The Suzaku Data Reduction Guide

–also known as the ABC Guide–

Version 1.1

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Copies of this guide are available in `html`, `postscript` and `pdf` formats.

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Chapter 1

Introduction

This document is meant as a guide and reference for the scientists who are generally familiar with astronomical X-ray analysis and the *Suzaku* instruments and want to use *Suzaku* data to extract scientific results. General information on the *Suzaku* satellite may be obtained from the *Suzaku* Guest Observer Facility (GOF) page, `http://suzaku.gsfc.nasa.gov`. Readers who are not familiar with the *Suzaku* instruments may wish to read the technical appendix of the NASA Research Announcement (NRA), available at `http://suzaku.gsfc.nasa.gov/docs/suzaku/prop_tools/suzaku_td`.

This is only meant to be a brief guide to *Suzaku* data analysis. Unusual data modes, complex data reduction techniques, and advanced data analysis techniques are outside its present scope but could be added as time progresses. The software needed for *Suzaku* data analysis is described in Chapter 2, including instructions for downloading and installing software. In Chapter 3, we explain *Suzaku* data directory structure, coordinate system, and file names and formats. Chapter 4 contains all the restrictions that applies to the current document. This chapter will be updated very frequently in the first months of the mission as we expect new calibration files, and changes in the processing at the beginning of the data distribution phase. In Chapter 5 and 6, we explain how to analyze data from the X–Ray Imaging Spectrometer (XIS) and Hard X–Ray Detector (HXD). data, and explain the issues linked to the background in both analysis. Acronyms used in this document are described in Appendix A. Useful email addresses and websites are given in Appendix B.

Chapter 2

Software

Suzaku data reduction is primarily performed using the HEAsoft package, which is described in detail at `http://heasarc.gsfc.nasa.gov/docs/software/lheasoft`. HEAsoft is a multimission collection of programs and scripts (frequently also called FTOOLS, for historical reasons), all using a similar interface which can be used both interactively and via scripts. A suite of new programs has been added to HEAsoft to support the *Suzaku* mission, collectively called the "*Suzaku* FTOOLS." Since *Suzaku* data files are in FITS format, other analysis suites (such as CIAO) can be used with *Suzaku* files to complete certain tasks. However, due to limited resources the *Suzaku* GOF will focus support on using HEAsoft to analyze *Suzaku* data and only support other tools as time permits. Users should have installed HEAsoft version 6.0.6 or later, including the *Suzaku* FTOOLS.

Suzaku data analysis will be supported on major Unix architectures, such as Linux, Solaris and OS X. FTOOLS runs on Windows in principle, but not as smoothly as on Unix yet. Therefore, *Suzaku* users are strongly suggested to use one of the supported Unix systems, listed on the HEAsoft website.

Suzaku FTOOLS will evolve rapidly in the early stage of the mission, hence shorter release cycle will be required. In order to catch up with the rapid development cycle, we are planning to release the "*Suzaku* add-on" package in a shorter interval ($\sim$ months) as needed, which users may install with the release version of the FTOOLS. All the software required to calibrate *Suzaku* data are written by the instrument teams and released as FTOOLS so that the latest calibration by the instrument teams are promptly made available to general *Suzaku* users. Also, *Suzaku* users are able to recalibrate their data using FTOOLS when new calibration information is made available. Readers who are interested in how the *Suzaku* FTOOLS are developed and maintained can find more detailed explanations at the following page, as well as the complete *Suzaku* FTOOLS list at `http://suzaku.gsfc.nasa.gov/docs/suzaku/analysis/suzaku_ftools.html`.

2.1 XSELECT

`xselect` is a multi-mission FTOOLS which has been widely used to analyze data from *ASCA*, *ROSAT*, *BeppoSAX*, *Einstein*, *Chandra* and other high energy missions. After passing through standard processing, *Suzaku* event files do not require any particular analysis software, since they comply with FITS event file standards. Nonetheless, the *Suzaku* GOF recommends `xselect` as a convenient and straightforward analysis tool. Therefore, in this document it is assumed readers will use `xselect` to extract *Suzaku* data into spectra, images, and lightcurves. The primary purpose of `xselect` is to provide a "shell" that translates simple commands (such as "extract image") into more complicated mission- or instrument-dependent FTOOLS commands. This guide, however, will not describe all the features of `xselect`. Users unfamiliar with `xselect` should read the `xselect` manual, available at `http://heasarc.gsfc.nasa.gov/docs/software/lheasoft/ftools/xselect/xselect.html`. The most important FTOOL used by `xselect`, `extractor` actually extracts the images, spectra, light curves or newly filtered event files from input event files. Users wishing to create scripts based on `xselect` commands will likely need to use `extractor` directly.

2.2 XANADU

XANADU is a mission independent data analysis software package for high energy astrophysics which is normally distributed with the HEAsoft package. Currently XANADU includes XSPEC for spectral analysis, XIMAGE for image analysis, and XRONOS for timing analysis. *Suzaku* spectral, image, and timing analysis may be carried out within XANADU. In particular, the *Suzaku* GOF will fully support spectral analysis using XSPEC, and provide spectral response files (and/or response generators) with the XSPEC standard format. This guide assumes that the user is generally familiar with the XANADU package but if not, more information can be found at `http://heasarc.gsfc.nasa.gov/docs/xanadu/xanadu.html`.

2.3 Profit

Profit is a new spectral analysis tool with a graphical user interface, designed generally for high-resolution spectroscopy but with *Suzaku* in mind. *Profit* is in active development and the reader is directed to the web page, `http://heasarc.gsfc.nasa.gov/docs/software/profit/profit.html`, for download instructions and details of its current functionality. In its initial release, *Profit* can display *Suzaku* spectra, focusing in and out as desired. Emission lines in the spectrum can be labelled using atomic data from either the ATOMDB or XSTAR line lists. The user can also select individual emission lines and redisplay the data in velocity space to search for line broadening or a Doppler shift. *Profit* has some ability to fit spectra, although this is rudimentary compared to XSPEC which is recommended when performing measurements for publication. Despite this limitation, *Profit* may be useful as a "first-look" tool when examining *Suzaku* data, especially for users not familiar with X-ray spectroscopy.

Chapter 3

Suzaku Data Specifics and Conventions

This chapter describes the contents of an *Suzaku* observation data set, including the directory structure, included data files, and the format of those files. The *Suzaku* data structure is similar to previous X-ray missions, with small variations.

3.1 Directory and Data File Structure

The standard *Suzaku* "pipeline processing" products (encrypted for proprietary data) are available from the GSFC HEASARC archive at `http://suzaku.gsfc.nasa.gov/docs/suzaku/aehp_archive.html` or at the ISAS DARTS site (for Japanese and European-based observers). Standard data formating and calibration are carried out in the pipeline processing, and all the *Suzaku* users should start scientific data analysis from the pipeline processing products.

3.1.1 Retrieving the data

This section is relevant only for US PI only

When the data are processed, the PI of the observation will receive a mail from the *Suzaku* GOF at GSFC giving the FTP location to access and download the data. The location will be of the form of ftp://legacy.gsfc.nasa.gov/suzaku/data/obs/M/NNNNNNNNN. There are two options available for the download: FTP and `wget`.
To retrieve the data via FTP type:

```
ftp legacy.gsfc.nasa.gov
login:  anonymous
password : your_email_address@your_domain_address
ftp> cd suzaku/data/obs/M
```

```
ftp> binary
ftp> get NNNNNNNNN.dat.gz
ftp> quit
```

To retrieve the data via `wget`[1], type:

```
wget --passive-ftp -q -nH --cut-dirs=5 -r -l0 -c -N -np --retr-symlinks ftp_address_received
```

Once retrieved, the data have to be decrypted using either PGP or GPG software and a perl script available at the website `http://heasarc.gsfc.nasa.gov/docs/cookbook/decrypt_data.pl`. General information on how to decrypt the data is available at `http://heasarc.gsfc.nasa.gov/docs/cookbook/decrypt.html`.

3.1.2 Organization of the data

All *Suzaku* data (including ground calibration and test data) have unique 9-digit observation numbers (*e.g.* 900000450) which is used as the name of the top level directory. Under this directory are a series of sub-directories, each of which carries a particular kind of data files, as explained below. All the data files are in the standard FITS format, although some output products are in Postscript, HTML, GIF or simple ASCII[2]. The subdirectories are:

auxil Auxiliary files not associated with a particular instrument, such as the spacecraft attitude (file named aeYYYYMMDD.att – see Section 3.2 for an explanation of the name structure) and orbital data (file named aeYYYYMMDD.orb). The most important of these is the "filter file" (with the suffix "mkf"), in which various satellite and instrumental parameters to be used for data screening are recorded as a function of time.

log Log files from the pipeline processing

hxd Data from the Hard X-ray Detector (HXD)

xis Data from the X-ray Imaging Spectrometers (XIS)

Within each of the two instrumental directories (`hxd, xis`) there are four subdirectories:

hk Instrumental housekeeping files containing information such as voltages, temperatures and other detector-specific data.

event_uf Second FITS Files (SFF) are unfiltered events files derived from the First FITS Files (FFF). FFF are effectively the telemetry data converted into FITS format

[1] wget is available at `http://www.gnu.org/software/wget/wget.html`

[2] In the early stage of the mission, some calibration files may be ASCII files, which will eventually be converted into FITS format.

event_cl Cleaned events in this directory have gone through the standard cuts (grades, SAA and such) and they are in principle directly useful for analysis. However, users can re-run these cleaning processes (see Chapters 5 and 6 for more on the standard cuts applied).

products Output products from the pipeline, such as GIF images of the data and automatically generated lightcurves.

The filename conventions in each of the these directories is instrument dependent, as described in the next section.

3.2 Filenames

The filenames for the science files use the following general convention:

`aeXXXXXXXXXiii_N_mmmmmmmm_ll.ext.gz`

where

ae is short for *Astro-E2* the initial name of *Suzaku*.

XXXXXXXXX is the observation sequence number and is identical to the directory name.

iii is the instrument specification. This string is set as follows: hxd=HXD, xi[0-3]=XIS-[0-3]. xis is used for files common to all the XIS units.

N ranges from 0 to 9 and indicates the RPT file number. The original telemetry file is divided in RPT files and more than one RPT can contribute to one observation. The value of 0 is used when the science file combines data from different RPT or if there is only one RPT file that contributes to that sequence.

mmmmmmmm is the file identifier. The string allows to distinguish between files from the same instrument.

ll indicates the file level (i.e "uf" or "cl" to indicate the "unfiltered" or "cleaned" files. This flag is not used for the instrument housekeeping files.

ext is the file extension.

The filenames for the auxiliary files use the following convention:

`aeXXXXXXXXX.ext.gz`

where

ae is short for *Astro-E2* the initial name of *Suzaku*.

XXXXXXXXX is the observation sequence number and is identical to the directory name.

All these files are in the /aux directory.

The filenames for the science files use the following convention:

`aeXXXXXXXXX_mmmmmmmm.ext.gz`

or

`aeXXXXXXXXXiii_N.ext.gz`

or

`aeXXXXXXXXX.ext.gz`

where

ae is short for *Astro-E2* the initial name of *Suzaku*.

XXXXXXXXX is the observation sequence number and is identical to the directory name.

iii is the instrument specification. This string is set as follows: hxd=HXD, xi[0-3]=XIS-[0-3]. xis is used for files common to all the XIS units.

N ranges from 0 to 9 and indicates the RPT file number. The original telemetry file is divided in RPT files and more than one RPT can contribute to one observation. The value of 0 is used when the science file contains data from different RPT or if there is only one RPT file that contributes to that sequence.

mmmmmmmm is the file identifier. The string allows to distinguish between files from the same instrument.

ext is the file extension. This string can be either ".com" or ".log".

For more informations on file names of the products of the pipeline processing, please refer to the documentation that can be found at `http://suzaku.gsfc.nasa.gov/docs/suzaku/aehp_data_analysis.html`.

3.3 *Suzaku* Coordinates

The XIS is an imaging instrument (unlike the HXD), and the coordinate values in the header of XIS files indicate the pixel center positions. The XIS coordinate systems are described below:

Sky coordinates "X" and "Y" are used to describe the sky positions of the events relative to a celestial reference point. The "tangential" projection is used, and North is defined up (increasing Y), and East is left (decreasing X). "X" and "Y" columns are computed using attitude information.

Focal plane coordinates These are the event locations on the focal plane, which is common to the four (there are four XIS detectors) imaging instruments. "FOCX" and "FOCY" event file columns are used. The FOC coordinates differ from the Sky images in that the satellite attitude is not considered in the latter. FOC images of the four instruments should match, as instrument misalignments are already taken into account.

Detector coordinates These give the physical positions of the pixels within each sensor. Misalignments between the sensors are not taken into account. The DET X and Y values take 1 to 1024 for XIS. The XIS DETXY pixels correspond to the actual 1024x1024 CCD pixels, and the DETXY pixel size is the same as the CCD physical pixel size. The DET images will give correct sky images of the objects (not mirrored images), except that attitude wobbling is not taken into account. Note that X-ray images focused by the mirrors and detected by the focal plane instruments will be the mirror images , which have to be flipped to be the actual images of the celestial objects. Thus, the original look-down images are flipped (and rotated if necessary) so that the satellite +Y-axis direction will be the DETY direction.

ACT and RAW coordinates The ACT coordinates are used to tell actual pixel locations on the chip. One XIS chip is composed of the four Segments, and the RAW coordinates tell pixel locations on each Segment 4 . Note that XIS-0 and XIS-3 installations on the baseplate are aligned, whereas XIS-1 and XIS-2 are 90 degree rotated relative to them, in opposite directions respectively. Therefore relation between the ACT and DET coordinates is dependent on each XIS sensor.[3]

3.4 Photon Energies and Pulse-heights

All *Suzaku* instruments are energy-sensitive, and each event has a measured "Pulse Height Amplitude" (PHA). The PHA may be both position- and time-varying, depending upon the instrument. Therefore, a calculated "PHA Invariant" (PI) is also determined using the PHA in combination with the instrumental calibration and gain drift. In all cases, the PI columns should be used to

[3]Conversion from the RAW to ACT coordinates is not straightforward, because of the particular order of the pixel read-out and possible use of the Window option.

Type		Type	Minimum	Maximum	Origin	Unit
Sky	X/Y	Integer	1	1536	768.5	0.0174′
	ROLL	Real	0.0	360.0	–	degree
FOC	X/Y	Integer	1	1536	768.5	0.0174′
DET(XIS)		Integer	1	1024	512.5	0.024 mm
ACT	X/Y	Integer	0	1023	–	–
SEGMENT		Integer	0	3	–	–
RAWX(XIS)		Integer	0	255	–	–
RAWY(XIS)		Integer	0	1023	–	–

Table 3.1: Types of coordinates and coordinate related variables and their possible values

extract energy spectra, or to produce energy-band selected images or light curves. For reference, the approximate relationship between "true" X-ray energy E and the event PI is shown below for each instrument. The exact relationship between energy and PI is given in the second extension of the instrument response matrix file, or "RMF."

XIS The PI column name is "PI", which takes values from 0 to 4095. The PI vs. energy relationship is the following: E [eV] = 3.65×PI [channel].

HXD The "PI_SLOW" column (as opposed to "PI_FAST") should be used for GSO spectral analysis, which takes values from 0 to 4095. The PI vs. energy relationship is the following: E [keV] =2×(PI_SLOW + 0.5) For PIN spectral analysis, "PI_PIN" column should be used, which takes values from 0 to 255. The value in this column is copied from the PI column of the triggered PIN, which is one of the PI_PIN0, PI_PIN1, PI_PIN2 or PI_PIN3. The PI vs. energy relationship is the following: E [keV] =0.375×(PI_PIN + 1.0)

3.5 Timing Information

The *Suzaku* event arrival time is represented by the "*Suzaku* time," which is defined as the elapsed time in seconds from the beginning of the year 2000 (January 1st, 00:00:00.000) in UTC (when TAI is 32 second ahead). There will always be a constant offset between TT and *Suzaku* time, and this is reflected in the time-related keywords. The event time resolution of each detector as follows:

XIS In the Normal observation modes (5x5, 3x3 or 2x2) without a Window option, the time resolution is 8 sec, corresponding to a single frame exposure. The midpoint of each exposure frame is associated with each event in that frame. When the Window option is used, depending on its size, the time resolution will be 4 s (1/2 Window), 2 s (1/4 Window), or 1 s (1/8 Window). In Timing mode, the time resolution is 7.8125 ms, regardless of the number of lines to be combined (either 64, 128 or 256). Users should note that when combining a small number of lines, there could be a noticeable amount of cross-talk between one time bin and the next, due to the wings of the PSF. For example, 64 lines is only about 1.2 arcmin, so a fraction of the source count will fall on the neighboring groups of 64 lines, and so mis-time-tagged by +/-N times 7.8125 ms. For this reason, it may be safer to use always a grouping of 256 lines.

HXD Nominal time resolution is 61μs, which corresponds to the HXD_WPU_CLK_RATE_HK parameter = 1 (Fine). A higher time resolution, 30.5μs is possible by commands, in which case HXD_WPU_CLK_RATE will be 2 (Super-Fine), although this is not user-selectable at this time.

3.6 *Suzaku* Telemetry

3.6.1 Data rates

The telemetry rate determines the data transfer rate from the onboard instruments to the Data Recorder. Being limited by the data storage and downlink capacity, the highest data rates may not be used all the time[4]. Basically, combination of the following three telemetry rates will be used for observations; High rate (262 kbps), Medium rate (131 kbps), or Low rate (33 kbps)[5]. Among the 10 Gbit raw data per day, 4 Gbits will be taken between the contacts (contact passes) with High and Medium bitrates, and 6 Gbits will be taken after the contacts (remote pass) using Medium and Low bitrates.

3.6.2 Allocations

Although the maximum Data Recorder recording rate is limited by the telemetry rate for each bitrate, allocation of the telemetry to various instruments is variable. The XIS and HXD telemetry limits will be dependent on the bitrates. Telemetry allocation among different instruments will be adjusted after the launch.

3.6.3 Telemetry Limits

XIS The approximate XIS telemetry limits (events/s for four XIS combined) for different bitrates and observational modes will be the following:

XIS events are compressed on-board and actual telemetry limits may vary within $\sim \pm 40\%$ depending on the PHA values. Note that different XIS sensors may be operated by different modes and telemetry allocations.

[4]The amount of the data taken per day is mainly limited by the capacity of the Data Recorder (6 Gbits) and the downlink rate at Uchinoura Space Center (2 Gbits/ground contact). There will be 5 ground contacts per day separated by 90 minutes, so it is expected that usually 10 Gbits/day raw data will be taken.

[5]In addition, there is Super-High rate (524 kbps), which may not be allowed for general observations.

	5x5	3x3	2x2	Timing
Super-High	985	1971	3942	9381
High	475	949	1899	4528
Medium	221	441	883	2114
Low	29	58	116	292

Table 3.2: Telemetry limits in different XIS modes

HXD The approximate HXD Well telemetry limits will be the following (in counts/s): Super-High=1150, High=550, Medium=250, and Low=30. This is based on the assumption that HXD will take 30% of the telemetry. Note that the Crab rate in the HXD is $\sim 200\,\mathrm{cts/s}$.

3.7 `xselect` Default Parameters

The xselect mission database file is usually located at $FTOOLS/bin/xselect.mdb[6]. The *Suzaku* entries in the mission database files are made so that the following things are enabled:

- Common for all the instruments
  - Default light curve bin is 16 sec
  - "extractor" is used to extract products
  - WMAP[7] is created at the spectral file header
  - Default image coordinates are Sky coordinates (X and Y)
  - Default WMAP coordinates are Detector coordinates (DETX and DETY)
  - Event file has either of the following names; ae*xis0*.*, ae*xis1*.*, ae*xis2*.*, ae*xis3*.*, or ae*hxd wel*.*
  - The filter file has the name ae*mkf*, and is in the directory ../auxil relative to the event file directories
- XIS
  - Default image binning is 8 (makes 384×384 image)
  - Default WMAP binning is 4 (256×256 WMAP)
  - "RAWX' and "RAWY" coordinates are set to "ACTX" and "ACTY", so the "set image raw" command creates ACT coordinate images

[6]Users may specify their own mission database file with an environmental parameter XSELECT_MDB.

[7]WMAP is a part of the detector image from which the energy spectrum has been extracted, and will be used to create spectral responses by downstream FTOOLS.

  - Pixels in the WMAP outside of the selected region will have the value "-1"
  - Spawns "rbnpha" when saving a spectral file, and rebin by 2 to reduce the number of channels from 4096 to 2048 linearly

- HXD

  - "PI_SLOW" is the default energy column to make energy spectrum (= GSO spectrum is the default). Users need to "set phaname PI_PIN" to extract the PIN spectrum.
  - The UNITID event column is used in lieu of standard X, Y, RAWX, RAWY and DETX of imaging instruments, so that the "sky" or "raw" images will be a pseudo-diagonal image of UNITID [8]
  - The DET_TYPE event column is used in lieu of DETY, so that the WMAP is created with UNITID vs. DET_TYPE, which will be useful to create ARFs and RMFs
  - No binning for image and WMAP
  - Spawns "rbnpha" when saving a spectral file, and rebins by 4 to reduce the number of channels from 4096 to 1024. For PIN, the original channel is 256, so users should answer 'no' to this option when saving PIN spectrum. The GSO response will be made with 1024 channels.

[8]For each HXD event, UNITID and DET_TYPE tells the Well unit-ID and the detector type. UNITID takes a value in the range of 0 to 15 corresponding to the 16 Well units. DET_TYPE = 0 corresponds to GSO, and 1 to 4 correspond to PIN0 to 3 respectively.

Chapter 4

The "README FIRST" of the *Suzaku* data analysis

4.1 Introduction

This chapter, updated frequently, contains the details of the current status of the data analysis. Most of the same information (in a more condensed form) can be found at `http://suzaku.gsfc.nasa.gov/docs/suzaku/aehp_proc.html` or `http://www.astro.isas.jaxa.jp/suzaku/process`. Users are encouraged to contact us via the comment webpage at `http://heasarc.gsfc.nasa.gov/cgi-bin/Feedback`.

4.2 XIS

4.2.1 Contamination

In late November 2005, contamination in the optical path of each sensor became apparent. Spectra of celestial sources show that the contaminant is predominantly carbon. Monitoring of 1E 0102.2-7219 and RX J1856.5-3754 shows that the contamination is increasing at a different rate for each unit, from less than 0.3 to 0.9mg cm^{-2} day^{-1} leading to an equivalent additional column density of C of 6×10^{18} cm^{-2} (see Figure 4.1). There are some indication that the rate of accumulation has recently stopped increasing. Observations of the bright earth show that the contaminant is twice as thick at the center of the field of view than at the edge, a pattern that tracks the temperature distribution on the optical blocking filter (OBF). This suggests that the contaminant is on the spacecraft side of the OBF, rather than on the CCD detector surfaces. Recent studies suggest that the contaminant is DEHP (C24H38O4, or C/O = 6 by number) although the XIS team is still investigating the material's exact composition.

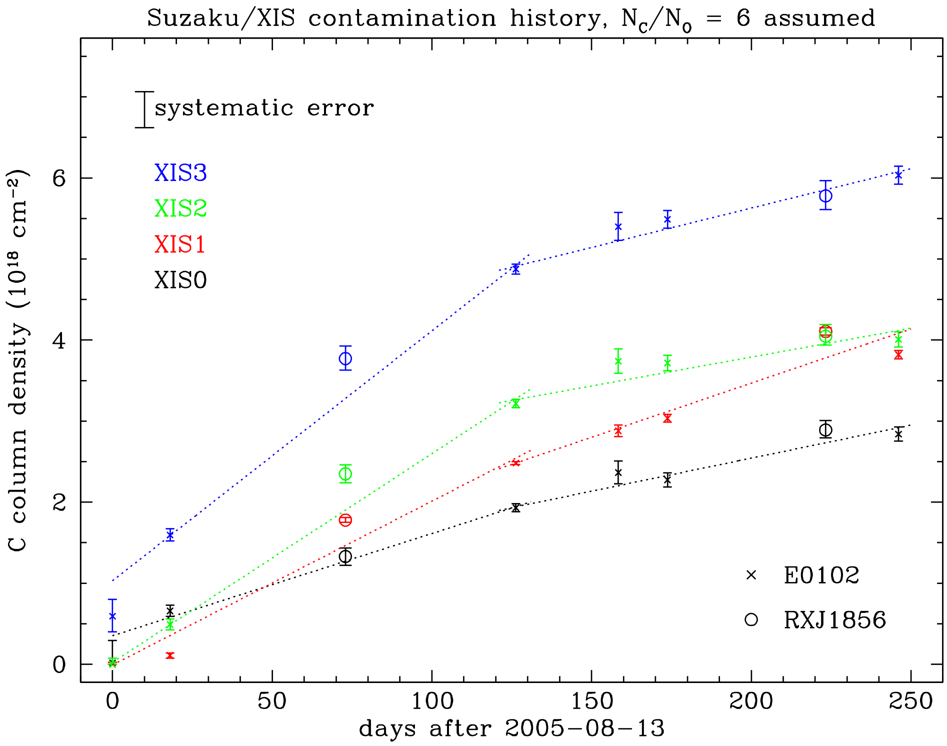

Figure 4.1: XIS contamination history as of April 2006

The XIS design allows the CCDs to be warmed to room temperature by reversing the current in the thermoelectric coolers. Independently, the OBF temperatures can be raised by activating heaters on the heatpipes that cool the sensor housings in which the filters are mounted. Either or both may help to reduce or reverse the contamination.

Currently no contamination correction is included in the software distribution, nor in the response matrices distributed. There are plans to include it to the arf generator routines in the next FTOOLS release. Please check the GOF website for updates on the exact timescale.

4.2.2 Imaging analysis

The software to produce exposure maps is not yet available

4.3 HXD

4.3.1 Background

The HXD background estimator is currently being tested by the instrument teams. At present the PIN background subtraction is accurate at the 5% level whereas the GSO background still have large uncertainties and GSO data should not yet be used for scientific purposes. Users should be aware of the fact that cosmic X-ray background is not included in the background models used by the HXD instrument team.

4.3.2 Energy range

The current response matrix cannot reproduce the Crab spectrum below 12 keV. The instrument team has been studying the energy scale of individual PIN diodes, in parallel with fine-tuning the response matrix but this study of response is still ongoing.

4.3.3 Deadtime

The deadtime correction (necessary for accurate flux measurement) is done by measuring the ratio of pseudo-events that are issued by the on-board electronics to the true X-ray events. Since events issued during a dead time aren't recorded, the ration gives the dead-time percentage. For the moment, there are no pseudo-events files delivered and no deadtime correction applied to the data in the processing. Users can assume that the dead-time correction is of the order of 5% for background dominated sources.

4.3.4 Timing modes

Currently timing mode data are not processed (nor distributed) and Fine timing assignment (¡ 8sec) is not done when window/burst options are used.

The software to apply barycentric corrections is not yet available

4.4 Cross calibration

There is currently a 5% normalization uncertainties in the HXD-XIS calibration.
Cen A was observed with RXTE and Swift and there are no noticeable differences with the Suzaku data. The agreement with XMM-Newton and the HXD is about 10%, although a power-law fit yields to a somewhat steeper slope.

4.5 Attitude Solution

There is currently a 30 arcsec level attitude wobble which is not currently in the attitude solution.

Chapter 5

XIS Data Analysis

5.1 Introduction

The XIS consists of four CCD detectors, three of which are "front-illuminated" (FI) and one "back-illuminated" (BI). The BI chip was a late addition to the XIS which increases the effective area of the entire system substantialy at low ($< 1\,\mathrm{keV}$) energies with only a small decrease at higher energies. Although the detectors have seen significant improvements from the ASCA SIS, the data reduction is expected to be quite similar to that of ASCA SIS.

5.2 Initial Processing

XIS data begins as part of the RPT telemetry downloaded from *Suzaku*, and is converted into a collection of FITS files by the `mk1stfits` routine at ISAS. `mk1stfits` does not reject any events or apply any calibration to the data but merely converts it to FITS files. Once the files have been processed through the pipeline (SFF), they are included in the standard data download in the directory "xis/event_uf".

The XIS `mk2ndfits` pipeline task is then run on the `mk1stfits` output to create filtered, calibrated output event files, lightcurves, and images, which are found in the directories "xis/event_cl" and "products". As the mission progresses, it is expected that these outputs will be the primary data for users. However, during the early stages of the mission we expect that the calibration applied by `mk2ndfits` will change frequently. The user should check the date of `mk2ndfits`, which is listed in the event file in the FITS keyword DATE. This can be compared again the list of calibration updates, found at `http://suzaku.gsfc.nasa.gov/docs/suzaku/aehp_proc.html`. If any substantial changes have occurred, the data should be reprocessed as needed, as described below.

5.2.1 Calculating Sky Coordinates

`xiscoord` combines the position of the observed counts on the XIS detector with the orbit and attitude information to calculate the ACT, DEC, FOC and sky X/Y values for XIS event files. `xiscoord` uses either the attitude file assigned on the basis of the event input file name (the default), or fixed Euler angles if the keyword ATTITUDE is set to EULER. The RA and DEC used by the program can be either read off the header of the input event file or set manually.

Typically, users should not run this as it has been already run on the SFF file distributed in the event_uf directory. However, some user may want to rerun the command (especially when the attitude solution is improved and accuracy to better than 30 arcsec is necessary). In this case the command is:

```
xiscoord infile=input-infile.sff attitude=DEFAULT pointing=KEY outfile=outfile.unf
```

where
`infile` is the XIS event fits file name.
`attitude` indicates where to get the attitude information
`pointing` indicates where to read the RA and Dec – a pointing set to KEY read them off the header of the input event file
`outfile` is the XIS event fits created file name.

5.2.2 Computing the PI for XIS events

As its name indicates, the `xispi` routine calculates the XIS PI and grades values from the PHAs. In addition to the input event file, the routine needs the CALDB file ae_xi[0-3]_makepi_[date].fits and the house keeping file associated with the input event file. If the CALDB option is not set properly and the file has to be input manually, users should check what is the latest "makepi" file to be used.

5.3 User specific processing

Both bad pixel filtering and grade selections are done by the processing pipeline and implemented in the cleaned files distributed to the users.

5.3.1 Bad pixel filtering

The cleaning of hot and flickering pixels is done in `cleansis` and available as a stand alone script at the GOF website `http://suzaku.gsfc.nasa.gov`. `cleansis` was originally written for analysis of the *ASCA* SIS data and removes hot and flickering pixels based on a Poissonian analysis. It

has since been adapted for work on the *Suzaku* XIS. This generalized version is available in all releases after 6.0.6 of HEAsoft. Users of an older version of HEAsoft will need to update their version of cleansis by downloading cleansis.f from the site mentioned above and replacing the copy in ftools/asca/src/cleansis in their source distribution of HEAsoft. Running hmake followed by hmake install in this directory will build the new version. If users only have the HEAsoft binary distribution, they can install the new xselect.mdb in ftools/operating-system/bin where operating-system is the appropriate directory for their system (it is the end of the directory string written by eg printenv HEADAS). If they don't have write-access to the HEADAS distribution, they should use the `setenv` command to set the XSELECT_MDB keyword to
tt directory-tree/xselect.mdb where directory-tree is the location they have placed the file. To run cleansis on Suzaku XIS event files type from the command line cleansis chipcol=SEGMENT, give the input and output filenames and use the default values of the remaining parameters.

5.3.2 Grade Filters

The GRADE column tells the event grade, which is determined from distribution of the pulse heights among the 5x5 (or 3x3 or 2x2) pixels. The standard spectral responses XIS team is going to provide will assume GRADE 0,2,3,4, and 6. You may select only events with these grades: `select event ''GRADE==0||GRADE==2||GRADE==3||GRADE==4||GRADE==6''`

5.4 Extracting Data within `xselect`

The primary tool for extracting data products (spectra, lightcurves, exposure maps) from XIS data is `xselect`, which is part of the general HEAsoft distribution. `xselect` can apply filters which select user-defined times, sky regions, or particular event flags. It then uses the filtered events to create a (binned) spectrum (as well as generating the necessary calibration files), a lightcurve, or an exposure map. Some basic parameters to be used for common data screening are in the filter file. The "select mkf" command is used to screen the output of `cleansis` file (that is to be read by `xselect`). The *Suzaku* instrument teams recommend the following cuts to be applied within `xselect`.

```
select mkf  "SAA==0  && T_SAA> 436 && COR > 6 && ELV> 10 && DYE_ELV>20"
```

Satellites, such as *Suzaku* launched into low-Earth orbit pass through the South Atlantic Anomaly (SAA). During a passage, the high particle flux makes the instruments unusable. The `mkf` keyword SAA is set to 0 when the satellite is **not** in the SAA and so the selection condition is SAA==0. Even when the satellite emerges from the SAA, the background is still high, the `mkf` keyword T_SAA indicates the amount of time since an SAA passage. T_SAA can be as low as 60 seconds. For HXD data, the condition reads T_SAA_HXD>436 (the background stays high much longer after the passage through SAA). The instrument teams have recommended adopting the same condition for both instruments, hence the cut of T_SAA>436 imposed on the XIS data. In addition

to the SAA, there are still regions of high particle background where the geomagnetic rigidity is low. Data taken in regions of low rigidity (greater than 6) should be discarded. We encourage the user to explore the effect of slightly different boundaries on their data. The two last cuts are recommended by the instrument teams to cut the contamination from the Earth's atmosphere. The first is applied to the elevation angle, `mkf` keyword ELV, the angle between the target and the Earth's limb. Only data with an elevation angle larger than 10 should be considered. The second concerns the elevation angle from the day Earth rim and helps reduce the contamination in the Nitrogen and Oxygen lines from scattered X-ray on the Earth's atmosphere.
Users are encouraged to explore the effects of different values for all the cuts and selections described above on their own dataset.

5.4.1 Region Selection

Sky regions

It often happens that users want to extract light curves or energy spectra from some specific regions on the sky. Such region selection can be done on the "SKY" image displayed by ds9/saoimage; select a region and create a region file to use for the xselect "filter region" command. Users are cautioned that not all coordinates systems available in ds9 can be used in xselect and care about the format of the regions should be taken when saving their coordinates. Sky coordinates are the default image coordinates in xselect. After using other coordinates, enter `set image sky` to go back to the Sky coordinates.

Detector regions

Particular regions within a single detector may be selected using the Detector coordinates. Use `set image det` command before extracting images. While Detector coordinates are defined so that all the XIS images have the same direction (§3.3), the four XIS sensors on the baseplate are rotated by 90° or 180° relative to each other. The ACT coordinates tell actual location on the CCD chip, which may be useful when investigating instrumental characteristics on particular chip positions (such as extracting the calibration source spectra). `set image raw` followed by `extract image` will extract XIS ACT images. XIS performance will be dependent on Segments, and particular Segments may be selected with the select event command. Events on Segment A, B, C and D have "SEGMENT" column value 0, 1, 2, 3 and 4 respectively.

5.5 Extracting a calibrated spectrum

Right now only pre-computed ARF for point sources on-axis are available through CALDB. For each of the XIS, two ARF were generated: one for a XIS and one for an HXD nominal pointing.

Moreover the ARF generators do not include the contamination (see Chapter 4). As the time of this writing, the release of xissimarfgen (the ARF generator) is planned for within one month. Users are invited to check the analysis website at `http://suzaku.gsfc.nasa.gov/docs/suzaku/aehp_data_analysis.html`regularly for updates.

Chapter 6

HXD Data Analysis

6.1 Introduction

HXD significantly extends the spectral range of *Suzaku* (to 600 keV), and is expected to have the lowest background rate of any instrument ever operated in the 10-600 keV energy range. Please check the *Suzaku* HXD data analysis website at `http://suzaku.gsfc.nasa.gov/docs/suzaku/aehp_data_analysis.html`for updates, before attempting any analysis of HXD data.

The HXD is signifcantly different from the XIS. First, it does not have any imaging capability, although it does have a collimator which makes it act as a "light bucket." Second, it has two independent detector systems. These are the GSO/BGO phoswich counters and the PIN silicon diodes. The PIN diodes are sensitive below $\sim 60\,\mathrm{keV}$, while the GSO/BGO phoswich counters detect photons above $\sim 30\,\mathrm{keV}$. The energy resolution of the PIN diodes is $\sim 3.0\,\mathrm{keV}$, while the phoswich counters have a resolution of $7.6\sqrt{E}$ % where E is the photon energy in MeV. For more information about the HXD detector, please see the *Suzaku* Technical Description at `http://suzaku.gsfc.nasa.gov/docs/suzaku/prop_tools/suzaku_td`.

6.2 Initial Processing

HXD data begins as part of the RPT telemetry downloaded from *Suzaku*, and is immediately converted into a collection of FITS files by the `mk1stfits` routine at ISAS. `mk1stfits` does not reject any events or apply any calibration to the data, but merely converts it to FITS files. These files are included in the standard data download in the directory "hxd/event_uf".

The HXD `mk2ndfits` pipeline is then run on the `mk1stfits` output to create filtered, calibrated output event files, lightcurves, and images, which are found in the directories "hxd/event_cl" and "products". As the mission progresses, it is expected that this output will be the primary data for users. However, during the early stages of the mission the calibration applied by `mk2ndfits` may rapidly. The user should check the date of `mk2ndfits`, which is listed in the event file in the FITS keyword DATE. This can be compared again the list of calibration updates, found at `http://suzaku.gsfc.nasa.gov/docs/suzaku/aehp_proc.html`. If any substantial changes have occurred, the data should be reprocessed as needed, as described below.

6.3 Processing description

For the HXD, the standard pipeline processing steps are listed (in the recommended order) below. We will describe first the processing for the PIN and GSO, and address later the processing for the WAM. **Please note that general users should not have to run these routines as the files delivered have already been proceed with these routines.** The descriptions below are given more for completion than for general use by GOs.

6.3.1 Time Correction

The first step is to calculate the HXD event arrival-time correction. The arrival time of each true event time (in column TIME) is calculated from the HXD internal detector time value and others detector corrections. The computed time is then converted to *Suzaku* time coordinates using four separate methods (selected using the input parameter "time_convert_mode"). In addition. the tool `hxdtime` measures the actual time resolution of "TIME" during the observation. (not sure of what this really means..) The standard way to run the `hxdtime` tool is to type:

```
hxdtime input_name=aeNNN_hxd_wel.uff  create_name=aeNNN_hxd_wel.fff \
leapsec_name=leapsec.fits hklist_name=aeNNN_hxd.hk tim_filename=aeNNN.tim \
time_convert_mode=4
```

where
`input_name` is the HXD event fits file name.
`create_name` is the HXD event fits created file name.
`leapsec_name` is the name of the leap-seconds file located under the HEADAS ref area
`hklist_name` is the name of the HXD HK file.
`tim_filename` is the name of TIM file.
`time_convert_mode` is put to 1, 2, 3 or 4 according to the method used. The default is 4.

6.3.2 Gain Correction

After calculating the corrected event time, the next step is to adjust the detector gain for both HXD detectors. This is done by fitting a calibration line present in the detector as a function of time. In the case of the GSO, an intrinsic Gd line is used. For the PIN diodes, the gain drift is not yet known, and so the gain histogram routine here is simply a placeholder until better calibration can be done in flight.

The `hxdmkgainhist_gso` routine calculates the time variation of the PMT gain for both SLOW_PHA and FAST_PHA data by fitting the intrinsic Gd line peak appearing in the background energy spectra. The tool makes GTIs for each Well unit using the high voltage value of PMTs, 'HXD_HV_Wn_CAL' (where n=0,1,2,3) in HK FITS, and then separates these into several epochs with period set by the *exposure* parameter. The fit process is performed using XSPEC for SLOW_PHA and FAST_PHA, and summarized in the output fitlog file *gs_fitlog_name*.

```
hxdmkgainhist_gso input_name=aeNNN_hxd_wel.uff \
hk_name=aeNNN_hxd.hk gso_fitlog_name=aeNNN_gso_ghf.tbl \
gso_511_fitlog_name=aeNNN_gso_511_ghf.tbl gso_152gd_fitlog_name=aeNNN_gso_152gd_ghf.tbl \
process_id=aeNNN
```

where
`input_name` is the HXD WEL FITS file input name
`hk_name` is the HXD HK FITS file list name
`gso_fitlog_name` is the name of the GSO fit log (ASCII output) – input of `hxdmkgainhist`
`gso_511_fitlog_name` is the HXD GSO 511keV fitlog file name (output file)
`gso_152gd_fitlog_name` is the HXD GSO 152 Gd fitlog file name (output file)
`process_id` is the identifier for the observation

The `hxdmkgainhist_pin` routine calculates the gain history for the HXD WELL_PIN. As noted above, for the the moment the routine simply creates an appropriately formatted output `pin_fitlog_name` file. Once the detector is better understood, this routine will be updated.

```
hxdmkgainhist_pin input_name=aeNNN_hxd_wel.uff \
hk_name=aeNNN\_hxd.hk pin_fitlog_name=aeNNN_pin_ghf.tbl process_id=aeNNN
```

where
`input_name` is the HXD WEL FITS file input name
`hk_name` is the HXD HK FITS file list name
`pin_fitlog_name` is the name of the PIN fit log (ASCII output) – input of `hxdmkgainhist`
`process_id` is the identifier for the observation

Once the gain drift for the two detector subsystems has been calculated, the `hxdmkgainhist` routine converts the output fitlog files created by the `hxdmkgainhist_gso` and `hxdmkgainhist_pin` routines into gain history FITS files.

```
hxdmkgainhist input_name= aeNNN_hxd_wel.uff\
```

```
pin_fitlog_name=aeNNN_pin_ghf.tbl gso_fitlog_name=aeNNN_gso_ghf.tbl \
pin_gainhist_name=CALDB/ae_hxd_pinghf_20051125.fits\
gso_gainhist_name=CALDB/ae_hxd_gsoghf_20051126.fits \
leapsec_name=leapsec.fits valid_date = MM-DD-YYYY valid_time=HH:MM:SS
```

where
`input_name` is the HXD WEL FITS file input name
`pin_fitlog_name` is the name of the log output of `hxdmkgainhist_pin`
`gso_fitlog_name` is the name of the log output of `hxdmkgainhist_gso`
`pin_gainhist_name` is the name of CALDB file containing the PIN gain history
`gso_gainhist_name` is the name of CALDB file containing the GSO gain history
`leapsec_name` is the name of the leap-seconds file located under the HEADAS ref area
`valid_date` is the date of validity as stored in the CALDB database
`valid_time` is the time of validity as stored in the CALDB database
Please note that the CALDB files provided will change over time. It is the responsibility of the user to check that the files that are used are indeed the latest in CALDB.

6.3.3 Pulse Height Corrections

Once the gain drift has been measured, the (time) invariant event pulse-heights (PI) values can be determined. For the HXD, `hxdpi` calculates the HXD PI columns (PIN[0-3]_PI, SLOW_PI, FAST_PI) based on the relevant _PHA data, the gain history and other calibration data, such as non-linearity in the analog-to-digital conversion. The Gd edge effect is not included in SLOW/FAST_PI. The effect is included in the response matrix table for the GSO.

```
hxdpi input_name=aeNNN_hxd_wel.uff\
create_name=hxd_picorr_evt.fits hklist_name=@hk_list.dat\
pin_gainhist_name=CALDB/ae_hxd_pinghf_20051125.fits\
gso_gainhist_name=CALDB/ae_hxd_gsoghf_20051126.fits\
hxdpinlin_fname=CALDB/ae_hxd_pinlin_20051011.fits\
hxdgsolin_fname=CALDB/ae_hxd_gsolin_20051125.fits
```

where
`input_name` is the HXD FITS file input name
`create_name` is the output file name
`hklist_name` is the HXD HK FITS file list name or input as @hk file list
`pin_gainhist_name` is the name of CALDB file containing the PIN gain history
`gso_gainhist_name` is the name of CALDB file containing the GSO gain history
`hxdpinlin_fname` is the name of CALDB file containing the PIN integrated non-linearity of ADC
`hxdgsolin_fname` is the name of CALDB file containing the GSO integrated non-linearity of ADC

6.3.4 Calculating Event Grade

HXD event files have 5 grade columns filled by the `hxdgrade` routine. The first column is simply GRADE_QUALTY which stores the data quality. All events with a GRADE_QUALTY flag not equal to 0 should be ignored. The two next columns indicate the origin of the event. The column GRADE_PMTTRG is set to 1 for any PMT triggered event while the column GRADE_PINTRG is set for 1 for any PIN triggered event. Column GRADE_PSDSEL gives the GSO likelihood in the Slow Fast diagram while the fifth column GRADE_HITPAT gives the hit pattern grade. (not sure of what it all means...)

```
 hxdgrade input_name=aeNNN_hxd_wel.uff  create_name=outputfile.fits \
hxdgrade_psdsel_fname=CALDB/ae_hxd_gsopsd_20051116.fits \
hxdgrade_pinthres_fname=CALDB/ae_hxd_pinthr_20050916.fits
```

where
`input_name` is the HXD FITS file input name
`create_name` is the output file name
`hxdgrade_psdsel_fname` is the name of CALDB file containing the GSO PSD selection criteria
`hxdgrade_pinthres_fname` is the name of CALDB file containing the PIN lower discriminator threshold

Please note that the CALDB files provided will change over time. It is the responsibility of the user to check that the files that are used are indeed the latest in CALDB.

6.4 WAM Processing

The HXD Wideband All-Sky Monitor (WAM) utilizes the BGO anti-coincidence detectors to create an all-sky monitor. Although from the same detector, these data are processed independently. There should be no need for the user to reprocess the data from the WAM (the HXD team will analyze the WAM data and make the results public) but we have included the description of the processing pipeline for completeness.

6.4.1 `hxdwamtime`

The `hxdwamtime` routine compute the HXD event arrival-time correction. The arrival time for events detected in the WAM is computed in a manner similar to the `hxdtime` routine, where the conversion to *Suzaku* time coordinate is done using one of four methods to be specified by the parameter "time_convert_mode".

```
 hxdwamtime input_name=aeNNN_hxd_wam.fff  create_name=aeNNN_hxd_wam.uff \
```

```
hklist_name=@hk_list.dat leapsec_name=leapsec.fits tim_filename=aeNNN.tim
```

where
`input_name` is the HXD WAM FITS file name to archive the time correction
`created_name` is the HXD WAM FITS output name
`hklist_name` is the HXD HK FITS file list name or input as @hk file list
`leapsec_name` is the name of the leap-seconds file located under the HEADAS ref area
`tim_filename` is the name of the TIM file.

6.4.2 hxdmkwamgainhist

This routine produces a gain history file for the WAM FITS, where gain-correction factor is given as a function of time. It is determined by fitting the data of the 511 keV line, much as the gain histogram is calculated for the HXD GSO from the Gd line. The fitting results are recorded in a log file. The gain history file will be used as input for `hxdwampi`.

```
hxdmkwamgainhist input_name=aeNNN_hxd_wam.uff trn_fitlog_name=aeNNN_hxd_wam_fit.log \
trn_gainhist_name=aeNNN_hxd_wamghf.fits  leapsec_name=leapsec.fits
```

where
`input_name` is the HXD WAM FITS file name
`trn_fitlog_name` is the name of the log (ASCII output)
`trn_gainhist_name` is the name of the gain history file (output) to be used as input for `hxdwampi`
`leapsec_name` is the name of the leap-seconds file located under the HEADAS ref area

6.4.3 hxdwampi

The `hxdwampi` routine calculates the time-invariant pulse-height value for each HXD WAM event, which is stored in the TRN_PI column. By default, the input file is used as the output, although this can be modified by setting the create_name parameter. The gain drift is not corrected in the current `hxdwampi`, but instead is considered in the response matrix. The task expands the reduced PH table via HXD-DE on-board process. The setting is identified by the column 'TRN_TBL_ID', which is defined in the caldb FITS file named "ae_hxd_wampht_YYYYMMDD.fits" (currently "ae_hxd_wampht_20050916.fits").

```
 hxdwampi input_name = aeNNN_hxd_wam.uff  hklist_name = @hk_list.dat\
 trn_bintbl_name =   CALDB/ae_hxd_wampht_20050916.fits \
trn_gainhist_name = aeNNN_hxd_wamghf.fits
```

where
`input_name` is the input HXD WAM file name
`hklist_name` is the HXD HK FITS file list name or input as @hk file list
`trn_bintbl_name` is the name of the CALDB file associated with the PH compression process
`trn_gainhist_name` is the file name of the gain history file output of hxdmkwamgainhist.

6.4.4 `hxdwamgrade`

This routine calculates the event grade for a WAM event, much as the `hxdgrade` tool does for a standard HXD event. As with the `hxdwampi` tool, by default the input event file is also used as the output file, simply modifying the QUALITY column.

```
hxdwamgrade input_name=aeNNN_hxd_wam.uff
```

where
`input_name` is the input HXD WAM file name

6.4.5 `hxdbsttime`

Fill the 'BST_FRZD_TM' keyword in the header of the BURST FITS.

```
hxdbsttime input_name=aeNNN_hxd_bst_0.fff create_name=aeNNN_hxd_bst_0.uff\
 hklist_name=@hk_list.dat  leapsec_name=leapsec.fits  tim_filename=aeNNN.tim
```

where
`input_name` is the HXD WAM FITS file name
`create_name` is the HXD WAM FITS output name
`hklist_name` is the HXD HK FITS file list name or input as @hk file list
`leapsec_name` is the name of the leap-seconds file located under the HEADAS ref area
`tim_filename` is the name of the TIM file.

6.4.6 Deadtime correction

For the moment there are no deadtime applied to the data.

6.5 Extracting Data

As described in Chapter 5, the primary tool for extracting data products (spectra, lightcurves, exposure maps) from HXD data is `xselect`. `xselect` can apply filters which select user-defined times, or particular event flags. It then uses the filtered events to create a (binned) spectrum (as well as generating the necessary calibration files), a lightcurve, or an exposure map. Some basic parameters to be used for common data screening are in the filter file. The "select mkf" command will be used to carry out filter file based data screening, by specifying boolean expression of the parameters and calculating corresponding Good Time Intervals (GTI). *Suzaku* GOF and instrument teams are currently working to determine recommended parameters and screening criteria.

6.5.1 Event Flag Selection

Note that "select event" creates new event files of the selected events, and the extract command afterwards will work on the new event files.

HXD event files have both GSO and PIN events. An X-ray event can hit only a single detector (either GSO, PIN0, PIN1, PIN2 or PIN3) in a single Well-unit at a time, and the the UNIT ID and DET TYPE columns tell the unit ID and detector type for each event. To carry out a spectral analysis, GSO and PIN events have to be separated (spectral responses are completely different), where these events might be combined to make a light curve. All the GSO sensors are considered to have almost identical characteristics, so are the PIN detectors. Therefore events from the 16 GSO sensors can be combined to make GSO spectra; the same for 64 PIN sensors to make PIN energy spectra. To select only GSO events: `select event ''DET_TYPE==0''`. Or, to select only PIN events: 2 hxdrti ftool will fill this column, but this may not happen in an early stage of the mission.

```
select event ''DET_TYPE==1||DET_TYPE==2||DET_TYPE==3||DET_TYPE==4''
```

Users should note that GSO and PIN event selections are exclusive. Therefore, when extracting GSO and PIN energy spectra from the same event file, one needs to clear the select buffer after the first selection. There is an integer GRADE column which tells legitimacy of the GSO events. For example, for spectral analysis, HXD team may provide standard GSO responses which are valid only for some limited GRADE values; only events which have such GRADE values have to be selected. On the other hand, for light curve analysis, GRADE selection criterion may be loosened.

Particular Well units may be chosen with the select event command, specifying UNITID to use (from 0 to 15). This can be combined with the detector selection (GSO, PIN0, 1, 2, 3 or 4) using DET ID, as explained in section 4.2.4. For example, `select event ''UNITID==0&&DET_TYPE==1''` will select only PIN0 events from UNITID=0. Although HXD is not an imaging instrument, xselect can create HXD pseudo-mages, which may have some use. For example, set image det will create a pseudo-image of UNITID vs. DET TYPE 5 . This "image" tells number of counts for each

Detector on each Unit at a glance. Users may choose particular Units and Detectors graphically on saoimage by the point selection. The HXD Sky and Raw images will be a diagonal pseudo-image of UNITID, which tells number of counts for each UNITID, regardless of the Detector type (either GSO, PIN0, 1, 2, or 3) 4 Click "cursor" and choose the "point" type selection on the left.

6.6 Extracting a calibrated spectrum

6.6.1 Response Generation

Currently only response files are available through CALDB. There are two files for the PIN (one for a nominal XIS pointing and one for an HXD nominal pointing) and two files for the GSO (for the same pointing conditions). Users are invited to check regularly for updates.

6.6.2 Background Generation

Background event files for both GSO and PIN have not been finalized. There are currently three models available and the instrument team is still discussing on whether releasing all models or wait to finalize the "best" of the three models. Here again, users are invited to check regularly for updates.

Appendix A

Acronyms

The following table lists acronyms used in this document.

Chapter	Acronym	Definition
	ADC	Analogue to Digital Converter
	ARF	Ancillary Response File
	ASCA	Advanced Satellite for Cosmology and Astrophysics
	ASCII	American Standard Code for Information Interchange
	ATOMDB	ATOMic DataBase
	BGO	Bismuth Germanate
	BI	Back-illuminated
	CALDB	CALibration DataBase
	CCD	Charge-Coupled Devices
	CIAO	Chandra Interactive Analysis of Observations
	Co-I	Co-investigator
	CXB	Cosmic X–ray Background
	DARTS	Data ARchive and Transmission System
	DEC	Declination
	DET	DETector (coordinates DETX and DETX)
	EEF	Encircled Energy Function
	FI	Front-illuminated
	FITS	Flexible Image Transport System
	FFF	First FITS Files
	FOC	FOCal plane (coordinates FOCX and FOCY)
	FTOOLS	FITS Tools
	FW	Filter Wheel (on XRS)
	FWHM	Full-Width at Half-Maximum
	GIF	Graphics Interchange Format
	GO	Guest Observer

Chapter	Acronym	Definition
	GOF	Guest Observer Facility
	GRB	Gamma-Ray Burst
	GSFC	Goddard Space Flight Center
	GSO	Gadolinium Silicate
	GTI	Good Time Interval
	HEA	High Energy Astrophysics
	HEASARC	High Energy Astrophysics Science Archive Research Center
	HK	House Keeping
	HPD	Half-Power Diameter
	HTML	HyperText Markup Language
	HXD	Hard X–Ray Detector
	ISAS	Institute of Space and Astronautical Science
	JAXA	Japan Aerospace Exploration Agency
	NRA	NASA Research Announcement
	NASA	National Aeronautics and Space Administration
	NXB	Non-X–ray Background
	OBF	Optical Blocking Filter
	OS	Operating System
	PDMP	Project Data Management Plan
	PHA	Pulse Height Amplitude
	PI	Principal Investigator
	PI	Pulse Invariant
	PIN	Positive Intrinsic Negative
	PMT	Photon Multiplier Tube
	QDE	Quantum Detection Efficiency
	RA	Right Ascension
	RDD	Residual Dark-current Distribution
	RMF	Redistribution Matrix File
	ROSAT	RÖntgen SATellite
	RPT	Raw Packet Telemetry
	RXTE	Rossi X–ray Timing Explorer
	SAA	South Atlantic Anomaly
	SAX	Satellite per Astronomia X
	S/C	Spacecraft
	SFF	Second FITS Files
	SIS	Solid-state Imaging Spectrometers
	SWG	Science Working Group
	TAI	Temps Atomique International
	TOO	Target Of Opportunity
	USC	Uchinoura Space Center
	UTC	Universal Time Coordinated

Chapter	Acronym	Definition
	WAM	Wideband All-sky Monitor
	WPU	Well Processing Unit
	XIS	X–Ray Imaging Spectrometer
	XMM	X–Ray Multi-Mirror Mission
	XRS	X–Ray Spectrometer
	XRT	X–Ray Telescope
	XRT-I	X–Ray Telescope for one of the four XIS detectors
	XRT-S	X–Ray Telescope for the XRS detector

Appendix B

Important Web/e-mail/postal addresses

Primary Suzaku Sites

Japan: http://www.astro.isas.jaxa.jp/suzaku/
http://darts.isas.jaxa.jp/

US : http://suzaku.gsfc.nasa.gov/
ESA: http://www.rssd.esa.int/Astro-E2/

Questions:

The US GOF can be reached using the web form available at
http://suzaku.gsfc.nasa.gov/docs/suzaku/astroe_helpdesk.html

Tools:

Viewing	http://heasarc.gsfc.nasa.gov/Tools/Viewing.html
PIMMS	http://heasarc.gsfc.nasa.gov/docs/software/tools/pimms.html
MAKI	http://heasarc.gsfc.nasa.gov/Tools/maki/maki.html
XSPEC	http://heasarc.gsfc.nasa.gov/docs/xanadu/xspec/index.html
WebPIMMS	http://heasarc.gsfc.nasa.gov/Tools/w3pimms.html
WebSPEC	http://heasarc.gsfc.nasa.gov/webspec/webspec.html