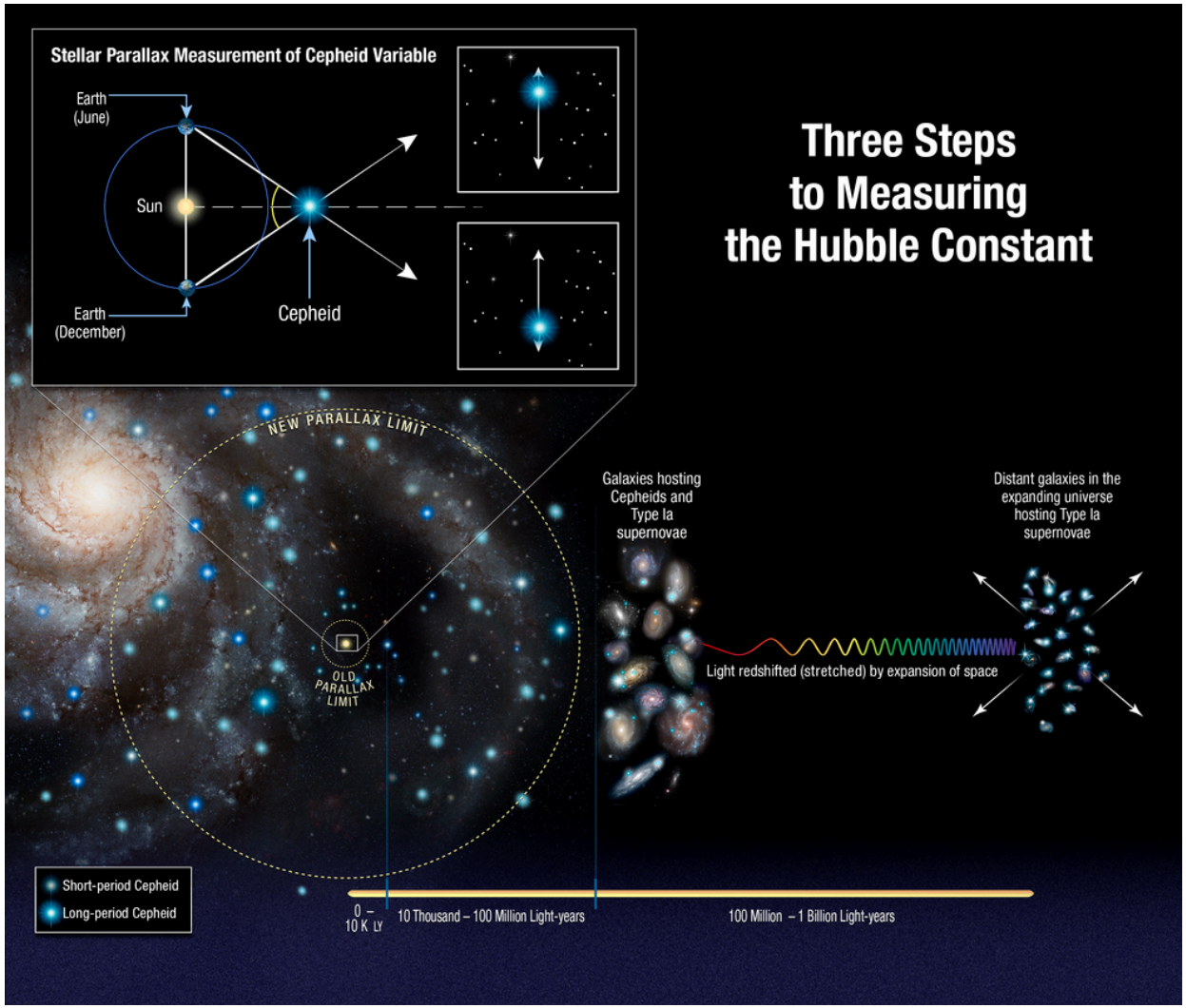
Goddard Space Flight Center

HST/GSFC Project Report



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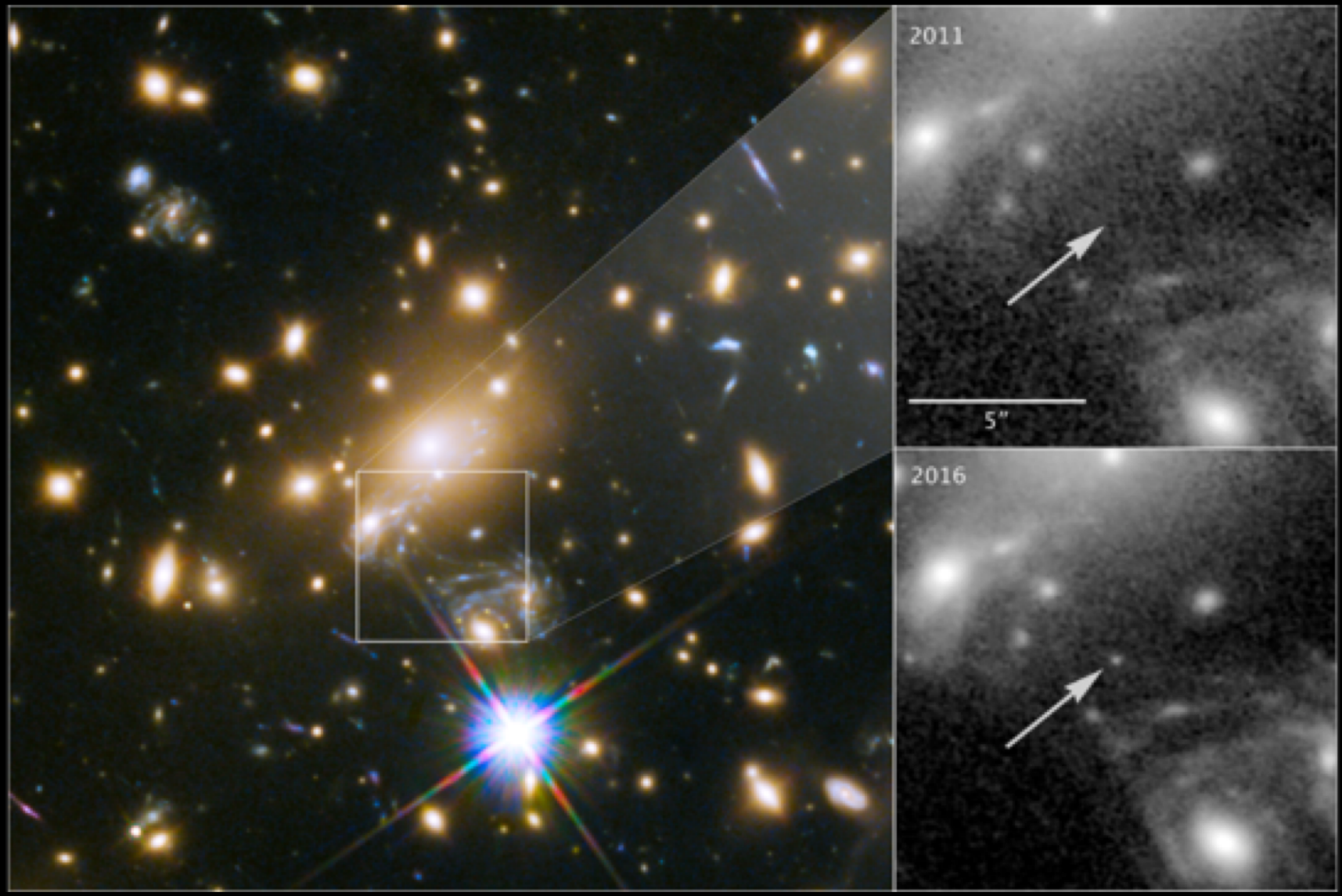
Space Telescope Users Committee Meeting
April 19, 2018

Agenda

- Science highlights
- Outstanding scientific productivity
- Observatory Status
- Mission Operations
- Budget Status

ICARUS: Farthest Individual Star Ever Seen!



NASA, ESA, and P. Kelly (University of Minnesota)

Spiral Galaxy NGC 1309

Hubble Heritage

NASA, ESA, The Hubble Heritage Team (STScI/AURA), and A. Riess (STScI)
Hubble Space Telescope ACS • STScI-PRC06-07


No Dark Matter?
NASA, ESA, and P. van Dokkum (Yale University)

Project Science – Looking Ahead

Prepare for Senior Review and beyond: What's the best use of Hubble in its remaining years?

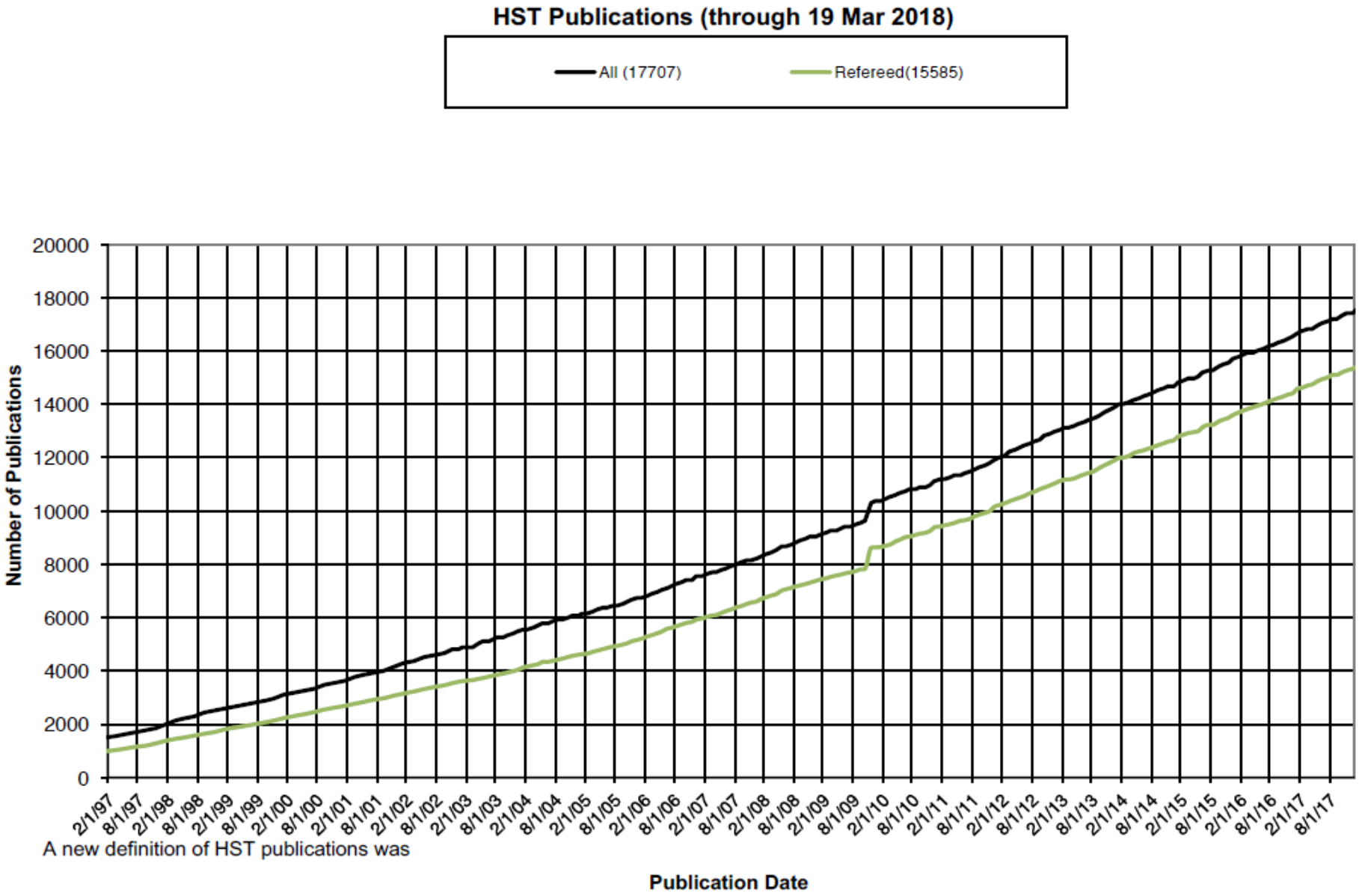
- **Continue to center Hubble in Agency goals and vision**
- **Maximize Hubble's complementary science achievements with other missions (Chandra, JUNO, ALMA, etc.) – look for unique opportunities while multiple observatories operating**
- **Hubble in preparation for JWST**
- **Hubble in complement to JWST**
- **Support strong and continuing Hubble science productivity**
- **Encourage innovative uses of Hubble (spatial scanning, etc.)**
- **Public Outreach -- Hubble's Science is diverse, of broad interest, and continues**

Hubble Inspires People a Lot Younger Than Hubble!

Secondary School Students, New Zealand

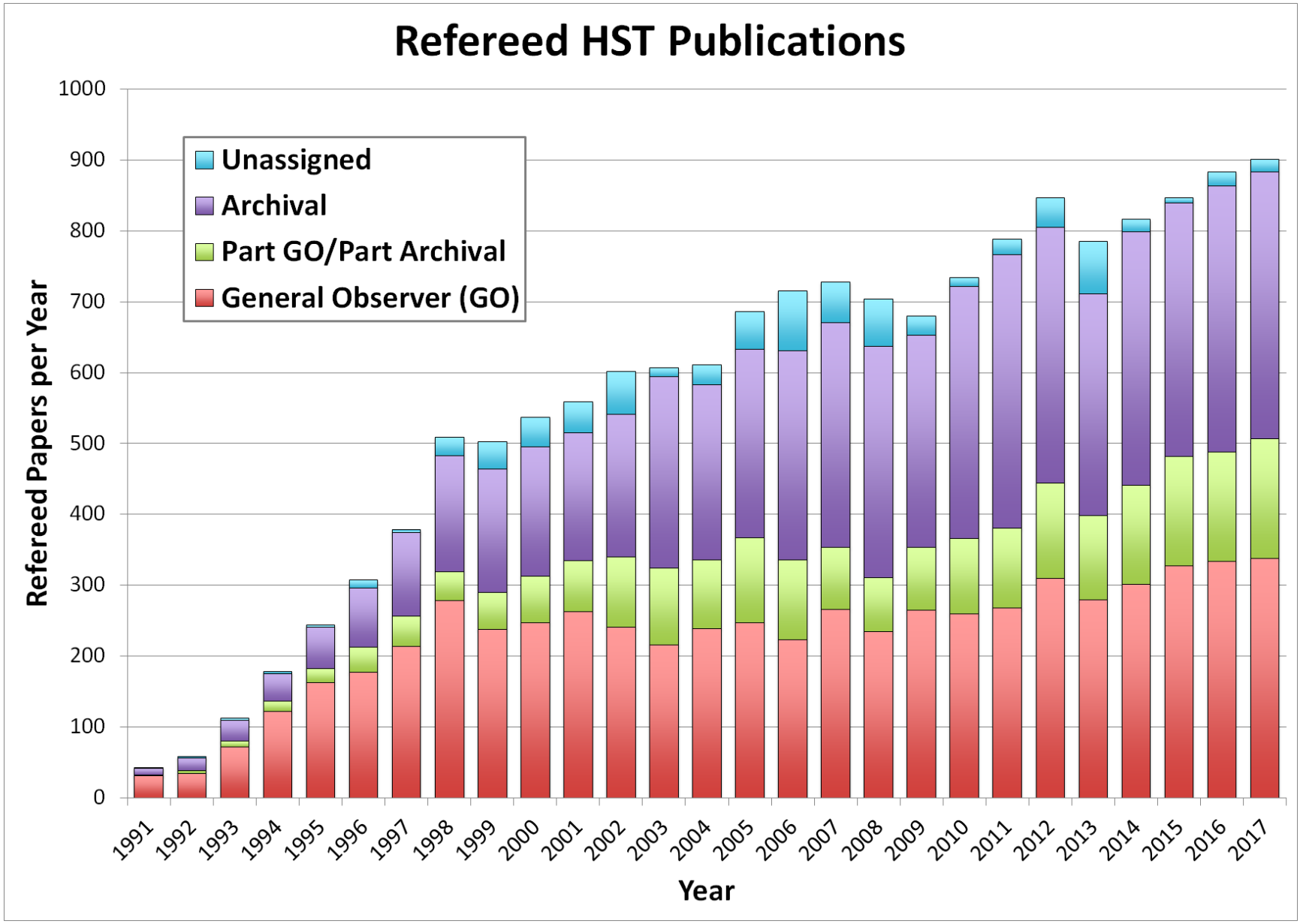
HST Science Productivity

3/31/18



HST Publications

3/31/18



HST Observatory Status

3/31/18

Subsystem		Summary
Science Instruments (SI)	G	• WFC3 performance excellent; Channel Select Mechanism (CSM) movements have been significantly reduced without science impact, and appearance of dust particles on the optic are being monitored; no impact to science; No new recommendations from January 2018 Tiger Team meeting, continue monitoring • COS – Moved to 4th position 10/2017; COS 2025 initiatives should extend 4th lifetime to ~2023 – FUV detector sensitivity monitoring continues following completion of sensitivity ARB closure 4/2011 • ACS and STIS repaired instruments (SM4) performing nominally • NICMOS in standby following decision to not restart following Cycle 19 proposal evaluations
Electrical Power System	G	• Excellent battery performance; 510 Amp hour benchmark; raised voltage temperature cutoff 80mV on March 1 • Solar Array 3 performance remains excellent • Solar Array Drive Electronics (SADE) investigation following 2/15/13 SWSP completed; no further actions
Pointing Control System	G	• Gyro 5 failed on 3/7/14; Gyro 6 powered off 3/13/14; Operating in 1-2-4 configuration; Gyro 3 removed from control loop and powered off in 2011; all gyros configured to operate on secondary heater controller • Motor current increases; G4 120 mA to 190 mA in 9/2011; G2 increased to 165 mA on 11/8/15, and G1 to 202 mA on 11/11/15; G2 to stall (310 mA) and back to 212 mA on 10/19/17; ~220 mA 11/15/17 • Elevated Motor Current Tiger Team-recommended autonomous running restart flight software installed 6/2016; executed on 10/19/17 when G2 exceeded 310 mA, returned to 212 mA • Attitude Observer Anomaly (AOA) (ARB report 10/2011) mitigation completed 11/2012 • FGS-3 bearings degraded (~10% duty cycle to preserve life); FGS-2R2 Clear Filter operations began 1/2015
Data Management System	G	• SI Control and Data Handling (C&DH) has had 12 lockup recoveries since 6/15/09; most recent was 1/19/18 • SI FSW enhanced to protect detectors from SI C&DH lock up events • Science Data Formatter (SDF) input cycling modified to reduce thermal load • Solid State Recorders (SSRs) 1&3 each experienced lock up in 2011 in the South Atlantic Anomaly (SAA); SRR3 experienced another lockup in SAA on 1/9/18; Alert monitors detect condition to minimize data loss
Communications	G	• Multiple Access Transponder 2 (MAT2) coherent mode failed (12/24/2011); Two-way tracking unavailable • Joint Space Operations Center (JSpOC) now the source for the operational ephemeris via Conjunction Avoidance Risk Assessment (CARA) team and the Flight Dynamics Facility
Thermal Protection System	G	• New Outer Blanket Layers (NOBLs) installed on Bays 5,7, and 8 during SM4 • Thermal performance is nominal

Mission Operations – Gyro Run Time Performance

3/31/18

Current Gyro Runtimes

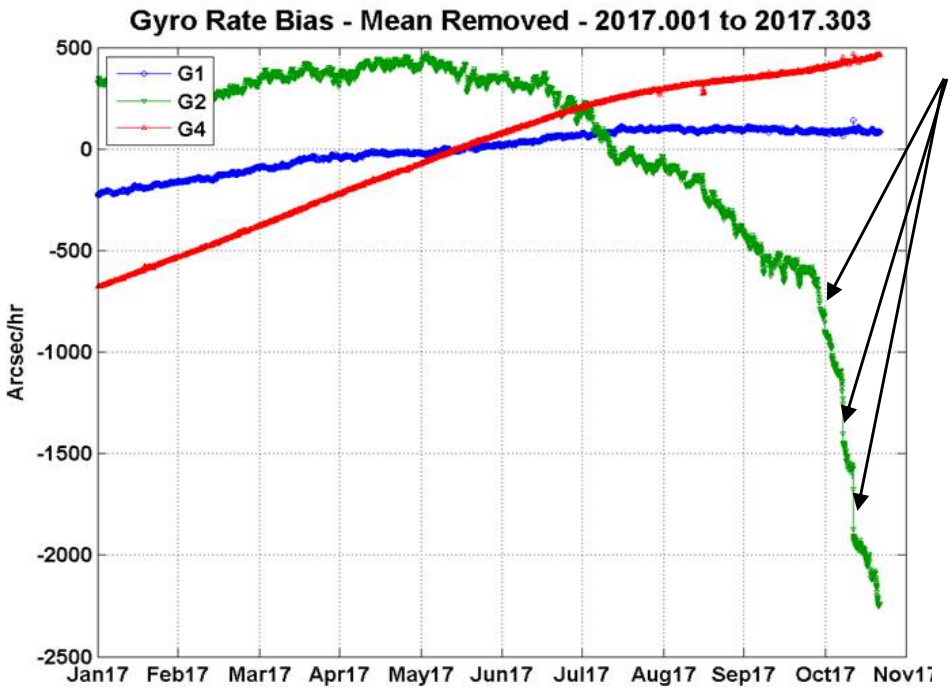
Post SM4 RGA	Status	Flex Lead	Total Hours 2018/090
G1	On	Standard	42868
G2	On	Standard	43040
G3	Off – AOA 2011	Enhanced	22353
G4	On – Max Hrs	Enhanced	88337
G5	Failed 2014	Standard	51497
G6	Off	Enhanced	35945

Previous Flex Lead Failure Runtimes

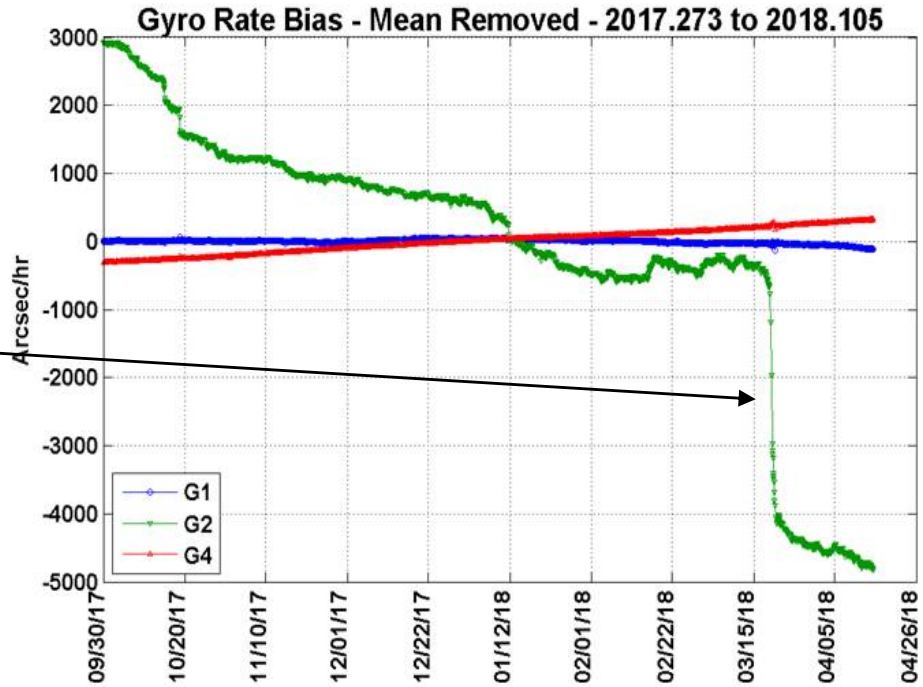
Date of Failure	Gyro	Flex Lead	Total hours at failure
1992.281	G6	Standard	34825
1997.099	G4	Standard	31525
1998.295	G6	Standard	46276
1999.110	G3	Standard	51252
1999.317	G1	Standard	38470
2007.243	G2	Standard	58039
2014.066	G5	Standard	51497

Maximum runtime hours (current G4)	88,337
Minimum runtime hours (SM3A G5, rotor restriction)	13,857
Mean runtime hours for 6 current onboard gyros	47,340
Mean runtime hours for all 22 HST operational gyros	42,998
Mean runtime hours for the 7 HST flex lead failure gyros	44,555

Mission Operations – Gyro-2 Performance



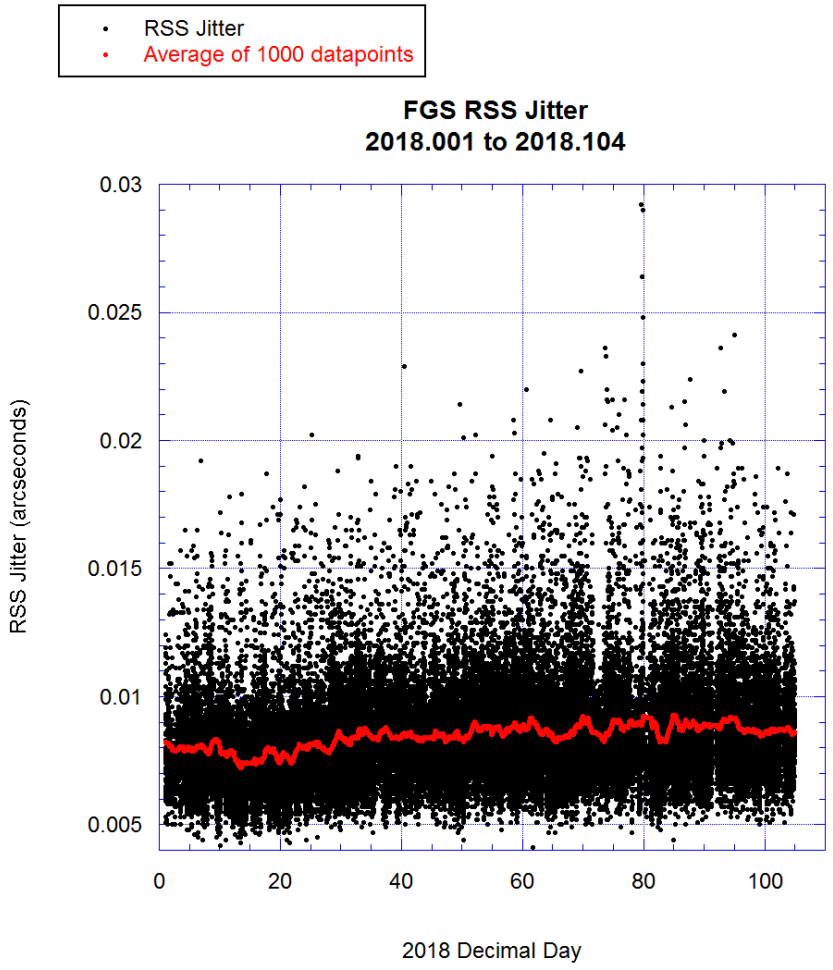
- Large bias shifts occurred in October 2017
- Motor current increase triggered onboard Running Restart software on October 19, 2017
- Nominal, noisy performance was restored and continued through mid-March 2018



- Very large bias shift occurred in March
- Lost half-day of targets prior to successful ground intervention restored successful target acquisitions
- Nominal, noisy performance has continued since

Gyro-2 performance and Jitter

- HST boresight jitter due to gyro-2 high frequency noise has been increasing since early 2017, and average is currently ~9 mas rss
- Mission and Science Operations are monitoring the performance and evaluating the threshold to change the operational configuration ahead of an actual gyro-2 failure



Gyro-2 Mission Operations Updates

- **FGS Acquisition Timing Changes**
  - Large Gyro-2 rate bias shifts are causing the FGSs to search a larger area during the Re-acquisition sequence, thus taking more time to find the stars and subsequently set the Fine Lock Status signal (Take Data Flag or TDF)
  - Most of the Science Instrument Detector modes do not begin exposing if the TDF is down at the start of the exposure, resulting in lost science data
  - Mitigations have been implemented that utilized time margin in the on board re-acquisition logic and the science target scheduling system to successfully address this issue, and performance continues to be monitored.

- **Scale Factor Updates**
  - Gyro-2 scale factor continues to change requiring the uplink of new gyro scale corrections on a periodic basis, with the last update in March
  - The updates are to the gyro 2 linear scale correction trend fit and the non-linear scale factor trend fit for all 3 gyros
  - The uplinked values are computed by extrapolating the scale factor trends out ~ 60 days which allows for less frequent updates

HST Engineering Activities

4/9/18

- **Solid State Recorder (SSR)-3 Anomaly Investigations**
  - Experienced uncorrectable EDAC errors in November that are believed to be caused by intermittent failure of the 1773 Bus Controller to receive an acknowledgement signal from the Remote Terminal at Memory Card 2
    - Errors were not present when data was re-dumped
    - SSR was reconfigured in late November to initiate the transfers using the secondary bus in the recorder. No uncorrectable EDAC errors have been observed following the reconfiguration.
    - Developing operations procedures to provide capabilities to reconfigure the bus logic in the event additional failures occur
  - SSR-3 also experienced a 1773 Bus Lock-up event in January
    - Believed to be associated with an SEU occurring in conjunction with processing of a flight software SKIP command
    - A power cycle of the unit was required to recover from the lock-up. As a result, all science data on the recorder at the time of the event was lost.
    - A contingency procedure to quickly recover from SSR3 bus controller lockups has been developed
    - A 1773 bus watch-dog concept is being considered to autonomously reset the bus upon detection of a lock-up condition; creation of the watchdog patch will not be pursued until another SSR latch-up event occurs
    - HST486 FSW group is preparing a development and test environment to support future SSR software maintenance

HST Engineering Activities

4/9/18

- **Space Telescope Imaging Spectrograph flight software update April 23**
  - Updates the CCD Bias value to improve faint target acquisitions
- **Cosmic Origins Spectrograph flight software updates in September**
  - LV060 contains an expansion of the number of available central wavelength settings for each FUV grating
  - LV 061 Patch release contains focus values for two new Central Wavelength Modes
    - Two new slots provided via LV0060, will contain a G160M mode central wavelength that overlaps with the red end of G130M/1222A and a G140L mode that places the full G140L spectrum on FUV Segment A; provides more efficient observational strategies consistent with the COS2025 initiative
- **Spacecraft flight software update in November**
  - The release includes the new Diagnostic Data Recorder, logic to perform autonomous gyro scale factor updates, as well as an update to the safemode recovery macros
- **General support upgrades**
  - Updated the Control Center PCs from Windows 7 to Windows 10
  - Finalizing re-host of obsolete Technical Management Information System (TMIS)

Budget Status

- **Budget Outlook**
  - FY17 appropriated budget was $97.3M

$M	FY18	FY19	FY20	FY21	FY22	FY23	FY24
PPBE-18	$98.3	$98.3	$98.3	$98.3	$98.3	$98.3	
PPBE-19	$83.3	$88.3	$88.3	$93.3	$98.3	$98.3	
PBR-19	$83.3	$78.3	$88.3	$93.3	$98.3	$98.3	
PPBE-20	$98.3	$78.3	$88.3	$93.3	$98.3	$98.3	$98.3

  - Expected to manage $35M reduction by utilizing the existing large uncosted carryover associated with awarded grants; have adjusted the grants funding profile going forward
  - Not expected to reduce any existing contract scope
- **General Observer / Archival Research Outlook**
  - Cycle 24 ($31.6M), Cycle 25 ($47.1M) awarded the value recommended by the Financial Review Committee (FRC)
  - Plan to award Cycle 26 (~$15M) as recommended by FRC
  - *Cycle values beginning in FY20 (Cycle 27), prior to Webb becoming operational, may be impacted by the above budget guidance*

Discussion

- **Questions?**