



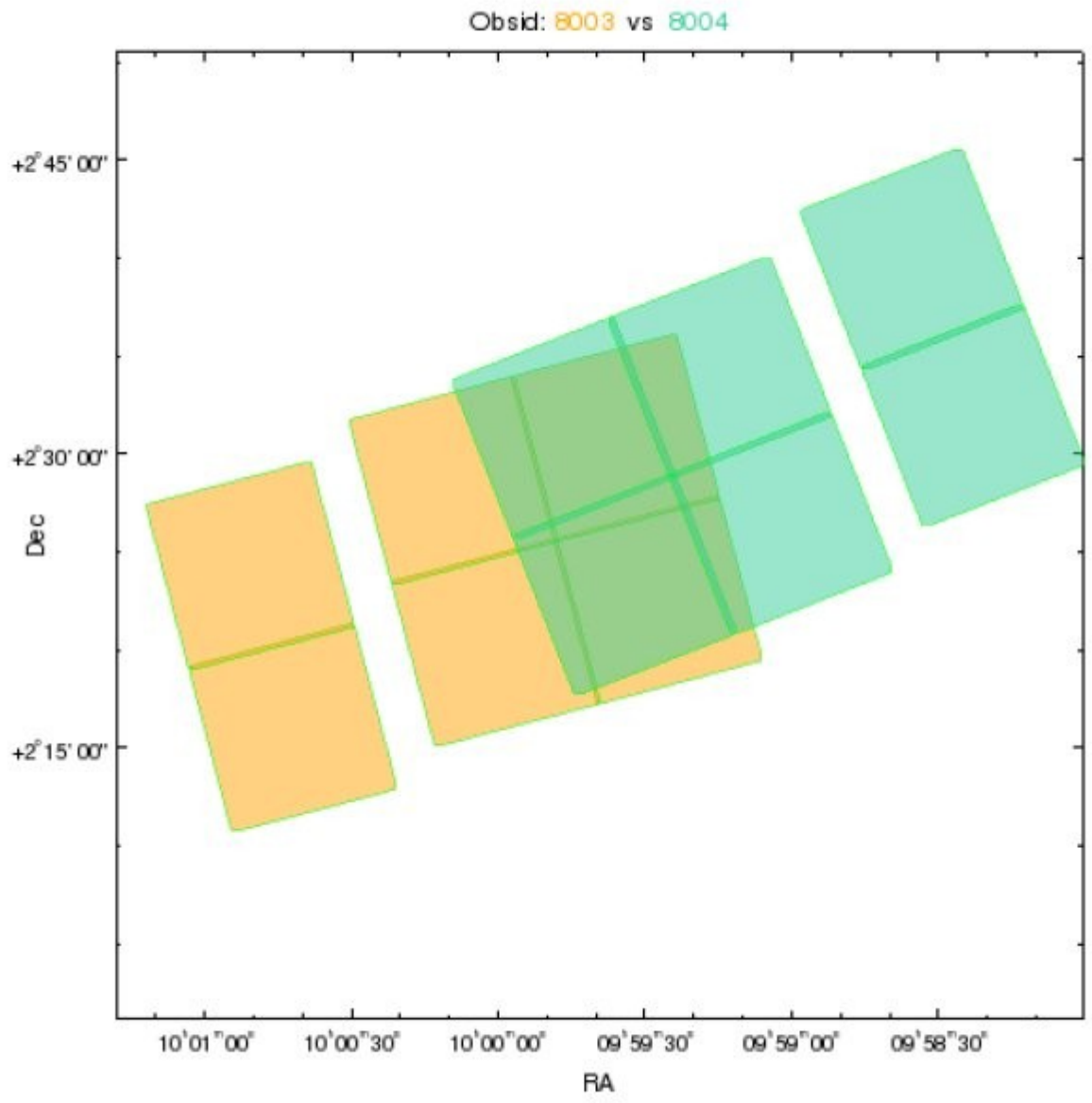
Merging and Combining Data

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The archive contains many cases where the same object or sky area has been observed many times

The low background and stable systematics of Chandra mean that one can coadd data from different epochs – but with important limitations





So, what is wrong with

```
% cd /data/ciao_demo/workshop/merge
% set a = 8003/primary/acisf08003N002_evt2.fits
% set b = 8004/primary/acisf08004N001_evt2.fits
% dmmERGE $a,$b merged_wrong.fits
...
omit - DEC_NOM values different more than 0.000300
warning: OBS_ID has different value...Merged...
...
```



Potential pitfalls -

1) May have different processing histories if you take data straight for the archive. Fix by running `chandra_repro` on each.

2) Each observation has header keywords describing them. The merged data may not be able to fill these keywords with sensible values

`OBS_ID = 'Merged'`

`RA_NOM, DEC_NOM` - omitted since different

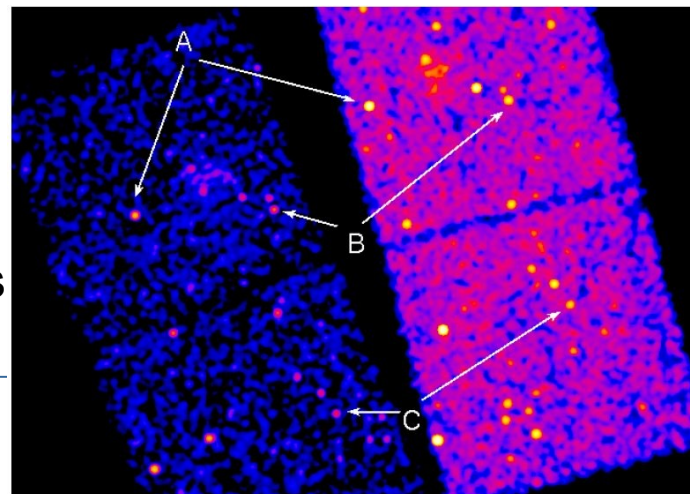
Later software may be expecting these keywords!

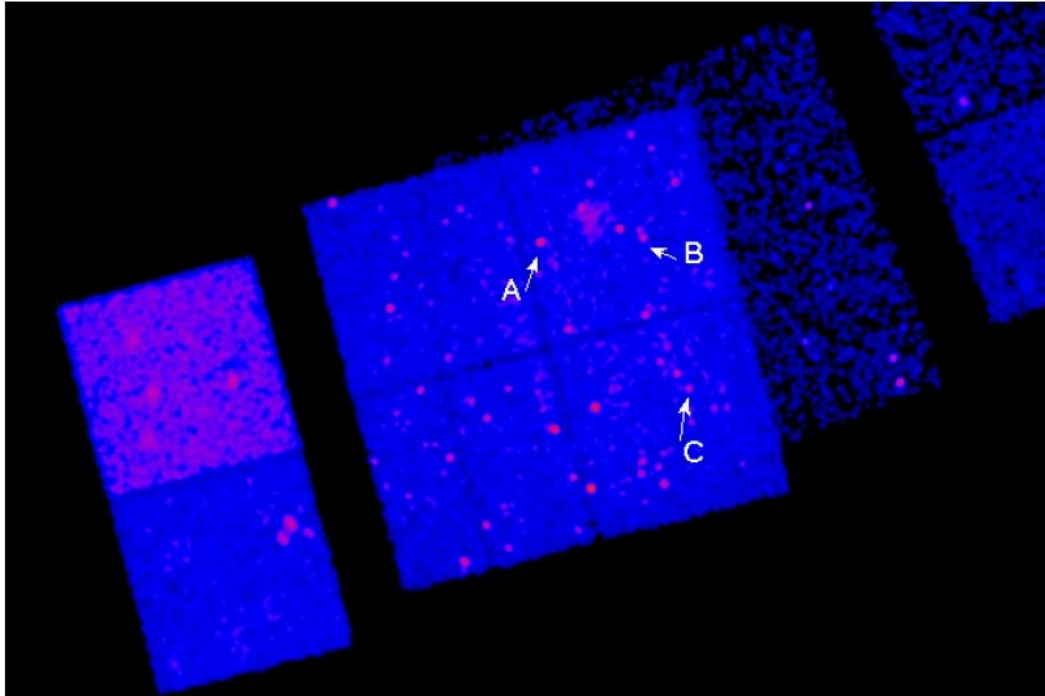
3) Sky coordinates are relative to the `RA_NOM, DEC_NOM` so are in different systems for each of the observations. So `ds9` will not display the result correctly

Need to first reproject to same origin

The `reproject_events` tool can do this

Easiest to use `merge_obs`





[merge_obs](#) gives you a combined event file with the correct source positions, suitable for image analysis.

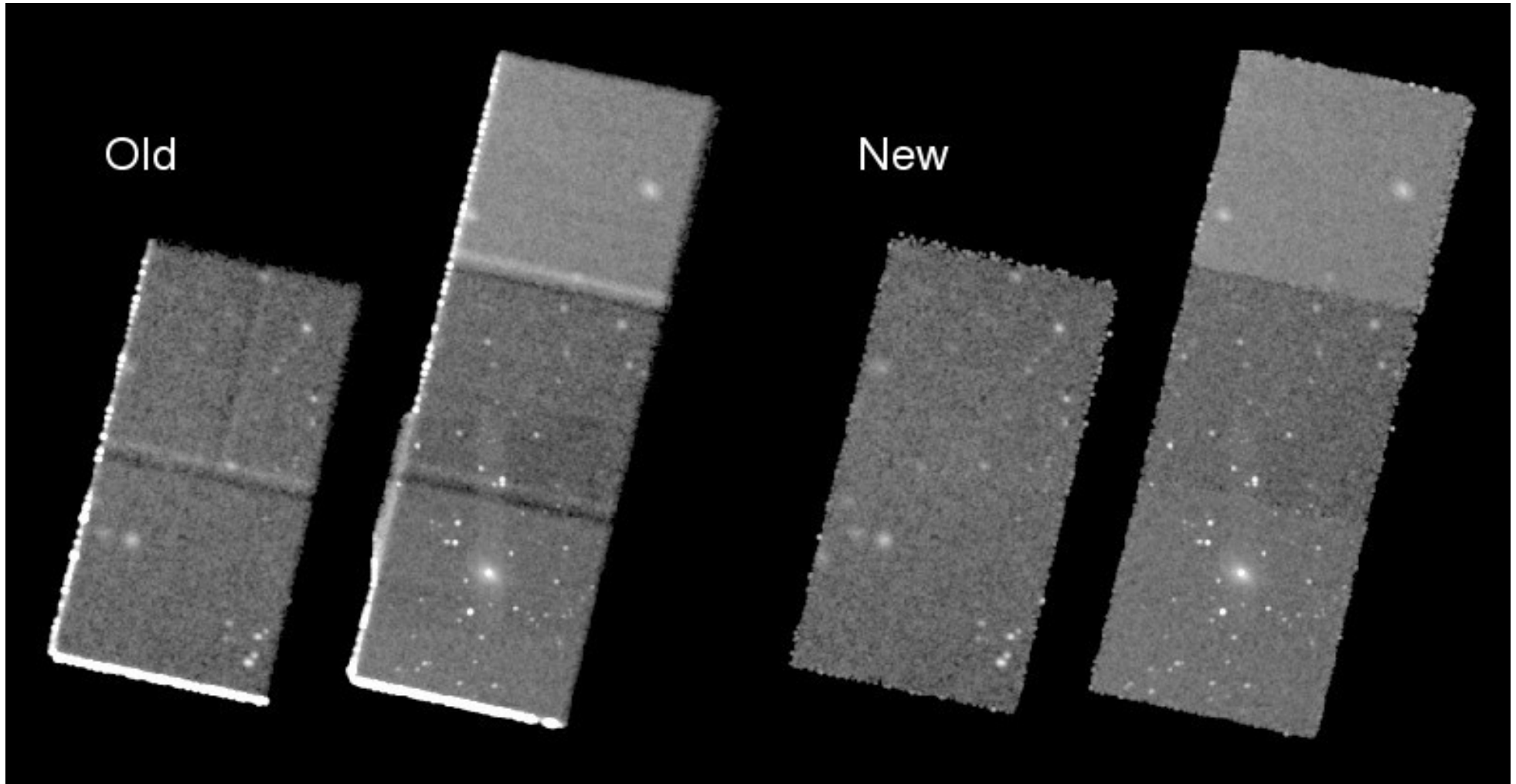
BUT - there's still a problem with spectral analysis

Scripts for extracting spectra and generating spectral responses don't have enough header information in the merged files to generate the right spectral response weighting

Recommend always doing spectral analysis by extracting spectra from individual observations and then coadding using tools like [addressp](#)



Combining Observations – Example 1



Adding four observations shows pitfalls if merging not done carefully: obsid no 3 has a different SIM position and obsid 4 is a subarray; the merge_obs script handles the exposure maps and reprojection correctly in these cases. Avoid bad pixels at edge with thresholding

CXC-SDS



merge_obs – Summary.

The merge_obs 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 projected 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



merge_obs – low level tools

The merge_obs script is made up of two stages but it can sometimes be useful to do them separately:

reproject_obs	-> reproject event files and aspect sols to common tangent point
flux_obs	-> take event files, make exposure maps, correct and make coadded fluxed image

There's also a script
fluximage -> make exposure maps and fluxed image for single obs

and lower level tools:
reproject_image, reproject_image_grid, reproject_aspect



Combining Observations – Example 2



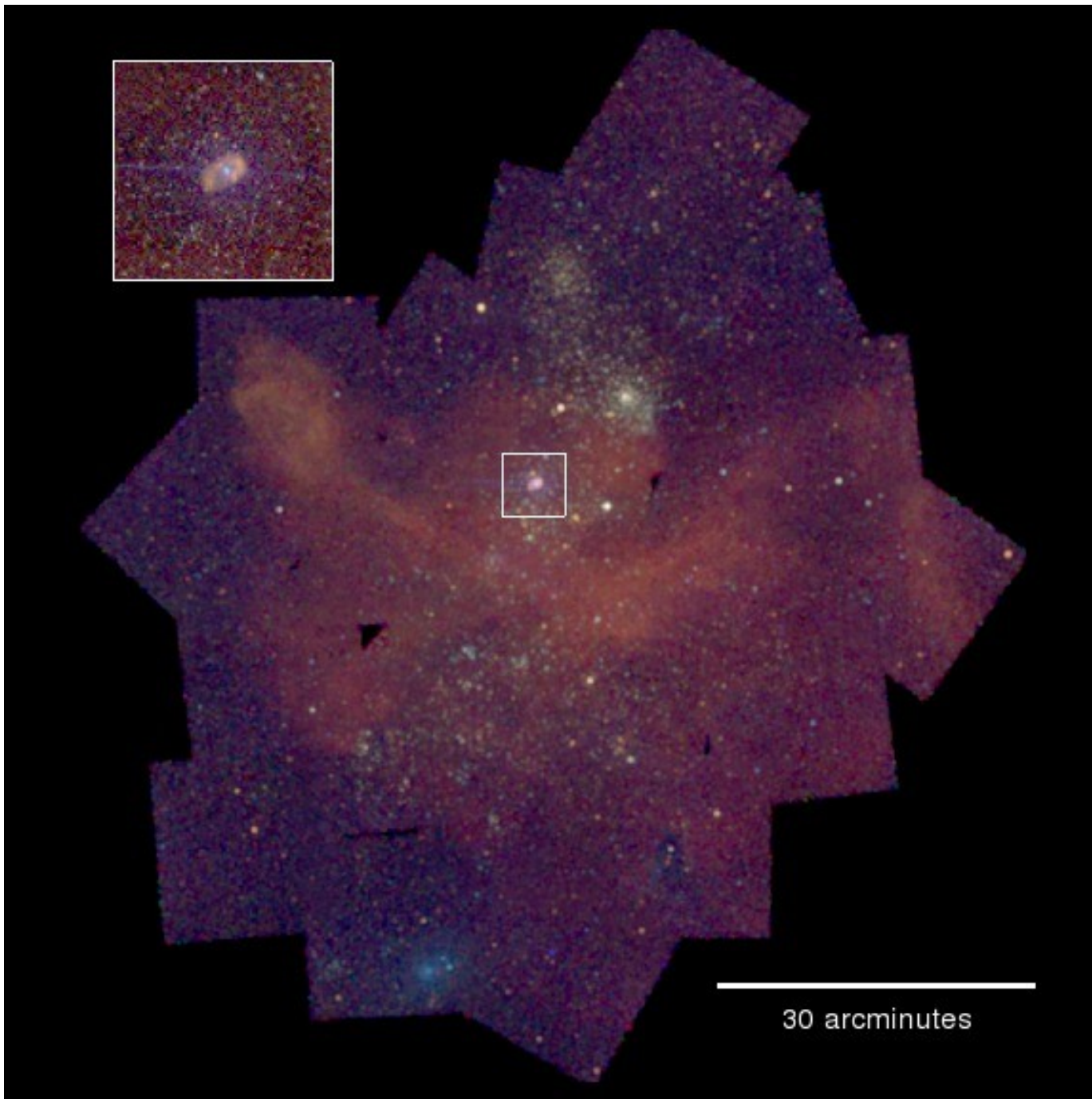
Eta Carina

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

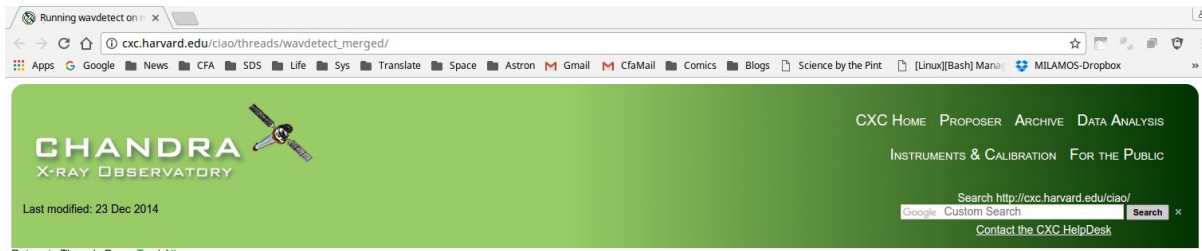
Input was simple list of event files:

```
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)

Source detection on merged data



Thread takes you through using map of weighted PSF size in merged image

Running wavdetect on merged data: choosing psffile

CIAO 4.9 Science Threads

Overview

Synopsis:

The primary reason to combine (aka merge) observations is to detect faint sources. The most popular CIAO source detection tool is [wavdetect](#), which works by correlating the input image with a series of Mexican hat wavelets. The optimum wavelet size or scale is that which matches the size of the sources being detected. For point sources, this scale is comparable to the size of the [Point Spread Function \(PSF\)](#). Users can provide wavdetect an input file with the size of the PSF via the 'psffile' parameter.

Unfortunately, the Chandra PSF varies significantly across the field of view, varying in size from a fraction of an arc-second near the aimpoint to several arc-seconds at the edge of the field. Moreover, the observed orientation varies with the roll angle of the spacecraft. Therefore there is no *single* PSF size when arbitrary observations are merged.

This thread demonstrates several alternate ways in which users can combine PSF maps from individual observations, and the effects that are demonstrated for a single target; users should not conclude that similar results will be obtained in all datasets.

Purpose:

To illustrate different ways to combine per-observation PSF map files and the effects on the detections.

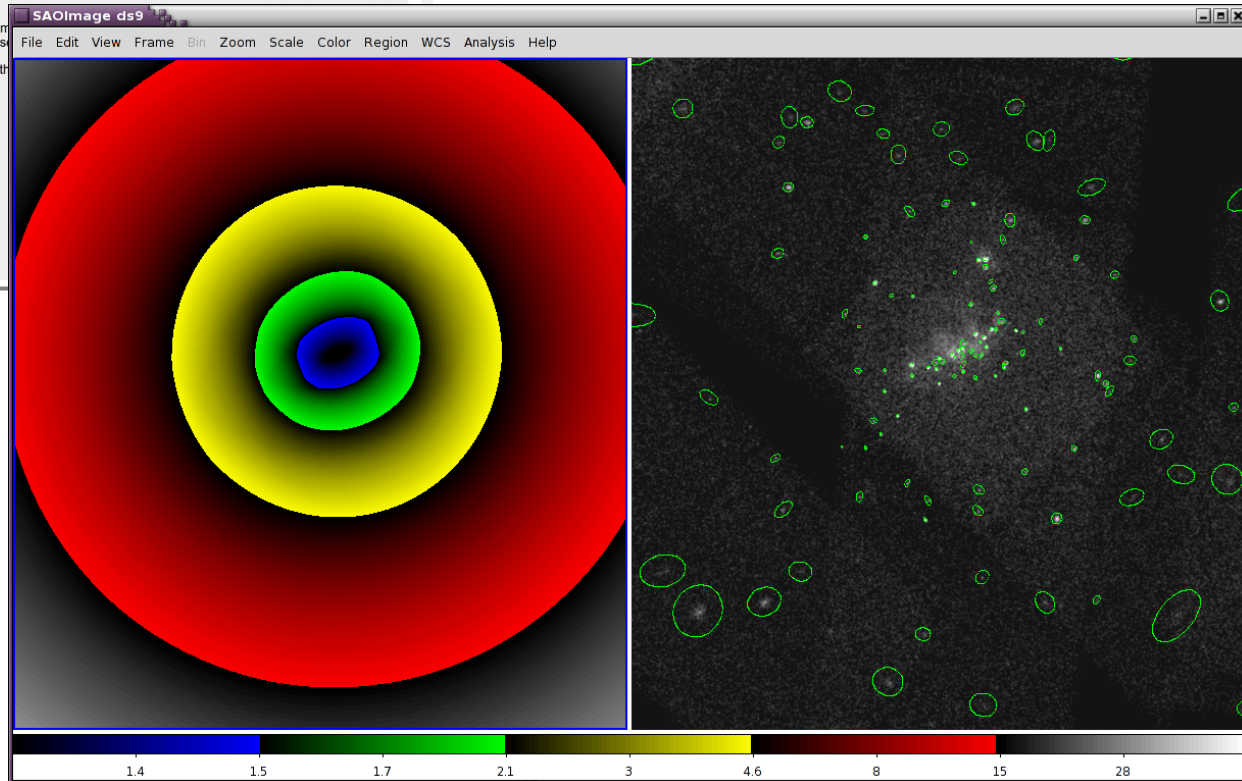
Related Links:

- [Running wavdetect thread](#)
- [Using merge_obs to combine observations thread](#)
- [mkpsfmap help file](#)

Last Update: 23 Dec 2014 - Reviewed for CIAO 4.7; minor edits.

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Combining spectra

Consider spectra of a source in two ACIS imaging observations

- different exposure times
- different effective areas $A(E)$ and responses $R(E,p)$

Need correct metadata for each spectrum – extract from individual obs
Then use the [combine_spectra](#) script to merge them

Generates coadded spectrum paired with weighted responses

see cxc.harvard.edu/ciao/threads/coadding/