User's Guide to ROSAT Data in the Rationalized Data Format (RDF)

M.F. Corcoran, M. Conroy

US ROSAT Guest Observer Facility

November 1994

Table of Contents

I. Introduction

The magnetic tape you receive with your data products has on it data files containing information pertinent to your ROSAT observation. The files on this data tape use the FITS (Flexible Image Transport System) format and its extensions as described in NASA/OSSA Office of Standards and Technology (NOST) draft 100–0.3b, *"Implementation of the Flexible Image Transport System."* Starting in the Spring of 1994, the data files distributed on tape by the USRSDC and by MPE will conform to the Rationalized Data Format (**RDF**) as specified by the High Energy Astrophysics Science Archive Research Center (HEASARC) and the Center for Astrophysics (CfA). This represents a major change in the organization of the FITS files as compared to the previous FITS formats distributed prior to Spring 1994. This change was made in order to present ROSAT data in a more user–friendly, multi–mission context. In RDF,

- important tabulated quantities are more easily identified by the user through use of more descriptive column names;
- primary headers and extension headers contain more useful information;
- COMMENT and HISTORY cards are extensively used to provide the user with detailed information about the files.

Because both MPE and the USRSDC have adopted RDF, the format of the ROSAT data products will be independent of where the data were processed; thus users of ROSAT data processed at MPE will easily be able to interpret and use ROSAT datasets processed in the US, and vice–versa. In addition, RDF is being adopted by numerous other mission (EINSTEIN, ASCA and XTE, to name a few) which means that software which can interpret and analyze ROSAT data should be able to interpret and analyze data from these and other missions.

II. The data tape

II.a. Brief description of the FITS files

The files distributed on the data tape adhere to the FITS standard as described in the NASA/OSSA Office of Standards and Technology (NOST) draft 100–0.3b, *"Implementation of the Flexible Image Transport System (FITS),"* dated November 6, 1991. The ROSAT files use FITS primary images and FITS IMAGE extensions and ASCII and BINARY table extensions, although most data (apart from images) are stored in BINARY table (BINTABLE) extensions. Data contained in these files can be accessed using standard FITS readers, as provided by IRAF or IDL, or through use of the FITSIO package available from the HEASARC.

II.b. Reading the tape using PROS

After receiving the data tape, the user should copy the files on the tape to disk for analysis. The FITS files on the tape can be read to disk using any FITS tape reader you choose. The IRAF/PROS environment offers a particularly easy way to download the data tape to disk through use of the `t2d` command under the `dataio` package. The `t2d` routine lets the user select the number of files to download, and to specify an output file root name. Each file as it is read off the disk will be named <`root-name`>`nnn`, where `nnn` is a 3–digit number giving the position of the file on the tape (the first file on the tape is 001, the second 002, etc.) For example, if files 1–12 are downloaded using `t2d` with `rosat` as the root name, `t2d` would write files named `rosat001, rosat002,..., rosat012` to disk. The PROS task `rfits2pros` in the `xray.xdatio` package can then be used to rename and reformat the files dumped by `t2d` to the standard IRAF/PROS format. See the PROS User's Guide for more information.

II.c. List of Files: PSPC

The first file on the PSPC data tape is a FITS file containing a primary header with NULL primary array, and one ASCII table extension consisting of a header followed by an ASCII table. The ASCII table contains the list of the data files as they appear on the tape, in the order in which they appear, with a one–line description of the contents of each of the files. This file can be read using any standard FITS reader which can handle ASCII table extensions (XTENSION= 'TABLE '). In addition, once on disk, the file contents can be displayed and read using standard operating system commands (`cat` or `more` in UNIX or `type` in VMS).

A dump of the contents of this file for the PSPC sequence 110590n00 (a PV phase observation of AR Lac) is below.

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / number of bits per data pixel
```

```
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
CONTENT = 'TAPE    '           / TAPE CONTENTS
FILENAME= 'rp110590n00_tap.fits' / Suggested file name
IRAFNAME= 'null_image'   / IRAF file name
DATE    = '04/11/94'     / Date of creation of this file (DD/MM/YY)
HISTORY
HISTORY   This is the tape contents description file.
HISTORY
HISTORY   This file has been structured as an ASCII table
HISTORY   whose rows contain 80 columns of data to allow it
HISTORY   to be read by either a FITS reader or by a simple program.
HISTORY   There are no carriage returns or line feeds.
HISTORY   The file can be treated as consisting of 80-byte
HISTORY   fixed records.
HISTORY
HISTORY   The ASCII table entries give the file number on the
HISTORY   tape (files are separated by single tape marks), the
HISTORY   suggested name of the file (its ROSAT name) and a description
HISTORY   of the data contained as extensions in the FITS file.
HISTORY
HISTORY   General information for this tape:
HISTORY   ROSAT FITS data
HISTORY   ROSAT Title: XRT/PSPC PSF AR LAC
HISTORY   PI: MPE, ROSAT-TEAM
HISTORY   ROSAT FITS Name: RP110590N00
HISTORY
END

XTENSION= 'TABLE   '           / ASCII table extension
BITPIX  =                    8 / 8-bit ASCII characters
NAXIS   =                    2 / 2-dimensional ASCII table
NAXIS1  =                   80/ width of table in characters
NAXIS2  =                   32/ number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required)
TFIELDS =                    1 / number of fields in each row
TTYPE1  = 'RECORD  '           / Simple 80-byte ASCII record
TBCOL1  =                    1 / beginning column of field  1
TFORM1  = 'A80     '           / Fortran-77 format of field
TUNIT1  = 'NONE    '           / physical unit of field
EXTNAME = 'TAP.trl '           / A ROSAT Tape Description file
INSTRUME= 'PSPC    '           / Instrument name
IRAFNAME= 'rp110590n00_tap.lst' / IRAF file name
HISTORY
HISTORY   The FITS files were created in directory
HISTORY   F$RDFOP_8:[CA110590P_N9_P1_F2.P2]
```

```
HISTORY   and copied to tape.
HISTORY
END

FILE_NUMBER   1, FILENAME = rp110590n00_tap.fits
This file contains a description of the tape files
FILE_NUMBER   2, FILENAME = rp110590n00_bas.fits
This file contains the PSPC basic science data (events & good times)
FILE_NUMBER   3, FILENAME = rp110590n00_im1.fits
This file contains the PSPC total-band image
FILE_NUMBER   4, FILENAME = rp110590n00_im2.fits
This file contains the PSPC hard-band image
FILE_NUMBER   5, FILENAME = rp110590n00_im3.fits
This file contains the PSPC soft-band image
FILE_NUMBER   6, FILENAME = rp110590n00_bk1.fits
This file contains the PSPC total-band background
FILE_NUMBER   7, FILENAME = rp110590n00_bk2.fits
This file contains the PSPC hard-band background
FILE_NUMBER   8, FILENAME = rp110590n00_bk3.fits
This file contains the PSPC soft-band background
FILE_NUMBER   9, FILENAME = rp110590n00_mex.fits
This file contains the PSPC merged exposure map
FILE_NUMBER  10, FILENAME = rp110590n00_ime.fits
This file contains the PSPC energy-coded image
FILE_NUMBER  11, FILENAME = rp110590n00_src.fits
This file contains the PSPC source extraction information
FILE_NUMBER  12, FILENAME = rp110590n00_anc.fits
This file contains the PSPC spacecraft ephemeris, aspect & ancillary data
FILE_NUMBER  13, FILENAME = rp110590n00_his.fits
This file contains the PSPC processing parameter and log files
FILE_NUMBER  14, FILENAME = rp110590n00_prt.fits
This file contains the PSPC PostScript and list files
FILE_NUMBER  15, FILENAME = rp110590n00_raw.fits
This file contains the PSPC uncorrected event coordinates
FILE_NUMBER  16, FILENAME = rp110590n00_ltc.fits
This file contains the PSPC source lightcurve information
```

II.d. List of Files: HRI

The first file on the HRI data tape is a FITS file containing a primary header with NULL primary array, and one ASCII table extension consisting of a header followed by an ASCII table. The ASCII table contains the list of the data files as they appear on the tape, in the order in which they appear, with a one–line description of the contents of each of the files. This file can be read using any standard FITS reader which can handle ASCII table extensions (XTENSION= 'TABLE '). In addition, once on disk, the file contents can be displayed and read using standard operating system commands (`cat` or `more` in UNIX or `type` in VMS).

A dump of the contents of this file for the HRI sequence 110267n00 (a PV phase observation of AR Lac) is below.

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
CONTENT = 'TAPE    '           / TAPE CONTENTS
FILENAME= 'rh110267n00_tap.fits' / Suggested file name
IRAFNAME= 'null_image'   / IRAF file name
DATE    = '04/11/94'     / Date of creation of this file (DD/MM/YY)
HISTORY
HISTORY   This is the tape contents description file.
HISTORY
HISTORY   This file has been structured as an ASCII table
HISTORY   whose rows contain 80 columns of data to allow it
HISTORY   to be read by either a FITS reader or by a simple program.
HISTORY   There are no carriage returns or line feeds.
HISTORY   The file can be treated as consisting of 80-byte
HISTORY   fixed records.
HISTORY
HISTORY   The ASCII table entries give the file number on the
HISTORY   tape (files are separated by single tape marks), the
HISTORY   suggested name of the file (its ROSAT name) and a description
HISTORY   of the data contained as extensions in the FITS file.
HISTORY
HISTORY   General information for this tape:
HISTORY   ROSAT FITS data
HISTORY   ROSAT Title: XRT/HRI PSF AR LAC
HISTORY   PI: MPE, ROSAT-TEAM
HISTORY   ROSAT FITS Name: RH110267N00
HISTORY
END

XTENSION= 'TABLE   '           / ASCII table extension
BITPIX  =                    8 / 8-bit ASCII characters
NAXIS   =                    2 / 2-dimensional ASCII table
NAXIS1  =                   80/ width of table in characters
NAXIS2  =                   16/ number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required)
TFIELDS =                    1 / number of fields in each row
TTYPE1  = 'RECORD  '           / Simple 80-byte ASCII record
TBCOL1  =                    1 / beginning column of field  1
TFORM1  = 'A80     '           / Fortran-77 format of field
```

```
TUNIT1   = 'NONE   '       / physical unit of field
EXTNAME  = 'TAP.trl '      / A ROSAT Tape Description file
INSTRUME= 'HRI    '        / Instrument name
IRAFNAME= 'rh110267n00_tap.lst' / IRAF file name
HISTORY
HISTORY   The FITS files were created in directory
HISTORY   F$RDFOP_8:[CA110267H_N9_P1_F2.P2]
HISTORY   and copied to tape.
HISTORY
END
```

```
FILE_NUMBER   1, FILENAME = rh110267n00_tap.fits
This file contains a description of the tape files
FILE_NUMBER   2, FILENAME = rh110267n00_bas.fits
This file contains the HRI basic science data (events and good times)
FILE_NUMBER   3, FILENAME = rh110267n00_im1.fits
This file contains the HRI image
FILE_NUMBER   4, FILENAME = rh110267n00_bk1.fits
This file contains the HRI background image
FILE_NUMBER   5, FILENAME = rh110267n00_src.fits
This file contains the HRI source extraction information
FILE_NUMBER   6, FILENAME = rh110267n00_anc.fits
This file contains the HRI spacecraft ephemeris, aspect & ancillary data
FILE_NUMBER   7, FILENAME = rh110267n00_his.fits
This file contains the HRI processing parameter and log files
FILE_NUMBER   8, FILENAME = rh110267n00_prt.fits
This file contains the HRI PostScript and list files
```

III. The PSPC fileset

This section gives more detailed information concerning the structure of the data files for PSPC data distributed in RDF.

III.a. The BASIC file

Each data set contains a 'BASIC' file, which contains the 'bare–bones', calibrated science data. This is the essential information which anyone needs to know to perform standard scientific analyses. The BASIC file can be identified by its official name, which ends in **_bas.fits**. Basic data generally consist of times which define the length of the observation, and the photon event list which gives (for the PSPC) time of arrival, sky position, detector position, and raw and corrected amplitudes for each photon. Status histories which can be used to filter the data are also given.

For PSPC data, the BASIC file consists of a NULL primary array and the following binary table (XTENSION= 'BINTABLE') extensions.

III.a.1 The standard good time intervals extension

EXTNAME = 'STDGTI '
This extension gives the time intervals which the standard analysis software system (SASS) has deemed to contain good science time as defined by the standard screening criteria (see below), and the corresponding observation interval (OBI) number.

III.a.2 The STANDARD events list extension

EXTNAME = 'STDEVT '
This extension contains the list of photons which have passed the standard screening. For each detected photon, the list contains x, y position, arrival time, pulse height, gain corrected pulse height, and linearized detector coordinates. For each photon a status is given designating whether that photon passed or failed the standard screening. By definition all photons in the standard events list passed standard screening.

III.a.3 The REJECTED events list extension

EXTNAME = 'REJEVT '
This extension contains the list of photons which were rejected by the standard screening. For each detected photon, the list contains x, y position, arrival time, pulse height, gain corrected pulse height, and linearized detector coordinates. For each photon a status is given designating whether that photon passed or failed the standard screening. By definition all photons in the rejected events list failed standard screening.

III.a.4 Temporal Status History extension

EXTNAME = 'TSI '
This table lists the quality flags as a function of time. The quality flags consist of PASSFAILS and LOGICALS. PASSFAILS indicate why data were rejected at a given time. LOGICALS indicate the status of various spacecraft subsystems. PASSFAILS and LOGICALS are bit-encoded. The description of the coding used to define both PASSFAILS and LOGICALS is described in the extension header.

III.a.5 Quality Limits extension

EXTNAME = 'STDQLM '
This table gives the allowable values of the quality flags.

III.a.6 All Quality Limits extension

EXTNAME = 'ALLQLM '
This table gives the quality limits for accepting the data as part of the observation, regardless of whether the data are scientifically useful. These limits are used in determining the entire set of photons (accepted + rejected events) detected during the observation.

III.b. The ANCILLARY file

Each PSPC data set distributed in RDF contains a file of ANCILLARY data. The ANCILLARY file can be identified by its official name, which ends in `_anc.fits`. The data provided in the ANCILLARY file, while not essential for scientific analysis of the BASIC data, is often very useful if more detailed analyses are required. Ancillary data include orbit and spacecraft pointing information, and other engineering or housekeeping information.

For PSPC data, the ANCILLARY file consists of a NULL primary array and the following binary table (XTENSION= 'BINTABLE') extensions.

III.b.1 The observation summary extension

EXTNAME = 'OBSTABLE'
This extension gives a summary of information describing the observation. This includes start and stop times of the observation intervals, pointing directions and roll angles, boresights and the aspect delay used throughout the observation.

III.b.2 The spacecraft ephemeris extension

EXTNAME = 'EPHEM '
This extension gives information about the orbital ephemeris of the spacecraft as a function of time. It includes the satellite position vector, satellite longitude, latitude and altitude.

III.b.3 The spacecraft pointing extension

EXTNAME = 'ASPECT '
This extension gives information about the pointing of the spacecraft as a function of time. It includes spacecraft right ascension, declination and roll.

III.b.4 The Housekeeping extension

EXTNAME = 'HKP '
This extension lists values of engineering and other housekeeping data as a function of time. For the PSPC, the instrument in use flag, the detector temperature, pressure, high voltage, the missing housekeeping flag, and the filter type are given.

III.b.5 The Event Rate extension

EXTNAME = 'EVRATE '
This table lists rates of detected events as a function of time. Accepted or rejected event rates, South Atlantic Anomaly (SAA) rates, Master Veto Rate (MV_ACO), and other quantities are given.

III.b.6 The Housekeeping Status extension

EXTNAME = 'HKSTA '
This table records the values of the status of the housekeeping parameters such as the high voltage status, the carrousel status, the detector status, etc. These values are also available in the temporal status history TSI extension. They are given here for compatibility with the EXSAS software package. The TSI records contain statuses that have been collected from several sources and reduced to summary records, to show the status only when something has changed. The HKSTA records, on the other hand, are stored at fixed read–out intervals defined by the ROSAT telemetry, usually on the order of a few seconds.

III.b.7 The Guide Star extension

EXTNAME = 'GSTAR '
This table gives a list of the catalog numbers of the guide stars used to derive the aspect solution as a function of spacecraft time. The actual catalog numbers are of no real importance; what is important is the number of non–zero catalog numbers listed for each time interval in the table, since this tells the user how many guide stars went into solving aspect. In general, there should be no aspect problems if 3 or more guide stars were found.

III.c. Images

Images are stored as 512 x 512 primary arrays in separate FITS files. All images use the convention in which (1,1) is the CENTER of the pixel in the LOWER left corner (*i.e.*, the eastern-most/southern-most pixel). Derived images include both total (source + background) and background images.

There are 8 PSPC image files included as part of the standard processing – source images in 3 energy bands (total, hard, and soft), background images in 3 bands, the broad–band exposure map, and the energy encoded color map. The images are a compression of the focal plane scale by a factor of 30 (*i.e.*, each pixel has a dimension of 15 x 15 arcseconds, rather than the 0.5 x 0.5 arcsecond pixels used in the STDEVT and REJEVT tables). The header keywords PIMIN, PIMAX give the PI values used to filter the images.

III.c.1 The TOTAL–BAND image file

FILENAME: r*_im1.fits
This file contains as the 512 x 512 primary array the X–ray image derived from all accepted photons in the total energy range. The file also contains 2 binary table extensions, the first of which gives the source detections from the local detect algorithm in the broad band, the second of which gives the broad–band source detections from the map detect algorithm.

III.c.2 The TOTAL–BAND background file

FILENAME: r*_bk1.fits
This file contains the broad–band background map as a 512 x 512 primary array. This background image was constructed from the TOTAL–BAND image file after removal of detected X–ray sources.

III.c.3 The MERGED exposure map file

FILENAME: r*_mex.fits
This file contains the exposure map as a 512 x 512 primary array. This map was created by casting the TOTAL–BAND instrument map in sky coordinates using the information in the aspect histogram and represents the amount of exposure each area of the field of view received taking into account vignetting and the spacecraft wobble. The MERGED exposure map can be used to flat–field the TOTAL–BAND image and background.

III.c.4 The HARD–BAND image file

FILENAME: r*_im2.fits
This file contains as the 512 x 512 primary array the X–ray image derived from all accepted photons in the hard energy band. The file also contains 2 binary table extensions, the first of which gives the source detections from the local detect algorithm in the hard band, the second of which gives the hard–band source detections from the map detect algorithm.

III.c.5 The HARD–BAND background file

FILENAME: r*_bk2.fits
This file contains the hard–band background map as a 512 x 512 primary array. This background file was constructed from the HARD–BAND image file after removal of detected X–ray sources.

III.c.6 The SOFT–BAND image file

FILENAME: r*_im3.fits
This file contains as the 512 x 512 primary array the X–ray image derived from all accepted photons in the soft energy band. The file also contains 2 binary table extensions, the first of which gives the source detections from the local detect algorithm in the soft band, the second of which gives the soft–band source detections from the map detect algorithm.

III.c.7 The SOFT–BAND background file

FILENAME: r*_bk3.fits
This file contains the soft–band background map as a 512 x 512 primary array. This background file was constructed from the SOFT–BAND image file after removal of detected X–ray sources.

III.c.8 The ENERGY–CODED image

FILENAME: r*_ime.fits
This file contains the energy–coded image as a 512 x 512 array. Each pixel in the image represents the mean photon energy detected (and not intensity as in the other images).

III.d. The SOURCE file

The SOURCE file contains information about sources in the field of view of the detector. It can be identified by its official name, which ends in `_src.fits`. This file contains the following binary table (BINTABLE) extensions:

III.d.1 The DETECTED X–RAY source extension

EXTNAME = 'SRCTBL '
This table contains information about sources in the field of view as detected by the standard processing system. Positions, counting rates, variability flags, hardness ratios, etc. are included.

III.d.2 The SIMBAD source list

EXTNAME = 'SKYTBL '
This table contains information derived from the SIMBAD (Set of Identifications, Measurements, and Bibliographies for Astronomical Data) database about all catalogued sources in the field of view of the detector. (The SIMBAD database is operated at CDS, Strasbourg, France.) Positions, names, spectral type or morphology, V and B magnitudes are among the information provided.

III.d.3 The SPECTRAL FIT results table

EXTNAME = 'FITSS '
This table contains the results of fitting of bright sources with standard spectral models (absorbed power laws or thermal models). Source and background position, brightness, and the spectral fit values are provided. Note that this information will not be provided if there are no sources bright enough for the spectral fitting package (at present, spectral fitting is only done for sources with greater than 200 net counts and a likelihood greater than 50).

III.d.4 The source VARIABILITY table

EXTNAME = 'VARY '
This table contains the results of the standard source variability analysis. Variability tests include χ^2, Kolmogorov-Smirnov (KS), and Fast Fourier Transform (FFT). These tests are performed on all sources with a likelihood greater than 50; if no such sources appear in the field of view the variability information will not be provided.

III.d.5 The BACKGROUND SPECTRUM table

EXTNAME = 'BKGSPC '
This table contains the background spectrum (counts per channel) over the whole field of view as defined by SASS after removal of detected sources.

III.d.6 The BACKGROUND LIGHTCURVE table

EXTNAME = 'BKGRTE '
This table contains the background lightcurve (rate plus error vs. time) over the whole field of view as defined by SASS after removal of detected sources.

III.d.7 Extracted source spectra/Off–axis histograms

Spectra (rates versus channel plus other information) extracted by SASS for each source with a likelihood greater than 50 and more than 200 net counts are provided in individual binary table extensions at the end of the SOURCE file (one extension per source). Each spectrum extension is designated by an EXTNAME of the form `EXTNAME = 'SPnnn '` where `nnn` is a three–digit number corresponding to the source ID number given in the MPLSX source lists and recorded in the SRCTBL extension.

Each extracted source spectrum has associated with it an extension which gives the off–axis histogram (fraction of time versus off–axis angle). Each off–axis histogram can be identified by the EXTNAME of the form `EXTNAME = 'OAHnnn '` where `nnn` is the three–digit number corresponding to the source ID number given in the MPLSX source lists and recorded in the SRCTBL extension.

III.e. *The PRINT file*

This file can be identified by its official name, which ends in `_prt.fits`. It contains various source lists and PostScript plots and images which the analysis software produces as individual FITS extensions. These extensions can be converted to ascii text files and printed or displayed to a terminal.

III.f. *The HISTORY file*

This file can be identified by its official name, which ends in `_his.fits`. It contains the processing log and parameter files generated/used by SASS during sequence (SEQ) and OBI processing as 80 ASCII characters per row binary table extensions. These extensions provide some documentation of the SASS processing setup. However, the information contained in these extensions is fairly cryptic; interpretation of this information generally requires at least some familiarity with the SASS processing system.

III.g. *The RAW EVENTS file*

This file can be identified by its official name, which ends in `_raw.fits`. It contains position, time of arrival and energy information for each photon before any corrections are applied. The file consists of a NULL primary array and one BINTABLE extension.

III.g.1 *The Uncorrected Events Table*

EXTNAME = 'RAWCOORD '
This extension contains the list of all photons before any screening is done and before any corrections are applied. For each photon, time of arrival, uncorrected detector positions, and uncorrected pulse heights are given in the table.

III.h. The SOURCE LIGHTCURVE file

This file was added to the PSPC fileset starting with RDF version 3.0 in November 1994, and can be identified by its official name, which ends in `_ltc.fits`. It contains the light-curves for all sources for which lightcurves have been extracted by the processing system. The file contains the **STDGTI** extension (which defines the accepted times used for the lightcurve extraction) and the lightcurve extensions, one extension per source. Each extension is named **LCnnnn**, where **nnnn** is the number of the source from the MPLSX list (=MPLSX_ID), padded with leading zeros if necessary.

IV. The HRI fileset

This section gives more detailed information concerning the structure of the data files for HRI data distributed in RDF.

IV.a. The BASIC file

Each data set contains a 'BASIC' file, which contains the 'bare–bones', calibrated science data. This is the essential information which anyone needs to know to perform standard scientific analyses. The BASIC file can be identified by its official name, which ends in `_bas.fits`. Basic data generally consist of times which define the length of the observation, and the photon event list which gives (for the HRI) time of arrival, sky position, raw (uncorrected) detector position, and raw amplitudes for each photon. Status histories which can be used to filter the data are also given.

For HRI data, the BASIC file consists of a NULL primary array and the following binary table (XTENSION= 'BINTABLE') extensions.

IV.a.1 The standard good time intervals extension

EXTNAME = 'STDGTI '
This extension gives the time intervals which the standard analysis software system (SASS) has deemed to contain good science time as defined by the standard screening criteria (see below), and the corresponding observation interval (OBI) number.

IV.a.2 The STANDARD events list extension

EXTNAME = 'STDEVT '
This extension contains the list of photons which have passed the standard screening. For each detected photon, the list contains x, y position, arrival time, pulse height, and raw (uncorrected) detector coordinates. For each photon a status is given designating whether that photon passed or failed the standard screening. By definition all photons in the standard events list passed standard screening.

IV.a.3 The REJECTED events list extension

EXTNAME = 'REJEVT '
This extension contains the list of photons which were rejected by the standard screening. For each detected photon, the list contains x, y position, arrival time, pulse height, and raw (uncorrected) detector coordinates. For each photon a status is given designating whether that photon passed or failed the standard screening. By definition all photons in the rejected events list failed standard screening. For HRI data, the STDEVT and REJEVT event lists can be merged, in which case the STATUS word then clearly defines the origin of each event–record in the new file. Also, the ALLQLM and TSI extensions described below can

then be used to redefine the screening parameters and allow recovery of some or all of the events rejected by standard processing.

IV.a.4 Temporal Status History extension

EXTNAME = 'TSI '
This table lists the quality flags as a function of time. The quality flags consist of PASSFAILS and LOGICALS. PASSFAILS indicate why data were rejected at a given time. LOGICALS indicate the status of various spacecraft subsystems. PASSFAILS and LOGICALS are bit-encoded. The description of the coding used to define both PASSFAILS and LOGICALS is described in the extension header.

IV.a.5 Quality Limits extension

EXTNAME = 'STDQLM '
This table gives the allowable values of the quality flags. For the HRI these values are actual minimum and maximum values within which the quality flags must fall.

IV.a.6 All Quality Limits extension

EXTNAME = 'ALLQLM '
This table gives the quality limits for accepting the data as part of the observation, regardless of whether the data are scientifically useful. These limits are used in determining the entire set of photons (accepted + rejected events) detected during the observation.

IV.b. The ANCILLARY file

Each HRI data set distributed in RDF contains a file of ANCILLARY data. The ANCILLARY file can be identified by its official name, which ends in `_anc.fits`. The data provided in the ANCILLARY file, while not essential for scientific analysis of the BASIC data, is often very useful if more detailed analyses are required. Ancillary data include orbit and spacecraft pointing information, and other engineering or housekeeping information.

For HRI data, the ANCILLARY file consists of a NULL primary array and the following binary table (XTENSION= 'BINTABLE') extensions.

IV.b.1 The observation summary extension

EXTNAME = 'OBSTABLE'
This extension gives a summary of information describing the observation. This includes start and stop times of the observation intervals, pointing directions and roll angles, boresights and the aspect delay used throughout the observation.

IV.b.2 *The spacecraft ephemeris extension*

EXTNAME = 'EPHEM '
This extension gives information about the orbital ephemeris of the spacecraft as a function of time. It includes the satellite position vector, satellite longitude, latitude and altitude.

IV.b.3 *The spacecraft pointing extension*

EXTNAME = 'ASPECT '
This extension gives information about the pointing of the spacecraft as a function of time. It includes spacecraft right ascension, declination and roll.

IV.b.4 *The Housekeeping extension*

EXTNAME = 'HKP '
This extension lists values of engineering and other housekeeping data as a function of time. For the HRI, 3 detector temperatures are given.

IV.b.5 *The Event Rate extension*

EXTNAME = 'EVRATE '
This table lists rates of detected events as a function of time. Primary and secondary science rates, background levels, and SAA rates are among the tabulated quantities.

IV.b.6 *The Guide Star extension*

EXTNAME = 'GSTAR '
This table gives a list of the catalog numbers of the guide stars used to derive the aspect solution as a function of spacecraft time. The actual catalog numbers are of no real importance; what is important is the number of non–zero catalog numbers listed for each time in the table, since this tells the user how many guide stars went into solving aspect. In general, there should be no aspect problems if 3 or more guide stars were found.

IV.c. *Images*

Images are stored as 512 x 512 primary arrays in separate FITS files. All images use the convention in which (1,1) is the CENTER of the pixel in the LOWER left corner (*i.e.*, the eastern-most/southern-most pixel). Derived images include both total (source + background) and background images.

There are 2 HRI image files included as part of the standard processing – one total image and one derived background image. The images use a compression of the scale by a factor of 16 (*i.e.*, each pixel has a dimension of 8 x 8 arcseconds, rather than the 0.5 x 0.5 arcsecond pixels used in the STDEVT and REJEVT tables). Compression of the focal plane scale saves an enormous amount of space for an image containing the entire HRI field of view. However, given the intrinsic spatial resolution of the HRI (which is a few arc-seconds) compression by a factor of 16 is somewhat unsatisfactory and may result in the loss of information. Detailed analysis of the HRI usually requires the user to create an image of a sub–region of the HRI field of view at a smaller compression factor.

IV.c.1 The TOTAL image file

FILENAME: rh*_im1.fits
This file contains the total image constructed from all photons which passed the standard screening as a 512 x 512 primary array.

IV.c.2 The TOTAL background image file

FILENAME: rh*_bkg.fits
This file contains the total background image constructed from the TOTAL image after removal of detected X–ray sources as a 512 x 512 primary array.

IV.d. The SOURCE file

The SOURCE file contains information about sources in the field of view of the detector. It can be identified by its official name, which ends in **_src.fits**. This file contains the following binary table (BINTABLE) extensions:

IV.d.1 The detected X–RAY source extension

EXTNAME = 'SRCTBL '
This table contains information about sources in the field of view as detected by the standard processing system. Positions, counting rates, variability flags, etc. are included.

IV.d.2 The SIMBAD source list

EXTNAME = 'SKYTBL '
This table contains information derived from the SIMBAD (Set of Identifications, Measurements, and Bibliographies for Astronomical Data) database about all catalogued sources in the field of view of the detector. (The SIMBAD database is operated at CDS, Strasbourg, France.) Positions, names, spectral type or morphology, V and B magnitudes are among the information provided.

IV.e. The PRINT file

This file can be identified by its official name, which ends in **_prt.fits**. It contains various source lists and PostScript plots and images which the analysis software produces as individual FITS extensions. These extensions can be converted to ascii text files and printed or displayed to a terminal.

IV.f. The HISTORY file

This file can be identified by its official name, which ends in `_his.fits`. It contains the processing log and parameter files generated/used by SASS during sequence (SEQ) and OBI processing as 80 ASCII characters per row binary table extensions. These extensions provide some documentation of the SASS processing setup. However, the information contained in these extensions is fairly cryptic; interpretation of this information generally requires at least some familiarity with the SASS processing system.