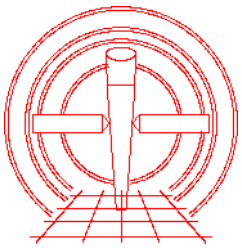
AXAF Science Center



ACIS Data Products:
Level 1 to ASC Archive Interface Control Document

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07/02/98	1.2	4	KJG, DMcE comments; per-SR processing paradigm

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LIST OF UNDETERMINED ITEMS

1.0 Introduction

This document describes the interface to be employed in transferring the products of ACIS Standard Data Processing from the ASC Level 1 processing pipeline to the ASC Data Archive, according to the requirements stipulated in Applicable Documents 5 and 7.

1.1 Purpose

ACIS Level 1 processing, described in Applicable Documents 6 and 12, consists of standard event processing (bias subtraction [if nec.], event grading, pulse height summation, gain and CTI correction, coordinate transformations, event attribute flagging). This document describes the structure and content of the resulting Event files and (optional) Bias Map files. In addition, it describes the structure and content of Exposure Statistics, Bad Pixel List, Spatial Mask, and Summary files that are generated from Level 0 products during Level 1 processing.

1.2 Scope

This interface shall apply to all ACIS-specific data products that are generated by ASC Level 1 pipelines and distributed to the ASC Data Archive (see Applicable Documents 5 and 6) during the course of the AXAF mission.

1.3 Applicable Documents

	Document	Description
1	MIT 36-01103 Rev. J	ACIS Flight Software Requirements Specification http://acis.mit.edu/sreqj/
2	MIT 36-53226 Rev. A	ACIS Flight Software Detailed Design Specification
3	MIT 36-53204 Rev. K	ACIS Instrument Procedures and Command Language http://acis.mit.edu/ipcl/
4	...	ACIS Level 0 to Archive Interface Control Document http://space.mit.edu/ASC/docs/
5	...	ASC Data Products Guide http://head-cfa.harvard.edu/~jcm
6	ASC AMO-2400 (SE03)	ASC Data System Requirements (ASC.302.93.0008)
7	ASC AMO-2401 (DS01)	ASC Data System Software Design (ASC.500.93.0006)
8	...	Definition of the Flexible Image Transport System (FITS) http://www.gsfc.nasa.gov/astro/fits/documents.html
9	...	HEASARC FITS Standards: http://legacy.gsfc.nasa.gov/docs/heasarc/ofwg/docs/summary/ogip_93_001_summary.html
10	ASC-FITS-1.0	ASC FITS File Designer's Guide http://hea-www.harvard.edu/~arots/asc/fits/ascfits.ps
11	...	AXAF Coordinate Systems http://head-cfa.harvard.edu/~jcm
12	...	ASC Science Data Systems Toolbook

1.4 Functional Description

1.4.1 Data Content Summary

All ACIS data sets generated by the Level 1 processing pipeline shall conform to the FITS format (Applicable Document 8), including relevant HEASARC and ASC standards (Applicable Documents 9 and 10, respectively). These files contain header keyword entries and binary table (BINTABLE) extensions (except for bias files, which contain binary image arrays).

1.4.2 Source and Transfer Method

ACIS Level 1 products shall be created by the ACIS Level 1 Pipeline. An overview of this pipeline is provided in Applicable Document 6; detailed descriptions of the ACIS Level 1 Pipeline tools are provided in Applicable Document 12.

1.4.3 Recipients and Utilization

The primary recipients of ACIS Level 1 data products, via distribution from the archive, are AXAF observers, who will utilize these data products for scientific data analysis. The ASC may also make use of specific Level 1 data products for instrument calibration, instrument and/or spacecraft monitoring and trends analysis, and validation and verification of the Level 0 and Level 1 software and of the data products themselves. Level 1 data products will also be used in Level 2 (standard data analysis) pipelines, the products of which will be used for all of the above

purposes.

1.4.4 Pertinent Relationships with Other Interfaces

Changes to the definition of ACIS science telemetry packets and their data fields, as specified in Applicable Document , or changes to ACIS Level 0 data products, as described in Applicable Document 4, may affect the Level 1 data products described in the current document.

1.5 Assumptions and Constraints

For each ACIS science event run reported in the AXAF telemetry stream, Level 1 processing shall generate a set of product files as shown in Table 1.

1.6 Products Not Covered

ACIS Level 1 products that are used for maintenance and diagnostic purposes (i.e., that are not supplied to the User for science data analysis), and/or are generic AXAF Level 1 products, are not currently included within the interface defined by this document.

2.0 Environment

2.1 Hardware Characteristics and Limitations

All binary integers within ACIS Level 1 products are written in "big-endian" format, i.e. with their more significant bytes preceding their less significant bytes. Within FITS keyword headers, unsigned integer values are represented as positive decimal quantities. Within FITS binary table extensions, unsigned *n*-byte integers whose most significant bit can be ON[1] shall be described by the `TSCAL/TZERO` convention used by *cfitsio* subroutines. Certain products may contain double-precision binary floating point fields. They are written in IEEE-754 format, using the "big-endian" convention, *i.e.* the sign bit and the high-order 7 bits of the exponent are in the first byte, the 4 low-order bits of the exponent and the 4 high-order bits of the mantissa and in the second byte, and so on.

2.2 Interface Medium and Characteristics

Level 1 products shall be created on a UNIX file system. While they are being written, their FITS headers may contain invalid keyword values (*e.g.* `NAXIS2`, the number of binary table rows), and the bias image files may be sparse. Care must be taken not to read or copy these files until they are complete.

2.3 Failure Protection, Detection, and Recovery Features

2.3.1 Backup Requirements

Once created, ACIS Level 1 products are transmitted to the ASC Archive by TBD means. All further responsibility for the products rests with the Archive.

2.3.2 Security / Integrity Measures

The keyword headers of all Level 1 products shall contain an indication of their total byte length so that a file truncation can be detected. For bias image files, this is $|L_{HDR}|_{2880} + |2*x*y|_{2880}$, where L_{HDR} is the length of the keyword header (in bytes), *x* is the value of the `NAXIS1` header keyword, *y* is the value of the `NAXIS2` header keyword, and $|n|_{2880}$ denotes the smallest multiple of 2880 that is greater than, or equal to, *n*. The equivalent expression for the length of a Level 1 binary table file is $|L_{HDR}|_{2880} + |L_{THDR}|_{2880} + |x*y|_{2880}$, where L_{THDR} is the byte length of the binary table header, and *x* and *y* are the values of `NAXIS1` and `NAXIS2` within that header.

2.4 End-Of-File (or Medium) Conventions

All Level 1 products obey the FITS conventions of Applicable Document —headers are terminated by `"END"` keywords; the size of image arrays and binary tables is defined by the `NAXIS1` and `NAXIS2` header keywords.

1. i.e. $T_{max} > 2^{8*n-1}-1$, where T_{max} is the `TLMAX` value of the n-byte data field.

3.0 Access

3.1 Access Tools; Input / Output Protocol

Since ACIS Level 1 products obey the formatting rules described in Applicable Document 8, they may be accessed by any software that conforms to those standards, including all versions of the `FITSIO` libraries that support the `BINTABLE` extension. In addition, since they adhere to HEASARC and ASC standards (Applicable Documents 9 and 10), ACIS Level 1 data product files are compatible with the input/output routines that constitute the ASC Data Model.

3.2 Timing and Sequencing Characteristics

The “natural” subdivision of ACIS Level 1 processing is the Science Run (TBD), which is also the “atomic unit” of ACIS telemetry. This is in keeping with the general philosophy of ASC Level 1 pipeline processing, which is that processing will proceed on batches of data, each batch encompassing a single Observation Interval (OBI). That is, it is expected that in most cases an OBI will consist of a single Science Run (although in certain circumstances - e.g. perigee passage, very long OBI, ACIS on-board computer crash - a single OBI may span more than one ACIS science run.

4.0 Detailed Interface Specifications

4.1 Labeling and Identification

The data files generated by the Level 1 processing pipeline shall be assigned external names as shown in Table 1. The names obey the following convention:

`acis`*`sTTTTTTTT`*`n`*`PPP_c_type`*`1.fits`

where '`acis`' specifies that this is an ACIS data product file, '*`s`*' denotes the origin of the data (possible values: `x = XRCF, f = flight, t = TRW, b = Ball, s = simulation`),'*`TTTTTTTT`*' is the time tag at the start of the OBI in which the data were taken (*`TTTTTTTT`* = `TSTART`), 'n*`PPP`*' specifies the processing pass (*`PPP`* = pass number), '*`c`*' is an (optional) filename discriminator specifying either CCD ID (for bias image files; see Section 4.6) or exposure cycle (for event files obtained in interleaved frame time mode; see Section 4.4.2), *`type`* specifies the file type (see Table 1, below), and the '1.fits' specifies that this is a FITS file created by Level 1 software.

Table 1: ACIS Level 1 Data Product Files

Title	File Name	Contents
event data	`*_`*`c`*`_evt1.fits`	event records; *c* specifies exposure cycle (optional); includes "standard" chip-specific GTI tables
telemetry GTIs	`*_flt1.fits`	chip-specific GTI tables, representing telemetry saturation and/or dropout *only*
bias images	`*_`*`c`*`_bias1.fits`	bias images, 1 per active CCD; *c* specifies CCD_ID (optional: "faint with bias" mode only)
exposure stats table	`*_stat1.fits`	exposure by exposure vital statistics; dropped exposures
spatial mask	`*_msk1.fits`	mask generated from subarrays &/or BEP window lists
bad pixel lists	`*_bpix1.fits`	bad pixel and column lists
Level 1 summary	`*_sum1.fits`	ACIS setup and event summary information

Additional, non-instrument-specific data products may be output by the ACIS Level 1 processing pipeline; these will be described in a separate ICD (TBD).

4.2 Substructure Definition and Format

4.2.1 Header / Trailer Description Details

All ACIS Level 1 products shall consist of files in FITS format, as defined in Applicable Document 8. Each FITS file is comprised of a primary component and optional extension components. Each of these components is divided into two parts: a header section and an (optional) data section. The length of each section is a multiple of 2880 bytes. The header section is further subdivided into 80-byte "records" containing only ASCII characters.

With the exception of bias image files, all ACIS Level 1 files contain Binary Table extensions. Hence ACIS Level 1 products shall conform to one of two FITS file "designs" as defined in Applicable Document 10: Principal Image (bias files) or Auxilliary Null + Principal Table + (optional) Auxilliary Table(s) (all other products). Table 2 shows the keyword sections that should be present in the headers of the Auxilliary Null section of all ACIS Level 0 products, according to

Applicable Document 10 (its Table 6; see also Appendix 1 of that document). This header is divided into sections comprised of keywords that are generic to all ASC L1 data; the meaning and content of these keywords are described in detail in Applicable Document 10. Each 80 byte line is left justified and ASCII blank filled on the right. Following the 'END' keyword, ASCII blanks are appended until the header length is a multiple of 2880 bytes (36 lines).

Table 2: Format of a Level 1 Auxilliary Null FITS Keyword Header

```
SIMPLE  =                    T / FITS STANDARD
BITPIX  =                    8 / Binary Data
NAXIS   =                    0 / No image data array present
EXTEND  =                    T / There may be standard extensions
COMMENT
COMMENT   AXAF FITS Event File: ACIS Level 1
COMMENT
.............Required keywords (see Applicable Document 10):.........
.............Section M: mandatory FITS keywords for HDU type.........
.............Section CC (short): configuration control keywords......
.............Section T (short): timing keywords.......................
.............Section O (short): observation info keywords.............
END
```

The binary tables are further described by an extension header (the Principal Extension header) that immediately follows the Auxilliary Null header of Table 2. The format of such a "generic" FITS binary table extension follows the recommendations of Applicable Document 10 and is shown in Table 2. The header, composed of lines of 80-byte ASCII characters, begins with a group of "required" keywords (XTENSION through GCOUNT), and continues with required AXAF keywords followed by ACIS-specific keywords. These keywords are largely replicated from the corresponding Level 0 product files. However, in certain cases (e.g., the observation information component) additional keywords must be inserted. The header continues with product-specific keywords, if required, and ends with TFIELDS and groups of keywords (TFORM*m* through TLMAX*m*) that define each column of the binary table that follows the FITS header. The values of EXTNAME, HDUNAME, and HDUCLASn depend on the product and remain to be established for some of the products described here (TBD). After the terminating 'END' keyword, ASCII blank bytes are added until the length of the extension header is a multiple of 2880 bytes. In the file definition Tables that follow, each Level 1 product is defined in terms of its product-specific keywords and its binary table fields.

The table itself immediately follows the extension header. Its length is determined by the values of the NAXIS1 and NAXIS2 keywords in the extension header and blank bytes are added until it, too, is a multiple of 2880 bytes in length.

Table 3: Format of a Level 1 FITS Principal Binary Table Extension Header

```
XTENSION= 'BINTABLE'     / This is a binary table
BITPIX  =              8 / Bits per 'pixel'
NAXIS   =              2 / Number of 'axes'
NAXIS1  =           size / Width of a table row in bytes
NAXIS2  =           rows / Number of rows of binary data
PCOUNT  =              0 / Random parameter count (required but ignored)
GCOUNT  =              1 / Number of data groups
COMMENT
.............Required keywords (see Applicable Document 10):..........
.............Section M: mandatory FITS keywords for HDU type..........
.............Section CC: configuration control keywords..............
.............Section T: timing keywords.............................
.............Section O: observation info keywords.....................
COMMENT
COMMENT           AXAF FITS File: ACIS-specific Keywords
COMMENT
READMODE= 'TIMED   '            / CCD exposure mode
DATAMODE= 'FAINT   '            / CCD event telemetry mode
SCI_RUNS=                      1 / Number of science runs processed
STARTMJF=                      0 / Maj frame containing start of 1st Sci Run
STARTMNF=                      0 / Min frame containing start of 1st Sci Run
STOPMJF =                      0 / Maj frame containing end of last Sci Run
STOPMNF =                      0 / Min frame containing end of last Sci Run
COMMENT
COMMENT  Product-specific keywords are inserted here
COMMENT
TFIELDS =              m / Number of data fields per row
.............Section TC:table coordinate keywords.....................
COMMENT
COMMENT Groups of keywords to describe each column of the binary extension
COMMENT
TFORM1  =             nC / Dimension and data type of first field
TTYPE1  = 'name1   '     / Label of first field
TUNIT1  = 'units1  '     / Data units of first field (optional)
TLMIN1  =        minval1 / Minimum field value (optional)
TLMAX1  =        maxval1 / Maximum field value (optional)
.
.
.
TFORMm  =             nC / Dimension and data type of m'th field.
TTYPEm  = 'namem   '     / Label of m'th field
TUNITm  = 'unitsm  '     / Data units of m'th field (optional)
TLMINm  =        minvalm / Minimum field value (optional)
TLMAXm  =        maxvalm / Maximum field value (optional)
END
```

followed by padding sufficient to make the binary table header a multiple of 36 lines (2880 bytes)

FITS binary table contents

(*size* x *rows*) bytes of binary data

followed by padding sufficient to make the length of the binary table a multiple of 2880 bytes

4.3 Telemetry GTI files (*_flt1.fits)

The specification of good time intervals (GTIs) for ACIS must be capable of taking into account periods when the instrument was dropping exposures from specific CCDs due to telemetry saturation. Telemetry dropout can also manifest itself in the form of dropped events and/or exposure records from specific CCDs, and such a circumstance is also interpreted as “bad exposure(s)” (and hence a “bad time interval”) by the Level 1 software. Hence, the ACIS event file contains up to 6 GTI extensions, one per CCD. To populate these extensions, the telemetry good times are merged with the other, “standard” telescope and spacecraft GTIs. The telemetry good times are derived from the “dropped exposures” extension of the exposure statistics file (Section 4.5) and are contained in a set of (up to 6) table extensions within the Telemetry GTI File, as described in Table 4.

Table 4: Telemetry Good Time Interval File

Additional FITS Keyword Header Items
EXTNAME = ‘GTI*n*‘ / GTI table extension for CCD_ID=*n* CCD_ID = *n* / Chip for this GTI FEP_ID = *m* / FEP corresponding to chip HDUNAME = ‘GTI ‘ CONTENT = ‘GTI ‘ HDUCLASS= ‘OGIP ‘ HDUCLAS1= ‘GTI ’ HDUCLAS2= ‘TELEMETRY‘

FITS binary table contents (one entry per GTI)					
#	**TTYPE**	**TUNIT**	**TFORM**	**LO/HI[a]**	**Comment**
1	START	s	1D	n/a	GTI start time
2	STOP	s	1D	n/a	GTI stop time

a. The value of TLMIN is given by “LO”, the value of TLMAX is given by “HI”.

4.4 Event Data Files (*_evt1.fits)

As described in Applicable Document 1, ACIS event data are obtained in one of two different readout modes (timed exposure [TE] or continuous clocking [CC]) and can be telemetered in a variety of formats (which fall under the general categories of “faint” or “graded”). Level 1 Event Data Extension specifications for the principal combinations of readout and telemetry packing modes - `TE faint, TE graded, CC faint,` and `CC graded` - are described in Tables 4-7.

There are two TE data-taking modes that have distinct event record types output by Level 0 but are also described by the `TE faint` data format (Table 5): `TE very faint` and `TE faint with bias. TE faint with bias` Level 1 event data files will be identical in every respect to `TE faint` files; `TE very faint` Level 1 event data files will differ only in the `PHAS` field, which has a format of `25I`.

4.4.1 Event Coordinates

During Level 1 processing event coordinates, which originate (at Level 0) in the CCD (0-1023) coordinate system, undergo multiple transformations as described in Applicable Documents 11 and 12. Coordinates in the `CCDX, CCDY` system are converted to `CHIPX,CHIPY` merely by adding 1 to each value of `CCDX, CCDY. CHIPX,CHIPY,` combined with `CCD_ID,` then specify Tiled Detector Coordinates `TDETX, TDETY` (in integer pixels) and Focal Plane Coordinates `DETX, DETY`. Finally, `DETX, DETY` are converted to Sky Pixel Coordinates `X,Y` by applying the aspect solution. The data types of `DETX, DETY` and `X,Y` are reals. As described in Applicable Documents 10 and 11, World Coordinate System (WCS) keywords are attached to the X, Y columns to give an RA and Dec tangent plane coordinate system. WCS also are attached to the `DETX, DETY` columns to give the off-axis angle and azimuth relative to the HRMA, and to the `CHIPX, CHIPY` columns to give millimeters on the chip (TBD).

Only `CHIPX,Y` and `TDETX,Y` are calculated for events obtained in CC mode (see Section 4.4.3).

4.4.2 Timed-Exposure modes (Tables 5, 6)

Typically a single CCD exposure time will apply to all events obtained in TE mode observations by ACIS. In such cases, Level 1 software produces a single event file from the (up to 6) Level 0 event files output by telemetry processing of a single science run. This event file will be named `*_evt.fits` (see Sec. 4.1 for expansion of the ‘*’).

However, in TE readout mode, ACIS can be configured to “interleave” exposures with two different exposure times. This special mode is indicated by a non-zero value of `DTYCYCLE` in the header of the Level 0 parameter block file and by the value of the `CYCLE` keyword in the Level 0 output event file. If `DTYCYCLE` is non-zero (corresponding to `CYCLE`=’B’), then `DTYCYCLE` CCD frames of (“primary”) exposure time `EXPTIMEA` will be obtained for each exposure of (“secondary”) exposure time `EXPTIMEB (`where both `EXPTIMEA` and `EXPTIMEB` are contained in the parameter block file header). In such cases, two event files are created for each science run (`*_1_evt.fits` [`EXPTIMEA`] and `*_2_evt.fits` [`EXPTIMEB`]) and, during “Level 0.5” processing, events are collated into the two files depending on the exposure in which they were obtained.

Table 5: TE Faint Event Data File

Additional FITS Keyword Header Items

```
COMMENT
COMMENT     ACIS setup keywords
COMMENT
FIRSTROW=              1 / Index of first row of CCD (sub)array readout
NROWS   =           1024 / Number of rows in (sub)array readout
EXPTIME =            3.3 / commanded exposure time (s)
COMMENT
COMMENT     Applied event correction/flagging reference files
COMMENT
BIASFIL0= ‘acis0Vnn_nns000000000_1_bias0’/ bias file used: CCD 0
BIASFIL1= ‘acis0Vnn_nns000000000_3_bias0’/ bias file used: CCD 1
BIASFIL2= ‘acis0Vnn_nns000000000_0_bias0’/ bias file used: CCD 2
BIASFIL3= ‘acis0Vnn_nns000000000_4_bias0’/ bias file used: CCD 3
BIASFIL6= ‘acis0Vnn_nns000000000_6_bias0’/ bias file used: CCD 6
BIASFIL7= ‘acis0Vnn_nns000000000_5_bias0’/ bias file used: CCD 7
BPIXFIL0= ‘acis1f000000000n001_0_bpix1’/ bad pixel file used: CCD 0
BPIXFIL1= ‘acis1f000000000n001_1_bpix1’/ bad pixel file used: CCD 1
BPIXFIL2= ‘acis1f000000000n001_2_bpix1’/ bad pixel file used: CCD 2
BPIXFIL3= ‘acis1f000000000n001_3_bpix1’/ bad pixel file used: CCD 3
BPIXFIL6= ‘acis1f000000000n001_6_bpix1’/ bad pixel file used: CCD 6
BPIXFIL7= ‘acis1f000000000n001_7_bpix1’/ bad pixel file used: CCD 7
COMMENT
COMMENT     Applied event calibration/transform reference files/systems
COMMENT
ACSYSCHP= ‘AXAF-ACIS-1.0’     / reference for CHIP coord system
ACSYSDFP= ‘ASC-FP-STF-1.0’    / reference for focal plane coord system
ACSYSSKY= ‘ASC-SKY-STF-1.0’   / ???reference for sky (X,Y) coord system
GAINFILE= ‘ACISgain_V1.0.fits’/ PHA to PI gain table file
GRD_FILE= ’ACISgrades_v1.0.fits’    / Event grading scheme lookup table file
GRD_SCHM= ’ACIS’              / Event grading scheme: ASCA/ACIS/USER...
```

FITS binary table contents (one entry per event)					
#	**TTYPE**	**TUNIT**	**TFORM**	**LO/HI[a]**	**Comment**
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	CCD_ID	n/a	1I	0/9	CCD reporting event
3	EXPNO	n/a	1J	$0/2^{31}-1$	Exposure number of CCD frame containing event
4	CHIPX	pixel	1I	1/1024	X position of center pixel of event, chip coords
5	CHIPY	pixel	1I	1/1024	Y position of center pixel of event, chip coords
6	TDETX	pixel	1I	1/8192	X position of event, ACIS tiled detector coordinates
7	TDETY	pixel	1I	1/8192	Y position of event, ACIS tiled detector coordinates
8	DETX	pixel	1E	n/a	X position of event, ACIS detector coordinates
9	DETY	pixel	1E	n/a	Y position of event, ACIS detector coordinates
10	X	pixel	1E	n/a	X position of event, sky coordinates
11	Y	pixel	1E	n/a	Y position of event, sky coordinates
12	PHAS	chan	9I	-4096/ 4095	3x3 array of bias-corrected pixel pulse heights (ADU)
13	PHA	chan	1J	0/ 73710	total pulse height of event (ADU)
14	PI	chan	1J	0/10^6	nominal energy of event (eV)
15	FLTGRADE	n/a	1I	0/255	event grade, flight system
16	GRADE	n/a	1I	0/15	“binned” event grade (ACIS/ASCA/USER system)
17	STATUS	coded	1I	n/a	event status bits

a. The value of TLMIN is given by “LO”, the value of TLMAX is given by “HI”.

Table 6: TE Graded Event Data File

Additional FITS Keyword Header Items

```
COMMENT
COMMENT     ACIS setup keywords
COMMENT
FIRSTROW=              1 / Index of first row of CCD (sub)array readout
NROWS   =           1024 / Number of rows in (sub)array readout
EXPTIME =            3.3 / commanded exposure time in units of s
COMMENT
COMMENT     Applied event correction/flagging reference files
COMMENT
BPIXFIL0= ‘acis1f000000000n001_0_bpix1’/ bad pixel file used: CCD 0
BPIXFIL1= ‘acis1f000000000n001_1_bpix1’/ bad pixel file used: CCD 1
BPIXFIL2= ‘acis1f000000000n001_2_bpix1’/ bad pixel file used: CCD 2
BPIXFIL3= ‘acis1f000000000n001_3_bpix1’/ bad pixel file used: CCD 3
BPIXFIL6= ‘acis1f000000000n001_6_bpix1’/ bad pixel file used: CCD 6
BPIXFIL7= ‘acis1f000000000n001_7_bpix1’/ bad pixel file used: CCD 7
COMMENT
COMMENT     Applied event calibration/transform reference files
COMMENT
ACSYSCHP= ‘AXAF-ACIS-1.0’   / reference for CHIP coord system
ACSYSDFP= ‘ASC-FP-STF-1.0’  / reference for focal plane coord system
ACSYSSKY= ‘ASC-SKY-STF-1.0’  / ???reference for sky (X,Y) coord system
GAINFILE= ‘ACISgain_V1.0.fits’/ PHA to PI gain table file
GRD_FILE= ’ACISgrades_v1.0.fits’ / Event grading scheme lookup table file
GRD_SCHM= ’ACIS’             / Event grading scheme: ASCA/ACIS/USER...
```

FITS binary table contents (one entry per event)					
#	**TTYPE**	**TUNIT**	**TFORM**	**LO/HI**[a]	**Comment**
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	CCD_ID	n/a	1I	0/9	CCD reporting event
3	EXPNO	n/a	1J	$0/2^{31}-1$	Exposure number of CCD frame containing event
4	CHIPX	pixel	1I	1/1024	X position of center pixel of event, chip coords
5	CHIPY	pixel	1I	1/1024	Y position of center pixel of event, chip coords
6	TDETX	pixel	1I	1/8192	X position of event, ACIS tiled detector coordinates
7	TDETY	pixel	1I	1/8192	Y position of event, ACIS tiled detector coordinates
8	DETX	pixel	1E	n/a	X position of event, ACIS detector coordinates
9	DETY	pixel	1E	n/a	Y position of event, ACIS detector coordinates
10	X	pixel	1E	n/a	X position of event, sky coordinates
11	Y	pixel	1E	n/a	Y position of event, sky coordinates
12	PHA	chan	1J	0/ 73710	total pulse height of event (ADU)
13	CORN_PHA	chan	1I	0/4095	mean of event corner pixel PHA (ADU)
14	PI	chan	1J	0/10^6	nominal energy of event (eV)
15	FLTGRADE	n/a	1I	0/255	event grade, flight system
16	GRADE	n/a	1I	0/15	“binned” event grade
17	STATUS	coded	1I	n/a	event status bits

a. The value of TLMIN is given by “LO”, the value of TLMAX is given by “HI”.

4.4.3 Continuous Clocking Event Files(Tables 7, 8)

Continuous clocking Level 1 event data files appear to closely resemble their TE cousins, however faint events are reported as 1x3 pixel islands, and there is no meaningful spatial information in the Y event coordinates in the absence of external information concerning the location of the source(s). Hence a `CHIPY` column is included largely to facilitate data visualization and for compatibility with software that is expecting event coordinates to come in X,Y pairs. An (arbitrary) value of `TROW+1` is assigned to all entries in this column. `TDETX, TDETY` are then assigned based on `CHIPX, CHIPY` in the usual manner (see Applicable Document 11), but no further coordinate transformations are performed on CC events during Level 1 processing.

Table 7: CC Faint Event Data File

Additional FITS Keyword Header Items

```
EXPTIME =            0.003 / inferred row clocking time (s)
COMMENT
COMMENT     Applied event correction/flagging reference files
COMMENT
BIASFIL0= ‘acis0Vnn_nns000000000_1_bias0’/ bias file used: CCD 0
BIASFIL1= ‘acis0Vnn_nns000000000_3_bias0’/ bias file used: CCD 1
BIASFIL2= ‘acis0Vnn_nns000000000_0_bias0’/ bias file used: CCD 2
BIASFIL3= ‘acis0Vnn_nns000000000_4_bias0’/ bias file used: CCD 3
BIASFIL6= ‘acis0Vnn_nns000000000_6_bias0’/ bias file used: CCD 6
BIASFIL7= ‘acis0Vnn_nns000000000_5_bias0’/ bias file used: CCD 7
BPIXFIL0= ‘acis1f000000000n001_0_bpix1’/ bad column file used: CCD 0
BPIXFIL1= ‘acis1f000000000n001_1_bpix1’/ bad column file used: CCD 1
BPIXFIL2= ‘acis1f000000000n001_2_bpix1’/ bad column file used: CCD 2
BPIXFIL3= ‘acis1f000000000n001_3_bpix1’/ bad column file used: CCD 3
BPIXFIL6= ‘acis1f000000000n001_6_bpix1’/ bad column file used: CCD 6
BPIXFIL7= ‘acis1f000000000n001_7_bpix1’/ bad column file used: CCD 7
COMMENT
COMMENT     Applied event calibration/transform reference files
COMMENT
ACSYSCHP= ‘AXAF-ACIS-1.0’   / reference for CHIP coord system
GAINFILE= ‘ACISgain_V1.0.fits’/ PHA to PI gain table file
GRD_FILE= ’ACISgrades_v1.0.fits’ / Event grading scheme lookup table file
GRD_SCHM= ’ACIS’             / Event grading scheme: ASCA/ACIS/USER...
```

FITS binary table contents (one entry per event)

Field	TTYPE	TUNIT	TFORM	LO/HI[a]	Comment
1	TIME	s	1D	n/a	S/C TT corresponding to CCD row readout
2	CCD_ID	n/a	1I	0/9	CCD reporting event
3	EXPNO	n/a	1J	$0/2^{31}-1$	Exposure number of CCD frame containing event
4	CHIPX	pixel	1I	1/1024	X position of center pixel of event, chip coords
5	CHIPY	pixel	1I	1/1024	Y position of center pixel of event, chip coords
6	TDETX	pixel	1I	1/8192	X position of event, ACIS tiled detector coordinates
7	TDETY	pixel	1I	1/8192	Y position of event, ACIS tiled detector coordinates
8	PHAS	chan	3I	-4096/ 4095	1x3 array of bias-corrected pixel pulse heights (ADU)
9	PHA	chan	1J	0/ 12287	total pulse height of event (ADU)
10	PI	chan	1J	0/ 100000	nominal energy of event (eV)
11	FLTGRADE	n/a	1I	0/3	event grade, flight system
12	GRADE	n/a	1I	0/15	“binned” event grade (ACIS or ASCA system)
13	STATUS	coded	1I	n/a	event status bits

a. The value of TLMIN is given by “LO”, the value of TLMAX is given by “HI”.

Table 8: CC Graded Event Data File

Additional FITS Keyword Header Items

```
EXPTIME =            0.003 / inferred row clocking time (s)
COMMENT
COMMENT     Applied event correction/flagging reference files
COMMENT
BPIXFIL0= ‘acis1f000000000n001_0_bpix’/ bad pixel file used: CCD 0
BPIXFIL1= ‘acis1f000000000n001_1_bpix’/ bad pixel file used: CCD 1
BPIXFIL2= ‘acis1f000000000n001_2_bpix’/ bad pixel file used: CCD 2
BPIXFIL3= ‘acis1f000000000n001_3_bpix’/ bad pixel file used: CCD 3
BPIXFIL6= ‘acis1f000000000n001_6_bpix’/ bad pixel file used: CCD 6
BPIXFIL7= ‘acis1f000000000n001_7_bpix’/ bad pixel file used: CCD 7
COMMENT
COMMENT     Applied event calibration/transform reference files
COMMENT
ACSYSCHP= ‘AXAF-ACIS-1.0’   / reference for CHIP coord system
GAINFILE= ‘ACISgain_V1.0.tab’/ PHA to PI gain table file
GRD_FILE= ’ACISgrades_v1.0.fits’ / Event grading scheme lookup table file
GRD_SCHM= ’ACIS’                 / Event grading scheme: ACIS/ASCA/USER/...
```

FITS binary table contents (one entry per event)

Field	TTYPE	TUNIT	TFORM	LO/HI[a]	Comment
1	TIME	s	1D	n/a	S/C TT corresponding to CCD row readout
2	CCD_ID	n/a	1I	0/9	CCD reporting event
3	EXPNO	n/a	1J	$0/2^{31}-1$	Exposure number of CCD frame containing event
4	CHIPX	pixel	1I	1/1024	X position of center pixel of event, chip coords
5	CHIPY	pixel	1I	1/1024	Y position of center pixel of event, chip coords
6	TDETX	pixel	1I	1/8192	X position of event, ACIS tiled detector coordinates
7	TDETY	pixel	1I	1/8192	Y position of event, ACIS tiled detector coordinates
8	PHA	chan	1J	0/ 12287	total pulse height of event (ADU)
9	PI	chan	1J	0/ 100000	nominal energy of event (eV)
10	FLTGRADE	n/a	1I	0/3	event grade, flight system
11	GRADE	n/a	1I	0/15	“binned” event grade (ACIS or ASCA system)
12	STATUS	coded	1I	n/a	event status bits

a. The value of TLMIN is given by “LO”, the value of TLMAX is given by “HI”.

4.4.4 ACIS Event File GTI Extensions

As described in Section 4.3, the ACIS event file contains up to 6 GTI extensions, one per CCD. To populate these extensions, described in Table 9, the telemetry good times (Table 4) are merged with the other, “standard” telescope and spacecraft GTIs. In addition, the requisite Data Model keywords describing the GTI extensions must be present in the principal (event) extension (TBD).

Table 9: Good Time Interval Event File Extension

Additional FITS Keyword Header Items
EXTNAME = ‘GTI*n*‘ / GTI table extension for CCD_ID=*n* CCD_ID = *n* / Chip for this GTI FEP_ID = *m* / FEP corresponding to chip HDUNAME = ‘GTI ‘ CONTENT = ‘GTI ‘ HDUCLASS= ‘OGIP ‘ HDUCLAS1= ‘GTI ’ HDUCLAS2= ‘STANDARD‘

FITS binary table contents (one entry per GTI)					
#	**TTYPE**	**TUNIT**	**TFORM**	**LO/HI**	**Comment**
1	START	s	1D	n/a	GTI start time
2	STOP	s	1D	n/a	GTI stop time

4.5 Exposure Statistics Files (*_stat1.fits)

An Exposure Statistics file is created for each science run (Table 10). This file contains up to seven extensions, each pertaining to the sequence of ACIS CCD exposures processed and recorded into telemetry. The first extension is a binary table with one row for each exposure generated by each CCD. This extension is almost entirely derived from a merge operation on the (per-CCD) Exposure Records Files generated by Level 0 processing (see Applicable Document 4, Sec. 4.4.4). The exception is the `OVRCLOCK` column, which is derived by straightforward addition of the values contained in the `DELTOCLK(i)` column of the Level 0 Exposure Records file and the values in the `INITOCLi` keywords contained in the Level 0 Bias File (or the Level 0 event file, in the case of `faint with bias` mode) for the same CCD.

The exposure statistics extension is followed by up to six extensions, 1 per active CCD, containing "dropped exposures" tables. These extensions effectively provide a record of time intervals (i.e. exposure numbers) during which CCDs were and were not reporting exposures into telemetry (the `MISEXP` column), and/or time intervals during which events are determined to be missing by Level 1 software, due to telemetry dropouts or other anomalies(the `MISEVT` column). For the `MISEXP` column, the possible values are 0 (a Level 0 exposure record file entry exists) or 1 (no exposure record file entry exists). For the `MISEVT` column, the possible values are 0 (no. of events in Level 0 event file = no. telemetered), 2 (no events in Level 0 event file, but at least 1 event was sent, according to Level 0 exp. records file), 3 (no. of events in Level 0 event file < no. telemetered), or 4 (no. of events in Level 0 event file > no. telemetered).

Table 10: Exposure Statistics File

Additional FITS Keyword Header Items, extension 1

```
EXTNAME = 'EXPSTATS'              / Table name
HDUNAME = 'EXPSTATS'
CONTENT = 'EXPSTATS'
HDUCLASS= 'ASC     '
HDUCLAS1= 'TEMPORALDATA'
HDUCLAS2= 'EXPOSURES'
INITOCLA=                    123 / Average initial overclock for node A
INITOCLB=                    123 / Average initial overclock for node B
INITOCLC=                    123 / Average initial overclock for node C
INITOCLD=                    123 / Average initial overclock for node D
```

FITS binary table contents, extension 1 (one entry per exposure)

#	TTYPE	TUNIT	TFORM	LO/HI	Comment
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	CCD_ID	n/a	1I	0/9	CCD to which statistics apply
3	EXPTIME	s	1I	1.e-3/10.0	Duration of exposure (TE), or row readout time (CC)
4	EXPNO	n/a	1J	$0/2^{31}$-1	exposure number since start of science run
5	EVTSENT	n/a	1J	$0/2^{31}$-1	number of events sent in data records
6	THR_PIX	n/a	1J	$0/2^{20}$	pixels above respective threshold level
7	DROP_AMP	n/a	1J	$0/2^{31}$-1	# discarded events due to corrected amplitude
8	DROP_POS	n/a	1J	$0/2^{31}$-1	# discarded events due to CCD position
9	DROP_GRD	n/a	1J	$0/2^{31}$-1	# discarded events due to grade code
10	BERR_SUM	n/a	1J	$0/2^{31}$-1	# pixel bias errors so far in science run
11	OVRCLOCK	ADU	4I	-4096/4095	output node overclock values

Additional FITS Keyword Header Items, extensions 2-N (N<=7)

```
EXTNAME = 'DROPEXPn'              / Dropped exposures, CCD_ID = n
HDUNAME = 'DROPEXP '
CONTENT = 'DROPEXP '
HDUCLASS= 'ASC     '
HDUCLAS1= 'TEMPORALDATA'
HDUCLAS2= 'EXPOSURES'
CCD_ID  =                        n / CCD ID (0-9)
FEP_ID  =                        n / FEP ID (0-5)
EXPINTVL=                    3.333 / time between successive exposures (s)
```

FITS binary table contents, extensions 2-N (N<=7) (one entry per time interval)

#	TTYPE	TUNIT	TFORM	LO/HI[a]	Comment
1	TIME	s	1D	n/a	S/C TT corresponding to start of time interval
2	EXPNO	n/a	1J	$0/2^{31}$-1	exposure number corresponding to start of time interval
3	MISEVT	n/a	1I	0/4	Events missing from L1 evt file? (0=no)
4	MISEXP	n/a	1I	0/1	L0 exposure record exists for this EXPNO (0) or not (1)?

a. The value of TLMIN is given by “LO”, the value of TLMAX is given by “HI”.

4.6 Bias Map Files (*_c_bias1.fits)

Bias Map files are created and output by the Level 1 pipeline on a CCD by CCD basis for `TE faint with bias` mode *only.* For all other modes, it is assumed the User will receive the Bias Map files produced by Level 0 software, and should refer to these files for bias data. For information on the format and content of Level 0 Bias Map files, see Applicable Document 4.

"Good" bias map pixel values are in the range 0-4093. Pixels belonging to the current bad-pixel or bad-column lists, and pixels lying outside the area read out in sub-array mode, will be assigned the value `PIXEL_BAD` (decimal 4095). Pixels that have caused parity errors during a science run before the bias map was copied to the telemetry stream will be assigned the value `BIAS_BAD` (decimal 4094). Pixels whose bias values are unknown (because events have not been extracted from those pixels or their neighbors) are assigned the value `BIAS_UNKNOWN` (decimal 4096)

The format of the Level 1 bias map file is identical to that of the Level 0 bias map file (see Section 4.4.9 and Table 19 of Applicable Document 4), with the exception that Level 1 files require a full (rather than short) Observation Information header component (TBD).

4.7 Mask Files (*_msk1.fits)

The CCD active surface (subarray) descriptions and Level 0 BEP event processing window lists (which include event energy selection and event sampling criteria) are captured by Level 1 processing in the Mask File (Table 11), which (in combination with Bad Pixel List files; Section 4.8) is used by exposure map tools to determine exposure times and photon detection efficiencies as a function of position on the sky. See the description of `acis_build_mask` in Applicable Document 12. The mask file may have multiple mask extensions; one extension will be created for each science run within the OBI (TBD).

Each entry in the mask file table corresponds to a BEP window as defined in the 2-D or 1-D window list files output by Level 0 (see Applicable Document 4); in the absence of such windows for a given CCD (i.e., no BEP windows defined for the science run in question) the default entry corresponds to the active (sub)array as specified in the Parameter Block. The mask extension format makes use of the REGION table format described in Appendix 3 of Applicable Document 10, where `SHAPE` is ‘rectangle’. The `OVERLAP` column contains a bitmap specification of window overlap. If, for example, the 2nd and 5th windows of CCD 0 overlap, then the 5th bit of the `OVERLAP` column will be set for the 2nd window and the 2nd bit of the `OVERLAP` column will be set for the 5th window.

The last extension of the file is reserved for the dead time factor (DTF) table. The dead time factor is calculated (TBD) as

`DTF` = 1.0 - (`EXPTIME/NOMINAL_EXPTIME`)

for `EXPTIME` < `NOMINAL_EXPTIME`, where the default `NOMINAL_EXPTIME` is 3.3s (DTF = 0.0 for `EXPTIME` greater than or equal to `NOMINAL_EXPTIME`). For ACIS observations, the

DTF table will contain one row per science run, so it will typically be only one line long.

Table 11: Mask file

Additional FITS Keyword Header Items: Mask Extension(s)

```
EXTNAME = ‘MASK01’       / Table name (last two digits: science run #)
HDUNAME = ‘WINDOW  ‘
CONTENT = ‘MSK     ‘
HDUCLASS= ‘ASC     ‘
HDUCLAS1= ‘CONFIG  ‘
HDUCLAS2= ‘WINDOW  ‘
MTYPE1  = ‘chip    ‘      / data_model keyword
MFORM1  = ‘CHIPX,CHIPY’    / data_model keyword
FIRSTROW=              1 / first row of CCD subarray, CHIP coords
LASTROW =           1024 / last row of CCD subarray, CHIP coords
PHAMIN  =                  0 / Minimum acceptable pulse height
PHARANGE=              65535 / Range of accepted pulse heights
GRADEMA1= ‘FFFFFFFF’           / Hex bit pattern of accepted grade flags
GRADEMA2= ‘FFFFFFFF’         / Hex bit pattern of accepted grade flags
GRADEMA3= ‘FFFFFFFF’         / Hex bit pattern of accepted grade flags
GRADEMA4= ‘FFFFFFFF’         / Hex bit pattern of accepted grade flags
GRADEMA5= ‘FFFFFFFF’         / Hex bit pattern of accepted grade flags
GRADEMA6= ‘FFFFFFFF’         / Hex bit pattern of accepted grade flags
GRADEMA7= ‘FFFFFFFF’         / Hex bit pattern of accepted grade flags
GRADEMA8= ‘FFFFFFFF’         / Hex bit pattern of accepted grade flags
SCI_RUNS=                     5 / total number of science runs in OBI
RUN_ID  =                     1 / Science run index
STARTBEP=                     0 / BEP timer value at TSTART
DTYPE1  = ‘STARTBEP’         / DM Keyword: Descriptor name.
DFORM1  = ‘V       ‘         / DM Keyword: Descriptor datatype.
STOPBEP=                      0 / BEP timer value at TSTOP
DTYPE1  = ‘STOPBEP’          / DM Keyword: Descriptor name.
DFORM1  = ‘V       ‘         / DM Keyword: Descriptor datatype.
PBLOCK  = ‘0x800000001’       / parameter block ID
WIND_ID = ‘0x0000EFF23’       / window block ID
PBKFILE = ‘../test_data/pbkCC.fits’ / parameter block file name
WINFILE = ‘../test_data/winCC.fits’ / window block file name
DTYCYCLE=                  0 / Number of Secondary exposures per Primary
NNUMWIN =                   10 / number of NUMWIN keywords
NUMWIN0 =                    4 / number of windows defined for CCD 0
NUMWIN1 =                    1 / number of windows defined for CCD 1
NUMWIN2 =                    1 / number of windows defined for CCD 2
NUMWIN3 =                    1 / number of windows defined for CCD 3
NUMWIN4 =                    0 / number of windows defined for CCD 4
NUMWIN5 =                    0 / number of windows defined for CCD 5
NUMWIN6 =                    1 / number of windows defined for CCD 6
NUMWIN7 =                    1 / number of windows defined for CCD 7
NUMWIN8 =                    0 / number of windows defined for CCD 8
NUMWIN9 =                    0 / number of windows defined for CCD 9
```

FITS binary table contents: mask extension(s) (one entry per window or per CCD)					
#	**TTYPE**	**TUNIT**	**TFORM**	**LO/HI**[a]	**Comment**
1	SHAPE	n/a	1A	n/a	shape of window (default: rectangle)
2	CHIPX	pixel	2I	1/1024	Window bottom left/top right corner X, CHIP coords
3	CHIPY	pixel	2I	1/1024	Window bottom left/top right corner Y, CHIP coords
4	CCD_ID	n/a	1I	0/9	CCD ID (0-9)
5	WINDOW	n/a	1I	0/5	window index (0-5); up to 6 per CCD
6	SAMP_CYC	n/a	1I	0/255	Event sampling: 0=reject all, 1= accept all, 2=accept every other, 3=accept every 3rd...
7	PHAMIN	chan	1I	0/4095	Minimum event amplitude accepted by window (ADU)
8	PHAMAX	chan	1I	0/ 65535	Maximum event amplitude accepted by window (ADU)
9	OVERLAP	coded	1I	n/a	Window overlap bitmap

a. The value of TLMIN is given by “LO”, the value of TLMAX is given by “HI”.

Additional FITS Keyword Header Items: DTF Extension

```
EXTNAME = ‘DTF’                / Table name
HDUNAME = ‘DTF     ‘
CONTENT = ‘DTF     ‘
HDUCLASS= ‘ASC     ‘
HDUCLAS1= ‘TEMPORALDATA’
HDUCLAS2= ‘DTCOR   ‘
DTCOR   = 8.29871514496790E-01 / Deadtime correction factor
DTF_VAR =                    F / T if ltf variable, F if not
ONTIME  = 1.23510000000000E+04 / Total exposure time
LIVETIME= 1.02497430755498E+04 / livetime
```

FITS binary table contents: DTF extension (one entry per science run)					
#	**TTYPE**	**TUNIT**	**TFORM**	**LO/HI**	**Comment**
1	TIME	s	1D	n/a	S/C TT at start of time interval
2	DTF	n/a	1D	n/a	dead time factor (DTF)
3	DTF_ERR	n/a	1D	n/a	estimated error in DTF

4.8 Bad Pixel List Files (*_bpix1.fits)

Bad pixel/column lists, as captured in the Analysis Reference Data contained in the ASC Archive and in Level 0 CCD Bias Maps and Bias Error files specific to a science run, are compiled and output at Level 1. The resulting products are Bad Pixel List files (Table 11). The file extension includes the time at which a bad pixel (or bad column) was reported or catalogued. The criteria for assigning a `TIME` to each element in the bad pixel table are detailed in the description of `acis_build_badpix` (see Applicable Document 12).

Each extension of the bad pixel list file contains the bad pixel/column list applicable to a given science run. The format is that of the REGION table described in Appendix 3 of Applicable Document 10, where `SHAPE` is 'point' for bad pixels and 'rectangle' for bad columns. Only the first elements of each position vector are used for bad pixels. For bad columns, the `CHIPY` vector values are [1,1024].

In the `STATUS` column of the bad pixel extension is encoded a bitmap description of the origin of the bad pixel. Bits 0-4 denote, respectively, bad pixel in the calibration DB bad pixel list, bad column in the calibration DB bad column list, bias parity error from Level 0 *_berr file, bad pixel recorded in bias map [value 4095], and bias error recorded in bias map [value 4094].

Table 12: Bad Pixel List File

Additional FITS Keyword Header Items

```
EXTNAME = 'BADPIX01'       / Table name (digits represent SR number)
HDUNAME = 'BADPIX  '
CONTENT = 'BADPIX  '
HDUCLASS= 'ASC     '
HDUCLAS1= 'TEMPORALDATA'
HDUCLAS2= 'BADPIX  '
SCI_RUNS=                    5 / total number of science runs in OBI
RUN_ID  =                    1 / Science run index
STARTBEP=                    0 / BEP timer value at TSTART
DTYPE1  = 'STARTBEP'         / DM Keyword: Descriptor name.
DFORM1  = 'V       '         / DM Keyword: Descriptor datatype.
STOPBEP=                     0 / BEP timer value at TSTOP
DTYPE1  = 'STOPBEP'          / DM Keyword: Descriptor name.
DFORM1  = 'V       '         / DM Keyword: Descriptor datatype.
MFORM1  = 'CHIPX,CHIPY'
MTYPE1  = 'chip    '
```

FITS binary table contents (one entry per bad pixel)

#	TTYPE	TUNIT	TFORM	LO/HI[a]	Comment
1	SHAPE	n/a	16A16	n/a	shape of bad element (pixel= point; column=rectangle)
2	CHIPX	pixel	2I	1/1024	bad pixel (or bias error) X, CHIP coords
3	CHIPY	pixel	2I	1/1024	bad pixel (or bias error) Y, CHIP coords
4	TIME	s	1D	n/a	Time assoc. w/ bad pixel or bias error
5	CCD_ID	n/a	1I	0/9	CCD ID (0-9)
6	STATUS	coded	1I	n/a	origin of bad pixel (bitmap)

a. The value of TLMIN is given by "LO", the value of TLMAX is given by "HI".

4.9 Level 1 Summary File (*_sum.fits)

Accompanying each Level 1 dataset is a Summary File (TBD), whose elements are mainly derived from the Parameter Block and Science Run Report files generated by Level 0 processing. Additional table columns describe the number of exposures telemetered for each CCD, as well as the total number of events reported for each CCD.

The format is slightly different depending on whether the instrument was configured for TE read-out mode (Table 13) or CC readout mode (Table 14).

Table 13: Level 1 Summary File, Timed Exposure mode

Additional FITS Keyword Header Items
EXTNAME = ‘SUMMARY‘ / Table name COMMENT COMMENT The following keywords are derived from the COMMENT LO Science Run Report file COMMENT EXPTOT = 335 / total number of exposures produced BERR_CNT= 0 / number of pixel bias map errors detected DEA_ERRS= 0 / errors detected on DEA Interface Board, 1 flag TERMCODE= 1 / Code indicating the reason for the end of run SOFT_VER= 11 / Instrument software version number COMMENT COMMENT The following keywords are derived from the COMMENT L0 Parameter Block file COMMENT FEP_MODE= 2 / 0:Raw; 1:Histogram; 2:3x3; 3:15 TBD BEP_MODE= 1 / 0:Faint; 1:Faint Bias; 2:Graded; 3:15 TBD SUM_2X2 = 0 / On-chip summing. 0:None; 1:Sum 2x2 NOBADPIX= 1 / Disable bad pixel map. 0:Use map; 1:Ignore map NOBADCOL= 1 / Disable bad column map. 0:Use map; 1:Ignore mp BIAS_CAL= 1 / Enable bias calibration. 0:Don’t compute; 1:Comp SENDBIAS= 0 / Telemeter bias data. 0:Don’t send; 1: Send STARTROW= 0 / Index of first row to clock out CCDs ROWCNT = 1023 / One less than the number of rows to clock out OCLKPAIR= 8 / Number of pairs of overclock pixels per output ORC_MODE= 0 / Output register clocking mode EXPTIMEA= 35 / Primary exposure time in units of 1/10s EXPTIMEB= 0 / Secondary exposure time in units of 1/10s DTYCYCLE= 0 / Number of Secondary exposures per Primary PHAMIN = 0 / Minimum acceptable pulse height PHARANGE= -1 / Range of accepted pulse heights GRADEMA1=’FFFFFFFF’ / Hex bit pattern of accepted grade flags GRADEMA2=’FFFFFFFF’ / Hex bit pattern of accepted grade flags GRADEMA3=’FFFFFFFF’ / Hex bit pattern of accepted grade flags GRADEMA4=’FFFFFFFF’ / Hex bit pattern of accepted grade flags GRADEMA5=’FFFFFFFF’ / Hex bit pattern of accepted grade flags GRADEMA6=’FFFFFFFF’ / Hex bit pattern of accepted grade flags GRADEMA7=’FFFFFFFF’ / Hex bit pattern of accepted grade flags GRADEMA8=’FFFFFFFF’ / Hex bit pattern of accepted grade flags
FITS binary table contents (one entry per active FEP)

Field	TTYPE	TUNIT	TFORM	TLMAX [a]	Comment
1	FEP_ID	n/a	1I	5	Front end processor ID
2	CCD_ID	n/a	1I	9	CCD ID
3	VIDRESP	n/a	1I	1	CCD video chain response selection, 0 for 1:1
4	EVT_THR	ADU	4I	4095	Event thresholds for nodes A-D (TLMIN=-4096)
5	SPL_THR	ADU	4I	4095	Split thresholds for output nodes A-D
6	VID_OFF	n/a	4I	4095	Video offsets for CCD output nodes A-D
7	CCD_ERRS	n/a	1I	1	code indicating errors on DEA during science run
8	FEP_ERRS	n/a	1I	255	code indicating errors on FEP during science run
9	EXP_SENT	n/a	1I	0/???	total number of exposures telemetered
10	EVT_SENT	n/a	1J	0/???	total number of events telemetered

a. TLMIN = 0 unless noted.

Table 14: Level 1 Summary File, Continuous Clocking mode

Additional FITS Keyword Header Items

```
EXTNAME = 'SUMMARY'      / Table name
COMMENT
COMMENT  The following are derived from the L0 Science Run Report file
COMMENT  (as are last 2 columns of the binary table)
COMMENT
EXPTOT  =            335 / total number of exposures produced
EXPSENT =             50 / total number of exposures telemetered
BERR_CNT=              0 / number of pixel bias map errors detected
DEA_ERRS=              0 / errors detected on DEA Interface Board, 1 flag
TERMCODE=              1 / Code indicating the reason for the end of run
SOFT_VER=             11 / Instrument software version number
COMMENT
COMMENT  The following are derived from the L0 Parameter Block file
COMMENT  (as are remaining columns of the binary table)
COMMENT
FEP_MODE=              2 / 0:Raw; 1:Histogram; 2:1x3; 3:15 TBD
BEP_MODE=              1 / 0:Faint; 1:Graded; 2:15 TBD
NOBADCOL=              1 / 0:Use bad CC column map; 1:Ignore bad column map
BIAS_CAL=              1 / 0:Don't recompute bias maps; 1:Recompute maps
SENDBIAS=              0 / 0:Don't Telemeter bias maps; 1: Telemeter them
SUMROW  =              0 / Number of CCD rows to sum (powers of 2)
SUMCOL  =              0 / Number of CCD columns to sum (powers of 2)
OCLKPAIR=              8 / Number of pairs of overclock pixels per output
ORC_MODE=              0 / Output register clocking mode
PHAMIN  =              0 / Minimum acceptable pulse height
PHARANGE=             -1 / Range of accepted pulse heights
GRADEMAP='FFFF'          / Hex bit pattern of accepted grade flags
```

FITS binary table contents (one entry per active FEP)

Field	TTYPE	TUNIT	TFORM	TLMAX [a]	Comment
1	FEP_ID	n/a	1I	5	Front end processor ID
2	CCD_ID	n/a	1I	9	CCD ID
3	VIDRESP	n/a	1I	1	CCD video chain response selection, 0 for 1:1
4	EVT_THR	ADU	4I	4095	Event thresholds for nodes A-D (TLMIN=-4096)
5	SPL_THR	ADU	4I	4095	Split thresholds for output nodes A-D
6	VID_OFF	n/a	4I	4095	Video offsets for CCD output nodes A-D
7	CCD_ERRS	n/a	1I	1	code indicating errors on DEA during science run
8	FEP_ERRS	n/a	1I	255	code indicating errors on FEP during science run

a. TLMIN = 0 unless noted.

4.10 Volume, Size, and Frequency Estimates

TBD.