



CIAO

Jonathan McDowell



## SDS team

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- M. Noble left MIT team
- A. Fruscione now 50 percent time for CDO
- No other staff changes

### SDS team at SAO:

Jonathan McDowell	Management, algorithms and libraries
Antonella Fruscione (1/2)	Docs and release
Margarita Karovska	Regression testing, PSF and high spatial resolution
Aneta Siemiginowska	Sherpa and astrostatistics
Frank Primini	Catalog, HRC, statistical algorithms
Doug Burke	User interfaces, scripts, ChIPS, algorithms, libraries, R&D
Nancy Brickhouse (1/2)	Atomic database research
Elizabeth Galle, Nina Bonaventura, Nick Lee	– Helpdesk, testing, docs, scripts

### SDS team at MIT:

Mike Nowak	Management, Catalog, timing
Dave Huenemorder	Gratings
Glenn Allen	ACIS
John Davis	Responses, MARX, ACIS, algorithms
John Houck	Catalog, Gratings

CIAO development is a collaboration between SDS and the Data Systems software engineers and developers



## Community support

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- Helpdesk: 149 new tickets (Apr 10-Oct 10), 10 still open
  - Median time to first answer 1.3 hours (longest 2 weeks, waiting for user response)
  - Median time to final answer 8 hours, but some stay open for several months ( resolved with new software release; delays in user response)
  - Answers generated 19 new docs, 3 new bugs, 10 RFEs
  - 64% did not require scientist or DS support
  - 10 open tickets from previous period all now closed
- Some problems this summer with undergrads sending repeated out-of-scope questions; being somewhat stricter with this due to resource limitations.
- CIAO support at Miami AAS (summer 2010) - 1 data aide
- Aneta ran SOC for “Accretion Processes” workshop Jul 13-15
- Aneta organized workshop on Computational Astrostatistics, Aug 24-25
- Planning to attend/present at ADASS conference next month
- Next CIAO workshop tentatively planned for summer 2011 together with the X-ray school



CIAO 4.2 was released in December; the core package has seen over 1000 downloads since then.

A Sherpa update was released Jul 19 and has been downloaded 240 times since then.

782 downloads of 'core' CIAO4.2 since April:

Linux	488	(of which 73 were 64-bit)
Mac (Intel)	226	(of which 38 were 64-bit)
Mac (PPC)	14	
Solaris	4	
Source build	50	

Still a few downloads of older versions: 6 CIAO 4.1, 3 CIAO3.4

Conclusion: Linux and Mac-Intel remain our users' dominant platforms  
Mac PPC and Solaris continue to decline – very few users. No outside users have downloaded the Solaris version since Jan 2010.

The Sherpa release in July did not include Mac PPC support and neither will the December CIAO release.



Added Google Analytics to the web sites to track usage:

Total unique visitors (by IP address) from May to Sep:

CIAO 2108  
ChIPS 991  
Sherpa 1304  
Chart 169

Users spend an average of 2-5 minutes on the site per visit and show a high 'bounce rate' (visit one page, do not click to another CIAO page).  
37% direct page views, 60% via search engine.  
We conclude users are coming for specific info, not just browsing.

### ***Infrastructure improvements:***

All the CIAO websites now use CSS for the page layouts. This makes the sites easier to maintain, more accessible to both users and search engines, and makes them look better and easier to use on different screen sizes, e.g. iphone, ipad, cinema displays. The CSS print stylesheets mean that we no longer generate PDFs on any webpages, making the system lighter and more maintainable.

Improvements to the online ahelp pages: the ahelp pages have been updated to match the style of the rest of the CIAO website. We are in the process of automatically including the list of known bugs for each tool as part of the ahelp page. (should be released with c4.3)



### ***Content improvements:***

The ahelp XML files packaged in CIAO are continually updated with new examples and additional tool information to make them as useful as possible for our users.

Removed all S-Lang reference from documentation pages (help files, threads, etc.) to prepare for the full Python transition.

Improved the CIAO download web pages.

Updated data products guide.

Added documentation on new calibration products: two analysis threads and a script to use the HRC stowed background files.

Updates analysis threads as needed to make them as clear as possible for users (often as a result of users' queries) and to take into account of e.g. new processing scripts.

Sherpa documentation updates for summer release (see below)

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## **Regression tests:**

Restructured, reorganized and updated the full set of  
~1100 regression tests

Converting tests from S-Lang to Python

## **Sherpa release testing:**

Completed Sherpa release testing on multiple platforms  
Added new regression tests, ran complete set to ensure  
system stability.

## **CIAO 4.3 release testing:**

Science testing under way  
Regression testing under way on internal pre-release drop  
of system; testing will continue through December release.



## Summer Sherpa Release (CIAO 4.2 version 2)



We released an update to Sherpa in July, together with general Sherpa documentation improvements:

New thread for fitting PHA data with multiple responses  
Updated many Sherpa threads and ahelp pages  
Seven new FAQ pages  
New “Python Resources” page  
Sherpa Blog: [pysherpa.blogspot.com](http://pysherpa.blogspot.com)

“Sherpa for Python Users” package (limited I/O and plotting)

Improved user model interface  
Support for fitting with convolved and non-convolved model combinations e.g. (ARF\*spectrum) + background : see next slides  
Improved PSF fitting support  
XSPEC table models  
Support for iteration methods (Primini, sigma-rejection): see next slides  
Assorted bug fixes

This was the first time that we released only one subpackage of CIAO (vs. a full CIAO release or a patch).



# Sherpa CIAO4.2 Version 2



•Most of the new functionality has been placed in [Model Library](#):

- New functions `set_full_model()` `set_bkg_full_model()` allow to build model expressions that include both convolve and unconvolved models. This is in support of users' request to be able to specify detector models that should not be convolved with response functions.
- New functions that return information about response models and files
- Example of UI with the new expressions:

```
sherpa> arf = get_arf()
sherpa> rmf = get_rmf()
sherpa> set_full_model(rmf(arf(xsphabs.abs1*powlaw1d.p1)+const1d.c1)
```

```
sherpa> rsp = get_response()
sherpa> set_full_model(rsp(xsphabs.abs1*powlaw1d.p1)+const1d.c1)
```



## Sherpa CIAO4.2 Version 2



- Iterative fitting methods have been added (these existed in CIAO 3.4 but didn't make it into the rewritten Sherpa until now).
  - **Primini** - Chi-sq with variance given by the model-predicted values from the preceding iteration.
  - **sigmarej** - iteratively ignores the data point which deviate from the model by a given sigma and fits model to the remaining data points.
- New UI functions to support iterative fitting methods:
  - **set\_iter\_method** "none", "primini", "sigmarej"
  - **get\_iter\_method\_name** information about the current iterative method
  - **list\_iter\_methods** - list all available iterative methods



### Sherpa and algorithms

- Model library, MCMC
- Response averaging (addressp, combine\_spectra)

### Scripts

#### Instruments:

- Graded CTI support
- Temperature dependent CTI correction
- HRC-S tgain corrections and improved textract filters, reducing LETGS background by factor two
- Improvements to contaminated bias repair in V&V

#### PSF and high spatial resolution

- Sub-pixel correction algorithm
- Support for PSF aperture correction for ARF (arfcrr)
- Continuing analysis of PSF calibration and support
- MARX enhanced for new contamination correction

#### Data Model

- Support for tab-separated file variant used in CSCView format
- Updated support for FITS WCS conventions



# Sherpa Development

- Finalizing the CIAO 4.3 development including:
  - New development work within model library
    - Developing support for broad band models (accretion disk, SED templates) where X-ray data is integrated with e.g optical/IR/UV data
    - Work on improving performance for complex models - model caching.
  - New development work on MCMC simulation package:
    - Working on a full Bayesian model which will be released initially as a contributed Sherpa Python module `pyBloCXs` (A result of the Astrostatistics collaboration)
    - Writing tests and examples
    - Writing documentation in preparation for release
- Work to support December 2010 release
  - Developed new tests for added functionality
  - Running standard internal tests to check existing functionality still working
  - Writing ahead files for new functions
  - Developing new documentation threads



This year we began a new effort within the SDS team developing python scripts to make data analysis easier. Among the releases are:

`chandra_repro`: A reprocessing script to automate the CIAO analysis threads.

- read data from the standard data distribution  
    primary/ secondary/
- perform data cleaning and filtering starting with level 1 data and generating new level 2 event files.
- covers ACIS and HRC imaging data

`combine_spectra`: A script to combine (sum or average) imaging source spectra (with or without corresponding ARFs and RMFs) and optionally background spectra (and responses), with appropriate doc caveats that simultaneous fitting is theoretically preferable; the CIAO4.3 version will make use of the new `addressp` tool to make (ARF\*t)-weighted RMFs.

We will eventually replace `specextract` and `acisspec` with a thread using this script. We are also preparing a new script, `obs_align`, to prepare datasets for merging and a new version of `merge_all`; these should be out early next year.

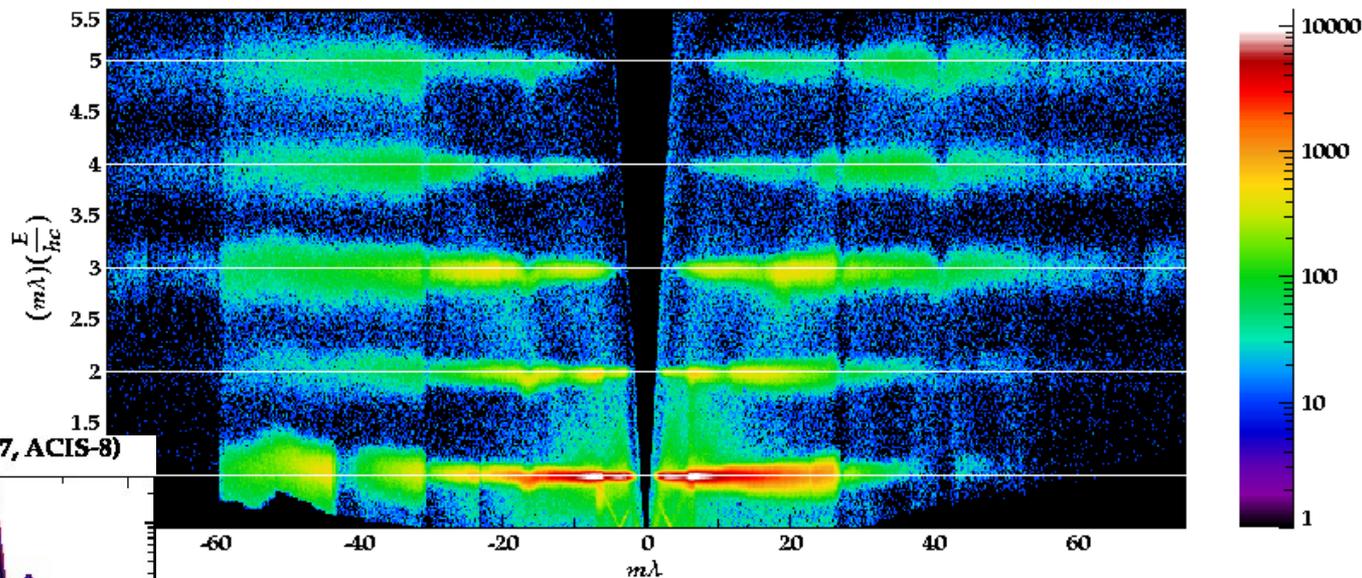


# CTI temperature dependence

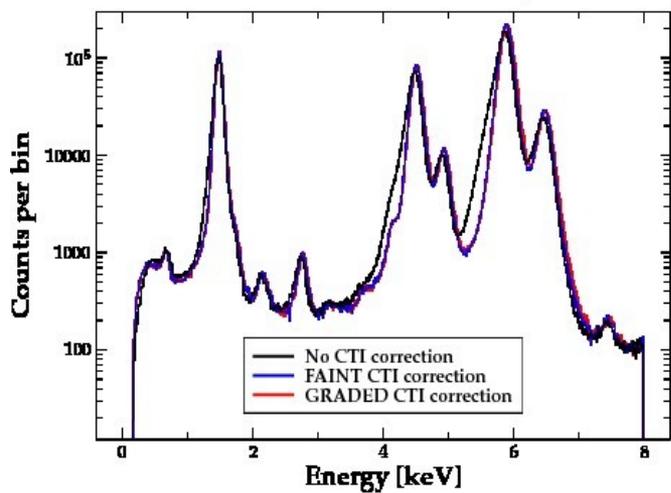
- Revised CTI correction spec to account for temperature dependence
  - incorporates correction developed by ACIS team
- Interpolate in mission timeline file to evaluate focal plane temperature for each event, apply a temperature dependent scaling factor to the charge adjustments for that event
- Provided updated CALDB CTI file with scaling factors for each CCD
- Preparing to test implementation in CIAOX.



OBSID 4148



44 random ECS obsids (2000-2007, ACIS-8)

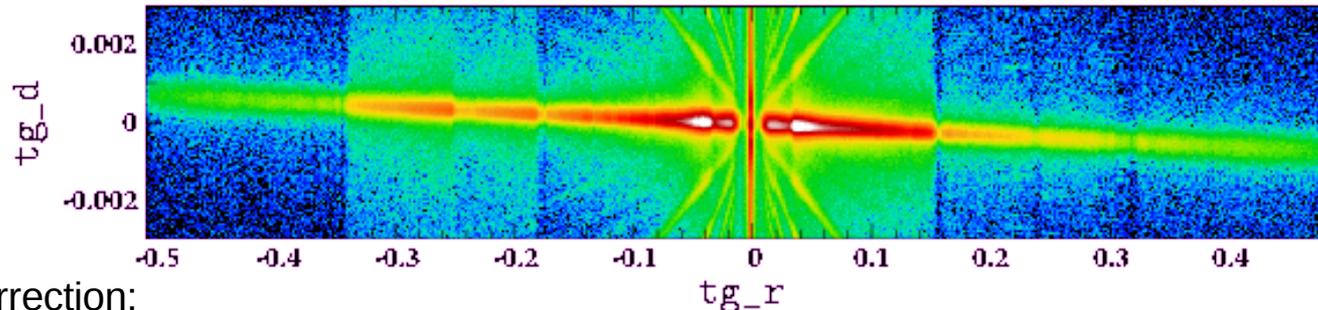




# LETG-ACIS rotation issue

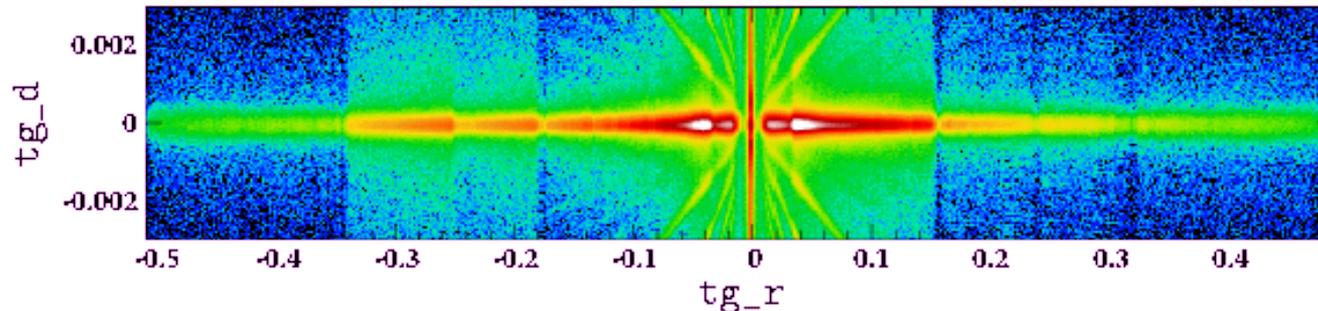
Markarian 421, in grating coordinates --- the spectrum should be horizontal!

OBSID 4148



After correction:

OBSID 4148



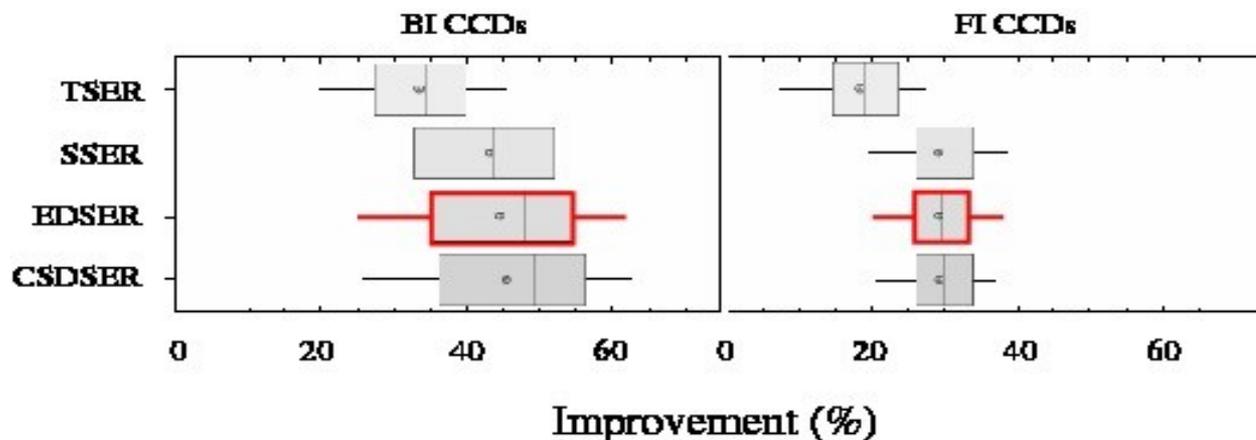
The LETG angle appears different in HRC and ACIS. We believe the residual is due to a degeneracy in the aspect/HRMA/SIM calibration, which is revealed by the gratings.

In CIAO 4.3 we use ad hoc rotation angles for each grating/detector combination.



# Sub-pixel R&D

- Defined spec for sub-pixel event repositioning (SER) in `acis_process_events`
  - based on the EDSER algorithm of Rochester team (Li et al 2004 ApJ 610,1204)
  - evaluated multiple approaches
    - EDSER superior to PSU algorithms Mori et al 2001 (SSER), Tsumeni et al 2001 (TSER)
    - CSDSER (Li et al 2004) marginally better in some respects, but cannot be used for GRADED mode while EDSER can.

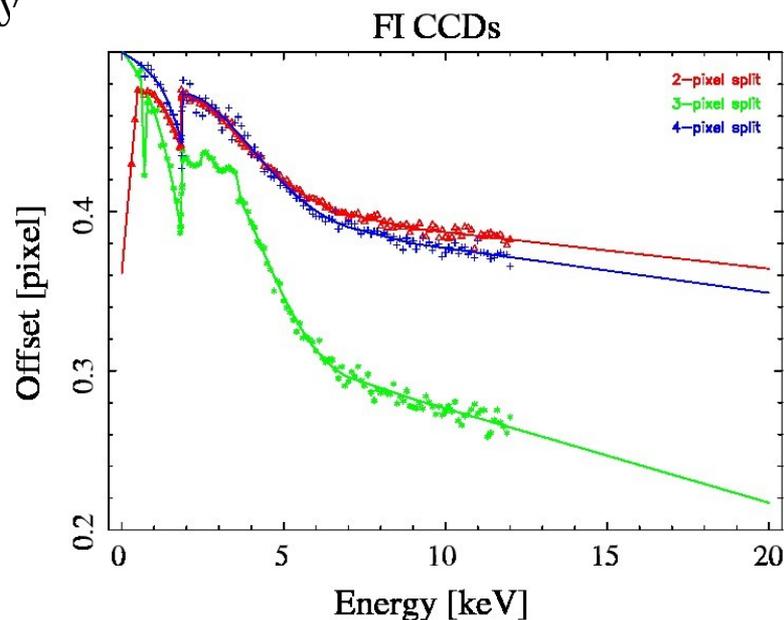
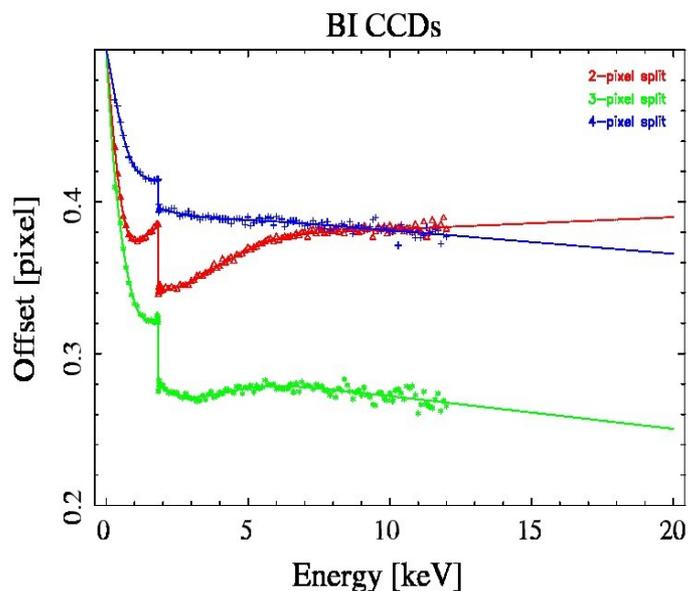


Comparison of SER methods, from Li et al 2004



# Sub-pixel implementation

- `acis_process_events` will include the EDSER algorithm for use by users
  - new `pix_adj` parameter controls pixel correction (none, randomize or EDSER)
- Algorithm depends on:
  - event ENERGY (scaled PI, corrected for CTI and time dependent gain)
  - event FLTGRADE
  - Sub Pixel Calibration File
- Calibration file contains energy/fltgrade dependent correction for each chip
  - $\Delta(\text{ChipX}, \text{ChipY})$  vs FLTGRADE, ENERGY
  - piecewise linear fit vs energy





## Sub-pixel forward plan

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- Release EDSER-enabled `acis_process_events` to users (CIAO4.3, Dec 2010)
- Evaluate for use in pipeline
- SER improves the PSF, but that improved PSF needs to be calibrated as a function of energy and position.
- Need to enhance simulators to generate SER-enhanced PSF for comparisons to corrected data. This is a significant effort since you need to reproduce the correct FLTGRADE distribution as well as spatial PSF shape, if you want simulated data that can run through `acis_process_events` to produce simulated event lists that can be compared with actual flight data to determine the reality of features.
- Gratings: tests suggest that SER yields a small improvement to the ability to measure line widths, but may not be worth the effort of recalibration.
- CC mode: SER could in principle improve the ACIS continuous-clocking mode time resolution, with the SER correction being used to adjust the estimated photon arrival time and the one spatial CC mode coordinate.



## Other tool development

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- 'arfcorr' tool uses circular ECF data files to estimate PSF extent as a function of energy and generate an energy-dependent PSF correction to the ARF, given an arbitrary source region
- New algorithm developed by DS team to make weighted ARFs which take chip edges and bad pixels correctly into account ; uses new 'sky2tdet' tool.
- Updates to dmextract (improved output for light curves, etc.)
- Improvement to aprates based on user feedback
- Supporting HEASARC with development of standalone CALDB tools package

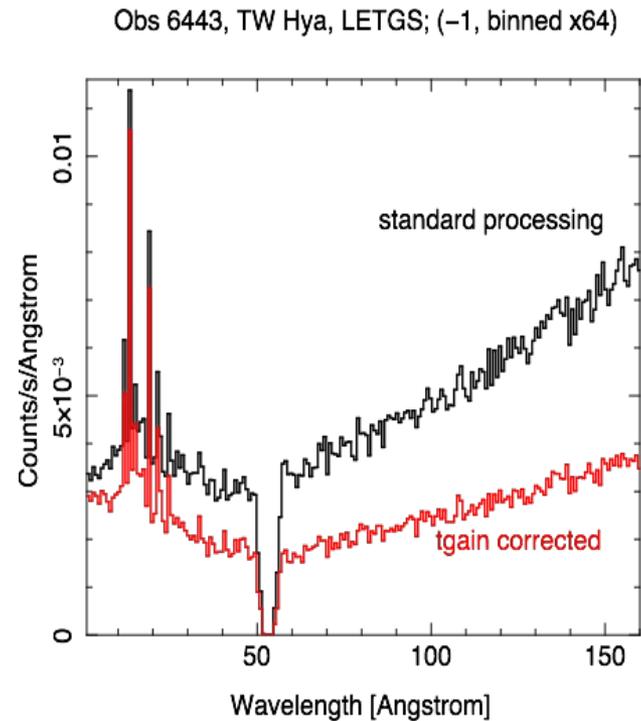


# TgCat

<http://tgcatalog.mit.edu/>

The Chandra Grating Spectra Catalog and Archive  
Over 1000 observations processed.

Reprocessed all HRC-S data to apply the recently improved tgain/PI algorithm which reduces background.





## Exploring the Chandra PSF at sub-arcsecond scales

As part of efforts to push the spatial resolution of Chandra, we have identified a feature in HRC data (and possibly ACIS data too) which will affect high fidelity deconvolutions on sub-arcsecond scales.

### What do we know?

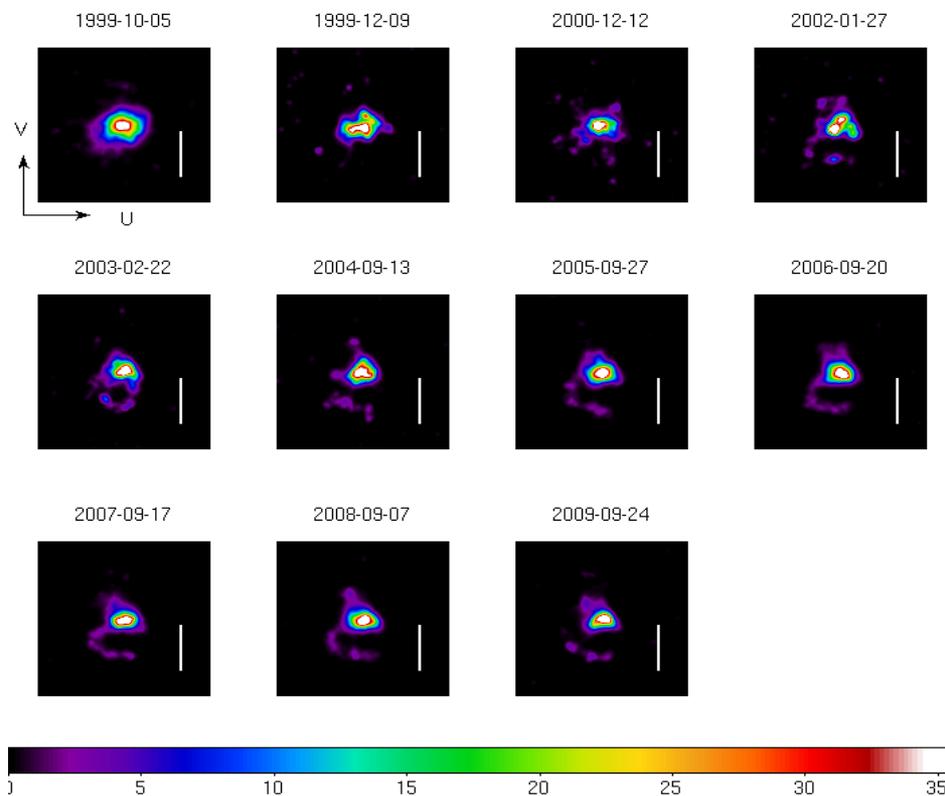
HRC images show an asymmetry at  $\sim 0.6\text{--}0.8''$  in the -CHIPY direction

The flux in the feature is about 5 percent of the total source flux

It seems to be fixed in detector (spacecraft) coordinates at PA 170-220 deg

This was discovered in AR Lac observations and confirmed in data on Capella and other sources. It does NOT appear to be present in the Dec 2000 AR Lac observation – it may have appeared sometime in 2001.

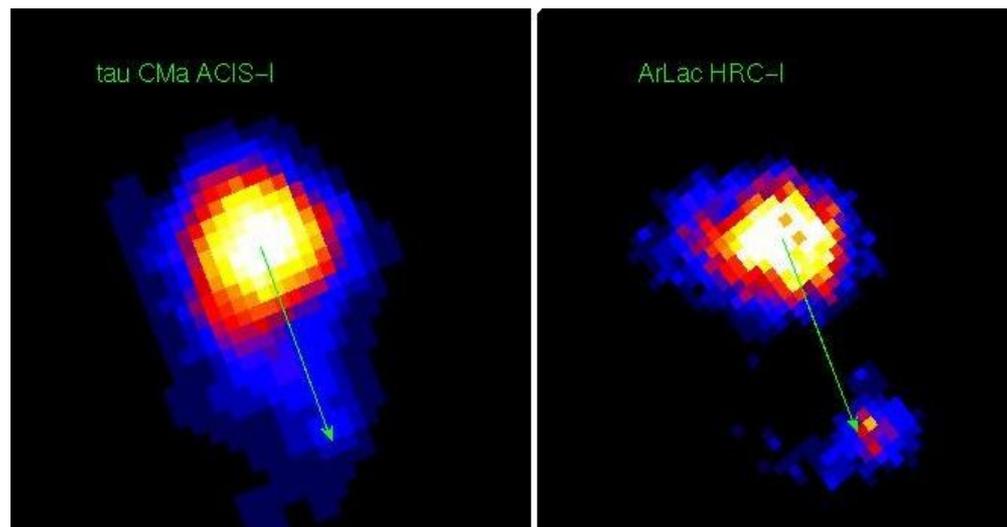
We see the feature by (1) fitting to gaussians and examining residuals (2) deconvolution using SAOTrace PSFs; (3) SAOTrace PSF subtraction and examining residuals.





## PSF artifact study - continued

What do we suspect?



Analysis of several ACIS images (SER, deconvolution, subtraction) show a feature in a similar direction with a similar spatial scale.

ACIS is harder because the pixels are larger, so we are not prepared to make a definitive assessment of the reality of the feature in ACIS at this time – but feel that the circumstantial evidence is that it is present in both instruments and therefore probably originates in the mirrors.



## PSF artifact study – advice to users

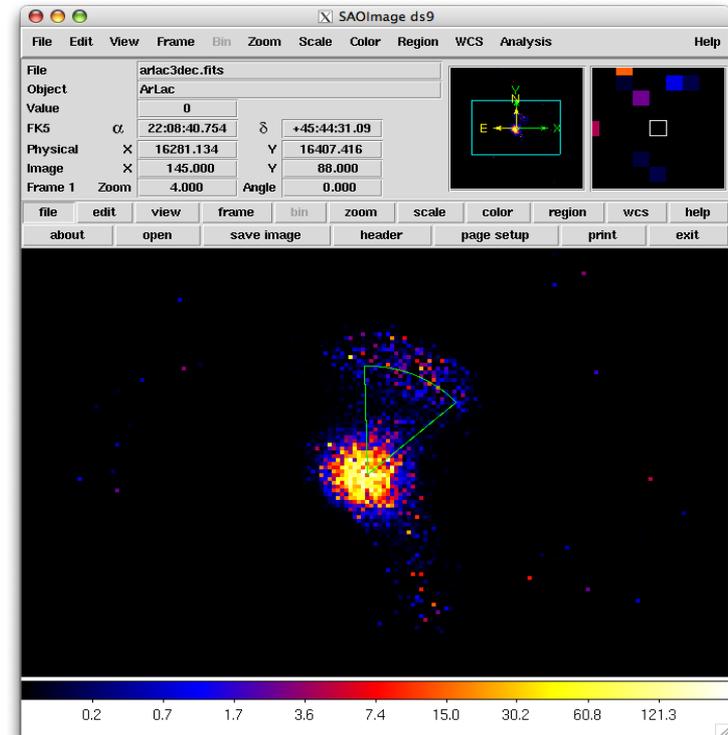
### What should users do?

Users should treat with suspicion any extent in their images at scales less than 1 arcsecond in a direction of 170-220 deg position angle from +DETY, or 260-310 deg in the PHI azimuthal mirror spherical coordinate measured counterclockwise from +DETX, whose flux is less than ~10 percent of the total brightness of the source. Two observations at different spacecraft rolls may be necessary to search for structure at this spatial scale.

We will soon release a script which will allow users to make a region file to isolate the position of the artifact in their data – displaying this region in DS9 will help you evaluate whether you have a problem, and filtering on it will let you estimate the counts associated with the artifact in your data.

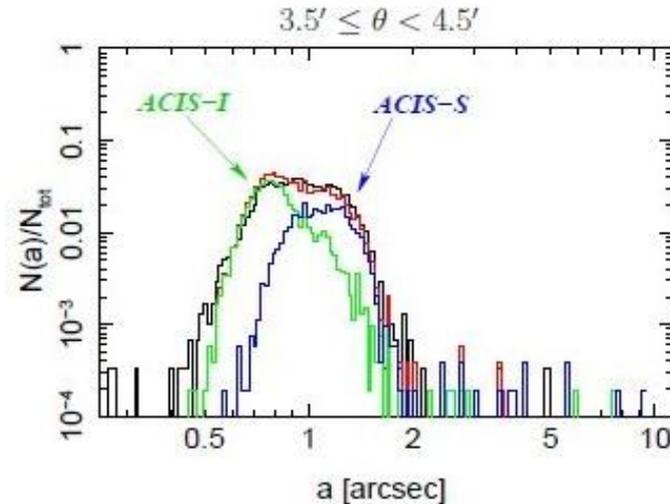
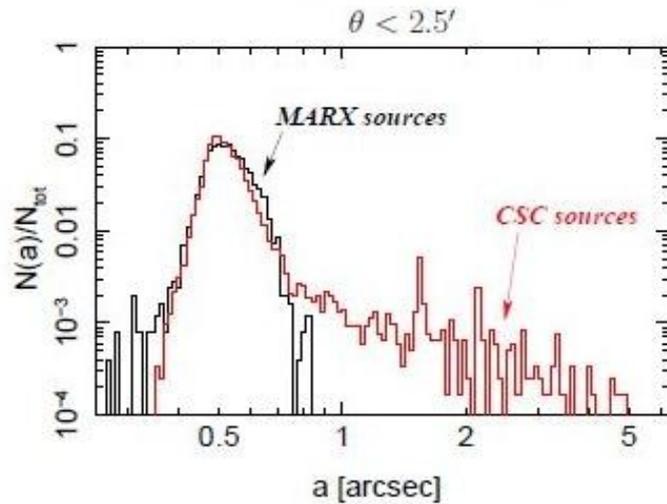
The feature is detectable in encircled energy analyses for sources with several hundred counts.

The CXC will continue investigation with archival analysis, simulations and additional calibration observations. In the longer term we hope to improve our models of the combined HRMA/instrument PSF.





## Source sizes: CSC vs. MARX



$$\text{Source size: } a = \frac{1}{\sqrt{2}} (\sigma_1^2 + \sigma_2^2)^{1/2}$$

$\sigma_1, \sigma_2$  are elliptical Gaussian parameters determined by `srcextent`.

	$\theta < 2.5'$	$3.5' \leq \theta < 4.5'$
$N_{tot}(\text{CSC})$	12120	5277
$N_{tot}(\text{MARX})$	2502	3021

Plotted here are effective (not deconvolved) source sizes  
 On and off axis, distribution of measured source sizes from MARX sims and actual (CSC) data agree well at small sizes – implies MARX PSF is like reality.  
 On axis, we see a tail of large effective-size sources in the real data: implies we are measuring true extent.  
 Off axis, consistent with all point sources – implies CSC is not sensitive to extent at large theta, as expected.



## ATOMDB update



The ATOMDB project (<http://cxc.harvard.edu/atomdb>) is a collaboration originated by the CXC. Current members are N. Brickhouse (CXC), R. Smith, A. Foster, L. Ji, and T. Kallman. The CXC currently leverages this project, with grant funding supporting some of the work.

Current release: ATOMDB v1.3, (also known as the Astrophysical Plasma Emission Database or APED), FITS format tables

- support for modeling the spectra and cooling of plasmas in collisional ionization equilibrium.
- used for high (grating) and moderate (ACIS) spectral resolution data
- available in Sherpa, ISIS, XSPEC
- Initial paper (Smith et al. 2001, ApJ, 556, L91, incl Brickhouse as co-author) has 493 ADS citations to date

This database has also been used for modeling absorption spectra of AGN (PHASE, Krongold et al. 2003) but is insufficient for full photoionization modeling. Our future goal is to provide a single database which can be used for modeling both collisional and photoionized plasmas, including non-equilibrium cases.

A new release, ATOMDB v1.4, is in testing for release at the end of 2010.

- Includes extra elements (complete to  $Z=30$ ), updated Fe L-shell data, Bryans et al (2009) ionization and recombination data.
  - Adds state-selective radiative recombination and dielectronic recombination to populate levels; required significant negotiation with tokamak community to obtain these data.
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The planning cycle for 2011 work is now beginning. We anticipate a similar development cycle with a major release in Dec 2011 and one or two package releases before then.

We are considering the following items as candidates for 2011 work:

- Sub-pixel calibration and simulation support
- Improved support for continuous clocking mode data
- New afterglow algorithm (delayed from 2010)
- More threads packaged as scripts
- Rewritten merge\_all (nearly ready)
- Sherpa template fitting and SED fitting
- R&D on background modelling for improved extended source analysis
- R&D on grating zero-order calibration
- ChIPS GUI for easier plotting
- Source detection in stacked fields (see Ian's talk)

We also expect to carry out a new archive reprocessing, Repro IV. This will include:

- subpixel event positions
- aspect pipeline improvements (periscope drift)
- calibration updates (graded CTI, temp-dep. CTI, FEPO badpixel, HRC time-vary gain)
- FITS standard updates (WCS keywords)

We propose omitting the run of celldetect from the Level 2 pipeline as those source lists have not proven very useful, and for most datasets are superseded by the CSC.

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