Chandra X-ray Center

CIAO

Jonathan McDowell

I will report on CIAO (user software) and the standard processing pipeline software, which come into being thanks to:

CXC Data Systems team:
software design, development. operations/archive, etc.

CXC Science Data Systems team:
requirements, documentation, testing, helpdesk,
interface with science community

Your SDS Contacts

•Staff changes:
MIT is hiring M. Guenther to replace J. Davis as MARX expert

Current team:
- Jonathan McDowell - Management, data model, coords

Antonella Fruscione (½) – SAO dep.lead, Docs and Release lead
Aneta Siemiginowska - Sherpa, Astrostatistics
Doug Burke - Scripts, Infastructure (Crates/Chips/DM), Releases
Frank Primini - HRC, Catalog, Photometry, Source Detection
Kenny Glotfelty - Helpdesk, scripts, docs, legacy expertise
Nick Lee Helpdesk, scripts, docs

Mike Nowak MIT lead, Catalog, timing, responses
Dave Huenemorder Gratings, responses
Glenn Allen ACIS (e.g. acis_process_events)
Moritz Guenther (soon): MARX

Chandra X-ray Center

Community Support: Downloads, Documentation, Helpdesk

CIAO 4.5, 4.6 Downloads

CIAO 4.6 is the current supported release.

Downloads of CIAO 4.6 (released 2013 Dec 12)

	CIAO 4.5 (Sep 2013-Sep 2014)	CIAO 4.6 (Dec – Sep)
Linux	297 (of which 88 were 32-bit)	699 (165)
Mac	175 (46 OS10.6.8)	550(130 OS10.8)
Source build	47	111
Total	519	1360

Summary:

- Total CIAO demand remains stable (5% drop compared to same time last year)
- Linux/Mac mix unchanged (Mac up by 4% to 44%)
- Shrinking demand for older MacOS, 32-bit Linux

Older platform support

Chandra X-ray Center

DS reports lack of resources to support multiple platforms
- DS build, test; SDS test, doc, support

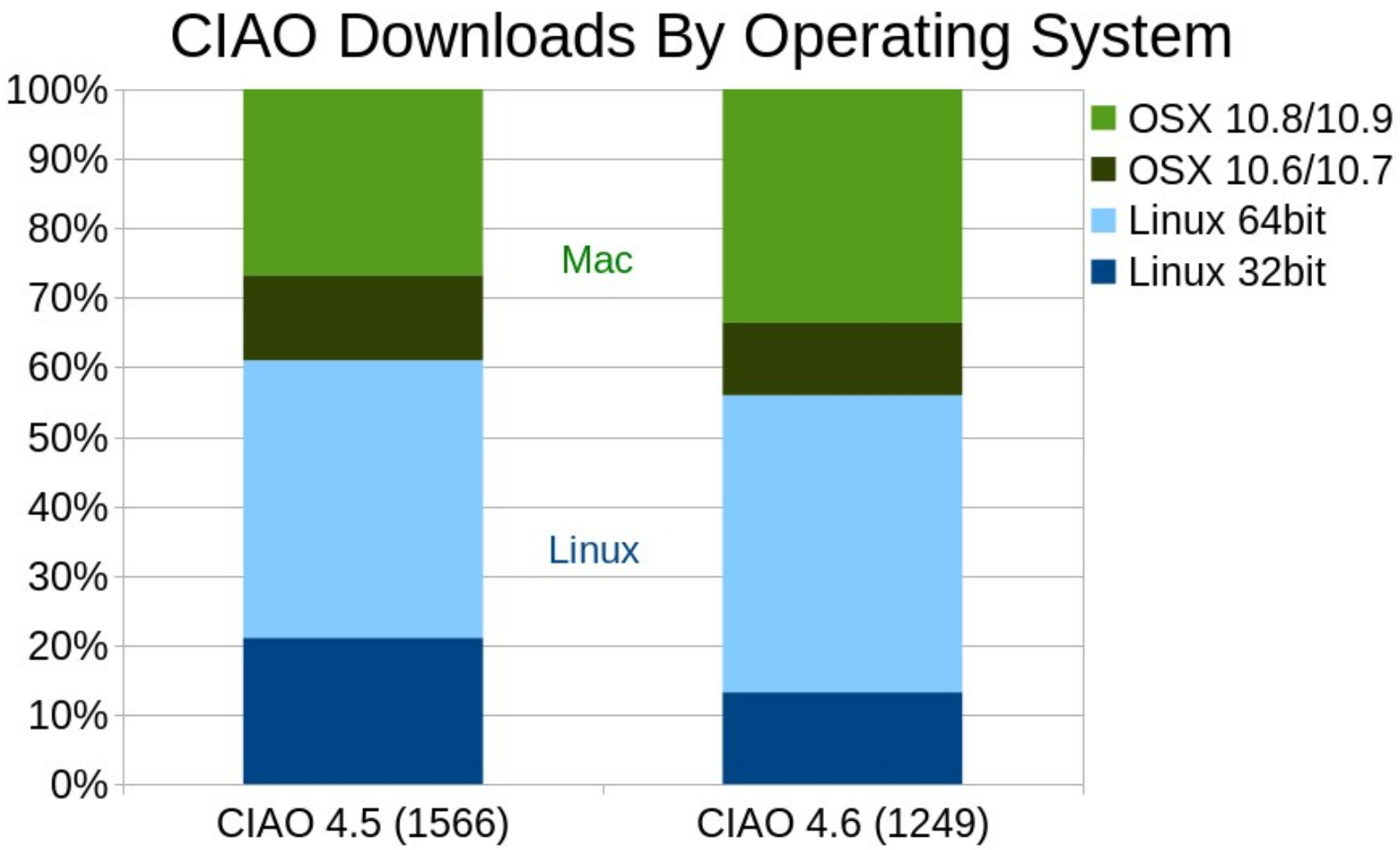
Circulated survey to 'chandra_users' list to determine demand for older operating systems
- MacOS 10.6/7
- 32-bit Linux systems

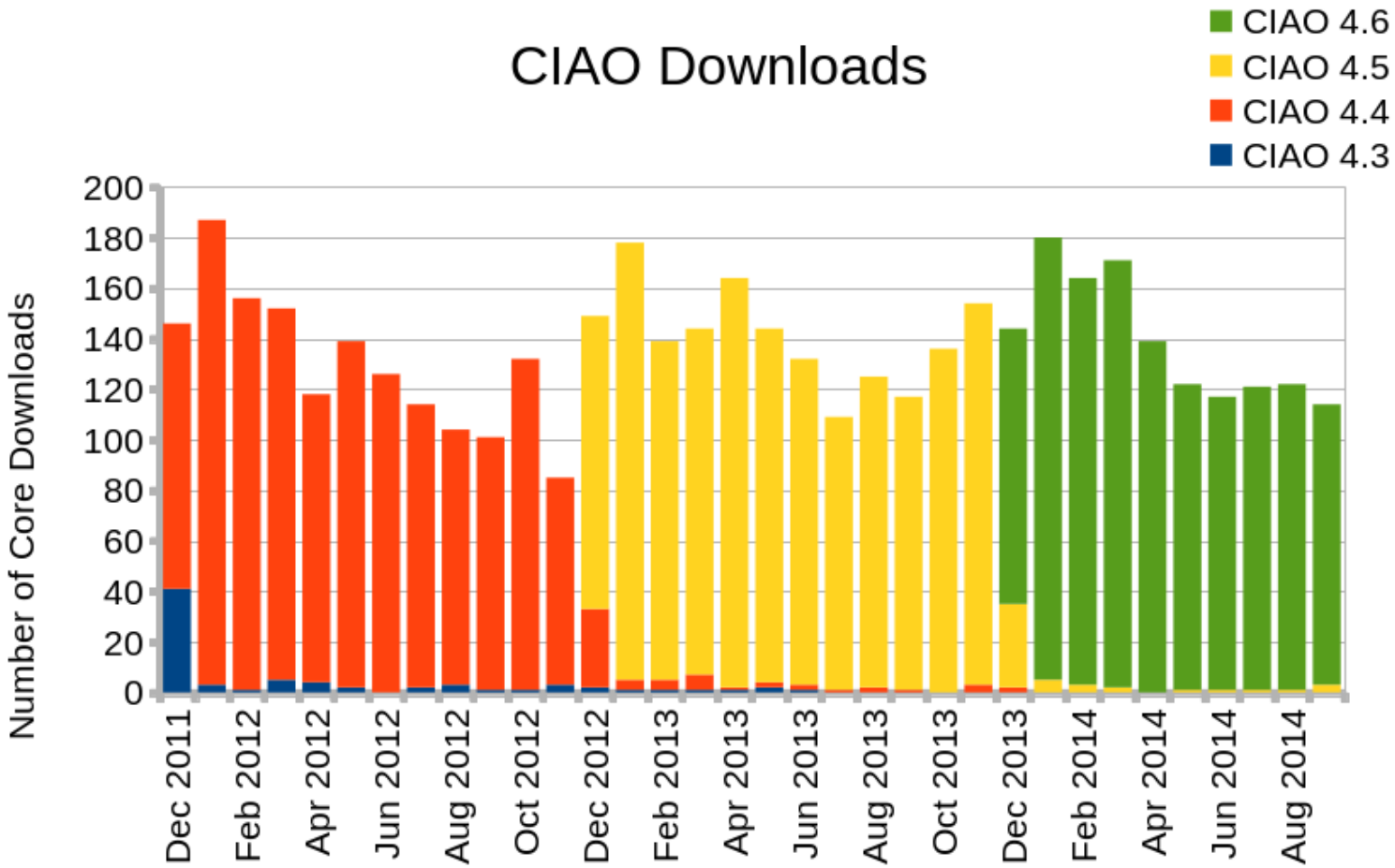
22 responses, 20 requests to continue support

Low response doesn't match the continued demand seen in actual downloads: 25 to 30 percent of our ~1000 users download the older platforms

(maybe chandra_users reaches
PIs but not the postdocs/students doing the work?)

Further work on source builds would decrease need to support multiple platforms.


CIAO Downloads By Operating System
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Mac
Linux
OSX 10.8/10.9
OSX 10.6/10.7
Linux 64bit
Linux 32bit
CIAO 4.5 (1566)
CIAO 4.6 (1249)


CIAO Downloads
CIAO 4.6
CIAO 4.5
CIAO 4.4
CIAO 4.3
Number of Core Downloads
200
180
160
140
120
100
80
60
40
20
0
Dec 2011
Feb 2012
Apr 2012
Jun 2012
Aug 2012
Oct 2012
Dec 2012
Feb 2013
Apr 2013
Jun 2013
Aug 2013
Oct 2013
Dec 2013
Feb 2014
Apr 2014
Jun 2014
Aug 2014

CIAO Documentation

All threads and web pages reviewed for CIAO4.6 release, updated as required

New Youtube Tutorials

Spectral fitting with DS9/dax
Aperture photometry with DS9/dax

New Threads

Calculate source counts and fluxes (srcflux)

Calculate effective region area in cases where region dithers off the detector

Using FOV files to determine whether a given celestial position is in the field

Dividing field into regions with a fixed number of counts per region (e.g. for smoothing)

Tag events or image pixels with the source number that they belong to

New Threads (continued)

Revived and revised old thread for processing ACA optical monitor data.

Added thread to find region that encloses given minimum number of counts

Thread to determine if RA,Dec is within given field of view

Thread on how to use XSpec user models with Sherpa

Rewrite of thread to correct absolute astrometry

Rewrite of thread to calculate HRC dead time

Revision to thread to calculate responses for moving (solar system) objects

Documentation for spectral analysis of CC mode imaging data (complements Cal work on CC mode grating data)

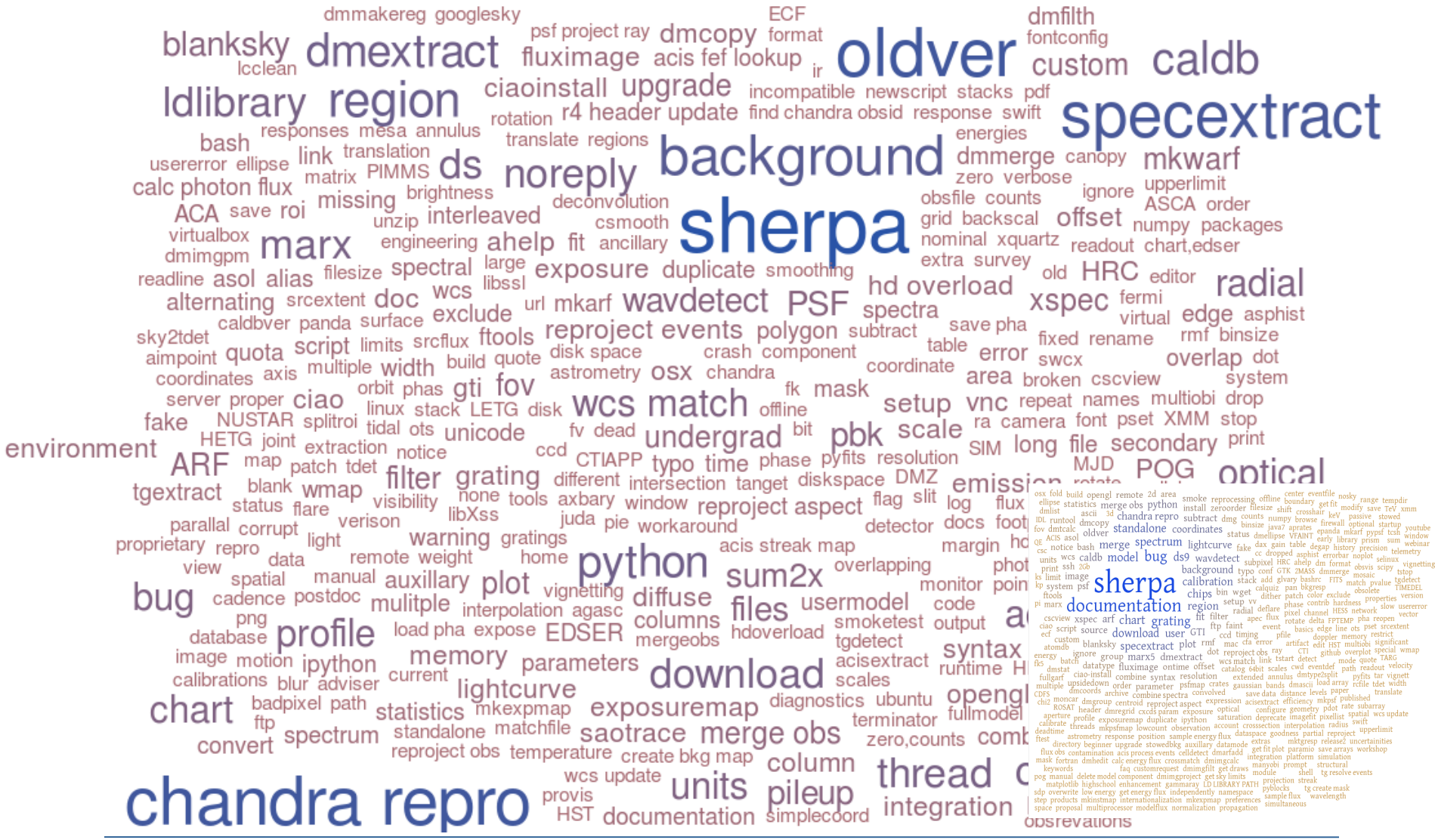
In Work

Improved PSF threads and documentation

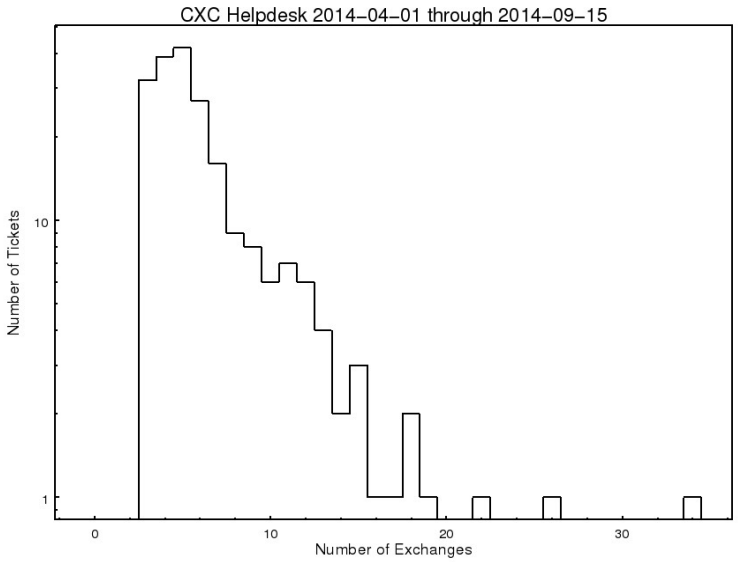
Community Support

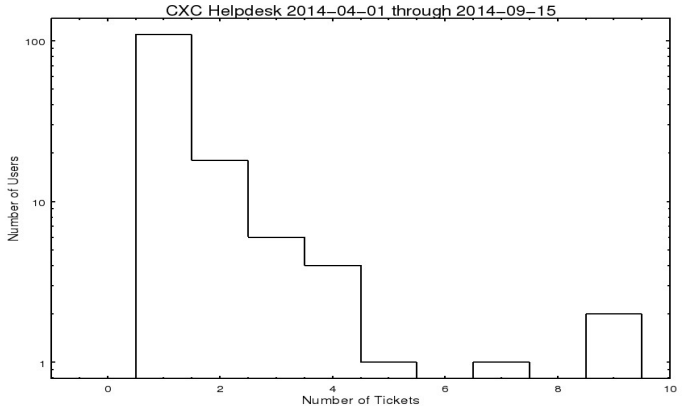
- Helpdesk: 287 new tickets (Sep 30 2013 –Sep 15 2014)
  - compare 359 tickets for same period last year
  - Median time to first ticket answer 0.5 hour
  - Median time to final answer 2.7 hr
    - » Two new scripts generated as a result of helpdesk tickets:
      - method to convert stack of FOV files into a footprint search
      - monitor_photom script to handle ACA optical monitor data
    - » Bugs found: issues with long column names; issues with handling XMM and NuSTAR files; issue with reproject_events not handling the RA 0h-24h wraparound correctly; issue with srcextent program
    - » RFEs: support for polygons in roi tool, chandra_repro issue with write permissions
    - » Documentation: updated reproject_aspect thread (several user qs)
    - » Documentation: 8 documents updated as a result of tickets
  - 86% of tickets did not require scientist or DS support
  - We also get direct contacts to SDS scientists outside the helpdesk system, at the rate of several per week

Community Support: Helpdesk topics



Sherpa remains major topic but not as dominant as last year; lots of chandra_repro qs reflecting the fact that users are making a lot of use of it...





Helpdesk:

Most tickets have 4 user interactions -

1) User asks question
2) Gets message saying ticket has been assigned
3) We contact user with proposed answer
4) User confirms resolution

A few tickets are far more complex and require many interactions (see top figure)

A few users send us many tickets (lower figure)

Chandra X-ray Center

A one day Chandra Calibration and CIAO workshop will be held on Monday, 17 November 2014 at CFA (1 day before the 15 Years of Chandra meeting in Boston).

The workshop will focus on getting the most out of Chandra data, with discussions of CIAO capabilities and the impact of calibration on cutting edge science. About half of the day will be spent on hands-on sessions, with CXC staff available to answer individual questions and assist with data analysis.

The program will be somewhat tailored to the participants' interests which we will gather once the registration is completed. The workshop is mainly aimed at students and postdocs new to Chandra data, who will be given precedence, but participation is encouraged for anyone interested.

Science Organizing Committee:

Antonella Fruscione + Kenny Glotfelty SDS

Vinay Kashyap + R. Nicholas Durham CAL

CALDB Releases

- SDS supports all CALDB releases:
  - test the downloading of the files
  - test that the files work with CIAO tools
  - Update threads, add new threads, add “Why” documents etc as needed to reflect changes in calibration data and in methods of applying them
  - Add a section in the release notes “How CALDB x.x Affects Your Analysis”
    - Crucial extra help for users: do **my** data need to be reprocessed because of a given calibration change? How **much** is the change for a typical user?

- In the reporting period: CALDB 4.5.9, 4.6.1, 4.6.1.1, 4.6.2, 4.6.3

Chandra X-ray Center

CIAO 4.7 Overview

CIAO Release

•CIAO 4.6:

Released in December as planned

- Centroid sub-pixel algorithm added to acis_process_events
- New grating zero order methods added to CIAO and to pipeline
- New scripts (srcflux)
- tool cleanup

•CIAO 4.7:

Maintenance release planned for Dec 2014

- Supporting DS work on improved source build, standalone Sherpa
- Bug fixes
- Working on improved CC mode processing (also for pipeline) to address errors in photon arrival times, PHA values, good time intervals
- New scripts

* R&D:

- Further dataset merging improvements

Analysis Scripts

SDS Contributed Scripts

Script release Dec 12 (with CIAO4.6), Feb 3, Mar 26, Apr 9, Jun 12, Sep 24

Old merge_all script has been retired

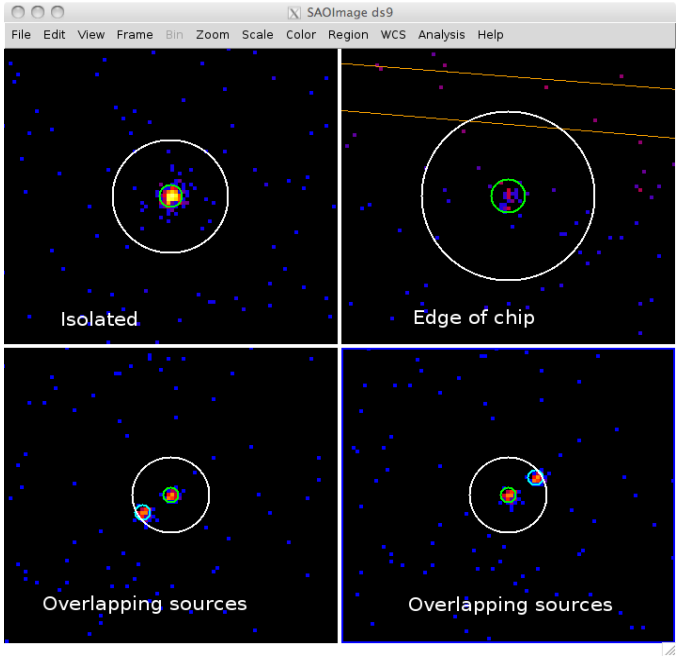
New scripts

- srcflux script previewed in the last Quarterly was released with CIAO4.6

  It includes two helper scripts for calculating source region size, PSF correction

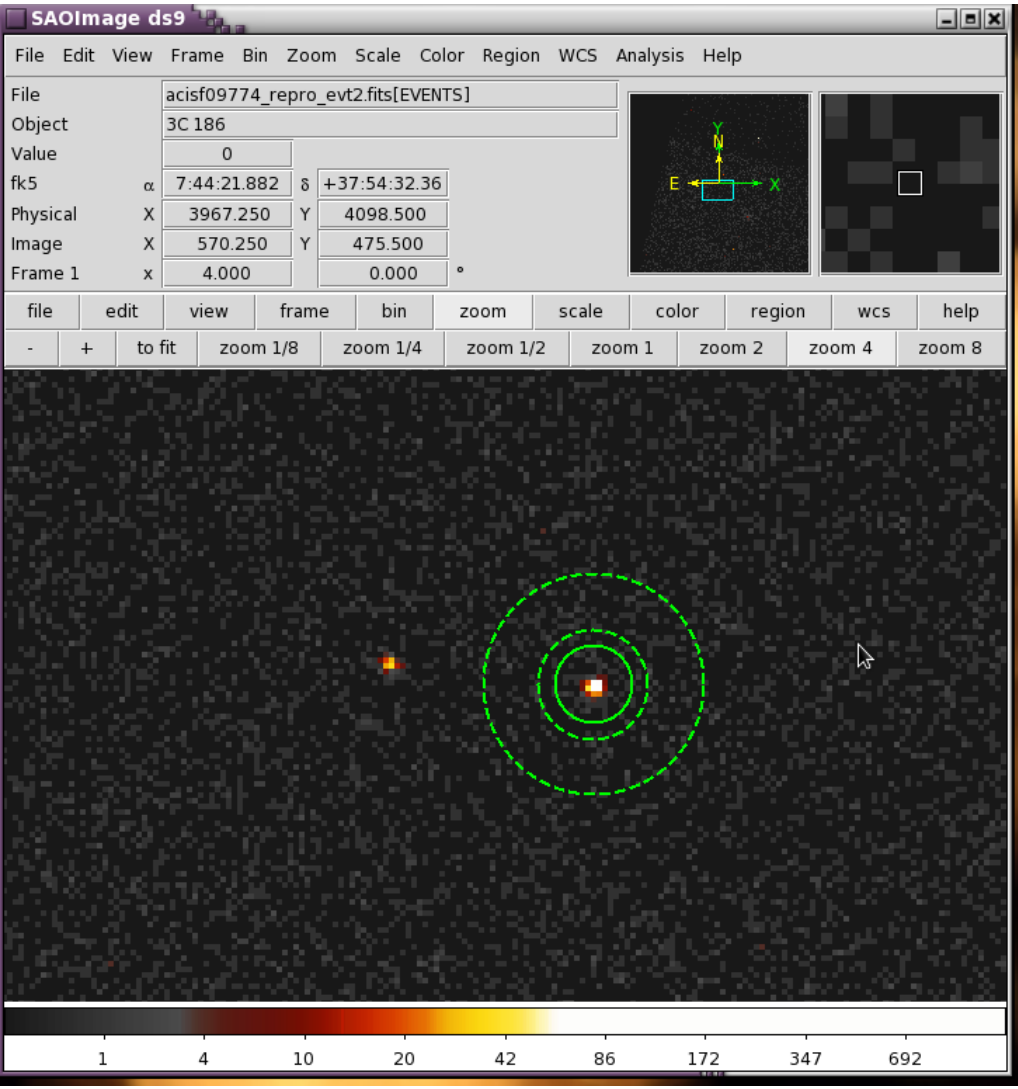
- ecf_calc – new small script to calculate enclosed count fraction of a source

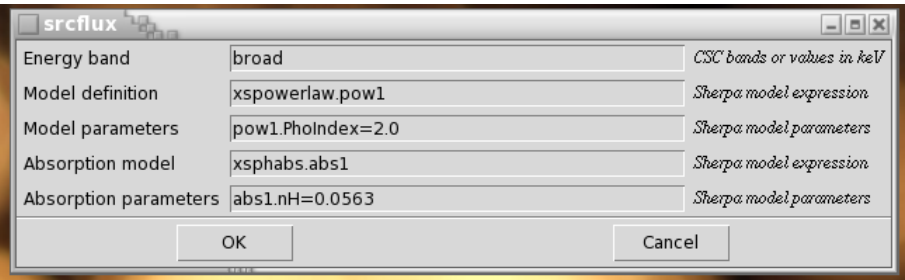
- dax (DS9 analysis menu scripts): aperture photometry and spectral fitting

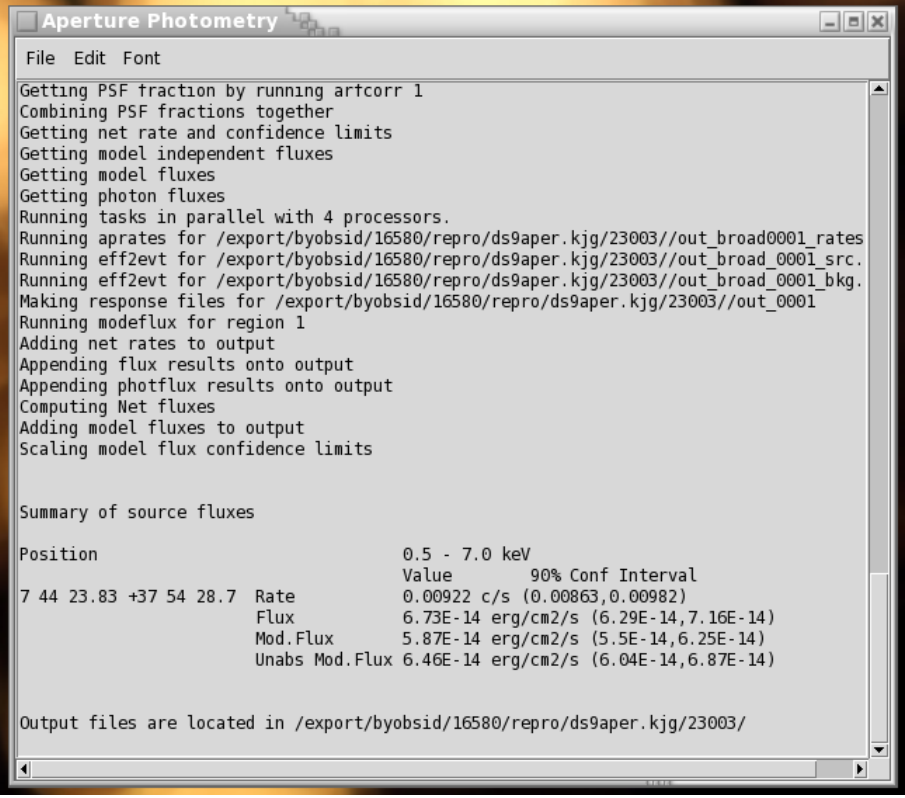


ds9/DAX: Aperture photometry

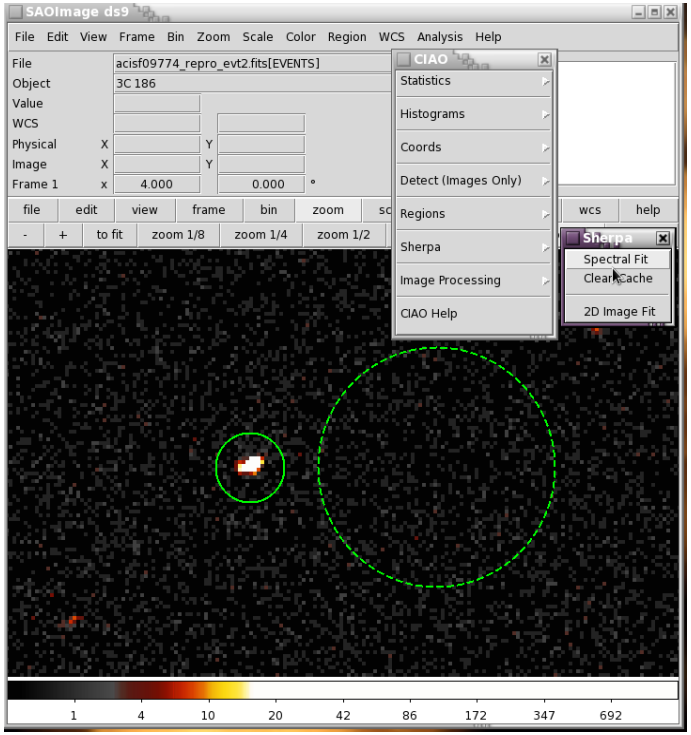
The srcflux script is invoked on an interactively selected region using the ds9 menu Analysis->CIAO->Regions->Aperture Photometry

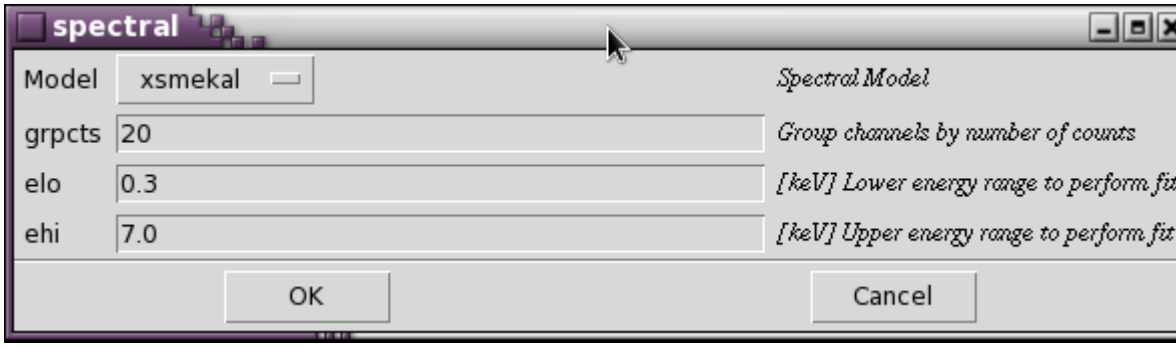




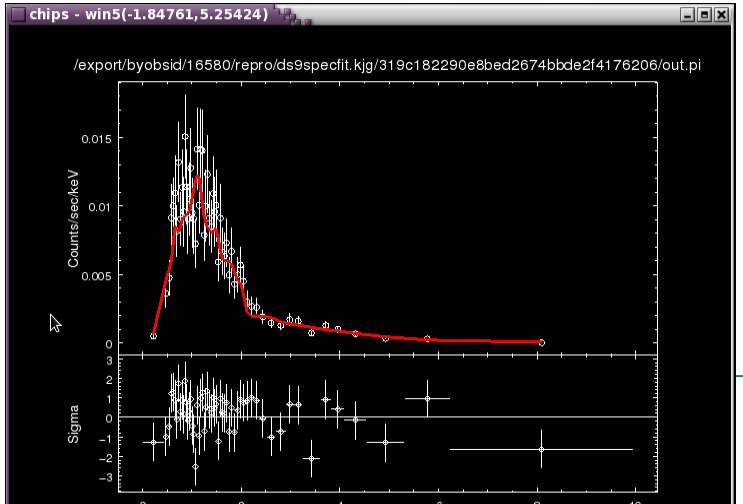


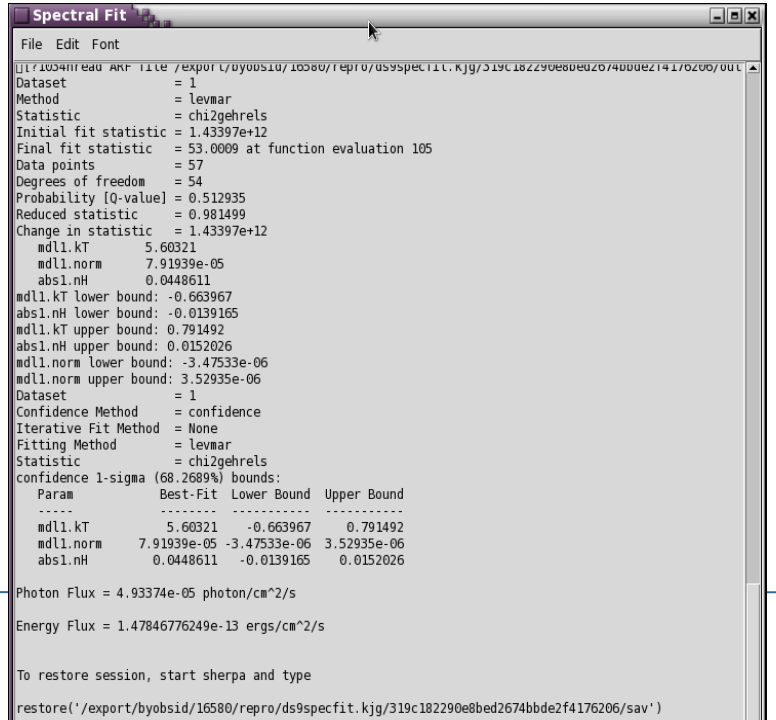
ds9/DAX: Spectral fit





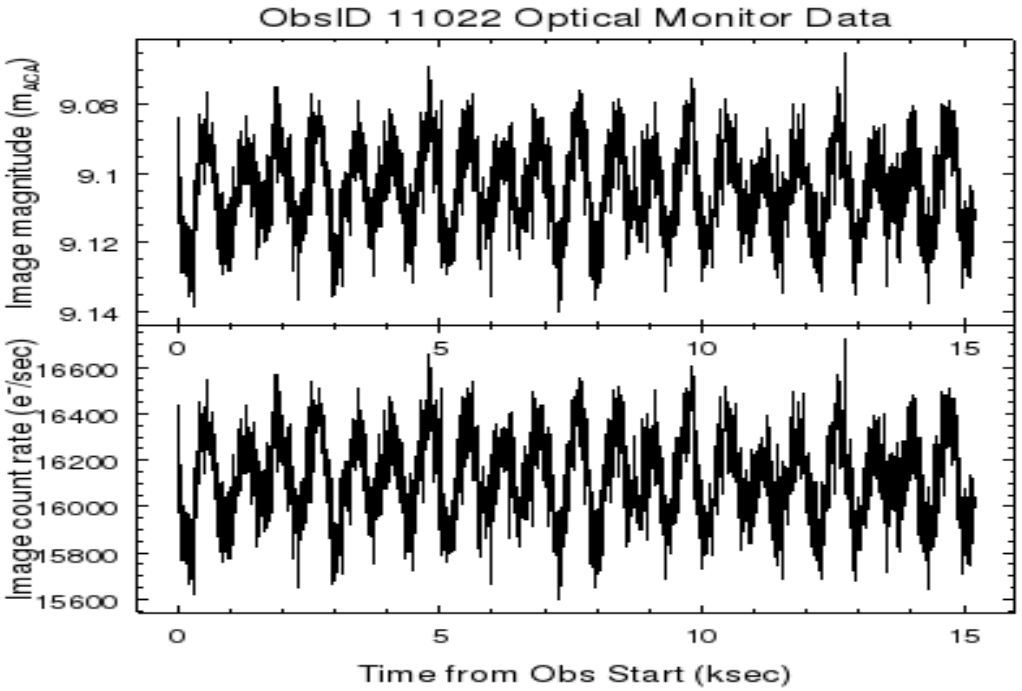
Menu dialog lets you select model and parameters
Runs specextract on interactively selected regions
Invokes Sherpa to determine best fit spectrum





SDS Contributed Scripts

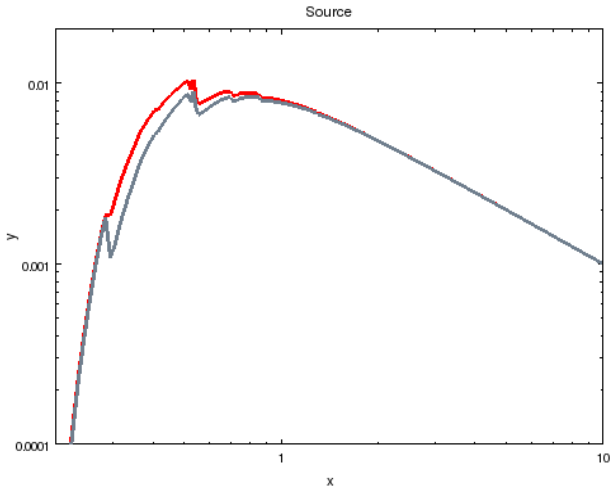
monitor_photom: generate a photometric light curve from ACA data files for observations where an ACA slot is monitoring a star.



convert_xspec_user_model

Experimental script to let users use certain types of XSpec user model in Sherpa
(e.g. ismabs, a high resolution ISM absorption model)

Limitations: No support for udmget memory allocation, XFLT keyword access



ismabs: fine control over ion composition can change predicted absorption

Also: prototype python support for XSpec convolution models
- work led to several bug reports for XSpec team, now addressed

apply_fov_limits - script makes event file into image clipping on the field of view

To get an image covering the area of interest, without a lot of blank space around the side (and possibly a too big image that exceeds convenient memory limits) users used to have to do e.g.

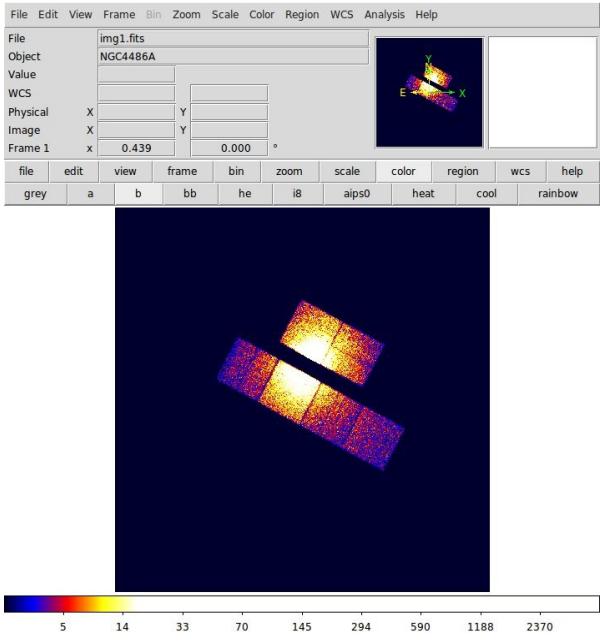
dmcopy “evt.fits[bin x=2500:7500:4,y=2800:7800:4]”out.img

where the numerical values were read off ds9 or by using dmstat.

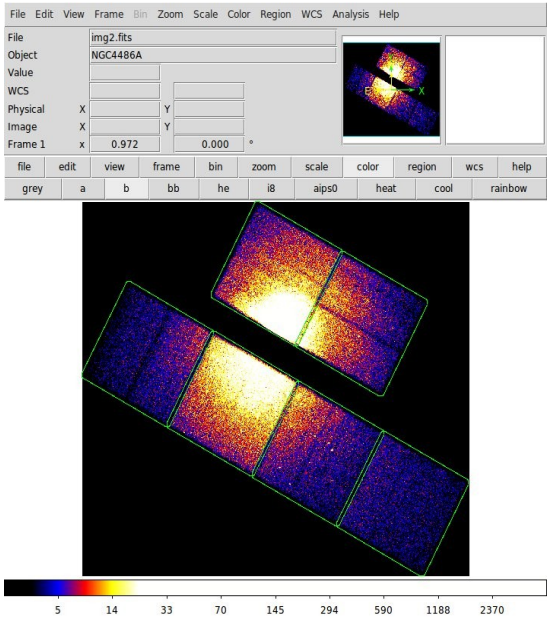
But now if you have the FOV file handy you can just do

apply_fov_limits “evt.fits” out.img fov=fov.fits bin=8

ds9 on full ACIS image



ds9 on output of apply_fov_limits



summarize_status_bits

Our interface to the ACIS and HRC status bit columns has been rather clunky. This new script, suitable for use on an HRC level 1 or 2 event file or an ACIS level 1 event file (since ACIS level 2 has status=0 events only), provides an easy way to see why events are being marked bad.

```
urania-103:  summarize_status_bits acisf03721_000N002_evt1a.fits

BitName    Bit  NumEvt   %Evt  BitDesc
-------    ---  ------   ----  -------
BADPIX       4  143817    7.9  Center of event island falls on bad pixel
BADPIXE      5   34911    1.9  Surrounding event island falls on bad pixel
BADBIAS      6    4919    0.3  Bad bias value (4095)
GLOW        16   13050    0.7  Event is part of a cosmic ray afterglow
GLOW1       17    3642    0.2  Length of afterglow (obsolete)
GLOW2       18     586    0.0  Length of afterglow (obsolete)
GLOW3       19     131    0.0  Length of afterglow (obsolete)
```

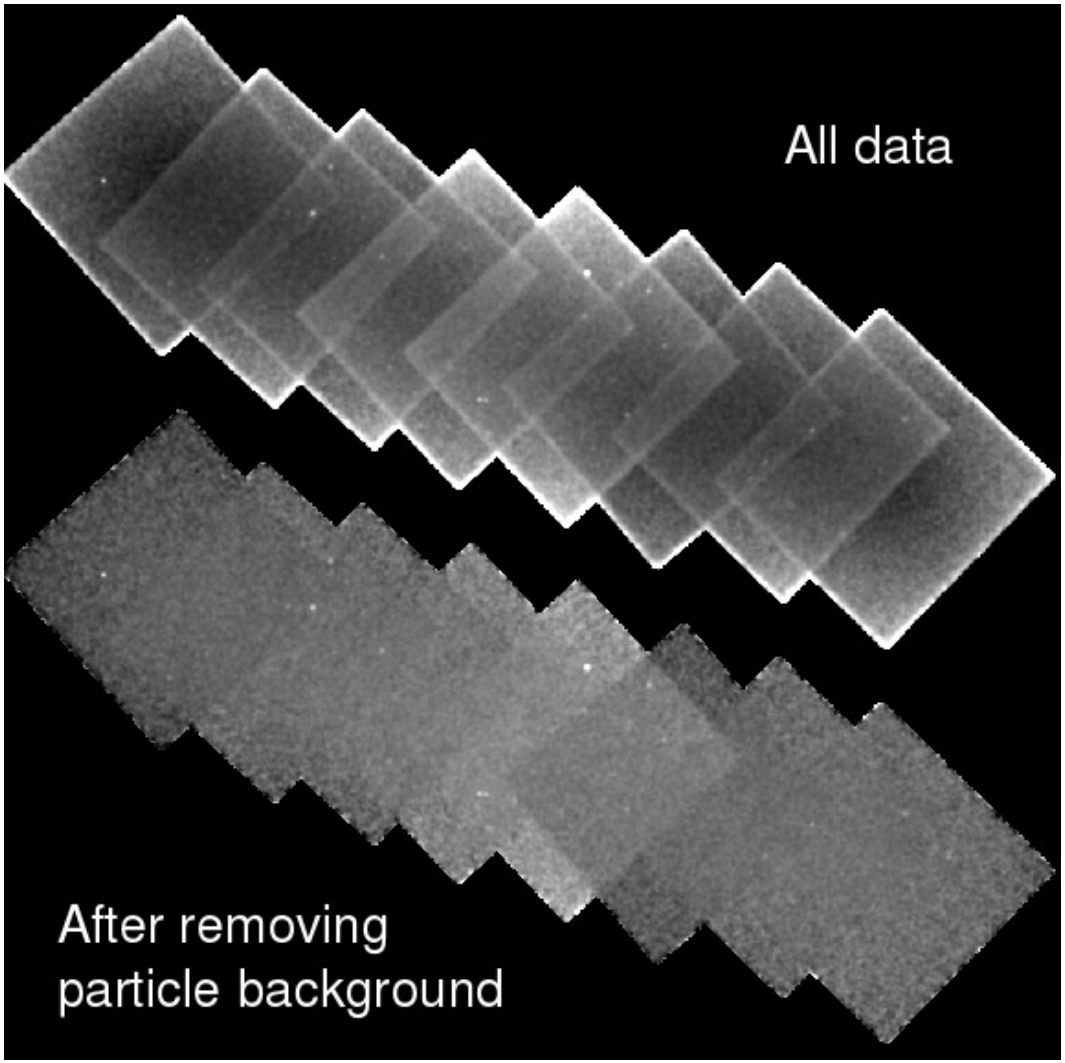
SDS Contributed Scripts

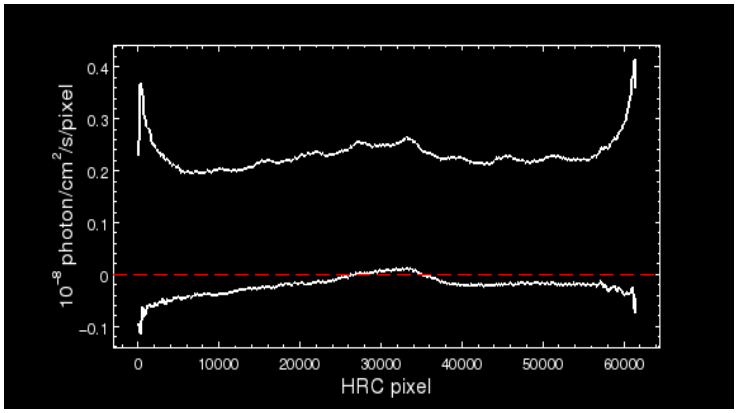
Chandra X-ray Center

Updated scripts

- updated various scripts to make use of new keywords added to archival data in Repro4
  - Simplifies interfaces, removes need for users to have the PBK file
- updated chandra_repro to add the new Repro4 keywords if they are not already there
- updated chandra_repro to support new event centroiding algorithmn, new grating zero order centroiding scheme (tgdetect2)
- updated specextract to support HRC spectra (not useful for spectral fitting, but needed to get broadband fluxes in modelflux and srcflux scripts)
- updated specextract to handle case with no counts in spectrum (to support srcflux upper limits; requires user to specifiy the position)
- updated fluximage, merge_obs to improve HRC background using CALDB particle background data.

Updated merge_obs using HRC-I background files in CALDB





SDS Contributed Scripts

Chandra X-ray Center

Updated scripts - continued

- updated chandra_repro to update FOV file if observation is reprojected
- enhance fluximage to support CAL group work on HRC_I particle background
- updated combine_spectra to add correct exposure time keywords to output ARF file
- Support new tmpdir parameter in several scripts to handle case where user cannot write to /tmp (e.g. some cluster systems)
- updated specextract for more robust bad pixel file handling, and to add COLDEN-derived galactic NH values to the PHA header.
- updated srcflux to fix bug in background and net photon flux values, and to allow sub-pixel analysis
- add optimization to fluximage family of scripts to avoid reprojecting for very small shifts (e.g. merging almost coaligned observations)
- acis_clear_status_bits bug fix for 32-bit systems
- combine_spectra major rewrite to clean up code (reported last time)
- download_chandra_obsid added support for evt1a (grating) and adat (ACA image) files.

For full release content see

http://cxc.harvard.edu/ciao/download/scripts/history.html

SDS Contributed Scripts

Chandra X-ray Center

Forthcoming scripts

combine_grating_spectra: Will replace add_grating_spectra, add_grating_orders,
more flexible, layered on combine_spectra code
Status: in final testing prior to release

PSF ray tracers – significant user demand for easier interface to Marx, and ability to run saotrace on user machines

We now have prototype scripts to:

- install Marx and Saotrace2 (single command, like ciao-install)
- run both programs with setup parameters read from an event file

On hold pending issues with Saotrace2 installation on recent Linux/Mac releases

Chandra X-ray Center

Sherpa

Sherpa 2013 Development

Chandra X-ray Center

- Sherpa Released with CIAO 4.6 in December 2013

  Final implementation of 1D Template models:
  - interpolation on parameter space
  - combined template and analytical models
  - allows for a choice of the fit optimization method

  Bug fixes include areas of plotting, statistics, models, psf, simulations.

- Patch Release in February 2014

  Addresses bug in analysis in wavelength space for grating spectra, and issues with simulations for proposal planning.

Sherpa 2014 Development

- Focus on Standalone Sherpa build
- Binary release Oct 2014
- Source release scheduled for Dec 2014
- Aimed at python users who are not necessarily X-ray astronomers
- Enables all Sherpa fitting capabilities, but with restricted infrastructure (no CIAO data model filtering, ..)

- Development focused on UI for multiple data sets ('datastacks') to support users with split observations - simultaneous modeling of several spectra, allows clean interface for thermally split observations. Implementation will be based on existing prototype from T. Aldcroft
- Investigated *get_draws* for measuring parameter uncertainties in 2D modeling with PSF

Sherpa Standalone

Chandra X-ray Center

- Standalone - independent of CIAO

- Provides a general modeling and fitting package for Python community
- Open and community driven software model
- Allows direct community contributions to future development
- People can immediately incorporate their own ideas for their specific problems

- How to incorporate contributions from the community?

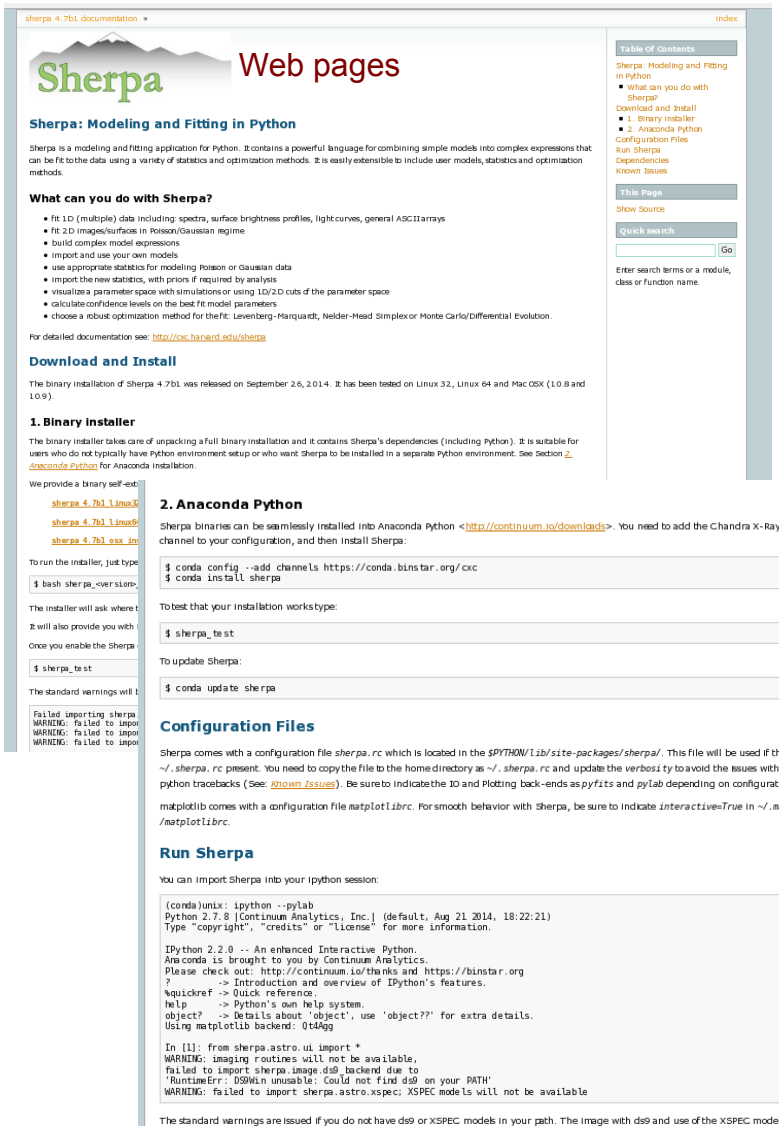
- Sherpa binary released on **Sep.26, 2014**
- Documentation pages made with Python Sphinx

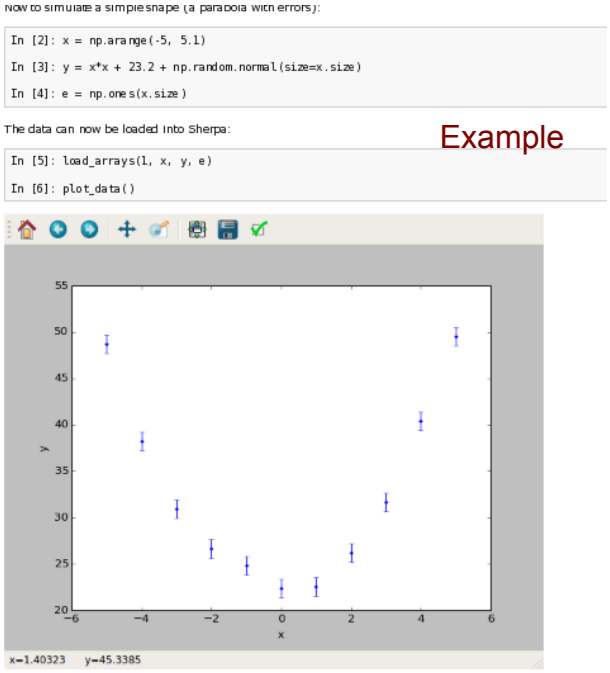
- Sherpa source release planned for December 2014.
- Code on *github* for distribution
  - allows users to extend the functionality to support their needs
  - potential input from users
  - but need to monitor, review code and test before incorporating it.

- Documentation needs to support standalone users
  - move to Python Sphinx
  - working on a roadmap for new docs.

Sherpa Standalone Binary

1/ A complete shell installer for
Linux 32, Linux 64 and MacOSX includes Sherpa's dependencies + Python
2/ Installer for Anaconda Python:
use a standard *"conda install sherpa"*

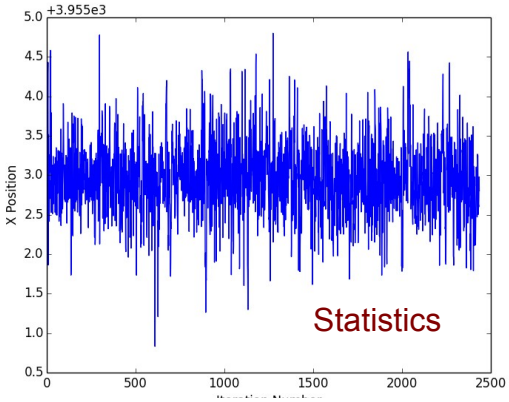


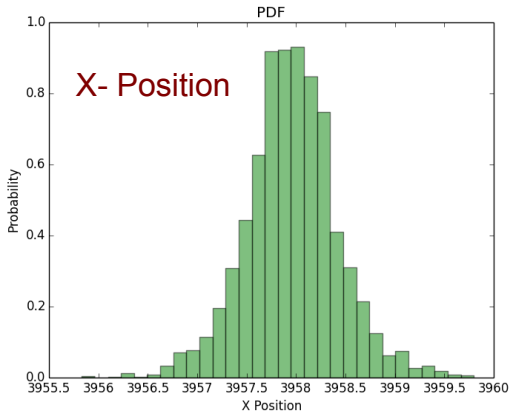


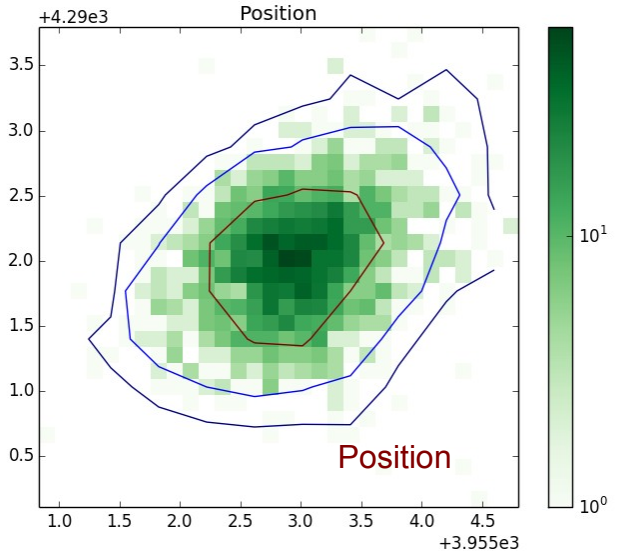
get_draws for measuring parameter uncertainties

"*get_draws*" - Sherpa function to run MCMC and obtain the simulation sample of parameters from posterior distribution (true model distribution given the data).

Idea: use the function to estimate the uncertainties of the source position returned by MLE for the CSC

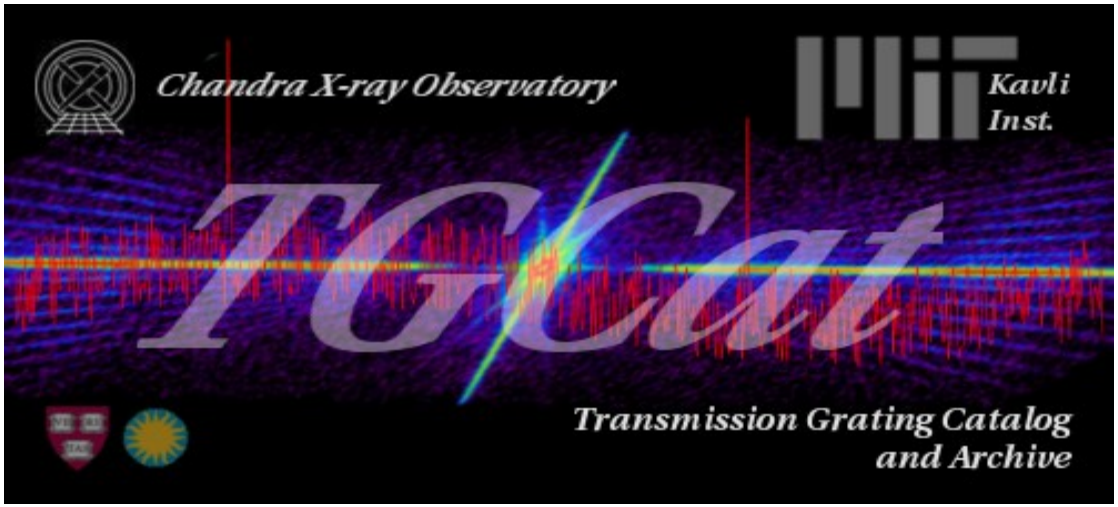






Chandra X-ray Center

Gratings



TGCAT updates continue

- Apr 2014 to Sep 2014: 2458 web and 459 CLI accesses from 211 separate IP addresses; 107 package downloads total 96 Gbyte
- Oct 2013 to Apr 2014: statistics/logs lost in disk crash

Chandra X-ray Center

CC Mode with Gratings:

- Larger dispersion angles more affected by changes to photon times and CTI correction.

Current approach: use zero order CHIPY to calculate times, CTI
New approach: use estimated CHIPY of dispersed photon

- changes arrival times by up to 0.73 s
- causes mismatch with good time intervals
- CTI and gain depend on position – effective gain wrong by of order 10 %
  (and different at different energies)

Improved quantities:
  event time
  CTI-corrected PHA
  Subpixel-correct CHIPY location

Future work: handle bad columns and afterglows in CC mode