



# Simplifying Chandra Aperture Photometry With srcflux

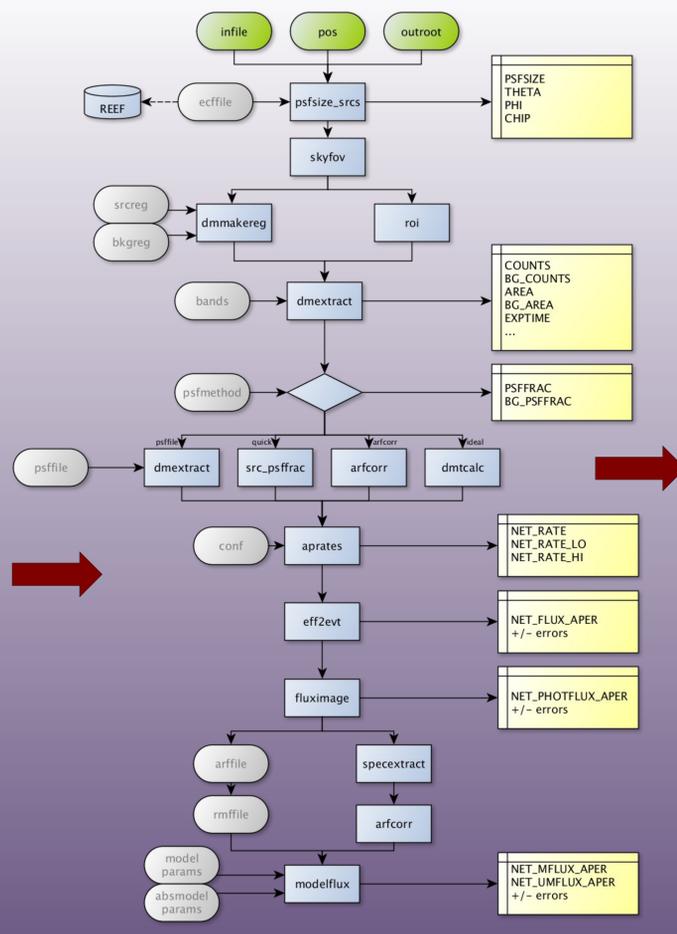
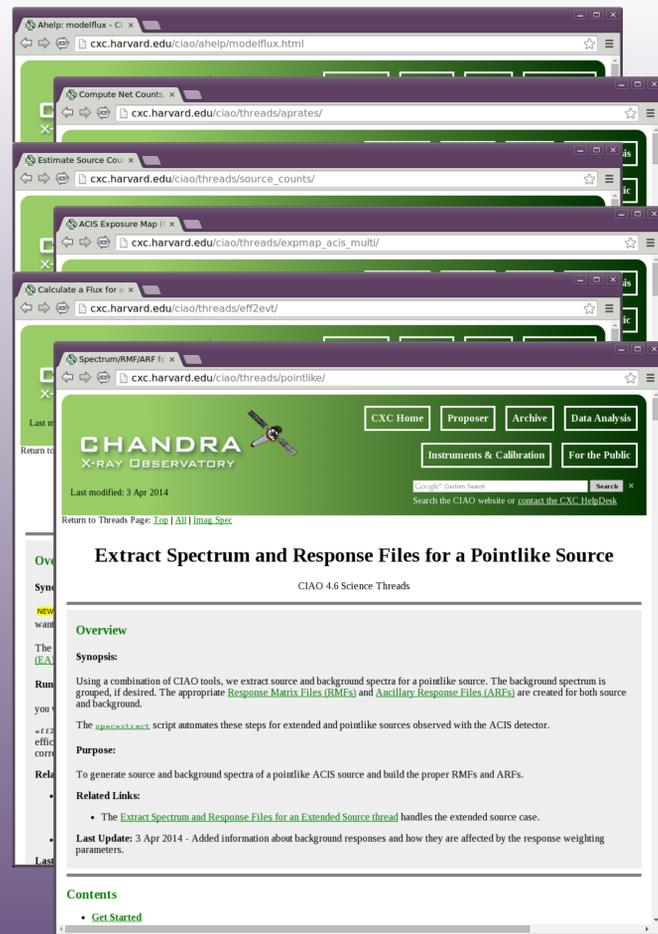
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As part of the ongoing effort to simplify Chandra data analysis for both novice and expert users, the srcflux script has been released. This script automates the steps necessary to compute net source counts, count rates, photon fluxes, as well as model-independent and model-dependent fluxes. For casual users it provides a simple interface with sensible defaults to determine robust flux estimates for a single source. For expert users it has the flexibility to iterate over multiple sources, multiple energy bands, using customized extraction regions, arbitrary confidence limits, and arbitrarily complex spectra models. The script is built on core CIAO components (eg CXC Datamodel, dmextract, sherpa) and uses existing frameworks to run tasks in parallel to maximize CPU utilization.

<http://cxc.harvard.edu/ciao/ahelp/srcflux.html>

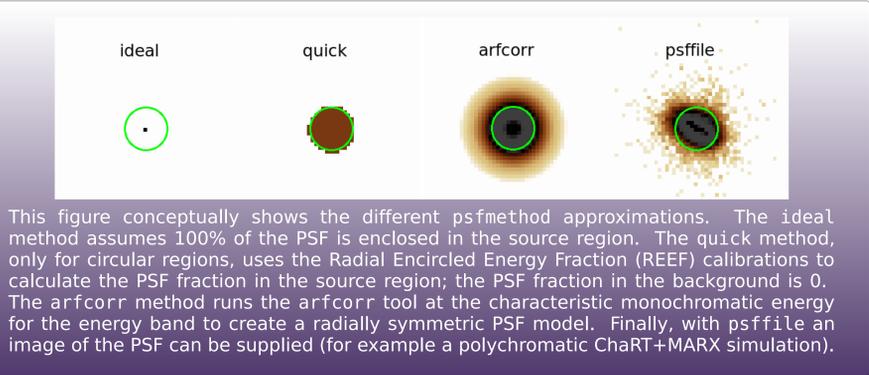


```
% srcflux acisf04425_repro_evt2.fits "11:33:04.923 +25:53:55.14" grb030226
srcflux
  infile = acisf04425_repro_evt2.fits
  pos = 11:33:04.923 +25:53:55.14
  outroot = grb030226
  bands = broad
  srcreg =
  bkgreg =
  bkgresp = yes
  psfmethod = ideal
  psffile =
  conf = 0.9
  binsize = 1
  rmfile =
  arffile =
  model = xspshabs.abs1*xspowerlaw.powl
  paramvals = abs1.nH=0.0;powl.PhIndex=2.0
  absmodel =
  absparams =
  abund = angr
  fovfile =
  asolfile =
  mskfile =
  bpixfile =
  dtffile =
  ecffile = CALDB
  parallel = yes
  nproc = INDEF
  tmpdir = /tmp
  clobber = no
  verbose = 1
  mode = ql

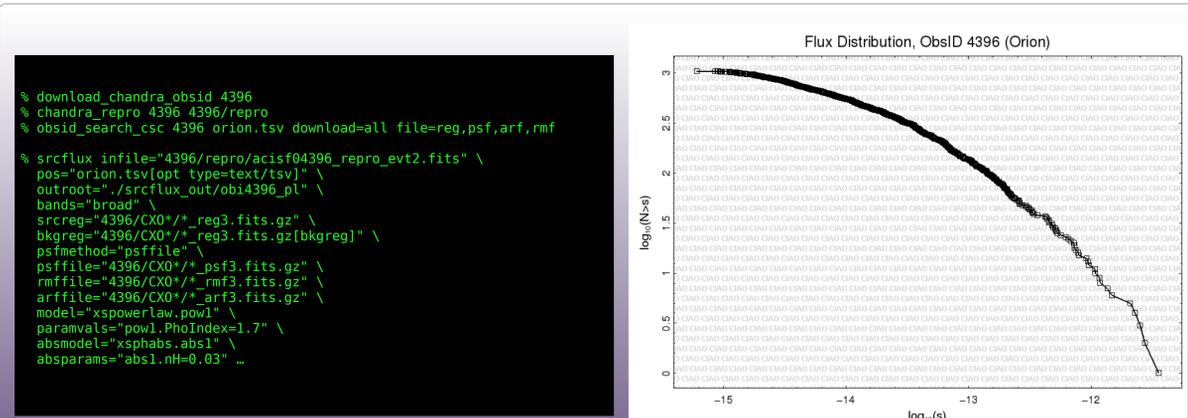
Extracting counts
Setting Ideal PSF : alpha=1 , beta=0
Getting net rate and confidence limits
Getting model independent fluxes
Getting photon fluxes
Running tasks in parallel with 4 processors.
Running eff2evt for grb030226_broad_0001_src.dat
Running eff2evt for grb030226_broad_0001_bkg.dat
Running aprates for grb030226_broad0001_rates.par
Making response files for grb030226_0001
Running modelflux for region 1
Adding net rates to output
Appending flux results onto output
Appending photflux results onto output
Computing Net Fluxes
Adding model fluxes to output
Scaling model flux confidence limits

Summary of source fluxes
Position          0.5 - 7.0 keV
Value             90% Conf Interval
11 33 4.92 +25 53 55.1 Rate      0.00816 c/s (0.00738, 0.00894)
Flux              4.81E-14 erg/cm2/s (4.35E-14, 5.27E-14)
Mod.Flux         4.49E-14 erg/cm2/s (4.06E-14, 4.92E-14)
```

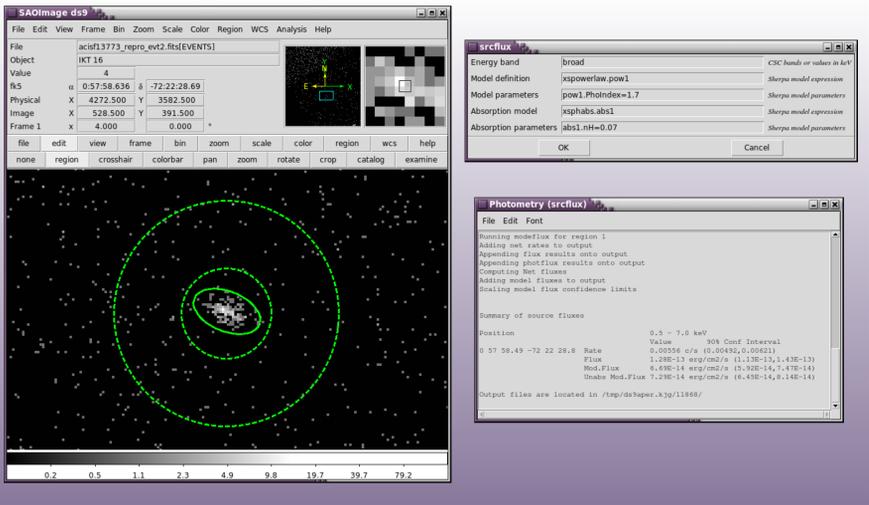
(Left) CIAO provides many tools and threads that show how to extract counts, rates, and fluxes in various units. (Center) The srcflux script combines the logic of at least six different threads. Only 3 parameter are necessary: infile, position, and outroot. The script has reasonable defaults for the other parameter and will locate or regenerate the other data products it requires. The additional parameter are provided to allow user to optimize the output for their science goals. (Right) Shows the output with all the default parameters. The key points are (A) given an input position, the tool will create a source region that encloses 90% of the 1.0keV PSF and a background annulus with an outer radius equal to 5 times the source (inner) radius. (B) The Chandra Source Catalog (CSC) bands<sup>1</sup> can be used by name; the CSC broad band is 0.5 to 7.0 keV. (C) There are different options to include PSF corrections which are shown below. (D) The script will take advantage of multi-core CPUs to run individual CIAO tools in parallel. (E) The net count rate, model independent flux (eff2evt), and flux assuming the specific spectral model (modelflux) are reported to the terminal as well as saved in the output file : grb030226\_broad.flux which contains other columns including the photon flux (photon/cm2/s) as well as other ancillary information such as source and background counts, area, and coordinates.



This figure conceptually shows the different psfmethod approximations. The ideal method assumes 100% of the PSF is enclosed in the source region. The quick method, only for circular regions, uses the Radial Encircled Energy Fraction (REEF) calibrations to calculate the PSF fraction in the source region; the PSF fraction in the background is 0. The arccorr method runs the arccorr tool at the characteristic monochromatic energy for the energy band to create a radially symmetric PSF model. Finally, with psffile an image of the PSF can be supplied (for example a polychromatic ChART+MARX simulation).



srcflux provides the flexibility to process multiple sources, using user specified regions, response files, and spectral models. As shown in this example it requires only four commands to download and processes all 1,040 sources included in the Chandra Source Catalog for ObsID 4396 (Orion). The srcflux command will iterate over all the sources using multiple CPUs to complete the catalog. (Right) Shows the flux distribution log(N)-log(s) plot for the unabsorbed flux assuming a powerlaw with slope=1.7 and nH=0.03.



srcflux can be run directly from within ds9. Using the latest CIAO 4.6.7 contributed software package release users will find it as Analysis -> CIAO -> Statistics -> Photometry (srcflux). Users simply draw a source and background region, provide a few simple parameters (or choose the defaults) and the task will run in the background to locate or create all the ancillary files it needs. The screen output is captured to a text window and the output files (spectrum, ARF, RMF, and fluxes) are saved in a temporary directory for more detailed analysis. Watch a demo at

<http://youtu.be/wvDzJQRVvo8>



- Other features include:
- Provides upper limits on faint sources. It will also report if a source position is entirely off the detector as might happen if starting with a non X-ray catalog.
  - Spectra, RMF, and ARF files are provided for more detailed spectral analysis
  - Output file contains additional properties: coordinates (detector and off-axis angles), areas, PSF fractions, surface brightness

- Future enhancements:
- Simulate the PSF directly within srcflux by running SAOTrace and/or MARX.
  - Automatic look-up of nH from either the spectrum or by running prop\_colden.
  - Integrate next generation aperture photometry tool<sup>2</sup> to better deal with overlapping sources
  - Support stack/merged observations
  - External background files
  - Save additional data products such as postage stamp images and exposure maps along with flux probability density functions.
  - Perform additional types of analysis, for example running srcextent

References:  
<sup>1</sup>Evans et al 2010, ApJS 189, 37  
<sup>2</sup>Primini and Kashyap, 2014 Astrophys. J. 796 24

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