



X-ray and Cryogenic Facility



The X-ray and Cryogenic Facility at NASA's Marshall Space Flight Center in Huntsville, Ala., is a unique, world class optical, cryogenic and X-ray test facility — in fact, the world's largest X-ray telescope test facility. Built in 1975 to perform ground tests and calibration of the High Energy Astronomy Observatory-2, the X-ray Calibration Facility, as it was first known, was extensively modified in 1989–1991 to perform full-scale calibration tests for the Chandra X-ray Observatory. Chandra is the most sophisticated X-ray observatory built to date — an instrument that is providing unprecedented views of the universe. In 1999, the X-ray facility was upgraded to perform cryogenic, or extremely low temperature, testing without compromising X-ray calibration test capability and was renamed the X-ray and Cryogenic Facility.

Today, the X-ray and Cryogenic Facility supports the James Webb Space Telescope program. Scheduled for launch in 2013, the Webb telescope is an infrared telescope, meaning it senses the heat of stars and galaxies which are millions and even billions of light years away. The telescope itself must be kept extremely cold in order to pick up incredibly faint signs of warmth. It will operate in space at a temperature of minus 396 F (35 Kelvin). To prepare the Webb structures and mirrors to meet the extreme temperatures of space, engineers will carefully examine telescope components inside a vacuum chamber that simulates the hyper-cold of space, chilling the hardware from room temperature down to frigid minus 414 F. Results will reveal any distortion that happens to the components so changes can be made if needed. Testing and calibration of instruments prior to launch can help reduce unexpected and costly problems before they happen in space.

General Facility Description

The X-ray and Cryogenic Facility consists of a 1,700-foot-long X-ray guide tube, a horizontal cylindrical vacuum chamber called the Instrument Chamber, and two clean rooms.

For instruments headed to space, the word “clean” takes on a new emphasis. Calling a room “clean” at the X-ray and Cryogenic Facility means that room has a low level of environmental pollutants like dust, airborne microbes, aerosol particles and chemical vapors. A clean room's contamination level, indicated by the room's classification, is controlled to a specified number of particles per cubic foot at a specified particle size. For example, class 2000 means the room's contamination level is less than 2,000 particles $\frac{1}{2}$ micron and larger in diameter per cubic foot.

The X-ray and Cryogenic Facility's instrument chamber opens into a 5,400-square-foot class 2000 clean room in which the test article is prepared for thermal vacuum testing and placed onto a test stand. Another clean room, this one a 2,000-square-foot and class 10000 facility, serves



JWST Mirror Simulators in Clean Room

as an airlock for the larger clean room. This clean room has direct access to the X-ray and Cryogenic Facility unloading dock. The clean rooms and unloading area are outfitted with a lift platform, forklifts and overhead cranes, and staffed with highly skilled personnel for handling large optics and other test hardware.

The extremely clean instrument chamber test vacuum — 20 feet in diameter and 60 feet long — has several electrical and fluid interfaces needed for running tests. Cryogenic and vacuum pumps provide typical test pressures of less than 10^{-6} Torr. Torr is a unit of pressure, and 10^{-6} Torr equals about one-billionth atmospheric pressure.

A sophisticated control system monitors and records more than 2,000 channels of temperatures, pressures and other data. The instrument chamber's main test volume can be thermally controlled in an operating range of minus 180 F to 180 F.

Two remotely operated motion tables are available for mounting test articles in the vacuum environment. Both the Five Axis Mount typically used for X-ray testing, and the Mirror Table used for cryogenic testing, can precisely position a test article at any angle desired.

X-ray Test Capability

The X-ray and Cryogenic Facility's X-ray source system, used to simulate emissions from distant celestial objects, is located on the end of the X-ray guide tube 1,700 feet from the instrument chamber. The source system produces a 57.5-inch X-ray beam at the chamber entrance. The X-ray detectors monitor the X-ray beam and provide feedback to the X-ray generator. An adjustable optical mount on a moveable stage at the instrument chamber entrance traces incoming X-ray beams. Detectors also are mounted on motion stages, allowing them to be moved in or out of focus and/or to scan across the X-ray image. An array of pinholes and slits can be remotely inserted between the detectors and the mirror under test to redirect X-ray beams as needed.

More than 20 X-ray mirror, instrument and telescope calibrations have been completed since 1991, including Chandra, five Solar X-ray Imagers for a series of National Oceanic and Atmospheric Administration meteorological satellites, and Hinode's X-ray Telescope — a project that is exploring the magnetic fields of the sun.

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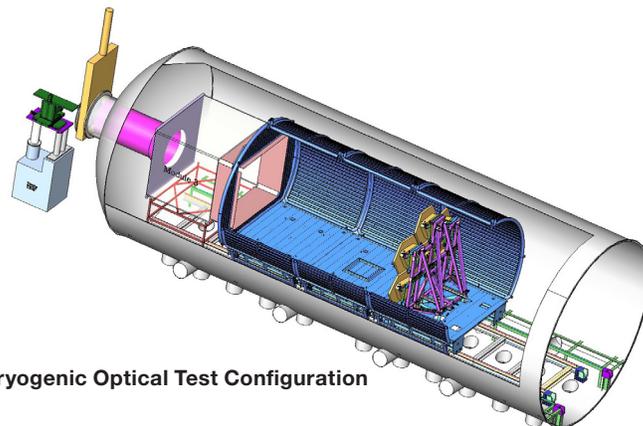
Cryogenic and Cryogenic Optical Test Capability

The X-ray and Cryogenic Facility is equipped with a helium-cooled enclosure that provides a test environment from ambient to minus 414 F (25 Kelvin). Two helium refrigerators cool the enclosure by expansion of pre-cooled helium gas. The outside of the enclosure is insulated like the walls of a home refrigerator, but with 30 layers of insulation. The combination of the vacuum environment and insulated walls allows the enclosure to reach a temperature of less than minus 414 F (25 Kelvin). The inside of the enclosure has provisions to hold a test article that is vibration isolated from the enclosure walls and the chamber. The facility has a variety of enclosures that can be connected to the refrigerators in several shapes and sizes. Temperature can be controlled in 0.1 Kelvin increments from 300 to 15 Kelvin, and programmed profiles are possible.

The X-ray and Cryogenic Facility can test mirrors up to 13.12 feet in diameter. The facility has two interferometers — instruments for optically measuring structural distortions that occur during cryogenic testing of telescope mirrors. Both interferometer systems offer fast, quantitative surface figure measurement that is relatively insensitive to the effects of vibration. These instruments can detect thermal distortions as small as a few nanometers (billionths of a meter). More than 30 cryogenic test operations have been completed since 1999 — most in support of the James Webb Space Telescope.

Additional Capabilities

In addition to the large vacuum chamber, the facility has a smaller, more cost-effective cryogenic and cryogenic optical testing chamber. The helium-cooled test volume in the small chamber is a horizontal cylinder 40 inches in diameter and 88 inches deep. This chamber achieves test pressures and temperatures comparable to those of the large chamber, but in about one-tenth the time. It uses control and data acquisition systems similar to those of the larger chamber and uses the same interferometer systems. More than 25 cryogenic test operations have been completed in the small chamber since it was commissioned in 2001.



Cryogenic Optical Test Configuration