GMT Software and Controls Data Product Files

Release 1.4-1

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Sep 01, 2018

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INTRODUCTION

This report provides a list of the FITS data product files produced by the Data Processing Subsystem.

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THREE

FITS-STANDARD DATA CONTAINERS

A minimum set of keywords are mandatory to define the FITS standard containers. The mandatory keywords shown below define empty storage containers. The mandatory keywords must appear in the numeric order shown below; no other keywords may intervene.

3.1 Primary HDU (PHDU)

Description: This is a basic model that defines the primary header data unit, or PRI, of a FITS container. This model creates an empty storage container.

Format: Position attribute 'pos' defines the order in the FITS header; 0 specifies no particular location. The last keyword in the header must be END.

File: <inst>_PRI.fits

Table 3.1: Primary HDU: Basic FITS Primary Header Data Unit

Keyword	Description	Value/Table Format	Type	HDU
SIMPLE	Indicates whether the file conforms to the standard	T	boolean	PRI
BITPIX	Bits per data value	8	integer	PRI
NAXIS	Number of axes	2	integer	PRI
NAXIS1	Size along the axis 1 dimension		integer	PRI
NAXIS2	Size along the axis 2 dimension		integer	PRI
END	Marks the end of the header keywords			PRI

3.2 Extension HDU: Image

Description: This is a basic model that defines an empty FITS storage container for an image extension. This base 'image' defines an area of 1024 columns and 1024 rows.

Format: The header keywords must follow the order shown, i.e. the first keyword must be XTENSION = 'IMAGE ', the second BITPIX = 16, and so on. The last keyword in the header must be END.

File: <inst>_bimg.fits

Table 3.2: Extension HDU: Basic FITS Image Extension

Keyword	Description	Value/Table Format	Type	HDU
EXTEND	Indicates whether the FITS file contain extensions	T	boolean	PRI
XTENSION	Marks beginning of new HDU	IMAGE	string	EXT
BITPIX	Bits per data value	16	integer	EXT
NAXIS	Number of axes	2	integer	EXT
NAXIS1	Size along the axis 1 dimension		integer	EXT
NAXIS2	Size along the axis 2 dimension		integer	EXT
PCOUNT	Parameter Count		integer	EXT
GCOUNT	Group count	1	integer	EXT
END	Marks the end of the header keywords			EXT

3.3 Extension HDU: ASCII Table

Description: This is a basic model that defines an empty FITS storage container for an ASCII table extension. An ASCII table can store catalogues and tables of data. Each row of the table has a fixed length of ASCII characters, divided into columns by TBCOLn. This base 'table' defines an area of ASCII text that has one column which is 80 characters wide and 100 rows deep.

Format: The header keywords must follow the order shown, i.e. the first keyword must be XTENSION = 'TABLE ', the second BITPIX = 16, and so on. The last keyword in the header must be END.

File: <inst>_atbl.fits

Table 3.3: Extension HDU: Base ASCII Table

Keyword	Description	Value/Table Format	Type	HDU
EXTEND	Indicates whether the FITS file contain extensions	T	boolean	PRI
XTENSION	Marks beginning of new HDU	TABLE	string	EXT
BITPIX	Bits per data value	16	integer	EXT
NAXIS	Number of axes	2	integer	EXT
NAXIS1	Size along the axis 1 dimension		integer	EXT
NAXIS2	Size along the axis 2 dimension		integer	EXT
PCOUNT	Parameter Count		integer	EXT
GCOUNT	Group count	1	integer	EXT
TFIELDS	Number of columns in the table	1	integer	EXT
TTYPE1	Column name		string	EXT
TBCOL1	Beginning column number	1	integer	EXT
TFORM1	Column data format		string	EXT
END	Marks the end of the header keywords			EXT

3.4 Extension HDU: Binary Table

Description: This is a basic model that defines an empty FITS storage container for an binary table extension. This base 'table' defines storage for 1 column and 100 rows of integers, where each row has 1024 bytes in width.

Format: The header keywords must follow the order shown, i.e. the first keyword must be XTENSION = 'BINTABLE', the second BITPIX = 16, and so on. The last keyword in the header must be END.

File: <inst>_btbl.fits

Table 3.4: Extension HDU: Basic Binary Table Extension

Keyword	Description	Value/Table Format	Type	HDU
EXTEND	Indicates whether the FITS file contain extensions	T	boolean	PRI
XTENSION	Marks beginning of new HDU	BINTABLE	string	EXT
BITPIX	Bits per data value	16	integer	EXT
NAXIS	Number of axes	2	integer	EXT
NAXIS1	Size along the axis 1 dimension		integer	EXT
NAXIS2	Size along the axis 2 dimension		integer	EXT
PCOUNT	Parameter Count		integer	EXT
GCOUNT	Group count	1	integer	EXT
TFIELDS	Number of columns in the table	1	integer	EXT
TTYPE1	Column name	Col	string	EXT
TFORM1	Column data format	1024I	string	EXT
TUNIT1	Column units	Counts	string	EXT
END	Marks the end of the header keywords			EXT

CHAPTER

FOUR

COMMON DATA PRODUCT PATTERNS

This section contain keywords that are commonly found in uncalibrated and calibrated data products.

4.1 Base Exposure Primary HDU (PHDU)

Description: This is a basic model that specifies baseline headers that are found in an GMT exposure. This ought to be inherited by all imaging and spectroscopy exposures.

Format: Standard FITS Image

File: <inst>_PRI.fits

Table 4.1: Primary HDU: Base Exposure

Keyword	Description	Value/Table Format	Type	HDU
DATE	Date of file creation	YYYY-MM-DDTHH:MM:SS[.sss]	string	PRI
IRAF-TLM	(IRAF-TLM) Time of last modification [To be Deleted?]		string	PRI
NEXTEND	The number of standard extensions [To be Deleted?]		integer	PRI
ORIGIN	Organization or person responsible for the data		string	PRI
ROOTNAME	Rootname of the observation set		string	PRI
FILENAME	Name of the originating data file		string	PRI
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)		string	PRI
TELESCOP	Name of telescope	GMT	string	PRI
INSTRUME	Name of instrument		string	PRI
EQUINOX	Equinox of celestial coordinate system		float	PRI
PROPOSID	Proposal ID		string	PRI
pr_inv_l[TBD]	[TBD]	[TBD]	[TBD]	PRI
pr_inv_f[TBD]	[TBD]	[TBD]	[TBD]	PRI
pr_inv_m[TBD]	[TBD]	[TBD]	[TBD]	PRI
TARGNAME	Target name		string	PRI
OBJECT	Name or type of observed object		string	PRI
RA_TARG	Right ascension of the target in mean places of equinox		float	PRI
DEC_TARG	Declination of the target in mean places of equinox		float	PRI

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Keyword	Description	Value/Table Format	Type	HDU
TEQUINOX	Equinox of the target		float	PRI
EXPNAME	Exposure identifier		string	PRI
DATE-OBS	Date of the observation	YYYY-MM-DD	string	PRI
TIME-OBS	[Deprecated in favor of DATE-OBS] UT time of start of observation (hh:mm:ss)	HH:MM:SS[.sss]	string	PRI
EXPSTART	[Deprecated in favor of TSTART] Exposure start time (Modified Julian Date)		float	PRI
EXPEND	[Deprecated in favor of TSTOP] Exposure end time (Modified Julian Date)		float	PRI
EXPTIME	[Deprecated in favor of XPOSURE] On-detector, open-shutter, integration time (seconds)		float	PRI
NRPTEXP	Number of repeat exposures in set: default 1	1	integer	PRI
CRSPLIT	Number of cosmic ray split exposures		integer	PRI
QUALCOM1	Data quality comment n		string	PRI
QUALCOM2	Data quality comment n		string	PRI
QUALCOM3	Data quality comment n		string	PRI
QUALITY	Data quality summary		string	PRI
POSTARG1	Telescope Offset in axis 1 direction (usually x)		float	PRI
POSTARG2	Telescope Offset in axis 2 direction (usually y)		float	PRI
EQNX_OFF	Equinox of the offset, in case different from target equinox		float	PRI
OBSTYPE	Observation type - imaging or spectroscopic		string	PRI
OBSMODE	GMT Observing mode		string	PRI
PHOTMODE	Observation configuration mode for photometric calibration		string	PRI
SCLAMP	Lamp status, NONE or name of lamp which is on		string	PRI
LAMP_ID	Lamp ID		string	PRI
LAMP_VOL	Lamp voltage status		float	PRI
SUBARRAY	Data from a subarray (T) or full frame (F)	F	boolean	PRI
DETECTOR	Detector name in use		string	PRI
CMDGAIN	Commanded A-to-D conversion gain of detector		float	PRI
OPT_ELEM	Optical element in use		string	PRI
PROPAPER	Aperture specified in an observing proposal		string	PRI
APERTURE	Aperture name		string	PRI
APER_FOV	Aperture field of view		string	PRI
FILTER	Filter name selected from filter wheel		string	PRI
CENWAVE	Proposed central wavelength of spectrum		integer	PRI
ATODGN$1	Measured gain for amplifier n		float	PRI

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Keyword	Description	Value/Table Format	Type	HDU
RDNOISE$1	Measured readnoise for amplifier n		float	PRI
DETOFFSt	Commanded detector bias offset		string	PRI
PLATESC	Detector plate scale [arcsec]			PRI
CENTERA1	Subarray axis n center point in unbinned detector pix		integer	PRI
SIZAXIS1	Subarray axis n size in unbinned detector pixels		integer	PRI
SIZAXIS2	Subarray axis n size in unbinned detector pixels		integer	PRI
BINAXIS1	Axis n bin size in unbinned detector pixels		integer	PRI
BINAXIS2	Axis n bin size in unbinned detector pixels		integer	PRI
BPIXTAB	Bad pixel table		string	PRI
DARKFILE	Superdark image file name		string	PRI
PFLTFILE	Pixel to pixel flatfield file name		string	PRI
DFLTFILE	Delta flatfield file name		string	PRI
LFLTFILE	Low order flat file		string	PRI
FFLTFILE	Fringe correction flat file		string	PRI
PHOTTAB	Photometric throughput table		string	PRI
APERTAB	Relative aperture throughput table		string	PRI
CCDTAB	Detector calibration parameters		string	PRI
ATODTAB	Analog to digital correction file		string	PRI
BIASFILE	Superbias image file name		string	PRI
SHADFILE	Shutter shading correction file		string	PRI
CRREJTAB	Cosmic ray rejection parameter table		string	PRI
WAVECALF	Wavelength image file name		string	PRI
SPTRCTAB	Spectrum trace table		string	PRI
DISPTAB	Dispersion coefficient table		string	PRI
LAMPTAB	Template calibration lamp spectra table		string	PRI
SDCTAB	2-D spatial distortion correction table		string	PRI
XTRACTAB	Parameters for 1-D spectral extraction tab		string	PRI
PCTAB	Photometry correction table		string	PRI
WCPTAB	Wavelength calibration parameter table		string	PRI
ASN_ID	Unique identifier assigned to association		string	PRI
ASN_TAB	Name of the association file		string	PRI
MEANEXP	Reference exposure time for parameters		float	PRI
SCALENSE	Multiplicative scale factor applied to noise		float	PRI
INITGUES	Initial guess method (MIN or MED)		string	PRI
SKYSUB	Sky value subtracted (MODE or NONE)		string	PRI
CRSIGMAS	Statistical rejection criteria		string	PRI
CRRADIUS	Rejection propagation radius (pixels)		float	PRI
CRTHRESH	Rejection propagation threshold		float	PRI
BADINPDQ	Data quality flag bits to reject		integer	PRI

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Keyword	Description	Value/Table Format	Type	HDU
REJ_RATE	Rate at which pixels are affected by cosmic rays		float	PRI
CRMASK	Flag CR-rejected pixels in input files (T/F)		boolean	PRI
PATTERN1	Primary pattern type		string	PRI
P1_SHAPE	Primary pattern shape		string	PRI
P1_PURPS	Primary pattern purpose		string	PRI
P1_NPTS	Number of points in primary pattern		integer	PRI
P1_PSPAC	Point spacing for primary pattern (arc-sec)		float	PRI
P1_LSPAC	Line spacing for primary pattern (arc-sec)		float	PRI
P1_ANGLE	Angle between sides of parallelogram pattern (deg)		float	PRI
P1_FRAME	Coordinate frame of primary pattern	POS-TARG	string	PRI
P1_ORINT	Orientation of pattern to coordinate frame (deg)		float	PRI
P1_CENTR	Center pattern relative to pointing (yes/no)	NO	string	PRI
proptl1[TBD]	[TBD]	[TBD]	[TBD]	PRI
OBSET_ID	Observation set ID		string	PRI
TARGDESC	Target description		string	PRI
PM_FLAG	Does this target have proper motion?	F	boolean	PRI
PARALLAX	Target parallax		float	PRI
PM_RA	Target proper motion in RA		float	PRI
PM_DEC	Target proper motion in DEC		float	PRI
PM_EQNX	Equinox of target proper motion		string	PRI
PA_V3	Position angle of the V3 axis.		float	PRI
AIRMASS	Airmass at the center of exposure		float	PRI
GS1_RA	Right ascension of the guide stars in mean places of equinox		float	PRI
GS1_DEC	Declination of the guide stars in mean places of equinox		float	PRI
GS1_MAG	Guide star magnitude		float	PRI
GS1_FILT	Passband of guide star magnitude		string	PRI
GS1_EQNX	Equinox of the guidestars		float	PRI
GS2_RA	Right ascension of the guide stars in mean places of equinox		float	PRI
GS2_DEC	Declination of the guide stars in mean places of equinox		float	PRI
GS2_MAG	Guide star magnitude		float	PRI
GS2_FILT	Passband of guide star magnitude		string	PRI
GS2_EQNX	Equinox of the guidestars		float	PRI
GS3_RA	Right ascension of the guide stars in mean places of equinox		float	PRI
GS3_DEC	Declination of the guide stars in mean places of equinox		float	PRI
GS3_MAG	Guide star magnitude		float	PRI
GS3_FILT	Passband of guide star magnitude		string	PRI
GS3_EQNX	Equinox of the guidestars		float	PRI

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Keyword	Description	Value/Table Format	Type	HDU
GS4_RA	Right ascension of the guide stars in mean places of equinox		float	PRI
GS4_DEC	Declination of the guide stars in mean places of equinox		float	PRI
GS4_MAG	Guide star magnitude		float	PRI
GS4_FILT	Passband of guide star magnitude		string	PRI
GS4_EQNX	Equinox of the guidestars		float	PRI
PROCTIME	Pipeline processing time (MJD)		float	PRI
HISTORY	Processing history of the data		string	PRI

4.2 Base Exposure Extension HDU (EHDU)

Description: This is a basic model that specifies baseline headers that are found in an GMT exposure. This ought to be inherited by all imaging and spectroscopy exposures.

Format: Standard FITS image extension

File: <inst>_EXT.fits

Table 4.2: Extension HDU: Base Exposure

Keyword	Description	Value/Table Format	Type	HDU
EXTNAME	Name of the extension		string	EXT
EXTVER	Version of the extension	1	integer	EXT
IRAF-TLM	(IRAF-TLM) Time of last modification [To be Deleted?]		string	EXT
INHERIT	Indicates whether header of primary HDU is inherited into extensions		boolean	EXT
EXPNAME	Exposure identifier		string	EXT
BUNIT	Physical units of the array values		string	EXT
ASN_MTYP	Role of the member in the association		string	EXT
WCSAXES	The number of axes in the WCS description		integer	EXT
CRPIX1	Coordinate system reference pixel	0.0	float	EXT
CRPIX2	Coordinate system reference pixel	0.0	float	EXT
CRVAL1	Coordinate system value at reference pixel	0.0	float	EXT
CRVAL2	Coordinate system value at reference pixel	0.0	float	EXT
CTYPE1	Name of the coordinate axis		string	EXT
CTYPE2	Name of the coordinate axis		string	EXT
CD1_1	Linear transformation matrix between axes i and j		float	EXT
CD1_2	Linear transformation matrix between axes i and j		float	EXT
CD2_1	Linear transformation matrix between axes i and j		float	EXT
CD2_2	Linear transformation matrix between axes i and j		float	EXT
LTV1	Offset in X to subsection start		float	EXT
LTV2	Offset in Y to subsection start		float	EXT
LTM1_1	Reciprocal of sampling rate in X		float	EXT
LTM2_2	Reciprocal of sampling rate in Y		float	EXT
RA_APER	Right ascension of aperture reference position		float	EXT
DEC_APER	Declination of aperture reference position		float	EXT
PA_APER	Position angle of reference aperture center (deg)		float	EXT
DISPAXIS	Dispersion axis: 1= axis 1, 2 = axis 2, none		string	EXT
CUNIT1	Units of CRVAL and CDELT		string	EXT
CUNIT2	Units of CRVAL and CDELT		string	EXT

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Keyword	Description	Value/Table Format	Type	HDU
ORIENTAT	Position angle of image Y-axis (degrees East of North)		float	EXT
SUNANGLE	Angle between sun and z-axis		float	EXT
MOONANGL	Angle between moon and z-axis		float	EXT
SUN_ALT	Altitude of the sun		float	EXT
REFFRAME	Guide star catalog version		string	EXT
DATE-OBS	Date of the observation	YYYY-MM-DD	string	EXT
TIME-OBS	[Deprecated in favor of DATE-OBS] UT time of start of observation (hh:mm:ss)	HH:MM:SS[.sss]	string	EXT
EXPSTART	[Deprecated in favor of TSTART] Exposure start time (Modified Julian Date)		float	EXT
EXPEND	[Deprecated in favor of TSTOP] Exposure end time (Modified Julian Date)		float	EXT
EXPTIME	[Deprecated in favor of XPOSURE] On-detector, open-shutter, integration time (seconds)		float	EXT
EXPFLAG	Exposure interrupt indicator		string	EXT
RV_HELIO	Target heliocentric radial velocity		float	EXT
PATTSTEP	Position number of this point in the pattern		integer	EXT
NCOMBINE	Number of image sets combined, such as during CR rejection, or for any other purpose		integer	EXT
NGOODPIX	Number of good pixels		integer	EXT
SDQFLAGS	Serious data quality flags		integer	EXT
GOODMIN	Minimum value of good pixels		float	EXT
GOODMAX	Maximum value of good pixels		float	EXT
SNRMIN	Minimum signal-to-noise of good pixels		float	EXT
SNRMAX	Maximum signal-to-noise of good pixels		float	EXT
SNRMEAN	Mean value of signal-to-noise of good pixels		float	EXT
SOFTERRS	Number of soft error pixels (DQF1)		integer	EXT
MEANDARK	Average dark level subtracted		float	EXT
MEANBLEV	Average bias level subtracted		float	EXT
SPORDER	Spectral order		integer	EXT

4.3 Base Calibration Reference Table (CRT)

Description: This is a basic model that specifies baseline headers for GMT calibration reference tables.

Format: Standard FITS binary table

File: <inst>_crt.fits

Table 4.3: Extension HDU: Base Calibration Reference Table

Keyword	Description	Value/Table Format	Type	HDU
EXTEND	Indicates whether the FITS file contain extensions	T	boolean	PRI
TELESCOP	Name of telescope	GMT	string	PRI
INSTRUME	Name of instrument		string	PRI
DATE	Date of file creation	YYYY-MM-DDTHH:MM:SS[.sss]	string	PRI
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	BASE CALIB TABLE	string	PRI
USE_DATE	Use this file for obs taken on or after this date	YYYY-MM-DD	string	PRI
descrip[TBD]	[TBD]	[TBD]	[TBD]	PRI
APERTURE	Aperture name		string	PRI
CENWAVE	Proposed central wavelength of spectrum		integer	PRI
XTENSION	Marks beginning of new HDU	BINTABLE	string	EXT
BITPIX	Bits per data value	16	integer	EXT
PCOUNT	Parameter Count	0	integer	EXT
GCOUNT	Group count	1	integer	EXT
TFIELDS	Number of columns in the table		integer	EXT
EXTNAME	Name of the extension	CRT	string	EXT
EXTVER	Version of the extension	1	integer	EXT
INHERIT	Indicates whether header of primary HDU is inherited into extensions	T	boolean	EXT
END	Marks the end of the header keywords			EXT

CHAPTER

FIVE

CALIBRATION AND REFERENCE FILE DATA PRODUCTS

This Section summarizes a list of baseline calibration reference images and tables produced by the data processing system (DPS). GMT calibration reference data products (images and tables) are those used by the DPS to pipeline-process or calibrate science and telescope operations data. The keywords below supplement the mandatory FITS standard keywords and the Common Data Product patterns, thus are not repeated here.

5.1 Bias Frame (BIA)

Description: This is an image of the electronic zeropoint-level of an instrument, obtained with all light sources turned off, the detector shutter closed, and zero-second (or shortest possible) integration time. Usually, multiple (>10) bias images are taken at the beginning and/or end of the night and combined into one image. The file for the combined bias frame has the 'bia' suffix; pre-combined bias frames have a 'raw' suffix. The combined bias image is removed from the science images, usually as the first step in the data reduction.

Format: For both a single and multi-chip detector, the combined bias image is stored as an multi-extension file, with each set corresponding to each detector chip. If it is possible to change the binning mode of a detector, the binning factors are given by BINAXIS1 and BINAXIS2 header parameters. The bias image [SCI] and the error array [ERR] have raw detector data units (DN), such that GAIN * DN = electrons.

File: <inst>_bia.fits

Table 5.1: Data Product HDU: Bias Frame

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	BIAS	string	PRI
EXTNAME	Name of the extension	BIA	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
BUNIT	Physical units of the array values	DN	string	PRI

5.2 Dark Frame (DRK)

Description: This image records the dark-current signal of an instrument, obtained with ambient light turned off, the detector shutter closed. Typically, multiple dark exposures are taken at the beginning and/or end of the night, using different integration time settings. After subtracting out the bias, the individual dark images are combined into one and normalized to 1 second. The file for the combined dark frame has the "drk" suffix; pre-combined dark frames have a "raw" suffix. When applying dark correction to a science image, the combined dark image is scaled to the exposure time of the science image and removed, usually either as the second (after bias subtraction) or third (after overscan correction, if relevant) step in the data reduction.

Format: A combined dark image is stored as an MEF of the type shown in Figure 5-1 for an optical/UV detector, and Figure 5 2 for a NIR detector. When it is possible to change the binning mode of a detector, the binning factors are given by BINAXIS1 and BINAXIS2 header parameters. The dark image [SCI] and the error array [ERR] have raw detector data units per second (DN/sec), such that GAIN * DN = electrons/sec, for both UVIS and IR images. The header keyword EXPTIME = 1 is set to indicate the normalization.

Two flags in the [DQ] extension that potentially are present are 16 (hot pixels) and 128 (bad reference pixels, for IR detectors). Other, more permanent flags, e.g. dead and unstable pixels, should be stored in the bad pixel table (suffix "BPX") file. IR detectors – For IR detectors, the SAMP and the TIME image extensions (see Figure 5 2) are used to calculate the total exposure times (TIME * SAMP) at each pixel. The SAMP extension gives the total number of retained input samples after image combination, and is an image. The TIME extension gives the total open shutter exposure time at that readout sequence and is a single value for all pixels, thus the exposure time is stored as a PIXVALUE keyword value and not as EXPTIME (==1.0).

NUMEXPOS is intended for NIR MEF, where the keyword in the PRI contains the number of sets.

PIXVALUE is used for the TIME extension, for image exposure time.

SAMP_SEQ, for NIR data, name the sampling sequence for a MULTIACCUM readout.

File: <inst>_drk.fits

Table 5.2: Data Product HDU: Dark Frame

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	DARK	string	PRI
EXTNAME	Name of the extension	DRK	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
numexpos[TBD]	[TBD]	[TBD]	[TBD]	PRI
BUNIT	Physical units of the array values	DN/s	string	PRI
PIXVALUE	Value of all the pixels in an uniform image		float	EXT
EXPTIME	[Deprecated in favor of XPOSURE] On-detector, open-shutter, integration time (seconds)	1	float	EXT
SAMP_SEQ	MULTIACCUM exposure time sequence name		string	EXT

5.3 Dome Flat Field (DFL)

Description: The dome-flat is an image that records the pixel-to-pixel response of a detector, using a bright artificial light source in the dome to provide the illumination. Dome flats contain wavelength-dependent information about the uniformity of the detector response. After bias and dark subtraction, the combined dome flat is divided from the science images for calibration.

Format: A combined dome image is stored as an MEF of the type shown in Figure 5-1 for all optical/UV and NIR detectors, with only a single set of extension HDUs. The suffix "DFL" is used only for combined flat; individual raw flatfield images have the "RAW" suffix.

The median of the pixel value distribution is normalized to 1.

File: <inst>_dfl.fits

Table 5.3: Data Product HDU: Dome Flat Field Frame

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	DOME FLAT	string	PRI
EXTNAME	Name of the extension	DFL	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
BUNIT	Physical units of the array values	DN	string	PRI
LAMP_ID	Lamp ID		string	PRI
LAMP_VOL	Lamp voltage status		float	PRI

5.4 Night Sky Flat Field (NFL)

Description: A night-sky flatfield is an image that records the pixel-to-pixel response of a detector using sky observations. Night-sky flatfields contain wavelength-dependent information about the uniformity of the detector response. They are similar to twilight-sky flats (or "twiflats," suffix TFL, Appendix B.01f), except they are taken in the middle of the night rather than near sunrise or sunset for twiflats. The images used to combine night-sky flats may sometimes be intended for other purposes, such as science images themselves. Often, night-sky flats are observed immediately surrounding the intended science images. Night-sky and twi-flats may be derived using different data processing procedures. After bias and dark subtraction, the combined flat is divided from the science images for calibration.

Format: A combined night-sky flatfield image is stored as an MEF of the type shown in Figure 5-1 for all optical/UV and NIR detectors, with only a single set of extension HDUs. The suffix "NFL" is used only for combined flat; individual raw flatfield images have the "RAW" suffix.

Median of the pixel value distribution is normalized to 1.

File: <inst>_nfl.fits

Table 5.4: Data Product HDU: Night-Sky Flat Field Frame

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	NIGHT SKY FLAT	string	PRI
EXTNAME	Name of the extension	NFL	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
BUNIT	Physical units of the array values	DN	string	PRI

5.5 Twilight Flat Field (TFL)

Description: A twilight sky-flat (or 'twiflats') is an image that records the pixel-to-pixel response of a detector using sky observations. Twiflats contain wavelength-dependent information about the uniformity of the detector response, and by definition are taken close to sunset or sunrise. The distinction between night-sky flatfield, dome flats, and twiflats should be made clear, as different data processing procedures are sometimes involved. After bias and dark subtraction, the combined flat is divided into the science images for calibration.

Format: A combined twiflat image is stored as a multi-extension file for all optical/UV and NIR detectors, with only a single set of extension HDUs. The suffix 'TFL' is used only for combined flat; individual raw flatfield images have the 'RAW' suffix.

File: <inst>_tfl.fits

Table 5.5: Data Product HDU: Twilight Flat Field Frame

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	TWILIGHT SKY FLAT	string	PRI
EXTNAME	Name of the extension	TFL	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
BUNIT	Physical units of the array values	DN	string	PRI

5.6 Background Illumination Pattern (ILM)

Description: This is an image of spatially variable background illumination pattern. Correcting for the background pattern involves dividing the illumination image from data. When the signal is low, the background illumination pattern file is sometimes constructed using multiple (potentially science) images with object rejection, or by smoothing the background illumination pattern image. Details of image combination and smoothing are stored under the header keyword HISTORY, or potentially in a data processing trailer file.

Format: A background illumination file is stored as an MEF of the type shown in Figure 5 1 for all optical/UV and NIR detectors. The suffix "ILM" is used only for combined illumination file; individual raw flatfield images have the "RAW" suffix.

File: <inst>_ilm.fits

Table 5.6: Data Product HDU: Background Illumination Pattern Frame

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	ILLUMINATION PATTERN	string	PRI
EXTNAME	Name of the extension	ILM	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
BUNIT	Physical units of the array values	DN	string	PRI

5.7 Bad Pixel Mask (MSK)

Description: This is an image of all known, long-term, bad pixels for a detector. It is an image counterpart the "Bad Pixel Table (BPX)" discussed in Appendix B.02b. Transient hot pixels or cosmic rays detected during data reduction are stored in the data quality extension (DQ) of an MEF, or in the dark current reference file (file suffix "DRK"), depending on the purpose. The pixel values correspond to the data quality file as shown in Table 5-2.

Format: The coordinate origin of the bad pixel image is at the lower left corner after trimming the overscan region. The types of bad pixels recorded and their code values are:

4 – dead pixels

8 – deviant zeroth read (NIR) or bad pixel in bias (UVIS)

32 – unstable (NIR)

512 – bad in flatfield

These values are reflected in the data quality extensions during data processing.

File: <inst>_msk.fits

Table 5.7: Data Product HDU: Bad Pixel Mask Frame

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	STATIC BAD PIXEL MASK	string	PRI
EXTNAME	Name of the extension	MSK	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
BUNIT	Physical units of the array values		string	PRI

5.8 Post Flash Image (FLS)

Description: A post-flash image corrects for the signal added to CCD exposures after a post-flash procedure. Correcting for post-flash signal involves: scaling the reference image in exposure time and gain to the science image, followed by image subtraction.

Format: A post-flash reference is an MEF of the same FITS data structure, image dimension and binning factor, as the science image. Like the raw science image, it consists of both the physical and virtual overscan regions.

File: <inst>_fls.fits

Table 5.8: Data Product HDU: Post Flash Image

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	POST FLASH	string	PRI
EXTNAME	Name of the extension	FLS	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
BUNIT	Physical units of the array values	DN	string	PRI
detamp[TBD]	[TBD]	[TBD]	[TBD]	PRI

5.9 Analog to Digital Table (A2D)

Description: This table provides a more detailed account of the A-to-D gain of a detector, i.e. number of actual counts (electrons) for each detected count (ADU) in an image, than provided in the image header keyword GAIN. This table is useful when the actual, measured, gain of a detector drifts with respect to an independent variable (REF_NAME), such as the exposure time, despite the nominal GAIN setting. The values of the independent variable are stored in the REF_VALUE array while the corresponding actual gain values are in ATOD.

Format:

File: <inst>_a2d.fits

Table 5.9: Data Product HDU: Analog-to-Digital Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	ANALOG TO DIGITAL	string	PRI
EXTNAME	Name of the extension	A2D	string	EXT
XTENSION	Marks beginning of new HDU	BINTABLE	string	EXT
TTYPE1	Column name	DETAMP	string	EXT
TFORM1	Column data format	A4	string	EXT
TDISP1	Display format	A4	string	EXT
TTYPE2	Column name	CMDGAIN	string	EXT
TFORM2	Column data format	I2	string	EXT
TDISP2	Display format	I2.1	string	EXT
TUNIT2	Column units	Integer	string	EXT
TTYPE3	Column name	DETCHIP	string	EXT
TFORM3	Column data format	I1	string	EXT
TDISP3	Display format	I1.1	string	EXT
TTYPE4	Column name	NELEM	string	EXT
TFORM4	Column data format	I2	string	EXT
TDISP4	Display format	I2.1	string	EXT
TTYPE5	Column name	REF_NAME	string	EXT
TFORM5	Column data format	A12	string	EXT
TDISP5	Display format	A12	string	EXT
TTYPE6	Column name	REF_VALUE	string	EXT
TFORM6	Column data format	I2	string	EXT
TDISP6	Display format	I2.1	string	EXT
TTYPE7	Column name	ATODGAIN	string	EXT
TFORM7	Column data format	F5.2	string	EXT
TDISP7	Display format	F5.2	string	EXT
TTYPE8	Column name	DATESTAMP	string	EXT
TFORM8	Column data format	A10	string	EXT
TDISP8	Display format	A10	string	EXT
TTYPE9	Column name	TIMESTAMP	string	EXT
TFORM9	Column data format	A12	string	EXT
TDISP9	Display format	A12	string	EXT
TTYPE10	Column name	DESCRIP	string	EXT
TFORM10	Column data format	A67	string	EXT
TDISP10	Display format	A67	string	EXT

5.10 Bad Pixel Table (BPX)

Description: A bad pixel table contains a list on all known, long-term, bad pixels for a detector. This is the table counterpart of the "Static Bad Pixel Image (MSK)" discussed in Appendix B.01i. Transient hot pixels or cosmic rays detected during data reduction are stored in the data quality extension (DQ) of an MEF, or in the dark current reference file (file suffix "DRK"), depending on the purpose.

Format:

File: <inst>_bpx.fits

Table 5.10: Data Product HDU: Bad Pixel Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	BAD PIXEL	string	PRI
EXTNAME	Name of the extension	BPX	string	EXT
XTENSION	Marks beginning of new HDU	BINTABLE	string	EXT
TTYPE1	Column name	DETAMP	string	EXT
TFORM1	Column data format	A4	string	EXT
TDISP1	Display format	A4	string	EXT
TTYPE2	Column name	XPOS	string	EXT
TFORM2	Column data format	I5	string	EXT
TDISP2	Display format	I5.1	string	EXT
TTYPE3	Column name	YPOS	string	EXT
TFORM3	Column data format	I5	string	EXT
TDISP3	Display format	I5.1	string	EXT
TTYPE4	Column name	VALUE	string	EXT
TFORM4	Column data format	I4	string	EXT
TDISP4	Display format	I4.1	string	EXT
TTYPE5	Column name	DESCRIP	string	EXT
TFORM5	Column data format	A67	string	EXT
TDISP5	Display format	A67	string	EXT

5.11 Detector Characteristics Table (DCT)

Description: A detector can have several readout modes, distinguished by readout speed, gain, bias level, binning factor settings, which an observer may manually set to optimize observations. Each readout mode is associated with a set of calibrated values in gain, bias level, readnoise, saturation level, etc.. For example, faster readout speeds usually result in higher readnoise. This master table stores information that maps a selected readout mode setting with measured performance parameters.

Format: In the FITS table, each row corresponds to a readout configuration. Each row is uniquely specified by the following parameters: the readout amplifiers configuration (AMPCONFIG), the detector chip (DETCHIP), speed of the readout (RDSPEED), commanded gain (CMDGAIN), commanded bias (CMDBIAS), and chip binning factors (BINAXIS1, BINAXIS2), as well as the date and time stamps (DATESTAMP, TIMESTAMP). The actual measured parameters for the readout modes are the bias levels (BIASA through BIASD), gain (ATODGNA through ATODGND), and readnoise (RDNOISEA through RDNOISED).

The table below show an example where a detector chip is read out by 4 amplifiers (A-D), each amplifier reading out one quadrant. The AMPX and AMPY keywords indicate the dividing rows and columns of the quadrants. For example, For a 4096x4096 pixels in area, AMPX=2049 and AMPY=2049 indicate that the first quadrant runs from rows and columns 1-2048, while the fourth quadrant runs from 2049-4096 rows and columns.

File: <inst>_dct.fits

Table 5.11: Data Product HDU: Detector Characteristics Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	DETECTOR CHARACTERISTICS	string	PRI
EXTNAME	Name of the extension	DCT	string	PRI
TTYPE1	Column name	DETAMP	string	EXT
TFORM1	Column data format	A4	string	EXT
TDISP1	Display format	A4	string	EXT
TTYPE2	Column name	DETCHIP	string	EXT
TFORM2	Column data format	I1	string	EXT
TDISP2	Display format	I1.1	string	EXT
TTYPE3	Column name	RDSPEED	string	EXT
TFORM3	Column data format	A4	string	EXT
TDISP3	Display format	A4	string	EXT
TTYPE4	Column name	CMDGAIN	string	EXT
TFORM4	Column data format	I2	string	EXT
TDISP4	Display format	I2.1	string	EXT
TTYPE5	Column name	CMDBIASA	string	EXT
TFORM5	Column data format	F5	string	EXT
TDISP5	Display format	F5.2	string	EXT
TTYPE6	Column name	CMDBIASB	string	EXT
TFORM6	Column data format	F5	string	EXT
TDISP6	Display format	F5.2	string	EXT
TTYPE7	Column name	CMDBIASC	string	EXT
TFORM7	Column data format	F5	string	EXT
TDISP7	Display format	F5.2	string	EXT
TTYPE8	Column name	CMDBIASD	string	EXT
TFORM8	Column data format	F5	string	EXT
TDISP8	Display format	F5.2	string	EXT
TTYPE9	Column name	BINAXIS1	string	EXT

Continued on next page

Table 5.11 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TFORM9	Column data format	I2	string	EXT
TDISP9	Display format	I2.1	string	EXT
TTYPE10	Column name	BINAXIS2	string	EXT
TFORM10	Column data format	I2	string	EXT
TDISP10	Display format	I2.1	string	EXT
TTYPE11	Column name	BIASA	string	EXT
TFORM11	Column data format	F5	string	EXT
TDISP11	Display format	F5.2	string	EXT
TTYPE12	Column name	BIASB	string	EXT
TFORM12	Column data format	F5	string	EXT
TDISP12	Display format	F5.2	string	EXT
TTYPE13	Column name	BIASC	string	EXT
TFORM13	Column data format	F5	string	EXT
TDISP13	Display format	F5.2	string	EXT
TTYPE14	Column name	BIASD	string	EXT
TFORM14	Column data format	F5	string	EXT
TDISP14	Display format	F5.2	string	EXT
TTYPE15	Column name	ATODGNA	string	EXT
TFORM15	Column data format	F5	string	EXT
TDISP15	Display format	F5.2	string	EXT
TTYPE16	Column name	ATODGNB	string	EXT
TFORM16	Column data format	F5	string	EXT
TDISP16	Display format	F5.2	string	EXT
TTYPE17	Column name	ATODGNC	string	EXT
TFORM17	Column data format	F5	string	EXT
TDISP17	Display format	F5.2	string	EXT
TTYPE18	Column name	ATODGND	string	EXT
TFORM18	Column data format	F5	string	EXT
TDISP18	Display format	F5.2	string	EXT
TTYPE19	Column name	RDNOISEA	string	EXT
TFORM19	Column data format	F5	string	EXT
TDISP19	Display format	F5.2	string	EXT
TTYPE20	Column name	RDNOISEB	string	EXT
TFORM20	Column data format	F5	string	EXT
TDISP20	Display format	F5.2	string	EXT
TTYPE21	Column name	RDNOISEC	string	EXT
TFORM21	Column data format	F5	string	EXT
TDISP21	Display format	F5.2	string	EXT
TTYPE22	Column name	RDNOISED	string	EXT
TFORM22	Column data format	F5	string	EXT
TDISP22	Display format	F5.2	string	EXT
TTYPE23	Column name	AMPA	string	EXT
TFORM23	Column data format	I6	string	EXT
TDISP23	Display format	I6.1	string	EXT
TTYPE24	Column name	AMPB	string	EXT
TFORM24	Column data format	I6	string	EXT
TDISP24	Display format	I6.1	string	EXT

5.12 Cosmic Ray Rejection Parameter (CRR)

Description: This table contains the parameters used to identify pixels affected by cosmic-rays (CR) when observed data images are split into multiple sub-exposures for the purpose. The affected pixels are marked for rejection in the data quality (DQ) extension of individual frames. The identification process begins by median-combining or minimum thresholding a list of CR-split images (FILTSCHEME) to estimate the background sky level (SKYSUB) and noise (SCALENSE) values. Those pixels above a certain threshold value given by CRTHRESH and CRSIGMAS are identified as being cosmic-ray hit. If CRMASK is set to 'Y', then the CR-hit pixels take on values given by BADINDPDQ in the DQ extension of the affected image. If CRRADIUS is specified, then neighboring pixels are also identified as being affected.

Format:

File: <inst>_crr.fits

Table 5.12: Data Product HDU: Cosmic Ray Rejection Parameters

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	COSMIC RAY REJECTION	string	PRI
EXTNAME	Name of the extension	CRR	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
TTYPE1	Column name	DETCHIP	string	EXT
TFORM1	Column data format	I1	string	EXT
TDISP1	Display format	I1.1	string	EXT
TTYPE2	Column name	CRSPLIT	string	EXT
TFORM2	Column data format	I2	string	EXT
TDISP2	Display format	I2.1	string	EXT
TTYPE3	Column name	MEANEXP	string	EXT
TFORM3	Column data format	I2	string	EXT
TDISP3	Display format	I2.1	string	EXT

5.13 Image Distortion Coefficients (IDC)

Description: This reference table contains information on geometric distortion models for generic imaging detectors. More specifically, the table contains coefficients and values for a polynomial that maps the coordinates from a raw image (distorted) to an undistorted space and vice versa.

Format: The format for the image distortion coefficient table is shown in Table B-22. The header keyword NORDER indicates the order of the polynomial and the number of coefficients used in the transformation.

File: <inst>_idc.fits

Table 5.13: Data Product HDU: Image Distortion Coefficients

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	DISTORTION COEFFICIENTS	string	PRI
EXTNAME	Name of the extension	IDC	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
norder[TBD]	[TBD]	[TBD]	[TBD]	EXT
parity[TBD]	[TBD]	[TBD]	[TBD]	EXT
TTYPE1	Column name	DETCHIP	string	EXT
TFORM1	Column data format	I1	string	EXT
TDISP1	Display format	I1.1	string	EXT
TTYPE2	Column name	DIRECTION	string	EXT
TFORM2	Column data format	I2	string	EXT
TDISP2	Display format	I2.1	string	EXT
TTYPE3	Column name	FILTER	string	EXT
TFORM3	Column data format	A10	string	EXT
TDISP3	Display format	A10	string	EXT
TTYPE4	Column name	XSIZE	string	EXT
TFORM4	Column data format	I5	string	EXT
TDISP4	Display format	I5.1	string	EXT
TUNIT4	Column units	pixel	string	EXT
TDESC4	Column description	Raw image size in X-direction	string	EXT
TTYPE5	Column name	YSIZE	string	EXT
TFORM5	Column data format	I5	string	EXT
TDISP5	Display format	I5.1	string	EXT
TUNIT5	Column units	pixel	string	EXT
TDESC5	Column description	Raw image size in Y-direction	string	EXT
TTYPE6	Column name	XREF	string	EXT
TFORM6	Column data format	F10	string	EXT
TDISP6	Display format	F10.6	string	EXT
TUNIT6	Column units	pixel	string	EXT
TDESC6	Column description	X position of reference point	string	EXT
TTYPE7	Column name	YREF	string	EXT
TFORM7	Column data format	F10	string	EXT
TDISP7	Display format	F10.6	string	EXT
TUNIT7	Column units	pixel	string	EXT
TDESC7	Column description	Y position of reference point	string	EXT

Continued on next page

Table 5.13 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TTYPE8	Column name	THETA	string	EXT
TFORM8	Column data format	F10	string	EXT
TDISP8	Display format	F10.6	string	EXT
TUNIT8	Column units	arcsec	string	EXT
TDESC8	Column description	Scale of square corrected pixel	string	EXT
TTYPE9	Column name	V2REF	string	EXT
TFORM9	Column data format	F10	string	EXT
TDISP9	Display format	F10.6	string	EXT
TUNIT9	Column units	arcsec	string	EXT
TDESC9	Column description	V2 position of reference point [Axis name TBC]	string	EXT
TTYPE10	Column name	V3REF	string	EXT
TFORM10	Column data format	F10	string	EXT
TDISP10	Display format	F10.6	string	EXT
TUNIT10	Column units	arcsec	string	EXT
TDESC10	Column description	V3 position of reference point [Axis name TBC]	string	EXT
TTYPE11	Column name	CX10	string	EXT
TFORM11	Column data format	F10.6	string	EXT
TDISP11	Display format	F10.6	string	EXT
TDESC11	Column description	Distortion coefficients for X position	string	EXT
TTYPE12	Column name	CX11	string	EXT
TFORM12	Column data format	F10.6	string	EXT
TDISP12	Display format	F10.6	string	EXT
TDESC12	Column description	Distortion coefficients for X position	string	EXT
TTYPE13	Column name	CY10	string	EXT
TFORM13	Column data format	F10.6	string	EXT
TDISP13	Display format	F10.6	string	EXT
TDESC13	Column description	Distortion coefficients for Y position	string	EXT
TTYPE14	Column name	CY11	string	EXT
TFORM14	Column data format	F10.6	string	EXT
TDISP14	Display format	F10.6	string	EXT
TDESC14	Column description	Distortion coefficients for Y position	string	EXT

5.14 Overscan Region (OSC)

Description: The overscan region table defines: the physical and virtual overscan locations on a detector, the locations of the bias sections, and the regions to trim during data processing. Each row in the table corresponds to a readout configuration, which is uniquely identified by the following table columns: DETAMP, DETCHIP, BINX, BINY, and NX, NY (see Table B 24).

The table columns TRIMXn and TRIMYn give the number of columns/rows to trim off at the beginning/end of each image columns/rows during data processing. As such they completely specify the physical overscan region for each chip. The region of the image that remains after trimming off TRIMXn and TRIMYn from NX and NY is the full aperture on a detector for science imaging.

The columns BIASSECTA1 and BIASSECTA2 give the beginning and ending columns to use for computing the bias level in the leading overscan region. Likewise, the BIASSECTB1 and BIASSECTB2 columns are used for the trailing overscan region. Finally, the virtual overscan window starts at pixel (VX1, VY1) and extends to (VX2, VY2).

All coordinates and column numbers refer to those in the untrimmed, raw, image.

NOTE: This would most likely have to be revisited for each detector, but this is the general idea. . . .

Format:

File: <inst>_osc.fits

Table 5.14: Data Product HDU: Overscan Region

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	OVERSCAN	string	PRI
EXTNAME	Name of the extension	OSC	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
TTYPE1	Column name	DETAMP	string	EXT
TFORM1	Column data format	A4	string	EXT
TDISP1	Display format	A4	string	EXT
TTYPE2	Column name	DETCHIP	string	EXT
TFORM2	Column data format	I1	string	EXT
TDISP2	Display format	I1.1	string	EXT
TTYPE3	Column name	BINX	string	EXT
TFORM3	Column data format	I2	string	EXT
TDISP3	Display format	I2.1	string	EXT
TDESC3	Column description	Commanded bin size for axis 1	string	EXT
TTYPE4	Column name	BINY	string	EXT
TFORM4	Column data format	I2	string	EXT
TDISP4	Display format	I2.1	string	EXT
TDESC4	Column description	Commanded bin size for axis 2	string	EXT
TTYPE5	Column name	TRIMX	string	EXT
TFORM5	Column data format	I2	string	EXT
TDISP5	Display format	I2.1	string	EXT
TDESC5	Column description	Number of overscan columns to trim off beginning and end of each line	string	EXT

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Table 5.14 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TTYPE6	Column name	TRIMY	string	EXT
TFORM6	Column data format	I2	string	EXT
TDISP6	Display format	I2.1	string	EXT
TDESC6	Column description	Number of overscan rows to trim off beginning and end of each line	string	EXT
TTYPE7	Column name	BIASSECTA1	string	EXT
TFORM7	Column data format	I5	string	EXT
TDISP7	Display format	I5.1	string	EXT
TDESC7	Column description	Beginning column in the leading section for estimating the bias level in the overscan	string	EXT
TTYPE8	Column name	BIASSECTA2	string	EXT
TFORM8	Column data format	I5	string	EXT
TDISP8	Display format	I5.1	string	EXT
TDESC8	Column description	Ending column in the leading section for estimating the bias level in the overscan	string	EXT
TTYPE9	Column name	BIASSECTB1	string	EXT
TFORM9	Column data format	I5	string	EXT
TDISP9	Display format	I5.1	string	EXT
TDESC9	Column description	Beginning row in the leading section for estimating the bias level in the overscan	string	EXT
TTYPE10	Column name	BIASSECTB2	string	EXT
TFORM10	Column data format	I5	string	EXT
TDISP10	Display format	I5.1	string	EXT
TDESC10	Column description	Ending row in the leading section for estimating the bias level in the overscan	string	EXT
TTYPE11	Column name	VX1	string	EXT
TFORM11	Column data format	I5	string	EXT
TDISP11	Display format	I5.1	string	EXT
TDESC11	Column description	X coordinate of the origin of the virtual overscan region	string	EXT
TTYPE12	Column name	VX2	string	EXT
TFORM12	Column data format	I5	string	EXT
TDISP12	Display format	I5.1	string	EXT
TDESC12	Column description	Y coordinate of the origin of the virtual overscan region	string	EXT
TTYPE13	Column name	VY1	string	EXT
TFORM13	Column data format	I5	string	EXT

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Table 5.14 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TDISP13	Display format	I5.1	string	EXT
TDESC13	Column description	X coordinate of the top corner of the virtual overscan region	string	EXT
TTYPE14	Column name	VY2	string	EXT
TFORM14	Column data format	I5	string	EXT
TDISP14	Display format	I5.1	string	EXT
TDESC14	Column description	Y coordinate of the top corner of the virtual overscan region	string	EXT
TTYPE15	Column name	DATESTAMP	string	EXT
TFORM15	Column data format	A10	string	EXT
TDISP15	Display format	A10	string	EXT
TDESC15	Column description	Date stamp	string	EXT
TTYPE16	Column name	TIMESTAMP	string	EXT
TFORM16	Column data format	A12	string	EXT
TDISP16	Display format	A12	string	EXT
TDESC16	Column description	Time stamp	string	EXT

5.15 Photometric Calibration (PHT)

Description: This reference file contains photometry keywords and calibrated values: PHOTMODE, PHOTFLAM, PHOTFNU, PHOTZPT, PHOTPLAM, PHOTBW for an instrument camera and filter combination used in an observation. If the science image has units in [DN sec-1], multiplying the pixel value by PHOFLAM or PHOTFNU yields absolute source fluxes in [ergs sec^-1 cm^-2 Ang^-1] or [Jy], respectively.

Format: The photometry parameters file consists the columns shown in Table B-26. The PHOTMODE string is a comma-separated string of: instrument name, camera name/number, and filter or grating name. The HISTORY keyword in the HDU header or a trailer file contains detailed information on the calibration files used to derive the photometric parameters.

File: <inst>_pht.fits

Table 5.15: Data Product HDU: Photometric Calibration

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	PHOTOMETRIC CALIBRATION	string	PRI
EXTNAME	Name of the extension	PHT	string	EXT
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
TTYPE1	Column name	PHOTMODE	string	EXT
TFORM1	Column data format	A19	string	EXT
TDISP1	Display format	A19	string	EXT
TDESC1	Column description	Instrument observing mode	string	EXT
TTYPE2	Column name	PHOTFLAM	string	EXT
TFORM2	Column data format	E10	string	EXT
TDISP2	Display format	E10.5	string	EXT
TUNIT2	Column units	ergs/cm^2/Ang/DN	string	EXT
TDESC2	Column description	Inverse sensitivity	string	EXT
TTYPE3	Column name	PHOTFNU	string	EXT
TFORM3	Column data format	E10	string	EXT
TDISP3	Display format	E10.5	string	EXT
TUNIT3	Column units	Jy sec DN^-1	string	EXT
TDESC3	Column description	Inverse sensitivity	string	EXT
TTYPE4	Column name	PHOTPLAM	string	EXT
TFORM4	Column data format	E10	string	EXT
TDISP4	Display format	E10.5	string	EXT
TUNIT4	Column units	Angstrom	string	EXT
TDESC4	Column description	Inverse sensitivity	string	EXT
TTYPE5	Column name	PHOTBW	string	EXT
TFORM5	Column data format	E10	string	EXT
TDISP5	Display format	E10.5	string	EXT
TUNIT5	Column units	Angstrom	string	EXT
TDESC5	Column description	Bandwidth	string	EXT
TTYPE6	Column name	PHOTZPT	string	EXT
TFORM6	Column data format	E10	string	EXT
TDISP6	Display format	E10.5	string	EXT
TUNIT6	Column units	mag	string	EXT
TDESC6	Column description	Photometric zero-point	string	EXT
TTYPE7	Column name	DATESTAMP	string	EXT

Continued on next page

Table 5.15 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TFORM7	Column data format	A10	string	EXT
TDISP7	Display format	A10	string	EXT
TDESC7	Column description	Date stamp	string	EXT
TTYPE8	Column name	TIMESTAMP	string	EXT
TFORM8	Column data format	A12	string	EXT
TDISP8	Display format	A12	string	EXT
TDESC8	Column description	Time stamp	string	EXT

5.16 Aperture Throughput Table (APT)

Description: This is a table containing the wavelength-dependent transmission of each aperture with respect to a nominated reference aperture.

Format: The columns consist of: Aperture ID, number of elements in the throughput array, wavelength array, array of system throughput at corresponding wavelength, pedigree (datestamp) of reference data, and description. The suffix 'APT' is used to denote the file type.

File: <inst>_apt.fits

Table 5.16: Data Product HDU: Aperture Throughput Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	APERTURE THROUGHPUT TABLE	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	SPECTROSCOPIC	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
EXTNAME	Name of the extension	APT	string	EXT
TTYPE1	Column name	APERTURE	string	EXT
TFORM1	Column data format	A19	string	EXT
TDISP1	Display format	A19	string	EXT
TDESC1	Column description	Aperture name	string	EXT
TTYPE2	Column name	NELEM	string	EXT
TFORM2	Column data format	I6	string	EXT
TDISP2	Display format	I6.1	string	EXT
TUNIT2	Column units		string	EXT
TDESC2	Column description	Number of data points in throughput array	string	EXT
TTYPE3	Column name	WAVELENGTH	string	EXT
TFORM3	Column data format	E12	string	EXT
TDISP3	Display format	E12.7	string	EXT
TUNIT3	Column units	Angstrom	string	EXT
TDESC3	Column description	Reference wavelength array	string	EXT
TTYPE4	Column name	THROUGHPUT	string	EXT
TFORM4	Column data format	F6	string	EXT
TDISP4	Display format	F6.4	string	EXT
TUNIT4	Column units	percent	string	EXT
TDESC4	Column description	Total system throughput at each wavelength	string	EXT
TTYPE5	Column name	DATESTAMP	string	EXT
TFORM5	Column data format	A67	string	EXT
TDISP5	Display format	A67	string	EXT
TUNIT5	Column units	date	string	EXT
TDESC5	Column description	Date stamp	string	EXT
TTYPE6	Column name	DESCRIP	string	EXT
TFORM6	Column data format	A67	string	EXT
TDISP6	Display format	A67	string	EXT

Continued on next page

Table 5.16 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TDESC6	Column description	Description of reference data	string	EXT

CHAPTER

SIX

SCIENCE AND OPERATIONS DATA PRODUCTS

6.1 Raw Data (RAW)

Description: This is the first FITS data product produced by the DPS after receiving data from an instrument, where the data are in their unprocessed image state. To arrive at this stage, the DPS:

- Packaged the raw instrument data stream into FITS binary data format,
- Parsed the telemetry stream to obtain meta data and to assign FITS header information,
- Created a FITS file with the "raw" suffix, without regard to how the data would subsequently be used.

At this stage, the file suffix does not yet reflect the intended purpose of the data. The purpose is only apparent after additional data processing when another suffix (e.g. "bia", "drk", "dfl", etc.) would replace the "raw" suffix. The raw FITS file is stored permanently into the data archive.

Format: The default file format for an UVIS CCD is shown in Figure 5-1 and discussed in Section 5.2.3, whereas for an NIR array, the format is shown in Figure 5-2 of Section 5.2.4.

File: <inst>_raw.fits

Table 6.1: Data Product HDU: Raw Data

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	RAW	string	PRI
EXTNAME	Name of the extension	RAW	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	IMAGING	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI
BUNIT	Physical units of the array values	DN	string	PRI
XTENSION	Marks beginning of new HDU	IMAGE	string	EXT

6.2 Wavelength Calibration Exposure (WAV)

Description: This is an image containing 2-D spectral lines as observed from a spectral calibration light source, where the spectrum is dispersed along one dimension while spatial information is along the other dimension. This file is used to determine the wavelength solution of a corresponding science data spectral image. The spatial and dispersion directions might not necessarily be perfectly orthogonal, nor aligned with the detector pixel directions.

Format: The 2-D lamp spectral image is stored as a multi-extension file. The suffix 'WAV' is used to denote the file type.

File: <inst>_wav.fits

Table 6.2: Data Product HDU: Wavelength Calibration Exposure

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	WAVELENGTH CALIBRATION SPECTRAL IMAGE	string	PRI
EXTNAME	Name of the extension	WAV	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	SPECTROSCOPIC	string	PRI
FILTER	Filter name selected from filter wheel	CLEAR	string	PRI

6.3 Template Calibration Lamp Spectra Table (LMP)

Description: The template calibration table contains spectra of the calibration lamp obtained at different operating voltage levels. These spectra are used to create template spectra or images, from which wavelength corrections can be determined, and wavelength solution determined.

Format: The lamp spectral calibration table is stored as a multi-extension file. The suffix 'LMP' is used to denote the file type.

File: <inst>_lmp.fits

Table 6.3: Data Product HDU: Template Calibration Lamp Spectra Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	TEMPLATE CAL LAMP SPECTRA TABLE	string	PRI
OBSTYPE	Observation type - imaging or spectroscopic	SPECTROSCOPIC	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
EXTNAME	Name of the extension	LMP	string	EXT
TTYPE1	Column name	SCLAMP	string	EXT
TFORM1	Column data format	A20	string	EXT
TDISP1	Display format	A20	string	EXT
TDESC1	Column description	Name of calibration lamp that is on	string	EXT
TTYPE2	Column name	LAMPVOLT	string	EXT
TFORM2	Column data format	F6	string	EXT
TDISP2	Display format	F6.2	string	EXT
TUNIT2	Column units	voltage	string	EXT
TDESC2	Column description	Spectral calibration lamp voltage setting	string	EXT
TTYPE3	Column name	NELEM	string	EXT
TFORM3	Column data format	I10	string	EXT
TDISP3	Display format	I10	string	EXT
TDESC3	Column description	Number of data points in spectrum	string	EXT
TTYPE4	Column name	Flux	string	EXT
TFORM4	Column data format	F8	string	EXT
TDISP4	Display format	F8.4	string	EXT
TUNIT4	Column units	counts	string	EXT
TDESC4	Column description	Lamp flux	string	EXT
TTYPE5	Column name	DATESTAMP	string	EXT
TFORM5	Column data format	A67	string	EXT
TDISP5	Display format	A67	string	EXT
TDESC5	Column description	Date stamp	string	EXT
TTYPE6	Column name	DESCRIP	string	EXT
TFORM6	Column data format	A67	string	EXT
TDISP6	Display format	A67	string	EXT
TDESC6	Column description	Description of reference data	string	EXT

6.4 Association Table (ASN)

Description: This is a binary table containing information on associations of multiple exposures. Data files that need to be processed together to produce a product, or log files that are needed to make proper use of the data, constitute an association. Association tables are used to track the complex relationships that exist between multiple exposures, e.g. repeat observations, CR-split, dithered exposures, etc., for data processing purposes. Associations exist at all levels of data processing, from low-level data calibration to high-level mosaic image combination for science. Data associations can both be defined implicitly or explicitly, such as those that naturally exist between calibration reference files and raw data frames, or groups that are implied by choosing dither patterns. The DPS will use associations to perform quick-look data reduction that may involve image stacking, calibration (bias, dark, and flat-field removal) and sky subtraction. Associations are also used in the data archiving context, where it may be more useful to query and retrieve data as bundles rather than as individual files in a group.

An association has the same "ipppssoot" root name as an association data product, with a suffix "_asn". The last character in the root name will be a number between 0 and 9 to indicate association products and sub-products (see Figure 6 2 and Table 6 3). The content of the file is a table that lists all data files making up the association.

Format: [TBD] An association table has an 'ASN' file suffix.

File: <inst>_asn.fits

Table 6.4: Data Product HDU: Association Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	ASSOCIATION TABLE	string	PRI
EXTNAME	Name of the extension	ASN	string	PRI
XTENSION	Marks beginning of new HDU	BINTABLE	string	EXT
TTYPE1	Column name	MEMNAME	string	EXT
TFORM1	Column data format	A14	string	EXT
TDISP1	Display format	A14	string	EXT
TDESC1	Column description	Name of association member	string	EXT
TTYPE2	Column name	MEMTYPE	string	EXT
TFORM2	Column data format	A14	string	EXT
TDISP2	Display format	A14	string	EXT
TDESC2	Column description	Type of association member	string	EXT
TTYPE3	Column name	MEMPRSNT	string	EXT
TFORM3	Column data format	L	string	EXT
TDISP3	Display format	L6.1	string	EXT
TDESC3	Column description	Flag to indicate if member is present (T/F)	string	EXT

6.5 Jitter File (JIF)

Description: This data product contains information on how the telescope behaved during an observation. Observation log files, sometimes called "jitter" files, record telemetries on pointing, jitter, guiding, open-loop tracking, laser operations, etc., during an observation. Observation log files are produced by the DPS; the information to produce the log files come by way of querying different data sources: the acquisition and guiding wavefront sensors, the mount control system, the telescope control system, on-instrument wavefront sensor, science instruments, etc.. Observation log files share the same rootname (Figure 6-2) as the main observation data except with the suffixes "_jit" or "_jif" (see Table 6-4).

The exact contents of this file is TBD, but generally speaking, this file contains a 2-D histogram of time-averaged telescope pointing excursion during an observation, stored in an image format. The amount of time averaging depends on the source of the data and the observing mode (natural seeing vs. adaptive optics) involved. The FITS header contains keywords providing information regarding the file structure, observation details, background light, telescope control system, jitter summary, problem flags, and warnings. The header values for extension 1+ will inherit keywords from the primary HDU.

Format: Content TBD

File: <inst>_jif.fits

Table 6.5: Data Product HDU: Telescope Jitter Image

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	JITTER HISTOGRAM	string	PRI
EXTNAME	Name of the extension	JIF	string	PRI
XTENSION	Marks beginning of new HDU	IMAGE	string	EXT

6.6 Telescope Jitter File (JIT)

6.7 Aperture Description Table (APD)

Description: The aperture description table describes the geometries of the apertures (size, orientation) and their offsets (in arcsec) from a reference position.

Format: Each row of the table contains the aperture name, size (length and width) of the aperture, offset from the center of aperture to the center of a reference (which is named in the header), and the orientation of the aperture's y-axis relative to a coordinate system that is fixed to the, ground, the telescope, or the instrument rotator, depending on the mounting location [TBD].

File: <inst>_apd.fits

Table 6.6: Data Product HDU: Aperture Description Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	APERTURE DESCRIPTION TABLE	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
EXTNAME	Name of the extension	APT	string	EXT
TTYPE1	Column name	APERTURE	string	EXT
TFORM1	Column data format	A20	string	EXT
TDISP1	Display format	A20	string	EXT
TDESC1	Column description	Name of aperture	string	EXT
TTYPE2	Column name	WIDTH1	string	EXT
TFORM2	Column data format	F8	string	EXT
TDISP2	Display format	F8.5	string	EXT
TUNIT2	Column units	arcsec	string	EXT
TDESC2	Column description	Width along axis 1	string	EXT
TTYPE3	Column name	WIDTH2	string	EXT
TFORM3	Column data format	F8	string	EXT
TDISP3	Display format	F8.5	string	EXT
TUNIT3	Column units	arcsec	string	EXT
TDESC3	Column description	Width along axis 2	string	EXT
TTYPE4	Column name	ANGLE	string	EXT
TFORM4	Column data format	F10	string	EXT
TDISP4	Display format	F10.3	string	EXT
TUNIT4	Column units	degrees	string	EXT
TDESC4	Column description	Orientation of long or y-axis of aperture	string	EXT
TTYPE5	Column name	OFFSET1	string	EXT
TFORM5	Column data format	F12	string	EXT
TDISP5	Display format	F12.5	string	EXT
TUNIT5	Column units		string	EXT
TDESC5	Column description	Offset from reference position in axis 1	string	EXT
TTYPE6	Column name	OFFSET2	string	EXT
TFORM6	Column data format	F12	string	EXT
TDISP6	Display format	F12.5	string	EXT
TUNIT6	Column units		string	EXT

Continued on next page

Table 6.6 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TDESC6	Column description	Offset from reference position in axis 2	string	EXT
TTYPE7	Column name	DATESTAMP	string	EXT
TFORM7	Column data format	A67	string	EXT
TDISP7	Display format	A67	string	EXT
TDESC7	Column description	Date stamp	string	EXT
TTYPE8	Column name	DESCRIP	string	EXT
TFORM8	Column data format	A67	string	EXT
TDISP8	Display format	A67	string	EXT
TDESC8	Column description	Description of reference data	string	EXT

6.8 2D Spectrum Distortion Correction Table (SDC)

Description: This table consists of a set of WCS information used to rectify and linearize observed spectra in a 2-D image. Each set of WCS corresponds to a spectral order for a long slit spectrum, spectrum aperture ID for an integral field or multi-slit/fiber spectral image.

Format: The columns of the table are: optical element, central wavelength, spectral order, the pixel position of the center of the spectrum, and the WCS information of the output rectified spectra.

File: <inst>_sdc.fits

Table 6.7: Data Product HDU: 2D Spectrum Distortion Correction

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	2-D SPECTRUM DISTORTION CORRECTION TABLE	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
EXTNAME	Name of the extension	SDC	string	EXT
TTYPE1	Column name	OPT_ELEM	string	EXT
TFORM1	Column data format	A20	string	EXT
TDISP1	Display format	A20	string	EXT
TDESC1	Column description	Spectroscopic element in the grating wheel	string	EXT
TTYPE2	Column name	CENWAVE	string	EXT
TFORM2	Column data format	F8	string	EXT
TDISP2	Display format	F8.2	string	EXT
TUNIT2	Column units	Angstrom	string	EXT
TDESC2	Column description	Central wavelength	string	EXT
TTYPE3	Column name	SPORDER	string	EXT
TFORM3	Column data format	I3	string	EXT
TDISP3	Display format	I3	string	EXT
TDESC3	Column description	Spectral order	string	EXT
TTYPE4	Column name	APERTURE	string	EXT
TFORM4	Column data format	A20	string	EXT
TDISP4	Display format	A20	string	EXT
TUNIT4	Column units		string	EXT
TDESC4	Column description	Spectral aperture ID	string	EXT
TTYPE5	Column name	WCENTER	string	EXT
TFORM5	Column data format	F10	string	EXT
TDISP5	Display format	F10.3	string	EXT
TUNIT5	Column units	pixel	string	EXT
TDESC5	Column description	Nominal pixel (along dispersion direction) corresponding to center of spectrum	string	EXT
TTYPE6	Column name	NPIX1	string	EXT
TFORM6	Column data format	I5	string	EXT
TDISP6	Display format	I5	string	EXT
TUNIT6	Column units	pixel	string	EXT

Continued on next page

Table 6.7 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TDESC6	Column description	Number of axis 1 pixels in rectified image	string	EXT
TTYPE7	Column name	NPIX2	string	EXT
TFORM7	Column data format	I5	string	EXT
TDISP7	Display format	I5	string	EXT
TDESC7	Column description	Number of axis 1 pixels in rectified image	string	EXT
TTYPE8	Column name	CRPIX1	string	EXT
TFORM8	Column data format	I5	string	EXT
TDISP8	Display format	I5	string	EXT
TUNIT8	Column units	pixel	string	EXT
TDESC8	Column description	Axis 1 coordinate a reference pixel in rectified image	string	EXT
TTYPE9	Column name	CRPIX2	string	EXT
TFORM9	Column data format	I5	string	EXT
TDISP9	Display format	I5	string	EXT
TUNIT9	Column units	pixel	string	EXT
TDESC9	Column description	Axis 2 coordinate a reference pixel in rectified image	string	EXT
TTYPE10	Column name	CRVAL1	string	EXT
TFORM10	Column data format	F10	string	EXT
TDISP10	Display format	F10.3	string	EXT
TUNIT10	Column units	Angstrom	string	EXT
TDESC10	Column description	Axis 1 value at reference pixel in rectified image	string	EXT
TTYPE11	Column name	CRVAL2	string	EXT
TFORM11	Column data format	F12	string	EXT
TDISP11	Display format	F12.5	string	EXT
TUNIT11	Column units	arcsec	string	EXT
TDESC11	Column description	Axis 2 value at reference pixel in rectified image	string	EXT
TTYPE12	Column name	CDELT1	string	EXT
TFORM12	Column data format	F8	string	EXT
TDISP12	Display format	F8.4	string	EXT
TUNIT12	Column units	Angstrom/pixel	string	EXT
TDESC12	Column description	Axis 1 pixel spacing in rectified image	string	EXT
TTYPE13	Column name	CDELT2	string	EXT
TFORM13	Column data format	F8	string	EXT
TDISP13	Display format	F8.5	string	EXT
TUNIT13	Column units	arcsec/pixel	string	EXT
TDESC13	Column description	Axis 2 pixel spacing in rectified image	string	EXT
TTYPE14	Column name	DATESTAMP	string	EXT

Continued on next page

Table 6.7 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TFORM14	Column data format	A67	string	EXT
TDISP14	Display format	A67	string	EXT
TDESC14	Column description	Date stamp	string	EXT
TTYPE15	Column name	DESCRIP	string	EXT
TFORM15	Column data format	A67	string	EXT
TDISP15	Display format	A67	string	EXT
TDESC15	Column description	Description of reference data	string	EXT

6.9 Dispersion Coefficients Table (DSP)

Description: This table consists of dispersion coefficients of a nominal, calibrated, dispersion solution, to apply to extracted 1-D spectra.

Format: The columns of the table are: optical element (e.g. grating), central wavelength, spectral order, aperture ID, reference aperture name, and coefficients to a dispersion function.

File: <inst>_dsp.fits

Table 6.8: Data Product HDU: Dispersion Coefficients Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	DISPERSION COEFFICIENTS TABLE	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
EXTNAME	Name of the extension	DSP	string	EXT
TTYPE1	Column name	OPT_ELEM	string	EXT
TFORM1	Column data format	A20	string	EXT
TDISP1	Display format	A20	string	EXT
TDESC1	Column description	Spectroscopic element in the grating wheel	string	EXT
TTYPE2	Column name	CENWAVE	string	EXT
TFORM2	Column data format	F8	string	EXT
TDISP2	Display format	F8.2	string	EXT
TUNIT2	Column units	Angstrom	string	EXT
TDESC2	Column description	Central wavelength	string	EXT
TTYPE3	Column name	SPORDER	string	EXT
TFORM3	Column data format	I3	string	EXT
TDISP3	Display format	I3	string	EXT
TDESC3	Column description	Spectral order	string	EXT
TTYPE4	Column name	APERTURE	string	EXT
TFORM4	Column data format	A20	string	EXT
TDISP4	Display format	A20	string	EXT
TUNIT4	Column units		string	EXT
TDESC4	Column description	Spectral aperture ID	string	EXT
TTYPE5	Column name	REF_APER	string	EXT
TFORM5	Column data format	A12	string	EXT
TDISP5	Display format	A12	string	EXT
TUNIT5	Column units		string	EXT
TDESC5	Column description	Name of reference aperture	string	EXT
TTYPE6	Column name	WCENTER	string	EXT
TFORM6	Column data format	F10	string	EXT
TDISP6	Display format	F10.3	string	EXT
TUNIT6	Column units	pixel	string	EXT
TDESC6	Column description	Nominal pixel (along dispersion direction) corresponding to center of spectrum	string	EXT
TTYPE7	Column name	NCOEFF	string	EXT

Continued on next page

Table 6.8 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TFORM7	Column data format	I2	string	EXT
TDISP7	Display format	I2	string	EXT
TDESC7	Column description	Number of coefficients in dispersion solution	string	EXT
TTYPE8	Column name	COEFF	string	EXT
TFORM8	Column data format	E10	string	EXT
TDISP8	Display format	E10.7	string	EXT
TUNIT8	Column units		string	EXT
TDESC8	Column description	Dispersion solution coefficients	string	EXT
TTYPE9	Column name	DATESTAMP	string	EXT
TFORM9	Column data format	A67	string	EXT
TDISP9	Display format	A67	string	EXT
TDESC9	Column description	Date stamp	string	EXT
TTYPE10	Column name	DESCRIP	string	EXT
TFORM10	Column data format	A67	string	EXT
TDISP10	Display format	A67	string	EXT
TDESC10	Column description	Description of reference data	string	EXT

6.10 1D Spectrum Trace Table (1DT)

Description: This table defines the spectral trace prior to extracting 1-D spectrum. If a spectrum is dispersed mostly along the x-axis, then the table consists of y-displacements of the spectrum as a function of x that defines the spectral trace.

Format: The dispersion column consists: Optical element, central wavelength, aperture ID for multi-fiber/slit spectra, the reference position of the aperture on a 2-D spectral image, spectral order, and an array of y-displacements of the spectrum as a function of nominal dispersion position (often x-position).

File: <inst>_1dt.fits

Table 6.9: Data Product HDU: 1D Spectrum Trace Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	1-D SPECTRUM TRACE TABLE	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
EXTNAME	Name of the extension	1DT	string	EXT
TTYPE1	Column name	OPT_ELEM	string	EXT
TFORM1	Column data format	A20	string	EXT
TDISP1	Display format	A20	string	EXT
TDESC1	Column description	Spectroscopic element in the grating wheel	string	EXT
TTYPE2	Column name	CENWAVE	string	EXT
TFORM2	Column data format	F8	string	EXT
TDISP2	Display format	F8.2	string	EXT
TUNIT2	Column units	Angstrom	string	EXT
TDESC2	Column description	Central wavelength	string	EXT
TTYPE3	Column name	APERTURE	string	EXT
TFORM3	Column data format	A20	string	EXT
TDISP3	Display format	A20	string	EXT
TDESC3	Column description	Spectral aperture ID	string	EXT
TTYPE4	Column name	SPORDER	string	EXT
TFORM4	Column data format	I3	string	EXT
TDISP4	Display format	I3	string	EXT
TUNIT4	Column units		string	EXT
TDESC4	Column description	Spectral order	string	EXT
TTYPE5	Column name	A1CENTER	string	EXT
TFORM5	Column data format	F10	string	EXT
TDISP5	Display format	F10.3	string	EXT
TUNIT5	Column units	pixel	string	EXT
TDESC5	Column description	Nominal pixel (along dispersion direction) corresponding to wavelength center of spectrum	string	EXT
TTYPE6	Column name	A2CENTER	string	EXT
TFORM6	Column data format	F10	string	EXT
TDISP6	Display format	F10.4	string	EXT
TUNIT6	Column units	pixel	string	EXT

Continued on next page

Table 6.9 – continued from previous page

Keyword	Description	Value/Table Format	Type	HDU
TDESC6	Column description	Nominal pixel corresponding to spatial center of spectrum	string	EXT
TTYPE7	Column name	A2DISPL	string	EXT
TFORM7	Column data format	F10	string	EXT
TDISP7	Display format	F10.4	string	EXT
TUNIT7	Column units		string	EXT
TDESC7	Column description	Spectral displacement along axis 2	string	EXT
TTYPE8	Column name	DATESTAMP	string	EXT
TFORM8	Column data format	A67	string	EXT
TDISP8	Display format	A67	string	EXT
TDESC8	Column description	Date stamp	string	EXT
TTYPE9	Column name	DESCRIP	string	EXT
TFORM9	Column data format	A67	string	EXT
TDISP9	Display format	A67	string	EXT
TDESC9	Column description	Description of reference data	string	EXT

6.11 1D Spectral Extraction Parameter Table (1DX)

Description: This table describes the science and background extraction apertures and the functions used in extractions.

Format: The extraction apertures are defined by the height of the box (EXTRSIZE, BK1SIZE, BK2SIZE), the extraction algorithm (XTRACALG, polynomial function), and functional coefficients (SLTCOEFF, BKTCOEFF).

File: <inst>_1dx.fits

Table 6.10: Data Product HDU: 1D Spectral Extraction Parameter Table

Keyword	Description	Value/Table Format	Type	HDU
FILETYPE	Type of data found in data file (SCI, CALIB, RAW, etc.)	1-D SPECTRAL EXTRACTION PARAMETER TABLE	string	PRI
XTENSION	Marks beginning of new HDU	BINABLE	string	EXT
EXTNAME	Name of the extension	1DX	string	EXT
TTYPE1	Column name	OPT_ELEM	string	EXT
TFORM1	Column data format	A20	string	EXT
TDISP1	Display format	A20	string	EXT
TDESC1	Column description	Spectroscopic element in the grating wheel	string	EXT
TTYPE2	Column name	CENWAVE	string	EXT
TFORM2	Column data format	F8	string	EXT
TDISP2	Display format	F8.2	string	EXT
TUNIT2	Column units	Angstrom	string	EXT
TDESC2	Column description	Central wavelength	string	EXT
TTYPE3	Column name	APERTURE	string	EXT
TFORM3	Column data format	A20	string	EXT
TDISP3	Display format	A20	string	EXT
TDESC3	Column description	Spectral aperture ID	string	EXT
TTYPE4	Column name	SPORDER	string	EXT
TFORM4	Column data format	I3	string	EXT
TDISP4	Display format	I3	string	EXT
TUNIT4	Column units		string	EXT
TDESC4	Column description	Spectral order	string	EXT
TTYPE5	Column name	EXTRSIZE	string	EXT
TFORM5	Column data format	F8	string	EXT
TDISP5	Display format	F8.3	string	EXT
TUNIT5	Column units	pixel	string	EXT
TDESC5	Column description	Height of spectrum extraction box	string	EXT
TTYPE6	Column name	NCOEFFSL	string	EXT
TFORM6	Column data format	I3	string	EXT
TDISP6	Display format	I3	string	EXT
TUNIT6	Column units		string	EXT
TDESC6	Column description	Number of coefficients in solution to slit tilt correction	string	EXT
TTYPE7	Column name	SLTCOEFF	string	EXT
TFORM7	Column data format	E8	string	EXT

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Keyword	Description	Value/Table Format	Type	HDU
TDISP7	Display format	E8.6	string	EXT
TUNIT7	Column units		string	EXT
TDESC7	Column description	Spectrum extraction coefficients	string	EXT
TTYPE8	Column name	BK1SIZE	string	EXT
TFORM8	Column data format	F8	string	EXT
TDISP8	Display format	F8.3	string	EXT
TUNIT8	Column units	pixel	string	EXT
TDESC8	Column description	Height of background extraction box 1	string	EXT
TTYPE9	Column name	BK2SIZE	string	EXT
TFORM9	Column data format	F8	string	EXT
TDISP9	Display format	F8.3	string	EXT
TUNIT9	Column units	pixel	string	EXT
TDESC9	Column description	Height of background extraction box 2	string	EXT
TTYPE10	Column name	BK1OFFST	string	EXT
TFORM10	Column data format	F8	string	EXT
TDISP10	Display format	F8.3	string	EXT
TUNIT10	Column units	pixel	string	EXT
TDESC10	Column description	Offset of background extraction box 1 from spectrum	string	EXT
TTYPE11	Column name	BK2OFFST	string	EXT
TFORM11	Column data format	F8	string	EXT
TDISP11	Display format	F8.3	string	EXT
TUNIT11	Column units	pixel	string	EXT
TDESC11	Column description	Offset of background extraction box 2 from spectrum	string	EXT
TTYPE12	Column name	NCOEFFBK	string	EXT
TFORM12	Column data format	I3	string	EXT
TDISP12	Display format	I3	string	EXT
TUNIT12	Column units		string	EXT
TDESC12	Column description	Number of coefficients in solution to slit tilt correction	string	EXT
TTYPE13	Column name	BKTCOEFF	string	EXT
TFORM13	Column data format	E8	string	EXT
TDISP13	Display format	E8.6	string	EXT
TUNIT13	Column units		string	EXT
TDESC13	Column description	Background extraction coefficients	string	EXT
TTYPE14	Column name	BACKORD	string	EXT
TFORM14	Column data format	I3	string	EXT
TDISP14	Display format	I3	string	EXT
TUNIT14	Column units		string	EXT

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Keyword	Description	Value/Table Format	Type	HDU
TDESC14	Column description	Order of polynomial fit to background	string	EXT
TTYPE15	Column name	XTRACALG	string	EXT
TFORM15	Column data format	A20	string	EXT
TDISP15	Display format	A20	string	EXT
TDESC15	Column description	Extraction algorithm to use	string	EXT
TTYPE16	Column name	DATESTAMP	string	EXT
TFORM16	Column data format	A67	string	EXT
TDISP16	Display format	A67	string	EXT
TDESC16	Column description	Date stamp	string	EXT
TTYPE17	Column name	DESCRIP	string	EXT
TFORM17	Column data format	A67	string	EXT
TDISP17	Display format	A67	string	EXT
TDESC17	Column description	Description of reference data	string	EXT

CHAPTER

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