

Briefing to STUC

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Topics

- SM4 Manifest and Priorities
- COS Gratings
- WFC3 Status
- SM4 Early Release Observations

Establishing SM4 Content and Priorities

- **Mission content and priorities recommended by HST Project were developed in collaboration with Space Telescope Science Institute (STScI) and Space Shuttle Program (SSP)**
 - Relative priorities of WFC3, COS, ACS Repair, and STIS Repair reviewed and approved by Space Telescope Users Committee (STUC) after broad consultation with science community
 - Recommendations were based on the desire to maximize scientific productivity over the remaining five years of the Hubble mission and to limit spacecraft maintenance only to what is necessary to insure five additional years of operation
- **Recommendations presented to Alan Stern and SMD Program Management Council on July 12**
- **Letter of direction from AA/SMD received on August 6**
- **Follow-up discussions initiated by Jon Morse to emphasize that factors in addition to SMD priorities should determine SM4 timeline, e.g. crew training, timeline efficiency. “You have the flexibility to do the right thing.”**



SM4 Manifest and Priorities Recommended by HST Program to SMD

1. RSUs
2. WFC3
3. COS
4. Battery Modules
5. ACS Repair
5. STIS Repair
7. NOBL 8
8. FGS2
9. NOBL 5
10. NOBL 7

Notes: 1. Relative prioritization of ACS and STIS repair is deferred pending further demonstration of ACS repair feasibility
2. SCM and Reboost are parallel activities that do not contend with other EVA tasks and, therefore, do not affect priorities



SM4 Mission Manifest and Priorities Per Direction From Associate Administrator for SMD

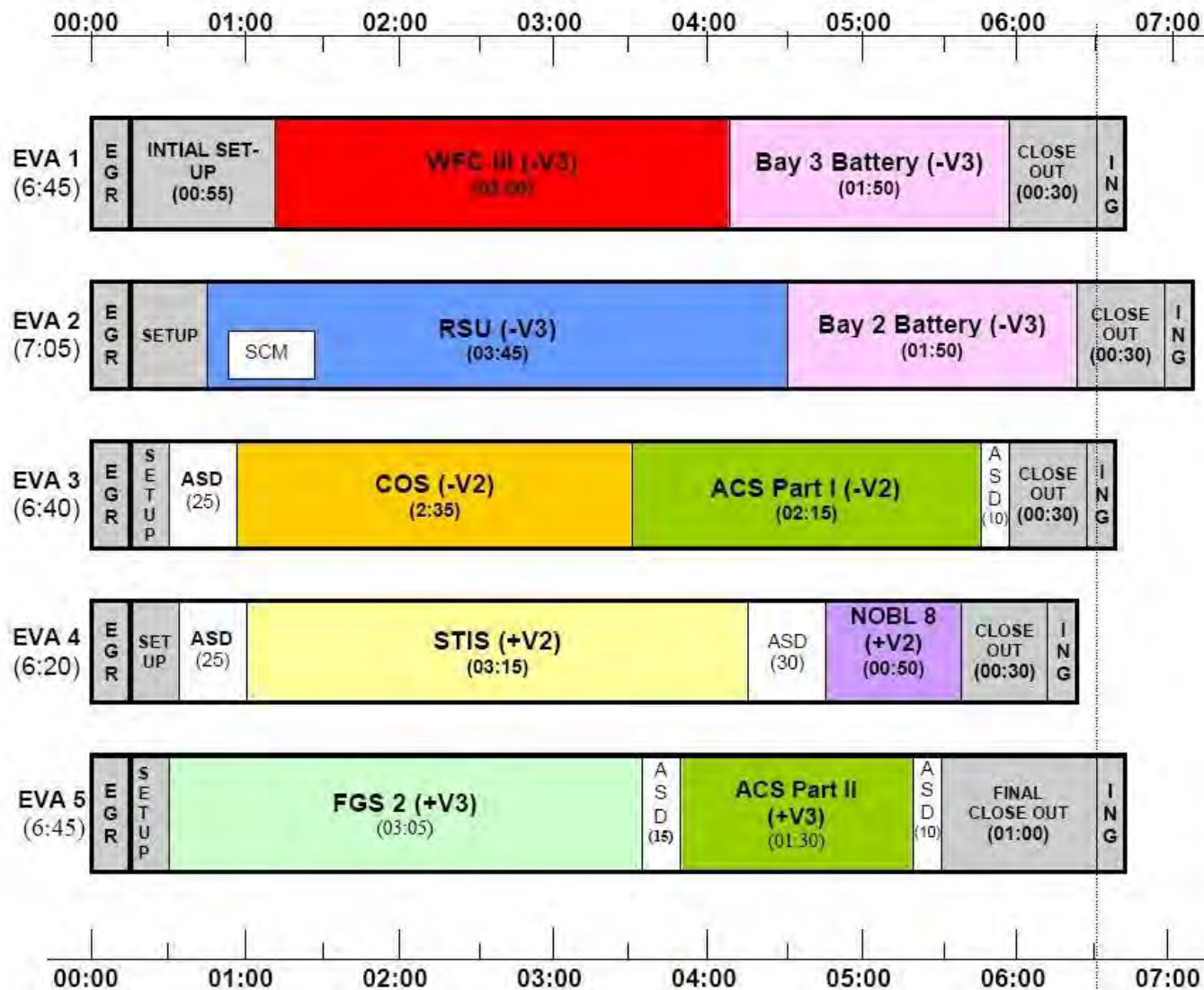
Core Priorities:

1. RSUs (Gyros)
2. WFC3
3. COS
4. Battery Modules
5. FGS2RR

Supplemental Priorities

6. STIS Repair
7. ACS Repair
8. NOBL 8
9. NOBL 5
10. NOBL 7

HST SM4 EVA Timelines - w/ ACS Breakout #2



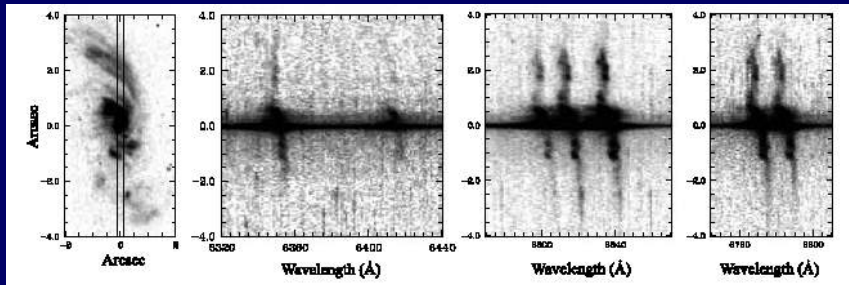
Note: Total ACS task time is 3 hours. If placed on one day with COS, EVA duration is 7:25. By splitting into two days, setup and cleanup need to be performed twice. At the end of ACS Part I, two cards have been removed.

MISSION GOAL: Five working, complementary instruments for the first time since 1993; Hubble at its APEX.

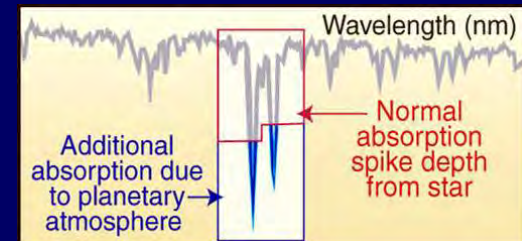
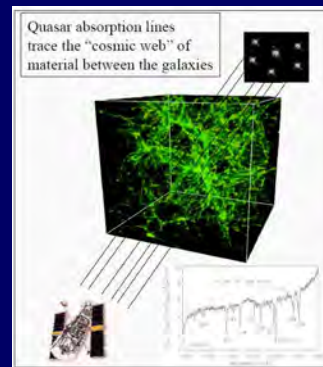
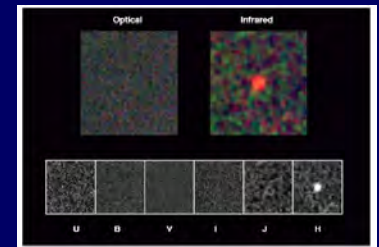
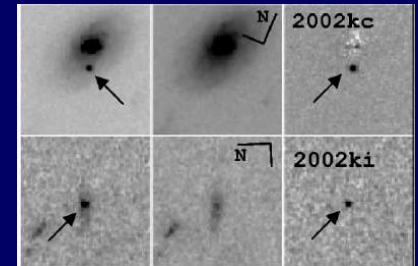
Batteries+Gyros+FGS = Sustained HST Lifetime



COS+STIS = Full set of tools for astrophysics

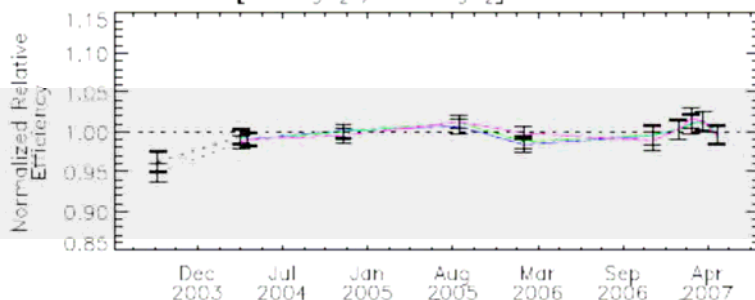


WFC3+ACS = Most powerful imaging ever

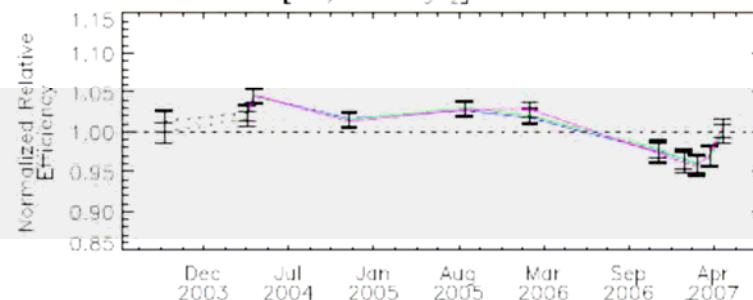


Variation Of COS NUV Bare Aluminum Grating Efficiency With Time

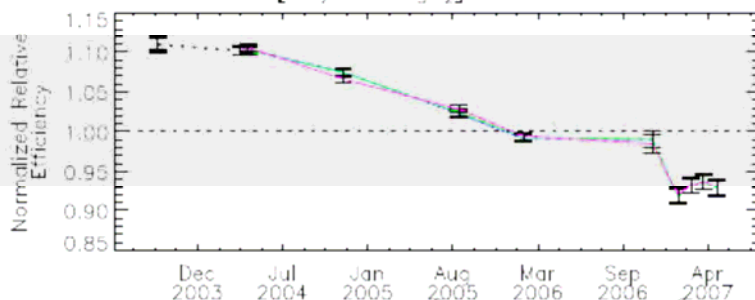
2003 2004 2005 2005 2006 2006 2007
 E5 = G185M (2010Å) / G230L (3360Å)
 [Al+MgF₂ / Al+MgF₂] @ 2130Å



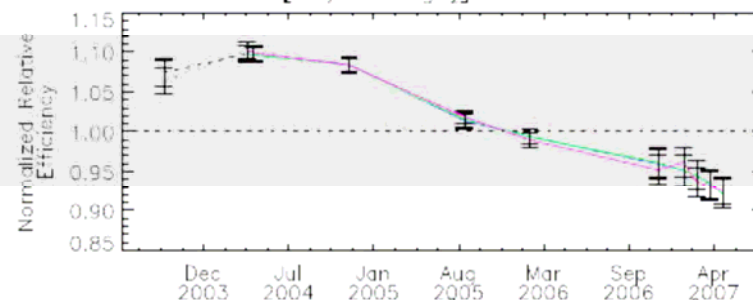
2003 2004 2005 2005 2006 2006 2007
 E6 = G225M (2217Å) / G230L (3360Å)
 [Al / Al+MgF₂] @ 2130Å



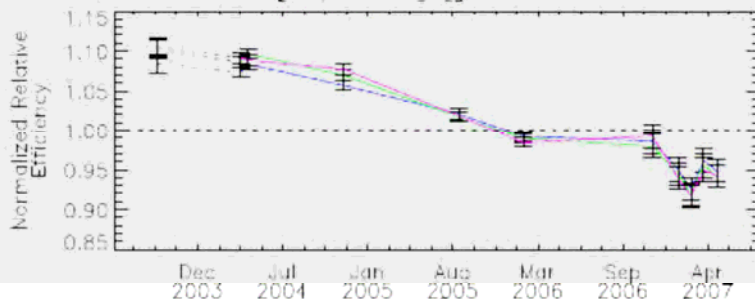
2003 2004 2005 2005 2006 2006 2007
 E7 = G285M (2617Å) / G230L (2635Å)
 [Al / Al+MgF₂] @ 2490Å



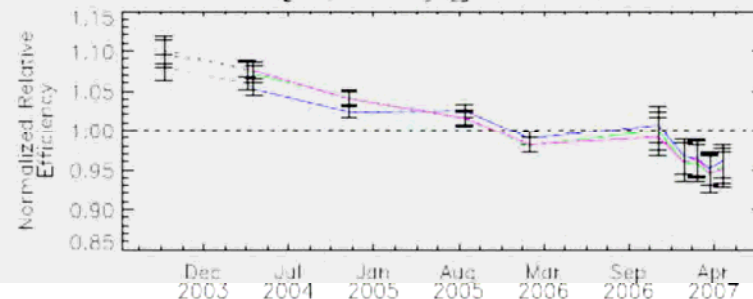
2003 2004 2005 2005 2006 2006 2007
 E8 = G285M (2637Å) / G230L (2635Å)
 [Al / Al+MgF₂] @ 2510Å



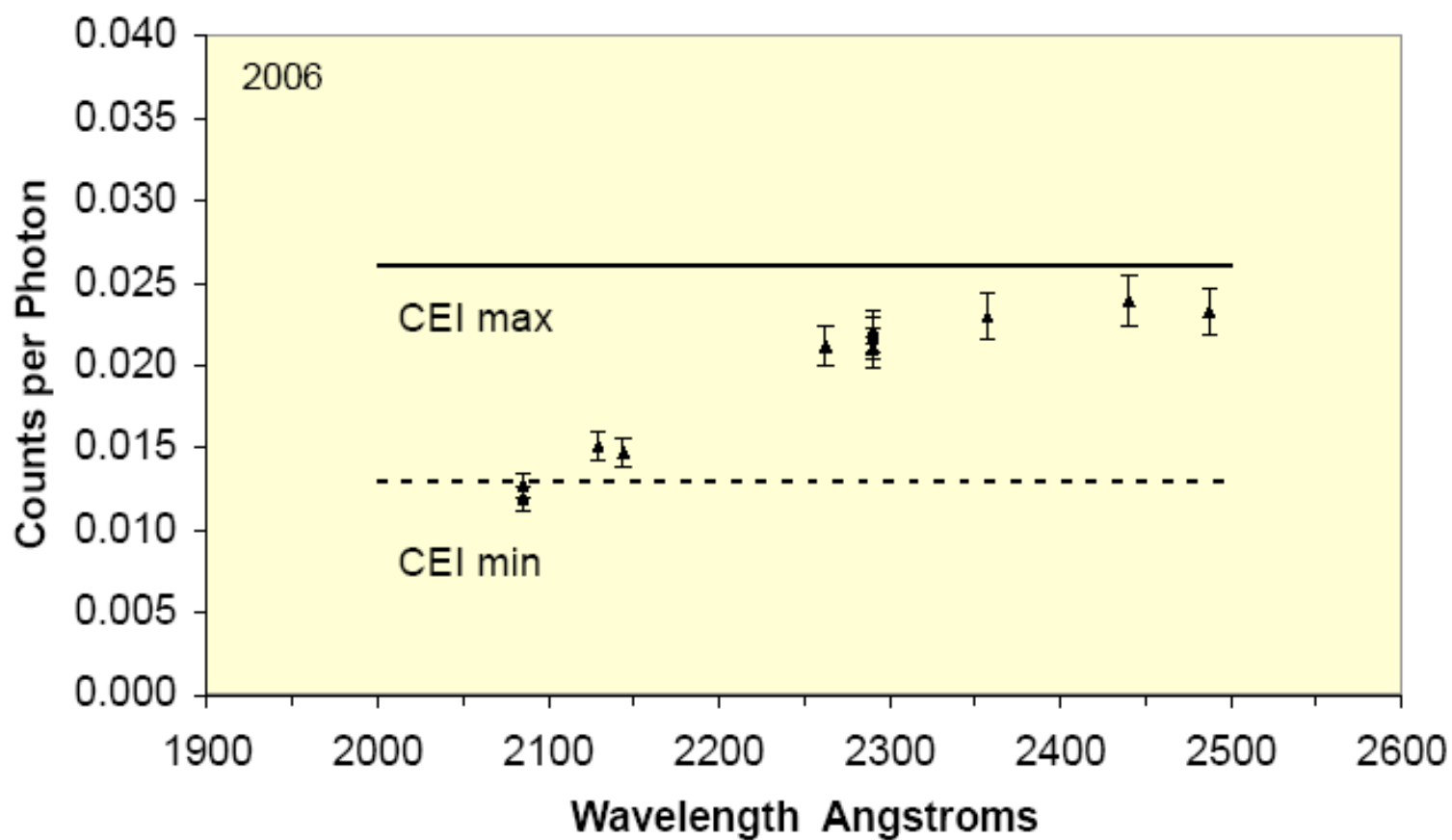
2003 2004 2005 2005 2006 2006 2007
 E9 = G285M (2617Å) / G230L (2635Å)
 [Al / Al+MgF₂] @ 2620Å



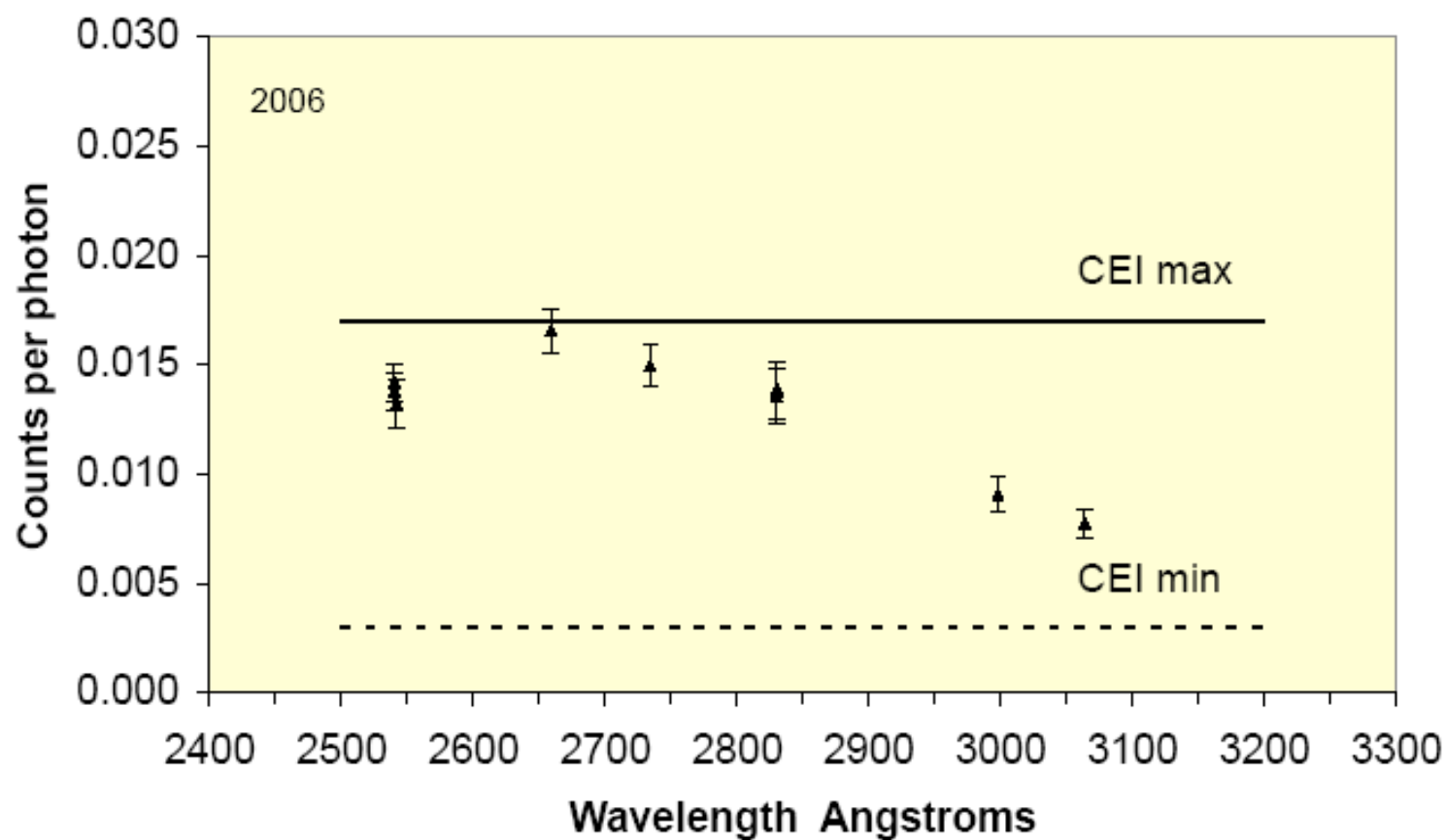
2003 2004 2005 2005 2006 2006 2007
 E10 = G285M (2637Å) / G230L (2635Å)
 [Al / Al+MgF₂] @ 2750Å



COS G225M Measured Throughput



COS G285M Measured Throughput



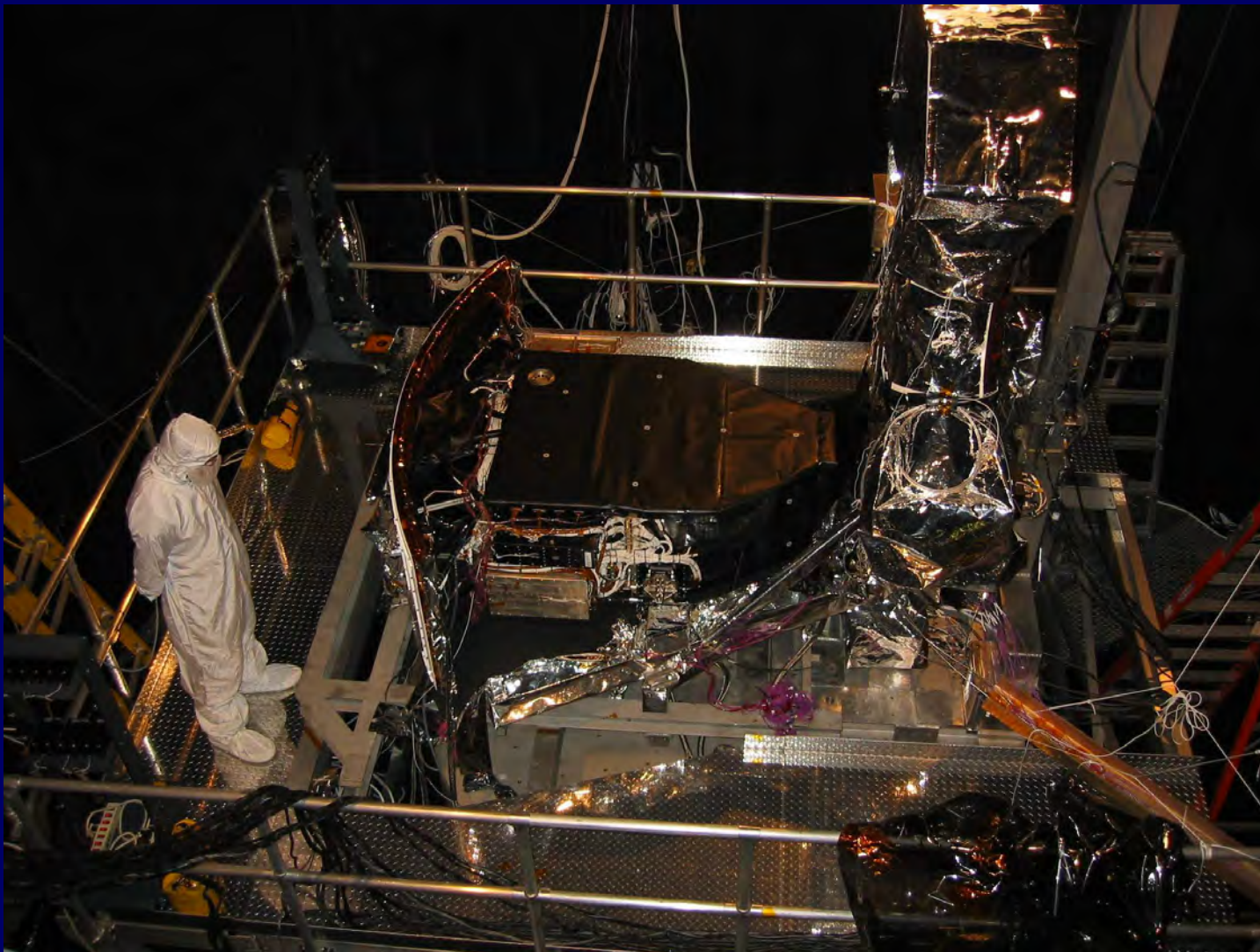
G225M and G285M NUV gratings: possible sources of sensitivity loss

- **Polarization differences in 2003 and 2006 TV**
 - Explains 2003/2006 thermal vac differences for all modes except G225M and G285M
 - Flight spare gratings show similar degradation; measurements of spares done with polarization carefully controlled
- **Contamination**
 - Ruled out due to fact that other channels (particularly FUV seem unaffected)
- **Oxide growth on bare Al and loss of reflectivity**
 - Ruled out due to non-degradation of witness samples
- **Migration of substrate layers (especially Au) into surface Al layer**
 - Ruled out by non-detection of Au (the base metal) in X-ray photoelectron spectroscopy (XPS) after Ar-ion etching through overlying oxide layer
- **Polymerized hydrocarbons on NUV gratings degrading performance**
 - Intentional exposure to hydrocarbons and UV radiation on spare gratings showed no significant performance changes
- **Calibration lamp temporal degradation**
 - not consistent with multi-yr test data with parallel lamps
- **Oxide growth on bare Al and loss of groove efficiency**
 - Current best theory – models of thick oxides layers can match results. Currently trying to measure oxide layer depth
 - Atomic Force Microscopy (AFM) surface profiles of spare grating showed no pinholes, existence of which would have provided natural mechanism for long-term oxide layer growth
 - chemisorption of oxygen in extremely low relative humidity environment is a possibility for slow, long-term oxide growth—water molecules in higher humidity environment can serve to fill “surface sites”, preventing/greatly-slowng oxide growth.

Rx: don't jeopardize COS by attempting grating c/o. Live w/ small add'l loss before SM4 and expect degradation to cease after reaching orbit.



T/V Configuration



WFC3 T/V configuration (without T/V shroud)



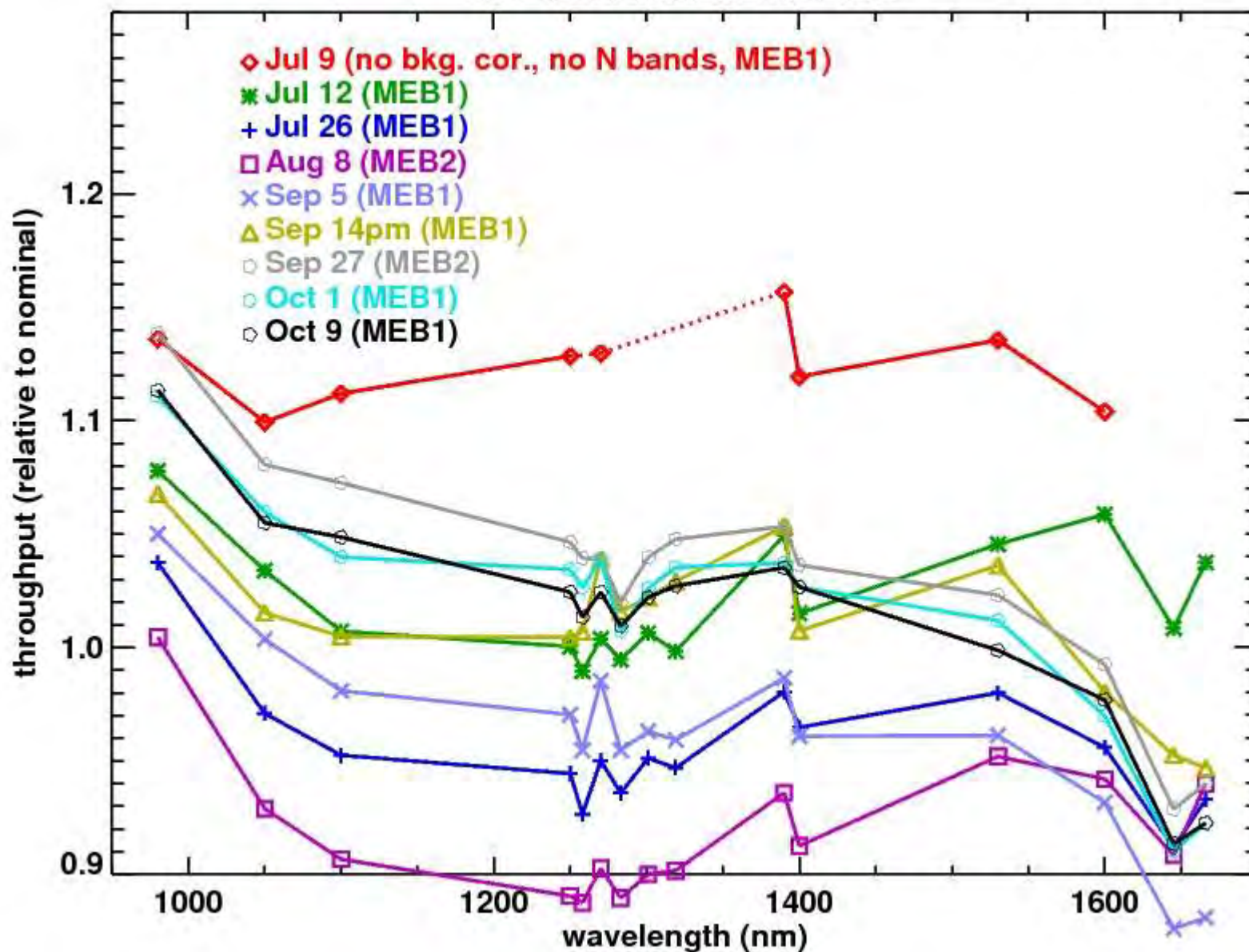
WFC3 Status

- **WFC3 completed thermal-vac test #2 on October 15 after 127 days of around-the-clock operations!! Enormous effort by a large team to diagnose and correct three major problems**
- **Poor control of IR focal plane temperature**
 - Traced to multiple problems in control electronics
 - Several board re-works required
 - Problem resolved; currently “tweaking” TEC gain settings
- **Large and unpredictable variation in IR channel throughput**
 - Multiple candidate explanations were ruled out (e.g. contamination, faulty electronics, QEH in focal plane arrays)
 - Problem traced to subtle, uncontrolled systematics in coupling of Castle calibration light source to optical fiber input to instrument
 - Further diagnostics are being done on Castle performance
 - New, more reliable calibration procedures will be developed for TV-3 in January
 - **THE BOTTOM LINE: THE APPARENT VARIABILITY OF IR THROUGHPUT IS NOT AN INSTRUMENT PROBLEM; IT’S A PROBLEM WITH THE CALIBRATION SOURCE AND PROCEDURE**
- **Failure of two internal flat-field lamps; degraded performance of the other two**
 - Entirely new lamps procured from another vendor



Variations in Measured IR-Channel Throughput

IR11S11 results to date

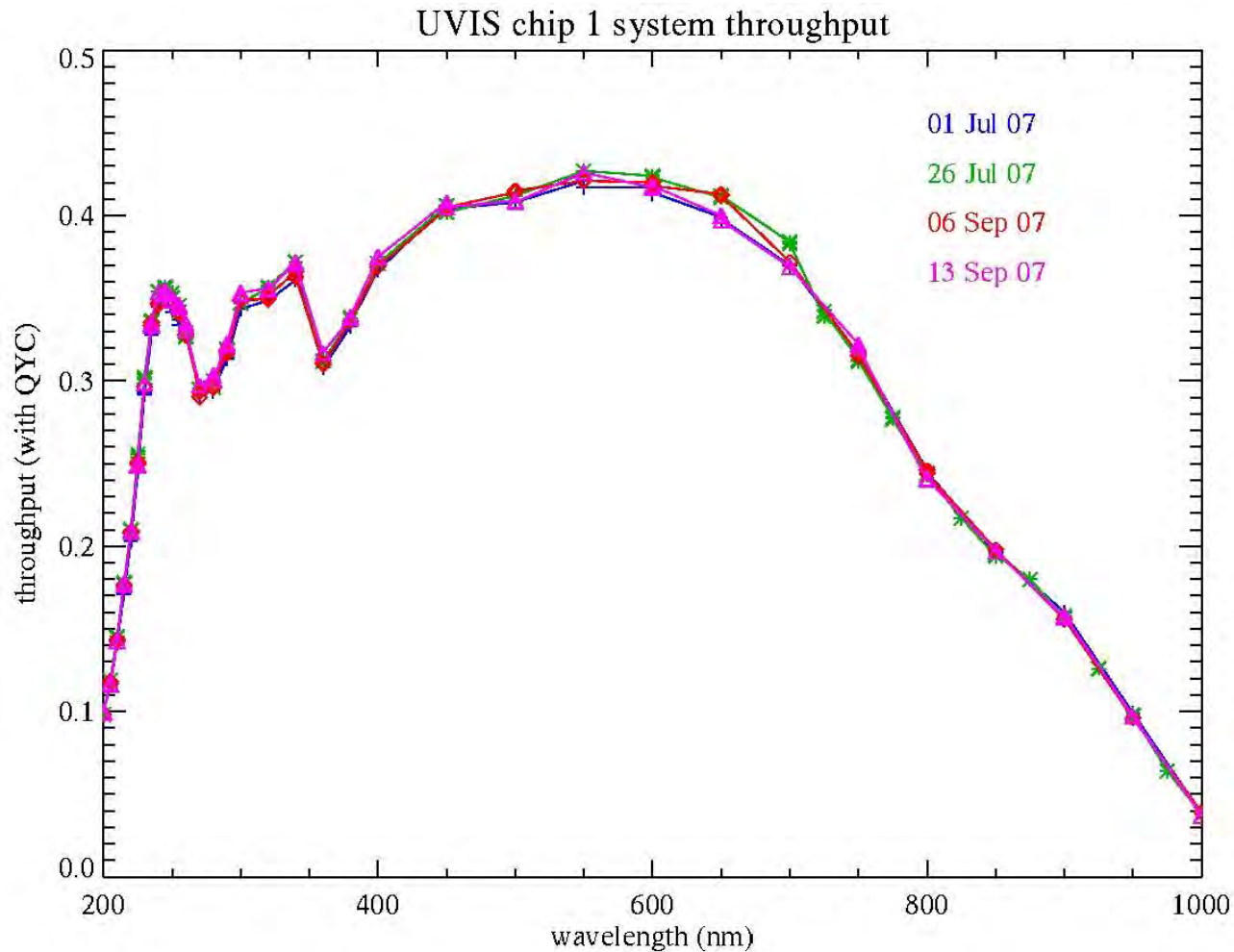




UVIS Throughput Very Stable



- UVIS end-to-end throughput still stable over several test runs





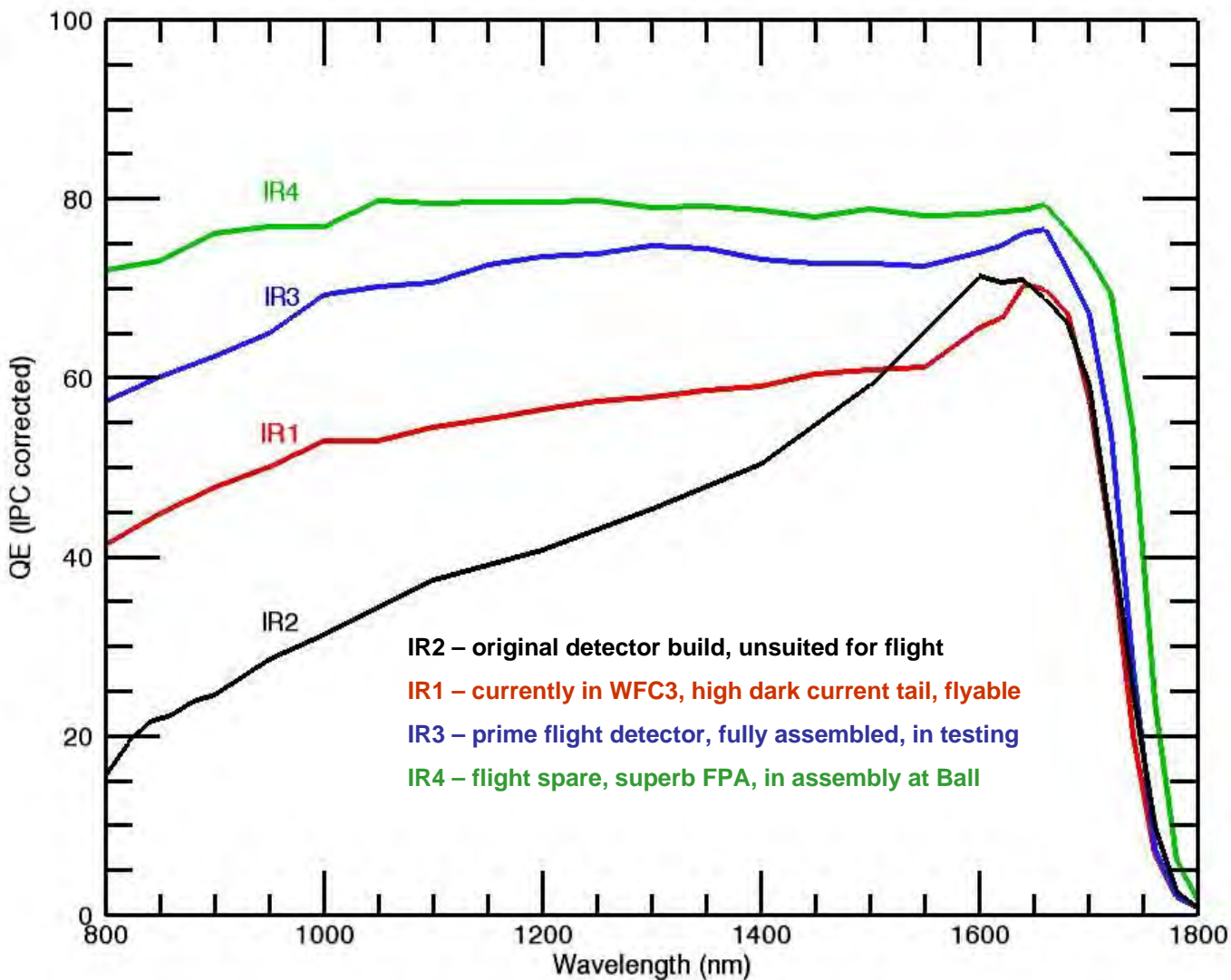
WFC3 Status (cont'd.)

● Flight Detectors Approaching the “Finish Line”

- IR3 (flight spare) is safely in storage at GSFC
- IR4 (flight prime) developed small leak in vent tube weld as it was completing acceptance testing at Ball; will be repaired and delivered ahead of schedule
- UVIS 1 (flight prime) has undergone several rounds of re-work at Ball to replace cracked TEC, remove conductive particles, repair broken wire bonds and insert anti-glnt baffle; current issue is source of conducting gold particulates
- UVIS 3 (flight spare) in early stages of build-up using extra flight-quality CCD's we had in hand
- UVIS 2 (deep flight spare) performed flawlessly in TV2, but has potential TEC crack that might not survive launch



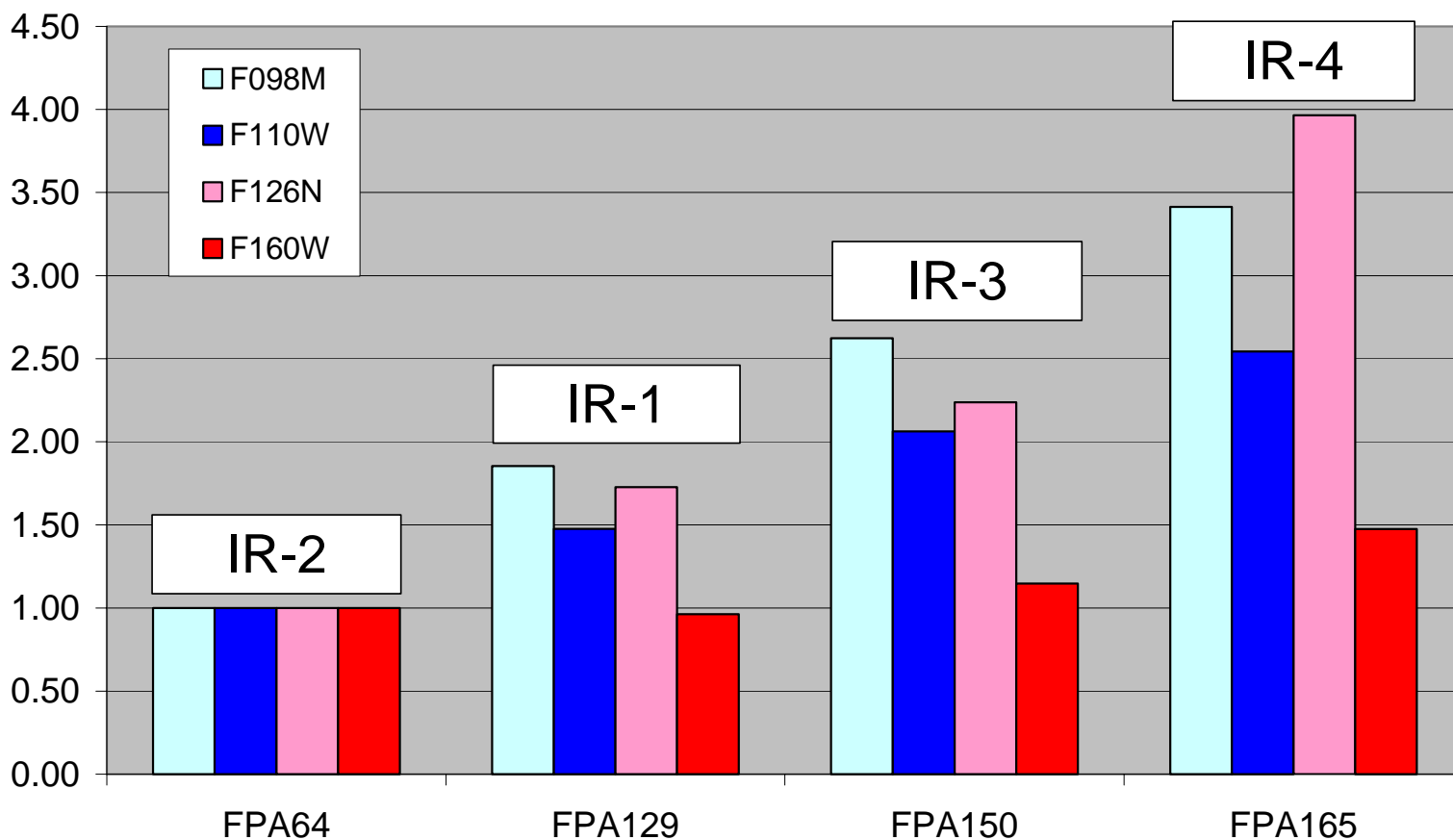
Quantum Efficiency vs. Wavelength for WFC3 NIR Detector Builds





Survey Speed Metric Normalized to FPA64 (with no radiation bkgd)

Discovery Efficiency relative to FPA64
Point sources - Average zodi - 2400s



Detectors are normalized to FPA64 performance without including the uncertain background increase in that detector due to radiation-induced luminescence



SM4 Early Release Observations (ERO's)

- **Both Jon Morse and Alan Stern will play a more direct role in defining the SM4 ERO program than has been the case in the past**
- **SMD desire is for a more robust and extensive ERO program than in previous missions**
 - “Normal” ERO's to demonstrate what the mission accomplished to the public
 - Extended ERO's to demonstrate new observing capabilities to the scientific community, anticipating upcoming HST Senior Review and Decadal Survey
- **HST Program and STScI objective is to work with SMD to define optimum ERO+ERS+Early GTO program to achieve desired objectives**



Goddard Space Flight Center

HUBBLE SPACE TELESCOPE PROGRAM SM4 Mission CDR/TRR

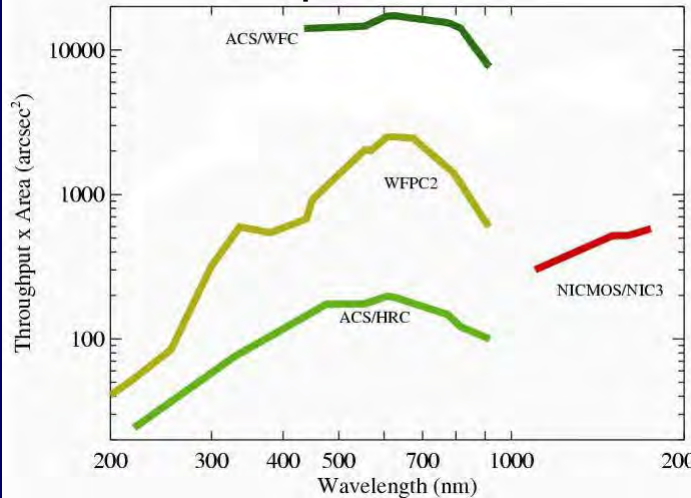


BACKUP

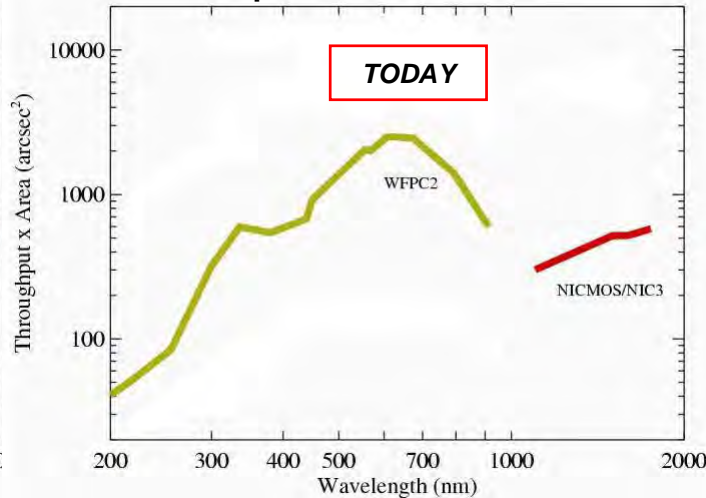


ACS-R + WFC3 = The Most Powerful Imaging Survey Capability Ever On HST

HST Capabilities Post-SM3B

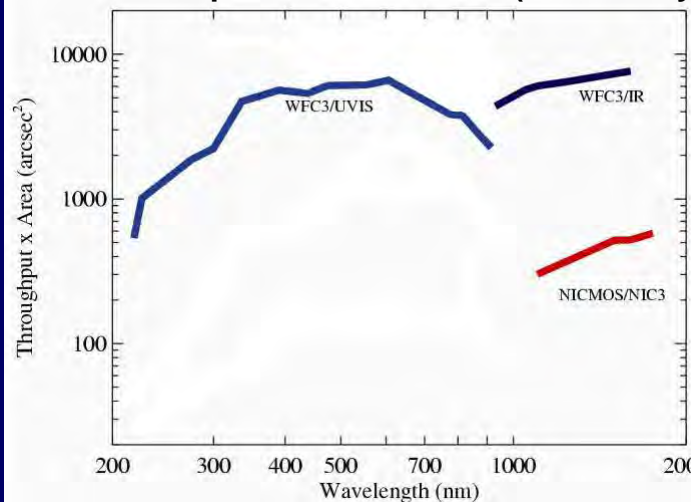


HST Capabilities After ACS Failure

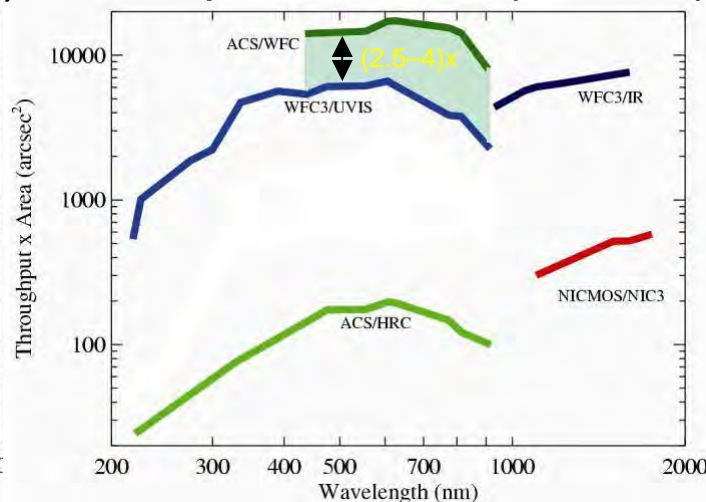


ACS-R restores redundancy in HST core capability of UV/visible imaging

HST Capabilities Post-SM4 (WFC3 Only)



HST Capabilities Post-SM4 (WFC3+ACS)



ACS-R restores unique capabilities not duplicated by WFC3