The Far Ultraviolet Spectroscopic Explorer (FUSE) Mission: Three Years and Counting

Operated by The Johns Hopkins University

Overview

The Far Ultraviolet Spectroscopic Explorer (*FUSE*) satellite was launched from Cape Canaveral on a Delta-II rocket on 24 June 1999. It resides in a 765 km (480 miles) circular orbit inclined 25 degrees to the Earth's equator, and orbits once every 100 minutes.

Figure 1. *FUSE* was launched on a Delta-II rocket on 24 June 1999 from Cape Canaveral, Florida. Three solid strap-on boosters were needed to lift the 3000 pound, 5-meter (18-foot) tall satellite into orbit.

The *FUSE* scientific instrument consists of four telescopes that focus far-ultraviolet (900 - 1187 Å) light from distant astronomical sources into devices called "spectrographs" that break the light into a spectrum and record it electronically. These spectra are then relayed to radio antennas on Earth, and then sent by ground link to a Satellite Control Center at JHU.

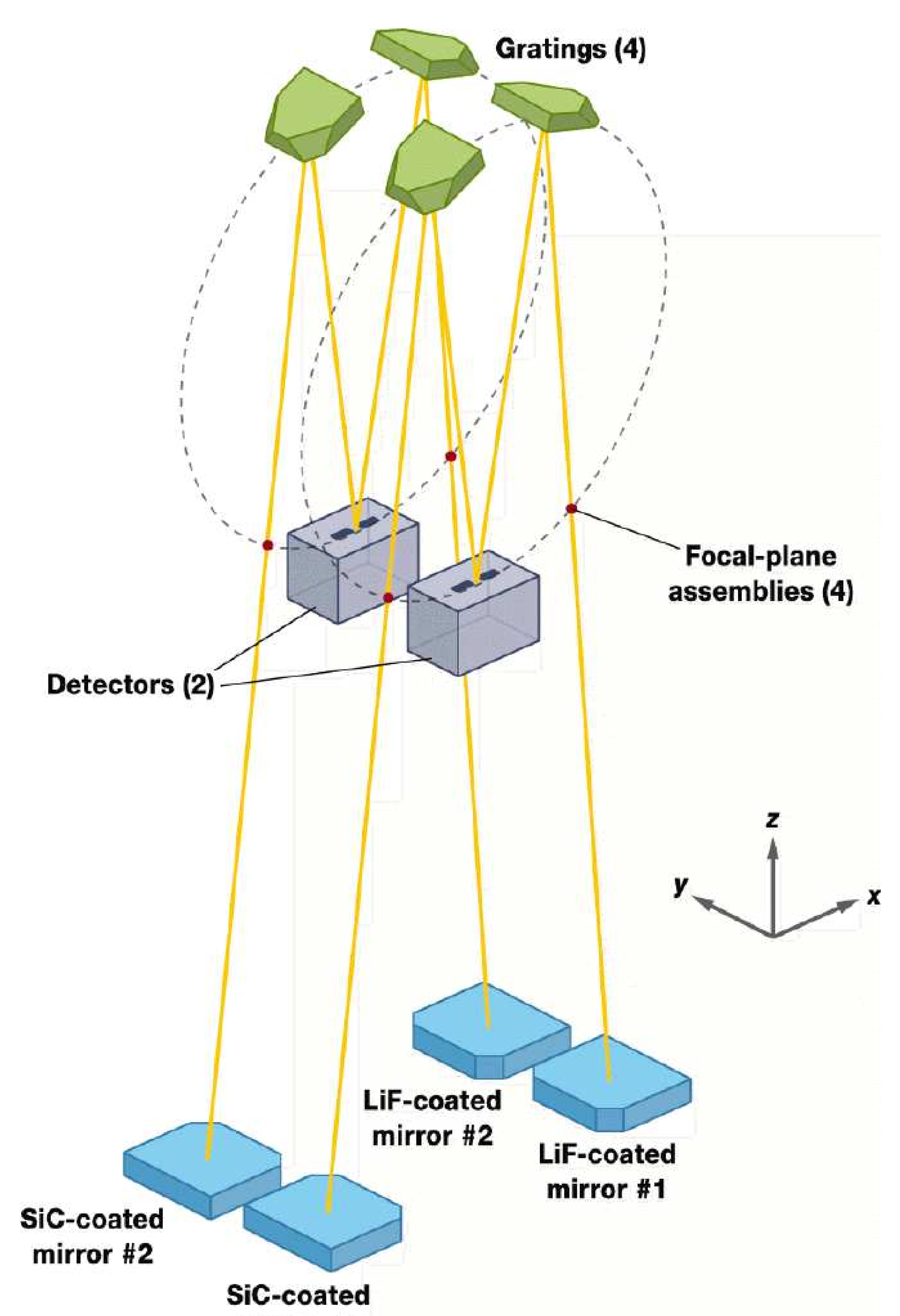

Figure 2. The *FUSE* science instrument is shown in schematic form. Four telescope mirrors feed far-ultraviolet light to four spectrographs that image their data onto two microchannel plate detectors. The data are encoded electronically and downlinked to the ground for processing and analysis.

Many Institutions and nearly 600 people participated in the development of the *FUSE* satellite. The mission is funded by NASA with significant contributions from international partners: The Canadian Space Agency, which provided the Fine Error Sensor guide cameras for *FUSE*, and the French Space Agency, Centre National d'Etudes Spatiale (CNES), which provided the high quality holographic diffraction gratings that allow *FUSE* spectrographs to do their job. The University of California, Berkeley, and the University of Colorado Boulder built and qualified the detectors and spectrographs, respectively.

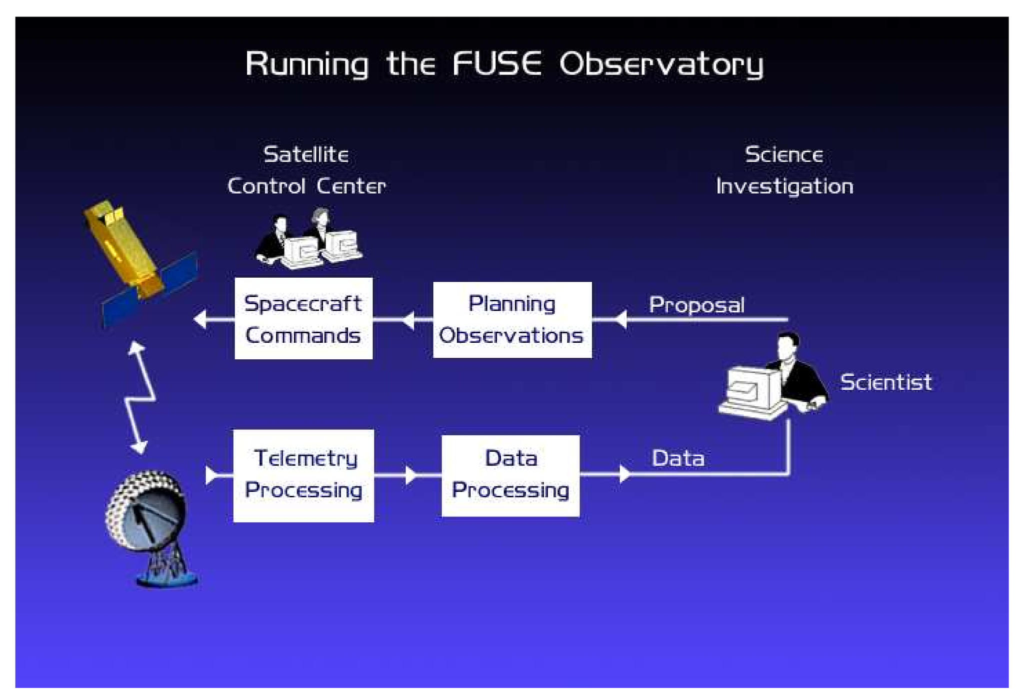

Figure 3. All critical functions for operating the *FUSE* satellite as an Observatory for the Astronomical community are handled at JHU. This includes such things as processing and technical review of proposals from astronomers who wish to use the satellite, creation of event and observation timelines, uplink and downlink of commands and data from the satellite, and processing of the data into a format useful to the astronomers who requested the data. About 25 people are currently involved in satellite operations at JHU.

Figure 4. The *FUSE* Satellite Control Center (SCC) is located on the first floor in the Bloomberg Center for Physics and Astronomy on the Homewood campus at JHU. All command loads, ground station scheduling, satellite health and safety monitoring, and telemetry and data processing are handled by the Mission Operations Team for *FUSE*.

Figure 5. The *FUSE* ground station antenna is located at the University of Puerto Rico in Mayaguez. The antenna is housed in a protective Radome, which also allows the electronics to be climate controlled, improving reliability in this subtropical climate. (The Radome passes radio signals, and does not have to move "out of the way" to permit operation.) This antenna is operated remotely from JHU or by staging automated control of ground station passes when the control center is unstaffed. The *FUSE* satellite passes over Puerto Rico about 6-7 times per day and can link to the satellite for 10-15 minutes per contact. At other times, the satellite operates autonomously using commands stored onboard.

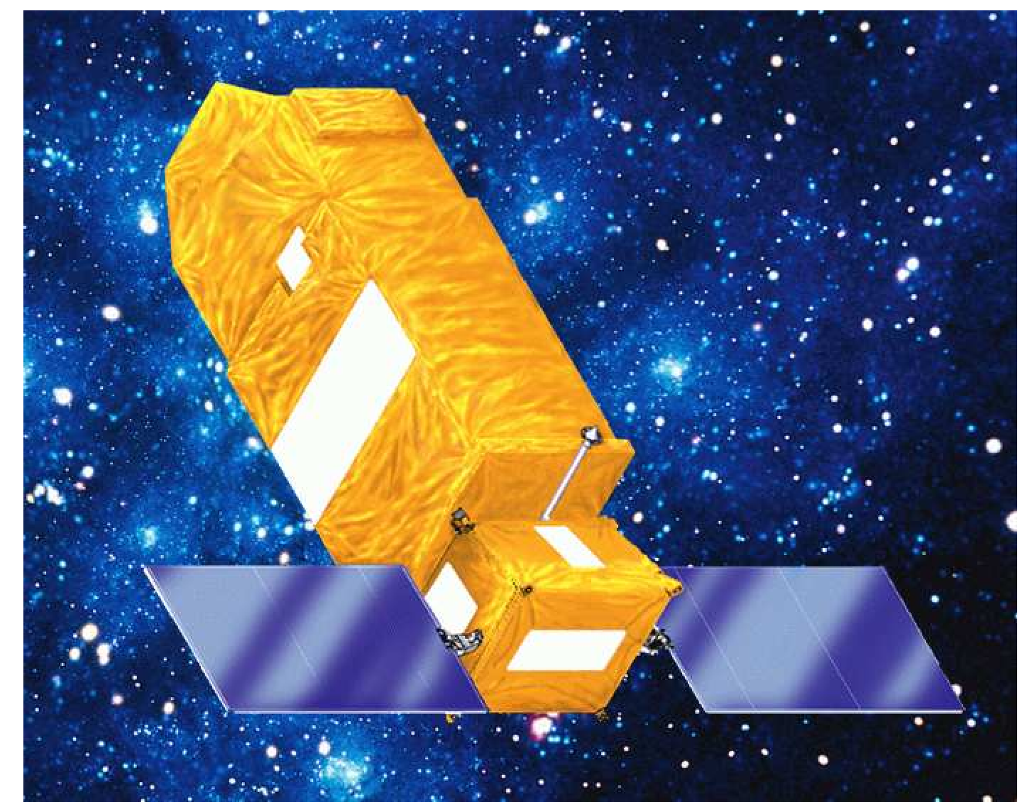

Figure 6. This is an artist's concept of what *FUSE* looks like on-orbit. The model of *FUSE* to your right is full scale, but is incomplete in the sense that portions have been left open so you can see inside. The box at the bottom is the spacecraft and the large section on top is the science instrument. The blue rectangles in the picture above are the solar panels (not included on the model). The pipe sticking out of one side of the spacecraft represents one of two radio antennas used by the satellite to talk to the ground. The white rectangles in the picture show positions of radiators on *FUSE* that remove excess heat from the onboard electronics. The black circle at the bottom of the model matches the size of the Delta-II rocket shroud into which *FUSE* had to fit to be launched. It was a tight fit!

Pointing the FUSE Satellite

***FUSE* does not carry any rockets or other expendable gas jets. Rather, its pointing and stability are controlled by devices in the spacecraft section of the satellite that are computer-controlled. Spinning wheels called Reaction Wheel Assemblies (RWAs) create torques (forces) that control the pointing, and gyroscopes inside two Inertial Reference Units (IRUs) sense the changes in position and feed this information to the control computer. In late 2001, problems developed with two of the RWAs, and the control system was updated to use other devices (called Magnetic Torquer Bars, essentially electromagnets) to assist in controlling the pointing. By running electric current through the MTBs, magnetic fields are generated locally that interact with the Earth's magnetic field to help stabilize the satellite pointing. *FUSE* can be pointed to better than 1 arcsecond (1/3600th of a degree) using this control system.**

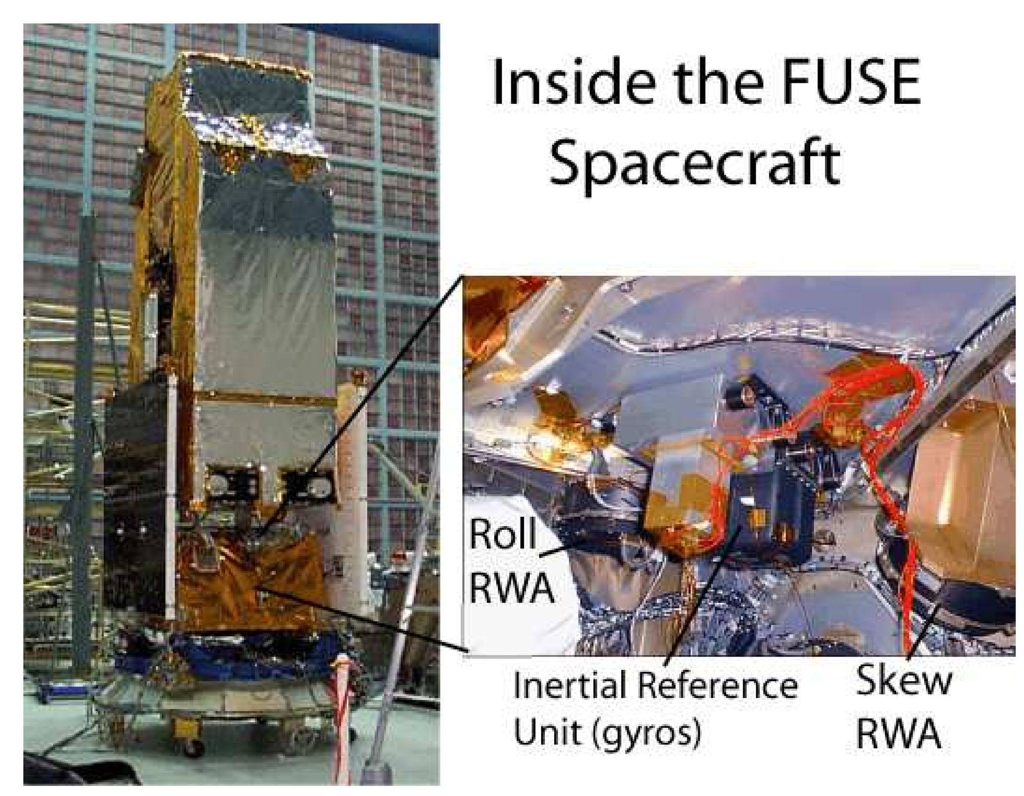

Figure 7. The inside of the *FUSE* spacecraft is mostly empty space! Computers, electronics, and attitude control (pointing) devices such as reaction wheels and gyros are all needed to point *FUSE* around the sky and hold it steady during observations of astronomical sources.

Prime and Extended Missions

The *FUSE* project was initially funded by NASA for a Prime Mission period that included three years of science operations. During this time, *FUSE* has performed a mixture of observations proposed by the *FUSE* Science Team (the scientists who proposed *FUSE* to NASA) and Guest Investigators (astronomers selected by NASA to participate in the mission). The Prime Science Mission concluded March 30, 2003.

However, the demand to use *FUSE* remains high, and a peer review committee established by NASA has recommended that *FUSE* continue to be operated for at least several more years. This time period, called the Extended Mission, will be devoted entirely to observations proposed by astronomers from around the world.

The *FUSE* project is part of NASA's *Origins* initiative, and is supported by NASA Contract NAS5-32985 to The Johns Hopkins University.

Figure 8. The *FUSE* Science and Mission Operations team, near its peak size (photo from May 1998).