The Hubble Space Telescope (HST) Wide Field Camera 3 (WFC3) Instrument

History & Overview

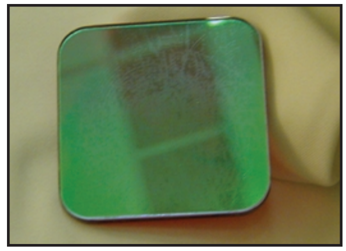
In June 1997, NASA made the decision to extend the end of the HST mission from 2005 until 2010. As a result, the age of the instruments on board the HST became a consideration. After careful study, NASA decided to ensure the imaging capabilities of the HST by replacing the Wide Field Planetary Camera 2 (WFPC2) with a low-cost facility instrument, the Wide Field Camera 3 (WFC3).

The WFC3 optical bench has been fabricated at Swales Aerospace, tested at GSFC, and delivered to Ball Aerospace for mounting the optical and mechanical components.

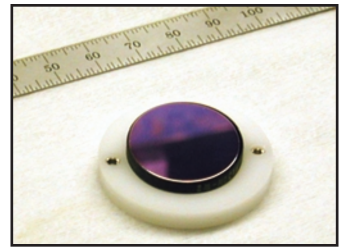
Scientific Goals

The WFC3 was originally conceived as a way to provide a backup imaging capability for HST during the latter part of its mission. The study phase for the instrument made clear that there are some key scientific questions that the instrument can be tailored to address.

A main theme for WFC3 science is the ability to do wide-field, panchromatic imaging. Its UV/visible (UVIS) channel extends



UVIS Filter



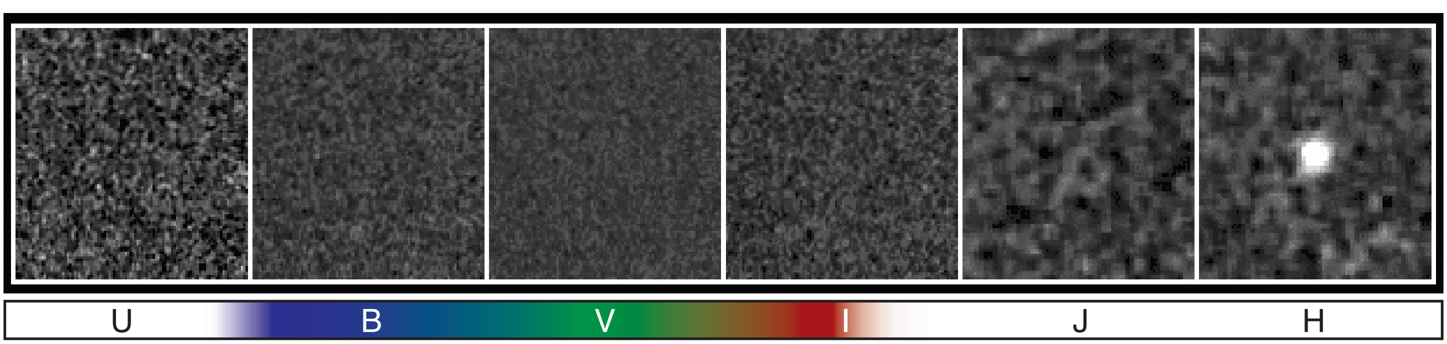
IR Filter

WFC3 incorporates a broad suite of filters selected by the WFC3 Scientific Oversight Committee after consultation with the community. The UVIS channel offers 47 filters and a UV grism that complements and backs up the ACS filter set. The IR channel has 14 filters and two grisms providing a full set of broad band filters between 900 and 1700 nm plus narrow band filters for key spectral features.

large-format imaging to the near-UV. Its wide-field infared (IR) channel will explore the IR universe that has been revealed by the NICMOS deep field observations. With an appropriate set of narrow-band filters, both of these wide-field and low-noise channels are well tailored for probing the astrophysics of the interstellar medium.

These features can also be brought to bear to provide an unprecedented panchromatic view of galaxy evolution. It will allow for studying the controlling mechanisms of star formation in galaxies, and help interpret the flood of tantalizing data on very distant galaxies. These data are often observed in the rest frame UV, and we require high quality UV-optical-IR imaging of nearby objects for which good correlative radio, infrared, and X-ray data are available.

WFC3 is uniquely capable of providing such imaging. The UV conveys the most information about the history of star formation over the past 500 Myr, and allows direct detection of massive stars responsible for most of the ionization, photodissociation, kinetic energy input, and element synthesis in galaxies. The IR traces the mature stellar population, most of the stellar mass,

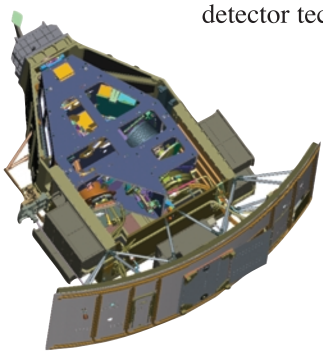


J-Band Dropout. The panels show a source identified in the Hubble Deep Field North with WFPC2 and NICMOS. This object has no significantly detectable flux in the UV, optical, and J band but is detected in the NICMOS H band image. Its spectral energy distribution is consistent with a star forming galaxy at a redshift $z \geq 10$. Similar objects could be the first population of galaxies to appear in the Universe and be responsible for the re-ionization of the interstellar medium. They can only be studied with an IR camera. They will be primary targets for the WFC3 IR channel.

and probes dusty star-forming regions. The panchromatic coverage of WFC3 from the near-UV at 200 nm to the near-IR at 1700 nm, with high resolution over a wide field, therefore offers powerful insights into galaxy evolution.

Instrument Configuration

The WFC3 is configured as a two channel instrument. The incoming beam from the HST is directed into the instrument using a pick-off mirror. Within the instrument, the beam is directed to either the UVIS channel or the IR channel. The WFC3 wide-wavelength coverage at high efficiency is made possible by this dual-channel design using two detector technologies.



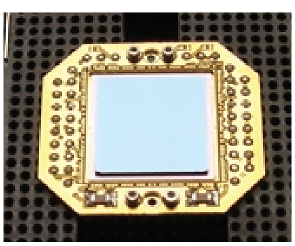
This is an isometric view of the WFC3 instrument. The outer enclosure and the radiator (bottom) are re-used WF/PC (1) items. The interior optical bench (lavender) is a new structure that contains all the optics and detector subsystems.

The optical purity of the instrument will support diffraction-limited imaging through 300 nm for the UVIS channel, and 1000 nm for the IR channel. This allows the instrument to exploit another unique HST capability, that of a well-defined and uniform point-spread-function over the entire field-of-view.

New Technology

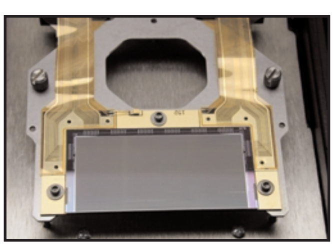
The WFC3 is a fourth-generation instrument for HST. It is built on a low-cost paradigm that maximizes the reuse of existing designs and parts. In order to improve its scientific productivity, we have incorporated new detector technologies wherever possible.

The UVIS channel uses a large format, 2 x 2K x 4K CCD design based on CCDs from Marconi Applied Technologies. This is similar to the configuration used by the HST



Rockwell MCT WFC3 IR detector in its flight package. This 1024 x 1024 pixel detector extends the HST NICMOS heritage to a larger format, higher QE, and lower noise detector. A long wavelength cutoff of 1.7 microns maximizes performance where HST has low internal background while permitting zodical background limited observations in J and H bands.

Marconi CCD detector in an ACS - derived flight mounting. WFC3 uses two 4096 x 2048 pixel detectors with optimized QE from 200 to 1000 nm and readout noise below 4 electrons.



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Instrument Performance

	UVIS	IR	
Format	4K x 4K UV Coating	1K x 1K	pixels
Field Size	160 x 160	135 x 135	arcsec
Pixel Size	39	130	mas
Spectral Range	200 to 1000	800 to 1700	nm
Dark Current	< 0.003	< 0.4	e-/pix/sec
Readout Noise	< 4	< 15	e-/pix/ readout
Filters / Grisms	47 / 1	14 / 2	

This table summarizes the WFC3 performance parameters.

Advanced Camera for Surveys, scheduled for deployment in 2002. The additional time available for WFC3 permits using advanced coating technology for the backside-illuminated WFC3 CCDs. These coatings can provide greater than 50% quantum efficiency (QE) at 250 nm to improve near-UV capabilities.

The near-IR channel uses a state-of-the-art Mercury-Cadmium Telluride (MCT) focal plane array from Rockwell Scientific. This detector is a more advanced version of the ones in the HST Near-Infrared Camera and Multi-Object Spectrometer (NICMOS) instrument, providing a factor of 16 increase in the number of pixels, and over a factor of 2 increase in quantum efficiency. Another innovation in the MCT detectors is tailoring the long-wavelength cutoff to a shorter wavelength than is usual. This cutoff (at ~1.7 μm) allows the detector to operate at relatively warm temperatures (~ –120C) with acceptable dark current. This feature simplifies the instrument, allowing the use of thermoelectric cooling systems instead of the cryogens or mechanical cryocoolers that are typical in other IR instruments.

Scientific Oversight Committee

The WFC3 Scientific Oversight Committee (SOC) is chartered to provide broad scientific advice to the WFC3 project. It will define the key scientific objectives achievable by the WFC3, within the instrument's main programmatic and technical constraints. The SOC members are:

Bruce Balick	Howard E. Bond	Daniela Calzetti
C. Marcella Carollo	Michael J. Disney	Michael A. Dopita
Jay A. Frogel	Donald N. B. Hall	Jon A. Holtzman
Gerard Luppino	Patrick J. McCarthy	Francesco Paresce
Robert W. O'Connell, (Chair)	Abhijit Saha	Joseph I. Silk
John T. Trauger	Alistair R. Walker	Brad C. Whitmore
Rogier A. Windhorst	Erick T. Young	
Edward Cheng (Ex Officio)	John MacKenty (Ex Officio)	

For further information, feedback, and contacts, please visit the WFC3 Web Site at: http://wfc3.gsfc.nasa.gov