



Jonathan McDowell
(CXC Science Data Systems)



Chandra data and software

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, operation, archive, etc.

CXC Science Data Systems team

requirements, documentation, testing, helpdesk, interface with the science community

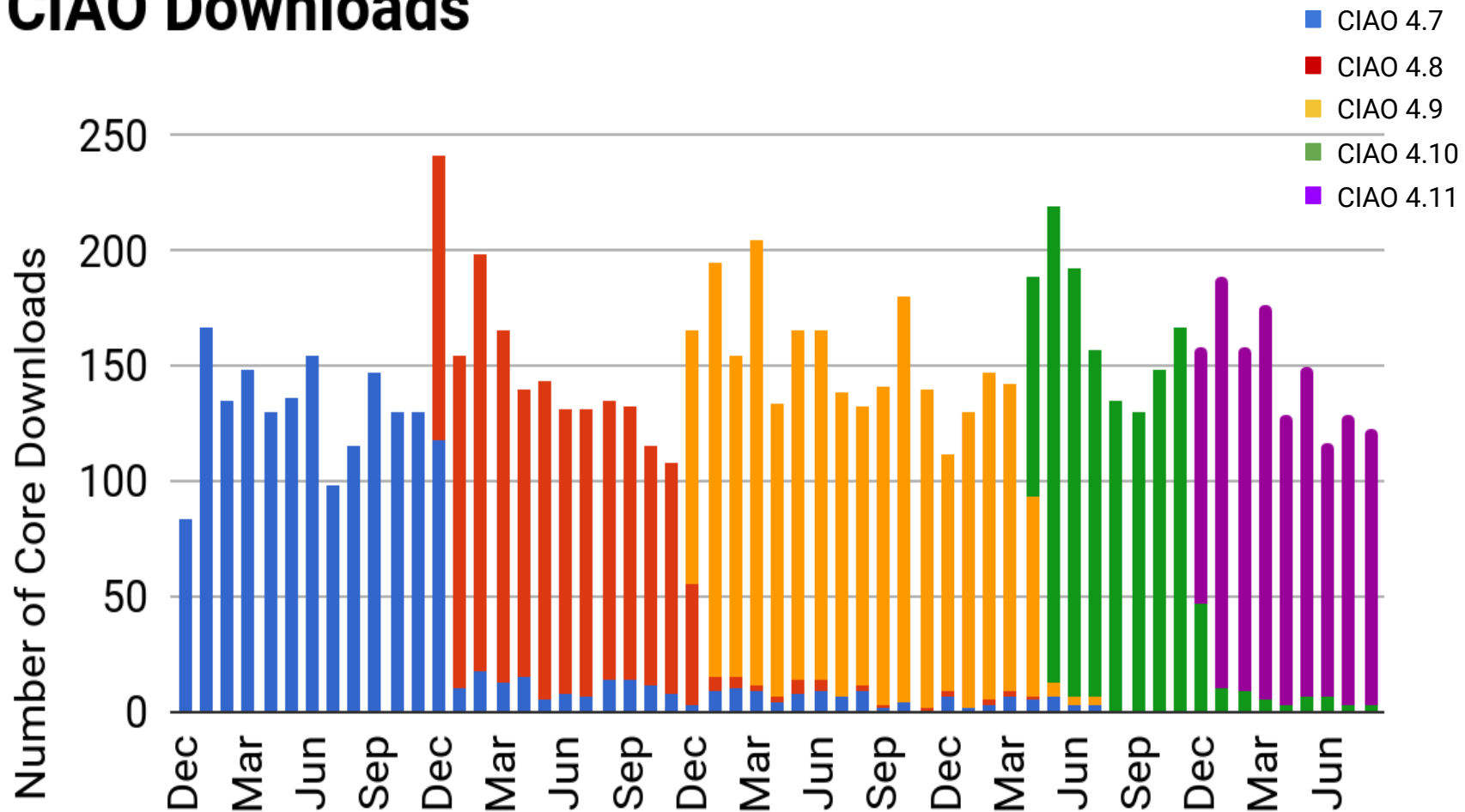


Community Support:

Downloads,
Documentation,
Helpdesk

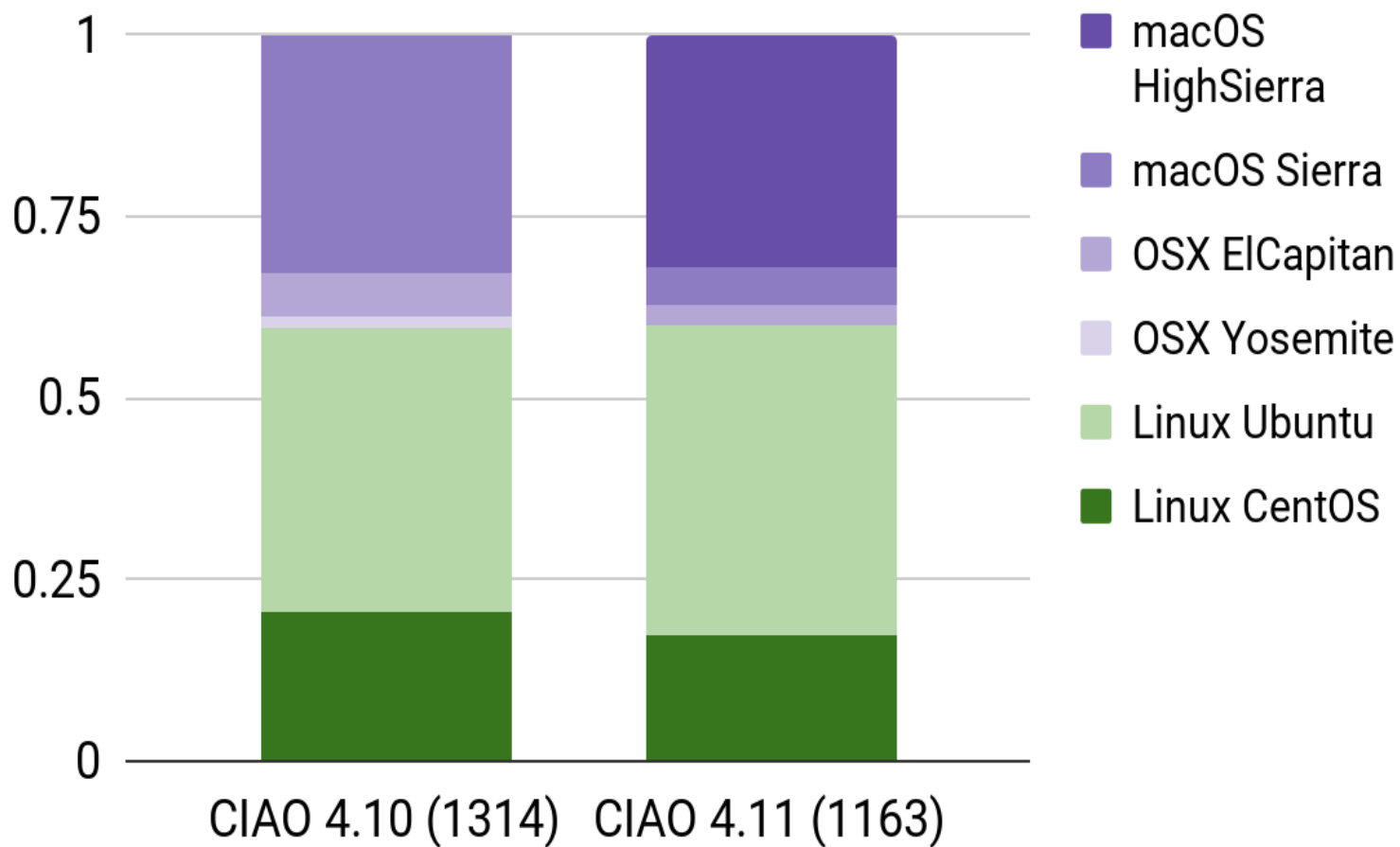


CIAO Downloads





Download by OS





Downloads (lifetime)

| OS | CIAO 4.10 | | CIAO 4.11 | |
|------------------|-----------|-----|-----------|-----|
| Linux CentOS | 268 | 782 | 201 | 700 |
| Linux Ubuntu | 514 | | 499 | |
| OSX Yosemite | 23 | 532 | 0 | 463 |
| OSX ElCapitan | 76 | | 33 | |
| macOS Sierra | 433 | | 56 | |
| macOS HighSierra | 0 | | 374 | |
| Source | 40 | | 52 | |
| Total | 1354 | | 1215 | |



Documentation



Documentation

- CIAO 4.12 routine roll-out and updates
- Improved python documentation
 - Matplotlib, jupyter notebooks, installing external python code
- Improved documentation to pip install astropy
 - Restrictions due to difference in numpy versions.
- Improved dmextract GTI usage description when making light curves.
 - Only the 1st GTI is used. Typically this is correct since the GTIs are usually identical; however, for some situations such as telemetry saturation users need to process each CCD separately.
- Improved links to MARX documentation
- New TSTART/TSTOP dictionary entry:

http://cxc.cfa.harvard.edu/ciao/dictionary/tstart_tstop.html

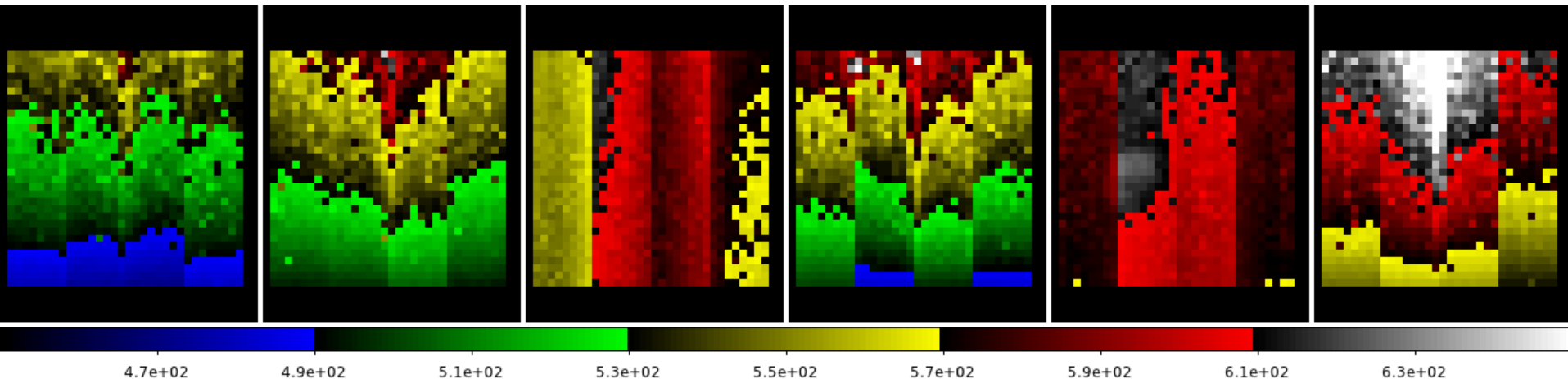




Internal technical documentation

Will review for migration to public docs

- CC mode spatial mask vs. GTIs
- Definition of TSTART and TSTOP
- Discussion of ACIS events not processed beyond L0
- Analysis challenges using on-board energy filters
- Analysis challenges using on-board event sub-sampling
- WCS issues in dmregrid tools
- Computational underflows when computing probabilities
- Improvements to ACA products' metadata.

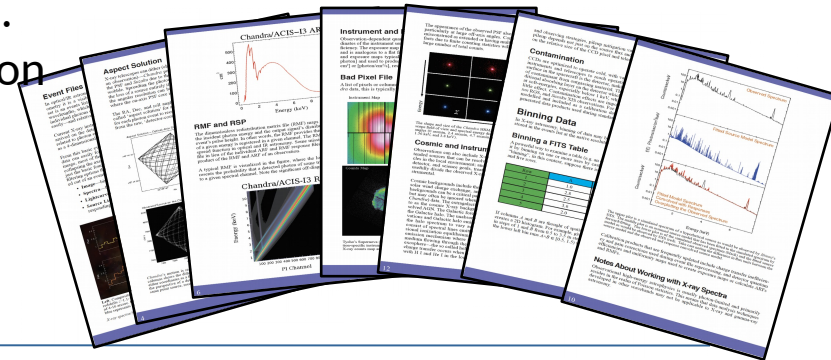
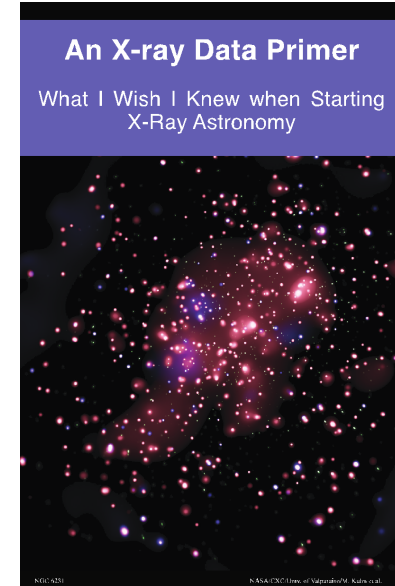




X-ray astronomy primer (cxc.harvard.edu/cdo/xray_primer.pdf)

Documentation for the wider astronomical community

- Inspired by community interactions at the CXC booth over several AAS meetings and helpdesk.
- For the most part, not *Chandra*-specific, intended as introductions for those new to X-ray astronomy.
 - introduction for astronomers new to X-ray astronomy.
 - overview of data products and highlights analysis considerations.
- Made available as handout for workshop and at this year's winter and summer AAS meetings.
- Intended to be updated with more information over time and with community input.





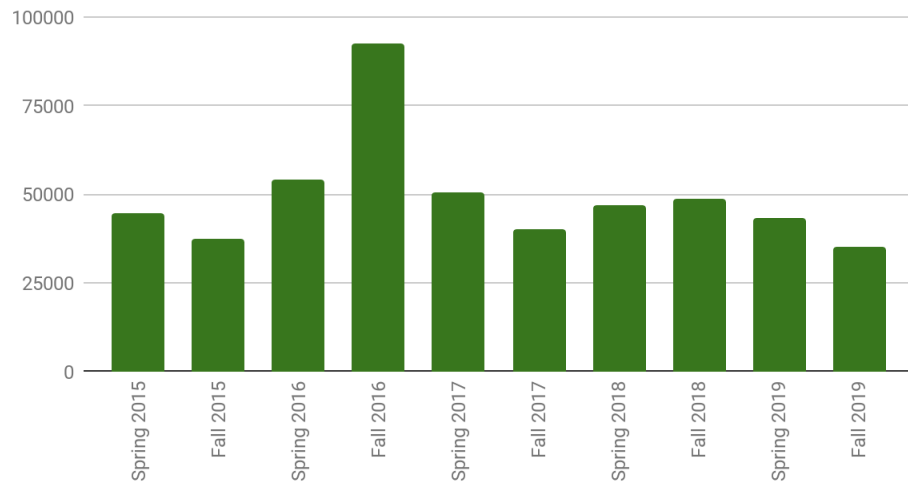
Website statistics: 2018-09-01 through 2019-08-31

| | CIAO | Sherpa | Chips |
|------------|-------------|---------------|--------------|
| Sessions | 64,253 | 16,606 | 4,001 |
| Users | 21,804 | 7,332 | 3,201 |
| Page Views | 203,779 | 43,271 | 6,825 |
| Duration | 5:55 | 4:16 | 1:19 |

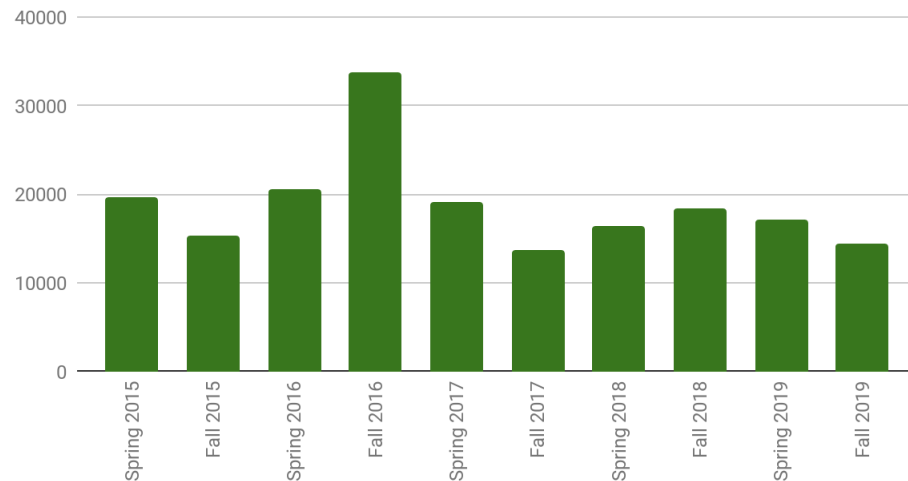


Long Term Website Trends

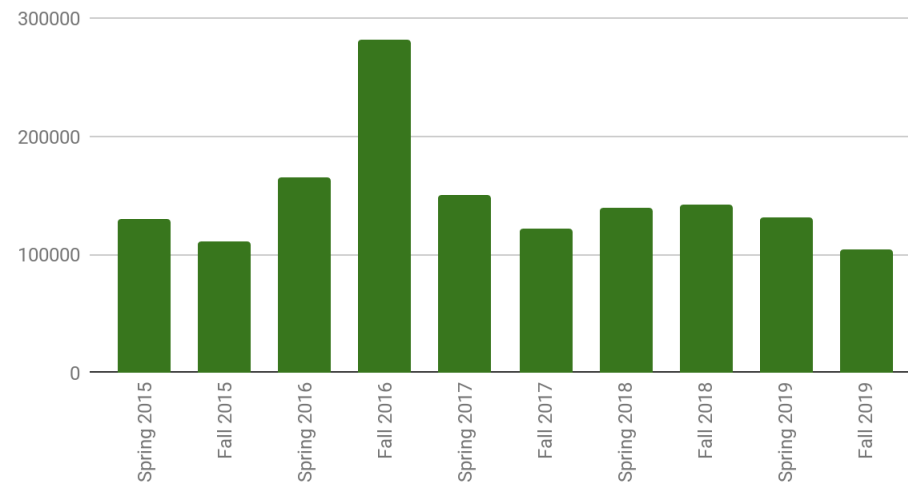
Sessions



Users



Page Views





Helpdesk



Helpdesk Stats

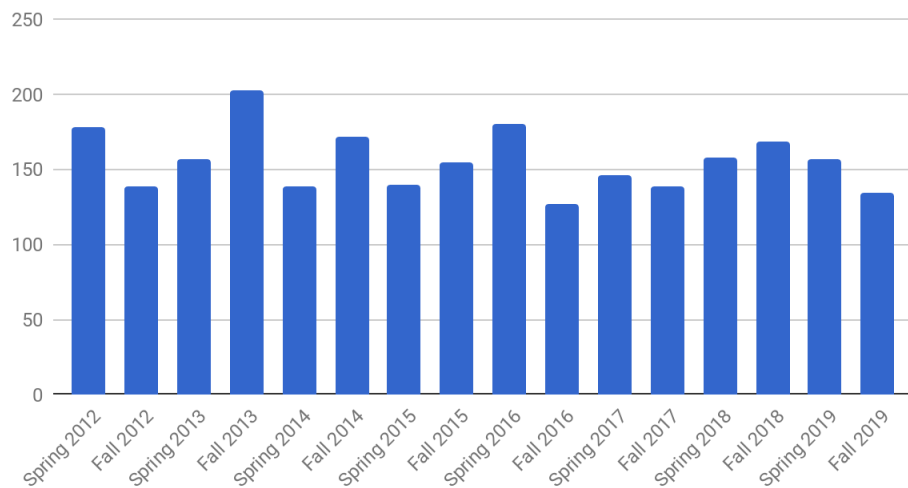
| | 2018 | 2019 |
|---|-------------|-------------|
| Number of Tickets | 298 | 317 |
| Median time to 1st contact [hrs] | 1.01 | 1.67 |
| Median time to close [hrs] | 7.07 | 7.78 |
| Maximum time to close [days] | 50 | 46 |
| % handled by techs | 84.9 | 83.3 |

Maximum time was for a question about limiting sensitivity, blank sky backgrounds, units, and exposure maps; extended over end-of-year & AAS.

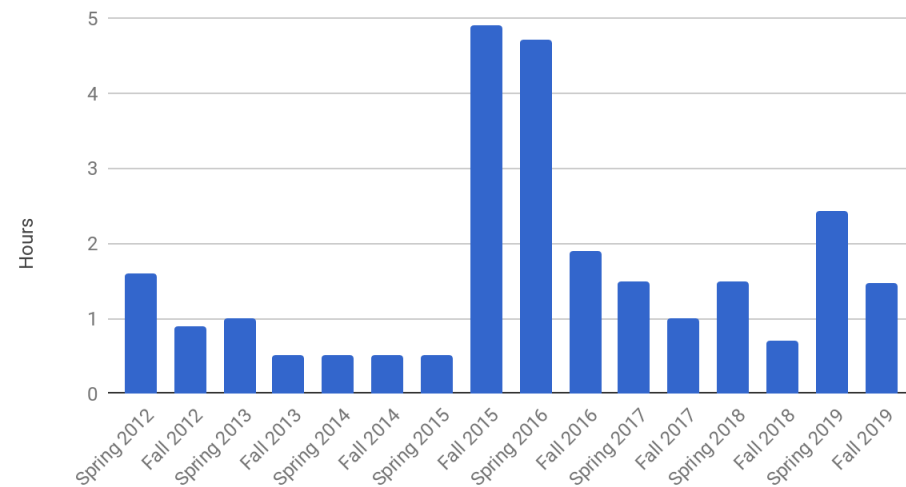


Long Term Helpdesk Trends

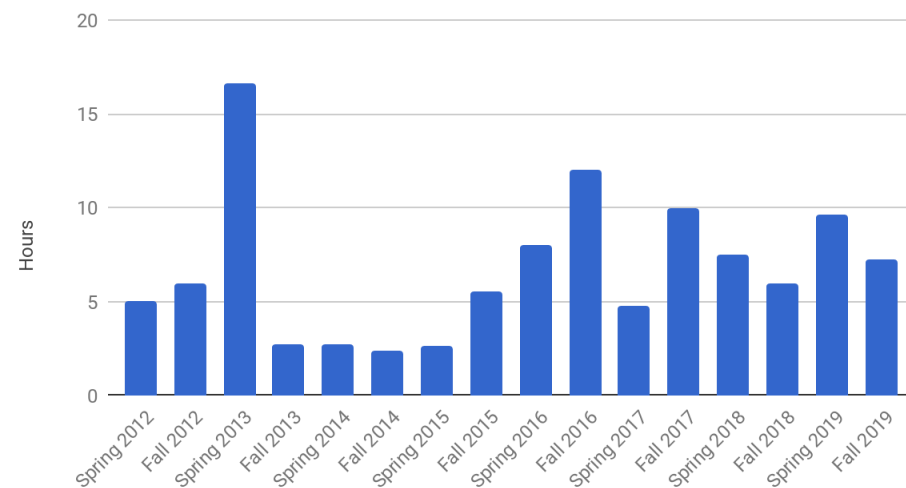
Number of Tickets



Time To Answer

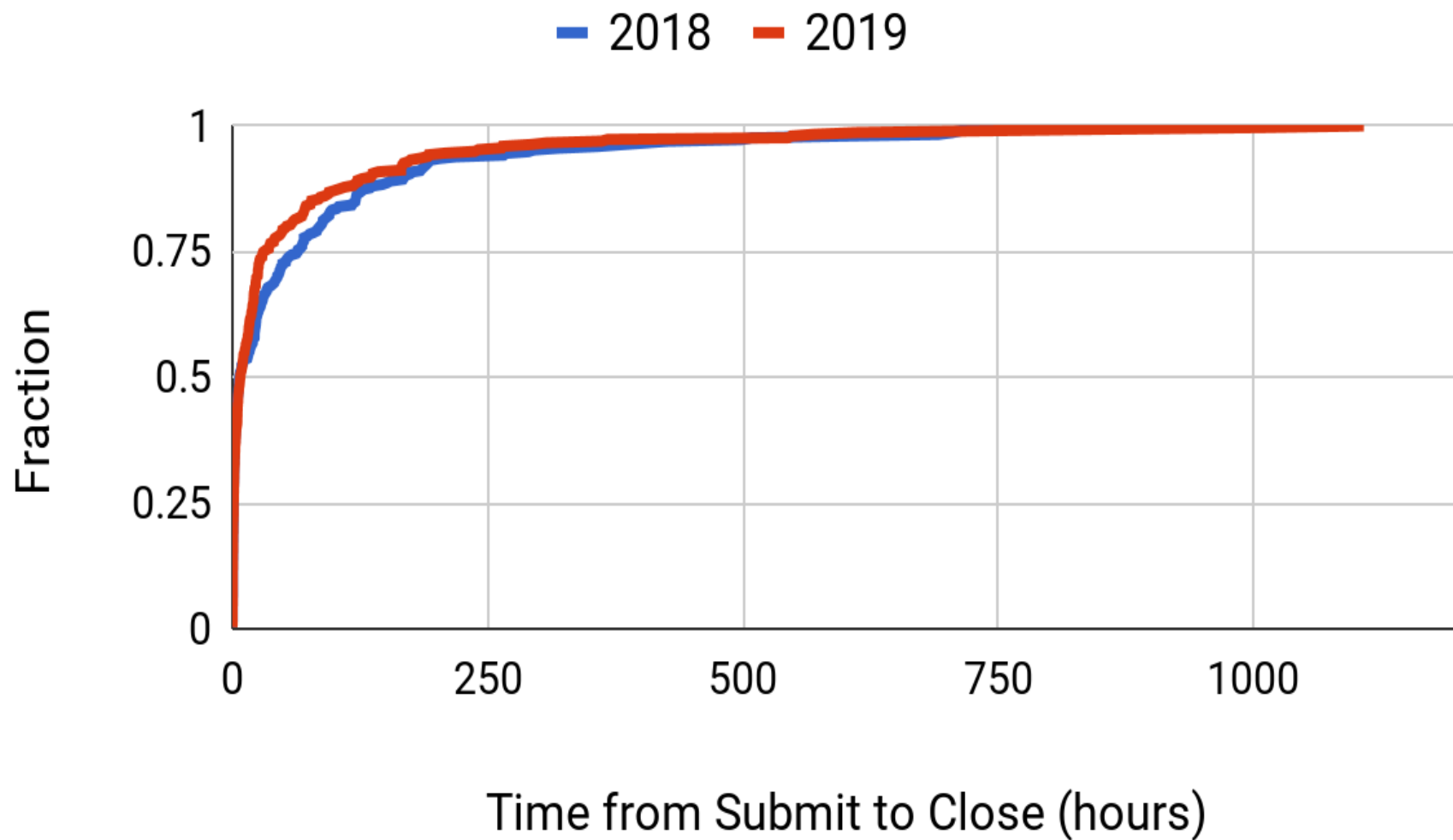


Time To Close



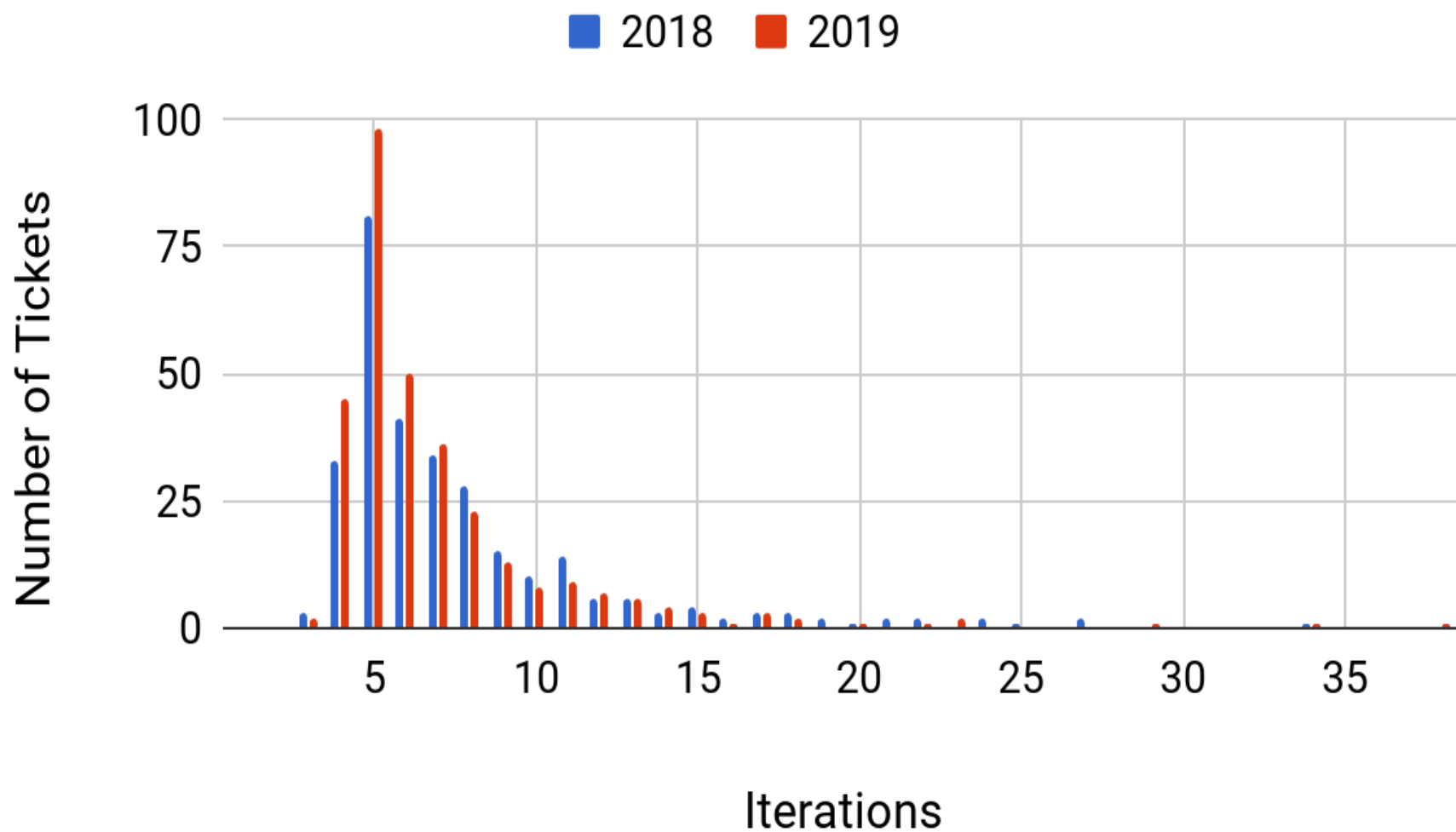


Ticket Aging



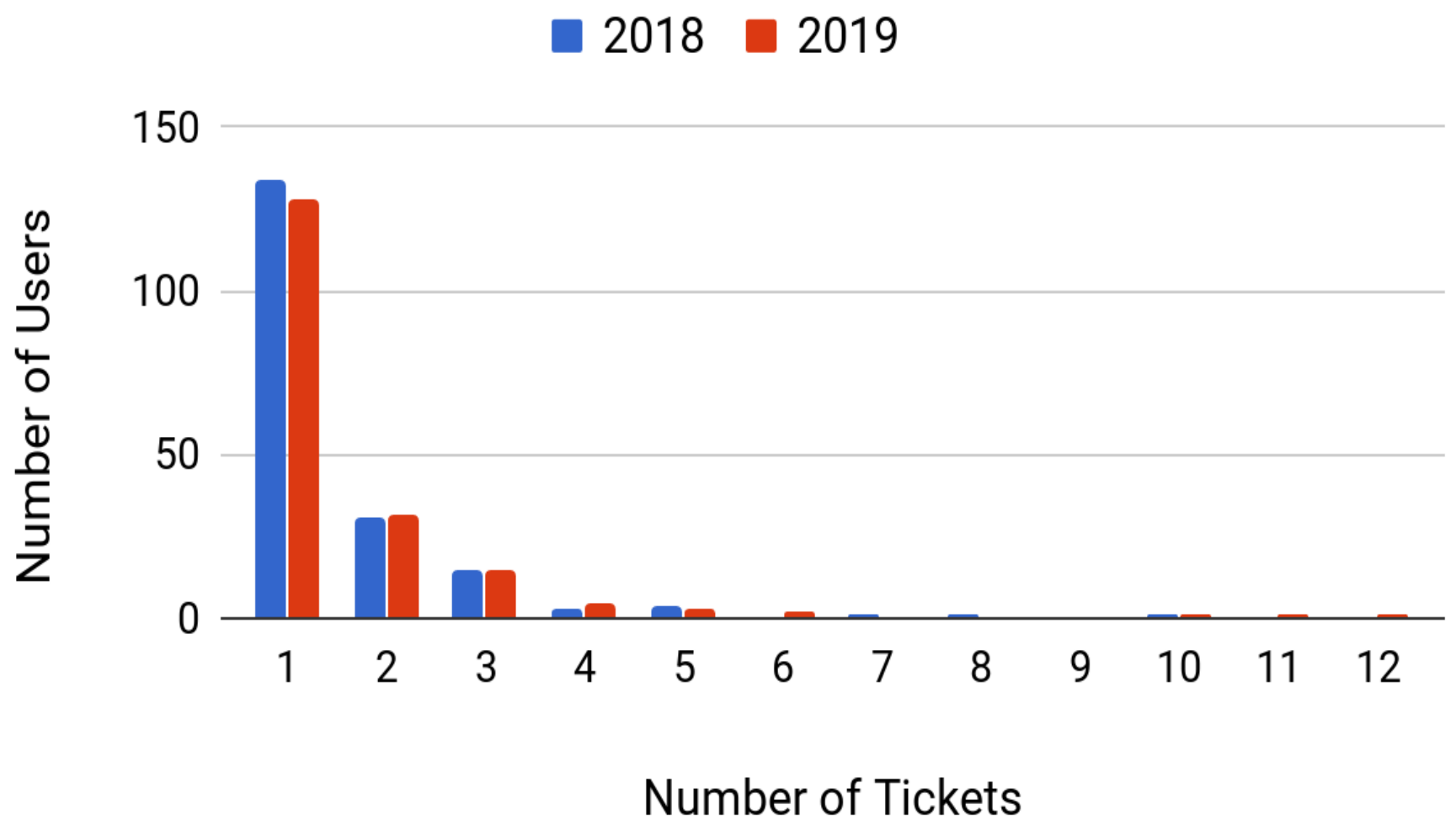


Iterations per Ticket





Tickets per User





Common helpdesk topics

- **Examples of bugs**
 - Problem with `find_chandra_obsid` on macOS with incompatible libssl
 - Issue with sherpa optical models (voigt)
 - ciao-install issue with proxy servers
 - user contributed software patch (parameter interface)
 - **Example of documentation updates**
 - Definition of TSTART & TSTOP
 - Multiple GTI handling when creating lightcurves
 - Instruction of installing numpy-compatible version of astropy
 - **Examples of calibration questions passed on to science staff**
 - Fe line shifts between observations
 - Accuracy of wavelengths, x-cal between HETG & LETG
 - Differences between nH from CXC's 'colden' and HEASARCs 'nH'
 - Creating HRC RMF files on arbitrary grids
-



Community



Community Support

- January 2019 - AAS/Seattle First Chandra/CIAO AAS Workshop
- September 2019 – Chandra/CIAO regional workshop in Bologna





CIAO Workshop #15 at AAS233/Seattle Jan 2019



- 2 days workshop held on Saturday and Sunday before conference.
- 29 Students registered out of 30 available seats. 24 students attended including several walk-ons.
- Mostly grad students, some Professors and even High School students.
- Morning talks (incl 1 remote), afternoon hands on.



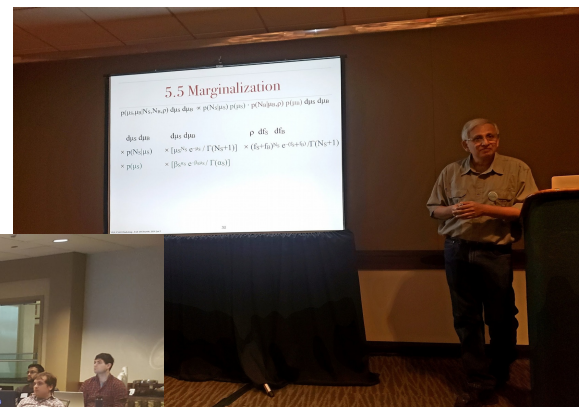
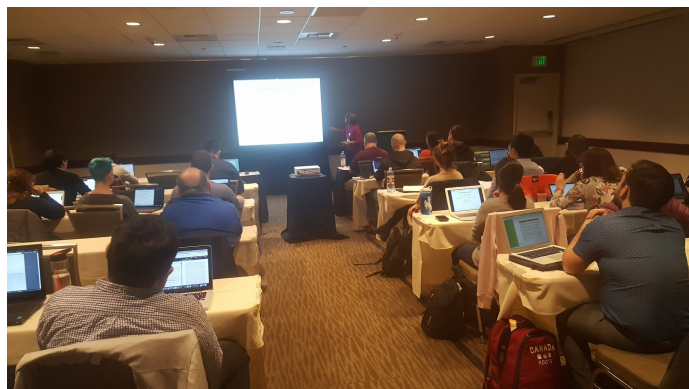
CIAO Workshop #15 User Feedback

- YES! **100%**
 - Overall, did you find the CIAO workshop beneficial?
 - Did you get all the support you needed during the hands-on session?
 - Would you recommend to your students, colleagues, and/or adviser that they attend a similar workshop?
- Are there specific topics you wish we had addressed?
 - I didn't come in with any specific topics, I wanted support getting started on CIAO and doing the workbook. I came out with a solid understanding of the functions in the workbook, and how to problem solve and look up other functions. Though the program was meant for graduate students and postdocs, everyone was very supportive and worked with me until I understood how to do it myself.
 - **Gratings** data -- I felt like there was a large emphasis on imaging spectroscopy
 - **Grating**, more spectral analysis, HETG/LETG
 - The nitty gritty of spectroscopic analysis; running a point source from observation to Lx, Gamma, etc.
 - Additional information on **grating** spectroscopy would be beneficial.
 - More specific demo of DS9 using.



CIAO Workshop #15 laudatory quotes

- *Everyone's positivity was appreciated!*
- *Thank you very much for an excellent workshop!*
- *The duration and the content are perfect. Thanks the team so much!*
- *Keep up the great work!*
- *One of the best I have seen*
- *The documentation appears to be very well laid out, and the workbook is very helpful.*





CIAO Workshop #16 after X-Ray Meeting, Bologna, Italy 14-15 September 2019

- first time in Europe
- 24 participants from institutions in 11 countries





CIAO Workshop #16

- Followed feedback from workshop #15 and added grating + advanced stats talks
- Comments still trickling in
- For now YES! **100% to the questions:**
 - Overall, did you find the CIAO workshop beneficial?
 - Did you get all the support you needed during the hands-on session?
 - Would you recommend to your students, colleagues, and/or adviser that they attend a similar workshop?

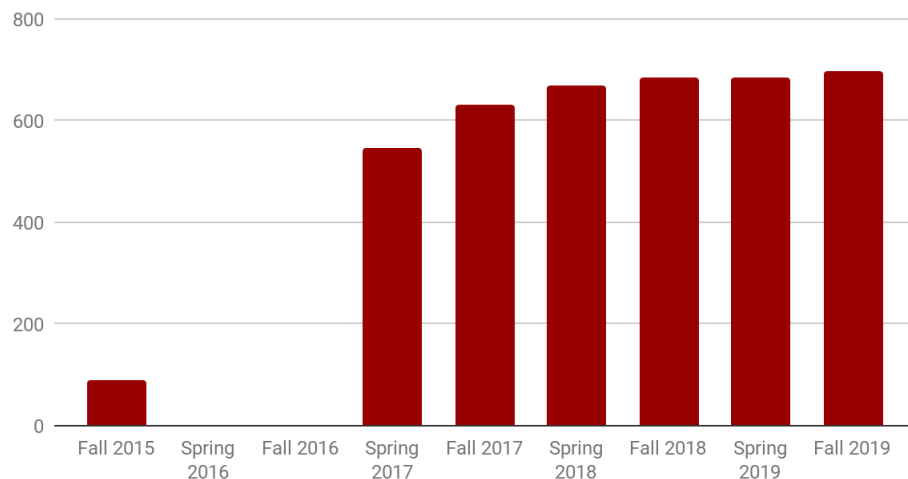
CIAO Workshop #17 AAS235/Honolulu - Jan 2020

- Registration currently open
-

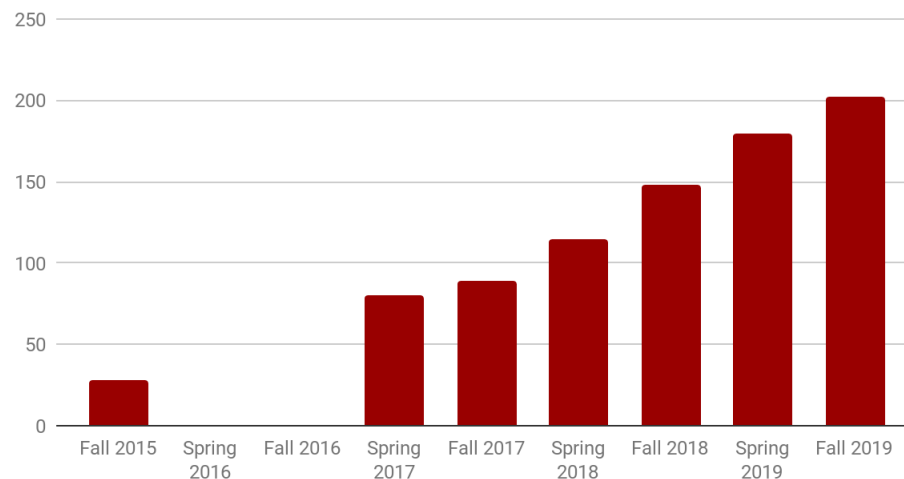


Long Term Social Media Trends

Facebook



Twitter



| | |
|--------------|---------------|
| ChandraCIAO | 698 followers |
| @chandraCIAO | 202 followers |



CIAO 4.11 and Scripts Overview

CIAO 4.11 Highlights

- Python 3 only (previous release had both Python 2 and 3)
- Improved python compatibility
- Ships with Jupyter notebook and matplotlib

CIAO 4.12 plan

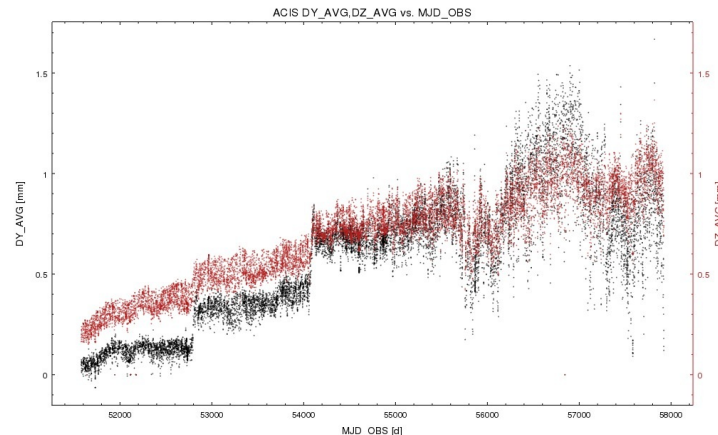
- Remove ChIPS and rely on matplotlib
 - Scripts with plotting rewritten to use matplotlib
 - DS9/DAX analysis scripts which used ChIPS now using DS9 internal plotting
 - Move UI tools from Gtk+ version 2 to version 3
 - SSL libraries in package, simplifying multiple platform support
 - focus support on tcsh and bash shells
 - ciao-install:
 - Single Linux distribution
 - Single macOS distribution
 - Experimental support for installing CIAO using the conda package/environment management system
 - Linux and macOS
 - currently finalising OTS versions (primarily Python)
-

Repro 5 (2020)

- First complete archive reprocessing in 6 years
 - Update header keywords etc (like running `chandra_repro` on all archive data)
 - Improved off-axis angles (see next slide)
 - Other algorithm improvements
 - Pre-compute grating responses
 - Uniformly processed archive
-

Off-axis angle algorithm

- New off axis angle calculation to be introduced in 2020
- Will not change RA/Dec values
- Will change DETX/DETY values and off-axis angles (up to 20" change)



Background:

Fiducial lights on ACIS/HRC projected onto aspect camera field

- gives us shifts of ACA frame wrt instrument frame every 2 seconds
- Up to few arcseconds over an observation
- Trend of 20" over life of mission

BUT

- degeneracy: cannot separate instrument/mirror shift from mirror/ACA shift
- 20 years of PSF observations finally allow us to disentangle this:
mirror/ACA is shifting, not instrument/mirror
- Oops! We guessed wrong in 1998
- Minimal science impact so far, but want to fix, just in case the change trends larger



Contributed Scripts

- CIAO 4.11 highlights (four releases: December, April, May, and August)
 - bugfix: srcflux was overestimating fluxes (net_photflux, net_flux), typically by 5% to 15%
 - Major DAX update:
 - replace ChIPS plotting by DS9 (BLT toolkit)
 - new and updated tasks
 - provide access to the output products of the tasks
 - Create psfmaps needed by wavdetect/celldetect in “imaging” scripts: eg fluximage, merge_obs
 - Convert scripts and modules to use Matplotlib rather than ChIPS (eg deflare, calc_ecf)
 - Retain all columns in HRC L2 data products
 - Address user tickets (mainly corner cases such as event files with 0 exposure)
 - Update CSC scripts in preparation for the CSC2 release
 - Continue our pithy naming convention: convert_ds9_region_to_ciao_stack
- 2020 Planning
 - DAX: continue plotting improvements (thanks to recent DS9 updates)
 - Removal of ChIPS support
 - Support distribution via conda



Tracking Testing with Trello

- Seeded with information from weekly CIAO builds (ciaox)
- Used to track testing status: backlog, working, test submitted, added to automated regression tests, etc.
- Identify doc update, team assignments, etc.

The screenshot shows a Trello board for 'CIAO 4.12 Testing' with the following columns and cards:

- Backlog in CIAOX**
 - Ready To Test: ds9 v8.0.1 (Area: cm:OTS, Docs: Other)
 - Ready To Test: CM-100: ciao-install incorrect path with --caldb option when installing patch (Area: cm: CIAO_INSTALL, Docs: None)
 - Ready To Test: SL-91: ASCII kernel, CONTINUE keys missing description (Area: lib: CXCDM, Docs: None)
 - Ready To Test: SM-39: CXCRRegion to be able to handle slices (Area: py:module: REGION, Docs: None)
 - Ready To Test: SM-51: adding history record with no parameters does not work (Area: py:module: OTHER, Docs: None)
 - Ready To Test: SL-99: DM ASCII kernel column detection mistakes 1999-09-23 as a number (Area: cm: CIAO_INSTALL, Docs: None)
- Working**
 - Ready To Test: CM-121 References to "linux" and "ubuntu" have been removed from ciao-install (v1.15) (Area: cm:OTS, Assign: Doug, Docs: Other)
 - Ready To Test: SAT-64 - Updated a number of tools to pass correct units from input images to the output FITS file. (Area: tools:DM IMAGE, Assign: Kenny, Docs: Other)
- Tested in CIAOXIT**
 - Test Failed: PTPL-35 - skyfov only output chips in subspace (Area: tools: OTHER, Assign: Kenny, Docs: Ahelp)
 - Test Failed: PTPL-68 - Fix skyfov so that it now produces a warning if the asol file has zero rows (Area: tools: OTHER, Assign: Kenny, Docs: Ahelp)
 - Test Failed: PTPL-32 - new convexhull algorithm (Area: tools: OTHER, Assign: Kenny, Docs: Threats)
 - Partial Pass, Needs Work: PTPL-34 - skyfov check obsid in asol vs infile (Area: tools: OTHER, Assign: Kenny, Docs: Ahelp)
- Added to Regression Suite**
 - + Add a card
- No SDS Testing**
 - No SDS Testing: CM-102 - CIAOX is now built at a consistent "-O3" optimization level, (Area: cm: BUILD, Assign: TBD, Docs: None)
 - No SDS Testing: SL-141: no-op cleanup of internal code using CoordTransform data structure (drop 2) (Area: lib: CXCDM, Docs: None)
 - No SDS Testing: SL-147: test code consolidation (Area: lib: CXCDM, Docs: None)
 - No SDS Testing: CM-90: Update ciao-install to check for strings before accessing it (Area: cm: CIAO_INSTALL, Docs: None)
 - No SDS Testing: CM-89: Adding SYS Error Checks to ciao-install (Area: cm: CIAO_INSTALL, Docs: None)
 - No SDS Testing: CM-72 histlib and stlib have been moved from tools into the core segment (Area: cm: BUILD, Docs: None)
- Release**
 - Ready To Test: CM-99: Update scripts to use T for ASCDS_WORK instead of /tmp (Area: cm: CIAO_INSTALL, Assign: TBD, Docs: None)



Catalog Support



SDS Support for Catalog



SDS supports the catalog at 2.0 FTE level (Primini, Burke, Lee, with some additional relevant work by others)

Details of progress in I Evans presentation

Primini:

- Statistical Characterization of the catalog
- Quality assurance and reviews on data, detect list and data products

Burke

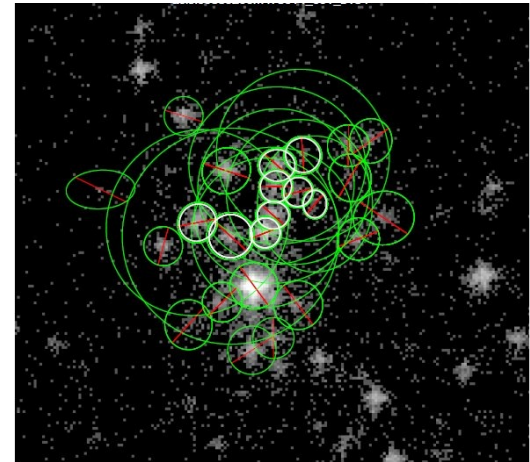
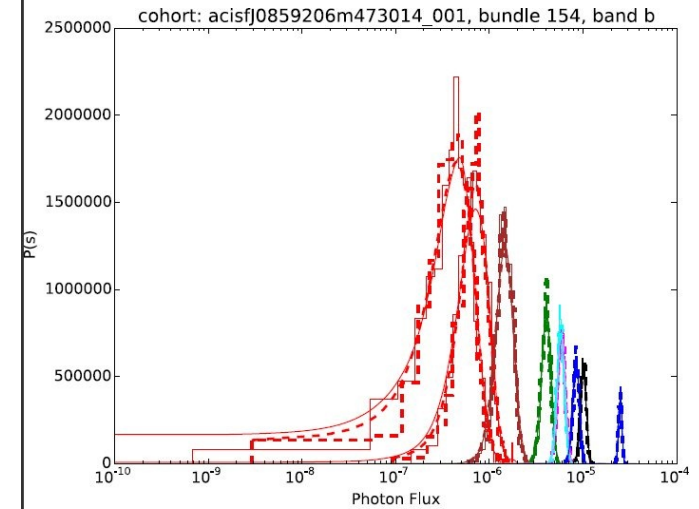
- convex hull support,
- quality assurance/reviews of source properties pipeline
- visualization (catalog display in WWT)

Siemiginowska

- fitting

Burke, McDowell, Lee, Primini, Siemiginowska

- Documentation.





Sherpa



Sherpa Development

- Standalone Releases: 4.10.1 (Oct.16), 4.10.2 (Dec 14), 4.11.0 (Feb.20, 2019), 4.11.1 (Aug.1, 2019)
- Sherpa 4.11 for CIAO was released on Dec. 13, 2018; It contains the code introduced in the Sherpa standalone during 2018 development year:
 - Sherpa runs under Python 2.7 and 3 (3.5 in CIAO; 2.7 will be deprecated)
 - The main updates include:
 - the XSPEC models in the version 12.10.0e and modifications to model parameters names and limits to reflect changes introduced by XSPEC
 - matplotlib for plotting in CIAO
 - Details on <https://github.com/sherpa/sherpa/releases>
- Development in 2019 focused on a few specific issues:
 - Model evaluation on arbitrary grid – allowing the size of the PSF bins to be independent of the data bins - partial functionality released in 4.11
 - Function to define a diagonal matrix (e.g. RMFs) - 4.11
 - Function to calculate uncertainties on line equivalent width using sampling - 4.11
 - Performance updates to simultaneous fitting of multiple data sets. - in testing for 4.12
 - Documentation changes – use *sphinx* for building web documents - 4.11
 - <https://sherpa.readthedocs.io/en/4.11.1/>



← → ↻ 🔒 https://sherpa.readthedocs.io/en/latest/

📱 Apps ★ Bookmarks 📧 News 🌤️ Weather 📧 Gmail 📅 Calendar 📁 Cabin 📁 Kitchen 📁 Work 🧩 Sudoku 🍴 Food 📁 Imported From Fir... 📁 Impor

🏠 Sherpa
latest

🔍 Search docs

INTRODUCTION

Installation
A quick guide to modeling and fitting in Sherpa
Sherpa and CIAO

USER DOCUMENTATION

What data is to be fit?
Creating model instances
Evaluating a model
Available Models
What statistic is to be used?
Optimisers: How to improve the current parameter values
Fitting the data
Visualisation
Markov Chain Monte Carlo and Poisson data
Utility routines

WORKED EXAMPLES

Simple Interpolation
Simple user model

AN INTERACTIVE APPLICATION

Using Sessions to manage models and data

GETTING HELP

Bug Reports
Contributing to Sherpa development
Indices and tables

```
from sherpa.models import *
```

```
from sherpa.observations import *
```

```
from sherpa.observations.models import *
```

```
from sherpa.observations.models import *
```

```
from sherpa.observations.models import *
```

```
from sherpa.observations.models import *
```

TAKE THE QUIZ!

Beat Triplebyte's online coding quiz. Get offers from top companies. Skip resumes

📖 Read the Docs v: latest ▾

Docs » Welcome to Sherpa's documentation [Edit on GitHub](#)

Sherpa

Welcome to the Sherpa documentation. [Sherpa](#) is a Python package for modeling and fitting data. It was originally developed by the [Chandra X-ray Center](#) for use in [analysing X-ray data \(both spectral and imaging\)](#) from the Chandra X-ray telescope, but it is designed to be a general-purpose package, which can be enhanced with domain-specific tasks (such as X-ray Astronomy). Sherpa contains an expressive and powerful modeling language, coupled with a range of statistics and robust optimisers.

Sherpa is released under the [GNU General Public License v3.0](#), and is compatible with Python versions 3.5, 3.6, and 3.7. Information on recent releases and citation information for Sherpa is available using the Digital Object Identifier (DOI) [10.5281/zenodo.593753](#).

The last version of Sherpa compatible with Python 2.7 was the [4.11.1 release](#).

Introduction

- [Installation](#)
 - [Quick overview](#)
 - [Requirements](#)
 - [Releases and version numbers](#)
 - [Installing a pre-compiled version of Sherpa](#)
 - [Building from source](#)
 - [Testing the Sherpa installation](#)
- [A quick guide to modeling and fitting in Sherpa](#)
 - [Getting started](#)
 - [Fitting a one-dimensional data set](#)
 - [Including errors](#)
 - [Fitting two-dimensional data](#)
 - [Simultaneous fits](#)
- [Sherpa and CIAO](#)

User Documentation

- [What data is to be fit?](#)
 - [Overview](#)
 - [Reference/API](#)
- [Creating model instances](#)
 - [Creating a model instance](#)
 - [Combining models](#)
 - [Changing a parameter](#)



Using Sherpa in Astronomy Research

1178 publications in ApJ, AJ, MNRAS and A&A use Sherpa (since 2001 and including astro-ph abstracts)

252 citations to Freeman et al 2001 SPIE paper

65 research papers in Jan-Sep 2019, 68 papers in 2018

7 PhD theses listed in ADS that used Sherpa



Instruments

Gratings



acis_process_events updates for CIAO 4.12:

The relationship between Charge Transfer Inefficiency (CTI) and ACIS focal plane temperature is changing as ACIS operates at warmer temperatures. To account for this change, a modified CTI routine has been implemented in acis process events in CIAO 4.12

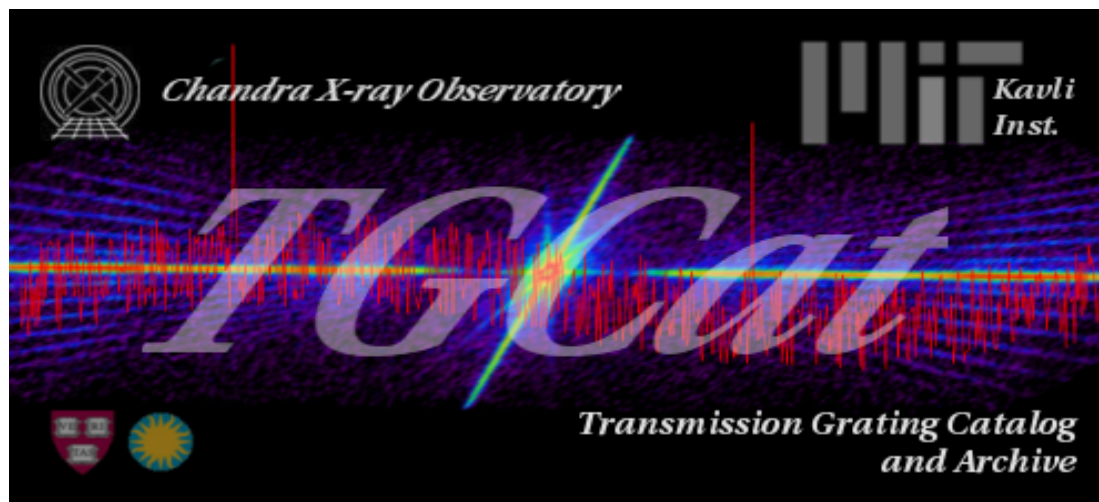
Additional error checking has been implemented in ACIS process events and descriptive warning/error messages will be reported to users that provide unusual input parameters.

An explanation regarding the setting of event status bits has been added to the acis process events specification version 4.17

Events that land in the region affected by the ACIS frame store shadow will now be set as bad by default (event STATUS[4] = 1). This will affect only a small number of rows near the edge of each ccd.



TGCAT and other grating updates



TGCAT updates continue

1969 extractions for 490 objects (increase of 76 extractions, 7 objects since last report)

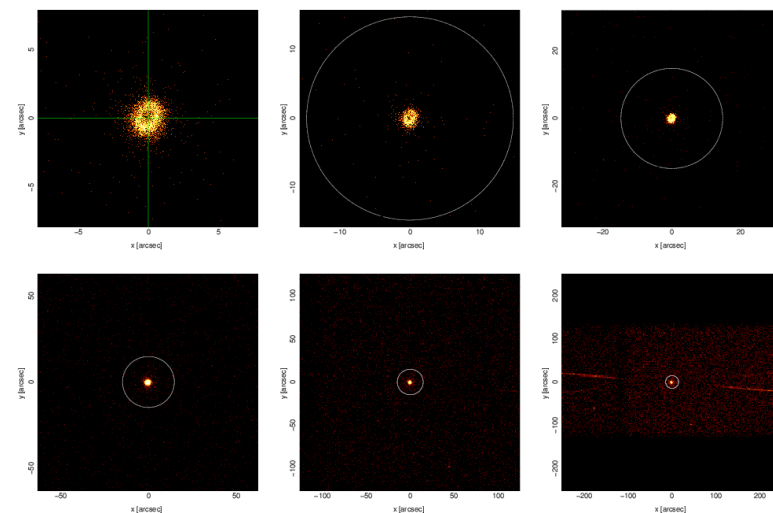
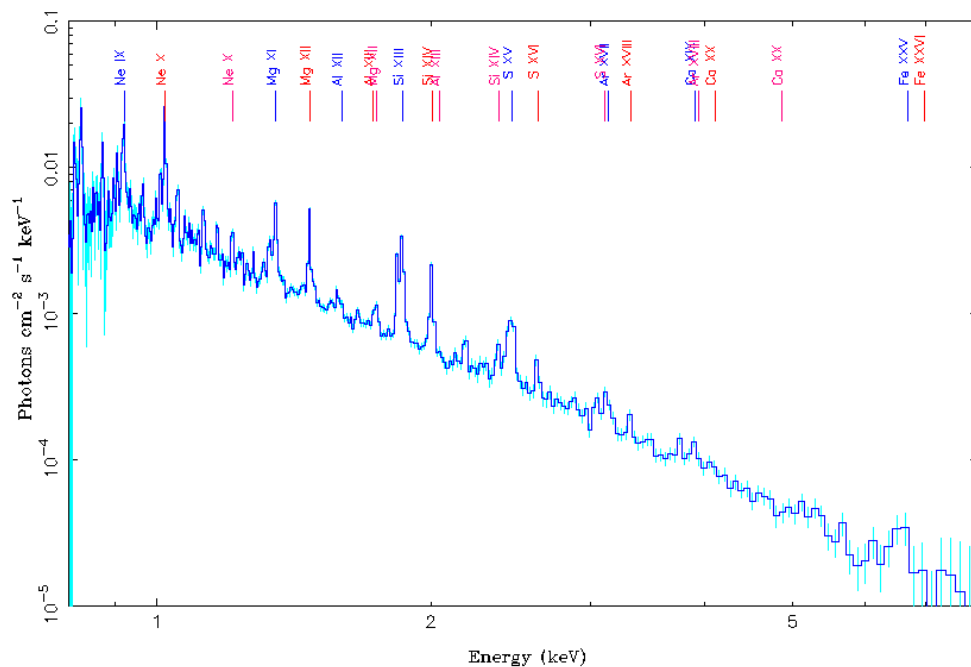
Total volume 444 GB

Downloads during period: 199 packages, 65 GB

In progress: upgrade server, port to CentOS 7



Example of data recently added to TGCAT:
13 observations of SN1987a (310 ks)





Working on improved analysis for light curves and spectra for multiple obsids of one source.

Planning cal products and updates to support rare grating/instrument combos (HRC-I/HETG, HRC-I/LETG)

Working on script to handle crowded regions in HETG

Evaluating possibility of adding grating responses to archive

Working on improved grating proposal cookbook

A Method for Handling Confusion in Crowded Regions Verified with Marx Simulations

Purpose

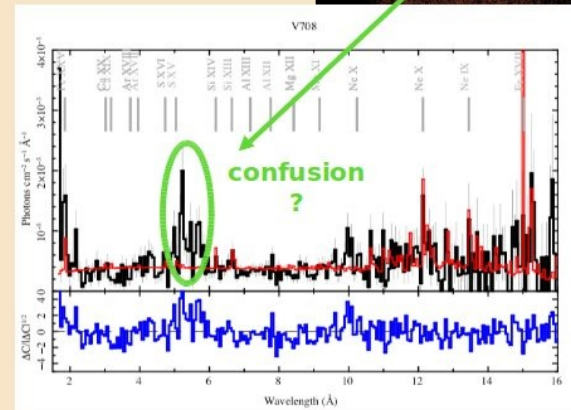
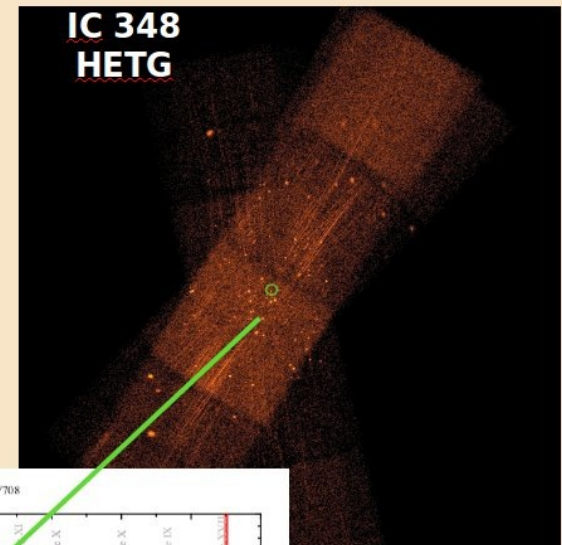
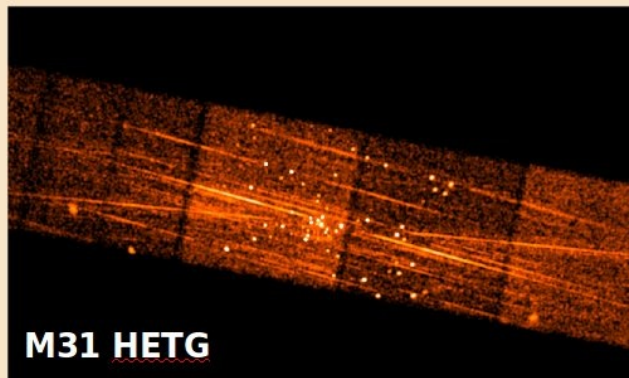
To identify regions in your extracted HETG spectra with contaminating photons from a different source.

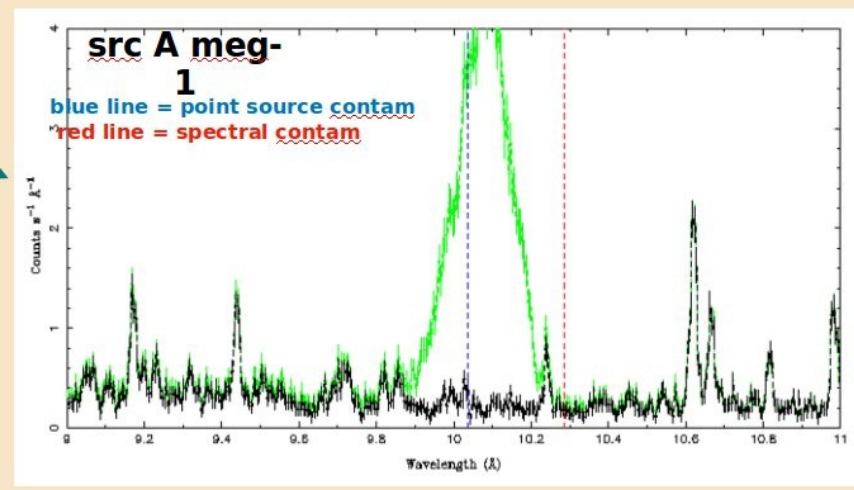
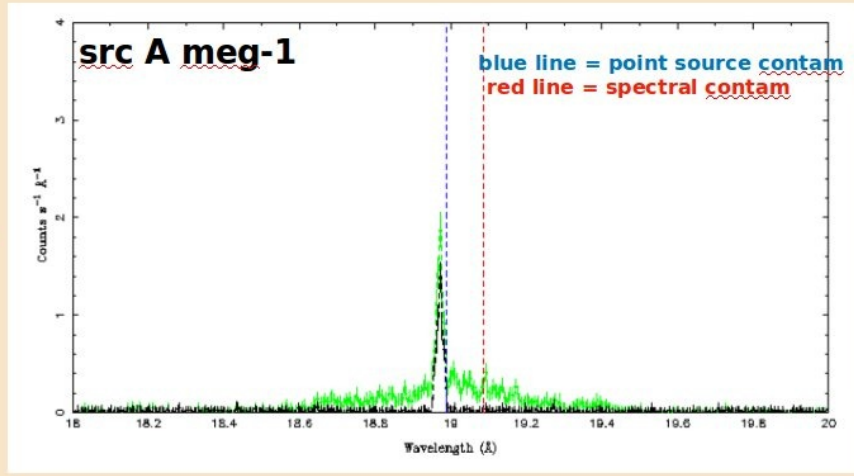
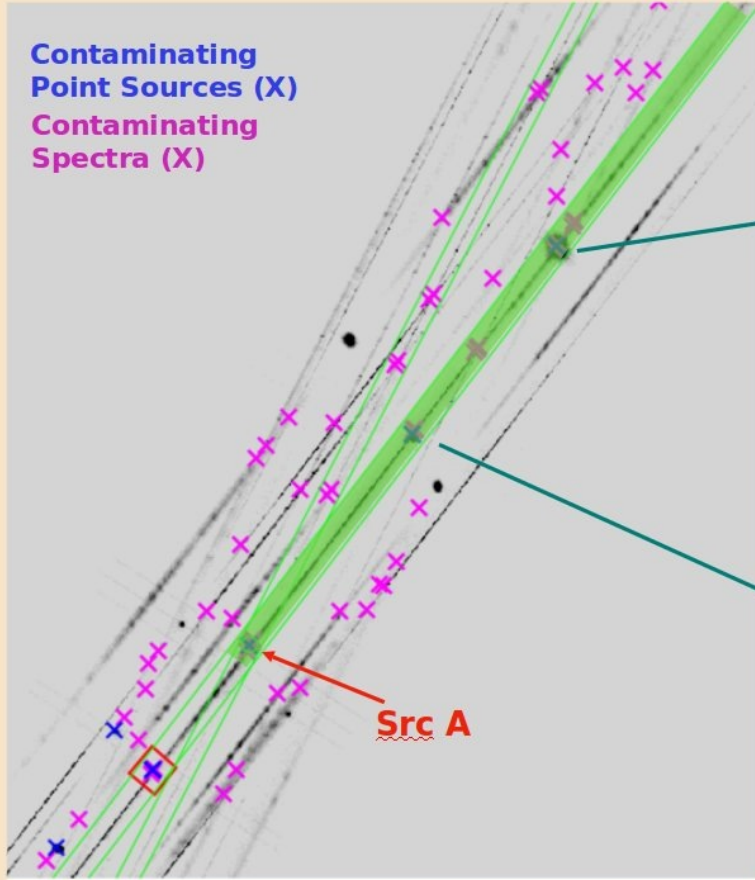
Input

- RA and DEC of sources if field
- Estimate of source counts
- Observation event file
- User tweak-able parameters

Output

For each input object, the python routine will identify where confusion from another source can occur and creates Sherpa/ISIS scripts to allow the user to over plot this location in the spectrum and to ignore it for model fitting. The routine will output several ds9 region files used for visual verification of confusion for very crowded fields.



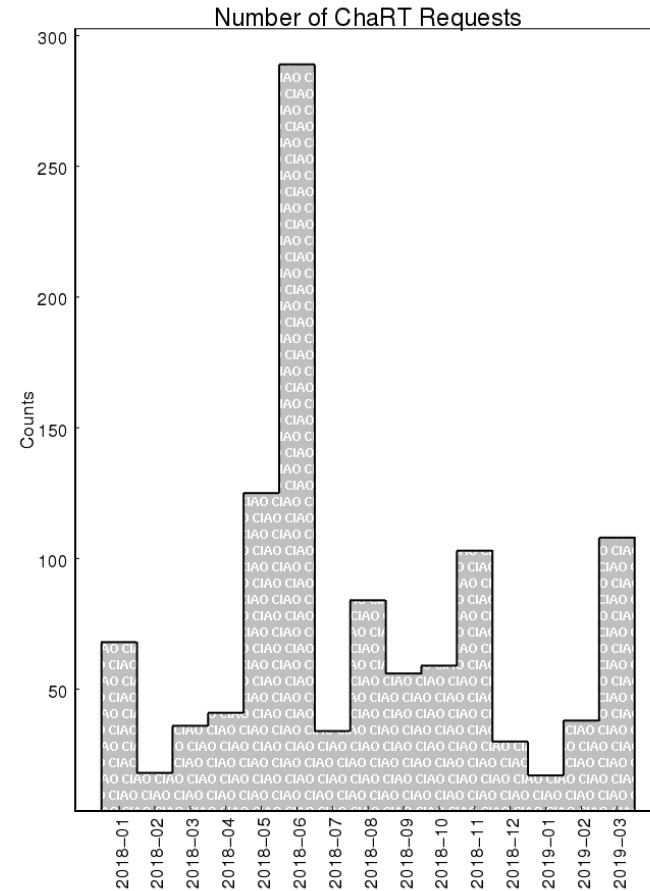
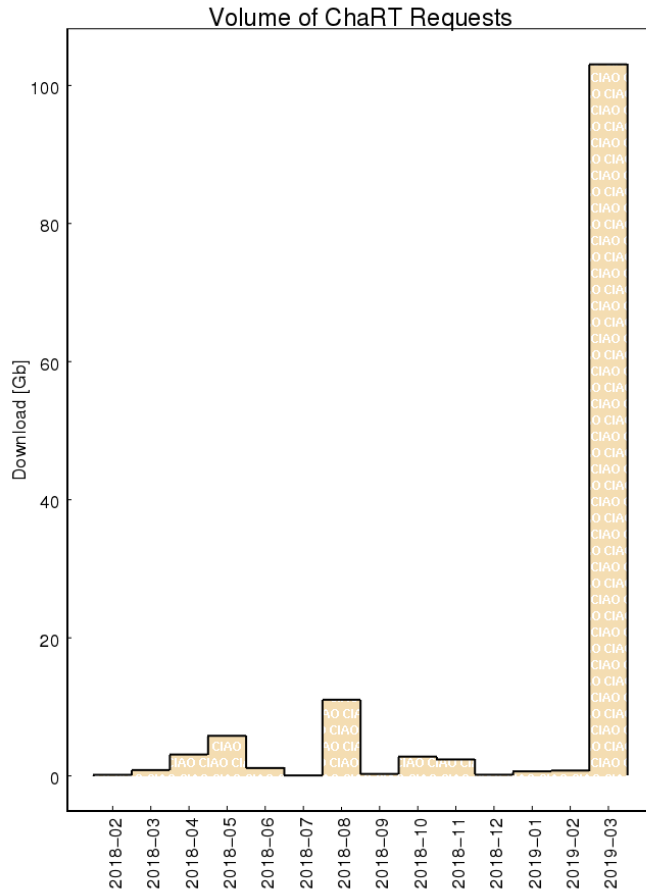




PSF



ChaRT

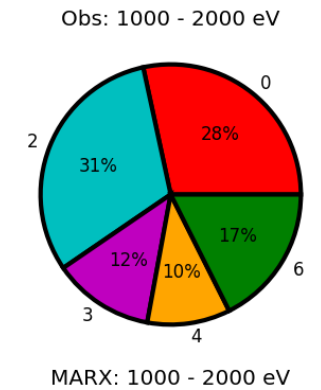
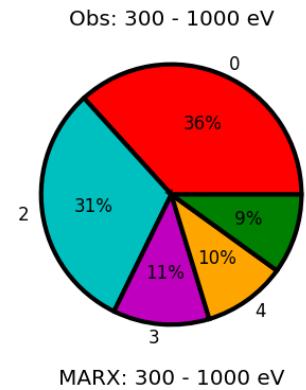
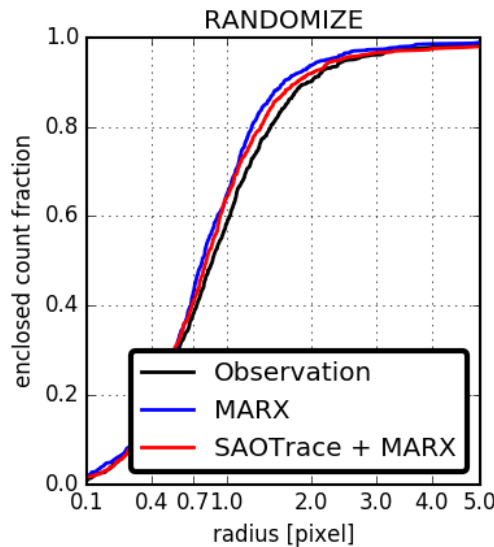
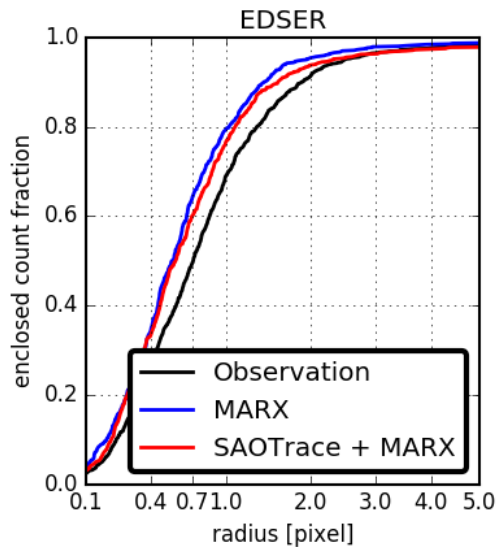


Volume spike in 2019-03 is real. Mostly a single user doing large simulation of Pictor A observations.



MARX

- Continue to update calibration files in MARX with CALDB updates
- prepare conda package for easier installation in the future
- user questions show that MARX is mostly use to simulate the PSF, and users commonly hit the limitations
 - for < 1 -2 pix (limited calibration for sub-pixel repositioning)
 - for “hook feature” in PSF (not reproducible with current mirror models)
 - for PSF wings > 20 pix (not reproduced well by mirror models)
- Current work is on improving simulated grade distribution for sub-pixel event positioning



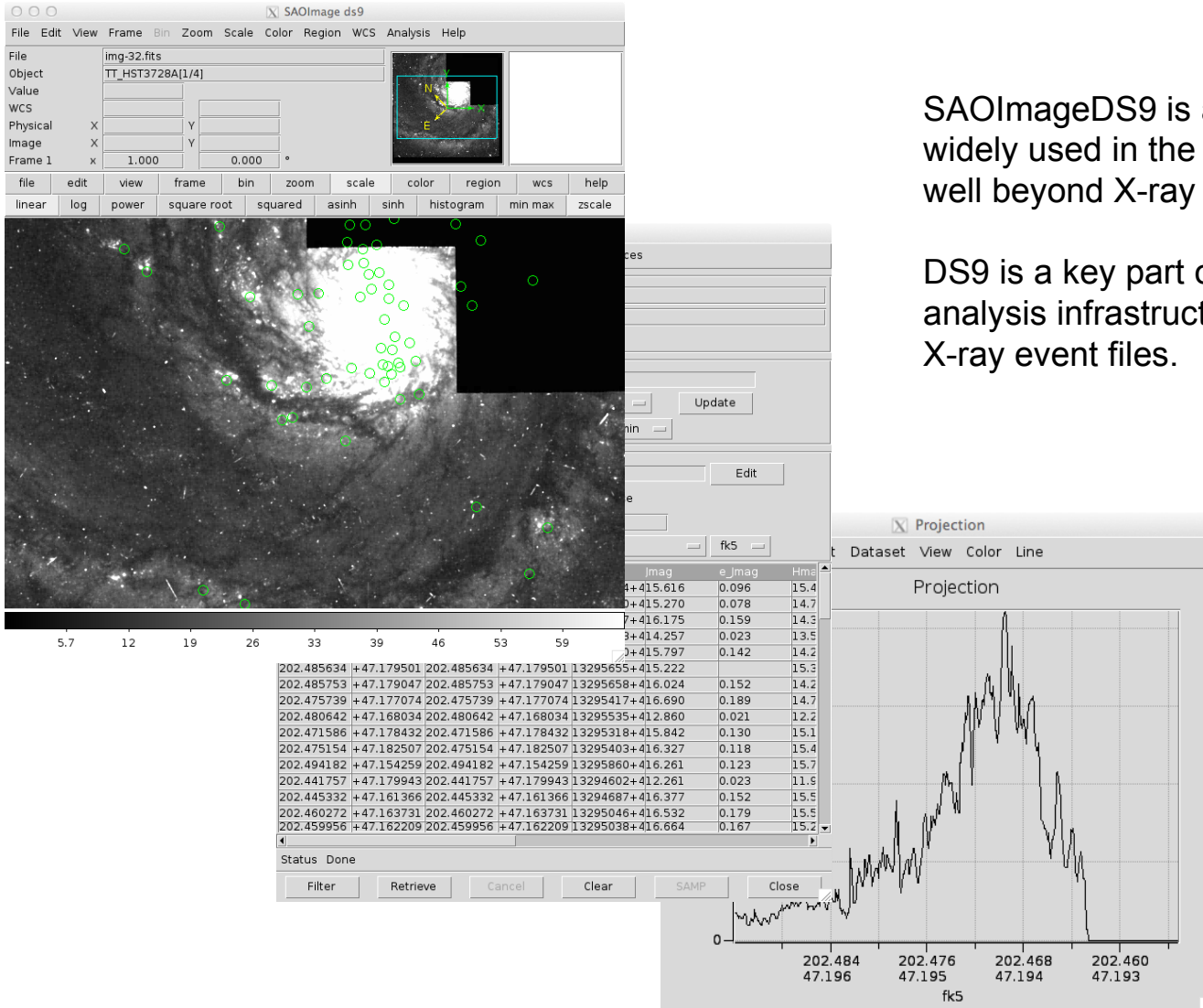


Visualization





SAOImageDS9



SAOImage ds9

File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help

File: img-32.fits
Object: TT_HST3728A[1/4]
Value: []
WCS: [] []
Physical: X Y
Image: X Y
Frame 1: x 1.000 0.000 °

file edit view frame bin zoom scale color region wcs help
linear log power square root squared asinh sinh histogram min max zscale

| l_maj | e_l_maj | l_min | e_l_min | l_max | e_l_max |
|------------|------------|------------|------------|----------|----------|
| 202.485634 | +47.179501 | 202.485634 | +47.179501 | 13295655 | +415.222 |
| 202.485753 | +47.179047 | 202.485753 | +47.179047 | 13295658 | +416.024 |
| 202.475739 | +47.177074 | 202.475739 | +47.177074 | 13295417 | +416.690 |
| 202.480642 | +47.168034 | 202.480642 | +47.168034 | 13295535 | +412.860 |
| 202.471586 | +47.178432 | 202.471586 | +47.178432 | 13295318 | +415.842 |
| 202.475154 | +47.182507 | 202.475154 | +47.182507 | 13295403 | +416.327 |
| 202.494182 | +47.154259 | 202.494182 | +47.154259 | 13295860 | +416.261 |
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| 202.445332 | +47.161366 | 202.445332 | +47.161366 | 13294687 | +416.377 |
| 202.460272 | +47.163731 | 202.460272 | +47.163731 | 13295046 | +416.532 |
| 202.459956 | +47.162209 | 202.459956 | +47.162209 | 13295038 | +416.664 |

Status Done

Filter Retrieve Cancel Clear SAMP Close

Projection

Dataset View Color Line

Projection

fk5

SAOImageDS9 is an imaging program widely used in the astronomical community, well beyond X-ray astronomy.

DS9 is a key part of the Chandra data analysis infrastructure – it directly supports X-ray event files.



SAOImageDS9

Releases

- Version 8.0 – release in Dec 2018 with CIAO 4.11
- Version 8.1b1 – release in May 2019
- Version 8.1b2 – release in Aug 2019
-

New Features 8.1

- Improved Mask support, based on WCS
- Support for Animated GIF movies
- Enhanced Plot Tool to replace ChIPS line plot functionality
- Simplified internal code to support a wide variety of operating systems
- Better command line parser, error messages

Ongoing Development

- Add Chandra Footprint Server support
 - Support Catalog FITS Tables
 - Position Angle convention
 - Convert regions into pixel masks
-



SAOImageDS9

GitHub Activity

- 308 Commits
- 39 Release Note Entries

Help Desk

- 38 From CXC HelpDesk
- 43 From DS9 HelpDesk (Non-SAO)
- 20 From SAO Help Requests

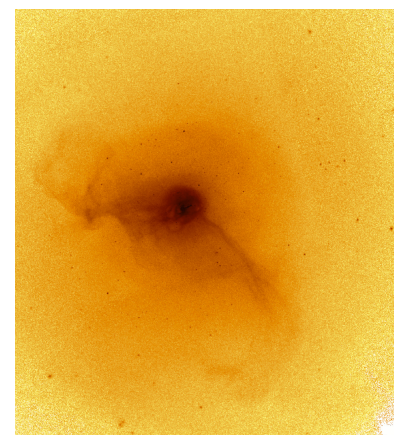
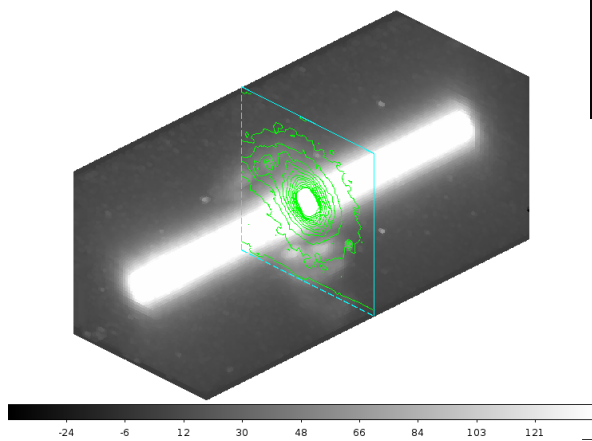
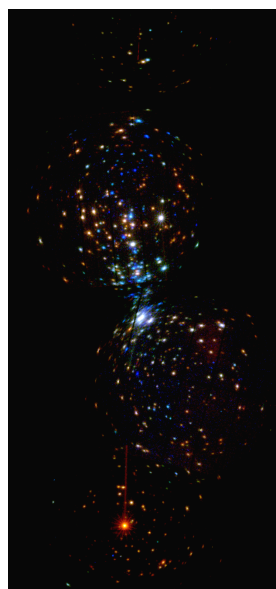
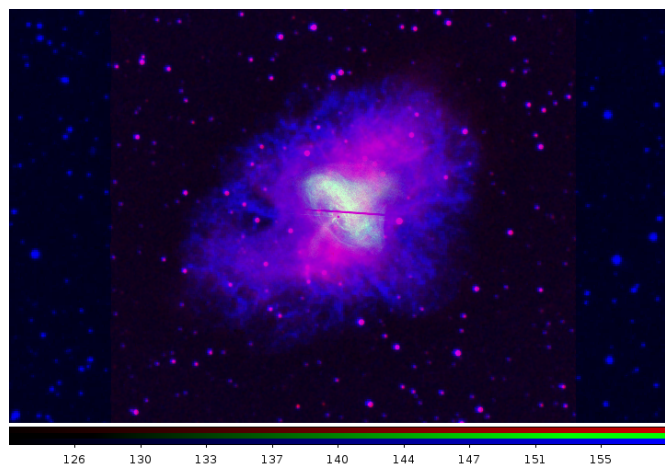
Downloads

- 3215 April
 - 3304 May
 - 2997 June
 - 3000 July
 - 3014 August
-



SAOImageDS9

Sample Image Gallery





SAOImageDS9

Crab Nebula Animated GIF
courtesy of Kenny Glotfelty

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