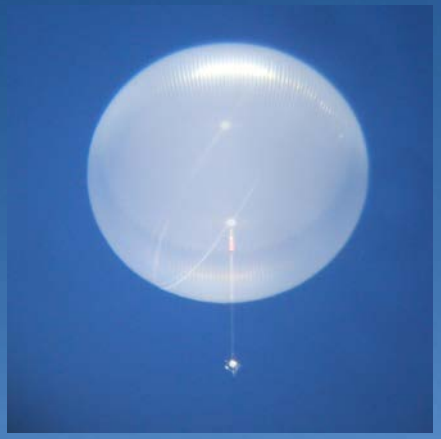
Balloon Program Update

Astrophysics Subcommittee, March 26-27, 2014



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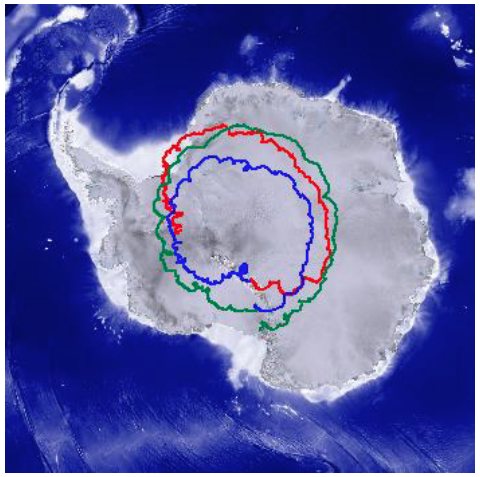
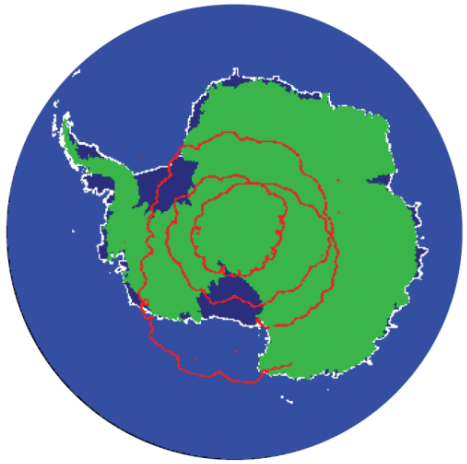
Topics to be Covered

- ✧ Balloon Program Mission Model
  - ✓ Launch sites and Campaigns
- ✧ Antarctica: Center Piece of NASA Ballooning
  - ✓ From record-breaking FY13 Campaign
  - ✓ To cancelled FY14 Campaign !
  - ✓ Recovery and “moving-on” in FY15 !
  - ✓ Long Duration Ballooning (LDB)
- ✧ Evolution to Super Pressure Ballooning (SPB)
  - ✓ LDB in non-polar regions: mid-latitudes
  - ✓ Ultra Long Duration Balloon (ULDB) flights



55-day SuperTIGER Flight
Dec - Feb 2012-13

Zero Pressure Balloon



42-day CREAM flight
Dec - Jan 2004-05

Balloon Program Mission Model

- NASA/SMD conducts an average of about 10-15 Balloon Missions per year.
  - Domestic Campaigns: Fort Sumner, NM, and Palestine, TX.
  - Foreign Campaigns: Antarctica, Australia, and Sweden.
  - Future Foreign Campaign: New Zealand.
- Campaign includes setup, payload checkout, launch, and flight operations.
  - Current Budget Supports 1 - 2 Foreign Campaigns / Year.

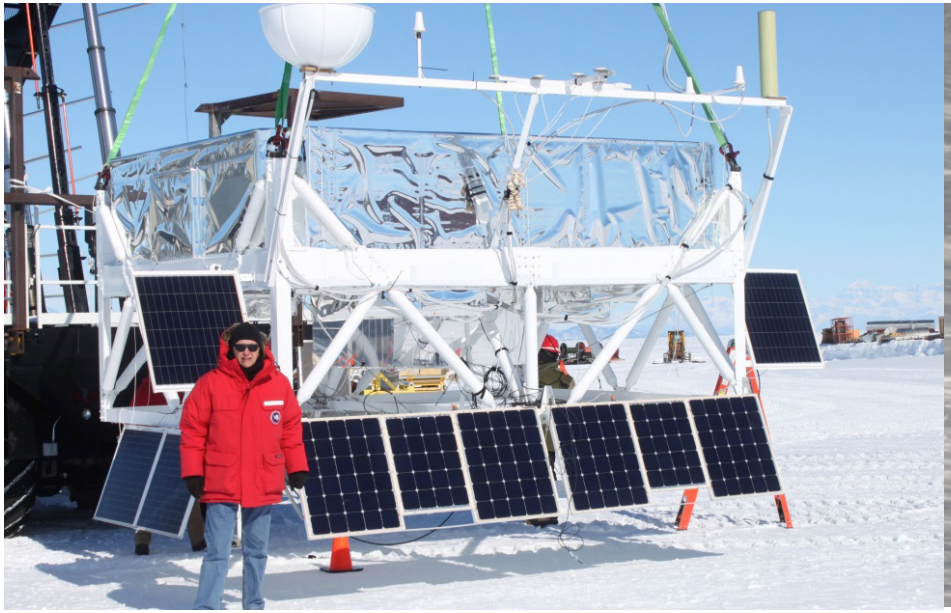
	Launches	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
New Zealand	1-2			LDB	LDB	LDB					I&T	I&T	
Antarctica	3-4	LDB						I&T	I&T			LDB	
Australia	3			CONV	CONV								
Fort Sumner	3-4				CONV	CONV							
Sweden	3-4	I&T	I&T			LDB	LDB						
Palestine	1-2						CONV	CONV					
Fort Sumner	6-8								CONV	CONV			

Antarctica is the Center Piece of NASA Ballooning

- 44 Antarctic **Long-Duration Balloon (LDB)** Flights Since 1991.
  - 31 single circumpolar flights with durations of 8 - 25 days.
  - 6 double circumpolar flights with durations of 20 - 32 days.
  - 5 triple circumpolar flights with durations of 35 – 55 days.
  - 2 super-pressure balloon (SPB) test flights: 54 days; 22 days.
- Recent History and Near-Term Plan for Antarctic LDB Flights.
  - FY 2013 Campaign (2012-2013 Season): 96 days; 2 P/L left on the Ice.
    - Balloon Large Aperture Sub-millimeter Telescope (BLAST): 16 days.
    - E and B EXperiment (EBEX): 25 days.
    - Super-Trans Iron Galactic Element Recorder (Super-TIGER): 55 days.
  - FY 2014 Antarctic Campaign (2013-2014 Season).
    Cancelled due to U. S. Government Shutdown October 1-16, 2013 !
  - FY 2015 Campaign LDB Candidates (2014-2015 Season) PIC 01/23/14
    - Antarctic Impulsive Transient Antenna (ANITA).
    - A Large Angular Scale Millimeter-wave Polarimeter (SPIDER).
    - ~~Nuclear~~ Compton Telescope (NCT) on Super-Pressure Balloon (SPB).
  - FY 2016 Campaign LDB Candidates (2015-2016 Season) Undetermined.
    - Boron And Carbon Cosmic-rays in the Upper Stratosphere (BACCUS) was brought back from Christchurch, NZ, along with Spider and SPB.

FY-2014 Antarctic Activities

- NSF notified NASA on10/24/14 that they could not open the LDB Camp, as a result of the government shutdown.
  - This **cancelation** impacted two science missions (SPIDER and BACCUS) and the Super Pressure Balloon (SPB) test.
- Several Activities not requiring the LDB Camp were approved.
  - Launch Vehicle Transmission Repair – Completed.
  - Build New Berms for Launch Vehicle & Buildings – Completed.
  - EBEX Payload Recovery – Completed.
  - Super-Tiger Payload Recovery – Unsuccessful, so postponed to FY2015.



SuperTIGER Prior to Launch

SuperTIGER Inverted at impact site 1 yr post launch

Mix of LDB/ULDB & Polar/Non-Polar Missions

- NASA-NSF/PLR Long-Duration Ballooning (LDB) provides:
  - NASA's lowest cost access to near-space (~ upper stratosphere).
  - Spacecraft-scale payloads (1000 - 2000 kg science instruments).

- The NASA Balloon Program has focused on expanding the highly successful LDB flights **OVER & AROUND** Antarctica.
  - Flight durations of up to 4-8 weeks, for up to 3 flights each year.
  - Moderate trajectory control would greatly facilitate this objective.

- Frontier Astrophysics on Super-Pressure Balloons (SPB) would justify Ultra Long Duration Balloon (ULDB) flights **FROM** Antarctica in the near future.

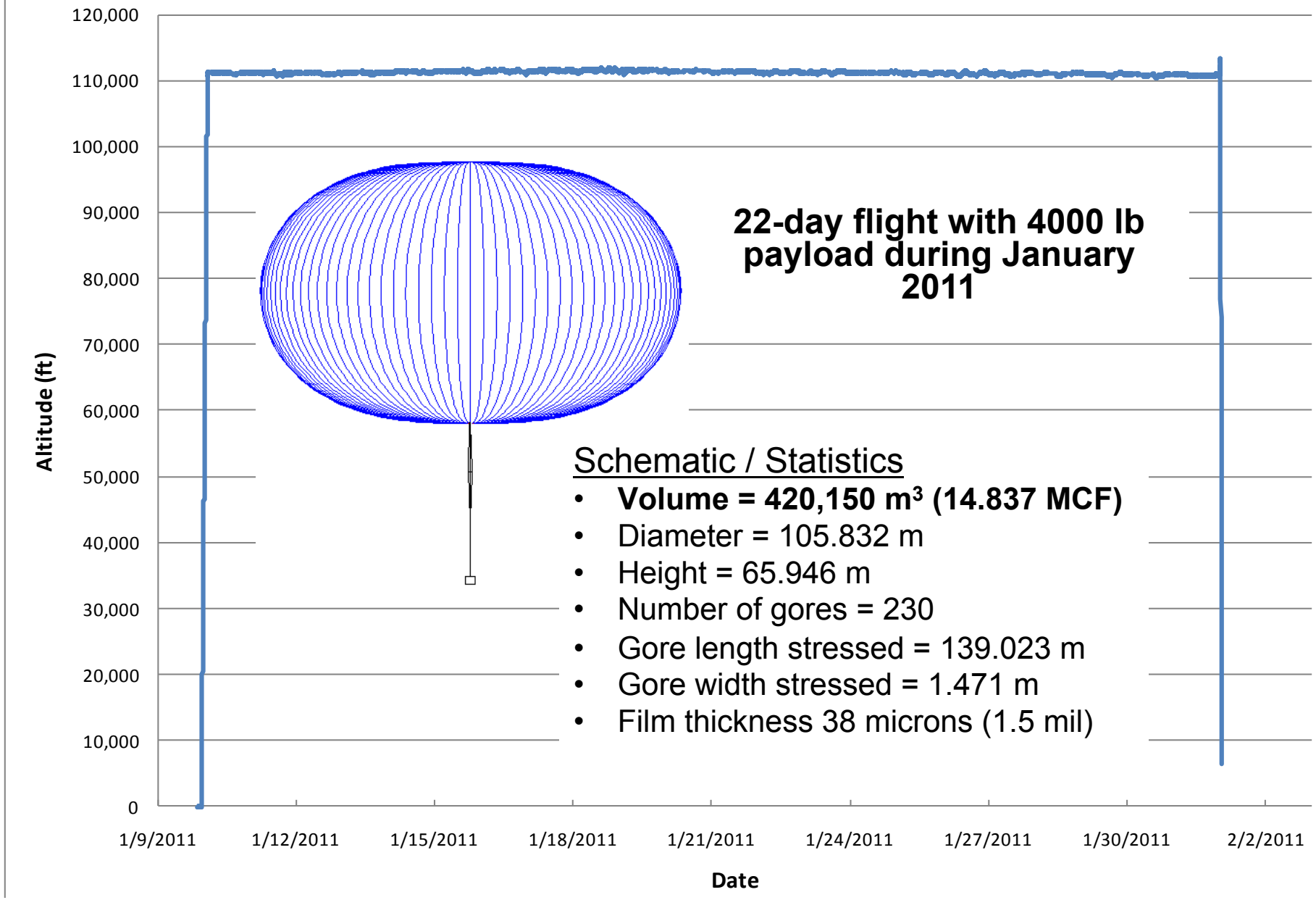
- Flights **FROM** Antarctica could yield 60 to 100-day long exposures.
  - NASA is working with NSF to enable **FLIGHTS TO LEAVE ANTARCTICA** for potential recovery in South America, New Zealand, Australia.

- NASA has identified a potential launch site at Wanaka, New Zealand to accommodate non-Polar LDB missions on SPB.
  - There may be non-trivial risk of losing the payload in the Southern Ocean.

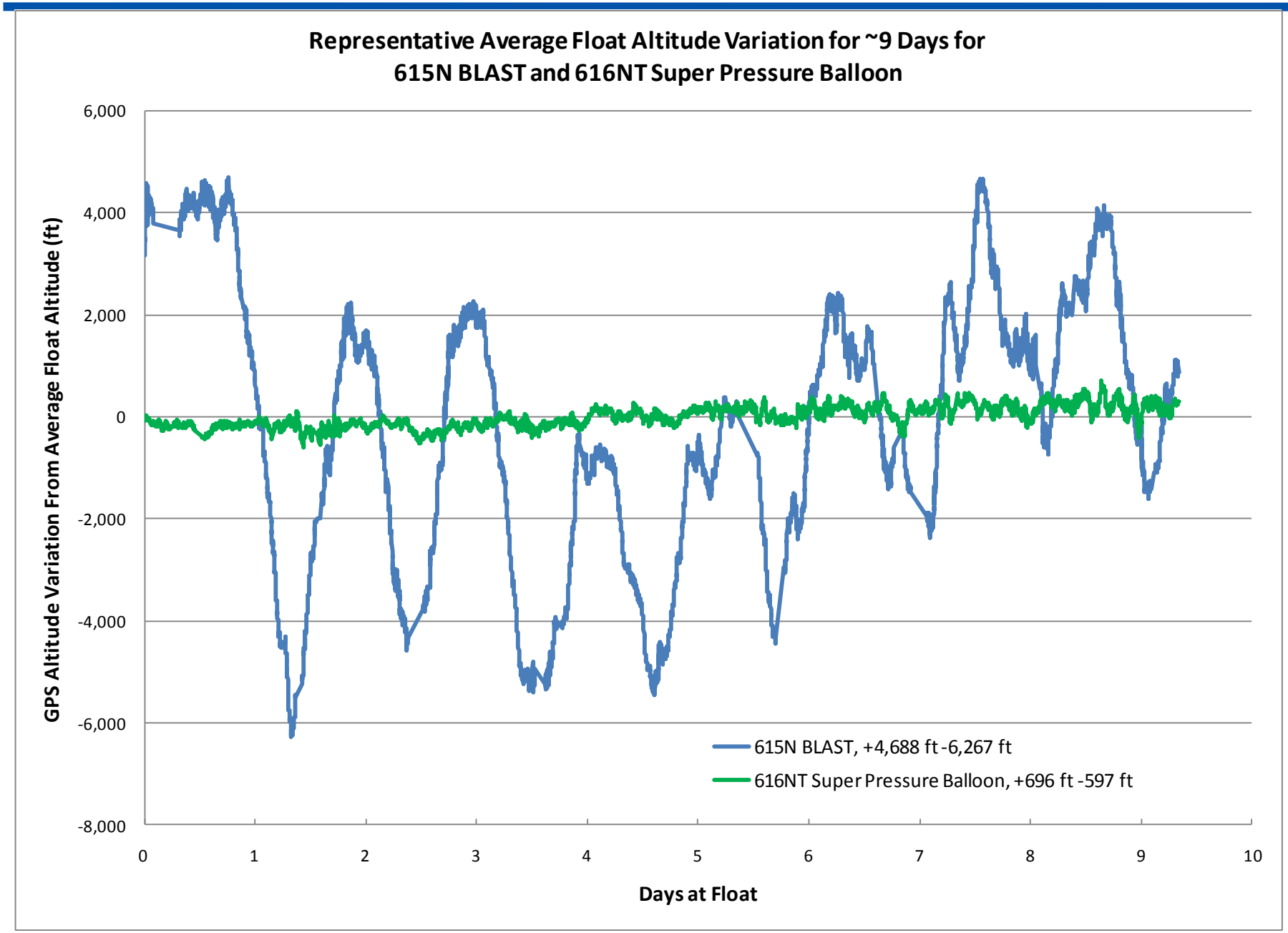
Evolution to Super Pressure Ballooning

- LDB flights employing conventional, zero-pressure balloons have a proven history of scientific discovery, with many cited achievements.
  - Most high priority projects are proposing multiple flights.
- Super-pressure balloons offer order of magnitude increase in capability.
  - They enable Ultra Long Duration Balloon (ULDB) flights (60-100 days).
  - They open areas of exploration closed to zero-pressure balloons, e.g., LDB flights in non-polar-regions.
- Costs to convert most LDB payloads for ULDB flights are modest.
  - LDB and ULDB together would form a science opportunity continuum.
  - They offer significant science at fraction of the cost of a space mission.
  - ULDB missions may be acceptable alternative to some Small Explorer (SMEX) missions..
- Balloon payloads are solicited as Missions of Opportunity (MO) in Explorer Announcements of Opportunity (AO).
  - Two proposed balloon missions (ANITA, GUSSTO) were selected for Explorer Phase A studies, but neither was down-selected for flight.

Super Pressure Balloon (SPB)
“ First New Balloon Design in more than 60 Years ”



Zero- and Super-Pressure Balloon Altitude Comparison

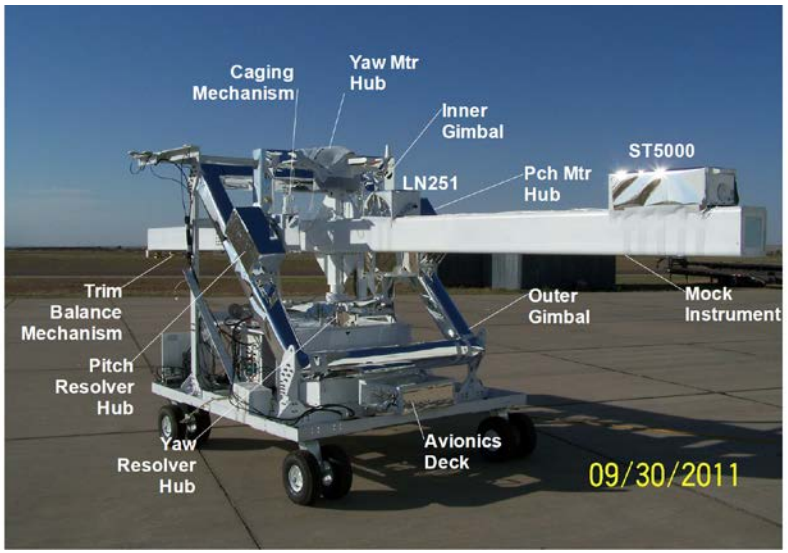


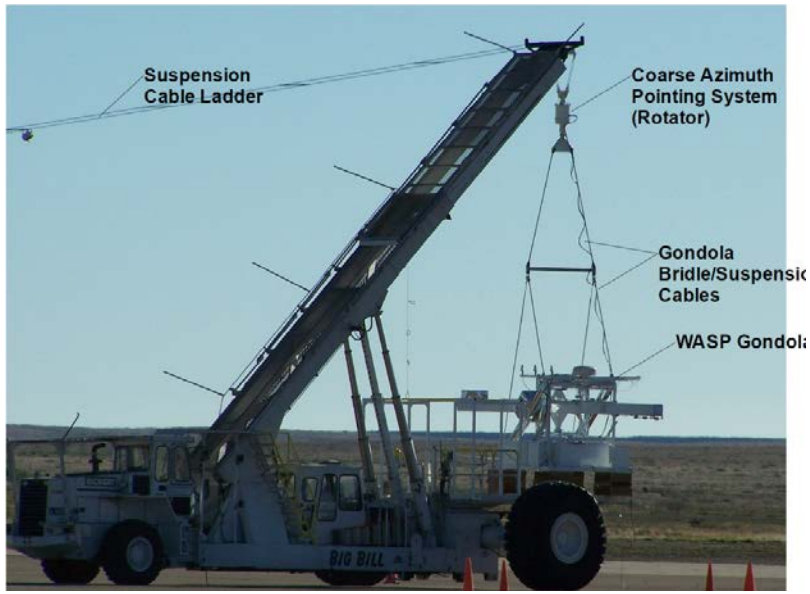
18.8 MCF SPB By the Numbers

- **Inflated volume ~ 18.8 million cubic feet**
- Number of Gores = 280
- Length of Each Gore ~ 492 feet
- Inflated Diameter ~ 376 feet
- Inflated Height ~ 233 feet
- Fitting diameter ~ 4.8 feet
- Shell film thickness ~ 1.5 mil (0.0015 in = 38 micron)
- Final Weight of Balloon ~ 5,114 pounds
- Number of Gore Width Measurements = 6,440 (23 per gore)
- Amount of Load Tape Tendon in Balloon **~ 137,760 ft (26 miles)**
- Amount of film visually inspected, re-rolled and dispensed for this balloon **> 1.3 million square feet - over 30 acres of film!**
- **Minimum amount of walking just to seal balloon = 55 miles**
- Balloon shipping box ~16 ft x ~6 ft x ~5.3 ft
- Gross Weight of Balloon in Box ~ 8,832 pounds

Wallops Arc Second Pointer (WASP) Project

- WASP test flight flew 5 hr from Ft. Sumner, N.M. with on October 7, 2011.
- In ~ 2 hr at float altitude of 102,000 ft (32 m), it demonstrated sub-arc second pointing stability with a mock telescope.
- Inertial target offsets were issued from the ground to demonstrate science operations mode and target acquisition dynamics.
- The “Hyper Spectral Imager for Climate Science (HySICS)” science payload flown on WASP in FY13 Fall Fort Sumner campaign is planned for a re-flight in FY14.
- The “Observatory for Planetary Investigations from Stratosphere (OPIS)” project will fly a telescope on WASP TF2 gondola in FY14 to image Jupiter, Exoplanet and Asteroid targets.
- TF2 will remain as test bed: new gimbal frames and hubs are being fabricated.





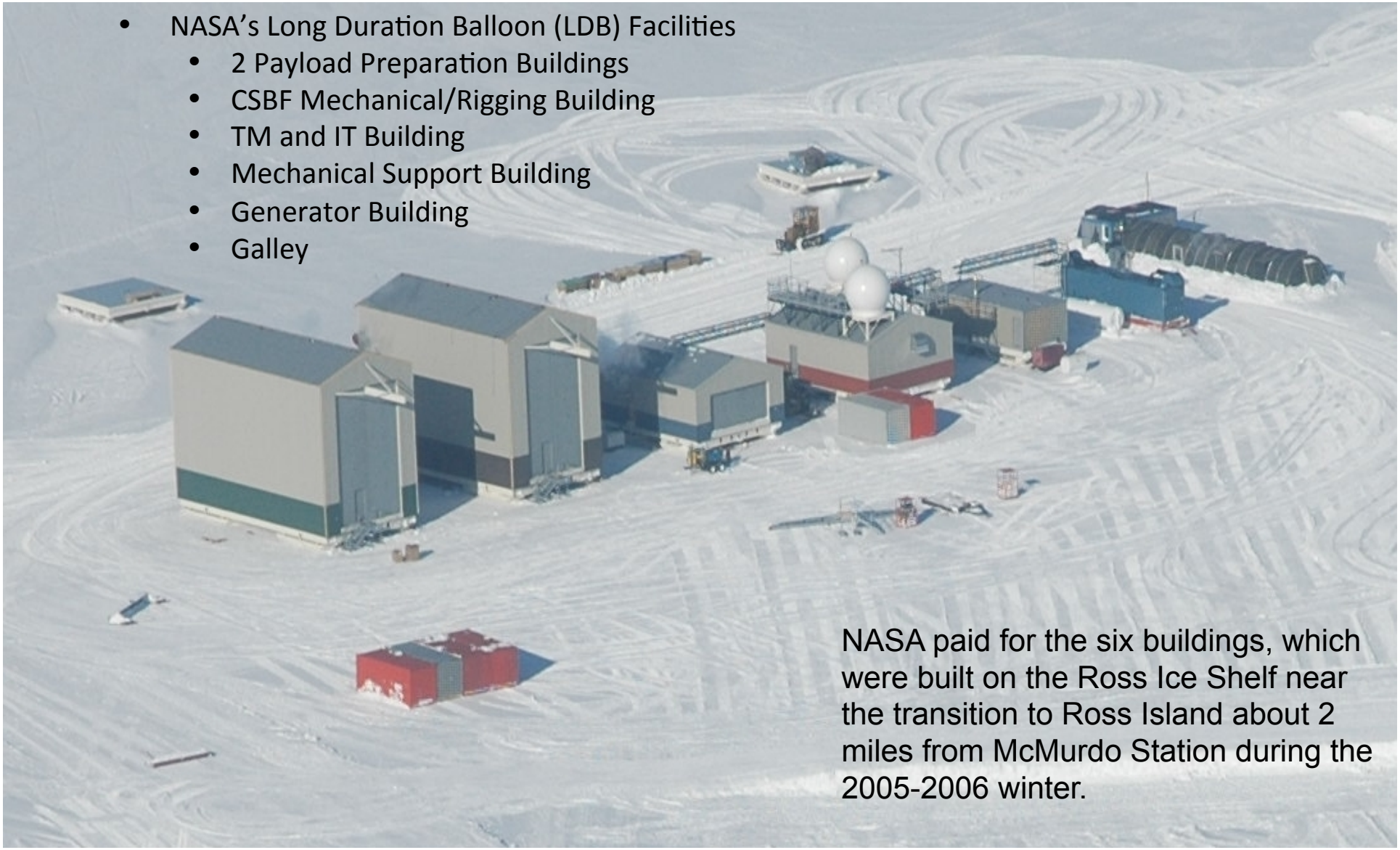
Antarctica 3rd Payload Building

- NASA/Astrophysics has awarded a $1M over-guide spread over two years for a 3rd Antarctic Payload Building.
- Balloon Program is reviewing building specifications with NSF.
- The plan is to put a pre-fab building on the resupply ship in late 2014.
- NSF would assemble the pre-fab building during FY15 'winter over."
- Available for use during FY16 Campaign: Dec 2015 – Jan 2016.

Photos from Fabrication of Original Payload Buildings in 2005

NASA LDB Launch Site, McMurdo

- NASA's Long Duration Balloon (LDB) Facilities
  - 2 Payload Preparation Buildings
  - CSBF Mechanical/Rigging Building
  - TM and IT Building
  - Mechanical Support Building
  - Generator Building
  - Galley



NASA paid for the six buildings, which were built on the Ross Ice Shelf near the transition to Ross Island about 2 miles from McMurdo Station during the 2005-2006 winter.

Concluding Remarks

- Some balloon trajectory modification is needed to take full advantage of super-pressure balloons (SPB) for ULDB flights.
  - Payload recovery cannot be assured without some level of trajectory control.
- NASA has identified a potential launch site at Wanaka, New Zealand to accommodate non-Polar LDB / ULDB missions.
  - There is potential risk of losing the payload in the Southern Ocean.
  - High bandwidth data downlink would help offset the loss.
- SPB / ULDB is quasi-level of effort, in that its development is within the same budget as balloon operations for science missions.
- The balloon program throughput is highly dependent on payload funding, but there has been no increase in ROSES/APRA for more payloads.
  - Explorers accept Balloon Missions of Opportunity, but none selected to date.
  - Recently GUSSTO and earlier ANITA successfully completed Phase A studies, but neither was down-selected for flight.
- The overall flight rate is down, with a large fraction of non-science flights, due to budgets being inadequate to build / refurbish science payloads.
  - Astro2010 recommended substantial ballooning enhancements, especially for cosmic microwave background and particles.

Thank You !

Key Events in a Balloon Launch Sequence