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

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ehrenreich et al.</td>
<td>Hint of a Transiting Extended Atmosphere on 55 Cancri b</td>
</tr>
<tr>
<td>Grazian et al.</td>
<td>The Size-Luminosity Relation at z = 7 in CANDELS and Its Implication on Reionization</td>
</tr>
<tr>
<td>Bianchi et al.</td>
<td>A Hubble Space Telescope Treasury Study of Star-forming Regions in the Local Group. II. Young Stellar Populations in M31</td>
</tr>
<tr>
<td>Maguire et al.</td>
<td>Hubble Space Telescope studies of low-redshift Type Ia supernovae: evolution with redshift and ultraviolet spectral trends</td>
</tr>
<tr>
<td>San Roman et al.</td>
<td>Newly Identified Star Clusters in M33 - III. Structural Parameters</td>
</tr>
<tr>
<td>Adamo et al.</td>
<td>Revealing a Ring-like Cluster Complex in a Tidal Tail of the Starburst Galaxy NGC 2146</td>
</tr>
<tr>
<td>Brammer et al.</td>
<td>3D-HST Grism Spectroscopy of a Gravitationally Lensed, Low-metallicity Starburst Galaxy at z = 1.847</td>
</tr>
<tr>
<td>Braun et al.</td>
<td>A Hydrodynamic Study of the Circumstellar Envelope of α Scorpii</td>
</tr>
<tr>
<td>France et al.</td>
<td>A Hubble Space Telescope Survey of H$_2$ Emission in the Circumstellar Environments of Young Stars</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instrument</th>
<th>ACS</th>
<th>COS</th>
<th>FGS</th>
<th>FOC</th>
<th>FOS</th>
<th>GHRS</th>
<th>NICMOS</th>
<th>STIS</th>
<th>WFPC</th>
<th>WFPC2</th>
<th>WFC3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>398</td>
<td>36</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>14</td>
<td>85</td>
<td>89</td>
<td>3</td>
<td>217</td>
<td>159</td>
</tr>
</tbody>
</table>
• 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

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Orbits</th>
<th>Diff from Oct 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>13</td>
<td>-0</td>
</tr>
<tr>
<td>18</td>
<td>64</td>
<td>-5</td>
</tr>
<tr>
<td>19</td>
<td>530</td>
<td>-251</td>
</tr>
<tr>
<td>20</td>
<td>2881</td>
<td>+29</td>
</tr>
<tr>
<td>Total</td>
<td>3488</td>
<td>-227</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visits not in current plan</th>
<th>Orbits</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unschedulable</td>
<td>62</td>
<td>-76</td>
</tr>
<tr>
<td>No plan windows</td>
<td>189</td>
<td>+125</td>
</tr>
<tr>
<td>C19 misc (Too, etc)</td>
<td>1</td>
<td>-42</td>
</tr>
<tr>
<td>C20 misc</td>
<td>90</td>
<td>-75</td>
</tr>
<tr>
<td>Total not in plan</td>
<td>342</td>
<td>-105</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Orbits</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFC3</td>
<td>1996</td>
<td>-76</td>
</tr>
<tr>
<td>COS</td>
<td>598</td>
<td>-57</td>
</tr>
<tr>
<td>ACS</td>
<td>524</td>
<td>-64</td>
</tr>
<tr>
<td>STIS</td>
<td>399</td>
<td>-47</td>
</tr>
<tr>
<td>FGS</td>
<td>17</td>
<td>+9</td>
</tr>
<tr>
<td>Total</td>
<td>3534(1)</td>
<td>-235</td>
</tr>
</tbody>
</table>

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

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

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

1. Difference from 10/7
## Long Range Plan
### New Cycle 20 Large & Treasury Programs

<table>
<thead>
<tr>
<th>C20 Large &amp; Treasury</th>
<th>Total alloc</th>
<th>Exec/sched by 11/18/12</th>
<th>Planned before 9/30/13</th>
<th>Planned 10/1/13+</th>
<th>Not in plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bean</td>
<td>60</td>
<td>16</td>
<td>44</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bedin</td>
<td>120</td>
<td>10</td>
<td>110</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cushing</td>
<td>125</td>
<td>0</td>
<td>121</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Gaensicke$^{(1)}$</td>
<td>122</td>
<td>20</td>
<td>91</td>
<td>15</td>
<td>26</td>
</tr>
<tr>
<td>Gladders</td>
<td>107</td>
<td>0</td>
<td>89</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Kirshner (ToO)</td>
<td>100</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>92</td>
</tr>
<tr>
<td>Riess</td>
<td>112</td>
<td>0</td>
<td>83</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>Sabbi</td>
<td>60</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sahu</td>
<td>64</td>
<td>0</td>
<td>56</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

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

STUC - November 2012
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

![Graph showing the relationship between WFC3 signal loss and background level.](image-url)

SOURCES WHERE DEEP IMAGE PREDICTS BETWEEN 85 and 115 e⁻

LOCAL SKY BACKGROUND (e⁻)

STUC - November 2012
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 $\Rightarrow \geq 12e$-
  - 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)
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.
• Charge transfer efficiency 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.
• 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

3×3 FLUX from “truth” image

190e⁻  174  163  172  170  172  168  170
160e⁻  152  137  127  148  155  162
130e⁻  111  110  114  132  114  137
105e⁻  61  65  51  66  60  100
85e⁻  42  65  74  70  76  78
68e⁻  14  60  51  60  77  80
50e⁻  11  64  46  43  46  48
28e⁻  0  14  26
17e⁻  7  10
• 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
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

STUC - November 2012
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 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.
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
• 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 past 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

### Figure 2.2
**Probability of ACS and WFC3 Being Operational**

**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)