IUE OBSERVING GUIDE

by

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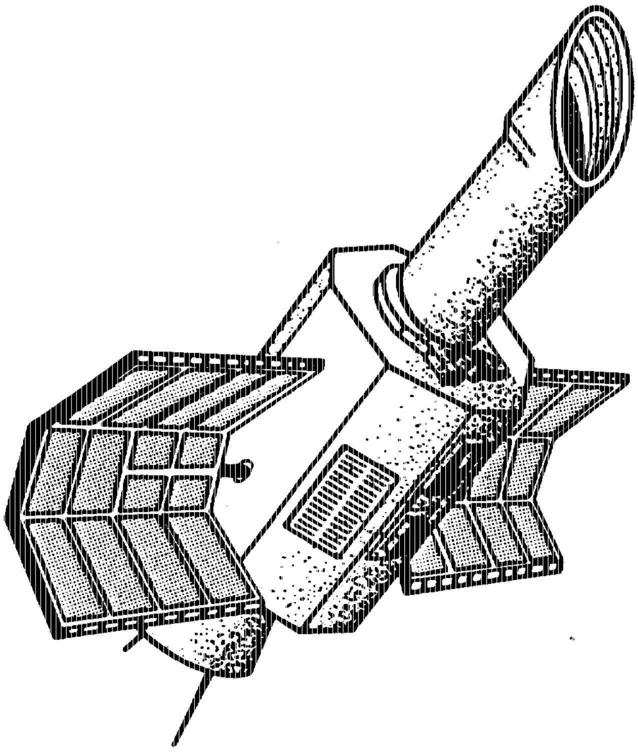


1. Introduction

This guide is intended to convey most of the information a Guest Observer (GO) needs for observing with the International Ultraviolet Explorer (IUE) satellite. It represents a considerable enhancement of the previous guides, "Observing with the IUE" (Holm and Wu 1980), and the "Preliminary IUE Observers Guide" (Oliversen et.al. 1983). Many subjects receive a more thorough discussion and several new topics have been added. Several recent developments worth noting are the installation of the two-gyro/Fine Sun Sensor (FSS) spacecraft control system, the switch to the Long-Wavelength Prime (LWP) camera as the default long-wavelength camera, and the new battery discharge guidelines (see sections 2.4, 3.9 and 3.4, respectively). We urge all IUE GOs, novice and veteran, to make use of this guide.

The Guest Observer will be aided in using the IUE by a Resident Astronomer and Telescope Operator who are responsible for implementing the GO's observational requirements. The constraints and capabilities of the IUE System are constantly evolving. The Resident Astronomer can provide the latest up-to-date information on all aspects of IUE observing capabilities and instrument performance and calibration.

In several respects, observing with the IUE is similar to using ground-based optical telescopes to obtain spectra on photographic plates. All of the activities of the instrument are initiated by real-time commands. The telescope is slewed to the epoch 1950.0 coordinates of the target. The slewing error is typically 3 arc minutes, but may be much larger, so that observer-supplied finding charts should be available. The observer identifies the target by inspection of a 10.8-arc-minute-square visual image of the sky on an interactive image display system. The observer specifies the spectrograph and dispersion mode that is desired. The length of the exposure may be altered in real-time but the exposure level cannot be sampled without reading out the image. As with developing a photographic plate, however, reading the image prevents any subsequent signal from being added to that spectrum. The observer may conduct quick-look analysis at the observing console as soon as 15 minutes after completion of the exposure.

There are some aspects of IUE observing that may be unfamiliar to the new user. Van-Allen-belt radiation may limit the length of the exposures that can be obtained during the second half of the 16-hour NASA operation shift (US2). As seen from the spacecraft, the Earth will appear to circle the sky once every 24 hours, no doubt covering the desired target at just the wrong time. These and other problems will be discussed further below.

IUE Guest Observers can make the most efficient use of allocated observing time through adequate preparation and awareness of potential pitfalls. A brief description of the instrument is given in section 2. Recommended preparations prior to the observing run are discussed in section 3 and a pre-observing run checklist is included in Appendix IV. GO activities during observing shifts and other important information is given in sections 4 and 5.

Articles reporting on spacecraft status, changes in observing activities or policies, image processing, data analysis, and so forth are published in the NASA IUE Newsletter. Guest Observers may keep up-to-date on IUE-related matters through the Newsletters. The IUE Image Processing Manual (Version 2.0; Turnrose and Thompson 1984) contains details of the standard image processing performed by the Observatory before it is given to the GO.

Information about subsequent IUE image processing, calibration, data reduction, and the Regional Data Analysis Facilities (RDAF) is presented in the IUE Data Analysis Guide (Grady 1987). Current IUE addresses and phone numbers are listed in section 5.4.

2. Description of the System

A schematic illustration of the IUE scientific instrument is shown in Figure 1. The instrument contains two spectrographs which function independently. Each spectrograph has a prime and a redundant camera. The Long-Wavelength Prime (LWP) and Short-Wavelength Prime (SWP) cameras are the standard detectors. The Long-Wavelength Redundant (LWR) camera suffers from some problems, but is still available for use with reduced sensitivity (see section 3.9). The Short-Wavelength Redundant (SWR) camera is not operational. More detailed descriptions of the cameras and spacecraft are given in Boggess *et al.* (1978a,b) and in the Camera User's Guide (Coleman *et al.* 1977).

2.1. The Cameras

During an exposure the image is integrated in the SEC Vidicon section of the camera. There is no exposure meter so the length of the exposure must be estimated. The duration of the exposure is controlled by the on-board computer (OBC). The exposure length is quantized in units of 0.4096 seconds and can be modified in real-time.

At the conclusion of the exposure the camera retains the image until a read is initiated. A read consists of a raster scan of 768 X 768 pixels. The video signal is digitized into one of 256 discrete levels (0 to 255 Data Numbers, or DN) by an eight-bit analog-to-digital converter. Since there is no on-board data recorder, the signal is concurrently transmitted to the ground station in real-time as the read scan is performed. At the highest available telemetry rate, 20 kilobits/sec, the transmission of an entire image and associated engineering data takes 5.24 minutes. The read is destructive, so if something happens to the quality of the received signal or to the ground data-handling system during the read, portions of the image can be permanently lost.

After a camera has been read, residual images are erased and a reproducible electronic pedestal of 15 to 40 DN is produced by exposing the camera to a tungsten flood lamp, reading the camera with a defocussed beam, and then exposing and reading again. This sequence is called a PREP. Standard and overexposed preps are available (see section 4.6). Technical details on the cameras are given in the IUE Camera User's Guide (Coleman *et al.* 1977).

2.2. The Spectrograph

With the LWP, LWR and SWP cameras, the spectrographs cover the spectral ranges given in Table 1. Gaps in wavelength coverage in high dispersion are caused by truncation of the lower orders by the edge of the camera faceplate.

Each spectrograph has two entrance apertures. The small aperture is a circle 3 arc seconds in diameter; the large aperture is a 10 x 20 arc second oval. More precise dimensions are given by Panek (1982 a,b). The throughput of the small aperture is 50 ± 25 percent, varying from image to image.

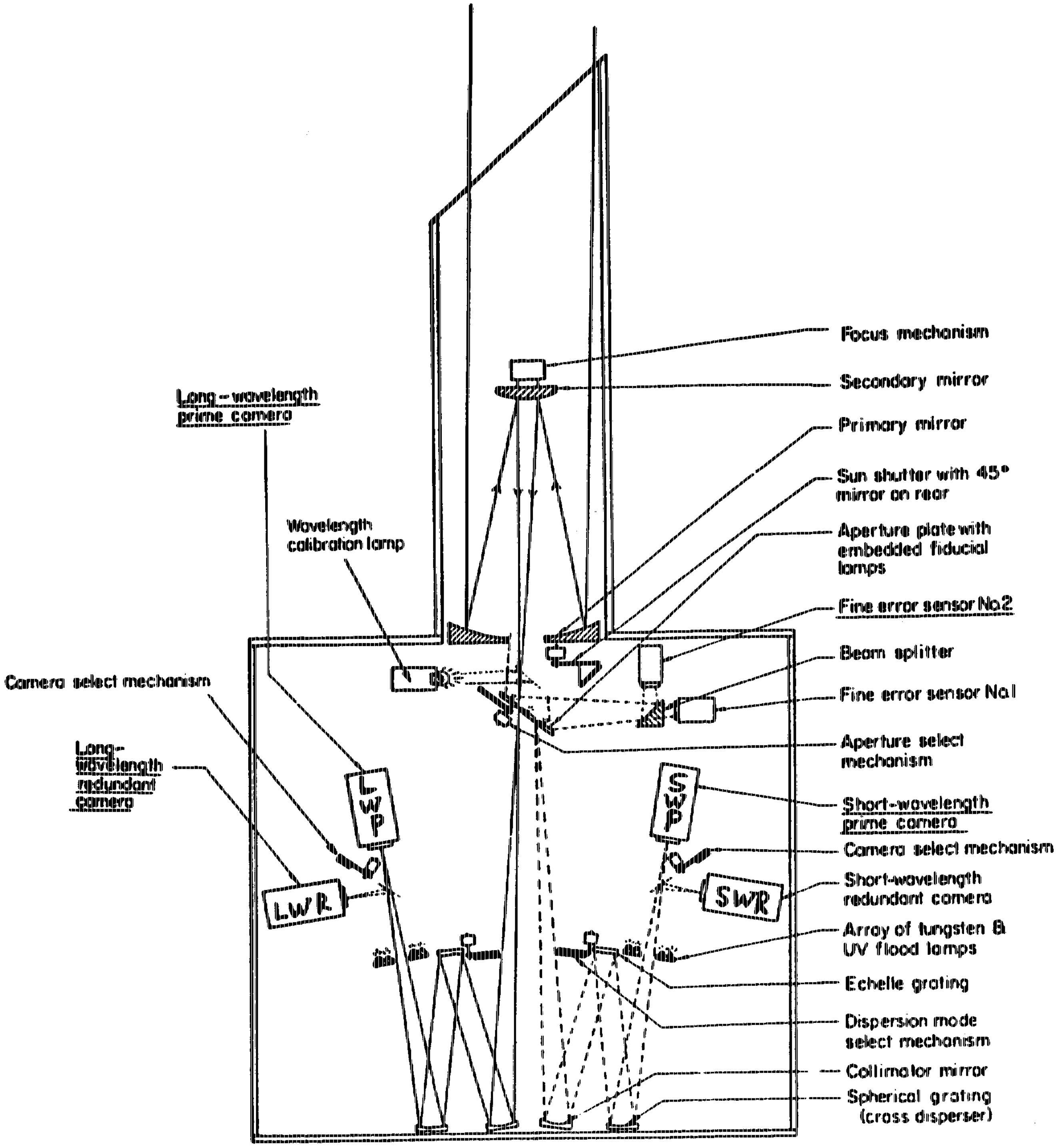


Figure 1. Optical schematic of the IUE Scientific Instrument derived from Colemman, et al. (1977). The available detectors are underlined. This schematic does not show two plane mirrors which are located behind the entrance apertures for the long-wavelength spectrograph in order to allow separation of the optical paths.

Table 1
IUE Camera Wavelength Coverage

Camera	High Dispersion		Low Dispersion
	Full Coverage	Partial Coverage	
SWP	1145-1930 A	1930-2198 A	1150-1975 A
LWR	1845-3105 A	3105-3230 A	1860-3300 A
LWP	1845-2980 A	2980-3230 A	1910-3300 A

2.3. The Fine Error Sensor

Target acquisition is carried out with the Fine Error Sensor (FES). The FES is an image dissector with an S-20 photocathode. Its response extends over 4000-7000 A, with an effective wavelength of about 5200 A. The FES can be used in three modes. The first, field camera mode, is a raster scan that provides an image of the field of view with 8-arc-second resolution. The second, prime mode, is a tracking mode that measures the brightness and relative position of an object with a precision of about 0.25 arc seconds. The FES can track stars of about 13th magnitude or brighter. The third mode, search and track, is a fast raster scan, where the scan beam stops and tracks the first star found to be brighter than a specified threshold. This can be useful for finding very bright stars ($m_v < 5$). The FES can be used in only one of these modes at a time.

The FES can view a field of up to 16 arc minutes on a side containing the entire reflective area of the aperture plate, but an FES field of 10.8 arc minutes square is standard for target identification. This field is typically recorded once at the end of a maneuver, enabling the GO to identify the target. A limiting magnitude of 12.0 can be reached with a standard FES image. The detection of fainter stars requires proportionally longer integrations. The FES limiting visual magnitude is about 15.0 to 15.5 in field camera mode, depending on the background sky brightness. Normal practice for viewing such faint targets is to do an offset maneuver from a nearby bright star and then raster scan a smaller (1 or 2 arc minute) square field, known as a "postage stamp". FES images are normally not archived, but can be if the GO so requests.

In the tracking (prime) mode, the FES is used as an image dissector with a cross-shaped pattern. The dimension of the scan pattern is ±12 arc seconds for stars fainter than 4.7 mag (overlap mode) and ±22 arc seconds for brighter stars (underlap mode). Near the center of the telescope field of view the FES can give relative stellar positions that are accurate to about 0.25 arc seconds. Away from the center of the field distortions reduce the accuracy to about 3 arc seconds.

Since the FES receives the telescope field of view as reflected by the aperture plate, it cannot see a target that is in one of the spectrograph apertures. Therefore, the FES can be commanded to track on a convenient field star for offset guiding during long exposures.

Because the FES is a visual-sensitive instrument, scattered Earth and Moon light can contribute to the measured sky brightness. Sky brightess can hinder the identification of a star field or corrupt the FES automatic tracking mode. The normal sky brightness is about 16th magnitude per pixel (8 x 8 arc seconds), but will be increased to 14th magnitude at a distance of 50 degrees from the Earth and 10th magnitude at a distance of 15 degrees. Viewing at 0.5 degrees from the full Moon gives a sky brightness of 8th magnitude per pixel.

The FES has occasionally suffered from errors of up to 5 arc seconds in its positional reference. These errors correlate with opening and closing of the large apertures and the sun shutter, and are referred to as "reference point shifts". Accordingly, to reduce the risks of degradation of spectra and to minimize the overhead time used to measure the error, closing and opening of the large aperture and the sun shutter is done only in the case of a strong scientific need. The acquisition of platinum-neon lamp spectra used for wavelength calibration requires use of the shutter mechanism. If special purpose wavelength-calibration spectra are requested by the GO, they should be taken after, not before, the astronomical data. Normal wavelength calibration and monitoring is provided by biweekly wavelength-calibration spectra obtained by the Observatory. This, combined with the Observatory image reduction software, provides more than sufficient accuracy (i.e. internal errors of less than 3 km/sec for high dispersion spectra; Turnrose and Thompson 1984) for virtually all GO programs.

In the prime mode, an object's FES counts can be used to derive an estimate of its visual magnitude (see section 4.7).

As seen in Figure 1, there are actually two Fine Error Sensors. IUE Project policy is to have only one turned on at a time. FES No.2 has been used continuously since March 1978 because it is 2 magnitudes more sensitive than FES No.1. FES No.1 is available for use in case of the failure of FES No.2.

2.4 The IUE Spacecraft

The IUE satellite was launched on 26 January 1978 into an elliptical geosynchronous orbit, in which it is always visible from Goddard Space Flight Center (GSFC). Science operations are conducted in real-time from GSFC for 16 hours each day. During the remaining 8 hours, operations are conducted by the European Space Agency at the Villafranca Satellite Tracking Station (VILSPA) near Madrid, Spain. Due to the ellipticity of the orbit and the subsequent daily variations in the satellite's elevation above the horizon, VILSPA can view the satellite for only a portion of each day. Since IUE's orbit is fixed with respect to sidereal time, the handover times between the GSFC and VILSPA observing shifts are normally changed by 2 hours each month. The monthly UT and local starting times of US1 and US2 shifts are given in Table 2.

Spacecraft power is provided by two large solar panels. At most orientations the power generated by the arrays is more than sufficient to run the spacecraft. When the spacecraft is tipped at a large angle from the sun, however, it may be necessary to draw additional power from the spacecraft batteries. The primary function of the batteries is to provide power to IUE during Earth shadow periods. Shadow seasons occur when a portion of the IUE's orbit passes through the Earth's shadow once each day for 3 weeks in the late summer and winter. Additional observing constraints are invoked during these periods (see section 3.3) to ensure that the batteries are fully recharged before the next day's shadow.

Table 2.
Starting Times of NASA IUE Observing Shifts

	US1		US2	
Month	UT	local time	UT	local time
Jan	15:00	10:00 EST	23:00	18:00 EST
Feb	13:00	08:00 EST[1]	21:00	16:00 EST[1]
Mar	11:00	06:00 EST[1]	19:00	14:00 EST[1]
Apr	09:00	04:00 EST[2]	17:00	12:00 EST[2]
May	07:00	03:00 EDT	15:00	11:00 EDT
Jun	05:00	01:00 EDT	13:00	09:00 EDT
Jul	03:00	23:00 EDT	11:00	07:00 EDT
Aug	01:00	21:00 EDT[1]	09:00	05:00 EDT[1]
Sep	23:00	19:00 EDT[1]	07:00	03:00 EDT[1]
Oct	21:00	17:00 EDT[2]	05:00	01:00 EDT[2]
Nov	19:00	14:00 EST	03:00	22:00 EST
Dec	17:00	12:00 EST	01:00	20:00 EST

[1] Shift times may be adjusted by up to 2.0 hours during the 3-week shadow seasons.

[2] Note time change between EST and EDT on the first Sunday in April and the last Sunday in October.

The spacecraft is three-axis stabilized with a nominal 1-arc-second pointing accuracy. Control of the telescope pointing and execution of all spacecraft motion is the primary function of IUE's on-board computer (OBC). The OBC also performs other important functions, such as controlling camera exposures. Prior to August 1985, the OBC used data from three or more of IUE's six gyros to control attitude. Following the fourth gyro failure on August 17, 1985, a backup attitude-control system has been used. The new system (Femiano 1986) uses the two functional gyros and the spacecraft Fine Sun Sensor (FSS). The FSS measures the orientation of IUE with respect to the sun. In the two-gyro/FSS system, the FSS is used primarily to control the roll motion about the telescope optical axis. The two-gyro/FSS system has operational capabilities and accuracies essentially identical to the original three-gyro control system, with the exception that the telescope can no longer be pointed within 15 degrees of the anti-solar position. The two-gyro/FSS has been described and compared with the original three-gyro system by Sonneborn (1985b) and Femiano (1986).

The OBC processes data from the two functional gyros and the FSS and commands the reaction wheels so that either the telescope pointing stays fixed or the desired maneuver is performed. The reaction wheels act as flywheels to store angular momentum. By changing speed, the three reaction wheels cause the spacecraft to rotate about the desired axis.

The spacecraft moves from target to target by executing a series of OBC-controlled slews at a rate of 3 to 6 degrees per minute. These spacecraft-oriented axes are pitch, yaw, and roll (see Figure 2). Only maneuvers preserving optimum illumination of the solar panels are allowed. Under the two-gyro/FSS system, maneuvers are executed as a sequence of slews in pitch (changing Beta, or sun angle) and at a constant sun angle ("sunline" slew). The wheel speeds must stay within certain limits, so after most maneuvers, angular momentum must be added to or removed from the wheels. This is done by firing small hydrazine jets and is known as a "wheel unload". Since the wheel speeds also slowly change with time while maintaining telescope pointing, wheel unloads may also be needed prior to maneuvering after a shift-long exposure.

At the Telescope Operations Center (TOC), the Telescope Operator (TO) under the supervision of the Resident Astronomer (RA) controls all aspects of the scientific instrument operation (target acquisition, telescope focus, exposures, and camera reads) and many spacecraft functions (maneuvering, gyro trims, offset guiding, etc.). The TO runs control programs, known as procedures, on the ground command computer to check ground system configuration and spacecraft telemetry for proper status of the relevant systems before transmitting the appropriate commands to the spacecraft. The procedures also record scientific and engineering data which are archived with each spectrograph or FES image. The commands are transmitted at VHF frequencies to the spacecraft. IUE transmits a continuous telemetry stream to the ground at S-band frequencies, normally at a data rate of 20 kilobits/sec. The signal is received by an 18-meter antenna at the IUE tracking station located at the NASA Wallops Flight Facility, Wallops Island, Virginia. The helical VHF command antennas are also located at Wallops. The commands and incoming telemetry are relayed between GSFC and Wallops through a communications satellite. Once the telemetry reaches GSFC, it is processed by the ground computer and displayed on consoles in the Operations Control Center (OCC) for the various spacecraft subsystems as well as in the TOC.

During GSFC observing shifts the RA and TO in the TOC are in continuous voice communication with the OCC located in Building 14 at GSFC. The Operations Director (OD), two Systems Analysts, the Data Operations Controller (DOC), and computer operators monitor the various spacecraft sub-systems and the ground computer to ensure proper operational status at all times. The OCC has ultimate responsibility for the health and safety of the spacecraft and for all spacecraft engineering functions 24 hours per day. The OCC staff is in continuous voice communication with the Wallops tracking station technicians who operate the command and receiving antennas.

IUE's orbit is frequently monitored to provide accurate pointing predictions for the ground commanding and receiving antennas. A VHF signal is transmitted from the ground and retransmitted by the spacecraft, giving an accurate distance and velocity of the spacecraft (this is referred to as "ranging"). Gravitational perturbations cause the gradual westward precession of the orbit's semi-major axis. A station-keeping maneuver is performed at intervals of 6 to 9 months to prevent the satellite from passing outside the range of ground antennas at GSFC and VILSPA. At this time, the large hydrazine jets are fired to slightly modify the semi-major axis so that the orbit drifts eastward again.

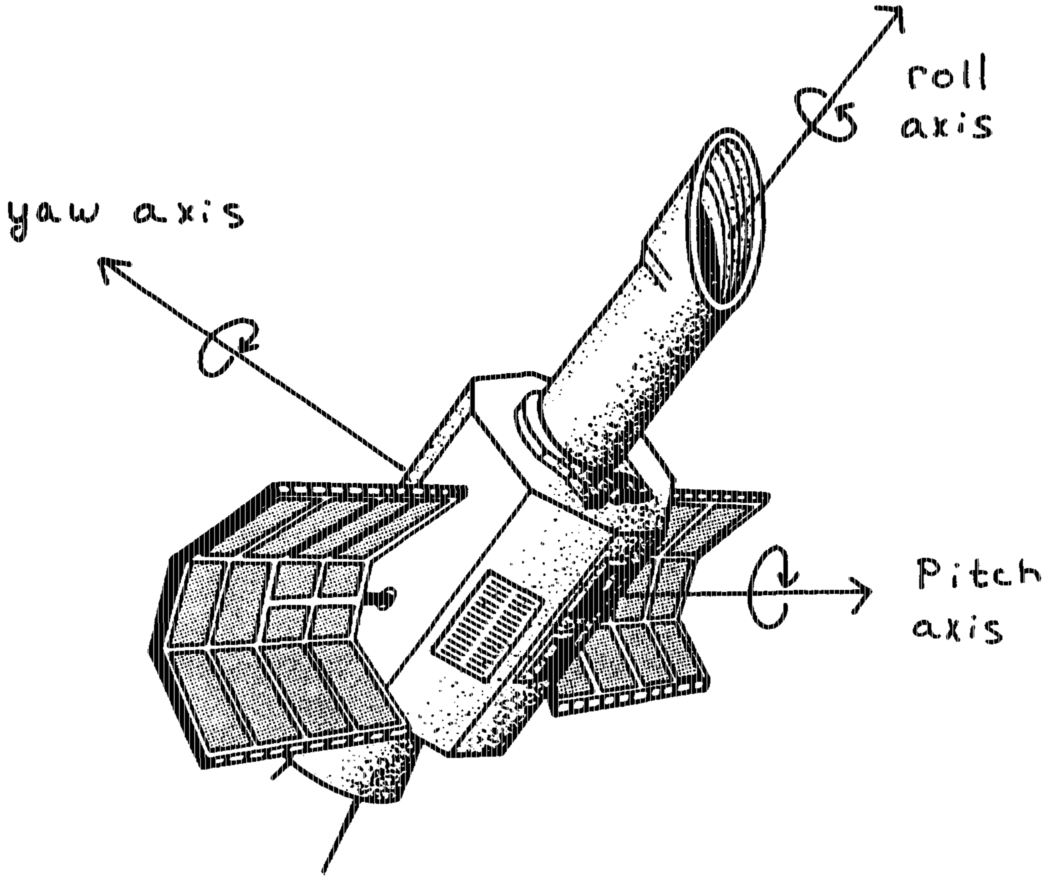


Figure 2. IUE spacecraft maneuver axes. A positive rotation around a given axis is in the direction specified by the "right hand rule". Pitch is the angle between the sun and the telescope pointing. At zero degrees pitch, the telescope would be pointed at the sun while a pitch angle of 180 degrees corresponds to the anti-solar position. The Beta angle is then defined as 180 degrees minus the pitch angle. A "sunline slew" is a combination of yaw and roll motion with the Beta angle remaining constant.

3. Pre-Observation Preparations

Advance preparation will enhance the efficiency of your observing run. This includes communicating your program's scheduling requirements and target priorities to the observatory scheduler at the start of the observing episode. Requirements and priorities for subsequent shifts should be revised, if necessary, after completion of your first run. The NASA IUE scheduling policy is included as Appendix II and a pre-observing run check list is provided in Appendix IV.

IUE skymaps will be sent to you or to your designated Lead Investigator at the beginning of the month preceding your scheduled shifts. The skymaps are designed to help you plan your observing session (see Section 3.1). In addition to your program's primary objects, your target list should also include a few alternate targets, to allow you to work around possible spacecraft constraints (sections 3.2 and 4.4).

Observing a target which is at a large or small angle to the sun may cause the batteries to discharge. If battery discharge is expected during your shift, approval from the Project Scientist prior to arrival at GSFC is normally required. Project policy for spacecraft operations which result in battery discharge is discussed in Section 3.3 and Appendix I. If you should need to add targets to your observing program, contact the Project Scientist prior to arrival at GSFC (see Section 3.4).

Correct 1950 coordinates and field identification are essential. Finding charts are recommended for targets and offset stars fainter than about 6th magnitude (Section 3.5) or for fields where there is another object of comparable brightness within about 15 arc minutes of a bright target.

The presence of fainter stars within the FES's tracking pattern at the target may cause acqusition problems, spectral contamination, or reduced wavelength accuracy. If a target is part of a multiple-star system, is diffuse, or has a visual magnitude below 13.5, an offset maneuver from a nearby star may be necessary (Section 3.6). Special acquisition and observing techniques are used for moving targets (planets, their satellites, asteroids, and comets; see Section 3.7). The orientation of the apertures with respect to the equatorial coordinate system is a function of the spacecraft attitude and time of year. If a particular aperture position angle is required, your observing session can usually be scheduled accordingly (Section 3.8).

The LWP camera is now the long-wavelength camera in general use. The LWR can be used, but it is now configured with a reduced sensitivity to avoid recurrence of a flare in the Ultraviolet Converter section of the detector. The characteristics of the LWP and LWR cameras are compared in Section 3.9.

Several methods of estimating exposure times are discussed in detail in Section 3.10.

Even the best-planned program can experience unforseen problems. Section 3.11 summarizes the more common acquisition and observing problems.

Limited amounts of observing time are available for projects which, for scientific reasons, cannot wait until the next IUE observing year. Procedures for applying for this telescope time, referred to as the Project Scientist's Discretionary Observing Time, are described in Section 3.12.

Finally, it is very important that the observatory be informed on a timely basis of your exact observing plans. The annual scheduling of some two hundred programs, along with spacecraft constraints, collaborative programs, and coordination with other telescopes, often results in limited time windows for observing particular objects. Programs are scheduled using information available to the scheduler at the time the monthly schedule is generated, which is 90 days prior to its use.

The GO can take several steps to insure that information available to the scheduler is complete and current. When writing the episode proposal, carefully and completely fill out the required Observation Specification Form. In addition, include any special requirements such as: specific times of the year, partial shifts, collaborative programs, coordination with other telescopes, specific aperture orientations, specific shift sequences, time-critical observations, and high-priority targets.

Shortly after receiving the letter of acceptance for your program, you will be asked to update your original scheduling requests. This information must be provided promptly. When you have a number of shifts scheduled throughout the year, please alert the scheduler to changes in your target priorities. Many scheduling decisions are made at the beginning of the episode. GOs needing time in the first two months of an episode (i.e. June and July) should contact the scheduler as soon as possible after receiving their letters of acceptance. Collaborative NASA/ESA shifts for the entire episode are also scheduled at this time (see Appendix II).

3.1 Skymaps

As a planning aid the IUE Observatory provides sky maps which illustrate the celestial sphere as viewed from the satellite (Figure 3). Superimposed on the equatorial coordinate grid are a number of symbols representing various features and constraints to be kept in mind when planning your observing shift. These are:

skymap date	– This is the date for which the map was generated. Positions of lines, Beta angles, etc. will noticably change over a period of days. Targets near regions of spacecraft-pointing constraints may be observable at the beginning of a run, but not at its end.
circle of S's	– The boundary of the forbidden region around the sun. The telescope may not point within a region of 45 degrees in radius, centered on the apparent position of the sun (i.e. for Beta $\geq$ 135 degrees).

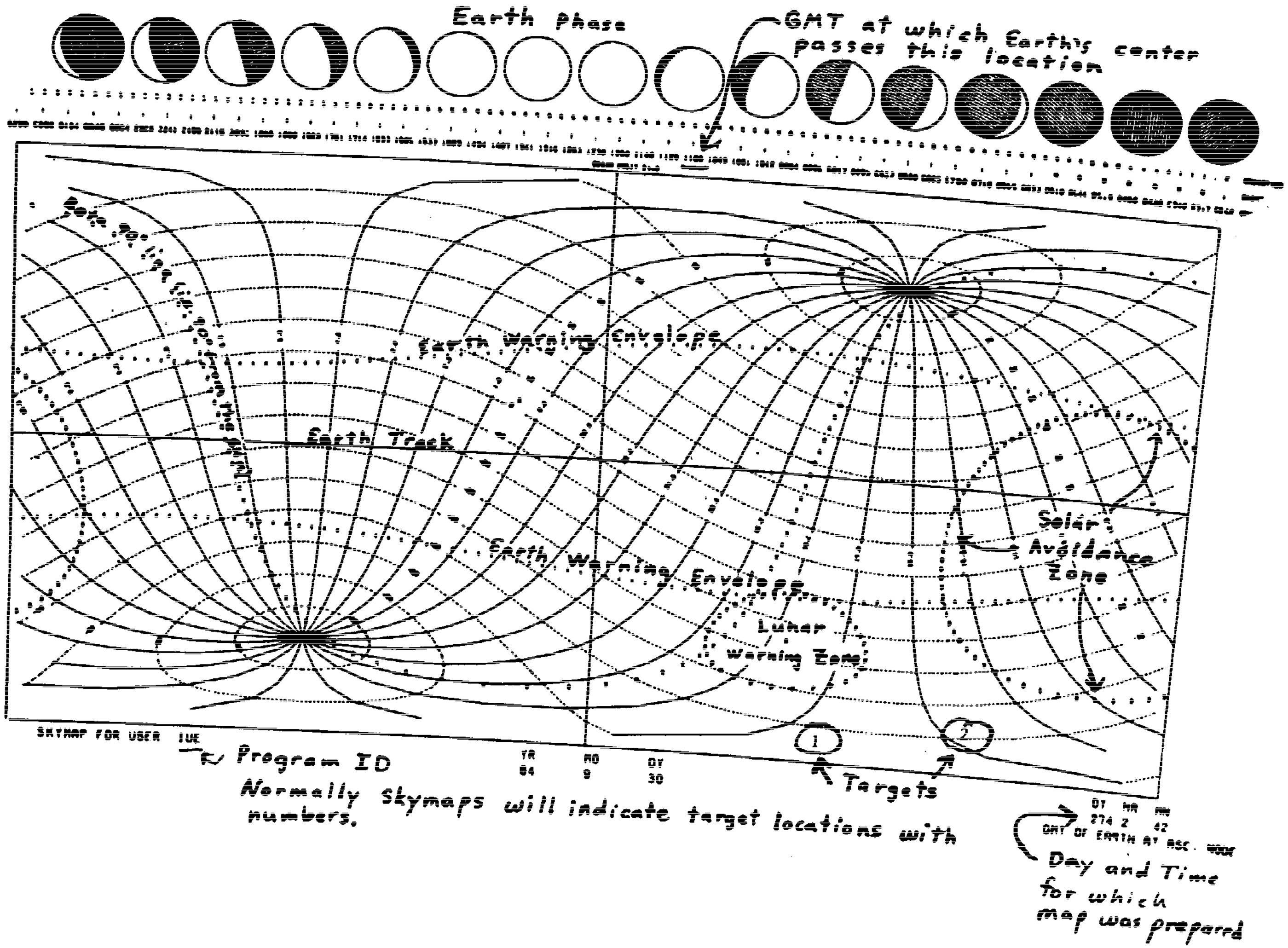


Figure 3. Sample IUE skymap

horizontal line across center of the map - The satellite orbital plane. The timeline at the top of the map gives the UT at which the Earth's center passes the point on the orbital plane directly below. The shaded circles above the timeline represent the Earth's phase at that time, as seen by IUE.

envelope of E's - A warning zone around the Earth. The width of this zone is 40 degrees larger than the Earth's apparent diameter (14.2 degrees at apogee and 22.4 degrees at perigee). It provides an indication of where operational problems may develop due to scattered light and weak telemetry signal strength.

circle of M's - A 15 degree warning zone around the Moon's position at 0h UT for the skymap date.

a lone large 'A' - The anti-solar point (Beta = 0 degrees). The telescope may not point within 15 degrees of the anti-solar position.

line of small A's - The Beta-90 line. This is the great circle 90 degrees from the apparent position of the sun.

The warning zones about the Earth and Moon may be freely encroached upon. However, occultations and/or significant scattered light within the telescope optics may hamper observations and limit the period of time at a particular target on a given shift. Morever, there is no transmitting antenna on the telescope-end of the spacecraft, so the quality of the received signal may be poor when the telescope is pointing near the Earth. Near the time of sunrise or sunset (Eastern Standard Time) when the spacecraft has a solar panel pointed at the Earth, telemetry may be of poor quality as far as 110 degrees from the Earth. While observations may be made with a poor signal, the cameras can not be read down (i.e. the spectral image transmitted to the ground) without adequate signal strength in order to avoid permanent loss of data. Targets at poor signal locations thus require extra overhead time to slew the spacecraft to a location of good signal strength for reading down the cameras.

The Moon and lunar scattered light actually occupy a very small part of the lunar warning zone. The lunar envelope allows for the considerable parallax of the Moon as seen by IUE as well as for the Moon's large orbital motion. In practice, observations of targets within the lunar warning zone are seldom a problem, though the potential exists and should be kept in mind for time-critical observations or for single-target programs.

Skymaps can help in making efficient use of your observing time. You can use them to plan around the Earth and Moon. In addition, they can help you judge the environment affecting the spacecraft during your observations. The great-circle distance between the anti-solar point and the target, called the Beta angle (see Figure 2) is the primary quantity which sets many spacecraft operational constraints. Along with the skymap, you will receive a listing of your targets. The last column of this list gives the Beta angle for each target on the date for which the skymap was generated. (Beta angles may be calculated for any date; see Section 3.8).

As of September 1986 the following limitations apply as a function of Beta:

$\text{Beta} \geq 135^\circ$	Solar avoidance zone; no observations allowed.
$125^\circ \leq \text{Beta} < 135^\circ$	Severe power constraints; battery discharge expected. Power drain on batteries may not permit observations longer than 1 hour. Project approval is required for all observations.(see Section 3.3).
$115^\circ \leq \text{Beta} < 125^\circ$	Some power constraints. Observations may normally be obtained, but some battery discharge will occur. Some increase in overhead time may be required to avoid significant levels of battery discharge. If planned exposures are to be longer than 10 to 15 minutes duration, consult with the observatory staff prior to your arrival at GSFC to determine whether Project approval to discharge the batteries will be required.
$\text{Beta}_U < \text{Beta} < 115^\circ$	Cool Beta region. OBC is at a cool temperature and battery power is good. (Beta_U refers to the upper Beta angle limit for the OBC temperature constraint zone. See below and Table 3)
$\text{Beta}_L \leq \text{Beta} \leq \text{Beta}_U$	"Hot Betas"; OBC temperature will rise, possibly forcing a move to cooler Betas after a few hours. Maximum power to solar arrays. Table 3 gives the monthly upper (Beta_U) and lower (Beta_L) Beta angle limits within which observations can be restricted if the OBC temperature gets too hot. Note that there are normally no OBC temperature-related observing constraints during May, June, July, and August. (see Sonneborn 1985a). If the OBC is already at its high-temperature limit, a target in this zone may not be observed until the OBC temperature decreases.
$30^\circ \leq \text{Beta} < \text{Beta}_L$	Cool Betas. Battery power is good.
$25^\circ \leq \text{Beta} < 30^\circ$	Cold Betas. OBC temperature will decrease. Telescope focus may degrade over several hours. Battery discharge may occur. Observations may normally be obtained, but with somewhat lower efficiency in order to conserve power. Maneuvering within the low beta region may be time-consuming.
$15^\circ < \text{Beta} \leq 25^\circ$	Severe power problems; battery discharge will occur. Project approval required for all observations.
$\text{Beta} \leq 15^\circ$	Anti-solar region; no observations allowed.

For long exposures the target should generally be located at a "cool Beta angle," as defined above, to insure that power or OBC temperature constraints do not necessitate an interruption of the exposure. Short exposures (less than 30 minutes) may usually be performed at any Beta between 120 and 25 degrees. If the OBC is very hot, observing at cold Betas for an hour or two can sufficiently cool the OBC to allow a long exposure of a target at a hot OBC Beta.

Table 3.

Monthly Beta Angle Regions with OBC Temperature Constraints

Month	Lower Limit	Upper Limit	Month	Lower Limit	Upper Limit
January	55.0°	100.0°	July	—	—
February	55.0°	95.0°	August	—	—
March	60.0°	95.0°	September	70.0°	85.0°
April	65.0°	90.0°	October	65.0°	90.0°
May	—	—	November	60.0°	90.0°
June	—	—	December	60.0°	95.0°

3.2 Choice of Targets for Observation

Targets should be limited to those needed to carry out your research objectives, plus a few alternate targets to provide some degree of flexibility during your observing run. Alternate targets may be needed to work around any spacecraft-pointing constraints that may arise during the observing shift. These constraints may result from an underpowered or overheated condition in the spacecraft or if the particle radiation is unusually high (see sections 3.3, 4.4, and 4.9). Such problems can usually be avoided by scheduling an observing program for dates when the principal targets are at desirable orientations with respect to the sun. If there are a large number of targets on your program, be sure to indicate your high priority targets to the Resident Astronomer in charge of scheduling.

3.3 Battery Discharge Guidelines

The primary function of the two batteries on board IUE is to provide spacecraft power during the semi-annual Earth shadow seasons. Observations at high or low Beta angles may also discharge the batteries. In order to prolong the life of the batteries and the IUE mission lifetime, the number of times that the batteries can be discharged per year for normal science operations is very limited. In most cases, proper scheduling of your observing program can preclude the need to operate at high or low Betas. However, battery discharge may be necessary in some circumstances, such as time-critical observations or targets of opportunity. It is recommended that approval to discharge the batteries be obtained from the Project Scientist prior to your arrival at GSFC. The general guidelines for battery discharge are reviewed below (also see Appendix I). Please refer to the articles in the NASA IUE Newsletter (Kalinowski 1983 and Sonneborn 1983) for further details.

In any 12-month period, the batteries may be discharged below 22.5 Volts only 36 times (24 times for GSFC and 12 for VILSPA). Of these 36 discharges, the batteries may reach the 'red-line' limit (20.9 Volts) only 12 times (8 for GSFC and 4 for VILSPA). If a red-line limit is reached, the spacecraft must be promptly slewed to a power-positive attitude to allow the batteries to recharge. Depending on the initial depth of discharge, the recharging period may take up to 16 hours. This could restrict observing plans for the remainder of the shift and the next observer's shift as well.

The rate of discharge depends upon the level of observing activity. Reading images from the cameras consumes more power than exposing. The camera deck heaters, which are used to control the focus at low Betas, draw about twice as much current as reading a camera. Spacecraft rangings draw even more power than the deck heaters. Although rangings normally only last about 10 minutes, they can rapidly drain the batteries down to the 22.5 Volt limit if the spacecraft is at a high or low Beta. A plot of the estimated time before the 20.9 Volt limit is reached, as a function of time and Beta angle, is shown in Figure 4. Two lines are plotted. One is for a minimum level of observing activity and the other is for a higher level of activity. An observing plan for exposing one camera with a primary mirror heater turned on is an example of a minimum level of observing activity. Exposing one camera with both primary mirror heaters turned on, while reading the other camera once per hour, is an example of a high level of activity.

Since the solar arrays are gradually degrading with time, the actual Beta limits at which battery discharge is likely to occur are also gradually changing. Predictions of future power positive regions are given by Sonneborn (1986). The current range of power positive Betas is somewhat better than previously predicted, since the two-gyro/FSS system uses slightly less power than the former three-gyro system. The letter you receive with your skymap will give the current Beta limits for the month of your observations.

Twice a year, for about three weeks in late summer and winter, the IUE's orbit carries it through the Earth's shadow once each day. During the shadow passages, which may last as long as 75 minutes, the batteries lack sufficient power to permit observations or maneuvers. On exiting shadow, normal operations resume, although battery discharge is not permitted. During the August-September 1986 shadow season observations were confined to Beta angles between about 35 and 110 degrees.

3.4 Adding Targets

Targets not on the original proposal list may nevertheless be observed, subject to the prior approval by the IUE Project Scientist. A list of general guidelines for adding targets to a program follows. Full details are given by Kondo and Holm (1982).

(1) The scientific reasons for adding a target should be relevant to the current IUE program. For example, you should not add a suddenly brightened QSO as a target to an IUE program to observe B stars!

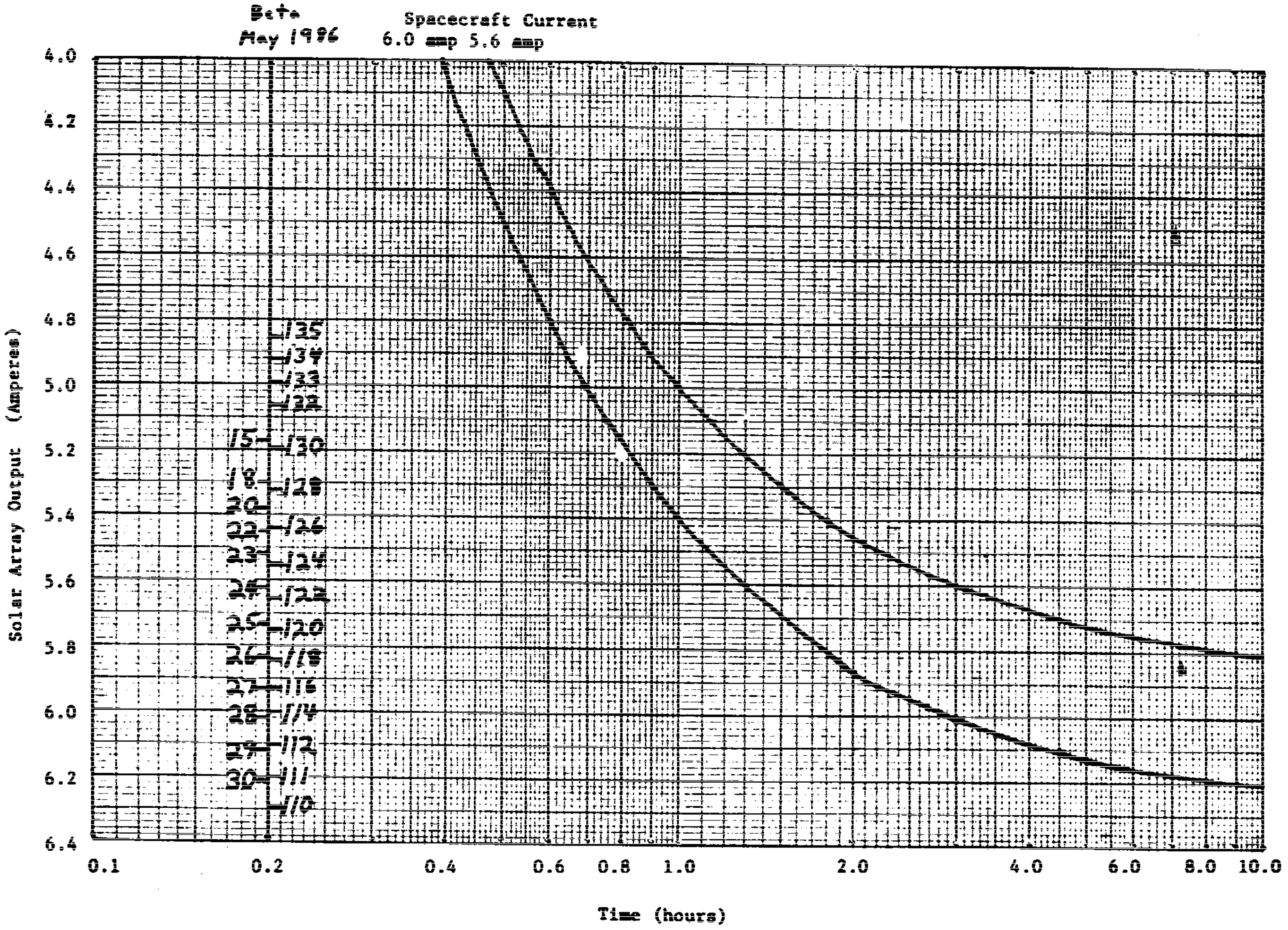


Figure 4. Observing time predictions for red-line discharge. The curves represent, as a function of Beta, the estimated total length of observing time available before the "red-line" battery limit is reached. Two curves are shown. The 6.0 amp curve is typical of a maximum load while the 5.6 amp curve is typical of a minimum load.

(2) In requesting Project approval, the Principal Investigator must write to the Project Scientist, describing the scientific reasons for observing the target(s) and explaining why it was not on the original target list.

(3) The written request should include a completed Observation Specification Form and the following information: the five-letter program ID code, the target name, 1950.0 coordinates, visual magnitude, and IUE object class for each new target. Copies of the form can be found in the Proposal Instruction package, the GO packet at the beginning of the episode, with this guide (see Appendix V), or are available from the Observatory on request. Observations of added targets will be permitted only at the precise coordinates as stated on the form.

(4) The request for additional targets should reach the Observatory several weeks prior to the observing run.

(5) It is recommended that at least 75 percent of your observing time be devoted to targets specified in your original proposal.

3.5 Finding Charts

The ability to identify your target by pattern matching is essential. Hours have been wasted observing the wrong object because of misidentifications or while the GO pondered identification of the target.

For stars fainter than 6th magnitude, the GO is advised to bring finding charts. This is true for an offset star as well as for the target. The FES can view a generally circular field of up to 16 arc minutes in diameter. A 10.8 arc minute square field is standard. Finding charts in the form of photographic prints or transparencies are recommended; slides or hand-drawn charts may be adequate. Scales of 6 to 12 arc seconds/mm are most easily compared with the FES image. Charts should show stars as faint as 12-13th magnitude. Transparencies are convenient because they can be rotated and flipped to match the orientation of the image produced by the FES.

Please keep the following problems in mind:

(1) While maneuvers are usually accurate to several arc minutes, occasionally the errors may be as large as 10 to 15 arc minutes, especially for slews with a large beta angle change. There is no guarantee that the bright star nearest the center of the field is your target.

(2) BD, SAO, or AAVSO charts are not adequate for targets of eighth magnitude or fainter because there may be field stars nearly as bright as the target that were not included in the catalog.

(3) The relative brightness of stars in the FES field may be distorted slightly due to non-uniform reflectivity of the aperture plate.

(4) The FES gives no color information. A target which is readily identifiable visually by its unique color must be identified using star patterns.

(5) Identifying stars by magnitudes is risky, especially when using magnitudes from the SAO catalogue or a comparable source.

(6) Finding charts are recommended for offset stars if they are fainter than about 6th magnitude.

(7) Finding charts are occasionally needed even for bright stars which may have optical doubles in the field or may be members of a small open cluster.

3.6 Blind Offsets and Faint Object Acquisition

After a long slew, identification of a faint target can be difficult or even impossible. An offset maneuver to your target from a relatively bright nearby star with accurate coordinates will generally be necessary. Possible reasons for using an offset maneuver are to observe objects which are too faint to be detected by the FES, to save time in locating targets which are marginally detectable in the FES, to observe precise locations in diffuse sources, to observe targets with close companions, or to locate some classes of moving targets.

For arc-second maneuver accuracy, the distance from the offset star to the target should be less than 0.25 degrees, ideally only a few arc minutes. A plot of offset maneuver accuracy as a function of total slew length is shown in Figure 5. If accurate 1950 right ascension and declination, corrected for proper motion, for both the target and offset star are used for calculating the offset maneuver, and if the offset slew distance is less than 15 arc minutes, then the slew should place the target within two arc seconds of the reference point. (The offset star is centered at the FES reference point before the offset slew.)

At the normal telemetry rate of 20 Kbps, the limiting magnitude for a star in an FES image is 12.0. At a telemetry rate of 5 Kbps, the limiting magnitude is 13.5. Such an image with the default of 10.8 arc minutes in size requires over 3 minutes of integration. Special acquisition techniques are required for fainter objects.

One method is to command the FES, in track mode, to look at the reference point at the end of the offset maneuver. If the target falls within the FES's track pattern (±12 arc seconds), a long integration (i.e. about one minute) is obtained of the target's position and brightness. Using this position the target is then centered at the reference point before maneuvering the target to the desired aperture with standard slews. This technique can be used for point sources down to approximately 14.0 magnitude. A second technique is to map out a one-arc-minute-square portion of sky around the reference point. The long integration at each pixel in this "postage stamp" FES image allows detection of objects as faint as 15.0 - 15.5 magnitude, depending on the sky background brightness. From the postage stamp, small corrections in telescope pointing can be commanded so that most of the light from the target falls on one FES pixel (8 arc seconds square) centered on the reference point. The target can then be maneuvered to the desired aperture by the standard slews. Because of the low spatial resolution (±4 arc seconds) in FES images this technique is not as accurate as the FES tracking mode. However, it can be used for much fainter objects.

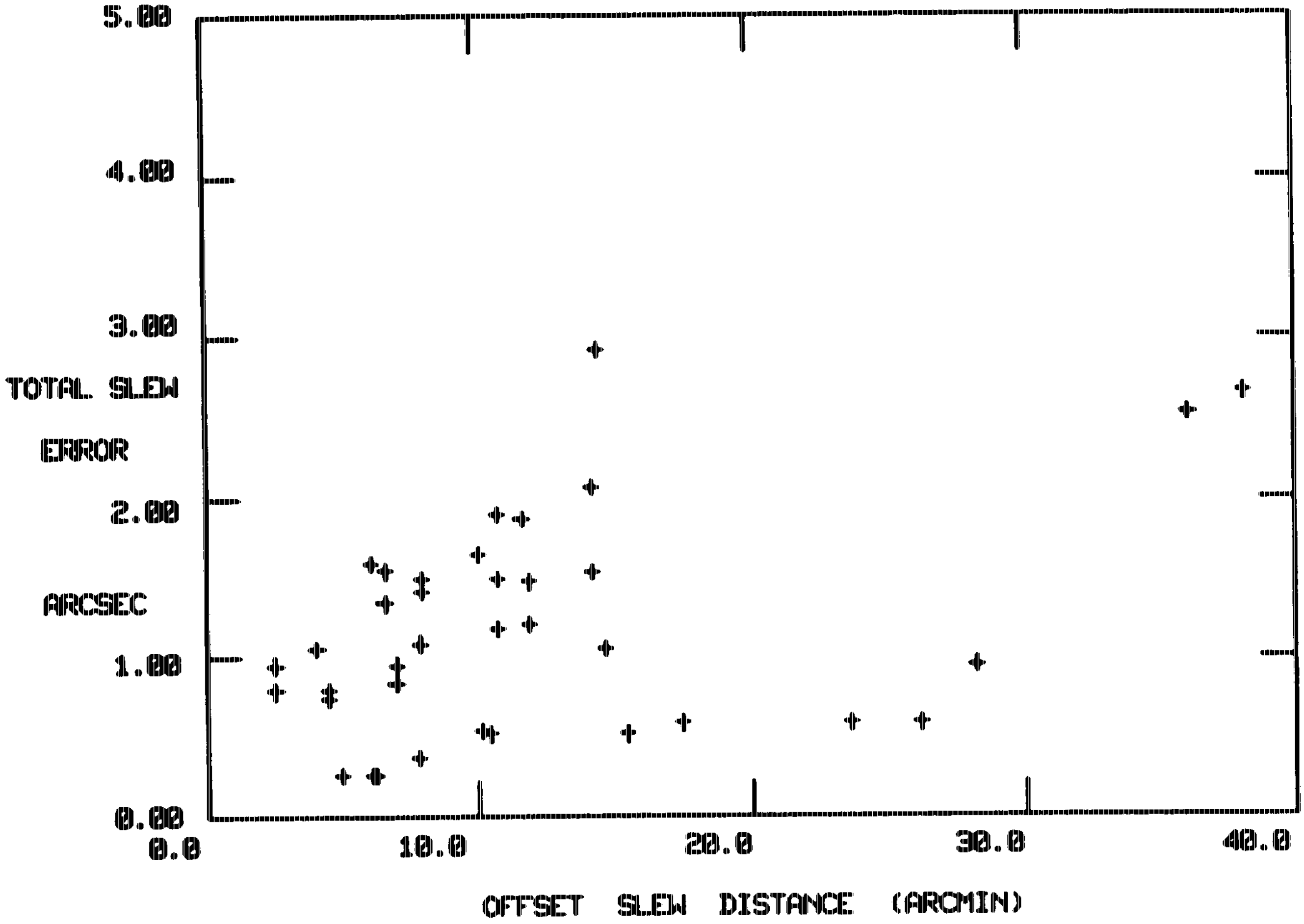


Figure 5. Blind offset maneuver accuracy. The total slew error in arc seconds is shown as a function of the offset distance in arc minutes. The data is taken from Sonneborn (1985c). The recommended maximum offset distance to insure a total slew error of no more than 2.0 arc seconds is 15 arc minutes.

If the target is fainter than approximately 15.5 magnitude, it cannot be seen by the FES and the acquisition must be done blindly. Since the large aperture is only a 10 x 20 arc second oval (the small aperture is a 3 arc-second-diameter circle), positions accurate to one arc second or better, corrected for proper motion, are necessary for the offset star and target.

3.7 Moving Targets

Solar system objects, with the exception of the outermost planets, are moving sufficiently fast that their motion has to be compensated for by the spacecraft's attitude control system. This involves trimming the gyros to the drift rate of the target, so that the telescope tracks at the same rate as the target motion. During the exposure, the telescope pointing is held either by gyros or tracking on a nearby planetary satellite.

The Earth, Moon, Jupiter, Saturn and Venus are so bright that the FES is saturated when viewing them. A technique has been developed for using the FES measurement of scattered light to put an object as bright as Venus into an aperture, but both the Moon and the Earth must be observed by blind offset techniques under gyro control. The coordinates of solar system objects with a geocentric distance less than 1 A.U. (the Moon and some comets and asteroids) should be corrected for the parallax shift due to IUE's orbit. The Galilean satellites of Jupiter can be tracked to within 2 arc minutes of the planet.

Moving-target observers must prepare an ephemeris of target position in right ascension and declination (epoch 1950), including spacecraft parallax correction to geocentric coordinates, before arrival at GSFC. An ephemeris should also be prepared for any satellite to be used for offsetting. The ephemeris should also give the target drift rates in right ascension and declination (arc seconds/hour). If a planetary satellite is to be used as a "guide star," a table giving the distance and change of distance between target and guide object as a function of time is desirable. The time interval between entries in this ephemeris depends on the rates involved, the accelerations, and the degree of pointing accuracy your observing program requires. Plan to contact the Resident Astronomers well in advance of your visit to discuss your observing run's requirements.

3.8 IUE Aperture Orientation

It is occasionally important to know the astronomical orientation of the spectrograph apertures, as in observations of nebulae, galaxies, and close double stars. Equations for the spacecraft roll angle and the orientation angles of the apertures are given in an article by Schiffer (1980a) and are reprinted below. The orientation, especially with respect to the spectrum, is not always intuitively obvious. As a visual aid in finding the orientation of the apertures, formats of the FES field and the cameras are depicted and discussed below.

Since the FES and spectrographs are fixed within the spacecraft, the FES coordinate system (labelled X and Y) is defined relative to the inertial axes of the spacecraft (see Figure 6a). These coordinates are used to specify the locations of the apertures, guide stars, and so forth, in the telescope field of view.

The aperture and spectrum orientation in the plane of the sky is a function of the spacecraft roll angle. The spacecraft roll is defined as the angle, in the plane of the sky, between north and a reference vector (see below) pointing to the sun. This angle, measured 0 to 360 degrees eastward from the reference vector, changes as a function of the day of the year for a given right ascension and declination, as the spacecraft orientation must keep the solar arrays optimally facing the sun.

Angles in the FES field of view are also defined with respect to the reference vector which points to the sun and is parallel to the pitch direction. When the spacecraft roll is 0 degrees, the reference vector points north. Due to the odd number of reflections in the optical path to the FES, the FES image is displayed in a left-handed coordinate system. All angles in the FES, therefore, increase in a counterclockwise direction. The reference vector for FES No.2, the system in current use (see Figure 6a), is rotated approximately 28.31 degrees in the FES coordinate system from the negative Y axis toward the negative X axis.

Let the FES position angle in the plane of the sky be defined such that 0 degrees points north and 90 degrees east. [These definitions are slightly different than those of Schiffer (1980a).] The position angle is related to the spacecraft roll by:

position angle = aperture orientation angle - spacecraft roll angle,

where the orientation angles of the apertures are defined with respect to the reference vector and increase counterclockwise from the reference vector. The aperture orientation angles are given in Table 4.

The orientation of the apertures relative to the FES coordinate system is given in Figure 6a. The orientation of the field as projected on the camera faceplates may also be determined. The north direction in the FES image is, therefore, rotated counterclockwise from the reference vector by an amount equal to the spacecraft roll angle (see Figure 6a). Figure 6b shows the placement of the large and small apertures with respect to low-dispersion LWP, LWR and SWP spectra. (The apertures have been enlarged for clarity.) While the orientation of the FES coordinate system is different for each camera, the dispersion direction is approximately aligned with the FES Y axis in low dispersion and with the FES X axis in high dispersion.

Table 4
IUE Aperture Plate Orientation Angles

Aperture	Orientation Angle	Separation
LWLA major axis	73° ± 3°	---
SWLA major axis	73° ± 2°	---
LWLA to LWSA	238°	42.7 arc seconds
SWLA to SWSA	242°	39.9
LWLA to SWLA	275°	66.3
LWSA to SWSA	279°	66.2

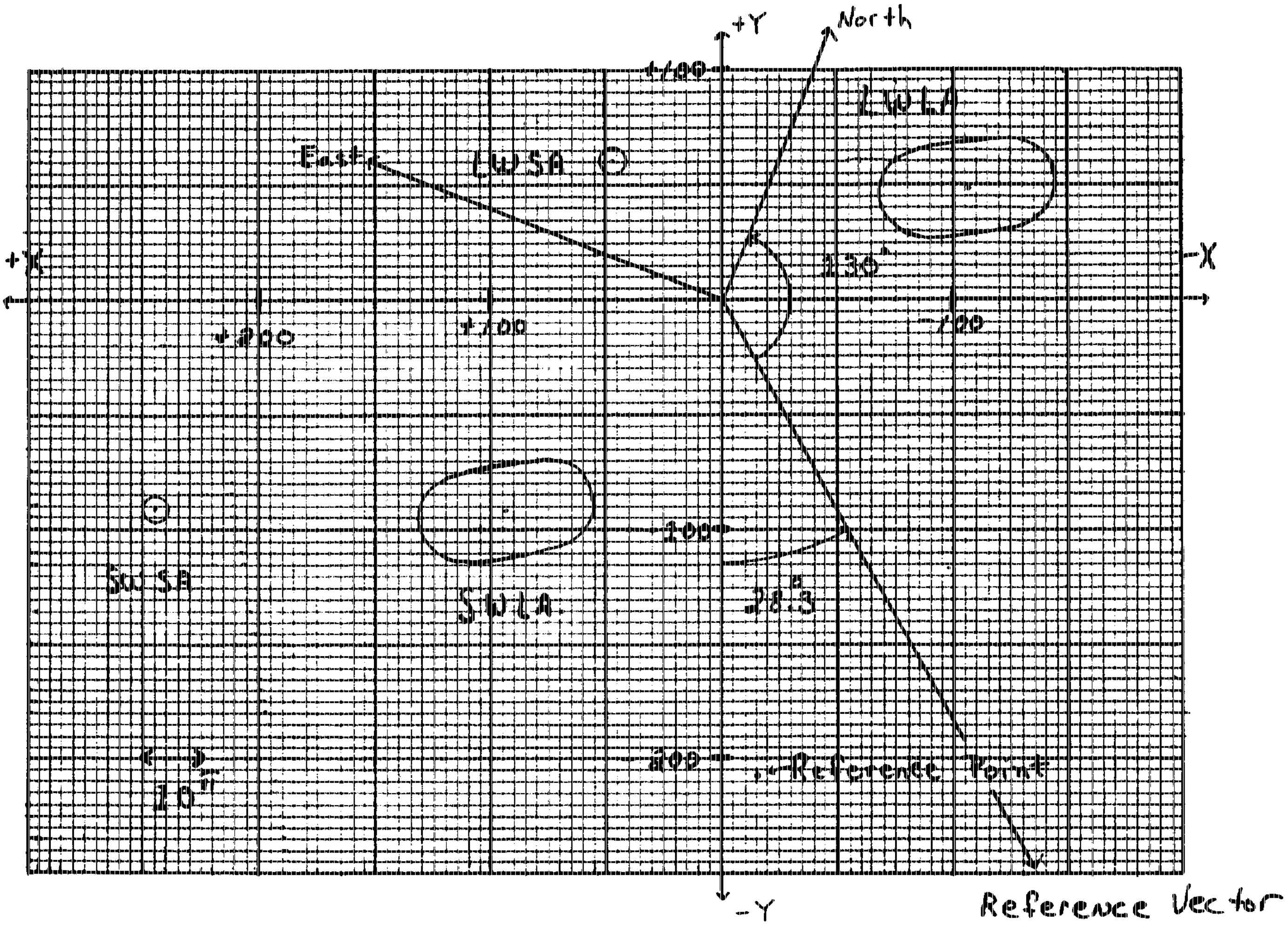


Figure 6a. Aperture plate as viewed by FES No. 2. The locations of the apertures and the reference point are shown as seen by FES No.2. The direction of the reference vector (the direction of stellar motion for a positive pitch slew) is indicated. The X and Y FES coordinates are given in FES fine units (1 unit = 0.26 arcseconds). The North and East directions are shown for a spacecraft roll of 130 degrees.

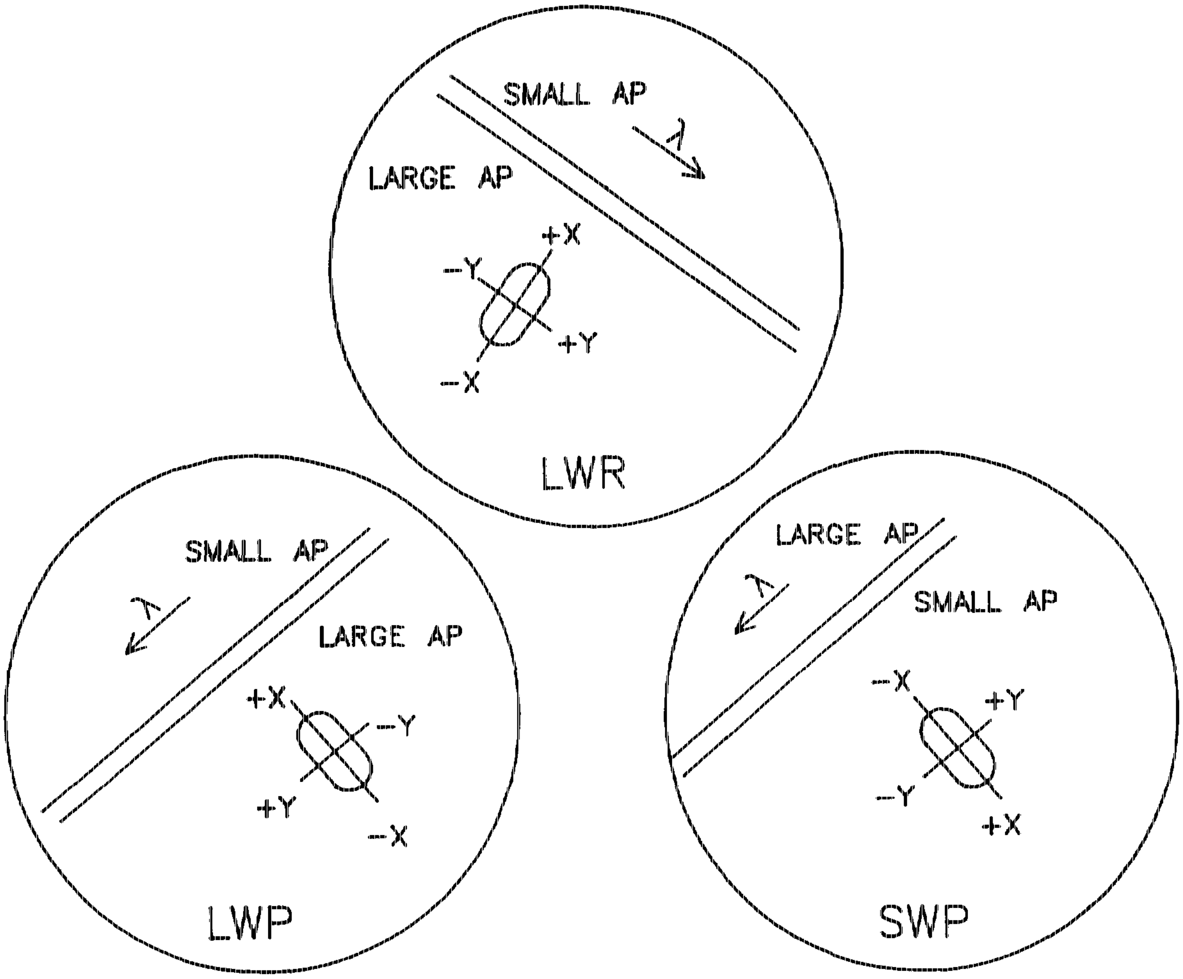


Figure 6b. Aperture orientation on the camera faceplates. The locations of low-dispersion spectra for the large and small apertures are shown for the LWP, LWR, and SWP cameras. The projection of the large aperture is also indicated for each camera. FES No.2 X and Y directions are displayed relative to the apertures and spectra. The relative sizes and angles in this figure are for illustration only.

The spacecraft roll angle can be obtained from GSFC scripts for images after LWR 6528 and SWP 7549, listed as "S/C ROLL". For those scripts where the roll is not given, it may be calculated by the method given below. Note: there is another roll angle ("FSS ROLL") written on the scripts. This is the roll with respect to the sun and is not equivalent to the spacecraft roll angle.

Calculation of the spacecraft roll and Beta angles for a specific date requires the target and solar equatorial coordinates (precessed to 1950.0) and are given by the following equations:

$$\beta = \cos^{-1}\left(-\sin\delta \ \sin\delta_{\odot} - \cos\delta \ \cos\delta_{\odot} \ \cos(\alpha - \alpha_{\odot})\right)$$

$$\gamma = \cos^{-1}\left(-\sin\delta_{\odot}/(\sin\beta \ \cos\delta) - \tan\delta \,/\, \tan\beta\right)$$

If $\sin(\alpha - \alpha_{\odot}) < 0$, then S/C roll = $180 + \gamma$

If $\sin(\alpha - \alpha_{\odot}) > 0$, then S/C roll = $180 - \gamma$

where
$\alpha_{\odot}$ = Right ascension of the sun
$\delta_{\odot}$ = Declination of the sun
α = Right ascension of the target
δ = Declination of the target.

These calculations can be performed easily using a scientific hand calculator. For example, consider Eta UMa on July 2, 1985.

The sun's position on July 2, 1985 at 00:00 UT was
= $06^h \ 41^m \ 39.4^s$ = 23° 05' 37" (1950)

The target Eta UMa is at
= $13^h \ 45^m \ 34.3^s$ = 49° 33' 44" (1950)

Computed Result: Beta = 97° 43' 03" Spacecraft Roll = 63° 10' 38"

Thus Eta UMa was in a good Beta angle region for battery power.

North is thus 63 degrees counterclockwise from the reference vector. In this case the large apertures are oriented along a line running from NE to SW. For a given camera, the small aperture is located south of the large aperture.

The major axes of the SWLA and LWLA are oriented 10 degrees East of North.

The LWSA is 175 degrees East of North from the LWLA.

The SWSA is 179 degrees East of North from the SWLA.

The SWLA is 32 degrees West of South from the LWLA.

3.9 Choice of Long-Wavelength Camera

The LWP is currently the prime camera for use by Guest Observers. Its characteristics have been described in several articles (Settle *et al.* 1981, Holm 1981, Barylak 1983, Cassatella and Harris 1983, Imhoff 1983, Thompson 1983, Harris 1984, Imhoff 1984a,b, Oliversen 1984, and Harris 1985).

The LWR camera was the default long-wavelength camera until October 1983. The changeover was due to the appearance of a "flare" or discharge in the camera's ultraviolet converter (UVC). The flare had grown in strength, forcing the reconfiguration to a lower UVC voltage at which the flare did not appear. This reconfiguration has reduced the overall sensitivity of the camera by a factor of 1.37, but its performance is otherwise essentially unchanged (see Harris 1985 and Imhoff 1985c).

Guest Observers may request use of the LWR camera in its new, lower sensitivity configuration. This may be arranged with the RA prior to the observing shift. However, the GO is expected to absorb the overhead required to switch between long-wavelength cameras. For thermal stability, only one of the two long-wavelength cameras may be used at any given time. A camera may be turned on and off only once during a given 8-hour shift. Finally, the LWP camera must be on at the time the spacecraft is handed over to the next observer unless he or she also wishes to use the LWR camera and has made advance arrangements to do so.

The following is a brief list of comparisons between the LWP and LWR cameras:

(1) The overhead required to switch to the LWR camera will be 15 to 45 minutes, depending on how much of the camera's operations can be "hidden" in other activities such as slewing the spacecraft. The overhead to turn the LWP camera back on and verifiy its operational status will normally be about 15 minutes.

(2) The sensitivity of the LWP camera is significantly greater than that of the LWR except at the shortest wavelengths (see Figure 7).

(3) The LWP camera has somewhat better signal to noise (S/N) at wavelengths longward of 2500 A than the LWR.

(4) The repeatabilities of the two cameras are about equal (i.e. about ±3.5 percent for binned, single, point-source spectra; Sonneborn and Garhart 1986).

(5) The LWR camera is affected by microphonic noise; however, this can generally be avoided by requesting the use of a special avoidance technique (see Section 4.2) which requires an extra 4 minutes of overhead prior to reading the image.

(6) The camera preparation sequence takes longer for the LWP camera because longer tungsten lamp exposures are required. The LWP SPREP cycle is about 4.5 minutes longer, the XSPREP cycle 10.4 minutes longer. The total SPREP and XSPREP cycle times are thus 18 and 35 minutes respectively.

(7) Due to increased use, the LWP camera now experiences somewhat greater fogging due to phosphorescence during low radiation shifts than the LWR camera. The LWP is also about 80 percent more sensitive than the LWR to

particle radiation during the US2 shift (low dispersion) for a given exposure time (see Section 4.9). However, since the camera is also more sensitive to flux from the target, the fogging due to either radiation or phosphorescence is nearly constant when integrating to a given exposure level, such as 200 DN.

(8) The sensitivity of the LWR camera has changed with time, differentially with wavelength. The LWP camera has shown little change (see Sonneborn and Garhart, 1986).

(9) The LWP camera has been known to experience failures in its scan control logic, but since the camera went into routine daily use in 1983, no such anomalies have been reported.

3.10 Exposure Time Estimates

The IUE scientific instrument does not have an exposure meter, so an accurate estimate of the exposure time is necessary. Several methods of estimating exposure times are available. Details for scaling existing information to arrive at an accurate exposure time are given below. If the object has been previously observed with IUE, you can usually scale the exposure times to the appropriate dispersion, aperture,and desired DN level. If the object has been observed previously by another UV satellite, such as TD-1 or OAO-2, you can first scale the fluxes to the IUE flux scale and then to the correct dispersion, aperture, and desired DN level. If the object has not been previously observed in the UV, you can estimate the exposure time from similar objects observed by IUE which are listed in the IUE Merged Log. Models may also be used to predict the expected UV fluxes and thus the exposure times. Be sure to include the effects of extinction in your calculations since UV extinction is much larger and more variable than that in the visual or infrared (e.g. Savage and Mathis, 1979; Bless and Savage, 1972). See Table 5 for the average normalized interstellar extinction as a function of wavelength in the ultraviolet region.

Table 5
Average Normalized UV Extinction as a Function of Wavelength[1]

Wavelength (A)	$E(\lambda-V)/E(B-V)$	Wavelength (A)	$E(\lambda-V)/E(B-V)$
1000	11.30	1900	4.90
1050	9.80	2000	5.52
1110	8.45	2100	6.23
1180	7.45	2190	6.57
1250	6.55	2300	5.77
1390	5.39	2400	4.90
1490	5.05	2500	4.19
1600	5.02	2740	3.10
1700	4.77	3440	1.80
1800	4.65	4000	1.30

[1] Values taken from Savage and Mathis (1979).

The specified exposure time is quantized in units of 0.4096 seconds by the ground computer for execution by the OBC. The OBC times the exposure for the correct number of counts. For very short exposures, exposure time quantization must be taken into account when estimating correct exposure times. For example, a commanded exposure time of one second corresponds to two counts, or 0.8192 seconds. A second-order effect is the camera response time. The net rise and fall time of the detector's high voltage is 0.120±0.015 seconds for each exposure (LWR, SWP Schiffer 1980b; LWP Crenshaw 1986). Therefore, a single count exposure (0.4096 seconds) has an effective exposure time of 0.289 seconds.

There are a number of steps involved in scaling published UV flux or IUE Merged Log exposure data into an estimated exposure time for a particular camera, aperature, and dispersion. Please read carefully all applicable subsections.

3.10.1 Estimating Exposure Times from Known UV Fluxes

The procedures for determining exposure times from known or estimated UV fluxes are given below. Low-dispersion exposure times are scaled from the corresponding estimates for high dispersion.

3.10.1.1 High-Dispersion Large Aperture Exposures

A. Estimating Peak Blaze Continuum Exposures Approximate IUE exposure times in seconds may be determined using the following expression:

$t_{high} = E^{-1}_{\lambda} / F_{\lambda}$ for large aperture, high dispersion

where E^{-1}_{λ} is the inverse sensitivity function (see Figure 7),

and F_{λ} is the flux in erg $cm^{-2}s^{-1}A^{-1}$ for a continuum point source or erg $cm^{-2}s^{-1}A^{-1}$ (10 $arcsecond^{2})^{-1}$ for an extended source.

Estimates of F_{λ} in ergs $cm^{-2}s^{-1}A^{-1}$ may be obtained from published results of OAO-2 (e.g. Code and Meade, 1979), Copernicus (e.g. Snow and Jenkins, 1977), TD-1 (e.g. Jamar et al., 1976 or Thompson et al., 1978) and ANS satellites (Wesselius et al., 1982).

The values of E^{-1} given in Figure 7 are based on the stellar flux calibration used by OAO-2 and Copernicus. TD1 and ANS fluxes are based on different calibrations. Multiply TD1 and ANS fluxes by the factors given in Table 6 to convert to the OAO-2 scale.

Be sure to correct for interstellar extinction when estimating fluxes for reddened stars from those for unreddened stars. Interpolated average normalized interstellar extinction for the TD1 and ANS fluxes are also included in Table 6.

Table 6
TD1 and ANS Flux Scale Conversion Factors and the Corresponding Average Normalized Interstellar Extinction[1] as a Function of Wavelength

Wavelength	TD1	ANS	$E(\lambda-V)/E(B-V)$
1380A	1.35	-----	5.44
1550A	1.37	1.35	5.04
1800A	1.15	1.14	4.65
2200A	1.02	0.93	6.55
2500A	1.13	1.02	4.19
2700A	1.32	-----	3.24
3300A	-----	1.09	1.95

[1] Values interpolated from those of Savage and Mathis (1979).

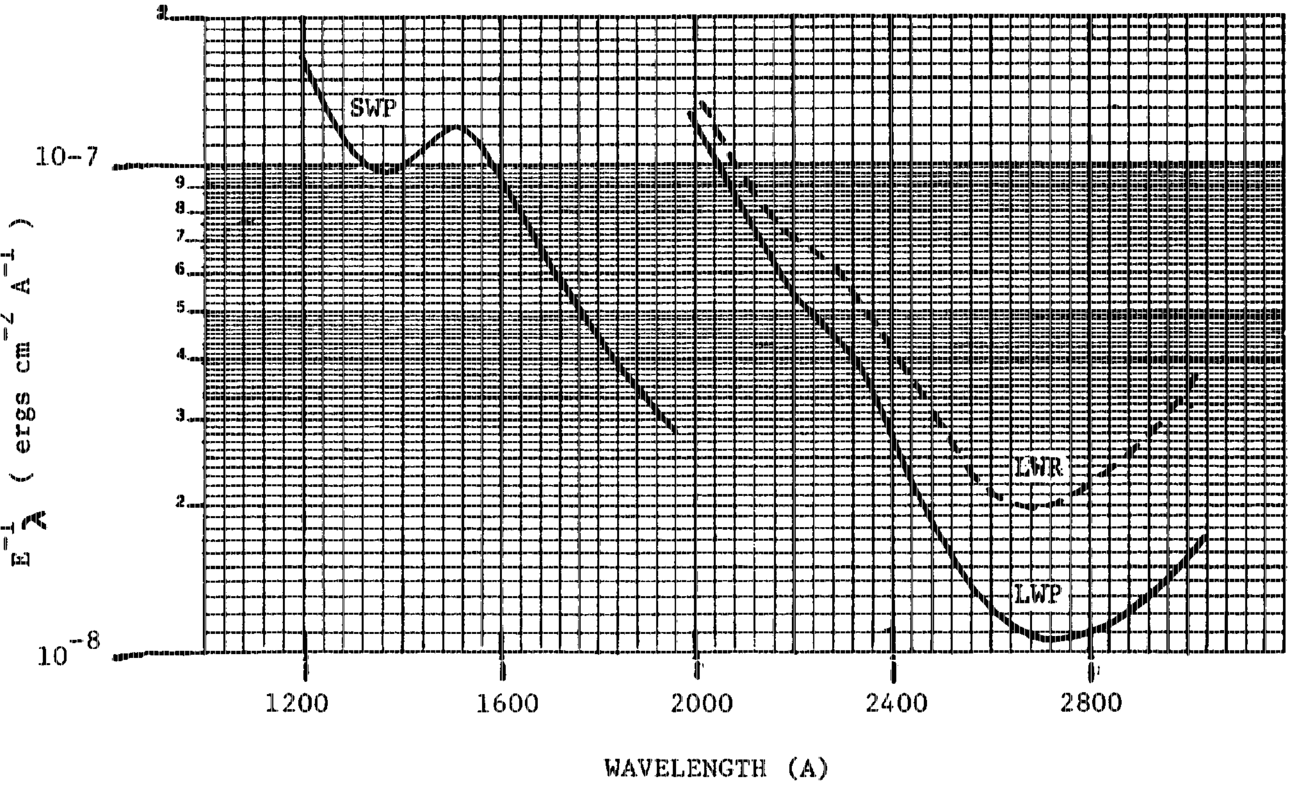


Figure 7. IUE inverse sensitivity functions. (Note: LWR sensitivity curve is for the 4.5 kV configuration and includes the sensitivity degradation as of mid-1986)

B. Estimating Off-Peak Blaze Exposures Features which are located off the peak of the echelle blaze will require longer exposure times to bring them up to the optimum level. For example, if an exposure is optimized for the 2798A Mg II absorption line, the adjacent continuum in the center of the order (2780-2790A) may be overexposed.

$$t_{\text{off-peak}} = X^2/\sin^2(X) \quad t_{\text{high}}$$

where $X = \pi m^2 \,(\lambda - K/m)/K$

$K = 137{,}725$ for the SWP camera

$K = 231{,}150$ for the LWR camera

$K = 230{,}701$ for the LWP camera

and m = the order number, where $m = \text{INTEGER}[K/\lambda + 0.5]$

3.10.1.2 High-Dispersion Small Aperture Exposures For small aperture spectra, multiply large aperture exposure times by 1.9 or 2.0 for the short- and long-wavelength spectrograph, respectively, to compensate for the reduced throughput of the small apertures. Note that the relative throughput of the small aperture is variable (50% ±25) and so the small aperture is not appropriate for absolute flux determination.

3.10.1.3 Low-Dispersion Large Aperture Exposures Low dispersion exposure time estimates are derived from scaling the high dispersion estimates, as described below.

A. Continuum Point Source The following relations provide the factors to scale exposures times between low and high dispersion for point source, large aperture spectra:

$$t_{\text{low}} = t_{\text{high}} / 87 = (E^{-1}_{\lambda} / F_{\lambda}) / 87 \qquad \text{for SWP}$$

$$t_{\text{low}} = t_{\text{high}} / 70 \qquad \text{for LWP}$$

$$t_{\text{low}} = t_{\text{high}} / 65 \qquad \text{for LWR}$$

B. Emission Point Source The ratio of high-to-low dispersion exposure times for emission line sources will depend on the width of the line in question. For emission line sources this ratio will be smaller by a factor of W/6 than that for continuum sources where W is the FWHM of the emission line in Angstroms. Typically W/6 is 0.3 to 0.5 so that, for example, the ratio for the LWP would drop from 70 to range of 21 to 35.

C. Trailed (Widened) Spectra (see Section 4.8)

3.10.1.4 Low-Dispersion Small Aperture Exposures Refer to Section 3.10.1.2.

3.10.2 Estimates Based on Merged Log Data The observer may also get a better feeling for exposure times by looking through the IUE Observatory Merged Log, a listing of all IUE images to date, for exposures of similar objects and by discussing the planned observations with the Resident Astronomers in advance. Most Merged Log entries contain data indicating the exposure level in DN for the maximum continuum level, emission lines if present, and a mean background level. A browse file of photowrites (photographic reproductions of raw and processed images) and copies of the original scripts for all GSFC images is available at GSFC for GO use. The scaling procedures for going from high to low dispersion and for varying apertures is the same in Section 3.10.1.

3.10.3 Other Factors Influencing Exposure Time Estimates.

3.10.3.1 Variation of Optimal Exposure with Long-Wavelength Camera. Note that the older long-wavelength data were usually obtained with the LWR camera, but that the LWP is now in use. The low dispersion exposure times may be scaled from one camera to the other, depending upon the wavelength region of interest. The following relations give approximate scaling factors for estimating LWP exposure times (t) from previous LWR (i.e. 5.0 kV configuration) exposures (all large aperture spectra):

t (LWP low disp) = 0.8 * t (LWR low disp) for 2800 A

t (LWP low disp) = 1.1 * t (LWR low disp) for 2400 A

t (LWP high disp) = 0.9 * t (LWR high disp) for 2800 A continuum

t (LWP high disp) = 0.8 * t (LWR high disp) for Mg II emission lines

The LWR camera was permanently reconfigured to the 4.5 kv configureation in October 1985. In the 4.5 kv configuration, the LWR camera is 1.37 less sensitive at all wavelengths than for the 5.0 kv configuration. This fact should be taken into account for recent LWR images. Most LWR images taken between October 1983 and 1985 were obtained with the 5.0 kv configuration, but there are exceptions.

3.10.3.2 Variation of Optimal Exposure with Wavelength. The values of E^{-1} given in Figure 7 were chosen to give a peak camera response of approximately 200 DN. In some parts of the image, exposure levels greater than approximately 200 DN will be processed less accurately, as they exceed the highest level of the Intensity Transfer Function (ITF), the calibration which linearizes the raw data. Table 7 gives an estimate of the DN of the highest unsaturated ITF level as a function of wavelength for low-dispersion spectra. A DN value of 255 is saturated and all intensity information is lost. For pixels having DN values greater than the highest unsaturated ITF level but less than 255, as given in Table 7 for low dispersion spectra, the given pixel's intensity is derived by extrapolating the data for the lower ITF levels. The flux level for such pixels therefore have reduced photometric accuracy.

Table 7
DN Value for Highest Unsaturated ITF Level

Wavelength	SWP	Wavelength	LWR	LWP
1200 A	197 DN	2100 A	245 DN	205 DN
1300	216	2300	245	220
1400	235	2500	240	240
1500	245	2700	225	245
1600	243	2900	220	245
1700	239	3100	190	245
1800	228	3300	180	245
1900	242			

3.10.3.3 Non-Target Contributions to the Signal. When deriving exposure time estimates, all contributions to the signal must be included, such as camera phosphorescence (Section 4.6) and radiation fogging (Section 4.9). In addition, the spectrum is recorded on a repeatable camera pedestal. Table 8 lists the pedestal levels for the three cameras in the region of maximum sensitivity.

Table 8
Camera Pedestals

Camera	Pedestal
LWP	38 DN
LWR	23 DN
SWP	25 DN

3.10.3.4 Overexposing the Camera to Optimize Spectral Regions. Unreddened stars with spectral types B3 and earlier will produce maximum camera response at 1300A and 2700A in the short- and long-wavelength spectral ranges, respectively. Cooler and reddened stars will produce maximum camera response at 1800-1900 A and 2800-3000 A. The continuum around 1500 A and 2200 A will be less heavily exposed, regardless of stellar type. In the echelle (high-dispersion) mode, the intensity decreases toward the ends of each order. Hence, to obtain well-exposed spectra of a feature near the end of an order (for example, Mg II 2803A), it may be necessary to overexpose the central part of the order. The telescope operations staff should be informed before beginning an exposure which will intentionally overexpose part of the camera.

If there is some uncertainty in the target's UV flux and a heavy overexposure (i.e. 20X or more) is needed to bring up certain spectral features, a test exposure is strongly advised. Very heavy overexposures (i.e. > 500X) may permanently damage the cameras. Even at exposure levels which do not damage the cameras, phosphorescence in the UVC can effect subsequent images for up to several days after the overexposure has occured and thus possibly effect both you and subsequent observers and their programs (see Section 4.6). This phosphoresence can be generated either from a single heavy overexposure, or a series of moderate overexposures (i.e. < 2X). Project approval is required for all overexposures of > 100X.

3.10.3.5 Examples.

Example 1. A previous IUE exposure yielded a peak signal of 85 DN and a background of 45 DN in a 3 hour exposure on the SWP camera. Thus the net signal was accumulating at a rate of 13 DN/hour. (Note that the background above the pedestal of 25 DN was also accumulating at a rate of 7 DN per hour). For a 7 hour exposure, the predicted peak signal would be

25 DN (Pedestal) + 7 x 7 DN/hour (Background Phospherescence)
+ 7 x 13 DN/hour (Signal) = 160 DN.

If the background radiation were averaging 1.0 volts for the last hour of the exposure, an additional 10 DN background would be added to the more sensitive regions of the camera and about 7 DN to the remaining regions resulting in a peak signal of 170 DN. If the radiation climbed above 1.0 volt, the GO might shorten the exposure since the background noise from radiation would be accumulating at a rate several times that of the target.

Example 2. A previous LWR low-dispersion spectrum was obtained with optimum DN levels in 30 seconds. The spectrum is that of a continuum point-source. To estimate the exposure time for an LWP, high-dispersion small aperture spectrum, we have:

t_{needed} = 65 (low to high dispersion) x 2 (large to small aperture) x 0.9 (LWR to LWP high dispersion) x 30 seconds (original exposure)
= 58.5 minutes

3.11 Common Acquisition/Observation Problems

A variety of operational problems can make the observation of a given object difficult or even impossible. A number of these can be anticipated, and frequently avoided with advance planning of your observing run.

Earthlight or moonlight - Bright scattered earthlight or moonlight can make the acquisition of a target impossible. The Earth or Moon will have to move away from the target before it can be acquired by IUE. This could mean a loss of one to three hours for the Earth, and 30 to 60 minutes for the Moon. Earthlight or moonlight can also be a problem if it approaches the target during an exposure. If the FES is being used for offset guiding, earthlight could confuse the tracker and cause the spacecraft to track on the earthlight rather than the guide star! This could result in considerable loss of observing time and potentially endanger the safety of the spacecraft.

Loss of telemetry - There are four S-band antennas on the IUE spacecraft which transmit science and engineering data to the ground. Two are located on the bottom of the spacecraft and two on the sides parallel to the solar arrays. There is no antenna which efficiently transmits in the direction of the telescope pointing. Consequently, when the Earth is within 30 degrees of the telescope pointing the received signal strength may be very poor. A weak signal can slow down acquisitions and result in permanent loss of image data if the signal is lost while reading a camera. In a weak-signal situation the spacecraft might have to be slewed away from the target to another position with more favorable antenna orientation before an image could be read.

Accurate coordinates - It is essential that accurate coordinates for epoch 1950 be provided for each target. Inaccurate coordinates can result in loss of spacecraft attitude reference, requiring up to several hours to recover attitude. For blind offsets and faint targets the coordinates for the target and offset star should be corrected for proper motion to the current date. Failure to do so has resulted in wasted hours observing the wrong target or blank sky.

Double- and Multiple-Star Systems - Close companions (within 24 arc seconds for targets fainter than about 5th magnitude and 44 arcseconds for targets brighter than 5th magnitude) may confuse the FES, preventing accurate placement of the light from the target in the aperture. Targets in crowded fields, such as multiple-star systems and open clusters, have been observed using the blind offset technique for faint targets as discussed above. Accurate positions for both target and offset star are essential.

Extended Sources - The FES will normally track the center of light of a source with some central concentration, including most comets, globular clusters, and galaxies. Offsets can be generated if the target is not at the center of light. Sources lacking central concentration must be observed as blind offsets as described in Section 3.6 above.

3.12 Project Scientist's Discretionary Observing Time

The Project Scientist's Discretionary Observing Time is intended for short observing projects for which no approved observing program exists. Proposals for such projects will normally be held for consideration during the next proposal review cycle. However, the Project Scientist may approve Discretionary Observing Time in cases where observation is required by a certain date or where the project's scientific nature dictates urgency. Requests will also be considered when one or two observations are needed to complete an already approved observing program or if a few exploratory observations are needed to demonstrate the feasibility of a new observing program. A proposal for Discretionary Time normally consists of an informal letter describing the proposed observations, scientific objectives, and explaining why discretionary time should be granted in lieu of consideration during the next proposal cycle. Discretionary proposals, like all other requests for observing time, are reviewed by the observatory staff for technical feasibility and spacecraft constraints. An Observation Specification form with target information (see Appendix V), desired exposure times, specific dates for time-critical observations, and so forth, should accompany the proposal for Discretionary Time. Such requests should be sent to the IUE Project Scientist at the address given in Section 5.4.

4. Observing at GSFC

4.1 Typical Target Acquisition and Guest Observer Activities during an Observing Shift

The Guest Observer (GO) is assisted in using the IUE by a Resident Astronomer and Telescope Operator who are responsible for implementing the GO's observational requirements. By reviewing the observing plans with the RA and TO prior to the start of the shift, the GO can modify the target and exposure sequence to make efficient use of telescope time, taking into account up-to-date information on spacecraft and camera status (e.g. current telescope pointing, OBC temperature, and overexposures), radiation background, and any operational constraints which may be anticipated. New GOs may want to arrive at GSFC a day before the first shift to familiarize themselves with the IUE observing facilities. Experienced GOs should plan on arriving 30 to 60 minutes before the shift begins. At this time, the TO will need to see your first observing script (see Section 4.2). An early look at the scripts allows the staff to plan out the most efficient sequence of maneuvering and camera preparation before acquiring the first target, thus minimizing operational overhead.

Special requirements (e.g. offset slews or time-critical exposures), as well as anticipated problems (e.g. earth occultation or planned observations at a Beta angle likely to heat the OBC), should be indicated in advance. Spacecraft constraints (Section 4.4 and Section 3.3) may limit the length of time spent at a particular target and need to be taken into account by the RA and TO when planning the observing sequence. In general, it is advantageous to plan the target and exposure sequence at the beginning of the shift. This allows the staff to minimize overhead and anticipate any potential spacecraft constraints which might necessitate a change in the observing plans. Last-minute changes to enhance the scientific value of your observations can be made, but may require additional time for proper execution. Observing overhead times for some of the more commonly performed activities are given in Table 9.

The TO will enter the coordinates of the first target or offset star into the computer and calculate the maneuver (see Section 4.5). At this time, a wheel unload may be required before the slew can be made (see Section 2.4). Once the spacecraft has been configured for the maneuver, the commands to begin the slew are sent. The average maneuver time is about 30 minutes.

Cameras can usually be prepared during maneuvers. There are two camera preparation sequences: the standard "prep" (SPREP) and the XSPREP, which is used following significant overexposure levels (see Section 4.6). The SPREP is used for the vast majority of cases.

When the maneuver is completed, the TO will collect a FES image of the field so that you can identify the target or offset star. If the stars in the field are expected to be relatively faint (fainter than 11th magnitude), you may request a deeper FES image with an appropriately longer integration time. Following most slews, the target should fall within a few arc minutes of the center of the field. However on some occasions, there may be pointing errors as large as 10 to 12 arc minutes. Thus it is best to have a finding chart slightly larger than the approximate 11 x 11 arc minute field provided by the default FES image (see Section 3.5). Section 3.6 discusses techniques for acquiring objects with visual magnitudes fainter than 13.5. A wheel unload (see Section 2.4) is usually performed by the Operations Control Center staff while you are identifying your target in the FES image. The wheel unload usually takes from 3 to 5 minutes.

Once you have identified your target, the TO will initiate a series of slews to position it at a standard FES location called the reference point. From the reference point, calibrated slews are used to accurately position the target in the desired aperture. While the target is at the reference point, the TO checks for any measurable drift in the gyro position reference. An accurate gyro "trim" is needed to prevent target motion away from the aperture center before offset-guiding is initiated.

During the acquisition process, the FES provides visual brightness measurements for targets brighter than 14th magnitude. There is a visual magnitude calibration for the FES measurements (Imhoff and Wasatonic, 1986, and references therein). Note that the FES photometric calibration is preliminary and has not yet been officially adopted by the Project. Since the FES was not designed for photometric work, the FES photometric calibration is accurate to no better than ±0.1 magnitudes. The calibration accuracy is complicated by the development over the years of a "fatigue" spot at the reference point. The effect of the fatigue spot is included in the Imhoff and Wasatonic (1986) calibration. If accurate relative magnitudes are desired, please inform the TO that you want FES measurements to be taken exactly at the reference point. This usually requires an additional 1 to 2 minutes per measurement.

If the exposure is longer than a minute or two, the TO normally will use a star in the field for automatic on-board guiding to insure that the spacecraft pointing remains stable. Such a star is often found in the FES image taken to identify the target. If the field is sparse, however, additional time may be needed to locate a guide star. This time may be reduced by using guide star information from a previous GSFC observation of the target (the observing script, see Section 4.2) or its measured equatorial (1950) coordinates. The guide star should be within 7 arc minutes of the target and brighter than 13th or 14th magnitude. For short exposures, or if no guide star can be found, the spacecraft pointing is maintained by the gyros. Some drift will occur, typically at a rate of 0.06 arc seconds per minute or less.

Even with a guide star, circumstances exist where recentering of a target should be done during long exposures. On the two-gyro/FSS control system, the roll axis of the spacecraft is normally controlled by data from a sun sensor. However, since the sun sensor effectively tracks the sun, the changing apparent solar position due to Earth's orbital motion results in the spacecraft roll orientation changing slowly with time. For targets near the ecliptic this roll motion is negligible, but at the ecliptic poles the motion can be up to 4 arc minutes per hour. For low-Beta targets (Beta < 35°), the motion may be larger. If the guide star is near the edge of the field, this motion can change the position of the target in the aperture during long exposures. The staff can calculate the expected motion of the target due to the changing spacecraft roll angle. If it is more than 1.5 arc seconds, you may wish to take the exposure in several sections to improve the centering.

Table 9

Characteristic overhead times
for typical observing activities

Activity	Time Required (Minutes)	Comments
SPREP on LWP	18	Standard Camera Prep. Only one camera can be commanded at a time. Camera preps can be done during a slew or while exposing the other camera.
LWR	14	
SWP	13	
XSPREP on LWP	33	Overexposed Camera Prep.
LWR	19	
SWP	17	
READ (All Cameras)	10	Camera reads are not performed while the spacecraft is slewing.
Target acquisition (Excluding time to identify target)		
FES image	2	Default size with limiting visual magnitude of 11.5.
deep FES image	8	Default size with limiting visual magnitude of 13.5.
wheel unload	3-5	Normally required after and sometimes before a maneuver.
gyro trim	3-7	
position target in aperture and start exposure	5	
Blind-offset acquisition	15-20	Additional time required over a normal acquisition.
Switching target from one aperture/camera to another and starting exposure	5	
Spacecraft ranging	5-10	Normally performed once per hour for 24 hours twice each month.
Slewing	20-30	Longer slews (> 120 degrees) may require up to 40-50 minutes.

If no guide star is available and a long exposure is required, the exposure will be done in 15 to 30 minute segments. At the end of each segment the target must be returned to the reference point, where the target is recentered and gyro trim corrected. This introduces 5 to 7 minutes of overhead per exposure segment. For blind offsets without guide stars, slews to the offset star between segments are necessary, introducing a large increase in overhead. Blind offsets to fields lacking guide stars are therefore not recommended.

During moderate to long exposures, especially during the US2 shift, you will need to monitor the trapped particle radiation levels (see Section 4.9) to avoid an excessive accumulated background on the image.

If the next exposure is to be taken at a different target, the TO will calculate the maneuver toward the end of the first exposure. At the end of the exposure, the TO will prepare to read the image, verifying that the telemetry signal from the spacecraft is good. (Note: If you have taken an LWR spectrum, you may wish to specify a special read sequence which reduces the likelihood of microphonic noise contamination (see Section 4.11)). Once the camera read is started, any data lost in transmission may not be recoverable. Telemetry dropouts (i.e. momentary loss of spacecraft telemetry) due to very weak signals can not be recovered. Dropouts for other reasons (e.g. problems with ground system hardware or data transmission from the Wallops Island tracking station) can normally be recovered by replaying an analog recording of the spacecraft telemetry made at the tracking station. Such a "history replay" is usually done within 24-48 hours of the observation. Consequently, you would not able to see the complete image at the EDS console during your shift (see Section 4.14 for a discussion of the image header).

The spacecraft maneuver is started at the end of the read. The camera may be prepared for the next exposure during the slew. The spectrograph data collected by the ground computer is stripped from other spacecraft telemetry, and reconstructed into a two-dimensional image. The image and science header are archived onto magnetic tape and disk. Finally, the image is transmitted from the ground computer to the color display console for the observer's inspection.

The console display allows some interactive, quick-look analysis of the raw image. Various contrasts and expansions may be used. Exposure levels in DN and approximate wavelengths may be determined. Quick-look plots of the raw data may be generated; it is not, however, possible to do any data processing at this point.

It is most efficient to alternate long- and short-wavelength cameras when obtaining a sequence of exposures. If an exposure is 30 minutes or longer, it is possible to read down an image obtained on the first camera and prepare it while the second camera is exposing. If an overexposed spectrum is expected, you should warn the TO, so that the correct camera preparation procedure is preformed. Otherwise, observing time may be lost while a second "prep" is performed (see Section 4.6). Additional sources of time loss are discussed in Section 4.12.

4.2 Observing Scripts

The GO specifies the desired observations on an "Observing Script" (see Figures 8a and 8b). The portion above the dashed line must be completed by the GO before the TO can begin target acquisition. The portion below the dashed line is completed by the TO during acquisition.

At the top of the script, the observer specifies the target name, 1950 coordinates, the observer's name, program ID code, target number, desired camera, dispersion, aperture, and exposure time.

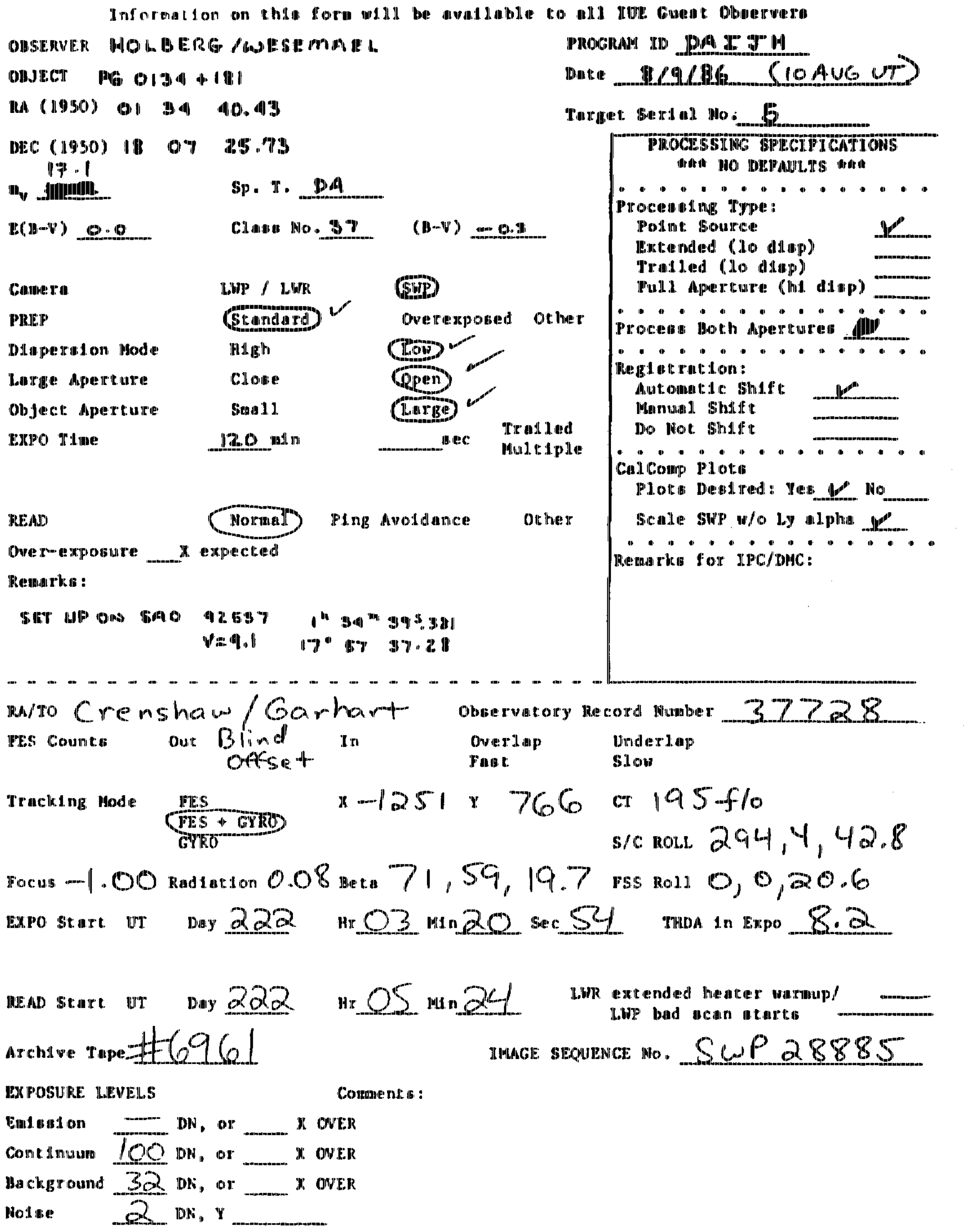
The type of camera preparation sequence, or "prep", to be used depends largely on the exposure level of the previous image. If the previous image was overexposed by three or more times, an "overexposed" prep (i.e. XSPREP) may be recommended. If the previous image was exposed by no more than two to three times then the standard prep (SPREP) is usually sufficient. For further discussion of the effects of overexposures, see Section 4.6.

As discussed in Section 2.3, opening and closing of the large aperture can cause an FES reference point shift of up to 5 arc seconds, resulting in a miscentering of the target in the aperture. Opening and closing of the large aperture is discouraged, therefore, except in cases of strong scientific need.

For the LWR camera the "ping avoidance" technique may be requested. This technique uses a 4-minute heater warm-up before the read, to reduce the probability that LWR microphonics will contaminate your spectrum. If the 4 minute heater warm-up is not desired, circle "normal". The SWP and LWP camera reads are always "normal". For further discussion of microphonics and use of the warm-up technique, see Section 4.11.

Three processing types are available: point, extended, and trailed sources. Trailed processing also applies to multiple exposures in the large aperture. The GO may specify the spectral "registration" method (see Appendix III) after inspecting the image. The registration type defines the programs to be used by the Image Processing Specialists to locate the center of the spectrum for proper extraction. The GO may optionally request Calcomp plots of the spectrum. Since a long SWP exposure may be dominated by geocoronal Lyman-alpha emission, the plots may optionally be scaled disregarding that line. For details on image processing options and procedures, see Turnrose and Thompson (1984).

The lower half of the script completed by the TO includes the exposure start time, read time, telescope focus, guide star position and brightness, and related items concerning a history of precisely how the exposure was obtained. This is often very useful to subsequent observers who may wish to repeat an observation of the same target. In addition, it is often more efficient for the RA to calculate the position of a faint guide star from data on an archival script rather than to attempt to locate it with the FES at the time of acquisition. Observing scripts for all GSFC images are available at the observatory for GO use.



Information on this form will be available to all IUE Guest Observers

OBSERVER HOLBERG /WESEMAEL
PROGRAM ID DAIJH
OBJECT PG 0134+181
Date 8/9/86 (10 AUG UT)
RA (1950) 01 34 40.43
Target Serial No. 5
DEC (1950) 18 07 25.73
m_v 17.1
Sp. T. DA
E(B-V) 0.0
Class No. 57
(B-V) -0.3

Camera: LWP / LWR [✓ SWP]
PREP: [✓ Standard] ✓ Overexposed Other
Dispersion Mode: High [✓ Low] ✓
Large Aperture: Close [✓ Open] ✓
Object Aperture: Small [✓ Large] ✓
EXPO Time 120 min ____ sec Trailed Multiple

READ: [✓ Normal] Ping Avoidance Other
Over-exposure ___ X expected
Remarks:

SET UP ON SAO 92657 1ʰ 34ᵐ 39ˢ.381
V=9.1 17° 57 37.28

PROCESSING SPECIFICATIONS
*** NO DEFAULTS ***

Processing Type:
- Point Source ✓
- Extended (lo disp) ____
- Trailed (lo disp) ____
- Full Aperture (hi disp) ____

Process Both Apertures ____

Registration:
- Automatic Shift ✓
- Manual Shift ____
- Do Not Shift ____

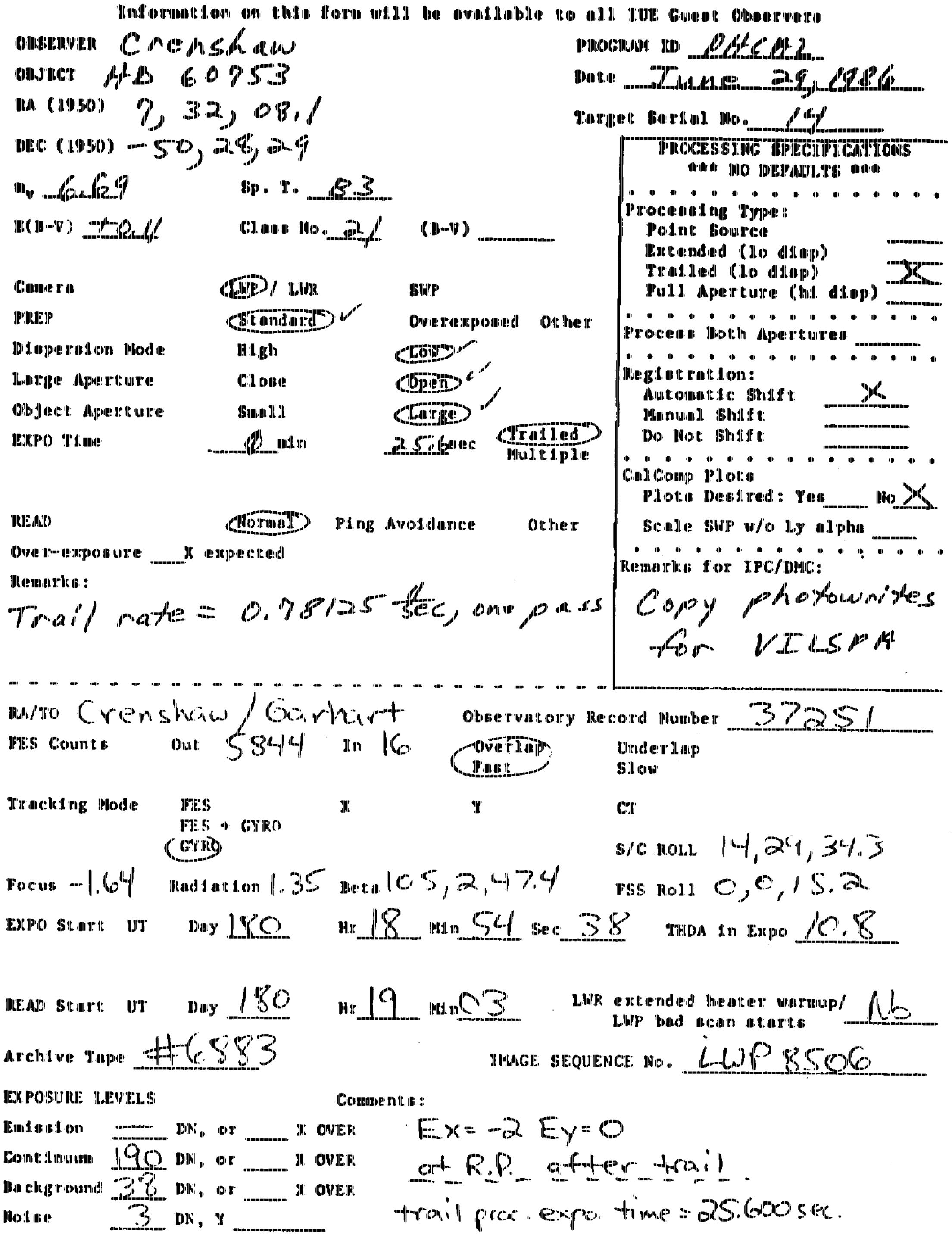
CalComp Plots
- Plots Desired: Yes ✓ No ____
- Scale SWP w/o Ly alpha ✓

Remarks for IPC/DMC:

RA/TO Crenshaw / Garhart
Observatory Record Number 37728
FES Counts Out Blind offset In Overlap Fast Underlap Slow
Tracking Mode: FES [✓ FES + GYRO] GYRO X -1251 Y 766 CT 195-f/o
S/C ROLL 294, 4, 42.8
Focus -1.00 Radiation 0.08 Beta 71, 59, 19.7 FSS Roll 0, 0, 20.6
EXPO Start UT Day 222 Hr 03 Min 20 Sec 54 THDA in Expo 8.2
READ Start UT Day 222 Hr 05 Min 24
LWR extended heater warmup/ LWP bad scan starts ____
Archive Tape #6961
IMAGE SEQUENCE No. SWP 28885

EXPOSURE LEVELS
Comments:
Emission ___ DN, or ___ X OVER
Continuum 100 DN, or ___ X OVER
Background 32 DN, or ___ X OVER
Noise 2 DN, Y ____

Figure 8a. A typical observing script for a blind-offset exposure. A 120 minute low-dispersion SWP exposure was requested. The GO provided the required offset star information under "Remarks". The guide star information from the exposure is provided in the row beginning with "Tracking Mode" on the lower half of the script.



Information on this form will be available to all IUE Guest Observers

OBSERVER Crenshaw
OBJECT HD 60753
RA (1950) 7, 32, 08.1
DEC (1950) −50, 28, 29
m$_V$ 6.69 Sp. T. B3
E(B-V) ±0.4 Class No. 21 (B-V) ____

PROGRAM ID LHCMJ
Date June 29, 1986
Target Serial No. 14

PROCESSING SPECIFICATIONS
*** NO DEFAULTS ***

Processing Type:
Point Source ____
Extended (lo disp) ____
Trailed (lo disp) X
Full Aperture (hi disp) ____

Process Both Apertures ____

Registration:
Automatic Shift X
Manual Shift ____
Do Not Shift ____

CalComp Plots
Plots Desired: Yes ____ No X
Scale SWP w/o Ly alpha ____

Remarks for IPC/DMC:
Copy photowrites for VILSPA

Camera [✓ LWP] / LWR SWP
PREP [✓ Standard] ✓ Overexposed Other
Dispersion Mode High [✓ Low] ✓
Large Aperture Close [✓ Open] ✓
Object Aperture Small [✓ Large] ✓
EXPO Time 0 min 25.6 sec [✓ Trailed] Multiple

READ [✓ Normal] Ping Avoidance Other
Over-exposure ____ X expected
Remarks:
Trail rate = 0.78125 "/sec, one pass

RA/TO Crenshaw / Garhart Observatory Record Number 37251
FES Counts Out 5844 In 16 [✓ Overlap Fast] Underlap Slow

Tracking Mode FES X Y CT
FES + GYRO
[✓ GYRO]
S/C ROLL 14, 29, 34.3
Focus −1.64 Radiation 1.35 Beta 105, 2, 47.4 FSS Roll 0, 0, 15.2
EXPO Start UT Day 180 Hr 18 Min 54 Sec 38 THDA in Expo 10.8

READ Start UT Day 180 Hr 19 Min 03 LWR extended heater warmup/ LWP bad scan starts No
Archive Tape #6883 IMAGE SEQUENCE No. LWP 8506

EXPOSURE LEVELS
Emission —— DN, or ____ X OVER
Continuum 190 DN, or ____ X OVER
Background 38 DN, or ____ X OVER
Noise 3 DN, Y ____

Comments:
Ex = −2 Ey = 0
at R.P. after trail.
trail proc. expo. time = 25.600 sec.

Figure 8b. An observing script for a trailed exposure. A 25.6 second LWP trailed exposure was requested. This is equivalent to a 6.9 sec point-source exposure. The RA has written the corresponding trail rate under the "Remarks" heading for the TO to use in running the TRAIL procedure. Trailed exposures are always done on gyros. Under the "Comments" heading at the bottom of the script, the TO has noted the drift that occured while the trail was being performed. In this case the drift was −2 units in FES X (about 0.5 arcseconds) and no drift in FES Y.

4.3 Description of SIOPSA2 Page.

In addition to the color image display, the Telescope Operator uses three video display pages to monitor the scientific instrument and ground system. Two consoles may select any of over two dozen pages. They usually display the Attitude Control System (ACSM2) page (telemetry associated with spacecraft pointing and maneuvering) and the EVENT page (current activities of the ground command computer and procedure execution). The Science Operations (SIOPSA2) page is displayed all the time and contains information on the scientific instrument, including the FES, spectrographs, and cameras. Some of this information may prove useful to you during the shift. This Section describes the more important items on the SIOPSA2 page (see Figure 9). The RA and TO are always available to help you interpret the display.

(1) The five-letter observing program identification code.

(2) The observer's name.

(3) The target name currently loaded in the ground computer.

(4) The coordinates of a loaded target or an offset star. Note that this is not necessarily the target at which the spacecraft is currently pointing. This position is used to calculate maneuvers. Items 1-4 are archived with the spectral data in the image header (Section 4.14).

(5) The current attitude of the IUE. RA and DEC are both given in degrees. The spacecraft roll determines the orientation of the field as seen by the FES (see Section 3.8).

(6) The current location of the target. (LWLA = long wavelength, large aperture; SWSA = short wavelength, small aperture; RPNT = reference point).

(7) The Flux Particle Monitor (FPM) radiation level (see Section 4.9).

(8) The most recently computed telescope focus "step" (see Section 4.10).

(9) The FES counts of the object currently being tracked by the FES. This is usually the target if an exposure is being set up, or the guide star if an exposure is in progress.

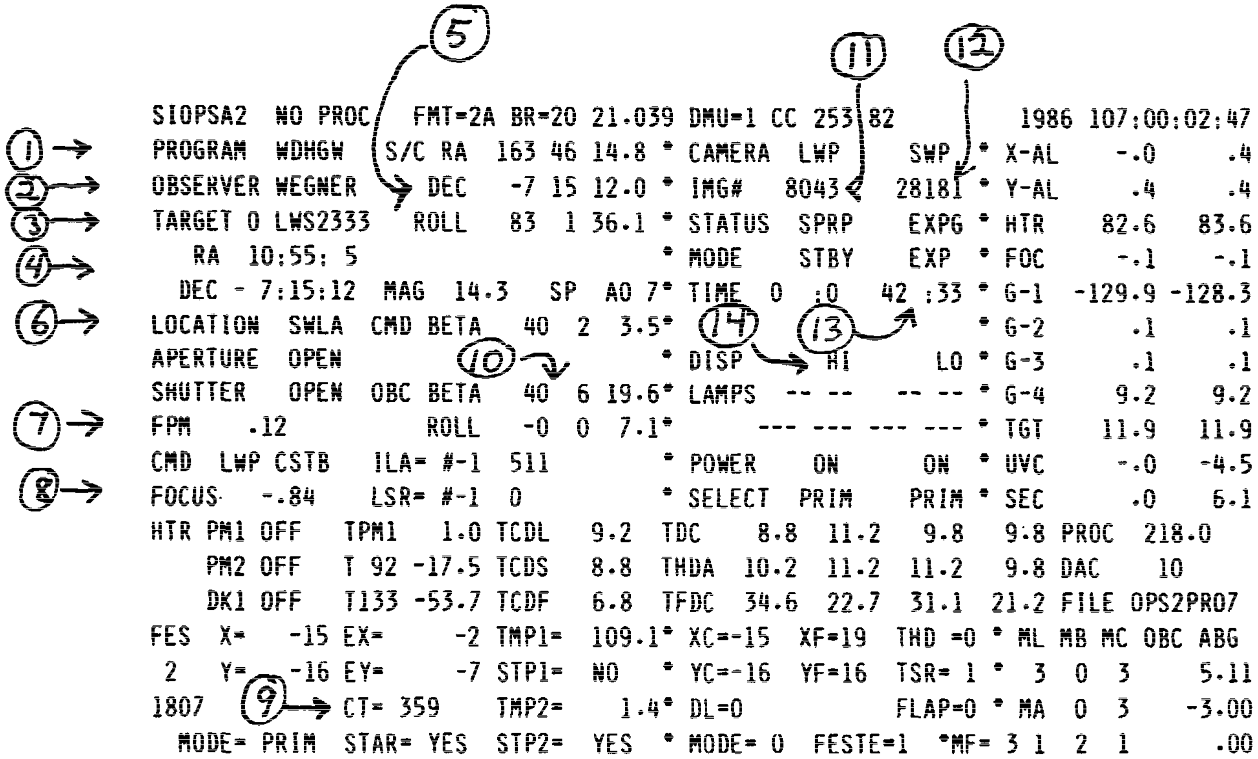
(10) The Beta angle as determined from the Fine Sun Sensor on the spacecraft.

(11) The LWP camera image number. Note that it is incremented _after_ a camera read is started.

(12) The SWP camera image number. As for the LWP, this is for the _last_ image read.

(13) The camera status and remaining exposure time. The LWP camera is standard "prepped" and in standby mode. The SWP camera is exposing, with 42 minutes and 33 seconds remaining in the exposure.

(14) The current dispersion modes of the spectrographs are shown. The long-wavelength spectrograph is in high disperison while the short-wavelength spectrograph is in low dispersion.



```
SIOPSA2  NO PROC   FMT=2A BR=20 21.039 DMU=1 CC 253 82         1986 107:00:02:47
PROGRAM  WDHGW    S/C RA  163 46 14.8 * CAMERA  LWP     SWP  * X-AL     -.0     .4
OBSERVER WEGNER      DEC   -7 15 12.0 * IMG#   8043   28181 * Y-AL      .4     .4
TARGET 0 LWS2333    ROLL   83  1 36.1 * STATUS  SPRP   EXPG * HTR     82.6   83.6
   RA  10:55: 5                       * MODE    STBY   EXP  * FOC      -.1    -.1
  DEC - 7:15:12  MAG  14.3   SP  AO 7* TIME  0  :0   42 :33 * G-1  -129.9 -128.3
LOCATION  SWLA  CMD BETA   40  2  3.5*                      * G-2       .1     .1
APERTURE  OPEN                        * DISP     HI      LO * G-3       .1     .1
SHUTTER   OPEN  OBC BETA   40  6 19.6* LAMPS  -- --   -- -- * G-4      9.2    9.2
FPM    .12          ROLL   -0  0  7.1*      --- --- --- --- * TGT     11.9   11.9
CMD  LWP CSTB   ILA= #-1  511         * POWER    ON      ON * UVC      -.0   -4.5
FOCUS   -.84    LSR= #-1  0           * SELECT  PRIM   PRIM * SEC       .0    6.1
HTR PM1 OFF   TPM1   1.0 TCDL   9.2  TDC    8.8  11.2   9.8   9.8 PROC  218.0
    PM2 OFF   T 92 -17.5 TCDS   8.8  THDA  10.2  11.2  11.2   9.8 DAC    10
    DK1 OFF   T133 -53.7 TCDF   6.8  TFDC  34.6  22.7  31.1  21.2 FILE OPS2PRO7
FES  X=   -15 EX=     -2 TMP1=  109.1* XC=-15  XF=19  THD =0 * ML MB MC OBC ABG
 2   Y=   -16 EY=     -7 STP1=  NO   * YC=-16  YF=16  TSR= 1 *  3  0  3     5.11
1807          CT= 359    TMP2=    1.4* DL=0           FLAP=0 * MA  0  3    -3.00
  MODE= PRIM  STAR= YES  STP2=  YES  * MODE= 0  FESTE=1  *MF= 3 1  2  1      .00
```

Figure 9. SIOPSA2 Page. An explanation of the numbered items is given in the text.

4.4 Spacecraft Constraints

Several operational constraints must be satisfied to ensure the safety of the spacecraft and scientific instrument.

(1) The spacecraft may not be slewed within 45 degrees of the sun (Beta > 135 degrees) or more than 165 degrees from the sun (Beta < 15 degrees), so that the sun is always in the field of view of the Fine Sun Sensor. The former restriction also prevents sunlight from falling within the telescope tube. These constraints apply to observing as well as maneuvering. Similarly, the spacecraft is kept very close (<0.1°) to optimum roll with respect to the sun.

(2) The OBC normally operates with a temperature in the vicinity of 52 degrees Celsius. Observing targets in the "Hot OBC Beta" region (between about 55 < Beta < 95 degrees) may cause the computer to overheat, especially during the winter months when the earth is near perihelion. If the OBC temperature reaches the maximum operating limit (55.8 degrees), the spacecraft must be slewed to a target outside the hot zone. The "Hot OBC Beta" zone has precisely defined boundaries (see Table 3, Section 3.1) which are allowed to vary from month to month to provide maximum observing flexibility.

(3) At high and low Betas, the solar arrays present a smaller collecting area and therefore produce less power. As of August 1986, Betas greater than approximately 117 degrees and less than about 27 degrees the batteries will discharge significantly. (Note: This power-positive Beta zone is gradually contracting with time due to solar array degradation. The letter accompanying your skymap will give the zone's current limits.) The number of times per year that the batteries may be discharged below specific levels (excluding shadow seasons) is limited. See Section 3.3 for details.

(4) Twice each year, in late summer and winter, the IUE's orbit carries it through the earth's shadow once each day for about three weeks. During shadow passages, which can last up to 80 minutes, no observations or maneuvers can be performed due to insufficient battery capacity.

4.5 Maneuvers

With the original three-gyro operating system, the telescope could be slewed only along one axis (i.e. pitch, yaw, or roll) at a time when moving from one target to another. The two-gyro/FSS control system permits pitch slews (changing Beta) and "sunline" slews (a rotation at a constant Beta, a combination of yaw and roll motion). The sunline slews increase the efficiency of many maneuvers at lower Beta angles, when compared to those under the three-gyro control system. Normal slew rates are in the range of 3 to 6 degrees per minute. However, in order to maintain accurate attitude control and adequate power, the solar panels must remain optimally oriented toward the sun to within fairly narrow limits. These constraints on solar panel orientation may require maneuvers longer than expected, if only the great-circle distance between two targets is considered. Additional information is given in Section 2.4.

Maneuvers normally require 3 to 5 minutes for calculation and proper configuration of the spacecraft for the maneuver. A typical maneuver requires 30 minutes to perform, although careful choice of targets can keep this overhead to a minimum. Some functions, such as camera preparations, can be performed during the slew. After the maneuver, 15–20 minutes are normally needed to identify the target, trim the gyros, move the telescope so that the target is in the aperture, locate a guide star, and begin the exposure.

4.6 Overexposures and Camera Phosphorescence

An overexposed spectrum may be obtained either by design to obtain an adequate signal for weak features or underexposed portions of the spectrum, or by accident, due to the presence of a previously unknown hot companion or errors in estimated exposure times. Severe overexposures can affect the photometric accuracy of subsequent spectra and potentially damage the cameras. The residual image from an overexposure of a few times the optimal exposure time is effectively erased from the camera target by the standard camera preparation sequence (SPREP). An overexposure of 4 times or greater may require a special overexposure preparation sequence (XSPREP). If the identical portions of several images are expected to be overexposed to a similar degree, the XSPREP may be delayed until the series of exposures is completed. A reliable estimate of the degree of overexposure is helpful in determining the appropriate preparation of the cameras for subsequent exposures.

Overexposures also temporarily increase the phosphorescence in the affected area of the camera, producing a ghost image of the previous spectrum on any subsequent long exposure. This may result in significant photometric errors; false detections, if both spectra were taken at the same dispersion and in the same aperture; or a contaminated spectrum, if the overexposure occurred in the other dispersion mode. The XSPREP usually cannot eliminate this phosphoresence. Moreover, a residual image from a large overexposure may contaminate long exposures up to several days later.

The history of camera preparations preceeding your shift affects the general background level during long exposures. Overexposed tungsten flood lamp exposures (i.e. 200 percent) are performed as part of the normal camera preparation sequence, resulting in a weak phosphorescence across the camera faceplate. Typically, this background accumulates at a rate of 5 to 10 DN/hour, but a recent XSPREP (which contains an 800 percent tungsten flood lamp overexposure) may raise this value. It is possible for the phosphorescence background to contribute 80 DN or more to the signal of an eight-hour exposure. The only method for diminishing camera phosphorescence is to avoid using the camera for a number of hours. Snijders (1983) discusses how to estimate the phosphoresence resulting from a previous overexposure.

4.7 FES Photometric Calibration

The FES can be used to estimate a visual magnitude of stars and other objects with centrally-condensed brightness distributions. This magnitude may be used to modify exposure time estimates for a variable target. The most recent FES calibration is that performed by Imhoff and Wasatonic (1986), who found:

$$\mathrm{CC} = \mathrm{FES\ CTS} / [0.98568 + 0.00791 (T - 1978.0) - 0.00396 (T - 1978.0)^2]$$

$$\mathrm{COLOR} = -0.271087 (B-V) - 0.063880 (B-V)^2 + 0.137764 (B-V)^3$$

$$V = -2.5 \log (\mathrm{CC} / [1 - 1.2 \times 10^{-4} \mathrm{CC}^{0.781}]) + \mathrm{COLOR} + K$$

where FES CTS = counts OUT (of the aperture) recorded on the script,
T = Current date in decimal years,
K = 11.16 for underlap mode,
K = 16.52 for overlap mode,
and CC = CC/4 for slow track.

The term in the denominator is the dead-time correction and is especially important for stars with large FES counts (>5000). The FES tracking mode is recorded on the script. Underlap mode is used for stars brighter than 4.5 magnitude. Slow track (which integrates four times longer than fast track) is required for stars fainter than magnitude 11.5. No FES photometric calibration has as yet been officially adopted by Three-Agency agreement. The raw FES counts of a target, measured at the reference point before the exposure is started, are written on the script by the TO and (after April 1986) automaticlly recorded by the ground system in the event round-robin portion of the science header.

This calibration has formal statistical errors of ±0.07 magnitude for averaged counts taken precisely at the reference point. Should greater accuracy in derived FES magnitudes be desired, you are advised to make differential measurements using a nearby star with a color and magnitude similar to that of your target, or by using a field star as described by Rahe et al. (1980). See also Holm and Rice (1981).

4.8 Trailed and Multiple Exposures

The signal-to-noise ratio (S/N) of low-dispersion spectra of sufficiently bright targets may be improved by trailing the target along the long axis of the large aperture, perpendicular to the dispersion direction. Such trailed spectra, if optimally exposed, have S/N of nearly two times that of untrailed spectra. The exposure time required for a trailed exposure is 3.7 times that for an optimum point-source exposure.

Trailed exposures may also be performed in high dispersion by trailing the star along the short axis of the large aperture. However, this reduces the width of the interorder background required to reduce these echelle spectra. Since the crowding of the orders is greatest at shorter wavelengths, high dispersion trails should be performed only if the spectral features of interest are at relatively long wavelengths. The improvement in S/N is about 1.4 for high-dispersion spectra which are optimally exposed. The exposure time required for a trailed exposure is 1.85 times that for an optimum point-source high-dispersion exposure.

Equations for computing the trailed exposure times and trailing rates are given below. Point-source exposure times may be estimated as described in Section 3.10, or determined from previous exposures.

low dispersion $t_{tr} = 3.7\ t_{point}$

Trail rate = $20.0/t_{tr}$ arc seconds/second

high dispersion $t_{tr} = 1.85\ t_{point}$

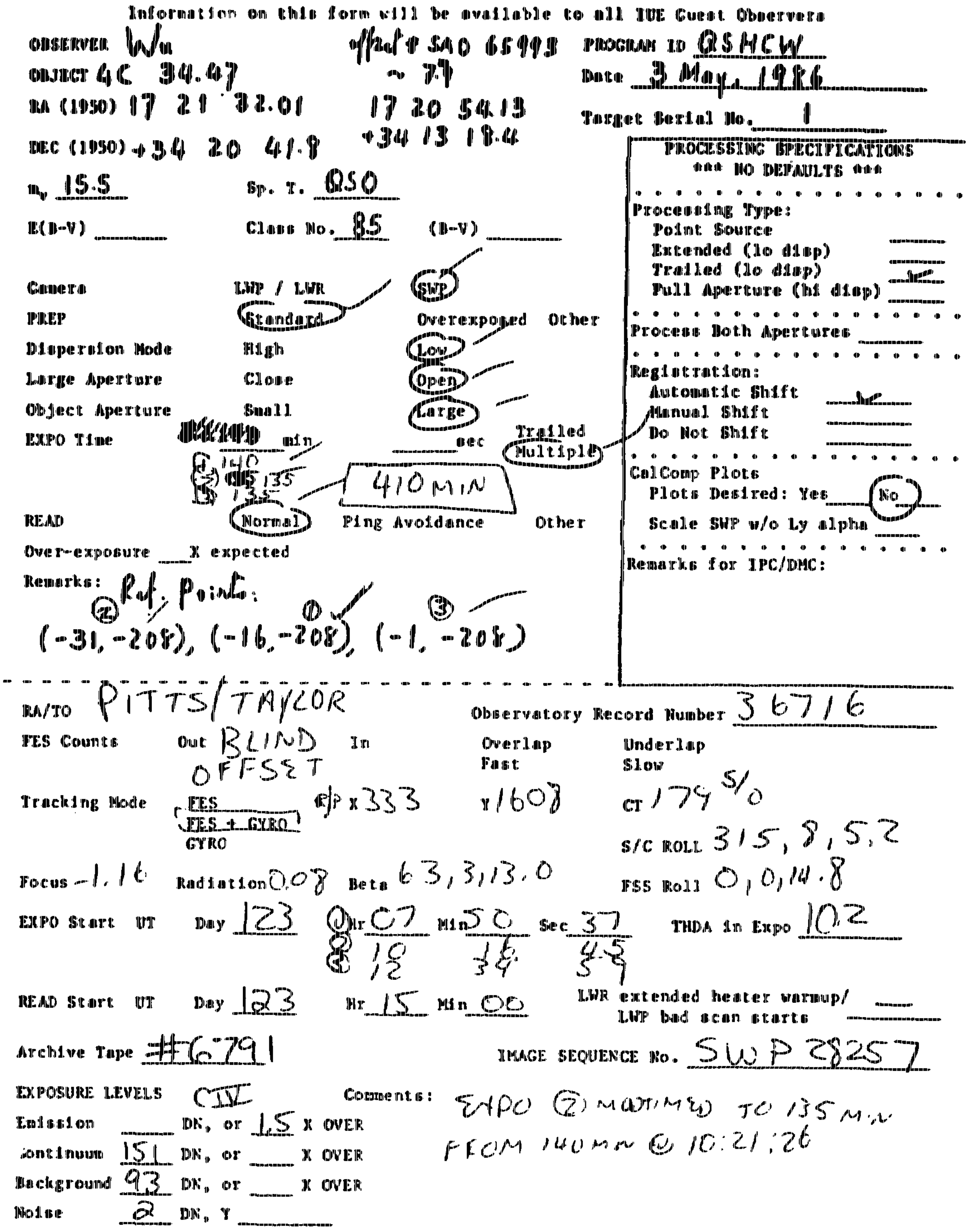
Trail rate = $10.0/t_{tr}$ arc seconds/second

Trailed exposures have greater observing overhead than point-source spectra. Generally, they require a total of from 10 to 15 minutes plus twice the trailed exposure time to perform. Rates of 0.03 to 25.0 arc seconds/second may be used for normal trails, but those performed at 0.1 to 10 arc seconds/second are more reliable. This corresponds to a trailed exposure time range of from 2 seconds to 3.3 minutes. More than one pass may be used to increase the exposure time. While the trail is being performed on one camera, it is *not* possible to read or prepare the other camera. In general, the target must be stellar and relatively bright (< 10th magnitude) so that the FES can track it accurately. Despite increased overhead, trailed exposures are more efficient than adding together four exposures read down separately, and result in comparable signal-to-noise. In addition, because the trailed spectrum is spread across a larger portion of the camera faceplate, some sources of camera noise (such as fixed-pattern noise) are averaged out.

For trailed exposure times between 0.2 and 2 seconds, a new "fast trail" technique is being developed to obtain near-optimal exposures for very bright stars, which would otherwise be overexposed at the shortest point-source exposure time of 0.41 seconds (1.52 second trailed exposure). Testing is still underway (see Imhoff 1985a,b). For optimal results, these trails should be performed when the target is at a Beta angle of 90±10 degrees. At this time, it is not yet known whether slew rates between 40 and 120 arcseconds/second are sufficiently uniform and reproducible to yield accurate absolute fluxes.

For trailed exposures times longer than approximately 10 minutes, multiple exposures may be placed side by side in the large aperture producing a "pseudotrailed" exposure. Usually three or four such spectra are placed within the aperture. The pseudotrail can often be performed with little extra overhead and yields a similar factor of two improvement in S/N. Operationally, a multiple exposure is specified by the "offset reference points," where the target is positioned prior to being placed in the aperture. The observer should specify the offset reference points to be used in the "Remarks" section of the observing script, a sample of which is shown in Figure 10. The exposure time for each segment is the point-source exposure time. The RA can recommend which offset reference points to use for a given type of observation.

For special purposes, such as time-critical observations, it is often possible to place two separate exposures within the large aperture at low dispersion (e.g. Holm et.al. 1985). The star is offset by 5 or 6 arc seconds towards either end of the aperture for the two exposures. The amount of the separation is not sufficient in eliminating overlap of the two spectra. The standard image processing system cannot extract the individual spectra; special user techniques are therefore required to do so. Good results have


Information on this form will be available to all IUE Guest Observers

OBSERVER W/u offset SAO 65993 PROGRAM ID QSHCW
OBJECT 4C 34.47 ~ 7.7 Date 3 May, 1986
RA (1950) 17 21 32.01 17 20 54.13 Target Serial No. 1
DEC (1950) +34 20 41.8 +34 13 18.4

m_v 15.5 Sp. T. QSO
E(B-V) ____ Class No. 85 (B-V) ____

Camera LWP / LWR [✓ SWP]
PREP [✓ Standard] Overexposed Other
Dispersion Mode High [✓ Low]
Large Aperture Close [✓ Open]
Object Aperture Small [✓ Large]
EXPO Time ____ min ____ sec Trailed [✓ Multiple]
① 140
② 135
③ 135
410 MIN
READ [✓ Normal] Ping Avoidance Other
Over-exposure ___X expected
Remarks: Ref. Point:
② (-31, -208), ① (-16, -208), ③ (-1, -208)

PROCESSING SPECIFICATIONS
*** NO DEFAULTS ***

Processing Type:
Point Source ____
Extended (lo disp) ____
Trailed (lo disp) ✓
Full Aperture (hi disp) ____

Process Both Apertures ____

Registration:
Automatic Shift ✓
Manual Shift ____
Do Not Shift ____

CalComp Plots
Plots Desired: Yes ____ [✓ No]
Scale SWP w/o Ly alpha ____

Remarks for IPC/DMC:

RA/TO PITTS/TAYLOR Observatory Record Number 36716
FES Counts Out BLIND OFFSET In Overlap Fast Underlap Slow
Tracking Mode FES [✓ FES + GYRO] GYRO E/P X 333 Y 1608 CT 179 S/O
S/C ROLL 315, 8, 5.2
Focus -1.16 Radiation 0.08 Beta 63, 3, 13.0 FSS Roll 0, 0, 14.8
EXPO Start UT Day 123 ① Hr 07 Min 50 Sec 37 THDA in Expo 10.2
② 10 16 45
③ 12 34 59
READ Start UT Day 123 Hr 15 Min 00 LWR extended heater warmup/ LWP bad scan starts ____
Archive Tape #6791 IMAGE SEQUENCE No. SWP 28257
EXPOSURE LEVELS CIV Comments: EXPO ② MODIFIED TO 135 MIN FROM 140 MIN @ 10:21:26
Emission ____ DN, or 1.5 X OVER
Continuum 151 DN, or ____ X OVER
Background 93 DN, or ____ X OVER
Noise 2 DN, Y ____

Figure 10. An observing script for a multiple or "pseudotrailed" exposure. The requested offset reference points are written under "Remarks." Three point-source spectra of 140, 135, and 135 minutes were obtained for a total exposure time of 410 minutes which is the value listed in the merged log. This was a blind offset target. Positioning of the target in the aperture corresponding to the offset reference points was performed by displacing the guide star by the appropriate number of fine FES units in Y.

been obtained by fitting Gaussian profiles to cuts across the spectra (Panek and Holm, 1984).

Information for deriving fluxes from trailed spectra is given in Section 5.3.

4.9 Particle Radiation

During the US2 operations shift (the second eight-hour NASA shift) the IUE passes through the outer Van Allen radiation belts. Cherenkov radiation from high-energy electrons entering the ultraviolet converter section of the camera produces phosporescence there, but only while the camera is actually exposing. This increases the background level on the entire image and usually limits the length of exposures that can be obtained. There is a Flux Particle Monitor (FPM) on the IUE which measures the particle radiation level in volts. The fogging effect of the radiation can be quantified in terms of DN per hour. The rate at which the background level accumulates on the most sensitive part of the detector is an exponential function of FPM, and is given by:

DN/hour = 1.35 x 10FPM for the LWP camera,
= 0.73 x 10FPM LWR camera,
= 1.00 x 10FPM SWP camera.

This rate should be used to estimate the accumulated background in high dispersion images. For low-dispersion spectra, Table 10 can be used to estimate the background accumulation rate as a function of wavelength.

In addition to the radiation-induced background, there is a 5 to 10 DN/hour accumulation of background caused by phosphorescence in the detectors (see Section 4.6). An exposure level of 205 DN is regarded as an optimum exposure. The telemetry saturates for any DN exceeding 254.

The average intensity of particle radiation varies with solar activity. A survey of the peak radiation levels (i.e. daily maxima) from 1981 through 1985 is given in Table 11. The data are taken from Walter and Imhoff (1983), Broude and Imhoff (1984), and Taylor and Imhoff (1986).

Table 10

Background Accumulation Rates for Low-Dispersion Spectra

	Rate (DN/Hour)					
	LWP		LWR		SWP	
FPM (Volts)	3000 A	2000 A	3000 A	2000 A	1800 A	1200
2.0	135	79	35	45	100	50
2.5	427	250	110	142	316	158
3.0	1350	790	350	450	1000	500

Table 11

History of Peak Particle Radiation

Peak Radiation Level		Percentage of Days Affected				
FPM(Volts)	DN/hour	1981	1982	1983	1984	1985
FPM < 1.0 V	< 10	19.2	8.8	1.4	2.7	4.4
1.0 < FPM < 1.7	10 to 50	39.2	22.7	19.7	26.0	21.6
1.7 < FPM < 2.0	50 to 100	21.4	26.6	15.9	12.3	11.0
2.0 < FPM < 2.4	100 to 250	14.2	19.7	26.3	19.9	25.5
2.4 < FPM < 2.8	250 to 500	4.7	18.9	26.6	22.4	26.6
2.8 < FPM < 3.0	500 to 1000	1.1	1.6	6.8	6.6	7.1
4 FPM => 3.0V	> 1000	0.3	1.9	3.2	10.1	3.8

4.10 Telescope Focus

The focus of IUE's telescope is thermally controlled. Heaters near the primary mirror and on the camera deck are used to maintain optimum focus values. The focus setting is calibrated in units of focus "step", where -2 < "step" < -1 is the best focus (Cassatella et al. 1984). The focus is normally kept near optimum values by the manipulation of the primary-mirror heaters. However, at low Betas (less than 35 degrees) it is not possible to maintain thermal stability and thus the focus deteriorates with time. At Betas less than 20 degrees, the focus "step" may reach +3 or more after several hours and the width of the spectrum may be increased by roughly 20-30 percent. Power considerations may restrict the use of heaters at low and high Betas (Beta < 30 and Beta > 115 degrees). Without use of the heaters, the focus may degrade even more rapidly.

4.11 Microphonics

Two of the IUE cameras experience some form of periodic microphonic noise during the read of an image. The noise is most noticeable on the LWR camera, where it is often strong (sometimes exceeding 100 DN) and localized in a half-dozen or so lines in the image (a "ping"). Microphonics also occur on the SWP camera but at a much lower level, typically with a maximum of 3 DN, and cannot easily be discerned by inspecting the image under normal contrast. A ping on an LWR image, on the other hand, can severely affect portions of the long-wavelength spectrum. The microphonics usually occurs in the lower half of the LWR image, missing a low-dispersion spectrum. In high dispersion, however, its placement frequently puts it near the MgII lines. The LWP camera has not experienced any microphonic noise.

A technique has been developed to displace the LWR ping to the top of the image, or off it entirely. A camera warm-up period of 4 minutes precedes the read of the camera. The ping still occurs in about one-quarter of the LWR images but generally falls near the top of the image, above the useful spectrum. The warm-up is known to cause a marginal increase in raw DN levels, but there does not seem to be any effect on extracted spectra at reasonable exposure levels. A report describing the photometric consequences of the "ping avoidance" read technique is given by Holm and Panek (1982). (Please note that the material on pages 56 and 57 of this report were printed in inverted order.)

The "ping avoidance" read may be requested on the standard observing script. The technique is used most often for high dispersion images and for long exposures in low dispersion which cannot easily be repeated, should a ping affect an important part of the spectrum. The standard read may be preferred for short exposures in low dispersion for which the extra 4 minutes of overhead is costly, or for exposures requiring the highest photometric accuracy.

4.12 Possible Sources of Time Loss

Even with optimal planning, observing time may be lost due to a variety of hardware or software problems.

The ground control computer simultaneously handles a large variety of tasks; it is known to crash typically once per eight-hour shift. Given the mildest problems, it may be restarted within several minutes. In the most severe situations (e.g. electrical power surges during a severe thunderstorm), it may take several hours to bring the system back on-line. As an image is read down to the ground, the telemetry stream is recorded on analog tape at the receiving station at Wallops Island, Virginia. Therefore, if the ground system crashes during the read of a camera, the image can normally be recovered at a later date from a "history replay" of the tape.

The receiving and commanding antennas at Wallops Island are computer-controlled. If the receiving antenna hardware or its control computer malfunctions during as an image is being read, portions of the data will be permanently lost.

On rare occasions, (perhaps once per year) the OBC may halt. This crash usually causes a loss of attitude as the spacecraft drifts away from its original pointing. Recovery may take three or more hours.

The OBC normally operates with a temperature near 52 degrees celsius. Observing targets at Betas between approximately 55 and 95 degrees causes a gradual increase in the OBC temperature. Maximum heating occurs in the winter months when the Earth nears perihelion. When the temperature in the OBC exceeds safe operating levels, the telescope must be slewed to a target outside this hot zone. The observer should therefore have some targets available at cool Betas. For more information on specific Beta limits see Sections 3.1 and 4.4.

Twice each year, in late summer and winter, IUE's orbit carries it through the earth's shadow once each day for three weeks. During shadow passages, which may last up to 80 minutes, no observations or maneuvers can be performed due to heavy battery discharge. Up to 60 minutes each day may be required to prepare the spacecraft for shadow and afterwards reconfigure it for normal science operations. During most of the shadow passages, both long-wavelength cameras are turned off to conserve power. Since the shadow helps cool the spacecraft, observing targets at hot Betas for extended periods rarely presents a problem during shadow season. The shadow occurs at the end of the US2 shift in late winter and at the end of the US1 shift in late summer.

Spacecraft ranging (see Section 2.4) is performed periodically to monitor IUE's orbit to derive accurate orbital elements for ground station antenna tracking. Any given shift may include several rangings, normally lasting from 5 to 10 minutes each. In general, 24 such rangings constitute a complete set and are usually obtained over a period of several days. These are considered to be time-critical "observations" and have priority over normal science operations. Although observatory staff attempt to perform rangings during other observing activities as often as possible, rangings may result in the loss of small amounts of observing time.

Despite all potential problems, the amount of time actually lost is quite small. Major losses of time, due to hardware or software problems, are typically about one per cent of the total observing time.

The IUE Project Scientist is informed when an observer has lost a significant amount of time (usually 30 minutes or more) due to hardware or software problems or to errors in execution. Such time loss will be considered for compensation at the request of the Principal Investigator in accordance with Observatory policy.

4.13 Data Processing and Shipping

IUE images are usually processed within a day or two of acquisition according to specifications indicated on the observing scripts. [Note: Images cannot be processed unless the Processing Specification section of the observing script has been completed (see Appendix III).] Production of some of the associated data products, such as photowrites, normally requires several additional working days. Details of the standard processing schemes may be found in the IUE Image Processing Information Manual (Turnrose and Thompson 1984) and the IUE Data Analysis Guide (Grady 1987).

The data products (i.e. tapes, photowrites, CalComp plots, and copies of observing scripts) are shipped approximately two to three weeks following the completion of your observing run (see Appendix III). Unless otherwise specified, the data products are shipped to the program's Principal Investigator. If processing of the data is time-critical or you plan to reduce the data at the GSFC Regional Data Analysis Facility (RDAF) during your observing run, you may request priority processing (see the RA for details). This will normally make the reduced data available to the observer at the GSFC RDAF (see Section 5.2) one to two working days after the shift. Image processing is normally not performed on weekends.

The PI has exclusive rights to the data for a six month period beginning with the date it is received. After this period, the data are made available to anyone requesting them from the National Space Science Data Center at GSFC and the corresponding data center in Europe.

4.14 The Science image header

Associated with each each image is a set of 100 72-byte header, or label, records. These header records are generated automatically by the IUE operations ground system software during image acquisition and readout. The header contains spacecraft scientific and engineering data, an event "round-robin", information provided by the observer about the object, and comments about the observation. The time-tagged event "round-robin" section documents the sequence of procedures used to slew the spacecraft, acquire the target, start the exposure, and read the image. The label is appended in a sequential manner by IUESIPS to record significant processing parameters. Turnrose and Thompson (1984, Section 9) describe the image header contents. During the first year or so of the IUE mission, the ground system science header software was not fully operational. Consequently, very early IUE images have incomplete headers.

Occasionally a problem occurs with archiving an image during real-time operations and the spectral data must be recovered from the history tapes which record the spacecraft telemetry stream. Unfortunately, since the science header is generated by the ground system and is not contained in the telemetry stream, the image header cannot be recreated in its entirety from the history tapes. Images recovered and archived in this manner have incomplete information in the header and are usually identifiable by the phrase "history replay" or "history tape image recovery" in the Telescope Operator comments (the first five to seven lines of the header). Other errors in the header information can occur, so it is important to check critical data (such as exposure time) against other records and the IUE merged log.

5. Other Information

5.1 Surviving at GSFC

During your stay at GSFC, you will be able to use a desk in room G53, next door to the Telescope Operations Center. The number of the telephone in that office is (301) 286-3924. You may receive mail in care of:

The IUE Observatory
Code 684.9
NASA Goddard Space Flight Center
Greenbelt, MD 20771

Telephone messages can be received at (301) 286-7664 or 286-7537.

The GSFC cafeteria is located in the same building as the IUE Science Operations Center, but is closed on weekends and holidays. Its hours of operation are adjusted from time to time. Currently the weekday schedule is

Breakfast	7:15 A.M. - 9:00 A.M.
Continental Breakfast	9:00 A.M. - 11:00 A.M.
Lunch	11:00 A.M. - 2:00 P.M.
Snacks	2:00 P.M. - 3:00 P.M.

To help provide for those intervals when the cafeteria is closed, the Observatory has a refrigerator and microwave oven in room G54. Please help keep these units clean.

Smoking is not permitted in the Telescope Operations Center or offices but is permitted in the hallways.

You might consider leaving the phone number of your motel with the Resident Astronomer or Telescope Operator so that they may be able to contact you if necessary.

5.2 Regional Data Analysis Facilities (RDAF)

Computer facilities for interactive analysis of IUE data are available at GSFC and at the University of Colorado. Identical hardware and software exist at both these facilities to allow the observer to display and reduce IUE spectra; to make measurements (e.g., radial velocities, equivalent widths, etc.); and to make wet-ink plots suitable for publication. Both facilities have a library of IUE spectra of standard stars which may be used for purposes of comparison. Both have the capability of recovering IUE spectra from the data archives for analysis at the facility, and may be used to augment an observer's data for comparative purposes. In addition, the facility at Goddard is available to IUE observers who wish to begin analysis of their data during or immediately following their observing run. This capablity will normally allow an observer to examine data within 24 to 48 hours of its acquisition. Both facilities are staffed by astronomers and assistants to aid in the analyses.

To reserve computer time at the Goddard facility during or following your observing run, please contact the RDAF office at (301) 286-8800. Messages relayed through Resident Astronomers or other project personnel do not constitute a formal reservation and may result in unavailability of data or terminals. Additional information on the two RDAFs is given in the IUE Data Analysis Guide (Grady 1986).

5.3 Calibration Recommendations

Determination of the best calibration for IUE data is an ongoing process. Due to the stability of the cameras, absolute calibrations derived early in the mission are still in use. During the last few years data have been obtained for new absolute calibrations for all three operational cameras. Announcements of calibration improvements are published in the IUE Newsletters. RDAF users will find the absolute calibrations used in the software to be current. A summary of present calibrations follows, with further discussion given in the IUE Data Analysis Guide (Grady 1986).

Low-Dispersion Calibration:

LWR and SWP	Holm *et al.* 1982
LWP	Cassatella and Harris 1983

High-Dispersion Calibration:

Spectra processed before November 10, 1981 (GSFC) March 11, 1982 (VILSPA)	Cassatella, Ponz, and Selvelli 1981
Spectra processed subsequently to the present (preliminary)	Cassatella, Ponz, and Selvelli 1983

Large Aperture Size for Trailed and Extended Sources:

	LW	SW	
Trail length (arc seconds)	20.5±1.0	21.4±0.4	Panek 1982a
Trail width (arc seconds)	9.3±0.1	8.9±0.3	Panek 1982b
Area (square arc seconds)	203. ±6.	200. ±5.	Panek 1982a

Exposure Length: LWP, LWR, and SWP:

$$t_{\mathrm{actual}} = 0.4096 * \mathrm{INTEGER}(t_{\mathrm{commanded}} / 0.4096) - 0.12 \pm 0.03$$

Shiffer 1980b
& Imhoff 1984b

5.4 Mailing Addresses and Telephone Numbers

The address for the observatory is:

IUE Observatory
Code 684.9
NASA Goddard Space Flight Center
Greenbelt, MD 20771
Telephone: (301) 286-7537

The code is very important. Mail without the proper code may be either delayed or lost. For packages delivered by courier, the addition of "Building 21" immediately following the NASA code is also useful for avoiding delay.

Scheduling requests, should be addressed to the Resident Astronomers. Observing scripts, finding charts, or other material relevant to scheduled shifts should be marked accordingly with the observing date.

Written inquiries concerning the Regional Data Analysis Facility should be addressed to the attention of the RDAF Manager, in care of the observatory address.

Written inquiries concerning the image processing system and production data products should be addressed to the attention of the SIPS Manager.

Written inquiries regarding the shipping and handling of your data should be addressed to the attention the IUE Data Managenent Center.

Requests for Discretionary Observing Time (Section 3.12), added targets, battery discharge, and general IUE Project correspondence should be sent to Dr. Yoji Kondo, IUE Project Scientist. The address of the Project and Operations Scientists is:

Code 684
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771

IUE Project Personnel

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Data Management Center		286-8301	FTS 888-8301

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Appendix I
A Summary of IUE Project Policies

The following is a brief description of Project's policies of which GOs should be aware in planning and carrying out IUE research. Further details about these policies are available through the references given below and by consulting the Project Scientist, Yoji Kondo (301-286-6247), the Operations Scientist, Donald K. West (301-286-6901), or the IUE Resident Astronomers (301-286-7537).

The GO has broad latitude to define how the telescope and scientific instruments are to be used during his scheduled observing shifts, subject to general spacecraft constraints and instrument safety considerations. Certain operations (e.g. battery discharge, overexposures greater than 100X) and non-standard or experimental observing techniques require approval of the Project Scientist before the observing shift, even if the planned activities were discussed in the proposal for telescope time.

1. IUE Badges and Car Passes

Guest Observers (GOs) officially listed as Principal Investigators (PIs), Lead Investigators, and Co-Investigators normally receive special IUE badges and car passes. These should be retained for the several years' duration of the investigator's involvement with IUE. The PI may request a temporary badge for any other visitor to IUE on a visit-by-visit basis. Requests for badges and car passes should be made to the Operations Scientist or Resident Astronomers at least two weeks in advance of a visit. Name, affiliation, citizenship, and visit dates must be provided. Badges and car passes prepared on request are normally held for pickup at the GSFC main gate.

Access to GSFC is by badge and car pass. Each GO must have in his or her possession an IUE badge or temporary GSFC visitor's badge. IUE badges are non-transferable and can only be issued to the GOs officially listed as Lead Investigators or Co-Investigators on approved programs. All other GOs must be issued temporary badges on a visit-by-visit basis. (It is the PI's prerogative to add Co-Investigators to a program at any time via a letter to the IUE Project Scientist.)

At the beginning of a new episode, the Project will try to issue badges and car passes automatically to most PIs, Lead-Is, and Co-Is who our records show have not received these items previously. We will intentionally exclude only those non-U.S. Co-Is who are part of large collaborative efforts having U.S. PIs and whose travel to GSFC on IUE business is considered unlikely. Nevertheless, omissions may occur. The PI is responsible for ensuring that all persons traveling to GSFC in connection with your program have the proper credentials.

2. Added Targets

It is expected that GOs may wish to add targets to their programs to provide observing flexibility. The PI should submit target information on a Object Specification form (see Appendix V), with a brief explanatory letter, to the Project Scientist at least one month in advance of the observing run. Required information includes target name, 1950 coordinates, object class, and the PI's program identification (five-letter code). Approval is contingent on suitability of the targets to the program and lack of conflict with the approved targets on other GO programs.

3. Assignment of Responsibility

The PI is responsible for all aspects of the observing program, including scheduling, adding targets, observing, and receiving the data. A PI may delegate these duties to a colleague by informing the IUE Project Scientist or RAs in writing. No prior notification is required for a colleague to perform the observations (assuming he or she has arranged for a GSFC badge and all necessary observing information such as the schedule, skymaps, target lists, etc.). Delegation of either pre-visit planning (scheduling, receipt of skymaps) or receipt of the processed data requires notifying the Observatory in writing. An Assignment of Responsibility Form is available for this purpose (see Appendix V).

4. Service Observing

In special cases, experienced GOs may not need to be present to perform routine observations requiring no real-time decisions. Requests should be submitted to the Project Scientist at least 6 weeks in advance of the observing run. Details are available in the Service Observing Guidelines included in the GO packet.

5. Targets of Opportunity

Novae, supernovae, and like objects will be observed, either by staff astronomers or GOs with approved target of opportunity programs, as approved by the Project Scientist. PIs with approved target of opportunity programs should contact the Project Scientist to activate the program when suitable observing opportunities arise. (IUE User Guidelines 1979; also NASA IUE Newsletter No. 5, pp. 15-16, 1979.)

6. Battery Discharge

IUE battery discharge outside of Earth shadow season is limited to important observations that are time-critical or otherwise cannot be rescheduled when there are no power problems. A request providing justification for observing an object at power negative beta angles (see letter accompanying skymap for current power negative betas) should be submitted to the Project Scientist well in advance of the shift. (See also NASA IUE Newsletter No. 23, pp. 10-13, 1983.)

7. Use of LWR Camera

There are no longer any restrictions on use of the LWR camera. However, due to the flare in the Ultraviolet Converter (UVC), the LWR camera has been permanently reconfigured with a reduced UVC voltage of 4.5 kv. This reduces the sensitivity of the camera by a factor of 1.37. The extra overhead required to turn the camera on and off is absorbed by the observer's program. (See also NASA IUE Newsletter No. 28, pgs. 7, 10, and 22, 1985.)

8. Priority and Special Processing

GOs who wish to have their IUE data processed quickly for use at the GSFC RDAF may routinely request priority processing through the IUE staff before the observing run. All other requests for priority or special processing must be submitted in advance to the Operations Scientist for review.

9. Duplicate Copies of Data Products

Copies of data for official VILSPA collaborators may be routinely requested through the IUE staff during the observing run. Only images initiated at one ground station and read down at the other are covered by this Three Agency agreement. The US GO must provide a shipping address for the VILSPA collaborator. All other requests for duplicate data products must be submitted in advance to the Operations Scientist for review.

10. Data Reprocessing

Requests for reprocessing IUE archival data should be submitted directly to the National Space Science Data Center (NSSDC) on their data request forms. A copy of the current NSSDC form is given in Grady 1986, or may be obtained from the Observatory or NSSDC. A brief letter justifying the scientific need for the reprocessing should accompany the data request. This letter will be forwarded to the Project Scientist for review and approval. A magnetic tape should be provided; it will be returned containing the reprocessed data. Any astronomer can request data from the NSSDC, either as available in the archives or including reprocessing. (See also NASA IUE Newsletter No. 29, p. 39, 1986).

11. Data Distribution

The PI has exclusive right to new IUE observations for six months following receipt of the data. After this, the data will be available to all US astronomers through the NSSDC and foreign scientists through the World Data Center. (IUE User Guidelines 1979; also NASA IUE Newsletter No. 5, pp. 15-16, 1979.)

12. Publication and Acknowledgements

GOs are asked to send preprints and reprints of their IUE-related papers to the IUE Observatory in care of the Operations Scientist. The author's name should be annotated on the title page with the footnote: "Guest Observer with the International Ultraviolet Explorer Satellite" (IUE User Guidelines 1979; also NASA IUE Newsletter No. 5, pp 15-16, 1979).

The IUE Project asks that investigators publishing data obtained from the IUE archives acknowledge the original PI who acquired the IUE data. In addition, the IUE Project asks that investigators acknowledge the use of the Regional Data Analysis Facilities and/or the National Space Science Data Center as appropriate.

Appendix II
Scheduling Policies
(revised 1 May 1986)

All Principal Investigators (PI) are sent a Scheduling Request Form and an Assignment of Responsibility Form for each approved program at the beginning of the episode. PIs are asked to complete the scheduling form to make each program's scheduling requirements known to the Observatory. The Assignment of Responsibility Form (see Appendix V) must be completed if someone other than the PI is to be authorized to make observing plans or receive the Guest Observer (GO) data.

At the beginning of the episode a scheduling request deadline is established. This date is usually 4-6 weeks after the Project Scientist announces the accepted programs. PIs are requested to send scheduling requirements for the entire episode for each observing program to the Observatory by this date. If a program's scheduling requirements remain as stated in the observing proposal, this fact must also be communicated to the Observatory. These requests are used to establish a draft schedule for the episode. Requests received before the deadline are weighted according to scientific need and are not considered in order of receipt. Requests received after the deadline will be accomodated only to the extent allowed by the earlier requests. In view of increasing constraints on telescope operations GOs are strongly urged to observe the deadline.

The Observatory attempts to honor all reasonable requests for specific observing dates to perform time-critical or coordinated ground-based observations or to satisfy other scientific requirements. It is the GO's responsibility to verify that the target will be at a favorable beta angle on the dates in question. Specific time requests should include information concerning scientific constraints of the observations and specify a range of dates, if appropriate, rather than a single date to permit some flexibility in scheduling. Except for observing dates for collaborative programs, specific observing dates cannot be guaranteed. Collaborative programs are scheduled for the entire year at the beginning of the episode.

Requests should be made for specific dates (or range of dates) to observe solar system objects. It is the GO's responsibility to check the dates for best planet-satellite configuration, if applicable, and to provide an ephemeris specifying UT or local time and including the object's drift rates (in arcseconds per hour) in right ascension and declination prior to the observing run.

Programs will be scheduled, if possible, at a time when high-priority targets are at beta angles where the spacecraft batteries will not discharge, but outside the OBC heating region (see Table 3, Section 3.1). In the absence of designated target priorities, programs are scheduled at a time when a majority of their targets will be available. The availability of all targets cannot be assured for those programs with a small number of shifts and/or a long target list. For programs having a small number of targets or all targets in a localized region, possible conflict with the moon will be checked manually. For those programs with large numbers of targets or with changing target priorities and with remaining shifts to be scheduled, GOs should fill out a Scheduling Update form (see Appendix V). A supply of these forms is kept at the GO desk in TOC. Completed forms should be left with the on-duty RA or mailed to the scheduler.

The monthly NASA IUE observing schedule is finalized three months in advance. Once the schedule for a given month is complete the Observatory will not initiate any revisions without strong scientific justification to do so. If a GO wishes to change the dates of his/her scheduled shifts, we ask that he/she contact the GOs thereby affected to arrange a time trade. The Observatory must be notified of any such arrangements as soon as these trades are finalized.

When major targets of opportunity appear, such as comets or novae, the Project Scientist will consult with the PIs having approved Target of Opportunity programs to determine how much observing time should be allotted to the particular event under discussion. In the case of comets, there is usually sufficient lead time to incorporate them into the normal scheduling process. The sudden appearance of a bright nova or supernova would require last-minute scheduling, possibly preempting previously scheduled observers. Programs thereby affected will be compensated for the lost observing time.

Programs are scheduled for eight-hour low (US1) and high (US2) radiation shifts according to the shift allocations given by the Project Scientist. The Observatory will attempt to honor requests for partial shift scheduling if there is scientific justification. As a rule, observing time will not be scheduled in segments less than four hours duration; partial US1 shifts will be scheduled only for highly time-critical observations.

Approximately four shifts per month (usually US2) are set aside for calibration and maintenance. At the end of the month the Observatory normally absorbs the two hour loss due to the monthly shift time change.

Conflicts with teaching obligations, AAS meetings, IAU symposia, etc., will not be taken into consideration for scheduling purposes, since many GOs tend to have similar conflicts. Should the observer have other, more compelling reasons for not being scheduled on a given date, these should be presented in writing to the Obsevatory as soon as possible.

Appendix III

IUE DATA PROCESSING AND SHIPPING PROCEDURES

The Guest Observer is responsible for designating how this/her scientific data is processed and shipped. The processing specifications box on the script should be completed for each observation. There are no defaults. Below is a brief description of the options available. Details are presented in the IUE Image Processing Manual - Version 2, available on request.

1. Processing Type: Choose one.
   Point Source (high and low dispersion)
   Extended Source (only low dispersion)
   Trailed (only low dispersion)
   Full Aperture (only high dispersion): equivalent to extended source processing for low dispersion

2 Process Both Apertures: Check this box if you have acquired both a large and small aperture spectrum in the same image.

3. Registration: The normal processing procedure is automatic registration (alignment of the pseudo-slit and the spectrum). If this procedure fails due to a weak continuum, a manual registration will be employed. The observer may specify manual registration if the spectrum has weak or no continuum. The registration will be based on the strongest emission line present or the portion of the spectrum with the highest intensity. If there is very little or no detectable signal, the observer can specify "do not shift".

4. CalComp Plots: The CalComp plots of the spectrum are optional. If they are requested, they will be generated at 50 angstroms per inch for low dispersion and for high dispersion at 2 angstroms per inch. The plots can be scaled with or without Lyman Alpha. If nothing is marked, no plots will be generated.

5. Remarks for IPC/DMC: Special instructions for the Image Processing and Data Management Center are noted here (see discussion below).

The IUE Observatory will hold or ship your data according to your needs. The data are normally shipped to the PI of the program about a week or so after processing. If you prefer different handling of the data, please let us know.

Please note that once the data are shipped, the Observatory has no easy access to the data during the six-month proprietary data period. If you wish to analyze your data at the RDAF at a later date, you should arrange to hold the data at GSFC or be sure to bring your tapes with you for the RDAF visit.

A summary of the catagories of typical special requests is given below.

RDAF Priority Processing: You may request priority processing if you plan to analyze your data at the RDAF during your observing visit. The data will be processed as soon as possible during normal processing shifts, then loaded into your RDAF account. Please submit a priority processing request form through an RDAF staff member or Resident Astronomer. Priority processing for reasons other than RDAF analysis is considered a special request and should be discussed with a Resident Astronomer.

Collaborative Program Duplicate Data Products: You may request that duplicate data products (tapes, photowrites, CalComp plots) be produced for a collaborative exposure for your European collaborator. A collaborative exposure is one that is started at VILSPA and read down at GSFC. Please submit a duplicate data products request form. Generation of duplicate data products for any other reason is considered a special request.

Alternative Tape Density: Currently Guest Observer tapes are written at 800 bpi. There is a limited capacity to generate 1600 bpi tapes for GOs who require them. To request this tape density, please write "1600 bpi GO tape" in the Remarks section of the processing specifications for each observing script.

Change of Shipping Address: The PI may request that the data for the program be shipped to a co-investigator or other collaborator. The PI should submit an assignment of responsibility form. Note that only a request from the PI can be honored by the staff, due to the proprietary nature of the data.

Hold for RDAF Use: Your data can be held at the Observatory for a subsequent visit to the RDAF. Please notify the Data Management Center (Room G69) and the RDAF staff promtly of your request. A written note, including the expected date of the return visit, is needed.

Appendix IV

Pre-Observing Run Checklist

_____ Badges amd car passes ready. (Note: Permanent Badges should be kept for future use and should not be turned in at the gate when your observing run is completed.)

_____ Target priorities set and expected observing sequence laid out, including alternative sequences in the event scapecraft constraints or high radiation force a change of plans

_____ Skymaps and beta angles checked for possible constraints. Please have the skymap and accompanying target list available during your observing run.

_____ Added targets (if any) approved

_____ Accurate 1950 epoch coordinates for targets

_____ Offset stars with accurate coordinates selected

_____ Finder charts, including visual magnitudes, for target identification.

_____ Guide stars available? (Should be brighter than 13.5 magnitude visual)

_____ Estimated exposure times computed

_____ Special information ready (e.g. moving target ephemeris, special observing techiniques, etc.) Please contact the Resident Astronomers prior to your visit and discuss any special requirements or techniques you may wish to use. This will allow the staff to assist you in anticipating possible problems or constaints thay may arise.

_____ Special requests approved. (Battery discharge, service observing, priority processing, etc.)

_____ RDAF time reserved, if needed.

Appendix V

Selected Forms

The following forms are included in this appendix:

1. Scheduling Update form.
2. Assignment of Responsibility form.
3. Change of Address form
4. Observation Specification form and instructions.

Additional copies of these as well as all other forms are available on request from the observatory.

Scheduling Update

Often the results of one IUE shift can affect the scheduling requirements for remaining shifts. Please fill in this form so that any unscheduled shifts can be used optimally.

P. I.:________________ Program I. D.:________________

Date:________________

What targets did you observe today? Nos:________________

Do you want to reobserve any on later shifts? Nos:____________

Have your priorities changed? How? ____________________

Comments:

Not applicable: ____________

Many targets to choose from: ________

Only one target: ________

Other: ________

Please return to Chris Shrader

Assignment of Responsibility

Pre-Visit Planning I wish to designate the following person as responsible for the pre-visit planning for my IUE program. Schedules, skymaps, and pre-visit telephone calls should be directed as given below. He or she is empowered to request that targets be added to the program and to make scheduling requests.

- [] Responsibility reserved to Principal Investigator
- [] Responsibility designated to:

Name:

Address:

Telephone:

Post-Visit Data Shipment I wish to designate the following person as responsible for receiving the data products for my IUE program. The magnetic tapes, photowrites, scripts, and CalComp plots are to be shipped as given below.

- [] Responsibility reserved to Principal Investigator
- [] Responsibility designated to:

Name:

Address:

Telephone:

Program:

P.I.:

Signature:

Date:

Return to:

IUE Resident Astronomers
Code 684.9/CSC
Goddard Space Flight Center
Greenbelt, MD 20771

NOTIFICATION OF CHANGE OF ADDRESS

NAME: ______________________________

CURRENT IUE 5-LETTER PROGRAM ID(S): ________________

OLD ADDRESS:

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NEW ADDRESS:

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NEW PHONE NUMBER: ______________________

___ PERMANENT CHANGE. EFFECTIVE ___________________

___ TEMPORARY CHANGE. EFFECTIVE FROM ______________ TO ________________

Please send the completed form to:

Resident Astronomers
IUE Observatory Code 684.9
Goddard Space Flight Center
Greenbelt Maryland 20771

OBSERVATION SPECIFICATION FORM INSTRUCTIONS

The information submitted on the Observation Specification Form is used for scheduling Observatory operations and for estimating the exposure times required for each object. One full-size Observation Specification Form should be returned with a regular episode proposal. For added targets and the initial requests for discretionary time, a copy of the reduced size form contained in this appendix is acceptable. Upon approval of a discretionary time program, the proposer will be asked to complete a full size form if he/she has not already done so. Full size forms are available on request from the observatory. An attempt has been made to provide an information format flexible enough to satisfy each user's observing needs, and every attempt will be made to schedule in accordance with the information given.

To ensure that your high priority objects receive greater consideration in scheduling, the importance of each target to your program should be noted in the target priority (RANK) columns of the Observation Specification Form. See the end of this section for detailed instructions on completing the form and specifying priority. Examples which show how the Observation Specification Form should be filled out for various types of objects are included.

Target coordinates are to be specified in 1950 epoch, giving right ascension to a tenth of a second of time and declination to one second of arc. Valid coordinates are necessary because the accuracy of a spacecraft maneuver depends upon the positional accuracy of both the desired target and the previously observed object. The necessity of having an accurate position is not reduced by any presumed "ease" of identifying the target. Furthermore, these coordinates are used to verify that requested (post-peer-review) additions to one program do not duplicate targets on another approved program.

When filling out the forms please note the following:

(1) The list of catalog codes to be used for specifying object names has been reduced compared to some previous years' lists. In general, coding was retained for (a) objects whose designations are larger than 8 characters, and (b) HD, HR and NGC numbers, since their coordinates are verified from tape files at GSFC. For these it is necessary for the object numbers to be right-justified, with no leading zeroes.

(2) "O" means the letter "oh"

"Ø" means the number "zero"

(3) The FORMAT given in the parameter description below refers to the standard FORTRAN format field specification under which the item will be read. Formats of the type Fn.Ø can accept integer or floating point numbers. The decimal point, if omitted, is assumed to be to the right of the rightmost digit position in the field.

(4) Except where noted, all entries should be right justified within the appropriate fields.

OBSERVATION SPECIFICATION FORM

PROGRAM ID ☐☐☐☐☐	**PROGRAM NAME**	**USER'S INITIALS** ☐☐☐	**DATE**	**PAGE OF**

SEQ	A	IDENT	RA (1950)			DEC (1950)			SP	L	E F	VIS MAG OR FLUX	B-V E(B-V) WAVELENGTH	RW	RANK		DAY	OBJ CLASS
			HR	MIN	SEC · T	± DEG	MIN	SEC										
1 2 3	4	5 6 7 8 9 10 11 12	14 15	17 18	20 21 · 23	25 26 27	29 30	32 33	35 36	38	40	42 43 44 45 46 47	49 50 51 52 53 54	56 57	59 60 61		70 71 72 73 74 75 76	78 79 80
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680-2 (6/80)

PARAMETER	NAME	FORMAT	COLUMN
Sequence Number	SEQ	I3	1-3

Integer running from 1 to N, where N is the total number of entries.

Catalog Source	A	A1	4

The preferred catalog source is the HD.

Y - Bright Star Catalog
1 - BD
2 - CD
3 - CPD
G - Boss General Catalog
H - HD catalog
N - NGC
P - PG numbers
K - Parkes catalog numbers
Q - other extragalactic sources with designations of the form HHMM±DM; e.g., Burbidge catalog of quasars
S - SAO catalog numbers
X - X-ray sources with designations of the form HHMM±DDM; e.g., 2A, MXB, 4 U numbers.
O - other designations as chosen by the observer; e.g., RHO CAS, AR PAV, 3C120 (right justified)

Object Number/Name	IDENT	A8	5-12

Eight alpha-numeric characters, right justified.

A	IDENT	
Y	XXXX	XXXX is the Bright Star Catalog number
1	±XX YYYY	BD number X = declination zone (omit minus
2	XX YYYYY	CD number sign for CD and CPD entries)
3	XX YYYYY	CPD number Y = star number
G	XXXXX	XXXXX is the GC number
H	XXXXXX	XXXXXX is the HD number
N	XXXX	XXXX is the NGC number
P	XXXX±YYY	XXXX is the RA portion of the designation
K	XXXX±YYY	in the form HHMM
Q	XXXX±YYY	YYY is the Dec portion of the designation
X	XXXX±YYY	in the form DDM
S	XXXXXX	XXXXXX is the SAO number
O	XXXXXXXX	XXXXXXXX is specified by the observer

PARAMETER	NAME	FORMAT	COLUMN
Coordinates (1950 epoch only)			
RIGHT ASCENSION: HOURS	HR	I2	14–15
MINUTES	MIN	I2	17–18
SECONDS	SEC	I2	20–21
TENTHS OF SECONDS	SEC/10	I1	23
DECLINATION: SIGN	±	A1	25
DEGREES	DEG	I2	26–27
MINUTES	MIN	I2	29–30
SECONDS	SEC	I2	32–33
Spectral Type	SP	A2	35–36

Spectral types are used to derive exposure times.
First character––one of the letters W, O, B, A, F, G, K, M, C, R, N, S.
Any other character will be treated as an M.
Second character––one of the digits 0–9; C or N for WC, WN.
If no type is specified, B0 is assumed for exposure time estimation.

Luminosity Class	L	I1	38

A single digit from 1 to 9 given as follows. If not specified, a default value of 5 will be assumed.

CLASS	L
Ib	1
II	2
III	3
IV	4
V	5
SD	6
WD	7
Ia	8
Iab	9

Brightness Mode Indicator	E/F	A1	40

Indicates the type of information
specified in the next two fields
(blank) means VIS MAG and B–V.
E means VIS MAG and E(B–V).

Visual Magnitude	VIS MAG	F6.2	42–47

For BRIGHTNESS MODE E or blank,
specify visual magnitude, right justified.

PARAMETER	NAME	FORMAT	COLUMN
Color or Wavelength If BRIGHTNESS MODE is blank, specify B-V. If omitted, the target is treated as unreddened. For BRIGHTNESS MODE E, specify E(B-V). If omitted, the target is treated as unreddened. Should be right justified.	B-V/E(B-V)	F6.2	49-54
Resolution R=1 (HIGH) R=2 (LOW) R=3 (BOTH)	R	I1	56
Wavelength Range W=1 (LONG) W=2 (SHORT) W=3 (BOTH)	W	I1	57
Target Priority To assist the Observatory in scheduling programs, targets should be ranked by priority, with RANK=1 being the highest. Targets of equal priority can be given equal ranking and rankings need not be sequential. Backup targets, for instance, can be given much lower ranking than the primary targets. If all targets have equal priority and no preferences exist, all targets should be assigned RANK=1. Right justify.	RANK	I3	59-61
Day of Observation Day of year for the desired time of observation if the date and/or time of observation is scientifically critical beyond the normal beta-angle requirements. This may be specified with a time resolution of up to .001 days, and should be right justified. The year is implied by the approximate dates of the observing episode (12 months in length) beginning in June 1987. In order to ensure that requests for specific dates and/or times are considered by the Observatory's scheduler, the Principal Investigator should communicate the program's requirements in writing to the Observatory immediately following program approval.	DAY	F7.3	70-76

PARAMETER	NAME	FORMAT	COLUMN
Object Class	OBJ CLASS	A3	78-80

Classify each target according to the codes (01 through 99) supplied on the enclosed description of Object Classification. Right justify.

Examples of Entries on the IUE Observation Specification Form

The following examples should clarify any questions regarding the application of the coding form parameters.

EXAMPLE 1
HD 30614 is to be observed at high resolution (R=1), both long and short wavelength (W=3). Visual magnitudes and B-V are specified (E/F = blank). It is a backup for high radiation shifts and has been given a low (relative) priority (RANK = 10).

EXAMPLE 2
HD 36512 is to be observed at low resolution (R=2), long wavelength (W=1). Visual magnitude and E(B-V) are specified (E/F=E). It too is given a RANK = 10.

EXAMPLE 3
3C 273 is to be observed at low resolution (R=2), short wavelength (W=2). An approximate visual magnitude is given. A spectral type entry is not appropriate and so it is omitted.

EXAMPLES 4 AND 5
NGC 4472 is to be observed at low resolution (R=2) and both long and short wavelength (W=3). The short wavelength exposure, as well as those planned for target 7, are the highest priority observations to be made and are assigned RANK = 1. The long wavelength exposure is of a lower, but still important, priority (RANK = 2).

EXAMPLE 6
Jupiter is to be observed on July 29, when it is in a region which will not cause heating of the on-board computer (cool Beta, 47°). The observer should check the position of the Moon before requesting a specific date or time.

EXAMPLE 7
The subdwarf O star BD+28 4211 is the desired target.

EXAMPLE 8
RU Peg is a variable star, an example of an "OTHER" Catalog Source.

EXAMPLE 9
PKS 2216-038 is the target. Even if the observer does not care about the exposure time (an 8-hour exposure is not expected to overexpose the spectrum of this source), he should still provide as much information as possible, for example the visual magnitude and (B-V), so that it can be included in the observatory log.

OBJECT CLASSIFICATION CODES

Classification of Objects Used in the IUE Observation Log

00	Sun
01	Earth
02	Moon
03	Planet
04	Planetary Satellite
05	Minor Planet
06	Comet
07	Interplanetary Medium and Sky Background
08	Great Red Spot
09	
10	WC
11	WN
12	Main Sequence O
13	Supergiant O
14	Oe
15	Of
16	O sub-dwarf
17	WD O
18	
19	Other Strong UV Sources
20	B0-B2 V-IV
21	B3-B5 V-IV
22	B6-B9.5 V-IV
23	B0-B2 III-I
24	B3-85 III-I
25	B6-B9.5 III-I
26	Be
27	Bp
28	B sub-dwarf
29	WDB
30	A0-A3 V-IV
31	A4-A9 V-IV
32	A0-A3 III-I
33	A4-A9 III-I
34	Ae
35	Am
36	Ap
37	WDA
38	Horizontal Branch Stars
39	Composite Spectral Types
40	F0-F2
41	F3-F9
42	Fp
43	Late-Type Degenerates
44	G V-IV
45	G III-I
46	K V-IV
47	K III-I
48	M V-IV
49	M III-I
50	R, N, or S Type Star
51	Long-Period Variable Stars
52	Irregular Variables
53	Regular Variables
54	Dwarf Novae
55	Classical Novae
56	Supernovae
57	Symbiotic Stars
58	T Tauri stars
59	X-Ray Source
60	Shell Star
61	Eta Carinae
62	Pulsar
63	Nova-Like
64	Other
65	Misidentified Targets
66	Interacting Binary Stars
67	
68	
69	
70	Planetary Nebula + Central Star
71	Planetary Nebula - Central Star
72	H II Region
73	Reflection, Nebula
74	Dark Cloud (Absorption Spectrum)
75	Supernova Remnant
76	Ring Nebula (Shock Ionized)
77	
78	
79	
80	Spiral Galaxy
81	Elliptical Galaxy
82	Irregular Galaxy
83	Globular Cluster
84	Seyfert Galaxy
85	Quasar
86	Radio Galaxy
87	BL Lacertae Object
88	Emission Line Galaxy (Non-Seyfert)
89	
90	Intergalactic Medium
91	
92	
93	
94	
95	
96	
97	
98	Wavelength Calibration Lamp
99	Nulls and Flat Fields

Index

Note: **Bold Face Print** may indicate either a definition, a more extensive section, or a section containing details of general interest