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# New User Requirements for Astronomical Data Visualization

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**Abstract.** The astronomical community has benefited greatly from the dramatic increase of speed and storage capacity of computers and the wide availability of high speed Internet access. Armed with the latest hardware, users have placed increased demands on astronomical data visualization software that no one could have imagined just a few years ago.

Until recently, a typical FITS file was composed of a single image less than 100Mb in size. Now FITS files composed of mosaics images, multiple-extension FITS images, FITS data cubes, and RGB composite images are common. These FITS files now test the limits of hardware and operating systems with regard to file size and address space. And along with this explosion of new data file representations comes demands for more flexibility in visualization, support for external and remote analysis, and seamless Web integration.

We will present a discussion of new user requirements and solutions we have encountered in development and support of SAOImage DS9.

## 1. FITS File Interpretation

There has been an explosion of new data representations within the FITS file framework. In the past, a FITS file consisted of a primary header, followed by image data. Now, multiple extension FITS files are common. Users are taking advantage of the flexibility of the FITS format to store a dynamic range of data representations. They naturally demand the ability to display and render these data in a variety of ways. Today's data visualization software must be flexible enough to support such options. SAOImage DS9 provides the user several different ways to interpret and render a FITS file. For example, a multiple extension FITS file can be opened as a Single Image, a Mosaic Image, an RGB Image, or a 3D Data Cube.

## 2. Breaking the 2Gb File Size Barrier

Concomitant with the explosion of FITS file representations has been an explosion of FITS file size. Users routinely require the ability to display images that have a combined sizes of over 2Gb. This can be accomplished by implementing Large File Support (LFS). LFS allows the user to read, write, and seek into

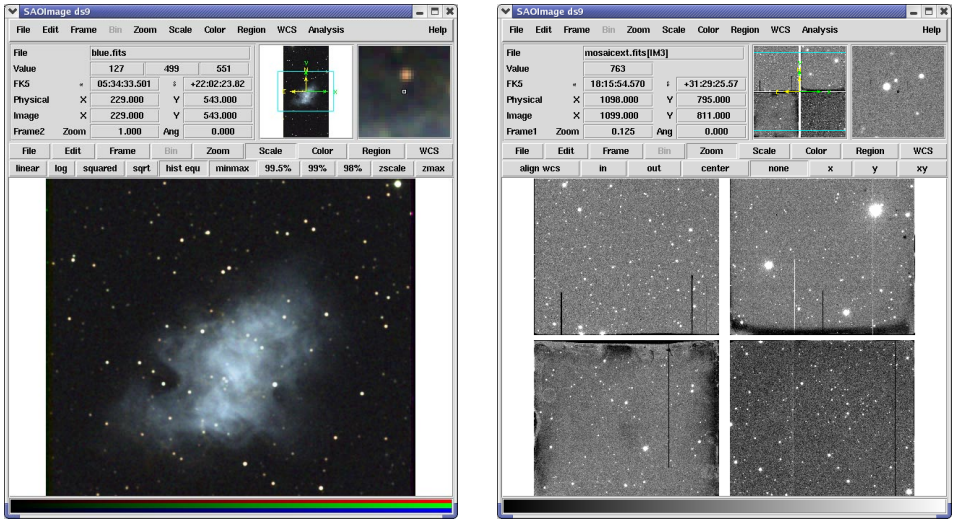


Figure 1. FITS Multiple Extension Images

files over 2Gb in size. To support LFS, software must be modified to support I/O addressing beyond 2Gb and must be linked against 64-bit-aware standard libraries. GCC 3.x now supports LFS on most platforms. By recompiling with the correct options, GCC will seamlessly substitute 64-bit-aware library procedures for their 32-bit counterparts. SAOImage DS9 now supports LFS for most platforms.

## 3. Remote Analysis

One of the exciting trends in astronomical analysis software has been the growth in remote analysis projects. With the availability of large on-line data archives, a wide range of specialized analysis software, and high speed Internet connectivity, it is now possible to provide users with a complete analysis suite of tools, not restricted to one or two popular packages, but incorporating parts of many different packages.

SAOImage DS9 supports a wide range of remote analysis services. Any XPA-enabled site can permit DS9 to register itself with the XPA name server running at that site. The DS9 web interface then will display the site's web page, which can be used to send FITS data to DS9 for display.

For example, the Chandra Education site, `http://chandra-ed.harvard.edu`, offers Chandra-based educational activities. Once DS9 is connected to Chandra-Ed, FITS images can be sent back to DS9 for display and further analysis as part of these activities.

Chandra-Ed sends to DS9 compressed FITS images along with definitions of analysis tools that can operate on the original event data maintained at the Chandra-Ed site. These CGI-based definitions become part of the DS9 Analysis Menu. Thus, after setting up regions of interest, the user can select a remote analysis program. The associated CGI call sends parameter information back to the Chandra-Ed site, where the remote analysis program is executed on the

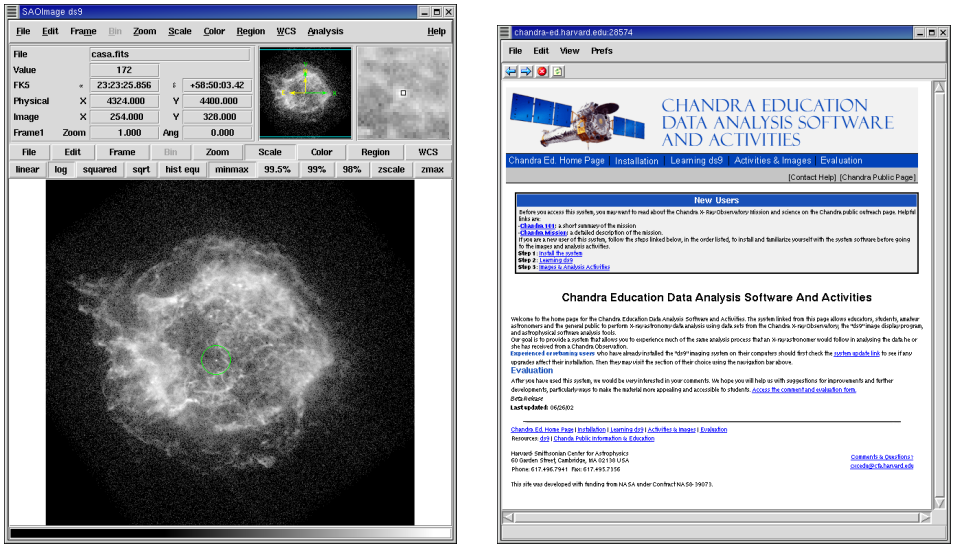


Figure 2. Chandra Education Remote Analysis Site

original event data. Results are sent back to DS9 for display. All such analysis requests are processed in a secure chroot'ed environment.

In this way, DS9 can be used as a local front-end to remote archive/education servers that offer both data and analysis support. Moreover, this can be done without moving large data sets or complex software to the local machine.

## 4. The Virtual Observatory

The term *Virtual Observatory* means different things to different people. The VO promises to '"make data easier to use, easier to find, and easier to join with other data"[1]. Users require easy access to on-line image and catalog servers. This support must be fully integrated into data visualization software and provide full access to existing and future web services as they become available.
[1]`http://www.us-vo.org/`

SAOImage DS9 now supports access to web-based image archive servers via HTTP. Support for MAST, SkyView, 2MASS, ISSA, NVSS, First, NED and many others are provided. FITS images are automatically displayed within DS9, while other image formats, such as GIF, TIFF, JPEG, are displayed within the web display window. When a user first invokes an archive server Web page, DS9 automatically fills in certain form fields such as RA and DEC with coordinates from the current image. This allows the user to browse and retrieve images from the archive quickly and easily. As new VO web services become available, they will be supported within DS9.

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[1]`http://www.us-vo.org`

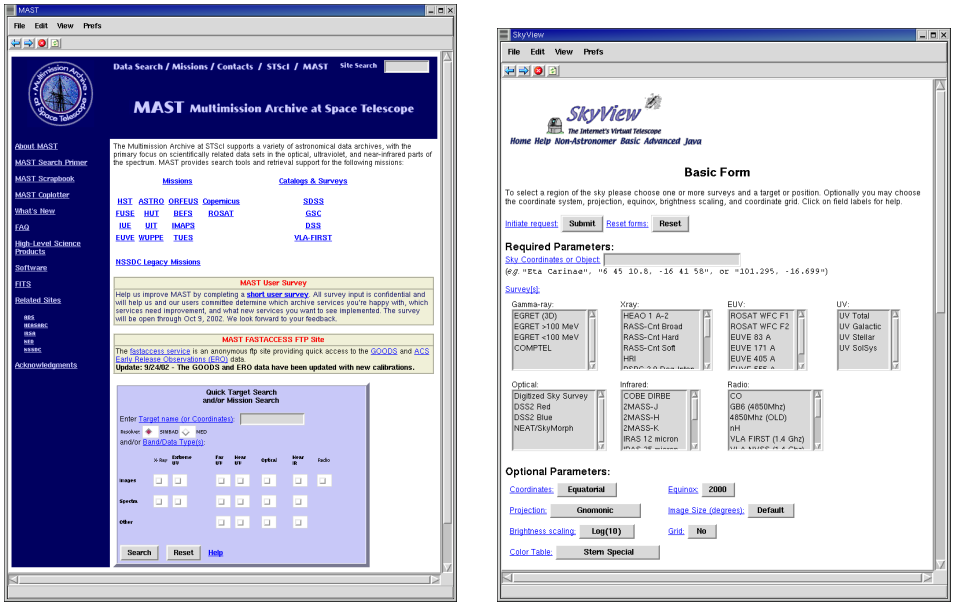


Figure 3. Web Based Archive Servers

## 5. Availability

DS9 is available on the Web at `http://hea-www.harvard.edu/saord/ds9` or via anonymous FTP from `ftp://sao-ftp.harvard.edu/pub/rd/ds9`.

## 6. Acknowledgments

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