Catalogs Help

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Catalog Search Tool: Overview

The Catalog Search Tool allows users to search IRSA's catalogs using potentially complex constraints. These queries can be built using either a web-based interface (which is most of what is covered by this documentation) or a program interface. The catalogs are stored as two-dimensional tables. Each row represents a record of the information for an individual source, such as a point-source in a catalog of point sources. Each column holds one datum or item of information about the source, such as position, magnitude, quality flags and so on.

Information in a database is accessed with the Structured Query Language (SQL), a syntax optimized for database tasks. SQL queries are interpreted by a Relational Database Management System (RDBMS), the engine that manages and organizes information in a database. While SQL is an easy language to master, complex queries are long and tedious to debug. The Catalog Search Tool shields users from the need to write SQL by providing a web-based form that allows users to build their query interactively. The Catalog Search Tool builds an SQL query based on the user's requests, launches it, and writes the retrieved data to an ASCII file for download. Complex search constraints can be quickly entered and run.

Searching

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

Results: Visualization

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

See the visualization section for more on visualization.

Results: Tables

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

Results: Plots

Plots from your catalog search results appear in the upper right of your results. See the Plots section for more on plots.

API

You can also interact with the Catalog Search Tool from code you write, e.g., the application programming interface (API). See the API section for more on that.

Acknowledgements

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

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

Searching

There are many ways to search the Catalog Search Tool. Results are described on other pages; start from the Overview page.

In summary, you must go through two interfaces, one for selecting a catalog (accessible from the "Catalogs Listing" button), and then another for building a query to extract data from that catalog. Submitting the job automatically brings up the process monitor, which reports the status of the job, and which gives the link to the returned data. These data are always written to an ASCII file of size up to about 2 GB, which is kept on-line for 72 hours after the job was started. (A processing summary is also sent to you by email if you request it.)

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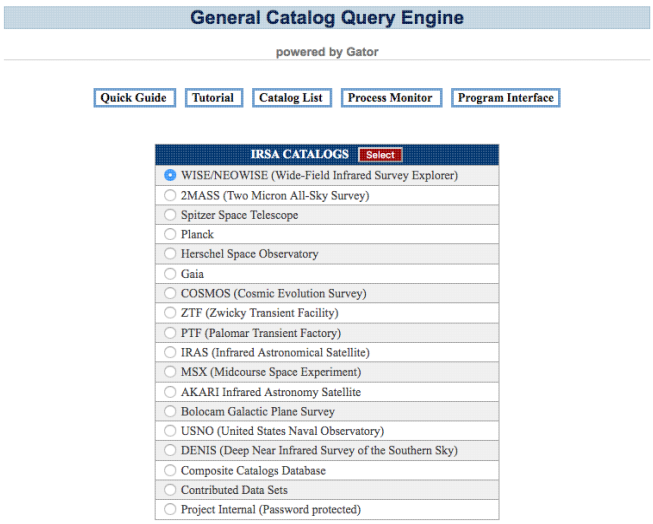
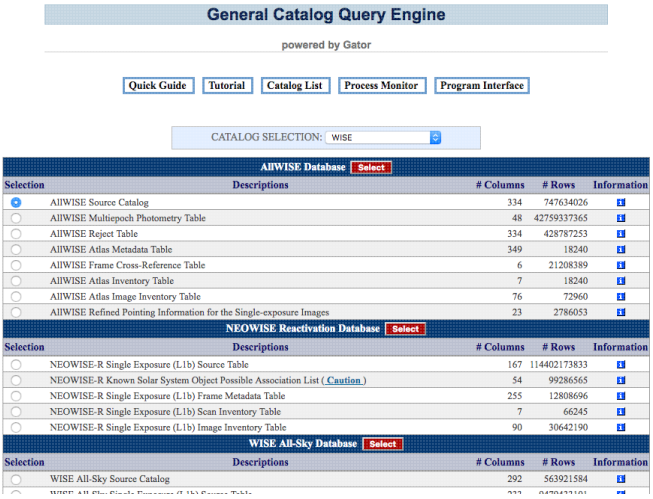
Selecting a Catalog

The Catalog Search Tool begins with a list of the broad data sets available at IRSA. Choose one and click on the red "Select" button. Example:



You then have a list of the individual catalogs associated with your chosen data set, along with information on the size of each catalog and links to the relevant documentation. Choose a catalog and click on any of the red "Select" buttons. Example:

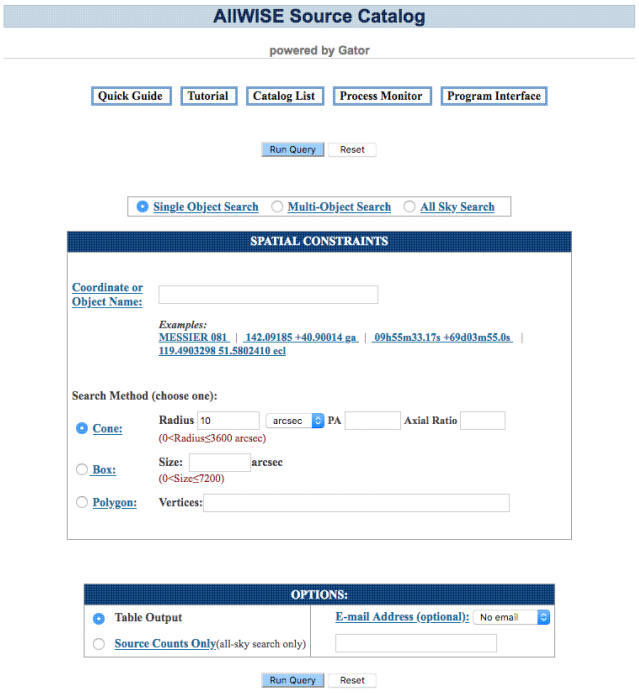


The next screen allows you to build a query for your selected catalog. It has four main parts, each of which is described in detail next.

Information about any given catalog is given in the catalog listing -- the number of columns, the number of rows, and links to more information about the catalog appear next to each catalog in the list.

Building a Query

The query builder interface constrains which rows and columns will be retrieved from the catalog. Example:



There are three classes of constraints:

- spatial constraints - which regions of the sky over which to select rows;
- column constraints - which columns to return, and upper and lower limits on the values of the entries in these columns, and
- user-defined custom constraints, which permit more complex queries than can be specified through the spatial and column constraints alone.

Rather than asking for a tabular listing of the requested rows and columns (the default), you can click the optional "Source Count Only" button to return a summary of the number of sources matching your constraints. This is useful for testing queries that might result in a very large output catalog.

Single Object: Coordinate or Object Name

A single object search performs a query on a single contiguous region of the sky, returning sources within a specified circle, ellipse, square, or polygon.

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

Examples of valid inputs include:

- M101
- NGC 2264
- 0042443-411608
- 00:42:44.3 -41:16:08
- 00h42m44.3s -41d16m08s
- 00 42 44.3 -41 16 08
- 34.5565 54.2321 gal
- 34. 54. ecl
- M83
- 344.489624 40.248115 Equ B1950
- Barnard's Star

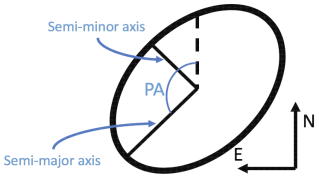
Search Methods

Search Methods: Cone

A Cone Search Query allows you to search for objects that lie within a cone defined by an ellipse projected on the sky. To define this ellipse, enter the following information (also see figure below).

Parameter	Description	Is it required?	Notes
Radius	the radius of a circular projected search area (i.e. Axial Ratio = 1); OR the semi-major axis of an elliptical projected search area (i.e. Axial Ratio < 1).	required	Radius must be positive; max value depends on the catalog being queried, and is shown in red on the search form.

PA	Position Angle in degrees of the semi-major axis of an elliptical projected search area, measured East from North	not required	default = 0
Axial Ratio	semi-minor axis divided by semi-major axis for an elliptical projected search area	not required	Axial Ratio ≤ 1; default = 1



Search Methods: Box

The Box Query returns objects that lie within a square centered on the search position. The width of the square is defined by the Size parameter, which must be positive. The maximum value depends on the catalog being queried. The maximum value is shown on the search form in red.

Search Methods: Polygon

The Polygon Query returns objects that lie within a convex (no interior angles larger than 180 degrees) polygonal area defined by up to 15 vertices. Each input vertex must be entered as a J2000 RA and Dec pair, in decimal degrees. Each vertex must be separated by a comma. The first vertex does not need to be repeated.

Example: Define a search area that is a one degree wide square. Vertices: 20.5 21.5, 20.5 20.5, 21.5 20.5, 21.5 21.5

Multi-Object

A multi-object search performs a search on a list of targets as specified in an uploaded table. Each search is for objects that lie within a cone defined by an ellipse projected on the sky, just as for a single target, above.

First choose "Multi-Object Search". Then click on the "Browse" button to upload a table that contains the following information in IPAC table file format. This is just plain ASCII, with some formatting requirements.

Column Name	Is it required?	Description	Units
ra	required	right ascension	decimal degrees
dec	required	declination	decimal degrees
major	optional	semi-major axis of elliptical cone search, or radius of circular cone search	arcsec
ratio	optional	semi-minor axis divided by semi-major axis for elliptical cone search	none
angle	optional	position angle of elliptical cone search	degrees

If you wish to have the same search parameters for every object in your input table, then you may specify these parameters once in the web interface. If you do not include the columns major, ratio, and angle in your input

table, the default values are assumed.

Example 1: Search a circular area around each of two positions.

First, make sure the radius box on the web interface is blank or "0". Next, create a table like this:

```
\ EQUINOX = 'J2000.0'
|   ra     |   dec    |  major |
|   double |   double | double |
 185.500000  15.500000    1000.
 186.000000  15.000000     500.
```

The "major" column is optional; you can submit a table consisting just of RA and Dec. Since there is no column labeled "ratio," the value under major is interpreted as the radius of a circular search.

Example 2: Search an elliptical area around each of two positions.

First, make sure the radius box on the web interface is blank or "0". Next, create a table like this:

```
\ Example of ellipse search
\ EQUINOX = 'J2000.0'
|   ra     |   dec    |  major | ratio |
|   double |   double | double | double|
 185.500000 15.500000    1000.   0.25
 186.000000 15.000000     500.   0.50
```

Since there is no column labeled angle, the default position angle of zero is assumed.

Example 3: Search an elliptical area around each of two positions, specifying the position angle.

First, make sure the radius box on the web interface is blank or "0". Next, create a table like this:

```
\ Example of ellipse search
\ EQUINOX = 'J2000.0'
|   ra     |   dec    |  major | ratio | angle |
|   double |   double | double | double| double|
 185.500000 15.500000    1000.    0.25    30
 186.000000 15.000000     500.    0.50    60
```

One-to-One Match

By default, all sources matching the query constraints (positional or otherwise) for a given input row will be returned in the output table. Conversely, if no sources match the query constraints for a given input row, then there will be no corresponding output rows. This can result in output tables which have a different number of rows than the input table. If the "One to One Match" box is checked, then the output table will have the same number of rows as the input table. If there are any objects that match the query constraints for a given input row, only the closest positional match will be returned in the output table. If no objects match the query constraints for a given input row, then the corresponding output row will be filled with nulls. The resulting table will be row-matched with the input table.

All Sky Search

An all-sky search performs a query without specifying any spatial constraints. Column Constraints and Additional Constraints may be applied.

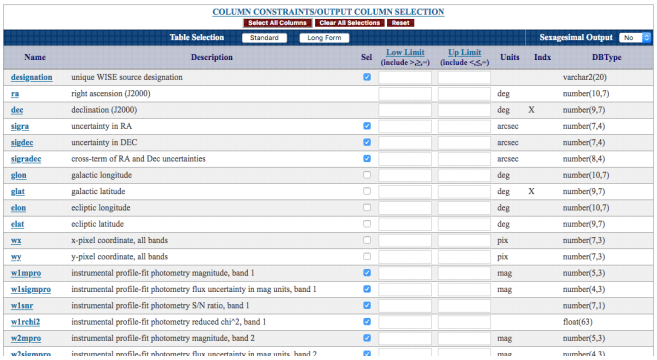
Use caution to avoid generating output files that exceed the 2 GB file size limit. You may wish to use the "Source Counts Only" option to estimate the size of your result before downloading the results in table format.

Search Options

Option	Description	Is it required?
Table Output	Click this option to return an IPAC table file ☑. This is the default output.	Required for Single Object and Multi-Object Searches. Optional for All-Sky Searches.
Source Counts Only	Click this option to return the number of sources matching your constraints. This is useful for estimating the size of a table result before actually requesting the table. This option is only supported for an all-sky search.	Optional
E-mail Address	To receive an e-mail containing a URL link to the results when your query has completed, select "Send email" from the drop-down menu, and enter your e-mail address in the space provided.	Optional

Output Column Selection

By default, the service provides a "Standard" list of columns that you can choose to output. To see a list of all columns available, click on the "Long Form" button. Regardless of whether you choose "Standard" or "Long Form", you can further tailor the output by checking the boxes under the "Sel" column in the table. Example:



COLUMN CONSTRAINTS/OUTPUT COLUMN SELECTION

Select All Columns | Clear All Selections | Reset

Table Selection: Standard | Long Form — Sexagesimal Output: No

Name	Description	Sel	Low Limit (include >=)	Up Limit (include <=)	Units	Indx	DBType
designation	unique WISE source designation	☑					varchar2(20)
ra	right ascension (J2000)				deg		number(10,7)
dec	declination (J2000)				deg	X	number(9,7)
sigra	uncertainty in RA	☑			arcsec		number(7,4)
sigdec	uncertainty in DEC	☑			arcsec		number(7,4)
sigradec	cross-term of RA and Dec uncertainties	☑			arcsec		number(8,4)
glon	galactic longitude	☐			deg		number(10,7)
glat	galactic latitude	☐			deg	X	number(9,7)
elon	ecliptic longitude	☐			deg		number(10,7)
elat	ecliptic latitude	☐			deg		number(9,7)
wx	x-pixel coordinate, all bands	☐			pix		number(7,3)
wy	y-pixel coordinate, all bands	☐			pix		number(7,3)
w1mpro	instrumental profile-fit photometry magnitude, band 1	☑			mag		number(5,3)
w1sigmpro	instrumental profile-fit photometry flux uncertainty in mag units, band 1	☑			mag		number(4,3)
w1snr	instrumental profile-fit photometry S/N ratio, band 1	☑					number(7,1)
w1rchi2	instrumental profile-fit photometry reduced chi^2, band 1	☑					float(63)
w2mpro	instrumental profile-fit photometry magnitude, band 2	☑			mag		number(5,3)
w2sigmpro	instrumental profile-fit photometry flux uncertainty in mag units, band 2	☑			mag		number(4,3)

Some columns have no checkbox in the "Sel" column, and those are linked to the prior column, such as in the case of errors. If you are asking for a brightness measurement, you get the errors on that measurement "for free" along with your query.

To find out what columns are, click on the column name to be taken to additional documentation describing the column.

Column Constraints

Some columns are indexed for fast access, and are indicated by an "X" in the "Indx" column. Queries with constraints on indexed columns run faster than queries with constraints on unindexed columns.

Ranges on any column can be specified by filling out the corresponding "Low Limit" and "Upper Limit" boxes. Each constraint must include one of the following comparison operators: =, <, <=, >, >=.

Blank spaces are ignored.

If the DBType of the column is "character", then the constraint entered must include a character in single quotes. When specifying a constraint on a column with a character DBType, "<" means earlier in the alphabet, and ">" means later in the alphabet.

When comparing dates, "<" means earlier and ">" means later.

Example:

The MSX6C catalog includes a source name field, called "name", encoded on the basis of the galactic position of the source. For example, the source with name = G090.5476+07.9157 is at l=90.5476 and b=+07.9157 in galactic coordinates. Entering the following constraint in either the upper limit or the lower limit field will retrieve all sources with the name G090.5476+07.9157.

```
='G090.5476+07.9157'
```

Entering the following constraint in the lower limit field will retrieve all sources with galactic longitudes greater than 90.4576 degrees.:

```
>'G090.5476+07.9157'
```

If you require more complicated constraints than allowed by the spatial and column constraints described above, you can include them in SQL format in the "Additional Constraints" box. The additional constraints page describes the possiblities in detail and provides examples of each. They include comparison operators (e.g. =, <, >), ranges (between and not between), lists and set membership (in, not in), pattern and character string matching (like, not like), nulls and unknown values (is null and is not null), logical operators (and, or, not), mathematical computations, and data constraints.

Order of Results

The rows in a relational database have no particular order. As a result, the output is similarly not ordered.

For single-source cone searches, the rows will be returned in order of distance from the requested position. For other single-source search regions or all-sky searches via the web interface, there is no particular order, but the output table has sorting capability (by clicking on the column name).

For table upload, the service orders by distance from each source.

We note here that, for API queries, you can control how the output is ordered. For single-source or all-sky searches, a parameter "order=(column_name)" may be used to order the rows by that column (in ascending

order).

Running the Query

Once you have filled out each of the above sections, click on one of the blue "Run Query" buttons at the top and bottom of the screen. You can monitor the progress of the query, cancel the query, or look at the log file associated with a query by clicking on the "Process Monitor" button at the top of the screen.

The log file in the Process Monitor has been designed to allow users to monitor the status of their jobs, while providing IRSA sufficient information to trace the cause of any errors. This information is given in the square brackets, and contains messages returned by the DBMS. The status messages are generally self-explanatory, but if you run into problems and mail the helpdesk, we may ask for information from that log.

Results are described on other pages; start from the Overview page.

Tips for Fast Queries

Here are some tips for making your large catalog searches return faster:

- Queries that result in very large files may take a long time to return, and can impact other users. Queries that result in tables that are larger than 2GB will truncate the output and output the warning message in red: "The output of the query may be truncated." Before going on to execute your full query, first experiment by doing a similar query that returns fewer than 1000 sources. This can be done by making your cone search radius small, or limiting the number of entries in a multi-object search to less than 1000, or setting outrows=1000, or reduce the number of selected columns in the output to reduce file size. Inspect the output table to see how large it is in GB. (Even when the number of rows is known, the size varies from catalog to catalog based on the number of columns requested and their contents.) Use this information to scale your query up to produce output files that are less than 2 GB.

- Query on indexed columns as much as possible. If you are using the web interface, you can see which columns are indexed in the table that allows you to select which columns to download. The indexed columns are marked with an X.

- Choose logical 'AND' and avoid 'OR' whenever possible when providing multiple constraints.

- For users with spatial constraints, a polygon search is generally faster than adding ra and dec constraints in the column constraint fields.

- In user-defined queries, avoid inefficient operations such as square roots and trigonometric functions.

Example Queries

Example 1: Perform a cone search of all measurements within 1 degree of M51 in the 2MASS Point Source Catalog; return ra, dec, J, H and K_s magnitudes.

1. At the start-up page, choose the 2MASS catalogs.
2. At the second page, choose the 2MASS All-Sky Point Source Catalog by clicking the selection button for that catalog; click 'Select' to bring up the query builder window for that catalog.
3. SPATIAL CONSTRAINTS: Select "Single Object Search" and enter "M51". Select "Cone," and enter 4

arcminutes radius of radial search ('PA' and "axial ratio' can be left blank for circular searches).
4. COLUMN CONSTRAINTS: Check the box in the "Sel" column for ra, dec, j_m, h_m and k_m; uncheck the "Sel" column for other columns.
5. ADDITIONAL CONSTRAINTS: clear out any constraints typed in this space.
6. Click "Run Query"
7. The Process Monitor window briefly appears, and then the results are loaded into the interactive viewer. (For documentation explaining the results, start from the Overview page.)

Example 2: Find all sources in the 2MASS Point Source Catalog that lie within 60 arcseconds of a list of sources; list the standard column output for these sources, and have a link to the results returned via e-mail upon completion.

1. At the start-up page, choose the 2MASS catalogs.
2. At the second page, choose the 2MASS All-Sky Point Source Catalog by clicking the selection button for that catalog; click 'Select' to bring up the query builder window for that catalog.
3. SPATIAL CONSTRAINTS: select "Multi-Object Search". Copy this source list to your disk and then upload it into the tool. The table must be in IPAC table file format.
4. OPTIONS: Enter a fully qualified email address; e.g. yourname@yourinstitution.edu.
5. COLUMN CONSTRAINTS: click 'Standard' column selection
6. ADDITIONAL CONSTRAINTS: clear out any constraints typed in this space.
7. Click "Run Query".
8. The Process Monitor window briefly appears, and then the results are loaded into the interactive viewer. (For documentation explaining the results, start from the Overview page.) An email is also sent upon completion.

Example 3: Simple query on the 2MASS Point Source catalog to retrieve all columns for all point sources fainter than 15th magnitude and confined to a strip of sky between declinations 17 and 18 degrees.

1. At the start-up page, choose the 2MASS catalogs.
2. At the second page, choose the 2MASS All-Sky Point Source Catalog by clicking the selection button for that catalog; click 'Select' to bring up the query builder window for that catalog.
3. SPATIAL CONSTRAINTS: Select "All-Sky Search" to search the entire catalog without spatial constraints.
4. OPTIONS: Enter a fully qualified email address; e.g. yourname@yourinstitution.edu.
5. COLUMN CONSTRAINTS: click "Long Form."
6. ADDITIONAL CONSTRAINTS: clear out any constraints typed in the space; type '(j_m > 15) and (h_m > 15) and (k_m > 15) and (dec between 17 and 18)'.
7. Click "Run Query".
8. The Process Monitor window appears for several seconds as it executes the query. You can check the status or stop the process from this screen. (It will result in 1205701 rows from the catalog, so it takes a little bit.)
9. The results are loaded into the interactive viewer. (For documentation explaining the results, start from the Overview page.) An email is also sent upon completion.

Additional Constraints

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Context

The Catalog Search Tool allows potentially complex constraints to be specified in SQL format in the "Additional Constraints" section of the search interface. These include several classes of constraints, both keywords and operators.

The examples given below show how queries can be built intuitively; these examples are given for each of the five types of search constraints that are supported.

Comparisons
Compares the values of one expression to another. The great majority of queries will be of this type, which use simple mathematical operators.
- ◊ declination > 40 selects rows with declinations above 40 degrees; user defined constraints then allow for broader constraints than can be entered through the spatial constraints form.
- ◊ j_m <= 11 and declination > 40 selects all rows having J magnitudes fainter than 11 and declinations above 40 degrees.

Ranges
Tests whether an expression falls within a certain range.
- ◊ ra between 12 and 14 selects rows having Right Ascension values between 12 and 14 hours
- ◊ ra not between 12 and 14 selects rows not between 12 and 14 hours

Set memberships
Tests whether an expression matches any one of a set of values.
- ◊ Hubble_Type in ('Sa', 'Sb', 'Sc') selects rows where the Hubble Type has values of Sa, Sb or Sc. This is equivalent to Hubble_Type ='Sa' or Hubble_Type ='Sb' or Hubble_Type ='Sc'

Pattern Matching
Tests whether the value of a column containing string data matches a specified pattern.
- ◊ cc_flag ='000' selects rows where the quality flag has values of '000'
- ◊ id_opt like ' USNOA %' selects rows where the optical counterpart has a name beginning with USNOA.

Null values
Checks whether a column has a null value.
- ◊ Fnu(60) is not null returns only those entries whose 60 micron flux has a measured (non-null) value.

This query on the 2MASS All Sky Point Source Catalog:

> "return all sources at galactic latitudes greater 30 degrees with K magnitudes between 14 and 17 and uncertainties of less than 0.05 mag, that are not flagged as contaminated by extended sources and have a blue-red optical color of less then 1.5"

is built by the user-defined constraint:

(glat > 30) and (k_m between 14 and 17) and (k_msigcom < 0.05) and (gaLcontam=0) and (b_m_opt - r_m_opt)

For users conversant with SQL, the tool uses the user-defined constraints to set up a WHERE clause in the SQL statement submitted to the DBMS.

List of operators/keywords

Any blank spaces around operators are ignored (for instance, "> =" is equivalent to ">="). In comparing character data, "" means later in the alphabet. In comparing dates, "" means later. Be sure to put single quotation marks (') around all text and date/time columns.

The only WHERE conditions that you can use on character columns are "=" (equals), LIKE or NOT LIKE. There are numerous character columns in the astronomical catalogs maintained at IPAC. Use the "COLUMN CONSTRAINTS / OUTPUT COLUMN SELECTION" panel to view the data type for any column of interest.

keyword/operator	description	syntax	example using AllWISE Source Catalog 1000 arcsecond cone search centered on M81
=	Compares two expressions. The result is TRUE if both operands are equal. Otherwise, the result is FALSE.	expression = expression	designation = 'J095824.30+685729.3'
!=	Compares two expressions. The result is TRUE if the left operand is not equal to the right operand. Otherwise, the result is FALSE.	expression != expression	designation != 'J095824.30+685729.3'
<	Compares two expressions. When comparing numeric values, the result is TRUE if the left operand has a lower value than the right operand.	expression < expression	w1mpro < 16 designation < 'J095824.30+685729.3'

keyword/operator	description	syntax	example using AllWISE Source Catalog 1000 arcsecond cone search centered on M81
	When comparing character values, the results is TRUE if the left operand is earlier in the alphabet than the right operand. When comparing dates, the results is TRUE if the left operand is earlier than the right operand. Otherwise, the result is FALSE.		
<=	Compares two expressions. When comparing numeric values, the result is TRUE if the left operand is less than or equal to the right operand. When comparing character values, the results is TRUE if the left operand is earlier in the alphabet or equal to the right operand. When comparing dates, the results is TRUE if the left operand is earlier or equal to the right operand. Otherwise, the result is FALSE.	expression <= expression	w1mpro<=16 designation<='J095824.30+685729.3'
>	Compares two expressions.	expression > expression	w1mpro>16 designation>'J095824.30+685729.3'

keyword/operator	description	syntax	example using AllWISE Source Catalog 1000 arcsecond cone search centered on M81
	When comparing numeric values, the result is TRUE if the left operand is greater than the right operand. When comparing character values, the results is TRUE if the left operand is later in the alphabet than the right operand. When comparing dates, the results is TRUE if the left operand is later than the right operand. Otherwise, the result is FALSE.		
>=	Compares two expressions. When comparing numeric values, the result is TRUE if the left operand is greater than or equal to the right operand. When comparing character values, the results is TRUE if the left operand is later in the alphabet or equal to the right operand. When comparing dates, the results is TRUE if the left operand is later than or equal to the right	expression >= expression	w1mpro>=16 designation>='J095824.30+685729.3'

keyword/operator	description	syntax	example using AllWISE Source Catalog 1000 arcsecond cone search centered on M81
	operand. Otherwise, the result is FALSE.		
NOT	Used to negate an operation.	NOT expression	w2sigmpro IS NOT NULL dec NOT BETWEEN 69 AND 69.1
BETWEEN	Specifies a range to test. BETWEEN returns TRUE if the value of test_expression is greater than or equal to the value of begin_expression and less than or equal to the value of end_expression.	test_expression [NOT] BETWEEN begin_expression AND end_expression	ra BETWEEN 148.6 AND 149.2 dec NOT BETWEEN 69 AND 69.1
IN	Determines if a given value matches any value in a subquery or a list.	test_expression [NOT] IN ('expression', 'expression', ... , 'expression')	ph_qual IN ('ABUU', 'BUUU', 'BCCU')
LIKE	Determines whether a character string matches a specified pattern. A pattern can include regular characters and wildcard characters. During pattern matching, regular characters must exactly match the characters specified in the character string. Wildcard characters, however, can be matched with arbitrary fragments of the character string. IRSA's Catalog Search Service accepts two	match_expression [NOT] LIKE pattern	designation LIKE 'J0958%' - selects any designation that starts with 'J0958%' designation LIKE '%0958%' - selects any designation with '0958' in it. ph_qual LIKE 'AAA_' - selects any ph_qual with four letters, the first three of which are 'AAA'.

keyword/operator	description	syntax	example using AllWISE Source Catalog 1000 arcsecond cone search centered on M81
	wildcards: % (percent; matches any string of >0 characters) _ (underscore; matches any single character) If you would like to include percent or underscore in your pattern, but do not wish them to be interepreted as wildcards, then you may specify an escape character using "ESCAPE escape_parameter".		
IS [NOT] NULL	An entry of NULL in a data table means that there is no entry (e.g., missing data). NULL is not synonymous with 'zero' or 'blank'. 'NULL' and 'null' are equivalent. If the value of expression is NULL, IS NULL returns TRUE; otherwise, it returns FALSE. If the value of expression is NULL, IS NOT NULL returns FALSE; otherwise, it returns TRUE.	expression IS [NOT] NULL	w2sigmpro IS NOT NULL w2sigmpro IS NULL
AND	Combines two expressions and returns TRUE when	expression AND expression	(w2sigmpro IS NOT NULL) AND (ra BETWEEN 148.6 AND 149.2)

keyword/operator	description	syntax	example using AllWISE Source Catalog 1000 arcsecond cone search centered on M81
	both expressions are TRUE. When more than one logical operator is used in a statement, AND operators are evaluated first. You can change the order of evaluation by using parentheses.		
OR	Combines two conditions. When more than one logical operator is used in a statement, OR operators are evaluated after AND operators. However, you can change the order of evaluation by using parentheses.	expression OR expression	(ra BETWEEN 148.6 AND 149.2) OR (dec NOT BETWEEN 69 AND 69.1)
+	plus	expression + expression	
-	minus	expression - expression	
/	divided by	expression / expression	
*	multiply	expession * expression	
%	modulo, the remainder left after division of two numbers.	expression % expression	
ABS	Absolute Value	abs(expression)	
ACOS	Arc Cosine	acos(expression)	
ASIN	Arc Sine	asin(expression)	
ATAN	Arc Tangent	atan(expression)	
COS	Cosine	cos(expression)	
EXP	Returns the exponential value in scientific notation of the argument	exp(expression)	EXP(198.1938327) = 1.18710159597953E+86
FLOOR	Returns the largest integer equal to or less than the specified argument.	floor(expression)	floor(15.7) = 15.

keyword/operator	description	syntax	example using AllWISE Source Catalog 1000 arcsecond cone search centered on M81
LOG	Logarithm (base 10)	log(10, expression)	
POWER	numeric_expr raised to the power of p	power(expression, p)	
RAND	Produce a random float number between 0 and 1. When invoked with the optional integer argument, that value will be used to seed the random number generator. For a specified seed value, the result returned is always the same.	rand([integer_expression])	rand() rand(10)
ROUND	Returns the rounded value of the first expression, out to integer_expression digits	round(expression, integer_expression)	ROUND(123.9994, 3)=123.999 ROUND(123.9995, 3)=124.0000 ROUND(150.75, 0)=151.00
SIN	Returns the trigonometric sine of the specified angle, in radians.	sin(expression)	
SQRT	Returns the square root of the specified float.	sqrt(expression)	
TAN	Returns the trigonometric tangent of the specified angle, in radians.	tan(expression)	

Catalog Search Tool: Solar System Objects

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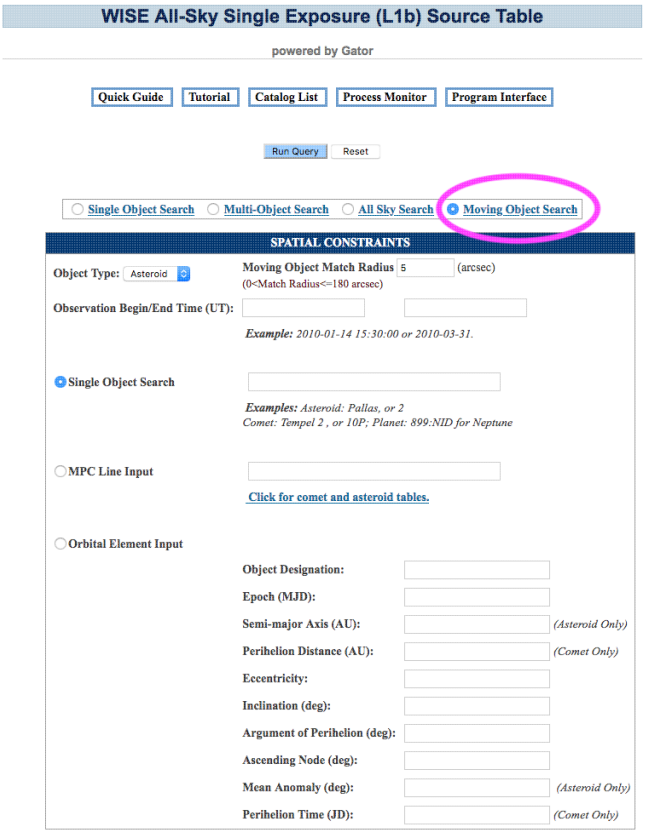
Overview

For some IRSA catalogs, it is possible to search for moving objects (Solar System objects) using the Catalog Search Tool. This is useful for a "pre-covery" search, looking for possible prior observations of a known target, whether or not that target was known or identified at the time. This search mode is only available for catalogs having single-epoch position and timestamp information within them, such as the WISE All-Sky Single Exposure (Level 1b) Source Table, or the NEOWISE-R Single Exposure (Level 1b) Source Table.



The object's ephemeris is used to calculate predicted positions within the time range of the catalog of interest, and then a position cone search match against the catalog is done. Additional constraints may be supplied by the user, e.g. adjusting the search radius in the Moving Object Match Radius box.

There are three Solar System object/orbit search types:

- by the object name or numeric designation;
- using the Minor Planet Center (MPC) one-line element format; or
- using the six orbital elements at a given epoch supplied by the user.

Using the object name or numeric designation is preferred, as the osculating orbital elements nearest in time to the observations will be used.

Object Name

Search by object name by entering the name or numeric designation in the "Single Object Search" field. For asteroids, one can enter either the ID number, name, or designation; e.g. 1917, Cuyo, or 1968 AA. It can handle names with apostrophes and dashes like O'Connell and Pic-du-Midi. For comets one can enter the numeric ID, e.g. 10P for 10P/Tempel 2, or a designation, e.g. 2009 WJ50 for 233P/La Sagra. Planetary satellites (and planets, where possible) can be input by name, e.g. Titan.

There can be name ambiguities. For example, entering "WISE" is a problem as there were many asteroids and comets discovered by the WISE mission. Entering "Neptune" is unclear as there are ephemeris files for both Neptune and the Neptune system barycenter. The tool will deliver a messsage if there is an ambiguity, either via the web page, or via a link to a log file for a non-interactive session. The message will contain suggested NAIF ID's, and you can use them as follows, e.g. "1003094:NID" for comet 317P/WISE or "899:NID" for Neptune. In a few cases, there are satellites and asteroids with the same name, and you may distinguish them by, e.g. "Europa:SAT" and "Europa:AST".

MPC Input

One can also search using a Minor Planet Center input string. The format is given here for minor planets and comets.

If the data were taken at the same epoch as the epoch of the MPC orbital elements, one could cut-and-paste a line directly from a table, e.g. the MPC Orbit (MPCORB) Database.

MPC One-line Element Input Examples, where e=eccentricity, a=semimajor axis, M=mean anomaly, i=inclination, Node=longitude of the ascending node, w=argument of perihelion, q=perihelion distance, Tp=time of perihelion passage, n=mean motion, H=absolute magnitude and G=slope parameter.

ASTEROID: Icarus

Designation	H	G	Epoch	M	w	Node	i	e	n	a
01566	16.9	0.15	K1128	78.13687	31.35339	88.02734	22.82772	0.8268277	0.88069351	1.0779191

COMET: C/2010 A4 (Siding Spring)

Name/Design	Tp	q	e	w	Node	i	Epoch	H	G	Name
CK10A040	2010 10 8.7896	2.738033	0.990439	271.6989	346.6856	96.7301	20110208	12.5	4.0	C/2010 A4 (Siding Spring)

Orbit Element Input

The user can alternately input the standard six orbital elements for an object. Best results will be obtained if these are the osculating elements at the same epoch as the observations. For an asteroid these are

- eccentricity,
- semimajor axis,
- mean anomaly,
- inclination,
- longitude of the ascending node, and
- argument of perihelion.

For comets, the elements are

- eccentricity,
- perihelion distance,
- time of perihelion passage,
- inclination,
- longitude of the ascending node, and
- argument of perihelion.

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.

A good description of the orbital parameters is given in JPL's Solar System Dynamics web site.

Observation Time

The user has the option to fill in specific observation begin and end times in UT, or leave them blank. In the latter case, the whole observation range of the catalog is used.

The rest of the options are the same as a non-moving (inertial, not in the Solar System) object search.

Catalog Search Tool: Images

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

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HiPS Images: General Information & Definitions

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

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

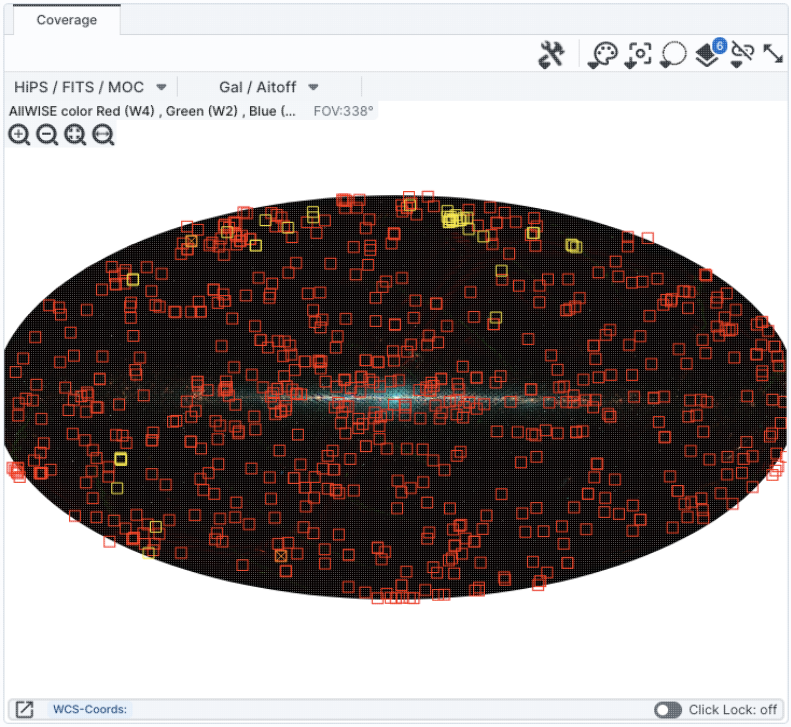
There are HiPS images from all over the world available via the web; the complete list of HiPS images available from the images search page includes (once the "IRSA Featured" checkbox is unchecked) many HiPS images from CDS.

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

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

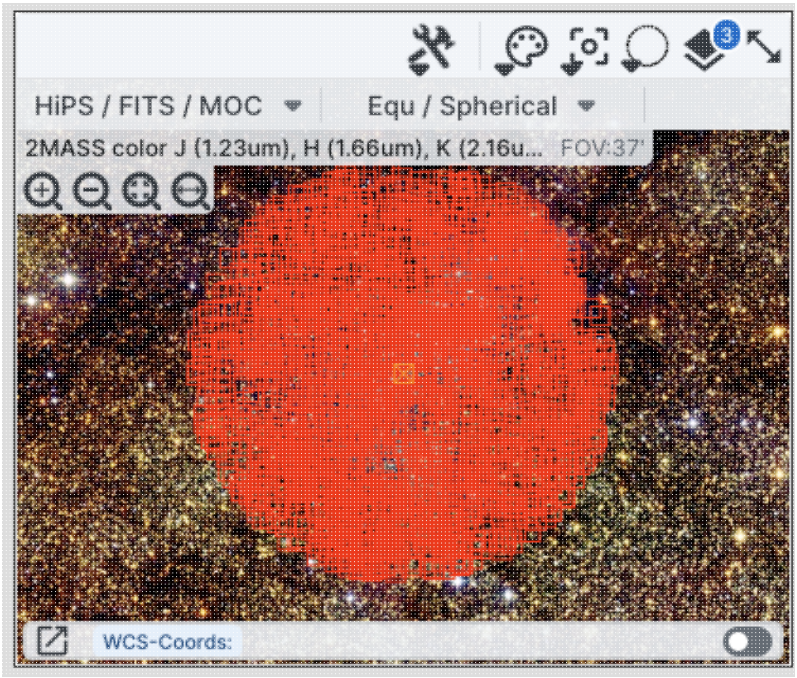
Coverage Image

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



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

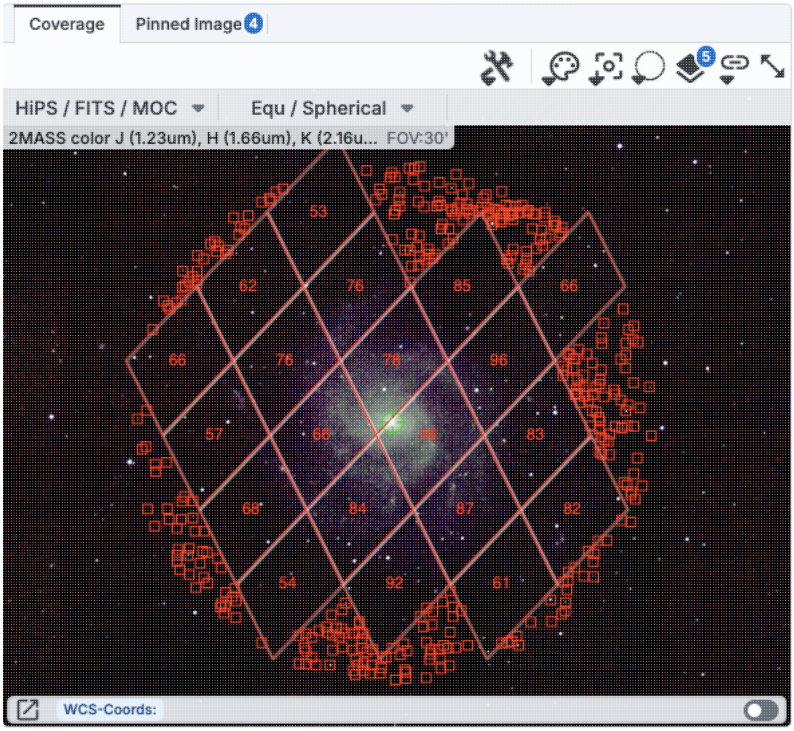
Note that in this case, the catalogs cover the whole sky, so the HiPS image is displayed in HiPS/Aitoff projection to show the whole sky.



You can also have a coverage image like this, which shows a coverage image that has polygons demonstrating the coverage of each a list of loaded images (large polygons) and the locations of spectra (small squares). This case only has data over a relatively small region, so the HiPS image is zoomed in comparatively tightly on the relevant region.

You might have a coverage image something like this, which shows a coverage image with a complex catalog overlaid. (This case still only has data over a relatively small region, so the HiPS image is zoomed in comparatively tightly on the relevant region.) In this case, the catalog is more than 1000

sources, so the tool has shown you individual sources in the HEALPix cells where there are fewer sources than a given threshold, and where there are more sources, it simply shows you the cell and the total number of sources in that cell. The tool is rendering the catalogs in a hierarchical fashion, similar to how HiPS images work. You can control what this threshold is and how it renders the cells from the layers pop-up.

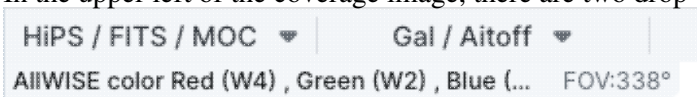


In all cases, you can interact with the coverage image in pretty much exactly the same way as you would any other image loaded into this tool; see the the visualization chapter for much more about those tools.

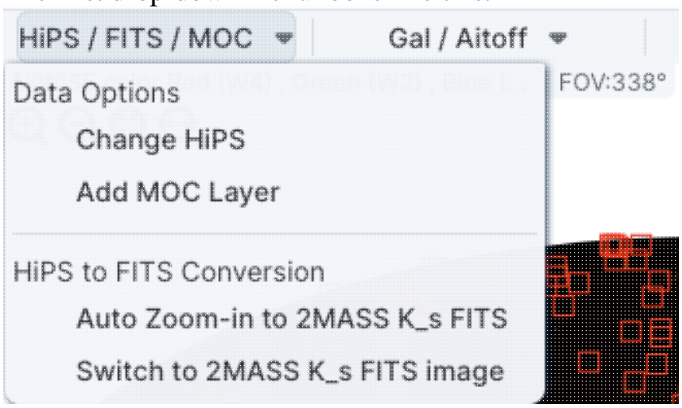
The thing that makes a coverage image a little bit different, however, is that it can automatically adapt, even beyond what a HiPS image can intrinsically do. The next subsection includes more details about how it can automatically change to accomodate your needs and zoom level.

Upper Left HiPS menus

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



The first drop-down menu looks like this.

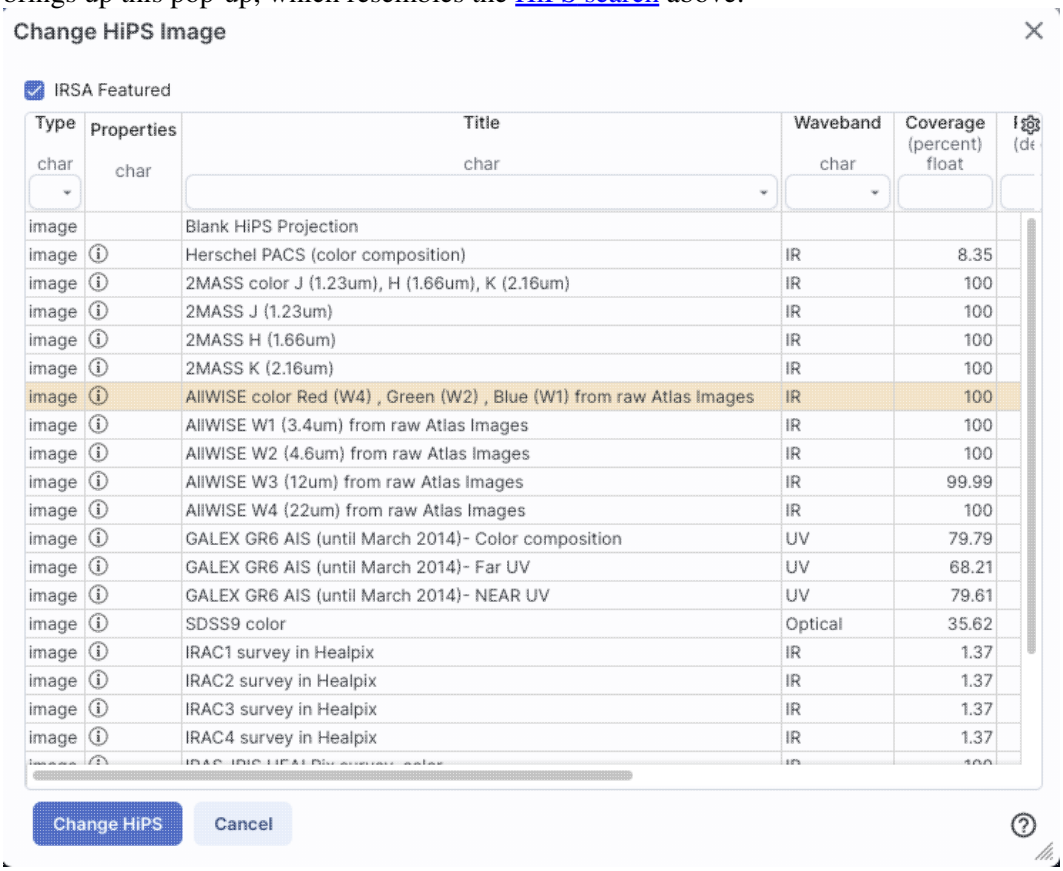


There are two sections here.

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

Change HiPS: Changing HiPS images

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



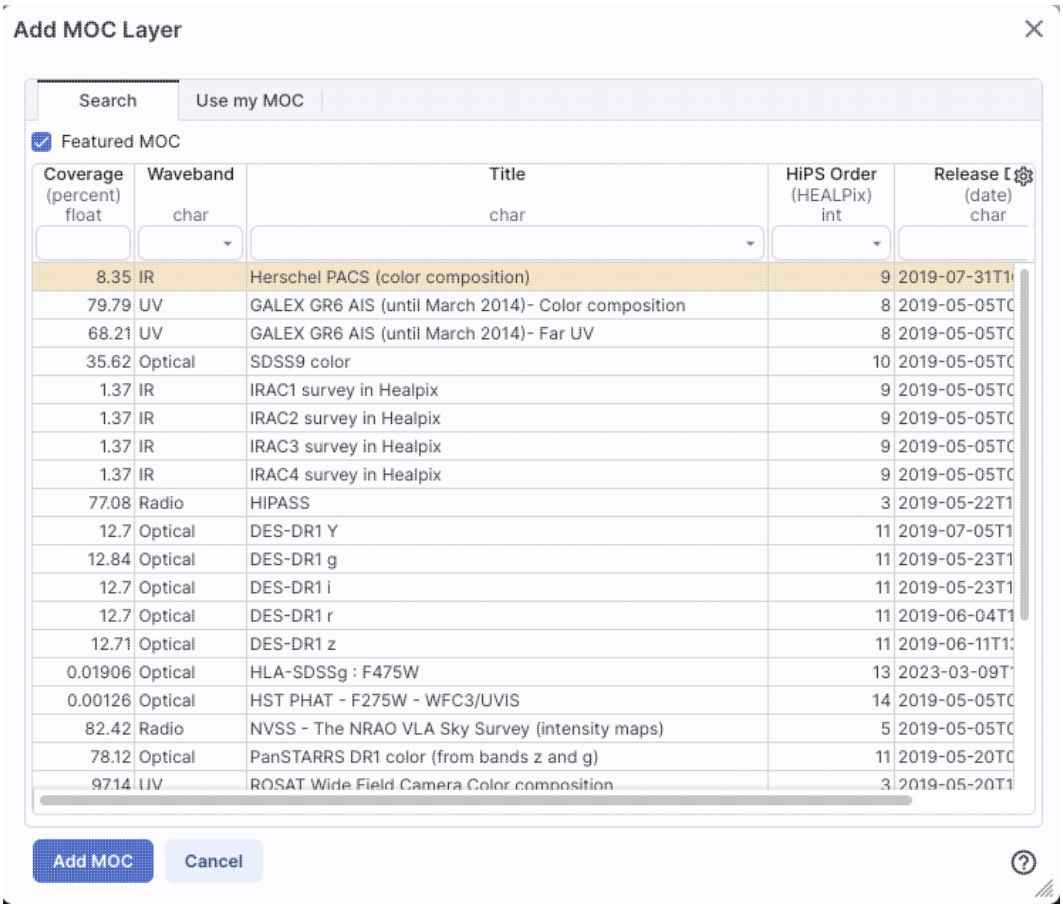
Type (char)	Properties (char)	Title (char)	Waveband (char)	Coverage (percent) (float)
image		Blank HiPS Projection		
image	ⓘ	Herschel PACS (color composition)	IR	8.35
image	ⓘ	2MASS color J (1.23um), H (1.66um), K (2.16um)	IR	100
image	ⓘ	2MASS J (1.23um)	IR	100
image	ⓘ	2MASS H (1.66um)	IR	100
image	ⓘ	2MASS K (2.16um)	IR	100
image	ⓘ	AllWISE color Red (W4) , Green (W2) , Blue (W1) from raw Atlas Images	IR	100
image	ⓘ	AllWISE W1 (3.4um) from raw Atlas Images	IR	100
image	ⓘ	AllWISE W2 (4.6um) from raw Atlas Images	IR	100
image	ⓘ	AllWISE W3 (12um) from raw Atlas Images	IR	99.99
image	ⓘ	AllWISE W4 (22um) from raw Atlas Images	IR	100
image	ⓘ	GALEX GR6 AIS (until March 2014)- Color composition	UV	79.79
image	ⓘ	GALEX GR6 AIS (until March 2014)- Far UV	UV	68.21
image	ⓘ	GALEX GR6 AIS (until March 2014)- NEAR UV	UV	79.61
image	ⓘ	SDSS9 color	Optical	35.62
image	ⓘ	IRAC1 survey in Healpix	IR	1.37
image	ⓘ	IRAC2 survey in Healpix	IR	1.37
image	ⓘ	IRAC3 survey in Healpix	IR	1.37
image	ⓘ	IRAC4 survey in Healpix	IR	1.37

Things to note:

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

Add MOC Layer: Adding a MOC Overlay

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



Things to note:

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

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

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

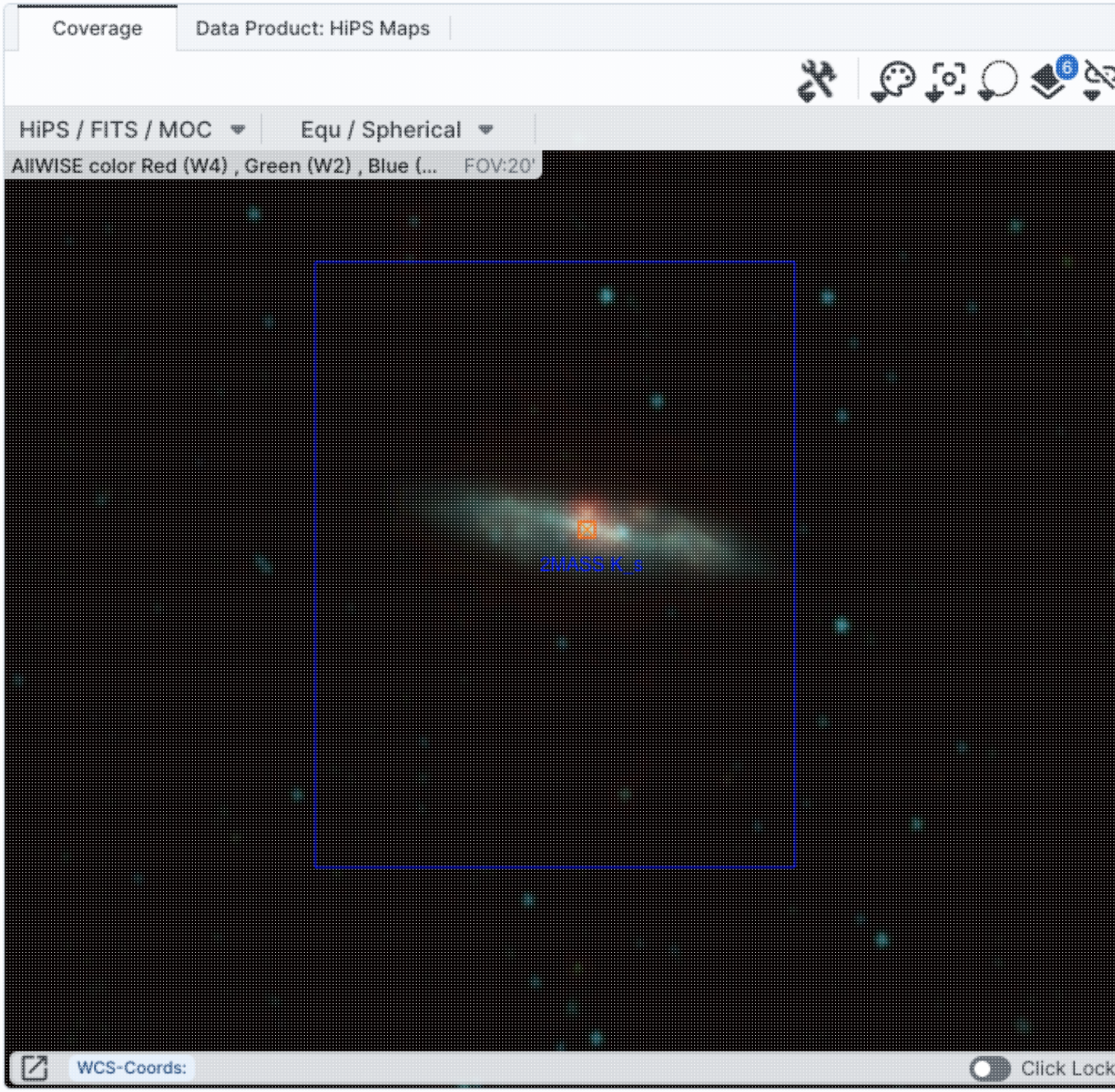
Auto Zoom-in to 2MASS K_s FITS:

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

Switch to 2MASS K_s FITS image:

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

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



The second drop-down menu looks like this.

There are three sections in this menu.

Orientation

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

Center Galactic

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

Projection

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

Catalog Search Tool: Visualization

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

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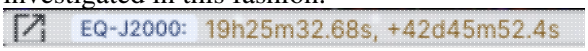
FITS/HiPS Image Viewer

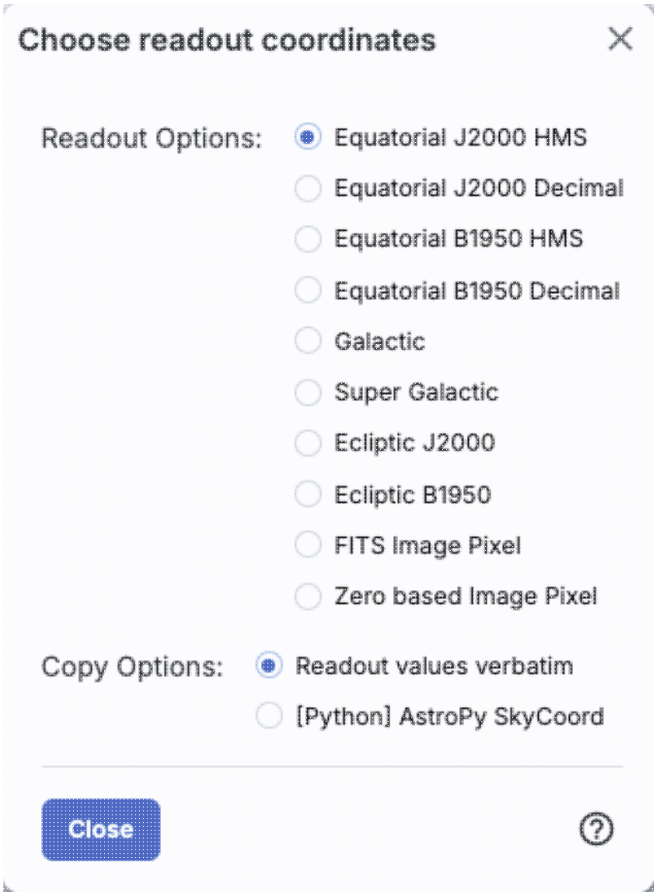
You can interactively explore the image with the mouse. Move your mouse over any image that is loaded into the viewer. Details about the image, specifically, the pixel beneath your mouse cursor, appear along the bottom left of the image window. The image coordinates are updated in real time. The image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



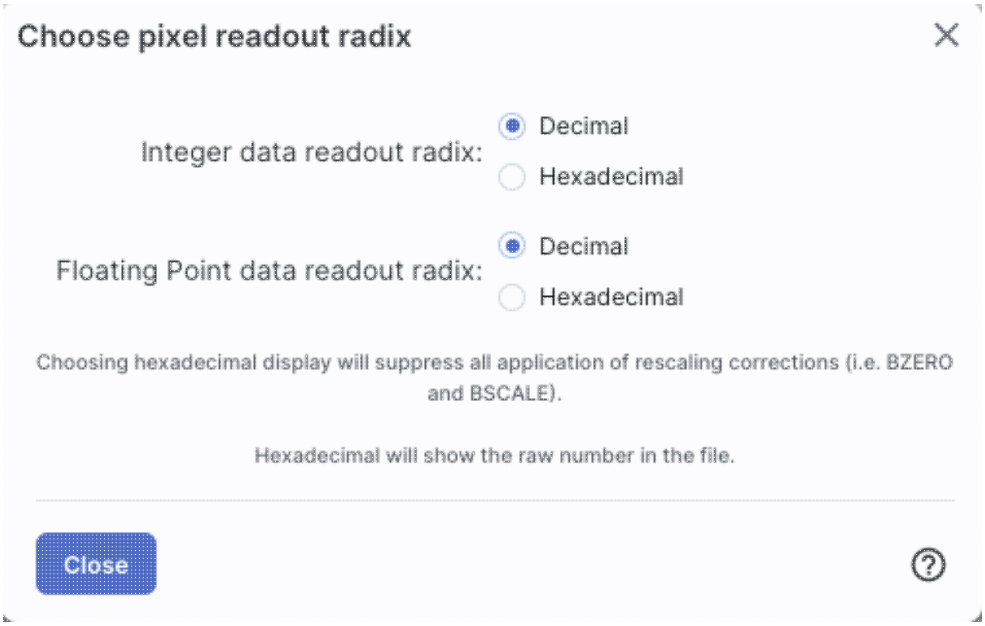
If you click on the label of the coordinates, "EQ-J2000" in the screenshot example above, you get this pop-up, from which you can choose the coordinates from among:

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

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



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



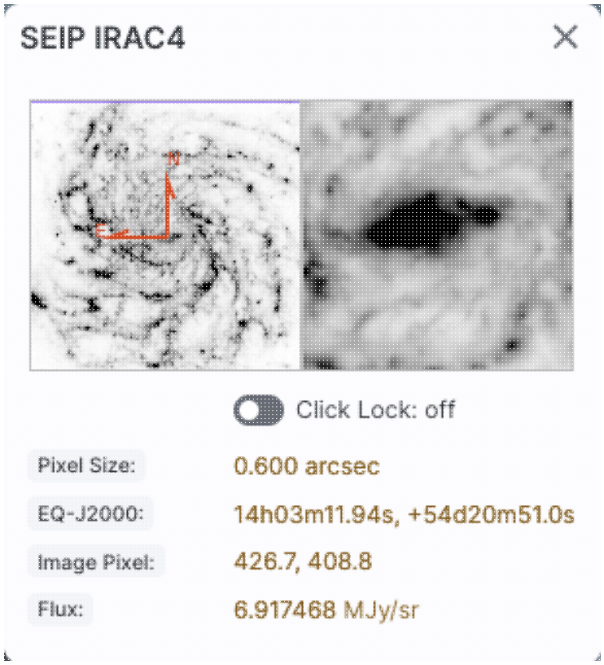
If you have a FITS image loaded, you have an additional readout. Click on the label of the readout, "Value" in the screenshot example above, you get this pop-up, from which you can choose the pixel readout from among:

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

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

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

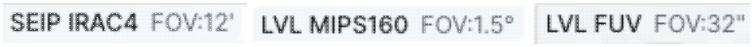
In the lower left of the images, if you click on this: , you get this pop-up. If you have a FITS image loaded, at the top of this pop-up, it shows the whole image; the orientation of the image is given with a compass rose. There is also a zoom-in of the image at the location under your cursor. Underneath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



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

Image Information

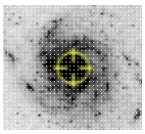
The upper left corner of the loaded image has a label that tells you basic things about the image you are viewing. The telescope and/or instrument and/or channel and/or data release is first, in black. The field of view follows, in a paler font; this corresponds to the (horizontal) width of the image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



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

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

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


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

Breaking Out of the Pane (and Going Back)

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

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

Go back the way it was: 

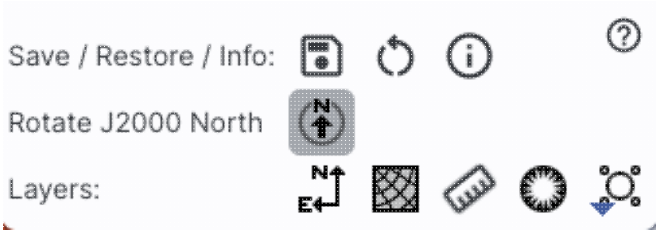
The large "Close" arrow at the upper left is always available in the expanded views, and enables you to return back to the pane view.

Image Toolbar (FITS and HiPS)

The image toolbox:

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


Tools drop down
The choices here look like this:



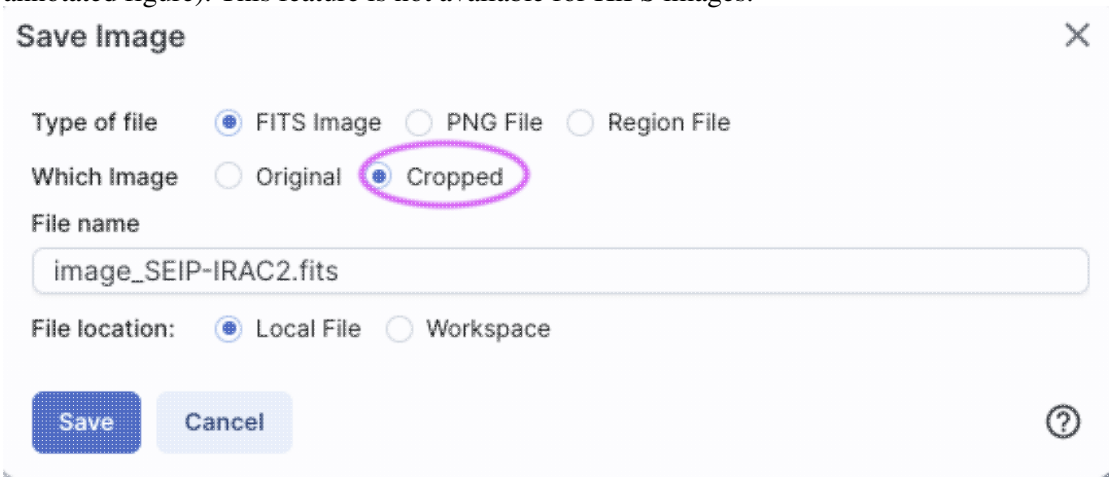
jump to save
jump to rotate
jump to layers

Saving the image

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

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

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



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 >5,000 sources, it's entirely likely that not every source will be overlaid on the image (because of hierarchical catalogs display), 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 before saving the PNG.

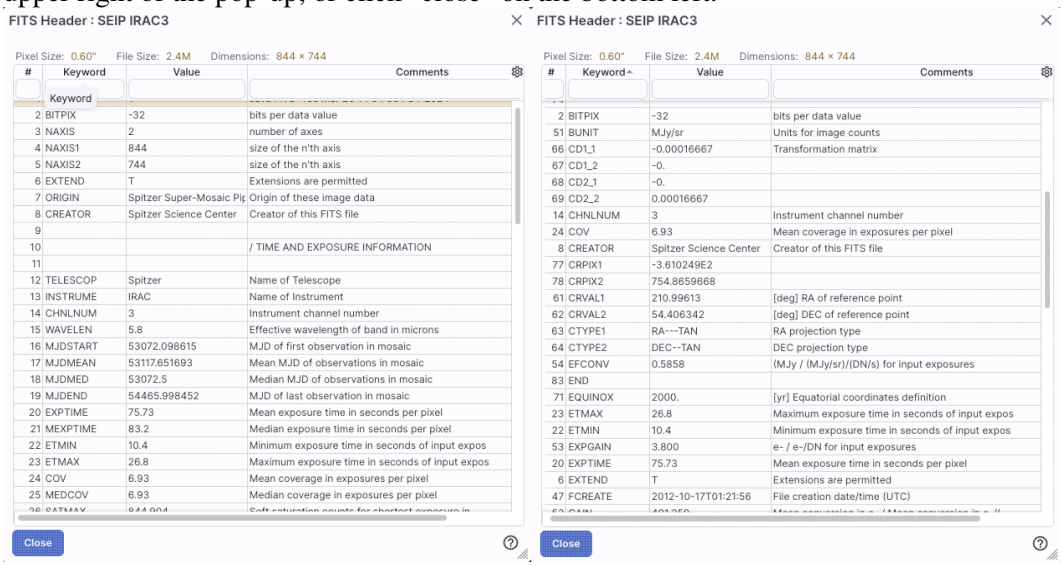
You can't save HiPS images from within IRSA's tool. To download your own copy, you will have to track down the original source of the image.

Restoring everything to the defaults

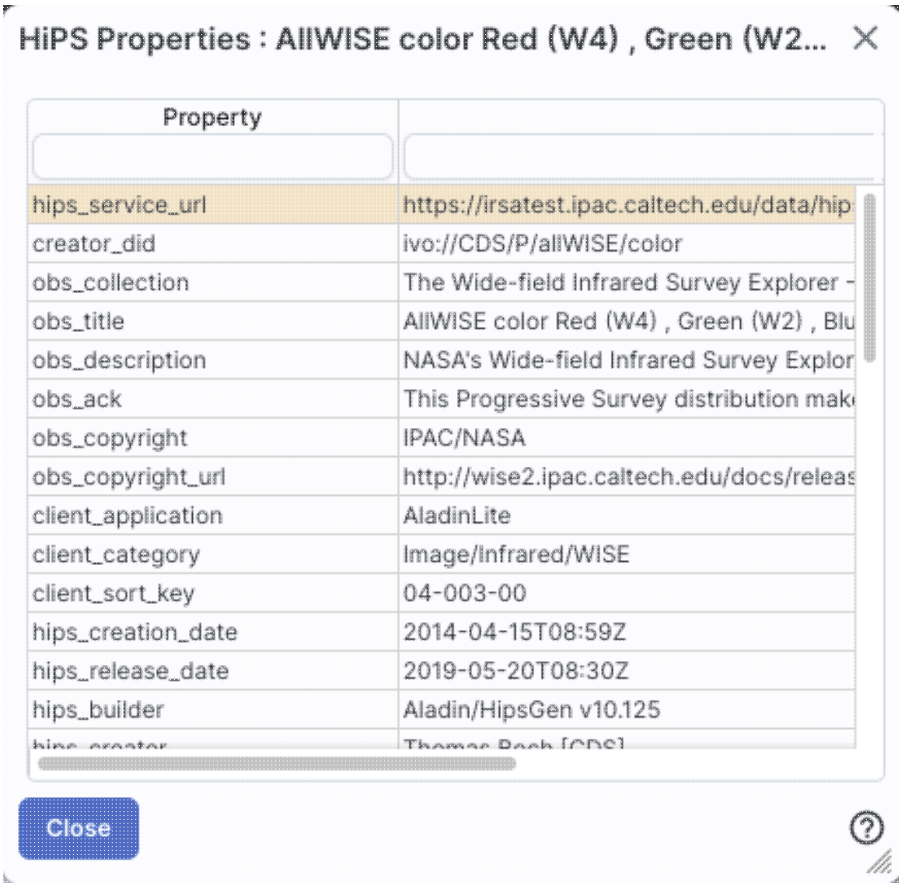
If you've played around a lot with the image, you may want to undo everything you've done. Click this button to restore everything to their original default values. Some layers may persist; remove them via the layers icon.

Viewing the image header

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



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



Rotating the image so that North is up

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

Flipping the image on the y-axis

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

Add a compass rose

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

Add a coordinate grid

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

Measuring a distance

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

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

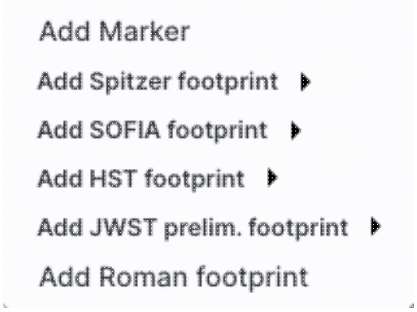
Read in a DS9 Regions file

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

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

Put a marker on the image

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



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

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

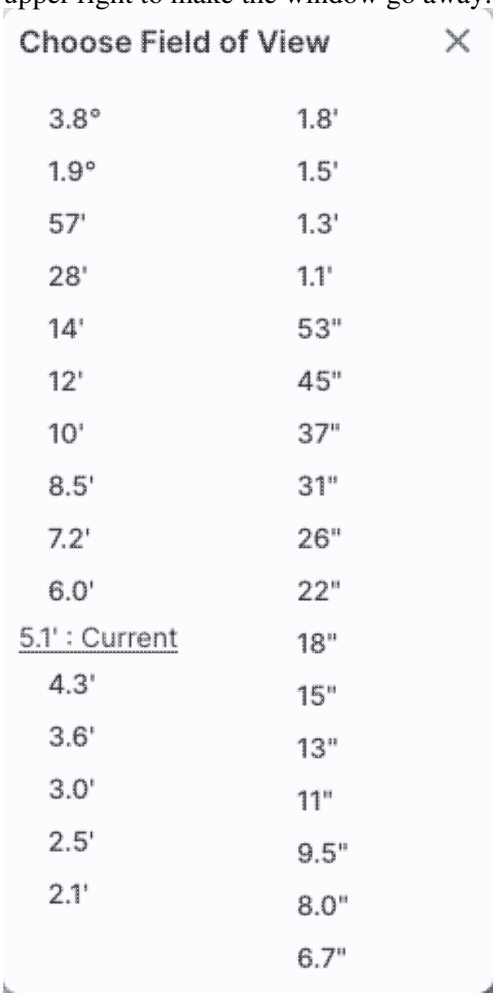
Zoom

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

Zooming in or out

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

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



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

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

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

Fit image to screen or fill screen

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

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

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

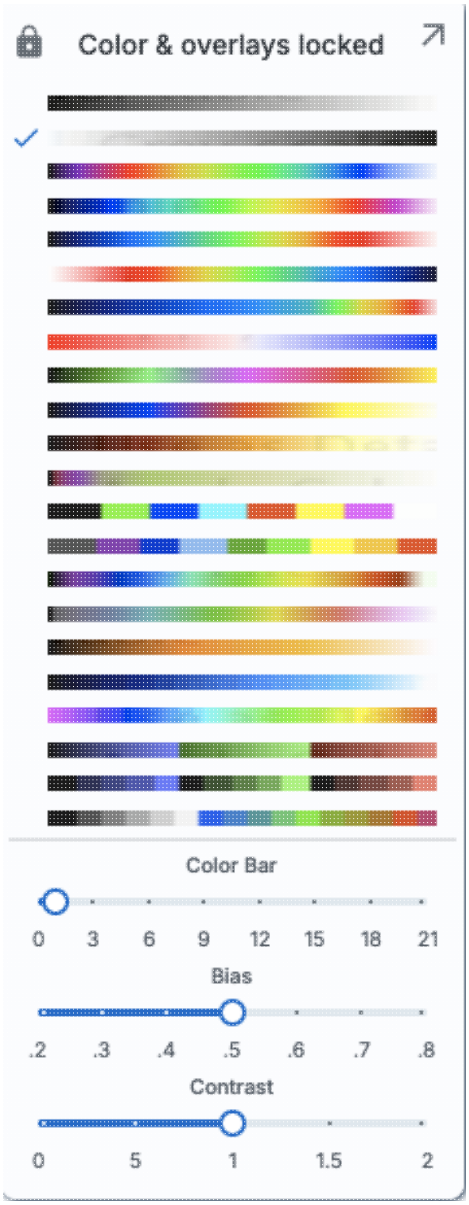
 *Zooming to a 1-to-1 size*

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

 *Color table drop down*

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

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




Color stretch drop down

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


Re-center the image drop down

Clicking this icon produces a drop-down menu:

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

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

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

Selecting a region drop down

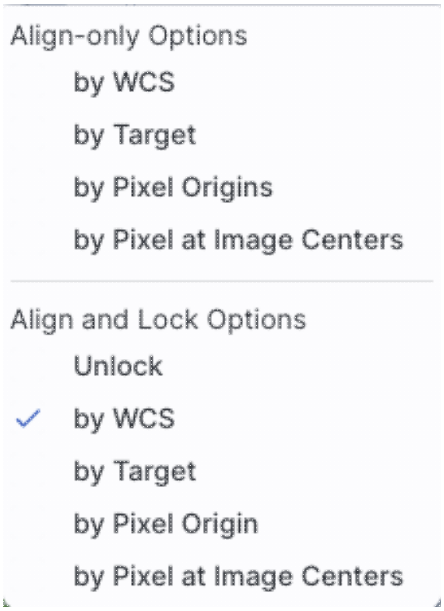
When you click this icon, you can select a region of the image for further actions. Because this is complicated, for much more information, please see below.

Image Layers: Viewing/Changing the Layers on the Image

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

Lock/unlock images

You may or may not have this "lock images" icon appear in your toolbar; it will appear as the first icon if they are locked and the second icon if they are unlocked. The main purpose of this icon is to lock all the images you have loaded for zooming, scrolling, etc. You need to specify how it locks and for how long. Clicking it produces this drop-down menu:

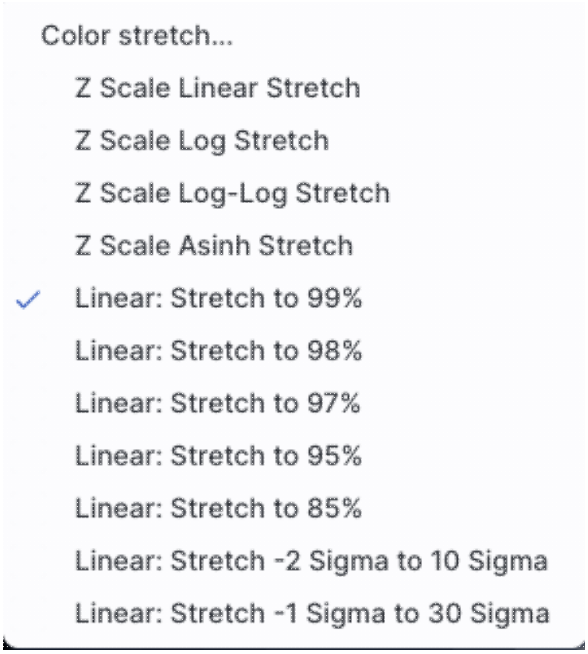


The first set of options aligns the images only once, temporarily; the second set of options makes the alignment persist ("lock") when you move the images (that is, when you move one, they all move). You can align by the images' WCS (e.g., RA and Dec), by the target, by the pixels according to the origin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

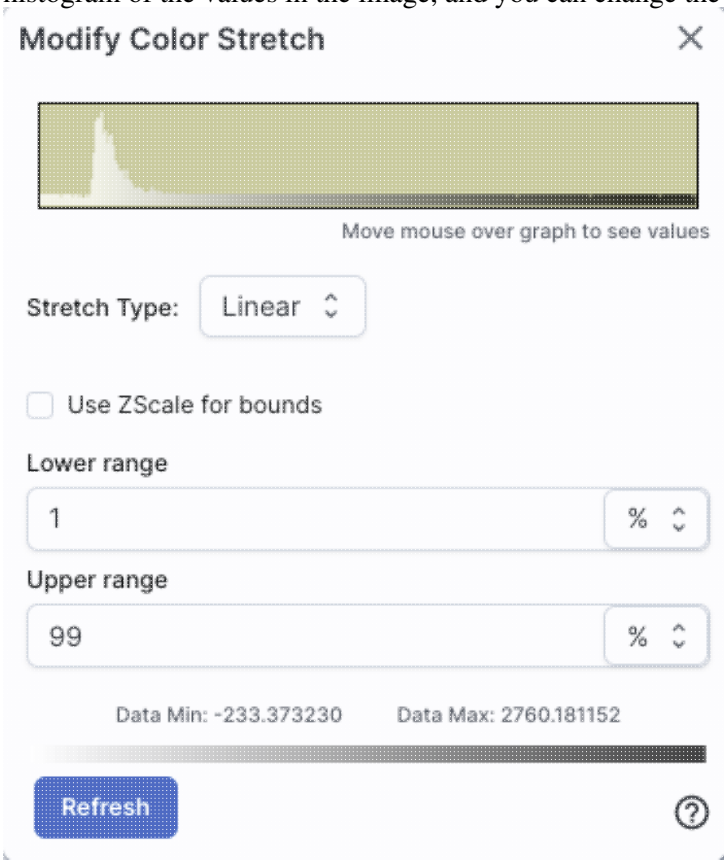
Getting help
Clicking on this icon takes you to this help page.

Color Stretches

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



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



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

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

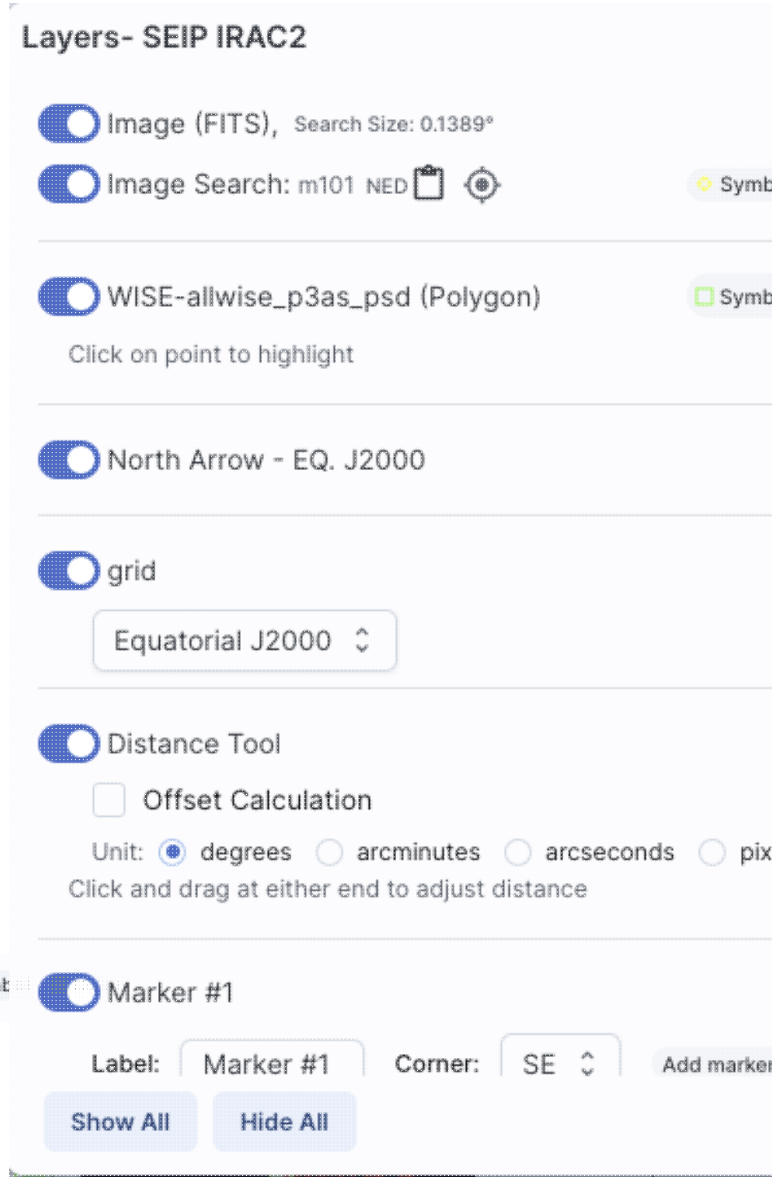
from the standard options. Note that the values in the pop-up change to reflect this current choice. From the pop-up, pick a different stretch type -- try "histogram equalization." Select "refresh" to update the images. Go back to the drop-down menu. The last 7 items have changed to be based on histogram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

Viewing/changing the layers on the image

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

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

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



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

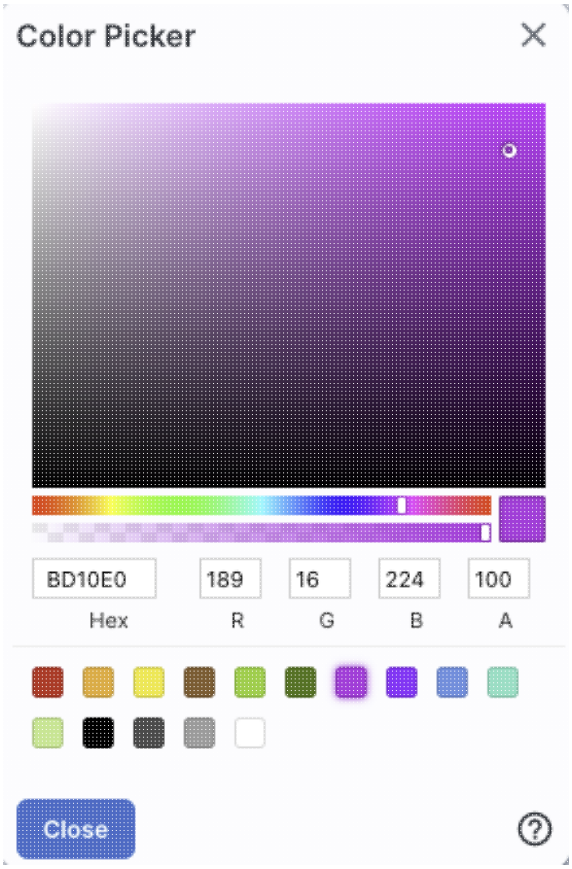
To add entirely new layers, though, you need to go to other options within the toolbar.

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

Note the target description:

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

clipboard" and "center image on this position."

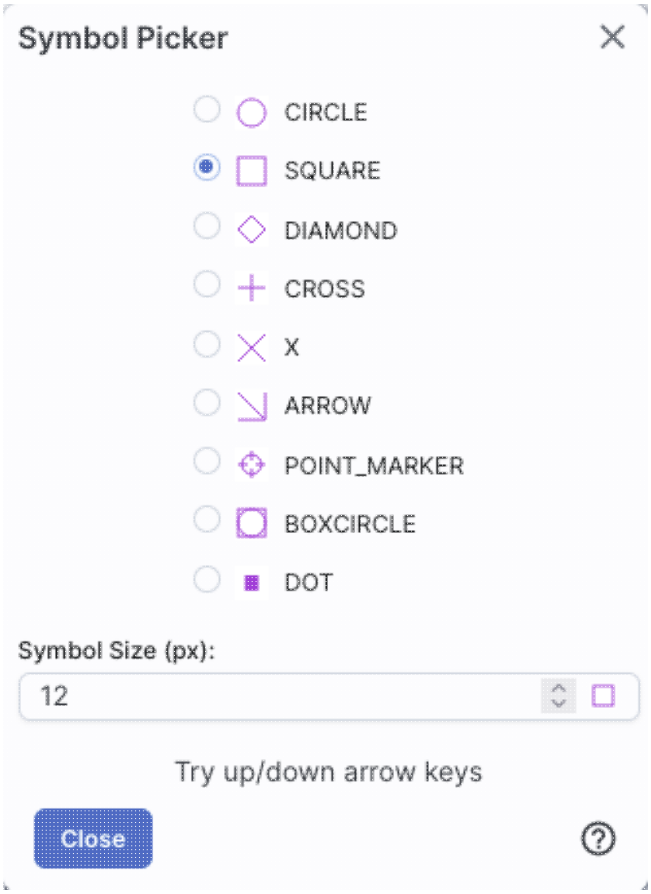


Where it's possible to change colors of a layer, click on the 'colors' link to be taken to a new pop-up from which you can select a new color.

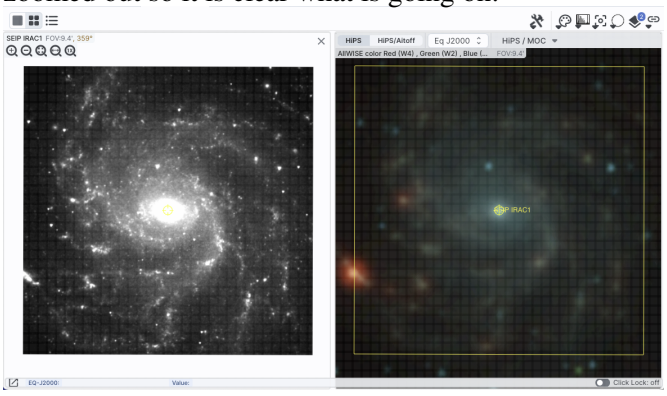
From here, you can click on your desired color in the top colorful box. Immediately below that box, you can change the color and saturation of the top box so that you can select from a different range of colors. Below that, you can enter numerical hex codes or RGBA values (where the value for RGB is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

If you have more than one catalog loaded into the tool, you can also obtain this pop-up by clicking on the color swatch in the heading of the catalog tab.

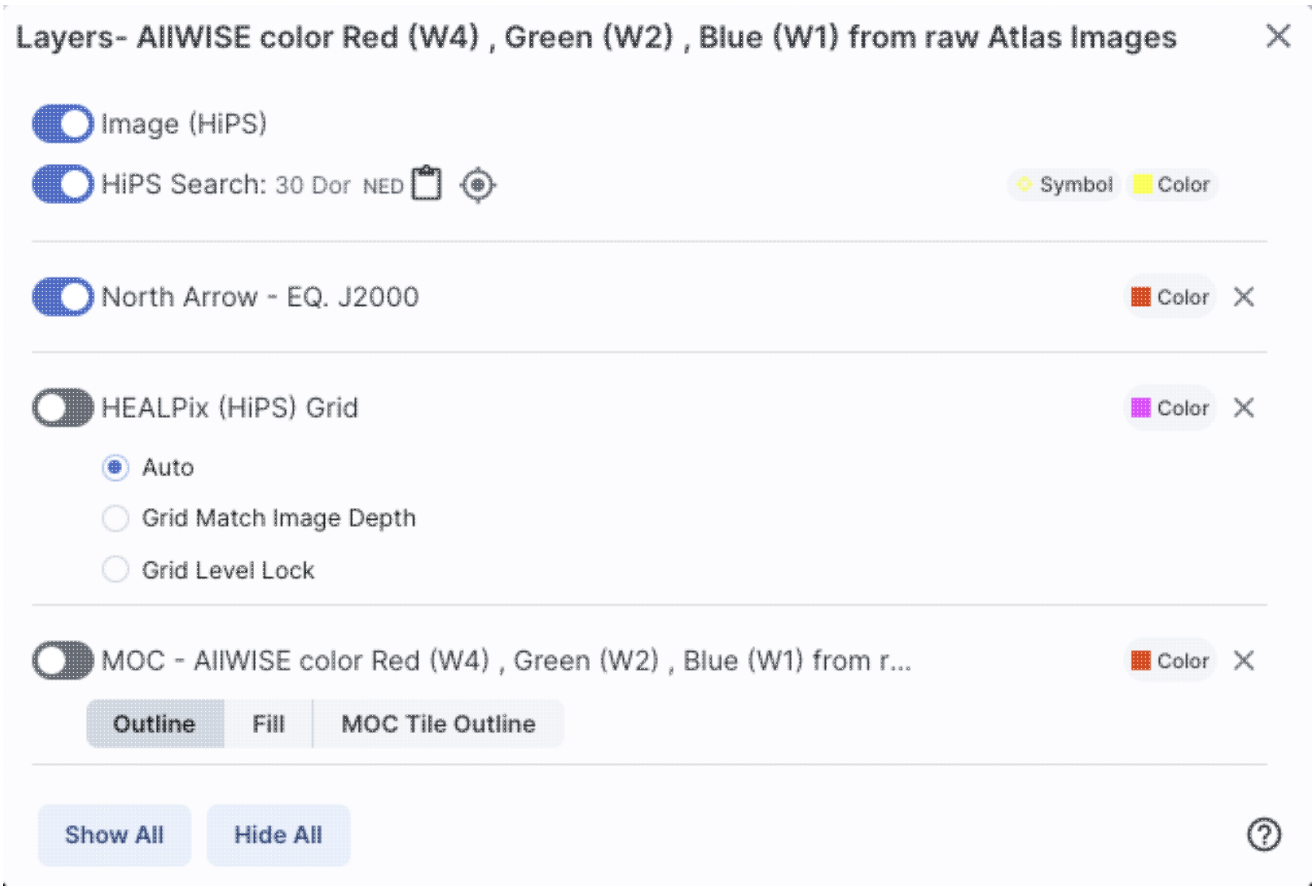
For catalogs or the search target, you can also select the symbol shape and size. To adjust the size, type in the symbol size in pixels or use the up/down arrow keys to change the size by one pixel at a time. Your choices are implemented as soon as you select them. Click 'Close' to close the window,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



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



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



HEALPix (HiPS) Grid

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

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

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

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

HiPS MOC

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

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

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

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

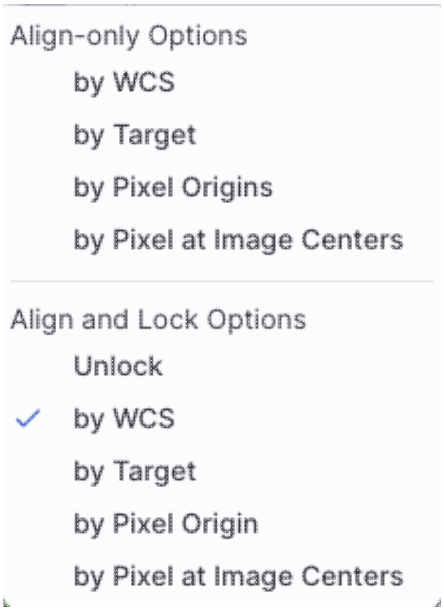
Tips and Troubleshooting:

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

World Coordinate System (WCS) Alignment

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

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



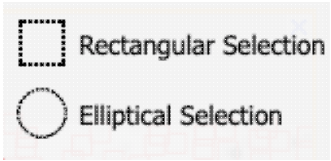
The first set of options aligns the images only once; the second set of options makes the alignment persist ("lock") when you move (zoom, etc.) the images.

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

Region Selection

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

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



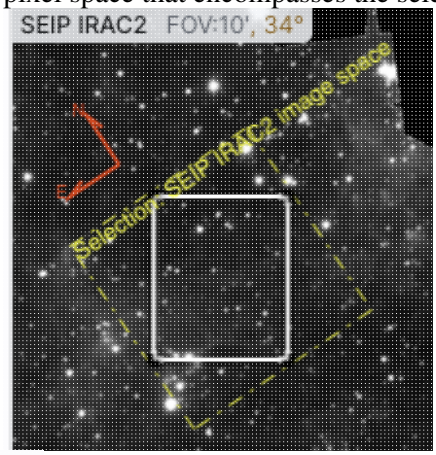
After you make that choice, you can click and drag in the image, selecting a box or a circle on the image. For the circle, your click is the center of the circle and the drag is the radius of the circle; for the box, your first click is one corner of the rectangle, and the drag is the opposite corner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

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

Crop the image

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

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



Select sources (and *cancel selection*)

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

Filter sources

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

Zoom the image

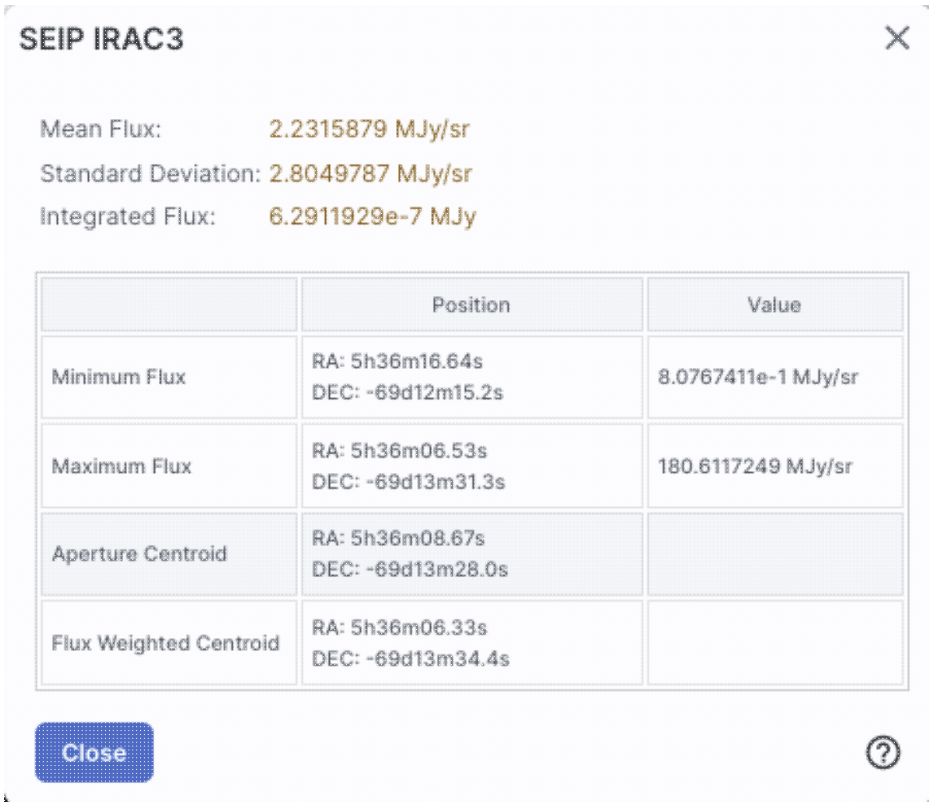
Zoom the image to fit the selected area into your field of view.

Recenter the image

Recenter the image on the selected area.

Obtain statistics

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

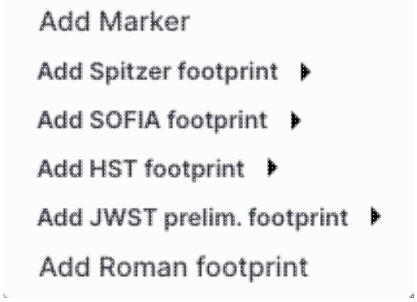


Note that it calculates the location of the minimum and maximum fluxes, and the aperture and flux-weighted centroids; the flux values given are in the same units as the FITS file. If you put your mouse over the row of the table in the pop-up, that location appears as an 'x' on the image.

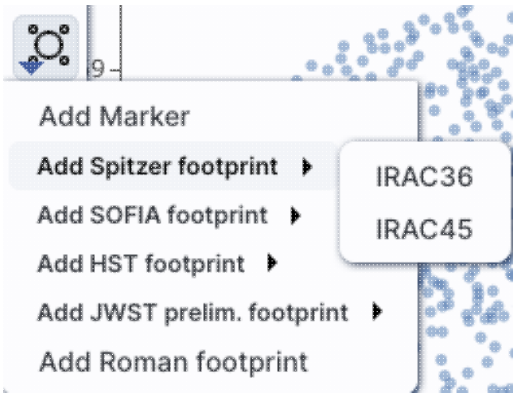
When you are working with the selection tool, this: End Select appears next to the image toolbar to remind you that you are in that mode. When you are done with the selection tool, if your other actions don't turn off the selection tool, click on that text to turn it off.

Footprints

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



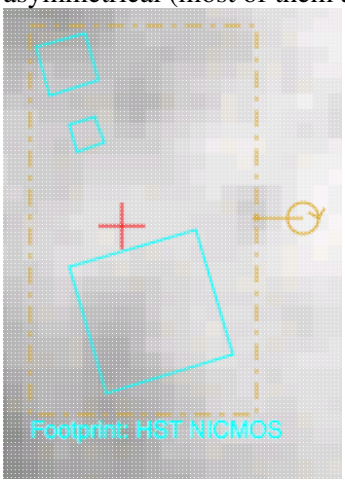
Any of the options with an arrow on the right can expand to additional subsidiary choices, e.g.,:



We now describe these various footprints here.

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

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



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

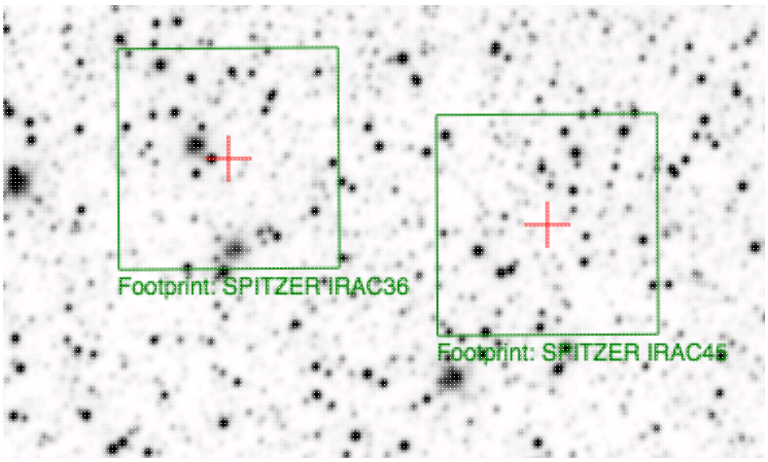
Tips and Troubleshooting

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

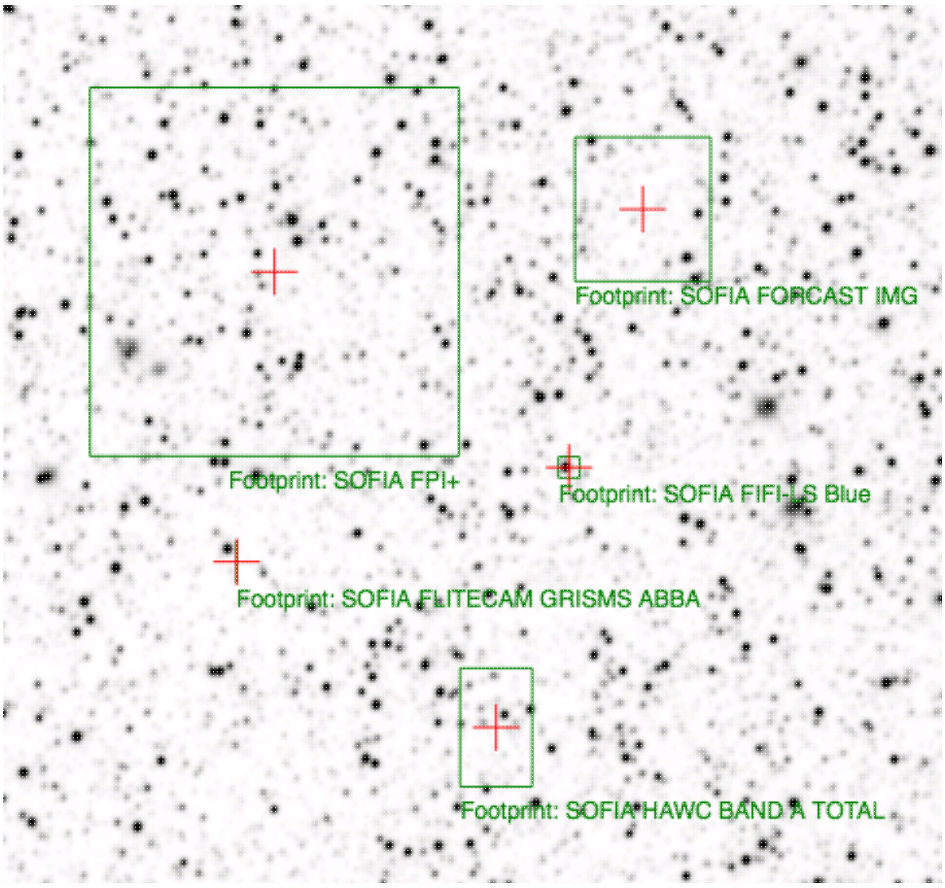
- If you have images of very different resolutions loaded (e.g., IRAS and really anything else), sometimes it struggles to render the marker on each image. You may need to place markers on one image at a time. (Unclick the "lock color & overlays" option to place markers one image at a time.)

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

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



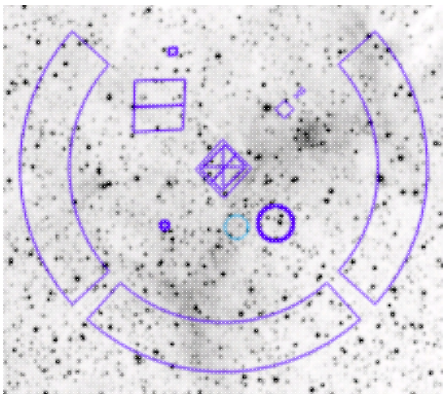
Spitzer/IRAC 3.6 and 4.5 micron footprints. These two footprints are placed separately from each other. The footprint can be moved or rotated. Click and drag the center of the footprint. A circle appears with four small circles ("handles") around it. Grab and drag the small circles to rotate it, or drag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



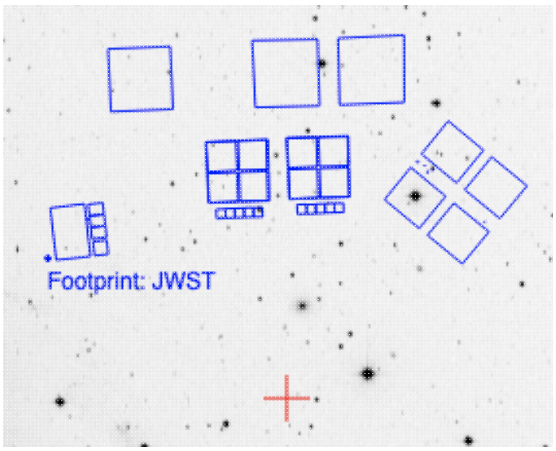
SOFIA footprints. Several different SOFIA footprints are available; the graphic here shows a selection of them. The available footprints (all of which are placed separately) are:

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

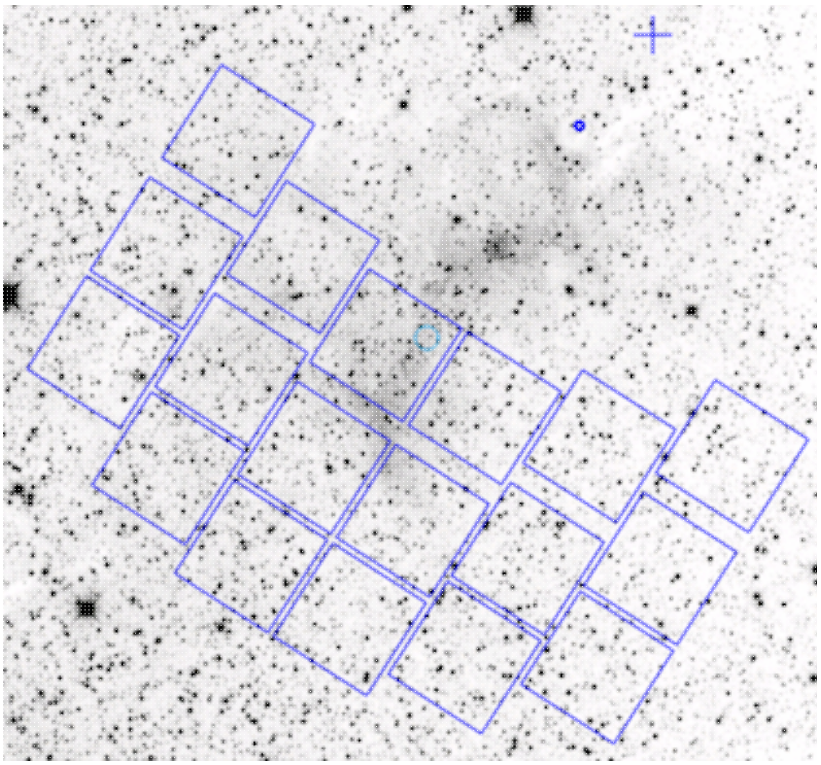
Change the color, delete, or add more copies of the SOFIA footprints from the layers pop-up.



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



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



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

Catalog Search Tool: Tables

The Catalog Search Tool returns catalogs as interactive tables. This section describes features of these interactive tables.

Contents of page/chapter:

Interacting with Catalogs

When you get a catalog, the tool creates a table, a plot, and overlays the catalog on an image. The tables, plots, and overlays on images are all interlinked and interactive.

Details of how to interact with the table is later in this chapter. Plots are covered in a different chapter, as are basic information about images and the visualization tools.

When you have more than one catalog loaded into the tool, the header of each catalog has the name of the catalog and a color swatch:

This color swatch corresponds to the symbol color that is used in the image overlays. You can change the color by clicking on the color swatch in the header, or by navigating to the layers in the image pane. See the color picker section of the visualization chapter for more information.

Tips and Troubleshooting

- Large catalogs will be displayed hierarchically! See next section.
- If you save the overlays from an image as a regions file, you may not get your complete catalog, especially if it is a large catalog (see next section!). 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.
- The "color swatches" may not appear immediately. To make loading faster, sometimes the colors don't load until they are actually needed.

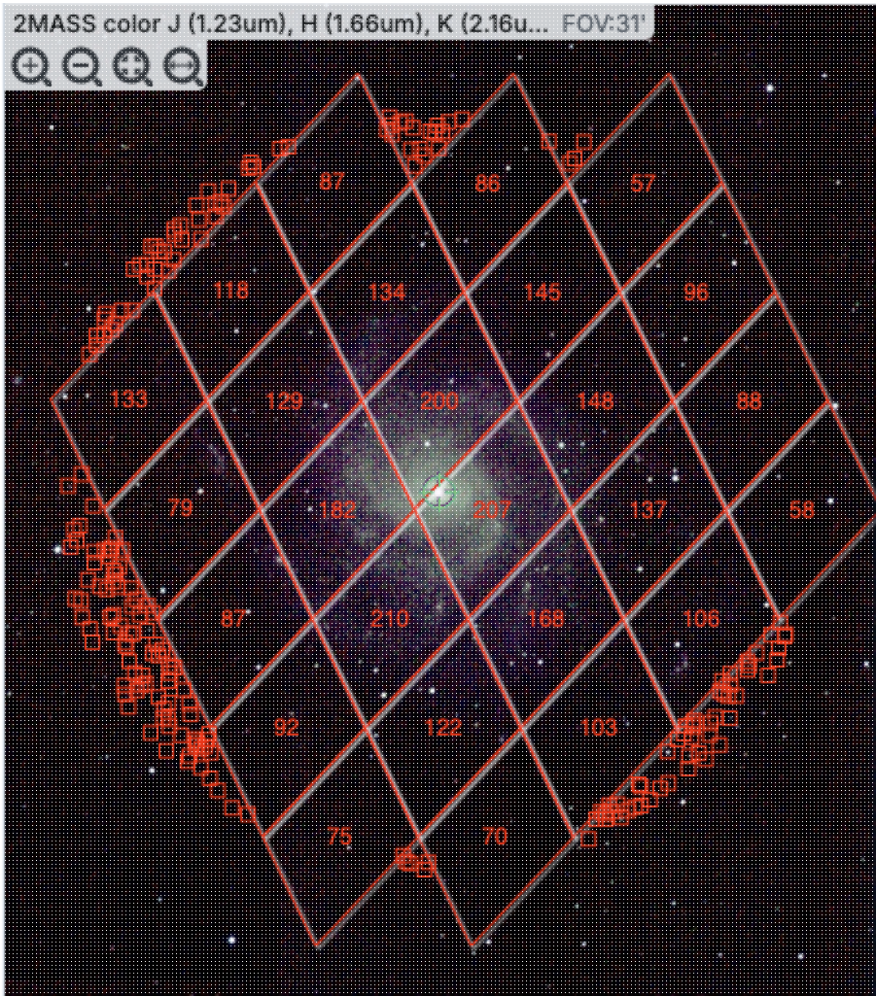
Hierarchical Catalog Display

For catalogs below about 1000 points, the tool will show the individual points on the image.

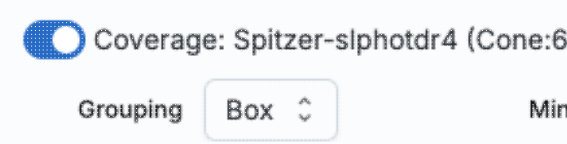
For catalogs above that threshold, the tool will bin up the catalogs based on HEALPix pixels (see HiPS section here for more links). In summary, the sky is broken up into sections, and the tool will show symbols with a

number indicating the number of sources in that region. Then, when you zoom in, it will dynamically adapt to show you smaller and smaller cells until it shows you all the individual sources.

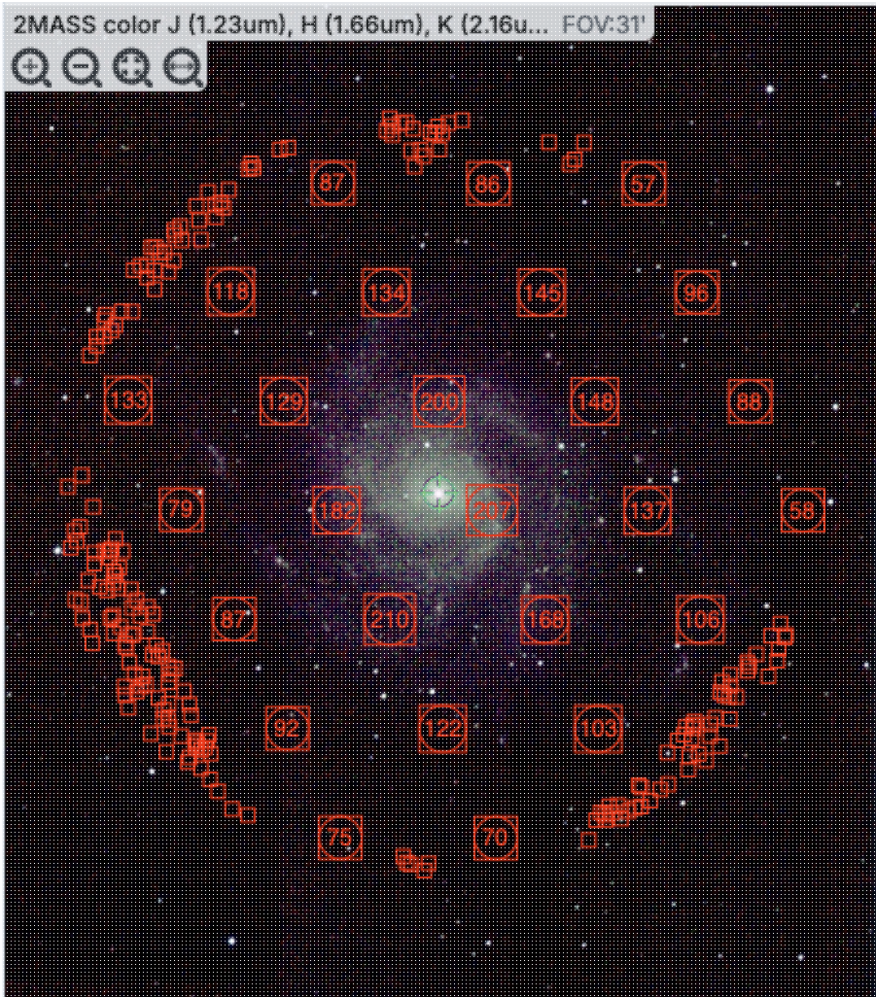
From the layers icon (see visualization chapter), you can bring up many display options. Below are examples of what is displayed, the options seen in the layers, and additional options. The same catalog and zoom level and minimum group size are used for each view. The "Min Group" option here is 50, so if there are cells with fewer than 50 sources, then the individual sources are shown, and if there are more than 50 sources, then the cell is shown with a number inside corresponding to the number of sources from the catalog. (See below for additional information.)



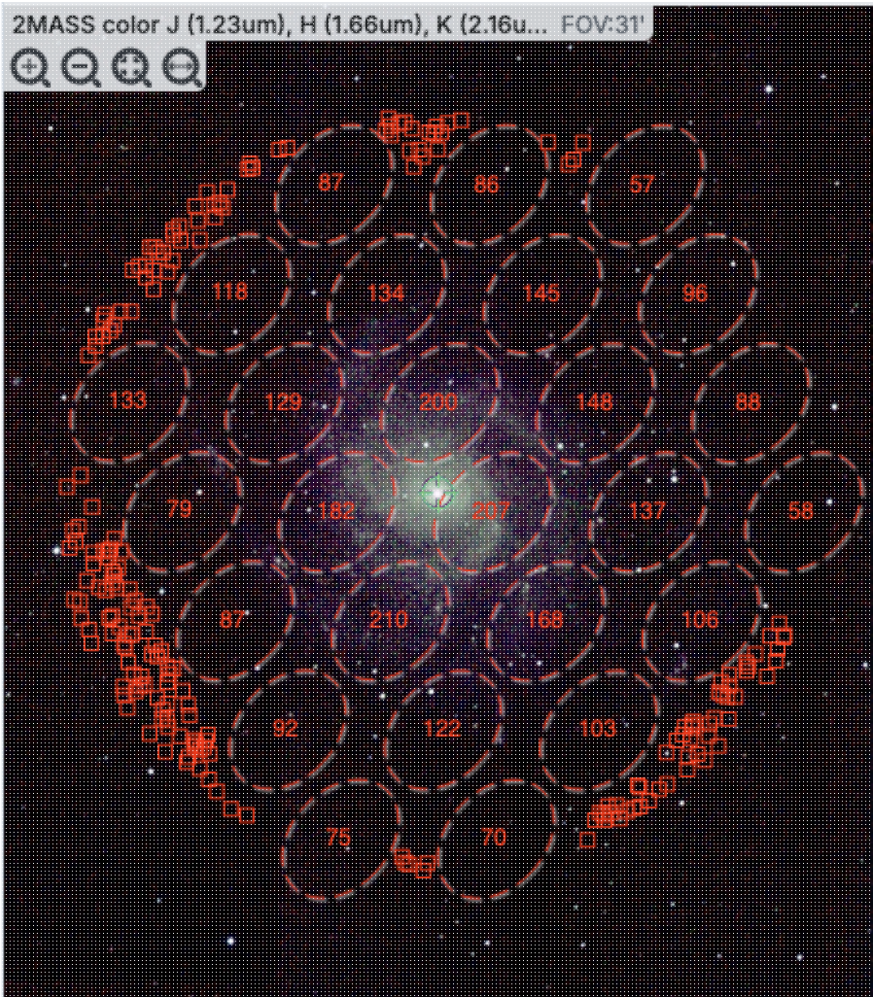
In this view, the 'cells' used are the cells explicit the size of the cells is very clear. In the top row across the top have fewer than 50 sources (so the individual sources are shown), then the next row 57 sources respectively.

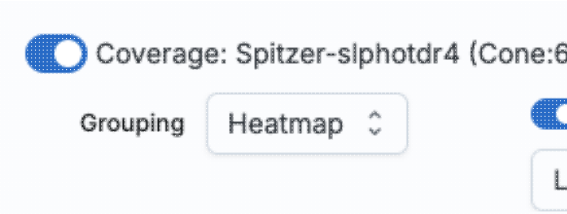


In this view, the 'cells' are shown by circles encl sizes are the same as in the prior screenshot, but obvious to new users.

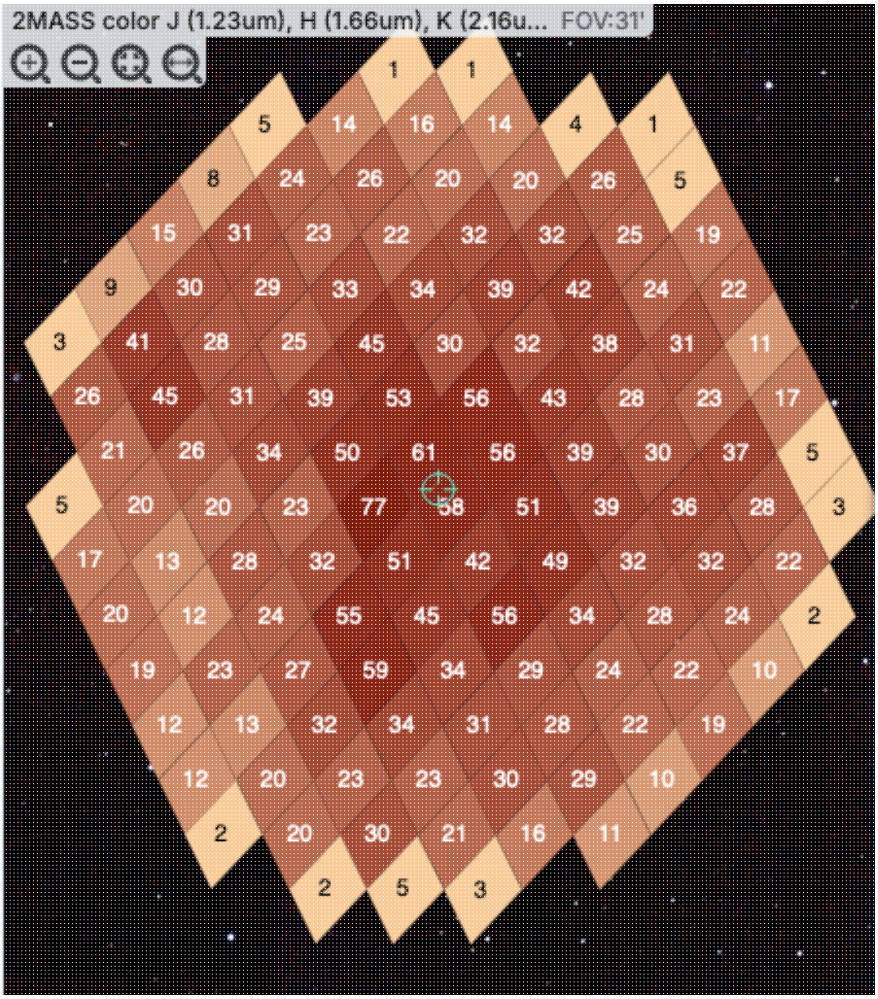


In this view, the 'cells' are shown by ellipses sho
cell sizes are the same as in the prior screenshot,
less obvious to new users. It may be more obvio
groups of points.



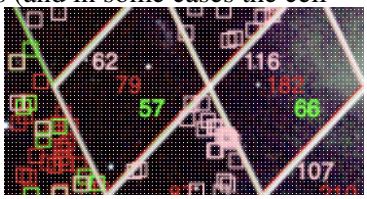


Finally, in this view, the 'cells' are again shown a
color of the cells corresponds to the number of s
"Linear", "Linear Compressed", or "Log Stretch
the color range by changing the color using the
which you can also change the transparency. Thi
how many sources are in each cell, but makes it
though you can change the transparency of this
still can make seeing the image challenging in so



Tips and Troubleshooting

- For all of these renditions, when you zoom in close enough, it will dynamically adapt and show you individual sources when you zoom in. (That is, it no longer decimates the overlaid catalog, which is what it used to do.)
- For all of these renditions, if you click on a cell, it will display all of the sources in the cell. You can click on many cells in a row and it will continue to display all the sources it can until it reaches the point at which it thinks performance will suffer, at which point it will turn some of the points back into cells.
- If you want to have more of your catalog shown as individual sources, pick a smaller "min group" number.
- If you have more than one catalog loaded, the numbers within the cells (and in some cases the cell indicators themselves) will be offset slightly so that you can see them.



- If you have a catalog that includes sources from all over the sky, it very well may just give you box groupings, and may not allow you to change that view until you zoom in.
- If you have cells where only 1/4 of a cell is populated, it automatically renders a smaller cell, so if you have a sparsely populated but still large catalog, the size of the display will always be "small" size cells.

- If you are looking at many footprints from, say, a complex, and long ObsCore search, if you have more than 30,000 footprints, it may not be able to render all of the outlines of all of those images. It may render the centers of all of those images as if it were a catalog, in which case you will encounter these kinds of hierarchical catalog display options.

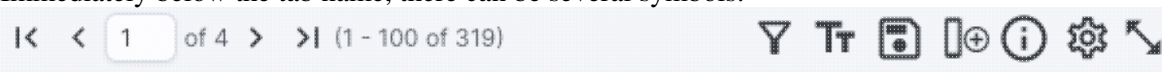
Table Header

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.

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.

It can be that the table has a tab with a name on it. The tab (and table) name itself likely indicates its origin. It may be that you can remove the tab; if so, you can click on the "X" on the tab to remove it.

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



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

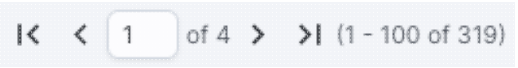


Table navigation

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

Filter

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

Table as text

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

Save table

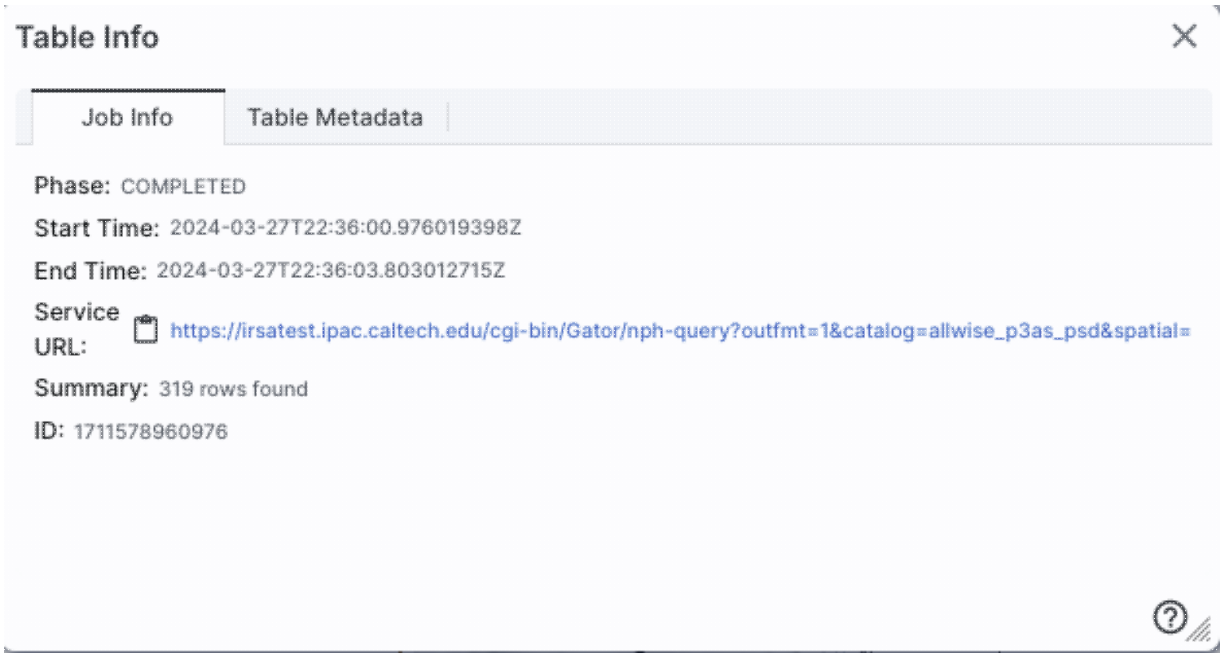
This is how you can save the table. It has a separate section below.

Add a column

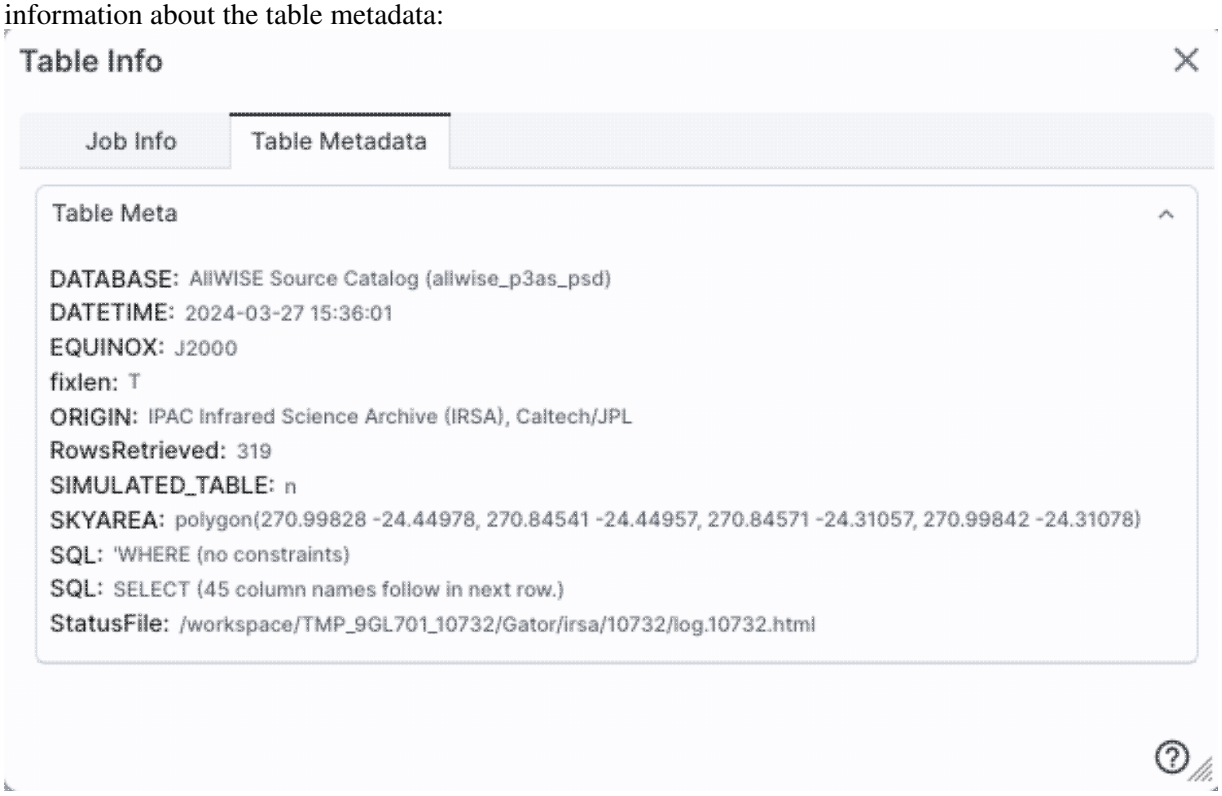
This icon adds a new column to the table. This has a separate section below.

Info link

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



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



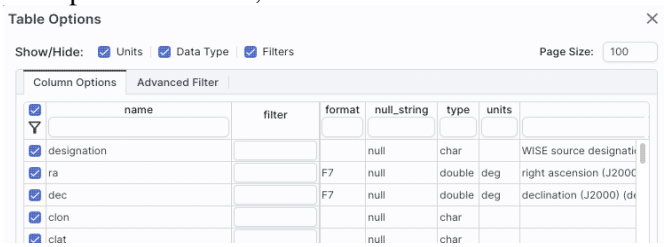
where the information about this table includes information about the query that produced it.

Row details

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

Table options

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



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

 Expand

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

 Help

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

Table Columns

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

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

Clicking on the column names sorts the table by that column; clicking once sorts in ascending order, clicking a second time sorts in descending order, and clicking a third time returns the table to the original order. Small arrows appear next to the column names to remind you if the column is sorted in ascending or descending order. When you do a single-position search on catalogs, two new columns are 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.

Columns in the uploaded table will be included in the output table, with a suffix attached. This suffix will be "_01" unless the column name ends with "_NN" where NN is any integer from 01 to 98. In the latter case, the suffix will be incremented by one, to a maximum value of 99.

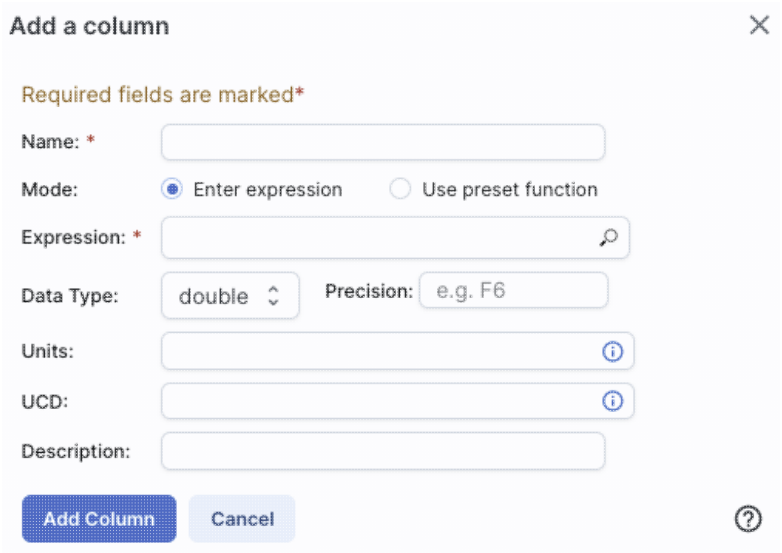
When you do a multi-position search on catalogs, and you choose "one-to-one matching", one line (and only one line) of output is included for each line of input. It chooses the closest source within the radius you specify, or if there is no match, it adds a line indicating no match.

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.

Adding Columns

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



This window asks for:

- *Name* of the column (required) -- it cannot have special characters like a minus sign or a percent symbol; you can only use letters, numbers, and underscores.
- *Mode* "Enter expression" or "Use preset function" -- options shown here correspond to "Enter expression" options; the preset function options are included in the last bullet here.
- *Expression* (required) -- using basic SQL operators, you can manipulate columns to create the new column. (See more on this below.)
- *Data Type* -- specify if your new column is a double precision floating point ("double"), a long integer ("long"), or a string ("char").
- *Precision* -- if you have selected "double" for data type, select how many decimal places your new column should display. For example, if you want the numbers to display as 1.23, enter "F2".
- *Units* -- specify the units of your new column. For more information, see IVOA documentation

- *UCD*, or unified content descriptor -- for VO compliance, add this for your new column. For more information, see IVOA documentation
- *Description* -- add a description for your new column.
- *Select a preset* -- if you select "Use preset function", you can choose (a) "set filtered rows to 'true' and the rest to 'false'", (b) "set selected rows to 'true' and the rest to 'false'", or (c) "number rows in current sort order". These options are useful for tagging items you have selected in myriad ways (from plots, images, complicated filters), or ordered in complicated ways. For example, if you have constructed a complicated filter, then you can create a column that is true for the selected rows; if you cancel the complicated filter, you can then easily recreate the complicated filter by simply filtering on your newly created column.

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

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

- "w3mpro" - "w4mpro"
- sqrt(power("w3sigmpro",2) + power("w4sigmpro",2))
- ("ra"-82.0158188)*cos(radians("dec"))
- "phot_g_mean_mag"-(5*log10(1000/"parallax") - 5)

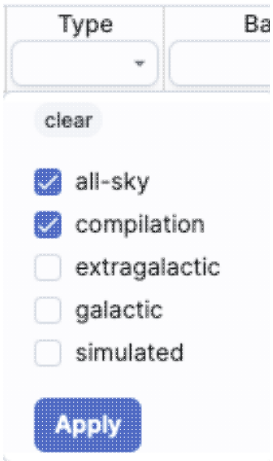
Tips and Troubleshooting

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

Table Filters

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

Example: From a catalog, show only those sources with declination above a certain value (say, 31 degrees), type "> 31" in the box at the top of 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, in the box at the top of the 'w1mpro' column, type "< 6" in the form.



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

After you impose a filter, then the number of rows in the table is restricted according to the rules you have specified, and the "filters" icon on the top right of the catalog pane has changed to remind you that there has been a filter applied, in this case four filters:  . 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 !=

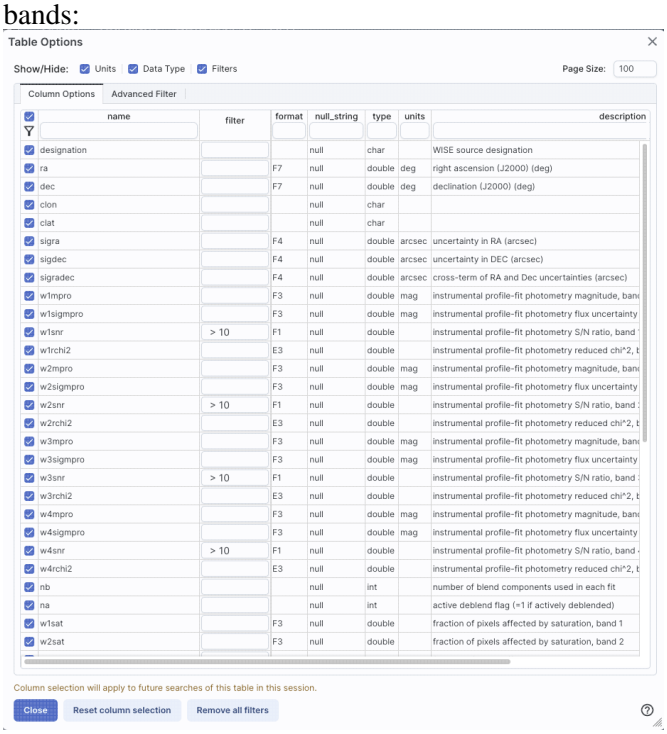
Examples:

- 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 interactively impose filters from plots from a catalog. Moreover, all the same operators that are available for making plots can be applied in filters. In both cases, see the plots section for more information.

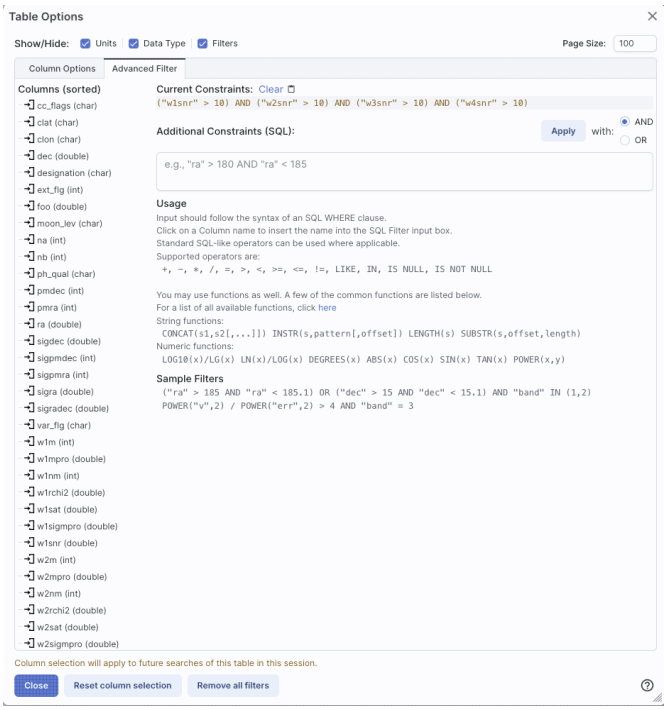
You may also be able to select rows one at a time via the far left column and then filter that down. Example: Retrieve a catalog of any sort. Select rows by ticking the box on the far left, say, every other row out of the first 12. Click on the filter icon on the top of the column. The filter is imposed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

If you click on the table options icon ( ), you get a pop-up that includes a place to filter columns. Here is an example of the table columns for a 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.

Cancelling filters

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

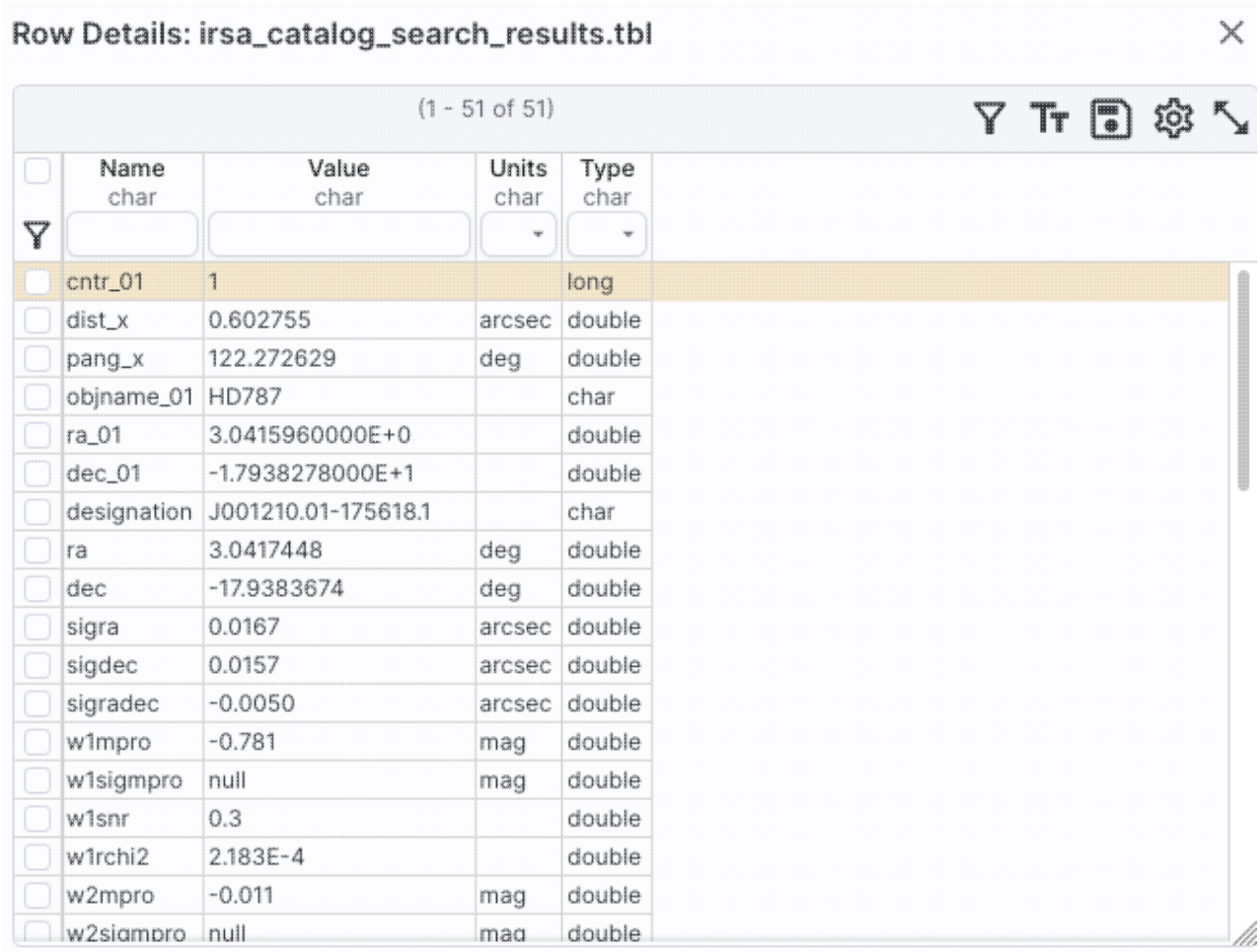
Tips and Troubleshooting

- If you impose logically inconsistent restrictions such as "exposure_time > 160" and "exposure_time < 100" (">160;<100" in the filter box for a column called "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 "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 click on the clipboard icon to copy the entire string, and then paste it into another field or application to see what it is.
- If you are choosing filters from a list of terms, cancelling those filters might not work the way it cavalierly seems like it should. If a down arrow appears next to the filter box, then a list of options you can select is available. Tick the boxes you want, and click "Apply" to apply the filter. Now, if you want to change the filter, click the down arrow, select different options, and click "Apply" again to re-impose the new filter. To remove the filter, you have to treat it like you would when applying a modified second filter -- unselect the choices, or hit 'clear', and **then hit Apply again**. If you deselect the choices and then click elsewhere in the window without hitting clear, your actions are interpreted as 'cancel without doing anything' as opposed to 'impose the new filter I just set' (which is 'cancel all filters'). When you are resetting the filter to be 'select nothing', it is treating that as a new filter setting, so you need to set up that filter and click 'Apply' in order for it to understand.
- If you impose filters from a plot, image, or table, you can cancel them from a plot, image, or table. That is, if you impose filters from a plot, and different additional filters from the image, when you click the 'cancel filters' icon from the table, *all* the filters are canceled at once. If you have filters imposed from multiple places, clicking on 'cancel filters' doesn't cancel just the filters imposed from that place; it cancels all of them. If you want to be able to reconstruct a complicated set of filters, though, you can add a column to your table that is one of the preset functions -- set it to true if the row is filtered. Then you can cancel all your filters at any time but you can easily recover the filtered data by filtering on that one new column.

Row Details

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



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

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

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

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

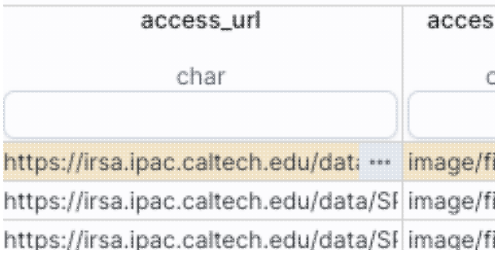
Tips and Troubleshooting

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

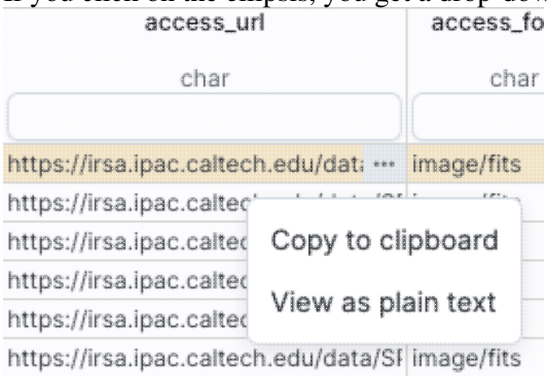
- When changing rows in the main table, the property sheet scrolls to preserve the visibility of whatever row in the details tab is highlighted. If you scroll down in the property sheet *without changing the highlight*, when you change rows in the main table, because the first row in any table is always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

Table Cells

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



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



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

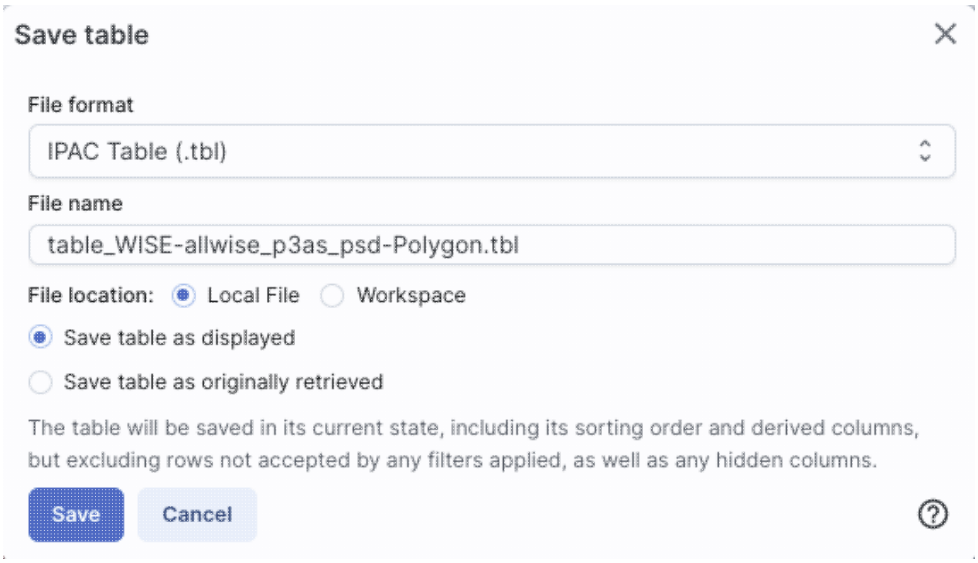
If you view it in a pop-up window, it will attempt to format it in a readable fashion:

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

Saving Tables

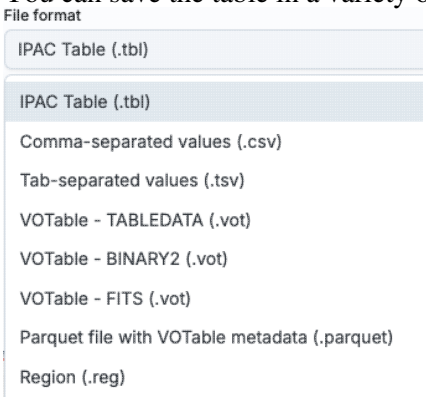
Click on the diskette icon (), if available, to save the table.

You obtain this pop-up:



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

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



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

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

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

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

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

Table Navigation

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

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

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

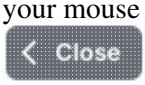
Catalog Search Tool: Plots

Plots (sometimes called charts) can be made from Tables, and plots are made automatically in the Catalog Search Tool when catalogs are loaded. Plotting is covered in this section. The Tables section discusses tables more generally. The Visualization section covers how a catalog is overlaid on images.

Contents of page/chapter:

Default Plot

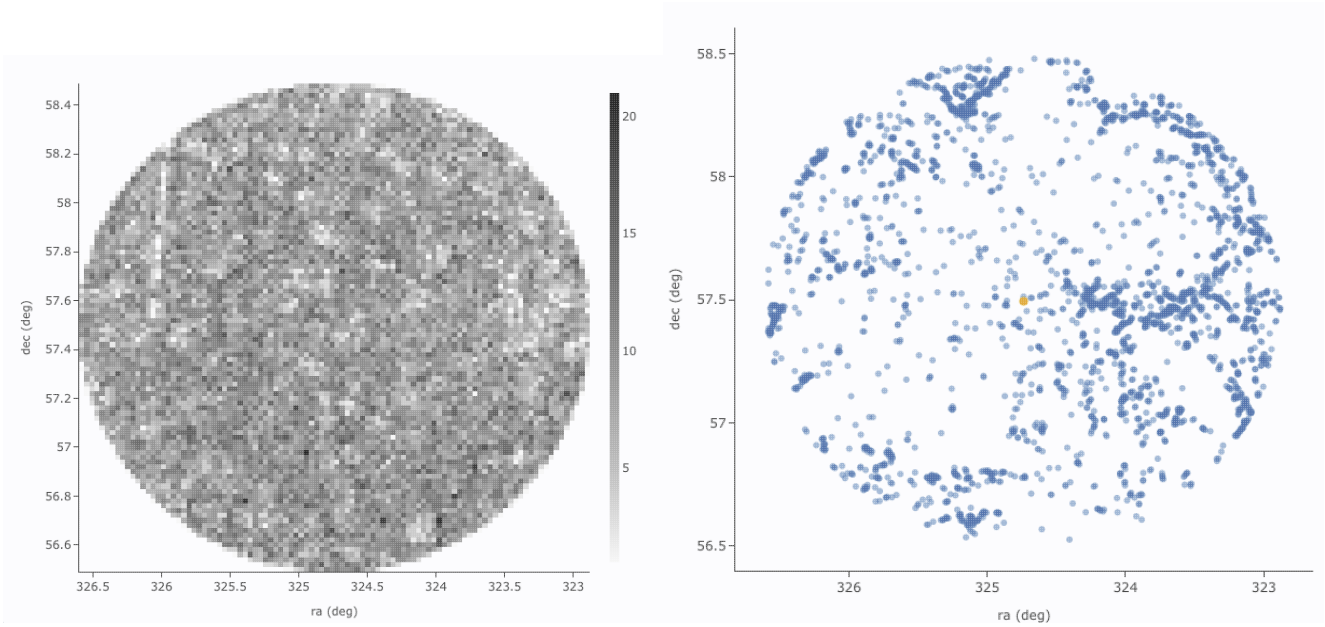
By default, after a catalog has loaded, a plot appears in the upper right of your browser window.

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.

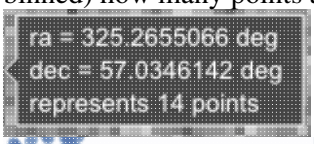
Plot format: a first look

If you have loaded a catalog with many (> 5,000) 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 (< 5,000) 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 -- the shades of grey correspond to how many points are encompassed in each 'cell', with the density scale given on the right hand side of the plot. 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**. Note that even when individual points are shown, where the points overlap, the color is darker.

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 it.

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). You can change the bin size and shading via the plot options pop-up (more on this below).

Plot Navigation

The top right of the plot window has a row of icons:


which we now describe.


Plot mode

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

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

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

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

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

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

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

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

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

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

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

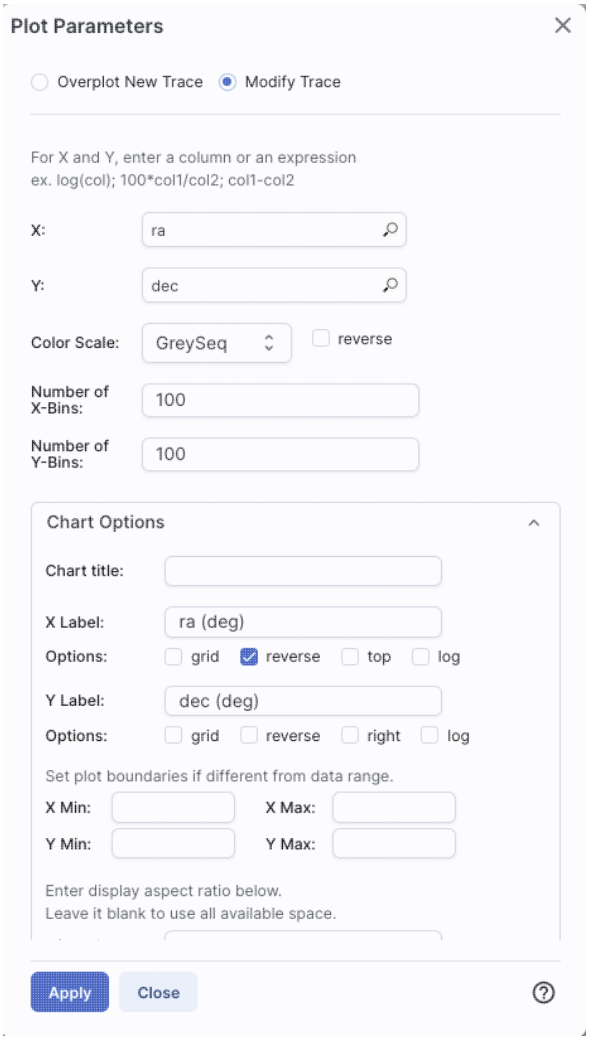
 Help
This icon may not appear, but if it does, it is a context-sensitive help marker, which should bring you to this online help.

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

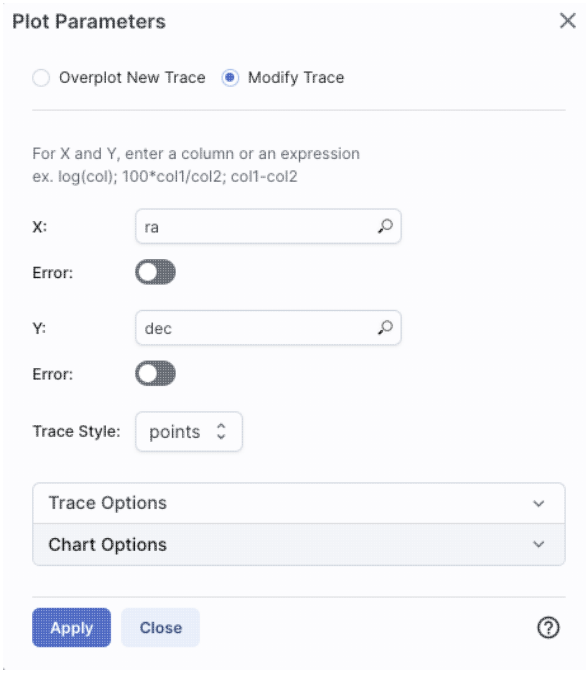
If you move your mouse over any of the points in the plot, you will get a pop-up telling you the values corresponding to the point under your cursor. For scatter plots, if you click on any of the points, the object(s) corresponding to that point will be highlighted in the overlays in the images shown, 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.

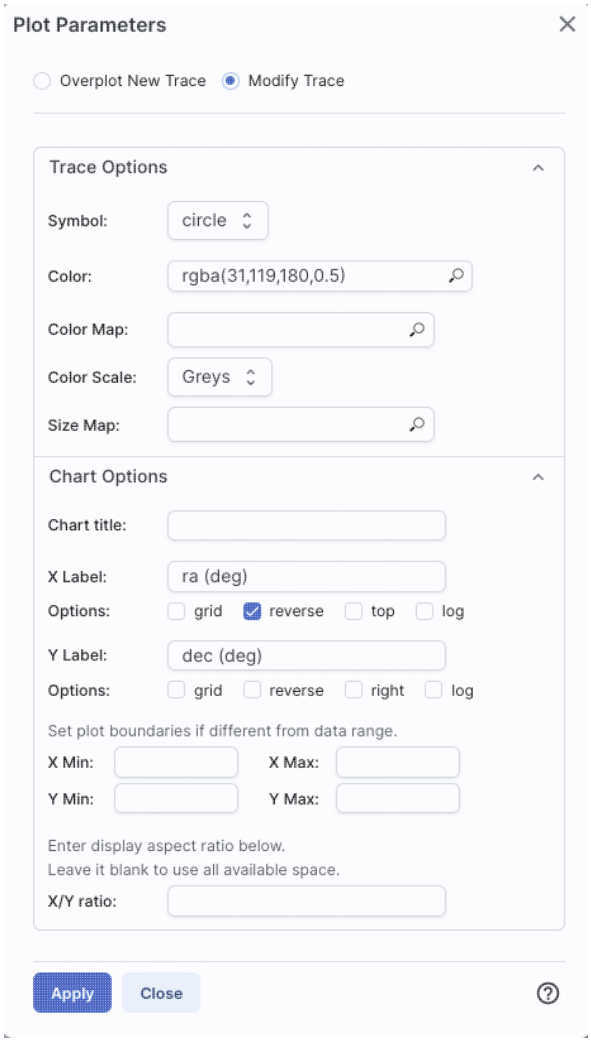
Changing What is Plotted

To change what is plotted, click on the gear 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. This section describes how to change what is plotted, i.e., the "Modify Trace" option at the top of both of these pop-ups. The overplotting option (and, for that matter, adding plots) are covered in more detail below.



This is the configuration window for a binned (a.k.a. heatmap and/or greyscale) plot. By default, the "chart options" may be hidden; to reveal them, click on the name "Chart Options" or the disclosure arrow on the right. To hide them again, click on the disclosure arrow on the right.





The configuration window for a plot that shows individual points, once fully extended, is much longer (and scrollable), and so is shown here in two parts. Both the "Trace Options" and "Chart Options" may be hidden by default; to reveal them, click on the name or the disclosure arrow on the right. To hide them again, click on the disclosure arrow on the right.

Options found in both kinds of plots

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", and it is case-sensitive. 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 shown;
- ◊ 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. (For the latter, you can also click the 'x' in the upper right.)

Options found only in binned plots

(Plots are binned by default if there are > 5,000 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. The default value for the number of bins is 100 in both directions.

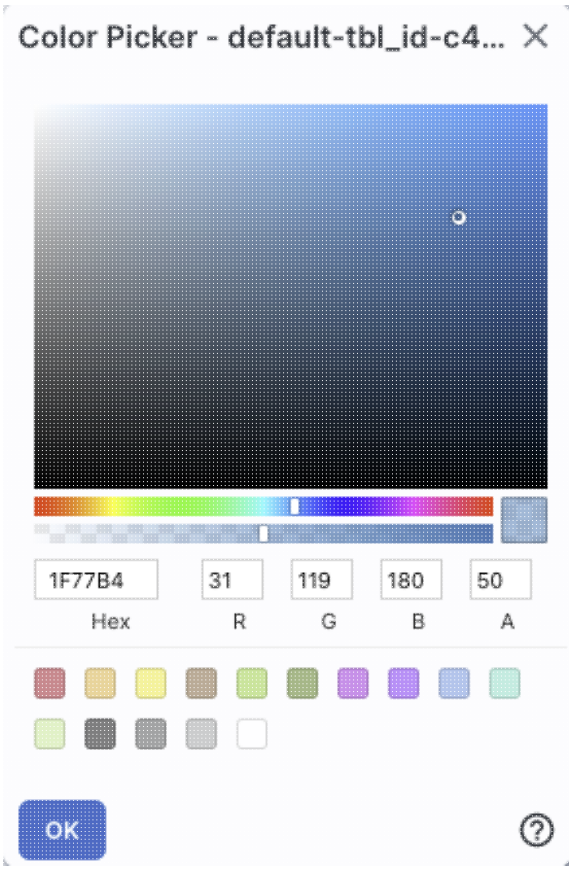
Options found only in plots showing individual points

You can add errors. Toggle the error switch, and then additional choices appear. From there, you can select symmetric or asymmetric errors, and then you can specify an error as either an existing column in the catalog, or calculated from a column in the catalog.

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

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

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



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

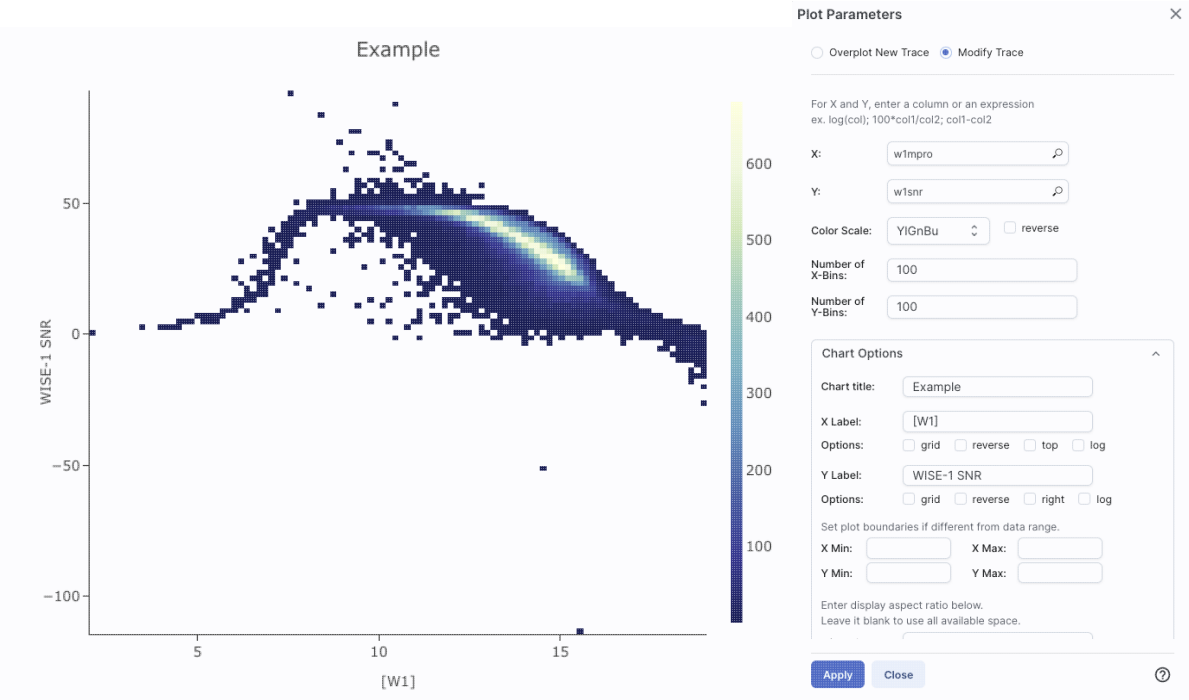
Tips and Troubleshooting: Don't like the transparency feature of the points that makes them darker when there are more points? Set the last value of the vector (A) to 1. Don't like the blue? Pick a diferent color entirely. Want the faintest point to be brighter than it is by default? Set the last element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

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

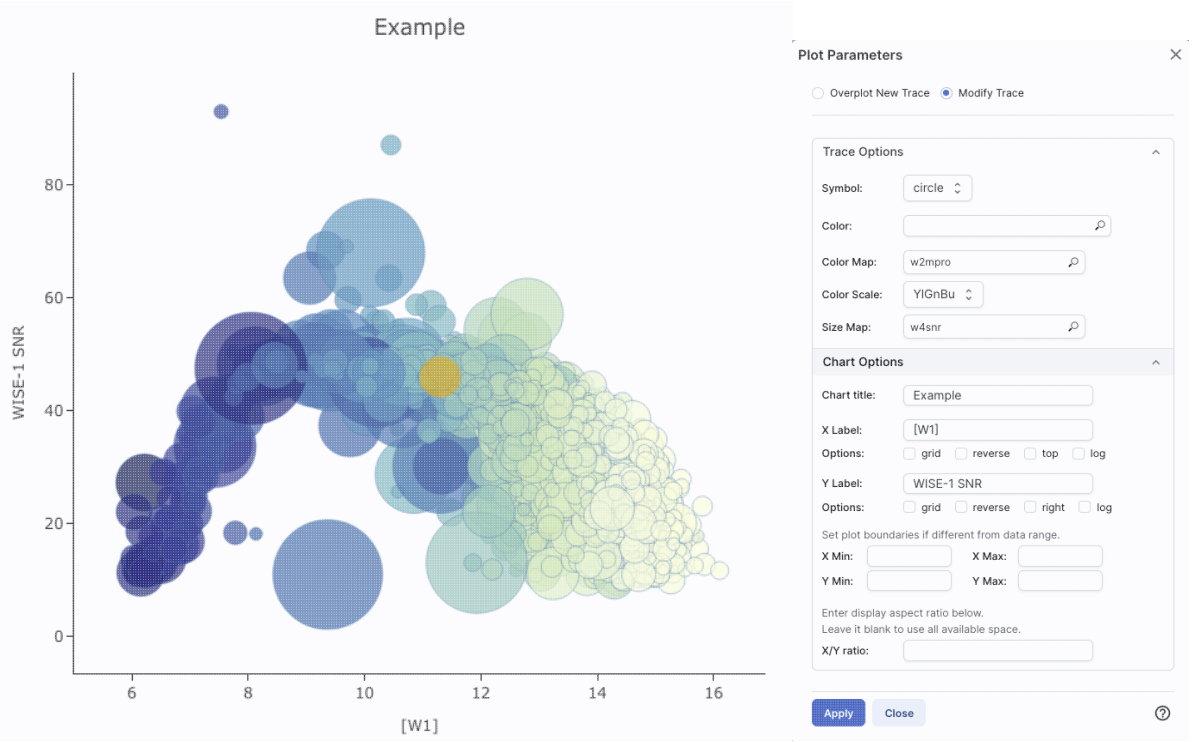
◊ Choose the **size map**. By default, all of the points are the same size. You can change this such that the color scale of the points is tied to a column value, such as w1snr (WISE-1 signal-to-noise ratio) in a WISE catalog. Simple mathematical relations (as above) are also permitted in this box.

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, making the y-axis label "WISE-1 SNR" rather than the more cryptic column header "w1snr". Change the x-axis label to "[W1]." Change the greyscale to

yellow-green-blue ("YlGnBu") to make it easier to see the lowest-populated bins. Depending on your catalog, you may need to adjust the ranges. Obtain this plot:



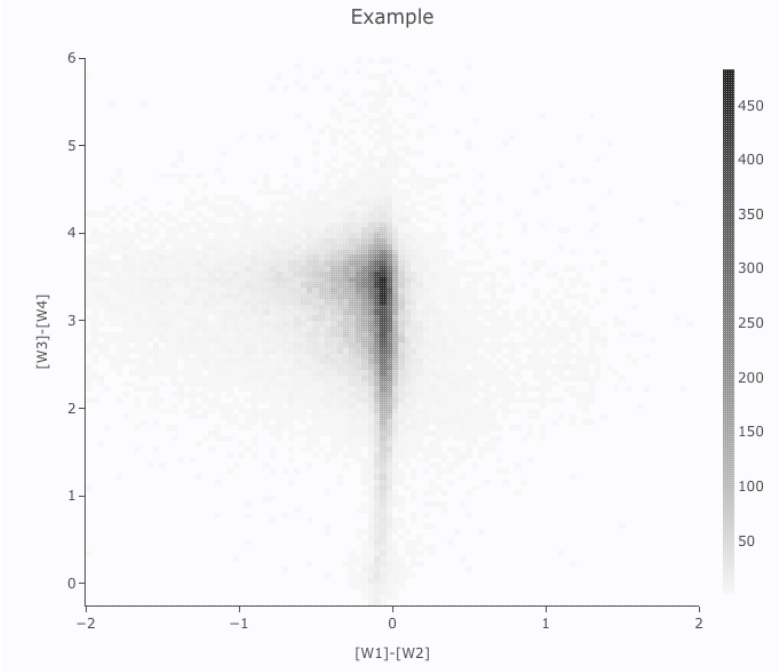
Example: Load either a smaller WISE catalog, or the same large WISE catalog, but filter it down such that w1snr, w2snr, and w3snr are all greater than 10, which limits the number of points to be <5,000. Plot w1snr vs. w1mpro. It shows the points individually. Change the labels. Change the point color 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:

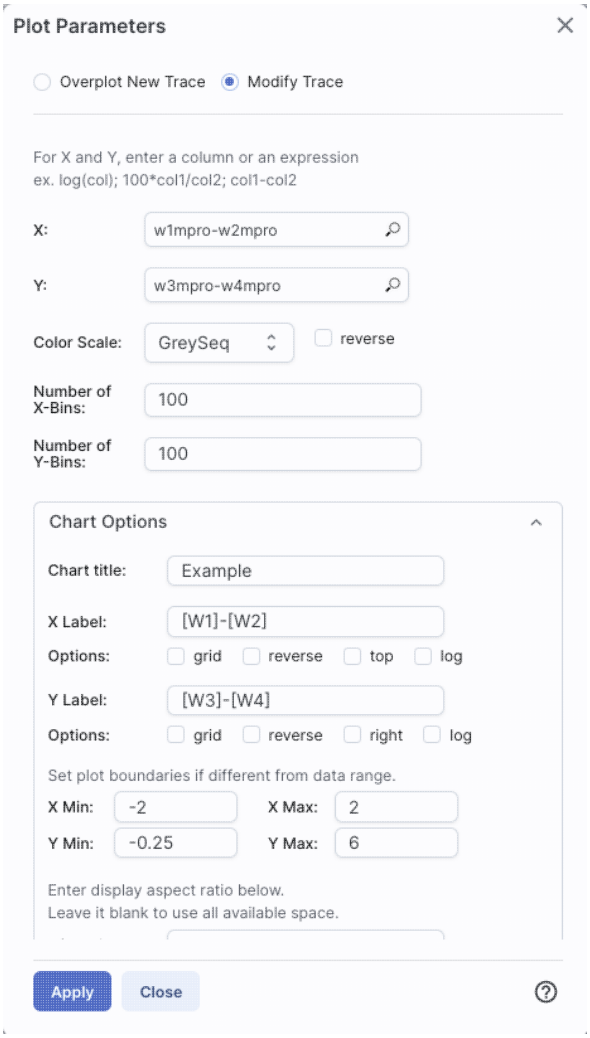


Plotting Manipulated Columns

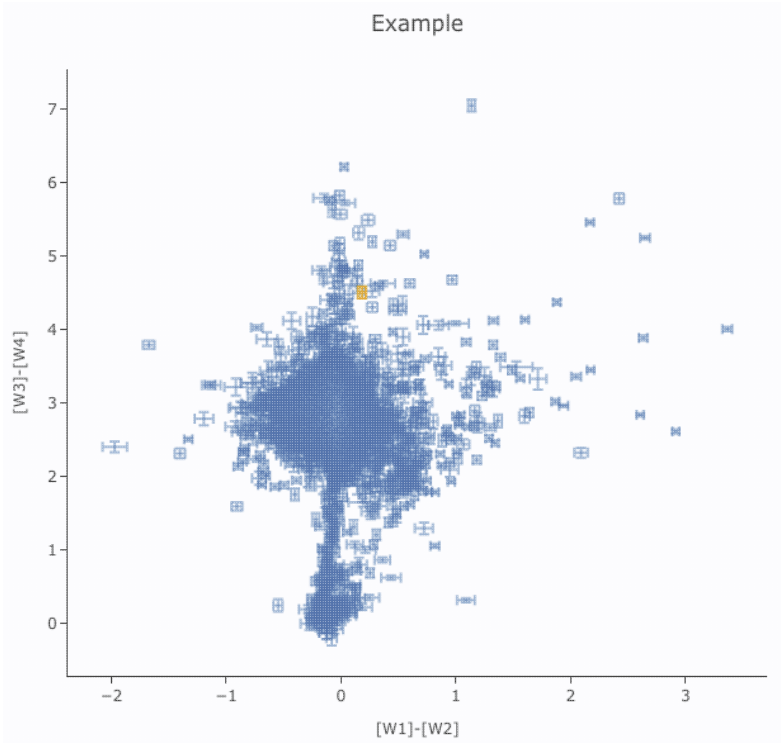
You can choose a single column to plot against another column, as above. However, you can also do simple mathematical manipulations.

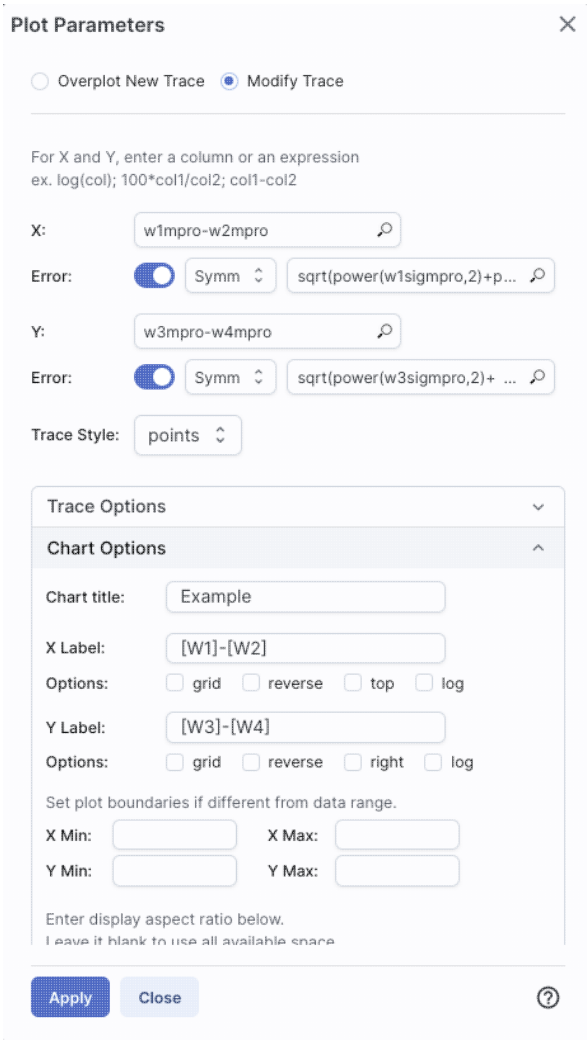
For example, if you have loaded a WISE catalog, you can plot [W1]-[W2] vs. [W3]-[W4]. In terms of the names of the columns in the database, this is w1mpro-w2mpro vs. w3mpro-w4mpro.





If you have few enough points that the plot is not binned, you can add errors that you calculate. 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)) -- that is, the errors for the individual photometric points added in quadrature.





Restricting What is Plotted

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).

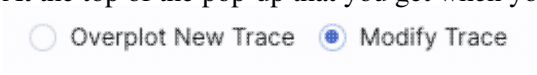
However, and perhaps more powerfully, you can set limits from the plot itself using a rubber band zoom. Click on the select icon in the plot  Then, click and drag in a sub-region of the plot. New icons appear:  If you click on the funnel icon, only those data points that pass the filter are shown in 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 detections at all four WISE bands. (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.

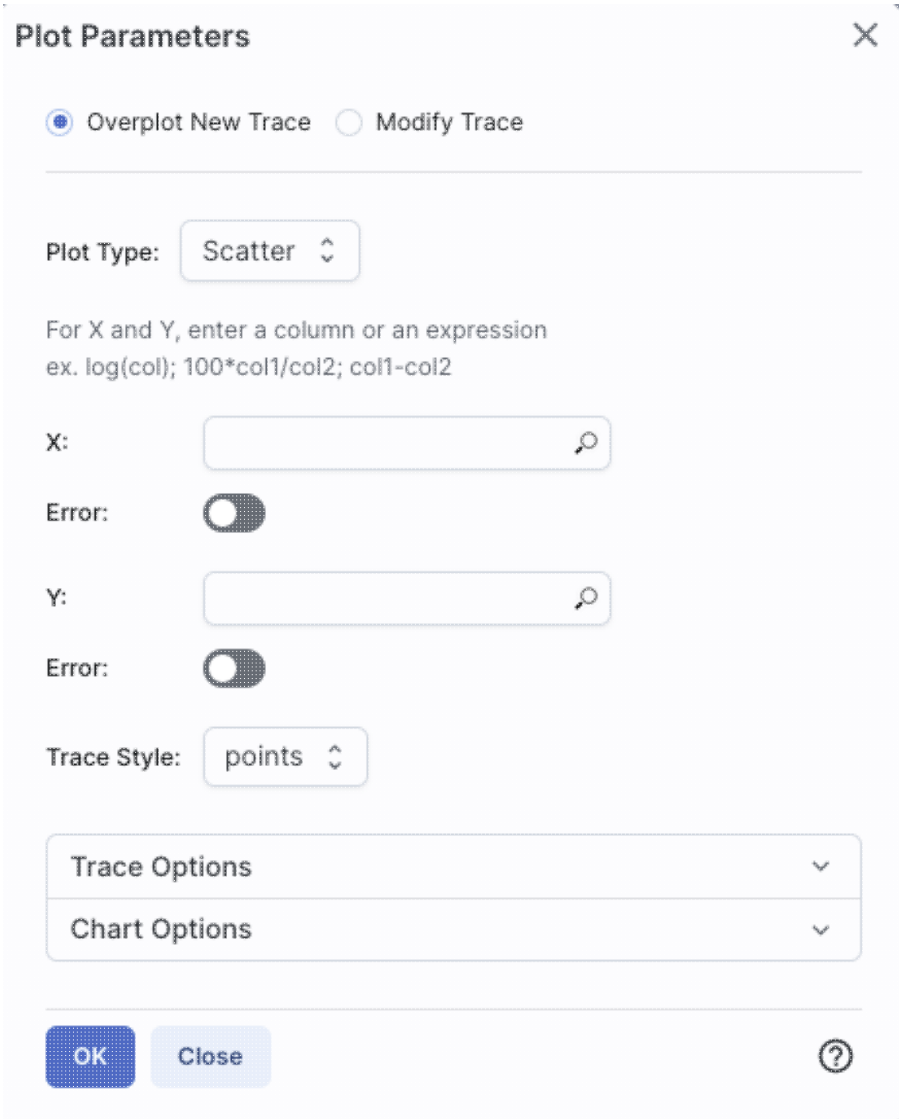
Overplotting

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



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

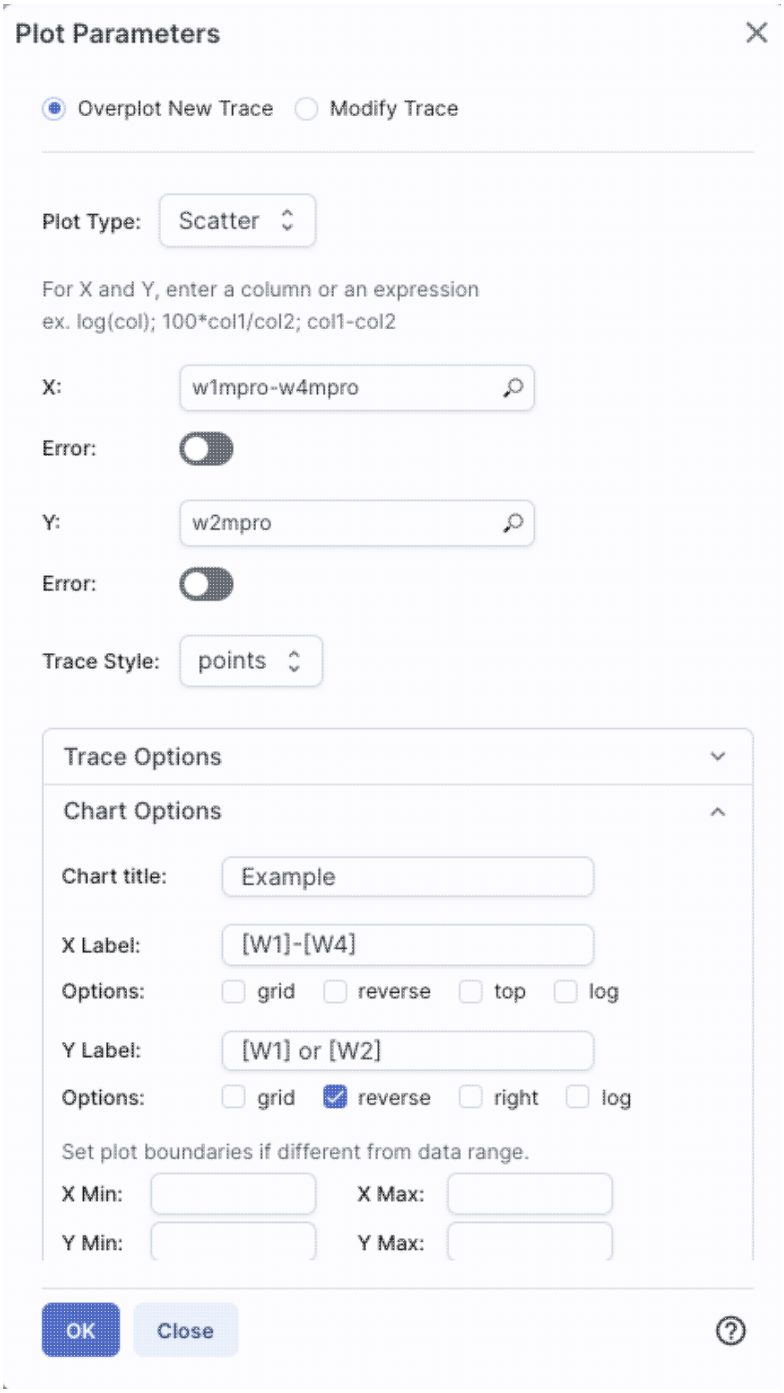
When you select "Overplot New Trace," you get a new interface that is very similar to the original interface where you selected what to plot:



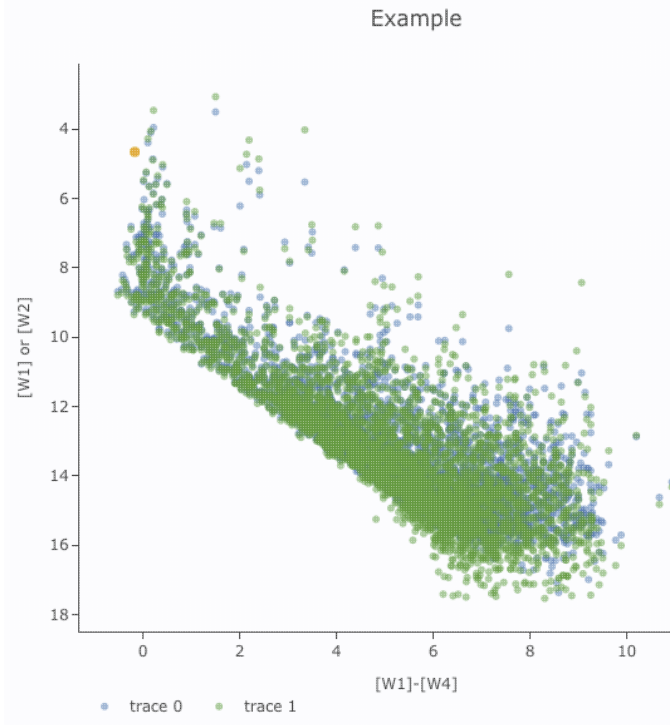
As before, you need to :

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

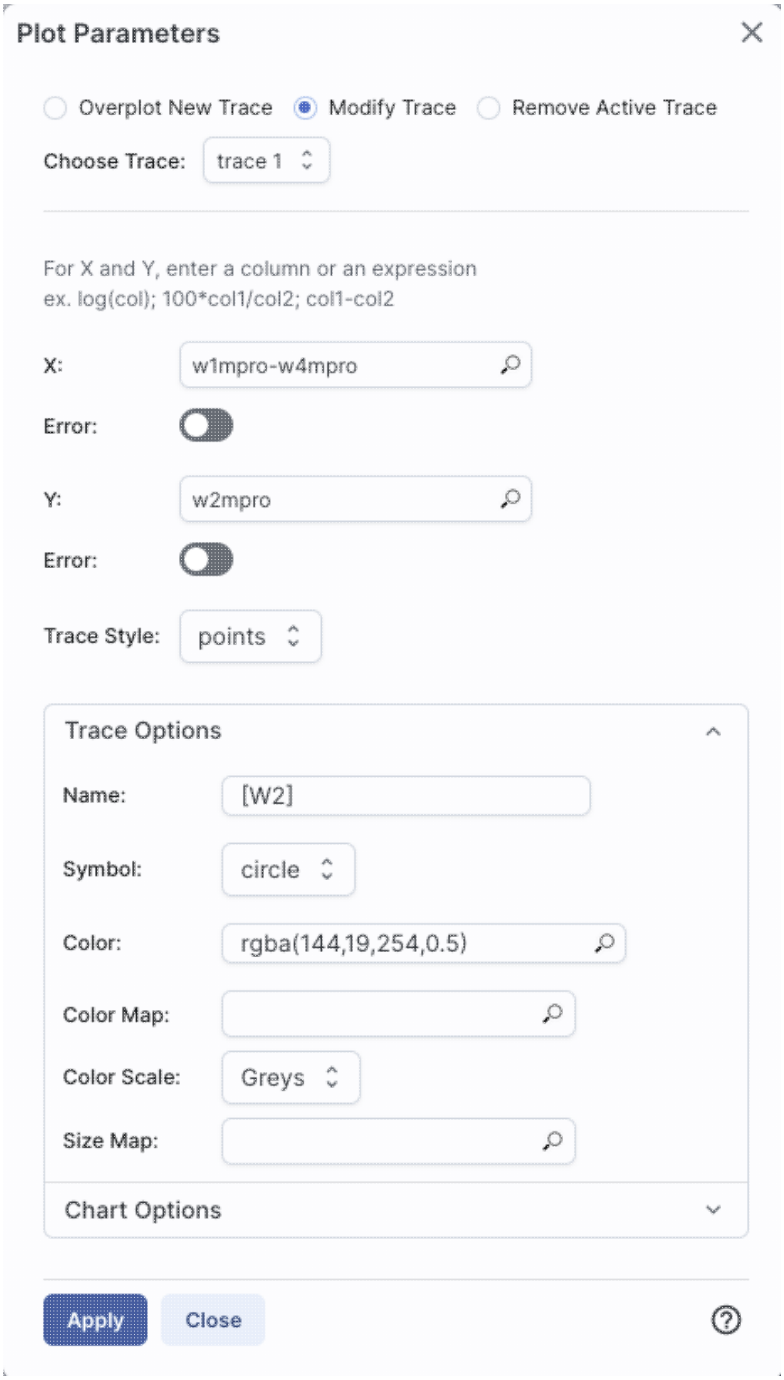
The best way to explain how to use this feature is probab
example. I have a plot of [W1] vs. [W1-W4]. Now I am
add on top of it a plot of [W2] vs. [W1-W4]. Click on the
bring up the pop-up. Select "Overplot New Trace." Enter
"w1mpro-w4mpro" for x and "w2mpro" for y. Expand "
Options." Note that it has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



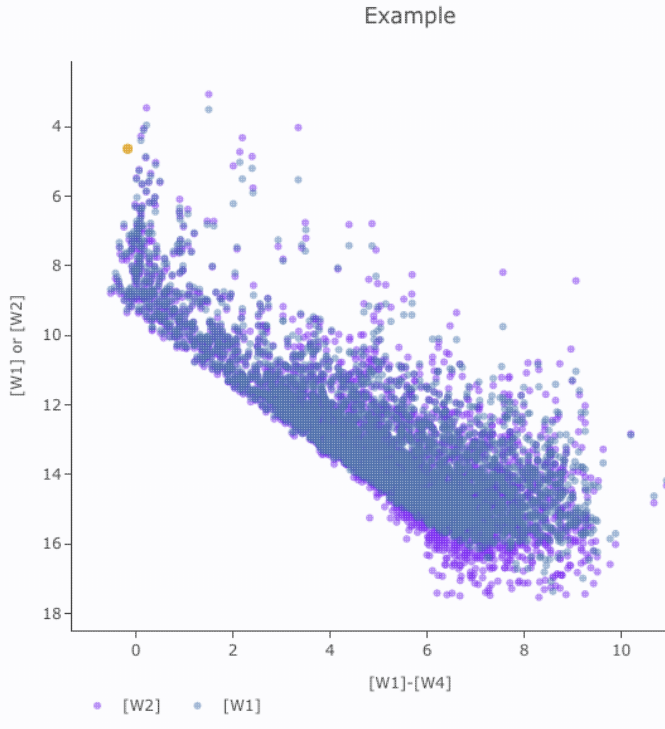
window right before clicking "ok", and the resultant plot



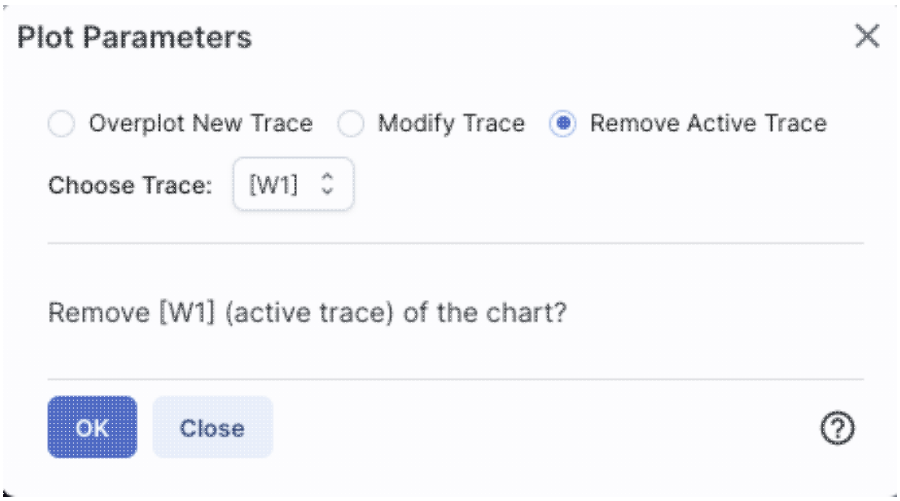
After you add the overplot, if you click on the gears agai
that the choices at the top of the window have changed. Y
add another overplotted trace, modify a trace, or remove
trace. Each trace that you add is a new 'layer' on the plot.
drop-down menu near the top of the window controls wh
is 'active'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



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



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



Tips and Troubleshooting

- Right now, the overplotting only works from the same catalog -- that is, you cannot plot [W1] vs. [W1]-[W4] from one catalog and overplot [W1] vs. [W1]-[W4] from another catalog. (We enthusiastically await this capability too.)
- You can easily get yourself into a physically nonsensical situation, say, by overplotting a histogram onto a scatter plot. If you find yourself in a hopeless mess, click on the "undo" icon to reset everything and try again.
- When you have more than one thing (trace) plotted, double click on the legend to bring that trace to the foreground and temporarily hide the other traces.
- You can force the tool to make a scatter plot even if you have a catalog of >5,000 points; it just might make your browser slow down. You can even overplot a scatter plot on top of a heatmap if you really want to!

Examples of catalog plots

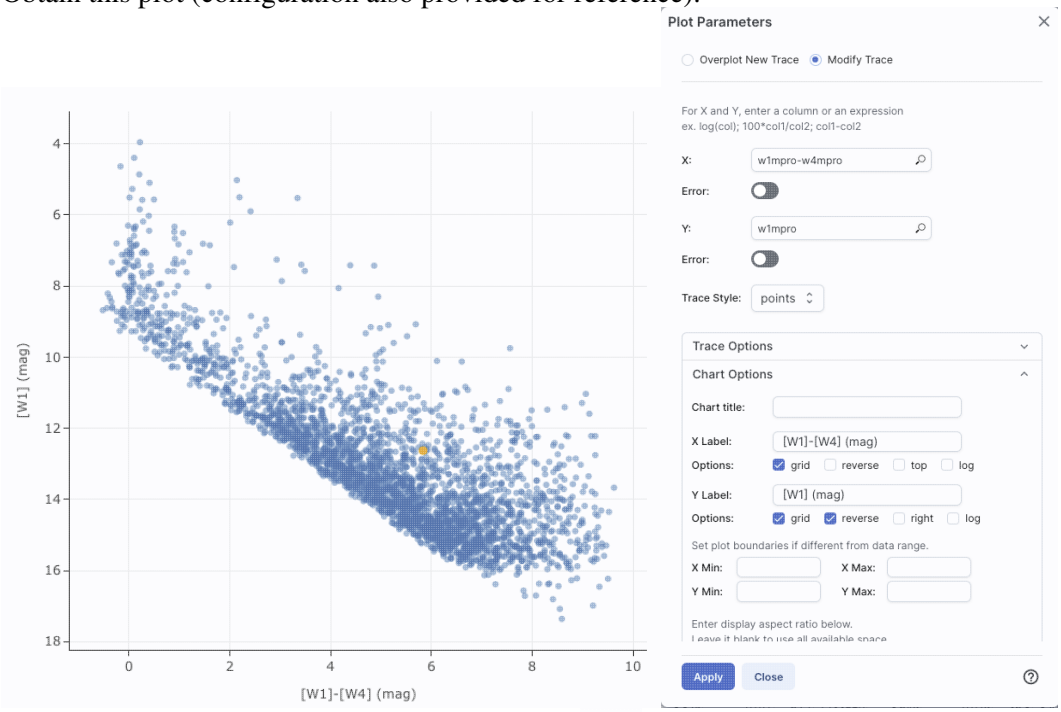
Example: Plotting [W1] vs. [W1]-[W4] in a star-forming region

For this example, we are trying to find young stars in a star-forming region. We are searching in the WISE AllWISE catalog. Stars without circumstellar dust should be at a variety of W1 brightnesses, but all have [W1]-[W4]~0. Background galaxies should be faint and red. Stars with circumstellar dust (e.g., young stars) should be bright and red. Here, we will make a plot, identify a bright and red object in the plot.

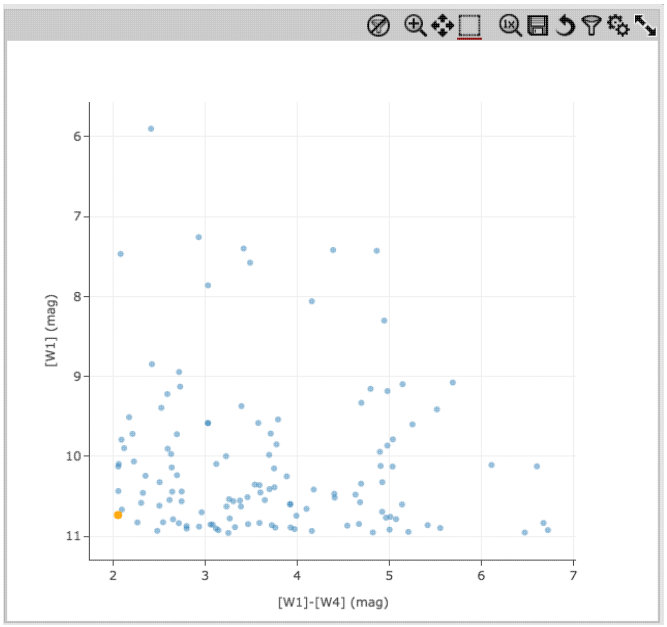
1. Launch the Catalog Search Tool. Select WISE AllWISE. Enter target as IC1396. Select a radius size of 0.5 degree. Click 'Run Query.'
2. The catalog is plotted in the upper right, overplotted on the image in the upper left, and listed as a table at the bottom. Note that the plot on the upper right is a greyscale plot, which means that the plot shows a binned "heatmap" where darker colors mean more points. Only the first 100 are shown in the catalog on the bottom, though all are loaded, and you can page through the list, 100 at a time. Note that selecting a source in the image makes its corresponding row in the catalog change color. It doesn't highlight in the plot, because there are too many points in the plot.
3. Filter down the catalog to only have detections. In the upper right of the catalog, click on the funnel icon to add filters to the top of each column in the catalog. In this catalog, limits have null errors. To limit the catalog to just those with high-quality detections, in the top of the "w1sigmpro" (WISE-1

profile fittted magnitude error) column, type ">0" (without the quotes). Repeat for w2sigmpro, w3sigmpro, and w4sigmpro. At the top of the "w1snr" (WISE-1 signal-to-noise ratio) column, type ">10" (without the quotes). Repeat for w2snr, w3snr, and w4snr. After this process, you should have ~3,000 sources, enough fewer that the plot now has individual blue points (it is no longer a heatmap). Now the individual sources are also **all** shown on the image.

4. The plot comes up with an RA/Dec plot by default. Click on the gears  icon in the upper left of the plot window to change what is plotted.
5. Ensure "Modify Trace" is selected in the pop-up window. Enter in the x box: w1mpro-w4mpro. This is WISE-1 profile-fitted measurement in magnitudes minus WISE-4 profile-fitted measurement in magnitudes,or [W1]-[W4].
6. Enter in the y box: w1mpro. This is the [W1] mag.
7. Click on the triangle next to "Chart Options", and enter "[W1]-[W4] (mag)" for the x-label, and "[W1] (mag)" for the y-label. Click on "reverse" for the y-axis to make the brighter objects appear at the top of the plot. Check "grid" to make the grid appear for both axes.
8. Click "Apply."
9. Obtain this plot (configuration also provided for reference):



10. Ensure that the select icon is "active" in the plot (). Click and drag from corner given approximately by (2,6) to (7,11).
11. The icons in the upper right change after you do this, and we want to filter on this region. Click on the filter icon. This filters the table and the image overlays as well as the plot.
12. After this filtering, you should have about 100 points left in the catalog. The scatter plot after the filtering looks something like this:



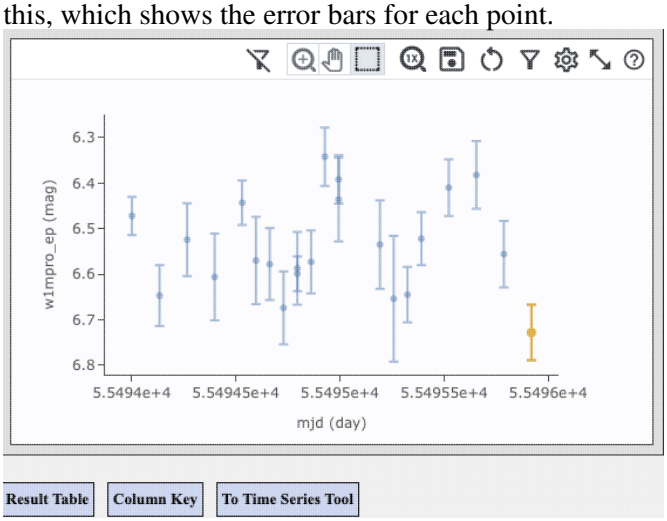
The points are shown as blue circles. Where they overlap, the blue appears darker.

13. We want to find an (astrophysically) bright and red object in the plot and catalog. Now, find the brightest source near [W1]-[W4]~4.5 in the plot. Click on that point. It is highlighted in the catalog (though you may need to scroll slightly in the catalog to find the highlighted line). If you have been following closely, it should be J213808.44+572647.6.

Abbreviated Example: Plotting [W1] vs. time with errors

From the Catalog Search Tool, select the "AllWISE Multiepoch Photometry Table." Search on RR Lyr, and ask it for a radius of only 3 arcsec. It comes back with 49 epochs. The default plot looks a little odd because all the individual epochs are at the same position (RA and Dec).

Click on the gears to change what is plotted. For the x-axis: Ask it to plot mjd. For the y-axis, ask it to plot w1mpro_ep, and use w1sigmpro_ep for the errors. Reverse the y-axis to get bright objects at the top. There are two epochs of data obtained for this source, one near MJD~55,300 and one near 55,500. Click and drag in the plot to select one of the two epochs and filter via the icon at the top of the plot. Obtain a plot something like this, which shows the error bars for each point.

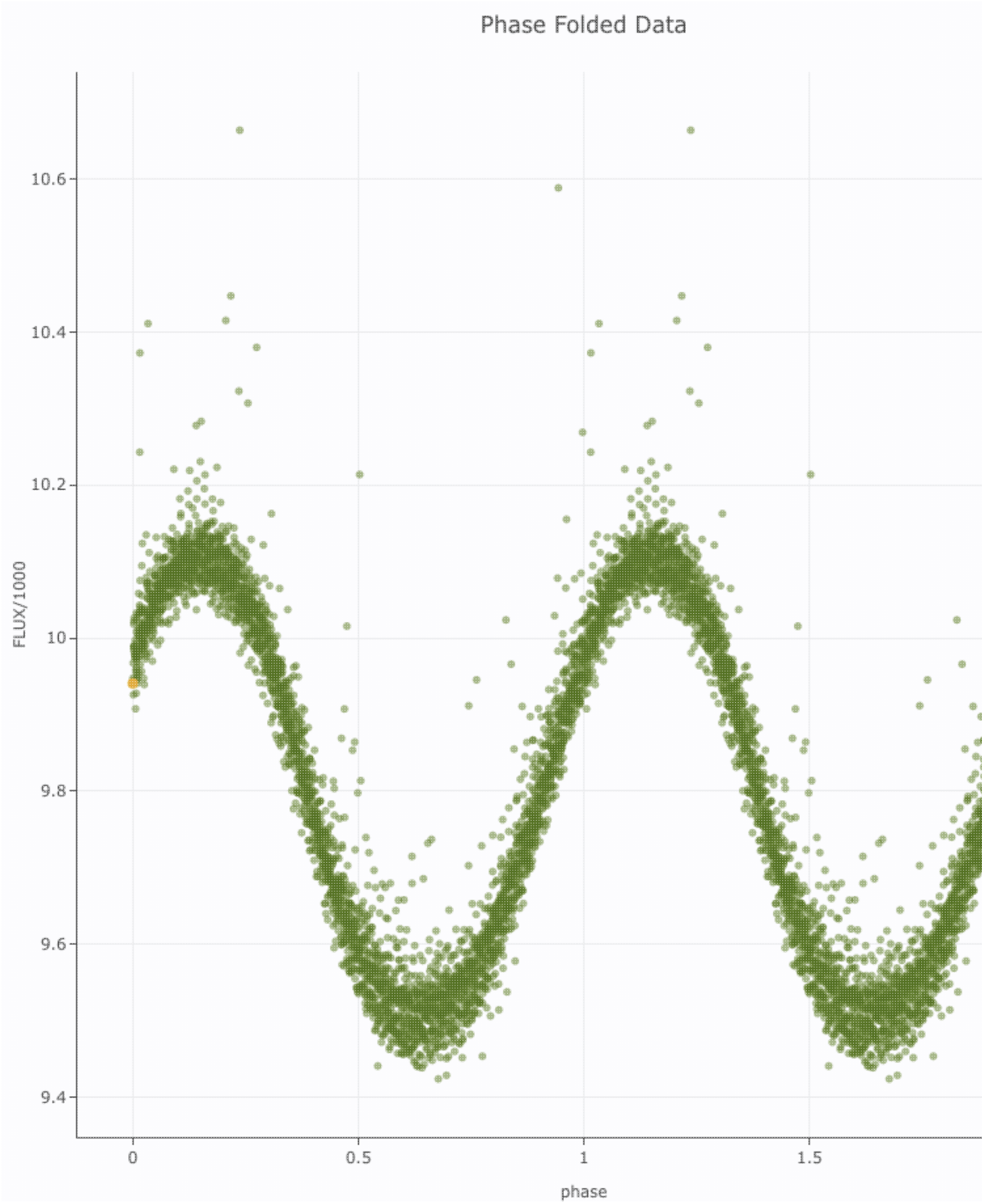


You can send the light curve so obtained to the Time Series Tool for further analysis by clicking on the "To Time Series Tool" button below the plot.

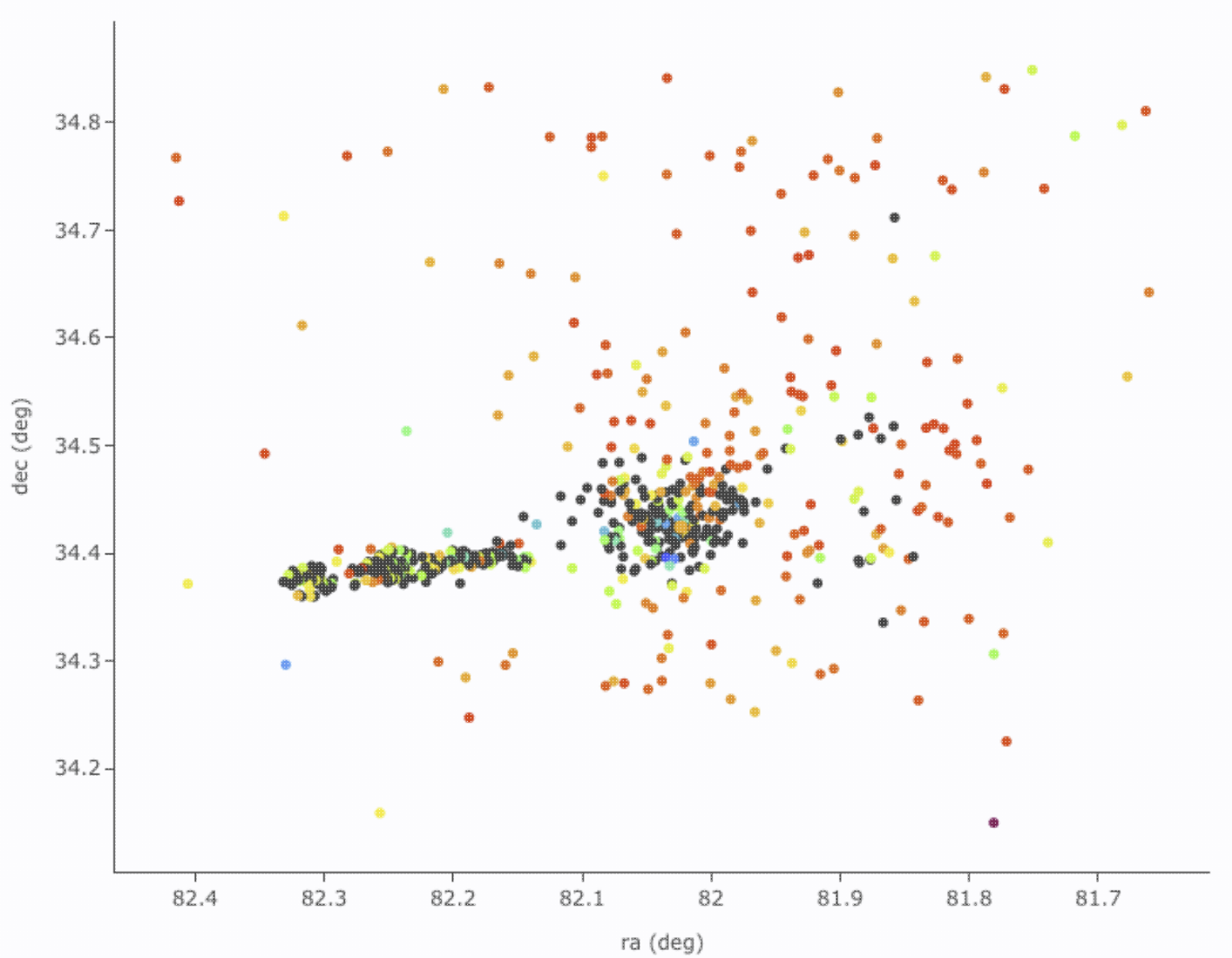
Still More Plots

Here are several more examples of plots made with IRSA tools.

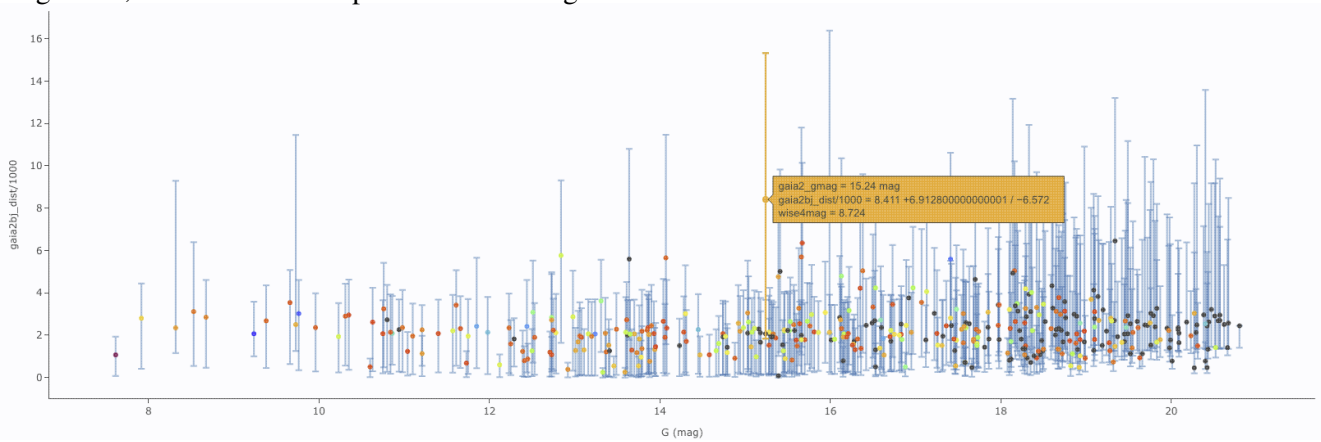
Phase-folded light curve from K2 data:


Phase Folded Data
10.6
10.4
10.2
10
9.8
9.6
9.4
FLUX/1000
0
0.5
1
1.5
phase

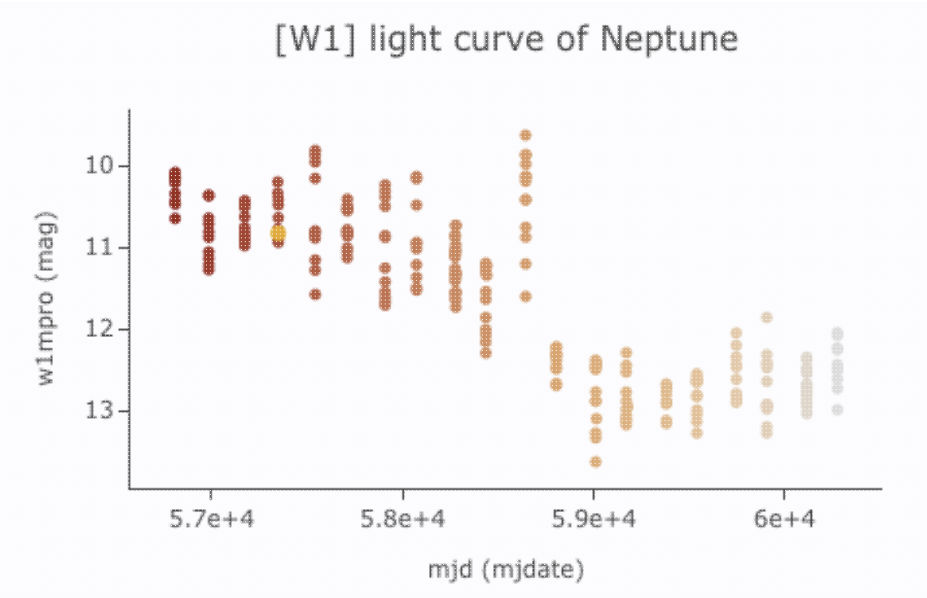
Plot on the sky of stars where the color of the point is scaled to brightness in WISE-4:



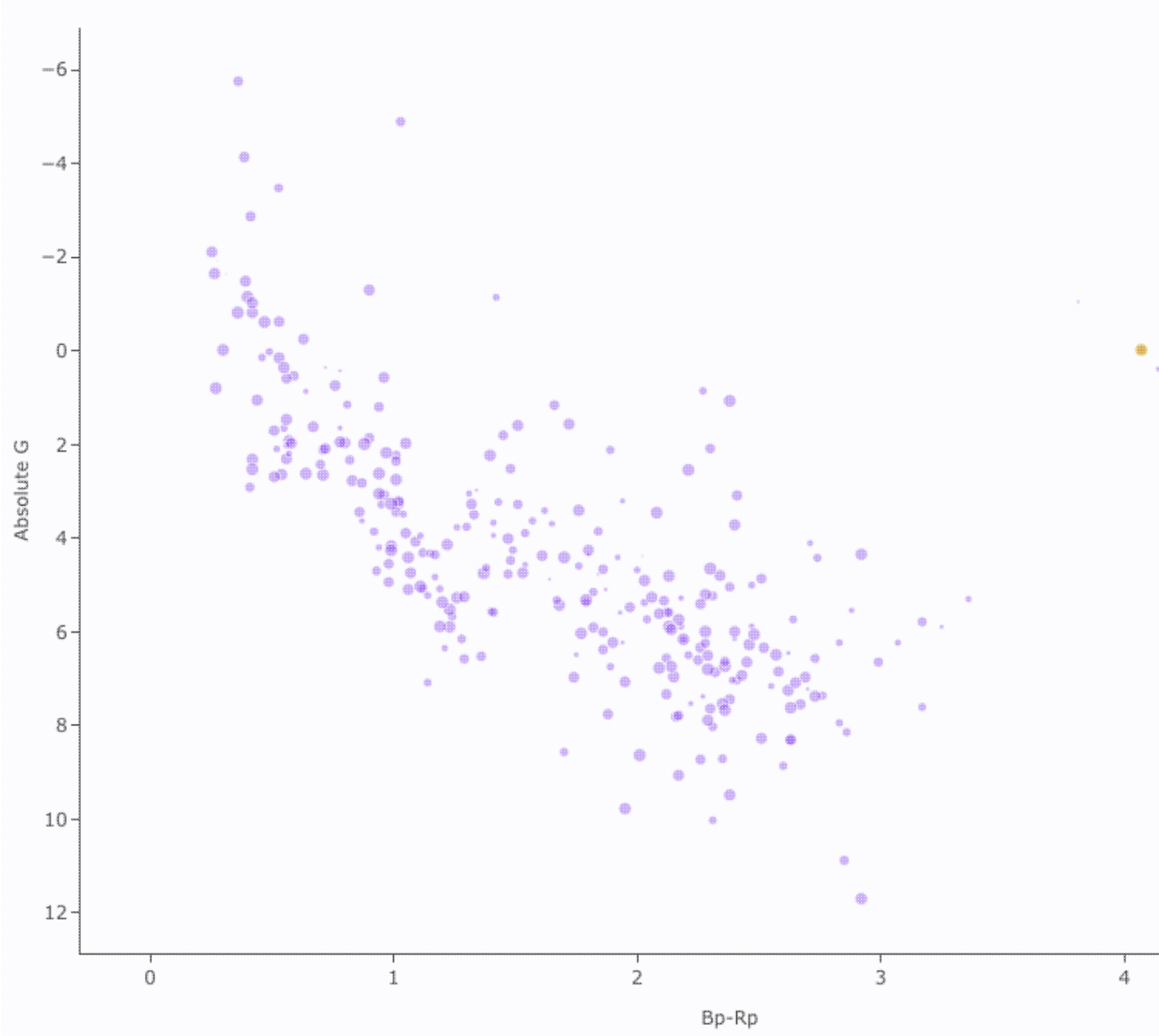
Gaia distance (in kpc, from Bailer-Jones et al. 2018), with asymmetric errors, as a function of Gaia G magnitude, with colors of the point scaled to brightness in WISE-4:



[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:


−6
−4
−2
0
2
4
6
8
10
12
Absolute G
0
1
2
3
4
Bp-Rp

API

You can write programs to interact with the Catalog Search Tool via an API, an application program interface. This page describes APIs.

Contents of page/chapter:

Overview

IRSA offers program-friendly interfaces to all of its catalogs. Through an application program interface (API), users can access IRSA catalogs directly (within a script or on the command line) without the need to go through interactive web pages.

IRSA offers three APIs for searching catalogs.

Simple Cone Search (SCS)

SCS is a VO-compliant method of searching catalogs for sources that lie within a specified radius of any position on the sky. The output can be VO Table, IPAC Table, comma-separated values (CSV) table, tab-separated values table, or FITS table. The ability to upload a list of sources positions is not supported. Users interested in table upload functionality should use the TAP protocol (below).

Table Access Protocol (TAP)

TAP is a VO-compliant method of searching catalogs. TAP allows cone, box, polygon, and multi-position searches with optional SQL constraints, a variety of output formats, and the option of selecting output columns.

IRSA Catalog Search API

This is an older API that does not conform to VO standards and is maintained for historical reasons. New users should choose from either of the two protocols above.

The rest of this page describes this API.

The output can be HTML, VO table, IPAC table file (ASCII text with a certain format), Extensible Markup Language (XML), or a simple SVC (software handshaking structure) message. It also provides the option of selecting output columns. Some catalogs are equipped with a moving object search capability; see Moving Objects below.

In the context of just the Catalog Search Tool, in some cases, information on specific catalogs and their attributes is needed to construct the interface. This information is returned by two other servers: CatList returns the list of catalogs archived at IRSA. CatDD generates and displays a database data dictionary for a specific

catalog; and data dictionary specifies the attributes of the columns in a catalog.

Quick Start Example

IRSA's Catalog Search Tool API consists of three services.

- Catalog Search Service - This service returns the rows from a given catalog that meet spatial or other constraints set by the user. The bulk of this page describes this service.
- Catalog List Service - This service returns a list of catalogs held at IRSA in either XML or HTML format.
- Catalog Data Dictionary Service - This service returns information about the columns in a given catalog.

The following example uses each of these three services: Search the AllWISE Source Catalog for all objects within 300 arcsec of the position ra = 00h 42m 44.32s, dec = 41d 16m 08.5s. Return only a subset of the photometric measurements in an ASCII table.

1. Get a list of all public catalogs in IPAC Table format.
```
curl -o irsa_catalogs.tbl "https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-scan?mode=asc
```
   Examining the 'description' and 'catname' columns of this file, we find that the AllWISE Source Catalog has a cat name of "allwise_p3as_psd".
2. Get a list of the available columns in the AllWISE Source Catalog.
   The following URL can be typed right into a browser window, and will result in a nicely formatted table containing the columns and their descriptions. Alternatively, this URL could be embedded in a wget or curl command to download an XML version.
   https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-dd?mode=html&catalog=allwise_p3as_psd

   Examining the output, the basic photometry is in the columns w1mpro, w2mpro, w3mpro, and w4mpro.
3. Execute the search.
   (this should all be on one line, but it is broken across multiple lines here for formatting convenience.)
   curl -o search_results.tbl
   "https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?catalog=allwise_p3as_psd&spatial=cone&radius=300&radun

Constructing a Catalog Search Service Query URL

The general format for the Catalog Search Service query URL is:
https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?[keyword1=value1]&[keyword2=value2]&...[keywordn=valuen]

Note especially that setting the 'spatial' field to "No Spatial Constraints" will search the entire catalog, and additional constraints should be placed on the query. Users are cautioned to use this feature wisely as very large result tables are possible.

Input keywords:

Keyword	Required?	Description	Values
catalog	required	Catalog name in IRSA's database	Query for catalog names
spatial	required	Type of query	cone

			box polygon Upload (see example below) None (= All-sky search)
objstr	required when spatial=cone or box	Target name or coordinates of spatial search center	
radius	optional if spatial=cone, otherwise ignored	Cone search radius in units of radunits	Limit varies; default=10 arcsec
radunits	optional if spatial=Cone, otherwise ignored	Units of Cone search radius	arcsec, arcmin, deg; default = arcsec
posang	optional	Position angle (E of N) in deg of semi-major access of elliptical cone	0-180 deg; default=0
ratio	optional	Semi-minor/semi-major axis ratio of elliptical cone	<=1.0; default=1.0
uradius uradunits uposang uration	optional	As above for table upload.	NOTE: Absence of a value for uradius will lead it to use values of radius ("major") from table.
size	required when spatial=box	Width of box in arcsec	Limit varies
polygon	required if spatial=polygon	Vertices of an irregular, convex (interior angles < 180 degrees) polygon within which to search. Up to 15 vertices may be specified. Each vertex is given as a space-separated RA Dec pair. For the program interface, the space must be URL encoded as "+" (plus sign). The coordinates must be in decimal degrees, J2000. Each vertex must be separated by a comma. You do not need to repeat the first vertex.	
outfmt	optional	Output format	0: HTML (default) 1: ASCII table 2: SVC (software handshaking structure) message

			3: VO Table 6: XML
constraints	optional	SQL query constraints	
selcols	optional	Comma-separated list of output columns desired	Query for available columns
one_to_one	optional	If nonzero, then a one-to-one match will be performed	
order	optional	Column by which to order results	
outrows	optional	Maximum number of rows to return	
mailcheck	optional	Send email upon completion.	use this combination to have it email you upon completion: &mailcheck=Send+email&email=your_email

Objstr Keyword

An optional keyword is objstr, which specifies the search center for a cone or box spatial search. The keyword objstr is a string that specifies either the target name (as resolved by SIMBAD or NED) or the coordinates of the spatial search center.

This string must be URL encoded. URL encoding replaces unsafe ASCII characters with a percent sign ("%") followed by two hexadecimal digits. See the table below for a list of commonly used values that need to be URL encoded.

URL Encoding for Commonly Used Characters

Character	URL encoding
Plus ("+")	%2B
Comma (",")	%2C
Forward slash ("/")	%2F
Colon (":")	%3A
Semi-colon (";")	%3B
Equals ("=")	%3D
Question mark ("?")	%3F
Space (" ")	%20 or +
Quotation marks (")	%22
Less than ("<")	%3C
Greater than (">")	%3E
Percent ("%")	%25

Examples

1. What is the objstr corresponding to M31?

   objstr=M31

2. What is the objstr correspond to the ra dec coordinates: 00 42 44.3, -41 16 08?

objstr=00+42+44.3+-41+16+08

Query URL Examples

Search the 2MASS Point Source Catalog for all objects within 300 arcsec of M31. Return the result in HTML format.

https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?spatial=cone&catalog=fp_psc&objstr=M31&radius=300&rad

Search the AllWISE Source Catalog for all objects within a 300 arcsec wide box centered on the position ra = 00h 42m 44.32s, dec = 41d 16m 08.5s. Return the results as an ASCII table.

https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?spatial=box&catalog=allwise_p3as_psd&objstr=00h+42m+44

Search the Spitzer Enhanced Imaging Products Source List for all objects within the polygon with corners described by the following coordinates. Return the results as a program interface xML, and only return the MIPS 24 micron PSF fit flux density and error.

(ra1 dec1) = (148.87 69.8)
(ra2 dec2) = (148.87 69.9)
(ra3 dec3) = (148.90 69.9)

https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?catalog=slphotdr4&spatial=polygon&polygon=148.87+69.8,1

Search the COSMOS Cassata Morphology Catalog v1.1 for the nearest match within 2 arcsec for each object listed in the IPAC Table cosmos_example.tbl. Return the otuput as an IPAC Table.

```
curl -F filename=@cosmos_example.tbl \
-F catalog=cosmos_morph_cassata_1_1 \
-F spatial=Upload \
-F uradius=2 \
-F outfmt=1 \
"https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query" \
-o cosmos_output.tbl
```

Search the entire HERITAGE LMC PACS 100 micron Catalog all-sky search for objects with flux > 0. Order the output by flux, and only return the first 7 rows as an ASCII table.

https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?catalog=heritage1100&spatial=None&outfmt=1&order=flux&

Moving Objects

Some IRSA catalogs allow queries on moving objects. The query calculates the object's ephemeris to determine positions (and times) within the data, and does a cone search around those positions. Below is an example: a search by object name (324 Bamberga) over the entire time range of the WISE All-Sky Single Exposure (L1b) Source Table with output in an IPAC ASCII table. (For the larger merged NEOWISE catalogs, it is best to restrict the time range.):

```
curl -o out.tbl
"https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?outfmt=1&searchForm=MO&spatial=cone&catalog=allsky_
```

Note that "mobjstr" is the asteroid number in this case; the name Bamberga would also work. It can also search for a comet using its numeric designation. For example, periodic comet P/29 Schwassmann-Wachmann 1 can be called 29P or P/29 (but not P29). For non-periodic comets, use for example C/2010+N1, where the "+" is shorthand for a space for URL encoding. Planetary satellites (or planets, where available in the dataset) are searchable by name, e.g. Titan.

There can be name ambiguities. For example, entering "WISE" is a problem as there were many asteroids and comets discovered by the WISE mission. Entering "Neptune" is unclear as there are ephemeris files for both Neptune and the Neptune system barycenter. Gator will deliver a messsage if there is an ambiguity. This will be via a link to a log file. The message will contain suggested NAIF ID's, and you can use them as follows, e.g. "1003094:NID" for comet 317P/WISE or "899:NID" for Neptune. In a few cases, there are satellites and asteroids with the same name, and you may distinguish them by, e.g. "Europa:SAT" and "Europa:AST".

It is also possible to input objects in Minor Planet Circular (MPC) format, or by orbital elements, see the Solar System Object page and the examples below. But **object name/number input is best**, as it will query JPL Horizons to get the osculating orbital elements closest in time to the observations.

The general format for the Moving Object query URL is:

https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?searchForm=MO&spatial=cone&[keyword1=value1]&[keywo

Adjustable keywords:

Keyword	Required?	Description	Values
catalog	required	Catalog name. NOTE: Catalog needs to be moving-object search enabled.	Current moving-object enabled catalogs: All-Sky: allsky_4band_p1bs_psd WISE 3band: allsky_3band_p1bs_psd WISE 2band: allsky_2band_p1bs_psd NEOWISE-R: neowiser_p1bs_psd
moradius	optional	Cone search radius (arcsec)	default=10 arcsec
mobj	required	Type of input	smo = by name or number mpc = MPC format obt = orbital elements
mobjstr	required for object input	Name or numeric designation of object (see above)	e.g. "324" or "Bamberga" (asteroid) or "29P" (comet)
mobjtype	required for MPC or orbital elements input	Solar-system object type	Asteroid or Comet
mpc	required for MPC input	MPC string	See Moving Object page or examples below.
mobjmaj/perih_dist	required for orbital elements input	Semi-major axis (asteroid) or perihelion distance (comet) in AU	>0
mobjecc	required for orbital elements input	Eccentricity of orbit	0.0-1.0
mobjinc	required for orbital	Inclination of orbit (deg)	0.0-180.0

	elements input		
mobjper	required for orbital elements input	Argument of perihelion (deg)	0.0-360.0
mobjasc	required for orbital elements input	Longitude of ascending node (deg)	0.0-360.0
mobjanom/perih_time	required for orbital elements input	Mean anomaly (asteroid) in deg, or perihelion time (comet) in yyyy+mm+dd+hh:mm:ss	0.0-360.0 for mean anomaly
mobjdsg	required for orbital elements input	Designation for returned ephemeris	e.g. Bamberga
mobjepo	required for orbital elements input	Epoch of coordinates in MJD (Modified Julian Date)	e.g. 55203.0 for start of WISE mission
btime	optional	Earliest observation date (UT) to include	yyyy+mm+dd+hh:mm:ss
etime	optional	Latest observation date (UT) to include	yyyy+mm+dd+hh:mm:ss
outfmt	optional	Output format	0: HTML (default) 1: ASCII table 2: SVC (software handshaking structure) message 3: VO Table 6: XML output
selcols	optional	Comma-separated list of output columns desired	Query for available columns
outrows	optional	Maximum number of rows to return	

Asteroid:

Example with MPC input at time of WISE 4-band observation of Bamberga:

```
curl -o out.tbl
"https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?searchForm=MO&spatial=cone&catalog=allsky_4band_p1bs
327.9898280+11.1080776+0.33709263+0.2240550+2.684723515+0+MPO344295+2289+63+
1892-2015+0.50+M-v+38h+MPCLINUX+0000+(324)+Bamberga+20150614"
```

Example with orbital elements at time of WISE 4-band observation of Bamberga:

```
curl -o out.tbl
"https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?searchForm=MO&spatial=cone&catalog=allsky_4band_p1bs
```

Comet:

Example with MPC input at time of WISE 4-band observation for comet P/2010 N1 (WISE):

```
curl -o out.tbl
"https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?searchForm=MO&spatial=cone&catalog=allsky_4band_p1bs
```

```
153.4910+113.2118+12.8762+20100621+17.0+4.0+
P/2010+N1+(WISE)+MPC+75712"
```

Example with orbital elements at time of WISE 4-band observation for comet P/2010 N1 (WISE) :

```
curl -o out.tbl
"https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query?searchForm=MO&spatial=cone&catalog=allsky_4band_p1bs
```

Catalog Search Tool: User Registration for the IRSA Archives

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

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

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

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

Login

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

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

Create New Account

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

Select this option to create a new account.

Forgot your Username or Password

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

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

Edit Profile

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

Change Password

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

Update Email

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

Catalog Search Tool: FAQs

Do you have any tutorial videos?

Yes. There are Catalog Search Tool video tutorials, including quick start and longer AAS-demo style overviews, available at the IRSA YouTube channel. Also see the Catalog Search Tool playlist (combines all the relevant vidoes together), as well as the playlist of tutorials relevant for more than one archive.

How do I get more help?

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

You can submit questions to the IRSA Help Desk.

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

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