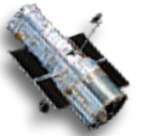




Goddard Space Flight Center

Hubble Space Telescope Program



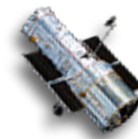
HSTP/GSFC Project Science Office Report

Presentation to:

**Space Telescope
User's Committee**

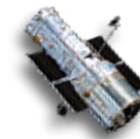
**Malcolm Niedner
George Sonneborn
Kenneth Carpenter**

14 April 2010



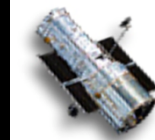
Topics

- **Scientific Perspective**
- **NICMOS/NCS Status & Purge/Refill Study**
- **SIC&DH “glitching”: Cause and Mitigation**
- **COS FUV & NUV Sensitivity Studies**
- **ACS CTE Degradation Amelioration**



Top-level Scientific Perspective

- **Observatory is functioning extremely well, and the scientific promise of SM4 is playing out**
 - Oversubscriptions of 12:1 (MCT) and 9:1 (C18) confirm that community is enthused and energized!
 - NICMOS recovery would add to the current excellent state
- **Early nervousness over SI C&DH2 CU/SDF lock-ups is much reduced**
 - Mean frequency of lock-ups is manageable, not an efficiency killer
 - Lock-up mechanism now understood
 - Steps taken to protect SIs and minimize downtime have been very effective; work continues to enhance our response to lock-ups
- **Other anomalies that can affect science are not serious at current time, but are being vigorously pursued.**



What is it? Solar System offers up a Puzzle

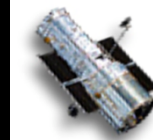
Comet-like Asteroid P/2010 A2 • January 29, 2010

Hubble Space Telescope • WFC3/UVIS

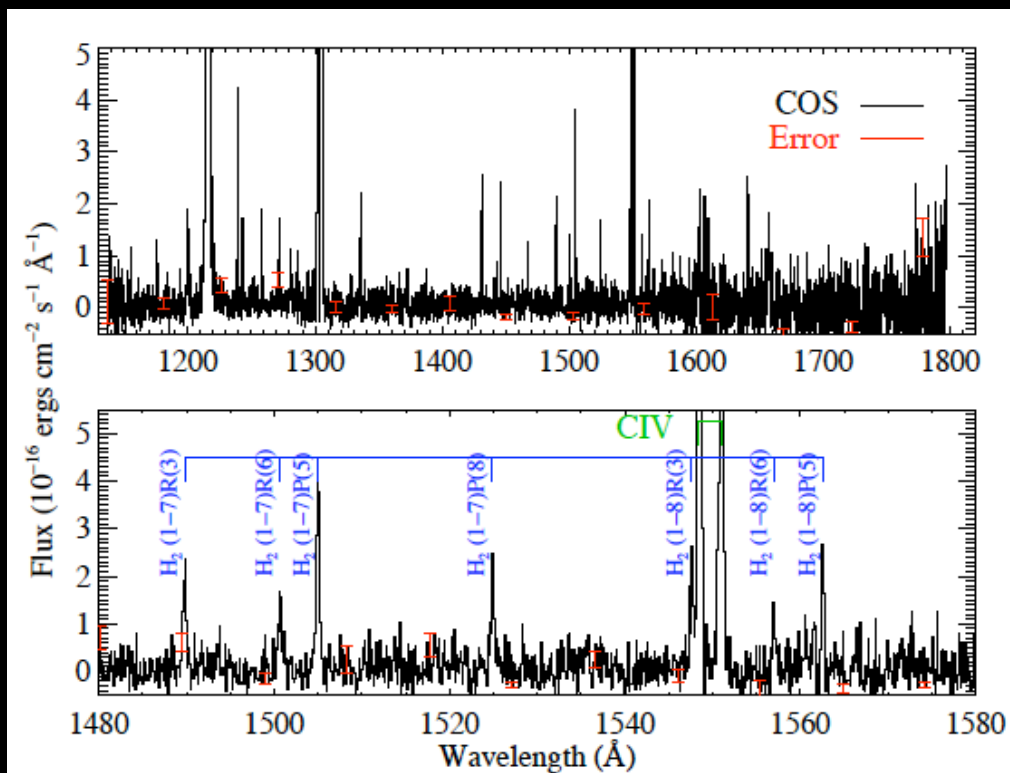


NASA, ESA, and D. Jewitt (UCLA)

STScI-PRC10-07



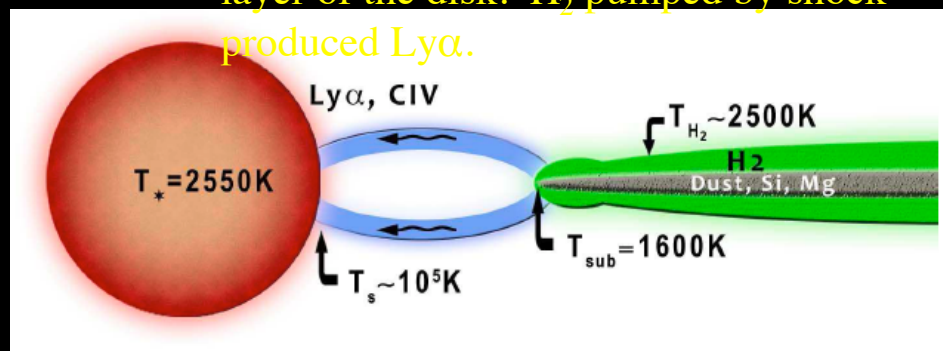
COS and brown dwarfs (mostly unexplored in the FUV)

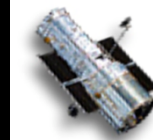


France et al., 2010, ApJ, accepted

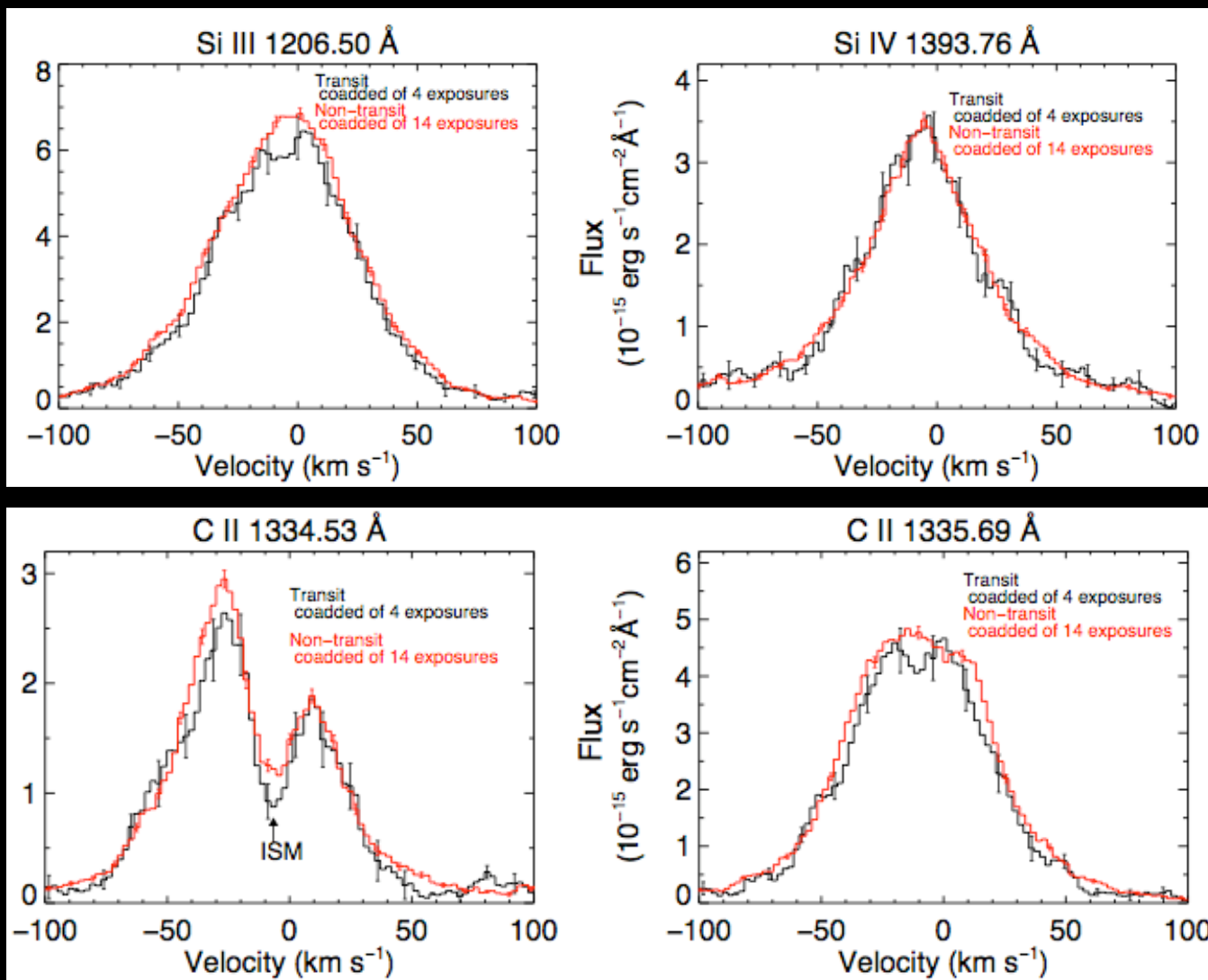
Low-mass analogue to a classical T Tauri star

- 2M1207 is an M8 BD w/ 6 M_J companion
- STIS observed it, but w/ 15x less spectral resolution than COS
- Hot gas exists in this system: C I-IV, He II, N V (known before COS)
- Other species expected at 10^4 -5 K (Si II-IV, Mg II, etc.) not seen, suggesting depletion onto grains in accretion disk (also known before COS)
- A unique COS contribution is resolving the (summed) H_2 lines, leading to kinematical placement of H_2 in a warm molecular layer of the disk. H_2 pumped by shock-produced Ly α .



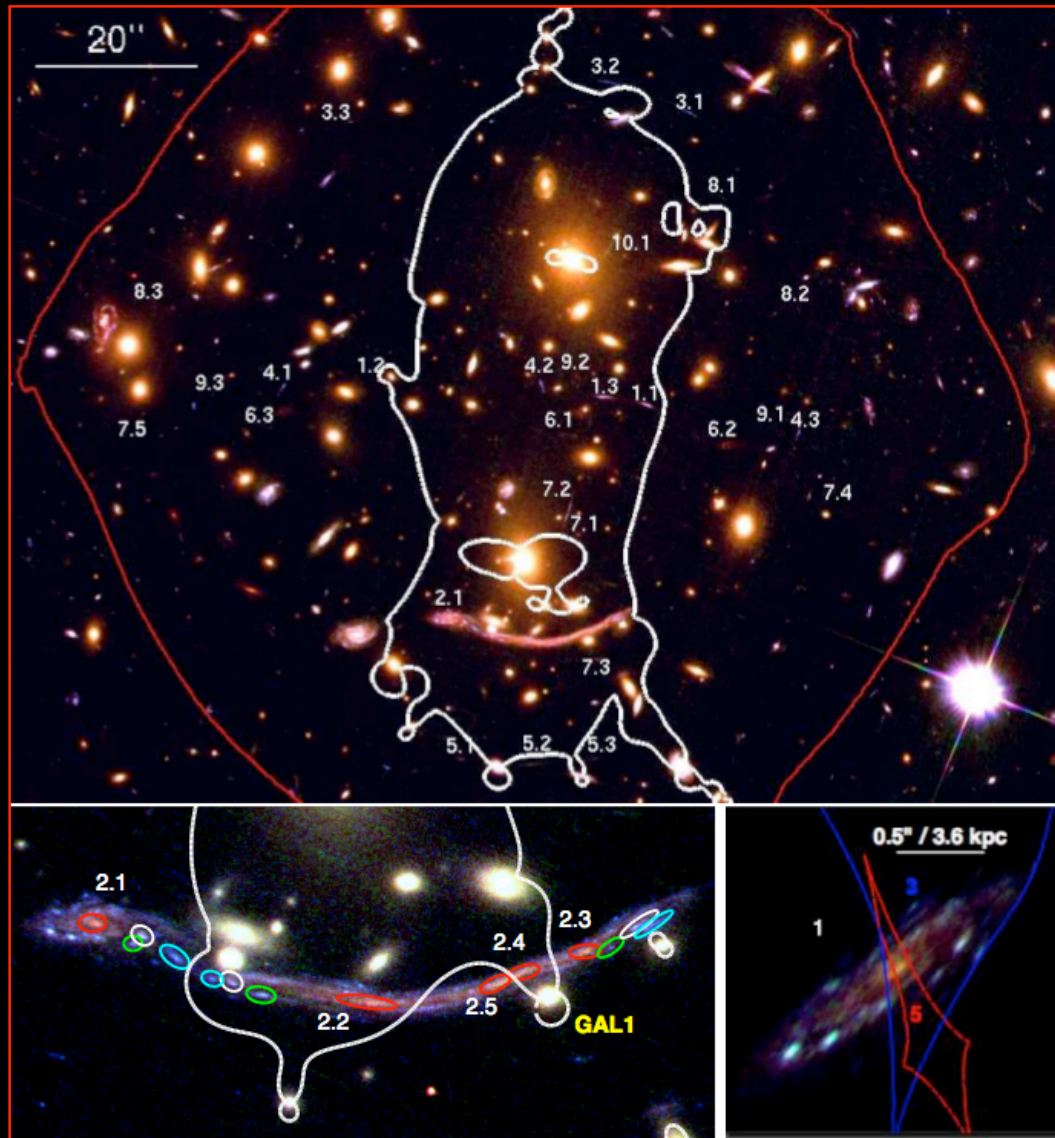
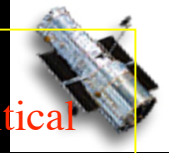


COS is observing exoplanetary atmospheres! HD 209458b (Linsky et al., paper close to acceptance)



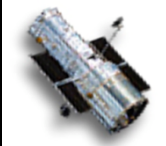
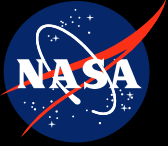


Abell 370 observed with ACS

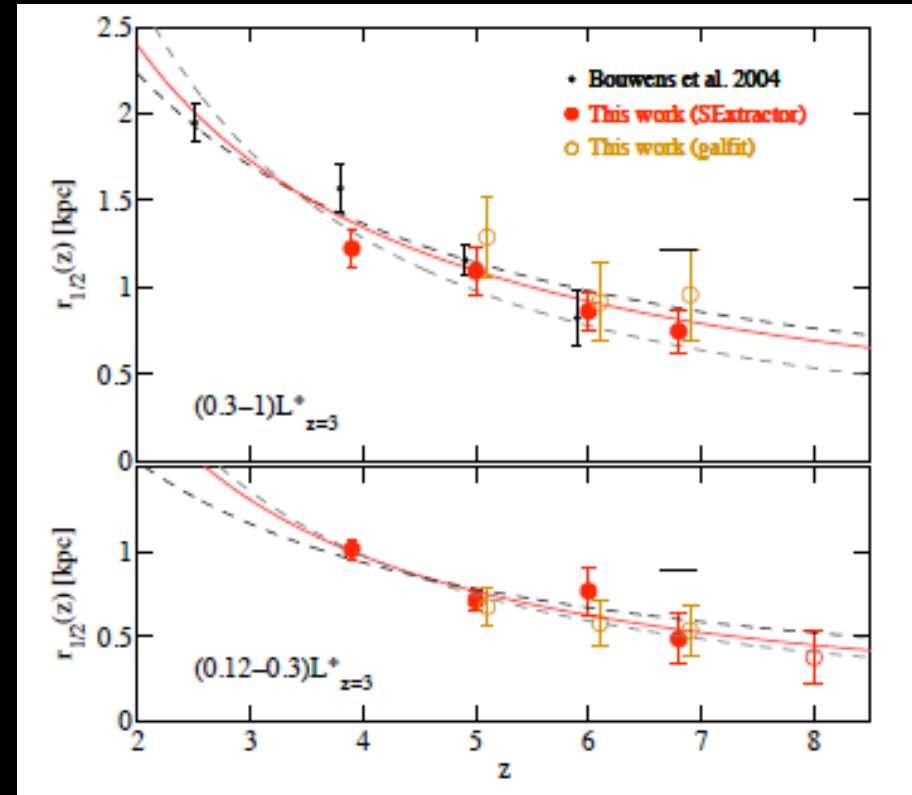
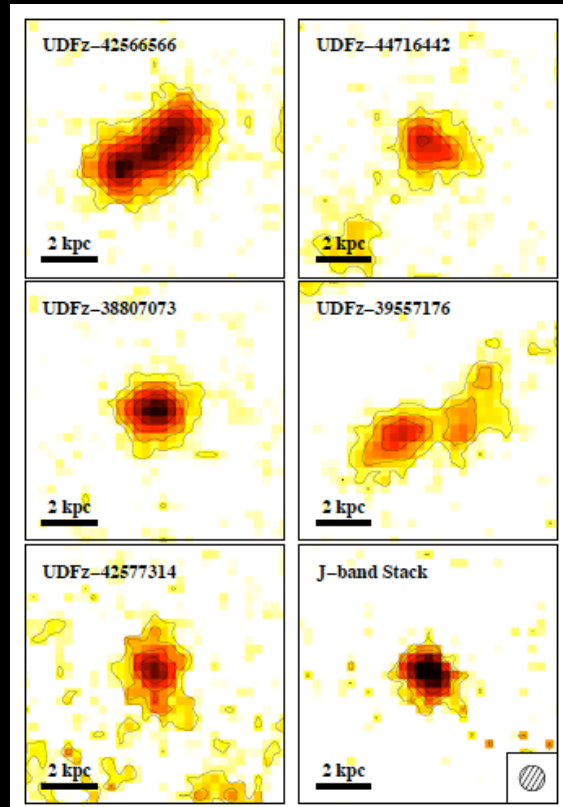


Richard *et al.*, 2010, accepted *MNRAS Letters*

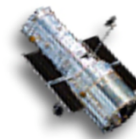
- Multi-color, hi-res imaging **critical** to finding multiply-imaged sources, constraining the DM distribution
- 10 multiply imaged sources in this system, 32 separate images
- “Giant arc” contains 5 images of spiral galaxy core, 3 and 1 images of other portions
- Cluster- and galaxy-scale DM components used in SL model, and accurate fit to observed arcs requires bi-modal cluster-scale DM
- Flux magnification factor of 32x for entire giant arc
- Chandra X-ray, visible light galaxy distribution, and radial velocities also show double peak
- Two colliding clusters along LOS



Structure and Morphology of $z \sim 7-8$ galaxies with WFC3/IR (Oesch et al. 2010, *ApJL*, 709, 21)

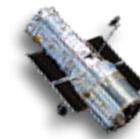


- WFC3/IR enables first-time morphology studies at $z > \sim 6.5$
- galaxies extremely compact, with slow size evolution over $z = 6-8$
- mean star formation surface densities \sim constant over $z = 4-7$



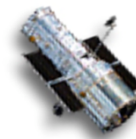
NICMOS Status and Purge/Refill Study

- **NICMOS has not been operational since Oct 2009 due to the inability to restart the NICMOS Cooling System (NCS) in a cold state**
 - NCS problems widely believed to be the result of trace H₂O in the cooling system
 - NCS has been successfully restarted recently only when warmed to approximately room temperature
 - Warm up/cool down cycle takes months, comparable to CU/SDF lockup intervals
- **NCS could be returned to a reliable operational status by venting the existing neon coolant (and accompanying water) and refilling it from a reserve supply of neon.**
 - There is sufficient neon supply to perform the refill once
- **In November 2009, HST Project began developing plans to be able to purge/refill the NCS with the following guidelines:**
 - Perform the process using less than 24 hours of dedicated HST time
 - Limit high-voltage cycling (FHST, FGS, instruments)
- **In preparation for a possible purge/refill, the NICMOS TECs were turned off on Dec. 9, 2009 to allow the dewar to warm up**
 - Entire NICMOS system is now at T~270K



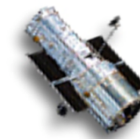
NICMOS Purge/Refill Study

- **HSTP studied in detail several technical issues**
 - Reliability of the valves to be opened and closed during the purge/refill process
 - Possible contamination of SI optical surfaces by the vented gas
 - Potential impact on the HST observatory by power cycling high voltage units
- **NCS valve operation determined to be highly reliable**
 - Any risk of a valve not reseating fully (i.e. a long term leak) would pose a risk only to the operation of NICMOS
- **Transport analysis of vented neon gas, including trace water and a hypothetical small amount of hydrocarbons, found zero risk of deposition and contamination on sensitive surfaces in the other instruments.**
- **Study of FHST power cycling found that no technical reasons preclude power cycling the FHSTs several times to support NCS purge.**
 - NASA and Ball Aerospace have no record of a FHST similar to HST's failing due to power cycles; Ball has no reservations about a few power cycles at this time
 - Goddard engineering states that long-term reliability of FHSTs for remaining mission not significantly affected by 2-3 power cycles now



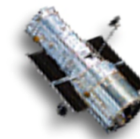
Conclusions of NICMOS Purge/Refill Study

- **HSTP has identified and developed a NCS purge/refill procedure that**
 - Would successfully return NICMOS to a operational status for science, assuming the H₂O theory is correct (*there is no competing theory*)
 - Would make it possible to restart the NCS quickly (i.e., cold) following future SI C&DH resets,
 - Would use less than 24 hours of HST time to execute, and
 - Poses no credible risk to the long-term health of the HST observatory
- **The decision of whether or not to restore NICMOS to a operational status is one of scientific priorities, and is contingent on the results of the Cycle 18 panel/TAC review.**
- **Should an HST instrument with unique capabilities be left turned off and unavailable to the scientific community?**



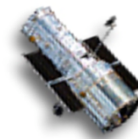
SIC&DH2 Anomaly: Update and Cause

- **Three CU/SDF-B lock-ups inside SIC&DH2 since its SM4 installation: June 15, Oct. 22, and Nov. 3, 2009**
 - Power-cycling of entire SIC&DH2 tray has always succeeded in resetting CU/SDF-B, permitting a return to science operations (excluding NICMOS)
 - Since the first recovery, Project and STScI have introduced operations changes to protect SIs and minimize science down-time (now < 1 day)
- **Project ARB formed after the initial lock-up, and Independent Review Team chartered after the last 2 events, reached the same conclusions:**
 - Anomaly due to small wiring change made in 1980s (for reasons unknown) to Generation 2 CU/SDF microcontroller circuitry. Changes were made to *both* CU/SDFs inside spare SIC&DH: ***problem not solved by going to Side A.***
 - Analysis of new design revealed rare non-synchronous state between two strobed power control circuits which must be in same state (ON or OFF) to avoid infinite loop (hang-up) condition. Non-synchronicity and lock-up are random.
 - Lock-up will occur again, but no evidence that damage is being done or that problem will worsen. Power-cycling SIC&DH2 is the only way to clear it.
 - ARB & IRT unable to create condition in lab testing due to its infrequency.



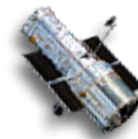
SIC&DH2 Anomaly: Mitigations Enabled

- **Future lock-ups will happen: protect SIs, recover quickly!**
 - Fully autonomous CU/SDF recovery not possible since only method of resetting CU/SDF is through power-cycling SIC&DH2 tray—a special command that is non-executable by the 486 spacecraft computer
 - New 486 Autonomous Command Routine (ACR) serves as back-up to ensure SI MEBs do go into “pseudo boot mode” upon CU/SDF lock-up
- **Initial recovery from lock-up was lengthy: after manually safing SIs, commanding to recover occurred after Project meeting(s) and led to large detector thermal swings. New procedure:**
 - Real-time CU/SDF power cycle and recovery of science computer and SIs by ground controllers does not require Project pre-brief: the lock-up has a well-recognized signature by now, and on the Operation Manager’s “GO” call the recovery can begin
 - Special safe-mode procedures developed for WFC3 TECs
 - Thermal swings for all SIs strictly minimized
- **Future work includes autonomous shutter closing, starting with COS; development of procedure for partial side-switch if power-cycling SIC&DH2 fails, etc.**



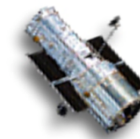
COS FUV & NUV Sensitivity

- **Analysis of existing data and a special engineering test showed that FUV QE degradation is not due to aging effects caused by total photon exposure (i.e., fluence).**
- **The current leading theory, with large uncertainty, is photocathode exposure to atomic oxygen (AO)**
 - FUV detector is “open”, so will see AO as well as other species
- **Examination of other flown FUV missions shows no exact analogues, i.e., open CsI photocathode detectors**
 - Degradations that have been seen have different causes, or are dissimilar in important details
- **Although effective mitigation doesn’t exist, we still want to know if AO is the cause of what we are seeing, as well as the likely time evolution of the degradation (if AO is the culprit, is a “cliff” approaching?)**
- **This is not answerable from the published literature. Our only recourse is to gain knowledge through ground testing (next chart).**



COS FUV & NUV Sensitivity, cont'd

- **Project is assembling a test plan (O. Lupie, D. Hughes, Leads) in which a Csl “detector” will be subjected to thermalized (“flight-like”) atomic oxygen and QE performance will be measured**
 - *We will add NUV bare Al gratings to the AO testing since we continue to be in the dark about their continuing degradation on-orbit*
 - The Csl “detector” will not be the COS FUV flight spare, but rather one or both of: a Csl-overcoated metal substrate and a Csl MCP
- **Assembly of “full-up” test chamber in which AO bombardment and QE measurements occur without breaking “vacuum” is an issue (i.e., avoiding transfer from “AO-chamber” to “QE-chamber”)**
 - Glenn Research Center (GRC) has the thermalized AO-equipped chamber
 - Olivia and Dave are working with GRC, UC-Berkeley, the COS IDT, and the GSFC optical group (the latter for the gratings) to put all the pieces together
- **Project also pursuing X-ray Photo Spectroscopy of AO-exposed Csl witness material to look for composition changes.**

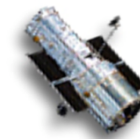


ACS CTE Amelioration

- **Not surprisingly, the WFC CCD has a much decreased charge transfer efficiency (CTE) since launch**
 - The current value is 0.99989, which, although near pre-SM4 projections, is considered border-line “problematic” for some kinds of programs
- **Ed Cheng, Augustyn Waczynski, et al., have tested radiation-degraded, ACS-like CCDs in GSFC’s Detector Characterization Laboratory (DCL) to see if the on-orbit h/w and electronics have the means to improve the CTE. It seems they do:**
 - h/w necessary for direct electron charge injection of the CCD exists for ACS/WFC
 - Charge injection of (say) 10,000 e- per pixel not subject to ruinous Poissonian noise, but something much smaller (next sub-bullet).
 - DCL testing of radiation-bombarded CCDs shows that electron traps are completely filled by 10,000 e-/pix, *leading to a restoration of CTE from 0.99985 (initial) to 0.999993, with the penalty of ~15 e- of effective read noise.*
- **Team is building a plan for possible on-orbit test of the charge injection scheme this fall. We are working with the STScI ACS Team.**



Hubble Space Telescope Program



END