ACIS Extract : A *Chandra*/ACIS Tool for Automated Point Source Extraction and Spectral Fitting

Applied to the Rosette, M17, & Orion Star-forming Regions

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INTRODUCTION

ACIS Extract (AE) is a computer program (IDL) that can assist the observer in performing the many tasks involved in analyzing the spectra of large numbers of point sources observed with the ACIS instrument on *Chandra.*

The **starting point** for AE is cleaned and calibrated X-ray event data, possibly from multiple ACIS observations, plus a catalog of point sources derived from those data.

;; Source Name	RA	DEC	PSF_FRAC	@energy
063344.47+042905.1	98.435294	4.484754	0.900	1.49670
063255.18+043651.3	98.229946	4.614259	0.900	1.49670
063457.28+043535.2	98.738690	4.593124	0.607	1.49670
063217.36+044927.9	98.072363	4.824423	0.787	1.49670
063224.46+045223.6	98.101944	4.873247	0.900	1.49670

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The **ending point** for AE and its several accessory tools is a set of spectral model fit parameters and light curves for each source, plus a wide variety of statistical properties of the sources.

Table 1. X-ray photometric properties

Source	RA_{2000}	DEC_{2000}	C_{tot}	HR_{vm}	HR_{ms}	HR_{hs}	F_{soft}	F_{hard}	F_{full}
182026-3-160926	275.08078	-16.15713	213	$-0.57^{+0.09}_{-0.07}$	$-0.00^{+0.05}_{-0.06}$	$-0.01^{+0.02}_{-0.07}$	4.16E-06	1.61E-05	1.72E-05
182021-2-161207	275.08936	-16.20184	374	$-0.31^{+0.06}_{-0.05}$	$0.14^{+0.02}_{-0.02}$	$0.14^{+0.02}_{-0.02}$	3.96E-06	2.69E-05	3.06E-05
182028-2-161040	275.11733	-16.18031	563	$-0.34^{+0.05}_{-0.05}$	$0.26^{+0.02}_{-0.02}$	$-0.06^{+0.02}_{-0.02}$	8.16E-06	3.78E-05	4.42E-05
182030-2-161055	275.12955	-16.18212	556	$-0.28^{+0.05}_{-0.05}$	$0.64^{+0.02}_{-0.02}$	$0.16^{+0.02}_{-0.02}$	1.78E-06	2.44E-05	2.29E-05
182030-3-161131	275.12921	-16.19201	251	$-0.32^{+0.08}_{-0.06}$	$0.20^{+0.03}_{-0.03}$	$-0.13^{+0.03}_{-0.03}$	3.90E-06	1.61E-05	1.96E-05
182032-0-161620	275.13327	-16.17506	258	$-0.47^{+0.06}_{-0.07}$	$0.51^{+0.02}_{-0.02}$	$0.37^{+0.02}_{-0.02}$	3.03E-06	3.42E-05	3.06E-05

FEATURES

Data processing tasks addressed by AE and its accessory tools include:

* **Refining** the accuracy of source **positions.**
* Assisting the observer in **reviewing the catalog** for spurious and crowded sources.
* Defining **extraction regions** that are contours of the local PSF.
* Defining **mask regions** that completely cover the sources (to facilitate derivation of background spectra and extended emission studies).
* Extraction of **source spectra.**
*Extraction & scaling of local **background spectra.**
*Grouping of source spectra.
*Computation of **instrument responses** (RMFs & ARFs).
* Corrections to the ARFs to account for the **energy-dependent PSF fraction** enclosed by the extraction regions.
*Computation of **binned light curves, adaptively smoothed light curves, median energy time series, and K-S tests** for variability.
* **Automated spectral fitting.**
* **Review** of fitting results, and **compilation** of results into LaTeX tables

Notably, all these tasks are performed in a context that may include **multiple observations of the field.**

A variety of **interactive plots** are produced showing various source properties across the catalog.

A variety of **source metrics and statistics** (e.g. mean position of extracted events, light curve variability) are computed, displayed, and saved as IDL variables for further manipulation by the user.

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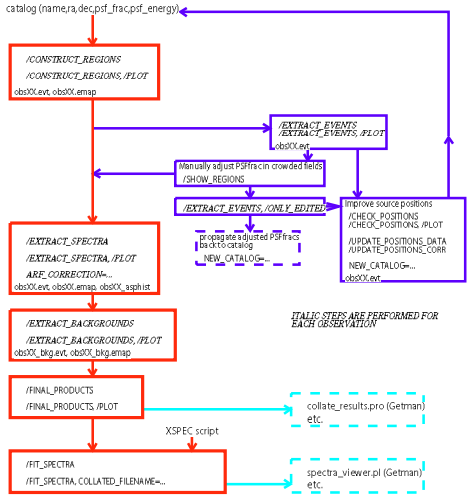
The authors happily acknowledge that AE is derived from the ideas,software, and testing efforts of David Alexander, Keith Arnaud, George Chartas, Eric Feigelson, Nicolas Grosso, Scott Koch, Bertil Olsson,Yohko Tsuboi, and the authors of various CIAO threads and manuals.



OVERVIEW OF AE STAGES

DETAILS

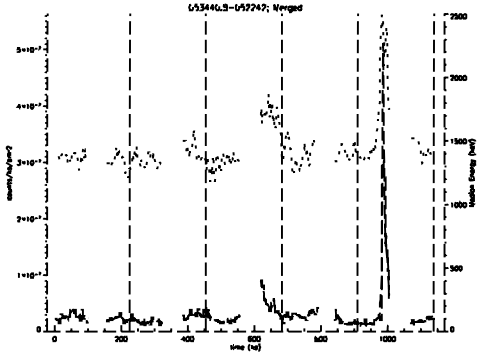
For individual observations:

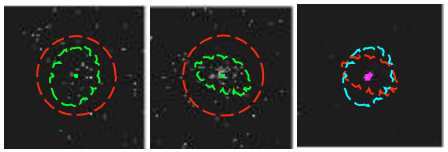
* ARFs computed correctly for **sources that span CCDs**.
* RMFs are either computed with **mkrmf** or chosen from the RMF library associated with the **PSU CTI corrector** (Townsley et al. 2002, NIM-A 486, 751).
* **Local background spectra** obtained from "swiss-cheese" (sources removed) data set.
* **Scaling of background spectra** takes into account exposure differences (not simply geometric areas) in source and background regions.

For multiple observations:

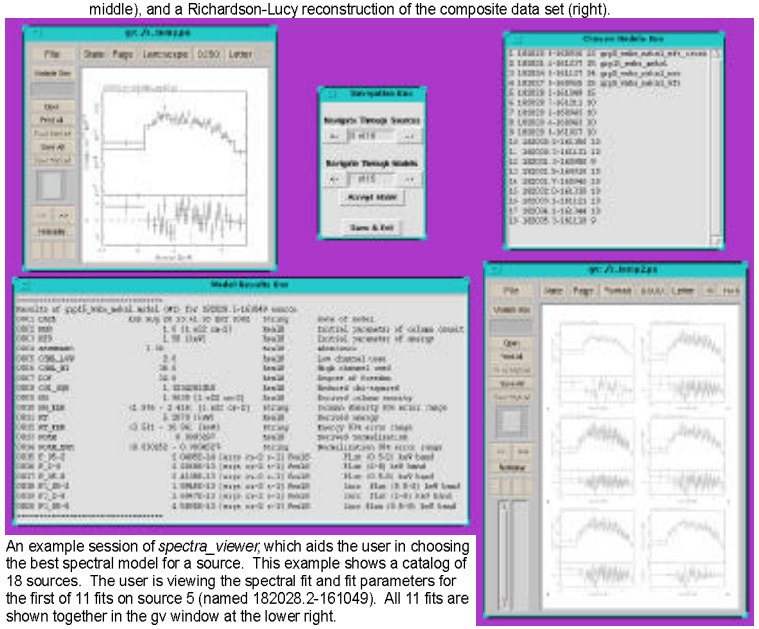
* **Composite source images & PSFs** are constructed, then correlated to improve source position estimates.
* Composite **neighborhood images reconstructed** (Richardson-Lucy) to help find missed crowded sources.
* **Composite** source & scaled background **spectra** are computed.
* **Composite RMFs & ARFs** are computed.
* **Photometry** is performed over observer-supplied energy bands.

* Binned light curves, adaptively smoothed **light curves, & median energy time series** from each observation are **plotted** (example right).





AE's CHECK_POSITIONS stage displays the source's data and extraction region in ds9 for all observations. This example shows 2 observations of an off-axis source (left & middle), and a Richardson-Lucy reconstruction of the composite data set (right).



An example session of *spectra_viewer,* which aids the user in choosing the best spectral model for a source. This example shows a catalog of 18 sources. The user is viewing the spectral fit and fit parameters for the first of 11 fits on source 5 (named 182028.2-161049). All 11 fits are shown together in the gv window at the lower right.

IMPLEMENTATION

The implementation strategy for AE was to use **CIAO tools** for specific computations whenever possible, and **ds9** for display and editing of extraction regions. Thus, for example, ARFs are computed by the CIAO tool mkarf, although AE significantly manipulates those ARFs to account for non-unity PSF fraction, sources that span CCDs, and multiple observations.

AE is called multiple times, with specific functionality governed by the choice of keywords. Each processing stage is followed by a plotting stage to allow users to check results.

Automated spectral fitting is performed via **XSPEC scripts**. Example scripts for common spectral models are included in the release package.

The tool *spectra_viewer* (Perl) allows the user to **browse multiple spectral fits** for a given source, choose the most appropriate fit, & **tabulate the fit properties.**

Perl scripts are used to collate photometry and spectral fit parameters into **LaTeX tables** appropriate for direct inclusion in journal articles.

WHERE'S THE CODE?

ACIS Extract, with a 48-page User's Guide:
http://www.astro.psu.edu/xray/docs/TARA/ae_users_guide.html

Accessories:
http://www.astro.psu.edu/users/gkosta/AE/accessory_tools.html

ACIS Extract was released on the CXC's Contributed Software Webpage and announced to the ``chandra-users" e-mail exploder on 11 Feb 2003.
Release of version 3.0 is expected in September, 2003.