HST Mission Office Report

Tom Brown

STUC – 19 May 2022
Hubble Celebrates 32\textsuperscript{nd} Anniversary

STScI-2022-012
**Summary**

- Progress on recent hardware anomalies
- Hubble Advanced Products
- Long-range plan
- Instrument support
- Cycle 30 extended to 14 months (1 Oct 2022 to 30 Nov 2023) to accommodate Webb Cycle 2 support
  - Pool expanded from ~3000 to ~3500 orbits
  - 1062 proposals submitted
  - Cycle 31 will be 10 months and restore normal schedule
- Hubble science ops contract signed (16 Nov 2021)
- Hubble Senior Review
  - Proposal submitted on 8 Feb 2022
  - Review panel held on 15-17 Mar 2022
  - Expect results this summer
Hubble hardware highlights

• Lost minor frame sync signal Oct 23 & 25
  o Instruments safed
  o No repeat of anomaly
  o Mitigations implements in flight software patches
    ▪ COS Dec 21, WFC3 Feb 4, STIS Feb 15, ACS Mar 2
  o Longer term, investigating more robust mitigations

• SIC&DH Side B Failure in mid-2021
  o Operations have continued on Side A
  o Staff are working on restoration of Side B operations to provide redundancy

• COS suspended on April 5
  o Single event upset while passing through South Atlantic Anomaly
  o Instrument quickly recovered to science
Hubble Advanced Products

- Hubble Data Management System began producing Multi-Visit Mosaics on 28 Apr 2022  
  (Single-Visit Mosaics operational Dec 2020)
- Public ACS & WFC3 data drizzled onto grid of pre-defined sky cells
- Separate products for each filter and detector combination, but all on same pixel grid
- Adjacent sky cells can be pieced together using the HAPcut package ([https://mast.stsci.edu/hapcut](https://mast.stsci.edu/hapcut)) or directly from MAST using an API
Long Range Plan Status

Prepared by Dave Adler
Long Range Plan: Current Status

Cycle 29 update

- Through the SMS ending May 15, 2022 averaging: **74.8 orbits/week** over 33 weeks
  - Remove four weeks with no/partial observing due to minor frame sync issue: **82.0 orbits/week** over 29 weeks

Comparison to previous cycles

- **Cycle 28** averaged 75.1 orbits/week over 52 weeks
  - five-week down-time before the SIC&DH Side B->A switch in July 2021
- **Cycle 27**: 85 orbits/week
- **Cycle 26**: 80 orbits/week
  - Three weeks downtime due to Gyro 2 failure
- **Cycle 17-25**: averaged 84 orbits/week

Previous Cycle Completeness

- **Cycle 25**: one 4-orbits from Trappist exoplanet program **15304** (de Wit)
- **Cycle 26**: complete
- **Cycle 27**: 100 orbits left, some as late as spring 2023
  - Over half from large exoplanet programs waiting for opportunities
Cycle 29 LRP: features

- Cycle 29 is full into mid-July 2022
- Current subscription levels drop off from 12 orbits/day to ~9 orbits/day in mid-July 2022 to save room for:
  - Unschedulables/not ready visits
  - ~100 orbits of not-yet-submitted ULLYSES programs
  - Usual number of ToOs, Director’s Discretionary programs, HOPRs, etc.
- If under-subscription still exists in the early summer, programs will be moved up from end of cycle as needed
  - Gives adequate time for Contact Scientist reviews
LRP: Highlights – Exoplanet Programs

Cycle 25-27

• 4 programs (55 orbits) remain
• Highlights:
  − Collecting the Puzzle Pieces: Completing HST's UV+NIR Survey of the TRAPPIST-1 System ahead of JWST (deWit, Cycle 25, 114-orbits)
  − Seeing in 3D: Unlocking the dynamical properties of a canonical exoplanet (Mikal-Evans, Cycle 27, 60 orbits), with a 29-orbit string and 9-orbit string remaining

Cycle 28

• 20 programs, 279 orbits awarded
• 8 programs, 90 orbits left

Cycle 29

• 21 programs; 403 orbits allocated
• 13 programs/179 orbits contain period/phase constraints, limiting scheduling opportunities
  − 32 orbits have executed to date.
• Highlights:
  − Essential Ultraviolet Stellar Characterization for Cycle 1 JWST Transiting Planet Targets (Youngblood, 110 orbits)
  − Cloudy mornings and clear afternoons: mapping atmospheric dynamics at the limbs of an exceptional hot Saturn (Rustamkulov, 23 orbits)
  − A comparative study of atmospheric escape in the brightest system of super-earths straddling the evaporation valley (Ehrenreich, 35 orbits)
LRP: Highlights – Solar System Programs

Cycle 28:
- 2 orbits of moving targets currently in the operational plan

Cycle 29:
- 12 programs, 216 orbits allocated at cycle start
- 10 programs, 171 orbits currently remaining in the plan

Highlights:
- A combined HST and JWST study of the composition of the faintest trans-Neptunian objects: Testing hypotheses for the formation of the Solar System (Trilling, 99 orbits)
- OPAL: Outer Planet Atmospheres Legacy (Simon, 41 orbits)
- Observing Jupiter's FUV auroras during the Juno Extended Mission (Nichols, 18 orbits)
- Characterization and Temporal Evolution of the Ejecta Created by the DART Impact on Dimorphos (Li, 19 orbits)
- Characterization and Temporal Evolution of the Ejecta Created Are the surfaces of the large moons of Uranus modified by charged particle bombardment? (Cartwright, 16 orbits)
LRP: Highlights

Other programs of note

• **Two large M31 programs:**
  • Mapping Andromeda's Inner Circumgalactic Medium (**Lehner, 137 orbits**).
    • 37 executed, 100 left
  • The Panchromatic Hubble Andromeda Southern Treasury (PHAST) (**Williams, 195 orbits**)
    • 72 executed, 123 left

• **Reverberation program:**
  • Shedding light on light echoes: mapping the accretion disk and broad line region in Mrk 279 (**Chelouche, 50 orbits**)
  • All visits in a 40-day period, with a visit every 0.7-0.9 days. But as STIS MAMAs, they can only schedule in SAA-free times
  • Might execute in November/December 2022

• **Joint HST-JWST TNO search**
  • A combined HST and JWST study of the composition of the faintest trans-Neptunian objects (**Trilling, 99 orbits**)
  • Must be done with minimal interruption, over 10-11 days
  • Simultaneous coordination with 45-hour JWST program
  • Currently planned for December 2022.
**ULLYSES**

**HST UV Legacy Library of Young Stars as Essential Standards (ULLYSES)**

- **Cycle 28** programs mostly done
- **Cycle 29** – not all have been submitted; numbers are as of 5/6/22

<table>
<thead>
<tr>
<th>Program(s)</th>
<th>alloc</th>
<th>progs</th>
<th>Exec/sched by 5/15/22</th>
<th>Planned before 10/1/22</th>
<th>Planned after 10/1/22</th>
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<tbody>
<tr>
<td>C27 Dwarf Galaxy</td>
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<tr>
<td>C28 LMC</td>
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<td>C28 SMC</td>
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## Large/Treasury programs

### Remaining Cycle 25-28 Large Programs

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<th>C25-28 Program</th>
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<tr>
<td>deWit</td>
<td>114</td>
<td>109</td>
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<td>Kelly (c27-c28)</td>
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<tr>
<td>Jones</td>
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<td>7</td>
<td>GULP; 1 not in plan</td>
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## Large/Treasury programs

### Cycle 29 Large Programs

<table>
<thead>
<tr>
<th>C29 Program</th>
<th>alloc</th>
<th>Exec/sched by 5/15/22</th>
<th>Planned before 10/1/22</th>
<th>Planned after 10/1/22</th>
<th>comment</th>
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<tbody>
<tr>
<td>Pala</td>
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<td>19</td>
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<td>26</td>
<td>22 orbits of ToO; 62 not in LRP</td>
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<tr>
<td>Levan</td>
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<td>0</td>
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<tr>
<td>Youngblood</td>
<td>110</td>
<td>28</td>
<td>65</td>
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<td>Exoplanets; 2 not in LRP</td>
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<td>99</td>
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<tr>
<td>Lehner</td>
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<td>0</td>
<td>M31; 2 not in LRP</td>
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<td>Williams</td>
<td>195</td>
<td>72</td>
<td>78</td>
<td>45</td>
<td>M31-PHAST</td>
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</table>
ACS Developments since the October STUC Meeting

ACS continues to operate nominally. (Celebrated 20 yrs service in March)

- Continued stable WFC readnoise since Jul 2020 AmpD glitch (upper left); slow trending of WFC dark current & CTE
- WFC pixel stability monitoring (upper right) shows steady 99.8% usability
- CAL observations to commission new spectropolarimetry mode (lower left)
- Early onset of elevated SBC dark current has returned (lower right); schedulers will avoid back-to-back SBC orbits
ACS Highlights of Recent & Ongoing Work

- Assessment of sky backgrounds in ACS/WFC broadband filters for the ACS ETC
  - ACS/WFC history provides many tens of thousands of sky-background estimates
  - Derived sky-background rates include careful statistical pruning of crowded and/or nebular fields
  - Distribution functions of WFC sky background compared against ETC estimates
  - For the redder WFC broadband filters, the measured sky background rates increasingly fall below the ETC predictions, especially severely in the case of F850LP (similarly for WFC3/UVIS)
  - ACS team working with ETC developers to improve sky-background estimates for GOs

- Commissioning nearly complete for new ACS observing mode: WFC spectropolarimetry
  - Crossing the WFC grism filter (G800L) with the polarizer filters (POL0V; POL60V; POL120V)
  - New ACS CAL observations of radio galaxy 3C 234 obtained at multiple position-angles
  - Wavelength calibration excellent; flux calibration shows polarizer efficiency fall-off beyond 0.8μm
  - Goal is to advertise Optical/NIR (0.55-0.85μm) grism spectropolarimetry capability in C31 CfP
New ACS Documentation since the Oct’21 STUC Meeting

- ISR ACS 2021-02 : “Long-term Monitoring of the ACS Tungsten Lamp Brightness” (Cohen & Grogin)
- ISR ACS 2022-01 : “Revisiting ACS/WFC Sky Backgrounds” (Anand et al.)
- ISR ACS 2022-02 : “Fading Hot Pixels in ACS/WFC” (Ryon et al., in prep.)
- ISR ACS 2022-03 : “One-Pass HST Photometry with hst1pass” (Anderson et al., in prep.)
- TIR ACS 2022-01 : “Python Build of the IDC Table Generator for ACS/WFC” (Hoffmann et al.)
- ACS Instrument & Data Handbooks for Cycle 30 [both available in HDox format]
- “Advice for Planning ACS Observations – HST Cycle 30” (Lucas et al., in prep.)
COS General Updates

- COS is Operating Nominally
  - Time Dependent Sensitivity trends constant; approaching 5% flux calibration spec, update planned this year
  - FUV and NUV dark rate increased by ~10%
  - LP4 FUVB high voltage (HV) will be increased to 175 in the next months (highest approved HV)

- New reference files:
  - Update to FUV FLUXTAB (new CALSPEC models and Vega zeropoint)
  - Update to SPOTTAB to mask transient hotspot in background region of LP4

- Documentation since September 2021: 5 STANS, 5 ISR, and COS IHB v14
  - IHB: Updates on LP6, choosing G160M lifetime position, and split-wavecals information

<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
<th>Number</th>
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<tbody>
<tr>
<td>W. Fischer et al.</td>
<td>Cycle 27 COS NUV Spectroscopic Sensitivity Monitor</td>
<td>ISR 2021-09</td>
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<tr>
<td>W. Fischer et al.</td>
<td>Cycle 27 COS FUV Wavelength Scale Monitor</td>
<td>ISR 2021-10</td>
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<tr>
<td>W. Fischer et al.</td>
<td>Cycle 27 COS NUV Wavelength Scale Monitor</td>
<td>ISR 2021-11</td>
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<tr>
<td>C. Johnson et al.</td>
<td>COS FUV Detector Gain Maps Obtained at the Start of LPS Operations</td>
<td>ISR 2021-12</td>
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<tr>
<td>D. Dashtamirova et al.</td>
<td>Cycle 27 COS FUV Dark Monitor Summary</td>
<td>ISR 2022-01</td>
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</tbody>
</table>
**Reminder: The COS2030 Plan**

- Now operating multiple lifetime positions at the same time: LP2, LP3, LP4, & LP5
- LP6 Operations begin with Cycle 30 for G160M exposures

<table>
<thead>
<tr>
<th>Date</th>
<th>Blue Modes</th>
<th>G130M-1222</th>
<th>G130M-1291 + 1300s</th>
<th>G160M-short</th>
<th>G160M-long</th>
<th>G140L</th>
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<td>5</td>
<td>4</td>
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<td>4</td>
<td>6</td>
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<td>Late 2026</td>
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<td>4</td>
<td>6</td>
<td>2→?</td>
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<td>Late 2028</td>
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<td>4→6</td>
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# LP6 (G160M) timeline with start Cycle 30 October 2022

<table>
<thead>
<tr>
<th>LP6 Activity</th>
<th>Programs</th>
<th>Status</th>
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<tr>
<td>FSW &amp; commanding</td>
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<td>SIAF</td>
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<td>Complete</td>
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<td>TRANS</td>
<td>N/A</td>
<td>Available restricted, update summer</td>
</tr>
<tr>
<td>APT</td>
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<td>Available restricted, update summer</td>
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<tr>
<td>End to End test</td>
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<td>Complete</td>
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<td>LP6 Pipeline</td>
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<td>Focus</td>
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<td>Target Placement</td>
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<tr>
<td>Target ACQ Parameters (FUV spectroscopic ACQs)</td>
<td>16851</td>
<td>V1 in hand, V2&amp;V3 data in summer, V4: data taken at start of Cycle 30</td>
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<tr>
<td>Profiles and Traces</td>
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<td>Observations finish May 14, 2022</td>
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<td>Sensitivities and Flat Fields</td>
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<td>Lamp Templates</td>
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<tr>
<td>Gain Maps</td>
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<td>Code V model LSFs and PSFs</td>
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<td>In progress</td>
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<tr>
<td>Bad Pixel Table</td>
<td>16829, 16472</td>
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Future Work FY22

- Calibrate LP6
- Update time dependent sensitivity (new slope and/or break point)
- Start work on HV sensitivity correction in pipeline
- Geometric and walk correction effort is now ramping up, large effort in FY23
- Cycle 30 calibration programs and contact scientist support
- Additional python notebook tutorials (co-addition of spectra, exception report)
- Begin Hubble Spectroscopic Legacy Archive (HSLA) revamp including COS & STIS
- Develop, upgrade, & document additional monitors (e.g., new hot spot monitor)
- Support Pandeia ETC development
STIS Status

General Status

• STIS Operating nominally, though at slightly elevated temperature
  → Slightly higher than nominal dark rate in CCD
  → Marginal degradation in CCD dark correction

Documentation

• 2 ISRs published; 1 under review will be published soon
  • ISR 2022-01: Long-Term Rotational Evolution of the STIS CCD Flatfields (K. Ward-Duong et al.)
  • ISR 2022-02: STIS CCD & MAMA Full Field Sensitivity & Its Time Dependence (L. Prichard)
  • ISR 2022-03 (under review): Comparison of STIS CCD CTI Photometric Calibrations (L. Prichard)

• 2 STANs published (March, April 2022)
• IHB Updates for Cycle 30
Flux Recalibration – 1st Delivery April 2022

• On-going work to bring sensitivity of all STIS modes onto the CALSPEC v11 standard

• Modes updated in 1st Delivery
  • **FUV**: G140L, E140M
  • **NUV**: G230L
  • **CCD**: G230LB, G430L
  • All above modes have a single cenwave

• 10 modes planned for 2nd Delivery
  • **FUV**: G140M/1222
  • **NUV**: G230M/1933, E230M/1978, 2707, & 2415
  • **CCD**: G750L, G430M/3936 & 4194, G750M/7283 & 8561

Project status: [https://www.stsci.edu/hst/instrumentation/stis/flux-recalibration](https://www.stsci.edu/hst/instrumentation/stis/flux-recalibration)
New Jupyter Notebook Repository

- STIS has a new GitHub Repository for Jupyter notebooks, with 2 notebooks:
  - Previously released Coronagraphy Visualization notebook moved over
  - A new Jupyter notebook tutorial demonstrates how to use DrizzlePac with STIS data, including
    - CTI correction
    - image alignment
    - drizzling
- A STIS intern will be joining this spring (@50% time for a year) to further populate notebooks
- Repository Link: [https://github.com/spacetelescope/STIS-Notebooks](https://github.com/spacetelescope/STIS-Notebooks)
On-Going/Future Work

A deeper look at CCD Anneals

• A new technical team member is working on updating the CCD Anneal Monitor
• An exploratory project tested unsupervised machine learning algorithms to classify CCD pixel behavior during a single anneal → future work will span multiple anneals

Additional Future Work:

• Work recalibration imaging modes will begin later this year
• Plans for a stand-alone tool to inter-combine STIS echelle data
WFC3 Highlights

WFC3 operating nominally
- About 309,000 WFC3 images in MAST archive
- Post-Nov 2021 safing recovery data normal

WFC3 Quicklook system improved

Addressing IR time-variable background in calwf3
- ID presence of time-variable background
  - HeI or scattered Earth limb light
- Encode results in image header keywords to alert observers
- Procedures/notebooks to correct affected data
  - ISR 2014-13, ISR 2016-16, DHB, Software Library
- Next: calwf3 automatic correction
WFC3 Highlights

Updated TrExoLiSTS
- Landing page for planning observations
- Includes staring and scanning mode data
- Each target connects to exoMAST entry, WFC3 direct Image, white light curve, XY drift map

UVIS scanned standard star data (ISR in prep)
- 5 wide near-UV filters + F606W, F814W
- Scans 2-3x precision over staring mode
- Trend: 0.1-0.2%/yr decline
- Hints of decline slowing, more data will tell

UVIS encircled energy (ISR 2022-02)
- Five filters added (F336W, F200LP, F350LP, F775W, and F850LP)
  - plus incorporated time-dependent sensitivity
- Improved values for 2 chips: agree to ~0.1%
- UV EE now in better agreement with Hartig 2009 solution
Application of machine learning to UVIS ghosts (ISR 2022-03)

- Exploratory analysis for anomaly detection
- Five different models: 54–83% accuracy
- Significant work remains
- Includes software repository of ML models + tutorials

WFC3/IR spatial scan data

- High-precision measurements of M35 open cluster
- Through 2021: -0.02 %/year +/- 0.008 (ISR 2021-05)
- New data from 2022: F140W shows ~ -0.07%/yr
  Consistent with G141 grism flux trend
  (-0.06%/yr +/- 0.01, Bohlin)

<table>
<thead>
<tr>
<th>Model</th>
<th>Number of trainable parameters</th>
<th>Training time</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>TP</th>
<th>Test Accuracy</th>
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<tbody>
<tr>
<td>Synthetic</td>
<td>4.2M</td>
<td>1.5H</td>
<td>0.98</td>
<td>0.02</td>
<td>0.01</td>
<td>0.99</td>
<td>54%</td>
</tr>
<tr>
<td>A</td>
<td>2.1M</td>
<td>1.5H</td>
<td>0.93</td>
<td>0.07</td>
<td>0.13</td>
<td>0.87</td>
<td>83%</td>
</tr>
<tr>
<td>B</td>
<td>1.07M</td>
<td>1H</td>
<td>0.99</td>
<td>0.01</td>
<td>0.12</td>
<td>0.88</td>
<td>78%</td>
</tr>
<tr>
<td>C</td>
<td>160K, 130K (for transfer)</td>
<td>1H, 15m</td>
<td>0.94</td>
<td>0.06</td>
<td>0.25</td>
<td>0.75</td>
<td>79%</td>
</tr>
<tr>
<td>D</td>
<td>2.12M, 2.10M (for transfer)</td>
<td>1H, 15m</td>
<td>0.65</td>
<td>0.35</td>
<td>0.09</td>
<td>0.91</td>
<td>62%</td>
</tr>
</tbody>
</table>
WFC3 Highlights

IR sensitivity

- Staring mode for external clusters
  - F110W, F160W
  - Aperture photometry: -0.1 to -0.2 %/yr

- Grism integrated fluxes through 2021
  - All: -0.136, -0.066 %/yr +/- 0.01 for G102, G141
  - FOV center only: -0.12, -0.06 %/yr +/- 0.01

- Astrometry data – best time coverage
  - Crowded field (Omega Cen core)
  - ePSF analysis: -0.23 %/yr +/- 0.03 (ISR 2020-05)

Persistence effects?
Without previous IR: -0.01%/yr +/- 0.06
User support/documentation

- Instrument Handbook (Jan 2022)
- STAN (Jan 2022; next one: June 2022)
- 2021 ADASS meeting: virtual talk on WFC3 IR Blob Classification

Software
- Additions to Jupyter notebooks
- New repository for machine learning tests (DeepWFC3)

Instrument Science Reports
- 2022-03   UVIS Figure-8 Ghost Classification using CNNs (Dauphin et al.)
- 2022-02   UVIS Encircled Energy (Medina et al.)
- 2022-01   Cold and Unstable Pixels in WFC3/IR (Khandrika)
- 2021-16   UVIS Deuterium Lamp and Filter Performance 2009-2021 (Kuhn et al.)

- Submitted to AJ : Photometric Calibration of the WFC3 Detectors (Calamida et al.)
- Imminent
  - Jupyter notebook to assist observers who receive an Exception Report
  - ISR 2022-07 Monitoring UVIS Photometric Sensitivity with Spatial Scans
The Hubble Team is working to maximize the integrated scientific productivity over the next decade

Thank you for your insights & support