



# HST/GSFC Project Report



In celebration of the 31st anniversary of the launching of NASA's Hubble Space Telescope, astronomers aimed the renowned observatory at a brilliant "celebrity star," one of the brightest stars seen in our galaxy, surrounded by a glowing halo of gas and dust. The star, called AG Carinae, is waging a tug-of-war between gravity and radiation. The expanding shell of gas and dust that surrounds the star is about five light-years wide, which equals the distance from here to the nearest star beyond the Sun, Proxima Centauri. The huge structure was created from one or more giant eruptions about 10,000 years ago. Image Credit: NASA, ESA, STScI

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**Space Telescope  
Users Committee  
Meeting  
April 27, 2021**

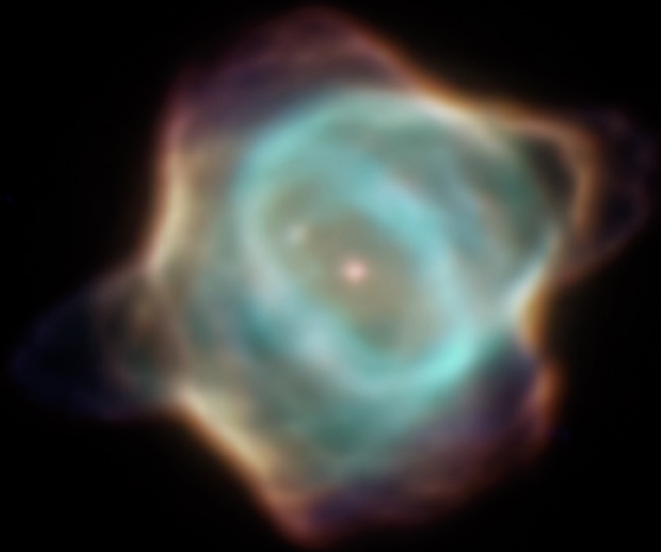
# Agenda

- **Science Highlights**
- **Recent Events**
- **Observatory Status**
- **Contract Status/Budget**

# Hubble's Longevity Reveals A Fading Nebula



Hen 3-1357 (Stingray Nebula)



1996

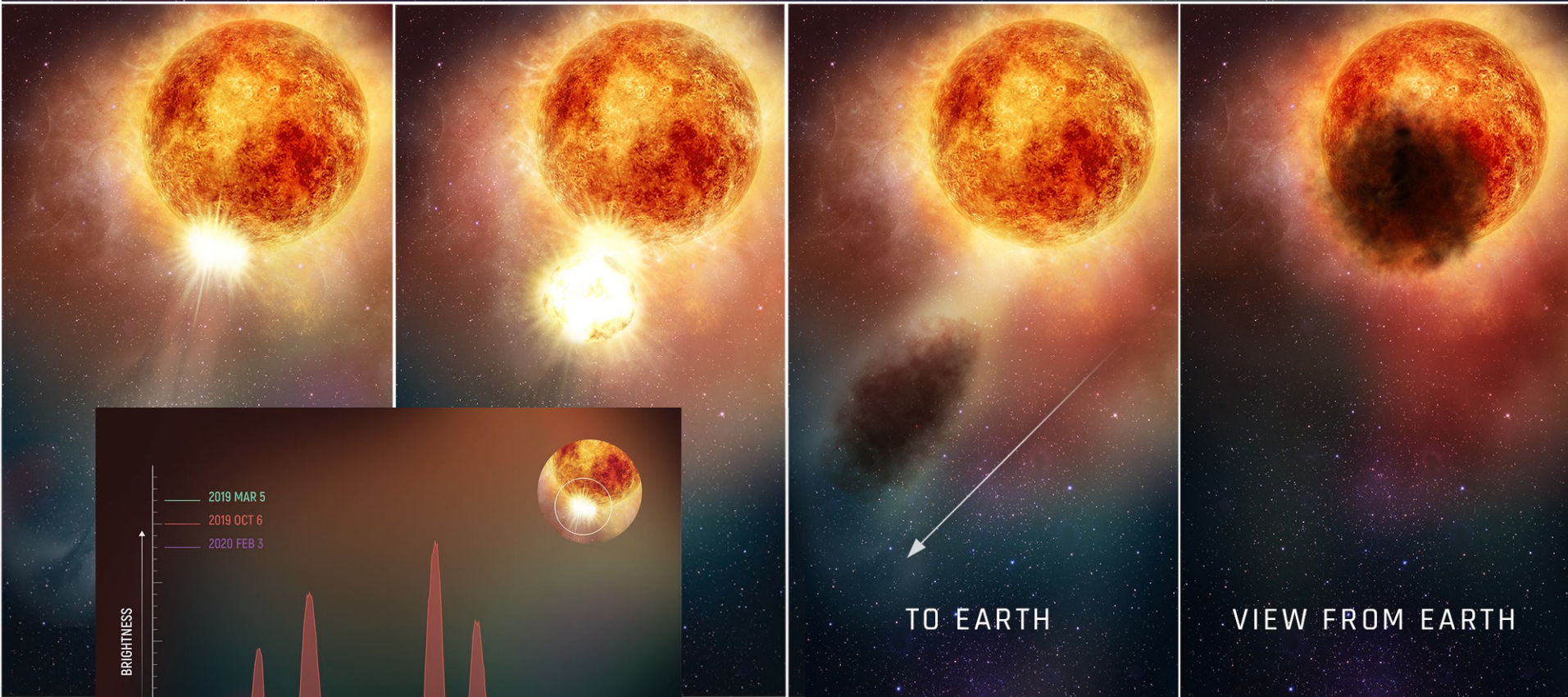


2016



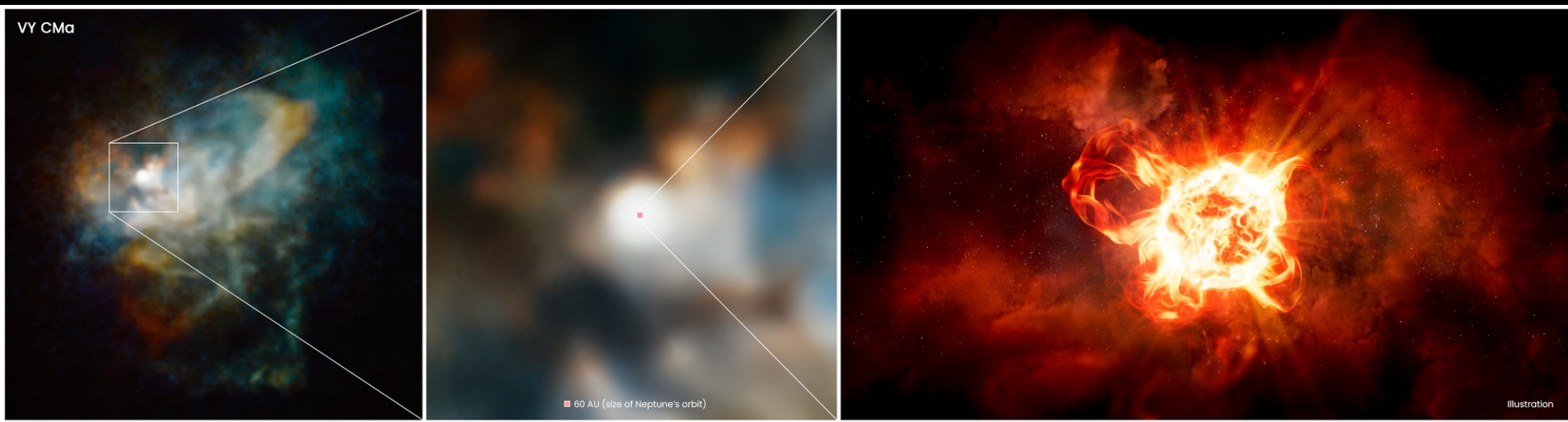
# Hubble is solving mysteries of stellar dimming

OUTBURST FROM THE GIANT STAR BETELGEUSE BLOCKS SOME OF ITS LIGHT



NASA, ESA, A. Dupree (CfA), and E. Wheatley (STScI)

# Hubble Observes Dimming Hypergiant Star VY Canis Majoris



NASA, ESA, Roberta Humphreys (UMN), Joseph Olmsted (STScI)

# Agenda

- **Science Highlights**
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# Recent Events

- **Hubble entered Hardware Sun Point (HWSP) safe mode at ~09:00 GMT (4 am EST) on Sunday, March 7**
  - Due to an error in new flight software code (version 4.7) to support hybrid mode caused a general protection fault that halted software control and commanded HWSP
  - Software was installed February 23, and hybrid was enabled on March 2
- **The HWSP safe mode entry sent commands to close the Aperture Door, however the door failed to close**
  - Formed an Anomaly Review Board, chaired by Tupper Hyde, GSFC Chief Engineer
  - Testing, approved by the ARB, isolated the issue to the primary motor path
  - Secondary motor path was effective in moving the door; Hubble is currently configured for autonomous door closure on this secondary path
  - Modified safing responses to minimize commanding the door closed
  - ARB did not recommend additional testing of the primary path. They did recommend an annual test of the secondary/redundant path to move the door a few degrees
- **ARB concurred with assessment of flight software fault and recommended flight software update process changes that have been accepted and are being followed for the 4.7B release to fix the flight software error**



# Recent Events

- **During recovery to science, Wide Field Camera 3 suspended on March 11**
  - Low voltage power supply lower limit was exceeded
  - Following Tiger Team review in agreement with the ARB, it was determined to be safe to reduce the low voltage lower limit, and WFC3 was recovered on March 13
  - Tiger team assessed telemetry trends and recommended that a few telemetry limits be adjusted to prevent unnecessary future suspends
- **Space Telescope Imaging Spectrograph suspended on March 18**
  - Suspend was caused by relative timing of the planned instrument Target Acquisition exposures, shutter commanding associated with the planned exposures, and shutter commanding associated with the Take Data Flag status, which came up late due to a delayed guide star acquisition
  - Resulted in a mismatch between commanded and expected shutter position within the allowed settle time
  - Flight software responded appropriately
  - Recovery was completed successfully on March 19
  - Examining options to prevent future suspend events, however, the time constraint is such that repeat events should be rare

# HST Observatory Status

3/31/2021

Subsystem		Summary
Science Instruments (SI)	G	<ul style="list-style-type: none"> <li>WFC3 performance is excellent; Channel Select Mechanism movements minimized without science impact; 7 dust particles on the optic in 2018, one in 2019; one in 2020; no impact to science</li> <li>COS               <ul style="list-style-type: none"> <li>4<sup>th</sup> lifetime position began 10/2017 using COS 2025 initiatives;</li> <li>FUV High Voltage increased on October 5, 2020 for 3 segments and 3 lifetime positions; Plan to use 5<sup>th</sup> position beginning October 2021</li> <li>Exploratory programs to characterize potential 6<sup>th</sup> LP began late December 2020 <u>appear promising</u></li> <li>FUV detector sensitivity loss continues as expected; Sensitivity ARB closure 4/2011</li> </ul> </li> <li>ACS monthly anneal process updated October 2019 to no longer cycle the Main Electronics Box</li> <li>ACS and STIS repaired instruments (SM4) performing nominally</li> <li>NICMOS in standby following decision to not restart following Cycle 19 proposal evaluations</li> </ul>
Electrical Power System	G	<ul style="list-style-type: none"> <li>Excellent battery performance; 510 Amp hour benchmark; Solar Array 3 performance remains excellent</li> <li>Solar Array Drive Electronics (SADE) investigation following 2/15/13 SWSP completed; no further actions</li> </ul>
Pointing Control System	G	<ul style="list-style-type: none"> <li>3-gyro mode using 3-4-6 gyro complement</li> <li>Gyro 4 exceeded 110,000 hours on 9/19/2020; Gyro 6 became 2<sup>nd</sup> longest running on 2/5/2021</li> <li>Gyro 6 motor current: ~120 to ~180mA on 3/21/2019; ~183 to ~203mA on 6/19/2020; ~210mA on 12/13/2020</li> <li>Gyro 3 powered on 10/6/2018 – anomalous rates reduced to normal 10/19/2018; noisy bias trends</li> <li>Gyro 2 failed on 10/5/2018; Gyro 1 failed on 4/21/2018; Gyro 6 powered on 4/21/2018</li> <li>Gyro 5 failed on 3/7/2014; Gyros 1&amp;2 powered on; Gyro 6 powered off 3/13/2014</li> <li>Attitude Observer Anomaly (AOA) (ARB report 10/2011) mitigation completed 11/2012</li> <li>Due to AOA, Gyro 3 removed from control loop/powered off and Gyro 6 powered on in 2011</li> <li>FGS-3 bearings degraded (~10% duty cycle to preserve life); FGS-2R2 Clear Filter operations began 1/2015</li> </ul>
Data Management System	G	<ul style="list-style-type: none"> <li>SI Control and Data Handling (C&amp;DH) has had 16 lockup recoveries since 6/15/09; most recent was 8/12/20</li> <li>Solid State Recorders (SSRs) 1&amp;3 each experienced lock up in 2011 in the South Atlantic Anomaly (SAA); SSR3 experienced another lockup in SAA on 1/9/18; Alert monitors detect condition to minimize data loss</li> </ul>
Communications	G	<ul style="list-style-type: none"> <li>Multiple Access Transponder 2 (MAT2) coherent mode failed (12/24/2011); Two-way tracking unavailable</li> <li>Combined Space Operations Center (CSpOC) now the source for the operational ephemeris via Conjunction Avoidance Risk Assessment (CARA) team and the Flight Dynamics Facility</li> </ul>
Thermal Protection System	G	<ul style="list-style-type: none"> <li>New Outer Blanket Layers (NOBLs) installed on Bays 5,7, and 8 during SM4</li> <li>Thermal performance is nominal</li> </ul>

# Mission Operations – Gyro Run Time Performance

3/31/2021

**Current Gyro Runtimes**

Post SM4 RGA	Status	Flex Lead	Total Hours 2021/090 (3/31/2021)
G1	Failed April 2018	Standard	43,359
G2	Failed October 2018	Standard	47,550
G3	On	Enhanced	44,143
G4	On	Enhanced	114,641
G5	Failed March 2014	Standard	51,497
G6	On	Enhanced	61,755

**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
2018.111	G1	Standard	43359

**G4 (Enhanced Flex Lead) – Highest runtime hours on program 114,641**

Mean runtime hours for the 3 Enhanced Flex Lead gyros 73,513

**G6 (Enhanced Flex Lead) – 2<sup>nd</sup> highest hours 61,755**

Third highest hours (Standard Flex Lead G1 from SM3A) 60,444

Mean runtime hours for all 22 HST gyros 46,584

Mean runtime hours for the 8 HST Standard Flex Lead failure gyros 44,405

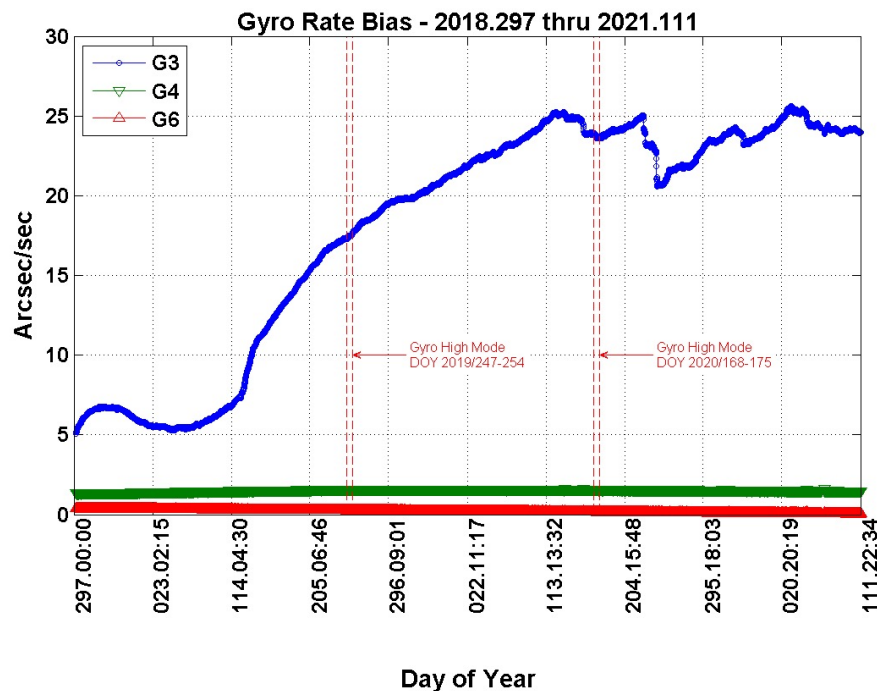
**G3 (Enhanced Flex Lead) – 11<sup>th</sup> highest hours 44,143**

# HST Operations Significant Events

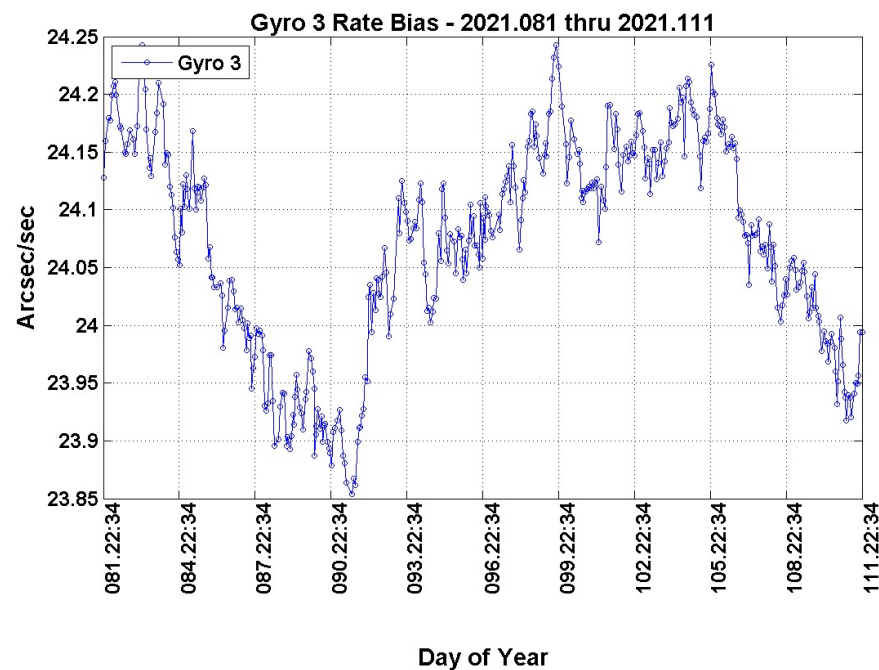
4/21/2021

## Gyro-3 Bias Trend

Since October 2018 Turn On



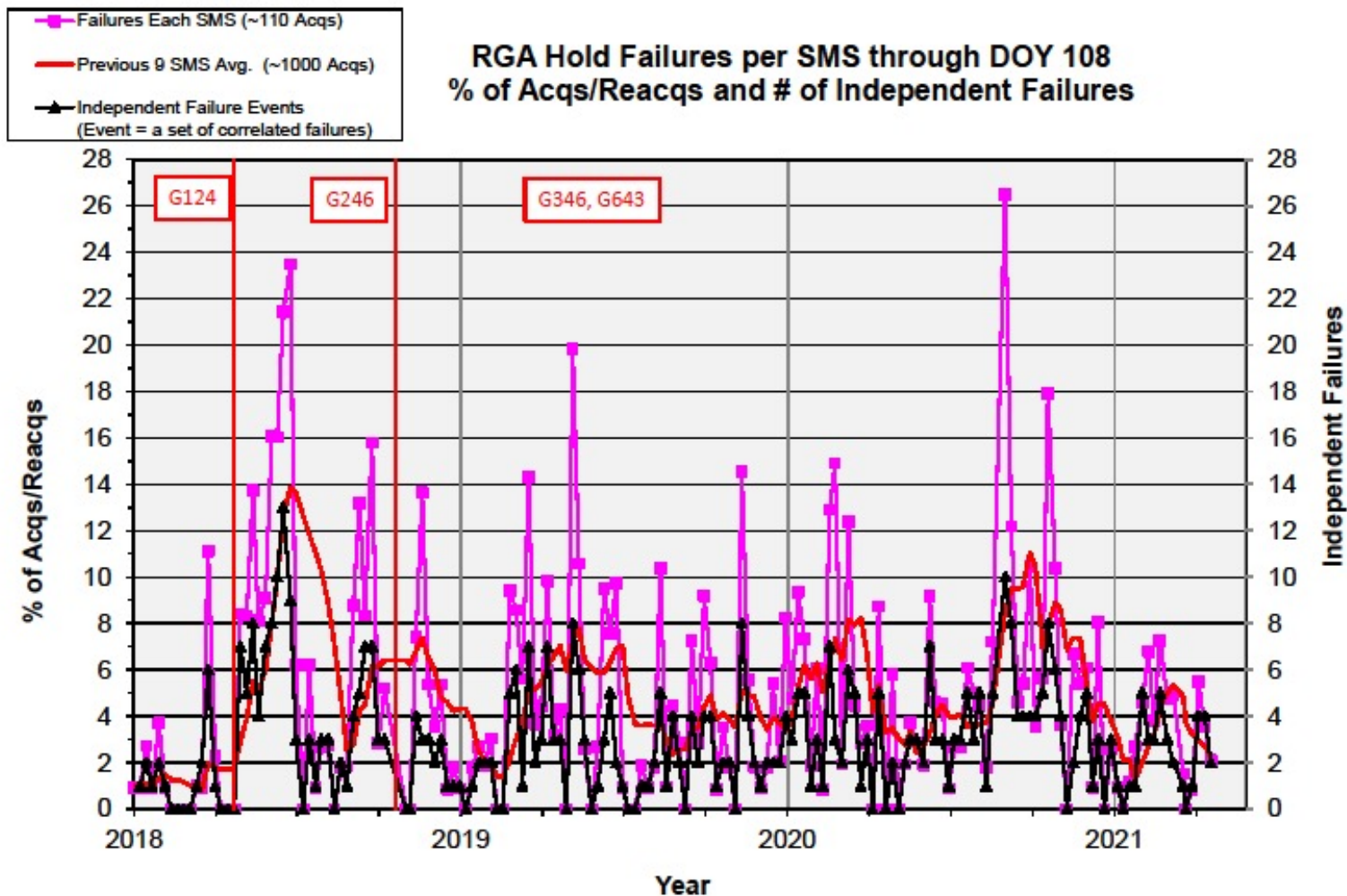
Past 30 days



# HST Operations Significant Events

## Target Acquisition Trend

4/21/2021





# Budget Status

FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27
\$98.3	\$90.8	\$93.3	\$98.3	\$98.3	\$98.3	\$98.3	\$98.3	\$98.3

- **Budget Outlook (New Obligation Authority (NOA) - \$M)**
- **Preparing to negotiate the science operations and mission operations contracts for next 5 years**
- **PPBE-23 budget guidance details are in flux with administration change**
- **2022 Senior Review Call for Proposal expected this Fall**
- **Discussing the negative impact that a flat budget will have on the mission; stressing the need for inflation adjustments to continue Hubble's scientific productivity**
- **Without budget relief, increasing costs to maintain operations capabilities and overall risk posture will reduce the budget available for future Calls for Proposals**