Discovery Help

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Data Discovery Tool: Overview

The Data Discovery Tool allows users to survey IRSA's holdings to see what data (images, catalogs, spectra) overlap a position on the sky.

The results from this tool include a spectral energy distribution (SED) obtained from either NED (works best for extragalactic objects) or VizieR.

The results from this search also include an option to pass the data to IRSA Viewer, which is a different tool, or other tools at IRSA.

Different data sets have different DOIs; see the page corresponding to each data set to find the DOI and canonical paper to cite.

. Note that you can use the \facilities call in AASTeX to acknowledge IRSA as a facility you used in your journal article.

Searching

See the searching section for more information on how to search.

Results: Visualization

The images loaded into the visualizer appear in a 'window pane' in the top left of the results of your search.

See the visualization section for more on visualization.

Results: Tables

Search results appear in an interactive table at the bottom of your results. These tables can be sorted and filtered. See the tables section for more on tables.

Results: Links in Tables

Search results within the tables can be loaded into other tools at IRSA, such as IRSA Viewer, Atlas, or tools specific to individual missions. Click on the link to launch the other tool, and consult that tool's documentation for more details.

Results: Plots

A spectral energy distribution (SED) obtained from either NED (works best for extragalactic objects) or VizieR appears in the upper right of your results. See the Plots section for more on plots.

Results: Links at the Bottom

Links at the bottom of the search results page will send you to Finder Chart (another IRSA tool, pre-loaded with your target), NED (another IPAC archive, pre-loaded with your target), or Vizier's SED service (a tool in France, pre-loaded with your target).

Data Discovery Tool: Searching

The Data Discovery Tool allows users to survey IRSA's holdings to see what data (images, catalogs, spectra) overlap a position on the sky.

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Single Object: Coordinate or Object Name

Enter the name or coordinates (decimal degrees or sexigesimal format) of the center of your position search. If the input string cannot be recognized as coordinates, then it will be sent first to NED, then to SIMBAD to attempt name resolution.

Examples of valid inputs include:

- m83
- 17h 44m 34s -27d 59m 13s Equatorial J2000
- 17h44m34s -27d59m13s
- 00h42m44.3s +41d16m08s b1950
- 00:42:44.3 -41:16:08
- 00 42 44.3 -41 16 08 b1983
- 004244.3 -411608
- 17h -27d Equ J2000
- 17h -27d
- 34.5565 54.2321 gal
- 34. 54. ecl

Cutting and pasting from other sources can be done quickly and data entry in general can be performed without moving back and forth between the keyboard and mouse.

Search Methods

A search performs a cone search on a single contiguous region of the sky, returning sources within the specified radius.

NOTE THAT the smallest search radius you can use is 30 arcseconds. The largest search radius you can use is 6.25 degrees.

In order to be listed in the results, a data set must intersect the search region specified by the cone search center and radius. *Images are approximated as circles for determining intersection with the search radius. So are spectroscopic slits.* As such, then, the search results are an estimate, and additional work will be required to determine how useful the data set is. Click on the link corresponding to each row of the search results to send the data set to another IRSA tool and assess whether or not the data set actually intersects your target.

Each data set is queried separately and given equal weight. This means that you can get preliminary releases that are superceded by later releases.

Spectral Energy Distributions

The tool also provides for you as part of the search results its best guess as to the spectral energy distribution (SED) of the object.

See this section for more about exactly what it is doing to obtain this.

Data Discovery Tool: Images

The Data Discovery Tool returns an image for orientation purposes as part of the search results. This chapter covers the basics of that; visualization tools are covered in another chapter. It can load images that are FITS and HiPS formats. Any catalogs you have loaded are overlaid on the images; see visualization chapter for more information.

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HiPS Images: General Information & Definitions

HiPS stands for hierarchical progressive surveys, and these kinds of images are multi-resolution HEALPix images (where HEALPix stands for Hierarchical Equal Area isoLatitude Pixelation). (Also see IVOA docs on HiPS.) In practice, what this means is that you can interact with images of a very large chunk of sky, and as you zoom, the pixel size changes dynamically. HiPS images are fundamentally different than FITS images, and as such, what you can do with the HiPS images are different than what you can do with the FITS images.

The whole point of HiPS images is to provide on-demand resolution changes. Zoom out, and it loads large pixels. Zoom in, and it loads smaller pixels. HiPS images are designed to cover large areas of sky efficiently. If you need to visualize many degrees, this is the image type to use.

There are HiPS images from all over the world available via the web; the complete list of HiPS images available from the images search page includes (once the "IRSA Featured" checkbox is unchecked) many HiPS images from CDS.

HiPS images typically have the color and stretch set by the person who originally made them. The color table can be remapped within this tool. But, you cannot, in general, change the stretch of HiPS images with as much flexibility as you can with FITS images. This is why there may be multiple versions of some data sets in the list of HiPS images.

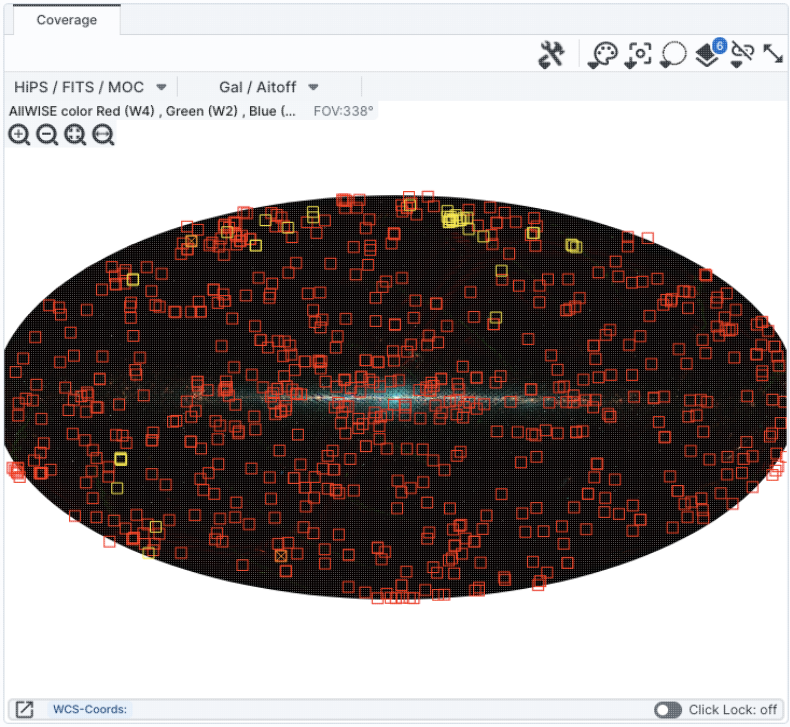
HiPS maps typically come with a **Multi-Order Coverage map (MOC)**. A MOC is a format developed by the International Virtual Observatory Alliance to specify sky regions. In this context, a MOC tells you via a simple boolean yes/no, is there sky coverage from this data set in this region. You can overlay a MOC from one data set onto a completely different data set's HiPS image.

Coverage Image

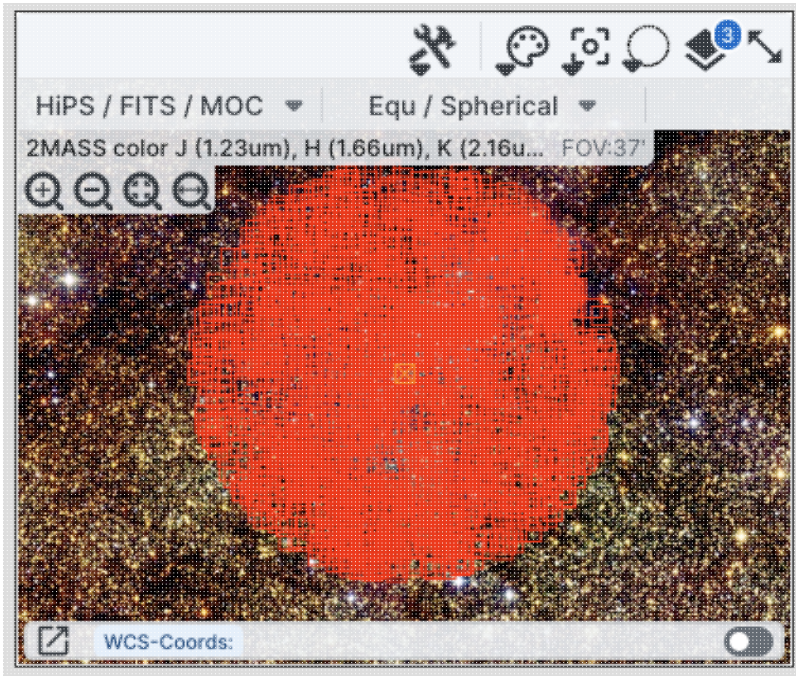
The Catalog Search Tool provides for you a "coverage image", which is basically a way for it (and you) to keep track of where you are working on the sky. This is provided on the upper left of your search results.

You may have a coverage image like this -- this is an example of a coverage image showing two different overlaid catalogs.

Note that in this case, the catalogs cover the whole sky, so the HiPS image is displayed in HiPS/Aitoff projection to show the whole sky.



You can also have a coverage image like this, which shows a coverage image with a catalog overalid. This case only has data over a relatively small region, so the HiPS image is zoomed in comparatively tightly on the relevant region.

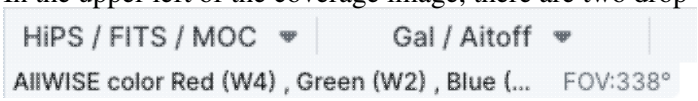


In all cases, you can interact with the coverage image in pretty much exactly the same way as you would any other image loaded into this tool; see the the visualization chapter for much more about those tools.

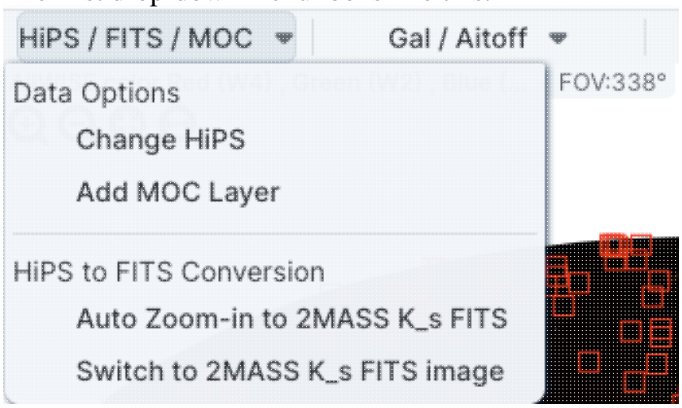
The thing that makes a coverage image a little bit different, however, is that it can automatically adapt, even beyond what a HiPS image can intrinsically do. The next subsection includes more details about how it can automatically change to accomodate your needs and zoom level.

Upper Left HiPS menus

In the upper left of the coverage image, there are two drop-down menus.



The first drop-down menu looks like this.

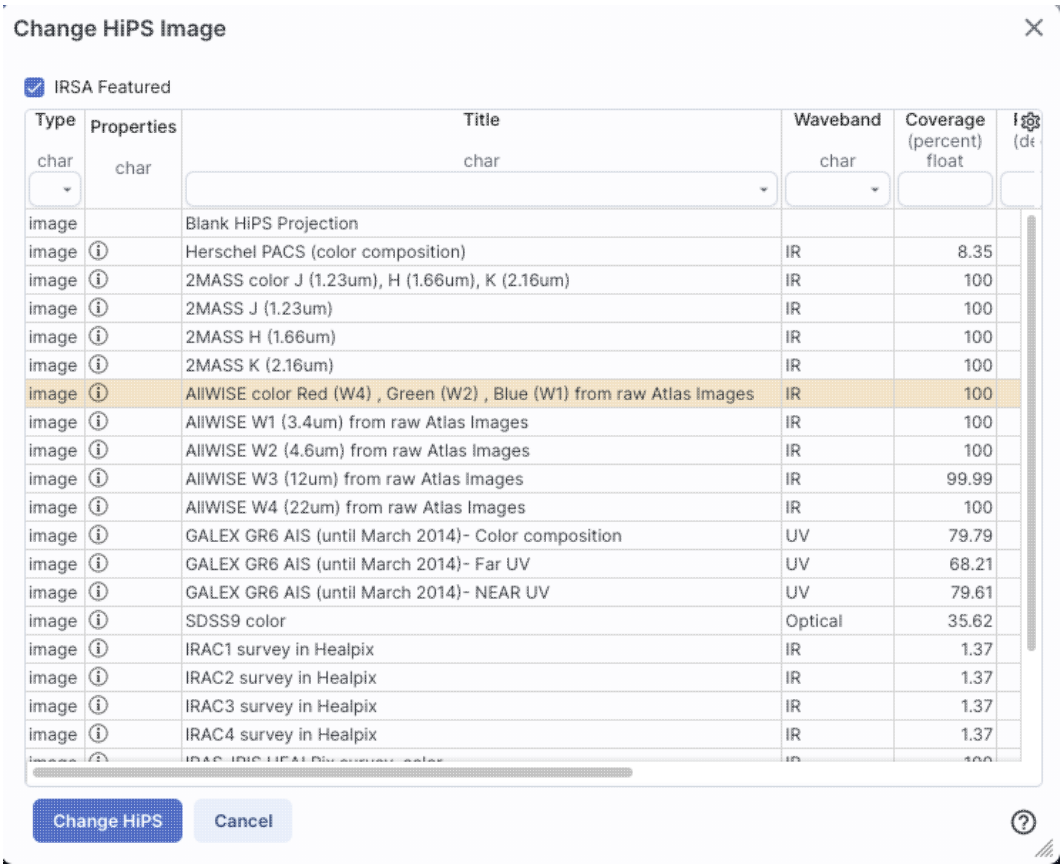


There are two sections here.

Under "Data Options", you can change what data are shown.

Change HiPS: Changing HiPS images

The choices made by any given creator of a HiPS image may result in any particular region being saturated or too faint to see. Color stretches are set by the creator of the HiPS map and cannot be changed; color tables can be somewhat changed by this tool, but that may be insufficient for your needs. If the HiPS map as shown does not suit your needs and you wish to change the HiPS image, click on the "HiPS/MOC" menu, and then click "Change HiPS". It brings up this pop-up, which resembles the HiPS search above:

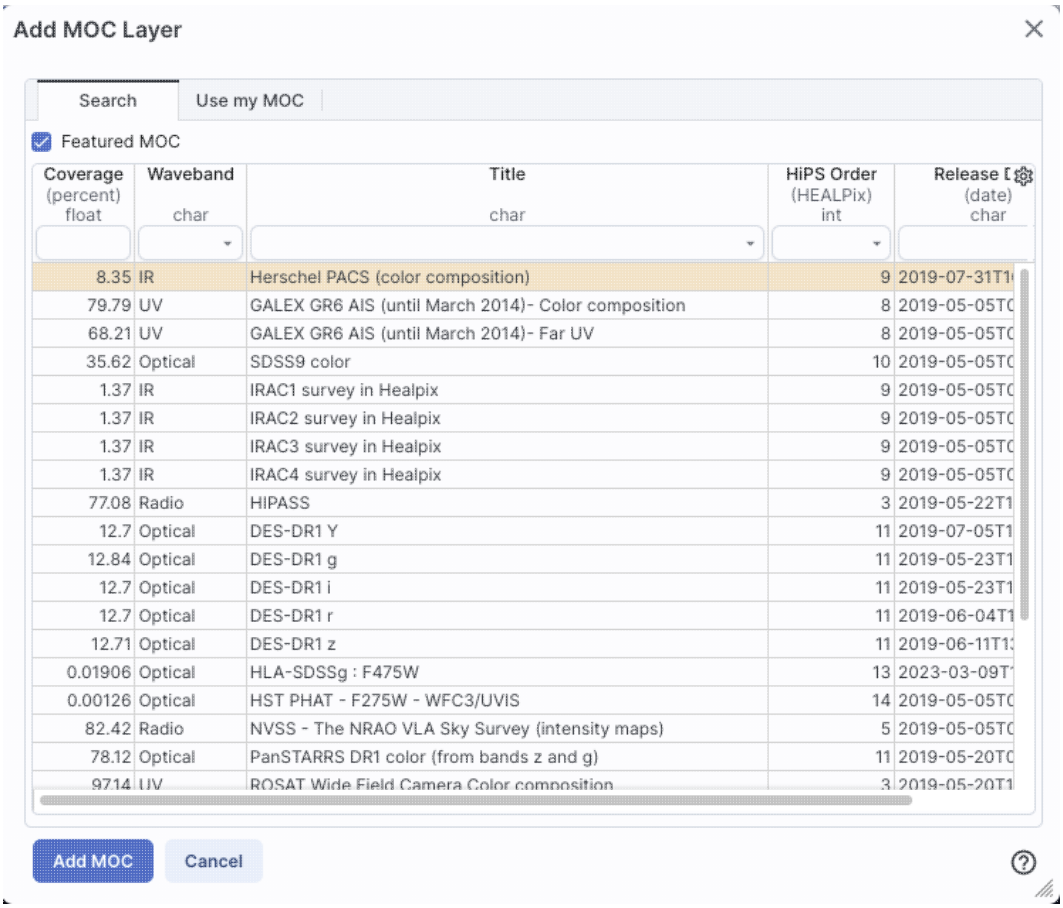


Things to note:

- To select a new image, click on the row corresponding to the new HiPS image you want, and click "Change HiPS" on the bottom left.
- To cancel without selecting a new image, click "Cancel."
- This is an interactive table, so all the filtering and column manipulation tools apply here too. You can filter down the columns to find the image you want to use.
- To learn more about each HiPS map, click on the i with the circle in the second column. It will spawn another window with standardized information about the HiPS map.
- By default, it shows HiPS maps corresponding to IRSA data collections. To see a more comprehensive list, unclick the box marked "IRSA Featured."

Add MOC Layer: Adding a MOC Overlay

It is often useful to see what other data are available. Looking at a Herschel/PACS far-IR HiPS map? Overlay a Chandra MOC to see what X-ray data might be available to go with your IR data. Click on the "HiPS/MOC" menu, and then click "Add MOC Layer." It brings up this pop-up:



Things to note:

- Coverage (the first column) is the fraction of the sky covered by that MOC.
- To select a new MOC, click on the row corresponding to the new MOC you want, and click "Add MOC" on the bottom left.
- To cancel without selecting a new image, click "Cancel."
- This is an interactive table, so all the filtering and column manipulation tools apply here too. You can filter down the columns to find the image you want to use.
- By default, it shows MOCs likely to be most interesting for IRSA users. To see a more comprehensive list, unclick the box at the top left.
- If you have your own MOC FITS file, you may upload it via the "Use my MOC" tab on the top center.
- If you try to upload a MOC FITS file via the upload tab, it will behave as if you have uploaded it here.

Under "HiPS to FITS Conversion", you can control whether the viewer will automatically toggle between image types as needed.

By default, the coverage image is most likely a HiPS image. FITS images are best for small regions of the sky, and HiPS images are best for large regions of sky.

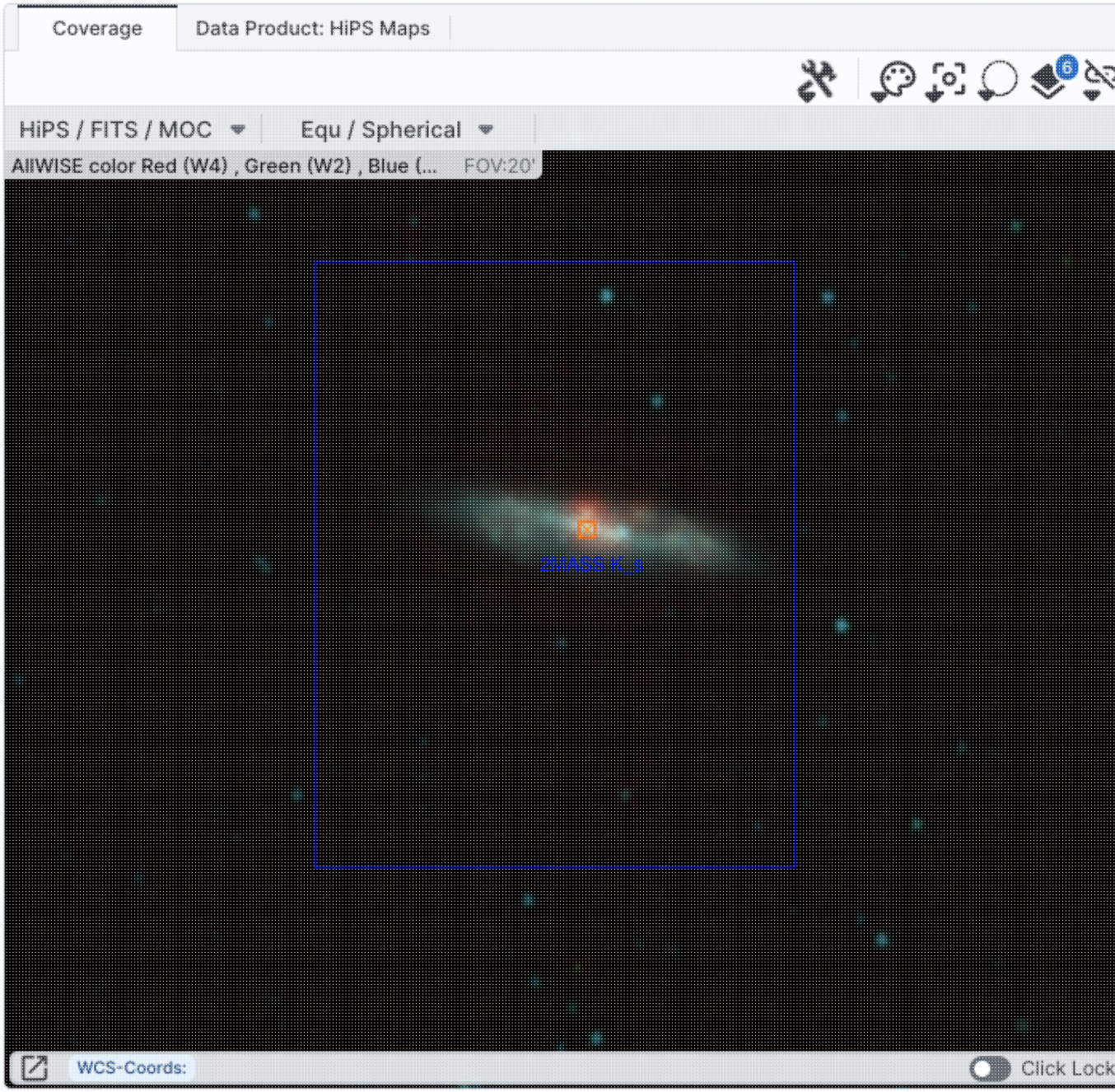
Auto Zoom-in to 2MASS K_s FITS:

If you select this, then when you zoom in very close to a target, it will automatically convert to a FITS image when you get close enough.

Switch to 2MASS K_s FITS image:

If you select this, then it will jump directly to a FITS image centered on the currently selected target.

Note that if you swap between HiPS and FITS and back again, it will include a region on the HiPS image that is the footprint of the FITS images you had just loaded. A label appears at the center of that footprint, which may be disconcerting if you are not zoomed out enough to see the region itself. Here is an example, zoomed out so it is more clear what is going on:



The second drop-down menu looks like this.

There are three sections in this menu.

Orientation

Under "Orientation", you can control whether the coordinates are in Galactic or Equatorial J2000 (RA/Dec). This can be used in conjunction with the image readout and/or the coordinate layer button (both described in the visualization section)

Center Galactic

If you select "Center Galactic", the HiPS image slews to put Galactic North up, the Galactic Center in the center of the field of view, and the Galactic Plane horizontally across your field of view. This is useful if you have been zooming or scrolling around to look at individual sources and need to bring it back to a familiar orientation quickly.

Projection

Under "Projection", you can control whether the display is in Spherical or Aitoff coordinates. Aitoff projection works better for all-sky displays.

Data Discovery Tool: Visualization

Once you have launched the visualizer portion of the application, a window appears with an image pane that is populated with an image related to your search. This section describes the available tools for working with that image.

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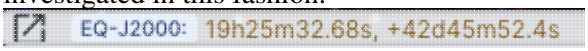
FITS/HiPS Image Viewer

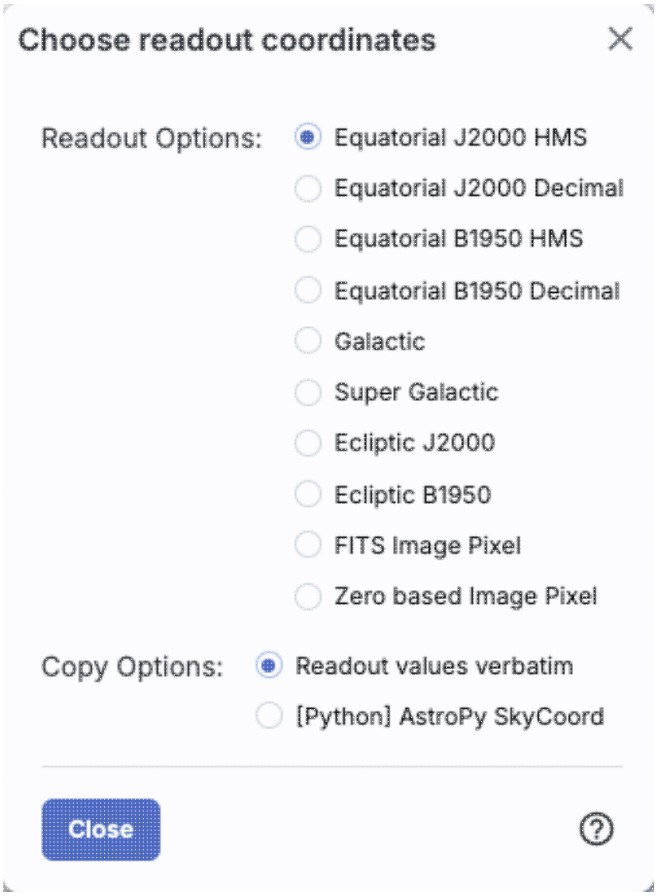
You can interactively explore the image with the mouse. Move your mouse over any image that is loaded into the viewer. Details about the image, specifically, the pixel beneath your mouse cursor, appear along the bottom left of the image window. The image coordinates are updated in real time. The image can be interactively investigated in this fashion.



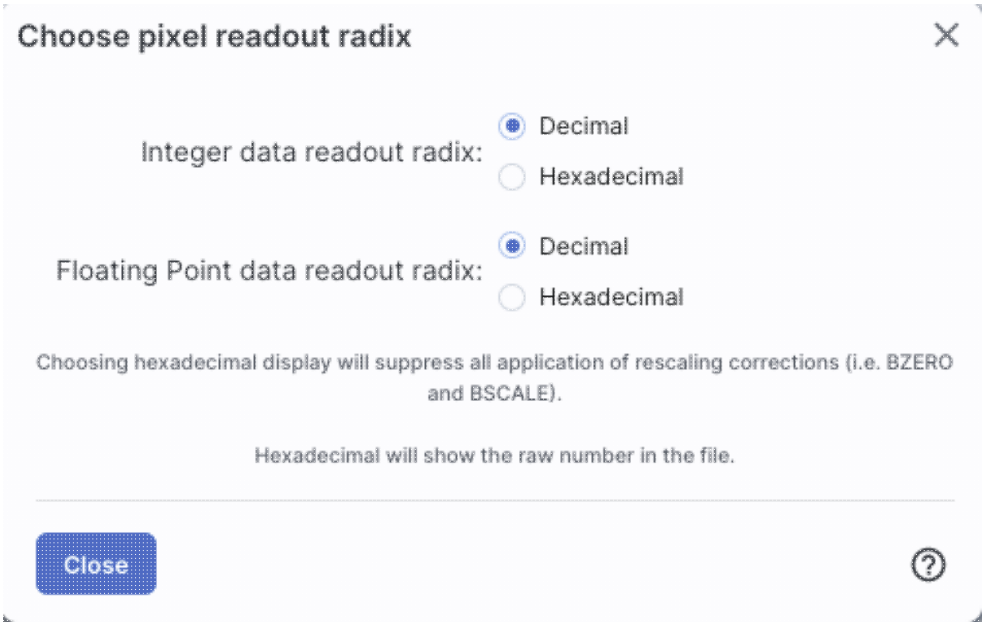
If you click on the label of the coordinates, "EQ-J2000" in the screenshot example above, you get this pop-up, from which you can choose the coordinates from among:

- Equatorial (RA/Dec) J2000 in hh:mm:ss ddd:mm:ss format
- Equatorial (RA/Dec) J2000 in decimal degrees
- Galactic in decimal degrees
- Equatorial B1950
- Ecliptic J2000
- Ecliptic B1950
- FITS Image Pixel
- Zero-based Image Pixel

If you click on the "click lock" toggle, the coordinates stop dynamically updating when you move your mouse, and they update only when you click on the image. When you do that, little clip boards appear next to each coordinate readout; clicking on those copy the position to your clipboard. From this pop-up window here as shown, you can control the format of the



coordinates that are copied to your clipboard -- they can be as shown in the readout, or in the format that Python is expecting (for easy pasting into code).



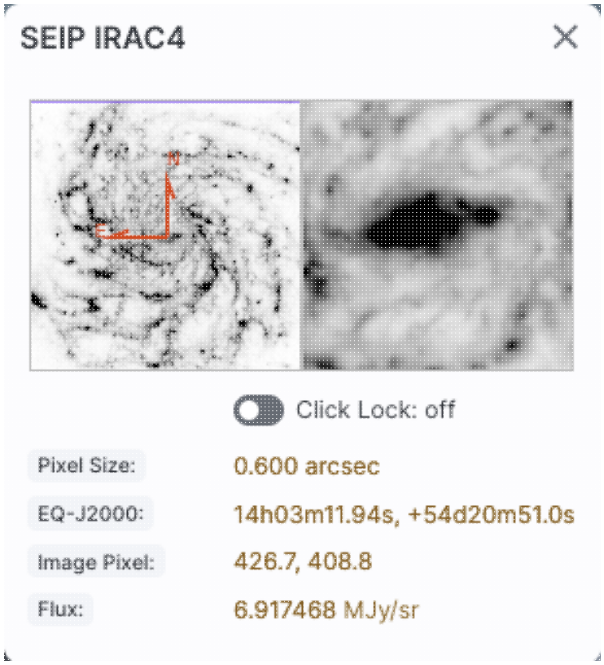
If you have a FITS image loaded, you have an additional readout. Click on the label of the readout, "Value" in the screenshot example above, you get this pop-up, from which you can choose the pixel readout from among:

- Integer data readout in decimal
- Integer data readout in hexadecimal
- Floating point data readout in decimal
- Floating point data readout in hexadecimal

If you choose the hexadecimal options, it will suppress all rescaling corrections found in the

header, like BZERO or BSCALE. It will just show you the raw binary number in the file. (For example, if the value in decimals is 5.13795757, the binary value in the file is 0x40a46a26; here is a conversion tool between decimal and hex.)

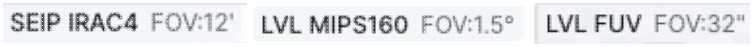
In the lower left of the images, if you click on this: , you get this pop-up. If you have a FITS image loaded, at the top of this pop-up, it shows the whole image; the orientation of the image is given with a compass rose. There is also a zoom-in of the image at the location under your cursor. Underneath that in the pop-up, whether you have a FITS or HiPS image loaded, you can get a readout of the pixel size, a readout of location on the image in two different coordinate systems, and a readout of the pixel value. You can change the units of those values by clicking on the name of the field: "Pixel Size", "EQ-J2000", "Image Pixel", and "Value". Each results in a pop-up, as above.



You can make the cursor 'stick' on a particular place on the image -- tick the "Lock by click" box (either in the pop-up or in the lower right of the image window), and then click on the image at your desired location. When this is clicked, small "clipboards" appear near the position readout. Click on that icon to copy that position to your clipboard.

Image Information

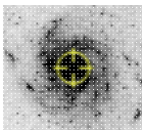
The upper left corner of the loaded image has a label that tells you basic things about the image you are viewing. The telescope and/or instrument and/or channel and/or data release is first, in black. The field of view follows, in a paler font; this corresponds to the (horizontal) width of the image window. The currently selected image is outlined in brown; other images are outlined in grey.



Here are three examples of image labels. The first is from Spitzer Enhanced Imaging Products (SEIP), IRAC channel 4, which is 8 micron data, and the field of view is 12 arcmin. The second is from data delivered by the Local Volume Legacy (LVL) project, and it is from MIPS channel 3, which is 160 micron data; the field of view is 1.5 degrees. The third is also from the LVL project, but it is far-ultraviolet (FUV) data, and the field of view is 32 arcseconds.

For HiPS images, the FOV is the angular size of the width of the HiPS viewer. Even if the image as displayed is smaller than the window, the FOV readout is the width of the window, not the image. If you shrink your browser screen, the FOV can get smaller because the viewer gets smaller. If you load more than one image, the FOV can get smaller because two viewers must fit in the same pane. As a result, the HiPS FOV requested in the search panel is approximate.

For FITS images, the FOV label on FITS images works analogously to the FOV label on HiPS images. If you zoom out, the FOV will increase even when the FITS image is entirely within the viewer. That's because the FOV is what the viewer can show you based on the pixel size. If you drag the image so that it is only partially seen through the viewer, the FOV will not change. For FITS images, the cutout size is not the same as the FOV.


The target on which you searched is overlaid on the main image with a cross-hair marker, sometimes called a "reticle." You can remove this (or change its color) from the layers pop-up, described below.

Breaking Out of the Pane (and Going Back)

Panes: The screen is broken up into panes - one for the coverage image on the upper left, one for the plot on the upper right, and one for catalog on the bottom.

Make it big! For some purposes, it is useful to individually view just the table, or the images, or the plots, as large as possible. In any pane, this icon  appears in the upper right of the pane. Clicking on it will expand the pane into a larger window, as big as possible given your browser size.

Go back the way it was: 

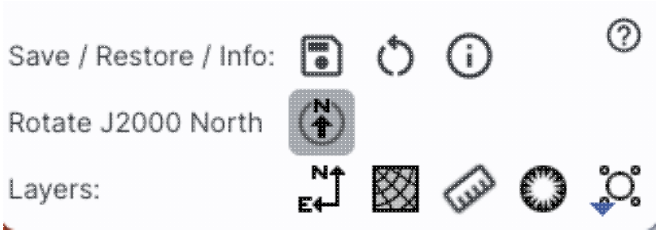
The large "Close" arrow at the upper left is always available in the expanded views, and enables you to return back to the pane view.

Image Toolbar (FITS and HiPS)

The image toolbox:

is always present as a row of tools associated with the image loaded on your behalf. Letting your mouse hover over any of these icons will result in a "tool tip" that appears in order to remind you what the icon does. Most items apply equally to FITS and HiPS images, but some only apply to FITS images.Many of the icons have a downward pointing black triangle, which means that there are additional options in a drop-down menu that appear when you click on the icon.


Tools drop down
The choices here look like this:



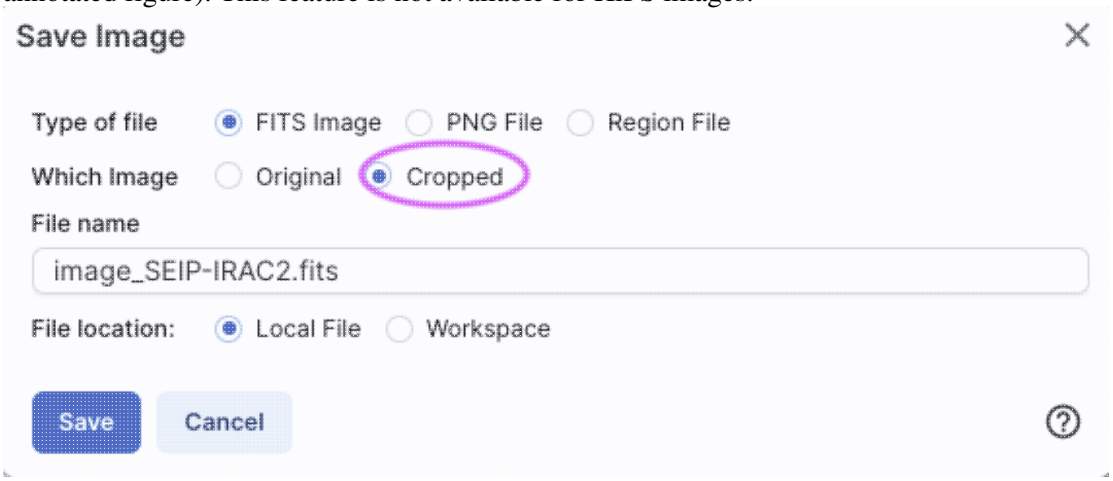
jump to save
jump to rotate
jump to layers

Saving the image

The diskette icon will allow you to save the current image. You can save files to your local disk or to the IRSA Workspace. Note that **you** control where the file is saved on your disk through your browser; your browser may be configured to store all downloads in a particular location on your disk.

If the current image is a FITS file, you can save it as a FITS or PNG or regions file to your local disk. If it is a HiPS file, your only choices are PNG or regions file. Saved FITS images will not save the color stretches or overlays; it will just save the underlying FITS image. Saved PNG files WILL include any overlays or annotations you have placed on the image, but will not include the underlying FITS image. Saved regions files will not save the underlying image, but will just save the overlays as a DS9 Regions file. See the DS9 website for more information on the syntax of these DS9 region files.

Note that you can save the original or a cropped version of a FITS file; see the "select region" icon below to crop, then click on the save icon. Be sure to save the cropped FITS image (see annotated figure). This feature is not available for HiPS images.



The saved PNG is the same size as it is on your screen. If you want a big version, make the desired image big on your screen before saving the PNG.

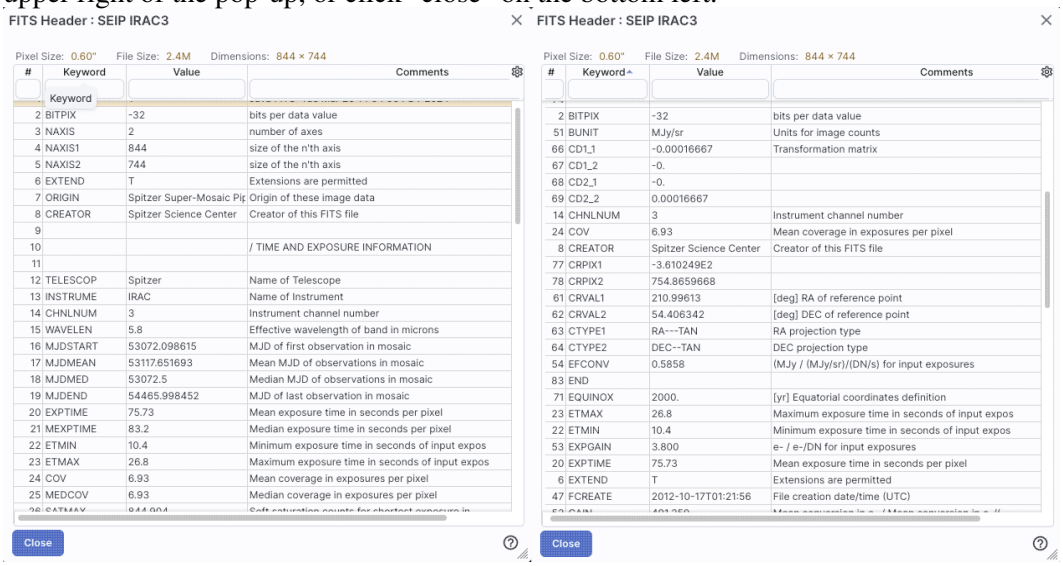
You can't save HiPS images from within IRSA's tool. To download your own copy, you will have to track down the original source of the image.

Restoring everything to the defaults

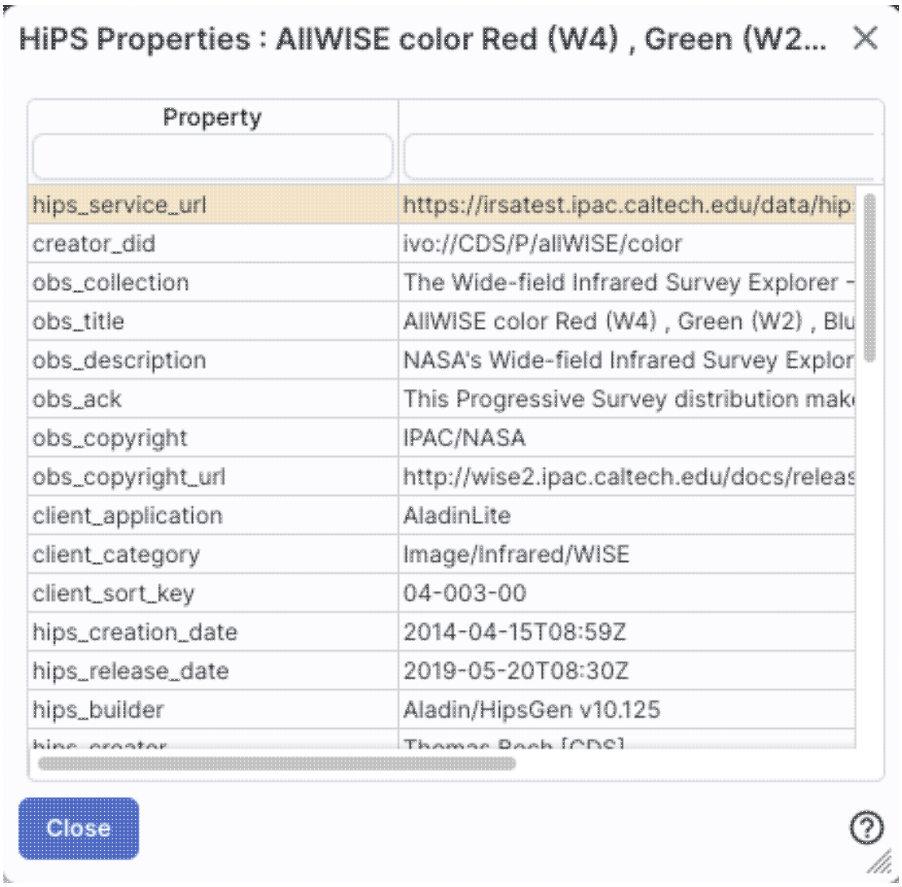
If you've played around a lot with the image, you may want to undo everything you've done. Click this button to restore everything to their original default values. Some layers may persist; remove them via the layers icon.

Viewing the image header

This icon displays a pop-up window with information about the image. If a FITS image is selected, it will show the FITS header of the image; if a HiPS image is selected, it will show the HiPS properties of the image. These are Firefly tables like all the other tables in this tool, so they are sortable and filterable, etc. If you click on the columns in the pop-up, it will sort the keywords alphabetically by that column. This is useful for finding individual keywords in particularly densely populated FITS headers. Click the header again to sort in reverse-alphabetical order, and a third time to return to the default order. Below are examples of an original and sorted FITS header. To make this window go away, click on the 'x' in the upper right of the pop-up, or click "close" on the bottom left.



For comparison, an example of the HiPS properties window is here:



Rotating the image so that North is up

Images retrieved in the Catalog Search Tool are frequently already oriented such that North is up, or close to it. However, when interactively investigating images, or loading images from other sources, you could find yourself in a situation where North is not necessarily up. Clicking this icon will orient the selected image so that North is up. (This option is only available for FITS, not HiPS, images.)

Flipping the image on the y-axis

Clicking on this icon flips the image on the y-axis. (This option is only available for FITS, not HiPS, images.)

Add a compass rose

When you click this icon, arrows appear on the image showing which direction is North and which is East. Clicking on this icon a second time removes this compass rose. (You can also remove this layer via the layers icon, described below.)

Add a coordinate grid

Click on this icon to overlay a coordinate grid on the image. (Only available for FITS images, not HiPS, but see information on HiPS grid in the WCS section.) Click it again to remove it. Customize the units of the grid (to, e.g., Galactic coordinates) via the "layers" icon (described below).

Measuring a distance

When you click this icon, at first, nothing seems to happen. However, you can now click and drag to draw a line on the image, and the length of the line is displayed (in the middle of the line). The units for the measured distance (and the color of the overlay) can be changed from the "layers" icon (described below). You can calculate the difference in RA and Dec separately via the layers icon as well; find the layer associated with the distance measurement and tick the "offset calculation" box. When it displays the offset calculation, it will give you the angle in degrees in one corner, and the length of the line segment in the RA and Dec directions, in the units you have specified. When you are done with the distance tool, you can click on the

that appears next to the image toolbar, or click on this icon a second time to remove the distance tool. (You can also remove this layer via the layers icon.)

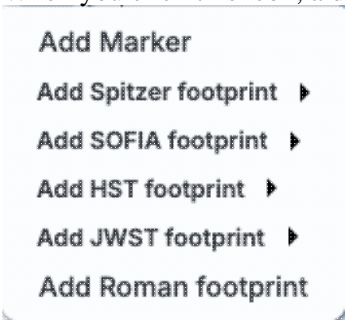
Read in a DS9 Regions file

When you click this icon, you get a pop-up window from which you can read in a DS9 regions file from your local disk. See the DS9 website for more information on the syntax of these DS9 region files. The supported regions are text, circle, box, polygon, line, and annulus. To make this window go away without doing anything, click on the 'x' in the upper right of the pop-up.

Tips and Troubleshooting: If you overlay a list of sources you created in ds9 regions format from your disk, it will only be overlaid on the current image, not all of the images you have loaded. If you want to have it overlaid on all the images you have loaded, create a catalog from your source list and overlay it as a catalog. Then it will appear on all of the images you have loaded, provided that the positions overlap on the sky.

Put a marker on the image

When you click this icon, a drop-down menu appears with several possible options:



The first overlay choice (simply called 'marker') is a red circle. Initially, it appears in the center of the images, and is meant to be moved to wherever you first click in the image. It looks like this:

. The dash-dot line around it means that it is 'active', so you can move (click and drag the marker) or resize it (click and drag the dash-dot boundary). You can change the color of the marker (and change the label) via the "layers" icon (described below). You can also remove this layer via the layers icon. There are several additional options in the drop-down, enough that they have their own section below.

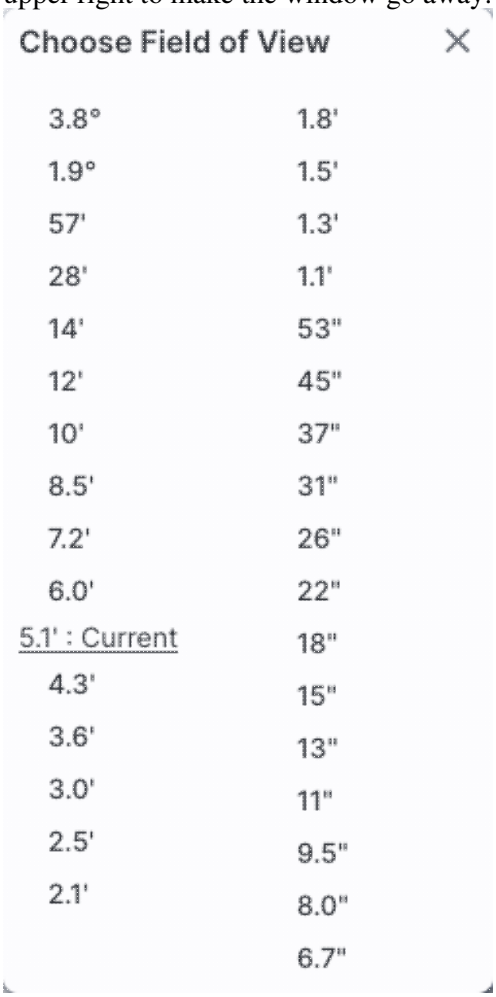
Zoom

When your mouse is in an image, these options appear in the upper left of the image.

Zooming in or out

Clicking on these magnifying glass icons zooms in or out of the image. The readout of the net effect of your zooming on the displayed field of view (FOV) appears at the top left of each image.

If you click zoom in or out rapidly, a pop-up window appears to allow you to more rapidly select the zoom level (field of view) you want. Select the desired level, or click on the 'x' in the upper right to make the window go away. Here is an example:



You can alternatively zoom using the mouse wheel (or drag forward and backward on a touchpad or magic mouse).

Note that there is a maximum (or minimum) allowed zoom level, and they are different for FITS and HiPS images. A notification will appear when you have reached the maximum (or minimum) allowed zoom level for a given image. To enlarge images more (or less) than that, please repeat your search to obtain new images with smaller (or larger) spatial extent. HiPS images are specifically designed for large areas, so if you need a big area, use HiPS. If you want to zoom in close enough to see individual original pixels, your best choice is FITS.

See also the section in the Images chapter on changing coverage images, specifically that on automatic transitions while zooming.

Fit image to screen or fill screen

These two icons are designed to maximize the available space in your browser window. The first one automatically picks a zoom level such that the image entirely fits within the available space (which could be your whole browser window, or just the portion of it where that image is loaded). The second one automatically picks a zoom level such that the image fills as much of the available space as possible (e.g., it is zoomed such that short axis of the window is filled with the image, whether that short axis is left-right or up-down).

By default, the images that are returned are frequently but not always centered on your search target. Clicking on these icons let you see the whole image that is returned, whether or not it is centered on your target.

This is available for both FITS and HiPS images, though note that FITS images retrieved from IRSA using this tool are typically square, and HiPS images cover the sky, so fitting the image to the screen might not be what you want to do.

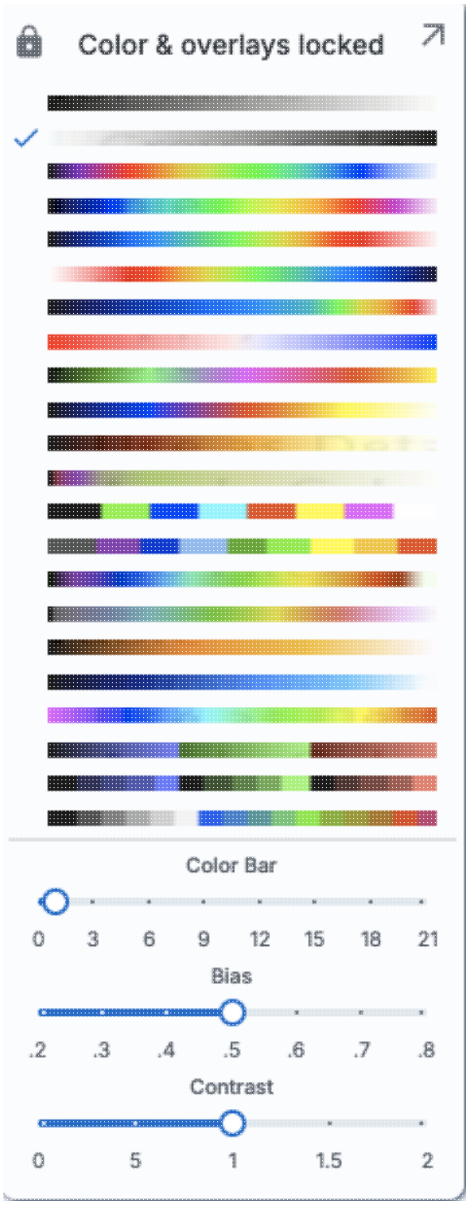
 *Zooming to a 1-to-1 size*

Clicking this icon will zoom the image such that one pixel in the image is one pixel on your screen. This option is only available with FITS images; HiPS images by their nature have pixels of varying sizes, so this button would have no meaning in this case.

 *Color table drop down*

This icon enables you to change the color table of the displayed image. (This option is available for FITS and HiPS images.) When you click the button, a drop-down menu appears.

- The top of the menu either says "Color and overlays locked" or "Color and overlays unlocked" -- by default, all of the (FITS) images that you have loaded are locked together for color and overlays. What that means is if you change the color table (via this menu), then the color table for all the (FITS) images are changed. (Or, if you add a layer to one image, then the layer is added to all the images; see below.) If you don't want this to happen, select "Color and overlays locked" to unlock it. Select the text again to lock it again.
- The arrow in the upper right creates a pop-up window out of this drop-down menu so that you can leave the choices up while settling on the best option.
- The next portion of the menu has a wide variety of color table choices. Select your new color table from the options shown.
- Alternatively, you can use the "color bar" slider to move among the color tables by number. These numbers correspond to the color bar number used in the Python implementation of the Firefly tools.
- Below the color bar slider, there are sliders controlling the bias and contrast. Click or drag the slider to change the image display.



Color stretch drop down

This icon enables you to change the color stretch of the displayed image. (This option is only available for FITS, not HiPS, images.) Because this is complicated, for much more information, please see below.

Re-center the image drop down

Clicking this icon produces a drop-down menu:

By default, "Pan by table row" is turned on (checked), but, depending on how you have loaded your images, or whether you have catalogs loaded, it may not seem to do very much. However, if you have a catalog loaded and are zoomed in on your images, as you scroll through your catalog, the FITS image underneath will move as needed when you have selected an observation in a different part of the sky than was originally shown.

Other choices are to center on the target of the observation, center the image in the window, or center on a target of your choice. For the last of those, you can simply center on that target, or center and leave a marker on the image at that location.

The last option may or may not appear, depending on what you have been doing before getting to this screen. If it can, it gives you a choice to center on recent positions. Move your mouse over to the black arrow to select from a list.

Selecting a region drop down

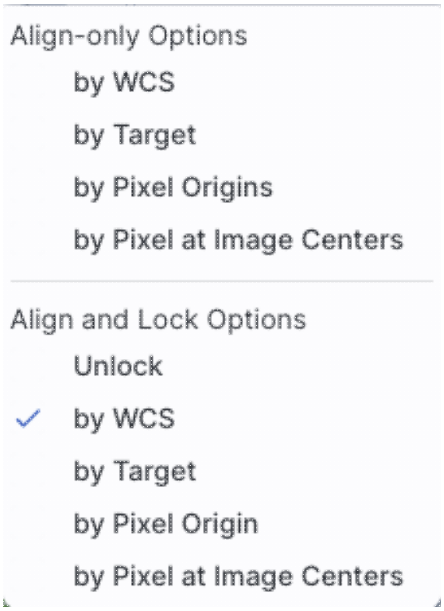
When you click this icon, you can select a region of the image for further actions. Because this is complicated, for much more information, please see below.

Image Layers: Viewing/Changing the Layers on the Image

Every time you add something new to the image, you add a 'layer' to the image. This is complex, so please see below for much more information.

Lock/unlock images

You may have this "lock images" icon appear in your toolbar; it will appear as the first icon if they are locked and the second icon if they are unlocked. The main purpose of this icon is to lock all the images you have loaded for zooming, scrolling, etc. You need to specify how it locks and for how long. Clicking it produces this drop-down menu:

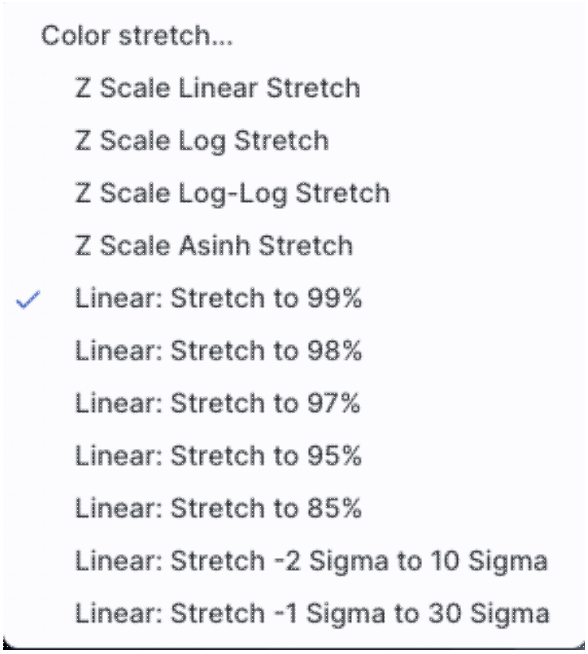


The first set of options aligns the images only once, temporarily; the second set of options makes the alignment persist ("lock") when you move the images (that is, when you move one, they all move). You can align by the images' WCS (e.g., RA and Dec), by the target, by the pixels according to the origin of the coordinate system in the image header, or by the pixel at the image center. The most common choice is likely the WCS align and lock. You can align FITS and HiPS images to each other. This is discussed in more detail in the WCS section.

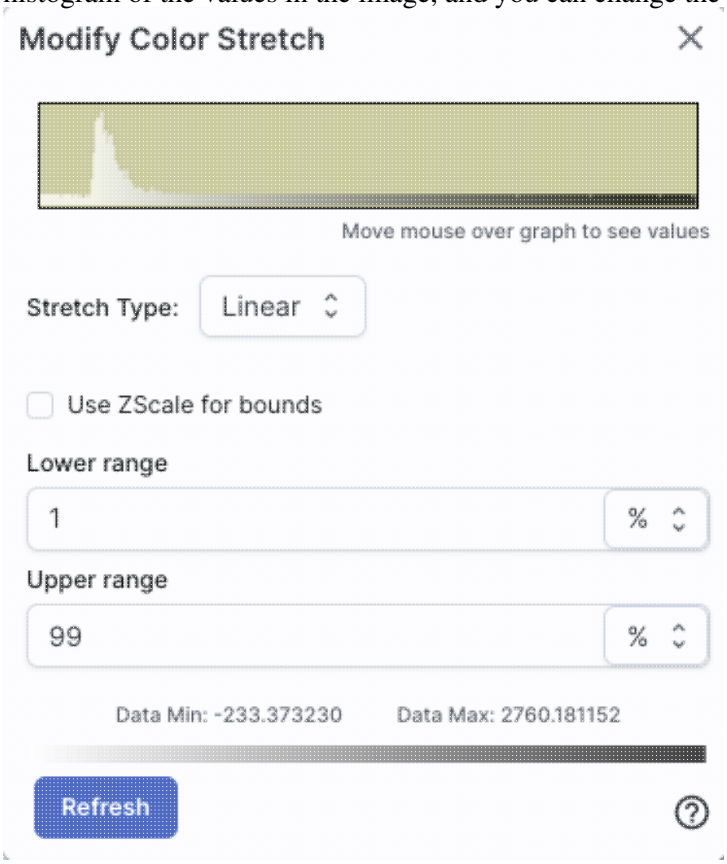
Getting help
Clicking on this icon takes you to this help page.

Color Stretches

This icon enables you to change the color stretch of the displayed image. (This option is only available for FITS, not HiPS, images.) When you click the button, a drop-down menu appears with a variety of choices. You can choose from a set of pre-selected options:



If you pick the first one, "color stretch", you can customize the stretch. A pop-up window appears with a histogram of the values in the image, and you can change the stretch type and range.



If you pick a color stretch from the pre-defined options, the pop-up window reflects this change. If you change the color stretch in the pop-up window, the drop-down menu changes correspondingly.

Example: Display the pop-up for color stretch. From the main drop-down, pick 'Linear stretch to 99%'. Go back to the color stretch pop-up. Note that it has filled out the stretch type and ranges to reflect the current choice. Then -- either with the pop-up window still up or not -- go back and pick a different pre-defined stretch

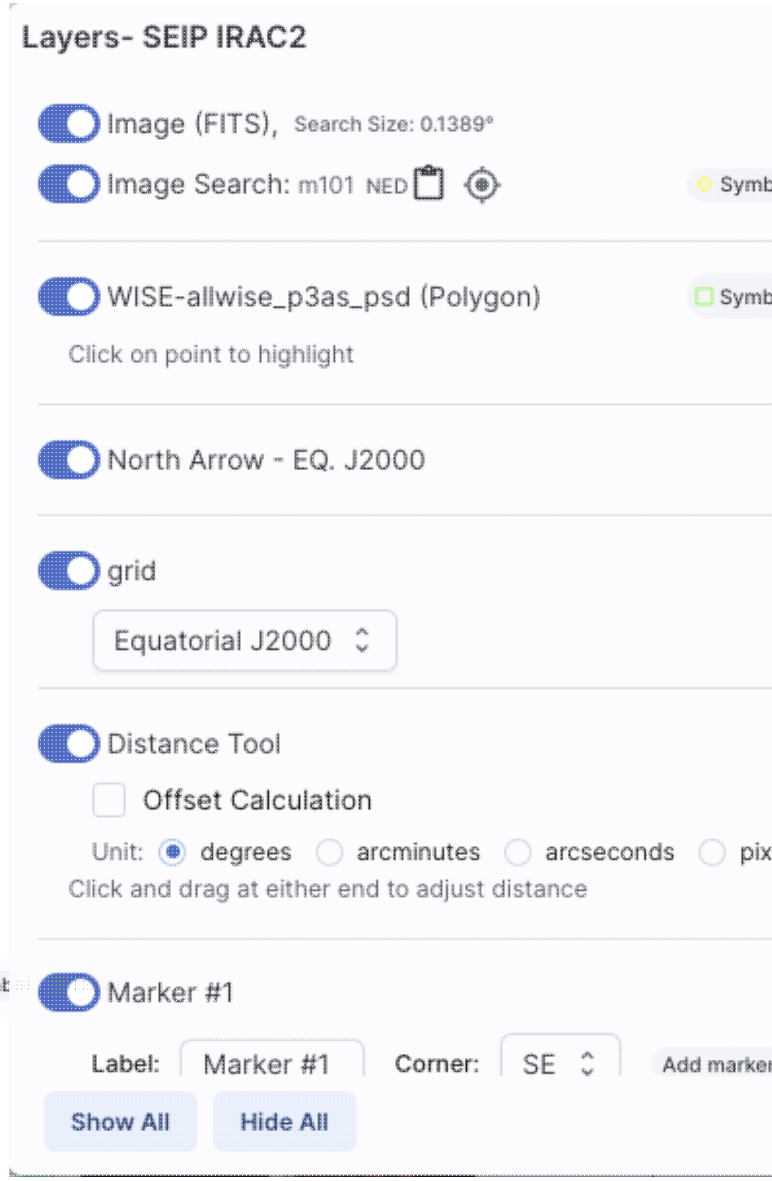
from the standard options. Note that the values in the pop-up change to reflect this current choice. From the pop-up, pick a different stretch type -- try "histogram equalization." Select "refresh" to update the images. Go back to the drop-down menu. The last 7 items have changed to be based on histogram equalization, as opposed to the "linear" default.

Viewing/changing the layers on the image

Every time you add something new to the image, you add a 'layer' to the image. You can have an image with a lot of annotations on it.

The number that appears circled in blue over the layers icon tells you at any given time how many layers you have on the currently selected image (the image outlined in brown).

If you click this layers icon, you will get a pop-up window with a list of all the layers you have on top of the image. Here (on the right) is an example of a well-populated layers pop-up; in real life, this is scrollable to see several more layers). From this pop-up, you can:



- turn layers off and on (click on the switch on the left of the corresponding row);
- remove layers entirely (click on the 'x' on the right of the corresponding row);
- change colors of overlays (see below);
- change symbol shapes and sizes (for overlaid catalogs);
- change annnotations (for markers);
- or change units (for the coordinate grid or the distance tool).

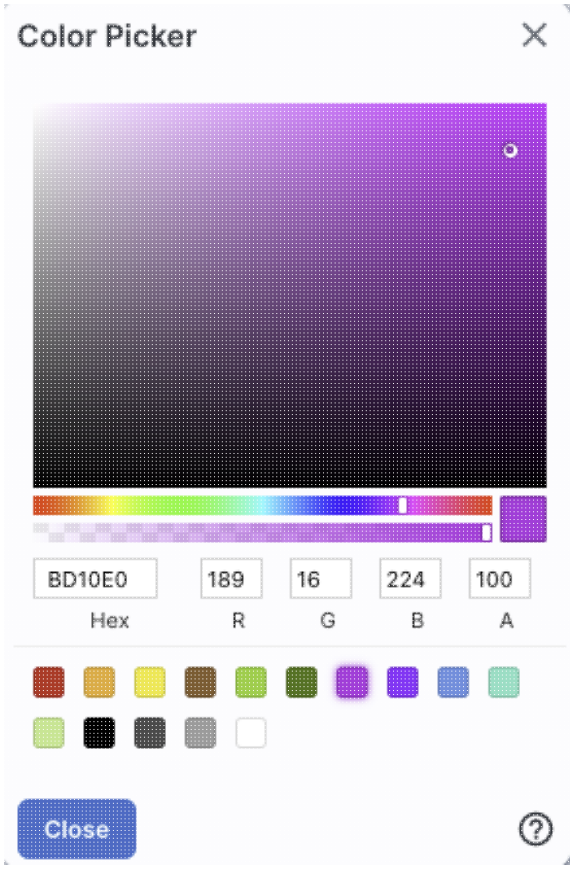
To add entirely new layers, though, you need to go to other options within the toolbar.

You can "show all" or "hide all" with the buttons on the lower left of the pop-up window. To make this pop-up window go away, click on the 'x' in the upper right of the pop-up.

Note the target description:

This reminds you of the target on which you searched -- here, it was M101, where the coordinates were resolved by NED (as opposed to Simbad). The two icons next in that row indicate, respectively, "copy this location to the

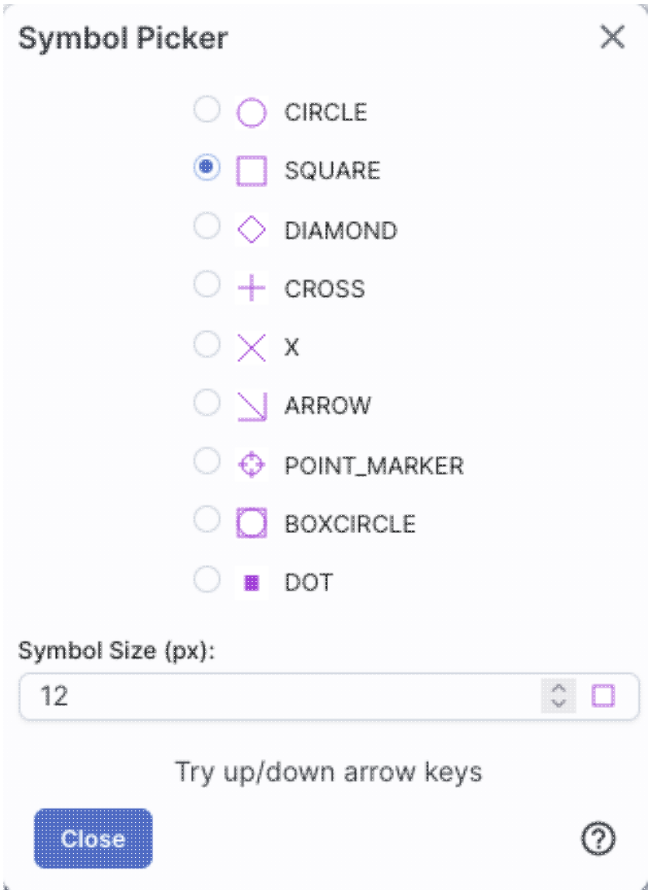
clipboard" and "center image on this position."



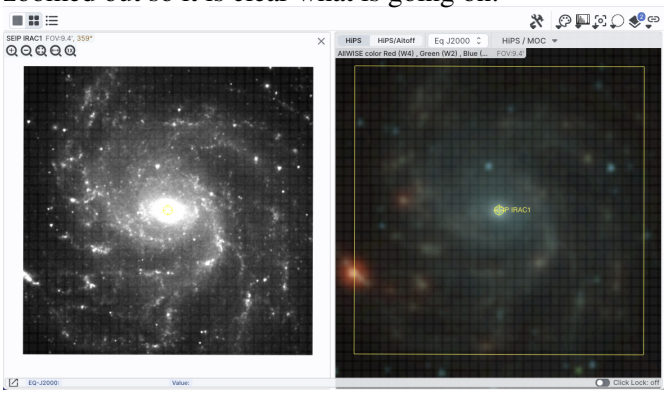
Where it's possible to change colors of a layer, click on the 'colors' link to be taken to a new pop-up from which you can select a new color.

From here, you can click on your desired color in the top colorful box. Immediately below that box, you can change the color and saturation of the top box so that you can select from a different range of colors. Below that, you can enter numerical hex codes or RGBA values (where the value for RGB is between 0 and 255, and A is in units of percent, e.g., 50 = 50%). Finally, you can also select from a pre-defined set of 15 colors by clicking on any of the small boxes. Note that the numerical codes update as you select different colors. Your choices are implemented as soon as you select them. Click 'Close' to close the window, or click 'x' in the upper right.

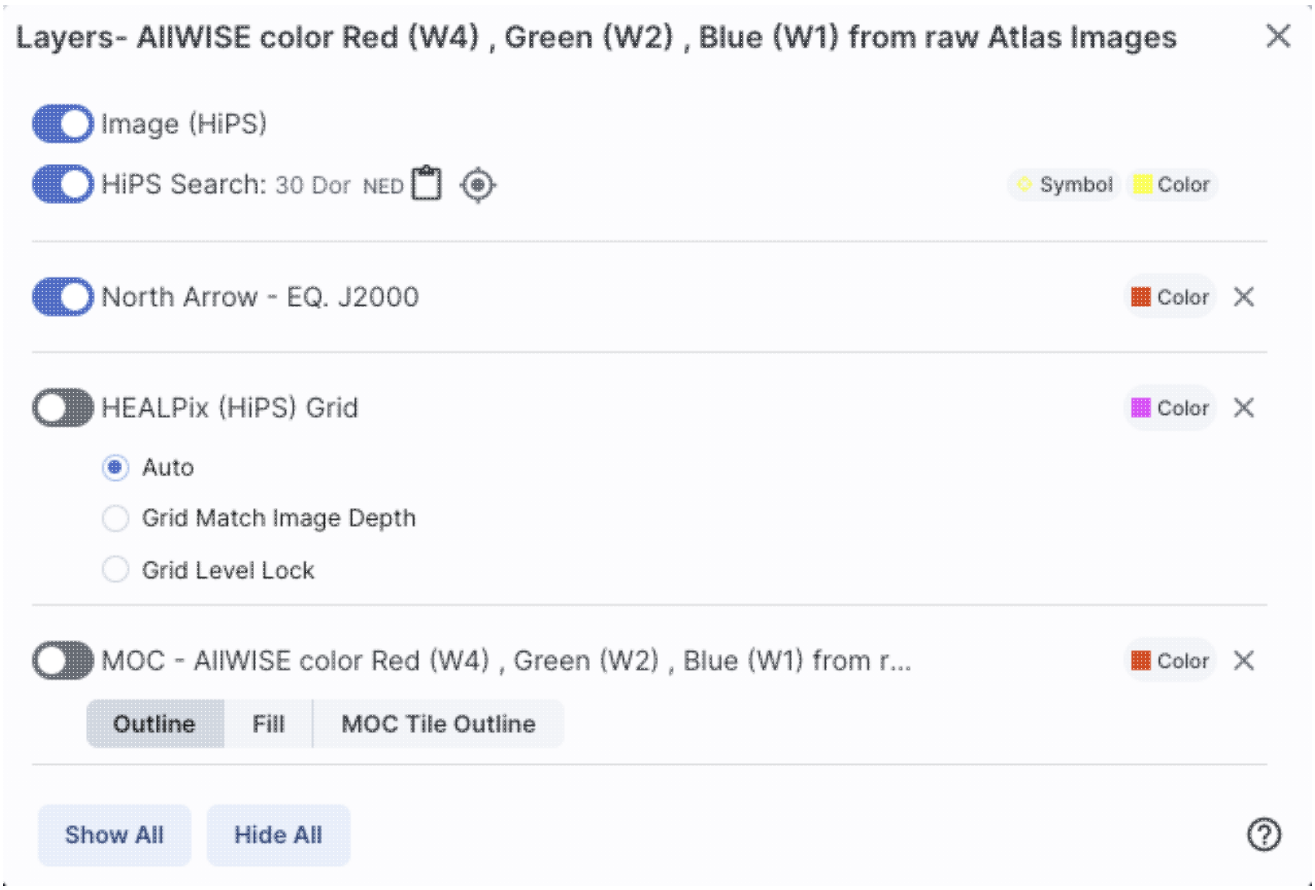
For catalogs or the search target, you can also select the symbol shape and size. To adjust the size, type in the symbol size in pixels or use the up/down arrow keys to change the size by one pixel at a time. Your choices are implemented as soon as you select them. Click 'Close' to close the window, or click 'x' in the upper right.



Note that if you load both FITS and HiPS images at the same time, it can include a marked layer on the HiPS image that is the footprint of the FITS images you have loaded. A label appears at the center of that footprint, which may be disconcerting if you are not zoomed out enough to see the region itself. Here is an example, zoomed out so it is clear what is going on:



Once you have loaded a HiPS image, if you select the HiPS image and click on the layers icon (), you will have new, HiPS-specific choices in the layers:



HEALPix (HiPS) Grid

To turn on these choices, toggle the switch to the left of "HEALPix (HiPS) Grid". (See here for more information on HiPS images in general.)

Auto: This option overlays a position grid, with the tile numbers marked in the center of each box. As you continue to zoom in, when smaller tiles are needed, they are drawn, with the new tile numbers marked. You may not zoom beyond HiPS Norder level 14 tiles. The numbers after the "/" is in the "NESTED" (as opposed to RING or NUNIQ) numbering system; see the IVOA standards document for more information.

Grid Match Image Depth: If you select this option, the grid will adjust to a new level when you zoom in and a new level of HiPS image both exists and is used for the display.

Grid Level Lock: Selecting this option yields an additional numerical drop-down menu. The higher number you pick, the smaller the grid boxes are that are drawn. When this option is selected, the boxes stay the same size regardless of how zoomed-in on the image you are.

HiPS MOC

To turn on these choices, toggle the switch to the left of "MOC".

(See here for more information on MOCs in general.) A MOC tells you via a simple boolean yes/no, is there sky coverage from this data set in this region. The choices here are:

◊ Outline - an attempt to outline the entire region covered by the data; it still sometimes struggles near the edges of coverage, so zoom in to get a better sense of the coverage edges.

◊ Fill - filled regions, where you can control the opacity of the overlay by going to the color picker; you control the opacity by changing the number above the "A".
◊ MOC Tile Outline - individual tile outlines, where the tiles are set by the MOC tiles themselves (as opposed to tiles created by the mosaic tiles that make up the data set).

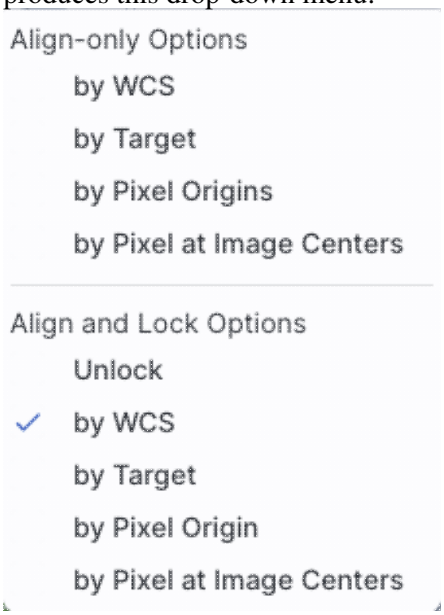
Tips and Troubleshooting:

- The entire concept of a MOC is built upon the "tiles" that are inherent to the HiPS concept. As a result, those tiles are imprinted on how the MOC is rendered, especially near edges or corners of coverage. Strange behavior may result; you can always zoom in to get a better sense of the coverage. For authoritative information, download the actual data for the region you are concerned about.
- For the "fill" option for a MOC, depending on how you display a MOC, you may see two shades of color in the MOC. It is important to note, though, that the information it is displaying does not include depth of coverage, merely boolean "is there data there or not." Why is it displaying shading? Well, it's rounding. For example, a given WISE MOC might be generated at order 13. At this order, there are 805,306,368 HEALPixels on the sky, and they are about 26 arcseconds across. When zoomed out far, there is no point in trying to show each of these pixels, so the application "rounds up" the MOC to an order in which there are roughly 100-200 displayed HEALPixel polygons horizontally across the image. When it does this, it flags the rounded up polygons with the paler color. So the boundaries of a coverage region in the MOC all get a paler color. If you zoom in far enough on a MOC, the two-tone colors go away.

World Coordinate System (WCS) Alignment

As described above, there is a way to lock/unlock images to each other  for position matching. This section describes the image locking in more detail.

When aligning images, you can specify how the images align and for how long. Clicking the lock images icon produces this drop-down menu:



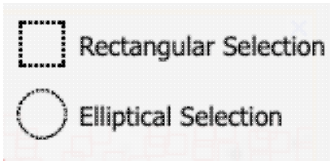
The first set of options aligns the images only once; the second set of options makes the alignment persist ("lock") when you move (zoom, etc.) the images.

You can align by the images' WCS (world coordinate system, e.g., RA and Dec), by the target (align by target on the screen, regardless of position in the sky), by the pixels according to the origin of the coordinate system in the image header, or by the pixel at the image center. The most common choice is likely the WCS align and lock.

Region Selection

 When you click this icon, you can select a region of the image, from which then you can do a whole host of things to the image and to the catalog you may have overlaid upon it.

First, from the drop-down, you are given a choice of a rectangular selection or an elliptical selection:



After you make that choice, you can click and drag in the image, selecting a box or a circle on the image. For the circle, your click is the center of the circle and the drag is the radius of the circle; for the box, your first click is one corner of the rectangle, and the drag is the opposite corner of the rectangle. This region can be resized by grabbing and dragging the corners of the box or the pixels delineating the corners of a box around your code. If you need to move the image underneath, you can hold the shift key and click and drag.

When you have selected a region of the image, additional icons appear above the image, and exactly which icons you see is a function of whether you are working on a FITS or HiPS image:  These icons allow you to do several things:

 *Crop the image*
(FITS only) Crop the image to the selected region. Then you can save the cropped FITS image via the save icon described above.

Note that, if you have a rotated FITS image such that a crop would have to bisect pixels, it will show you the region that encompasses your selection. If you crop at that point, then, it will crop in image space (such that pixels are not bisected). See the figure below -- in the original image, north is up. This has been rotated 45 degrees. The selected region is in white. The yellow dash-dot line is the crop in pixel space that encompasses the selected region.

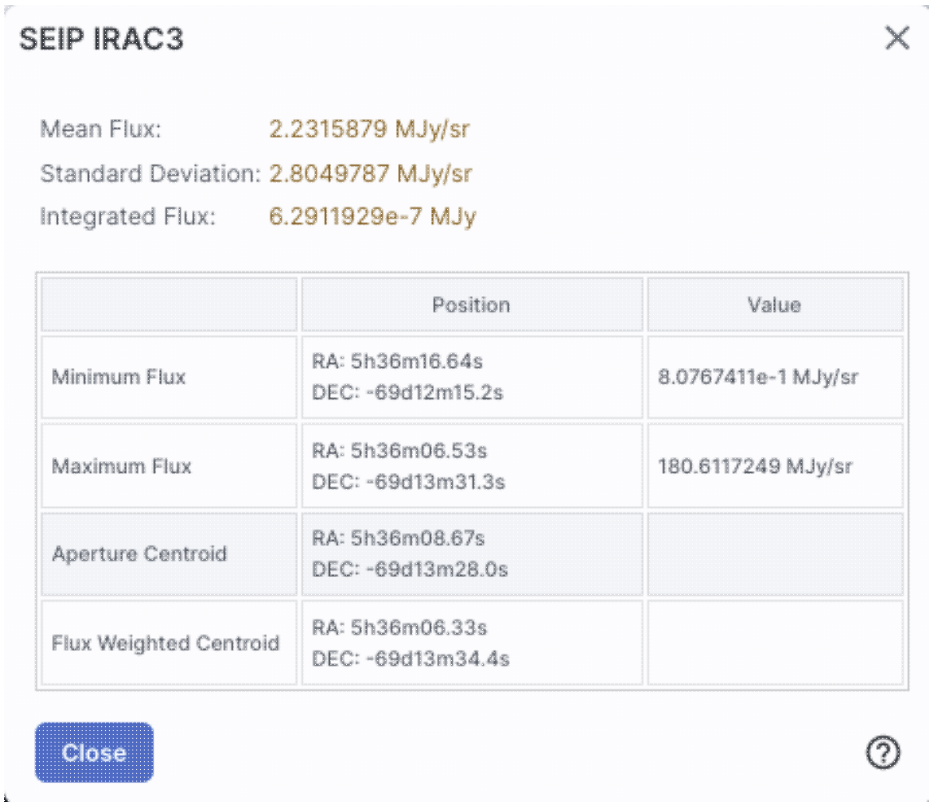
Select sources (and *cancel selection*)
(Only if a catalog is overlaid) Select the catalog sources overlaid on the image within the region. Selecting highlights the sources in the list and plot with a different color row or symbol. Once there are selections made, the second icon appears to give you an option to cancel the selection.

Filter sources
(Only if a catalog is overlaid) Filter the overlaid catalog down to the sources within the enclosed area. When you choose to impose a filter via this selection mechanism; the filters icon changes above the catalog to indicate that there is a filter applied ( ). To clear the filters, click on the cancel filters icon (which also appears after you impose filters): . There is much more on filters in the Tables section.

Zoom the image
Zoom the image to fit the selected area into your field of view.

Recenter the image
Recenter the image on the selected area.

Obtain statistics
(FITS only) Obtain statistics from the image on the region. The statistics option results in a pop-up that looks something like this:

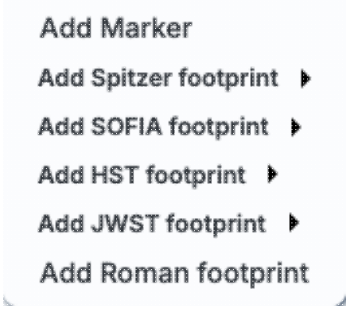


Note that it calculates the location of the minimum and maximum fluxes, and the aperture and flux-weighted centroids; the flux values given are in the same units as the FITS file. If you put your mouse over the row of the table in the pop-up, that location appears as an 'x' on the image.

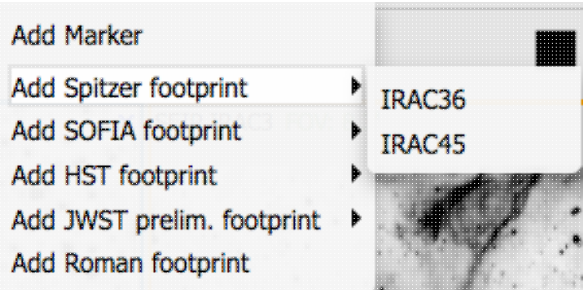
When you are working with the selection tool, this: End Select appears next to the image toolbar to remind you that you are in that mode. When you are done with the selection tool, if your other actions don't turn off the selection tool, click on that text to turn it off.

Footprints

The marker icon () has a drop-down menu with several possible options:



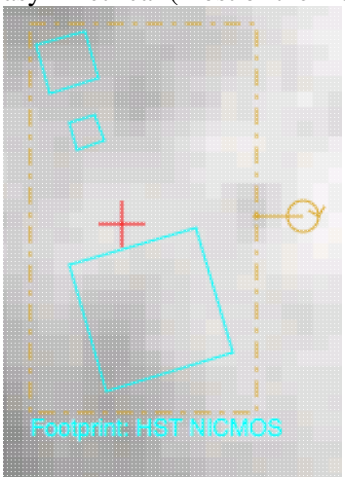
Any of the options with an arrow on the right can expand to additional subsidiary choices, e.g.,:



We now describe these various footprints here.

For each of these choices, the markers appear initially in the center of the loaded images. The first mouse click you make in any of the images will move the marker to that location.

Each of these marker choices, when overlaid and/or selected as 'active', has a dot-dash square around it. If it is asymmetrical (most of them are), it has an additional "appendage" and a red plus at the center of the footprint:



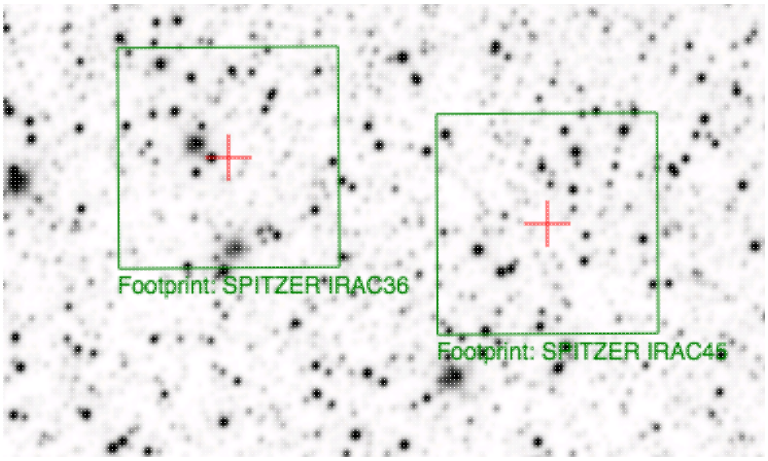
These so-called "handles" allow you to resize and/or rotate the marker, depending on the nature of the marker. These handles only appear when the marker is selected as active; if you wait a few seconds, they vanish.

Tips and Troubleshooting

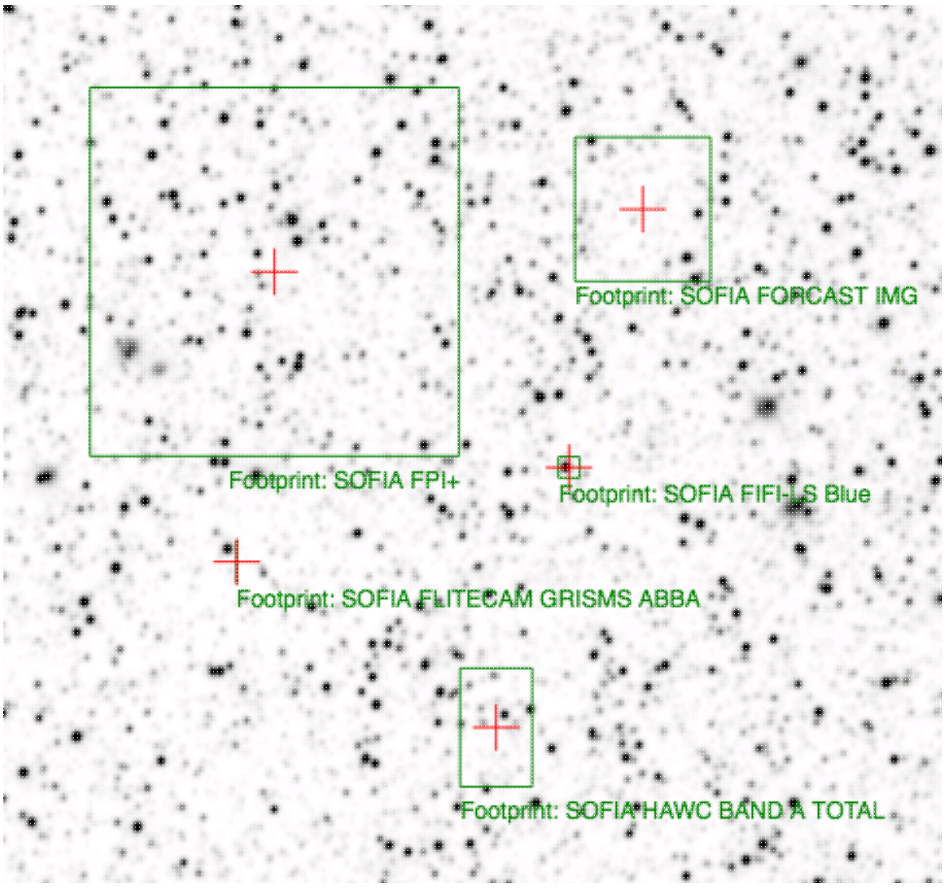
- Some of these footprints are *large*. If you have a small image, some of these footprints will be larger than your image. Zoom out to see it, or find a larger image to use. If you overlay, say, a Nancy Grace Roman Space Telescope (formerly WFIRST) footprint on a 2MASS Atlas FITS image, you may need to zoom out a considerable amount before you can see the Roman footprint. You will see the center indicator of the marker before you will see the Roman footprint itself.
- You can add multiple copies of the same marker using the layers pop-up (described generally above). From the layers pop-up, there is a link right under the 'angle' option that says "Add another [marker type]" -- click on that to get an additional marker of the same type. You can also add a label to the marker from the layers pop-up, or change its color.
- If you have many footprints on the same image, you may have trouble grabbing and moving footprints lower in the stack of layers on the image. For example, overlay footprint 1, then footprint 2, and you might have a hard time grabbing and rotating footprint 1 after footprint 2 has been added. The only workaround here is to use the layers pop-up (described generally above) to temporarily hide footprint 2, then move footprint 1, then restore footprint 2.
- If you have images of very different resolutions loaded (e.g., IRAS and really anything else), sometimes it struggles to render the marker on each image. You may need to place markers on one image at a time. (Unclick the "lock color & overlays" option to place markers one image at a time.)

The first overlay choice (simply called 'marker') is a red circle.

The remaining markers are all footprints from various telescopes: Spitzer, SOFIA, HST, JWST, and Roman. HST, JWST and Roman are derived from information provided via MAST (see http://gsss.stsci.edu/webservices/footprints/help.html) For Roman in particular, they are pre-launch values.



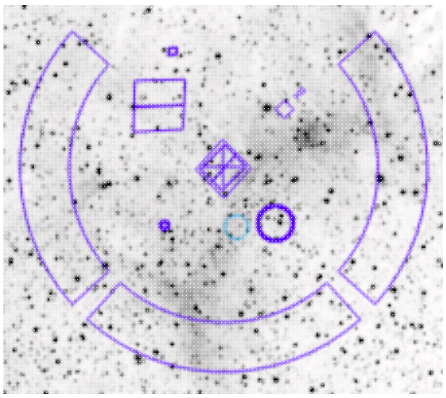
Spitzer/IRAC 3.6 and 4.5 micron footprints.
These two footprints are placed separately from each other. The footprint can be moved or rotated. Click and drag the center of the footprint. A circle appears with four small circles ("handles") around it. Grab and drag the small circles to rotate it, or drag the big circle to move it. Change the color, delete, or add more copies of the IRAC footprints from the layers pop-up.



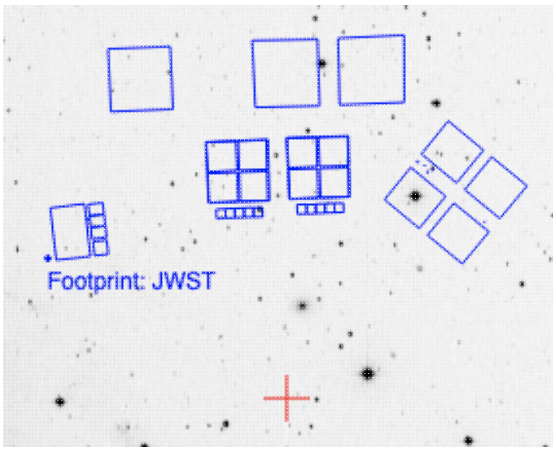
SOFIA footprints. Several different SOFIA footprints are available; the graphic here shows a selection of them. The available footprints (all of which are placed separately) are:

- FIFI-LS
  - Blue (50-120 microns)
  - Red (110-200 microns)
- FLITECAM
  - Imaging
  - Grism ABBA
  - Grism AB
- FORCAST
  - Imaging
  - Grism a
  - Grism b
- FPI+
- HAWC+
  - 53 microns (Band A), Total Intensity
  - 53 microns (Band A), Polarization
  - 89 microns (Band C), Total Intensity
  - 89 microns (Band C), Polarization
  - 154 microns (Band D), Total Intensity
  - 154 microns (Band D), Polarization
  - 214 microns (Band E), Total Intensity
  - 214 microns (Band E), Polarization

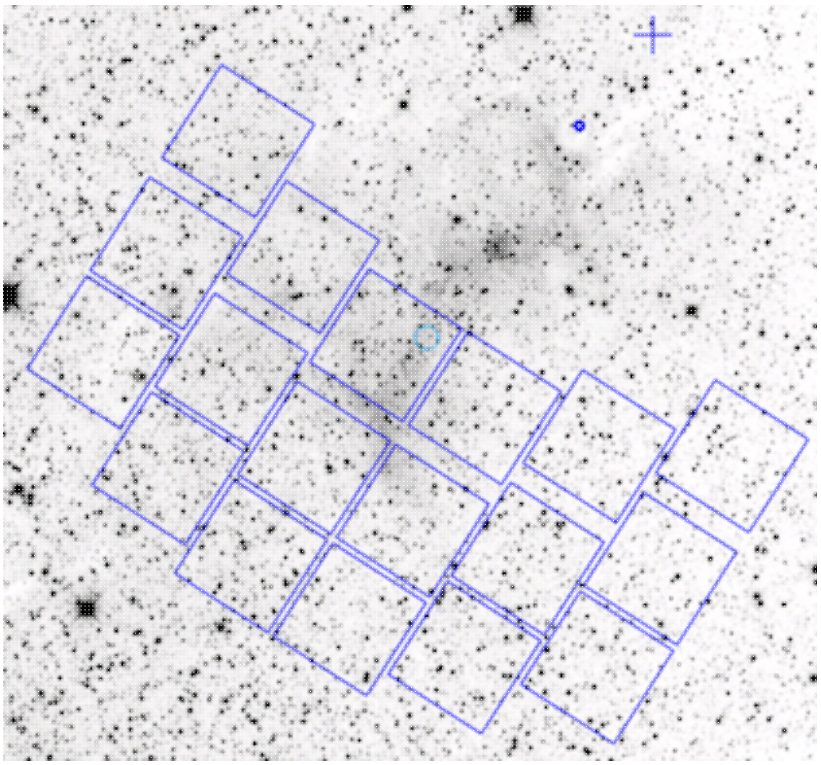
Change the color, delete, or add more copies of the SOFIA footprints from the layers pop-up.



HST footprints. You can overlay the whole focal plane footprint, shown here, or individual instrument footprints (NICMOS, WFPC2, ACS/WFC, ACS/HRC, ACS/SBC, WFC3/UVIS, and WFC3/IR). Consult the HST documentation for specifics on which apertures are which. The footprint can be moved or rotated. Click and drag the center of the footprint. A circle appears with four small circles ("handles") around it. Grab and drag the small circles to rotate it, or drag the big circle to move it. **Note that** if you overlay the footprint on a very small image, nothing will appear to have happened. You need at least a 45 arcmin image to comfortably see the footprint. Change the color, delete, or add more copies of the HST footprints from the layers pop-up.



JWST footprints. You can overlay the whole focal plane footprint, shown here, or individual instrument footprints (FGS, MIRI, NIRCAM, NIS, and NIRSPEC). **Note that** if you overlay the footprint on a very small image, nothing will appear to have happened. You need at least a 30 arcmin image to comfortably see the entire JWST focal plane. Please consult the JWST documentation for details about the footprints. In all cases, if the footprint is 'active', a circle near the middle of the footprint will appear with four small circles ("handles") around it. Grab and drag the small circles to rotate it, or drag the big circle to move it. Change the color, delete, or add more copies of the footprints from the layers pop-up.



Nancy Grace Roman Space Telescope focal plane footprint. As above, the footprint can be moved or rotated. Click and drag the boresight (the cross hairs), which appears by default to the upper right of the array of squares. A circle appears, centered on the boresight, with four small circles ("handles") around it. Grab and drag the small circles to rotate it, or drag the big circle to move it. **Note that** if you overlay the footprint on a very small image, nothing will appear to have happened. You need at least a 60 arcmin image to comfortably see the footprint, and even then you will probably have to click and drag to see the entire footprint. Consult the Roman documentation for specifics on the apertures. Change the color, delete, or add more copies of the Roman footprint from the layers pop-up.

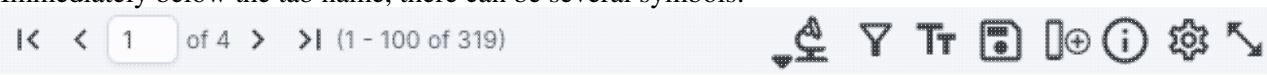
Data Discovery Tool: Tables

The Data Discovery Tool returns results in an interactive table. This section describes features of this interactive table.

Contents of page/chapter:

Table Header

Immediately below the tab name, there can be several symbols:



which we now describe, going from left to right along the top of the catalog tab.

Table navigation

The first thing to notice is that (typically) only the first 100 rows of the retrieved table are displayed. In the example here, there are 319 sources that were retrieved as a result of the search, grouped into 4 'pages.' The left/right black arrows plus the page number allow you to navigate among these 'pages' of 100 sources each. Note that the entire set of results (not just the 100 rows you are currently viewing) can be sorted by clicking on any column's name.

Filter

Filters are complex and powerful enough that they are covered in a separate section below.

Table as text

Clicking on this changes the table display into a fixed-width text display. The icon then changes to  click this again to return to the default table view.

Save table

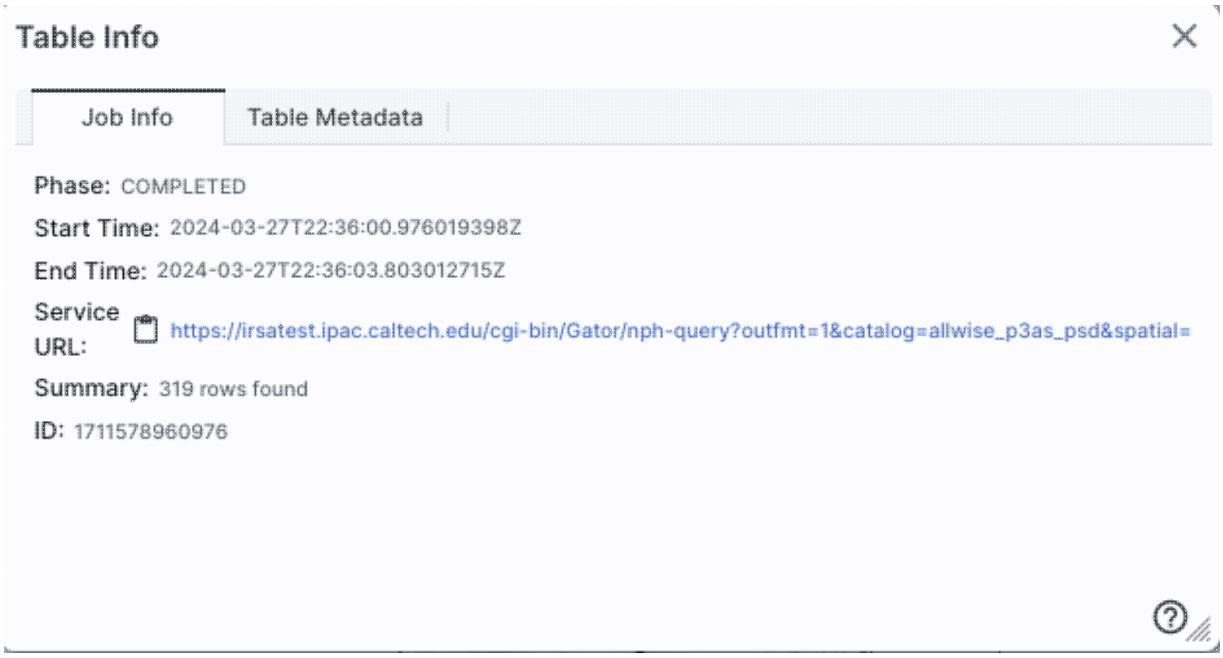
This is how you can save the table. It has a separate section below.

Add a column

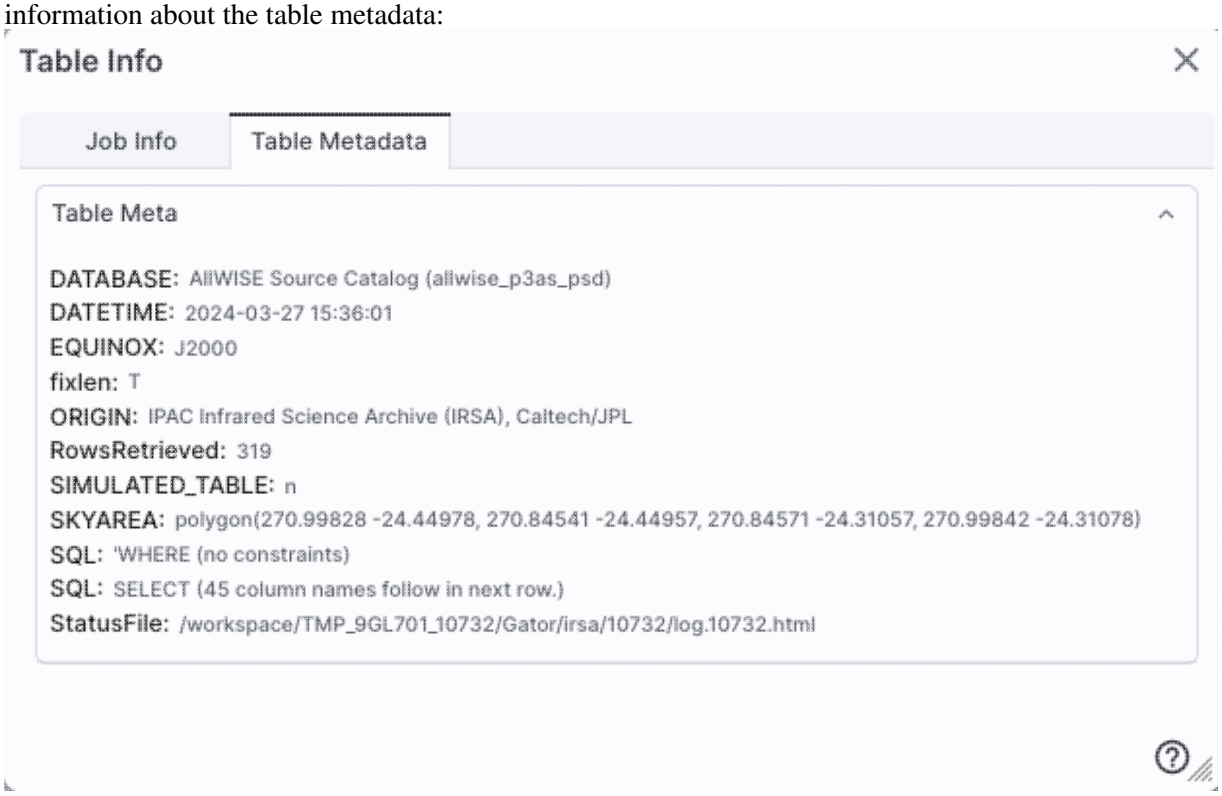
This icon adds a new column to the table. This has a separate section below.

Info link

You may or may not see this icon. This is an "information" button and, if it exists, it may provide additional information about the table. It could have information about the job that was used to retrieve it:



where the direct link to the job is given there (and can be copied by clicking on the clipboard, ready to be pasted into a helpdesk query, for example), with a job id as shown. It could also just have information about the table metadata:



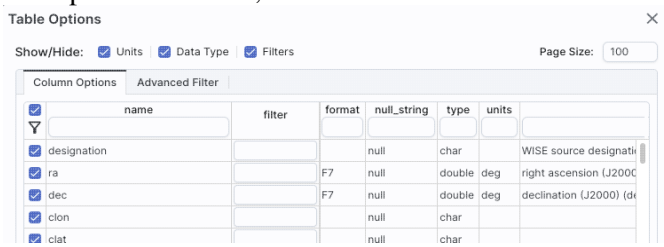
where the information about this table includes information about the query that produced it.

Row details

You may or may not see this icon. This is how you get more information about the currently-selected row. It has a separate section below.

Table options

Clicking on this icon brings up options for the table, e.g., how many rows are displayed per page, which columns are shown, metadata about each column if available, whether units and data types are shown at the top of the column, shown here:



By default, it is often but not always the case that all columns are shown. To show or hide columns, select the tickbox in each given row. The default page size is 100 rows. Note that expanding the page size to numbers much greater than 100 may result in a substantial performance degradation (e.g., your browser will appear to freeze or not appear to be doing anything while it manages and renders the large table). See the Filters section below for more things to do from the table options pop-up.

Expand

Clicking on this expands the catalog window pane to take up the entire browser window. To return to the prior view, click on "Close" in the upper left.

Help

The last option on the top of the catalog tab may be a context-sensitive help marker, which should bring you to this online help.

Table Columns

The table is shown exactly as it appears in the corresponding database, with all columns as defined for that catalog. To understand what each column is, please see the documentation associated with that catalog. (For IRSA catalogs, this documentation is available via navigating through the IRSA website.)

Depending on what you did to display a table, the columns that are shown may be in easily-human-readable form, or may reflect column names used within the individual catalog. Please consult the detailed documentation associated with your specific archive if the headers are not clear to you.

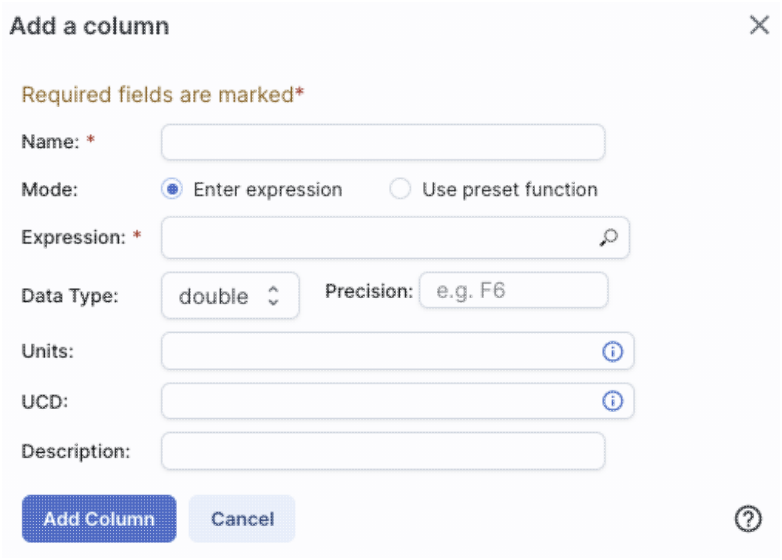
Clicking on the column names sorts the table by that column; clicking once sorts in ascending order, clicking a second time sorts in descending order, and clicking a third time returns the table to the original order. Small arrows appear next to the column names to remind you if the column is sorted in ascending or descending order.

Tips and Troubleshooting

- You can hide or display columns; click on the gears ( ) to get to the table options, and tick the box corresponding to the row you want to hide or show.

Adding Columns

This icon allows you to add a new column to your catalog. When you click on it, it brings up this pop-up window:



This window asks for:

- *Name* of the column (required) -- it cannot have special characters like a minus sign or a percent symbol; you can only use letters, numbers, and underscores.
- *Mode* "Enter expression" or "Use preset function" -- options shown here correspond to "Enter expression" options; the preset function options are included in the last bullet here.
- *Expression* (required) -- using basic SQL operators, you can manipulate columns to create the new column. (See more on this below.)
- *Data Type* -- specify if your new column is a double precision floating point ("double"), a long integer ("long"), or a string ("char").
- *Precision* -- if you have selected "double" for data type, select how many decimal places your new column should display. For example, if you want the numbers to display as 1.23, enter "F2".
- *Units* -- specify the units of your new column. For more information, see IVOA documentation
- *UCD*, or unified content descriptor -- for VO compliance, add this for your new column. For more information, see IVOA documentation
- *Description* -- add a description for your new column.
- *Select a preset* -- if you select "Use preset function", you can choose (a) "set filtered rows to 'true' and the rest to 'false'", (b) "set selected rows to 'true' and the rest to 'false'", or (c) "number rows in current sort order". These options are useful for tagging items you have selected in myriad ways (from plots, images, complicated filters), or ordered in complicated ways. For example, if you have constructed a complicated filter, then you can create a column that is true for the selected rows; if you cancel the complicated filter, you can then easily recreate the complicated filter by simply filtering on your newly created column.

In order to construct the expression for your new column, your input should follow the syntax of an SQL expression. If you click on the magnifying glass next to the form input, you get a pop-up window that can help you construct an expression; click "apply" to apply the expression.

You need to use the column names exactly as they appear in your catalog. Supported operators are: +, -, *, /, =, >, <, >=, <=, !=, LIKE, IN, IS NULL, IS NOT NULL. You may use functions as well; for a list of all available functions, see here. Some examples include:

- "w3mpro" - "w4mpro"
- sqrt(power("w3sigmpro",2) + power("w4sigmpro",2))
- ("ra"-82.0158188)*cos(radians("dec"))

- "phot_g_mean_mag"-(5*log10(1000/"parallax") - 5)

Tips and Troubleshooting

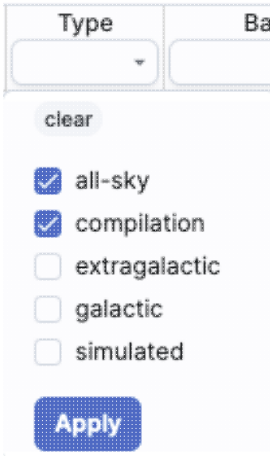
- When you create a new column that is calculated from other columns, it is created statically. That is, it is not dynamically updated like a spreadsheet, but calculated once and left alone after that.
- When you create a new column, the header of the new column is red to let you know that the column is not present in the original catalog.
- When you save the catalog, the header of the saved catalog indicates that you have added a column. When you load the catalog back into the tool, the header of the new column is still red.
- You can edit or delete columns after you have created them; click on the gears () to get to the table options, and then click on the edit icon to bring up a dialog box to edit or delete the column.
- You can hide columns; click on the gears () to get to the table options, and tick the box corresponding to the row you want to hide or show.
- If you create a new column that turns a floating point column into an integer with the "FLOOR()" function, you need to be sure to set the resulting column type to "long". For example, if you have data covering several days or years, and you have a column that is a floating-point MJD, you can convert it into an integer, e.g., via FLOOR(mjd) for days or FLOOR(mjd/365.24) for years, then you can use the drop-down filter menu for the new column to quickly compare different time ranges. But, the new column must be an integer (e.g., "long") in order for this to work properly.
- If you need to, say, take the square root of a column that occasionally has a negative number, and you want it to attempt to handle this in a physically reasonable manner, you can construct expressions like this for a column named 'col' that has some positive and some negative numbers:
  if("col">=0,sqrt("col"),-sqrt(-"col"))

Table Filters

Filters are a *very* powerful way of exploring the table full of search results. Click on this icon  in order to start the process of adding filters. A text entry box appears above each of the current catalog columns, with a small version of the filter icon corresponding to that row on the far left. You can type operators and values in these boxes -- hit return after typing or click in another box to implement the filter. For fields with a limited set of choices, instead of a text entry box, a filter icon will appear; click on it to select from the available choices.

Example: Your search results are a list of data, both images and catalogs. Click on the filter icon, and click on the downard pointing black triangle at the top of the "Data Type" column. Select "image" and click "filter." The table is now limited to images.

> For columns (fields) with a limited set of choices, on the right edge of the text entry box, an arrow appears; click on it to get a drop-down from which you can select the available choices. To implement the filter, make the choices, and click "Apply" when you are done. Click "clear" in the top of the drop-down menu to remove that filter.



After you impose a filter, then the number of rows in the table is restricted according to the rules you have specified, and the "filters" icon on the top right of the catalog pane has changed to remind you that there has been a filter applied, in this case just one filter:  . To clear the filters, click on the cancel filters icon (which also appears after you impose filters):  .

Filters can be used in combination. Note that the filters between columns are logically "AND"ed together, but filters within the same column can be logically "AND"ed or "OR"ed together; examples are below.

The available logical operators are :

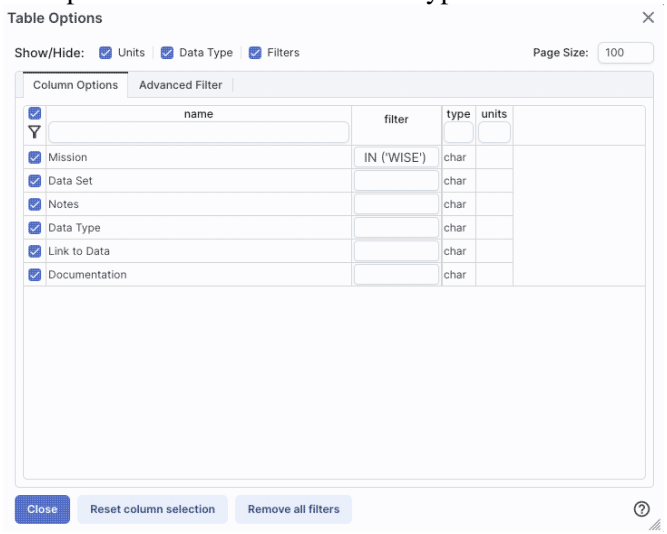
- = which means 'equal to' (exactly!), e.g., the parameter on which you are querying (the column headers as shown) is exactly equal to this value you are specifying.
- > which means 'greater than'
- < which mean 'less than'
- != which means 'not equal to' (exactly!)
- >= which means 'greater than or equal to'
- <= which means 'less than or equal to'
- IN which means 'included within this list', e.g., the parameter on which you are querying is included within the list you are specifying (if the column filter is free-form text, type "value1,value2" and it will give you rows that have value1 or value2).
- LIKE which means 'resembles the text that is entered', e.g., the text resembles the text that you type in the box.
- IS which effectively is the same as =
- IS NOT which effectively is the same as !=

Examples:

- Retain rows for which a certain parameter is not an empty string: !="
- Retain rows for which a certain parameter is not NULL and is larger than 1.234: > 1.234 and IS NOT NULL
- Retain rows that have values between -0.5 and 1.25: > -05 and < 1.25
- Retain rows with a parameter greater than one value or exactly not equal to another value: > 12345 or != 3000
- Retain rows with a parameter equal to one of the values in a list: IN a,b,c,d

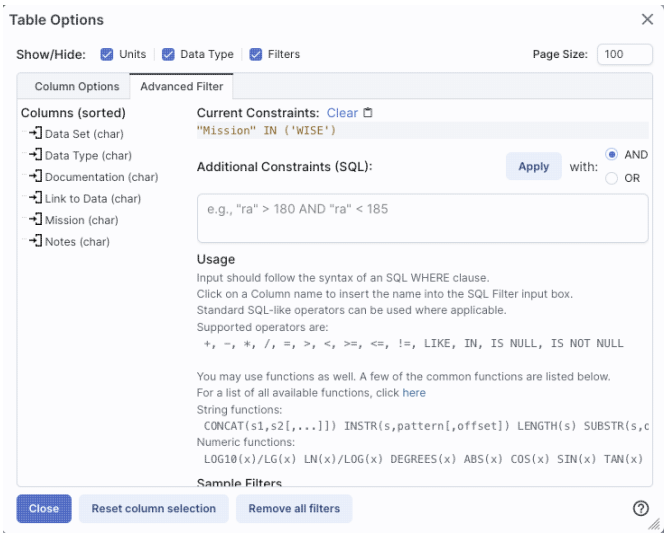
You may also be able to select rows one at a time via the far left column and then filter that down. Example: Retrieve a catalog of any sort. Select rows by ticking the box on the far left, say, every other row out of the first 12. Click on the filter icon on the top of the column. The filter is imposed to only include the 6 rows you selected.

If you click on the table options icon ( ), you get a pop-up that includes a place to filter columns. Here is an example of the table columns for a typical Data Discovery result, filtered to just be data from WISE:



You can type in constraints in the filter box in much the same way as you can from the catalog itself; note that the column description is included here, which may make this way of setting filters more useful when working with a new (to you) catalog.

The second tab is the advanced filter interface:



Here, the columns are listed alphabetically on the left, the constraints you have imposed are in the "current constraints" box, and you can apply additional SQL constraints via the free-form text box. Hints for syntax are given below the entry box. This window can be resized such that you can see the whole set of hints and imposed filters. Note that in this interface, column headers must be enclosed within double quotes.

Cancelling filters

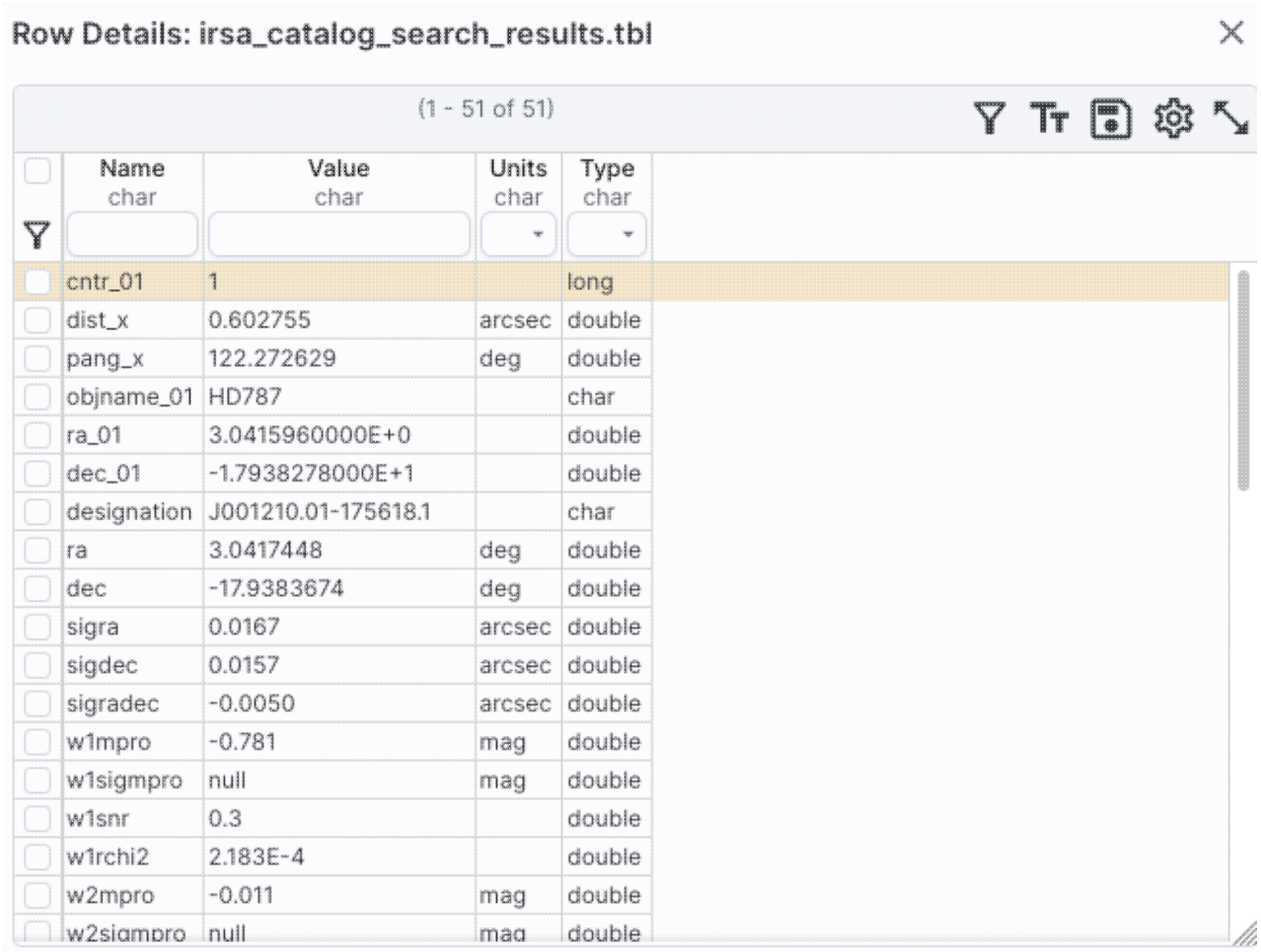
After you impose a filter, then the "filters" icon on the top right of the catalog pane has changed to remind you that there has been a filter applied, in this case just one filter:  To clear all the filters at once, click on the cancel filters icon (which also appears after you impose filters):  .

Tips and Troubleshooting

- If you impose logically inconsistent restrictions such as "exposure time > 160" and "exposure time < 100" (">160;<100" in the filter box for the column marked "exposure time"), no data will result, because no data are (can be) both less than 160 seconds long and greater than 100 seconds long at the same time. However, "exposure time > 160 or < 100" works just fine (">160 or <100" in the filter box for the column marked "exposure time").
- If you impose nonsensical filters (like using a letter where a number should be, like "w1snr < f") then it will let you know that something has gone really wrong, and let you go back to fix it.
- However, a filter like "ph_qual < f" could be valid -- if the column with which you are working is a string, then a string is a valid filter. It is case-insensitive. For the ph_qual column in the 2MASS catalog, the values are always three letters, such as AAA or ABA or CUU. A filter like "ph_qual < f" will operate as if you have alphabetized the list. Any string that starts with A comes before F and so will be retained. If you do "ph_qual < BBB" then AAA will be left in, but so will "BAU", because alphabetically, BAU precedes BBB.
- If you impose filters from a plot, it can manifest as several filters on the catalog, e.g., one for each side of the square you have drawn on the plot. If you want to remove, say, just one of the four filters (rather than all of them by cancelling all filters), you can do so from the table options pop-up.
- If you want to copy all of the "current constraints", even if the entire field is not visible to you, you can triple-click with your mouse to select the entire field, and then paste it into another field or application to see what it is.
- If you are choosing filters from a list of terms, cancelling those filters might not work the way it cavalierly seems like it should. If a down arrow appears next to the filter box, then a list of options you can select is available. Tick the boxes you want, and click "filter" to apply the filter. Now, if you want to change the filter, click the down arrow, select different options, and click "filter" again to re-impose the new filter. To reset the filter, you have to treat it like you would when applying a modified second filter -- unselect the choices, or hit 'clear', and **then hit filter again**. Hitting 'clear' and the 'x' doesn't work in this context because 'x' means 'cancel without doing anything' as opposed to 'impose the filter I just set'. When you are resetting the filter to be 'select nothing', it is treating that as a new filter setting, so you need to set up that filter and click 'filter' in order for it to understand.

Row Details

 This icon is not always available. When it is available, when you click on it, a new pop-up window appears with information about the row you have selected:



Name char	Value char	Units char	Type char
cntr_01	1		long
dist_x	0.602755	arcsec	double
pang_x	122.272629	deg	double
objname_01	HD787		char
ra_01	3.0415960000E+0		double
dec_01	-1.7938278000E+1		double
designation	J001210.01-175618.1		char
ra	3.0417448	deg	double
dec	-17.9383674	deg	double
sigra	0.0167	arcsec	double
sigdec	0.0157	arcsec	double
sigradec	-0.0050	arcsec	double
w1mpro	-0.781	mag	double
w1sigmpro	null	mag	double
w1snr	0.3		double
w1rchi2	2.183E-4		double
w2mpro	-0.011	mag	double
w2sigmpro	null	mag	double

In some tools, this content appears as additional tab elsewhere in the tool (not in the table pane, but often viewable at the same time as the table itself), as an additional tab called "Details."

In either incarnation, this information is sometimes called a "property sheet."

This table consists of each of the columns of the retrieved catalog with additional information about each field where available. (Not every catalog may have this information available.) For additional information, please consult the full documentation that accompanies the catalog.

Note that if you leave the pop-up or tab open as you select different rows in your main table (or catalog), it is dynamically updated.

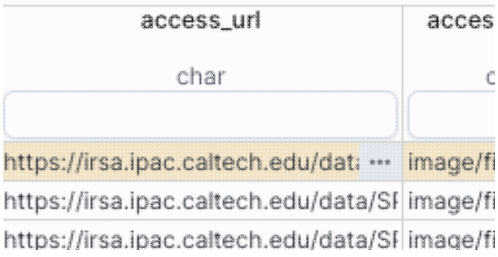
Tips and Troubleshooting

- The property sheet is a more expanded, vertical view of the information shown in a row of a catalog, along with documentation of the catalog columns. If you think of the main table (catalog) view as a single row that you have to scroll left and right to see in its entirety, this view is sort of an orthogonal view, where you have all of the same contents of that row but shown as its own table, with the full header description, if available, and you can scroll up and down to see the entire contents (as opposed to left-right). *This is sometimes a more user-friendly way to view any given row.*
- Because you can sort/filter the data in the property sheet, you can restrict what values are shown. Those filters are respected as you page through your main table.

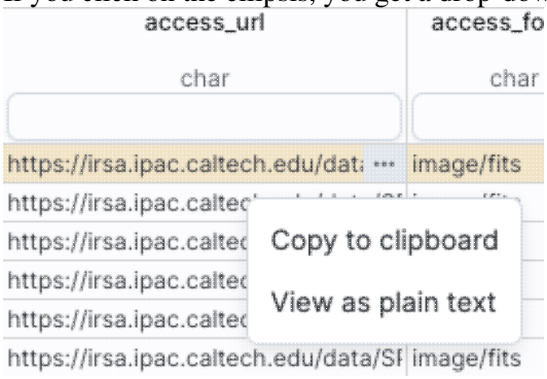
- When changing rows in the main table, the property sheet scrolls to preserve the visibility of whatever row in the details tab is highlighted. If you scroll down in the property sheet *without changing the highlight*, when you change rows in the main table, because the first row in any table is always highlighted by default, the property sheet will scroll back to the top.

Table Cells

Some cell values may be too long for the cell space. If that is the case, an ellipsis ("...") will appear in the cell as you mouse over it:



If you click on the ellipsis, you get a drop-down menu:



from which you can choose to copy the cell value or view it in a pop-up window.

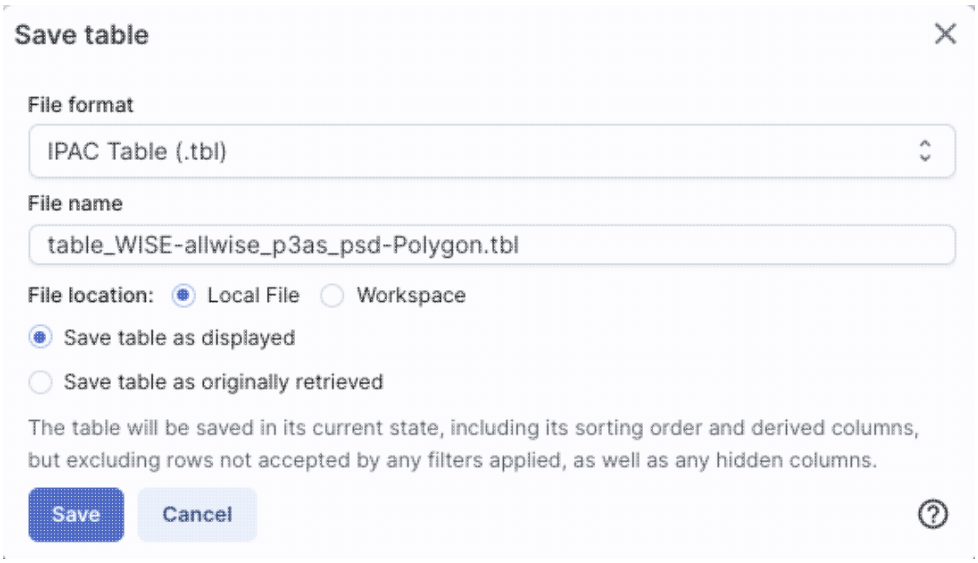
If you view it in a pop-up window, it will attempt to format it in a readable fashion:

which, for most cells, will be functionally indistinguishable from no special formatting. It will only matter for very complicated cells.

Saving Tables

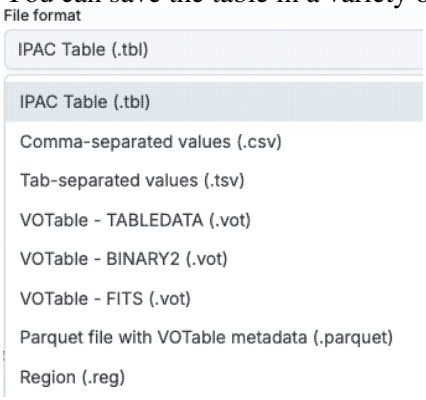
Click on the diskette icon (), if available, to save the table.

You obtain this pop-up:



You have several choices to make. In order, they are:

File format
: You can save the table in a variety of formats:



It defaults to saving it as an IPAC table file, which is basically ASCII text with headers explaining the type of data in each column, separated by vertical bars.

Other formats include comma-separated values (csv, suitable for, e.g., Excel), tab-separated values (tsv), and three different versions of VO tables. You can also save the file in DS9 Regions file format. See the DS9 website for more information on the syntax of these DS9 region files. The advantage of saving it here (as opposed to from the visualization) is that this way, the entire catalog is guaranteed to be saved.

File name
: The tool tries to make a guess at a sensible filename. Feel free to change it to something that makes sense to you.

File location
: You may save your file to a local file (on your disk) or, if you are logged in, in the IRSA Workspace.

Modifications to the table
: Depending on what you have been doing to the table at this point, you may have filtered or added columns. If you want to save the table as it is currently displayed, with all filters as imposed and any columns hidden, and any added columns as shown, select "Save table as displayed." If you want to save the original table, with all rows and the original columns intact, choose "Save table as originally retrieved."

Table Navigation

At any time, you can move among tables by just clicking on the tab name.

There is also another way to navigate among the table tabs.

On the far right, there is a downward pointing arrow. When you click on it, you get a drop-down, showing all the tabs that are loaded. From there, you can select the tab you want to bring to the foreground.

Data Discovery Tool: Plots

Plots can be made from Tables, and plots are made automatically in the Data Discovery Tool -- it attempts to make an SED for you (from either NED or VizieR). Plotting is covered in this section. The Tables section discusses tables more generally. The Visualization section covers intearcting with images.

Contents of page/chapter:

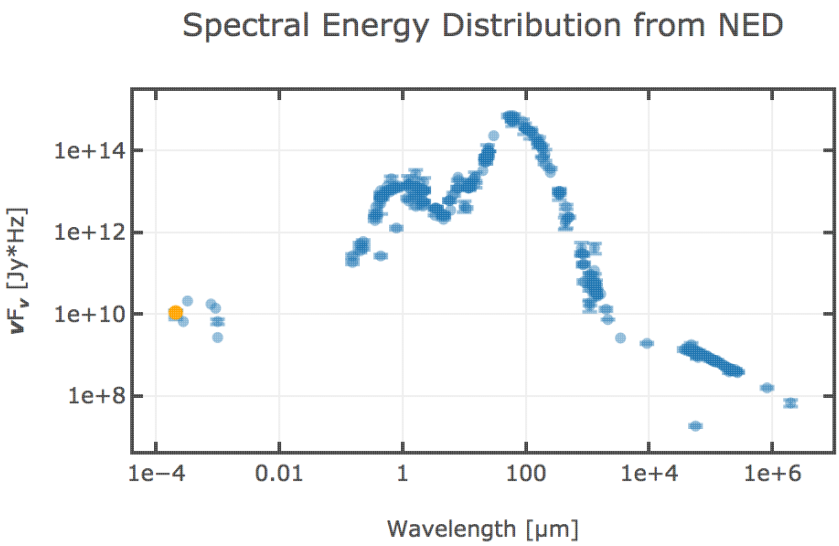
Default Plot

By default, after doing a search, a plot appears in the upper right of your browser window.

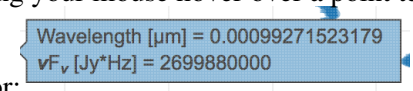
To obtain a full-screen view of the plot, click on the expand icon in the upper right of the window pane when your mouse is in the window: . To return to the prior view, click the "Close" arrow in the upper left.

The plotting tool in the Data Discovery tool, by default, has the spectral energy distribution (SED) for your search target, pulled either from NED (works best for extragalactic objects) or VizieR.

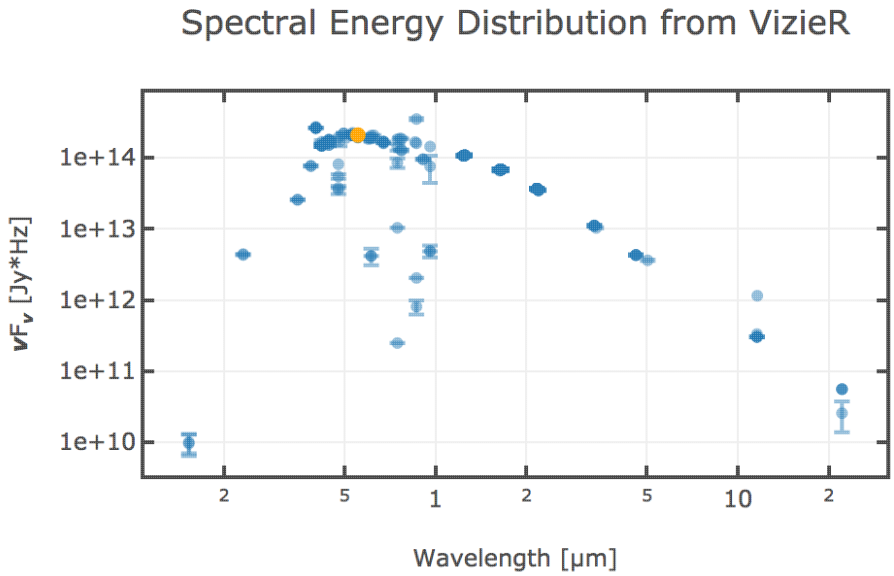
Plot format: a first look



This is the SED that the Data Discovery tool shows for Arp 220, with the data being retrieved from NED.

Letting your mouse hover over a point tells you the values of the point under your cursor: 

. Clicking (in an unbinned plot) highlights that point, and it stays highlighted, though you must keep your mouse on the point in order to see the information about how many points it represents.



This is the SED that the Data Discovery tool shows for HD 878, with the data being retrieved from Vizier.

What is it Plotting?

The tool is plotting its best guess as to what the SED is of the object. The y-axis is nuF_nu and the x-axis is wavelength in microns.

NED

If it uses NED to translate the name of the object to RA/Dec, then it will use NED data to get an SED. Very common names are resolved via NED but may not have an SED in NED. Try "M101" to get an SED; try "M16" to get the coordinates from NED but find no SED.

The units from the points are what are supplied by NED. (Note that the carats are used in an on/off sense, e.g., erg s^-1^ cm^-2^ means ergs per second per centimeter squared, where the first carat means "superscript" and the second carat means "back to normal".) No additional translation has been done here, aside from multiplying to get nuF_nu.

The points that NED reports can come in a variety of units, but the data are filtered down to only include those in units of Jy before multiplying and plotting.

VizieR

If it uses SIMBAD to translate the name of the object to RA/Dec, then it will use VizieR to get an SED. Try the name of a star (like HD 878) to get an SED.

The VizieR photometry tool allows for easy visualization of photometry points extracted around a sky position from photometry-enabled catalogues in VizieR. Even when an object name is used as a target, what is returned is just a list of photometry points found within some search radius, and should not be mistaken for an actual SED for the target object -- there is no guarantee that all photometry points correspond to the target, especially for extended sources or stars in a cluster in close (projected) proximity.

Note that, for VizieR searches, an additional circle appears on the image on the left; this is the search radius used to retrieve the points from VizieR that are shown here.

Plot Linking: Plots are linked to catalog and image(s)

If you move your mouse over any of the points in the plot, you will get a pop-up telling you the values corresponding to the point under your cursor. If you click on any of the points, the object(s) corresponding to that point will be highlighted in the SED table -- you may need to click on the SED tab at the bottom to bring it to the foreground. This works the other way too - click on a row in the SED tab, and the object will be highlighted in the plot or the catalog or the image.

The actual data table is a a table like any other here, so you can search and sort that table too.

Plot Navigation

The top right of the plot window has a row of icons:
 which we now describe.

 *Plot mode*
This trio of icons controls the plot interaction 'mode'. By default, you are in 'selection' mode, as seen here -- the last icon is darker, like a pushed-in button. To activate the other modes, click on the other icons, and they become darker or "pushed in."

 *Zoom mode*
When this mode is active, when you click and drag in the plot, the plot is zoomed to the region you have selected. Even when this mode isn't active, you can also zoom using your scroll feature on your mouse. To return to the original view, click on  .

 *Pan mode*
When this mode is active, when you click and drag in the plot, it moves around in response to where you drag. To return to the original view, click on  .

 *Select mode*
When this mode is active, when you click and drag in the plot, you are given additional options at the top of the plot :  The checkmark means "select" and the funnel means "filter." The difference is that filtering (temporarily) limits what is shown in the plot, catalog, and image (see general information on filters), and selecting just highlights the points enclosed within your selection. To cancel either one, click on cancel filters  or cancel selection  .

 *Re-scale plot*
Return to the view that optimizes the range of x and y to show the currently displayed points.

Tips and Troubleshooting: Did you accidently zoom in the plot with your magic mouse or touchpad? Click on this icon to reset the plot.

Save plot
Save the plot. It will save as a png file, wherever your browser is configured to save files. The saved png is the same size as it is on your screen. If you want a big version, make the desired plot big on your screen (expand the view to take up as much space as possible) before saving the png.

Undo
Restore everything to the defaults. If you've played a lot with the plot, you may want to undo everything you've done. Click this icon to restore everything back to the defaults.

Filter from plot
Pull up interactive filters. This button brings up filters for the displayed catalog in an interface like all the other tables here, except you don't see the values in the catalog themselves; you can enter filters here in the same way you can everywhere else in this tool (see general information on filters).

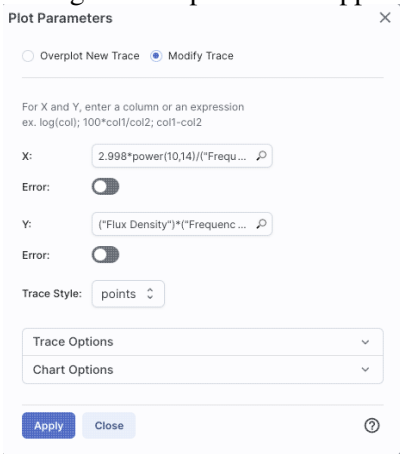
Configure plot
Click on this icon to change what is plotted (much more on this below).

Expand plot
Click on this icon to make the plot take up the whole browser window. To return to the prior view, click the "Close" arrow in the upper left.

Help
This icon may not appear, but if it does, it is a context-sensitive help marker, which should bring you to this online help.

Changing what is plotted

To change what is plotted, click on the gears icon in the upper right of the plot window pane: . Configuration options then appear; the options are a little different than other plots in tools like this:



This section describes how to change what is plotted, i.e., the "Modify Trace" option at the top of the pop-up. Overplotting is covered in more detail below.

You can **specify what should be plotted on each axis**. The magnifying glass is a link that brings up a table that lists all of the available columns in the catalog. Alternatively, you can just start typing, and viable options

appear below the box. Whatever you put in the box must match the column name as shown in the catalog *exactly*.

Click on the black triangle to reveal additional options.

The default plot is an SED from either NED or VizieR (see above) and is manipulating the columns to make the SED in reasonable units. You can change what column is plotted, and whether or not errors are shown.

By default, the boundaries of the plot are set to encompass the full data range. Here you can change the boundaries to specific numbers. (This can also be set via filtering from the plot; see below.)

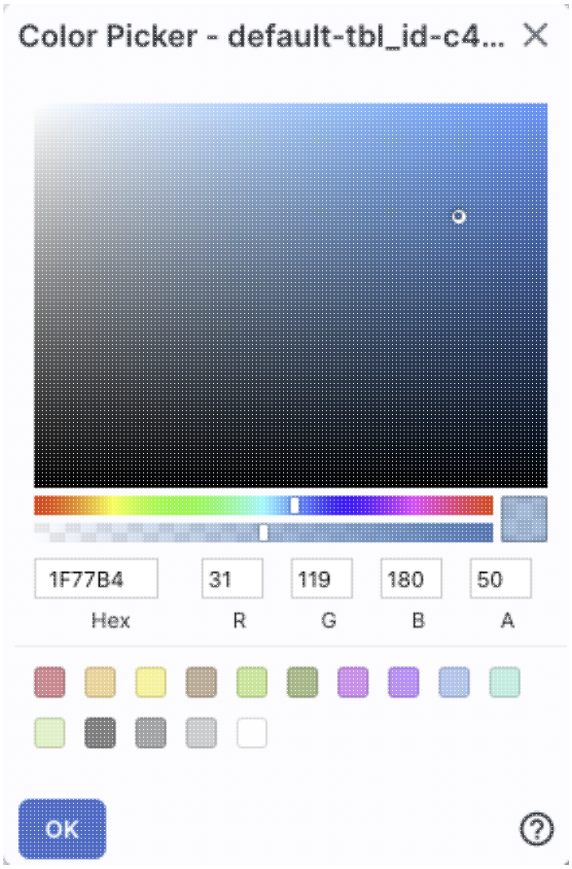
You can enter **simple mathematical relations** in these boxes too, such as (for a WISE catalog) "w1mpro-w4mpro" to put [W1]-[W4] on one axis. Supported operators:

- +,-,*,/
- abs(x), acos(x), asin(x), atan(x), atan2(x), ceil(x), cos(x), exp(x), floor(x), lg(x), ln(x), log10(x), log(x), power(x,y), round(x), sin(x), sqrt(x), tan(x)
- degree(x) and radians(x) are also supported -- these are the same functions as in ADQL and convert radians to degrees or degrees to radians. For small astrometric offsets, you could make a scatterplot of dec2-dec1 vs. (ra2-ra1)*cos(radians(dec1)) instead of typing cos(dec1*pi()/180). (NB: pi() is also a supported function you can use, instead of typing 3.14159.)
- Non-alphanumeric column names (e.g., those with - or + or similar characters) should be quoted in expressions.

Under "**Trace Style**," you can control whether the points are shown as individual points, connected points, or just lines connecting the points.

Under **Trace Options**, you have many choices.

- Choose the **symbol type**: circle (default), open circle, square, open square, diamond, open diamond, cross, x, upward-pointing triangle, hexagon, or star.
- Choose the **color**. By default, the point color is a mid-range blue that is darker where more points. This is specified by the rgba vector shown in the example here (31, 119, 180, 50) where the last number is in units of fraction of 1, so 0.5=50% in this example. Click on the magnifying glass to bring up a color picker window:



From here, you can click on your desired color in the top colorful box. Immediately below that box, you can change the color and saturation of the top box so that you can select from a different range of colors. Below that, you can enter numerical hex codes or RGBA values (where the value for RGB is between 0 and 255, and A is in units of percent, e.g., 50 = 50%). Finally, you can also select from a pre-defined set of 15 colors by clicking on any of the small boxes. Note that the numerical codes update as you select different colors. Click "OK" to implement your color choice, or click 'x' in the upper right to close the window without changing the color.

Tips and Troubleshooting: Don't like the transparency feature of the points that makes them darker when there are more points? Set the last value of the vector (A) to 1. Don't like the blue? Pick a diferent color entirely. Want the faintest point to be brighter than it is by default? Set the last element of the color vector ("A") to be 0.7 or 0.8.

- Choose the **color map**. By default, all of the points are the same color, but darker where there are more points. You can change this such that the color scale of the points is tied to a column value, such as w1snr (WISE-1 signal-to-noise ratio) in a WISE catalog. If you select this option, you can also change the color scale to any of many different options (see the drop-down). Simple mathematical relations (as above) are also permitted in this box.
- Choose the **size map**. By default, all of the points are the same size. You can change this such that the color scale of the points is tied to a column value, such as w1snr (WISE-1 signal-to-noise ratio) in a WISE catalog. Simple mathematical relations (as above) are also permitted in this box.

Under "**Chart Options**", you can specify:

- title of the plot;
- labels on the x and y-axis;
- whether or not there is a grid;

- whether or not the axis is reversed (as for ra in the examples above);
- whether the x-axis is on the top or bottom and the y-axis is on the left or right;
- whether or not the axis is logarithmic;
- the maximum and minimum values of the plot range;
- the aspect ratio of the plot (e.g., square or rectangular).

By default, the boundaries of the plot are set to encompass the full data range. Here you can change the boundaries to specific numbers. (This can also be set via filtering from the plot; see below.)

Tips and troubleshooting:

- VizieR searches by position to find all counterparts. As such, you may want to change the plot to be RA/Dec and filter down so that you select different counterparts. Then, you'll want to return to the SED view of your now filtered points. The values to copy back into the plot parameters box are:
  - x: 2.998*power(10,14)/("_sed_freq"*power(10,9))
  - no x errors by default
  - y: ("_sed_flux")*("_sed_freq"*power(10,9))
  - y error, symmetric: ("_sed_eflux")*("_sed_freq"*power(10,9))
- NED SEDs are curated, so outliers are less likely to be a problem. BUT if you need them, the values to copy back into the plot parameters box are:
  - x: 2.998*power(10,14)/("Frequency")
  - no x errors by default
  - y: ("Flux Density")*("Frequency")
  - y error, symmetric: ("Upper limit of uncertainty")*("Frequency")

Restricting What is Plotted

You can also restrict what data are plotted in any of several different ways.

You can filter the table itself (discussed in another section).

You can set axis limits on the plot itself from the plot options pop-up (discussed above).

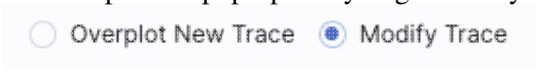
However, and perhaps more powerfully, you can set limits from the plot itself using a rubber band zoom. Click on the select icon in the plot () Click and drag in a sub-region of the plot. New icons appear:  If you click on the funnel icon, only those data points that pass the filter are shown in the plot, in the table, and/or overlaid on the image(s). (This is the behavior of 'filter', as opposed to 'select'; the former restricts what is shown, the latter just highlights the points.) For more on filters, see the filtering discussion in the tables section.

If you move your mouse over any of the points, you will get a pop-up telling you the values corresponding to the point under your cursor. If you click on any of the points, the object(s) corresponding to that point will be highlighted in SED table. This works the other way too - click on a row in the SED table, and the object will be highlighted in the plot.

You can also zoom with your mouse on the plot -- do whatever you would do with your mouse to scroll but with your mouse over the plot.

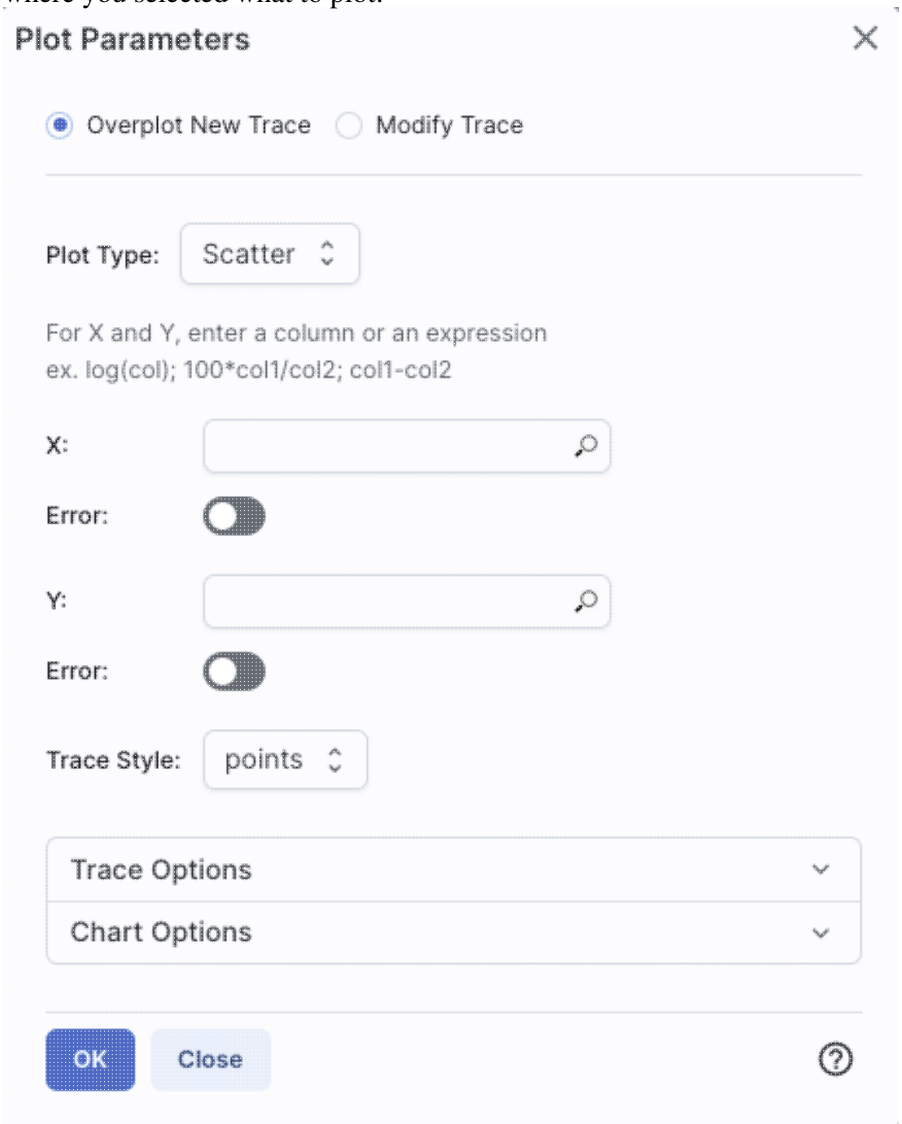
Overplotting

At the top of the pop-up that you get when you click on the gears, you have two radio buttons:



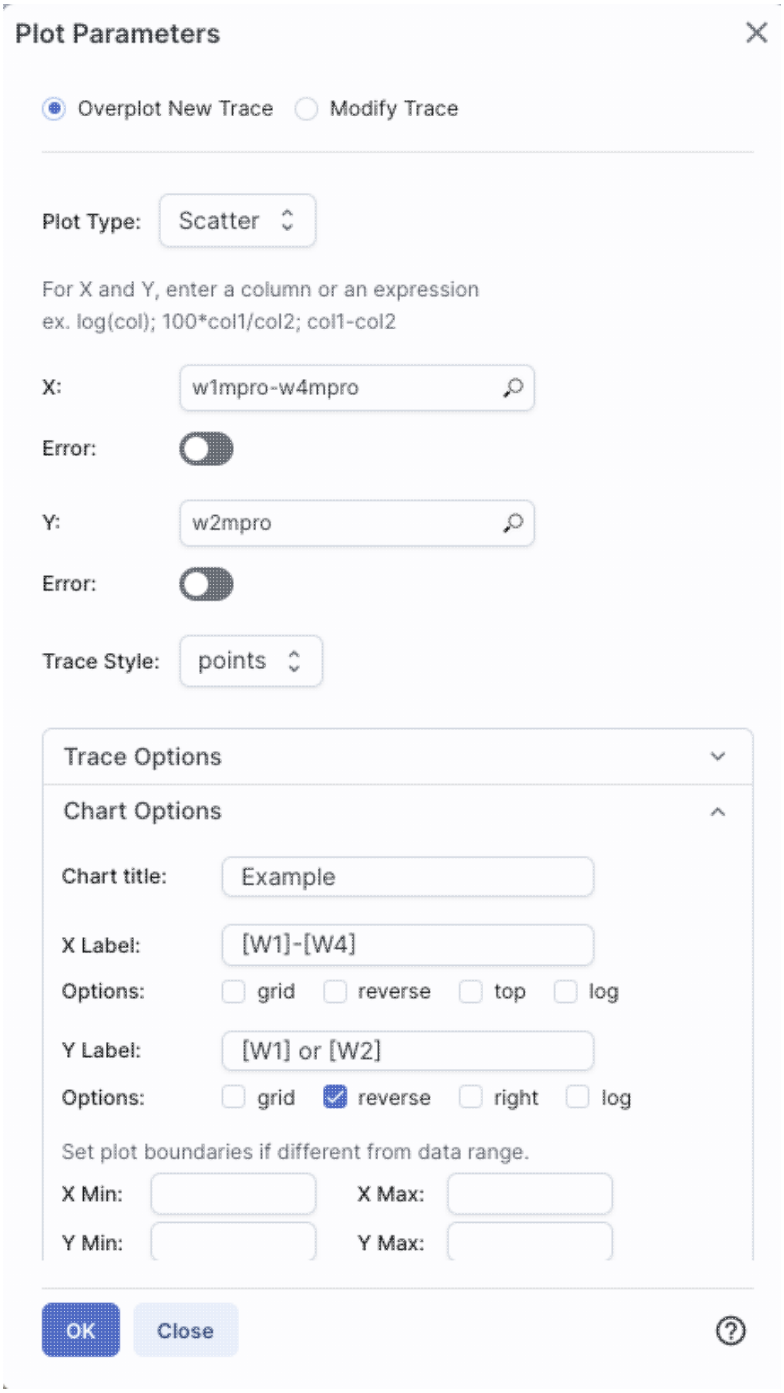
They are "Overplot New Trace" and "Modify Trace." Modifying traces (plots) has been covered above; in this section, we will cover overplotting. This is sometimes called "multi-trace," meaning that more than one thing is plotted.

When you select "Overplot New Trace," you get a new interface that is very similar to the original interface where you selected what to plot:

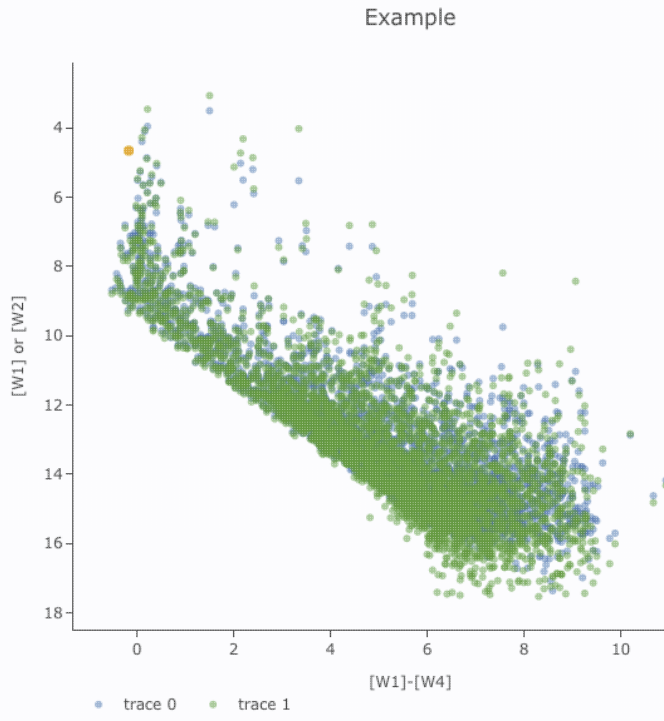


As before, you need to :

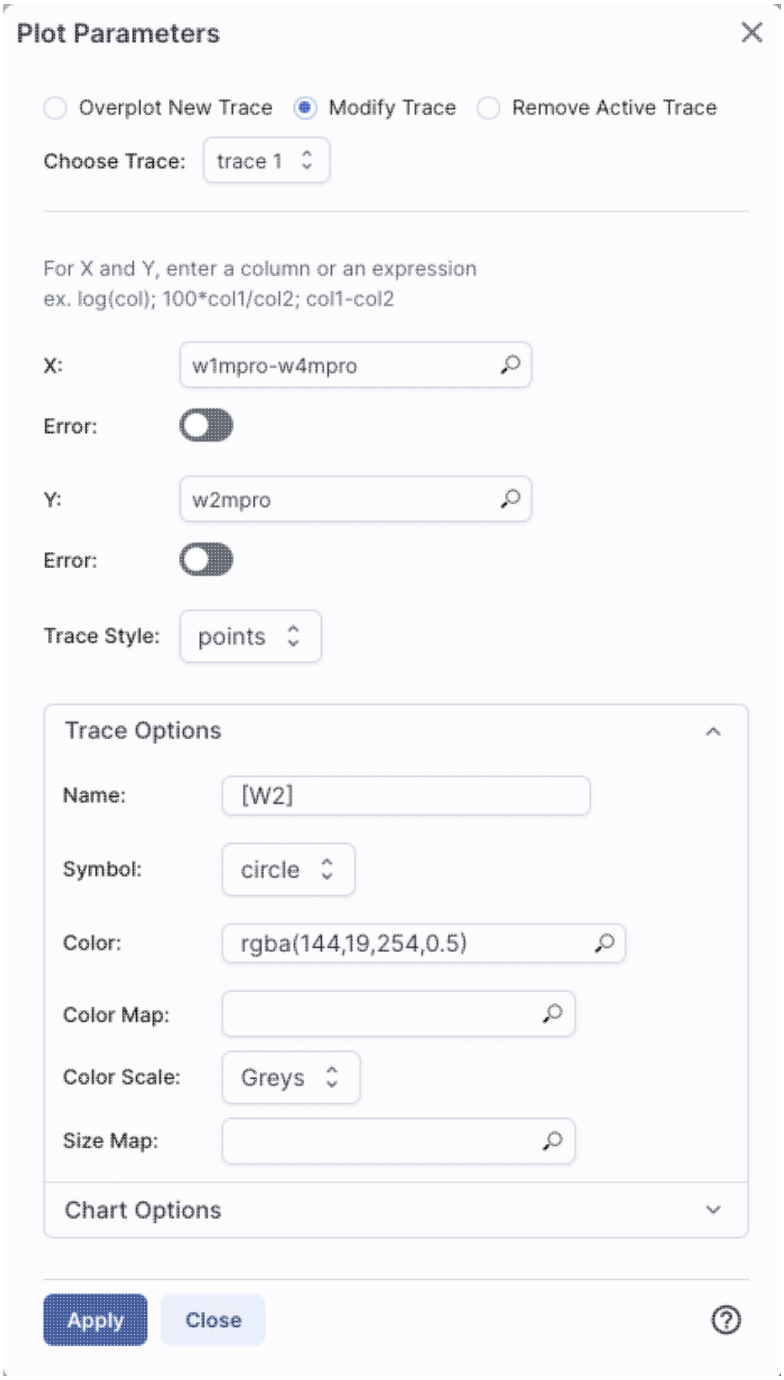
- select a plot type (scatter, heatmap, histogram);
- tell it what column(s) (and and manipulations thereof) you want for x, y, and associated errors;
- select the trace style (points, connected points, lines);
- set any additional trace options;
- set any additional chart options.



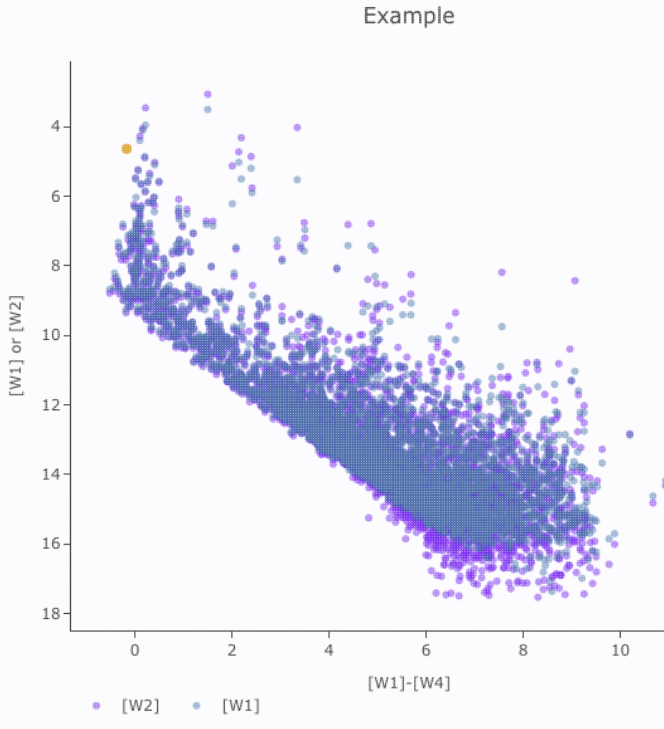
The best way to explain how to use this feature is probab
example. I have a plot of [W1] vs. [W1-W4]. Now I am
add on top of it a plot of [W2] vs. [W1-W4]. Click on the
bring up the pop-up. Select "Overplot New Trace." Enter
"w1mpro-w4mpro" for x and "w2mpro" for y. Expand "
Options." Note that it has preserved the overall chart title
before, but has erased the X and Y labels (and lost the re
the y axis) because the overplot could literally be anythin
need not be the same columns or even the same units as
already plotted. Type them in again. Here is the configur
window right before clicking "ok", and the resultant plot



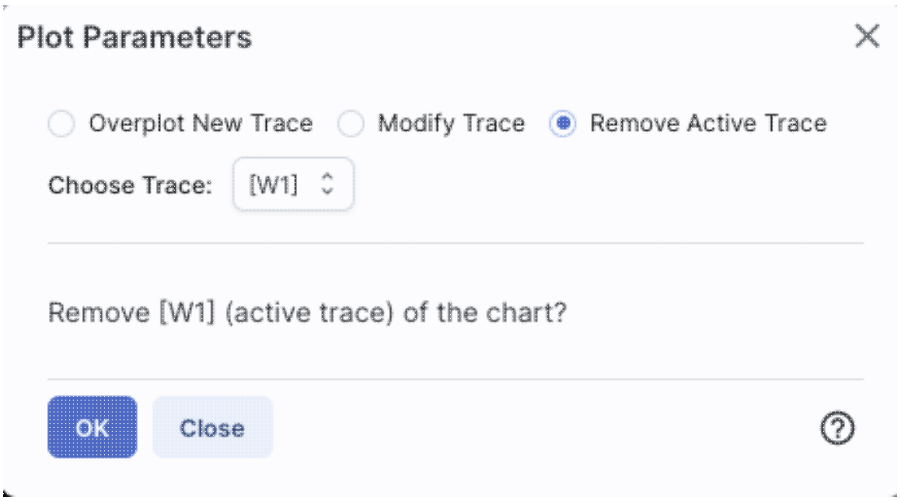
After you add the overplot, if you click on the gears agai
that the choices at the top of the window have changed.
add another overplotted trace, modify a trace, or remove
trace. Each trace that you add is a new 'layer' on the plot.
drop-down menu near the top of the window controls wh
is 'active' for setting the x, y, errors, trace style, name, sy
color, etc. there is now a drop-down menu at the top of th
There is a legend on the plot specifying which color corr
to which trace. In this example, the plot above has appea
a blue and green color scheme, which may be too hard to



differentiate. To change the new points' color, click on th
ensure "Modify Trace" is selected, select "trace 1" (as op
"trace 0", the first one you loaded), go down and expand
"Trace Options" and pick a different color. You can also
the legend name from "Trace 1" to, in this case, "[W2]".
"apply" to apply the changes to the plot. Note that once y
change the trace name, the relevant drop-down menus in
pop-up window and the legends on the plot update accor



Note that the pop-up spawned by clicking the gears now has an additional option at the top: "Add New Chart", "Overplot New Trace", "Modify Trace", and "Remove Active Trace." From here, you can modify a trace you have already plotted (as described above), overplot another trace (also as described above), or remove the selected trace:



Tips and Troubleshooting

- Right now, the overplotting only works from the same catalog -- that is, you cannot plot [W1] vs. [W1]-[W4] from one catalog and overplot [W1] vs. [W1]-[W4] from another catalog. (We enthusiastically await this capability too.)
- You can easily get yourself into a physically nonsensical situation, say, by overplotting a histogram onto a scatter plot. If you find yourself in a hopeless mess, click on the "undo" icon to reset everything and try again.
- When you have more than one thing (trace) plotted, double click on the legend to bring that trace to the foreground and temporarily hide the other traces.

Data Discovery Tool: User Registration for the IRSA Archives

There is one user registration for all IRSA applications, but data access, preferences, search history, data tagging, etc., are all unique to each archive.

While you certainly **do not have to register** to search the archive, download data, analyze data, and write a paper, you may wish to register.

Most catalogs in the Catalog Search Tool are public, so for most users, there is no need to log in.

On the other hand, ***if you are trying to gain access to some of the proprietary data in a particular archive, you will need to log in*** so that the system grants you access to that data. Not all archives served by IRSA have proprietary data. If you got email from an archive's Help Desk about account information, you may already have an account; else you can set up an account (see below). Once you have set up an account, please send us an email at the IRSA Help Desk and we'll tie your new account to your proprietary data.

Login

The "Login" link is in the far top right of the page.

Select this option to log in if you know your password, or to create a new account.

Create New Account

Find this option by selecting "Sign in" in the far top right of the browser window, and then "Create an account" appears as an option in the lower left of the pop-up window.

Select this option to create a new account.

Forgot your Username or Password

If you do not remember your username or password, select this option to retrieve this lost information.

Find this option by selecting "Sign in" in the far top right of the browser page, and then "forgot your password?" appears as an option below the Login button.

Edit Profile

Find this option by logging in, and then clicking on your account name in the top right of the browser window. Then, select "Edit Profile" to change your password on an existing account.

Change Password

Find this option by logging in, and then clicking on your account name in the top right of the browser window. Then, select "Change Password" to change your password on an existing account.

Update Email

Find this option by logging in, and then clicking on your account name in the top right of the browser window. Then, select "Update Email" to change your email on an existing account.

Data Discovery Tool: FAQs

Do you have any tutorial videos?

Yes. There are Data Discovery Tool video tutorials available at the IRSA YouTube channel. Also see the playlist of tutorials relevant for more than one archive.

How do I get more help?

The "Help" blue tab leads you into this online help. You can also download a PDF version of this manual; look at the top of the help window.

You can submit questions to the IRSA Help Desk.

Found a bug? If you think you have found a bug, before reporting it, please check this this central list, and read this online help. It may be a "feature" we already know about. If you have found a new, real bug then please do contact us via the IRSA Help Desk. Please include your operating system version and your browser software and version. If you can, please also include any specific error message you may have gotten. (NB: In our testing, copying shortcuts worked on Windows and Linux; the command-C did not work on Macs, but selecting and clicking the right mouse button did.)

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- The date and time you access our site
- The pages you access (recorded by the text and graphics files that compose that page)
- The Internet address of the website from which you linked directly to our site.

We use the summary statistics to help us make our site more useful to visitors, such as assessing what information is of most and least interest to visitors, and for other purposes such as determining the site's technical design specifications and identifying system performance or problem areas.

The website also collects and stores information about your search options, such as

- Name resolver choice (NED/Simbad)
- Page size (number of rows)
- Which search results (tabs) should be displayed
- Email address, if provided, for email notifications
- Search parameters so that you can resubmit your search via your search history
- Data tags, if you create one
- Plus, additional preferences that may be developed in the future, such as those tied to the visualization options.

If you register as a user, these options will be kept in our database (along with your login ID and password via MD5 hash) and used for your session the next time you log in. If you do not register as a user, these options are set via cookies kept on your computer; if you clear your cookies and start a new session, these preferences are lost.

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