Chapter 22

STIS Error Sources

In This Chapter...

In this chapter we discuss the sources of uncertainty in STIS data, and provide pointers to resources beyond this manual for the latest descriptions of our evolving understanding of these issues.

22.1 Calibration Goals

STIS is a new and complex instrument. As of the date of this *Data Handbook*, our understanding of STIS as an instrument, as well as our development and optimization of the pipeline calibration for STIS (both the software and the reference files) is at an early stage.

In Table 22.1 through Table 22.5, we publish the calibration goals for Cycle 7. These are the accuracies we aim to provide to users by the end of Cycle 7 for data taken in supported modes at any time during Cycle 7. That is, at the end of Cycle 7, if you use the most up to date **calstis** calibration software and the most appropriate reference files to recalibrate your data, then these are the accuracies we aim to be able to provide. In the interim, as we obtain and process the on-orbit calibration data needed to produce the reference files to support this level of calibration accuracy, and as we improve the calibration software in tandem, the level of accuracy you will receive in your data will be different (lower) than these values. Information about the accuracies obtainable at any one time and about data foibles will be regularly posted to the STIS WWW page and announced in Space Telescope Analysis Newsletters (STANs) sent via e-mail to the STIS community (see below).

Table 22.1: CCD Spectroscopic Accuracies

Attribute	Accuracy	Limiting Factors
Relative wavelengths—within an exposure	0.1–0.25 pixels	Stability of optical distortion
Absolute wavelengths—across exposures	1.0 pixels	• Thermal stability • Internal versus external illumination • Derivation of wavecal zero point
Absolute photometry	10%	Instrument stability and photometric calibration
Relative photometry (within an exposure)	5%	Instrument stability and photometric calibration

Table 22.2: MAMA Spectroscopic Accuracies

Attribute	Accuracy	Limiting Factor
Relative wavelengths—within an exposure	0.25–0.5 pixels	Stability of small scale geometric detector + optical distortion
Absolute wavelengths—across exposures	1.0 pixels	• Thermal stability • Internal versus external stability • Derivation of wavecal zero point
Absolute photometry	15%	Instrument stability and calibration
Relative photometry (within an exposure)	5–10%	Instrument stability/flat fields

Table 22.3: CCD Imaging Accuracies

Attribute	Accuracy	Limiting Factor
Relative astrometry—within an image	0.1 pixels	Stability of optical distortion
Absolute photometry	5–10%	Instrument stability
Relative photometry within an image	5%	External illumination pattern

Table 22.4: MAMA Imaging Accuracies

Attribute	Accuracy	Limiting Factor
Relative astrometry—within an image	0.25 pixels	Small scale distortion stability
Absolute photometry	15%	Instrument stability and calibration
Relative photometry within an image	10%	Flat fields/external illumination

Table 22.5: Target Acquisition Accuracies

Attribute	Accuracy	Limiting Factor
Guide star acquisition	1–2”	Catalog uncertainties
Following target acquisition exposure	0.2”	Centering accuracy plus plate scale accuracy to convert pixels to arcsecond
Following peakup acquisition exposure	30% of the slit width	Number of steps in scan + PSF

22.2 Calibration Accuracy Resources

We will continue to update information under the “Calibration” area on the STIS Instrument World Wide Web (WWW) page which will help you to understand the accuracy you can achieve with your data at any given time. Among the types of information we provide there are the following.

The STIS web page can be found at:

`http://www.stsci.edu/ftp/instrument_news/STIS/`

The STIS Data Foibles Listing

The “STIS Data Foibles” page provides examples of commonly found data attributes and anomalies that are unique to STIS and that can affect the interpretation of your data. Currently described in this area are:

- Fringing for CCD spectroscopic observations.
- CCD long wavelength detector halo.
- CCD Gain-4 detector noise.
- CCD hot pixels.
- CCD flat fields and “dust motes.”
- NUV-MAMA dark current.
- Optical ghosts and artifacts in imaging mode.
- Optical ghosts and artifacts in spectroscopic modes.
- Echelle inter-order scatter.
- MAMA PSF and LSF halos.

STIS Performance Summaries

On-orbit determined performance summaries will be updated on the web as information continues to become available. Currently we provide information under the Calibration page on:

- Sensitivity measures and accuracies.
- Target acquisitions.

- MAMA detector performance.
- CCD detector performance.
- Point spread functions.
- Line spread functions and spectral resolution.
- Cross dispersion profiles.
- Aperture locations and throughputs.
- Geometric distortions.
- MAMA flat fields.
- Chronographic performance.
- Instrument flexure, thermal stability.
- Dispersion solutions and wavelength zeropoints.

Calibration Accuracy

We plan to maintain an up-to-date listing of the current levels of calibration accuracy provided by the pipeline at any one time, including such things as absolute sensitivity accuracy (by grating and central wavelength when applicable for spectroscopy and by filter for imaging modes), the relative sensitivity accuracies (across grating modes and across wavelengths within a giving grating mode), the aperture throughput accuracy, the absolute and relative wavelength accuracies and the astrometric accuracies, etc.

Pipeline Software History

The pipeline software history listing provides an ongoing log of the changes made to the **calstis** software and the implications for the accuracy of data calibrated with **calstis**. This history is useful if you are trying to decide whether you wish to download a new version of the **calstis** software.

Reference File History

The reference file listing provides a high-level summary of the history of updates to reference files, which can help you decide whether you wish to recalibrate your data.

Cycle 7 Calibration Plan

Here you can see what observations are planned for Cycle 7 calibration and which calibrations have already been taken. We note that all calibration data are non-proprietary. If we have not yet been able to process existing calibration data—especially data that are particularly appropriate for your science—into a reference file or a GO advisory, you can retrieve those datasets and analyze them directly yourself. New information about STIS instrument performance will be announced regularly in the STANs and posted to the STIS Instrument WWW pages.

22.3 Factors Limiting Flux and Wavelength Accuracy

22.3.1 Flux Accuracy

The accuracy to which you can trust the absolute flux calibration of your STIS spectroscopic data at slit center is limited by several factors including:

- The accuracy of the absolute sensitivity calibration of the grating and central wavelength setting. The on-orbit absolute sensitivity calibration is determined by observing a standard star, with known absolute flux calibration, well centered in both wavelength and cross dispersion in a large slit. The STIS spectrum of this star is then extracted over a standard aperture extraction box and the sensitivity required to return the known flux from the star is determined as a function of wavelength. The standard aperture extraction box is large enough to be relatively insensitive to spacecraft jitter and breathing but small enough that the signal-to-noise of a typical stellar spectrum will not be degraded. STIS calibration accuracies are defined for the standard aperture extraction box; the standard boxes are mode dependent and are given in the XTRACTAB reference file.
- The accuracy of the calibration of the aperture throughput for the aperture you are using for your science relative to the aperture which was used for the absolute sensitivity calibration.
- The accuracy to which your source is centered in your slit.
- The size of the extraction aperture you use to measure your flux and the accuracy to which the cross dispersion profile is known in the mode in which you are observing. Because the corrections for the aperture extraction can be large (e.g., 30% in the near-infrared and the far-UV) this effect can be important.
- Bias and background subtraction can add considerable additional uncertainty for faint sources or spectra with significant variations in flux, particularly for the echelle modes.
- The importance of scattering, which can play an important role, particularly in the G230LB and G230MB gratings.

Additional uncertainties arise for flux measurements not at slit and field center. These uncertainties are relevant when, for example, you wish to determine relative fluxes in an extended source along the long slit or when you have used POS TARGs to move a target along the long slit. They include:

- The variation in slit throughput along the slit. The slits have 5 micron (corresponding to ~0.2 arcsecond) variations along their widths, which for a 0.1 arcsecond wide slit on a diffuse source, would produce a 20% variation in flux. For a point source the variation would be more in the 5% range for that same slit. There are also dust specks with appreciably higher opacity along some places in some slits. These specks have not yet been cataloged.

- The accuracy to which the vignetting along the cross-dispersion direction is known for your grating and central wavelength
- The accuracy to which the low-order flatfield along the dispersion direction is known off of field center for your grating and central wavelength.

At this early stage, the accuracies to which these factors are known are changing dramatically, as we finish analyzing the Servicing Mission Orbital Verification (SMOV) data and embark on Cycle 7 Calibration. Updated calibration information is provided on the STIS WWW page.

22.3.2 Wavelength and Spatial Accuracies

The accuracy with which the wavelength scale is known in your calibrated STIS spectrum will depend on several factors:

- The accuracy of the dispersion solutions, which governs the accuracy to which relative wavelengths are known in a given spectrum
- The accuracy of the wavelength zeropoint, which governs the accuracy to which relative wavelengths are known across spectra.
- The accuracy to which your source is centered in the science slit (a pixel of miscentering corresponds to a pixel in absolute wavelength space).

The dispersion solutions used to calibrate STIS on orbit data were derived on the ground during thermal vacuum testing. On-orbit tests confirm the applicability and accuracy of the ground dispersion solutions for on-orbit data, producing relative wavelength accuracies of 0.2 pixels across the spectrum for first-order gratings at the prime settings and appreciably better in some instances. For the echelle modes, at the prime settings, the accuracies are roughly 0.2 pixels for wavelengths in the same order and approximately 0.5 pixels for the entire format. The intermediate wavelength settings have roughly twice these errors.

Due to the lack of repeatability of the Mode Select Mechanism (STIS's grating wheel—see page 19-3), the projection of your spectrum onto the detector in both wavelength and space will vary slightly (1 to 10 pixels) from observation to observation (if the grating wheel is moved between observations). In addition, thermally induced motions can also affect the centering of your spectrum. The **calstis** pipeline removes the zeropoint offsets using the contemporaneously obtained auto-wavecals (see "WAVECAL Processing" on page 21-23). The wavelength zeropoint in your calibrated data (the *rootname*`_sx2.fits`, `_x2d.fits`, `_x1d.fits`, and `_sx1.fits` files) is corrected for these offsets and should have a wavelength zeropoint accuracy of ~0.1–0.2 pixels (better when the wavecal is taken through small slits, worse for those taken through wider slits). This accuracy should be achieved, so long as contemporaneous wavecals were taken along with the science data, distributed at roughly one hour intervals among the science exposures, and assuming the target was centered in the slit to this accuracy or better.

The accuracy of the zeropoint pipeline calibration in the spatial direction is slightly less, roughly 0.2-0.5 pixels. This is because the finding algorithm, which must locate the edges of the aperture for short slits and the edges of the fiducial bars on the slits for the long slits, is less robust. Observers need to be aware of possible offsets between spectra in the spatial direction, particularly when deriving line ratios for long-slit observations of extended targets taken with different gratings.