STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Hubble Space Telescope Status

Cycle 34 TAC Presentation

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Welcome!

Thank you for serving on the Cycle 34 HST TAC

- The Hubble Space Telescope has been operating for over 36 years!!!
  - We are nearly 17 years past Servicing Mission 4 (SM4)
    - At that time, planning was for 5 years of science operations
  - In most respects, Hubble continues to work as it has since SM4 in 2009
    - There are some slight instrument performance degradation
      - CCDs slowly accumulate damage – impacts mitigated with anneals, “flashing”, and reference file updates
      - COS/FUV gain sag – impacts mitigated with lifetime position changes and usage policies for extending the life
    - Some degradation in the pointing control system results in more failed acquisitions than the long-term average (more later), but pointing of successful observations are unaffected
  - We all (GOs and STScI+GSFC) have become smarter in how we use the observatory and to get the best science from its observations
- You, by serving the HST TAC process, have the privilege and responsibility of defining what Hubble does next!

Spacecraft Status: Continuing Longevity into the 2030s

- HST orbit stable well beyond 2030
  - <10% probability of atmospheric re-entry before 2032
  - Median re-entry late 2033
  - Predictions are converging as the solar cycle winds down

- Work nearly completed to restore redundancy in SI C&DH system (BSO:“B-side Sci Ops”)
  - Critical system that permits science operations has been single string since 2021
  - Significant engineering effort at GSFC and STScI now in late stages of testing

- Power, thermal, communications, etc. retain significant redundancy→ 2030+ *likely!*

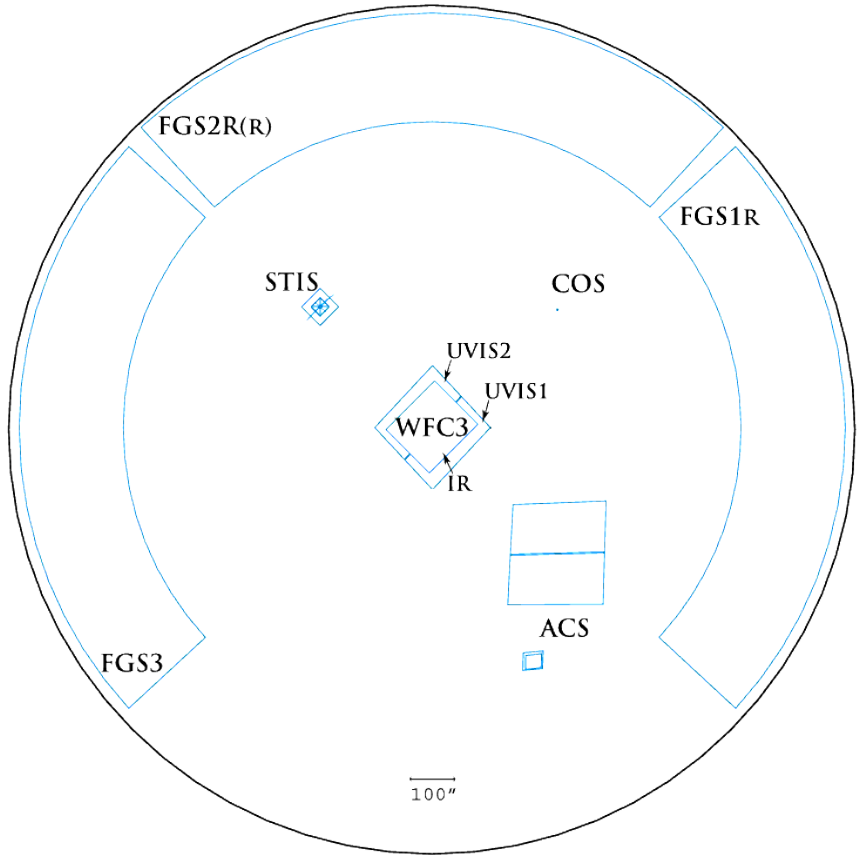
Spacecraft Status: Pointing Control System – Reduced Gyro Mode

- HST's complement of 6 Gyro's after SM4 (2009) has now declined to 2 operational gyros
  - Both are of the "enhanced" variety, each with long lifetimes (>2035) expected
- In June 2024, HST transitioned to RGM after ~5.5 years of operational efforts to mitigate the impacts of noisy Gyro 3 to maintain three-gyro operations
  - The move from three gyro to one gyro maintains redundancy if one gyro fails
  - Zero HST safing events since the transition to RGM!
  - RGM implications
    - Instantaneous field-of-regard decreased from ~80% to 40-50% of the sky (similar to Webb's)
    - Decreased scheduling efficiency from ~82-84 orbits/week to ~81 (but approaching pre-RGM average in Cy 33)
    - Limits or exclusion of some edge cases (no very long cadence, gyro guiding, DASH mode, etc.)
  - No impact to guiding during science observations – one gyro has been the norm since 2021
- HST is limited in where it can point and how it can roll at a given time; thus, timing, position, and orientation restrictions are co-dependent

Please consider constraints and special requirements carefully and check that they are well justified as ***absolutely necessary*** to achieve the ***science goals.*** (But leave the scheduling to us!)

Spacecraft Status: Pointing Control System – Fine Guidance Sensors

- Ideally, HST uses 2 guide stars (acquired on 2 of the 3 fine guidance sensors, FGSs) to maintain exceptional pointing stability during observations
- The FGS units (especially FGS2) have servo saturation events, causing lost observations
    - Historical failed acquisitions or loss of lock was 2-4%; now 5-10+%
    - Large variance on months timescales
- Ongoing efforts to adjust operational parameters and optimize use of FGS1 and FGS3, but avoiding FGS2 entirely is not feasible as it adds additional restrictions
- **New for Cycle 34:** All ACS/WFC and WFC3 imaging observations with short (< 1001 sec) exposure times taken as part of 1-2 orbit visits will, by default, observe with single guide star guiding.
    - This will extend FGS lifetimes and increase scheduling efficiency with no impact to science
    - GOs can opt out at Phase II – no action needed at Phase I



HST Instruments

- HST ***fully*** supports four science instruments (plus the FGS may be used for astrometry)
  - ACS = Advanced Camera for Surveys (installed 2002; SM3b) → Including ACS/WFC!
  - COS = Cosmic Origins Spectrograph (installed 2009; SM4)
  - STIS = Space Telescope Imaging Spectrograph (installed 1997; SM2)
  - WFC3 = Wide Field Camera 3 (installed 2009; SM4) → Including WFC3/IR!

- For TAC purposes, the science performance of these instruments has been basically stable since 2009
- More information: https://www.stsci.edu/hst/instrumentation

Science Instruments Considerations

- Preserving HST's UV capabilities:
  - **New COS Lifetime Usage Policy:** Starting in Cycle 33, COS FUV programs will be limited to a maximum of 2% lifetime usage per Lifetime Position (LP), with usage beyond 1% requiring justification in the Phase I proposal. Proposers should consult the updated lifetime usage table to determine whether their proposed observations approach or exceed the usage limits.
  - **General Bright Object Limits**: All COS, STIS/MAMA, and ACS/SBC programs are required to confirm that proposed observations do not exceed the instrument's bright object limits
  - **TAC guidance**: Request a technical review for programs that raise concerns (e.g., UV bright objects without statements of detector safety or COS estimated usage)
- Graceful aging of ACS & WFC3 CCD detectors
  - Charge transfer efficiency degradation mitigated by flashing and corrected at the pixel level with algorithms of increasing sophistication
  - Vast majority of defective pixels (warm, hot, dead) mitigated through extensive monitoring, reference files, and appropriate algorithms

Support for ACS/WFC and WFC3/IR

- ACS/WFC and WFC3/IR are currently fully supported
- These modes may be offered as shared risk in the future, pending future NASA appropriations
- "Shared risk" means:
  - Only basic calibration activities (anneals, superdark, and superbias updates for ACS/WFC; bad pixel updates for WFC3/IR) would be performed. The calibration accuracy would drift at a rate of a few tenths of a mmag per year → most science cases would not be impacted for a few years.
  - No user support: no contact scientists, no helpdesk, no documentation updates, etc.
  - HOPRs would not be allowed as there would be no staff to assess the quality of data in case of suspected observation failure.

Cycle 34 CfP Late Breaking News:

ACS/WFC and WFC3/IR are anticipated to remain available and fully supported in Cycle 34. While the Call for Proposals notes that these modes "may be offered as shared risk" in future cycles, "shared risk" does not mean the instruments would be unavailable or poorly calibrated. **Proposers with science goals best served by ACS/WFC or WFC3/IR are encouraged to propose for these modes in Cycle 34.**

Supporting Time Domain Science

Hubble increasingly operates in an era of all-sky + multi-messenger surveys

- Increasing excitement & pressure from discoveries of transient phenomena
  - All-sky O/IR surveys (e.g., Rubin, Roman, Zwicky Transit Facility)
  - Gravitational wave experiments (e.g., LIGO, Kamioka, Virgo, LISA)
  - Neutrino observatories (e.g., IceCube Gen2, Super Kamiokande, Hyper Kamiokande)
  - Hubble can provide crucial context on various timescales (days to years)
  - UV evolution distinct & provides physical insights unavailable at longer wavelengths
- Scheduling tension between exciting science programs
  - Exoplanet & Solar System programs require tight timing constraints, as do observations coordinated with other facilities
  - Transient phenomena often require rapid response
  - Proposers are required to justify all special requirements & constraints
- We are exploring ways to maximize scientific return while accommodating competing pressures

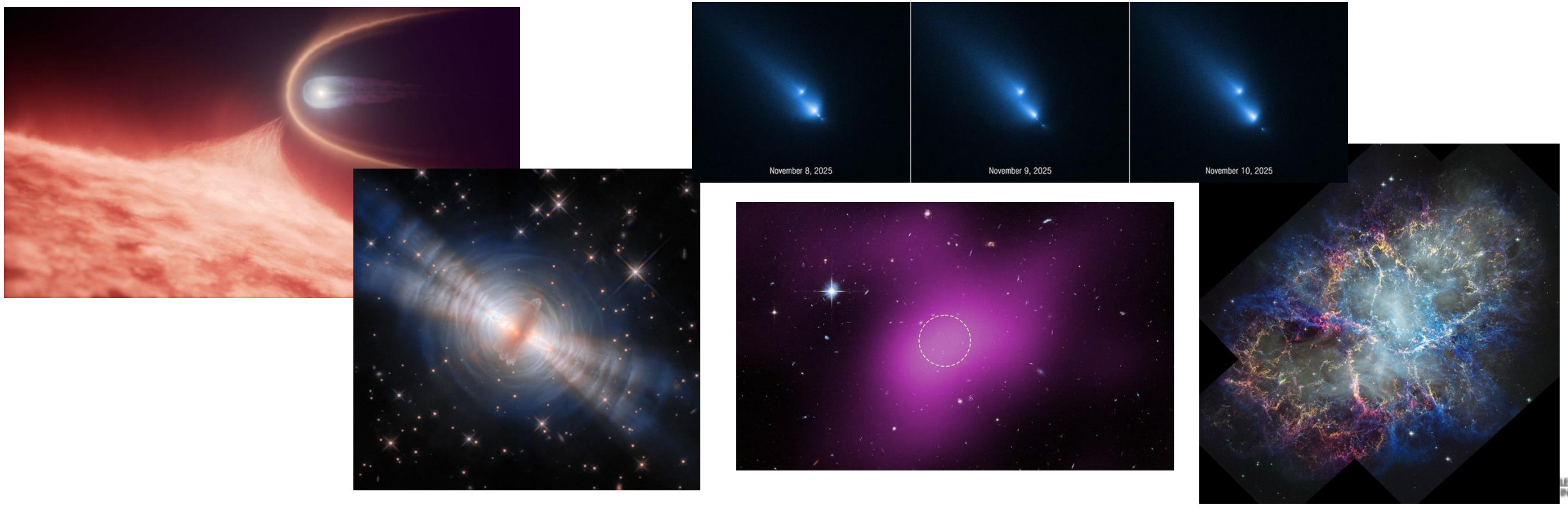
"Flexible Thursdays"

Since Cycle 31, we have offered "Flexible Thursdays" to more easily accommodate rapid Target of Opportunity response with minimal disruption of other science. STScI can accommodate 24 Flexible Thursday ToOs (3x more than regular disruptive ToOs).

Please Share Your Science with the Public

- STScI provides support for sharing your findings with the public. Please visit
  - http://www.stsci.edu/news/scientist-resources

- Simplified email-based system will initiate a process with the news team



Please Leave the Scheduling, Technical, and "Uncertainties" to Us

In reviewing Cycle 34 proposals, Panels and TAC should focus on the best science

- Constraints/Special Requirements must be scientifically justified
- But don't penalize a proposal if those constraints are necessary - leave scheduling constraints to us to consider in the context of the entire Cycle 34 pool of recommended proposals
- *always assume current state of Hubble performance*!

Thank you again for participating in this important process!