Chapter 1

Introduction

This latex file has been assembled from the International Ultraviolet Explorer New Spectral Image Processing System (NEWSIPS) Information Manual: Low-Dispersion Data Version 1.0 prepared by the Computer Sciences Corporation under contract NAS 5-31230 in December, 1993. The individual chapters from that manual were supplied by C. Imhoff, whose help we gratefully acknowledge. The figures were scanned at the University of Maryland and are provided as separate JPG files, described in the accompanying PDS label. Only those figures relevant to the data supplied for the Comet Shoemaker-Levy 9 archive are digitized. For more information please contact the Small Bodies Node of the PDS.

Chapter 2

Description of IUE Data

2.1 Raw Image Data and Label Parameters

Each raw *IUE* image consists of a 768×768 array of 8-bit picture elements or "pixels". Partial-read images, which are not full 768×768 images, are discussed in Chapter 3.3. Each vidicon scan line consists of 768 pixels or "samples" obtained in minor frame units of 96 pixels; 768 such scan lines compose the entire image. Line 1, sample 1 is at the upper left corner of the image; line 768, sample 768 is at the lower right corner of the image. Each raw pixel value lies in the range 0 to 255 (integers only). The units of raw pixel values are data numbers (DN), which are proportional (up to the telemetry system limit of 255) to the integrated charge read out from the SEC Vidicon target in the camera scanning process. Since the telemetry system saturates at 255, the DN/charge proportionality breaks down at that level.

Associated with each raw image is a set of 20 header, or label, records. Each record is 360 8-bit bytes long (a concatenation of five 72-byte logical records). This set of 20 label records is generated by the *IUE* Operations Control Center (OCC) software during image acquisition and contains various identifying parameters and scientific/engineering data pertinent to the image.

Raw *IUE* images must be corrected for the instrumental effects of the SEC Vidicon camera system before quantitatively meaningful data can be extracted from them. The methods of compensation for the radiometric (photometeric) non-linearities and non-uniformities and the geometric distortion introduced by the vidicon system are described in Chapters 5, 6, and 7. The layout of the spectral format in either dispersion mode is mathematically described by the methods discussed in Chapter 8. Figures 2.1 through 2.15 illustrate schematically the spectral formats in both dispersion modes, for both apertures, for all three operational cameras. These diagrams refer to raw image space. The square border defines the 768×768 array comprising the whole image, whereas the inscribed arcs roughly define the target ring, which is the area within which the photometric correction is applied (Chapter 6) and from which spectral information is extracted. For high dispersion, the extracted odd and even echelle orders are shown in separate figures. Numbers and tick marks mark the wavelengths in angstroms.

2.2 Spectrograph Geometry

Both the long and short wavelength *IUE* spectrographs have two entrance apertures: a small aperture (nominal 3 arcsec diameter circle) and a large aperture (nominal 10 arcsec by 20 arcsec slot). Although the various methods available for determining the fundamental dimensions do not always yield results which agree to within the limits set by the internal consistency of each (see Panek 1982), the *IUE* Three Agency Coordination Meeting adopted recommended values for certain dimensions, which are presented in Table 2.1. These values do not reflect the true physical size of the apertures but rather the size as projected on the camera faceplate. As a result, each spectrograph has its own distinct measurement of the aperture sizes.

Table 2.1: Officially Adopted Dimensions for the Apertures in Each Spectrograph, Measured on LWP and SWP Images

Dimension	LWP	SWP
Major Axis Trail Length (*arcsec*)	21.84±0.39	21.48±0.39
Large-Aperture Length (*arcsec*)	22.51±0.40	21.65±0.39
Minor Axis Trail Length (*arcsec*)	10.21±0.18	9.24±0.11
Large-Aperture Width (*arcsec*)	9.91±0.17	9.07±0.11
Large-Aperture Area ($arcsec^2$)	203.26±9.28	209.74±6.23
Small-Aperture Area ($arcsec^2$)	6.32±0.86	6.58±0.86

An accurate measurement of the trail length is needed, as such information is used to calculate the trailed exposure time. In addition, knowledge of the effective aperture area is needed to calibrate properly spectra of extended objects.

For the purposes of image processing, we continue to utilize the previously quoted plate scale of 1.525±0.01 arcsec/pixel (Bohlin *et al.* 1980). Coupled with the known separation of the large and small apertures (approximately 40 arcsec in the short wavelength spectrograph and 41 arcsec in the long wavelength spectrograph) and the known geometrical orientation of the apertures (see the discussion of Figures 2.18 through 2.17 below), the aperture separations in the directions along and perpendicular to the dispersion are given in Table 2.2.

These values are defined in the geometrically corrected frame of reference where the spectrum has been aligned horizontally in the image. The total offset is defined as the square root of the sum of the squares of the individual terms. The offsets along the dispersion have been incorporated into the geometric correction step such that the wavelength scales for the small and large apertures are aligned.

The geometry of the two entrance apertures in relation to the image scan lines and the high and low resolution dispersion directions are shown in Figures 2.16 through 2.18 for

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Figure 2.1: LWP small-aperture high-dispersion (even orders) format.

Figure 2.2: LWP small-aperture high-dispersion (odd orders) format.

Figure 2.3: LWP large-aperture high-dispersion (even orders) format.

Figure 2.4: LWP large-aperture high-dispersion (odd orders) format.

Figure 2.5: LWP large- and small-aperture low-dispersion format.

Figure 2.6: SWP small-aperture high-dispersion (even orders) format.

Figure 2.7: SWP small-aperture high-dispersion (odd orders) format.

Figure 2.8: SWP large-aperture high-dispersion (even orders) format.

Figure 2.9: SWP large-aperture high-dispersion (odd orders) format.

Figure 2.10: SWP large- and small-aperture low-dispersion format.

Figure 2.11: LWR small-aperture high-dispersion (even orders) format.

Figure 2.12: LWR small-aperture high-dispersion (odd orders) format.

Figure 2.13: LWR large-aperture high-dispersion (even orders) format.

Figure 2.14: LWR large-aperture high-dispersion (odd orders) format.

Figure 2.15: LWR large- and small-aperture low-dispersion format.

Table 2.2: Standard Offsets from the Small to the Large Spectrograph Aperture as used by NEWSIPS (in pixels)

Camera	Along Dispersion	$\perp$ to Dispersion	Total Offset
LWP	−2.3	26.2	26.3
LWR	−2.3	26.4	26.5
SWP	0.8	26.1	26.1

the LWP, LWR, and SWP cameras. These figures are drawn in the geometrically corrected frame of reference with the origin at the upper left. Note particularly the fact that the displacement between the short wavelength large aperture (SWLA) and the short wavelength small aperture (SWSA) is very nearly along the echelle dispersion direction. Therefore, short wavelength high-dispersion images in which both apertures are exposed will result in nearly complete superposition of the large- and small-aperture spectra (with a wavelength offset). The displacement of the long wavelength large aperture (LWLA) and the long wavelength small aperture (LWSA) is less coincident with the echelle dispersion direction in those spectrographs, so that superposition of large- and small-aperture high-dispersion spectra is not as serious in the long wavelength spectrograph.

For the purposes of judging the extent and separation of the apertures in the spectral domain, the scales given in Table 2.3 may be used in conjunction with the quantities in Tables 2.1 and 2.2. Note that in high dispersion a given shift along the dispersion corresponds closely to a constant Doppler velocity shift, whereas in low dispersion a given shift corresponds to a constant wavelength shift.

Table 2.3: Approximate Spectral Scales in Each Dispersion Mode

Camera	Low Dispersion (Å/px)	High Dispersion (km/s/px)
LWP	2.66	7.21
LWR	2.66	7.27
SWP	1.68	7.72

2.3 Instrumental Resolution

The instrumental resolution (both spectral and spatial) is determined by the camera resolution, the dispersion mode, the aperture used, the focussing conditions in the telescope, and the pointing stability of the spacecraft. While the dominant effect is the camera resolution, telescope focus and stability of spacecraft pointing also play a major role in defining the

Figure 2.16: LWP Geometry

Figure 2.17: LWR Geometry

Figure 2.18: SWP Geometry

resolution. In addition, it is well known that the camera resolution is highly wavelength-dependent. According to the *IUE* Camera Users Guide (Coleman *et al.* 1977), the camera point spread function (PSF) consists of a narrow, gaussian-like core with long shallow wings. The actual resolution in either the spatial or spectral direction can be defined as a function of the full width at half maximum (FWHM). Two spectra (spatial direction) or two spectral features (spectral direction) can be resolved provided their separation is as follows:

$$d \geq 0.849 \times FWHM$$

where d is the distance separating the two features (or spectra). Spatial resolution is specified in pixels, while spectral resolution is denoted in angstroms.

2.3.1 Low-Dispersion Mode

Resolution Along the Dispersion

A study of the NEWSIPS spectral resolution was performed by measuring the FWHM of several features for the emission line sources V1016 Cyg, RR Tel, AG Dra, CI Cyg, and Z And. The analysis indicates a slight improvement in the NEWSIPS resolution (approximately 10% for the SWP and 7% for the LWR) over the IUESIPS results reported by Cassatella, Barbero, and Benvenuti (1985). Plots of the spectral resolution data are shown in Figure 2.19. The small-aperture data are slightly offset in wavelength from the large-aperture data for clarity.

LWP - Large-aperture spectral resolution is best between 2700 and 2900Å with an average FWHM of 5.2Å and decreases to approximately 8.0Å on either side of this range. Small-aperture resolution is optimal between 2400 and 3000Å with an average FWHM of 5.5Å and decreases to 8.1Å at the extreme wavelengths.

LWR - Maximum resolution in the large aperture occurs longward of 2300Å, with an average FWHM of 5.3Å, while shortward of this point the FWHM decreases to 7.7Å. Small-aperture resolution is best from 2700–3200Å, with an average FWHM of 5.4Å, and decreases to 7.7Å at 3350Å and 7.5Å shortward of 2400Å.

SWP - The best resolution occurs around 1200Å, with a FWHM of 4.6Å in the large aperture and 3.0Å in the small aperture, and gradually worsens towards longer wavelengths: 6.7Å at 1900Å in the large aperture and 6.3Å in the small. On average, the small-aperture resolution is approximately 10% better than the large-aperture resolution.

Resolution Perpendicular to the Dispersion

The NEWSIPS spatial resolution has been determined by analyzing the spectra of several low-dispersion standard stars (*viz.*, HD 60753, HD 93521, BD+33° 2642, and BD+75° 325). The FWHM of large- and small-aperture spectra were measured at several wavelengths and plotted (see Figure 2.20). As is the case with the spectral resolution studies, the NEWSIPS

Figure 2.19: Low-dispersion spectral resolution.

values show, in general, an improvement over IUESIPS. As is the case with the spectral resolution plots, the small-aperture data are slightly offset from the large-aperture data.

LWP - The spatial resolution for the LWP is best near 3000Å where the FWHM for the large aperture is 2.4 pixels (3.6 arcsec), and decreases to values of around 3.0 pixels at the short and long wavelength ends of the spectrum. There is no significant difference between the large- and small-aperture spatial resolutions.

LWR - The behavior of the LWR camera as a function of wavelength is similar to the LWP, with the smallest FWHM values for the large aperture of 2.6 pixels (3.9 arcsec) occurring near 3000Å, and increasing to 3.6 and 3.0 pixels at the wavelength extremes. The small aperture, unlike the other two cameras, shows a dramatic decrease in resolution of approximately 10%.

SWP - The SWP camera shows the best spatial resolution near 1400Å with mean FWHM values for the large aperture of 2.7 pixels (4.1 arcsec), increasing slightly to 2.8 pixels at 1250Å, and 3.7 pixels at 1950Å. The SWP small-aperture resolution response is approximately the same as the large-aperture resolution.

Figure 2.20: Low-dispersion spatial resolution.

Chapter 3

IUE Final Archive Data Products

The output files for the *IUE* Final Archive are fundamentally different in content, quantity, size, and format from those of the current IUESIPS. We have given a brief description of each file below along with a definition of the associated FITS format. All output data from the Final Archive will be available only in FITS format. Table 3.1 lists the output files that will be available only for low-dispersion data, along with the file ID, file size, and an indication of the type of FITS file to be used. Table 3.2 gives the same data for the files which will be available for high-dispersion images. Table 3.3 lists the FES data to be included in the Final Archive.

3.1 File Naming Conventions

The file names are defined so as to allow the unique identification of the information stored in the file. It is expected that the FITS reader will assign the file names according to the keyword `FILENAME`. Files with extensions include the keyword both for the main data set and for the extensions so that the FITS reader could either store the information in a single file or store the main data set and the extension in different files. There are three possible combinations of data files: (1) main data set with extension (*e.g.*, resampled image with resampled flag image), (2) main data set with no extension (*e.g.*, raw image), and (3) extension with no main data set (*e.g.*, extracted image).

The file name is formed by the concatenation of the following codes:

- Camera: 3 letter code (`LWP, LWR, SWP, SWR`).
- Image number: 5 digits.
- File type: 2 letter code as:

  `RI` raw image

  `VD` vector displacement

  `XC` cross correlation coefficients (binary table extension of the `VD` file)

`LI` linearized image

`LF` flags associated with the linearized image (image extension of the LI file)

`SI` resampled image

`SF` flags associated with the resampled image (image extension of the SI file)

`SW` wavelengths associated with the high-dispersion resampled image

`MX` merged extracted spectrum (large, small or both apertures)

`WH` whole high-dispersion extracted spectrum

- Dispersion: 2 letter code (`HI, LO`).

For example the files generated for LWP 12345, low-dispersion image, are the following

main data set	extension
LWP12345.RILO	-
LWP12345.VDLO	LWP12345.XCLO
LWP12345.LILO	LWP12345.LFLO
LWP12345.SILO	LWP12345.SFLO
-	LWP12345.MXLO

The files generated for SWP 9876, high-dispersion image, are

main data set	extension
SWP09876.RIHI	-
SWP09876.VDHI	SWP09876.XCHI
SWP09876.LIHI	SWP09876.LFHI
SWP09876.SIHI	SWP09876.SFHI, SWP09876.SWHI
-	SWP09876.MXHI
-	SWP09876.WHHI

Images which are processed as both high dispersion and low dispersion will therefore have both sets of files in the archive. Note that in this case two copies of the raw image will appear in the archives, due to the dispersion dependent Core Data Items (CDIs) assigned during processing.

3.2 Raw Image (RILO/RIHI)

The *IUE* raw image is the fundamental input file for the *IUE* image processing system. Except for the conversion from VICAR format to FITS format (including the addition of the CDIs as FITS keywords), the data remain unaltered.

The RILO/RIHI FITS file contains a two-dimensional primary array consisting of 768 $\times$ 768 pixels, with no group structure or extensions. Each pixel is a data number (DN), coded as an 8 bit unsigned integer ranging from 0 to 255. The Basic Keywords are shown in Table 3.4.

Table 3.1: File Formats for *IUE* Final Archive (Low Dispersion)

File Name	File ID	File Size	Format	FITS Type
Raw Image	.RILO	768x768	8-bit	primary array
Linearized Image	.LILO	768x768	I*2	primary array
LI Flag Image	.LFLO	768x768	I*2	image extension
Resampled Low-Disp Image	.SILO	640x80	I*2	primary array
SILO Flag Image	.SFLO	640x80	I*2	image extension
Vector Displacement	.VDLO	2x768x768	R*4	primary array
Cross-correlation Coefficients	.XCLO	7x∼140	R*4	table extension
Extracted Low-Disp Spectra	.MXLO	640x5	8-bit	binary table extension

Table 3.2: File Formats for *IUE* Final Archive (High Dispersion)

File Name	File ID	File Size	Format	FITS Type
Raw Image	.RIHI	768x768	8-bit	primary array
Linearized Image	.LIHI	768x768	I*2	primary array
LI Flag Image	.LFHI	768x768	I*2	image extension
Resampled High-Disp Image	.SIHI	768x768	I*2	primary array
SIHI Flag Image	.SFHI	768x768	I*2	image extension
Vector Displacement	.VDHI	2x768x768	R*4	primary array
Cross-correlation Coefficients	.XCHI	7x∼500	R*4	table extension
Extracted High-Disp Spectra	.MXHI	TBD	8-bit	binary table extension
Concatenated High-Disp Spectra	.WHHI	TBD	8-bit	binary table extension

Table 3.3: File Formats for *IUE* Final Archive (FES Images)

File Name	File ID	File Size	Format	FITS Type
FES Image	FES	81x81 7x7 113x113 127x127 other	I*2	primary array

Table 3.4: RILO/RIHI File - Basic FITS Keywords

Keyword and value	**Description**
`SIMPLE  =                    T`	Standard FITS Format
`BITPIX  =                    8`	8-bit integer pixels
`NAXIS   =                    2`	Two-dimensional image
`NAXIS1  =                  768`	Dimension along x-axis
`NAXIS2  =                  768`	Dimension along y-axis
`CTYPE1  = 'SAMPLE  '`	x-axis
`CTYPE2  = 'LINE    '`	y-axis
`BUNIT   = 'DN      '`	Data Numbers
`TELESCOP= 'IUE     '`	International Ultraviolet Explorer
`FILENAME= 'AAAnnnnn.RIdd'`	Filename (camera)(number).RI(disp)
`DATE    = 'dd/mm/yy'`	Date file is written
`ORIGIN  = 'VILSPA  '`	Institution generating the file
`DATAMIN =              nnn.0`	Minimum pixel value
`DATAMAX =              nnn.0`	Maximum pixel value

3.3 Linearized Image (LILO/LIHI)

The linearized image is a primary array containing linearized (photometrically-corrected) pixels in FN units (I*2). Only the pixels inside the target ring in high dispersion, or in a swath including the spectrum in low dispersion, have been photometrically corrected. The actual FN values have been scaled up by a factor of 32 for storage. The scale factor of 32 will automatically be applied by standard FITS readers; the FITS keyword "BSCALE" is equal to 1/32.

The LILO/LIHI file will contain the linearized image as a two-dimensional primary array consisting of 768×768 pixels, with each pixel value coded as 16 bits, two's complement integers with bits stored in decreasing order of significance. The associated pixel quality flags are stored as an image extension using 16-bit, two's complement integers. Basic Keywords in the main header and the image extension header are shown in Table 3.5.

3.4 Linearized Flag Image (LFLO/LFHI)

This image extension is the same size as the LILO/LIHI file. For every pixel that is photometrically corrected, this file contains a ν flag for specific error conditions in the corresponding pixel in the LILO/LIHI image. The values are stored as integer. The ν flags are inherently 2 bytes (negative values). Pixels which suffer from saturation, are close to the edge of the photometric correction region, or require ITF curve extrapolation to compute an FN value are flagged in the LFLO/LFHI file. In addition, all pixels on the target region which have not been photometrically corrected but are known to suffer from bright spots, reseaux, microphonics, and missing minor frames are appropriately flagged. Flagging for microphonic noise is performed over the entire 768×768 image for the LWR camera only.

3.5 Resampled Image (SILO/SIHI)

The resampled image is a primary array produced by resampling the photometrically corrected portion of the LILO/LIHI image using the modified Shepard algorithm taken from the Numerical Algorithms Group (NAG) software package. Each pixel is resampled to the position determined by the summation of the vectors needed for:

1. shift to photometric correction (ITF) raw space,
2. shift from ITF space to geometrically-rectified space,
3. rotation such that orders are horizontal,
4. wavelength linearization,
5. detilting of large-aperture spectra for low-dispersion extended sources only,

Table 3.5: LILO/LIHI File - Basic FITS Keywords

Keyword and value	Description
SIMPLE = T	Standard FITS Format
BITPIX = 16	16-bit, 2's complement pixels
NAXIS = 2	Two-dimensional image
NAXIS1 = 768	Dimension along x-axis
NAXIS2 = 768	Dimension along y-axis
EXTEND = T	Extensions are present
CTYPE1 = 'SAMPLE '	x-axis
CTYPE2 = 'LINE '	y-axis
BUNIT = 'FN '	Flux Numbers
BSCALE = 3.1250E-02	real=tape*bscale+bzero
BZERO = 0.	offset
TELESCOP= 'IUE '	International Ultraviolet Explorer
FILENAME= 'AAAnnnnn.LIdd'	Filename (camera)(number).LI(disp)
DATE = 'dd/mm/yy'	Date file is written
ORIGIN = 'VILSPA '	Institution generating the file
DATAMIN = nnnnn.n	Minimum pixel value
DATAMAX = nnnnn.n	Maximum pixel value
XTENSION= 'IMAGE '	Image extension
BITPIX = 16	16-bit, 2's complement pixels
NAXIS = 2	Two-dimensional image
NAXIS1 = 768	Dimension along x-axis
NAXIS2 = 768	Dimension along y-axis
PCOUNT = 0	number of bytes following data matrix
GCOUNT = 1	number of groups
CTYPE1 = 'SAMPLE '	x-axis
CTYPE2 = 'LINE '	y-axis
BUNIT = ' '	unitless
FILENAME= 'AAAnnnnn.LFdd'	Filename (camera)(number).LF(disp)
EXTNAME = 'LIF '	LILO/LIHI pixel quality flags

6. alignment of the low-dispersion apertures for constant wavelength in the line direction,
7. adjustment so that both LW cameras provide coverage of the same spectral range,
8. adjustment to maintain the spectrum at approximately the same location in the file in the spatial direction (low dispersion only),
9. adjustment to LWP data to put the large-aperture data at the top of the file,
10. corrections for the spatial deviations (cross-dispersion wiggles) for the LWP and LWR low-dispersion data,
11. heliocentric velocity correction for high dispersion,
12. de-splaying correction for high-dispersion data, and
13. order centroiding for high-dispersion data.

The resampled image (SILO/SIHI) is I*2, in scaled FN units, with the y coordinate in pixels and the x coordinate in angstroms (Å). Starting wavelength and wavelength increment are stored in the FITS header for low dispersion. Both large- and small-aperture data are present in one resampled image for low-dispersion data. The FITS header will indicate predicted line center for large-aperture and for small-aperture data.

The SILO image is stored as a two-dimensional primary array consisting of 640×80 pixels, while the SIHI is 768×768 pixels. Each pixel represents a flux number (FN) scaled by a factor of 32 for storage purposes. The pixels are coded as 16 bits, two's complement integers, with the bits stored in decreasing order of significance. The associated pixel quality flags are stored as an image extension which has the same dimensions as the primary array. Table 3.6 shows the basic FITS Keywords for the main header and the image extension header.

3.6 Resampled Flag Image (SFLO/SFHI)

This image extension is the same size as the resampled image. Like the linearized flag image, it contains the ν flag for specific error conditions for the corresponding pixel in the SILO/SIHI image. The values are stored as I*2.

3.7 Vector Displacement File (VDLO/VDHI)

The vector displacement file is a primary array that provides, for each pixel in the LILO/LIHI file, the final coordinate values in the x (wavelength) and in the y (spatial) directions in the resampled space. "Resampled space" is defined to be a geometrically corrected 768×768

Table 3.6: SILO/SIHI File - Basic FITS Keywords

Keyword and value	Description
SIMPLE = T	Standard FITS Format
BITPIX = 16	16-bit, 2's complement pixels
NAXIS = 2	Two-dimensional image
NAXIS1 = nnn	Dimension along x-axis
NAXIS2 = nnn	Dimension along y-axis
EXTEND = T	Extensions are present
CRPIX1 = 1.	x reference pixel
CRPIX2 = 1.	y reference pixel
CRVAL1 = nnnn.nn	Wavelength at reference pixel
CRVAL2 = 1.	Coordinate of CRPIX2
CDELT1 = nn.nnnn	Increment in wavelengths
CDELT2 = 1.	Increment unit along y-axis
CTYPE1 = 'WAVELENGTH'	x-axis
CTYPE2 = 'SCAN '	y-axis
BUNIT = 'FN '	Flux Numbers
BSCALE = 3.1250E-02	real=tape*bscale+bzero
BZERO = 0.	Pixel offset
TELESCOP= 'IUE '	International Ultraviolet Explorer
FILENAME= 'AAAnnnnn.SIdd'	Filename (camera)(number).SI(disp)
DATE = 'dd/mm/yy'	Date file is written
ORIGIN = 'VILSPA '	Institution generating the file
DATAMIN = nnnnn.n	Minimum pixel value
DATAMAX = nnnnn.n	Maximum pixel value
XTENSION= 'IMAGE '	Image extension
BITPIX = 16	16-bit, 2's complement pixels
NAXIS = 2	Two-dimensional image
NAXIS1 = nnn	Dimension along x-axis
NAXIS2 = nnn	Dimension along y-axis
PCOUNT = 0	number of bytes following data matrix
GCOUNT = 1	number of groups
CRPIX1 = 1.	x reference pixel
CRPIX2 = 1.	y reference pixel
CRVAL1 = nnnn.nn	Coordinate of CRPIX1
CRVAL2 = 1.	Coordinate of CRPIX2
CDELT1 = nn.nnnn	Increment unit along x-axis
CDELT2 = 1.	Increment unit along y-axis
CTYPE1 = 'WAVELENGTH'	x-axis
CTYPE2 = 'SCAN '	y-axis
BUNIT = ' '	unitless
FILENAME= 'AAAnnnnn.SFdd'	Filename (camera)(number).SF(disp)
EXTNAME = 'SIddF '	SILO/SIHI pixel quality flags

image. In order to determine the final coordinates in the "resampled image" (the SILO/SIHI file) for any photometrically corrected pixel in the LILO/LIHI file:

$$Fin\_coord(x) = VD(i, j, 1) - offset(x, cam, disp)$$

$$Fin\_coord(y) = VD(i, j, 2) - offset(y, cam, disp)$$

where i and j range from 1 to 768 and

	Offset X		Offset Y	
	disp=L	H	L	H
LWP	100	0	297	0
LWR	~100	0	~250	0
SWP	130	0	490	0

The displacement vectors are recoverable by:

$$DELTA_x = VD(i, j, 1) - i$$

and

$$DELTA_y = VD(i, j, 2) - j,$$

where i and j range from 1 to 768. $Fin\_coord(x)$ contains the final x coordinate in the SILO/SIHI file and $Fin\_coord(y)$ contains the final y coordinate in the SILO/SIHI file. The final coordinate values are coded as 32 bits, R*4 numbers.

Basic Keywords in the VDLO/VDHI file header and in the table extension are shown in Table 3.7.

3.8 Cross-Correlation Coefficients (XCLO/XCHI)

This file allows the user to recover the calculated displacement vectors which produced the mapping from science image raw space to the ITF. For each of the approximately 500 (140 for low-dispersion) points used to obtain the displacement between the science image and the corresponding level of the ITF, this file contains (1) science image x-position (I*2), (2) science image y-position (I*2), (3) ITF x-position at position of best match (R*4), (4) ITF y-position at position of best match (R*4), (5) cross-correlation coefficient (R*4), (6) number of points used to calculate the coefficient (I*2), and (7) the ITF level used in the correlation (I*2). The x and y positions correspond to the sample and line numbers in the raw image. The resulting ITF positions of the best match are pre-filtered positions (before bogus matches have been identified and deleted), and will not necessarily correspond exactly to the photometric registration displacement components utilized to create the final displacement vector.

Note: The keyword `NAXIS1` of the table extension has a value of 20 corresponding to the number of bytes in a row of the table.

Table 3.7: VDLO/VDHI File - Basic FITS Keywords

Keyword and value	Description
SIMPLE = T	Standard FITS Format
BITPIX = -32	IEEE single precision floating point
NAXIS = 3	Three-dimensional image
NAXIS1 = 2	Dimension along x-axis
NAXIS2 = 768	Dimension along y-axis
NAXIS3 = 768	Dimension along z-axis
EXTEND = T	Extensions are present
CTYPE1 = ' '	Units along x-axis
CTYPE2 = 'PIXEL '	Units along y-axis
CTYPE3 = 'PIXEL '	Units along z-axis
BUNIT = 'PIXEL '	Pixel units
BZERO = nnnn.	Pixel offset
BSCALE = nn.n	Scale factor
TELESCOP= 'IUE '	International Ultraviolet Explorer
FILENAME= 'AAAnnnnn.VDdd'	Filename (camera)(number).VD(disp)
DATE = 'dd/mm/yy'	Date file is written
ORIGIN = 'VILSPA '	Institution generating the file
DATAMIN = nnnnn.n	Minimum pixel value
DATAMAX = nnnnn.n	Maximum pixel value
XTENSION= 'BINTABLE'	Table extension
BITPIX = 8	binary data
NAXIS = 2	Two-dimensional image
NAXIS1 = 20	width of table in bytes
NAXIS2 = nnn	number of entries in table
PCOUNT = 0	number of bytes following data matrix
GCOUNT = 1	number of groups
TFIELDS = 7	number of fields in each row
TFORM1 = '1I '	16-bit integer
TTYPE1 = 'XRAW '	science image x-position
TUNIT1 = 'PIXEL '	unit is pixel
TFORM2 = '1I '	16-bit integer
TTYPE2 = 'YRAW '	science image y-position
TUNIT2 = 'PIXEL '	unit is pixel
TFORM3 = '1E '	single precision float
TTYPE3 = 'XITF '	ITF x-position of best match
TUNIT3 = 'PIXEL '	unit is pixel
TFORM4 = '1E '	single precision float
TTYPE4 = 'YITF '	ITF y-position of best match
TUNIT4 = 'PIXEL '	unit is pixel
TFORM5 = '1E '	single precision float
TTYPE5 = 'XCOEFF '	cross correlation coefficient
TUNIT5 = ' '	unitless
TFORM6 = '1I '	16-bit integer
TTYPE6 = 'NPOINTS '	number of points used
TUNIT6 = ' '	unitless
TFORM7 = '1I '	16-bit integer
TTYPE7 = 'ITFLEVEL'	ITF level
TUNIT7 = ' '	unitless
FILENAME= 'AAAnnnnn.XCdd'	Filename (camera)(number).XC(disp)
EXTNAME = 'XCOEF '	cross correlation coefficients

3.9 Extracted Low-Dispersion Spectra (MXLO)

The extracted low-dispersion file uses the binary 3-D table extension with fixed-length floating point vectors to contain the extracted fluxes and associated data quality flags. Since no primary data are included, the extension header immediately follows the primary FITS header. Each row of the binary table includes the following columns:

1. Aperture designation as 'LARGE' or 'SMALL', stored in 5 ASCII characters.
2. Number of extracted points, one 16-bit integer. The number of extracted points is 640.
3. Starting wavelength, one single precision floating point value.
4. Wavelength increment, one single precision floating point value.
5. Net flux spectrum, array with 640 single precision floating point values.
6. Background flux spectrum, array with 640 single precision floating point values.
7. Sigma vector, array with 640 single precision floating point values.
8. Data quality flags, array of 640 16-bit integers.
9. Absolutely calibrated net flux spectrum, array with 640 single precision floating point values.

Wavelengths are linearly sampled, and referenced to vacuum. Double aperture low-dispersion spectra will contain two rows in the above format, with one row for each aperture. Table 3.8 shows the basic FITS Keywords for the MXLO file.

Note: The keyword `NAXIS1` in the table extension defines the number of bytes per row in the table, computed as $15 + 18 \times 640$.

3.10 FES Image File

The Fine Error Sensor (FES) is an image dissector with an S-20 photocathode sensitive in the wavelength range from 4000–7000Å. Although not routinely archived, FES images are frequently read down from the satellite and stored in a format similar to the raw image file. The FES image size can range from 1×1 to 127×127 pixels, but they are generally archived in sizes of 7×7, 81×81, 113×113, or 127×127 pixels. Although this file is converted from VICAR to FITS format, with the VICAR label and appropriate CDIs stored as keywords in the FITS header, the FES data remain unaltered.

The FES file is stored as a two-dimensional primary array, with no group structure or extensions. Each pixel is coded as 16 bits, two's complement integers. Basic Keywords are shown in Table 3.9.

Table 3.8: MXLO File - Basic FITS Keywords

Keyword and value	Description
SIMPLE = T	Standard FITS Format
BITPIX = 8	8 bits ASCII
NAXIS = 0	No image data
EXTEND = T	Extensions are present
TELESCOP= 'IUE '	International Ultraviolet Explorer
DATE = 'dd/mm/yy'	Date file is written
ORIGIN = 'VILSPA '	Institution generating the file
XTENSION= 'BINTABLE'	Table extension
BITPIX = 8	Binary data
NAXIS = 2	Two-dimensional table array
NAXIS1 = 11535	With of the table row in bytes
NAXIS2 = n	Number of apertures (1-single, 2-both)
PCOUNT = 0	Number of bytes following data matrix
GCOUNT = 1	Only one group
TFIELDS = 9	Number of column in the table
TFORM1 = '5A '	character string
TTYPE1 = 'APERTURE'	aperture type (large or small)
TUNIT1 = ' '	unitless
TFORM2 = '1I '	16-bit integer
TTYPE2 = 'NPOINTS '	number of points
TUNIT2 = ' '	unitless
TFORM3 = '1E '	single precision
TTYPE3 = 'WAVELENGTH'	starting wavelength
TUNIT3 = 'ANGSTROM'	unit is angstrom
TFORM4 = '1E '	single precision
TTYPE4 = 'DELTAW '	wavelength increment
TUNIT4 = 'ANGSTROM'	unit is angstrom
TFORM5 = '640E '	single precision array
TTYPE5 = 'NET '	net flux array
TUNIT5 = 'FN '	unit is IUE FN
TFORM6 = '640E '	single precision array
TTYPE6 = 'BACKGROUND'	background flux array
TUNIT6 = 'FN '	unit is IUE FN
TFORM7 = '640E '	single precision array
TTYPE7 = 'SIGMA '	sigma
TUNIT7 = 'ERG/CM2/S/A'	unit is erg/cm2/sec/angstrom
TFORM8 = '640I '	16-bit integer array
TTYPE8 = 'QUALITY '	data quality flag
TUNIT8 = ' '	unitless
TFORM9 = '640E '	single precision array
TTYPE9 = 'FLUX '	calibrated flux
TUNIT9 = 'ERG/CM2/S/A'	unit is erg/cm2/sec/angstrom
FILENAME= 'AAAnnnnn.MXLO'	Filename (camera)(number).MXLO
EXTNAME = 'MXLO '	name of table

Table 3.9: FES File - Basic FITS Keywords

Keyword and value	Description
SIMPLE = T	Standard FITS Format
BITPIX = 16	16-bit, 2's complement pixels
NAXIS = 2	Two-dimensional image
NAXIS1 = nnn	Dimension along x-axis
NAXIS2 = nnn	Dimension along y-axis
CTYPE1 = 'SAMPLE '	x-axis
CTYPE2 = 'LINE '	y-axis
CUNIT1 = 'PIXEL '	Units along x-axis (8 arcsec/pixel)
CUNIT2 = 'PIXEL '	Units along y-axis (8 arcsec/pixel)
BUNIT = 'COUNTS '	Pixel units
TELESCOP= 'IUE '	International Ultraviolet Explorer
FILENAME= 'AAAnnnnn.FES'	Filename (camera)(number).FES
DATE = 'dd/mm/yy'	Date file is written
ORIGIN = 'VILSPA '	Institution generating the file
DATAMIN = nnn.n	Minimum pixel value
DATAMAX = nnn.n	Maximum pixel value

Chapter 4

Image Header Contents

4.1 Image Header

The structure of each new file header in FITS format will contain:

- Basic FITS keywords.
- Core Data Items.
- Original *IUE* label.
- NEWSIPS Image Processing History.

This header is attached to each of the files stored in the archive. Core Data Items (CDIs), the *IUE* label and the cumulative NEWSIPS Image Processing History will be contained only in the primary FITS header; the extension headers will not duplicate this information.

It should be noted that the structure of the FITS header is such that some information may appear in more than one form. For example, specific information may appear in multiple places in the original *IUE* label as well as in a CDI FITS keyword and/or the processing history. In cases where these entries disagree, the CDIs should always be considered the most reliable source for the specific information.

4.2 VICAR Label Format

Each image has an associated VICAR header which is generated by the *IUE* Operations Control Center software during image acquisition and contains various scientific and engineering data pertinent to the image. This header, called the image label, consists of 72-byte lines containing EBCDIC and binary information. The contents of the image label are shown in Table 4.1.

Note that lines 3–9 are entered by the Telescope Operator (TO) at the console and may occasionally contain errors. Lines 36–37, normally input from the POT (Preplanned

Observation Tape), may be modified by the TO and hence are also subject to errors. The automatic entries on the other lines (10–32) are more accurate but can be affected, for instance, by ground computer problems. The binary-format portion of the image label (located in lines 51–82 and 86–100) is not usefully decoded when interpreted in EBCDIC characters. See Van Steenberg (1989) for translation of the event round robin in *IUE* VICAR image labels.

Table 4.1: *IUE* VICAR Header

Line number	**Description**	**Code**
1-2	Image info. written by the system	EBCDIC
3-9	General comments	EBCDIC
10-32	Real-time command buffer	EBCDIC
33-35	Blanks	EBCDIC
36-37	GO information from POT tape	EBCDIC
38-45	Spares	EBCDIC
46	Computer switch info used at GSFC	EBCDIC
47-50	Spares	EBCDIC
51-75	Data quality bits	Binary
76-82	S/C snapshot	Binary
83-85	Orbital elements and S/C info	EBCDIC
86-100	Camera snapshots	Binary

The raw image VICAR header label, as well as any appendages which had been added for database information or label corrections, are stored in the primary FITS header. Each line contains the original label information coded in ASCII, in bytes 9 to 80, with blanks in bytes 1 to 8. Lines originally coded in EBCDIC have been converted to ASCII, and lines containing binary data have been converted into 2 lines containing hexadecimal ASCII characters. (*e.g.*, the unsigned integer byte value 63 will become '3F'). The first line of hexadecimal ASCII characters contain bytes 1 through 33 of the original line of binary data and are stored in columns 9 through 74. The second line contains bytes 34 through 66 in columns 9 through 74. The traditional VICAR line number and continuation character are stored at the end of each line in bytes 75 through 80. In this format, the *IUE* raw-image label generally consists of approximately 150 lines in the FITS header.

Four `COMMENT` lines precede the *IUE* label and one `COMMENT` line flags the end of the label.

4.3 NEWSIPS Processing History

The NEWSIPS image processing history includes the cumulative processing information generated by NEWSIPS. The history documents the processing system (software identification, version if required, and hardware platform), and the individual application modules with the corresponding time stamps. Relevant variables used or computed by the various processing routines (*e.g.*, median cross-correlation coefficient, dispersion constants, shifts used during the extraction, etc.) are reported in the history lines.

Each line of the processing history contains the keyword `HISTORY` in bytes 1 to 8, with processing information stored in bytes 9 to 71. Bytes 73 to 80 are reserved for time stamps, which designate the GMT times at which the individual application modules were executed. Separate lines containing the processing date indicate the start and end of the log. An example of the processing history is outlined in the following section.

4.4 Header Example

The following example shows the FITS header corresponding to a low-dispersion, double aperture raw image. In the case of a single aperture spectral image, the header includes only the corresponding large- (or small-) aperture set.

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
SIMPLE  =                    T / Standard FITS Format
BITPIX  =                    8 / 8-bit integer pixels
NAXIS   =                    2 / Two-dimensional image
NAXIS1  =                  768 / Dimension along x-axis
NAXIS2  =                  768 / Dimension along y-axis
CTYPE1  = 'SAMPLE  '           / x-axis
CTYPE2  = 'LINE    '           / y-axis
BUNIT   = 'DN      '           / Data Numbers
TELESCOP= 'IUE     '           / International Ultraviolet Explorer
FILENAME= 'SWP26067.RILO'      / Filename(camera)(number).RI(disp)
DATE    = '29/10/93'           / Date file was written
ORIGIN  = 'GSFC    '           / Institution generating the file
DATAMIN =                  0.0 / Minimum pixel value
DATAMAX =                255.0 / Maximum pixel value
COMMENT *
COMMENT * CORE DATA ITEMS - COMMON SET
COMMENT *
CAMERA  = 'SWP     '           / Camera
IMAGE   =                26067 / Sequential image number
DISPERSN= 'LOW     '           / Spectrograph dispersion mode
APERTURE= 'BOTH    '           / Aperture
DISPTYPE= 'LOW     '           / Dispersion processing type
READMODE= 'FULL    '           / Read mode
READGAIN= 'LOW     '           / Read gain
EXPOGAIN= 'MAXIMUM '           / Exposure gain
UVC-VOLT=                 -5.0 / UVC voltage
ABNNOSTD= 'YES     '           / Non-standard image acquisition
ABNBADSC= 'NO      '           / LWP bad scans
ABNHTRWU= 'NO      '           / LWR heater warmup
ABNREAD = 'NO      '           / Read at other than 20 KB
ABNUVC  = 'NO      '           / Non-standard UVC voltage
ABNHISTR= 'NO      '           / History replay
ABNOTHER= 'NO      '           / Other abnormality
THDAREAD=                 9.17 / THDA at read of image
EQUINOX =              1950.00 / Epoch of coordinates
STATION = 'GSFC    '           / Observing station
ORBEPOCH= '27/05/85'           / Orbital elements epoch
ORBSAXIS=              42171.0 / Semi-major axis in kilometers
ORBECCEN=            0.1993815 / Eccentricity
```

```
ORBINCLI=               29.542 / Inclination in degrees
ORBASCEN=              152.284 / Ascending node in degrees
ORBPERIG=              312.282 / Argument of perigee in degrees
ORBANOMA=               84.056 / Mean anomaly in degrees
POSANGLE=               127.21 / Pos angle of the large aperture (deg)
LAMP    = 'NONE    '           / Lamp
PGM-ID  = 'OD58K   '           / Program identification
ABNMINFR= 'NO      '           / Bad/missing minor frames
CC-PERCN=                 94.9 / Cross-correlation % successful
CC-WINDW=                   29 / Cross-correlation window size
CC-TEMPL=                   23 / Cross-correlation template size
CC-MEDN =                0.656 / Median cross-correlation coefficient
CC-STDEV=                0.112 / St dev of cross-corr coefficients
SHFTMEAN=                0.165 / Mean shift between image and ITF
SHFTMAX =                0.450 / Maximum shift between image and ITF
ITF     = 'SWP85R92A'          / ITF identification
TILTCORR= 'NO      '           / Tilt correction flag
MEANRAT =                1.002 / SI vs LI mean
STDEVRAT=                0.977 / SI vs LI standard deviation
COMMENT BY RA:  EXP 1 APER L E=242,C=110,B=32
COMMENT BY RA:  EXP 2 APER S E=175,C=90,B=32
COMMENT BY RA:     0 MISSING MINOR FRAMES NOTED ON SCRIPT
COMMENT BY RA:  EXP 1 TRACKED ON FES
COMMENT BY RA:  EXP 2 TRACKED ON FES
COMMENT BY RA:  S   PREP USED
COMMENT BY RA:  OFFSET 1  FROM: GC 28144
COMMENT BY RA:  OFFSET 1  COORDINATES: 20 13 20.0 +23 21 16
COMMENT BY RA:  OFFSET 1  MAGNITUDE: 5.400
COMMENT BY RA:  LGAP expo started in high disp for 1 min 08 sec, then exposed
COMMENT BY RA:  for 15 min in low disp.
COMMENT BY GO:  GO has no special comments.
COMMENT BY GO:  GO has no special comments.
COMMENT *
COMMENT * CORE DATA ITEMS - LARGE APERTURE SET
COMMENT *
LDATEOBS= '02/06/85'           / Observing date
LTIMEOBS= '13:56:31'           / Observing time
LMJD-OBS=          46218.58091 / Mod. JD start of obs. (JD - 2400000.5)
LEXPTRMD= 'NO-TRAIL'           / Trail mode
LEXPMULT= 'NO      '           / Multiple exposure mode
LEXPSEGM= 'NO      '           / Segmented exposure code
LEXPTIME=              967.755 / Integration time in seconds
LTHDASTR=                 9.20 / THDA at start of exposure
LTHDAEND=                 9.17 / THDA at end of exposure
LRA     =             304.5125 / Homogeneous R.A. in degrees
LDEC    =              20.9450 / Homogeneous Dec. in degrees
LLAPSTAT= 'OPEN    '           / Large aperture status
LFES2MD = 'SO      '           / FES(2) mode
LFES2CN =                  263 / FES(2) counts on target
LTARGET = 'V SGE   '           / Object as given by Guest Observer
LTARGRA =             304.5042 / R.A. in degrees (given by GO)
LTARGDEC=              20.9444 / Dec. in degrees (given by GO)
LOBJECT = 'V*  V SGE'                    / Homogeneous Object ID
LIUECLAS=                   11 / Object class
LFOCUS  =                -1.73 / Focus
LFPM    =                 0.75 / Flux particle monitor
LGSTAR2X=                  696 / X coordinate of guide star in FES 2
LGSTAR2Y=                  416 / Y coordinate of guide star in FES 2
LGSTAR2C=                  137 / Guide star counts in FES 2
LGSTAR2M= 'FO      '           / Guide star mode FES2
LMJD-MID=          46218.58651 / Mod. JD middle of obs. (JD - 2400000.5)
LHELCORR=              0.00218 / Heliocentric corr to midpoint (days)
LDATABKG=                   24 / Estimated mean background level (DNs)
LDATACNT=                  107 / Estimated maximum continuum level (DNs)
```

```
LCNTRAPR=                 51.0 / Predicted center line of spectrum
LXTRMODE= 'POINT   '           / Extraction mode
LXTRPROF= 'EMPIRICAL'          / Profile used
LXTRASYM= 'NO      '           / Asymmetrical profile in extraction
LXTRCNTR=                 51.0 / Center line of extracted spectrum
LFLUXAVE=                 80.9 / Average flux (FNs)
COMMENT *
COMMENT * CORE DATA ITEMS - SMALL APERTURE SET
COMMENT *
SDATEOBS= '02/06/85'           / Observing date
STIMEOBS= '14:00:13'           / Observing time
SMJD-OBS=          46218.58348 / Mod. JD start of obs. (JD - 2400000.5)
SEXPTRMD= 'NO-TRAIL'           / Trail mode
SEXPMULT= 'NO      '           / Multiple exposure mode
SEXPSEGM= 'NO      '           / Segmented exposure code
SEXPTIME=             1199.588 / Integration time in seconds
STHDASTR=                 9.17 / THDA at start of exposure
STHDAEND=                 9.17 / THDA at end of exposure
SRA     =             304.5125 / Homogeneous R.A. in degrees
SDEC    =              20.9450 / Homogeneous Dec. in degrees
SLAPSTAT= 'OPEN    '           / Large aperture status
SFES2MD = 'SO      '           / FES(2) mode
SFES2CN =                  242 / FES(2) counts on target
STARGET = 'V SGE   '           / Object as given by Guest Observer
STARGRA =             304.5042 / R.A. in degrees (given by GO)
STARGDEC=              20.9444 / Dec. in degrees (given by GO)
SOBJECT = 'V*  V SGE'                    / Homogeneous Object ID
SIUECLAS=                   11 / Object class
SGSTAR2X=                  846 / X coordinate of guide star in FES 2
SGSTAR2Y=                  415 / Y coordinate of guide star in FES 2
SGSTAR2M= 'FO      '           / Guide star mode FES2
SMJD-MID=          46218.59043 / Mod. JD middle of obs. (JD - 2400000.5)
SHELCORR=              0.00218 / Heliocentric corr to midpoint (days)
SDATABKG=                   24 / Estimated mean background level (DNs)
SDATACNT=                   78 / Estimated maximum continuum level (DNs)
SCNTRAPR=                 24.9 / Predicted center line of spectrum
SXTRMODE= 'POINT   '           / Extraction mode
SXTRPROF= 'EMPIRICAL'          / Profile used
SXTRASYM= 'NO      '           / Asymmetrical profile in extraction
SXTRCNTR=                 24.4 / Center line of extracted spectrum
SFLUXAVE=                 51.1 / Average flux (FNs)
COMMENT *
COMMENT * THE IUE VICAR HEADER
COMMENT *
COMMENT IUE-VICAR HEADER START
                        0001000107680768   1 1 013126067           1  C
          6246*   4*IUESOC  *   *   *  2168*      *   *  * * * * * *     *  2  C
        SWP 26067, V SGE, 15 MIN LOW DISP & 68 SEC HIGH DISP LGAP          3  C
        ALSO EXPOSED FOR 20 MIN LOW DISP SMALL APERTURE                    4  C
                                                                           5  C
                                                                           6  C
        OBSERVER: KOCH    ID: OD58K1  DAY 153/02 JUNE 1985                 7  C
                                                                           8  C
                                                                           9  C
        85153145015* 9   * 218 *OPSPRC40*125506 S/C READY FOR MANEUVER   * 10  C
        144611 TARGET IN LWLA           *125525 READPREP 3 IMAGE 26066   * 11  C
        144801 GDE TRACK X 499  Y 557   *125600 SCAN READLO SS 1 G3 44   * 12  C
        144901 EXPOBC 1 12 0   MAXG NOL *125616 X 60 Y 76 G1 82 HT 105   * 13  C
        144951 TLM,SWPROM               *131624 TLM,FES2ROM              * 14  C
        145022 READ 3 IMAGE 26067       *133318 FESIMAGE 0 0 81          * 15  C
        145058 SCAN READLO SS 1 G3 44   *134037 TARGET IN SWLA           * 16  C
        145118 X 60 Y 76 G1 82 HT 105   *135034 TARGET FROM SWLA         * 17  C
        145050                          *135256 TARGET IN SWLA           * 18  C
        145117                          *135539 GDE TRACK X 697  Y 417   * 19  C
```

```
        054657 FESCT 1981 IN 3 0 0      *135636 EXPOBC 3 15 0   MAXG NOL * 20  C
        054817 GDE TRACK X 687  Y 154   *135751 MODTIME 3 0 0            * 21  C
        054919 EXPOBC 3 200 0  MAXG NOL *135821 FIN 3 T 68 S 97 U 109    * 22  C
        090740 TLM,SWPROM               *135842 MODE SWL                 * 23  C
        090921 FIN 3 T 11999 S 97 U 109 *140021 EXPOBC 3 15 0   MAXG NOL * 24  C
        090944 READPREP 3 IMAGE 26065   *140112 MODE LWL                 * 25  C
        091017 SCAN READLO SS 1 G3 44   *141521 FIN 3 T 968 S 97 U 109   * 26  C
        091030 X 60 Y 76 G1 82 HT 105   *141616 TARGET FROM SWLA         * 27  C
        093022 TLM,FES2ROM              *141953 TARGET IN SWSA           * 28  C
        093351 EXPOBC 3 200 0  MAXG NOL *142145 GDE TRACK X 845  Y 418   * 29  C
        125303 TLM,SWPROM               *142244 EXPOBC 3 20 0   MAXG NOL * 30  C
        125354 FIN 3 T 11999 S 97 U 109 *144251 FIN 3 T 2168 S 97 U 109  * 31  C
        125433 TARGET FROM SWLA         *144332 TARGET FROM SWSA         * 32  C
                                                                           33  C
                                                                           34  C
                                                                           35  C
        OD58K*1*07*KOCH           *  1*   *0*   V SEG*0*0*1*020            36  C
        2018009+205639*  0*WN*0*11.4*99.00*        *    * 999.99*   *      37  C
                                                                           38  C
                                                                           39  C
                                                                           40  C
                                                                           41  C
                                                                           42  C
                                                                           43  C
                                                                           44  C
                                                                           45  C
                                                                           46  C
                                                                           47  C
                                                                           48  C
                                                                           49  C
                                                                           50  C
.
.                  (binary portion of the VICAR label)
.
         2446212.5      .0 42171.1 .199381 29.5417152.2832312.2817 84.055  83  C
        153042054 1257131-69562511552 2 153050021 2017424+3834233093533    84  C
        153131052 2013204+2321163071239 153132820 2018  8+2056393054710    85  C
.
.                  (binary portion of the VICAR label)
.
        52202048202061482049202020202020202020202020202020202020202020203031 100 C
        ***** RAW IMAGE *** T3LBAC  *****                                      C
        *ARCHIVE   10:26Z JUN 03,'85                                          HL
COMMENT IUE-VICAR HEADER END
HISTORY IUE-LOG STARTED                           29-OCT-1993 05:21:28
HISTORY PROCESSING SYSTEM: NEWSIPS VERSION 2.3
HISTORY ULTRIX VERSION
HISTORY SWP26067
HISTORY PROCESSED AT GODDARD SPACE FLIGHT CENTER
HISTORY ****************************************************************
HISTORY ****************************************************************
HISTORY START RAW_SCREEN                          29-OCT-1993 05:22:22
HISTORY    9 BRIGHT SPOTS DETECTED
HISTORY    0 MISSING MINOR FRAMES DETECTED
HISTORY LARGE APERTURE SPECTRUM WILL BE EXTRACTED AS
HISTORY           POINT SOURCE
HISTORY LARGE APERTURE CONTINUUM DN LEVEL = 107
HISTORY SMALL APERTURE CONTINUUM DN LEVEL =  78
HISTORY BACKGROUND DN LEVEL =  24
HISTORY END   RAW_SCREEN                          29-OCT-1993 05:22:49
HISTORY ****************************************************************
HISTORY START TTDC                                29-OCT-1993 05:22:53
HISTORY TEMPERATURE USED FOR CORRECTING DISPERSION CONSTANTS =  9.17
HISTORY DATE OF OBSERVATION USED FOR CORRECTING
```

```
HISTORY          DISPERSION CONSTANTS =  2/ 6/85  13:56:31
HISTORY THIRD-ORDER FIT OVER TIME USED
HISTORY FIRST-ORDER FIT OVER TEMPERATURE USED
HISTORY ZERO-POINT CORRECTION =   1.09 ANGSTROMS
HISTORY SPATIAL CORRECTION =  -0.86 PIXELS
HISTORY END   TTDC                                  29-OCT-1993 05:22:54
HISTORY ***************************************************************
HISTORY START CROSS-CORR                            29-OCT-1993 05:23:04
HISTORY WINDOW SIZE USED:    29 X  29 PIXELS
HISTORY TEMPLATE SIZE USED:  23 X  23 PIXELS
HISTORY ITF USED:  SWP85R92A
HISTORY  95.0  PERCENT SUCCESSFUL CORRELATIONS (132 OUT OF 139)
HISTORY MEDIAN CORRELATION COEFFICIENT: 0.656
HISTORY STANDARD DEVIATION OF CORRELATION COEFFICIENT: 0.112
HISTORY MEAN SHIFT IN PIXELS: 0.165
HISTORY MAXIMUM SHIFT IN PIXELS: 0.450
HISTORY NUMBER OF SUCCESSFUL SHIFTS FILTERED AS UNRELIABLE IN
HISTORY     POST-FILTER ROUTINE:   1
HISTORY END   CROSS-CORR                            29-OCT-1993 05:24:47
HISTORY ***************************************************************
HISTORY START PHOTOM                                29-OCT-1993 05:25:55
HISTORY ITF USED: SWP85R92A
HISTORY MEAN TEMPERATURE OF ITF:  9.3 C
HISTORY ITF UVC=-5.0 KV; UVFLOOD WAVELENGTH = 2536 A; ITF SEC =-6.1 KV
HISTORY ITF CONSTRUCTION: RAW SPACE, FOURIER FILTERED; JAN92
HISTORY END   PHOTOM                                29-OCT-1993 05:27:45
HISTORY ***************************************************************
HISTORY START GEOM                                  29-OCT-1993 05:29:01
HISTORY WAVELENGTH LINEARIZATION APPLIED USING CHEBYSHEV COEFFICIENTS:
HISTORY      C(0) = 319.620
HISTORY      C(1) = 318.820
HISTORY      C(2) = 0.87967
HISTORY      C(3) = 0.67988
HISTORY WAVELENGTH ZEROPOINT AND SPATIAL SHIFT APPLIED:
HISTORY      ZERO-POINT SHIFT = -16.47 ANGSTROMS
HISTORY      SPATIAL SHIFT =   3.79 PIXELS
HISTORY FINAL TIME/TEMP CORRECTED DISPERSION CONSTANTS USED:
HISTORY      1050.00 ANGSTROMS, 1.6763 ANGSTROMS/PIXEL
HISTORY PREDICTED CENTER LINE OF LARGE APERTURE = LINE 51.0
HISTORY PREDICTED CENTER LINE OF SMALL APERTURE = LINE 24.9
HISTORY END   GEOM                                  29-OCT-1993 05:35:01
HISTORY ***************************************************************
HISTORY START SWET                                  29-OCT-1993 05:35:36
HISTORY  NOISE MODEL USED: SWP  VERSION 1.0
HISTORY
HISTORY  *********************LARGE APERTURE DATA***********************
HISTORY
HISTORY  PREDICTED SPECTRUM CENTER AT LINE 51, CENTROID FOUND AT
HISTORY       LINE 51, PEAK AT LINE 52, AVERAGE PEAK FN =    80.9
HISTORY  CROSS-DISPERSION PROFILES BINNED WITH A BLOCKSIZE OF   1 PIXELS,
HISTORY       FOR A TOTAL OF 526 BLOCKS, OF WHICH  71 ARE REJECTED
HISTORY  FIT PROFILE WITH 15 NODES AND  3.50 SIGMA REJECTION
HISTORY  PROFILE CENTROID AT LINE  51.0
HISTORY  EXTRACT FLUX FROM LINES 45 THROUGH  57
HISTORY  REJECT PIXELS DEVIATING BY  4.0 SIGMA
HISTORY  OUT OF    8320 PIXELS      82 REJECTED AS COSMIC RAY HITS,
HISTORY          141 FLAGGED AS BAD
HISTORY  ABSOLUTE FLUX CALIBRATION SWP VERSION 1.2 APPLIED USING:
HISTORY       MODE = LARGE APERTURE POINT SOURCE
HISTORY       CALIBRATION EPOCH = 1985.00
HISTORY       CAMERA RISE TIME = 0.130 SECONDS
HISTORY       EFFECTIVE EXPOSURE TIME =   967.755 SECONDS
HISTORY  TEMPERATURE-DEPENDENT SENSITIVITY CORRECTION APPLIED USING:
HISTORY       THDA OF IMAGE =  9.17
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HISTORY       REFERENCE THDA =  9.40
HISTORY       TEMPERATURE COEFFICIENT = -0.0046
HISTORY       TEMPERATURE CORRECTION FACTOR =   0.999
HISTORY  SENSITIVITY DEGRADATION CORRECTION SWP VERSION 1.0 APPLIED USING:
HISTORY       MODE = LARGE APERTURE POINT SOURCE
HISTORY       CALIBRATION EPOCH = 1985.00
HISTORY       OBSERVATION DATE = 1985.419
HISTORY
HISTORY  *********************SMALL APERTURE DATA***********************
HISTORY
HISTORY  PREDICTED SPECTRUM CENTER AT LINE 25, CENTROID FOUND AT
HISTORY       LINE 24, PEAK AT LINE 25, AVERAGE PEAK FN =    51.1
HISTORY  CROSS-DISPERSION PROFILES BINNED WITH A BLOCKSIZE OF   1 PIXELS,
HISTORY       FOR A TOTAL OF 526 BLOCKS, OF WHICH  56 ARE REJECTED
HISTORY  FIT PROFILE WITH 15 NODES AND  3.50 SIGMA REJECTION
HISTORY  PROFILE CENTROID AT LINE  24.4
HISTORY  EXTRACT FLUX FROM LINES 18 THROUGH  30
HISTORY  REJECT PIXELS DEVIATING BY  4.0 SIGMA
HISTORY  OUT OF    8320 PIXELS      17 REJECTED AS COSMIC RAY HITS,
HISTORY          101 FLAGGED AS BAD
HISTORY  ABSOLUTE FLUX CALIBRATION SWP VERSION 1.2 APPLIED USING:
HISTORY       MODE = SMALL APERTURE POINT SOURCE
HISTORY       CALIBRATION EPOCH = 1985.00
HISTORY       CAMERA RISE TIME = 0.130 SECONDS
HISTORY       EFFECTIVE EXPOSURE TIME =  1199.588 SECONDS
HISTORY  TEMPERATURE-DEPENDENT SENSITIVITY CORRECTION APPLIED USING:
HISTORY       THDA OF IMAGE =  9.17
HISTORY       REFERENCE THDA =  9.40
HISTORY       TEMPERATURE COEFFICIENT = -0.0046
HISTORY       TEMPERATURE CORRECTION FACTOR =   0.999
HISTORY  SENSITIVITY DEGRADATION CORRECTION SWP VERSION 1.0 APPLIED USING:
HISTORY       MODE = LARGE APERTURE POINT SOURCE
HISTORY              APPLIED TO SMALL APERTURE DATA
HISTORY       CALIBRATION EPOCH = 1985.00
HISTORY       OBSERVATION DATE = 1985.419
HISTORY END   SWET                               29-OCT-1993 05:36:35
HISTORY ***************************************************************
HISTORY START FITSCOPY                           29-OCT-1993 05:36:41
END
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