



CIAO

Jonathan McDowell
Science Data Systems



SDS develops requirements and algorithms for the CXCDs (Data Systems) team, then tests and documents the resulting software and provides user support. SDS is the interface between the analysis software and the user community; most of the work I discuss is done in collaboration with CXCDs

SDS primary focus is now on maintenance and user support

What we do

Drivers (why we do it)

1 Maintenance & User Support (releases, docs..)	40%	Internal (plus user input)
2 Making Chandra analysis easier	15%	CUC, helpdesk, users
3 Instrument/observatory/Calibration changes	15%	CXC Cal Team
4 Improving algorithms and data quality	10%	Review of bugs, analyse user issues
5 Catalog: maximize science legacy	15%	Led by CXCDs (Ian's talk)
6 New advanced techniques	5%	Internal, and input from advanced users



1 Maintenance/User Support



- 1.1 CIAO 4.3 downloads
- 1.2 Releases
- 1.3 Community outreach and support
- 1.4 Helpdesk
- 1.5 Documentation
- 1.6 Sherpa improvements



CIAO 4.3 Downloads

CIAO 4.3 is the current supported release. **User demand remains strong:**

Dec 15-Aug 31 : 1473 downloads (core+tools, mostly with Sherpa/Chips too)

Linux	825 (of which about half were 64-bit)
Mac	516 (of which 45 were 32-bit)
Solaris	9
Source build	123

This period we also saw 8 downloads of the older release CIAO4.2
CIAO 3.4 is no longer available and we haven't had any requests for it.

Solaris downloads from Kyoto, IPAC, MIT

Solaris still used internally for some mission-critical Data System (e.g. database) uses
but could save some effort by not packaging it for release

* Should we retire the Solaris CIAO release?
CIAO 4.4 (Dec 2011) to be the last support for Solaris?



Releases



- CIAO 4.3 released Dec 2010
- CIAO 4.3.1 patch to 'mkrmf' (problem with -100C 1999 data)
- CIAO 4.4 release planned for Dec 2011
 - maintenance/incremental improvements
 - new afterglow tool, new Sherpa functions, ChIPS GUI
- CXCDS internal pipeline releases, including DS8.4 (Jun 28)
 - Aspect pipeline periscope correction
 - Subpixel correction now is default for ACIS TIMED
 - HRC dead time correction modified
 - Improved ACIS/LETG extraction
 - Celldetect not run any more
 - FITS keywords updated to match new standard

REPRO 4 - new uniform reprocessing of archive now in prep.
Subpixel, afterglow, BI serial CTI, Temp-dept. CTI, aspect, grating
order sorting, header keyword consistency



Community outreach



- Supported booths at June AAS (Boston)
- SDS scientists attended HEAD meeting
- Organized X-ray Astronomy School and CIAO Workshop in August



X-ray Astronomy School 2011

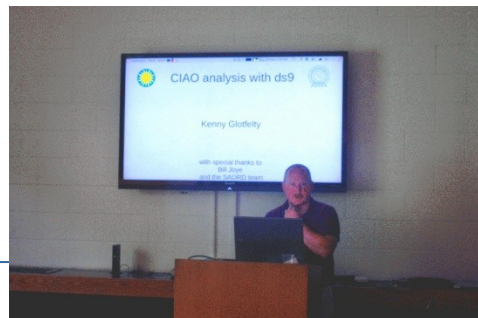




X-ray Astronomy School



- 2011 X-ray Astronomy School held at CfA in August
- 31 students from US, Italy, Spain, Canada (mostly grad students and postdocs)
- Sponsored by NASA, CXC and ESA-XMM
- <http://cxc.cfa.harvard.edu/xrayschool/>
- Lecturers from CfA, MIT, JHU, GSFC and MSFC (SDS: Aneta, Jonathan, Mike N, Dave H)
- Provided pre-prepared hands-on projects (although most students brought their own analysis problems)
- Support and tutoring during hands-on analysis sessions (SDS and DS)
- Very positive feedback
- Students focussed on Chandra data more than in previous XAS at GSFC
- XAS lectures focus on X-ray science and generic X-ray data analysis
- XAS was followed by 1-day (Saturday) 8th CIAO Workshop
- Similar format (talks followed by hands-on session)
- Focus on CIAO and Chandra data analysis
- Kudos to Liz Galle for a great job organizing

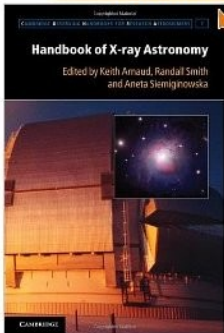


amazon.com Hello, Jonathan Mc Jonathan's Amazon

Shop All Departments Search Books

Books Advanced Search

Click to LOOK INSIDE!



[Search inside this book](#)

Tell the Publisher!

[I'd like to read this book on Kindle](#)

Don't have a Kindle? [Get your Kindle here](#), or download a [FREE Kindle Reading App](#).

Handbook of X-ray Astronomy

Edited by Keith Arnaud, Randall Smith and Aneta Siemiginowska



Handbook of X-ray Astronomy based on previous X-ray astronomy schools chapters contributed by lecturers at schools

Order yours now!
<http://www.amazon.com>

New: Kindle with Special Offers - \$114

Your Digital Items | Your Account | Help

GO Cart Wish List

ifol Bargain Books Textbooks

over]

Prime Quantity: 1

Pre-order: Add to Cart
or 1-Click Checkout

Ship to: JCM Home

Get it: **Not yet released**
(Free Two-Day Shipping once released)

Pre-order with 1-Click

This will be a Gift

Add to Wish List

Share [email icon] [facebook icon] [twitter icon]

Book Description

Series: Cambridge Observing Handbooks for Research /

Modern x-ray data, available through online arch researchers who want to start working in this field calibration of x-ray data, scientific analysis, archi The concepts behind common x-ray astronomy /

Special Offers and Product Promotions

- Pre-order Price Guarantee! Order now and if

Editorial Reviews

Book Description

Written for graduate students, professional astron the concepts behind common x-ray astronomy d



- Helpdesk: 271 new tickets (Oct 25 – Aug 31), 3 still open
 - Median time to first answer 1.7 hours (longest 7 days, waiting for user to provide sample files and for input from scientists)
 - Median time to final answer 5 hours, longest this time was 60 days (followup questions from user)
 - Answers generated 20 new docs, 21 new bugs, 15 RFEs
 - » what were the bugs? examples:
 - » - bug in Sherpa PSF fitting
 - » - bug in mkrmf (EBOUNDS handled wrong for -110C files in CIAO4.3, now patched)
 - » - bug in aprates for nonstandard choice of parameters
 - 63% did not require scientist or DS support
 - 5 open tickets from previous period all now closed
 - We also get direct contacts to SDS scientists outside the helpdesk system, at the rate of several per week



CIAO Documentation

- Using Google Analytics on the websites to track usage.

Total number of unique visitors (as determined by IP address) from Mar 1 to Aug 31:

CIAO - 13400

ChIPS - 1000

Sherpa - 3600

Chart - 600

- Tested, documented and updated reports on known software bugs, advertised bug updates
- Documented DS releases, CALDB releases and CIAO script updates (release notes, threads, why topics); updated CSC pages
- Improved various threads and explanations following user feedback
- Documented the ChaRT ray trace interface update
- Reorganized and improved the imaging spectroscopy documentation, simplifying threads
- Released a data caveat on the recent aimpoint shift
- New 'Sherpa Snapshot' page for new Sherpa users; 2 new Sherpa threads, 3 updated, updated 'Python resources' page



Ran link-checking script on all CIAO component web sites
Corrected broken, dead links

Added check for javascript errors on CIAO download page as part of site-wide security review

Redesigned code for CIAO bugs pages

Created an RSS feed for the CIAO news page

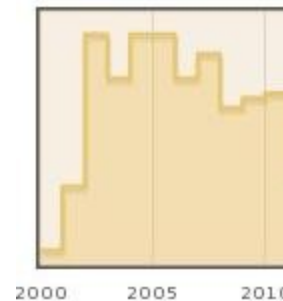
Went to CXC-wide include files for header and footer code
(improved maintenance)

Revised software and calibration sections in thread synopsis and improved tagging of software-change-related information for easy searching



Sherpa improvements

- Sherpa is our multipurpose parameter-fitting application
- Improvements to Performance and Optimization – (ongoing by DS)
- Independent Python build - has been made available as a contributed package. Mac OSX version includes dmg image files for easy installation -
<http://cxc.harvard.edu/contrib/sherpa>
 - 83 downloads of the standalone Sherpa (Jan 1 – Oct 5)
- Attended Randall Smith's mini-symposium on 'X-rays from Non-Equilibrium Plasmas' and participated in discussions between XSPEC, XSTAR, ATOMDB and Sherpa groups on the future of atomic models and their application to the data
- Beginning plans for a python library with flexible access functions to ATOMDB, providing more advanced capabilities to the user – can currently run ATOMDB via XSPEC support within Sherpa.
- Internal XSPEC support upgraded to XSPEC 12.7
- Advanced capabilities – see later
- ADS papers citing Sherpa - 352





2 Making Data Analysis Easier

- 2.1 Scripts
- 2.2 Statistics utilities
- 2.3 ChIPS GUI
- 2.4 TGCAT



SDS Contributed Scripts

We continue our effort to simplify Chandra analysis with improved threads and with scripts that wrap up the threads for simple use cases. Over the past few years we have been working our way through the analysis process from getting the s/w and data to analysing it...

- `ciao_install` (CXCDS script) made getting CIAO much easier
- `download_chandra_obsid` gets you data if you know the obsid
- `chandra_repro` runs the thread to reprocess and get the updated evt2 file
- `fluximage` (new) makes a set of exposure-corrected image in multiple energy bands – e.g.
`fluximage evt2.fits out=outdir bin=4 bands=CSC`
- `specextract` makes PHA and response products
- `combine_spectra` coadds multiple ACIS spectra and responses

Next step is to make it easier to get a flux for a source by wrapping the `aprates`, `modelflux`, `eff2evt` functionality, and to make it easier to merge observations with WCS alignment.



SDS Contributed Scripts

Six releases of the CIAO contributed scripts package since March 2011. These are Python scripts written by SDS members for specific scientific tasks (see <http://cxc.harvard.edu/ciao/download/scripts/>).

- Positive feedback in helpdesk and email about some of the new scripts, especially `specextract`, `chandra_repro` and `fluximage`.

Examples of new scripts:

- `fluximage`: creates an exposure-corrected image for a single observation in one or more bands. Replaces use of `merge_all` for this case. This script was partly written as a component for developing `merge_all2`, a forthcoming `merge_all` replacement
- `check_ciao_version`: report any packages that need to be updated – helper script which supports bug reporting.
- `get_fov_limits`: where is the data in my image?



SDS Contributed Scripts - releases

Full release content (see <http://cxc.harvard.edu/ciao/download/scripts/history.html> for details). Contains new and updated scripts; releases typically monthly

Examples -

- 4 Apr 2011, `chandra_repro` fixed to work around DM bug, handle CC mode right; `specextract` enhanced to allow user control of bkg. responses and to support RA/Dec regions (work around `arfcorr` limitation)
- 25 Apr 2011, added `get_fov_limits` script – helps find good binning parameters for an image
- 7 Jul 2011, new `fluximage` script, and improve `specextract` to handle -110C data



SDS Contributed Scripts: In Prep

- Preparing new merge_all2 script.
 - This script will fix a longstanding bug in which exposure maps are not correctly calculated. It does this by calculating exposure maps for each observation rather than for the merged events, and is therefore significantly slower
 - The old merge_all is fine for cases where the observations are cogenerated and close in time (same calibration) – e.g. recent split obsids
 - The final version of the script will handle multiple energy bands, create fluxed images (as in the fluximage script) and will have the capability to automatically align observations using wcs_update
 - We will release an initial version that replicates, with improvements, the scope of old merge_all (no WCS corrections, just reprojection) in the near future and phase in additional capabilities as resources allow.
-



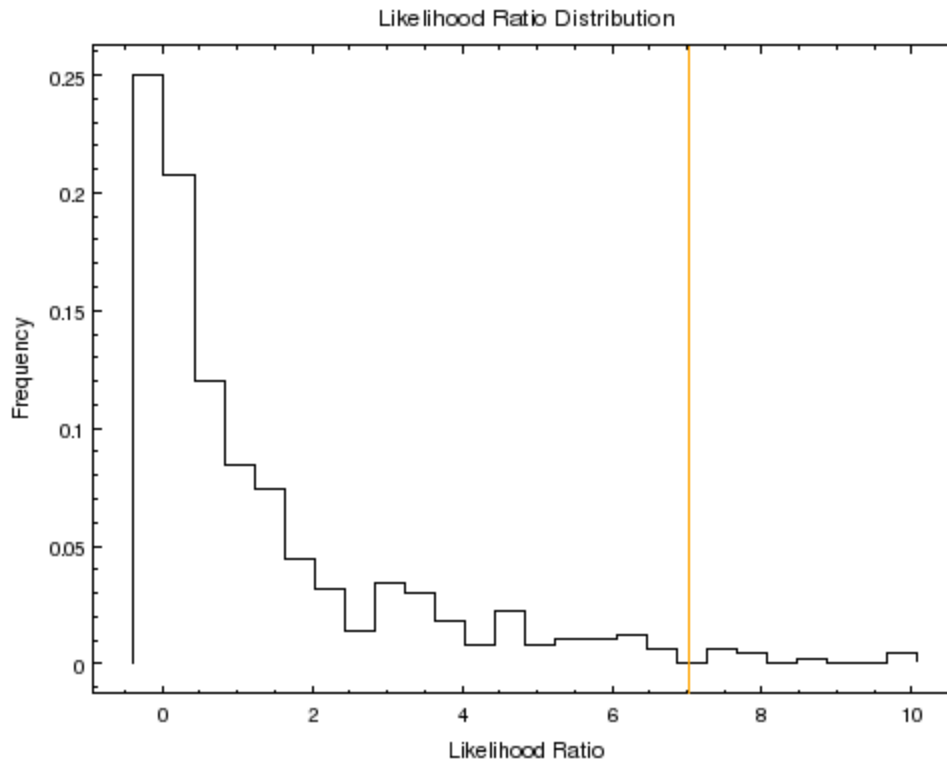
Statistics utilities

- Goal – make it easier to interpret results of fitting
- New python statistics functions
- Callable in Sherpa



Sherpa – Likelihood Ratio Test (example of new stats functions)

```
sherpa-45> plot_lrt(p1, p1+g1, conv_model=rspl, num=500)
Likelihood Ratio Test
null statistic      = -129848.325947
alt statistic       = -129855.339755
likelihood ratio    = 7.01380810166
p-value             = 0.016
sherpa-46> print_window("plot_lrt_example.png")
```



Is the addition of a gaussian line significant? Apply LRT to compare power law (p1) with power law + line (p1+g1)

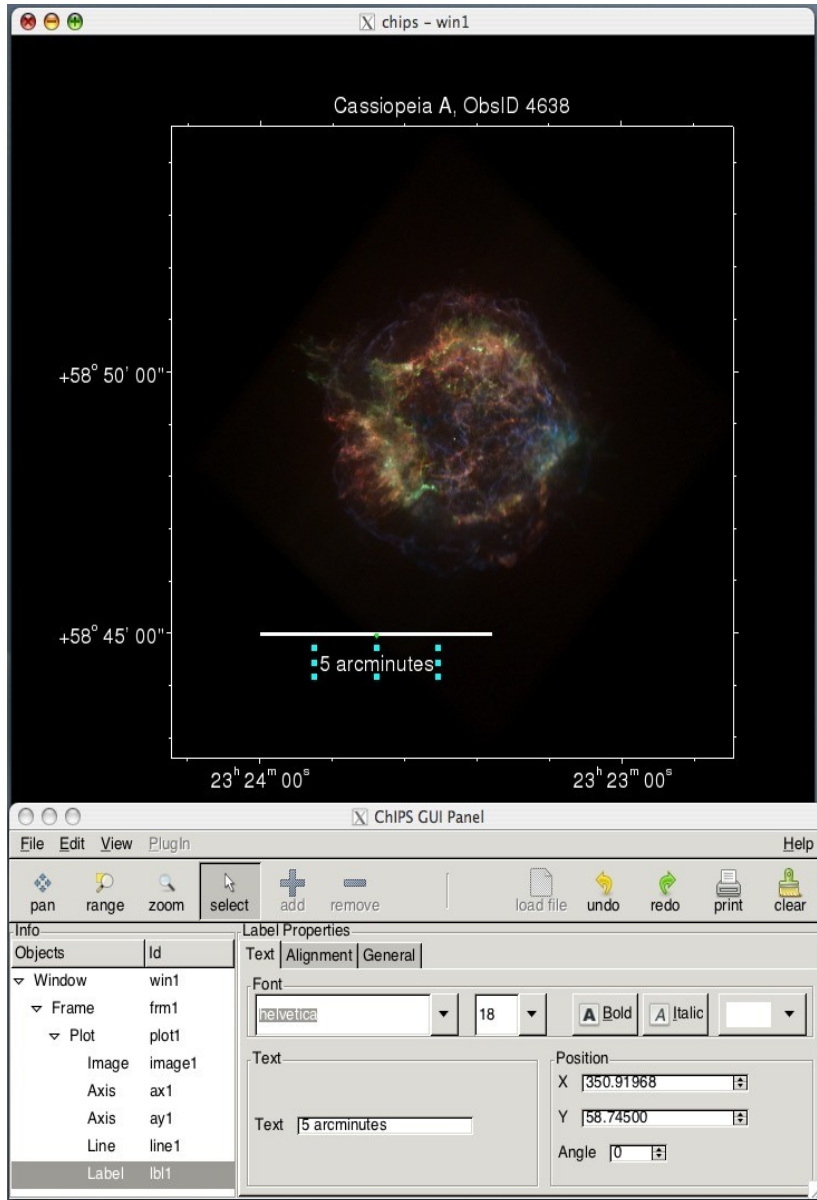
Answer: $p = 0.016$
Significant at 1.6 % Level

Black line: distribution of ratio of (likelihood with line)/(likelihood with no line) for ensemble of simulations

Orange line: same for actual data



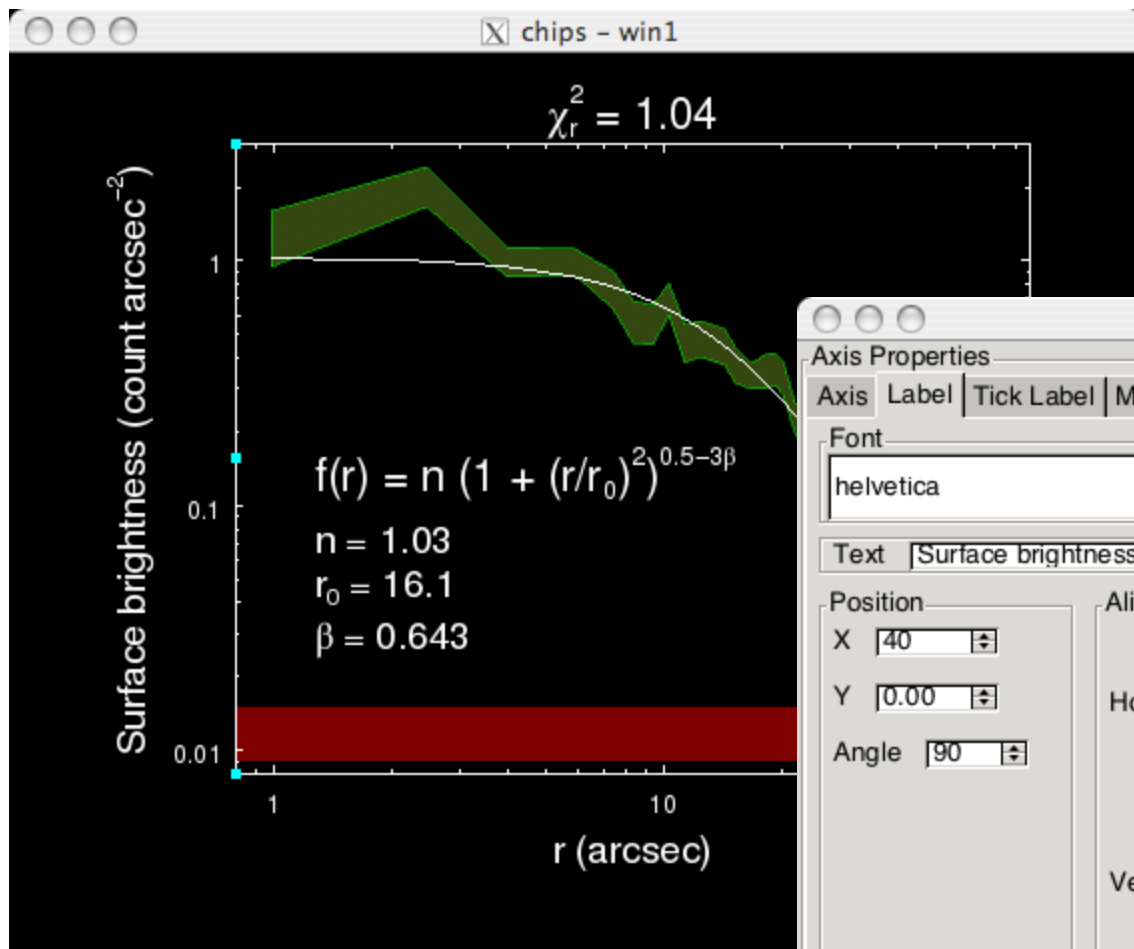
ChIPS GUI – making plotting easier



ChIPS GUI – under development by DS after SDS prototyping.

SDS testing and feedback underway.

Makes existing power of ChIPS much more accessible to users.



CHIPS Edit Properties

Axis Properties

Axis Label Tick Label Major Tick Minor Tick Grids General

Font

helvetica 18 Bold Italic

Text [Surface brightness (count arcsec⁻²)]

Position

X [40] Y [0.00] Angle [90]

Alignment

Horizontal [Left] [Center] [Right] 0.50

Vertical [Bottom] [Center] [Top] 0.00

Visible

Close

The dialog box is titled 'CHIPS Edit Properties' and has tabs for 'Axis Properties', 'Label', 'Tick Label', 'Major Tick', 'Minor Tick', 'Grids', and 'General'. The 'Label' tab is selected. It contains settings for font (helvetica, size 18, bold and italic), text ('Surface brightness (count arcsec⁻²)'), position (X: 40, Y: 0.00, Angle: 90), and alignment (Horizontal: Center, Vertical: Bottom). A 'Visible' checkbox is checked. A 'Close' button is at the bottom right.



ChIPS GUI Panel

File Edit View PlugIn Help

pan range zoom select add delete load file undo redo print clear

Coordinates
plot1: ax1 & ay1

Data Extent
X 0.9840 : 70.3560
Y 0.0141 : 1.0245

X [0.79484] [87.09966] [log] [flip] [auto]
Y [0.00800] [3.00000] [log] [flip] [auto]

Info

Objects	Id
Window	win1
Frame	frm1
Plot	plot1
Curve	crv1
Axis	ax1
Axis	ay1
Region	reg1
Region	reg2
Label	lbl1

Axis Properties

Axis | Label | Tick Label | Major Tick | Minor Tick | Grids | General

Appearance

Color [] Thickness [1.0] Style [inside]

Show Major Grid Show Minor Grid

Label

Surface brightness (count arcsec⁻²)

Tick Setup

Mode [limits] Manual Ticks

Tick	Value
0.000000	0

Add Remove

Shell Errors

```
Warning: Importing CRATES version 0.0.0; CRATES version 4.2.1 is now available, consider upgrading.

chips-2> connect('ChipsServer_24954_1')
chips-3> [ ]
```



The screenshot displays the ChIPS GUI Panel with two overlapping windows. The main window, titled "ChIPS GUI Panel", has a menu bar (File, Edit, View, PlugIn) and a toolbar with icons for pan, range, zoom, select, add, remove, load file, undo, redo, print, and clear. The "View" menu is open, showing options for pan, range, zoom, select, add, and remove. The "Plot Properties" window is also open, showing a "Style" dropdown set to "closed" and a "Corner" dropdown set to "miter". The "Plot Properties" window has tabs for "General", "Aspect", and "Title". The "General" tab is active, showing "Style" and "Corner" dropdowns, and "Margins" for Top (0.10), Bottom (0.20), Left (0.25), and Right (0.10). The "ChIPS Edit Properties" window is also open, showing "Plot Properties" for "plot1: ax1 & ay1". It displays "Data Extent" (X 76.4431 : 258.6343, Y 114.6950 : 290.3524) and "Coordinates" (X 239.656, Y 27.161). The "Info" section shows a tree view of objects: Window (win1), Frame (frm1), Plot (plot1), Contour (ctr1), Axis (ax1), and Axis (ay1). The "Shell" tab is active, showing a terminal emulator with the following text: CIAO 4.3 ChIPS version 1 Tuesday, August 16, 2011; chips-2> connect('ChipsServer_65308_1'); chips-3> []

Full GUI panel includes terminal emulator (bottom), panel showing relationship of plot components (left). Use “View” menu to control which things appear.

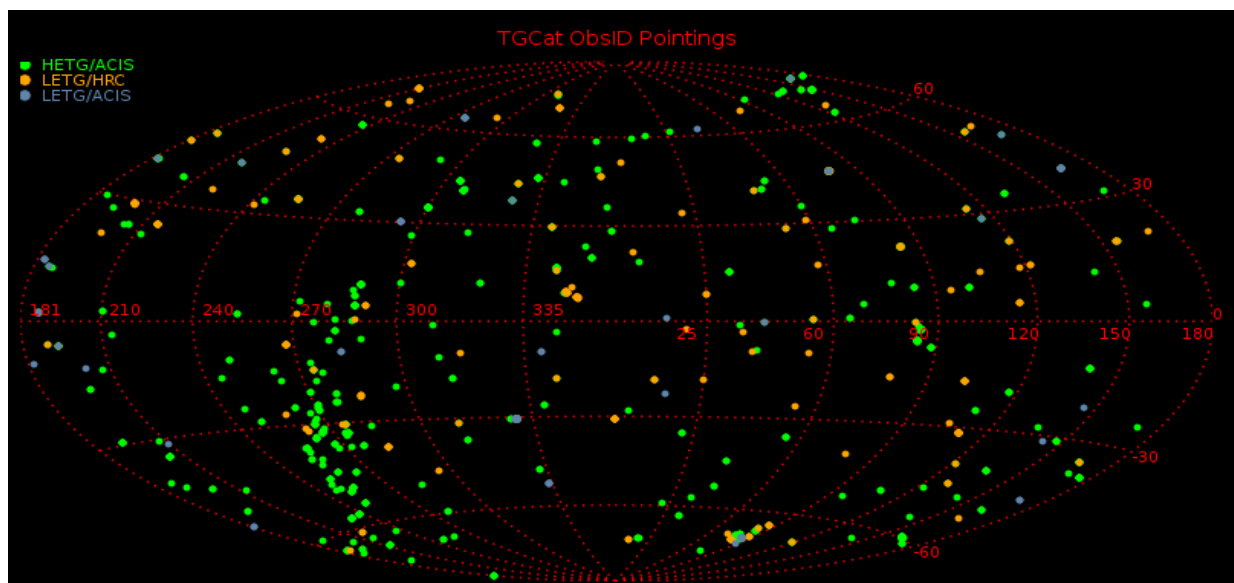


We have previously reported on the TGCAT grating data archive
TGCAT continues to be kept up to date as new grating data go public – currently 1201 Obsids (833 HETG, 121 ACIS/LETG, 247 HRC/LETG) for 358 distinct sources

Planned enhancement: ability to save plot configuration and apply it to a list of extractions
(efficient way to compare many spectra)

TGCAT queries: 6601 from 454 ip addresses (1 Mar -31 Aug)
(VO 59% Web 31% CLI 10%)

42 package and 996 single-file downloads total 5.8 Gb





3. Instrument/Observatory/Cal changes

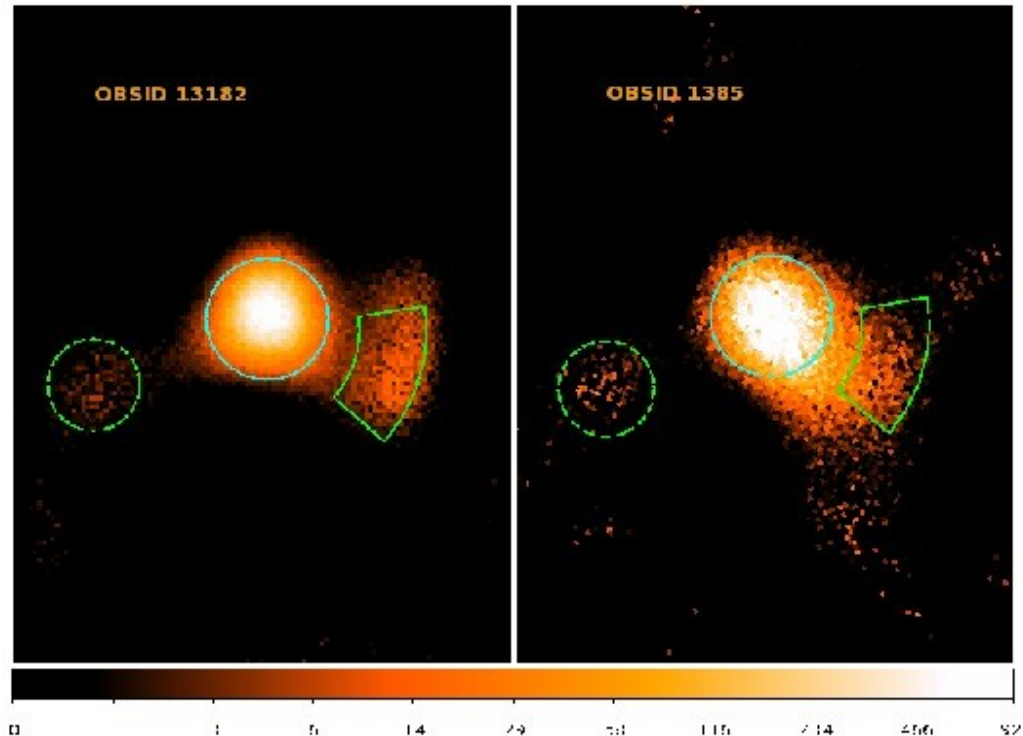


- 3.1 PSF artifact study
- 3.2 HRC blur calibration
- 3.3 Handling ACIS afterglows
- 3.4 Grating CC mode calibration



Followup study of PSF Asymmetry

Reported artifact (asymmetry) in PSF at previous quarterlies (at $0.7''$, few percent of flux)
Now investigated data from 1999-2010
Found PSF artifact was already there in Oct 1999 (Obsid 1385) although closer to PSF center ($0.5'' \pm 0.1''$) and at slightly different PA
Dec 2010 AR Lac data suggests artifact stable since Dec 2000
HRMA modelling required to identify cause (post-launch shift, shell misalignment, ?)



Deconvolved images
of AR Lac
 $0.3''$ Core
 $0.7''$ sector (artifact)
 $1''$ out, on left ("blob")

Left: 2010 Dec
Right : 1999 Oct



Studied HRC-I instrumental blur:

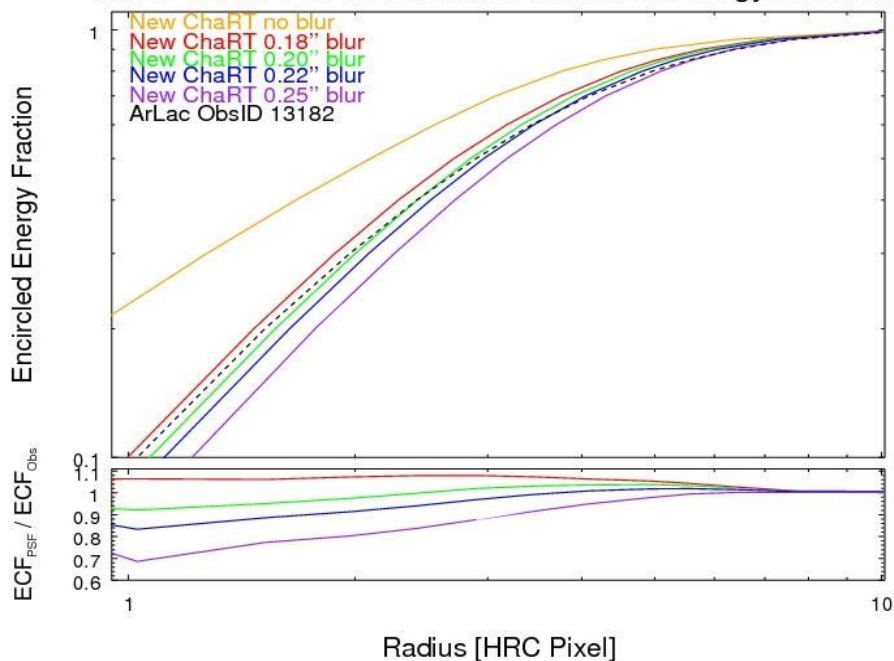
How do you need to blur an SAOTrace HRMA PSF to match HRC-I data?

Used AR Lac data since 1999, including high S/N (18 ks) Dec 2010 obsn.

Result: Blur factor 0.18" to 0.22" for $r < 4$ HRC-I pixels ($r < 0.5''$)

Blur factor 0.25" for $r = 4 - 10$ pixels ($r = 0.5''$ to $1.3''$)

ArLac 13182 PSF PPR Blurred Encircled Energy Fractions



Black line shows data
Colored lines are PSF models with different gaussian blurs

Recommend: blur with $\sigma = 0.2''$ for most data.
Extra blur beyond $0.5''$ could be due to artifact?

Will document for users



Afterglows

A couple of years ago we found that our current afterglow treatment in the pipeline misses some afterglows that can show up as faint (~ 7 count) (false) sources. The new `acis_find_afterglow` tool continues to undergo extensive testing. It is doing a good job identifying afterglows. We are currently testing the behaviour for identifying hot pixels – testing is looking good but is not yet complete.

Improvements:

- added extra parameters:
 - `cntthresh` - minimum events in an afterglow
 - `nfpxreg`, `nfrepeat`, `tolerance` - iterative calculation for nominal fluence
 - `probthresh` - significance threshold for potential afterglow, $3\sigma = 0.001$
 - `regwidth` - size of reference region
- improved understanding of computation of median fluence and its standard deviation
- identified bugs in afterglow code and tested fixes

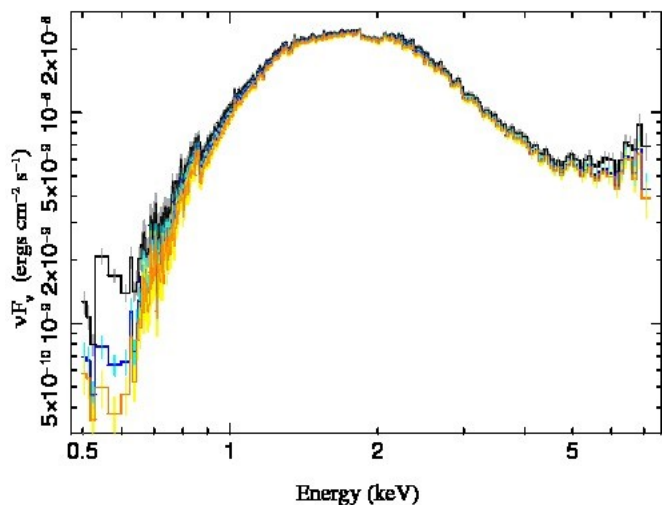
Testing: explored set of 10 Obsids including all ten CCDs, with 22M events and 10k glows. Explored full algorithm parameter space and confirmed that afterglow part of the tool now is performing to spec. Determined that default parameters are a robust choice (changing parameters does not significantly improve detection efficiency).

Hot pixel detection: modified spec to clarify the definition of a hot pixel, the computation of the number of events on a possible hot pixel and of its significance. Analysed existing bad pixel files and discovered that ACIS S4 streaks are sometimes identified as hot pixels; changed pipeline settings for `destreak` and modified pipeline to use it before afterglow detection.

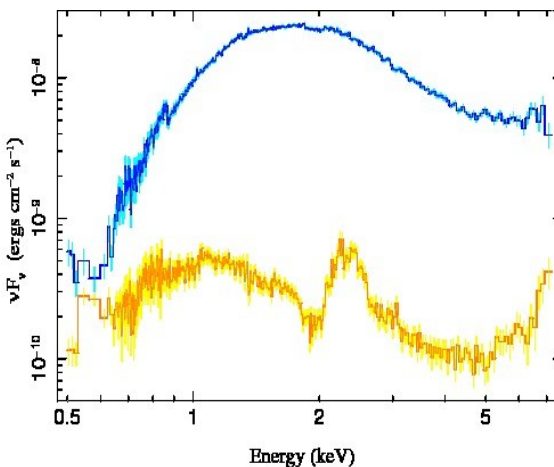


- Goals:
- improve CC-mode HETG order sorting
 - develop method to determine HETG CC-mode background spectrum

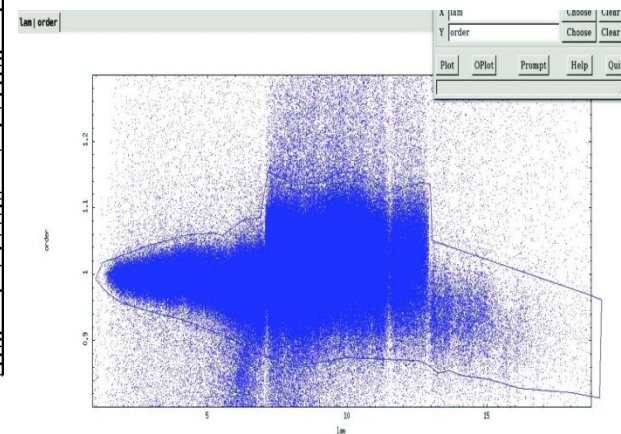
- * Default CC mode order sorting window is wide to allow for gain variations
- * Because we collapse to 1D, background from instrument is enhanced
- * Developed prototype code to support ACIS Cal team development of CC-mode CTI correction
 - input user-created order sorting window, event file, PHA-based background file



Cyg X-1 -
current (black)
narrow window (blue)
b/g subtracted (orange)



Narrow window (blue)
and background
spectrum (orange)



Lambda, order plot



4. Improving algorithms and data quality

- 4.1 Improved PSF simulation: MARX enhancements
- 4.2 Improved PSF simulation: Sub-pixel in MARX
- 4.3 Improved grating processing: zero order location
- 4.4 HRC dead-time factor – improved calculation (not discussed)



ChaRT is the Chandra Ray Trace web page.
It is a web interface to the CXC Optics Group's SAOTrace program.

SDS supported release of the new ChaRT in April (revised SAOTrace wrapper for internal use in the web service)

We tested it against both old ChaRT and against the HRMA team's standalone SAOTrace.

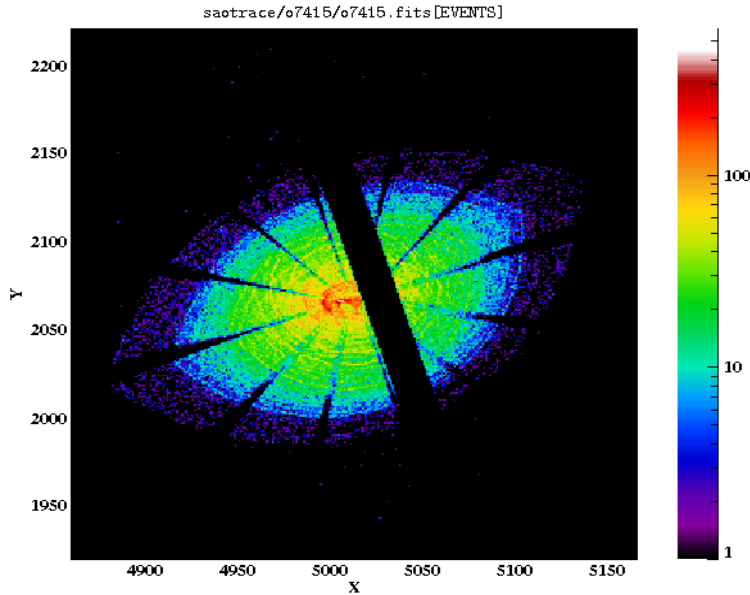
MARX is the (MIT SDS developed) simplified, portable ray trace.
We are enhancing it to be more flexible and more accurate.

ChaRT and MARX are both being used to investigate properties of the PSF by comparing with real data.

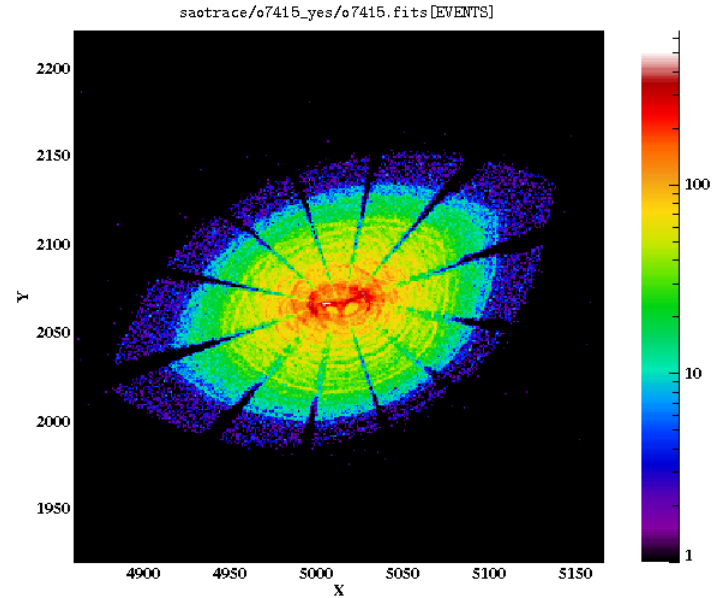
.



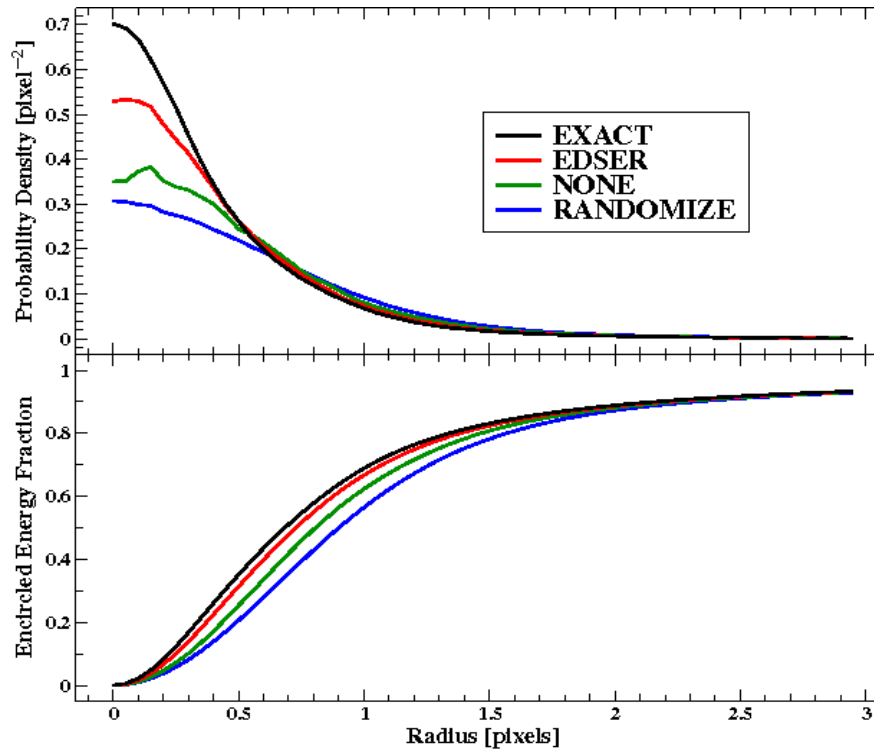
MARX improvements: extended chip option



Standard behaviour: apply chip gaps for realistic detector PSFs



New optional behaviour: do not discard off-chip photons, suitable for calculation of PSFs for interpolation, encircled energies, etc.



MARX knows the exact ray-traced position of an event within a pixel. We can simulate the effect of lost information due to ACIS pixelization and reconstruct the PSFs that should be observed for different processing choices (pixel center, pixel randomization and EDSER sub-pixel reconstruction).

Here we show the profiles and encircled energies for simulated PSFs with these different methods. Previous versions of MARX used the 'randomize' method.



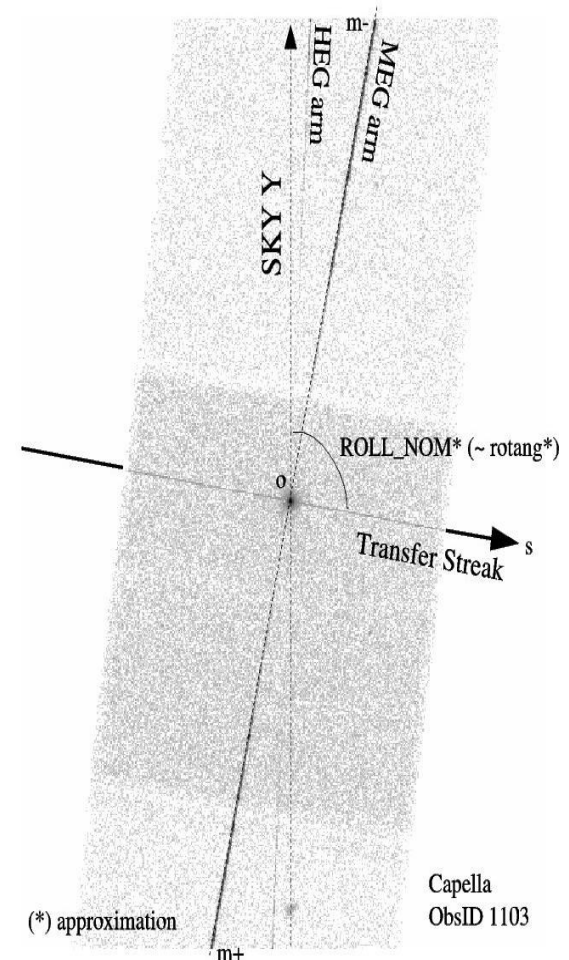
Grating zero order

Zero order can be distorted by pileup for bright sources
Need zero order centroid for accurate grating coordinates
(wavelength scale)

Existing 'findzo' script isolates MEG and readout streak an fits
their intersection – run if deemed necessary during V&V
review

In cases where even this fails, use a priori source
position. Results of this in V&V to date:

	HETG/ACIS-S	LETG-ACIS-s
Total	833	121
tgdetect	65%	69%
findzo	23%	27%
a priori	12%	3%

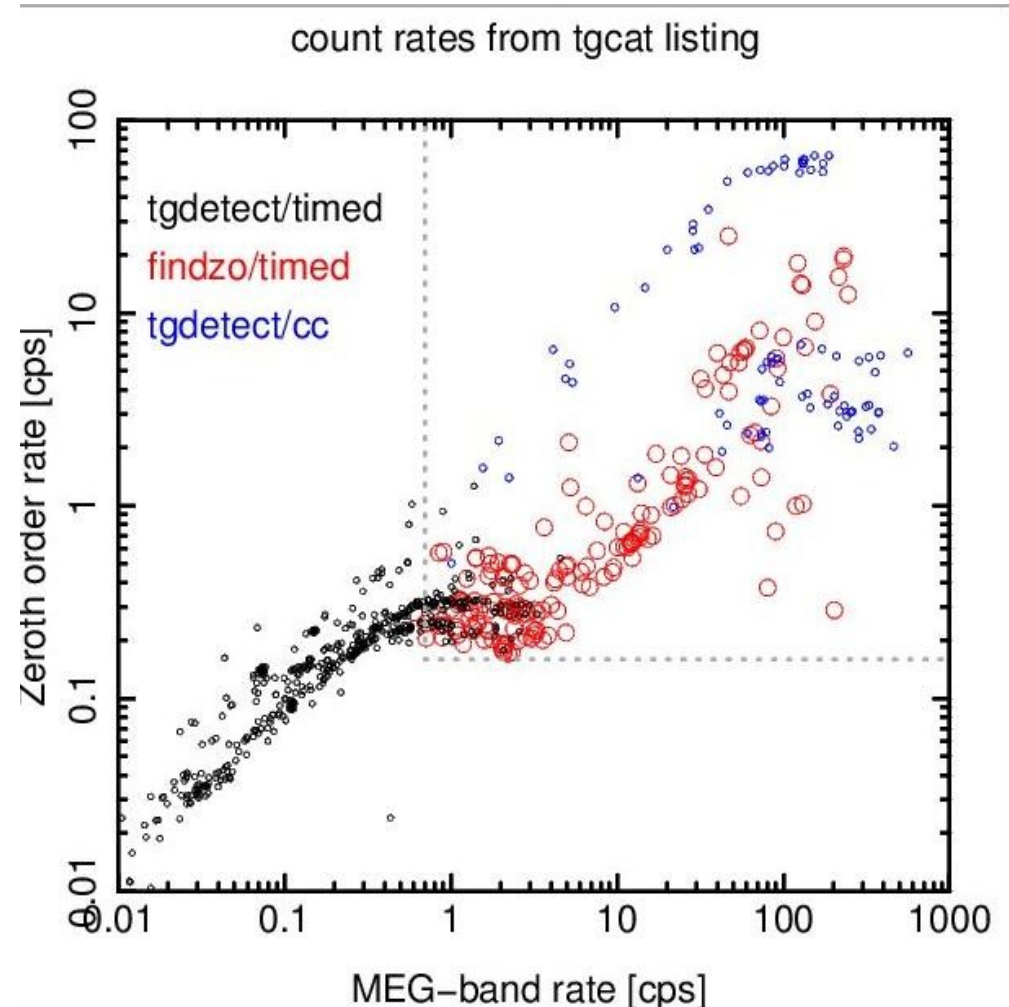




Grating zero order

Plan to include this algorithm within “tgdetect” pipeline/user tool
- then can choose to run this instead of current celldetect method used by tgdetect.
Second phase (2012) will be to review current data and develop heuristic for which method to use – will allow us to automate the choice in many (but not all) cases

Plot shows that the need for findzo kicks in when the MEG count rate is about 0.7 c/s .





5. Chandra Source Catalog: SDS Support

- Covered in Ian's talk

Paper 2 (Characterization: Primini et al 2011) published as 2011 ApJS..194...37P

- Supporting algorithm development for multi-obsid detect
 - Developed improved aperture photometry algorithm for crowded field case
 - Bayesian formalism to support contamination from nearby sources, allow informative priors for source intensity (eg. $\log N \log S$), improved (more robust and faster) implementation
 - Paper 3 (aperture photometry) in preparation
 - Limiting Sensitivity algorithm development – now using a likelihood approach based on C-statistic in the MLE source fit, approach similar to 2XMM's
 - Simulation code for multiple obsids, instrumented to tag events for each source; event tagging within MARX as a new standard feature.
 - Catalog threads: new thread on Proposer website for 'finding a point source in CSC'
<http://cxc.cfa.harvard.edu/proposer/threads/csc>
-



6. Sherpa advanced capabilities

- Flexible fitting with templates (1D and 2D) – iterating with DS on specs and development, investigating fitting techniques, collecting example applications to real data. Supports fitting multiwavelength SEDs combined with X-ray data
 - Statistics functions including goodness-of-fit simulations with Cash, ppp hypothesis test and improvements to flux error simulations – DS provided to SDS for evaluation and test in mid-Sep.
 - Testing performance and behaviour of pyblockx statistics code using simulations (work continuing)
-