Not Your Advisor's CIAO...

- an update on Chandra's CIAO analysis system

Jonathan McDowell
Doug Burke, Antonella Fruscione, Aneta Sieimiginowska
and the CIAO team
Chandra X-Ray Center, SAO

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Google Custom Search Search
Search the CIAO website or contact the CXC HelpDesk

CIAO

Chandra Interactive Analysis of Observations

WHAT'S NEW | WATCH OUT

Quick CIAO links: Download CIAO | Science Threads | Help Files | Scripts

Related CXC sites: ChIPS | Sherpa | PSFs with ChaRT | CALDB

Chandra Source Catalog | TGCat: Chandra Gratings Catalog

Install CIAO 4.5 & CALDB 4.5.6

Read the CIAO 4.5 release notes for detailed information on this release, including How CALDB 4.5.6 Affects Your Analysis.

Subscribe to the CIAO News RSS feed

I've never used CIAO before. Where should I begin?

Welcome to CIAO
Introduction to the Tools & Applications

Download CIAO 4.5
Installing CIAO 4.5 thread

Introductory Science Threads

Analysis Guides

Has a new version of CIAO or CALDB been released?
What has changed in the site recently?

What's New

"Watch Out" List

A Short History of Chandra Analysis

CIAO 1 was released in 1999 as Chandra was completing orbital checkout

Heritage from the IRAF-based ROSAT PROS system (Worrall et al 1992)
Incorporating some ideas from the ETOOLS project (Mark Abbott et al 1995)
Incorporated software developed in 1990s for Chandra ground calibration (XRCF)
Compatibility with HEASARC/OGIP FITS files and header conventions
Standalone Unix tool architecture – like FTOOLS developed at similar time

CIAO 2 series in 2000 with improved portability
CIAO 3 in 2003 with rewritten infastructure
CIAO 4 in 2007 with Python support, new Sherpa/Chips fitting/plotting

Now on annual release cycle with CIAO 4.5 released Dec 2012

MAKING X-RAY ANALYSIS EASIER

ciao_install - automated installation process
- tunable, also supports source builds

What data is there? WebChaser is still great, but sometimes find_chandra_obsid is handy for CL use or scripting::

```
neptune>
neptune> find_chandra_obsid "NGC 2403"
# obsid  sepn   inst grat   time    obsdate piname       target
2014      0.2 ACIS-S NONE   36.0 2001-04-17  CAPPI      NGC2403
2937      2.6  HRC-I NONE    2.8 2002-01-27 SUGIHO "NGC2403 S3"
4628      2.7 ACIS-S NONE   47.1 2004-08-23  Lewin  "SN 2004dj"
4629      2.7 ACIS-S NONE   45.1 2004-10-03  Lewin  "SN 2004dj"
4630      2.7 ACIS-S NONE   50.6 2004-12-22  Lewin  "SN 2004dj"
neptune>
```

There's also the footprint service cxc.harvard.edu/cda/footprint

find_chandra_obsid can also download the data, or you can use...

```
File  Edit  View  Search  Terminal  Help

neptune>
neptune>
neptune> download_chandra_obsid 4628,4629
Downloading files for ObsId 4628, total size is 204 Mb.

  Type     Format      Size  0........H.........1  Download Time Average Rate
  ------------------------------------------------------------------------
  oif      fits        25 Kb  ####################          < 1 s  179.5 kb/s
  vv       pdf         40 Kb  ####################          < 1 s  224.1 kb/s
  full_img jpg         60 Kb  ####################          < 1 s  422.4 kb/s
  cntr_img fits       175 Kb  ####################          < 1 s  933.2 kb/s
  full_img fits        92 Kb  ####################          < 1 s  603.0 kb/s
  evt2     fits        21 Mb  ####################            7 s  2882.5 kb/s
  asol     fits        12 Mb  ####################            4 s  2715.4 kb/s
  bpix     fits        44 Kb  ####################          < 1 s  385.3 kb/s
  fov      fits         6 Kb  ####################          < 1 s  68.0 kb/s
  eph1     fits       282 Kb  ####################          < 1 s  1150.0 kb/s
  cntr_img jpg        573 Kb  ####################          < 1 s  1604.3 kb/s
  stat     fits         2 Mb  ####################          < 1 s  2201.2 kb/s
  flt      fits         6 Kb  ####################          < 1 s  67.6 kb/s
  msk      fits         5 Kb  ####################          < 1 s  65.2 kb/s
  mtl      fits         2 Mb  ####################          < 1 s  2504.2 kb/s
  evt1     fits       125 Mb  ####################           53 s  2440.5 kb/s
  bias     fits       443 Kb  ####################          < 1 s  1198.8 kb/s
  bias     fits       493 Kb  ####################          < 1 s  1394.2 kb/s
  bias     fits       448 Kb  ####################          < 1 s  1495.9 kb/s
  bias     fits       431 Kb  ####################          < 1 s  1373.8 kb/s
  bias     fits       431 Kb  ####################          < 1 s  1313.7 kb/s
  bias     fits       441 Kb  ####################          < 1 s  1300.8 kb/s
  pbk      fits         4 Kb  ####################          < 1 s  45.1 kb/s
  vv       pdf         35 Mb  ####################           16 s  2255.8 kb/s
```

download_chandra_obsid gets the data for you
This one makes subdirs 4628/ and 4629/ each with the usual primary/, secondary/ subdirs that you are used to

Next we update the archive processing with the latest calibrations using chandra_repro

```
neptune> ls 4628
axaff04628N002_VV001_vv2.pdf  oif.fits  primary/  secondary/
neptune> chandra_repro
Input directory (./): 4628
Output directory (default = $indir/repro) ():
```

Now we have a new repro/ subdirectory with (hopefully) all the files you'll need for further analysis, including "repro_evt2.fits"

```
neptune> ls 4628
axaff04628N002_VV001_vv2.pdf  oif.fits  primary/  repro/  secondary/
neptune> ls 4628/repro
acisf04628_000N003_bpix1.fits  acisf04628_000N003_stat1.fits  acisf209642202N003_pbk0.fits
acisf04628_000N003_fov1.fits   acisf04628_asol1.lis           pcadf209643885N003_asol1.fits
acisf04628_000N003_msk1.fits   acisf04628_repro_bpix1.fits
acisf04628_000N003_mtl1.fits   acisf04628_repro_evt2.fits
neptune>
```

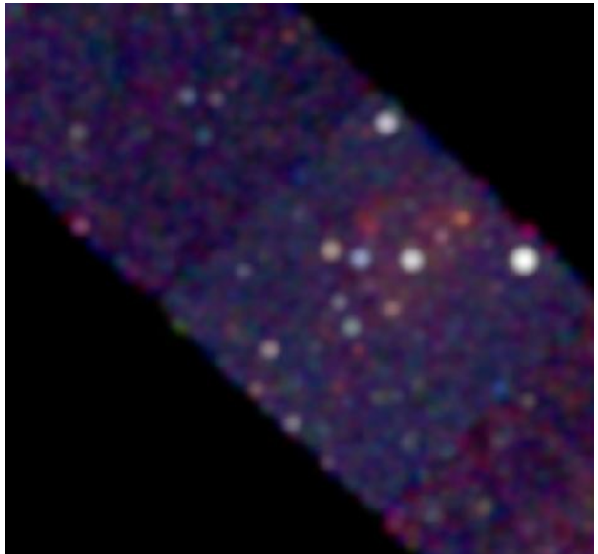
chandra_repro also works on grating data

Now you have calibrated data and are ready to do science.
You may want to take a look at the data by making a three color fluxed image using 'fluximage'; cd into the repro directory and run as shown here.

- knows about CSC bands soft, med, hard, broad

- finds the asol, badpix, mask etc. on its own

- makes exposure maps etc.:



```
neptune> fluximage *repro_evt2.fits out=fimg bin=4 bands=CSC
Running fluximage
Version: 08 November 2012

Using CSC ACIS soft science energy band.
Using CSC ACIS medium science energy band.
Using CSC ACIS hard science energy band.
Aspect solution pcadf209643885N003_asol1.fits found.
Bad pixel file acisf04628_repro_bpix1.fits found.
Mask file acisf04628_000N003_msk1.fits found.
PBK file acisf209642202N003_pbk0.fits found.

The output images will have 1301 by 1286 pixels, pixel size of 1.968 arcsec,
    and cover x=1336.5:6540.5:4,y=1672.5:6816.5:4.

Running tasks in parallel with 8 processors.
Creating aspect histograms for obsid 4628
Creating 18 instrument maps for obsid 4628
Creating 18 exposure maps for obsid 4628
Combining 6 exposure maps for 3 bands (obsid 4628)
Thresholding data for obsid 4628
Exposure-correcting 3 images for obsid

The following files were created:

 The clipped counts images are:
     fimg_soft_thresh.img
     fimg_medium_thresh.img
     fimg_hard_thresh.img

 The clipped exposure maps are:
     fimg_soft_thresh.expmap
     fimg_medium_thresh.expmap
     fimg_hard_thresh.expmap

 The exposure-corrected images are:
     fimg_soft_flux.img
     fimg_medium_flux.img
     fimg_hard_flux.img
```

Combining Observations: merge_obs

The legacy script merge_all was used to combine observations but it had many limitations

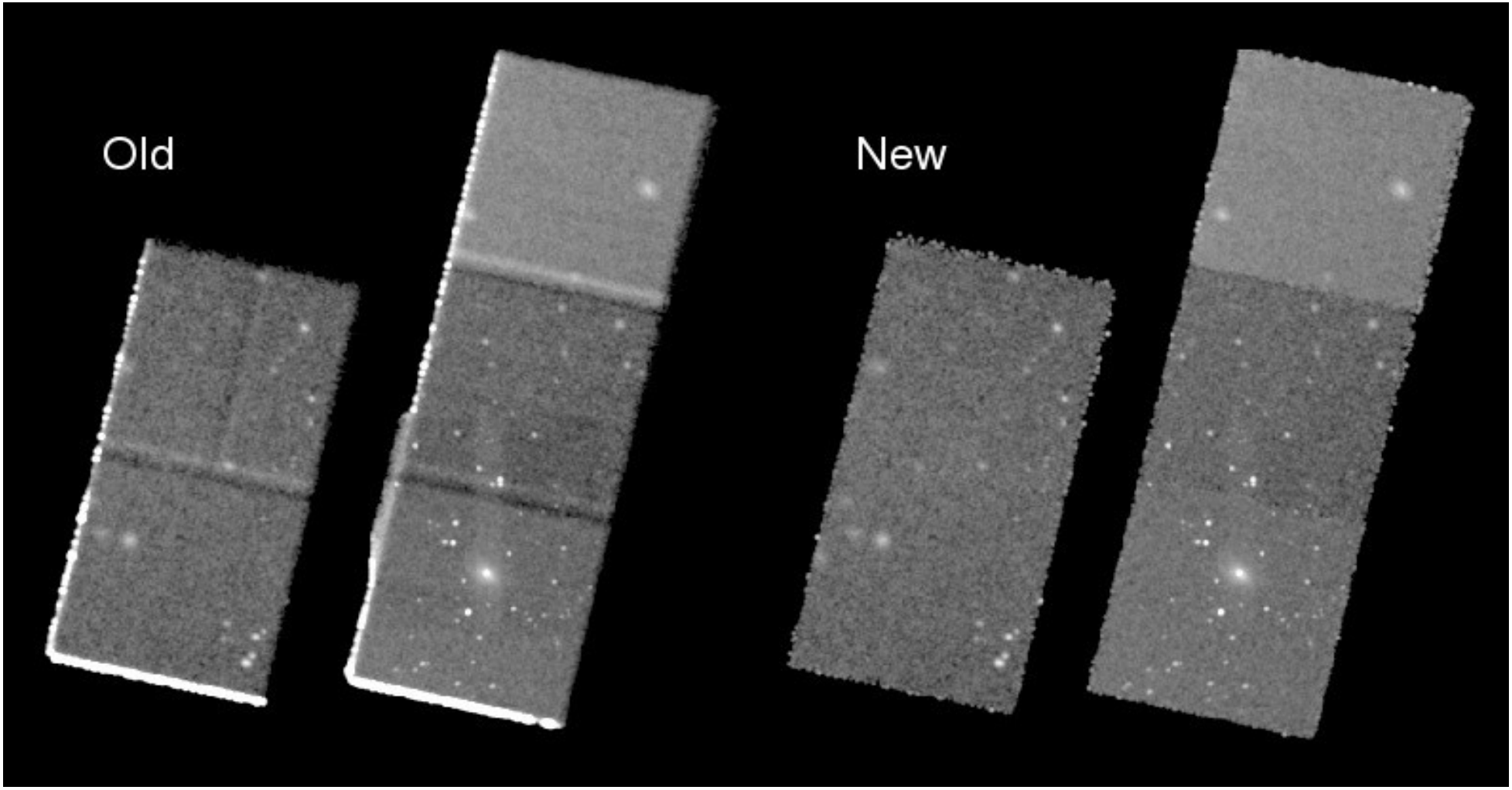
- only worked for observations with similar pointing directions and with the same SIM position
- does not take the bad pixel masks correctly into account

The new script merge_obs allows users to easily create fluxed mosaic images of large regions

Given a list of event files, it automatically locates needed auxiliary files in the same directory

The script makes exposure-corrected and exposure-thresholded images in one or several user-specified bands

Combining Observations – Example 1



Adding four observations shows limitations of old script: obsid no 3 has a different SIM position and obsid 4 is a subarray; the new script handles the exposure maps and reprojection correctly in these cases. Avoid bad pixels at edge with thresholding

merge_obs – Summary.

Chandra X-ray Center

The new script

- parallelizes the computation across multiple processors on the host machine
- automatically determines the center and size of the mosaic (if the user doesn't specify) by averaging the unit vectors of the pointing directions and taking the union of the reprojected field-of-view polygons
- modifies headers to account for the fact that the 'sky' pixel coords go beyond their normal range (which can cause ds9 not to display part of the image)
- automatically handles different event input formats by trimming columns as needed
- automatic location and use of mask, aspect, bad pixel, parameter block files using values seeded in event file header
- sorts input files in time order
- for HRC-I, subtract particle background model
- thresholds final image using exposure map (default 1.5% of max exposure)
- cleans up intermediate files on exit
- supports standard catalog energy bands e.g. 'CSC', 'soft' as well as user-specified ones; can use spectral weight files for exposure maps if supplied

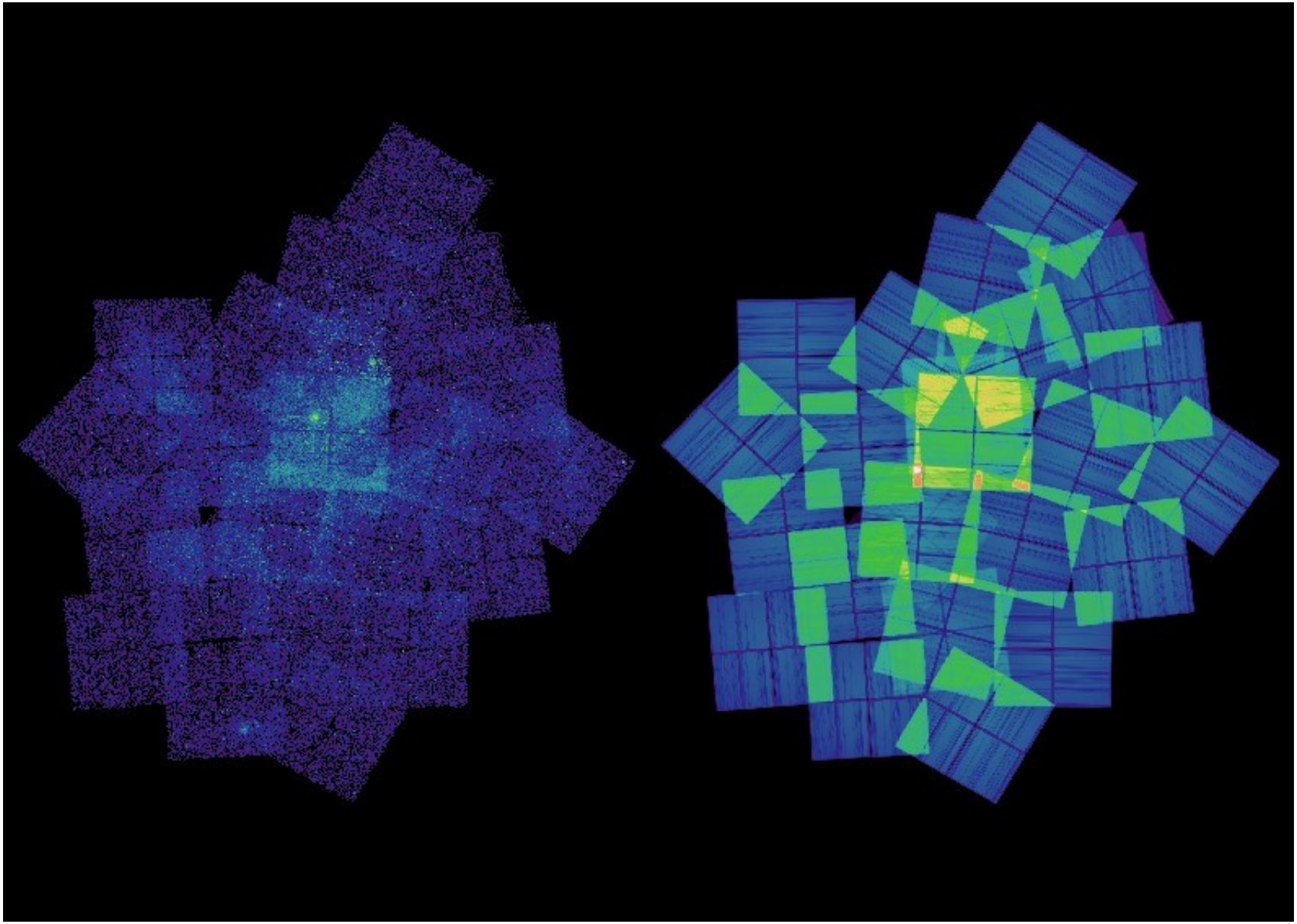
Limitations:

Cannot combine ACIS with HRC-I/S, or HRC-I with HRC-S

No ACIS background subtraction

No support yet for improving astrometry before merging

Combining Observations – Example 2

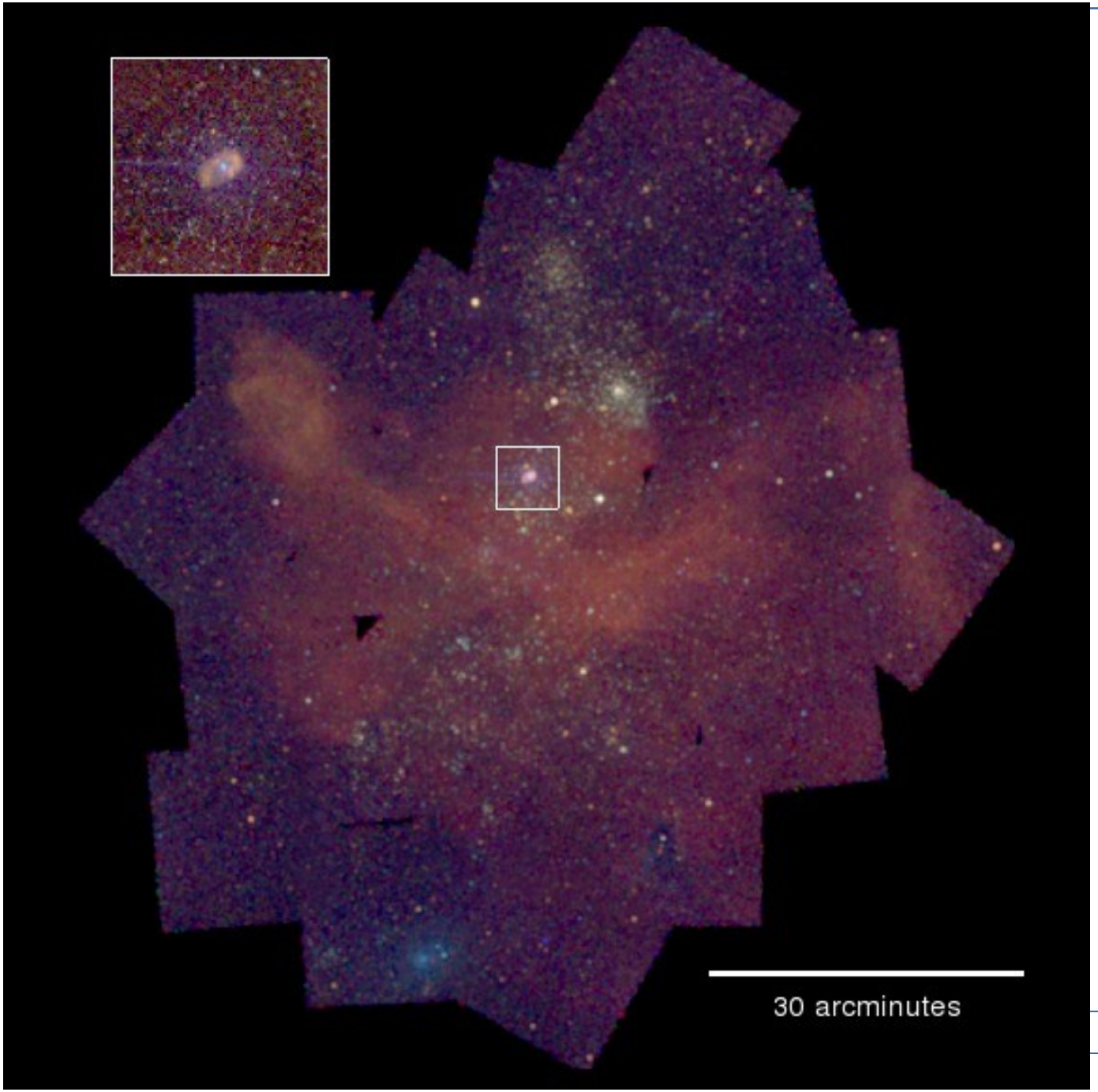


Eta Carina

Raw counts (left)

Exposure map (right)

Combining Observations – Example 2 cont



Eta Carina

40 ACIS-I datasets 1999-2008

Mix of FAINT and VFAINT

Exposure times from 10 to 90 ks

Input was simple list of event files:

ls */*evt2* > lis

merge_obs @lis"[ccd_id=:3]" out

Result is a set of 1363 x 1537 pixel images (size autocalculated to cover the field)

Grating data

chandra_repro:
- extracts PHA2 file
- recent mod to retain manal V&V extraction region rather than overwrite
- plan to enhance to include responses for each arm and order

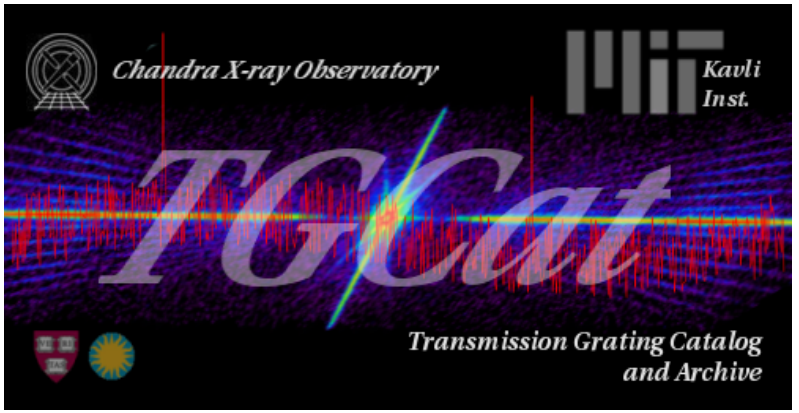
tgextract2
- extract spectra with customized source, bkg extraction regions
- useful for multiple source case

combine_grating_spectra
- coming soon, will coadd spectra and weight responses for
  - multiple orders
  - multiple exposures

tg_findzo:
- methods to find zero order pos even when center is blanked or piled

TGCAT (Huenemorder et al)
- tgcat.mit.edu

Processed grating archive -
manually optimized extraction regions
extractions for almost all grating observations
high level extracted properties



Coming Soon: Easier Fluxes

specextract - currently handles old specextract, psextract cases
- Source and background ACIS spectra for point and extended cases
- Weighted or unweighted ARF and RMF, grouped spectra
- BUT: still sometimes awkward to use

will improve to automatically locate auxiliary files if chandra_repro has been used

combine_spectra
- sum multiple imaging PHA spectra, responses
(better to do independent fits but more covenient at low S/N)

will supplement specextract with higher level script srcflux which wraps use of several existing CIAO tools and scripts

srcflux evt2.fits ra,dec src.out

- generate regions using typical psf size
- use aprates to determine count rates and confidence intervals (or upper limits)
- run specextract to generate responses
- use eff2evt to estimate fluxes
- use modelflux to estimate fluxes given spectral model