STScI | SPACE TELESCOPE SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Hubble Space Telescope Status

Cycle 32 TAC Presentation

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Welcome!

Thank you for serving on the Cycle 32 HST TAC

- The Hubble Space Telescope has been operating for nearly 34 years!!!
  - We are almost 15 years past Servicing Mission 4
    - 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 is some slight instrument performance degradation (mainly in CCD charge transfer efficiency)
      - This results in very minimal change over the past 5+ years and very slow future impacts are expected
    - Some degradation in the pointing control system results in more failed acquisitions than the long term average (2% has increased to about 5% and sometimes more for short periods – more later)
    - 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!

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)
- 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
  - <u>Proposers are required to justify all special requirements & constraints</u>
- We are exploring ways to maximize scientific return while accommodating competing pressures
  - Hubble can provide crucial context on various timescales (days to years)
  - UV evolution distinct & provides physical insights unavailable at longer wavelengths
  - Starting Cycle 31 “Flexible Thursdays” allowed rapid Target of Opportunity response with minimal disruption of other science

Flexible Thursdays – A new scheduling opportunity initiated last year

- In addition to the long-standing Target of Opportunity (ToO) categories, a new ToO category became available starting in Cycle 31 → FLEXIBLE THURSDAYS
- One Thursday per month, the Hubble schedule will include a Flexible Thursday (beginning at approximately 12:00 UT) with targets that can be rescheduled relatively easily (*i.e.* Thursday's original schedule can be disrupted with only minor impacts)
- Triggers for a ToO must be received with fully detailed activation and Phase II submission by 10:00 UT on Tuesday (nearly as fast as a rare "ultra-disruptive" ToO)
- This significantly increases the potential number of fast turn-around observations with HST for Cycle 32 from 8 disruptive ToO's (2-5 days) by adding 24 possible ToO (2-3 days) over 12 Thursdays during the Cycle
- There are a number of hard constraints on the use of the ToO necessary to limit both its impact of the scheduling of HST and the workload of the scheduling teams

Spacecraft Status

- High confidence in operations into the 2030s
- Current engineering efforts by STScI and GSFC are extending time in 3-gyro mode
  - 3 (of 6) Gyros remain functional although one (G3) has higher noise and drift rate
    - Results in more frequent acquisition failures; operational and software mitigation efforts have improved this and recent improvements will reduce recovery time
  - 1-Gyro mode is available and tested
  - TAC should assume 3-gyro mode for Cycle 32
- FGS2 experiences periods of servo saturation events, causing lost observations
- Work ongoing to restore redundancy in SI C&DH system (CDR April 24-25, 2024)
- HST orbit stable well beyond 2030
- Power, thermal, communications, etc. retain significant redundancy→ 2030+ *possible!*

HST Instruments

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

- For TAC purposes, the performance of these instruments has been basically stable since 2009
- More information:
  - https://www.stsci.edu/files/live/sites/www/files/home/hst/_documents/HST-Booklet.pdf
  - https://hst-docs.stsci.edu/hsp/hubble-space-telescope-science-policies-group-and-peer-review-information/general-info-getting-started/hubble-and-its-instruments
  - https://www.stsci.edu/hst/instrumentation

Science Instruments Status

- Engineering estimates give high confidence for long term operation well beyond 2025
  - >95% COS and WFC3, >85% for ACS and STIS
- Re-designed management of COS FUV detector extends useful life to ~2030 or longer
- Graceful aging of 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
- Recent increase in ACS/SBC MAMA detector dark rate
  - Appears to have corrected itself; being monitored and some mitigation possible if needed in future
  - Assume nominal performance at this time
- Changes in flat fields and sensitivities monitored and addressed in calibration pipelines
- Drifts in focus and alignment corrected by both mechanism motions and calibration updates

Please Leave the Scheduling and Technical Issues to Us

- In reviewing Cycle 32 proposals, Panels and TAC should focus on the best science

  - Constraints/Special Requirements must be scientifically justified
  - However, leave scheduling constraints to us to consider in the context of the entire Cycle 32 pool of recommended proposals
  - Also, do not concern yourselves with the suitability of observing programs if we do not remain in the nominal 3-gyro configuration
    - That is, ***assume current state of Hubble performance***!

- Thank you again for participating in this important process.

Backup Material

Advanced Camera for Surveys (ACS)

- ACS/WFC has the largest field of view and highest throughput in visible light of any HST instrument
- The ACS/WFC grism provides well-calibrated, wide-field slitless spectroscopy of visible to near-IR light
- ACS is the only active space-based, high spatial resolution polarimeter, providing synergy with JWST dust studies
- The ACS/SBC is especially optimized for FUV imaging, but also supports slitless spectroscopy
- Starting in Cy31 red light spectropolarimetry with 0°/60°/120° polarizers × G800L grism

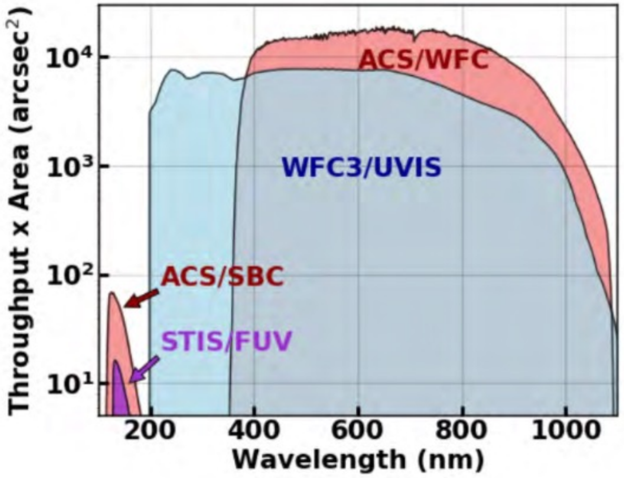
Wide Field Channel (WFC)

- Optical imaging and slitless spectroscopy (3,500–11,000 Å)
- Highest throughput on HST in visible light
- 202'' x 202'' field of view, largest on HST
- 13 wide, medium, and narrowband filters
- 15 tunable wavelength filters
- Grism (5,500–10,500 Å); R ~ 100 at 8,000 Å
- Near-UV / visible linear polarization filters

Please see the ACS Instrument Handbook for more detailed information on ACS capabilities.
https://hst-docs.stsci.edu/display/ACSIHB/

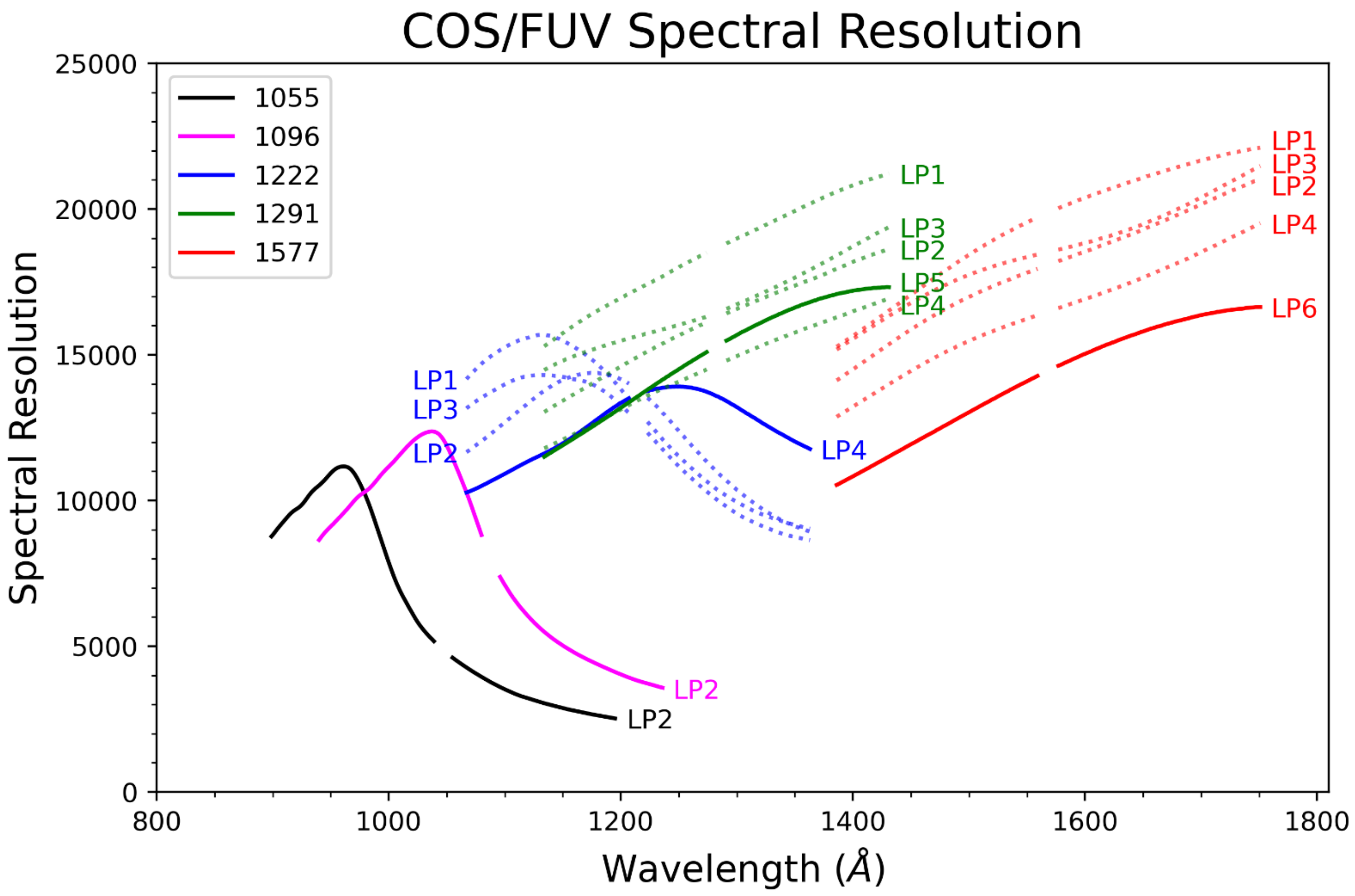
Solar Blind Channel (SBC)

- FUV imaging and slitless spectroscopy (1,150–1,700 Å)
- High throughput, best for FUV imaging
- 35'' x 31'' field of view
- 5 longpass filters, 1 Lyman α filter
- Two prisms; R ~ 79 and 96 at 1,500 Å



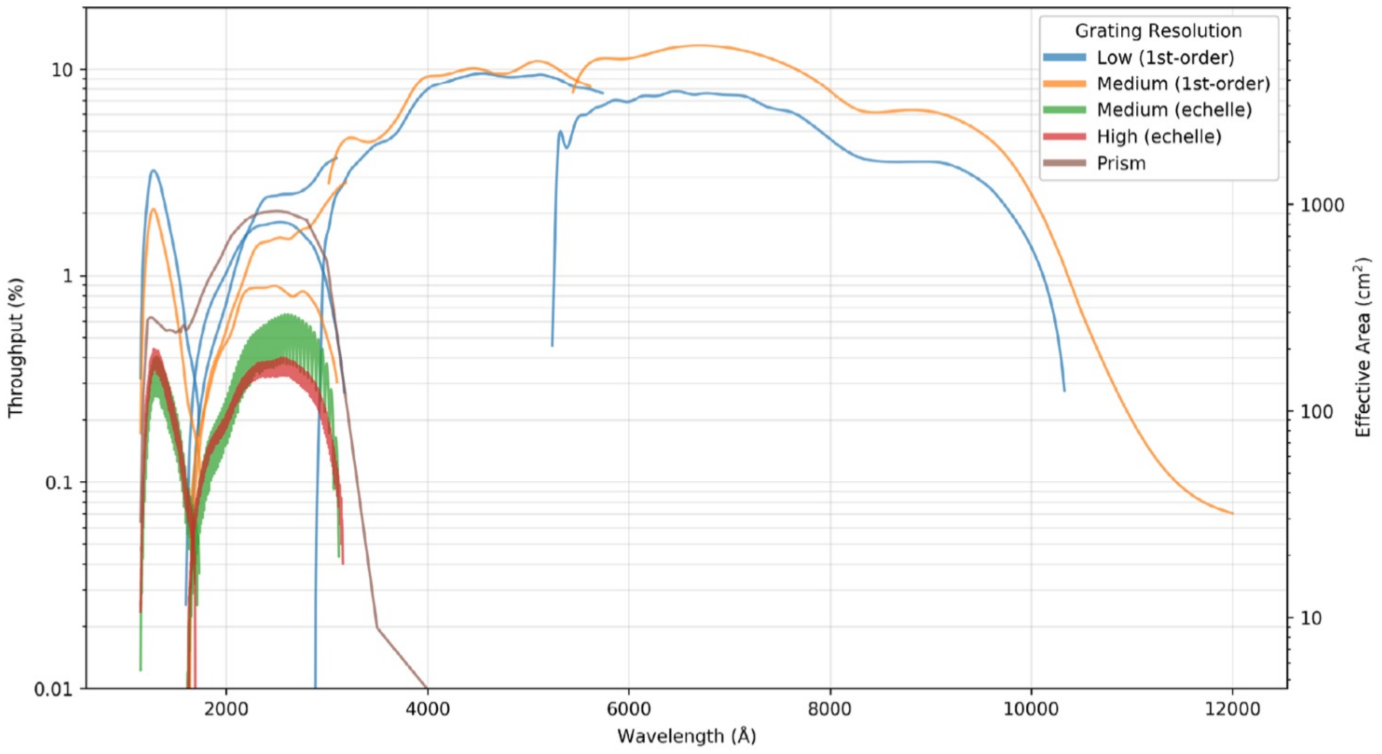
Cosmic Origins Spectrograph (COS)

- COS provides low to medium resolution spectroscopy from 800 to 3200 A.
- Has a fixed 2.5 arc second diameter aperture
- High sensitivity for observing faint sources
- Spectroscopy down to 800 A with the blue modes



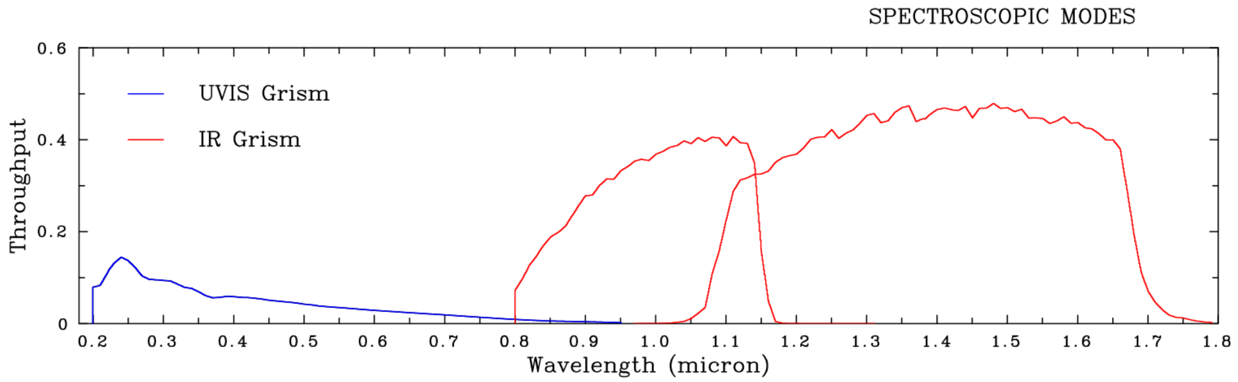
Space Telescope Imaging Spectrograph (STIS)

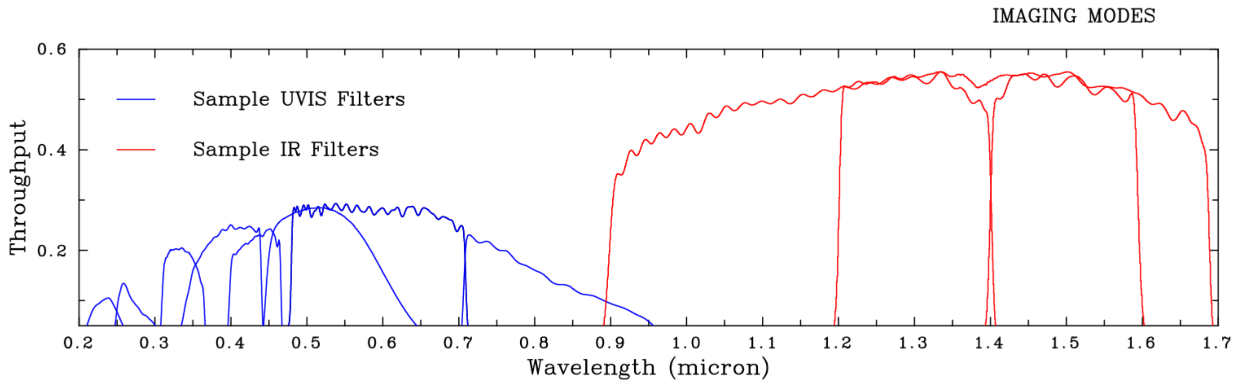
- STIS UV and visible imaging and low to high resolution spectroscopy with a variety of apertures.
- Has a coronagraphic mask and occulting bars
- Time-tag mode in the UV allows time-resolved observations
- Spatial scanning with the CCD allows high SNRs to be obtained while avoiding saturation
- High spatial resolution in the UV and visible



Wide Field Camera 3 (WFC3)

- Two channels: UVIS operating between 2000 to 10000 A, and IR operating between 0.9 to 1.7 microns.
- High resolution imaging from 2000 A to 1.7 micron with a wide complement of filters
- Grism spectroscopy providing low resolution spectra at high spatial resolution in the UV/visible and IR
- Spatial scanning by slewing during an exposure to achieve high SNR photometry while avoiding saturation with direct imaging
- Grism scanning by slewing during an exposure to provide extremely high SNR spectra





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