



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

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- Staff changes:

MIT is hiring M. Guenther to replace J. Davis as MARX expert

Current team:

- Jonathan McDowell - Management, data model, coords

Antonella Fruscione (1/2) – SAO dep.lead, Docs and Release lead

Aneta Siemiginowska - Sherpa, Astrostatistics

Doug Burke - Scripts, Infrastructure (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



# Community Support: Downloads, Documentation, Helpdesk

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# 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



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

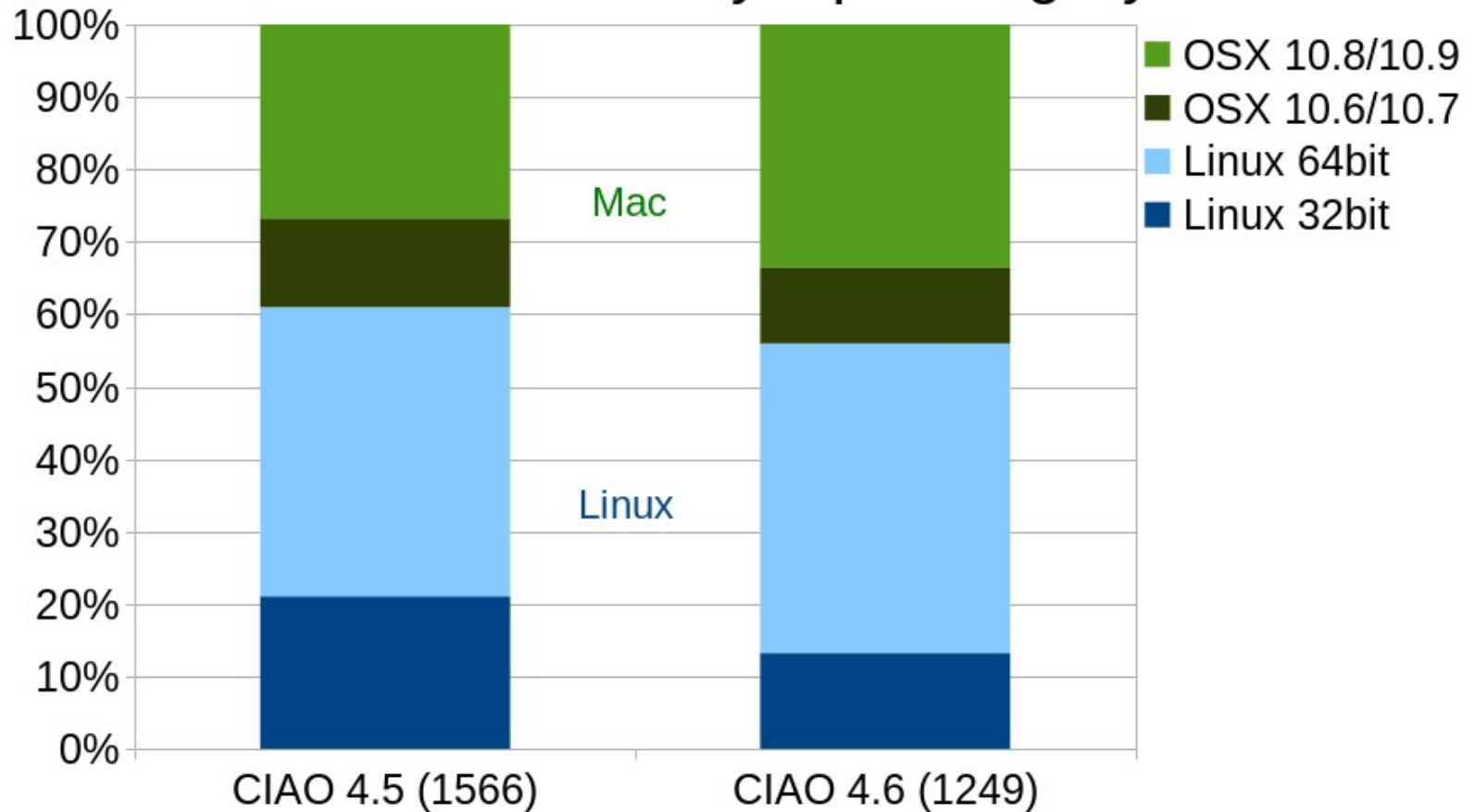
Low response doesn't match the continued demand seen in actual downloads: 25 to 30 percent of our ~1000 users download the older platforms

(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.

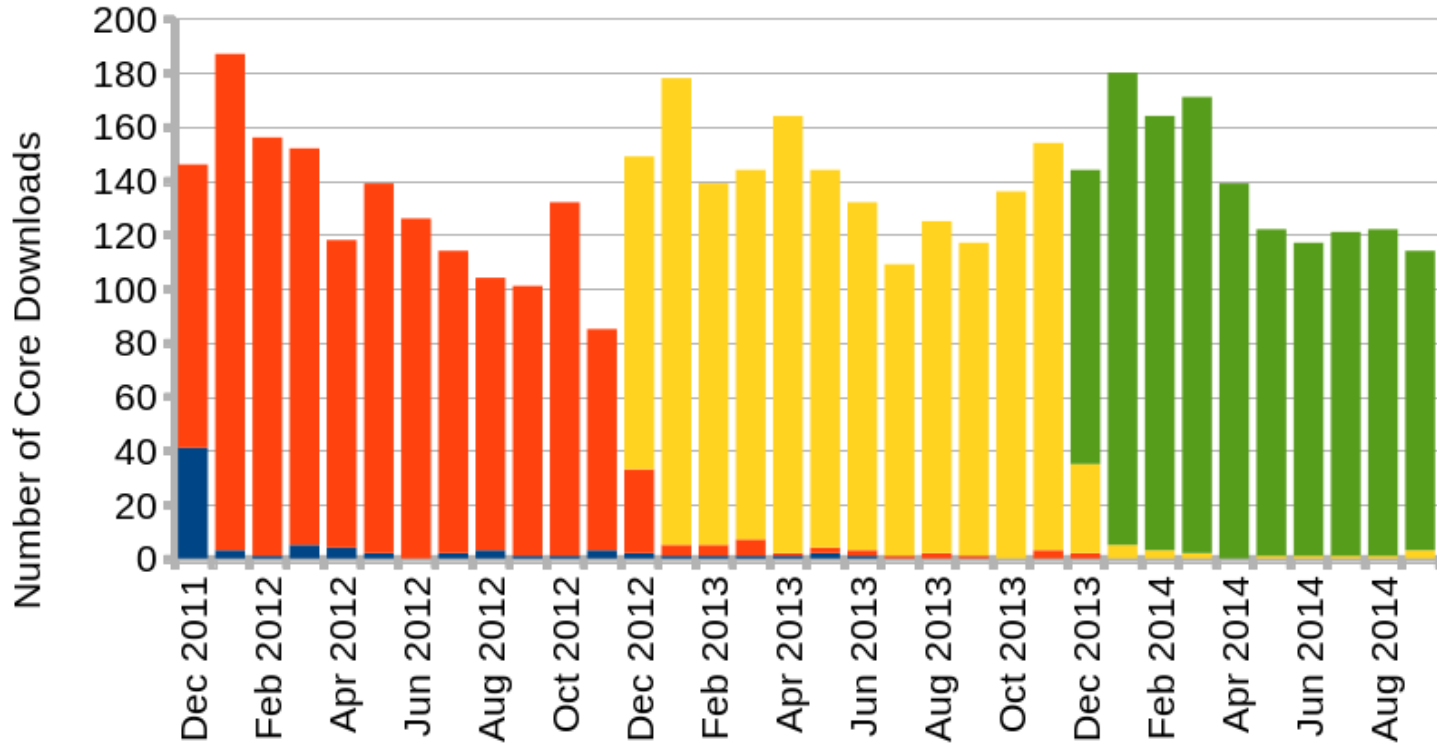
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# CIAO Downloads By Operating System



# CIAO Downloads

- CIAO 4.6
- CIAO 4.5
- CIAO 4.4
- CIAO 4.3







# 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



# CIAO Documentation

## 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



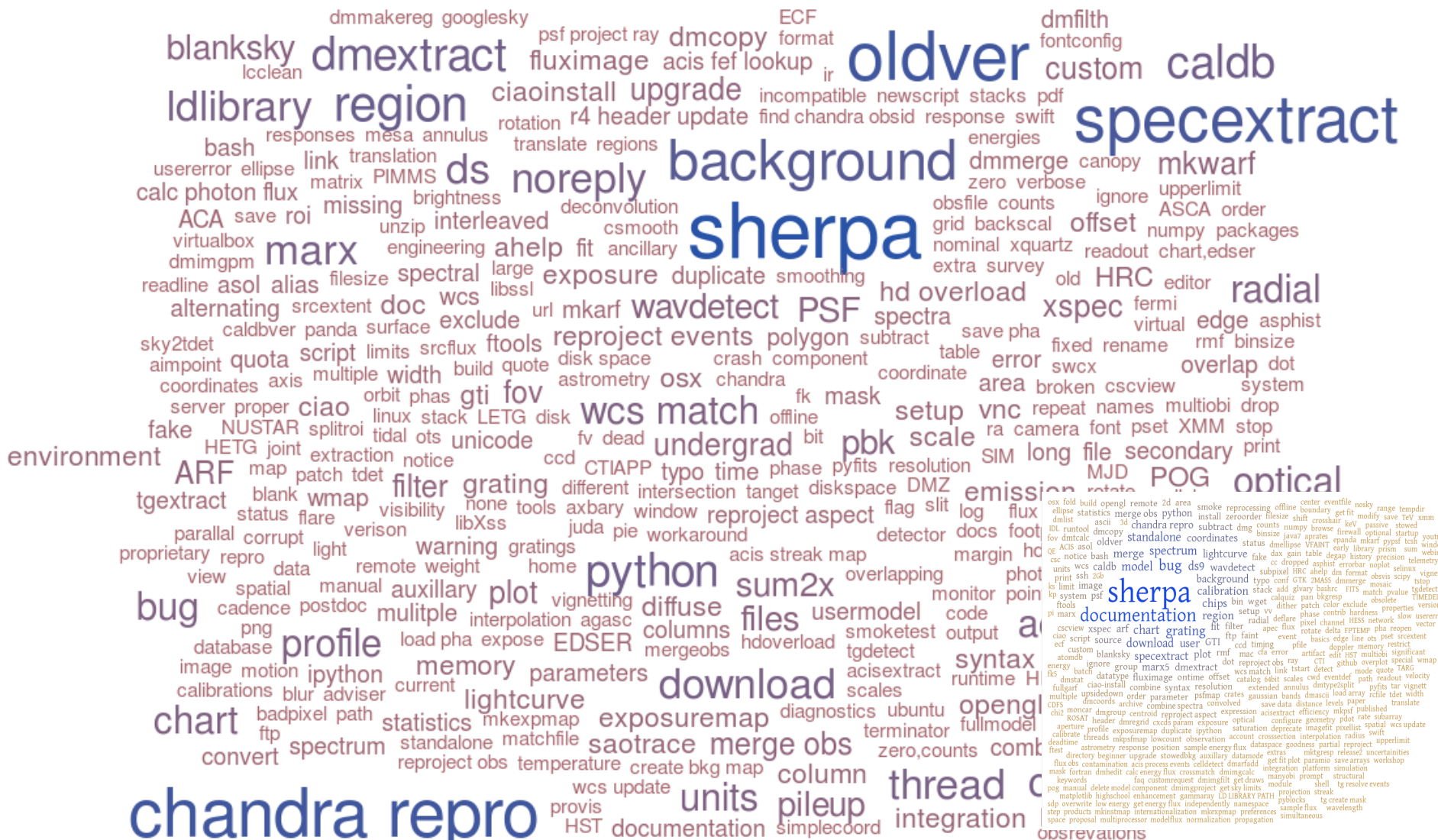
# Community Support



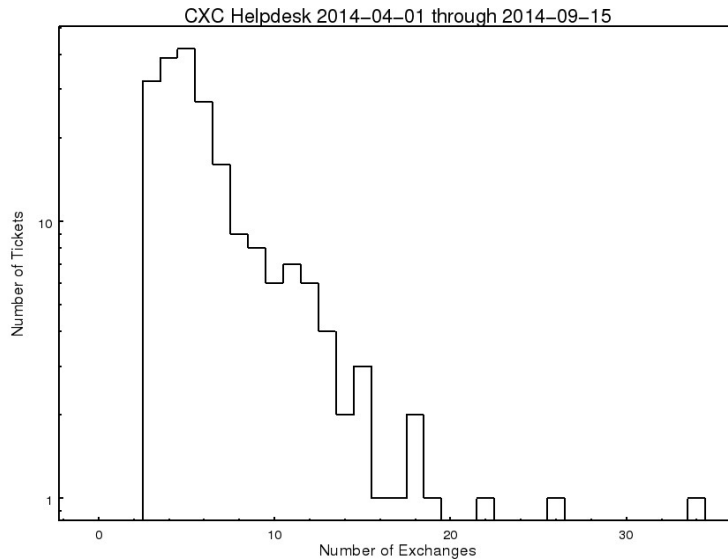
- Helpdesk: 287 new tickets (Sep 30 2013 –Sep 15 2014)
  - compare 359 tickets for same period last year
  - Median time to first ticket answer 0.5 hour
  - Median time to final answer 2.7 hr
  - » Two new scripts generated as a result of helpdesk tickets:
    - method to convert stack of FOV files into 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...



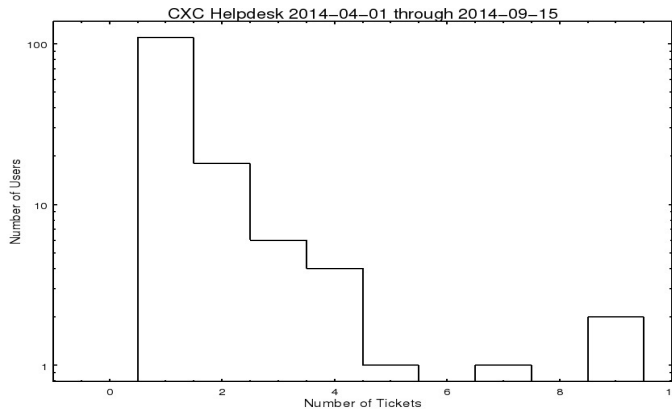
Helpdesk:

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)





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

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# CALDB Releases

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- 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



# CIAO 4.7 Overview

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# CIAO Release

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- 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

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# Analysis Scripts

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# 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

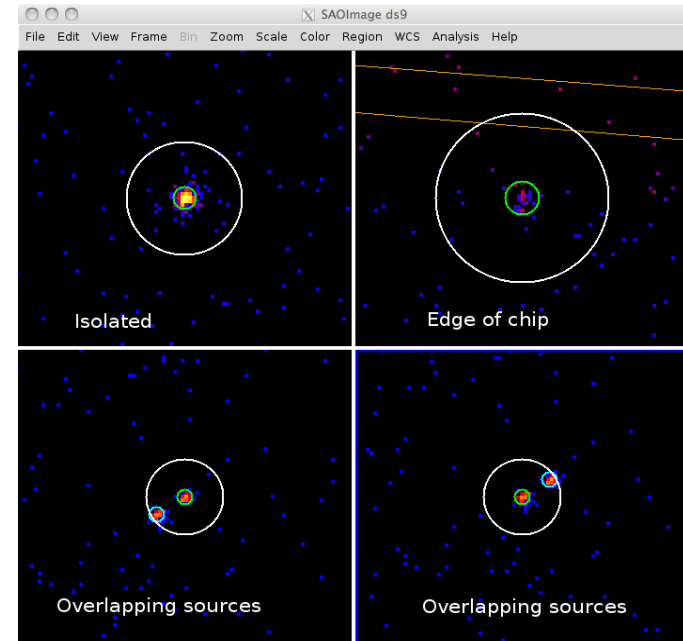
## New scripts

- 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

The screenshot displays the ds9 interface with the srcflux script results. The ds9 window shows the file 'acisf09774\_repro\_evt2.fits[EVENTS]' and object '3C 186'. The srcflux window shows the following parameters:

- Energy band: broad
- Model definition: xspowerlaw.pow1
- Model parameters: pow1.PhIndex=2.0
- Absorption model: xspfabs.abs1
- Absorption parameters: abs1.nH=0.0563

The Aperture Photometry window shows the following output:

```
Getting PSF fraction by running artcorr 1
Combining PSF fractions together
Getting net rate and confidence limits
Getting model independent fluxes
Getting model fluxes
Getting photon fluxes
Running tasks in parallel with 4 processors.
Running aprates for /export/byobsid/16580/repro/ds9aper.kjg/23003//out_broad0001_rates
Running eff2evt for /export/byobsid/16580/repro/ds9aper.kjg/23003//out_broad_0001_src.
Running eff2evt for /export/byobsid/16580/repro/ds9aper.kjg/23003//out_broad_0001_bkg.
Making response files for /export/byobsid/16580/repro/ds9aper.kjg/23003//out_0001
Running modeflux 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
7 44 23.83 +37 54 28.7 Rate      0.00922 c/s (0.00863,0.00982)
Flux                  6.73E-14 erg/cm2/s (6.29E-14,7.16E-14)
Mod.Flux              5.87E-14 erg/cm2/s (5.5E-14,6.25E-14)
Unabs Mod.Flux       6.46E-14 erg/cm2/s (6.04E-14,6.87E-14)

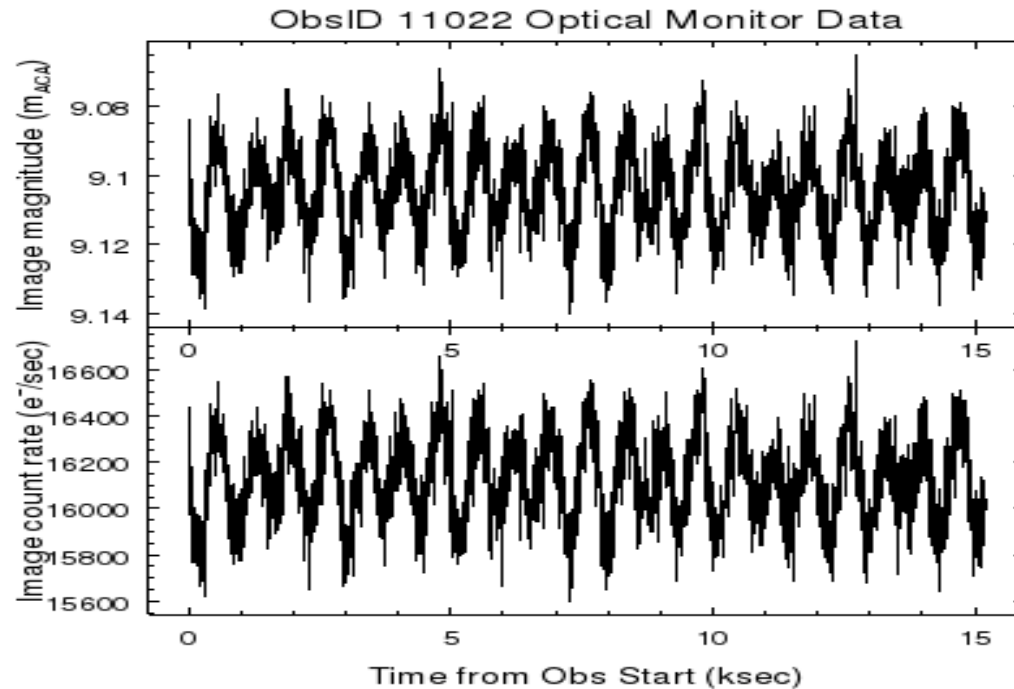
Output files are located in /export/byobsid/16580/repro/ds9aper.kjg/23003/
```





# SDS Contributed Scripts

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

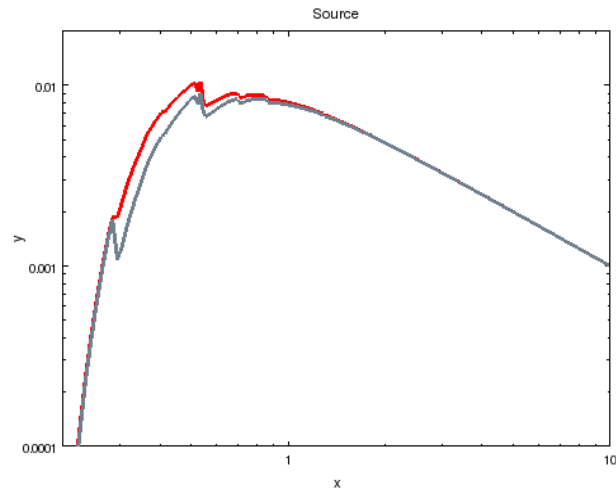


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convert\_xspec\_user\_model

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

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`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.

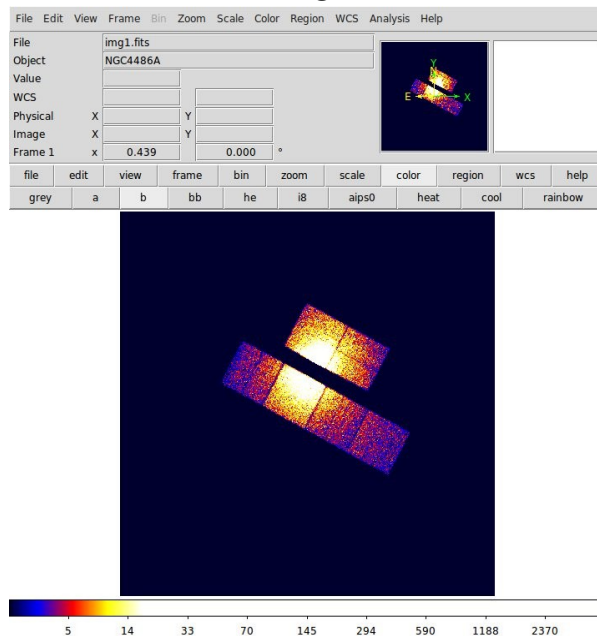
`dmcopy "evt.fits[bin x=2500:7500:4,y=2800:7800:4]" out.img`

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

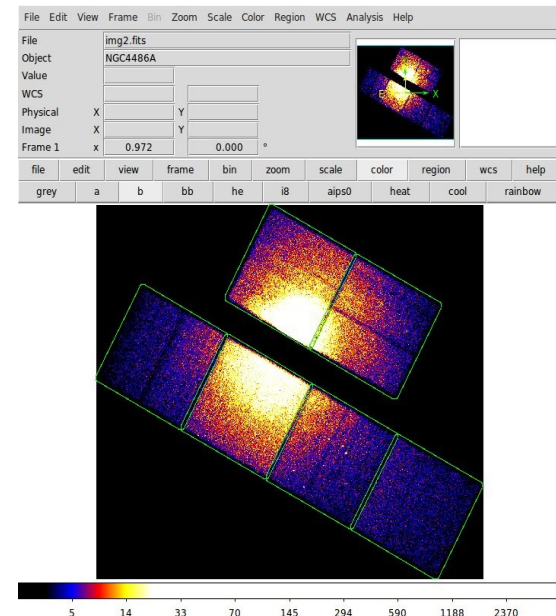
But now if you have the FOV file handy you can just do

`apply_fov_limits "evt.fits" out.img fov=fov.fits bin=8`

ds9 on full ACIS image



ds9 on output of `apply_fov_limits`





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## 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

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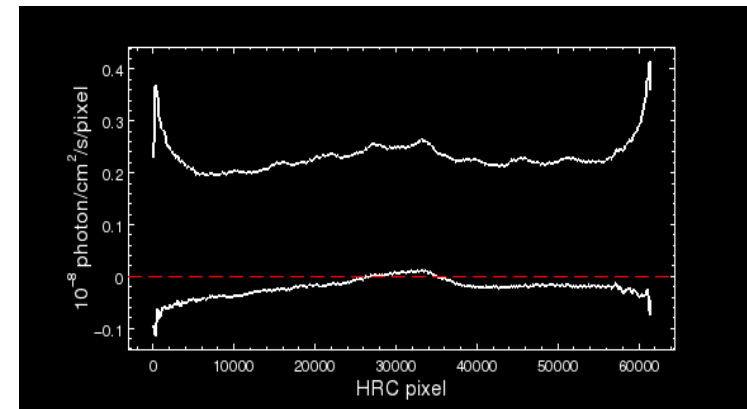
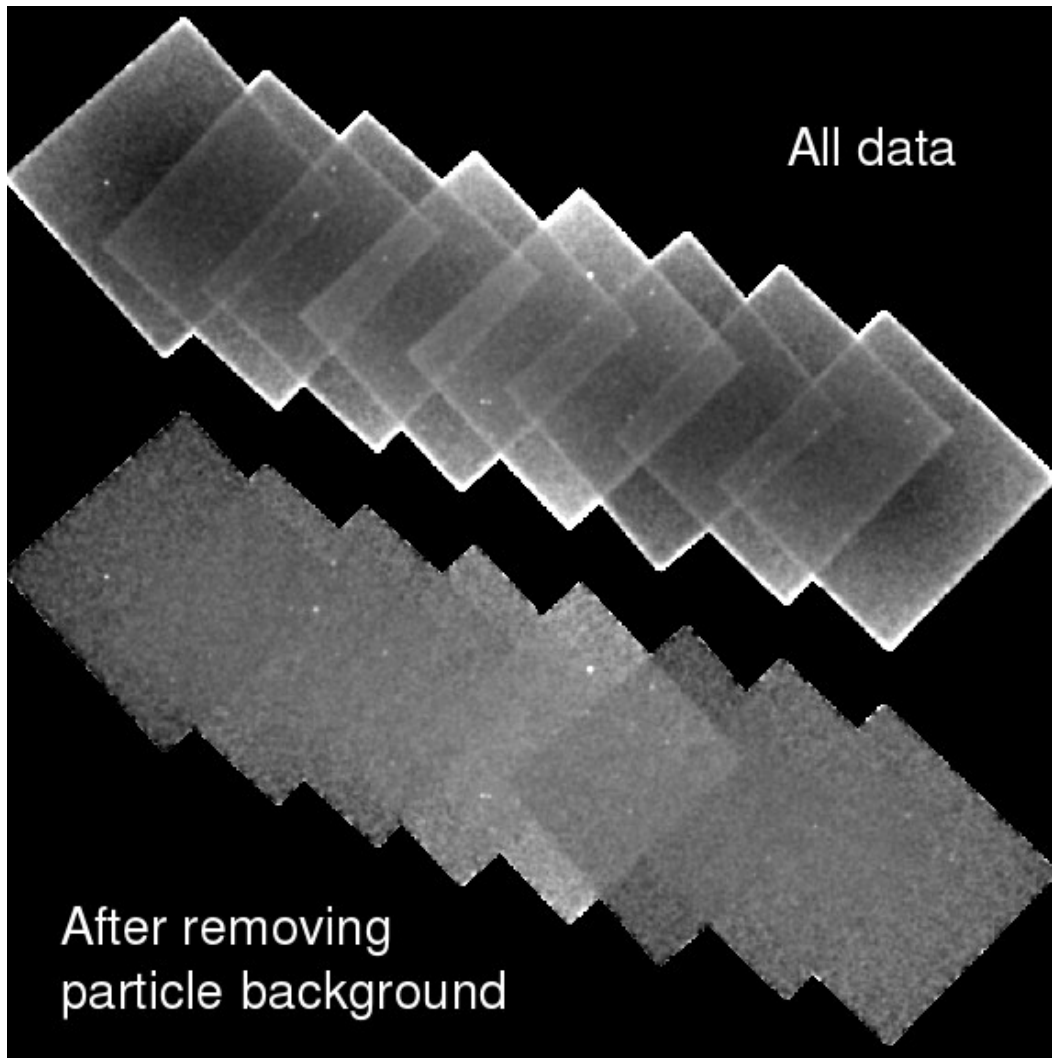
## Updated scripts

- 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 specify the position)
- updated fluximage, merge\_obs to improve HRC background using CALDB particle background data.

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Updated merge\_obs using HRC-I background files in CALDB

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# SDS Contributed Scripts



## 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

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## 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



# Sherpa



# Sherpa 2013 Development

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- **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

- 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 4.7b1 documentation Index

# Sherpa

## Web pages

### Sherpa: Modeling and Fitting in Python

Sherpa is a modeling and fitting application for Python. It contains a powerful language for combining simple models into complex expressions that can be fit to the data using a variety of statistics and optimization methods. It is easily extensible to include user models, statistics and optimization methods.

**What can you do with Sherpa?**

- Fit 1-D (multiple) data including: spectra, surface brightness profiles, light curves, general ASCII arrays
- Fit 2-D images/surface in Poisson/Gaussian regime
- Build complex model expressions
- Import and use your own models
- Use appropriate statistics for modeling Poisson or Gaussian data
- Import the new statistics, with priors if required by analysis
- Visualize parameter space with simulations or using 1D/2D cuts of the parameter space
- Calculate confidence levels on the best fit model parameters
- Choose a robust optimization method for the fit: Levenberg-Marquardt, Nelder-Mead Simplex or Monte Carlo/Differential Evolution.

For detailed documentation see: <http://cxc.harvard.edu/sherpa>

#### Download and Install

The binary installation of Sherpa 4.7b1 was released on September 26, 2014. It has been tested on Linux 32, Linux 64 and MacOSX (10.8 and 10.9).

#### 1. Binary Installer

The binary installer takes care of unpacking a full binary installation and it contains Sherpa's dependencies (including Python). It is suitable for users who do not typically have Python environment setup or who want Sherpa to be installed in a separate Python environment. See Section 2, [Anaconda Python](#) for Anaconda installation.

We provide a binary self-extracting installer for:

- [sherpa 4.7b1 Linux 32](#)
- [sherpa 4.7b1 Linux 64](#)
- [sherpa 4.7b1 OSX 32](#)

To run the installer, just type:

```
$ bash sherpa_overstore.sh
```

The installer will ask where it will also provide you with:

```
$ sherpa_test
```

Once you enable the Sherpa:

```
$ sherpa_test
```

The standard warnings will be:

```
Failed importing sherpa
WARNING: failed to import
WARNING: failed to import
WARNING: failed to import
```

**Table of Contents**

- Sherpa: Modeling and Fitting in Python
  - What can you do with Sherpa?
  - Download and Install
    - 1. Binary Installer
    - 2. Anaconda Python Configuration Files
  - Run Sherpa
  - Dependencies
  - Known Issues
- This Page
- Show Source
- Quick search

Enter search terms or a module, class or function name.

#### 2. Anaconda Python

Sherpa binaries can be seamlessly installed into Anaconda Python <<http://continuum.io/downloads>>. You need to add the Chandra X-Ray Center's channel to your configuration, and then install Sherpa:

```
$ conda config --add channels https://conda.binstar.org/cxc
$ conda install sherpa
```

To test that your installation works type:

```
$ sherpa_test
```

To update Sherpa:

```
$ conda update sherpa
```

#### Configuration Files

Sherpa comes with a configuration file `sherpa.rc` which is located in the `$PYTHON/lib/site-packages/sherpa/`. This file will be used if there is no `~/.sherpa.rc` present. You need to copy the file to the home directory as `~/.sherpa.rc` and update the `verbosity` to avoid the issues with standard python tracebacks (See [known Issues](#)). Be sure to indicate the IO and plotting back-ends as `pyfits` and `pylab` depending on configuration. `matplotlib` comes with a configuration file `matplotlibrc`. For smooth behavior with Sherpa, be sure to indicate `interactive=True` in `~/.matplotlib/matplotlibrc`.

#### Run Sherpa

You can import Sherpa into your ipython session:

```
(conda)unix: ipython --pylab
Python 2.7.8 [Continuum Analytics, Inc.] (default, Aug 21 2014, 18:22:21)
Type "copyright", "credits" or "license()" for more information.

ipython 2.2.0 -- An enhanced Interactive Python.
Anaconda is brought to you by Continuum Analytics.
Please check out: http://continuum.io/thanks and https://binstar.org
?               -> Introduction and overview of IPython's features.
quickref       -> Quick reference.
help           -> Python's own help system.
object?       -> Details about 'object' or 'object?' for extra details.
Using matplotlib backend: Qt4Agg

In [1]: from sherpa.astro.ui import *
WARNING: Imaging routines will not be available,
failed to import sherpa.image.ds9_backend due to
'RuntimeError: DS9Win unusable: Could not find ds9 on your PATH'
WARNING: failed to import sherpa.astro.xspec; XSPEC models will not be available
```

The standard warnings are issued if you do not have ds9 or XSPEC models in your path. The Image with ds9 and use of the XSPEC models will not

# 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"*

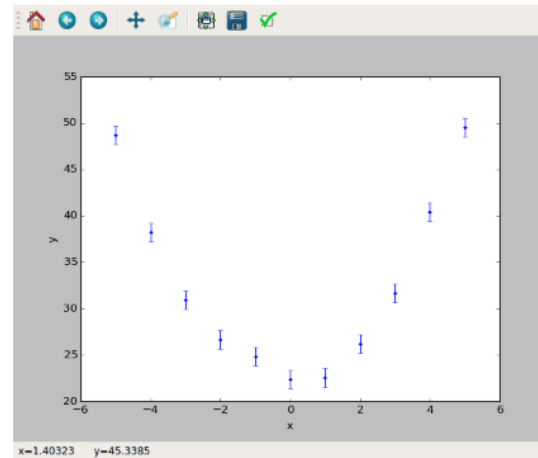
now to simulate a simple shape (a parabola with errors):

```
In [2]: x = np.arange(-5, 5.1)
In [3]: y = x*x + 23.2 + np.random.normal(size=x.size)
In [4]: e = np.ones(x.size)
```

The data can now be loaded into Sherpa:

```
In [5]: load_arrays(1, x, y, e)
In [6]: plot_data()
```

## Example

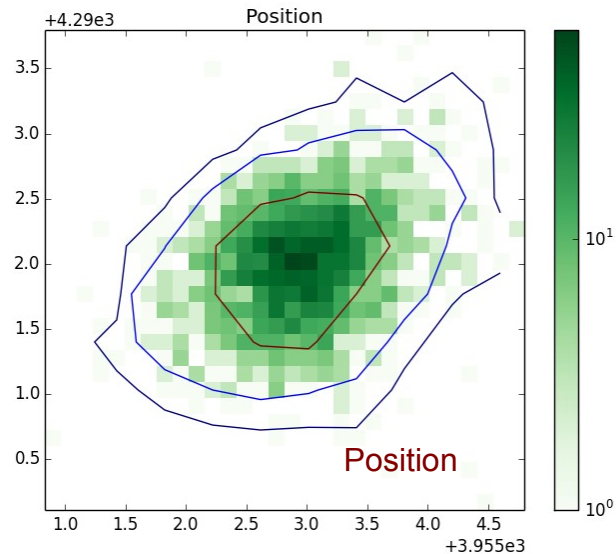
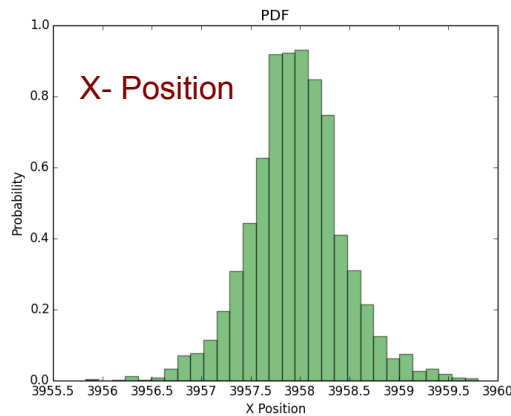
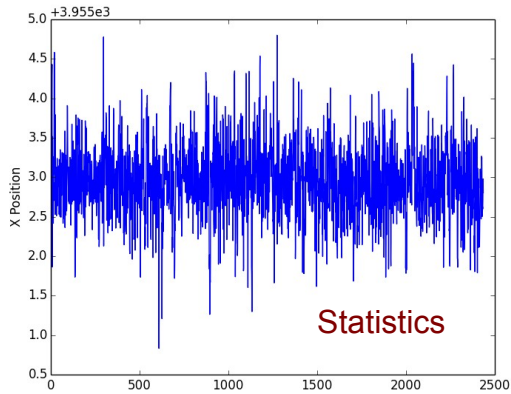


For this example we know what model to use, so pick a polynomial and free-up some of the parameters:



# get\_draws for measuring parameter uncertainties

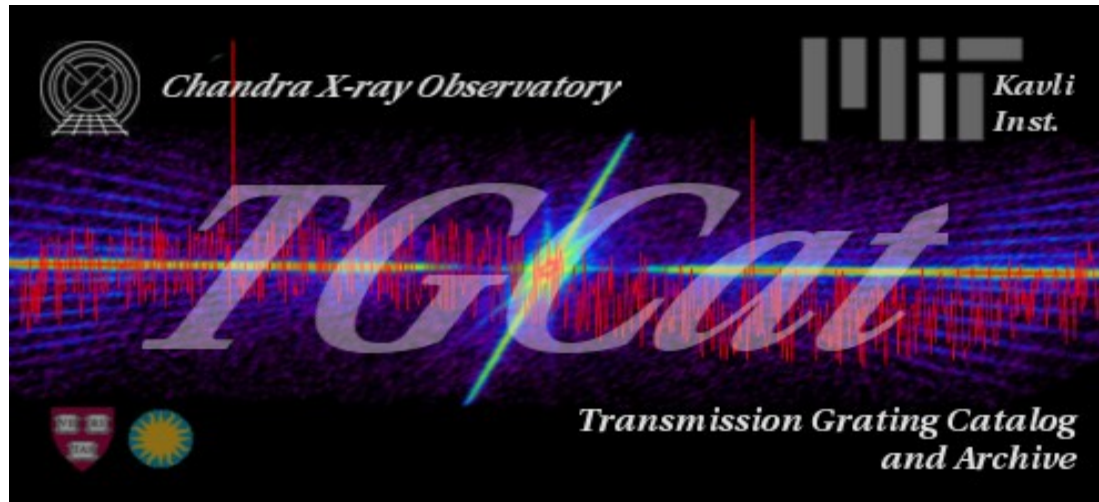
“get\_draws” - Sherpa function to run MCMC and obtain the simulation sample of parameters from posterior distribution (true model distribution given the data).  
Idea: use the function to estimate the uncertainties of the source position returned by MLE for the CSC





# Gratings

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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



### 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

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