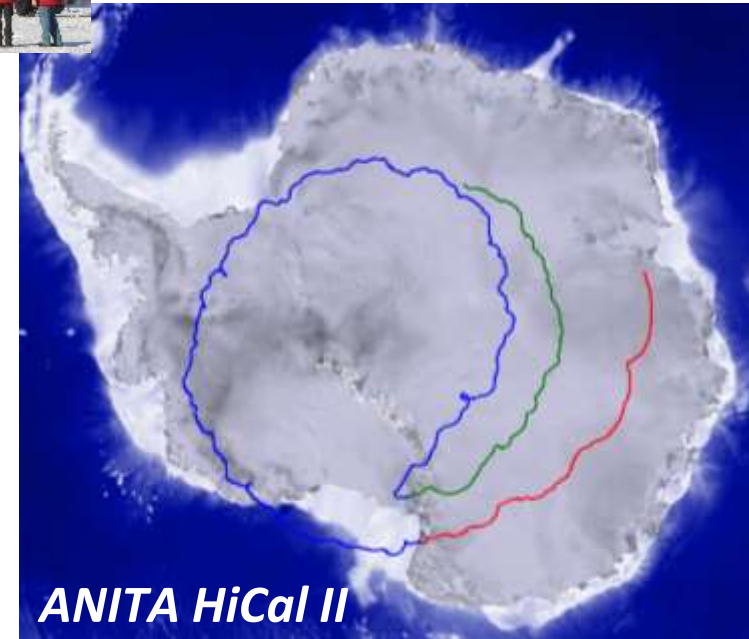


FY15 Antarctica – HiCal Flights



December 18, 2014

4 Days 20 Hours



January 6, 2015

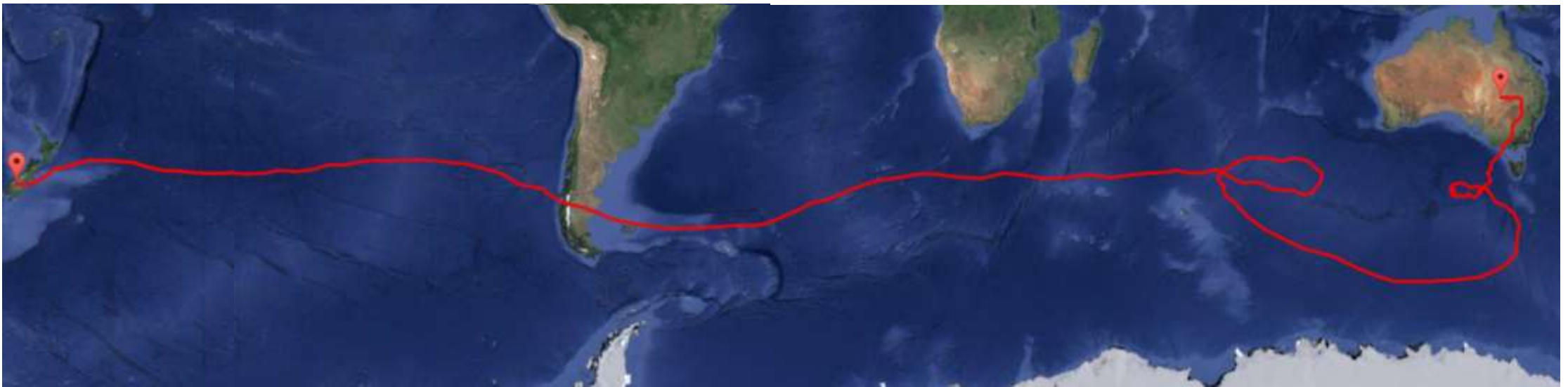
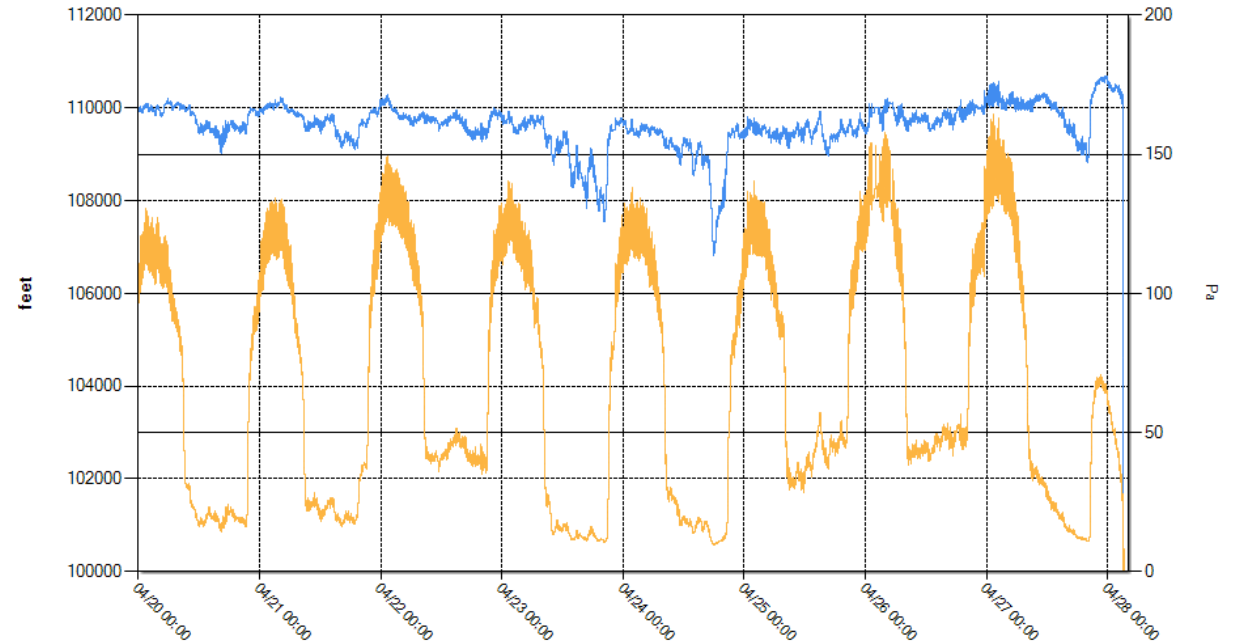
5 Days 13 Hours

Hi-CAL 2 Track
ANITA 1st Track
ANITA 2nd Track

FY15 New Zealand – Flight 662NT

Super Pressure Balloon – 18.8 MCF

- Launched March 26, 2015 from Wanaka, NZ
- Terminated in outback of Australia
- Anomalous performance detected April 27
- Total time aloft: 32 days, 5 hours, 51 minutes



Low Density Supersonic Decelerator (LDSD) Dr. Adler, JPL

- Second Full Scale LDSD Flight
- Flight Time: 3 hr., 45 min.
- Operations and Test Success

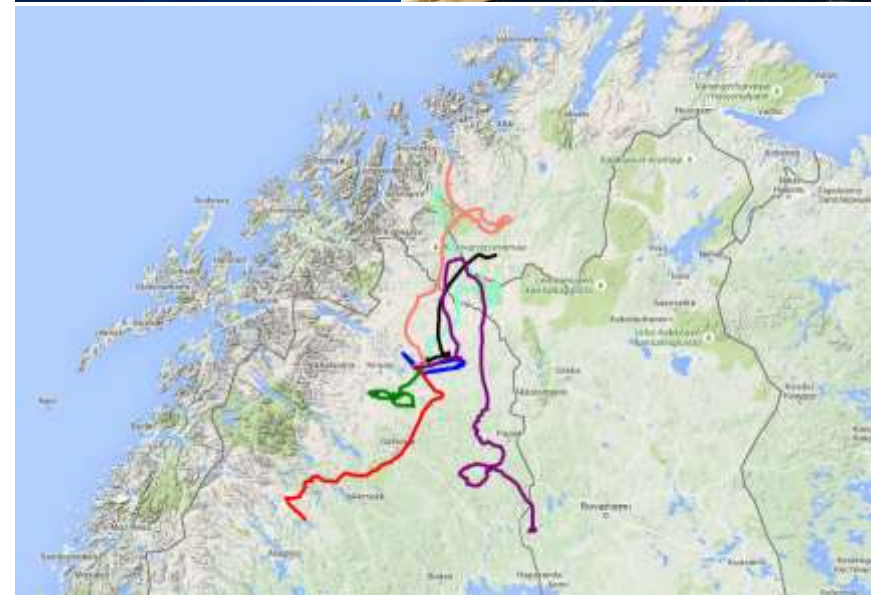


Balloon Array for Radiation-belt Relativistic Electron Losses (BARREL), a Living With a Star (LWS) Mission of Opportunity (MoO), will extend the Antarctic Science campaigns into the northern hemisphere with science launches from Esrange Space Center.

BARREL will quantify and reveal the processes responsible for catastrophic losses of electrons from Earth's outer radiation belt. BARREL is managed out of WFF.

BARREL Sweden Campaign Achievements and Highlights:

- Seven successful flights with durations ranging from roughly 7-36 hours.
- 92.8 hours of observations above our science altitude of 27 km.
- 10 very close conjunctions between a balloon and a Van Allen Probes satellite. Additional conjunctions with the FIREBIRD and AC-6 cubesats, and nearby passes of Cluster, THEMIS, and MMS.



Test Flight I – Robert Salter, CSBF

- Launch Date: 4 September 2015 / 14:55 Z
- Balloon: 29.47 MCF
- Flight Duration: 7 hrs 45 min
- *Operational and Science Success!!!*



High Altitude Student Platform (HASP) – Dr. Greg Guzik, Louisiana State University

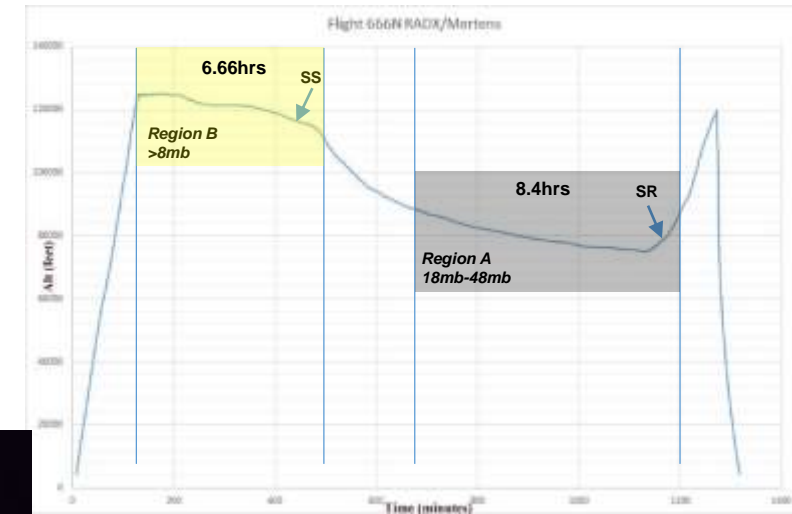
- Launch Date: 7 September 2015 / 13:47 Z
- Balloon: 11.82 MCF
- Flight Duration: 26 hours 31 minutes
- *Operational and Science Success!!!*

10th HASP mission!



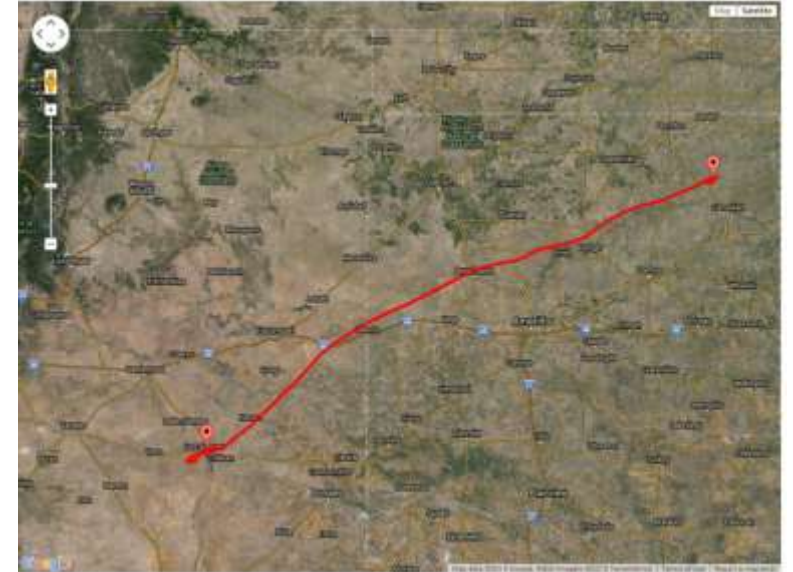
Radiation Dosimetry Experiment (RaD-X) – Dr. Chris Mertens, LaRC

- Launch Date: 25 September 2015 / 17:05:39 Z
- Balloon: 11.82 MCF
- Flight Duration: 21hrs 52 min
- *Operational and Science Success!!!*



Test Flight II–Bryan Stilwell, CSBF

- Launch Date: 10 October 2015 / 14:51:47 Z
- Balloon: 11.82H MCF
- Flight Duration: 11hrs 27 min
- *Operational and Science Success!!!*



2015 Fort Sumner – Missions of Opportunity

Flight	Org.	PI/Mission	Description
Test Flight #1	MSFC	Christl/ ANS	Advanced Neutron Spectrometer (ANS) will evaluate trigger (identify neutrons, reject gamma rays and charge particles) and measure atmosphere neutron spectrum. ANS planned to fly on both test flights but received all data needed on TF#1 and will not fly on TF#2.
Test Flight #1	GRC	Stevenson/ ANGEL	Autonomously Navigated paragliding Experimental Lander (ANGEL) is designed to demonstrate a controlled descent of a high altitude balloon payload to a predetermined landing zone using an Airborne Systems Microfly guided precision ram-air canopy controlled by an automated guidance unit.
Test Flight #1	U of AZ	Walker/ LBRSP	The Large Balloon Reflector Sensing Package will fly two instrument packages – one on the apex, the other on the gondola – to measure balloon dynamics.
Test Flight #2	KSC/ ARC	Smith/ EMIST	The Exposing Microorganisms in the Stratosphere (EMIST) is a reflight from last year to find out if known-quantities of spore-forming bacteria can survive once reaching Mars.
Test Flight #2	UAH	Adams/ EUSO IR	Extreme Universe Space Observatory (EUSO) IR is the prototype of the IR camera which will be part of the EUSO Mission on the International Space Station. Biological samples will also be flown with EUSO.
Test Flight #2	USIP/ UVa	Goyne/ JSATCRM	The JefferSat Cosmic Ray Mission (JSATCRM) will measure radiation levels at high altitudes in order to validate existing NASA radiation models. It will also test some controls via smartphone.
Test Flight #2	USIP/ UT St	Fullmer/ RLAGS	The Red-Line Air Glow Sensor (RLAGS) will take high temporal resolution measurements of wind speed over a wide range of altitudes to augment high resolution data on wind speeds in the thermosphere and help answer questions about how neutral winds contribute to energy distributions in the upper atmosphere.
Test Flight #2	GSFC IRAD	Esper/ MIRCA	The Micro-Return Capsule (MIRCA) will verify vehicle COTS avionics and UHF communications link in dynamic environment during ascent and at altitude in near-space environment. MIRCA will also test flight software and collect IMU data both on-board and on the ground in preparation for a drop test on a future flight.

FY16 Flight Manifest

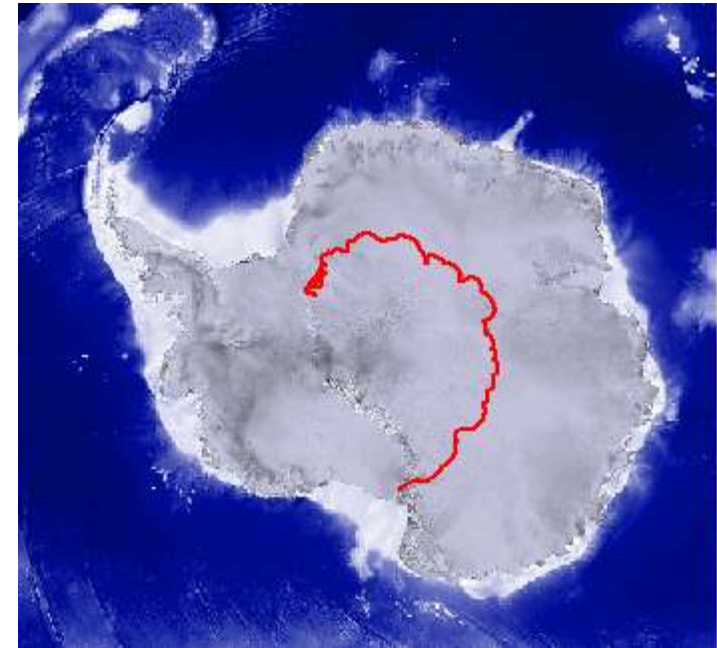
Principal Investigator (PI) / Institution / Instrument	Discipline	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Fort Sumner, New Mexico	Fall 15												
Stilwell / CSBF / Test	Test Flight	◆	SUCCESS										
McMurdo, Antarctica	Winter 15												
Saint Hilaire / UCB / GRIPS	Heliophysics				↔	↔	SUCCESS						
Walker / UA / STO	IR-Submillimeter				POSTPONED UNTIL FY17								
Wanaka, New Zealand	Spring 16												
Fairbrother / WFF / SPB / Boggs / UCB / COSI	Test Flight								↔	↔	SUCCESS		
Palestine, Texas	Summer 16												
Jones / Princeton / Super-BIT	UV/Visible									◆	SUCCESS		
Esrang, Sweden	Summer 16												
Millan / DC / BARREL [8 PI-Hand Launched]	Heliophysics									SUCCESS	◆◆◆◆		
Fort Sumner, New Mexico	Fall 16												
Guzik / LSU / HASP	Student Flight Project									SUCCESS	◆		
Krawczynski / WUSL / X-Calibur / Stuchlik / WFF / WASP	Gamma Ray/X-Ray										SUCCESS	◆	
Margitan / JPL / Remote	Upper Atmosphere										SUCCESS	◆	
Field / CSBF / Test Flight	Test Flight										SUCCESS	◆	
Reinhart / GSFC / BETTII	IR-Submillimeter							POSTPONED UNTIL FY17					
Kogut / GSFC / PIPER	IR-Submillimeter							POSTPONED UNTIL FY17					

Gamma-Ray Imager/Polarimeter for Solar flares (GRIPS) -

Dr. Pascal Saint-Hilaire, UC Berkeley

- Flight Ready: December 25, 1st Antarctica Flight
- Balloon: 39.57MCF
- Launch Date: January 19
- Total Flight Time: 11 days, 19 hours, 50 minutes
- Operations and Science Success

Latest LDB Launch in History!



FY16 Antarctica Campaign – STO II

Wallops Flight Facility

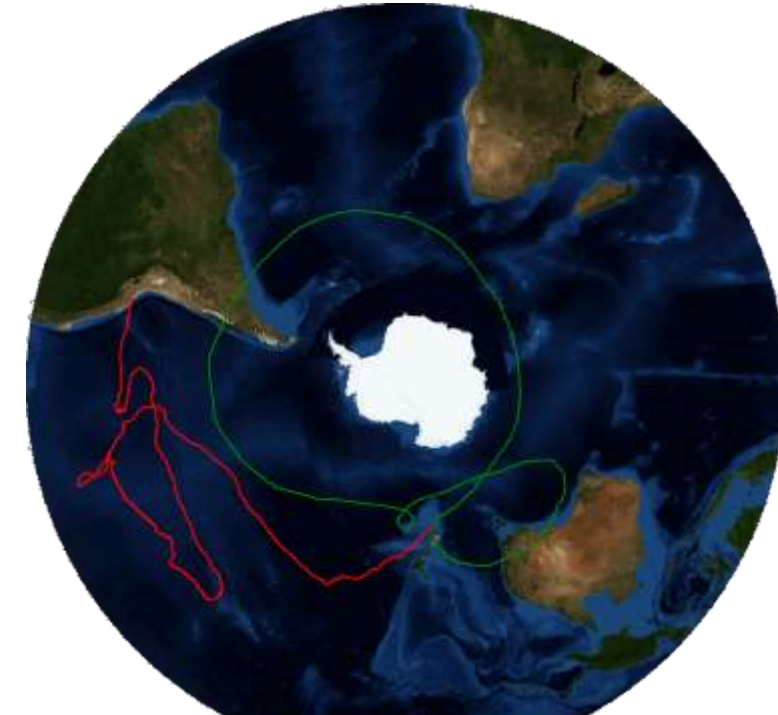
Stratospheric Terahertz Observatory (STO-II) - Dr. Chris Walker, University of Arizona

- Flight Ready January 2; 2nd Antarctica Flight
- Balloon: 39.57MCF
- *Mission postponed until FY17 Antarctic Campaign. Science team and CSBF disassembled and winterized the gondola and support equipment.*



Super Pressure Balloon (SPB)/ Compton Spectrometer and Imager (COSI) – WFF/UC Berkeley

- Launched (Finally!): 16 May at 23:35Z
- Terminated: 2 July at 19:14Z near Camana, Peru
- Over 46 days
- The balloon encountered performance issues during the latter part of the mission due to suspected loss of gas in the system.

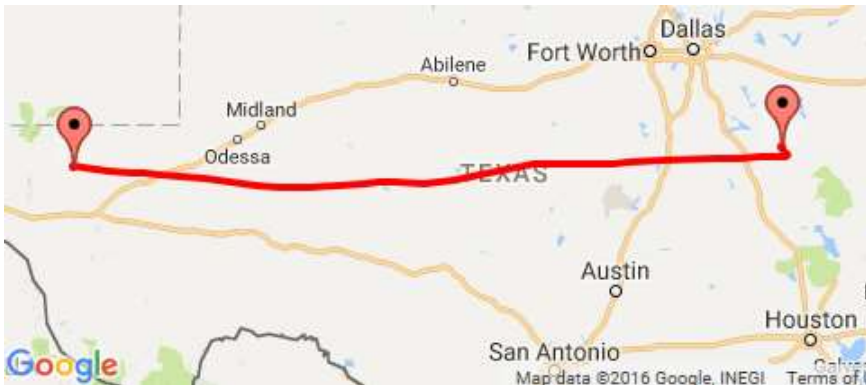


Balloon-Borne Imaging Telescope for Super Pressure Balloon (Super-BIT) - Dr William Jones, Princeton

- Balloon: 11.82 MCF
- Launch Date: 1 July 2016 at 00:13 Z
- Total Flight Time: 10 hours, 36 min
- Operations and Science Success

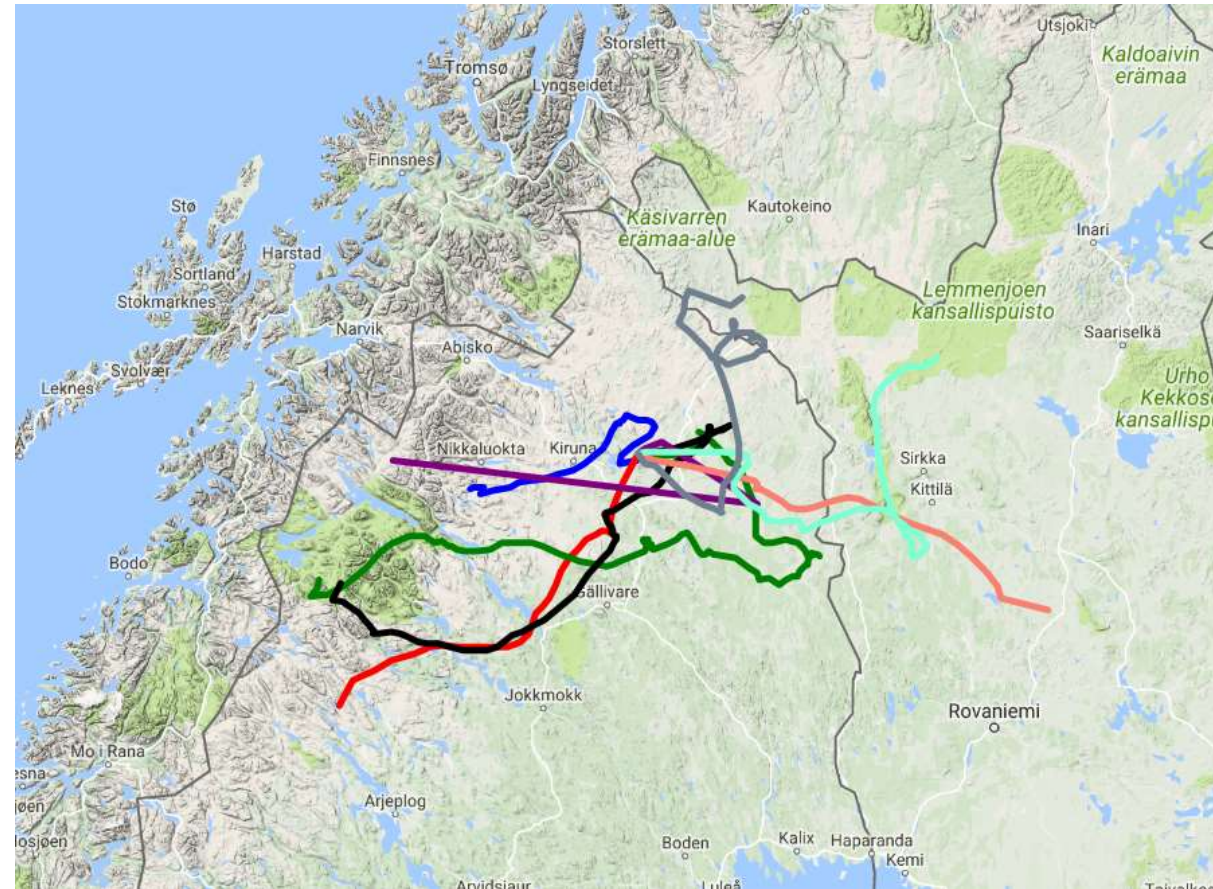
First major launch from Palestine since 2007

Balloons aloft in Northern and Southern Hemispheres (SPB).



Balloon Array for Radiation-belt Relativistic Electron Losses (BARREL)

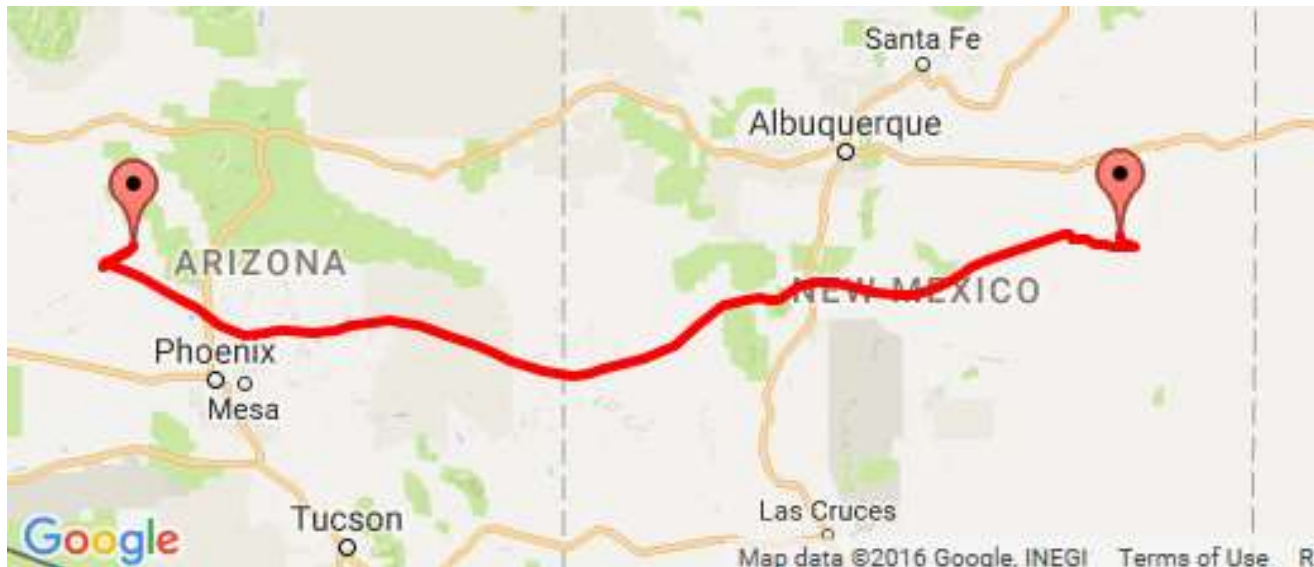
- Launched: 8 Flights flown between August 13 and 31 from Esrange in Sweden
- Terminated: In Sweden and Finland
- Over 116 hours of flight
- Multiple conjunctions with both the Van Allen Probes and the MMS spacecraft



High Altitude Student Platform (HASP) – Dr. Guizik, LSU

- Launch Date: 1 September 2016 16:08:42 Z
- Balloon: 11.82 MCF
- Flight Duration: 18 hrs 19 min
- *Operational and Science Success!!!*

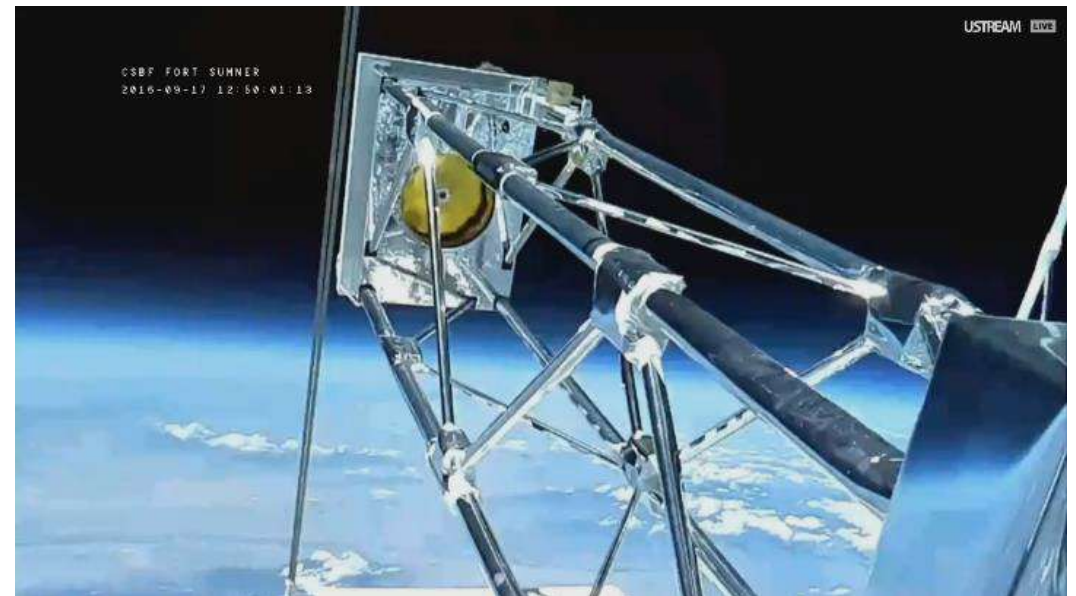
11th Flight of the HASP Mission!!



X-Calibur – Dr. Krawczynski / Washington University St. Louis

- Launch Date: 17 September 2016 / 13:28 Z
- Balloon: 39.57 MCF
- Flight Duration: 28 hrs 15 min
- *Operational and Science Success!!!*

*First science mission in which the Wallops Arc Second Pointer is a support system.
Currently going through integration in Palestine for upcoming FY19 Antarctica Campaign.*



JPL Remote – Dr. Margitan, JPL

- Launch Date: 27 September 2016 / 14:28 Z
- Balloon: 29.47 MCF
- Flight Duration: 14 hrs, 47 min
- *Operational and Science Success!!!*



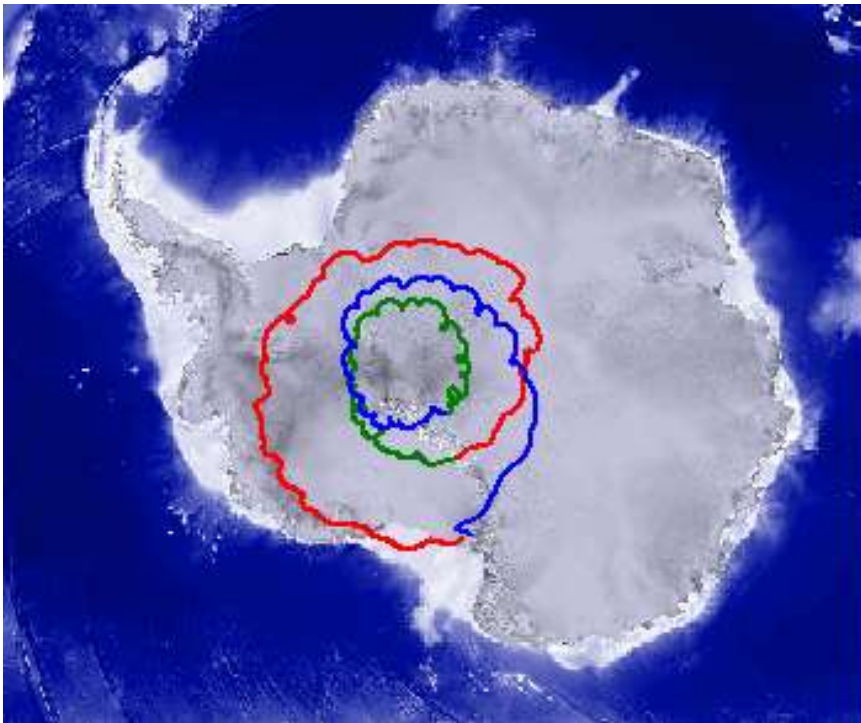
LDB Test – Chris Field/Justin Marsh, CSBF

- Launch Date: 28 September 2016 / 14:28 Z
- Balloon: 29.47 MCF
- Flight Duration: 9 hrs 57 min
- *Operational and Science Success!!!*



Boron and Carbon Cosmic rays in the Upper Stratosphere (BACCUS) – Dr. Seo, University of Maryland

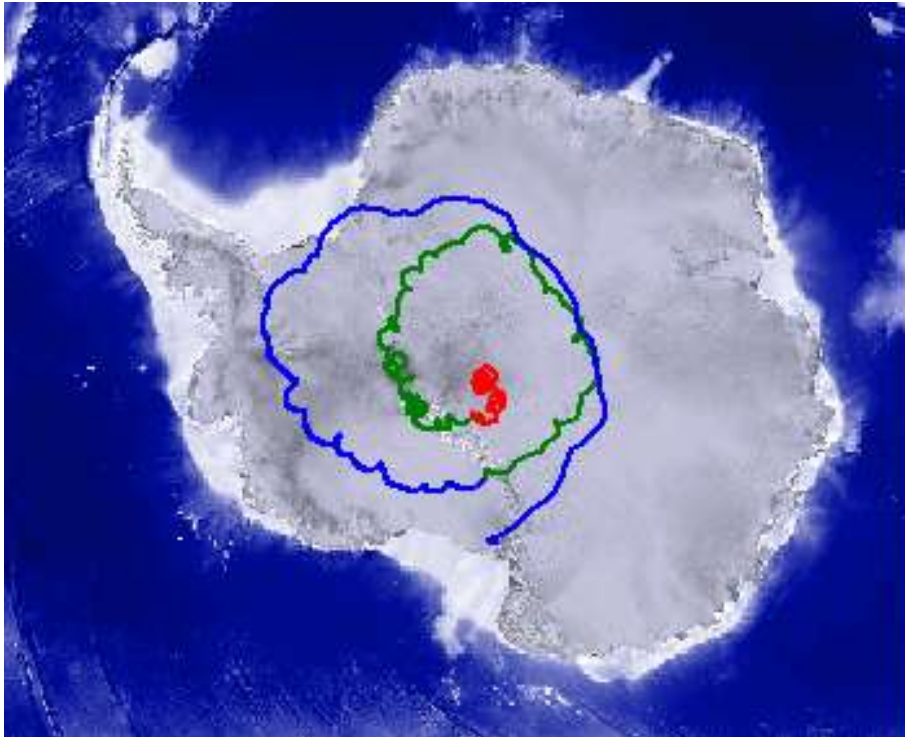
- Launch Date: 28 November 2016 19:00 Z
- Balloon: 39.57 MCF
- Flight Duration: 29 days, 21 hrs, 11 min
- *Operational and Science Success!!!*



Antarctic Impulsive Transient Antenna (ANITA) –

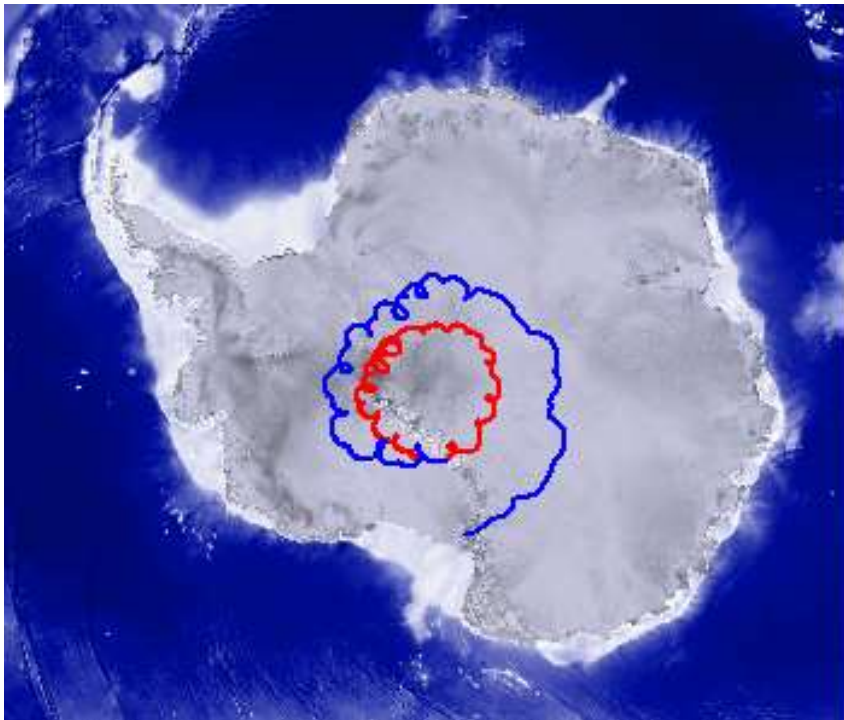
Dr. Gorham, University of Hawaii

- Launch Date: 2 December 2016 13:11 Z
- Balloon: 39.57 MCF
- Flight Duration: 27 days, 11 hrs, 15 min
- *Operational and Science Success!!!*

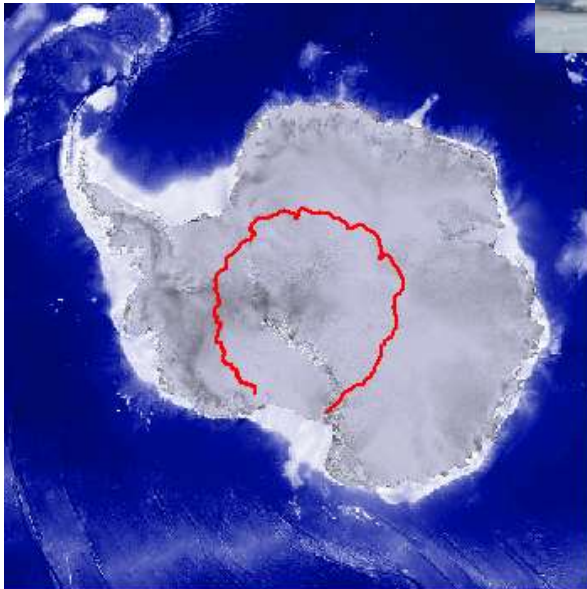


Stratospheric Terahertz Observatory (STO-2) Dr. Walker, University of Arizona

- Launch Date: 8 December 2016 20:53 Z
- Balloon: 39.57 MCF
- Flight Duration: 21 days, 19 hrs, 17 min
- *Operational and Science Success!!!*



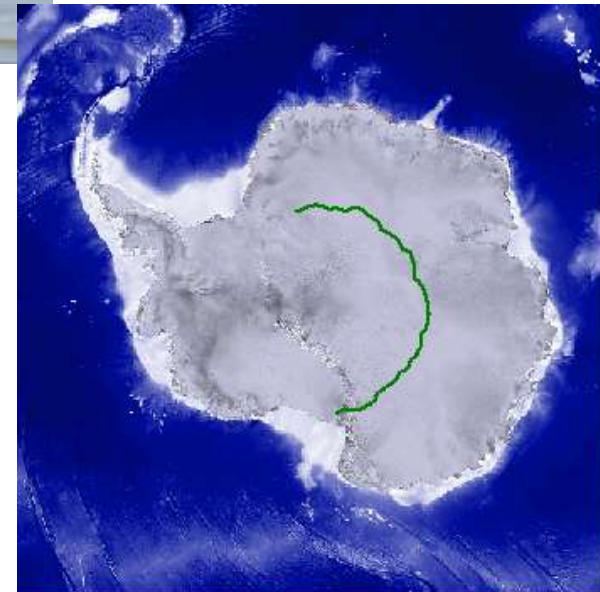
FY17 Antarctic Campaign – ANITA HiCal



ANITA HiCal2- 1

December 11, 2016

13 days ,12 hrs, 32 min



ANITA HiCal2- 2

December 12, 2016

5 days, 23 hrs, 1 min

Super Pressure Balloon/ Extreme Universe Space Observatory (SPB/EUSO) - D. Fairbrother - WFF

- Volume: $\sim 532,152 \text{ m}^3$ ($\sim 18,793,000 \text{ ft}^3$)
- Launch Date: April 24, 2017 @ 22:50 Z
- Suspended Load: 2,495 kg (5,500 lbs.)
- Flight Time – 12 days, 4 hours, 34 mins
- EUSO flown as a Mission of Opportunity



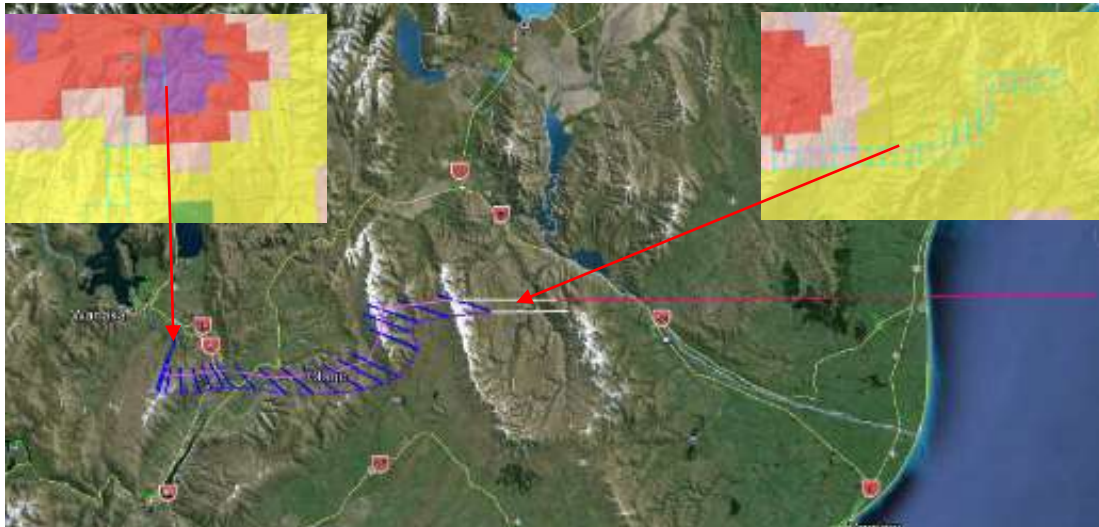
New Zealand Launch Pad

Wallops Flight Facility



Active Risk Assessment

- Cumulative risk criteria calculated for Ascent, Float, Descent
 - Collective Casualty Expectation (CE) < 100×10^{-6}
 - Individual Probability of Casualty (Pc) < 1×10^{-6} (for Ascent < 16K ft.)
- L-1 and Show, CSBF delivers climbout trajectories, with descent vectors for both Payload and Balloon
 - MRSO evaluates trajectory. Provides results at the L-1 weather briefing. Process repeated at Show to validate risk and incorporate trajectory change.
 - MRSO Provides GO/NO GO to CM prior to Gondola pickup.



Balloon- Experimental Twin Telescope for Infrared Interferometry (BETTII) - Dr Rinehart, GSFC

- Balloon: 39.57 MCF
- Launch Date: 9 June 2017 at 00:14 Z
- Total Flight Time: 15 hours, 19 min
- Operations and Science Success
- Close call at termination event



High Altitude Student Platform (HASP)

Dr. Guzik, LSU

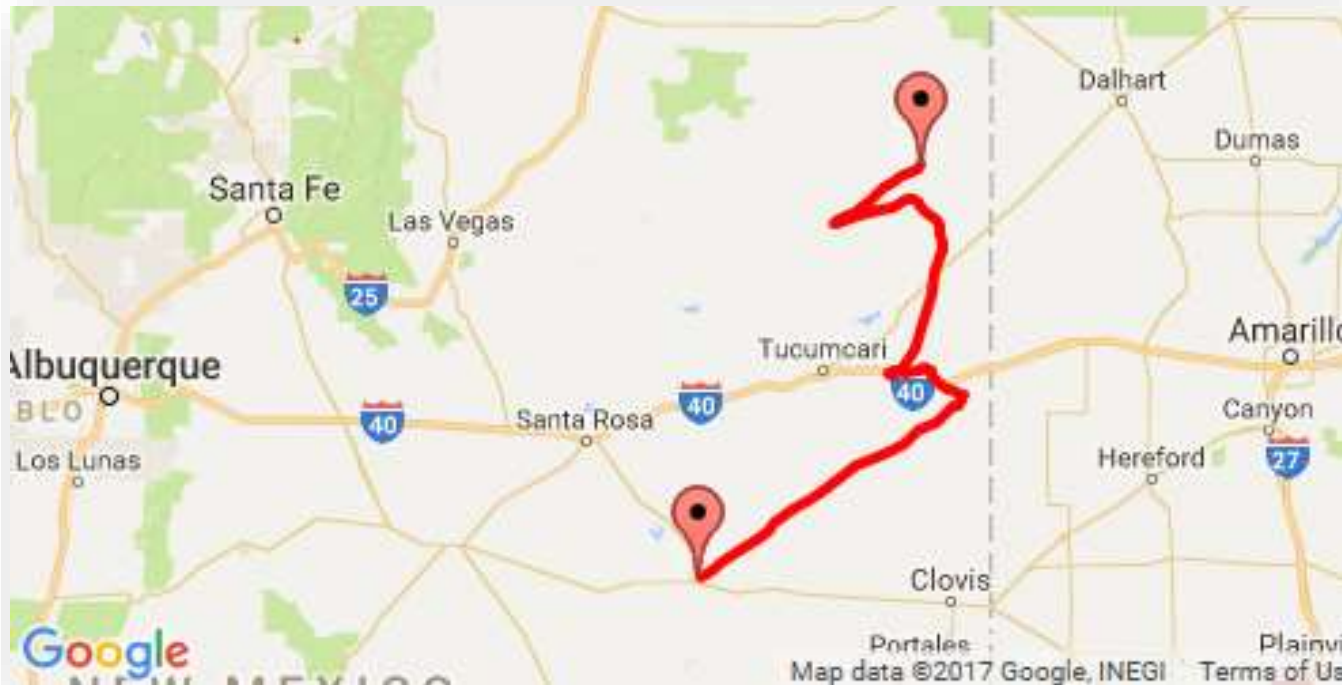
- Balloon: 4 MCF
- Launch Date: 4 September at 14:04 Z
- Total Flight Time: 11 hours, 22 min
- Operations and Science Success



Primordial Inflation Polarization Explorer (PIPER)

Dr. Kogut / GSFC

- Balloon: 11.82 MCF
- Launch Date: 13 October 2017 at 16:12 Z
- Total Flight Time: 11 hours, 20 min
- Operations and Science Success



Super Trans-Iron Galactic Element Recorder (Super-TIGER II)

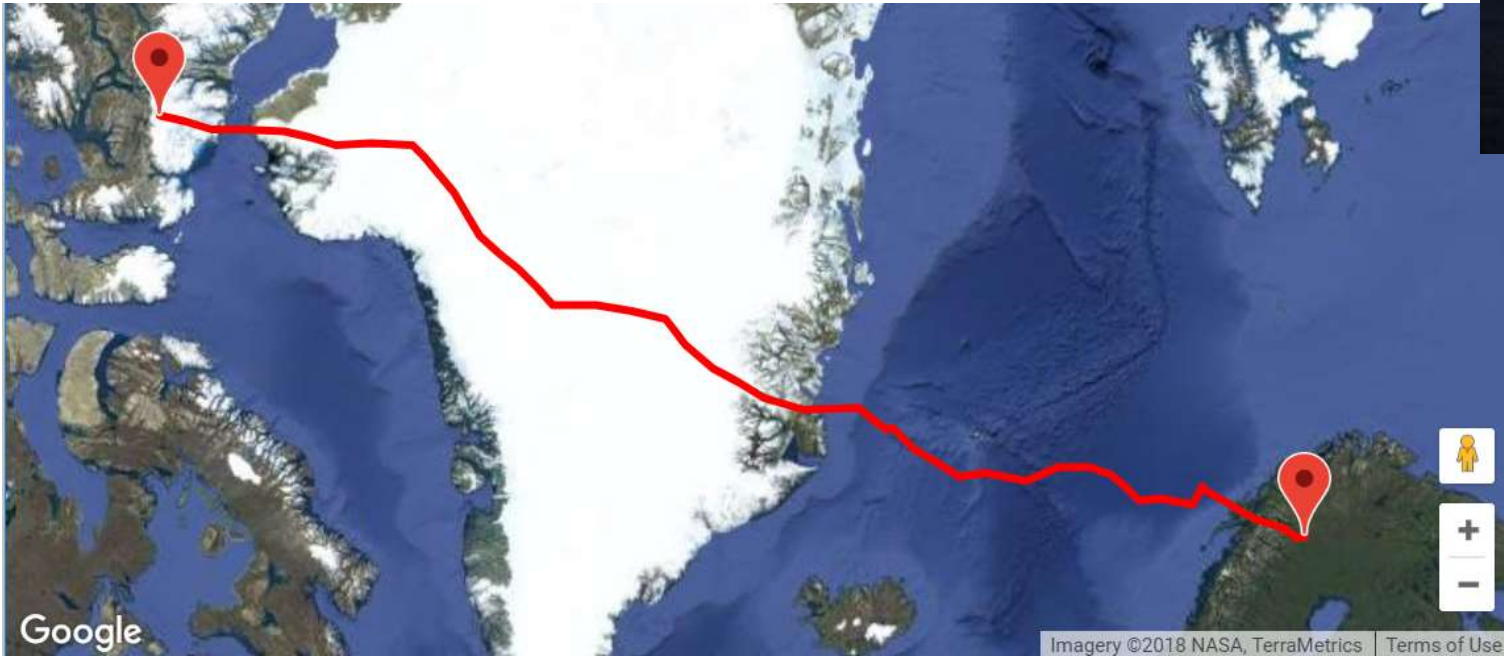
- Dr. Bob Binns, Washington University [Current LDB duration record holder: 55 days]
- Super-TIGER II is a new, large-area instrument for measurement of the abundances of elements. It will test and clarify the emerging model of cosmic-ray origin in OB associations and will measure the energy spectra of the more abundant elements [4th Antarctica Flight]
- Launch weather did not cooperate.
- Payload stored in payload building.
- Planned for FY19 Antarctica.



Low Energy Anti-Electron Sub-Orbital Payload (AESOP-Lite)

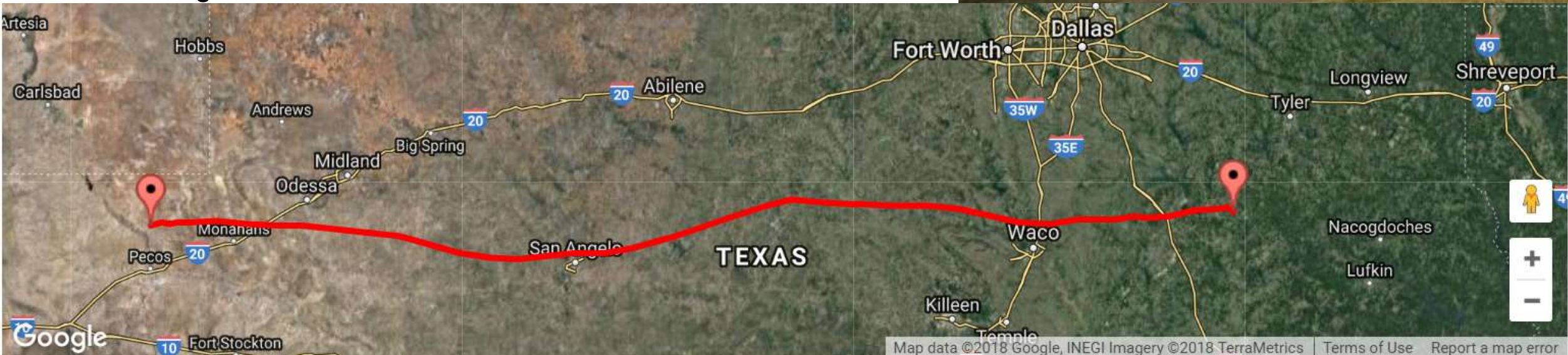
Dr. John Clem, University of Delaware

- AESOP-Lite will explore the source of the negative spectral index of low-energy cosmic ray electrons (20-100 MeV). The primary science objective is to make a definitive determination of the cosmic electron and positron energy spectrum from 20-Mev to above 500-MeV.
- Launched: 15 May 2018 at 22:08 Z
- Terminated: 21 May 2018 at 13:26 Z
- Total Flight Time: 5 days, 15 hours and 55 minutes



Super Pressure Balloon Balloon-borne Imaging Telescope (Super-BIT) *Dr. Bill Jones, Princeton*

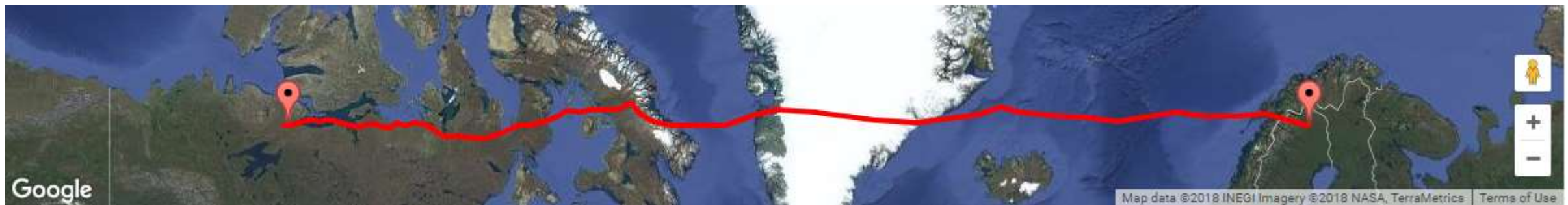
- The Balloon-borne Imaging Telescope (aka. SuperBIT) is a wide-field (0.4 deg) instrument operating in the visible-to-near-UV bands (300-900 nm) at a diffraction-limited resolution of 0.25 arc seconds. This requires 20 milliarcsecond image stability over a 0.5 degree field-of-view for integration periods ranging from 10-30 minutes.
- Launched: 6 June 2018/ 00:16:23 Z
- Terminated: 6 June 2018 / 20:35:03 Z
- Total Flight Time: 21 hours 13 minutes



HIWIND

Dr. Qian Wu, High Altitude Observatory, (HAO) NCAR

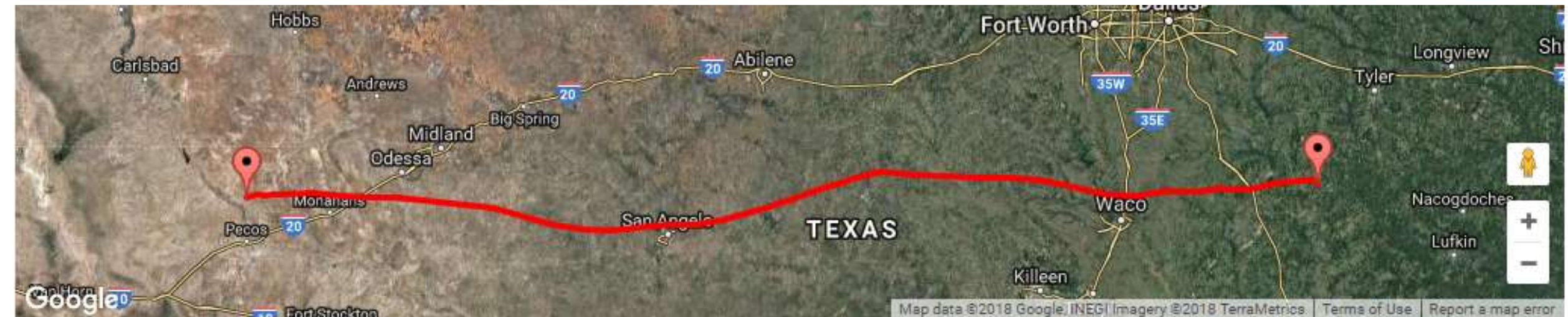
- Measure polar thermospheric winds.
- Piggyback Missions of Opportunities:
 - Balloon Array for RBSP Relativistic Electron Losses (BARREL)
Dr. Robyn Millan, Dartmouth College
NaI X-ray Spectrometer
 - Distributed Irradiance Monitoring System (DIMS)
Phil Oakley, Scott Sewell, Nicole Ela, High Altitude Observatory/National Center for Atmospheric Research
Demonstrate commercial off-the-shelf spectrometer use for solar physics applications
- Launched: 24 June 2018/ 22:29:50 Z
- Terminated: 30 June 2018 / 13:53:29 Z
- Total Flight Time: 5 days 16 hours and 13 minutes



Advanced Scintillator Compton Telescope (ASCOT)

Dr. Peter Bloser, University of New Hampshire

- Prototypes a Compton telescope designed to observe the universe in medium-energy gamma-rays, historically a difficult energy range.
- Technology would permit groundbreaking astrophysical observations.
- Launched: 5 July 2018 / 12:13:09 Z
- Terminated: 5 July 2018 / 19:32:54 Z
- Total Flight Time: 8 hours



PMC Turbo – Flight 684N

Dr. Dave Fritts, GATS, Boulder

- High altitude turbulence studies by measurements of Polar Mesospheric Clouds (PMCs).
- Test of Balloon Lidar Experiment (BOLIDE).
- Piggyback Missions of Opportunities:
 - Trans-Atlantic Infrasond Payload (TAIP)
Daniel Bowman, Sandia National Laboratories
Measure low frequency sound over the Arctic
 - Payload for Infrasond Measurement in the Arctic
Siddharth Krishnamoorthy, JPL
Measure and characterize infrasond from seismic activity
- Launched: 8 July 2018/ 07:27:30 Z
- Terminated: 14 July, 2018 / 04:47:27 Z
- Total Flight Time: 5 days, 22 hours, 8 minutes



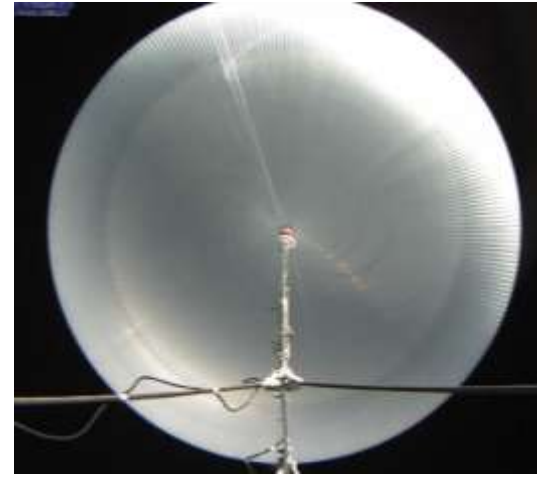
Engaging the Public

Wallops Flight Facility



Summary

- The NASA Balloon Program has continued to provide stable platforms for science.
- The WASP is now operational and supporting science missions.
- SPB development continues with numerous science missions requesting.
- Balloons provide an excellent training ground for scientists and engineers



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Questions

