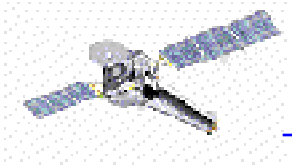
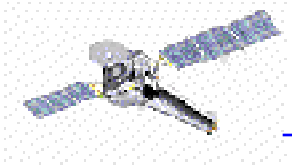


Analysis of ACIS data

- Use the CIAO analysis threads at

  http://cxc.harvard.edu/ciao/documents_threads.html

- Write paper



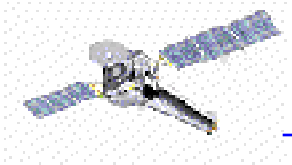
1: Data

The observation data comes on CD from the CXC or from the Chandra Data Archive, via ***ChaSeR***.

What issues affect my data?

- Observation date (DATE-OBS)
- Pipeline/processing version (ASCDSVER)
- CALDB version (CALDBVER)
- Observing mode (DATAMODE, READMODE)

```
unix% dmlist acisf00548N002_evt2.fits header,clean | egrep \
        'DATE | DATE-OBS | ASCDSVER | CALDBVER | READMODE | DATAMODE'
ASCDSVER          R4CU5UPD12.1              ASCDS version number
DATE              2000-11-29T10:39:06       Date and time of file creation
DATE-OBS          2000-02-27T03:25:15       Date and time of observation start
CALDBVER          1.8
DATAMODE          FAINT                     Data mode
READMODE          TIMED                     Read mode
```



More recent ASCDSVER keywords look like DS6.0.0.

Where are the issues listed?

- **http://cxc.harvard.edu/ciao/data.html**

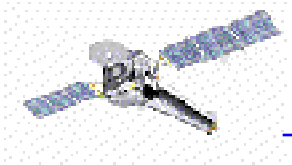
- **http://cxc.harvard.edu/ciao/data_datacaveats.html**
- **http://cxc.harvard.edu/ciao/caveats/acis_caveats.html**

- **http://cxc.harvard.edu/proc_stat/rel_notes/**
- **http://cxc.harvard.edu/caldb/version_release_notes.html**

- Workshop pages

It's also important to understand any issues that may be present in the current CALDB:

http://cxc.harvard.edu/cal/Cal_Status_Report.html



http://cxc.harvard.edu/ciao/documents_threads_data.html

2: Data preparation

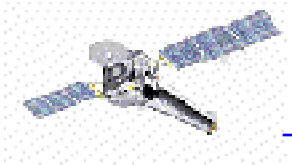
If your data has not been processed recently, it is almost certainly worth *re-processing* it using acis_process_events rather than worry about it...

Thread: Create a New Level=2 Events File

Goes from the L1 to a new L2 events file:

- Apply the latest gain correction (PHA to ENERGY/PI)
- "Randomize" the PHA and pixel positions
- Apply the "L2" filters (grade, status, GTI)

It's more complicated for grating data since you have to create the L1.5 file as well.



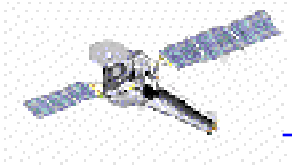
Optional filters are:

- Flag background events if in VFAINT mode
- Flag "after glow" events (acis_detect_afterglow)
- Flag "streak" events on ACIS-S4 (destreak)

The acisreadcorr tool can be used to flag "out-of-time" events (ie those associated with the readout streak, which is different from the streaks that destreak removes). A thread will soon be available to describe the necessary steps.

Thread: Use Observation-specific Bad Pixel Files

Use the bad-pixel mask appropriate for your dataset. Be careful when analyzing multiple datasets: always reset ardlib or have a parameter directory for each dataset.

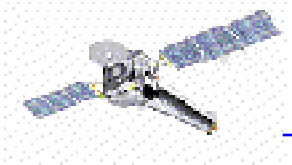


Common ACIS issues:

- How good is the astrometry?

Thread: Improving the astrometry of your data

Most re-processed ACIS-I observations show an offset of up to 1.5" for which there's a simple fix. You may also want to cross-correlate X-ray sources with those from another catalgoue to improve the positions. The align_evt software (available from the Software Exchange page via the thread) allows you to easily combine multiple observations of the same field.



- Are there any background flares?

Thread: Filtering Light Curves

As shown in the "X-ray Data Analysis" talk on Monday, the ACIS chips (particularly the BI ones) are susceptible to flares in the proton background. A lightcurve (ie count rate as a function of time) of the background (if you have any) can be used to search for flares.

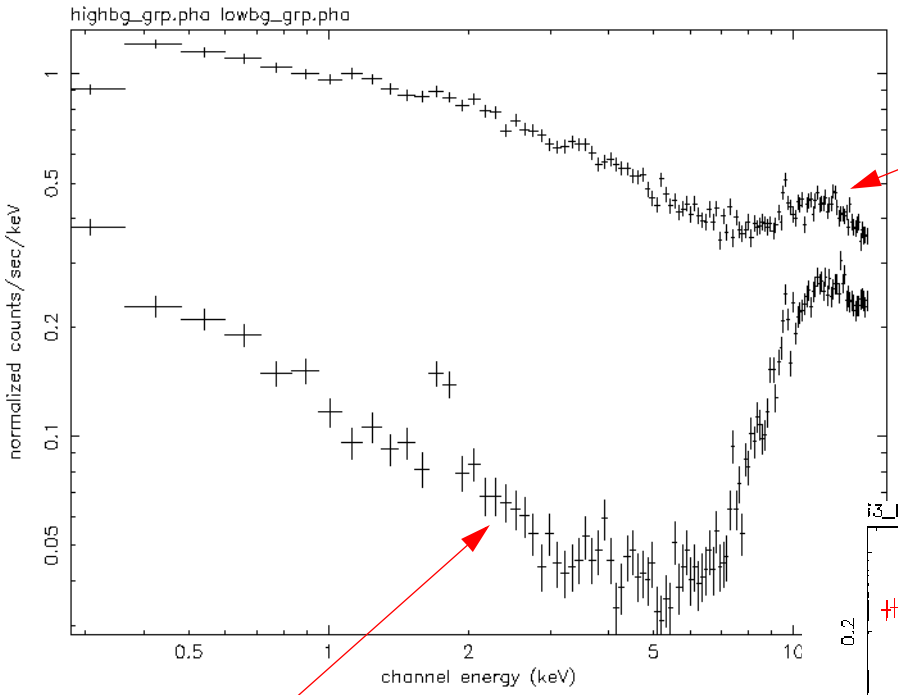
Thread: ACIS Background Subtraction (Blank-Sky Files)

If you are going to be using the "blank-sky files" available from the CALDB then you must filter your data in the same manner as the background files.

Suggested reading:

http://cxc.harvard.edu/cal/Links/Acis/acis/Cal_prods/bkgrnd/current/background.html

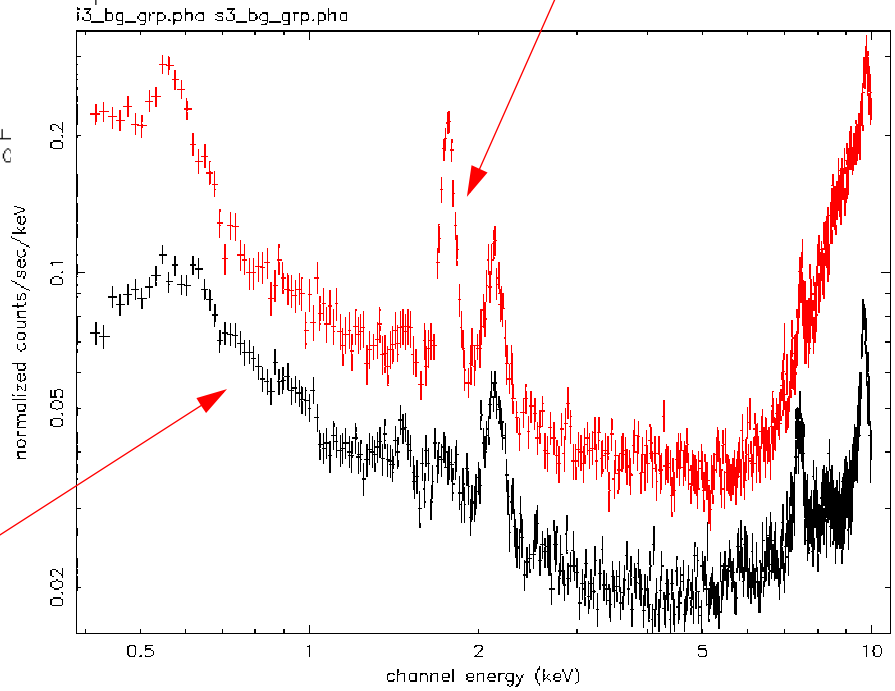
Figures from M. Markevitch



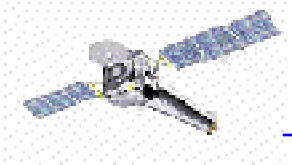
Flare

Quiescent

BI quiescent



FI quiescent



http://cxc.harvard.edu/ciao/documents_threads_timing.html

- Timing Analysis

Thread: Apply Barycenter Correction
Thread: Create a Phase-binned Spectrum

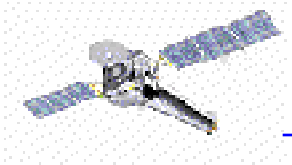
- CTI Correction

CIAO 2.2.1 does not contain any code to remove the effect of CTI from your data. There will be CIAO software and calibration products to do this but we do not yet have a release date.

It is possible to use the PSU corrector, available from

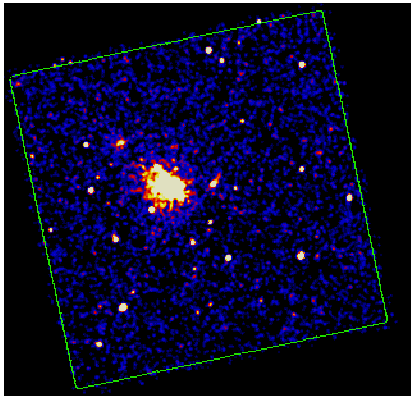
http://www.astro.psu.edu/users/townsley/cti/

but note that you then *must* use their QEU and RMF files and not the ones from CALDB and created by mkrmf respectively.



http://cxc.harvard.edu/ciao/documents_threads_imag.html

3: Image Analysis



- What does the data look like?

ds9 is your friend, as is dmcopy.

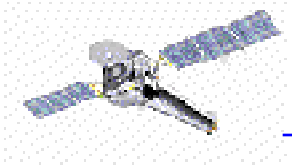
Thread: Using SAOImage ds9

- Where are the individual chips?

A quick & easy way is to use dmstat and a DM filter:

```
unix% dmstat evt2.fits"[ccd_id=3][cols sky]"median-sigma- | egrep 'min|max'
   min:        ( 3722.4834 3036.44702 )
   max:        ( 4954.45459 4273.25586 )
```

A more ingenious (hence slower) solution is to use dmcontour to create a region file describing the exposure map for the chip.



Regions are also your friend

Thread: Using CIAO Region Files

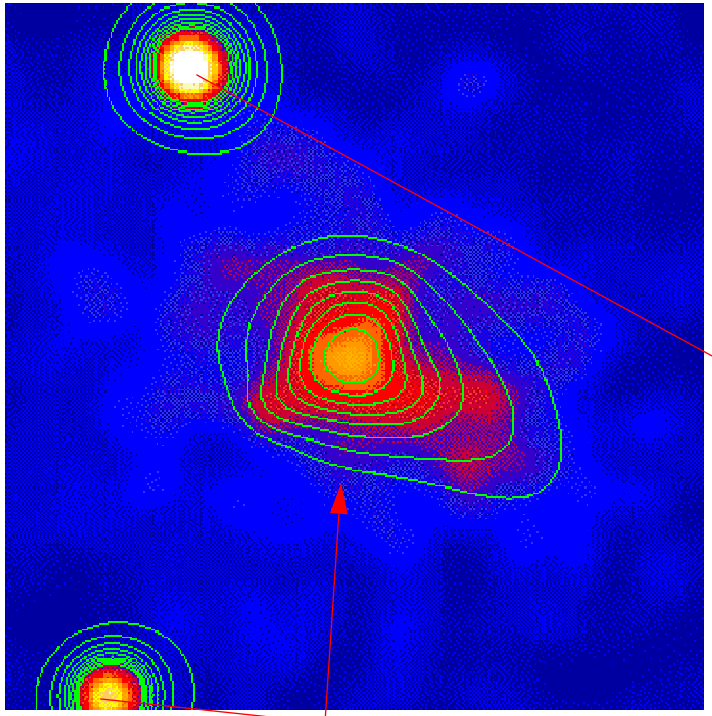
- Source detection

Thread: Detecting Sources in Imaging Observations - Overview

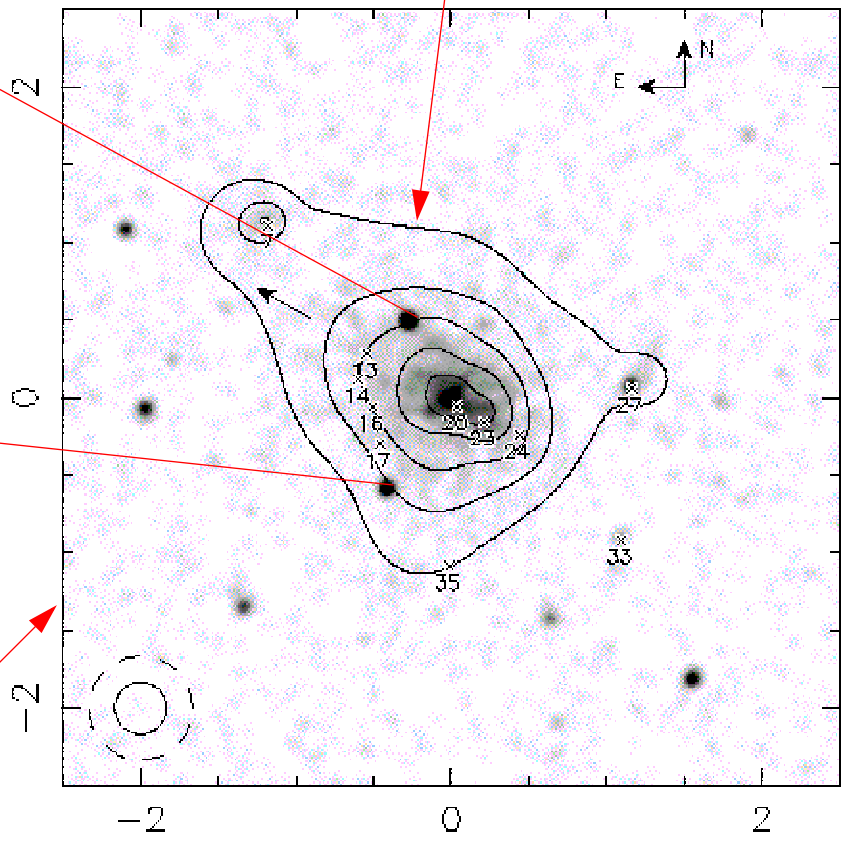
- Diffuse emission

wavdetect and vtpdetect may detect extended emission, depending on the extent and surface brightness. Other CIAO tools can be used to highlight such regions, such as aconvolve or csmooth - to smooth the data - and this can be done with *or* without point sources (dmfilth).

Thread: Create an Image of Diffuse Emission

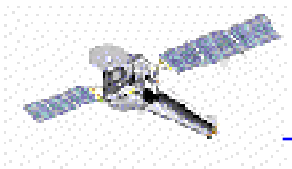


contours: csmooth run on output of dmfilth

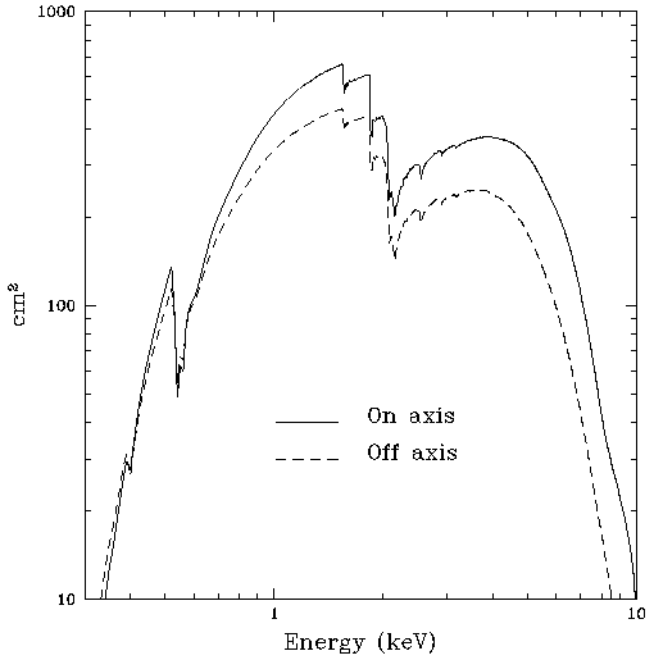


contours: output of wavdetect

Image smoothed by a gaussian (aconvolve)



- Fluxes & Instrumental effects

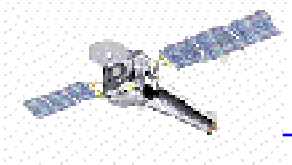


To convert a count (rate) to a flux we need the effective area - aka the ARF - for the source or the exposure map (effectively the integrated ARF).

Since the ARF varies with energy, the exposure map depends on how you decide to "integrate" over energy: pick a single energy; analyze your data in small energy bands in which you assume the response is flat; weight the sum by a spectral model.

The exposure map also takes out instrumental effects such as chip gaps/edges and bad pixels/columns.

Thread: Compute Single Chip ACIS Exposure Map and Fluxed Image Step-by-Step



- Spatial analysis

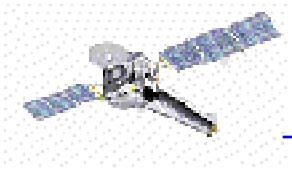
The counts within a region can be as simple as dmstat + DM filter. When used on an image with a spatial filter, use the "opt null" modifier (see ahelp dmstat) to account for those pixels in the image but excluded by the filter.

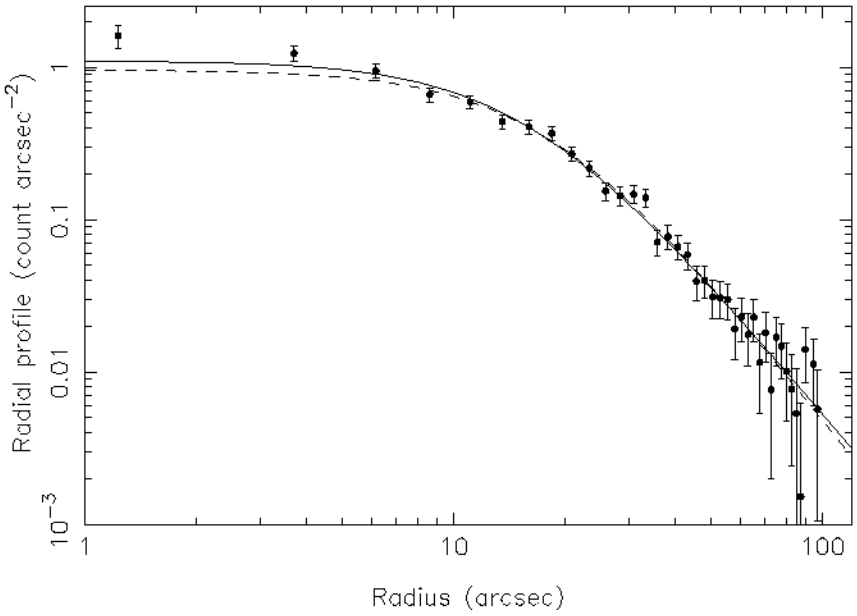
The dmextract tool is versatile: as well as binning on PI or PHA to produce a spectrum, it can bin on TIME to create a lightcurve and can even handle vector columns such as SKY which allows it to be used to calculate source counts for regions.

Thread: Estimate Source Counts in an Image

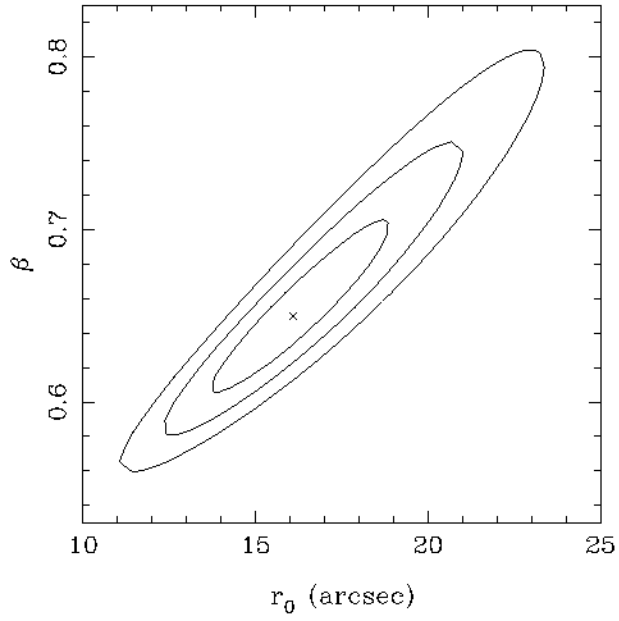
Since radial profiles are just counts within annular regions, it can therefore create radial profiles of your source.

Thread: Obtain and Fit a Radial Profile





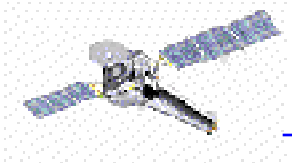
Radial profile with best fit models



Confidence contours from Sherpa

It is also possibel to fit two-dimensional spatial models to your images with Sherpa and analyze the residuals (e.g. smooth them with aconvolve to look for substructure). The PSF may be of interest too.

Thread: Create a PSF



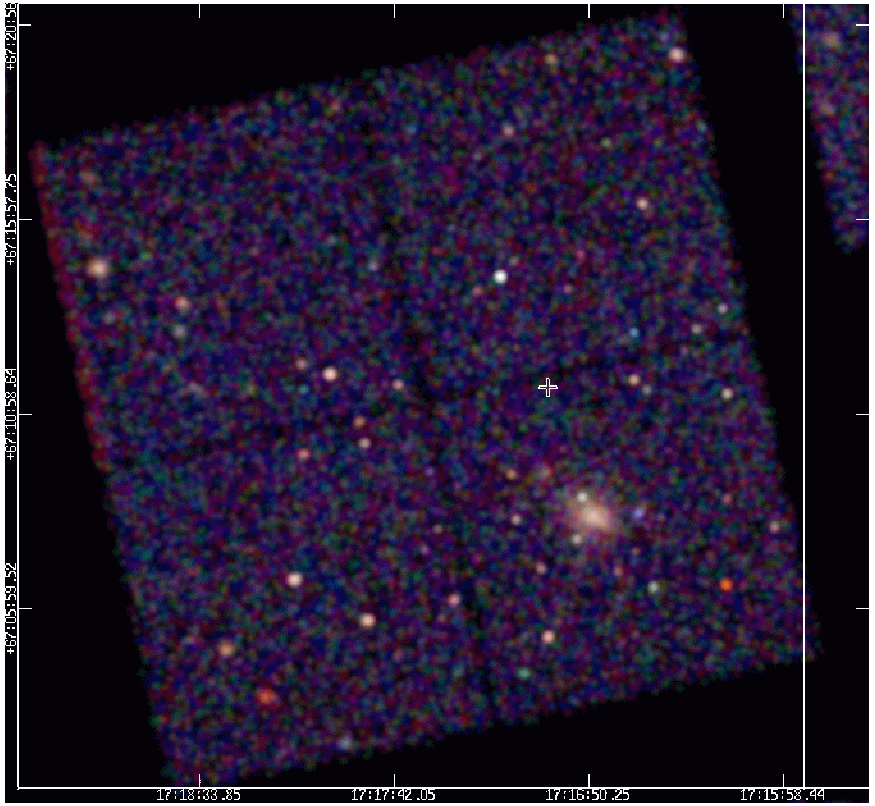
4: Imaging spectroscopy

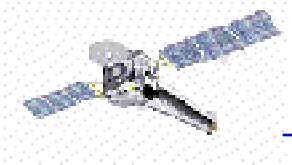
An easy/quick way to understand the spectral differences of source regions in your data is to create a "true color" image.

Thread: Create A True Color Image

Some of the variation is "instrumental", since the PSF and ARF change with off-axis distance.

Note that the three images need not all be X-ray images; dmimg2jpg has been used to combine X-ray and radio data.





http://cxc.harvard.edu/ciao/documents_threads_ispec.html

- Obtaining a source spectrum

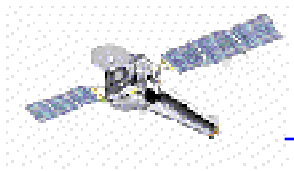
For point-like sources, the psextract script provides a simple means of obtaining the spectrum and necessary response files (ARF and RMF).

Thread: Extract ACIS Spectra for Pointlike Sources and Make RMFs and ARFs

There is also the acisspec script available from

http://cxc.harvard.edu/ciao/download_scripts.html

which can be used to coadd spectrum (even though Peter Freeman tells us not to do this) and calculate spectra of extended sources using weighted responses. Thread coming soon.



- Is my source an "extended" sour ce?

We do not have calibration data for each pixel, so the RMF is assumed constant over small regions (for a focal-plane temperature of -120 C the smallest-such region is 32x32 pixels for S3, the largest is 256x32 for the FI devices). By looking at the photon distribution in CHIP coordinates we can see how many such response regions our source covers.

Thread: Displaying the FEF Regions Covered by a Source

Thread: Weighting ARFs and RMFs: multiple sources

(the weightfile created by mkwarf also shows how the source counts are distributed across these response tiles)