The Hubble Space Telescope Orbital System Test (HOST) Mission

Edward S. Cheng

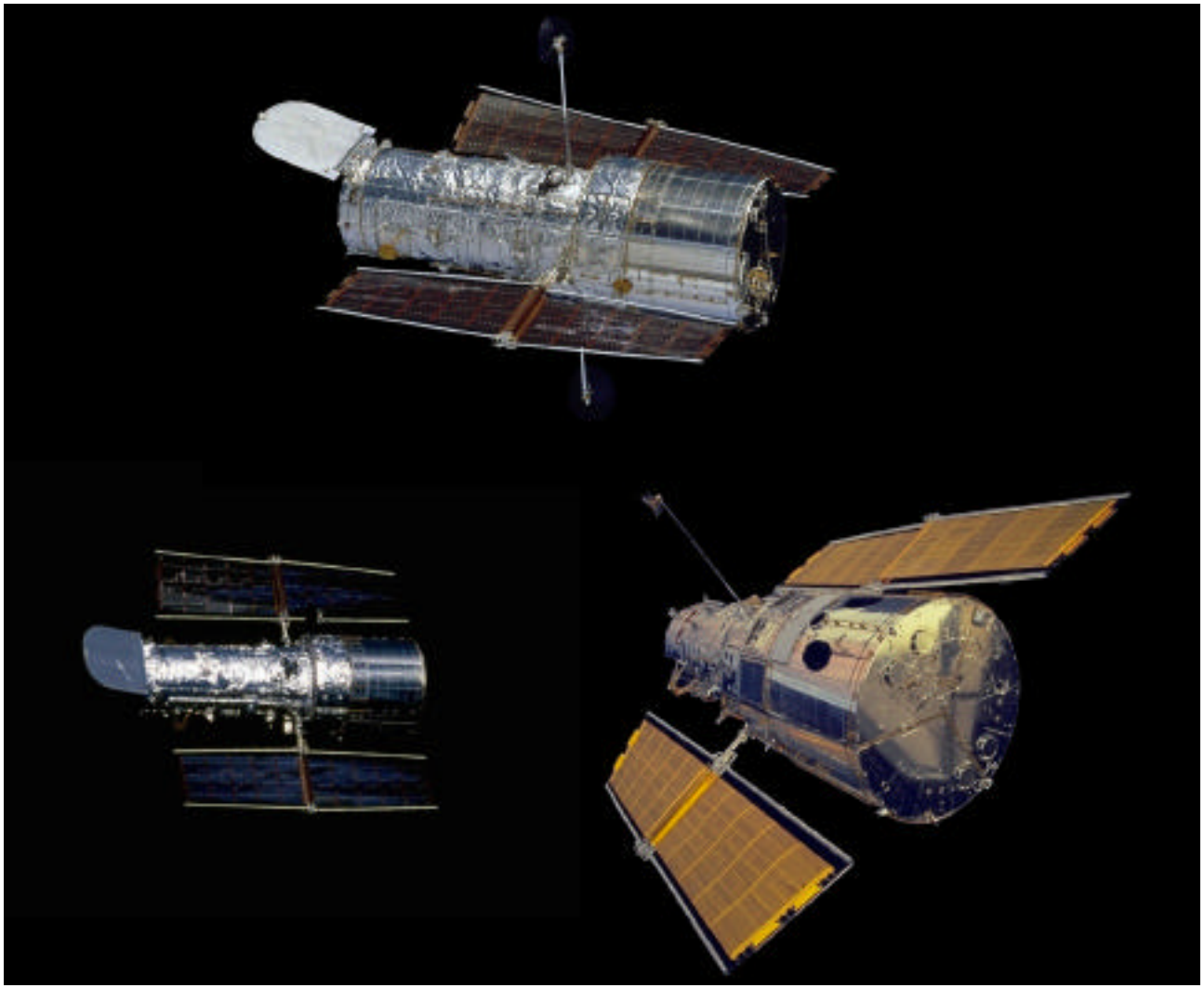
Project Scientist/HST Flight Systems and Servicing Project

Excerpts from the HOST Mission Prelaunch Briefing

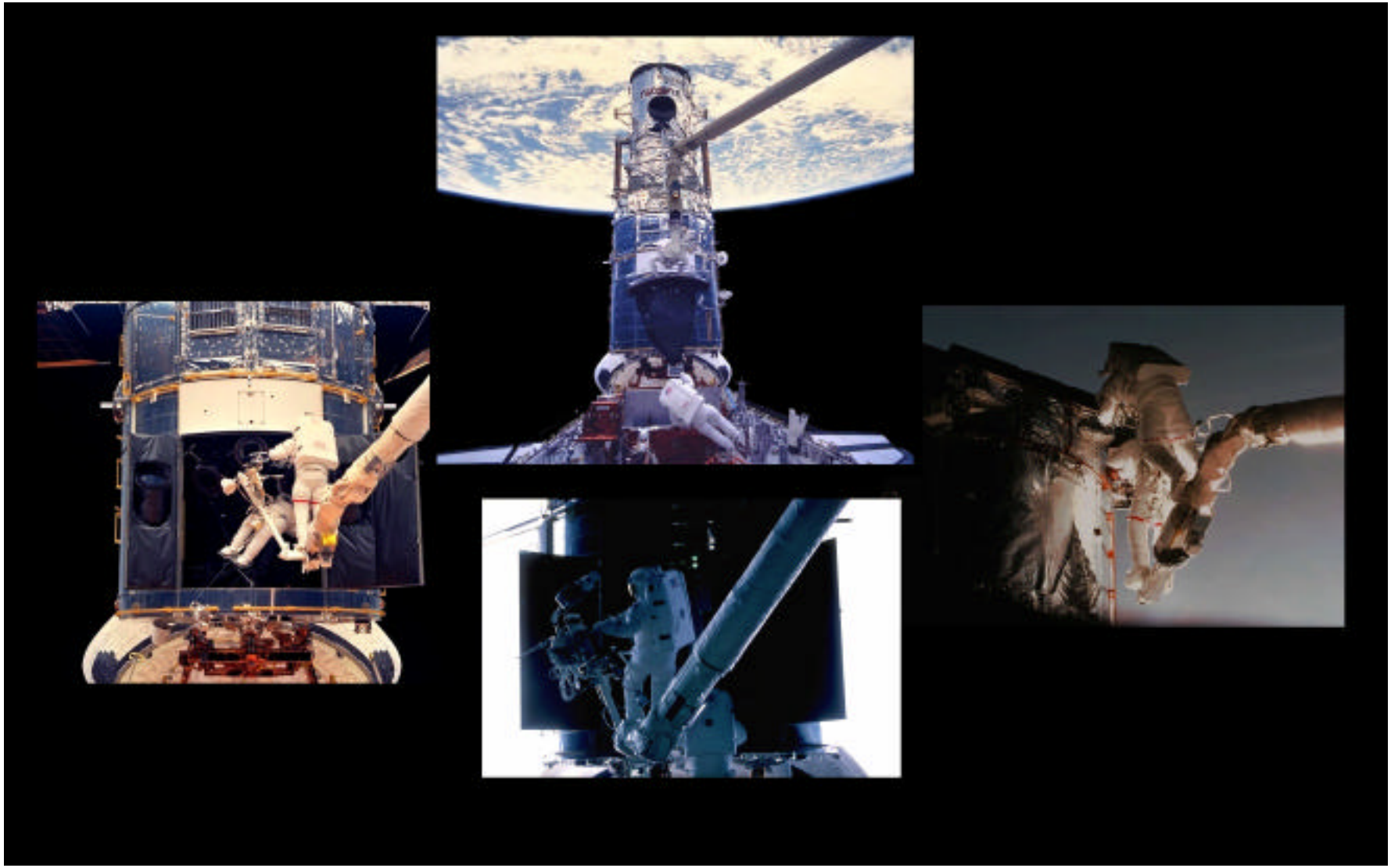
The Hubble Space Telescope (HST)

- NASA's premier orbiting astronomical observatory for near-ultraviolet through near-infrared observations (120 nm through 2500 nm).
- Managed by the Hubble Space Telescope Project at NASA's Goddard Space Flight Center in Greenbelt, Maryland.
  - Science operations.
  - Spacecraft operations.
  - Hardware development.
  - Servicing mission planning and execution.
- Deployment in April 1990, planned deorbit in 2010.
- Unprecedented scientific return on investment through planned, periodic maintenance and upgrades using new technology.
  - Four generations of scientific instruments spanning two decades of technology.

The HST As It Looks In Space



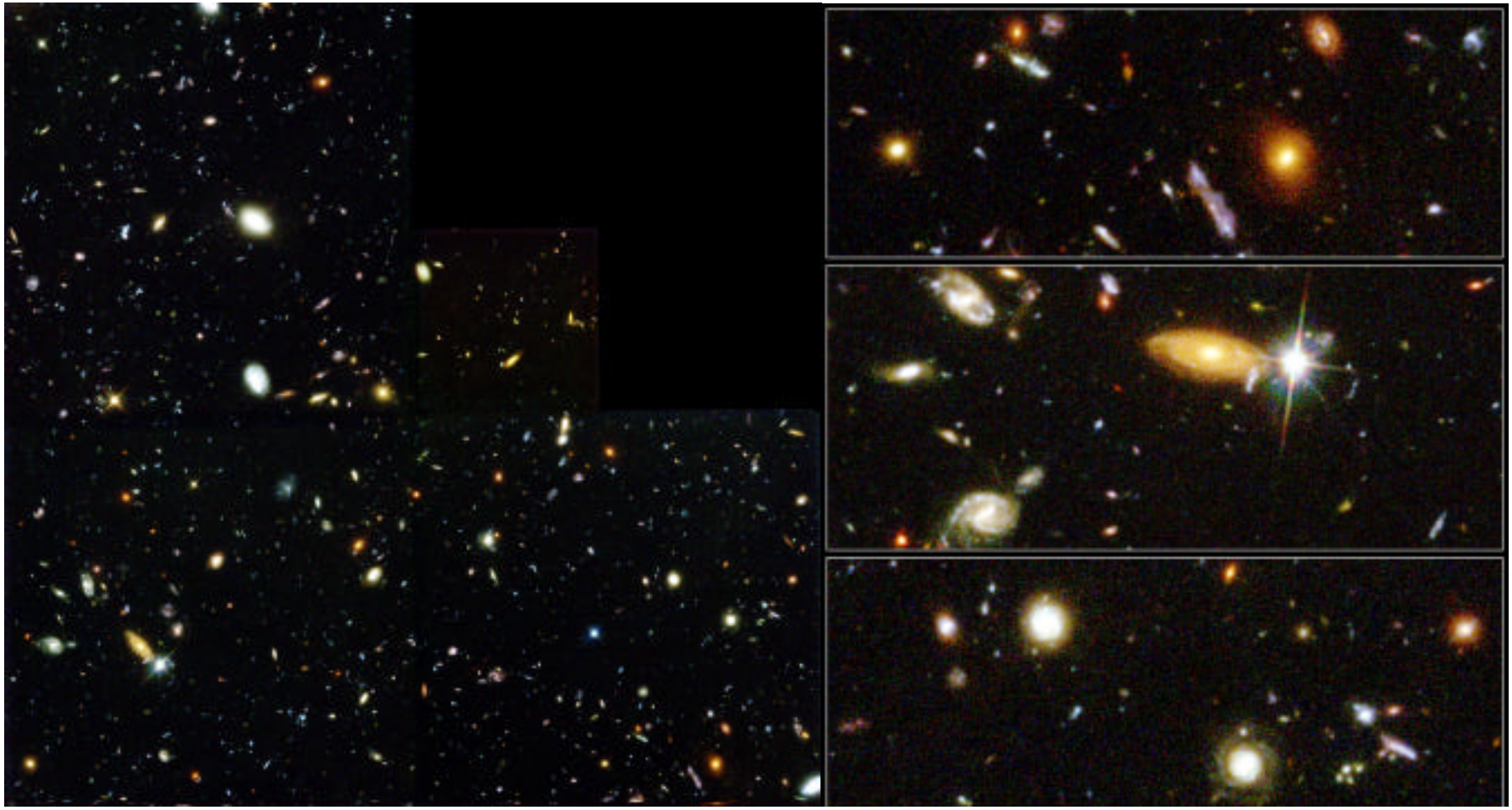
Astronaut Servicing Key To HST Productivity



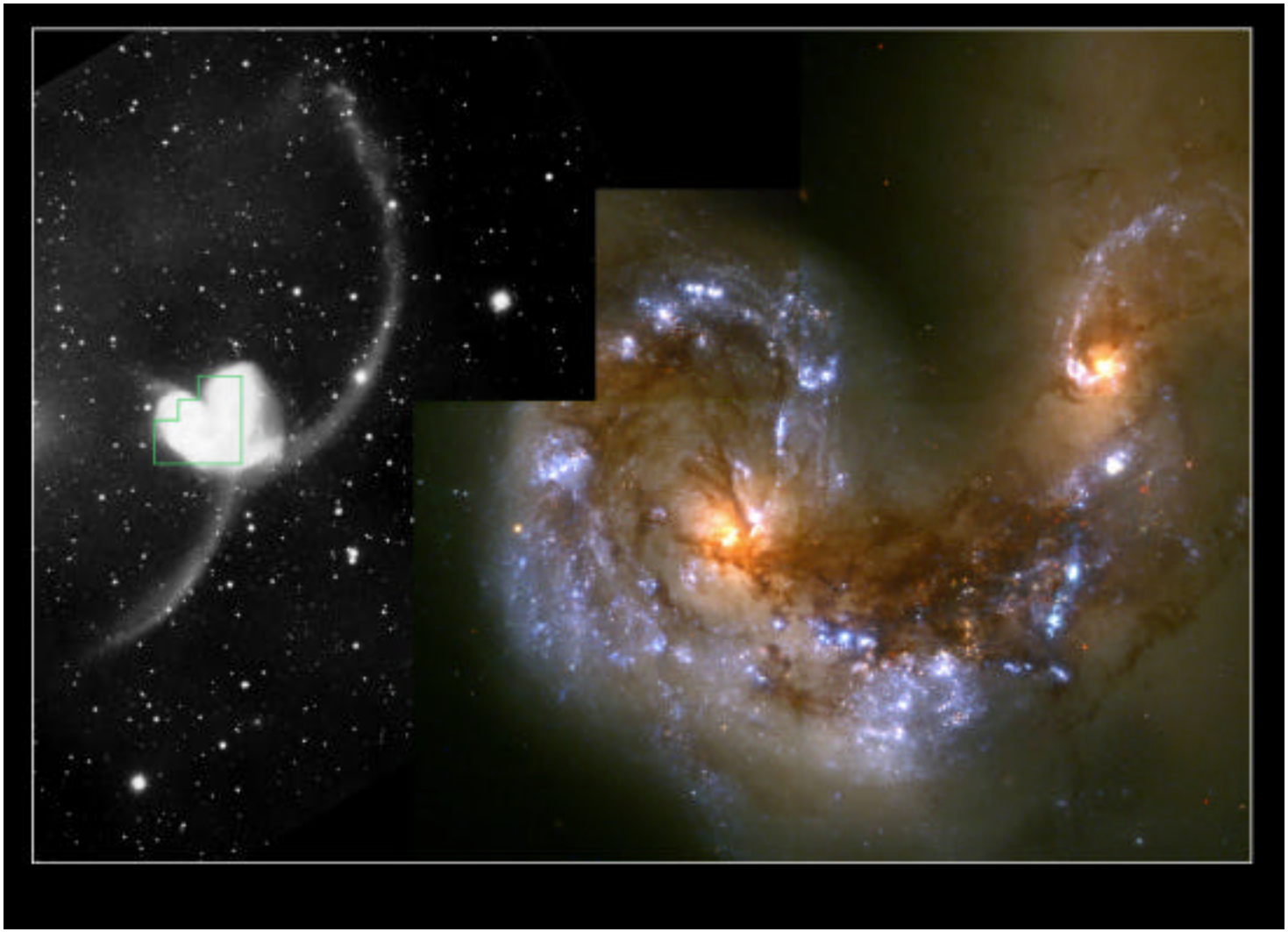
HST Scientific Highlights

- Astonishing results from the edge of the visible Universe to our local Solar System neighborhood.
- Refining and defining our knowledge of all aspects of astronomy and astrophysics.

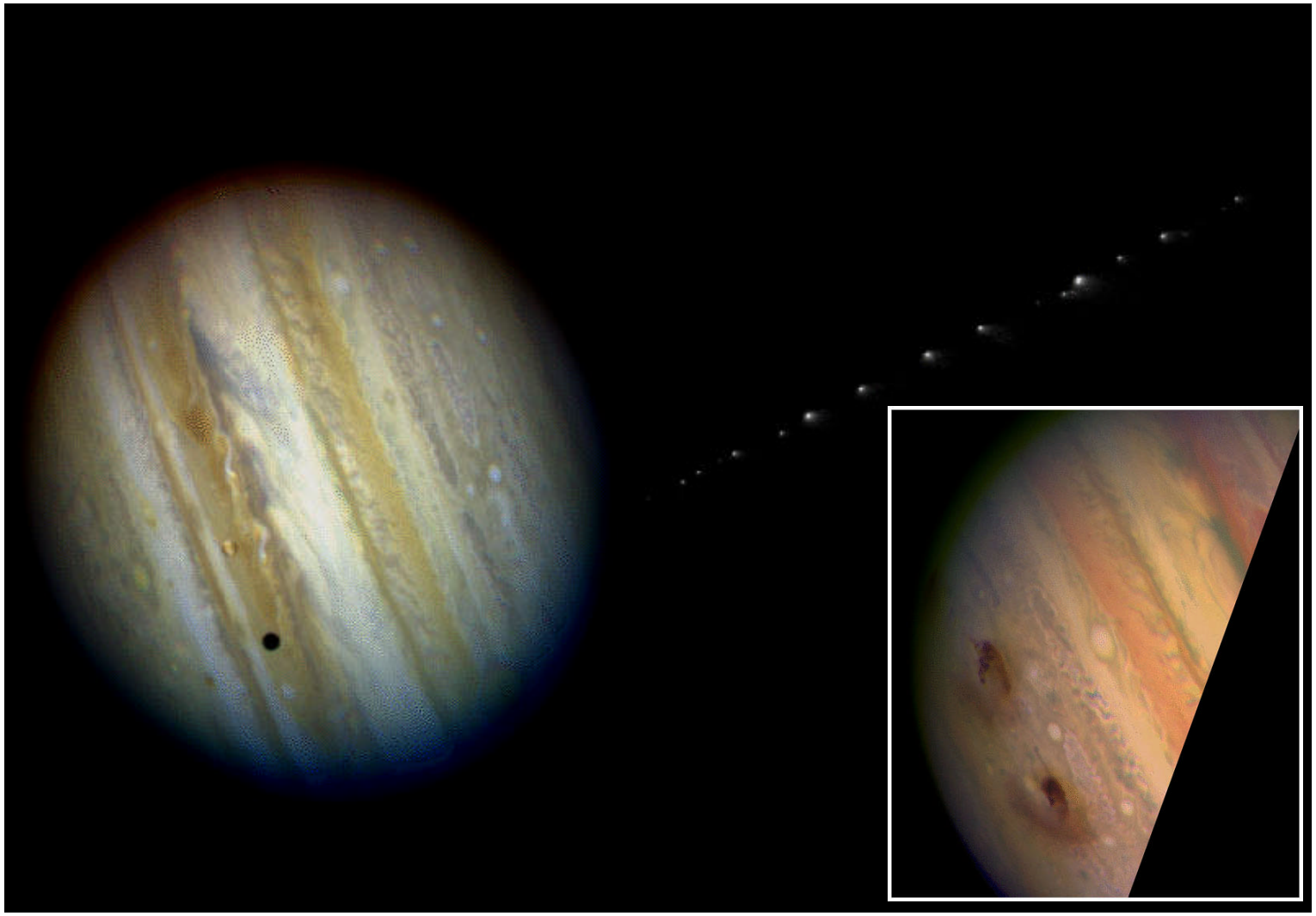
Mystery! What Lurks in the Darkest Parts of the Sky?



Romance! Galaxies are Social Creatures ...

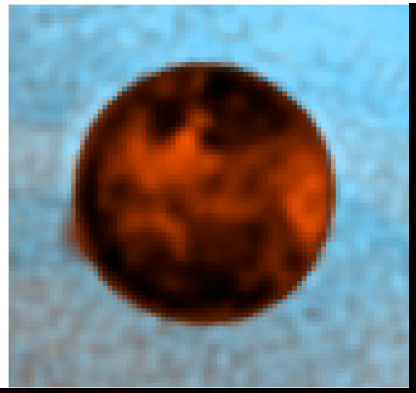


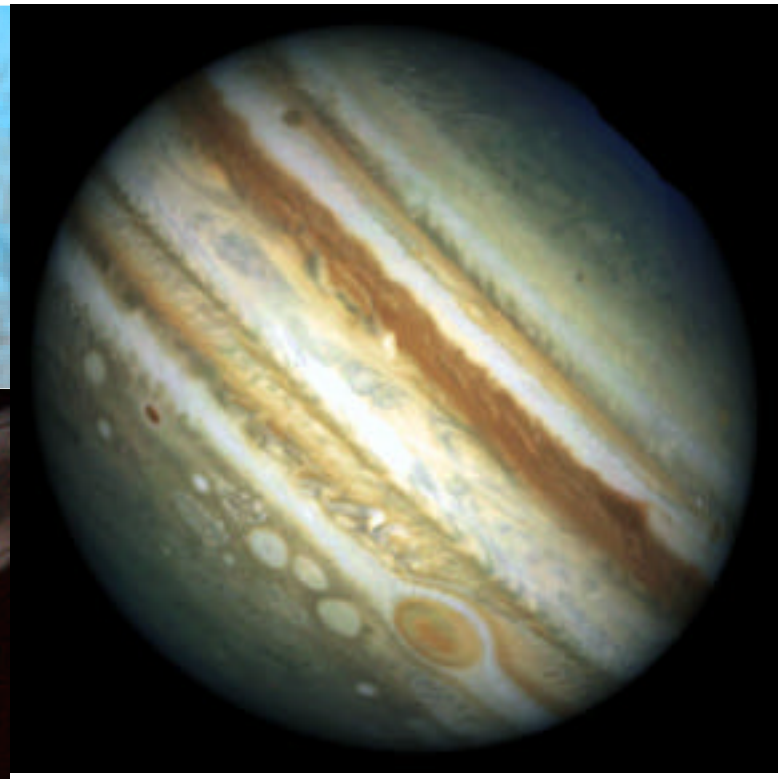
Excitement! A Comet Collides with Jupiter ...



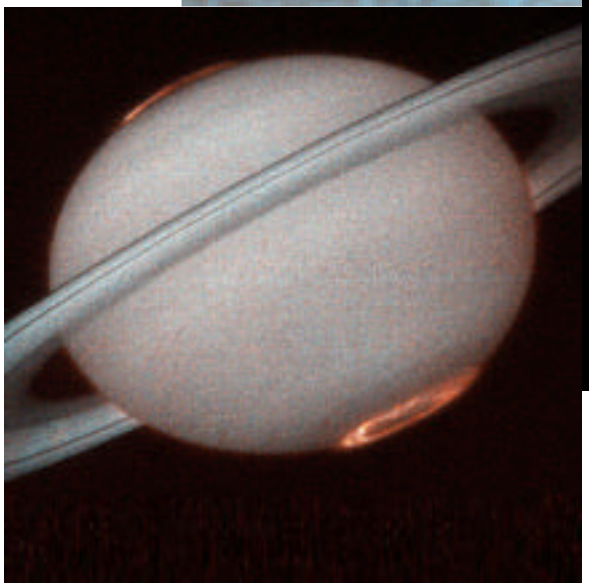
Weather! Stormy Conditions Today ...

Volcanic Eruption on Io



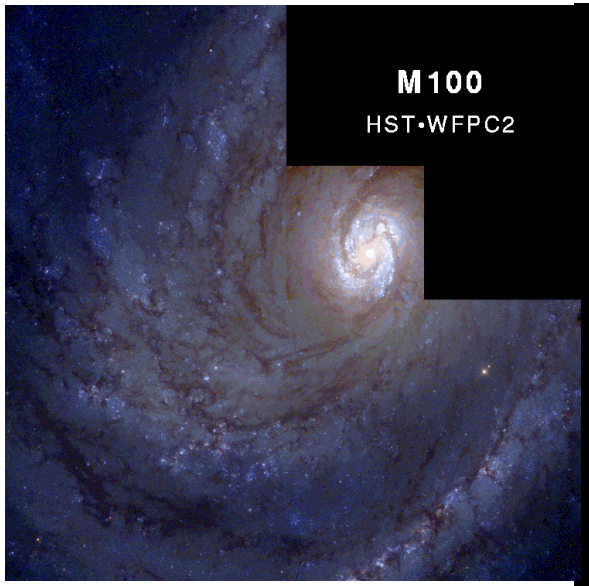


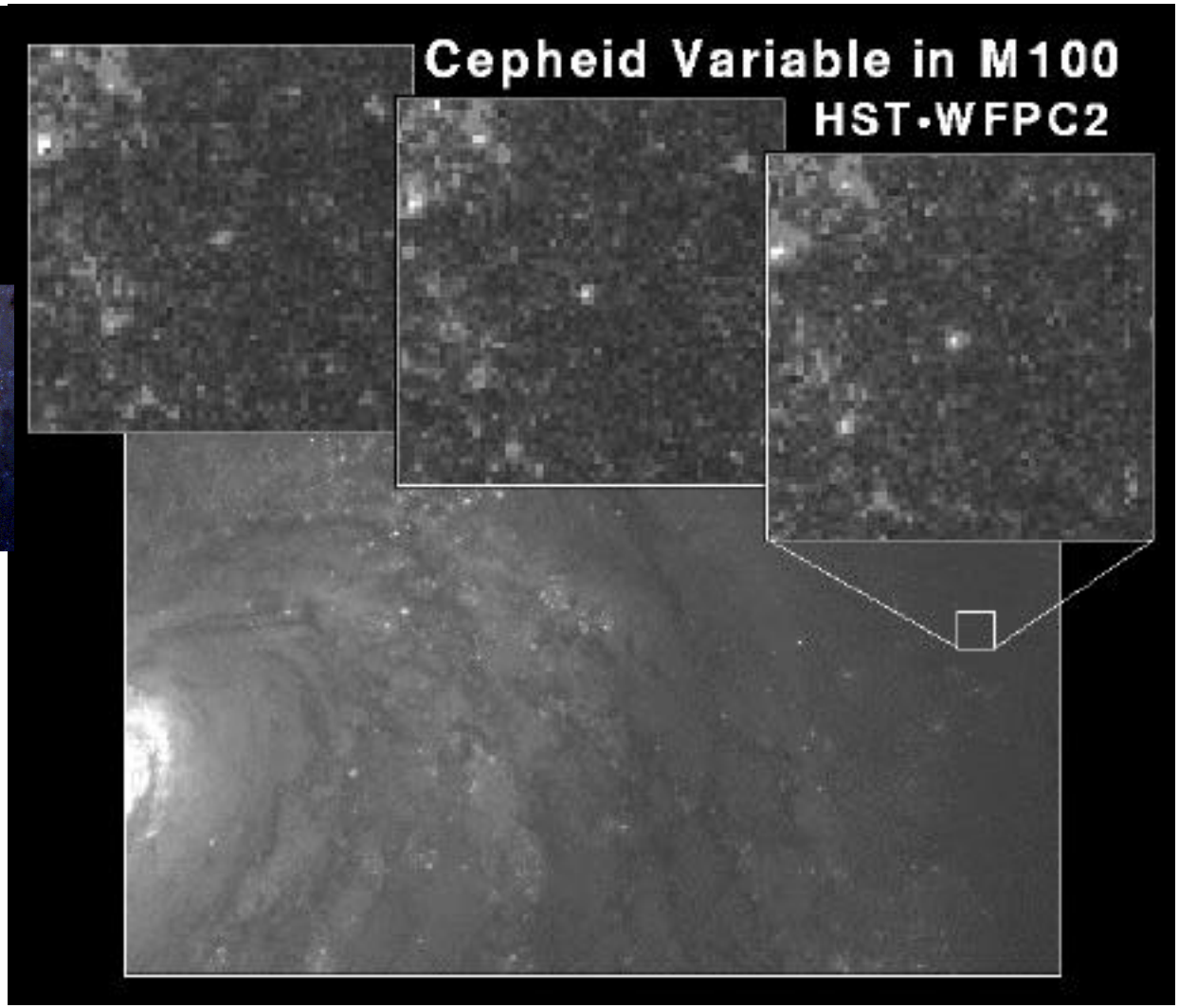
Storms on Jupiter



Saturn's Aurorae

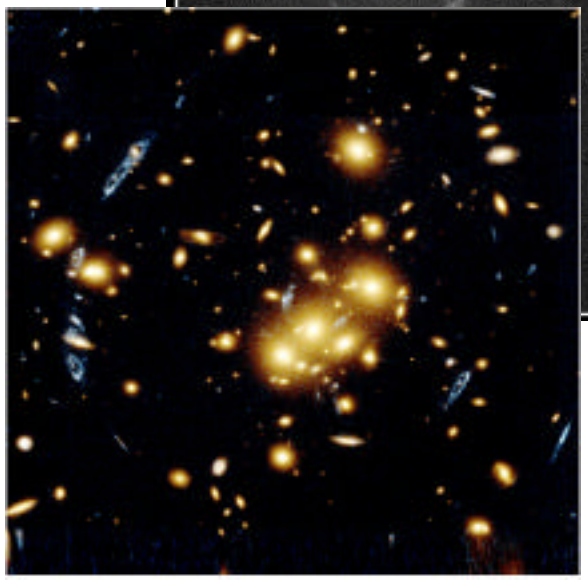
Measuring the Girth of the Universe ...





Cepheids are nature's certified "light bulbs."

And How Much It Weighs ...



Planned Servicing is a Key To This Productivity

- Regular visits to the observatory for upgrades and maintenance.
  - Every three years on average.
- New scientific instruments installed on every visit.
  - Brings the newest and most capable technologies .
  - Address the most current scientific questions.
  - Implements the best ideas of the international HST scientific community.
- Upgrade spacecraft systems to increase scientific productivity.
  - More power to operate advanced instruments.
  - Maintain the thermal environment to support greater power consumption..
  - Increased data handling capabilities.
- Maintain proper operation of the observatory.
  - Improved Fine Guidance Sensors.
  - New gyroscopes.
  - New batteries.

Key Results of Past Servicing Missions

- First Servicing Mission (December 1993).
  - Corrective Optics Space Telescope Axial Replacement (COSTAR).
    - Corrects spherical aberration in the Primary Mirror for the axial instruments.
  - Wide Field and Planetary Camera 2 (WFPC2).
    - Improved detectors.
    - Optical correction.
  - Solar Arrays.
    - More power.
- Servicing Mission 2 (February 1997).
  - Space Telescope Imaging Spectrograph (STIS).
    - Increases the efficiency of spectral measurements up to 50 times.
  - Near-Infrared Camera and Multi-Object Spectrometer (NICMOS).
    - Enables near-infrared science on HST.
  - Solid State Recorder (SSR).
    - Improves spacecraft data management capabilities.

SM3 Scientific Highlights

- Advanced Camera for Surveys (ACS) deployment.
  - Unprecedented sensitivity and field of view for HST imaging.
  - A factor of 10 to 30 improvement in “discovery efficiency.”
  - Addresses fundamental questions of cosmology.
    - How big is the Universe?
    - How much mass is there in the Universe?
    - What is the nature of this mass and how is it distributed?
- NICMOS Cooling System.
  - This hardware is being flown on HOST.
  - Deployment on HST depends on the outcome on HOST.
  - Extends the infrared imaging capability of HST by extending NICMOS lifetime.

SM3 Items of Scientific Interest

- Improved Fine Guidance Sensor to ensure reliable pointing.
- New Solar Arrays for increased power capability.
- New Solid State Recorder to allow more data to be taken and stored between “data dumps” from the spacecraft.
- New Central Computer for more efficient spacecraft operations.
- Replacement Gyroscopes for increased reliability.

With every Servicing Mission, HST becomes more powerful and productive than it had ever been.

Future Servicing Missions will continue this trend.

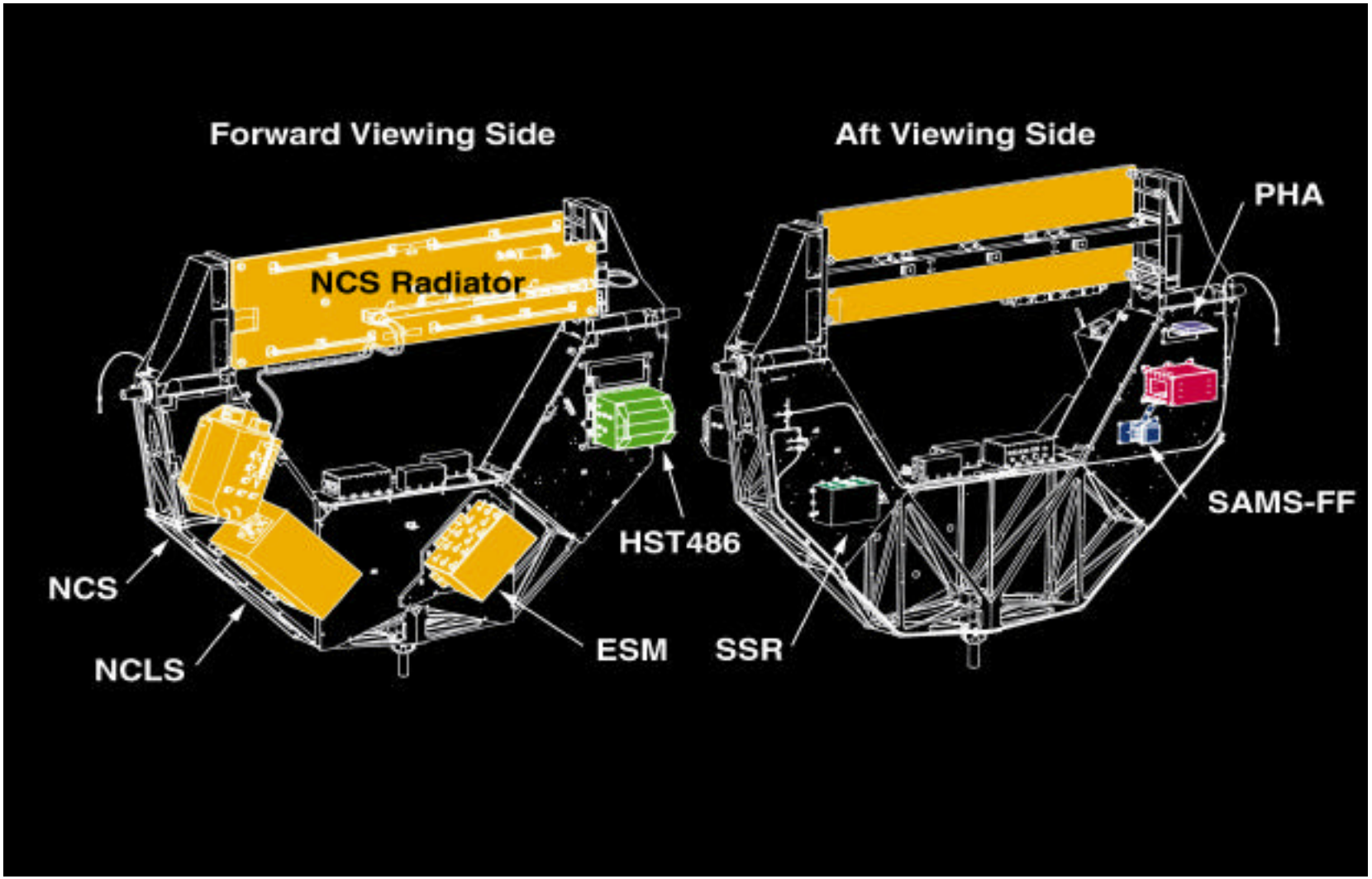
HOST Goals

- Test new technology items before use on HST.
  - Long development times for flight hardware is a major challenge for advanced missions.
  - Conservatism is driven by the perceived need to completely qualify subsystems before use. A flight test converts “worries to knowledge.”
  - Zero-gravity and exposure to the radiation fields in space cannot be simulated.
  - The HOST strategy is to follow a **comprehensive ground test program** with a **flight demonstration**.
- Reuse as much “second-hand” flight hardware and experience as possible to support these tests.
  - Faster mission development (one year time scale).
  - Minimize cost.

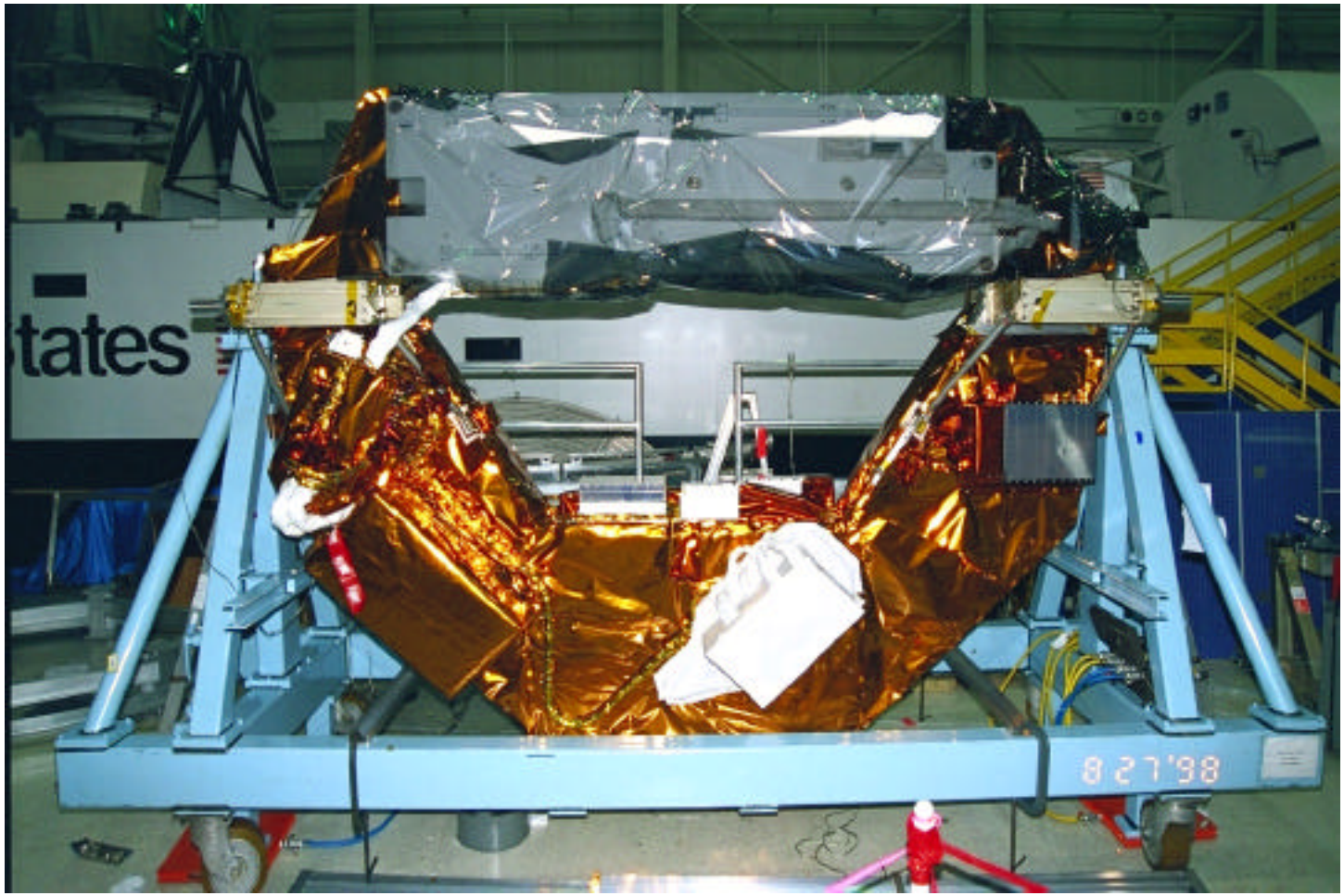
Major HOST Components

- UARS carrier holds the hardware in the Space Shuttle (the “Orbiter”).
- There are four experiments on HOST.
  - NICMOS Cooling System (NCS).
  - HST 486 Computer.
  - Solid State Recorder (SSR).
  - KSC Fiber Optic Flight Experiment (FOFE).
- There are two sets of (non-routine) avionics that support these experiments.
  - Space Acceleration Measurement System for Free Flyers (SAMS-FF).
  - Pulse Height Analyzer (PHA).

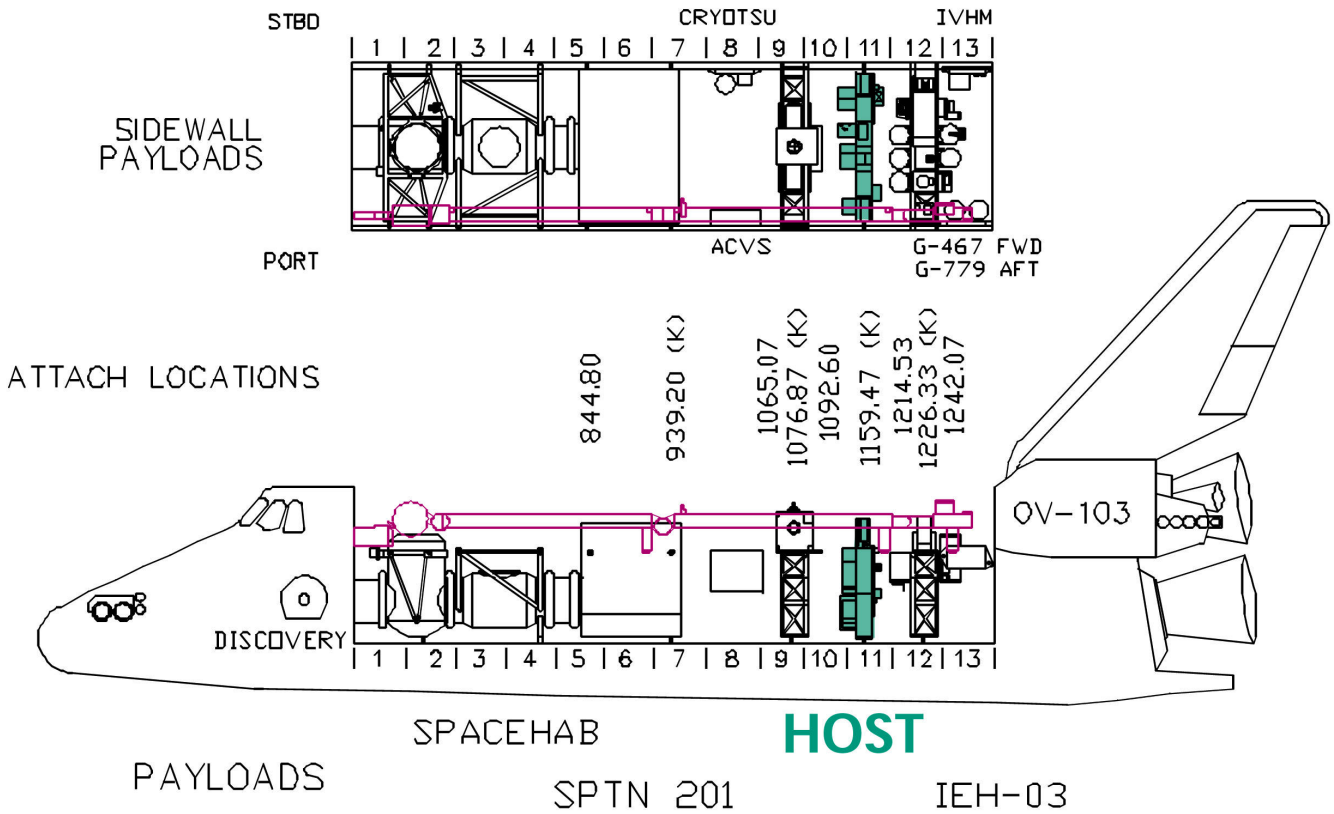
The HOST Carrier



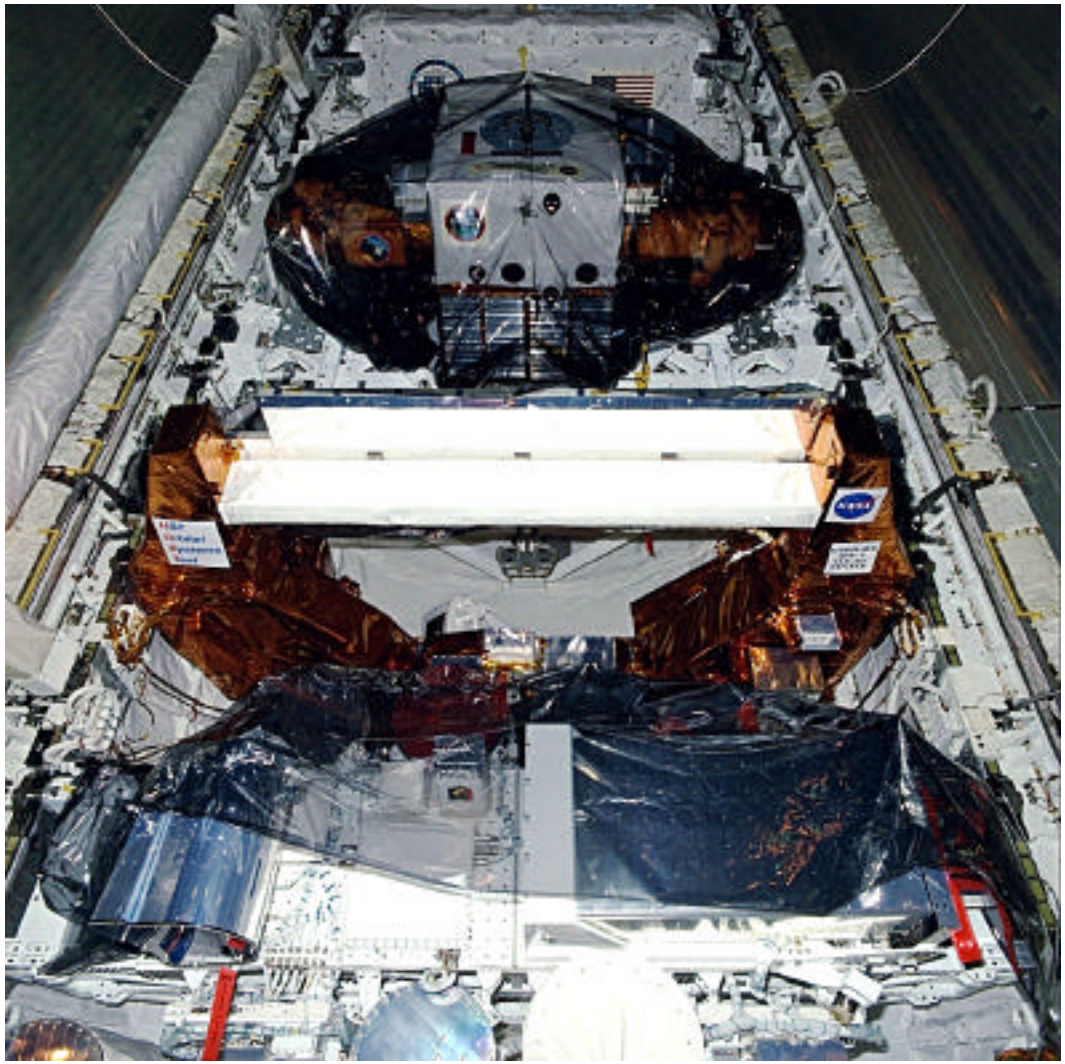
The HOST Hardware at GSFC



The STS-95 Orbiter Bay

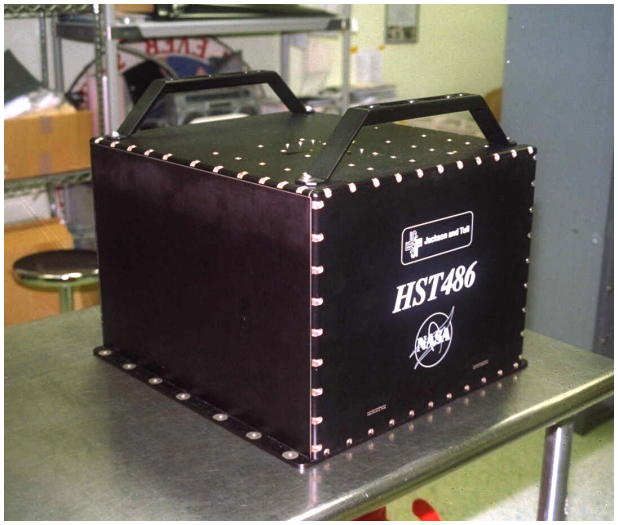


HOST in the Orbiter



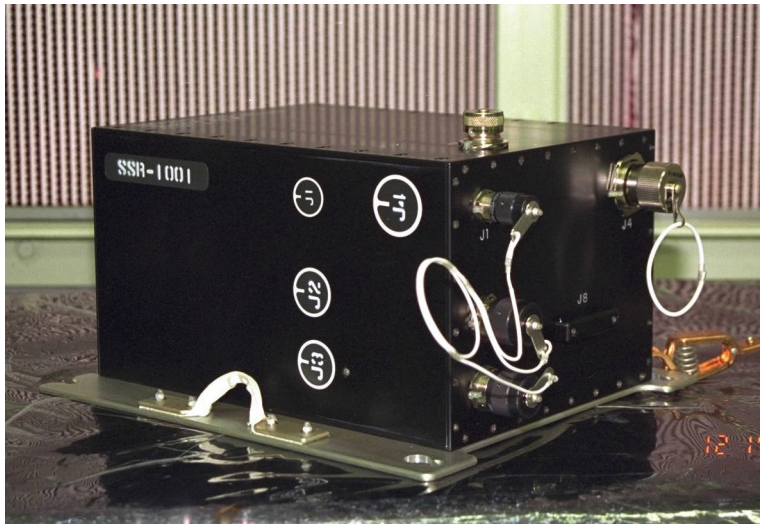
HST 486 Computer

- Advanced computer to replace aging DF-224 machine (a processor from the early 70's that is comparable in performance to modern calculators).
- This is "brain" of the HST.
- A 386 co-processor was installed during SM1 (December 1993) to supplement performance, improve reliability, increase memory, and to allow for software migration to a new computer architecture.
- This flight test will demonstrate correct operation of the new computer in an HST-like radiation environment.



Solid State Recorder

- Direct replacement for the mechanical tape recorders on HST.
- Dramatically increases data storage capability, making data management for the new HST instruments more tractable.
- Mechanical recorders are 1 Gbit, the SSR provides 11 Gbits.
- One SSR already installed on the HST during SM2 (February 1993).
- The unit in HST shows unexpected behavior from ionizing particles, but error checking and recovery maintains normal operation.



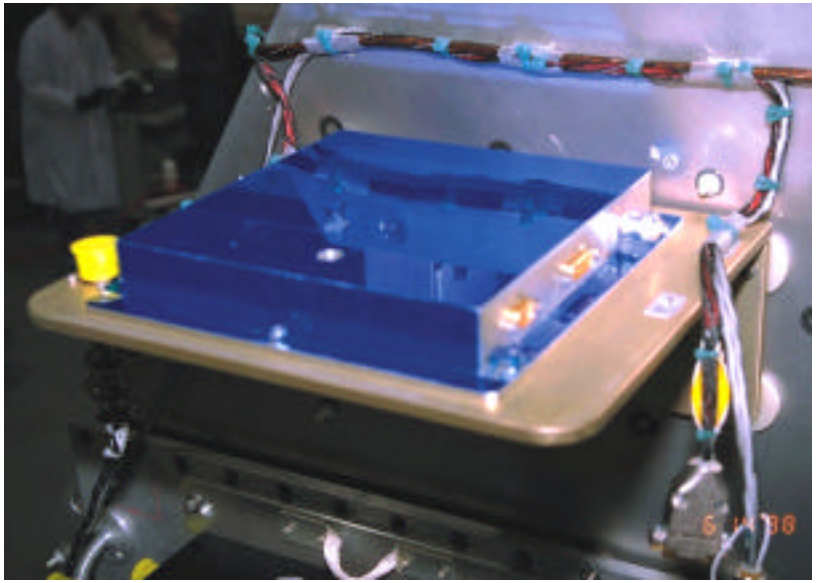
- The goal is to test this second unit in HOST to ensure that the observed behavior is generic (as expected), and that there are no hidden faults in the HST unit.

Fiber Optic Flight Experiment

- KSC/Orbiter experiment.
- Tests advanced data transfer technology for the Orbiter for potential upgrade.
- Increases data handling capacity and decreases weight for internal Orbiter communication.
- Simplifies interfaces to the payloads.
- Simplifies ground processing and testing.
- Data gathered on HOST will be compared in detail with data recorded by the FOFE experiment (after the mission) in order to detect any differences caused by the environment.

Pulse Height Analyzer

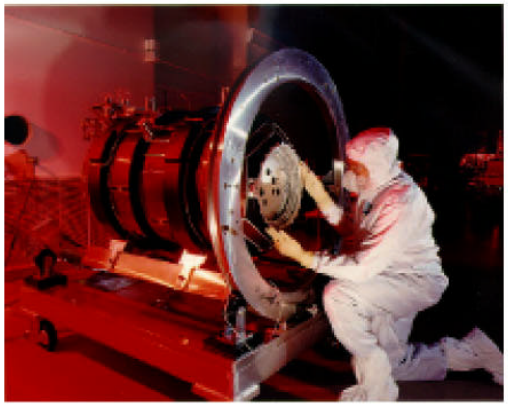
- Monitors the radiation environment to correlate with the other experiments and to verify models of the radiation environment.
- Provides a measurement of the number and energy of impinging ionizing particles every 32 seconds.
- Novel design – it is a small memory chip with electronics to determine when a “bit flip” occurs.



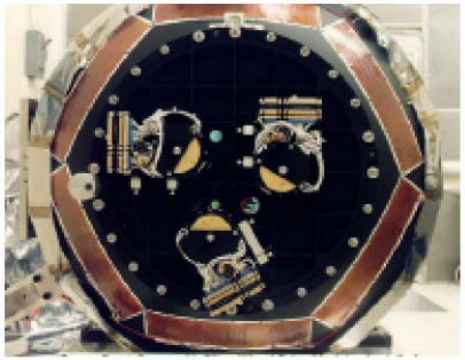
NICMOS Cooling System (NCS)

- Provides auxiliary cooling to the HST Near Infrared Camera and Multi-Object Spectrograph (NICMOS) instrument.
  - The NICMOS is cooled using a solid block of Nitrogen ice at a very cold temperature of 60 K (or -210 C).
  - Anticipated end of cryogen is December 1998.
- Intended to fly on HST SM3 (March 2000 flight readiness) if successful on HOST.
  - NICMOS Cryogenic Cooler (NCC) is the refrigerator.
  - Capillary Pumped Loop (CPL) removes heat from the NCC.
  - NCS Radiator radiates this heat into space.
- NCS deployment on HST is a best-effort new-technology demonstration (16 months from project start to HOST flight).
- If successful, there is the potential of dramatically increasing the infrared scientific return from the observatory.

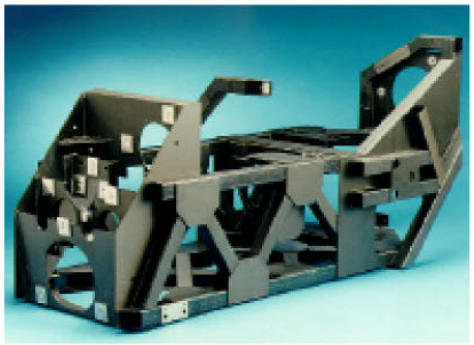
Cryostat In Assembly Fixture



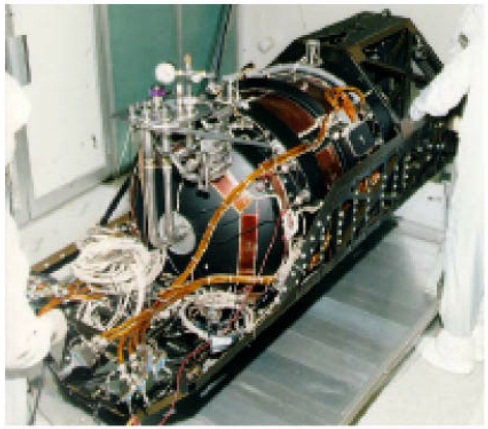
Cryostat Front View



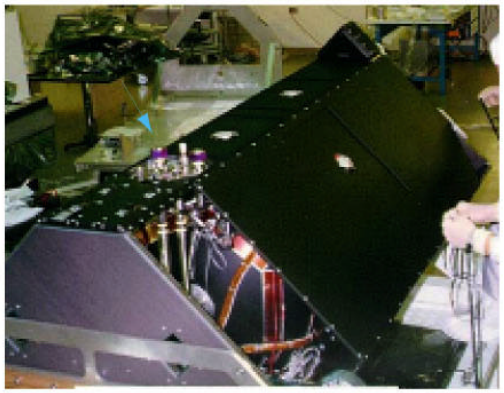
Cryostat Side View



Optical Bench

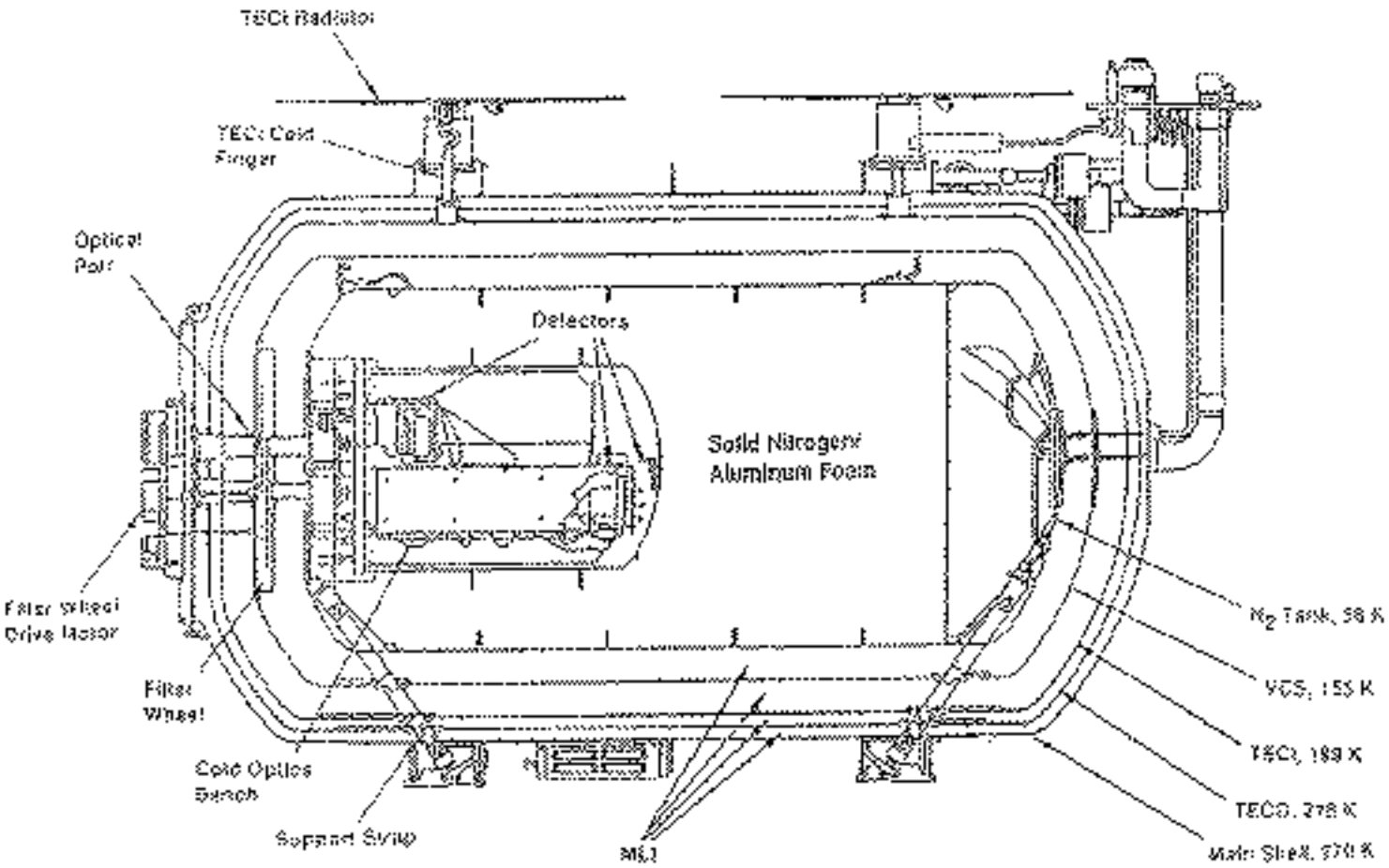


Rear View of Cryostat in the Optical Bench



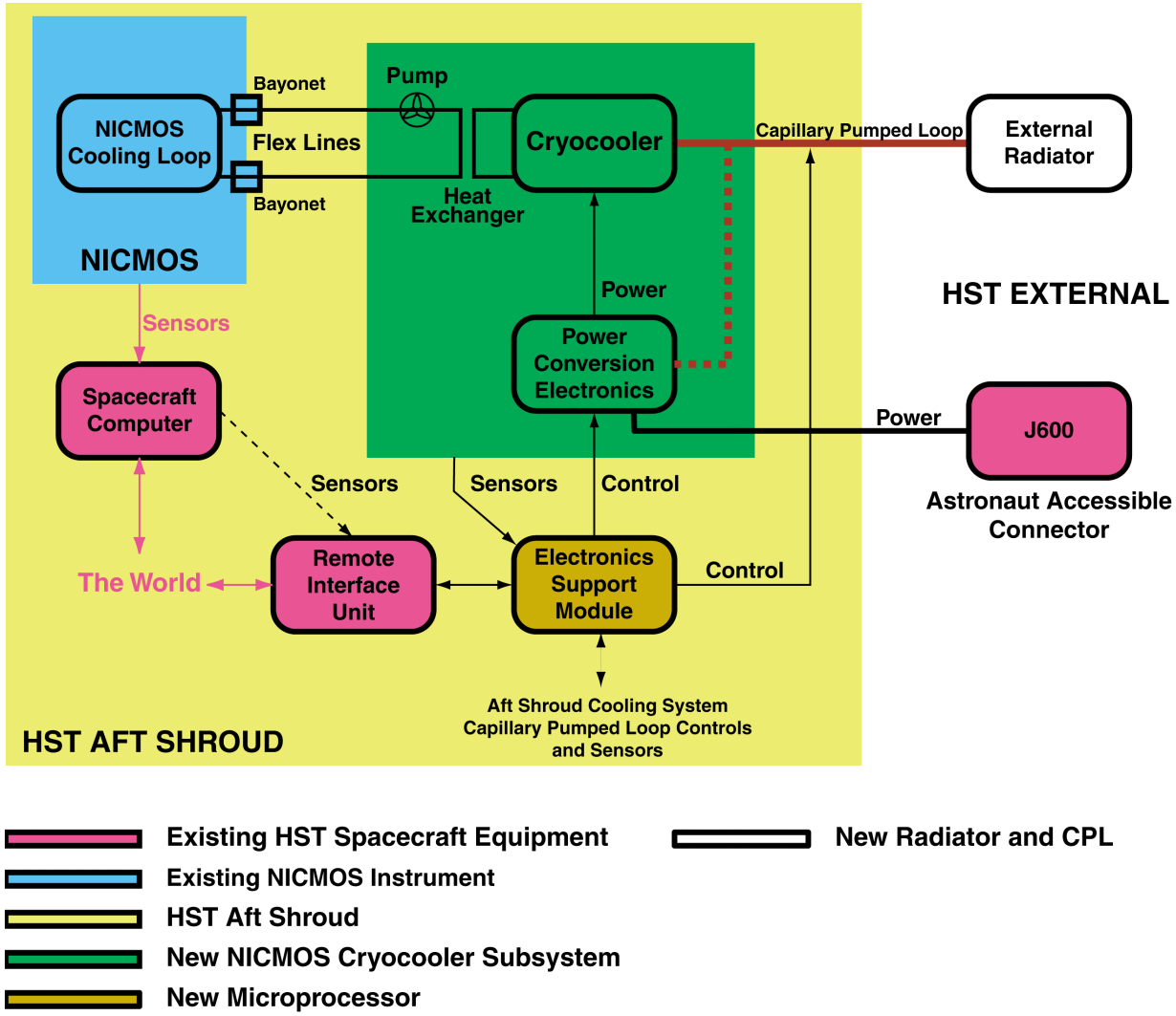
The Assembled Instrument (note Cryo Interface Panel)

The NICMOS Cryostat

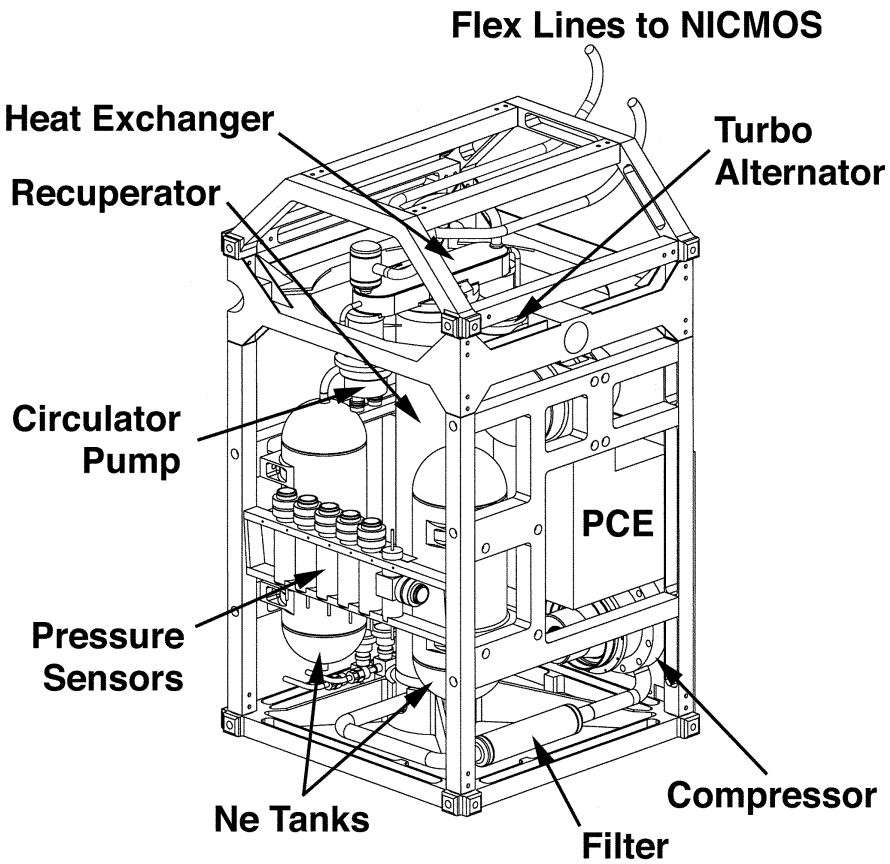


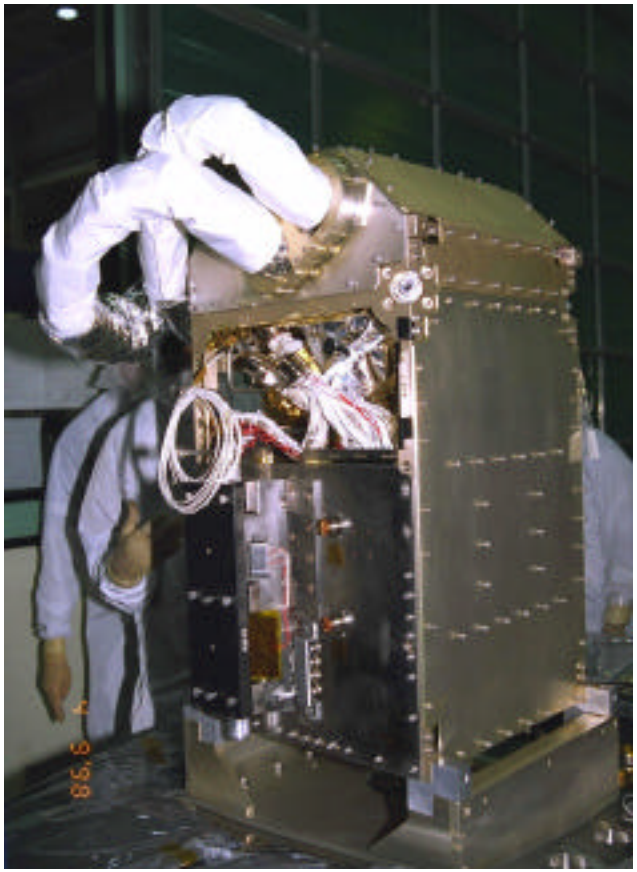
A Section Through the NICMOS Dewar's Main Shell and Nitrogen Tank

NCS Block Diagram

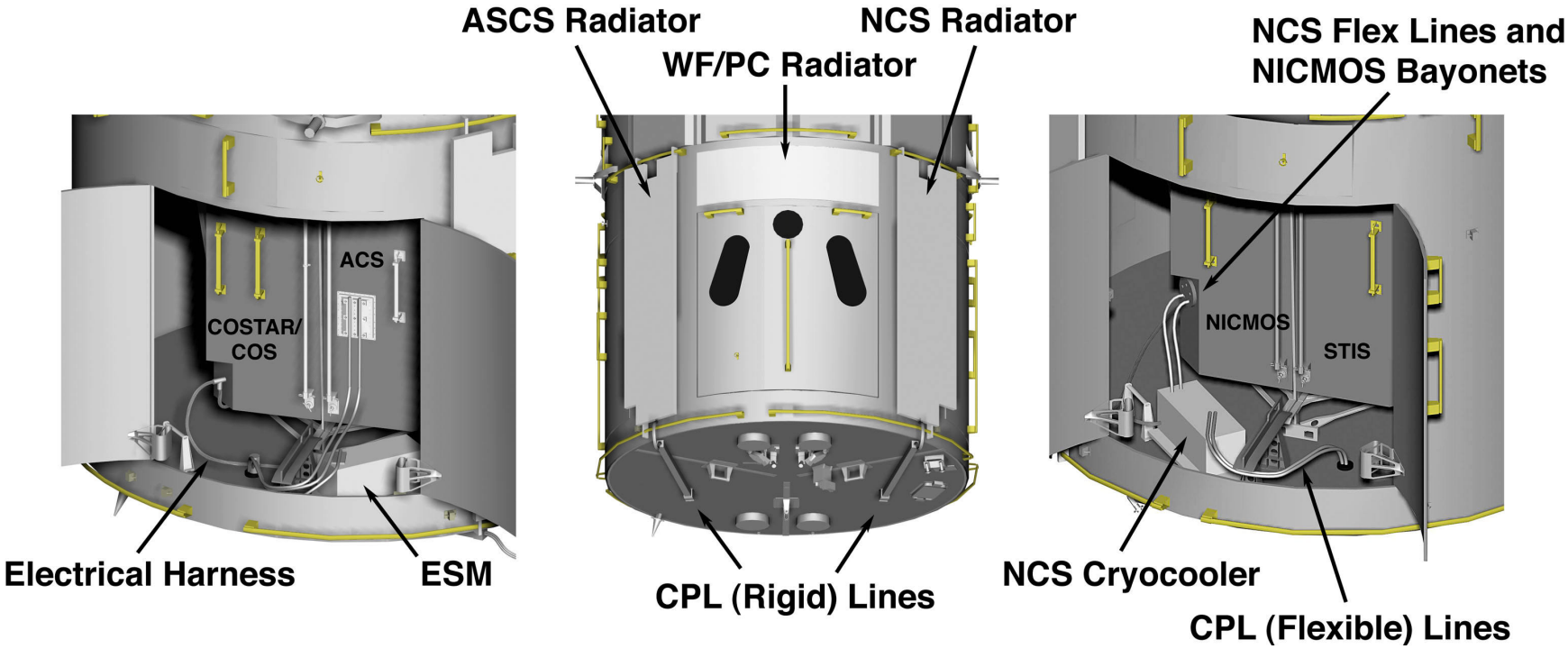


NCC Mechanical Layout

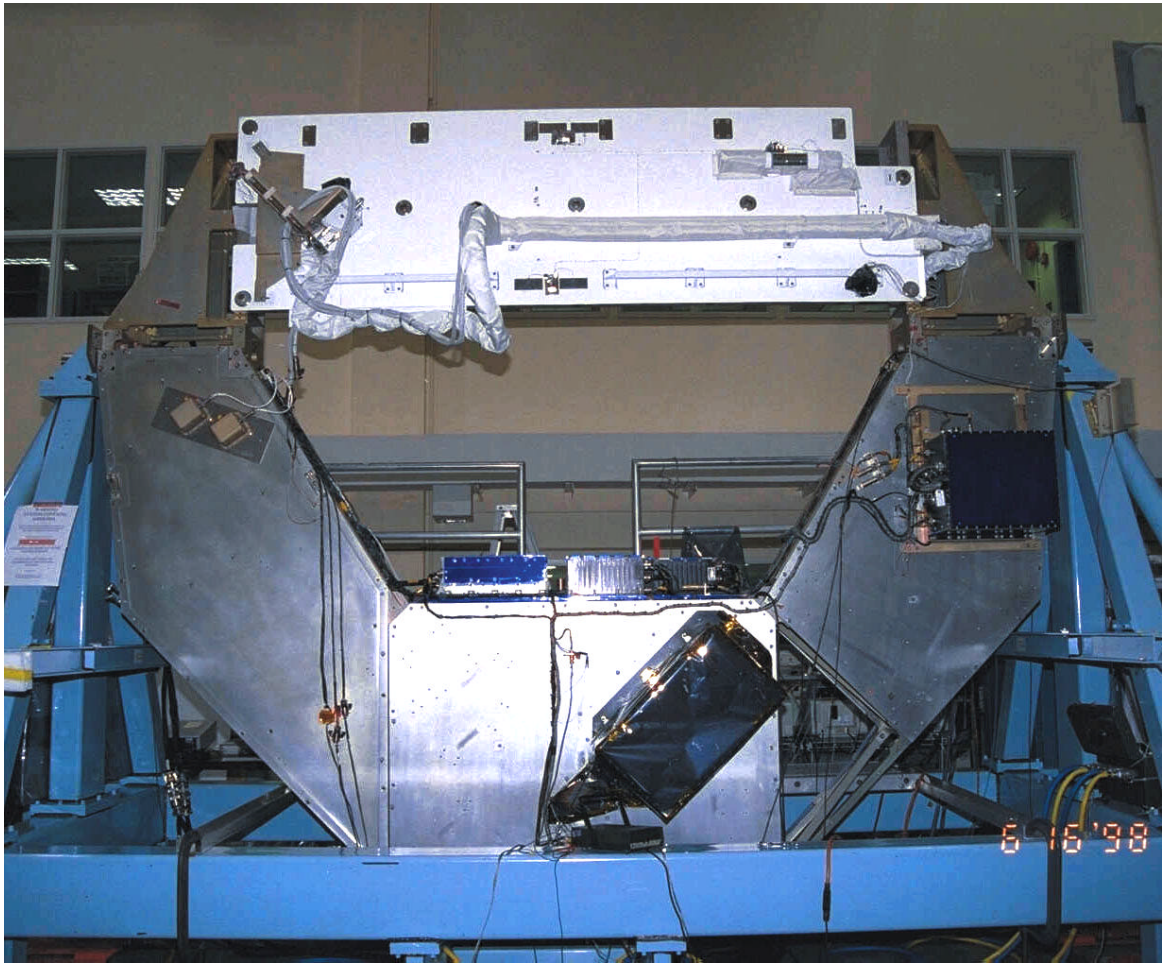




NCS Components in the HST

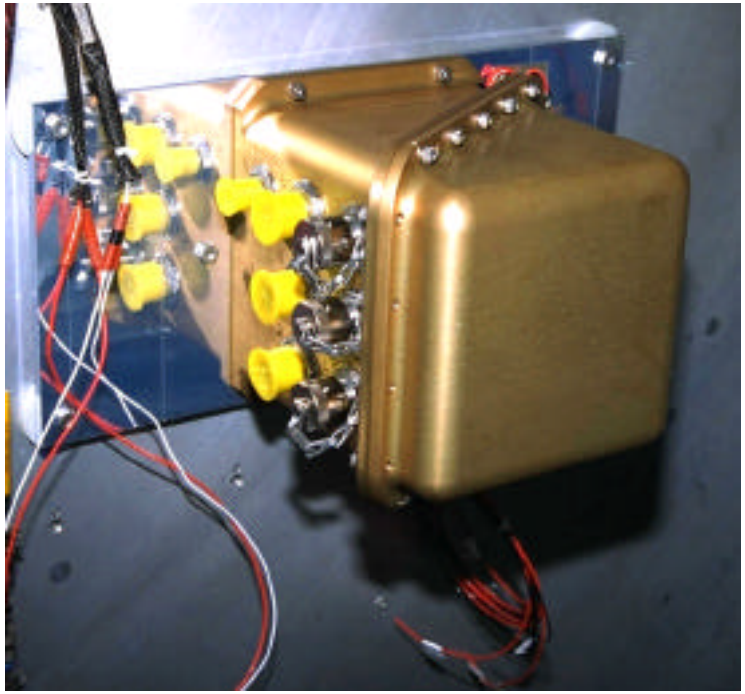


The NCS Radiator and CPL



SAMS-FF

- This is a standalone package for measuring minuscule accelerations in space environments.
- Data will be retrieved and analyzed after the mission and correlated with NCS operation.
- Commandable to record data during periods of vibration testing for the NCS, up to 120 minutes total for HOST.
- Sensitive to less than 1/10,000’th the acceleration of gravity at the surface of the Earth (60 micro-g RMS).



Infrared Science on HST

- The HST covers a wavelength range from 120 nm to 2500 nm.
- The range from 1000 nm to 2500 nm is exclusively covered by NICMOS.
- This long-wavelength light is important for two unique reasons.
  - As we look farther and farther away, the cosmological redshift makes the light emitted by distant objects appear as longer wavelength “redder” light.
  - Small particles in galaxies and in the intervening space scatter short wavelength light, but allow longer wavelength light to pass unimpeded. Infrared instruments can therefore peer deep into galactic centers and dusty regions of star formation.

Mission Updates and Further Information

- A HOST mission overview and daily updates during the mission are available on the Web through:

http://hstsci.gsfc.nasa.gov/host

- General HST information and HST data and images can be found at the Space Telescope Science Institute:

http://www.stsci.edu/