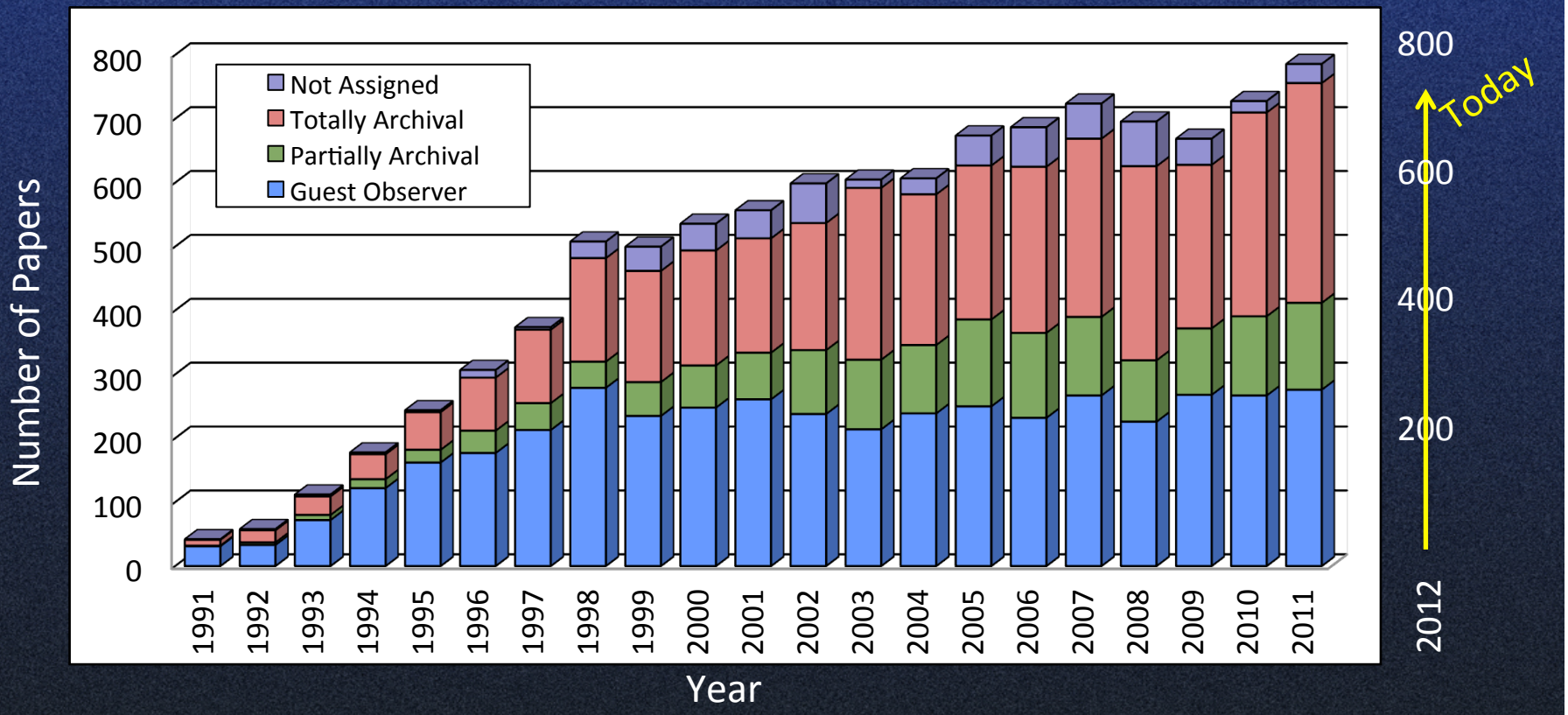
Hubble Space Telescope

STUC Meeting – November 8, 2012

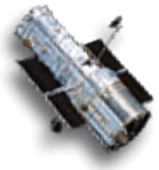
K. Sembach

HST Productivity Remains Outstanding

- 10,921 refereed science papers based on HST data to date
- 790 papers in 2011 was highest output ever
- 704 papers so far in 2012 => on track for 800+ papers



A Sample of Recent Science Papers

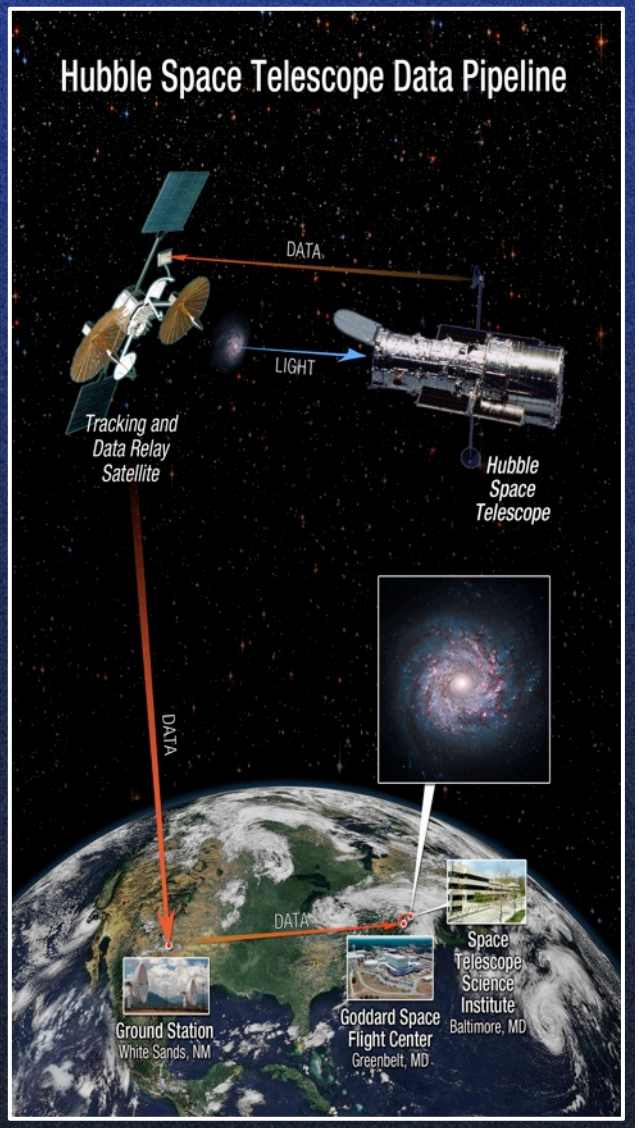


Ehrenreich et al.	Hint of a Transiting Extended Atmosphere on 55 Cancri b
Grazian et al.	The Size-Luminosity Relation at z = 7 in CANDELS and Its Implication on Reionization
Bianchi et al.	A Hubble Space Telescope Treasury Study of Star-forming Regions in the Local Group. II. Young Stellar Populations in M31
Maguire et al.	Hubble Space Telescope studies of low-redshift Type Ia supernovae: evolution with redshift and ultraviolet spectral trends
San Roman et al.	Newly Identified Star Clusters in M33 - III. Structural Parameters
Adamo et al.	Revealing a Ring-like Cluster Complex in a Tidal Tail of the Starburst Galaxy NGC 2146
Brammer et al.	3D-HST Grism Spectroscopy of a Gravitationally Lensed, Low-metallicity Starburst Galaxy at z = 1.847
Braun et al.	A Hydrodynamic Study of the Circumstellar Envelope of α Scorpii
France et al.	A Hubble Space Telescope Survey of H_2 Emission in the Circumstellar Environments of Young Stars

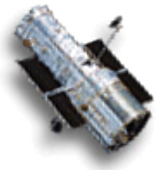
ACS	COS	FGS	FOC	FOS	GHRS	NICMOS	STIS	WFPC	WFPC2	WFC3
398	36	3	4	12	14	85	89	3	217	159

Current Status

- All science instruments are performing well.
  - ACS, COS, FGS1r, STIS, and WFC3 are in use
  - Detectors have received major attention over past 6 months
- We are considering a small telescope focus change in the next 6-12 months.
- Scheduling efficiency remains at ~84 orbits per week.
  - One-time (Cycle 20) observing restrictions to clear backlog of large programs in some regions of the sky have resulted in a very efficient long range plan
- Multi Cycle Treasury program observations conclude in Cycle 20.
- Cycle 20 Guest Observer funding is $30.15M.
- Cycle 20 began on October 1, 2012.



Long Range Plan
Status through calendar ending 11/18/12



Cycle	Orbits	Diff from Oct 7
17	13	-0
18	64	-5
19	530	-251
20	2881	+29
Total	3488	-227

Visits not in current plan	Orbits	Diff
Unschedulable	62	-76
No plan windows	189	+125
C19 misc (Too, etc)	1	-42
C20 misc	90	-75
Total not in plan	342	-105

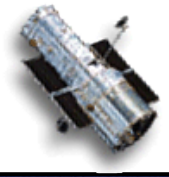
Instrument	Orbits	Diff
WFC3	1996	-76
COS	598	-57
ACS	524	-64
STIS	399	-47
FGS	17	+9
Total	3534(1)	-235

C19 snaps	644	-0
C20 snaps	1096	-32
Total snaps	1740	-32

1. Some programs have more than one prime science instrument.

Cycle 17 orbits complete in Feb 2013
Cycle 18 orbits complete in Jul 2013

Long Range Plan
Progress of MCT, Large, & Treasury Programs

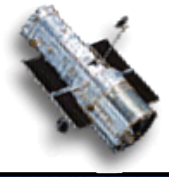


Multi-Cycle Treasury	Total alloc	Exec/sched by 11/18/12	Planned before 9/30/13	Planned 10/1/13+	Comment
Dalcanton	834	676	158	0	Finishes 8/13
Faber/Ferg	750	598	152	0	Finishes 8/13
Postman	474	379	97	0	Finishes 7/13
Riess (ToO)	202	157	1	0	44 unplanned

C18/19 Large	Total alloc	Exec/sched by 11/18/12	Planned before 9/30/13	Planned 10/1/13+	Comment
Van Dokkum	248	245	3	0	Finishes 4/13
Heckman	119	80	39	0	Finishes 6/13
Sing	124	95	29	0	Finishes 10/13

1. Difference from 10/7

Long Range Plan
New Cycle 20 Large & Treasury Programs



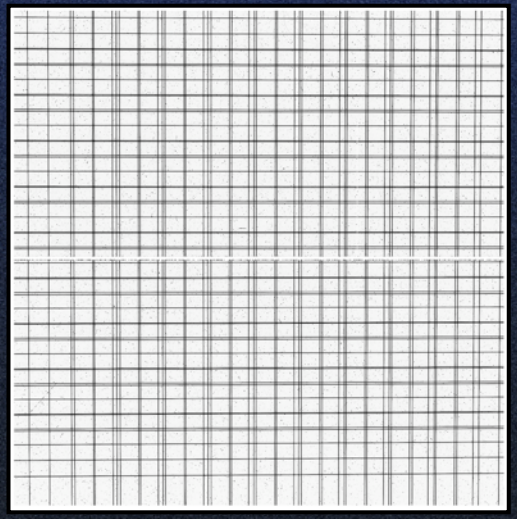
C20 Large & Treasury	Total alloc	Exec/sched by 11/18/12	Planned before 9/30/13	Planned 10/1/13+	Not in plan
Bean	60	16	44	0	0
Bedin	120	10	110	0	0
Cushing	125	0	121	4	0
Gaensicke[(1)]	122	20	91	15	26
Gladders	107	0	89	18	0
Kirshner (ToO)	100	6	2	0	92
Riess	112	0	83	29	0
Sabbi	60	0	60	0	0
Sahu	64	0	56	8	0

1. Total orbits > allocation due to extra visits to set flags and check for bright objects.

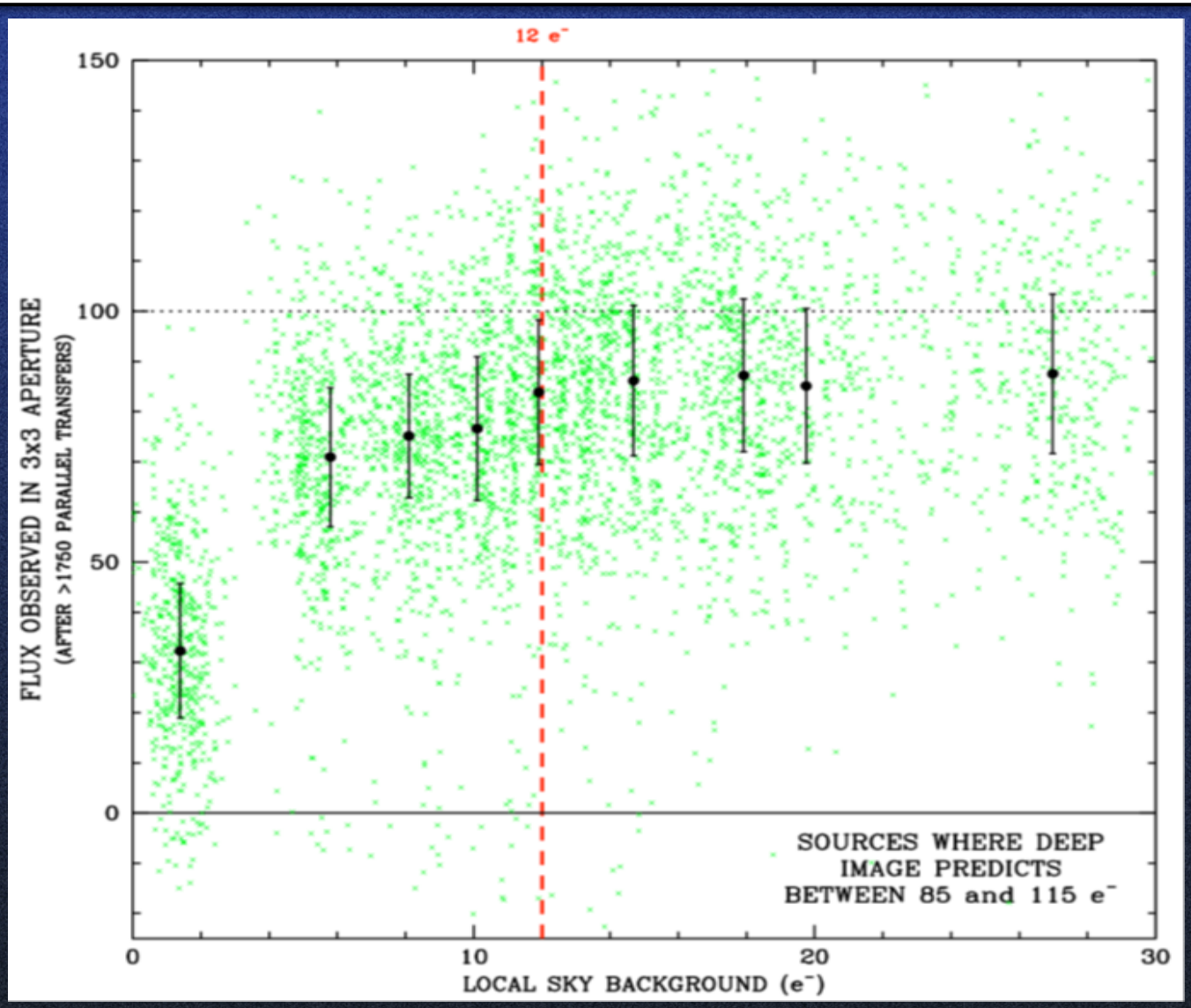
WFC3 Status

(J. MacKenty and the WFC3 Team)

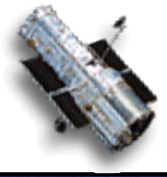
- WFC3 is operating nominally
  - Photometric zero points remain stable to <0.3% (UVIS) and <0.5% (IR)
  - Quality in-flight flat fields are available in both channels
  - Improved UV flats are being worked this year
- IR image persistence exposure history tracking is available for all WFC3/IR images
  - Downloads from MAST with estimates of persistence levels in each pixel
  - Manual identification of "bad actors" to aid scheduling
- Spatial scans supported for Cycle 20 GOs
  - Increased potential for exoplanet transit observations
  - Astrometric precision better than FGS
    - Parallax to ~25-30 micro-arcsec
  - Key calibration activities:
    - IR zero-points of Vega
    - Multiple scans to test/improve flat fields



WFC3 Signal Loss as a Function of Background Level



Mitigating WFC3/UVIS CCD Charge Transfer Efficiency Degradation



- Key discovery: Modest backgrounds significantly improve transfer of small charge packets (*i.e.,* faint sources do not disappear)

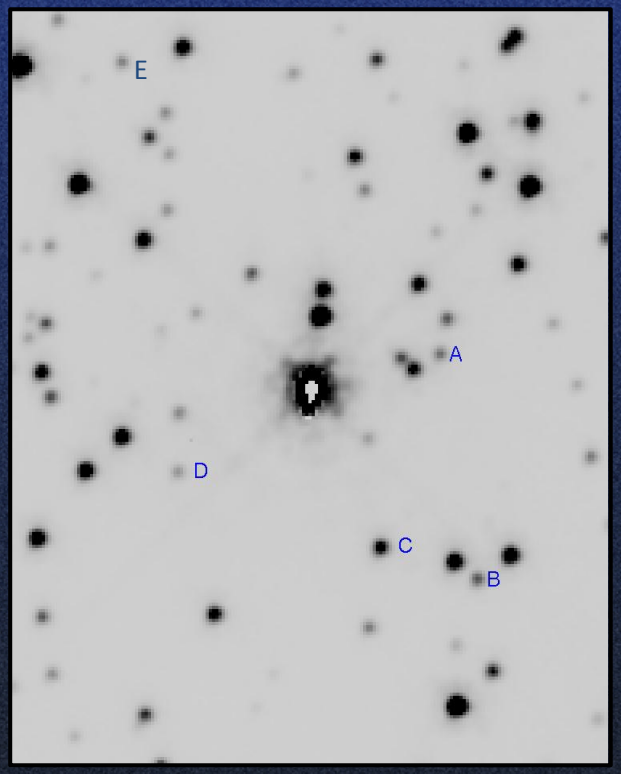
- WFC3 decided to implement post-flash in March 2012
  - Permits observers to add small amount of uniform signal
    - Combination of existing background plus added signal → >= 12e-
  - Available and documented by Cycle 20 Phase 2 deadline (40% use)
  - Cost is reduced S/N (*i.e.* higher effective background)
  - Benefits are more uniform sensitivity and better detectability of faint sources

- Future Work
  - Pipeline support and updated calibration reference files (in place by Dec 2012)
  - Pixel based correction algorithm similar to ACS for bright source trailing
    - Anderson-Bedin approach
    - Charge Injection to calibrate trap population (<<hot pixels than ACS)

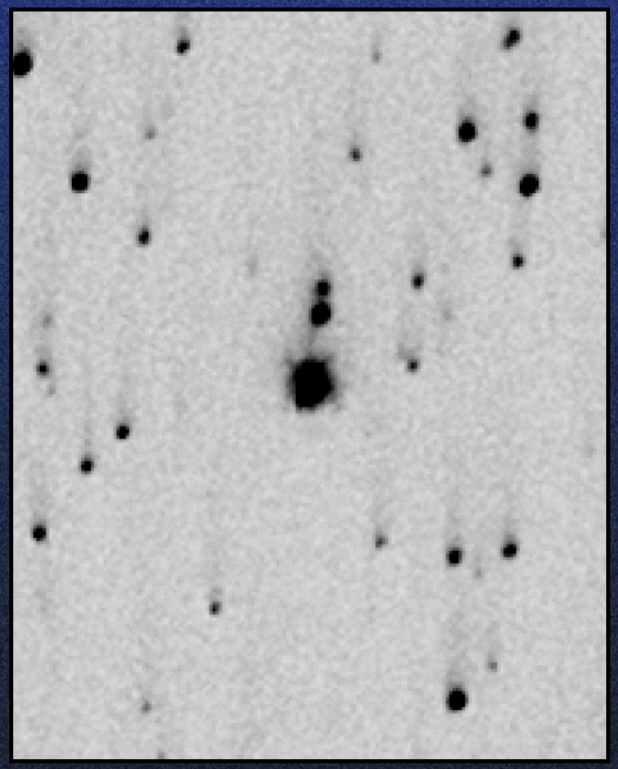
WFC3 Post-flash Demonstration

Omega Cen

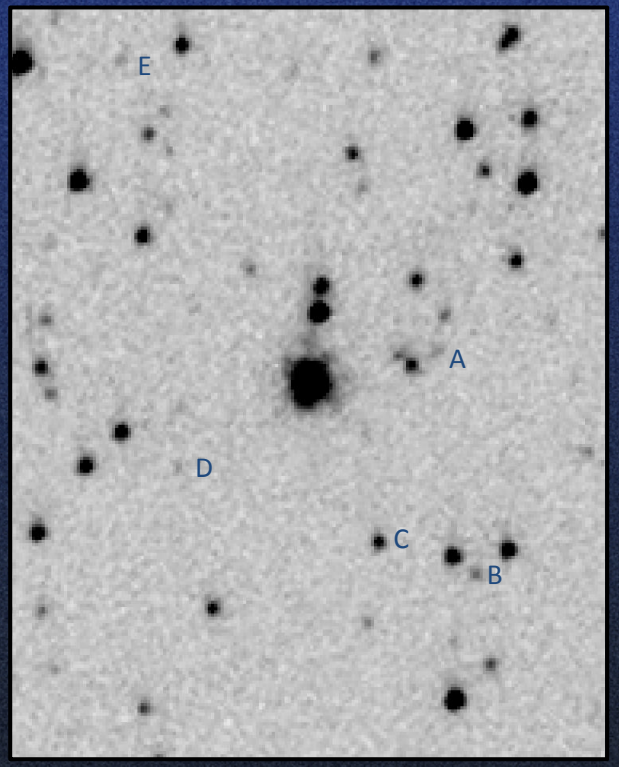
8x700 sec



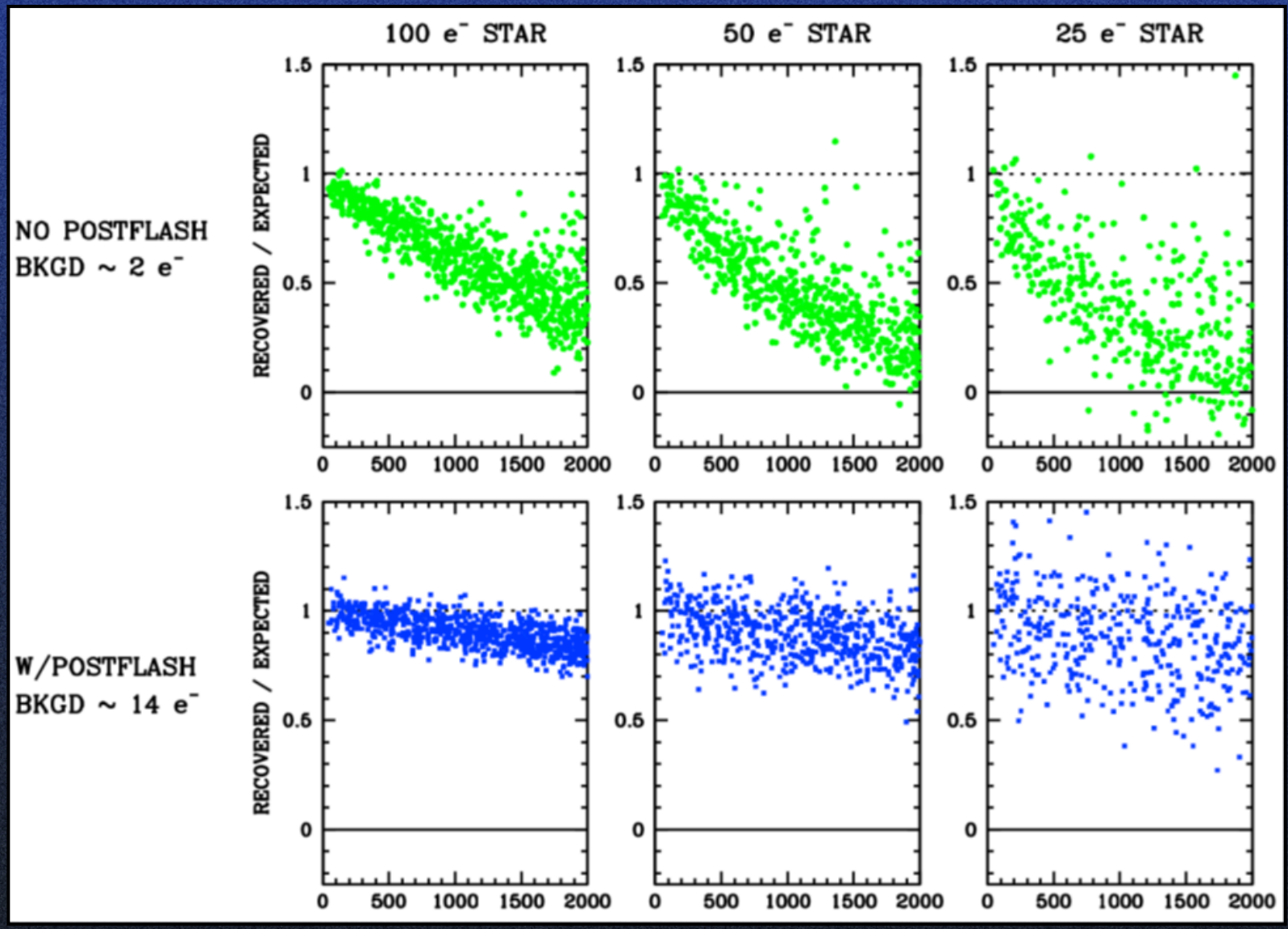
9x10 sec (w/o post-flash)



9x10 sec (w/ post-flash)

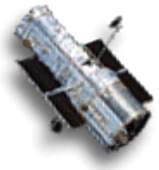


Improvement to Faint Star Detection (3x3 pixel aperture fluxes)



ACS Status

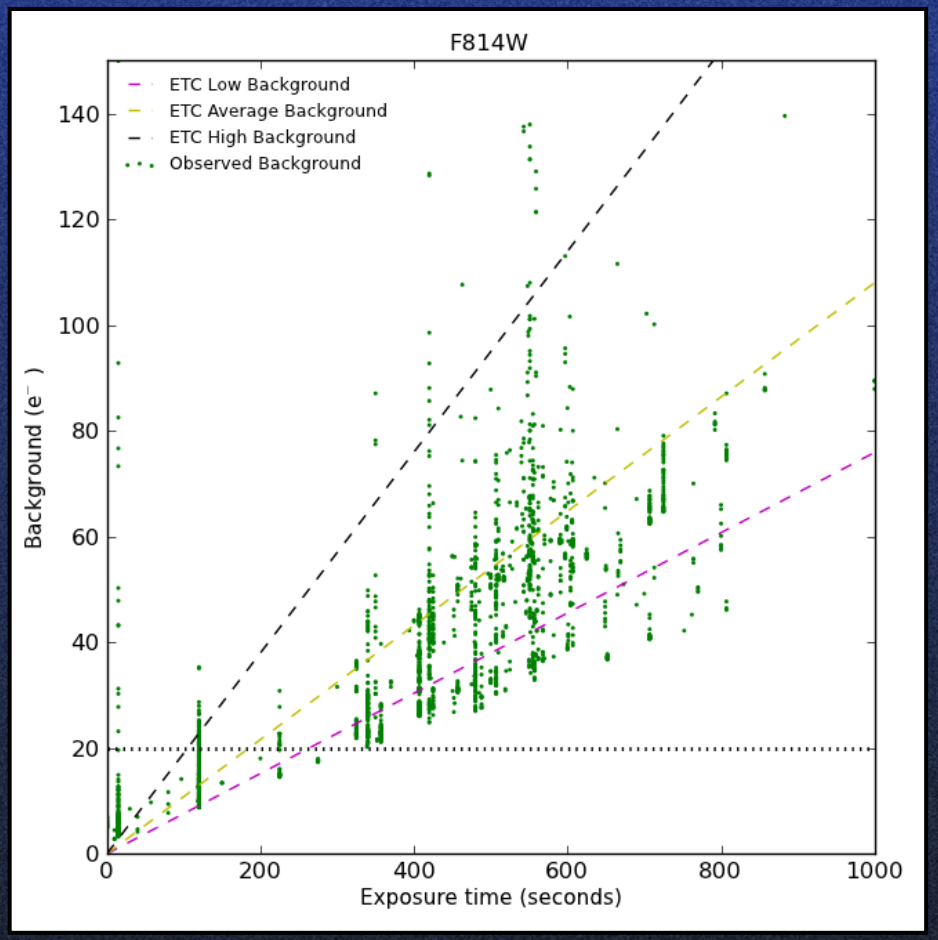
(L. Smith and the ACS Team)



- ACS/WFC and ACS/SBC channels are both working well. The repaired ACS has now been in operation nearly 3.5 years.
- Major progress has been made in the past 6 months on implementing calibration improvements in the ACS data processing pipeline.
- CALACS 2012.2 was released on May 16, 2012.
  - Includes CTE-corrected data products
  - Includes corrections for all post-SM4 electronic artifacts (bias striping, bias shifts, and crosstalk)
- AstroDrizzle replaced MultiDrizzle in OPUS pipeline for ACS data on July 11, 2012.

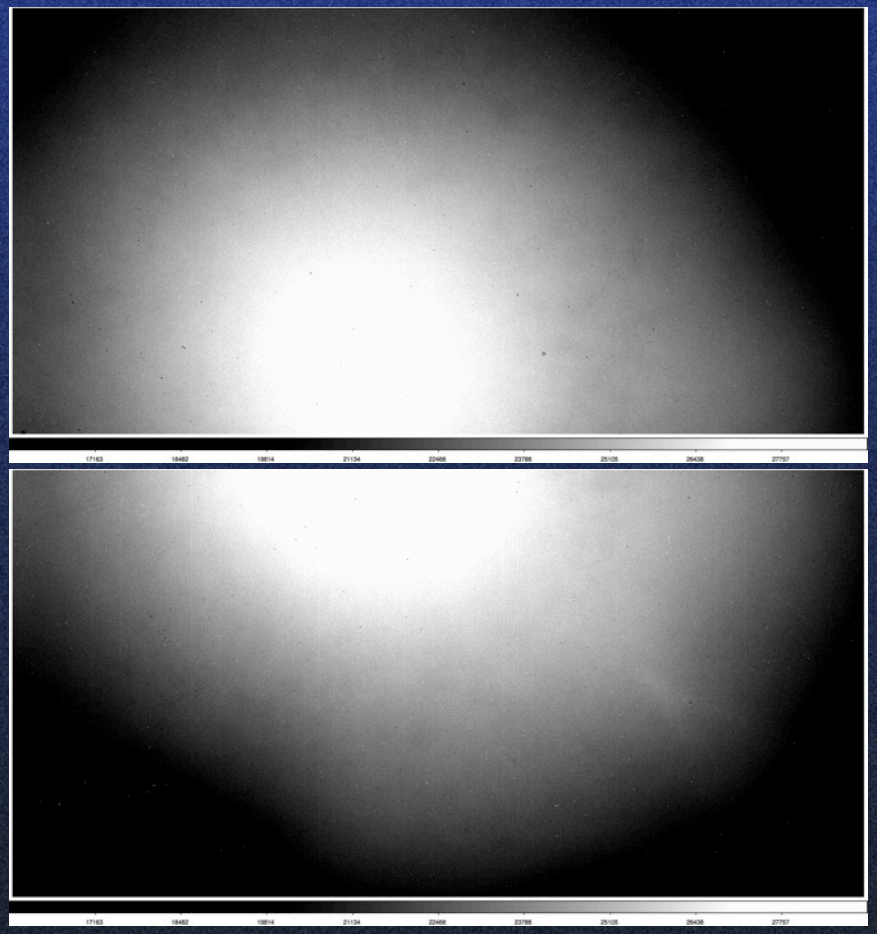
ACS CTE – Low Background Cases

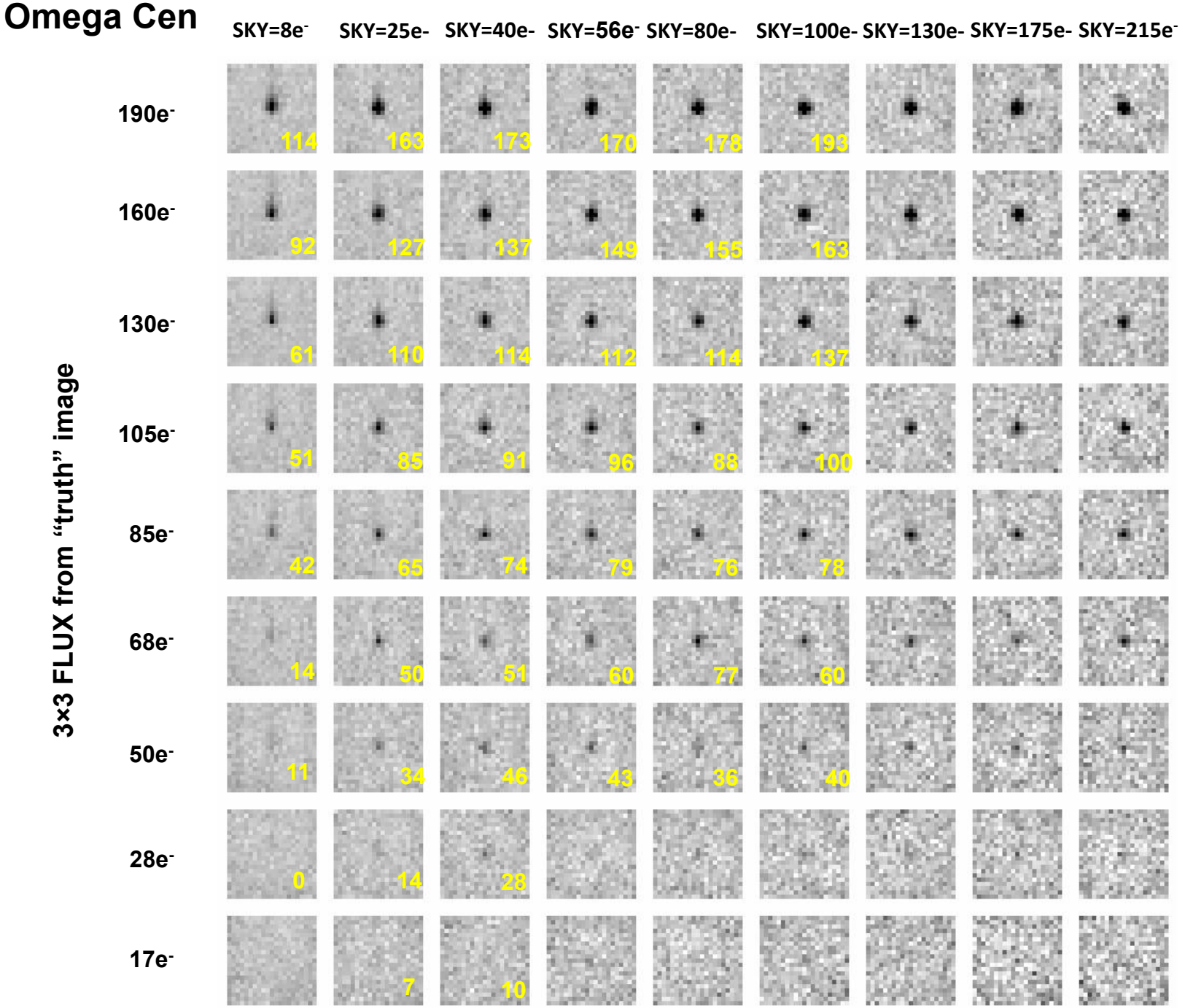
- Charge transfer efficency losses are severe for exposures with low sky backgrounds (<20 e^-).
- Anderson-Bedin post-observation charge transfer reconstruction is not possible because most of the charge is lost.
- Post-flashing exposures with backgrounds < 20 e^- improves charge transfer.
- Post-flash performance is being calibrated in Cycle 20.



ACS Post-flash Results

- LED is used to provide post-flash illumination of WFC CCDs.
  - 25% decrease in output since 2006, probably due to radiation damage
- Lamp output is stable for repeated exposures.
- Post-flash is much less uniform than UVIS.
  - 50% variation across field
  - more difficult to calibrate




Omega Cen
SKY=8e-
SKY=25e-
SKY=40e-
SKY=56e-
SKY=80e-
SKY=100e-
SKY=130e-
SKY=175e-
SKY=215e-
3×3 FLUX from "truth" image
190e-
160e-
130e-
105e-
85e-
68e-
50e-
28e-
17e-
114 163 173 170 178 193
92 127 137 149 155 163
61 110 114 112 114 137
51 85 91 96 88 100
42 65 74 79 76 78
14 50 51 60 77 60
11 34 46 43 36 40
0 14 28
7 10

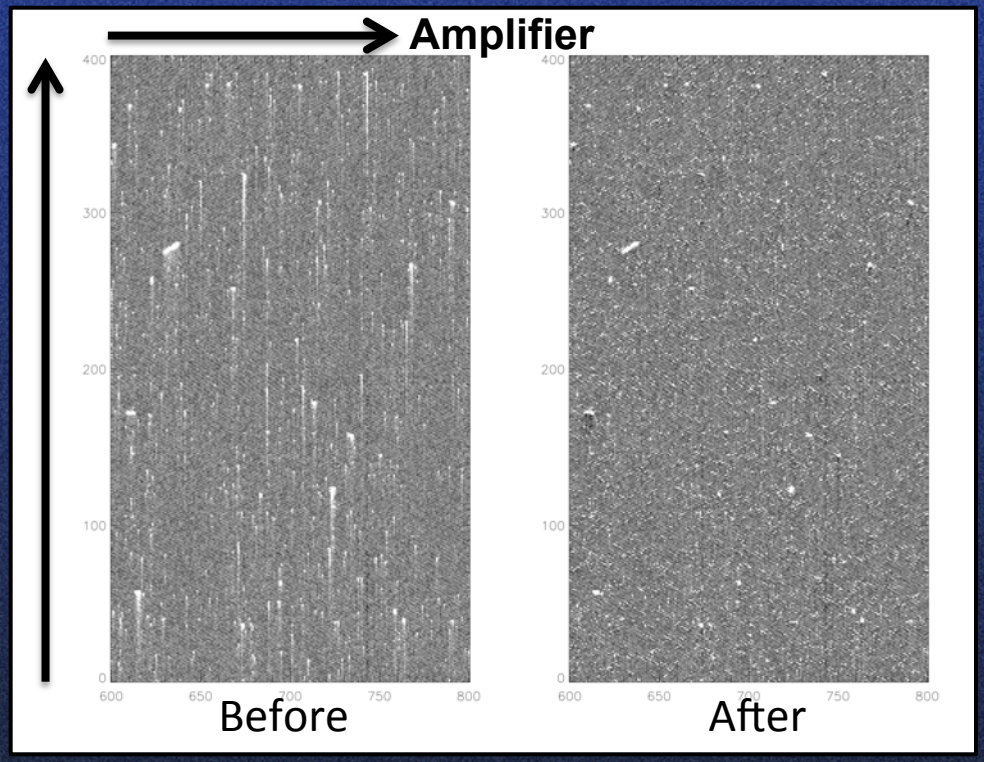
STIS Status

(A. Aloisi, C. Proffitt, and the COS/STIS Team)

- STIS/MAMA and STIS/CCD channels are working well. The repaired STIS has now been in operation nearly 3.5 years.

- Currently investigating feasibility of a pixel-based CTE correction
  - Since Side-1 failure, STIS CCD lacks active temperature control which may complicate corrections
  - Used ACS WFC CTE tools to perform preliminary evaluation of STIS CCD data
    - STIS hot pixel trails qualitatively similar to ACS/WFC3
    - Trail length only weakly temperature dependent
    - Preliminary tests on individual dark frames yield good correction of trails (see figure on next page)
    - Have not yet fully optimized correction algorithm parameters for STIS
  - STIS CCD can be readout from either end of detector
    - Potentially useful in better characterizing traps (also for ACS/WFC3)
    - Will perform tests as part of Cycle 20 Calibration Program

STIS Charge Transfer Reconstruction



Single Dark Frame Correction

Left: Trails from warm pixels and cosmic rays are clearly seen extending away from the amplifier.

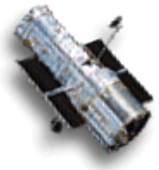
Right: Same area of the detector with a pixel-based CTE correction implemented through the PixCteCorr Pyraf routine.

Some increase in background noise occurs in corrected image, but this is compensated for by removal of hot pixel tails

- Next step will be to test some science cases to quantify improvements in S/N and limiting flux levels
  - Necessary to first remove herringbone electronic noise pattern (~ 3.6 e^-) before correction

COS Status

(A. Aloisi, C. Proffitt, and the COS/STIS Team)

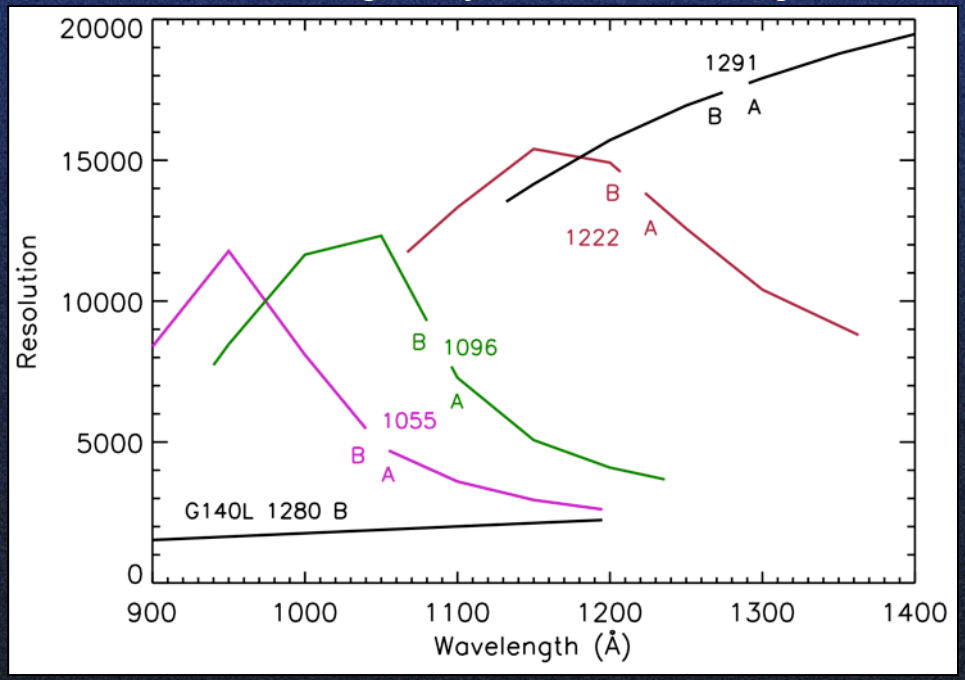


- COS is performing well at its new detector lifetime position.
- Routine science operations at new position started on July 23, 2012.
- Data quality meets expectations.
  - Gain sag ameliorated and “holes” from Ly-α exposure are avoided
  - Resolution 85-90% of that at original position
  - Throughput at all wavelengths within ~ 2% of that at original position
  - Detailed re-calibration observations at new position are being analyzed
-

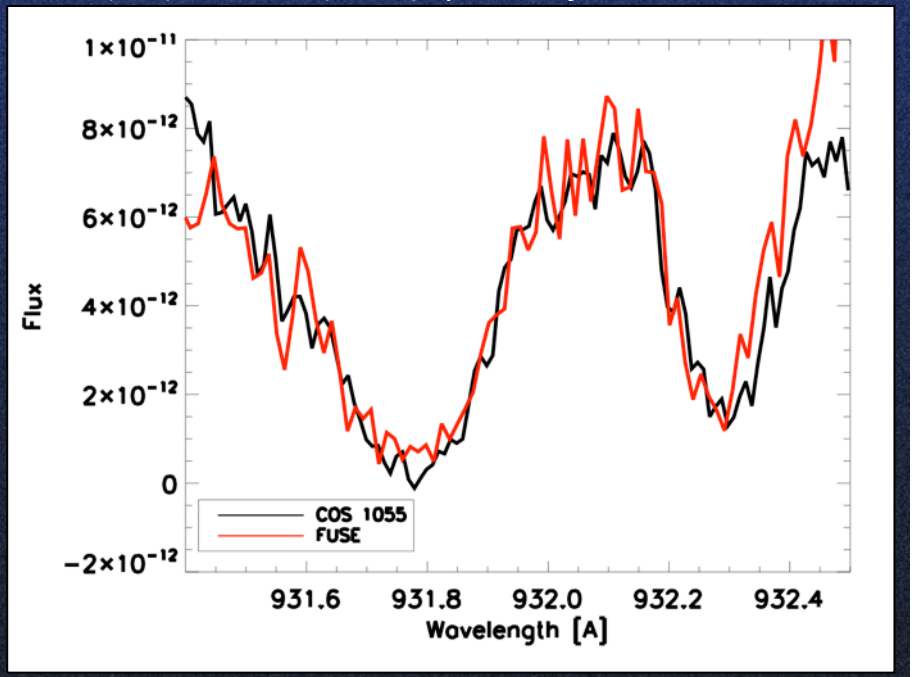
COS G130M
1055 Å and 1096 Å Central Wavelengths

- New focus settings for "blue" 1055 and 1096 COS G130M central wavelength settings provide a dramatic improvement in spectral resolution below 1080 Å.
- Data quality at these wavelengths is comparable to that obtained by FUSE.

Predicted G130M resolution as a function of CENWAVE & segment for the short λ settings.

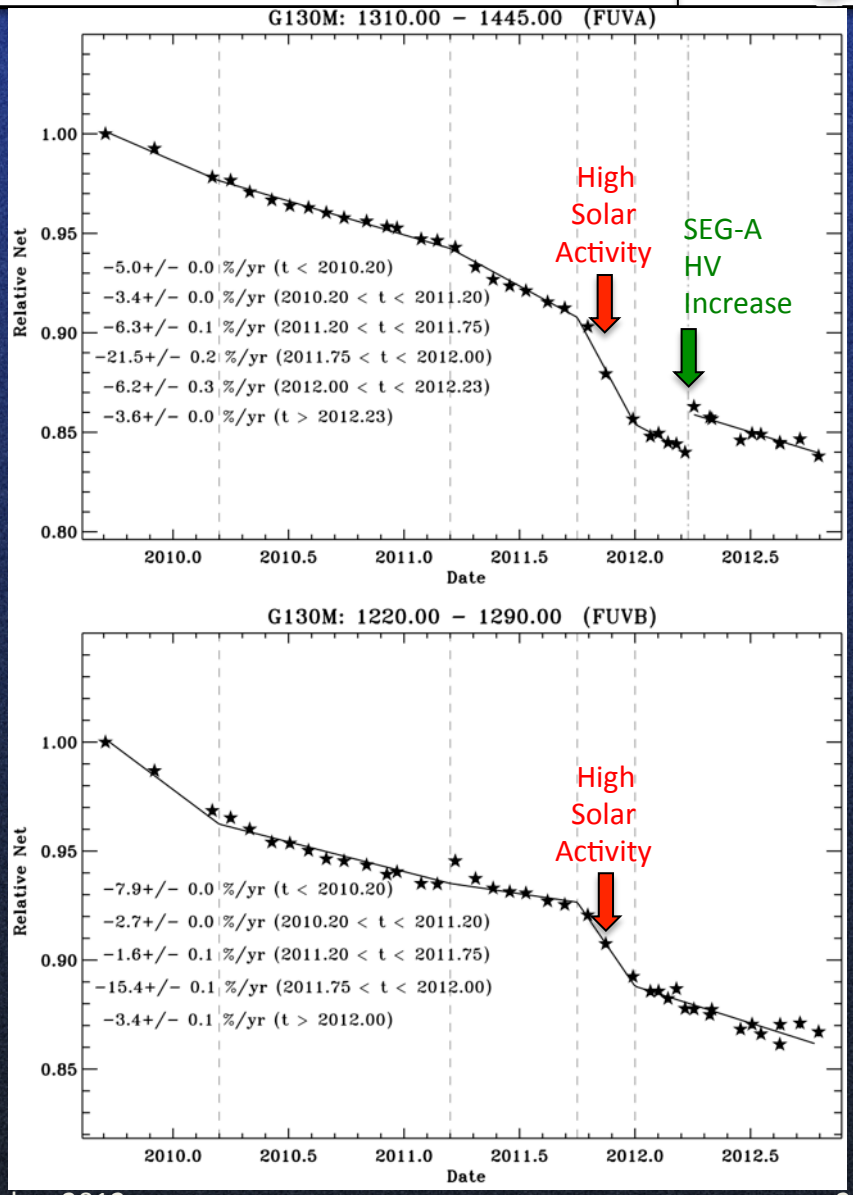


Comparison of observed ISM H_2 lines in FUSE (red) and COS (black) spectra of HD 93205.



COS Time-Dependent Sensitivity

- COS FUV throughput exhibited a steep drop in late 2011 (as much as −20% per year), coincident with a period of very high solar activity.
- Subsequent throughput declines have been much more modest (−4% to −6% per year).
- High voltage increase on segment A in March 2012 caused a small (~2%) increase in QE, as expected.
- Observations at new lifetime position (last three points) appear to be very close to previous trends.



Spectroscopy Workshop

Chairs:
Alessandra Aloisi
and Stefano Casertano

- Current status of spectroscopic observations and data handling
- Optimizing the utilization of spectroscopic data: the community view
- Future HST observations
- Demos and hands-on experience

Joint Calibration Workshop

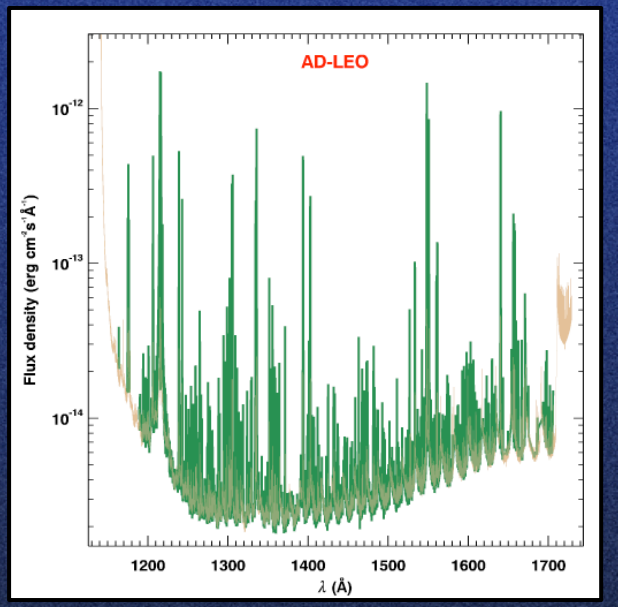
- Calibrations that exploit the capabilities of both HST and JWST
- Astronomical calibration needs
- Cross-observatory calibrations
- Last HST calibration workshop: July 2010

Organizer: Dean Hines

Hubble Legacy Archive
Data Release 7 (November 2012)

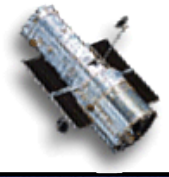
- New Data Products
  - HLSP spectra: 586 spectra from the StarCAT project
  - Additional HLSP from CANDELS, CLASH, PHAT
  - New HLSP imaging products: BORG, ORION, GHOSTS

- *User Interface Enhancements*
  - Scatter plotting tool that allows users to plot the properties of HLA source lists
  - View spectral HLSP through the Interactive Display
  - Faster overlay of catalogs in interactive display
  - Spectrum/line plot tool rewritten in HTML5
  - Line plots now available for HLSP images
  - Footprint view automatically adapts for large or all-sky searches to show filtered sky area

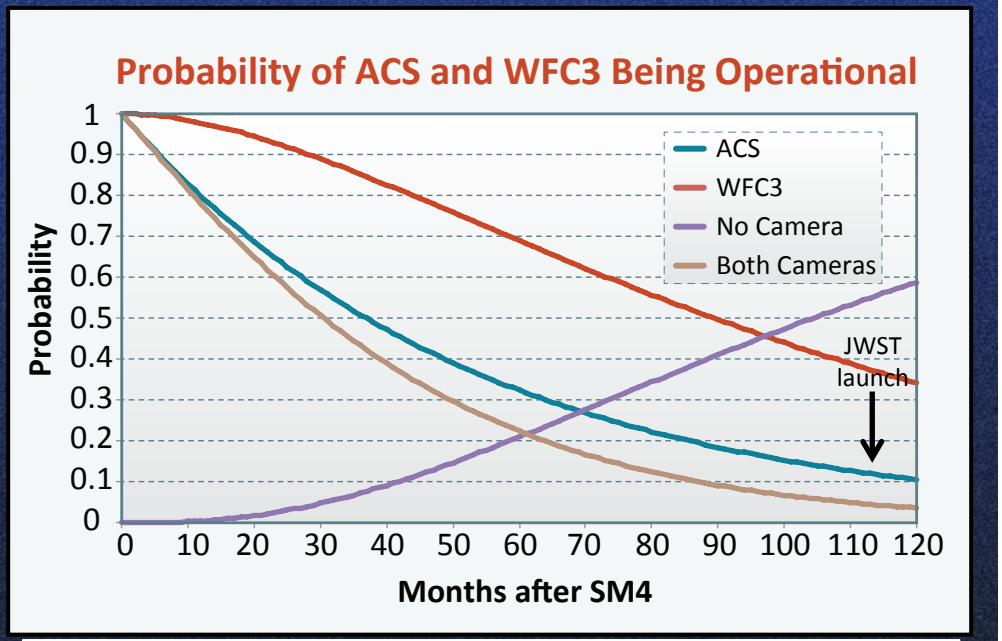


Q: How Long Will Hubble Last?

A: Until it can no longer do cutting edge science

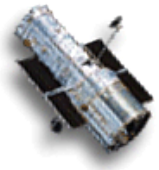


- **Goal**: At least one year of overlap between HST and JWST science operations
  - JWST launch in October 2018, with start of science operations in mid-2019
- Instruments
  - Based on <u>past</u> history, there is ~35% chance of having WFC3 operational at JWST launch
- Subsystems:
  - Prudent management and lifetime extension initiatives
    - Gyros – 3 gyro mode as long as possible to maximize science, then 1-gyro mode to extend lifetime
    - Reaction wheels
    - Transmitters/transponders
    - SI C&DH
    - Solid state recorders
    - Batteries and solar arrays



Probability of having the Hubble cameras operational as a function of time since SM4. Swap ACS and WFC3 with STIS and COS to determine the probabilities of spectrograph operation. (Assumes historical failure rates, which may be pessimistic for the SM4 instruments.)

Preparing for the Out Years



- Planning for FY14-FY16 has begun, with an eye on JWST overlap goal
- Analysis of hardware infrastructure is underway
- Areas of concentrated work effort
  - Data Management Systems and workflow
  - Archive accessibility, data retrieval
  - Archive products (including Hubble Source Catalog – See Whitmore presentation)
- Potential areas of declining effort
  - Science software support – fewer products supported for external community
  - Instrument mode FSW changes/updates – getting closer to steady state support
  - Interface systems (APT, GMS) – fewer updates, more stable systems
- Transitioning of OPO to multi-mission organization (HST <-> JWST)