# Spitzer Heritage Archive Help

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# Spitzer Heritage Archive: Overview

The Spitzer Heritage Archive (SHA) is the final repository for all of the data collected by Spitzer.

Note that there are also SHA video tutorials, available at the IRSA YouTube channel. Look for the playlist that combines all the SHA videos together.

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+Terminology
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+Results Overview
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+Logging in
+Getting More Help

## The Spacecraft and Instruments

The Spitzer Space Telescope (formerly SIRTF, the Space Infrared Telescope Facility), was launched into an Earth-trailing orbit on 25 August 2003, and ceased operations on 30 January 2020. Consisting of a 0.85-meter telescope and three science instruments, at the time of its launch, Spitzer was the largest infrared telescope ever launched into space. The instruments aboard Spitzer (IRAC, IRS and MIPS) obtained images and spectra at wavelengths between 3 and 180 microns, with spatial resolution ranging from 2 arcseconds at the shortest wavelengths to 40 arcseconds at the longest. More information on Spitzer is available.

## Terminology

This archive of Spitzer data is called the Spitzer Heritage Archive, or the SHA.

An individual Spitzer observation sequence is an *AOR, or Astronomical Observation Request*. In certain cases (often calibration or sometimes science observations), you may also see an *IER, or Instrument Engineering Request*. Either one involves many individual frames.

The individual data frames that emerge, calibrated, from the Spitzer pipeline are *Level 1, or Basic Calibrated Data, or BCDs*.

The products that come from combining these individual data frames (such as mosaics of individual pointings) are *Level 2, or post-BCD, or PBCD data*.

*Enhanced Products* come from combining AORs or doing post processing (such as synthetic photometry from spectra or source extraction from images). These can be contributed by the community, or generated by the Spitzer Science Center (SSC) itself.

One AOR may have *many* Level 2 (PBCD) files associated with it, and a *very large number* of Level 1 (BCD) files associated with it. Not every AOR may have enhanced products associated with it.

*IRSA and the Spitzer Heritage Archive utilize technology developed for the Virtual Astronomical Observatory (VAO), funded by the National Science Foundation and the National Aeronautics and Space Administration under Cooperative Agreement AST-0834235.*

## Searching (Quick Start)

Several search options are provided, which are documented in more detail in the Searching section.

Searching by position is the most popular search, and you can also search in "batch mode" by uploading a table, from your local disk or the IRSA Workspace (which is a bit of disk space for you at IRSA).

You can also search for Solar System objects by NAIF ID, or search over the whole archive.

You can also search for only observations from one program or a certain block of time. Go to the Searching section for much more detailed information.

## Results Overview

The search results appear in two "panes" (like "window panes"). You can grab and drag the division between the two panes to change their relative sizes.

The left pane of the search results contains lists of observations that met your criteria. The right pane of the search results contains more details of the observations. The right pane changes depending on what row you have selected (clicked on) in the left pane. (And the left pane can change depending on what you have selected in the right pane.)

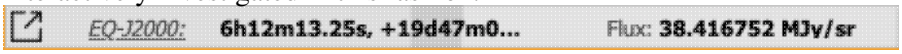
The basic table manipulation tools are documented in the Tables section.

For more information, see the Results section.

## Visualization Overview

Any images meeting your search criteria are shown as the results of the search, in the instrument tabs. The small circle overlaid by default is the search position you submitted.

Move your mouse over any image that is returned by your search. Details about the image and, specifically, the pixel beneath your mouse cursor, appear along the top of the window with a variety of useful items (see screenshot below). Some information is updated in real time (such as coordinates); some information (such as flux densities) is updated when you stop moving your mouse for a second or two. The image can be interactively investigated in this fashion.




There is a toolbar across the top of the window from which you can interact with the displayed FITS image files -- you can control the stretch, add a coordinate grid, etc. Clicking on the icon that looks like this: enlarges the images to take up more space in the browser, and you can further zoom to make a single image take as much space in the browser as possible. You can scroll through all of the images in this maximally "zoomed-in" view. You can also add or remove overlays (such as coordinates or distances) to your images. See the Visualization section for more on visualization.

## Downloading Data Overview

You can download to your disk the observations you have selected. Check the box at the start of each row (or the box at the top of the column of boxes to select all) and click "Prepare download." See the section on Downloads or the section on the Background Monitor for more information.

## Logging in (Overview)

The Spitzer Heritage Archive can remember you when you return. See the user registration section for more information.

## Getting More Help

The "Help" blue tab leads you into this online help. There are also context-sensitive help markers throughout the tools ( ). You can also download a PDF version of this manual; look at the top of the help window. (The PDF may be easier to search than the web pages; use your PDF reader's search function.)

You can submit questions to the IRSA Help Desk.

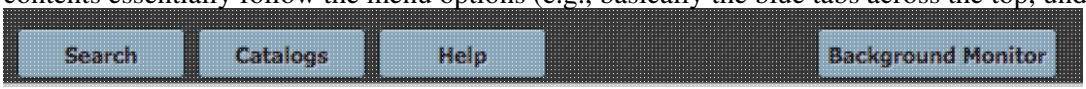
The IRSA YouTube channel has lots of short videos about IRSA tools, including specifically the SHA.

A set of frequently asked questions (FAQs) is here.

**Found a bug?** The known bugs and issues in this version of the Spitzer Heritage Archive are listed here. If you think you have found a bug, before reporting it, please check this 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.)

# Spitzer Heritage Archive: Basic Features and Functions

This section is an overview of the basic features and functions of the Spitzer Heritage Archive (SHA). The contents essentially follow the menu options (e.g., basically the blue tabs across the top, under the IRSA menu).




Besides the online help (also available as a PDF), there are also Spitzer Heritage Archive video tutorials, available at the IRSA YouTube channel. There is a playlist that collects together all of the SHA videos. Also see the list of "micro-tutorials" relevant for more than one tool, and the list of tutorials using more than one tool.

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+Catalogs -- Retrieving and Using Catalogs
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+Downloading data
+Background Monitor

## Searching Overview

Searching the archive is straightforward -- the most common search is a search by position on the sky for a cone search. You may enter a target name, and have NED or Simbad resolve the target name into coordinates. Alternatively, you may enter coordinates directly.

You specify the radius over which you want to search. You may enter this radius in arcseconds, arcminutes, or degrees; just change the drop-down option accordingly. **Caution:** pick your units from the drop-down first, and then enter a number; if you enter a number and then select from the drop-down, it will convert your number from the old units to the new units. There are both upper and lower limits to your search radius; it will tell you if you request something too big or too small.

Several additional search options are provided, which are documented in more detail here.

The search window can be retrieved after a search by clicking on the blue "Searches" tab near the top left.

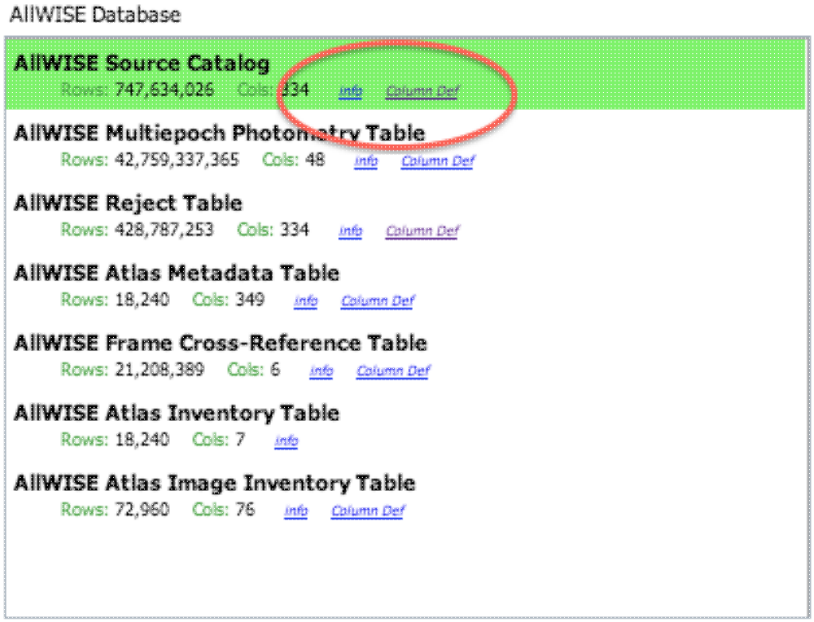
## Catalogs -- Retrieving and Using Catalogs

(Note that catalogs are available via a blue tab that appears at the top of the page, but this might only make sense after you have performed at least one search -- in essence, you might want to have something on which to overlay the catalog before searching for catalogs.)

You can choose from any of a wide variety of catalogs (from IRSA or your own disk) to load in preparation for overlaying on your visualized data. You can manipulate catalogs just like any other table in this tool.

In most cases, catalog searching remembers the most recent search you did and constructs a query that will cover the same area. You may change the search criteria and select catalogs from a wide variety of places. The IRSA catalogs need to be selcted based first on the "project" under which they are housed at IRSA, such as 2MASS, IRAS, WISE, MSX, etc. The options under the "category" and the specific clickable catalog on the

right change according to the project you have selected. A short description is provided for each of the catalogs, with links for more information.; an example is here:




Click on "Search" to initiate the search. **NOTE THAT** the search may take a long time to return, especially if you have asked for a large catalog, and you may think that nothing has happened, but be patient and eventually it will either spin off to the background monitor, or return a tab directly.

Use large search radii with caution! Be sure you understand how many sources you are likely to retrieve. Searches that retrieve more rows will take a long time.

Once you have a catalog loaded, to return to the view where the image takes up as much of the screen as possible, let your mouse hover over the image and then click on this 'expand' icon in the upper right of the image: A similar expand icon can be found in the catalog window pane, or the catalog plotting pane, so that you can view those panes as large as possible.

For more information, please see the Catalogs section (or the Tables section for generic table help).

## Getting More Help

The "Help" blue tab leads you into this online help. There are also context-sensitive help markers throughout the tools ( ). You can also download a PDF version of this manual; look at the top of the help window. (The PDF may be easier to search than the web pages; use your PDF reader's search function.)

You can submit questions to the IRSA Help Desk.

The IRSA YouTube channel has lots of short videos about IRSA tools, including specifically the Spitzer Heritage Archive.

A set of frequently asked questions (FAQs) is here.

**Found a bug?** The known bugs and issues in this version of the Spitzer Heritage Archive are listed here. If you think you have found a bug, before reporting it, please check this 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 always work on Macs, but selecting and clicking the right mouse button often did when command-C did not.)

## Downloading Data

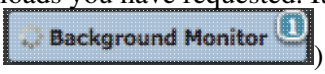
After deciding which data to download, click the checkboxes to select specific data files to download (click the checkbox at the top of the column of checkboxes to 'select all'), and then click "Prepare Download" to begin the packaging and downloading process. A pop-up window will appear in order to define exactly what kinds of data you would like to have packaged up. Clicking "Prepare Download" in the pop-up initializes this packaging process.

The packaging process spins off into the background monitor, which keeps track of its progress and notifies you when the downloads are complete. You can monitor its progress by clicking on the background monitor link. You can choose to have an email sent to you to let you know when things are ready, even after the packaging process has started.

Note that **you** control where the data are saved on your disk through your browser; your browser may be configured to store all downloads in a particular location on your disk. Look for a "Downloads" folder or search for recently modified files.

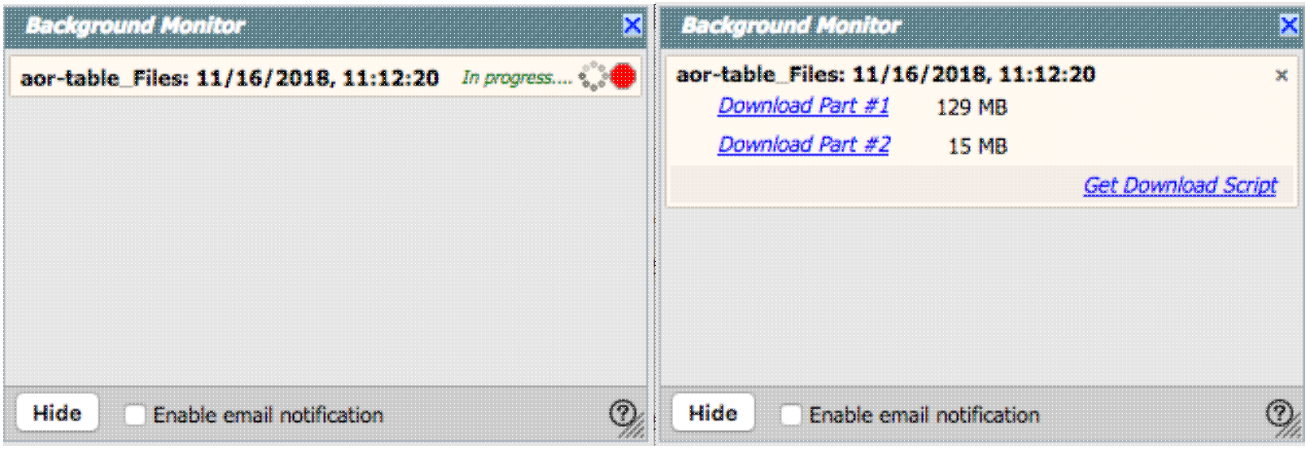
For more information, please see the Downloads section.

## The Background Monitor

The Background Monitor appears as a blue tab (or button) in the upper right of your window to keep track of the data downloads you have requested. It actively changes to reflect what it is doing (e.g., this is preparing a data package: 

) Data packaging all goes to the Background Monitor; larger catalog requests can also be sent to the Background Monitor.

A pop-up window can be called up at any time by clicking the "Background Monitor" tab. You can watch your data being retrieved. It will update that window when the data are available for download and/or overlay on your image, providing a link (or links) for obtaining the data. It also keeps track of the downloads you have requested during the same session, and indicates with a checkmark those that you have already loaded. Remove them from the list by clicking on the blue 'x'.




To stop any query mid-way through, click on the little red octagon ("stop sign") that appears next to the query in the Background Monitor pop-up.

If you forgot to put in your email at the beginning, or if the packaging is taking longer than you expected, you can click on "Enable email notification" from the bottom of the Background Monitor popup and add your email during the packaging process.

# Spitzer Heritage Archive: Searching

There are many different options for searching the Spitzer Heritage Archive (SHA). Searching by position is the most commonly used option.

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+Searching by AORKEY
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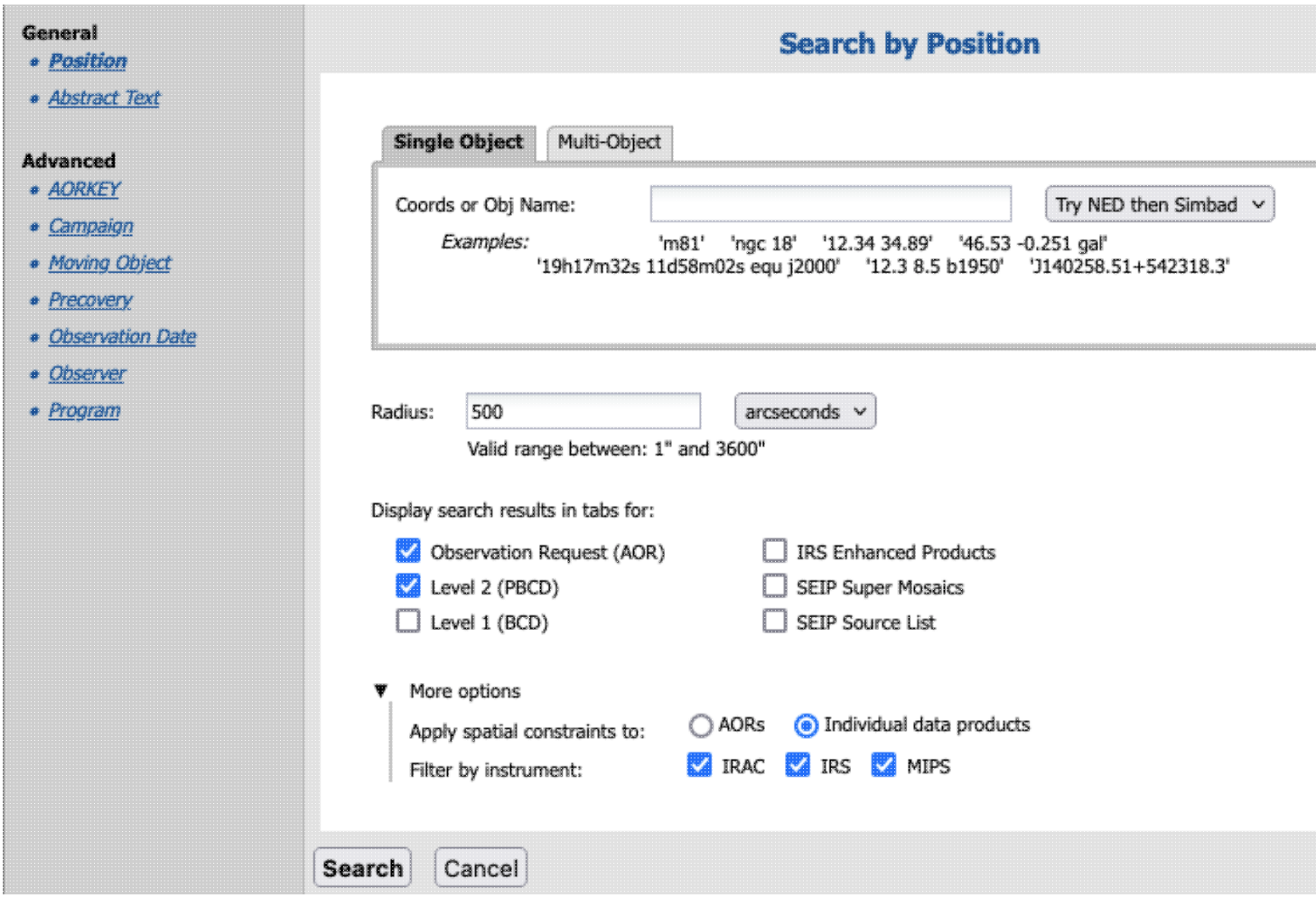
+Searching by NAIF ID (Solar System Object)
+Precovery (Solar System Object)
+Searching by Date Range
+Searching by Observer Name
+Searching by Program
+More on Enhanced Products

## Searching by Position (Spatial Constraints)

This search is the most common search performed on astronomical archives. Enter your central position and cone (circle) radius, then all observations (those meeting all the rest of your entered criteria) intersecting that cone are returned.




You may enter a target name, and have either NED-then-Simbad or Simbad-then-NED resolve the target name into coordinates (such as M17 or NGC6946). Alternatively, you may enter coordinates directly. These coordinates can be in decimal degrees or in hh:mm:ss dd:mm:ss format. By default, it assumes you are working in J2000 coordinates; you can also specify galactic, ecliptic, or B1950 coordinates as follows:

- '141.607 -47.347 gal' means 141.607, -47.347 degrees in galactic coordinates
- '42.76037 3.17750 ecl' means 42.76037, +3.17750 degrees in ecliptic coordinates
- '12h34m27.0504s + 2d11m17.304s Equ J2000" specifies the RA and Dec in J2000 coordinates
- '20h27m36.3467s +40d01m21.649s Equ B1950' specifies the RA and Dec in B1950 coordinates

As you are completing a valid coordinate entry, it echoes back to you what it thinks you are entering. Look right below the box in which you are typing the coordinates to see it dynamically change.

You specify the radius over which you want to search. You may enter this radius in arcseconds, arcminutes, or degrees; just change the drop-down option accordingly. **Caution:** pick your units from the drop-down first, and then enter a number; if you enter a number and then select from the drop-down, it will convert your number from the old units to the new units. There are both upper and lower limits to your search radius; it will tell you if you request something too big or too small.

You then need to select what kinds of results you want:

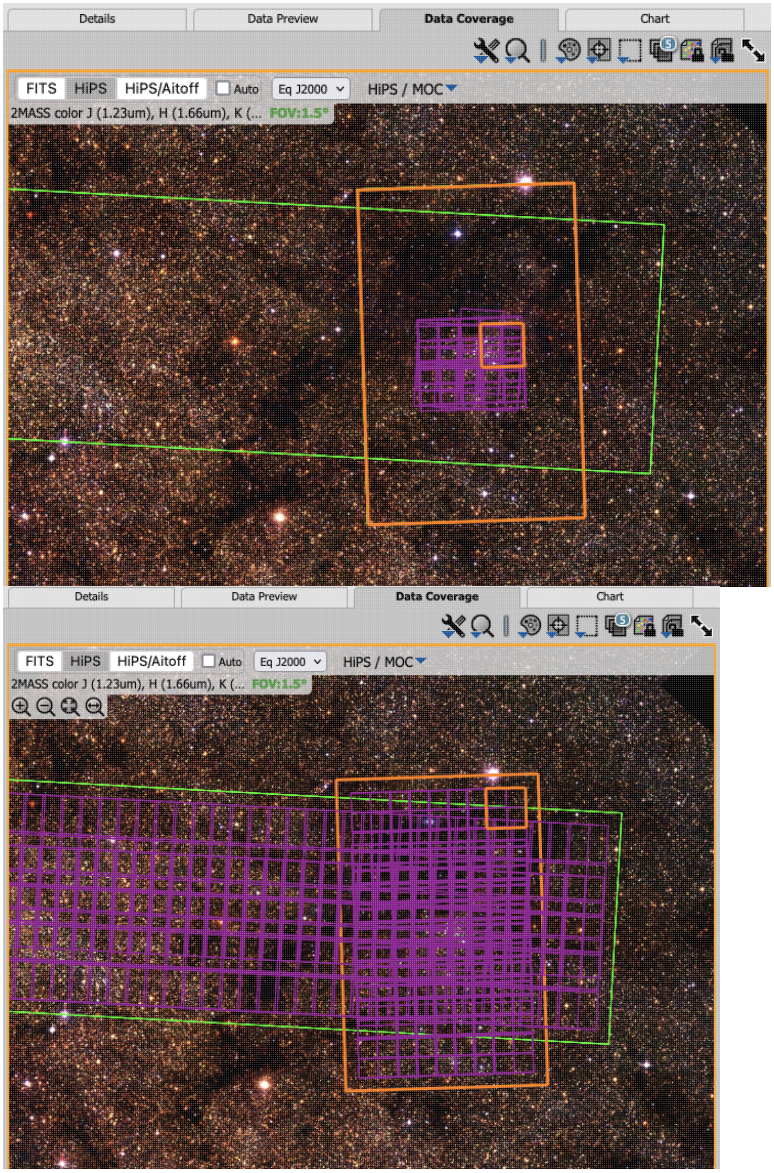
- Observation requests (AOR)

- Level 2 (PBCD)
- Level 1 (BCD)
- IRS Enhanced Products
- SEIP Super Mosaics
- SEIP Source List

Each of these results will be displayed in different tabs.

Under the "more options" triangle, you can apply the spatial constraints to AORs or individual data products, or ask for results from just one, two, or all three instruments.

*What does it mean to apply spatial constraints to AORs or individual data products?*




This is probably best explained via a quick example. If we search for M16 using a 100 arcsecond radius, we return two cryo-era IRAC AORs. The Level 2 PBCD mosaics are all returned, with the same footprint per AOR for all four channels shown on the coverage image, where one AOR is long and narrow, and the other AOR is more square, shown here as green and orange polygons. However, if the spatial constraints are applied to the individual data products, only the BCDs meeting those constraints are returned (e.g, those within 100 arcseconds of the requested target) -- shown as purple polygons in the first visualization. If the spatial constraints are not applied to the individual data products, then all of the BCDs corresponding to each of those AORs are returned, shown as purple polygons in the second visualization.

If we download data from the AOR or Level 2 tab, and select Level 1 data there, we should get all of the BCDs. If we download data from

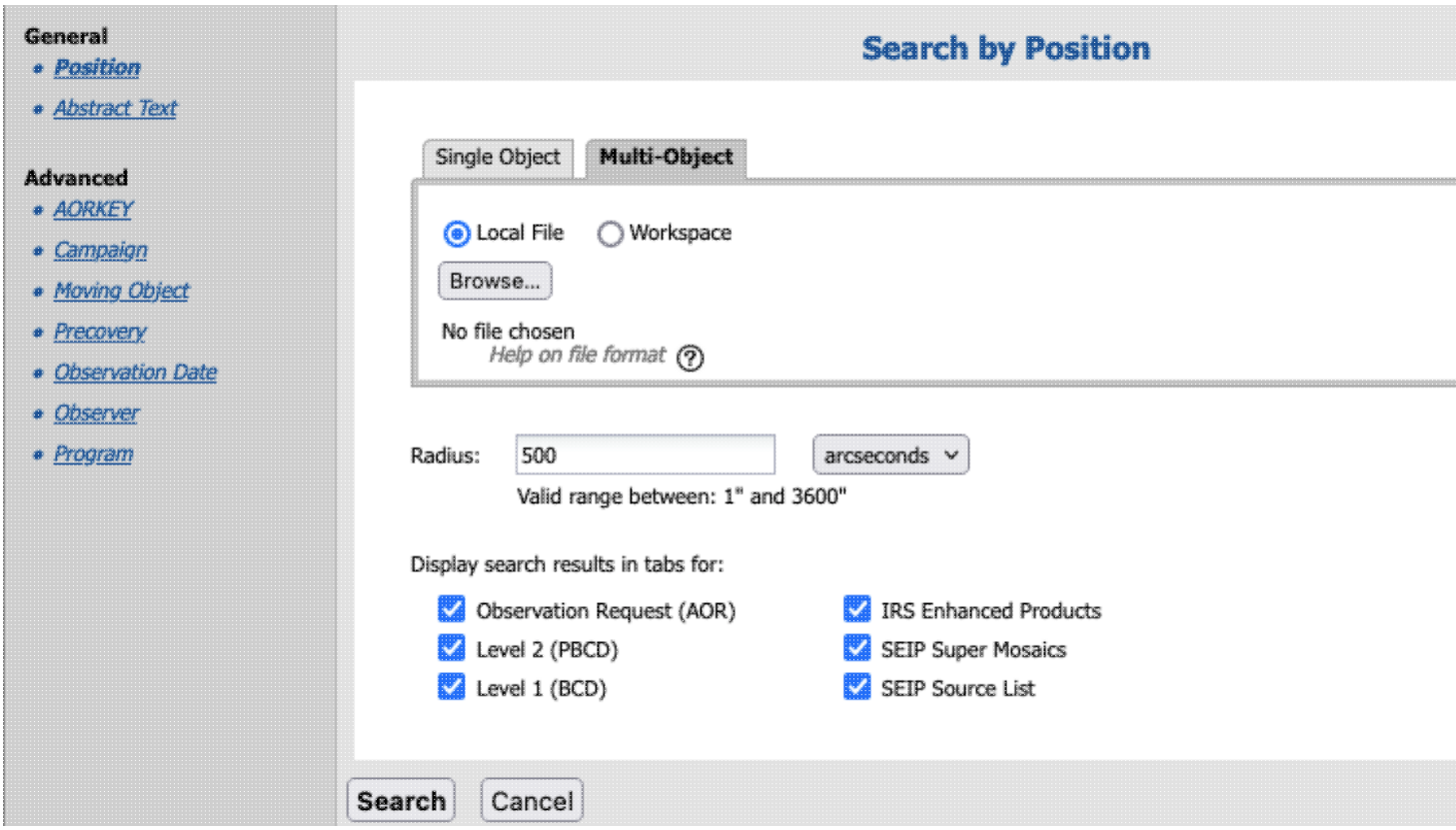
the Level 1 tab for a constrained-by-position data product search, we should only get the limited BCDs as shown.

**Tips and Troubleshooting**:

- For astronomers investigating Spitzer data for the first time, note that many investigators delivered high level science data products back to IRSA; try searching by position from the box in the upper left on IRSA's main page to see what data sets we have covering your position on the sky. (See also the first example here.)
- If you don't understand why you're getting the results you're getting, explore what is being returned in the coverage tab. (See also the third example here.)

## Searching by Position in Batch Mode

The position search can also be done for multiple positions in "batch mode" from a list of objects given in a file. Select "Multiple positions" from the left. You can load a file from your local disk or the IRSA Workspace, which is a bit of disk space for you at IRSA.




The file must be in IPAC table file format, which is ASCII text with headers explaining the type of data in each column, separated by vertical bars.

A sample input file looks like this:

```
|              ra|             dec|
|          double|          double|
|             deg|             deg|
 266.461876096161 -28.9303475510113
 317.385694084404 -41.1537816217576
 267.210580557307 -27.7929408211594
 229.172700517754   0.2598861324350
 299.510225672473 -38.7735055243326
 213.945501950887  13.3596597685085
 262.341432853080 -23.7518928284717
 271.202769466020 -21.7274227022229
 291.167629785682 -29.2569222675305
 272.336516119634 -20.2761650442889
 237.391628608612   2.5906013137112
```

As for searching on targets one at a time, from the front screen, you specify the radius over which you want to search. You may enter this radius in arcseconds, arcminutes, or degrees; just change the drop-down option accordingly. **Caution:** pick your units from the drop-down first, and then enter a number; if you enter a number and then select from the drop-down, it will convert your number from the old units to the new units. There are both upper and lower limits to your search radius; it will tell you if you request something too big or too small.

For batch searches, if you want to use a different search radius for each target, add a column to the input table. If the table uploaded has a 'radius' column, the API will overwrite the single radius search and take the one specified in each row in the table.

So that you can more easily tie results to input, when you get results back from a batch search, the input RA and Dec are columns appended to the end of your results tables.

**Tips and Troubleshooting**: Having problems making a valid IPAC table? Assemble something close to the correct IPAC table file format, then pass it through the the IPAC table validator. The most common errors include the following :

- No hyphens allowed in column names, or filename!
- Column names should be all in lower case
- No empty lines at the end of the input file.
- IPAC table files should end in ".tbl".
- Make sure there are not lots of extra whitespace (spaces, tabs, etc.) at the ends of lines, particularly the header lines.
- Check for and remove odd non-standard characters like curly quotes or Greek letters, and other non-printing special characters (like tabs).
- If using the table verification service, name resolution may fail for some targets with Greek letters or other unusual characters -- provide coordinates for the troublesome names, or remove them.

Please note that the maximum number of targets that can be requested in a batch search is 1000.

After selecting your table of positions, you then need to select what kinds of results you want:

- Observation requests (AOR)
- Level 2 (PBCD)
- Level 1 (BCD)
- IRS Enhanced Products
- SEIP Super Mosaics

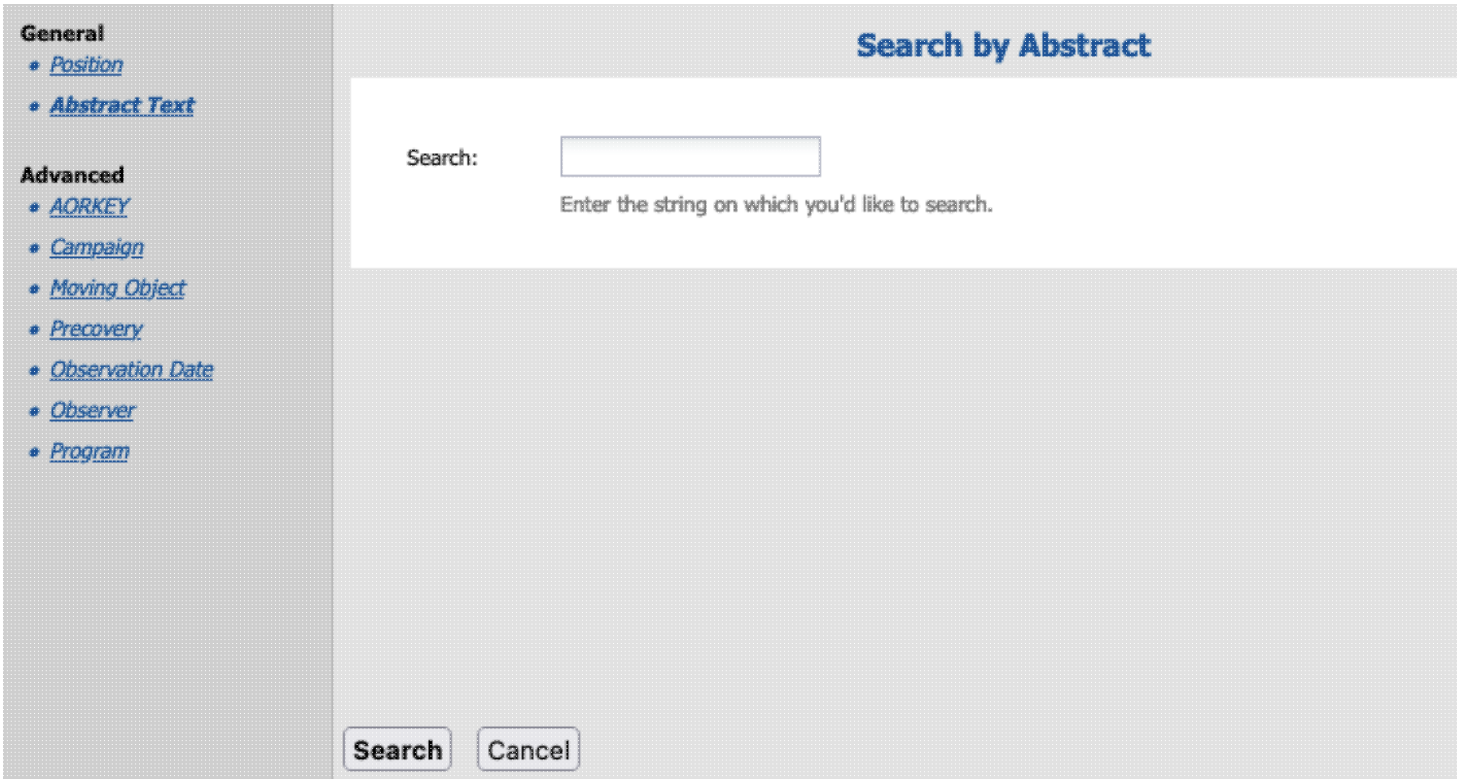
- SEIP Source List

Each of these results will be displayed in different tabs.

## Searching by Abstract Text

You can search on a string through all of the Spitzer program abstracts. You can search on any text you would like, from principal investigator (PI) last names to instrument names to compound terms (such as "brown dwarf"). You can also use simple logic statements, e.g., "star formation -galaxy" means find all instances of the terms "star" and "formation" but not those that also use the word "galaxy." To enforce the appearance of a compound term, e.g., the word "star" next to the word "formation", enclose the term in quotes.

The results of this search are a list of programs; you should click on the title of the program, and then the search becomes a search by program.

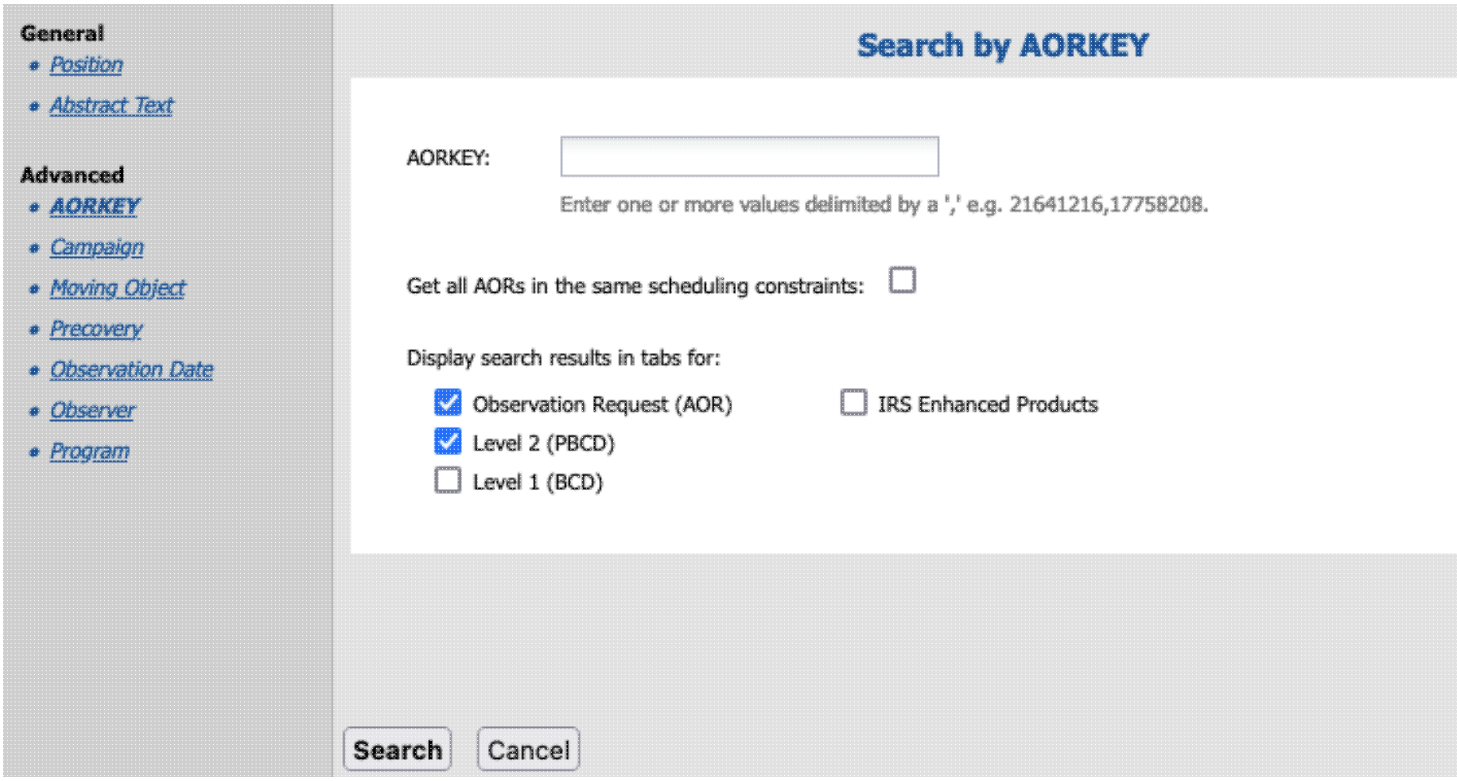



## Searching by AORKEY

An AORKEY is a large integer that uniquely identifies the observation (AOR) within the Spitzer mission. All Level 1 (BCD) and Level 2 (PBCD) files carry with them the fingerprints of this AORKEY (in the filenames, in the directory structure, in the FITS headers...). Specific AORKEYs should be listed in journal articles reporting on Spitzer results.

You can retrieve a specific observation by searching on this AORKEY. Note that a single AORKEY corresponds to a single AOR, so if you search on a single AORKEY, you will always get a single AOR in the AOR tab.

You can search for many AORKEYs at once by entering a list of them separated by commas.




Some observations were obtained with some scheduling constraints, e.g., 'observe this series of 8 AORs in this order within this time window.' In the AORKEY search panel, there is an option to retrieve all the other AORs within the same scheduling constraint. **However, note that** some time series observations were obtained in the following manner. For a series of observations (a, b, c, d, e), a was tied to b with a particular constraint, b tied to c, c tied to d, and d tied to e. If you search on the AORKEY corresponding to observation b, and ask the SHA to give you all of the AORs constrained to that observation, it does exactly (and only) what you asked it to do -- b is tied to a and c, but not explicitly tied to d or e. So it returns to you observations a, b, and c, and not d or e.

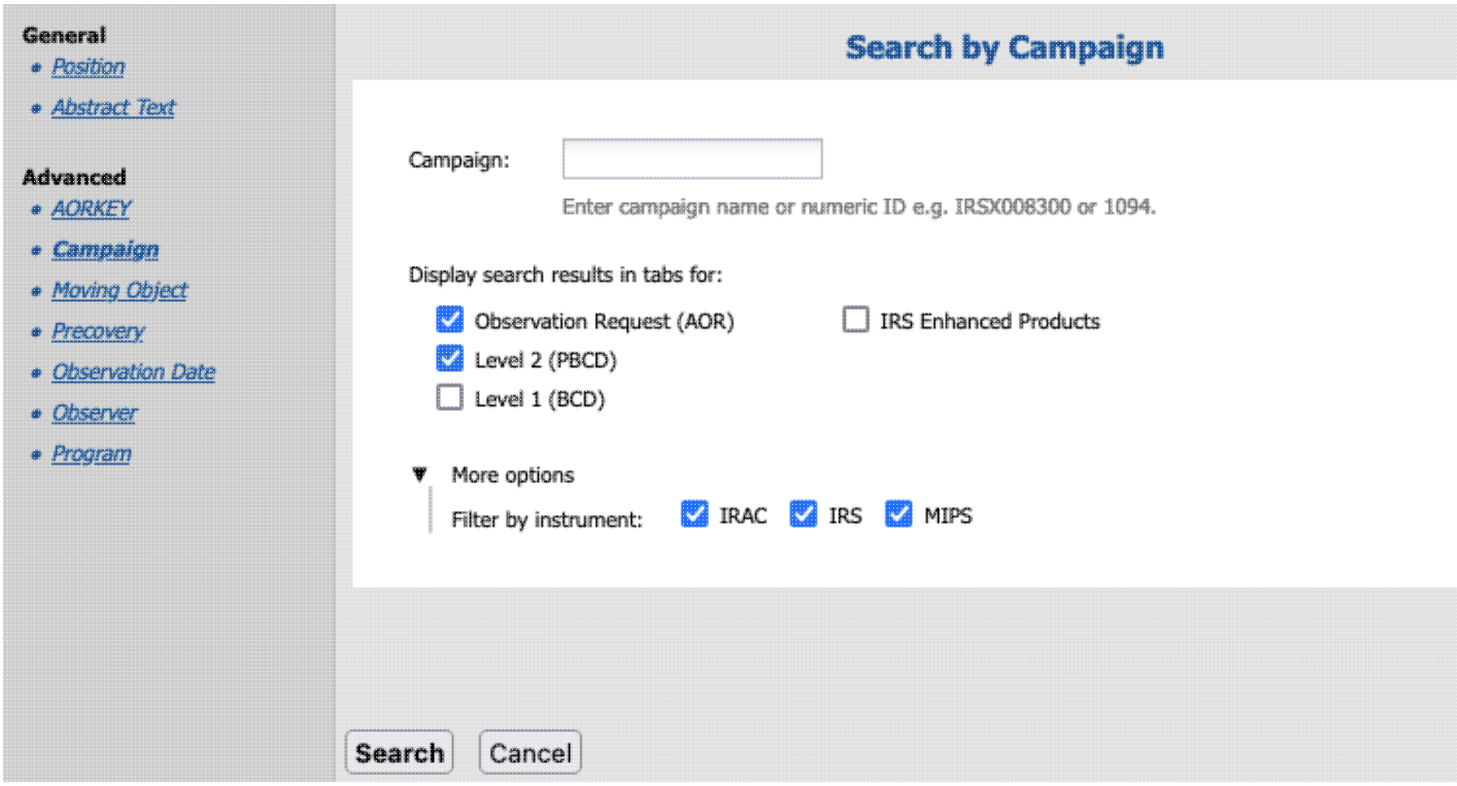
After typing in your AORKEY(s), you then need to select what kinds of results you want:

- Observation requests (AOR)
- Level 2 (PBCD)
- Level 1 (BCD)
- IRS Enhanced Products

Each of these results will be displayed in different tabs.

## Searching by Campaign

In some cases, you may wish to browse all of the data taken during a specific campaign, e.g., to investigate bright object artifacts in your data from observations preceeding yours. This feature allows you to do exactly that. A complete list of Spitzer campaigns can be found at the Spitzer documentation.




Note that there are a few different ways to refer to a given Spitzer campaign, and the search only recognizes two of them. For example, IRS campaign 47 was run between 9 Jan 2008 and 23 Jan 2008. The formal campaign ID (which works in the search) is IRSX008300, and the search also works with the numerical id 1094 listed as synonymous with this campaign in the Spitzer documentation.

After typing in your campaign(s), you then need to select what kinds of results you want:

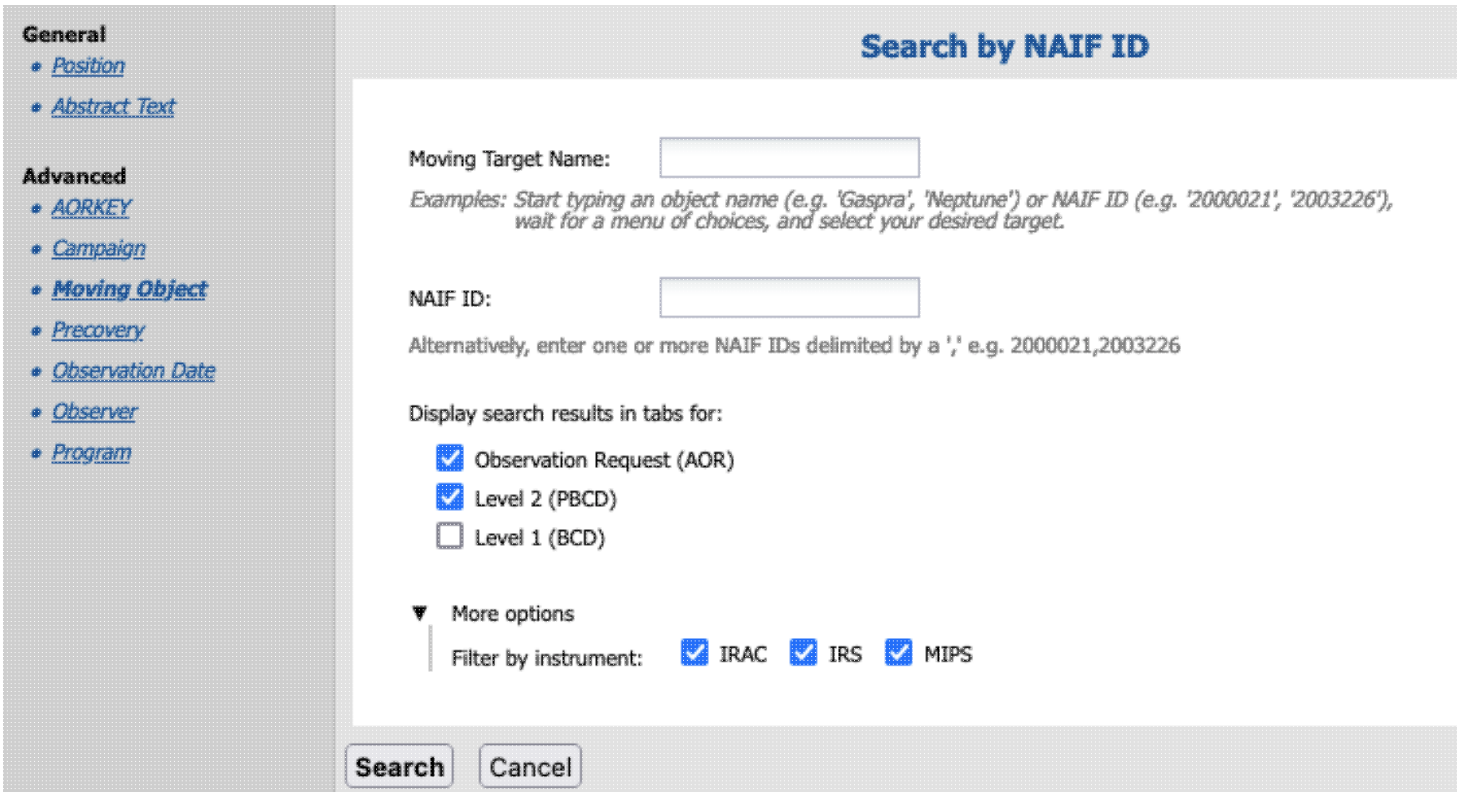
- Observation requests (AOR)
- Level 2 (PBCD)
- Level 1 (BCD)
- IRS Enhanced Products

Each of these results will be displayed in different tabs.

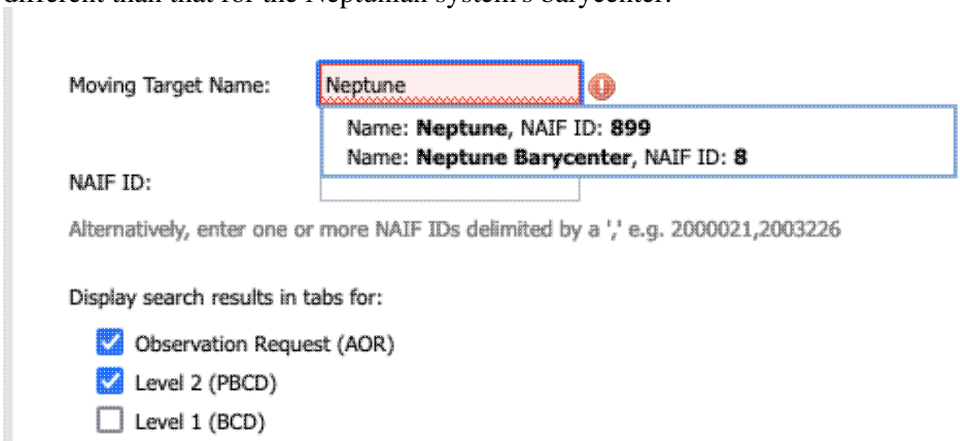
Under the "more options" triangle, you can ask for results from just one, two, or all three instruments.

## Searching by NAIF ID (for Solar System Objects, SSOs)

You can search on the name of a moving target (Solar System Object, SSO), or the NAIF ID. The accepted naming conventions are the ones that have been approved for use by the CSBN and its predecessors. SSOs are assigned NAIF IDs, which are a unique integer identifier for known Solar System bodies. (See here or here for more about NAIF and NAIF IDs; in brief, every body in the Solar System has a number.)




If you know the NAIF ID, just type that in; if you know only the name, it will attempt to resolve the name for you into a NAIF ID. You may need to wait a second or two. You may need to carefully read what it is suggesting to make sure you have selected the NAIF ID you really want. For example, Neptune's NAIF ID is different than that for the Neptunian system's barycenter:




Even if only one suggestion is given, you need to explicitly select that suggestion in order to implement the search.

This search will retrieve data explicitly declared to be observations of these moving targets in the Spitzer database. This means, for example, that observations of a moving target performed as a fixed-target observation of an RA/Dec will not appear, nor will serendipitous observations of a moving target that happens to appear in a fixed-target observation. To find such observations, see the next section on "Precovery." Note also that if incorrect target information was entered at the telescope, observations may not be retrieved.

After selecting your NAIF ID, you then need to select what kinds of results you want:

- Observation requests (AOR)
- Level 2 (PBCD)
- Level 1 (BCD)

Each of these results will be displayed in different tabs.

Under the "more options" triangle, you can ask for results from just one, two, or all three instruments.

**Tips and Troubleshooting**: You need to select the NAIF ID, even if there is only one, in order to make the search work.

## Moving Object Precovery

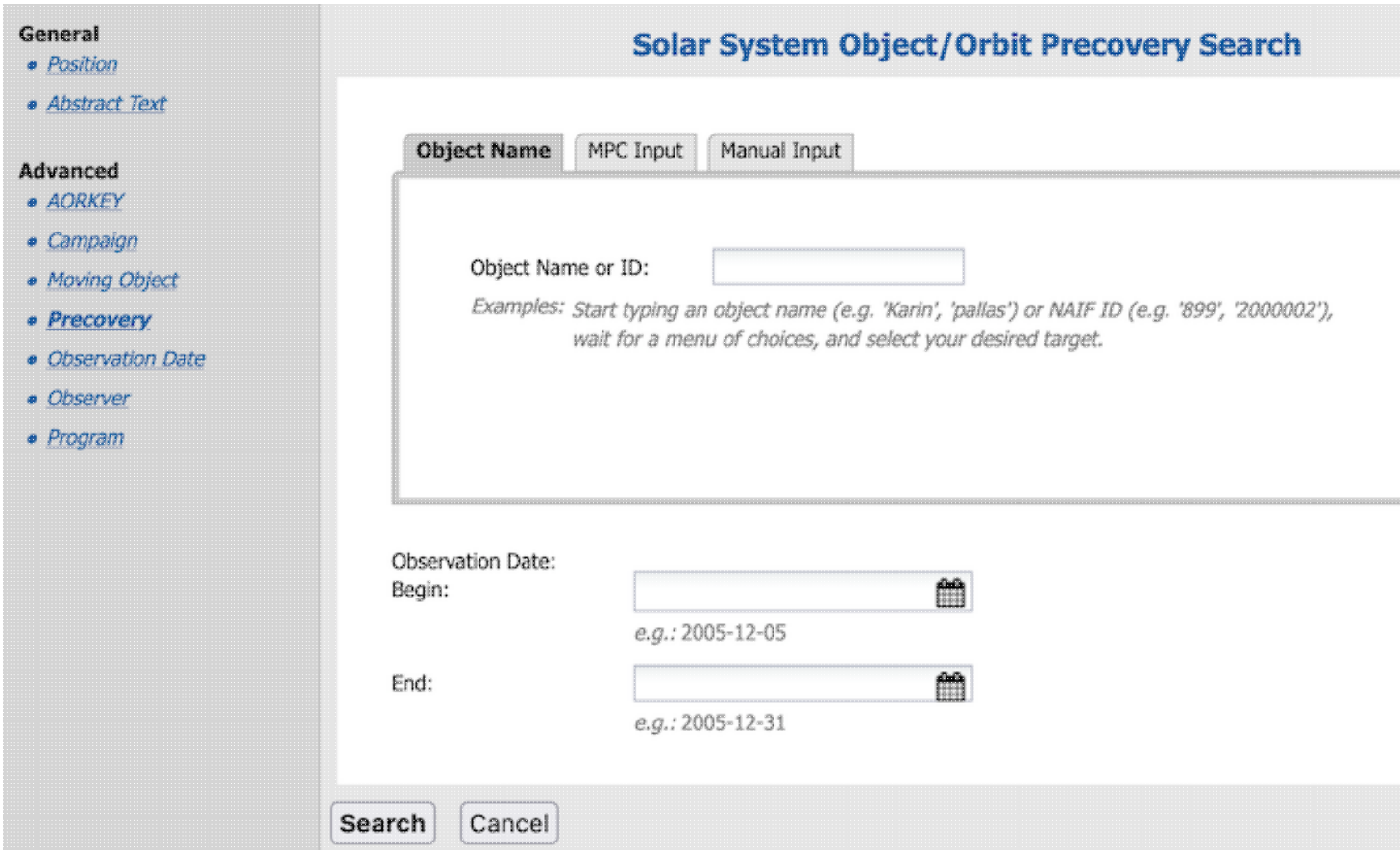
While many moving objects were deliberately observed over the course of the Spitzer mission, many also were serendipitously observed while conducting observations of other things. The Precovery search option enables you to detemine if there are deliberate *or* serendipitous observations of a given object. (Note that this depends on having accurate orbital parameters and image positions/times to work.) The reason it's called "precovery" is because you can obtain pre-discovery images of a newly discovered object using this approach.

The search can be performed for comets or asteroids using the object name or the six orbital parameters supplied by the user either individually or in the Minor Planet Center (MPC) one-line element format.

What the system is doing is using IRSA's Moving Object Search Tool (MOST), taking the orbital ephemeris (either searching for the ephemeris based on the name that you enter, or taking the orbital information you give it), calculating where the object was over the time range that you request (over the entire mission if date constraints are left blank), identifying the individual exposures in which it calculates that your object should be present, and returning to you all those data.

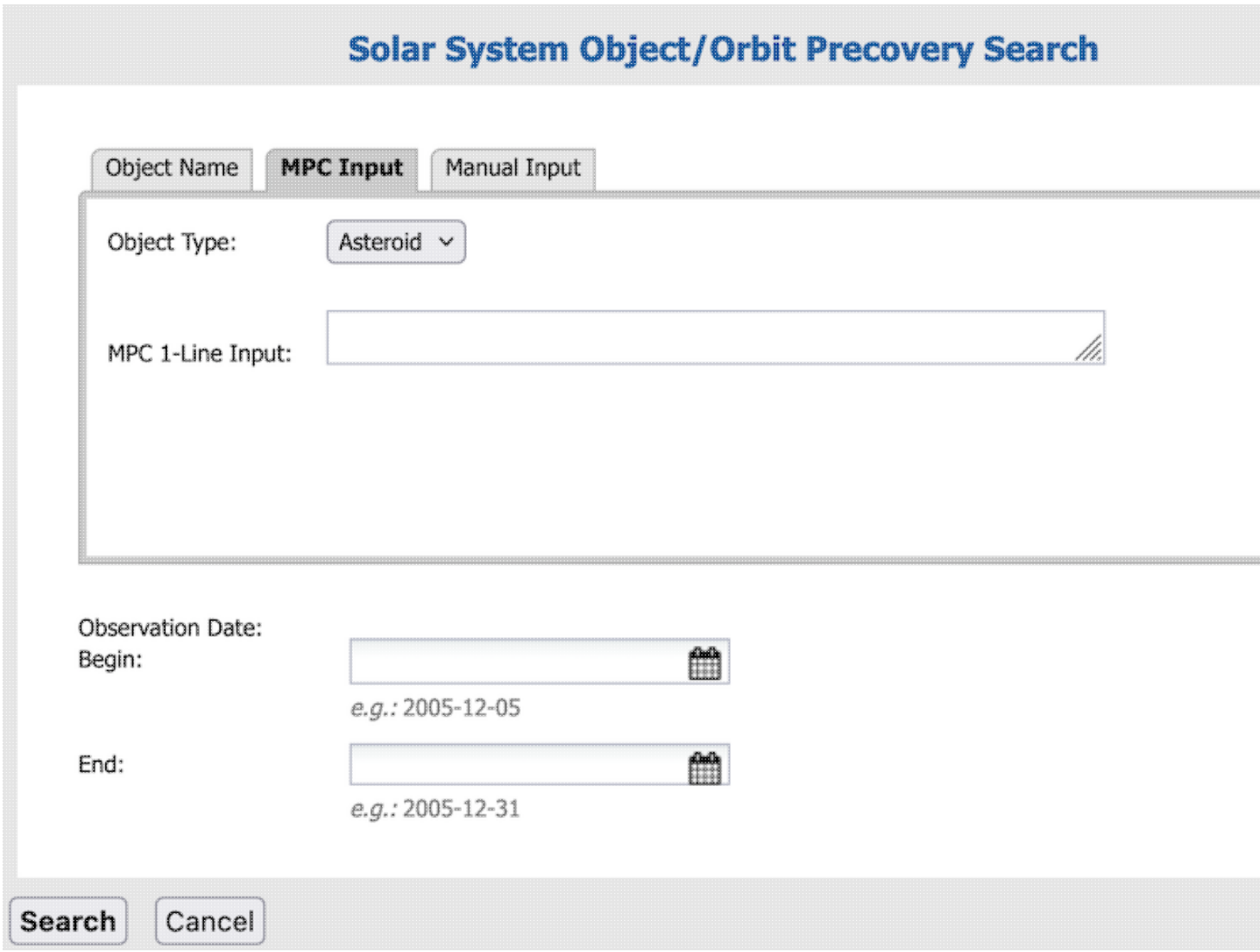
As a result, **requests over long time baselines can take a long time.** You can make a request that takes so much time that it times out, and you get no search results. In order to shorten search times, ask it to search over a smaller time baseline.

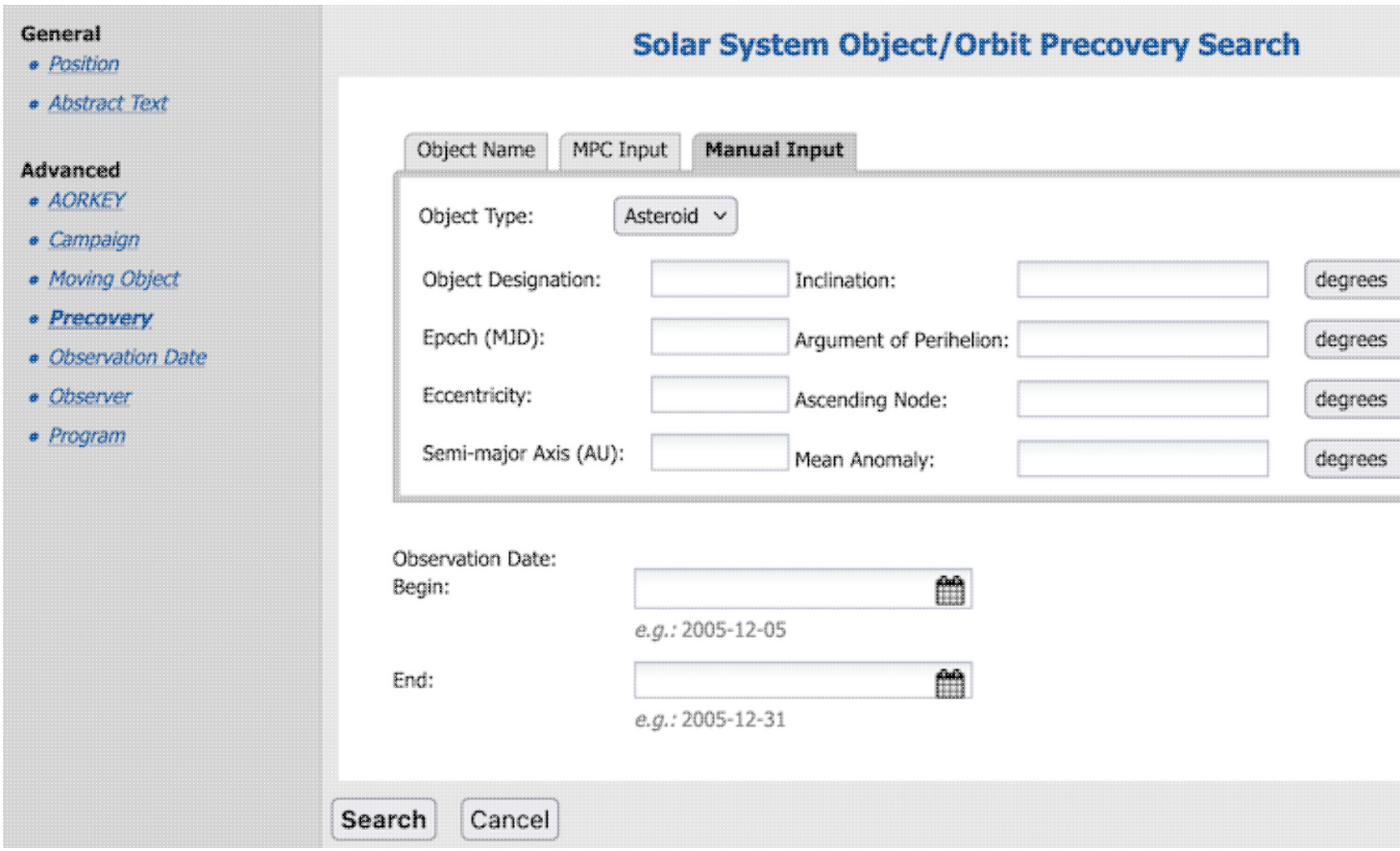
**Searching by object name** :




You can search by object names by entering the name in the "Object Name" field. It looks up the NAIF ID for you; select the NAIF ID corresponding to your object. The accepted naming conventions are the ones that have been approved for use by the CSBN and its predecessors. News reports occasionally use unofficial or unapproved names; you cannot use these names to access objects. For asteroid names, one can enter either the ID number, name or designation, e.g. 2, 887, 1917, Pallas, Alinda, Cuyo, 1981 QB, 1996 GQ, or 2010 CG18. It can also handle names with apostrophes and dashes like O'Connell and Pic-du-Midi. For comet names, one can enter either the whole name e.g. 10P *or* Tempel 2, 73P-B *or* Schwassmann-Wachmann 3, 2009 WJ50, or 2010 D1. (For experts: we are calling this API.)

**Searching by orbit (MPC or manual)**:


Solar System Object/Orbit Precovery Search
Object Name
MPC Input
Manual Input
Object Type:
Asteroid
MPC 1-Line Input:
Observation Date:
Begin:
e.g.: 2005-12-05
End:
e.g.: 2005-12-31
Search
Cancel




The standard six orbital elements for asteroids are *eccentricity (e), semimajor axis (a), mean anomaly (M), inclination(i), longitude of the ascending node ("Node"),* and *argument of perihelion (w)*. For comets, the elements are *eccentricity (e), perihelion distance (q), time of perihelion passage (Tp), inclination(i), longitude of the ascending node ("Node"),* and *argument of perihelion (w)*. Notice that for comets, *perihelion distance* is used instead of *semimajor axis* and *time of perihelion passage* is used instead of *mean anomaly*. The reason for replacing these two parameters is to allow for cases where long period comets have a parabolic or hyperbolic orbit. Other parameters you may see include mean motion (n), absolute magnitude (H), and slope parameter (G). A good description of the orbital parameters is given in JPL's Solar System Dynamics website.

You can search for objects by either inputting the orbital parameters by hand or by using a properly-formatted Minor Planet Center input string. This latter option allows the user to cut-and-paste a line directly from a table of orbital elements in MPC Format into the search field. There are a number of orbital element tables available at the MPC website, for example, observable NEO and observable comets. The complete list of minor planets can be found at the MPC Orbit (MPCORB) Database.

Information on the format of the element tables is given by following sites: minor planet format and comet format.

**Observation Date (Begin and End)**:

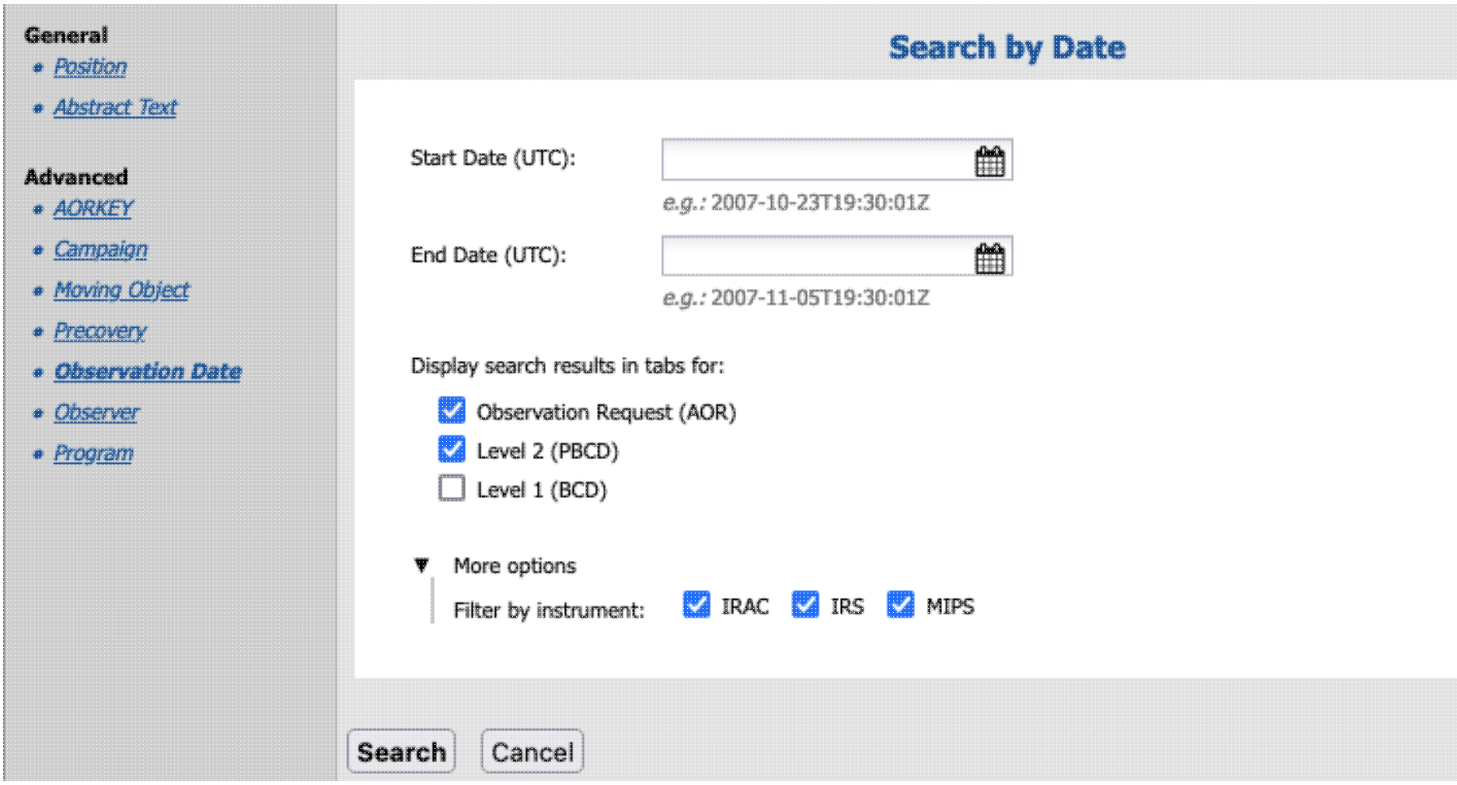
You may provide a time baseline over which the search should be constrained. If left blank, it searches the entire Spitzer Heritage Archive. **Requests over long time baselines can take a long time.** You can make a request that takes so much time that it times out, and you get no search results. In order to shorten search times, ask it to search over a smaller time baseline.

**Tips and Troubleshooting**:

- Be cautious about using one-line or manually entered ephemerides in general but for comets in particular, as non-gravitational forces can render them irrelevant rapidly. Searching by object name is more likely to return results.
- An example to try that will return results in the SHA is the following manually entered parameters: designation=Karin, epoch in MJD=53724, eccentricity=e=8.136848767936521E-02, SMA=a=2.863363473756811, inclination=i=1.003191830335564, argument of perihelion=w=1.180729790805203E+02, ascending node=OM=2.546015989297557E+02, mean anomaly=MA=1.364457866568047E+02, observation dates 2005-12-01 to 2005-12-31.
- Searching over the entire Spitzer mission may result in a query that times out before yielding results. Try a shorter time baseline.

## Searching by Date Range

You can search for observations conducted between two dates. The dates must be specified in Universal Time (UT) and be in the format YYYY-MM-DD hh:mm:ss. The maximum date range allowable is relatively small; use large date ranges with caution because thousands of observations can be obtained via this search.




After selecting your date range, you then need to select what kinds of results you want:

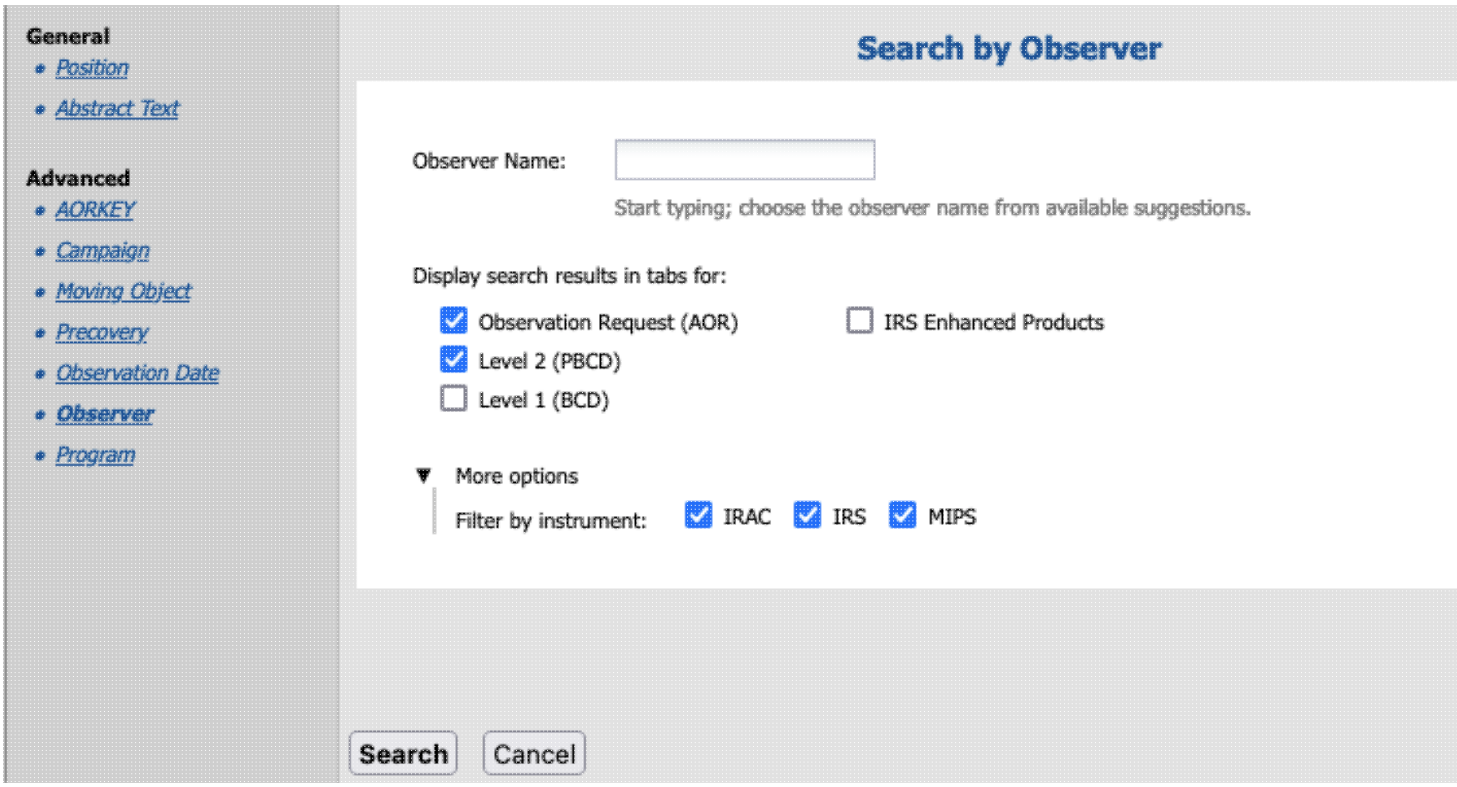
- Observation requests (AOR)
- Level 2 (PBCD)
- Level 1 (BCD)

Each of these results will be displayed in different tabs.

Under the "more options" triangle, you can ask for results from just one, two, or all three instruments.

## Searching by Observer Name

You can search by name through all of the principal investigators for all Spitzer programs. Note that there is an auto-complete on this feature, which shows you available suggestions as you type in a string.




Note also that searching on any of the instrument PIs (Fazio, Houck, Rieke) or the Instrument Support Team leads (Reach/Carey, Latter/Noriega-Crespo, Armus) will return *many* programs tied to their guaranteed time (GTO) programs, or calibration programs from early in the mission.

To retrieve calibration programs during regular operations, search on "IRS Calibration" or "IRAC Calibration" or "MIPS Calibration."

After typing in the observer name, you then need to select what kinds of results you want:

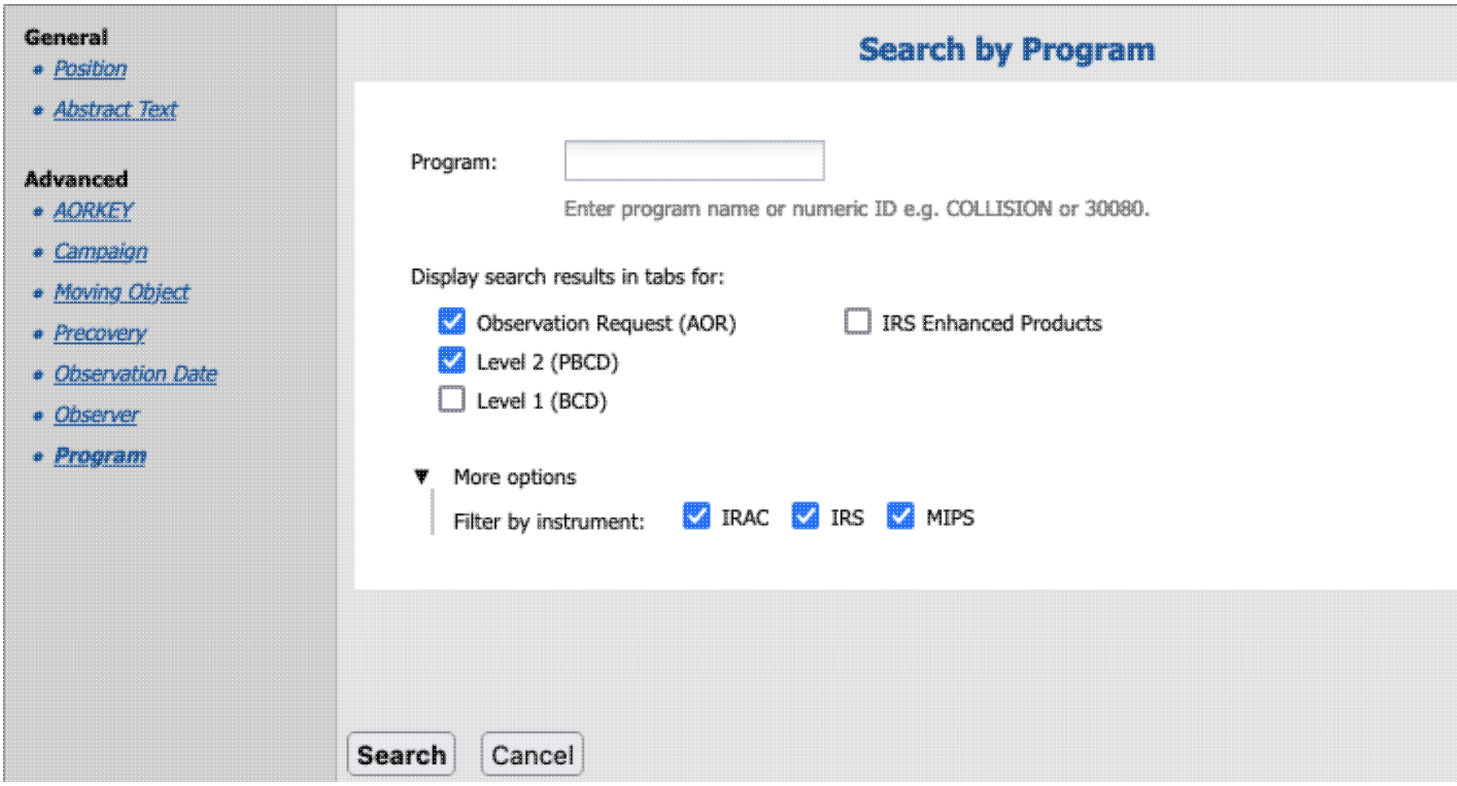
- Observation requests (AOR)
- Level 2 (PBCD)
- Level 1 (BCD)
- IRS Enhanced Products

Each of these results will be displayed in different tabs.

Under the "more options" triangle, you can ask for results from just one, two, or all three instruments.

## Searching by Program

All of the observations that correspond to individual observing programs are grouped under a program identifier (PID). This program identifier can be both a string and a number. Either the string (assigned by the observer) or a number (assigned roughly by the order in which the original proposal was submitted) can be used to retrieve all of the observations that were part of that program. A complete list of all of the Spitzer programs can be found in the Spitzer documentation.




Note that some programs can include literally thousands of AORs, whereas others may be just one or two AORs. Note also that some large science programs may be split over multiple program IDs.

After typing in the program name, you then need to select what kinds of results you want:

- Observation requests (AOR)
- Level 2 (PBCD)
- Level 1 (BCD)
- IRS Enhanced Products

Each of these results will be displayed in different tabs.

Under the "more options" triangle, you can ask for results from just one, two, or all three instruments.

## More on Enhanced Products

The enhanced products available via this interface are the IRS Enhanced products and the Spitzer Enhanced Imaging Products (SEIP), both of which were provided by the Spitzer Science Center (SSC).

There are *many* more enhanced products available at IRSA that were contributed by the community. To obtain a high-level summary of what data are available at IRSA for any given position on the sky, try searching by position from the box in the upper left on IRSA's main page to see what data sets we have covering your position on the sky.

In order to learn more about any enhanced data product, the particular values that are returned, how the data were reduced, its strengths and weaknesses, etc., please see the documentation corresponding to the products.

# Spitzer Heritage Archive: Search Results

Results of a search of the Spitzer Heritage Archive appear in two different window panes, each of which could have several tabs.

*Contents of page/chapter:*
+Terminology
+Layout
+Filtering
+Visualization

## Terminology

The search results appear in two "panes" (like "window panes"). You can grab and drag the division between the two panes to change their relative sizes.

The contents of the left pane are dictated by the choices you made on the search screen. The contents of the right pane depend on the kind of search you initiated, but have some commonalities. All possible contents are described below.

For more terminology, please see this summary in the overview section.

## Layout

The left pane of the search results contains lists of observations that met your search criteria. The right pane of the search results contains more details of the observations. The right pane changes depending on what row you have selected (clicked on) in the left pane. (Similarly, the highlighted row on the left can change depending on what you click on in the right pane.)

**Left pane**

The left pane of the search results could have several tabs.

AOR
: This tab provides the most compact view of the observations meeting your search criteria.

Level 2 (PBCD)
: Level 2 data include mosaics or extracted spectra from an AOR. There can be multiple Level 2 products per AOR.

Level 1 (BCD)
: Level 1 data include individual exposures from an AOR. There are many Level 1 products per AOR.

IRS Enhanced Products
: If there are extracted spectra available, these products are shown here.

SEIP Super Mosaics
: If there are super mosaics available, these products are shown here.

SEIP Source List
: If there are sources from the Source List available, these sources are shown here.

{name of moving target}

If you have done a "precovery" Solar System search, any matched observations appear in tab named for the object on which you searched.

Orbital Path

If you have done a "precovery" Solar System search, the calculated orbit appears in tab called "orbital path"

{Catalog name}

If you have done a catalog search via the blue catalogs tab, you may have an additional tab named for the catalog you searched.

Each tab is its own table, which behaves in the same way that tables throughout IRSA tools with this look and feel. See the Tables section for more details, but in summary you can change the width of the columns, sort by columns, filter by column values, etc.

The corresponding data can be downloaded by checking the box at the start of each row (or the box at the top of the column of boxes to select all) and clicking "Prepare download". (See the section on downloads for more information.)

**Tips and Troubleshooting**:

- The target name was provided by the original observer, and it may very well be confusing, cryptic, and/or misleading, intentionally or unintentionally.
- Additional columns may be available for any given tab -- see Tables section for how to turn on columns via the table options.
- For IRAC subarray data, only Level 1 (BCD) data are returned. There is no Level 2 product.
- Particularly in the case of MIPS, the arrays may be on and collecting data even if the telescope is being used to observe using one of the other fields of view in the instrument. For any given row, if the telescope was optimized for use of the field of view to which the specific file applies, then the "primary field" column is 1; other values indicate that this is serendipitous data.
- Since there can be files that are not images (such as tables of data), the "File Type" column lists the nature of the file. "Image" will be the most common.

**Right pane**

The right pane of the search results contains four tabs that enable exploration of the data returned by your search. Click on a row in the left pane and the contents of the right pane change.

Data Coverage

The "Data Coverage" tab shows footprints of all the returned observations. Note that if you have a lot of data returned, this may take a measurable time to render.

Data Preview

If possible, this tab previews the data product you have selected on the left. If the AOR tab is in the foreground, it will show you a depth of coverage map. It is more informative if nearly any tab other than AOR is in the foreground.

Details

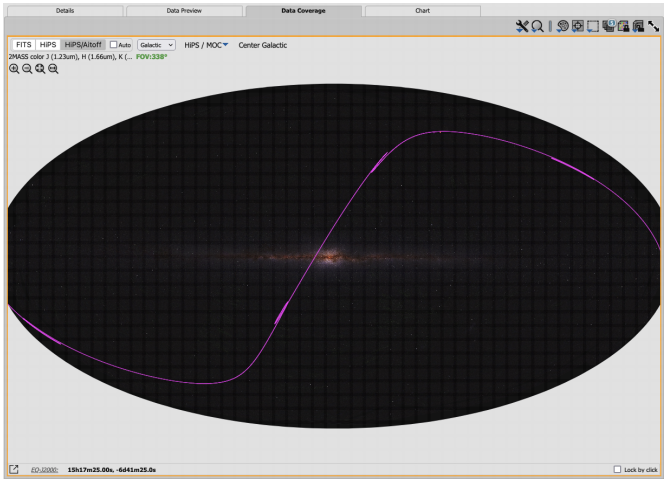
This tab is basically another view of the row shown in the left pane; it may be easier to absorb when shown in this format.

Chart

This tab is a plot of data shown on the left; for nearly any tab other than the SEIP Source List or an orbital path, it's fairly boring.

When an image is in the foreground on the right, you can interact with this FITS file using the visualization tools; you can also overlay catalogs on the image.

If you have done a search for a Solar System Object, you may have a calculated orbit show up on the coverage tab.




## Filtering Results

Filters can provide a powerful tool for weeding down search results to the observations you want. Near the top of the search results window, there is this icon: 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. 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 the filters, click on the cancel filters icon (which also appears after you impose filters): .

There is a whole section just on filtering, which has much more information.

## Visualization

Once you have data that you wish to investigate further, you can interact with the FITS files corresponding to most observations. See the Visualization section for more on visualization, and the the Spectra section for more on the specific case of visualizing a spectrum.

# Spitzer Heritage Archive: Visualization

A list of the data files meeting your search criteria are shown in the tabs that are the results of your search on the left. Where possible, the data files are shown on the right. When they are images, you can interact with them using the tools described on this page; you can also interact with the coverage image using the tools on this page. (Spectra are covered on another page.) You can also add and overlay catalogs.

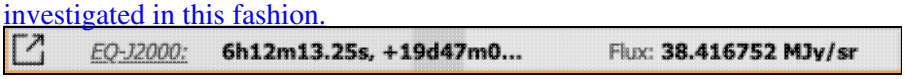
Here we describe the interactive image visualization tools, in roughly the order in which you might encounter them in the window.

*Contents of page/chapter:*

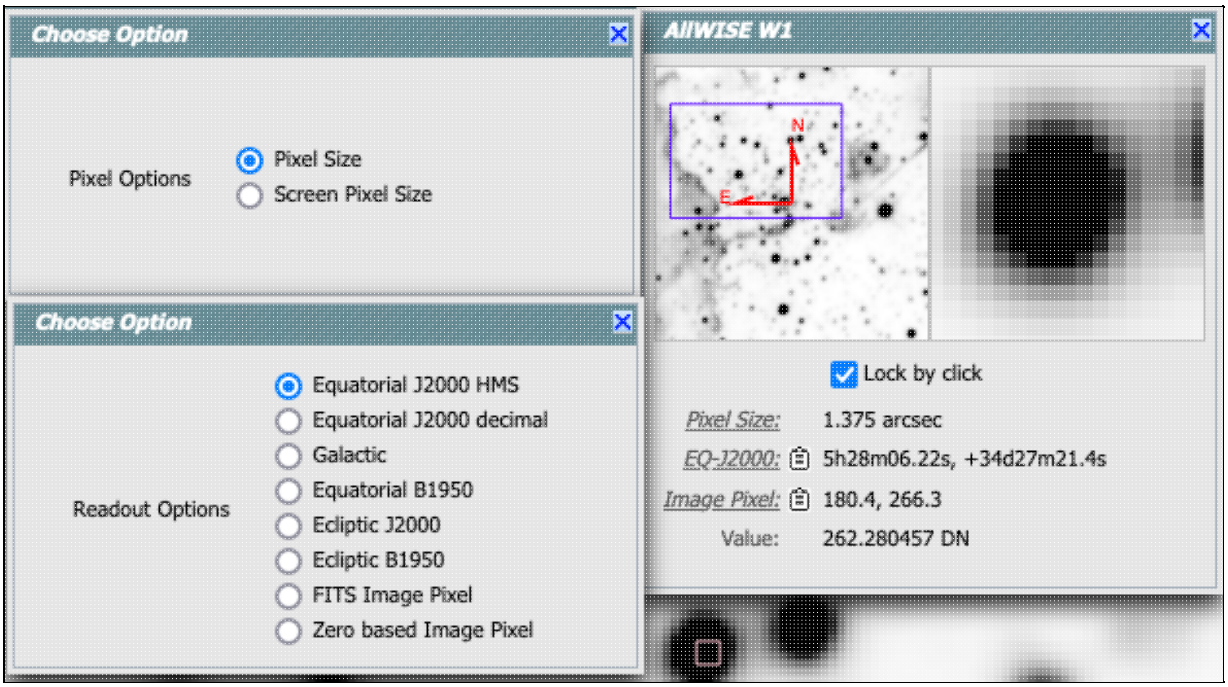
+The FITS/HiPS Viewer
+Image Information
+Image Toolbar
+Extraction Tools
+Information on Color Stretches
+Specific HiPS features
+Footprints -- overlaying markers
+Catalogs and Layers
+Breaking out of the pane (and going back)
+Image Navigation
+Coverage Image
+Automatic FITS-HiPS-Aitoff Transitions
+"Catalog" loading

## The FITS/HiPS 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 and, specifically, the pixel beneath your mouse cursor, appear along the bottom left of the image window. Some information is updated in real time (coordinates); some information (pixel value) is updated when you stop moving your mouse for a second or two. The image can be interactively investigated in this fashion.

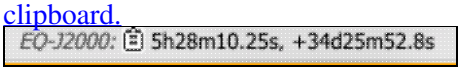



To get more information or to change the units of the readout, click on icon on the far left to "pop out" a window with additional information:




In this example, by clicking on the words "Pixel size", "EQ-J2000", or "Image Pixel", you can get these options in additional pop-up windows to change the units of what is shown.

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 readout. Click on that icon to copy that position to your clipboard.



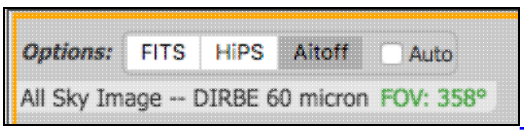

In the pop-up window, the orientation of the image is given with a compass rose on the right, next to a zoomed-in view of the image under your cursor.

## Image Information

The upper left of the loaded image tells you basic things about the image you are viewing. The instrument is in black. The field of view is in green font; this corresponds to the (horizontal) width of the image window.

Often, the label is simple, telling you the instrument and the field of view (FOV).

Spectra won't have a field of view, but will tell you the instrument and the zoom factor.

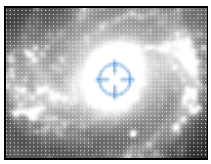



Coverage images can have many choices. See below for much more information, but in summary:

- An Aitoff projection (selected in this example, indicated with the darker grey) is an all-sky projection (in this case, a DIRBE 60 micron image). This is showing the results of an all-sky search.
- A search over a large region might result in a HiPS (hierarchical progressive survey) image, or you can force it to give you a HiPS image by clicking on "HiPS" in the upper left of the coverage image. HiPS images are created specifically to enable fast, dynamic resolution changes; zoom in and find smaller pixels than if you zoom out. Choices of what you can do and what you can manipulate with HiPS images can be different than your choices for FITS images, but are largely the same as discussed in the rest of this chapter.
- A search over a small area will result in a FITS image, or you can force it to give you a FITS image by clicking on "FITS" in the upper left of the coverage image. It will select a FITS image corresponding to your current target. All of the available options for FITS images are discussed in this chapter.

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.

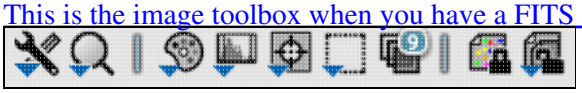


The target on which you searched is overlaid on the main image with a cross-hair marker. You can remove this (or change its color) from the layers pop-up, described below.

## Image Toolbar (FITS and HiPS)

The image toolbox is always present as a row of tools associated with the images you have loaded, or that are 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.

This is the image toolbox when you have a FITS image loaded:



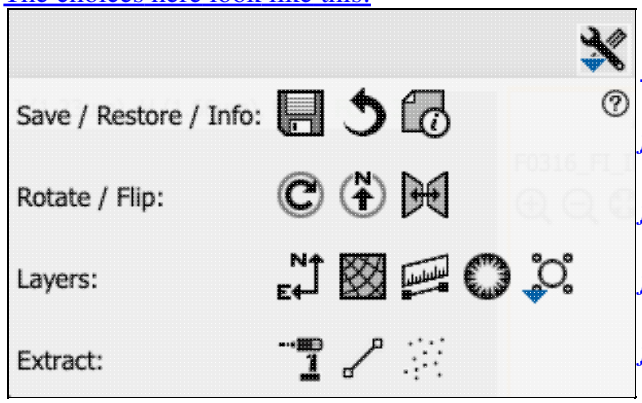
And, this is the image toolbox when you have clicked on a HiPS image you have loaded:

The two toolbars are different, but if the same icon appears, it has the same effect on the image. Many of the icons have a downward pointing blue triangle, which means that there are additional options in a drop-down menu that appear when you click on the icon.

We now discuss each icon in the order in which they appear.

*Tools drop down*

The choices here look like this:




*jump to save*

*jump to rotate*

*jump to layers*

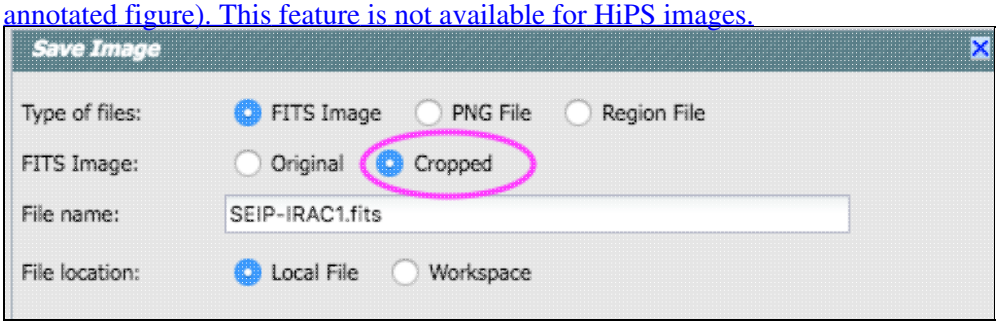
*jump to extract*

*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.




Note that if you overlay a large catalog on an image, then turn around and save a regions file from the catalog overlay, the full catalog may not be saved to the regions file. If you have >10,000 sources, **not every source will be overlaid on the image**, even if you zoom in, and thus will not be in the regions file. If you want to save your entire catalog as a regions file, save the catalog from the table pane.

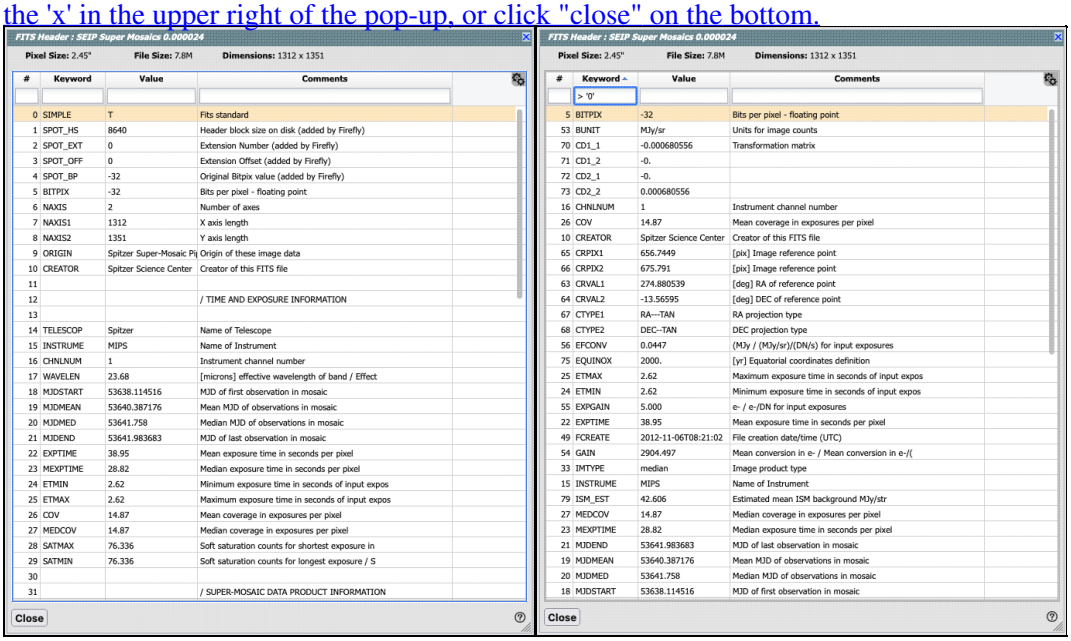
The saved PNG is the same size as it is on your screen. If you want a big version, make the desired image big on your screen (view one-at-a-time) before saving the PNG.

*Restoring everything to the defaults*

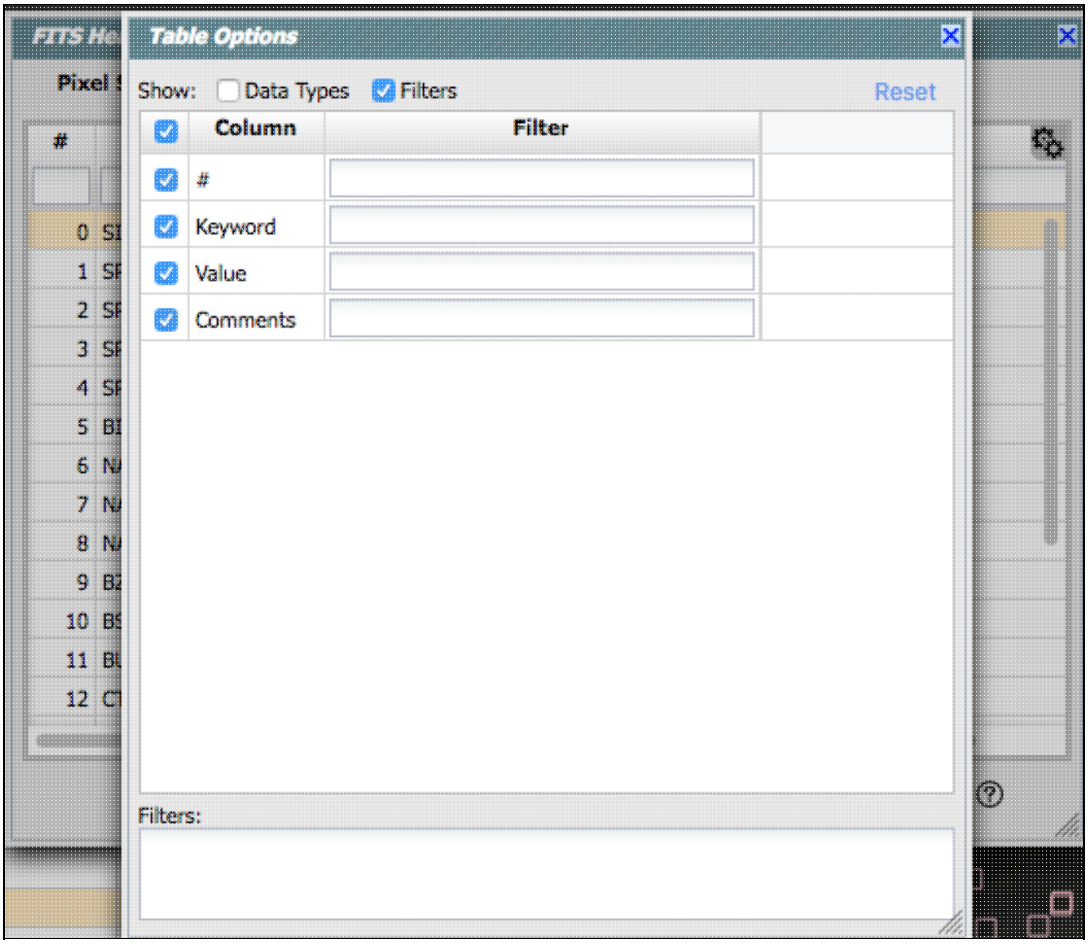
If you've played around a lot with the image, you may want to undo everything you've done. Click this button to restore everything to their original default values. Some layers may persist; remove them via the layers icon.

*Viewing the image header*

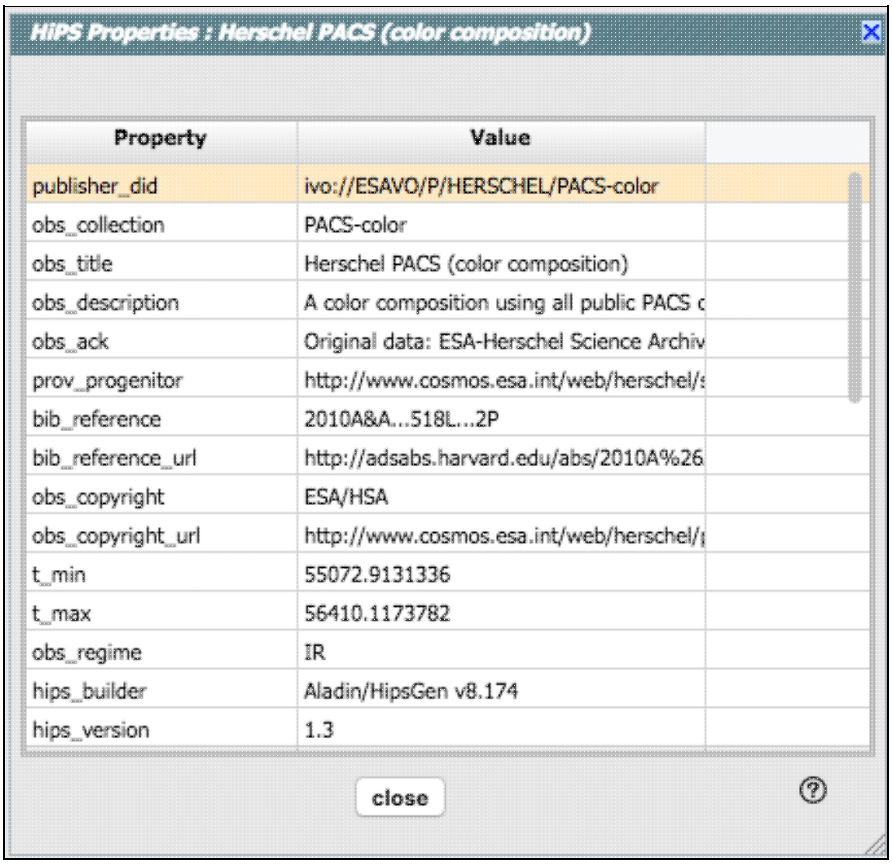
This icon displays a pop-up window with information about the image. If a FITS image is selected, it will show the FITS header of the image; if a HiPS image is selected, it will show the HiPS properties of the image. If you click on the columns in the pop-up, it will sort the keywords alphabetically 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 (and filtered!) 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.




Further, you can click on the gears in the upper right of the window to bring up a dialog box via which you can filter down the header keywords (using the same syntax as other filters):

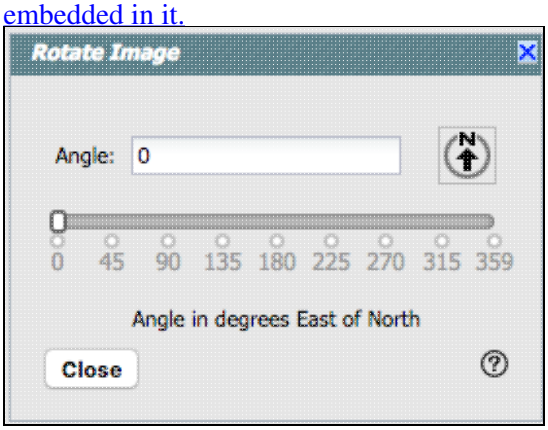



An example of the HiPS properties window is here:



*Rotating the image to any angle*

This feature allows you to rotate the image about the displayed center of your image to any angle of your choice, in degrees. (This option is only available for FITS, not HiPS, images.) It will rotate the image counter-clockwise (to the left) East of North if the image has a WCS embedded in it.




You can type a number in the "angle" box, or use the slider, to rotate the image. To bring it back to North-up, click on the "North up" icon in the pop-up or in the main image toolbar. To exit the pop-up without making further changes, hit the 'x' in the upper right of the pop-up.

*Rotating the image so that North is up*

Images retrieved from the IRSA Viewer are commonly 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.)

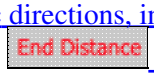
*Add a compass rose*

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 the 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 below.) 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 red 

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.)

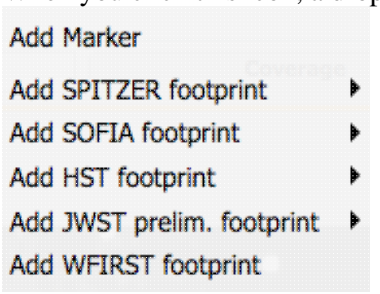
*Read in a DS9 Regions file*

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*

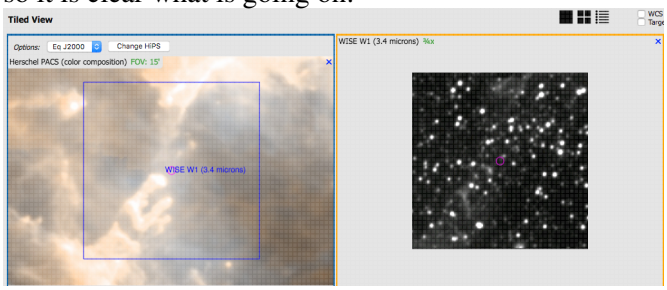
When you click this icon, a drop-down menu appears with several possible options:



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.

Note that if you load both FITS and HiPS images at the same time, it will include a region 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:



*Drill down through the image*

If your FITS image has multiple planes or HDUs, especially if each plane or HDU represents a different wavelength, it can be useful to "drill" down through the image cube at a given position on the sky. This tool allows you to do just that. When activated, this tool extracts the data at the place your mouse clicks down through the cube. For more information on saving the information, see the extraction section below.

*Draw a line in the image*

When this tool is activated, you can draw a line in your FITS image with your mouse, and it will extract for you the pixel values along that line. If you have more than one image loaded and visible, you can shift-click in another image to see the same line in another image. For more information on saving the information, see the extraction section below.

*Make points in the image*

When this tool is activated, you can click in your FITS image with your mouse, and it will extract for you the pixel values at the location of your click, creating a catalog for you as you click. If you have more than one image loaded and visible, you can shift-click in another image to extract points from another image. For more information on saving the information, see the extraction section below.

*Zoom drop down*

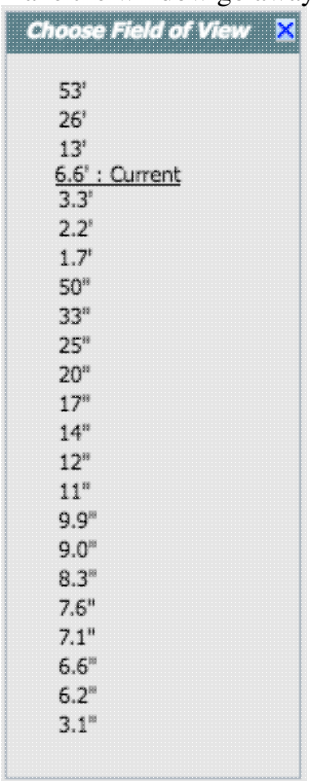
The choices here look like this:

Four of these also appear in the upper left of each image when your mouse cursor is in 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, in green.

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 below on changing coverage images, specifically that on automatic transitions while zooming.

Note also that if spectra are displayed, sometimes the zoom level isn't particularly well behaved, because spectra are intrinsically different than images.

*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 has no meaning in this case.

*Fit image to screen or fill screen*

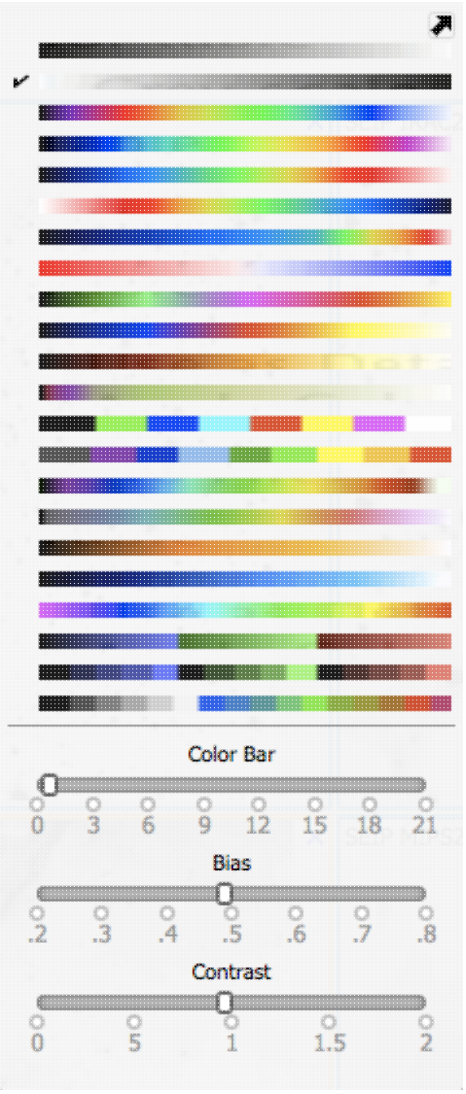
These two icons are designed to maximize the available space in your browser window. The first one automatically picks a zoom level such that the image entirely fits within the available space. The second one automatically picks a zoom level such that the image fills as much of the available space as 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).

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 HiPS images cover the sky, so fitting the image to the screen might not be what you want to do.

*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 with a wide variety of color table choices. Select your new color table from the options shown:



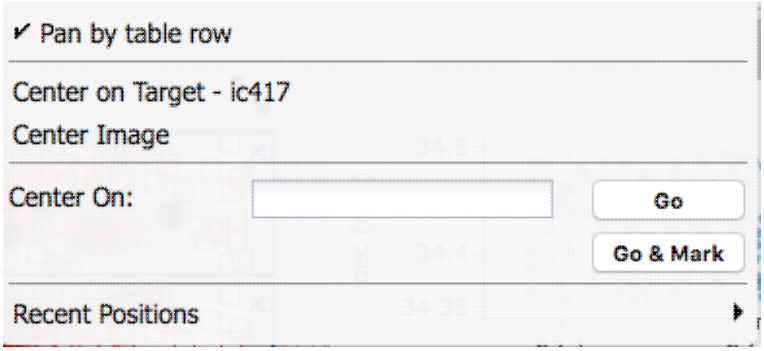

The arrow in the upper right creates a pop-up window out of this drop-down menu so that you can leave the choices up while settling on the best option. Click to select the color table you want. Alternatively, you can use the "color bar" slider to move among the color tables. Below the color bar slider, 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:



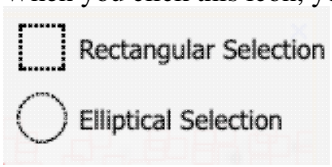

By default, "Pan by table row" is turned on, but, depending on how you have loaded your images, or whether you have catalogs loaded, it may not seem to do very much. If you have a catalog loaded and are zoomed in on your images, as you scroll through your catalog, the FITS image underneath will move 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 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 an ellipse on the image. 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 ellipse. If you need to move the image underneath, you can hold the shift key and click and drag.

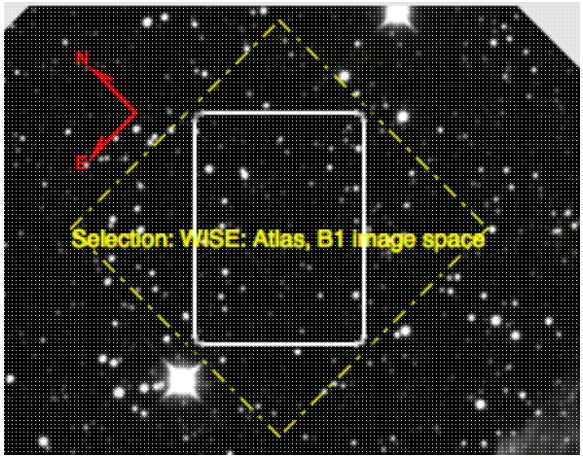
When you have selected a region of the image, additional icons appear above the image, and exactly which icons you see is a function of whether you are working on a FITS or HiPS image, and whether or not you have a catalog overlaid:

These icons will 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.



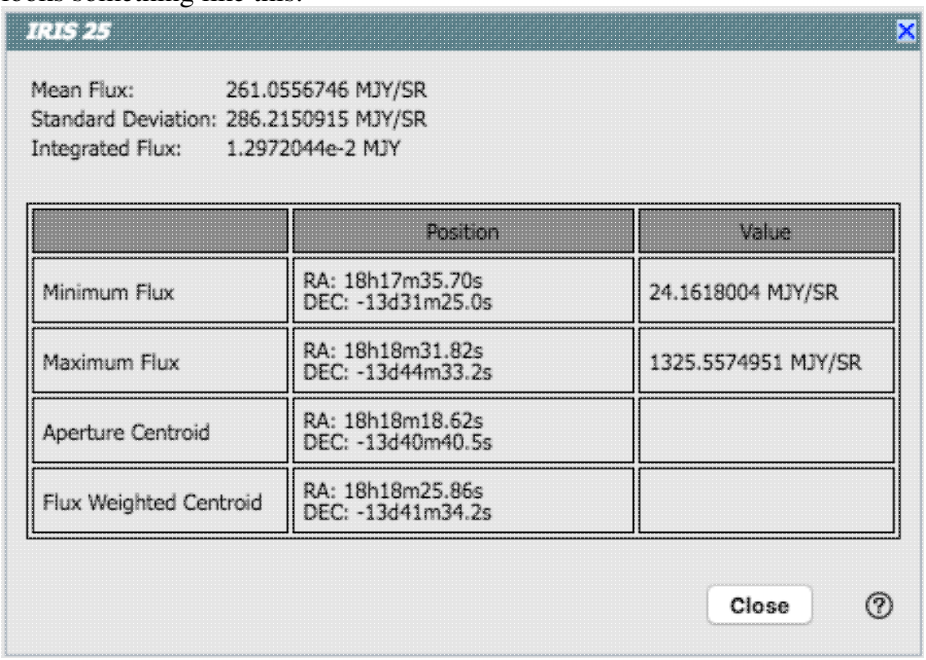

*Select sources*
(Only if a catalog is overlaid) Select the catalog sources overlaid on the image within the region. Selecting highlights the sources in the list and plot with a different color row or symbol.

*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:

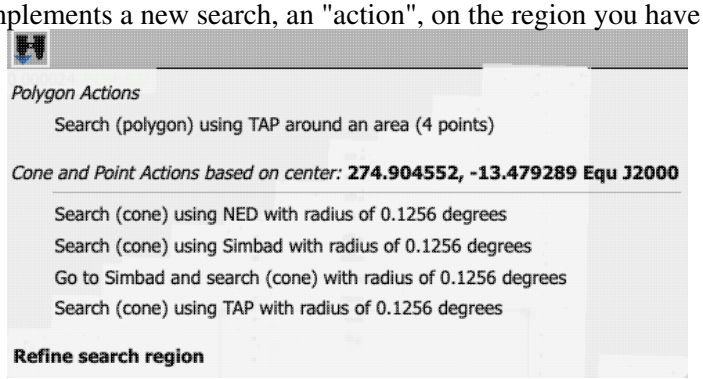



Note that it calculates the location of the minimum and maximum fluxes, and the aperture and flux-weighted centroids; the flux values given are in the same units as the FITS file. If you put your

mouse over the row of the table in the pop-up, that location appears as an 'x' on the image.

*Search*

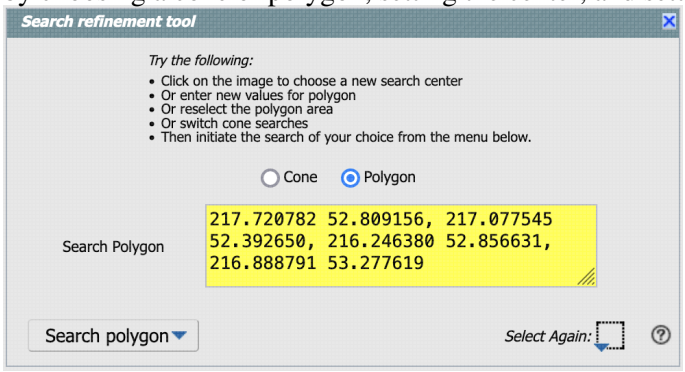
This tool implements a new search, an "action", on the region you have selected. It results in this drop-down:




where this example is based on a region centered on 274.904552, -13.479289, J2000 decimal degrees, over a 4-cornered polygon. (You can also use the region tool to define a cone; this example is a rectangle.) From this drop-down, you can launch:

- A TAP polygon search over this region (more information about TAP searches)
- A NED cone search at this position with a radius attempting to correspond to this polygon (more information about NED searches); results loaded into this tool.
- A Simbad cone search at this position with a radius attempting to correspond to this polygon; results loaded into this tool.
- A Simbad cone search at this position with a radius attempting to correspond to this polygon, but launch another browser window or tab at Simbad with the results.
- A TAP cone search at this position with a radius attempting to correspond to this polygon (more information about TAP searches); results loaded into this tool.
- Refine the search region

The last option brings up another pop-up window that allows you to refine the search region iteratively by choosing a cone or polygon, setting the center, and setting the cone size or polygon vertices.



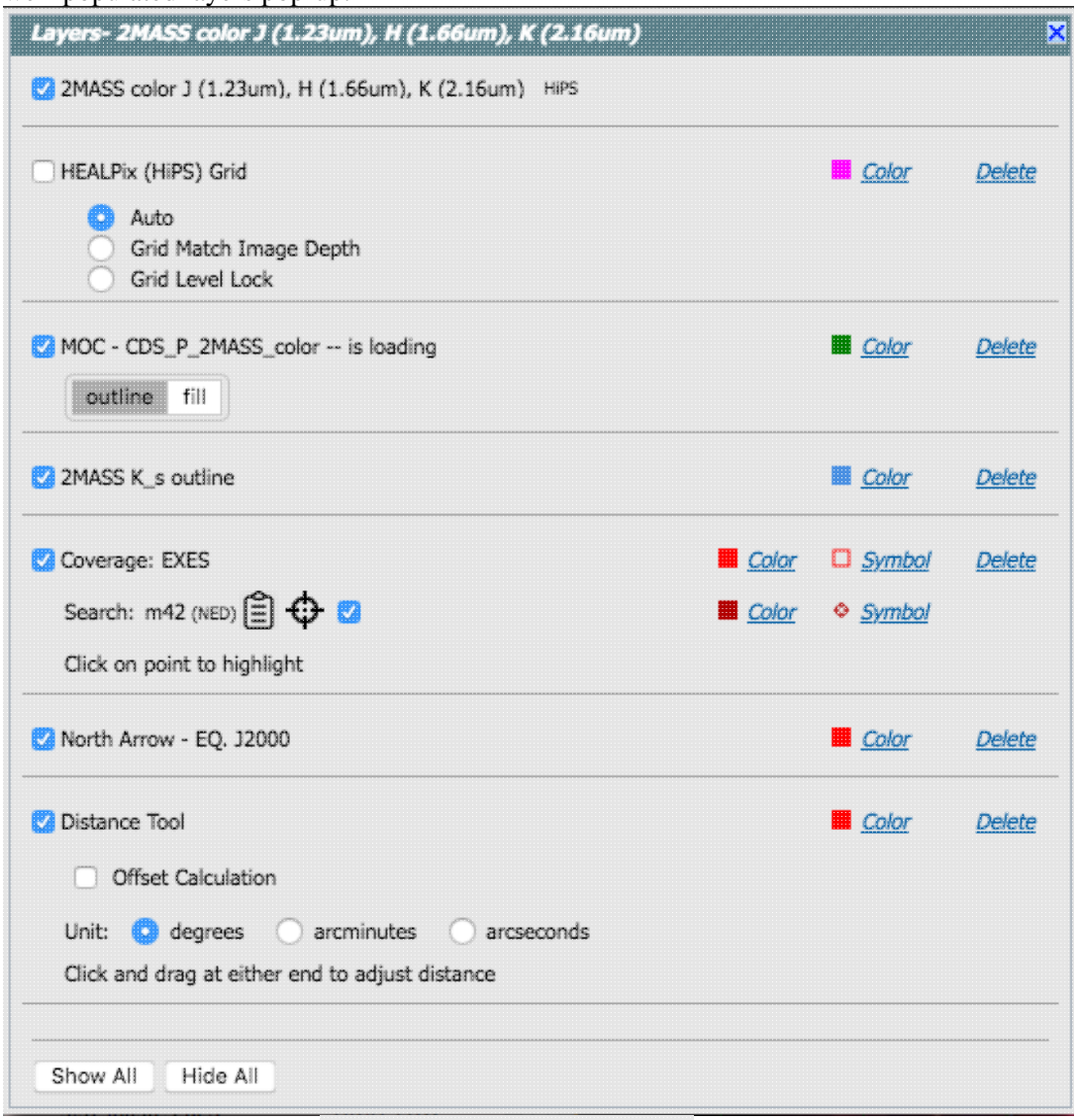

From here, you can change the kind of search, refine the positions, select from the image again, and launch searches from your refined position.

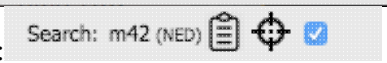
When you are working with the selection tool, a red End Select appears next to the image toolbar to remind you that you are in that mode. When you are done with the selection tool, click on that red text to turn it off.

*Viewing/changing the layers on the image*

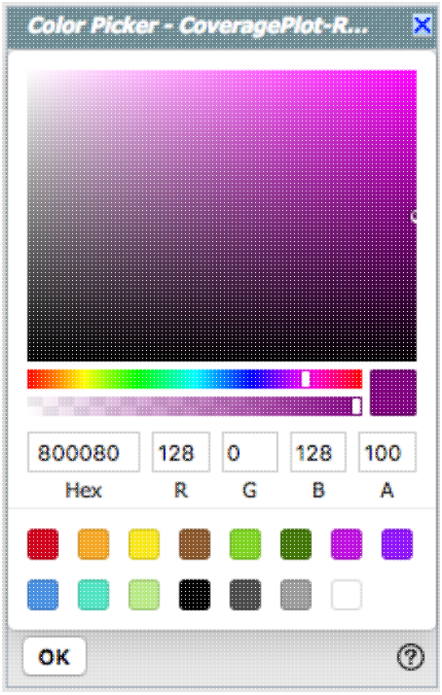
If you've been following along by trying these various options, you now have an image with a lot of annotations on it. The number that appears in blue over the layers icon tells you at any given time how many layers you have on the currently selected image (the image outlined in orange). If you click this layers icon, you will get a pop-up window with a list of all the layers you have on top of the image. From the pop-up, you can turn layers off and on, at minimum, but you can often also change exactly what is displayed and what colors get used for it.

To add new things, though, you need to go to other options within the toolbar. Here is an example of a well-populated layers pop-up.



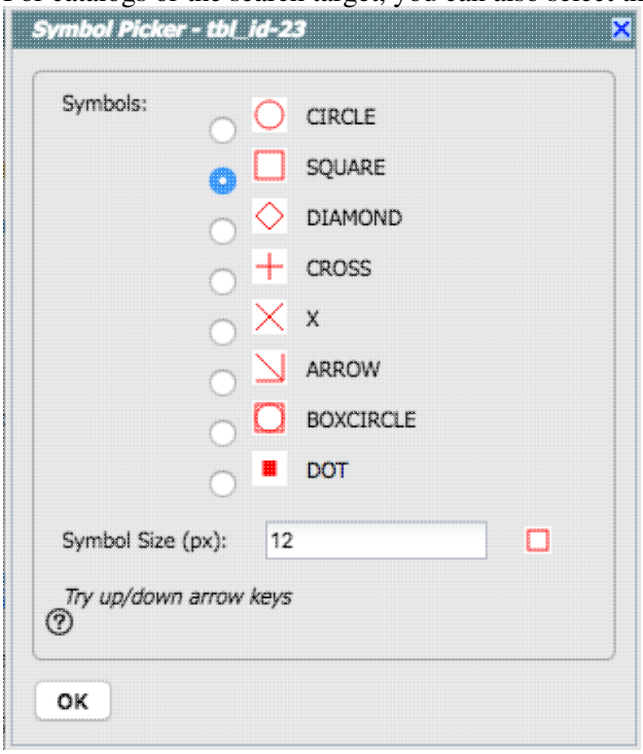

Note the target description:  This reminds you of the target on which you searched -- here, it was M16, where the coordinates were resolved by NED (as opposed to Simbad). The two icons next in that row indicate, respectively, "copy this location to the clipboard" and "center image on this position." The tickbox here means "show this target" (as opposed to the tickbox at the left, which means "show this image").

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 the small box. Note ha 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.

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. Click OK to implement your choices.

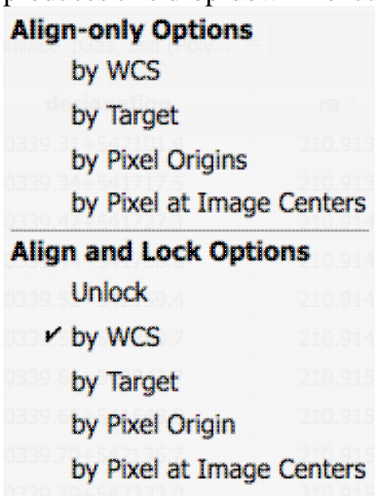
To delete a layer, click on "delete." Some layers do not have that option; to remove that layer, click on the corresponding icon from which you added that feature. Alternatively, you can "show all" or "hide all" with the buttons on the lower left of the pop-up window. To make this pop-up window go away, click on the 'x' in the upper right of the pop-up.

*Lock/unlock image color tables and overlays*

When this is set to "lock", all the images that you have loaded are linked together for color tables and overlays. This image lock is turned on by default. You can click on this icon to turn off this linkage among the images, enabling you to change images on an individual basis. Click it again to re-enable it.

*Lock/unlock images*

Depending on what you've done to this point, and what view you have of the images you've loaded, you may have this "lock images" icon appear in your toolbar. 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; the second set of options makes the alignment persist ("lock") when you move the images. 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 below.

*Getting help*

Clicking on this icon takes you to this help page.

To remove an image (or catalog) entirely, click on the small 'x' in the upper right of the image in the tiled view, or on the small 'x' in the corner of the image (or catalog) tab in the window pane view.

## Specific information on Extraction Tools

Several tools allow you to extract information from images or image planes, but only for FITS (not HiPS) files.

- -- Extract down through image planes
- -- Extract a line from the image

- -- Extract points from the image

All three of these follow the same basic structure --

1. Intitiate extraction mode
2. Set aperture
3. Try extraction; repeat if desired
4. Pin (Save) extraction if desired
5. Download (as table or chart) if desired
6. Repeat if desired
7. Click on "end extraction" to finish the process.

The drill pokes down through multiple planes, the line moves across pixels in a plane, and the points extracts points from a plane.

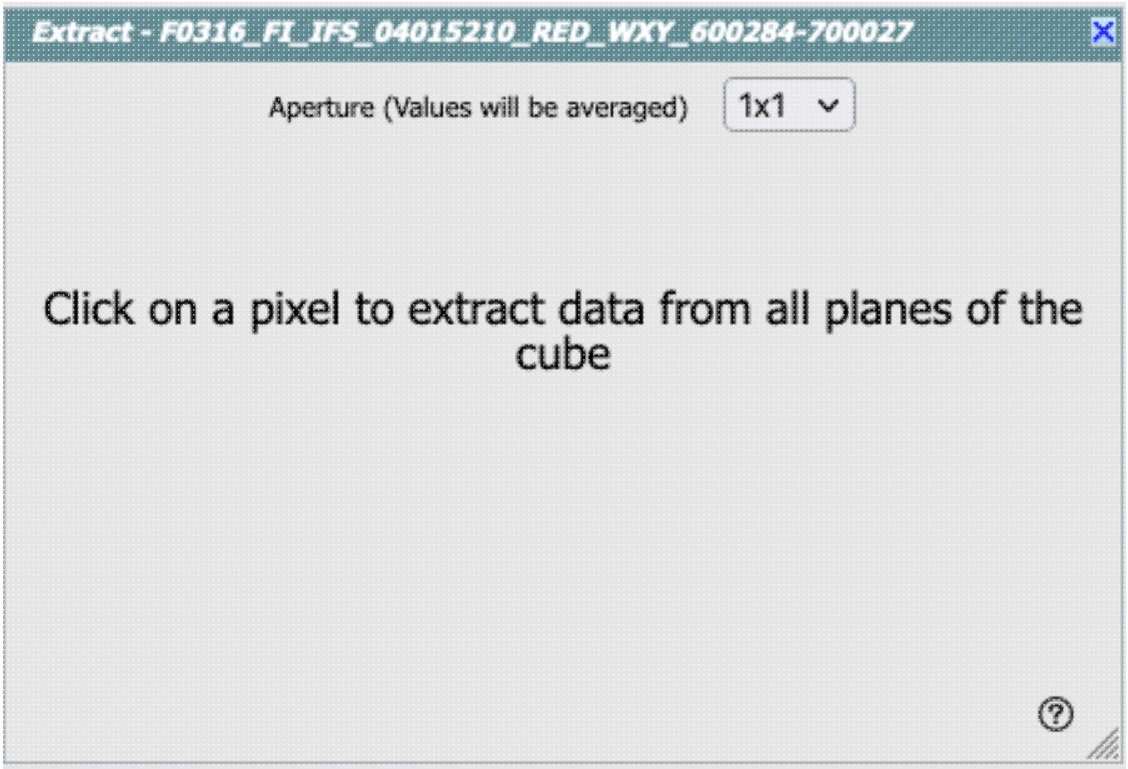
Here, we cover the basic approach, with specifics of each tool integrated as we go along.

When you click on one of these icons, you enter into the extraction mode. Red text appears next to the image toolbar to remind you that you are in this mode:

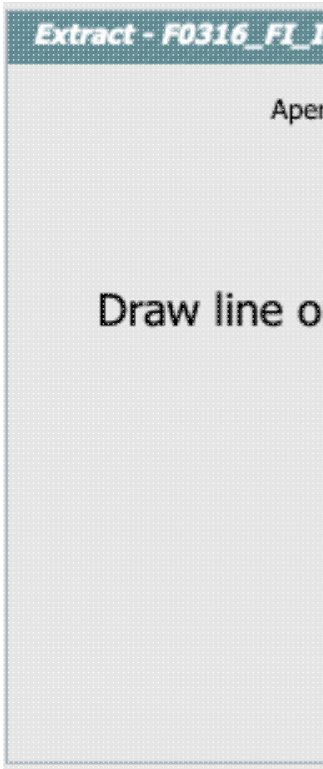
When you are done, to end this mode, click on this red "end extraction."

When starting out, the pop-up window that you get depends on the tool you pick.

For the drill:



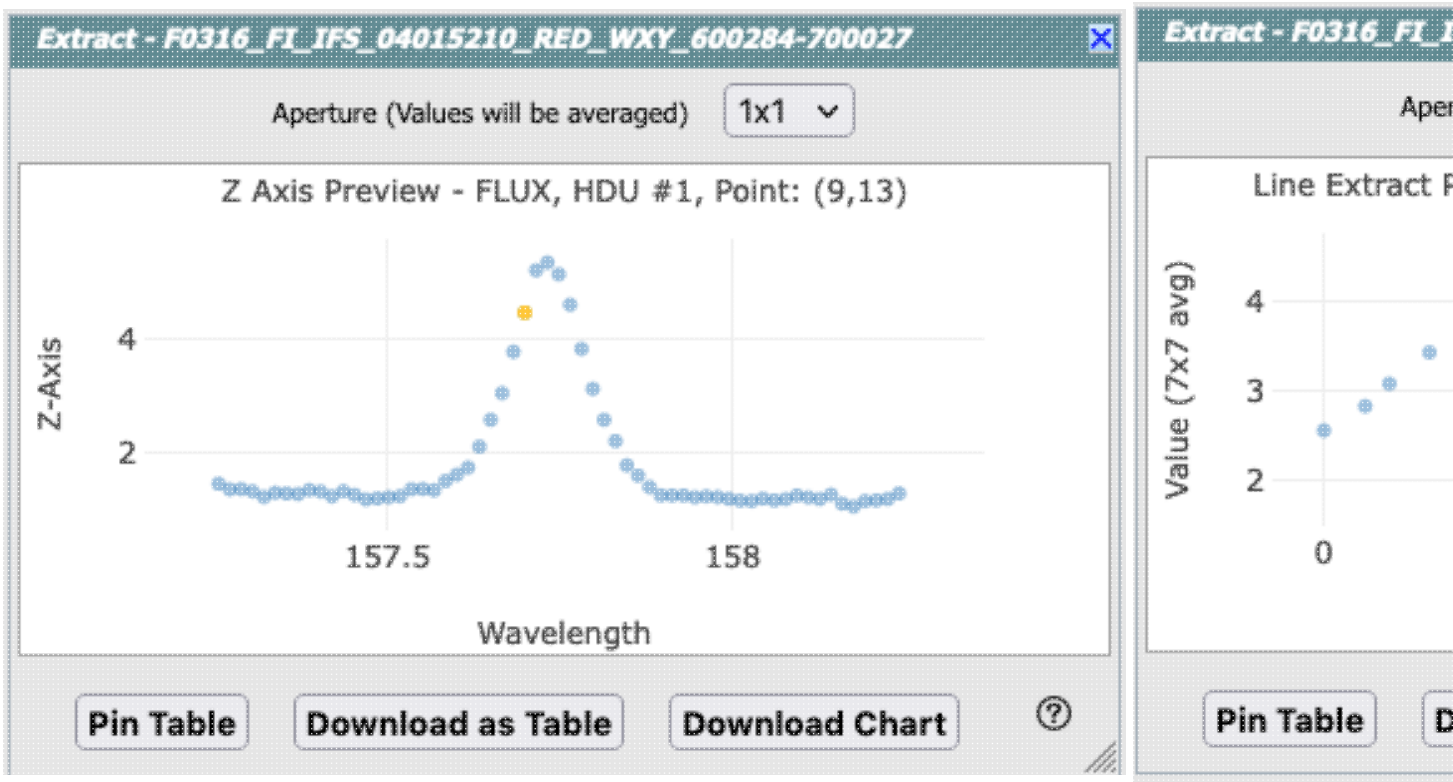

for the line:




In all three cases, the top center of the extract pop-up window has a drop-down from which you can select the aperture value. You can choose, in pixels, 1x1, 3x3, 5x5, or 7x7. Values will be averaged.

From this point, you can click on your image, or click and drag for the line tool. The pop-up then contains a plot of your extraction.

For the drill: for the line:

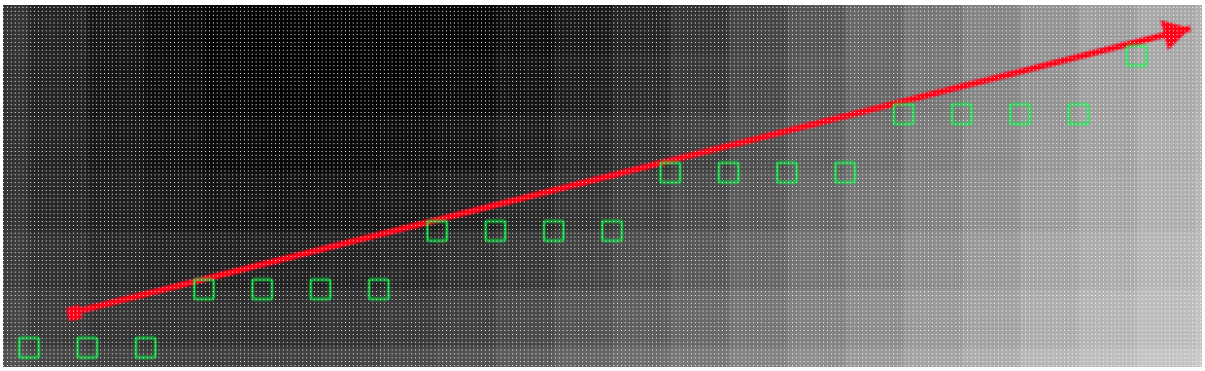



In each of these cases, it does the best that it can to label the axes accordingly. The cube that is used for the drill example here follows the spectral data model so that it is recognized as a spectrum, and it plots against wavelength. The line extraction is a 7x7 average and plots the offset in arcseconds from the initial mouse click, given the WCS information in the header of the image. The point extraction is given in image x coordinates, but can be changed to be in image y coordinates.

Note that for the line, if you have more than one image loaded and visible, you can shift-click on a new image to see the same line on a new image. And, for the points, you can shift-click to change images without extracting points.

Once you have an extraction that you like, you can retain the extraction for further analysis, in any of three ways. "**Pin table**" extracts the information as a table, just like any of the other tables in this tool, with an accompanying plot. You can then manipulate the table/plot just like any other table or plot in this tool. If the tool recognizes the extraction as a spectrum, you may have additional capabilities. **Download as Table** saves the table to your local disk with all the same options as a regular table. **Download Chart** saves the plot as shown, as a png file.

Once you pin or save your extraction, the tool leaves a "footprint" of your extraction on the image so that you can remember what the extraction was. **NOTE THAT it is not interpolating** across fractional pixels here. It is averaging if you have asked it to average, but particularly if your pixels are large, if you draw a line that is diagonally across pixels, it will be immediately obvious that it's not interpolating. This line gets rendered as these pixels:

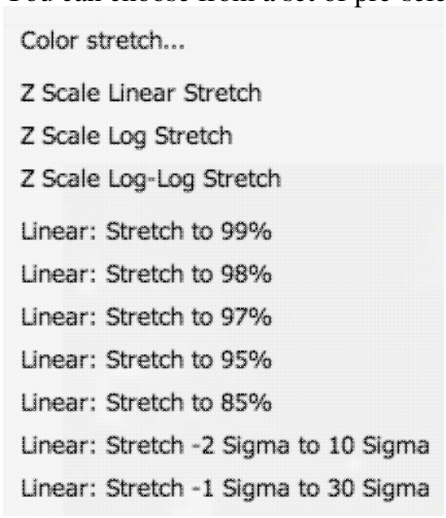


The point appears on the image at the lower left corner of the relevant pixel.

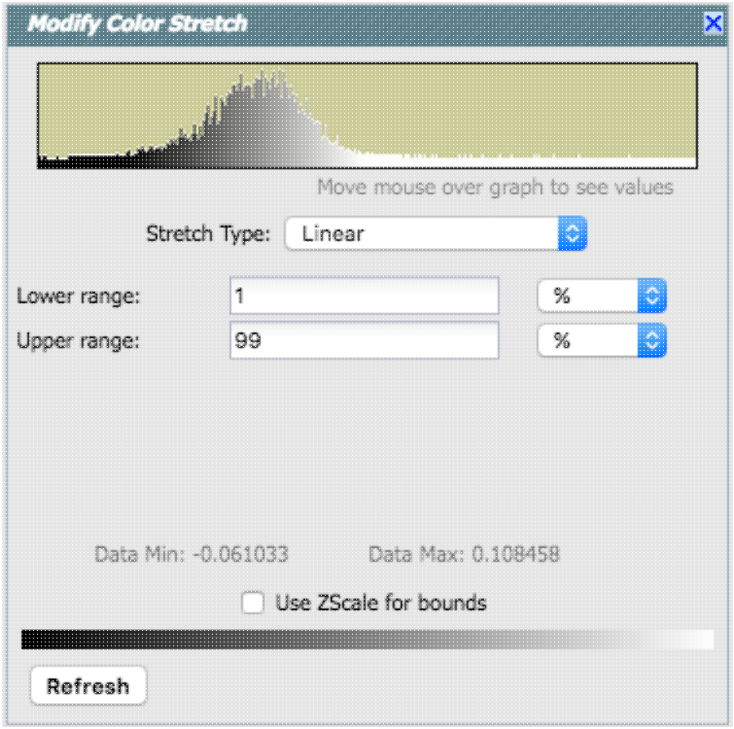
You can pin as many different extractions as you want. Each one will result in new tabs with the corresponding table at the bottom of the screen. There are navigation aids within the tables section that may help.

## Specific information on 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.

## Specific Information on HiPS Features

### General Information

HiPS (hierarchical progressive survey) images are different than FITS images, and as such, the choices of what you can do with the HiPS images are different than what you can do with the FITS images. Choices you can make for HiPS images are sometimes different than what you get for 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; the complete list of HiPS images available from the IRSA Viewer search page includes (once the "IRSA Featured" checkbox is unchecked) many HiPS images from CDS.

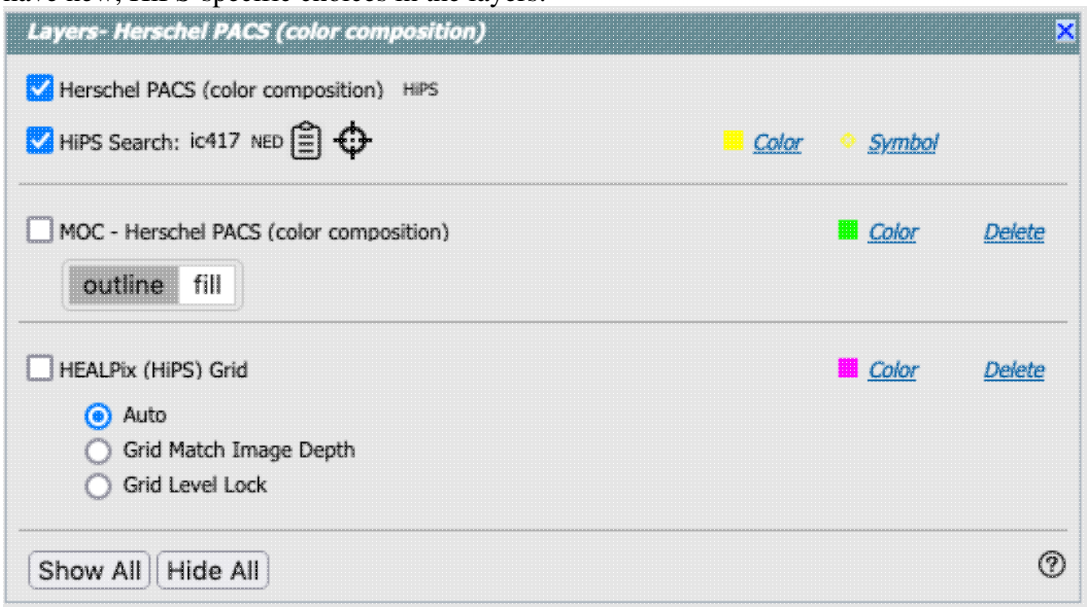
HiPS images have the color and stretch set by the person who originally made them. The color table can be remapped within this tool. But, you cannot change the stretch of HiPS images from within IRSA Viewer. This is why there may be multiple versions of some data sets in the list of HiPS images.

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.

**Overlays on HiPS Images**

Catalog searches (see Catalogs section) on top of HiPS images are limited to a maximum of 5 degrees.

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




**HiPS Grid**

To turn on these choices, click the checkbox to the left of "HEALPix (HiPS) Grid".

**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, click the checkbox to the left of "MOC".

A multi-order coverage map (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 ask for the MOC to be displayed via this layers dialog via tile outlines or filled tiles.

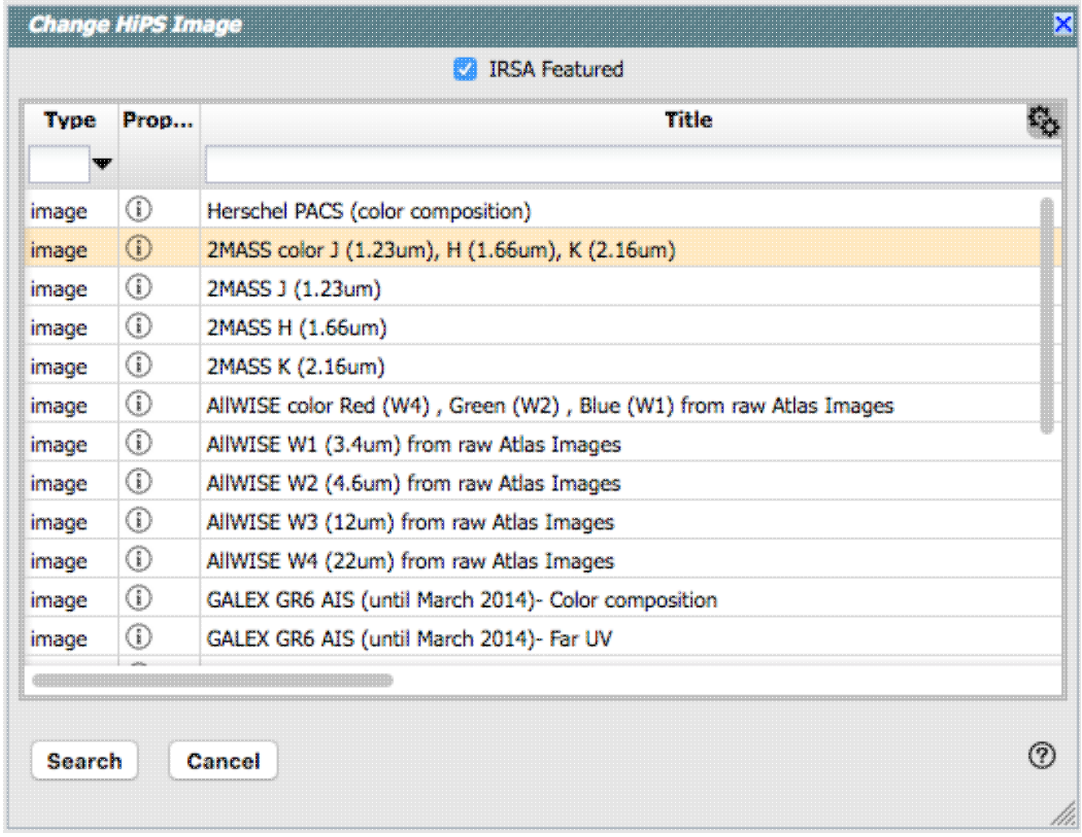
**Tips and Troubleshooting**: Depending on how you display a MOC, you may see two shades of color in the MOC, but the information it is displaying does not include depth of coverage, merely boolean "is there data there or not." Why is it displaying shading? Well, it's rounding. For example, a given WISE 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.

**HiPS/MOC**

This menu allows you to do two things: Change the HiPS Image, and add MOC overlays.

**Changing HiPS images**

The choices made by any given creator of a HiPS image may result in any given region being saturated. Color stretches are set by the creator of the HiPS map and cannot be changed; color tables can be changed by this tool. 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:

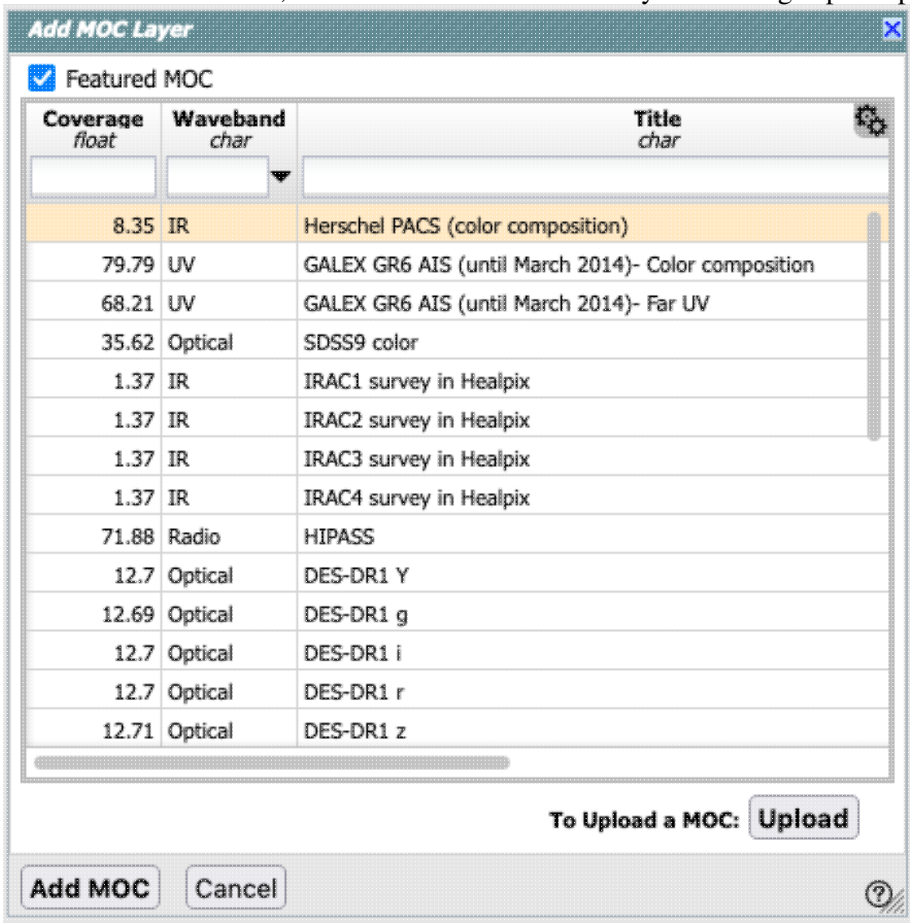



Things to note:

- 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."

**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:



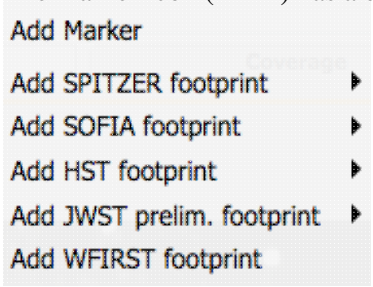

Things to note:

- 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.

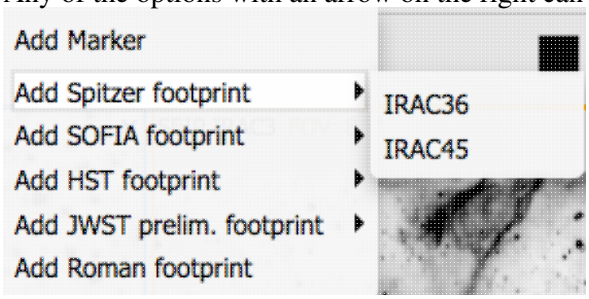
- If you have your own MOC FITS file, you may upload it via the "upload" button on the lower right.
- If you try to upload a MOC FITS file via the catalogs interface, it will behave as if you have uploaded it here.

## Footprints

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



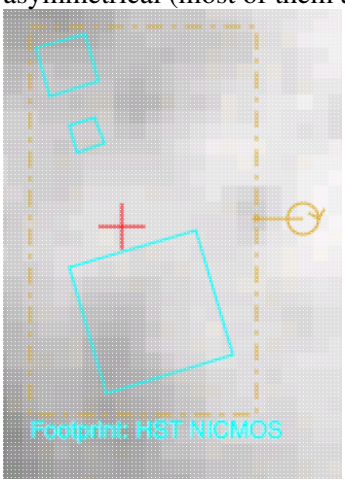

Any of the options with an arrow on the right can expand to additional subsidiary choices, e.g.,:




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:



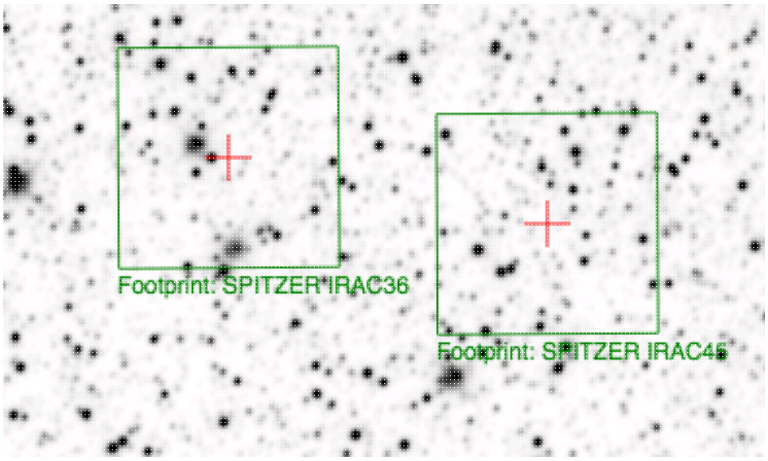

These so-called "handles" allow you to resize and/or rotate the marker, depending on the nature of the marker. These handles only appear when the marker is selected as active; if you wait a few seconds, they vanish.

**Tips and Troubleshooting**

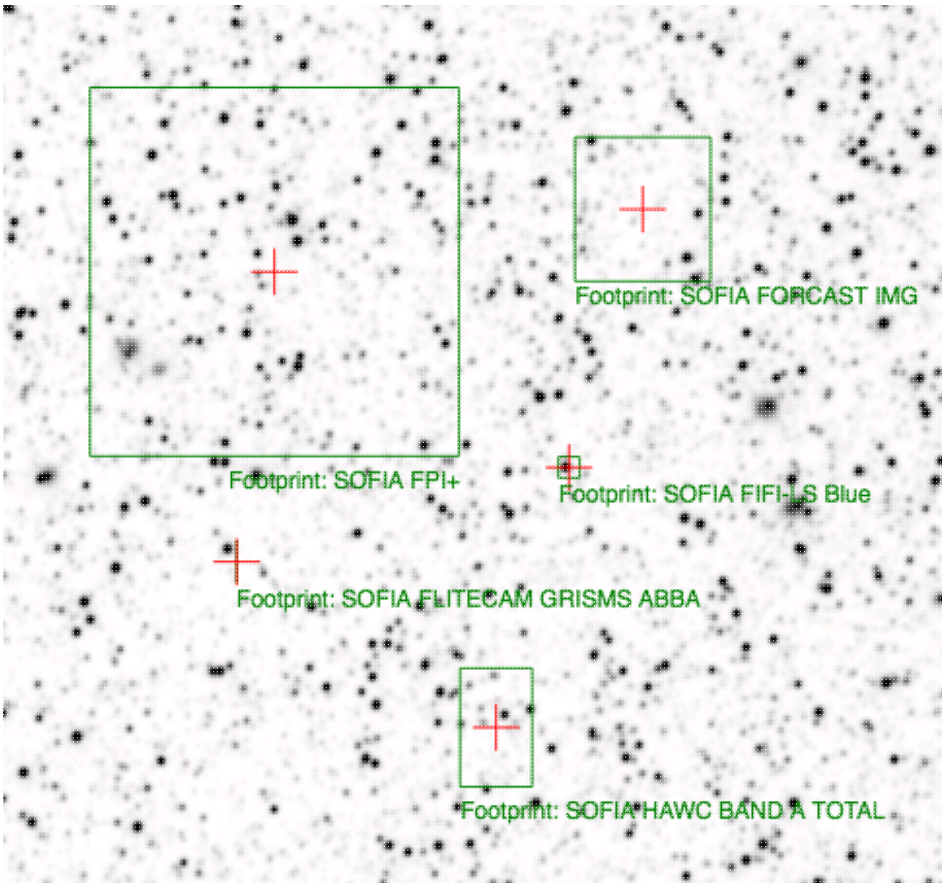
- Some of these footprints are *large*. If you have a small image, some of these footprints will be larger than your image. Zoom out to see it, or find a larger image to use. If you overlay, say, a Nancy Grace Roman Space Telescope (formerly WFIRST) footprint on a 2MASS image, you may need to zoom out 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 [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 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 overlays" button 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 JWST and Roman in particular, they are pre-launch values.



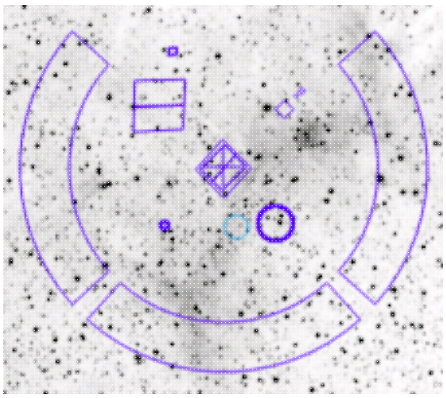
**Spitzer/IRAC 3.6 and 4.5 micron footprints.** These two footprints are placed separately from each other. The footprint can be moved or rotated. Click and drag the center of the footprint. A circle appears with four small circles ("handles") around it. Grab and drag the small circles to rotate it, 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.



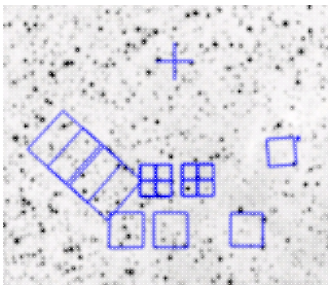

**SOFIA footprints.** Several different SOFIA footprints are available; the graphic here shows a selection of them. The available footprints (all of which are placed separately) are:

- 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

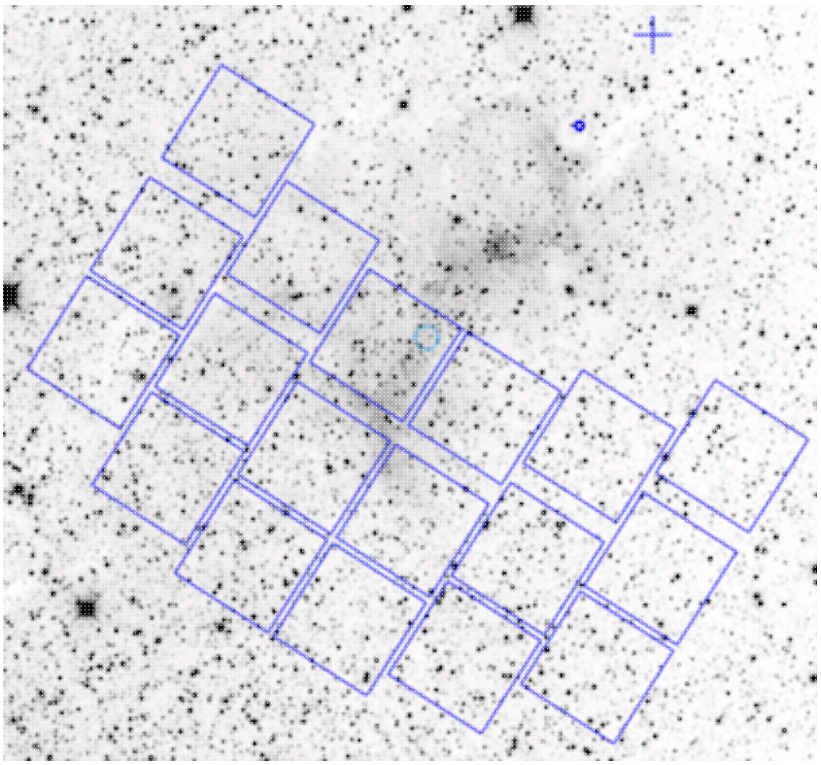
Change the color, delete, or add more copies of the SOFIA footprints from the layers pop-up.



**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.

## Catalogs and Layers

If you search on catalogs from the search results page, then the Spitzer Heritage Archive will overlay these catalogs on your images as additional layers. In order to see the layers on any given image, you need to click on the layers icon ( ) in the image toolbox (described above). See the Catalogs section for much more information on catalogs in general.

To remove a catalog entirely, click on the small 'x' in the upper right of the catalog tab in the window pane view.

## Breaking out of the pane (and going back)

By default in the Spitzer Heritage Archive, the screen is broken up into 2 panes, the list of observations on the left and the details of the selected observation on the right. For some purposes, it is useful to view either of

these panes as large as possible. On the upper right of any pane, there is an expand icon . Clicking on it will expand these tables into a larger window, taking up as much space in your browser window as possible.

**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.

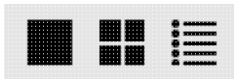
**Go back the way it was:**

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.

Also see the next section on image navigation.

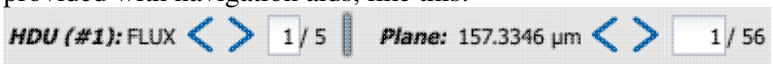
## Image Navigation

**Single or Tiled Images**

When you have many images loaded in, you can have icons like this:  that portray (in icon form) the different views you can have of the images you have loaded. The first icon (the big square) denotes "show one image at a time." The second icon (the cluster of small squares) denotes "show smaller images of all the images I have loaded at once," e.g., tiled images. Whether the images (tiled or not) take up all the space or not depends on whether you are viewing in panes or in the full-screen mode (see immediately above on Breaking out of the pane).

**Paging through single image views**

If you have many images loaded in and click on the single big square to view one image at a time, you are provided with navigation aids, like this:




The arrows allow you to scroll through your list of HDUs and planes.

## Coverage Image

The Spitzer Heritage Archive will pick an image on your behalf, called a coverage image, on which it places the footprints of the observations in your search results.

The next subsection covers more details about the coverage image.

## Automatic FITS-HiPS-Aitoff Transitions

The entire point of a coverage image is to provide an 'orientation' to, say, the coverage of the image results of a search. As such, then it is likely that the coverage image needs to cover a lot of sky. By default, most searches will probably result in a HiPS coverage image. The nature of HiPS images is to provide adaptive spatial resolution. But, if you zoom in far enough, you may need a FITS image instead. If you zoom out far enough, you may need something other than a HiPS image, or at least a different projection may be helpful.

The top of the coverage image will look like one of these three options:

The darker choice is a "pushed in" button, and represents the image type you are currently viewing.

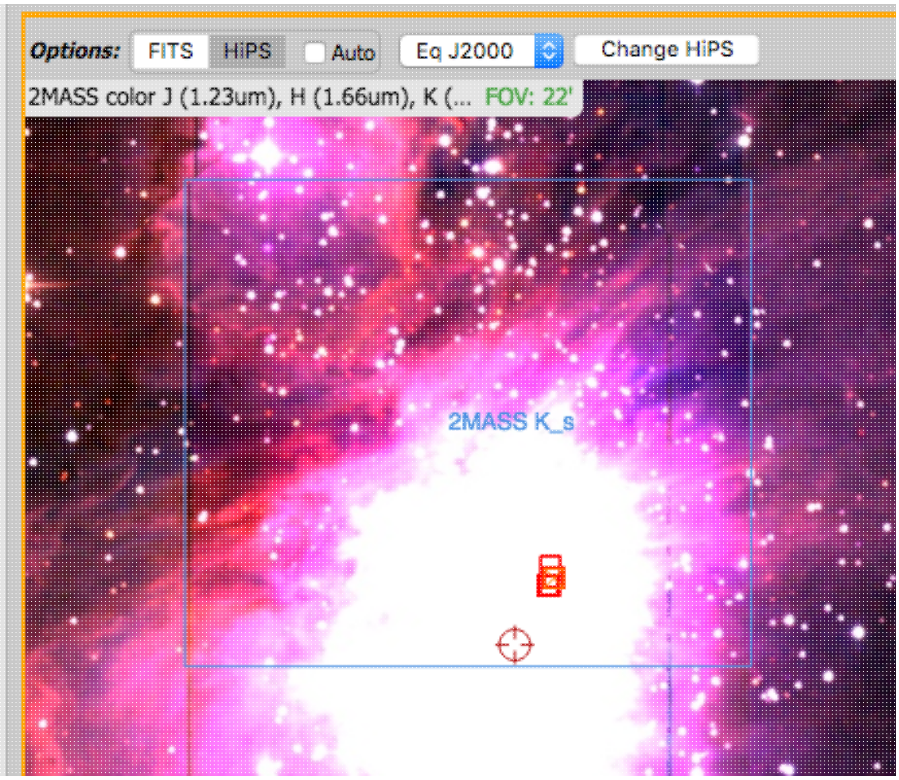
**Type of image**

- A search over a small area will result in a FITS image, or you can force it to give you a FITS image by clicking on "FITS" in the upper left of the coverage image. It will select a FITS image for you, corresponding to your current target.
- A search over a large region will result in a HiPS image, or you can force it to give you a HiPS image by clicking on "HiPS" in the upper left of the coverage image. It will load a HiPS image corresponding to your current target. (More information about HiPS images can be found above, including how to change the HiPS image or add a MOC layer with the drop-down menu on the right.)
- A search over a very large region (including Solar System objects that move over a large area) will result in an Aitoff projection HiPS image, or you can force it to do this by clicking on "HiPS/Aitoff" in the upper left of the coverage image. This is a HiPS image whose projection has been changed to an Aitoff projection. (If you're zoomed in when you click this button, it may seem like nothing has changed.) By default, north is not necessarily up, nor is the equator necessarily where you might expect. The "Center Galactic" button will center the Galactic Plane, with the galactic north up. All other options are the same as for HiPS images above.

**Automatic changes**

Because FITS images are best for small regions of the sky and HiPS images are best for large regions of sky, if you tick the "Auto" box and then zoom in or out, the viewer will automatically toggle between image types as needed. Zoom in enough, and it will swap from HiPS to FITS. Zoom out again enough, and it will swap from FITS to HiPS.

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 clearer what is going on:




**Coordinates**

The drop-down menu allows you to select between coordinate systems. Used in conjunction with the image readout and/or the coordinate layer button (both described above), you can change what coordinate system it uses.

## "Catalog" loading

As discussed in the catalogs section, you can upload several different types of files into the tool, including files that have images, or mixtures of images and tables.

Because this tool is restricted in what it can do, it is restricted in what kinds of files you can upload. If you attempt to load in a mixture of images and tables, it will tell you that the tool cannot load in images.

# Spitzer Heritage Archive: Tables

All of the tables in the Spitzer Heritage Archive (whether they are catalogs, or the contents of a FITS or HiPS header) are interactive tables, and they have the same basic properties, discussed in this section. The specific broad case of Catalogs is in another section.

*Contents of page/chapter:*
+Table Header
+Table Columns
+Adding Columns
+Table Filters
+Table Cells
+Saving Tables
+Table Actions
+Table Navigation

## Table Header

These interactive tables -- called Firefly tables, after the software that is running here -- all have the same functionality, regardless of the contents of the table. If it looks like this sort of table, you can work with it whether it is a catalog, an image header, a list of images, etc.

If you have loaded a catalog into a tab and it doesn't take up the whole screen, to see more of the window, grab the divider between the window panes and slide it up/down or over as needed, or use the expand arrow icon ( ) to enlarge the window pane to take up the whole window.

The table is shown exactly as it has been provided to the tool, with all columns as defined by the creator of the table. To understand what each column is, please see the documentation associated with that catalog or table.

The tab (and table) name itself likely indicates its origin. To remove the tab, it is likely that you can click on the "X" on the tab.

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

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

Table navigation
The first thing to notice is that only the first 100 rows of the retrieved list of observations are displayed in the table. In the example here, there are 265 observations that were retrieved as a result of the search. 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.

Table action: Searches
This launches a new search, and as such, it has its own section below.

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 text display. The icon then changes to -- click this again to return to the default table view.

Save table

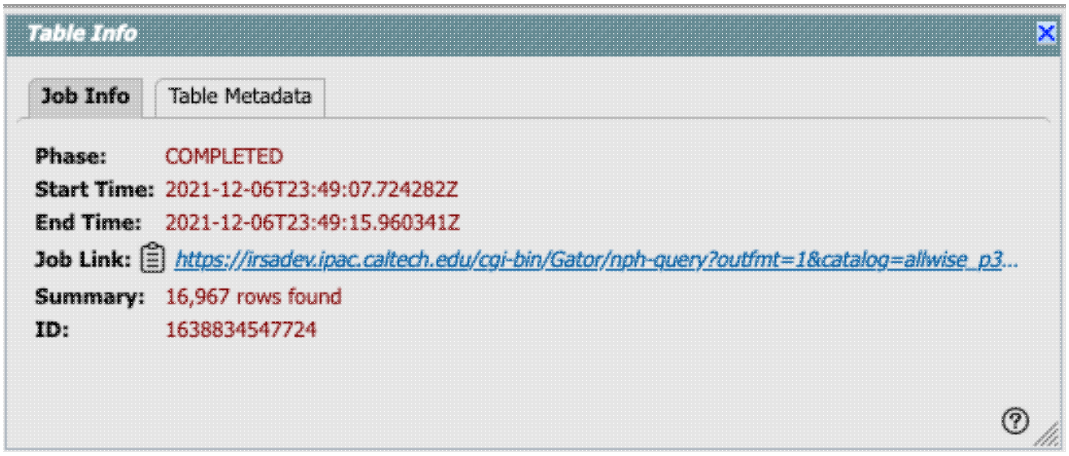
This is how you can save the catalog. It has its own section below.

Add a column

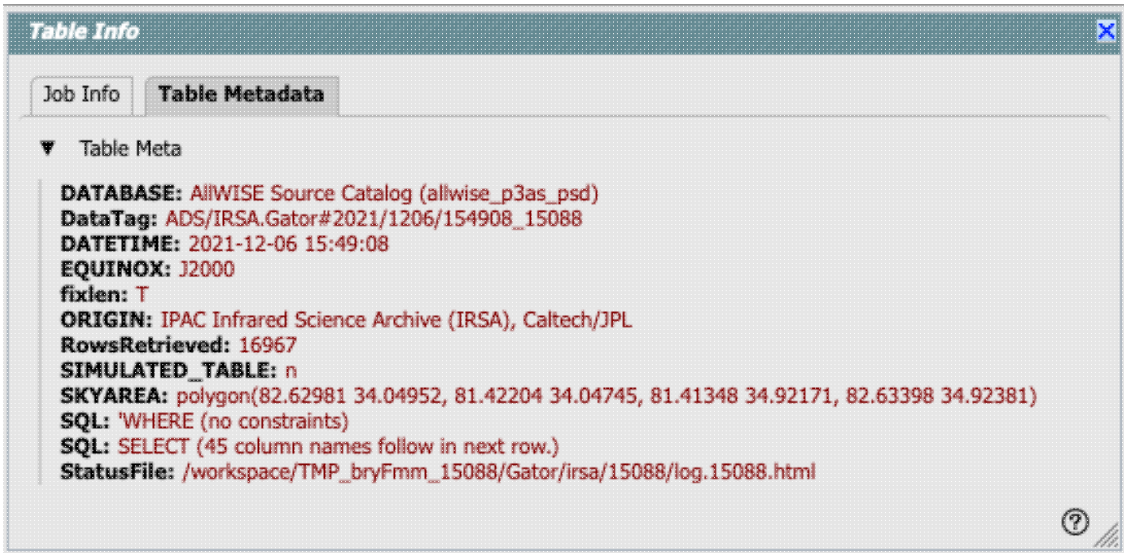
This icon adds a new column to the table. This has its own section below.

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:



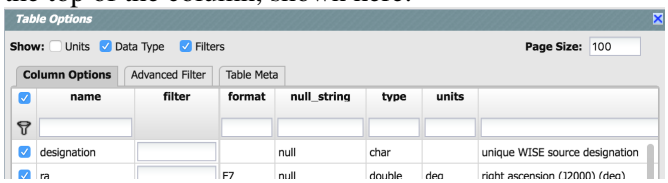

where the direct link to the job is given there (and can be copied by clicking on the clipboard, ready to be pasted into a helpdesk query, for example), with a job id as shown. It could also just have information about the table metadata:




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

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

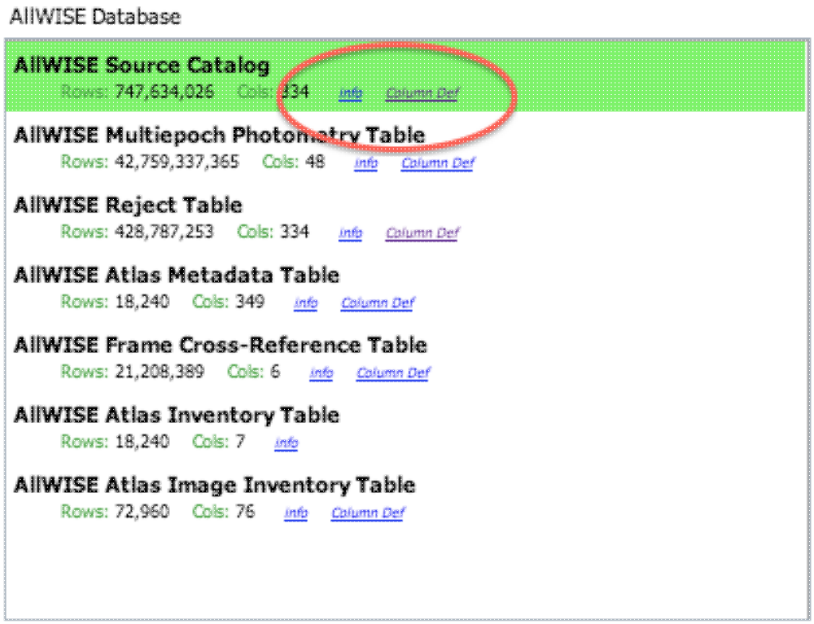
Clicking on this expands the catalog window pane to take up the entire browser window. To return to the prior view, click on "Close" in the upper left.

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 (or as it appeared on your disk), 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 the catalog searching popup window, see figure below, or by 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. When you do a single-position search on catalogs, two new columns could be appended to the end of the catalog as it is returned to you. These columns are:

- dist - the distance between the source in question and the location you specified
- angle - the position angle between the target position you requested and the object it found (degrees E of N)

When you do a multi-position search on catalogs, you could have three new columns prepended to the catalog as it is returned to you. These columns are :

- cntr_01 - the target position you requested
- dist_x - the distance between the target position you requested and the object it found
- pang_x - the position angle between the target position you requested and the object it found (degrees E of N)

These additional columns can help you assess if the target it found is the target that should be matched to the position you requested.

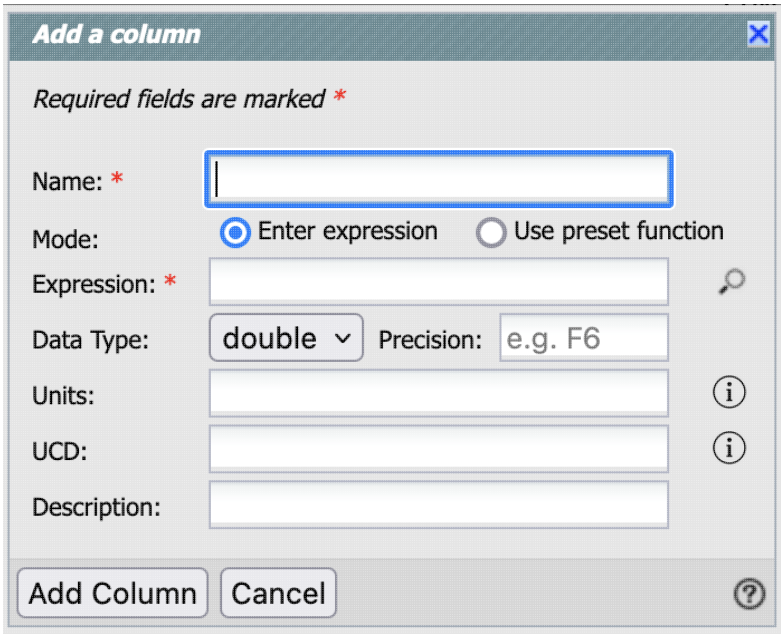
It could be that, when you do a multi-position search on catalogs, you have an option for "one-to-one matching". If that is selected, the line (and only one line) of output is included for each line of input. It chooses the closest source within the radius you specify, or if there is no match, it adds a line indicating no match.

**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.
- If you are constructing your own catalog, the tool tries to guess the formatting of the column based on the first row's values. Therefore, if you have a value in the first row that happens to be a string like "null" where the rest of the column isn't like that, or happens to have only one decimal place where the rest of the column has 2 or more, it will guess incorrectly and format the other rows just like the first one. Try editing your catalog file to put the most general case as the first row.

## 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 immediately below this point correspond to "Enter expression" options; the preset function options are lower below.
- *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. (This option appears for both modes.)
- *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.

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.

## 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:** From a catalog, show only those sources with declination above a certain value (say, 31 degrees), type "> 31" in the box above the "dec" column. Or, if you have retrieved a WISE catalog and would like to only view the objects with a W1 (3.4 micron) profile-fitted magnitude less than 6 magnitudes, above the 'w1mpro' column, type "< 6" in the form.

For columns (fields) with a limited set of choices, instead of a text entry box, an arrow next to the filter box will appear; 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 "filter" when you are done. Click "clear" in 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**:

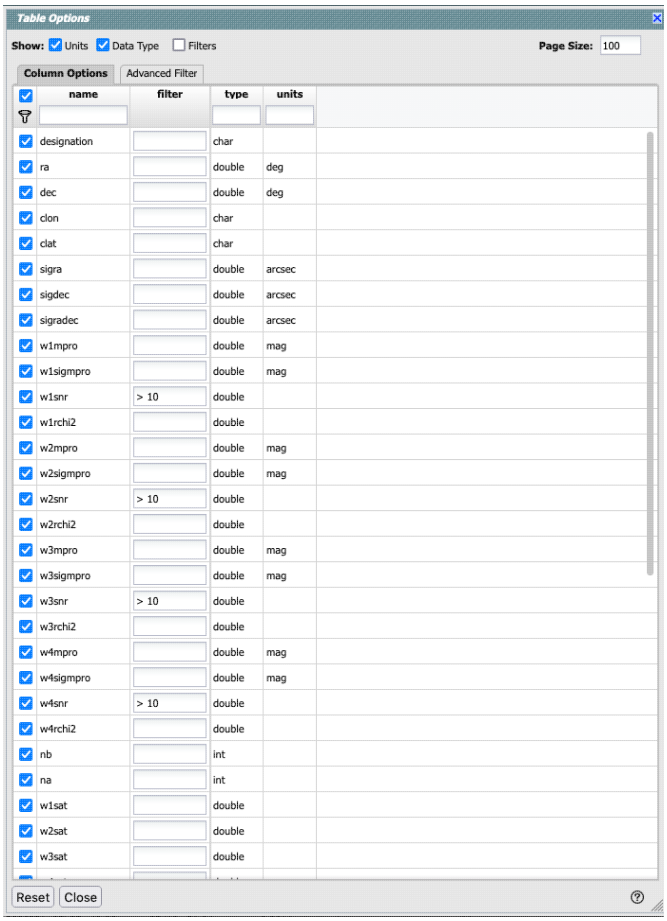
- Retain rows for which a certain parameter is not an empty string: !=''
- Retain rows for which a certain parameter is not NULL and is larger than 1.234: > 1.234 and IS NOT NULL
- Retain rows that have values between -0.5 and 1.25: > -05 and < 1.25
- Retain rows with a parameter greater than one value 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 can also select rows one at a time from the far left column and then filter that down. Example: Search on anything. Select rows by ticking the box on the 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.

You can also interactively impose filters from plots from a catalog - see the plots section.

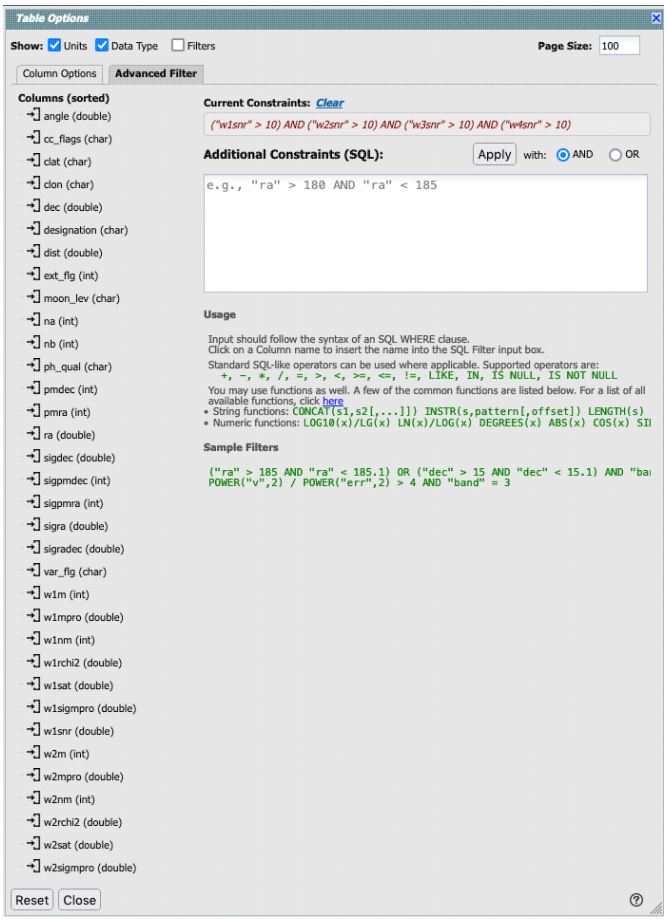
Additionally, all the same operators that are available for making plots can be applied in filters - see the plots section.

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 WISE catalog that has been filtered to just have SNR>10 for each of the four bands:




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.

### 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

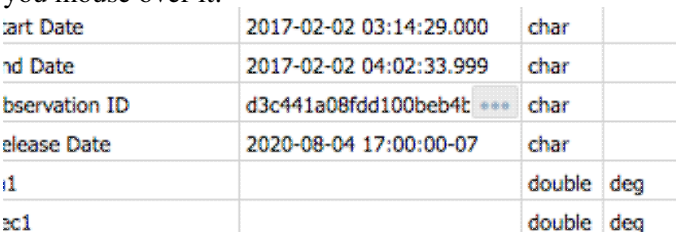
to see what it is.

**Cancelling filters**

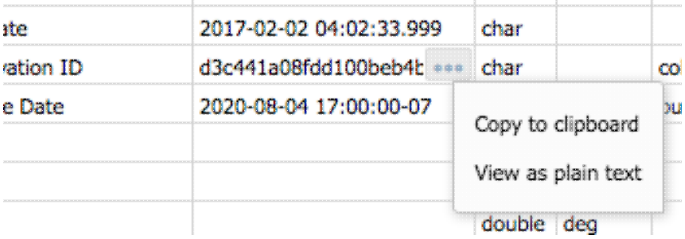
After you impose a filter, then the "filters" icon on the top right of the catalog pane has changed to remind you that there has been a filter applied, in this case just one filter: To clear the filters, click on the cancel filters icon (which also appears after you impose filters): .

## 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:

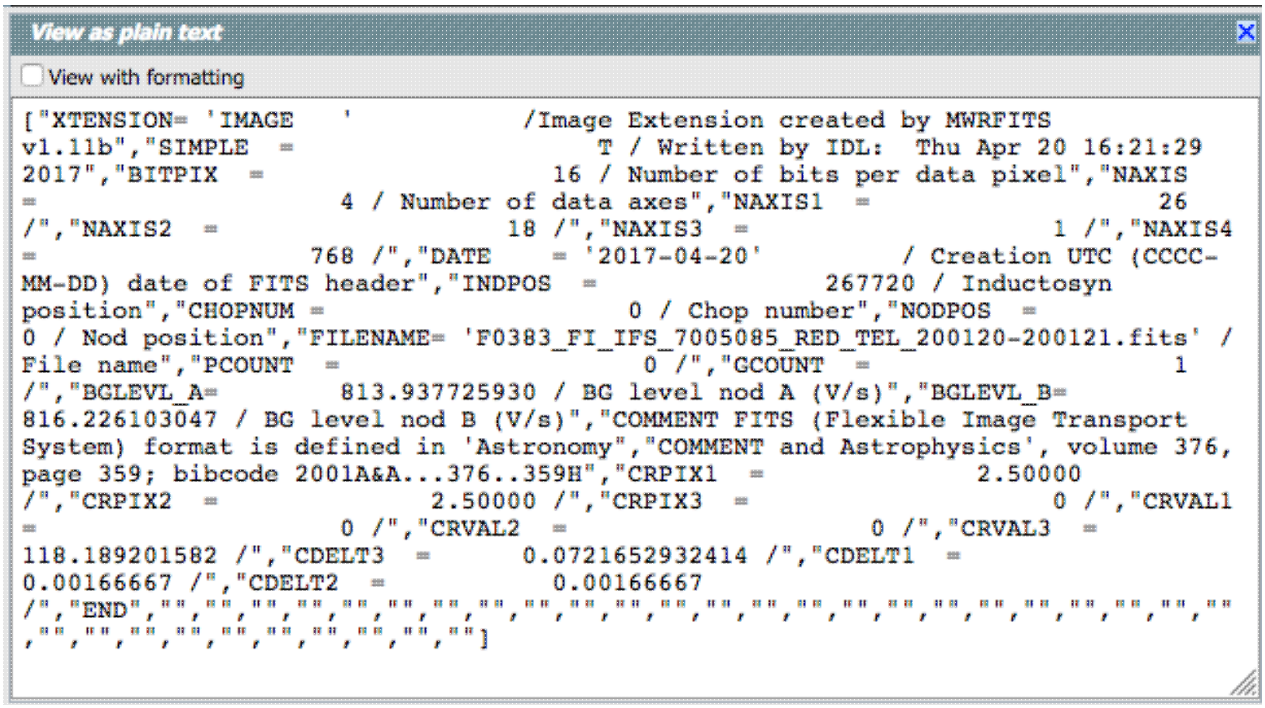



If you click on the ellipsis, you get a drop-down menu:

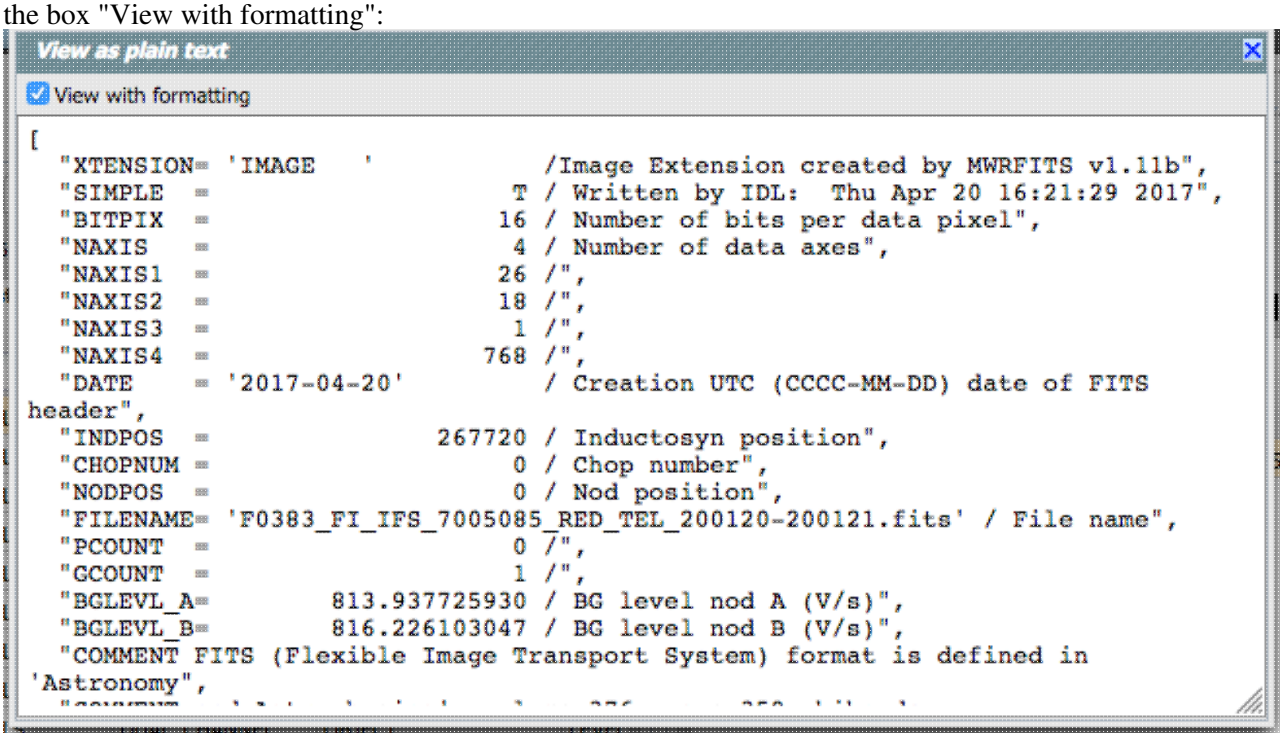



from which you can choose to copy the cell value or view it in a pop-up window.

If you view it in a pop-up window, it will come up with no special formatting:



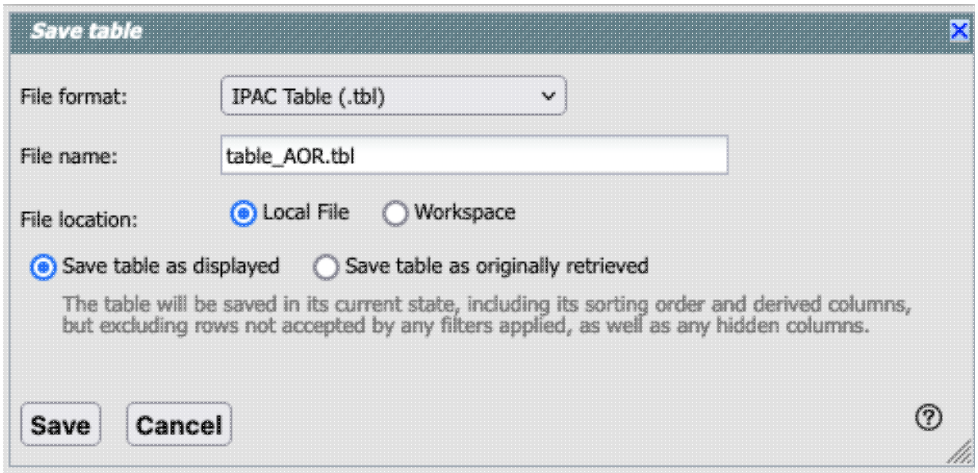

If the cell has a lot of information, it may help to impose simple formatting, which it attempts to do if you tick the box "View with formatting":




## Saving Tables

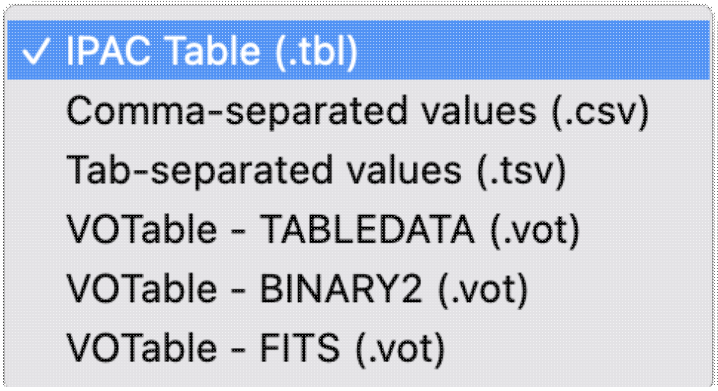
Click on the diskette icon ( ), if available, to save the table.

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.

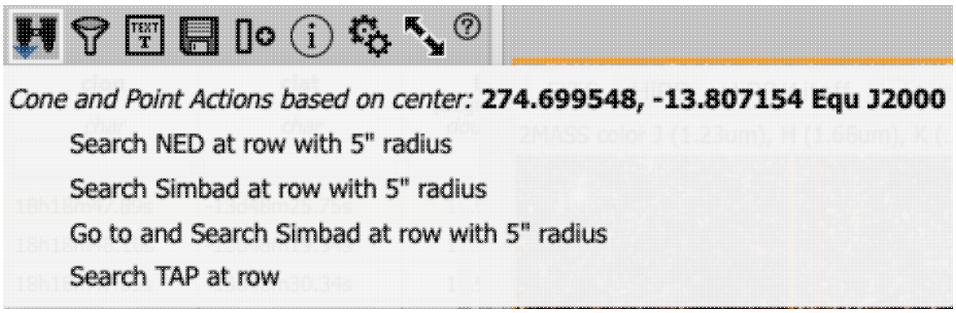
File name
: The tool tries to make a guess at a sensible filename. Feel free to change it to something that makes sense to you.

File location
: You may save your file to a local file (on your disk) or, if oyu 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 Actions

This icon implements a new search, an 'action', on the currently selected row of the table. When you click on it, it reveals a drop-down:




For this example, the selected row is 274.699548, -13.807154 in J2000 decimal degrees. From this drop-down, you can:

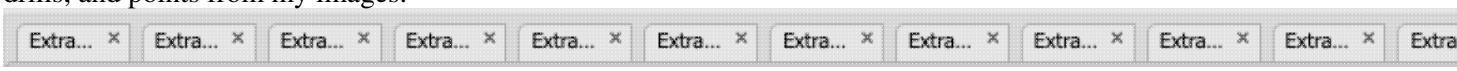
- Launch a NED search at this position with a 5 arcsecond radius (more information about NED searches)
- Launch a Simbad search at this position with a 5 arcsecond radius, and put the results in a table here in the tool
- Launch a Simbad search at this position with a 5 arcsecond radius, but start another browser window or tab at Simbad with the results
- Launch a TAP cone search at this position (more information about TAP searches)

Any of these searches (except the search that launches another browser window with the Simbad results) places the search results into this same tool.

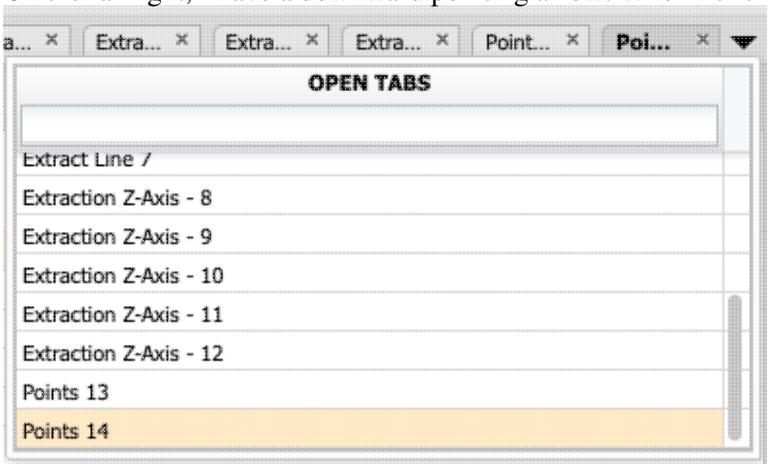
## Table Navigation

Particularly with the ability to extract data from images comes the ability to rather quickly drown in tables. There is a way to navigate among a lot of table tabs that have accumulated.

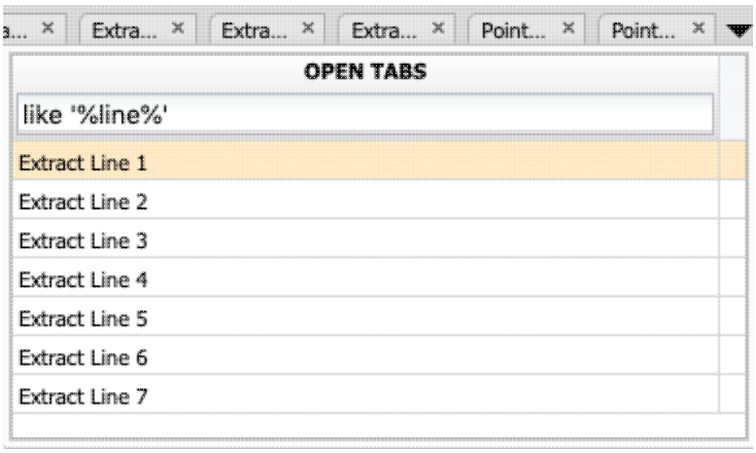
This is probably best explained via an example. Here, I have tabs showing that I have extracted several lines, drills, and points from my images:




On the far right, I have a downward pointing arrow. When I click on this, I get a drop-down:




This drop-down shows that the tab marked "Points 14" is in the foreground (it is shaded yellow) and it has a filter box at the top. That filter box at the top works just like the filters discussed above, so if I want to find the tabs with the extracted lines, I can type "line" in the box, and it will filter down the list, leaving only those tabs with "line" in the name:




Then, from there, I can select the tab I want to bring to the foreground. (When I select a tab to bring to the foreground, that tab is also in the foreground for plotting.)

In this fashion, you can navigate among many tabs that are open at the same time.

# Spitzer Heritage Archive: Catalogs

Catalogs are a special case of tables; the basic functionality of tables is covered in the Tables section. You can choose from any of a wide variety of catalogs to load for overlaying on your visualized data.

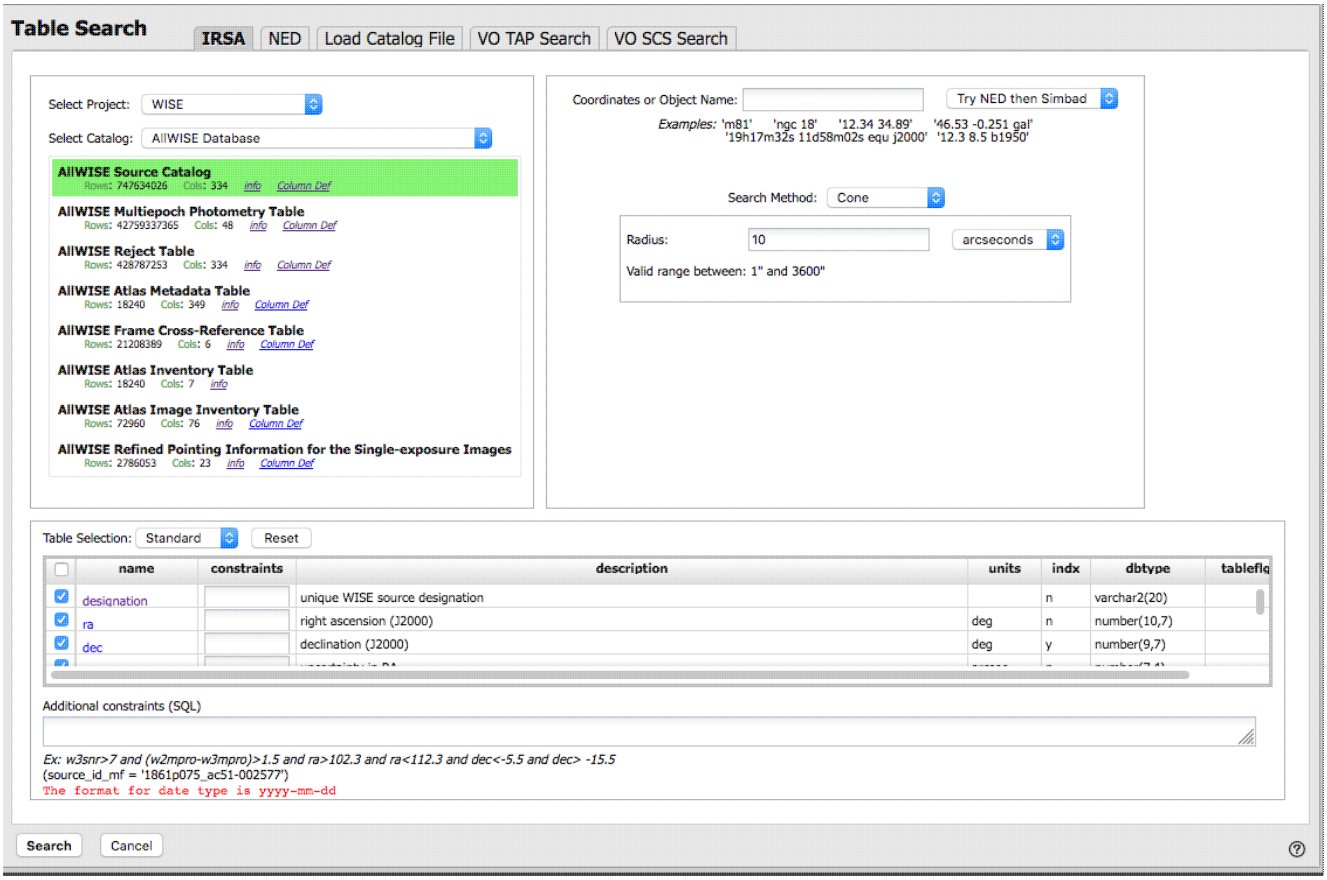
(Note that catalogs are available via a blue tab that appears at the top of the page only after you have performed at least one search -- you need to have something on which to overlay the catalog before it will let you search.)

*Contents of page/chapter:*

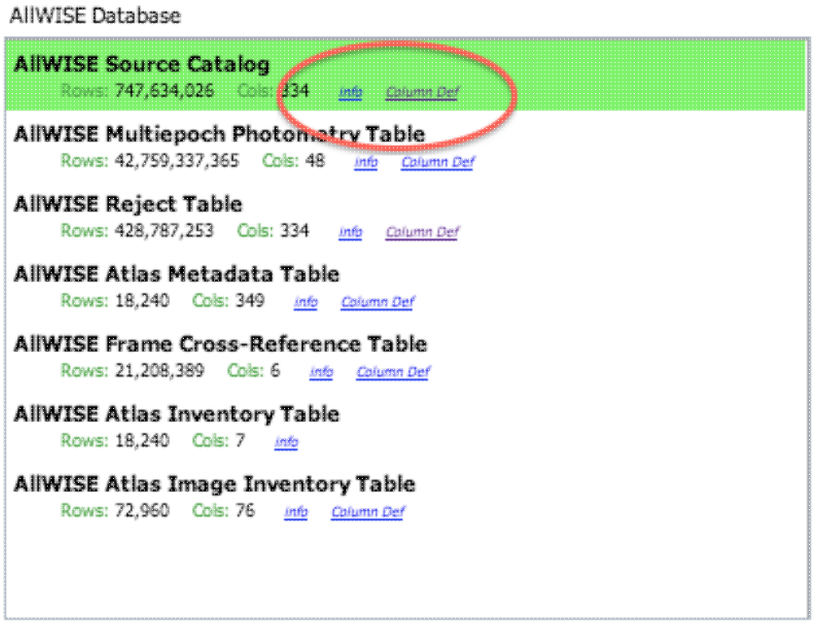
+IRSA Catalogs -- Searching for catalogs from IRSA
+NED Objects -- Searching for NED objects
+Catalogs from Disk -- Loading catalogs from disk
+VO TAP Search -- Searching for catalogs via VO TAP services
+VO TAP: More about constraints
+VO SCS Search -- Searching for catalogs via VO SCS services
+Interacting -- Interacting with catalogs
+Details Tab -- More information about the columns

## IRSA Catalogs -- Searching for catalogs from IRSA

By clicking on the blue "Catalog" tab, a window appears with several options, as follows.



The upper left quadrant of this window is where you specify which catalog you want to search. To change catalogs, first select the "project" under which they are housed at IRSA, such as 2MASS, IRAS, WISE, MSX, etc. The available choices underneath that change according to the project you have selected. A short description is provided for each of the catalogs, with links for more information (including definitions of the sometimes cryptic column names); an example is here:

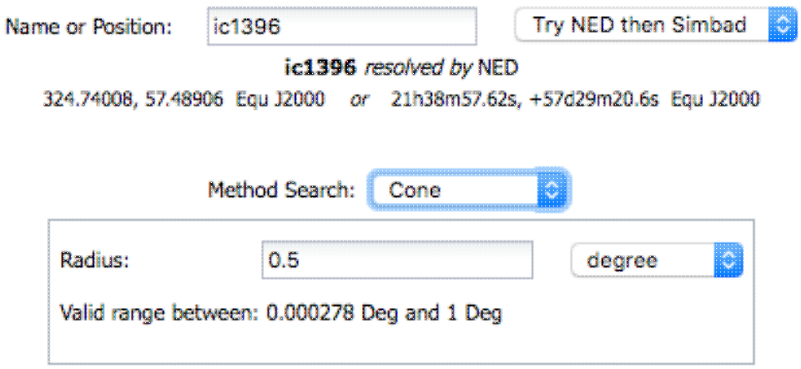



The upper right quadrant of this window is where you specify the target (the position can be pre-filled with its best guess as to what you want) and the search method (cone, elliptical, box, polygon, multi-object, all-sky), and the parameters that go with that search method (e.g., the radius of the cone). The parameters for each of these searches change dynamically as you select search options, as follows:

**Caution**:

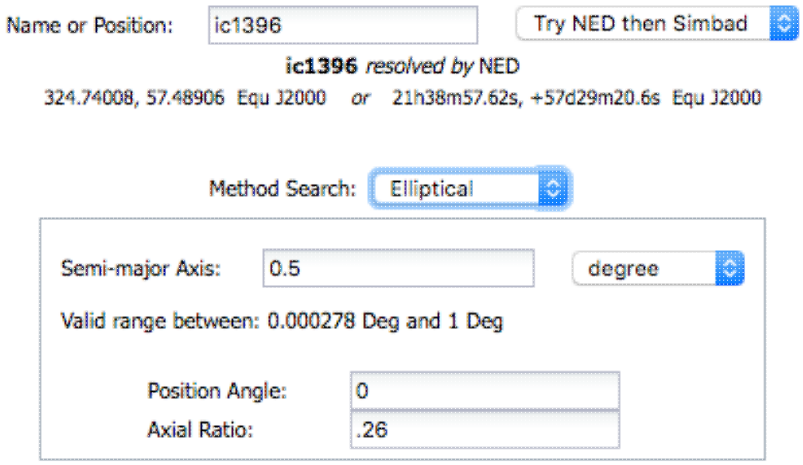
Pick your units from the drop-down first, and then enter a number; if you enter a number and then select from the drop-down, it will convert your number from the old units to the new units. There are both upper and lower limits to your search radius; it will tell you if you request something too big or too small. Note that these limits are catalog-dependent.

**Cone search**:



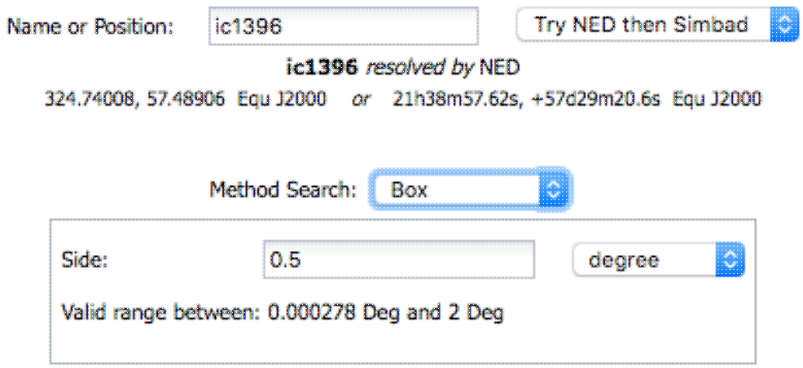

In this example, it has guessed a position, based on prior searches. You specify the cone radius.

**Elliptical search**:



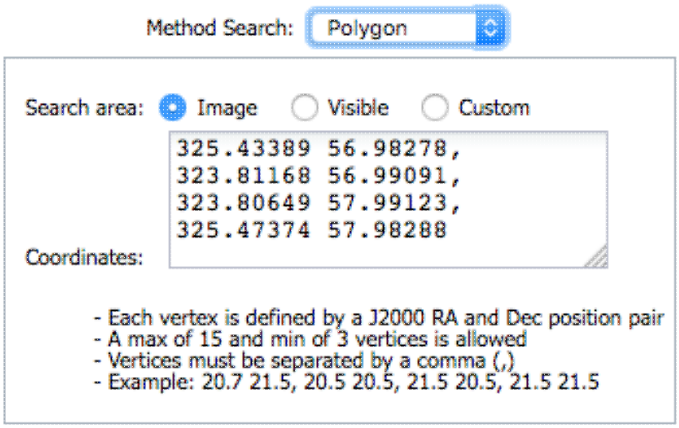

In this example, it has guessed a position, based on prior searches. You specify the search ellipse's semi-major axis, position ratio, and axial ratio.

**Box search**:




In this example, it has guessed a position, based on prior searches. You specify the box's length on a side.

**Polygon search**:

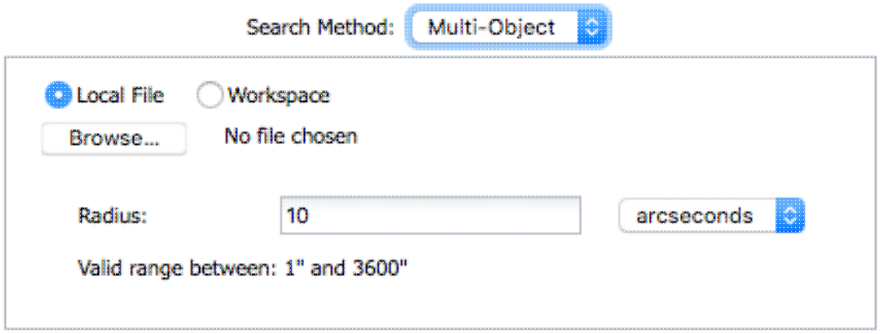



Now, note that it no longer has a single target location. It has pre-filled the vertices of the position it thinks you want, based on prior searches or the current image. You can select whether you want the catalog request to match the entire area of the image you have selected ("image"), or just the portion of the image you can see in the current view ("visible"), or your own ("custom") area. The list of vertices

in the coordinates box are in decimal RA and Dec in degrees. You must enter at least 3 and at most 15 vertices, separated by a comma. Note that, for overlaying catalogs on HiPS images, you cannot select "image", because HiPS images are generally very, very large, so this would result in too many points being returned. There is a maximum of 5 degrees imposed on catalog searches to match HiPS images.

If you select a rectangular region of your image and then select a polygon catalog search, you will have a fourth radio button above, "selection", which matches the corners of your selected image region.

**Multi-Object search**:



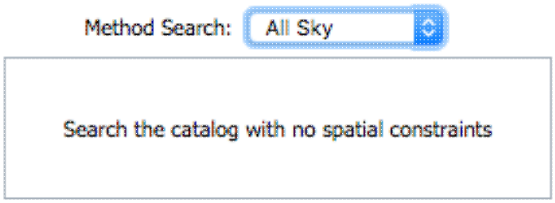

In this case, it has not attempted to guess what position you want. You need to upload a file (from your disk or the IRSA Workspace) in IPAC table format, which is a varietal of plain text. (IRSA has a table validator which may be helpful.) Note that you also have to specify the radius over which to search for each of the targets in your list.

When you do a multi-position search on catalogs, three new columns are added to the catalog as it is returned to you. These columns are :

◊ cntr_01 - the target position you requested
◊ dist_x - the distance between the target position you requested and the object it found
◊ pang_x - the position angle between the target position you requested and the object it found

These additional columns can help you assess if the target(s) it found is the target that should be matched to the position you requested.

**All-sky search**:




Because this is an all-sky search, it does not have a single target entry box. In order to constrain this search, you need to impose constraints on the bottom of the screen (see below).

The bottom of this window allows you to set restrictions on specific columns. It gives you a list of all the available column names in the corresponding catalog. (Most catalogs have identical "standard" and "long form" selections, but some have more columns available in "long form".) From here, you can choose what to display (tickboxes on the left), and filter what is returned ("constraints" column). For example, only return objects with values in column y that are greater than x. If you add more than one restriction, they are combined logically using an "AND" operators; be careful, because you can thus restrict data such that none of the catalog meets your criteria.

Click on "Search" to initiate the search. It will load the catalog into a tab of its own. The objects will also be overlaid on any images you have loaded, and a default x-y plot will be shown. (For more on the x-y plots, see Plots section.) All of these representations are interlinked -- clicking on a row in the table shows it on the image and in the plot, and clicking on an object in the image shows it in the table and in the plot, and clicking on an object in the plot shows it in the table and on the image.

To close the catalog search window without searching for a catalog, click on "Cancel".

**Tips and Troubleshooting**

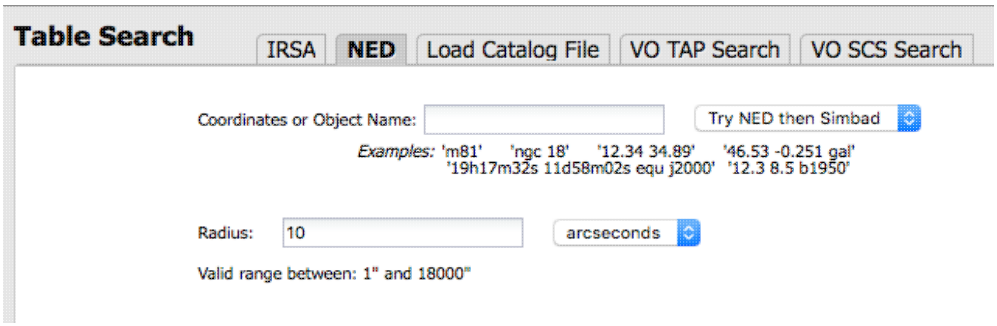
- If the catalog search is successful quickly, it will promptly return the results in a tab of its own.
- The search may take a long time to return, especially if you have asked for a large catalog, and you may think that nothing has happened, but be patient and eventually it will return a tab.
- Use large search radii with caution! Be sure you understand how many sources you are likely to retrieve. Searches that retrieve more rows will take longer. Searches that retrieve tens of thousands of rows will take quite a while.
- If you want to impose additional constraints on the catalog during your initial search, you can do so in the lower half of the screen (e.g., SNR > n in some band, or an SQL command), you can place constraints at this point. However, be advised that it is easy to combine constraints such that no sources are retrieved!
- If you overlay a large catalog, large enough that the plot is a binned heatmap, **the entire source list is NOT overlaid, even if you zoom in a lot**. The way to work within these constraints is to impose a filter on the catalog to get it below the threshold for a regular plot -- weed out lower SNR sources, or filter based on RA/Dec, etc. Then all the individual sources will be shown.
- If you overlay a large catalog, then turn around and save a regions file from the catalog overlay, then unusual things can happen. If the plot that results from the catalog is small enough to show individual points in the plot, then all of the overlays will be saved to the regions file. BUT if you have a plot with enough points that it is a binned heatmap, the greatly abbreviated ("decimated") source list overlay will be saved, **NOT** the entire catalog!
- If you have "pan by table row" turned on (see Visualization chapter), then it may be disconcerting to have the images "jump" right after the catalog loads. It is centering the selected catalog object (the first one upon catalog loading) in the viewer. If you don't like this, turn off "pan by table row".
- By default, it may show you fewer columns than are available in the full catalog. By selecting "long form" (above the list of columns), you can access the full range of available columns. In some cases, there are literally hundreds of columns that you can access!

The search results are then shown and interacted with in the same way as the other catalogs described here.

## NED Objects -- Searching for NED objects

(NED= NASA Extragalactic Database.)

By clicking on the blue "Catalogs" tab, you are by default dropped into the interface for searching for catalogs at IRSA. However, you can pick another tab, "NED", to search for and load objects from a cone search at NED.



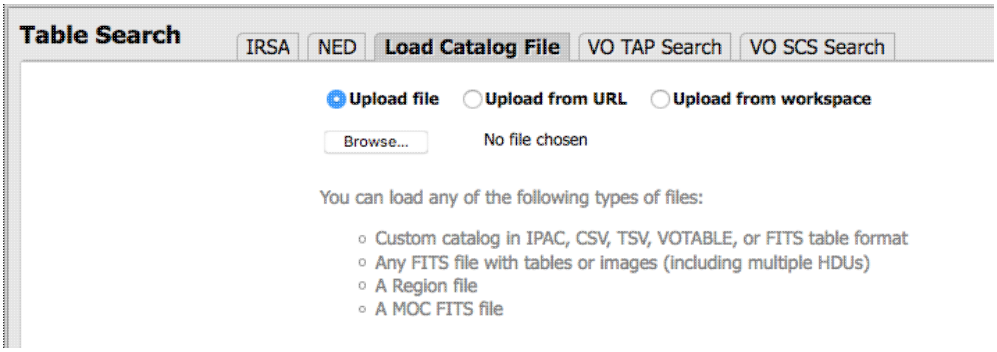

As for the other catalog searches, the tool pre-fills the target position with its best guess of the coordinates of the target with which you have been working. You can use an object name in place of coordinates. Note that although NED is used for name resolution, the actual search is then performed using coordinates, as opposed to name. In this case, you are limited to a cone search, so the next option is the cone search radius. Pick your units from the drop-down first, and then enter a number; if you enter a number and then select from the drop-down, it will convert your number from the old units to the new units. There are both upper and lower limits to your search radius; it will tell you if you request something too big or too small.

From the NED results, you have one-click access to the fully detailed information from NED on any object returned from such a search. The search results will generally include a column "Details", though you may have to scroll to the right to see it. Clicking on a link in this column takes you directly to the full NED information display for the selected object in a new window.

The search results are then shown and interacted with in the same way as the other catalogs described here.

## Loading your own catalogs from disk

By clicking on the blue "Catalogs" tab, you are by default dropped into the interface for searching for catalogs at IRSA. However, you can pick another tab from the top, "Load Catalog File", to load your own catalog.




You may upload a file from disk, from the web via a URL, or from the IRSA Workspace. The file can be in any of a number of formats, which we now briefly describe.

**IPAC table format (*.tbl)**

IPAC table format is plain text with a particular formatting. IRSA has a table reformatting and validation service which may be helpful, or you can download just about any catalog you find through IRSA, and mimic that format.

Your table file MUST have RA and Dec values, and unless it is specified, it assumes J2000.

You can add a "SYMBOL" parameter to change the shape (X, SQUARE, CROSS, EMP_CROSS, DIAMOND, DOT) of catalog marks, e.g.:

```
\SYMBOL = X
```

You can add a "DEFAULT_COLOR" parameter to assign a CSS color name or a HEX value to catalog marks, e.g., either of these two:

```
\DEFAULT_COLOR = lightcyan
\DEFAULT_COLOR = #00FF00
```

You can find the CSS color code or the CSS color HEX values online.

**Comma-separated values (CSV) format (*.csv)**

CSV format is often accepted by spreadsheet programs, and most spreadsheet programs can output CSV. It is plain text, with values for each column separated by commas.

**Tab-separated values (TSV) format (*.tsv)**

TSV format is sometimes accepted (or generated) by spreadsheet programs, and sometimes in tabular data downloaded from journal articles from the 90s. It is plain text, with values for each column separated by tab characters.

**VOTable (*.vot)**

Virtual Observatory (VO) tables are a special case of XML tables. (All VO Tables are XML but not all XML are VO Tables.) It is a format developed by the International Virtual Observatory Alliance (more information here). XML tables initially look to the human eye like it might be HTML, but they are easier to parse with code. There are packages in astropy that handle VO Tables.

**FITS files (*.fits)**

Flexible image transport system (FITS) files are widely used in astronomy and are an easy way to store images. FITS tables can be loaded into this tool. Note that this tool is flexible enough to handle multiple header data units (HDUs), so that you can upload a FITS file that has both images and tables. You can specify which HDU you would like to load, and if you choose more than one image, it will give you a choice of loading them into individual frames or all into one frame.

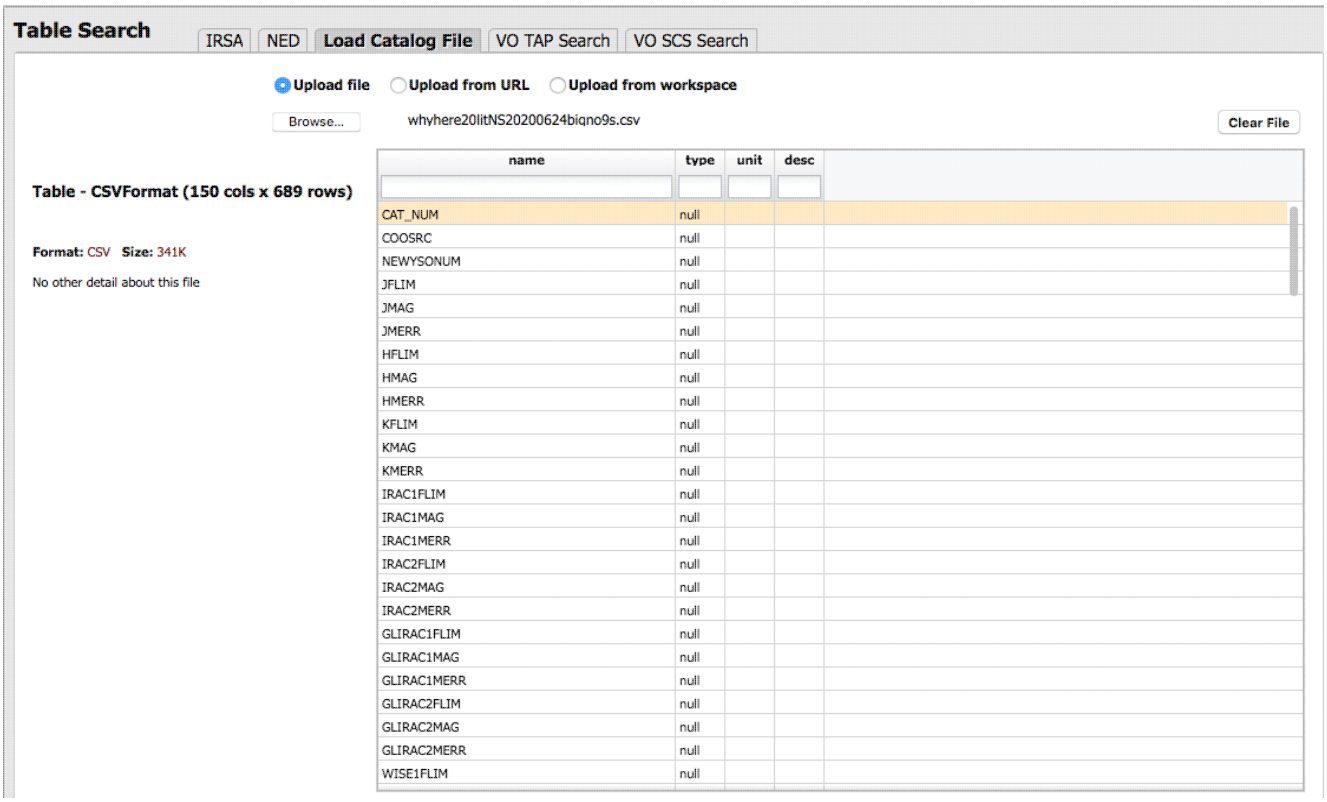
**Region files (*reg)**

Region files are plain text overlays originally used in ds9. Regions files can be overlaid on images (see here), but they can be loaded from this portion of the tool, and overlaid on images that way.

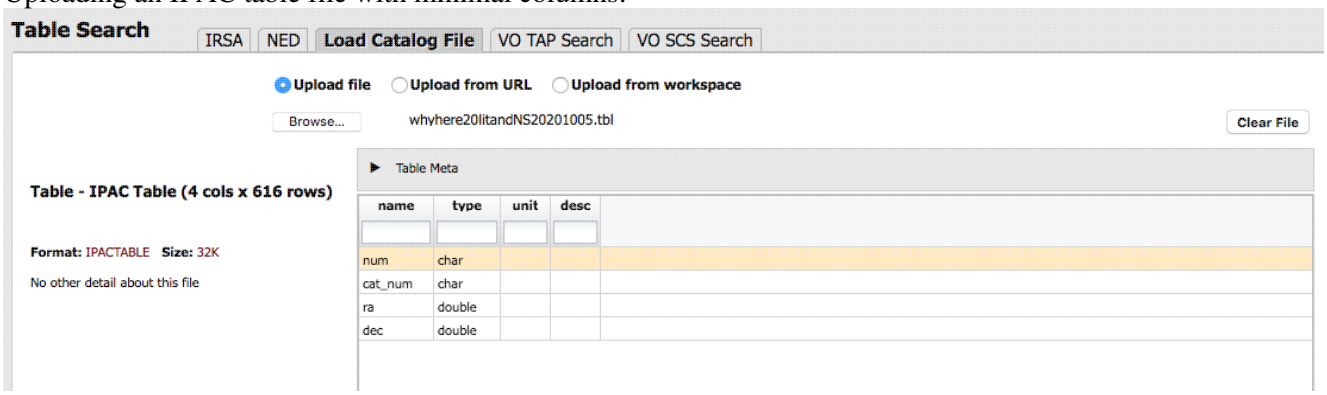
**MOC FITS files**

A multi-order coverage map (MOC) is a format developed by the International Virtual Observatory Alliance to specify sky regions. You might use this kind of file to describe the region over which a given survey has observations. These files can also be loaded into this tool.

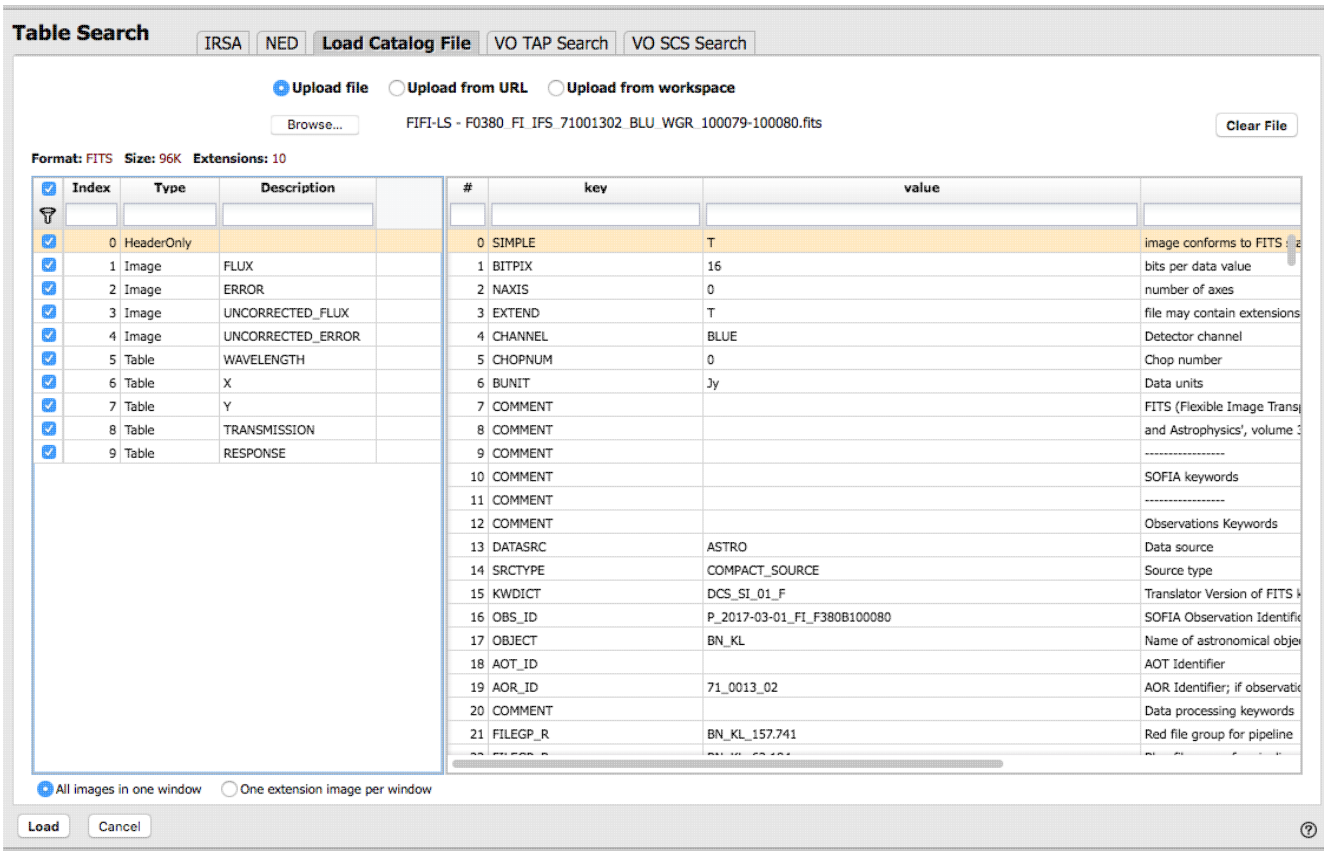
Nearly every file you load will result in a preview of the file you have uploaded. Examples include the following: Uploading a CSV file with many columns:



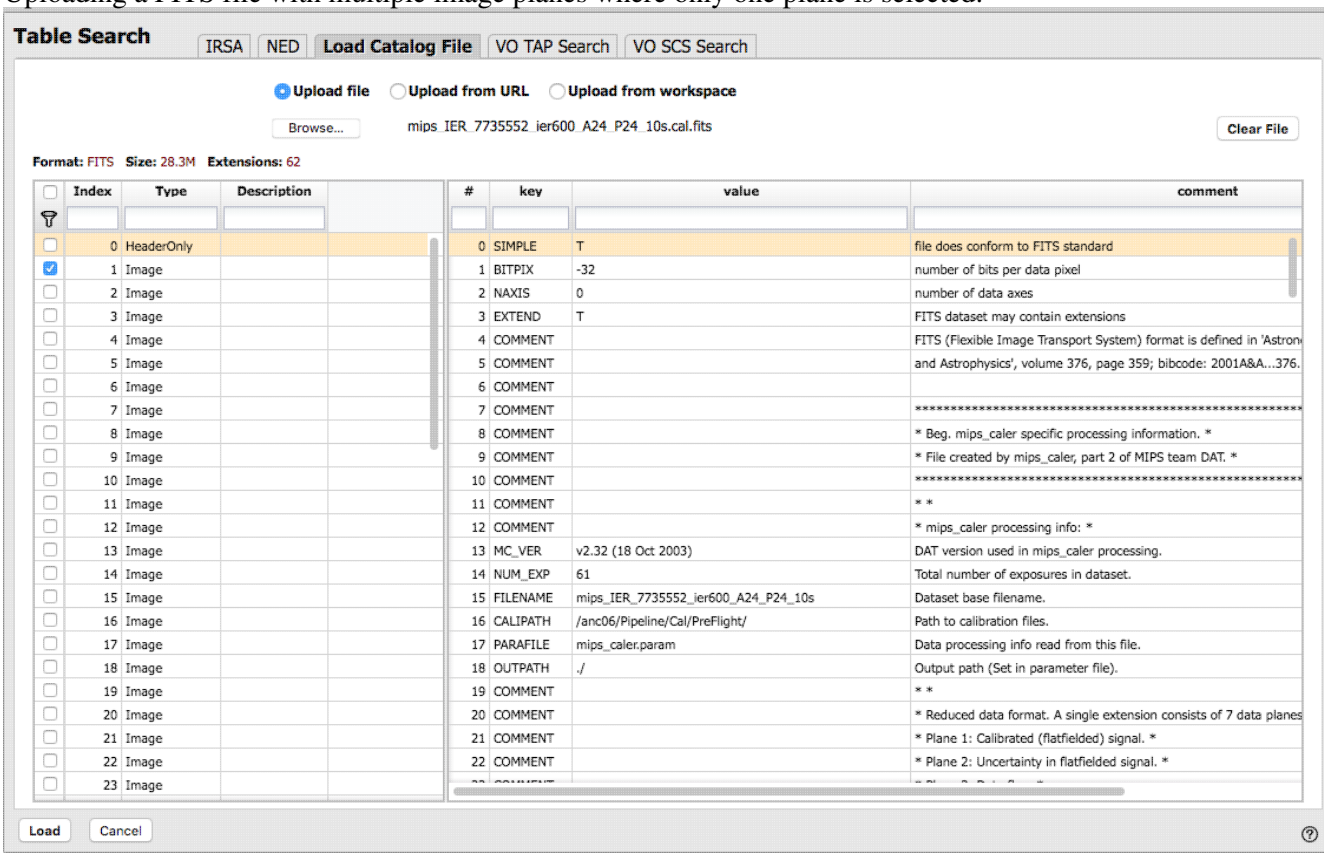

Uploading an IPAC table file with minimal columns:




Uploading a multi-HDU FITS file containing a mixture of tables and images. (Note that in this case, all planes are selected and the lower left gives a choice for loading all the images into one window or one extension per window.)




Uploading a FITS file with multiple image planes where only one plane is selected:



After you verify that the tool is reading your file correctly, and, if applicable, selected the HDU(s) you wish to load, click "Load" to load the file into the tool.

**Tips and Troubleshooting.**

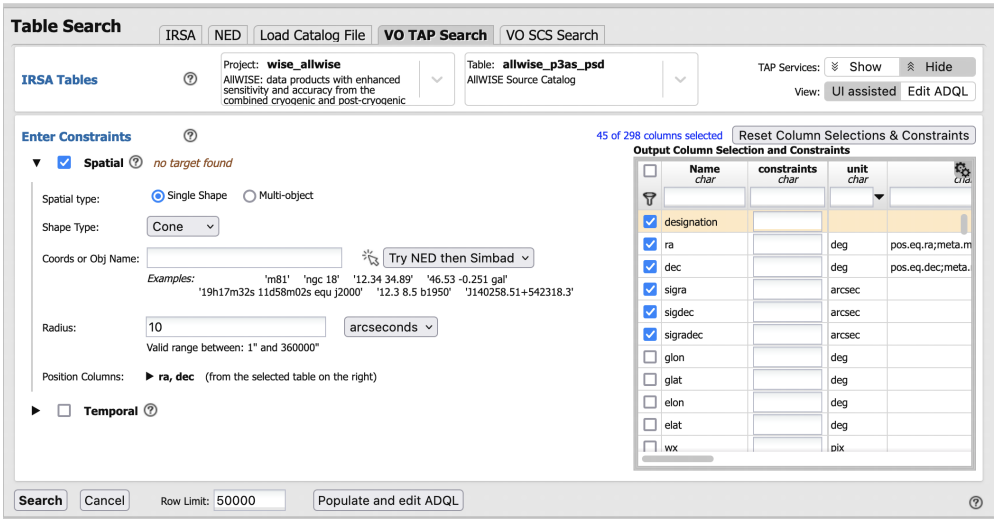
- If you would like to have your catalog overlaid on an image, it needs to have RA and Dec columns. If the tool doesn't seem to recognize your RA and Dec columns, check your formatting, or try headers of "ra" instead of "RA" and "dec" instead of "DEC" or "Dec".
- Unless specified, the tool assumes any coordinates you give it are J2000.
- If there are no discernible positions in the uploaded file, it will still let you plot columns from the file after you've loaded it.
- If you have multiple HDUs in your file, you can load a plane, and then come back to the the "Load catalog file" tab to pick another HDU without having to upload it again.

The search results are then shown and interacted with in the same way as the other catalogs described here.

## VO TAP Search -- Searching for catalogs via VO TAP services

(VO= Virtual Observatory and TAP = table access protocol.) TAP services enable complex queries of tables using astronomical data query language (ADQL). There are myriad places on the web to learn more about TAP queries and ADQL. We just provide a brief overview here in the context of this tool.

This is what the search screen looks like by default:




**Just do it: a quick start**

**Select Table**: It comes up ready to search on *IRSA Tables* (in the IRSA TAP service). Then you first need to select the "project" (sometimes called "Table Collection" or "Schema" in other contexts). Then, having selected that, the drop-down menu on the right changes to reflect the tables available under that schema.

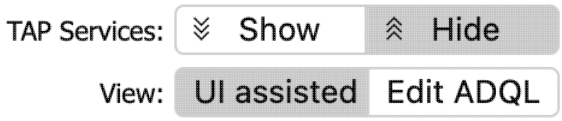
Then **Enter Constraints**: On the **left**, you can impose a variety of constraints. In addition to selecting the tickbox indicating that you wish to impose a particular kind of constraints, you need to specify which columns should be used for those constraints. More information on these constraints is below. On the **right** is a list of the columns in the selected table, with tickboxes to indicate which columns will

be returned. You can also set constraints on the columns from here, following the same filter rules as for any tables here. Above this section of the screen, there is an indication of which columns are selected (e.g., 45 of 298 columns). You can reset the column selection via the button here as well.

Then to **actually do it**, click "Search."

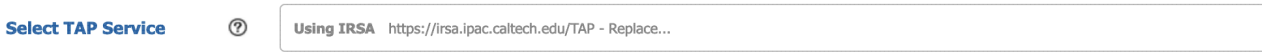
## Getting more out of it: Taking advantage of additional options

On the far right of the top row, there are two sets of buttons:




### Selecting a TAP Service

Next to "TAP Services", if you click on "show", you get this new choice appearing at the top:




There are many TAP services available, worldwide. By default, this tool uses IRSA's TAP service, but you can choose others via the drop-down menu, or just start typing in your TAP URL.

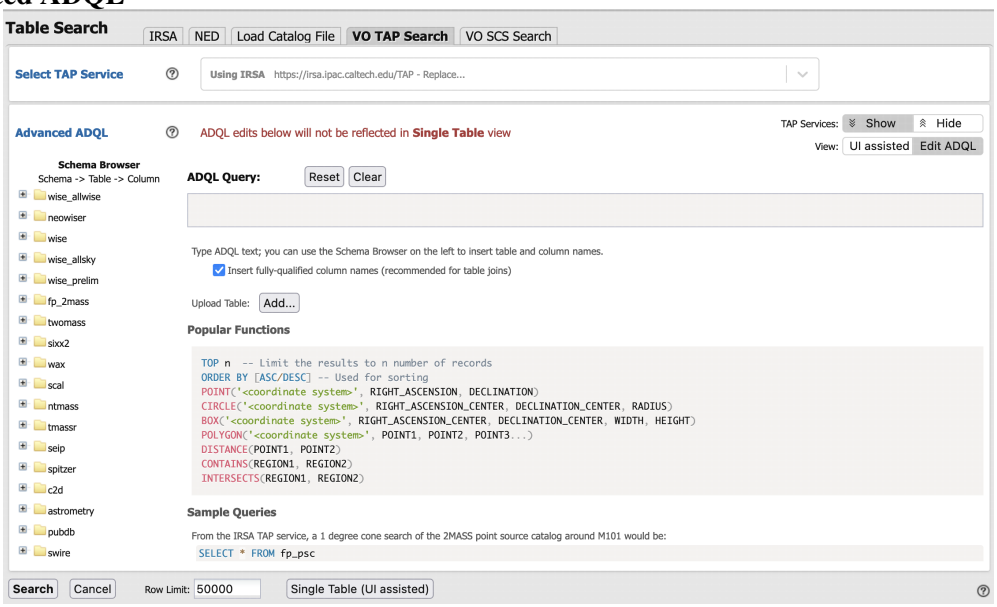
Once you choose a different TAP service, the tables available to select (further down on the page) change accordingly.

### Selecting a Query Type

The second option in the upper right is "UI-assisted" or "Edit ADQL". Especially when starting out, UI-assisted is easier. By using the UI assisted" option, you can select pre-defined options and have the interface construct the query in ADQL. Alternatively, if you are already fluent in ADQL, you can select the second option, "Edit ADQL", to construct even more complex queries.

After populating the search parameters using the UI, you can click the button on the bottom, "Populate and edit ADQL" -- this takes the parameters you have entered, creates the ADQL, and launches the "Edit ADQL (advanced)" interface.

### Advanced ADQL



You can get to this screen by selecting "Edit ADQL (advanced)" in step two, or by clicking on "Populate and edit ADQL" after filling out the UI.

You can select the schema from the left side of the screen. Each of the schemas can expand into viable tables and then columns within each table via clicking on the "+" to the left of the folder icon. Click on a column name to have it appear at the location of your cursor in the ADQL query box on the right. If you have the tickbox checked on the right that says "Insert fully-qualified column names", clicking on the column name inserts fully-qualified column names at your cursor location in the box.

You can type the ADQL directly into the box. If you configured a search on the "UI assisted" page, this box is already pre-filled with the ADQL version of your search, and you can proceed to edit it further.

Examples of useful functions and queries are given on the lower right of this window; you may need to scroll down.

**Tips and Troubleshooting**

- All the drop-downs near the top are searchable. This is very useful if you are trying to find a particular table or service that you can't quite recall. Click in the drop-down area, start typing a string, and it will try to find the matching values.
- Not every table available via this interface even has RA/Dec or, if it does, it may not be searchable via positions. If you have selected a table that doesn't have positions, it will not yield results if you try to search by position.
- There is a maximum number of returned rows at the bottom. If you are anticipating more than this number of rows, increase this number!
- If you arrive at the advanced ADQL page from the "Populate and edit ADQL" button, this is a one-way trip -- any changes you make to the ADQL here are NOT transmitted automatically back to the "UI Assisted" query page.

## VO TAP Searches: More information about constraints

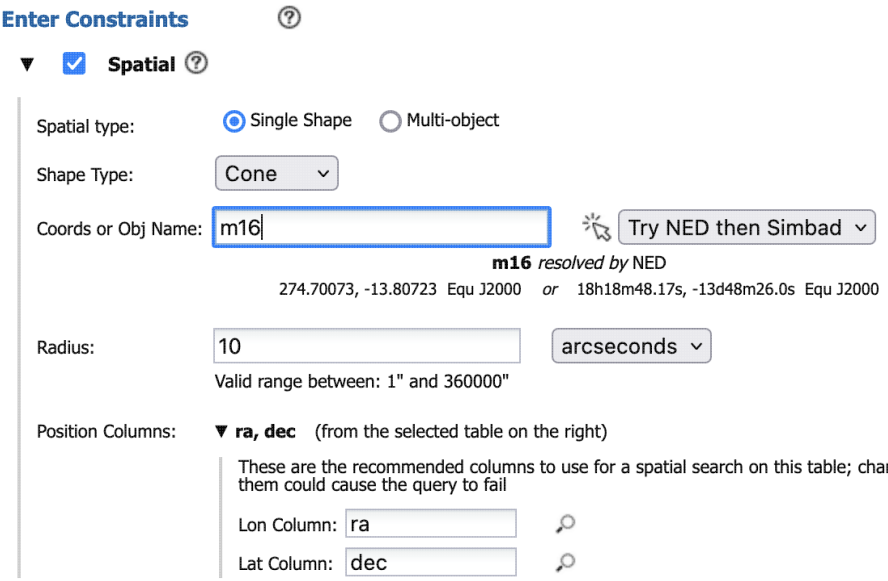
You can have several different ways of constraining your search depending on the options you have selected before the "Enter Constraints" section, and the options depend on what kind of service is available at the TAP service you have selected. If the options do not appear initially, click on the black triangle to "unfold" the options.

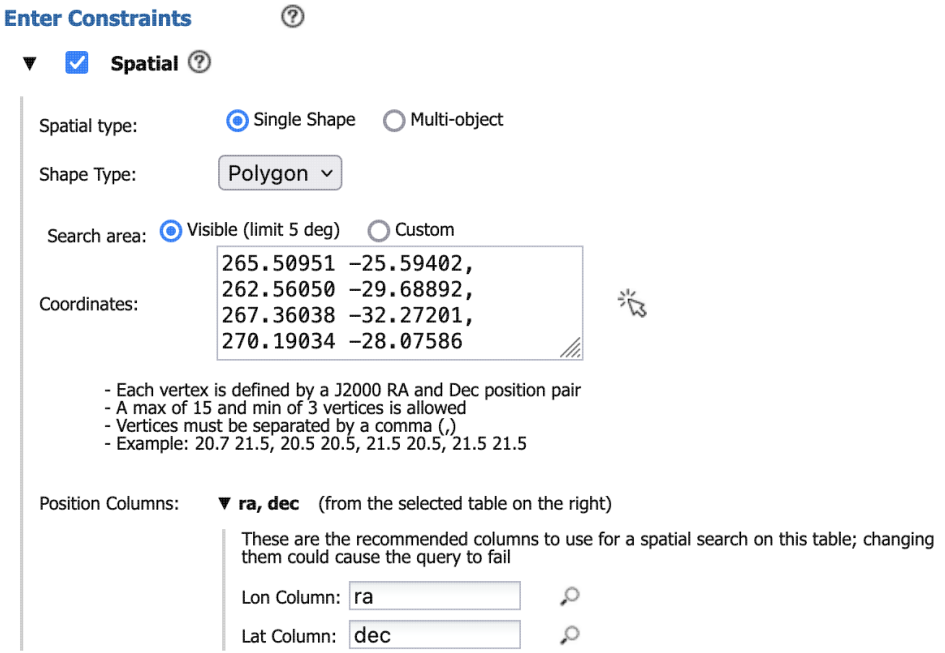
**Enter Constraints: Spatial**

This part of the interface allows you to specify the details of a spatial search. You need to specify both what kind of search you want to do and which columns of the catalog are to be used for coordinates.

This is what it looks like when you do a **single target cone search**; note that you have the same name resolution options as in a

simpler search.

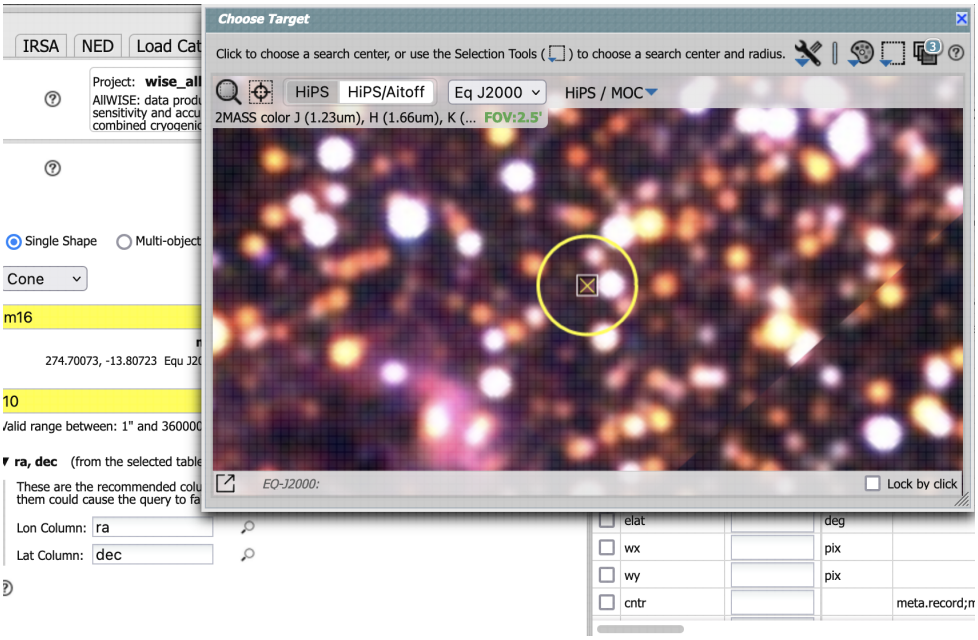


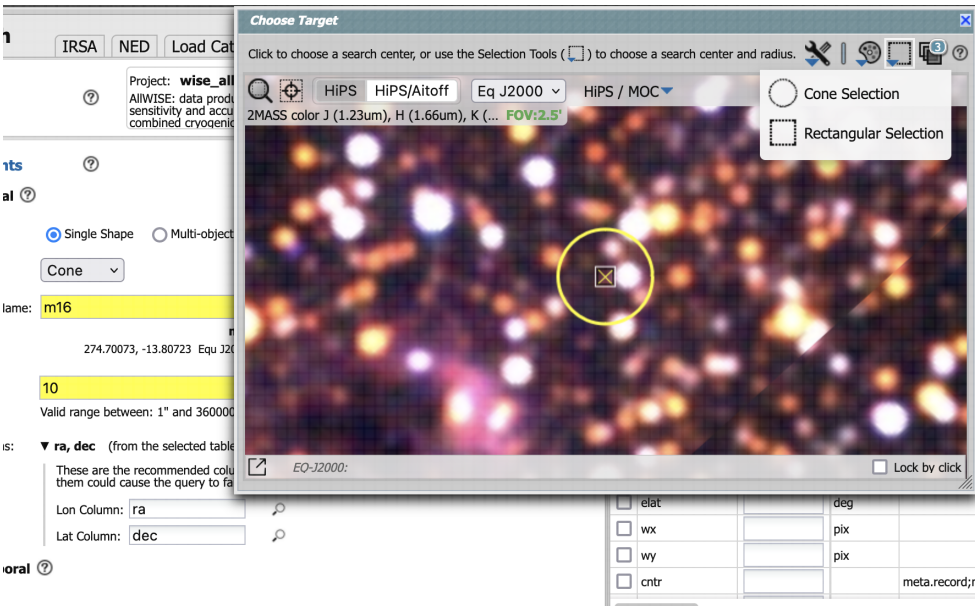

And, this is what it looks like when you do a **single target polygon search**.

For both of these spatial searches, you can **adjust the search via clicking on a HiPS map**. Click on this icon: to bring up a window:

If you have entered a target already, the window arrives already centered on the target. If not, it is centered on the galactic center, zoomed out. If you have entered a cone search radius



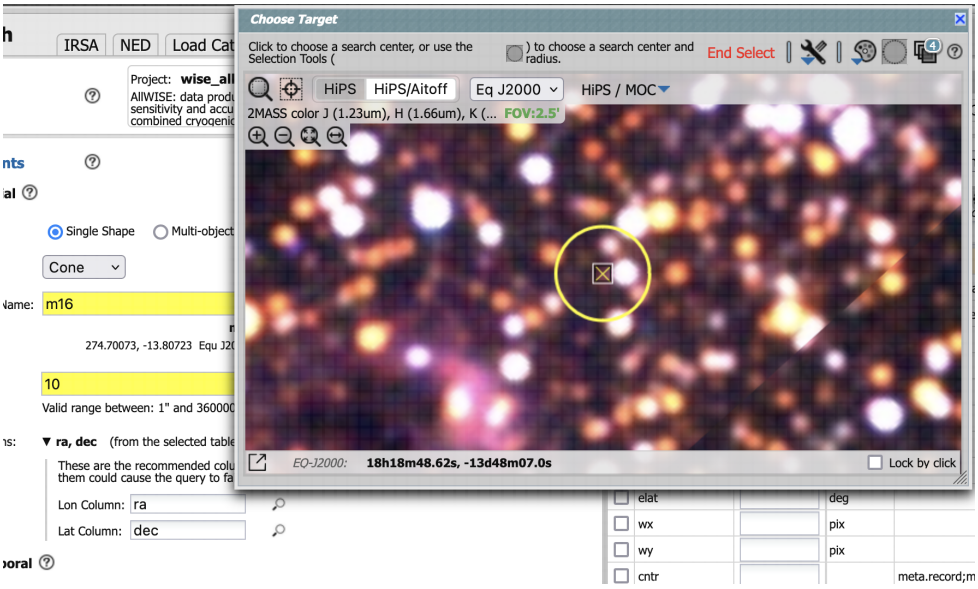

already, then the circle drawn on the image is that cone size. You can manipulate this image with the same basic tools as in the visualization tools.

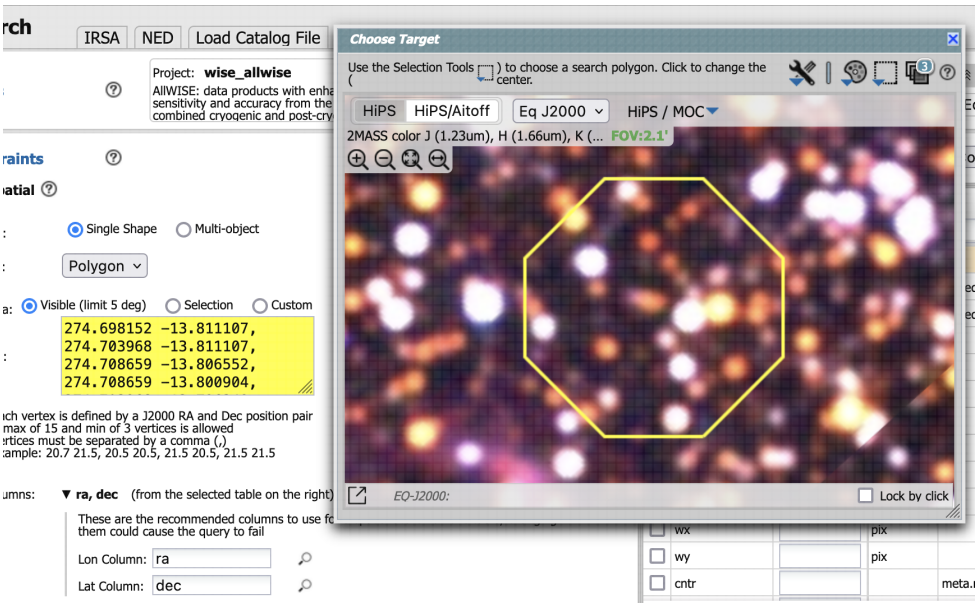



To change the search region interactively, choose the selection tools and draw a shape on the image.

**Note that** if you have selected a cone search on the left, no matter what you select on the right, it will give you a cone search. If you change the cone position or radius in the yellow boxes after you change the selection, it will update the region in the image.

If you want to quit out of the selection without changing, click on "end selection" (the red text near the top of the image).

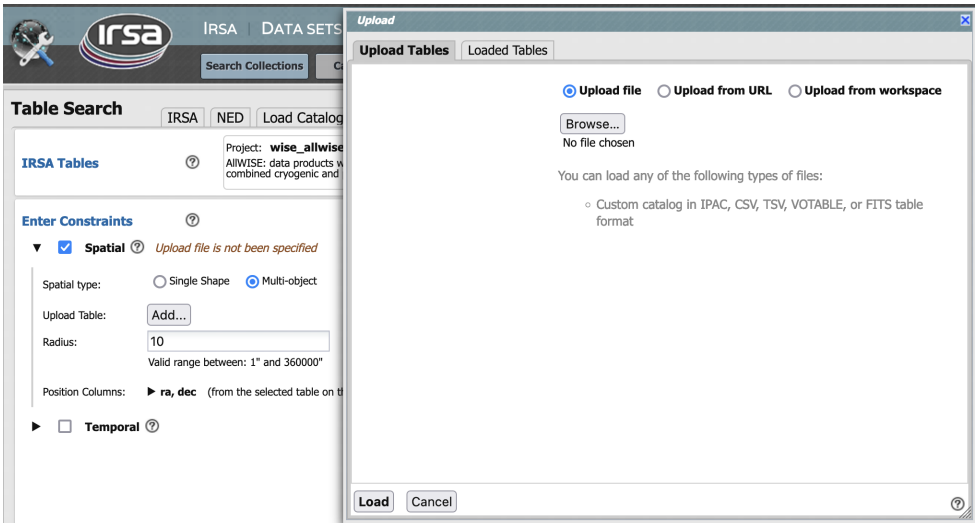


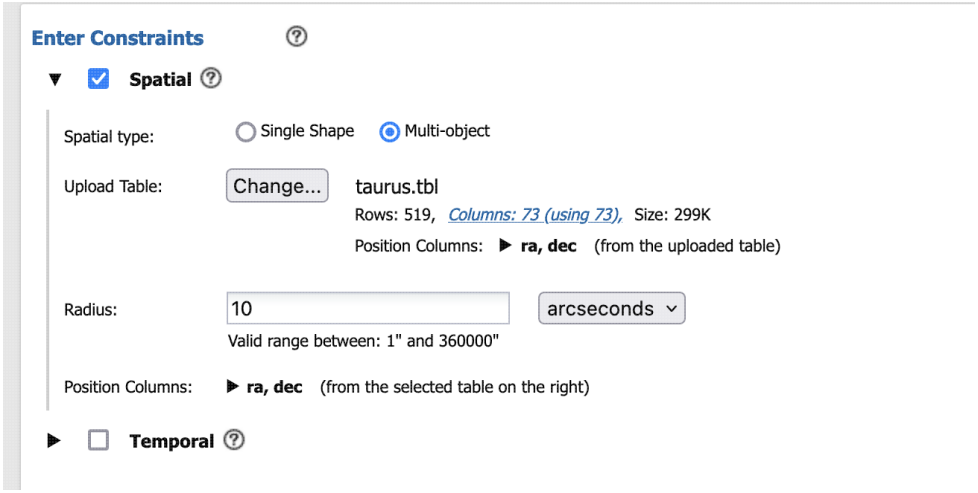

If you select polygon on the left, and you use the selection tool for "cone selection" on the right, you will get a spherical polygon (a polygon where the line segments are on a sphere).

When you are done with this pop-up window, click on the 'x' in the upper right of the window. Then you can continue to enter constraints, or just search from this point.

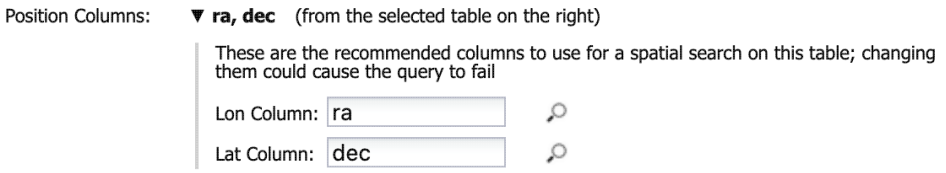
If you want to perform a **multi-target search**, click on "multi-object", which automatically brings up this pop-up, from which you can load a table from disk ("Upload tables" tab) or select one of the




tables you have already loaded into the tool (click on the "Loaded tables" tab). Your uploaded catalog has to follow all the same rules as normal catalogs from disk.




After you select a file and upload it, the tool attempts to guess which two columns are the position columns. In this example, it has (correctly) guessed that the position columns are "ra" and "dec". If it guesses wrong, or can't figure it out, you can help it along by clicking on the black triangle to 'expand' that part of the panel and help it by selecting the two coordinate columns to use.




Regardless of what configuration you use, the last thing to check is which columns the tool has assumed are the position columns in the catalog to be matched to your position, region, or list of positions.

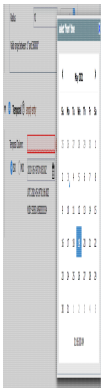
Again, it attempts to make an educated guess as to the right columns, but if it guesses wrong, you can help it along by clicking on the black triangle to 'expand' that part of the panel and help it by selecting the two coordinate columns to use.

**Enter Constraints: Temporal**

This part of the interface allows you to specify which column of the catalog is to be used for timing, and allows you to constrain the date in two different systems.

This is what the panel looks like initially, where you specify the column with the time and then the dates:

If you click on the calendar icon at the far right of the entry box, you get a pop-up from which you can specify the date, shown here.



Click on the time below the calendar pop-up to select a time of day, if necessary. Click on the date at the top of the pop-up to go back to the month view.

If you would like to work in MJD instead of ISO dates, select the "MJD" radio button. Note that it echoes below the box what it thinks you've entered in two different systems (UTC and MJD) to verify what

you have entered.

**Enter Constraints: Object ID**

This part of the interface allows you to match object IDs.

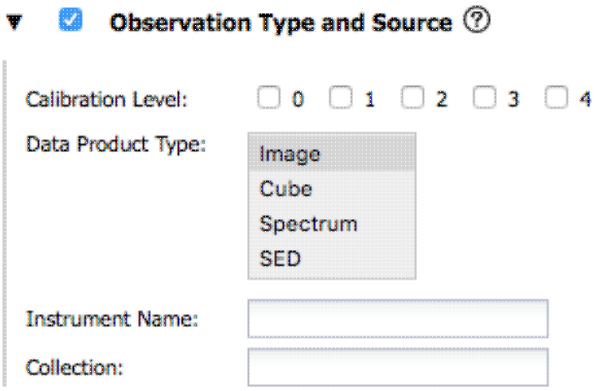
This is what the panel looks like initially:

This is what the panel looks like after you have selected your uploaded list of IDs (in this case, a file called "gaiaids.tbl", which consists of an IPAC table file that is just the list of Gaia IDs, in a column called "gaiaid"), and it is being matched against the Gaia DR3 main catalog, where the relevant catalog is "source_id".

**Tips and Troubleshooting**

◊ The names have to match exactly, so in the case of this example, since the Gaia column source_id is a long, the IPAC table file must also cast the Gaia ID as a long.
◊ If the catalog to which you are matching is not indexed by the name column you are using, the search may take a long time.
◊ If you are doing an object ID search, you need to turn off the position search, otherwise it doesn't understand what you want it to do.

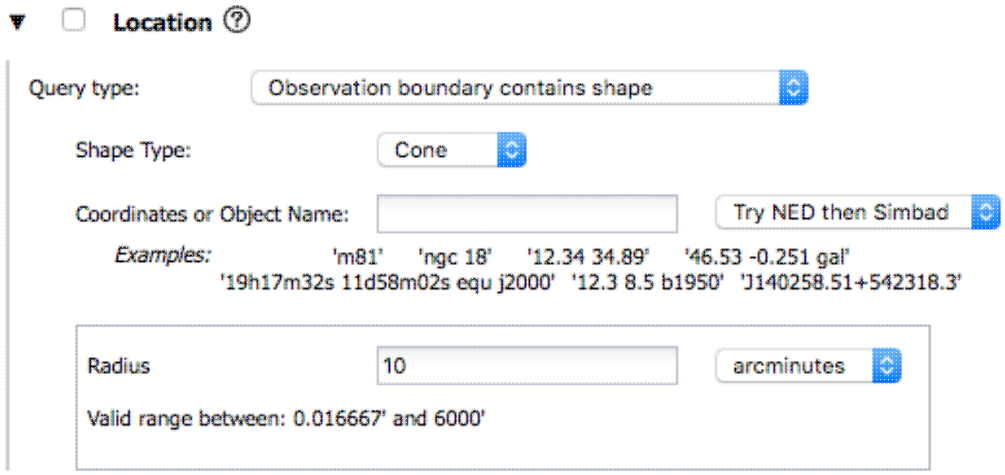
**Enter Constraints: Observation Type and Source** (You may or may not have these options.)




This panel provides a way to constrain the:

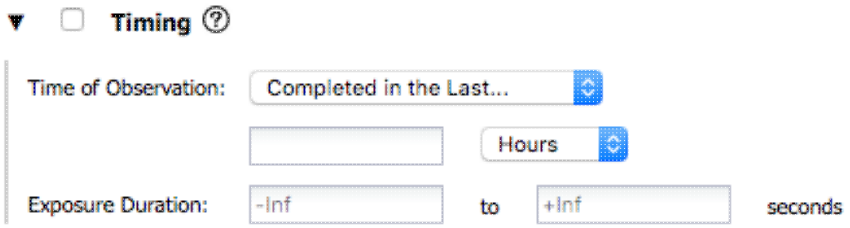
◊ Calibration level - 0 is the least processed and 4 is the most processed, and not all instruments provide all levels
◊ Data product type - image, cube, spectrum, SED, time series, visibility, event, measurement, or none specified. You can select more than one of these at a time by using a right mouse click.
◊ Instrument name - must match exactly, wild cards not accepted
◊ Collection - must match exactly, wild cards not accepted

**Enter Constraints: Location** (You may or may not have these options.)

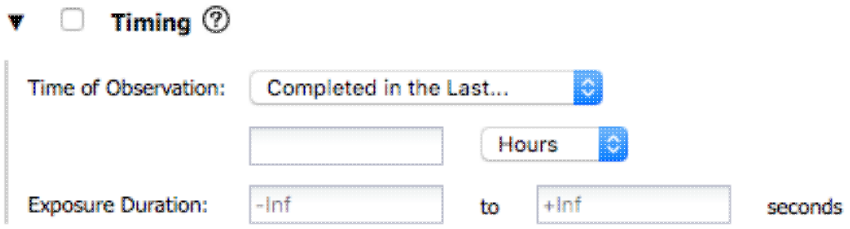



This panel provides a way to constrain the location of your search. You can specify via the drop-down the type of your query: "observation boundary contains point", "observation boundary contains shape" (default), "observation boundary is contained by shape", "observation boundary intersects shape", and "central point (s_ra, s_dec) is contained by shape." The latter refers to the columns "s_ra" and "s_dec" in the ObsTAP table.

**Enter Constraints: Timing** (You may or may not have these options.)

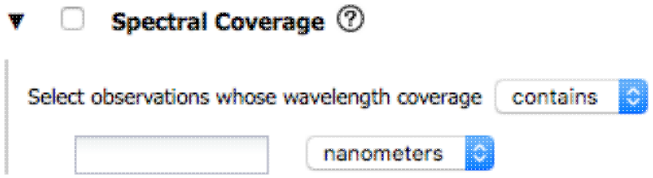



This panel provides a way to constrain the observation time of your search. This is the default option, where you want data completed in the last x hours.

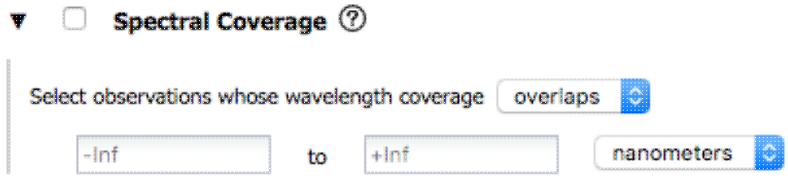



This is the alternate option, where you want data overlapping a specified date range, where you can specify UTC or MJD times.

**Enter Constraints: Spectral Coverage** (You may or may not have these options.)




This panel provides a way to constrain the spectral coverage of your search. This is the default option, where you want data containing a given wavelength.



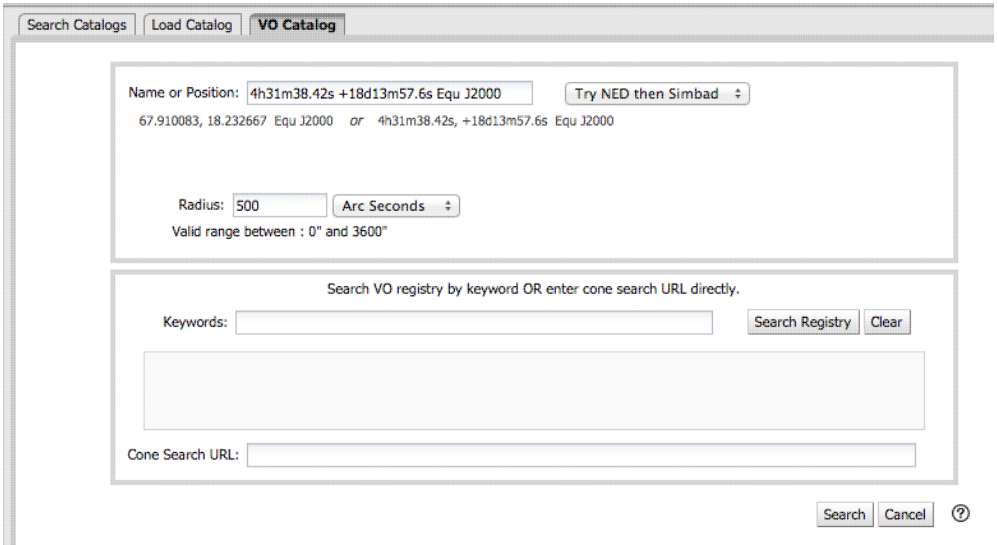

This is the alternate option, where you want data overlapping a specified wavelength range.

The search results are then shown and interacted with in the same way as the other catalogs described here.

## VO SCS Search -- Searching for catalogs via VO SCS services

(VO= Virtual Observatory ☑ and SCS = simple cone search.)

By clicking on the blue "Catalogs" tab, you are by default dropped into the interface for searching for catalogs at IRSA. However, you can pick another tab, "VO SCS Search", to search for and load catalogs from the VO simple cone search services.



As for the IRSA catalog search, the tool tries to pre-fill the target position with the coordinates of the target with which you have been working. In this case, you are limited to a cone search, so the next option is the cone search radius. As usual, pick your units from the drop-down first, and then enter a number; if you enter a number and then select from the drop-down, it will convert your number from the old units to the new units. There are both upper and lower limits to your search radius; it will tell you if you request something too big or too small.

If you know your VO URL already, you can jump down to the Cone Search URL box and type or paste your URL into the box and hit search.

More commonly, however, users do not know *a priori* which URL to use. Click on "Find Astronomical Data Resources" to be dropped into a VO search. Find the URL corresponding to the catalog you want, copy it, and go back and paste it in the URL box. The URL should not have the RA and Dec in it; the tool will add your RA and Dec as listed to the URL in the right syntax. Click on "Search" to initiate the search.

The search results are then shown (and interacted with) in the same way as the other catalogs described here.

**Example**

Load the tool. Search on IC1396. Go to the catalogs tab. Choose "VO Catalog." It wants the root URL for a cone search. Click on "Find Astronomical Data Resources", which goes here. Search on IPHAS. Get this page. Look for the complete catalog release (not just one associated with one specific study). The name of the catalog goes here. Hit the [+] to expand it. There is one URL listed there, under "available endpoints for the standard interface." Copy that URL and paste it into the search form. The IRSA tool will append your coordinates and radius and return you a table.

**Tips and Troubleshooting**

- Note that searching the VO means that you are using resources not specifically housed at IRSA, so servers may be down, or timeouts set, or limits on numbers of returned sources, etc., that are beyond our control. In most cases the solution is to specify as precise a search as possible. The URL you enter into the box in the search panel must be a Cone Search base URL (not containing RA and Dec parameters, which are inserted into the URL by the tool in response to the search parameters you give it).
- The master list of registries is here. You can also search the registries directly via that link (as opposed to via the IRSA tools).

The search results are then shown and interacted with in the same way as the other catalogs described here.

## Interacting with catalogs

When you load a catalog, the tools may create a table, a plot, and/or, if your catalog has position information (e.g., RA and dec), it overlays the catalog on an image. All three of these ways of displaying the catalog are interlinked and interactive.

Catalogs are a special case of tables; the basic functionality of tables is covered in the Tables section. You can sort and filter the table.

Plots are also covered in a different section. You can make scatter plots, heat maps, and histograms. You can plot columns from your catalog, including simple mathematical manipulations of catalog columns.

If the catalog has positions included, the catalog will also be overlaid on an image. The Visualization section includes information about that. Each catalog that you load is overlaid on the image using different, customizable symbols and colors.

**Tips and Troubleshooting**

- Note that if you overlay a large catalog on an image, the **full contents of the catalog may not be displayed in the overlay**. Catalog overlays on images are statistically "thinned" to avoid overcrowding the display. This occurs when the number of catalog entries in an overlay exceeds 10,000. Currently, this thinning is not reversed even when zooming in to the image. However, if you select a catalog entry from its table, or from a point in an associated chart, the corresponding point in the image display overlay will be displayed even if that entry was originally "thinned out." Also, geometric selections on an image (using the rectangle or circle tools) will still select all the catalog entries in the selection region, even ones that have been "thinned out", or "decimated."
- Because of the prior item, if you save the overlays from an image as a regions file. If you initiate that save from the image toobar, catalogs that have been "thinned out" will not appear in their entirety in the resulting regions file. However, you can save the full contents of a single catalog as a regions file using the "save" (diskette) icon in the table toolbar, instead of the image toobar.

## Details Tab

If you load the SEIP source list, or any of the other catalogs from IRSA, the "Details" tab on the right has additional information about the catalog. This additional tab is sometimes called a "property sheet." This tab is, itself, another Firefly table, and 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.) This information can be used to learn more about each of the columns in retrieved. For additional information, please consult the full documentation that accompanies the catalog.

# Spitzer Heritage Archive: Plots

Plots can be made from Tables, and, more commonly from Catalogs. Plotting is covered in this section. The Tables section discusses tables more generally, and the specific case of loading catalogs is in another section. If your table has RA and Dec in it, the Visualization section covers how the catalog can be overlaid on images. If your plot is a spectrum, the Spectra section also covers that.

*Contents of page/chapter:*
+Default Plot
+Plot Format: A First Look
+Plot Navigation
+Plot Linking
+Changing What is Plotted
+Plotting Manipulated Columns
+Restricting What is Plotted
+Overplotting
+Adding Plots
+Example Plots

## Default Plot

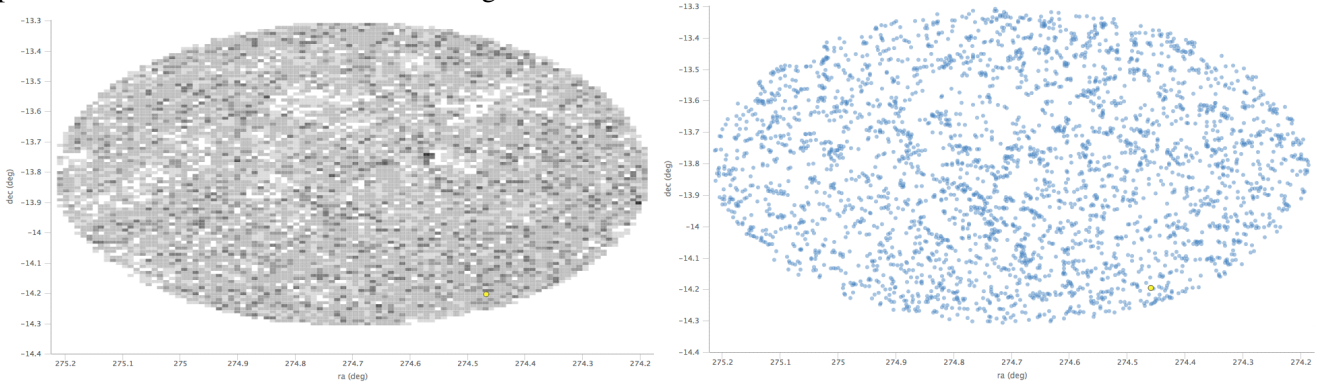
By default, after a catalog has loaded, a plot appears in the browser window.

To obtain a full-screen view of your 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, by default, starts with RA and Dec plotted if it can find RA and Dec in the catalog. Note that it does so following astronomical convention -- RA increases to the left. If the catalog does not have RA and Dec, it plots the first two numerical columns it finds.

## Plot format: a first look

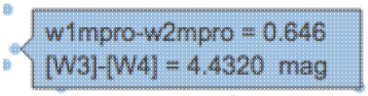
If you have loaded a catalog with many (> 15,000) points, you may have an RA/Dec plot that looks something like the one on the left here. If you have loaded a catalog with few (< 15,000) points, you will have an RA/Dec plot that looks more like the one on the right here.



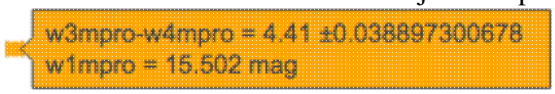
The difference between them is that, for larger catalogs (left), the plot is binned -- more points are encompassed in a black tile and fewer points are encompassed in a white tile. In the context of this tool, this is called a **heatmap**. For smaller catalogs (right), each individual point is shown as a blue dot. In the context of this tool, this is called a **scatter plot**.

In either case, letting your mouse hover over a point tells you the values of the point under your cursor, and (if binned) how many points are represented:

for binned plots, and



for just one point.



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.

You can change the bin size and shading. If you have a binned plot, you have a "binning options" arrow near the bottom of the plot options pop-up. You can choose whether the binning is set automatically (leave boxes blank), or by you (populate the boxes). You can also choose if the grey shading is set linearly or logarithmically. NOTE THAT you can't change the bin size in just one direction; if you enter a number for the "Number of x-bins" box, you must also enter a number for the "Number of y-bins" box.

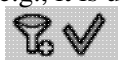
The reason the tool makes a heatmap for large catalogs is to more fairly represent the point density -- and to make the plotting faster. In these cases, though, it will not give you the option to overplot errors (see below). If you have a heatmap and want a scatter plot, you need to filter or otherwise restrict the catalog to have fewer points (see below).

## Plot Navigation

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

*Zoom in plot*
When you click on this icon, it becomes "active", e.g., it is underlined in red. Then, when you click and drag in the plot, the plot is zoomed to the region you have selected. You can also zoom using your scroll feature on your mouse. To return to the original view, click on .

*Pan across plot*
When you click on this icon, it becomes "active", e.g., it is underlined in red. Then, 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 within plot*
When you click on this icon, it becomes "active", e.g., it is underlined in red. Then, when you click and drag in the plot, you are given additional options :  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.

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

*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).

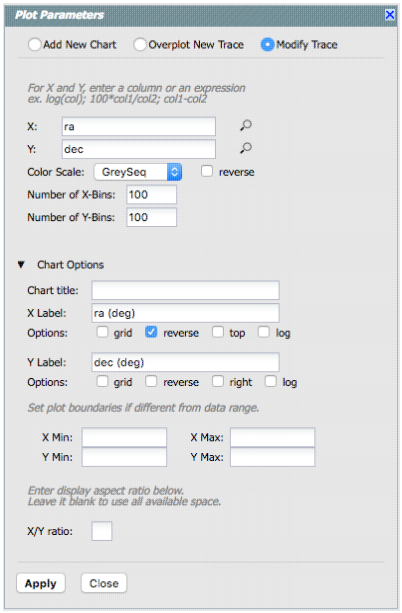
*Expand plot*
Click on this icon to make the plot take up the whole browser window. To return to the prior view, click the "Close" arrow in the upper left.

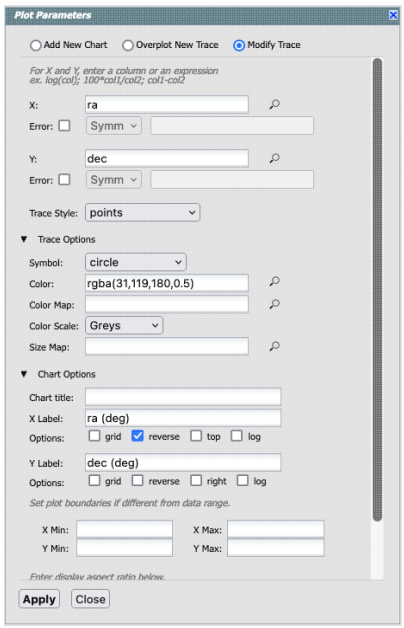
## Plot Linking: Plots are linked to catalog and image(s)

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. For scatter plots, if you click on any of the points, the object(s) corresponding to that point will be highlighted in the overlays in the images shown, and highlighted in the catalog table. This works the other way too - click on a row in the catalog, or an object in the images, and the object will be highlighted in the plot or the catalog or the image.

## 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 depending on whether the points are binned or not:




The left has the options for binned plots, and the right has the options for plots that have individual points shown.

This section describes how to change what is plotted, e.g., the "Modify Trace" option at the top of both of these pop-ups. Both overplotting and adding plots are covered in more detail below.

**Both kinds of plots have the following options.**

In either case, 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.

In both of the examples above, RA is plotted on the x-axis. It has pulled the column name for the label; in this table, the column is "ra" rather than "RA". It has copied over the units ("deg") from the catalog, and plotted the x-axis increasing to the left as per astronomical convention. You can change what column is plotted, and whether or not errors are shown. 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.)

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.

Click "Apply" to apply, and "Close" to return to the plot without making changes.

**Options found only in binned plots**

(Plots are binned if there are > 15,000 points in the catalog.) From the pop-up, you can control the color table that is used (greyscale is the default; there are many other choices in the drop-down menu), as well as the number of bins in the x and y directions. If you change the number of bins but then want to go back to the original default values, leave the "Number of bins" boxes blank.

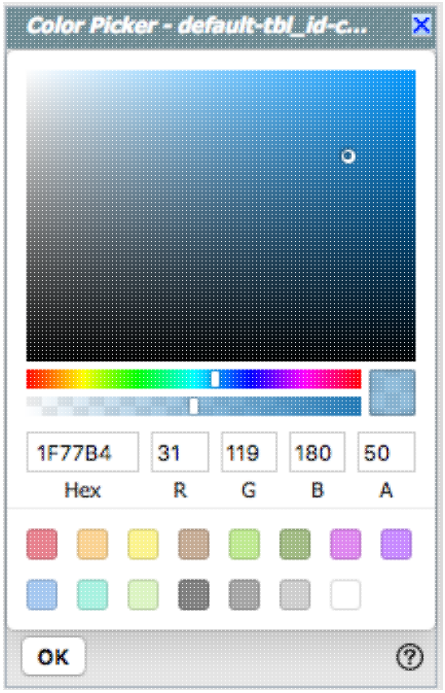
**Options found only in plots showing individual points**

You can specify an error (either a column in the catalog, or calculated from a column in the catalog). Those errors can be symmetric or asymmetric (toggle the errors on by selecting the tickbox, then select from the drop-down menu).

Right below where you specify the columns for the x and y axis, 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 above (31, 119, 180, 0.5) where the last number is a unit of fraction of 1, so 50% in this example. Click on the magnifying glass to bring up a color picker window:



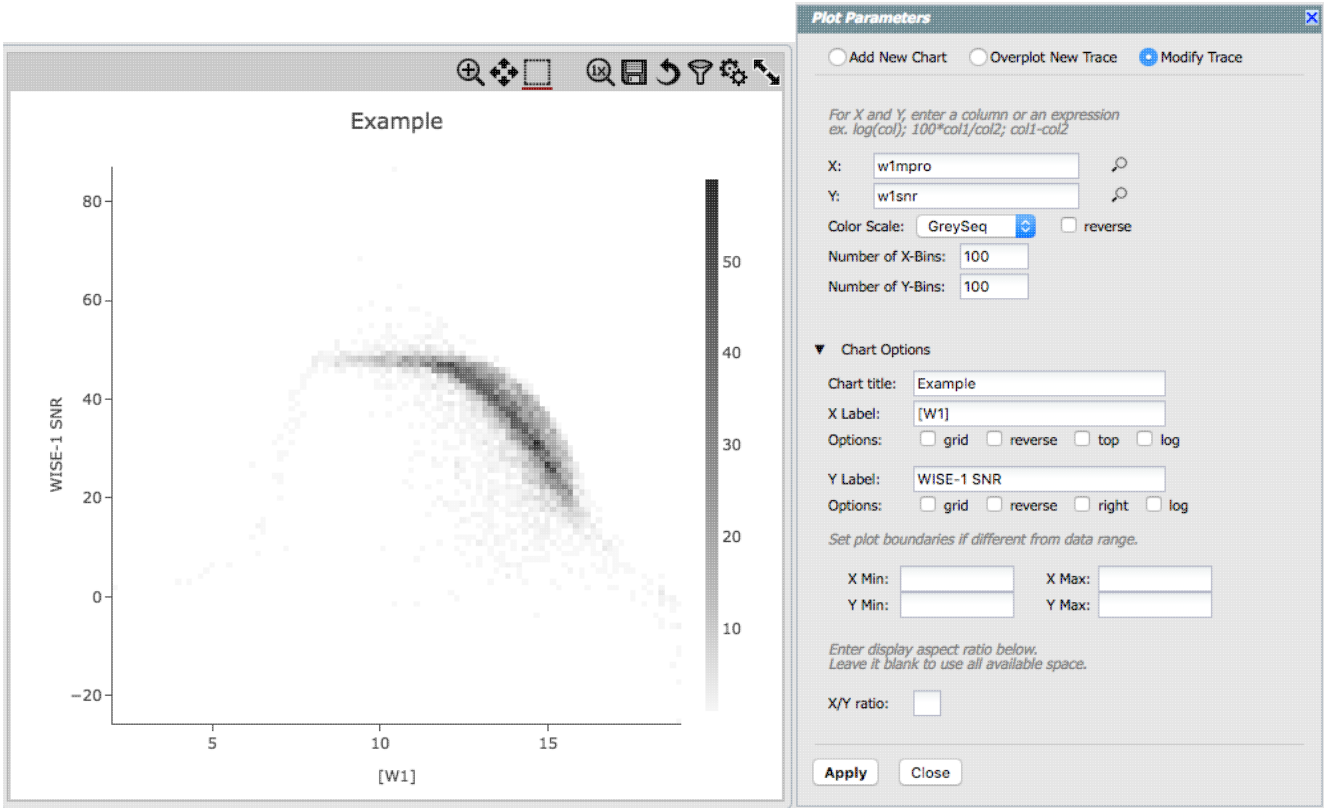

From here, you can click on your desired color in the top colorful box. Immediately below that box, you can change the color and saturation of the top box so that you can select from a different range of colors. Below that, you can enter numerical Hex codes or RGBA values (where the value for RGB is 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 the small box. Note ha 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.

**Tip:** 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.

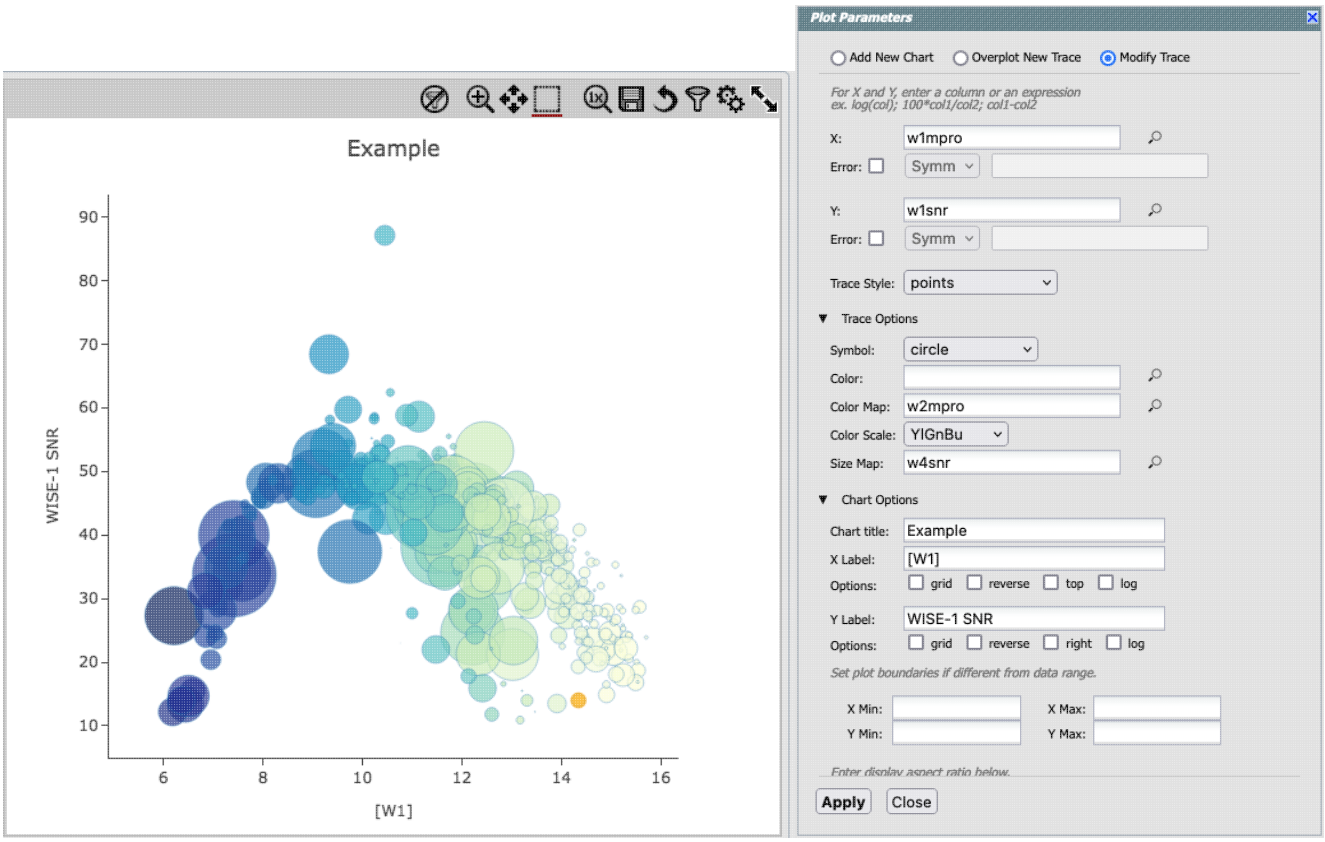
◊ Choose the **color map**. By default, all of the points are the same color, but darker where there are more points. You can change this such that the color scale of the points is tied to a column value, such as w1snr (WISE-1 signal-to-noise ratio) in a WISE catalog. If you select this option, you can also change the color scale to any of 18 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.

Example: Load a large WISE catalog. Plot w1snr (WISE-1 signal-to-noise ratio) vs. w1mpro (WISE-1 profile fitted magnitude). It defaults to a heatmap. Change the labels by clicking on the triangles below each entry box, and make the y-axis label "WISE-1 SNR" rather than the more cryptic column header "w1snr". Change the x-axis label to "[W1]." Depending on your catalog, you may need to adjust the y axis range. Obtain this plot:



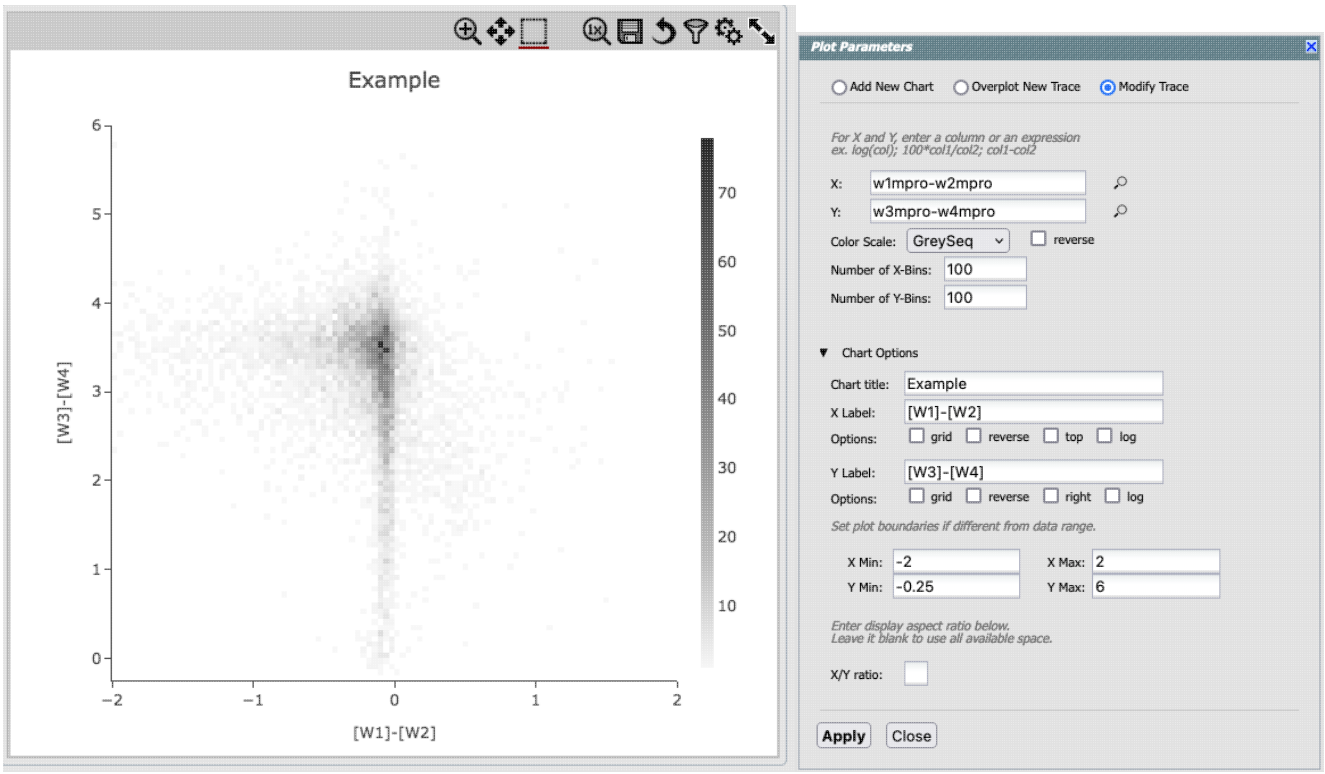

Example: Load either a smaller WISE catalog, or the same large WISE catalog, but filter it down such that w1snr, w2snr, and w3snr are all greater than 10, which limits the number of points to be <15,000. Plot w1snr vs. w1mpro. It shows the points individually Change the labels. Change the point color map to scale with w2mpro (WISE-2 profile fitted magnitude). Change the point size map to scale with w4snr (WISE-4 signal-to-noise). Obtain this plot:



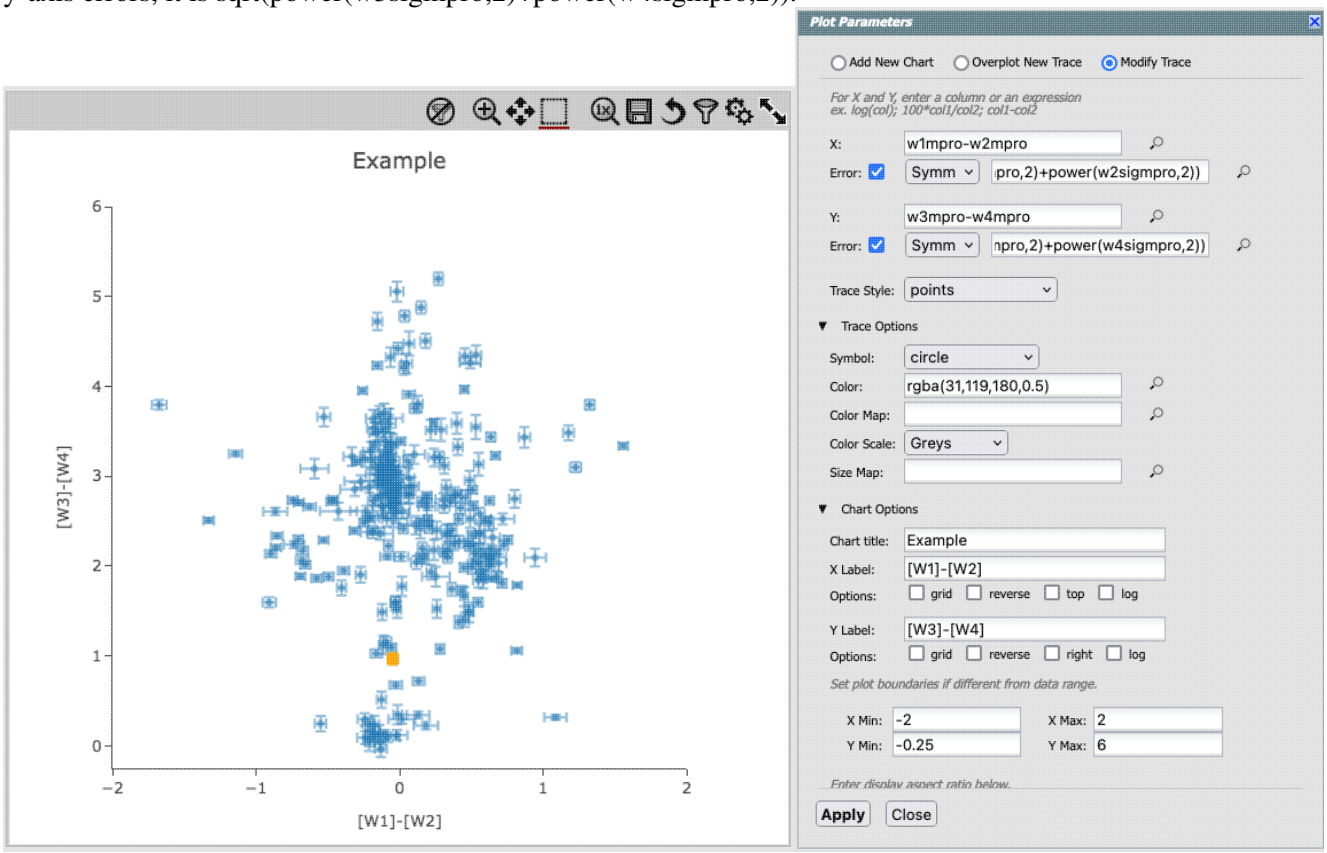

## Plotting Manipulated Columns

You can choose a single column to plot against another column, as above. However, you can also do simple mathematical manipulations.

For example, if you have loaded a WISE catalog, you can plot [W1]-[W2] vs. [W3]-[W4]. In terms of the names of the columns in the database, this is w1mpro-w2mpro vs. w3mpro-w4mpro.




If you have few enough points that the plot is not binned, you can add errors, and you can also manipulate those. Here, the expression for the x-axis errors is sqrt(power(w1sigmpro,2)+power(w2sigmpro,2)) and for the y-axis errors, it is sqrt(power(w3sigmpro,2)+power(w4sigmpro,2)).



## Restricting What is Plotted (from the plot)

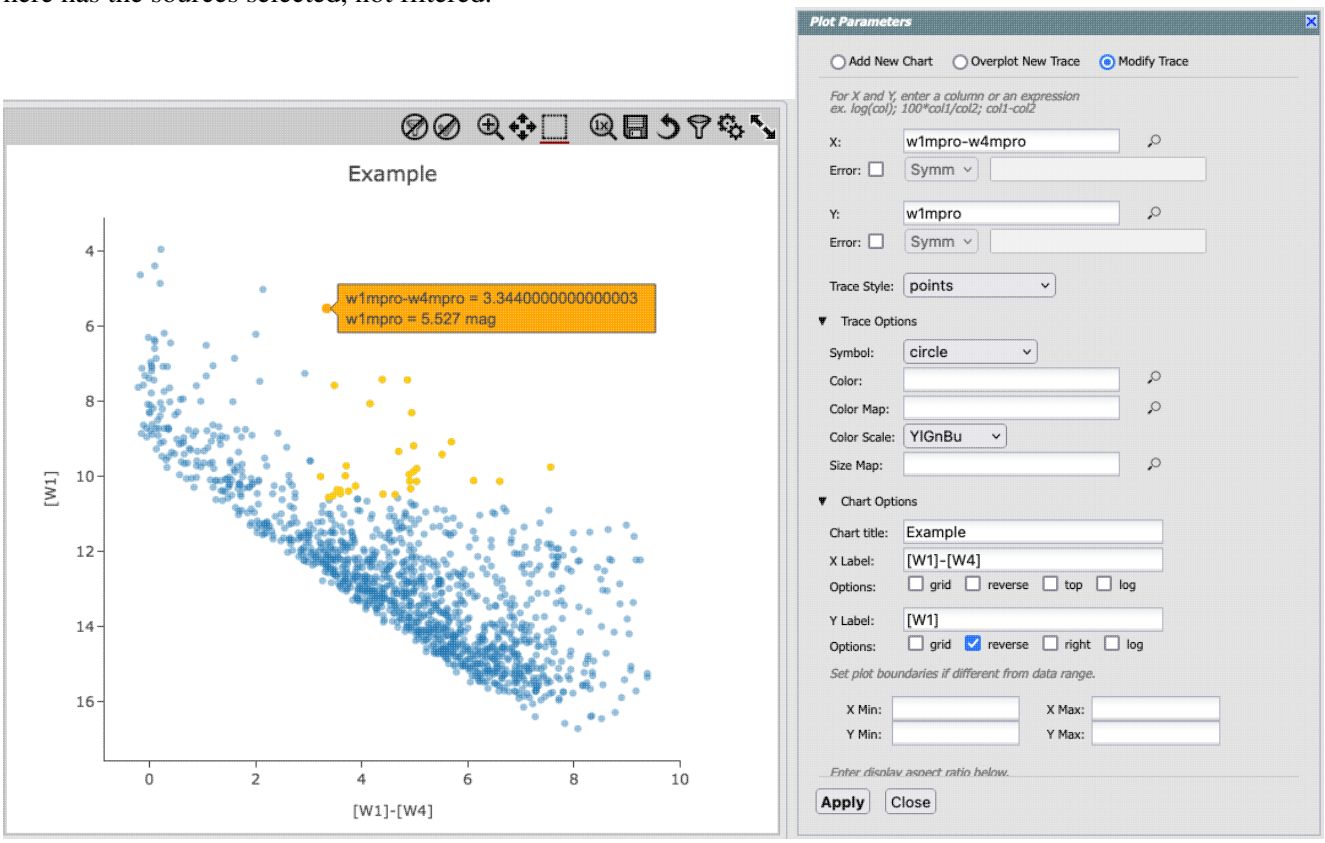
You can also restrict what data are plotted in any of several different ways.

You can filter the catalog from 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.

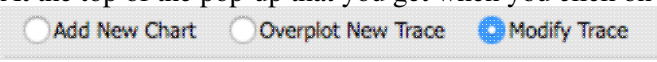
Example: Obtain a WISE catalog of a star-forming region, say IC1396. Filter down the catalog to only have WISE-1 and WISE-4 detections (limits have undefined errors, so ask the catalog to filter down such that w1sigmpro>0, w2sigmpro>0, w3sigmpro>0, and w4sigmpro>0). Plot w1mpro-w4mpro on the x-axis, and w1mpro on the y-axis. Reverse the y-axis to put bright objects at the top. Click and drag in the plot to select the bright and red objects, and filter them down to get a subset of bright and red sources. For clarity, the screenshot here has the sources selected, not filtered.




## Overplotting

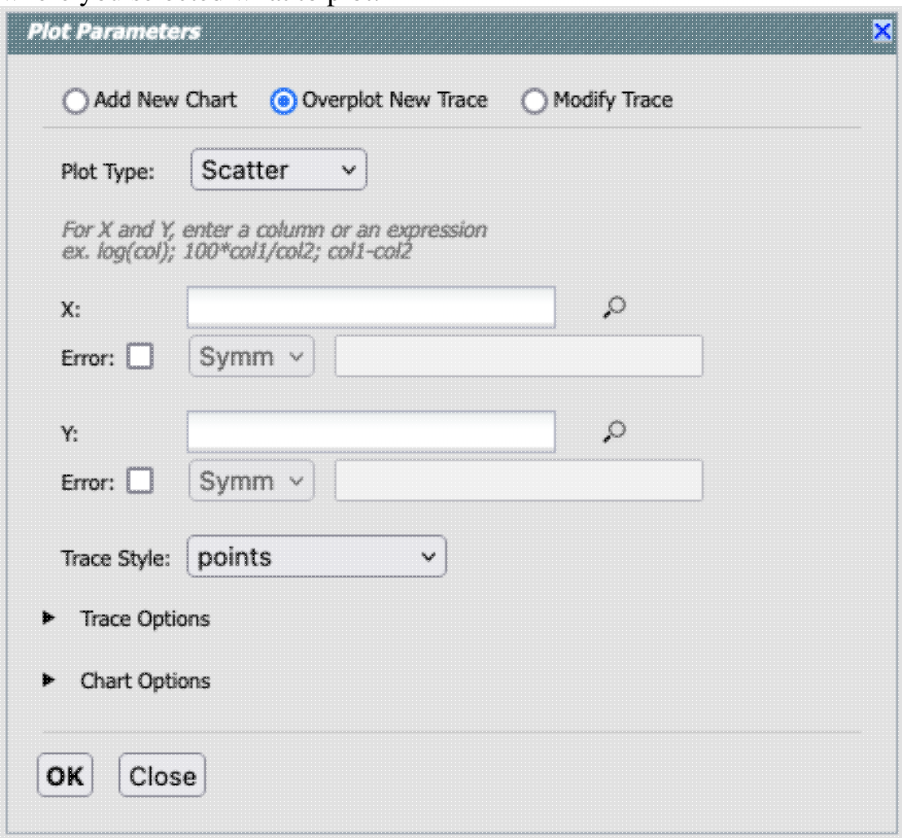
*(As of this writing, this is an "alpha" release of this capability, and the plan is to continue development.)*

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




They are "Add New Chart" (see next section), "Overplot New Trace" (this section), and "Modify Trace" (see above sections). 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 :

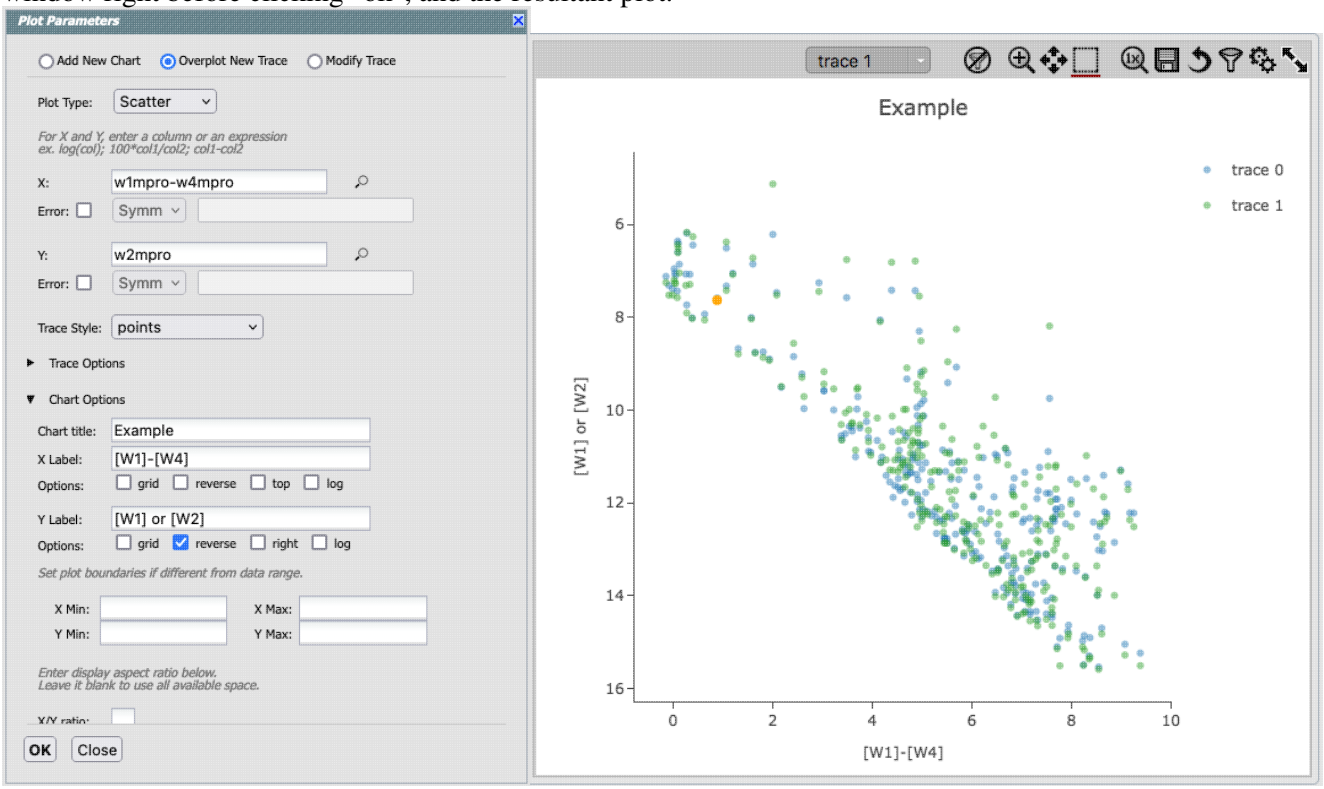
- select a plot type (scatter, heatmap, histogram);
- tell it what column(s) you want for x, y, and associated errors;
- select the trace style (points, connected points, lines);
- set any trace options;
- set any chart options.

Right now, the overplotting can only work 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.

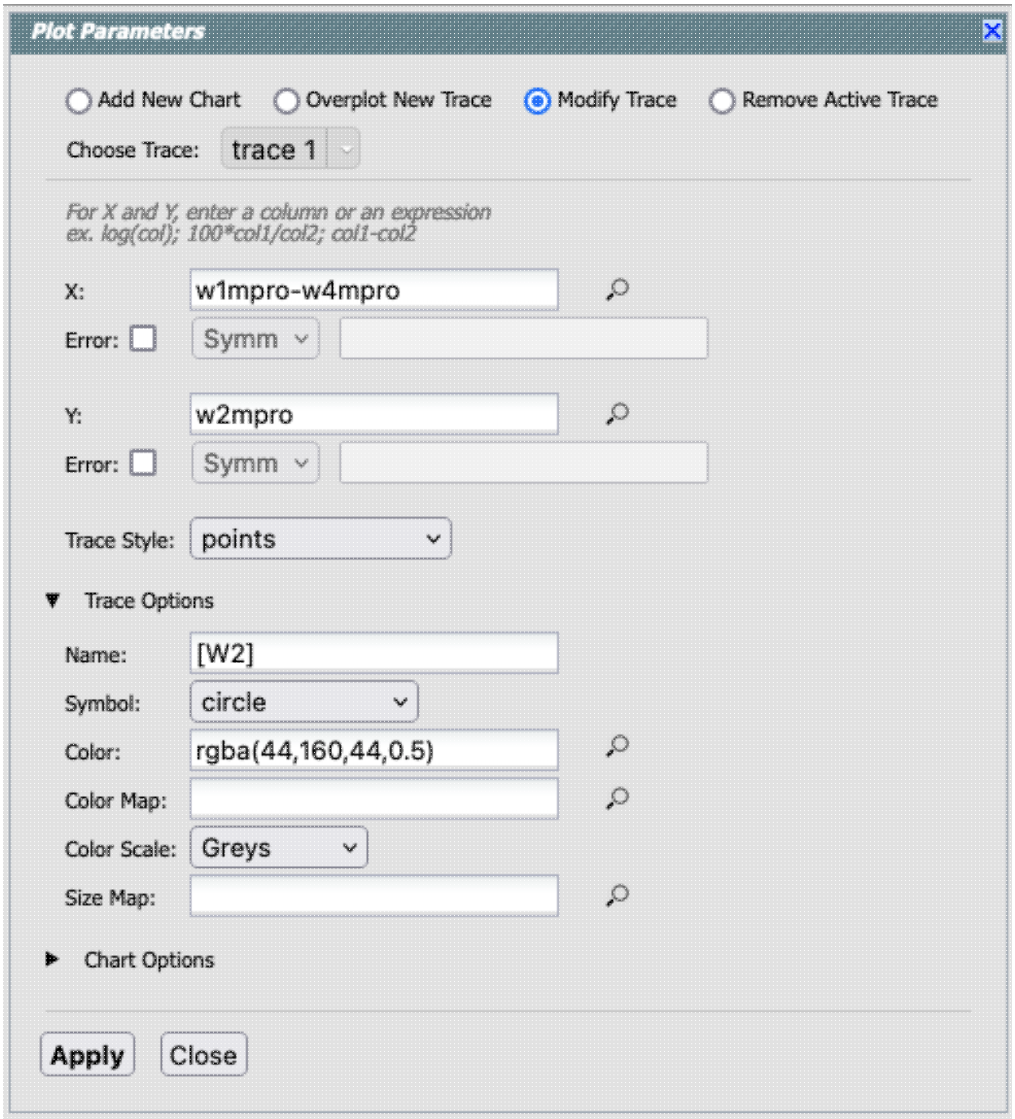
You can easily get yourself into a physically nonsensical situation, say, by overplotting a histogram onto a scatter plot. If you find yourself in a hopeless mess, click on the "undo" icon to reset everything and try again.

The best way to explain how to use this feature is probably via an example. We have a plot of [W1] vs. [W1-W4] from above. Now add on top of it a plot of [W2] vs. [W1-W4]. Click on the gears to bring up the pop-up. Select "Overplot New Trace." Enter "w1mpro-w4mpro" for x and "w2mpro" for y. Expand "Chart

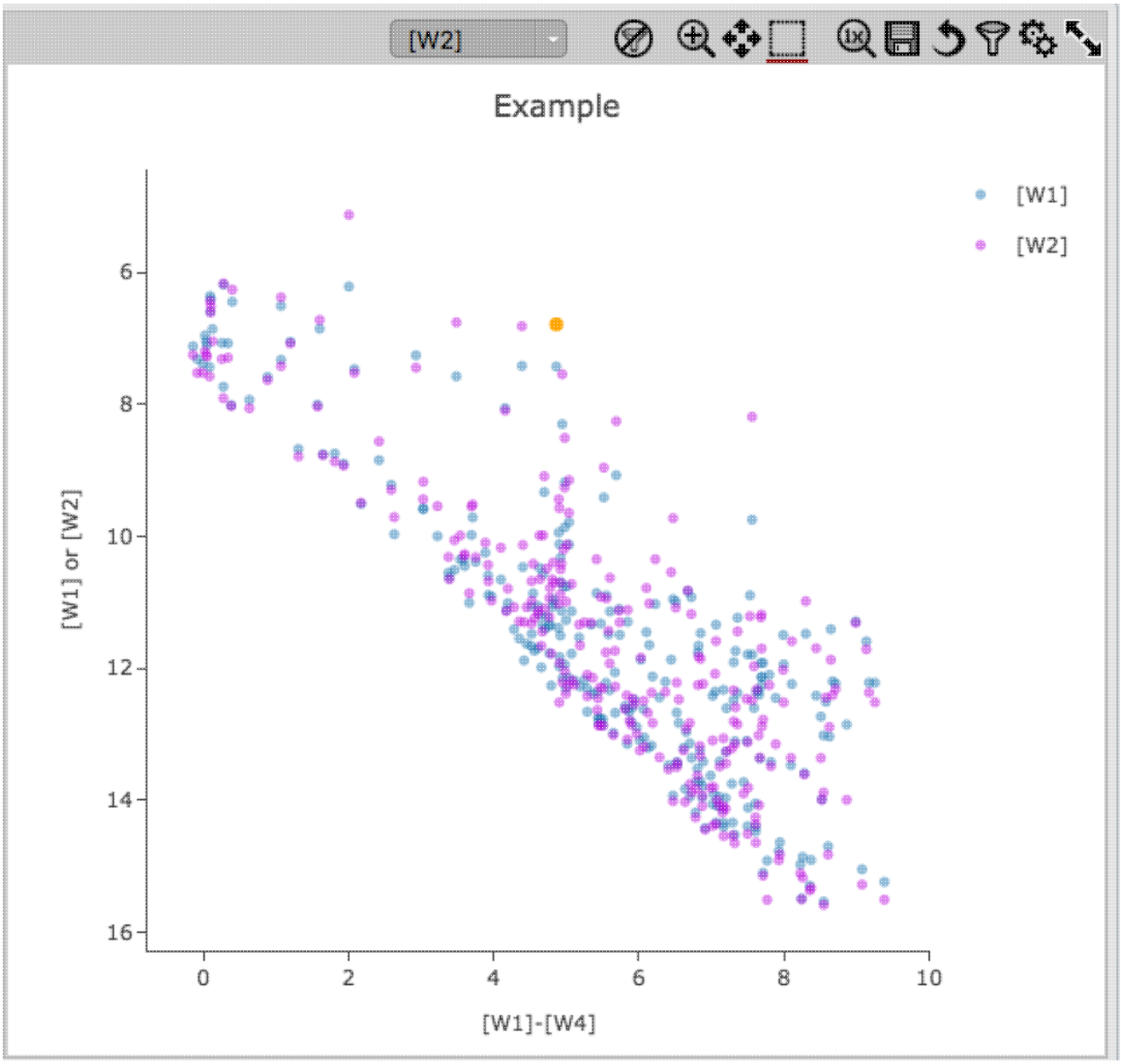
Options." Note that it has preserved the overall chart title from before, but has erased the X and Y labels (and lost the reversal of the y axis) because the overplot could literally be anything, and need not be the same columns or even the same units as what is already plotted. Type them in again. This is the configuration window right before clicking "ok", and the resultant plot.



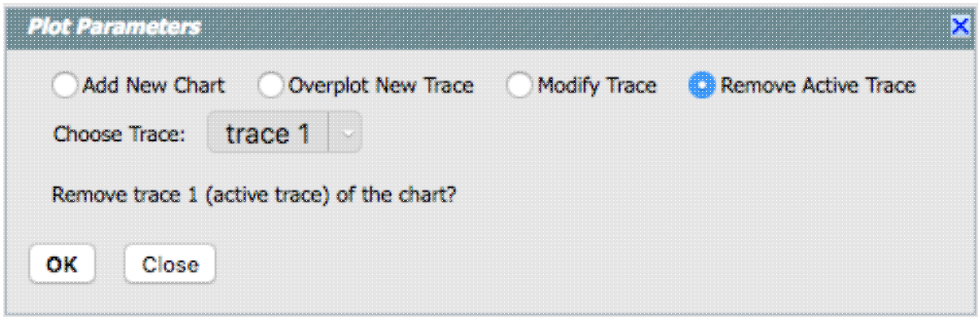

Note that there is now a drop-down at the top of the plot -- from here, you select which is the "active" trace, i.e., which one is in the top layer and therefore affected by changes you make. There is a legend on the plot specifying which color corresponds to which trace. In this example, the plot has appeared using a blue and green color scheme, which may be too hard to differentiate. To change the second plot points' color, click on the gears, ensure "Modify Trace" is selected, select "trace 1" (as opposed to "trace 0", the first one you loaded), go down and expand the "Trace Options" and pick a different color. You can also change the legend name from "Trace 1" to, in this case, "W2." Click "apply" to apply the changes to the plot:




Note that once you change the trace name, the relevant drop-down menus and legends update accordingly:

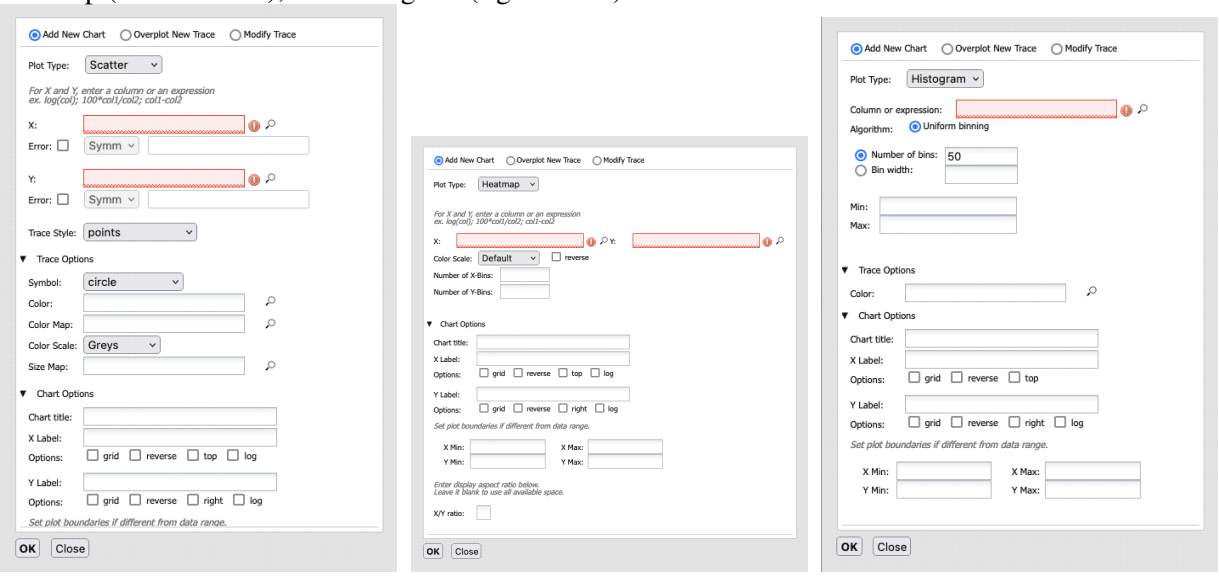



Note that the pop-up spawned by clicking the gears now has additional options at the top: "Add New Chart", "Overplot New Trace", "Modify Trace", and "Remove Active Trace." From here, you can modify a trace you have already plotted (as described above), overplot another trace (also as described above),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



## Adding Plots

If you want to make additional plots, after you have a catalog loaded, click on the blue tab at the top labeled "Charts." This brings up a dialog from which you can choose to make another scatter plot (left below), a heatmap (center below), or a histogram (right below):




The options for these plots here are the same as they are when you click on the gears in one of these plots. You can change what is plotted after plotting once by clicking on the gears.

Using this "charts" tab, you can have as many plots up at the same time as you need. Note that many plots of a large catalog may make your browser run slowly; it will refuse to make a scatter plot for catalogs with >15,000 points.

**Scatter plots** allow you to choose points, connected points, or lines; you can add errors to each point. There is a maximum of 15,000 points for scatter plots.

**Heatmap plots** are binned scatter plots; you can choose what color scale and how many bins to use.

**Histogram plots** allow you to choose how many bins or the bin width.

All of them allow you to reverse axes and change labels. You can plot single columns or mathematical manipulations of columns.

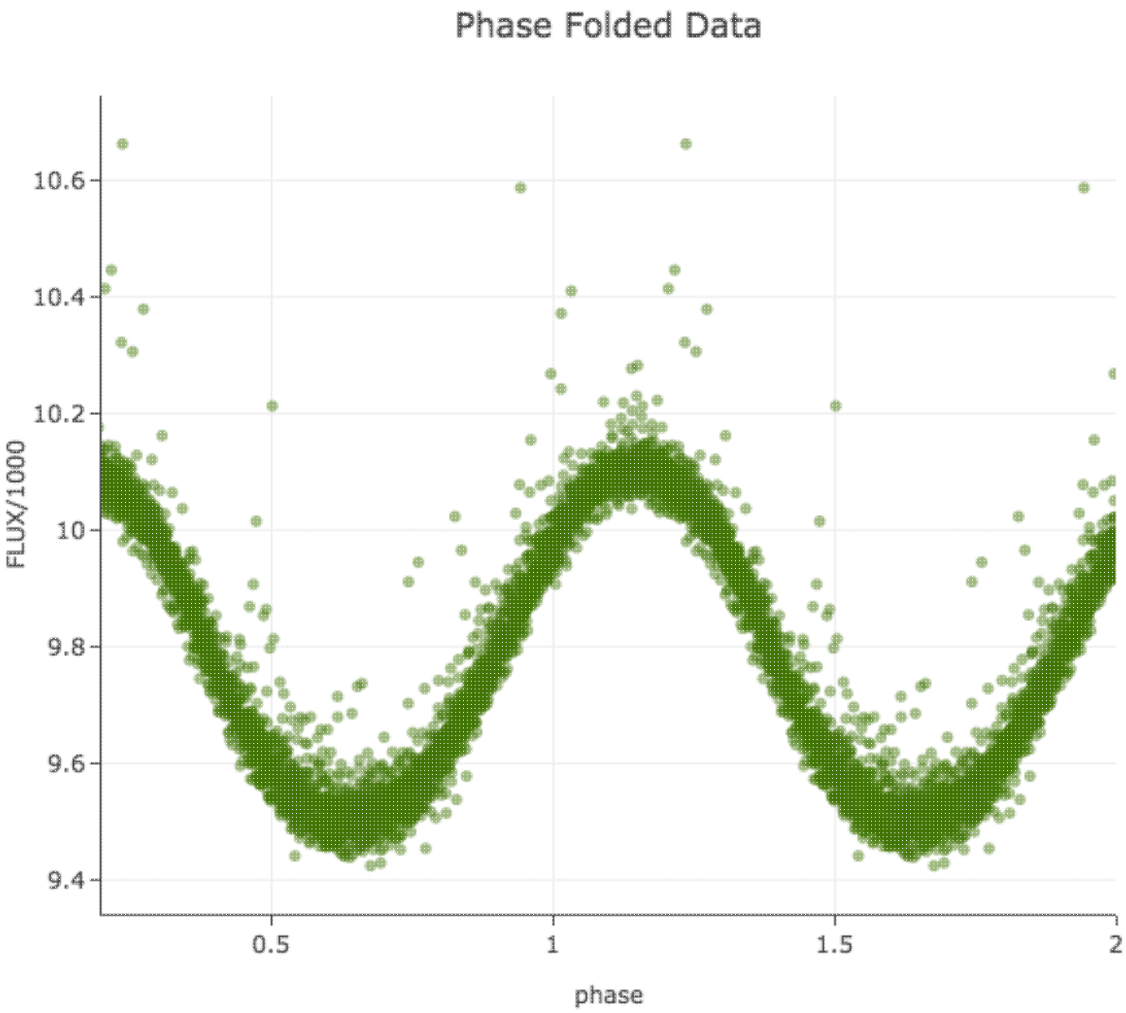
Note that, if you provide a minimum number, the binning starts at the minimum value you provide, and may exceed the maximum you entered in order to fit in a whole bin.

You can view these plots all at once or one at a time by clicking on the corresponding icons above the plots (just as when you have multiple images loaded): . If you are viewing one at a time and have more than one plot loaded, you can scroll between them by clicking on the arrows (just as when you have multiple images loaded).

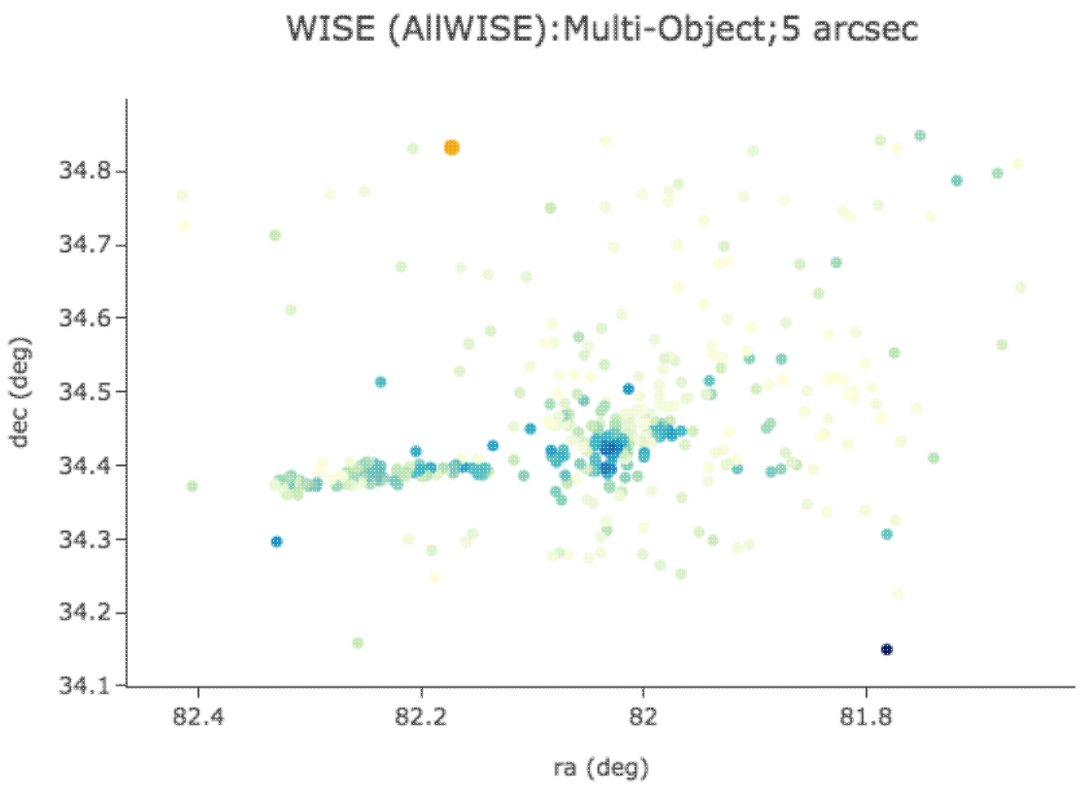
## Examples of catalog plots

Here are several examples of plots made with IRSA tools.

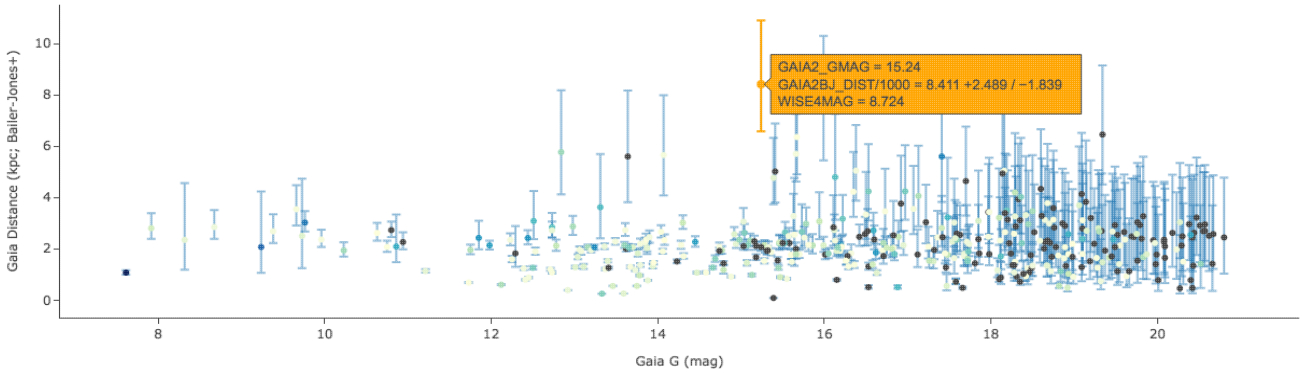
Phase-folded light curve from K2 data:



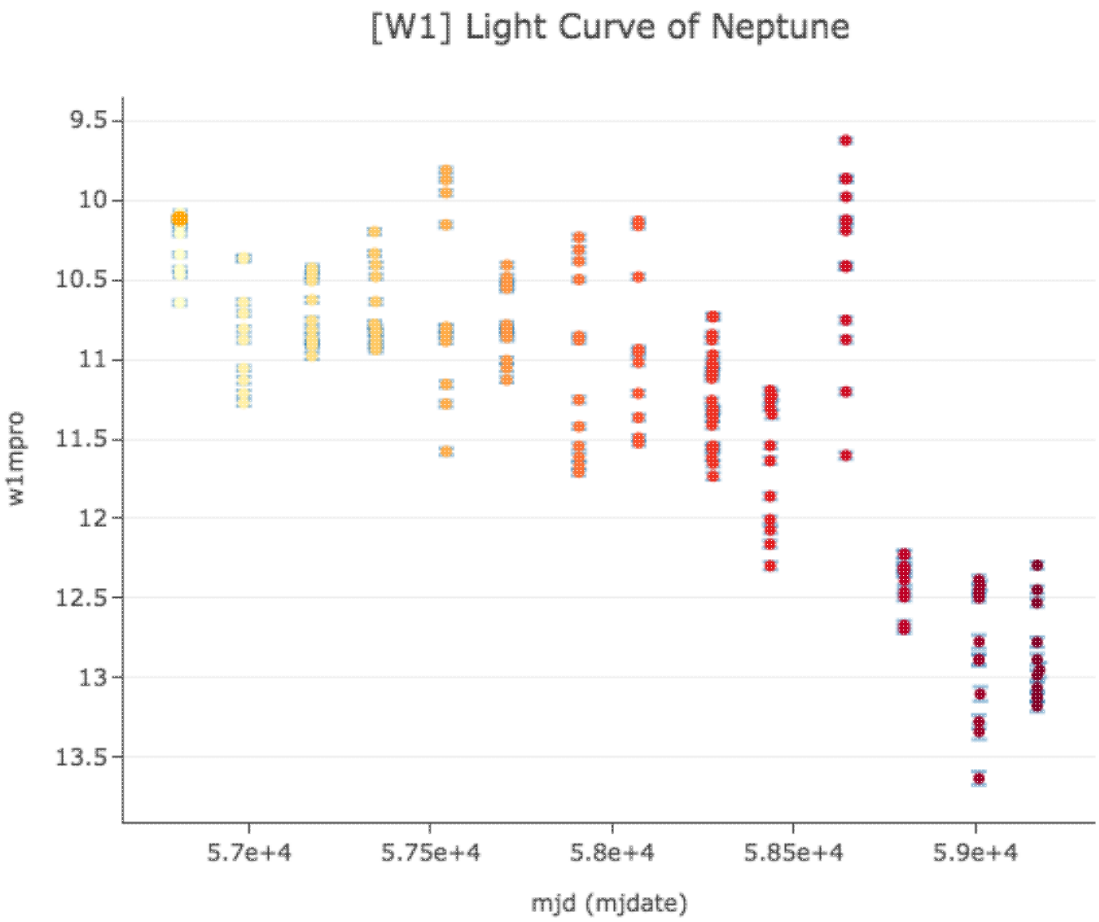

Plot on the sky of stars where the color of the point is scaled to brightness in WISE-4:



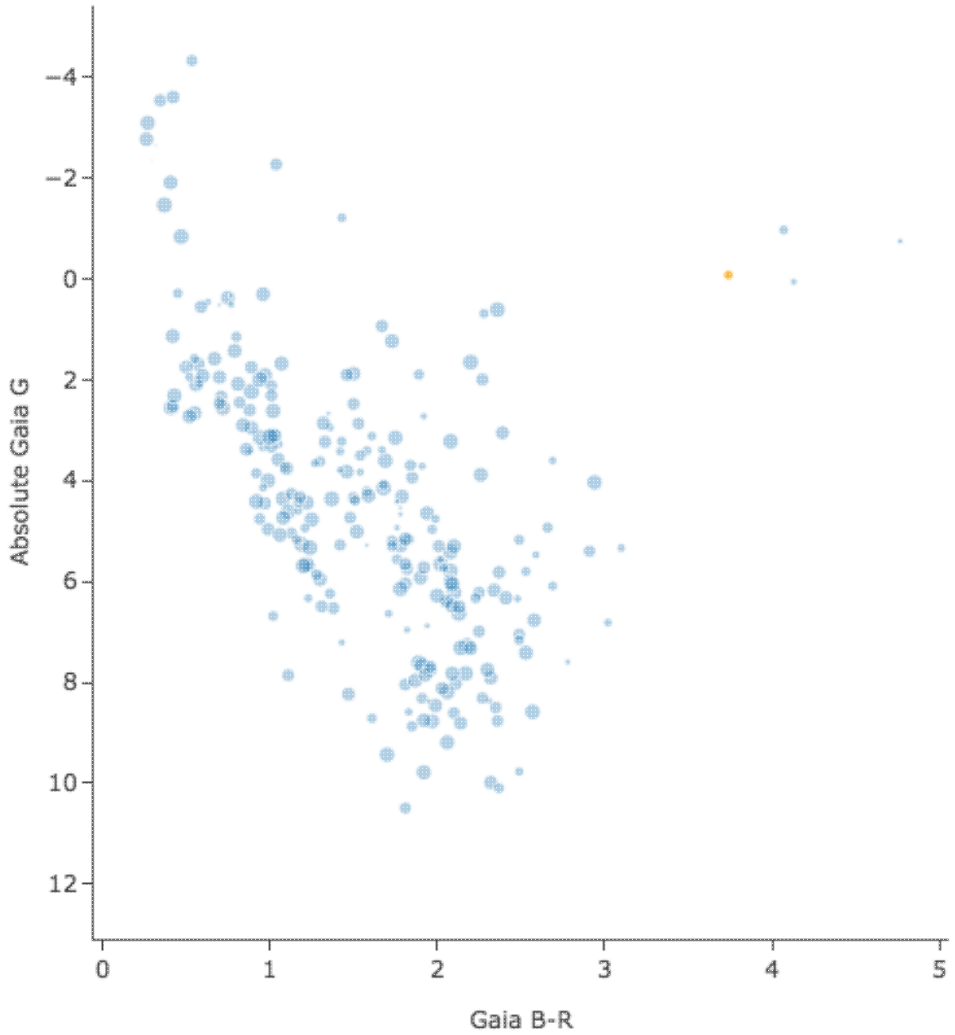

Gaia distance (in kpc, from Bailer-Jones et al. 2018), with asymmetric errors, as a function of Gaia G magnitude, with colors of the point scaled to brightness in WISE-4:




[W1] light curve of Neptune over several years, with colors of the point scaled to heliocentric distance:




Absolute Gaia color-magnitude diagram of candidate members of a star-forming region (note some background giants still in the list), where point size is scaled by WISE-4 brightness:


Absolute Gaia G
−4
−2
0
2
4
6
8
10
12
0
1
2
3
4
5
Gaia B-R

# Spitzer Heritage Archive: Spectra

Visualization of spectra within the Spitzer Heritage Archive use capabilities of Tables, (image) Visualization, and Plots. Generic help on those capabilities can be found in those other sections; since spectra are a special case of plots, this section focuses on spectra specifically found in the Spitzer Heritage Archive.

*Contents of page/chapter:*
+Introduction
+Images
+Data Tables and Plots

## Introduction

Some of the spectral files in the Spitzer Heritage Archive show the spectrum as an image, and for some you are given a choice to view it as as a table or a plot.

To visualize spectra, you must be on the search results page, with an Level 2 (PBCD) or Level 1 (BCD) or IRS Enhanced Product instrument tab in the foreground on the left (not any of the other ones) and have the "Data Preview" tab in the foreground on the right. (And, of course, your search must have returned spectra.)

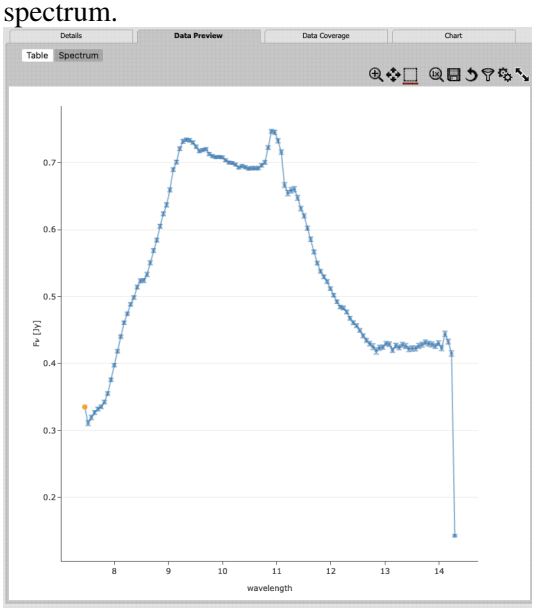
## Images

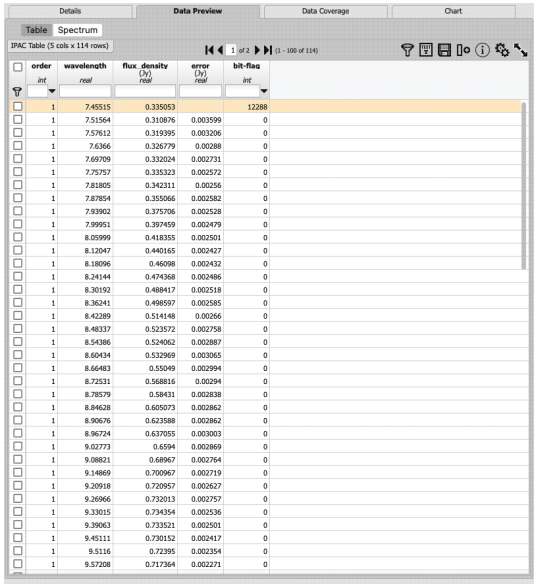
If the data are stored as FITS file images, it will show the image to you, as in this Level 2 IRS LL data product:

Each of these images can be interacted with as described in the (image) Visualization section. However, zooming has a somewhat different physical meaning in this sort of image than it does for, say, an IRAC image.

## Data Tables and Plots

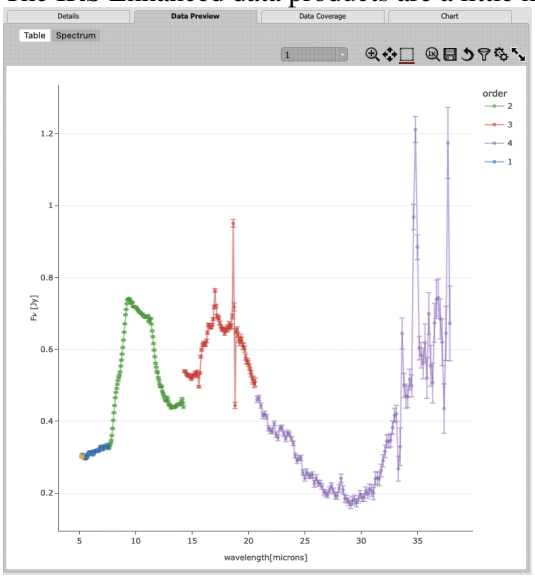
Some data products can be viewed as plots or as tables, as in the case of this IRS Level 2 background-subtracted spectrum.

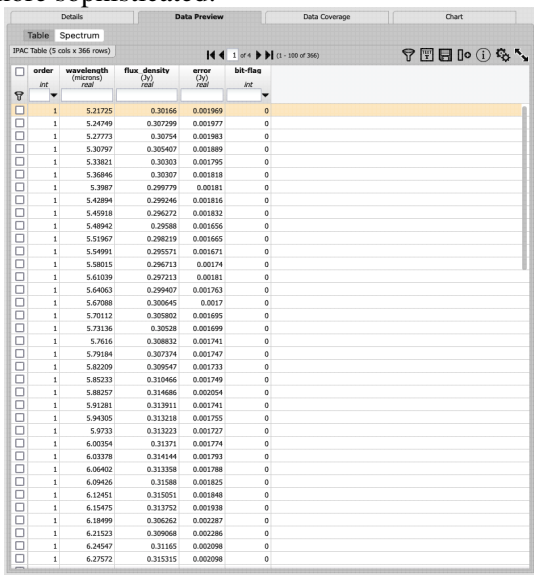



You can toggle between plot and table using the buttons on the top left. Note that the plot is only as smart as the information given to it by the data file -- there are no units provided in the data table for the wavelength, so there are no units provided on the plot. It did add error bars though.

The IRS Enhanced data products are a little more sophisticated:




The tool is smart enough to understand that there are multiple spectral orders in the file and plots them in the same plot, with different colors, and this time it gets the units right. (It has included error bars here too.) These tables can be interacted with as described in the Tables section, and the plots can be interacted with as described in the Plots section.

# Spitzer Heritage Archive: Data Downloads

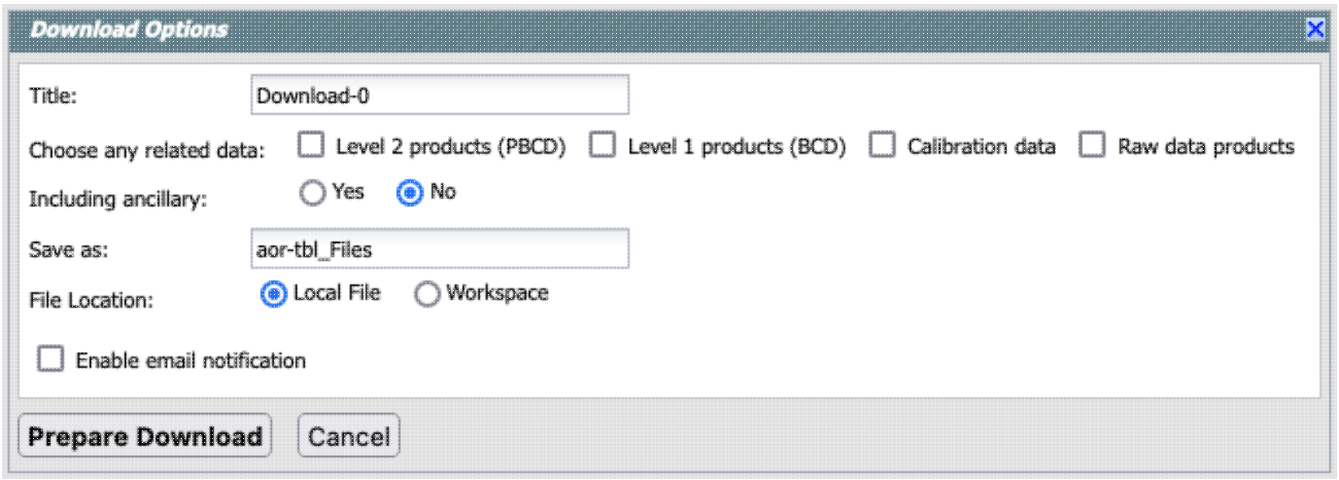
*Contents of page/chapter:*
+Overview
+Deciding what files to download
+The Background Monitor
+Help! I have a lot of zipfiles!
+Help! These things are unzipping into separate directories!
+Acknowledging Spitzer and the SHA

## Overview

After searching and investigating your results, you have presumably decided which data to download, and the next step is actually downloading.

On the search results page, click the checkboxes on the left of each row to select specific data files to download (click the checkbox at the top of the column of checkboxes to 'select all'), and then click "Prepare Download" (near the top left of the image results window pane,

) to begin the packaging and downloading process. A pop-up window will appear.




The first row is the name by which this packaging job will be known to the background monitor - change it to whatever you want (time or a description of your search is usually the most helpful).

The second row is an indicator of what kinds of data you want -- the Level 2 (PBCD) data products, the Level 1 (BCD) data products, the calibration data associated with this observation, and/or the raw data products. The Level 2 data are often science-ready, but depending on your science goals, you may need different data products; consult the Spitzer documentation.

The third row controls whether additional ancillary (frequently calibration- or pipeline-related) files are included. Again, consult the Spitzer documentation for more information.

The next row controls the filename for the packaged download file -- by default it has a string constructed based on the tab from which you initiated the download (in this case, the AOR tab).

The "File Location" row controls whether the file is saved to your local disk or the IRSA Workspace.

The last row toggles whether or not the background monitor sends you email when it is done.

When you click "Prepare Download", then the packaging process spins off into the background monitor, which keeps track of its progress and notifies you in the browser when the downloads are complete. You can choose (even after you have sent the job) to have an email sent to you to let you know when things are ready.

**Tips and Troubleshooting**:

- Select one row at a time by clicking the tickboxes on the far left of each row. Select all of them at once by selecting the tickbox at the top of that column of tickboxes.
- If you initiate the packaging process and decide later that it is taking longer than you thought, you can add an email in the middle of packaging.
- Note that **you** control where the data are saved on your disk through your browser; your browser may be configured to store all downloads in a particular location on your disk.
- If you select data products from the AOR, Level 2, Level 1, or even the IRS Enhanced Products tab, the tool is smart enough to be able to trace back all the data products and give you the option to download the constituent products (e.g., from the IRS enhanced tab, you can still immediately download BCD data products that went into that IRS enhanced data product). However, the SEIP Super Mosaics are not quite as clever. You can only download the mosaics (plus optional ancillary materials) from this tool. The traceback information is in the SEIP delivery, but you will have to do that tracing back yourself to find the constituent observations.
- To save any SEIP source lists you retrieve, use the diskette icon on the table, not the "prepare download" button.

The packaging process is spun off to the Background Monitor. Once the packaging is complete, to download the data, just click on the "Background Monitor" link, then click on any of the provided links reading "Download Now".

## Deciding what files to download

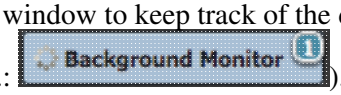
All users should consult the corresponding Instrument Handbook (available in the Spitzer documentation) for details and for information to consider for your own project.

Most new users probably will want the most highly processed data versions available -- Enhanced Products first, then Level 2 (PBCD) products.

More experienced users, or users wanting more control over the analysis (e.g., wanting highly accurate photometry), will want to download the Level 1 (BCD) data.

Very experienced users may want the Level 0 (raw) data. Choose this option with caution! Note also that some raw data was not included in the generation of the final products. When selecting the 'raw data' download option, *all* of the frames associated with your AORs are downloaded, not just the ones, e.g., within a smaller search radius.

## The Background Monitor

The Background Monitor appears in the upper right of your window to keep track of the data download. It actively changes to reflect what it is doing ("Preparing", etc.: 

).

A pop-up window can be called up at any time by clicking the "Background Monitor" (or "Preparing", etc.). You can watch your data being packaged, and when the data are available for download, it will update that window, providing a link (or more than one link) for downloading the packaged data.

The Background Monitor also keeps track of very large catalog queries, ones that take a long time to render in the SHA itself.

To stop any query mid-way through, click on the little red octagon ("stop sign").

If you forgot to put in your email at the beginning, or if the packaging is taking longer than you expected, you can click on "Add email" from the lower right of the Background Monitor popup and add your email during the packaging process.

## Help! I have a lot of zipfiles!

When downloading large quantities of data (big programs, whole campaigns, etc.), the SHA may break up the downloads into "manageable" pieces, where "manageable" is defined as "not larger than common computers and software can handle." We understand your frustration if you computer is customized to handle much larger files than the average computer.

## Acknowledging Spitzer and IRSA

Now that you've got your data, you're going to write a great paper. Please consult this page to find the acknowledgments to use for Spitzer, and this page for IRSA in general. Also note that many data sets have dois that should be cited.

# Quick examples for the the Spitzer Heritage Archive

Recipes for downloading and analyzing data can be found in the IRSA Spitzer site, specifically the Data Analysis Cookbook. There are also SHA video tutorials available at the IRSA YouTube channel. Look for the playlist that combines all the SHA videos together.

Here, we capture a few brief examples with text and screen shots.

*Contents of page/chapter:*
+I have detected an object at a non-Spitzer band, and I want to know if Spitzer (or, for that matter, WISE or Herschel) saw anything there.
+I study {this subject, as opposed to this target}, and I want to know if there were any Spitzer programs specifically studying {this subject}.
+I have a whole pile of results and I want to understand it better by seeing something less confusing on the coverage image.
+Quick Example: Just getting calibration data.
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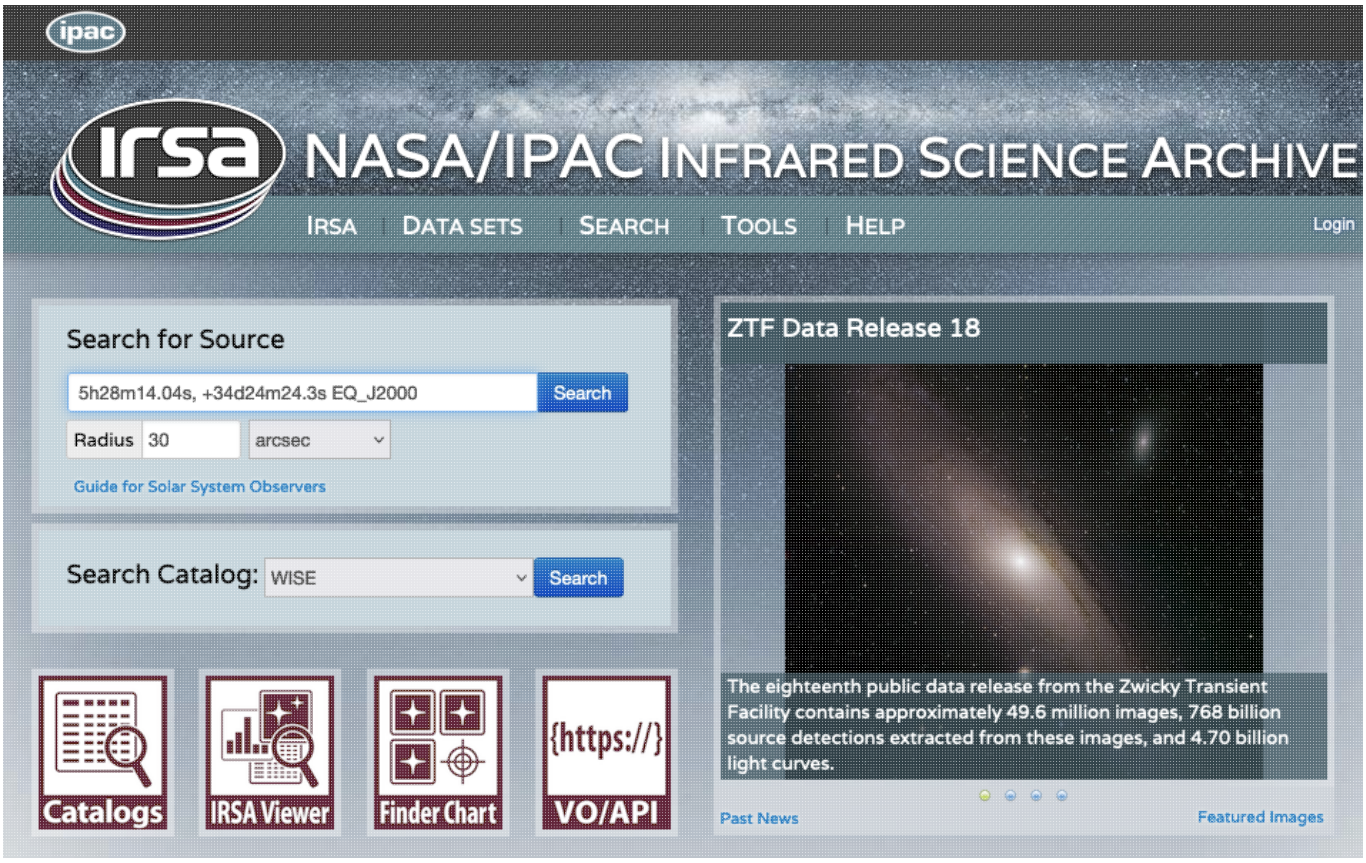
+Quick Example: Finding data from two different channels at once.
+Quick Example: Finding just MIPS prime or non-prime data.
+Quick Example: Filtering by PI.
+Quick Example: Finding AORs that were constrained together.
+Quick Example: Finding IRAC subarray Level 2 data.
+Quick Example: Finding other IRAC Level 2 data that appears to be missing.
+Quick Example: Downloading Raw Data.
+Quick Example: Apparent logical inconsistencies in position searches.

## I have detected an object at a non-Spitzer band, and I want to know if Spitzer (or, for that matter, WISE or Herschel) saw anything there.

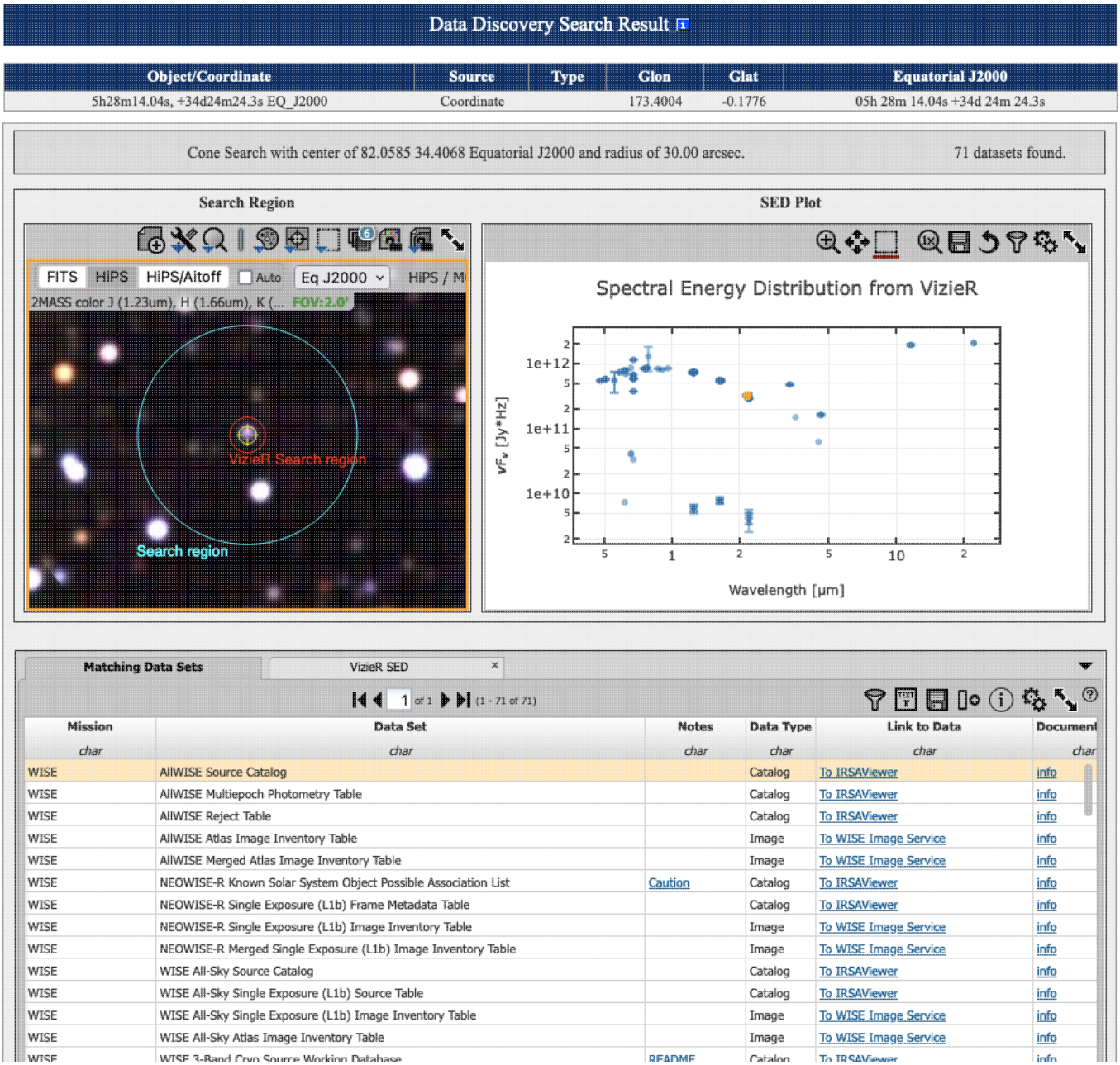
The goal here is to see first if there are any Spitzer (or WISE, or Herschel) data at this location, and then to see if there are any detections that have already been quantitatively measured that you can pick up and do science with right now. If there aren't measurements you can work with right now, then you can go get the data to work with yourself.

Let's work with an object at 5h28m14.04s +34d24m24.3s (J2000).

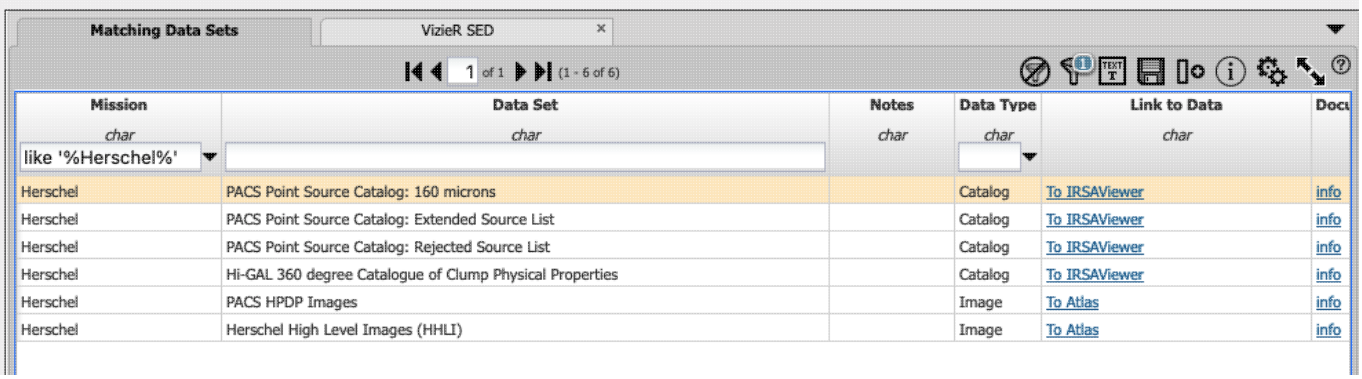
Go to IRSA's main front page, and put these coordinates in the box in the upper left. Search to see what IRSA has at that position.



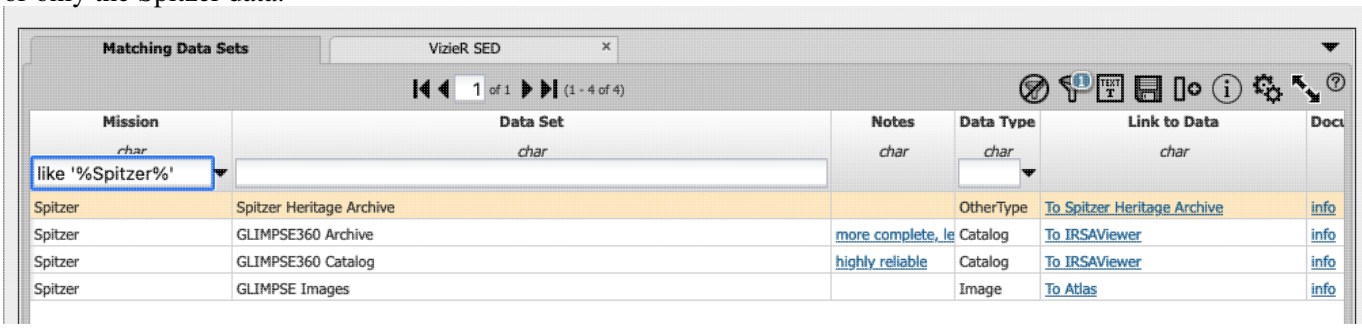

It returns with 71 possible data sets, even somewhat of an SED pulled from VizieR.




Scroll down to the bottom of the page, and inspect the list of "Matching Data Sets." This is a Firefly table, so it behaves like all the other tables in tools with this look and feel. We can impose filters such that we can list only the Herschel data:



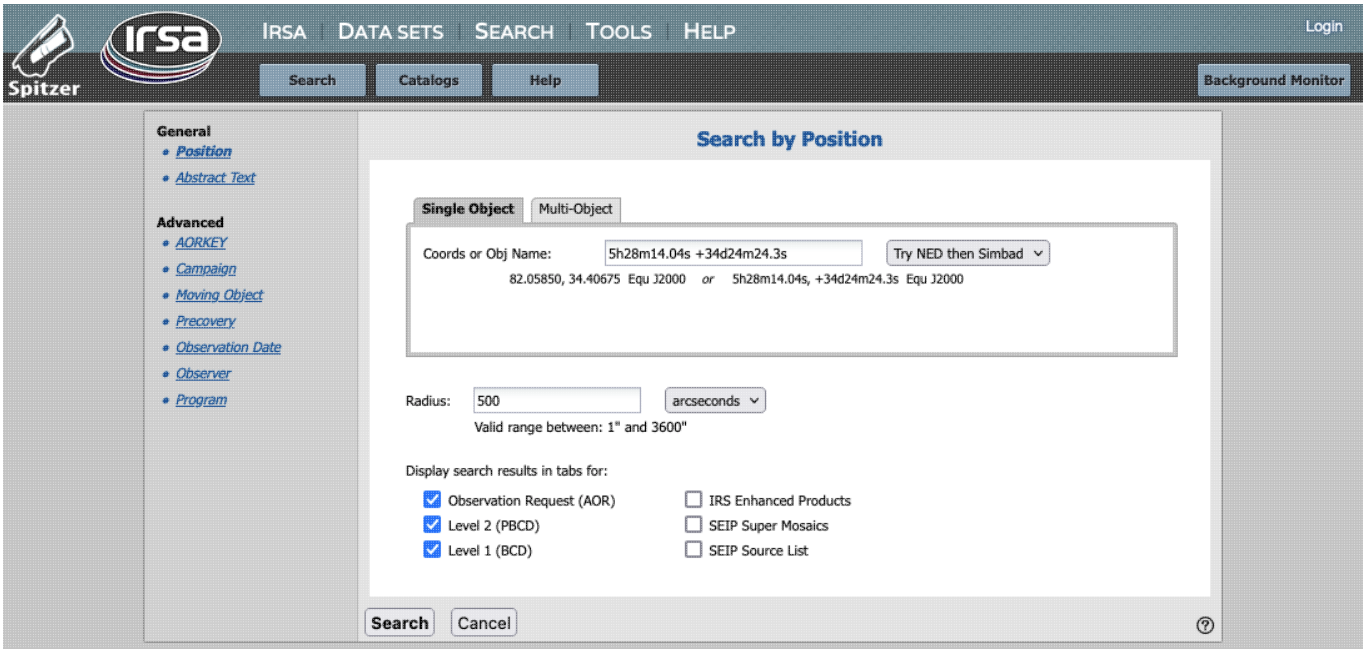
or only the Spitzer data:



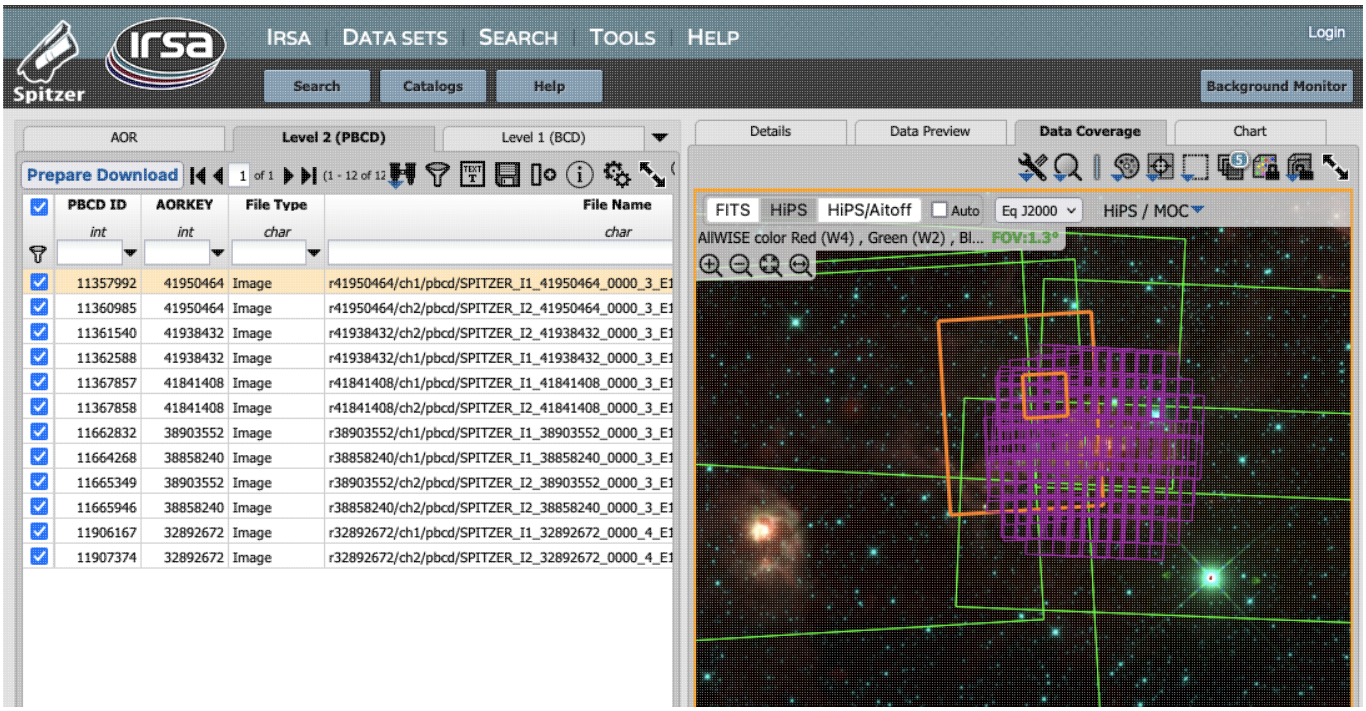

From these results, we can click on the links starting with "To [...]" on the right to launch other IRSA tools with data at this postion pre-loaded in them. Through this kind of exploration, we find that there are both Spitzer and Herschel data here (as well as WISE and for that matter 2MASS), and we can see a source in the Spitzer image at this location, but there is no ready-made photometry to be had of this specific source. So, we need to go get the images.

In truth, we could (and probably should) start from the GLIMPSE data products that we get from IRSA Viewer and do photometry straight from those science-ready mosaics, because they combine data from more than one AOR, but this is the SHA help, so we'll go get the data from the SHA.

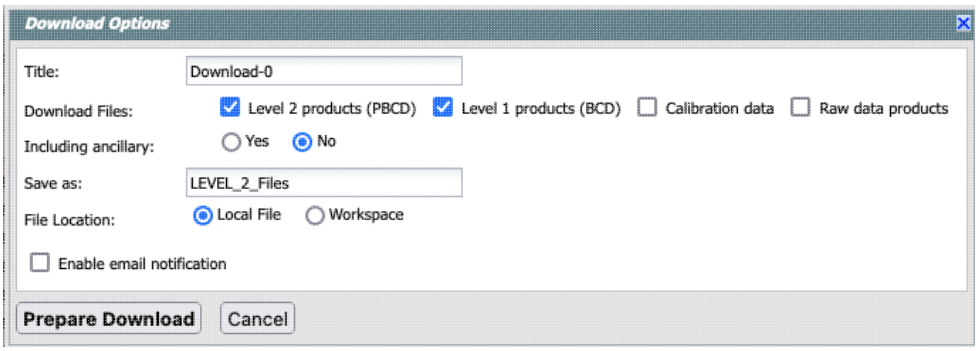
Launch the SHA, either by clicking on "To Spitzer Heritage Archive" from the Data Discovery results above, or by starting a fresh SHA session and pasting in the position above. If the latter, be sure to ask for at least Level 2 data.




Then, in the results, we can see that there are several mosaics that cover this region, as well as many individual frames.



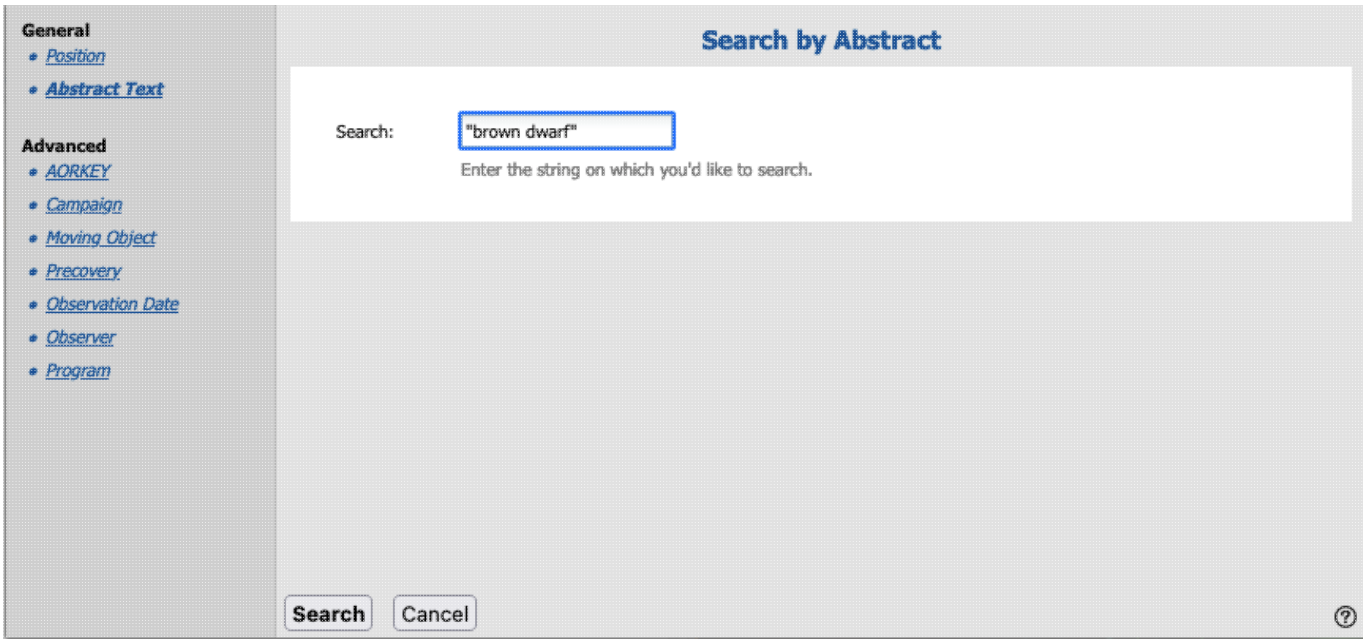

Select all of the rows, and click on "prepare download".



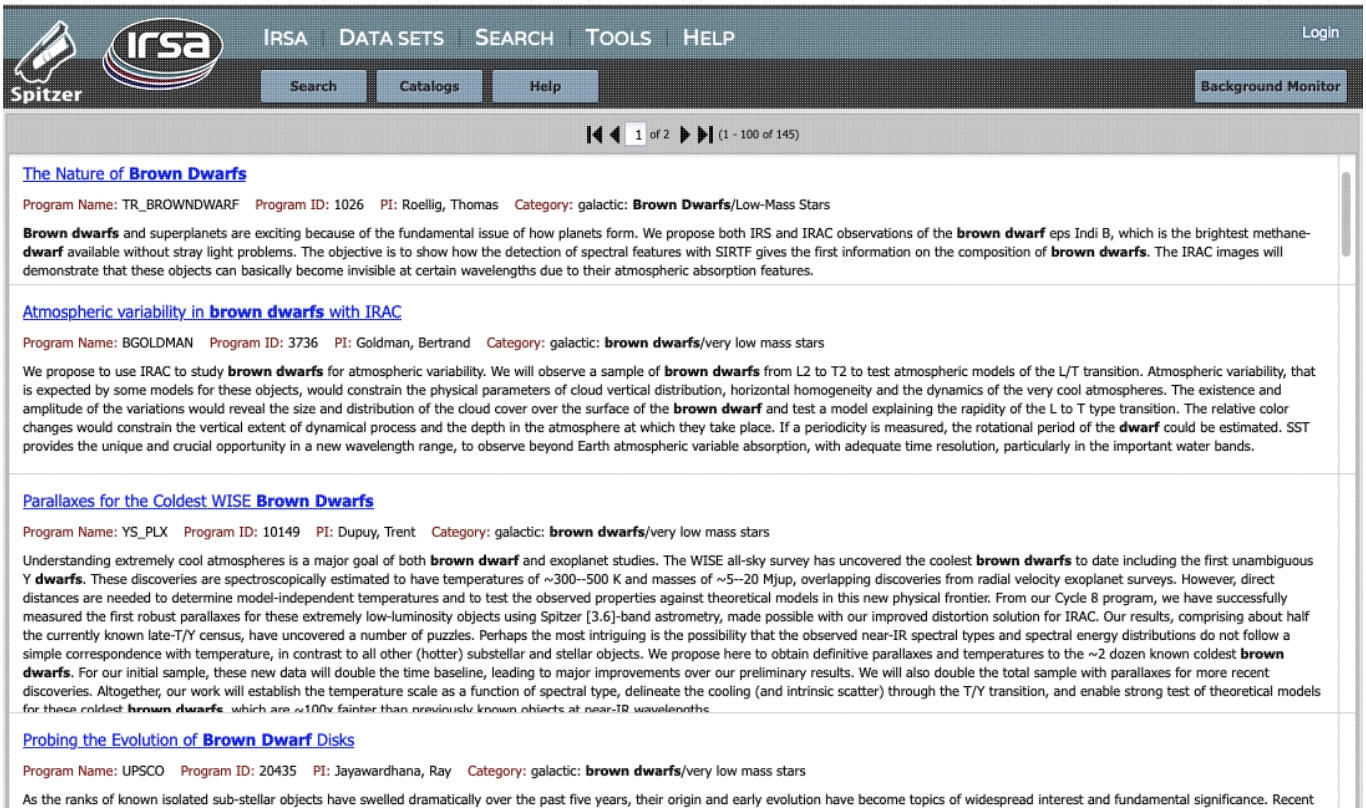

Be sure to get the Level 1 and Level 2 products. Then we can combine the frames or individual mosaics (by channel) into one final mosaic on which we can do photometry for our source.

## I study {this subject, as opposed to this target}, and I want to know if there were any Spitzer programs specifically studying {this subject}.

From the main search page, pick "Abstract" to do an abstract search. If you study planetary nebulae, then a search on "planetary nebula" ought to pull up both the singular and plural forms of the noun. Note that big surveys will cover huge swaths of sky that will contain objects of many different types (e.g., many planetary nebulae in the galactic plane covered by both GLIMPSE and MIPSGAL), and this sort of search will only return projects which mentioned your search words in the abstract. However, it should give you some good leads to follow.



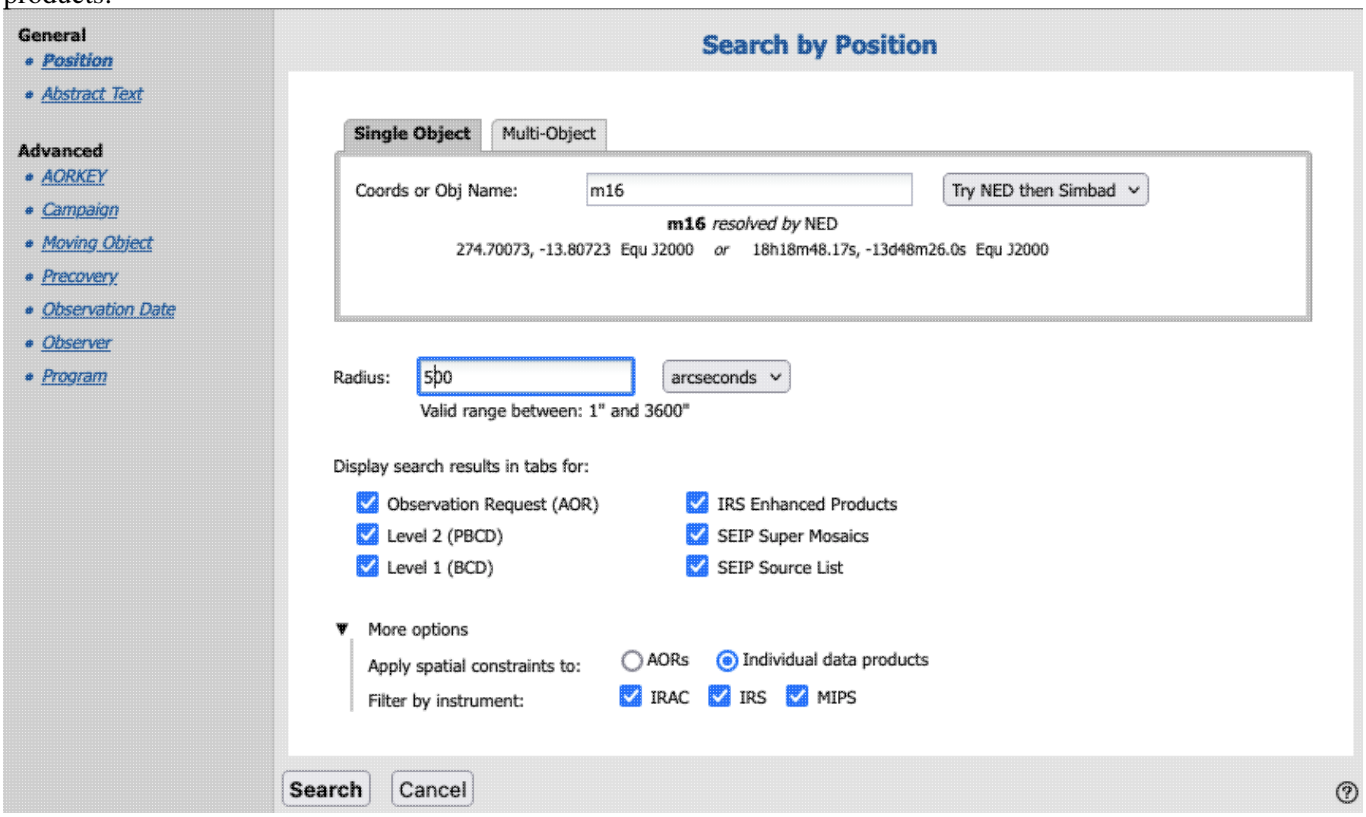

Click on any project to pull up all of the observations associated with that program into the Search Results window pane, and proceed from there as with any other search.



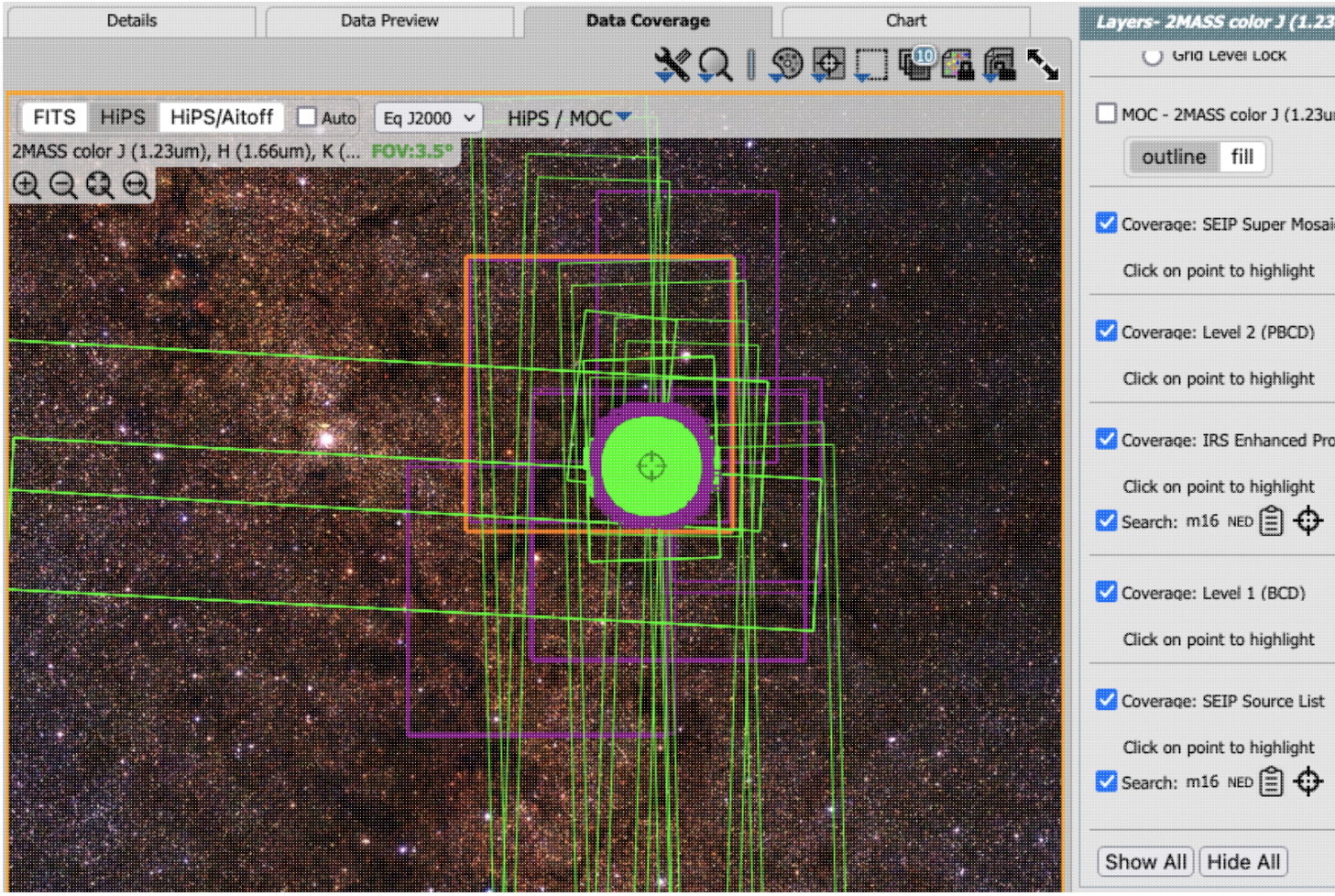

## I have a whole pile of results and I want to understand it better by seeing something less confusing on the coverage image.

Search on M16, over 500 arcsec, and ask it to return everything, but apply spatial constraints to individual data

products:



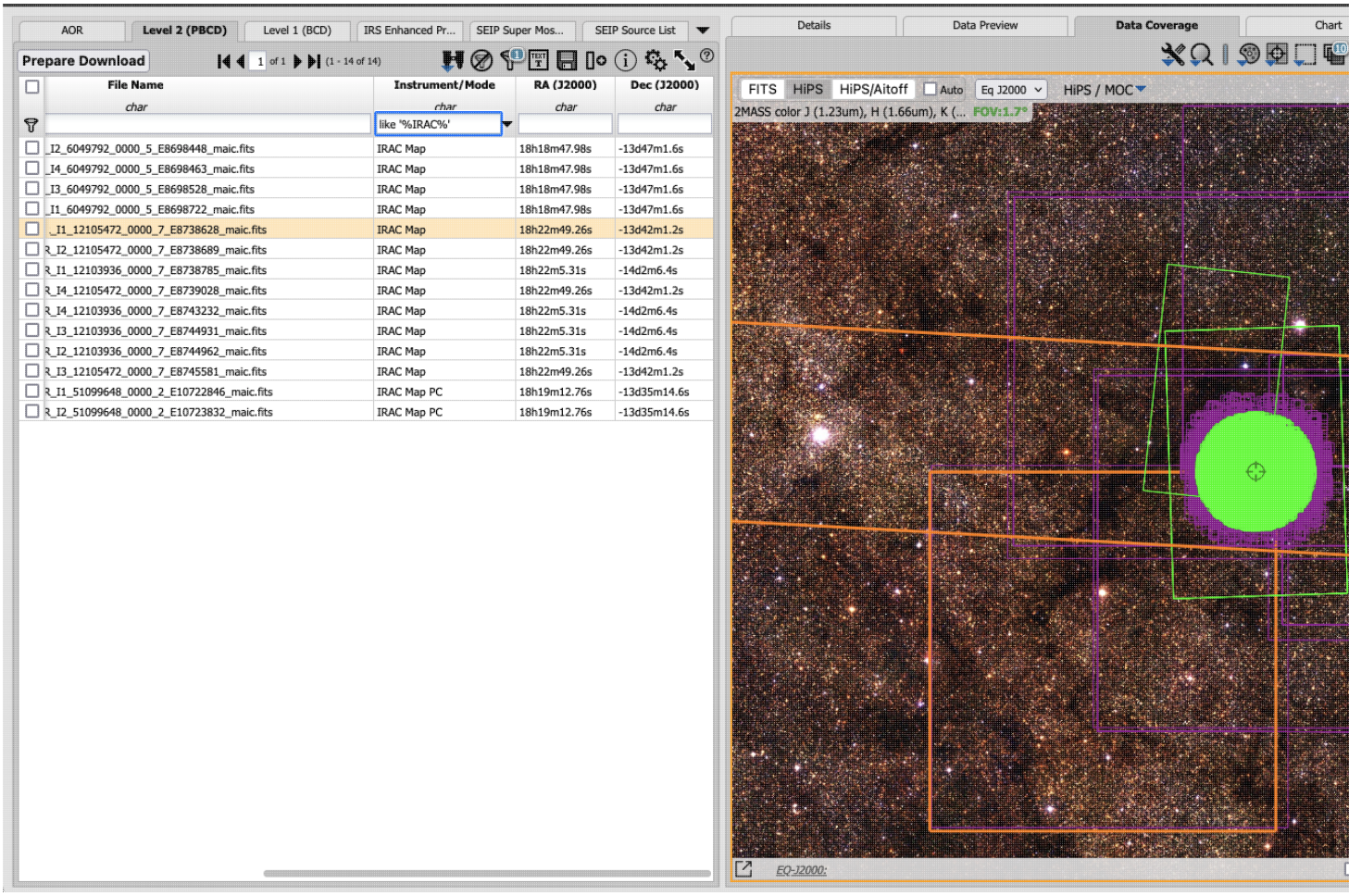

When it comes back, the coverage tab is confusing and overwhelming!




it has all the polygons from everything it retrieved, as well as all the sources from the SEIP Source List,

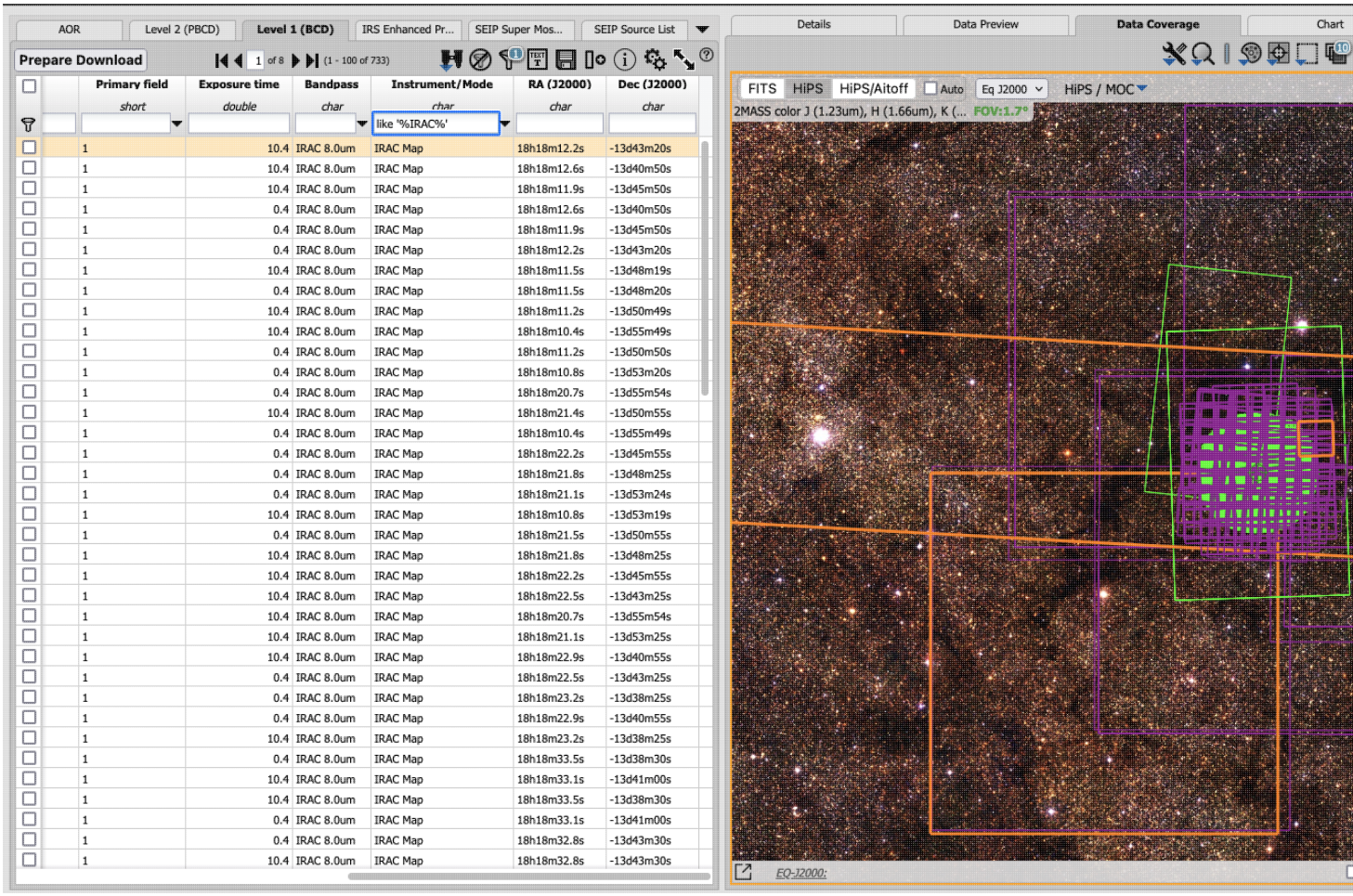
overlaid. By clicking on the layers icon ( ), we can get a list of all the layers on the coverage image, and there are a lot. We can change the colors (see the Visualization section), but for these purposes here, let's see if we can just limit what is shown from the search results.

Go to the Level 2 (PBCD) tab and find the "Instrument/Mode" column. Turn on filters. Filter it to just be IRAC data.




It's already looking better - only 14 PBCD results are now in the table and therefore also on the image.

Go to the Level 1 (BCD) tab and find the "Instrument/Mode" column. Turn on filters. Filter that to also just be IRAC data.




Now we have only 733 BCD results in the table and therefore also on the image.

The SEIP Super Mosaic tiles are often the same size across instruments, so filtering that down to just IRAC won't simplify the overlays much.

The SEIP Source List is the densest patch in the overlays. We can go to the layers ( ) in the data coverage tab and literally turn it off, but we can also go filter that catalog too. Go to that tab, and turn on filters. Find the columns called i[1-4]_f_ap1 -- these are the aperture fluxes for IRAC channels 1-4, for aperture 1 (see the SEIP documentation for more information). Add a constraint at the top of each of these columns that the values should be ">0". This limits the catalog to be just those sources with detections at all four IRAC bands, so a catalog of about 3500 is whittled down to about 450 sources. The overlay of the source list on the coverage image becomes much less opaque as a result. One could also change the symbol size from the layers popup (see the Visualization section) to make the image more visible underneath the overlay.

## Quick Example: Just getting calibration data.

**Why?** Some investigators may wish to find the calibration data that are tied to a particular campaign.

**How?** Search by campaign for the one you want. Many AORs will be returned, but only the first n rows will appear (where n defaults to 50). Calibration observations are likely to be among the first in the campaign. Look at one of these rows by selecting the row (clicking anywhere on it) and noting the details that appear in the

Details pane. Calibration programs will have a program ID, title, and PIs just like a regular science observing program, but the titles will look like "Calibration Program" and the PI will look like "IRAC Calibration". Each campaign should have its own calibration program ID, though some may have more than one. You can explore these and note the program ID (PID) and the PI of a calibration observation in your campaign. Apply a filter to the search results to leave only programs like that calibration program. Click on "Filters" in the upper right of the "Campaign Search Results" pane and note that text boxes and/or filter icons appear on the top of each column. Locate the "PI" column and either enter the PI of the calibration program, being careful to match the text exactly, OR if it has given you a pop-up with a finite number of options, select your desired PI from the list, and click on 'Apply.' Just the AORs from that campaign and that program will appear. Select all of them by clicking the checkbox on the top of the column of checkboxes. Click 'Prepare Download' and select which data you want packaged. Once packaged, download the data from the background monitor.

## Quick Example: Finding other data that are similar to yours.

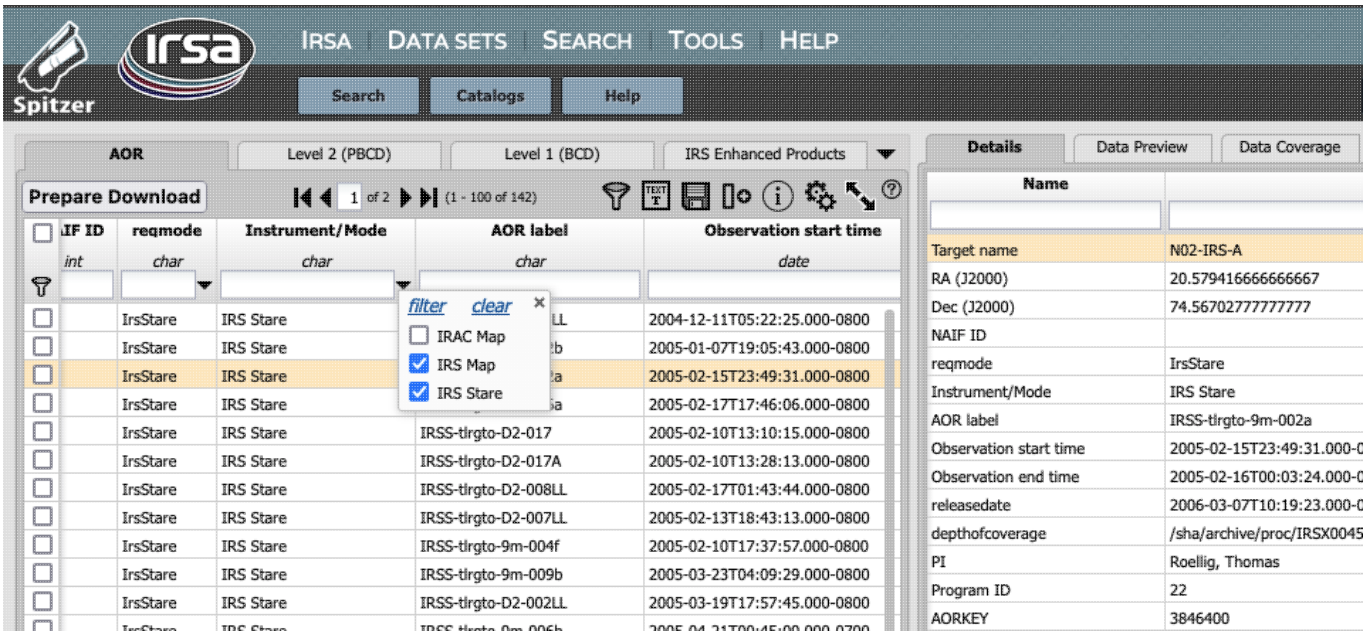
**Why?** Here is a real-life example of a request: I have spent xxx months slaving over my time-series data of yyy taken on zzz, and I don't have the scatter that I expect to have in my non-variable stars. I would like to know if it's my analysis or this particular data set which is the problem, so I need to find another observation of something (anything, doesn't much matter what) taken with staring mode IRAC, 30 second frame time, so that I can push the new data set through my analysis and see if I am getting the same scatter.

**How:** There is no easy way to find observations in a particular very specific mode without a priori knowing which targets were observed with those modes. You'd have to search the whole sky for observations matching a particular set of criteria. The best way to do this is to contact us through the Help Desk, and we will get into the database itself and help you find similar observations.

## Quick Example: Finding data from two different instruments or modes at once.

**Why?** If you have searched on, e.g., the observer T. Roellig, you are then looking at a list of 142 AORs, only some of which are IRS observations. What if you wish to just view the IRS Stare and IRS Map observations?

**How?** If you have already searched and are looking at the grid of results, you can impose filters. Find the Instrument/Mode column, enable filters if you haven't already, find the drop-down arrow in the filter, select both IRS Map and IRS Stare, and click "filter".

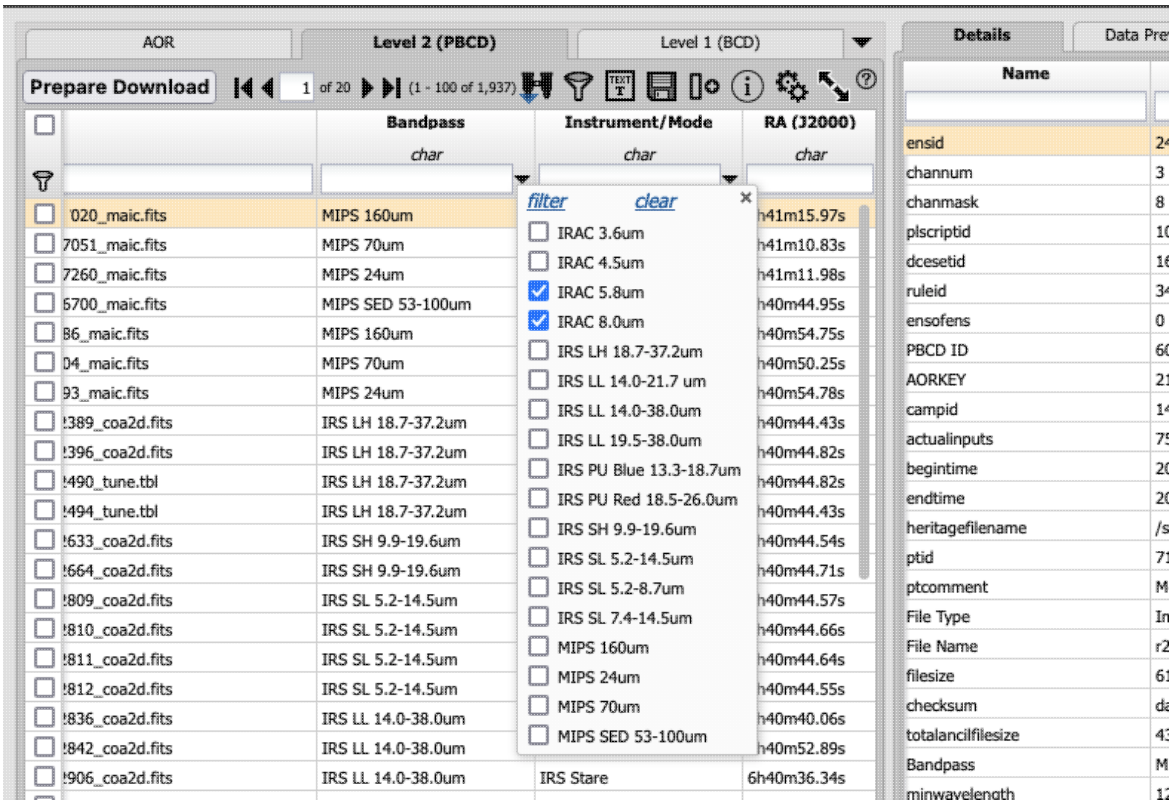



It will then remove the IRAC observations from the results.

## Quick Example: Finding data from specific channels.

**Why?** If you have searched on IRAC data and are looking at a stack of results, perhaps you only want to examine and download the 5.8 and 8 micron results.

**How?** Search on NGC 2264, with at least the AOR and Level 2 tabs selected. There are nearly 500 AORs returned. Go to the Level 2 tab. You may have to go to the gears for the Level 2 tab and turn on (enable) the column named "Bandpass." Close the gears pop-up if need be, and find the Bandpass column. Enable filtering if need be, and select the IRAC 5.8 and 8 bandpasses.




Click "filter." You should now have only 44 rows remaining, consisting solely of IRAC 5.8 and 8 micron products.

## Quick Example: Finding just MIPS prime or non-prime data.

**Why?** MIPS had three cameras on board, and, when MIPS was operating, all three cameras were always on. In certain observing modes (e.g., 70 micron photometry), the commanded action of the spacecraft + scan mirror was designed to image a particular section of sky at that band (the 'prime' band), and the other cameras (e.g., 24 micron) imaged whatever section of sky happened to be visible to it during that sequence (the 'non-prime' band). When the 24 micron array was the primary array, the Germanium arrays (70 and 160 microns) did not have the right calibration sequence for the data to be scientifically viable, but the 24 micron array did take viable data when the 70 or 160 micron arrays were primary. Observers looking for serendipitously obtained data may wish to specifically obtain non-prime data.

**How?** Search on your desired position/observation/program/etc. Under "More options" on the search page, ask it to only return MIPS observations, and ensure that you are asking it to return Level 1 data as well as anything else you want returned. When the search results appear, click on the Level 1 tab to bring it to the foreground. Scroll over, and find the column labeled "Primary field." This value is 1 if that array was prime, and 0 if it was not. Go up to the upper right of the search results window, and click on "Filters." Locate "Primary field," then click on the filter icon and select the value you want to select (1= yes, it was prime, 0= no, it was not prime but instead ancillary). Apply the filter and close the window. The remaining observations as displayed are the observations that meet the criterion you have imposed.

## Quick Example: Finding AORs that were constrained together.

**Why?** In general, Spitzer discouraged use of constraints to link AORs together; fewer constraints on the observations made them easier to schedule. However, for some observations, it was scientifically necessary to

require that, say, observation "b" be obtained after 4 hours but not more than 6 hours after observation "a". You may want to obtain observations that were constrained to a given observation.

**How:** Go to the AORKEY search. Enter the AORKEY you want to search. Ensure that the "Get all AORs in the same scheduling constraints" checkbox is checked, and submit the search. All AORs that are linked to that AOR will be returned.

The SSC website summarizes all of the flavors of constraints that were available.

NOTE THAT some time series observations were obtained in the following manner. For a series of observations (a, b, c, d, e), a was tied to b with a particular constraint, b tied to c, c tied to d, and d tied to e. If you search on the AORKEY corresponding to observation b, and ask the SHA to give you all of the AORs constrained to that observation, it does exactly (and only) what you asked it to do -- b is tied to a and c, but not explicitly tied to d or e. So it returns to you observations a, b, and c, and not d or e.

## Quick Example: Finding IRAC subarray Level 2 data.

**Why?** When you do a search on most IRAC data, individual data frames (Level 1) as well as mosaics (Level 2) are returned. But no mosaics are produced for IRAC subarray data! If you search on subarray data (or if subarray data are some of the results you have uncovered), and if you do not select Level 1 data as one of your desired results, these subarray data will appear to vanish because they have no data to display in the Level 2 tab.

**How:** Since no subarray mosaics are created, there will never be any to display. You must download the Level 1 BCD frames, and make your own mosaic from the BCD data using MOPEX or another software package of your choice.

*Potential gotcha:* If you search for a list of observations of, e.g., certain exoplanet targets, you will return many observations in the AOR tab, some of which will be subarray and some of which will be full array. When you go directly to the Level 2 tab for this search, there will be entries from the full array observations, but not the subarray observations. If you have searched only for subarray observations, it is obvious that something unusual is going on when you go to the Level 2 tab and get 'no data to display.' But, when you have a mixture of kinds of observations in the AOR tab, then there are still rows to display in Level 2, and it is not obvious that something unusual has happened.

*Why the heck does the pipeline not make mosaics for subarray data?* The post-BCD pipeline was not designed to work with the three-dimensional data cubes that are the subarray BCDs. When the software was developed it was deemed unlikely that subarray observations would be used for anything other than photometry of single bright objects and mosaics would not be a desired product. Please see the IRAC Instrument Handbook for more information on dealing with subarray data.

## Quick Example: Finding other IRAC Level 2 data that appears to be missing.

**Why?** When you do a search on most IRAC data, individual data frames (Level 1) as well as mosaics (Level 2) are returned. But, for some other kinds of IRAC observations (some IERs), there are also no Level 2 products produced.

**How:** Since no mosaics are or will be produced, there will never be any Level 2 products for download. You must download the Level 1 data and make your own mosaic from the BCD data using MOPEX or another software package of your choice.

The IERs where there are missing Level 2 products are ones where there are more than 8000 frames within a single observation. These are most commonly exoplanet monitoring observations, in which case a single mosaic is not particularly the desired product in any case.

## Quick Example: Downloading Raw Data.

**Why?** Some expert users will want to download the raw data for an observation.

**How:** When requesting packaging of the data, you can request that the raw data also be packaged for download. Most users will never need to access the raw data. You cannot search on the raw data directly.

NOTE THAT not every frame (DCE, or data collection event) was used in the creation of the BCD and PBCD products. All of the original DCEs are still in the SHA, and can still be obtained, even if you cannot search on the raw data directly.

When packaging by AOR and asking for the raw data, all products matching the designated AORKEY are packaged, regardless of whether "apply spatial constraints to individual data products" is selected and the DCEs fall out of that cone.

When packaging by BCD or PBCD and asking for the raw data, all products matching the designated AORKEY and channel are packaged, regardless of whether "apply spatial constraints to individual data products" is selected and the DCEs fall out of that cone. This may change in the future such that if you package by BCD or PBCD, only the data that when into those products will be packaged.

## Quick Example: Apparent logical inconsistencies in position searches.

**Why?** If you search by position with the default radius, you may see that, for example, both IRAC warm channels were observed in the AOR tab, and are there in the Level 2/PBCD tab but find that one channel appears to be missing in the Level 1/BCD tab.

**How:** This is a weird one, but it is actually doing exactly what it is supposed to be doing, for several reasons. By default, the SHA applies the spatial constraints to the individual data products -- this radio button option appears under "More options" so you have to consciously find this button if you want to change it. The default search radius of ~8 arcmin is smaller than two fields of view for IRAC. The Level 2/PBCD mosaics are produced on an AOR basis, and include the area observed by both fields of view even if it is filled with NaNs. It is quite possible, therefore, to have AORs covering a default search region, and Level 2 mosaics apparently covering a default search region, but because of the "apply spatial constraints to individual data products" option, the Level 1/BCD images are not returned.

Here is the real-life case that prompted this example. Search by position with the defaults in place for NGC 2264, asking it to return the AOR, Level 1, and Level 2 tabs. Some of these observations are single pointings (not mosaics), for the purposes of monitoring young stars in this cluster. Thus, the 3.6 micron channel always points at the same portion of sky and the 4.5 micron channel points at a slightly different portion of sky, and the observation does not dither back to make sure that there is 3.6 micron coverage of the original 4.5 micron field of view.

Pick any of the post-cryo (PC) data AORs, such as 29340160 or 29347328 or 29347072. Click on Level 2. Filter it down by AORKEY to be just one of those AORs. See two mosaics there. Filter it down to just be IRAC channel 1. Click on Level 1, filter it down by the same AORKEY, channel 1, and there are BCDs there. Go back to Level 2. Filter down to be channel 2. Go back to Level 1. Filter down to be channel 2. "There are no

data to display."

This is because the 4.5 micron BCDs are just outside of the search radius. These data were obtained as part of the observation, and the resultant pipeline mosaic includes the search position, but that search position does not actually include any 4.5 micron data.

Of course, **searching by AORKEY** does NOT reproduce this, because searching by AORKEY returns the whole AOR. Searching using a larger radius will recover the 4.5 micron data. Most non-monitoring observations tiled the larger area such that most of the sky covered by 3.6 microns is also covered by 4.5 microns, and thus BCDs would be returned for both channels, appropriately limited by position. BUT in this particular case, because this was a single field, monitored in one IRAC channel, you can get this seemingly inconsistent result, where there is a 4.5 micron mosaic but "no BCDs."

# Spitzer Heritage Archive: API

*Contents of page/chapter:*
+Overall Introduction
+SHA-specific API Examples
+SHA-specific API Input Parameters

## Overall Introduction

There are several ways to interact with the SHA in an automatic or semi-automatic fashion.

The semi-automatic way is to pass a list of sources to the SHA web interface. You can pass a list of up to 1000 sources to the SHA from the search screen. More information on that is in the Searching section. For this, you still need to examine the output of this by hand, but at least you do not have to send targets individually to the server.

An API, or application programming interface, can also be known as a "command-line" interface.

You can write code that constructs a URL that launches an SHA session in a browser, either ready to search, or with search results, or with search results already loaded. That's what the rest of this page covers.

There are other ways to interact via code with all of IRSA's holdings, including the data held in the SHA. All of that documentation is elsewhere at IRSA.

## SHA-specific API Examples

Open search panel with Program ID prefilled and default data products selected
/applications/Spitzer/SHA/?api=search&searchoption=PROGRAM&program=30080&execute=false
Search and return an SHA result with the following criteria: Program ID and selected data products
/applications/Spitzer/SHA/?api=search&searchoption=PROGRAM&program=50180&selectProducts=levelAor,lev
Open position search panel with position and search radius filled in and data products selected
/applications/Spitzer/SHA/?api=search&searchoption=POSITION&WorldPt=83.773986;-5.418506;EQ_J2000&sel
Search and return an SHA result for a given position and search radius
/applications/Spitzer/SHA/?api=search&ra=83.7739862708531&dec=-5.41850696034436&sr=350s&searchoption=
Open search panel with AORKEY filled in and data products selected
/applications/Spitzer/SHA/?api=search&searchoption=AORKEY&aorKey=21641216&selectProducts=levelAor,lev
Search and return an SHA result with following criteria: AORKEY and selected data products
/applications/Spitzer/SHA/?api=search&searchoption=AORKEY&aorKey=21641216&selectProducts=levelAor,lev
Open NAIF ID search panel and select some data products
/applications/Spitzer/SHA/?api=search&searchoption=NAIFID&naifId=2003226&selectProducts=levelAor,level2,
Search and return an SHA result with NAIF ID filled in and data products selected
/applications/Spitzer/SHA/?api=search&searchoption=NAIFID&naifId=2003226&selectProducts=levelAor,level2&

## SHA-specific API Input Parameters

The input parameters are entered as standard HTTP *parameter=value* pairs. In this syntax, the parameter name is followed by an equals sign (=) which is then followed by a value. No extra spaces are allowed, and if the

value contains any spaces or special characters that might be ambiguous, they have to be encoded formally as in any HTTP or URL reference (more discussion here: http://www.w3schools.com/html/html_entities.asp ). As shown above, these pairs are separated from each other by ampersand (&) characters.

| | |
|---|---|
| WorldPt or ra/dec | coordinates of the search position.<br>worldPt format - lon;lat;Csys - eg: 1.0;2.3;EQ_J2000 or 5;4;GAL<br>ra, dec format - ra=1&dec=2 - always j2000 |
| searchoption | SHA search options: POSITION, PROGRAM, AORKEY, NAIFID |
| program | Alphanumeric value representing a Program |
| aorKey | Spitzer Astronomical Observation Request Number (AORKEY) |
| naifId | Unique number allocated to Solar System Objects (e.g. planets, asteroids, comets, spacecraft) by JPL |
| selectProducts | SHA data products: levelAor, level2, level1, levelssc, levelSuperMosaics, sourceList.<br>Optional parameter, if not specified, set to default value. |
| sr | radius of search (optional)<br>sr format options: d or none - degrees, m - arcminutes, s - arcseconds<br>sr=1.1d or sr=1.1 - 1.1 degrees<br>sr=150s - 150 arcseconds<br>sr=22m - 22 arcminutes |
| execute | true or false - if true, execute the search and show the results |

# User Registration for the Spitzer Heritage Archive

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

Note that there is a single user account/password combination for all IRSA services, but that data access is unique to each archive.

## Log In

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

# Frequently Asked Questions (FAQs) about the Spitzer Heritage Archive (SHA)

## Interface questions

What does SHA/AOR/IER/BCD/PBCD/Level 1/Level 2 mean?

Here are some common definitions. The archive of Spitzer data is the Spitzer Heritage Archive (SHA). An individual Spitzer observation sequence is an AOR, or Astronomical Observation Request. In certain cases (often calibration or sometimes science observations), you may also see an IER, or Instrument Engineering Request. Either one involves many individual frames. The individual data frames that emerge, calibrated, from the Spitzer pipeline are Level 1, or Basic Calibrated Data, or BCDs. The products that come from combining these individual data frames (such as mosaics of individual pointings) are Level 2, or post-BCD, or PBCD data. Enhanced products come from combining AORs or doing post processing (such as synthetic photometry from spectra or source extraction from images). These can be contributed by the community, or generated by the SSC itself.

Do you have any tutorial videos?

Yes. The IRSA YouTube channel has several tutorials that are relevant to the SHA -- see the Spitzer playlist as well as the set of "micro-tutorials" relevant for more than one archive. The videos are in HD; you may need to manually use the YouTube gear menu to force it to realize this. There is also English closed-captioning available.

How do I download all of the data shown at once?

Click on the checkbox at the top of the column of checkboxes, at the top left of the search results pane. Then click on "prepare download."

How come I can't make a 3-color image from Spitzer data I am exploring interactively?

The visualization tools currently only allow you to create 3-color images that you load from disk or from the web. If you want to create 3-color images using Spitzer data, download the data to disk and then load them from your disk into other IRSA tools with this look and feel, such as IRSA Viewer -- it is easier to create 3-color images there.

I know that there are a lot more files that should come as part of Level 1 (BCD) or Level 2 (PBCD) data. How come I can't see them in the Level 1 or 2 tabs?

Yes, there are a lot more files than what are shown, such as the errors! We decided for clarity that only certain files of primary interest to users would appear for individual examination in the SHA interface, but of course the download includes many more files -- you don't even have to tell it to include ancillary products. The IRAC, IRS, and MIPS Instrument Handbooks list (and define) all of the files that are included in the downloads.

How come it is only showing me mosaic files in the Level 2/PBCD tab? Where are the errors, shorter exposure frames for HDR data, etc?

Only the highest level products are shown in the Level 2/PBCD tab, and for that matter the Level 1/BCD tab. This is designed for you to inspect the data enough to see if you want to download it. If you package up the data for downloading, the most frequently used standard files (errors, coverage, masks, etc.) will come with the download; to ensure you have all the files, select "incuding ancillary" when packaging.

I did a search, left the SHA window up, and now that I've come back to this session, it's in a funny state and does not appear to be responding as it should. Why?

Sometimes, if there is a network hiccup (e.g., you pick up and move your laptop to a different wireless hub), the SHA can be left in a funny state. (In some extreme cases, you will need to not just restart the browser but clear your browser cache.) To avoid losing a search, if you've accomplished a complex search, log in to the SHA and save or tag the search. That way, you can recover it easily with a single click the next time you log in.

Is there a way to interact with the SHA via a computer program? (Is there an application program interface, or API?)

Yes; learn more about it here.

I asked it for just MIPS data, but the SEIP tab is returning IRAC data. What gives?

Many of the 'more options' obtainable for a position search don't apply to enhanced products of any sort. For example, if you ask the SHA to give you just IRAC observations at a particular position, but also ask it to give you IRS Enhanced Products (which are of course completely independent of any IRAC observations), it will return just IRAC observations in the AOR/Level 1/Level 2 tabs, but the IRS Enhanced Products search is independent of the AOR search, and may still return viable results in that tab. Similarly, if you restrict your search to MIPS results but still ask it to give you IRS Enhanced Products and SEIP Super Mosaics, it will give you IRS and IRAC data, respectively, in those tabs, regardless of the MIPS filter you have imposed (that MIPS filter applies just to the AOR/Level 1/Level 2 tabs).

## File questions

How long do these zip files stick around on IRSA's disk after they are prepared?

72 hours, sometimes longer if the SHA is not under heavy use.

What do I do with the zip files I get when I download data?

To uncompress the files you have downloaded, type "unzip foo.zip". To uncompress multiple files at once, type "unzip '*.zip'" (the single quotes are important), or "unzip *.zip" -- you just have to escape out the wildcard.

What is the file naming scheme for all these files? Why do I have so many files for a single observation? Which files do I need to download my data?

Each of the instruments (IRAC, IRS, and MIPS) has an Instrument Handbook, which lists and defines each of the files. They also describe instrument artifacts, and give guidance as to how to reduce the data.

Why does my IRAC observation appear to have no post-BCD (Level 2) data?

If the data was taken in IRAC's subarray mode, or for certain IERs (Instrument Engineering Requests), there will be no post-BCD data for the observation. Data in IRAC subarray mode are not processed through the online post-BCD pipeline. The post-BCD pipeline was not designed to work with the three-dimensional data cubes that are the subarray BCDs. When the software was developed it was deemed unlikely that subarray observations would be used for anything other than photometry of single bright objects and mosaics would not be a desired product. As a result, post-BCD products (e.g., mosaics and source lists) are not available from the pipeline. Please see the IRAC Instrument Handbook for more information on dealing with subarray data.

Where are my dmask files?

Pipeline products after S18.5 no longer provide dmasks as they contain misleading and incomplete information. They have been superseded by the information contained in the imask files. The imasks are more robust, include flagging of various artifacts that are not present in dmasks and make full use of the saturation correction made by the pipeline. Please see the IRAC Instrument Handbook (Appendix A) for more information.

Why does my IRAC observation appear to have incorrect header information?

If the data was taken in as IERs (Instrument Engineering Requests), the pipelines will not necessarily run to completion, which means that there may be incorrect values of some header keywords.

Why does my MIPS 24+70 photometry observation appear to have no serendipitous 24 um data?

If the 70 um data was taken in MIPS-70's fine scale mode, no serendipitous 24 um data were obtained during the 70 um observation. Please see the MIPS Instrument Handbook for more information on dealing with these data.

## Getting more Help on Using the Spitzer Heritage Archive

More information on Spitzer's cryogenic mission can be found at IRSA's Spitzer site.

You can submit questions to the IRSA Help Desk.

Note that there are also SHA video tutorials, including a quick start and a longer AAS-demo-style overview, available at the IRSA YouTube channel. Look for the playlist that combines all the SHA videos together.

**Found a bug?** The known bugs and issues in this version of the Spitzer Heritage Archive (SHA) are listed here. If you think you have found a bug, before reporting it, please check this list, and read the online SHA 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.)

*IRSA and the Spitzer Heritage Archive utilize technology developed for the Virtual Astronomical Observatory (VAO), funded by the National Science Foundation and the National Aeronautics and Space Administration under Cooperative Agreement AST-0834235.*

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- Which search results (tabs) should be displayed
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- Data tags, if you create one
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