HITOMI
DESCRIPTION OF THE HITOMI CALIBRATION FILES

Version 1.2

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CHANGE RECORD PAGE (1 of 2)

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Version 1	24 June 2016	all	First version
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1 Introduction

This document describes the format of Hitomi Calibration Files and their organization into CALibration DataBase (CALDB). CALDB 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 whenever possible standard OGIP format layout. These files are recorded in CALDB for archival purposes and they are used in the Hitomi processing software. Specifically the CALDB files are used in the Hitomi pipeline to create Level 1 and Level 2 science files and in the interactive analysis.

The Hitomi calibration files are produced by the instrument teams and collected at GSFC. The files are checked at GSFC for their formats, mandatory CALDB keywords and their validity. Once the files have been checked and amended, a CALDB index is created. These files are then made available via the HEASARC that archives and distributes the data.

*NOTE: The satellite name is assigned after launch, therefore the Hitomi name is changed in all the calibration files and directories as well as within this document.

1.1 Scope

During the course of the Hitomi mission the CALDB provides:

- A way to store and archive the calibration data;
- A naming convention and header structure for the calibration files;
- An index for the software that access the calibration database using FITS header keywords;
- A traceable history of the calibration data by maintaining the history of versions.

1.2 References

[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

1.3 Acronyms

ARF	Ancillary Response File
BCF	Basic Calibration File
CALDB	Calibration Database
CAMS	Camera Alignment Monitor Sensor
CC	Compton Camera
CCD	Charge Coupled Device
CIF	Calibration File
CPF	Calibration Product File
CTI	Charge Transfer Inefficiency

EEF	Encircled Energy Fraction
FITS	Flexible Image Transport System
GOF	Guest Observer Facility
GSFC	Goddard Space Flight Center
HDU	Header Data Unit
HEASARC	High Energy Astrophysics Science Archive Research Center
HFWG	High Energy FITS Working Group
HXI	Hard X-ray Images
HXT	Hard X-ray Telescope
ISAS	Institute of Space and Astronomical Science
OGIP	Office of the Guest Investigator Programs
MXS	Monitoring X-ray Source
PHA	Pulse Height Amplitude
PI	Pulse Invariant
PSF	Point Spread Function
QE	Quantum Efficiency
RMF	Redistribution Matrix File
SGD	Soft Gamma Ray detector
SXI	Soft X-ray Images
SXT	Soft X-ray Telescope
SXS	Soft X-ray Spectrometer

2 Hitomi Calibration File General

2.1 Filename convention

The filename convention is the following:

<mi>_<int>_<datatype>_[<date>]vxxx.ext

where:

mi is a 2 digit string that identifies the mission. The mission identifier string is set to ‘ah’ named after the initial of Hitomi. The mission identifier does not change even as tradition the mission changes name after launch. Caldb and archive retain the identifier “ah”;

int is a 3 or 4 digit string identifying the instrument. The 3 digits string is for the detecting instruments (HXD, XIS and XRS), 4 digits string is used in files carry information on the telescopes. The instrument identifiers are set as follows:

- 'cm1', 'cm2', 'cms' the CAMS1, CAMS2 or both CAMS respectively;
- 'hx1', 'hx2', 'hxi' for the HXI1 and HXI2 or both HXI respectively;
- 'sg1', 'sg2', 'sgd' for the SGD1 and SGD2 or both SGD respectively;
- 'sgn1', 'sgn2', 'sgn3' for SGDn (n=1,2) and detname CC1, or CC2 or CC3 respectively ;
- 'sxi' for the SXI;
- 'sxs' for the SXS.
- 'gen' for files applicable to all instruments unless noted.

These strings are used in the filenames of CALDB and science files. File related to the telescopes associated to the HXIs (HXT), SXI (SXT-I) and SXS (SXT-S) use the same string of the corresponding instrument.

datatype is the calibration data type identifier. The string should describe the file content unambiguously within 8 characters long. Underscores or mathematical symbols are not allowed. Longer strings may be considered on case by case basis (up to 10 see HXD responses), but they are strongly discouraged;

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' or 'rsp' is used for the redistribution matrix and 'arf' is used for the ancillary response files.

2.2 Directory Structure

The CALDB of Hitomi is divided in the following directories :

/hitomi

/gen /hxi /sgd /sxi /sxs

/bcf /cpf / bcf /cpf /bcf /cpf /bcf /cpf /bcf /cpf

/... /... /... /... /... /... /.../... /... /... /... /... /.../... /... /...

The /gen directory contains files that are applicable to all instruments. The /hxi directory contains files that are related to the detector HXI1 and HXI2, the telescope HXT1 and HXT2, the shields as well as the CAMS1 and CAMS2. The /sgd directory contains the files related to the SGD1 and SGD2 and the shields. The /sxi directory contains files related to the detector SXI and the telescope SXT. The /sxs directory contains the files related to the /SXS detector and the telescope SXT.

Each instrument directory is subdivided in /bcf and /cpf containing the basic and high level calibration file. Both the /bcf and /cpf are divided

2.3 Datatype

Table 2.1 contains a summary of all the different type of calibration files :

Table 2.1

Datatype	Caldb directory	Used in pipeline	Description
delay	bcf	yes	Delay for timing assignment all subsystems

coldef	bcf	yes	Column & extension names for time assignment all subsystems
qclocka/qclockb	bcf	yes	Clock stability for time assignment
atmsca	bcf	no	Atomic data to calculate the mirror
rigidity	bcf	yes	Cut-off rigidity (suzaku & 2016 version)
linefit	bcf	yes	Line energies component for the gain fitting (SXS,SXI,HXI,SGD)
saa	bcf	yes	Hold the SAA vertices
mkfconf	bcf	yes	Configuration file
select	bcf	yes	Selection criteria
vigncoef	bcf	no	Coefficient to describe the vignetting function valid for the SXT/HXT telescopes
leapsec	bcf	yes	Leap seconds
HXI & CAMS			
teldef	bcf/teldef	yes	Telescope definition for HXI & CAMS
mirror	bcf/mirror	no	Description of the HXT mirror components
reftrans	bcf/mirror	no	Description of the HXT mirror reflectivity
scatter	bcf/mirror	no	Description of the HXT mirror scatting
telarea	bcf/mirror	no	Telescope on axis Effective area
psf	bcf/	no	Point Spread Function Library
vignet	bcf/	no	Vignetting Function
event	pcf	no	Library from ray-tracing
tempxy	bcf/cams	yes	Description of the CAMS coefficient to calculate X Y
offset	bcf/cams	yes	Description of the CAMS offset file
gain	bcf/gain	yes	Description of the Gain parameters for the HXI (2 files)
enecut	bcf/gain	yes	Contain the energy cut for top and bottom HXI layers (2 files)
line	bcf/gain	yes	Fluorescence data for the HXI
instmap	bcf/instmap	yes	Instrument map of the HXI FOC for the simulator (2 files)
badpix	bcf/instmap	yes	Bad pixel and threshold of the HXI (2 files)
remap	bcf/instmap	yes	Description of the HXI detector component
lsf	bcf/quanteff	yes	Response parameters for each layer of the HXI (2 files)
quanteff	bcf/quanteff	yes	Quantum efficiency for the HXI (2 files)
rmf (x layer)	cpf/response	no	HXI Response Function per each layer

back	cpf/background		Pre-launch NXB Background prelaunch
SGD			
teldef	bcf/teldef	yes	Telescope definition file SGD1 & SGD2
gain	bcf/gain	no	Description of the Gain parameters for the SGD and CC component (2 files 3ext each)
line	bcf/gain	no	Fluorescence data for the SGD
probfov	bcf/prob	no	Probability of FOV for each of the SGD
probseq	bcf/prob	no	Probability associated of sequences of hits for the SGD
tranrat	bpf/response	no	Instrument transmission ratio for the SGD (2 files 3 ext)
badpix	bcf/instmap	no	Bad pixel and threshold of the SGD and CC component (2 files 3 ext)
remap	bcf/instmap	no	Description of the SGD detector component
instmap	bcf/instmap	no	Instrument map for the SGD
rsp	cpf/response	no	Response Function for each of the CCn
back	cpf/background	no	Pre-launch NXB for all CC combined
SXI			
teldef	bcf/teldef	yes	Telescope definition file.
mirror	bcf/mirror	no	Description of the SXT-I mirror components
reftrans	bcf/mirror	no	Description of the SXT-I mirror reflectivity
scatter	bcf/mirror	no	Description of the SXT-I mirror scattering
telarea	bcf/mirror	no	Effective area library
psf	bcf	no	Point Spread Function Library
vignet	bcf	no	Vignetting Function/File
event	pcf	no	Library from ray-tracing
quanteff	bcf/quanteff	no	Quantum efficiency.
contami	bcf/quanteff	no	Contamination for the SXI
rmfparam	bcf/response	no	Instrumental parameters to build the SXI rmf
mask	bcf/instmap	yes	Mask table for the SXI in ACT & DET coordinates
instmap	bcf/instmap	yes	Instrument map for the SXI in DET and FOC coordinates
badpix	bcf/instmap	yes	Bad pixel in the SXI
config	bcf/instmap	no	Contain the DATACLASS used on-board

vtevnodd	bcf/gain	yes	Video temperature even and odd for the SXI
chtrail	bcf/gain	yes	Charge trail parameters for the SXI
cti	bcf/gain	yes	Charge transfer inefficiency of the SXI
spth	bcf/gain	yes	Split Threshold for the SXI
gain	bcf/gain	yes	Gain coefficients for the SXI
pattern	bcf/gain	yes	Grade pattern of the 3x3 island for the SXI
back	cpf/background	no	Pre-launch Non X-ray Background spectrum
SXS			
teldef	bcf/teldef	yes	Telescope definition file for the SXS
mirror	bcf/mirror	no	Description of the SXS mirror components
reftrans	bcf/mirror	no	Description of the SXS mirror reflectivity
scatter	bcf/mirror	no	Description of the SXS mirror scatting
effarea	bcf	no	Effective area library
psf	bcf	no	Point Spread Function Library
vignet	bcf	no	Vignetting Function
event	bcf	no	Library from ray-tracing
gainpix	bcf/gain	yes	Coefficient to calculate the gain for the SXS pixel
scale	bcf/gain	yes	Scale all the pixel gain calculated using pix12
gainant	bcf/gain	yes	Coefficient to calculate the gain for the SXS antico
badpix	bcf/instmap	yes	Bad pixels
instmap	bcf/instmap	yes	Instrument map for the SXS in DET and FOC coordinates
pixmap	bcf/instmap	yes	SXS Pixel numbering definition
quanteff	bcf/quanteff	no	Quantum efficiency.
rmfparam	bcf/response	no	Instrumental parameters to build the SXS rmf
coeftime	bcf/time	yes	SXS specific times constant
blckfilt	bcf/quanteff	no	Blocking Filter Transmission inside the dewar
fwbe	bcf/quanteff	no	Be filter on filter wheel
fwnd	bcf/quanteff	no	ND filter on filter wheel
fwfe55	bcf/quanteff	no	Filter Fe55 on filter wheel
fwpoly	bcf/quanteff	no	Filter Polyimide on filter wheel

gatevalv	bcf/quanteff	no	Transmission of the gate valve
contami	bcf/quanteff	no	Contamination for the SXS
secpulse	bcf/gain	yes	Calibration for secondary events
confthre	bcf/instmap	no	Configuration threshold

3 Hitomi General keywords

All Hitomi calibration files are FITS files. Keywords required by FITS OGIP standards and listed in this chapter are described in documents [1], [2] and [3] (see references in Section 1). Chapter 4, 5, 6, 7, 8,and 9 give the exact strings used in the CALDB keywords for the GEN, HXI, SGD, SXI, SXS and common respectively and as well as the description of different file FITS format.

3.1 Mandatory Keywords

Table 3.1 lists the mandatory keywords added to the primary and to the headers of all extensions of the Calibration FITS files. The text for the comment column is shown as **it should appear in the files**. Remarks on specific comments are added in italics.

Table 3.1

Keyword name	Keyword value	Comment (as it should appear in the file)
TELESCOP	'HITOMI'	/Telescope (mission) name
INSTRUME	<instrument>	/Instrument Name *Not applicable to general files*
DETNAM	<detector name>	/Detector Name *Applicable for the HXI, SGD, SXI and SXS*
FILTER	<filter>	/Filter keyword *Applicable only to the SXS if necessary and omitted from the primary header*
DATE	YYYY-MM-DDThh:mm:ss	/Creation Date *This keyword is omitted from **empty** primary headers.*
CHECKSUM	<up to date checksum>	/HDU checksum updated <date>
DATASUM	<up to date datasum>	/Data unit checksum updated <date>

Table 3.2 lists the additional mandatory keywords common to all table headers. Each CALDB keyword has different values for different Calibration Files. The values for the CALDB and the EXTNAME keywords are specified for each datatype in the chapter dedicated to each of the instruments.

Table 3.2		
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
CALDB keywords:		
CCLSxxxx	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
CCNMxxxx	<extension codename>	/Type of Calibration data
CDESxxxx	<descriptive string>	/ Description
CVSDxxxx	<start valid data>	/UTC date when file should first be used
CVSTxxxx	<start valid time>	/UTC time when file should first be used

Table 3.1 and 3.2 list header keywords required in specific cases. These keywords are specified, when necessary, for each datatype. The keywords content is described in the chapters dedicated to each of the instruments.

Note that the "CBDnxxx" keyword, Table 3.3, should be used to differentiate otherwise identical extensions in a file or applicability of the extension. The first CBD keyword should be named CBD10001, the second CBD20001, etc... All CBD keywords should follow the syntax "KEYWORD (SELECTION)" where "keyword" is the quantity on which a selection is done.

For example, in order to distinguish between two extensions in the SXI-I reflectivity table FITS file :

CBD10001 ='ENERG(0.1-12.0)' and CBD20001=POS(FRONT) for the extension describing the FRONT mirror and CBD10001 = 'ENERG(0.1-12.0)' and CBD20001=POS(BACK) for the extension describing the BACK mirror.

Table 3.3		
Keyword name	Keyword value	Comment (as it should appear in the file)
CBDnxxxx	Array describing parameter limitations of the dataset	/Parameter boundaries
TDIMnnn	Number of elements & Ordering of *n*-d array	/Array dimensions
HDUCLASS	'OGIP '	/Format conforms to OGIP standards *(Only when applicable)*
HDUDOC	<document number>	/Document describing the format *(Only when applicable)*
HDUCLAS*n*	<character string to classify the extension	/(Specific to the type) *(Only when applicable)*
HDUVERS*n*	<string giving the format version>	/Version of file format *(Only when applicable)*

The keywords in the table 3.4 should be present if the binary table contains columns related to time.

Table 3.4		
Keyword name	Keyword value	Comment (as it should appear in the file)
TIMESYS	TT	/Time system
MJDREFI	56658	/MJD reference day 2014-01-01 00:00:00 UTC
MJDREFF	0.0007775925926	/MJD reference (fractional of day)
CLOCKAPP	T	/If clock corrections are applied (F/T)

The content for the keywords INSTRUME, DETNAM, FILTER and DATAMODE are listed in the following tables. These strings are also used in the science data files.

Table 3.5		
Keyword Name	Keyword String	Explanation (not FITS comment)
INSTRUME	HXI	INSTRUME is set to HXI if the calibration or the science files contains information valid for both HXI. The keyword is set to HXI1 or HXI2 if the calibration or science data are for the HXI1 or HXI2 respectively. The string HXI (1&2) is used to indicate the combination of the sensor and the telescope.
	HXI1	
	HXI2	
DETNAM	CAMERA	CAMERA is used in files applicable to the HXI1 & HXI2 detectors
	SHIELD	SHIELD is in files applicable only to the HXI shield collected by a single APMU
	HXT	HXT is used in files applicable to the telescope of the HXI
DATAMODE	CAMERA_NORMALn AM241_NORMALn PSEUDO_NORMALn FORCE_NORMALn CALMODE_NORMALn	The DATAMODE is set to XXX_NORMALn where n (set to 1, 2, 3..) is changed within the mission. There is only one valid n at any time during the mission. The detector processes data in different stream CAMERA, AM241, PSEUDO, FORCE and CALMODE. These strings are pre-appended to the mode.
	GRB SCALAR HISTOGRAM	If DETNAM is set to SHIELD, the DATAMODE is one of the values GRB SCALAR or HISTGRAM
SGD		
INSTRUME	SGD	INSTRUME is set to SGD if the calibration or the science files contains information valid for both SGD. The keyword is set to SGD1 or SGD2 if the calibration or science data are for the SGD1 or SGD2 respectively.
	SGD1	
	SGD2	
DETNAM	CC CC1 CC2	Each SGD has 3 Compton Cameras. CC is used for files valid for any Compton Camera of the SGD. The string for each Compton Camera is CC1, CC2 and CC3 respectively.

	CC3	
	SHIELD SHIELD1 SHIELD2	Each SGD has the shield data that are telemetered via separate two separate APMU. SHIELD1 is in files associated to the APMU1 and SHIELD2 is in files associated to the APMU2. The string SHIELD is used for file
DATAMODE	CC_NORMALn PSEUDO_NORMALn FORCE_NORMALn CALMODE_NORMALn	The DATAMODE is set to XXX_NORMALn where n (set to 1, 2, 3..) is changed within the mission. There is only one valid n at any time during the mission. The detector processes data in different stream CC, PSEUDO, FORCE and CALMODE. These strings are pre-appended to the mode.
	GRB SCALAR HISTOGRAM	If DETNAM is set to SHIELD, the DATAMODE is one of the values GRB SCALAR or HISTOGRAM
SXI		
INSTRUME	SXI	INSTRUME is set to SXI in calibration and science files taken with the CCD instrument. The string SXI is used to indicate the combination of the sensor and the telescope.
DETNAM	CCD CCD12 CCD34	CCD is used in calibration or science files applicable to all four CCDs. It also indicates that all CCD are on. CCD12 is used in calibration or science files applicable to the CCD 1 & 1. CCD34 is used in calibration or science files applicable to the CCD 3 & 4.
	SXT	SXT is used in files applicable to the telescope of the SXI
DATAMODE	WINDOW1 WINDOW2 WINDOW1BURST WINDOW2BURST	These strings for the DATAMODE keyword specified the windowing of the CCD. WINDOW1 indicates that all four CCD are in full window. WINDOW2 indicates that two CCD are in 1/8 window setting and two CCD are in full window. The integration of the pairs of the two CCD is different. WINDOW1BURST indicates that all four CCD are in full window using a shorter exposure. WINDOW2BURST indicates that two CCD are in ¼ window setting with a shorter exposure and two CCD are in full window with a short exposure full window using a shorted exposure. The integration of the pairs of the two CCD is different. These keywords are applicable to the event files or to calibration data
	DFRAME RFRAME IFRAME	These strings for the DATAMODE keyword are in used in the science file where the entire frame is downloaded. DFRAME is the dark frame. RFRAME is the real frame. IFRAME is the image frame.
	EXPOSURE	The string for the DATAMODE keyword is used in the science file that collect the header information for each exposure
SXS		
INSTRUME	SXS	INSTRUME is set to SXS in calibration and science files taken with the CCD instrument. The string SXS is used to indicate the combination of the sensor and the telescope.

DETNAM	PIXEL PIXnn	The string PIXEL is used in calibration or in science file applicable to all pixels that composite the detectors. The PIXnn is used in calibration and science files applicable to the pixel number n where n is running from 0-35. The calibration pixel is the number 12.
	BASELINE	The string BASELINE is used in calibration files applicable to baseline events
	ANTICO	The string ANTICO is used in calibration or in science files applicable to anti-coincident events
	FWE	The FWE is used in calibration or in science files applicable to filter wheel and MXS data
	SXT	SXT is used in files applicable to the telescope of the SXS
FILTER	OPEN1 OPEN2 BE FE55 ND25 POLYIMIDE UNDEF	These strings are set for the filters mounted on the filer wheel. There are six positions : OPEN1 and OPEN2 filters are an open hole and correspond to the filter wheel position 1 & 4; BE is the beryllium filter at the wheel position 5; FE55 is the calibration source at the filter position 6; ND25 is the neutral filter at position 3. It is made of layer of aluminum ?? with several hole that corresponds to a 25% transmission; POLYIMIDE is a filter position 2. UNDEF is used when the filter is rotated to a position not corresponding to any known filter.
	GATEVALV	The string GATEVALV is positioned at the dewar opening. It is made of a support structure crossed shaped with a mesh covering the parts left open by the cross with a transmission of 70%. Underneath there is beryllium filter. This valve is used during the check out phase in conjunction with the filters of the FWE. When the gate opens can not longer be closed and this string is not longer used (1)
	BLCKFILT	The string BLCKFIL are positioned within the dewar below the gatevalve and above the SXS detector. These filters stay in place for all observations. This string is only used for calibration files
DATAMODE	PX_NORMAL PX_MIDRES AC_NORMAL AC_MIDRES PX_BASELINE MXSOFF MXSON1 MXSON12 MXSON2 MXSON34 MXSON3 MXSON4	These strings for the DATAMODE keyword specified the MXS usage. MXSOFF indicate that the MXS is off. MXSON1 and MXSON3 indicate that the MXS direct source are on. MXSON2 and MXSON4 indicate that the MXS indirect source are on. MXSON12 indicates that the MXS direct source 1 and indirect 2 are on. MXSON34 indicates that the MXS direct source 3 and indirect 4 are on.
	PX_PULSEREC PX_NOISEREC PX_TEMPLATE PX_NOISESPC PX_AVGPULSE PX_WFRB AC_NOISEREC	These strings for the DATAMODE keyword specified data telemetered with special mode.

	AC_WFRB	
GATEVALV	OPEN/CLOSE	The keyword GATEVALV is used in event data file when the GATEVALV is still in the close position at the dewar opening. When the gate opens can not longer be closed and this string is not longer used (1)

Note (1) : During the check-out phase of the mission the GATEVALV is always in place until is opened

3.2 Usage : INSTRUME , DETNAM, FILTER and DATAMODE

Table 3.6

System	INSTRUME	DETNAME	DATAMODE	FILTER
HXI	HXI1 HX2 HXI	CAMERA	CAMERA_NORMALn AM241_NORMALn PSEUDO_NORMALn FORCE_NORMALn CALMODE_NORMALn	N/A
	HXI1 HXI2 HXI	SHIELD	GRB SCALAR HISTOGRAM	N/A
	HXI1 HXI2 HXI	HXT	N/A	N/A
	HXI1 HXI2 HXI	CAMS1 CAMS2 CAMS	N/A	N/A
SGD	SGD1 SGD2 SGD	CC1 CC2 CC3 CC	CC_NORMALn PSEUDO_NORMALn FORCE_NORMALn CALMODE_NORMALn	N/A
	SGD1 SGD2 SGD	SHIELD1 SHIELD2 SHIELD	GRB SCALAR HISTOGRAM	N/A
SXI	SXI	CCD12 CCD34 CCD	WINDOW1 WINDOW2 WINDOW1BURST WINDOW2BURST	N/A
	SXI	CCD	DFRAME RFRAME IFRAME	N/A
	SXI	CCD	EXPOSURE	N/A
SXS	SXS	PIXEL or PIXnn	PX_PULSEREC PX_NOISEREC PX_WFRB PX_NORMAL PX_MIDRES PX_BASELINE	OPEN1 OPEN4 BE FE55 ND25 POLYIMIDE & (GATEVALV)
				BLCKFILT

			PX_TEMPLATE PX_NOISESPC PX_NOISESPC8K PX_AVGPULSE	N/A
	SXS	ANTICO	AC_NOISEREC AC_WFRB AC_NORMAL	
	SXS	FWE	N/A	N/A
CAMS	CAMS1 CAMS2 CAMS			N/A

4 Hitomi General File applicable to all instruments

The files listed in this section are applicable to all instruments and they reside in the mission general directory of CALDB.

4.1 Time Delay Lookup Table

This file contains the time delays between the SMU and instruments electronics as function of the mission time. This delay account for the difference between the arrival time on the detector of the event and the time recorded in the SMU master data processer. The delay may change with the mission time. The filename is:

ah_gen_delay_YYYYMMDDvxxx.fits

where YYYYMMDD to the start validity of the file.

The file has an empty primary header and five bintable extensions one for each instrument or subsystem, Specifically the extension are for the SXS, HXI, SGD, SXI, FW and CAMS. Each extension has the following columns:

- TIME that defines time applicable interval of the delay values.
- DELAY1 and DELAY2 that contain delay values. Their content is different for each instrument as follows :
  - SXS extension: DELAY1 corresponds to PSP-A (PSP_ID=0,1), DELAY2 to PSP-B (PSP_ID=2,3);
  - HXI extension: DELAY1 corresponds to HXI1, DELAY2 to HXI2;
  - SGD extension: DELAY1 corresponds to SGD1, DELAY2 to SGD2;
  - SXI extension: DELAY1 corresponds to the SXI, DELAY2 is not used and set to 0;
  - CAMS extension: DELAY1 corresponds to the CAMS1, DELAY2 to CAMS2;
  - FW extension: DELAY1 corresponds to the MXS, DELAY2 is not used and set to 0.

The file may be updated when needed and if only one of delay column, either DELAY1 or DELAY2 is updated, the prior value for the other is carried over. This file is used in the *ahtime* time assignment task to correct the TIME column. It is also used in the *mxstime* task that calculates the Start and Stop time for each of the LED. The relevant reference document is ASTH-SCT-021 (Hitomi Time Assignment System).

4.1.1 File Format

Table 4.1.1		
Extension N.	Type	Ext. Name

Table 4.1.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1–6	BINTABLE	1: HXI, 2: SGD, 3: SXI, 4: SXS, 5: CAMS, 6: FW	
	Column Names	Format	Units
	TIME	D	s
	DELAY1	D	s
	DELAY2	D	s

4.1.2 Header Keywords

All the extensions contain the keywords listed in Table 3.1 and Table 3.2. Since the time column is present also the keywords in Table 3.4 are mandatory. Specific settings of some of the CALDB keywords and others in Table 3.1 and Table 3.2 relevant to this file are listed below.

Table 4.1.2		
Keyword name	Keyword value	Comment
Table 3.1 & 3.2 & 3.4 - Mandatory header keywords		
CALDB Keywords for all extensions		
INSTRUME	GEN	/ Instrument name
EXTNAME	‘XXX’ (XXX is instrument name)	/Name of the binary table extension
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'DELAY_XXX'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Delay Time for XXX’	/Description

where XXX is set to HXI, SGD, SXI, to SXS, CAMS, and FW in the extension 1,2,3,4,5 and 6 respectively.

4.2 Time Column Definition File

This file contains all column names in the event or HK files that must be identified for application of instrument-dependent time correction. The filename is

ah_gen_coldef_YYYYMMDDvxxx.fits

where YYYYMMDD to the start validity of the file. The file has an empty primary header and one bintable extension named TIMECOLDEF with the following columns:

(all 32A but for BITS)

- SYSTEM : This columns contains a string to identify the HK or instrument system or subsystem used by ahtime to include the specific steps to calculate time. The current values are: SXS-Pixel, SXS-Antico, SXI, HXI_Camera, HXI_Shield, SGD_CC, SGD_Shield1, SGD_Shield2, CAMS, HK.
- SCITI : The SCITI column contains the column name corresponding to the Hitomi time indicator (either lower or upper 32 bits) present in the FITS science and HK data files. This column is named “L32TI”
- SCIS_TIME : The SCIS_TIME column contains the column name corresponding to the packet sending time present in the FITS science and HK data files. This column is named “S_TIME”
- LTIME1EVT : The LTIME1EVT column contains the “Local time” column name in the science file used to calculate TIME. The local time is the telemetered value of the free running clock of that SYSTEM. If the SYSTEM is HK, LTIME1EVT is empty. For example SAMPLECNT for SXS or LOCAL_TIME for HXI and SGD.
- BITS : Number of bits in LTIME1EVT
- LTIME2EVT : The LTIME2EVT column contains additional column name in the science file containing telemetered value necessary to calculate TIME. Used only for SXS to id PSP_ID column.
- HKEXTNAME : The HKEXTNAME column contains the HK extension name that contains the “Local Time” in the HK.
- LTIME1HK : The LTIME1HK column contains the “Local time” column name in the HK file used to calculate TIME. The local time is the telemetered value of the free running clock of that SYSTEM. If HKEXTNAME is empty, LTIME1HK is empty.
- LTIME2 : The LTIME2 column contains additional column name in the HK file containing telemetered value necessary to calculate TIME. Used only for SXS to id PSP_ID column.
- TI1HK : correspond to LTIME1EVT, LTIME2EVT, and TI1Sc for the HK extension defined by HKEXTNAME.
- LTFACTHK factor ratio of precision of the local time of the event divided the local time of the HK (LTRSEVT/LTRESHK)
- LTFACTBITS stored the value $2^{ltfactbits}$ =LTFACTHK that is different for each instrument HK
- LTRESEVT column name of local time resolution event
- LTRESHK column name of local time resolution of HK

4.2.1 File Format

Table 4.2.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	TIMECOLDEF	
	Column Names	Format	Units
	SYSTEM	32A	
	SCITI	32A	
	SCIS_TIME	32A	

Table 4.2.1			
Extension N.	Type	Ext. Name	
	LTIME1EVT	32A	
	BITS	I	
	LTIME2EVT	32A	
	HKEXTNAME	32A	
	LTIME1HK	32A	
	LTIME2	32A	
	TI1HK	32A	
	LTFACTHK	I	
	LTFACTBITS	I	
	LTRESEVT	E	s
	LTRESHK	E	s

4.2.2 Header Keywords

The primary extension keywords are listed in the Table 1.1 of this document and they are mandatory. All the extensions contain the keywords listed in Table 3.1 and Table 3.2. Specific settings of some of the CALDB keywords and others relevant to this file are listed below.

Table 4.2.2		
Keyword name	Keyword value	Comment
Table 3.1 & 3.2 - Mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'TIMECOLDEF'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Column and Extension Names’	/Description

4.3 Quartz Clock Trend Data File

These files contain the collected pre-flight and in-flight calibration frequency and temperature measurements for each of the SMU quartz clock counters (SMUA SMUB). The filenames are:

ah_gen_qclocka_YYYYMMDDvNNN.fits

ah_gen_qclockb_YYYYMMDDvNNN.fits

where qclocka and qclockb are for the SMUA or SMUB and YYYYMMDD is the data from when the file is valid. This file is is used by *ahtime* when the satellite is *not* synchronized with the GPS. The task *ahtrendtemp* calculates the clock vs temperature for each sequence. The CALDB files are updated when differences are founds between the version in CALDB and the analysis of the combine trend output of *ahtrendtemp.* Its structure is an empty primary header with bintable extensions with columns:

- FREQ : contains the quartz clock frequency, converted from the quartz counter, in units of quartz clock ticks per second.
- TEMP : contains the quartz temperature.
- NPTTEMP: contains the number of point averaged to calculate the temperature and frequency stored in TEMP and FREQ

The file is updated only when the values are found different from the previous. A new extension is added and the time validity is changed.

4.3.1 File Format

Table 4.3.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1–N	BINTABLE	FVT	
	Column Names	Format	Units
	FREQ	D	
	TEMP	D	
	NPTTEMP	I	

4.3.2 Header Keywords

The primary extension keywords are listed in the Table 1.1 of this document and they are mandatory. All the extensions contain the keywords listed in Table 3.1 and Table 3.2. Specific settings of some of the CALDB keywords and others relevant to this file are listed below.

Table 4.3.2		
Keyword name	Keyword value	Comment
Table 3.1 & 3.2 - Mandatory header keywords		
CALDB Keywords		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'TIME_FREQ'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used

CDB10001	SMUUNIT(A) or SMUUNIT(B)	
CDES0001	‘quartz clock temperature vs frequency pre-flight’	/Description
File Keywords		
EXTNAME	'FVT’	/Name of the binary table extension
SMUUNIT	‘A’ or ‘B’	/SMUUNIT A or B
NUMCLQRZ	-1	/Number of rows in the HK file
TEMPBIN	-1	/Temperature bin size used to average
STIMEMAX	-1	/Time Gap when temperature is not evaluated
AVGMODE	-1	/AVG Mode

4.4 Atomic Scattering File

This file contains the real and imaginary components of atomic scattering factors as a function of energy for atoms of different elements. There are several sets of atomic scattering factors for a given element, originating from different theoretical calculations in the literature. The different sets of calculations are in different extensions of the file and values of the atomic scattering factor from different theoretical calculations may differ for the same element. The atomic scattering factors are used to calculate optical constants for different materials. The filename is

ah_gen_atmsca_YYYYMMDDvNNN

where YYYYMMDD to the initial validity date of the file and NNN the version number. This file is used by *xrtreftable*, to generate the reflectivity table, the transmission tables for the coatings on the front-side mirrors of X-ray telescopes, and the mass-absorption coefficients for transmission probabilities in other components of the mirror foils. The structure is an empty primary with several bintable extensions. In each extension one row corresponds to a specific energy and each element has a number of rows corresponding to the number of tabulated energy points. The number of energy points is not the same for each element. Also, the number of elements included in each extension varies, and there may be gaps in atomic number in some of the extensions. The column names are :

- Z contain the atomic number (Z) of the element to which a particular row belongs
- ROWINDEX contain an integer row number that starts with 1 for the first row of each unique element, and increases by 1 for each row (energy point)
- ENERGY contain the energy (in eV) pertaining to a particular row
- F1REAL contain the real part of the atomic scattering factor for the energy and atomic number in each row (dimensionless)
- F2IMG, contains the imaginary part of the atomic scattering factor for the energy and atomic number in each row (dimensionless)

The file is updated only when new set of atomic scattering factor are calculated, which is expected to be infrequent.

4.4.1 File Format

Table 4.4.1		
Extension N.	Type	Ext. Name

Table 4.4.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	(Extension name see below)	
	Column Names	Format	Units
	Z	J	-
	ROWINDEX	J	
	ENERGY	D	eV
	F1REAL	D	
	F2IMG	D	

References for the data:

- Extension 1: (henke97): Henke et al. (1993), Atomic Data and Nuclear Data Tables Vol. 54 (no.2), 181-342, but with data for Au modified to fit ASCA data better around the Au edges (Tamura et al. 2006, SPIE Vol. 6269).
- Extension 2: (BrennanCowan) Brennan, S., and Cowan, P. L. (1992), Rev. Sci. Instrum. 63, 850
- Extension 3: (Chantler) Chantler, C. T., Journal of Physical and Chemical Reference Data (1995), 24, 71
- Extension 4: (CromerLiberman) Cromer, D. T. (1983) J. Appl. Cryst. 16, 437-437.
- Extension 5: (EPDL97) "EPDL97 The Evaluated Data Library, 97 Version," Cullen, D. E., et al. (1997) UCRL-50400, Vol 6, Rev 5
- Extension 6: (Henke2013) Henke data downloaded in November 2013 from http://henke.lbl.gov/optical_constants/, containing updates for several elements compared to the data in Henke et al. (1993). The Au data in this extension are *not* modified in any way.
- Extension 7: (Kissel) Kissel, L., Radiation physics and chemistry 59 (2000) 185-200
- Extension 8: (Sasaki) Sasaki, S. (1989) Numerical Tables of Anomalous Scattering Factors Calculated by the Cromer and Liberman Method, KEK Report, 88-14, 1-136
- Extension 9: (Windt) Atomic scattering factors calculated by D. Windt (see http://cletus.phys.columbia.edu/~windt/idl/)
- Extension 10: (Shadow) A concatenation of 3 sources of atom scattering factors. 0.1-2 keV: Henke et al. (1982) Atom. Data Nucl. Data Tables, 27; 2-10 keV: Auerbach et al. Software for Reflectivity calculations of X-ray mirrors, LLNL Report UCRL91230 (1984); 10-100 keV: Sasaki, S. (1989), KEK Report, 88-14, 1-136
- Extension 11: (HenkeSskChantler): A concatenation of 3 sources of atomic scattering factors. In the energy range 0.03-4.275 keV the data are the same as in Henke2013 extension; In the energy range 4.275-123 keV the data are the same as in the Sasaki extension for all except the three elements, H, He, and Be. For these three elements the data are identical to the corresponding data in the extension Chantler.
- Extension 12: (HENKEMODSXT): Henke data modified specific for the SXT.

4.4.2 Header Keywords

There is no primary header keywords specific to this file. Extension 1 contains the keywords listed in Table 3.1 and 3.2. Specific settings of some of the CALDB keywords and others relevant to this file are listed below.

Extension 1 :

Extension 1		
Keyword name	Keyword value	Comment
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Henke	/Description
CBD10001	Z(1-92)	/Atomic number range 1-92
CBD20001	ATMSCTNG(henke97)	Atomic scattering factors source
CBD30001	ENERGY(10-30000)	Energy range 10-30,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	henke97	/Name of the binary table extension
Extension 2		
Keyword name	Keyword value	Comment
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Brennan and Cowan 1992	/Description
CBD10001	Z(3-92)	/Atomic number range 3-92
CBD20001	ATMSCTNG(BrennanCowan)	Atomic scattering factors source
CBD30001	ENERGY(1000-70000)	Energy range 1,000-70,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific

EXTNAME	BrennanCowan	/Name of the binary table extension
Extension 3		
Keyword name	Keyword value	Comment
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Chantler 1995	/Description
CBD10001	Z(1-92)	/Atomic number range 1-92
CBD20001	ATMSCTNG(Chantler)	Atomic scattering factors source
CBD30001	ENERGY(17-432000)	Energy range 17-432,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	Chantler	/Name of the binary table extension
Extension 4		
Keyword name	Keyword value	Comment
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Cromer & Liberman 1983	/Description
CBD10001	Z(3-98)	/Atomic number range 3-98
CBD20001	ATMSCTNG(CromerLiberman)	Atomic scattering factors source
CBD30001	ENERGY(1000-70000)	Energy range 1,000-70,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	CromerLiberman	/Name of the binary table extension

Extension 5		
Keyword name	Keyword value	Comment
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Cullen et al. (1997)	/Description
CBD10001	Z(1-100)	/Atomic number range 1-100
CBD20001	ATMSCTNG(EPDL97)	Atomic scattering factors source
CBD30001	ENERGY(1-10000000)	Energy range 1-10,000,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	EPDL97	/Name of the binary table extension
Extension 6		
Keyword name	Keyword value	Comment
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Henke (updates to 2013)	/Description
CBD10001	Z(1-92)	/Atomic number range 1-92
CBD20001	ATMSCTNG(Henke2013)	Atomic scattering factors source
CBD30001	ENERGY(10-30000)	Energy range 10-30,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	Henke2013	/Name of the binary table extension
Extension 7		

Keyword name	Keyword value	Comment
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Kissel (2000)	/Description
CBD10001	Z(1-99)	/Atomic number range 1-99
CBD20001	ATMSCTNG(Kissel)	Atomic scattering factors source
CBD30001	ENERGY(1-10000000)	Energy range 1-10,000,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	Kissel	/Name of the binary table extension
Extension 8		
Keyword name	Keyword value	Comment
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Sasaki (1989)	/Description
CBD10001	Z(4-83,92)	/Atomic number range 4-83,92
CBD20001	ATMSCTNG(Sasaki)	Atomic scattering factors source
CBD30001	ENERGY(4290-123000)	Energy range 4290-123,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	Sasaki	/Name of the binary table extension
Extension 9		
Keyword name	Keyword value	Comment

CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Windt	/Description
CBD10001	Z(1-92)	/Atomic number range 1-92
CBD20001	ATMSCTNG(Windt)	Atomic scattering factors source
CBD30001	ENERGY(10-100000)	Energy range 10-100,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	Windt	/Name of the binary table extension
Extension 10		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from http://www.xraylith.wisc.edu/shadow	/Description
CBD10001	Z(1-92)	/Atomic number range 1-92
CBD20001	ATMSCTNG(Shadow)	Atomic scattering factors source
CBD30001	ENERGY(30-100000)	Energy range 30-100,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	Shadow	/Name of the binary table extension
Extension 11		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data

CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors merged from Henke, Sasaki, Chantler	/Description
CBD10001	Z(1-83,92)	/Atomic number range 1-92
CBD20001	ATMSCTNG(HenkeSskChantler)	Atomic scattering factors source
CBD30001	ENERGY(10-123000)	Energy range 10-123,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	HenkeSskChantler	/Name of the binary table extension
Extension 12		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SFATOM	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Atomic scattering factors from Henke (updates to 2013)	/Description
CBD10001	Z(1-92)	/Atomic number range 1-92
CBD20001	ATMSCTNG(HenkeSskChantler)	Atomic scattering factors source
CBD30001	ENERGY(10-30000)	Energy range 10-30,000 eV
TELESCOP	HITOMI	Mission non-specific
INSTRUME	GEN	Instrument Non-Specific
EXTNAME	HENKEMODSXT	/Name of the binary table extension

4.5 Line fitting

This file contains the lines that are used to calculate the gain. The line are from either calibration sources part of the detectors or lines that are observed in the sky. The filename is :

ah_gen_linefit_YYYYMMDDvNN.fits

where YYYYMMDD to the initial validity date of the file and NN the version number. This file is used by the *sxsgain* and *ahgainfit* tasks to monitor the gain. In both tasks, the science data are binned in time dependent spectra and the line centroid and shape is fitted using the information in this CALDB file. The file contains several extensions one dedicated to a line feature. Each extension may contain many lines to describe the specific line feature. For the SXS the line features are : 1) Mn Kα and Kβ lines

emitted by an Fe55 source that illuminates one pixel offset from the array as well as emitted by one of the Filter Wheel (FW) filter that illuminates the whole array and 2) the lines emitted by the Modulated X-ray Source (MXS) which are the Cu and Cr Kα and Kβ, for when the MXS works in the direct mode and the Al and Mg Kα and Kβ for when the MXS works in the indirect mode. For the SXI the line features are also the Mn Kα and Kβ lines emitted by an Fe55 source positioned at the internal corners of the CCD. For the HXI the calibration feature is the AM241 that is constantly recorded in the data. For the SGD the lines are the activation lines. For each line feature there is one extension. Each extension contain the following columns:

- ENERGY column refers to the peak energy of the Lorentzian component.
- WIDTH column refers to FWHM of the Lorentzian component.
- AMPLITUDE column refers to the peak height of the Lorentzian component.
- AREA column refers to integrated area under the curve for this component as a fraction of the sum over all components.

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4.5.1 File Format

The file format is composite by N extensions all designed the same. The extension is named after the energy lines relative to the specific energy feature.

Table 4.5.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
N	BINTABLE	XXX	
	Column Names	Format	Units
	ENERGY	1D	eV
	WIDTH	1D	eV
	AMPLITUDE	1D	
	AREA	1D	

4.5.2 Primary Header Keywords

Table 4.5.2		
Keyword name	Keyword value	Comment
CALDB Keywords for all extensions		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	(Same as EXTNAME)	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data

CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	Theoretical Energy of xxx Lines	/Description
Ext 1 :		
EXTNAME	'MnKa’	/Name of the binary table extension
ENERGREF	8	/Total Number of Calibration Line Components
ENERGAVE	5894.62	/Energy Centroid of Calibration Line Complex
Ext 2 :		
EXTNAME	'MnKb’	/Name of the binary table extension
ENERGREF	5	/Total Number of Calibration Line Components
ENERGAVE	6486.37	/Energy Centroid of Calibration Line Complex
Ext 3 :		
EXTNAME	'CrKa’	/Name of the binary table extension
ENERGREF	7	/Total Number of Calibration Line Components
ENERGAVE	5411.20	/Energy Centroid of Calibration Line Complex
Ext 4:		
EXTNAME	'CrKb’	/Name of the binary table extension
ENERGREF	5	/Total Number of Calibration Line Components
ENERGAVE	5943.09	/Energy Centroid of Calibration Line Complex
Ext 5 :		
EXTNAME	'CuKa’	/Name of the binary table extension
ENERGREF	4	/Total Number of Calibration Line Components
ENERGAVE	8040.72	/Energy Centroid of Calibration Line Complex
Ext 6 :		
EXTNAME	'CuKb’	/Name of the binary table extension
ENERGREF	5	/Total Number of Calibration Line Components
ENERGAVE	8904.76	/Energy Centroid of Calibration Line Complex
Ext 7 :		
EXTNAME	'AlKa’	/Name of the binary table extension
ENERGREF	5	/Total Number of Calibration Line Components

ENERGAVE	1487.50	/Energy Centroid of Calibration Line Complex
Ext 8 :		
EXTNAME	'AlKb’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	1557.4	/Energy Centroid of Calibration Line Complex
Ext 9:		
EXTNAME	'MgKa’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	1253.60	/Energy Centroid of Calibration Line Complex
Ext 10 :		
EXTNAME	'MgKb’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	1302.20	/Energy Centroid of Calibration Line Complex
Ext 11 :		
EXTNAME	'NpLa’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	13930.00	/Energy Centroid of Calibration Line Complex
Ext 12 :		
EXTNAME	'NpLb’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	17510.00	/Energy Centroid of Calibration Line Complex
Ext 13 :		
EXTNAME	'NpLg’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	21010.00	/Energy Centroid of Calibration Line Complex
Ext 14 :		
EXTNAME	'Am26keV’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	26344.80	/Energy Centroid of Calibration Line Complex
Ext 15 :		
EXTNAME	'Am33keV’	/Name of the binary table extension

ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	33196.40	/Energy Centroid of Calibration Line Complex
Ext 16 :		
EXTNAME	'Am60keV’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	59541.20	/Energy Centroid of Calibration Line Complex
Ext 17 :		
EXTNAME	'103mRh’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	39700.00	/Energy Centroid of Calibration Line Complex
Ext 18 :		
EXTNAME	'127mTe’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	88200.00	/Energy Centroid of Calibration Line Complex
Ext 19 :		
EXTNAME	'129mTe’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	105500.00	/Energy Centroid of Calibration Line Complex
Ext 20 :		
EXTNAME	'125mTe’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	144700.00	/Energy Centroid of Calibration Line Complex
Ext 21 :		
EXTNAME	'123mTe’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	247500.00	/Energy Centroid of Calibration Line Complex
Ext 22 :		
EXTNAME	'115mIn’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	336200.00	/Energy Centroid of Calibration Line Complex
Ext 23 :		
EXTNAME	'511keV’	/Name of the binary table extension
ENERGREF	1	/Total Number of Calibration Line Components
ENERGAVE	511000.00	/Energy Centroid of Calibration Line Complex

Ext 24 :		
EXTNAME	'SXI_MnK’	/Name of the binary table extension
ENERGREF	13	/Total Number of Calibration Line Components
ENERGAVE	5993.25	/Energy Centroid of Calibration Line Complex

4.6 South Atlantic Anomaly vertices Data File

This file contains the region describing the South Atlantic Anomaly (SAA) and the HXI regions of high background. The filename is ah_gen_saa_YYYYMMDDvNNN.fits

where YYYYMMDD to the initial validity date of the file and NN the version number. The SAA is defined by the region vertices. The file has two extensions. The first contains the SAA region one region for each of the instruments and the number of vertices may be variable. Its structure is an empty primary header with bintable extensions with the following columns:

- SXI_SAA : contains the vertices of the SAA region appropriated for the SXI instrument. Each vertex is defined by two numbers, respectively the latitude and longitude.
- SXS_SAA : contains the vertices of the SAA region appropriated for the SXS instrument. Each vertex is defined by two numbers , respectively the latitude and longitude.
- HXI1_SAA : contains the vertices of the SAA region appropriated for the HXI1 instrument. Each vertex is defined by two numbers , respectively the latitude and longitude.
- HXI2_SAA : contains the vertices of the SAA region appropriated for the HXI2 instrument. Each vertex is defined by two numbers , respectively the latitude and longitude.
- SGD1_SAA : contains the vertices of the SAA region appropriated for the SGD1 instrument. Each vertex is defined by two numbers, respectively the latitude and longitude.
- SGD1_SAA : contains the vertices of the SAA region appropriated for the SGD2 instrument. Each vertex is defined by two numbers, respectively the latitude and longitude.

The latitude and longitude are written in degrees an they vary from -180 +180 ; -90 +90 respectively. The number of vertices for each of the instrument is set in header keywords SXINVERT, SXSNVERT, HX1NVERT, HX2NVERT, SG1NVERT, SG2NVERT. The table contains always the same number of rows for all columns and that corresponding to the larger number of vertices needed for one or more instruments. If one instrument needs less vertices, the rows in excess are patted with invalid points set to (-1000, 1000). If a point is valid for a given latitude but for any longitude < of the maximum longitude in any of the other vertices than the point is set to (number, -1000). The file does not contain the column time and if values are changed during the mission a new file with different validity date is issued.

The second contains the HXI region for high background. Each region is described by a number of vertices as latitude and longitude. Each row contains only one point (latitude and longitude) of a region and the regions are separated by one row set to INDEF. The files contains region of high background for the HXI1 and HXI2 but it also contains pre-made columns for the SGD1 and SGD2 with the same setting of the HXI. Its structure is bintable extensions with the following columns:

- HXI1_SAA2 : contains the vertices of the high background region appropriated for the HXI1 instrument. Each vertex is defined by two numbers , respectively the latitude and longitude.
- HXI2_SAA2 : contains the vertices of the high background region appropriated for the HXI2 instrument. Each vertex is defined by two numbers , respectively the latitude and longitude.
- SGD1_SAA2 : contains the vertices of the high background region set equal to the HXI instrument and currently not used. Each vertex is defined by two numbers, respectively the latitude and longitude.
- SGD1_SAA2 : contains the vertices of the high background region set equal to the HXI instrument and currently not used. Each vertex is defined by two numbers, respectively the latitude and longitude.

4.6.1 File Format

Table 4.6.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	SAA_VERTICES	
	Column Names	Format	Units
	SXI_SAA	2E	deg
	SXS_SAA	2E	deg
	HXI1_SAA	2E	deg
	HXI2_SAA	2E	deg
	SGD1_SAA	2E	deg
	SGD2_SAA	2E	deg
2	BINTABLE	SAA2_VERTICES	
	Column Names	Format	Units
	HXI1_SAA	2E	deg
	HXI2_SAA	2E	deg
	SGD1_SAA	2E	deg
	SGD2_SAA	2E	deg

4.6.2 Header Keywords

Table 4.6.2		
Keyword name	Keyword value	Comment
CALDB Keywords for all extensions		
INSTRUME	‘GEN’	/Instrument name
EXTNAME	‘SAA_VERTICES’	/Name of the binary table extension
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	‘SAA’	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used

CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SAAvertices’	/Description
SXINVERT	xx	/ SXI number of vertices
SXSNVERT	xx	/ SXS number of vertices
HX1NVERT	xx	/ HX1number of vertices
HX2NVERT	xx	/ HX2 number of vertices
SG1NVERT	xx	/ SGD1 number of vertices
SG2NVERT	xx	/ SGD2 number of vertices
Keyword name	Keyword value	Comment
CALDB Keywords for all extensions		
INSTRUME	‘GEN’	/Instrument name
EXTNAME	‘SAA2_VERTICES’	/Name of the binary table extension
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	‘SAA2’	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SAA2 Vertices’	/Description

The keywords set to ‘xx’ represent the number of vertices that defines the SAA polygon included for each of the detectors.

4.7 MKF Configuration file

This file contains the list of columns that are included in the make filter file, *mkf*. This is the configuration file used by *makefilter* The filename is :
ah_gen_mkfconf_ YYYYMMDDvNNN.fits
where YYYYMMDD to the initial validity date of the file and NNN the version number. The file contains one extension with the following columns:

- INCOL column name to read present in the file specified in FILE
- FILE : name of the file to read
- EXTENSION: extension name of the FILE where the INCOL to read is present
- INTERP: set to either D, discrete interpolation, or I, near interpolation.
- CALIB : (deprecated)
- OUTCOL: output column name that is listed in MKF
- COMMENT : contain a comment for the output column

4.7.1 File Format

Table 4.7.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	MKFCONF	
	Column Names	Format	Units
	INCOL	40A	
	FILE	10A	
	EXTENSION	71A	
	INTERP	1A	
	CALIB	1A	
	OUTCOL	11A	
	COMMENT	71A	

4.7.2 Header Keywords

Table 4.7.2		
Keyword name	Keyword value	Comment
CALDB Keywords		
EXTNAME	MKFCONF	/Name of the binary table extension
TELESCOP	HITOMI	/ Telescope (mission) name
INSTRUME	GEN	/ Instrument name
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	MKCONF	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used

4.8 Select file

This file contains the selection criteria used in the pipeline for screening. The filename is :
ah_gen_select_ YYYYMMDDvNNN.fits
where YYYYMMDD to the initial validity date of the file and NNN the version number.The file contains one extension with the following columns:

- LABEL : contain a name associated to a specific screening
- SUBSYS : contain the names of the valid sub system name. These corresponds to the instrument name.
- FROMFILE: contain the file type from where the expression has to be applied. If set to MHK or EHK the expression is only valid for the MKF and EHK respectively and the result is a GTI file. If set to EVENT, the screening expression remove events in the event file.
- EXPR : expression to be applied to the
- GTIEXTNAME: report the GTI extension name

4.8.1 File Format

Table 4.8.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	SELECT	
	Column Names	Format	Units
	LABEL	32A	
	SUBSYS	8A	
	FROMFILE	8A	
	EXPR	1400A	
	GTIEXTNAME	80A	

4.8.2 Header Keywords

Table 4.8.2		
Keyword name	Keyword value	Comment
CALDB Keywords for the first extension		
TELESCOP	HITOMI	/ Telescope (mission) name
INSTRUME	GEN	/ Instrument name
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	SELECT	/Type of calibration data

CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	Selection Criteria	Description

4.9 Parameter for vignetting function

The file contains the parameters values of the functions that reproduce the vignetting of the telescopes that represents the measured values.. The functions are for the HXT and SXT respectively. There are different functions, one for the HXT and one for the SXT, but both uses 5 parameters. This CALDB file contains the 5 parameters for both HXT and SXT. The file is a bintable with empty primary header and to avoid repetition a single file is provided that contains all parameters for all telescopes. The filename is

ah_gen_vigncoef_YYYYMMDDvNNN.fits

The 5 parameters are different for HXI1 and HXI2 and are the same for the SXT-S and SXT-I however the file includes the is stored in the genral part of the astroh caldb sinc. Since the format is the same for all

The structure is an empty primary with 1 bintable extension. The extension has the following columns:

- INSTRUMENT: string to ID the instrument
- PAR0, PAR1, PAR2, PAR3, PAR4 : columns containing parameters for the vignetting function

4.9.1 File Format

Table 4.9.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	atomdata	
	Column Names	Format	Units
	INSTRUMENT	4A	-
	PAR0	1E	-
	PAR1	1E	-
	PAR2	1E	-
	PAR3	1E	-
	PAR4	1E	-

4.9.2 Header Keywords

Table 4.9.2		
Keyword name	keyword value	Comment
CALDB Keywords for the first extension		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘GEN’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘VIGNCOEFF’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘Vignetting coefficient’	/ Brief descriptive summary of this file

4.10 Atomic data file

The file contains basic information such as average weight and density for each atom. This is not a mission-specific CALDB, so contained in the data/gen directory (not data/astroh/gen). The file name is

atomicdata_YYYYMMDD.fits

This file is used by *xrtreftable*, which generates reflectivity tables, transmission tables, and mass-absorption coefficients for the coatings on the front-side mirrors of X-ray telescopes. The structure is an empty primary with 1 bintable extension. The extension has the following columns:

- Z contains the atomic numbers (Z) of elements (dimensionless)
- SYMBOL contains the chemical symbol of the elements corresponding to column 1
- NAME contains the full names of the elements corresponding to column 1
- WEIGHT contains the atomic weights of the elements corresponding to column 1 (dimensionless)
- DENSITY contains the densities of the elements corresponding to column 1 (units g cm^{-3})

4.10.1 File Format

Table 4.10.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	atomdata	
	Column Names	Format	Units
	z	1J	-

Table 4.10.1			
Extension N.	Type	Ext. Name	
	symbol	2A	-
	name	16A	-
	weight	1D	-
	density	1D	g/cm**3

4.10.2 Header Keywords

Table 4.10.2		
Keyword name	keyword value	Comment
CALDB Keywords for the first extension		
TELESCOP	‘GEN	/ Telescope (mission) name
INSTRUME	‘INS’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘ATOMDATA’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘Atomic data values (general)’	/ Brief descriptive summary of this file
CBD10001	‘Z(1-92)’	/ Atomic Numbers allowed

4.11 Leap second file

The file contains leap second information. This is not a mission-specific CALDB file and is stored in the data/gen directory instead of data/astroh/gen. The file name is generally :

leapsec_DDMMYY.fits

Note that the order of year (YY), month (MM), and day (DD) is opposite to those for other mission-specific files.

The file contains an empty primary and one extension with bintable. The column structure is as follows.

- DATE refers to the date when leap seconds occurred.
- TIME refers to the time when leap seconds occurred.
- MJD refers to the MJD day when leap seconds occurred.
- SECONDS refers to the seconds when leap seconds occurred.
- LEAPSECS refers to the length of leap seconds in second, so is usually 1.0.

4.11.1 File Format

Table 4.11.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	LEAPSEC	
	Column Names	Format	Units
	DATE	8A	-
	TIME	15A	-
	MJD	D	-
	SECONDS	D	s
	LEAPSECS	D	s

4.11.2 Header Keywords

Table 4.11.2		
Keyword name	Keyword value	Comment
CALDB Keywords for the first extension		
TELESCOP	‘GEN’	/ Telescope (mission) name
INSTRUME	‘INS’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘LEAPSECS’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'1970-01-01'	/ Validity start date (UTC)
CVST0001	'00:00:00'	/ Validity start date (UTC)
CDES0001	‘Table of times at which Leap seconds occurred’	/ Brief descriptive summary of this file

4.12 Rigidity file

The file contains cut-off rigidity information. This is not a mission-specific CALDB file and is stored in the data/gen directory instead of data/astroh/gen. The file name is generally :

rigidity_YYYYMMDD.fits

The file contains just primary extension with image data.

4.12.1 Header Keywords

Table 4.12.1		
Keyword name	Keyword value	Comment
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'RIGIDITY'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	'Table of cut-off rigidity (COR)'	/Description
TELESCOP	'GEN'	/ Telescope (mission) name
INSTRUME	'INS'	/ Instrument name
CTYPE1	'GEO_LON'	Name of the X axis
CTYPE2	'GEO_LAT'	Name of the Y axis
CUNIT1	'deg'	Unit for X-axis
CUNIT2	'deg'	Unit for Y-axis
CRVAL1	0.0	Value of the X reference pixel
CRPIX1	13	Position of the X reference pixel
CDELT1	15.0	X-axis increment
CRVAL2	0.0	Value of the Y reference pixel
CRPIX2	8	Position of the Y reference pixel
CDELT2	5.0	Y-axis increment

5 HXI and CAMS

5.1 HXI Teldef File

This file contains the telescope definition file for the HXI. The format consists in a primary header that contains all keywords that defines the telescope coordinate systems.There are two files one for each HXI with the following filenames:

ah_hx1_teldef_ yyyymmddvnn.fits (HXI-1)

ah_hx2_teldef_ yyyymmddvnn.fits (HXI-2)

For the HXI, there are four coordinate types defined in the COORDn keywords (RAW, ACT, DET, FOC, SKY). Each coordinates type is defined by the keywords: nnn_XSIZ, nnnXPIX1 nnn_XSCL, nnn_YSIZ, nnnYPIX1, nnn_YSCL, nnn_UNIT. The transformation types between coordinate systems are defined as:

TRTYPE0 = 'SKYATT' / RAW to ACT transformation

TRTYPE1 = 'BASIC' / ACT to DET

TRTYPE2 = 'BASIC ' / DET to FOC

TRTYPE3 = 'SKYATT ' / FOC to SKY

The RAW to ACT transformation is governed by the RAW_Mxx keywords and the delta-attitude file derived using *cams2det*. The ACT to DET transformation is governed by keywords DETXFLIP, DETYFLIP, and DET_ROTD. The DET to FOC transformation is governed by the keywords FOC_XOFF, FOC_YOFF, FOC_ROT and FOC_SCAL. The FOC to SKY transformation is governed by the FOC_Mxx , FOCALLEN and aligned matrix (ALIGNnn) keywords, and uses the spacecraft attitude file. The OPTnnnn keywords defined the optical axis measured in ground in DET coordinates. The ROLLnnnn keywords defined the sign of the rlll angle and the offset.

There are additional keywords HXI_xxxx used by *cams2det* and *det2att* that define the physical location of the HXI sensors in spacecraft coordinates as well as . The keywords and their meaning are the same for the two HXI units, but in a number of cases the keyword values are different.

The keyword TD_VERS distinguishes the teldef version. These files are all made under the teldef version 0.2 and the TD_VERS is written in all extensions of the teldef in CALDB.

5.1.1 Primary Header Keywords

The mandatory CALDB keywords are listed below together with their values for the HXI teldef

Table 5.1.1		
Keyword name	Keyword value	
CALDB Keywords		
TELESCOP	'HITOMI '	/ Telescope (mission) name
INSTRUME	'HXI1' or 'HXI2'	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'TELDEF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'TELESCOPE DEFINITION FILE'	/ Brief descriptive summary of this file

5.2 Telescope Definition Files for CAMS

This file contains the Telescope definition file for the CAMS. The format consists in a primary header that contains all keywords that defines the telescope coordinate systems. There are two files one for each CAMS with the following filenames:

ah_cm1_teldef_yyyymmddvnn.fits (CAMS-1)

ah_cm2_teldef_yyyymmddvnn.fits (CAMS-2)

These files provide a description of the physical locations and orientations of the CAMS detector units and on the contrary of the teldef HXI file they do not define coordinate system transformations. The physical location of the CAMS sensors in spacecraft coordinates and the orientation of the sensors (rotation and flip) relative to spacecraft coordinates are described in the CAM_XLOC, CAM_YLOC CAM_ZLOC, CAM_ROTD, CAMXFLIP, CAMYFLIP, CAM_SCAL, CAM_XOFF, and CAM_YOFF keywords. All of the keywords are identical for the two CAMS units, but their values are different.

5.2.1 Primary Header Keywords

The mandatory CALDB keywords are listed below together with their values for the CAMS teldef

Table 5.2.1		
Keyword name	Keyword value	
CALDB Keywords		
TELESCOP	'HITOMI '	/ Telescope (mission) name
INSTRUME	'CAMS1' or 'CAMS2'	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'TELDEF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'TELESCOPE DEFINITION FILE'	/ Brief descriptive summary of this file

5.3 HXI Telescope Description File

This file contains data for the structure of the HXI X-ray telescope, describing the mirror foils and their reflective surfaces, the support structure, a pre-collimator if present, as well as rotational and translational offsets of the telescope components relative to each other. See the common part chapter for details.

There are two files one for each HXI with the following filenames:

ah_hx1_mirror_YYYYMMDDvxxx.fits.

ah_hx2_mirror_YYYYMMDDvxxx.fits.

5.4 HXI Reflectivity and Transmission File

This file contains data for the reflectivity and transmission of the front-side mirror coatings of an X-ray telescope, and reflectivity tables for the backside of mirror foils and for pre-collimator foils. It also contains, in a different extension, the mass-absorption coefficients of all the materials that a complete mirror foil is composed of. The coatings may be of single-layer or multi-layer types. See the common part chapter for details.

There are two files one for each HXI with the following filenames:

ah_hx1_reftrans_YYYYMMDDvxxx.fits.

ah_hx2_reftrans_YYYYMMDDvxxx.fits.

5.5 HXI Scattering File

This file contains data for the probability of a photon scattering relative to the reflection direction for specular reflection when reflecting on the an XRT foil. See the common part chapter for details.

There are two files one for each HXI with the following filenames:

ah_hx1_scatter_YYYYMMDDvxxx.fits.

ah_hx2_scatter_YYYYMMDDvxxx.fits.

5.6 HXI Telescope area

This file contains the teslescope area derived from ray-tracing calculation. See the common part chapter for details.

ah_hx1_telarea_YYYYMMDDvxxx.fits.

ah_hx2_telarea_YYYYMMDDvxxx.fits.

5.7 HXI Point Spread Function File

This file contains point spread function (PSF) library. See the common part chapter for details.

ah_hx1_psf_YYYYMMDDvxxx.fits.

ah_hx2_psf_YYYYMMDDvxxx.fits.

5.8 HXI Vignetting File

The file name is

ah_hx1_vignet_YYYYMMDDvxxx.fits.

ah_hx2_vignet_YYYYMMDDvxxx.fits.

This file contains vignetting function library. See the common part chapter for details.

5.9 HXI Event File

This file contains library from ray-tracing. See the common part chapter for details.

There are two files one for each HXI with the following filenames:

ah_hx1_event_YYYYMMDDvxxx.fits.

ah_hx2_event_YYYYMMDDvxxx.fits.

5.10 CAMS Temperature correction file (HXI/CAMS)

This file contains the temperature variation corrections to apply to the CAMS telemetered X and Y delta positions. The filename is:

ah_cms_tempxy_YYYYMMDDvXXX.fits

The values are applied to the CAMS FFF file to correct the X_RAW, Y_RAW telemetered values to the X, Y. The cause of this effect is understood as thermal deformation of optics (laser, lens, and support structure) in CAMS-LD, since error correlates with optics temperature. Preliminary measurements indicate that the temperature dependence is linear, of the form

$X_{corrected} = X_{raw} + (dX/dT)(T - T_{ref})$ and $Y_{corrected} = Y_{raw} + (dY/dT)(T - T_{ref})$

where the (X_{raw}, Y_{raw}) are the uncorrected values, $(X_{corrected}, Y_{corrected})$ are the corrected values. Then T is the temperature from the

telemetry and the remaining factors are the calibration numbers:

- dX/dT is the slope of the relationship X vs T (XCOEFF column).
- dY/dT is the slope of the relationship Y vs T (YCOEFF column).
- T_{ref} is a reference temperature for the calibration (XOFFSET, YOFFSET columns).

The correction can depend on as many as six sets of parameters for each dimension (X and Y). These six sets are denoted by RTn, where n is numbered 1:6. There are two extensions in this file, one for each CAMS unit. The formats are identical containing the following columns :

- Columns 1-4 contain the first set of coefficients, in order RT1_XCOEFF (dX/dT), RT1_XOFFSET (T_{ref}), RT1_YCOEFF (dY/dT), RT1_YOFFSET (T_{ref}).
- Columns 5-8 contain the second set of coefficients, in order RT2_XCOEFF (dX/dT), RT2_XOFFSET (T_{ref}), RT2_YCOEFF (dY/dT), RT2_YOFFSET (T_{ref}).
- Columns 9-12 contain the second set of coefficients, in order RT3_XCOEFF (dX/dT), RT3_XOFFSET (T_{ref}), RT3_YCOEFF (dY/dT), RT3_YOFFSET (T_{ref}).
- Columns 13-16 contain the second set of coefficients, in order RT4_XCOEFF (dX/dT), RT4_XOFFSET (T_{ref}), RT4_YCOEFF (dY/dT), RT4_YOFFSET (T_{ref}).
- Columns 17-20 contain the second set of coefficients, in order RT5_XCOEFF (dX/dT), RT5_XOFFSET (T_{ref}), RT5_YCOEFF (dY/dT), RT5_YOFFSET (T_{ref}).
- Columns 21-24 contain the second set of coefficients, in order RT6_XCOEFF (dX/dT), RT6_XOFFSET (T_{ref}), RT6_YCOEFF (dY/dT), RT6_YOFFSET (T_{ref}).

5.10.1 File Format

Table 5.10.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1 & 2	BINTABLE	CAMS_TEMPXY	
	Column Names	Format	Units
	RT1_XCOEFF	1D	mm/degC
	RT1_XOFFSET	1D	degC
	RT1_YCOEFF	1D	mm/degC
	RT1_YOFFSET	1D	degC
	RT2_XCOEFF	1D	mm/degC
	RT2_XOFFSET	1D	degC
	RT2_YCOEFF	1D	mm/degC
	RT2_YOFFSET	1D	degC
	RT3_XCOEFF	1D	mm/degC

Table 5.10.1			
Extension N.	Type	Ext. Name	
	RT3_XOFFSET	1D	degC
	RT3_YCOEFF	1D	mm/degC
	RT3_YOFFSET	1D	degC
	RT4_XCOEFF	1D	mm/degC
	RT4_XOFFSET	1D	degC
	RT4_YCOEFF	1D	mm/degC
	RT4_YOFFSET	1D	degC
	RT5_XCOEFF	1D	mm/degC
	RT5_XOFFSET	1D	degC
	RT5_YCOEFF	1D	mm/degC
	RT5_YOFFSET	1D	degC
	RT6_XCOEFF	1D	mm/degC
	RT6_XOFFSET	1D	degC
	RT6_YCOEFF	1D	mm/degC
	RT6_YOFFSET	1D	degC

5.10.2 Header Keywords

The mandatory CALDB keywords are listed below together with their values for the gain coefficient table:

Table 5.10.2		
Keyword name	Keyword value	Comment
Extension 1		
EXTNAME	CAMS1_TEMPXY	/ Name of the binary table extension
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘CAMS1’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘TEMP_CORRECTION’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data

CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘CAMS TEMP CORRECTION’	/ Brief descriptive summary of this file
Extension 2		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘CAMS2’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘TEMP_CORRECTION’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘CAMS TEMP CORRECTION’	/ Brief descriptive summary of this file

5.11 CAMS Timing offset file (HXI/CAMS)

This file contains the time offset and time_code used in the calculation of the times for each of the CAMS measurements. The filename is:

ah_cms_offset_YYYYMMDDvXXX.fits

In the CAMS data stream, there are five values of X and Y positions for each read out timestamp. The times for each X and Y value is calculated based on the common timestamp and an offset. The adjusted time TIME_ADJ is derived from:

TIME_ADJ = TIME_ORIG – TPERIOD + OFFSET[TIME_CODE] + DELAY.

The TIME_ORIG is the timestamp for a given read out. The TIME_CODE is a number associated with each position value within a readout and is associated to an OFFSET. The file contains two columns: TIME_CODE and OFFSET. The header contains also the keywords TPERIOD and TFREQ. TPERIOD is the period of the read out. This is nominally one second. TFREQ is the number of measurements within a time stamp.

The TIME_CODE index for OFFSET runs 0:63 and if TPERIOD is one second, each successive OFFSET value is 1/64 second. The DELAY is common to the CAMS and is read from a different calibration file.

5.11.1 File Format

Table 5.11.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	CAMS_OFFSET	
	Column Names	Format	Units

Table 5.11.1			
Extension N.	Type	Ext. Name	
	OFFSET	1D	s
	TIME_CODE	1J	-

5.11.2 Keywords

Table 5.11.2		
Keyword name	Keyword value	
CALDB Keywords for the first extension		
EXTNAME	CAMS_OFFSET	/ Name of the binary table extension
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘CAMS’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘TIME_OFFSET’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘CAMS TIMING OFFSETS’	/ Brief descriptive summary of this file
TFREQ	5	/Number of measurement in a period
TPERIOD	1	/Period of the start for the measurements

5.12 Gain calculation coefficient File

This file contains the coefficients for calculating the HXI gain. There are two files one for each HXI with the following filenames:

ah_hx1_gain_yyyymmddvnn.fits

ah_hx2_gain_yyyymmddvnn.fits

Each of the gain file contain a single binary extension each contain a single extension. The coefficients in the files are used to construct for each channel a 3rd order spline. The columns for the HXI are defined as follows:

- ASIC_ID : contain the hardware address of the ASIC from which the data is read. There are 8 ASICs for each of 5 layers for a total of 40 ASICs. The ASIC_ID runs 0,16,32,48,64,80,96,112 for layer 1; 1,17,33,49,65,81,97,113 for layer 2; 2,18,34,50,66,82,98,114 for layer 3; 3,19,35,51,67,83,99,115 for layer 4; and 4,20,36,52,68,84,100,116 for layer 4.
- READOUT_ID : contain the ASIC channel number, which runs 0:31.
- READOUT_ID_RMAP: contain the remapping of the READOUT_ID into a continuous numbering running 1:1280.

- NINTERVAL: contain the number of intervals over which the spline function is constructed for each channel.
- INTERVALX: contain the lower value of the PHA for each of the interval.
- COEFFX3 : contain the coefficient of the cubic (x^3) term.
- COEFFX2 :contain the coefficient of the squared (x^2) term.
- COEFFX1: contain the coefficient of the linear (x) term.
- COEFFX0 : contain the coefficient of the constant term.

5.12.1 File Format

Table 5.12.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	PHAGAIN	
	Column Name	Format	Units
	ASIC_ID	1I	-
	READOUT_ID	1I	-
	READOUT_ID_RMAP	1I	-
	NINTERVAL	1I	-
	INTERVALX	PE(n+1)	-
	COEFFX3	PE(n)	-
	COEFFX2	PE(n)	-
	COEFFX1	PE(n)	-
	COEFFX0	PE(n)	-

where n is a value in “NINTERVAL” column.

5.12.2 Header Keywords

Table 5.12.2		
Keyword name	Keyword value	
CALDB Keywords for the first extension		
EXTNAME	PHAGAIN	/ Name of the binary table extension
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘HXI1’ or ‘HXI2’	/ Instrument name

DETNAM	‘CAMERA’	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘GAIN’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘HXI*n* GAIN COEFFICIENTS’	/ Brief descriptive summary of this file

5.13 HXI energy cut File

This file contains the coefficients to construct curves that defined valid energies regions between the top and the bottom side for each layer. There are two files one for each HXI with the following filenames:

ah_hx1_enecut_yyyymmddvnn.fits
ah_hx2_enecut_yyyymmddvnn.fits

The curves are defined by a 3rd order spline function using the coefficient in the table. Hits that fall within the curve defining for the top side and the bottom side are considered valid. The file consists of two extensions LOWER and UPPER each with the following the same columns:

- LAYER is layer of detector.
- NINTERVAL: contain the number intervals over which the spline function is constructed.
- INTERVALX: contain the lower value of the PHA for each of the interval.
- COEFFX3 : contain the coefficient of the cubic (x^3) term.
- COEFFX2 : contain the coefficient of the squared (x^2) term.
- COEFFX1 : contain the coefficient of the linear (x) term.
- COEFFX0 : contain the coefficient of the constant term.

5.13.1 File Format

Table 5.13.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	LOWER/UPPER	
	Column Name	Format	Units
	LAYER	I	-
	NINTERVAL	I	-
	INTERVALX	PE(n+1)	-
	COEFFX3	PD(n)	-

Table 5.13.1			
Extension N.	Type	Ext. Name	
	COEFFX2	PD(n)	-
	COEFFX1	PD(n)	-
	COEFFX0	PD(n)	-

5.13.2 Header Keywords

Table 5.13.2		
Keyword name	Keyword value	
CALDB Keywords for the first and second extensions		
EXTNAME	LOWER (ext 1) /UPPER (ext 2)	/ Name of the binary table extension
TELESCOP	'HITOMI'	/ Telescope (mission) name
INSTRUME	'HXI1' or 'HXI2'	/ Instrument name
DETNAM	'CAMERA'	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'ECUT_LOWER' (ext 1) 'ECUT_UPPER' (ext 2)	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	'YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'ENERGY CUT CONDITION'	/ Brief descriptive summary of this file

5.14 Fluorescence line profile file

This file contains the energies of the fluorescence for the CdTe and Si material used in the HXI detector. The file name is ah_hxi_lineYYYYMMDDvxxx.fits
For each line the center, minimum and maximum energies are provided. A keyword, HXIRESOL, indicates the energy resolution. The file has one extension with the following columns :

- MATERIAL: contain the material number (0:2). Si is 0 , CdTe bottom is 1, CdTe top is 2.
- MATERIALNAME: contain the material name (Si or CdTe, and the CdTe side and bottom for the SGD).
- FLUORESCENCE: indicate which the fluorescence line.
- ENERGY : contain the center of the line energy in keV.

- LINEMIN and LINEMAX : column contain the minimum and maximum energies for the line energy.

5.14.1 File Format

Table 5.14.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	FLUORESCENCE	
	Column Names	Format	Units
	MATERIAL	1I	-
	MATERIALNAME	10A	-
	FLUORESCENCE	12A	-
	ENERGY	1E	keV
	LINEMIN	1E	keV
	LINEMAX	1E	keV

5.14.2 Header Keywords

Table 5.14.1		
Keyword name	Keyword value	
CALDB Keywords for the first extension		
EXTNAME	FLUORESCENCE	/ Name of the binary table extension
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘HXI’	/ Instrument name
DETNAM	‘CAMERA’	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘LINE_ENERGY	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'FLOURESCENCE LINE ENERGY’	/ Brief descriptive summary of this file
HXIRESOL	1.0	/ HXI energy resolution (keV in FWHM)

5.15 HXI Instrument Map

The file contains images in the FOC and RAW coordinates in the primary and first extensions, respectively. There are two files one for each od the HXI with the following filenames :

ah_hx1_instmap_YYYYMMDDvxxx.fits
ah_hx2_instmap_YYYYMMDDvxxx.fits

The file contain an image in the primary header and one image in the first extension using an IMAGE FITS format extension The array is 2430 x 2430 for the primary, and 128 x 128 for the first extension. Each pixel has a value of 1 if the pixel is included in the FOV, and a value of 0 if out of FOV. The primary and 1st Image extensions contain the WCS keywords. The image in RAW coordinates contains additional keywords to useful to coordinates transformation.

5.15.1 Header Keywords

1st ext:

Table 5.15.1.1

Keyword name	Keyword value	Comment
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'INSTMAP_FOC'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	‘Instrument Map file’	/Description
INSTRUME	'HXI1' or 'HXI2'	/Instrument name
CTYPE1	‘FOCX’	Name of the X axis
CTYPE1	‘FOCY’	Name of the Y axis
CUNIT1	‘pixel’	Unit for X-axis
CUNIT2	‘pixel’	Unit for Y-axis
CRVAL1	1215.5	FOCX image reference pixel value
CRPIX1	1215.5	FOCX image reference pixel
CDELT1	1	FOCX pixel scale
CRVAL2	1215.5	FOCY image reference pixel value
CRPIX2	1215.5	FOCY image reference pixel
CDELT2	1	FOCY pixel scale

2nd ext:

Table 5.15.1.2		
Keyword name	Keyword value	Comment
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'INSTMAP_RAW’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	‘Instrument Map file’	/Description
EXTNAME	‘INSTMAP	/Name of the binary table extension
INSTRUME	'HXI1' or 'HXI2'	/Instrument name
CTYPE1	‘RAWX	Name of the X axis
CTYPE1	‘RAWY	Name of the Y axis
CUNIT1	‘pixel’	Unit for X-axis
CUNIT2	‘pixel’	Unit for Y-axis
CRVAL1	64.5	DETX image reference pixel value
CRPIX1	64.5	4.5
CDELT1	1	DETX pixel scale
CRVAL2	64.5	DETY image reference pixel value
CRPIX2	64.5	DETY image reference pixel
CDELT2	1	FOCY pixel scale
OPTAXISX	128.470 (HXI1), 126.63(HXI2)	optical axis x in DET coordinates (pixel)
OPTAXISY	127.010 (HXI1), 123.3424 (HXI2)	optical axis y in DET coordinates (pixel)
RAW_XSCL	0.250	RAW X scale (mm/pixel)
RAW_YSCL	0.250	RAW Y scale (mm/pixel)
ACT_XSCL	0.250	ACT X scale (mm/pixel)
ACT_YSCL	0.250	ACT Y scale (mm/pixel)
ACT_XSIZ	256	ACT address space x size (pixel)

ACT_YSIZ	256	ACT address space y size (pixel)
DET_XSCL	0.250	DET X scale (mm/pixel)
DET_YSCL	0.250	DET Y scale (mm/pixel)
DETXFLIP	-1	Flip to DET X system
DETYFLIP	1	Flip to DET Y system
FOCALLEN	12000.0	SXI focal length (mm)
FOC_XSCL	0.103	FOC X scale (mm/pixel)
FOC_YSCL	0.103	FOC Y scale (mm/pixel)
DET_XSIZ	256	DET address space x size (pixels)
DET_YSIZ	256	DET address space y size (pixels)
FOC_XSIZ	2430	FOC address space x size (pixels)
FOC_YSIZ	2430	FOC address space y size (pixels)
FOC_XOFF	0.401 (HXI1), -1.063 (HXI2)	DETX offset (pixel) to the FOC center position
FOC_YOFF	-2.042 (HXI1), 5.744 (HXI2)	DETY offset (pixel) to the FOC center position
FOC_ROTD	22.5 (for HXI1), -22.5 (for HXI2)	DET rotation angle (deg) in FOC coordinates
OPT_ROTD	0.0	rotation of telescope output system wrt DET
OPTXFLIP	1	flip of telescope axes relative to DETX/Y
OPTYFLIP	-1	flip from (look-down) to (look-up)
ROT00	-2.24554053	transform matrix component
ROT01	0.93013334	transform matrix component
ROT10	0.93013334	transform matrix component
ROT11	2.24554053	transform matrix component
SHIFTX	1301.3426 (HXI1), 1428.0607(HXI2)	translation in X
SHIFTY	1015.6274 (HXI1), 1118.7466(HXI2)	translation in Y

5.16 Bad/active pixel file

The file contains active pixels and energy thresholds for the HXI. There are two files one for each od the HXI with the following filenames:

ah_hx1_badpix_yyyymmddvnn.fits

ah_hx2_badpix_yyyymmddvnn.fits

The file has one extension with the following columns:

- TIME: contain the time as second since the mission elapse time.

- ALIVE_ASIC: contain the number of alive ASIC.
- ASIC_ID : contain the hardware address of the ASIC from which the data is read. There are 8 ASICs for each of 5 layers for a total of 40 ASICs. The ASIC_ID runs 0,16,32,48,64,80,96,112 for layer 1; 1,17,33,49,65,81,97,113 for layer 2; 2,18,34,50,66,82,98,114 for layer 3; 3,19,35,51,67,83,99,115 for layer 4; and 4,20,36,52,68,84,100,116 for layer 4.
- READOUT_ID : contain the ASIC channel number, which runs 0:31.
- READOUT_ID_RMAP: contain the remapping of the READOUT_ID into a continuous numbering running 1:1280.
- ACTIVE_FLAG: contain a flag that indicates if a pixel is active or not (0=bad, 1=good, 2=strange).
- EPI_THRE: contain the energy threshold for conversion from PHA to EPI for each readout channel.
- DATAMODE: contain the datamode value, NORMALn where n start from 1 and is incremented if ACTIVE_FLAG or EPI_THRE are updated.

5.16.1 File Format

Table 5.16.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	BADPIX	
	Column Names	Format	Units
	TIME	1D	s
	ALIVE_ASIC	1I	-
	ASIC_ID	1280I	-
	READOUT_ID	1280I	-
	READOUT_ID_RMAP	1280I	-
	ACTIVE_FLAG	1280B	-
	EPI_THRE	1280E	keV
	DATAMODE	12A	-

5.16.2 Header Keywords

Table 5.16.2		
Keyword name	Keyword value	
CALDB Keywords for the first extension		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘HXI1’or ‘HXI2’	/ Instrument name

DETNAM	‘CAMERA’	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘BADPIX’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘ACTIVE PIXEL AND THRESHOLD’	/ Brief descriptive summary of this file

5.17 Channel remapping file

The file contains a remapping table to identify each ASIC and readout channel with a unique number. The basic hardware values are ASIC_ID (0:116 for HXI) and READOUT_ID (0:31 for HXI). The range of ASIC_ID are 0:4, 16:20, 32:36 ,48:52,64:68, 80:84,96:100,112:116. The filename is :

ah_hxi_remap_YYYYMMDDvxxx.fits

The file contains one binary table with the following columns:

- ASIC_ID : contain the hardware address of the ASIC from which the data is read. There are 8 ASICs for each of 5 layers for a total of 40 ASICs. The ASIC_ID runs 0,16,32,48,64,80,96,112 for layer 1; 1,17,33,49,65,81,97,113 for layer 2; 2,18,34,50,66,82,98,114 for layer 3; 3,19,35,51,67,83,99,115 for layer 4; and 4,20,36,52,68,84,100,116 for layer 4.
- READOUT_ID : contain the ASIC channel number, which runs 0:31.
- ASIC_ID_RMAP : contain the remapping of the ASIC_ID into a continuous numbering running 1:40.
- READOUT_ID_RMAP: contain the remapping of the READOUT_ID into a continuous numbering running 1:1280.
- SENSOR_ID : contain the number of the sensor or layer, which runs 0:4.
- ASIC_INDEX: contain the index number 0:7 for the ASICs in a given layer.
- RAWX : contain the strip index in the X-direction (bottom layer).
- RAWY: contain the strip index in the Y-direction (top layer).

5.17.1 File Format

Table 5.17.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	REMAPPING	
	Column Names	Format	Units
	ASIC_ID	1I	-
	READOUT_ID	1I	-
	ASIC_ID_RMAP	1I	-

Table 5.17.1			
Extension N.	Type	Ext. Name	
	READOUT_ID_RMAP	1I	-
	SENSOR_ID	1I	-
	ASIC_INDEX	1I	-
	LAYER	1I	-
	RAWX	1I	-
	RAWY	1I	-

5.17.2 Header Keywords

Table 5.17.2		
Keyword name	keyword value	
CALDB Keywords		
TELESCOP	'HITOMI'	/ Telescope (mission) name
INSTRUME	'HXI'	/ Instrument name
DETNAM	'CAMERA'	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'REMAPPING'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'HXI Channel Remapping Table'	/ Brief descriptive summary of this file

5.18 HXI Quantum Efficiency

The quantum efficiency is used to generate the arf. The names of these two files are the following

ah_hxX_quanteff_YYYYMMDDvxxx.fits

where X is either 1 or 2 to identify the HX1 or HXI2.

The quantum efficiency file has 2 extensions. The first has for each RAWX and RAWY the QE for each of the layers and the 2nd contains the energy at which the QE is sampled. The input energy grid is sample course and identical to the one of the quantum efficiency sampling. The quantum efficiency BINARY table extension contain the following columns:

- RAWX is the coordinates calculated from the event reconstruction (X value)

- RAWY is the coordinates calculated from the event reconstruction (Y value)
- QE_LAYER0(n) are the quantum efficiency for each pixel derived for n energy for layer 0
- QE_LAYER1(n) are the quantum efficiency for each pixel derived for n energy for layer 1
- QE_LAYER2(n) are the quantum efficiency for each pixel derived for n energy for layer 2
- QE_LAYER3(n) are the quantum efficiency for each pixel derived for n energy for layer 3
- QE_LAYER4(n) are the quantum efficiency for each pixel derived for n energy for layer 4

The 2nd extension contains only one column recording the ENERGY.

5.18.1 File Format

Table 5.18.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	QE	
	Column Names	Format	Units
	RAWX	1I	-
	RAWY	1I	-
	QE_LAYER0	nE	-
	QE_LAYER1	nE	-
	QE_LAYER2	nE	-
	QE_LAYER3	nE	-
	QE_LAYER4	nE	-
2	BINTABLE	ENERGY	
	ENERGY	1E	keV

5.18.2 Header Keywords

Table 5.18.2		
Keyword name	Keyword value	
CALDB Keywords first extension		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘HXI1’ or ‘HXI2’	/ Instrument name
DETNAM	‘CAMERA’	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File

CCNM0001	‘QE’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘Quantum efficiency per layer’	/ Brief descriptive summary of this file
CALDB Keywords second extension		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘HXI1’ or ‘HXI2’	/ Instrument name
DETNAM	‘CAMERA’	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘ENERGY’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘Energy for quantum efficiency and line spread function’	/ Brief descriptive summary of this file

5.19 HXI Line Spread Function file

The file contains line spread function (or redistribution matrix) for each layer of the HXI. The file name is

ah_hxX_lsf_YYYYMMDDvNNN.fits

where X is either 1 or 2 to identify the HX1 or HXI2. The structure is an empty primary with 6 bintable extensions. The first 5 extensions have the same format of the MATRIX table in the RMF table and the 6th extension the same of EBOUNDS in a RMF (see common section). The line spread function files are not used for spectral fitting nor for calibration.

5.19.1 File Format

Table 5.19.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1-5	BINTABLE	RMF_LAYERn (n=0-4)	
	Column Names	Format	Units
	ENERG_LO	1E	keV
	ENERG_HI	1E	keV

Table 5.19.1			
Extension N.	Type	Ext. Name	
	N_GRP	1I	-
	F_CHAN	1I	-
	N_CHAN	1I	-
	MATRIX	PE(*n*)	-
6	BINTABLE	EBOUNDS	
	Column Names	Format	Units
	CHANNEL	1I	-
	E_MIN	1E	keV
	E_MAX	1E	keV

5.19.2 Header Keywords

Extension 1-5:

Table 5.19.2.1		
Keyword name	Keyword value	Comment
CALDB Keywords		
INSTRUME	‘HXI1’ or ‘HXI2’	/Instrument name
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	‘RMF_LAYERn’	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Line Spread Function’	/Description

Extension 6:

Table 5.19.2.2		
Keyword name	Keyword value	Comment
Mandatory header keywords		
CALDB Keywords		
INSTRUME	‘HXI1’ or ‘HXI2’	/Instrument name

CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'EBOUNDS'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'Energy boundaries of spectral bins'	/Description

5.20 HXI Redistribution Matrix File (RMF)

These files are rmf for each HXI layer and a RMF combining all layers. There is one set valid for both HXI and the filename is

ah_hxi_layerN_YYYYMMDDvxxx.rmf

where N is 0-4 to id the 5 HXI layers and a for all layers. These files are in the Calibration product file (CPF) directory. The structure is an empty primary with 2 bintable extensions with the standard OGIP format for matrix. See the common part section for details. Each file has standard CALDB keywords and they differs by the calibration boundaries keyword values:

Table 5.20.1		
Keyword name	Keyword value	Comment
CALDB Keywords		
INSTRUME	‘HXI’	/Instrument name
CCLS0001	'CPF'	/Dataset is Basic Calibration File
CCNM0001	'MATRIX’ or EBOUNDS'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘RESPONSE MATRIX’ or ‘EBOUDS’	/Description
CBD10001	LAYER(n)	/ Parameter boundaries
CBD10002	DETCHANS(2048)	/Parameter boundaries
CBD10001	CHAN(0-2047)	/Parameter boundaries
CBD10001	CHANTYPE(‘PI’)	/Parameter boundaries

5.21 HXI Ancillary Response File (ARF)

A prepared ARF for a simulation purpose based on the ground calibrations. The file name is

ah_hxi_arfpnt_YYYYMMDDvxxx.arf
ah_hxi_arfext_YYYYMMDDvxxx.arf

This is a Calibration product file (CPF). The structure is an empty primary with 1 bintable extension, with columns in the standard OGIP format. See the common part section for details.

5.22 HXI Non X-ray Background Spectrum File (NXB)

These files are the Non X-ray Background for the HXI. The version pre-launch is named as :

ah_hxi_nxbpntl_yyyymmddvnn.pha
ah_hxi_nxbpnts_yyyymmddvnn.pha
ah_hxi_ nxbext _yyyymmddvnn.pha

where nxbpntl is the NXB for point source with extraction region of 4 arcmin; nxbpnts is the NXB for point source with extraction region of 1.8 arcmin and nxbext is the NXB for extended region. These files are in the Calibration product file (CPF) directory. The structure is an empty primary with 1 bintable extensions with the standard OGIP format for pha file. See the common part section for details. Each file has standard CALDB keywords and they differs by the calibration boundaries keyword values:

Table 5.22

Keyword name	Keyword value	Comment
CALDB Keywords		
INSTRUME	'HXI'	/Instrument name
CCLS0001	'CPF'	/Dataset is Basic Calibration File
CCNM0001	'SPECTRUM'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'NXB spectrum for point source' (for nxbpntl and nxbpnts) 'NXB spectrum for extended source' (for nxbext)	/Description
CBD10001	SRCTYPE(PNT)(for nxbpntl and nxbpnts) SRCTYPE(EXT) (for nxbext)	/ Parameter boundaries
CBD20001	EXTRAD(4.0) (for nxbpntl) EXTRAD(1.8) (for nxbpnts) Not defined for nxbext	/Parameter boundaries

6 SGD

6.1 SGD Teldef File

This file contains the telescope definition file for the SGD. The format consists in a primary header that contains all keywords that defines the telescope coordinate systems. There are two files one for each SGD with the following filenames:

ah_sg1_teldef_ yyyymmddvnn.fits (SGD1)

ah_sg2_teldef_ yyyymmddvnn.fits (SGD2)

For the HXI, there are two coordinate types defined in the COORDn keywords (FOC, SKY). Each coordinates type is defined by the keywords: nnn_XSIZ, nnnXPIX1 nnn_XSCL, nnn_YSIZ, nnnYPIX1, nnn_YSCL, nnn_UNIT. The transformation types between coordinate systems are defined as:

TRTYPE3 = 'SKYATT ' / FOC to SKY

The FOC to SKY transformation is governed by the FOC_Mxx , FOC_ROTD, FOCALLEN and aligned matrix (ALIGNnn) keywords, and uses the spacecraft attitude file. The OPTnnnn keywords defined the optical axis measured in ground in DET coordinates. The ROLLnnnn keywords defined the sign of the rlll angle and the offset.

6.1.1 Primary Header Keywords

The mandatory CALDB keywords are listed below together with their values for the SGD teldef.

Table 6.1.1.		
Keyword name	keyword value	
CALDB Keywords		
TELESCOP	'HITOMI '	/ Telescope (mission) name
INSTRUME	'SGD1' or 'SGD2'	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'TELDEF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'TELESCOPE DEFINITION FILE'	/ Brief descriptive summary of this file

6.2 Gain calculation coefficient File

This file contains the coefficients for calculating the SGD gain. There are two files one for each SGD with the following filenames:

ah_sg1_gain_yyyymmddvnn.fits

ah_sg2_gain_yyyymmddvnn.fits

Each of the gain file contain a single binary extension each containing 6 extensions. Three extensions are for each the three Compton Camera when the trigger is occurring in Silicon layer (GAIN) , the other additional 3 extensions are for when the trigger is not in Silicon (ALTGAIN) . The coefficients in the files are used to construct for each channel a 3rd order spline. The columns for each of the SGDm-CCn are defined as follows:

- ASIC_ID : contain the hardware address of the ASIC from which the data is read. There are 208 total ASICs, organized as Silicon: 32 layers * 4 ASIC/layer = 128; CdTe bottom: 8 layers * 4 ASIC/layer = 32; CdTe side: 4 sides * 2 layers * 6 ASIC/layer = 48.
- READOUT_ID : contain the ASIC channel number, which runs 0:63
- READOUT_ID_RMAP: contain the remapping of the READOUT_ID into a continuous numbering running 1:13312.
- NINTERVAL: contain the number of intervals over which the spline function is constructed for each channel.
- INTERVALX: contain the lower value of the PHA for each of the interval.
- COEFFX3 : contain the coefficient of the cubic (x^3) term.
- COEFFX2 :contain the coefficient of the squared (x^2) term.
- COEFFX1: contain the coefficient of the linear (x) term.
- COEFFX0 : contain the coefficient of the constant term.

6.2.1 File Format

Table 6.2.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1-3	BINTABLE	PHAGAIN	
	Column Names	Format	Units
	ASIC_ID	1I	-
	READOUT_ID	1I	-
	READOUT_ID_RMAP	1I	-
	NINTERVAL	1I	-
	INTERVALX	PE(n+1)	-
	COEFFX3	PE(n)	-
	COEFFX2	PE(n)	-
	COEFFX1	PE(n)	-
	COEFFX0	PE(n)	-

where n is a value in “NINTERVAL” column.

6.2.2 Header Keywords

The mandatory CALDB keywords are listed below together with their values for the gain coefficient table:

Table 6.2.2		
Keyword name	Keyword value	Comment
CALDB Keywords		
TELESCOP	'HITOMI'	/ Telescope (mission) name
INSTRUME	'SGD1' or 'SGD2'	/ Instrument name
DETNAM	'CC1' or "CC2' or CC3'	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'GAIN' or 'ALTGAIN'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'INSTRUME DETNAM GAINCOEFFICIENTS' or 'INSTRUME DETNAM ALTERNATIVE GAIN COEFFICIENTS'	/ Brief descriptive summary of this file

6.3 Fluorescence line profile file

This file contains the energies of the fluorescence for the CdTe and Si material used in the SGD detector. The file name is ah_sgd_lineYYYYMMDDvxxx.fits

For each line the center, minimum and maximum energies are provided. Two keywords indicate the energy resolution in Si and CdTe and other the Error in Si and cdTe top and bottom. The file has one extension with the following columns:

- MATERIAL: contain the material number (0:2). Si is 0 , CdTe bottom is 1, CdTe top is 2.
- MATERIAL_NAME: contain the material name (Si or CdTe, and the CdTe side and bottom for the SGD).
- FLUORESCENCE: indicate which the fluorescence line.
- ENERGY : contain the center of the line energy in keV.
- LINEMIN and LINEMAX : column contain the minimum and maximum energies for the line energy.

6.3.1 File Format

Table 6.3.1		
Extension N.	Type	Ext. Name
0	PRIMARY	

Table 6.3.1			
Extension N.	Type	Ext. Name	
1	BINTABLE	FLUORESCENCE	
	Column Names	Format	Units
	MATERIAL	1I	-
	MATERIALNAME	10A	-
	FLUORESCENCE	12A	-
	ENERGY	1E	keV
	LINEMIN	1E	keV
	LINEMAX	1E	keV

6.3.2 Header Keywords

The mandatory CALDB keywords are listed below together with their values for the fluorescence line

Table 6.3.2		
Keyword name	Keyword value	Comment
CALDB Keywords		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘SGD’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘LINE_ENERGY	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'SGD FLUORESCENCE LINE ENERGY’	/ Brief descriptive summary of this file
ERRSI	‘2.0,0.0,0.06’	/ Error for SI
ERRCDBTM	‘2.5,0.0,0.02’	/ Error for CdTe bottom
ERRCDSID	‘2.5,0.0,0.02’	/ Error for CdTe side
SGDCDRES	2.0	/ SGD CdTe energy resolution
SGDSIRES	3.0	/ SGD Si energy resolution

6.4 Field-of-View Probability file

This file contains the probability that an event is in the field of view of the SGD. The filename is
ah_sgd_probfov_YYYYMMDDvXXX.fits
The file format has one empty primary header and 9 extensions with the following names:

- LIKELIHOOD: probability corresponding to the combination of all parameters listed in the following extension
- ENE_TOTAL: total energy
- DISTANCE0 : minimum distance
- CAMERAX [mm] : physical location of the pixel in the X-direction.
- CAMERAY [mm] : physical location of the pixel in the Y-direction.
- CAMERAZ [mm] : physical location of the pixel in the Z-direction.
- COMPTON_PH [deg] : phi angle.
- COMPTON_TH [deg] : theta angle.
- OFFAXIS [deg] : off-axis angle.

Each extension has a single column: first extension the column name is 'LIKELIHOOD', whereas the others extensions the column is named 'VALUE'. The extensions from 2-9 contain the value of the parameters that are used to derived the likelihood. The order in which the likelihood values are stored in the column LIKELIHOOD depends on how the combination of the parameters that contribute to the likelihood, The header of the 1st extension contains keywords named PARAMn set to indicate how he parameter order is combined to get the value in the LIKEliHOOD. The PARAMn established which parameter changes fast higher n is changing faster, lower n changes slow. The 1st value of the LIKELIHOOD column is obtained using the 1st value of all parameter, the second is using the same parameter setting of the 1st row but using the second value of the last parameter setting (higher N) and so on. The row number is obtained using the expression:

$$row = 1 + SUM_{\{j=1, N\}} (I_j - 1) PROD_{\{k=j+1, N\}} n_K$$

where N is the total number of parameter (8 in this case) , n is the number of parameter value for each parameter and that is different for each of the parameter, I_j is the set of parameters for which need to find the likelihood.

6.4.1 File Format

Table 6.4.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	LIKELIHOOD	
	Column Names	Format	Units
	LIKELIHOOD	1E	-
2		ENE_TOTAL	
	Column Names	Format	Units
	VALUE	1E	keV
3		DISTANCE0	
	Column Names	Format	Units
	VALUE	1E	mm

Table 6.4.1			
Extension N.	Type	Ext. Name	
4		CAMERAX	
	Column Names	Format	Units
	VALUE	1E	mm
5		CAMERAY	
	Column Names	Format	Column Names
	VALUE	1E	VALUE
6		CAMERAZ	
	Column Names	Format	Column Names
	VALUE	1E	VALUE
7		COMPTON_PH	
	Column Names	Format	Column Names
	VALUE	1E	deg
8		COMPTON_TH	
	Column Names	Format	Column Names
	VALUE	1E	deg
9		OFFAXIS	
	Column Names	Format	Column Names
	VALUE	1E	deg

6.4.2 Extension Keywords for each extension

Table 6.4.2		
Keyword name	keyword value	Comment
CALDB Keywords		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘SGD’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	same as the extension name	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)

CDES0001	'SGD FIELD OF VIEW PROBABILITY'	/ Brief descriptive summary of this file
Keywords only for Ext 1		
PARAM0	OFFAXIS	offaxis
PARAM1	DISTANCE0	distance
PARAM2	ENE_TOTAL	energy total
PARAM3	CAMERAX	camera x
PARAM4	CAMERAY	camera y
PARAM5	CAMERAZ	camera z
PARAM6	COMPTON_PH	phi for Compton scattering
PARAM7	COMPTON_TH	theta for Compton scattering

6.5 Sequence Probability file

This file contains the probability associated with a sequence of hits for the SGD. The filename is ah_sgd_probseq_YYYYMMDDvXXX.fits

The file contains an empty primary and one binary extension with the following columns:

- NUMHITS: contain the number of hits, ranging from 1 to 4.
- SEQUENCE: contain five numbers where the values are set based on the material where the hit is identified: 0=Si 1=CdTe bottom 2=CdTe side 3= if escape -1= NA. The order of the five numbers is:

  1st position = 1st hit,
  2nd position=2nd hit
  3rd position=3rd hit
  4th position=4th hit
  5th position=escape
- PROBHITS: contain the probability value calculated from simulation.
- MECHANISM : contain a sequential number identifying the physical mechanism.
- MECHANISM1: contain a string value corresponding to the combination of physical mechanisms, where C= Compton P=photoabsorption E= escape

Here are three examples:

1) NUMHITS=1; SEQUENCE = (0,-1,-1,-1,-1) : Si; MECHANISM =1; MECHANISM1= P.
2) NUMHITS=2; SEQUENCE = (1,1,-1,-1,-1) : CdTe-CdTe; MECHANISM =8; MECHANISM1= CP.
3) NUMHITS=3; SEQUENCE = (0,1, 2,-1, 3) : Si-CdTe-CdTe & escape; MECHANISM =126; MECHANISM1 = CCCE.

6.5.1 File Format

Table 6.5.1		
Extension N.	Type	Ext. Name

Table 6.5.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	PROB_SEQUENCE	
	Column Names	Format	Units
	NUMHITS	1I	-
	SEQUENCE	5I	-
	PROBHITS	1E	-
	MECHANISM	1I	-
	MECHANISM1	15A	-

6.5.2 Header Keywords

Table 6.5.2		
Keyword name	keyword value	Comment
CALDB Keywords		
TELESCOP	'HITOMI'	/ Telescope (mission) name
INSTRUME	'SGD'	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'PROB_SEQUENCE'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'SGD SEQUENCE PROBABILITY'	/ Brief descriptive summary of this file

6.6 Transmission Ratio File (SGD)

This file contains the transmission ratio as a function of position in the detector. There is one file for each SGD unit and each file has three separate extensions, one for each Compton Camera. The fourth extension contains the definition of energy channel. The filenames are:

ah_sg1_ transrat_yyyymmddvnn.fits

ah_sg2_ transrat_yyyymmddvnn.fits

The transmission ratio is provided as a function of position in FOCX, FOCY coordinates where the origin (FOCX=0, FOCY=0) corresponds to the on-axis of the satellite. The convention relative to the satellite coordinates of the FOCX, FOCY is the same as

for the other imaging instruments on HITOMI (i.e., FOCX=SATX, FOCY= - SATY, where FOC is a lookup coordinate and SAT is a lookdown one). The extension 1-3 contains the following columns:

- FOCX : contain the coordinates value for the X-axis in arcmin
- FOCY : contain the coordinates value for the X-axis in arcmin
- TRANS_RATIO : contains an array of transmission ratio for each of the 2048 energy channels. This is unitless and set 1 at FOCX, FOCY =0,0

The 4th extension contains the two columns, E_MIN and E_MAX corresponding to the lower and upper energy boundaries for each of the 2048 channel.

6.6.1 File Format

Table 6.6.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	TRANS_CC1	
	Column name	Format	Units
	FOCX	1E	arcmin
	FOCY	1E	arcmin
	TRANS_RATIO	2048E	-
2	BINTABLE	TRANS_CC2	
	FOCX	1E	arcmin
	FOCY	1E	arcmin
	TRANS_RATIO	2048E	-
3	BINTABLE	TRANS_CC3	
	FOCX	1E	arcmin
	FOCY	1E	arcmin
	TRANS_RATIO	2048E	-
4	BINTABLE	ART_ENERGIES	
	CHANNEL	1I	-
	E_MIN	1E	keV
	E_MAX	1E	keV

6.6.2 Header Keywords

Table 6.6.2

Keyword name	keyword value	Comment
CALDB Keywords for the 1st, 2nd, and 3rd extensions		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘SGD1’ or ‘SGD2’	/ Instrument name
DETNAM	‘CC1’, ‘CC2’, or ‘CC3’	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘TRANS_CC1’ (ext 1) ‘TRANS_CC2’ (ext 2) ‘TRANS_CC3’ (ext 3)	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘INSTRUME DETNAM TRANSMISSION BY ANGLE’	/ Brief descriptive summary of this file
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘ART_ENERGIES	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘INSTRUME DETNAM DEFINITION OF ENERGY CHANNELS’	/ Brief descriptive summary of this file

6.7 Instrument Map File

The file contains images in the FOCX coordinates in the primary extension. There are two files one for each of the SGD with the following filenames :

ah_sg1_instmap_YYYYMMDDvxxx.fits
ah_sg2_instmap_YYYYMMDDvxxx.fits

The file contain an image in the primary header and one image using an IMAGE FITS format extension ach pixel has a value of 1 if the pixel is included in the FOV, and a value of 0 if out of FOV. The primary extension contains the WCS keywords.

6.7.1 Primary Header Keywords

Table 5.15.1

Keyword name	Keyword value	Comment
Mandatory Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'INSTMAP_FOC'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	'Instrument Map file'	/Description
Keywords		
INSTRUME	'SGD1' or 'SGD2'	/Instrument name
CTYPE1	'FOCX'	Name of the X axis
CTYPE1	'FOCY'	Name of the Y axis
CUNIT1	'pixel'	Unit for X-axis
CUNIT2	'pixel'	Unit for Y-axis

6.8 Bad/active pixel file

The file contains active pixels and energy thresholds for the SGD. There are two files one for each of the SGD with the following filenames:

ah_sg1_badpix_yyyymmddvnn.fits

ah_sg2_badpix_yyyymmddvnn.fits

The file has threes identical extensions one for each Compton Camaera (CCn) with the following columns:

- TIME: contain the time as second since the mission elapse time.
- ALIVE_ASIC : contain the number of alive ASIC.
- ASIC_ID : contain the hardware address of the ASIC from which the data is read. There are 208 total ASICs, ASIC_ID_RMAP remaps the ASIC_ID into a continuous sequence 1:208 organized as Silicon: 32 layers * 4 ASIC/layer = 128; CdTe bottom: 8 layers * 4 ASIC/layer = 32; CdTe side: 4 sides * 2 layers * 6 ASIC/layer = 48
- READOUT_ID : contain the ASIC channel number, which runs 0:63.
- READOUT_ID_RMAP: contain the remapping of the READOUT_ID into a continuous numbering running 1:13312.
- ACTIVE_FLAG: contain a flag that indicates if a pixel is active or not (0=bad, 1=good, 2=strange).
- EPI_THRE: contain the energy threshold for conversion from PHA to EPI for each readout channel.
- DATAMODE: contain the datamode value, NORMALn where n start from 1 and is incremented if ACTIVE_FLAG or EPI_THRE are updated.

6.8.1 File Format

Table 6.8.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	BADPIX	
	Column Names	Format	Units
	TIME	1D	s
	ASIC_ID	13312I	
	READOUT_ID	13312I	
	READOUT_ID_RMAP	13312I	
	ACTIVE_FLAG	13312B	-
	EPI_THRE	13312E	keV
	ALIVE_ASIC	1I	-
	DATAMODE	12A	-

6.8.2 Extension Keywords

Table 6.8.2		
Keyword name	keyword value	
CALDB Keywords		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘SGD1’or ‘SGD2’	/ Instrument name
DETNAM	‘ CC1’, ‘CC2’, or ‘CC3’	/ Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘BADPIX’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘ INSTRUME DETNAM ACTIVE PIXEL AND THRESHOLD’	/ Brief descriptive summary of this file

6.9 Channel remapping file

The file contains a remapping table to identify each ASIC and readout channel with a unique number. The basic hardware values are ASIC_ID (0:869 for SGD) and READOUT_ID (0:63 for SGD). The total number of ACIS is 208 for each SGD. The ranges of ASIC_ID are: 0:7, 16:23, 32:39, 48:55, 64:71, 80:85, 96:101, 256:263, 272:279, 288:295, 304:311, 320:327, 336:341, 352:357, 512:519, 528:535, 544:551, 560:567, 576:583, 592:597, 608:613, 768:775, 784:791, 800:807, 816:823, 832:839, 848:853, 864:869. The filename is :

ah_sgd_remap_YYYYMMDDvxxx.fits

The file contains one binary table with the following columns:

- ASIC_ID : contain the hardware address of the ASIC from which the data is read. ASIC_ID is the hardware address of the ASIC from which the data is read. There are 208 total ASICs, organized as Silicon: 32 layers * 4 ASIC/layer = 128; CdTe bottom: 8 layers * 4 ASIC/layer = 32; CdTe side: 4 sides * 2 layers * 6 ASIC/layer = 48.
- READOUT_ID : contain the ASIC channel number, which runs 0:63.
- ASIC_ID_RMAP : contain the remapping of the ASIC_ID into a continuous numbering running 1:208.
- READOUT_ID_RMAP: contain the remapping of the READOUT_ID into a continuous numbering running 1:13312.
- SENSOR_ID : contain the number of the sensor or layer. The number of sensors (208) is the same as the number of ASICs, but they are identified with different numbers.
- ASIC_INDEX: contain the index number 0:3 for the ASICs in a given layer.
- LAYER: contain the number of the sensor, which runs 0:207.
- RAWX : contain the pixel ID in the X-direction (0:15).
- RAWY : contain the pixel ID in the Y-direction (0:15).
- CAMERAX : contain the physical location of the pixel in the X-direction. Range is -38.925 to +38.925 given in mm.
- CAMERAY : contain the physical location of the pixel in the Y-direction. Range is -38.925 to +38.925 given in mm.
- CAMERAZ : contain the physical location of the pixel in the Z-direction. Range is -76.075 to +2.525 given in mm.

6.9.1 File Format

Table 6.9.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	REMAPPING	
	Column Names	Format	Units
	ASIC_ID	1I	-
	READOUT_ID	1I	-
	ASIC_ID_RMAP	1I	-
	READOUT_ID_RMAP	1I	-
	SENSOR_ID	1I	-

Table 6.9.1			
Extension N.	Type	Ext. Name	
	ASIC_INDEX	1I	-
	RAWX	1I	-
	RAWY	1I	-
	CAMERAX	1D	mm
	CAMERAY	1D	mm
	CAMERAZ	1D	mm
	LAYER	1I	-

6.9.2 Header Keywords

Table 6.9.2		
Keyword name	keyword value	
TELESCOP	'HITOMI'	/ Telescope (mission) name
INSTRUME	'SGD'	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'REMAPPING'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'CHANNEL REMAPPING TABLE'	/ Brief descriptive summary of this file
SURSIDE1	200	LAYER (SENSOR_ID 200,201,202,203,204,205)
SURSIDE2	202	LAYER (SENSOR_ID 220,221,222,223,224,225)
SURSIDE3	204	LAYER (SENSOR_ID 240,241,242,243,244,245)
SURSIDE4	206	LAYER (SENSOR_ID 260,261,262,263,264,265)
SURBTM	100	LAYER(SENSOR_ID100,101,102,103,104)
DISTAN01	3.2	Shortest distance to adjacent pixel
DISTAN02	4.526	Distance to diagonally adjacent pixel

DISTAN03	2.750	Distance between CdTe layers
DISTAN04	6.975	Distance for Si-CdTe fluor (Si-Cdte side)
DISTAN05	2.5	Distance for Si-Si scattering
DELZSI	0.3	CAMERAZ coordinate error for Si layers
DELZCDTE	0.375	Out-of-plane CAMERA[XYZ] error for CdTe
DELXYANY	1.6	In-plane CAMERA[XYZ] error for Si and CdTe

6.10 SGD Redistribution Matrix File (RSP)

These files are rmf for each SGDm-CCn combination and a RMF combining all SGD and CC. The filename are:

ah_sgd1_ccN_ YYYYMMDDvxxx.rsp

ah_sgd1_ccN_YYYYMMDDvxxx.rsp

ah_sgd_cc_YYYYMMDDvxxx.rsp

These files are in the Calibration product file (CPF) directory. The structure is an empty primary with 2 bintable extensions with the standard OGIP format for matrix. See the common part section for details. Each file has standard CALDB keywords and they differs by the DETNAM keyword.

6.11 SGD Non X-ray Background Spectrum File (NXB)

This file contains the spectrum for the Non X-ray Background. The file name is

ah_sgd_nxb_yyyymmddvnn.fits

This is in the Calibration Product File (CPF) directory. The structure is an empty primary with 1 bintable extension, with columns in the standard spectrum OGIP format. See the common part section for details.

7 SXI

7.1 SXI Teldef File

This file contains the telescope definition file for the SXI. The format consists in a primary header and one BINTABLE extension The primary header contains all keywords that defines the telescope coordinate systems. The extension contains coefficient for specific multi segment transformation. The filename is:

ah_sxi_teldef_YYYYMMDDvxxx.fits

For the SXI, there are four coordinate types defined in the COORDn keywords (RAW, ACT, DET. FOC, SKY). Each coordinates type is defined by the keywords: nnnXSIZ, nnnXPIX1 nnnnXSCL, nnnnYSIZ, nnnnYPIX1, nnnnYSCL, nnnnUNIT. The transformation types between coordinate systems are defined as:

- TRTYPE0 = 'MULTISEG' / RAW to ACT transformation
- TRTYPE1 = 'RAWTODET' / ACT to DET

- TRTYPE2 = 'BASIC ' / DET to FOC
- TRTYPE3 = 'SKYATT ' / FOC to SKY

The RAW to ACT transformation is governed by the values in the MULTISEG0_COEFF extension and ACT_SCOL, ACT_NSEG ACTXFLIO and ACTYFLIP. The ACT to DET transformation is governed by the CO1_xxxx keywords and DETXFLIP, DETYFLIP, and DET_ROTD. The DET to FOC transformation is governed by the keywords FOC_XOFF, FOC_YOFF, FOC_ROT. The FOC to SKY transformation is governed by the FOC_Mxx keywords, FOCALLEN and aligned matrix (ALIGNnn) keywords, and uses the spacecraft attitude file. The OPTnnnn keywords defined the optical axis measured in ground in DET coordinates. The ROLLnnnn keywords defined the sign of the roll angle and the offset. The keywords RANCOORD and RAN_SCAL define the coordinates to which randomization is applied. The keywords IN1_XCEN and IN1_YCEN defines the ACT center.

The MULTISEG0_COEFF extension contains a table with coefficients for the RAW to ACT transformation. The first four columns are used to identify the state of the SXI for each event and are linked to four properties (columns) found in the input event file, either as header keywords or column names. These properties are:

- PROP0 = 'SEGMENT ' /The segment ID number within a chip (0:1)
- PROP1 = 'READNODE' /The read-out node (0:1)
- PROP2 = 'WINOPT ' /The windowing mode (0:1)
- PROP3 = 'WIN_SIZE' /The window size (640,160,80,40)

The remaining columns are coefficients whose values depend on the SXI mode as derived from the four properties. There are five X coefficients and five Y coefficients.

7.1.1 File Format

Table 7.1.1				
Extension N.	Type	Ext. Name		
0	PRIMARY			
1	BINTABLE	MULTISEG0_COEFF		
	Column Names	Format	Units	Comment
	PROPERTY0	1I	-	SEGMENT
	PROPERTY1	1I	-	READNODE
	PROPERTY2	1I	-	WINOPT
	PROPERTY3	1I	-	WIN_SIZE
	COEFF_X_A	1I	-	X coefficient A (X offset)
	COEFF_X_B	1I	-	X coefficient B (X scale)
	COEFF_X_C	1I	-	X coefficient C (Y scale in X conversion)
	COEFF_X_D	1I	-	X coefficient D (X window size)
	COEFF_X_E	1I	-	X coefficient E
	COEFF_Y_A	1I	-	Y coefficient A (Y offset)
	COEFF_Y_B	1I	-	Y coefficient B (X scale in Y conversion)

Table 7.1.1				
Extension N.	Type	Ext. Name		
	COEFF_Y_C	1I	-	Y coefficient C (Y scale)
	COEFF_Y_D	1I	-	Y coefficient D (Y window size)
	COEFF_Y_E	1I	-	Y coefficient E

7.1.2 Header keywords

Table 7.1.2		
Keyword name	Keyword value	Comment
Primary Header General Keywords		
TELESCOP	'HITOMI '	/ Telescope (mission) name
INSTRUME	'SXI'	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'TELDEF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'TELESCOPE DEFINITION FILE'	/ Brief descriptive summary of this file
First extension Header General Keywords		
TELESCOP	'HITOMI '	/ Telescope (mission) name
INSTRUME	'SXI'	/ Instrument name
TD_VERS	0.2	/ Teldef file format specification version
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'MULTISEG0_COEFF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'TELESCOPE DEFINITION FILE'	/ Brief descriptive summary of this file
NPROP	4	/ Number of segment property columns

PROP0	'SEGMENT'	/The segment ID number within a chip (0:1)
PROP1	'READNODE'	/The read-out node (0:1)
PROP2	'WINOPT'	/The windowing mode (0:1)
PROP3	'WIN_SIZE'	/The window size (640,160,80,40)
WINOFFX	'NONE'	/Windowing X offset keyword name
WINPROX	'NONE'	/Windowing X offset property name
WINOFFX	'WIN_ST'	/Windowing Y offset keyword name
WINPROY	'NONE'	/Windowing Y offset property name

7.2 SXT-I Telescope Description File

This file contains data for the structure of the SXI X-ray telescope, describing the mirror foils and their reflective surfaces, the support structure, a pre-collimator if present, as well as rotational and translational offsets of the telescope components relative to each other. See the common part chapter for details. The filename is :

ah_sxi_mirror_YYYYMMDDvxxx.fits.

7.3 SXT-I Reflectivity and Transmission File

This file contains data for the reflectivity and transmission of the front-side mirror coatings of an X-ray telescope, and reflectivity tables for the backside of mirror foils and for pre-collimator foils. It also contains, in a different extension, the mass-absorption coefficients of all the materials that a complete mirror foil is composed of. The coatings may be of single-layer or multi-layer types. See the common part chapter for details. The filename is:

ah_sxi_reftrans_YYYYMMDDvxxx.fits.

7.4 SXT-I Scattering File

This file contains data for the probability of a photon scattering relative to the reflection direction for specular reflection when reflecting on the an XRT foil. See the common part chapter for details. The filename is :

ah_sxi_scatter_YYYYMMDDvxxx.fits.

7.5 SXT-I Telescope area

This file contains the teslescope area derived from ray-tracing calculation. See the common part chapter for details.

ah_sxi_telarea_YYYYMMDDvxxx.fits.

7.6 SXT-I Point Spread Function File

This file contains point spread function (PSF) library. The file name is

ah_sxi_psf_YYYYMMDDvxxx.fits.

See the common part chapter for details.

7.7 SXT-I Vignetting File

This file contains vignetting function library. The file name is

ah_sxi_vignet_YYYYMMDDvxxx.fits.

See the common part chapter for details.

7.8 SXT-I Event File

This file contains library from ray-tracing. The file name is

ah_sxi_event_YYYYMMDDvxxx.fits.

See the common part chapter for details.

7.9 SXI Quantum efficiency

This file contains the definition of the quantum efficiency and used in software to calculate the total SXI effective area including telescope and detector proprieties. The filename is:

ah_sxi_quanteff_YYYYMMDDvxxx.fits.

The SXI ARF represents effective areas multiplied by detector's efficiency (both of which depend on the X-ray energy) for each pixel. The calibration consists of two parts: the telescope (SXT) and detector (SXI). The latter is separated to four components, (1) quantum efficiency (QE) of the CCD chip itself, (2) transmittance of the optical blocking layer (OBL) attached to the CCD, (3) transmittance of contamination blocking filter (CBF), and (4) contamination accumulated on the CBF. The OBL is deposited directly on the CCD, while the CBF is detached from the detector and located about 50 cm above it. For this reason, the QE and OBL transmittance cannot be calibrated separately, and the QE values are derived being multiplied by the transmittance of OBL. Both QE+OBL and CBF are calibrated only on ground, and never updated on board, while only the contamination changes with time. This CALDB file describes the time-independent part, while the time-dependent part (i.e., contamination) is provided in a separate file (see next section).

The CALDB file contains two extensions, QE_OBL in the first extension, and CBF in the second extension. QE_OBL depends on both position and energy, of which the calibration values are provided for each 32 x 32 subregion for each CCD. On the other hand, CBF depends only on the energy, and have no subregion. The structure is an empty primary with 2 bintable extensions.

The columns in the first extension (QE+OBL) are :

- CCD_ID: contain the CCD ID. 0, 1, 2, and 3 indicate CCD1, CCD2, CCD3, and CCD4, respectively.
- SEGMENT: contain the segment ID. 0 and 1 indicate Segment AB and CD, respectively.
- CORNER_ACTX and CORNER_ACTY: contain 4-element vectors specifying the (ACTX, ACTY) positions of the corners of each subregion. The order is anticlockwise in all CCDs.
- CORNER_DETX and CORNER_DETY: contain 4-element vectors specifying the (DETX, DETY) positions of the corners of each subregion. These correspond to the values in columns 4 and 5, so the order is clockwise in all CCDs.
- ENERGY: contain an *n*-element vector of energy grid values, in keV.
- QE : contain an *n*-element vector of parameters describing the QE multiplied by the OBL transmittance.

The columns in the first extension (CBF) are:

- ENERGY contains energy grid values, in keV.
- TRANSMISSION contains the CBF transmittance at the given energies.

The second extension does not have dependency on position.

7.9.1 File Format

Table 7.9.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	QE_OBL	
	Column Names	Format	Units
	CCD_ID	1B	-
	SEGMENT	1B	-
	CORNER_ACTX	4E	-
	CORNER_ACTY	4E	-
	CORNER_DETX	4E	-
	CORNER_DETY	4E	-
	ENERGY	*n*E	keV
	QE	*n*E	-
2	BINTABLE	CBF	
	Column Names	Format	Units
	ENERGY	1E	keV
	TRANSMISSION	1E	-

7.9.2 Header Keywords

Table 7.9.2		
Keyword name	Keyword value	Comment
Keywords for the first extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'QE_OBL'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'Quantum Efficiency Multiplied by OBL Transmission’	/Description
EXTNAME	'QE_OBL'	/Name of the binary table extension

INSTRUME	'SXI'	/Instrument name
Keywords for the second extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'CBF'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'CBF Transmission’	/Description
EXTNAME	'CBF'	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name

7.10 SXI Contamination Calibration File

This file contains the information of time-dependent contamination column density and elemental composition (plus partial covering factor; see below) and used in software to calculate the total SXI effective area including telescope and detector proprieties. The filename is:

ah_sxi_contami_YYYYMMDDvxxx.fits.

The file contains three bintable extensions. The first extension contains the time-dependent part, the column densities and covering factor of arbitrary elements for each subregion per time stamp. The second extension contains the theoretical values of energy-dependent transmittance for each element. The last extension contains only the region information that is never updated. The contamination calibration is performed for 32x32 subregions per CCD, similarly to the QE. It is expected that the first extension has a number of time stamps (typically one per a few weeks). The detailed region information is therefore separately provided in the third extension to reduce the file size.

The columns in the first extension (COLUMN_DENSITY) are :

- TIME: contain the time in unit of second(s).
- REGION_ID : contain Region ID defined in Extension 3. The value is from 0 to 4095 (4 x 32 x 32).
- COLUMN : contain column density of arbitrary elements. This is a vector column where the size of the array is determinded by the number of elements included in the contaminant.
- FACTOR: contain partial covering factors for the same elements as in the COLUMN. Therefore, this column is also a vector with the same element numbers as COLUMN. The value should be in the range between 0 and 1, where 1 means that the relevant subregion is fully covered by this material with the column density given in COLUMN. A value less than 1 enables to represent a ‘smoothed’ absorption edge.

The columns in the first extension (COLUMN_TRANS) are :

- ENERGY: contain X-ray energy in keV.
- TRANSMISSION : contain theoretical values of energy-dependent transmittance for the elements given in COLUMN in Extension 1. This is a vector column with the same element numbers as COLUMN in Extension 1.

The columns in the first extension (SUBREGION) are :

- REGION_ID : contain Region ID for each subregion. The value is from 0 to 4095 (4 x 32 x 32).
- CCD_ID: contain CCD_ID number.
- SEGMENT : contain Segment number

- CORNER_ACTX and CORNER_ACTY: contain 4-element vectors specifying the (ACTX, ACTY) positions of the corners of each subregion. The order is anticlockwise.
- CORNER_DETX and CORNER_DETY: contain 4-element vectors specifying the (DETX, DETY) positions of the corners of each subregion. These correspond to the values in columns 4 and 5, so the order is clockwise in all CCDs.

7.10.1 File Format

Table 7.10.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	COLUMN_DENSITY	
	Column Names	Format	Column Names
	TIME	1D	s
	REGION_ID	1I	-
	COLUMN	*n*E	10**18 cm**(-2)
	FACTOR	*n*E	-
2	BINTABLE	COLUMN_TRANS	
	Column Names	Format	Units
	ENERGY	1E	keV
	TRANSMISSION	*n*E	-
3	BINTABLE	SUBREGION	
	Column Names	Format	Units
	REGION_ID	1I	-
	CCD_ID	1B	-
	SEGMENT	1B	-
	CORNER_ACTX	4E	-
	CORNER_ACTY	4E	-
	CORNER_DETX	4E	-
	CORNER_DETY	4E	-

7.10.2 Header Keywords

Table 7.10.2		
Keyword name	Keyword value	Comment
Keywords for the first extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'COLUMN_DENSITY'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Column density of contamination materials’	/Description
EXTNAME	'COLUMN_DENSITY'	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name
Keywords for the second extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	COLUMN_TRANS'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Energy-dependent transmittance for contamination materials’	/Description
EXTNAME	COLUMN_TRANS'	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name
Keywords for the third extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'SUBREGION'	/Type of calibration data
CDTP0001	‘DATA’	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Subregion definition’	/Description
EXTNAME	‘SUBREGION’	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name

7.11 SXI RMF parameters

This file contains the rmf parameters used to calculate the SXI the redistribution matrix file (RMF). The filename is

ah_sxi_rmfparam_YYYYMMDDvxxx.fits

The response of the SXI is a combination of line and continuum profile components that describe the probability of a photon at a given energy being detected as a certain PI channel value. These components are described by parameters (for example, the width, amplitude, central channel of a Gaussian) contained within this CALDB file. These parameters are energy dependent, and are calculated and stored in this CALDB file on an energy grid. These parameters are interpolated for any other energy. The RMF parameters are position dependent identified by CCD_ID, SEGMENT, and subregion coordinates are time dependent. These responses are weighted by a weighted map (given in the DET coordinates) and combined in the final RMF. Each TIME stamp typically has ~180 rows, one for each of the subregions. The shape of the subregions should be a rectangle, but the size can be flexible. The number of subregions is also flexible, and is specified by the header keyword "NSUBREG". The structure is an empty primary with a number of identical format bintable extensions for each datamode. The columns in each extensions are:

- TIME: contain the time in unit of second (s).
- CCD_ID : contain the CCD ID. 0, 1, 2, 3 indicate CCD1, CCD2, CCD3, and CCD4, respectively.
- SEGMENT: contain the segment ID. 0 and 1 indicate Segment AB and CD, respectively.
- CORNER_ACTX and CORNER_ACTY : contain 4-element vectors specifying the (ACTX, ACTY) positions of the corners of each subregion. The order is anticlockwise.
- CORNER_DETX and CORNER_DETY: contain 4-element vectors specifying the (DETX, DETY) positions of the corners of each subregion. These correspond to the values in columns 4 and 5, so the order is clockwise in all CCDs.
- ENERGY : contain a *n*-element vector of energy grid values, in keV.

(The remaining columns contain *n*-element vectors of parameters describing the shape of the response profile.)

- PRIMARY_FWHM: contain FWHM in keV of the primary Gaussian component in keV.
- SECONDARY_OFFSET: contain the center energy offset of the secondary Gaussian compnent in keV with respect to the primary component.
- SECONDARY_AMP : contain relative amplitudes (normalization) of the secondary Gaussian component with respect to the primary response component.
- SECONDARY_FWHM : contain FWHM in keV of the secondary Gaussian component in keV.
- ESCAPE_OFFSET : contain the center energy offset of the Si-escape Gaussian compnent in keV with respect to the primary component.
- ESCAPE_AMP : contain relative amplitudes (normalization) of the Si-escape Gaussian component with respect to the primary response component.
- ESCAPE_FWHM : contain FWHM in keV of the Si-escape Gaussian component in keV.
- FLUOR_OFFSET : contain the center energy offset of the Si-fluorescence Gaussian compnent in keV with respect to the primary component.
- FLUOR_AMP : contain relative amplitudes (normalization) of the Si-fluorescence Gaussian component with respect to the primary response component.
- FLUOR_FWHM : contain FWHM in keV of the Si-fluorescence Gaussian component in keV.
- CONST_AMP : contain relative amplitudes (normalization) of the constant component with respect to the primary response component.

7.11.1 File Format

Table 7.11.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	RMF_PARAMETERS	
	Column Names	Format	Units
	TIME	1D	s
	CCD_ID	1B	-
	SEGMENT	1B	-
	CORNER_ACTX	4E	-
	CORNER_ACTY	4E	-
	CORNER_DETX	4E	-
	CORNER_DETY	4E	-
	ENERGY	*n*D	keV
	PRIMARY_FWHM	*n*D	keV
	SECONDARY_OFFSET	*n*D	keV
	SECONDARY_AMP	*n*D	-
	SECONDARY_FWHM	*n*D	keV
	ESCAPE_OFFSET	*n*D	keV
	ESCAPE_AMP	*n*D	-
	ESCAPE_FWHM	*n*D	keV
	FLUOR_OFFSET	nD	keV
	FLUOR_AMP	nD	-
	FLUOR_FWHM	nD	keV
	CONST_AMP	nD	-

7.11.2 Header Keywords

Table 7.11.2		
Keyword name	Keyword value	Comment
Keywords for the 1st and 2nd extension		

CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'RMF_PARAMETERS'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CBD10001	'DATAMODE(WINDOW1)' (ext 1) 'DATAMODE(WINDOW2)' (ext 2)	/Data mode
CBD20001	'CISTATUS (1)'	/Charge Injection (0: off, 1: on)
CDES0001	'RMF Parameters for Full Window Mode' or 'RMF Parameters for 1/8 Window Mode'	/Description
EXTNAME	'RMF_PARAMETERS'	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name
NSUBREG	183 (ext 1), 119 (ext 2)	/Number of sub regions

7.12 SXI Pixel Mask File

This file contains the mask image for the SXI, formatted as a pixel list. The filename is:

ah_sxi_mask_YYYYMMDDvxxx.fits

This file is used by the software routine *sxiflagpix* to identify regions of the SXI field of view that should be flagged. The structure is an empty primary HDU with one bintable extension. The extension contains a list of pixels and a flag giving the reason for masking, and has the following columns:

- CCD_ID contains the CCD_ID. 0, 1, 2, 3 indicate CCD1, CCD2, CCD3, and CCD4, respectively.
- ACTX and ACTY contain the ACT coordinates of each pixel in the mask.
- DETX, DETY contains the DET coordinates of each pixel in the mask.
- VALUE contains a value which identifies whether and why a pixel is masked. The following VALUEs correspond to specific regions of the SXI field of view:

VALUE	DESCRIPTION
0	within FOV (good pixel)
1	within calibration source region
2	on a CCD boundary
3	on a segment boundary
4	within calibration source regions and on a CCD boundary
5	in the gap between CCDs

7.12.1 File Format

Table 7.12.1		
Extension N.	Type	Ext. Name

Table 7.12.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	MASK	
	Column Names	Format	Units
	CCD_ID	1B	-
	ACTX	1I	-
	ACTY	1I	-
	DETX	1I	-
	DETY	1I	-
	VALUE	1I	-

7.12.2 Header Keywords

Table 7.12.2		
Keyword name	Keyword value	Comment
Keywords for the 1st extension		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'MASK'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	'SXI Masked Pixels’	/Description
EXTNAME	‘MASK’	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name

7.13 SXI Instrument Map

This file is used by the Monte-Carlo simulator *ahsim* and *ahexpmap*. The filename is:

ah_sxi_instmap_YYYYMMDDvxxx.fits

The file contains images in the FOC and DET coordinates in the primary and first extensions, respectively. None of the extensions has column data. The image indicates the CCD field of view (imaging area). The Dimension is 2430 x 2430 for the primary, and

1810 x 1810 for the first extension. The value is 1 for the FoV, and 0 for out of FoV. The first extension (HDU2) contains several keywords that are needed for arf generation.

7.13.1 File Format

There is no bin table. Instead, both of primary and first extensions contain an image with the values 0 (out of the field of view) or 1 (in the field of view).

7.13.2 Header Keywords

Table 7.13.2

Keyword name	Keyword value	Comment
Keywords for the first extension		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'INSTMAP_FOC'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	‘Instrument Map file’	/Description
INSTRUME	'SXI'	/Instrument name
CTYPE1	‘FOCX’	Name of the X axis
CTYPE2	‘FOCY’	Name of the Y axis
CUNIT1	‘pixel’	Unit for X-axis
CUNIT2	‘pixel’	Unit for Y-axis
CRVAL1	1215.5	FOCX image reference pixel value
CRPIX1	1215.5	FOCX image reference pixel
CDELT1	1	FOCX pixel scale
CRVAL2	1215.5	FOCY image reference pixel value
CRPIX2	1215.5	FOCY image reference pixel
CDELT2	1	FOCY pixel scale
Keywords for the second extension		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'INSTMAP_DET'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data

CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	‘Instrument Map file’	/Description
EXTNAME	‘INSTMAP_DET’	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name
CTYPE1	‘DETX’	Name of the X axis
CTYPE1	‘DETY’	Name of the Y axis
CUNIT1	‘pixel’	Unit for X-axis
CUNIT2	‘pixel’	Unit for Y-axis
CRVAL1	905.5	DETX image reference pixel value
CRPIX1	905.5	DETX image reference pixel
CDELT1	1	DETX pixel scale
CRVAL2	905.5	DETY image reference pixel value
CRPIX2	905.5	DETY image reference pixel
CDELT2	1	FOCY pixel scale
OPTAXISX	783.464	optical axis x in DET coordinates (pixel)
OPTAXISY	794.180	optical axis y in DET coordinates (pixel)
RAW_XSCL	0.048	RAW X scale (mm/pixel)
RAW_YSCL	0.048	RAW Y scale (mm/pixel)
ACT_XSCL	0.048	ACT X scale (mm/pixel)
ACT_YSCL	0.048	ACT Y scale (mm/pixel)
ACT_XSIZ	640	ACT address space x size (pixels)
ACT_YSIZ	640	ACT address space y size (pixels)
DET_XSCL	0.048	DET X scale (mm/pixel)
DET_YSCL	0.048	DET Y scale (mm/pixel)
DETXFLIP	1	FLIP to DET X system
DETYFLEP	1	FLIP to DET Y system
FOCALLEN	5600.0	SXI focal length (mm)
FOC_XSCL	0.048	FOC X scale (mm/pixel)
FOC_YSCL	0.048	FOC Y scale (mm/pixel)
DET_XSIZ	1810	DET address space x size (pixels)
DET_YSIZ	1810	DET address space y size (pixels)
FOC_XSIZ	2430	FOC address space x size (pixels)
FOC_YSIZ	2430	FOC address space y size (pixels)

FOC_XOFF	-122.646	DETX offset (pixel) to the FOC center position
FOC_YOFF	-113.663	DETY offset (pixel) to the FOC center position
FOC_ROTD	0.0	DET rotation angle (deg) in FOC coordinates
OPT_ROTD	0.00000	rotation of telescope output system wrt DET
OPTXFLIP	1	flip of telescope axes relative to DETX/Y
OPTYFLIP	-1	flip from (look-down) to (look-up)
ROT00	1.0	transform matrix component
ROT01	0.0	transform matrix component
ROT10	0.0	transform matrix component
ROT11	1.0	transform matrix component
SHIFTX	432.6460	translation in X
SHIFTY	423.6630	translation in Y

7.14 SXI Bad Pixel File

This file contains the bad pixel list for the SXI. The filename is:

ah_sxi_badpix_YYYYMMDDvxxx.fits

This file is used by the software routine *sxiflagpix* to identify pixels in the SXI CCDs that are not to be used because they are dead, routinely hot, or otherwise bad. The structure is an empty primary HDU with 1 bintable extension. This extension contains the location of and reason for each bad pixel in all four SXI CCDs, and has the following columns:

- TIME contains the time in unit of second (s).
- CCD_ID contains the CCD ID. 0, 1, 2, 3 indicate CCD0, CCD1, CCD2, and CCD3, respectively.
- SEGMENT contains the segment ID. 0 and 1 indicate Segment AB and CD, respectively.
- ACTX, ACTY, DETX, and DETY contain ACT and DET coordinates of the bad pixel.
- YEXTEND contains the number of trailing pixels in ACTY column. For a bad column, this parameter specifies the extension (in positive ACTY pixels) from the pixel starting at ACTX,ACTY. All pixels within this extension are also considered bad. For a single bad pixel, YEXTEND should be 1. The value of YEXTEND equals the total number of pixels in the bad column.

7.14.1 File Format

Table 7.14.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	BADPIX	
	Column Names	Format	Units
	TIME	1D	s

Table 7.14.1			
Extension N.	Type	Ext. Name	
	CCD_ID	1B	-
	SEGMENT	1B	-
	ACTX	1I	-
	ACTY	1I	-
	DETX	1I	-
	DETY	1I	-
	YEXTEND	1I	-

7.14.2 Header Keywords

Table 7.14.2		
Keyword name	Keyword value	Comment
CALDB Keywords		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'BADPIX'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	'SXI BAD PIXEL LIST	/Description
EXTNAME	‘BADPIX’	/Name of the binary table extension
INSTRUME	‘SXI’	/Instrument name

7.15 SXI Even-Odd Correction Calibration File

This file is used by the software routine *sxipi* that determines a pulse invariant (PI) value of each event after several corrections and GRADE assignment. The file name is

ah_sxi_vtevnodd_YYYYMMDDvxxx.fits

The PI calculation by *sxipi* consists of five steps, and each step refers to at least one CALDB file. This file is read in the first step, called “even odd correction”. An event detected by the CCD sensor is transferred and processed by the analog ASIC. Each CCD/segment has two related ASICs; one of them processes charges detected in the even-RAWX pixels and the other processes those in the odd-RAWX pixels. Since the performance of the ASICs can be different with each other, the even-odd correction

should be applied at the beginning so that the subsequent corrections will be straightforward. In addition, the photon energy-pulse height relation depends on the temperature of the ASIC, which is also taken into account by this correction.

The file contains coefficients for the correction formula (in the Columns 7-12 of the 1st extension). These coefficients can vary with time, and depend on the CCD ID, Segment, Readout node, ADC, and even or odd RAWX. We have 4 CCDs, 2 segments for each CCD, 2 readout nodes for each segment, 3 ADC operations (only 1 of 2 ADCs are used or both are used) for each node, and 2 ASICs (even or odd) for each ADC. Therefore, each TIME should have 4 x 2 x 2 x 3 x 2 = 96 rows.

The structure is an empty primary with 1 bintable extension.

- TIME contains the time in unit of second (s).
- CCD_ID contains the CCD ID. 0, 1, 2, 3 indicate CCD1, CCD2, CCD3, and CCD4, respectively.
- SEGMENT contains the segment ID. 0 and 1 indicate Segment AB and CD, respectively.
- READNODE contains the readout node ID. For Segment AB, 0 and 1 indicate Readout node A and B, respectively. For Segment CD, 1 and 0 indicate Readout node C and D, respectively.
- ADCAVE contains values identifying ADC.
- EVEN_ODD contains values identifying even or odd RAWX pixels. 0 and 1 mean even and odd, respectively.
- VT_GAIN_NORM, VT_GAIN_INDEX, and VT_GAIN_OFFSET contain coefficients for the temperature-dependence correction.
- GAIN_OFFSET, GAIN_LINR, and GAIN_QUAD contain coefficients for even-odd correction.

The file is updated when the new calibration is provided by the instrument team.

7.15.1 File Format

Table. 7.15.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	VT_EVEN_ODD	
	Column Names	Format	Units
	TIME	1D	s
	CCD_ID	1B	-
	SEGMENT	1B	-
	READNODE	1B	-
	ADCAVE	1B	-
	EVEN_ODD	1B	-
	VT_GAIN_NORM	1E	-
	VT_GAIN_INDEX	1E	-
	VT_GAIN_OFFSET	1E	-

Table. 7.15.1			
Extension N.	Type	Ext. Name	
	GAIN_OFFSET	1E	-
	GAIN_LINR	1E	-
	GAIN_QUAD	1E	-

7.15.2 Header Keywords

Table 7.15.2		
Keyword name	Keyword value	Comment
CALDB Keywords		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'VT_EVEN_ODD'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Video Temperature Gain (Even or Odd) Correction’	/Description
EXTNAME	'VT_EVEN_ODD’	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name
VT_MIN	-20.0	/ Minimum allowable temperature (degC)
VT_MAX	40.0	/ Maximum allowable temperature (degC)
VT_REF	25.0	Reference video temperature (degC)
PH_REF	982	Reference PHAS

7.16 SXI Charge Trail Correction Calibration File

This file is used by the software routine *sxipi* that determines a pulse invariant (PI) value of each event after several corrections and GRADE assignment. The file name is

ah_sxi_chtrail_YYYYMMDDvxxx.fits.

The PI calculation by *sxipi* consists of five steps. This file is read in the second step, called “charge trail correction”. When charges are transferred for readout, a portion of them is trapped by electron holes in the CCD chips created by radiation damage. This causes degradation of total readout charges (thus X-ray energy unless appropriate correction is applied). Generally, this effect is called “Charge Transfer Inefficiency (CTI)” and corrected in the next step of *sxipi* routine. However, during the ground calibration for the Suzaku XIS, it was found that a fraction of the trapped charges is released with the timescale comparable to the one-pixel

transfer, resulting in apparent “charge trail” toward the following pixel. The same phenomenon is expected for the SXI as well. This correction step also takes into account the ‘inverse echo’ effect, which is probable caused by analog electronics. This effect has an energy dependency.

The file contains coefficients for the correction formula (in the Columns 5-10 of the 1st extension). These coefficients can vary with time, and depend on the CCD ID, Segment, and Readout node. Therefore each TIME should have 4 x 2 x 2 = 16 rows.

The structure is an empty primary with 1 bintable extension.

- TIME contains the time in unit of second (s).
- CCD_ID contains the CCD ID. 0, 1, 2, 3 indicate CCD1, CCD2, CCD3, and CCD4, respectively.
- SEGMENT contains the segment ID. 0 and 1 indicate Segment AB and CD, respectively.
- READNODE contains the readout node ID. For Segment AB, 0 and 1 indicate Readout node A and B, respectively. For Segment CD, 1 and 0 indicate Readout node C and D, respectively.
- NORM_H, INDEX_H, OFFSET_H, NORM_V, INDEX_V, OFFSET_V contain coefficients for the charge trail correction. The subscript “H” indicates that these columns are related to the horizontal transfer charge trail correction, and “V” means the vertical transfers.
- PH_CUT contains threshold value for the trail correction. When PHAS is lower than this value, the correction factors are determined using the PH_CUT as PHAS (replacing original PHAS with PH_CUT only in the correction factor determination).
- ESLOPE and EOFFSET contain coefficients for the energy-dependency of the inverse echo effect.

7.16.1 File Format

Table 7.16.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	CHARGE_TRAIL	
	Column Names	Format	Units
	TIME	1D	s
	CCD_ID	1B	-
	SEGMENT	1B	-
	READNODE	1B	-
	NORM_H	1E	-
	INDEX_H	1E	-
	OFFSET_H	1E	-
	NORM_V	1E	-
	INDEX_V	1E	-
	OFFSET_V	1E	-

Table 7.16.1			
Extension N.	Type	Ext. Name	
	PH_CUT	1I	-
	ESLOPE	1E	-
	EOFFSET	1E	-

7.16.2 Header Keywords

Table 7.16.2		
Keyword name	Keyword value	Comment
CALDB Keywords		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'CHARGE_TRAIL'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'Charge Trail Correction for Full Window Mode' or 'Charge Trail Correction for 1/8 Window Mode'	/Description
CBD10001	'DATAMODE(WINDOW1)' (ext 1) 'DATAMODE(WINDOW2)' (ext 2)	/Data mode
CBD20001	'CISTATUS (1)'	/Charge Injection (0: off, 1: on)
EXTNAME	'CHARGE_TRAIL'	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name
PH_REF	982	Reference PHAS

7.17 SXI CTI Calibration File

This file is used by the software routine *sxipi* that determines a pulse invariant (PI) value of each event after several corrections and GRADE assignment. The file name is

ah_sxi_cti_YYYYMMDDvxxxx.fits .

The PI calculation by *sxipi* consists of five steps. This file is read in the third step, called "CTI correction". When charges are transferred for readout, a portion of them is trapped by electron holes in the CCD chips created by radiation damage, resulting in degradation of total readout charges (thus X-ray energy). Unlike Charge Trail, CTI is the effect due to a long-timescale charge trap, i.e., the trapped charges will be released far later the parent charge bundle is transferred. The CTI correction is applied to "recover" the lost charge, so the corrected pulse height should almost correspond to the charge number before the transfer.

Since the CTI strongly depends on whether spaced-row charge injection (CI; see the SXI document) is on or off, the CALDB files will be prepared for both modes. The sxipi routine identifies an appropriate CALDB by referring to a boundary keyword.

The file contains coefficients for the correction formula (in the Columns 5-14 of the 1st extension). These coefficients can vary with time, and depend on the CCD ID, Segment, and Readout node. Therefore each TIME should have 4 x 2 x 2 = 16 rows.

There are also RAWX column and GRADE dependencies. These are given as different elements in the vector columns (see below).

There are several “anomaly spots” where the CTI effect is particularly large. The regions are specified in the ANOMALY_REGION extension (the third extension for the default).

The structure is an empty primary with 3 bintable extensions.

The first and second extensions (for different window modes) contain the following columns. This is updated with time.

- TIME contains the time in unit of second (s).
- CCD_ID contains the CCD ID. 0, 1, 2, 3 indicate CCD1, CCD2, CCD3, and CCD4, respectively.
- SEGMENT contains the segment ID. 0 and 1 indicate Segment AB and CD, respectively.
- READNODE contains the readout node ID. For Segment AB, 0 and 1 indicate Readout node A and B, respectively. For Segment CD, 1 and 0 indicate Readout node C and D, respectively.
- PARA_F_NORM, PARA_F_PROB, PARA_F_SCALE, and PARA_F_INDEX contain coefficients for the CTI owing to the “fast” vertical transfer (i.e., all-together transfers from the imaging area to frame store region).
- PARA_S_NORM, PARA_S_PROB, PARA_S_SCALE, and PARA_S_INDEX contain coefficients for the CTI owing to the “slow” vertical transfer (one-by-one transfers in the frame store region following the fast transfer).
- PARA_A_NORM, PARA_A_PROB, PARA_A_SCALE, and PARA_A_INDEX contain coefficients for the CTI owing to the vertical transfer in CTI anomaly regions.
- GFACTOR GOFFSET_AL0, GOFFSET_AL1, GOFFSET_AL2, GOFFSET_AL3, GOFFSET_AM0, GGOFFSET_AM1, GOFFSET_AM2, GOFFSET_AM3, and GOFFSET_AH0 contain correction factors for the GRADE-dependent CTI correction.
- GOFFSET_EBL and GOFFSET_EBH contain the boundary pulse height for the GFACTORs.
- PH_CUT contains threshold value for the trail correction. When PHAS is lower than this value, the correction factors are determined using the PH_CUT as PHAS (replacing original PHAS with PH_CUT only in the correction factor determination).

The third extension contains the following columns. This has no time dependency.

- CCD_ID contains the CCD_ID.
- ACTX contains the ACTX coordinate values.
- ANOMALY_MIN and ANOMALY_MAX contain ACTY values of the anomaly regions for each ACTX column. If there is no anomaly region, both values are zero.

7.17.1 File Format

Table 7.17.1

Extension N.	Type	Ext. Name

0	PRIMARY		
1 & 2	BINTABLE	CTI	
	Column Names	Format	Units
	TIME	1D	s
	CCD_ID	1B	-
	SEGMENT	1B	-
	READNODE	1B	-
	PARA_F_NORM	320E	-
	PARA_F_PROB	320E	-
	PARA_F_SCALE	320E	-
	PARA_F_INDEX	320E	-
	PARA_S_NORM	320E	-
	PARA_S_PROB	320E	-
	PARA_S_SCALE	320E	-
	PARA_S_INDEX	320E	-
	PARA_A_NORM	320E	-
	PARA_A_PROB	320E	-
	PARA_A_SCALE	320E	-
	PARA_A_INDEX	320E	-
	GRACTOR	4E	-
	GOFFSET_AL0	4E	-
	GOFFSET_AL1	4E	-
	GOFFSET_AL2	4E	-
	GOFFSET_AL3	4E	-
	GOFFSET_AM0	4E	-
	GOFFSET_AM1	4E	-
	GOFFSET_AM2	4E	-
	GOFFSET_AM3	4E	-
	GOFFSET_AH0	4E	-
	GOFFSET_EBL	1E	-

	GOFFSET_EBH	1E	-
	PH_CUT	1I	-
3	BINTABLE	ANOMALY_REGION	
	Column Names	Format	Units
	CCD_ID	1B	-
	ACTX	1I	-
	ANOMALY_MIN	1I	-
	ANOMALY_MAX	1I	-

7.17.2 Header Keywords

The boundary keyword CBD00002 indicates whether CI is on (CISTATUS = 1) or off (= 0).

Table 7.17.2		
Keyword name	Keyword name	Keyword name
CALDB Keywords for the 1st and 2nd extensions		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'CTI'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CBD10001	'DATAMODE(WINDOW1)' (ext 1) 'DATAMODE(WINDOW2)' (ext 2)	/Data mode
CBD20001	'CISTATUS (1)'	/Charge Injection (0: off, 1: on)
CDES0001	'Charge Transfer Inefficiency Correction'	/Description
EXTNAME	'CTI'	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name
PH_REF	982	Reference PHAS
CALDB Keywords for the 3rd extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'ANOMALY_REGION'	/Type of calibration data

CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘CTI Anomaly Regions’	/Description
EXTNAME	'ANOMALY_REGION'	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name

7.18 SXI Optimum Split Threshold Calibration File

This file is used by the software routine *sxipi* that determines a pulse invariant (PI) value of each event after several corrections and GRADE assignment. The file name is

ah_sxi_spth_YYYYMMDDvxxx.fits

This file contains the parameters to optimize the split threshold in the grade assignment. The values in the file are independent from the FFF header keywords SPTHIN and SPTHOUT, which are used on board.

The file contains coefficients for the SPTH optimization formula (in the Columns 5 & 6 of the 1st extension). These coefficients can vary with time, and depend on the CCD ID, Segment, and Readout node. Therefore each TIME should have 4 x 2 x 2 = 16 rows.

The structure is an empty primary with 1 bintable extension.

- TIME contains the time in unit of second (s).
- CCD_ID contains the CCD ID. 0, 1, 2, 3 indicate CCD1, CCD2, CCD3, and CCD4, respectively.
- SEGMENT contains the segment ID. 0 and 1 indicate Segment AB and CD, respectively.
- READNODE contains the readout node ID. For Segment AB, 0 and 1 indicate Readout node A and B, respectively. For Segment CD, 1 and 0 indicate Readout node C and D, respectively.
- SPTH_OFFSET, and SPTH_LINR contain coefficient for the SPTH optimization which follows the formula:
- from the following formula:

  SPTH = SPTH_OFFSET + “tentative PHA” * SPTH_LINR

7.18.1 File Format

Table 7.18.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	SPLIT_TH	
	Column Names	Format	Units
	TIME	1D	s
	CCD_ID	1B	-

Table 7.18.1			
Extension N.	Type	Ext. Name	
	SEGMENT	1B	-
	READNODE	1B	-
	SPTH_OFFSET	1E	-
	SPTH_LINR	1E	-

7.18.2 Header Keywords

Table 7.18.2		
Keyword name	Keyword value	Comment
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'SPLIT_TH	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Split threshold optimization parameters’	/Description
EXTNAME	'SPLIT_TH’	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name

7.19 SXI PHA to PI conversion (Gain Correction) Calibration File

This file is used by the software routine *sxipi* that determines a pulse invariant (PI) value of each event after several corrections and GRADE assignment. The file name is

ah_sxi_gain_YYYYMMDDvxxx.fits

The PI calculation by *sxipi* consists of five steps. For the SXI, 1 PI corresponds to 6 eV.

The file contains coefficients for the gain correction (in the Columns 5-13 of the 1st extension). These coefficients can vary with time, and depend on the CCD ID, Segment, and Readout node. Therefore each TIME should have 4 x 2 x 2 = 16 rows.

The PHA to PI conversion is done by following the quadric equation:

PI = OFFSET_aaa + PHA * LINR_aaa + PHA^2 * QUAD_aaa

where “aaa” contains “LOW”, “MED”, or “HI”, coefficients for different energy ranges. For example, the coefficients with the subscript “LOW” are the values for the low energy band. The boundaries between the low and med, and med and high energy

bands are defined in the BOUND_LM and BOUND_MH columns, respectively. The lower bound of “LOW” is set to 0 PHA, and upper bound of “HI” is set to 25 keV.

The structure is an empty primary with 1 bintable extension.

- TIME contains the time in unit of second (s).
- CCD_ID contains the CCD ID. 0, 1, 2, 3 indicate CCD1, CCD2, CCD3, and CCD4, respectively.
- SEGMENT contains the segment ID. 0 and 1 indicate Segment AB and CD, respectively.
- READNODE contains the readout node ID. For Segment AB, 0 and 1 indicate Readout node A and B, respectively. For Segment CD, 1 and 0 indicate Readout node C and D, respectively.
- OFFSET_LOW, LINR_LOW, and QUAD_LOW contain coefficients for the PHA-to-PI conversion for the low energy band.
- OFFSET_MED, LINR_MED, and QUAD_MED contain coefficients for the PHA-to-PI conversion for the medium energy band.
- OFFSET_HI, LINR_HI, and QUAD_HI contain coefficients for the PHA-to-PI conversion for the high energy band.
- BOUND_LM, and BOUND_MH define the boundary PHA between the low and med energy bands and between the med and high energy bands, respectively.

7.19.1 File Format

Table: Column definition for the Gain file

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	GAIN	
	Column Names	Format	Units
	TIME	1D	s
	CCD_ID	1B	-
	SEGMENT	1B	-
	READNODE	1B	-
	OFFSET_LOW	1E	-
	LINR_LOW	1E	-
	QUAD_LOW	1E	-
	OFFSET_MED	1E	-
	LINR_MED	1E	-
	QUAD_MED	1E	-
	OFFSET_HI	1E	-
	LINR_HI	1E	-

Table: Column definition for the Gain file			
Extension N.	Type	Ext. Name	
	QUAD_HI	1E	-
	BOUND_LM	1E	ch
	BOUND_MH	1E	ch

7.19.2 Header Keywords

Table 7.19.2		
Keyword name	Keyword value	Comment
CALDB keywords for the 1st and 2nd extensions		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'GAIN'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘PHA to PI conversion’	/Description
CBD10001	‘DATAMODE(Window1)’ (ext 1) ‘DATAMODE(Window2)’ (ext 2)	/Data mode
CBD20001	‘CISTATUS (1)’	/Charge Injection (0: off, 1: on)
EXTNAME	'GAIN’	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name

7.20 SXI Grade Hit Pattern File

This file is used by the software routine *sxipi*. The file name is

ah_sxi_pattern_YYYYMMDDvxxx.fits

This file is read in the forth step (GRADE assignment) of the sxipi routine.

This file contains all the possible hit pattern in a 3x3 pixel array, and defines GRADE for each pattern. Therefore, this is actually not calibration data, and all the values don’t change with time.

GRADE contains GRADE. An event with GRADE = 0, 2, 3, 4, or 6 is regarded as an X-ray event.

PATTERN contains 9 digit arrays indicating event hit pattern. PATTERN = 1 means PHAS in this pixel is equal to or more than split threshold; PATTERN = 2 means PHAS in this pixel is less than split threshold.

7.20.1 File Format

Table 7.20.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	HIT_PATTERN	
	Column Names	Format	Units
	GRADE	1B	-
	PATTERN	9B	-

7.20.2 Header Keywords

Table. Keyword list for Extension 1 of hit pattern file		
Keyword name	Keyword value	Comment
CALDB Keywords		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'HIT_PATTERN'	/Type of calibration data
CDTP0001	'DATA'	/data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Grade hit pattern’	/Description
EXTNAME	'HIT_PATTERN’	/Name of the binary table extension
INSTRUME	'SXI'	/Instrument name

7.21 SXI Dataclass File

This file contains configuration parameters (dataclass) if the SXI.

The file name is

ah_sxi_config_YYYYMMDDvxxx.fits

This file is only for a record purpose, and never used by any software.

The content of this file is one extension with the following columns.

- ID: contains an integer to identify the data class
- DATACLASS: contains a 4-digit hexadecimal number to identify the data class
- DATE: contains the date when the data class: contains defined
- REMARK: contains description about each data class
- WINDOW1_WINOPT: contains WINOPT (window option) value for full window mode
- WINDOW1_WIN_ST: contains WIN_ST (window start) value for full window mode
- WINDOW1_WIN_SIZE: contains WIN_SIZE (window size) value for full window mode
- WINDOW2_WINOPT: contains WINOPT (window option) value for 1/8 window mode
- WINDOW2_WIN_ST: contains WIN_ST (window start) value for 1/8 window mode
- WINDOW2_WIN_SIZE: contains WIN_SIZE (window size) value for 1/8 window mode
- HUCLEGTH: contains horizontal under clock length
- HOCLEGTH: contains horizontal over clock length
- VUCLEGTH: contains vertical under clock length
- VOCLEGTH: contains vertical over clock length
- IMGHEGHT: contains image height
- PIXEL_BINNING: contains the size of on-board pixel binning. ‘2x2_bin’ is supposed.
- WINDOW1_TIMEDEL: contains exposure time of each frame for full window mode
- WINDOW1_TIMTRANB: contains transfer time from imaging to store area for full window
- WINDOW1_TIMTRANA: contains transfer time from imaging to store area for window mode
- WINDOW1_EXPDEADB: contains dead time before exposure for burst mode
- WINDOW1_EXPDEADA: contains dead time after exposure for burst mode
- WINDOW1_FLUSHIMB: contains flush time for burst mode
- WINDOW1_LASTDEAD: contains dead time of last sequence for window mode
- WINDOW1_LASTDEL: contains exposure time of last sequence for window mode
- WINDOW1_NOMEXP0: nominal exposure time
- WINDOW1_TIMEPIXR: reference time of center time
- WINDOW1BURST_TIMEDEL same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_TIMTRANB same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_TIMTRANA same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_EXPDEADB same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_EXPDEADA same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_FLUSHIMB same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_LASTDEAD same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_LASTDEL same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_NOMEXPO same as for WINDOW1 for WINDOW1BURST mode
- WINDOW1BURST_TIMEPIXR same as for WINDOW1 for WINDOW1BURST mode
- WINDOW2_TIMEDEL same as for WINDOW1 for WINDOW2 mode
- WINDOW2_TIMTRANB same as for WINDOW1 for WINDOW2 mode

- WINDOW2_TIMTRANA same as for WINDOW1 for WINDOW2 mode
- WINDOW2_EXPDEADB same as for WINDOW1 for WINDOW2 mode
- WINDOW2_EXPDEADA same as for WINDOW1 for WINDOW2 mode
- WINDOW2_FLUSHIMB same as for WINDOW1 for WINDOW2 mode
- WINDOW2_LASTDEAD same as for WINDOW1 for WINDOW2 mode
- WINDOW2_LASTDEL same as for WINDOW1 for WINDOW2 mode
- WINDOW2_NOMEXPO same as for WINDOW1 for WINDOW2 mode
- WINDOW2_TIMEPIXR same as for WINDOW1 for WINDOW2 mode
- WINDOW2BURST_TIMEDEL same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_TIMTRANB same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_TIMTRANA same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_EXPDEADB same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_EXPDEADA same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_FLUSHIMB same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_LASTDEAD same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_LASTDEL same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_NOMEXPO same as for WINDOW1 for WINDOW2BURST mode
- WINDOW2BURST_TIMEPIXR same as for WINDOW1 for WINDOW2BURST mode
- WINDOW1_CIOFFSET: contains CIOFFSET (charge injection offset) value for full window mode.
- WINDOW1_CIPERIOD: contains CIPERIOD (charge injection period) value for full window mode.
- WINDOW1_CIFIRST: contains CIFIRST (first charge injection row) value for full window mode.
- WINDOW1_CIAMOUNT: contains amount of injected charge for full window mode.
- WINDOW2_CIOFFSET: contains CIOFFSET (charge injection offset) value for 1/8 window mode.
- WINDOW2_CIPERIOD CIPERIOD (charge injection period) value for 1/8 window mode.
- WINDOW2_CIFIRST: contains CIFIRST (first charge injection row) value for 1/8 window mode.
- WINDOW2_CIAMOUNT: contains amount of injected charge for full window mode.
- EVENTTHR_LOWER: contains lower event threshold.
- EVENTTHR_UPPER: contains upper event threshold.
- EVENTTHR_LOWER_NDYE: contains lower event threshold for minus-Z day Earth time interval.
- EVENTTHR_UPPER_NDYE: contains upper event threshold for minus-Z day Earth time interval.
- SPTHIN: contains inner split threshold.
- SPTHOUT: contains outer split threshold.
- C0S0ARON indicates area discrimination on/off for CCD1 Segment AB.
- C0S0ARIN indicates inner area discrimination region for CCD1 Segment AB.
- C0S0AROU indicates outer area discrimination region for CCD1 Segment AB.
- C0S1ARON indicates area discrimination on/off for CCD1 Segment CD.
- C0S1ARIN indicates inner area discrimination region for CCD1 Segment CD.
- C0S1AROU indicates outer area discrimination region for CCD1 Segment CD.
- C1S0ARON indicates area discrimination on/off for CCD2 Segment AB.
- C1S0ARIN indicates inner area discrimination region for CCD2 Segment AB.

- C1S0AROU indicates outer area discrimination region for CCD2 Segment AB.
- C1S1ARON indicates area discrimination on/off for CCD2 Segment CD.
- C1S1ARIN indicates inner area discrimination region for CCD2 Segment CD.
- C1S1AROU indicates outer area discrimination region for CCD2 Segment CD.
- C2S0ARON indicates area discrimination on/off for CCD3 Segment AB.
- C2S0ARIN indicates inner area discrimination region for CCD3 Segment AB.
- C2S0AROU indicates outer area discrimination region for CCD3 Segment AB.
- C2S1ARON indicates area discrimination on/off for CCD3 Segment CD.
- C2S1ARIN indicates inner area discrimination region for CCD3 Segment CD.
- C2S1AROU indicates outer area discrimination region for CCD3 Segment CD.
- C3S0ARON indicates area discrimination on/off for CCD4 Segment AB.
- C3S0ARIN indicates inner area discrimination region for CCD4 Segment AB.
- C3S0AROU indicates outer area discrimination region for CCD4 Segment AB.
- C3S1ARON indicates area discrimination on/off for CCD4 Segment CD.
- C3S1ARIN indicates inner area discrimination region for CCD4 Segment CD.
- C3S1AROU indicates outer area discrimination region for CCD4 Segment CD.
- ADCAVE: contains ASIC usage.
- ACTVNODE: contains active node.
- DARKLOW: contains lower dark threshold.
- DARKUPP: contains upper dark threshold.
- HOTPIXTH: contains hot pixel threshold.
- HOCSUMSK: contains HOC sum skip value
- IFOFSET: contains iframe offset value
- ASICGAIN: contains ASIC gain
- COOLER: contains first cooler (A or B)
- TARGET_TEMP: contains target CCD temperature

7.21.1 File Format

Table 7.21.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	DATACLASS	
	Column Names	Format	Units
	ID	1I	-
	DATACLASS	4A	-
	DATE	10A	-

Table 7.21.1			
Extension N.	Type	Ext. Name	
	REMARK	160A	-
	WINDOW1_WINOPT	1B	-
	WINDOW1_WIN_ST	1I	-
	WINDOW1_WIN_SIZE	1I	-
	WINDOW2_WINOPT	1B	-
	WINDOW2_WIN_ST	1I	-
	WINDOW2_WIN_SIZE	1I	-
	HUCLEGTH	48A	-
	HOCLEGTH	48A	-
	VUCLEGTH	48A	-
	VOCLEGTH	48A	-
	IMGHEGHT	48A	-
	PIXEL_BINNING	16A	-
	WINDOW1_TIMEDEL	1E	-
	WINDOW1_TIMTRANB	1E	-
	WINDOW1_TIMTRANA	1E	-
	WINDOW1_EXPDEADB	1E	-
	WINDOW1_EXPDEADA	1E	-
	WINDOW1_FLUSHIMB	1E	-
	WINDOW1_LASTDEAD	1E	-
	WINDOW1_LASTDEL	1E	-
	WINDOW1_NOMEXP0	1E	-
	WINDOW1_TIMEPIXR	1E	-
	WINDOW1BURST_TIMEDEL	1E	-
	WINDOW1BURST_TIMTRANB	1E	-
	WINDOW1BURST_TIMTRANA	1E	-
	WINDOW1BURST_EXPDEADB	1E	-
	WINDOW1BURST_EXPDEADA	1E	-
	WINDOW1BURST_FLUSHIMB	1E	-
	WINDOW1BURST_LASTDEAD	1E	-
	WINDOW1BURST_LASTDEL	1E	-
	WINDOW1BURST_NOMEXP0	1E	-

Table 7.21.1			
Extension N.	Type	Ext. Name	
	WINDOW1BURST_TIMEPIXR	1E	-
	WINDOW2_TIMEDEL	1E	-
	WINDOW2_TIMTRANB	1E	-
	WINDOW2_TIMTRANA	1E	-
	WINDOW2_EXPDEADB	1E	-
	WINDOW2_EXPDEADA	1E	-
	WINDOW2_FLUSHIMB	1E	-
	WINDOW2_LASTDEAD	1E	-
	WINDOW2_LASTDEL	1E	-
	WINDOW2_NOMEXP0	1E	-
	WINDOW2_TIMEPIXR	1E	-
	WINDOW2BURST_TIMEDEL	1E	-
	WINDOW2BURST_TIMTRANB	1E	-
	WINDOW2BURST_TIMTRANA	1E	-
	WINDOW2BURST_EXPDEADB	1E	-
	WINDOW2BURST_EXPDEADA	1E	-
	WINDOW2BURST_FLUSHIMB	1E	-
	WINDOW2BURST_LASTDEAD	1E	-
	WINDOW2BURST_LASTDEL	1E	-
	WINDOW2BURST_NOMEXP0	1E	-
	WINDOW2BURST_TIMEPIXR	1E	-
	WINDOW1_CIOFFSET	1I	-
	WINDOW1_CIPERIOD	1I	-
	WINDOW1_CIFIRST	1I	-
	WINDOW1_CIAMOUNT	1A	-
	WINDOW2_CIOFFSET	1I	-
	WINDOW2_CIPERIOD	1I	-
	WINDOW2_CIFIRST	1I	-
	WINDOW2_CIAMOUNT	1A	-
	EVENTTHR_LOWER	48A	-
	EVENTTHR_UPPER	48A	-
	EVENTTHR_LOWER_NDYE	48A	-

Table 7.21.1			
Extension N.	Type	Ext. Name	
	EVENTTHR_UPPER_NDYE	48A	-
	SPTHIN	48A	-
	SPTHOUT	48A	-
	C0S0ARON	12A	-
	C0S0ARIN	16A	-
	C0S0AROU	64A	-
	C0S1ARON	12A	-
	C0S1ARIN	16A	-
	C0S1AROU	64A	-
	C1S0ARON	12A	-
	C1S0ARIN	16A	-
	C1S0AROU	64A	-
	C1S1ARON	12A	-
	C1S1ARIN	16A	-
	C1S1AROU	64A	-
	C2S0ARON	12A	-
	C2S0ARIN	16A	-
	C2S0AROU	64A	-
	C2S1ARON	12A	-
	C2S1ARIN	16A	-
	C2S1AROU	64A	-
	C3S0ARON	12A	-
	C3S0ARIN	16A	-
	C3S0AROU	64A	-
	C3S1ARON	12A	-
	C3S1ARIN	16A	-
	C3S1AROU	64A	-
	ADCAVE	24A	-
	ACTVNODE	24A	-
	DARKLOW	48A	-
	DARKUPP	48A	-
	HOTPIXTH	48A	-

Table 7.21.1			
Extension N.	Type	Ext. Name	
	HOCSUMSK	48A	-
	IFOFSET	48A	-
	ASICGAIN	48A	-
	COOLER	8A	-
	TARGET_TEMP	16A	-

7.21.2 First Extension Keywords

The mandatory CALDB keywords are listed below together with their values for the fluorescence line

Table 7.21.2		
Keyword name	Keyword value	
CALDB Keywords		
TELESCOP	'HITOMI'	/ Telescope (mission) name
INSTRUME	'SXI'	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'DATACLASS'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'SXI Data Class Configuration'	/ Brief descriptive summary of this file

7.22 SXI Redistribution Matrix File (RMF)

A prepared RMF for a simulation purpose based on the ground calibrations. The file name is

ah_sxi_YYYYMMDDvxxx.rmf

This is a Calibration product file (CPF). The structure is an empty primary with 2 bintable extensions, with columns in the standard OGIP format. See the common part section for details.

7.23 SXI Ancillary Response File (ARF)

A prepared ARF for a simulation purpose based on the ground calibrations. The file name is

ah_sxi_YYYYMMDDvxxx.arf

This is a Calibration product file (CPF). The structure is an empty primary with 1 bintable extension, with columns in the standard OGIP format. See the common part section for details.

7.24 SXI Non X-ray Background Spectrum File (NXB)

A prepared NXB PI file for a simulation purpose. The file name is

ah_sxi_nxb_YYYYMMDDvxxx.pi

This is a Calibration product file (CPF). The structure is an empty primary with 1 bintable extension, with columns in the standard OGIP format. See the common part section for details

8 SXS

8.1 SXS Teldef File

This is the Telescope definition file (Teldef) needed for coordinate transformation. The file name is

ah_sxs_teldef_ yyyymmddvnn.fits

The format of this foarmat is conform to Teldef v0.2 standard (see document “Teldef File Format Specification Version 0.2”). This is a FITS file containing in the primary HDU a set of keywords describing the coordinate systems and the transformations between them and a BINTABLE extention with the pixel size in X and Y.

For the SXS, the four transformation types between coordinate systems are:

- TRTYPE0 = 'RAWTODET' / RAW to DET transformation
- TRTYPE1 = 'BASIC' / ACT to DET
- TRTYPE2 = 'BASIC ' / DET to FOC
- TRTYPE3 = 'SKYATT ' / FOC to SKY

The RAW (PIXEL) to DET transformation uses the values in the PIXEL_MAP extension. The DET to ACT transformation uses the keywords DETXFLIP, DETYFLIP, DET_ROTD, DETX_OFF and DET_YOFF. The ACT to FOC transformation is governed by the keywords FOC_XOFF, FOC_YOFF, FOC_ROT. The FOC to SKY transformation is governed by the FOC_Mxx keywords and uses the spacecraft attitude file. There are additional keywords CAL_xxxx that define the SXS calibration pixel.

The PIXEL_MAP table extension is a mapping from SXS pixel number (0:35) and the physical locations of the four corners of each pixel.

- PIXEL: contains the pixel number.
- PIXELX and PIXELY : contain the coordinate of 4 pixel corners for each pixel.

8.1.1 File Format

Table 8.1.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	PIXEL_MAP	
	Column Names	Format	Units
	PIXEL	1I	-
	PIXELX	4E	mm
	PIXELY	4E	mm

8.1.2 Header Keywords

Primary extension:

Table 8.1.2		
Keyword name	Keyword value	Comment
TELESCOP	'HITOMI '	/ Telescope (mission) name
INSTRUME	'SXS'	/ Instrument name
TD_VERS	0.2	/ Teldef file format specification version
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'TELDEF'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'TELESCOPE DEFINITION FILE'	/ Brief descriptive summary of this file
CBD10001	'VERSION(1)'	/ Format version of HITOMI teldef file

Table 8.1.2.0		
Keyword name	Keyword Value	Comment
General Keywords		
NCOORDS	5	number of coordinates defined in this file
COORD0	'RAW '	0th coordinate system (RAWX,RAWY)

COORD1	'ACT '	1st coordinate system (ACTX,ACTY)
COORD2	'DET '	2nd coordinate system (DETX,DETY)
COORD3	'FOC '	3rd coordinate system (FOCX,FOCY)
COORD4	'SKY '	4th coordinate system (X,Y)
TRTYPE0	'RAWTODET'	RAW to ACT transformation
TRTYPE1	'BASIC '	ACT to DET
TRTYPE2	'BASIC '	DET to FOC
TRTYPE3	'SKYATT '	FOC to SKY
RANCOORD	'DET '	Origin coordinate for randomization
RAN_SCAL	'DET '	System to set scale for randomization
RAW_SCOL	'PIXEL '	Each XRS pixel is a segment
RAW_NSEG	36	number of segments, 36 pixels for SXS
RAW_XSIZ	1	only one pixel per segment
RAWXPIX1	1	arbitrary coordinate of single pixel
RAW_YSIZ	1	only one pixel per segment
RAWYPIX1	1	arbitrary coordinate of single pixel
RAW_UNIT	'mm '	physical unit of RAW
ACT_XSIZ	8	ACT address space x size (pixels)
ACTXPIX1	1	ACT address space x first pixel number (pixel)
ACT_XSCL	0.832	ACT X scale (mm/pixel)
ACT_YSIZ	8	ACT address space y size (pixels)
ACTYPIX1	1	ACT address space y first pixel number (pixel)
ACT_YSCL	0.832	ACT Y scale (mm/pixel)
ACT_UNIT	'mm '	physical unit of ACT
ACT_SCAL	0.832	pixel measurement unit (mm) per one ACT pixel
IN0_XCEN	0.0	x center of RAW pixel measurement coordinates
IN0_YCEN	0.0	y center of RAW pixel measurement coordinates
ACT_XOFF	0.832	RAWX offset (mm) to the ACT center position
ACT_YOFF	0.832	RAWY offset (mm) to the ACT center position
ACTXFLIP	1	do not flip x-axis in RAW -> ACT
ACTYFLIP	1	do not flip y-axis in RAW -> ACT
DET_XSIZ	8	DET address space x size (pixels)
DETXPIX1	1	DET address space x first pixel number (pixel)
DET_XSCL	0.832	DET address space mm per x det unit (mm/pixel)
DET_YSIZ	8	DET address space y size (pixels)
DETYPIX1	1	DET address space y first pixel number (pixel)
DET_YSCL	0.832	DET address space mm per y det unit (mm/pixel)
DET_UNIT	'mm '	physical unit of DET
DET_SCAL	1.000	Conversion between ACT and DET scales
DETXFLIP	1	do not flip x-axis in RAW -> DET
DETYFLIP	-1	flip y-axis in RAW (look-down) -> DET (look-up)
DET_ROTD	180	Rotate by 180 degrees between ACT and DET

DET_XOFF	-2	Correct to put the cal pixel at (1,1)
DET_YOFF	0	No correction for Y
FOC_XSIZ	2430	FOC address space x size (pixels)
FOCXPIX1	1	FOC address space x first pixel number (pixel)
FOC_XSCL	0.048	FOC X scale (mm/pixel)
FOC_YSIZ	2430	FOC address space y size (pixels)
FOCYPIX1	1	FOC address space y first pixel number (pixel)
FOC_YSCL	0.048	FOC Y scale (mm/pixel)
FOC_UNIT	'mm '	physical unit of FOC
FOC_SCAL	0.0577	Conversion between DET and FOC scales
FOC_XOFF	-1.055	DETX offset (pixel) to the FOC center position
FOC_YOFF	-0.998	DETY offset (pixel) to the FOC center position
FOC_ROTD	0.000	DET rotation angle (deg) in FOC coordinates
SKY_XSIZ	2430	SKY address space x size (pixels)
SKYXPIX1	1	SKY address space x first pixel number (pixel)
SKY_XSCL	0.048	SKY X scale (mm/pixel)
SKY_YSIZ	2430	SKY address space y size (pixels)
SKYYPIX1	1	SKY address space y first pixel number (pixel)
SKY_YSCL	0.048	SKY Y scale (mm/pixel)
SKY_UNIT	'deg '	physical unit of SKY
FOCALLEN	5600.0	SXT focal length (mm)
FOC_M11	1.0	SAT -> FOC coordinates alignment matrix Mij
FOC_M12	0.0	(look-down) (look-up)
FOC_M13	0.0	
FOC_M21	0.0	[3x3 rotation matrix, common to all sensors]
FOC_M22	1.0	
FOC_M23	0.0	FOCX = M11*SATX + M12*SATY + M13*SATZ
FOC_M31	0.0	FOCY = M21*SATX + M22*SATY + M23*SATZ
FOC_M32	0.0	FOCZ = M31*SATX + M32*SATY + M33*SATZ
FOC_M33	1.0	
ALIGNM11	1.0	
ALIGNM12	0.0	
ALIGNM13	0.0	
ALIGNM21	0.0	
ALIGNM22	1.0	
ALIGNM23	0.0	
ALIGNM31	0.0	
ALIGNM32	0.0	
ALIGNM33	1.0	
OPTCOORD	'DET '	optical axis is defined in DET coordinates
OPTAXISX	3.716	/optical axis x in DET coordinates (pixel)
OPTAXISY	3.343	optical axis y in DET coordinates (pixel)

OPT_ROTD	0.00000	rotation of telescope output system wrt DET
OPTXFLIP	1	flip of telescope axes relative to DETX/Y
OPTYFLIP	-1	flip from (look-down) to (look-up)
CALPIXEL	12	ID number of the calibration pixel
CAL_DETX	0	DET X value for the cal pixel
CAL_DETY	0	DET Y value for the cal pixel
CAL_FOCX	0	FOC X value for the cal pixel
CAL_FOCY	0	FOC Y value for the cal pixel
CAL_X	0	SKY X value for the cal pixel
CAL_Y	0	SKY Y value for the cal pixel
CAL_ROLL	0.0	ROLL value for the cal pixel
ROLLSIGN	-1.0	Roll sign convention
ROLLOFF	0.0	Roll offset (degrees)
NCOORDS	5	number of coordinates defined in this file

Extension 1:

Table 8.1.2.1		
Keyword name	Keyword value	Comment
General Keywords		
TELESCOP	'HITOMI '	/ Telescope (mission) name
INSTRUME	'SXS'	/ Instrument name
TD_VERS	0.2	/ Teldef file format specification version
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'PIXEL_MAP'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'TELESCOPE DEFINITION FILE'	/ Brief descriptive summary of this file
CBD10001	'VERSION(1)'	/ Format version of HITOMI teldef file

8.2 SXT-I Telescope Description File

The file name is

ah_sxs_mirror_YYYYMMDDvxxx.fits.

This file contains data for the structure of the SXI X-ray telescope, describing the mirror foils and their reflective surfaces, the support structure, a pre-collimator if present, as well as rotational and translational offsets of the telescope components relative to each other. See the common part chapter for details.

8.3 SXT-I Reflectivity and Transmission File

The file name is

ah_sxs_reflect_YYYYMMDDvxxx.fits.

This file contains data for the reflectivity and transmission of the front-side mirror coatings of an X-ray telescope, and reflectivity tables for the backside of mirror foils and for pre-collimator foils. It also contains, in a different extension, the mass-absorption coefficients of all the materials that a complete mirror foil is composed of. The coatings may be of single-layer or multi-layer types. See the common part chapter for details.

8.4 SXT-I Scattering File

The file name is

ah_sxs_scatter_YYYYMMDDvxxx.fits.

This file contains data for the probability of a photon scattering relative to the reflection direction for specular reflection when reflecting on the an XRT foil. See the common part chapter for details.

8.5 SXT-I Point Spread Function File

The file name is

ah_sxs_psf_YYYYMMDDvxxx.fits.

This file contains point spread function (PSF) library. See the common part chapter for details.

8.6 SXT-I Vignetting File

The file name is

ah_sxs_vignet_YYYYMMDDvxxx.fits.

This file contains vignetting function library. See the common part chapter for details.

8.7 SXT-I Event File

The file name is

ah_sxs_event_YYYYMMDDvxxx.fits.

This file contains library from ray-tracing. See the common part chapter for details.

8.8 Gain (Energy Scale) coefficient for the Pixel

This file contains temperature-dependent gain coefficients for each pixel. The filename is
ah_sxs_gainpix_YYYYMMDDvNNN.fits
where YYYYMMDD to the initial validity date of the file and NNN the version number.

The gain, table is used in the software routine *sxsgain* and *sxspha2pi* to calculate the EPI column and ultimately the values in PI column used to the derived the spectrum. The gain table contains distinct coefficients for high, medium, and low resolution primary event grades and there is a set of coefficient for different temperature. The file structure is an empty primary header with a bintable extension. If the energy scale changes, the polynomial coefficients are adjusted, and additional extensions appended containing updated CVSD0001 and CVST0001 keywords.

The extension has the following columns:

- TEMP : contains temperature in Kelvin.
- the pixel number (0-35) defined with respect to the entire array as described above.
- H0, H1, H2, H3, H4, and H5: contain the 0^{th}-5^{th} order polynomial coefficients for high-resolution events. Each column consists of 36 elements corresponding to PIXEL 0-35.
- M0, M1, M2, M3, M4, and M5 : contain the 0^{th}-5^{th} order polynomial coefficients for mid-resolution events. Each column consists of 36 elements corresponding to PIXEL 0-35.
- L0, L1, L2, L3, L4, and L5 : contain the 0^{th}-5^{th} order polynomial coefficients for low-resolution events. Each column consists of 36 elements corresponding to PIXEL 0-35.

8.8.1 File Format

Table 8.8.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	GAIN	
	Column Names	Format	Units
	TEMP	1D	K
	H0	36D	eV
	M0	36D	eV
	L0	36D	eV
	H1	36D	eV
	M1	36D	eV

Table 8.8.1			
Extension N.	Type	Ext. Name	
	L1	36D	eV
	H2	36D	eV
	M2	36D	eV
	L2	36D	eV
	H3	36D	eV
	M3	36D	eV
	L3	36D	eV
	H4	36D	eV
	M4	36D	eV
	L4	36D	eV
	H5	36D	eV
	M5	36D	eV
	L5	36D	eV

8.8.2 Header Keywords

Keyword name	Keyword value	Comment
Keywords for the 1st extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'GAINPIX'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS Pixel Gain Polynomial Coefficients’	/Description
CBD10001	SHPTEMPL(20150310)	/Boundary parameter
EXTNAME	'GAIN’	/Name of the binary table extension
DETNAM	‘PIXEL’	/Detector name
NCOEFF	6	/ Number of coefficients

8.9 SXS Scale File

The file contains energy scale coefficients per pixel to correct EPI values obtained using the cal pixel gain correction. The file is (optionally) used by *sxspha2pi*. The filename is:

ah_sxs_scale_YYYYMMDDvNNN.fits

where YYYYMMDD to the initial validity date of the file and NNN the version number.

The first extension contains parameters for SXS gain adjustments for each individual pixel. This adjustment is valid only when the *sxspha2pi* parameters 'scalefile' and if 'scaleepi' are set to 'CALDB' and 'yes', respectively. If the drift file is constructed using the MXS sources or the Fe55 filter the corrections are for each individual pixel in the array. This type of correction is only for test since the 'stretch' introduced by this correction to all other pixels is already included in the gain caldb for pixel data.

- PIXEL: contains pixel number (0-35).
- HP: contains scale factor to apply to Hp events.
- M: contains scale factor to apply to Mp and Ms events.
- L: contains scale factor to apply to Lp and Ls events.

8.9.1 File Format

Table 8.9.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	PIX12GAINCOR	
	Column Names	Format	Units
	PIXEL	1I	-
	HP	1D	-
	M	1D	-
	L	1D	-

8.9.2 Extension Header Keywords

The mandatory CALDB keywords are listed below together with their values for the gain coefficient table:

Table 8.9.2		
Keyword name	Keyword value	
CALDB Keywords		
TELESCOP	'HITOMI	/ Telescope (mission) name
INSTRUME	'SXS'	/ Instrument name

CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	'PIX12GAINCOR'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	'Scale all the pixel gain calculated using Pixel 12	/ Brief descriptive summary of this file

8.10 Gain (Energy Scale) coefficient for the Antico

The file contains gain coefficient for the SXS antico, and is used by the task *sxsanticopi*. The filename is
ah_sxs_gainant_YYYYMMDDvNNN.fits
where YYYYMMDD to the initial validity date of the file and NNN the version number.

The gain relates the signal pulse height amplitude measured by the antico detector, to the energy of the detected photon energy in keV. This energy scale (gain) correction is characterized, via ground calibration measurements, separately for the two reads out of the antico, PSPA and PSPB as third order polynomial ($PI=a_0+a_1(PHA)+a_2(PHA)^2+\ldots a_{N-1}(PHA)^{N-1}+a_N(PHA)^N$; N=3). The coefficient for each PSP are stored in this calibration file and used by the "sxsantpi" task to write out in the PI column in the antico event files.

The file structure is an empty primary header with a bintable extension. If the energy scale changes, the polynomial coefficients are adjusted, and additional extensions appended containing updated CVSD0001 and CVST0001 keywords.

The extension has the following columns:

- PSP_ID : contains PSP ID, set to 0 or 2. 0= PSPA0 & PSPA1, 2=PSPB0 & PSPB1
- COEF0, COEF1, COEF2, COEF3 : contain the 0^{th}-3^{th} order polynomial coefficients.

8.10.1 File Format

Table 8.10.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BITABLE	GAIN	
	Column Names	Format	Units
	PSP_ID	1I	
	COEF0	1D	keV
	COEF1	1D	keV
	COEF2	1D	keV

Table 8.10.1			
Extension N.	Type	Ext. Name	
	COEF3	1D	keV

8.10.2 Header Keywords

Table 8.10.2		
Keyword name	Keyword value	Comment
Keywords for the 1st and 2nd extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'GAINANT'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'SXS Antico Gain Polynomial Coefficients'	/Description
EXTNAME	'GAIN'	/Name of the binary table extension
DETNAM	ANTICO	/Detector name
NCOEFF	4	/ Number of coefficients

8.11 SXS Bad Pixel File

The file indicates pixel condition, good (active) or bad (dead) for each pixel. The filename is ah_sxs_badpix_YYYYMMDD.fits

This file contains the status ('good' or 'bad') of SXS pixels defined at times when there is a change in status. Its structure is an empty primary header with 1 bintable extension called BADPIX, with 37 columns: the TIME column (in seconds), and one additional column for each of the 36 SXS pixels (PIXEL0, PIXEL1..., PIXEL35) with either 0 (if pixel is OK) or 1 (if pixel is not OK). A new row is added whenever there is a change in status of any pixel with the corresponding time and updated statuses.

8.11.1 File Format

Table 8.11.1		
Extension N.	Type	Ext. Name
0	PRIMARY	

Table 8.11.1			
Extension N.	Type	Ext. Name	
1	BINTABLE	BADPIX	
	Column Names	Format	Units
	TIME	1D	s
	PIXEL0	1B	-
	PIXEL1	1B	-
	...	…	…
	PIXEL35	1B	-

8.11.2 Header Keywords

Table 8.11.2		
Keyword name	Keyword value	Comment
Keywords for 1st and 2nd extension		
CALDB Keywords		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'BADPIX'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'SXS BAD Pixel File'	/Description
EXTNAME	'BADPIX'	/Name of the binary table extension

8.12 SXS Instrument Map

This file is used by the Monte-Carlo simulator *ahsim* as well as *ahexpomap*. The filename is:

ah_sxs_instmap_YYYYMMDDvxxx.fits

The file contains images in the FOC and DET coordinates in the primary and first extensions, respectively. None of the extensions has column data. The image indicates the detector field of view. The Dimension is 2430 x 2430 for the primary, and 8 x 8 for the first extension. The value is 1 for the FoV, and 0 for out of FoV. The first extension (HDU2) contains several keywords that are needed for arf generation.

8.12.1 Header Keywords

Table. 8.12.1		
Keyword name	Keyword value	Comment
Keywords for the primary extension		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'INSTMAP_FOC'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	‘Instrument Map file’	/Description
INSTRUME	'SXS'	/Instrument name
CTYPE1	‘FOCX’	Name of the X axis
CTYPE1	‘FOCY’	Name of the Y axis
CUNIT1	‘pixel’	Unit for X-axis
CUNIT2	‘pixel’	Unit for Y-axis
CRVAL1	1215.5	FOCX image reference pixel value
CRPIX1	1215.5	FOCX image reference pixel
CDELT1	1	FOCX pixel scale
CRVAL2	1215.5	FOCY image reference pixel value
CRPIX2	1215.5	FOCY image reference pixel
CDELT2	1	FOCY pixel scale
SXSPXWID	814	Pixel width (um)
SXSPXGAP	18	Gap width between pixels (um)

Table. 8.12.2		
Keyword name	Keyword value	Comment
Keywords for 1st extension		

CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'INSTMAP_DET'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	‘Instrument Map file’	/Description
EXTNAME	‘INSTMAP	/Name of the binary table extension
INSTRUME	'SXS'	/Instrument name
CTYPE1	‘DETX’	Name of the X axis
CTYPE1	‘DETY’	Name of the Y axis
CUNIT1	‘pixel’	Unit for X-axis
CUNIT2	‘pixel’	Unit for Y-axis
CRVAL1	4.5	DETX image reference pixel value
CRPIX1	4.5	4.5
CDELT1	1	DETX pixel scale
CRVAL2	4.5	DETY image reference pixel value
CRPIX2	4.5	DETY image reference pixel
CDELT2	1	FOCY pixel scale
OPTAXISX	3.716	optical axis x in DET coordinates (pixel)
OPTAXISY	3.343	optical axis y in DET coordinates (pixel)
ACT_XSCL	0.832	ACT X scale (mm/pixel)
ACT_XSCL	0.832	ACT X scale (mm/pixel)
ACT_XSIZ	8	ACT address space x size (pixels)
ACT_YSIZ	8	ACT address space y size (pixels)
DET_XSCL	0.832	DET X scale (mm/pixel)
DET_YSCL	0.832	DET Y scale (mm/pixel)
DETXFLIP	1	Flip to DET X system
DETYFLIP	-1	Flip to DET Y system
FOCALLEN	5600.0	SXI focal length (mm)

FOC_XSCL	0.048	FOC X scale (mm/pixel)
FOC_YSCL	0.048	FOC Y scale (mm/pixel)
DET_XSIZ	8	DET address space x size (pixels)
DET_YSIZ	8	DET address space y size (pixels)
FOC_XSIZ	2430	FOC address space x size (pixels)
FOC_YSIZ	2430	FOC address space y size (pixels)
FOC_XOFF	-0.8637	DETX offset (pixel) to the FOC center position
FOC_YOFF	-0.8582	DETY offset (pixel) to the FOC center position
FOC_ROTD	0.0	DET rotation angle (deg) in FOC coordinates
OPT_ROTD	0.0	rotation of telescope output system wrt DET
OPTXFLIP	1	flip of telescope axes relative to DETX/Y
OPTYFLIP	-1	flip from (look-down) to (look-up)
SXSPXWID	814	Pixel width (um)
SXSPXGAP	18	Gap width between pixels (um)
ROT00	1.0	transform matrix component
ROT01	0.0	transform matrix component
ROT10	0.0	transform matrix component
ROT11	1.0	transform matrix component
SHIFTX	1163.0	translation in X
SHIFTY	1163.0	translation in Y

8.13 Pixel Definition

The filename is
ah_sxs_pixmap_YYYYMMDDvNNN.fits

This file contains the various indices used to identify each of the 36 SXS pixels. The pixel numbering is determined by the wire routing from each pixel to the bond pads such that pixels with adjacent wires have adjacent pixel number.
Pixel number is used in the “sxsflagpix” task to identify potential cross-talk pixel pairs (and multiplets), as well as the calibration pixel. With respect to onboard processing, half of the 36 pixels are processed in each of the two XBOX and the PSP MIO units where they are numbered from 0 to 17; a quarter of the 36 pixels are processed in each of the PSP SpaceCard units they are numbered from 0 to 8. The file structure is an empty primary header with 1 bintable extension called PIXMAP. The single extension has the following columns:

- PIXEL : contains the pixel number (0-35) defined with respect to the entire array as described above.
- XMSIDE : contains the array "side" (0 for PSP/XBOX A-side, 1 for PSP/XBOX B-side).
- XMPIXEL : contains the pixel number (0-17) defined with respect to the side identified by XMSIDE.
- SPCQUAD : contains the SpaceCard "quadrant" (0 for PSP-A0, 1 for PSP-A1, 2 for PSP-B0, 3 for PSP-B1).
- SPCPIXEL : contains the pixel number (0-8) defined with respect to the quadrant identified by SPCQUAD.

8.13.1 File Format

Table 8.13.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	PIXMAP	
	Column Names	Format	Units
	PIXEL	1I	-
	XMSIDE	1I	-
	XMPIXEL	1I	-
	SPCQUAD	1I	-
	SPCPIXEL	1I	-

8.13.2 Header Keywords

Table. 8.13.2		
Keyword name	Keyword value	Comment
CALDB keywords for the 1st extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'PIXMAP'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'SXS Pixel Definition Table'	/Description
EXTNAME	'PIXMAP'	/Name of the binary table extension
DETNAM	'PIXEL'	/Detector Name

8.14 Quantum Efficiency

This file contains the quantum efficiency (QE) as a function of energy for the SXS HgTe absorbers. The filename is
ah_sxs_quanteff_YYYYMMDDvNNN.fits
where YYYYMMDD refers to the initial validity date of the file and NNN the version number.
The quantum efficiency values are based on measurements performed on ground. The file structure is an empty primary header with 1 bintable extension, named QE. The table has two columns:

- ENERGY : contains the energy in eV
- QE : contains the normalized quantum efficiency at that energy and the values range from 0-1. The quantum efficiency is valid for all pixels in the SXS array.

8.14.1 File Format

Table 8.14.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	QE	
	Column Names	Format	Units
	ENERGY	1E	eV
	QE	1E	

8.14.2 Header Keywords

Table. 8.14.2		
Keyword name	Keyword value	Comment
CALDB keywords for the 1st extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'QE'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS Quantum Efficiency’	/Description
EXTNAME	'QE’	/Name of the binary table extension
DETNAM	‘PIXEL’	/Detector Name

8.15 SXS RMF Input Parameter File

This file contains the SXS line spread function (LSF) parameters required by the sxsrmf tool in order to construct the SXS rmf for each pixel.
The filename is

ah_sxs_rmfparam_YYYYMMDDvNN.fits [currently, rmfinput.fits]

where YYYYMMDD refers to the initial validity date of the file and NN the version number.

Its structure is an empty primary header with 2 bintable extensions called LINESIGMA and LINETAU. The LINESIGMA table has 37 columns: the ENERGY column (in eV), and one additional column for each of the 36 SXS pixels containing a 3-element array. The arrays are filled with the FWHM for the Gaussian components of the LSF for High-, Mid-, and Low-resolution events, respectively. The LINETAU table has 4 columns plus one column for each escape peak: ENERGY (in eV), TAU – the exponential decay width (in eV), F_TAU – the integrated fraction of the exponential tail contribution to the LSF, F_ELC – the integrated fraction of the electron loss continuum contribution to the LSF, and F_EP1 … F_EPn -- the integrated fraction of the escape peak 1...n contribution to the LSF. These components are assumed to be the same for all pixels

The sxsrmf task calculates the rmf for a single SXS pixel and resolution (High, Mid, or Low) using these parameters. The LSF is assumed to consist of (1) a Gaussian core with a pixel-dependent FWHM, (2) a low-energy exponential tail due to energy loss at the surface of the absorbers, (3) an extended low energy electron loss continuum, and (4) discrete escape peaks from M-shell fluorescence of Hg or Te in the absorber. The latter three components are assumed to pixel-independent. Four types of rmf files may be created by sxsrmf (s, m, l, x). S(mall) type accounts only for the Gaussian core calculated over the energy range defined in the first input file or extension by the RANGEHIG, RANGEMID, and RANGELOW keywords (for high-, mid-, and low-resolution rmf files). M(edium) type additionally includes the exponential tail, convolved with the Gaussian in the energy range defined by the RANGEHIG, RANGEMID, RANGELOW keywords and RANGETAU in the second input file/extension (i.e., the energy redistribution extends to the positive side according to the magntiude RANGEHIG, RANGEMID, or RANGELOW, and to the negative side by the maximum of RANGETAU and RANGEHIG, RANGEMID, or RANGELOW). L(arge) type additionally includes the escape peaks, using the Gaussian core component shifted by the energies given in the header of the second extension. Keywords specify the number of peaks (NPEAK) and energies (EP1, EP2...) for each peak. X(tra large) type additionally adds the electron loss continuum. The final normalizations are based on these values, the number of components included, and the requirement that the total rmf be normalized at each (input) energy.

The first extension contains the following columns.

- ENERGY: contains energy in eV.
- PIXELn (n = 0-35) : are 3-element vector and contain FWHM in eV for high-, mid-, and low-resolution events.

The first extension contains the following columns.

- ENERGY: contains energy in eV.
- TAU: contains exponential width of the tail component in eV.
- F_TAU: contains integrated flux fraction of the tail component.
- F_ELC: contains integrated flux fraction of the electron loss continuum
- F_EPn: contains flux of the escape peak n.

8.15.1 File Format

Table 8.15.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
eV	BINTABLE	LINESIGMA	
	Column Names	Format	Units
	ENERGY	1E	eV
	PIXEL0	3E	eV
	PIXEL1	3E	eV
	...	…	…
	PIXEE35	3E	eV
2	BINTABLE	LINETAU	
	ENERGY	1E	eV
	TAU	1E	eV
	F_TAU	1E	-
	F_ELC	1E	-
	F_EP1	1E	-
	...	…	…
	F_EPn	1E	-

8.15.2 Header Keywords

Table 8.15.2		
Keyword name	Keyword value	Comment
CALDB keywords for the 1st extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'RMFPARAM1'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used

CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS RMF Parameters’	/Description
CBD10001	‘SHPTEMP(20150310)’	/Boundary Parameters
EXTNAME	'LINESIGMA’	/Name of the binary table extension
DETNAM	‘PIXEL’	/Detector Name
RANGEHIG	12	Integration range for high-resolution Gaussian in eV
RANGEMID	14	Integration range for mid-resolution Gaussian in eV
RANGELOW	64	Integration range for low-resolution Gaussian in eV
CALDB keywords for the 2nd extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'RMFPARAM2'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS RMF Parameters’	/Description
CBD10001	‘SHPTEMP(20150310)’	/Boundary Parameters
EXTNAME	'LINETAU’	/Name of the binary table extension
DETNAM	‘PIXEL’	/Detector Name
RANGETAU	36	/Integration range for exponential tail in eV
NPEAK	51	/Number of escape peaks
EP1	4837.0	/ Energy of escape peak 1 in eV
LABEP1	‘Te Lg3 LINIII’	/ Label of escape peak 1
…		
EP13	2184.0	/ Energy of escape peak 13 in eV
LABEPn	'Hg Ma2 MVNVI'	/ Label of escape peak 13

8.16 Coefficient for SXS Time assignment

This file contains various time coefficients related to the SXS pixel and antico detectors. The filename is ah_sxs_coeftime_YYYYMMDDv000n.fits

Its structure is an empty primary header with 1 bintable extension called DELTIMES, with the following 11 columns, all with units of seconds. The Time column defines the time when the coefficients in that row become applicable. The dtprimary column stores the time interval that distinguishes primary from secondary events (based on the time from the preceding event), the dtlowmid column stores the time interval that distinguishes low from mid-resolution events, the dtmidhigh column stores the time interval that distinguishes high and mid-resolution events (based on the time until the following event). These intervals are used by the sxssecid task for identifying the primary event associated with a given secondary event, and in event re-grading.

The antshift column stores the time offset between event time and central time for defining the window used for antico flagging by the sxsflagpix task, the antdtpre column stores the time interval preceding the time of an antico event (shifted by antshift) used to define the lower limit of the window, and the antdtfol column stores the time interval following the time of an antico event (shifted by antshift) used to define the upper limit of the window. The ctrecdt column stores the time interval that defines event cross-talk due to cal-pixel recoil electrons. Events occuring within ctrecdt of a cal-pixel event may be flagged by sxsflagpix. The cteldt column stores the time interval between events required for electrical cross-talk to be flagged by sxsflagpix. The mxsdt column stores the time interval by which the MXS pulse stop times given in the MXS gti are extended to account for MXS afterglow in flagging events for coincidence with MXS operation in sxsflagpix.

- TIME: contains valid time.
- DTPRIMARY : contains times between events that define primary vs secondary
- DTLOWMID : contains the time interval that distinguishes low from mid-resolution events
- DTMIDHIGH : contains the time interval that distinguishes mid from high-resolution events
- ANTDTPRE & ANTDTFOL: contain for a given pixel event time , delta time prec/fol to search for an antico
- PROXDT: contains two pixel events within PROXDT are flagged the same event (note the event can be in different pixels)
- CTRECDT: contains time interval that defines crosstalk due to recoil. The time interval is measured between two pixel events
- CTELDT and CTEL2DT: contain time interval that defines crosstalk due to electrical. The time interval is measured between two pixel events
- MXSDT: contains time interval between a pixel event time and the stop time of the MXS GTI fine. If the event time is within the interval is flagged as MXS afterglow event
- ANTSHIFT : contains time shift that is applied to all antico time

Second and third extensions contain coefficients. The task uses only the second extension (ARRCOEFFS). In the third extension, the values are given in the unit of second.
SAMPLECNT = SAMPLECNTTRIG – [0.25 * A* risetime + b*deriv_max+ C]

- TIME refers to time.
- AH, BH, CH are coefficients for the time assignment for high-resolution events at the given time
- AM, BM, CM are coefficients for the time assignment for mid-resolution events at the given time
- AL, BL, CL are coefficients for the time assignment for low-resolution at the given time

8.16.1 File Format

Table 8.16.1		
Extension N.	Type	Ext. Name
0	PRIMARY	

Table 8.16.1			
Extension N.	Type	Ext. Name	
1	BINTABLE	DELTIMES	
	Column Names	Format	Units
	TIME	1D	s
	DTPRIMARY	1E	s
	DTLOWMID	1E	s
	DTMIDHIGH	1E	s
	ANTDTPRE	1E	s
	ANTDTFOL	1E	s
	PROXDT	1E	s
	CTRECDT	1E	s
	CTELDT	1E	s
	CTEL2DT	1E	s
	MXSDT	1E	s
	ANTSHIFT	2E	s
2 & 3	BINTABLE	ARRCOEFFS (ext 2) ARRCOEFFSSEC (ext 3)	
	AH	36D	s (only ext 3)
	BH	36D	s (only ext 3)
	CH	36D	s (only ext 3)
	AM	36D	s (only ext 3)
	BM	36D	s (only ext 3)
	CM	36D	s (only ext 3)
	AL	36D	s (only ext 3)
	BL	36D	s (only ext 3)
	CL	36D	s (only ext 3)

8.16.2 Header Keywords

Table 8.16.2		
Keyword name	Keyword value	Comment

CALDB keywords		
INSTRUME	SXS	/ Instrument name
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'DELTIMES' (ext 1) 'ARRCOEFFS' (ext 2) 'ARRCOEFFSSEC' (ext 2)	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS Time Coefficients File’	/Description
EXTNAME	'DELTIMES' (ext 1) 'ARRCOEFFS' (ext 2) 'ARRCOEFFSSEC' (ext 2)	/Name of the binary table extension

8.17 Blocking Filter Transmission file

This file contains transmission for the SXS blocking fileter as a function of energy . The filename is
ah_sxs_blckfilt_YYYYMMDDvNNN.fits
where YYYYMMDD refers to the initial validity date of the file and NNN the version number.

The file structure is an empty primary header with 1 bintable extension, named TRANSMISSION. The table has two columns:

- ENERGY column provides the energy in eV
- TRANSMISSION column provides the normalized transmission at that energy and the values range from 0-1. The transmission is valid for all pixels in the SXS array.

8.17.1 File Format

Table 8.17.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	TRANSMISSION	
	Column Names	Format	Units
	ENERGY	1E	eV
	TRANSMISSION	1E	

8.17.2 Header Keywords

Table 8.17.2		
Keyword name	Keyword value	Comment
Mandatory header keywords		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	‘TRANSBLOCKING'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS blocking filter transmission’	/Description
EXTNAME	‘TRANSMISSION’	/Name of the binary table extension
DETNAM	‘PIXEL’	/Detector name
FILTER	‘BLCKFILT’	/ Filter name

8.18 SXS Filter Wheel files (Be, Fe55, Neutral Density, Polyimide)

There are several files that contribute to the SXS transmission measurements, each corresponding to a specific filter located at a particular height. The Transmission curves are mainly used in the ARF calculation. The Transmission curve uses a standard format with the following columns The SXS transmission curves are from the following components:

- Blocking filters located on of the Dewar entrance. They are not movable therefore the transmission from these filters has to be always taken into account in the ARF calculation.
- Filters on the Filter wheel. The filter wheel has 6 filter locations that can be rotated with 5 different filters. The filters are: OPEN set in two positions 1 & 4 ; Beryllium (BE) ; Iron 55 (FE55) ; Neutral Density (ND25 25% open); and POLYMIDE. It is expected that any observation is
- Gate Valve filter located on top of the Dewar entrance. This is opened at the beginning of the mission and therefore its usage is quite limited to probably calibration observations.

The filenames are the following :

- Be: ah_sxs_fwbe_YYYYMMDDvNNN.fits
- Fe55: ah_sxs_fwfe55_YYYYMMDDvNNN.fits
- ND: ah_sxs_fwnd_YYYYMMDDvNNN.fits
- Poly: ah_sxs_fwpoly_YYYYMMDDvNNN.fits
- Gatevalve: ah_sxs_gatevalv_YYYYMMDDvNNN.fits

The files have identical structure with the primary extensions containing image data and three bintable extensions. The first and second extensions contain transmission as a function of the energy for different components. The column structure is as follows:

- ENERGY : The energy is provided in eV
- TRANSMISSION : The transmission is the fraction unit less value ranging between 0-1

The third extension is a pixel ratio map, which contains columns of

- PIXELID : The ID number of the pixels from 0 to 35.
- PIXELX : The DETX location of the pixels
- PIXELY : The DETY location of the pixels
- PIXELRATIOS : Transmission factor for each pixel

8.18.1 File Format

Table 8.18.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	TRANSMISSION	
	Column Names	Format	Units
	ENERGY	1E	eV
	TRANSMISSION	1E	
2	BINTABLE	SURFACETRANSMISSION	
	Column Names	Format	Units
	ENERGY	1E	eV
	TRANSMISSION	1E	
3	BINTABLE	PIXELRATIOMAP	
	Column Names	Format	Units
	PIXELID	1I	
	PIXELX	1I	
	PIXELY	1I	
	PIXELRATIOS	1E	

8.18.2 Header Keywords

1) Filter wheel files (Be, Fe55, ND, Poly)
Extension 0:

Table 8.18.2.0		
Keyword name	Keyword value	Comment
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'[filtername]GEOM' where [filtername] is either BE, FE55, ND, or POLY	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'SXS [filtername] Filter File' where [filtername] is either BE, FE55, ND, or POLY	/Description
INSTRUME	'SXS'	/Name of the binary table extension
DETNAM	'PIXEL'	/Detector name
FILTER	'BE', 'FE55', 'ND', or 'POLYIMIDE'	/SXS Filter Type
CTYPE1	'X'	/Source of X-axis
CRPIX1	1	/X-axis reference pixel
CRVAL1	-51.2 (BE, FE55) -51.0727260843 (POLY) -49.7756345005 (ND)	/X-coordinate at the reference pixel
CDELT1	0.1 (BE, FE55) 0.0550007011056 (ND)	/X-axis increment
CUNIT1	'mm'	/X-axis unit
CTYPE2	'Y'	/Source of Y-axis
CRPIX2	1	/Y-axis reference pixel
CRVAL2	-51.2 (BE, FE55) -55.1184672367 (POLY) -54.6156961978 (ND)	/Y-coordinate at the reference pixel
CDELT2	0.1 (BE, FE55, POLY) 0.0550007011056 (ND)	/Y-axis increment
CUNIT2	'mm'	/Y-axis unit
FLHEIGHT	921.0	/[mm] Height of filter above focal plane
FLRADIUS	44.0	/ [mm] Diameter of filter aperture
FKTHICK	0.25	/ [mm] filter thickness

FLROTANG	0.0 (BE, FE55, POLY) -45.0 (ND)	/ [deg] filter orientation
XOFFSET	0.0	/ [mm] filter X offset w.r.t SXS center
YOFFSET	0.0	/ [mm] filter Y offset w.r.t SXS center
SXSANGLE	0.0	/ [deg] SXS orientation w.r.t. XRT x-axis

Extension 1,2,3:

Table 8.18.2.1		
Keyword name	Keyword value	Comment
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'[filtername]TRANS' (ext 1) ‘[filtername]SURFACE’ (ext 2) ‘PIXELRATIOMAP’ (ext 3)	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS [filtername] Filter File’	/Description
INSTRUME	‘SXS’	/Name of the binary table extension
DETNAM	‘PIXEL’	/Detector name
FILTER	‘BE’, ‘FE55’, ‘ND’, or ‘POLYIMIDE’	/SXS Filter Type
FLHEIGHT	921.0	/[mm] Height of filter above focal plane
FLRADIUS	44.0	/ [mm] Diameter of filter aperture
FKTHICK	0.25	/ [mm] filter thickness
FLROTANG	0.0 (BE, FE55, POLY) -45.0 (ND)	/ [deg] filter orientation
XOFFSET	0.0	/ [mm] filter X offset w.r.t SXS center
YOFFSET	0.0	/ [mm] filter Y offset w.r.t SXS center
SXSANGLE	0.0	/ [deg] SXS orientation w.r.t. XRT x-axis
TRANTYPE	1	/ Type of transmission treatment (1 or 2) Only for Ext 1
SRCTYPE	‘POINT’	/ Source type (POINT/FLAT/BETAMODEL)
OFFAXIS	0.0	/ [arcmin] Off-axis angle of source

AZIMUTH	0.0	/ [deg] Rotation angle of source direction
ENERGMIN	12.0 (10.0 for POLY)	/ [eV] Lower energy of range Only for Ext 3
ENERGMAX	30000.0 (40000.0 for POLY)	/ [eV] Upper energy of range Only for Ext 3

2) Gate valve file

Extension 0:

Table 8.18.2.3		
Keyword name	Keyword value	Comment
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'GATEVALVGEOM'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS Gate Valve Calibration File’	/Description
INSTRUME	‘SXS’	/Name of the binary table extension
DETNAM	‘PIXEL’	/Detector name
CBD10001	‘GATEVALV(CLOSED)’	/CALDB index identifier
CTYPE1	‘X’	/Source of X-axis
CRPIX1	1	/X-axis reference pixel
CRVAL1	-15.345	/X-coordinate at the reference pixel
CDELT1	0.03	/X-axis increment
CUNIT1	‘mm’	/X-axis unit
CTYPE2	‘Y’	/Source of Y-axis
CRPIX1	1	/Y-axis reference pixel
CRVAL2	-15.345	/Y-coordinate at the reference pixel
CDELT1	0.03	/Y-axis increment
CUNIT1	‘mm’	/X-axis unit
GVHEIGHT	243.9	/[mm] Height of gate valve above focal plane
GVDIAMTR	27.0	/ [mm] Diameter of gate valve aperture

GVROTANG	45.0	/ [deg] Gate valve orientation
XOFFSET	0.0	/ [mm] filter X offset w.r.t SXS center
YOFFSET	0.0	/ [mm] filter Y offset w.r.t SXS center
SXSANGLE	0.0	/ [deg] SXS orientation w.r.t. XRT x-axis

Extension 1,2,3:

Table 8.18.2.4		
Keyword name	Keyword value	Comment
Mandatory Keywords		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'GATEVALVTRANS' (ext 1) ‘GVMESHTRANS’ (ext 2) ‘PIXELRATIOMAP’ (ext 3)	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘SXS Gate Valve Calibration File’	/Description
INSTRUME	‘SXS’	/Name of the binary table extension
DETNAM	‘PIXEL’	/Detector name
CBD10001	‘GATEVALV(CLOSED)’	/CALDB index identifier
GVHEIGHT	243.9	/[mm] Height of gate valve above focal plane
GVDIAMTR	27.0	/ [mm] Diameter of gate valve aperture
GVROTANG	45.0	/ [deg] Gate valve orientation
XOFFSET	0.0	/ [mm] filter X offset w.r.t SXS center
YOFFSET	0.0	/ [mm] filter Y offset w.r.t SXS center
SXSANGLE	0.0	/ [deg] SXS orientation w.r.t. XRT x-axis
SRCTYPE	‘POINT’	/ Source type (POINT/FLAT/BETAMODEL)
OFFAXIS	0.0	/ [arcmin] Off-axis angle of source
AZIMUTH	0.0	/ [deg] Rotation angle of source direction
ENERGMIN	12.0	/ [eV] Lower energy of range Only for Ext 3
ENERGMAX	30000.0	/ [eV] Upper energy of range

		Only for Ext 3

8.19 SXS Contamination File

This file is used by the software *sxsarfgen* and *ahsxtflatfield* that produce an ancillary response file (ARF) and a flat field image file, respectively, for the SXS. The file name is

ah_sxs_contami_YYYYMMDDvxxx.fits.

This CALDB contains the information of time-dependent contamination column density and elemental composition (plus partial covering factor; see below). The file format is totally same as the sxi contamination, but for extension 3 (where the number of columns are smaller than in SXI).

Extension 1:

- TIME contains the time in unit of second(s).
- REGION_ID contains Region ID defined in Extension 3.
- COLUMN contains column density of arbitrary elements. This is a vector column.
- FACTOR contains partial covering factors for the same elements as in the COLUMN. Therefore, this column is also a vector with the same element numbers as COLUMN. The value should be in the range between 0 and 1, where 1 means that the relevant subregion is fully covered by this material with the column density given in COLUMN. A value less than 1 enables to represent a ‘smoothed’ absorption edge.

Extension 2:

- ENERGY contains X-ray energy in keV.
- TRANSMISSION contains theoretical values of energy-dependent transmittance for the elements given in COLUMN in Extension 1. This is a vector column with the same element numbers as COLUMN in Extension 1.

Extension 3:

- REGION_ID contains Region ID for each subregion. Currently only 1 region is defined .
- CORNER_DETX and CORNER_DETY contain 4-element vectors specifying the (DETX, DETY) positions of the corners of each subregion.

8.19.1 File Format

Table 8.19.1

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

	REGION_ID	1I	-
	COLUMN	*n*E	10**18 cm**(-2)
	FACTOR	*n*E	-
2	BINTABLE	COLUMN_TRANS	
	Column Names	Format	Units
	ENERGY	1E	eV
	TRANSMISSION	*n*E	-
3	BINTABLE	SUBREGION	
	Column Names	Format	Units
	REGION_ID	1I	-
	CORNER_DETX	4E	-
	CORNER_DETY	4E	-

8.19.2 Header Keywords

Table 8.19.2.1		
Keyword name	Keyword value	Comment
Header keywords for the 1st extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'COLUMN_DENSITY'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘Column density of contamination materials’	/Description
EXTNAME	'COLUMN_DENSITY'	/Name of the binary table extension
INSTRUME	'SXS'	/Instrument name

Table 8.19.2.2		
Keyword name	Keyword value	Comment
Header keywords for the 2nd extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File

CCNM0001	COLUMN_TRANS'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'Energy-dependent transmittance for contamination materials'	/Description
EXTNAME	COLUMN_TRANS'	/Name of the binary table extension
INSTRUME	'SXS'	/Instrument name

Table 8.19.2.3		
Keyword name	Keyword value	Comment
Header keywords for the 3rd extension		
CCLS0001	'BCF'	/Dataset is Basic Calibration File
CCNM0001	'SUBREGION'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'Subregion definition'	/Description
EXTNAME	'SUBREGION'	/Name of the binary table extension
INSTRUME	'SXS'	/Instrument name

8.20 SXS Secondary Pulse File

This file contains SXS pulse amplitude for primary events. The filename is:

ah_sxs_secpulse_yyyymmddvnnn.fits

This file is used by *sxsseccor* to correct pha values for secondary events. The pulse amplitude is function of time in bins of 80 us. There are a set of pulse amplitude for each pixel and energy range.

- PIXEL: PIXEL number (0-35).
- ENERANGE: Energy group index.
- PHAMIN: Minimum PHA value for the energy group
- PHAMAX: Maximum PHA value for the energy group
- OFFSET: Time offset in 80 us used in the correction.

- PULSE: Array of pulse amplitudes

8.20.1 File Format

Table 5.12.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1,2	BINTABLE	SECPULSE	
	Column Names	Format	Units
	PIXEL	1I	-
	ENERANGE	1I	-
	PHAMIN	1J	-
	PHAMAX	1J	-
	OFFSET	1I	-
	PULSE	1024I	-

8.20.2 Header Keywords

Table 5.12.2		
Keyword name	Keyword value	
CALDB Keywords		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘SXS’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘SECPULSE’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘SXS Secondary Pulse’	/ Brief descriptive summary of this file
CBD10001	‘DEVPTHRE(A120a)’ for Ext 1 ‘DEVPTHRE(A75a)’ for Ext 2	/ Event threshold identifier

CBD20001	'SHPTEMPL(20150310)'	/ Validity date of pulse shape template

8.21 SXS Configuration Threshold File

This file contains configuration setting parameters. It is not used in the software but only for record the information. The filename is:

ah_sxs_confthre_yyyymmddvnnn.fits

The content of this file is to record the changes for the setting of the derivate pulse threshold and the pulse shape template.

DEVPTHRE set to 120 which about 165 eV for all pixel array and 10 keV for the antico channels
SHPTEMPL pulse shape template created first on ground in arch 2015 during instrument calibration at TKSC

- DATESTRT: contains the start date in YYYYMMDD
- TIMESTRT: contains the start time in hhmmss
- DATESTOP: contains the stop date in YYYYMMDD
- TIMESTOP: contains the stop time in hhmmss
- DEVPTHRE: contains event threshold identifier
- SHPTEMPL: contains validity date of pulse shape template
- DEVPTHAC: contains threshold values for antico
- DEVRTHPX: contains threshold vaules for pixels

8.21.1 File Format

Table 5.14.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	SXSTHRES	
	Column Names	Format	Units
	DATESTRT	8A	-
	TIMESTRT	8A	-
	DATESTOP	8A	-
	TIMESTOP	8A	-
	DEVPTHRE	8A	-
	SHPTEMPL	8A	-
	DEVPTHAC	2I	-

Table 5.14.1			
Extension N.	Type	Ext. Name	
	DEVRTHPX	36I	-

8.21.2 First Extension Keywords

Table 5.14.1		
Keyword name	Keyword value	
CALDB Keywords		
TELESCOP	‘HITOMI’	/ Telescope (mission) name
INSTRUME	‘SXS’	/ Instrument name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	‘SXSTHRES’	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ Validity start date (UTC)
CVST0001	hh:mm:ss	/ Validity start date (UTC)
CDES0001	‘SXS Threshold Definition’	/ Brief descriptive summary of this file

8.22 SXS Redistribution Matrix File (RMF)

A prepared RMF for a simulation purpose based on the ground calibrations. The file name is

ah_sxs_YYYYMMDDvxxx.rmf

This is a Calibration product file (CPF). The structure is an empty primary with 2 bintable extensions, with columns in the standard OGIP format. See the common part section for details.

8.23 SXS Ancillary Response File (ARF)

A prepared ARF for a simulation purpose based on the ground calibrations. The file name is

ah_sxs_YYYYMMDDvxxx.arf

This is a Calibration product file (CPF). The structure is an empty primary with 1 bintable extension, with columns in the standard OGIP format. See the common part section for details.

8.24 SXS Non X-ray Background Spectrum File (NXB)

A prepared NXB PI file for a simulation purpose. The file name is

ah_sxs_nxb_YYYYMMDDvxxx.pi

This is a Calibration product file (CPF). The structure is an empty primary with 1 bintable extension, with columns in the standard OGIP format. See the common part section for details.

9 Common format

9.1 SXT/HXT Telescope Description File

This file contains data for the structure of the X-ray telescope, describing the mirror foils and their reflective surfaces, the support structure, a pre-collimator if present, as well as rotational and translational offsets of the telescope components relative to each other. The filename is :

ah_xxx_mirror_YYYYMMDDvxxx.fits

where xxx is the instrument type. The TDF file is used in ray-tracing software, as well as in xrtreftable, which generates reflectivity tables, transmission tables, and mass-absorption coefficients for the coatings on the front-side mirrors of X-ray telescopes. The structure is an empty primary with 5 bintable extensions.

Extension 1 (MIRROR) has 22 columns, with each row corresponding to one mirror foil. The columns are as follows:

- LAYER contains an integer value 1 or 2 corresponding to primary or secondary mirror respectively
- ASSEMBLY contains an integer value 1 to 4, corresponding to the quadrant or segment that the mirror foil for a particular row corresponds to.
- NUMBER contains an integer value for the radial shell number that a particular mirror foil belongs to, regardless of whether it is a primary or secondary mirror foil, and regardless of which quadrant or segment the mirror foil belongs to.
- FRAGMENT is not currently used.
- FUNCTION is an integer that specifies the geometry of the foil component represented by a particular row:
    - 1 = cylinder = cone
- SCATTER contains an integer value indicating which scattering model to employ.
- FREFLECT contains the name of the column in the appropriate reflectivity FITS file and extension that contains reflectivity information for the front-side of the mirror foil corresponding to a particular row. Standard names of the form REFPROB01, REFPROB02, etc. Transmission column names corresponding to these will be inferred (and have the form TRANPROB01, TRANPROB02, etc.).
- BREFLECT contains the name of the extension in the appropriate reflectivity FITS file that contains reflectivity information for the backside of the mirror/pre- collimator foil. Note that the reflectivity for the pre-collimator is the same for the front and back so FREFLECT and BREFLECT values in the COLLIMATOR extension would normally be identical.
- FSTART contains the rotational (azimuthal) angle of the start of a mirror foil (sector) referred to by a particular row, in radians.
- FEND contains the rotational (azimuthal) angle of the end of a mirror foil (sector) referred to by a particular row, in radians.
- TOPINR contains the *inner* radius, in mm, in cylindrical coordinates (with the telescope optical axis coincident with the z-axis) of the *top* of the mirror foil section referred to by a particular row.

- TOPOUTR contains the *outer* radius, in mm, in cylindrical coordinates (with the telescope optical axis coincident with the z-axis) of the *top* of the mirror foil section referred to by a particular row.
- BOTINR contains the *inner* radius, in mm, in cylindrical coordinates (with the telescope optical axis coincident with the z-axis) of the *bottom* of the mirror foil section referred to by a particular row.
- BOTOUTR contains the *outer* radius, in mm, in cylindrical coordinates (with the telescope optical axis coincident with the z-axis) of the *bottom* of the mirror foil section referred to by a particular row.
- TOPD contains the distance, in mm, of the *top* of the mirror foil section referred to by a particular row, from the focal plane, as measured by a line parallel to the telescope optical axis (or equivalently, parallel to the z-axis).
- BOTD contains the distance, in mm, of the *bottom* of the mirror foil section referred to by a particular row, from the focal plane, as measured by a line parallel to the telescope optical axis (or equivalently, parallel to the z-axis).
- SCROSS contains a Boolean that is true or false, depending, respectively, on whether a photon can or cannot physically cross the radial boundary along the *starting* azimuthal angle (as defined by column 9) of the mirror foil section referred to by a particular row.
- ECROSS contains a Boolean that is true or false, depending, respectively, on whether a photon can or cannot physically cross the radial boundary along the *ending* azimuthal angle (as defined by FSTART) of the mirror foil section referred to by a particular row.
- SECTORNUMBER contains the sector ID number to which the sub-foil described by the row belongs. The sector number starts from 1 in each segment.
- SECTORSHIFT contains the radial shift of a foil in mm (although intended to be a single shift for all foils in the same sector, unique shifts can be applied to individual foil sections...i.e. individual rows).
- SYSTILT contains the systematic tilt angle of a foil section (in arcsec) relative to the default position.
- SYSTWIST contains the systematic twist angle of a foil section (in arcsec) relative to the default position.

Extension 2 (OBSTRUCT) has 5 columns, with each row corresponding to data for one vertex of one support structure component (obstruction) in a 2-dimensional representation of that component (i.e. a polygon). A single component of the support structure is then described by several rows, the number of rows being equal to the number of vertices of the polygon describing the support structure component. The columns are as follows:

- LAYER contains the group number that the obstruction vertex described by a particular row belongs to. Obstructions are organized in groups having the same distance from the focal plane (in a direction perpendicular to the focal plane).
- POLYNUM contains an integer identifying the polygon that the vertex described by the row belongs to. Polygon number starts from 1 for the first polygon.
- DISTANCE contains the perpendicular distance from the focal plane (the “z-distance”, in mm) of the polygon vertex described by a particular row.
- XVERTEX contains the x-coordinate (in mm) of the polygon vertex described by a particular row.
- YVERTEX contains the y-coordinate (in mm) of the polygon vertex described by a particular row.

Extension 3 (SEGMENT) contains information about translational and angular offsets of telescope segments relative to their default positions. The extension has 10 columns, with each row corresponding to one segment of one telescope. The segment information can be carried for any number of telescopes. The 8 columns are as follows:

- COMPONENT Label for the XRT component that the SEGMENT offset data refers to (each which has its own set of segments that can be assigned independent shifts and rotations), as follows:
  1= pre-collimator; 2=primary mirrors; 3=secondary mirrors.
- SEGMENT contains the label for the SEGMENT corresponding to a particular row.
- STARTANGLE contains the angle in radians of the beginning of the SEGMENT corresponding to a particular row.
- ENDANGLE contains the angle in radians of the end of the SEGMENT corresponding to a particular row.
- DELTAX contains the x-coordinate of the translational offset (in mm) of the segment that the row refers to.
- DELTAY contains the y-coordinate of the translational offset (in mm) of the segment that the row refers to.
- DELTAZ contains the z-coordinate of the translational offset (in mm) of the segment that the row refers to.
- DELTATX contains the rotational offset angle (in arcmin) about the telescope x-axis of the segment that the row refers to.

- DELTATY contains the rotational offset angle (in arcmin) about the telescope y-axis of the segment that the row refers to.
- DELTATZ contains the rotational offset angle (in arcmin) about the telescope z-axis of the segment that the row refers to.

Extension 4 (COLLIMATOR) contains information about the pre-collimator (if the telescope has one). It has 22 columns, with each row corresponding to one pre-collimator foil. The columns are as follows:

- LAYER contains an integer value 1 or 2 corresponding to primary or secondary mirror respectively
- ASSEMBLY contains an integer value 1 to 4, corresponding to the quadrant or segment that the mirror foil for a particular row corresponds to.
- NUMBER contains an integer value for the radial shell number that a particular mirror foil belongs to, regardless of whether it is a primary or secondary mirror foil, and regardless of which quadrant or segment the mirror foil belongs to.
- FRAGMENT is not currently used.
- FUNCTION is an integer that specifies the geometry of the foil component represented by a particular row:
    - 1 = cylinder = cone
- SCATTER contains an integer value indicating which scattering model to employ.
- FREFLECT contains the name of the column in the appropriate reflectivity FITS file and extension that contains reflectivity information for the front-side of the mirror foil corresponding to a particular row. Standard names of the form REFPROB01, REFPROB02 etc. Transmission column names corresponding to these will be inferred (and have the form TRANPROB01, TRANPROB02, etc.).
- BREFLECT contains the name of the extension in the appropriate reflectivity FITS file that contains reflectivity information for the backside of the mirror/pre- collimator foil. Note that the reflectivity for the pre-collimator is the same for the front and back so FREFLECT and BREFLECT values in the COLLIMATOR extension would normally be identical.
- FSTART contains the rotational (azimuthal) angle of the start of a mirror foil (sector) referred to by a particular row, in radians.
- FEND, contains the rotational (azimuthal) angle of the end of a mirror foil (sector) referred to by a particular row, in radians.
- TOPINR contains the *inner* radius, in mm, in cylindrical coordinates (with the telescope optical axis coincident with the z-axis) of the *top* of the mirror foil section referred to by a particular row.
- TOPOUTR contains the *outer* radius, in mm, in cylindrical coordinates (with the telescope optical axis coincident with the z-axis) of the *top* of the mirror foil section referred to by a particular row.
- BOTINR contains the *inner* radius, in mm, in cylindrical coordinates (with the telescope optical axis coincident with the z-axis) of the *bottom* of the mirror foil section referred to by a particular row.
- BOTOUTR contains the *outer* radius, in mm, in cylindrical coordinates (with the telescope optical axis coincident with the z-axis) of the *bottom* of the mirror foil section referred to by a particular row.
- TOPD contains the distance, in mm, of the *top* of the mirror foil section referred to by a particular row, from the focal plane, as measured by a line parallel to the telescope optical axis (or equivalently, parallel to the z-axis).
- BOTD contains the distance, in mm, of the *bottom* of the mirror foil section referred to by a particular row, from the focal plane, as measured by a line parallel to the telescope optical axis (or equivalently, parallel to the z-axis).
- SCROSS contains a Boolean that is true or false, depending, respectively, on whether a photon can or cannot physically cross the radial boundary along the *starting* azimuthal angle (as defined by column 9) of the mirror foil section referred to by a particular row.
- ECROSS contains a Boolean that is true or false, depending, respectively, on whether a photon can or cannot physically cross the radial boundary along the *ending* azimuthal angle (as defined by FSTART) of the mirror foil section referred to by a particular row.
- SECTORNUMBER contains the sector ID number to which the sub-foil described by the row belongs. The sector number starts from 1 in each segment.
- SECTORSHIFT contains the radial shift of a foil in mm (although intended to be a single shift for all foils in the same sector, unique shifts can be applied to individual foil sections...i.e. individual rows).
- SYSTILT contains the systematic tilt angle of a foil section (in arcsec) relative to the default position.
- SYSTWIST contains the systematic twist angle of a foil section (in arcsec) relative to the default position.

Extension 5 (SURFACE) contains information about the reflecting surfaces of the front-side of mirror foils in terms of their composition and grouping. One row corresponds to one layer of the surface coating of mirror foils in one group. The columns are as follows:

- GROUP contains an integer corresponding to the mirror foil group number that the coating information in a particular row refers to.
- FIRSTSHELL contains an integer corresponding to the first radial shell number that defines the mirror foil group associated with a particular row.
- LASTSHELL contains an integer corresponding to the last radial shell number that defines the mirror foil group associated with a particular row.
- LAYER contains an integer corresponding to the coating layer number that a particular row refers to for the mirror group appropriate for that row. The top-most coating is assigned a layer number of 1. The first coating that is a thick layer (a substrate) as opposed to a thin film is given a negative sign but the absolute value of the layer number increases consecutively by 1 for each layer (row).
- MATERIAL contains the molecular formula of the composition of the coating of the film layer that is referred to by a particular row.
- DENSITY contains the density of the material of the coating of the film layer that is referred to by a particular row.
- THICKNESS contains the thickness (in Angstroms) of the film layer that is referred to by a particular row.
- ROUGHNESS contains the roughness value (in Angstroms) for the film layer that is referred to by a particular row.

Extension 6 (AZIMUTHALSTRUCT) encodes structures that can be described by boundaries that are either circular arcs centered on the telescope symmetry axis, and/or straight lines that are radial. Each row in the file corresponds to one component of one structure.

- OBJECT contains sequential number for object
- SUBOBJECT contains sequential number for a component of the object labeled in the OBJECT column
- RMIN contains inner radius of part of object described by this row (in mm)
- RMAX contains outer radius of part of object described by this row (in mm)
- STARTANGLE contains start angle made by radial boundary defining object part (in degrees)
- ENDANGLE contains end angle made by radial boundary defining object part (in degrees)
- ZMIN contains smallest z-coordinate of plane defining boundary of object part (in mm)
- ZMAX contains largest z-coordinate of plane defining boundary of object part (in mm)
- EFFDENSITY contains effective density of composite material
- MATERIAL contains chemical formula of material that this object part is made of
- MABSINDEX contains where to get the mass-absorption coefficients for transmission in this object part. (Value +1) = column number in MASS_ABSORPTION extension in reflectivity file. A value of -1 instructs the raytracing code that this object part should be treated with zero transmission.

9.1.1 File Format

Table 9.1.1			
Extension	Type	Ext name	
0	PRIMARY		
1	BINTABLE	MIRROR	
	Column names	**Format**	**Units**
	LAYER	J	
	ASSEMBLY	J	
	NUMBER	J	
	FRAGMENT	J	

	FUNCTION	J	
	SCATTER	A	
	FREFLECT	A	
	BREFLECT	A	
	FSTART	D	radians
	FEND	D	radians
	TOPINR	D	mm
	TOPOUTR	D	mm
	BOTINR	D	mm
	BOTOUTR	D	mm
	TOPD	D	mm
	BOTD	D	mm
	SCROSS	L	
	ECROSS	L	
	SECTORNUMBER	J	
	SECTORSHIFT	D	mm
	SYSTILT	D	arcsec
	SYSTWIST	D	arcsec
2	BINTABLE	OBSTRUCT	
	Column names	**Format**	**Units**
	LAYER	J	
	POLYNUM	J	
	DISTANCE	D	mm
	XVERTEX	D	mm
	YVERTEX	D	mm
3	BINTABLE	SEGMENT	
	Column names	**Format**	**Units**
	COMPONENT	J	
	SEGMENT	J	
	STARTANGLE	D	radians
	ENDANGLE	D	radians
	DELTAX	D	mm
	DELTAY	D	mm
	DELTAZ	D	mm
	DELTATX	D	arcmin
	DELTATY	D	arcmin
	DELTATZ	D	arcmin
4	BINTABLE	COLLIMATOR	
	Column names	**Format**	**Units**
	LAYER	J	
	ASSEMBLY	J	
	NUMBER	J	
	FRAGMENT	J	
	FUNCTION	J	
	SCATTER	A	
	FREFLECT	A	
	BREFLECT	A	
	FSTART	D	radians
	FEND	D	radians
	TOPINR	D	mm

	TOPOUTR	D	mm
	BOTINR	D	mm
	BOTOUTR	D	mm
	TOPD	D	mm
	BOTD	D	mm
	SCROSS	L	
	ECROSS	L	
	SECTORNUMBER	J	
	SECTORSHIFT	D	mm
	SYSTILT	D	arcsec
	SYSTWIST	D	arcsec
5	BINTABLE	SURFACE	
	Column names	**Format**	**Units**
	GROUP	J	
	FIRSTSHELL	J	
	LASTSHELL	J	
	LAYER	J	
	MATERIAL	A	
	DENSITY	D	g/cm^3
	THICKNESS	D	angstrom
	ROUGHNESS	D	angstrom
6	BINTABLE	AZIMUTHALSTRUCT	
	Column names	**Format**	**Units**
	OBJECT	J	
	SUBOBJECT	J	
	RMIN	D	mm
	RMAX	D	mm
	STARTANGLE	D	degrees
	ENDANGLE	D	degrees
	ZMIN	D	mm
	ZMAX	D	mm
	EFFDENSITY	D	g/cm^3
	MATERIAL	26A	
	MABSINDEX	I	

9.1.2 Header Keywords

Table 9.1.2.1		
Keyword name	Keyword value	Comment
Header keywords for the 1st extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	MIRROR	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used

CDES0001	‘inst’ Mirror Geometry	/Description
TELESCOP	HITOMI	Mission name
INSTRUME	‘inst’	/Instrument name
DETNAM	‘SXT’ or ‘HXT’	Detector name
EXTNAME	MIRROR	/Name of the binary table extension
FOCALLEN	5600.0 (SXT) / 12000 (HXT)	/Focal length in mm
PMINRAD	56.8600 (SXT) / 56.5 (HXT)	/Inner radius of telescope aperture in mm
PMAXRAD	226.0000	/Outer radius of telescope aperture in mm
PRIMZMIN	5605.5500 (SXT) / 12005.52 (HXT)	/z-coordinate of bottom of primary mirror housin
PRIMZMAX	5707.1500 (SXT) / 12205.52 (HXT)	/z-coordinate of top of primary housing (mm)
SECDZMIN	5492.8500 (SXT) / 11794.48 (HXT)	/z-coodinate of bottom of secondary mirror housi
SECDZMAX	5594.4500 (SXT) / 11994.48 (HXT)	/z-coodinate of top of secondary mirror housing
HXPRSHFT	0.0	/X-axis offset of center of primary mirror housi
HYPRSHFT	0.0	/Y-axis offset of center of primary mirror housi
HXSRSHFT	0.0	/X-axis offset of center of secondary mirror hou
HXSRSHFT	0.0	/Y-axis offset of center of secondary mirror housing
TLTPVPRI	0.5 (SXT) / 0.0 (HXT)	/ Tilt pivot axis for primary mirrors
TLTPVSEC	0.5 (SXT) / 1.0 (HXT)	/ Tilt pivot axis for secondary mirrors
NGROUPS	3 (SXT) /14 (HXT)	/Number of groups of mirror foils
ORIGIN	NASA GSFC	/ Origin of the file

Table 9.1.2.2 :		
Keyword name	Keyword value	Comment
Header keywords for the 2nd extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	OBSTRUCT	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used

CDES0001	‘inst’ Mirror Obstruction Geometry	/Description
TELESCOP	HITOMI	Mission name
INSTRUME	‘inst’	/Instrument name
DETNAM	‘SXT’ or ‘HXT’	Detector name
EXTNAME	OBSTRUCT	/Name of the binary table extension
PMINRAD	56.86 (SXT) /56.5 (HXT)	/Minimum radius in mm
PMAXRAD	226.5 (SXT) / 226.0 (HXT)	/Maximum radius in mm
ORIGIN	NASA GSFC	/ Origin of the file

Table 9.1.2.3		
Keyword name	Keyword value	Comment
Header keywords for the 3rd extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SEGMENT	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	‘inst’ Mirror Segment Geometry and Offsets	/Description
TELESCOP	HITOMI	/Mission name
INSTRUME	‘inst’	/Instrument name
DETNAM	‘SXT’ or ‘HXT’	Detector name
EXTNAME	SEGMENT	/Name of the binary table extension

Table 9.1.2.4		
Keyword name	Keyword value	Comment
Header keywords for the 4th extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	COLLIMATOR	/Type of calibration data

CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	‘inst’ Mirror Pre-collimator Geometry	/Description
TELESCOP	HITOMI	/Mission name
INSTRUME	‘inst’	/Instrument name
DETNAM	‘SXT’ or ‘HXT’	Detector name
EXTNAME	COLLIMATOR	/Name of the binary table extension
ORIGIN	NASA GSFC	/ Origin of the file
PCOLMTRL	Al	Blade material name
PCOLZMIN	5718.95 (SXT) / 12205.52 (HXT)	z-coordinate of bottom of pre-collimator housing
PCOLZMAX	5772.15 (SXT) / 12255.52 (HXT)	z-ccordinate of top of pre-collimator housing
HXPCSHFT	0.0	X-axis offset of center of pre-collimator housing
HYPCSHFT	0.0	Y-axis offset of center of pre-collimator housing
TLTPVPCL	0.5	Pivot axis position for systilt (fractional distance)

Table 9.1.2.5		
Keyword name	Keyword value	Comment
Header keywords for the 5th extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SURFACE	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	‘inst’ Mirror Surface Details	/Description
TELESCOP	HITOMI	/Mission name
INSTRUME	‘inst’	/Instrument name
DETNAM	‘SXT’ or ‘HXT’	Detector name
EXTNAME	SURFACE	/Name of the binary table extension

NGROUPS	3 (SXT) / 14 (HXT)	/Name of the binary table extension

Table 9.1.2.6		
Keyword name	Keyword value	Comment
Header keywords for the 6th extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	AZIMUTHALSTRUCT	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	'inst' Azimuthal Structure	/Description
TELESCOP	HITOMI	/Mission name
INSTRUME	'inst'	/Instrument name
DETNAM	'SXT' or 'HXT'	Detector name

9.2 SXT/HXT Reflectivity and Transmission File

This file contains data for the reflectivity and transmission of the front-side mirror coatings of an X-ray telescope, and reflectivity tables for the backside of mirror foils and for pre-collimator foils. It also contains, in a different extension, the mass-absorption coefficients of all the materials that a complete mirror foil is composed of. The filename is:

ah_xxx_reftrans_YYYYMMDDvxxx.fits

ah_xxx_hreftrans_YYYYMMDDvxxx.fits

where xxx is the instrument type. The difference naming reftrans and hreftrans is to distinguish between the run made with the henke original table compared to the table where the henke value were combined with the measurement made on ground for specific energies.

The coatings may be of single-layer or multi-layer types. The front-side reflectivity and transmission data are used by ray-tracing software to calculate the reflection and transmission probabilities respectively, for photons impinging on the front-side of mirror foils. The transmission here refers only to penetration to the substrate. Transmission beyond the substrate, and from the backside of mirror foils, and through pre-collimator foils is calculated using the mass-absorption coefficient data.

The front-mirror reflectivity and transmission data are organized into columns that apply to different groups of mirror foils in the X-ray telescope (the foils are grouped by their radial distance from the optical axes). The number of groups (NGROUPS) varies for different telescopes.

Reflectivity and transmission arrays are given as a function of energy and angle and each row in the front-mirror extension corresponds to a particular energy and angle of an incident photon. There is one reflectivity column per group (named REFPROB01, REFPROB02, etc.), and one transmission column per group (named TRANPROB01, TRANPROB02, etc.). The number of columns in the front-mirror extension is therefore not universal (and is equal to 2+(2 x NGROUPS)).

The number of columns for the back-mirror reflectivity and pre-collimator reflectivity is always 2 since there is always only one group, and transmission is calculated using the mass-absorption coefficients in the MASS_ABSORPTION extension. The columns are energy, and reflection probability as a function of angle. The angle array has to be generated from keywords in the headers.

The front-mirror extension and the MASS_ABSORPTION extension are created by the tool xrtreftable. The data in the extensions for the reflectivity for the backside of the mirrors and for the pre-collimator are based on measurements.The primary extension is empty.

Extension 1 (FRONT) has 2+(2xNGROUPS) columns, where NGROUPS is the number of mirror groups , keyword specified in the header . Each row corresponds to data for one energy and one incident angle. The columns are as follows:

- ENERGY contains energy in units of keV
- ANGLE contains a 2D array of angle in radians for each energy
- REFPROBnn contain 2D arrays of reflection probability function of energy and angle. One column per mirror foil group.
- TRANPROBnn contain 2D arrays of transmission probability function of energy and angle. One column per mirror foil group

Extension 2 (MASS_ABSORPTION) has a number of columns equal to 1 + number of materials for which mass-absorption coefficients are given (specified in the keyword NMATERIA). Each unique material is associated with one column. The columns are as follows:

- ENERGY contains energy (in units of keV)
- MABSCOEFnn contain the mass-absorption coefficient function of energy for one material, in units of $cm^2 g^{-1}$

Extension 3 (REFPRPBBACK) contains the reflection probability as a function of energy and incident angle for the back of mirror foils. The columns are as follows:

- ENERGY contains energy in units of keV
- REFPROBBACK contains the reflection probability (reflectivity) as a function of energy and incident angle. The incident angle is generated from keywords in the header.

Extension 4 (REFPROBPCOL) contains the reflection probability as a function of energy and incident angle for pre-collimator foils. The columns are as follows:

- ENERGY contains energy in units of keV
- REFPROBPCOL contains the reflection probability (reflectivity) as a function of energy and incident angle. The incident angle is generated from keywords in the header

9.2.1 File Format

Table 9.2.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	AH_{INS}_FRONT	Where {INS} is SXT or HXT
	Column Names	**Format**	**Units**
	ENERGY	D	keV
	ANGLE	D	radians

Table 9.2.1			
Extension N.	Type	Ext. Name	
	REFPROB01, REFPROB02,…	D	
	TRANPROB01, TRANPROB02,…	D	
2	BINTABLE	MASS_ABSORPTION	
	Column Names	**Format**	**Units**
	ENERGY	D	
	MABSCOEF01, MABSCOEF02, …	D	$cm^2 g^{-1}$
3	BINTABLE	REFPROBBACK	
	Column Names	**Format**	**Units**
	ENERGY	D	keV
	REFPROBBACK	D	
4	BINTABLE	REFPROBPCOL	
	Column Names	**Format**	**Units**
	ENERGY	D	keV
	REFPROBPCOL	D	

9.2.2 Header Keywords

Table 9.2.2.1		
Keyword name	Keyword value	Comment
Header keywords for the 1st extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	REFLECT-TRANS	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	XRT foil reflectivity and transmission	/Description
CBD10001	ENERG(30-16500)eV	/Energy range used
TELESCOP	HITOMI	/Mission name

INSTRUME	‘inst’	/Instrument name
DETNAM	‘SXT’ or ‘HXT’	Detector name
EXTNAME	AH_SXT_FRONT/ AH_HXT_FRONT	/Name of the binary table extension
NGROUPS	3 (SXT) / 14 (HXT)	/Number of mirror groups
ROUGHMOD	NC	/Roughness model used
NMATERIA	5 (SXT) /6 (HXT)	/Number of materials with mass-absorption coefficients
NSUBSTRA	3	/Number of substrates in mirror foils
PCOLMTRL	4 (SXT) / 5 (HXT)	/Pre-collimator material index number
SUBSTR1	2	/Index of material for substrate 1
SUBSTR2	3 (SXT) / 4 (HXT)	/Index of material for substrate 2
SUBSTR3	4 (SXT)/ 5 (HXT)	/Index of material for substrate 3
SUBTHK1	2.000E-04 (SXT) / 5.000E-05 (HXT)	/ [mm] Thickness of substrate 1
SUBTHK2	2.540E-02 (SXT) / 2.000E-02 (HXT)	/[mm] Thickness of substrate 2
SUBTHK3	1.395E-01 (SXT) / 2.000E-01 (HXT)	/[mm] Thickness of substrate 3
VERSION	v1.07	/Version number of xrtreftable code
MULTLAYR	F	/Whether the reflecting surface is a multilayer

Table 9.2.2.2		
Keyword name	Keyword value	Comment
Header keywords for the 2nd extension (There is no second extension in the SXT file `ah_sxi_reftrans_20140101v002.fit`)		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	MASS_ABSORPTION	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Mass absorption coefficients	/Description
CBD10001	ENERG(4000-119800)eV / ENERG(2000-120000)eV (HXT)	/ Energy range used

TELESCOP	HITOMI	/Mission name
INSTRUME	'inst'	/Instrument name
DETNAM	'SXT' or 'HXT'	Detector name
EXTNAME	MASS_ABSORPTION	/Name of the binary table extension
NMATERIA	3 / 6 (HXT)	/Number of materials in this extension
MATERI01	Au / Pt (HXT)	/Chemical formula for material 1
DENSIT01	19.32 / 21.45 (HXT)	/Density of material in g cm^{-3}
MATERI02	C14H20O4 / C (HXT)	/Chemical formula for material 2
DENSIT02	1.3 / 2.267	/Density of material in g cm^{-3}
MATERI03	C14H20O4 (HXT)	/Chemical formula for material 3
DENSIT03	1.3 (HXT)	/Density of material in g cm^{-3}
MATERI04	Al (HXT)	/Chemical formula for material 3
DENSIT04	2.702 (HXT)	/Density of material in g cm^{-3}
MATERI05	HXT cover (cube) (HXT)	/ Name or formula of material
DENSIT05	2.69000 (HXT)	/[g/cm^3] Density of this material
MATERI06	HXT TS film (HXT)	/ Name or formula of material
DENSIT06	6.286700 (HXT)	/[g/cm^3] Density of this material
MULTLAYR	F / T(HXT)	/Whether the reflecting surface is a multilayer

Table 9.2.2.3		
Keyword name	Keyword value	Comment
Header keywords for the 3rd extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	REFLECTIVITY	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Reflectivity for back of mirror foils	/Description
TELESCOP	HITOMI	/Mission name

INSTRUME	‘inst’	/Instrument name
DETNAM	‘SXT’ or ‘HXT’	Detector name
EXTNAME	REFPROBBACK	/Name of the binary table extension

Table 9.2.2.4		
Keyword name	Keyword value	Comment
Header keywords for the 4th extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	REFLECTIVITY	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used
CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Reflectivity for pre-collimator foils	/Description
TELESCOP	HITOMI	/Mission name
INSTRUME	‘inst’	/Instrument name
DETNAM	‘SXT’ or ‘HXT’	Detector name
EXTNAME	REFPROBPCOL	/Name of the binary table extension

9.3 SXT/ HXT Scattering File

This file contains data for the probability of a photon scattering relative to the reflection direction for specular reflection when reflecting on the an XRT foil. The filename is:

ah_xxx_scatter_YYYYMMDDvxxx.fits

where xxx is the instrument type.

These files contain 4 columns. The first column is a grid of photon energies. The following columns are two-dimensional arrays for each energy. The first dimension of the array is scattering angle, and the second dimension is incident angle. The start angle and angular increment of the scattering and incident grids are given in keywords. The value in the field is the probability per radian that a photon with that energy (for that row) will undergo scattering in the angle range defined for that angle bin, given the grazing incident angle for which that scattering probability value corresponds to. There is one extension for segment of an X-ray telescope and the scattering probability for the front-side of mirror foil surfaces may be contained in 1 or more columns, each column corresponding to a physical region in the segment. In addition, there is one column for scattering on the backside of mirror foils, and another column for scattering on pre-collimator foils (front or back). Each XRT foil in the TDF is related explicitly to a column in the scattering file via a column "SCATTER" in the TDF. Each extension is identical in format and the SXT has four extensions, one for each of the three segments.An extension is given for each segment of the mirrors. Therefore, the SXI file has 4 extensions, whereas the HXI file has 3 extensions each with the following columns:

- ENERGY: energy in keV.
- SCATTERn, SCATTERBACK, and SCATTERPCOL contain the scattering.

9.3.1 File Format

Table 9.3.1			
Extension n.	Type	Ext name	
0	PRIMARY		
1	BINTABLE	SEGMENT001	
	Column names	**Format**	**Units**
	ENERGY	1D	keV
	SCATTER*n*	*m*E	
	SCATTERBACK	*m*	
	SCATTERPCOL	*m*	
2	BINTABLE	SEGMENT002	
	Column names	**Format**	**Units**
	ENERGY	D	keV
	SCATTER*n*	*m*	
	SCATTERBACK	*m*	
	SCATTERPCOL	*m*	
3	BINTABLE	SEGMENT003	
	Column names	**Format**	**Units**
	ENERGY	D	keV
	SCATTER*n*	*m*	
	SCATTERBACK	*m*	
	SCATTERPCOL	*m*	
4	BINTABLE	SEGMENT004 (only for SXT)	
	Column names	**Format**	**Units**
	ENERGY	D	keV
	SCATTER*n*	*m*	
	SCATTERBACK	*m*	
	SCATTERPCOL	*m*	

9.3.2 Header Keywords

Table 9.3.2.1		
Keyword name	Keyword value	Comment
Header keywords for the 1st extension		
CCLS0001	BCF	/Dataset is Basic Calibration File
CCNM0001	SEGMENT1-SCATTERING	/Type of calibration data
CDTP0001	DATA	/Calibration file contains data
CVSD0001	yyyy-mm-dd	/UTC date when calibration should first be used

CVST0001	hh:mm:ss	/UTC time when calibration should first be used
CDES0001	Scattering probability for incident, scattered angle	/Description
TELESCOP	HITOMI	/Mission name
INSTRUME	'inst'	/Instrument name
DETNAM	'SXT' or 'HXT'	Detector name
EXTNAME	SEGMENT*n*	/Name of the binary table extension
TDIM*n*	(83,100)	/ dimensions of column
1CTYP*n*	scattering	/ type of angle for first dimension
1CUNI*n*	rad	/ unit of first dimension angle
1CRVL*n*	-3.165200E-03	/ start value of scattering angle
1CDLT*n*	7.720000E-05	/ start value of scattering angle
1CRPX*n*	1.000000E+00	/ pixel value
2CTYP*n*	incident	/ type of angle for second dimension
2CUNI*n*	rad	/ unit of second dimension angle
2CRVL*n*	0.000000E+00	/ start value of incident angle
2CDLT*n*	3.490659E-04	/ delta value of incident angle
2CRPX*n*	1.000000E+00	/ pixel value

9.4 SXT Effective Area File

These files contain the telescope area derived from ray-tracing calculation. There is one file for telescope type and they are named as

ah_nnn_telarea_ YYYYMMDDvxxx.fits.

ah_nnn__YYYYMMDDvxxx.fits.

where xxx is the instrument type. The difference naming htelarea and telarea is to distinguish between area calculated either with the reflectivity file calculated using only the henke data or the henke value combined with the ground measurements.

The file contains a primary header with an image and two binary table extensions, EFFAREAFNE and EFFATREACRS. The primary header contains for the HXI the "image and reference" for the buffle and for the SXT is empty. The binary extensions are identical in format with two columns :

- ENERGY listing the energy in keV
- EFFEAREA containing the telescope area in cm^{-2}

The two extensions are for two different energy grid , the 1^{st} is fine the 2^{nd} is course.

9.4.1 File Format

Table 9.4.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1/2	BINTABLE	EFFAREAFNE/EFFAREACRS	
	Column Names	Format	Units
	ENERGY	D	keV
	EFFAREA	D	cm^{-2}

9.4.2 Header Keywords

Table 9.4.2.1		
Keyword name	Keyword value	Comment
Header keywords for the 1st extension		
CCLS0001	'BCF'	/ Dataset is Basic Calibration File
CCNM0001	'HXIBUFFLEMAP'	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	YYYY-MM-DD	/ UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/ UTC time when calibration should first be used
CDES0001	‘HXI buffle map’	/Description
TELESCOP	HITOMI	/Mission name
INSTRUME	'HXIn’	/Instrument name
CTYPE1	RAWX	Name of the X axis
CTYPE2	RAWY	Name of the Y axis
CUNIT1	pixel	Unit for X-axis
CUNIT2	pixel	Unit for Y-axis
CRVAL1	64.5	Value of the X reference pixel
CRPIX1	64.5	Position of the X reference pixel
CDELT1	1	X-axis increment
CRVAL2	64.5	Value of the Y reference pixel
CRPIX2	64.5	Position of the Y reference pixel
CDELT2	1	Y-axis increment

RAW_XSCL	0.25	RAW X pixel scale mm/pixel
RAW_YSCL	0.25	RAW Y pixel scale mm/pixel
OPTAXISX	64.5	Optical axis X in RAW coordinates (pixel)
OPTAXISY	64.5	Optical axis Y in RAW coordinates (pixel)
BAFLCENX	0	Baffle center X-OPTAXISX (pixel)
BAFLCENY	0	Baffle center Y-OPTAXISY (pixel)
BAFLTOPR	25.35	Radius of Top entrance of the Baffle [mm]
BAFLTOPZ	622.0	Z-coordinate of the Top entrance of the Baffle [mm]
BAFLBOTR	24.67	Radius of Bottom exit of the Baffle[mm]
BAFLBOTZ	124	Z-coordinate of the Bottom exit of the Baffle [mm]

Table 9.4.2.2		
Keyword name	keyword value	Comment
Header keywords for the 2nd extension		
TELESCOP	HITOMI	/Telescope (mission) name
INSTRUME	HXI1 or HXI2 or SXI or SXS	/Instrument Name
DETNAM	SXT or HXT	/Detector name
CCLS0001	'BCF'	/ Basic Calibration File
CCNM0001	EFFAREAFNE or EFFAREACRS	/ Type of calibration data
CDTP0001	'DATA'	/ Calibration file contains data
CVSD0001	' 2015-01-01'	/ Validity start date (UTC)
CVST0001	'00:00:00'	/ Validity start date (UTC)
CDES0001	‘ INSTRUME fine XRT area ‘ or ‘INSTRUMEcoarse XRT area’	/ Brief descriptive summary of this file

9.5 SXT Point Spread Function File

The file name is

ah_sxs_psf_YYYYMMDDvxxx.fits.

ah_sxi_psf_YYYYMMDDvxxx.fits.

These files are place holders for future updates.

9.6 SXT Vignetting File

The file name is

ah_sxs_vignet_YYYYMMDDvxxx.fits.

ah_sxi_vignet_YYYYMMDDvxxx.fits.

These files are place holders for future updates although a description of the vignetting is provided in the ah_gen_vigncoef calibration file.

9.7 Redistribution Matrix File (RMF)

The RMF common format is described here. The filename is

ah_xxx_yyyyyyyy_YYYYMMDDvNNN.rmf

where xxx is instrument name, yyyyyyyy is for specification of the rmf and NNN is the version number.

The structure is an empty primary with 2 bintable extensions, with columns in the standard OGIP format.

9.7.1 File Format

Table 9.7.1

Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	MATRIX	
	Column Names	Format	Units
	ENERG_LO	1E	keV
	ENERG_HI	1E	keV
	N_GRP	1I	-
	F_CHAN	1I	-
	N_CHAN	1I	-
	MATRIX	PE(*n*)	-
2	BINTABLE	CBF	
	Column Names	Format	Units
	CHANNEL	1I	-
	E_MIN	1E	keV
	E_MAX	1E	keV

9.7.2 Header Keywords

Table 9.7.2		
CALDB Keywords 1st Ext		
Keyword name	Keyword value	Comment
CCLS0001	'CPF'	/Dataset is Basic Calibration File
CCNM0001	'SPECRESP MATRIX'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'Energy Redistribution Matrix'	/Description
EXTNAME	'MATRIX'	/Name of the binary table extension
INSTRUME	‘inst’	/Instrument name
CALDB Keyword 2nd ext		
CCLS0001	'CPF'	/Dataset is Basic Calibration File
CCNM0001	'EBOUNDS'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'Energy boundaries of spectral bins'	/Description
EXTNAME	'EBOUNDS'	/Name of the binary table extension
INSTRUME	‘inst’	/Instrument name

9.8 Ancillary Response File (ARF)

A prepared ARF for a simulation purpose based on the ground calibrations. The file name is

ah_xxx_pntsim_YYYYMMDDvNNN.arf (for point sources)

ah_xxx_extsim_YYYYMMDDvNNN.arf (for extended sources)

where xxx is instrument name, and NNN is the version number.

This is a Calibration product file (CPF).

The structure is an empty primary with 1 bintable extension, with columns in the standard OGIP format.

9.8.1 File Format

Table 9.8.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	SPECRESP	
	Column Names	Format	Units
	ENERG_LO	1E	keV
	ENERG_HI	1E	keV
	SPECRESP	1E	cm**2
	RESPERR	1E	cm**2
	other columns for debug purpose?		-

9.8.2 Header Keywords

Table 9.8.2		
Keyword name	Keyword value	Comment
CALDB Keywords for the 1st extension		
CCLS0001	'CPF'	/Dataset is Basic Calibration File
CCNM0001	'SPECRESP'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	'Ancillary Response’	/Description
EXTNAME	'SPECRESP'	/Name of the binary table extension
INSTRUME	‘inst’	/Instrument name

9.9 Non X-ray Background Spectrum File (NXB)

The Non X-ray Background spectrum has the standard spectrum format. The filename is

ah_xxx_yyyyyyyy_YYYYMMDDvNNN.rmf

where xxx is instrument name, yyyyyyyy is for specification of the nxb and NNN is the version number.
The structure is an empty primary with 1 bintable extensions, with columns in the standard OGIP format.

9.9.1 File Format

Table 9.9.1			
Extension N.	Type	Ext. Name	
0	PRIMARY		
1	BINTABLE	SPECTRUM	
	Column Names	Format	Units
	CHANNEL	J	-
	COUNTS	J	counts

9.9.2 Header Keywords

The primary extension keywords are listed in the Table 1.1 of this document and they are mandatory. Specific settings of some of the CALDB keywords and others relevant to this file are listed below.

Table 9.9.2		
Keyword name	Keyword value	Comment
CALDB Keywords for the 1st extension		
CCLS0001	'CPF'	/Dataset is Basic Calibration File
CCNM0001	'SPECTRUM'	/Type of calibration data
CDTP0001	'DATA'	/Calibration file contains data
CVSD0001	YYYY-MM-DD	/UTC date when calibration should first be used
CVST0001	'hh:mm:ss'	/UTC time when calibration should first be used
CDES0001	‘NXB Data’	/Description
EXTNAME	“SPECTRUM”	/Name of the binary table extension
INSTRUME	‘inst’	/Instrument name