



# HST/GSFC Project Report



*April 19, 2022*

## Celebrating Hubble's 32<sup>nd</sup> Birthday with an Eclectic Galaxy Grouping

In a lonely patch of the universe, five tightly grouped galaxies engage in a leisurely dance. Called the Hickson Compact Group 40 (HCG 40), this eclectic bunch includes three spiral-shaped galaxies, an elliptical galaxy and a lenticular (lens-like) galaxy. In about 1 billion years, they will collide and merge to form a giant elliptical galaxy. For its 32<sup>nd</sup> birthday, Hubble captured these galaxies at a very special moment in their lifetimes as they fall together and continue their dance, but before they merge. Scientists have cataloged more than 100 such compact galaxy groups, but HCG 40 is one of the most densely packed. Tight groups like this may have been more common in the early universe when their superheated, infalling material may have fueled very energetic black holes called quasars. Studying nearby groups like HCG 40 helps astronomers learn about how galaxies formed.

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**Space Telescope  
Users Committee  
Meeting  
May 19, 2022**

# Agenda

- **Science highlights**
- **2022 Senior Review**
- **Observatory Status**
  - **SI C&DH**
  - **Fine Guidance Sensors**
  - **Gyros**
- **Contract Status/Budget**

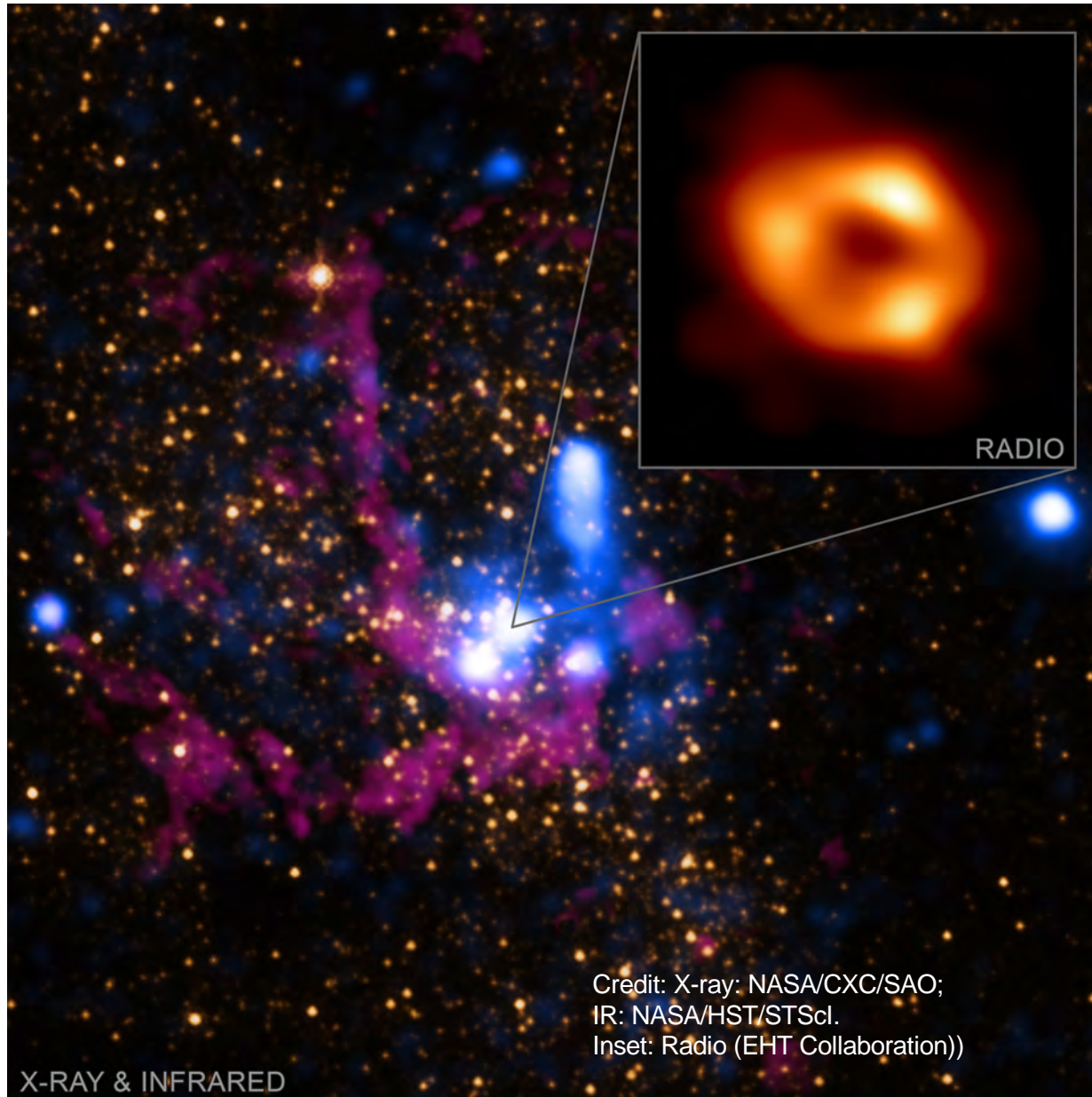
## ACS Still Going Strong!

On March 7, Hubble celebrated the 20th anniversary of the Advanced Camera for Surveys (ACS), installed on Hubble on March 7, 2002, and repaired in SM4. A press release, “Hubble’s Advanced Camera for Surveys Celebrates 20 Years of Discovery,” recognized the tremendous capability of the instrument and resulting science achievements and features an image collage and video detailing ACS’s rich contributions to science.





# Black Holes are Hot !



## **Sagittarius A\*: NASA Telescopes Support Event Horizon Telescope in Studying Milky Way's Black Hole**

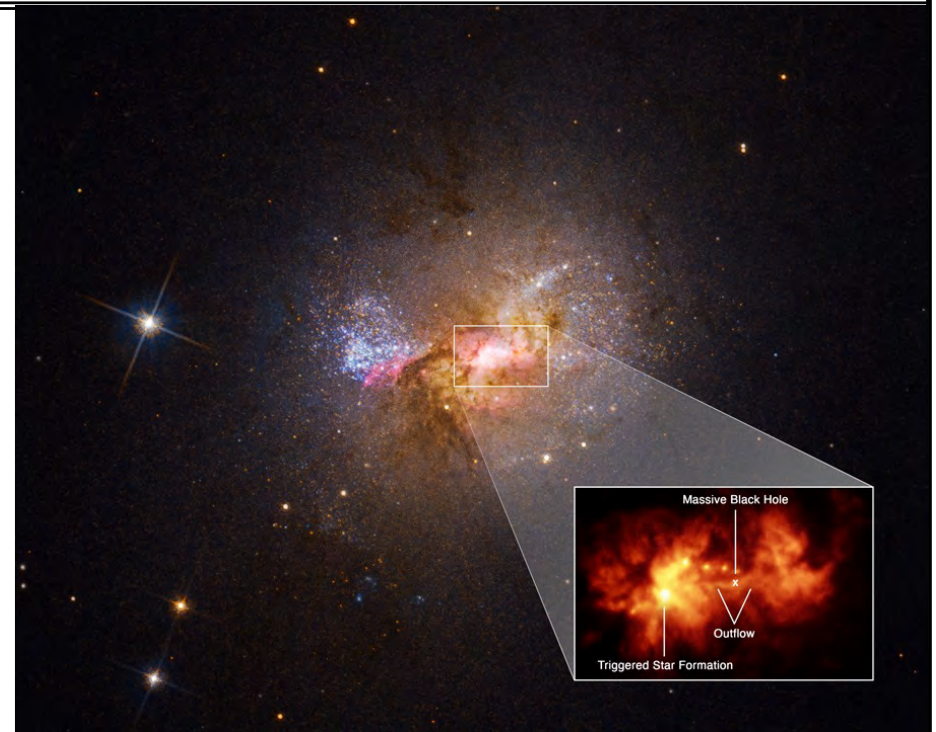
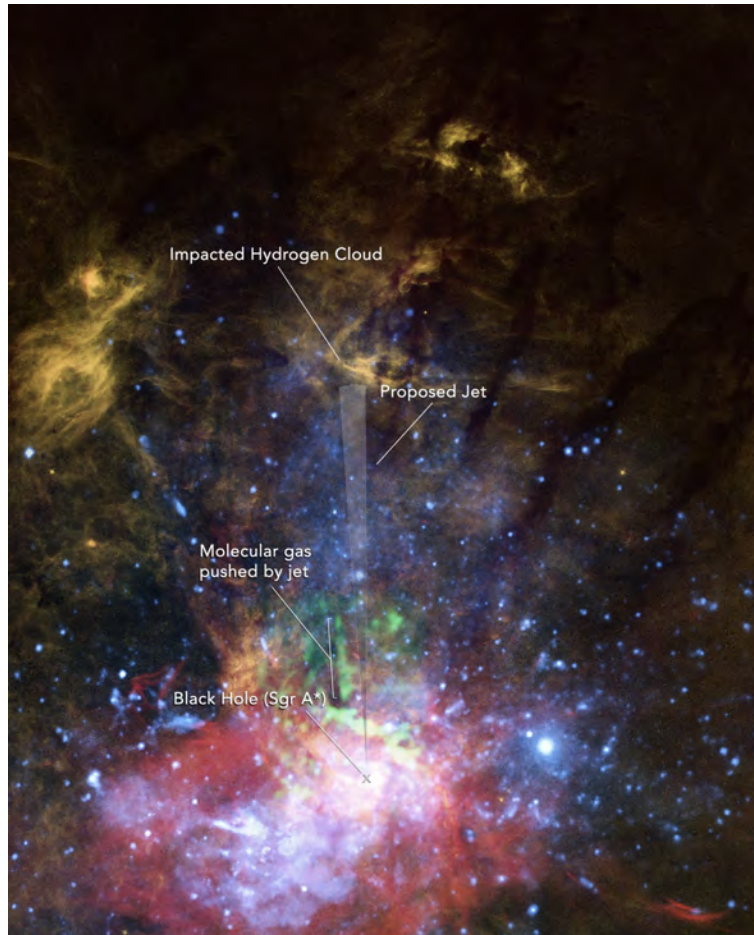
X-ray data from Chandra (blue) depicts hot gas that was blown away from massive stars near the black hole.

Two images of infrared light at different wavelengths from NASA's Hubble Space Telescope show stars (orange) and cool gas (purple). These images are seven light years across at the distance of Sgr A\*.

The pull-out shows the new EHT image, which is only about  $1.8 \times 10^5$  light years across (0.000018 light years, or about 10 light minutes).

# Black Holes are Hot !

“Mini-Jet Found Near Milky Way’s Supermassive Black Hole.” Hubble, together with radio telescopes, has found increasing evidence that the black hole near the Galactic center occasionally awakens when capturing a star or gas cloud that falls into it, and then releases powerful beams of radiation and particles. (Gerald Cecil et al., UNC)

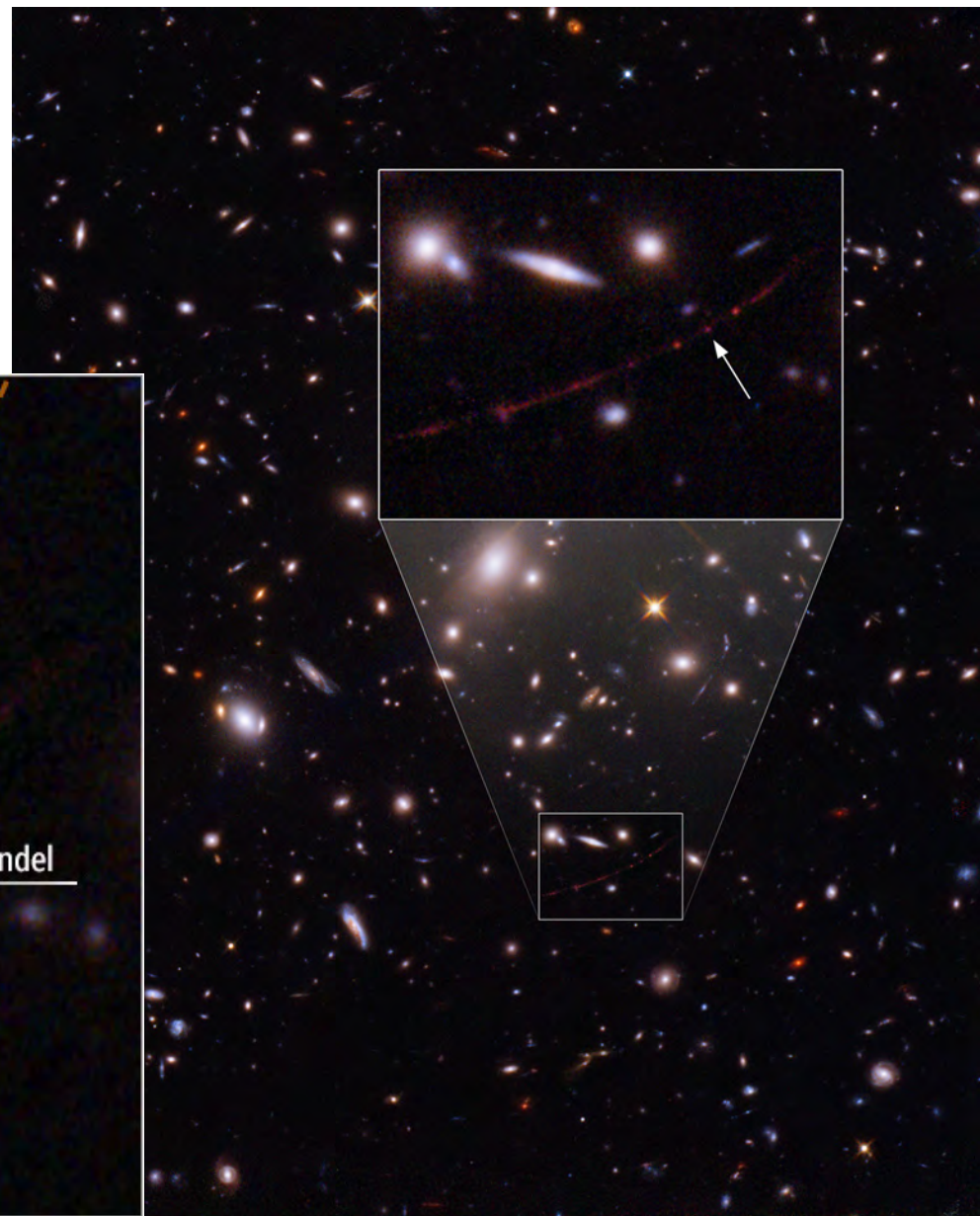
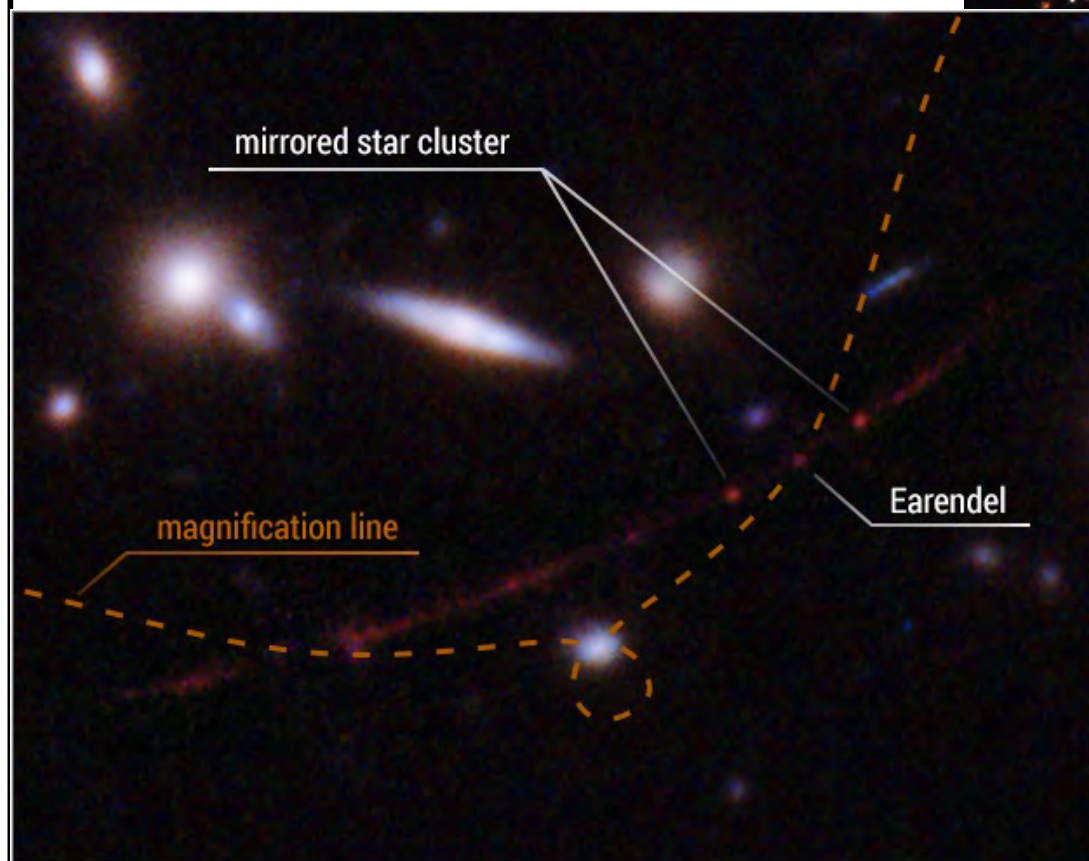


A black hole at the heart of the dwarf starburst galaxy Henize 2-10 is apparently contributing to a firestorm of new star formation taking place in the galaxy rather than quenching it. Hubble's (STIS) observations indicate a relatively gentle outflow from a central black hole is compressing gas into stars rather than superheating and disrupting it, typical in more massive galaxies. Dwarf galaxy black holes can serve as an analog for black holes in the early universe, when they were just beginning to form and grow. (Amy Reines et al, MSU)



## Hubble has detected the farthest individual star ever seen!

The newly detected lensed star, Earendel, is seen at a lookback time of 12.9 BY, appearing to us as it did when the universe was only 7 percent of its current age. Excellent alignment of the star's galaxy with an intermediate gravitational lensing cluster magnified the light by thousands of times, allowing the individual star to be picked out. Published in *Nature*. NASA's press release is entitled "Record Broken: Hubble Spots Farthest Star Ever Seen". (Brian Welch (JHU), Dan Coe (STScI), et al.)



# Senior Review 2022

- **2022 Senior Review**

- **Proposals submitted in early February, following months of preparation between STScI and the Goddard HST Project, including a NASA Red Team review**
- **Virtual panel review was held March 15-17**
- **Proposed in guide and over guide scenarios for FY23-27**
- **In guide budget was \$98.3M for all years**
- **Over guide budget requested additional funding beginning in FY24 to provide current level of science research “buying power” in the presence of future inflation**
- **Panel outbrief to Paul Hertz on March 17 expressed general support for the over guide request**
- **Anticipate guidance letter in June with firm guidance for FY23-25, and notional guidance for FY27-28 to be revisited in 2025 Senior Review**

# Senior Review 2022

- **2022 Senior Review**

Initial Senior Review Outbrief highlights:

“The scientific impact of HST and its associated archive have fundamentally transformed our understanding of the near and far Universe, from the earliest galaxies to exoplanets and the Solar System.”

“Remarkable return on investment...”

“HST is poised to be a leader in the burgeoning field of multi-messenger astrophysics and time domain astronomy.”

-- Recommend thoughtful preparation for continued science productivity in the event of a major failure or substantial degradation

**Full report of Senior Review findings and recommendations should be available soon...**



# Agenda

- **Science highlights**
- **2022 Senior Review**
- **Observatory Status**
  - **SI C&DH**
  - **Fine Guidance Sensors**
  - **Gyros**
- **Contract Status/Budget**

# Observatory Status

- **Science Instrument Control and Data Handler**
  - Currently operating on Side-A following the July 2021 side switch recovery from the power control circuit anomaly that prevented operation of the NASA Standard Spacecraft Computer-1 (NSSC-1) in Normal Mode
  - Experienced loss of minor frame synchronization anomaly on October 23 and again on October 25 when all instruments were safed
    - Incrementally recovered each instrument to normal operations November-December; no recurrence has been observed
    - Developed and installed patches for all four instruments to enable uninterrupted science data collection if minor frame synchronization messages are dropped
    - Developing/testing approach to provide an alternative source for minor frame synchronization messages on Side A should the loss of synchronization messages return and become more frequent and/or persistent

# Observatory Status

- **Science Instrument Control and Data Handler (Cont.)**
  - Developing approach/implementation plan for Blind Science Operations
    - Enable science capability on Side-B (or Side-A if similar anomaly occurred)
    - Demonstrated in the lab the ability to command instruments to take observations, collect data, and route data through the Science Data Formatter with NSSC-1 Fixed Mode
    - “Blind Science” refers to lack of instrument engineering data insight when the NSSC-1 is in Fixed Mode
    - Demonstrating in the lab the ability to bypass the power control circuit and promote the NSSC-1 to Normal Mode to enable telemetry collection and downlink
    - Bypass process prevents simultaneous Normal Mode and Science Data Formatter operations capability
    - Working groups are developing operations concepts, requirements, and implementation plan
    - Early in the process, and there are many challenges ahead to enable efficient operations
    - As stated to the Senior Review panel, assuming continued nominal Side-A operations, this is the highest priority sustaining engineering effort

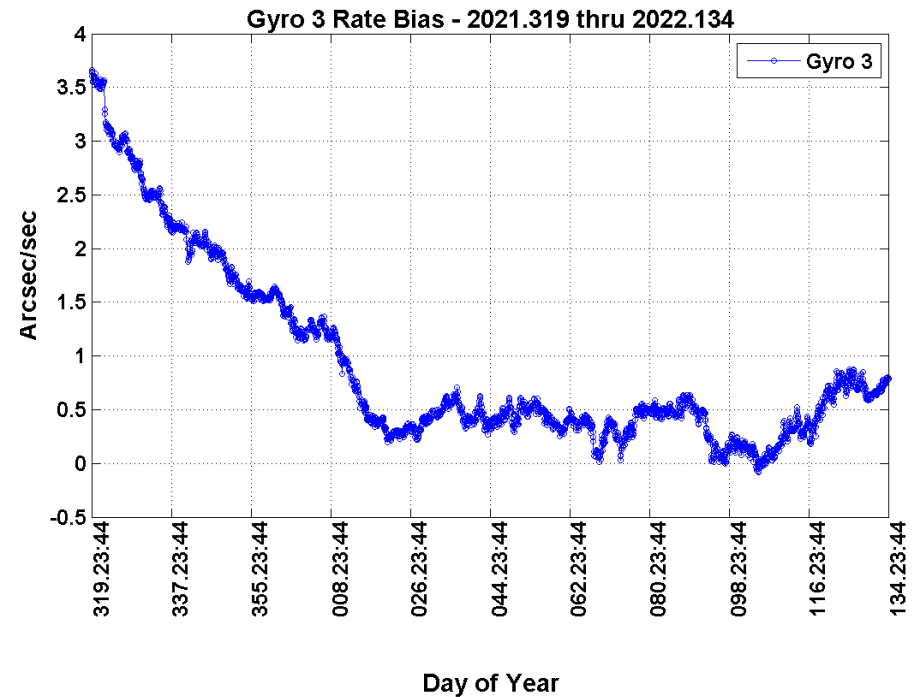
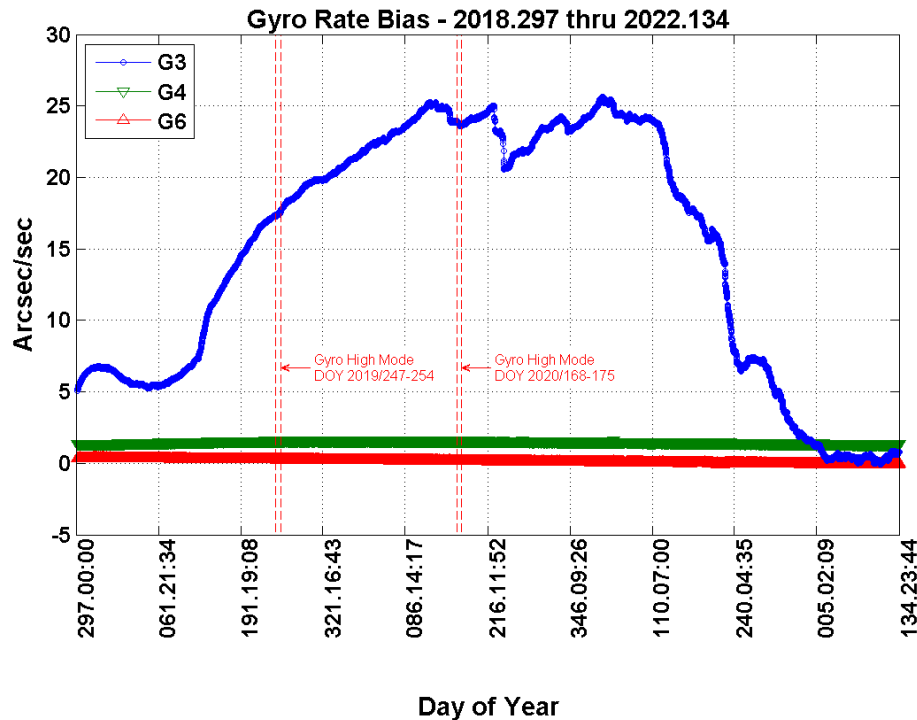


# Observatory Status

- **Fine Guidance Sensors**

- Following recovery from the 2021 SI C&DH Side-B anomaly, FGS-2 experienced “stall” events where the B-servo compensation error voltage became saturated and servo movement halted
  - Subsequent timeline commands typically freed the FGS (self-clearing slews) and normal operation resumed
  - Ground commanding was required in a few cases to free the servo and return to normal operations
  - Tiger Team concluded that the stalls were likely due to lubrication/debris on ball bearing or toroid preventing small motion slews as indicated by the compensation error saturating; normal use of the FGS resulted in improved performance
  - Last ground intervention was on August 5; and last self-clearing stall had been on September 6 and compensation error signal returned to pre-anomaly performance
- FGS 1 Compensation Error, while within nominal range, has trended up since last summer
- FGS-2 experienced 12 saturation events April 30-May 4, mainly associated with the same program; currently being investigated
- Have developed and are currently using servo maintenance slews within the timeline on a non-interference basis with science
  - Tiger Team recommended 6 slews per week initially for FGS-1 (been in use since April 18)
  - Performance status review and forward plan meeting May 19

# Observatory Status



- **Gyro-3 Performance**

- Following period of rapid decline in 2021 the Gyro-3 rate bias has been relatively flat
- Noisy bias performance with amplitude now in family with Gyros 4 and 6
- Large bias shifts impact target acquisitions; on board attitude determination and bias updates prior to acquisitions and other mitigation steps have been implemented
- Manual bias updates are required periodically
- Implementing flight software update to enable ground-based solution process onboard; expect to be installed early 2023

# Observatory Status

## Mission Operations – Gyro Run Time Performance

### Current Gyro Runtimes

Post SM4 RGA	Status	Flex Lead	Total Hours 2022/120 (4/30/2022)
G1	Failed April 2018	Standard	43,359
G2	Failed October 2018	Standard	47,550
G3	On	Enhanced	53,623
G4	On	Enhanced	124,121
G5	Failed March 2014	Standard	51,497
G6	On	Enhanced	71,235

### 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 124,121**

Mean runtime hours for the 3 Enhanced Flex Lead gyros 82,993

**G6 (Enhanced Flex Lead) – 2<sup>nd</sup> highest hours 71,235**

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

**G3 (Enhanced Flex Lead) – 6<sup>th</sup> highest hours 53,623**

Mean runtime hours for all 22 HST gyros 47,877

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



## Contract/Budget Status

FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28
\$93.3	\$98.3	\$98.3	\$98.3	\$98.3	\$98.3	\$98.3	\$98.3
		\$93.3					

- **Science Operations and Mission Operations contracts awarded through June 30, 2026; maintain scope, staffing, risk posture, includes escalation**
- **2022 Senior Review/PPBE-24**
  - Senior Review guidance \$98.3M FY23-27; PPBE-24 reduced FY23 by \$5M
  - HQ reviewing Senior Review/PPBE-24 submissions
  - In guide submission - increasing operations costs and future inflation will result in reduced future GO/AR Cycle Values as early as FY23
    - FY22 (\$32.5M), FY23 (\$30M), FY24 (\$30M), FY25 (\$25M), FY26 (\$21M), FY27 (\$17M), FY28 (\$12M)
  - Over guide submission seeks to maintain GO/AR buying power by increasing future Cycle Values commensurate with inflation
  - Expect Senior Review outcome budget guidance in June; firm guidance for FY23-25, notional for FY26-27 to be revisited at the 2025 Senior Review