



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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Current team:

### **SAO Scientists**

Jonathan McDowell	SDS lead, data model, coords
Antonella Fruscione (½ time)	SAO dep.lead, Docs and Release lead
Aneta Siemiginowska	Catalog, Sherpa, Astrostatistics
Doug Burke	Catalog, Sherpa, Scripts, Infrastructure, Releases
Frank Primini	Catalog, Photometry, Source Detection, HRC

### **SAO IT Specialists**

Kenny Glotfelty	Helpdesk, scripts, docs, legacy expertise
Nick Lee	Helpdesk, scripts, docs

### **MIT Scientists (~3.5FTE)**

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



# Community Support: Downloads, Documentation, Helpdesk

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# CIAO 4.6, 4.7 Downloads



CIAO 4.7 is the current supported release.

Downloads of CIAO 4.6 (released 2013 Dec 12)  
and CIAO 4.7 (released 2014 Dec 16)

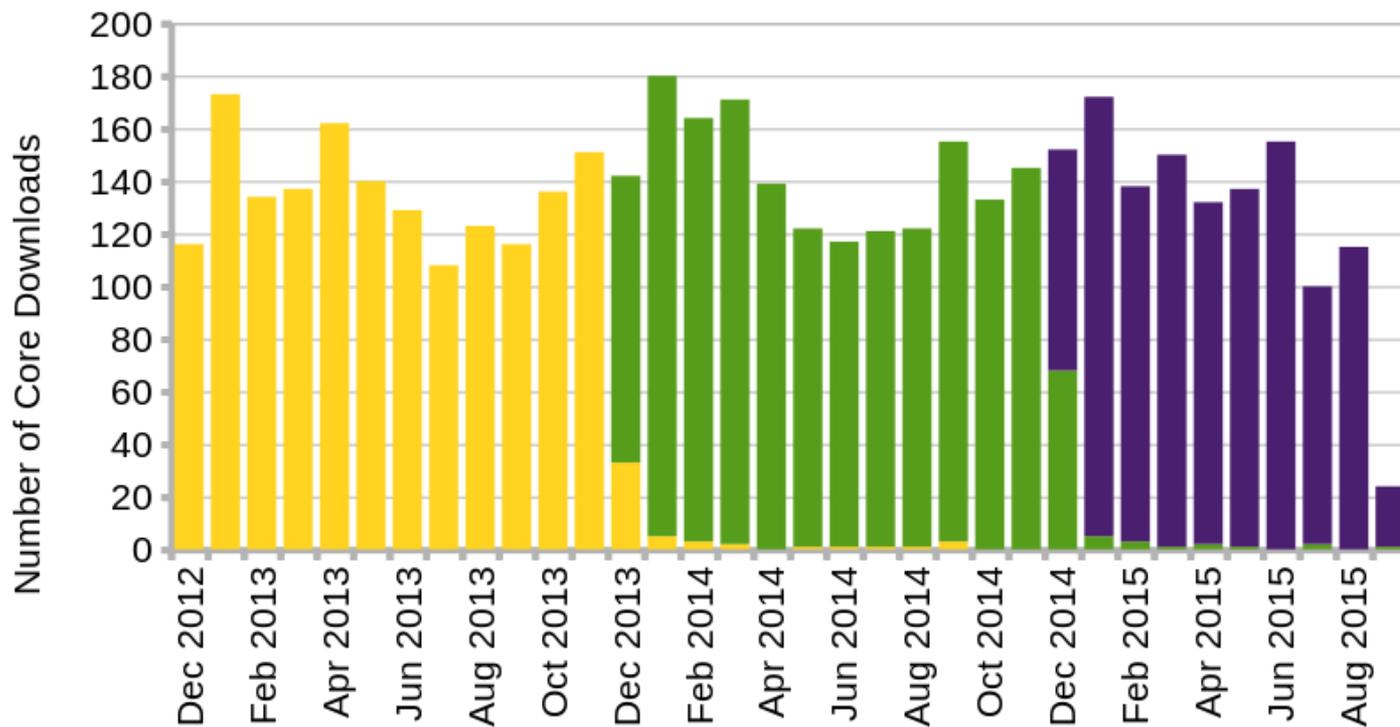
	CIAO 4.6 (Sep 2014-Aug 2015)	CIAO 4.7 (Dec – Aug )
Linux	293 (of which 54 were 32-bit)	656 (130)
Mac	226 (31 OS10.6.8)	468 (44 OS10.8)
Source build	65	91
Total	584	1215

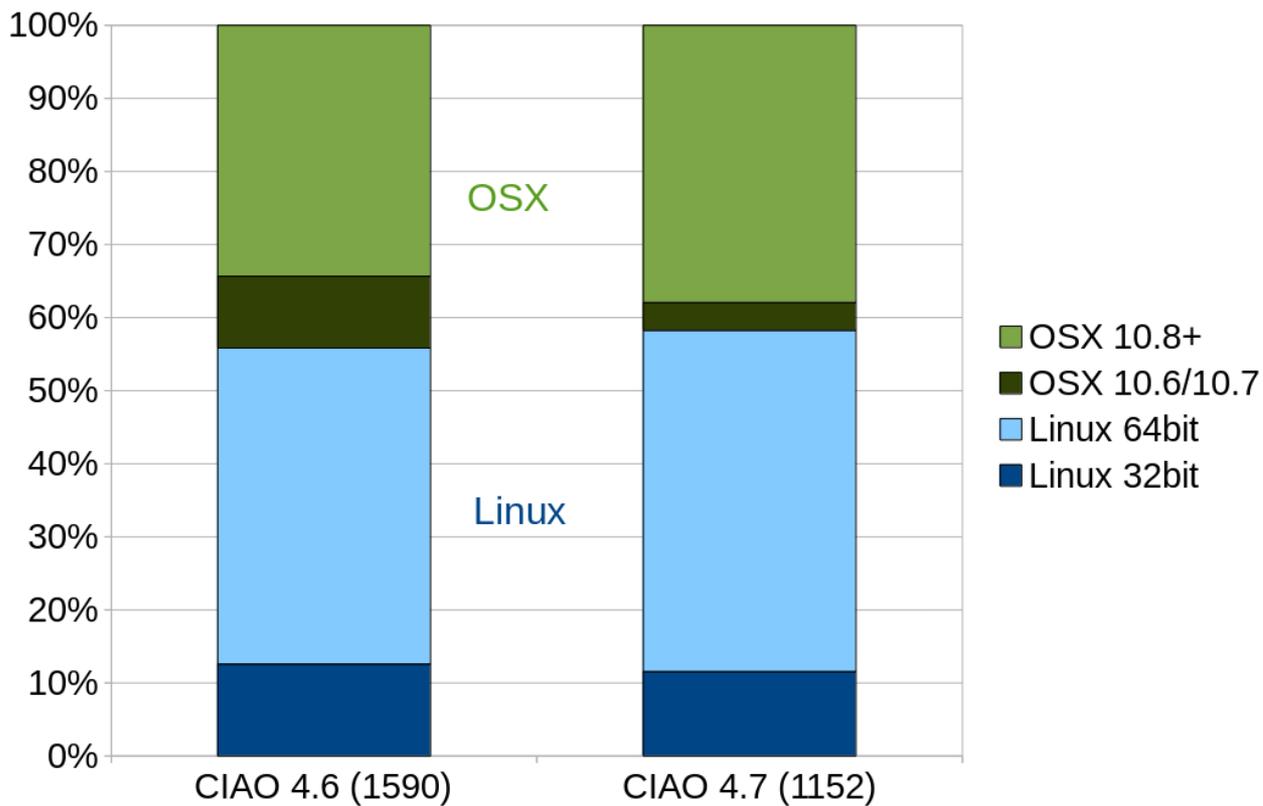
## Summary:

- Total CIAO demand still strong (4% drop compared to same time last year)
- Linux/Mac mix unchanged (Mac 42% vs 44% last year)
- Shrinking demand for older MacOS, slight drop for 32-bit Linux (down to 20% of CIAO4.7 Lin)

# CIAO Downloads

- CIAO 4.7
- CIAO 4.6
- CIAO 4.5





OS breakdown, CIAO4.7 (last 9 months) compared to 4.6 (since Dec 2013)



# CIAO Documentation



## Updated threads

acisbackground  
acisbadpixels  
acisfptemp  
add\_grating\_orders  
add\_grating\_spectra  
archivedownload  
axbary  
ciao\_install  
coadding  
combine  
createL2  
dmcoords\_displace

eff2evt  
hrci\_bg\_events  
param\_files  
pimms  
reproject\_aspect  
reproject  
spectra\_hetgacis  
spectra\_letgacis  
spectra\_letghrcs  
spectra\_multi\_hrcml  
xspec\_phabackground



# CIAO Documentation

## New and updated Threads

- Why topic on picking monochromatic energy when making flux estimates
- Updated axbary thread
- Rewritten 'Phase Resolved Spectroscopy' thread
- Rewritten 'Rebuilding CIAO from source' instructions
- Updated 'Correcting Absolute Astrometry' (more keyword changes)
- Thread for using ACA Optical Monitor data
- New PSF (mostly MARX) threads
  - Preparing to Run ChaRT
  - Using MARX to create an event file from ChaRT rays
  - Creating an image of the PSF
  - Additional MARX use cases

Also reviewed all threads for CIAO4.7 maintenance changes



# CIAO Documentation

PSF CENTRAL website developed and released

Effort to unify under one umbrella the wealth of information about the Chandra PSF (dictionary, ahelp files, threads, why documents etc.) currently scattered around the CIAO webpages

About 20 Helpdesk tickets per year mentioning the PSF

Organized by tool (first release) and by scientific questions (e.g. is my source extended? is this jet real? etc.)

Connection with SAOTRACE/CHART and MARX.

New Sep 2015 update in association with Chart V2 release

[CXC Home](#) | [Proposer](#) | [Archive](#) | [Data Analysis](#)  
[Instruments & Calibration](#) | [For the Public](#)  
     
Search the ChART website or contact the CXC HelpDesk

**PSF Ray Tracing and Tools**

[CXC Home](#) | [Proposer](#) | [Archive](#) | [Data Analysis](#)  
[Instruments & Calibration](#) | [For the Public](#)  
     
Search the ChART website or contact the CXC HelpDesk

**Tools that Make Use of PSFs**

[PSF Central](#)

Several of the available tools in CIAO make use of the PSF and are listed in the table below, with links to documents that have examples of uses.

Tool/Script	Description	Related Threads
<a href="#">desolve</a>	Applies the Lucy-Richardson deconvolution algorithm to 2D images.	<ul style="list-style-type: none"> <li>• Its use and results are shown in the <a href="#">Using MARX to Simulate an Existing Observation</a> thread.</li> </ul>
<a href="#">spsave</a>	Computes values and bounds for source intensity quantities. Requires a PSF fraction, derivable from a PSF image, as an input argument.	<ul style="list-style-type: none"> <li>• <a href="#">Computes Net Counts, Ratio or Flux for Point Sources</a></li> <li>• <a href="#">Calculate source count rates and fluxes</a></li> <li>• <a href="#">Computing the Intensity Upper Limit for an Unresolved Source</a></li> </ul>
<a href="#">ref_eaio</a>		
<a href="#">psfcenter</a>		
<a href="#">wardirect</a>		
<a href="#">psfsize_acis/psf_size</a>		
<a href="#">psfconv</a>		
<a href="#">new_psf_asymmetry_ratio</a>		
<a href="#">psf</a>		
<a href="#">ps_create_mask</a>		

Besides simulating the Chandra PSF, there are many tools available to help with PSF analysis. Below is a list of some of these tools:

- [Preparing to Run ChART](#)
- [Using MARX to Create an Event File](#)
- [Using MARX to Simulate an Existing Observation](#)
- [Using MARX to Simulate a Planned Observation](#)
- [Accounting for PSF Effects in 2D Image Fitting](#)

**psfsize and the PSF library**

`psfsize` is a now deprecated tool that was used to generate a PSF library. The PSF library consisted of a set of data files that were used to generate PSF images. The PSF images were used to generate PSF images. The PSF images were used to generate PSF images.



# CIAO Documentation

## Web site analytics

- Most users reach pages via Google search
- Threads and ahelp files are the most-visited pages
- Our web site is divided structurally into CIAO, Sherpa, ChiPS, ChaRT

	CIAO	Sherpa	Chips	ChaRT
Sessions	61350	16699	2905	1767
Users	23670	7866	1709	562
Pageviews	185620	44014	7217	5345
Duration	4:53	3:37	2:57	5:13 min:s



# Community Support



- Helpdesk: 278 new tickets (Sep 15 2014 –Aug 31 2015)
  - compare 287 tickets for same period last year
  - Median time to first ticket answer 5.0 hour
- New accounting method – previously we started the clock when ticket was assigned to a helpdesk tech, now we start it when email arrives at CXC (so, impacted by evenings and weekends). Value for old method remains 0.5hr
  - Median time to final answer after assignment 2.1 hr
  - » Bugs found: e.g. falsesrc parameter issue in wavdetect; problem with \$TMP\_DIR on SI cluster; wrong data type in CALDB blanksky file; bug in specextract due to compiler optimizer issue in colden program
  - » Documentation improved: NOM/PNT/TARG header keys and reprojecting; python with Frameworks numpy install; HRC gain files, axbary responses
- 93% 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



## CIAO Training at the 15 Years of Chandra meeting



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

15 students [grad students, postdocs] attended for hands-on CIAO training. Students were from CfA, PSU, Hawaii, Calgary, Columbia, Dartmouth, RIT and Amsterdam.

Science Organizing Committee:

Antonella Fruscione + Kenny Glotfelty SDS  
Vinay Kashyap + R. Nicholas Durham CAL

Talks: Intro to X-ray,  
Chandra PSF,  
Effective Area + Contamination,  
Background

Hands-on sessions: SDS team gave  
one-on-one support throughout the day

A. Siemiginowska served on the 15 Years SOC.





*D. Burke taught at the 2-week  
COSPAR Advanced School on X-ray  
Astrophysics (Nov 2014, Mexico)*

*We also provided booth  
support at the 15 Years  
meeting and at the Jan AAS.*



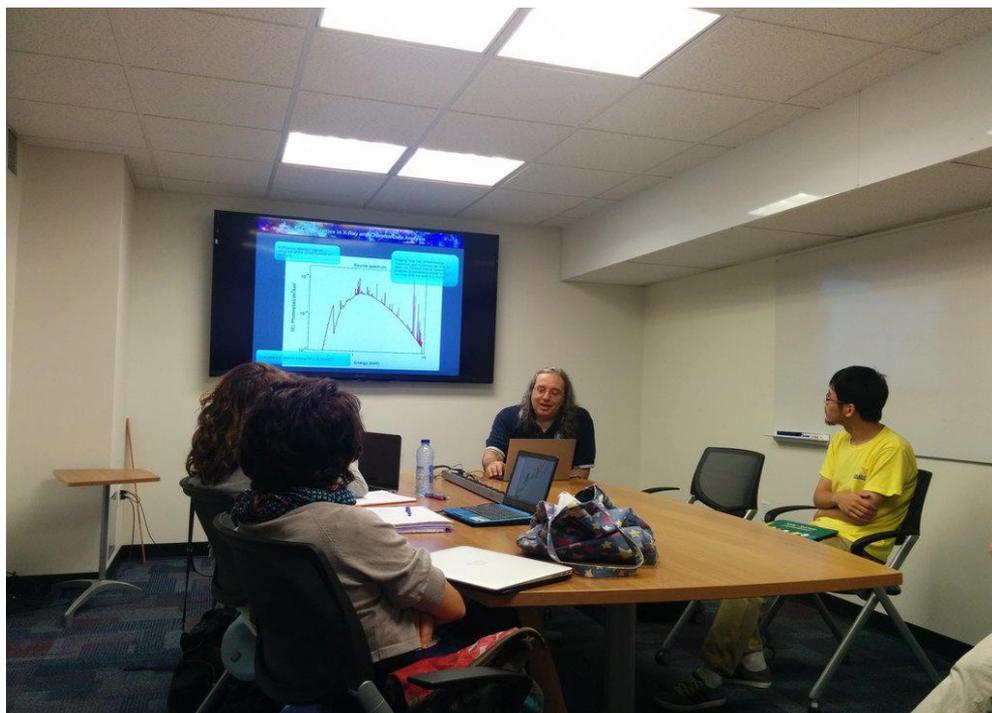


## CIAO Training at the High Res Spectroscopy workshop



A one day small-scale CIAO and grating analysis workshop was held on 18 August 2015 at CFA (1 day before the High Res Spectroscopy workshop).

4 students [grad students, postdocs] attended for hands-on CIAO training following an introductory talk.





## CIAO table at the IAU General Assembly



At the International Astronomical Union 2015 GA in Hawaii we staffed a table (with CDO) at the NASA booth complex and presented technical demos on CIAO and on the source catalog.





# CIAO Community Support – Social Media



## Social Media

- Facebook page
- Twitter stream @chandraCIAO
- Google+ page

Managed in an integrated way (same message can be sent automatically to all the streams)

Twitter now widely used by astronomers  
If we can get uptake, it's a useful channel to rapidly draw users' attention to new capabilities or to bugs

Will take some time to get traction though



# 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 4.6.4 to 4.6.9
- CALDB 4.6.9 release Sep 2015
  - New TGAIN
  - LSFARM (LETG encircled energy parameters, for improved background)
  - HRC-S,I QE (updated for consistency with LSFARM)
  - ACIS background files (header keyword fix only)
  - DET\_GAIN, P2\_RESP for ACIS-S1 (related to grating spectra improvements)



# CIAO 4.8 and Scripts Overview

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# CIAO Release

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- This year, top priority is Catalog Release 2 support
- CIAO 4.7:
  - Maintenance release, released as planned Dec 2014
  - Supporting DS work on improved source build, standalone Sherpa
  - Bug fixes
  - New scripts
  - CC mode improvements deferred, needed more work
- \* CIAO 4.8
  - Another maintenance release, with script releases during the year
  - CC mode improvements completed
  - [Improvements to dmcopy filtering on character string-type table columns](#)
  - New scripts but no major development except in areas related to source catalog
  - Script releases Nov, Dec, Apr, Jun, Sep



# SDS Contributed Scripts

## Updated scripts

- `specextract` fix for -110C data
- `dax menu` adjustments
- `mktgresp` supports 'orders' parameter and uses multiple CPUs when needed
- `srcflux` saves more data on the source, uses more accurate exposure time, support use of colden NH
- `acis_set_ardlib` enhanced to allow better user control of parameters in `specextract`  
(e.g. control over contamination model files)
- `chandra_repro` improvements (next slide)
- maintenance changes on `chandra_repro` to accommodate `acis_process_events` parameter change
- `merge_obs` et al: updated to use output of `splitobs` to handle multi-obi datasets
- `ecf_calc`: fixed to support image input as well as tables, responding to helpdesk request
- `combine_spectra`: minor fix to omit path from filenames stored in header
- `tgsplit`: fix to match CC mode response files with correct PHA files
- `mktgresp` improved to handle obsids with multiple aspect soln files



# SDS Contributed Scripts – chandra\_repro

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chandra\_repro improvements:

- support for FAINT\_BIAS datasets
- uses gti\_align to align good time intervals to time boundaries of frames in ACIS TIMED mode
- detects cases of multiple obi per obsid and interleaved mode, and warns user to use splitobi first
- catch case of events with no aspect solution (time boundary of mission timeline off from ACIS frame time)
- update internals to handle parameter changes in tools (e..g acis\_process\_events)



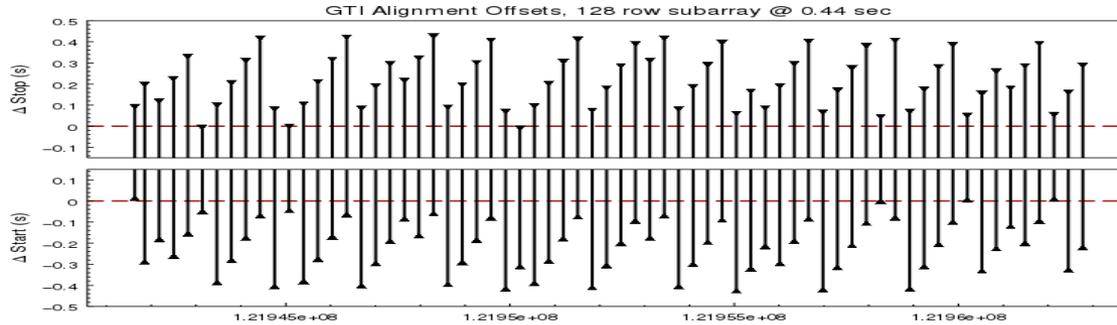
# SDS Contributed Scripts

## New scripts

- [combine\\_grating\\_spectra](#) (described in previous CUC)
- [tgsplit](#) : splits a Type II (grating) PHA file into separate orders
- [splitobi](#) separate multi-obi and interleaved-mode datasets so that the individual pieces can be handled by `chandra_repro`
- [gti\\_align](#) Synchronize good time intervals with ACIS exposure boundaries [SLIDE]
- .
- [detilt](#), [dewiggle](#) and [symmetrize](#) (Contributed by CAL group)  
Scripts to tweak HRC-S/LETG background  
Removes time-dependent tilts and small scale wiggles in spectra
- [readout\\_bkg](#): Implements Vikhlinin/Markevitch algorithm for readout streak background [SLIDE]
- [install\\_marx](#): Simplify installation of MARX simulator within CIAO
- [download\\_obsid\\_caldb](#): Download only part of CALDB you need [SLIDE]



# SDS Contributed Scripts – gti\_align

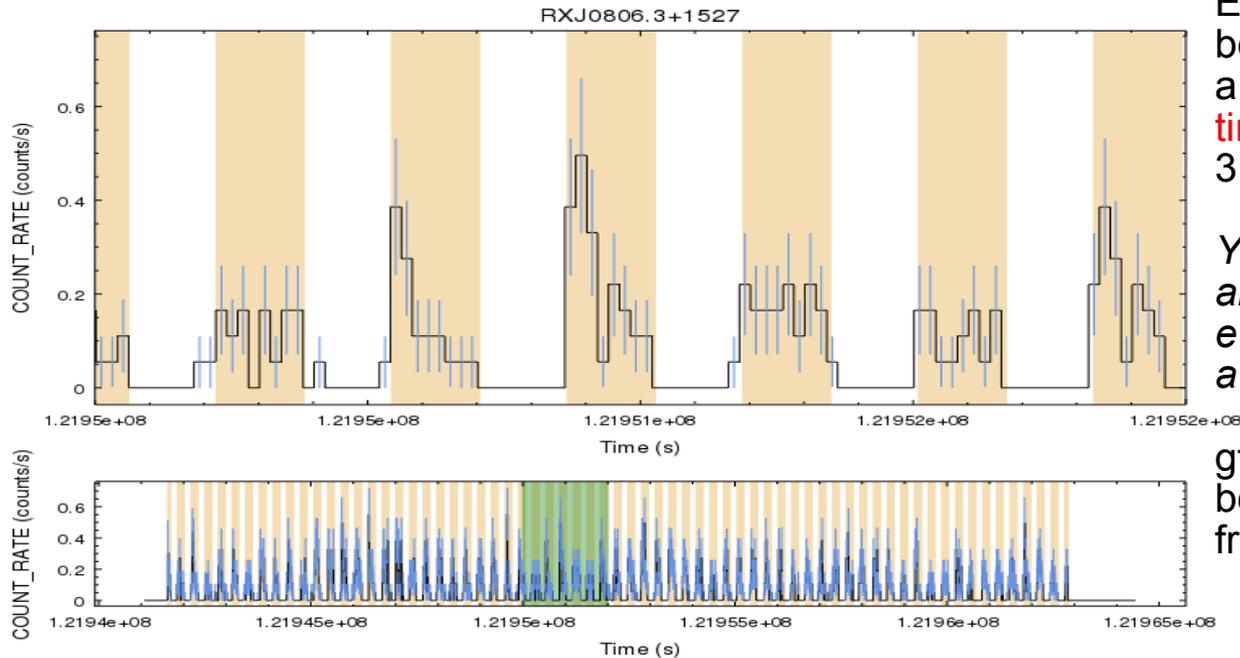


Phase binning light curve – 'phase align' thread uses `dmgti` tool, creates many good time intervals (GTIs)

Each GTI contributes to the estimated exposure time

Each has a small error because true exposure time is a multiple of the **ACIS frame time** (here 0.44s but usually 3.2s)

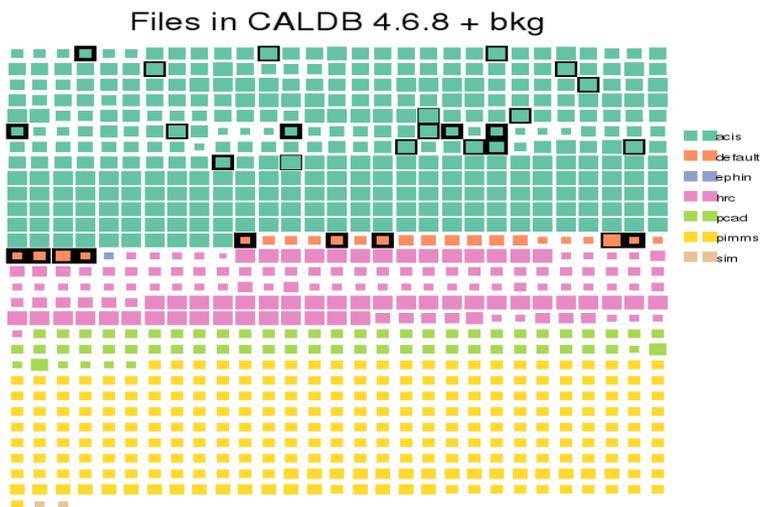
*You can't filter out only part of an ACIS frame! The event/photon time  $t$  is actually a range ( $t-1/2 dt, t+1/2 dt$ )*



`gti_align` corrects the GTI boundaries to lie on ACIS frame time boundaries



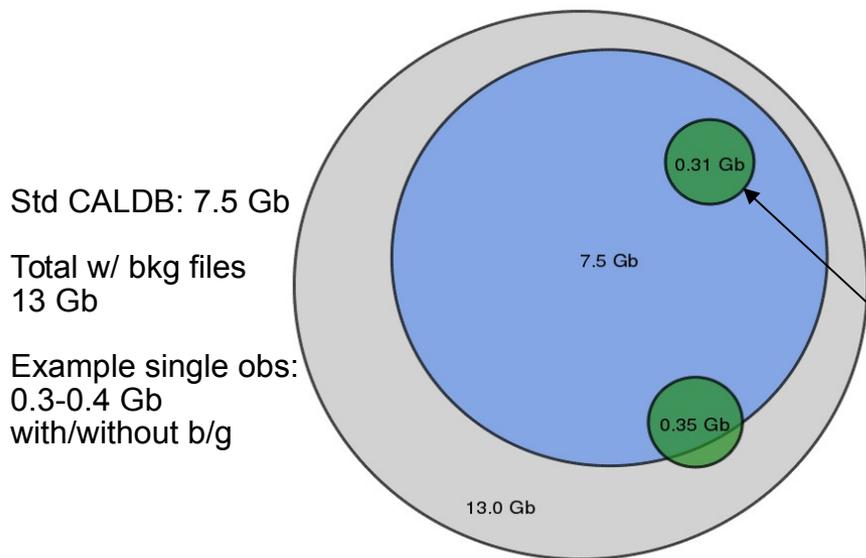
# download\_obsid\_caldb



Several recent help desk tickets have reported problems downloading CALDB due to size (3 Gb zipped, 7.5 Gb unzipped)

Only a small fraction of Chandra CALDB is needed to analyze any **one** ObsID

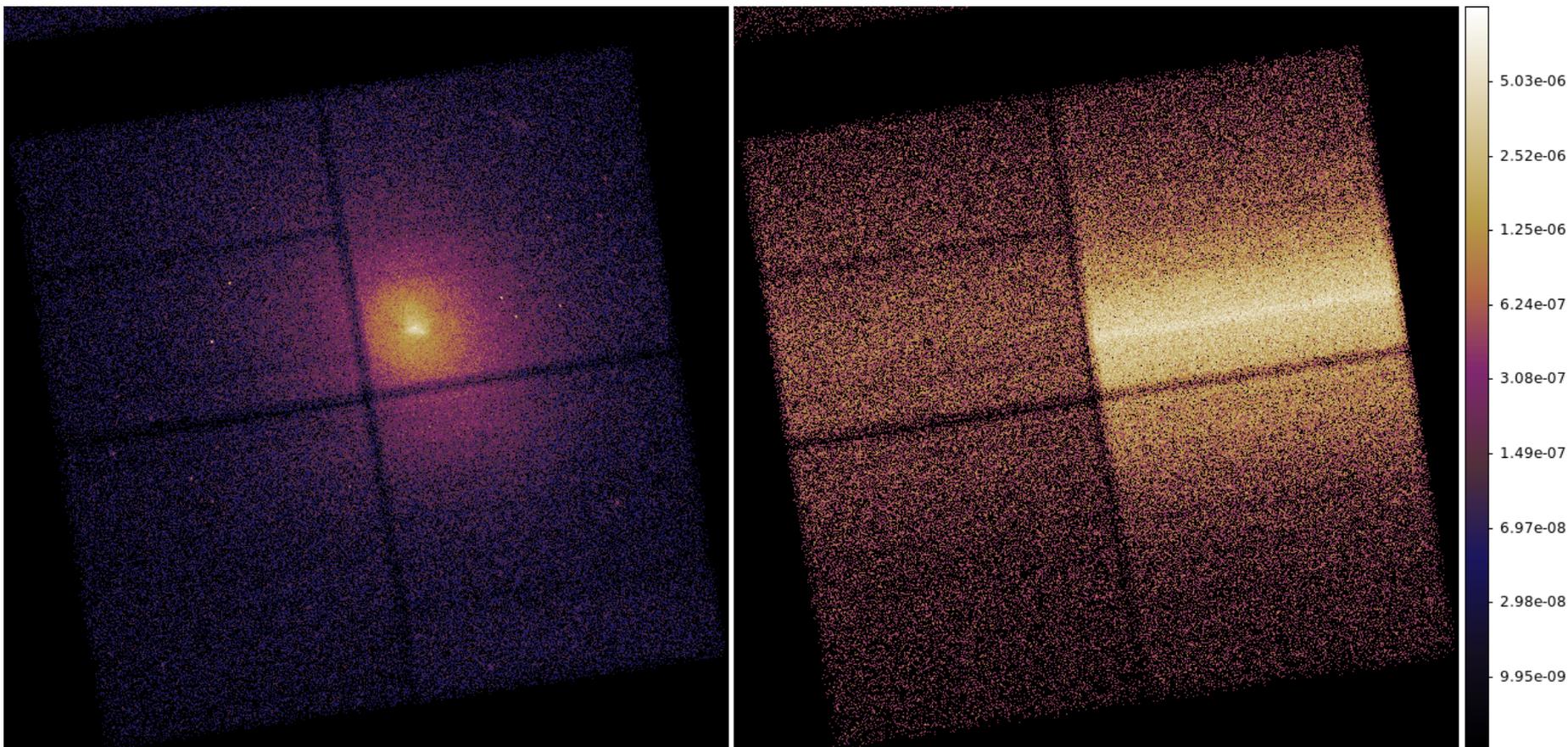
This new script figures out which CALDB files are needed for that ObsID and downloads **just those that user doesn't already have.**



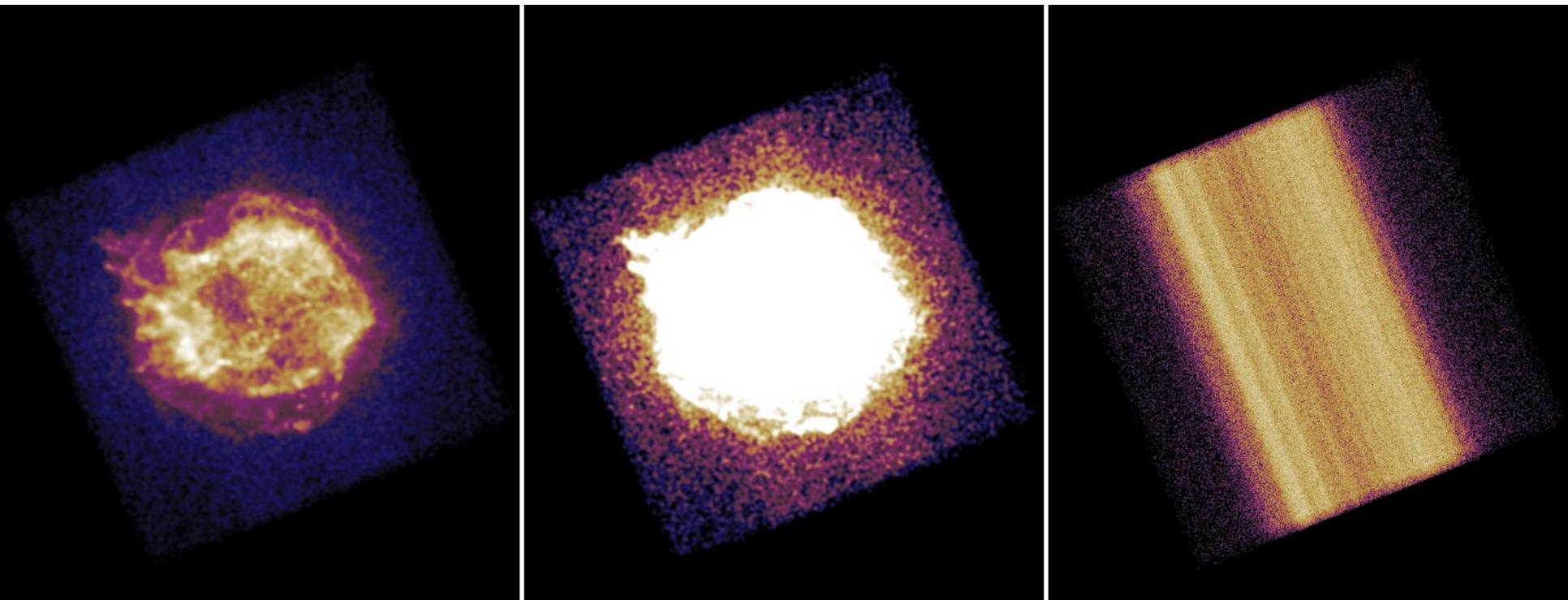
By default the files are added to user's standard CIAO CALDB location  
Allows user to accumulate CALDB files as needed, ObsID by ObsID

Particularly helpful for users with less-than-fully-reliable internet connections where a multi-Gbyte file can time-out.

```
% download_obsid_caldb 635
```



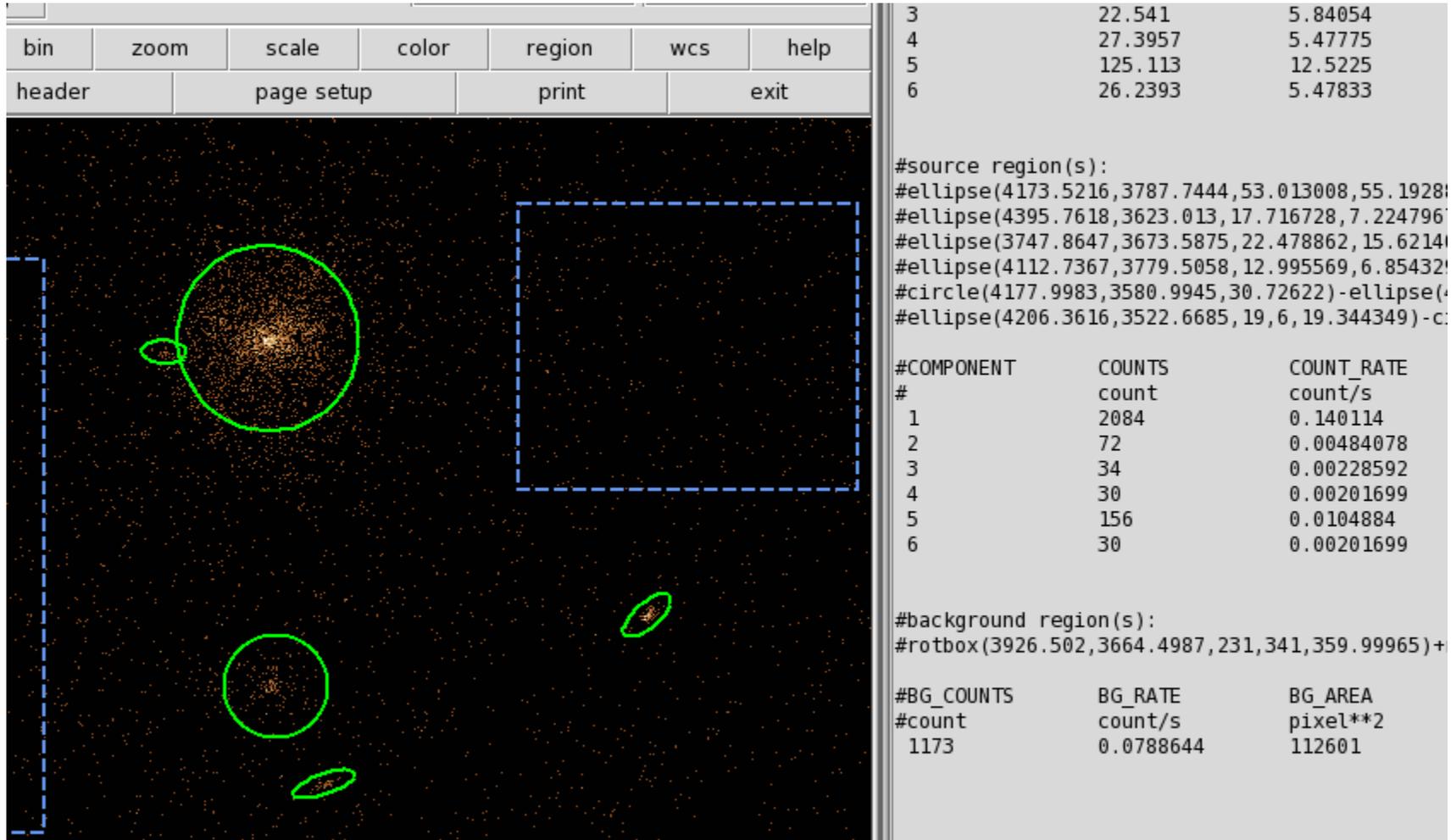
Vikhlinin et al. <http://adsabs.harvard.edu/abs/2005ApJ...628..655V>  
Creates out-of-time background event file from observed data  
ObsID 10805: Abell 2199 (left), background count rate (right)



In this case (Cas A) the readout background is clearly visible in the central, stretched, image of the data



# SDS Contributed Scripts – dax



New option: Net Counts



# Sherpa



“.. the CUC is concerned that resources are being spent to make Sherpa available to a wide astronomical community without a verified potential 'customer's market' ...”

CXC response: from Apr 2012 to early 2015 we had 38 helpdesk tickets which made use of the prototype standalone or were related to situations where it would have helped.

Level of effort for Sherpa in general has been low for 2015 except for catalog-support related work; the standalone project was not a large one. Standalone also motivated by needs of internal CXC operations environment

“.. consider reallocating resources to scientifically higher priority tasks (e.g. the source catalogue) if this can help with achieving them..”

CXC response: Sherpa lead scientist A. Siemiginowska has mainly worked on catalog support tasks (making use of Sherpa) this year. The other SDS scientist with a significant Sherpa role, D. Burke, has been reassigned approximately half-time to work on the catalog (Burke also has a key role in CIAO and script release work). *See also next slide*

“The CUC asks that a detailed outlook on the future of Sherpa is presented at the next CUC meeting.”



# Sherpa Resources

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- **Scientists in SDS:** Aneta Siemiginowska (0.25FTE) Doug Burke (0.25FTE)
  - Science requirements, specs, prototypes
  - End-to-end testing (science threads)
  - Documentation - threads, functions, manual
  - Helpdesk and user support.
- **Data Systems:** Omar Laurino, Dan Nguyen, Warren McLaughlin
  - Infrastructure - including OTS, compilers etc.
  - Development of the code from SDS-provided requirements
  - Code documentation and code review
  - Unit and integration tests
  - User support, bug fixes
- **Bi-weekly status meetings to review issues and pull requests**
- **Set up system to monitor GitHub tickets and code changes**
- **'Hotseat' schedule with scientist/developer pair assignment**



# Sherpa 2015 Development



- Sherpa Source code (CIAO version 4.7) was released on GitHub on April 20, 2015 <https://github.com/sherpa/sherpa>
  - Easy build with “python setup.py install” into the users Python environment.
  - Source code open for collaboration and users' input
  - Improved workflow between SDS scientists and DS team
  - Poster presented at 'Python in Astronomy' conference
- Infrastructure work to incorporate Travis continuous integration testing
  - standard testing environment for efficient and automatic testing
  - also important if accepting contributed code from users.
- Bug fixes and limited new functionality in CIAO 4.8 (code freeze Oct.1)
  - Support for XSPEC12.9 models and bug fixes in model interface
  - New statistics ‘wstat’ - cstat with Poisson background
    - planned for spectral modeling in the Catalog pipeline.



# Sherpa Future



## 1) Improve and expand current documentation

- Documentation within the code
- Web documentation both system and content:
  - » Sphinx - documentation integrated into the code
  - » Threads and Notebooks
  - » Sherpa Manual

## 2) Support Chandra Source Catalog

- Spectral fitting - statistics, datastack, simultaneous fitting, background models
- Functions to support analysis of MCMC samples
  - » Calculation of autocorrelation, assessment of convergence,
  - » Output plots, output probabilities

## 3) Support CXC Operational Needs:

\* Respond as requested by CXC teams

## 4) Support Chandra Users:

Focus on 2D image analysis - independent PSF binning, temperature maps

Improved handling of MCMC outputs

Model selection tests based on Catalog work

Incorporate calibration uncertainties, as defined by the calibration team

Incorporate useful algorithms developed by other groups

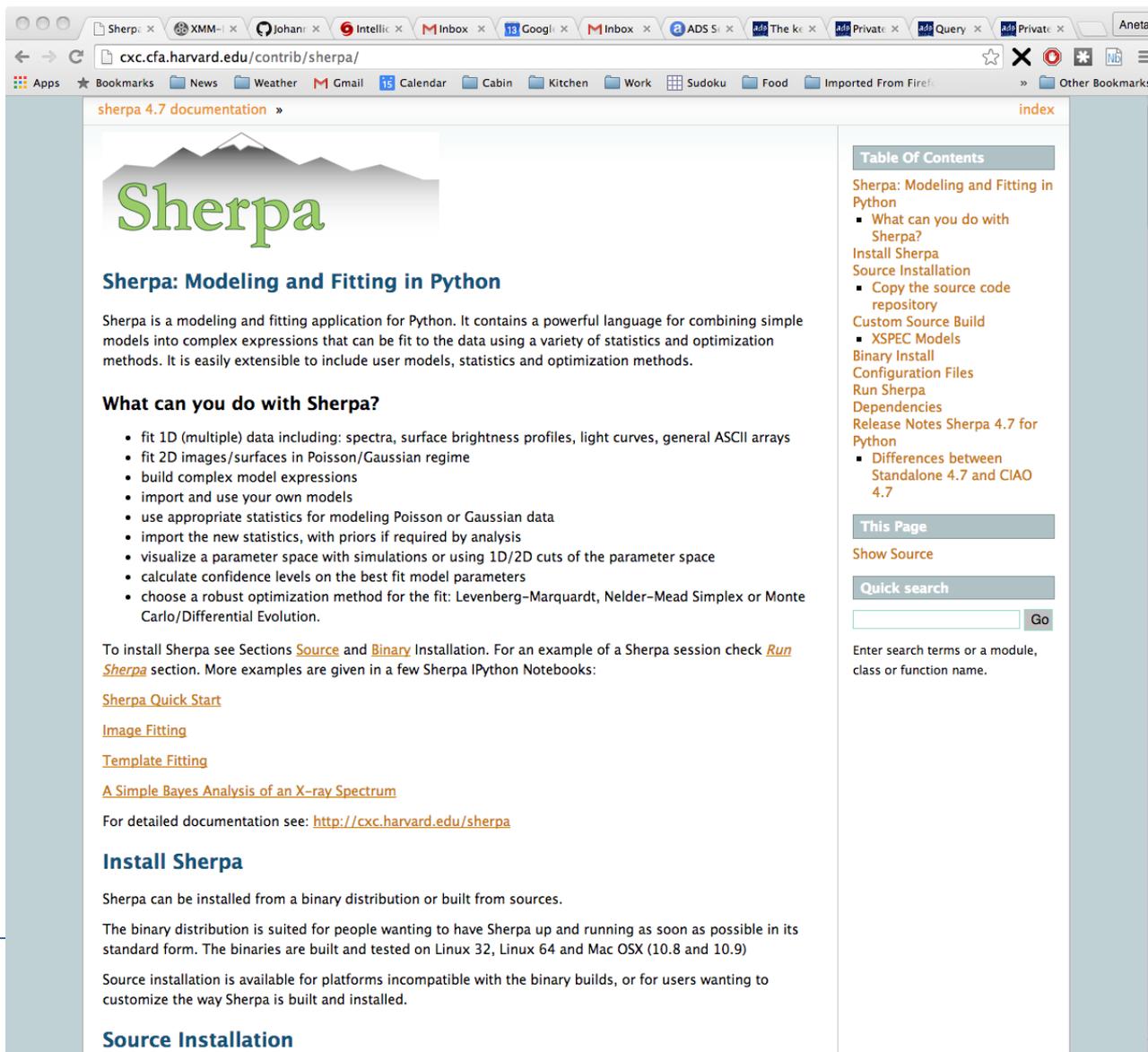
## 5) Support non-Chandra Users (limited):

Respond to GitHub tickets as resources allow



# Sherpa future 1: Documentation

cxc.cfa.harvard.edu/contrib/sherpa



The screenshot shows a web browser window with the URL `cxc.cfa.harvard.edu/contrib/sherpa/`. The page title is "sherpa 4.7 documentation" and it includes an "index" link. The main content area features a large "Sherpa" logo with a mountain range background. Below the logo is the heading "Sherpa: Modeling and Fitting in Python" and a paragraph describing the application. A section titled "What can you do with Sherpa?" lists various capabilities. The right sidebar contains a "Table Of Contents" with links to sections like "What can you do with Sherpa?", "Install Sherpa", and "Differences between Standalone 4.7 and CIAO 4.7". There is also a "Quick search" box and a "This Page" section.

sherpa 4.7 documentation » index

## Sherpa

### 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 1D (multiple) data including: spectra, surface brightness profiles, light curves, general ASCII arrays
- fit 2D images/surfaces 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 a 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.

To install Sherpa see Sections [Source](#) and [Binary](#) Installation. For an example of a Sherpa session check [Run Sherpa](#) section. More examples are given in a few Sherpa IPython Notebooks:

[Sherpa Quick Start](#)

[Image Fitting](#)

[Template Fitting](#)

[A Simple Bayes Analysis of an X-ray Spectrum](#)

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

### Install Sherpa

Sherpa can be installed from a binary distribution or built from sources.

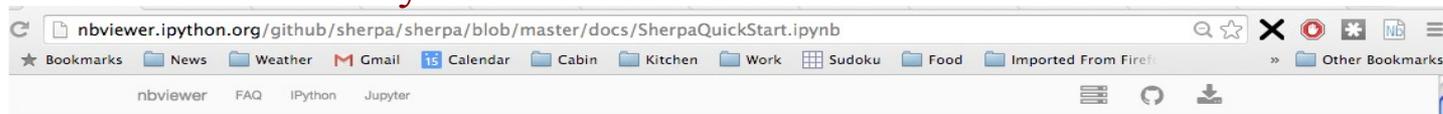
The binary distribution is suited for people wanting to have Sherpa up and running as soon as possible in its standard form. The binaries are built and tested on Linux 32, Linux 64 and Mac OSX (10.8 and 10.9)

Source installation is available for platforms incompatible with the binary builds, or for users wanting to customize the way Sherpa is built and installed.

### Source Installation



# Sherpa future1: Documentation (cont.) IPython Notebooks



## Sherpa Quick Start

This tutorial shows some basic Sherpa features.

Workflow:

- create synthetic data: a parabola with noise and error bars
- load data in Sherpa
- plot data using matplotlib
- set, inspect, edit a model to fit the data
- fit the data
- compute the confidence intervals for the parameters
- explore the parameter space

First of all, let's activate the inline matplotlib mode. Sherpa seamlessly uses matplotlib to provide immediate visual feedback. Sherpa requires the matplotlib package to be installed.

```
In [1]: %matplotlib inline
```

The following commands just avoid some unnecessary logging duplication when using Sherpa:

```
In [2]: import logging
logging.getLogger('sherpa').propagate = 0
```

Now, let's create a simple synthetic dataset, using numpy: a parabola between x=-5 and x=5, with some noise

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

Let's import Sherpa:

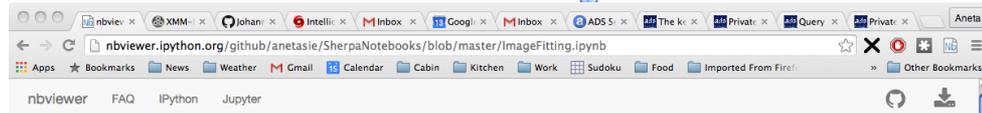
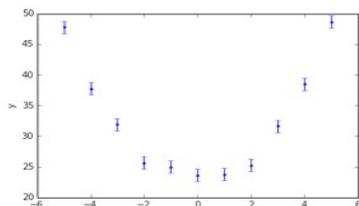
```
In [4]: from sherpa.astro import ui as sherpa
```

WARNING: failed to import sherpa.astro.xspec; XSPEC models will not be available

Depending on how you installed Sherpa, certain special features may be enabled or disabled. Sherpa prints out the status of these features, as shown above. These warnings are benign. You can refer to the Sherpa documentation to find out how to enable them.

Let's load and plot the data we just created. Notice we are assigning the ID mydata to the dataset we are using in the rest of the tutorial. Sherpa can deal with multiple datasets, fit them simultaneously with the same model, read ASCII table and FITS files (provided the pyfits package is installed).

```
In [5]: sherpa.load_arrays("mydata", x, y, e)
sherpa.plot_data("mydata")
```



## Image Fitting in Sherpa: Accounting for the PSF effect

Images can be easily fit in Sherpa. In the following example we show how to include the PSF in the modeling of the central source. The X-ray Chandra image data are modeled with the gaussian shape that accounts for the point source emission (quasar in this case) and a constant for the background. We ignore the region of the image with the additional structure in the vicinity of a point source.

```
In [1]: from sherpa.astro.ui import *
from IPython.core.display import Image
```

After importing Sherpa package we define the statistics and an optimization method. X-ray counts are modeled using a Poisson likelihood defined via Cash (1979) and we will use Monte Carlo (differential evolution algorithm) implemented in Sherpa.

```
In [2]: set_stat("cash")
set_method("moncar")
```

We first load the X-ray fits image first and then the PSF image which matches the binning of the X-ray image.

```
In [3]: load_image("image.fits")
```

```
In [4]: load_psf("myspf", "psf.fits")
set_psf(myspf)
print get_psf()
```

Param	Type	Value	Min	Max	Units
myspf.kernel	frozen	psf_center_33x33_0.5.fits			
myspf.size	frozen	(33, 33)	(33, 33)	(33, 33)	
myspf.center	frozen	(16, 16)	(16, 16)	(16, 16)	
myspf.radial	frozen	0	0	1	
myspf.norm	frozen	1	0	1	

PSF image is defined as 'myspf' and the source model will be convolved with this psf image during the fit. The center of the PSF image needs to be redefined to the central location on the pixel.

```
In [5]: myspf.center = (17.0, 17.0)
```

Gaussian model (gauss2d) and a constant (const2d) are set to model the image. Note that these two models are named q1 and c0 in this Sherpa session.

```
In [6]: set_model(gauss2d.q1+const2d.c0)
guess(q1)
```

We display the data with ds9 (the ds9 window will appear outside the browser) and set the filter to ignore the extension around the point source.



# Sherpa future 1: Documentation (cont). GitHub

Issues

Sherpa is a modeling and fitting application for Python <http://cxc.cfa.harvard.edu/contrib/sherpa>

653 commits 12 branches 3 releases 4 contributors

Branch: master sherpa / +

Merge PR #81 (DougBurke) - Ensure Xspec models return 0's in case of ...

DougBurke authored 3 days ago latest commit 92a7b2d978

- docs Remove S-Lang files. 2 months ago
- extern remove generated region library files and gitignore them 4 months ago
- helpers make sure setupools is not required (needed for CIAO) 2 months ago
- recipes/conda bump version in conda recipe metadata 5 months ago
- scripts Remove S-Lang files. 2 months ago
- sherpa-test-data @ 7b0e89d add missing acis model file in sherpa-test-data 3 months ago
- sherpa Merge PR #81 (DougBurke) - Ensure Xspec models return 0's in case of ... 3 days ago
- .coveragerc add branch coverage 4 months ago
- .gitattributes add git versioneer (modified version of the conda-build versioneer) 5 months ago
- .gitignore remove generated region library files and gitignore them 4 months ago
- .gitmodules add sherpa-test-data submodule 4 months ago
- .travis.yml allow Xspec build to fail 2 months ago
- CITATION Added CITATION document 20 days ago
- CONTRIBUTING.md Remove the suggestion to skip the tests 18 days ago
- COPYRIGHT clarify Sherpa license is GPLv3+ 3 months ago
- LICENSE add licensing and copyright information 5 months ago
- MANIFEST.in add new files to MANIFEST.in 4 months ago
- README.md Improve XSPEC build instructions [ci skip] 3 months ago
- pytest.ini tweak pytest configuration to better support additional arguments 4 months ago
- setup.cfg Add wcslib\_xxx options to setup.cfg for XSPEC 3 months ago

Pull Requests  
- code changes

sherpa / sherpa

Issues Pull requests Labels Milestones

32 Open 9 Closed

- save\_all does not save the source model for PHA data **type:bug** #97 opened 12 days ago by DougBurke
- Use of mutable default arguments **1 - Backlog area:code priority:low type:bug** #95 opened 16 days ago by olarino
- Some issues with sherpa\_test **1 - Backlog area:tests note:can-workaround priority:medium type:bug** #93 opened 17 days ago by olarino 4.8
- Give a more helpful error message when no FITS backend can be imported **1 - Backlog area:code priority:medium type:enhancement** #92 opened 17 days ago by olarino 4.8
- Importing sherpa.astro.ui generates deprecation warnings in IPython 4.0.0 **note:note-bug type:other** #85 opened 25 days ago by DougBurke
- Support Python 3 **1 - Backlog area:build area:code priority:medium type:feature** #78 opened on Aug 11 by codel
- Should Xspec model parameter names be changed to match Xspec 12.9.0? **dep:xspec type:question** #74 opened on Aug 4 by DougBurke

sherpa / sherpa

Issues Pull requests Labels Milestones

9 Open 51 Closed

- Fix handling of non-contiguous grids in XSPEC models **3 - Working area:code dep:xspec priority:high type:bug type:enhancement** #101 opened 2 days ago by DougBurke 4.8
- Fix set\_source output from save\_all **3 - Working area:code type:bug** #100 opened 3 days ago by DougBurke
- bugfixes for the save\_all command **3 - Working area:code type:bug type:enhancement** #98 opened 4 days ago by DougBurke
- Feature/wstat **3 - Working area:science type:feature** #94 opened 17 days ago by dnguyen12 4.8
- bug #46 handle commentary cards with astropy **3 - Working area:code type:bug** #91 opened 17 days ago by DougBurke
- add background data to user-defined statistics **3 - Working area:science type:feature** #90 opened 19 days ago by dnguyen12 4.8
- Bug #27 update pyfits deprecated interfaces **3 - Working area:code type:enhancement** #89 opened 19 days ago by DougBurke
- Bug #39 plotting counts vs channel **3 - Working** #86 opened 24 days ago by olarino 4.8
- Fix and clean up of the interface to XSPEC models **area:code dep:xspec note:obsolete pr:hold priority:high type:bug** #83 opened on Jul 9 by DougBurke 4.8

# Bug #39 plotting counts vs channel #86

Open olaurino wants to merge 2 commits into master from bug-#39-plotting-counts-vs-channel

Conversation 5 Commits 2 Files changed 1



olaurino commented 24 days ago

## Release Note

Sherpa incorrectly divided counts by the number of channels in a bin, so that, it would return counts per channel rather than counts. Similarly, the default plot show a plot of counts/channel vs channel. Now Sherpa always assumes that 1, even when it is the result of a grouping scheme, so that get\_counts().sum() ylabel has been updated accordingly from counts/channel to counts.

## Description

This is a rather simple fix, but I wonder whether there was a good reason for SI did. I am pushing this sooner rather than later, so that we can start the review. visually, but I am adding more automated tests.

olaurino added some commits 24 days ago

- always assume channels have width 1, even if they are grouped
- change channel, counts plot ylabel from counts/channel to counts

olaurino added the 3 - Working label 24 days ago



olaurino commented 24 days ago

@DougBurke, @anetasie are we sure that the counts/channel calculation was question is seems so, but maybe it was intentional to have counts/channel jus

olaurino commented 24 days ago

@DougBurke, @anetasie are we sure that the counts/channel calculation was a bad idea? From Nick's question is seems so, but maybe it was intentional to have counts/channel just as one would have counts/keV.

I am just being the advocate's devil, as I think it is more rational to have channels count as one even when they are grouped.

Also, we must be sure that this change does not affect anything elsewhere in the code, although all the tests are passing.

olaurino added this to the 4.8rc1 milestone 24 days ago

anetasie was assigned by olaurino 24 days ago

DougBurke commented 24 days ago

I am not at all convinced that you do not want coubtbs/channel but I haven't really thought about it

olaurino commented 20 days ago

@DougBurke @anetasie I need to be sure about the expected behavior of get\_counts() and, in turn, of what should be plotted, so that I can add the tests. So I am holding off on this one for now.

anetasie commented 20 days ago

This is tricky.

Sherpa has 'set\_analysis' which defines the analysis space and the y-axis for plotting. For ungroup data it is straightforward:  

```
set_analysis(1, 'energy', 'counts', 0)
set_analysis(1, 'channel', 'counts', 0)
```

 would result in plotting counts on y axis for ungroup data. After the data is grouped the y axis would contain counts/channel.

So the question is what should be plotted in the case of grouped data - total number of counts in a group at the center of a new group, or the number of counts in a group/number of channels that goes into that

Commits on Aug 25, 2015

add background data to user-defined statistics dtrnguyen2 authored 20 days ago ✓

Commits on Aug 27, 2015

For UserStat: If response has bkg then user must add bkg to the model... dtrnguyen2 authored 17 days ago ✓

add wstat dtrnguyen2 authored 20 days ago ✓

pep8 clean up dtrnguyen2 authored 17 days ago ✓

Commits on Sep 2, 2015

1) rename a local variable (response\_time -> exposure\_time). dtrnguyen2 authored 11 days ago ✓

ACorral\_T.pdf

888f262

37422f4

Show All



## Sherpa future 2: Chandra Source Catalog support

---

(see also Catalog presentation)

- Use **Sherpa MCMC** for position uncertainties - **probability of a source position** given the MLE best fit position. Simulated arrays will be stored as a part of the catalog - probabilistic approach to cataloging the source location (see Brewer, Foreman-Mackey, Hogg 2013, AJ, 146, 7B)
- The parameters of error ellipses - **approximations to the probability distributions** will be given in the catalog source lists.
- **Characterization of special cases:**
  - developed Sherpa simulations to investigate multiple and overlapping sources, faint sources at the edge of detector, position uncertainties in different energy bands.
  - working towards criteria for identifying these cases in the catalog
  - performed analysis of the correlations within the MCMC runs:
    - developed Python post-processing scripts to calculate one-lag autocorrelation and R-hat parameter for assessing convergence
- Research **methods for identifying non-unimodal distributions** in the MCMC sample:
  - discussions with statisticians
  - performed tests using Gaussian mixture models to identify the number of modes - this seems promising.



# Sherpa future 3: Chandra Operations

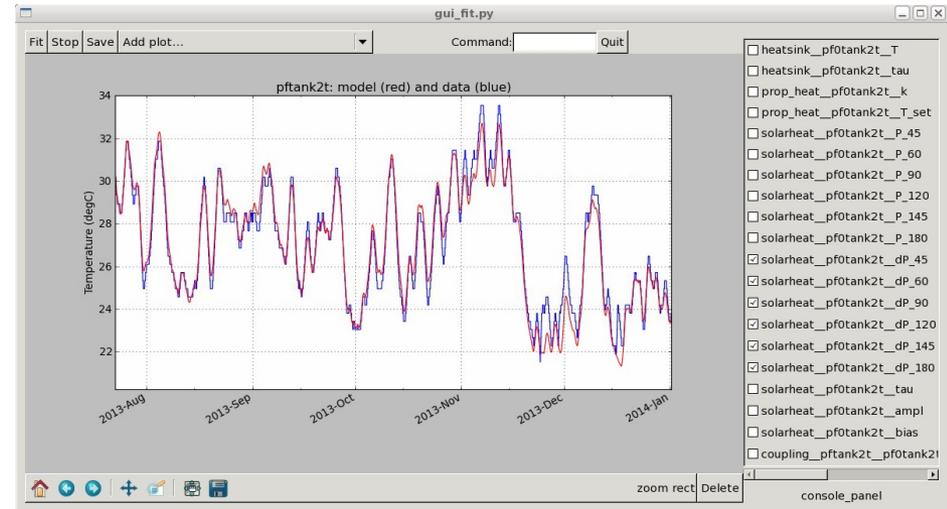


*The Chandra operation environment is a fully integrated environment with its own Python installation and hundreds of packages. Because of the different build-time libraries it is not possible to call the CIAO Sherpa package from the operations environment Python interpreter. Sherpa needs to build from source using the operations version of Python.*

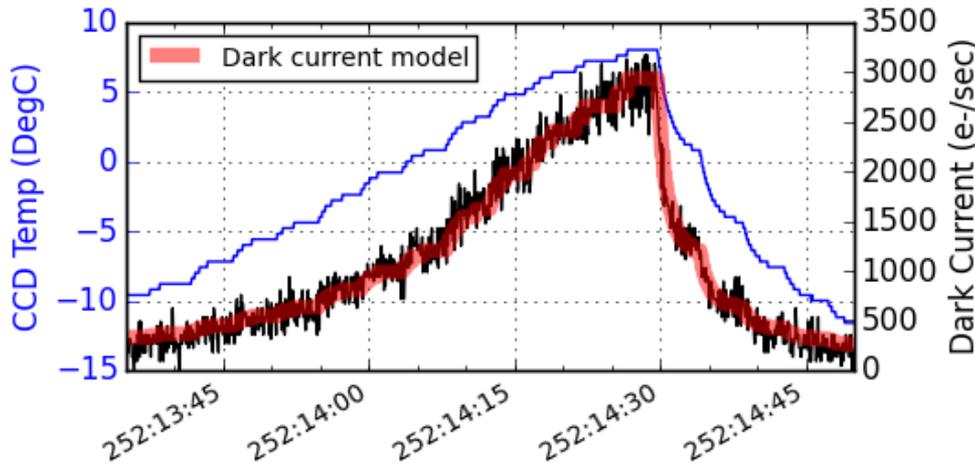
- Thermal model development and calibration for thermal constraint management within Flight operation mission planning
- Modeling of space radiation impact on ACIS CTI
- Real-time fitting for ACA CCD dark current scaling with temperature during the recent ACA annealing pathfinder activity. CCD was gradually warmed during comm by ground command and scale factor was used at each step to evaluate potential risk of losing track on guide stars.
- Future Operations needs not yet defined – will support as requested



Graphical tool using Sherpa to fit a 20 parameter model that predicts the temperature of the Chandra Integral Propulsion System tank. This is used in flight operations to ensure that the critical thermal limits are not exceeded. Blue - data red -model.



### The ACA annealing pathfinder activity



An example of the temperature of one ACA pixel with the model fit to dark current. The model fit updated during the procedure as new data points were collected to prevent a safing action.



# Sherpa future 4: Chandra users MCMC Output and visualization

---

- Improved Documentation
- Plotting and Imaging
  - addition of 2D and 3D visualization of samples
- Convergence of the chains
  - autocorrelation plots
  - r-hat
  - calculate number of independent samples
- Characterization of the probability density of the parameters and uncertainties based on the MCMC samples
  - modes
  - multimodality
  - quantiles



# Sherpa future 4: Chandra users 2D Image Analysis

---



- **Independent binning of the PSF image**
  - currently PSF has to have the same binning as the data - in both 1D profile analysis and modeling 2D images.
  - This is the limitation in 2D image fitting in the analysis of structures on arcsec scales.
- **Adaptive binning of the images**
  - based on required number of counts per bin
  - based on the spectral fit parameters as in temperature maps.
- **Gaussian Mixture Models**



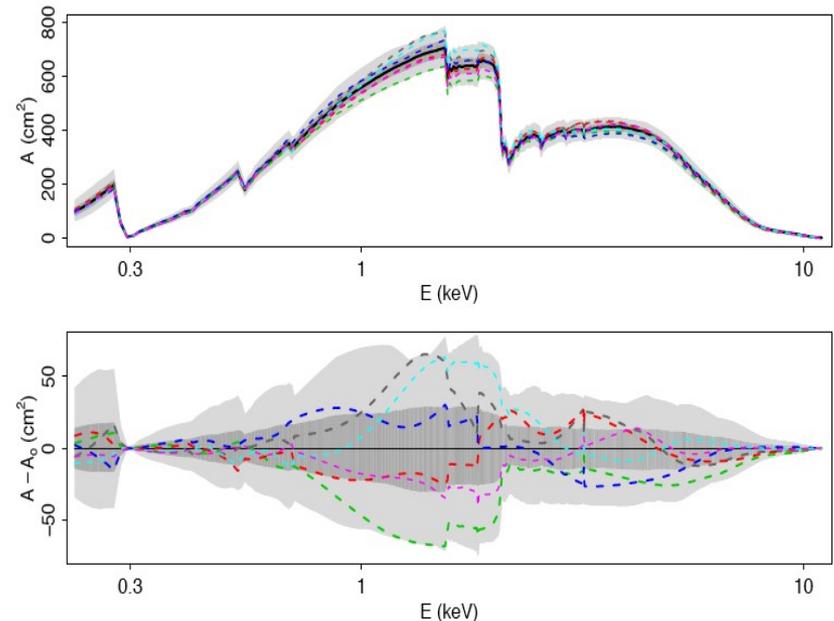
# Sherpa future 4: Chandra users Calibration Uncertainties

- Non-linear uncertainties in ACIS ARF dominate and have to be taken into account in high S/N data.
- They can be accounted for as described in

*Lee et al 2011 ApJ 731, 126, Xu et al 2014, ApJ 794, 97*

- If calibration product describing the ARF uncertainty is available Sherpa can already be used for calculating the errors via `get_draws`
- Needs UI and documentation
- This can be already done in Sherpa
- Work on RMF and PSF is needed
- This approach is being studied by IACHEC

- Non-linear errors cannot simply add to stats errors.
- Include a draw from an ensemble of effective area curves in the MCMC simulations.
- Drake et al 2006, SPIE,





# Sherpa future 5: Non-Chandra users



Sherpa used in Python packages  
developed by other groups:

- VAO - IRIS SED tool

<http://www.usvao.org/science-tools-services/iris-sed-analysis-tool/>

- Gammapy - gamma-ray analysis environment

<https://github.com/gammapy/gammapy>

- Naima - gamma-ray spectral analysis package

[https://github.com/zblz/naima/blob/master/naima/sherpa\\_models.py](https://github.com/zblz/naima/blob/master/naima/sherpa_models.py)

- XMM source catalog - web interface for spectral fitting

<http://xmm-catalog.irap.omp.eu/docs/spectral-fitting>

- MultiNest algorithm for Sherpa MCMC

<https://github.com/JohannesBuchner/PyMultiNest>



# Using Sherpa in Astronomy



- Spectral modeling of X-ray data
- Simulations of the Poisson noise to calculate evidence for a line in X-ray spectrum
- Fitting Chandra spectra with pileup model
- Flux calculations at the limited number of counts
- Spectral modeling of high resolution optical/UV spectra from HST, VLT/XShooter
- Modeling surface brightness profile in Chandra data
- 2D image fitting of Poisson images in Chandra
  - Binary black holes
  - Morphology of PWN, SNR, X-ray clusters
- Fitting X-ray luminosity functions of ULX
- Image and spectral modeling of HESS TeV data



# Using Sherpa in Astronomy Research



691 publications in ApJ, AJ, MNRAS and A&A use Sherpa (since 2001 and not including astro-ph abstracts)

[http://adsabs.harvard.edu.ezp-prod1.hul.harvard.edu/cgi-bin/nph-abs\\_connect?library&libname=Sherpa2013&libid=49b464b31c](http://adsabs.harvard.edu.ezp-prod1.hul.harvard.edu/cgi-bin/nph-abs_connect?library&libname=Sherpa2013&libid=49b464b31c)

but only 158 citations to Freeman et al 2001 SPIE paper

50 research papers in 2015, 64 papers in 2014

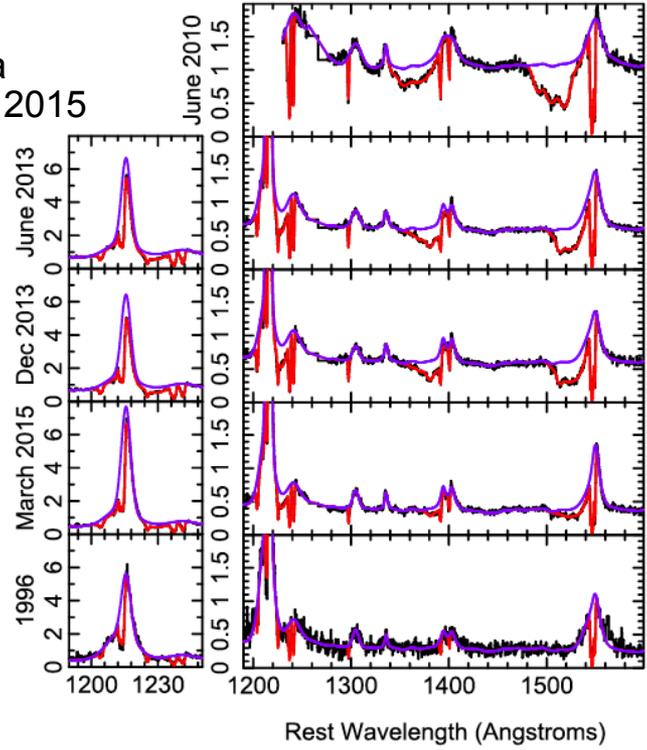
5 PhD thesis listed in ADS that used Sherpa

Selected and retrieved 691 abstracts. Sort options

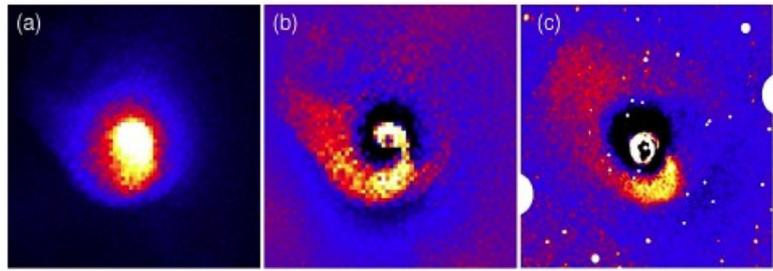
#	Bibcode Authors	Score Title	Date	List of Links Access Control Help
1	2015MNRAS.452.1112E Esposito, P.; Israel, G. L.; Milsavljevic, D.; Mapelli, M.; Zampieri, L.; Sidoli, L.; Fabbiano, G.; Rodriguez Castillo, G. A.	1.000 Periodic signals from the Circinus region: two new cataclysmic variables and the ultraluminous X-ray source candidate GC X-1	09/2015	A E F L X D R U
2	2015MNRAS.452...24C Cseh, D.; Miller-Jones, J. C. A.; Jonker, P. G.; Grisé, F.; Paragi, Z.; Corbel, S.; Falcke, H.; Frey, S.; Kaaret, P.; Körding, E.	1.000 The evolution of a jet ejection of the ultraluminous X-ray source Holmberg II X-1	09/2015	A E F L X D R U
3	2015A&A...581A..64R Rózańska, A.; Mróz, P.; Mościbrodzka, M.; Sobolewska, M.; Adhikari, T. P.	1.000 X-ray observations of the hot phase in Sagittarius A*	09/2015	A E F L X R U
4	2015ApJ...809L..13L Leighly, Karen M.; Cooper, Erin; Grupe, Dirk; Terndrup, Donald M.; Komossa, S.	1.000 Variable Reddening and Broad Absorption Lines in the Narrow-line Seyfert 1 Galaxy WPVS 007: An Origin in the Torus	08/2015	A E F L X R C U
5	2015ApJ...809..68H Hui, C. Y.; Park, S. M.; Hu, C. P.; Lin, L. C. C.; Li, K. L.; Kong, A. K. H.; Tam, P. H. T.; Takata, J.; Cheng, K. S.; Jin, Ruolan; and 2 coauthors	1.000 Searches for Millisecond Pulsar Candidates among the Unidentified Fermi Objects	08/2015	A E F L X D R U
6	2015ApJ...808..137J Jones, David E.; Kashyap, Vinay L.; van Dyk, David A.	1.000 Disentangling Overlapping Astronomical Sources Using Spatial and Spectral Information	08/2015	A E F L X D R C U
7	2015ApJ...808..130L Luo, J.; Ng, C.-Y.; Ho, W. C. G.; Bogdanov, S.; Kaspi, V. M.; He, C.	1.000 Hunting for Orphaned Central Compact Objects among Radio Pulsars	08/2015	A E F L X D R C U
8	2015MNRAS.450.2551M Mauerhan, Jon; Smith, Nathan; Van Dyk, Schuyler D.; Morzinski, Katie M.; Close, Laird M.; Hinz, Philip M.; Males, Jared R.; Rodigas, Timothy J.	1.000 Multiwavelength observations of NaSt1 (WR 122): equatorial mass loss and X-rays from an interacting Wolf-Rayet binary	07/2015	A E F L X D R U
9	2015ApJ...808..100T Temim, Tea; Slane, Patrick; Kolb, Christopher; Blondin, John; Hughes, John P.; Bucciantini, Niccolò	1.000 Late-Time Evolution of Composite Supernova Remnants: Deep Chandra Observations and Hydrodynamical Modeling of a Crushed Pulsar Wind Nebula in SNR G327.1-1.1	07/2015	A E F L X D R C S U
10	2015ApJ...808..81P Pennucci, T. T.; Possenti, A.; Esposito, P.; Rea, N.; Haggard, D.; Baganoff, F. K.; Bassani, M.; Gal, Zoltan; E. Terzani; C. J. ...	1.000 Simultaneous Multi-band Radio and X-Ray Observations of the Galactic Center Magnetar SGR 1745-2900	07/2015	A E F L X D R C S U



### HST Spectra Leighly et al 2015

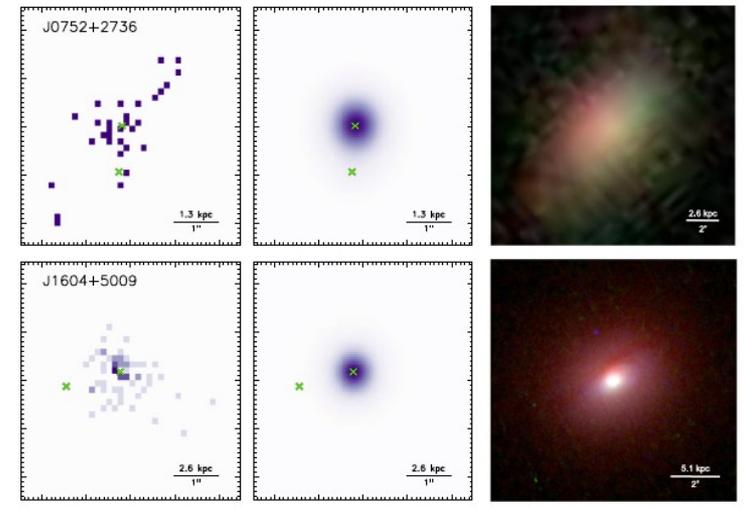


### Elliptical 2D beta-model Machado&Lima Neto 2015



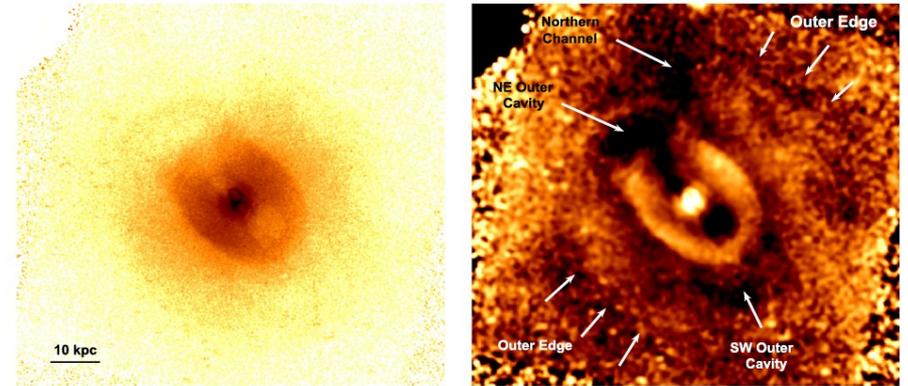
**Figure 3.** For model A: (a) simulated X-ray surface brightness map of model A. (b) Residuals from the subtraction of a fitted  $\beta$  model from the simulated X-ray emission. (c) Residuals from the observational data (*Chandra*). Each frame is 500 kpc wide.

### Binary BH - Comerford et al 2015



**Figure 2.** *Chandra* 0.3–8 keV observations (left), model to the *Chandra* observations (middle), and imaging (right) for the two dual AGN candidates that were not a part of our *HST* program. In all panels, north is up and east is to the left. The left and middle panels are  $5'' \times 5''$  images centered on the coordinates of each SDSS spectrum. The left panels show one-fourth size *Chandra* pixels (purple) and best-fit locations of two X-ray sources (green crosses) that coincide within  $3\sigma$  to the positions of two observed [O III]  $\lambda 5007$  components. The middle panels show the model fits to the two X-ray sources (purple) and the locations of two X-ray sources (green crosses). The right panels show an SDSS *gri* color composite image (top) and an archival *HST* image (red: F105W; green: F621M; blue: F547M; GO 12521, Liu; bottom).

### 2D Gaussian model, Randall et al 2015



**Figure 2.** Left: exposure-corrected, background-subtracted, 0.3–3 keV *Chandra* image, with point sources removed and smoothed with a  $\sigma = 15''$  Gaussian. The image shows bright rims surrounding an inner pair of cavities, a prominent elliptical edge surrounding a pair of cavities at intermediate radii (with the more obvious cavity to the SW and the NE cavity apparently broken into two connected cavities), and a subtle outer edge associated with a faint pair of outer cavities (with the more obvious cavity to the NE). Right: X-ray image divided by a 2D fitted beta model and smoothed with a  $\sigma = 6''$  Gaussian, shown on the same scale. The outer cavities and edges are more clearly seen in this residual image, while the inner cavities are not visible due to the larger smoothing scale and saturation of the color scale. The image also reveals a faint “channel” of decreased surface brightness extending to the north, apparently connected to the NE outer cavity.

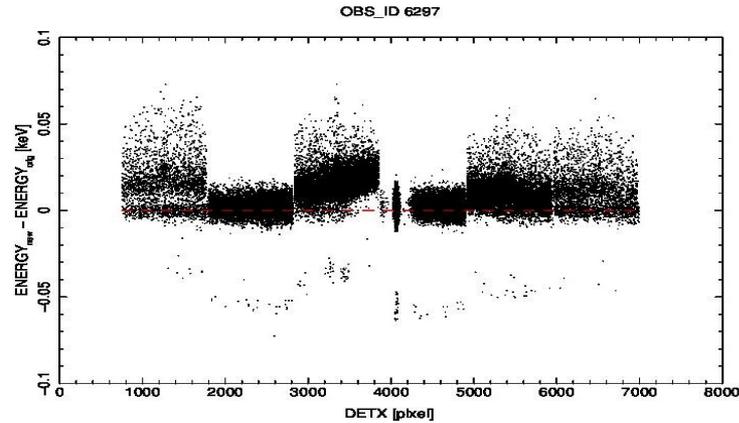
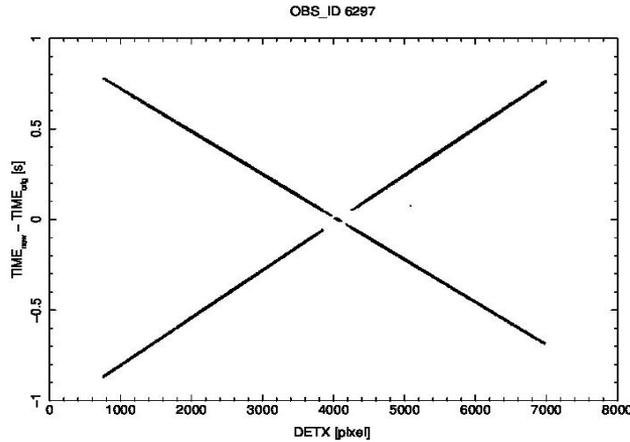


# Gratings

---



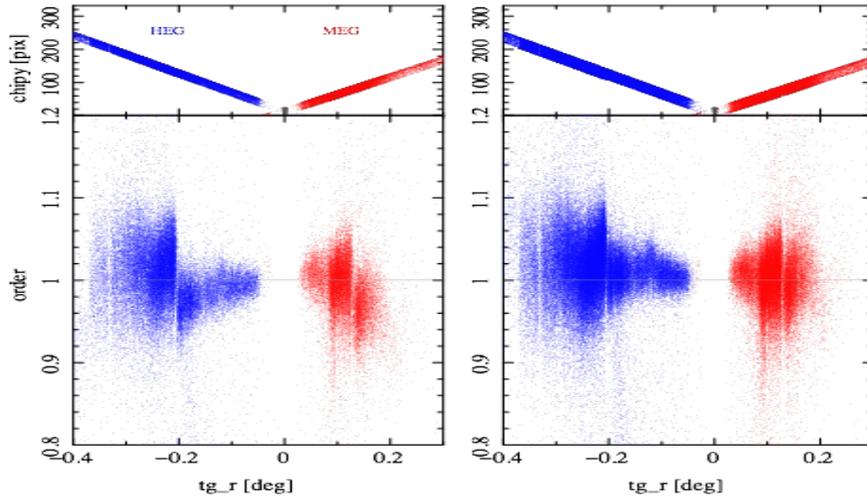
# CC mode



CC mode changes showing:

Left: Effect on photon arrival time vs X position – amplitude about 1 second

Right: Corrections to photon CCD energies (i.e. PI pulse heights) versus position – amplitude about 100 eV



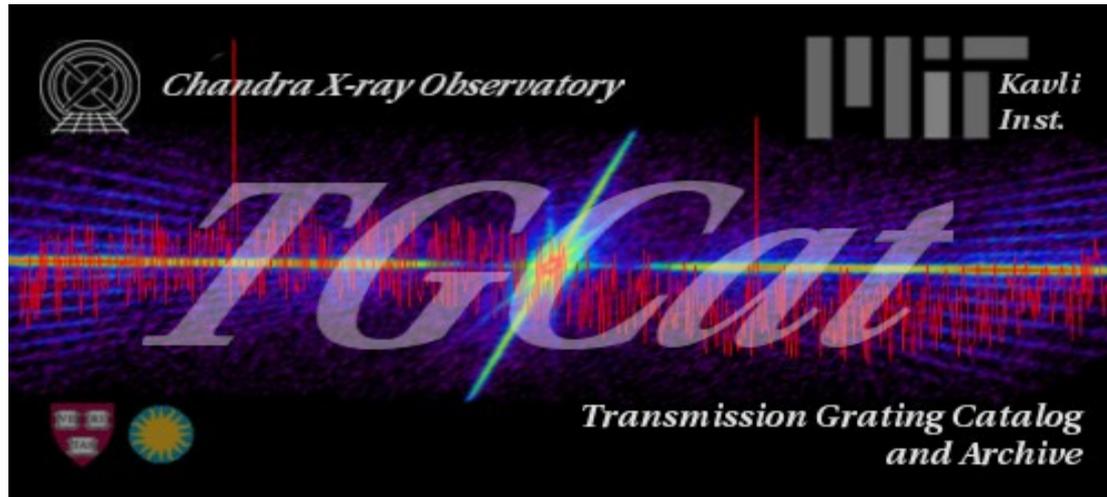
Old analysis resulted in discontinuities in order vs. dispersion angle

In new analysis, discontinuities are removed

- Improved:
- times
- energies
- CTI correction
- order sorting
- Subpixel correction to CHIPY

Left: CIAO4.7 Right: CIAO4.8

Some user parameter fixes left to do



TGCAT updates continue

- working processing script changes to accommodate updated CC mode algorithms

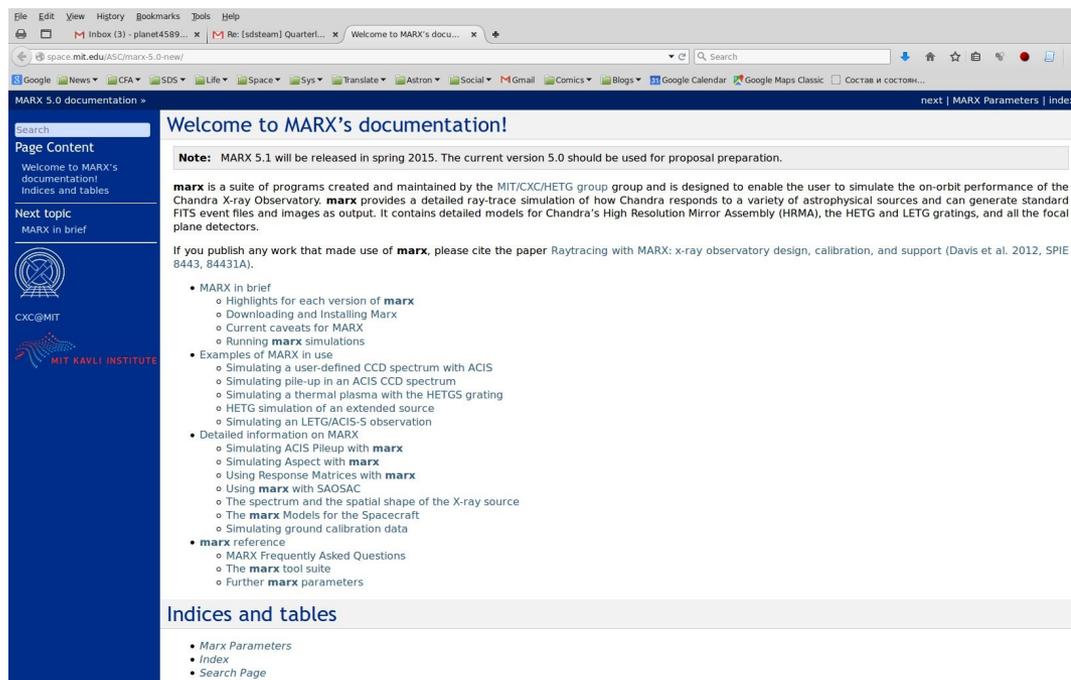
Statistics:

5937 web queries from 435 ip addresses

270 package and 1881 single-file downloads totalling 64 Gbyte



MARX: Updated and significantly revised documentation  
MARX 5.1 release Apr 2015  
Updated keywords in output files to work more smoothly with CIAO  
Fixed problem with compiling on Mac using 'clang'  
Uses updated calibration files (CALDB 4.6.5)



The screenshot shows a web browser displaying the MARX 5.0 documentation page. The page title is "Welcome to MARX's documentation!". A note states: "Note: MARX 5.1 will be released in spring 2015. The current version 5.0 should be used for proposal preparation." The main text describes MARX as a suite of programs for simulating the on-orbit performance of the Chandra X-ray Observatory. It lists various simulation capabilities and provides a list of links for further information, including "MARX in brief", "Examples of MARX in use", "Detailed information on MARX", and "MARX reference". The page also includes a search bar and navigation links like "Page Content", "Next topic", and "Indices and tables".

Planning future enhancements (use CALDB directly? Use gain map instead of FEF?)  
Working on thread to include background in simulation  
Investigated effects of finite grating facet size



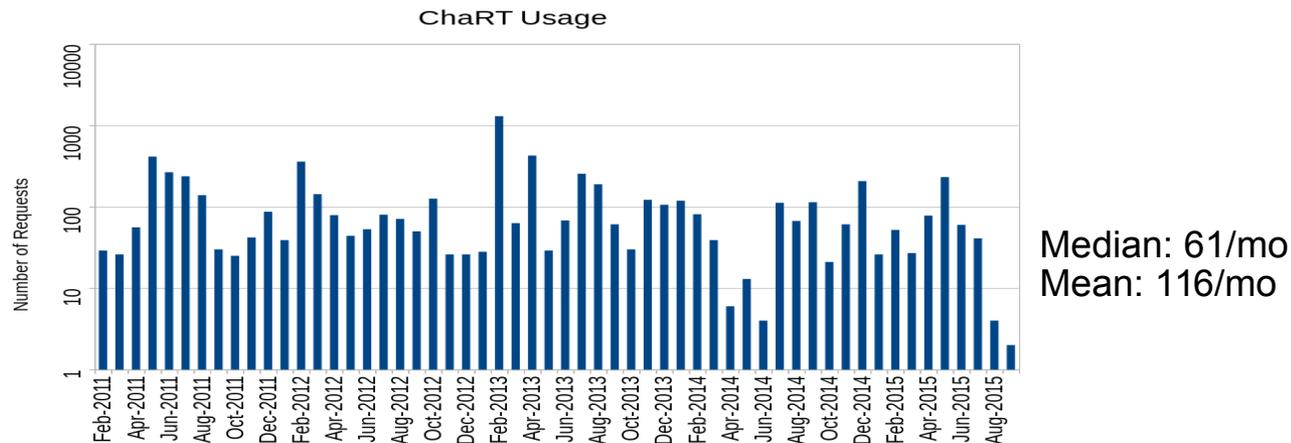
# ChaRT 2, Phase 1

ChaRT is a web interface to the CXC Optics group's mirror simulator: SAOTrace.

Phase 0: ChaRT was updated in 2014 to use the latest version of SAOTrace, v2.0.4, keeping the interface the same.

Phase 1: Allows users to supply aspect information enabling EDSER subpixel analysis when combined with MARX 5.

SDS has taken over development, maintenance, and operation of ChaRT; DS has provided updated archive interfaces to allow aspect file retrieval.





# CIAO Documentation

## CHART v2

Provides support for the telescope's dithering, allowing for its results be compatible with sub-pixel analysis.

Includes use of observation-specific aspect files.



### Introducing ChaRT v2

NEW

Several changes to the options and inputs required to run ChaRT have been introduced in the latest version—allowing for simulations compatible with sub-pixel analysis, in particular—including input source spectrum format or inclusion of observation-specific aspect solution files. Details are described in the [Preparing to Run ChaRT](#) thread.



Last modified: 2 September 2015

Instruments & Calibration    For the Public

Search:

Search the CIAO website or contact the CXC HelpDesk

**CIAO**

**PSF Central**

- [Understanding the Chandra PSF](#)
- [Modeling the Chandra PSF](#)
- [Characterizing the Chandra PSF](#)
- [Using the Chandra PSF](#)
- [Issues and Caveats](#)
- [PSF Analysis Threads](#)

**ChaRT**

- [About](#)
- [How to use ChaRT](#)
- [Run ChaRT](#)
- [Bugs](#)

**PSF Links**

- [SAOTrace](#)
- [MARX](#)

**CXC Links**

- [CIAO](#)
- [Sherpa](#)
- [ChIPS](#)
- [CalDB](#)

## Run ChaRT

**Introducing ChaRT v2**

NEW

Several changes to the options and inputs required to run ChaRT have been introduced in the latest version—allowing for simulations compatible with sub-pixel analysis, in particular—including input source spectrum format or inclusion of observation-specific aspect solution files. Details are described in the [Preparing to Run ChaRT](#) thread.

ChaRT is a web interface to the SAOSac raytrace code which was developed by the CXC for calibration purposes. A raytrace matching the user inputs is run through the Chandra optics to produce a collection of rays. An email is sent to the user when the raytrace data is available for download.

This web interface handles one simulation at a time (i.e. you can't submit multiple sources at once), but users can submit multiple jobs one after another to simulate multiple sources.

For detailed instructions on obtaining ChaRT inputs, follow the [Preparing to Run ChaRT thread](#).

[Explanation of ChaRT inputs](#)

**User Information**

Email Address:

**Source Coordinates**

Celestial: R.A.:  Dec.:

Off Axis Angle:  $\theta$   [arcmin],  $\phi$   [deg]

**Source Spectrum**

Spectrum file:  No file selected.

Monochromatic Energy:  [keV], Photon Flux:  [photons/cm<sup>2</sup>/sec]

**Pointing Information**

Observation: OBS\_ID:  OBI\_NUM:

Upload aspect solution file:  No file selected.

Other, specify: R.A.:  Dec.:  Roll:  Exposure:  [ksec]

**Realizations**

Number of iterations:

Random Seed:

CUC Sep 2015

CXC



# ChaRT Phase 1 Interface

Run ChaRT - CIAO 4.7 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

Run ChaRT - CIAO 4.7 Welcome to PSF Cen... x +

cxcdmz-prev/ciao/PSFs/chart2/runchart.html

Search

CXCDS Email Archives Boston.com CNN.com WebChaser CSCview Launch Trello PNG Daily OTS What is the 'What is...

MARX  
CXC Links  
CIAO  
Sherpa  
ChIPS  
CalDB

This web interface handles one simulation at a time (i.e. you can't submit multiple sources at once), but users can submit multiple jobs one after another to simulate multiple sources.

For detailed instructions on obtaining ChaRT inputs, follow the [Preparing to Run ChaRT thread](#).

[Explanation of ChaRT inputs](#)

User Information

Email Address

Source Coordinates

Celestial: R.A.  Dec.

Off Axis Angle:  $\theta$   [arcmin],  $\phi$   [deg]

Source Spectrum

Spectrum file:  No file selected.

Monochromatic Energy:  [keV], Photon Flux:  [photons/cm<sup>2</sup>/sec]

Pointing Information

Observation: OBS\_ID  OBL\_NUM

Upload aspect solution file:  No file selected.

Other, specify: R.A.:  Dec.:  Roll:  Exposure:  [ksec]

Realizations

Number of iterations

Random Seed

**Explanation of ChaRT inputs**

For detailed instructions on obtaining ChaRT inputs, follow the [Preparing to Run ChaRT thread](#).

Email Address

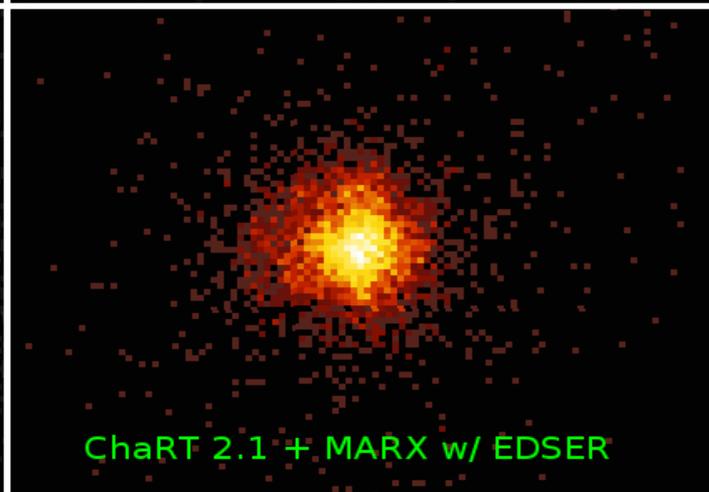
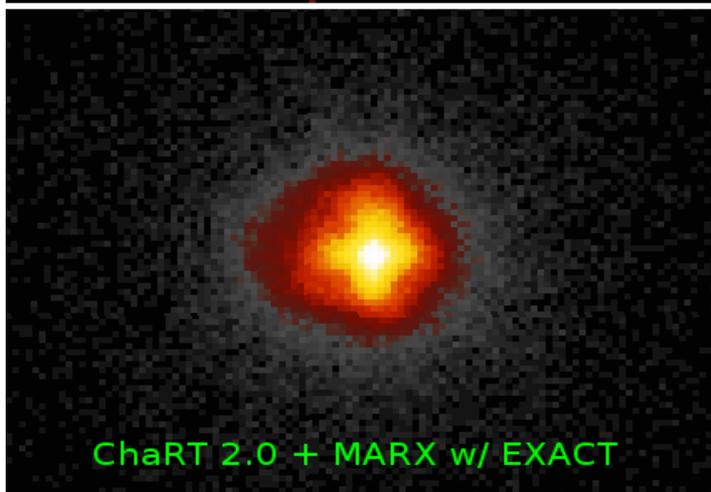
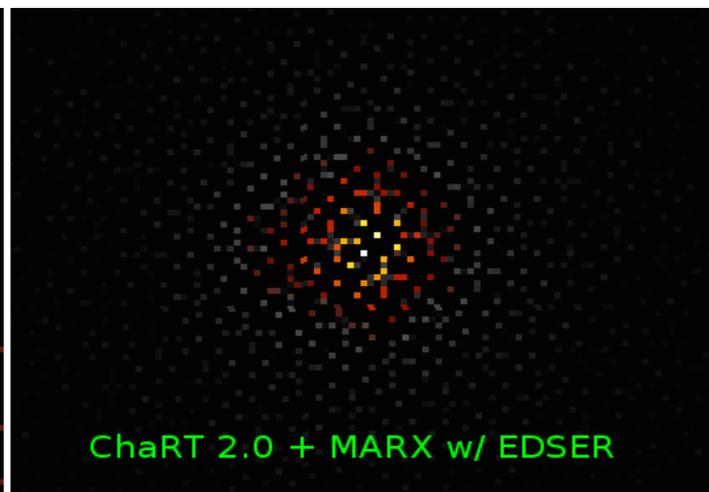
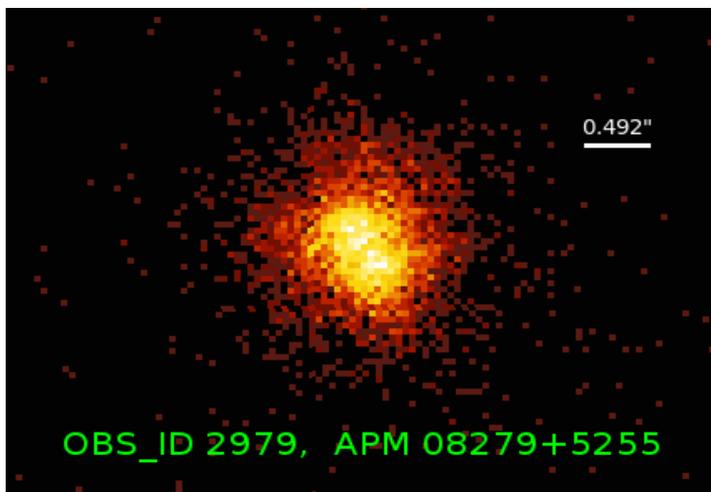
ChaRT sends an email when your job has finished running and the data is available on the FTP site. The CXC may also contact you at this email address if there is a problem running the ChaRT job.

Coordinates



## ChaRT v2.1 Example

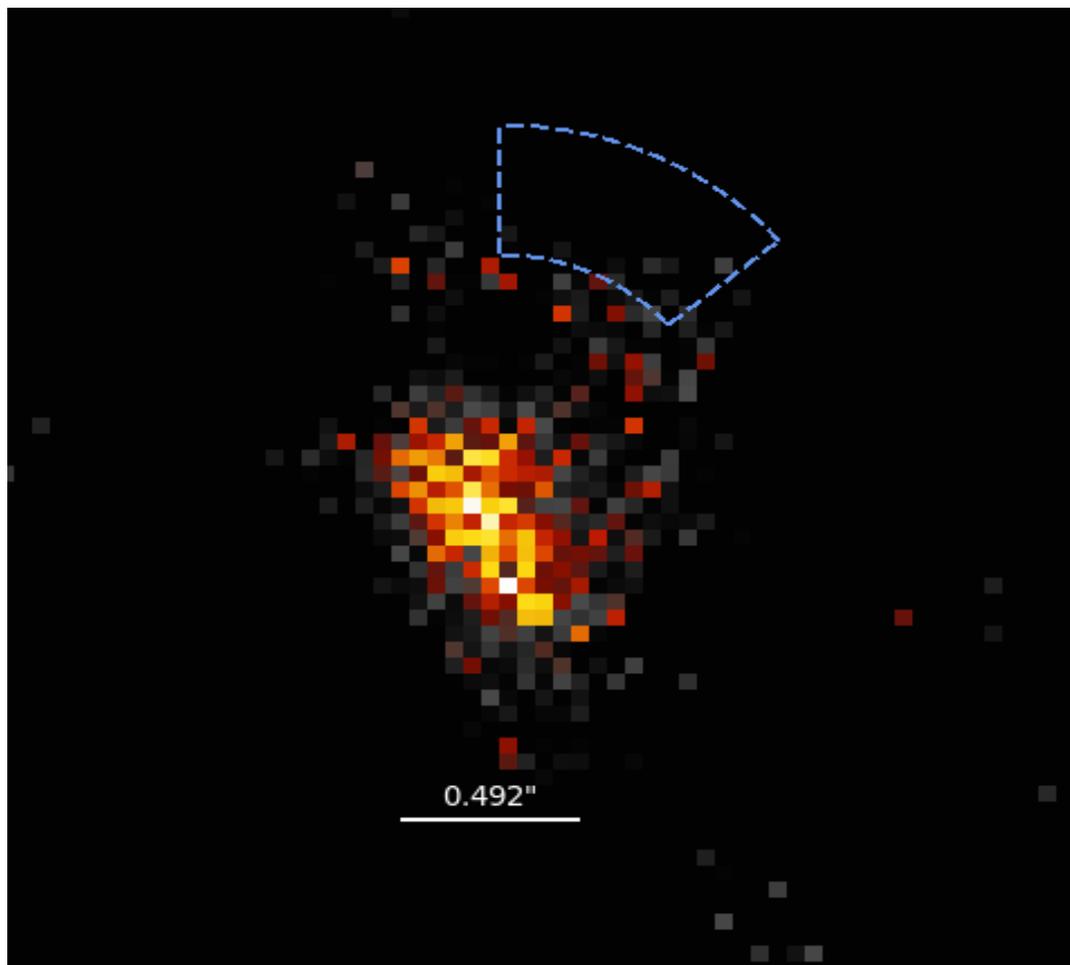
theta=0.57'





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## EDSER Example: arestore



Data from previous slide  
Deconvolved using CHART PSF

Blue PIE shows expected  
location of PSF artifact.