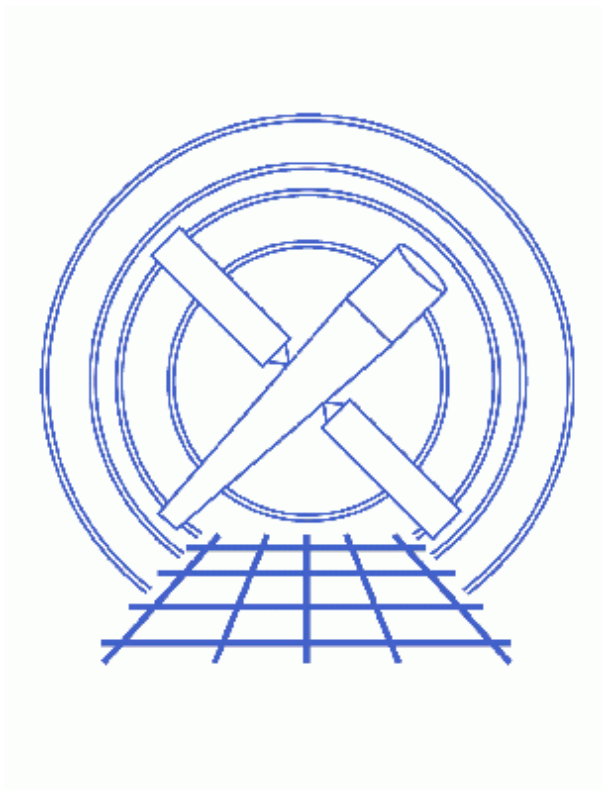


Using psextract to Extract ACIS Spectra and Response Files for Pointlike Sources



CIAO 3.4 Science Threads

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Using psextract to Extract ACIS Spectra and Response Files for Pointlike Sources

CIAO 3.4 Science Threads

Overview

Last Update: 31 Mar 2008 – updated for CALDB 3.4.3: use `mkacisrmf` for –110 BI chips if TGAIN calibration has been applied

Synopsis:

Recommended use of the `specextract` script: It has been determined that the `mkwarf` tool, which is used for ARF generation by `specextract`, may not produce accurate results for point sources. The `mkarf` tool, used by `psextract`, is preferred for point source extraction. `specextract` should be used for the analysis of extended sources only. Users working with point sources should instead use the `psextract` script. ***Analysis of point sources that was done with `mkwarf`/`specextract` should be redone with `mkarf`/`psextract` for the most accurate results***, e.g. taking bad columns into account.

The `psextract` script allows you to compute different RMFs and ARFs for the source and background spectra, if needed. The output files are the source and (ungrouped) background spectra and the source RMF and ARF. If the source and background extraction regions have different average detector coordinates or the source and background event files are different, then the background RMF and ARF and a "linearly grouped" (by a factor of 20) background spectrum are also created.

Purpose:

To generate source and background PI (PHA) spectra of a pointlike ACIS source and build the proper RMFs and ARFs.

Read this thread if:

you are working with any ACIS observation, whether imaging or grating data. If the source is at the very edge of a CCD, subarray or window, do not use this thread. Instead, run the [Step-by-Step Guide to Creating ACIS Spectra thread](#) which includes the use of the [mask file](#) when making an ARF.

Calibration Updates:

- **[CALDB v3.3.0.1](#) (2 Feb 2007):** The CALDB 3.3.0.1 patch corrects an indexing problem that may affects users of this thread. Read the [Caveat: ACIS –120C FEF for CTI-corrected ACIS data](#) for details.
- **[CALDB v2.26](#) (2 Feb 2004):** New FEF files containing updated information for ACIS S3 were added to the CALDB; there are CTI-corrected and uncorrected versions available. The ACIS contamination files were also included in this update.

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- ***CALDB v2.21*** (14 Feb 2003): The new CTI-corrected FEF file (`acisD2000-01-29fef_pha_ctiN0002.fits`) contains updated information for chips S0, S1, and S3–5, eliminating the calibration problem announced in December 2002. Applying the CTI correction to these chips will no longer have a negative effect on the data.

Related Links:

- [Step-by-Step Guide to Creating ACIS Spectra](#): the manual version of this thread.

Proceed to the [HTML](#) or [hardcopy \(PDF: \[A4\]\(#\) | \[letter\]\(#\)\)](#) version of the thread.

Get Started

Sample ObsID used: 459 (HETG/ACIS–S, 3C 273)

File types needed: evt2; asol1

Please ensure that you have set up ardlb to use the [bad pixel file for your observation](#) before following this thread.

CALDB 3.3.0.1 patch

The [CALDB 3.3.0.1 patch](#), released on 02 February 2007, corrects an indexing problem that may affect users of this thread. Read the [Caveat: ACIS –120C FEF for CTI-corrected ACIS data](#) for details.

Make sure that this patch has been installed in your CALDB before continuing:

```
unix% dmlist "$CALDB/docs/chandra/caldb_version/caldb_version.fits[cols caldb_ver,ciao_ver]" data
...
 52 3.2.4      CIAO3.3.0.1
 53 3.3.0      CIAO3.4
 54 3.3.0.1    CIAO3.4
```

This file is automatically updated each time the CALDB is upgraded on your system, so the final row always indicates the current version.

Using Consistent Calibration: `mkrmf` vs `mkacisrmf`

The tool `mkacisrmf` is used to create RMFs for:

- all –120 ACIS data taken in (V)FAINT mode that has the time-dependent gain adjustment and CTI correction applied
- –120 ACIS GRADED mode data on the back-illuminated chips (ACIS–S1 and S3) only
- –110 ACIS data taken on the back-illuminated chips (ACIS–S1 and S3) only

All new analyses with these types of data should be done with `mkacisrmf` instead of `mkrmf`. Although this script runs `mkrmf`, it can still be used to create the spectrum and ARF files for the data. Then follow the [Creating](#)

[ACIS RMFs with mkacisrmf thread](#) to generate new RMFs.

It is important that the calibration applied to the event file is consistent with the RMF tool chosen, as explained in the "[Using Consistent Calibration](#)" section of the [why](#) topic. *If necessary, reprocess your data with the correct gain file before beginning this thread.*

The ACIS dead area correction

There is a fractional area loss per unit time due to cosmic ray flux incident on the ACIS detector. Calibration to account for this ACIS "dead area" was included in CALDB 3.3.0 on 15 December 2006. The correction is non-zero for the 8 front-illuminated ACIS chips; the effect is not detectable for the BI chips, so the nominal calibration value is 0.0. The resulting chipy-dependent reduction in the EA will be approximately 2.2% at the readout, and 4.0% at the top of the chip. Refer to the [ACIS Dead Area Correction why topic](#) for technical details.

In CIAO 3.4, the application of the dead area correction is *turned off* by default. However, users may opt to include it in the analysis by setting the `pbkfile` and `dafile` parameters in this script. Refer to the script help file for details on these parameters.

Downloading the Scripts

The most recent version of `psextract` is v4.0 (07 February 2007):

```
unix% grep version_ `which psextract`  
version_str="4.0"  
version_date="07 February 2007"
```

The most recent version of `acis_fef_lookup` is 1.20 (13 February 2007):


```
unix% grep Id `which acis_fef_lookup`  
% $Id: acis_fef_lookup,v 1.20 2007/02/13 19:36:28 egalle Exp $
```

Please check that you are using the most recent version before continuing. If you do not have the scripts installed or need to update to a newer version, please refer to the [Scripts page](#).

Build Source and Background Regions

We need to define two regions, one for the source and another for the background. To do this, first display the image:

```
unix% ds9 acisf00459N002_evt2.fits &
```

In this example, we define the jet as the source with a rectangle (see [this FAQ](#) on how to rotate shapes in ds9) and four 10-pixel radius circles for the background (from source-free parts of the image around the source). All the regions are shown in [Figure 1](#) . The background region can be also selected from a different event file.

To save the regions, follow these steps:

1. Region -> File Format-> Ciao

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2. Region → File Coordinate System → Physical
3. Region → Save Regions... → Save As "3c273.reg" (source) and "3c273_bg.reg" (background). To select multiple regions for saving, hold down the <SHIFT> key and click on each one.

Note that both the "CIAO" and "SAOtnG" region formats are supported by this script; we choose to use "CIAO" here. The imaging window may be closed by choosing "File → Exit".

The resulting region files will look something like this:

```
unix% more 3c273.reg
# Region file format: CIAO version 1.0
rotbox(4148.125,4043.625,7.58978,22.338761,44.516094)

unix% more 3c273_bg.reg
# Region file format: CIAO version 1.0
circle(4119,4014.75,10)
circle(4077,4025.75,10)
circle(4186.5,4023.25,10)
circle(4196.25,4064.5,10)
```

Run psextract

psextract runs the following tools in order:

1. dmextract: to extract source and background spectra
2. dmkeypar: to find out the start-time of the observation (for source and background)
3. dmstat: to get statistics on chipx, chipy, ccd_id, x and y (for source and background)
4. acis_fef_lookup: to find the proper FEF file (for source and background)
5. mkrmf: to build the proper RMF(s)
6. asphist: to create the aspect histogram(s)
7. mkarf: to create the proper ARF(s) In the case of grating data, psextract reads the GRATING keyword from the header of the event file and passes it to mkarf
8. dmgroup: to group the source spectrum and, if needed, the background spectrum
9. dmhedit: to update the BACKFILE, RESPFILE and ANCRFILE keys in the source PHA file, and the RESPFILE and ANCRFILE keys in the "linearly grouped" background PHA file (if needed).

In this case, since we are using an ACIS/HETG observation, mkarf will extract the 0th order spectra and ARF.

To extract the spectra in PI space and group the source spectrum to contain the new grouping-scheme; that is, there will be a minimum number of 15 counts per new channel:

```
unix% punlearn psextract
unix% pset psextract events="acisf00459N002_evt2.fits[sky=region(3c273.reg)]"
unix% pset psextract bgevents="acisf00459N002_evt2.fits[sky=region(3c273_bg.reg)]"
unix% pset psextract root=3c273
unix% pset psextract asol=@pcad_asol1.lis
unix% pset psextract gtype=NUM_CTS
unix% pset psextract gspec=15
```

If you wish to include the ACIS dead area correction (not applied in this thread), set the pbkfile and dafile parameters as well:

Make ACIS Spectrum/RMF/ARF – CIAO 3.4

```
unix% pset psextract pbkfile=acisf063875928N002_pbk0.fits dafile=CALDB
```

Running the tool with verbose=2 shows what it is doing:

```
unix% psextract verbose=2
Source events specification (acisf00459N002_evt2.fits[sky=region(3c273.reg)]):
Background events specification (acisf00459N002_evt2.fits[sky=region(3c273_bg.reg)]):
Root name for output files (3c273):
Source aspect solution file (@pcad_asol1.lis):
Background aspect solution file ():

    events=acisf00459N002_evt2.fits[sky=region(3c273.reg)]
    bgevents=acisf00459N002_evt2.fits[sky=region(3c273_bg.reg)]
    root=3c273
    aoff=@pcad_asol1.lis bgaoff=@pcad_asol1.lis
    pbkfile=NONE dafile=NONE
    ptype=pi
    gtype=NUM_CTS grouping=15
    verbose=2

Extract source spectrum 3c273.pi from acisf00459N002_evt2.fits[sky=region(3c273.reg)]
dmextract infile="acisf00459N002_evt2.fits[sky=region(3c273.reg)][bin pi]" outfile=3c273.pi
opt=phal clobber=no verbose=0

Extract background spectrum 3c273_bg.pi from acisf00459N002_evt2.fits[sky=region(3c273_bg.reg)]
dmextract infile="acisf00459N002_evt2.fits[sky=region(3c273_bg.reg)][bin pi]" outfile=3c273_bg.pi
opt=phal clobber=no verbose=0
Inspecting events file acisf00459N002_evt2.fits[sky=region(3c273.reg)]
Inspecting background events file acisf00459N002_evt2.fits[sky=region(3c273_bg.reg)]
Running dmstat on source and background events files:

Source Event statistics: CHIP 7 280.28940217 373.73097826 SKY 4146.0548958 4045.9470477
Background Event statistics: CHIP 7 290.40277778 379.9537037 SKY 4144.8603323 4032.6548281

Look up FEF spectral calibration file(s)
Source FEF file is /data/CALDB/test_2/data/chandra/acis/cpf/fefs/acisD1999-09-16fef_phaN0002.fits
[FUNCTION][ccd_id=7,chipx=257:288,chipy=353:384]
Background FEF file is /data/CALDB/test_2/data/chandra/acis/cpf/fefs/acisD1999-09-16fef_phaN0002.
fits[FUNCTION][ccd_id=7,chipx=289:320,chipy=353:384]
Verified Source FEF file is present
Verified background FEF file is present

Source and background FEFs are different
Building different RMFs and ARFs for source and background

Make source RMF file 3c273.rmf with mkrmf
mkrmf infile=/data/CALDB/test_2/data/chandra/acis/cpf/fefs/acisD1999-09-16fef_phaN0002.fits[FUNCTION]
[ccd_id=7,chipx=257:288,chipy=353:384] outfile=3c273.rmf logfile=./.psp.mlog axis1=energy=0.1:11.0:0
01 axis2=pi=1:1024:1 clobber=no verbose=2

Created source RMF file 3c273.rmf

Make background RMF file 3c273_bg.rmf with mkrmf
mkrmf infile=/data/CALDB/test_2/data/chandra/acis/cpf/fefs/acisD1999-09-16fef_phaN0002.fits[FUNCTION]
[ccd_id=7,chipx=289:320,chipy=353:384] outfile=3c273_bg.rmf logfile=./.psp.bgmlog axis1=energy=0.1:1
0:0.01 axis2=pi=1:1024:1 clobber=no verbose=2

Created background RMF file 3c273_bg.rmf

Running asphist to create source aspect histogram 3c273.asphist
asphist infile="@pcad_asol1.lis" outfile=3c273.asphist evtfile="acisf00459N002_evt2.fits[ccd_id=7]"
Running mkarf to create source 3c273.arf at (4146.0548958,4045.9470477)
```

Make ACIS Spectrum/RMF/ARF – CIAO 3.4

```
mkarf detsubsyst=ACIS-S3 outfile=3c273.arf asphistfile="3c273.asphist" sourcepixelx=4146.0548958 sourcep
epixelx=4045.9470477 grating=HETG obsfile="3c273.asphist" pbkfile=NONE dafile=NONE maskfile=NONE
verbose=0 engrid="grid(3c273.rmf[MATRIX][cols ENERG_LO,ENERG_HI])" clobber=no
***ARLIB warning: Filename 3c273.asphist does not specify an extension. Assuming the first "interest
ing" extension.
Running mkarf to create background 3c273_bg.arf at (4144.8603323,4032.6548281)
mkarf detsubsyst=ACIS-S3 outfile=3c273_bg.arf asphistfile="3c273.asphist" sourcepixelx=4144.8603323 so
urcepixelx=4032.6548281 grating=HETG obsfile="3c273.asphist" pbkfile=NONE dafile=NONE maskfile=NONE
verbose=0 engrid="grid(3c273_bg.rmf[MATRIX][cols ENERG_LO,ENERG_HI])" clobber=no
***ARLIB warning: Filename 3c273.asphist does not specify an extension. Assuming the first "interest
ing" extension.

Group source spectrum using NUM_CTS 15
dmgroup infile=3c273.pi outfile=./3c273.tmp binspec= tabspec= grouptype=NUM_CTS grouptypeval=15 ycolu
mn=counts xcolumn=channel tabcolumn= clobber=no verbose=0
Source spectrum 3c273.pi has been grouped

Group Background spectrum using BIN=1:1024:20
dmgroup infile=3c273_bg.pi outfile=3c273_bg_grp.pi binspec="1:1024:20" tabspec= grouptype=BIN groupty
peval= ycolumn=counts xcolumn=channel tabcolumn= clobber=no verbose=0
Background spectrum 3c273_bg_grp.pi has been grouped

Updating PHA file 3c273.pi with BACKFILE RESPFILE ANCRFILE keys
Background spectrum (BACKFILE) = 3c273_bg.pi
SOURCE RMF (RESPFILE) = 3c273.rmf
SOURCE ARF (ANCRFILE) = 3c273.arf
Updating PHA file 3c273_bg_grp.pi with RESPFILE ANCRFILE key
BACKGROUND RMF (RESPFILE) = 3c273_bg.rmf
BACKGROUND ARF (ANCRFILE) = 3c273_bg.arf
```

The ARDLIB warning may be ignored as it does not adversely affect the output.

Important: the output source spectrum (in this case, 3c273.pi) is grouped if a grouping was specified; currently there *is not* an ungrouped spectrum created in this case.

The contents of the parameter file may be checked with [plist psextract](#).

Creating an RMF with mkacisrmf

If you would like to create a new RMF with the `mkacisrmf` tool after running this script, follow the instructions in the [Using mkacisrmf with the psextract script section](#) of the [mkacisrmf thread](#).

Update Background File Header

Currently `psextract` only updates the RESPFILE and ANCRFILE header keywords in the source and grouped background file. These should be added to the ungrouped background file as well, in order to integrate more smoothly with *Sherpa*.

```
unix% dmhedit infile=3c273_bg.pi filelist="" operation=add key=RESPFILE value=3c273_bg.rmf
unix% dmhedit infile=3c273_bg.pi filelist="" operation=add key=ANCRFILE value=3c273_bg.arf
```


Notes

There are several things to note about how the tool works:

- Due to the satellite dithering, a point-like source can in principle move across all 4 nodes of a single chip (or different chips) during the observation. This tool builds ARFs and RMFs for the position occupied by the source during most of its exposure (> 50 %).
- The output source and background spectra are by default created in the PI channel space, and so are the respective response matrices. To create PHA output files, set the `ptype` parameter to `pha`:

```
unix% pset psextract ptype=pha
```

- `psextract` uses a hardcoded binning for the RMF of `axis2 = (energy=0.1:11.0:0.01)`, which defines the binning to go from `Emin=0.1 keV` to `Emax=11 keV` in steps of 0.01 keV.

Analysis Caveats

Users should be cautious about analyzing the data for sources near the edges of the ACIS CCDs.

1. For X-rays passing through the mirrors, the very bottom of each CCD is obscured by the frame store. As a result, some of the events in rows with `CHIPY <= 8` are not detected. (The set of rows affected varies from CCD to CCD.) Since the CIAO tools do not compensate for this effect, the ARFs and exposure maps for sources in these regions may be inaccurate.
2. For sources within about thirty-two pixels of any edge of a CCD, the source may be dithered off the CCD during part of an observation. The aspect histogram, which is used to create ARFs and exposure maps, is designed to compensate for this effect.
3. A contaminant has accumulated on the optical-blocking filters of the ACIS detectors, as described in the [ACIS QE Degradation why topic](#). Since there is a gradient in the temperature across the filters (the edges are colder), there is a gradient in the amount of material on the filters. (The contaminant is thicker at the edges.) Within about 100 pixels of the outer edges of the ACIS-I and ACIS-S arrays, the gradient is relatively steep. Therefore, the effective low-energy (< 1 keV) detection efficiency may vary within the dither pattern in this region. The ARF and instrument map tools are designed to read a calibration file which describes this spatial dependence.

Fitting

If you would like to fit the background-subtracted source spectrum using a common RMF and ARF for source and background, simply read the source spectrum FITS file into *Sherpa*, subtract the background, and fit it. See the [Introduction to Fitting PHA Spectra](#) thread for details.

To fit source and background spectra simultaneously with proper and distinct RMFs and ARFs, load the source and background as different datasets. This procedure is discussed in the [Independent Background Responses](#) thread.

Summary

The thread is now complete. The source and the ungrouped background spectra are named `3c273.pi` and `3c273_bg.pi`; the grouped background spectrum is named `3c273_bg_grp.pi`. The source and background (common) RMF is named `3c273.rmf`, while source and background ARFs are named `3c273.arf` and `3c273_bg.arf` respectively.

Parameters for `/home/username/cxcds_param/psextract.par`

```

events = acisf00459N002_evt2.fits[sky=region(3c273.reg)] Source events specification
bgevents = acisf00459N002_evt2.fits[sky=region(3c273_bg.reg)] Background events specification
root = 3c273 Root name for output files
asol = @pcad_asol1.lis Source aspect solution file
bgasol = Background aspect solution file
(pbkfile = NONE) NONE, or name of the parameter block file
(dafile = NONE) CALDB, NONE, or name of ACIS dead-area calibration file
(ptype = pi) pi or pha
(gtype = NUM_CTS) Spectrum grouping type (same as grouptype in dmgroup)
(gspec = 15) Spectrum grouping specs (NONE,1:1024:10,etc)
(clobber = no) OK to overwrite existing output file?
(verbose = 2) Debug Level(0-5)
(mode = ql)

```

History

- 14 Dec 2004 updated for CIAO 3.2: created [Using Consistent Calibration](#) and [Downloading the Scripts](#) sections
- 23 Jun 2005 CIAO 3.2.2 patch: new calibration for `mkacisrmf` is available; see the [Using Consistent Calibration: mkrmf vs mkacisrmf](#) section
- 15 Dec 2005 updated for CIAO 3.3: the `psextract` script has been updated to version 3.3 for the new `asphist` tool syntax; note about `specextract` in the Overview; default value of `dmextract` error and `bkgerror` parameters is "gaussian" (this tool is called by `psextract`)
- 01 Feb 2006 added link to [specextract thread](#)
- 31 Mar 2006 `specextract` use update added to Overview; title changed from "Extract ACIS Spectra for Pointlike Sources and Make RMFs and ARFs" to "Using `psextract` to Extract ACIS Spectra and Response Files for Pointlike Sources"
- 14 Jun 2006 corrected link in "Calibration Updates"; clarified information on GRADED mode data
- 25 Jul 2006 added [Creating an RMF with mkacisrmf](#) section, moved "Using Consistent Calibration: mkrmf vs mkacisrmf" section
- 01 Dec 2006

Make ACIS Spectrum/RMF/ARF – CIAO 3.4

updated for CIAO 3.4: psextract version 3.4 (mkarf obsfile parameter is set to event file instead of asphist file); acis_fef_lookup version 1.19 (changes for CTI lookup)

02 Feb 2007 updated for CALDB 3.3.0.1 patch

26 Feb 2007 psextract v4.0 and acis_fef_lookup v1.20: Dead area correction parameters added to the psextract.par file: pbkfile and dafile (added ACIS dead area correction section). Script prints a warning if RMF should be remade with mkacisrmf. Several other minor code changes that don't affect the output files (see the Script History page for details).

31 Mar 2008 updated for CALDB 3.4.3: use mkacisrmf for -110 BI chips if TGAIN calibration has been applied

URL: <http://cxc.harvard.edu/ciao/threads/psextract/>

Last modified: 31 March 2008

Image 1: Extraction regions overlaid on the image

