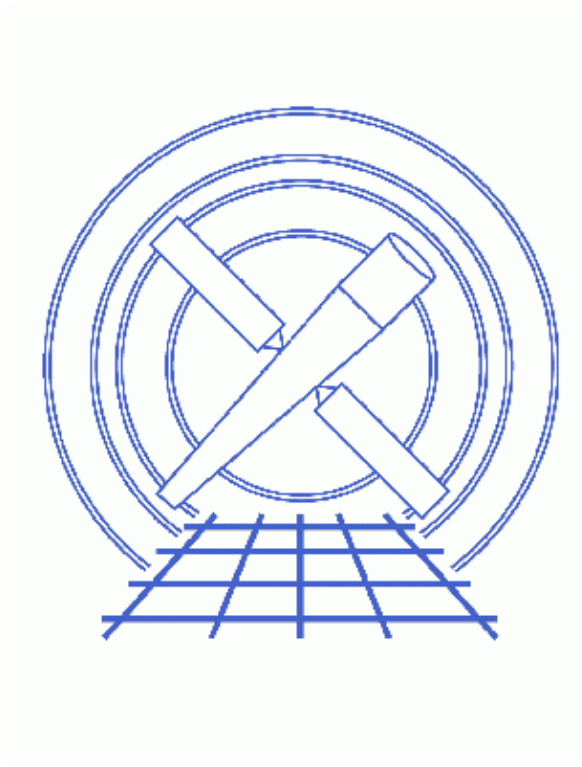


# Calculating Statistics of Images



## ***CIAO 3.4 Science Threads***

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# Calculating Statistics of Images

*CIAO 3.4 Science Threads*

## Overview

**Last Update:** 1 Dec 2006 – reviewed for CIAO 3.4: ChIPS version

### *Synopsis:*

Although in many cases it is easier (and faster) to use the `dmstat` tool, the `sstats.sl` script described in this thread allows you to ignore regions of the image by using a mask file.

### *Purpose:*

Use the *S-Lang* interpreter in *ChIPS* and *Sherpa* to calculate statistics of images.

### *Read this thread if:*

you are interested in calculating the statistics of an ACIS or HRC image.

### *Related Links:*

- [Estimating Source Counts](#) thread: related functionality of the `dmextract` tool.
- `dmopt` and `dmstat` ahelp pages: an alternative method of marking image regions as "uninteresting" – setting such pixels to the Null value for that image type – is discussed. Note that the `sstats.sl` script will *not* handle such cases.

Proceed to the [HTML](#) or [hardcopy \(PDF: \[A4\]\(#\) / \[letter\]\(#\)\)](#) version of the thread.

## Getting Started

**Sample ObsID used:** 1838 (ACIS-S, G21.5-09)

It is assumed that you have completed the [Single Chip Exposure Map](#) thread.


This thread uses the `sstats.sl` script. The most recent version of `sstats.sl` is v0.4 (4 Oct 2001):

```
unix% grep Id $ASCDS_CONTRIB/share/slsh/local-packages/sstats.sl
% $Id: sstats.sl,v 0.4 2001/10/04 18:45:12 dburke Exp $
```

Note that `$ASCDS_CONTRIB/share/slsh/local-packages/` is the default path in the standard CIAO scripts installation; see the [Scripts page](#) for more information. **Please check that you are using the most recent version before continuing.** If you do not have the script installed or need to update to a newer version, please refer to the [Scripts page](#).

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## Create an image of the region of interest


For this thread, we want to look at the average signal level in an annulus  surrounding the source center (this is for the `1838_img_s3.fits` file created in the [Single Chip Exposure Map](#) thread). We saved the selected region to `stat.reg` in CIAO format; its contents are:

```
unix% cat stat.reg
# Region file format: CIAO version 1.0
annulus(4070.5,4248.5,130,218)
```

Further details are available for [interactive region definition](#) using `ds9`.

We create an image of the region using this spatial filter. For the mask region – which should contain pixel values greater than 0 only for those pixels within the filter – we use a filtered copy of the exposure map (we can not use `img_stat.fits` as the mask image, since some of the pixels within the annulus contain no counts).

```
unix% dmcoppy "1838_img_s3.fits[sky=region(stat.reg)]" img_stat.fits
unix% dmcoppy "expmap_1.7kev_7.fits[sky=region(stat.reg)]" emap_stat.fits
```

We show a mosaic  of the original image (log scaling) together with the filtered image (sqrt scaling) and the filtered exposure map (linear scaling).

---

## Statistics of the selected region

We show results from using the `dmstat` tool and the `sstats.sl` S-Lang script:

### A. `dmstat`

```
unix% punlearn dmstat
unix% dmstat img_stat.fits centroid=no
EVENTS_IMAGE
  min:      0          @:      ( 4057.6402575 4030.9302575 )
  max:      2          @:      ( 4089.6402575 4082.9302575 )
  mean:     0.027786151623
  sigma:    0.16761614994
  sum:      2673
  good:     96199
  null:     94770
```

The mean and standard deviation values represent the signal level within the annulus. This could equivalently be found from the original image:

```
unix% dmstat "1838_img_s3.fits[sky=region(stat.reg)]" centroid=no
EVENTS_IMAGE
  min:      0          @:      ( 4057.6402575 4030.9302575 )
  max:      2          @:      ( 4089.6402575 4082.9302575 )
  mean:     0.027786151623
  sigma:    0.16761614994
  sum:      2673
  good:     96199
  null:     94770
```

---

## B. sstats.sl

```

unix% chips --slscript sstats.sl

Welcome to ChIPS, version CIAO 3.4
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chips> sstats( "img_stat.fits" )
Statistics of img_stat.fits.
Mean = 1.3997e-02  RMS = 1.1977e-01  Total      = 2.6730e+03
Min   = 0.0000e+00  Max   = 2.0000e+00  Num pixels = 190969

```

The statistics have been calculated over the whole image. To restrict the calculation to just those pixels within the annulus we need a mask: an image the same size as `img_stat.fits` in which those pixels which should be considered for the calculation have values `> 0`. In this case we use the filtered exposure map (`emap_stat.fits`):

```

chips> sstats( "img_stat.fits", "emap_stat.fits" )
Statistics of img_stat.fits using (emap_stat.fits > 0) as a mask.
Mean = 2.7784e-02  RMS = 1.6761e-01  Total      = 2.6730e+03
Min   = 0.0000e+00  Max   = 2.0000e+00  Num pixels = 96205

```

It is also possible to pass the routine "virtual files", so it is not necessary to create the images beforehand:

```

chips> sstats( "1838_img_s3.fits[sky=region(stat.reg)]", "expmap_1.7kev_7.fits[sky=region(stat.r
Statistics of 1838_img_s3.fits[sky=region(stat.reg)] using (expmap_1.7kev_7.fits[sky=region(stat.r
Mean = 2.7784e-02  RMS = 1.6761e-01  Total      = 2.6730e+03
Min   = 0.0000e+00  Max   = 2.0000e+00  Num pixels = 96205

chips> exit

```

The reason for the small difference in the RMS values reported by `dmstat` and `sstats()` is because `dmstat` calculates

$$\text{rms} = \sqrt{(\text{mean}(x*x) - \text{mean}(x)*\text{mean}(x)) / N}$$

whereas `sstats()` uses

$$\text{rms} = \sqrt{(\text{mean}(x*x) - \text{mean}(x)*\text{mean}(x)) / (N-1)}$$

where `x` is a list of `N` numbers and `mean(x)` refers to the mean value of the list `x`.

## Further examples

Above we show an example of looking at the signal level within the region in different energy bands, using the virtual file syntax to filter and bin the event list "on the fly". In this example, we do not apply any spatial filtering to the event list; instead we create a filtered, full-size image of the exposure map using the [DM \[opt full\]](#) syntax.

```

unix% dmcopu "expmap_1.7kev_7.fits[sky=region(stat.reg)][opt full]" emap_stat_full.fits

unix% more chip_s3.reg
# Region file format: CIAO version 1.0
rotbox(4182.860000,4393.150000,1024,1024,93.192576)

unix% chips

Welcome to ChIPS, version CIAO 3.4
Copyright (C) 1999-2003, Smithsonian Astrophysical Observatory

```

## Calculating Statistics of Images – CIAO 3.4

```
chips> () = evalfile( "sstats.sl" )

chips> sstats( "acisf01838N001_evt2.fits[energy=500:2000,sky=region(chip_s3.reg)][bin sky=1]", "emap_st
Statistics of acisf01838N001_evt2.fits[energy=500:2000,sky=region(chip_s3.reg)][bin sky=1] using (emap_
as a mask.
Mean = 1.0561e-02  RMS = 1.0273e-01  Total      = 1.0160e+03
Min  = 0.0000e+00  Max  = 2.0000e+00  Num pixels = 96205

chips> sstats( "acisf01838N001_evt2.fits[energy=2000:8000,sky=region(chip_s3.reg)][bin sky=1]", "emap_s
Statistics of acisf01838N001_evt2.fits[energy=2000:8000,sky=region(chip_s3.reg)][bin sky=1] using (emap_
as a mask.
Mean = 1.4583e-02  RMS = 1.2100e-01  Total      = 1.4030e+03
Min  = 0.0000e+00  Max  = 2.0000e+00  Num pixels = 96205
```

---

## History

14 Dec 2004 updated for CIAO 3.2: path for script  
20 Dec 2005 reviewed for CIAO 3.3: no changes  
01 Dec 2006 reviewed for CIAO 3.4: ChIPS version

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URL: [http://cxc.harvard.edu/ciao/threads/image\\_stats/](http://cxc.harvard.edu/ciao/threads/image_stats/)

Last modified: 1 Dec 2006

### Image 1: Annulus in which we wish to measure the signal level

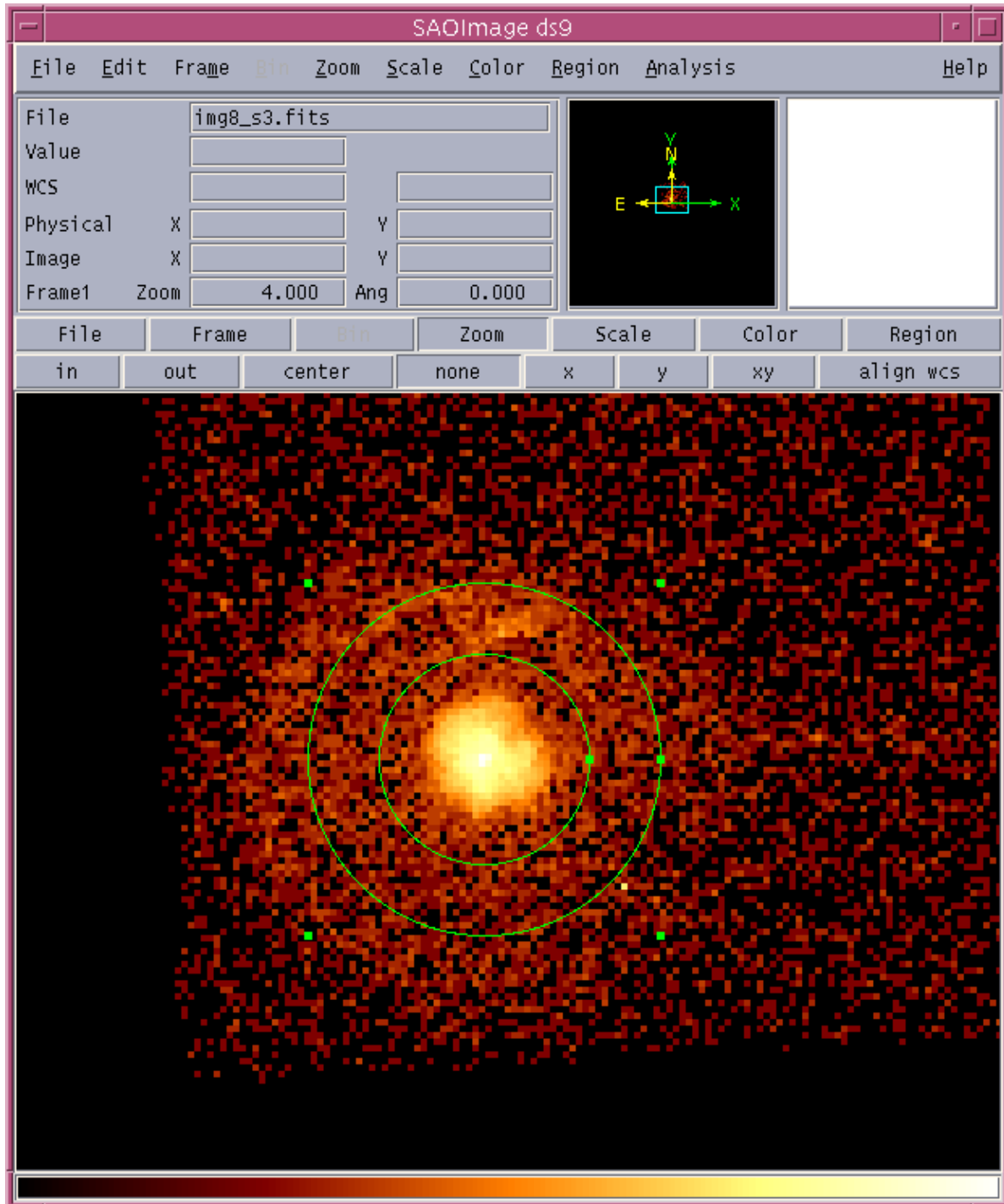
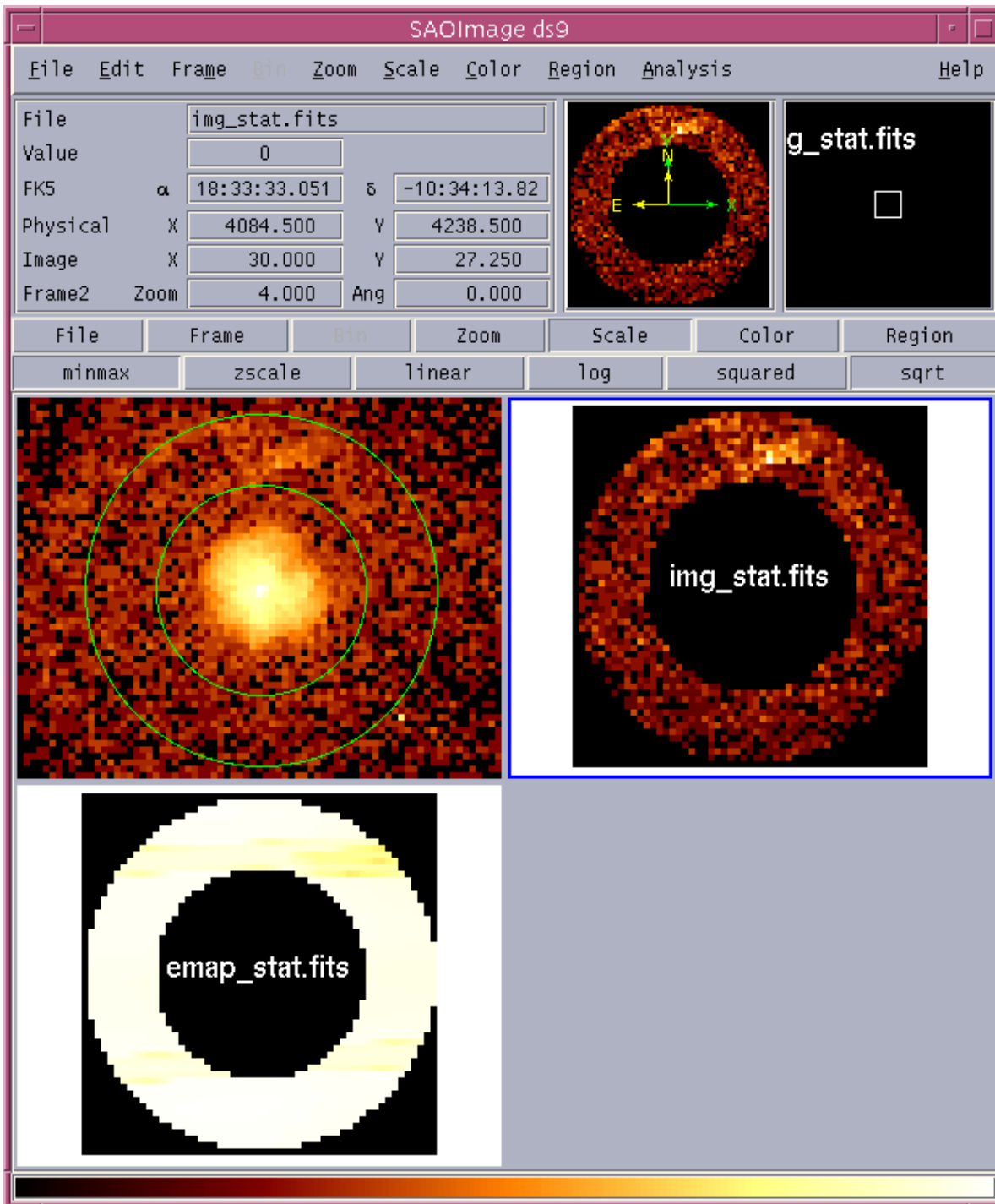


Image 1: Annulus in which we wish to measure the signal level

## Image 2: Image mosaic



The top-left image is the original image (log scaling), the top-right image is the filtered image (sqrt scaling), and the bottom-left image shows the filtered exposure map (linear scaling).