CORNELL ASTRONOMICAL SOCIETY NEWSLETTER

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LETTER FROM THE EDITOR

I hope your summer has been relaxing, and you are ready to start the Fall semester! In this special edition of the CAS Newsletter, we want to reveal another batch of posters for our Museum Restoration Project. The Project also exhibits astronomy as it is now, how it might change, and how the Astronomy Department here at Cornell has shaped it. As fellow astronomy enthusiasts, we want to write posters acknowledging the telescopes that have made the advancements of the last fifty years possible, and how our very own Cornell Astronomy Department has contributed to them. We want to contrast our historic building and telescope with the cutting edge of astronomy research and give our visitors a sense of how astronomy was, is, and will be. We hope you'll come to visit the Fuertes Observatory!

Shane Kuo, Editor-in-Chief

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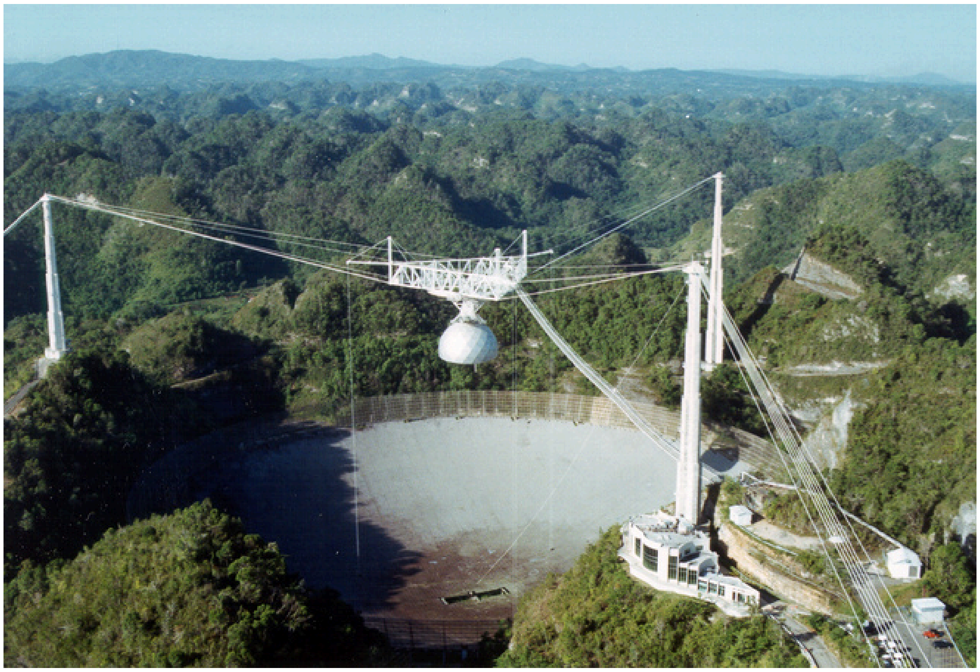
ARECIBO/RADIO ASTRONOMY

BY BEN JACOBSON-BELL & GILLIS LOWRY

The Arecibo Observatory was a 1,000-foot dish built into a valley near the city of Arecibo, Puerto Rico. It led the field of radio astronomy, aided in the search for broadcasts from extraterrestrial life, and even sent its own message to the stars.

Arecibo was operated by Cornell for 42 years, from 1969 to 2011. Past directors have included Cornell faculty Frank Drake, Riccardo Giovanelli, and Donald Campbell. Arecibo was the largest single telescope in the world for 53 years, from its construction in 1963 to the completion of the Five-hundred-meter Aperture Spherical Telescope (FAST), also a radio telescope, in China in 2016. Arecibo has made many discoveries during these 42 years, from determining the rotation period of Mercury to taking the first pictures of an asteroid and even finding the first exoplanets. It even transmitted a radio message, designed partly by Cornell faculty Frank Drake and Carl Sagan, to the globular cluster Messier 13, found over 25 thousand light-years from Earth.



The 305-meter (1000-foot) Arecibo Telescope is shown here nested into a natural valley.
Source: This photo is [courtesy of the NAIC - Arecibo Observatory, a facility of the NSF]

The Arecibo Message, sent from Arecibo in 1974.
Source: [SETI]

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An aerial view of the Arecibo Observatory, showing the 1000-foot dish and the surrounding forests.
Source: This photo is [courtesy of the NAIC - Arecibo Observatory, a facility of the NSF]

Cornell is a leading participant in the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), a collaboration that used Arecibo before the telescope's collapse. NANOGrav now uses interferometry to observe pulsars—neutron stars with rapidly spinning, lighthouse-like beams, which hit the Earth with "pulses" of radio-frequency light with every rotation. By timing the arrivals of pulses across the sky and searching for correlated delays, NANOGrav aims to detect gravitational waves that stretch and squeeze the spacetime between the pulsars and us.

Arecibo tragically collapsed in December 2020, when the suspended instrumentation platform fell and struck the dish. However, Arecibo's influence in the field of radio astronomy lives on, and the data it collected continue to be used in cutting-edge projects at Cornell today.

The future of radio astronomy is not in single telescopes but in spread-out arrays of smaller dishes that combine the inputs to their receivers in a technique called interferometry. In effect, the array forms a telescope as big as the maximum separation between any two of its receivers — potentially even as big as Earth itself!

A radio antenna in the Very Large Array (VLA); an interferometer used by NANOGrav.
Source: [Dave Finley, NRAO/AUI/NSF]

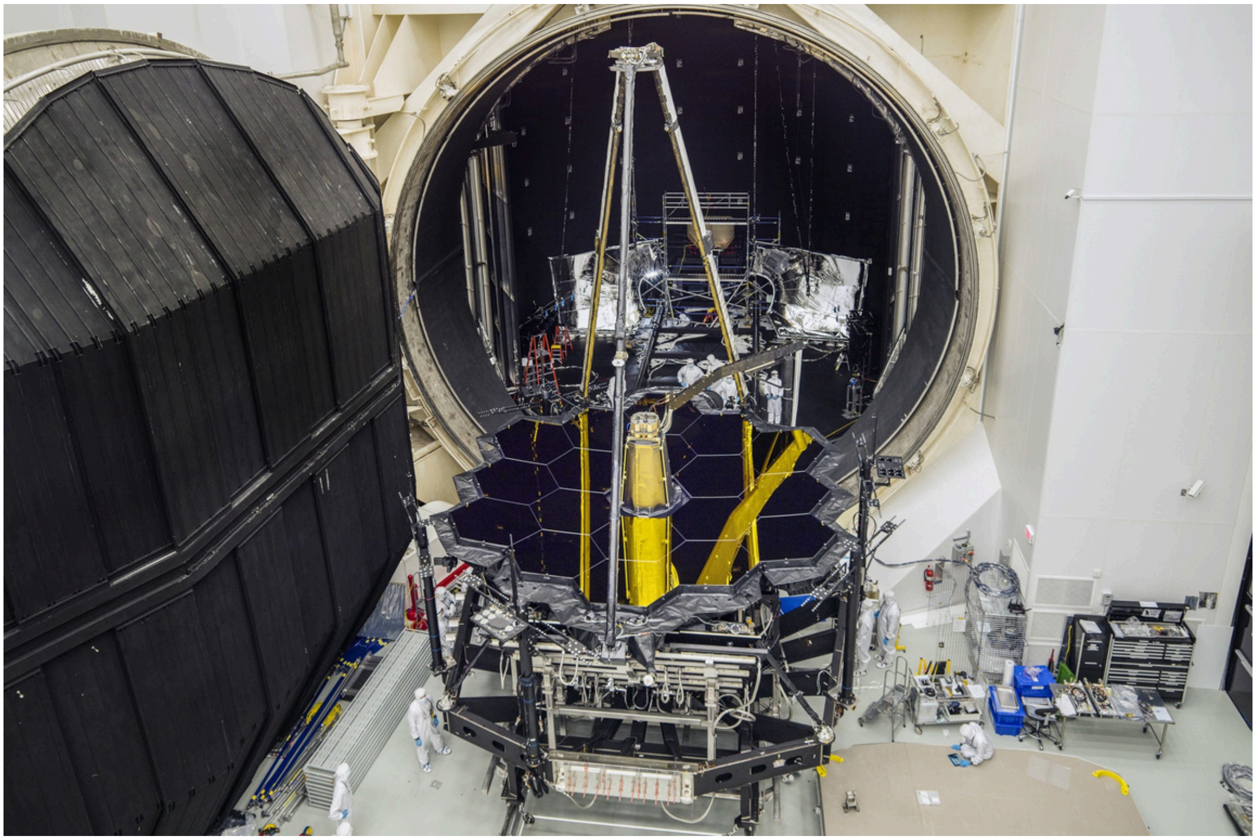
JAMES WEBB SPACE TELESCOPE

BY ABIGAIL BOHL & TREYTON GRAHN

From alien worlds to distant galaxies, the James Webb Space Telescope (JWST) peels back the layers of our universe. Its infrared images see beyond the gas and dust that once blocked our view, revealing the evolution of early structures, the rhythm of stellar life cycles, and the properties of planets in both our Solar System and beyond.

JWST is the result of decades of research, first proposed in September 1989 as a potential successor of the Hubble Space Telescope. While Hubble studies the universe in primarily visible and ultraviolet wavelengths, JWST's infrared abilities build upon the results from Hubble.

One of the most unique and characteristic aspects of JWST is its hexagonal primary mirror, segmented to allow folding inside the rocket and unfolding once in space Since JWST was designed to observe distant galaxies, its beryllium primary mirror must be huge in order to collect sufficient light, measuring 6.5 meters (21.3 feet) across.



NASA's James Webb Space Telescope at NASA's Johnson Space Center in December 2017
Source: NASA/Chris Gunn

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One of JWST's scientific goals is to study exoplanets, or planets outside our Solar System. When a planet passes in front of its star, the starlight passes through the planet's atmosphere. Since different elements absorb light at different wavelengths, or colors, we can tell what elements are present in the planet's atmosphere based on what colors are missing from the starlight's full rainbow. The act of splitting up starlight into a measurable rainbow is called spectroscopy, and it allows scientists to determine what the composition and chemistry of these planets are—and if life might exist on their surfaces.

Another science goal is the study of very distant, very early galaxies. As the universe expands, space itself expands, stretching the light that travels through it. This shifts the wavelength of the light to redder, lower-energy wavelengths in a phenomenon known as 'redshift'. Distant galaxies have extremely redshifted light; JWST's infrared capabilities make it far more suited to detecting redshifted galaxies than the visible-light Hubble instruments. Studying distant, early galaxies will reveal the properties of our universe's first massive structures.

Infrared Deep Field image taken by NIRCam for the JWST Advanced Deep Extragalactic Survey. The galaxy shown in the pullout, JADES-GS-z14-0, has a measured redshift of 14.32 (+0.08/-0.20), and was formed an estimated 290 million years after the Big Bang, making it the furthest known galaxy to date.
Credit: [NASA, ESA, CSA, STScI, Brant Robertson (UC Santa Cruz), Ben Johnson (CfA), Sandro Tacchella (Cambridge), Phill Cargile (CfA)]

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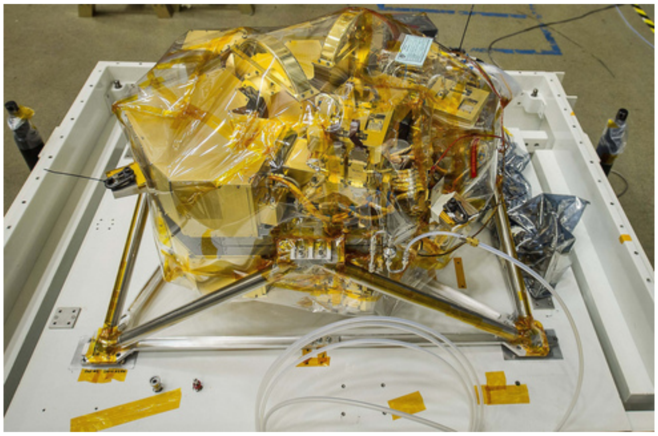
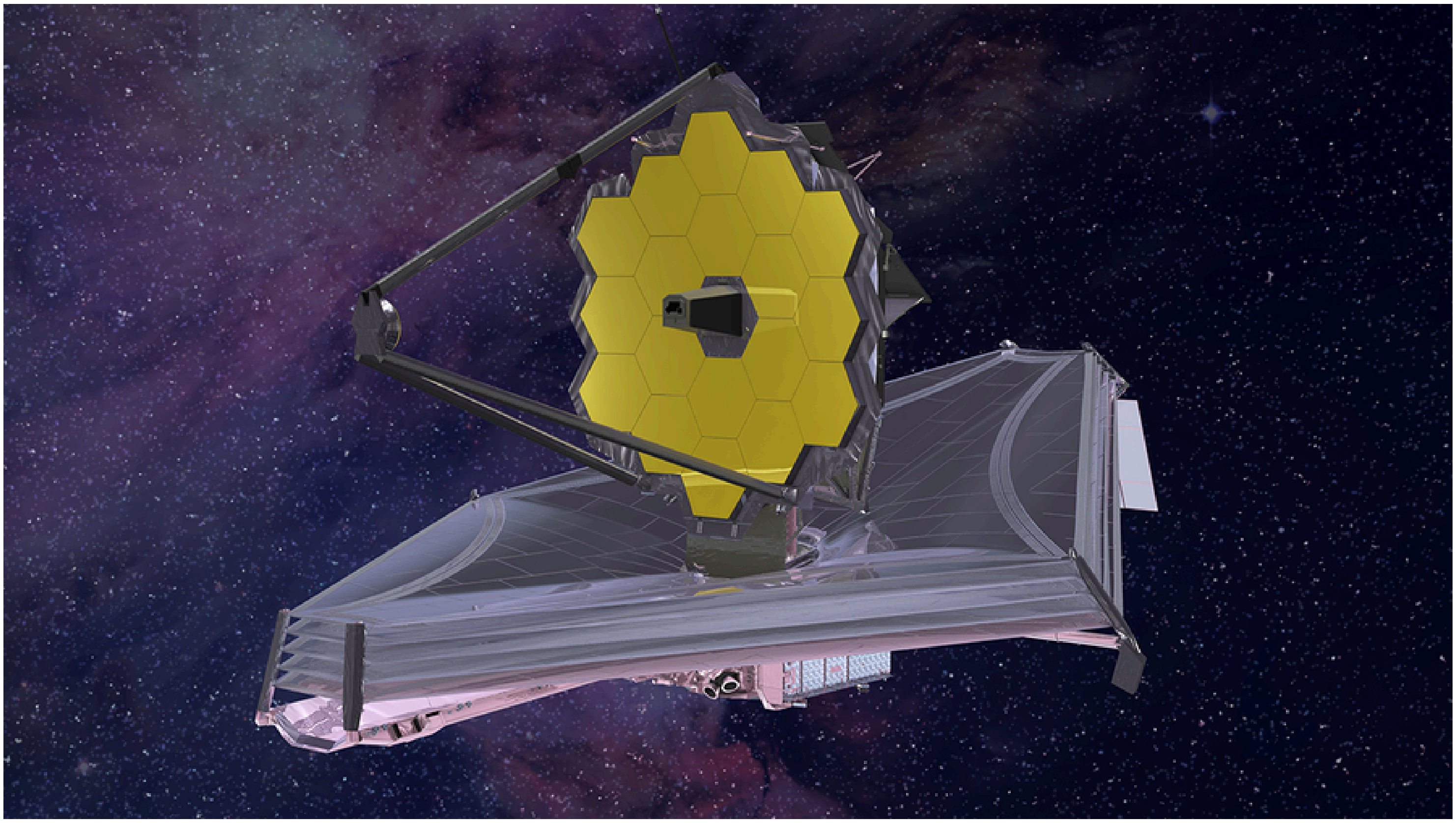
JWST is equipped with four scientific instruments: Mid-Infrared Instrument (MIRI), Near-Infrared Camera (NIRCam), Near-Infrared Spectrograph (NIRSpec), and Near-Infrared Imager and Slitless Spectrograph/Fine Guidance Sensor (NIRISS/FGS). These instruments allow JWST to observe over a wide range of wavelengths, as well as take breathtaking astrophotography.



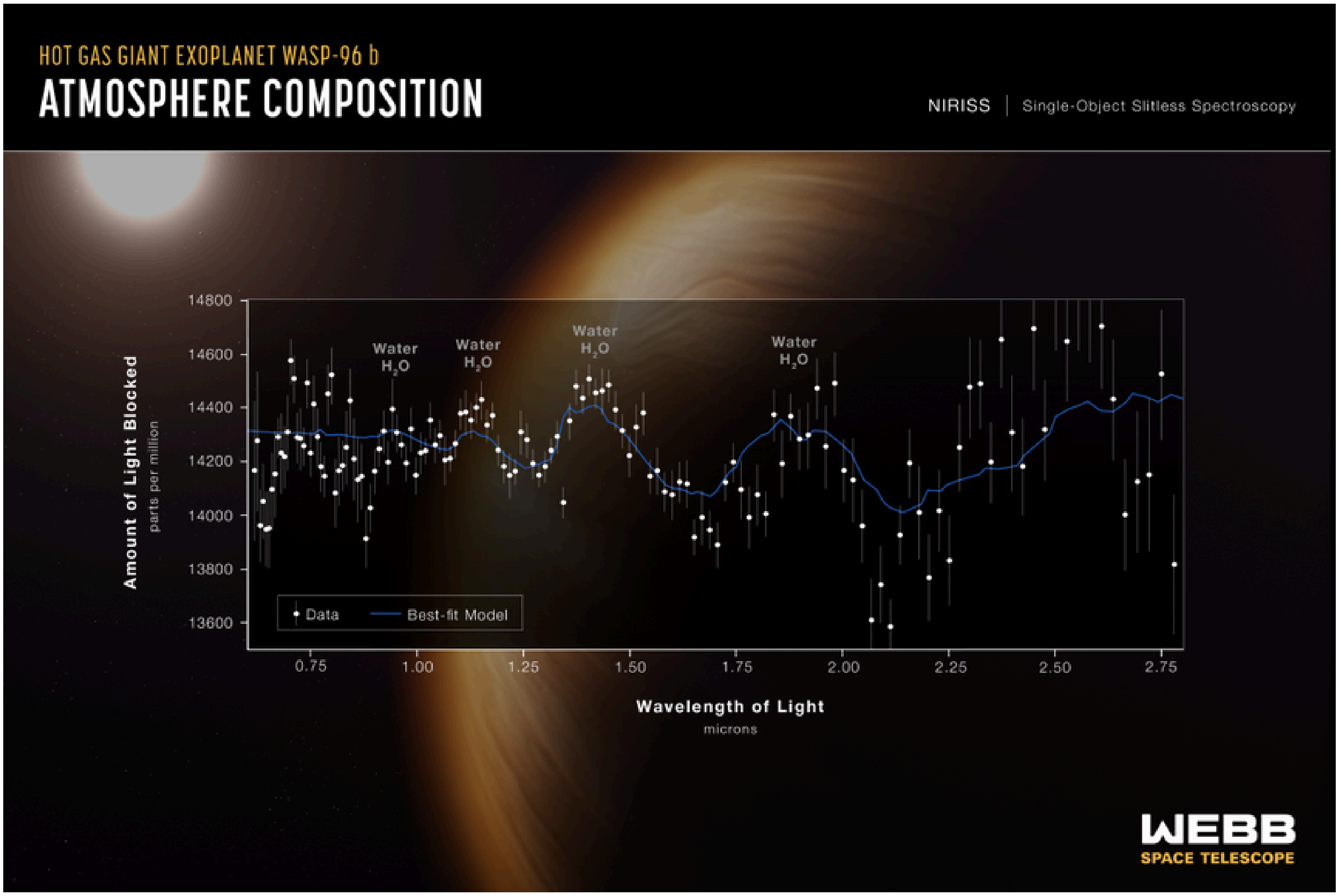
JWST's NIRCam optics module in a Goddard clean room.
Source: *NASA Goddard*

To observe at infrared wavelengths, some devices need to be kept extremely cold. Infrared waves are emitted when an object is warm; if the telescope had too much heat, it would drown out distant objects. JWST's instruments are kept at a minimum of just 7 Kelvin (-447 degrees Fahrenheit), thanks to its five-layer sunshield.



Artist's rendition of JWST floating in space. This illustration depicts the five-layered sunshield that helps protect the sensitive infrared detectors from the sun's heat beneath the gold-plated primary mirror.
Source: NASA, ESA, CSA, Northrop Grumman

At Cornell, both exoplanet scientists and cosmologists, who study the history of the universe and its early structures, continue to benefit from JWST's astounding data. Cornell professors Ray Jayawardhana, Dean of Arts and Sciences, and Lisa Kaltenegger, the current director of the Carl Sagan Institute, are part of a team guaranteed 200 hours of JWST observing time to study exoplanets. Professor Jonathan Lunine, the current chair of the Department of Astronomy at Cornell and interdisciplinary scientist for astrobiology on the Webb mission, will mostly study the atmospheres of hot Jupiters, which are large and mostly gaseous exoplanets that orbit extremely close to their home star and thus have very high temperatures. In 2023, he co-authored a paper documenting exceptionally high levels of carbon and oxygen in the hot Jupiter HD149026b, demonstrating how the makeup of planets differs significantly in the Milky Way and providing information about how the planet formed. The James Webb telescope will continue to revolutionize astronomy and allow observations at an unprecedented level of detail throughout its operation.



This image depicts the atmospheric transmission spectrum of hot Jupiter WASP-96 b. It shows how the amount of light the planet's atmosphere blocks as it passes in front of its host star varies with wavelength. By analyzing this information, scientists can learn about what its atmosphere is made of.
Source: [NASA, ESA, CSA, STScI]

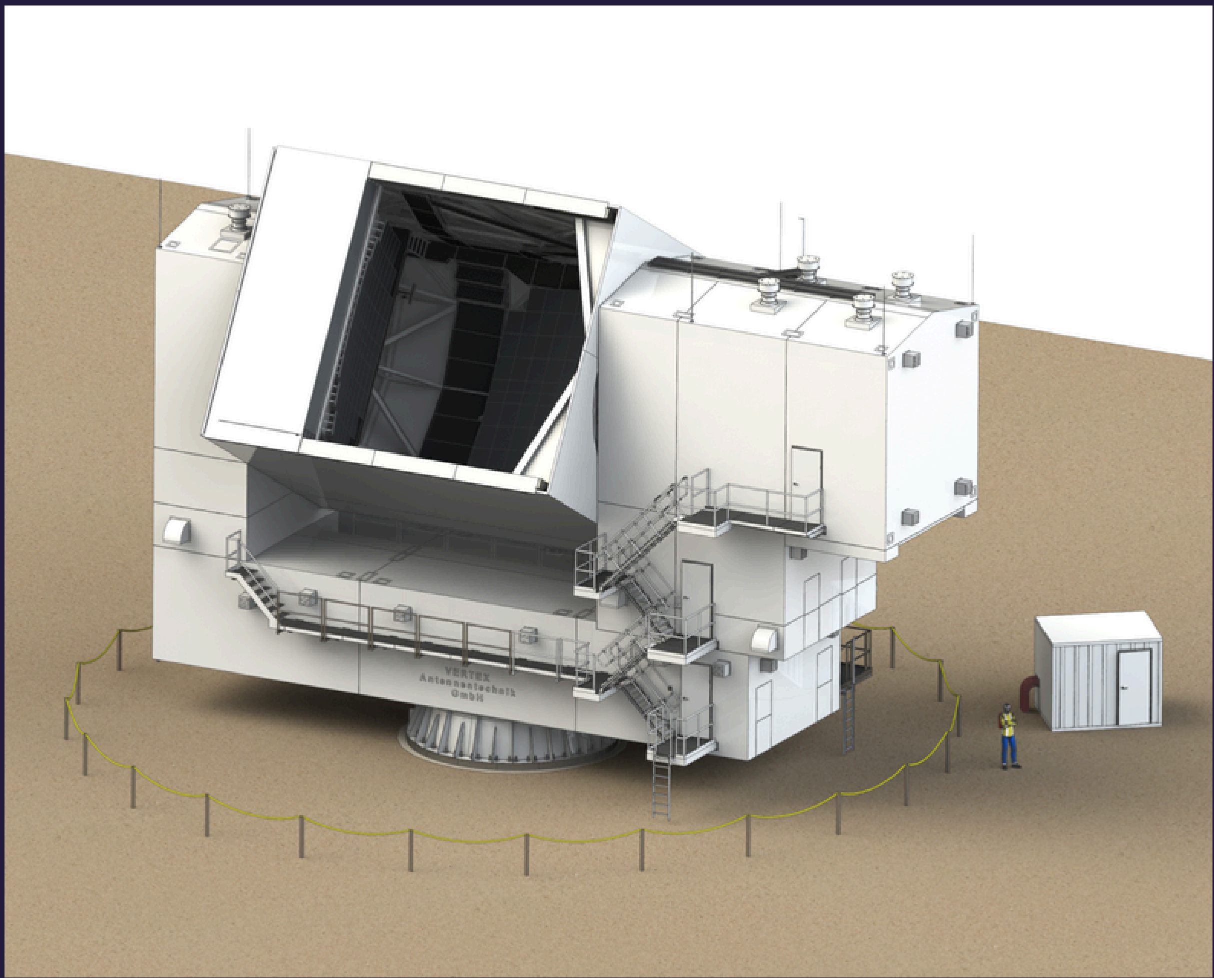
CCAT-PRIME / FYST / CCAT

BY HAONAN GONG & IONA LESLIE

The Cerro Chajnantor Atacama Telescope (CCAT) is an international collaboration unveiling the smallest and largest scales of the universe, from its earliest moments following the Big Bang to its overall galactic structure.

CCAT comprises the Fred Young Submillimeter Telescope (FYST), a 6-meter reflector that records highly accurate data in submillimeter and millimeter wavelengths. The high altitude and dry conditions provide cleaner measurements, and the telescope's ability to sweep through large swaths of the night sky provides a massive wealth of measurements.

Cornell Professors Martha P. Haynes and Riccardo Giovanelli were the ones to originally propose the idea for CCAT in the mid-1990s. Although submillimeter telescopes already exist in the Atacama Desert of Chile, the CCAT project strove for even higher altitudes, with more advanced astronomical instrumentation.



Rendition of the Fred Young Submillimeter Telescope
Source: [Vertex Antennentechnik GmbH]

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The CCAT project traces the formation of the first stars following the Big Bang, during a time in cosmic history known as the Epoch of Reionization. Cornell professors also use CCAT to uncover magnetic signals from the earliest moments after the Big Bang, which reveals how the expansion of the universe first began. These signals have been difficult to measure due to noise from the Milky Way's dust, but CCAT is equipped to separate the Big Bang signals from such noise.

CCAT is also equipped to measure the motions and distributions of galaxies, mapping the structure of the universe at the largest scale possible.

Location of the CCAT Observatory
Source: CCAT Observatory

Fred Young in front of the Fred Young Submillimeter Telescope
Source: Cornell Chronicle/Martha Haynes

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Sources for "Arecibo/Radio Astronomy"

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Image credit: SETI, NAIC, NAIC, Dave Finley, NRAO/AUI/NSF

Sources for "James Webb Space Telescope"

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Sources for "CCAT-prime / FYST / CCAT"

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Image credit: Vertex Antennentechnik GmbH, CCAT Observatory, Cornell Chronicle/Martha Haynes

Cornell Astronomical Society (CAS) is a student-run non-profit organization founded in 1972.

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Southern Ring Nebula, taken by JWST's NIRCam
Source: NASA, ESA, CSA, STScI