DESCRIPTION OF THE XRT CALIBRATION FILES

Version 1.8

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CHANGE RECORD PAGE (1 of 2)

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ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Arf modification	16 Feb 2005		Change the nameing convention of the arf and add a CALDB keyword to describe the grade
Gain and Hkrange modification	20 March 2005		Change the format for the gain files and the hk range file. For the gain it has been introduced the gain temperature dependence. For the hk range file it has been introduced the capability to mark how to combine parameters in the screening expression.
Version 1.2	5 April 2006		Add new file to account for the mismatch of the column numbering for the window timing mode
Version 1.3	18 Nov 2006		Add the PSF changes
Version 1.4	10 July 2007		Insert the Substrate voltage ; New CDB in gain , arf,rmf and hkrange files ; new threshold file
Version 1.5	4 Dec 2007		hkrange add new extensions
Version 1.6	25 June 2008		Change GAIN CALDB file format to account for the voltage changes
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Version 1.8	15 May 2009		Add caldb file for the 3x3 order pixel

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1 Introduction

This document describes the format of XRT Calibration Files and their organization into the XRT CALibration DataBase (XRTCALDB).

The Calibration Data are the results of the pre-launch and in-flight calibration activities and they are recorded in the Calibration Database for archive purposes and to be used in the XRT Pipeline processing software. Specifically the XRT CALDB files are used in the XRT pipeline to create Level 1 and Level 2 calibrated files. They are also used in the Level 3 Data Products Generation and analysis either via pipeline or interactive processing.

The files are stored in CALDB in FITS format with the layout described in this document. Whenever possible standard OGIP layouts were used.

1.1 Applicable Documents

[1] - *BCF & CPF Calibration File Guidelines* - OGIP Calibration Memo CAL/GEN/92-003

[2] - *HFWG Recommendation R8* -1994 February 02

[3] - *Required and Recommended FITS keywords for Calibration Files* -OGIP Calibration Memo CAL/GEN/92-011

[4] - XRT Software Build Plan - v. 1.9 March 2001

[5] - *A Panchromatic Gamma Ray Burst MIDEX Mission* - Phase A Study Report in response to AO-98-0SS-03

[6] - XRT-PSU-028 - *XRT Data Formats* - v 3.8 November 2001

[7] - XRT-PSU-004 - *SWIFT XRT Readout Modes* - v 2.3 October 2001

1.2 Definitions, acronyms and abbreviations

ARF	Ancillary Response File
ASDC	ASI Science Data Center
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
CCD	Charge Coupled Device
CTE	Charge Transfer Efficiency
EEF	Encircled Energy Fraction
FITS	Flexible Image Transport System
GNEST	Ground Network for Swift
GRB	Gamma Ray Burst
GSFC	Goddard Space Flight Center
GTI	Good Time Intervals
HEASARC	High Energy Astrophysics Science Archive Research Center
HK	Housekeeping
ISAC	Italian Swift Archive Center
OAB	Osservatorio Astronomico di Brera (Brera Observatory)
OGIP	Office of the Guest Investigator Programs
PHA	Pulse Height Amplitude
PI	Pulse Invariant
PSF	Point Spread Function
QE	Quantum Efficiency
RMF	Redistribution Matrix File
SDC	Swift Data Center
SSC	Swift Science Center
TAM	Telescope Alignment Monitor
TBD	To Be Defined
TBC	To Be Confirmed
XCFS	XRT Calibration File Set
XRT	X-Ray Telescope

2 XRTCALDB

The XRT calibration database (XRTCALDB) includes the pre-launch results obtained from the analysis of the ground calibration data and also those derived from calibration observations taken in flight during the lifetime of the mission. The results are stored in the OGIP CALDB structure as FITS file following the OGIP standard.

The XRT calibration files are produced by the XRT Calibration team and delivered to the ISAC/ASDC which maintains the XRTCALDB. ISAC/ASDC checks the validity, integrity and format of the files and whether the proper CALDB mandatory keywords are included correctly.

The XRTCALDB is delivered by ISAC/ASDC to the SSC each time an update is performed. The XRTCALDB is delivered by the SSC to the HEASARC for archiving and distribution.

2.1 Scope

During the course of the Swift mission the XRTCALDB shall provide:

- a way to store and archive XRT calibration data;
- naming convention and header structure for XRT calibration files;
- indexing for software access to XRT calibration data based on FITS header keywords;
- a traceable history of XRT calibration data in the database by maintaining the history of versions.

3 XRT Calibration File Set (XCFS)

The Calibration Files are stored into the XRTCALDB database. They are used in the data reduction software and in the data analysis.

3.1 File Naming Convention

The XCFS constituents are named as follows:

swx<datatype>[<date>]v<version>.ext

where:

datatype is the calibration data type identifier (at most eight characters long);

date is an integer giving the date when the file should first be used, with the format: YYYYMMDD;

version is a three digit integer giving the file issue number;

ext is set to 'fits' for all files with the following exceptions: 'rmf' is used for the redistribution matrix, 'arf' is used for the ancillary response file and 'teldef' is used for the telescope definition file.

There are some exceptions to this naming convention to conform the names of some datatypes to the ones more frequently used by other missions. Names adopted for each datatype are described in the related paragraph.

3.2 XCFS Datatypes

Table 1 lists the files included into the XCFS with a short description.

Datatype	***Cal directory***	***Used in pipeline***	***description***
teldef	bcf	yes	Telescope definition file
Bad pixel	bcf	yes	Table of dead/hot pixels apply to data and table dead/hot loaded on board
Bias	bcf	yes	Bias for the photodiode (pre-launch) and image mode
Effeara	bcf	yes	Mirror effective area
Ftrans	bcf	yes	Filter Transmission curves
Gain	bcf	yes	Conversion factors of the digitalized signal to Pulse Invariant for Photon counting, Windowed Timing and Photodiode Modes
Grade	bcf	yes	Grade definition for Photon Counting, Windowed Timing and Photodiode modes
Instrument /ccd temp	bcf	No. Temperature read from HK file	CCD operating temperature
Instrument /dn2flux	bcf	yes	Conversion factor from adu to flux
Instrument /evtrange	bcf	yes	Parameter ranges for event selection

Instrument /hkconv	bcf	no	Housekeeping parameter conversion factors
Instrument /hkrange	bcf	yes	Range of nominal values for the housekeeping parameters
Instrument /mkfconf	bcf	yes	Parameters for makefilter
Instrument /poserr	bcf	yes	Component of the error on position due to source intensity
Instrument /preconf	bcf	yes	Parameters for prefilter
Instrument /region	bcf	yes	Regions definition for the field of view, calibration sources, and detector corners
Instrument /waveamp	bcf	yes	Setting of the waveform, amplifier and gain for different reads-out
Instrument /vsubthr	bcf	yes	Contain the standard threshold used in software for the different substarte voltage
Quantum efficency	bcf	no yet	Quantum Efficiency
tam	bcf	yes	Telescope Alignment Monitor reference positions and related parameters
arf	cpf	yes	On-axis Ancillary Response File for standard extraction region
eef	cpf		Encircled Energy Function
psf	cpf		Point Spread Function
rmf	cpf	yes	Response matrices for the Photon counting, Windowed Timing, Photodiode mode for PI spectra. Response matrices for the Photodiode and windowed timing for PHA spectra for the TDRSS messages
vign	cpf	yes	Parameters for the vignetting function
Bkg spectrum	cpf		Background spectra
Bkg events	bcf		Background events

Table 1 -Datatypes and short description of XCFS files

4 XCFS Files General Description

All XCFS files are FITS files. Keywords required by FITS OGIP standards and listed in this paragraph are described in documents [1], [2] and [3] (section 1.1). See chapter 5 for a detailed description of XRT XCFS Fits files.

4.1 Mandatory keywords

Table 2 lists the mandatory keywords to be added to the primary header and to the headers of all extensions of the XCFS Fits files. See documents [1] [2] (section 1.1) for keyword description.

keyword name	***keyword value***	***comment***
TELESCOP	'SWIFT'	/ Telescope (mission) name
INSTRUME	'XRT'	/ Instrument Name
DATE	YYYY-MM-DDThh:mm:ss	/ Creation Date This keyword is omitted for empty Primary Headers.
CHECKSUM	<up to date checksum>	/ HDU checksum updated <date>
DATASUM	<up to date datasum>	/ Data unit checksum updated <date>

Table 2 - XCFS mandatory header keywords

Table 3 lists the XCFS additional mandatory keywords common to all table headers. Each CALDB keywords has different values for different XCFS Calibration Files. The CALDB keywords and the EXTNAME keyword are specified for each *datatype* in the related paragraph in section 5.

keyword name	***keyword value***	***comment***
EXTNAME	<extension name>	/ Name of the binary table extension or /Name of the image extension This is omitted if data are stored in the Primary Header
ORIGIN	<organization name>	/ Source of FITS file
CREATOR	< task name and version number>	/ Creator
CONTENT	<short description of the content>	/File content
FILENAME	<file name>	/ File name
VERSION	<version number>	/ Extension version number
CALDB keywords:		
CCLS*xxxx*	OGIP-class of calibration file	/Dataset is a Calibration Product File /Dataset is a Basic Calibration File
CDTP*xxxx*	<datatype code>	/Calibration file contains data
CCNM*xxxx*	<extension codename>	/Type of Calibration data
CDES*xxxx*	<descriptive string>	/ Description
CVSD*xxxx*	<start valid data>	/UTC date when file should first be used
CVST*xxxx*	<start valid time>	/UTC time when file should first be used

Table 3 - XCFS Table Headers mandatory keywords

Table 4 lists XCFS table header keywords required under certain circumstances. These keywords are specified, when necessary, for each *datatype* in the related paragraph in section 5.

Keyword name	***Keyword value***	***Comment***
CBD*nxxxx*	array describing parameter limitations of the dataset	/ Parameter boundary
CSYSNAME	spatial coordinate system in use	/spacial coord system used in this dataset
TDIM*nnn*	Number of elements & Ordering of *n*-d array	/ Array dimensions
HDUCLASS	'OGIP '	/ format conforms to OGIP standards
HDUDOC	<document number>	/ Document describing the format
HDUCLAS*n*	<character string to classify the extension	/ (Specific to the type)
HDUVERS*n*	<string giving the format version>	/ Version of file format
TIMESYS	TT	/ Time system
MJDREFI	51910	/ Reference MJD, Interger part
MJDREFF	7.4287037e-4	/Reference MJD, fractional part
CLOCKAPP	F	/ If clock corrections are applied (F/T)

Table 4 - XCFS Table Headers keywords required under certain circumstance

Calibration files which depends on the instrument readout mode has the mode specified in a CBDnxxxx keyword. The keyword value is given 'DATAMODE(<datamode>)' where the <datamode> strings are listed in the following table together with their short description used in the filename. The same <datamode> string values are also used in the XRT science files .

<datamode>	**Short filename**	**Description**
PHOTON	pc	Photon Counting Mode also
WINDOWED	wt	Windowed Timing Mode
LOWRATE	pd	Low Rate Photodiode Mode
PILEDUP		Piled Up Photodiode Mode
SHORTIMA	im	Fast Imaging Mode (Short Image)
LONGIMA		Slow Imaging Mode (Long Image)
BIASMAP		Bias Map Mode
RAWCCD		Raw Image Mode

Table 5 - XRT 'DATAMODE' keyword allowed values

The order in which the header keywords are layout in the calibration files is the following :

- Required FITS keywords
- Descriptive column keywords for binary table

- EXTNAME, TELESCOP, INSTRUME, FILTER, ORIGIN, CREATOR, VERSION, FILENAME, CONTENT
- TIMESYS, MJDREFI, MJDREFF, CLOCKAPP
- CALDB keywords
- Comment keywords
- Additional Local keywords
- DATA, DATASUM, CHECKSUM

The description of the calibration file within this document includes the file structure, the setting of CALDB keywords and specific keywords related to the file

5 XCFS files format

5.1 Telescope Definition File

5.1.1 File Name

The file name of the Telescope Definition Calibration file does not conform standard naming convention described in paragraph 3.1.

swxYYYYMMDDvNNN.teldef

5.1.2 Description

The XRT data reduction software requires as input the Telescope Definition file (teldef). This is a FITS file containing in the primary HDU a set of keywords describing the telescope and instrument characteristics, the coordinate systems definition and the transformations between them. This file has been introduced for the first time for the ASCA mission.

There are three sets of coordinates defined for the SWIFT XRT: raw, detector and sky. The keyword NCOORDS is set therefore to 3 (NCOORDS=3) and the keywords COORDn are set to:

COORD0='RAW'

COORD1='DET'

COORD2='SKY'

The RAW coordinates come from the telemetry and ranges between 0 and 599 (RAWX) and between 0 and 599 (RAWY); the DET coordinates are derived from the RAW coordinates and range from 1 to 600 for the horizontal axis and from 1 to 600 for the vertical axis.

The SKY coordinates run from 1 to 1000, to accommodate the detector even when it is rotated 45 degrees with respect to RA/Dec reference frame. The conversion from RAW to DET involves two steps:

- The RAW coordinates are transformed in a set of internal coordinates. This is done to support detectors that are made by more than one sub-unit, each one with its own RAW coordinates system;
- The internal coordinates system is transformed into a detector coordinates system.

The first transformation uses the formula:

Xint = COE_Xn_B * RAWX + COE_Xn_C * RAWY + COE_Xn_A

Yint = COE_Yn_B * RAWX + COE_Yn_C * RAWY + COE_Yn_A

The XRT focal plane detector is a single CCD, but to take into account the two amplifiers, Amp 1 and Amp 2, two sets of coefficients are included. The values of the Amp 1 and Amp 2 coefficients are defined in following keywords of the teldef file :

COE_X1_A = 1

COE_X1_B = 1

COE_X1_C = 0

COE_Y1_A = 1

COE_Y1_B = 0

COE_Y1_C = 1

and

COE_X2_A = 600

COE_X2_B = -1

COE_X2_C = 0

COE_Y2_A = 1

COE_Y2_B = 0

COE_Y2_C = 1

where the X1 and X2 are the suffixes to identify the Amp 1 and Amp 2 respectively.

The second transformation uses the formula:

DETX = DET_XCEN + DETXFLIP * (Xint - INT_XCEN - DET_XOFF)/DET_SCAL

DETY = DET_YCEN + DETYFLIP * (Yint - INT_YCEN - DET_YOFF)/DET_SCAL

DET_XCEN = DETXPIX1 + (DET_XSIZ - 1)/2.0

DET_YCEN = DETYPIX1 + (DET_YSIZ - 1)/2.0

For one CCD we have:

INT_XCEN = DET_XCEN

INT_YCEN = DET_YCEN

DET_XOFF = 0

DET_YOFF = 0

The conversion from DET to SKY coordinates occurs via a separate transformation. The components of the 3x3 alignment matrix are specified in the teldef file and give the orientation of the detector coordinates with respect to the spacecraft axes. The alignment matrix is currently set to the identity matrix.

Keywords containing other information about the detector such as number and size of the CCD pixels and focal length of the telescope are also included following the document "Teldef File Format Specification".

5.1.3 File Format

Extension N.	*Type*	*Ext. Name*
0	PRIMARY	

Table 6 - Telescope Description Calibration File Format

5.1.4 Primary Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

Keyword name	*keyword value*	*Comment*
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'TELDEF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'TELESCOPE DEFINITION FILE'	/Description

Table 7 - Telescope Description File Primary Header Keywords

The content of the teldef file header is the following

```
COMMENT ---------------------------------------------------------------------
COMMENT Generic coordinate keywords
COMMENT ---------------------------------------------------------------------
NCOORDS =                    3 / number of coordinates defined in this file
COORD0  = 'RAW     '           / 1st coordinate system (RAWX,RAWY)
COORD1  = 'DET     '           / 2nd coordinate system (DETX,DETY)
COORD2  = 'SKY     '           / 3rd coordinate system (X,Y)
COMMENT ---------------------------------------------------------------------
COMMENT RAW coordinate definition
COMMENT These are the pixel coordinates found in the telemetry
COMMENT ---------------------------------------------------------------------
RAW_XSIZ=                  600 / RAW address space x size (pixels)
RAWXPIX1=                  0.0 / RAW address space x first pixel number (pixel)
RAW_XSCL=                0.040 / RAW X scale (mm/pixel)
RAW_XCOL= 'RAWX    '           / Name of raw X column in event files
RAW_YSIZ=                  600 / RAW address space y size (pixels)
RAWYPIX1=                  0.0 / RAW address space y first pixel number (pixel)
RAW_YCOL= 'RAWY    '           / Name of raw Y column in event files
RAW_YSCL=                0.040 / RAW Y scale (mm/pixel)
RAW_UNIT= 'mm      '           / physical unit of RAW coordinates
COMMENT ---------------------------------------------------------------------
COMMENT DET coordinate definition
COMMENT DET coordinates are fixed to the detector, look-up
COMMENT ---------------------------------------------------------------------
DET_XSIZ=                  600 / DET address space x size (pixels)
DETXPIX1=                  1.0 / DET address space x first pixel number (pixel)
DET_XSCL=                0.040 / DET X scale (mm/pixel)
DET_XCOL= 'DETX    '           / Name of DET X column in event files
DET_YSIZ=                  600 / DET address space y size (pixels)
DETYPIX1=                  1.0 / DET address space y first pixel number (pixel)
DET_YSCL=                0.040 / DET Y scale (mm/pixel)
DET_YCOL= 'DETY    '           / Name of DET Y column in event files
DET_UNIT= 'mm      '           / physical unit of DET coordinates
```

```
COMMENT -------------------------------------------------------------------
COMMENT Translation from RAW to DET coordinates:
COMMENT This translation comes in two parts. First there is a translation to
COMMENT an intermediate coordinate system as follows:
COMMENT     Xint = COE_X0_A + COE_X0_B * RAWX + COE_X0_C * RAWY
COMMENT     Yint = COE_X0_A + COE_X0_B * RAWX + COE_X0_C * RAWY
COMMENT
COMMENT The XRT can be readout in two different ways depending on the
COMMENT amplifier selected. We model this as two different raw coordinate
COMMENT segments, though there is physically only one detector.
COMMENT -------------------------------------------------------------------
SEG_COL = 'Amp     '
COMMENT Amp A (1): raw and det are the same
COE_X1_A=                    1
COE_X1_B=                    1 / These could be used to align the DET
COE_X1_C=                    0 / coordinates to the spacecraft axes or to
COE_Y1_A=                    1 / align the XRT and UVOT coordinate with one
COE_Y1_B=                    0 / another.
COE_Y1_C=                    1
COMMENT Amp B (2): raw coords are flipped in x and y w.r.t amp A
COE_X2_A=                  600
COE_X2_B=                   -1 / These could be used to align the DET
COE_X2_C=                    0 / coordinates to the spacecraft axes or to
COE_Y2_A=                    1 / align the XRT and UVOT coordinate with one
COE_Y2_B=                    0 / another.
COE_Y2_C=                    1
COMMENT -------------------------------------------------------------------
COMMENT ... followed by a translation from the intermediate coordinates
COMMENT to the DET coordinates as follows:
COMMENT
COMMENT   DETX = DET_XCEN + DETXFLIP * (Xint - INT_XCEN - DET_XOFF) / DET_SCAL
COMMENT   DETY = DET_YCEN + DETYFLIP * (Yint - INT_YCEN - DET_YOFF) / DET_SCAL
COMMENT
COMMENT         DET_XCEN = DETXPIX1 + (DET_XSIZ - 1) / 2.0
COMMENT         DET_YCEN = DETYPIX1 + (DET_YSIZ - 1) / 2.0
COMMENT
COMMENT          PIXELY
COMMENT            ^
COMMENT            |
COMMENT            |  x (DET_XOFF,DET_YOFF)
COMMENT            |
COMMENT            +--------> PIXELX
COMMENT
COMMENT   (DET_XOFF,DET_YOFF) is origin of the DET coordinates
COMMENT
DET_XOFF=                  0.0 / X Offset between intermediate and DET coords
DET_YOFF=                  0.0 / Y Offset between intermediate and DET coords
DETXFLIP=                    1 / do not flip x-axis in RAW -> DET
DETYFLIP=                    1 / do not flip y-axis in RAW -> DET
DET_SCAL=                  1.0 / no scaling done
DET_ROTD=                  0.0 / no rotation done
COMMENT -------------------------------------------------------------------
COMMENT SKY coordinate definition:
COMMENT -------------------------------------------------------------------
SKY_XSIZ=                 1000 / SKY address space x size (pixels)
SKYXPIX1=                  1.0 / SKY address space x first pixel number (pixel)
SKY_XCOL= 'X       '           / Name of SKY X column in event files
SKY_YSIZ=                 1000 / SKY address space y size (pixels)
SKYYPIX1=                  1.0 / SKY address space y first pixel number (pixel)
```

```
SKY_YCOL= 'Y       '           / Name of SKY Y column in event files
SKY_UNIT= 'deg     '           / physical unit of SKY coordinates
SKY_FROM= 'DET     '           / SKY coords are calculated from DET coords
COMMENT ---------------------------------------------------------------------
COMMENT Translation from DET to SKY:
COMMENT
COMMENT SKY coordinates are a tangent-plane projection of RA and Dec.
COMMENT The DET->SKY transformation is done by first adding a third axis
COMMENT perpendicular to each coordinate system, then rotating one with respect
COMMENT to the other and projecting onto the original 2-D SKY coordinates.
COMMENT
COMMENT The 3-D rotation between DET and SKY has two components.
COMMENT One is the orientation of the spacecraft with respect to the celestial
COMMENT sphere. The other is the rotation of the DET axes to make them line up
COMMENT with the satellite axes. Note that we assume the telescope axis is
COMMENT directly over the center of the DET coordinates. Any misalignment is
COMMENT respresented by a fictitious tilt.
COMMENT The orientation of the DET coordinates with respect to the
COMMENT satellite axes is specified by the following matrix:
COMMENT ---------------------------------------------------------------------
ALIGNM11=                   0.0 / DET -> SAT coordinates alignment matrix Mij
ALIGNM12=                   1.0
ALIGNM13=                   0.0
ALIGNM21=                   0.0 / [3x3 rotation matrix, common to all sensors]
ALIGNM22=                   0.0
ALIGNM23=                   1.0 / SATX =    M11*DETX + M12*DETY + M13*DETZ
ALIGNM31=                   1.0 / SATY =    M21*DETX + M22*DETY + M23*DETZ
ALIGNM32=                   0.0 / SATZ =    M31*DETX + M32*DETY + M33*DETZ
ALIGNM33=                   0.0
COMMENT ---------------------------------------------------------------------
COMMENT The plate scale is determined from the size of the SKY pixels in the
COMMENT focal plane and the focal length of the telescope.
COMMENT 1 mm roughly corresponds to atan(1/FOCALLEN) radians on tke sky.
COMMENT ---------------------------------------------------------------------
FOCALLEN=               3500.0 / Telescope focal length (mm)
COMMENT ---------------------------------------------------------------------
COMMENT  The true optical axis position is not used in the coordinate
COMMENT transformations, but is needed to calculate the detector response.
COMMENT ---------------------------------------------------------------------
OPTAXISX=                   300 / optical axis x in DET coordinates (pixel)
OPTAXISY=                   300 / optical axis y in DET coordinates (pixel)
HISTORY ---------------------------------------------------------------------
```

5.2 Bad Pixel Table File

5.2.1 File Name

swxbadpixYYYYMMDD.fits & swxonboardbpYYYYMMDDvNNN.fits

5.2.2 Description

The files contain the list of bad pixel in the XRT detector. There are two files with identical structure. The first is the file as loaded on-board and used in the on-board processing, the second is the file used in the ground analysis. The content of the two files can differ because of pixels or columns found during ground

analysis and not yet loaded in the on-board processor. The file format consists of an empty primary header and two extensions with identical layout. The first is valid for the Photon Counting and Image modes, the second is valid for the Windowed timing mode. Each extension contains the following columns:

- TIME: is time after which the pixel or column is known to be bad;
- RAWX and RAWY: is the raw coordinates of the pixel;
- Amp : identify the amplifier used;
- TYPE: identify if it is a single pixel (1), or a column (2);
- YEXTENT: contains the number of the consecutive bad pixels in the Y direction starting from the first bad pixel located at RAWX, RAWY;
- BADFLAG: stores a 16 bit binary number which indicates the origin of the bad pixel. The values are flagged differently if they are from the on-board bad pixel table or from ground analysis. The bit setting for pixels in the on-board table always include the 'b0000000000000010' value, instead the bit setting from pixels found in the ground analysis always includes the 'b0000000000000001' value.

A new row is added to these files when new pixel or column locations are found to be bad from ground data analysis. Each row is tagged with the time (TIME column) and this corresponds to the time when the pixel or column is no longer considered good. The time value is used by the ground software to flag bad pixel according with the epoch of the observation

5.2.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	PCBADPIX	
	Column Names	**Format**	**Units**
	TIME	D	s
	RAWX	I	pixel
	RAWY	I	pixel
	Amp	I	-
	TYPE	I	-
	YEXTENT	I	pixel
	BADFLAG	16X	-
2	BINTABLE	WTBADPIX	
	Column Names	**Format**	**Units**
	TIME	D	s
	RAWX	I	pixel
	RAWY	I	pixel

	Amp	I	-
	TYPE	I	-
	YEXTENT	I	pixel
	BADFLAG	16X	-

Table 8 - On board or CALDB Bad Pixel Calibration File Format

5.2.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.2.5 Extension 1 & 2 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for these HDU. Below are listed specific setting of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is a Basic Calibration File
CCNM0001	<string>	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	<string>	/Parameter boundary
CBD20001	<string>	/Parameter boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	<string>	/Description see separate table
Badpix File Keywords		
EXTNAME	<string>	/ Name of the binary table extension
CONTENT	<string>	/ File content
TIMESYS	'TT'	/ Time system
MJDREFI	51910	/ Reference MJD integer part
MJDREFF	7.4287037e-4	/ Reference MJD fractional part
CLOCKAPP	F	/ If clock corrections are applied (F/T)

Table 9 - Bad Pixel Calibration File Extension 1 & 2 Keywords

The two files and the two extensions in each file differ for the values of the EXTNAME, CONTENT, CCNM001, CBDn0001 and CEDS1001 keywords.

The setting for these keywords for the on-board bad pixel table is :

On-board bad Pixel table		
1st Extension		
EXTNAME	'PCBADPIX'	/Name of the binary table extension
CONTENT	'XRT on-board Bad Pixels table'	/File content
CCNM001	'BADPIX	/Type of calibration data
CBD10001	'DATAMODE(PHOTON,LONGIMA,SHORTIMA)'	/Parameter boundary
CBD20001	'TYPE(ONBOARD)'	/Parameter boundary
CDES0001	'XRT on-board Bad Pixels '	/Description
2nd Extension		
EXTNAME	'WTBADPIX'	/Name of the binary table extension
CONTENT	'XRT on-board Bad Pixels table'	/File content
CCNM001	'BADPIX'	/Type of calibration data
CBD10001	'DATAMODE(WINDOWED)'	/Parameter boundary
CBD20001	'TYPE(ONBOARD)'	/Parameter boundary
CDES0001	'XRT on-board Bad Pixels for WT mode'	/Description

Table 10- On-board bad pixel keyword settings

The setting for these keywords for the ground bad pixel table is :

Ground bad Pixel table		
1st Extension		
EXTNAME	'PCBADPIX'	/Name of the binary table extension
CONTENT	'XRT ground Bad Pixels table'	/File content
CCNM001	'BADPIX'	/Type of calibration data
CBD10001	'DATAMODE(PHOTON,LONGIMA,SHORTIMA)'	/Parameter boundary
CBD20001	'TYPE(ONGROUND)'	/Parameter boundary
CDES0001	'XRT Ground Bad Pixels '	/Description
2nd Extension		
EXTNAME	'WTBADPIX'	/Name of the binary table extension
CONTENT	'XRT ground Bad Pixels table'	/File content
CCNM001	'BADPIX'	/Type of calibration data
CBD10001	'DATAMODE(WINDOWED)'	/Parameter boundary
CBD20001	'TYPE(ONGROUND)'	/Parameter boundary
CDES0001	'XRT Ground Bad Pixels for WT mode'	/Description

Table 11 – Ground bad pixel keyword settings

5.3 Bias Calibration Files

5.3.1 File Name

swximbiasYYYYMMDDvNNN.fits & swxpdbiasYYYYMMDDvNNN.fits

5.3.2 Description

The Photodiode and Image mode data taken in the pre-launch test observations have the bias not subtracted. The ground software subtracts a single value of bias appropriate for each mode. The pre-launch bias values (for each mode) are determined from ground calibration data, however these values can change as results of calibration during operations. For the Photodiode mode the bias subtraction has been implemented in the flight software and during operation it is not foreseen to subtract the bias on ground and/or updates for the bias calibration file. For the image mode instead is still foreseen to subtract the bias on ground, and updates for the bias calibration file are expected.

The pre-launch bias values for the Photodiode and Image mode are stored in separate CALDB files. The two bias calibration files have an identical structure that consists of an empty primary header and a binary table extension containing two columns, BIAS and TIME. The BIAS column contains the value to subtract to the data and the TIME column contains the start time of validity for the bias value. This is given in seconds from a reference time stored in the header.

5.3.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	BIAS	
	Column Names	**Format**	**Units**
	TIME	D	s
	BIAS	D	-

Table 12 - Bias Calibration Files Format

5.3.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.3.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File

CCNM0001	'BIAS'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'DATAMODE(<datamode>)'	/ Parameter boundery
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Bias for <MODE> Mode'	/Description
Bias File Keywords		
EXTNAME	'BIAS '	/ Name of the binary table extension
CONTENT	'XRT bias for <mode> mode'	/ File content
TIMESYS	'TT'	/ Time system
MJDREFI	51910	/ Reference MJD integer part
MJDREFF	7.4287037e-4	/ Reference MJD fractional part
CLOCKAPP	F	/ If clock corrections are applied (F/T)

Table 13 - Bias Calibration File Extension 1 Keywords

where the value of <datamode> is set to :

- 'LOWRATE,PILEDUP', for the photodiode mode bias calibration file
- 'LONGIMA,SHORTIMA', for the image mode bias calibration file

The <mode> value is set to :

- 'Imaging', for the image mode bias calibration file
- 'Photodiode', for the photodiode mode bias calibration file

5.4 Mirror Effective Area Calibration File

5.4.1 File Name

swxeffareaYYYYMMDDvNNN.fits

5.4.2 Description

The file contains the on-axis telescope mirror effective area as a function of the energy. Its dependence from the off-axis position is described in the vignetting calibration file. These effective area values come from a ray-tracing code and are expressed in units of cm^2. The energy step is of 4.8 eV. The file format consists of an empty primary header and a binary table containing the following columns:

- ENERGY: the energy in units of eV in steps of 4.8 eV;
- EA: mirror effective area in units of cm^2.

5.4.3 File Format

Extension N.	*Type*	*Ext. Name*

0	PRIMARY		
1	BINTABLE	EFFAREA	
	Column Names	**Format**	**Units**
	ENERGY	E	eV
	EA	E	cm^2

Table 14 - Mirror Effective Area Calibration File Format

5.4.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.4.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'EFFAREA'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'MIRROR ON-AXIS EFFECTIVE AREA'	/Description
CBD10001	'THETA(0)arcmin'	/Parameter boundary
CBD20001	'PHI(0)deg'	/Parameter boundary
CBD30001	'ENERG(0.1-20.0)keV'	/Parameter boundary
Mirror Effective Area File Keywords		
EXTNAME	'EFFAREA'	/ Name of the binary table extension

Table 15 - Mirror Effective Area Calibration File Extension 1 Keywords

5.5 Filter Transmission Calibration File

5.5.1 File Name

swxftransYYYYMMDDv004.fits

5.5.2 Description

The CCD on the XRT is protected by a thin filter to block optical light. The filter transmission property has been measured by ground calibration and the results are stored in this calibration file. The file format consists on an empty primary header and a binary table extension with two columns, ENERGY and TRANSMIS. The first contains the energy values where the filter transmission was evaluated and the second contains the corresponding transmission value. The energy column ranges between 0.1-20 keV

5.5.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	TRANSMISSION	
	Column Names	**Format**	**Units**
	ENERGY	E	eV
	TRANSMIS	E	-

Table 16 - Filter Transmission Calibration File Format

5.5.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.5.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific setting of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'FTRANS'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Filter Transmission'	/Description
CSYSNAME	'XMA_POL'	/Spatial coord system used in this dataset
CBD10001	'THETA(0-60.0)arcmin'	/ Parameter boundary
CBD20001	'PHI(0-360)deg'	/ Parameter boundary
CBD30001	'ENERG(0.1-20.0)keV'	/ Parameter boundary
Filter Transmission File Keywords		

EXTNAME	'TRANSMISSION'	/ Name of the binary table extension

Table 17 - Filter Transmission Calibration File Extension 1 Keywords

5.6 Gain Calibration Files

5.6.1 File Name

First version

swxpcgainYYYYMMDDvNNN.fits & swxwtgainYYYYMMDDvNNN.fits & swxpdgainYYYYMMDDvNNN.fits

Second version

swxpcgainsN_YYYYMMDDvNNN.fits & swxwtgainsN_YYYYMMDDvNNN.fits & swxpdgainsN_YYYYMMDDvNNN.fits

The summer 2007 the substrate voltage changed. These CALDB files were modified to include the value for the substrate voltage in the CALDB boundary and the filenames were changed to add the value of the substrate. The suffix for the substrate is identified by the characters 'sN' where N is either 0 or 6. The substrate value of 0 was used up the summer of 2007 after the substrate was changed to 6.

In Feb 2009 an additional change was included to account for the position dependent charge traps. The software that calculates the PI channels was updated to support this new format. The section of Description and file Format have been changed accordingly and the old section maintain within this document as old.

5.6.2 Description_old (pre Feb 2009)

The gain calibration files contain the coefficients of the function describing the detector gain. There is one file for each readout mode with identical format. The file format consists of an empty primary header with a binary table extension data. The coefficients describe the spatial dependence of the gain through the following formula

$$PI(PH) = ((PHA*(GC0 + x*GC1 + y*GC2) + GC3 + x*GC4 + y*GC5) / G)$$

where G represents the nominal gain stored in the header keyword NOM_GAIN, x and y are the RAW detector coordinates of each event position, PHA is the digital value measured and the coefficients GCn (n=1,5) are stored in separate columns of the binary table. For timing modes, the assumption is that all the events are from the source location, specified in RAW detector coordinates. To account for the temperature dependence of the gain, the columns for the GCn coefficients are vectors containing the coefficient values measured at three different temperatures.

The gain correction can vary during the mission due for example to the Charge Transfer Inefficiency (CTI) induced by radiation damage. It is foreseen for the gain file to contain therefore several rows corresponding to times when the coefficients are evaluated from calibration observations. A TIME column records the time of these calibration observations and it is used in the software to select the appropriate sets of values for a given observation epoch. The temperature values used to determine the gain for a given epoch are stored in a separate column CCDTEMP and provided in degrees Celsius. NOTE : The gain temperature dependence was introduce to cope with the failure of the cooling system during flight. For the pre-launch epoch all the three temperatures are all set to –100.

The gain correction applied to the data is calculated by the software via a linear interpolation that account for the time and temperature dependence considering two sets of coefficients measured at epochs and temperatures closer to the observation. The times in the TIME columns are expressed in seconds from the reference time.

5.6.3 File Format_old (pre Feb 2009)

Extension N.	*Type*	*Ext. Name*	
0	PRIMARY		
1	BINTABLE	GAIN	
	Column Names	**Format**	**Units**
	TIME	D	S
	CCDTEMP	3E	-
	GC0	3E	-
	GC1	3E	-
	GC2	3E	-
	GC3	3E	-
	GC4	3E	-
	GC5	3E	-

Table 18old -Gain Calibration Files Format

5.6.4 Description (After Feb 2009)

The gain calibration files contain the coefficients of the function describing the detector gain. There is one file for each readout mode with identical format. The file format consists of an empty primary header with a binary table extension data. The coefficients describe the spatial dependence of the gain through the following formula

$$PI(PH) = ((PHA*(GC0 + x*GC1 + y*GC2) + GC3 + x*GC4 + y*GC5) / G)$$

where G represents the nominal gain stored in the header keyword NOM_GAIN, x and y are the RAW detector coordinates of each event position, PHA is the digital value measured and the coefficients GCn (n=1,5) are stored in separate columns of the binary table. For timing modes, the assumption is that all the events are from the source location, specified in RAW detector coordinates. To account for the temperature dependence of the gain, the columns for the GCn coefficients are vectors containing the coefficient values measured at three different temperatures.

The gain correction can vary during the mission due for example to the Charge Transfer Inefficiency (CTI) induced by radiation damage. It is foreseen for the gain file to contain therefore several rows corresponding to times when the coefficients are evaluated from calibration observations. A TIME column records the time of these calibration observations and it is used in the software to select the appropriate sets of values for a given observation epoch. The temperature values used to determine the gain for a given epoch are stored in a separate column CCDTEMP and provided in degrees Celsius. NOTE : The gain temperature dependence was introduce to cope with the failure of the cooling system during flight. For the pre-launch epoch all the three temperatures are all set to –100.

The gain correction applied to the data is calculated by the software via a linear interpolation that account for the time and temperature dependence considering two sets of coefficients measured at epochs and temperatures closer to the observation. The times in the TIME columns are expressed in seconds from the reference time.

The file contains also additional columns to correct for the position dependent charge traps developed late into the mission. These columns are RAWX, RAWY, YEXTEND ,OFFSET, ALPHA1, ALPHA2, EBREAK. The charge traps interest part of the column. To account for this, the files records in the RAWX and RAWY the start pixel and in YEXTEND the number of pixels involved in the column. Currently the format allows for 20 of these charge traps pixel/column. The OFFSET is position and temperature dependent. The columns ALPHA1 ALPHA2 and EBREAK contain the coefficients of the relation used within the software to account for this correction and the result is added to the nominal PI.

5.6.5 File Format(After Feb 2009)

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	GAIN	
	Column Names	**Format**	**Units**
	TIME	D	S
	CCDTEMP	3E	-
	GC0	3E	-
	GC1	3E	-
	GC2	3E	-
	GC3	3E	-
	GC4	3E	-
	GC5	3E	-
	RAWX	20I	-
	RAWY	20I	-
	YEXTENT	20I	-
	OFFSET	60E	-
	ALPHA1	1E	
	ALPHA2	1E	
	EBREAK	1E	

Table 18 -Gain Calibration Files Format

5.6.6 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.6.7 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Specific settings of some of the CALDB keywords and others relevant to this file are listed below.

keyword name	*keyword value*	*comment*
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'GAIN'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	"DATAMODE(<datamode>)'	/Parameter Boundary
CBD20001	'XRTVSUB(<N>)	/Parameter Boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Gain with Position and Time Dependent CTI coefficients	/Description
Gain Files Keywords		
EXTNAME	'GAIN'	/ Name of the binary table extension
CONTENT	'<mode> gain'	/File content
TIMESYS	'TT'	/ Time system
MJDREFI	51910	/ Reference MJD integer part
MJDREFF	7.4287037e-4	/ Reference MJD fractional part
CLOCKAPP	F	/ If clock corrections are applied (F/T)
NOM_GAIN	10	/Nominal Gain for PI channel

Table 19 -Gain Calibration Files Extension 1 Keywords

where the <datamode> string in the CBD10001 is set to :

- 'PHOTON', for the gain calibration file for the photon counting mode
- 'WINDOWED', for the gain calibration file for the windowed timing mode
- 'LOWRATE,PILEDUP', for the gain calibration file for the photodiode modes

the <N> in CDB20001 is set as an integer to the value of the substrate voltage (added summer 2007)

and the <mode> string is set to :

- 'Photon Counting', for the gain calibration file for the photon counting mode
- 'Windowed timing', for the gain calibration file for the windowed timing mode

- ‘Photodiode’, for the gain calibration file for the photodiode modes

5.7 Grade Calibration File

5.7.1 File Name

swxgradeYYYYMMDDvNNN.fits

5.7.2 Description

The file contains the grade definition for Photon Counting, Windowed Timing and Photodiode readout modes. The file format consists of an empty primary header with two binary extensions one for the Photon Counting mode, named ‘PCGRADES’, and the other for the timing modes, Photodiode and Windowed Timing, named 'TMGRADES'. The binary tables contain the following columns:

- Amp identify the amplifier;
- GRADEID: grade identifier;
- GRADE: describes the event splitting corresponding to each GRADEID. The grade mapping contains a combination of the following values: ‘1’ for pixels above threshold, ‘2’ for pixels below threshold, ‘0’ indicates ‘don’t care’. In the first extension the grade definition for the Photon Counting mode is represented by an array of nine pixels (the 3x3 neighborhood). In the second extension the grade definition for Timing modes is represented by an array of seven numbers: the first is referred to the central pixel (the local maximum), the 3 following numbers refer to the 3 pixels on the left and the remaining 3 numbers refer to the 3 pixels on the right. For example: ‘1021120’, for a Timing mode, describes the distribution of charge of an event corresponding to the grade 3 in this classification. There are 32 grades defined for the Photon Counting mode and 15 for the timing modes.

5.7.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	PCGRADES	
	Column Names	**Format**	**Units**
	Amp	I	-
	GRADEID	I	-
	GRADE	9I	-
2	BINTABLE	TMGRADES	
	Column Names	**Format**	**Units**
	Amp	I	-
	GRADEID	1I	-
	GRADE	7I	-

Table 20 - Grade Files Format

5.7.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.7.5 Extension 1& 2 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for these HDUs. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	*keyword value*	*comment*
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'GRADES'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'’DATAMODE(<datamode>)’	/Parameter Boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Grades <MODE> Mode ‘	/Description
Grade Keywords		
EXTNAME	'<ff>GRADES'	/ Name of the binary table extension
CONTENT	‘XRT Grade’	/File content

Table 21 - Grade Extension 1 Keywords

where EXTNAME, CBD10001, and CDES10001 are set as follows:

Grade extension table		
1st Extension		
EXTNAME	‘PCGRADES’	/Name of the binary table extension
CBD10001	‘DATAMODE(PHOTON)’	/Parameter boundary
CDES10001	‘XRT Grade Photon Counting mode ‘	/Description
2nd Extension		
EXTNAME	‘TMGRADES’	/Name of the binary table extension
CBD10001	‘DATAMODE(LOWRATE,PILEDUP,WINDOWED,)’	/Parameter boundary
CDES10001	‘XRT Grade Timing mode'	/Description

Table 22- Grade specific keywords setting

5.8 CCD Temperature Calibration File

5.8.1 File Name

swxccdtempYYYYMMDDvNNN.fits

5.8.2 Description

The file contains the operating temperature of the CCD detector in the XRT. The file format consists of an empty primary header and a binary table extension, named 'CCDTEMP', and containing the following columns:

- TIME: contains the start time of validity for the temperature value stored in the CCDTEMP column. It is expressed in seconds, from a reference time;
- CCDTEMP: operating temperature of CCD expressed in Celsius degrees. This is not a standard units and a conversion factor is provide in the header comments.

5.8.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	CCDTEMP	
	Column Names	**Format**	**Units**
	TIME	D	s
	CCDTEMP	E	-

Table 23 - CCD Operating Temperature Calibration Files Format

5.8.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.8.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'CCDTEMP'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT CCD operating temperature'	/Description
CCD Temperature File Keywords		
EXTNAME	'CCDTEMP'	/ Name of the binary table extension
CONTENT	‘XRT CCD Operating Temperature’	/File content

TIMESYS	'TT'	/ Time system
MJDREFI	51910	/ Reference MJD integer part
MJDREFF	7.4287037e-4	/ Reference MJD fractional part
CLOCKAPP	F	/ If clock corrections are applied (F/T)

Table 24 - CCD Temperature Calibration File Extension 1 Keywords

5.9 Conversion factor from DN to flux

5.9.1 File Name

swxdn2flYYYYMMDDvNNN.fits

5.9.2 Description

The file contains the conversion factors for the rate DN as estimated in the Image mode data (0.3-10 keV) to flux in erg/cm**2/s. The flux conversion factors were obtained assuming a power law spectrum with photon index 2 for different absorbing hydrogen column density (NH). The file format consists in an empty primary header and a binary table extension, named RATEDN2FLUX, and containing the following columns:

- NH: contains the absorbing hydrogen column density;
- CONVFACT: conversion factor to obtain flux in ergs/cm**2/s from measured the DN/s.

5.9.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	RATEDN2FLUX	
	Column Names	**Format**	**Units**
	NH	E	cm**2
	CONVFACT	E	-

Table 25 – Conversion rate dn to flux Calibration Files Format

5.9.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.9.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3- XCFS mandatory header keywords		
CALDB Keywords		

CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'RATEDN2FLUX'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT DN/s to Flux conversion factors'	/Description
CCD Temperature File Keywords		
EXTNAME	'CCDTEMP'	/ Name of the binary table extension
CONTENT	'XRT DN/s Factor conversion'	/File content

Table 26 – Conversion rate DN to flux File Extension 1 Keywords

5.10 Event Parameter selection

5.10.1 File Name

swxevtrangeYYYYMMDDvNNN.fits

5.10.2 Description

The file contains the nominal range values of the parameters used to screen events. The file format consists of an empty primary header and three binary table extensions, one for each of the event read-out mode, containing the following columns:

- PARNAME: is the name of the parameter used in the screening;
- RANGE : contains the allowed value for the parameter stored in PARNAME

The three extensions are for Photon Counting, Windowed timing and Photodiode modes respectively.

5.10.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	PCRANGE	
	Column Names	**Format**	**Units**
	PARNAME	9A	-
	RANGE	30A	-
2	BINTABLE	WTRANGE	
	Column Names	**Format**	**Units**
	PARNAME	9A	-

Extension N.	*Type*	*Ext. Name*	
	RANGE	30A	-
3	BINTABLE	PDRANGE	
	Column Names	**Format**	**Units**
	PARNAME	9A	-
	RANGE	30A	-

Table 27 –Event range File Format

5.10.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.10.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Specific settings of some of the CALDB keywords and others relevant to this file are listed below.

keyword name	*keyword value*	*comment*
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'EVTRANGE	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	‘‘DATAMODE(<datamode>)’	/Parameter Boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Event range values’	/Description
Gain Files Keywords		
EXTNAME	'<ff>RANGE	/ Name of the binary table extension
CONTENT	‘Event range’	/File content

Table 28 –Event range Calibration File Extension 1 Keywords

where the <datamode> string is set to :

- ‘PHOTON’, for the event range calibration file for the photon counting mode
- ‘WINDOWED’, for the event range calibration file for the windowed timing mode
- ‘LOWRATE, PILEDUP’, for the event range calibration file for the windowed timing mode

and the prefix <ff> in the EXTNAME keyword is set to :

- ‘PC’, for the photon counting mode
- ‘WT’, for the windowed timing mode

- ‘PD’, for the windowed timing mode

5.11 Housekeeping conversion factors

5.11.1 File Name

swxhkconvYYYYMMDDvNNN.fits

5.11.2 Description

The file contains, for each housekeeping parameter of the XRT detector, the coefficients to transform the DN values into physical units according to the following formula:

Parameter $_{\text{phys. units}} = C0 + C1 * DN + C2 * DN^2$

The file format consists of an empty primary header and a binary table extension, named HKCONV, containing the following columns :

- PARNAME: name of the housekeeping parameter;
- C0: constant;
- C1: linear coefficient;
- C2: quadratic coefficient.

5.11.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	HKCONV	
	Column Names	**Format**	**Units**
	PARNAME	8A	-
	C0	E	-
	C1	E	-
	C2	E	-

Table 29 - Housekeeping conversion factors File Format

5.11.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.11.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***

Table 2 & 3- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'HKCONV'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Housekeeping conversion factors'	/Description
HK Conversion Factors File Keywords		
EXTNAME	'HKCONV'	/ Name of the binary table extension
CONTENT	'HK conversion factors'	/ File content

Table 30 - Housekeeping Conversion Factors Calibration File Extension 1 Keywords

5.12 Housekeeping Range Values

5.12.1 File Name

First version

swxhkrangeYYYYMMDDvNNN.fits

Second version

swxhkrangesN_YYYYMMDDvNNN.fits

The summer 2007 the substrate voltage changed. This CALDB file was modified to include the value for the substrate voltage in the CALDB boundary and the filename was changed to add the value of the substrate. The suffix for the substrate is identified by the characters 'sN' where N is either 0 or 6. The substrate value of 0 was used up the summer of 2007 after the substrate was changed to 6.

5.12.2 Description

The file contains the nominal range values of the housekeeping parameters used to generate Good Time Intervals. The file format consists of an empty primary header and two binary table extensions, one for HK parameters related to the attitude, and the second for HK parameters related to the instrument. On December 2007 a new extension was added to account for the star tracker parameters. All binary tables contains the following columns :

- PARNAME: is the name of the Housekeeping parameter;
- RANGE : contains the allowed value for the parameter stored in PARNAME used to construct the Good Time Intervals
- SYNTAX : contains a numeric value to identify how to combine the parameter. The value of zero is set when the parameters are related by an & in the screening expressions otherwise parameters with the same syntax numeric value are combined by an 'or'.

5.12.3 File Format

Extension N.	*Type*	*Ext. Name*	
0	PRIMARY		
1	BINTABLE	ATTRANGE	
	Column Names	**Format**	**Units**
	PARNAME	16A	-
	RANGE	30A	-
	SYNTAX	1I	-
2	BINTABLE	INSRANGE	
	Column Names	**Format**	**Units**
	PARNAME	16A	-
	RANGE	30A	-
	SYNTAX	1I	-
3	BINTABLE	SACRANGE	
	Column Names	**Format**	**Units**
	PARNAME	16A	-
	RANGE	30A	-
	SYNTAX	1I	-

Table 30 - Housekeeping Range Values Files Format

5.12.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.12.5 Extension 1,2 and 3 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	*keyword value*	*Comment*
Table 2- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'HKRANGE'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	“DATA(<hktype>)’	/Parameter Boundary
CBD20001	‘XRTVSUB(<N)>’	/Parameter Boundary

CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT HouseKeeping range values'	/Description
HK Range Values File Keywords		
EXTNAME	'<ff>RANGE'	/ Name of the binary table extension
CONTENT	'HK Range'	/File content

Table 31 - Housekeeping Range Values Calibration File Extension 1 Keywords

where the <hktype> string in the CDB10001 is set to :

- 'ATTITUDE', for the first extension of the Housekeeping range
- 'INSTRUMENT', for the second extension of the Housekeeping range
- 'SAC' , fro the third extension of the Star Tracker range

the <N> in CDB20001 is set as an integer to the value of the substrate voltage (added summer 2007),

and the prefix <ff> in the EXTNAME keyword is set to :

- 'ATT', for the first extension of the Housekeeping range
- 'INS', for the second extension of the Housekeeping range.

5.13 Makefilter file Parameters

5.13.1 File Name

swxmkfconfYYYYMMDDvNNN.fits

5.13.2 Description

This file contains the parameters for the configuration file as expected by the makefilter task to generate the makefilter file. Makfilter is used within the xrtfilter task. The file format consists of an empty primary header and a binary table extension, named MKFCONF. The binary table contains the following columns:

- PARNAME: contains the name of the parameters. These are both instrument HK parameters as well as attitude parameters.
- ORIGIN : contains a string to indicate if the parameter type is related to the HK or to the attitude. The string value is related to the files where the parameters are stored, e.g. ATTITUDE is for the attitude file , HK is for the HK XRT file (xhd).
- EXTENSION: name of the file extension where the parameters are recorded.
- INTERP : string required by the configuration file and set to 'D' for default.
- CALDB : string required by the configuration file and set to 'D' for default.

- OUTPARNAME: string containing the output name for the parameter in the makefilter file. The value of '%' indicates that the output parameter name is maintained as the input parameter name as stored in PARNAME.

5.13.3 File Format

Extension N.	*Type*	*Ext. Name*	
0	PRIMARY		
1	BINTABLE	MKFCONF	
	Column Names	**Format**	**Units**
	PARNAME	8A	-
	ORIGIN	10A	-
	EXTNAME	71A	-
	INTERP	1A	-
	CALDB	1A	-
	OUTPARNAME	71A	-

Table 31 - Makefilter parameter File Format

5.13.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.13.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	*keyword value*	*comment*
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'MKFCONF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT makefilter parameters'	/Description
HK Range Values File Keywords		
EXTNAME	'MKFCONF'	/ Name of the binary table extension
CONTENT	'Makefilter Parameters'	/File content

Table 32 – Makefilter parameter Calibration File Extension 1 Keywords

5.14 Position Error Calibration File

5.14.1 File Name

swxposerrYYYYMMDDvNNN.fits

5.14.2 Description

The file contains the different components that contribute to the XRT position error and the calibration measurements used to calculate one of the components. The components that contribute to the error on position are :

- Error due to the telescope alignment set too 1 arcsec.
- Error due to the attitude reconstruction set to 3 arcsec.
- Error due to the centroid calculation as function on the source intensity. The function counts or DN vs error circle, considering the source counts or DN and derived from the Panter data, has been fitted using the following function , e.g. err=PAR1 * (FF)**(-PAR2). The value for PAR1 and PAR2 are stored in this calibration file and FF corresponds to the counts or DN.
- Systematic error set to a value of 5 arcsec.

These components are added in quadrature and give the total positional error, e.g.

$$(\text{Tot\_pos\_err})^2 = \sigma(\text{ali})^2 + \sigma(\text{att})^2 + \sigma(\text{cen})^2 + \sigma(\text{sys})^2$$

The file format consists of an empty primary header and six binary table extensions. The first three extensions (from 1-3) contain the values of the different components to the error on position where the PAR1 and PAR2 where derived as follows:

- Using the on-board centroid calculation included with the TDRSS image message.
- Using the ximage centroid calculation on data taken in Image mode
- Using the ximage centroid calculation on data taken with the Photon Counting mode.

The columns included in these extensions are :

- TIME : contains time after which the components to the error are valid.
- ERRMIS : contains error due to the telescope alignement
- ERRATT : contains error due to the attitude reconstruction
- ERRSYS : contains ssystematic error
- PAR1 : contains the multiplicative constant of the function fitted to the data
- PAR2 : contains the exponent of the function fitted to the data

The other three extensions (from 4-6) contain instead the measured values used in the fitting procedure. The tables contains the measurements from the on-board centroid calculation (forth extension), and the measurements in image mode and photon counting mode derived using ground software (fifth and sixth extension respectively). The columns included in the extensions 4-6 are :

- DN or COUNTS : contains the intensity derived considering an extraction radius corresponding to the 90% of the PSF . The column is name DN for data taken in Image mode and COUNTS for data taken in Photon counting mode ;

- ACCURACY: centroid accuracy measurement;
- ERROR : contains the error on the accuracy ;

5.14.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	TDPOSERR	
	Column Names	**Format**	**Units**
	TIME	D	s
	ERRMIS	E	arcsec
	ERRATT	E	arcsec
	ERRSYS	E	arcsec
	PAR1	E	-
	PAR2	E	-
2	BINTABLE	IMPOSERR	
	Column Names	**Format**	**Units**
	TIME	D	s
	ERRMIS	E	arcsec
	ERRATT	E	arcsec
	ERRSYS	E	arcsec
	PAR1	E	-
	PAR2	E	-
3	BINTABLE	PCPOSERR	
	Column Names	**Format**	**Units**
	TIME	D	s
	ERRMIS	E	arcsec
	ERRATT	E	arcsec
	ERRSYS	E	arcsec
	PAR1	E	-
	PAR2	E	-
4	BINTABLE	TDPOSDATA	
	Column Names	**Format**	**Units**
	DN	D	-

	ACCURACY	E	arcsec
	ERROR	E	arcsec
5	BINTABLE	IMPOSDATA	
	Column Names	**Format**	**Units**
	DN	D	-
	ACCURACY	E	arcsec
	ERROR	E	arcsec
6	BINTABLE	PCPOSDATA	
	Column Names	**Format**	**Units**
	DN	D	-
	ACCURACY	E	arcsec
	ERROR	E	arcsec

Table 33 – Position error File Format

5.14.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.14.5 Extension 1 –3 Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is a Basic Calibration File
CCNM0001	'<string>	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	<datamode>	/Parameter boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT fit parameters for the CCD positional error <datamode>'	/Description
POSERR File Keywords		
EXTNAME	'<string>	/ Name of the binary extension
CONTENT	'XRT Position Error'	/File description
TIMESYS	'TT'	/ Time system

MJDREFI	51910	/ Reference MJD integer part
MJDREFF	7.4287037e-4	/ Reference MJD fractional part
CLOCKAPP	F	/ If clock corrections are applied (F/T)

Table 34 – Position Error File Extension 1 Keywords

The three extensions differ for the values of keywords, EXTNAME, CCNM001 and CDES0001. These are set as :

1st Extension		
CCNM0001	'TDPOSERR'	/ Type of calibration data
CDES0001	'XRT fit parameters for the CCD positional error (TDRSS)'	/Description
EXTNAME	'TDPOSERR'	/ Name of the binary extension
2nd Extension		
CCNM0001	'POSERR'	/ Type of calibration data
CDB10001	'DATAMODE(LONGIMA,SHORTIMA)'	/Parameter boundary
CDES0001	'XRT fit parameters for the CCD positional error (Imaging)'	/Description
EXTNAME	'IMPOSERR'	/ Name of the binary extension
3rd Extension		
CCNM0001	'POSERR'	/ Type of calibration data
CDB10001	'DATAMODE(PHOTON)'	/Parameter boundary
CDES0001	'XRT fit parameters for the CCD positional error (Photon Counting)'	/Description
EXTNAME	'PCPOSERR'	/ Name of the binary extension

Table 35 – Specific setting for keywords in the 1-3 extensions of the position file

5.14.6 Extension 4-6 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'<string>	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	<datamode>	/Parameter boundary

CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT data to calculate position error'	/Description
POSDATA File Keywords		
EXTNAME	'POSERR'	/ Extension name
CONTENT	'XRT Position Error'	/File description

Table 36- Position error file extensions 4-6 keywords

The three extensions differ for the values of keywords, EXTNAME, CCNM001 and CDES0001. These are set as :

1st Extension		
CCNM0001	'TDPOSDATA'	/ Type of calibration data
EXTNAME	'TDPOSERR'	/ Name of the binary extension
2nd Extension		
CCNM0001	'POSDATA'	/ Type of calibration data
CDB10001	'DATAMODE(LONGIMA,SHORTIMA)'	/Parameter boundary
EXTNAME	'IMPOSERR'	/ Name of the binary extension
3rd Extension		
CCNM0001	'POSDATA'	/ Type of calibration data
CDB10001	'DATAMODE(PHOTON)'	/Parameter boundary
EXTNAME	'PCPOSERR'	/ Name of the binary extension

Table 37 – Specific setting for keywords in the 4-6 extensions of the position file

5.15 Prefilter Parameters

5.15.1 File Name

swxpreconfYYYYMMDDvNNN.fits

5.15.2 Description

This file contains the parameter names that are used in the prefilter task. The file format consists of an empty primary header and a binary table extension, named PRECONF, with one column:

- PARNAME: contains the name of the parameters used by prefilter. These are parameters related to the attitude.

5.15.3 File Format

Extension N.	*Type*	*Ext. Name*	
0	PRIMARY		
1	BINTABLE	PRECONF	
	Column Names	**Format**	**Units**
	PARNAME	11A	-

Table 38 – Prefilter parameter File Format

5.15.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.15.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	*keyword value*	*comment*
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'PRECONF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT prefilter parameters’	/Description
HK Range Values File Keywords		
EXTNAME	'PRECONF'	/ Name of the binary table extension
CONTENT	‘Prefilter Parameters’	/File content

Table 39 – Prefilter parameters Calibration File Extension 1 Keyword

5.16 Regions description

5.16.1 File Name

swxregionYYYYMMDDvNNN.fits

5.16.2 Description

This file contains the region description of the XRT field of view, the calibration sources, and the region defining the corners of the XRT detector that can be used as background. These regions definition are in

detector coordinates and are applicable to Photon Counting and Image modes. The file format consists of an empty primary header and three binary table extensions, one for each of the region type. The extensions contain the following columns:

- SHAPE: contains a string defining the type of region. Within this file two type of regions are used ‘circle’ and ‘polygon’. The circle shape is used to describe the XRT FOV and the calibration sources. The polygon instead is used to describe the XRT corners.
- DETX & DETY: contain the center of the circle for shape equal ‘circle’ or the coordinates of the polygon for shape equal ‘polygon’. In the latter case the columns are arrays.
- R: contains the radius for shape equal ‘circle’. This column is not present for shape set to ‘polygon’.

5.16.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	REGION_FOV	
	Column Names	**Format**	**Units**
	SHAPE	16A	-
	DETX	E	pixel
	DETY	E	pixel
	R	E	pixel
2	BINTABLE	REGION_CAL	
	Column Names	**Format**	**Units**
	SHAPE	16A	-
	DETX	E	pixel
	DETY	E	pixel
	R	E	pixel
3	BINTABLE	REGION_CORNER	
	Column Names	**Format**	**Units**
	SHAPE	16A	-
	DETX	E	pixel
	DETY	E	pixel

Table 40 – Region Files Format

5.16.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.16.5 Extension 1-3 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Specific settings of some of the CALDB keywords and others relevant to this file are listed below.

keyword name	*keyword value*	*comment*
1ST Extension		
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'REGION'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'TYPE(FOV)'	/Parameter Boundary
CBD20001	"DATAMODE(PHOTON,SHORTIMA,LONGIMA)'	/Parameter Boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	Region describing the XRT Field of View'	/Description
Region Files Keywords		
EXTNAME	'REGION_FOV'	/ Name of the binary table extension
CONTENT	'Region describing the XRT Field of View'	/File content
2nd Extension		
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'REGION'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'TYPE(CALSOURCE)'	/Parameter Boundary
CBD20001	"DATAMODE(PHOTON,SHORTIMA,LONGIMA)'	/Parameter Boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'Regions description of the Calibration sources'	/Description
Region Files Keywords		
EXTNAME	'REGION_CAL'	/ Name of the binary table extension
CONTENT	'Regions description of the Calibration sources'	/File content

	Calibration sources’	
3rd Extension		
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'REGION’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	‘TYPE(DETCORNER)’	/Parameter Boundary
CBD20001	“DATAMODE(PHOTON,SHORTIMA,LONGIMA)’	/Parameter Boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	‘Regions of the detector corners’	/Description
Region Files Keywords		
EXTNAME	'REGION_CORNER’	/ Name of the binary table extension
CONTENT	‘Regions of the detector corners’	/File content

Table 41 – Region Calibration Files Extension 1-3 Keywords

5.17 Waveform and Amplifier Calibration File

5.17.1 File Name

swxwaveampYYYYMMDDvNNN.fits

5.17.2 Description

The file contains the numerical values for the waveform for different combination of the amplifier and the XRT readout mode. The file format consists of an empty primary header and a binary table extension, named WAVEAMP. The binary table contains the following columns:

- ROMODE: contains a string identifying the XRT readout mode. For the Windowed timing mode includes also the window size;
- WAVEFORM: contains the numerical value associated to the amplifier and readout mode combination;
- Amp: contains the amplifier value that together the readout mode defines a waveform;
- XRTMODE: contains the numerical value that identifies the XRT readout mode;
- GAIN: contains the string identifying the gain used for the specified readout mode.

5.17.3 File Format

Extension N.	***Type***	***Ext. Name***

0	PRIMARY		
1	BINTABLE	WAVEFORM	
	Column Names	**Format**	**Units**
	ROMODE	20A	s
	WAVEFORM	I	-
	Amp	I	-
	XRTMODE	I	-
	GAIN	6A	-

Table 42 - Waveform and Amplifier Calibration Files Format

5.17.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.17.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is a Basic Calibration File
CCNM0001	'WAVEAMP'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Waveform and Amplifier'	/Description
Waveform and Amplifier File Keywords		
EXTNAME	'WAVEAMP'	/ Name of the binary table extension
CONTEN	‘XRT Waveform and Amp'	/ File content

Table 43 - Waveform and Amplifier Calibration File Extension 1 Keywords

5.18 Quantum Efficiency Calibration File

5.18.1 File Name

swxpcqe20040325v004.fits , swxpdqe20040325v005.fits , swxwtqe20040325v005.fits

5.18.2 Description

These files contain the Quantum Efficiency of the CCD (QE) as function of energy and different grades. There are three files for the quantum efficiency one for the Photon counting, Windowed Timing and Photodiode modes. The file format consists in an empty primary table and a binary table extension. All files contain a column named 'ENERGY' and a variable number of columns, which depends on the read-out mode, containing the quantum efficiency for different grade selection. For the Photon counting mode quantum efficiency is reported for grade 0, 0-4 and 0-12, For Windowed timing mode quantum efficiency is reported for grade 0 and 0-2, and for Photodiode modes for grade 0, 0-2 and 0-5.

5.18.3 File Format

The following tables list the structure for the quantum efficiency files for the 3 different modes.

Photon counting			
Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	QE	
	Column Names	**Format**	**Units**
	ENERGY	E	eV
	QE0	E	-
	QE0_4	E	-
	QE0_12	E	-

Table 44 - Quantum Efficiency Calibration File Format for the Photon Counting

Windowed Timing			
Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	QE	
	Column Names	**Format**	**Units**
	ENERGY	E	eV
	QE0	E	-
	QE0_2	E	-

Table 45 - Quantum Efficiency Calibration file Format for the Windowed Timing

Photodiode		
Extension N.	***Type***	***Ext. Name***

0	PRIMARY		
1	BINTABLE	QE	
	Column Names	**Format**	**Units**
	ENERGY	E	eV
	QE0	E	-
	QE0_2	E	-
	QE0_5	E	-

Table 46- Quantum Efficiency Calibration File format for the Photodiode

5.18.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.18.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'QE'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Quantum Efficiency <mode>'	/Description
CBD10001	'DATAMODE(<datamode.)’	/Parameter boundary
CBD20001	'DETCHAN(1024)’	/Parameter boundary
CBD30001	'GRADE (<range>)'	/Parameter boundary
CBD40001	'ENERG(0.1-12.0)keV'	/Parameter boundary
Quantum Efficiency File Keywords		
EXTNAME	'QE'	/ Name of the binary table extension
CONTENT	‘XRT Quantum Efficiency’	/File description

Table 47 - Quantum Efficiency Calibration File Extension 1 Keywords

Where <mode>, <datamode> and <range> are set as follows :

PHOTON Counting		
CDES0001	'XRT Quantum Efficiency Photon counting '	/Description
CBD10001	'DATAMODE(PHOTON)''	/Parameter boundary
CBD30001	'GRADE (“0-12“)'	/Parameter boundary
Windowed Timing		
CDES0001	'XRT Quantum Efficiency windowed mode'	/Description
CBD10001	'DATAMODE(WINDOWED)''	/Parameter boundary
CBD30001	'GRADE (“0-2“)'	/Parameter boundary
Photodiode		
CDES0001	'XRT Quantum Efficiency windowed timing'	/Description
CBD10001	'DATAMODE(LOWRATE,PILEDUP)''	/Parameter boundary
CBD30001	'GRADE (“0-5“)'	/Parameter boundary

Table 48- Specific settings of keywords for the three quantum efficiency files

5.19 TAM Reference Position Calibration File

5.19.1 File Name

swxtamrefYYYYMMDDvNNN.fits

5.19.2 Description

The file contains the reference positions of the XRT Telescope Alignment Monitor. The file format consists of an empty primary header and a binary table extension, 'TAMREF', containing the following columns:

- TIME: contains time, expressed in seconds, from a reference time;
- LED: contains the value of the LED;
- XTRFC1L1: X reference coordinate of the Primary TAM centroid using the LED 1;
- YTRFC1L1: Y reference coordinate of the Primary TAM centroid using the LED 1;
- XTRFC2L1: X reference coordinate of the Secondary TAM centroid using the LED 1;
- YTRFC2L1: Y reference coordinate of the Secondary TAM centroid using the LED 1;
- XTRFC1L2: X reference coordinate of the Primary TAM centroid using the LED 2;
- YTRFC1L2: Y reference coordinate of the Primary TAM centroid using the LED 2;
- XTRFC2L2: X reference coordinate of the Secondary TAM centroid using the LED 2;

- YTRFC2L2: Y reference coordinate of the Secondary TAM centroid using the LED 2;
- TAMPLSW1: plate scale resolution for Primary image;
- TAMPLSW2: plate scale resolution for Secondary image;
- TAMPSOPG: optical gain ;
- TAMSCTHA: angle between TAM (and star tracker) coordinates and XRT axis;
- XBOSCTHA: misalignment angle between XRT and spacecraft axes;
- YBOSCCOR: misalignment angle between XRT and spacecraft axes;
- ZBOSCCOR: misalignment angle between XRT and spacecraft axes.

5.19.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	TAMREF	
	Column Names	**Format**	**Unit**
	TIME	D	s
	LED	I	-
	XTRFC1L1	E	pixel
	YTRFC1L1	E	pixel
	XTRFC2L1	E	pixel
	YTRFC2L1	E	pixel
	XTRFC1L2	E	pixel
	YTRFC1L2	E	pixel
	XTRFC2L2	E	pixel
	YTRFC2L2	E	pixel
	TAMPLSW1	E	arcsec
	TAMPLSW2	E	arcsec
	TAMPSOPG	E	-
	TAMSCTHA	E	deg
	XBOSCTHA	E	deg
	YBOSCCOR	E	arcsec
	ZBOSCCOR	E	arcsec

Table 49 - Housekeeping TAM reference positions values Files Format

5.19.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.19.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	*keyword value*	*comment*
Table 2- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'TAMREF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT TAM reference positions values'	/Description
TAM reference positions File Keywords		
EXTNAME	'TAMREF'	/ Name of the binary extension
CONTENT	'XRT TAM alignment parameters'	/File description
TIMESYS	'TT'	/ Time system
MJDREFI	51910	/ Reference MJD integer part
MJDREFF	7.4287037e-4	/ Reference MJD fractional part
CLOCKAPP	F	/ If clock corrections are applied (F/T)

Table 50 - TAM reference positions Calibration File Extension 1 Keywords

5.20 Ancillary Response File

5.20.1 File name

The name of the Ancillary files do not conform standard naming convention described in paragraph 3.1.

First version

swx<datamode><gradelow>to<gradehigh>_YYYYMMDDvNNN.arf

where <datamode> - specify the xrt readout mode (e.g. pc, wt and pd)

<gradelow> - is the lower grade of validity

<gradehigh> - is the higher grade of validity

For single grade matrix the filename is

swx<datamode><grade>_YYYYMMDDvNNN.arf

where <datamode> - specify the xrt readout mode (e.g. pc, wt and pd)

<grade>- is the grade of validity

Note: the original version of the arf released at launch at a different naming convention because did not modeled on the response matrix. The naming convention was swxYYYYMMDDvNNN.arf. These files are now obsolete.

Second version

swx<datamode><gradelow>to<gradehigh>s<substrate>_YYYYMMDDvNNN.arf

where <datamode> - specify the xrt readout mode (e.g. pc, wt and pd)

<gradelow> - is the lower grade of validity

<gradehigh> - is the higher grade of validity

<substrate> - is the value of the substrate

For single grade matrix the filename is

swx<datamode><grade>s<substrate>_YYYYMMDDvNNN.arf

where <datamode> - specify the xrt readout mode (e.g. pc, wt and pd)

<grade>- is the grade of validity

<substratee> - is the value of the substrate

The summer 2007 the substrate voltage changed. These CALDB files were modified to include the value for the substrate voltage in the CALDB boundary and the filenames were changed to add the value of the substrate. The suffix for the substrate is identified by the characters 'sN' where N is either 0 or 6. The substrate value of 0 was used up the summer of 2007 after the substrate was changed to 6.

5.20.2 Description

The ARF stored in the CALDB is the on-axis ARF for a standard extraction radius. It gives the area as function of energy and includes the effect of the mirror area and the filter transmission. The ARF generator tool is distributed with the XRT software, therefore users can create the ARF accordingly with the extracted spectrum. The file format consists in an empty primary table and a binary table extension. For each mode there are several files to match the grade selection of the rmf that describe the ARF on-axis. There are three files for the Photon counting, two for the Windowed Timing and two for the Photodiode modes.

5.20.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	SPECRESP	
	Column Names	**Format**	**Units**
	ENERG_LO	E	keV
	ENERG_HI	E	keV

	SPECRESP	E	cm^2

Table 51 - Ancillary Response Calibration File Format

5.20.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.20.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'CPF'	/ Dataset is a Calibration Product File
CCNM0001	'SPECRESP'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CBD10001	'DATAMODE(<datamode.)'	/Parameter boundary
CBD20001	'THETA(0)arcmin'	/ Parameter boundary
CBD30001	'PHI(0)deg'	/ Parameter boundary
CBD40001	'ENERG(0.1-12.0)keV'	/ Parameter boundary
CBD50001	`GRADE("Gn:m")'	/Parameter boundary
CDB60001	`XRTVSUB(<N>)'	/Parameter boundary
CDES0001	'XRT Ancillary Response Function'	/Description
Ancillary Response File Keywords		
EXTNAME	'SPECRESP '	/ Extension name
HDUCLASS	'OGIP'	/ Format conforms to OGIP/GSFC conventions
HDUCLAS1	RESPONSE	/ Extension contains response data
HDUCLAS2	SPECRESP	/ Extension contains response data

Table 52 - Ancillary Response Calibration File Extension 1 Keywords

Where the <datamode> is set as follows:

PHOTON Counting		
CBD10001	'DATAMODE(PHOTON)''	/Parameter boundary

Windowed Timing		
CBD10001	'DATAMODE(WINDOWED)''	/Parameter boundary
Photodiode		
CBD10001	'DATAMODE(LOWRATE,PILEDUP)''	/Parameter boundary

Table 53- Specific keyword setting for the three ARF files

and the <N> in the CDB60001 is set as an integer to the value of the substrate voltage (added summer 2007)

5.21 Encircled Energy Fraction

5.21.1 File Name

swxeefYYYYMMDDvNNN.fits

5.21.2 Description

The file contains the normalized integral profile of the PSF (or Encircled Energy Fraction, EEF). The EEF has been evaluated using the calibration data taken at the Panter and it has been calculated for a grid of 5 energies (0.3, 1.5, 4.5, 6.4, 8.0, keV) and 5 positions on the detector (0, 2, 5, 7, 10, arcmin). The file format consists of an empty primary header and 24 binary table extensions, each containing the following columns:

- RAD_PXL: is the radius, expressed in pixels, of the integration circle for a given energy and position on the detector;
- EEF: the corresponding Encircled Energy Fraction value.

5.21.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
n	BINTABLE	EEF_<xx>eV_<yy>arcmin	
	Column Names	**Format**	**Units**
	RAD_PXL	E	pixel
	EEF	E	-

n= 1…24

Table 54 - EEF Calibration Files Format

The file format is identical for the 24 extensions. The EXTNAME is defined as 'EEF_<xx>eV_<yy>arcmin' where <xx>=(300, 1500, 4500, 6400, 8000) eV and <yy>=(0, 2, 5 ,7,10) arcmin, e.g. for a given energy there are 5 extension tables cycling on different position on the detector.

5.21.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords

5.21.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	*keyword value*	*comment*
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'CPF'	/ Dataset is Calibration Product File
CCNM0001	'EEF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'THETA(<yy>)arcmin'	/Parameter boundary
CBD20001	'ENERG(<ZZ>)keV'	/Parameter boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT EEF'	/Description
EEF File Keywords		
EXTNAME	' EEF_<xx>eV_<yy>arcmin'	/ Name of the binary table extension'
CONTENT	'Encircled Energy Fraction'	/File description

<xx>=(0.3, 1.5, 4.5, 6.4, 8.0, keV), <yy>=(0, 2, 5, 7, 10, arcmin)

Table 55 - EEF Calibration File Extension 1-24 Keyword

Where <ZZ> is set to 0.3, 1.5, 4.5,6.4 and 8.0 keV while the <yy>=(0, 2, 5 ,7,10) arcmin.

In the EXTNAME keyword <xx> is defined as 300, 1500, 4500, 6400, 8000 eV and <yy> as 0, 2, 5 ,7,10 arcmin, e.g. for a given energy there are five table extensions cycling on different position on the detector.

5.22 Point Spread Function Calibration File

5.22.1 File Name

swxpsfYYYYMMDDvNNN.fits

5.22.2 Description

The PSF profile is considered radially symmetric and, for a given energy (E) and position in the field of view (off-axis angle θ), it is well described by a King+Gauss analytical profile ("SWIFT XRT Point Spread Function measured at the Panter end-to-end tests", Moretti A. et al., SPIE, 2004, 5165, 232 ; "In flight calibration of the Swift XRT Point Spread Function", Moretti A. et al., SPIE, 2005,5898,360):

PSF(r) = P0 * Gauss(P1) +(1-P0) *King(P2,P3)

The PSF profile changes as a function of offaxis angle and energy and the 4 free parameters of the analytical model, P0-P3, can be expressed as follows:

P_i=COEF0+COEF1*offaxis+COEF2*energy+COEF3*energy*offaxis

This CALDB file contains, for each parameter P_i the coefficients COEF0-COEF3 describing its dependence on energy given in units of kev/0.1, and the offaxis angle in units of arcmin/0.1. The file format consists of an empty primary header and a binary table extension, PSF_COEF containing the following columns:

- PAR: contains a string with value of the parameter P_i where n=0,3 ;
- COEF0, COEF1, COEF2 & COEF3; contains the values of the coefficient in the P_i function.

5.22.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	PSF_COEF	
	Column Names	**Format**	**Units**
	PAR	2A	-
	COEF0	E	-
	COEF1	E	-
	COEF2	E	-
	COEF3	E	-

Table 56 - PSF Coefficients Calibration Files Format

5.22.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords

5.22.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 &3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'CPF'	/ Dataset is Calibration Product File
CCNM0001	'PSF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used

CDES0001	'XRT PSF coefficients'	/Description
PSF Coefficients File Keywords		
EXTNAME	'PSF_COEF'	/ Name of the binary table extension
CONTENT	'XRT PSF coefficients'	/File content

Table 57 - PSF Coefficients Calibration File Extension 1 Keywords

5.23 Response Matrix

5.23.1 File Name

The names of the Redistribution Matrix files do not conform standard naming convention described in paragraph 3.1.

First version

swx<datamode><gradelow>to<gradehigh>_YYYYMMDDvNNN.rmf

where <datamode> - specify the xrt readout mode (e.g. pc, wt and pd)

<gradelow> - is the lower grade of validity

<gradelow> - is the higher grade of validity

For single grade matrix the filename is

swx<datamode><grade>_YYYYMMDDvNNN.rmf

where <datamode> - specify the xrt readout mode (e.g. pc, wt and pd)

<grade>- is the grade of validity

Response matrices valid for the TDRSS spectra are instead named

swx<datamode>mspha_YYYYMMDDvNNN.rmf (TBC)

Second version

swx<datamode><gradelow>to<gradehigh>s<substrate>_YYYYMMDDvNNN.rmf

where <datamode> - specify the xrt readout mode (e.g. pc, wt and pd)

<gradelow> - is the lower grade of validity

<gradehigh> - is the higher grade of validity

<substrate> - is the value of the substrate

For single grade matrix the filename is

swx<datamode><grade>s<substrate>_YYYYMMDDvNNN.rmf

where <datamode> - specify the xrt readout mode (e.g. pc, wt and pd)

<grade>- is the grade of validity

<substratee> - is the value of the substrate

The summer 2007 the substrate voltage changed. These CALDB files were modified to include the value for the substrate voltage in the CALDB boundary and the filenames were changed to add the value of the

substrate. The suffix for the substrate is identified by the characters ‘sN’ where N is either 0 or 6. The substrate value of 0 was used up the summer of 2007 after the substrate was changed to 6.

5.23.2 Description

The RMF generator tool is not distributed with the XRT software, but it is run at Leicester University. The response matrices are generated for specific grades and grade ranges considered ‘good’ for the data analysis and are available for the following read-out modes: Photon counting, Windowed Timing and Photodiode. They are applicable for spectra extracted in PI channel type. All available response matrices are included in CALDB. The file format consists of an empty primary table and two binary table extensions named ‘MATRIX’ and ‘EBOUNDS’. The 'MATRIX' includes the following columns:

- ENERG_LO: lower energy bound of the energy bin;
- ENERG_HI: upper energy bound of the energy bin;
- N_GRP: number of channel subset for the energy bin;
- F_CHAN: channel number of the of the start of each ' channel subset' for the energy bin;
- N_CHAN: number of channels within each 'channel subset' for the energy bin;
- MATRIX: response values for each 'channel subset' for the energy bin.

The ‘EBOUNDS’ extension includes the following columns :

- CHANNEL : contains the channel number
- E_MIN: Channel lower energy boundary in keV
- E_MAX: Channel upper energy boundary in keV

Additional responses are available for the spectra send down via TDRSS for the Windowed Timing and Photodiode modes respectively. These matrices are for spectra in PHA channels.

5.23.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	MATRIX	
	Column Names	**Format**	**Units**
	ENERG_LO	E	keV
	ENERG_HI	E	keV
	N_GRP	I	-
	F_CHAN	47I	-
	N_CHAN	47I	-
	MATRIX	212E	-

2	BINTABLE	EBOUNDS	
	Column Names	**Format**	**Units**
	CHANNEL	I	-
	E_MIN	E	keV
	E_MAX	E	keV

Table 58 - Response Matrix Calibration File Format

5.23.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.23.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'CPF'	/ Dataset is a Calibration product File
CCNM0001	'MATRIX'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'DATAMODE(<datamode>)'	/Parameter boundary
CBD20001	DETCHANS(1024)	/ Parameter boundary
CBD30001	GRADE("Gn:m")	/ Parameter boundary
CBD40001	CHAN(0 - 1023)	/Parameter boundary
CBD50001	CHANTYPE("PI")	/ Parameter boundary
CDB60001	XRTVSUB(<N>)	/Parameter boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Response Matrix generated by Monte-Carlo code'	/Description
Response Matrix File Keywords		
EXTNAME	'MATRIX'	/ Extension name
HDUCLASS	'OGIP'	/Format conforms to OGIP standards
HDUCLAS1	RESPONSE	/Extension contains response data
HDUCLAS2	RSP_MATRIX	/Extension contains RMF

TLMIN4	0	/First channel in the response
CHANTYPE	PI	/Channel type
DETCHANS	1024	/Total number of detector channels

Table 59 - Response Matrix Calibration File Extension 1 Keywords

where <datamode> is set to PHOTON or WINDOWED or LOWRATE,PILEDUP

and the <N> in CDB60001 is set as an integer to the value of the substrate voltage (added summer 2007).

The matrices for the TDRSS spectra differ in the following keyword settings :

- CHANTYPE is set to PHA ;
- CDB30001 is set to GRADE("G0:15");
- CDB50001 is set to CHANTYPE(“PHA”)

5.23.6 Extension 2 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific setting of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'CPF'	/ Dataset is Basic Calibration File
CCNM0001	'EBOUNDS'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'DATAMODE(<datamode>)'	/Parameter boundary
CBD20001	DETCHANS(1024)	/ Parameter boundary
CBD30001	GRADE("Gn:m")	/ Parameter boundary
CBD40001	CHAN(0-1023)	/Parameter boundary
CBD50001	CHANTYPE("PI")	/ Parameter boundary
CDB60001	XRTVSUB(<N>)	/Parameter boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	‘XRT Response Matrix generator by Monte Carlo code’	/Description
Response Matrix File Keywords		
EXTNAME	'EBOUNDS’	/ Extension name
HDUCLASS	'OGIP'	/Format conforms to OGIP standards
HDUCLAS1	‘RESPONSE’	/Extension contains response data

HDUCLAS2	'EBOUNDS'	/Extension contains EBOUNDS
CHANTYPE	'PI'	/Channel type
DETCHANS	1024	/Total number of detector channels

Table 60 - Response Matrix Calibration File Extension 2 Keyword

where <datamode> is set to PHOTON or WINDOWED or LOWRATE,PILEDUP
and the <N> in CDB60001 is set as an integer to the value of the substrate voltage (added summer 2007).
The matrices for the TDRSS spectra differ in the following keyword settings :

- CHANTYPE is set to PHA ;
- CDB30001 is set to GRADE("G0:15");
- CDB50001 is set to CHANTYPE("PHA")

5.23.7 Grade

The response matrices are available for a subset of grade selection. These are the available grades:

Grade	Photon Counting	Windowed Timing	Lowrate Phodiode Piledup Photodiode
0:0	yes	yes	yes
0:2		yes	yes
0:4	yes		
0:5			yes
0:12	yes		

Table 61- Grade selection for response matrices

Note : There is a different grade definition for the Photon counting mode and the Timing modes.
For the responses to use with the TDRSS spectra in PHA all grades are in used.

5.24 Vignetting Calibration File

5.24.1 File Name

swxvignYYYYMMDDvNNN.fits

5.24.2 Description

The XRT vignetting as function of the off-axis angle θ is described by the following formula:

$$v = 1 - c\,\theta^{2}$$

where the coefficient 'c' is a function of the energy E described by the following model:

c(E) = PAR0 * pow (PAR1, E) + PAR2

This CALDB file contains the three parameters of this analytical model. The file format is an empty primary header and a binary table extension, named VIG_COEFF, containing three columns corresponding to the parameters in the c(E) .

5.24.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	VIG_COEF	
	Column Names	**Format**	**Units**
	PAR0	E	-
	PAR1	E	-
	PAR2	E	-

Table 62 - Vignetting Coefficients Calibration Files Format

5.24.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords

5.24.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'CPF'	/ Dataset is a Calibration Product File
CCNM0001	'VIGNET'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Vignetting Coefficients'	/Description
Vignetting Coefficients File Keywords		
EXTNAME	'VIG_COEF'	/ Name of the binary table extension
CONTENT	'XRT Vignetting Coefficients'	/File description

Table 63 - Vignetting Coefficients Calibration File Extension 1 Keywords

5.25 Background Events Calibration File

5.25.1 File Name

swxpcbkgphaYYYYMMDDvNNN.evt.

swxwtbkgphaYYYYMMDDvNNN.evt,

swxpdbkgphaYYYYMMDDvNNN.evt

5.25.2 Description

The file contains the event list of a blank field for Photon Counting, Windowed Timing or Photodiode mode. These files are generated using on-orbit data. The file format is identical to 'EVENT' science data, an empty primary header and two binary table extensions, 'EVENTS' and 'GTI'. The file corresponds to the level 1 file where all the information is retained from the telemetry and new information is calculated and added in columns. The 'EVENTS' extension contains the following columns:

- TIME: contains time, expressed in seconds, from a reference time;
- CCDFrame: CCD frame number;
- Amp: amplifier number;
- RAWX: raw coordinates of the pixel (not present for Photodiode Mode);
- RAWY: raw coordinates of the pixel (not present for Photodiode Mode);
- DETX: detector coordinates of the pixel;
- DETY: detector coordinates of the pixel;
- X: celestial coordinates of the pixel (Not present in the Photodiode mode);
- Y: celestial coordinates of the pixel (Not present in the Photodiode mode);
- OFFSET: pixel offset from Frame header (for Photodiode Mode ONLY);
- PHA: DN channel;
- PI: Pulse Invariant channel;
- GRADE: grade of the event;
- STATUS: flag indicating the quality of the event;

A second extension GTI contains the Start and Stop time of the Good Time Intervals.

5.25.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	EVENTS	
	Column Names	**Format**	**Units**
	TIME	D	s

	CCDFrame	I	-
	Amp	I	-
	RAWX(not for PD mode)	I	pixel
	RAWY(not for PD mode)	I	pixel
	DETX	I	pixel
	DETY	I	pixel
	X (not for PD modes)	E	pixel
	Y (not for PD modes)	E	pixel
	OFFSET(PD mode only)	J	-
	PHA	I	chan
	PI	I	chan
	GRADE	I	-
	STATUS	16X	-
2	BINTABLE	GTI	
	Column Names	**Format**	**Units**
	START	D	s
	STOP	D	s

Table 64 - Background event Files Format

5.25.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.25.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords. There are several other keywords for the header of the event file. A sample header is given in the Appendix for each of the mode

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is a Basic Calibration File
CCNM0001	'BKGRND_EVTS'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CBD10001	'DATAMODE(<datamode>)'	/ Parameter Boundary

CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Background events'	/Description

Table 65 - Background events File Extension 1 Keywords

where <datamode> is set to PHOTON or WINDOWED or LOWRATE,PILEDUP.

5.25.6 Extension 2 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific setting of some of the CALDB keywords. Other header keywords are listed in the Appendix.

keyword name	***keyword value***	***comment***
Table 2- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'BKG_EVENTS'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'DATAMODE(<datamode>)'	/ Instrument Readout Mode
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Background events '	/Description

Table 66 - Background events File Extension 2 Keywords

where <datamode> is set to PHOTON or WINDOWED or LOWRATE,PILEDUP.

5.26 Background Spectra Calibration Files

5.26.1 File Name

swxwtbkgphaYYYYMMDDvNNN.pha

swxpdbkgYYYYMMDDvNNN.pha

swxpcbkgYYYYMMDDvNNN.pha

5.26.2 Description

These background spectra are used to subtract the background in the spectra send down via TDRSS as after Swift slew to a newly discovered GRB. The spectra taken are accumulated without event recognition in PHA channel and no background is subtracted. The background spectral format consists of an empty primary header and a binary table extension, SPECTRUM and it contains two columns CHANNEL and COUNTS. For completeness the spectrum for the PHOTON counting mode is also provided.

5.26.3 File Format

Extension N.	*Type*	*Ext. Name*	
0	PRIMARY		
1	BINTABLE	SPECTRUM	
	Column Names	**Format**	**Units**
	CHANNEL	I	-
	COUNTS	J	-
	QUALITY	I	-
	GROUPING	I	-

Table 67- Background spectrum format

5.26.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.26.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific setting of some of the CALDB keywords and others relevant to this file.

keyword name	*keyword value*	*comment*
Table 2 & 3- XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'CPF'	/ Dataset is a Calibration Product File
CCNM0001	'BKGRND_SPECTRUM'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CBD10001	'DATAMODE(<datamode>)'	/ Parameter Boundary
CBD20001	‘CHANTYPE(PHA)’	/Parameter boundary
CBD20001	‘GRADE(“G0-15”)’	/Parameter boundary
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	‘Background spectrum PHA Channel’	/Description
Background Spectrum File Keywords		
EXTNAME	'SPECTRUM'	/ Extension name
TLMIN1	0	/ minimum legal value in the column
TLMAX1	1023	/ maximum legal value in the column

HDUCLASS	‘SPECTRUM’	/Extension contains spectrum
HDUCLAS1	‘‘BKG’	/Extension contains background data
HDUCLAS2	‘COUNT’	/Extension contains counts
DATE-OBS	:YYYY-MM-DDThh:mm:ss.s’	/Start Date
DATE-END	:YYYY-MM-DDThh:mm:ss.s’	/Stop Date
DATAMODE	‘<datamode>’	/Instrument opearting mode
AREASCAL	1.	/ area scaling factor
BACKFILE	‘none’	/associated background file
BACKSCAL	1.	/background file scaling factor
CORRFILE	‘none’	/associated correction file
CORRSCAL	1.	/correction file scaling factor
RESPFILE	‘none’	/associated redistribution matrix filename
ANCRFILE	‘none’	/associated ancillary response filename
PHAVERSN	‘1992°’	/obsolete
DETCHANS	1024	/total number of channels
CHANTYPE	‘PHA’	/channels type (PHA or PI)
POISERR	T	/Poissonian errors to be assumed
STAT_ERR	0	/no statistical error specified
SYS_ERR	0	/no systematic error specified
GROUPING	0	/no grouping of data has been specified
QUALITY	0	/ no data quality information specified
EXPOSURE	<value>	/Total exposure, with all known correction
DEADC	<values>	/dead time correction

Table 68 - Background spectrum File Extension 1 Keywords

where data <datamode> is WINDOWED , LOWATE or PHOTON.

5.27 WT Bad Column Calibration File

5.27.1 File Name

swxwtcolumnYYYYMMDDvNNN.fits

5.27.2 Description

The file contains the WT offset for the bad columns to align the RAW coordinate system to the RAW PC mode system. This file is used in the software to flag the bad columns that are numbered using the PC coordinates system and stored in the bad pixel CALDB file. The file format consists of an empty primary header and a binary table extension, named WTCOLOFFSET. The binary table contains the following columns:

- WAVE: contains a numerical values to identify the waveform;
- Amp: contains the amplifier value that together the readout mode defines a waveform;
- WM1stCol : is the numeric value for the 1st column in use for a given WAVE and AMP. Within a specific observation, this value is stored in the file containing the packet trailer information;
- WMColNum: contains the numeric value for the number of columns in use for a given WAVE and Amp.
- OFFSET: is the numeric value that should be subtracted from the telemetered value to align the column with the PC coordinates system for a given WAVE and Amp.

5.27.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	WAVEFORM	
	Column Names	**Format**	**Units**
	WAVE	B	
	Amp	B	-
	WM1stCol	I	-
	WMColNum	I	
	OFFSET	I	-

Table 69 – WT columns Calibration Files Format

5.27.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.27.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is a Basic Calibration File

CCNM0001	'WTCOLOFFSET'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT WT 1st pixel and no of columns '	/Description
WT columns File Keywords		
EXTNAME	'WTCOLOFFSET'	/ Name of the binary table extension
CONTENT	'XRT WT column offset	/ File content

Table 70 – WT columns Calibration File Extension 1 Keywords

5.28 Threshold values Calibration File

5.28.1 File Name

swxvsubthrYYYYMMDDvNNN.fits

5.28.2 Description

The file contains the different threshold values that are used in the input parameters in the XRT tasks. This file is accessed if the tasks have set the 'thrfile' to CALDB and the threshold relative to the task is read by the CALDB file. The XRT tasks that read this file are : *xrtevtrec, xrtpcgrade, xrtflagpix, xrtpcbias, xrtwtcorr, xrtpdcorr.* The file format consists of an empty primary header and a binary table extension, named XRTVSUB. The binary table contains the following columns:

- XRTVSUB: give the numerical value of the substrate voltage;
- PCEVENT: give the event threshold for the task *xrtflagpix* parameter 'phas1thr';
- PCSPLIT: give the split threshold for the task *xrtpcgrade* parameter 'spli';
- WTEVENT: give the event threshold for the task *xrtevtrec* parameter 'event';
- WTSPLIT: give the split threshold for the task *xrtevtrec* parameter 'split';
- PDEVENT: give the event threshold for the task *xrtevtrec* parameter 'event';
- PDSPLIT: give the split threshold for the task *xrtevtrec* parameter 'split';
- PCEVTTHR: give the event threshold for the task *xrtpcbias* parameter 'evtthr';
- PCSPLITTHR: give the split threshold for the task *xrtpcbias* arameter 'splitthr';
- WTBIASTH: give the bias for the WT mode for the task *xrtwtcorr* parameter 'biasth' ;
- PDBIASTH: give the bias for the PD mode for the task *xrtpdcorr* parameter 'biasth' ;

5.28.3 File Format

Extension N.	*Type*	*Ext. Name*
0	PRIMARY	

1	BINTABLE	XRTVSUB	
	Column Names	**Format**	**Units**
	XRTVSUB	I	-
	PCEVENT	I	-
	PCSPLIT	I	-
	WTEVENT	I	-
	WTSPLIT	I	-
	PDEVENT	I	-
	PDSPLIT	I	-
	PCEVTTHR	I	-
	PCSPLITTHR	I	-
	WTBIASTH	I	-
	PDBIASTH	I	-

Table 71 – Threshold Calibration Files Format

5.28.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.28.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is a Basic Calibration File
CCNM0001	'XRTVSUB'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CDES0001	'XRT Sub Voltage and Thresh '	/Description
Threshold File Keywords		
EXTNAME	"XRTVSUB"	/ Name of the binary table extension
CONTENT	"XRT Substrate Voltage and Thresholds'	/ File content

Table 72 – Threshold Calibration File Extension 1 Keywords

5.29 PHA configuration values Calibration File

5.29.1 File Name

swxphasconfYYYYMMDDvNNN.fits

5.29.2 Description

The file contains the telemetered order of the PC mode 3x3 matrix pixel. With the version of the on-board software uploaded on 2008-05-29 at 17:58 UT, the DN values of the 3x3 array were telemetered to ground with a different pixel order compared to the standard one. The order of the 3x3 array, as telemetred by this on-board software version and subsequent ones, are recorded in this CALDB file together with their time of validity. This file is used by 'xrtphascorr' to order the 3x3 array according to the standard configuration. The file format consists of an empty primary header and a binary table extension, named PHASCONF. The binary table contains the following columns:

- TIME: give the time of the software upload as mission elapsed time;
- PHACONF: give the 3x3 order of the array as configured in the software upload.

5.29.3 File Format

Extension N.	***Type***	***Ext. Name***	
0	PRIMARY		
1	BINTABLE	PHASCONF	
	Column Names	**Format**	**Units**
	TIME	D	s
	PHASCONF	9I	-

Table 73 – PHAS Configuration Calibration Files Format

5.29.4 Primary Header Keywords

All keywords of Table 2 - XCFS mandatory header keywords.

5.29.5 Extension 1 - Header Keywords

All keywords listed in Table 2 and Table 3 are included in the header for this HDU. Below are listed specific settings of some of the CALDB keywords and others relevant to this file.

keyword name	***keyword value***	***comment***
Table 2 & 3 - XCFS mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is a Basic Calibration File
CCNM0001	'PHASCONF'	/ Type of calibration data

CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'2001-01-01'	/ UTC date when calibration should first be used
CVST0001	'00:00:00'	/ UTC time when calibration should first be used
CBD10001	‘DATAMODE(PHOTON)’	Parameter Boundery
CDES0001	'XRT PC PHAS array configuration'	/Description
PHAS configuration File Keywords		
EXTNAME	‘PHASCONF’	/ Name of the binary table extension
CONTENT	"XRT PC PHAS array configuration’	/ File content
STDCONF	‘123456789’	/Standard configuration for PHAS aray

Table 74 – PHAS Configuration Calibration File Extension 1 Keywords

6 File distribution and maintenance

The Calibration Files are produced by the XRT Calibration team and delivered to the ISAC/ASDC that take care to verify the validity and integrity of the format.

ISAC/ASDC stores the data into the XRTCALDB and delivers them to the SSC which delivers to the HEASARC for distribution. The XRT CALDB files include data results obtained before launch from ground calibration tests and those obtained during flight. Calibration observations will be performed in flight after launch and periodically repeated to monitor the instrument performance. Therefore it is expected for the Calibration files to change or to be updated during the mission as result of the analysis of these calibration observations. The Calibration Team will provide updated files to ISAC/ASDC when they are produced. In the following table all calibration files are listed with the following information:

- Institute in charged to produce a specific calibration file;
- the first release deadline;
- the update before launch deadline;
- the foreseen periodicity of files delivery after launch.

The table below is valid for the initial mission phase. During the mission several files were added and other changed to keep up with the instrument updates therefore filename and files might have changed.

File Name	***Institute***	***First Release***	***Periodicity after Launch***
	Person Charged	***Update before Launch***	
Telescope Definition File: swxYYYYMMDDvXXX.teldef	PSU	Already delivered	1 month after the launch and then Every ~ 6 months
On Board Bad Pixel File: swxbptabYYYYMMDDvXXX.fits	PSU	Already delivered	When new bad pixels are uploaded
Bad Pixel File for ground processing: swxbadpixYYYYMMDDvXXX.fits	PSU	Already delivered	When new bad pixels found by Calibration Team
Bias Files for Imaging Mode: swximbiasYYYYMMDDvNNN.fits swxpdbiasYYYYMMDDvNNN.fits	PSU	Already delivered	1 month after the launch and then every ~ 6 months
Effective Area: swxeffareaYYYYMMDDvXXX.fits	OAB	Already delivered	1 month after the launch and then every ~ 6 months
Filter Transmission: swxftransYYYYMMDDvXXX.fits	LU	Already delivered	1 month after the launch and then every ~ 6 months
Gain File: swxpcgainYYYYMMDDvXXX.fits swxwtgainYYYYMMDDvXXX.fits swxpdgainYYYYMMDDvXXX.fits	PSU	Already delivered	1 month after the launch and then Every ~ 6 months (with response matrixes)

Grade: swxgradeYYYYMMDDvNNN.fits	ISAC	Already delivered	If an update is needed
CCD Temperature: swxccdtempYYYYMMDDvXXX.fits	PSU	Already delivered	If an update is needed
DN 2 Flux: swxdn2fluxYYYYMMDDvNNN.fits	OAB	Already delivered	If needed
Event ranges: swxevtrangeYYYYMMDDvXXX.fits	ISAC	Already delivered	If an update is needed
Housekeeping Parameters conversion: swxhkconvYYYYMMDDvXXX.fits	PSU	Already delivered	Not expected
Housekeeping Parameters ranges: swxhkrangeYYYYMMDDvXXX.fits	PSU	Already delivered	If an update is needed
Makefilter : SwxmkconfYYYYMMDDvNNN.fits	ISAC	Already delivered	If needed
Position error : SwxposerrYYYYMMDDvNNN.fits	OAB	Already delivered	If needed
Prefilter swxpreconfYYYYMMDDvNNN.fits	ISAC	Already delivered	If needed
Region; swxregionYYYYMMDDvNNN.fits	PSU	Already delivered	Not expected
Waveform and Amplifier: swxwaveampYYYYMMDDvXXX.fits	PSU	Already delivered	If an update is needed
Quantum Efficiency: swxpcqeYYYYMMDDvXXX.fits swxwtqeYYYYMMDDvXXX.fits swxpdqeYYYYMMDDvXXX.fits	LU	Already delivered	Same as the response matrix
TAM Reference Positions and Parameters: swxtamYYYYMMDDvXXX.fits	LU	Already delivered	1 month after the launch and then every ~ 6 months
Ancillary Response File on-axis : swxpc20010101v002.arf swxwt20010101v002.arf swxpd20010101v002.arf	OAB	Already delivered	If an update is needed or otherwise use xrtmkarf
Encircled Energy Function swxeefYYYYMMDDvXXX.fits	OAB	Already delivered	1 month after the launch and then every ~ 6 months

Point Spread Function: swxpsfYYYYMMDDvXXX.fits	OAB	Already delivered	1 month after the launch and then every ~ 6 months
Response Matrix for PI channel : Photon Counting grade 0 , 0-4, 0-12 Windowed timing grade 0, 0-2 Photodiode grade 0, 0-2, 0-5	LU	Already delivered	New delivery before data public and than every ~ 6 months
Response Matrix for PHA channel : Windowed timing all grades Photodiode all grades	LU	Already delivered	New delivery before data public and than every ~ 6 months
Vignettig: swxvignYYYYMMDDvXXX.fits	OAB	Already delivered	1 month after the launch and then every ~ 6 months
Background spectra: swxpcbkgphaYYYYMMDDvXXX.pha swxpdbkgphaYYYYMMDDvXXX.pha swxwtbkgphaYYYYMMDDvXXX.pha	PU	Already delivered	Build up with observations
Background events: swxpcbkgphaYYYYMMDDvXXX.evt swxpdbkgphaYYYYMMDDvXXX.evt swxwtbkgphaYYYYMMDDvXXX.evt	PU	Already delivered	Build up with observations

7 Appendix

Here are listed sample headers for the event files containing the background data for the different read-out modes. The headers are identical to the level 1 files.

- Photodiode mode

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / 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 is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
TELESCOP= 'SWIFT '             / Telescope (mission) name
INSTRUME= 'XRT   '             / Instrument name
CHECKSUM= '6oG39lD06lD06lD0'   / HDU checksum updated 2004-07-15T18:15:26
DATASUM = '         0'         / data unit checksum updated 2004-07-15T18:14:25
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   37 / width of table in bytes
NAXIS2  =               433218 / number of rows in table
PCOUNT  =                    0 / size of special data area:
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    9 / number of fields in each row
TTYPE1  = 'TIME    '           / Time of events
TFORM1  = '1D      '           / data format of field
UNIT1  = 's       '           / physical unit of field
TTYPE2  = 'CCDFrame'           / CCD FRAME number
TFORM2  = '1J      '           / data format of field
TZERO2  =           2147483648 / data offset
TTYPE3  = 'OFFSET  '           / Pixel Offset from Frame Header
TFORM3  = '1J      '           / data format of field
TTYPE4  = 'DETX    '           / DETX source position
TFORM4  = '1I      '           / data format of field
TUNIT4  = 'pixel   '           / physical unit of field
TLMIN4  =                    1 / minimum legal value in the column
TLMAX4  =                  600 / maximum legal value in the column
TTYPE5  = 'DETY    '           / DETY source position
TFORM5  = '1I      '           / data format of field
TUNIT5  = 'pixel   '           / physical unit of field
TLMIN5  =                    1 / minimum legal value in the column
TLMAX5  =                  600 / maximum legal value in the column
TYPE6  = 'PHA     '           / label for field
TFORM6  = '1J      '           / format of field
TUNIT6  = 'chan    '           / physical unit of field
TTYPE7  = 'RAWPHA  '           / Telemetry Pulse Height Analyzer value
TFORM7  = '1J      '           / data format of field
TUNIT7  = 'chan    '           / physical unit of field
TLMIN7  =                    0 / minimum legal value in the column
TLMAX7  =                 4095 / maximum legal value in the column
TTYPE8  = 'Amp     '           / Amplifier mode used for readout
TFORM8  = '1B      '           / data format of field
TTYPE9  = 'ROTIME  '           / Frame Read Out Time
TFORM9  = '1D      '           / data format of field
TUNIT9  = 's       '           / physical unit of field
EXTNAME = 'EVENTS  '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / Format conforms to OGIP standards
HDUCLAS1= 'EVENTS  '           / Event extension
MTYPE1  = 'DET     '           / DM Keyword: Descriptor name
MFORM1  = 'DETX, DETY'         / [pixel]
METYP1  = 'B       '           / DM Keyword: Descriptor type: Range/Binned data
TIMESYS = 'TT      '           / Time system
MJDREFI =  5.1910000000000E+04 / Reference MJD Integer part
MJDREFF =  7.4287037000000E-04 / Reference MJD fractional
TIMEREF = 'LOCAL   '           / Time reference (barycenter/local)
TASSIGN = 'SATELLITE'          / Time assigned by clock
TIMEUNIT= 's       '           / Time unit
```

```
TIERRELA=                1E-08 / [s/s] Estimated relative clock rate error
TIERABSO=                   1 / [s] Estimated absolute clock offset error
TSTART  =  7.5221604401544E+05 / Start time
TSTOP   =  7.5246390942000E+05 / Stop time
DATE-OBS= '2001-01-09T16:56:56' / Date and time of observation start
DATE-END= '2001-01-09T17:01:03' / Date and time of observation stop
CLOCKAPP=                   F / default
TELAPSE =  2.4786540455907E+02 / TSTOP - TSTART
ONTIME  =     247.775090260198 / sum of all good time interval (s)
LIVETIME=     247.775090260198 / ONTIME adjusted for instrument response
EXPOSURE=     247.775090260198 / time for calculating counts/sec
DEADC   =                   1. / dead time
TIMEPIXR=  0.0000000000000E+00 / Bin time beginning=0 middle=0.5 end=1
TELESCOP= 'SWIFT   '           / Telescope (mission) name
INSTRUME= 'XRT     '           / Instrument name
DATAMODE= 'LOWRATE '           / Instrument operating mode
OBS_ID  = '00073320001'        / Observation ID
TARG_ID = '00073320'           / Target ID
SEG_NUM = '001     '           / Segment number
EQUINOX =  2.0000000000000E+03 / default
RADECSYS= 'FK5     '           / default
OBS_MODE= 'POINTING'           / default
ORIGIN  = 'GSFC    '           / Source of FITS file
CREATOR = 'XRT2FITS V2.0'      / Program that created this FITS file
TLM2FITS= 'V2.0    '           / Telemetry converter version number
DATE    = '2004-07-15T18:12:03' / file creation date (YYYY-MM-DDThh:mm:ss UT)
CCDEXPOS=  8.2615000000000E+00 / Nominal CCD Exposure Time
LLVLTHR =                  150 / Lower level Threshold
ULVLTHR =                 4000 / Upper level threshold
CHECKSUM= 'WaHAXZ92WaE8WY98'   / HDU checksum updated 2004-07-15T18:15:26
DATASUM = '2211735040'         / data unit checksum updated 2004-07-15T18:14:27
TCTYP4  = 'DETX    '           / World Axis Type
TCTYP5  = 'DETX    '           / World Axis Type
TCDLT4  =  4.0000000000000E-02 / DETX image scale (deg/pixel)
TCDLT5  =  4.0000000000000E-02 / DETY image scale (deg/pixel)
TCRPX4  =  3.0050000000000E+02 / DETX image reference pixel
TCRPX5  =  3.0050000000000E+02 / DETY image reference pixel
TCRVL4  =  0.0000000000000E+00 / DETX image reference pixel coords (mm)
TCRVL5  =  0.0000000000000E+00 / DETY image reference pixel coords (mm)
CCLS0001=   'BCF'               / Dataset is a Basic Calibration File
CCNM0001= 'BKGRND_EVTS'          /  Type of calibration data
CDTP0001=   'DATA'              / Calibration file contains data
CBD10001=  'DATAMODE(LOWRATE)'    / Parameter Boundary
CVSD0001=   '2001-01-01'        / UTC date when calibration should first be used
CVST0001=   '00:00:00'          / UTC time when calibration should first be used
CDES0001=   'XRT Background events dataset'    /Description
RA_NOM  =  0.0000000000000E+00 / RA of nominal aspect point
DEC_NOM =  3.8857805861880E-16 / Dec of nominal aspect point
SEQPNUM =                  19 / Number of times the dataset processed
PROCVER = '0.7.2   '           / Processing script version
RA_PNT  =                   0 / [deg] RA pointing
DEC_PNT = 3.88578058618805E-16 / [deg] Dec pointing
PA_PNT  = 3.88578058618805E-16 / [deg] Position angle (roll)
OBJECT  = 'XRT Ground Data'    / Object name
RA_OBJ  =                   0 / [deg] RA Object
DEC_PNT = 3.88578058618805E-16 / [deg] Dec pointing
PA_PNT  = 3.88578058618805E-16 / [deg] Position angle (roll)
OBJECT  = 'XRT Ground Data'    / Object name
RA_OBJ  =                   0 / [deg] RA Object
DEC_OBJ = 3.88578058618805E-16 / [deg] Dec Object
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                   8 / 8-bit bytes
NAXIS   =                   2 / 2-dimensional binary table
NAXIS1  =                  16 / width of table in bytes
NAXIS2  =                  30 / number of rows in table
PCOUNT  =                   0 / size of special data area
GCOUNT  =                   1 / one data group (required keyword)
TFIELDS =                   2 / number of fields in each row
TTYPE1  = 'START   '           / label for field   1
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'STOP    '           / label for field   2
```

```
TFORM2  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT2  = 's       '           / physical unit of field
EXTNAME = 'GTI     '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / Conforms to OGIP/GSFC standards
HDUCLAS1= 'GTI     '           / Contains good time intervals
HDUCLAS2= 'STANDARD'           / Contains standard good time intervals
HDUVERS = '1.0.0   '           / Version of GTI header
TIMEZERO=                   0. / Zero-point offset for TIME column
MJDREF  =     51910.0007428704 / TDB MJD corresponding to  SC clock start 1968.x
TSTART  =     752216.058685271 / Start time of GTI
TSTOP   =     752463.881741627 / Stop  time of GTI
TIMEDEL =              0.00014 / time resolution of data (in seconds)
DATE    = '2004-07-15T18:14:27' / FITS file creation date
ONTIME  =     247.775090260198 / sum of all good time interval (s)
LIVETIME=     247.775090260198 / ONTIME adjusted for instrument response
EXPOSURE=     247.775090260198 / time for calculating counts/sec
DEADC   =                   1. / dead time
CHECKSUM= 'XEaIZEXGXEaGXEUG'   / HDU checksum updated 2004-07-15T18:15:27
DATASUM = '1729165989'         / data unit checksum updated 2004-07-15T18:14:28
OBS_ID  = '00073320001'        / Observation ID
RA_PNT  =                    0 / [deg] RA pointing
DEC_PNT = 3.88578058618805E-16 / [deg] Dec pointing
PA_PNT  = 3.88578058618805E-16 / [deg] Position angle (roll)
TIERRELA=                1E-08 / [s/s] Estimated relative clock rate error
TIERABSO=                    1 / [s] Estimated absolute clock offset error
TARG_ID = '00073320'           / Target ID
SEG_NUM = '001     '           / Segment number
OBJECT  = 'XRT Ground Data'    / Object name
CCLS0001=   'BCF'               / Dataset is a Basic Calibration File
CCNM0001= 'BKGRND_EVTS'          /  Type of calibration data
CDTP0001=   'DATA'              / Calibration file contains data
CBD10001=  'DATAMODE(LOWRATE)'    / Parameter Boundary
CVSD0001=   '2001-01-01'        / UTC date when calibration should first be used
CVST0001=   '00:00:00'          / UTC time when calibration should first be used
CDES0001=   'XRT Background events'    /Description
RA_OBJ  =                    0 / [deg] RA Object
DEC_OBJ = 3.88578058618805E-16 / [deg] Dec Object
END
```

- Windowed Timing mode

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / 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 is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
TELESCOP= 'SWIFT '             / Telescope (mission) name
INSTRUME= 'XRT   '             / Instrument name
CHECKSUM= '6eAf7d4d6d9d6d9d'   / HDU checksum updated 2004-07-15T17:27:24
DATASUM = '         0'         / data unit checksum updated 2004-07-15T17:26:32
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   39 / width of table in bytes
NAXIS2  =                12281 / number of rows in table
PCOUNT  =                    0 / size of special data area:
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                   12 / number of fields in each row
TTYPE1  = 'TIME    '           / Time of events
TFORM1  = '1D      '           / data format of field
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'CCDFrame'           / CCD FRAME number
TFORM2  = '1J      '           / data format of field
TZERO2  =           2147483648 / data offset
TTYPE3  = 'X       '           / Event X position Sky coordinates
TFORM3  = '1I      '           / data format of field
TUNIT3  = 'pixel   '           / physical unit of field
```

```
TLMIN3  =                    1 / minimum legal value in the column
TLMAX3  =                  600 / maximum legal value in the column
TTYPE4  = 'Y       '           / Event Y position Sky coordinates
TFORM4  = '1I      '           / data format of field
TUNIT4  = 'pixel   '           / physical unit of field
TLMIN4  =                    1 / minimum legal value in the column
TLMAX4  =                  600 / maximum legal value in the column
TTYPE5  = 'RAWX    '           / Pixel OFFSET from frame header
TFORM5  = '1I      '           / data format of field
TUNIT5  = 'pixel   '           / physical unit of field
TLMIN5  =                    0 / minimum legal value in the column
TLMAX5  =                  599 / maximum legal value in the column
TTYPE6  = 'RAWY    '           / Event Y position RAW coordinates
TFORM6  = '1I      '           / data format of field
TUNIT6  = 'pixel   '           / physical unit of field
TLMIN6  =                    0 / minimum legal value in the column
TLMAX6  =                  599 / maximum legal value in the column
TTYPE7  = 'DETX    '           / DETX source position
TFORM7  = '1I      '           / data format of field
TUNIT7  = 'pixel   '           / physical unit of field
TLMIN7  =                    1 / minimum legal value in the column
TLMAX7  =                  600 / maximum legal value in the column
TTYPE8  = 'DETY    '           / DETY source position
TFORM8  = '1I      '           / data format of field
TUNIT8  = 'pixel   '           / physical unit of field
TLMIN8  =                    1 / minimum legal value in the column
TLMAX8  =                  600 / maximum legal value in the column
TTYPE9  = 'PHA     '           / Pulse Height Analyzer after event recognition
TFORM9  = '1J      '           / data format of field
TUNIT9  = 'chan    '           / physical unit of field
TLMIN9  =                    0 / minimum legal value in the column
TLMAX9  =                 4095 / maximum legal value in the column
TTYPE10 = 'Amp     '           / Amplifier node used for readout
TFORM10 = '1B      '           / data format of field
TTYPE11 = 'STATUS  '           / Event Quality Flag
TFORM11 = '16X     '           / data format of field
TTYPE12 = 'ROTIME  '           / Frame Read Out Time
TFORM12 = '1D      '           / data format of field
TUNIT12 = 's       '           / physical unit of field
EXTNAME = 'EVENTS  '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / Format conforms to OGIP standards
HDUCLAS1= 'EVENTS  '           / Event extension
MTYPE1  = 'RAW     '           / DM Keyword: Descriptor name
MFORM1  = 'RAWX, RAWY'         / [pixel]
MTYPE2  = 'DET     '           / DM Keyword: Descriptor name
MFORM2  = 'DETX, DETY'         / [mm]
MTYPE3  = 'SKY     '           / DM Keyword: Descriptor name
MFORM3  = 'X,Y     '           / [pixel]
TIMESYS = 'TT      '           / Time system
MJDREFI =  5.1910000000000E+04 / Reference MJD Integer part
MJDREFF =  7.4287037000000E-04 / Reference MJD fractional
TIMEREF = 'LOCAL   '           / Time reference (barycenter/local)
TASSIGN = 'SATELLITE'          / Time assigned by clock
TIMEUNIT= 's       '           / Time unit
TIERRELA=                1E-08 / [s/s] Estimated relative clock rate error
TIERABSO=                    1 / [s] Estimated absolute clock offset error
TSTART  =  5.6628084397920E+05 / Start time
TSTOP   =  5.6635293929920E+05 / Stop time
DATE-OBS= '2001-01-07T13:18:00' / Date and time of observation start
DATE-END= '2001-01-07T13:19:12' / Date and time of observation stop
CLOCKAPP=                    F / default
TELAPSE =  7.2095319999964E+01 / TSTOP - TSTART
ONTIME  =     70.7050386316841 / sum of all good time interval (s)
LIVETIME=     70.7050386316841 / ONTIME adjusted for instrument response
EXPOSURE=     70.7050386316841 / time for calculating counts/sec
DEADC   =                   1. / dead time
TIMEPIXR=  0.0000000000000E+00 / Bin time beginning=0 middle=0.5 end=1
TELESCOP= 'SWIFT   '           / Telescope (mission) name
INSTRUME= 'XRT     '           / Instrument name
DATAMODE= 'WINDOWED'           / Instrument operating mode
OBS_ID  = '00073213001'        / Observation ID
TARG_ID = '00073213'           / Target ID
SEG_NUM = '001     '           / Segment number
EQUINOX =  2.0000000000000E+03 / default
```

```
RADECSYS= 'FK5     '           / default
OBS_MODE= 'POINTING'           / default
ORIGIN  = 'GSFC    '           / Source of FITS file
CREATOR = 'XRT2FITS V2.0'      / Program that created this FITS file
TLM2FITS= 'V2.0    '           / Telemetry converter version number
DATE    = '2004-07-15T17:24:11' / file creation date (YYYY-MM-DDThh:mm:ss UT)
CCDEXPOS=  7.2100000000000E-01 / Nominal CCD Exposure Time
LLVLTHR =                   40 / Lower level Threshold
ULVLTHR =                 4000 / Upper level threshold
WM1STCOL=                  250 / Windowing mode first column
WMCOLNUM=                  100 / Windowing mode number of columns
CHECKSUM= 'iabFlVb9iZbCiZb9'   / HDU checksum updated 2004-07-15T17:27:24
DATASUM = '4188006320'         / data unit checksum updated 2004-07-15T17:26:34
TCTYP3  = 'RA---TAN'           / Coordinate projection TAN
TCTYP4  = 'DEC--TAN'           / Coordinate projection TAN
TCDLT3  = -6.5480890872090E-04 / X image scale (deg/pixel)
TCDLT4  =  6.5480890872090E-04 / Y image scale (deg/pixel)
TCRPX3  =  5.0050000000000E+02 / X image reference pixel
TCRPX4  =  5.0050000000000E+02 / Y image reference pixel
TCRVL3  =  0.0000000000000E+00 / X image reference pixel coords (deg)
TCRVL4  =  3.8857805861880E-16 / Y image reference pixel coords (deg)
TCTYP7  = 'DETX    '           / World Axis Type
TCTYP8  = 'DETX    '           / World Axis Type
TCDLT7  =  4.0000000000000E-02 / DETX image scale (deg/pixel)
TCDLT8  =  4.0000000000000E-02 / DETY image scale (deg/pixel)
TCRPX7  =  3.0050000000000E+02 / DETX image reference pixel
TCRPX8  =  3.0050000000000E+02 / DETY image reference pixel
TCRVL7  =  0.0000000000000E+00 / DETX image reference pixel coords (mm)
TCRVL8  =  0.0000000000000E+00 / DETY image reference pixel coords (mm)
RA_NOM  =  0.0000000000000E+00 / RA of nominal aspect point
DEC_NOM =  3.8857805861880E-16 / Dec of nominal aspect point
ABERRAT =                    T / Has aberration been corrected for in sky coords
FOLLOWSU=                    T / Has the Sun position been recalculated?
CCLS0001=   'BCF'               / Dataset is a Basic Calibration File
CCNM0001= 'BKGRND_EVTS'          /  Type of calibration data
CDTP0001=   'DATA'              / Calibration file contains data
CBD10001=  'DATAMODE(WINDOWED)'    / Parameter Boundary
CVSD0001=   '2001-01-01'        / UTC date when calibration should first be used
CVST0001=   '00:00:00'          / UTC time when calibration should first be used
CDES0001=   'XRT Background event'    /Description
RA_PNT  =                    0 / [deg] RA pointing
DEC_PNT = 3.88578058618805E-16 / [deg] Dec pointing
PA_PNT  = 3.88578058618805E-16 / [deg] Position angle (roll)
OBJECT  = 'XRT Ground Data'    / Object name
RA_OBJ  =                    0 / [deg] RA Object
DEC_OBJ = 3.88578058618805E-16 / [deg] Dec Object
END
TENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   16 / width of table in bytes
NAXIS2  =                  100 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'START   '           / label for field   1
TFORM1  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'STOP    '           / label for field   2
TFORM2  = 'D       '           / data format of field: 8-byte DOUBLE
TUNIT2  = 's       '           / physical unit of field
EXTNAME = 'GTI     '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / Conforms to OGIP/GSFC standards
HDUCLAS1= 'GTI     '           / Contains good time intervals
HDUCLAS2= 'STANDARD'           / Contains standard good time intervals
HDUVERS = '1.0.0   '           / Version of GTI header
TIMEZERO=                   0. / Zero-point offset for TIME column
MJDREF  =     51910.0007428704 / TDB MJD corresponding to  SC clock start 1968.x
TSTART  =       566280.7995049 / Start time of GTI
TSTOP   =     566352.816720726 / Stop  time of GTI
TIMEDEL =            0.0011875 / time resolution of data (in seconds)
DATE    = '2004-07-15T17:26:34' / FITS file creation date
ONTIME  =     70.7050386316841 / sum of all good time interval (s)
LIVETIME=     70.7050386316841 / ONTIME adjusted for instrument response
```

```
EXPOSURE=     70.7050386316841 / time for calculating counts/sec
DEADC   =                   1. / dead time
CHECKSUM= 'PeNHSdKHPdKHPdKH'   / HDU checksum updated 2004-07-15T17:27:24
DATASUM = '658311083'          / data unit checksum updated 2004-07-15T17:26:34
OBS_ID  = '00073213001'        / Observation ID
RA_PNT  =                    0 / [deg] RA pointing
DEC_PNT = 3.88578058618805E-16 / [deg] Dec pointing
PA_PNT  = 3.88578058618805E-16 / [deg] Position angle (roll)
TIERRELA=                1E-08 / [s/s] Estimated relative clock rate error
TIERABSO=                    1 / [s] Estimated absolute clock offset error
TARG_ID = '00073213'           / Target ID
SEG_NUM = '001     '           / Segment number
OBJECT  = 'XRT Ground Data'    / Object name
CCLS0001=   'BCF'               / Dataset is a Basic Calibration File
CCNM0001= 'BKGRND_EVTS'          /  Type of calibration data
CDTP0001=   'DATA'              / Calibration file contains data
CBD10001=  'DATAMODE(WINDOWED)'    / Parameter Boundary
CVSD0001=   '2001-01-01'        / UTC date when calibration should first be used
CVST0001=   '00:00:00'          / UTC time when calibration should first be used
CDES0001=   'XRT Background events'    /Description
RA_OBJ  =                    0 / [deg] RA Object
DEC_OBJ = 3.88578058618805E-16 / [deg] Dec Object
END
```

- Photon Counting mode

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / 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 is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
TELESCOP= 'SWIFT '             / Telescope (mission) name
INSTRUME= 'XRT   '             / Instrument name
CHECKSUM= '9mH2Ak909kE0Ak90'   / HDU checksum updated 2004-07-15T17:34:43
DATASUM = '         0'         / data unit checksum updated 2004-07-15T17:33:51
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   57 / width of table in bytes
NAXIS2  =                41180 / number of rows in table
PCOUNT  =                    0 / size of special data area:
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                   15 / number of fields in each row
TTYPE1  = 'TIME    '           / Time of events
TFORM1  = '1D      '           / data format of field
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'CCDFrame'           / CCD FRAME number
TFORM2  = '1J      '           / data format of field
TZERO2  =           2147483648 / data offset
TTYPE3  = 'X       '           / Event X position Sky coordinates
TFORM3  = '1I      '           / data format of field
TUNIT3  = 'pixel   '           / physical unit of field
TLMIN3  =                    1 / Minimum value for X column
TLMAX3  =                 1000 / Maximum value for X column
TTYPE4  = 'Y       '           / Event Y position Sky coordinates
TFORM4  = '1I      '           / data format of field
TUNIT4  = 'pixel   '           / physical unit of field
TLMIN4  =                    1 / Minimum value for Y column
TLMAX4  =                 1000 / Maximum value for Y column
TTYPE5  = 'RAWX    '           / Event X position RAW coordinates
TFORM5  = '1I      '           / data format of field
TUNIT5  = 'pixel   '           / physical unit of field
TLMIN5  =                    0 / minimum legal value in the column
TLMAX5  =                  599 / maximum legal value in the column
TTYPE6  = 'RAWY    '           / Event Y position RAW coordinates
TFORM6  = '1I      '           / data format of field
TUNIT6  = 'pixel   '           / physical unit of field
TLMIN6  =                    0 / minimum legal value in the column
TLMAX6  =                  599 / maximum legal value in the column
TTYPE7  = 'DETX    '           / Event X position DET coordinates
TFORM7  = '1I      '           / data format of field
```

```
TUNIT7  = 'pixel   '           / physical unit of field
TLMIN7  =                   1 / Minimum value for DETX column
TLMAX7  =                 600 / Maximum value for DETX column
TTYPE8  = 'DETY    '           / Event Y position DET coordinates
TFORM8  = '1I      '           / data format of field
UNIT8  = 'pixel   '           / physical unit of field
TLMIN8  =                   1 / Minimum value for DETY column
TLMAX8  =                 600 / Maximum value for DETY column
TTYPE9  = 'PHAS    '           / Array of Pulse Height Analyzer values
TFORM9  = '9I      '           / data format of field
TUNIT9  = 'chan    '           / physical unit of field
TLMIN9  =                   0 / minimum legal value in the column
TLMAX9  =                4095 / maximum legal value in the column
TTYPE10 = 'Amp     '           / Amplifier node used for readout
TFORM10 = '1B      '           / data format of field
TTYPE11 = 'PHA     '           / Pulse Height Analyzer after event recognition
TFORM11 = '1J      '           / data format of field
TUNIT11 = 'chan    '           / physical unit of field
TLMIN11 =                   0 / minimum legal value in the column
TLMAX11 =                4095 / maximum legal value in the column
TTYPE12 = 'PI      '           / Pulse invariant
TFORM12 = '1J      '           / data format of field
TUNIT12 = 'chan    '           / physical unit of field
TLMIN12 =                   0 / minimum legal value in the column
TTYPE13 = 'GRADE   '           / Event Grade
TFORM13 = '1I      '           / data format of field
TTYPE14 = 'PixsAbove'          / # of Pixels used for PHA reconstruction
TFORM14 = '1I      '           / data format of field
TTYPE15 = 'STATUS  '           / Event Quality Flag
TFORM15 = '16X     '           / data format of field
TCTYP5  = 'RAWX    '           / WCS  axis type
TCRVL5  =  2.9950000000000E+02 / WCS reference value
TCDLT5  =                   1 / WCS coordinate increment
TCRPX5  =  3.0050000000000E+02 / WCS Reference point
TCTYP6  = 'RAWY    '           / WCS  axis type
TCRVL6  =  2.9950000000000E+02 / WCS reference value
TCDLT6  =                   1 / WCS coordinate increment
TCRPX6  =  3.0050000000000E+02 / WCS Reference point
EXTNAME = 'EVENTS  '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / Format conforms to OGIP standards
HDUCLAS1= 'EVENTS  '           / Event extension
MTYPE1  = 'SKY     '           / DM Keyword: Descriptor name
MFORM1  = 'X, Y    '           / [pixel]
MTYPE2  = 'DET     '           / DM Keyword: Descriptor name
MFORM2  = 'DETX, DETY'         / [mm]
MTYPE3  = 'RAW     '           / DM Keyword: Descriptor name
MFORM3  = 'RAWX, RAWY'         / [pixel]
TIMESYS = 'TT      '           / Time system
MJDREFI =  5.1910000000000E+04 / Reference MJD Integer part
MJDREFF =  7.4287037000000E-04 / Reference MJD fractional
TIMEREF = 'LOCAL   '           / Time reference (barycenter/local)
TASSIGN = 'SATELLITE'          / Time assigned by clock
TIMEUNIT= 's       '           / Time unit
TIERRELA=                1E-08 / [s/s] Estimated relative clock rate error
TIERABSO=                   1 / [s] Estimated absolute clock offset error
TSTART  =  6.1130009488336E+05 / Start time
TSTOP   =  6.1380738584000E+05 / Stop time
DATE-OBS= '2001-01-08T01:48:20' / Date and time of observation start
DATE-END= '2001-01-08T02:30:07' / Date and time of observation stop
CLOCKAPP=                   F / default
TELAPSE =  2.5072909566390E+03 / TSTOP - TSTART
ONTIME  =  2.5072909566390E+03 / Sum of GTIs
LIVETIME=  2.4972649406281E+03 / Ontime multiplied by DEADC
EXPOSURE=  2.4972649406281E+03 / Total exposure, with all known correction
DEADC   =  9.9600125546484E-01 / dead time
TIMEPIXR=  0.0000000000000E+00 / Bin time beginning=0 middle=0.5 end=1
TIMEDEL =               2.4972 / Added by ISAC to the Original vesion
TELESCOP= 'SWIFT   '           / Telescope (mission) name
INSTRUME= 'XRT     '           / Instrument name
DATAMODE= 'PHOTON  '           / Instrument operating mode
OBS_ID  = '00073232001'        / Observation ID
TARG_ID = '00073232'           / Target ID
SEG_NUM = '001     '           / Segment number
EQUINOX =  2.0000000000000E+03 / default
```

```
RADECSYS= 'FK5     '           / default
OBS_MODE= 'POINTING    '       / default
ORIGIN  = 'GSFC    '           / Source of FITS file
CREATOR = 'XRT2FITS V2.0'      / Program that created this FITS file
TLM2FITS= 'V2.0    '           / Telemetry converter version number
DATE    = '2004-07-15T17:31:09' / file creation date (YYYY-MM-DDThh:mm:ss UT)
SPLITTHR=                   50 / Split threshold value
LLVLTHR =                   40 / Lower level Threshold
ULVLTHR =                 4000 / Upper level threshold
OUTERTHR=                 1000 / Outer threshold
WHALFWD =                  300 / Window Half Width
WHALFHT =                  300 / Window Half Height
CCDEXPOS=  2.4889600000000E+00 / CCD Exposure used for rates
RA_NOM  =  0.0000000000000E+00 / R. A. of nominal aspect point
DEC_NOM =  3.8857810000000E-16 / Dec. of nominal aspect point
ABERRAT =                    T / Has aberration been corrected for in sky coords
FOLOWSUN=                    T / Has the Sun position been recalculated for each
TCRPX7  =  3.0050000000000E+02 / DETX image reference pixel
TCRVL7  =  0.0000000000000E+00 / DETX image reference pixel coordinate (mm)
TCDLT7  =  4.0000000000000E-02 / DETX image scale (mm/pixel)
TCTYP7  = 'DETX    '           / DETX coordinate type
TCRPX8  =  3.0050000000000E+02 / DETY image reference pixel
TCRVL8  =  0.0000000000000E+00 / DETY image reference pixel coordinate (mm)
TCDLT8  =  4.0000000000000E-02 / DETY image scale (mm/pixel)
TCTYP8  = 'DETY    '           / DETY coordinate type
TCRPX3  =  5.0050000000000E+02 / X image reference pixel
TCRVL3  =  0.0000000000000E+00 / X image reference pixel coordinate (deg)
TCDLT3  = -6.5480890000000E-04 / X image scale (deg/pixel)
TCTYP3  = 'RA---TAN'           / X coordinate type
TCRPX4  =  5.0050000000000E+02 / Y image reference pixel
TCRVL4  =  3.8857810000000E-16 / Y image reference pixel coordinate (deg)
TCDLT4  =  6.5480890000000E-04 / Y image scale (deg/pixel)
TCTYP4  = 'DEC--TAN'           / Y coordinate type
CHECKSUM= 'HALDKAICHAICHAIC'   / HDU checksum updated 2004-08-06T07:06:56
DATASUM = '1156362416'         / data unit checksum updated 2004-07-15T17:33:54
TLMIN13 =                    0 / min value for this column
TLMAX13 =                   32 / max value for this column
TLMAX13 =                   32 / max value for this column
DSTYP1  = 'GRADE   '           / Data subspace descriptor: name
DSFORM1 = 'I       '           / Data subspace descriptor: datatype
DSVAL1  = '0:32    '           / Data subspace descriptor: value
TNULL12 =                -4095 / Illegal value for this column
TLMAX12 =                 1023 / max value for this column
CCLS0001=   'BCF'               / Dataset is a Basic Calibration File
CCNM0001= 'BKGRND_EVTS'          /  Type of calibration data
CDTP0001=   'DATA'              / Calibration file contains data
CBD10001=  'DATAMODE(PHOTON)'    / Parameter Boundary
CVSD0001=   '2001-01-01'        / UTC date when calibration should first be used
CVST0001=   '00:00:00'          / UTC time when calibration should first be used
CDES0001=   'XRT Background events'    /Description
RA_PNT  =                    0 / [deg] RA pointing
DEC_PNT = 3.88578058618805E-16 / [deg] Dec pointing
PA_PNT  = 3.88578058618805E-16 / [deg] Position angle (roll)
OBJECT  = 'XRT Ground Data'    / Object name
RA_OBJ  =                    0 / [deg] RA Object
DEC_OBJ = 3.88578058618805E-16 / [deg] Dec Object
END

XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                   16 / width of table in bytes
NAXIS2  =                    1 / number of rows in table
PCOUNT  =                    0 / size of special data area:
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    2 / number of fields in each row
TTYPE1  = 'START   '           / Interval START Time
TFORM1  = '1D      '           / data format of field
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'STOP    '           / Interval STOP Time
TFORM2  = '1D      '           / data format of field
TUNIT2  = 's       '           / physical unit of field
EXTNAME = 'GTI     '           / name of this binary table extension
HDUCLASS= 'OGIP    '           / Format conforms to OGIP standards
```

```
HDUCLAS1= 'GTI     '            / Good Time Interval
HDUCLAS2= 'STANDARD'            / Standard GTI
TIMESYS = 'TT      '            / Time system
MJDREFI =               51910. / Reference MJD Integer part
MJDREFF =         7.4287037E-4 / Reference MJD fractional
TIMEREF = 'LOCAL   '            / Time reference (barycenter/local)
TASSIGN = 'SATELLITE'           / Time assigned by clock
TIMEUNIT= 's       '            / Time unit
TSTART  =     611300.094883361 / Start time
TSTOP   =         613807.38584 / Stop time
DATE-OBS= '2001-01-08T01:48:20' / Date and time of observation start
DATE-END= '2001-01-08T02:30:07' / Date and time of observation stop
CLOCKAPP=                    F / default
TELAPSE =     2507.29095663899 / TSTOP - TSTART
ONTIME  =     2507.29095663899 / Sum of GTIs
TELESCOP= 'SWIFT '              / Telescope (mission) name
INSTRUME= 'XRT   '              / Instrument name
OBS_ID  = '00073232001'         / Observation ID
TARG_ID = '00073232'            / Target ID
SEG_NUM = '001     '            / Segment number
ORIGIN  = 'GSFC'                / Source of FITS file
DATE    = '2004-07-15T17:31:10' / file creation date (YYYY-MM-DDThh:mm:ss UT)
LIVETIME=     2497.26494062808 / Ontime multiplied by DEADC
EXPOSURE=     2497.26494062808 / Total exposure, with all known correction
DEADC   =    0.996001255464845 / dead time
CHECKSUM= '4MUO5LRO4LRO4LRO'    / HDU checksum updated 2004-07-15T17:34:43
DATASUM = '2020000379'          / data unit checksum updated 2004-07-15T17:33:51
RA_PNT  =                     0 / [deg] RA pointing
DEC_PNT = 3.88578058618805E-16 / [deg] Dec pointing
PA_PNT  = 3.88578058618805E-16 / [deg] Position angle (roll)
TIERRELA=                1E-08 / [s/s] Estimated relative clock rate error
TIERABSO=                    1 / [s] Estimated absolute clock offset error
OBJECT  = 'XRT Ground Data'     / Object name
CCLS0001=   'BCF'                / Dataset is a Basic Calibration File
CCNM0001= 'BKGRND_EVTS'           /  Type of calibration data
CDTP0001=   'DATA'               / Calibration file contains data
CBD10001=  'DATAMODE(PHOTON)'     / Parameter Boundary
CVSD0001=   '2001-01-01'         / UTC date when calibration should first be used
CVST0001=   '00:00:00'           / UTC time when calibration should first be used
CDES0001=   'XRT Background events'    /Description
RA_OBJ  =                     0 / [deg] RA Object
DEC_OBJ = 3.88578058618805E-16 / [deg] Dec Object
END
```