SphinX user guide

(version 1.1, January 2010)

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CONTENT

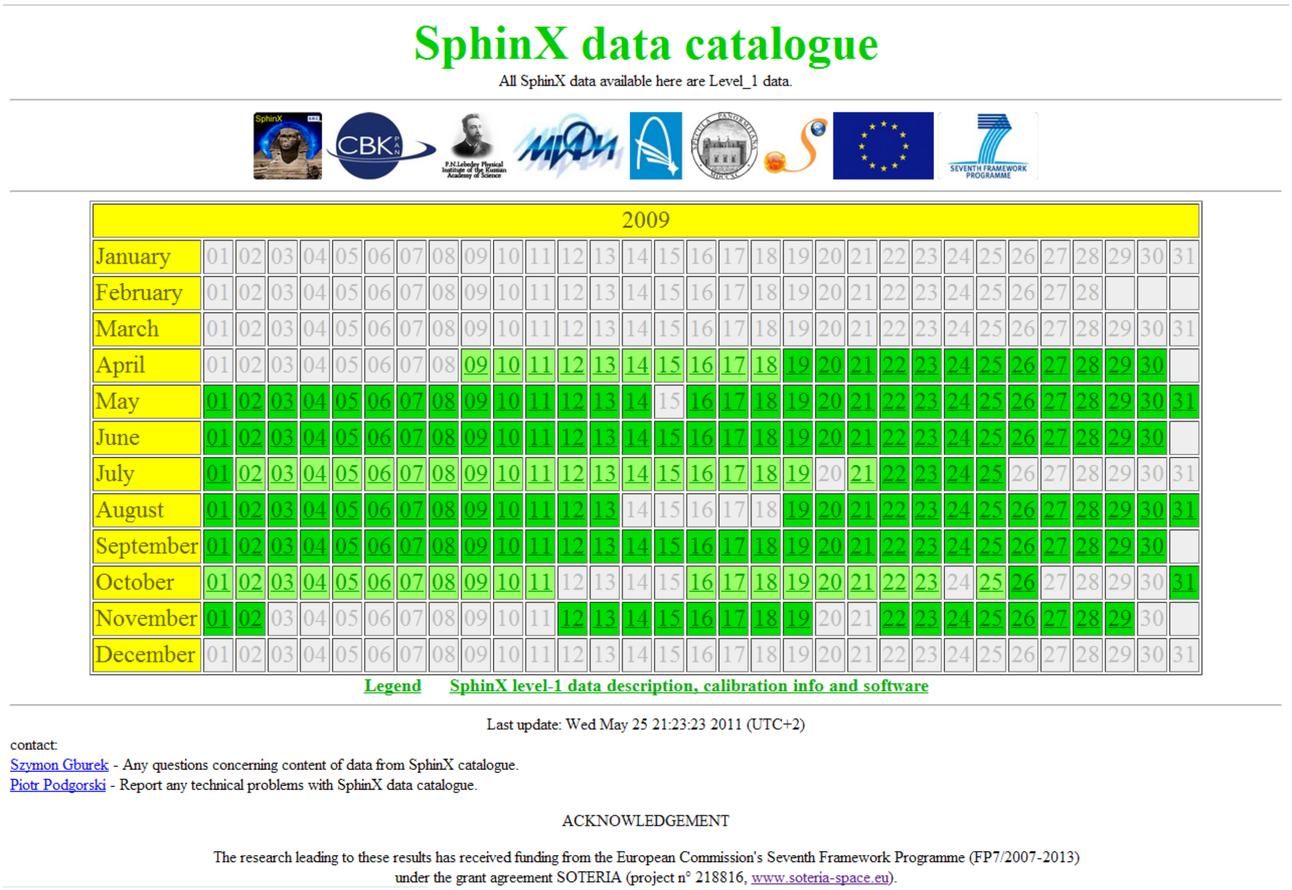
1 SphinX Level-1 Data repository

SphinX level-1 data are event lists stored in Flexible Image Transport System (FITS) files. Well documented and standardized Office of Guest Investigator Programs (OGIP) FITS format was used for preparation of SphinX level-1 FITS files. A description of the OGIP FITS format for event lists can be found for example on the WWW site

http://heasarc.gsfc.nasa.gov/docs/heasarc/ofwg/docs/events/ogip_94_003/ogip_94_003.html

Access to level-1 data can be obtained through the SphinX level-1 main catalogue page

http://156.17.94.1/sphinx_l1_catalogue/SphinX_cat_main.html


SphinX data catalogue

All SphinX data available here are Level_1 data.

2009																															
January	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
February	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
March	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
April	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
May	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
July	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
August	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
September	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
October	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
November	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
December	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Legend SphinX level-1 data description, calibration info and software

Last update: Wed May 25 21:23:23 2011 (UTC+2)

contact:
Szymon Gburek - Any questions concerning content of data from SphinX catalogue.
Piotr Podgorski - Report any technical problems with SphinX data catalogue.

ACKNOWLEDGEMENT

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Figure 1. SphinX level-1 main catalogue page.

This page (shown in Figure 1) is organized in a form of calendar in which day fields are link to SphinX daily summary pages. Days for which there are SphinX data available are indicated in green. In light green are days in which the satellite was not eclipsed by the Earth on its orbit. Below the calendar in the page there are links to Legend document with description of the catalogue sites. The second link *SphinX level-1 data description, calibration info and software* below the calendar on the right hand side opens a WWW site which contains

- guide for SphinX users,
- description of SphinX level-1 data and their format,
- IDL routines for processing SphinX level-1 data,
- example IDL programs.
- example level-1 FITS files and the calibration FITS with SphinX DRM
- description of SphinX flag system

Each day link opens a daily summary page with visualization of SphinX data and links for downloading level-1 data files. Top portion of a selected daily summary page is shown in

Figure 2 in which links to level-1 FITS also are indicated. All files from level-1 catalogue take ~116 GB of storage space.

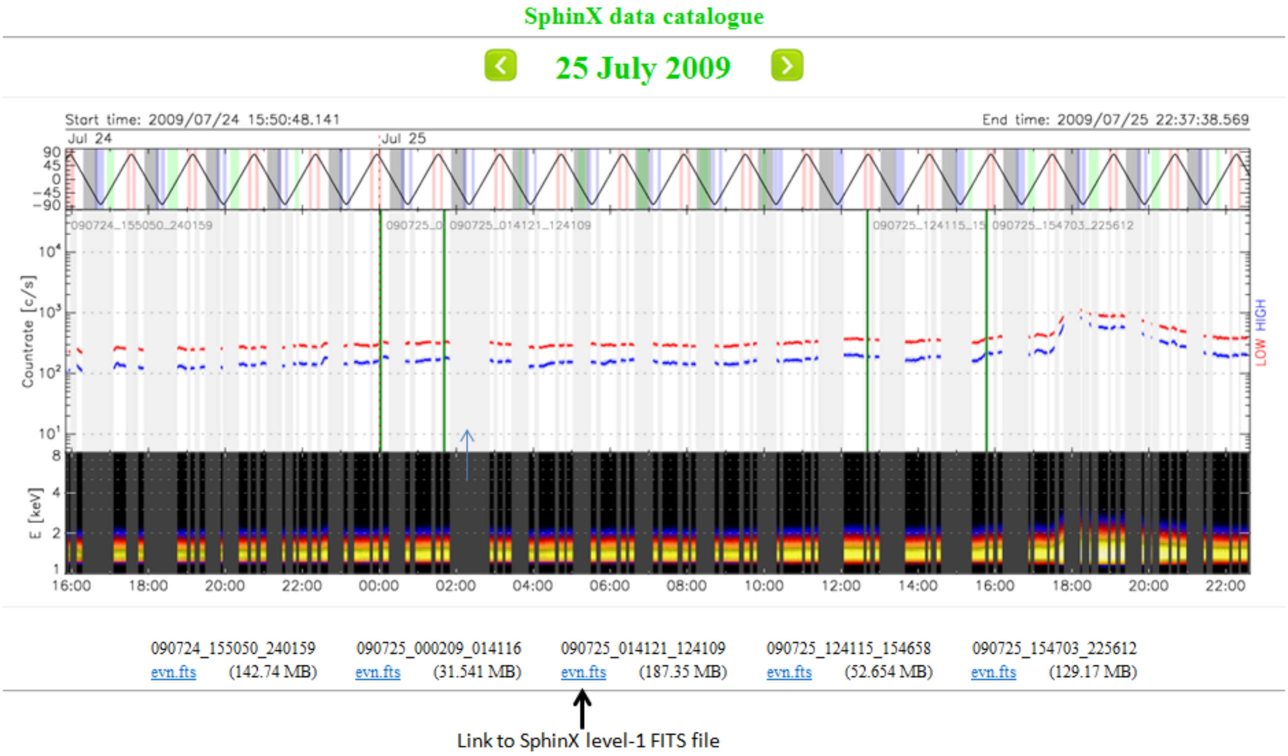

Figure 2. Top portion of a selected daily page from SphinX level-1 catalogue.

2 SphinX Level-1 Data format

2.1 SphinX Event Lists

Naming convention for SphinX level-1 event FITS files is

SPHINX_YYMMDD_HHMMSS_HHMMSS1_evn_D1_L1.fts,

where *YYMMDD* is the date on which measurements in the file were recorded, *HHMMSS* is the start time and *HHMMSS1* the end time of measurements in the file. If measurements extend beyond midnight to the next day then *HH* in *HHMMSS1* is greater than 24. For example in the file *SPHINX_090718_230838_260933_evn_D1_L1.fts* are data recorded by SphinX from 2009-07-18 23:08:38 Universal Time Coordinated (UTC) to 2009-07-19 02:09:33 UTC.

Each particular SphinX FITS event file contains

- primary header,
- EVENT extension,
- EXPOSURE extension,
- GTI standard good time interval extension – intervals of noninterrupted instrument operation.

2.1.1 Event Extension

The binary table of EVENT extension in SphinX FITS files consists of the following columns

TIME – time of event registration (in seconds from reference time)
PHA – channel in which an event was registered (0-255 for SphinX flight data)
PI – pulse invariant channel for an event
ENERGY – event energy
FLAG – an event origin and type description
NRM – SphinX specific column – gives a link to level-0 data (not important for users)

The reference time for conversion of TIME column to UTC is defined in the EVENT extension header. The conversion procedure to UTC is described in Time system in SphinX FITS section of this document below.

Not only events caused by hits of solar X-ray photons into detector crystals are tabulated in the SphinX FITS. The events coming from energetic particle hits, events recorded during satellite nights or electronic glitches are present in the SphinX event FITS files too. Therefore a FLAG is provided for each event in order to identify event origin. For good solar events the flag value is set to zero (FLAG = 0).

2.1.2 Exposure Extension

The binary table of EXPOSURE extension in SphinX FITS files consists of the following columns

TSTART
TSTOP
FRACEXP

SphinX registered events contiguously in a short time intervals. Between these intervals there are data gaps caused for instance by electronics resets, onboard processing or interruptions due to sending data to the telemetry buffer.

The columns TSTART and TSTOP of the EXPOSURE binary table give times between which, events were registered without interruptions. The FRACEXP column of the EXPOSURE binary table contains the correction factor which is necessary to calculate exposures. Actual exposures for events recorded between TSTART and TSTOP are defined as follows

$$EXPOSURES = (TSTOP - TSTART)*FRACEXP$$

TSTART and TSTOP times are in seconds from a reference time given in the EXPOSURE extension header (it is the same time as the reference time in EVENT extension header).

The reference time for conversion of TSTART and TSTOP columns to UTC is defined in the EXPOSURE extension header. The conversion procedure to UTC is described in Time system in SphinX fits section of this document below.

2.1.3 Good Time Interval Extension

The third extension in SphinX event FITS is Good Time interval extension – GTI extension. Its binary table has only two columns

TSTART
TSTOP

TSTART and TSTOP keyword values indicate times between which the instrument registered events continuously. If no additional event filtration was performed by user TSTART and TSTOP are exactly the same as in EXPOSURE extension.

TSTART and TSTOP are in seconds from a reference time given in the GTI extension header (it is the same time as the reference time in EVENT and EXPOSURE extension header).

2.2 Time System in SphinX FITS

Reference time for any time columns in SphinX event FITS is start of a day on which the measurement in the file were recorded. It is specified in the TIMEZERO and MJDREF keywords in EVENT, EXPOSURE and GTI extension headers. TIMEZERO gives the number of days that elapsed from 1979-01-01T00:00:00.000 till the reference time and MJDREF keyword value gives a modified Julian date of 1979-01-01T00:00:00.000 ($MJD = JD - 2400000{,}5$). Thus modified Julian date TIME_REF_MJD of the reference time is

$$\mathrm{TIME\_REF\_MJD} = \mathrm{MJDREF} + \mathrm{TIMEZERO}$$

2.3 Detector Response Matrix and Energy Boundary Information

Data from X-ray tests of SphinX in Palermo XACT facility (2007) and Bessy II synchrotron in Berlin (2008) were finally processed in 2010 in order to prepare all necessary calibration information for SphinX data analysis. The calibration information is stored in a single OGIP FITS file – SphinX response FITS file. This FITS is named SPHINX_RSP_256_nom_D1.fts. A description of the SphinX response FITS file format can be found on the site

ftp://legacy.gsfc.nasa.gov/caldb/docs/memos/cal_gen_92_002/cal_gen_92_002.pdf

The SphinX response FITS file contains:

- primary header,
- MATRIX extension,
- EBOUNDS extension.

2.3.1 Matrix Extension

The binary table of MATRIX extension in SphinX response FITS file contains the Detector Response Matrix DRM and consists of the following columns

ENERG_LO – the lower energy bound of the energy bin,
ENERG_HI – the upper energy bound of the energy bin,
N_GRP – contains the number of ’channel subsets’for the energy
F_CHAN – contains the channel number of the start of each “channel subset” for the energy bin,
N_CHAN – contains the number of channels within each “channel subset” for the energy bin,
MATRIX – containing all the response values for each ’channel subset’ for the energy bin.

There is no grouping of channels in SphinX DRM thus N_GRP, F_CHAN, N_CHAN are scalars of values 1, 1, 256 respectively. These columns are kept in the response FITS to be consistent with OGIP format requirements. Columns ENERG_LO and ENERG_HI are in units of keV.

2.3.2 Ebounds Extension

The second extension in SphinX response FITS is EBOUNDS extension with the following columns:

CHANNEL – SphinX channel number
E_MIN – nominal energy of lower boundary of the detector channel
E_MAX – nominal energy of upper boundary of the detector channel

where columns E_MIN and E_MAX are in units of keV.

3 Application of SphinX Calibration Information in Spectral Analysis

Nominal SphinX DRM, stored in the MATRIX extension of SphinX response FITS, is of the size of 256×281. SphinX DRM is used in spectral analysis according to the following equation

$$O = DRM\#(M*DE),$$

where M is a model spectrum vector in units photons/s/cm^2/keV defined for energy bin centers that are given as (ENERG_HI + ENERG_LO)/2. Energy bin width vector on the model side of the equation DE = ENERG_HI – ENERG_LO. O is the spectrum model folded with the instrument response in units of counts/s as it would be observed in SphinX channels. The # sign stays here for matrix multiplication. The energy edges for O vector channels are defined by E_MIN and E_MAX in EBOUNDS extension.

Users may work with different energy binnings from these defined in nominal SphinX response FITS by columns pairs (ENERG_HI, ENERG_LO) and (E_MIN, E_MAX) for both sides of the equation above. If it is the case, users also have to rebin DRM accordingly to their needs and energy edges specification. This can be done automatically in most of spectral analysis packages.

The vector O is next compared to real SphinX measurement D in order to find out if the model M fits to data. Normalized for degree of freedom chi-square distribution ${\chi_{norm}}^2$ can be used to test goodness of fit

$$ {\chi_{norm}}^2 = \frac{1}{\nu}\sum\frac{(D-O)^2}{\sigma^2}, $$

where ν is the number of degrees of freedom given by $N-n-1$, where N is the number of observations, and n is the number of the fitted model parameters. The errors σ can be calculated from the expression

$$ \sigma^2 = D + {I_{err}}^2, $$

where the first term describes squared Poisson error and I_{err} in the second term is the instrumental error which is less than 1% of D.

4 SphinX Data Processing

4.1 Tools for SphinX data Processing

Processing of SphinX event list consists of the following steps:

1) Reading data
2) Filtering out the selected for analysis event lists by energy bins and type. The type of an event can be determined by FLAG column. Description of SphinX flags is given in each event list extension header in SphinX FITS file and on the www site of SphinX level-1 data catalogue.
3) Preparing higher level data products (such as spectra lightcurves) from filtered event lists.
4) Performing data analysis.

Filtration and preparation of spectra/lightcurves can be done using, for example, XSELECT (FTOOLS) or EVTSELECT from XMM Newton Science Analysis System (SAS) environment.

Spectral analysis can be performed using spectral analysis packages such as XSPEC, OSPEX or by user software directly in IDL, C++ or other language. SphinX team uses OSPEX in IDL described on the site

http://hesperia.gsfc.nasa.gov/ssw/packages/spex/doc/ospex_explanation.htm

The tools for processing and analysis of SphinX data are available for downloading and install from

http://heasarc.gsfc.nasa.gov/docs/software.html
http://xmm.esa.int/sas/

It is also possible to perform SphinX data analysis using web interface on which on-line access to the newest version of FTOOLS is provided

http://heasarc.gsfc.nasa.gov/hera/

4.2 SphinX level-1 Data Processing in IDL

SphinX data analysis can be performed in any programistic language. Preferred environment is IDL with installed SolarSoft package. The SolarSoft installation and downloads are available on

http:/www.lmsal.com/solarsoft/

Recommended IDL routine for reading SphinX level-1 event list FITS and calibration file is *mrdfits* which is in SolarSoft package. To read SphinX event list FITS the following call of *mrdfits* can be used

data = mrdfits(filename, id, hdr, status=status).

Here *filename* is the SphinX event list file name, *data* is an IDL structure with FITS binary extension table and *hdr* is FITS extension header. *Status* keyword is greater or equal to zero if reading was successful and *id* is FITS extension number. Header data units are ordered by *id* in SphinX event FITS always in the same way. When reading SphinX event FITS using the mrdfits routine one obtains the following IDL variables:

id = 0 – *hdr* = primary header, *data* = 0,
id = 1 – *hdr* = events header, *data* = event list IDL structure,
id = 2 – *hdr* = exposure header, *data* = exposure IDL structure,
id = 3 – *hdr* = GTI header, *data* = GTI IDL structure.

For reading SphinX response FITS *filename* must point to SPHINX_RSP_256_nom_D1.fts file. In this case one gets:

id = 0 – *hdr* = primary header, *data* = 0,
id = 1 – *hdr* = DRM header, *data* = DRM MATRIX IDL structure,
id = 2 – *hdr* = EBOUNDS header, *data* = EBOUNDS IDL structure.

The SphinX FITS files should be in working directory or full path to them should be specified in *filename* variable.

Filtration of events by flags according to the user needs can be done with *SphinX_select.pro* IDL routine. Preparation of lightcurves and spectra, with which most users want to work, is possible using IDL routines *SphinX_lightcurve.pro* and spectra *SphinX_spectrum.pro*. All these routines can be downloaded from SphinX level-1 data catalogue

http://156.17.94.1/SphinX_l1_catalogue/SphinX_cat_main.html

under the link *SphinX level-1 data description, calibration info and software*. In the same place there are short sample IDL programs *SphinX_test_lc.pro*, *SphinX_test_spectrum.pro* which read SphinX level-1 event FITS, filter the events and produce lightcurves and spectra. In *SphinX_test_spectrum.pro* it is also shown how to read calibration information. Execution of these programs in IDL produces plots like the ones shown in Figure 3 and Figure 4.

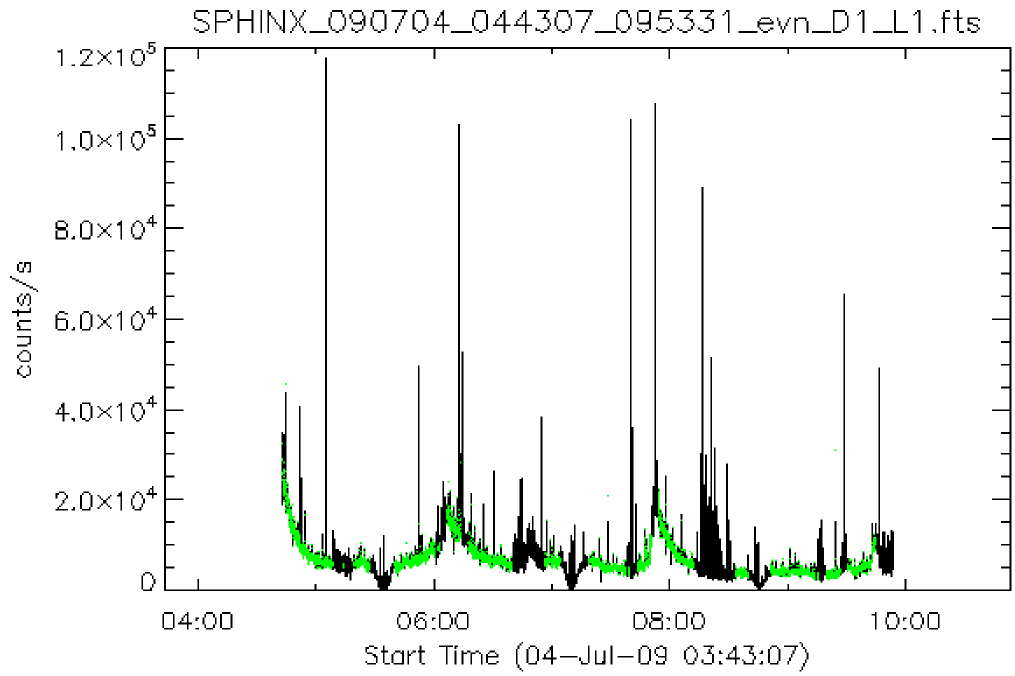

Figure 3. Example of SphinX lightcurves. Raw lightcurve obtained from events in SphinX FITS file SPHINX_090704_044307_095331_evn_D1_L1.fts is shown in black. A lightcurve binned only from good solar events (X-ray photons) is shown in green.

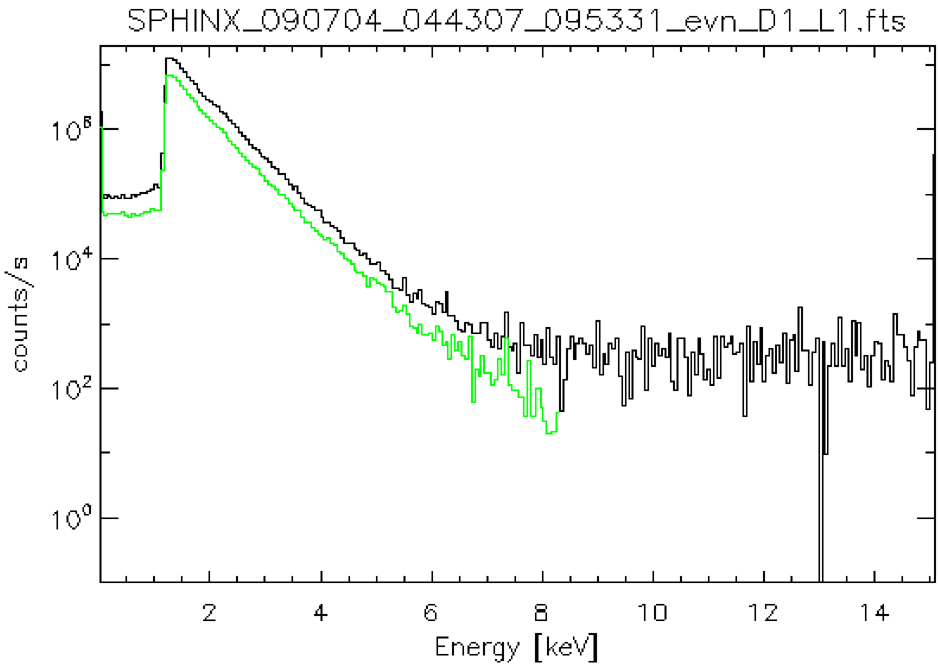

Figure 4. Example of SphinX spectrum. Raw spectrum obtained from events in SphinX FITS file SPHINX_090704_044307_095331_evn_D1_L1.fts is shown in black. A spectrum binned only from good solar events (X-ray photons) is shown in green.

APPENDIX 1 - SphinX FITS headers format

Event FITS Primary Header

SIMPLE = T	/Written by IDL: Fri May 02 16:43:31 2008
BITPIX = 16	/Number of bits per data pixel /channel
NAXIS = 0	/Number of data axes
EXTEND = T	/File contains extensions
DATE = '2011-03-17T20:15:13'	/File creation date (YYYY-MM-DDThh:mm:ss UTC)
ORIGIN = 'PAS SRC SPD Wroclaw'	/Origin of the file
SATELITE= 'CORONAS-Photon'	/Satellite name
OBSERVER= 'Unknown '	/Usually the name of the user who generated
TELESCOP= 'SPHINX '	/Name of the Telescope or Mission
INSTRUME= 'SPHINX '	/Name of the instrument
OBJECT = 'Sun '	/Object being observed
DATE_OBS= '2009-07-04T04:43:07.547'	/nominal U.T. date when integration of this
DATE_END= '2009-07-04T09:53:31.358'	/nominal U.T. date when integration of this
TIMESYS = '1979-01-01T00:00:00'	/Reference time in YYYY MM DD hh:mm:ss
TIMEUNIT= 'd '	/Unit for TIMEZERO, TSTARTI and TSTOPI
AUTHOR = 'sphinx_fits2.pro'	/Program name that produced this file
RA = 193.472441441	/Source right ascension in degrees
DEC = -6.54803262526	/Source declination in degrees
RA_NOM = 193.472441441	/r.a. nominal pointing in in degrees
DEC_NOM = -6.54803262526	/dec. nominal pointing in in degrees
EQUINOX = 2000.00	/Equinox of celestial coordinate system
RADECSYS= 'FK5 '	/Coordinate frame used for equinox

TIMVERSN= 'OGIP	/93-003' /OGIP memo number where the convention used
XENDIAN = 'BIG '	/Byte order
VERSION = '1.0 '	/File format version number
END	

EVENTS Extension Header

XTENSION= 'BINTABLE'	/Binary table written by MWRFITS v1.11
BITPIX = 8	/Required value
NAXIS = 2	/Required value
NAXIS1 = 24	/Number of bytes per row
NAXIS2 = 5511812	/Number of rows
PCOUNT = 0	/Normally 0 (no varying arrays)
GCOUNT = 1	/Required value
TFIELDS = 6	/Number of columns in table
COMMENT	
COMMENT *** End of mandatory fields ***	
COMMENT	
DATE = '2011-03-17T20:15:13'	/File creation date (YYYY-MM-DDThh:mm:ss UTC)
ORIGIN = 'PAS SRC SPD Wroclaw'	/Origin of the file
SATELITE= 'CORONAS-Photon'	/Satellite name
OBSERVER= 'Unknown '	/Usually the name of the user who generated
AUTHOR = 'sphinx_fits2.pro'	/Name of program that produced this file
TELESCOP= 'SPHINX '	/Name of the Telescope or Mission
INSTRUME= 'SPHINX '	/Name of the instrument
OBJECT = 'Sun '	/Object being observed
DATE_OBS= '2009-07-04T04:43:07.547'	/UTC start time of observation
DATE_END= '2009-07-04T09:53:31.358'	/UTC end time of observation
COMMENT --	
EQUINOX = 2000.00	/Equinox of celestial coordinate system
RADECSYS= 'FK5 '	/Coordinate frame used for equinox
RA = 193.472441441	/[deg] RA of target
DEC = -6.54803262526	/[deg] Dec of target
RA_NOM = 193.472441441	/[deg] RA of nominal boresight
DEC_NOM = -6.54803262526	/[deg] Dec of nominal boresight
COMMENT	
COMMENT *** Column names ***	
COMMENT	
TTYPE1 = 'TIME '	/
TTYPE2 = 'PHA '	/
TTYPE3 = 'PI '	/
TTYPE4 = 'ENERGY '	/
TTYPE5 = 'FLAG '	/
TTYPE6 = 'NRM '	/
COMMENT	
COMMENT *** Column formats ***	
COMMENT	

```
TFORM1  = 'D       '                                          /
TFORM2  = 'I       '                                          /
TFORM3  = 'I       '                                          /
TFORM4  = 'E       '                                          /
TFORM5  = 'J       '                                          /
TFORM6  = 'J       '                                          /
COMMENT
COMMENT *** Column units ***
COMMENT
TUNIT1  = 's       '                                          /
TUNIT2  = 'chan    '                                          /
TUNIT3  = 'chan    '                                          /
TUNIT4  = 'keV     '                                          /
TUNIT5  = '        '                                          /
TUNIT6  = '        '                                          /
COMMENT  ------ CHANNEL  /ENERGY conversion info ------------------------
COMMENT  from BESSY calibration it follows that nominally
COMMENT  ENERGY = 0.059217000*PHA + 0.0050194827
COMMENT  PI= fix(1. + 255. * ENERGY/15.105547)
COMMENT  ------ SPHINX FLAG VALUES AND MEANING ----------------------
COMMENT  BAD_DGI_TIME =  2L^0   -  Bad SphinX times for the entire
COMMENT  IRESET       =  2L^1   -  Instrument reset
COMMENT  HOT          =  2L^2   -  Increased detector temperature
COMMENT  NN_BAD       =  2L^3   -  upset of unknown origin
COMMENT  SHADOW       =  2L^4   -  instrument in shadow
COMMENT  X_NIGHT      =  2L^5   -  X night
COMMENT  OPT_NIGHT    =  2L^6   -  Optical night
COMMENT  RB           =  2L^7   -  Radiation belts
COMMENT  NRB          =  2L^8   -  RB - the north oval
COMMENT  SRB          =  2L^9   -  RB - the south oval
COMMENT  SAA          =  2L^10  -  SAA
COMMENT  PARTICLE     =  2L^11  -  Most likely particle event
COMMENT  HIPHA        =  2L^12  -  Event with exceptionally high PHA
COMMENT  NONGTI       =  2L^13  -  Event outside GTI
COMMENT  BAD_EVN_TIME =  2L^14  -  Bad Event time
COMMENT  More detail flag description is in sphinx_flag_routines.pro
COMMENT  ------ TIME SYSTEM -------------------------------------------
TIMESYS = '1979-01-01T00:00:00'                               /Reference time MJDREF in YYYY MM DD hh:mm:ss
TIME_UNI=                    1                                /
TIMEUNIT= 'd       '                                          /Unit for TIMEZERO, TSTARTI and TSTOPI
TIMEREF = 'LOCAL   '                                          /Reference frame for the times LOCAL=satellite
MJDREF  =            43874.000                                /TIMESYS in MJD (d)
TIMEZERO=        11142.0000000                                /Start day of the first bin rel to TIMESYS
TSTARTI =                11142                                /Integer portion of start time rel to TIMESYS
TSTARTF =      0.1966151286069                                /Fractional portion of start time
TSTOPI  =                11142                                /Integer portion of stop time rel to TIMESYS
TSTOPF  =      0.4121684955098                                /Fractional portion of stop time
TASSIGN = 'SATELLITE'                                         /Place of time assignment
TIERRELA=       5.0000000E-007                                /Relative time error [s]
```

TIERABSO= 0.00100000	/Absolute time error [s] baryc corr. etc ???
ONTIME = 1170.3904103795466	/sum of all Good Time Intervals - GTIs
TELAPSE = 18623.8109003658464	/Elapsed time in seconds between TSTART and TSTO
EXPOSURE= 1144.83609813	/Integration time, corrected for deadtime/gaps
LIVETIME= 1144.83609813	/Livetime
CLOCKCOR= 1	/Clock Correction to UT
COMMENT absTime[i] = mjd2any(MJDREF + TIMEZERO) + TIME[i]	
COMMENT --	
E_MIN = 0.00000	/lower energy boudary
E_MAX = 15.1352	/higher energy boundary
EUNIT = 'keV '	/Energy units
DETCHANS= 256	/Total number of detector channels available
CHANTYPE= 'PI '	/Channels assigned by detector electronics
COMMENT --	
VERSION = '1.0 '	/File format version
EXTNAME = 'EVENTS '	/Extension Name
HDUCLASS= 'OGIP '	/File conforms to OGIP /GSFC convention
HDUCLAS1= 'EVENTS '	/Extension contains Events
HDUCLAS2= 'ALL '	/extension contains all events detected
HDUVERS = '1.2 '	/File conforms to this version of OGIP
TIMVERSN= 'OGIP	/93-003' /OGIP memo number where the convention used
COMMENT --	
GROUPING= 0	/No grouping of data has been defined
DETNAM = 'D1 '	/Detector name
GEOAREA = 0.196350000000	/Detector area [cm^2]
FILTER = 'AlMyAlBe'	/Filter used
RESPFILE= ' '	/SRM matrix
COMMENT	
COMMENT *** SphinX specyfic keywords ***	
COMMENT	
AMPNAME = 'A '	/Detector amplifier name
OBS_ID = 'DS1 '	/Observation id code
END	

EXPOSURE Extension Header

XTENSION= 'BINTABLE'	/Binary table written by MWRFITS v1.11
BITPIX = 8	/Required value
NAXIS = 2	/Required value
NAXIS1 = 24	/Number of bytes per row
NAXIS2 = 21910	/Number of rows
PCOUNT = 0	/Normally 0 (no varying arrays)
GCOUNT = 1	/Required value
TFIELDS = 3	/Number of columns in table
COMMENT	
COMMENT *** End of mandatory fields ***	
COMMENT	
DATE = '2011-03-17T20:15:13'	/File creation date (YYYY-MM-DDThh:mm:ss UTC)

```
ORIGIN  = 'PAS SRC SPD Wroclaw'                      /Origin of the file
SATELITE= 'CORONAS-Photon'                           /Satellite name
OBSERVER= 'Unknown '                                 /Usually the name of the user who generated
AUTHOR  = 'SpX2OGIP.pro'                             /Name of program that produced this file
TELESCOP= 'SPHINX  '                                 /Name of the Telescope or Mission
INSTRUME= 'SPHINX  '                                 /Name of the instrument
OBJECT  = 'Sun     '                                 /Object being observed
DATE_OBS= '2009-07-04T04:43:07.547'                  /UTC start time of observation
DATE_END= '2009-07-04T09:53:31.358'                  /UTC end time of observation
COMMENT ----------------------------------------------------------------------
EQUINOX =             2000.00                        /Equinox of celestial coordinate system
RADECSYS= 'FK5     '                                 /Coordinate frame used for equinox
RA      =        193.472441441                       /[deg] RA of target
DEC     =       -6.54803262526                       /[deg] Dec of target
RA_NOM  =        193.472441441                       /[deg] RA of nominal boresight
DEC_NOM =       -6.54803262526                       /[deg] Dec of nominal boresight
COMMENT
COMMENT  *** Column names ***
COMMENT
TTYPE1  = 'TSTART  '                                 /
TTYPE2  = 'TSTOP   '                                 /
TTYPE3  = 'FRACEXP '                                 /
COMMENT
COMMENT  *** Column formats ***
COMMENT
TFORM1  = 'D       '                                 /
TFORM2  = 'D       '                                 /
TFORM3  = 'D       '                                 /
COMMENT *** Column units ***
TUNIT1  = 's       '                                 /
TUNIT2  = 's       '                                 /
TUNIT3  = 'FRACTION'                                 /
COMMENT  ------ TIME SYSTEM ------------------------------------------
TIMESYS = '1979-01-01T00:00:00'                      /Reference time MJDREF in YYYY MM DD hh:mm:ss fo
TIME_UNI=                    1                       /
TIMEUNIT= 'd       '                                 /Unit for TIMEZERO, TSTARTI and TSTOPI
TIMEREF = 'LOCAL   '                                 /Reference frame for the times LOCAL=satellite
MJDREF  =            43874.000                       /TIMESYS in MJD (d)
TIMEZERO=        11142.0000000                       /Start day of the first bin rel to TIMESYS
TSTARTI =                11142                       /Integer portion of start time rel to TIMESYS
TSTARTF =      0.1966151286069                       /Fractional portion of start time
TSTOPI  =                11142                       /Integer portion of stop time rel to TIMESYS
TSTOPF  =      0.4121684955098                       /Fractional portion of stop time
TASSIGN = 'SATELLITE'                                /Place of time assignment
TIERRELA=        5.0000000E-007                      /Relative time error [s]
TIERABSO=           0.00100000                       /Absolute time error [s] baryc corr. etc ???
ONTIME  =   1170.3904103795466                       /sum of all Good Time Intervals - GTIs
TELAPSE =  18623.8109003658464                       /Elapsed time in seconds between TSTART and TSTOP
EXPOSURE=        1144.83609813                       /Integration time, corrected for deadtime/gaps
```

```
LIVETIME=       1144.83609813                /Livetime
CLOCKCOR=                   1                /Clock Correction to UT
COMMENT absTime[i] = mjd2any(MJDREF + TIMEZERO) + TIME[i]
COMMENT ----------------------------------------------------------------
COMMENT FRACEXP was calculated as a ratio OCR    /ICR, where
COMMENT ICR was calculated by solving the following equation
COMMENT OCR = ICR*exp(-dt*ICR) with constant dt = 5.24d-6 [s]
COMMENT ----------------------------------------------------------------
EUNIT   = 'keV     '                         /Energy units
VERSION = '1.0     '                         /File format version
EXTNAME = 'EXPOSURE'                         /Extension Name
HDUCLASS= 'OGIP    '                         /File conforms to OGIP /GSFC convention
HDUCLAS1= 'EXPOSURE'                         /Extension contains exposures
HDUVERS = '1.2     '                         /File conforms to this version of OGIP
TIMVERSN= 'OGIP                              /93-003' /OGIP memo number where the convention used
COMMENT ----------------------------------------------------------------------
GROUPING=                   0                /No grouping of data has been defined
DETNAM  = 'D1      '                         /Detector name
GEOAREA =       0.196350000000               /Detector area [cm^2]
FILTER  = 'AlMyAlBe'                         /Filter used
COMMENT
COMMENT *** SphinX specyfic keywords ***
COMMENT
AMPNAME = 'A       '                         /Detector amplifier name
OBS_ID  = 'DS1     '                         /Observation id code
END
```

GTI Extension Header

```
XTENSION= 'BINTABLE'                         /Binary table written by MWRFITS v1.11
BITPIX  =                   8                /Required value
NAXIS   =                   2                /Required value
NAXIS1  =                  16                /Number of bytes per row
NAXIS2  =               21910                /Number of rows
PCOUNT  =                   0                /Normally 0 (no varying arrays)
GCOUNT  =                   1                /Required value
TFIELDS =                   2                /Number of columns in table
COMMENT
COMMENT  *** End of mandatory fields ***
COMMENT
DATE    = '2011-03-17T20:15:13'              /File creation date (YYYY-MM-DDThh:mm:ss UTC)
ORIGIN  = 'PAS SRC SPD Wroclaw'              /Origin of the file
SATELITE= 'CORONAS-Photon'                   /Satellite name
OBSERVER= 'Unknown '                         /Usually the name of the user who generated
AUTHOR  = 'SpX2OGIP.pro'                     /Name of program that produced this file
TELESCOP= 'SPHINX  '                         /Name of the Telescope or Mission
INSTRUME= 'SPHINX  '                         /Name of the instrument
OBJECT  = 'Sun     '                         /Object being observed
```

```
DATE_OBS= '2009-07-04T04:43:07.547'                  /UTC start time of observation
DATE_END= '2009-07-04T09:53:31.358'                  /UTC end time of observation
COMMENT ------------------------------------------------------------------------
EQUINOX =            2000.00                          /Equinox of celestial coordinate system
RADECSYS= 'FK5     '                                  /Coordinate frame used for equinox
RA      =       193.472441441                         /[deg] RA of target
DEC     =       -6.54803262526                        /[deg] Dec of target
RA_NOM  =       193.472441441                         /[deg] RA of nominal boresight
DEC_NOM =       -6.54803262526                        /[deg] Dec of nominal boresight
COMMENT
COMMENT  *** Column names ***
COMMENT
TTYPE1  = 'TSTART  '                                  /
TTYPE2  = 'TSTOP   '                                  /
COMMENT
COMMENT  *** Column formats ***
COMMENT
TFORM1  = 'D       '                                  /
TFORM2  = 'D       '                                  /
COMMENT *** Column units ***
TUNIT1  = 's       '                                  /
TUNIT2  = 's       '                                  /
COMMENT  ------ TIME SYSTEM -------------------------------------------
TIMESYS = '1979-01-01T00:00:00'                       /Reference time MJDREF in YYYY MM DD hh:mm:ss fo
TIME_UNI=                  1                          /
TIMEUNIT= 'd       '                                  /Unit for TIMEZERO, TSTARTI and TSTOPI
TIMEREF = 'LOCAL   '                                  /Reference frame for the times LOCAL=satellite
MJDREF  =          43874.000                          /TIMESYS in MJD (d)
TIMEZERO=       11142.0000000                         /Start day of the first bin rel to TIMESYS
TSTARTI =              11142                          /Integer portion of start time rel to TIMESYS
TSTARTF =     0.1966151286069                         /Fractional portion of start time
TSTOPI  =              11142                          /Integer portion of stop time rel to TIMESYS
TSTOPF  =     0.4121684955098                         /Fractional portion of
TASSIGN = 'SATELLITE'                                 /Place of time assignment
TIERRELA=       5.0000000E-007                        /Relative time error [s]
TIERABSO=          0.00100000                         /Absolute time error [s] baryc corr. etc ???
ONTIME  =  1170.3904103795466                         /sum of all Good Time Intervals - GTIs
TELAPSE =  18623.8109003658464                        /Elapsed time in seconds between TSTART and TSTOP
EXPOSURE=       1144.83609813                         /Integration time, corrected for deadtime/gaps
LIVETIME=       1144.83609813                         /Livetime
CLOCKCOR=                  1                          /Clock Correction to UT
COMMENT absTime[i] = mjd2any(MJDREF + TIMEZERO) + TIME[i]
COMMENT ---------------------------------------------------------------
EUNIT   = 'keV     '                                  /Energy units
VERSION = '1.0     '                                  /File format version
EXTNAME = 'GTI     '                                  /Extension Name
HDUCLASS= 'OGIP    '                                  /File conforms to OGIP /GSFC convention
HDUCLAS1= 'GTI     '                                  /Extension contains good time intervals
HDUCLAS2= 'STANDARD'                                  /Standard GTIs
```

```
HDUVERS = '1.2     '                          /File conforms to this version of OGIP
TIMVERSN= 'OGIP                               /93-003'  /OGIP memo number where the convention used
COMMENT -----------------------------------------------------------------------
GROUPING=                   0                 /No grouping of data has been defined
DETNAM  = 'D1      '                          /Detector name
GEOAREA =       0.196350000000                /Detector area [cm^2]
FILTER  = 'AlMyAlBe'                          /Filter used
COMMENT
COMMENT *** SphinX specyfic keywords ***
COMMENT
AMPNAME = 'A       '                          /Detector amplifier name
OBS_ID  = 'DS1     '                          /Observation id code
END
```

Response FITS Primary Header

```
SIMPLE  =                    T                / file does conform to FITS standard
BITPIX  =                   16                / number of bits per data pixel
NAXIS   =                    0                / number of data axes
EXTEND  =                    T                / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format defined in
Astronomy and
COMMENT   Astrophysics Supplement Series v44/p363, v44 /p371, v73
/p359, v73 /p365.
COMMENT   Contact the NASA Science Office of Standards and
Technology for the
COMMENT   FITS Definition document #100 and other FITS information.
DATE    = '03/03/11'                          / FITS file creation date (dd/mm/yy)
CONTENT = 'CONV RESPONSE MATRIX'              / (convolved) RMF and EBOUNDS extension
RMFVERSN= 'R6      '                          / Redistribution version number
ORIGIN  = 'PAS SRC SPD Wroclaw'               /Origin of the file
SATELITE= 'CORONAS-Photon'                    /Satellite name
TELESCOP= 'SPHINX  '                          /Name of the Telescope or Mission
INSTRUME= 'SPHINX  '                          /Name of the instrument
OBJECT  = 'Sun     '                          /Object being observed
ORIGIN  = 'SRC PAS SPD'                       / Organization which created this file
CREATOR = 'SG'                                / Creator
END
```

MATRIX   Extension Header

```
XTENSION= 'BINTABLE'                          / binary table extension
BITPIX  =                    8                / 8-bit bytes
NAXIS   =                    2                / 2-dimensional binary table
NAXIS1  =                 2074                / width of table in bytes
NAXIS2  =                  281                / number of rows in table
PCOUNT  =                    0                /
GCOUNT  =                    1                / one data group (required keyword)
TFIELDS =                    6                / number of fields in each row
TTYPE1  = 'ENERG_LO'                          / label for field   1
```

```
TFORM1  = 'D       '                    / data format of the field: 4-byte REAL
TUNIT1  = 'keV     '                    / physical unit of field
TTYPE2  = 'ENERG_HI'                    / label for field   2
TFORM2  = 'D       '                    / data format of the field: 4-byte REAL
TUNIT2  = 'keV     '                    / physical unit of field
TTYPE3  = 'N_GRP   '                    / label for field   3
TFORM3  = 'I       '                    / data format of the field: 2-byte INTEGER
TTYPE4  = 'F_CHAN  '                    / label for field   4
TFORM4  = 'J       '                    / data format of the field
TTYPE5  = 'N_CHAN  '                    / label for field   5
TFORM5  = 'J       '                    / data format of the field
TTYPE6  = 'MATRIX  '                    / label for field   6
TFORM6  = '256D    '                    / data format of the field
EXTNAME = 'MATRIX  '                    / name of this binary table extension
CHANTYPE= 'PI      '                    / Whether channels corrected
DETCHANS=                  256          / Type of channel PHA/PI
LO_THRES=          0.00000E+00          / Lower threshold for stored matrix
EFFAREA =          1.00000E+00          / Area scaling factor
RMFVERSN= 'R6      '                    / Redistribution version number
SATELITE= 'CORONAS-Photon'              /Satellite name
TELESCOP= 'SPHINX  '                    /Name of the Telescope or Mission
INSTRUME= 'SPHINX  '                    /Name of the instrument
OBJECT  = 'Sun     '                    /Object being observed
DETNAM  = 'D1      '                    /
FILTER  = 'AlMyAlBe'                    / Standard
CCLS0001= 'CPF     '                    / OGIP class of calibration file
CCNM0001= 'MATRIX  '                    / OGIP codename for this type of cal file
CBD10001= 'ENERGY(0-15)keV'             / Dataset parameter boundary
CBD20001= 'CHAN (0- 255)'               / Dataset parameter boundary
CDTP0001= 'DATA    '                    / OGIP type of dataset (DATA, TASK, etc)
CVSD0001= '03/03/11                     / Dataset validity start time (UTC)
CVST0001= '00:00:00'                    / Dataset validity start time (UTC, of day CVSD)
HDUCLASS= 'OGIP    '                    / Organisation which devised format
HDUCLAS1= 'RESPONSE'                    / Extension contains inst response
HDUCLAS2= 'RSP_MATRIX'                  / The type of data stored
HDUCLAS3= 'FULL    '                    / Nature of stored matrix
HDUVERS1= '1.0.0   '                    / Version of the HDUCLAS1 format in use
HDUVERS2= '1.1.0   '                    / Version of the HDUCLAS1 format in use
CDES0001= 'SphinX DRM'                  / General Comments to identify the dataset
END
```

EBOUNDS Extension Header

```
XTENSION= 'BINTABLE'                    / binary table extension
BITPIX  =                    8          / 8-bit bytes
NAXIS   =                    2          / 2-dimensional binary table
NAXIS1  =                   12          / width of table in bytes
NAXIS2  =                  256          / number of rows in table
```

```
PCOUNT  =                    0                    / size of special data area
GCOUNT  =                    1                    / one data group (required keyword)
TFIELDS =                    3                    / number of fields in each row
TTYPE1  = 'CHANNEL '                              / label for field   1
TFORM1  = 'J       '                              / data format of the field: 2-byte INTEGER
TTYPE2  = 'E_MIN   '                              / label for field   2
TFORM2  = 'E       '                              / data format of the field: 4-byte REAL
TUNIT2  = 'keV     '                              / physical unit of field
TTYPE3  = 'E_MAX   '                              / label for field   3
TFORM3  = 'E       '                              / data format of the field: 4-byte REAL
TUNIT3  = 'keV     '                              / physical unit of field
EXTNAME = 'EBOUNDS '                              / name of this binary table extension
CHANTYPE= 'PI      '                              / Whether channels corrected
DETCHANS=                  256                    / Total number of detector channels
EFFAREA =          1.00000E+00                    / Area scaling factor
RMFVERSN= 'R6      '                              / Redistribution version number
TELESCOP= 'SphinX  '                              /
INSTRUME= 'SphinX  '                              /
DETNAM  = 'D1      '                              /
FILTER  = 'AlMyAlBe'                              / Standard
CLASS   = 'Patterns 0-12'                         / X-ray Pattern Subset
HDUCLASS= 'OGIP    '                              / Organisation which devised format
HDUCLAS1= 'RESPONSE'                              / Extension contains inst response
HDUCLAS2= 'EBOUNDS '                              / The type of data stored
HDUVERS1= '1.0.0   '                              / Version of the HDUCLAS1 format in use
HDUVERS2= '1.1.0   '                              / Version of the HDUCLAS1 format in use
CCLS0001= 'CPF     '                              / OGIP class of calibration file
CCNM0001= 'MATRIX  '                              / OGIP codename for this type of cal file
CBD10001= 'ENERGY(0-15)keV'                       / Dataset parameter boundary
CDTP0001= 'DATA    '                              / OGIP type of dataset (DATA, TASK, etc)
CVSD0001= '01/01/11'                              / Dataset validity start time (UTC)
CVST0001= '00:00:00'                              / Dataset validity start time (UTC, of day CVSD)
CDES0001= 'Sphinx DRM'                            / General Comments to identify the dataset
END
```