Chapter 20
STIS Data Structures

In This Chapter...

This chapter explains how STIS observations are stored in STIS data files. When you receive STIS data files from the Archive, they will be in FITS format, and they should remain in FITS format (i.e., do not convert the format with **strfits**). Chapter 2 describes the structure of FITS files, explains how images and tables are stored in FITS extensions, and shows how to access data in these extensions. If you are not familiar with FITS extensions, please read Chapter 2 first.

20.1 Overview

Calibrated STIS data have been processed through the STScI **calstis** pipeline. The pipeline unpacks the databits from individual exposures, combines them into files containing raw, uncalibrated data, and performs image and spectroscopic reduction on the data to produce output files which can be used directly for scientific analysis (see Chapter 21 for a more detailed description of the STIS pipeline). Unlike previous HST pipelines, the STIS pipeline performs contemporaneous calibrations, processing data from multiple science exposures as well as contemporaneously obtained line lamp calibration exposures through the pipeline as a single unit. These multiple *associated* STIS exposures which are processed through the pipeline as a unit are combined into a single dataset, to allow easy identification and compact storage. (See Appendix B for a general explanation of HST data associations.)

To work effectively with your data you will need to understand:

- The basic format in which the STIS data are stored, the information and nature of the data stored for each observation—see "STIS File Structures", below.
- The nature of the individual files in your dataset, i.e., what data is stored in what file. Spectroscopic observers looking for the final calibrated product will want first to examine the `*_sx2.fits` or `*_x2d.fits` files, which store rectified, flux- and wavelength-calibrated, two-dimensional spectra, in the case of first order long slit data; or to examine the `*_sx1_fits` or `*_x1d.fits` files which store background subtracted, aperture extracted, flux- and wavelength-calibrated, one dimensional spectra, for the case of echelle spectroscopy—see "Types of STIS Files" on page 20-6.
- How to use the header keyword information to identify the principal parameters of your observation and to determine the calibration processing steps which were performed on your dataset—see "Headers, Keywords, and Relationship to Phase II" on page 20-9.
- The meanings of the error and data quality arrays, which are propagated through with each STIS science observation—see "Error and Data Quality Arrays" on page 20-13.
- How to use the STIS Paper Products—see page 20-15.

20.2 STIS File Structures

All STIS data products are FITS files. Images and two-dimensional spectroscopic data are stored in FITS image extension files, which can be directly manipulated, without conversion, in the IRAF/STSDAS environment. These FITS image extension files allow an *associated* set of STIS science exposures, processed through calibration as a single unit, to be packaged into a single file. Accessing the images in the FITS image extension files in IRAF follows a simple convention explained in detail in Chapter 2. The **catfits** task can be used to display the complete contents of the primary and extension headers of the data file. Section "Types of STIS Files" on page 20-6 describes the contents of these files and how to access them.

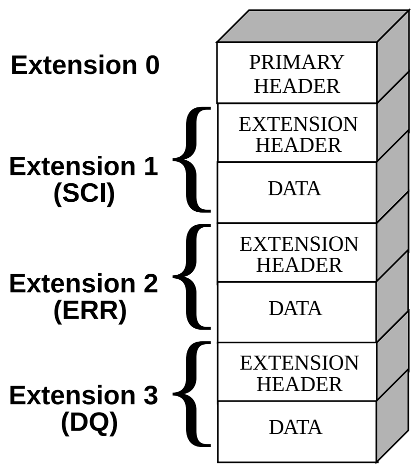
Tabular STIS information, such as extracted one-dimensional spectra or the `TIMETAG` mode event series are stored as three-dimensional FITS binary tables. The tables can be accessed directly in the IRAF/STSDAS environment using tasks in the **tables.ttools** package as described in Chapters 2 and 3.

20.2.1 STIS FITS Image Extension Files

Figure 20.1 illustrates the structure of a STIS FITS image extension file, which contains:

- A primary header that stores keyword information describing the global properties of all of the exposures in the file (e.g., the target name, target coordinates, total summed exposure time of all exposures in the file, optical element, aperture, detector, etc.).
- A series of image extensions, each containing a header with specific exposure-level keyword information only (e.g., exposure time, world coordinate system, etc.) and a data array.

Figure 20.1: FITS Image Extension File for STIS



Storage of STIS ACCUM Mode Science Data: Raw and Calibrated Two-Dimensional Spectroscopic and Imaging Data

All ACCUM mode uncalibrated science data from STIS and all calibrated STIS data, with the exception of the extracted one-dimensional spectra (see below) are stored in FITS image extension files with the particular format shown in Figure 20.1.

A triplet of FITS image extensions corresponds to each exposure in a STIS data file:

- The first, of extension type SCI, stores the science values.
- The second, of extension type ERR, contains the statistical errors, which are propagated through the calibration process.
- The third, of extension type DQ, stores the data quality values which flag suspect pixels in the corresponding SCI data.

The error arrays and data quality values are described in more detail in “Error and Data Quality Arrays” on page 20-13.

Two-Dimensional Extracted Spectra

The `*rootname*_sx2.fits`, `*rootname*_x2d.fits` files which hold the flux and wavelength-calibrated two-dimensional spectra for long-slit first-order observations are stored as FITS image, as are the raw data and the calibrated imaging data. The units of the data in the extracted two dimensional spectra are ergs sec^{-1} cm^{-2} A^{-1} $arcsec^{-2}$ $pixel^{-1}$. "Working with Two Dimensional Extracted Spectra" on page 23-3 describes how to work with these data to derive flux information and wavelengths.

Imaging Data

The final calibrated output product for CCD imaging data is the *rootname*`_crj.fits` file, and the final calibrated product for MAMA data is either the *rootname*`_flt.fits` or *rootname*`_sfl.fits files`. The units of the data in these files is in counts per pixel, just as in WFPC2 data, and in general these data can be manipulated just like WFPC2 data. See "Converting Counts to Flux or Magnitude" on page 3-15.

Storage of Acquisition and Acquisition/Peakup Images

Almost all STIS spectroscopic science exposures will have been preceded by an acquisition and possibly an acquisition/peakup exposure to place the target in the slit. Keywords in the header of spectroscopic data identify the dataset name of the acquisition (in the ACQNAME keyword) and acq/peak images (in the ACQPEAK1 and ACQPEAK2 keywords).

An acquisition exposure produces a raw data file (*rootname*`_raw.fits`) containing three science image extensions corresponding to the three stages of the acquisition procedure:

- [SCI,1] is a subarray image (100 x 100 for point source acquisitions; larger for diffuse acquisitions) of the sky obtained after the initial blind pointing.
- [SCI,2] is an image of the same subarray after the coarse locate phase of the acquisition.
- [SCI,3] is an image of the 32 x 32 subarray taken during the slit-illumination phase of the target acquisition.

An acquisition/peakup exposure will produce a single raw data file for a spiral search and one for each linear one-dimensional search (that is, if you have performed a peakup which requires LINEAR-AXIS1 and LINEAR-AXIS2 scans, then two data sets will be produced—one for each scan). The *rootname*`_raw` data file produced for an acq/peak exposure contains one science image extension:

- [SCI,1] is the confirmation image, taken at the end of the peakup, after the final move which places the target in the slit.
- To examine the flux values of the individual steps in the ACQ/PEAK, list the pixels (using the **listpix** task) of the fourth extension, i.e., *rootname*`_raw.fits[4]`.

20.2.2 Tabular Storage of STIS Data

Time-Tag

Time-tag event data is contained in a binary table extension in which each row of the table corresponds to a single event in the data stream and the columns of the table contain scalar quantities that describe the event, as shown in Table 20.1.

Table 20.1: Columns of a Time-Tag Data Table

Column Name	Units	Description
TIME	s	Elapsed time in seconds since the exposure start time
AXIS1	pixel	Doppler-corrected location of the event, AXIS1
AXIS2	pixel	Location of the event, AXIS2
DETAXIS1	pixel	Location of the event, raw AXIS1 (no Doppler correction applied)

The STIS pipeline collapses a time-tag event series into a single time-integrated image and processes it as if it were an ACCUM mode image. Outside of the pipeline the raw time-tag event stream can be manipulated to produce two-dimensional images which are integrated over user-specified times or manipulated directly (see “TIME-TAG Data” on page 23-5).

One-Dimensional Extracted Spectra

In the STIS pipeline, two-dimensional STIS echelle spectra are aperture extracted, order by order, and each extracted spectral order from a single spectral image is stored in a single table, one order per row. Each column of the table contains a particular type of quantity, such as wavelengths or fluxes. Table 20.2 shows the contents of the different columns in a STIS extracted spectrum table. Each table cell, corresponding to a particular spectral order and type of quantity, can contain either a scalar value or an array of values. For example, each cell in the WAVELENGTH column contains a one-dimensional array of wavelengths corresponding to a spectral order given by the scalar in the SPORDER column on the same row.

There will a separate table extension for each associated exposure in an associated set. For example, if you specified NEXP=3 on your proposal logsheet, you will find the extracted spectrum from the second exposure in the second table extension.

Table 20.2: Columns of a STIS Extracted Spectrum Table

Column Name	Contents	Units	Description
SPORDER	scalar		Spectral order number
NELEM	scalar		Number of valid elements in each array
WAVELENGTH	array	Angstroms	Wavelengths corresponding to fluxes
GROSS	array	counts s^{-1}	Extracted spectrum before subtracting BACKGROUND
BACKGROUND	array	counts s^{-1}	Background that was subtracted to obtain NET
NET	array	counts s^{-1}	Difference of GROSS and BACKGROUND arrays
FLUX	array	erg s^{-1} cm^{-2} A^{-1}	Flux calibrated NET spectrum
ERROR	array	erg s^{-1} cm^{-2} A^{-1}	Internal error estimate
DQ	array		Data quality flags

20.3 Types of STIS Files

The naming convention for STIS files is *rootname_xxx*.fits, where *xxx* is a three-character file suffix. The suffix identifies the type of data within the file. Table 20.3 lists the file suffixes for both uncalibrated and calibrated data files. Depending on the type of observation you have obtained, and therefore on the path it has taken through the calibration pipeline, you will find an appropriate subset of these files in your particular data set. Table 20.4 gives examples of typical STIS datasets for different types of observations. Shading indicates files most likely to be of use during data analysis.

20.3.1 Understanding Associations

A single FITS file will contain multiple science exposures whenever an *associated* set of science exposures is taken. Associations are created for target acquisitions, auto-wavecals, crsplits, and repeatobs (nexp=many in the RPS2 file). You can recognize a data file as an associated set for STIS because there will be a zero in the last position of the rootname (e.g., o3tt01010_raw.fits). The rootnames of the individual exposures in an associated data set are contained in the association file, which has suffix _asn (e.g., o3tt01010_asn.fits). An association file holds a single binary table extension, which can be displayed with the IRAF tasks **tprint** or **tread**. The information within an association table shows how the associated exposures are related. Figure 20.2 illustrates the contents of the association table for a CRSPLIT=2 observation, with an associated autowavecal.

Table 20.3: Data File Naming Conventions

Suffix	Type	Contents
		Unalibrated
_raw	image	Raw science[a]
_tag	table	Timetag event list
_spt	image	Support file (planning & telemetry information)
_wav	image	Associate wavecal exposure
_wsp	image	Wavecal support file (planning & telemetry information)
_asn	table	Association file
_trl	table	Trailer file (input)
_lrc	image	Local rate check image
_lsp	text	Local rate check support file
_jit	table	See Appendix C
_jif	image	See Appendix C
_pdq	table	See Appendix B
		Calibrated
_flt	image	Flatfielded science
_crj	image	Cosmic ray-rejected, flatfielded science
_sfl	image	Summed Flatfield ed science
_x1d	table	*1-D extracted spectra:* * aperture extracted, background subtracted, flux and wavelength calibrated spectra
_x2d	image	*2-D extracted data:* * rectified, wavelength and flux calibrated spectra or * geometrically corrected imaging data.
_sx1	table	Summed 1-D extracted spectra
_sx2	image	Summed 2-D extracted spectra
_trl	table	Trailer file (output); historical record of processing

a. Raw data from isolated wavecals, biases, darks, and flats, as well as from ACQs and ACQ/PEAKs, have the _raw suffix.

Table 20.4: Typical STIS Output Products by Observation Type

Observation Type	Uncalibrated Files	Calibrated Files
ACQ, ACQ/PEAK	`_raw`	none
IMAGING, ACCUM MODE, ASSOCIATED SET (crsplit or repeatobs)	`_raw, _spt, _asn, _trl`	`_flt, _crj, _sf1,` (MAMA only), `_crj` (CCD only)
IMAGING, ACCUM MODE, Single Exposure	`_raw, _spt, _asn, _trl`	`_flt`
FIRST ORDER SPECTROSCOPY, ACCUM MODE ASSOCIATED SET (crsplit or repeatobs)	`_raw, _wav, _asn, _spt, _wsp, _trl`	`_flt, _sx2, _crj`(CCD only) `_sx1` (CCD only)
FIRST ORDER SPECTROSCOPY, ACCUM MODE Single Exposure	`_raw, _wav, _asn, _spt, _wsp, _trl`	`_flt, _x2d`
ECHELLE SPECTROSCOPY, ACCUM MODE single exposure or ASSOCIATED SET	`_raw, _wav, _asn, _spt, _wsp, _trl`	`_flt, _x1d, _x2d`
TIMETAG IMAGING and SPECTROSCOPIC	`_tag` + ACCUM extensions	ACCUM extensions

Figure 20.2: Contents of Association Table

To display the association table for o3tt01010_asn.fits:

```
>tread o3tt01010_asn.fits
# row MEMNAME        MEMTYPE        MEMPRSNT
#
 1   O3TT01AVR        CRSPLIT           yes
 2   O3TT01AWR        CRSPLIT           yes
 3   O3TT01AXR        WAVECAL           yes
 4   O3TT01010        PRODUCT           yes
```

The association table above tells the user that the product, or data set, will have the rootname `o3tt01010`, that there will be two science exposures contained in the `o3tt01010_raw.fits` file which are CRSPLITS, and that a `o3tt01010_wav.fits` file should exist containing the contemporaneously obtained automatic wavecal. The `o3tt01010_raw.fits` file will contain six image extensions, one triplet of {SCI, ERR, DQ} for each exposure (see Figure 20.1). The pipeline will calibrate this data as a unit, producing a single cosmic ray rejected image (*rootname*`_crj.fits`) along with its data quality and error images as well as rectified spectra. Similarly, for `REPEATOBS` observations, in which many identical exposures are taken to obtain a time series, all the science data will be stored in sequential triplet extensions of a single FITS file. These will be processed through the **calstis** pipeline as a unit, with each image extension individually calibrated and the set of images also being combined to produce a total time-integrated, calibrated image. See Chapter 21 for more information about the pipeline processing.

20.4 Headers, Keywords, and Relationship to Phase II

As with previous HST instruments, the FITS header keywords in STIS data files store important information characterizing the observations and telemetry received during the observations and describe the post-observation processing of your dataset. Each keyword follows FITS conventions and is no longer than eight characters. Values of keywords can be integer, real (floating-point), or character string. Many are HST and STIS specific. Knowledge of the keywords and where to find them is an important first step in understanding your data. By examining your file headers, using either **infostis**, **catfits**, **imhead**, or **hedit**, you will find detailed information about your data including:

- Target name, coordinates, proposal id, and other proposal level information.
- Observation and exposure timing information such as observation start and duration.
- Instrument configuration information such as detector, grating, central wavelength setting, and filter.
- Readout definition parameters such as binning, gain, subarray parameters.
- Exposure-specific information such as more detailed timing, world coordinate system information, fine guidance sensor identification.
- Calibration information such as the calibration switches and reference files used by the pipeline and parameters derived from the calibration, such as image statistics, wavelength shifts.

The easiest way to quickly identify the observational parameters of a given dataset is to run the task **infostis** (see Figure 20.3 below) which prints selected header information for STIS FITS images. Wildcard characters or a file list may be used for input (e.g., `*.fits` or `@fitslist`).

Figure 20.3: Using infostis to Display Header Keywords

```
cl> infostis o3xi03a1m_raw.fits
--------------------------------------------------------------------------------
                                                S  T  I  S
--------------------------------------------------------------------------------

           Rootname: O3XI03A1M                 Detector: CCD
        Proposal ID: 7071                              Obs Type: IMAGING
       Exposure ID: 3.031                           Obs Mode: ACQ
                                                                    Lamp: NONE
       Target Name: GD153-1                       Aperture: F28X50LP
 Right Ascension:  12:57:02.3                          Filter: Long_Pass
         Declination: +22:01:53.2             Opt Element: MIRVIS
              Equinox: 2000.0                            CCD amp: D
                                                                      Gain: 4
     Axis 1 binning: 1                                      CR-split: 1
     Axis 2 binning: 1
              Subarray: yes

   Total Exp. Time: 0.3 sec
 Number of imsets: 3
```

STIS takes CCD and MAMA spectroscopic and imaging data, as well as acquisitions and acq/peakups. The keywords relevant for one of these data types will not necessarily be relevant to another. Accordingly, you will find that the header on your particular file contains a unique combination of keywords appropriate for your type of observation. Long definitions for the keywords can also be accessed from the following Web page, which provides detailed explanations of the contents and algorithm for populating the keywords. This site also provides sample headers for different STIS file types:

`http://archive.stsci.edu/keyword`

Keywords that deal with a particular topic, such as the instrument configuration, are grouped together logically throughout the headers. Table 20.5 lists a useful subset of these groups of keywords, indicates the name of the grouping, and where applicable, shows their relationship to the corresponding information from the Phase II proposal.

Table 20.6 summarizes the possible calibration switch keywords, and indicates whether they are present for a particular observation; it also indicates the reference file keyword corresponding to the particular calibration step. A calibration switch keyword is populated with one of OMIT, COMPLETE, or PERFORM. Similarly, Table 20.7 summarizes the reference file group of keywords that identify the files used by the pipeline during calibration (see Chapter 21 for a detailed description of pipeline processing).

Table 20.5: Selected Keywords and Relationship to Phase II

Keyword	Phase II Equivalent	Description
NEXTEND		Number of image extensions in the file.
	Target Information (Primary Header)	
TARGNAME	Target Name	Name of target.
RA_TARG	RA Position	Right ascension of the target (deg) (J2000).
DEC_TARG	DEC	Declination of the target (deg) (J2000).
	Proposal Information (Primary Header)	
PROPOSID		4 digit proposal number
LINENUM		Indicates the visit and exposure number from the phase II proposal; format vv-nnnn, visit number, exposure num..
	Summary Exposure Information (Primary Header)	
TDATEOBS		UT date of start of first exposure in file (a character string)
TTIMEOBS		UT start time of first exposure in file (a character string); primary header.
TEXPSTRT		Start time (MJD) of 1st exposure in file (a real number).
TEXPEND		End time (MJD) of last exposure in the file (a real number); primary header.
TEXPTIME	Time_per_Exposure	Total exposure time (a real number); summed for an association; primary header.

Table 20.5: Selected Keywords and Relationship to Phase II (Continued)

Keyword	Phase II Equivalent	Description
Science Instrument Configuration (Primary Header)		
OBSTYPE		Observation type (IMAGING or SPECTROSCOPIC).
OBSMODE	Opmode	Operating mode (ACQ,ACQ/PEAK,ACCUM,TIME-TAG).
DETECTOR	Config	Detector in use: NUV-MAMA, FUV-MAMA, or CCD.
OPT_ELEM	Sp_Element	Optical element in use (grating name or mirror).
MIRROR	Sp_Element	Mirror element used for imaging observations.
CENWAVE	Centra_Wavelength	Central wavelength for grating settings.
APERTURE	Aperture	Aperture name.
FILTER	Derirved from Aperture	Filter in use.
APER_FOV		Aperture field of view.
WAVEMIN		Minimum wavelength of the data.
WAVEMAX		Maximum wavelength of the data.
PLATESC		Plate scale (arcsec/pixel).
SCLAMP		Lamp status, NONE or name of lamp which is on.
LAMPSET		Spectral cal lamp current value (milliamps).
NRPTEXP	Number_of_Iterations	Number of repeat exposures in set: default 1.
SUBARRAY		Data from a subarray (T) or full frame (F).
CRSPLIT	CR-SPLIT (optional parameter)	Number of cosmic ray split exposures.
Readout Definition Parameters		
SIZAXIS1	SIZEAXIS1	Subarray axis 1 size in unbinned detector pixel.
SIZAXIS2	SIZEAXIS2	Subarray axis 2 size in unbinned detector pixel.
BINAXIS1	BINAXIS1	Axis 1 data bin size in unbinned detector pixel.
BINAXIS2	BINAXIS2	Axis 2 data bin size in unbinned detector pixel.
CCDAMP		CCD amplifier read out (A,B,C,D).
CCDGAIN	GAIN (optional parameter)	Commanded gain of CCD.
CCDOFFST		Commanded CCD bias offset.
ATODGAIN		Calibrated CCD amplifier gain value.
Exposure Information (Extension header only)		
DATE-OBS		UT date of start of observation (dd/mm/yy); extension header.
TIME-OBS		UT time of start of observation (hh:mm:ss); extension header.
PA_APER		Position angle of slit.
ORIENTAT		Position angle of detector.
CRPIX et al.		
DGESTAR		FGS ID(F1,F2,F3) concat. w/ dom. gd. star id.

Table 20.6: Calibration Switch Keywords

Keyword	Ref. File Keywords	Explanation	Spectra	Images	CCD	MAMA
STATFLAG	N/A	Calculate image statistics?	•	•	•	•
DQICORR	BPIXTAB	Initialize data quality image	•	•	•	•
LORESCORR	N/A	Convert MAMA image to low-res	•	•		•
DARKCORR	DARKFILE	Dark image correction	•	•	•	•
FLATCORR	LFLTFILE	Flatfield corrections	•	•	•	•
	PFLTFILE					
	DFLTFILE					
SGEOCORR	SDSTFILE	Small-scale distortion correction	•	•	•	•
RPTCORR	N/A	Add individual repeat observations	•	•	•	•
ATODCORR	ATODTAB	A-to-D correction	•	•	•	
BLEVCORR	N/A	Correct for CCD bias level (overscan)	•	•	•	
BIASCORR	BIASFILE	Bias image (structure) correction	•	•	•	
CRCORR	CRREJTAB	Cosmic ray rejection	•	•	•	
EXPSCORR	N/A	Process individual observations after CRCORR	•	•	•	
SHADCORR	SHADFILE	Shutter shading correction	•	•	•	
PHOTCORR	PHOTTAB	Populate header photometric keywords		•	•	•
GEOCORR	N/A	Geometric correction		•	•	•
X2DCORR	SDCTAB	Rectify 2-D spectral image	•		•	•
	DISPTAB		•		•	•
	INANGTAB		•		•	•
	APDESTAB		•		•	•
	MOFFTAB		•		•	•
	SPTRCTAB		•		•	•
X1DCORR	SPTRCTAB	Extract 1-D Spectrum	•		•	•
	XTRACTAB					
BACKCORR	XTRACTAB	Subtract spectral background	•		•	•
DISPCORR	DISPTAB	Apply dispersion solution	•		•	•
	INANGTAB					
	APDESTAB					
	MOFFTAB					
WAVECORR	N/A		•		•	•
FLUXCORR	APERTAB	Convert to absolute flux	•		•	•
	PHOTTAB					
HELCORR	N/A	Convert to heliocentric wavelengths	•			•
DOPPCORR	N/A	Doppler correction needed? (TIMETAG mode only)	•			•
GLINCORR	N/A	Global detector non-linearities	•			•
LFLGCORR	N/A	Flag pixels for local and global non-linearities	•			•

Table 20.7: Reference File Keywords

Keyword	File Suffix	Format	Explanation	Spectra	Images	CCD	MAMA
BPIXTAB	_bpx	Table	Bad pixel	•	•	•	•
ATODTAB	_a2d	Table	A-to-D correction	•	•	•	
CCDTAB	_ccd	Table	CCD parameters	•	•	•	
BIASFILE	_bia	Image	Bias (structure)	•	•	•	
CRREJTAB	_crr	Table	Cosmic ray rejection parameters	•	•	•	
SHADFILE	_ssc	Image	Shutter shading correction	•	•	•	
DARKFILE	_drk	Image	Dark	•	•	•	•
LFLTFILE	_lfl	Image	Low-order flat	•	•	•	•
PFLTFILE	_pfl	Image	Pixel-to-pixel flat	•	•	•	•
DFLTFILE	_dfl	Image	Delta-flat	•	•	•	•
SDSTFILE	_ssd	Image	Small-scale distortion correction	•	•		•
MLINTAB	_lin	Table	Flux linearity table	•	•		•
PHOTTAB	_pht	Table	Photometric conversion	•	•	•	•
APERTAB	_apt	Table	Aperture throughput	•		•	•
LAMPTAB	_lmp	Table	Template CAL lamp spectra	•		•	•
APDESTAB	_apd	Table	Aperture descriptions	•		•	•
IDCTAB	_idc	Table	Image distortion correction		•	•	•
SDCTAB	_sdc	Table	2-D spectrum distortion correction	•		•	•
INANGTAB	_iac	Table	Incident angle correction	•		•	•
MOFFTAB	_moc	Table	MAMA Offset correction	•			•
DISPTAB	_dsp	Table	Dispersion coefficients	•		•	•
SPTRCTAB	_1dt	Table	1-D Spectrum trace	•		•	•
XTRACTAB	_1dx	Table	1-D Extraction parameter	•		•	•

20.5 Error and Data Quality Arrays

The STIS pipeline propagates both statistical errors and data quality flags throughout the calibration process, combining, appropriately, the statistical errors and data quality flags from both the science data and the reference file data so as to produce triplets of science, error and data quality in the calibrated data and extracted spectra.

Note that both the error and data quality image extensions may be represented with a null array (i.e., NAXIS=0 following STScI conventions) if all the values are identically zero (see Table 20.8). See also *STIS ISR* 95-006.

20.5.1 The Error Array

The error array contains an estimate of the statistical error at each pixel. In the raw file, the error array is empty. The first step of **calstis** is to calculate the error array for the input data. This raw data error is simply given as:

$$\sigma_{DN} = \frac{\sqrt{\sigma_c^2 + R \cdot g}}{g} \qquad \text{Eq. 20.1}$$

where

- R is the observed data number (counts) minus the electronic bias of the pixel, which is zero for the MAMA.
- g is the gain factor which is set to unity for MAMA observations.
- σ_c is the white noise component, which is the readnoise in electrons for CCD observations, and is set to zero for MAMA observations.

The bias, gain factor, and readnoise are read from the CCD parameters reference file for CCD data. As the data are calibrated through the **calstis** pipeline,the statistical errors are propagated through, reflecting both the science and reference file errors.

20.5.2 Data Quality Flagging

Data quality flags are assigned to each pixel in the data quality extension. Each flag has a true (set) or false (unset) state. Flagged conditions are set as specific bits in a 16-bit integer word; in this way up to 15 data quality conditions can be flagged simultaneously for a single pixel, using the bitwise logical OR operation. Note that the data quality flags cannot be interpreted simply as integers but must be converted to base 2 and interpreted as flags. Table 2.4 gives the specific conditions which are flagged by the different bits being on or off.

The raw data quality files will be filled only when there is missing (datalost) or dubious (softerr) data. If no such errors were taken, generic conversion will produce an empty data quality file whose header has NAXIS=0.

These flags are set and used during the course of calibration, and may likewise be interpreted and used by downstream analysis applications.

Table 20.8: STIS Data Quality Flags

FLAG Value	Bit Setting	Quality Condition Indicated
1	0000 0000 0000 000**1**	Reed solomon decoding error.
2	0000 0000 0000 00**1**0	Lost data replaced by fill values.
4	0000 0000 0000 0**1**00	Bad detector pixel (e.g., bad column or row, mixed science and bias for overscan, or beyond aperture).
8	0000 0000 0000 **1**000	Data masked by occulting bar.
16	0000 0000 000**1** 0000	Pixel having dark rate > 5 sigma times the median dark level.
32	0000 0000 00**1**0 0000	Large blemish, depth > 40% of the normalized p-flat. Applies only to FUV-MAMA repeller wire at present.
64	0000 0000 0**1**00 0000	Reserved.
128	0000 0000 **1**000 0000	Reserved.
256	0000 000**1** 0000 0000	Saturated pixel, count rate at 90% of max possible—local non-linearity turns over and is multivalued; pixels within 10% of turnover and all pixels within 4 pixels of that pixel are flagged
512	0000 00**1**0 0000 0000	Bad pixel in reference file.
1024	0000 0**1**00 0000 0000	Small blemish, depth between 0.4 and 0.7 of the normalized flat. Applies only to MAMA p-flats at present.
2048	0000 **1**000 0000 0000	>30% of background pixels rejected by sigma-clip, or flagged, during 1-D spectral extraction.
4096	000**1** 0000 0000 0000	Extracted flux affected by bad input data.
8192	00**1**0 0000 0000 0000	Data rejected in input pixel during image combination for cosmic ray rejection.
16384	0**1**00 0000 0000 0000	Reserved.

20.6 STIS Paper Products

A routine product of the calibration pipeline is the post-calibration *paper products* that summarize the data obtained. Guest Observers (GO) will receive these automatically a few weeks after their data are taken. Archival observers can recreate these paper products by retrieving all of the science and jitter data for a particular observation and using the STSDAS **pp_dads** task (at the IRAF prompt type: `pp_dads *.fits`).

STIS paper products are designed to summarize a set of exposures, for a single visit. A given page in the STIS paper product falls into one of two categories: a visit-level page or an exposure-level page. Below we list the individual pages contained in the STIS paper products; Figure 20.4 through Figure 20.7 provide samples of several of the paper products pages. Users are encouraged to read *STIS ISR* 97-11, which provides much more detail about the STIS paper products.

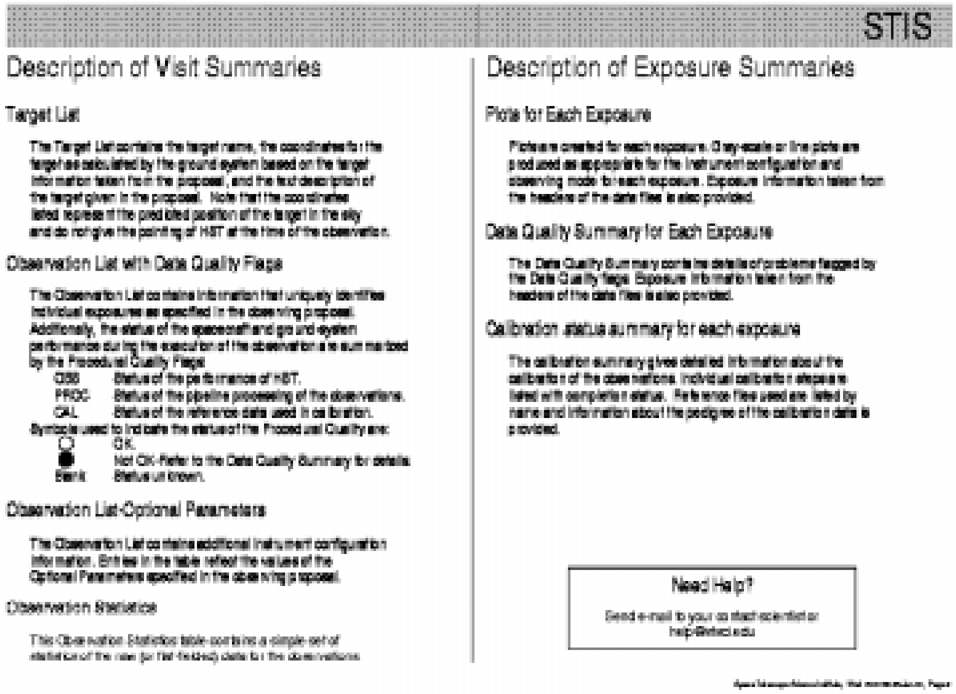
Visit-level Pages

- ***Cover Page***: A cover page containing the proposal ID, the visit number, the PI's name, and the proposal title.
- ***Explanatory Notes*** (Figure 20.4): A set of notes explaining the paper products and the information they contain.
- ***Target List*** (Figure 20.5): A table listing the targets in the set of observations being summarized.
- ***Observation List***: A table recapping the proposal information for each exposure for the set of observations being summarized, including three processing and data quality flags.
- ***Optional Parameters***: A table listing the proposal-level optional parameters for the set of observations being summarized.
- ***Statistics***: A table of simple statistics for the set of observations being summarized to allow for a quick comparison among observations.

Exposure-level Pages

- ***Exposure Plots***: A graphical representation of the data contained in each exposure. Plots are specific to a particular instrument configuration and observing mode. In some cases, more than one plot is produced. The types of exposure plots are: ACQ image plot (Figure 20.6), ACQ/PEAK image plot, image plot (Figure 20.7), Rectified two-dimensional spectral image plot, one-dimensional extracted spectrum plot, time-series plot, and local rate check image plot.
- ***Data Quality Summary***: A comprehensive summary of the spacecraft performance, pipeline processing status, and calibration data quality for each exposure.
- ***Calibration Reference File Summary***: A summary of the calibration processing switches and reference files used to process each exposure.

Figure 20.4: Explanatory Notes


STIS

Description of Visit Summaries

Target List

The Target List contains the target name, the coordinates for the target as calculated by the ground system based on the target information taken from the proposal, and the text description of the target given in the proposal. Note that the coordinates listed represent the predicted position of the target in the sky and do not give the pointing of HST at the time of the observation.

Observation List with Data Quality Flags

The Observation List contains information that uniquely identifies individual exposures as specified in the observing proposal. Additionally, the status of the spacecraft and ground system performance during the execution of the observation are summarized by the Procedural Quality Flags:

- OBS Status of the performance of HST.
- PROC Status of the pipeline processing of the observations.
- CAL Status of the reference data used in calibration.

Symbols used to indicate the status of the Procedural Quality are:

- ○ OK.
- ● Not OK-Refer to the Data Quality Summary for details.
- Blank Status unknown.

Observation List-Optional Parameters

The Observation List contains additional instrument configuration information. Entries in the table reflect the values of the Optional Parameters specified in the observing proposal.

Observation Statistics

This Observation Statistics table contains a simple set of statistics of the raw (or flat-fielded) data for the observations.

Description of Exposure Summaries

Plots for Each Exposure

Plots are created for each exposure. Grey-scale or line plots are produced as appropriate for the instrument configuration and observing mode for each exposure. Exposure information taken from the headers of the data files is also provided.

Data Quality Summary for Each Exposure

The Data Quality Summary contains details of problems flagged by the Data Quality flags. Exposure information taken from the headers of the data files is also provided.

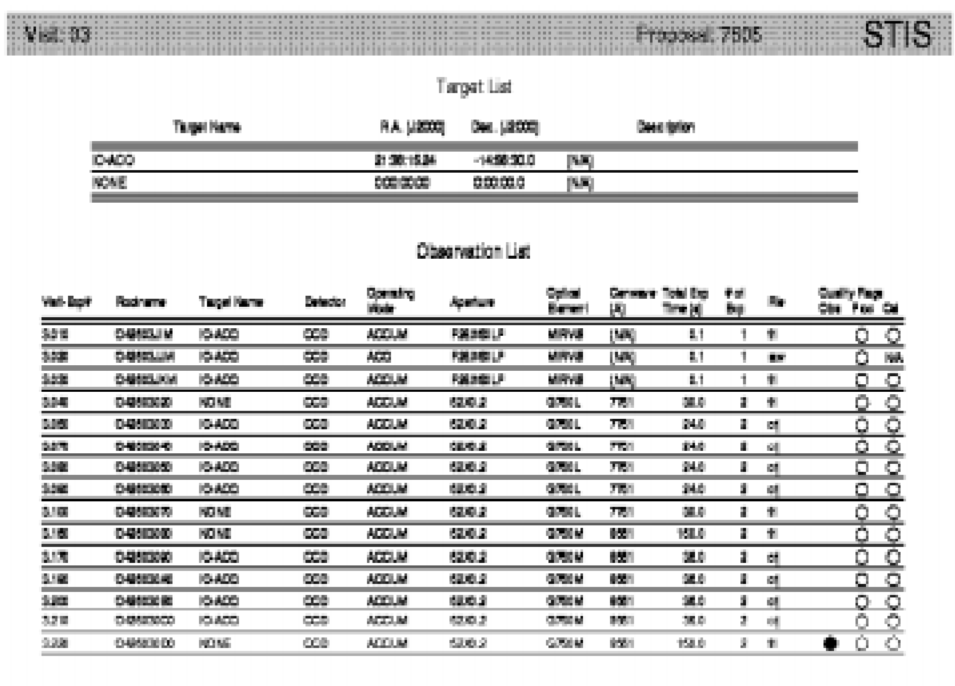
Calibration status summary for each exposure

The calibration summary gives detailed information about the calibration of the observations. Individual calibration steps are listed with completion status. Reference files used are listed by name and information about the pedigree of the calibration data is provided.

Need Help?

Send e-mail to your contact scientist or help@stsci.edu

Figure 20.5: Target List


Visit: 03 Proposal: 7505 STIS

Target List

Target Name	R.A. (J2000)	Dec. (J2000)	Description
IO-ADD	[illegible]	[illegible]	(N/A)
NONE	[illegible]	[illegible]	(N/A)

Observation List

Visit-Exp#	Rootname	Target Name	Detector	Operating Mode	Aperture	Optical Element	Cenwave (A)	Total Exp Time (s)	# of Exp	File	Quality Flags Obs	Proc	Cal
3.010	[illegible]	IO-ADD	CCD	ACCUM	F28X50LP	MIRVIS	(N/A)	5.1	1	flt		○	○
3.020	[illegible]	IO-ADD	CCD	ACQ	F28X50LP	MIRVIS	(N/A)	5.1	1	raw		○	NA
3.030	[illegible]	IO-ADD	CCD	ACCUM	F28X50LP	MIRVIS	(N/A)	5.1	1	flt		○	○
3.040	[illegible]	NONE	CCD	ACCUM	52X0.2	G750L	7751	36.0	2	flt		○	○
3.050	[illegible]	IO-ADD	CCD	ACCUM	52X0.2	G750L	7751	24.0	2	crj		○	○
3.070	[illegible]	IO-ADD	CCD	ACCUM	52X0.2	G750L	7751	24.0	2	crj		○	○
3.080	[illegible]	IO-ADD	CCD	ACCUM	52X0.2	G750L	7751	24.0	2	crj		○	○
3.090	[illegible]	IO-ADD	CCD	ACCUM	52X0.2	G750L	7751	24.0	2	crj		○	○
3.100	[illegible]	NONE	CCD	ACCUM	52X0.2	G750L	7751	36.0	2	flt		○	○
3.160	[illegible]	NONE	CCD	ACCUM	52X0.2	G750M	8561	150.0	2	flt		○	○
3.170	[illegible]	IO-ADD	CCD	ACCUM	52X0.2	G750M	8561	36.0	2	crj		○	○
3.180	[illegible]	IO-ADD	CCD	ACCUM	52X0.2	G750M	8561	36.0	2	crj		○	○
3.200	[illegible]	IO-ADD	CCD	ACCUM	52X0.2	G750M	8561	36.0	2	crj		○	○
3.210	[illegible]	IO-ADD	CCD	ACCUM	52X0.2	G750M	8561	36.0	2	crj		○	○
3.220	[illegible]	NONE	CCD	ACCUM	52X0.2	G750M	8561	150.0	2	flt	●	○	○

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Figure 20.6: ACQ Plot

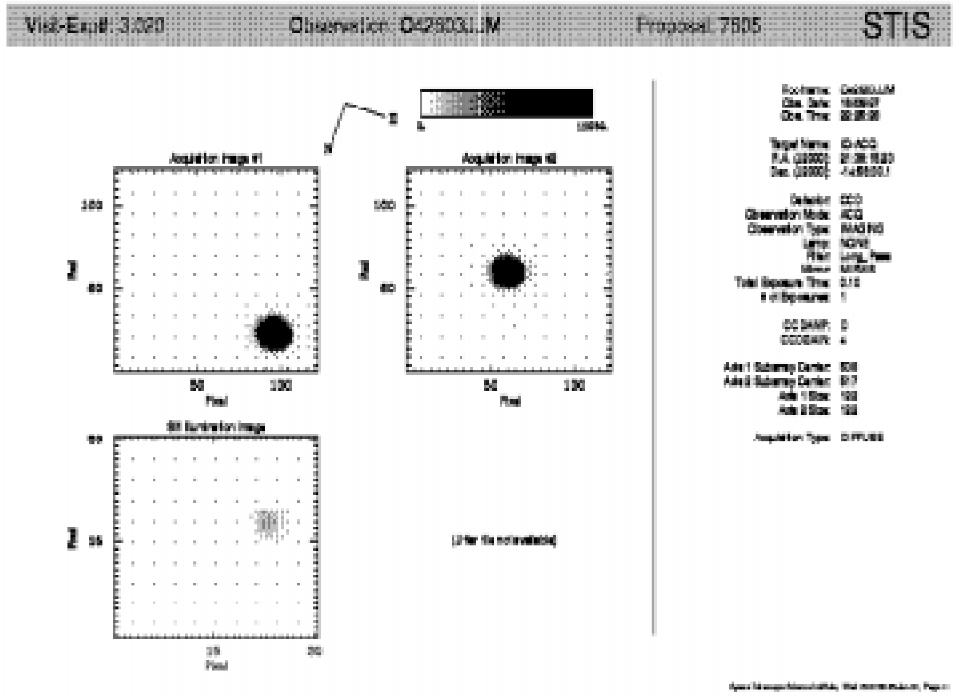

Figure 20.7: Image Plot