Analysis Guide: ACIS Data Preparation

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It is possible to analyze any Chandra dataset straight out of the box. However, to get scientifically accurate results, there are a number of data processing questions that should be considered. When Chandra data goes through Standard Data Processing (SDP, or the pipeline), the most recently available calibration is applied to it. Since this calibration is continuously being improved, one should check whether there are currently newer files available. Similarly, some science decisions are made during SDP; every user has the option to reprocess the data with different parameters.

This guide is designed to help the user decide how an ACIS dataset should be processed and filtered before starting the data analysis stage.

The following threads are referenced:

- Remove the acis_detect_afterglow Correction
- Create a New ACIS Bad Pixel File: Identify ACIS Hot Pixels and Cosmic Ray Afterglows
- Create a New Level=2 Events File
- Improving the Astrometry of your Data: Correct for a Known Processing Offset
- Correcting Absolute Astrometry with reproject_aspect thread
- Use Observation−specific Bad Pixel Files
- Filtering Data
- Filtering Lightcurves

The threads should be run in the order in which they are presented below. A change in the CIAO 3.4 documents is the recommendation that the Improving the Astrometry of your Data thread be run *after* reprocessing to create a level=2 event file; see the thread for details.

Thread: Remove the acis_detect_afterglow Correction

An afterglow is the residual change from the interaction of a cosmic ray in a CCD. Some of the excess charge is captured by charge traps and released in a few to a few dozen subsequent frames. If afterglow events are not removed from the data, they can result in the spurious "detection" of faint sources.

Prior to version DS 7.4.0, standard data processing (SDP, aka "the pipeline") used the tool `acis_detect_afterglow` to flag possible cosmic ray events in the level 1 event file; these are then filtered out in the level 2 event file. It was determined that 3−5 % of the valid source photons may be rejected from diffracted spectra. These rejections, though a small fraction of the total events, are systematic and non−uniform.

A new, more precise method for identifying afterglow events was introduced to SDP at version DS 7.4.0, namely

the ACIS hot pixel tools. The afterglow status bits in data that were processed with
`acis_detect_afterglow` must be reset so that they may be properly recomputed.

Thread: Create a New ACIS Bad Pixel File: Identify ACIS Hot Pixels and Cosmic Ray Afterglows

New tools were introduced in CIAO 3.2 to identify and flag hot pixel and afterglow events in ACIS observations. `acis_run_hotpix` is a script that runs the ACIS hot pixel tools in order; see the About the ACIS Hot Pixel Tools section of the thread for details.

These tools supersede `acis_detect_afterglow` and replaced that tool in standard data processing in DS 7.4.0. `acis_run_hotpix` is better because it finds some afterglows that `acis_detect_afterglow` does not, it also finds pixels that are hot or have bad bias values and it misidentifies far fewer legitimate X–ray events as bad.

It is necessary to reprocess the data with `acis_process_events` in order to apply the new bad pixel file. This is included in the next section: "Create a New Level=2 Events File".

Thread: Create a New Level=2 Events File

The Create a New Level=2 Events File thread generates a new level=2 event file for all possible grating/detector combinations. This thread is designed to guide users through a large set of threads, the majority of which are simply different ways of running the tool `acis_process_events`.

The following threads are combined into an easy–to–follow format:

- Apply the ACIS CTI Correction
- Apply an ACIS Gain Map
- Apply the Time–Dependent ACIS Gain Correction
- Remove Pixel Randomization
- Apply/Remove PHA Randomization
- Clean ACIS Background in VFAINT Mode
- Destreak the ACIS–S4 Chip

This thread also includes ***grade and status filtering***:

If you have been working with a level=1 event file, it needs to be filtered on grade and status to create a level=2 event file. In general, the data is filtered to remove events that do not have a good GRADE or that have one or more of the STATUS bits set to 1.

Thread: Use Observation–specific Bad Pixel Files

Although the majority of the calibration files are now contained within the Chandra Calibration Database (CALDB), the observation–specific bad pixel list must still be set by the user. This file will be used by many of the CIAO tools, such as `mkarf`, `mkgarf`, and `mkinstmap`. Setting the bad pixel file ensures that the most accurately known bad pixel list for any observation will consistently be used in the data processing.

It is very important that you know what files are set in your ardlib.par. If you do not set the bad pixel file for

your observation, the software will use a generic detector bad pixel file from the CALDB; pixels that are flagged as bad in a specific observation will not get filtered out when using this map. The criteria for a pixel to be flagged are described in the badpix dictionary entry.

Remember to "punlearn" or delete your ardlib.par file after completing analysis of this dataset to ensure that the proper bad–pixel maps are used the next time that ardlib.par is referenced by a tool.

Threads: Improving the Astrometry of your Data: Correct for a Known Processing Offset
Correcting Absolute Astrometry with reproject_aspect

There are two main reasons why you might need to change the aspect of your observation:

1. ***Correct for a known processing offset:*** to remove any known aspect offsets and obtain absolute astrometry which is accurate to 1". This case is addressed in the Improving the Astrometry of your Data: Correct for a Known Processing Offset thread.

   This aspect correction should be applied after creating a new level=2 event file, as the reprocessing may reverse a correction applied beforehand.

2. ***Apply an offset for improved astrometry:*** if the X–ray observation has point sources with very accurately known optical/radio/IR counterpart positions, it is possible to obtain absolute astrometry which is accurate to 0.1" – 0.2". In this case, users should follow the Correcting Absolute Astrometry with reproject_aspect thread.

For full details on the current status of Chandra astrometry, see the Notes on Chandra Astrometric Accuracy.

Threads: Filtering Data
Filtering Light Curves

Why Topic: Choosing an Energy Filter

The filtering applied to the event file should take into account the analyis goal, whether it is source detection or modeling of pileup. One may also want to filter the data to exclude the events with low or high energies. At the extrema of the spectrum (where the effective area is the smallest), the events may be dominated by background; to maximize the signal to noise ratio, exclude these energy ranges.

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