

Report to the Astro2020 Panel on Enabling Foundation for Research

D. Spergel, Chair

Carolyn Kierans, NPP Goddard Space Flight Center
speaking on behalf of **Abby Vieregg**
for the NASA Balloon Program Analysis Group



COSI 2014

Request from Panel

- What are the new scientific opportunities enabled for astrophysics by your platform? (response Gorham)
- **Discuss the role of the platform in technology development and training.**
- What are the challenges in exploiting the platform's capabilities? (response Gorham)
- **Are we training a diverse set of scientists and engineers?**



Discuss the role of the platform in technology development and training.



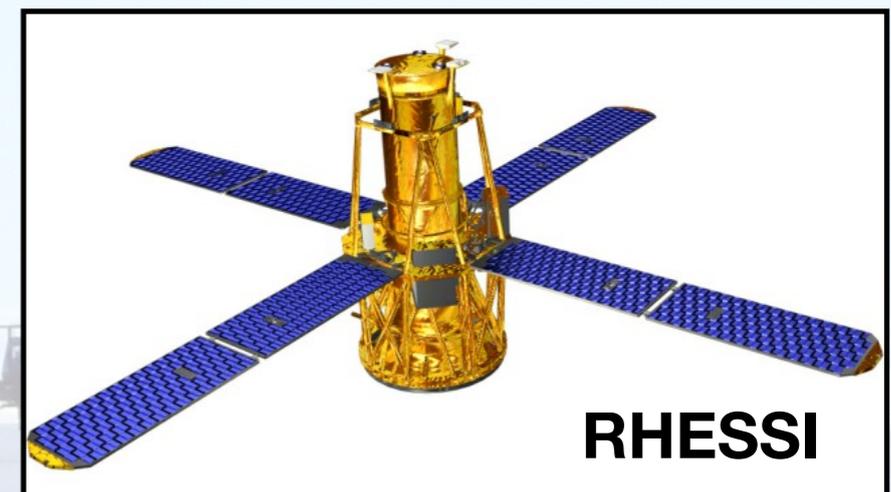
Technology development

Balloons are a necessary platform for technology development

- small and large scale tests of new technologies
- cheap access to space-like environment
- accessible to a variety of institutions
- recovery allows for incremental improvements
- raises TRL

Balloon technology lead to space missions

- **Past:** COBE, WMAP, RHESSI, ACE, GLAST, EOS-Aura, Swift, NuStar...
- **Future missions:** COSI-SMEX, X-Calibur, POEMMA, AMEGO...



Technology development

Mission of opportunity “Piggyback” flights

- small-scale tests
- cutting-edge technology development
- no burden of a full gondola

Hand launch payloads

- small-scale tests
- long-duration flights for small science payloads

Conventional flights in Fort Sumner or Palestine

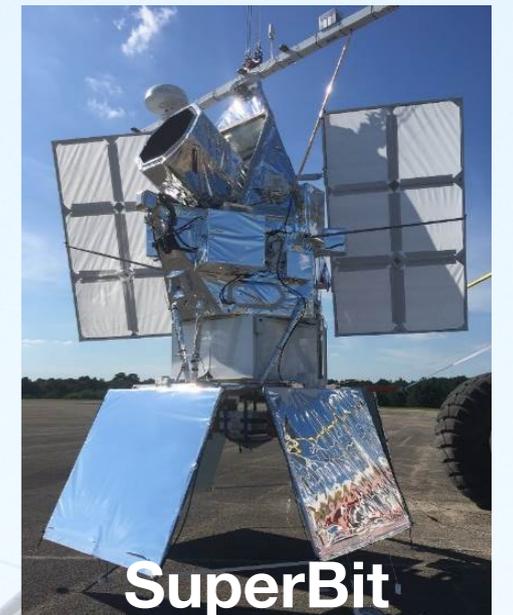
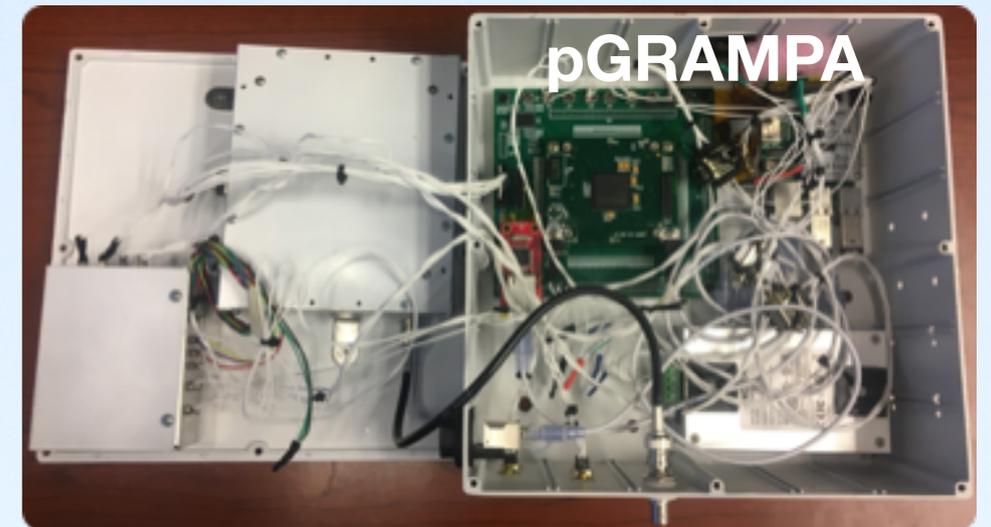
- test flights of full systems
- incremental improvements of technology

Long duration balloon (LDB) flights

- test flights of full systems
- demonstration of scientific goals
- flight operations with real-time monitoring and telemetered data

Ultra long duration (ULDB) flights

- Super Pressure Balloon technology
- test flights with night observations



Challenges in technology development

Duplication of key payload systems

- science groups are responsible for developing power system
 - high-risk subsystem, distracts from focus on science, CSBF has well developed technology
- ➔ **Balloon program should be given additional resources to support science groups with power systems.**
- payloads have common science instruments (star trackers, primary mirrors, pointing systems, etc.) that are developed from scratch
 - science groups are sharing designs, but there is no formal management
- ➔ **Can NASA manage and archive this intellectual property?**

Accessibility of the platform

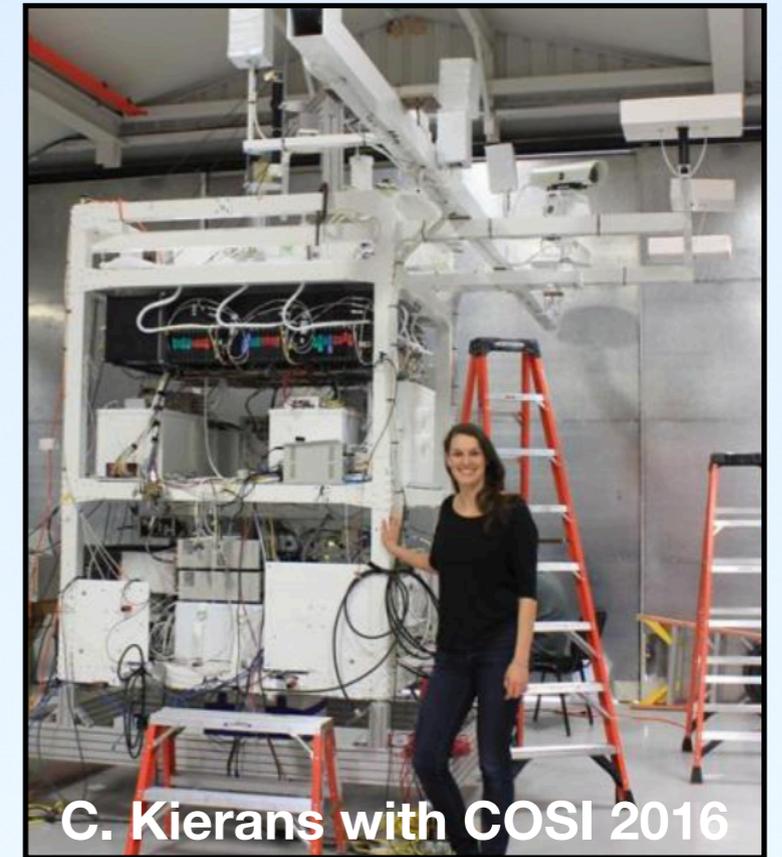
- many scientists do not know about piggyback or hand launch opportunity
 - these platforms are an accessible test bed for groups with no experience
- ➔ **Can NASA better advertise this unique opportunity?**

Training the next generation

Balloons provide unique and complete education experience:

- time scales consistent with the academic schedule
- students can contribute to hardware with higher acceptable risk relative to spacecraft

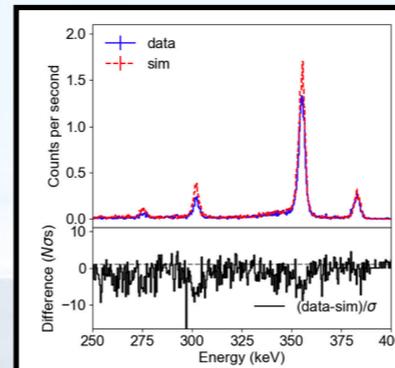
Allows for leadership development, campaign experience, and involvement in all aspects of a mission/instrument.



C. Kierans with COSI 2016



Subsystem	Item	Value	Unit	Status	Notes
Power	Power Monitor	25.51 V	442.26 W	OK	
Power	Back Light Sensor	11.84 A	206.21 W	OK	
Power	Radarm Out	0.83 A	148.21 W	OK	
Power	Radarm In	0.83 A	148.21 W	OK	
Power	Pump (H)	0.77 A	140.52 W	OK	
Power	Pump (L)	0.77 A	140.52 W	OK	
Power	Radarm CPU Sigs	0.76 A	138.72 W	OK	
Power	Radarm CPU	0.76 A	138.72 W	OK	
Power	Radarm CPU Sigs	0.76 A	138.72 W	OK	
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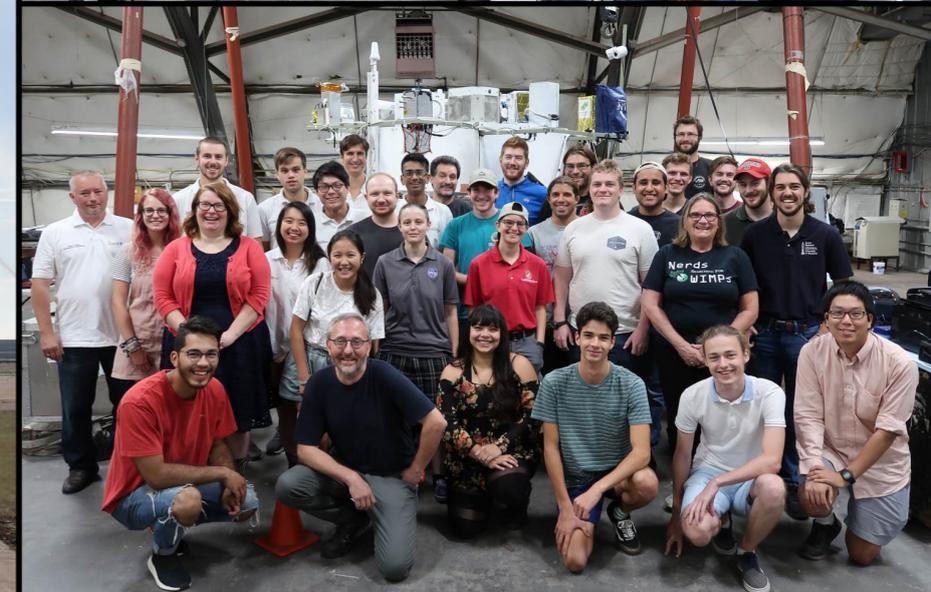
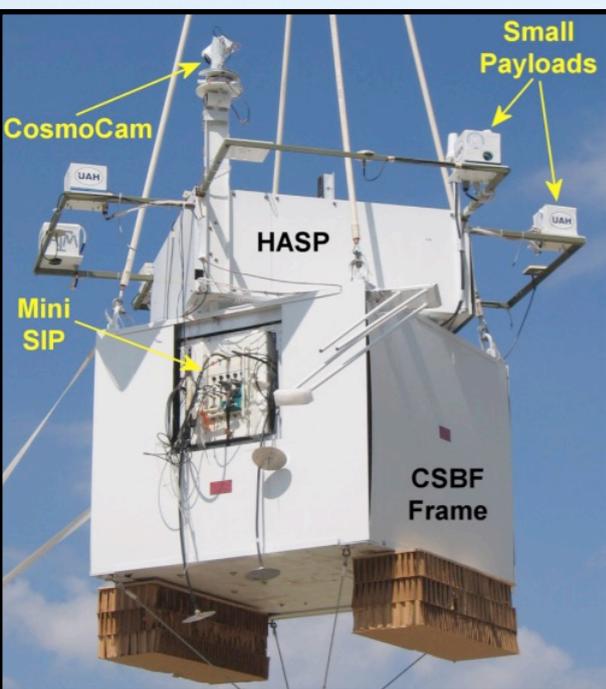
Over the past 10 years:
 300 undergraduates,
 200 grad students,
 100 postdocs trained

HASP - High Altitude Student Payload

Operates as a partnership between the NASA Balloon Program Office and Louisiana Space Consortium (LaSPACE)

Provides annual flight opportunities for student groups

- developed in 2005 to address a looming crisis in training the next generation of scientists and engineers.



846 undergrads and 136 grad students

Are we training a diverse set of scientists and engineers?



Diversity in balloon training

- Diversity can mean: science, institution, gender/race/background of scientists, trained skill set, PI's experience/age...

With information from 1/3 of the Astrophysics payloads, the percentage of female grad student involvement is 40-50%.



FIREBall-2



COSI



SuperBIT

Diversity of science payloads

	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	Total
Astrophysics	4	3	6	4	4	3	3	2	4	2	6	2	4	4	51
CMB IR/Sub mm			1	1	1	2	1		1		3		1	2	13
HE			1	1	1			2		1		1	1		8
Particle Astro	2	3	3	2	1	1	1		3		3		1	1	21
UV-VIS	2		1		1		1			1		1	1	1	9
Earth Science					2			1		1				1	5
Planetary							1	1	1						3
Heliophysics	3	1	3	4	5	1	4	1	1	1		3	2		29
Programmatic						2	4	1	1						8
Student	1	1	1		3	2		1	1	1	1	2	1		15
Test	5	8	3	2	2	4		1	3	3	1	3	2		37
Abort	1	1		2								1			5
Total	14	14	13	12	16	12	12	8	11	8	8	11	9	5	153

Diversity of science payloads and institutions

	Total
Astrophysics	51
CMB IR/Sub mm	13
HE	8
Particle Astro	21
UV-VIS	9
Earth Science	5
Planetary	3
Heliophysics	29
Programmatic	8
Student	15
Test	37
Abort	5
Total	153

In Astrophysics:

- 51 launches
- 32 different projects
- 22 different PI-institutions
- 5 payloads from NASA centers
- 4 Minority Serving Institutions

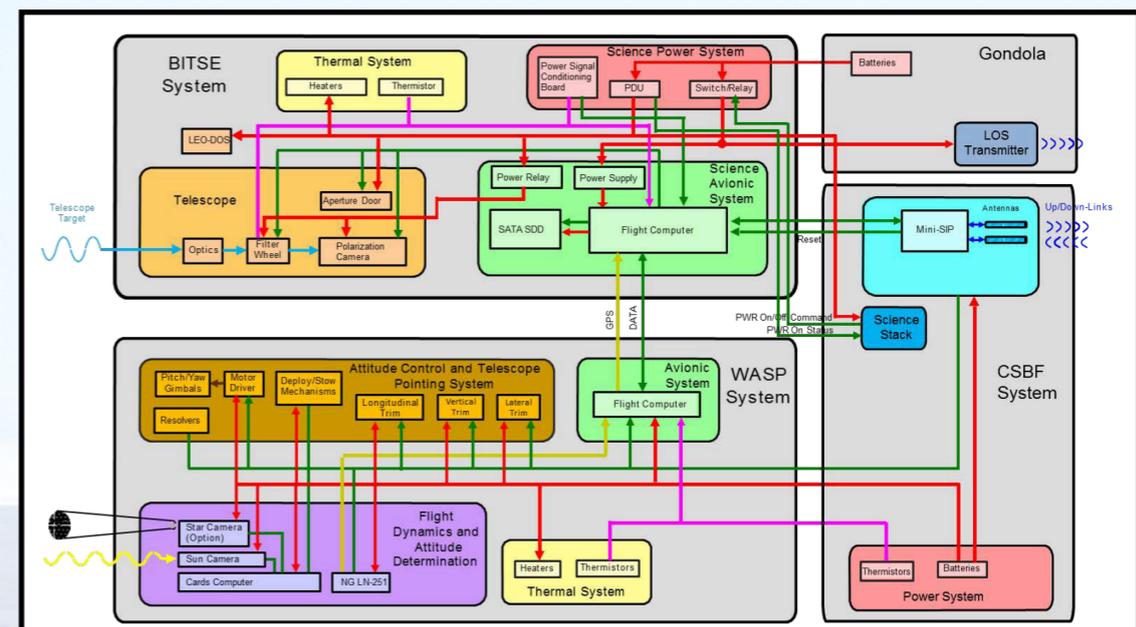
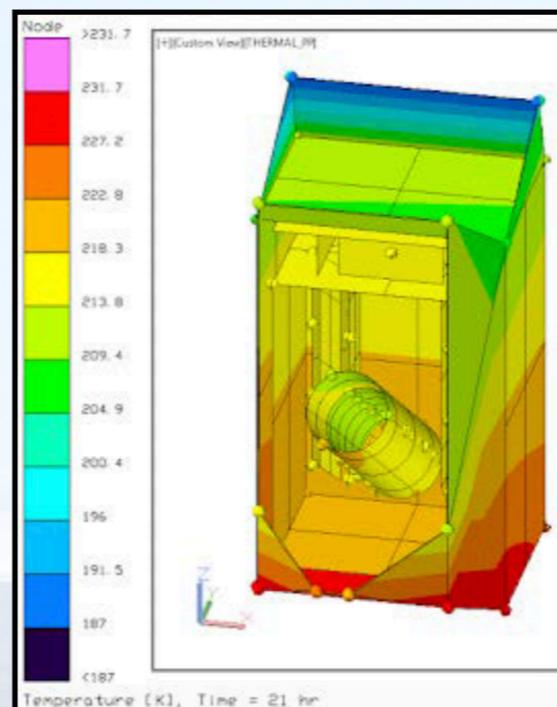
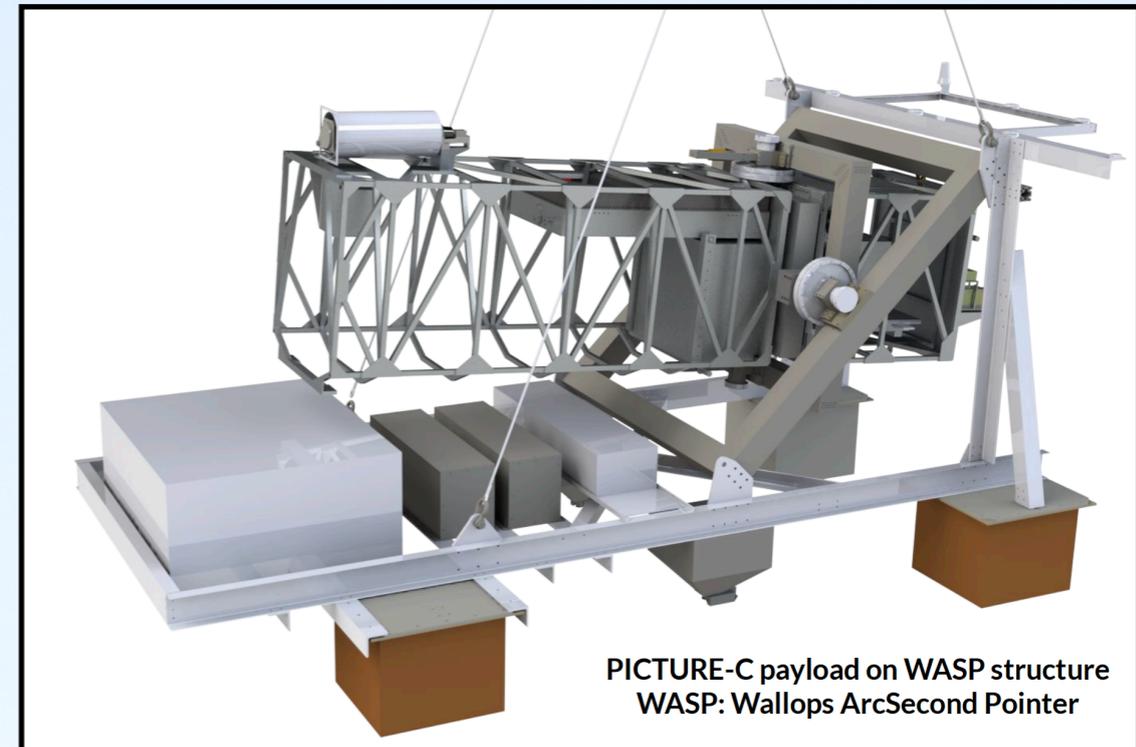
Balloon payloads, especially piggybacks, provide opportunities to institutions/groups that don't traditionally have access to hardware.

- 1/3 of current flight applications are new payloads

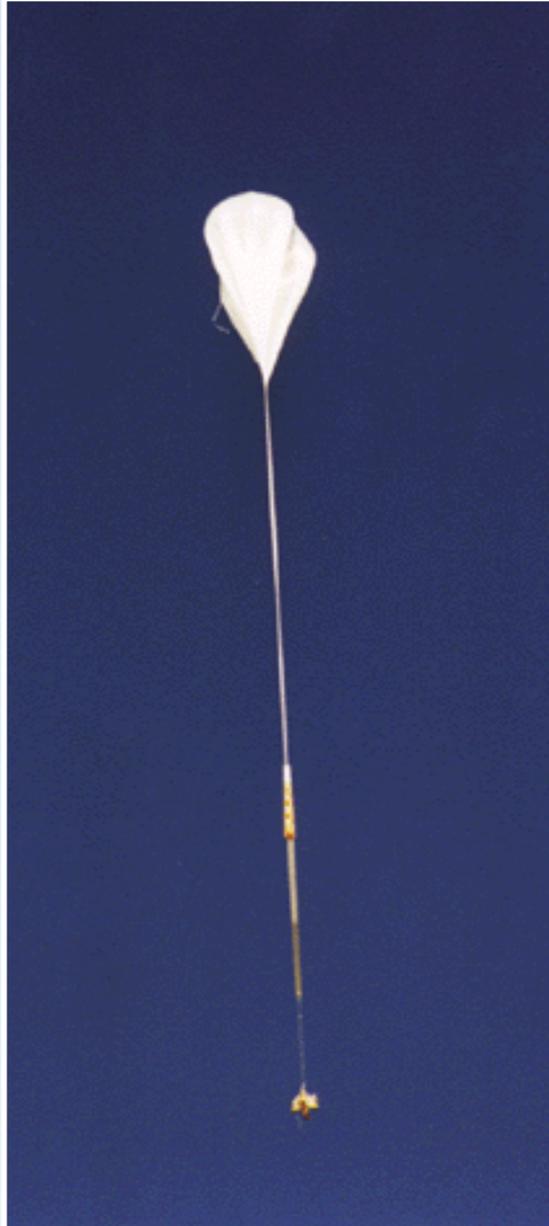
Diversity in skill sets

Balloon missions require a diverse skill set

- students involved in instrument conception through data analysis
- mix of science and engineering
- interdisciplinary training of valuable skills for industry and academia
- team work is critical



Balloon Platform Beyond Science



Balloons payloads provide for excellent science, and ...

- innovative technology development
- complete education experience
- training a diverse scientific workforce

This platform is a unique and necessary part of NASA.

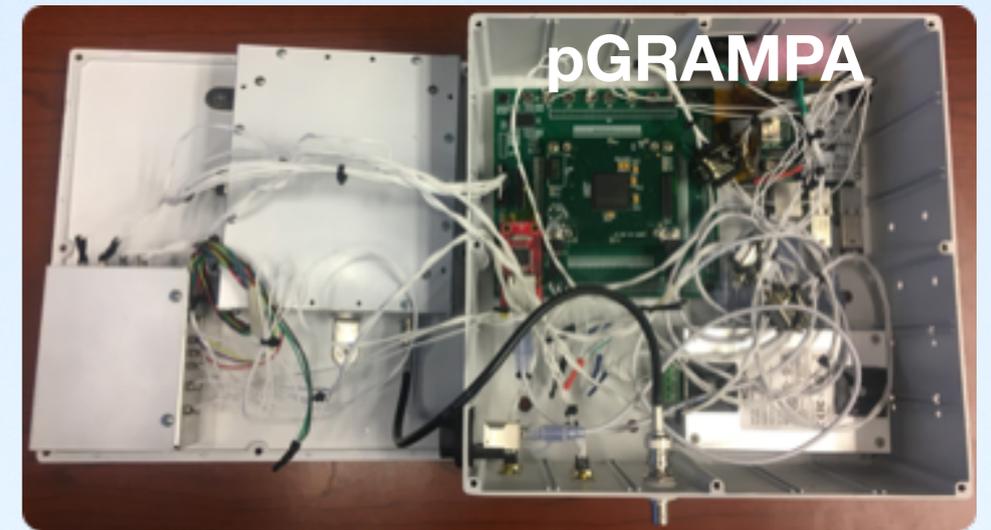
Backup Slides



Technology development

Mission of opportunity “Piggyback” flights

- small-scale tests of technologies
- cutting-edge technology development
- no burden of a full gondola
- e.g. single detectors, power systems, radiation monitors



**16 Piggyback payloads flown
2019 Fort Sumner Campaign**

e.g. ASCOT flew first as Piggyback before full-scale system on a conventional flight

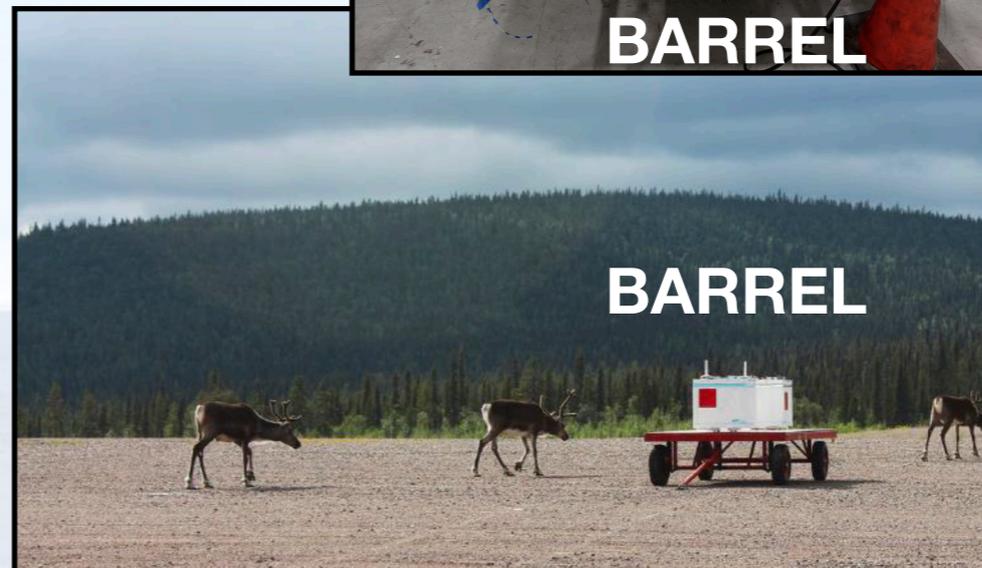


Technology development

Hand launch payloads

- small-scale tests of technologies
- long-duration flights for small science payloads
- Less stringent launch requirements

**3 hand launch payloads flown
2019 Fort Sumner Campaign**



The 2005 Fort Sumner Prototype Flight

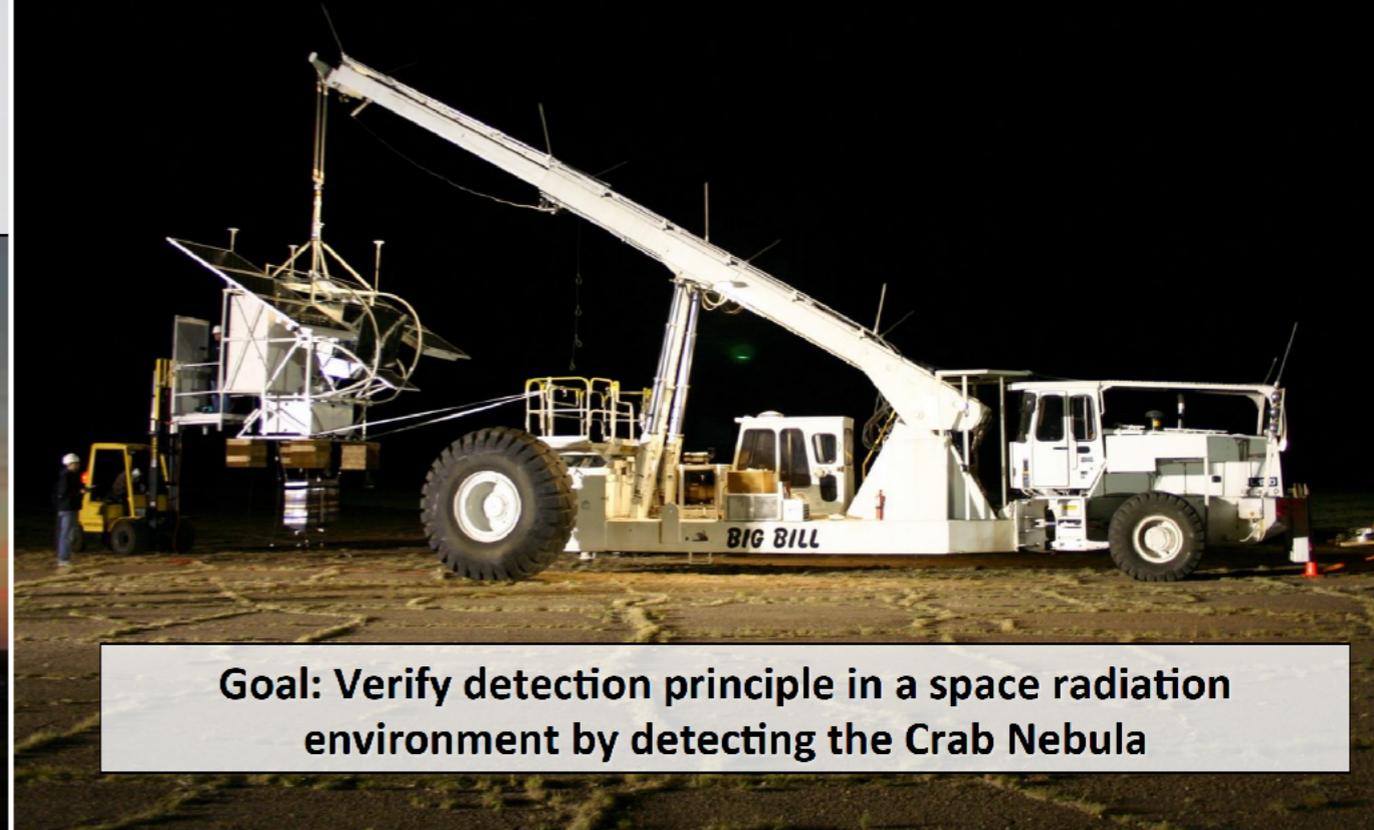
System:
2-detector prototype

Goal:
Measure background at float



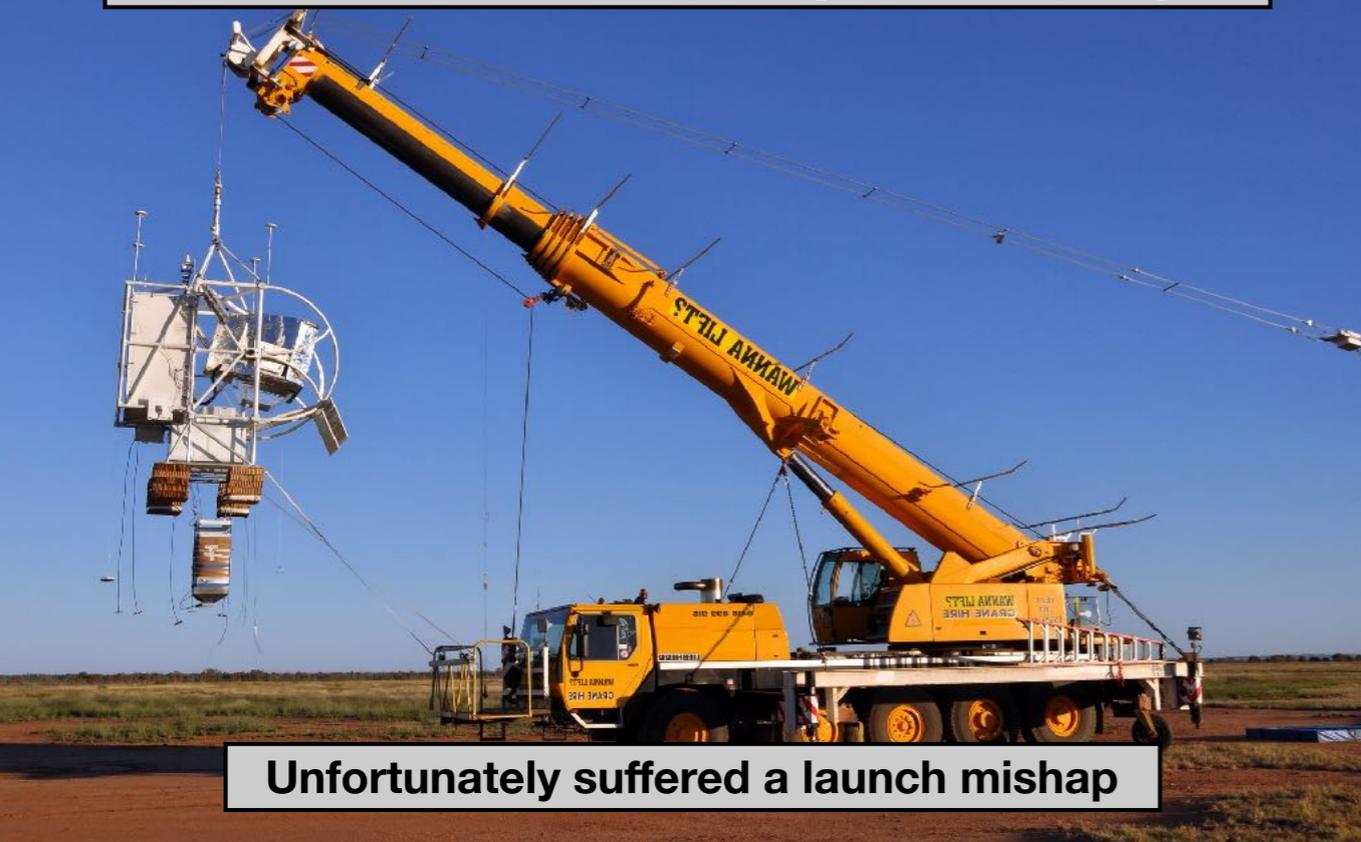
The Nuclear Compton Telescope

The 2009 Fort Sumner Campaign



Goal: Verify detection principle in a space radiation environment by detecting the Crab Nebula

The 2010 Alice Springs Campaign



Unfortunately suffered a launch mishap

The 2014 Antarctica Campaign

New name: COSI



Balloon developed leak, flight terminated after 43 hours.

The 2005 Fort Sumner Prototype Flight

System:
2-detector prototype

Goal:
Measure background at float



The Nuclear Com

The 2009 Fort Sumner Campaign



principle in a space radiation
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The 2016 Wanaka Campaign



The 2010 Alice Sp



Unfortunately suffered a launch mishap

artica Campaign

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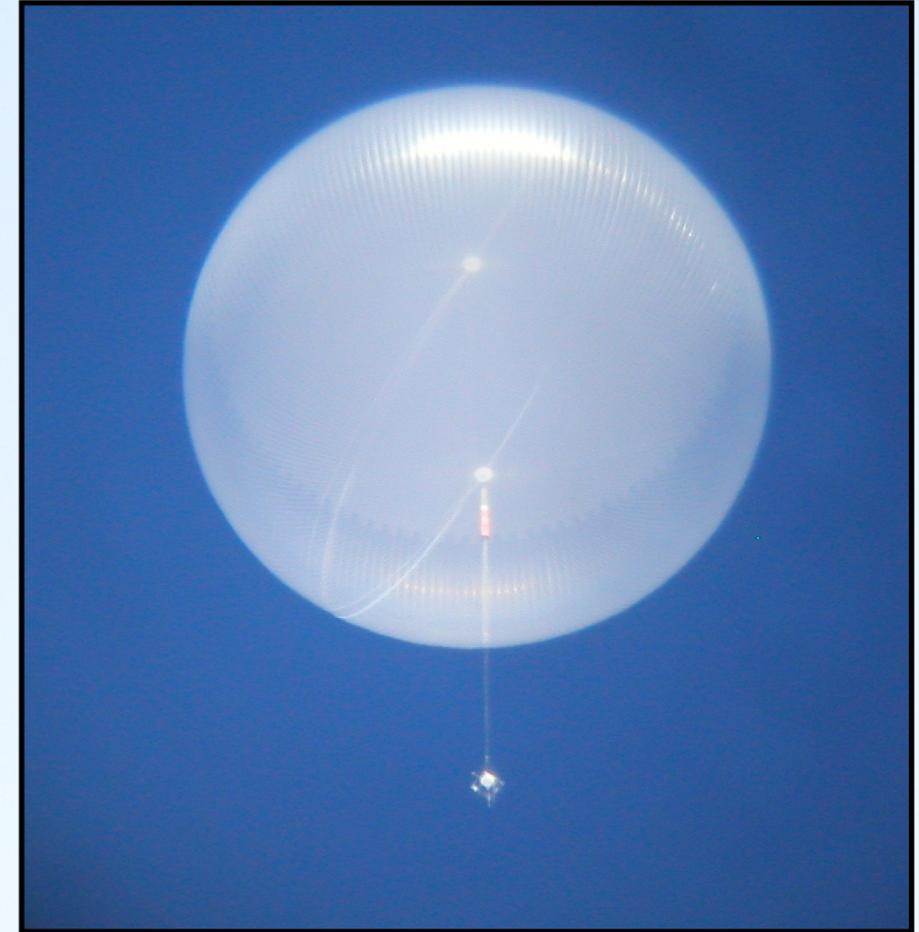


Balloon developed leak, flight
terminated after 43 hours.

Technology development

NASA Balloon Program Office technology development:

- Wallops Arc-Second Pointer
 - Picture-C, X-Calibur
- Super Pressure Balloon
- High-rate TDRSS



Ways to increase diversity?

Institutions

- Piggyback and hand launch opportunities allow for an accessible test bed
- not well known outside of the balloon community
- ➔ More involvement can increase diversity in **all** ways

Science

- the Super Pressure Balloon will provide for long-duration night-time astronomy
- ➔ Continued support of SPB technology development

People

- mentorship/apprenticeship is strong in the ballooning community
- the percentage of female grad students involved in ballooning higher than the national average in physics
- ➔ Continued support of the balloon program will have a positive impact on diversity

Experimenter's Handbook

Experimenter's Handbook

Best Practices

For

Scientific Balloon Instrument

Development

Second Draft For Discussion at the BWG Meeting

Paul Dowkontt

Physics Dept., Washington University in St. Louis

Rev 0.4, Nov 17, 2019

Developed through the Balloon Working Group

- allows for new groups to navigate payload development

