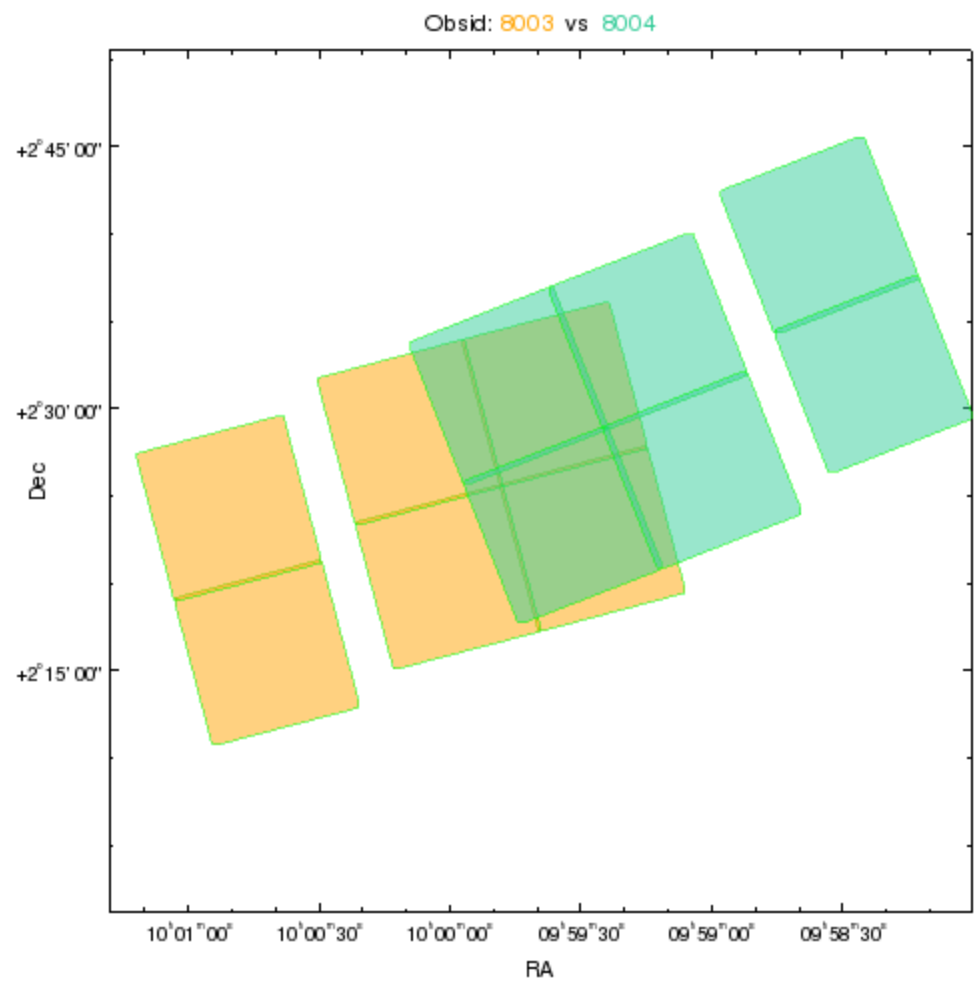




Merging Chandra Observations





Merging Chandra Observations

which was created by:

```
chips> from chips_contrib import *
chips> fa = "8003/primary/acisf08003_000N002_fov1.fits"
chips> fb = "8004/primary/acisf08004_000N001_fov1.fits"
chips> add_fov_region(fa, ["fill.color", "orange"])
chips> add_fov_region(fb, ["fill.color", 0x33CC99])
chips> set_plot_title(r"Obsid: {\color{orange}8003} vs" +
r" {\color{33CC99}8004}")
chips> print_window("fovs.png")
```



Merging Chandra Observations

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
% dmmmerge $a,$b merged_wrong.fits
...
omit - DEC_NOM values different more than 0.000300
warning: OBS_ID has different value...Merged...
...
```



Merging Chandra Observations

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
% dmmmerge $a,$b merged_wrong.fits
...
omit - DEC_NOM values different more than 0.000300
warning: OBS_ID has different value...Merged...
....
```

A: Different processing histories

(although a difference in version number of
the files doesn't always mean different
CALDB/software was used)



Merging Chandra Observations

Let's have a closer look

```
% 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...
...
```

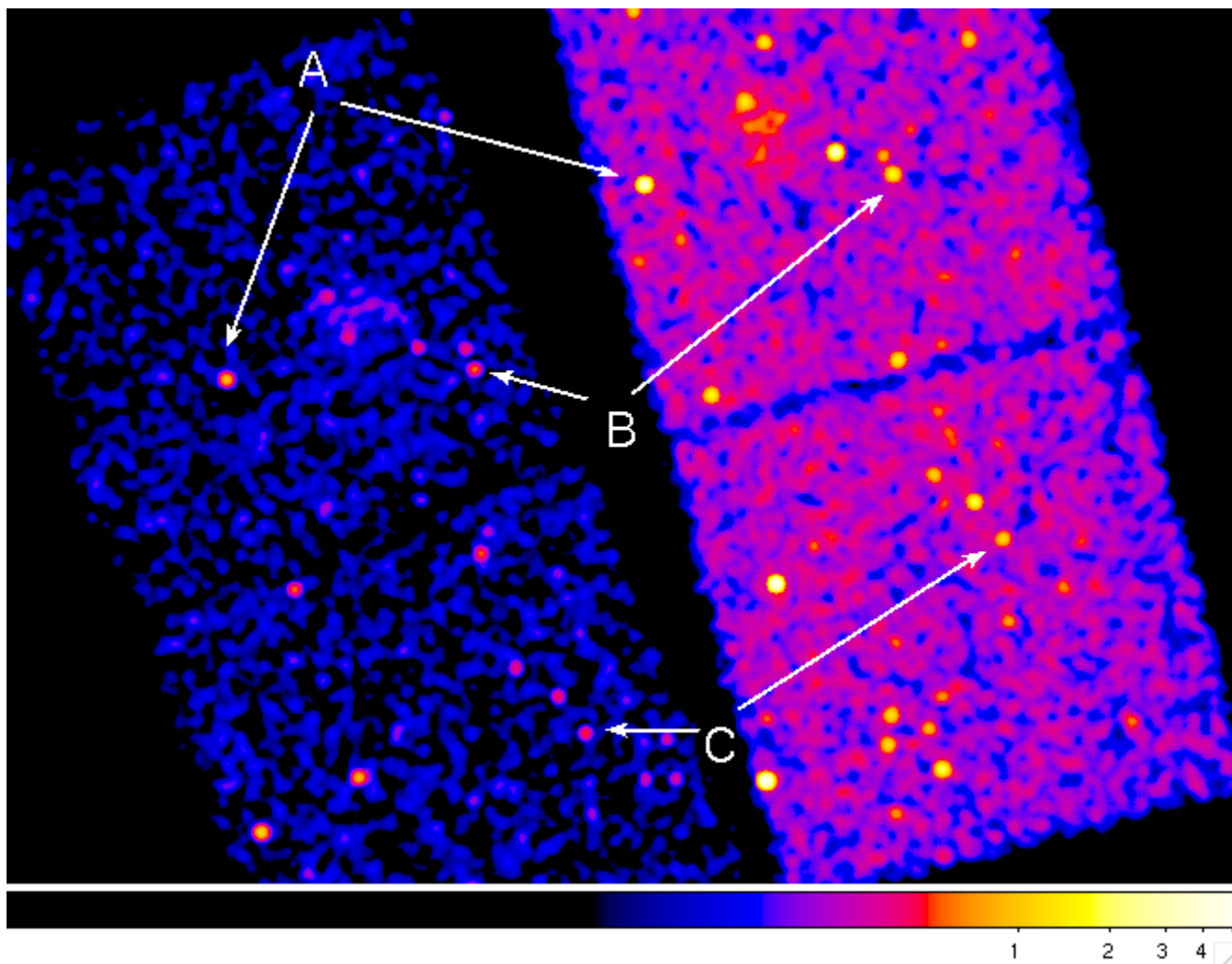
B: Keywords are all messed up

```
% dmkeypar merged_wrong.fits OBS_ID echo+
Merged
% dmkeypar merged_wrong.fits DEC_NOM echo+
# dmkeypar (CIAO 4.2): ERROR: Keyword 'DEC_NOM' was not
found in file 'merged_wrong.fits'.
```



Merging Chandra Observations

```
% ds9 merged_wrong.fits  
and use a filter of "energy=500:7000,ccd_id=0,1"
```



C: The SKY coordinates of the events do not agree, although the RA and Dec are, in general, in okay agreement.



Merging Chandra Observations

So, what are the differences in the processing of the observations (SDP)?

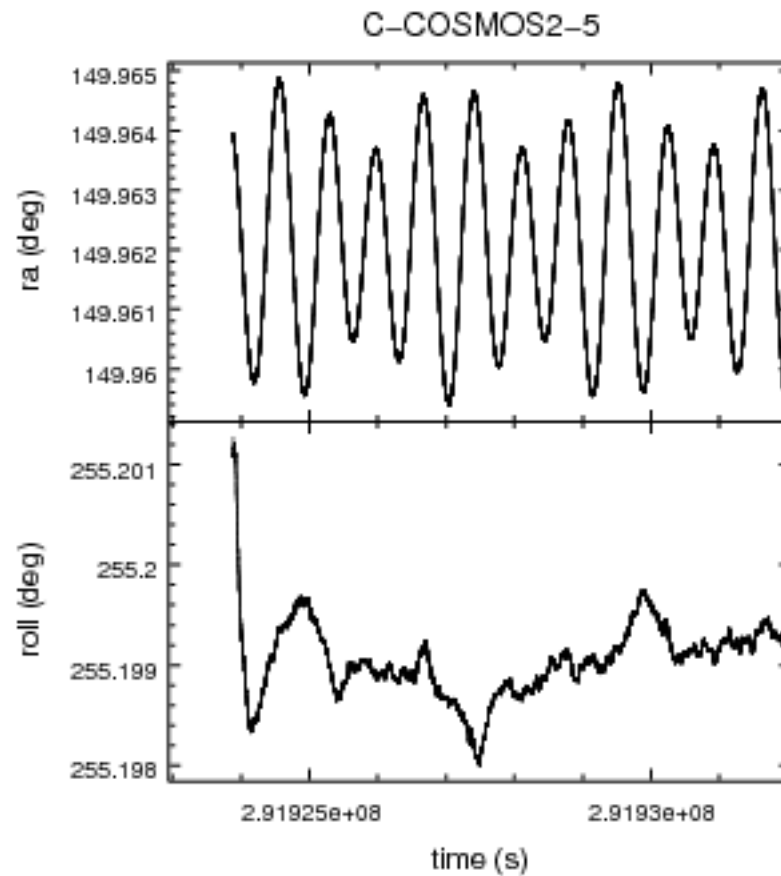
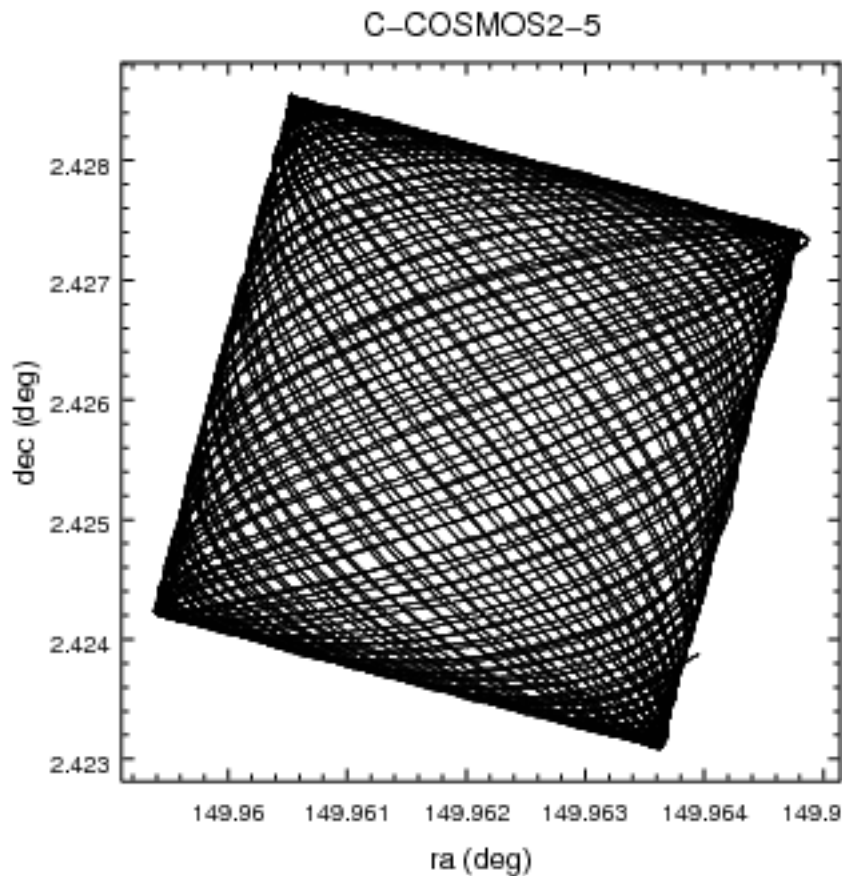
```
% cd /data/ciao_demo/workshop/merge
% ./view_headers.csh 8003/primary/acisf08003N002_evt2.fits
Results for 8003/primary/acisf08003N002_evt2.fits
  OBS_ID    8003
  OBJECT    C-COSMOS2-5
  DETNAM    ACIS-012367
  GRATING   NONE
  READMODE  TIMED
  DATAMODE  VFAINT
...
ASCDSVER  7.6.11
  DATE     2007-08-09T10:38:32
...
```

See the handout – handout.txt - for the script and full output for the two observations.



Merging Chandra Observations

A quick look at the aspect solution:





Merging Chandra Observations

Normally I would reprocess all the level 1 files to re-create the level 2 files, since it is generally easier than trying to work out whether the differences in software and calibration files impact the science analysis. For this demonstration we'll pretend we followed the threads

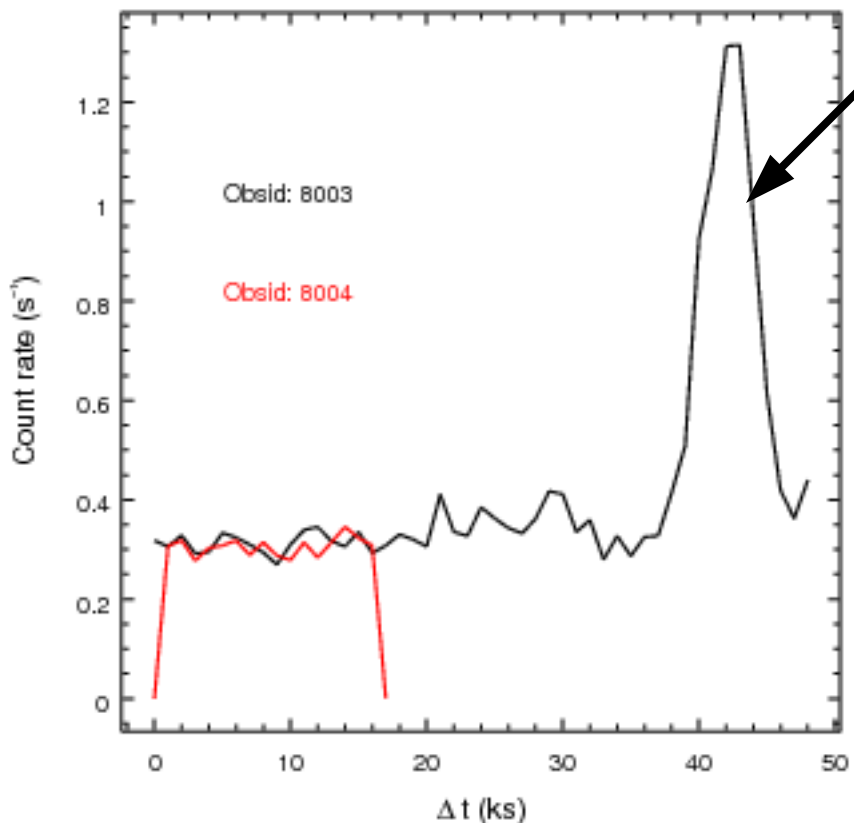
<http://cxc.harvard.edu/ciao/threads/createL2/>
<http://cxc.harvard.edu/ciao/threads/aciscleanvf/>

I will restrict analysis to ACIS-I0 of 8003 and ACIS-I1 of 8004 since they overlap, but you might want to use all four ACIS-I chips, depending on how they overlap (e.g. PSF changes with off-axis angle).

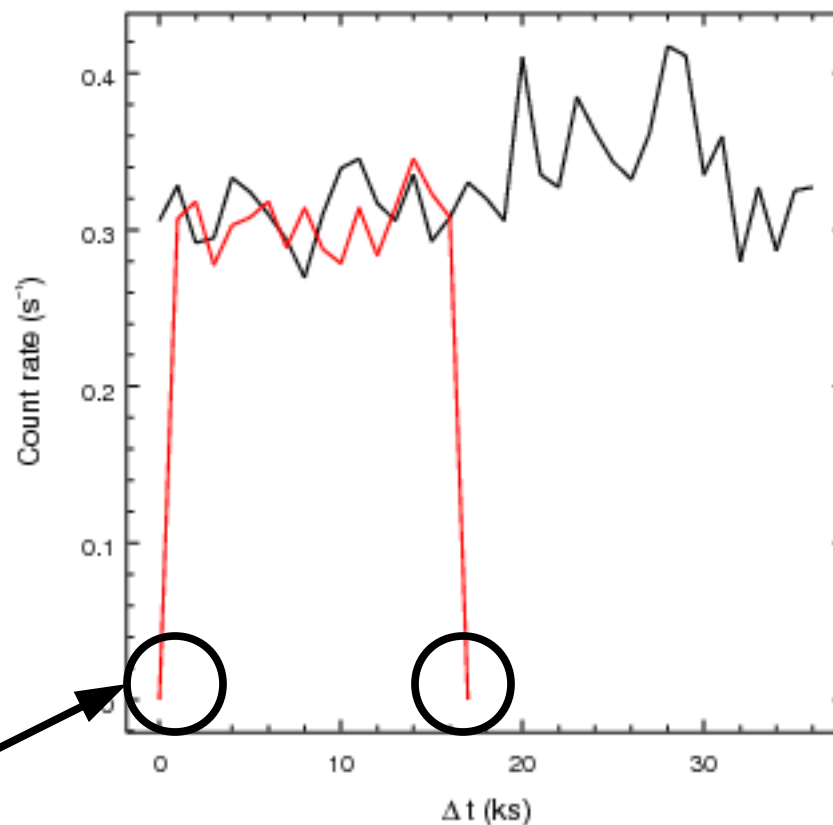
We start with a quick check the light curves to check for background flares (we really should exclude sources from this analysis), to get:



Merging Chandra Observations



Background (?) flare; is it going to affect your analysis?



Periods filtered out by the GTI block



Merging Chandra Observations

To merge the observations we need source positions, so we use wavdetect - see

```
http://cxc.harvard.edu/ciao/threads/wavdetect/
```

For this we need images, so we use the Field Of View files that came with the data (*fov*.fits).

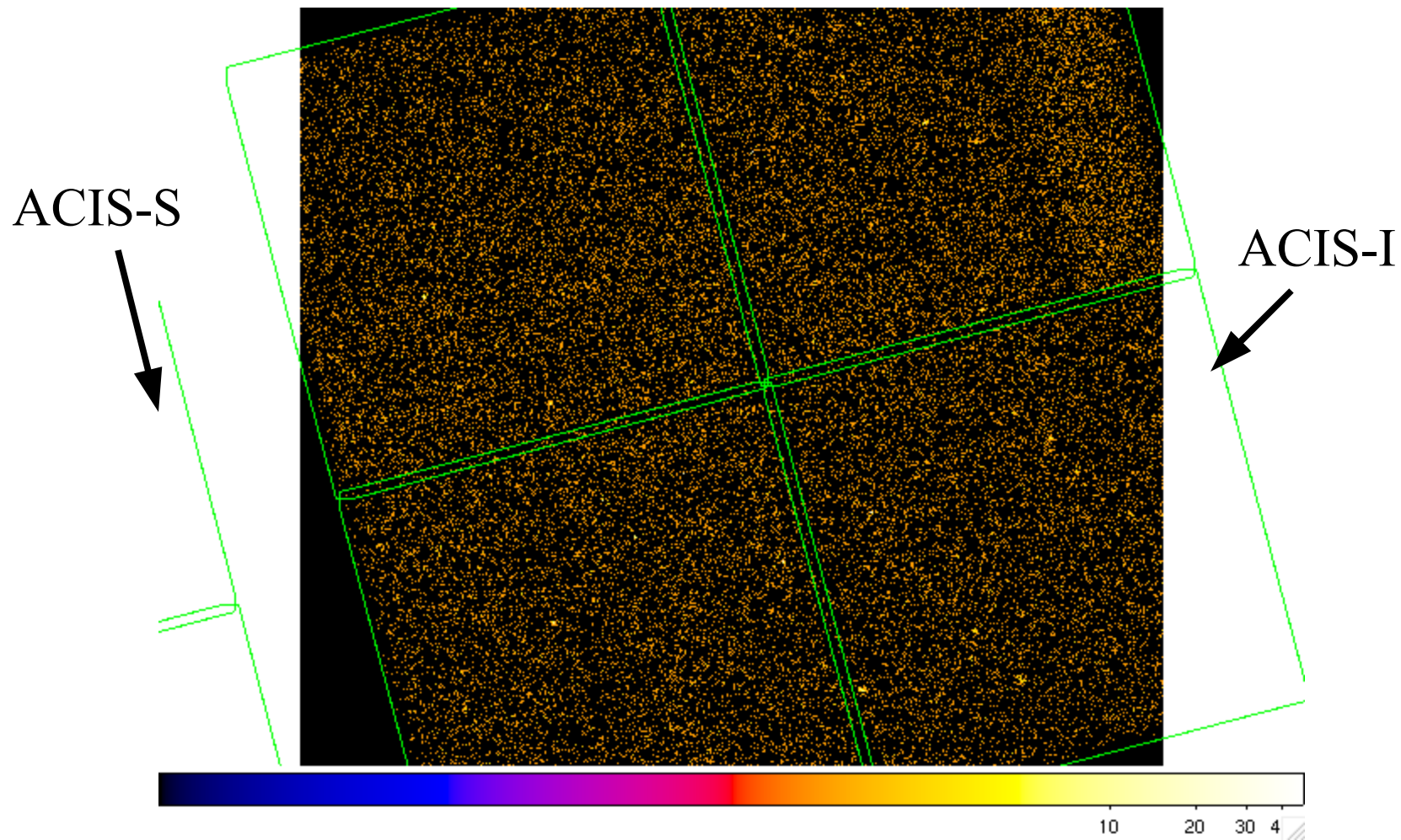
```
% cd /data/ciao_demo/workshop/merge/8003/primary/  
% ds9 acisf08003N002_evt2.fits \  
    -region acisf08003_000N002_fov1.fits
```

These regions are calculated from the aspect solution for the observation, so may be too generous but are a good starting point.



Merging Chandra Observations

Central region of Obsid 8003 with fov





Merging Chandra Observations

How do we use these regions to filter the event files? We can use our friend the Data Model syntax (see our other friend “ahelp dmsyntax” for the gory details).

```
% set in = acisf08003N002_evt2.fits
% set e = “energy=500:7000,ccd_id=0”
% set f = \
    “sky=region(acisf08003_000N002_fov1.fits[ccd_id=0])”
% set b = “[bin sky=::1]”
% dmcoppy “{ $in } [ $e, $f ] [ $b ]” images/ccd0.8003.fits
```

Or

```
% dmcoppy \
acisf08003N002_evt2.fits"[energy=500:7000,ccd_id=0,sky=reg
ion(acisf08003_000N002_fov1.fits[ccd_id=0])][bin sky=::1]"
images/ccd0.8003.fits
```



Merging Chandra Observations

And now wavdetect:

```
% punlearn wavdetect
% set o = wavdetect/8003/quick
% pset wavdetect infile=images/ccd0.8003.fits
% pset wavdetect outfile=$o.src
% pset wavdetct scellfile=$o.scell
% pset wavdetect imagefile=$o.img
% pset wavdetect defnbkgfile=$o.nbkg
% pset wavetect regfile=$o.reg
% pset wavdetect scales="1 2 4 8 16"
% wavdetect
```



Merging Chandra Observations

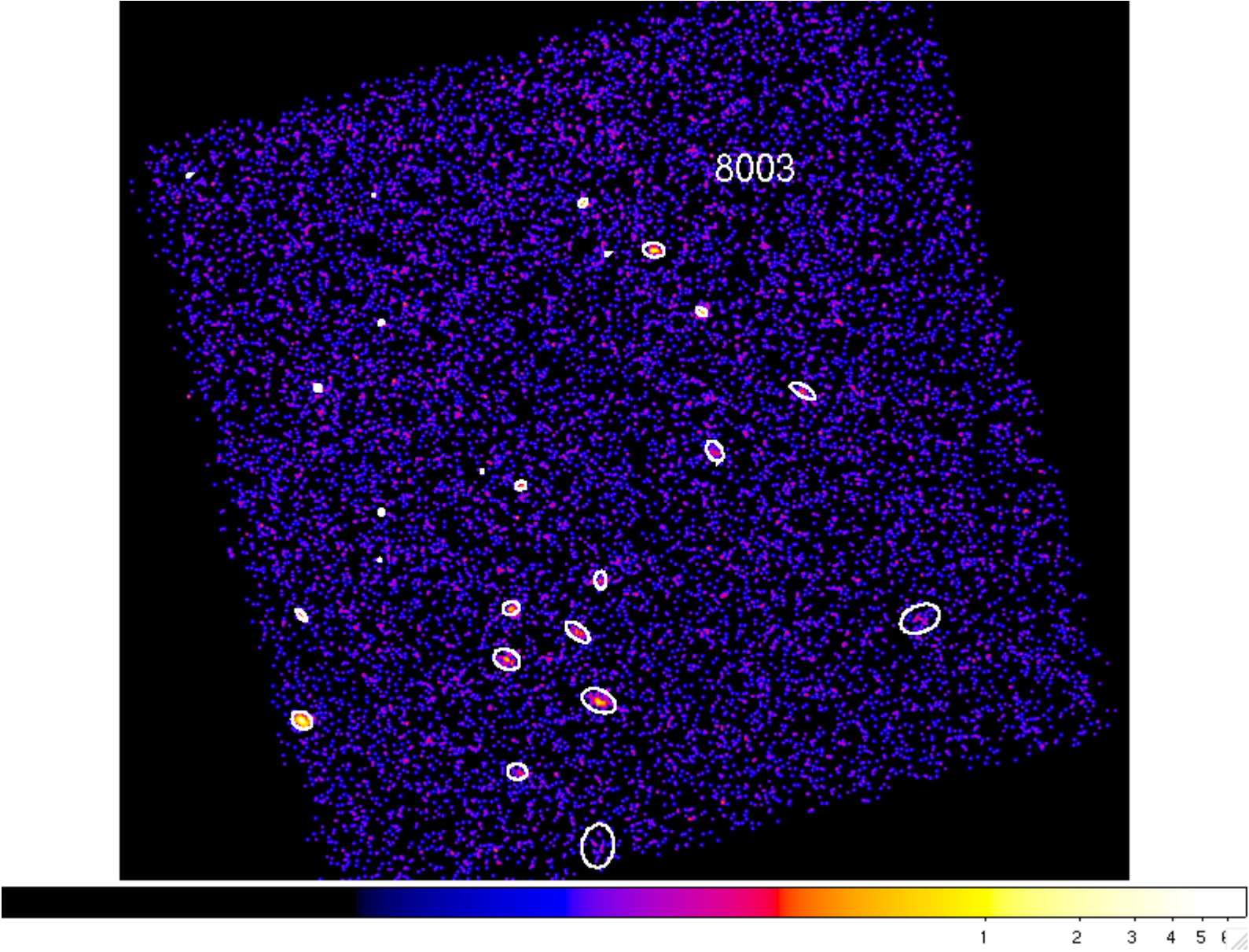
And now wavdetect:

```
% punlearn wavdetect
% set o = wavdetect/8003/quick
% pset wavdetect infile=images/ccd0.8003.fits
% pset wavdetect outfile=$o.src
% pset wavdetct scellfile=$o.scell
% pset wavdetect imagefile=$o.img
% pset wavdetect defnbkgfile=$o.nbkg
% pset wavdetect regfile=$o.reg
% pset wavdetect scales="1 2 4 8 16"
% wavdetect
```

Interested in point sources, close to the aim point,
and I did not listen to Frank/Kenny's talk, so use a
minimum scale of 1.



Merging Chandra Observations





Merging Chandra Observations

Reproject the aspect solution (map 8004 onto 8003):

```
% dmkeypar images/ccd0.8003.fits exposure echo+
47038.292698449
% dmkeypar images/ccd1.8004.fits exposure echo+
15721.489911643

% punlearn reproject_aspect
% pset reproject_aspect infile= \
      wavdetect/8004/quick.src"[net_counts=10:]"
% pset reproject_aspect refsrcfile= \
      wavdetect/8003/quick.src"[net_counts=10:]"
% pset reproject_aspect updfilename= \
      8004/primary/pcadf280982355N001_asol1.fits
% pset reproject_aspect outfile= \
      8004/primary/asol1.reproj.fits
% pset reproject_aspect wcsfile= images/ccd0.8003.fits
% reproject_aspect verbose=2
```



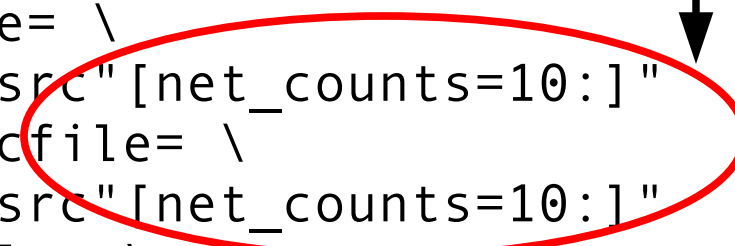
Merging Chandra Observations

Reproject the aspect solution (map 8004 onto 8003):

```
% dmkeypar images/ccd0.8003.fits exposure echo+  
47038.292698449  
% dmkeypar images/ccd1.8004.fits exposure echo+  
15721.489911643
```

Restrict matches to “bright” sources.

```
% punlearn reproject_aspect  
% pset reproject_aspect infile= \  
    wavdetect/8004/quick.src "[net_counts=10:]"  
% pset reproject_aspect refsrcfile= \  
    wavdetect/8003/quick.src "[net_counts=10:]"  
% pset reproject_aspect updfilename= \  
    8004/primary/pcadf280982355N001_asol1.fits  
% pset reproject_aspect outfile= \  
    8004/primary/asol1.reproj.fits  
% pset reproject_aspect wcsfile= images/ccd0.8003.fits  
% reproject_aspect verbose=2
```





Merging Chandra Observations

```
...
num_asolInFiles: 1      num_asolOutFiles: 1
Transform scale_factor: 0.998765
Transform rotation angle (deg): -0.016687
Transform x translation (pixels): 1.250266
Transform y translation (pixels): 1.006494
```

The dmdiff tool can compare the old and new aspect solutions:

```
% dmdiff 8004/primary/pcadf280982355N001_asol1.fits \
        8004/primary/asol1.reproj.fits" [#row=1:5]"
```

...

```
Values are not equal      1      ra
      149.844489946753    149.844318905412  -0.000171041
      (-0.000114 %)
```



Merging Chandra Observations

```
...
num_asolInFiles: 1      num_asolOutFiles: 1
Transform scale_factor: 0.998765
Transform rotation angle (deg): -0.016687
Transform x translation (pixels): 1.250266
Transform y translation (pixels): 1.006494
```

The dmdiff tool can compare the old and new aspect solutions:

```
% dmdiff 8004/primary/pcadf280982355N001_asol1.fits \
        8004/primary/asol1.reproj.fits "[#row=1:5]"
```

...

Restrict the number of rows

```
Values are not equal      1      ra
      149.844489946753    149.844318905412  -0.000171041
      (-0.000114 %)
```



Merging Chandra Observations

Reproject the events file (evt2):

```
% cd /data/ciao_demo/workshop/merge/8004/primary
% punlearn reproject_events
% pset reproject_events infile= acisf08004N001_evt2.fits
% pset reproject_events match= \
    ../../8003/primary/acisf08003N002_evt2.fits
% pset reproject_events aspect= asol1.reproj.fits
% reproject_events outfile= repro2.fits
Input dataset/block specification
(acisf08004N001_evt2.fits):
Output dataset/block specification (repro2.fits):
Match file (../../8003/primary/acisf08003N002_evt2.fits):
```

The trick is to set **both** the match and aspect parameters
and you may want to set the random parameter too.

```
% dmdiff acisf08004N001_evt2.fits repro2.fits "[#row=1:5]"
```



Merging Chandra Observations

```
Values are not equal    RA_NOM    149.840    149.962    +0.122
Values are not equal    DEC_NOM    2.4827    2.4258    -0.0568
```

...

```
Values are not equal    1          detx
                        3099.346    3099.528    +0.182 (+0.00586 %)
Values are not equal    1          dety
                        6166.608    6166.457    -0.151 (-0.00245 %)
Values are not equal    1          x
                        5661.868    6557.016    +895.147 (+15.8 %)
Values are not equal    1          y
                        5794.142    6211.536    +417.394 ( +7.2 %)
```



Merging Chandra Observations

Merge the reprojected event file:

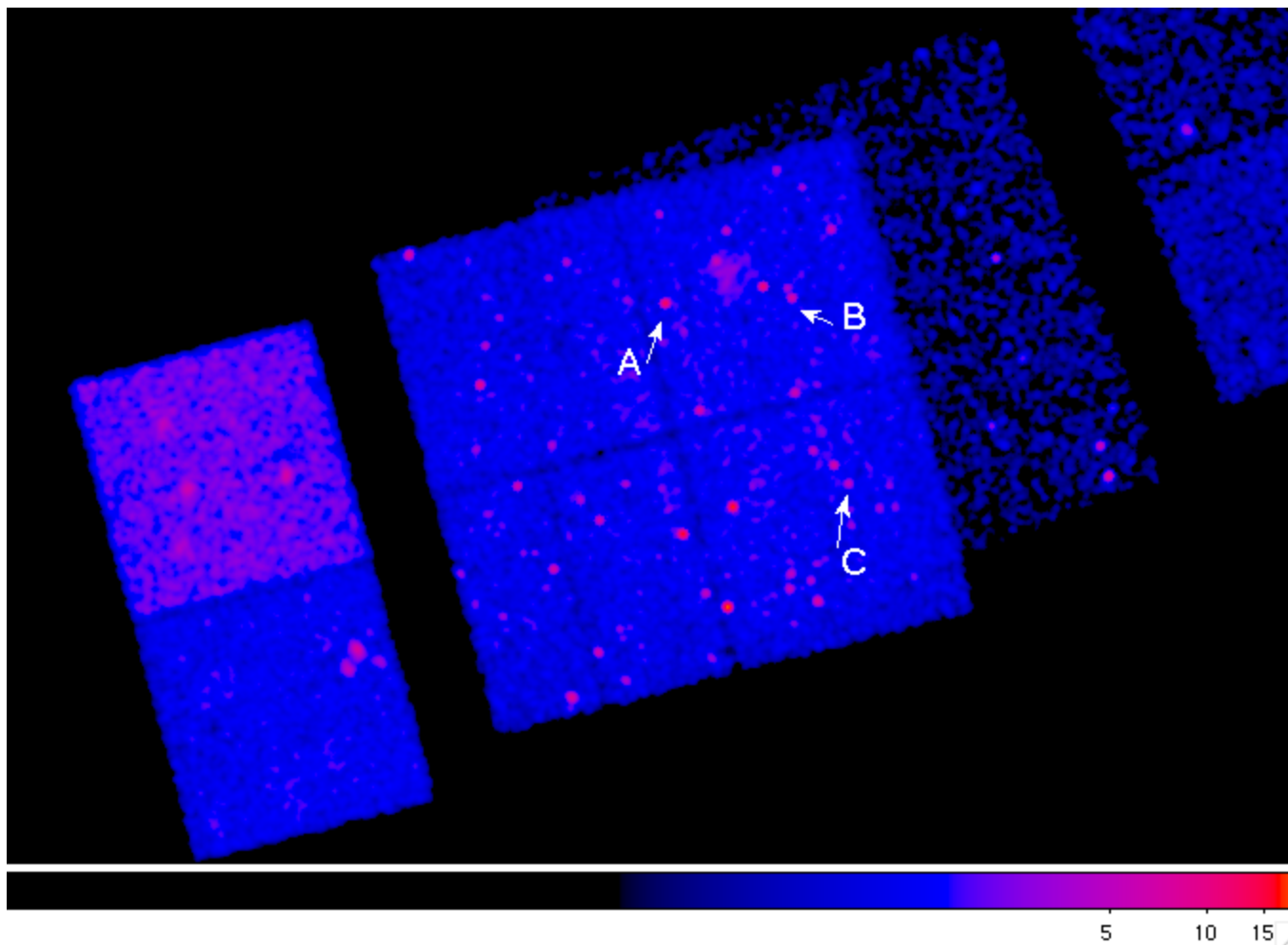
```
% set a = 8003/primary/acisf08003N002_evt2.fits
% set b = 8004/primary/repro2.fits
% dmmmerge $a,$b merged2.fits
BTIMDRFT values are different...FAIL...
BTIMNULL values are different...FAIL...
BTIMRATE values are different...FAIL...
omit - DEC_PNT values different more than 0.000300
warning: DS_IDENT has different value...Merged...
warning: OBJECT has different value...Merged...
warning: OBS_ID has different value...Merged...
omit - RA_PNT values different more than 0.000300
omit - ROLL_NOM values different more than 1.000000
omit - ROLL_PNT values different more than 1.000000
warning: SEQ_NUM has different value...Merged...
```

Keywords are still all messed up



Merging Chandra Observations

Merged event file for 8003 and 8004



0.5-7.0 keV
data for all the
chips, even
though
alignment was
calculated using
positions from
one chip.



Merging Chandra Observations

The merged event file can be used to create images, but we **strongly** advise spectral analysis is done using the individual event files. Book-keeping is vital here, since you need to use the re-projected aspect solution when calculating response files.

After re-projecting the event files, source (and background) regions can be defined using SKY coordinates, since that was the whole point of the exercise!

The observations have been matched together, but the absolute astrometry may still need tweaking:

<http://cxc.harvard.edu/cal/ASPECT/celmon/>