IUE Final Archive Data Products

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The output files for the *IUE* Final Archive is 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 in FITS format. Table 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 2 gives the same data for the files which will be available for high-dispersion images. Table 3 lists the FES data to be included in the Final Archive.

I. 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.

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 (extension of the `VD` file)

  `LI` linearized image

  `LF` flags associated with the linearized image

  `SI` resampled image

  `SF` flags associated with the resampled image

  `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, would be 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, would be

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 would therefore have both sets of files in the archive. Note that this applies to the raw image file as well as the processed files, due to the dispersion dependent Core Data Items (CDIs) involved.

II. Raw Image

The *IUE* raw image (RI) 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 remains unaltered.

The RI FITS file contains a two-dimensional primary array consisting of 768×768 pixels, with no group structure or extensions. Each pixel is a data number (DN), coded as an 8 bits unsigned integer ranging from 0 to 255. The Basic Keywords are shown in Table 4.

III. Linearized Image

The Linearized Image is a full image 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 down by a factor of 32 for storage.

The LI 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

Table 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
Cross-correlation Coefficients	.XCLO	7x~140	R*4	table extension
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
Extracted Low-Disp Spectra	.MXLO	640x5	8-bit	binary table extension

Table 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
Cross-correlation Coefficients	.XCHI	7x~500	R*4	table extension
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
Extracted High-Disp Spectra	.MXHI	TBD	8-bit	binary table extension
Concatenated High-Disp Spectra	.WHHI	TBD	8-bit	binary table extension

Table 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 4: RI 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

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 5.

IV. Linearized Flag Image

This file is the same size as the LI file. For every pixel that is photometrically corrected, this file contains a ν flag for specific error conditions in the corresponding pixel in the LI image. The values are stored as integer. The ν flags are inherently 2 bytes (negative values). In addition, all pixels on the target region which have not been photometrically corrected but are known to suffer from bright spots, 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.

V. Resampled Image

This image is produced by resampling the photometrically corrected portion of the LI image using the modified Shepard algorithm. 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,
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. heliocentric velocity correction for high dispersion,
11. de-splaying correction for high-dispersion data, and
12. order centroiding for high-dispersion data.

Table 5: LI 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 '	pixel quality flags

The Resampled Image (SILO) 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. Both large and small-aperture data are present in one resampled image for low-dispersion data. The FITS header will indicate center line for large-aperture and for small-aperture data.

The SILO image is stored as a two-dimensional primary array consisting of 640×80 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 and have the same dimensions as the primary array. Table 6 shows the basic FITS Keywords for the main header and the image extension header.

VI. Resampled Flag Image

This image 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 or SIHI image. The values are stored as I*2.

VII. Vector Displacement File

This file provides, for each pixel in the LI 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 image. In order to determine the final coordinates in the "resampled image" (the SILO or SIHI file) for any photometrically corrected pixel in the LI 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 the low-dispersion x and y offsets are as follows:

LWP: (~100,~297)

LWR: (~100,~250)

SWP: (130,490)

The high-dispersion offsets are zero in x and y.

The displacement vectors are recoverable by:

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

and

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

Table 6: SILO 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 = 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'	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.SILO'	Filename (camera)(number).SILO
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 = 640	Dimension along x-axis
NAXIS2 = 80	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.SFLO'	Filename (camera)(number).SFLO
EXTNAME = 'SILOF '	SILO pixel quality flags

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 displacements are the combination of vectors computed for: (1)photometric registration as calculated by the cross-correlation algorithm, (2)geometric correction defined as aligning the reseaux into a rectilinear grid, (3)rotation such that the spectral format lies along the horizontal, (4)wavelength linearization, (5)detilting of the large aperture (for extended sources only), (6)alignment of the apertures such that wavelength is constant in the line direction, (7)adjustment in the dispersion direction so that both LW cameras cover the same spectral range, (8)spatial adjustment such that the large-aperture spectrum is always approximately located at the same location in the file, (9)coordinate remapping so that the LWP large-aperture spectrum resides in the top half of the file (matching the other two cameras), and (10)desplaying, order centroiding, and heliocentric velocity correction of the spectral orders for high-dispersion data. The final coordinate values are coded as 32 bits, R*4 numbers.

The cross-correlation coefficients for each of the ~140 low-dispersion points (~500 for high dispersion) used to obtain the displacement between the science image and the corresponding level of the ITF, are to be stored as a binary 3-D table extension. This table will contain:

1. science image x-position (I*2),
2. science image y-position (I*2),
3. ITF x-position of best match (R*4),
4. ITF y-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 by the algorithm (I*2).

Basic Keywords in the VD file header and in the table extension are shown in Table 7

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.

VIII. Extracted Low-Dispersion Spectra

The Extracted Low-Dispersion (MELORES) file will use 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.

Table 7: VD 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. 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 as an array of 640 16-bit integers.

9. Abs. calibrated net flux spectrum, array with 640 single precision floating point values.

Wavelengths are assumed to be uniformly sampled, and measured in vacuum. Double aperture low-dispersion spectra will contain two rows in the above format, with one row for each aperture. Table 8 shows the basic FITS Keywords for the MELORES file.

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

IX. 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 similiar 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 9.

Table 8: MELORES 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	= 'MELO '	name of table

Table 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