STIS Target Acquisitions I: CCD Point Source Acquisitions

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ABSTRACT
In this ISR we describe the STIS CCD Point Source Target Acquisition procedure, for isolated point sources, and discuss the special cases of bright object target acquisition and the acquisition of targets in the STIS Coronographic apertures.

1. Introduction
Acquisition mode exposures are used to locate a target in the instrument field of view for subsequent science exposures. Target acquisitions and peakups are needed for STIS to center targets in spectroscopic apertures (slits) and to center targets behind occulting masks for coronography. The basic acquisition sequence is to image the acquisition target in the acquisition aperture (following the guide star acquisition), locate the target in the field of view, determine the spacecraft move needed to correctly position the target in the science aperture, and move HST to position the target. Target acquisition sequences are uploaded to the spacecraft as stored commands which initiate flight software macros.

This ISR describes the most basic type of STIS target acquisition, the CCD Point Source Acquisition. The remainder of this ISR is organized as follows:

- Section 2, Page 2, provides an “Overview of the Point Source Target Acquisition Sequence”,
- Section 3, Page 3, describes the “Details of the standard Point Source Acquisition Sequence”,
- Section 4, Page 8, describes “Requesting an isolated Point Source Target Acquisition”
- Section 5, Page 9, describes “CCD Bright Target Acquisition”
- Section 6, Page 13, describes “Special Cases: Intermediate slit acquisitions”.
2. Overview of the Point Source Target Acquisition Sequence

The CCD point source target acquisition sequence is shown schematically in Figure 1. The sequence comprises two discrete stages, the coarse locate phase, (steps 1-2) and the fine locate phase (steps 3-5). The coarse locate phase is performed to place the target as close as possible to the aperture center prior to the final telescope move. This assures that the final slew needed to move the target into the aperture is a small one, and minimizes uncertainties in the calculation of the required slew caused by detector/optical distortions. The resulting error in the target centering on the slit is expected to be small enough, (± 100 m arcsec), that ensuing peakup acquisitions will only be needed for the narrowest slit widths.

**Figure 1:** A schematic description of the CCD Point Source Target Acquisition procedure for isolated point sources.

1) Image the target using a 5”x5” (100x100 pixel) subarray and determine the target location in detector coordinates using a flux weighted centroid algorithm.

2) Look up the nominal detector coordinates of the science aperture in flight software tables, and perform a small angle maneuver to place the target at the predicted aperture center.

3) Re-image the target to determine its new location in detector coordinates.

4) Rotate the slit wheel to the science aperture and illuminate it with the HITM to determine the actual science aperture location on the detector. From the observed location, the science aperture center is calculated in detector coordinates using a threshold centroid algorithm.

5) Perform a small angle maneuver to place the target at the calculated aperture center or reference position.
3. Details of the standard Point Source Acquisition Sequence

The details of the coarse locate and fine locate sequences are described below for the case of an isolated point source, which is not classed as a bright target (see Section 5).

**Coarse Locate**

The coarse locate phase performs the following two tasks:

- **Target Locate**: Image the sky, and determine the location of the target on the detector in detector pixel coordinates,
- **Coarse Centering**: looks up the expected nominal location of the science aperture on the detector and performs a small angle maneuver to position the target at that predicted location.

**Target Locate**

The Target Locate consists of the following sequence:

- Two CCD images of duration EXPTIME are taken\(^1\),
- The flight software subtracts a constant bias value from each image pixel, with any negative values set to zero. The bias is a single parameter which has been determined from the analysis of STIS CCD images, one for each of the four CCD gain levels. The four bias values can be changed in future, as the need arises, by uploading new values.
- The two CCD images are combined to produce a single output image in which cosmic rays have been eliminated. The image combination is done by assigning the minimum value of the two pixels for each pixel in the 100x100 image array. The input images are overwritten in this process. For relatively long exposure times it is possible for cosmic ray events to be coincident in both CCD frames, so to reduce this probability to <1%, the maximum exposure time for a CCD acquisition is restricted to <300 seconds and a minimum S/N for the target of 40 is being recommended to GOs.
- From the output image, the flight software determines the fractional pixel location of the brightest point source using a point source centering algorithm. The algorithm works by calculating the flux in a checkbox of fixed size (3 x 3 detector pixels), for each detector pixel in the subarray. The brightest checkbox is then selected and the fractional pixel location of the flux weighted centroid of the pixels in the brightest checkbox is adopted as the target location. The operation of the algorithm is shown schematically in Figure 2.

This coarse locate target acquisition sequence produces a single image (from the CR-SPLIT images) which is sent to the ground and forms the first image extension in the science file of the acquisition dataset. The header of this image will be populated with keywords, which contain the fractional pixel coordinates of the target centroid.

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1. This assumes the Cosmic Ray Elimination Flag parameter has been passed as yes to the flight software. This Flag can be set to no in which case only a single CCD image will be taken and used to determine the target location. In the current implementation, this parameter is hardcoded to YES.
The steps in the locate sequence and their estimated durations are summarized in Table 1.

**Coarse Centering**

The process of coarse centering consists of three principal components:

- determine the expected nominal pixel coordinates of the science aperture center
- calculate the slew needed to place the target at the predicted science aperture location
- slew the telescope.
Table 1. Locate Sequence

<table>
<thead>
<tr>
<th>Step</th>
<th>Purpose</th>
<th>Estimated Durationa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Slit Wheel</td>
<td>Insert Target Acquisition aperture</td>
<td>75 seconds</td>
</tr>
<tr>
<td>Position MSM</td>
<td>Insert mirror in Grating Wheel, (acquisitions are always taken in undispersed light)</td>
<td>166 seconds</td>
</tr>
<tr>
<td>Detector Setup</td>
<td>Set up CCD for exposure; sets 100 x 100 pixel subarray; sets gain and readout Amp</td>
<td>5 seconds</td>
</tr>
<tr>
<td>Initialize Target Acquisition</td>
<td>Zero Flight Software parameters for calculation</td>
<td>2 second</td>
</tr>
<tr>
<td>Execute Target Locate</td>
<td>Image Field and determine fractional pixel location of acquisition target</td>
<td>2 x (exptimeb + readtimec) + process timed</td>
</tr>
</tbody>
</table>

a. The duration time includes only the macro execution time. There will be additional overhead.
b. The exposure time is as specified on the proposal log sheet for the acquisition exposure.
c. The readtime is expected to be 7 seconds for the 100x100 CCD array.
d. The processing time for a point source acquisition is expected to be ~5 secs.

The pixel coordinates of the aperture center are determined as follows. The ground software passes the flight software, the science aperture name. The flight software then looks up the predicted x and y detector coordinates for the aperture. Those coordinates are passed to the ground and appear in header keywords of the target acquisition dataset’s science file primary header.

The necessary slew is calculated by the flight software from the coarse target and aperture locations, using the detector plate scale. These calculations are performed using values for the plate scale which are stored in a flight software table. In the case of the STIS CCD it is assumed that geometric distortion will be negligible and so the actual plate scale will be stored in the table, unlike the case of the MAMAs where the plate scales are calculated by the FSW using a 3rd order polynomial which is designed to account for the geometric distortion. Finally, rotation from detector coordinates to vehicle coordinates is calculated and the slew is initiated. This completes the Coarse Locate Sequence. The target should now be centered to within +/-250 masec of the aperture center. It should be noted that the major contribution to this precision is the non-repeatability of the mode select mechanism, not the intrinsic pointing accuracy of HST.

**Fine Locate**

The Fine locate phase of the target acquisition is as follows:

- Image the target (Repeat Target Locate),
• Move the slit wheel to the desired science aperture, take a Hole-In-The-Mirror (HITM) lamp illuminated exposure and locate the aperture center (Locate Aperture),
• Recompute the move, and perform a small angle maneuver to place the target in the determined aperture center (Center Target).

Repeat Target Locate
The target locate sequence for Fine Locate is repeated exactly as in the coarse locate phase. The new detector coordinates of the target are computed in the exact same way as in the coarse locate phase. The coordinates and the combined image are delivered to the user as the second header and image extension in the science file of the target acquisition dataset.

Locate Aperture
The locate aperture step uses the HITM lamps to illuminate the science slit. Two images are obtained and then combined by assigning the minimum value to each pixel in the resulting image, thus eliminating cosmic rays. The center of the slit is then determined by the flight software using a threshold centroiding algorithm. The algorithm determines the number of pixels in the slit (N) from a lookup table, and sets the N brightest pixels in the image to a value of 1 and the remaining pixels to a value of 0. A flux-weighted centroid is then calculated to determine the center of slit to ~0.5 pixel accuracy. Note that the algorithm effectively determines the geometric center since the thresholding step equally weights all valid pixels (this minimizes the effects of non-uniform lamp illumination). The steps in locate aperture sequence and their duration are summarized in Table 3. Note that for long slits, the stated accuracy applies only in the dispersion direction.

The size of the sub-array used by “Locate Aperture” is a function of the science aperture the target is being acquired in. In general, for echelle slits the default CCD sub-array size is 100x100 pixels. For the case where a long-slit is being used, the subarray size is (100x1022), which includes the fiducial bars.

A subset of the STIS apertures present various problems for target acquisition with 100x100 arrays, or 100x1022 arrays. This subset includes long-slit fiducials, the high signal-to-noise slits and the planetary slits. These apertures will not be used for target acquisition, instead the 0.2x0.2 arcsecond aperture will be used, and then followed by selection of the final aperture and a SAM slew to place the target in the required aperture. A more detailed discussion of this procedure is presented in “Special Cases: Intermediate slit acquisitions”, page 13.

A complete summary of target acquisition array sizes for science apertures is given in Table 2.
Table 2. A summary of subarray sizes for Locate Aperture

<table>
<thead>
<tr>
<th>Apertures</th>
<th>Detector X</th>
<th>Detector Y</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1x0.06, 0.1x0.09, 0.1x0.2,</td>
<td>100</td>
<td>100</td>
<td>Echelle slits</td>
</tr>
<tr>
<td>0.2x0.06, 0.2x0.09, 0.2x0.2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3X0.06, 0.3X0.09, 0.3X0.2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x0.06, 1x0.2, 0.2x0.5,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1x0.03, 0.5x0.5, 2x2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2x0.05ND, 0.3x0.05ND,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6x6</td>
<td>200</td>
<td>200</td>
<td>Echelle</td>
</tr>
<tr>
<td>6x0.2, 6x0.5, 6x0.06</td>
<td>200</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>52X0.05, 52X0.1, 52X0.2, 52X0.5, 52X2.0</td>
<td>1022</td>
<td>100</td>
<td>1st Order</td>
</tr>
<tr>
<td>0.05x29, 0.09x29, 0.2x29,</td>
<td>100</td>
<td>700</td>
<td>Calibration slts</td>
</tr>
<tr>
<td>0.05x31NDA, 0.05x31NDB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31x0.05NDA, 31x0.05NDB, 31x0.05NDC</td>
<td>700</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>0.2x0.2 is used for target acquisition with the following apertures:</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>52X0.05F1, 52X0.05F2,</td>
<td></td>
<td></td>
<td>1st Order</td>
</tr>
<tr>
<td>52X0.1F1, 52X0.1F2,</td>
<td></td>
<td></td>
<td>Fiducial/Bars</td>
</tr>
<tr>
<td>52X0.2F1, 52X0.2F2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.5F1, 52X0.5F2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X2F1, 52X2F2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.0B0.5, 52X0.0B1.0, 52X0.0B3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.05F1-R, 52X0.05F2-R,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.1F1-R, 52X0.1F2-R,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.2F1-R, 52X0.2F2-R,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.5F1-R, 52X0.5F2-R,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X2F1-R, 52X2F2-R,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.1B0.5-R, 52X0.1B1.0-R, 52X0.1B3.0-R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2x0.06FPA, 0.2x0.06FPB, 0.2x0.06FPC</td>
<td>100</td>
<td>100</td>
<td>High S/N Slts</td>
</tr>
<tr>
<td>0.2x0.06FPC, 0.2x0.06FPE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2x0.2FPA, 0.2x0.2FPB, 0.2x0.2FPC,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2x0.2FPC, 0.2x0.2FPE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36X0.05P45, 36X0.05N45, 36X0.6P45, 36X0.6N45</td>
<td></td>
<td></td>
<td>Planetary slits</td>
</tr>
</tbody>
</table>

This locate aperture target acquisition sequence produces a single image of the slit which is sent to the ground. The image forms the third image extensions of the science file of the acquisition dataset. The header of this image will be populated with keywords which contain the FSW determined coordinates of the aperture center in 0.1 pixel units.

Center Target in Aperture

The final step in the acquisition sequence is to perform a small angle maneuver to position the target at the aperture center. The maneuver needed is computed by the flight software using the fine locate target and aperture location, the detector plate scale and the orientation angle with respect to the FGS system. At this point the target should be centered in the
aperture. The overall centering accuracy is expected to be +/-100 m arcsec. This figure is a conservative estimate based on the expected errors associated with each element of the target acquisition process.

Table 3. Locate Aperture Sequence.

<table>
<thead>
<tr>
<th>Step</th>
<th>Purpose</th>
<th>Estimate Durationsa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position Slit Wheel</td>
<td>bring science aperture into position</td>
<td>75 seconds</td>
</tr>
<tr>
<td>Detector Setup</td>
<td>Set up CCD for exposure, sets subarray size, sets gain and readout Amp</td>
<td>5 seconds</td>
</tr>
<tr>
<td>Initialize Target</td>
<td>Zero buffers for calculation in the Flight Software</td>
<td>2 second</td>
</tr>
<tr>
<td>Execute Find Slit</td>
<td>Image slit illuminated by HITM, determine pixel coordinates of aperture</td>
<td>2 x (exptimeb +</td>
</tr>
<tr>
<td></td>
<td></td>
<td>process time d</td>
</tr>
</tbody>
</table>

a. The duration time includes only the macro execution time. There will be additional overhead.
b. The exposure time for the Find Slit sequence is determined from a look up table for HITM exposure times based on slit. The range is from 0.1 seconds to 10.0 seconds, but is 0.1 seconds for most slits.
c. The readtime is predicted to be in the range of 7 seconds for a 100x100 array, to a maximum of ~32 seconds for a full 1024x1024 image.
d. The process time is expected to be in the range of 7 to 102 seconds.

4. Requesting an isolated Point Source Target Acquisition

The user requests a point source target acquisition exposure by specifying Mode=ACQ on the proposal logsheet, and setting the optional parameter ACQTYPE=POINT (this is the default acquisition for STIS). The normal target and exposure parameters, i.e. exposure time and spectral element, must also be selected on the proposal logsheet. The CCD gain is an engineering parameter and its default for target acquisition is 4. Finally, it should be noted that the target’s V magnitude must be specified on the proposal target list, or the target acquisition sequence cannot be completely processed. The apertures suitable for CCD target acquisitions are shown in Table 4. It is expected that the majority of CCD acquisitions will be made using the Longpass, [OII] and [OIII] filters. The 50’’x50’’ clear aperture should generally be avoided unless there is a clear need for its use, since bright sources may leave residual images on the CCDs which remain for several hours. The neutral density filters provide the opportunity to acquire targets which would saturate the CCD even with the minimum 0.1 second exposure time with the longpass, [OII] and [OIII] filters. Section 5 is devoted to the special case of CCD point source acquisitions for bright sources.
Table 4. STIS apertures for CCD target acquisition

<table>
<thead>
<tr>
<th>Axis1</th>
<th>Axis2</th>
<th>Aperture</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>50</td>
<td>Clear</td>
<td>CCD clear aperture for unfiltered imaging</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>Clear</td>
<td>Occulting bars/wedge for UV and Visible coronographic imaging</td>
</tr>
<tr>
<td>50</td>
<td>28</td>
<td>Filter</td>
<td>Visible long pass filter for target acquisition with the CCD</td>
</tr>
<tr>
<td>50</td>
<td>28</td>
<td>Filter</td>
<td>[OIII] narrowband filter for target acquisition with the CCD</td>
</tr>
<tr>
<td>50</td>
<td>28</td>
<td>Filter</td>
<td>OII narrowband filter for target acquisition with the CCD</td>
</tr>
<tr>
<td>24.7</td>
<td>24.7</td>
<td>Filter</td>
<td>ND3 filter for target acquisition with the CCD &amp; MAMA detectors</td>
</tr>
<tr>
<td>24.7</td>
<td>24.7</td>
<td>Filter</td>
<td>ND5 filter for target acquisition with the CCD &amp; MAMA detectors</td>
</tr>
</tbody>
</table>

A target acquisition exposure logsheet line is linked to science exposure logsheet lines using the special requirement parameter ONBOARD ACQ FOR <exp IDs>. The science aperture is defined to be the first aperture used by the exposure line list i.e. within the exposure which immediately follows the acquisition exposure. This is either a peakup/peakedown sequence or a science exposure in the case where high precision target centering is not requested.

The image data output from a target acquisition sequence will be a single dataset, containing two images and a third image of variable size:

- one of the target following guide star acquisition,
- one of the target following the coarse locate phase,
- one of the HITM illuminated science aperture.

The size for the third image is dependent upon the requested science slit (see Figure 1). It should be noted that there is no confirmation image taken at the end of the acquisition. If one is required, it can be requested by the GO. Header keywords will be populated with the relevant information determined by the FSW (target locations and aperture locations) in each image (see ICD 19).

5. CCD Bright Target Acquisition

Proposal checking

For CCD point source target acquisitions to be successful, it is important that the Coarse and Fine Locate acquisition images do not saturate the CCD or incorrect target coordinates will be calculated by the Point Source Locate Algorithm and the acquisition could fail. Thus, it is important that the combination of target acquisition exposure time and aperture are appropriate for the target. There are two cases where this may not be the case:
• The target is too bright for the specified aperture and cannot be imaged, even with the minimum CCD exposure time. Figure 5 summarizes the limiting V magnitudes as a function of aperture for the minimum CCD exposure time of 0.1 seconds. The calculations, made with Synphot, assume a CCD full well of ~100,000 electrons, an exposure level of 0.7xfull well, and 60% of the light falling in the central CCD pixel. The table illustrates that it is possible to image any star using the range of neutral density filters available, although it should be noted that the neutral density filter values are provisional. [Note that Table 5 may need further revision once the CCD performance has been fully characterized in its final configuration of operating voltages.

• The exposure time specified by the GO is too long and saturates the CCD

**Table 5.** V magnitude limits for 0.1 second CCD exposure time as a function of aperture.

<table>
<thead>
<tr>
<th>Spectral Type</th>
<th>Limiting Magnitudes&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50CCD</td>
</tr>
<tr>
<td>O5I</td>
<td>11.4</td>
</tr>
<tr>
<td>B1I</td>
<td>11.1</td>
</tr>
<tr>
<td>B3I</td>
<td>11.1</td>
</tr>
<tr>
<td>B5I</td>
<td>11.0</td>
</tr>
<tr>
<td>B8I</td>
<td>11.0</td>
</tr>
<tr>
<td>A1I</td>
<td>10.9</td>
</tr>
<tr>
<td>A3I</td>
<td>10.9</td>
</tr>
<tr>
<td>A5I</td>
<td>10.9</td>
</tr>
<tr>
<td>F0I</td>
<td>10.9</td>
</tr>
<tr>
<td>F2I</td>
<td>10.9</td>
</tr>
<tr>
<td>F5I</td>
<td>10.9</td>
</tr>
<tr>
<td>F8I</td>
<td>10.9</td>
</tr>
<tr>
<td>G2I</td>
<td>11.0</td>
</tr>
<tr>
<td>G5I</td>
<td>11.1</td>
</tr>
<tr>
<td>G8I</td>
<td>11.1</td>
</tr>
<tr>
<td>K0I</td>
<td>11.1</td>
</tr>
<tr>
<td>K4I</td>
<td>11.3</td>
</tr>
<tr>
<td>K7I</td>
<td>11.5</td>
</tr>
<tr>
<td>M2I</td>
<td>11.6</td>
</tr>
<tr>
<td>M4I</td>
<td>11.6</td>
</tr>
<tr>
<td>M6I</td>
<td>11.6</td>
</tr>
</tbody>
</table>

<sup>a</sup> The neutral density filter F25ND5 has no magnitude limit.
In order to deal with the acquisition of bright targets, the following procedures have been adopted for the ground system to be able to (1) identify exposure time errors and, (2) identify bright target acquisitions.

**Exposure time errors**

For STIS proposals it will be mandatory to specify a V magnitude for every target in the target list. In order to check for exposure time errors on the target acquisition exposure logsheet line, the ground system will take the V magnitude and apply the inequality

\[
\text{IF } (T_{\text{exp}} \times 10^{0.4 \cdot V} > T_{\text{exp, Limit}}) \text{ THEN Reduce } T_{\text{exp}}
\]

where \(T_{\text{exp}}\) is the CCD exposure time, \(V\) is the V band magnitude and \(T_{\text{exp, Limit}}\) is a product derived from the expression \(0.1 \times 10^{-0.4 \cdot V}\), given in Table 6. Since TRANS has no access to spectral type, the worst case V magnitude value for a clear aperture is used in Table 6 to determine the exposure time limit, \(T_{\text{exp, Limit}}\). Note that the locate aperture exposure is a HITM image, so the target will be in the aperture as well. Consequently, the limit for a clear aperture has to be used. It should also be noted that the value in Table 6 may need to be revised if the HITM lamp levels prove to be high enough to saturate the CCD in combination with sources fainter than Table 6.

If the exposure time is found to be too long the proposer will receive a warning that the proposal should be modified to reduce the target acquisition exposure time to a suitable level. If the exposure time is already at a minimum value of 0.1 seconds, another filter will have to be selected. The range of neutral density filters should allow acquisition of the brightest stars.

**Bright Target Alerts**

Once a proposal passes the exposure time error check, the ground system checks the target’s V magnitude against the Bright Limit specified in Table 6 to see if it should executed as a bright target acquisition (see “Bright Target Acquisitions”). The GO is not informed that a bright object acquisition has been selected by the ground system, however TRANS does not generate a warning message when a bright object acquisition is required.

**Table 6.** Lookup table for identifying bright target acquisitions

<table>
<thead>
<tr>
<th>Aperture</th>
<th>Bright Limit</th>
<th>(T_{\text{exp, Limit}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>50CCD</td>
<td>11.6</td>
<td>2.29E-06</td>
</tr>
</tbody>
</table>
Bright Target Acquisitions

The CCD bright target acquisition procedure differs from a standard CCD target acquisition in only one respect. During the Coarse Locate phase the target is not placed at the predicted location of the science aperture, but at a position offset from the aperture location (see Figure 3). The Coarse and Fine Locate images can be taken with a suitable aperture e.g. Neutral Density filter, however, if the target were not offset from the aperture, it could saturate the CCD during the Locate Aperture sequence when the target is usually imaged through the clear science aperture with the HITM lamp on. A saturated CCD image at this point would result in an incorrect determination of the predicted aperture center and an erroneous small angle maneuver. By placing the target at a position from the science aperture it is possible to complete the Locate Aperture phase, prior to the final small angle maneuver which places the target in the science aperture ready for a Peakup or science observation.

The amount by which the centered target is offset from the aperture center is dependent upon the destination aperture, and is determined from the parameters in Table 7. Note that some science apertures are disallowed as destination slits following a bright target acquisition.

Table 7. Lookup table for Bright Target Acquisition Offsets

<table>
<thead>
<tr>
<th>Apertures</th>
<th>Offset</th>
<th>Direction</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1x0.06, 0.1x0.09, 0.1x0.2,</td>
<td>1&quot;</td>
<td>Detector Y</td>
<td>Echelle slits</td>
</tr>
<tr>
<td>0.2x0.06, 0.2x0.09, 0.2x0.2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3X0.06, 0.3X0.09, 0.3X0.2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1x0.06, 1x0.2, 0.2x0.5, 6x0.2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6x0.5, 6x0.6, 0.1x0.025, 0.5x0.5,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2x0.06FP, 0.2x0.2FP, 0.2x0.05ND,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3x0.05ND, 0.3x0.05ND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2x0.3ND, 0.3x0.05ND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2x2</td>
<td>2&quot;</td>
<td>Detector Y</td>
<td>Echelle slit</td>
</tr>
<tr>
<td>52X0.05, 52X0.05F1, 52X0.05F2,</td>
<td>1&quot;</td>
<td>Detector Y</td>
<td>1st Order</td>
</tr>
<tr>
<td>52X0.1, 52X0.1F1, 52X0.1F2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.2, 52X0.2F1, 52X0.2F2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.5, 52X0.5F1, 52X0.5F2,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X0.1B0.5, 52X0.1B1.0, 52X0.1B3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52X2, 52X2F1, 52X2F2</td>
<td>2&quot;</td>
<td>Detector Y</td>
<td>1st Order</td>
</tr>
<tr>
<td>36X0.05P45, 36X0.05N45, 36X0.6P45,</td>
<td>2&quot;</td>
<td>Detector Y</td>
<td>Planetary slits</td>
</tr>
<tr>
<td>36X0.6N45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.054X29, 0.09x29, 0.2x29, 0.05x31ND</td>
<td>1&quot;</td>
<td>Detector X</td>
<td>Calibration slits</td>
</tr>
<tr>
<td>0.05x31NDA, 0.05x31NDB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31x0.05NDA, 31x0.05NDB, 31x0.05NDC</td>
<td>1&quot;</td>
<td>Detector Y</td>
<td>Calibration slits</td>
</tr>
<tr>
<td>50CCD, 24.7MAMA, 6X6</td>
<td>-</td>
<td>-</td>
<td>Disallowed</td>
</tr>
</tbody>
</table>
**Use of the External shutter**

With the addition of an external shutter to STIS, bright object acquisitions can be avoided by closing the external shutter for the aperture illumination phase of target acquisition. The use of the external shutter to simply target acquisitions will be reviewed in future.

**Figure 3:** A schematic description of the CCD Bright Target Acquisition Sequence

1) Image the target using a 5”x5” (100x100 pixel) subarray through the appropriate filtered aperture, and determine the target location in detector coordinates using a flux weighted centroid algorithm.

2) Look up the nominal detector coordinates of the science aperture in flight software tables, and perform a small angle maneuver to place the target at a position offset from the predicted aperture center by the value given in Table 7.

3) Re-image the target to determine its new location in detector coordinates.

4) Rotate the slit wheel to the science aperture and illuminate it with the HITM to determine the actual science aperture location on the detector. From the observed location, the science aperture center is calculated in detector coordinates using a threshold centroiding algorithm.

5) Perform a small angle maneuver to place the target at the calculated aperture center or reference position.

**6. Special Cases: Intermediate slit acquisitions**

A number of the STIS apertures are problematic if used with the target acquisition strategy outlined in this document. These are the coronographic apertures, the high signal to noise apertures (sometime known as the FP-Split slits) and the tilted planetary slits (see Table 2). In order to simplify target acquisitions with these apertures, a procedure has been defined which uses an intermediate aperture for the locate aperture phase of target acquisition. This procedure is based on the demonstrated repeatability of the STIS slit wheel.
mechanism. The target acquisition proceeds normally until the locate phase, when the 0.2x0.2 slit is illuminated. The target is then placed in the center of the 0.2x0.2 slit. Prior to the start of the science exposure, the requested science slit is moved into position and a small angle maneuver is performed to move the target into the science slit. Similarly, if the next logsheet line is a peakup, the requested peakup slit is moved into position and a small angle maneuver is performed to move the target into the peakup slit. This is transparent to the observer. It should be noted that while this procedure is currently implemented for the slits identified in Table 2, it could also be applied to target acquisitions for all other STIS slit apertures very easily.

**Coronographic acquisition**

For science observations with STIS there are two main types of coronographic observations:

- Spectroscopic coronography with the long slit occulting bars and fiducials
- Imaging Coronography with the aperture 50CORON

STIS coronographic observations will typically consist of an acquisition, possibly followed by a peakdown under an occulting mask. In this ISR, we discuss the technical issues associated only with the initial target acquisition. The procedures for Peakups and Peakdown are discussed in the ISR “Acquisition/Peakup”.

**Spectroscopic coronography**

There are two types of occulting bars for coronographic spectroscopy with STIS. Each of the 52” longslits have two fiducial bars which are shown schematically in Figure 4. The width of the bars is the same in each of the 52” slits, except for one case discussed below. Each of the fiducials may be used as occulting bars for the purpose of coronographic spectroscopy. In addition, there is one slit designed as a coronographic slit, which has three equally spaced occulting bars of different widths, as shown in Figure 5. This slit does not have fiducial bars. To summarize, the available occulting bars/fiducials for spectroscopic coronography are:

- 1.52x0.05” slit: 52x0.05F1 and 52x0.05F2
- 2.52x0.1” slit: 52x0.1F1 and 52x0.1F2
- 3.52x0.2” slit: 52x0.2F1 and 52x0.2F2
- 4.52x0.5” slit: 52x0.5F1 and 52x0.5F2
- 5.52x2” slit: 52x2F1 and 52x2F2
- 6.52x0.1” slit (with 3 bars): 52x0.B0.5, 52xB1.0 and 52x0.1B3.0,
where F1 designate the 0.5” fiducial and F2 designates the 0.9” fiducial. Currently, only one of these occulting bars is designated as a supported aperture, 52x0.2F1, the rest are available but not supported by STScI.

**Figure 4:** Schematic showing the 52” long slits and the location of the fiducial bars.

![Figure 4](image)

**Figure 5:** Schematic showing the 52” x 0.1” long slit with 3 occulting bars.

![Figure 5](image)

In order to facilitate target acquisition, each occulting bar/fiducial has been assigned two unique aperture names, an aperture for the occulting bar itself, and a corresponding aperture for a reference position located just off the bar. The reference aperture is designed to permit target peakups in the slit, prior to placing the target under the occulting fiducial. Each of these occulting bar/fiducials has been defined as a unique aperture so that when it is selected, the reference aperture for the occulting bar/fiducial is placed at the center of the detector’s field of view. In Table 8, the complete set of aperture names for the 0.5” fiducial on the 52x0.2” slit is summarized as an example.

**Table 8. Occulting bar apertures for 52x0.2”**

<table>
<thead>
<tr>
<th>Aperture name</th>
<th>Description</th>
<th>Aperture Location</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>52X0.1</td>
<td>Slit (width=0.2”, length=52”)</td>
<td>Target centered in slit</td>
<td>Long slit spectroscopy</td>
</tr>
<tr>
<td>52X0.2F1-R</td>
<td>Slit (width=0.19”, length=52”). Fiducial=0.5”. Reference point off-fiducial</td>
<td>Target centered in slit at reference position, offset from fiducial bar.</td>
<td>Locates target at reference position ready for peakup in slit.</td>
</tr>
<tr>
<td>52X0.2F1</td>
<td>Slit (width=0.2”, length=52”). Fiducial=0.5”.</td>
<td>Target centered in slit and located under fiducial bar</td>
<td>Locates target under bar ready for peakdown</td>
</tr>
</tbody>
</table>

Target acquisition with the slit occulting bars employs the intermediate slit strategy. As previously stated the use of the 0.2x0.2” slit is transparent to the user, who specifies the occulting mask aperture required on the exposure logsheet, as illustrated in Table 9.
Table 9. Logsheet sequence for a direct acquisition under 52X2F2.

<table>
<thead>
<tr>
<th>Line#</th>
<th>Logsheet line</th>
<th>Aperture</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Point source target acquisition Onboard acq for line 2</td>
<td>F28X50LP</td>
<td>1) Acquire star in large filtered aperture 2) Position under the aperture 0.2x0.2</td>
</tr>
<tr>
<td>2</td>
<td>Science exposure line</td>
<td>52X2F2</td>
<td>1) Small angle maneuver to 52X2F2 2) Science observation</td>
</tr>
</tbody>
</table>

Coronographic Imaging

STIS has one coronographic aperture for direct imaging, which is shown in Figure 6. The aperture comprises two occulting bars, and two intersecting wedges. One of the occulting bars was damaged during integration and will not be used for science observations. The aperture has no optical filter and so, when used with the CCD yields wide bandpass (3000-10000 Å) imaging.

Figure 6: Coronographic aperture

![Coronographic aperture diagram]

Coronographic acquisition

A series of apertures have been defined for the coronographic mask so that targets can be placed on the 3” wide bar, and 4 locations on each of the two wedges. These apertures are summarized in Table 10 below and shown in Figure 6.

Table 10. STIS aperture for Imaging Coronography

<table>
<thead>
<tr>
<th>Proposal Instructions aperture name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>50CORON</td>
<td>Coronographic mask - clear aperture in center of the field of view</td>
</tr>
</tbody>
</table>
Since the coronographic aperture is unfiltered and designed for imaging bright targets, it presents a problem for target acquisition. The Bright Target Acquisition procedure cannot be used with the 50CORON aperture itself, since it is not a slit, and so the target cannot be offset out of the field of view during Fine Locate. In addition, performing peakdowns meets with the same problem of imaging very bright sources in a clear aperture. If the minimum exposure time of 0.1 seconds saturates the CCD then the target cannot be centered under a wedge or bar using peakdowns.

In view of these considerations the intermediate slit strategy procedure is employed with 50CORON. An example is shown on the exposure logsheet in Figure 11.

Table 11. Logsheet sequence for an acquisition under the aperture 50CORON

<table>
<thead>
<tr>
<th>Line#</th>
<th>Logsheet line</th>
<th>Aperture</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Point source target acquisition</td>
<td>F28x50LP</td>
<td>Acquire star in coronographic aperture</td>
</tr>
<tr>
<td></td>
<td>Onboard acq for line 2</td>
<td></td>
<td>Flight software selects 0.2x0.2” mask and performs fine locate slit illumination using this aperture.</td>
</tr>
<tr>
<td>2</td>
<td>Science exposure line</td>
<td>WEDGEA1.0</td>
<td>1) Small angle maneuver to WEDGEB1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2) Science observation</td>
</tr>
</tbody>
</table>

**High signal to noise slits**

In order to facilitate high signal to noise observations with the echelle modes, STIS has two apertures, which each comprise five slits spaced at distances appropriate for optimum recombination of spectra, as is shown in Figure 7. The two apertures have different slit
widths, 0.063”x0.2 “slits and 0.2”x0.2” slits. As a result of the relatively small spacing between each of the slits in the aperture, the locate aperture phase of target acquisition, presents a problem, since more than one of the slits falls within the field of view. Consequently, the flight software is unable to correctly calculate the center of the slit. The adopted solution to this problem is use the intermediate slit strategy.

**Figure 7:** A schematic drawing showing the configuration of the ‘FP-Split slits’.

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**Planetary slits**

Two long slits, in the STIS aperture complement, are designed to facilitate observations of moving targets, where scheduling of specific roll angles may be problematic. For this reason each set of the two ‘45° tilted’ slits, are tilted at angles of +45° and -45°. The design of these slits is also different from the other long slits, as is shown in Figure 8. In common with the high signal to noise slits, the non-standard configuration of these slits has been found to present problems in slit center location, during the locate aperture phase of target acquisition. Consequently, the locate aperture phase of target acquisition for these slits will also be done with the 0.2x0.2 slit. The adopted solution to this problem is use the intermediate slit strategy.
Figure 8: schematic showing the STIS ‘45° tilted slits’ design.