Status of STIS Closeout Plan: October 2006 Update

Paul Goudfrooij

- News since last STUC meeting (April 2006)
- Finalization of Closeout (or *'Data Enhancement'*) Plan
- Appendix: Updated status of all Closeout Plan activities

STIS Documentation since April 2006

- ISR "*Spectroscopic PSF: Comparison of Data and Models for a Target Centered In and Out of the Aperture*" by L. Dressel

- ISR *"A new CTE Correction Algorithm for Point Source Spectroscopy with the STIS CCD: Correcting for charge trap filling by the 'red halo' of the CCD Point Spread Function redward of 8000 Å"* by P. Goudfrooij & R. Bohlin

- ISR *"Sensitivity of STIS First-Order Medium Resolution Modes"* by C. Proffitt

- STAN newsletters with calibration-related news distributed in April 2006; additional (and major) STAN is imminent (end of this month).

- Extensive article on Finalization of STIS Closeout in Fall 2006 STScI Newsletter (in press; to be released in November).

Planning/Status of Remaining Tasks in
STIS Closeout Plan (1)

- ***Calibrations are now ready to pursue Final Recalibration***
- Main projects implemented within imminent build of OTFR:
    1. Updated Echelle Flux Calibration & Blaze Shift Correction
        - Latter to vary as a function of Echelle order (significant effect)
        - Implementation incurred slight delay due to unexpected need for new sensitivity calibration
        - CALSTIS change implemented, reference file update imminent
    2. Implementation of associations for GO Wavecals and Fringe Flats
        - **science ↔ wavecal** or **science ↔ fringe flat** using *static* tables
        - Fringe flat association implemented as of August 2006
        - Wavecal association will need database cleanup (implementation ongoing)
    3. New Traces for spectral extraction – important for 2-D rectification
        - More accurate traces; allow for rotation as function of time
        - CALSTIS change and reference file update now implemented
        - Documentation in progress

Echelle Blaze Shift Correction vs. Order
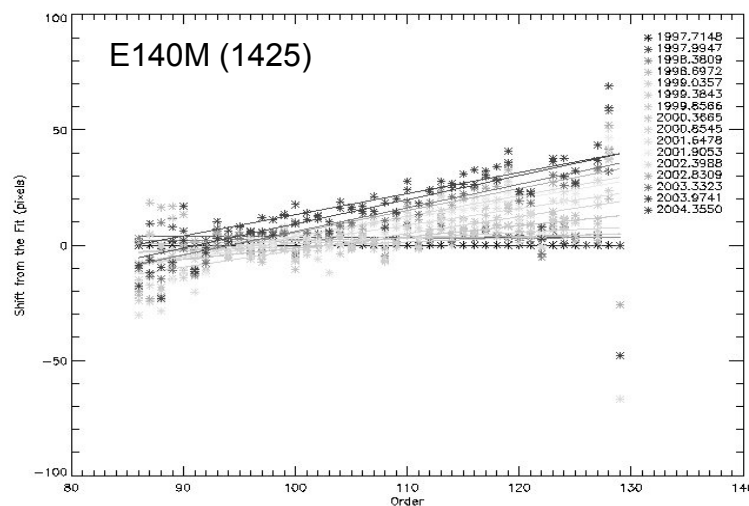
Figure by A. Aloisi

Many modes show strong change of time & order dependence past 2001

Echelle Blaze Shift Correction vs. Order

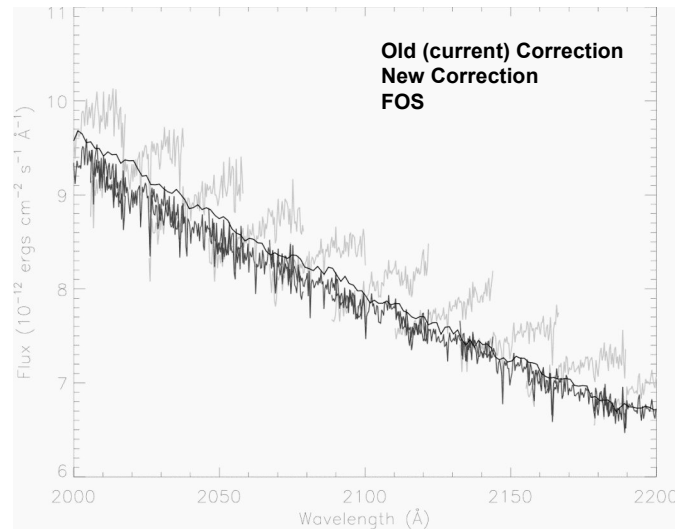Old (current) Correction
New Correction
FOS

Figure by
A. Aloisi

Red spectrum shows final flux accuracy (~1-3%)

Planning/Status of Remaining Tasks in STIS Closeout Plan (1)

- ■ *Calibrations are now ready to pursue Final Recalibration*
- ■ Main projects implemented within imminent build of OTFR:
  1. Update Echelle Flux Calibration & Blaze Shift Correction
     - ♦ Latter to vary as a function of Echelle order (significant effect)
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  2. Implementation of associations for GO Wavecals and Fringe Flats
     - ♦ **science ↔ wavecal** or **science ↔ fringe flat** using *static* tables
     - ♦ Fringe flat association now implemented
     - ♦ Wavecal association will need database cleanup (implementation ongoing)
  3. New Traces for spectral extraction – important for proper 2-D rectification
     - ♦ More accurate traces; allow for rotation as function of time
     - ♦ CALSTIS change and reference file update now implemented
     - ♦ Documentation in progress

Planning/Status of Remaining Tasks in STIS Closeout Plan (2)

- Main projects that are NOT considered part of Final Recalibration effort, but being implemented off-line within Fall 2006 STSDAS build:
  1. IRAF/STSDAS task to correct magnitudes in photometry tables based on STIS CCD imaging for CTE loss
     - Based on algorithm in PASP paper (in press, Oct 2006 issue)
  2. Spectral Trace Generation Tool – needed for best 2-D rectification
     - Using observed spectrum itself to generate trace file
     - Yields most accurate spectral extraction for high-S/N data
  3. New 2-D spectral rectification interpolation scheme
     - Wavelet-based algorithm
     - Can yield significant improvement over default bilinear interpolation
     - However, not in *all* cases or circumstances. Not applicable for pipeline.

Spectral Rectification Improvements

2 pixels @ center

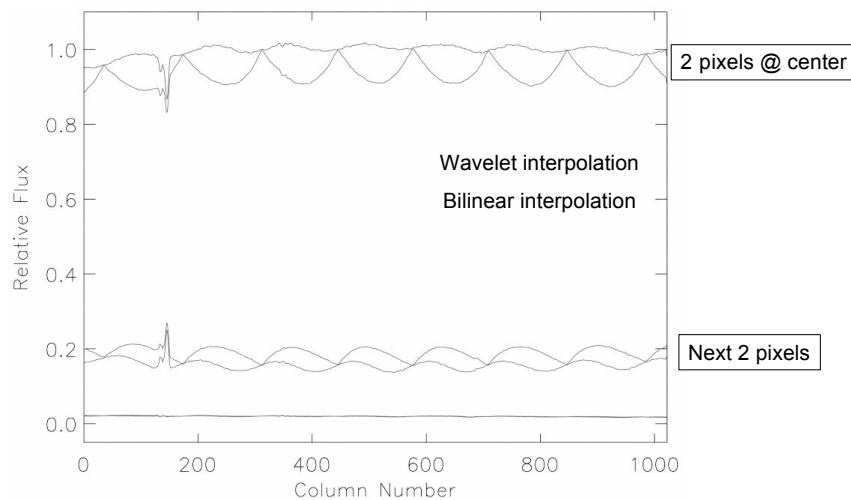Wavelet interpolation

Bilinear interpolation

Next 2 pixels

Figure by L. Dressel

- **Wavelet-based interpolation** *typically* better
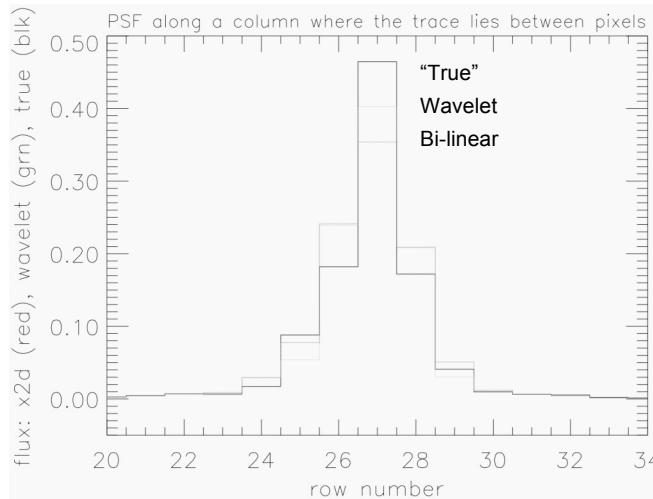 - Both for overall flux level and reduction of 'scallop' amplitude

Spectral Rectification Improvements

PSF along a column where the trace lies between pixels

"True"
Wavelet
Bi-linear

Figure by
L. Dressel

- … but not *always* better (note situation 2 pixels away from PSF center)

The STIS Recalibration Effort

- Schedule:
    1. STIS Team to test final pipeline using random datasets
        - ~5000 exposures, or ~2.5% of total datasets
        - Preparing scripts to allow quick examination of data quality
        - Oct 26 through mid-November
    2. Archive branch to start full recalibration effort
- Will use regular (operational) OTFR pipeline
    - Care to be taken to avoid undue burden on archive system
- Job submission schedule will be tuned to use relative downtimes of OTFR use
    - Current estimate for overall duration of project: 3-5 months
    - Estimate will be updated along the way
    - Keeping close eye on Large & Treasury project schedules

Remaining STIS Data Enhancement Program Activities

- Final Calibrations, to be implemented as off-line tasks:
    1. Spectroscopic Multidrizzle
        - ♦ To be considered for off-line STSDAS installation in 2007
        - ♦ Use framework provided by ECF *aXe* package (for ACS slitless modes)
    2. ECF Physical-model-based Echelle Wavelength Calibration
        - ♦ CALSTIS-compatible module handed to ECF for evaluation last spring
        - ♦ ECF evaluation revealed need for extra ECF software. Work ongoing.
        - ♦ Keeping solution for E140H in mind for Fall 2007 STSDAS build.
- Documentation:
    - Instrument Science Reports on recently finished calibrations
    - Update of STIS Data Handbook
    - Ongoing STANs and STScI Newsletter articles
- Archive Enhancement:
    - Improved archive interface for previews of spectral data
    - Spectroscopic PSF library & associated GUI

Appendix:
Activities in the STIS Closeout Plan

Note: Current status of activities are indicated in red.

STIS Calibration Activities

- **NUV-MAMA Prism Calibration** (PRIORITY: Med/High)
  - ◆ Software package to enable full calibration of spectra taken in slitless Objective Prism mode
    - ◆ Calibrating wavelength, time-dependent sensitivity and geometric distortion throughout FOV
    - ◆ Inputs: (a) direct image(s) in NUV-MAMA imaging mode, (b) Coordinate table of objects to be fitted, and (c) PRISM image
    - ◆ Products: Software; ISR; New Reference Files **(all done)**
    - ◆ *Routine to be converted into IRAF/STSDAS task by SSB (low priority)*

- **L– and M–mode Sensitivity updates** (PRIORITY: High)
  - ◆ Delivery of final sensitivity calibration for first-order modes
    - ◆ Using spectra of both Primary and Secondary Standard Stars, taken through Aug 2004 (previous update done in Jan 2004)
    - ◆ Flux calibration for several M modes not been done yet **(done now)**
  - ◆ Products: Updated Reference Files (done)

STIS Calibration Activities

- **Echelle-mode Sensitivities (done)** (PRIORITY: Crucial)
  - ◆ Prepare and deliver final sensitivity calibrations for E-modes using all CAL data collected through Aug 2004
  - ◆ Specs on Flux calibration (5% rel.) not achieved for last few HST cycles
  - ◆ Significant, multi-faceted effort:
    - ◆ Global, λ-dependent change in sensitivity
      - • Time dependence of sensitivity to be compared with that in place for the first-order modes and implemented (requires newly formatted photometric throughput reference file)
    - ◆ Blaze shift correction as a function of 'monthly offset'
      - • Blaze shift $\neq$ wavelength shift due to monthly MSM offsets
      - • IDT correction by Bowers & Lindler implemented 09/02
    - ◆ Two significant shortcomings:
      - • Blaze correction In place for primary λ_c only, not for secondary
      - • Time dependence of blaze shift correction is (currently) incorrect
      - • Synphot ref. files do not include blaze function for E modes.

STIS Calibration Activities

- **CCD & MAMA Full-field Sensitivity Monitoring**

  (PRIORITY: Medium)

  - Flux measurements of various isolated stars throughout the FOV of the detectors taken at regular time intervals so that star is imaged on different parts of detector. Compare results with those in existing ISR (data up to 2002);
  - Evaluate need for update to L-flat ref file(s) or ISR.

  Status: Small # of data affected (minor effect). Deferred to after STIS revival decision

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STIS Calibration Activities

- **FUV-MAMA Dark Correction**   (PRIORITY: High)

  - FUV-MAMA dark in "glow" region generally increasing w/ Charge Amp temp and time since HV turn-on, but so far not easily (nor thoroughly) parameterized; Also, engineering telemetry needed.
  - For "heritage" instrument, correction may be implemented using ENG telemetry (e.g., table containing MAMA turn-on times)
  - (Likely) Products: New Reference Files; *CALSTIS code change*

  Status: Deemed less important (now) than ECF Echelle Wavelength Calibration improvement. Deferred until after STIS revival decision.

STIS Calibration Activities

- **CCD Bias Monitor** (PRIORITY: High)
  - Investigation of the evolution of the CCD biases
    - Overscan level
    - 2-D structure of weekly superbiases
    - Number and level of hot columns
    - Products: ISR
- **CCD Dark Monitor** (PRIORITY: High)
  - Investigation of the evolution of the CCD darks
    - median dark level and its standard deviation
    - CTE-caused tail intensity
  - Products: ISR
- **CCD Anneal** (PRIORITY: High)
  - Re-evaluation of the monthly growth in hot pixel rates (at different intensity levels) and the effectiveness of the anneal over time, using all Anneal data through Aug 2004
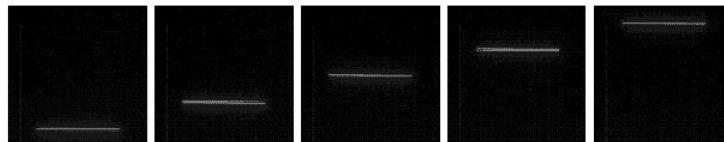 - Products: ISR (update of 98-06)   **Done now; ISR being reviewed**

STIS Calibration Activities

- **CCD Internal Sparse Field CTE program** (PRIORITY: High)

  - Series of lamp images through narrow slits, projected at 5 positions along parallel readout direction
  - Designed to represent "worst–case" point source spectroscopy (~no background to fill traps), and high S/N at a given signal level
  - Executed annually, first execution *before launch*
  - Yields best data on time dependence of CTE effect
  - Last epoch's data to be analyzed; Results to be compared with current time coefficient and P. Bristow (ECF)'s code based on physical model
  - Products: ISR; update to CCDTAB reference file if needed.
  - **Status: All Done**

STIS Calibration Activities

- **CCD External Sparse Field CTE program**

  (PRIORITY: High)

  - Annual monitoring (since 1999) of sparse fields (point sources) in imaging and slitless spectroscopy modes; also dedicated long-slit spectroscopy of faint standard stars (stepping along slit).
  - Analysis of last two epochs to be finished and compared with earlier results to finalize correction algorithm parameters
  - Results to be compared with P. Bristow (ECF)'s code based on physical model
  - Products:
    - ISR **(Done)**
    - PASP paper **(Done; in press for Oct 2006 issue)**
    - Update to CCDTAB reference file if needed (for spectroscopy) **(Done)**
    - IRAF/STSDAS task to correct photometry tables (for imaging). **(Done)**
      [Some SSB resources used for the latter]

STIS Calibration Activities

- **CCD CTE Effect on Extended Sources**   (PRIORITY: High)
  - Analysis of 3 CAL programs to determine effects of CTE on surface photometry and spectroscopy of extended sources:
    - Luminosity, ellipticity, PA measurements as function of surface intensity (imaging; 2 epochs)
    - Continuum and emission-line intensities (spectroscopy)
    - Absorption-line strengths and EWs (spectroscopy)
  - Results to be compared with
    - (a) correction based on point-source CTE analysis;
    - (b) P. Bristow (ECF)'s code based on physical model
  - Products:
    - 1 or 2 ISRs
    - If appropriate: Downloadable CCDTAB ref file for use with extended sources
  - **Status: Delayed until after Final Calibration Effort**

STIS Calibration Activities

- **Imaging Zeropoints and Color Terms** (PRIORITY: High)
  - Analysis of imaging data of stars with known (measured) SEDs, covering a large range of T_{eff}
    - Determine the influence of the intrinsic colors to the derived zeropoints (the 'color terms') – esp. important for MAMAs
    - Compare with predictions using synthetic spectra (using synphot)
  - Products: PASP paper **(Nearing submission)**
- **MAMA First-Order Dispersion Solutions** (PRIORITY: High)
  - CAL program to test accuracy of wavelength solutions for *all* primary and secondary central wavelengths, using the new Pt/Cr-Ne line list delivered by the ECF **(Done for FUV part)**
  - Products: ISR; New _dsp Reference File

STIS Calibration Activities

- **Sensitivities for the CCD E1 & E2 Apertures** (PRIORITY: High)
  - Analysis of spectrophotometric standard star spectra taken at these locations (near CCD row 900, to mitigate CTE loss)
    - Check of the influence of detector sensitivity and focus/PSF differences relative to central position
    - First results indicate changes of a few %, leading to errors in the extracted fluxes changing from one aperture to the next.
  - Products: ISR; Likely update to Reference Files (aperture throughput and/or L-flat) **(Done)**
- **Grating Scatter for the G230LB grating** (PRIORITY: Medium)
  - Analysis of G230LB spectra of red targets
    - To find correction for influence of grating scatter from far wings of the zeroth-order LSF (similar to effect seen for FOS UV gratings)
    - To investigate analysis done by GO (M. Gregg) who used red targets for G230LB, G430L and G750L

STIS Calibration Activities

- Spectroscopic PSF Across Slit (for 52x0.1 and 52x0.2)
  - (PRIORITY: High)
  - ◆ Stepped K giant across slit to sample PSF in the dispersion direction, and compare with that along the slit. **(Done)**

- Trace Stability for Often-Used Modes   (PRIORITY: High)
  - ◆ Projection of spectra onto CCD at given location along slit
  - ◆ Traces need to be very accurate when extracting individual rows
  - ◆ Current trace Ref. Files from 1997; now seen to be in error for last few cycles. Redetermination for often-used modes justified.
  - ◆ Products: ISR; Trace Reference Files **(Done)**

STIS Pipeline Block Activities

- Spectroscopic MultiDrizzle   (PRIORITY: High)
  - ◆ To allow handling of dithered spectroscopic STIS data
    - ♦ Along-slit vs. across-slit dithers have different image scales
    - ♦ To involve dedicated software and reference files to allow corrections depending on detector, grating and aperture.
  - ◆ Significant effort, but constitute unique data analysis resource and likely very highly appreciated by community
  - ◆ Products: ISR; New, dedicated Reference Files

- Rectification of non-dithered Spectra of Spatially Resolved Targets **(Done)**   (PRIORITY: High)
  - ◆ Improve quality of 1-3 pixel high extractions of G430M and G750M spectra
    - ♦ Current interpolation scheme produces significant undulations
    - ♦ Activity expected to involve interactions with ζ Car Treasury Program
    - ♦ Quality of new solution can be tested by comparison with results from preceding activity

STIS Pipeline Block Activities

- **TIR on Implementation of Time-Dependent Sensitivity into SYNPHOT** **(Done)** (PRIORITY: High)
  - ◆ Involved several steps not normally encountered in SYNPHOT ref. File deliveries
  - ◆ Relevant for ACS and COS later on
- **SYNPHOT Delivery Procedures TIR (Done)** (PRIORITY: High)
  - ◆ Descriptions of the several types of component files (incl. those currently missing from the original SYNPHOT documents) and how they are implemented within SYNPHOT. Relevant for all instruments.
- **STScI/ST-ECF Collaboration** (PRIORITY: High)
  - ◆ Work related to implementation of deliverables of the STIS Calibration Enhancement project run by ECF (physical model-based calibrations)
    - ♦ SSB assistance needed regarding implementation of software modules within CALSTIS and reference files (when judged to constitute significant improvement)

STIS Pipeline Block Activities

- **ECF Physical Model-based CTE correction**
  (PRIORITY: High/TBD)
  - ◆ Cost/benefit study regarding the implementation of physical model-based CTE correction code
    - ♦ Correction based on a physical model of the STIS CCD (its material / known charge traps and its readout properties (by Paul Bristow @ ECF))
    - ♦ Corrects whole image (pixel by pixel) instead of current implementation, which corrects flux based on observation epoch and measured (extracted) net & background counts
    - ♦ Pipeline implementation would require rebuild of (all) CCD superbias and superdark reference files as well as making the code run more efficiently in terms of CPU cycles
    - ♦ Consider releasing code as (off-line) IRAF/STSDAS task and making re-built set of superbiases/superdarks available through archive
- **Status: Cost/benefit study done; decided not to implement. Report sent to ECF (Feb 2006) who agreed with the reasoning.**

STIS Pipeline Block Activities

- **Final Calibration of STIS Data** (PRIORITY: High)
  - Comprehensive run of all STIS data through OTFR pipeline to produce final, static archive of raw & calibrated datasets
    - To be run after all final calibrations, coding updates, and reference files have been tested and delivered to OPUS/CDBS.
    - OTFR can then be switched off for STIS use, making more processing power available for OTFR requests of active HST instruments.

STIS Archive Enhancement Activities

- **Spectroscopic PSF Library** (PRIORITY: High)
  - Assembly of data base of well-exposed point source spectra covering the length of the long slits
    - Allow GOs to retrieve spectroscopic PSFs in given observing mode and location on detector
    - Products: ISR; GUI to perform archive retrieval
    - Requires some SSB/ESS resources
- **GO Wavecal Association** (PRIORITY: High)
  - Development of system within OPUS and Archive to associate STIS GO wavecals with the appropriate science spectra for automatic retrieval **(In Progress)**
- **Fringe Flat Association** (PRIORITY: High)
  - Similar to last item, now to associate GO-inserted fringe flats to G750L/G750M spectra **(Done)**

STIS Archive Enhancement Activities

- **Spectroscopic Preview Enhancement**   (PRIORITY: High)
  - Review and improvement of "preview" facility available within MAST/HST retrieval pages
    - Several aspects that need improvement (e.g., no 2-D image display, sky subtraction, display parameters, "not available" error messages)
    - Products: ISR; Coding for web interface
    - Requires Archive Branch resources
- **Imaging Preview Enhancement**   (PRIORITY: Medium)
  - Similar to above
  - **Status: Eliminated (cf. Fall 2005 presentation to STUC)**

STIS Information Block Activities

- **Final Data Handbook Update**   (PRIORITY: High)
  - Review and update of STIS Chapter of HST Data Handbook
    - Last update made before a number of significant pipeline updates and stand-alone STSDAS tasks were released
    - To include more complete "cookbook" to guide users in routine analysis of STIS spectral data
- **Summary Document (ISR): The STIS Experience**
  (PRIORITY: High)
  - Summary of experience with operation and calibration of STIS, to provide easy reference for comparison with operations of other (current and future) SIs.
  - Separate sections on (e.g.) MAMAs, CCD, Lamps / Optics
  - **STATUS: Deferred until after STIS repair decision**

STIS spectroscopic data that is not or should not be fully calibrated

- 98 long slit observations using echelle modes (will cause order overlap if source is extended).
- 2237 prime and 7371 parallel slitless observations (multiple or randomly centered targets).
- Data sets without associated auto-wavecal:
  - ~12293 out of 37886 of STIS prime external spectroscopic observations lack auto-wavecals
  - Identified those with GO specified wavecals. Will use these to calibrate the data during "Final Calibration"
- 3666 data sets where CFSTATUS = "AVAILABLE" and 135 "ENGINEERING" (unsupported and poorly calibrated modes).
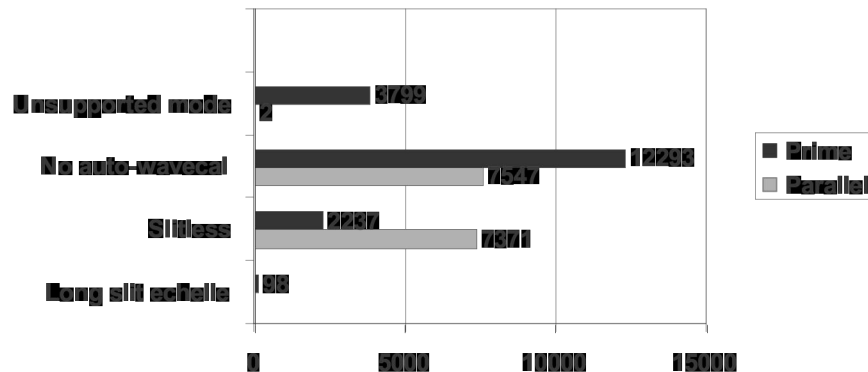

STIS external spectroscopic exposures that aren't or shouldn't be fully calibrated

- *All* STI external spectroscopic exposures total 37886 prime and 8197 parallel.
- Some exposures appear in more than one category (e.g., most slitless parallel observations also omitted a wavecal).

CFSTATUS="AVAILABLE"

- 3666 of the 37886 STIS prime external spectroscopic science observations are listed as cfstatus="available" in the archive, mostly because the aperture/grating combination was not supported when observation was done.
  - 800 of these are now fully supported combinations and are calibrated by OTFR when a wavecal is available.
  - 21 are small aperture echelles using non-standard apertures which can be easily calibrated.
  - 86 additional echelle and 1st-order observations taken through intermediate sized apertures or of point sources observed with long ND slits will be calibrated with some effort, but with reduced flux accuracy or modest scattered light and cross order contamination issues (to be documented)
  - 2587 (2464 from one program + 123 other) 1st order spectra using 2X2 or 6X6 apertures. Could be "supported" (but treat as slitless for 6X6).
  - 67 observations taken with unsupported fiducial bars – will be supported
  - 39 echelle observations through long slits of extended targets or using large slits, where archiving an x1d file probably doesn't make sense.
  - 15 calibration observations through miscellaneous imaging filters
  - 3 observations at "deleted" cenwave values (to be changed to engineering)

STIS external spectroscopic exposures in "unsupported" modes
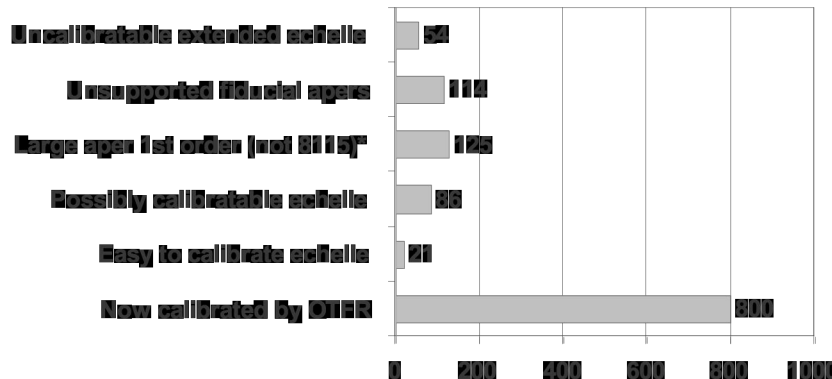
*Above chart excludes 2464 datasets from program 8115 (Valenti, Stellar Seismology). Also excludes 135 exposures flagged as "engineering".