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Event Files

Data Products Guide

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe
L1	ACIS	v2.3	ACIS L1 Event List	EVT1	ACIS1	evt1.fits	TG1.5 −or− ACIS2
L1.5	ACIS	v1.6	ACIS L1.5 Event List (Grating)	TGEVT1	TG1.5	evt1a.fits	TG2
L2	ACIS	v1.2	ACIS L2 Event List (Imaging)	EVT2	ACIS2	evt2.fits	none
L2	ACIS		ACIS L2 Event List (Grating)	EVT2	TG2	evt2.fits	none
L1	HRC	v1.7	HRC L1 Event List	EVT1	HRC1	evt1.fits	HRC1 −or− TG1.5
L1.5	HRC	v1.6	HRC L1.5 Event List (Grating)	TGEVT1	TG1.5	evt1a.fits	TG2
L2	HRC	v1.2	HRC L2 Event List (Imaging)	EVT2	HRC2	evt2.fits	none
L2	HRC		HRC L2 Event List (Grating)	EVT2	TG2	evt2.fits	none

Event List Overview

The reference document that defines FITS files standards for the CXC data products is the ASC FITS Designer's Guide (Version 2.0; postscript).

Event File description:

The event file contains photon event data stored as a table. The EVENT list is the primary component of the file and CIAO will accept this file in all tasks that accept EVENT files or IMAGE files. Additionally, Event files contain the good time interval (GTI) data stored as start and stop time records. The sum of the GTI times represents the acceptable science time (EXPTIME in the header) as determined by pipeline processing.

CIAO will accept an Event file as input in any task that accepts IMAGE files. However, please remember that in such cases, the original event list has been converted according to the user specification into an IMAGE

array. Also, a task that takes an EVENT list as input cannot be given an IMAGE since an EVENT list is read as a table and most of the event list details are not available in an IMAGE.

Time descriptions:

Time is derived by applying the Space Craft Clock Correlation to the VCDU readouts in the telemetry stream.

Column name	Description
TIME	S/C TT corresponding to mid−exposure

Coordinate descriptions:

Calibration corrections (gain, cti) are applied to the events, and the instrument readouts (CCD_ID, NODE_ID, CHIP coordinates) are transformed into sky pixel coordinates (X,Y). The sky coordinates are computed by applying the aspect solution correction that accounts for spacecraft motion as a function of time to the raw coordinates via a transformation library (pixlib). The intermediate transforms (TDET and DET) are saved and are sometimes useful to use as filters to view the image as it was before aspect correction. The instrument dither and spacecraft motion can often be traced in a point source.

The reference document that defines the coordinates convention for the CXC is the Coordinate Systems for Analysis of On−Orbit Chandra Data (Paper I: Imaging).

Column name	Description
CHIPX,CHIPY	position of center pixel of event
TDETX,TDETY	position of event in tiled detector coordinates
DETX,DETY	position of event in ACIS detector detector coordinates
X, Y	position of event in sky coordinates

Energy:

Column name	Description
PHAS[9]	3x3 array of bias−corrected pixel pulse heights
PHA	Total pulse height of event
ENERGY	nominal energy of event
PI	Pulse invariant energy of event

Gratings:

Column name	Description
TG_R	diffraction angle; default form is 1D.
TG_D	cross−dispersion angle; default form is 1D.
TG_MLAM	m x lambda. Default form is 1D.
TG_M	order (m)
TG_LAM	wavelength. (lambda) Default form is 1D.
TG_PART	component (0=zero order, 1=HEG, 2=MEG, 3=LEG, 99=background)
TG_SMAP	source map

TG_SRCID	source ID
GDPX	grating x diffraction pixel, dispersion direction (optional)
GDPY	grating y diffraction pixel,

ACIS L1 Event List

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe
L1	ACIS	v2.3	ACIS L1 Event List	EVT1	ACIS1	evt1.fits	TG1.5 −or− ACIS2

creator pipeline:

acis_L1

The ACIS L1 event list covers the time range of an Observation Interval (OBI). Most Chandra Observations are single OBI, but in some cases the observations are split into observing intervals.

The format of L1 event lists are ACIS mode dependent. By the end of L1, all ACIS modes for which we process (includes TE & CC, excludes RAW and HISTOGRAM) have been leveled to a common format.

Bias correction and overclock correction of data is performed on faint mode data. Then the pipeline performs grading and coordinate transformations on the data. During the coordinate transformations the aspect solution is applied to compensate for spacecraft dither which occurred while the data was being collected. In addition pulse invarience is calculated and charge transfer ineffiency is compensated for. Bad pixel corrections and graded data corner mean checks are done and the appropriate status bits are set.

The output L1 event list includes all events taken by ACIS.

The Standard GTIs for the OBI are computed in L1 but not applied to the events until L2. The output L1 event list contains all input events and the GTI extension reflects the OBI start and stop time intersected with telemetry dropouts so that gaps in the data are accounted for.

The Standard Chandra FITS header is attached to the event list.

creator tools:

acis_format_events − receives faint TE, faint CC, faint w/ bias, very faint, graded CC, and graded TE data and performs several functions on them. The tool is responsible for ensuring that a consistent data format is output so that `acis_process_events` does not have to handle multiple formats of data. This is primarily achieved by standardizing data column names. In addition, the routine produces auxiliary data products such as exposure stats and dropped exposure tables (specifications are defined in the level 1 ASC to Archive ICD). Bias correction and overclock correction of data is performed on faint mode data.

acis_process_events − receives an event file that has been processed by `acis_format_events` and performs grading and coordinate transformations on the data. During the coordinate transformations the aspect solution is applied to compensate for spacecraft dither which occurred while the data was being collected. In addition pulse invarience is calculated and charge transfer ineffiency is compensated for. Bad pixel corrections and graded data corner mean checks are done and appropriate status bits are set (this was formerly done in `acis_format_events`).

useful links:

- Event File entry in the CIAO Dictionary.

ACIS−specific columns:

Column Name	Description
FLTGRADE	event grade in flight system
GRADE	'binned' event grade in ACIS/ASCA/USER system
STATUS	bit description

Extensions: EVENTS & per CHIP GTI

1) EVENT extension columns:

Column Name	Description
TIME	S/C TT corresponding to mid−exposure
CCD_ID	ccd reporting event
NODE_ID	ccd serial readout amplifier node
EXPNO	exposure number of ccd frame reporting event
CHIPX	X position of center pixel of event
CHIPY	Y position of center pixel of event
TDETX	X position of event in tiled detector coordinates
TDETY	Y position of event in tiled detector coordinates
DETX	X position of event in ACIS detector coordinates
DETY	Y position of event in ACIS detector coordinates
X	X position of event in sky coordinates
Y	Y position of event in sky coordinates
SKY_1D	1D spatial coordinate
PHAS[9]	3x3 array of bias−corrected pixel pulse heights
PHA	Total pulse height of event
ENERGY	nominal energy of event
PI	Pulse invariant energy of event
FLTGRADE	event grade in flight system

GRADE	'binned' event grade in ACIS/ASCA/USER system
STATUS	bit description

2) GTI extension columns:

Column Name	Description
START	Good time interval start
STOP	Good time interval stop

ACIS L2 Event List (Imaging)

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe
L2	ACIS	v1.2	ACIS L2 Event List (Imaging)	EVT2	ACIS2	evt2.fits	none

creator pipeline:

acis_L2

The output L2 event list includes the Standard events for an Observation.

If the Chandra observation is a multi−OBI observation, then the first step of processing is to merge the stack of L1 event files for the Observation.

The Standard GTI time filter computed in L1 are applied to the events. The events are also filtered based on the following attributes: `status=0` (i.e. no bit filters set) and a standard ACIS grade set (currently `grade=0,2,3,4,6`).

The format of L2 event lists are not ACIS mode dependent. By the end of L1, all ACIS modes for which we process (includes TE & CC, excludes RAW and HISTOGRAM) have been leveled to a common format.

Simple data analysis in L2 includes running `celldetect` to create a source list. Also, a full and center image of the data is created along with html and postscript summary pages that provide the user with a synopsis of the observation.

The Standard Chandra FITS header is attached to the event list.

creator tools:

dmmerge − combine a stack of L1 event file and exclude the L1 PHAS and CORN_PHA columns in the L2 event list.

dmcopy − copy the merged event list with the following filter: (`status=0` and `grade=0,2,3,4,6`); and output the L2 event list

ACIS−specific columns:

Column Name	Description
FLTGRADE	event grade in flight system
GRADE	'binned' event grade in ACIS/ASCA/USER system
STATUS	bit description

Extensions: EVENTS & per CHIP GTI

1) EVENT extension columns:

Column Name	Description
TIME	S/C TT corresponding to mid−exposure
CCD_ID	ccd reporting event
NODE_ID	ccd serial readout amplifier node
EXPNO	exposure number of ccd frame reporting event
CHIPX	X position of center pixel of event
CHIPY	Y position of center pixel of event
TDETX	X position of event in tiled detector coordinates
TDETY	Y position of event in tiled detector coordinates
DETX	X position of event in ACIS detector coordinates
DETY	Y position of event in ACIS detector coordinates
X	X position of event in sky coordinates
Y	Y position of event in sky coordinates
SKY_1D	1D spatial coordinate
PHAS[9]	3x3 array of bias−corrected pixel pulse heights
PHA	Total pulse height of event
ENERGY	nominal energy of event
PI	Pulse invariant energy of event
FLTGRADE	event grade in flight system
GRADE	'binned' event grade in ACIS/ASCA/USER system
STATUS	bit description

2) GTI extension columns:

Column Name	Description
START	Good time interval start
STOP	Good time interval stop

ACIS L1.5 Event List (Grating)

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe
L1.5	ACIS	v1.6	ACIS L1.5 Event List (Grating)	TGEVT1	TG1.5	evt1a.fits	TG2

creator pipeline:

acis_L15

The ACIS L1.5 pipeline is run on the output of ACIS L1. The event list covers the time range of an Observation Interval (OBI).

In L1.5 for ACIS the first step is to Detect the zero order source(s) about the pointing position. It then creates a mask region description file of the gratings and uses the region file to separate all the grating events from the background. Grating coordinates are then assigned to all identified regions and the wavelength and order or these photons is calculated. Finally the fits region file is appended to the output event file, as a REGION extension.

The Standard Chandra FITS header is part of the event list.

creator tools:

tgdetect − Detects zero order source(s) using a wrapper script which sets up and executes several DM tools including `celldetect`. The steps are as follows: A box region about the center pointing position (nom_ra/dec in pixel coordinates) is created; `celldetect` is run over the section of the event list designated in the filter above and outputs a source list of all sources detected in that region; Several filtering steps are applied to the source list to find the zeroth order in the event that more than one source was detected.

tg_create_mask − Creates a region file to define spectrum sky boundaries. This is achieved as follows: Before wavelengths can be computed from diffracted event positions, each event is assigned to a part of the spectrum according to its spatial location. The parts are zero−order or diffracted order. If diffracted order, HETG has two diffracted parts, one for HEG and the other MEG. If LETG, there is only one diffracted part. The output is an ASCII region file which enumerates the parts and specifies the region shape, size, and orientation in sky pixel−plane coordinates.

The spatial region is determined via error−budget calculations incorporating the affects of the mirror point−spread function vs. off−axis angle, defocus, and Rowland spectrograph astigmatism. It is by default of generous dimensions compared to the one−sigma characteristic size so that sub−selection can be applied later into source and background regions when binning a spectrum (see `tgextract`). Prior to binning, rigorous

conversion of event coordinates to diffraction coordinates is done from chip coordinates and the aspect solution (see `tg_resolve_events`); sky coordinates are only used for spatial filtering.

Regions for up to 10 sources may be computed at a time and it is this default that are used in the pipeline. A descrtion of the region format is The document ASC−FITS−REGION−1.0 (PostScript) defines the conventions adopted for the REGION FITS binary table format.

tg_resolve_events − Assign grating events to spectral orders using PHA separation if available. This step compares event positions with 3−D locations (including PHA) to which dispersed photons can appear, given the grating equation and 0−order position, and assign them a wavelength and an order. First grating diffraction coordinates (primarily wavelength and cross−diffraction angle) are computed for each event in spatial regions assigned by the input mask (regionfile parameter) by decomposing the event coordinates into components parallel and perpendicular to the diffraction direction, as defined by the instantaneous zero−order centroid location, the event location, the grating node, and the grating bar rotation angle. If the detector has intrinsic energy resolution, an energy response table is used to assign each photon an order (cf., the one−dimensional grating equation: `m*lambda = P*sin(theta)`, where `m` is the order, `lambda` the wavelength, `P` the grating period, and `theta` the diffraction angle).

Extenions: EVENTS, per CHIP GTI, REGION

1) EVENT extension columns:

Column Name	Description
TIME	S/C TT corresponding to mid−exposure
CCD_ID	ccd reporting event
NODE_ID	ccd serial readout amplifier node
EXPNO	exposure number of ccd frame reporting event
CHIPX	X position of center pixel of event
CHIPY	Y position of center pixel of event
TDETX	X position of event in tiled detector coordinates
TDETY	Y position of event in tiled detector coordinates
DETX	X position of event in ACIS detector coordinates
DETY	Y position of event in ACIS detector coordinates
X	X position of event in sky coordinates
Y	Y position of event in sky coordinates
SKY_1D	1D spatial coordinate
PHAS[9]	3x3 array of bias−corrected pixel pulse heights
PHA	Total pulse height of event
ENERGY	nominal energy of event

PI	Pulse invariant energy of event
FLTGRADE	event grade in flight system
GRADE	'binned' event grade in ACIS/ASCA/USER system
STATUS	bit description
TG_R	diffraction angle; default form is 1D.
TG_D	cross−dispersion angle; default form is 1D.
TG_MLAM	m x lambda. Default form is 1D.
TG_M	order (m)
TG_LAM	wavelength. (lambda) Default form is 1D.
TG_PART	component (0=zero order, 1=HEG, 2=MEG, 3=LEG, 99=background)
TG_SMAP	source map
TG_SRCID	source ID
GDPX	grating x diffraction pixel, dispersion direction (optional)
GDPY	grating y diffraction pixel, cross−dispersion (optional)

2) GTI extension columns:

Column Name	Description
START	Good time interval start
STOP	Good time interval stop

2) REGION extension:

Column Name	Description
SHAPE	Shape of region
X[2]	X−coordinate Vector for SHAPE
Y[2]	Y−coordinate Vector for SHAPE
R[2]	Radius Vector for SHAPE
ROTANG[2]	Rotation angle vector for SHAPE
COMPONENT	Component number that shape belongs to
SOURCE	Source Number

GRATING	Applicable grating; one of: HETG, LETG, DRAKE

ACIS L2 Event List (Grating)

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe
L2	ACIS		ACIS L2 Event List (Grating)	EVT2	TG2	evt2.fits	none

creator pipeline:

acis_lev2.ped, acis_cc_lev2.ped

creator tool:

dmmerge − the event lists from multi−obi observations are merged by this tool. If it is a single obi observation, then the L2 event list is identical to the L1 event list.

Extensions: EVENTS & per CHIP GTI

1) EVENT extension columns:

Column Name	Description
TIME	S/C TT corresponding to mid−exposure
CCD_ID	ccd reporting event
NODE_ID	ccd serial readout amplifier node
EXPNO	exposure number of ccd frame reporting event
CHIPX	X position of center pixel of event
CHIPY	Y position of center pixel of event
TDETX	X position of event in tiled detector coordinates
TDETY	Y position of event in tiled detector coordinates
DETX	X position of event in ACIS detector coordinates
DETY	Y position of event in ACIS detector coordinates
X	X position of event in sky coordinates
Y	Y position of event in sky coordinates
SKY_1D	1D spatial coordinate
PHAS[9]	3x3 array of bias−corrected pixel pulse heights

PHA	Total pulse height of event
ENERGY	nominal energy of event
PI	Pulse invariant energy of event
FLTGRADE	event grade in flight system
GRADE	'binned' event grade in ACIS/ASCA/USER system
TG_R	diffraction angle; default form is 1D.
TG_D	cross−dispersion angle; default form is 1D.
TG_MLAM	m x lambda. Default form is 1D.
TG_M	order (m)
TG_LAM	wavelength. (lambda) Default form is 1D.
TG_PART	component (0=zero order, 1=HEG, 2=MEG, 3=LEG, 99=background)
TG_SMAP	source map
TG_SRCID	source ID
GDPX	grating x diffraction pixel, dispersion direction (optional)
GDPY	grating y diffraction pixel, cross−dispersion (optional)

2) GTI extension columns:

Column Name	Description
START	Good time interval start
STOP	Good time interval stop

HRC L1 Event List

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe
L1	HRC	v1.7	HRC L1 Event List	EVT1	HRC1	evt1.fits	HRC1 −or− TG1.5

creator pipeline:

hrc_L1

creator tools:

hrc_process_events

HRC−specific columns:

Column Name	Description
STATUS	event status bits

Extensions: EVENTS & per CHIP GTI

1) EVENT extension columns:

Column Name	Description
TIME	S/C TT corresponding to mid−exposure
CRSV	Coarse position V axis
CRSU	Coarse position U axis
AMP_SF	Amplitude scale factor
AV1	V axis ADC 1
AV2	V axis ADC 2
AV3	V axis ADC 3
AU1	U axis ADC 1
AU2	U axis ADC 2
AU3	U axis ADC 3
RAWX	Raw X (no degapping)
RAWY	Raw Y (no degapping)
CHIPX	Chip X (degapping applied)
CHIPY	Chip Y (degapping applied)
TDETX	Tiled X
TDETY	Tiled Y
DETX	Focal plane X
DETY	Focal plane Y
X	Sky X
Y	Sky Y

PHA	Total pulse height of event
PI	Pulse invariant energy of event
SUMAMPS	Sum of all amp readouts
CHIP_ID	Chip ID
STATUS	event status bits (memo)

2) GTI extension columns:

Column Name	Description
START	Good time interval start
STOP	Good time interval stop

HRC L1.5 Event List

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe
L1.5	HRC	v1.6	HRC L1.5 Event List (Grating)	TGEVT1	TG1.5	evt1a.fits	TG2

creator pipeline:

hrc_L15

creator tools:

tg_resolve_events

Extensions: EVENTS & per CHIP GTI

1) EVENT extension columns:

Column Name	Description
TIME	S/C TT corresponding to mid−exposure
CHIPX	Chip X (degapping applied)
CHIPY	Chip Y (degapping applied)
TDETX	Tiled X
TDETY	Tiled Y

DETX	Focal plane X
DETY	Focal plane Y
X	Sky X
Y	Sky Y
PHA	Total pulse height of event
PI	Pulse invariant energy of event
CHIP_ID	Chip ID
STATUS	event status bits
TG_R	diffraction angle; default form is 1D.
TG_D	cross−dispersion angle; default form is 1D.
TG_MLAM	m x lambda. Default form is 1D.
TG_M	order (m)
TG_LAM	wavelength. (lambda) Default form is 1D.
TG_PART	component (0=zero order, 1=HEG, 2=MEG, 3=LEG, 99=background)
TG_SMAP	source map
TG_SRCID	source ID
GDPX	grating x diffraction pixel, dispersion direction (optional)
GDPY	grating y diffraction pixel, cross−dispersion (optional)

2) GTI extension columns:

Column Name	Description
START	Good time interval start
STOP	Good time interval stop

HRC L2 Event List (Imaging)

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe
L2	HRC	v1.2	HRC L2 Event List (Imaging)	EVT2	HRC2	evt2.fits	none

creator pipeline:

hrc_L2

creator tools:

dmmerge

Extensions: EVENTS & per CHIP GTI

1) EVENT extension columns:

Column Name	Description
TIME	S/C TT corresponding to mid−exposure
CHIPX	Chip X (degapping applied)
CHIPY	Chip Y (degapping applied)
TDETX	Tiled X
TDETY	Tiled Y
DETX	Focal plane X
DETY	Focal plane Y
X	Sky X
Y	Sky Y
PHA	Total pulse height of event
PI	Pulse invariant energy of event
CHIP_ID	Chip ID

2) GTI extension columns:

Column Name	Description
START	Good time interval start
STOP	Good time interval stop

HRC L2 Event List (Gratings)

Level	Instrum	ICD	Data product	Content	Pipeline	Filename template	Next Pipe

L2	HRC		HRC L2 Event List (Grating)	EVT2	TG2	evt2.fits	none

creator pipeline:

rc_L2

creator tools:

dmmerge

Extensions: EVENTS & per CHIP GTI

1) EVENT extension columns:

Column Name	Description
TIME	S/C TT corresponding to mid−exposure
CHIPX	Chip X (degapping applied)
CHIPY	Chip Y (degapping applied)
TDETX	Tiled X
TDETY	Tiled Y
DETX	Focal plane X
DETY	Focal plane Y
X	Sky X
Y	Sky Y
PHA	Total pulse height of event
PI	Pulse invariant energy of event
CHIP_ID	Chip ID
TG_R	diffraction angle; default form is 1D.
TG_D	cross−dispersion angle; default form is 1D.
TG_MLAM	m x lambda. Default form is 1D.
TG_M	order (m)
TG_LAM	wavelength. (lambda) Default form is 1D.
TG_PART	component (0=zero order, 1=HEG, 2=MEG, 3=LEG, 99=background)
TG_SMAP	source map

TG_SRCID	source ID
GDPX	grating x diffraction pixel, dispersion direction (optional)
GDPY	grating y diffraction pixel, cross−dispersion (optional)

2) GTI extension columns:

Column Name	Description
START	Good time interval start
STOP	Good time interval stop

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2) GTI extension columns: