Plans for the STScI STIS Pipeline II: 
Calstis-1, Two-dimensional Image Reduction

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ABSTRACT
This ISR describes calstis-1, the two dimensional image reduction portion of calstis, which outputs a flat fielded image. This ISR contains a description of the need for and method of converting between image and detector pixels, the algorithmic steps in calstis-1 and the reference files used by calstis-1.

1. Introduction
In this ISR we describe the steps in calstis-1, the two dimensional image reduction portion of calstis. The output of calstis-1 is a flat fielded image, in which the photometric header keywords have been populated for imaging data. The flow of data through the calstis pipeline and the output products from it are described more generally in STIS ISR 95-06.

The remainder of this ISR is described as follows:
In Section 2 “Image to Detector Pixel Mapping”, page 2 we describe the work calstis has to do in mapping from image to detector pixels, in order to perform two dimensional image reduction.
In Section 3, “Algorithmic Steps in Calstis-1”, page 4 we describe each calibration step in the 2-D image reduction.
In Section 4, “Calibration Reference Files and Tables Used by calstis-1”, page 11, we describe the calibration reference files and tables used in 2-D image reduction, briefly describing the structure of the files and giving a brief overview of how they are expected to be produced.
2. Image to Detector Pixel Mapping

Calstis must map between image pixels and detector pixels in order to perform two dimensional image reduction. There are two important components to this for STIS data:

- formats other than full frame (use of subarrays and onboard pixel binning) and
- Doppler compensation.

Each of these is discussed in turn below.

Subarrays and Binning

An image may have been taken as a “subarray” which covers only a subset of the detector. In addition, each image pixel may correspond to a bin of more than one pixel on the detector. The subarray size and offset and the binning must be taken into consideration when applying a reference file.

The binning may be two pixels (‘lowres’) in either or both directions for the MAMAs and for the CCDs the binning may be nearly any integral value in either axis. However, the pipeline will only calibrate CCD data taken with BINX=1,2,4 and BINY=1,2,4 and for which the subarray includes the entire serial overscan region. Data taken with other subarrays or with other onchip binnings for the CCD will not be calibrated in the pipeline.

The starting detector pixel numbers in X and Y are given by keywords XCORNER and YCORNER, and the bin size by BINX by BINY. The image size (in binned pixels) is NAXIS1 by NAXIS2, so the portion of the detector covered by the image is

\[ \text{XCORNER to } \text{XCORNER} + \text{NAXIS1} \times \text{BINX} - 1 \]
\[ \text{YCORNER to } \text{YCORNER} + \text{NAXIS2} \times \text{BINY} - 1 \]

inclusive, in detector pixels. These ranges will be used as an image section when opening reference files. Pixel number \([i,j]\) in the science image corresponds to the following ranges of pixels on the detector:

\[ \text{in X: } \text{XCORNER} + (i - 1) \times \text{BINX} \text{ to } \text{XCORNER} + i \times \text{BINX} - 1 \]
\[ \text{in Y: } \text{YCORNER} + (j - 1) \times \text{BINY} \text{ to } \text{YCORNER} + j \times \text{BINY} - 1 \]

For data quality initialization files, the value to use for a given pixel in the science image is the maximum value in the corresponding bin in the data quality initialization file. For shutter shading correction, bias, dark, and flat field reference files, the average within the bin will be used. Subarray offset and bin size must be considered when interpreting the values in reference tables, e.g., dispersion coefficients. The limits to use when checking for MAMA local non-linearity will be affected by bin size. When combining CRSPLIT CCD images, the bin size will be a term in the noise model (since the CCD binning is on-chip and so read noise and dark current will behave differently in unbinned and binned param-
ter space). On the other hand, the PHOTFLAM keyword value and correction of extracted spectra to absolute flux units are not affected by binning, since the counts within a bin were summed rather than averaged. Binning of the reference files for MAMA low-res data will not be necessary if the reference files are themselves low-res: however for those modes where a Doppler correction is applied on board (medium resolution uv grating and echelle spectroscopy with the MAMAs), the full highres (2048 x 2048) reference files will need to be used, in order to correct for the Doppler smoothing, which is done in high res pixels. How subarrays and binning will be handled for geometric correction depends on the algorithm used for that correction.

**Doppler correction**

For MAMA ACCUMULATION mode observations using the Echelles or the medium resolution first order gratings the flight software corrects the location of each photon event on-board for the Doppler shift. In TIMETAG mode this correction is not applied. The Doppler correction must be computed by calstis in several situations:

- when processing TIMETAG data taken with the echelles or medium resolution gratings the timetag stream must be corrected for Doppler shifts in the pipeline. This correction will be applied both when integrating the uncalibrated TIMETAG stream (_tag.fit) in time (in calstis-9) to produce an uncalibrated accumulated science image (_sci.fit) and when processing the timetag stream directly through two dimensional image reduction (in calstis-10)

- when processing ACCUMULATION mode data for which the Doppler correction was applied in the flight software. In that case the flat field and dark reference files should be convolved with the Doppler smearing function, since the counts in a single image pixel were actually detected at different (Doppler shifted) detector pixel locations. If there is a data quality initialization file, bad pixels should be extended by the Doppler smearing function as well - assigning each image pixel all bad pixel values from detector pixels which contributed to it.

The Doppler shift in pixels at time T (MJD) will be computed by

\[
\text{shift} = \left( \frac{\text{DOPMAG}}{\text{BINY}} \right) \times \sin \left( \frac{2\pi}{\text{ORBITPER}} \times (T - \text{DOPZERO}) \right)
\]

where DOPMAG is the Doppler shift magnitude in high-res pixels, BINY is the number of high-res pixels binned together, and DOPZERO is the time when the Doppler shift was zero and was increasing. ORBITPER is the orbital period of HST, but it may be an assumed value (the one used on-board) rather than a true value. DOPMAG, BINY, DOPZERO and ORBITPER are all header keywords populated by generic conversion.

**Allowing Users to Convert from Image Pixels to Detector Pixels**

To allow users to easily convert from image to detector coordinates when examining their data in IRAF/STSDAS, a set of standard IRAF keywords used for the purpose of tracking subimages (LTV1, LTV2, LTM1 and LTM2) are populated. A number of IRAF tasks (e.g.
rimcursor, listpix) that display coordinate information allow the user to specify which coordinate system they want. The choice is usually between “logical”, “physical”, and “world”. World coordinates would be right ascension and declination, for example, or wavelength and distance along a slit. Logical coordinates are image pixel coordinates. Physical coordinates are also pixels, but they are in the “original” image in case the image at hand is a section of another image. The LTV (vector) and LTM (matrix) keywords give the linear transformation between logical and physical coordinates, while the FITS coordinate parameters CRVAL, CRPIX, etc. give the transformation between logical and world coordinates. In the case of STIS, the user’s image may be only a portion of the full detector, and the pixels may also have been binned, so we adopt the coordinates of the full detector as the physical system. If an IRAF task such as imcopy is used to further extract a subset (or to subsample, or to flip an axis), the LTV and LTM keywords are updated by that task so they still transform back to the original detector coordinates. Thus when a user displays an image and reads coordinates interactively using rincursor, for example, the user can choose to see either image pixel coordinates or original detector coordinates simply by changing the value of the rincursor wcs parameter from “logical” to “physical”.

3. Algorithmic Steps in Calstis-1

In Table 1 and Table 2 we summarize the steps in calstis-1 for CCD and MAMA data, respectively. Below we describe in more detail the algorithmic details of each calibration step. The steps are presented in alphabetical order.
Table 1. Two-dimensional Image Reduction (calstis-l) for the CCD

<table>
<thead>
<tr>
<th>Switch</th>
<th>Processing Step</th>
<th>Reference File</th>
</tr>
</thead>
<tbody>
<tr>
<td>DQICORR</td>
<td>initialize data quality</td>
<td>bpixtab</td>
</tr>
<tr>
<td>ATODCORR</td>
<td>correct for A to D conversion errors</td>
<td>atodfile</td>
</tr>
<tr>
<td>BLEVCORR</td>
<td>subtract bias level computed from overscan</td>
<td></td>
</tr>
<tr>
<td>BIASCORR</td>
<td>subtract bias image</td>
<td>biasfile, ccdgntab</td>
</tr>
<tr>
<td>DARKCORR</td>
<td>subtract dark image</td>
<td>darkfile, ccdgntab</td>
</tr>
<tr>
<td>FLATCORR</td>
<td>flat field image</td>
<td>pfftfile, dfftfile, lfftfile</td>
</tr>
<tr>
<td>SHADCORR</td>
<td>apply shutter shading correction</td>
<td>shadfile</td>
</tr>
<tr>
<td>PHOTCORR</td>
<td>populate photometric header keywords</td>
<td>phottab</td>
</tr>
</tbody>
</table>

Table 2. Two Dimensional Image Reduction (calstis-l) for the MAMAs

<table>
<thead>
<tr>
<th>Switch</th>
<th>Processing Step</th>
<th>Reference File</th>
</tr>
</thead>
<tbody>
<tr>
<td>LORESCNV</td>
<td>convert MAMA to BINX=BINY=2 before processing</td>
<td></td>
</tr>
<tr>
<td>TINCTCORR</td>
<td>integrate time tag data in time</td>
<td></td>
</tr>
<tr>
<td>DQICORR</td>
<td>initialize data quality</td>
<td>bpixtab</td>
</tr>
<tr>
<td>GLINCORR</td>
<td>correct for global non-linearities</td>
<td>mlintab</td>
</tr>
<tr>
<td>LINFLAG</td>
<td>flag local and global non-linearities</td>
<td>mlintab</td>
</tr>
<tr>
<td>DARKCORR</td>
<td>subtract dark image</td>
<td>darkfile</td>
</tr>
<tr>
<td>FLATCORR</td>
<td>flat field data</td>
<td>pfftfile, dfftfile, lfftfile</td>
</tr>
<tr>
<td>PHOTCORR</td>
<td>populate photometric header keywords</td>
<td>phottab</td>
</tr>
</tbody>
</table>

**ATODCORR**

The analog to digital correction will need to be applied if the CCD electronic circuitry which perform the analog to digital conversion is biased toward the assignment of certain DN (data number) values. The ATODCORR is a statistical correction which reassigned DN numbers based on a lookup in a reference file, the atodfile. The reference file is an image which gives the corrected data value as a function of the raw data value. Although the image is two-dimensional only one line is used for the correction. Different lines of the image give the correction for different values of temperature (although some other parameter could be used). The first line of the image contains temperatures. If the temperature during the observation was closest to the value in pixel number j in the first line of the image...
image, then line j of the image would be used for the analog-to-digital correction. To apply the correction, the raw data value is used as an index into line j. That is, if a raw data value is i, then the value of the reference image at pixel i (in line j) is the corrected value. It is not yet known whether an ATODCORR will need to be performed for the STIS CCDs; the need or lack of need for it should be established as part of the ground testing.

**BIASCORR**

The BIASCORR step removes any 2-dimensional additive stationary pattern in the electronic zeropoint of each CCD readout. To remove this pattern a bias image is subtracted. A bias image is the pattern left when an exposure is taken with zero exposure time, following the removal of the overscan bias level (see BLEVCORR, below).

The bias reference file (biasfile) is a full format image. If the science image is a subarray or was binned, a section of the bias image must be extracted and binned to match the science image. If CCD gains different than 1 are used, the bias reference file will be scaled by the gain factor from the ccdgntab prior to subtraction. The bias image will have an accompanying data quality file: bad pixels in the bias image will be flagged in the science data quality file.

**BLEVCORR**

The BLEVCORR step removes the electronic bias level for each line of the CCD image. The electronic bias level may vary with time and temperature; its value must be determined in the particular exposure being processed from the overscan region. Virtual overscan is created by continuing the readout of each line of the CCD past its real physical extent, physical overscan is created by unilluminated pixels in the detector. Currently for the STIS CCD in full frame unbinned mode, there are planned 20 rows of virtual parallel overscan region, and 20 leading and trailing columns of physical overscan in the serial direction. Physical overscan pixels can be affected by cosmic rays and dark current.

When on-chip pixel binning is used, if the binning factor does not divide evenly into 20 and 1064, then the raw image produced will contain both pure overscan pixels, overscan plus science pixels and science pixels. The initial version of the pipeline will only calibrate pixel binnings of 1, 2, and 4 (all of which divide evenly into 20 and 1064), in either x or y. The bias level will then be determined from the good (as indicated by the bad pixel table) leading and trailing (20/BINX) overscan columns of each line of the science image. For each line of the image, the median of the values in the overscan regions will be taken, after rejection of discrepant points has been performed in order to reject discrepant pixels. This value will be subtracted from the science data for that line. The output science image

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1. Thus, as currently planned, the size of the uncalibrated and unbinned full frame CCD image will be 1064 (serial) by 1044 (parallel) pixels.
from this step will be smaller than the input image by the width of the overscan regions. The parallel overscan will not be used in the pipeline, however it will be cropped in this step. The output size will therefore be 1024/BINX x 1024/BINY.

**DARKCORR**

The DARKCORR step removes the dark signal (count rate created in the detector in the absence of photons from the sky) from the science image by subtracting an integration time and gain scaled dark reference file image (darkfile)$^2$. If the science image is a subarray or was binned, a section of the dark image must be extracted and binned to match the science image. If Doppler correction was applied on-board for the science data (i.e., if the DOPPFLAG keyword = T), the Doppler smearing function should be computed and convolved with the dark image to account for the contributions of various detector pixels to a particular image pixel. The Doppler convolution should be done before binning the dark image. To apply the correction, the dark image is multiplied by the exposure time and subtracted from the science image. The science data quality file is updated for bad pixels in the dark reference file.

**DQICORR**

The DQICORR step takes the data quality file output from generic conversion for the science data and bitwise ORs it with the values in the bad pixel reference file table (bpixtab) to initialize the science data quality file for propagation through subsequent steps in calstis-1. If DOPPFLG=T, calstis-1 will Doppler smear the bpixtab prior to performing the OR operation with the (unsmearred) science input data quality image. See ISR STIS 95-06 for a description of the data quality flags.

**FLATCORR**

The FLATCORR step corrects for pixel to pixel and largescale sensitivity gradients across the detector by dividing the data by a flat field image. The flat field image used to correct the data is created from three flat field reference files:

- pffltfile - this flat is a configuration (grating, central wavelength and detector) dependent `pixel to pixel' flat field image, from which any largescale sensitivity variations have been removed (i.e., it will have a local mean value of unity across its entirety). Such configuration dependent flats are expected to be produced only once per year.

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2. Unless ground test shows that there is quantization in the conversion which requires us to maintain separate calibration files for different gains, the pipeline will maintain calibration files for gain=1 and scale the values for other gains, appropriately, using the value in the ccdgntab
• dfltfile - this flat is a ‘delta flat’ which gives the changes in the small scale flat field response relative to the pixel to pixel flat (pfltfile). Delta flats will be taken once per month; there will be a single delta flat for each detector (or over broad wavelength ranges for the CCD).

• lfltfile - this flat is a subsampled image containing the largescale sensitivity variation across the detector.

To flat field science data calstis will create a single flat field image from these three files\(^3\) as described below and multiply it by the science image. The pixels of the science data quality file will be updated to reflect bad pixels in the input reference files.

To create the single combined flat field file, calstis will use bilinear interpolation to expand the largescale sensitivity flat (lfltfile) to the subarray format of the science data and multiply it by the appropriate (subarray) portion of the pixel to pixel flat (pfltfile) and delta flat (dfltfile). The pixel-to-pixel flat, delta flat, and low order flats should be multiplied together, the Doppler convolution applied to the product, as appropriate, and the product binned, if necessary, to match the binning of the science image.

**GLINCORR and LINFLAG**

The MAMAs are photon counting detectors. At high photon (pulse) rates, the MAMA response becomes nonlinear due to three affects.

1. Pore paralysis in the Micro Channel Plates arises when charge cannot flow rapidly enough to replenish channels whose electrons have been depleted due to high local photon rates. This produces a local non-linearity. The local count rate is roughly linear up to counts rates of ~200 counts/second/pixel and then turns directly over, showing an inverted V shape. Thus it is not possible to reliably correct for or flag pixels which have exceeded the local linearity limit in the pipeline (since the relation is bi-valued).

2. The electronic processing circuitry has a “dead-time” of roughly 350 nano-seconds between pulses; thus at global count rates (across the detector) of 300,000 counts (pulses) per second, the electronic circuitry counts roughly 90% of the pulses. This electronic induced global non-linearity can be corrected for in the pipeline.

3. The MIE electronics/flight software is specified to process 300,000 pulses per second (i.e., is matched to the expected global count rate performance of the electronic circuitry). At count rates higher than this, the MIE will still count only 300,000 pulses per second - thus this represents a hard cutoff beyond which no information is available to allow correction to true count rate.

When LINFLAG = perform, the pipeline will flag pixels in the accompanying data quality file when they either themselves have count rates > 90% the local linearity limit or when

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\(^3\) The rationale for maintaining 3 types of flat field reference files rather than a single integrated reference file is described in detail in STIS ISR 95-09 'Calibration Plans for Flat Fielding STIS Data', Bohlin et al. in preparation.
they are within 4 pixels of a pixel which has a count rate > 90% the local linearity limit. When the global count rate (across the detector) is > 90% of global linearity limit all pixels in the accompanying data quality file will be flagged and the primary header unit keyword GLOBLIM will be set equal to “EXCEEDED”.

When GLINCORR=PERFORM, the pipeline will correct all the pixels in the input image for global non-linearity using expressions developed and tested on the ground. The expression below seems to fit the existing test data well (Ebbets 94, STIS SER CAL-005)

\[ y = xe^{-(tx)} \]

where

- \( x \) = true input count rate (cts/s)
- \( y \) = observed count rate (cts/s)
- \( t \) = time constant ~ 290 nano-seconds.

For subarrays, the hard cutoff limit of the MIE electronics/software will differ from that for full frame processing. The first step in the MIE processing is to determine the detector pixel origin of the incoming pulse: if it is outside of the specified subarray it will be thrown out, if it falls within the subarray it will be processed further. The performance of the sorting for subarray data, which is dependent on the global count rate across the full detector, slows down the MIE (i.e., lowers the cutoff), however the fact that the next processing step is performed on only those pulses within the subarray speeds up the MIE (i.e., raises the limit). Ground tests will have to be performed to determine the relevant time constants for the two parts (sorting and processing) in order to allow correction for global non-linearity when subarrays are used. The global count rate (across the entire detector) is determined as part of the bright object protection sequence and is passed down with the exposure as a header keyword.

**LORESCNV**

MAMA data are taken in high resolution mode (2048 x 2048 pixels), but they may be binned on-board to 1024 pixels in either or both axes. If they are not binned on-board, the binning may be done by calstis. This is a simple step, just adding counts in pairs of pixels. If binning was not done on-board, BINX and/or BINY will be one; they will both be set to two after binning is complete.
**PHOTCORR**

For image mode, the total system throughput will either be computed using synphot based on the observing mode (filter and detector) or read in from a reference table (phottab). The photometric keywords PHOTFLAM, PHOTBW, and PHOTPLAM will be computed and saved in the header of the output image. In the case that calstis computes the throughput using synphot, the throughput as a function of wavelength (or equivalently the phottab file) will be written in FITS bintable format as an output product. Initially, calstis-1 will be written to use the phottab reference table directly: should changes to synphot/cdbs occur which allow users to track changes in the throughput tables internal to synphot, a decision to switch over to synphot may be made in the future.

**SHADCORR**

This step corrects for shading by the shutter in very short integration time exposures. The STIS CCD shutter is specified to produce exposure non-uniformity less than or equal to 5 milliseconds for any integration time: the shortest possible STIS CCD exposure time is 100 milliseconds. Ground testing will verify the performance of the shutter.

The shutter shading correction reference file is a full frame image containing the extra time that each pixel is exposed, compared to the nominal exposure time. That is, if the nominal exposure time is EXPTIME, pixel [x,y] was exposed for a time EXPTIME + shadfile[x,y], where shadfile is the shutter shading correction image. The algorithm for correcting the data is:

\[
corrected[x,y] = \frac{\text{raw}[x,y] \times \text{EXPTIME}}{\text{EXPTIME} + \text{shadcorr}[x,y]} \\
= \frac{\text{raw}[x,y]}{1 + \text{shadcorr}[x,y] / \text{EXPTIME}}
\]

**TINTCORR**

Raw time-tagged data will be stored in a FITS binary table which contains at least three columns, the X and Y pixel coordinates and the time of each photon event. There may be an associated table containing “good time intervals.” In order to process time-tagged data through the rest of calstis as a pseudo ACCUM mode image, the events will be integrated over time and within pixels. For each event, the time will be compared with the set of good time intervals, and if the event falls within a good interval, then the raw X and Y coordinates will be scaled to the output pixel size and location, depending on binning and whether a subarray was used. If the amplitude of the Doppler shift is larger than one half image pixel, the Doppler shift at that time will be computed, and the Y coordinate will be adjusted by that amount. Finally, the output pixel closest to the scaled and shifted (X,Y) location will be incremented by one.
4. Calibration Reference Files and Tables Used by calstis-1

Table 3 lists all the calibration reference files used by calstis-1, and provides a brief description of them. The calibration reference images will be stored in FITS image extension files as triplets of science, error, and data quality images (in extensions 1, 2, and 3, respectively; the primary data unit will be left empty), and the calibration reference files will be stored in FITS binary tables, using the same conventions as for science data (see STIS ISR 95-06). For the CCD, all reference images will be maintained in 1024 x 1024 format (excluding the low order flat). For the MAMA, for the echelle and medium resolution modes, reference files must be maintained as 2048 x 2048 images (since the onboard Doppler correction is performed on highres pixels). However, for the low resolution gratings, we may choose to maintain both 1024 x 1024 and 2048 x 2048 format reference images so as not to burden lowres users with enormous reference files. A brief description of each reference file is provided below.
Table 3. Reference Files for Calstis-1

<table>
<thead>
<tr>
<th>reference file</th>
<th>format</th>
<th>calibration step</th>
<th>selection parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>atodfile</td>
<td>image</td>
<td>ATODCORR</td>
<td>applies only to CCD: gain, amplifier(^a)</td>
</tr>
<tr>
<td>biasfile</td>
<td>image</td>
<td>BIASCORR</td>
<td>applies only to CCD: amplifier</td>
</tr>
<tr>
<td>bpixtab</td>
<td>binary table</td>
<td>DQICORR</td>
<td>detector</td>
</tr>
<tr>
<td>ccdgntab</td>
<td>binary table</td>
<td>DARKCORR, BIASCORR, PHOTCORR</td>
<td>applies only to CCD: amplifier</td>
</tr>
<tr>
<td>darkfile</td>
<td>image</td>
<td>DARKCORR</td>
<td>detector</td>
</tr>
<tr>
<td>dltfile</td>
<td>image</td>
<td>FLATCORR</td>
<td>detector,</td>
</tr>
<tr>
<td>lltfile</td>
<td>image</td>
<td>FLATCORR</td>
<td>configuration(^b)</td>
</tr>
<tr>
<td>mlintab</td>
<td>binary table</td>
<td>GLINCORR, LINFLAG</td>
<td>applies only to MAMA: detector</td>
</tr>
<tr>
<td>pfftfile</td>
<td>image</td>
<td>FLATCORR</td>
<td>configuration</td>
</tr>
<tr>
<td>phottab</td>
<td>binary table</td>
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<td>configuration</td>
</tr>
<tr>
<td>shadfile</td>
<td>image</td>
<td>SHADCORR</td>
<td>applies only to CCD</td>
</tr>
</tbody>
</table>

\(^a\) Only a single amplifier will be used during any period - however, it is possible that over time the amp in use will change.

\(^b\) Where a STIS configuration is defined as a filter, optical element, central wavelength, detector combination.

**ATODFILE**

The atodfile is a two dimensional image with n rows and m columns, where n-1 is the number of temperatures at which the A-D correction has been determined, and m is the number of possible values of DN in the input image. Each line of the image gives the correction for a different value of temperature. The pixel values in line 1 of the image contain temperature values, corresponding to the temperatures at which the A-D correction has been determined. If the temperature during the observation was closest to the value in pixel number j in the first line of the image, then line j+1 of the image would be used for the analog-to-digital correction. The value of pixel n in line j+1 gives the corrected value (value to be assigned in output image) corresponding to input DN values of n.

**BIASFILE**

The biasfile is a full frame two dimensional image. It is created by taking a series of zero exposure images, subtracting the overscan bias level from each of them, and then median filtering them to create a low noise image of the two-dimensional bias pattern.
**BPIXTAB**

The bad pixel table is a tabular listing of detector pixels (x and y detector coordinates) with known conditions (non zero values) and their data quality conditions. It is used, with the input data quality file if one exists, in the data quality initialization step, to determine the data quality flags appropriate for the uncalibrated data. The possible error conditions which the data quality conditions flag and their values are described in STIS ISR 95-06. The data quality values are set as specific bits in a 16 bit word: thus multiple conditions will be flagged for a given pixel via the bitwise OR operation.

**CCDGNTAB**

The CCD gain table gives the calibrated gain values: i.e., the ratio of DN at alternate gain settings to DN at gain=1, as derived from calibration observations.

**DARKFILE**

The dark file is a two dimensional image of the dark counts scaled to a 1 second integration.

**DLFTFILE**

The delta flat file is a two dimensional image with a value indicating the change in the flat field response at that pixel relative to the response in the pixel to pixel flat field file (pflt-file). Delta flats with 100:1 signal to noise per pixel will be maintained on a roughly monthly basis in flight.

**LFLTFILE**

The low order flat field file is a 512 x 512 image of the largescale (low order) sensitivity variations across the detector. They are produced by median filtering in a 12 by 12 pixel boxcar region the values in a lamp illuminated flat field from which the lamp illumination pattern has been removed. Since only the low order response is being determined the calibration exposures for the low order flats need not be long (i.e., can be of relatively low signal to noise). Calstis will use bilinear interpolation to expand the image to the pixel format of the science image in order to correct for the low order flat field response.

**MLINTAB**

The linearity table contains the count rates at which to flag the data quality file for local and global nonlinearities and a series of coefficients needed to correct for global non-linearity.
**PFLTFILE**

The pixel to pixel flat field is a configuration dependent pixel to pixel flat field from which the low order sensitivity variations have been removed. Thermal vacuum test plans are to obtain pixel to pixel flats with a signal to noise of 100:1 per resolution element for the MAMAs (4 lowres pixels) at each primary grating setting.

**PHOTTAB**

The photometry table gives the total sensitivity per wavelength (ergs/sec/cm²/count/angstrom) for a given configuration.

**SHADFILE**

The shutter shading correction reference file is a full frame image containing the extra time that each pixel is exposed, compared to the nominal exposure time. That is, if the nominal exposure time is EXPTIME, pixel [x,y] was exposed for a time EXPTIME + shadfile[x,y], where shadfile is the shutter shading correction image.

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