Chapter 12

Final Archive Data Products

The output files for the *IUE* Final Archive are fundamentally different from those produced by IUESIPS, both in content and format. They are based on the Flexible Image Transport System (FITS) format (NOST 1995) and incorporate the FITS binary table extensions (NOST 1995) and FITS image extensions (Ponz, Thompson, and Muñoz 1994). Although some FITS reading routines may not yet support these new FITS extensions, it was felt that there was no convenient alternative FITS format available for storing *IUE* data. Note that only those features included in the basic binary table proposal (i.e., excluding the conventions described in the appendices of the proposal) have been used in the Final Archive file formats. The formats described below (as originally described in DCG 1995) have been approved by the *IUE* Three Agencies as well as the NOST FITS Support Office.

Because NEWSIPS data will be made available to the astronomical community via electronic transfer, the adopted FITS format is envisioned as both a disk file format and a tape file format. It should be pointed out, however, that disk file structures vary with operating systems. For this reason, users should consider the Final Archive data as being comprised of 2880-byte logical records which may or may not be identical to any physical record lengths. FITS files transferred to VAX VMS systems using FTP for example, typically have 512-byte rather than 2880-byte records.

12.1 FITS File Formats

The various files associated with each image represent the stages of NEWSIPS processing starting with the raw image (RI) file and ending with the merged extracted image (MX) file containing fluxes, wavelengths and data quality (ν) flags. The Final Archive FITS files produced for low-dispersion images include the following:

`RILO` The RI stored as a FITS primary array. If a partial read was used to obtain the image, an image extension is included containing the original unshifted RI (i.e., all corrections for registration errors are included in the primary array).

`LILO` The linearized (i.e., photometrically corrected) image (LI) stored as a primary array with the associated array of ν flags stored in a FITS image extension.

`VDLO` The vector displacements (VD) file contains the vector displacements, which map raw space into resampled space, and the cross-correlation coefficients (XC), which describe the mapping from raw space to the appropriate level of the raw space Intensity Transfer Function (ITF). The VD are stored as a three-dimensional (3-D) primary array, and the XC are stored in a FITS binary table extension.

`SILO` The resampled image (SI) stored as a primary array with the associated ν flags in an image extension.

`MXLO` The MX stored in a binary table extension, with each row containing the data extracted from one aperture.

If the RILO contains spectra collected through both the large and small aperture, the VDLO, SILO, and MXLO will contain data from both apertures. This is a slight change from the IUESIPS processing in which separate files were created for each aperture.

In the case of a high-dispersion spectrum the following files are generated:

`RIHI` The RI (no partial-read image extensions are applicable).

`LIHI` The LI and associated ν flags.

`VDHI` The VD and XC data.

`SIHI` The SI stored as a primary array, with wavelengths and predicted and found line positions stored in a binary table extension. The associated ν and cosmic ray flags are contained in two image extensions.

`MXHI` The MX stored in a binary table extension with each row of the table representing data for one spectral order.

Some images may be processed as both high- and low-dispersion images and, consequently, will have both sets of files in the archive. In these cases, two copies of the RI file will appear in the archives, due to the dispersion-dependent keywords assigned during processing. All low- and high-dispersion Final Archive file formats are summarized in Tables 12.1 and 12.2. File sizes and formats summarized as "various" in these tables are explicitly described in the subsequent sections of this chapter.

12.2 FITS Header Format

The main source of information regarding the format and nature of *IUE* data contained in each FITS file is stored in the primary header. Each primary header includes the following sections:

Table 12.1: Low-Dispersion File Formats

File ID	Data Stored	Size	Format	FITS Type
RILO	Raw Image	768x768	8-bit	primary array
	Original Raw Image*	768x768	8-bit	image extension
LILO	Linearized Image	768x768	I*2	primary array
	Linearized Flag Image	768x768	I*2	image extension
SILO	Resampled Image	640x80	I*2	primary array
	Resampled Flag Image	640x80	I*2	image extension
VDLO	Vector Displacements	768x768x2	R*4	primary array
	Cross-correlation Parameters	various	various	binary table extension
MXLO	Extracted Spectra	various	various	binary table extension

* In the case of partial-reads only.

Table 12.2: High-Dispersion File Formats

File ID	Data Stored	Size	Format	FITS Type
RIHI	Raw Image	768x768	8-bit	primary array
LIHI	Linearized Image	768x768	I*2	primary array
	Linearized Flag Image	768x768	I*2	image extension
VDHI	Vector Displacements	768x768x2	R*4	primary array
	Cross-correlation Parameters	various	various	binary table extension
SIHI	Resampled Image	768x768	I*2	primary array
	SIHI wavelengths and predicted and found line positions	various	various	binary table extension
	Resampled Flag Image	768x768	I*2	image extension
	SIHI Cosmic Ray Image	768x768	8-bit	image extension
MXHI	Extracted Spectra	various	various	binary table extension

- Basic FITS keywords,
- Core Data Items (CDIs),
- Original *IUE* VICAR label,
- NEWSIPS Image Processing History.

All of these items are contained solely in the primary header of each Final Archive file; the extension headers do not duplicate this information and contain only the basic FITS keywords needed to read the data stored in that extension (with the exception of the `FILENAME` keyword described below).

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 the instances where these entries disagree, the CDIs should always be considered the most reliable source.* The contents of each of these sections is described below. Examples

of complete low- and high-dispersion primary headers are also given at the conclusion of this section.

12.2.1 Basic FITS keywords

The basic FITS keywords define the structure and content of the files. These basic keywords include both the required FITS keywords and, when appropriate, certain optional reserved FITS keywords. Each line of the FITS header has the syntax `keyname = value / comments`, where `keyname` is the name of a FITS keyword conforming to the FITS keyword rules. The basic FITS keywords are itemized for each file type below. Although not shown, each FITS header must end with the required `END` keyword.

A project-defined keyword that needs to be mentioned is `FILENAME`. This keyword describes the camera image number and the type of data contained in the particular FITS header-and-data unit (HDU) and appears in every HDU containing data. For example, `FILENAME` would equal SWP09876.LILO in the LILO primary header and SWP09876.LFLO in the LILO extension header. In the corresponding MXLO, the `FILENAME` keyword appears in the binary table extension header with the value SWP09876.MXLO but does not appear in the primary header since the MXLO does not contain any primary array data.

One purpose of the `FILENAME` keyword is to provide users with a naming convention when separating FITS HDUs into separate disk files (e.g., when reading FITS files from tape). Since the primary header contains most or all of the information describing *IUE* images, it might be preferable to keep the files intact. In any event, the `FILENAME` keyword is useful for verifying the contents of the various data sets.

The value of the `FILENAME` keyword is formed by the concatenation of the following codes:

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

  `RI` raw image

  `RO` original `RI` (low dispersion only, in the case of partial-read images)

  `VD` vector displacements

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

  `LI` linearized image

  `LF` ν flag image extension of the `LI` file

  `SI` resampled image

  `WL` binary table extension of the high-dispersion `SI` file containing spectral wavelengths and spatial centroid positions of the orders

  `SF` ν flag image extension of the high-dispersion `SI` file

`CR` cosmic ray image extension of the high-dispersion `SI` file

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

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

12.2.2 Core Data Items

The CDIs are defined to be the minimum set of parameters needed for image processing and scientific analysis. They include both input CDIs, which are verified before processing and used by NEWSIPS to determine the type of processing to be performed, and output CDIs, which are generated by NEWSIPS and verified during quality control after pipeline processing. The CDIs appear in the FITS header of each file, as well as in the *IUE* Final Observing Log. Each CDI is assigned a unique FITS keyword, although some CDIs may have multiple values and, therefore, require more than one FITS keyword. For example, low-dispersion double-aperture image files will contain the FITS keywords `LEXPTIME` and `SEXPTIME` to store the large- and small-aperture effective exposure times. For those cases in which the CDI is either unknown or undefined for a particular image, the related keyword will not be included in the header. This follows the standard convention for optional FITS keywords. A complete description of the CDIs is included in Chapter 14.

The portion of the header containing the CDIs may be divided into three sections:

- Common set (includes aperture-independent parameters),
- Large-aperture set,
- Small-aperture set.

Each set will be preceded by three `COMMENT` lines as indicated in the header examples given at the end of this section. Low-dispersion files corresponding to a single aperture exposure and all high-dispersion files will contain only the corresponding (large or small) CDI set.

12.2.3 Original *IUE* VICAR Label

Each image has an associated RI VICAR header, which was generated by the *IUE* Operations Control Center (IUEOCC) 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 as described in Table 12.3.

The image label, as well as any appendages which had been added by IUESIPS for database information or label corrections, is 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 contains bytes 1 through 33 of the original line of binary data and is stored in

Table 12.3: Summary of the *IUE* Raw Image 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
38-50	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
101-end	Databank parameters/IUESIPS Process History	EBCDIC

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 image label generally consists of approximately 150 lines in the FITS header. Four `COMMENT` lines precede the image label, and one `COMMENT` line flags the end of the label.

Note that lines 3–9 were entered by the Telescope Operator (TO) at the console and may occasionally contain errors. Lines 36–37, normally input from the Preplanned Observation Tape (POT), 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 hexadecimal ASCII characters and has been omitted from the header examples shown in the following subsection. Further information concerning the contents of the image label can be found in the IUESIPS Information Manual, Version 2.0 (Turnrose and Thompson 1984) and the *IUE* Image Header Document (GSFC 1986). For a guide to the translation of the event round robin in the image label, see Van Steenberg (1989).

12.2.4 NEWSIPS Image Processing History

The image processing history includes the cumulative processing information generated by NEWSIPS. This 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 also reported in the history. A complete processing history is in-

cluded with every FITS file so that even the RILO/RIHI header contains this information. Chapter 13 explains the meaning and significance of those image processing history entries that bear directly on the quality of the derived data.

Each line of the history contains the keyword `HISTORY` in bytes 1 to 8, with processing information stored in bytes 9 to 74. Time stamps that designate the GMT times at which the individual application modules were executed are stored in bytes 65 to 72. Separate lines containing the processing date point out the start and end of the log. Examples of the processing history are outlined in the following subsections.

12.2.4.1 Low-dispersion Header Example

The following example shows the complete primary FITS header corresponding to an LWR, low-dispersion, double aperture RILO. In the case of a single aperture spectral image, the header includes only the corresponding large- or small-aperture set of CDIs.

```
        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= 'LWR05625.RILO'      / Filename(camera)(number).RI(disp)
DATE    = '15/03/97'           / 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  = 'LWR     '           / Camera
IMAGE   =                 5625 / 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= 'NO      '           / 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=               12.84 / THDA at read of image
EQUINOX =             1950.00 / Epoch of coordinates
STATION = 'GSFC    '           / Observing station
ORBEPOCH= '13/09/79'           / Orbital elements epoch
ORBSAXIS=             42158.2 / Semi-major axis in kilometers
ORBECCEN=           0.2363013 / Eccentricity
ORBINCLI=              28.324 / Inclination in degrees
ORBASCEN=              195.328 / Ascending node in degrees
```

```
ORBPERIG=              269.795 / Argument of perigee in degrees
ORBANOMA=              174.024 / Mean anomaly in degrees
POSANGLE=               136.46 / Pos angle of the large aperture (deg)
LAMP    = 'NONE    '           / Lamp
PGM-ID  = 'CMBBS   '           / Program identification
ABNMINFR= 'NO      '           / Bad/missing minor frames
ABNMICRO= 'NO      '           / Microphonics
CC-PERCN=                 97.3 / Cross-correlation % successful
CC-WINDW=                   29 / Cross-correlation window size
CC-TEMPL=                   23 / Cross-correlation template size
CC-MEDN =                0.807 / Median cross-correlation coefficient
CC-STDEV=                0.134 / St dev of cross-corr coefficients
SHFTMEAN=                0.084 / Mean shift between image and ITF
SHFTMAX =                0.515 / Maximum shift between image and ITF
ITF     = 'LWR83R96A'          / ITF identification
TILTCORR= 'NO      '           / Tilt correction flag
MEANRAT =                1.004 / SI vs LI mean
STDEVRAT=                0.968 / SI vs LI standard deviation
COMMENT BY RA:  EXP 1 APER L C=260,B=22
COMMENT BY RA:  EXP 2 APER S B=22
COMMENT BY RA:  LWR 0-MINUTE HEATER WARMUP
COMMENT BY RA:     0 MISSING MINOR FRAMES NOTED ON SCRIPT
COMMENT BY RA:  EXP 1 TRACKED ON GYROS
COMMENT BY RA:  EXP 2 TRACKED ON FES
COMMENT BY RA:  XS  PREP USED
COMMENT *
COMMENT * CORE DATA ITEMS - LARGE APERTURE SET
COMMENT *
LDATEOBS= '19/09/79'           / Observing date
LTIMEOBS= '06:46:55'           / Observing time
LJD-OBS =        2444135.78258 / Julian Date start of obs.
LEXPTRMD= 'NO-TRAIL'           / Trail mode
LEXPMULT= 'NO      '           / Multiple exposure mode
LEXPSEGM= 'NO      '           / Segmented exposure code
LEXPTIME=                4.789 / Integration time in seconds
LTHDASTR=                12.84 / THDA at start of exposure
LTHDAEND=                12.84 / THDA at end of exposure
LRA     =             119.3604 / Homogeneous R.A. in degrees
LDEC    =             -45.0787 / Homogeneous Dec. in degrees
LLAPSTAT= 'OPEN    '           / Large aperture status
LFES2MD = 'FO      '           / FES(2) mode
LFES2CN =                13578 / FES(2) counts on target
LTARGET = 'HD 65904'           / Object as given by Guest Observer
LTARGRA =             119.3604 / R.A. in degrees (given by GO)
LTARGDEC=             -45.0786 / Dec. in degrees (given by GO)
LOBJECT = 'HD  65904'                   / Homogeneous Object ID
LIUECLAS=                  21 / Object class
LFOCUS  =               -1.08 / Focus
LFPM    =                0.44 / Flux particle monitor
LGSTAR2M= 'NO      '           / Guide star mode FES2
LJD-MID =        2444135.78261 / Julian Date middle of obs.
LHELCORR=              -.00212 / Heliocentric corr to midpoint (days)
LDATABKG=                  27 / Estimated mean background level (DNs)
LDATACNT=                 255 / 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=               196.1 / Average flux (FNs)
COMMENT *
COMMENT * CORE DATA ITEMS - SMALL APERTURE SET
COMMENT *
SDATEOBS= '19/09/79'           / Observing date
```

```
STIMEOBS= '06:57:36'           / Observing time
SJD-OBS =        2444135.79000 / Julian Date start of obs.
SEXPTRMD= 'NO-TRAIL'           / Trail mode
SEXPMULT= 'NO      '           / Multiple exposure mode
SEXPSEGM= 'NO      '           / Segmented exposure code
SEXPTIME=                6.837 / Integration time in seconds
STHDASTR=                12.51 / THDA at start of exposure
STHDAEND=                12.84 / THDA at end of exposure
SRA     =             119.3604 / Homogeneous R.A. in degrees
SDEC    =             -45.0787 / Homogeneous Dec. in degrees
SLAPSTAT= 'CLOSED  '           / Large aperture status
SFES2MD = 'FO      '           / FES(2) mode
SFES2CN =                13704 / FES(2) counts on target
STARGET = 'HD 65904'           / Object as given by Guest Observer
STARGRA =             119.3604 / R.A. in degrees (given by GO)
STARGDEC=             -45.0786 / Dec. in degrees (given by GO)
SOBJECT = 'HD  65904'                    / Homogeneous Object ID
SIUECLAS=                   21 / Object class
SFOCUS  =                -1.08 / Focus
SJD-MID =        2444135.79004 / Julian Date middle of obs.
SHELCORR=              -.00212 / Heliocentric corr to midpoint (days)
SDATABKG=                   27 / Estimated mean background level (DNs)
SDATACNT=                  176 / Estimated maximum continuum level (DNs)
SCNTRAPR=                 24.6 / Predicted center line of spectrum
SXTRMODE= 'POINT   '           / Extraction mode
SXTRPROF= 'EMPIRICAL'          / Profile used
SXTRASYM= 'NO      '           / Asymmetrical profile in extraction
SXTRCNTR=                 24.7 / Center line of extracted spectrum
SFLUXAVE=                132.3 / Average flux (FNs)
COMMENT *
COMMENT * THE IUE VICAR HEADER
COMMENT *
COMMENT IUE-VICAR HEADER START
                              0001000107680768   1 1 012105625           1  C
  1448*   4*IUESOC  *   *   *    12*      *   *  * * * * * * *     *  2  C
        LWR 5625, HD 65904, LOW DISP, SM 7 SEC, LG 5 SEC, US1              3  C
                                                                           4  C
                                                                           5  C
        OBSERVER: B.SAVAGE  PROGRAM: IMBBS   DATE: 1979.262  19 SEP        6  C
                                                                           7  C
                                                                           8  C
                                                                           9  C
        79262075460* 9   * 218 *OPSDEV14*074851 TARGET FROM SWLA        * 10  C
        065220 EXPOBC 3 0 5    MAXG NOL *074925 APERTURE CLOSED          * 11  C
        065257 FIN 3 T 9 S 97 U 109     *075147 TARGET IN SWSA           * 12  C
        065338 TARGET FROM SWSA         *075251 FESTRK TRACKING          * 13  C
        065521 TARGET IN LWSA           *075343 EXPOBC 3 9 59   MAXG NOL * 14  C
        065618 FESTRK TRACKING          *075433 TLM,LWRROM               * 15  C
        065740 EXPOBC 2 0 6    MAXG NOL *075460 READPREP 2 IMAGE 5625    * 16  C
        065818 FIN 2 T 11 S 98 U 109    *075532 SCAN READLO SS 1 G3 58   * 17  C
        065859 TARGET FROM LWSA         *075547 X 56 Y 72 G1 99 HT 106   * 18  C
        070225 TLM,SWPROM               *075523                          * 19  C
        070527 S/C READY FOR MANEUVER   *075546                          * 20  C
        070605 READPREP 3 IMAGE 6565    *064206 TARGET IN SWLA           * 21  C
        070638 SCAN READLO SS 1 G3 44   *064222 FES 13265  IN 24 0 0     * 22  C
        070656 X 60 Y 76 G1 82 HT 105   *064321 EXPOBC 3 0 3    MAXG NOL * 23  C
        072635 TLM,FES2ROM              *064357 FIN 3 T 3 S 97 U 109     * 24  C
        072758 APERTURE OPEN            *064441 TARGET FROM SWLA         * 25  C
        073729 FESIMAGE 0 0 81          *064610 TARGET IN LWLA           * 26  C
        073929 ACQ STARTED              *064659 EXPOBC 2 0 4    MAXG NOL * 27  C
        074243 TARGET IN SWLA           *064735 FIN 2 T 4 S 98 U 109     * 28  C
        074257 FES 6065  IN 12 0 0      *064816 TARGET FROM LWLA         * 29  C
        074427 FESTRK TRACKING          *064839 APERTURE CLOSED          * 30  C
        074522 EXPOBC 3 2 29   MAXG NOL *065027 TARGET IN SWSA           * 31  C
```

```
        074757 FIN 3 T 149 S 97 U 109   *065123 FESTRK TRACKING          * 32  C
                                                                          33  C
                                                                          34  C
                                                                          35  C
        IMBBS*1*02*SAVAGE          *   *   *H*   65904* *0*1* 13         36  C
        0757264+450442*  0*B4*5* 6.0*     *         *    *       * 12*    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 suppressed in this example)
.
                                                                          83  C
                                                                          84  C
                                                                          85  C
.
.    (binary portion of the VICAR label suppressed in this example)
.
        00010082826B77697A2E7D000061404140000040404002040 50B0C4040404040400100  C
        ***RAW  IMAGE***                                                   C
        *ARCHIVE   01:21Z SEP 23,'79                                      HL
COMMENT IUE-VICAR HEADER END
HISTORY IUE-LOG STARTED                          15-MAR-1997 01:23:45
HISTORY PROCESSING SYSTEM: NEWSIPS VERSION 2.5.2
HISTORY ULTRIX VERSION
HISTORY LWR05625
HISTORY PROCESSED AT GODDARD SPACE FLIGHT CENTER
HISTORY ****************************************************************
HISTORY ****************************************************************
HISTORY START RAW_SCREEN                         15-MAR-1997 01:25:47
HISTORY   18 BRIGHT SPOTS DETECTED
HISTORY    0 MISSING MINOR FRAMES DETECTED
HISTORY    0 LINES AFFECTED BY MICROPHONICS:
HISTORY LARGE APERTURE SPECTRUM WILL BE EXTRACTED AS
HISTORY           POINT SOURCE
HISTORY LARGE APERTURE CONTINUUM DN LEVEL = 255
HISTORY SMALL APERTURE CONTINUUM DN LEVEL = 176
HISTORY BACKGROUND DN LEVEL =  27
HISTORY END   RAW_SCREEN                         15-MAR-1997 01:26:54
HISTORY ****************************************************************
HISTORY START CROSS-CORR                         15-MAR-1997 01:29:10
HISTORY WINDOW SIZE USED:    29 X  29 PIXELS
HISTORY TEMPLATE SIZE USED:  23 X  23 PIXELS
HISTORY ITF USED:  LWR83R96A
HISTORY   97.4 PERCENT SUCCESSFUL CORRELATIONS (147 OUT OF 151)
HISTORY MEDIAN CORRELATION COEFFICIENT: 0.807
HISTORY STANDARD DEVIATION OF CORRELATION COEFFICIENT: 0.134
HISTORY ITF NOT USED: 0.653 MEDIAN CORRELATION COEFFICIENT
HISTORY MEAN SHIFT IN PIXELS: 0.084
HISTORY MAXIMUM SHIFT IN PIXELS: 0.515
HISTORY NUMBER OF SUCCESSFUL SHIFTS FILTERED AS UNRELIABLE IN
HISTORY     POST-FILTER ROUTINE:   1
HISTORY END   CROSS-CORR                         15-MAR-1997 01:31:10
HISTORY ****************************************************************
```

```
HISTORY START TTDC                                  15-MAR-1997 01:31:28
HISTORY TEMPERATURE USED FOR CORRECTING DISPERSION CONSTANTS = 12.84
HISTORY DATE OF OBSERVATION USED FOR CORRECTING
HISTORY           DISPERSION CONSTANTS = 19/ 9/79  06:46:55
HISTORY THIRD-ORDER  FIT OVER TIME USED
HISTORY FIRST-ORDER FIT OVER TEMPERATURE USED
HISTORY ZERO-POINT CORRECTION =  -0.82 ANGSTROMS
HISTORY SPATIAL CORRECTION =  -2.18 PIXELS
HISTORY END   TTDC                                  15-MAR-1997 01:31:30
HISTORY ************************************************************
HISTORY START PHOTOM                                15-MAR-1997 01:31:49
HISTORY ITF USED: LWR83R96A
HISTORY MEAN TEMPERATURE OF ITF: 14.5 C
HISTORY ITF UVC=-5.0 KV; UVFLOOD WAVELENGTH = 2536 A; ITF SEC =-6.1 KV
HISTORY ITF CONSTRUCTION: RAW SPACE, FOURIER FILTERED; SEP96
HISTORY END   PHOTOM                                15-MAR-1997 01:33:48
HISTORY ************************************************************
HISTORY START GEOM                                  15-MAR-1997 01:34:14
HISTORY WAVELENGTH LINEARIZATION APPLIED USING CHEBYSHEV COEFFICIENTS:
HISTORY      C(0) = 320.974
HISTORY      C(1) = 318.839
HISTORY      C(2) = -.47393
HISTORY      C(3) = 0.66076
HISTORY WAVELENGTH ZEROPOINT AND SPATIAL SHIFT APPLIED:
HISTORY      ZERO-POINT SHIFT = -23.30 ANGSTROMS
HISTORY      SPATIAL SHIFT =   1.29 PIXELS
HISTORY FINAL TIME/TEMP CORRECTED DISPERSION CONSTANTS USED:
HISTORY      1750.00 ANGSTROMS, 2.6692 ANGSTROMS/PIXEL
HISTORY PREDICTED CENTER LINE OF LARGE APERTURE = LINE 51.0
HISTORY PREDICTED CENTER LINE OF SMALL APERTURE = LINE 24.6
HISTORY END   GEOM                                  15-MAR-1997 01:40:57
HISTORY ************************************************************
HISTORY START SWET                                  15-MAR-1997 01:41:25
HISTORY  NOISE MODEL USED: LWR  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 51, AVERAGE PEAK FN =   196.1
HISTORY  CROSS-DISPERSION PROFILES BINNED WITH A BLOCKSIZE OF   2 PIXELS,
HISTORY       FOR A TOTAL OF 300 BLOCKS, OF WHICH  61 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  5.0 SIGMA
HISTORY  OUT OF    8320 PIXELS      21 REJECTED AS COSMIC RAY HITS,
HISTORY          226 FLAGGED AS BAD
HISTORY  ABSOLUTE FLUX CALIBRATION LWR VERSION 1.0 APPLIED USING:
HISTORY       MODE = LARGE APERTURE POINT SOURCE
HISTORY       CALIBRATION EPOCH = 1985.00
HISTORY       CAMERA RISE TIME = 0.126 SECONDS
HISTORY       EFFECTIVE EXPOSURE TIME =     4.789 SECONDS
HISTORY  TEMPERATURE-DEPENDENT SENSITIVITY CORRECTION APPLIED USING:
HISTORY       THDA OF IMAGE = 12.84
HISTORY       REFERENCE THDA = 14.80
HISTORY       TEMPERATURE COEFFICIENT = -0.0089
HISTORY       TEMPERATURE CORRECTION FACTOR =   0.983
HISTORY  SENSITIVITY DEGRADATION CORRECTION LWR VERSION 1.0 APPLIED USING:
HISTORY       MODE = LARGE APERTURE POINT SOURCE
HISTORY       CALIBRATION EPOCH = 1985.00
HISTORY       OBSERVATION DATE = 1979.718
HISTORY
HISTORY  **********************SMALL APERTURE DATA***********************
HISTORY
```

```
HISTORY  PREDICTED SPECTRUM CENTER AT LINE 25, CENTROID FOUND AT
HISTORY       LINE 25, PEAK AT LINE 24, AVERAGE PEAK FN =   132.3
HISTORY  CROSS-DISPERSION PROFILES BINNED WITH A BLOCKSIZE OF   1 PIXELS,
HISTORY       FOR A TOTAL OF 600 BLOCKS, OF WHICH 122 ARE REJECTED
HISTORY  FIT PROFILE WITH 15 NODES AND  3.50 SIGMA REJECTION
HISTORY  PROFILE CENTROID AT LINE  24.7
HISTORY  EXTRACT FLUX FROM LINES 19 THROUGH  31
HISTORY  REJECT PIXELS DEVIATING BY  5.0 SIGMA
HISTORY  OUT OF    8320 PIXELS      23 REJECTED AS COSMIC RAY HITS,
HISTORY          121 FLAGGED AS BAD
HISTORY  ABSOLUTE FLUX CALIBRATION LWR VERSION 1.0 APPLIED USING:
HISTORY       MODE = SMALL APERTURE POINT SOURCE
HISTORY       CALIBRATION EPOCH = 1985.00
HISTORY       CAMERA RISE TIME = 0.126 SECONDS
HISTORY       EFFECTIVE EXPOSURE TIME =     6.837 SECONDS
HISTORY  TEMPERATURE-DEPENDENT SENSITIVITY CORRECTION APPLIED USING:
HISTORY       THDA OF IMAGE = 12.84
HISTORY       REFERENCE THDA = 14.80
HISTORY       TEMPERATURE COEFFICIENT = -0.0089
HISTORY       TEMPERATURE CORRECTION FACTOR =   0.983
HISTORY  SENSITIVITY DEGRADATION CORRECTION LWR 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 = 1979.718
HISTORY END   SWET                                  15-MAR-1997 01:42:18
HISTORY ************************************************************
HISTORY START FITSCOPY                              15-MAR-1997 01:42:30
END
```

12.2.4.2 High-dispersion Header Example

The following example shows the FITS header corresponding to an SWP high-dispersion RIHI.

```
         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= 'SWP37983.RIHI'      / Filename(camera)(number).RI(disp)
DATE    = '10/01/97'           / 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   =                37983 / Sequential image number
DISPERSN= 'HIGH    '           / Spectrograph dispersion mode
APERTURE= 'LARGE   '           / Aperture
DISPTYPE= 'HIGH    '           / Dispersion processing type
READMODE= 'FULL    '           / Read mode
READGAIN= 'LOW     '           / Read gain
EXPOGAIN= 'MAXIMUM '           / Exposure gain
```

```
UVC-VOLT=                 -5.0 / UVC voltage
ABNNOSTD= 'NO      '           / 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=                10.84 / THDA at read of image
EQUINOX =              1950.00 / Epoch of coordinates
STATION = 'GSFC    '           / Observing station
ORBEPOCH= '09/01/90'           / Orbital elements epoch
ORBSAXIS=              42162.1 / Semi-major axis in kilometers
ORBECCEN=            0.1507207 / Eccentricity
ORBINCLI=               32.096 / Inclination in degrees
ORBASCEN=              121.734 / Ascending node in degrees
ORBPERIG=              349.052 / Argument of perigee in degrees
ORBANOMA=              308.612 / Mean anomaly in degrees
POSANGLE=               181.87 / Pos angle of the large aperture (deg)
LAMP    = 'NONE    '           / Lamp
PGM-ID  = 'PHCAL   '           / Program identification
ABNMINFR= 'NO      '           / Bad/missing minor frames
CC-PERCN=                 81.3 / Cross-correlation % successful
CC-WINDW=                   29 / Cross-correlation window size
CC-TEMPL=                   23 / Cross-correlation template size
CC-MEDN =                0.385 / Median cross-correlation coefficient
CC-STDEV=                0.140 / St dev of cross-corr coefficients
SHFTMEAN=                0.467 / Mean shift between image and ITF
SHFTMAX =                2.850 / Maximum shift between image and ITF
ITF     = 'SWP85R92A'          / ITF identification
TILTCORR= 'NO      '           / Tilt correction flag
MEANRAT =                1.014 / SI vs LI mean
STDEVRAT=                0.984 / SI vs LI standard deviation
COMMENT BY RA:  EXP 1 APER L C=165,B=30
COMMENT BY RA:     0 MISSING MINOR FRAMES NOTED ON SCRIPT
COMMENT BY RA:  EXP 1 TRACKED ON GYROS
COMMENT BY RA:  S   PREP USED
COMMENT *
COMMENT * CORE DATA ITEMS - LARGE APERTURE SET
COMMENT *
LDATEOBS= '10/01/90'           / Observing date
LTIMEOBS= '03:56:12'           / Observing time
LJD-OBS =        2447901.66403 / Julian Date start of obs.
LEXPTRMD= 'NO-TRAIL'           / Trail mode
LEXPMULT= 'NO      '           / Multiple exposure mode
LEXPSEGM= 'NO      '           / Segmented exposure code
LEXPTIME=                5.604 / Integration time in seconds
LTHDASTR=                11.18 / THDA at start of exposure
LTHDAEND=                11.18 / THDA at end of exposure
LRA     =             206.3929 / Homogeneous R.A. in degrees
LDEC    =              49.5623 / Homogeneous Dec. in degrees
LLAPSTAT= 'OPEN    '           / Large aperture status
LFES2MD = 'FU      '           / FES(2) mode
LFES2CN =                 3935 / FES(2) counts on target
LTARGET = 'ETA UMA '           / Object as given by Guest Observer
LTARGRA =             206.3925 / R.A. in degrees (given by GO)
LTARGDEC=              49.5619 / Dec. in degrees (given by GO)
LOBJECT = 'HD  120315'                   / Homogeneous Object ID
LIUECLAS=                   21 / Object class
LFOCUS  =                -0.23 / Focus
LFPM    =                 0.59 / Flux particle monitor
LGSTAR2M= 'NO      '           / Guide star mode FES2
LJD-MID =        2447901.66406 / Julian Date middle of obs.
LHELCORR=             0.00131 / Heliocentric corr to midpoint (days)
```

```
LDATABKG=                   29 / Estimated mean background level (DNs)
LDATACNT=                  156 / Estimated maximum continuum level (DNs)
LCNTRAPR=               290.74 / Predicted center line of spectrum
LXTRMODE= 'POINT   '           / Extraction mode
LXTRCNTR=                290.5 / Center line of extracted spectrum
LRADVELO=                19.59 / Heliocentric velocity correction in km/s
COMMENT *
COMMENT * THE IUE VICAR HEADER
COMMENT *
COMMENT IUE-VICAR HEADER START
                              895 895 768 768   1 1 013037983   +101     1  C
  8964*  12*IUESOC  *   *   *     6*      *   *  * * * * * * *     *  2  C
        SWP 37983, ETA UMA, 6 SEC EXPO, HIGH DISPERSION, LGAP              3  C
        ERRORS AT REF POINT AFTER EXPO: EX = 1 , EY = -1                   4  C
                                                                           5  C
                                                                           6  C
        OBSERVER: GARHART      ID: PHCAL   10 JAN 1990, DAY 010            7  C
                                                                           8  C
                                                                           9  C
        90 10045117* 10  * 218 *OPS2PR11*043729 TLM,FES2ROM              * 10  C
        031754 MODE LWH                *045023 TLM,SWPROM                * 11  C
        031921 TLM,LWPROM              *045117 READPREP 3 IMAGE 37983    * 12  C
        031952 READPREP 1 IMAGE 17119  *045200 SCAN READLO SS 1 G3 44    * 13  C
        032031 SCAN READLO SS 1 G3 47  *045217 X 60 Y 76 G1 82 HT 105    * 14  C
        032046 X 53 Y 71 G1 97 HT 106  *045151                           * 15  C
        034446 TLM,FES2ROM             *045216                           * 16  C
        034926 FES CTS 3921 0 1 2560   *022057 TRAIL 3  .460830E 00      * 17  C
        035000 TARGET IN LWLA          *022128 FES CTS 473 0 0 2560      * 18  C
        035111 EXPOBC 1 0 5    MAXG NOL *022204 TARGET IN SWLA           * 19  C
        035152 FIN 1 T 4 S 97 U 108    *022559 EXPOBC 3 25 0   MAXG NOL * 20  C
        035243 TARGET FROM LWLA        *022918 MODTIME 3 0 0             * 21  C
        035429 FES CTS 3935 0 1 1024   *022953 FIN 3 T 193 S 97 U 109    * 22  C
        035507 TARGET IN SWLA          *023107 TARGET FROM SWLA          * 23  C
        035617 EXPOBC 3 0 6    MAXG NOL *023158 ITER 1 TIME  .433999E 02 * 24  C
        035701 FIN 3 T 5 S 97 U 109    *024404 S/C READY FOR MANEUVER    * 25  C
        035758 TARGET FROM SWLA        *024427 MODE SWH                  * 26  C
        041054 S/C READY FOR MANEUVER  *024459 TLM,SWPROM                * 27  C
        041121 TLM,LWPROM              *024547 READPREP 3 IMAGE 37982    * 28  C
        041202 READPREP 1 IMAGE 17120  *024622 SCAN READLO SS 1 G3 44    * 29  C
        041234 SCAN READLO SS 1 G3 47  *024637 X 60 Y 76 G1 82 HT 105    * 30  C
        041255 X 53 Y 71 G1 97 HT 106  *025155 S/C MANEUVERING           * 31  C
        041751 S/C MANEUVERING         *030825 TLM,FES2ROM               * 32  C
                                                                           33  C
                                                                           34  C
                                                                           35  C
        PHCAL*1*20*GARHART         * 21*   *0* ETA UMA*0*0*1* 21          36  C
        1345342+493343*  0*B3*5*1.84* 0.02*         *    * 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 suppressed in this example)
.
         2447886.5      .0 42163.1 .151032 32.0417121.9482-11.4203294.824  83  C
```

```
         10025151 1345342+493343251 8 2  10041747  034102+5337181124420    84  C
          9231403 1045335+3750 32744921  10004626  8 4431+75 6473473851    85  C
.
.    (binary portion of the VICAR label suppressed in this example)
.
        AED9D443496CB76DB731B731426140000000004040400103 19F1C2404040404040100  C
        90123104337983L                                      000006   G        1APC
        PHCALGO* ETA UMA            1345342493343+00112                       2APC
               GARHART                                                        3APC
             90365      6    90 1003570190 1004511714221108001H              4APC
        ***** RAW IMAGE:  T3HLAC  *****                                        C
        *GOT_FMTOUTTAPE/GOT_MASKCON 14:27Z JAN 10,'90                          HL
COMMENT IUE-VICAR HEADER END
HISTORY IUE-LOG STARTED                              10-JAN-1997 03:09:04
HISTORY PROCESSING SYSTEM: NEWSIPS VERSION 3.1_A
HISTORY OPEN VMS VERSION
HISTORY SWP37983
HISTORY PROCESSED AT GODDARD SPACE FLIGHT CENTER
HISTORY ************************************************************
HISTORY ************************************************************
HISTORY START RAW_SCREEN                             10-JAN-1997 03:09:14
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 = 156
HISTORY BACKGROUND DN LEVEL =  29
HISTORY ORDER REGISTRATION
HISTORY   GLOBAL OFFSET -0.08 PIXELS RELATIVE TO FIDUCIAL: SWP 13589
HISTORY   RELATIVE ORDER LOCATIONS DETERMINED FROM EMPIRICAL POSITIONS
HISTORY END   RAW_SCREEN                             10-JAN-1997 03:09:39
HISTORY ************************************************************
HISTORY START TTDC                                   10-JAN-1997 03:09:42
HISTORY TEMPERATURE USED FOR CORRECTING DISPERSION CONSTANTS = 11.18
HISTORY DATE OF OBSERVATION USED FOR CORRECTING
HISTORY           DISPERSION CONSTANTS = 10/ 1/90  03:56:12
HISTORY ORDER  66 ZERO-POINT CORRECTION =  -0.071 ANGSTROMS
HISTORY ORDER  67 ZERO-POINT CORRECTION =  -0.071 ANGSTROMS
HISTORY ORDER  68 ZERO-POINT CORRECTION =  -0.070 ANGSTROMS
HISTORY ORDER  69 ZERO-POINT CORRECTION =  -0.067 ANGSTROMS
HISTORY ORDER  70 ZERO-POINT CORRECTION =  -0.066 ANGSTROMS
HISTORY ORDER  71 ZERO-POINT CORRECTION =  -0.065 ANGSTROMS
HISTORY ORDER  72 ZERO-POINT CORRECTION =  -0.066 ANGSTROMS
HISTORY ORDER  73 ZERO-POINT CORRECTION =  -0.066 ANGSTROMS
HISTORY ORDER  74 ZERO-POINT CORRECTION =  -0.066 ANGSTROMS
HISTORY ORDER  75 ZERO-POINT CORRECTION =  -0.065 ANGSTROMS
HISTORY ORDER  76 ZERO-POINT CORRECTION =  -0.063 ANGSTROMS
HISTORY ORDER  77 ZERO-POINT CORRECTION =  -0.063 ANGSTROMS
HISTORY ORDER  78 ZERO-POINT CORRECTION =  -0.062 ANGSTROMS
HISTORY ORDER  79 ZERO-POINT CORRECTION =  -0.063 ANGSTROMS
HISTORY ORDER  80 ZERO-POINT CORRECTION =  -0.061 ANGSTROMS
HISTORY ORDER  81 ZERO-POINT CORRECTION =  -0.060 ANGSTROMS
HISTORY ORDER  82 ZERO-POINT CORRECTION =  -0.060 ANGSTROMS
HISTORY ORDER  83 ZERO-POINT CORRECTION =  -0.059 ANGSTROMS
HISTORY ORDER  84 ZERO-POINT CORRECTION =  -0.059 ANGSTROMS
HISTORY ORDER  85 ZERO-POINT CORRECTION =  -0.058 ANGSTROMS
HISTORY ORDER  86 ZERO-POINT CORRECTION =  -0.059 ANGSTROMS
HISTORY ORDER  87 ZERO-POINT CORRECTION =  -0.057 ANGSTROMS
HISTORY ORDER  88 ZERO-POINT CORRECTION =  -0.056 ANGSTROMS
HISTORY ORDER  89 ZERO-POINT CORRECTION =  -0.056 ANGSTROMS
HISTORY ORDER  90 ZERO-POINT CORRECTION =  -0.055 ANGSTROMS
HISTORY ORDER  91 ZERO-POINT CORRECTION =  -0.056 ANGSTROMS
HISTORY ORDER  92 ZERO-POINT CORRECTION =  -0.055 ANGSTROMS
HISTORY ORDER  93 ZERO-POINT CORRECTION =  -0.054 ANGSTROMS
```

```
HISTORY ORDER  94 ZERO-POINT CORRECTION =  -0.055 ANGSTROMS
HISTORY ORDER  95 ZERO-POINT CORRECTION =  -0.058 ANGSTROMS
HISTORY ORDER  96 ZERO-POINT CORRECTION =  -0.052 ANGSTROMS
HISTORY ORDER  97 ZERO-POINT CORRECTION =  -0.051 ANGSTROMS
HISTORY ORDER  98 ZERO-POINT CORRECTION =  -0.053 ANGSTROMS
HISTORY ORDER  99 ZERO-POINT CORRECTION =  -0.050 ANGSTROMS
HISTORY ORDER 100 ZERO-POINT CORRECTION =  -0.052 ANGSTROMS
HISTORY ORDER 101 ZERO-POINT CORRECTION =  -0.050 ANGSTROMS
HISTORY ORDER 102 ZERO-POINT CORRECTION =  -0.047 ANGSTROMS
HISTORY ORDER 103 ZERO-POINT CORRECTION =  -0.046 ANGSTROMS
HISTORY ORDER 104 ZERO-POINT CORRECTION =  -0.045 ANGSTROMS
HISTORY ORDER 105 ZERO-POINT CORRECTION =  -0.044 ANGSTROMS
HISTORY ORDER 106 ZERO-POINT CORRECTION =  -0.043 ANGSTROMS
HISTORY ORDER 107 ZERO-POINT CORRECTION =  -0.043 ANGSTROMS
HISTORY ORDER 108 ZERO-POINT CORRECTION =  -0.042 ANGSTROMS
HISTORY ORDER 109 ZERO-POINT CORRECTION =  -0.041 ANGSTROMS
HISTORY ORDER 110 ZERO-POINT CORRECTION =  -0.040 ANGSTROMS
HISTORY ORDER 111 ZERO-POINT CORRECTION =  -0.039 ANGSTROMS
HISTORY ORDER 112 ZERO-POINT CORRECTION =  -0.038 ANGSTROMS
HISTORY ORDER 113 ZERO-POINT CORRECTION =  -0.037 ANGSTROMS
HISTORY ORDER 114 ZERO-POINT CORRECTION =  -0.036 ANGSTROMS
HISTORY ORDER 115 ZERO-POINT CORRECTION =  -0.035 ANGSTROMS
HISTORY ORDER 116 ZERO-POINT CORRECTION =  -0.033 ANGSTROMS
HISTORY ORDER 117 ZERO-POINT CORRECTION =  -0.032 ANGSTROMS
HISTORY ORDER 118 ZERO-POINT CORRECTION =  -0.031 ANGSTROMS
HISTORY ORDER 119 ZERO-POINT CORRECTION =  -0.030 ANGSTROMS
HISTORY ORDER 120 ZERO-POINT CORRECTION =  -0.029 ANGSTROMS
HISTORY ORDER 121 ZERO-POINT CORRECTION =  -0.027 ANGSTROMS
HISTORY ORDER 122 ZERO-POINT CORRECTION =  -0.026 ANGSTROMS
HISTORY ORDER 123 ZERO-POINT CORRECTION =  -0.025 ANGSTROMS
HISTORY ORDER 124 ZERO-POINT CORRECTION =  -0.024 ANGSTROMS
HISTORY ORDER 125 ZERO-POINT CORRECTION =  -0.022 ANGSTROMS
HISTORY
HISTORY SPACECRAFT VELOCITY:
HISTORY X= -2.59     Y= -1.57     Z=  1.90
HISTORY EARTH VELOCITY:
HISTORY X=-28.54     Y= -9.29     Z= -4.03
HISTORY NET CORRECTION VECTOR TO HELIOCENTRIC VELOCITY:
HISTORY X=-31.13     Y=-10.86     Z= -2.13
HISTORY HELIOCENTRIC VELOCITY CORRECTION: +19.59 KM/S
HISTORY END   TTDC                                  10-JAN-1997 03:09:50
HISTORY ************************************************************
HISTORY START CROSS-CORR                            10-JAN-1997 03:09:56
HISTORY WINDOW SIZE USED:    29 X  29 PIXELS
HISTORY TEMPLATE SIZE USED:  23 X  23 PIXELS
HISTORY ITF USED:  SWP85R92A
HISTORY   81.4 PERCENT SUCCESSFUL CORRELATIONS (415 OUT OF 510)
HISTORY MEDIAN CORRELATION COEFFICIENT: 0.385
HISTORY STANDARD DEVIATION OF CORRELATION COEFFICIENT: 0.140
HISTORY MEAN SHIFT IN PIXELS: 0.467
HISTORY MAXIMUM SHIFT IN PIXELS: 2.850
HISTORY NUMBER OF SUCCESSFUL SHIFTS FILTERED AS UNRELIABLE IN
HISTORY     POST-FILTER ROUTINE:   7
HISTORY END   CROSS-CORR                            10-JAN-1997 03:10:47
HISTORY ************************************************************
HISTORY START PHOTOM                                10-JAN-1997 03:10:54
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                                10-JAN-1997 03:12:24
HISTORY ************************************************************
HISTORY START GEOM                                  10-JAN-1997 03:12:26
HISTORY  INTERIM EPOCH ORDER SPATIAL DEVIATION CORRECTION APPLIED
```

```
HISTORY  DE-SPLAYING ANGLE OF -0.29E-04 RADIANS
HISTORY  PREDICTED CENTER LINE OF ORDER 100 - LINE 290.74
HISTORY END   GEOM                                10-JAN-1997 03:21:27
HISTORY ************************************************************
HISTORY START COSMIC_RAY                          10-JAN-1997 03:21:43
HISTORY  MEAN FN VALUE OF INTERORDER BACKGROUND =    9.566
HISTORY  13789 PIXELS GREATER THAN 2.000   SIGMA FLAGGED IN
HISTORY  COSMIC_RAY IMAGE
HISTORY END   COSMIC_RAY                          10-JAN-1997 03:22:08
HISTORY ************************************************************
HISTORY START BCKGRD                              10-JAN-1997 03:22:09
HISTORY  INTERORDER POINTS IDENTIFIED FOR POINT    SOURCE
HISTORY  GLOBAL BACKGROUND DETERMINATION SUCCESSFUL
HISTORY     NORMAL GRID INTERPOLATION
HISTORY END   BCKGRD                              10-JAN-1997 03:22:58
HISTORY ************************************************************
HISTORY START EXTRACT                             10-JAN-1997 03:23:01
HISTORY BOXCAR EXTRACTION
HISTORY NOISE MODEL USED: SWP VERSION 1.0
HISTORY
HISTORY **********************LARGE APERTURE DATA**********************
HISTORY
HISTORY MEAN SLIT HEIGHT FOR LARGE APERTURE POINT SOURCE USED FOR EACH ORDER
HISTORY  ORDER 100 FOUND AT LINE 290.51
HISTORY *** WARNING: ORDER 111 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY *** WARNING: ORDER 114 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY *** WARNING: ORDER 118 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY *** WARNING: ORDER 120 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY *** WARNING: ORDER 121 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY *** WARNING: ORDER 122 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY *** WARNING: ORDER 123 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY *** WARNING: ORDER 124 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY *** WARNING: ORDER 125 EXPLICIT CENTROID DETERMINATION INVALID.
HISTORY              FIDUCIAL CENTROID USED.
HISTORY
HISTORY  SWP RIPPLE CORRECTION VERSION 2.0 APPLIED.
HISTORY  ABSOLUTE FLUX CALIBRATION DERIVED FROM LOW DISPERSION FLUX
HISTORY  CALIBRATION.
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 =     5.604 SECONDS
HISTORY  TEMPERATURE-DEPENDENT SENSITIVITY CORRECTION APPLIED USING:
HISTORY       THDA OF IMAGE = 11.18
HISTORY       REFERENCE THDA =  9.40
HISTORY       TEMPERATURE COEFFICIENT = -0.0046
HISTORY       TEMPERATURE CORRECTION FACTOR =   1.008
HISTORY  SENSITIVITY DEGRADATION CORRECTION SWP VERSION 2.0 APPLIED USING:
HISTORY       MODE = LARGE APERTURE POINT SOURCE
HISTORY       CALIBRATION EPOCH = 1985.00
HISTORY       OBSERVATION DATE = 1990.027
HISTORY END   EXTRACT                             10-JAN-1997 03:23:20
HISTORY ************************************************************
HISTORY START FITSCOPY                            10-JAN-1997 03:23:24
END
```

12.3 Raw Image FITS File (RILO/RIHI)

The RI is the fundamental input for NEWSIPS. For the final archive, the original GO format RIs have been converted to FITS. Although the RI data remains unaltered, the VICAR label has been converted to FITS commentary keywords (including the conversion of the binary information to hexadecimal ASCII characters).

The RILO/RIHI contain a two-dimensional (2-D) primary array consisting of 768×768 pixels. 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 12.4.

During the preparation of input data for Final Archive processing, it was discovered that some low-dispersion partial read images were not properly registered for processing. These raw images are therefore shifted to put them into proper registration for future processing by NEWSIPS. In order to preserve the original (unaltered) data, the RILO contain both the corrected data in the primary array and the original unshifted RI data in an image extension. The format of the image extension data is identical to that described above for the primary array. Note that the RIHI are not affected, and in low dispersion only the corrected data, in the primary array, is used for further processing by NEWSIPS. The basic keywords for partial-read files are shown in Table 12.5.

Table 12.4: RILO/RIHI - 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 was written
ORIGIN = 'VILSPA '	Institution generating the file
DATAMIN = nnn.0	Minimum pixel value
DATAMAX = nnn.0	Maximum pixel value

Table 12.5: RILO Partial Read - 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
EXTEND = T	Extension exists
CTYPE1 = 'SAMPLE '	x-axis
CTYPE2 = 'LINE '	y-axis
BUNIT = 'DN '	Data Numbers
TELESCOP= 'IUE '	International Ultraviolet Explorer
FILENAME= 'AAAnnnnn.RILO'	Filename (camera)(number).RI(disp)
DATE = 'dd/mm/yy'	Date file was written
ORIGIN = 'VILSPA '	Institution generating the file
DATAMIN = nnn.0	Minimum pixel value
DATAMAX = nnn.0	Maximum pixel value
XTENSION= 'IMAGE '	Image extension
BITPIX = 8	Binary data
NAXIS = 2	Two-dimensional image
NAXIS1 = 768	Dimension of x-axis
NAXIS2 = 768	Dimension of y-axis
PCOUNT = 0	number of bytes following data matrix
GCOUNT = 1	number of groups
CTYPE1 = 'SAMPLE '	x-axis
CTYPE2 = 'LINE '	y-axis
BUNIT = 'DN '	Data Numbers
FILENAME= 'AAAnnnnn.ROLO'	Filename (camera)(number).RO(disp)
EXTNAME = 'RISV '	Original raw image

12.4 Linearized Image FITS File (LILO/LIHI)

The LILO/LIHI contains linearized (i.e., photometrically-corrected) pixels expressed in flux number (FN) units and situated in RI space. Only the pixels in a swath along the spectrum (low dispersion) and inside the target ring (high dispersion) have been photometrically corrected. The actual FN values have been scaled up by a factor of 32 for storage. The LILO/LIHI contains the LI as a 2-D primary array consisting of 768×768 pixels, with each pixel value coded as 16-bit, two's complement integers with bits stored in decreasing order of significance.

The associated ν flags are stored as a 2-D array the same size as the LI data, in a FITS image extension using 16-bit, two's complement integers. No scaling is used for the array of ν flags. For every pixel that is photometrically corrected, this image contains a corresponding ν flag describing specific error conditions (if applicable) in the LI. Flagged pixels include those which suffer from saturation, are close to the edge of the photometric correction region, or require ITF curve extrapolation to compute an FN value. In addition, all pixels that have not been photometrically corrected, or are known to suffer from bright spots, reseaux, microphonics and/or missing minor frames, are appropriately flagged. Checking for microphonic noise is performed over the entire 768×768 image for the LWR camera only. Each error condition is flagged by setting specific bits in the data quality integer array. (See Chapter 3 for more information on how the various error conditions are encoded.) Basic keywords in the main header and the image extension header are shown in Table 12.6.

Table 12.6: LILO/LIHI - 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 was 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 the x-axis
NAXIS2 = 768	Dimension along the 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 '	LIF pixel quality flags

12.5 Vector Displacement FITS File (VDLO/VDHI)

The VD defines the final SI coordinate values in the x (wavelength) and y (spatial) directions for every LI pixel. The final coordinates in SI space for any photometrically-corrected pixel in the LILO/LIHI are determined by:

$$x_{final} = VD(i,j,1) - x\_offset(cam, disp)$$

$$y_{final} = VD(i,j,2) - y\_offset(cam, disp)$$

where i and j range from 1 to 768, and x_offset and y_offset are given in the following table.

	x_offset		y_offset	
	disp=L	H	L	H
LWP	100	0	297	0
LWR	100	0	250	0
SWP	130	0	490	0

The output displacements between the SI and LI coordinates are recoverable by:

$$DELTA_x = VD(i,j,1) - i \quad \text{and} \quad DELTA_y = VD(i,j,2) - j,$$

where i and j range from 1 to 768. x_{final} and y_{final} contain the final x and y coordinates in the SILO/SIHI. The x and y coordinates of the displacement vectors are stored as a 3-D primary array consisting of 768x768x2 elements. The displacements are coded as 32-bit, floating point numbers.

The XC allow the user to recover the calculated displacement vectors, mapping the science image (in 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, the binary table extension will contain the following columns of information: science image x-position (I*2), science image y-position (I*2), ITF x-position at position of best match (R*4), ITF y-position at position of best match (R*4), the cross-correlation coefficient (R*4), number of points used to calculate the coefficient (I*2), and the ITF level used in the correlation (I*2). The x and y positions correspond to the sample and line numbers in the RI. The resulting ITF positions of the best match are pre-filtered positions (before invalid 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.

Basic keywords in the VDLO/VDHI headers and binary table extensions are shown in Table 12.7. Note that the CTYPE1 and CTYPE3 keyword values listed and as stored in the archived VDLO/VDHI are incorrect and should be interchanged. Unfortunately, this error was not discovered until the majority of images were processed and so was left uncorrected for consistency. Note also that the VDLO/VDHI will not be available for images processed at VILSPA, nor for images processed at GSFC after July 31, 1997.

Table 12.7: VDLO/VDHI - 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 = 768	Dimension along x-axis
NAXIS2 = 768	Dimension along y-axis
NAXIS3 = 2	Dimension along z-axis
EXTEND = T	Extensions are present
CTYPE1 = ' '	Units x-axis
CTYPE2 = 'PIXEL '	Units y-axis
CTYPE3 = 'PIXEL '	Units z-axis
BUNIT = 'PIXEL '	Pixel units
TELESCOP= 'IUE '	International Ultraviolet Explorer
FILENAME= 'AAAnnnnn.VDdd'	Filename(camera)(number).VD(disp)
DATE = 'dd/mm/yy'	Date file was 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 table array
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 '	Count and data type for field 1
TTYPE1 = 'XRAW '	Science image x-position
TUNIT1 = 'PIXEL '	Unit is pixels
TFORM2 = '1I '	Count and data type for field 2
TTYPE2 = 'YRAW '	Science image y-position
TUNIT2 = 'PIXEL '	Unit is pixel
TFORM3 = '1E '	Count and data type for field 3
TTYPE3 = 'XITF '	ITF x-position of best match
TUNIT3 = 'PIXEL '	Unit is pixel
TFORM4 = '1E '	Count and data type for field 4
TTYPE4 = 'YITF '	ITF y-position of best match
TUNIT4 = 'PIXEL '	Unit is pixel
TFORM5 = '1E '	Count and data type for field 5
TTYPE5 = 'XCOEFF '	Cross correlation coefficient
TUNIT5 = ' '	Unitless
TFORM6 = '1I '	Count and data type for field 6
TTYPE6 = 'NPOINTS '	Number of points used
TUNIT6 = ' '	Unitless
TFORM7 = '1I '	Count and data type for field 7
TTYPE7 = 'ITFLEVEL'	ITF level
TUNIT7 = ' '	Unitless
FILENAME= 'AAAnnnnn.XCdd'	Filename (camera)(number).XC(disp)
EXTNAME = 'XCOEFF '	Cross correlation coefficients

12.6 Low-Dispersion Resampled Image FITS File (SILO)

The low-dispersion SI is produced by resampling the photometrically-corrected portion of the low-dispersion LI 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 computed for:

- shift to photometric correction (ITF) raw space,
- shift from ITF space to geometrically-rectified space,
- rotation such that orders are horizontal,
- wavelength linearization,
- detilting of large-aperture spectra for extended sources only,
- alignment of the apertures for constant wavelength in the line direction,
- adjustment so that both long wavelength cameras provide coverage of the same spectral range,
- adjustment to maintain the spectrum at approximately the same location in the file in the spatial direction,
- adjustment to LWP data to put the large-aperture data at the top of the file, and
- corrections for the spatial deviations (cross-dispersion wiggles) for LWP and LWR data.

The low-dispersion SI is stored in the SILO as a 2-D (640 samples $\times$ 80 lines) primary array, with the y coordinate in pixels and the x coordinate in Ångstroms. Each pixel represents a flux number (FN) scaled up by a factor of 32 for storage purposes. The pixels are coded as 16-bit, two's complement integers, with the bits stored in decreasing order of significance. When the image is displayed with the origin in the lower left corner, the large-aperture data appears at the top of the file and the wavelengths increase from left to right. The associated ν flags are stored as a SILO image extension, which has the same dimensions as the primary array. Table 12.8 shows the basic FITS keywords for the main header and the image extension header. The starting wavelength and wavelength increment are stored as keywords in the primary header.

Table 12.8: SILO - Basic FITS Keywords

Keyword and value	Description
SIMPLE = T	Standard FITS Format
BITPIX = 16	16-bits 2's complement pixels
NAXIS = 2	Two-dimensional image
NAXIS1 = 640	Dimension along x-axis
NAXIS2 = 80	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'	Units along x-axis
CTYPE2 = 'SCAN '	Units along 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.SILO'	Filename(camera)(number).SILO
DATE = 'dd/mm/yy'	Date file was 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 = 640	Dimension along the x-axis
NAXIS2 = 80	Dimension along the 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 the x-axis
CDELT2 = 1.	Increment unit along the y-axis
CTYPE1 = 'WAVELENGTH'	x-axis units
CTYPE2 = 'SCAN '	y-axis units
BUNIT = ' '	Unitless
FILENAME= 'AAAnnnnn.SFLO'	Filename (camera)(number).SF(disp)
EXTNAME = 'SILOF '	SILO pixel quality flags

12.7 High-Dispersion Resampled Image FITS File (SIHI)

The SIHI contains more information than stored in the corresponding low-dispersion file and, as a result, the FITS format is slightly more complex. Overall, the SIHI is comprised of a primary array containing the resampled image, a binary table of wavelengths and both predicted and found line positions, an image extension of ν flags, and a second image extension of background cosmic ray flags.

The high-dispersion SI data is similar to the low-dispersion SI data except that the high-dispersion wavelength linearization varies with spectral order, and the entire image is stored in the primary array. Each pixel is resampled to the position determined by the summation of the vectors computed for:

- shift to photometric correction (ITF) raw space,
- shift from ITF space to geometrically-rectified space,
- rotation such that orders are horizontal,
- wavelength linearization,
- adjustment to maintain the echelle orders at approximately the same locations in the file in the spatial direction,
- corrections for the spatial deviations (cross-dispersion wiggles) for LWP, LWR, and SWP data,
- heliocentric velocity correction, and
- de-splaying correction.

The high-dispersion SI is stored in the SIHI as a 2-D (768 samples $\times$ 768 lines) primary array. Each pixel represents an FN scaled up by a factor of 32 for storage purposes. The pixels are coded as 16-bit, two's complement integers, with the bits stored in decreasing order of significance. When the image is displayed with the origin in the lower left corner, the short-wavelength, closely-spaced high order numbers appear at the bottom, and the long-wavelength, low order numbers appear at the top. Within each order, the wavelengths increase from left to right.

Because the wavelength linearization varies with spectral order, the starting wavelength and wavelength increment values vary with each order. This information is stored in a binary table extension to the SIHI, which follows the primary array. The entire contents of the binary table extension include:

- Order Number, one 8-bit integer.
- Starting wavelength, one double-precision floating point number. Heliocentric velocity correction has been applied.

- Wavelength increment, one double-precision floating point number.
- predicted line position of order centroid, one single-precision floating point number.
- line position where spectral centroid is found, one single-precision floating point number. (This is determined by the high-dispersion spectral flux extraction module and written back into the SIHI file retroactively.)

The associated ν flags and cosmic ray flags are stored in the SIHI image extensions with the same dimensions and orientation as the high-dispersion SI data contained in the primary array. The pixel quality flags are stored as unscaled 16-bit integers, and the cosmic ray flags are unscaled 8-bit integers. Table 12.9 shows the basic FITS keywords for the main and extension headers for the SIHI.

Table 12.9: SIHI - Basic FITS Keywords (continued on next page)

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.SIHI'	Filename (camera)(number).SIHI
DATE = 'dd/mm/yy'	Date file was written
ORIGIN = 'VILSPA '	Institution generating the file
DATAMIN = nnnnn.n	Minimum pixel value
DATAMAX = nnnnn.n	Maximum pixel value
XTENSION= 'BINTABLE'	Binary table extension
BITPIX = 8	Binary data
NAXIS = 2	Two-dimensional table array
NAXIS1 = 25	Width of table in bytes
NAXIS2 = nn	Number of entries in table
PCOUNT = 0	Number of bytes following data matrix
GCOUNT = 1	Only one group
TFIELDS = 5	Number of fields in each row
TFORM1 = '1B '	8-bit byte
TTYPE1 = 'ORDER '	Order number
TUNIT1 = ' '	Unitless
TFORM2 = '1D '	Double precision floating point
TTYPE2 = 'WAVELENGTH'	Starting wavelength
TUNIT2 = 'ANGSTROM'	Unit is angstroms
TFORM3 = '1D '	Double precision floating point
TTYPE3 = 'DELTAW '	3rd field is wavelength increment
TUNIT3 = 'ANGSTROM'	Unit is angstrom
TFORM4 = '1E '	Single precision floating point
TTYPE4 = 'LINE_PREDICTED'	Predicted line position of order centroid
TUNIT4 = 'PIXEL '	Unit is pixel
TFORM5 = '1E '	Single precision floating point
TTYPE5 = 'LINE_FOUND'	Line number where spectral centroid is found
TUNIT5 = 'PIXEL '	Unit is pixel
FILENAME= 'AAAnnnnn.WLHI'	Filename (camera)(number).WLHI
EXTNAME = 'SIHIW '	Name of table

Table 12.9 SIHI File - continued

Keyword and value	Description
XTENSION= 'IMAGE '	Image extension
BITPIX = 16	16-bit 2's complement pixels
NAXIS = 2	Two-dimensional image
NAXIS1 = 768	Dimension of x-axis
NAXIS2 = 768	Dimension of 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.SFHI'	Filename (camera)(number).SF(disp)
EXTNAME = 'SIHIF '	SIHI pixel quality flags
XTENSION= 'IMAGE '	Image extension
BITPIX = 8	8-bit integer pixels
NAXIS = 2	Two-dimensional image
NAXIS1 = 768	Dimension of x-axis
NAXIS2 = 768	Dimension of 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.CRHI'	Filename (camera)(number).CR(disp)
EXTNAME = 'SIHIC '	SIHI cosmic ray background flags

12.8 Low-Dispersion Merged Extracted Image FITS File (MXLO)

The data extracted from the low-dispersion SI are stored in the MXLO using a binary table extension with fixed-length floating point vectors to contain the extracted fluxes and associated ν flags. Since no primary data are included, the extension header immediately follows the primary header. Each row of the binary table includes the following columns:

- Aperture designation as 'LARGE' or 'SMALL', stored in 5 ASCII characters.
- Number of extracted points, one 16-bit integer. The number of extracted points is always 640.
- Starting wavelength, one single-precision floating point value.
- Wavelength increment, one single-precision floating point value.
- Net flux spectrum, array with 640 single-precision floating point values.
- Background flux spectrum, array with 640 single-precision floating point values.
- Sigma vector, array with 640 single-precision floating point values.
- ν flags, array of 640 16-bit integers stored in two's complement form.
- Absolutely-calibrated net flux spectrum, array with 640 single-precision floating point values.

Wavelengths are linearly sampled to a uniform step size and measured in vacuum. Double aperture low-dispersion spectra will contain two rows in the above format, with one row for each aperture (LARGE first, then SMALL). Note the NAXIS1 keyword in the Binary table extension defines the number of bytes per row in the table and is equal to $15 + 18 * 640$, or 11,535 bytes.

The absolute calibration covers the range of 1150–1980Å for short-wavelength spectra and 1850–3350Å for long-wavelength spectra. Since the NEWSIPS software extracts data over a slightly larger wavelength range, data points outside this wavelength range are set to 0 in the absolutely-calibrated flux vector and -1 in the sigma vector. The net and background vectors are not affected. The uncalibrated data points are also flagged in the ν flag vector with the value of -2. Table 12.10 shows the basic FITS Keywords for the MXLO.

Table 12.10: MXLO - 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	Bytes per row (15+18*NPOINTS)
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 columns in the table
TFORM1 = '5A '	Count and data type of field 1
TTYPE1 = 'APERTURE'	Aperture type (large or small)
TUNIT1 = ' '	Unitless
TFORM2 = '1I '	Field 2 has one 2-byte integer
TTYPE2 = 'NPOINTS '	Number of points
TUNIT2 = ' '	Unitless
TFORM3 = '1E '	Count and data type of field 3
TTYPE3 = 'WAVELENGTH'	3rd field is starting wavelength
TUNIT3 = 'ANGSTROM'	Unit is angstrom
TFORM4 = '1E '	Count and data type of field 4
TTYPE4 = 'DELTAW '	4th field is wavelength increment
TUNIT4 = 'ANGSTROM'	Unit is Angstrom
TFORM5 = '640E '	Count and data type of field 5
TTYPE5 = 'NET '	5th field is net flux array
TUNIT5 = 'FN '	Unit is IUE FN
TFORM6 = '640E '	Count and data type of field 6
TTYPE6 = 'BACKGROUND'	6th field is background flux array
TUNIT6 = 'FN '	Unit is IUE FN
TFORM7 = '640E '	Count and data type of field 7
TTYPE7 = 'SIGMA '	7th field is the sigma
TUNIT7 = 'ERG/CM2/S/A'	Unit is erg/cm2/sec/Angstrom
TFORM8 = '640I '	Count and data type of field 8
TTYPE8 = 'QUALITY '	8th field is the data quality flag
TUNIT8 = ' '	Unitless
TFORM9 = '640E '	Count and data type of field 9
TTYPE9 = 'FLUX '	9th field is the 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

12.9 High-Dispersion Merged Extracted Image FITS File (MXHI)

The wavelengths, ν flags, and fluxes extracted from the SIHI are stored in the MXHI as a binary table extension using fixed-length floating point vectors. No primary data or additional extensions are included.

The binary table contains 17 fields of various data types. All vectors are padded with zeroes (both before and after the extracted data) to maintain a fixed length of 768 points. Wavelengths are uniformly sampled for each order, are measured in vacuum, and have had the heliocentric velocity correction applied. The width of each row (i.e., `NAXIS1`) is $65+22\times768 = 16,961$ bytes, and the number of rows (i.e., `NASIX2`) is equal to the number of extracted orders. In this manner, all the information pertaining to one spectral order is contained in one row of the binary table. The fields are defined in the order shown below:

- Order number, one 8-bit byte.
- Number of extracted points `n`, one 16-bit integer.
- Starting wavelength, one double-precision floating point value.
- Starting pixel at starting wavelength, one 16-bit integer.
- Wavelength increment, one double-precision floating point value.
- Slit height in pixels, one single-precision floating point number.
- Line number for found centroid of spectrum, one single-precision floating point number.
- Net flux spectrum, 768 single-precision floating point numbers with `n` extracted data points.
- Background flux spectrum, 768 single-precision floating point numbers with `n` extracted data points.
- Noise vector, 768 single-precision floating point numbers with `n` extracted data points.
- ν flags as `n` 16-bit integers stored in two's complement form.
- Ripple-corrected net flux spectrum, 768 single-precision floating with `n` extracted data points.
- Absolutely-calibrated, ripple-corrected net flux spectrum, 768 single-precision floating point numbers. with `n` extracted data points.
- Start pixel for background fit, one 16-bit integer number.*
- End pixel for background fit, one 16-bit integer number.*

- Chebyshev scale factor, one single-precision floating point number.*
- Chebyshev polynomial coefficients for global background correction, 7 single-precision floating point numbers.*

Note that unlike the MXLO, SILO, and SIHI, the starting wavelengths listed in the MXHI table do not refer to the first data point in the flux vectors, but rather the starting pixel listed in field four. In this manner, the 768-point flux vector can be mapped directly to the 768-pixel wide high-dispersion SI array.

As in low dispersion, since the absolute calibration covers the range of 1150–1980Å for short-wavelength spectra and 1850–3350Å for long-wavelength spectra, data points outside this wavelength range are set to 0 in the absolutely-calibrated flux vector. The net, background, and noise vectors are not affected. (Note that unlike the sigma vector in the MXLO file, the MXHI noise vector is uncalibrated.) Uncalibrated data points are also flagged in the ν flag vector with a value of -2. Table 12.11 shows the basic FITS Keywords for the MXHI.

* **IMPORTANT NOTE**: Several adjustments must be made to the last four parameters (fields 14–17) if the user wishes to evaluate the Chebyshev coefficients in order to reproduce the background fluxes as stored in the ninth field of the MXHI extension header. First, the parameters have inadvertently been stored in the reverse order (i.e., the parameters written in the first row of the table should have been stored in the last row, the parameters for the second row in the second to last row, etc.). So, for example, in the case of the LWR camera, the starting and ending pixels, Chebyshev scale factor, and Chebyshev coefficients found in row 1 (echelle order 127) actually pertain to row 61 (echelle order 67). Second, the true starting pixel is 768 minus the stored ending pixel and the true ending pixel is 768 minus the stored starting pixel. These true pixel values must be used to correctly evaluate the Chebyshev coefficients. Third, once the Chebyshev coefficients have been evaluated, the resultant background "fluxes" must be scaled in the following manner: multiply each background value by both the Chebyshev scale factor and the corresponding extraction slit height then divide this result by 32. Finally, the resultant array of background fluxes which are produced upon evaluation of the Chebyshev coefficients must be reversed (i.e., the computed background flux for pixel 1 becomes the background flux for pixel 768 and vice versa). We emphasize that these reversals and scalings are needed *only* when using the Chebyshev parameters in fields 14–17 to reproduce the background fluxes–the background fluxes themselves as contained in the ninth field are correct.

Table 12.11: MXHI - Basic FITS Keywords (continued on next page)

Keyword and value	**Description**
SIMPLE = T	Standard FITS Format
BITPIX = 8	Binary data
NAXIS = 0	No image data
EXTEND = T	Extensions are present
TELESCOP= 'IUE '	International Ultraviolet Explorer
DATE = 'dd/mm/yy'	Date file was written
ORIGIN = 'VILSPA '	Institution generating the file
XTENSION= 'BINTABLE'	Binary table extension
BITPIX = 8	Binary data
NAXIS = 2	Two-dimensional table array
NAXIS1 = 16961	Width of row in bytes
NAXIS2 = nn	Number of orders
PCOUNT = 0	Number of bytes following data matrix
GCOUNT = 1	Only one group
TFIELDS = 17	Number of columns in the table
TFORM1 = '1B '	8-bit byte
TTYPE1 = 'ORDER '	Order number
TUNIT1 = ' '	Unitless
TFORM2 = '1I '	16-bit integer
TTYPE2 = 'NPOINTS '	Number of non-zero points
TUNIT2 = ' '	Unitless
TFORM3 = '1D '	Double precision
TTYPE3 = 'WAVELENGTH'	Starting wavelength
TUNIT3 = 'ANGSTROM'	Unit is Angstrom
TFORM4 = '1I '	16-bit integer
TTYPE4 = 'STARTPIX'	Starting pixel at starting wavelength
TUNIT4 = 'PIXEL '	Unit is pixel
TFORM5 = '1D '	Double precision value
TTYPE5 = 'DELTAW '	Wavelength increment
TUNIT5 = 'ANGSTROM'	Unit is Angstrom
TFORM6 = '1E '	Single precision
TTYPE6 = 'SLIT HEIGHT'	Height of extraction slit
TUNIT6 = 'PIXEL '	Unit is pixel
TFORM7 = '1E '	Single precision
TTYPE7 = 'LINE_FOUND'	Line number where spectral centroid is found
TUNIT7 = 'PIXEL '	Unit is pixel

Table 12.11 MXHI - continued

Keyword and value	Description
TFORM8 = '768E '	Single precision array
TTYPE8 = 'NET '	Net flux array
TUNIT8 = 'FN '	Unit is IUE Flux Number (FN)
TFORM9 = '768E '	Single precision array
TTYPE9 = 'BACKGROUND'	Background flux array
TUNIT9 = 'FN '	Unit is IUE Flux Number(FN)
TFORM10 = '768E '	Single precision array
TTYPE10 = 'NOISE '	Noise spectrum
TUNIT10 = 'FN '	Unit is IUE Flux Number (FN)
TFORM11 = '768I '	16-bit integer array
TTYPE11 = 'QUALITY '	Data quality flag
TUNIT11 = ' '	Unitless
TFORM12 = '768E '	Single precision array
TTYPE12 = 'RIPPLE '	Ripple-corrected net flux array
TUNIT12 = 'FN '	Unit is IUE Flux Number (FN)
TFORM13 = '768E '	Single precision array
TTYPE13 = 'ABS_CAL '	Absolutely-calibrated net flux
TUNIT13 = 'ERGS/CM2/S/A'	Unit is ergs/cm2/sec/Angstrom
TFORM14 = '1I '	16-bit integer
TTYPE14 = 'START-BKG'	Beginning pixel of background fit
TUNIT14 = 'PIXEL '	X-axis in SIHI image
TFORM15 = '1I '	16-bit integer
TTYPE15 = 'END-BKG '	End pixel of background fit
TUNIT15 = 'PIXEL '	X-axis in SIHI image
TFORM16 = '1E '	Single precision
TTYPE16 = 'SCALE_BKG'	Chebychev scale factor
TUNIT16 = ' '	Unitless
TFORM17 = '7E '	Single precision array
TTYPE17 = 'COEFF '	Chebychev coefficients of background fit
TUNIT17 = ' '	Unitless
FILENAME= 'AAAnnnnn.MXHI'	Filename (camera) (number) .MXHI
EXTNAME = 'MEHI '	Name of table