
Bringing the high energy universe into focus
NuSTAR
nuclear spectroscopic telescope array
NuSTAR Science
Instrumentation

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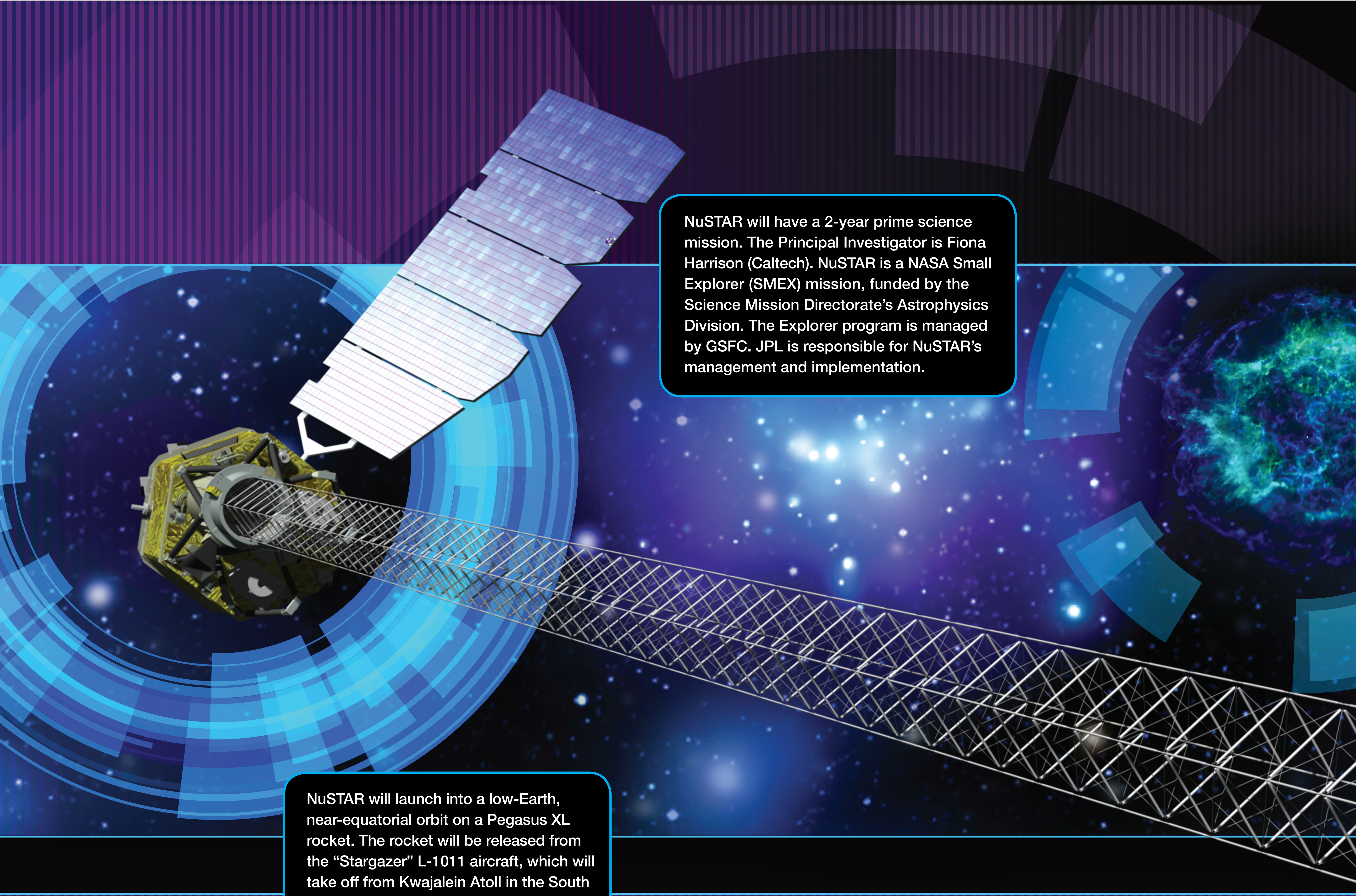
NuSTAR will open a new window on the universe by being the first satellite to focus high-energy X-rays into sharp images. NuSTAR's high-energy X-ray eyes will see with more than 100 times the sensitivity of previous missions that have operated in this part of the electromagnetic spectrum, and with 10 times better resolution. NuSTAR will shed light on some of the hottest, densest, and most energetic objects in the universe.

NuSTAR extends the power of focusing optics, employed by low-energy X-ray telescopes such as NASA's Chandra Observatory, to higher energies. This enables NuSTAR to use the penetrating power of high energy X-rays to peer through dust and gas, uncovering black holes and neutron stars buried in the heart of the Milky Way as well as in other galaxies.

NuSTAR will address exciting questions such as: How were elements that compose our bodies and the Earth forged and dispersed in the explosions of massive stars? What powers the most extreme active galaxies? Perhaps most exciting is the opportunity to discover wonders we have not yet dreamed of.



NuSTAR Science

In its two-year primary science phase, NuSTAR scientists will carry out a number of key programs that will change the way we understand the high-energy universe.

Conducting a Survey of Black Holes

Black holes, chasms in the fabric of space-time from which no light can escape, are among the most exotic objects in the universe. They can form as remnants left over by the collapse of massive stars. We also see super-massive black holes—millions to a billion times our Sun's mass—that grow in the hearts of galaxies over cosmic time by 'swallowing' surrounding dust and gas, entire stars, and even other black holes. One of NuSTAR's primary aims is to find black holes, both within our Milky Way Galaxy and in other galaxies, to study how they grow, how the in-falling matter radiates, and to understand them both as the fossil remnants of stars and the building blocks of galaxies.

Mapping Remnants From Recent Stellar Explosions

Massive stars end their lives in dramatic thermonuclear explosions called supernovae. These stars, and their explosions, are responsible for forging many of the elements central to our existence, including carbon, oxygen and calcium. The processes that cause stellar explosions, and the sequences that produce these elements, are still very poorly understood. NuSTAR, with its enhanced sensitivity in the high-energy X-ray band, will be able to view young remnants still glowing in radioactive material that will eventually decay to form stable elements, offering detailed views into the heart of the explosion.

Studying Nature's Most Powerful Cosmic Accelerators

A small fraction of super-massive black holes exhibit extreme behavior, spewing out jets of material moving very close to the speed of light. These jets can be so powerful that they choke off the creation of stars, leading to the death of the surrounding galaxy. The processes that create these jets, and which accelerate the high-energy particles within them, are not understood. By teaming with observatories the measure the radio to the high-energy gamma-ray band, NuSTAR will help unravel the exotic physics underlying these extreme black holes.

Finding the Compact Remnants of Exploded Stars in the Milky Way

The central region of the Milky Way Galaxy is littered with the compact remnants of stars that have exhausted their nuclear fuel. The majority leave behind white dwarfs, while a small fraction collapse to form neutron stars or black holes as the remaining material is expelled in a violent supernova explosion. This fossil record informs us about how stars evolve in isolation and in binary systems. These incredibly dense objects are laboratories in which to study the physics of matter at the extremes of gravity and magnetic field strength. NuSTAR's sensitivity in the high-energy X-ray range enables it to peer deep into the Galaxy to open a new window on these populations.

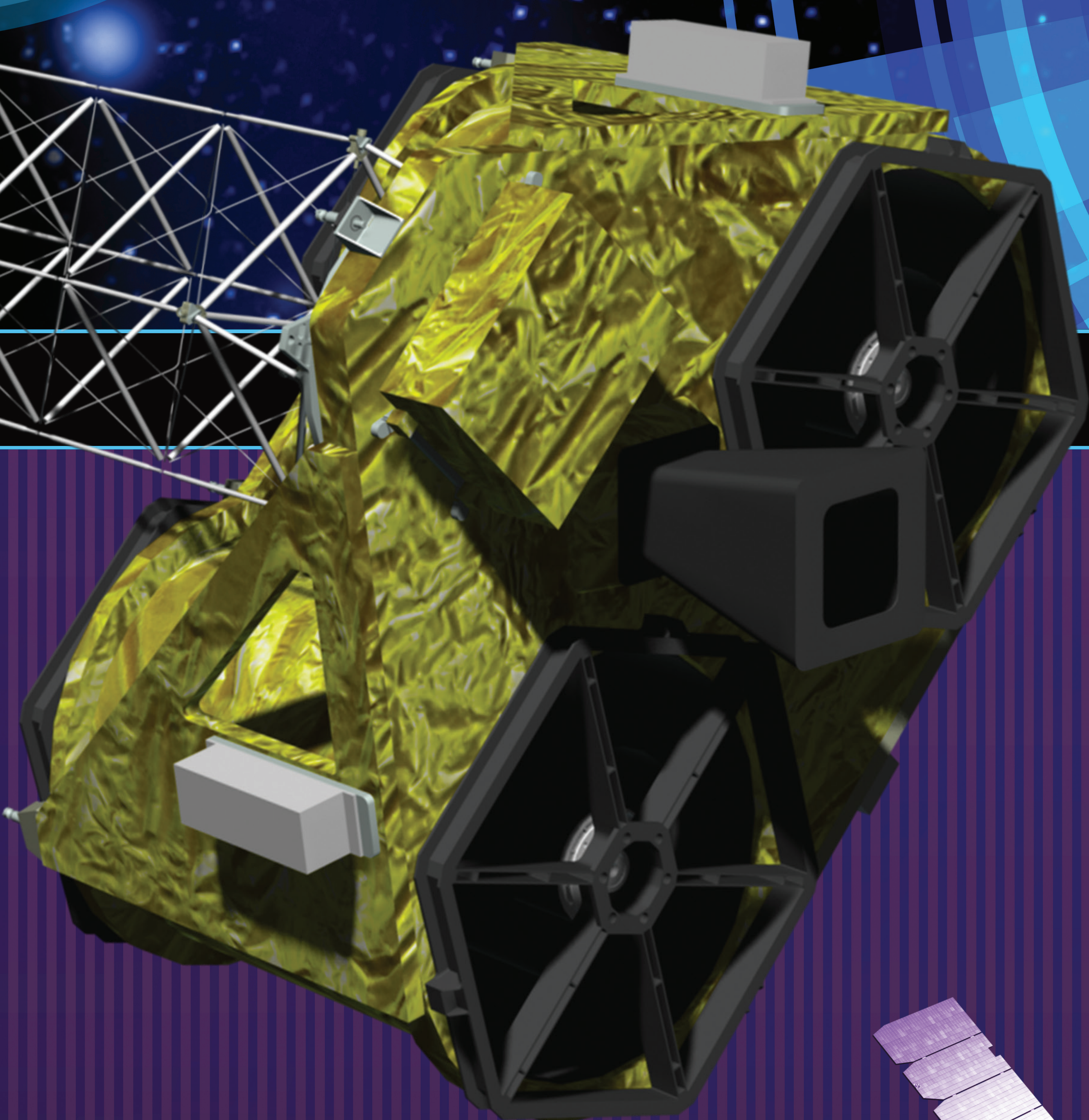
Other Science With NuSTAR

NuSTAR will undertake a wide variety of observations. In addition to its cosmic objectives, it will observe our own Sun and its ultra-hot atmosphere—the solar corona. NuSTAR will shed light on what heats this tenuous atmosphere, and the energetic processes underlying giant solar flares.

National Aeronautics and
Space Administration

At left is the Chandra X-ray Observatory image of Cassiopeia A, the remnant debris from the explosion of a massive star.

Above is an image of Centaurus A, the nearest luminous active galaxy, illustrating the power of a supermassive black hole.

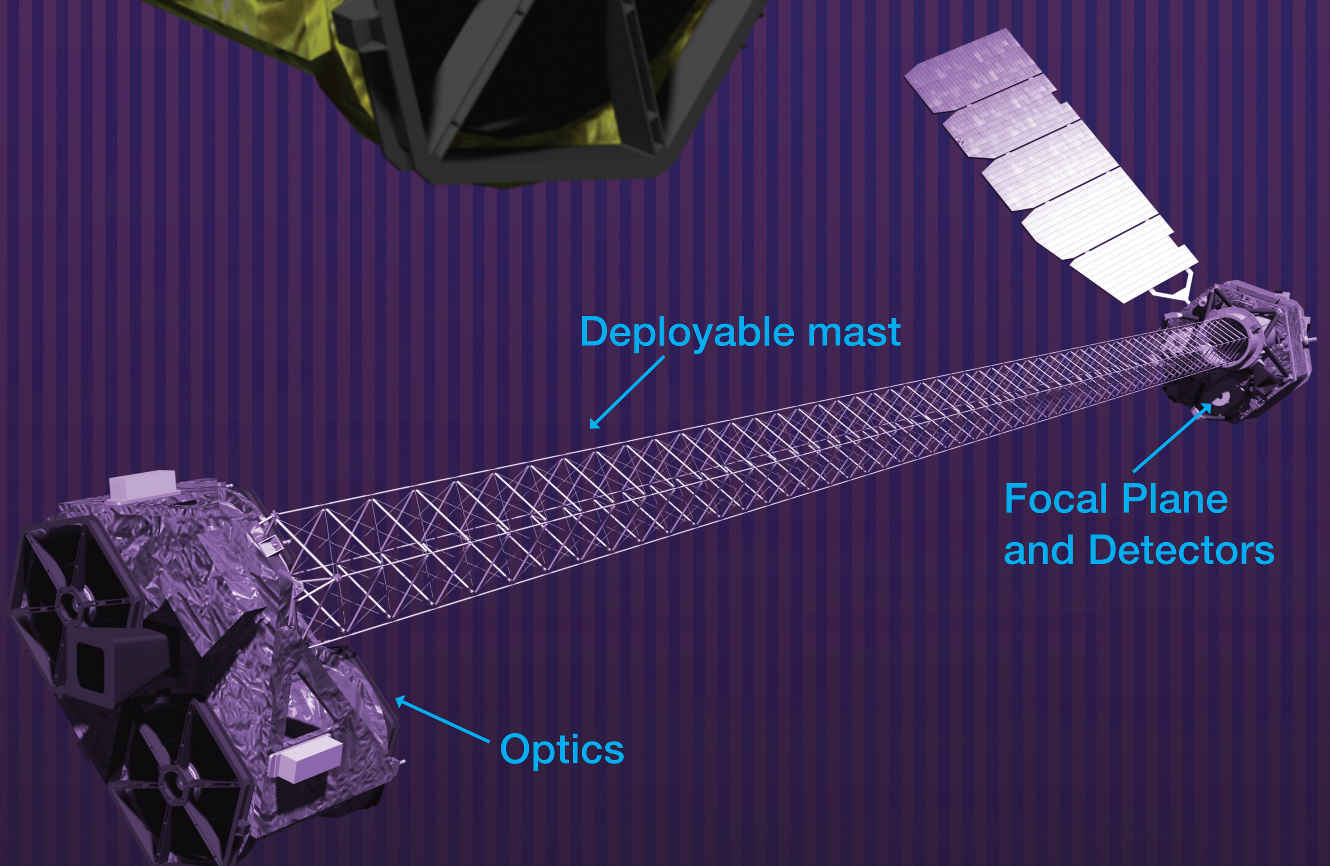


Instrumentation

The NuSTAR instrument's unprecedented sensitivity results from its ability to focus high-energy X-rays. Previous telescopes operating in this energy band have employed imaging techniques based on the pinhole camera. NuSTAR uses two novel mirror modules to focus, or concentrate, X-rays onto two imaging detectors.

Optics: Grazing-Incidence High-Energy X-ray Mirrors

Unlike visible light, X-rays only reflect off surfaces at glancing angles, as a rock might skip off the surface of a lake. X-ray mirrors must therefore be designed with the reflecting surfaces almost parallel to the incoming X-rays. The challenge for NuSTAR's optics is that the angles become more glancing with increasing X-ray energy, requiring 133 nested mirror shells as thin as a fingernail coated with special X-ray reflective films.



Deployable Mast

X-ray telescopes require long separations between the optics, which focus the radiation, and the detectors. To fit inside the low-cost Pegasus launch vehicle frequently used for launching SMEX-class missions, NuSTAR employs a school-bus-length 10-meter mast that folds up inside a 1-meter-tall canister. The mast will be deployed one week after NuSTAR reaches orbit.

State-of-the-art x-ray detectors

NuSTAR has two focal plane detector modules that act as the digital 'film' on which the image is recorded. Because high-energy X-rays are penetrating, the detectors use a special material, Cadmium-Zinc-Telluride, to stop them. A custom, very low-noise readout chip accurately measures the interaction position as well as the energy of each X-ray.