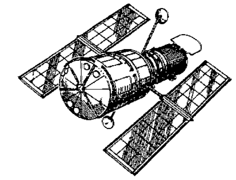


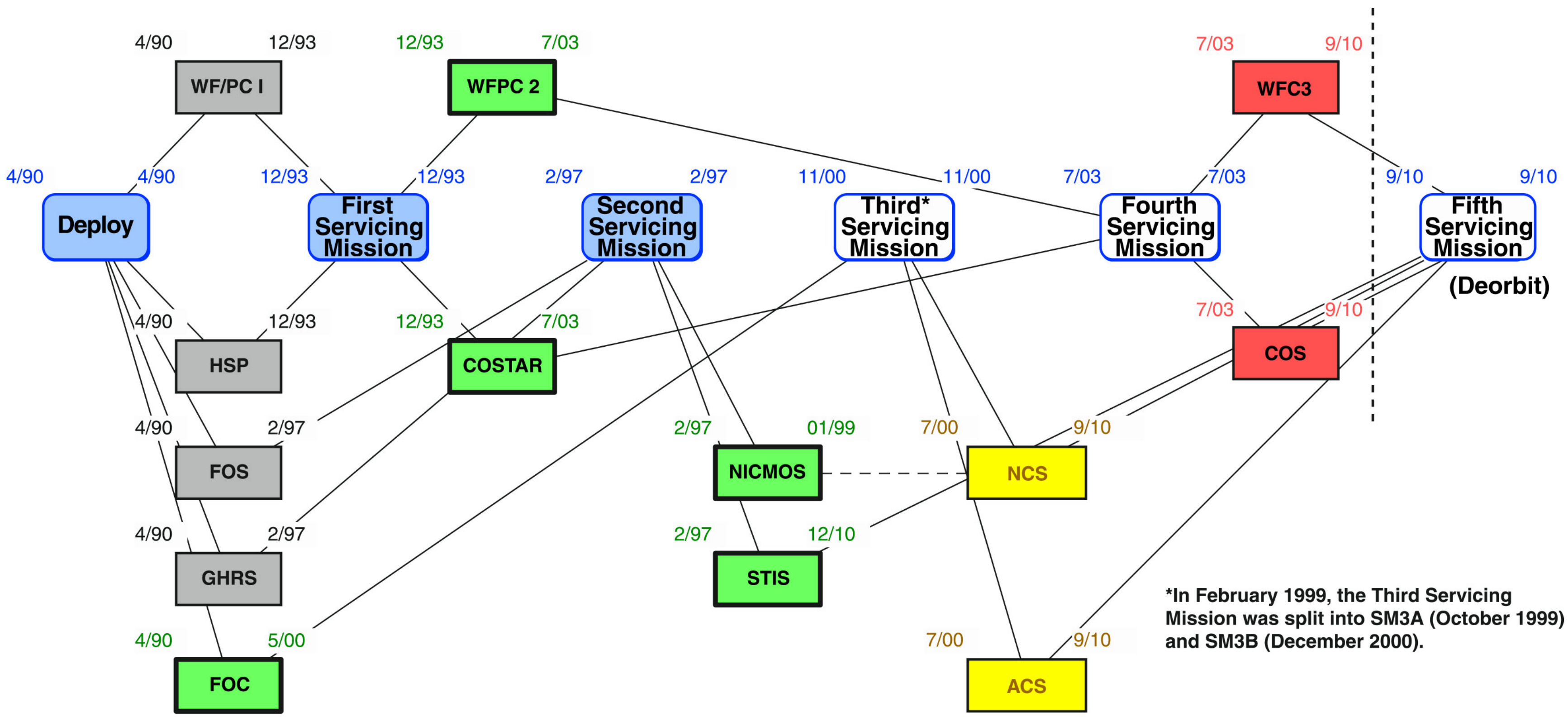
Science/Instrument Overview

Ed Cheng

Historical Context

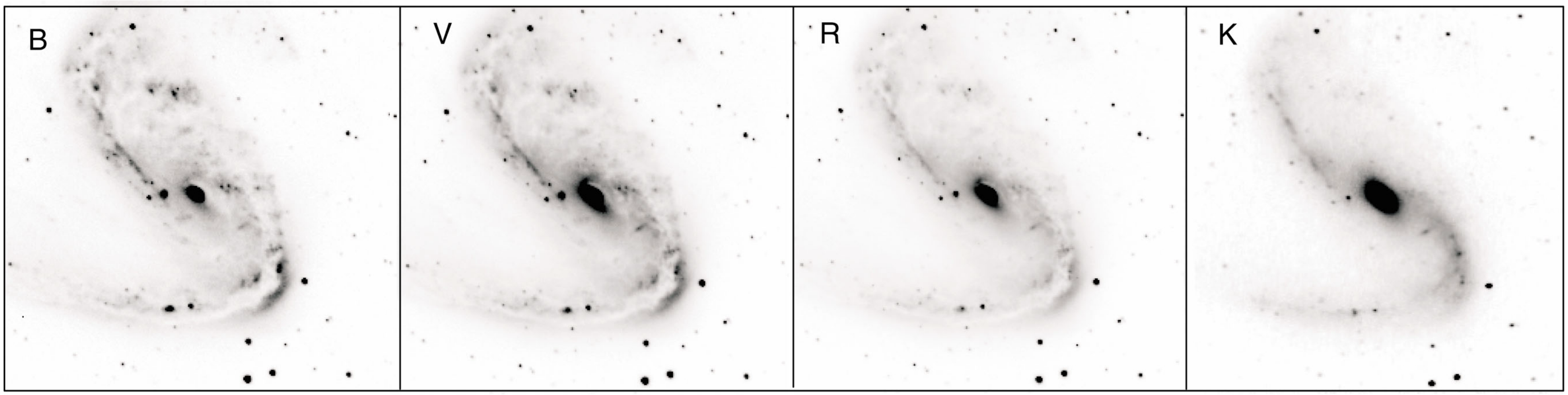
- As a result of the NASA/HQ decision to extend HST operations to 2010, the HST might have been left without a fully functional imaging camera in the last part of the mission.
  - The only planned camera at the time is the Advanced Camera for Surveys (ACS) that will be deployed in mid-2000.
  - Imaging is a critical scientific function of HST, and has high "visibility."
- WFC3 will help ensure an imaging capability through 2010.
- Using new technology charge-coupled device (CCD) detectors, the WFC3 will have wide field sensitivity to the near-UV (to 200 nm).
- WFC3 will be deployed during SM4 in mid-2003.
- This rationale drove the WFC3 "baseline" UV/visible (UVIS) design.
- Subsequent community input drove the requirements for a second, infrared (IR) channel, extending wavelength coverage to 1700 nm.

WFC3 Would Be The Last Camera on HST



*In February 1999, the Third Servicing Mission was split into SM3A (October 1999) and SM3B (December 2000).

WFC3 and Panchromatic Imaging

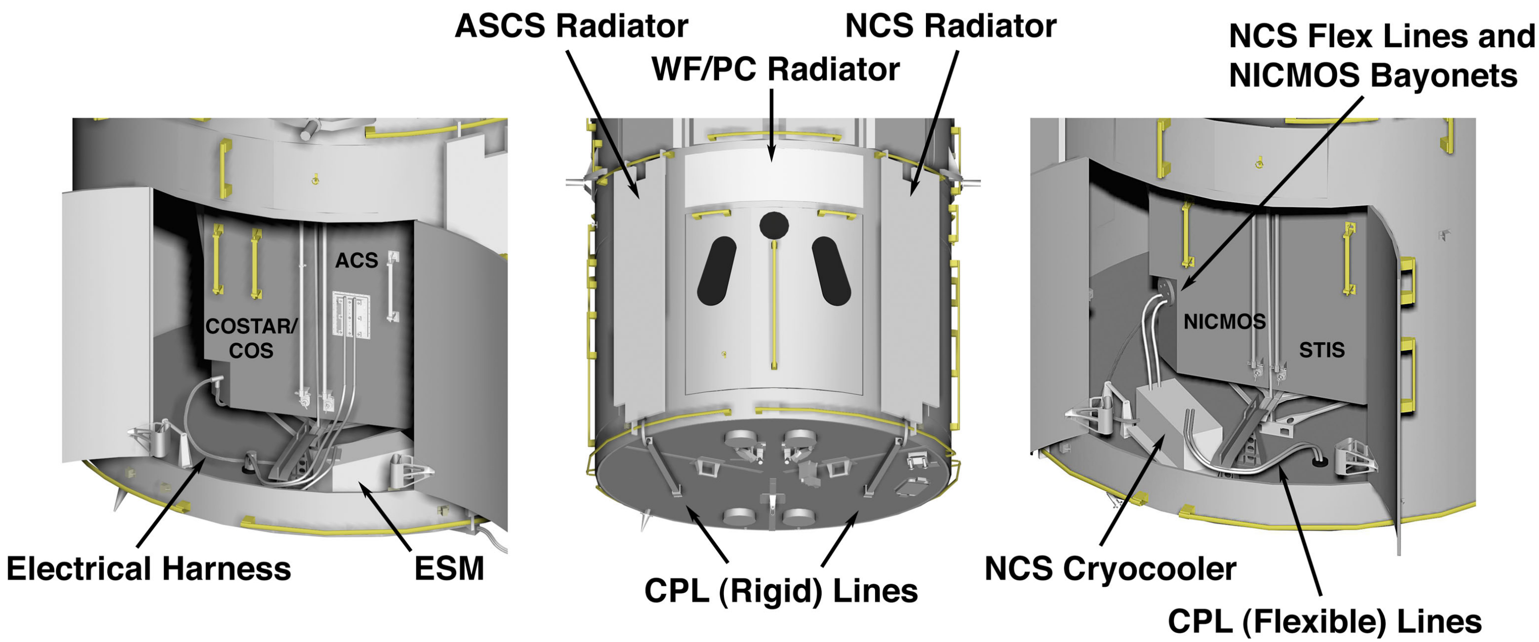


The WFC3 Concept

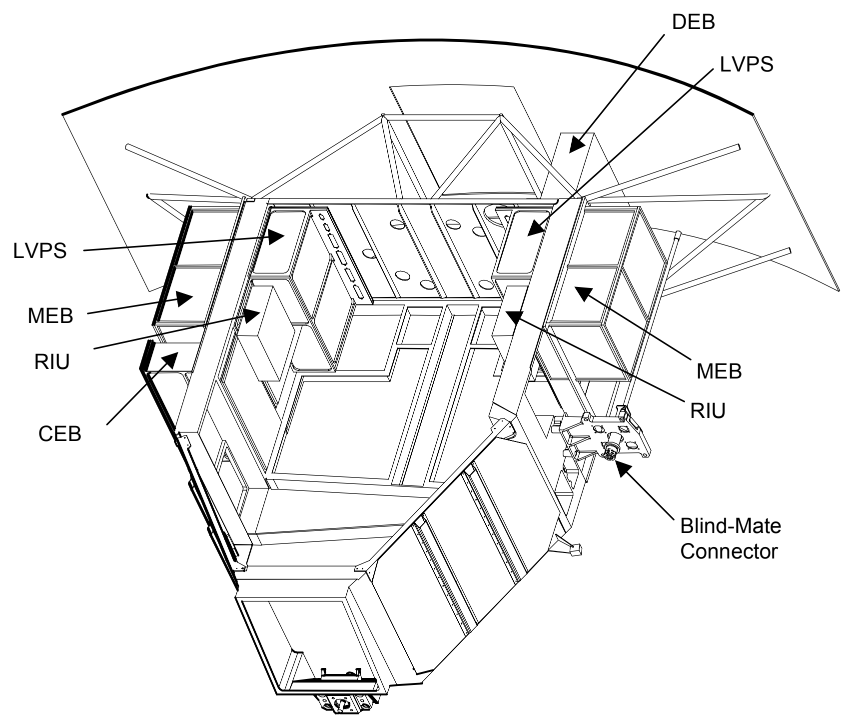
- Radial instrument.
  - Uses the center of the HST focal plane.
    - Wide-field and minimal distortion.
  - The external radiator optimally supports cold operation of detectors.
  - Reuse significant pieces of WF/PC (1) enclosure hardware.
- Supports two imaging channels.
  - The ultraviolet/visible (UVIS) channel supports imaging from 200 nm (near-UV) through 1000 nm (deep red) with a 160 x 160 arcsec FOV.
    - 2 x 2K x 4K CCD technology with high efficiency coatings.
  - The infrared channel (IR) supports imaging from 850 nm (red) through 1700 nm (near-IR) with a 120 x 120 arcsec FOV.
    - 1K x 1K Mercury-Cadmium-Telluride (HgCdTe) technology.

HST Spacecraft Layout

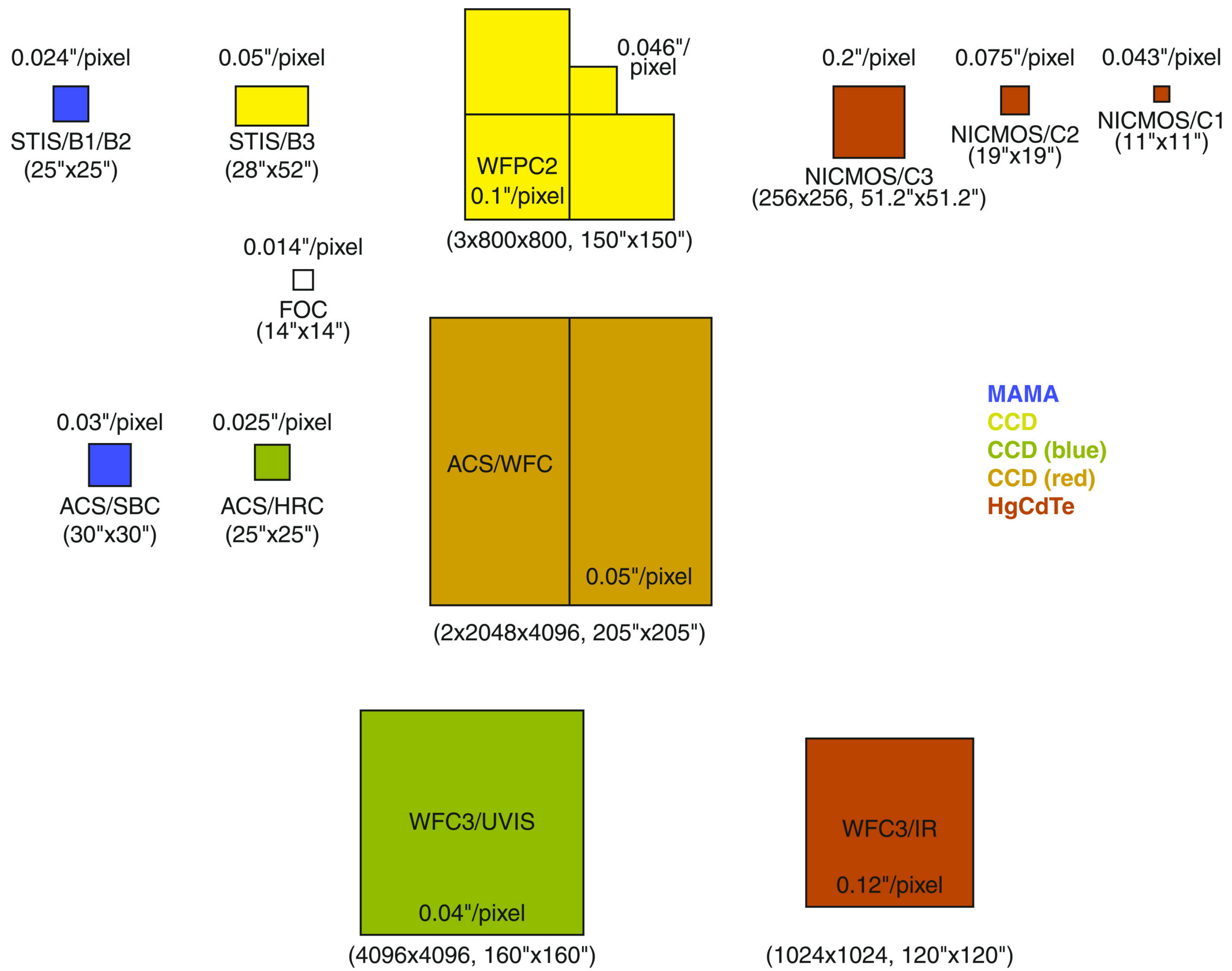
Scientific Instrument Locations in the HST



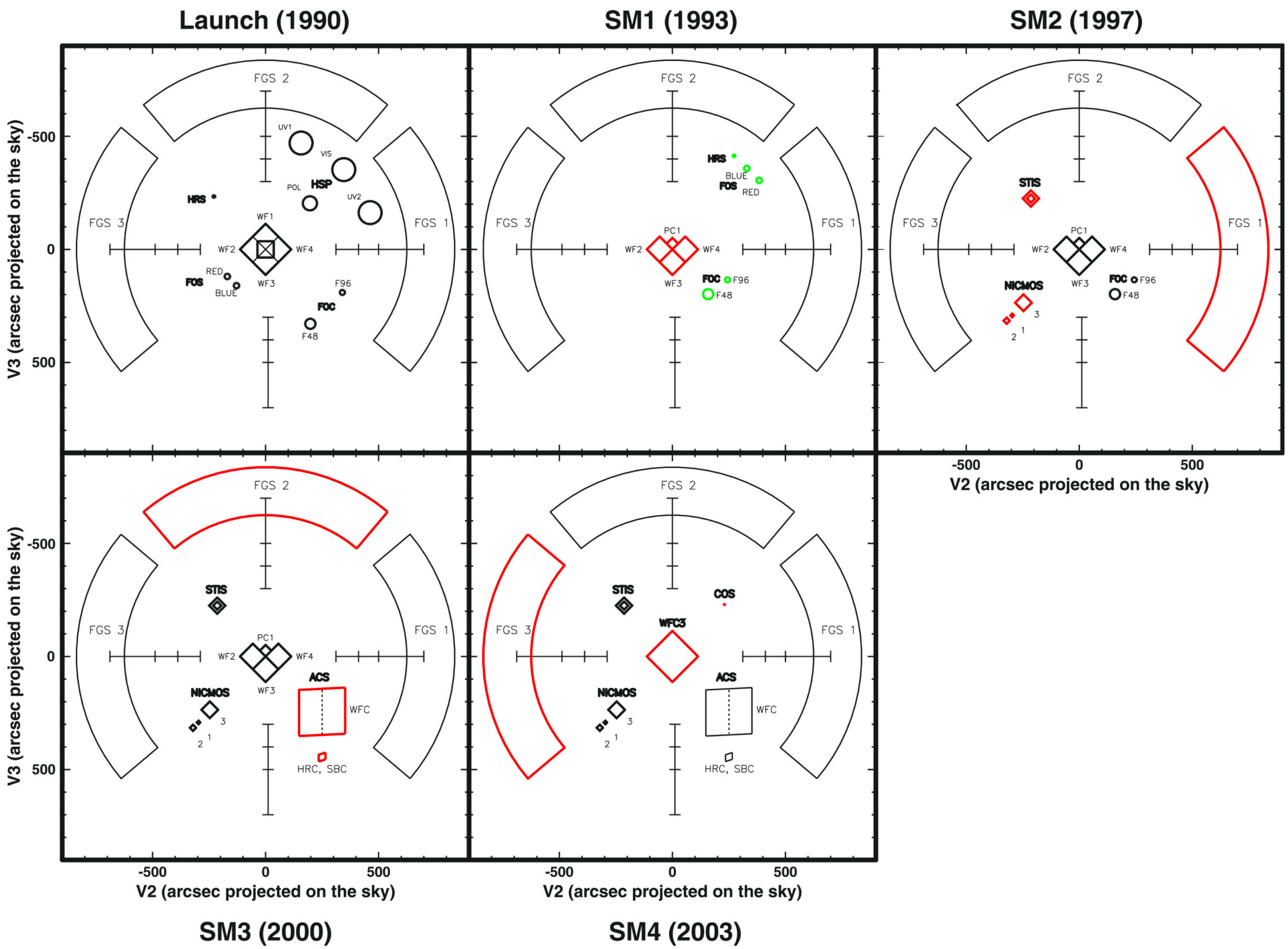
WFC3 Instrument Layout (preliminary)



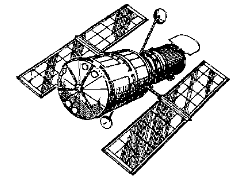
Comparison of HST Imaging FOV



History of the HST Focal Plane



WFC3 Scientific Implementation



- WFC3 is a “facility-class” instrument.
  - There are no guaranteed time observations (GTO) for the scientific staff. (Uses money for development that would otherwise support the staff during GTO activities.)
- Scientific leadership is provided by the Instrument Scientist.
  - Analogous to the Principal Investigator (PI).
- All scientific aspects of the instrument are the responsibility of the “Science IPT”.
  - Analogous to the Instrument Definition Team (IDT).
  - Detector characterization, calibration, Servicing Mission Orbital Verification (SMOV), Early Release Observations (ERO), etc.
  - GSFC, Space Telescope Science Institute (STScI), and JPL members.
- A Scientific Oversight Committee (SOC) represents the scientific community and advises the Project and STScI on the scientific priorities of the instrument.

WFC3 Low-Cost Development Philosophy

- **Hardware reuse.**
  - WFC3 will reuse as much of the WF/PC (1) hardware as possible.
    - WF/PC (1) was deployed with the HST in 1990, and was replaced by the WFPC2 during SM1 in 1993.
    - WFPC2 provided spherical aberration correction and improved detectors.
- **Design reuse.**
  - Where no flight-spare or returned hardware exists, reuse existing designs for WF/PC, STIS, NICMOS, or ACS as much as possible (build-to-print).
- **Experience reuse.**
  - WFC3 development team members are already expert on HST instruments.
- **Build-to-operate.**
  - A significant life-cycle cost of instruments is operations and science support of instrument modes.
  - WFC3 minimizes these modes, and reuses software and procedures from previous instruments with similar function.

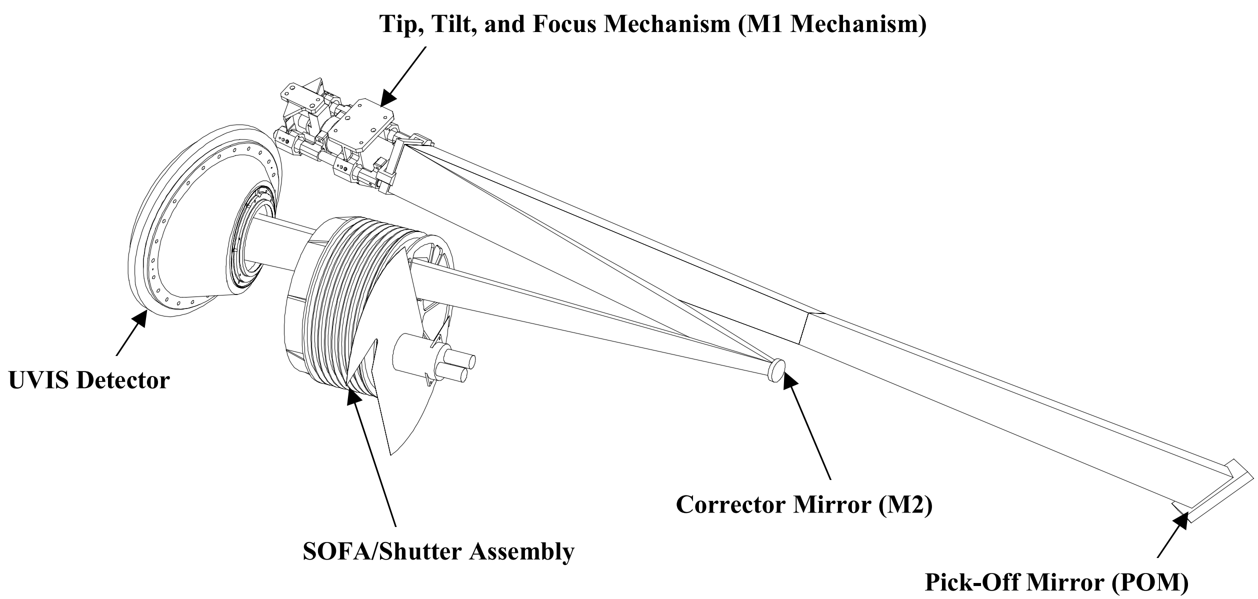
UVIS Channel Capabilities

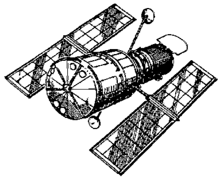
- Extends HST wide-field imaging to 200 nm.
  - Enables high-sensitivity surveys in this important wavelength range.
  - ACS wide-field channel (WFC) cuts off at 350 nm.
- Reinforces HST imaging capability.
  - Lower temperature CCDs improve radiation resistance for longer life.
  - Minichannel CCD design for low-light sensitivity in a radiation environment.
- Spectral filter suite will continue HST's productivity in emission line imaging.

UVIS Channel Characteristics

- 160 x 160 arcsec field-of-view (FOV).
- Simple optical system, yielding high throughput (3 reflections, compared to 5 for WFPC2).
- Mirror coatings optimized for near-UV response.
- 48 selectable filters.
- 2 x (2K x 4K) CCD detector.
  - Read noise < 4 electrons/readout (goal of 3 at 50 KHz).
  - Dark current < 20 electrons/pixel/hour at -83C.
  - UV-enhanced, backside-thinned.

UVIS Channel Optical Design (preliminary)

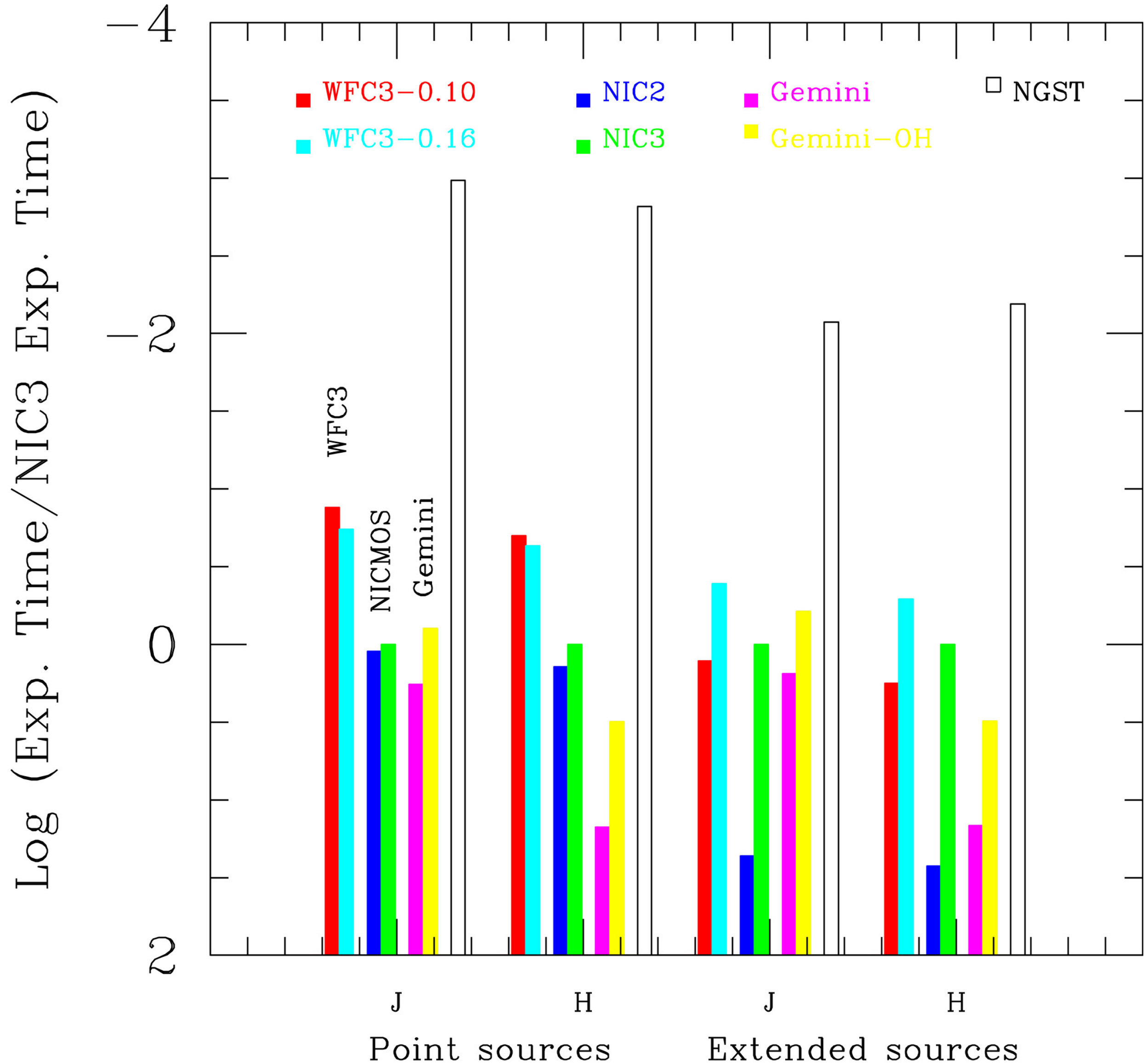




IR Channel Capabilities

- Vast improvement in HST near-IR discovery efficiency.
  - ACS discovery efficiency is a factor of 10 over WFPC2.
  - WFC3 IR channel discovery efficiency is a factor of 15 to 20 over NICMOS (depending on achieved QE).
- Excellent sensitivity compared with NICMOS.
  - Improved HgCdTe QE over previous generation devices.
  - Potential for IR channel sensitivity overlap with the CCD.
    - Previous generation cut on at 900 nm (extending to 2.5 um or 2500 nm).
    - Thinned CdZnTe technology can extend cut on wavelength into the visible.
    - Improved camera efficiency is possible from 700 nm to 900 nm because HgCdTe is more sensitive than CCDs in this wavelength range.

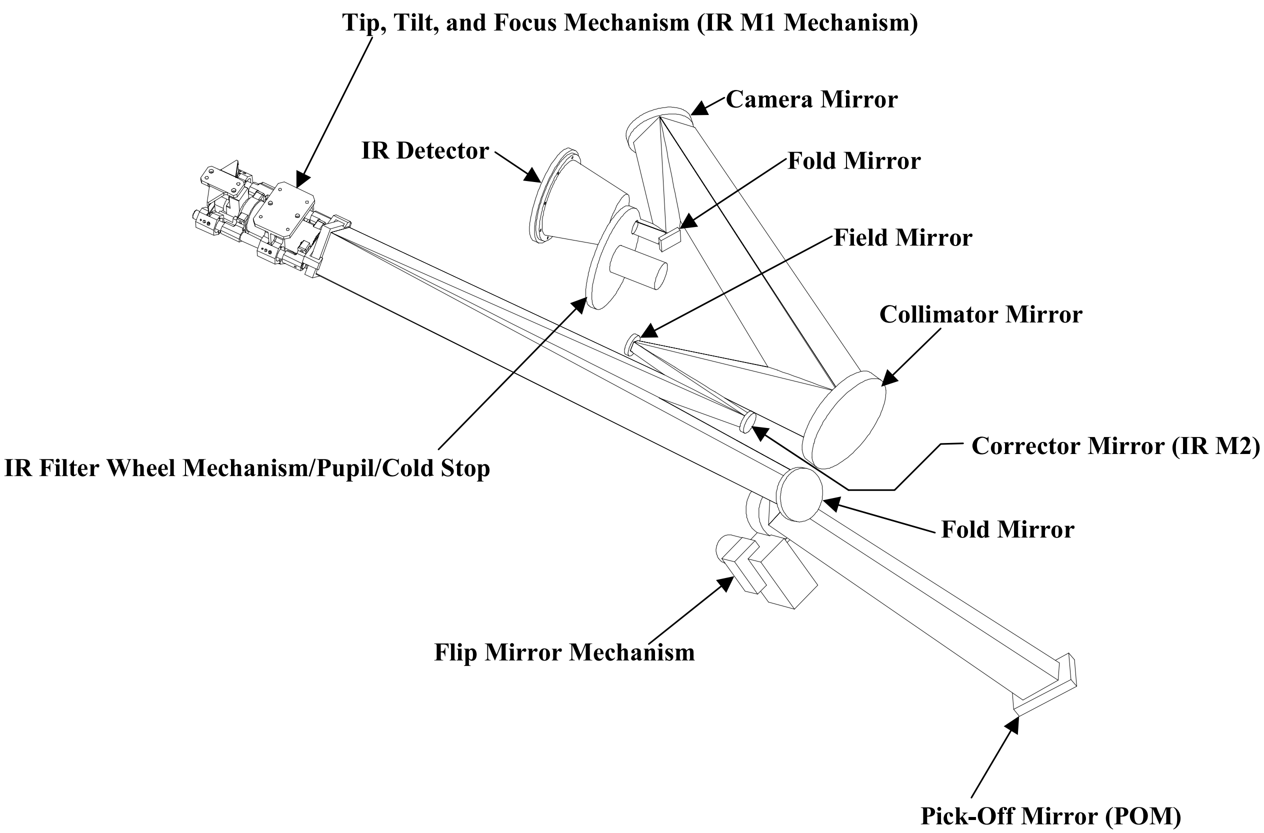
Sensitivity Comparison



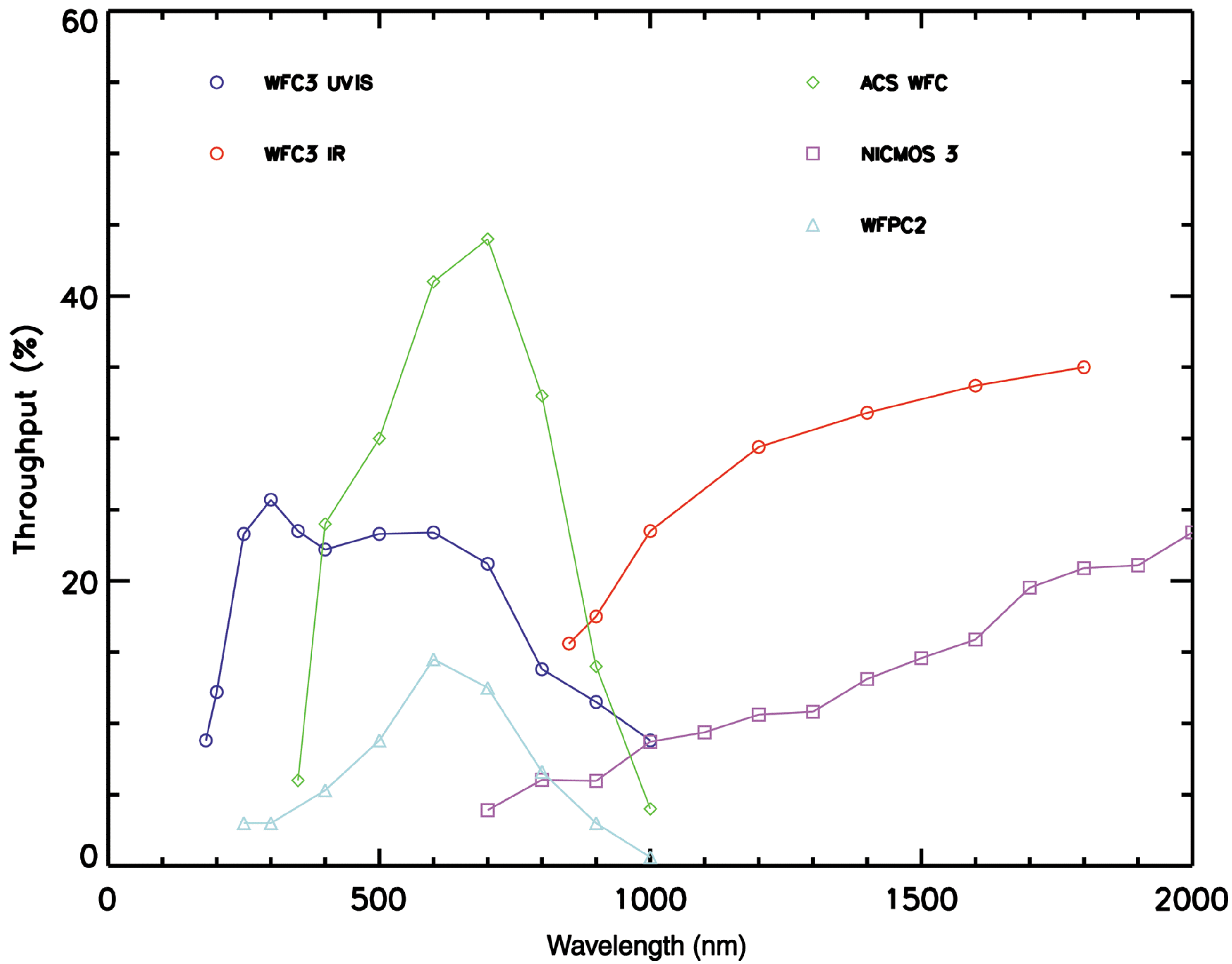
IR Channel Characteristics

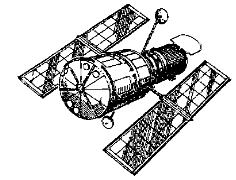
- 120 x 120 arcsec FOV, centered on UVIS channel FOV.
- Mirror coatings optimized for the IR.
- 15 selectable filters (goal of 20).
- 1024 x 1024 Mercury-Cadmium-Telluride (HgCdTe) detector.
  - 1.8 μm long-wavelength cutoff HgCdTe (1.7 μm useable).
  - Read noise < 15 electrons/readout (goal of 10) at 100 KHz.
  - Dark current < 0.4 electrons/second (goal of 0.1).
  - Thermoelectric cooling (no cryogens).

IR Channel Optical Design (preliminary)



WFC3 Instrument Throughput (preliminary)





Web Site

- Public information.
- Password-protected portion for WFC3 team use only.
  - Used to coordinate WFC3 Project activities.
  - Extensive document archive with search capability.

http://wfc3.gsfc.nasa.gov

Baseline CEIS for this SRR

- The baseline CEIS that all subsystems are reporting to includes:
  - A UVIS channel that maintains the maximum heritage with the ACS instrument subsystems.
  - An IR channel that maintains the maximum heritage with the NICMOS subsystems (with obvious modifications for a 1K x 1K format).
- This is the configuration that we have advertised to the scientific community as well as NASA HQs.
- Our on-orbit experience with previous instruments suggests a number of upgrades that are highly desirable but not included in the baseline CEIS.
- These upgrades will either improve scientific usefulness near EOL, allow the instrument to be more sensitive for low-background scenes, or improve science operations efficiency.

The Upgrades

	Description	CEIS Value	CCR Value	Potential Impacts
1	CCD operational temperature – minimize effects of radiation damage.	-83C	-100C	Power/thermal.
2	CCD anneal temperature – maximize repair of radiation damage.	-5C	+30C	New heater drive electronics.
3	CCD low-noise readout – increase sensitivity to low surface brightness objects.	4 e-	3 e-	Modification to front-end CCD electronics.
4	CCD sub-array readout – fast readout for bright objects.	1	2	Hardware exists – ops impact.
5	CCD on-chip binning – increase sensitivity to low surface brightness objects.	No	Yes	Hardware exists – ops impact.
6	CCD preflash - improve photometry at EOL.	No	Yes	Hardware impact for lamp and drive.
7	IR subarray readout – bright object handling.	No	Yes	Hardware exists – ops impact.
8	Optical bench temperature – reduce instrument self-emission to sky background levels.	+20C	0C	Power/thermal/weight/ NCS radiator.
9	Simultaneous operations – support serendipitous discoveries.	No	Yes	Ops/flight software/power.
10	Dithering mechanism for IR channel – enables support for parallel observations.	No	Yes	Additional mechanism.

Closure Plan for the Upgrades

- We will conduct cost-capped studies to determine which of these upgrades will fit within:
  - Instrument life-cycle cost.
  - HST observatory resources.
- These results will be weighed against the quantifiable scientific return from each upgrade.
- All upgrades will be decided upon by December 1, 1999, at which time the implemented upgrades will be executed via a CCR.
- Instrument design will proceed in such a way so that we do not preclude any of the upgrades, if at all possible.