SAOImage DS9 FAQ

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New Features

SAOImage DS9 is an astronomical imaging and data visualization application. DS9 supports FITS images and binary tables, multiple frame buffers, region manipulation, and many scale algorithms and colormaps. DS9 provides for easy communication with external analysis tasks and is highly configurable and extensible. A number of new and important features are now available in DS9 version 6.2:

- SAMP: DS9 now supports SAMP. Two methods are available, ds9.get and ds9.set. These methods implement full XPA functionality.
- Backup and Restore: When a backup is invoked, DS9 will save in a backup set, all files needed to restore DS9 to that state, including data files, colormaps, catalogs, contours, and regions.
- Colorbar: A number of new colorbar options are now available including size, font, horizontal or vertical layout and numerics distribution.
- WCS Editor: A basic WCS editor is now available for adding or modifying WCS keywords.
- Datacube: DS9 now supports FITS images up to 10 dimensions.
- SkyBot: Support for the SkyBot catalog server has been added to DS9.

How it Works

Here is a short description on how SAOImage DS9 decides to paint a pixel a color on the the screen: you need a color scale, a contrast/bias pair for the colorscale, clip values for the data, a scale distribution, and finally, the value of the pixel in question.

- Step 1. Select a color scale. A color scale is defined as a number of colors (RGB triplets). The number of RGB triplets can vary from just a few to over 200. DS9 contains a number of predefined color scales (Gray, A, B, I8, ...) or the user may load his own color scale.
- Step 2. Apply a contrast/bias pair. This step takes the result of step 1 and creates a new array with the contrast/bias applied. The length of the new array will between 200 (for pseudocolor) and 4096 (for truecolor).
- Step 3. Calculate the data clip values (low/high data values). The min/max data values may be used or an algorithm may be used to determine the clip data values.
- Step 4. Apply the scale distribution. This involves taking the result of step 2, and creating yet another array, this time of size 16384, redistributing the colors, based on the scale algorithm selected (see Scales).
- Step 5. Based on your data clip values, and the value of the pixel you have, index into the result of step 4, and you have an index into lookup table (for pseudocolor) and an RGB pair (for truecolor and postscript).

Scales

The log function is defined as the following:

$$y = \frac{\log(ax+1)}{\log a}$$

as x goes from 0 to 1. The user may specify an exponent a to change the distribution of colors within the colorbar. The default value of a is 1000. Typically, optical images respond well at 1000, IR images as low as 100, and high energy bin tables up to 10000. A value of 10000 closely matches the log function of SAOImage as defined as the following:

$$y = \frac{e^{-10x} - 1}{e^{-10} - 1}$$

The pow function is defined as the following:

$$y = \frac{a^x - 1}{a}$$

as x goes from 0 to 1. The user may specify an exponent a to change the distribution of colors within the colorbar. The default value of a is 1000.

The sqrt scale function is defined as the following:

$$y = \sqrt{x}$$

as x goes from 0 to 1.

The square scale function is defined as the following:

$$y = x^2$$

as x goes from 0 to 1.

The histogram equalization scale function distributes colors based on the frequency of each data value.

Smoothing

The user may select one of three types of smoothing kernels, Boxcar, Tophat, and Gaussian. For each, the kernel diameter or width is defined as $2r + 1$

And for the Gaussian function, where $mean = 0$ and $\sigma = r/2$

$$z = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\frac{(x^2+y^2)}{\sigma^2}}$$

Large Files

There are several factors that determine if SAOImage DS9 will be able to load a large file.

32 bit OS vs 64 bit OS : to address very large files, you may need to use an 64 bit OS with a 64 bit version of DS9. 32 bit apps can address up to 4Gb of address space. However, depending on the OS, this limit may be less. Linux, for example, the limit appears to be 3GB (the OS and shared libs eat up a lot of address space). Under Solaris 10, 32bit DS9 has a full 4Gb of space. MacOSX Aqua is only a 32 bit application and has a limit of 3Gb while MacOSX X11 is a full 64 bit application. Finally, Windows is currently limited to 2Gb.

- Large File Support: is the ability to sequence thru files larger than 4Gb. DS9 is compiled with LFS.
- File system: the OS file system must be able to support files larger than 4Gb. Most recent file systems fully support greater than 4Gb.

Memory Management: There are a number of memory management techniques supported in DS9 that will greatly affect the ability and speed of loading large files:

```
$ ds9 foo.fits # uses mmap
$ cat foo.fits | ds9 - # allocates memory
$ xpaset -p ds9 file foo.fits # uses mmap
$ xpaset -p ds9 fits foo.fits # allocates memory
```

Memory Map (mmap) is very fast, the limit is memory address space (see above). Allocate is very slow and the limit is amount of physical memory + swap partition.

Scanning Data: DS9 needs to determine the min and max data values to correctly display your image. For large files, this can take time. You have several options available under the Scale menu:

- Scan Data - reads all data
- Sample Data - samples every x values (much faster)
- Use FITS keyword DATAMIN/MAX or IRAFMIN/MAX - great if in the header, bad because they are always wrong.

The best thing to do is to use sample data, and set the data sample between 10 and 100.

Acknowledgments

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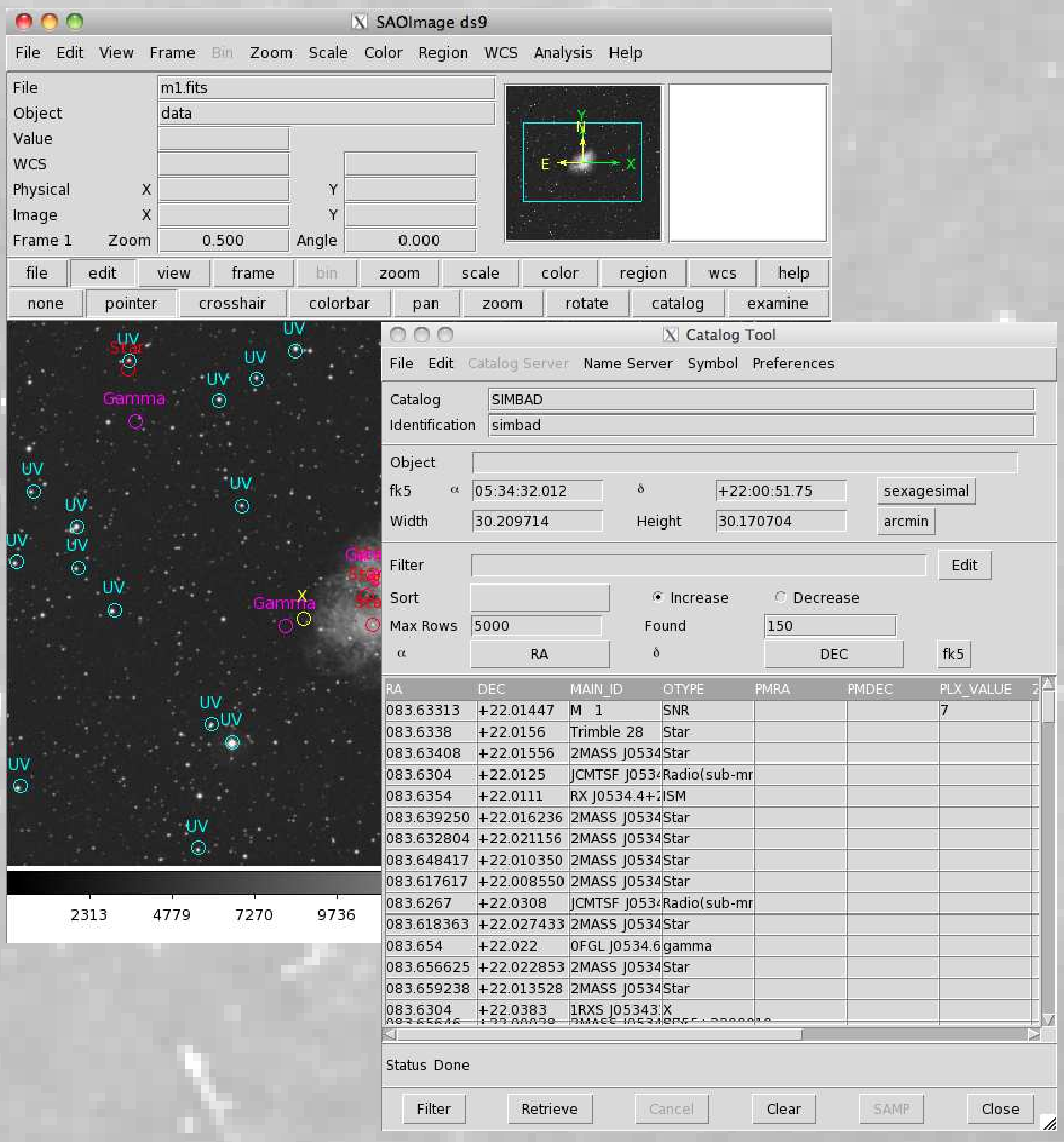

SAOImage ds9
File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help
file edit view frame bin zoom scale color region wcs help
none pointer crosshair colorbar pan zoom rotate catalog examine
Y
N
E
X
UV
Star
Gamma
2313
4779
7270
9736
Catalog Tool
File Edit Catalog Server Name Server Symbol Preferences
sexagesimal
arcmin
Edit
RA
DEC
fk5
Filter Retrieve Cancel Clear SAMP Close

File m1.fits
Object data
Value
WCS
Physical X Y
Image X Y
Frame 1 Zoom 0.500 Angle 0.000

Catalog SIMBAD
Identification simbad
Object
fk5 α 05:34:32.012 δ +22:00:51.75
Width 30.209714 Height 30.170704
Filter
Sort ● Increase ○ Decrease
Max Rows 5000 Found 150

RA	DEC	MAIN_ID	OTYPE	PMRA	PMDEC	PLX_VALUE
083.63313	+22.01447	M 1	SNR			7
083.6338	+22.0156	Trimble 28	Star			
083.63408	+22.01556	2MASS J0534	Star			
083.6304	+22.0125	JCMTSF J0534	Radio(sub-mr			
083.6354	+22.0111	RX J0534.4+2	ISM			
083.639250	+22.016236	2MASS J0534	Star			
083.632804	+22.021156	2MASS J0534	Star			
083.648417	+22.010350	2MASS J0534	Star			
083.617617	+22.008550	2MASS J0534	Star			
083.6267	+22.0308	JCMTSF J0534	Radio(sub-mr			
083.618363	+22.027433	2MASS J0534	Star			
083.654	+22.022	0FGL J0534.6	gamma			
083.656625	+22.022853	2MASS J0534	Star			
083.659238	+22.013528	2MASS J0534	Star			
083.6304	+22.0383	1RXS J05343:	X			

Status Done