

Introduction to LYRA FITS Files (incl. 1 Example)

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Contents, Purpose

All LYRA data transmitted to ground will be streamed into data bases located at ROB. Many of these data will be put into daily FITS files as a convenient, easily interchangeable format. Some of these FITS files will be for internal use only – e.g. technical data for instrument monitoring or cross-calibration – while some will be made public immediately – e.g. observed solar irradiances in physical units.

A short overview of LYRA and its planned data products can be found in a poster presented at the 5th European Space Weather Week and at SOHO22 (submitted for publication in a Special Issue of Advances in Space Research):

http://solwww.oma.be/users/dammasch/IED_SOHO22_LYRA_Poster.ppt

It also provides a definition of LYRA channels and data calibration levels.

Below, the way that the LYRA FITS files and their contents are organized is shown in a diagram.

The concept of the FITS files' structure and keywords is shown next. This information has also been integrated into the LYRA Data Management Plan.

The data structures to be expected are demonstrated in a simulated example covering one whole day with several hours of science data acquisition (at constantly 10 s integration time), performed successively with LYRA heads 1, 2, and 3. The FITS files are analyzed with a simple quicklook program displaying written and graphical information, from data Lev1 to Lev3.

Finally, it is demonstrated that these Lev1 (met, std), Lev2, and Lev3 LYRA FITS files were successfully scanned by the NASA FITS File Verifier, with no warnings and no errors.

This report is thought to be sent to potential LYRA “customers” first, for discussion. Eventually, it could emerge as an information package available to the scientific public who will download FITS files from the LYRA website in the future.

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Organizing LYRA FITS Files

file name format:

lyra_YYYYMMDD-HHMMSS_lev1_***_v01.fits
 lyra_YYYYMMDD-HHMMSS_lev2_v0101.fits
 lyra_YYYYMMDD-HHMMSS_lev3_v010101.fits

where

YYYYMMDD = observation date

HHMMSS = observation start time

(usually there will be max. one file per day for each type, thus, usually HHMMSS=000000)

*** = {met, std, ecl, bak, eng}

the software version number (v..) can be kept individual for each level (*TBC*)

metadata will be
 on *ancillary data time scale*
 (housekeeping DB,
 status DB,
 VFC-parameter tests)

the rest will be
 on *instrumental time scale*
 (Lev1: commanded integration time
 Lev2: commanded integration time
 Lev3: one minute)

met	std	ecl	bak	eng
<u>“metadata”</u>	<u>“standard”</u>	<u>“eclipse”</u>	<u>“back-up”</u>	<u>“engineering”</u>
- temperature - pointing - distance	- frequency (Lev1) - irradiance (Lev2) - average irradiance (Lev3)	- frequency (Lev1) - irradiance (Lev2)	- frequency (Lev1) - irradiance (Lev2)?	- frequency (Lev1)
- head (1,2,3) - mode (nominal,back-up) - cover (open,closed) - visLED (on,off) - uvLED (on,off) - DarkCurr1,2,3,4				
- VFCparameters1,2,3,4 (nominal <i>and</i> back-up)	standard science data from nominal unit (solar irradiance time series, suitable for public output)	eclipse science data from nominal unit (solar irradiance during occultation phase, suitable for atmosphere modelling)	standard or eclipse science data or engineering data from back-up unit (data needed for internal cross-calibration)	non-science data, everything that is <i>not</i> in std, ecl, or bak (nominal unit data taken with closed cover, or far off-pointing with open cover)
needed for: information on all levels especially calibration of Lev2, long-term detector analysis together w/ “engineering” data				

LYRA FITS File Structure

General

Many FITS files are used for storing 2D images, so they have two prefixed axes and (like SWAP, for example) constantly 1024x1024 data entries. This does not apply here, because LYRA produces time series of variable length. Therefore, LYRA will use a primary header with no data, plus - for the data - one or more binary table extensions whose lengths have to be determined by the software. In the case of Lev1-std, Lev2, and Lev3 data files, there will be one extension table containing the irradiance data. In the case of Lev1-met data files, three additional extension tables are needed, containing metadata on different time scales. So the general structure of LYRA FITS files will be as follows:

HEADER0 (no axes, no data) for Lev1-std, Lev2, Lev3
HEADER1 (bintable for time series)
DATA1

HEADER0 (no axes, no data) only for Lev1-met
HEADER2 (bintable for metadata)
DATA2
HEADER3 (bintable for metadata)
DATA3
HEADER4 (bintable for metadata)
DATA4

The headers of Lev1, Lev2, and Lev3, plus a few lines of sample data, can be found below in the example section.

In the TFORMn keyword within the bintables, 'A' stands for character (1 byte), 'L' for logical (1 byte), 'B' for 8-bit integer (1 byte), 'I' for 16-bit integer (2 bytes), 'E' for single precision floating point (4 bytes), and 'D' for double precision floating point (8 bytes).

HEADER0

SIMPLE=T means that the file conforms to FITS standard. BITPIX=8 has no meaning here, because the file does not contain "pixels". NAXIS=0 means that there are no data below this header, instead EXTEND=T means that the file contains extensions.

ORIGIN='ROB-SIDC', TELESCOP='PROBA2', INSTRUME='LYRA', and OBJECT='EUV solar irradi' are obvious and chosen in accordance with SWAP. Keyword FILTER does not apply here, because the file contains data from four different channels using four different filters. Keyword DETECTOR does not apply either, because the detector of one channel can be different in different heads. Also, DETECTOR cannot be used to denote one of three LYRA heads, because the heads may be changed during the day.

OBS_MODE='standard' will deliver irradiance time series observed in acquisition mode ("science data"). These should not be mixed with 'eclipse' (occultation) data, or with data that are - possibly on a regular basis - observed with another head in parallel ('back-up'); the entry 'engineering' can be used for commissioning, bake-out, off-pointing, dark current gathering, or LED data.

DATE denotes the creation date of the FITS file, DATE_OBS and DATE_END denote the time of the first and the last data entry within the FITS file; this will make it possible to distinguish between the various states of completeness of the growing data volume produced on a present day.

DEL_TIME=60 (seconds) only applies for Lev3 data that will deliver 1-minute averages; for Lev1 and Lev2 data, the acquisition time interval is variable, as commanded. DATASRC='Redu' denotes the receiving ground station. LEVEL='1', '2', or '3' denotes the calibration level; accordingly ALGOR_V denotes one, two, or three levels of software versions. FILENAME is obvious.

The next header levels will be described in ascending order of complexity, first Lev3 and Lev2 which are simpler, then Lev1.

HEADER1 for Lev3

XTENSION='BINTABLE' means that a binary table extension follows. BITPIX=8 again has no meaning here. NAXIS=2 means that this binary table is 2-dimensional. NAXIS1=39 means that each row contains 39 bytes of data (in this case, two bytes for the time, eight bytes for each of the four data columns (irradiances from the four channels in double precision), and five bytes for the 5-character warning code. The length of the table, NAXIS2, has to be calculated by the software for each daily file separately; the maximum value is the number of minutes in a day, i.e. 1440. If there are minutes without "standard" science observations, this entry will be lower.

PCOUNT=0 and GCOUNT=1 are required keywords. TFIELDS=6 denotes the six data fields within each row, which are defined below.

TTYPE1,2,3,4,5,6 are the field labels, in this case they are called 'TIME', 'CHANNEL1,2,3,4' and 'WARNING'. Time is given by one 16-bit integer (TFORM1='1I') and measured in minutes of the day (TUNIT1='MIN'). The four channels' irradiance observations are given by one double precision floating point value each (TFORM2,3,4,5='1D') and measured in watts per square meter (TUNIT2,3,4,5='W/M**2'). The warning code consists of one character for the time-interpolation quality, plus four characters for the calibration quality of the four channels, resulting in five characters (TFORM6='5A') with no physical unit (TUNIT6='').

The name of this binary table is EXTNAME='IRRAD LEVEL 3'. Its maximal size will be approx. 56 KB.

HEADER1 for Lev2

Most of the entries are similar to Lev3. The number of bytes per row is higher (NAXIS1=45), because Lev2 data are given at instrument resolution, i.e. in the temporal resolution that was commanded. This can go down to 0.01 s integration time, and thus the field TIME has to be given in double precision floating point (TUNIT1='1D') and in seconds.milliseconds of the day (TUNIT1='S'), thus using 6 additional bytes.

The length of the table, NAXIS2, has to be calculated by the software for each daily file separately; since the highest possible instrumental cadence is one observation every 0.01 seconds, the maximum value is the number of 1/100 of seconds in a day, i.e. 8 640 000. If there are intervals without "standard" science observations, this entry will be lower.

The name of this binary table is EXTNAME='IRRAD LEVEL 2'. Its maximal size will be approx. 388 MB, but only on the highly improbable assumption that LYRA will run on its highest cadence for a full day.

HEADER1 for Lev1

Most of the entries are similar to Lev2 and Lev3. The number of bytes per row is lower than in Lev2 (NAXIS1=41), because Lev1 data do not contain the 4-character calibration quality code, thus TTYPE6='QFACTOR' with TFORM6='1B', making it 4 bytes shorter. The four channels' time series are not calibrated and converted to irradiance in W/m² yet, so TUNIT2,3,4,5='kHz', since data are still "frequencies" (counts per time unit).

The name of this binary table is EXTNAME='FREQ LEVEL 1', and its size will again most probably be below 354 MB.

The necessary information to convert these frequencies into calibrated irradiances has to be stored in three additional binary extension tables, which originate from housekeeping and status data, or parts of science data, all observed on different time scales. Their lengths are variable and have to be calculated by the software. As will be shown below, these additional tables do not add significant amounts of storage size by their Lev1-met daily FITS file.

HEADER2 for Lev1

This table consists of housekeeping data that are observed and transmitted approx. every 30 seconds. They are not part of the science data stream, but they will be necessary to calibrate the science data, e.g. to estimate the detector dark currents as a function of on-board temperature, to correct irradiances according to off-pointing, or to adjust irradiances to 1-AU values.

NAXIS1=28 again denotes the bytes in each row: eight bytes for time, four bytes for temperature, two times four bytes for two pointing coordinates, and eight bytes for distance from Sun. NAXIS2=2880 should be the maximum length of this table, given that housekeeping data change approx. every half minute.

PCOUNT=0 and GCOUNT=1 again are required keywords. TFIELDS=4 denotes the four data fields within each row, which are defined below.

TTYPER1,2,3,4 are the field labels, in this case they are called 'TIME', 'TEMPERATURE', 'POINTING', and 'DISTANCE'. Time is given by one double precision floating point value (TFORM1='1D') and measured in seconds of the day (TUNIT1='S'). Temperature is given by one single precision floating point value (TFORM2='1E') and measured in degree Celsius. Pointing coordinates are given as two single precision floating point values (TFORM3='2E') and measured in arcsec. Distance from Sun is given as one double precision floating point value (TFORM4='1D') and measured in kilometers.

The name of this binary table is EXTNAME='HK LEVEL 1'. Its maximal size will be approx. 80 KB.

HEADER3 for Lev1

This table consists of data taken either from the status data base, or parts of the science data stream that are observed directly before covers open or LEDs are switched on. These status data will be necessary to calibrate the science data, e.g. to estimate the drift according to the time elapsed since the last detector switch-on and/or exposure to sunlight, or to subtract the last measured or extrapolated dark current.

NAXIS1=45 again denotes the bytes in each row: eight bytes for time, one byte for detector status (head 1, 2, and/or 3 being switched 'on'), one byte for detector mode (head 1,2,3 being 'nominal' or 'back-up'), one byte for cover status (head 1,2,3 being 'open' or 'closed'), one byte for the ultraviolet LED (being 'on' or 'off'), one byte for the visual LED (being 'on' or 'off'), and eight bytes for dark current in each of the four detectors of the head. NAXIS2=100 should be the maximum number of times in a day that the heads or their LEDs are switched and dark currents are measured with covers closed; actually, this will rather be close to once per day for the nominal head, once per week or month for the others.

PCOUNT=0 and GCOUNT=1 again are required keywords. TFIELDS=10 denotes the ten data fields within each row, which are defined below.

TTYPER1,2,3,4,5,6,7,8,9,10 are the field labels, in this case they are called 'TIME', 'HEAD', 'MODE', 'COVER', 'UVLED', 'VISLED', and 'DARKCURR1,2,3,4'. Time is given by one double precision floating point value (TFORM1='1D') and measured in seconds of the day (TUNIT1='S'). Head gives the LYRA unit whose observation data are used in this FITS file together with its switch-on time, thus one number – either 1, 2, or 3 - is needed (TFORM2='1B') but no physical unit (TUNIT2=' '). Mode can either be 1 (for nominal) or 0 (for back-up), i.e. one number is needed (TFORM3='1B') but no physical unit (TUNIT3=' '). Cover status is either 0 (open) or 1 (closed), i.e. one number is needed (TFORM4='1B') but no physical unit (TUNIT4=' '). Ultraviolet LED status is either 0 (off) or 1 (on), i.e. one number is needed (TFORM5='1B') but no physical unit (TUNIT5=' '). Visual LED status is either 0 (off) or 1 (on), i.e. one number is needed (TFORM6='1B') but no physical unit (TUNIT6=' '). Dark currents are given as one double precision floating point value each (TFORM7,8,9,10='1D') and measured in kilohertz (TUNIT7,8,9,10='kHz').

The name of this binary table is EXTNAME='STATUS LEVEL 1'. Its maximal size will be less than 4 KB.

HEADER4 for Lev1

This table consists of data acquired on a regular basis (the voltage-frequency converter is checked approx. every three minutes) and extracted from the science data stream. The VFC parameters are necessary to convert count rates to physical units.

NAXIS1=41 again denotes the bytes in each row: eight bytes for time, one byte for mode (nominal or back-up, i.e., either the first or the second unit of the multiplexer is used), and twice four bytes for the two VFC parameters for each of the four detectors of the head. NAXIS2=1440 should be the maximum number of times per day that these parameters are estimated, which will be in the order of minutes (*exact value to be selected during commissioning phase*).

PCOUNT=0 and GCOUNT=1 again are required keywords. TFIELDS=6 denotes the six data fields within each row, which are defined below.

TTYPER1,2,3,4,5,6 are the field labels, in this case they are called 'TIME', 'MODE', and 'VFC1,2,3,4'. Time is given by one double precision floating point value (TFORM1='1D') and measured in seconds of the day (TUNIT1='S'). Mode can either be 1 (nominal) or 0 (back-up), i.e. one number is needed (TFORM2='1B') but no physical unit (TUNIT2=' '). VFC parameters are given as two single precision floating point values each (TFORM3,4,5,6='2E') and have no physical units (TUNIT3,4,5,6=' ').

The name of this binary table is EXTNAME='VFC LEVEL 1'. Its maximal size will be less than 59 KB.

Example and Quicklook Illustration

After the re-definition of the Zirconium channel (*-4) and some minor changes, the Report on Calibration Software was updated:

http://solwww.oma.be/users/dammasch/IED_20090616_Calibration_Methods.pdf

The Report on Expected Variations is also currently updated. An earlier version can be found here:

http://solwww.oma.be/users/dammasch/IED_20080801_LYRA_Expected_Variations.pdf

The latest estimates of expected variations of the LYRA total signal were used as a foundation to simulate FITS files. The LYRA signals as estimated by the LYRA radiometric model with the help of several real solar spectra (2003 max - 2008 min) form a basic interval. This interval is extended in order to be safe to cover all probable situations. The borders of the extended interval for each of the 12 LYRA channels are then used to simulate approx. seven hours of data, linearly from min to max in the case of the long-wavelength channels *-1 and *-2, and exponentially from min to max for the short-wavelength channels *-3 and *-4. According to radiometric model simulations, the former appear to follow a more uniform distribution within narrower borders, while the latter follow a more logarithmic distribution within one or two orders of magnitude (high activity due to flares being more seldom).

The simulated example, reflected in the Lev1 metadata, develops as follows (all times in hh:mm:ss after 00:00:00 UTC for better readability; the day is assumed to be 30 Jul 2009):

00:01:00 Housekeeping data base is reporting 20° C temperature, 0°/0° pointing, and 1 AU distance
00:02:00 Status data base is reporting that head 1 is on and nominal, its cover is opened, and four dark currents for the four channels 1-1, 1-2, 1-3, 1-4 were measured immediately before opening (values result from test data taken at 20° C)
00:03:00 Within the science data stream, the parameters from the VFC test of the nominal channel are reported (values result from a linear fit of test data taken at 20° C)
00:04:00 While the first data - immediately after opening of the cover - are ignored (*TBC*), now 2496 values are taken with 10 s exposure time, which is reflected in the standard data
06:59:50 Last science data acquisition
07:00:00 Cover of head 1 is closed, followed by 1 hour pause

08:01:00 -
15:00:00 Procedure is repeated for head 2

16:01:00 -
23:00:00 Procedure is repeated for head 3

This leads to 7488 lines of standard science data. The expected LYRA total signals (in nA) are converted back to frequencies (in kHz) to form the expected Lev1 standard data. These are then – with the help of Lev1 metadata – converted to calibrated Lev2 data. These are converted to averaged Lev3 data. And these are again converted to graphics (currently called Lev4 data). Thus, the result of the simulation are four daily FITS files (Lev1-met, Lev1-std, Lev2, Lev3) and the daily plot (Lev4).

These will be (partly) shown in the following, with the help of a primitive “quicklook” software that can be made more sophisticated in the future, and possibly should also be put on the website, together with these FITS explanations and an IDL routine to read LYRA FITS files. The quicklook consists of the printed headers, header structure, data lists (shortened when too long) for all FITS files, and overview graphics for Lev1-met (2 pages), Lev1-std, and Lev2. As a graphic for Lev3, the planned daily plot (Lev4) is shown.

The sample FITS files can be downloaded here:

http://solwww.oma.be/users/dammasch/lyra_20090730-000000_lev1_met_v01.fits

http://solwww.oma.be/users/dammasch/lyra_20090730-000000_lev1_std_v01.fits

http://solwww.oma.be/users/dammasch/lyra_20090730-000000_lev2_v0101.fits

http://solwww.oma.be/users/dammasch/lyra_20090730-000000_lev3_v010101.fits

http://solwww.oma.be/users/dammasch/lyra_20090730-000000_lev4_v010101.eps

FITS file name ? **lyra_20090730-000000_levl_met_v01.fits**

```
SIMPLE = T /Written by IDL: Fri Jul 31 13:10:04 2009
BITPIX = 8 /
NAXIS = 0 /
EXTEND = T /File contains extensions
ORIGIN = 'ROB-SIDC' /
TELESCOP= 'PROBA2 ' /
INSTRUME= 'LYRA ' /
OBJECT = 'EUV solar irradi' /
OBS_MODE= 'metadata' /std, ecl, bak, eng, or met
DATE = '2009-07-31' /
DATE_OBS= '2009-07-30T00:00:00.000' /UTC start of observation
DATE_END= '2009-07-30T23:59:59.990' /UTC end of observation
DATASRC = 'Redu ' /receiving ground station
LEVEL = '1 ' /calibration level
ALGOR_V = '01 ' /LYRA calibration S/W version lev1
FILENAME= 'lyra_20090730-000000_levl_met_v01.fits' /name of this FITS file
END
```

```
XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 13:10:04 2009
BITPIX = 8 /
NAXIS = 2 /Binary table
NAXIS1 = 28 /Number of bytes per row
NAXIS2 = 3 /Number of rows
PCOUNT = 0 /Random parameter count
GCOUNT = 1 /Group count
TFIELDS = 4 /Number of columns
EXTNAME = 'HK LEVEL 1' /name of binary table extension
TFORM1 = '1D ' /Real*8 (double precision)
TTYPER1 = 'TIME ' /Label for column 1
TUNIT1 = 's ' /Units of column 1
TFORM2 = '1E ' /Real*4 (floating point)
TTYPER2 = 'TEMPERATURE' /Label for column 2
TUNIT2 = 'deg C ' /Units of column 2
TFORM3 = '2E ' /Real*4 (floating point)
TTYPER3 = 'POINTING' /Label for column 3
TUNIT3 = 'arcsec ' /Units of column 3
TFORM4 = '1D ' /Real*8 (double precision)
TTYPER4 = 'DISTANCE' /Label for column 4
TUNIT4 = 'km ' /Units of column 4
END
```

FITS Binary Table: HK LEVEL 1
Table contains 4 columns, by 3 rows

Col	Name	Type	Size	Units	Null
1	TIME	Dbl	1	s	
2	TEMPERATURE	Flt	1	deg C	
3	POINTING	Flt	2	arcsec	
4	DISTANCE	Dbl	1	km	

Col	Name	Type	Size	Units	Null
1	TIME	Dbl	1	s	
2	TEMPERATURE	Flt	1	deg C	
3	POINTING	Flt	2	arcsec	
4	DISTANCE	Dbl	1	km	

```
XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 13:10:04 2009
BITPIX = 8 /
NAXIS = 2 /Binary table
NAXIS1 = 45 /Number of bytes per row
NAXIS2 = 6 /Number of rows
PCOUNT = 0 /Random parameter count
GCOUNT = 1 /Group count
TFIELDS = 10 /Number of columns
EXTNAME = 'STATUS LEVEL 1' /name of binary table extension
TFORM1 = '1D ' /Real*8 (double precision)
TTYPER1 = 'TIME ' /Label for column 1
TUNIT1 = 's ' /Units of column 1
TFORM2 = '1B ' /Integer*1 (byte)
TTYPER2 = 'HEAD ' /Label for column 2
TUNIT2 = ' ' /Units of column 2
TFORM3 = '1B ' /Integer*1 (byte)
TTYPER3 = 'MODE ' /Label for column 3
TUNIT3 = ' ' /Units of column 3
TFORM4 = '1B ' /Integer*1 (byte)
TTYPER4 = 'COVER ' /Label for column 4
TUNIT4 = ' ' /Units of column 4
TFORM5 = '1B ' /Integer*1 (byte)
TTYPER5 = 'UVLED ' /Label for column 5
TUNIT5 = ' ' /Units of column 5
TFORM6 = '1B ' /Integer*1 (byte)
TTYPER6 = 'VISLED ' /Label for column 6
TUNIT6 = ' ' /Units of column 6
TFORM7 = '1D ' /Real*8 (double precision)
TTYPER7 = 'DARKCURR1' /Label for column 7
TUNIT7 = 'kHz ' /Units of column 7
TFORM8 = '1D ' /Real*8 (double precision)
TTYPER8 = 'DARKCURR2' /Label for column 8
TUNIT8 = 'kHz ' /Units of column 8
TFORM9 = '1D ' /Real*8 (double precision)
TTYPER9 = 'DARKCURR3' /Label for column 9
TUNIT9 = 'kHz ' /Units of column 9
TFORM10 = '1D ' /Real*8 (double precision)
```



```

TTYPE10 = 'DARKCURR4'      /Label for column 10
TUNIT10 = 'kHz'           /Units of column 10
END

```

```

FITS Binary Table: STATUS LEVEL 1
Table contains 10 columns, by 6 rows

```

Col	Name	Type	Size	Units	Null
1	TIME	Dbl	1	s	
2	HEAD	Byt	1		
3	MODE	Byt	1		
4	COVER	Byt	1		
5	UVLED	Byt	1		
6	VISLED	Byt	1		
7	DARKCURR1	Dbl	1	kHz	
8	DARKCURR2	Dbl	1	kHz	
9	DARKCURR3	Dbl	1	kHz	
10	DARKCURR4	Dbl	1	kHz	

1	120.00000	1	1	0	0	0	6.9800000	6.6000000	6.5600000	6.7800000
2	25200.000	1	1	1	0	0	6.9800000	6.6000000	6.5600000	6.7800000
3	28920.000	2	1	0	0	0	6.6000000	6.3800000	6.2900000	6.7300000
4	54000.000	2	1	1	0	0	6.6000000	6.3800000	6.2900000	6.7300000
5	57720.000	3	1	0	0	0	8.5700000	6.5300000	6.4800000	6.4700000
6	82800.000	3	1	1	0	0	8.5700000	6.5300000	6.4800000	6.4700000

```

XTENSION= 'BINTABLE'      /Written by IDL: Fri Jul 31 13:10:04 2009
BITPIX = 8 /
NAXIS = 2 /Binary table
NAXIS1 = 41 /Number of bytes per row
NAXIS2 = 3 /Number of rows
PCOUNT = 0 /Random parameter count
GCOUNT = 1 /Group count
TFIELDS = 6 /Number of columns
EXTNAME = 'VFC LEVEL 1'  /name of binary table extension
TFORM1 = '1D'            /Real*8 (double precision)
TTYPE1 = 'TIME'          /Label for column 1
TUNIT1 = 's'             /Units of column 1
TFORM2 = '1B'            /Integer*1 (byte)
TTYPE2 = 'MODE'          /Label for column 2
TUNIT2 = ' '              /Units of column 2
TFORM3 = '2E'            /Real*4 (floating point)
TTYPE3 = 'VFC1'          /Label for column 3
TUNIT3 = ' '              /Units of column 3
TFORM4 = '2E'            /Real*4 (floating point)
TTYPE4 = 'VFC2'          /Label for column 4
TUNIT4 = ' '              /Units of column 4
TFORM5 = '2E'            /Real*4 (floating point)
TTYPE5 = 'VFC3'          /Label for column 5
TUNIT5 = ' '              /Units of column 5
TFORM6 = '2E'            /Real*4 (floating point)
TTYPE6 = 'VFC4'          /Label for column 6
TUNIT6 = ' '              /Units of column 6
END

```

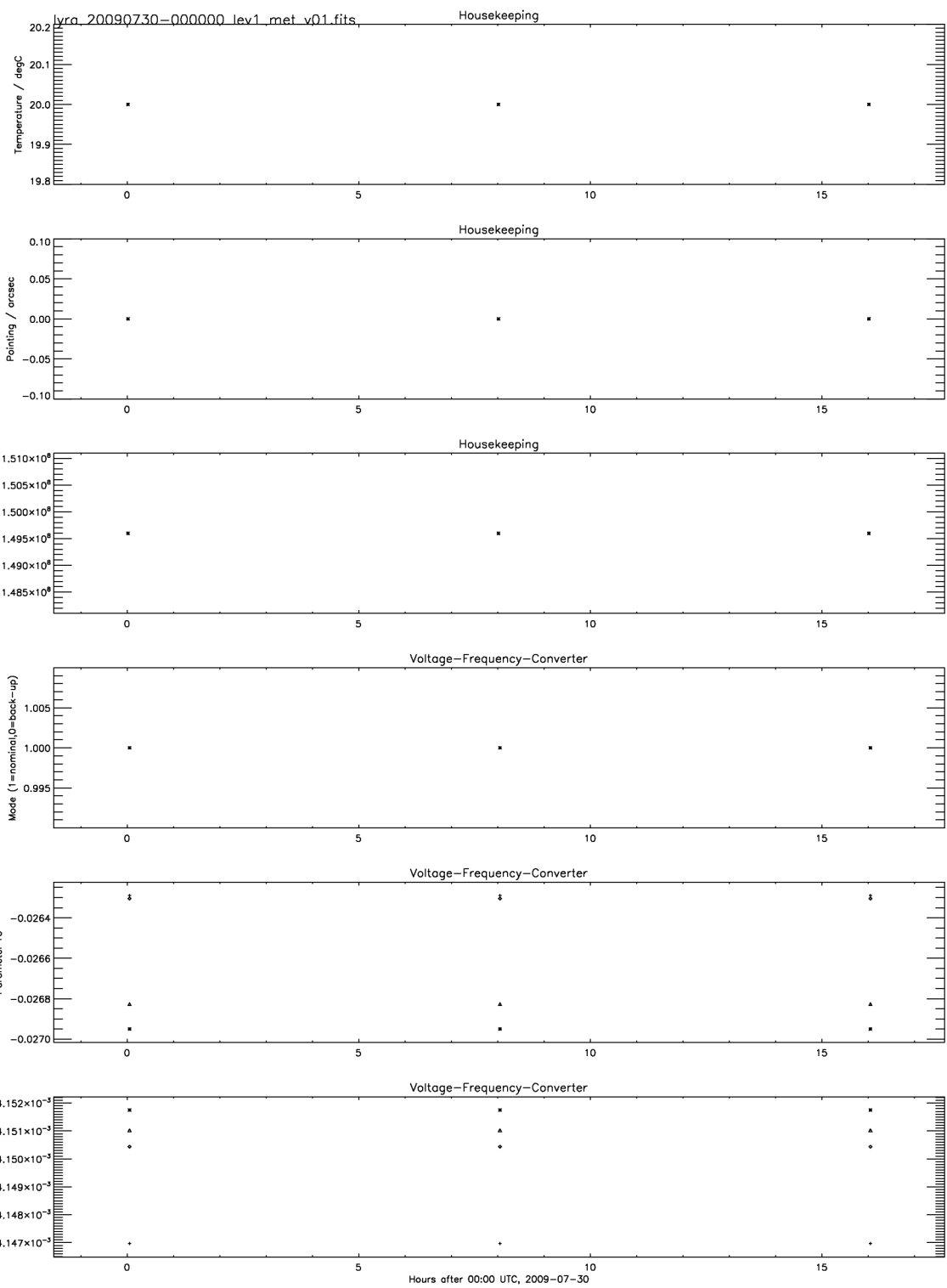
```

FITS Binary Table: VFC LEVEL 1
Table contains 6 columns, by 3 rows

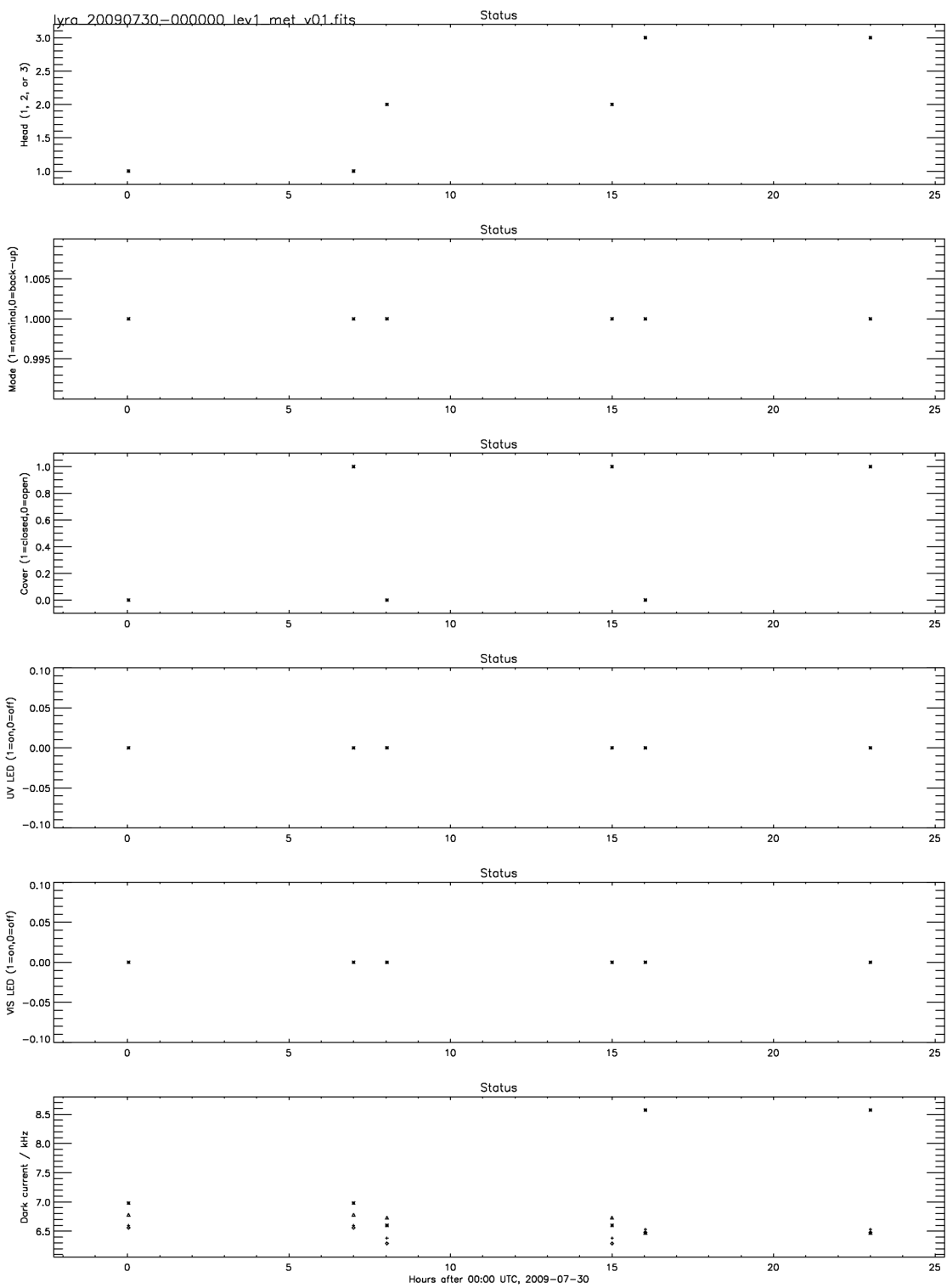
```

Col	Name	Type	Size	Units	Null
1	TIME	Dbl	1	s	
2	MODE	Byt	1		
3	VFC1	Flt	2		
4	VFC2	Flt	2		
5	VFC3	Flt	2		
6	VFC4	Flt	2		

1	180.00000	1	-0.0269503	0.00415175	-0.0262902	0.00414697	-0.0263052	0.00415044	-0.0268276	0.00415103
2	28980.000	1	-0.0269503	0.00415175	-0.0262902	0.00414697	-0.0263052	0.00415044	-0.0268276	0.00415103
3	57780.000	1	-0.0269503	0.00415175	-0.0262902	0.00414697	-0.0263052	0.00415044	-0.0268276	0.00415103



Graphical display of Lev1-met FITS file: Part 1 with Housekeeping and VFC entries



Graphical display of Lev1-met FITS file: Part 2 with Status entries

FITS file name ? **lyra_20090730-000000_lev1_std_v01.fits**

```
SIMPLE = T /Written by IDL: Fri Jul 31 13:10:04 2009
BITPIX = 8 /
NAXIS = 0 /
EXTEND = T /File contains extensions
ORIGIN = 'ROB-SIDC' /
TELESCOP= 'PROBA2' /
INSTRUME= 'LYRA' /
OBJECT = 'EUV solar irradi' /
OBS_MODE= 'standard' /std, ecl, bak, eng, or met
DATE = '2009-07-31' /
DATE_OBS= '2009-07-30T00:00:00.000' /UTC start of observation
DATE_END= '2009-07-30T23:59:59.990' /UTC end of observation
DATASRC = 'Redu' /receiving ground station
LEVEL = '1' /calibration level
ALGOR_V = '01' /LYRA calibration S/W version lev1
FILENAME= 'lyra_20090730-000000_lev1_std_v01.fits' /name of this FITS file
END
```

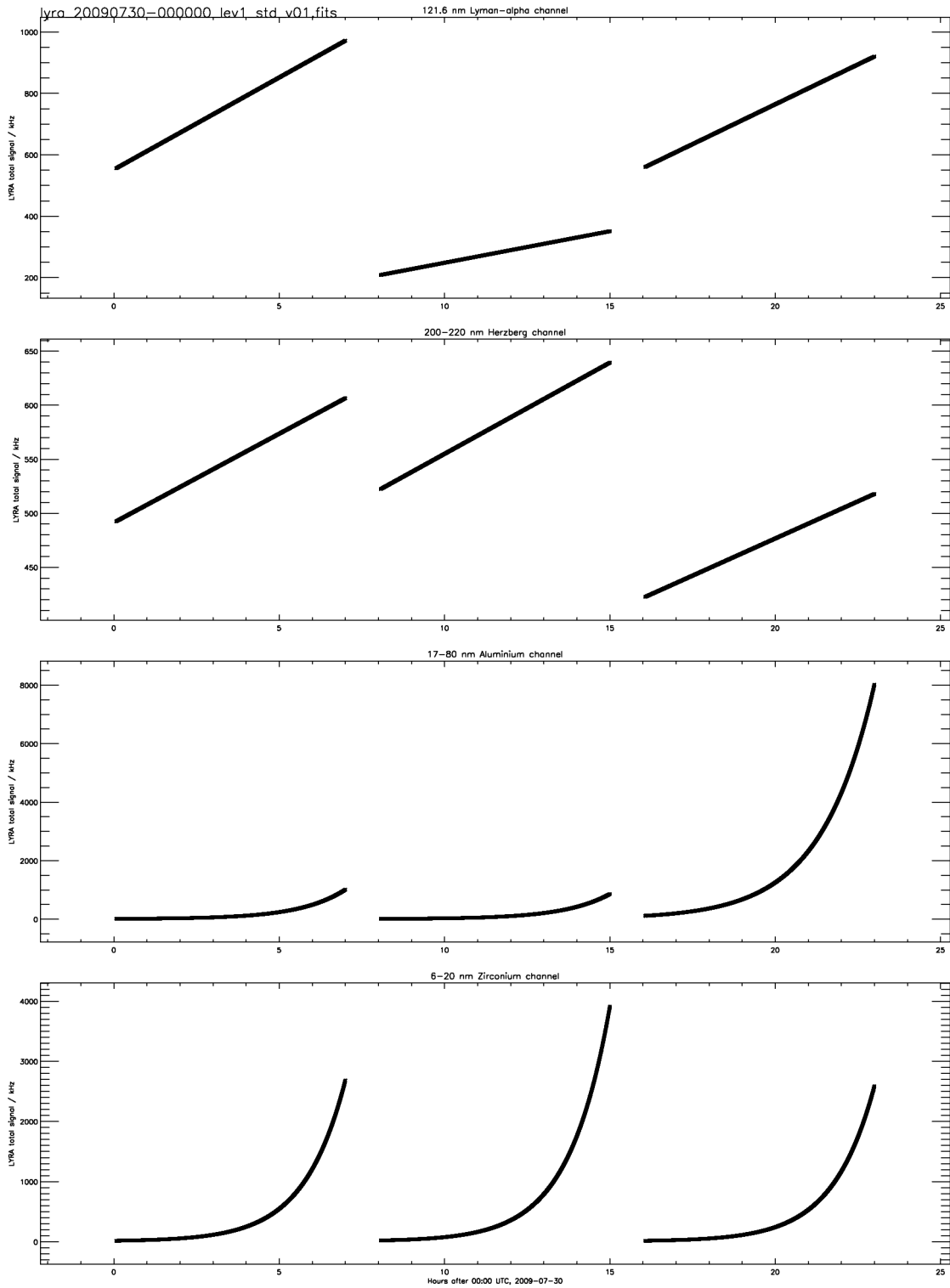
```
XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 13:10:04 2009
BITPIX = 8 /
NAXIS = 2 /Binary table
NAXIS1 = 41 /Number of bytes per row
NAXIS2 = 7488 /Number of rows
PCOUNT = 0 /Random parameter count
GCOUNT = 1 /Group count
TFIELDS = 6 /Number of columns
EXTNAME = 'FREQ LEVEL 1' /name of binary table extension
TFORM1 = '1D' /Real*8 (double precision)
TTYPE1 = 'TIME' /Label for column 1
TUNIT1 = 's' /Units of column 1
TFORM2 = '1D' /Real*8 (double precision)
TTYPE2 = 'CHANNEL1' /Label for column 2
TUNIT2 = 'kHz' /Units of column 2
TFORM3 = '1D' /Real*8 (double precision)
TTYPE3 = 'CHANNEL2' /Label for column 3
TUNIT3 = 'kHz' /Units of column 3
TFORM4 = '1D' /Real*8 (double precision)
TTYPE4 = 'CHANNEL3' /Label for column 4
TUNIT4 = 'kHz' /Units of column 4
TFORM5 = '1D' /Real*8 (double precision)
TTYPE5 = 'CHANNEL4' /Label for column 5
TUNIT5 = 'kHz' /Units of column 5
TFORM6 = '1B' /Integer*1 (byte)
TTYPE6 = 'QFACTOR' /Label for column 6
TUNIT6 = '' /Units of column 6
END
```

FITS Binary Table: FREQ LEVEL 1
Table contains 6 columns, by 7488 rows

Col	Name	Type	Size	Units	Null
1	TIME	Dbf	1	s	
2	CHANNEL1	Dbf	1	kHz	
3	CHANNEL2	Dbf	1	kHz	
4	CHANNEL3	Dbf	1	kHz	
5	CHANNEL4	Dbf	1	kHz	
6	QFACTOR	Byt	1		

```
-----
first and last 20 of 7488 rows
  1 240.00000 556.22790 492.51483 13.084814 17.242019 1
  2 250.00000 556.39440 492.56063 13.098014 17.265219 1
  3 260.00000 556.56100 492.60623 13.111214 17.288619 1
  4 270.00000 556.72760 492.65193 13.124514 17.311919 1
  5 280.00000 556.89420 492.69763 13.137714 17.335419 1
  6 290.00000 557.06070 492.74333 13.151014 17.358919 1
  7 300.00000 557.22730 492.78903 13.164414 17.382419 1
  8 310.00000 557.39380 492.83473 13.177714 17.406019 1
  9 320.00000 557.56050 492.88053 13.191114 17.429619 1
 10 330.00000 557.72700 492.92613 13.204514 17.453319 1
 11 340.00000 557.89360 492.97183 13.217914 17.477119 1
 12 350.00000 558.06010 493.01753 13.231414 17.500919 1
 13 360.00000 558.22660 493.06323 13.244814 17.524719 1
 14 370.00000 558.39330 493.10893 13.258314 17.548619 1
 15 380.00000 558.55980 493.15463 13.271914 17.572619 1
 16 390.00000 558.72630 493.20033 13.285414 17.596619 1
 17 400.00000 558.89300 493.24603 13.299014 17.620719 1
 18 410.00000 559.05950 493.29173 13.312714 17.644819 1
 19 420.00000 559.22610 493.33743 13.326314 17.668919 1
 20 430.00000 559.39260 493.38313 13.340014 17.693219 1
:::
7469 82600.000 917.50679 517.16896 7763.8563 2482.1073 3
7470 82610.000 917.65099 517.20716 7777.2396 2487.5919 3
7471 82620.000 917.79519 517.24536 7790.6468 2493.0887 3
7472 82630.000 917.93919 517.28356 7804.0756 2498.5977 3
7473 82640.000 918.08339 517.32176 7817.5252 2504.1187 3
7474 82650.000 918.22759 517.35986 7831.0012 2509.6521 3
7475 82660.000 918.37179 517.39816 7844.4996 2515.1977 3
7476 82670.000 918.51599 517.43626 7858.0188 2520.7557 3
7477 82680.000 918.65999 517.47446 7871.5653 2526.3261 3
7478 82690.000 918.80419 517.51276 7885.1341 2531.9087 3
7479 82700.000 918.94839 517.55086 7898.7237 2537.5037 3
```

7480	82710.000	919.09259	517.58906	7912.3389	2543.1101	3
7481	82720.000	919.23679	517.62726	7925.9789	2548.7295	3
7482	82730.000	919.38099	517.66546	7939.6381	2554.3629	3
7483	82740.000	919.52519	517.70366	7953.3245	2560.0076	3
7484	82750.000	919.66919	517.74196	7967.0350	2565.6650	3
7485	82760.000	919.81339	517.78006	7980.7694	2571.3350	3
7486	82770.000	919.95759	517.81826	7994.5230	2577.0174	3
7487	82780.000	920.10179	517.85646	8008.3046	2582.7122	3
7488	82790.000	920.24579	517.89466	8022.1086	2588.4196	3



Graphical display of Lev1-std FITS file

FITS file name ? **lyra_20090730-000000_lev2_v0101.fits**

```
SIMPLE = T /Written by IDL: Fri Jul 31 15:40:38 2009
BITPIX = 8 /
NAXIS = 0 /
EXTEND = T /File contains extensions
ORIGIN = 'ROB-SIDC' /
TELESCOP= 'PROBA2' /
INSTRUME= 'LYRA' /
OBJECT = 'EUV solar irradi' /
OBS_MODE= 'standard' /std, ecl, bak, eng, or met
DATE = '2009-07-31' /
DATE_OBS= '2009-07-30T00:00:00.000' /UTC start of observation
DATE_END= '2009-07-30T23:59:59.990' /UTC end of observation
DATASRC = 'Redu' /receiving ground station
LEVEL = '2' /calibration level
ALGOR_V = '0101' /LYRA calibration S/W version lev1.lev2
FILENAME= 'lyra_20090730-000000_lev2_v0101.fits' /name of this FITS file
END
```

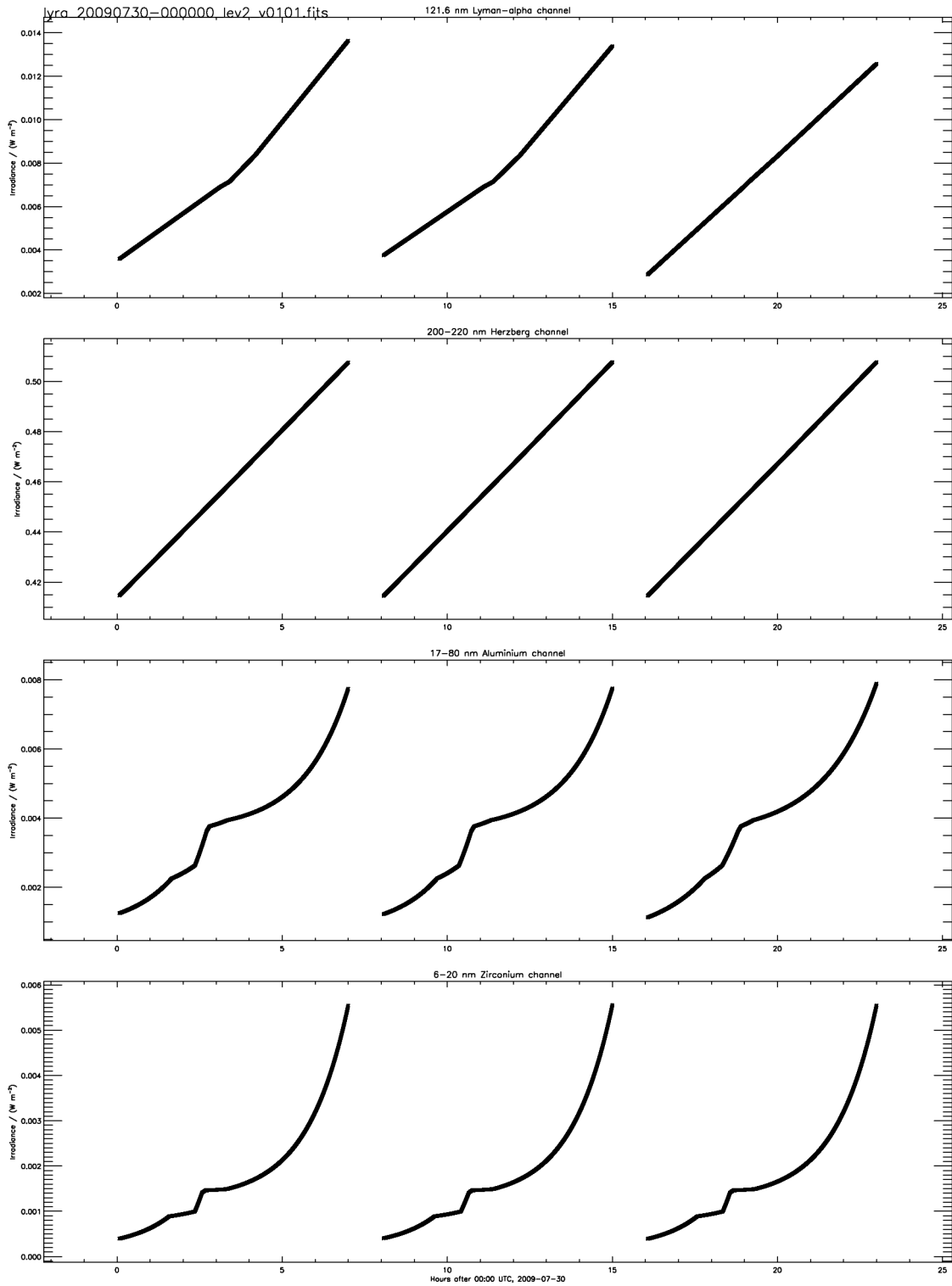
```
XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 15:40:38 2009
BITPIX = 8 /
NAXIS = 2 /Binary table
NAXIS1 = 45 /Number of bytes per row
NAXIS2 = 7488 /Number of rows
PCOUNT = 0 /Random parameter count
GCOUNT = 1 /Group count
TFIELDS = 6 /Number of columns
EXTNAME = 'IRRAD LEVEL 2' /name of binary table extension
TFORM1 = '1D' /Real*8 (double precision)
TTYPE1 = 'TIME' /Label for column 1
TUNIT1 = 's' /Units of column 1
TFORM2 = '1D' /Real*8 (double precision)
TTYPE2 = 'CHANNEL1' /Label for column 2
TUNIT2 = 'W/m**2' /Units of column 2
TFORM3 = '1D' /Real*8 (double precision)
TTYPE3 = 'CHANNEL2' /Label for column 3
TUNIT3 = 'W/m**2' /Units of column 3
TFORM4 = '1D' /Real*8 (double precision)
TTYPE4 = 'CHANNEL3' /Label for column 4
TUNIT4 = 'W/m**2' /Units of column 4
TFORM5 = '1D' /Real*8 (double precision)
TTYPE5 = 'CHANNEL4' /Label for column 5
TUNIT5 = 'W/m**2' /Units of column 5
TFORM6 = '5A' /Character string
TTYPE6 = 'WARNING' /Label for column 6
TUNIT6 = '' /Units of column 6
END
```

FITS Binary Table: IRRAD LEVEL 2
Table contains 6 columns, by 7488 rows

Col	Name	Type	Size	Units	Null
1	TIME	Dbl	1	s	
2	CHANNEL1	Dbl	1	W/m**2	
3	CHANNEL2	Dbl	1	W/m**2	
4	CHANNEL3	Dbl	1	W/m**2	
5	CHANNEL4	Dbl	1	W/m**2	
6	WARNING	Asc	1		

```
-----
first and last 20 of 7488 rows
1 240.00000 0.0035864908 0.41465471 0.0012520164 0.00039634080 11121
2 250.00000 0.0035895081 0.41469178 0.0012529567 0.00039680689 11111
3 260.00000 0.0035925271 0.41472868 0.0012538970 0.00039727700 11111
4 270.00000 0.0035955462 0.41476566 0.0012548444 0.00039774510 11111
5 280.00000 0.0035985652 0.41480265 0.0012557847 0.00039821722 11111
6 290.00000 0.0036015824 0.41483963 0.0012567321 0.00039868934 11111
7 300.00000 0.0036046015 0.41487662 0.0012576866 0.00039916146 11111
8 310.00000 0.0036076187 0.41491360 0.0012586341 0.00039963558 11111
9 320.00000 0.0036106396 0.41495067 0.0012595886 0.00040010971 11111
10 330.00000 0.0036136568 0.41498757 0.0012605431 0.00040058585 11111
11 340.00000 0.0036166759 0.41502455 0.0012614977 0.00040106399 11111
12 350.00000 0.0036196931 0.41506154 0.0012624594 0.00040154214 11111
13 360.00000 0.0036227103 0.41509852 0.0012634139 0.00040202028 11111
14 370.00000 0.0036257312 0.41513550 0.0012643756 0.00040250044 11111
15 380.00000 0.0036287484 0.41517249 0.0012653443 0.00040298260 11111
16 390.00000 0.0036317656 0.41520947 0.0012663060 0.00040346476 11111
17 400.00000 0.0036347865 0.41524646 0.0012672748 0.00040394894 11111
18 410.00000 0.0036378037 0.41528344 0.0012682507 0.00040443311 11111
19 420.00000 0.0036408228 0.41532042 0.0012692195 0.00040491728 11111
20 430.00000 0.0036438400 0.41535741 0.0012701954 0.00040540547 11111
:::
7469 82600.000 0.012496108 0.50695576 0.0077536776 0.0053701835 31111
7470 82610.000 0.012500043 0.50699339 0.0077610018 0.0053792805 32111
7471 82620.000 0.012503979 0.50703103 0.0077683392 0.0053883978 32111
7472 82630.000 0.012507909 0.50706866 0.0077756883 0.0053975354 32111
7473 82640.000 0.012511844 0.50710630 0.0077830489 0.0054066928 32111
7474 82650.000 0.012515780 0.50714384 0.0077904239 0.0054158708 32111
7475 82660.000 0.012519715 0.50718157 0.0077978112 0.0054250690 32111
7476 82670.000 0.012523651 0.50721911 0.0078052098 0.0054342878 32111
7477 82680.000 0.012527581 0.50725674 0.0078126233 0.0054435272 32111
7478 82690.000 0.012531516 0.50729448 0.0078200491 0.0054527868 32111
7479 82700.000 0.012535451 0.50733201 0.0078274863 0.0054620670 32111
```

7480	82710.000	0.012539387	0.50736965	0.0078349375	0.0054713660	32111
7481	82720.000	0.012543322	0.50740728	0.0078424022	0.0054806867	32211
7482	82730.000	0.012547258	0.50744492	0.0078498775	0.0054900305	32211
7483	82740.000	0.012551193	0.50748256	0.0078573676	0.0054993930	32211
7484	82750.000	0.012555123	0.50752029	0.0078648709	0.0055087767	32211
7485	82760.000	0.012559059	0.50755783	0.0078723873	0.0055181812	32211
7486	82770.000	0.012562994	0.50759546	0.0078799142	0.0055276064	32211
7487	82780.000	0.012566930	0.50763310	0.0078874565	0.0055370521	32211
7488	82790.000	0.012570860	0.50767073	0.0078950110	0.0055465187	32212



Graphical display of Lev2 FITS file

FITS file name ? **lyra_20090730-000000_lev3_v010101.fits**

SIMPLE = T /Written by IDL: Fri Jul 31 15:40:45 2009
BITPIX = 8 /
NAXIS = 0 /
EXTEND = T /File contains extensions
ORIGIN = 'ROB-SIDC' /
TELESCOP= 'PROBA2 ' /
INSTRUME= 'LYRA ' /
OBJECT = 'EUV solar irradi' /
OBS_MODE= 'standard' /std, ecl, bak, eng, or met
DATE = '2009-07-31' /
DATE_OBS= '2009-07-30T00:00:00.000' /UTC start of observation
DATE_END= '2009-07-30T23:59:59.990' /UTC end of observation
DEL_TIME= 60 /one-minute averages
DATASRC = 'Redu ' /receiving ground station
LEVEL = '3 ' /calibration level
ALGOR_V = '01.01.01' /LYRA calibration S/W version lev1.lev2.lev3
FILENAME= 'lyra_20090730-000000_lev3_v010101.fits' /name of this FITS file
END

XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 15:40:45 2009
BITPIX = 8 /
NAXIS = 2 /Binary table
NAXIS1 = 39 /Number of bytes per row
NAXIS2 = 1248 /Number of rows
PCOUNT = 0 /Random parameter count
GCOUNT = 1 /Group count
TFIELDS = 6 /Number of columns
EXTNAME = 'IRRAD LEVEL 3' /name of binary table extension
TFORM1 = 'I ' /Integer*2 (short integer)
TTYPE1 = 'TIME ' /Label for column 1
TUNIT1 = 'MIN ' /Units of column 1
TFORM2 = 'D ' /Real*8 (double precision)
TTYPE2 = 'CHANNEL1' /Label for column 2
TUNIT2 = 'W/M**2 ' /Units of column 2
TFORM3 = 'D ' /Real*8 (double precision)
TTYPE3 = 'CHANNEL2' /Label for column 3
TUNIT3 = 'W/M**2 ' /Units of column 3
TFORM4 = 'D ' /Real*8 (double precision)
TTYPE4 = 'CHANNEL3' /Label for column 4
TUNIT4 = 'W/M**2 ' /Units of column 4
TFORM5 = 'D ' /Real*8 (double precision)
TTYPE5 = 'CHANNEL4' /Label for column 5
TUNIT5 = 'W/M**2 ' /Units of column 5
TFORM6 = '5A ' /Character string
TTYPE6 = 'WARNING ' /Label for column 6
TUNIT6 = ' ' /Units of column 6
END

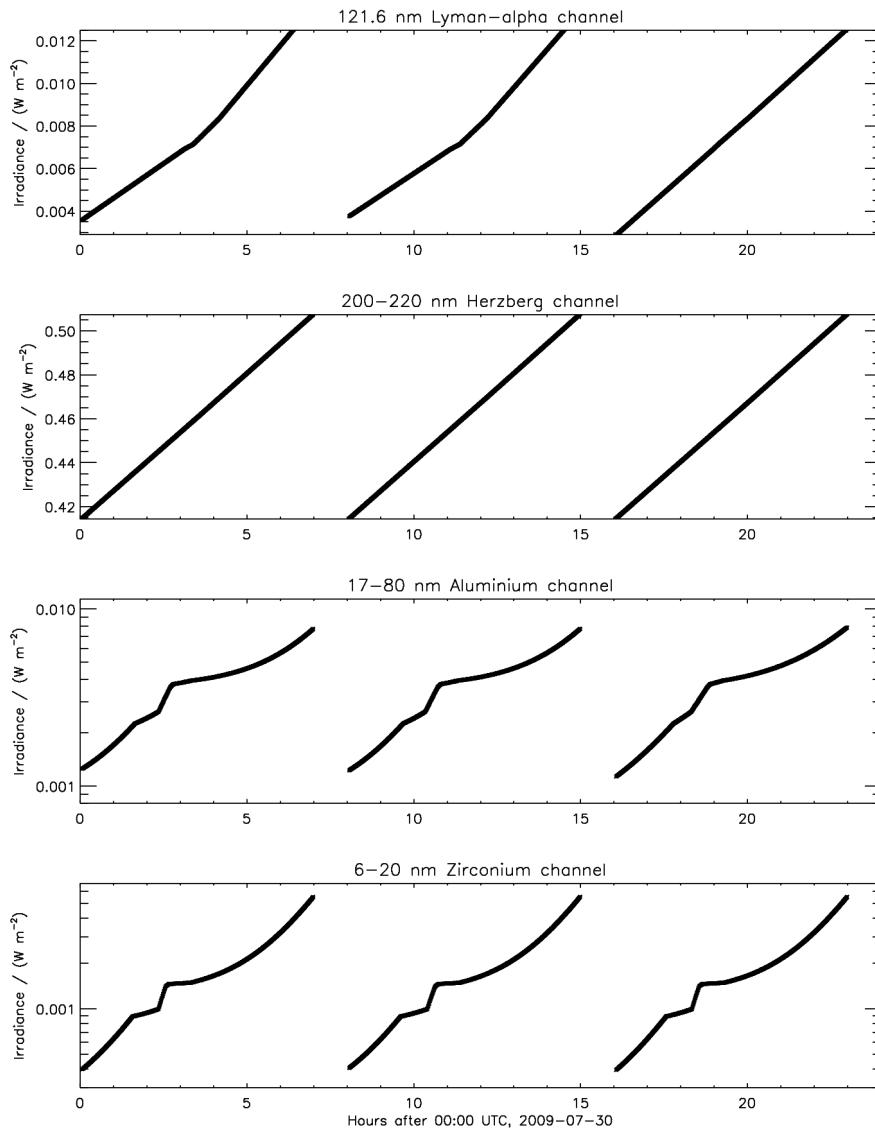
FITS Binary Table: IRRAD LEVEL 3
Table contains 6 columns, by 1248 rows

Col	Name	Type	Size	Units	Null
1	TIME	Int	1	MIN	
2	CHANNEL1	Dbl	1	W/M**2	
3	CHANNEL2	Dbl	1	W/M**2	
4	CHANNEL3	Dbl	1	W/M**2	
5	CHANNEL4	Dbl	1	W/M**2	
6	WARNING	Asc	1		

first and last 20 of 1248 rows

1	4	0.0035940366	0.41474719	0.0012543719	0.00039751273	11121
2	5	0.0036121476	0.41496909	0.0012600682	0.00040034979	11111
3	6	0.0036302576	0.41519098	0.0012658276	0.00040322502	11111
4	7	0.0036483683	0.41541287	0.0012716617	0.00040613842	11111
5	8	0.0036664786	0.41563476	0.0012775658	0.00040909134	11111
6	9	0.0036845889	0.41585667	0.0012835400	0.00041208343	11111
7	10	0.0037027002	0.41607856	0.0012895890	0.00041511637	11111
8	11	0.0037208105	0.41630043	0.0012957116	0.00041818949	11111
9	12	0.0037389209	0.41652234	0.0013019078	0.00042130413	11111
10	13	0.0037570315	0.41674423	0.0013081812	0.00042446062	11111
11	14	0.0037751416	0.41696613	0.0013145282	0.00042765930	11111
12	15	0.0037932522	0.41718801	0.0013209547	0.00043090051	11111
13	16	0.0038113631	0.41740993	0.0013274584	0.00043418625	11111
14	17	0.0038294735	0.41763182	0.0013340416	0.00043751552	11111
15	18	0.0038475841	0.41785368	0.0013407068	0.00044088966	11111
16	19	0.0038656951	0.41807559	0.0013474515	0.00044430866	11111
17	20	0.0038838051	0.41829749	0.0013542805	0.00044777421	11111
18	21	0.0039019154	0.41851938	0.0013611903	0.00045128563	11111
19	22	0.0039200261	0.41874129	0.0013681855	0.00045484459	11111
20	23	0.0039381364	0.41896319	0.0013752650	0.00045845077	11111
:::						
1229	1360	0.012112513	0.50328664	0.0070969663	0.0045732788	31111
1230	1361	0.012136120	0.50351244	0.0071342730	0.0046175129	31111
1231	1362	0.012159726	0.50373824	0.0071719663	0.0046623383	31111
1232	1363	0.012183332	0.50396402	0.0072100515	0.0047077628	31111
1233	1364	0.012206937	0.50418981	0.0072485330	0.0047537955	31111
1234	1365	0.012230543	0.50441561	0.0072874152	0.0048004417	31111
1235	1366	0.012254150	0.50464137	0.0073267004	0.0048477123	31111
1236	1367	0.012277755	0.50486717	0.0073663938	0.0048956154	31111
1237	1368	0.012301360	0.50509298	0.0074065008	0.0049441588	31111
1238	1369	0.012324967	0.50531876	0.0074470253	0.0049933505	31111

1239	1370	0.012348572	0.50554454	0.0074879699	0.0050431996	31111
1240	1371	0.012372178	0.50577032	0.0075293396	0.0050937149	31111
1241	1372	0.012395784	0.50599615	0.0075711411	0.0051449057	31111
1242	1373	0.012419391	0.50622191	0.0076133765	0.0051967804	31111
1243	1374	0.012442997	0.50644769	0.0076560500	0.0052493487	31111
1244	1375	0.012466602	0.50667351	0.0076991675	0.0053026208	31111
1245	1376	0.012490207	0.50689930	0.0077427340	0.0053566044	32111
1246	1377	0.012513813	0.50712508	0.0077867535	0.0054113089	32111
1247	1378	0.012537419	0.50735085	0.0078312293	0.0054667440	32211
1248	1379	0.012561026	0.50757666	0.0078761679	0.0055229213	32212



Lev4 daily plot, on the basis of data from Lev3 FITS file

NASA FITS File Verifier Results

File name: lyra_20090730-000000_lev1_met_v01.fits

Run Number 7207

fitsverify 4.15 (CFITSIO V3.181)

4 Header-Data Units in this file.

===== HDU 1: Primary Array =====

```
1 | SIMPLE = T /Written by IDL: Fri Jul 31 13:10:04 2009
2 | BITPIX = 8 /
3 | NAXIS = 0 /
4 | EXTEND = T /File contains extensions
5 | ORIGIN = 'ROB-SIDC' /
6 | TELESCOP= 'PROBA2 ' /
7 | INSTRUME= 'LYRA ' /
8 | OBJECT = 'EUV solar irradi' /
9 | OBS_MODE= 'metadata' /std, ecl, bak, eng, or met
10 | DATE = '2009-07-31' /
11 | DATE_OBS= '2009-07-30T00:00:00.000' /UTC start of observation
12 | DATE_END= '2009-07-30T23:59:59.990' /UTC end of observation
13 | DATASRC = 'Redu ' /receiving ground station
14 | LEVEL = '1 ' /calibration level
15 | ALGOR_V = '01 ' /LYRA calibration S/W version lev1
16 | FILENAME= 'lyra_20090730-000000_lev1_met_v01.fits' /name of this FITS file
17 | END
```

17 header keywords

Null data array; NAXIS = 0

===== HDU 2: BINARY Table =====

```
1 | XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 13:10:04 2009
2 | BITPIX = 8 /
3 | NAXIS = 2 /Binary table
4 | NAXIS1 = 28 /Number of bytes per row
5 | NAXIS2 = 3 /Number of rows
6 | PCOUNT = 0 /Random parameter count
7 | GCOUNT = 1 /Group count
8 | TFIELDS = 4 /Number of columns
9 | EXTNAME = 'HK LEVEL 1' /name of binary table extension
10 | TFORM1 = '1D ' /Real*8 (double precision)
11 | TTYPE1 = 'TIME ' /Label for column 1
12 | TUNIT1 = 's ' /Units of column 1
13 | TFORM2 = '1E ' /Real*4 (floating point)
14 | TTYPE2 = 'TEMPERATURE' /Label for column 2
15 | TUNIT2 = 'deg C ' /Units of column 2
16 | TFORM3 = '2E ' /Real*4 (floating point)
17 | TTYPE3 = 'POINTING' /Label for column 3
18 | TUNIT3 = 'arcsec ' /Units of column 3
19 | TFORM4 = '1D ' /Real*8 (double precision)
20 | TTYPE4 = 'DISTANCE' /Label for column 4
21 | TUNIT4 = 'km ' /Units of column 4
22 | END
```

22 header keywords

HK LEVEL 1 (4 columns x 3 rows)

Col#	Name (Units)	Format
1	TIME (s)	1D
2	TEMPERATURE (deg C)	1E
3	POINTING (arcsec)	2E
4	DISTANCE (km)	1D

===== HDU 3: BINARY Table =====

```

1 | XTENSION= 'BINTABLE'           /Written by IDL:  Fri Jul 31 13:10:04 2009
2 | BITPIX   =                    8 /
3 | NAXIS    =                    2 /Binary table
4 | NAXIS1   =                   45 /Number of bytes per row
5 | NAXIS2   =                    6 /Number of rows
6 | PCOUNT   =                    0 /Random parameter count
7 | GCOUNT   =                    1 /Group count
8 | TFIELDS  =                   10 /Number of columns
9 | EXTNAME  = 'STATUS LEVEL 1'   /name of binary table extension
10 | TFORM1   = '1D'               /Real*8 (double precision)
11 | TTYPE1   = 'TIME'            /Label for column 1
12 | TUNIT1   = 's'               /Units of column 1
13 | TFORM2   = '1B'              /Integer*1 (byte)
14 | TTYPE2   = 'HEAD'           /Label for column 2
15 | TUNIT2   = ' '               /Units of column 2
16 | TFORM3   = '1B'              /Integer*1 (byte)
17 | TTYPE3   = 'MODE'           /Label for column 3
18 | TUNIT3   = ' '               /Units of column 3
19 | TFORM4   = '1B'              /Integer*1 (byte)
20 | TTYPE4   = 'COVER'          /Label for column 4
21 | TUNIT4   = ' '               /Units of column 4
22 | TFORM5   = '1B'              /Integer*1 (byte)
23 | TTYPE5   = 'UVLED'          /Label for column 5
24 | TUNIT5   = ' '               /Units of column 5
25 | TFORM6   = '1B'              /Integer*1 (byte)
26 | TTYPE6   = 'VISLED'         /Label for column 6
27 | TUNIT6   = ' '               /Units of column 6
28 | TFORM7   = '1D'             /Real*8 (double precision)
29 | TTYPE7   = 'DARKCURR1'      /Label for column 7
30 | TUNIT7   = 'kHz'            /Units of column 7
31 | TFORM8   = '1D'             /Real*8 (double precision)
32 | TTYPE8   = 'DARKCURR2'      /Label for column 8
33 | TUNIT8   = 'kHz'            /Units of column 8
34 | TFORM9   = '1D'             /Real*8 (double precision)
35 | TTYPE9   = 'DARKCURR3'      /Label for column 9
36 | TUNIT9   = 'kHz'            /Units of column 9
37 | TFORM10  = '1D'             /Real*8 (double precision)
38 | TTYPE10  = 'DARKCURR4'      /Label for column 10
39 | TUNIT10  = 'kHz'            /Units of column 10
40 | END

```

40 header keywords

STATUS LEVEL 1 (10 columns x 6 rows)

Col#	Name (Units)	Format
1	TIME (s)	1D
2	HEAD	1B
3	MODE	1B
4	COVER	1B
5	UVLED	1B
6	VISLED	1B
7	DARKCURR1 (kHz)	1D
8	DARKCURR2 (kHz)	1D

```

9 DARKCURR3 (kHz)      1D
10 DARKCURR4 (kHz)    1D

```

===== HDU 4: BINARY Table =====

```

1 | XTENSION= 'BINTABLE'           /Written by IDL:  Fri Jul 31 13:10:04 2009
2 | BITPIX   =                      8 /
3 | NAXIS    =                      2 /Binary table
4 | NAXIS1   =                     41 /Number of bytes per row
5 | NAXIS2   =                      3 /Number of rows
6 | PCOUNT   =                      0 /Random parameter count
7 | GCOUNT   =                      1 /Group count
8 | TFIELDS  =                      6 /Number of columns
9 | EXTNAME  = 'VFC LEVEL 1'       /name of binary table extension
10 | TFORM1   = '1D'                /Real*8 (double precision)
11 | TTYPE1   = 'TIME'              /Label for column 1
12 | TUNIT1   = 's'                 /Units of column 1
13 | TFORM2   = '1B'                /Integer*1 (byte)
14 | TTYPE2   = 'MODE'              /Label for column 2
15 | TUNIT2   = ' '                 /Units of column 2
16 | TFORM3   = '2E'                /Real*4 (floating point)
17 | TTYPE3   = 'VFC1'              /Label for column 3
18 | TUNIT3   = ' '                 /Units of column 3
19 | TFORM4   = '2E'                /Real*4 (floating point)
20 | TTYPE4   = 'VFC2'              /Label for column 4
21 | TUNIT4   = ' '                 /Units of column 4
22 | TFORM5   = '2E'                /Real*4 (floating point)
23 | TTYPE5   = 'VFC3'              /Label for column 5
24 | TUNIT5   = ' '                 /Units of column 5
25 | TFORM6   = '2E'                /Real*4 (floating point)
26 | TTYPE6   = 'VFC4'              /Label for column 6
27 | TUNIT6   = ' '                 /Units of column 6
28 | END

```

28 header keywords

VFC LEVEL 1 (6 columns x 3 rows)

Col#	Name (Units)	Format
1	TIME (s)	1D
2	MODE	1B
3	VFC1	2E
4	VFC2	2E
5	VFC3	2E
6	VFC4	2E

+++++ Error Summary +++++

HDU#	Name (version)	Type	Warnings	Errors
1		Primary Array	0	0
2	HK LEVEL 1	Binary Table	0	0
3	STATUS LEVEL 1	Binary Table	0	0
4	VFC LEVEL 1	Binary Table	0	0

**** Verification found 0 warning(s) and 0 error(s). ****

File name: lyra_20090730-000000_level_std_v01.fits

Run Number 7208

fitsverify 4.15 (CFITSIO V3.181)

2 Header-Data Units in this file.

===== HDU 1: Primary Array =====

```
1 | SIMPLE = T /Written by IDL: Fri Jul 31 13:10:04 2009
2 | BITPIX = 8 /
3 | NAXIS = 0 /
4 | EXTEND = T /File contains extensions
5 | ORIGIN = 'ROB-SIDC' /
6 | TELESCOP= 'PROBA2 ' /
7 | INSTRUME= 'LYRA ' /
8 | OBJECT = 'EUV solar irradi' /
9 | OBS_MODE= 'standard' /std, ecl, bak, eng, or met
10 | DATE = '2009-07-31' /
11 | DATE_OBS= '2009-07-30T00:00:00.000' /UTC start of observation
12 | DATE_END= '2009-07-30T23:59:59.990' /UTC end of observation
13 | DATA_SRC = 'Redu ' /receiving ground station
14 | LEVEL = '1 ' /calibration level
15 | ALGOR_V = '01 ' /LYRA calibration S/W version lev1
16 | FILENAME= 'lyra_20090730-000000_level_std_v01.fits' /name of this FITS file
17 | END
```

17 header keywords

Null data array; NAXIS = 0

===== HDU 2: BINARY Table =====

```
1 | XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 13:10:04 2009
2 | BITPIX = 8 /
3 | NAXIS = 2 /Binary table
4 | NAXIS1 = 41 /Number of bytes per row
5 | NAXIS2 = 7488 /Number of rows
6 | PCOUNT = 0 /Random parameter count
7 | GCOUNT = 1 /Group count
8 | TFIELDS = 6 /Number of columns
9 | EXTNAME = 'FREQ LEVEL 1' /name of binary table extension
10 | TFORM1 = '1D ' /Real*8 (double precision)
11 | TTYPE1 = 'TIME ' /Label for column 1
12 | TUNIT1 = 's ' /Units of column 1
13 | TFORM2 = '1D ' /Real*8 (double precision)
14 | TTYPE2 = 'CHANNEL1' /Label for column 2
15 | TUNIT2 = 'kHz ' /Units of column 2
16 | TFORM3 = '1D ' /Real*8 (double precision)
17 | TTYPE3 = 'CHANNEL2' /Label for column 3
18 | TUNIT3 = 'kHz ' /Units of column 3
19 | TFORM4 = '1D ' /Real*8 (double precision)
20 | TTYPE4 = 'CHANNEL3' /Label for column 4
21 | TUNIT4 = 'kHz ' /Units of column 4
22 | TFORM5 = '1D ' /Real*8 (double precision)
23 | TTYPE5 = 'CHANNEL4' /Label for column 5
24 | TUNIT5 = 'kHz ' /Units of column 5
25 | TFORM6 = '1B ' /Integer*1 (byte)
26 | TTYPE6 = 'QFACTOR ' /Label for column 6
27 | TUNIT6 = ' ' /Units of column 6
28 | END
```

28 header keywords

FREQ LEVEL 1 (6 columns x 7488 rows)

Col#	Name (Units)	Format
1	TIME (s)	1D
2	CHANNEL1 (kHz)	1D
3	CHANNEL2 (kHz)	1D
4	CHANNEL3 (kHz)	1D
5	CHANNEL4 (kHz)	1D
6	QFACTOR	1B

+++++ Error Summary +++++

HDU#	Name (version)	Type	Warnings	Errors
1		Primary Array	0	0
2	FREQ LEVEL 1	Binary Table	0	0

**** Verification found 0 warning(s) and 0 error(s). ****

File name: lyra_20090730-000000_lev2_v0101.fits

Run Number 7209

fitsverify 4.15 (CFITSIO V3.181)

2 Header-Data Units in this file.

===== HDU 1: Primary Array =====

```
1 | SIMPLE = T /Written by IDL: Fri Jul 31 15:40:38 2009
2 | BITPIX = 8 /
3 | NAXIS = 0 /
4 | EXTEND = T /File contains extensions
5 | ORIGIN = 'ROB-SIDC' /
6 | TELESCOP= 'PROBA2 ' /
7 | INSTRUME= 'LYRA ' /
8 | OBJECT = 'EUV solar irradi' /
9 | OBS_MODE= 'standard' /std, ecl, bak, eng, or met
10 | DATE = '2009-07-31' /
11 | DATE_OBS= '2009-07-30T00:00:00.000' /UTC start of observation
12 | DATE_END= '2009-07-30T23:59:59.990' /UTC end of observation
13 | DATA_SRC = 'Redu ' /receiving ground station
14 | LEVEL = '2 ' /calibration level
15 | ALGOR_V = '0101 ' /LYRA calibration S/W version lev1.lev2
16 | FILENAME= 'lyra_20090730-000000_lev2_v0101.fits' /name of this FITS file
17 | END
```

17 header keywords

Null data array; NAXIS = 0

===== HDU 2: BINARY Table =====

```
1 | XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 15:40:38 2009
2 | BITPIX = 8 /
3 | NAXIS = 2 /Binary table
4 | NAXIS1 = 45 /Number of bytes per row
5 | NAXIS2 = 7488 /Number of rows
6 | PCOUNT = 0 /Random parameter count
7 | GCOUNT = 1 /Group count
8 | TFIELDS = 6 /Number of columns
9 | EXTNAME = 'IRRAD LEVEL 2' /name of binary table extension
10 | TFORM1 = '1D ' /Real*8 (double precision)
11 | TTYPE1 = 'TIME ' /Label for column 1
12 | TUNIT1 = 's ' /Units of column 1
13 | TFORM2 = '1D ' /Real*8 (double precision)
14 | TTYPE2 = 'CHANNEL1' /Label for column 2
15 | TUNIT2 = 'W/m**2 ' /Units of column 2
16 | TFORM3 = '1D ' /Real*8 (double precision)
17 | TTYPE3 = 'CHANNEL2' /Label for column 3
18 | TUNIT3 = 'W/m**2 ' /Units of column 3
19 | TFORM4 = '1D ' /Real*8 (double precision)
20 | TTYPE4 = 'CHANNEL3' /Label for column 4
21 | TUNIT4 = 'W/m**2 ' /Units of column 4
22 | TFORM5 = '1D ' /Real*8 (double precision)
23 | TTYPE5 = 'CHANNEL4' /Label for column 5
24 | TUNIT5 = 'W/m**2 ' /Units of column 5
25 | TFORM6 = '5A ' /Character string
26 | TTYPE6 = 'WARNING ' /Label for column 6
27 | TUNIT6 = ' ' /Units of column 6
28 | END
```

28 header keywords

IRRAD LEVEL 2 (6 columns x 7488 rows)

Col#	Name (Units)	Format
1	TIME (s)	1D
2	CHANNEL1 (W/m**2)	1D
3	CHANNEL2 (W/m**2)	1D
4	CHANNEL3 (W/m**2)	1D
5	CHANNEL4 (W/m**2)	1D
6	WARNING	5A

+++++ Error Summary +++++

HDU#	Name (version)	Type	Warnings	Errors
1		Primary Array	0	0
2	IRRAD LEVEL 2	Binary Table	0	0

**** Verification found 0 warning(s) and 0 error(s). ****

File name: lyra_20090730-000000_lev3_v010101.fits

Run Number 7210

fitsverify 4.15 (CFITSIO V3.181)

2 Header-Data Units in this file.

===== HDU 1: Primary Array =====

```
1 | SIMPLE = T /Written by IDL: Fri Jul 31 15:40:45 2009
2 | BITPIX = 8 /
3 | NAXIS = 0 /
4 | EXTEND = T /File contains extensions
5 | ORIGIN = 'ROB-SIDC' /
6 | TELESCOP= 'PROBA2 ' /
7 | INSTRUME= 'LYRA ' /
8 | OBJECT = 'EUV solar irradi' /
9 | OBS_MODE= 'standard' /std, ecl, bak, eng, or met
10 | DATE = '2009-07-31' /
11 | DATE_OBS= '2009-07-30T00:00:00.000' /UTC start of observation
12 | DATE_END= '2009-07-30T23:59:59.990' /UTC end of observation
13 | DEL_TIME= 60 /one-minute averages
14 | DATASRC = 'Redu ' /receiving ground station
15 | LEVEL = '3 ' /calibration level
16 | ALGOR_V = '01.01.01' /LYRA calibration S/W version lev1.lev2.lev3
17 | FILENAME= 'lyra_20090730-000000_lev3_v010101.fits' /name of this FITS file
18 | END
```

18 header keywords

Null data array; NAXIS = 0

===== HDU 2: BINARY Table =====

```
1 | XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 31 15:40:45 2009
2 | BITPIX = 8 /
3 | NAXIS = 2 /Binary table
4 | NAXIS1 = 39 /Number of bytes per row
5 | NAXIS2 = 1248 /Number of rows
6 | PCOUNT = 0 /Random parameter count
7 | GCOUNT = 1 /Group count
8 | TFIELDS = 6 /Number of columns
9 | EXTNAME = 'IRRAD LEVEL 3' /name of binary table extension
10 | TFORM1 = '1I ' /Integer*2 (short integer)
11 | TTYPE1 = 'TIME ' /Label for column 1
12 | TUNIT1 = 'MIN ' /Units of column 1
13 | TFORM2 = '1D ' /Real*8 (double precision)
14 | TTYPE2 = 'CHANNEL1' /Label for column 2
15 | TUNIT2 = 'W/M**2 ' /Units of column 2
16 | TFORM3 = '1D ' /Real*8 (double precision)
17 | TTYPE3 = 'CHANNEL2' /Label for column 3
18 | TUNIT3 = 'W/M**2 ' /Units of column 3
19 | TFORM4 = '1D ' /Real*8 (double precision)
20 | TTYPE4 = 'CHANNEL3' /Label for column 4
21 | TUNIT4 = 'W/M**2 ' /Units of column 4
22 | TFORM5 = '1D ' /Real*8 (double precision)
23 | TTYPE5 = 'CHANNEL4' /Label for column 5
24 | TUNIT5 = 'W/M**2 ' /Units of column 5
25 | TFORM6 = '5A ' /Character string
26 | TTYPE6 = 'WARNING ' /Label for column 6
27 | TUNIT6 = ' ' /Units of column 6
```

28 | END

28 header keywords

IRRAD LEVEL 3 (6 columns x 1248 rows)

Col#	Name (Units)	Format
1	TIME (MIN)	1I
2	CHANNEL1 (W/M**2)	1D
3	CHANNEL2 (W/M**2)	1D
4	CHANNEL3 (W/M**2)	1D
5	CHANNEL4 (W/M**2)	1D
6	WARNING	5A

+++++ Error Summary +++++

HDU#	Name (version)	Type	Warnings	Errors
1		Primary Array	0	0
2	IRRAD LEVEL 3	Binary Table	0	0

**** Verification found 0 warning(s) and 0 error(s). ****