Steward Observatory balloon mission breaks NASA record 22 miles above Antarctica

February 26 2024, by Hannah Hindley

Attached to the balloon, the gondola is being prepared for launch on Dec. 31, 2023. Credit: NASA

Fifty-eight days ago, on a nearly windless morning on the Ross Ice Shelf, a stadium-size balloon took flight above Antarctica, carrying with it far infrared technology from the University of Arizona's Steward Observatory in search of clues about the stellar life cycle in our galaxy and beyond.

GUSTO—short for the Galactic / Extragalactic ULDB Spectroscopic Terahertz Observatory—has now broken the record as NASA's longest-flying heavy-lift balloon mission, which previously stood at 55 days, 1 hour and 34 minutes. Currently, the enormous zero-pressure balloon is riding stratospheric air currents 120,000 feet above the Antarctic continent, collecting far infrared radio emissions from the matter between stars. GUSTO surpassed the previous record at 10:22 a.m. Saturday Tucson time.

The faint terahertz signals that GUSTO seeks—with frequencies up to a million times higher than the waves emitted by an FM radio—are easily absorbed by water vapor in the Earth's atmosphere before they can reach ground-based telescopes. Only very dry or high-elevation places are well-suited for observatories that catch some of those elusive photons, such as the high Atacama Desert and the South Pole.

In search of drier conditions, "we are driven to go to more and more remote places," said Steward Observatory astronomy professor Chris Walker, principal investigator for the GUSTO mission, who has worked on telescope projects in Antarctica since 1994. Balloon science opens new possibilities for the rapidly evolving field of terahertz spectroscopy, allowing observers to collect far infrared signals before they are lost in the lower layers of the atmosphere, at a fraction of the cost of a fully space-based telescope.

Balloon telescopes such as GUSTO marry the strength of space observation with the proximity of Earth-based operations, and they come with unique challenges. A successful launch requires a perfect weather window, with low wind speeds both on the ground and in the stratosphere.

When conditions allow, the launch itself is a high-drama spectacle. Support trucks driven out onto the ice shelf pipe helium into the balloon, which luffs and flaps "like a sail" as it fills, Walker said. "You begin to hear the rush of the helium as the balloon inflates, and when they let it go, it rumbles as it unfurls." This is a tenuous time—if there's an imperfection or a wind shear, the balloon can shred. Of the record-breaking project, Walker said "ballooning is the hardest thing I've done professionally, but it's also the most rewarding."

If all goes well—as it did for GUSTO—the balloon lifts the telescope inside its specialized gondola and carries it 22 miles above the Earth to the remote seam between the stratosphere and space. From here, astronomers rely on the circular currents of wind above the Antarctic continent during the Southern Hemisphere summer to carry the balloon in broad loops, collecting the light signatures of cosmic chemicals.

Aboard GUSTO, emission line detectors collect molecular information about the interstellar medium—the cosmic gas and dust between stars that gives birth to new stars and galaxies.

"We were all part of the interstellar medium—every atom and molecule in your body was at some point gas and dust flowing between the stars," Walker said. To complicate matters, the chemistry of the universe is different today than it was after the big bang. To understand the story of star formation in the universe—and by extension, the story of our own origins—astronomers are interested in comparing the composition of the interstellar medium in galaxies of different ages.

GUSTO aims to map out distribution of carbon, oxygen and nitrogen in the young Milky Way and in the neighboring Large Magellanic Cloud, which has characteristics comparable to much older galaxies. A comparison of the two galaxies will help the GUSTO team provide the first complete spectroscopic study of all phases of the stellar life cycle, from the development of interstellar gas clouds, to the formation of stellar nurseries, to the birth and evolution of stars.

The GUSTO mission has traveled a long path to reach the stratosphere. Walker's team submitted a NASA Explorer Program proposal in 2014, and the project was selected by NASA in 2017. The gondola for the mission was built by the Johns Hopkins University Applied Physics Laboratory; Walker's team from Steward Observatory at UArizona provided the telescope and instrumentation—called the "payload"—working alongside various partners including NASA's Jet Propulsion Laboratory.

In August 2023, the GUSTO team performed a hang test at the NASA Columbia Scientific Balloon Facility in Palestine, Texas. From there, the fully integrated gondola and payload, weighing roughly as much as an SUV, traveled to Antarctica aboard a NASA C-130H cargo aircraft—the first time a balloon mission had shipped fully assembled by air. In Antarctica, the GUSTO team spent the fall and winter months taking daily 12-kilometer trips from McMurdo Station to the hangar to prepare the telescope for launch, traveling aboard Antarctic vans with colossal low-pressure tires across the frozen terrain.

On Dec. 31, a decade after the GUSTO team had submitted its research proposal, the mission launched amid low winds and clear skies, the white balloon billowing up against the backdrop of icy Mount Erebus.

On the UArizona campus, GUSTO researchers continue to exercise endurance in extreme conditions. While many members of the GUSTO team traveled to McMurdo Station to prepare for the mission launch, Craig Kulesa, Steward Observatory associate research professor and GUSTO deputy principal investigator, "deployed" to the Applied

Research Building on the UArizona campus, Walker said. From there, in a windowless room, Kulesa operates the payload in flight, often sleeping on the floor and sharing the controls with a Steward Observatory team.

Data arrives in real-time through a diverse network of telecommunications technologies, including geosynchronous satellites, Iridium and StarLink. GUSTO team members at UArizona and Johns Hopkins work around the clock to monitor and remotely manage the instrumentation and gondola, respectively. A 24-hour Zoom line connects partners across continents, from Harvard to Holland.

Pulling up a live feed of GUSTO's flight path, Walker showed the path the balloon has already traveled above the 5.4-million-square-mile continent, each loop a different color on the screen. The mission has no set date for landing—for the first time, NASA has given clearance for the balloon to fly for as long as it can, even if it strays beyond the edge of the Antarctic continent or lands where it cannot be retrieved.

It will be the longest stratospheric heavy-lift balloon mission in history. Of the record-breaking flight.

"GUSTO has proven that balloons can be used to do really groundbreaking science, not just for a few days, but over weeks and weeks of time," Walker said.

The length of the flight will ultimately be dictated by how long the cooling system can run (onboard, a liquid helium tank is expected to last into March) and by the change in temperature as Antarctic days begin to shorten. Balloons such as GUSTO can only fly long-duration missions during the summer in polar regions, where the balloon stays in constant sunlight and does not sink in the cooling night air.

The overlapping blue, green and red signatures of GUSTO's flight loops show up small on Walker's screen, but they represent an enormous step in terahertz astronomy: 4,800 pounds of UArizona technology moving at the extreme edge of the atmosphere for longer than ever before.

If Walker's next research proposal goes through, the same instrumentation currently aboard GUSTO may be tested in space, in search of the elusive far infrared signatures of planet-forming systems and habitable zones.

"If you're not pushing the edge, what's the point?" Walker said.

Provided by University of Arizona

Citation: Steward Observatory balloon mission breaks NASA record 22 miles above Antarctica (2024, February 26) retrieved 27 April 2024 from https://phys.org/news/2024-02-steward-observatory-balloon-mission-nasa.html