

Advanced TOPCAT

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TOPCAT & STILTS

- Both do basically the same things but
 - TOPCAT
- Easier to learn.
- Good for interactive use, especially exploring data to get a feel for what's there.
- STILTS
- Better for reproducible work (it can be scripted). Steeper learning curve.

TOPCAT & STILTS

- Which is the best format?

- [4.1.1.1 FITS](#)
- [4.1.1.2 Column-oriented FITS](#)
- [4.1.1.3 VOTable](#)
- [4.1.1.4 CDF](#)
- [4.1.1.5 ASCII](#)
- [4.1.1.6 IPAC](#)
- [4.1.1.7 Comma-Separated Values](#)
- [4.1.1.8 GBIN](#)
- [4.1.1.9 Tab-Separated Table](#)
- [4.1.1.10 SQL Database Queries](#)
- [4.1.1.11 World Data Center](#)

- Small table (<1000 rows): **doesn't matter.**
- Medium-sized (rows*cols) < 20million): **FITS.**
- Big (millions of rows, especially with lots of columns): **colfits.**

- If the input file is not in this format you can convert it using STILTS:

- *stilts tpipe in=xxx.csv ifmt=csv out=xxx.fits*

TOPCAT & STILTS

- Output in Latex

The image shows a screenshot of the TOPCAT software interface. The main window displays the 'Current Table Properties' for a table named 'TAP_3_gaiadr1.tgas_source,extcat.hipparcos'. The properties include: Label: TAP_3_gaiadr1.tgas_source,extcat.hipparcos; Location: TAP_3_gaiadr1.tgas_source,extcat.hipparcos; Name: sync; Rows: 50; Columns: 5; Sort Order: (ascending); Row Subset: All.

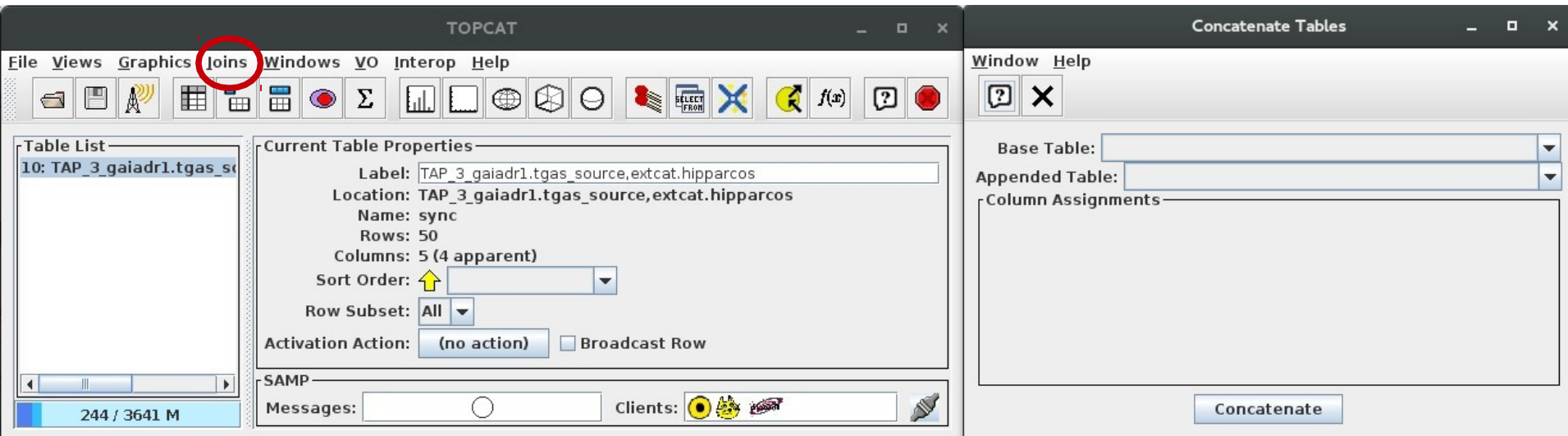
Overlaid on the TOPCAT window is an Emacs editor window titled 'tabla_latex.tex - emacs@esm.laptop'. The editor shows LaTeX code for generating a table with 5 columns. The code includes the following lines:

```
\documentclass{article}
\begin{document}
\begin{table}
\begin{tabular}{|r|r|r|r|r|}
\hline
\multicolumn{1}{|c|}{hip} &
\multicolumn{1}{|c|}{g_mag_abs_gaia} &
\multicolumn{1}{|c|}{g_mag_abs_hip} &
\multicolumn{1}{|c|}{b_v} &
\hline
95905 & 2.90110612385656 & 3.08139684809066 & 0.394 & \\
95838 & 3.36666243484313 & 3.60007543840966 & 0.707 & \\
95662 & 4.21575480915181 & 4.96691320323364 & 0.683 & \\
96089 & 3.67412200337596 & 3.99711049720092 & 0.609 & \\
97946 & 3.95220466256254 & 3.93122863291356 & 0.495 & \\
98189 & 4.08580555128650 & 3.90903495748743 & 0.639 & \end{table}
\end{document}
```

To the right of the Emacs window is the 'Save Table(s) or Session' dialog box. It shows the 'Current Table' tab selected, with the table name 'Table: 10: TAP_3_gaiadr1.tgas_source,extcat.hipp...'. The 'Output Format' is set to 'LaTeX-document'. There are 'OK' and 'Filestore Browser' buttons visible.

TOPCAT & STILTS

- Concatenating tables in TOPCAT



- Only two tables at a time.

TOPCAT & STILTS

- Concatenating multiple tables in STILTS

B.24.2 Examples

Here are some examples of `tcat`:

```
stilts tcat ifmt=ascii in=t1.txt in=t2.txt in=t3.txt out=table.txt
```

Concatenates the three named ASCII format tables to produce an output table. All three must have compatible numbers and types of columns.

```
stilts tcat ifmt=ascii in="t1.txt t2.txt t3.txt" out=table.txt
```

Has exactly the same effect as the previous example.

```
stilts tcat ifmt=ascii in=@inlist.lis out=table.txt
```

This will have the same effect as the previous two examples if a file name "inlist.lis" in the current directory contains three lines, "t1.txt", "t2.txt" and "t3.txt".

- Same input format
- Similar columns (in number and class).

TOPCAT & STILTS

- Concatenating multiple tables in STILTS

```
stilts tcatn nin=2 in1=survey.vot.gz ifmt2=csv in2=more_data.csv
      icmd1='addskycoords fk5 galactic RA2000 DEC2000 GLON GLAT' \
      icmd1='keepcols "OBJ_ID GLON GLAT"' \
      icmd2='keepcols "ident gal_long gal_lat"' \
      loccol=FILENAME
      omode=topcat
```

In this case we are trying to concatenate results from two tables which are quite dissimilar to each other. In the first place, one is a VOTable (no `ifmt1` parameter is required since VOTables can be detected automatically), and the other is a comma-separated-values file (for which the `ifmt2=csv` parameter must be given). In the second place, the column structure of the two tables may be quite different. By pre-processing the two tables using the `icmd1` & `icmd2` parameters, we produce in each case an input table which consists of three columns of compatible types and meanings: an integer identifier and floating point galactic longitude and latitude coordinates. The second table contains such columns to start with, but the first table requires an initial step to convert FK5 J2000.0 coordinates to galactic ones. `tcatn` joins the two doctored tables together, to produce a table which contains only these three columns, with all the rows from both input tables, and sends the result directly to a new or running instance of TOPCAT. An additional column named `FILENAME` is appended to the table before sending it; this contains "survey.vot.gz" for all the columns from the first table and "more_data.csv" for all the columns from the second one.

TOPCAT & STILTS

- Functions in TOPCAT

The screenshot displays two windows from the TOPCAT software. The left window, titled 'Define Synthetic Column', contains a form for defining a new column. The 'Name' field is empty, and the 'Index' field is set to 47. A red circle highlights the 'f(x)' icon in the top-left corner of the window. The right window, titled 'Available Functions', shows a tree view of function categories. The 'Arithmetic' category is expanded, and the 'julianToMjd(julianEpoch)' function is selected and highlighted. The right pane of this window displays the function's details:

Function `julianToMjd(julianEpoch)`

Description:
Converts a Julian Epoch to Modified Julian Date. For approximate purposes, the argument of this routine consists of an integral part which gives the year AD and a fractional part which represents the distance through that year, so that for instance 2000.5 is approximately 1 July 2000.

Parameters:
`julianEpoch` (floating point)
Julian epoch

Return Value (floating point):
modified Julian date

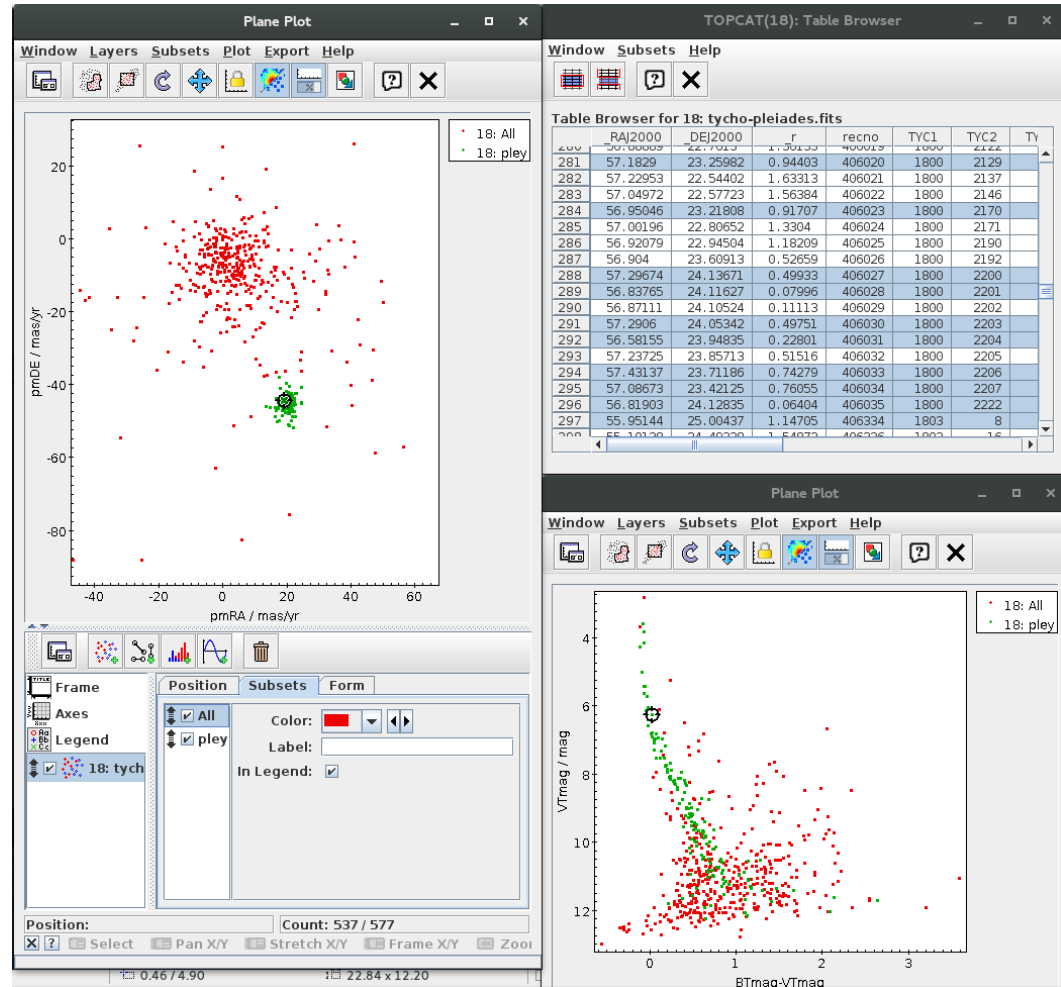
Example:
`julianToMjd(2000.0) = 51544.5`

Signature:
`double julianToMjd(double)`

TOPCAT & STILTS

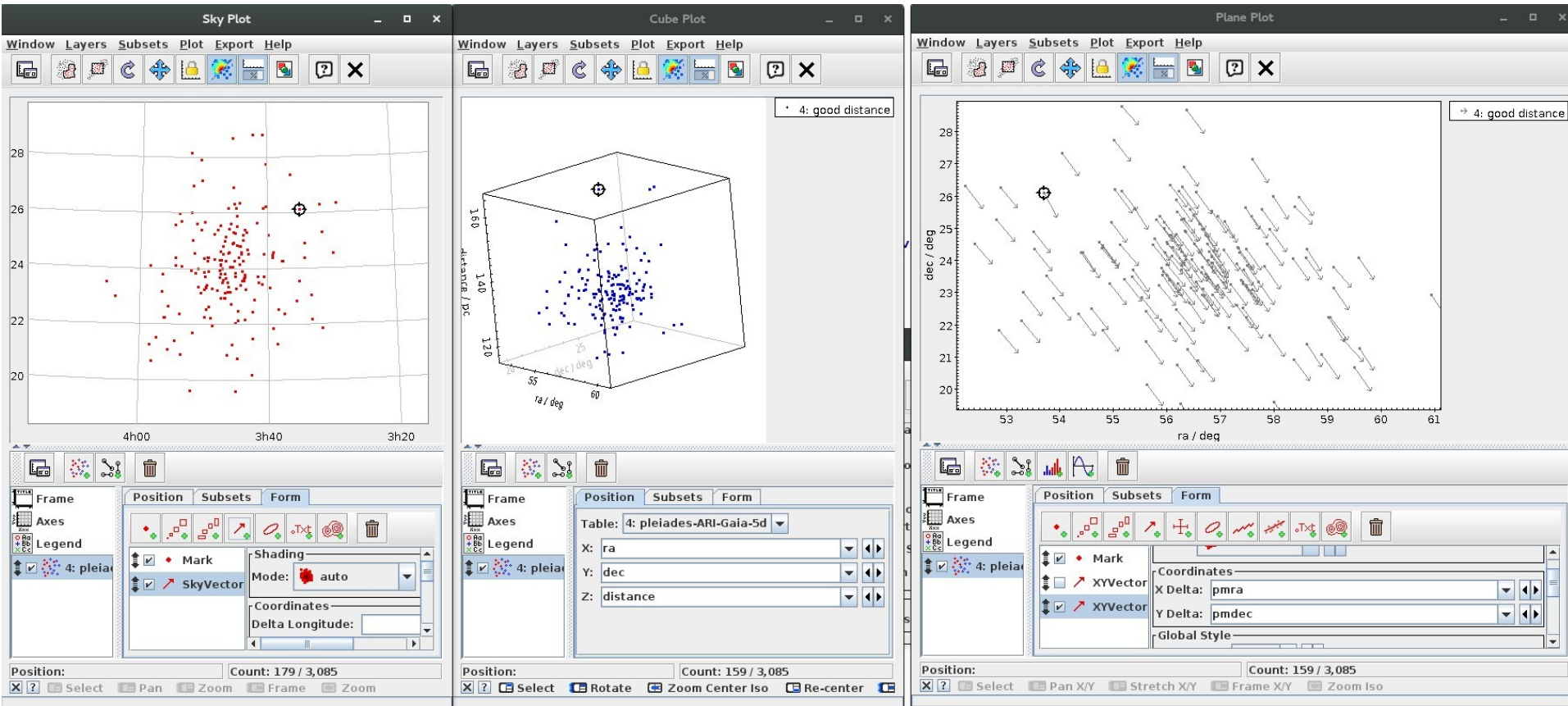
- **Linked views**

Same object is highlighted in the different planes



TOPCAT & STILTS

- **Linked views:** Good to identify anomalous objects



TOPCAT & STILTS

- Crossmatching



```
stilts tskymatch2 \  
  in1=tycho-pleiades.fits ra1=_RAJ2000 dec1=_DEJ2000 \  
    in2=2mass-pleiades.fits          ra2=_RAJ2000 \  
  dec2=_DEJ2000 \  join=1and2 find=best error=1 \  
  out=tycho-2mass.fits \  

```

- There are lots of different match types (Algorithm selector), not just Sky.
- Think about the output options. Especially in crowded fields, the default Best Match, Symmetric can give surprising results.

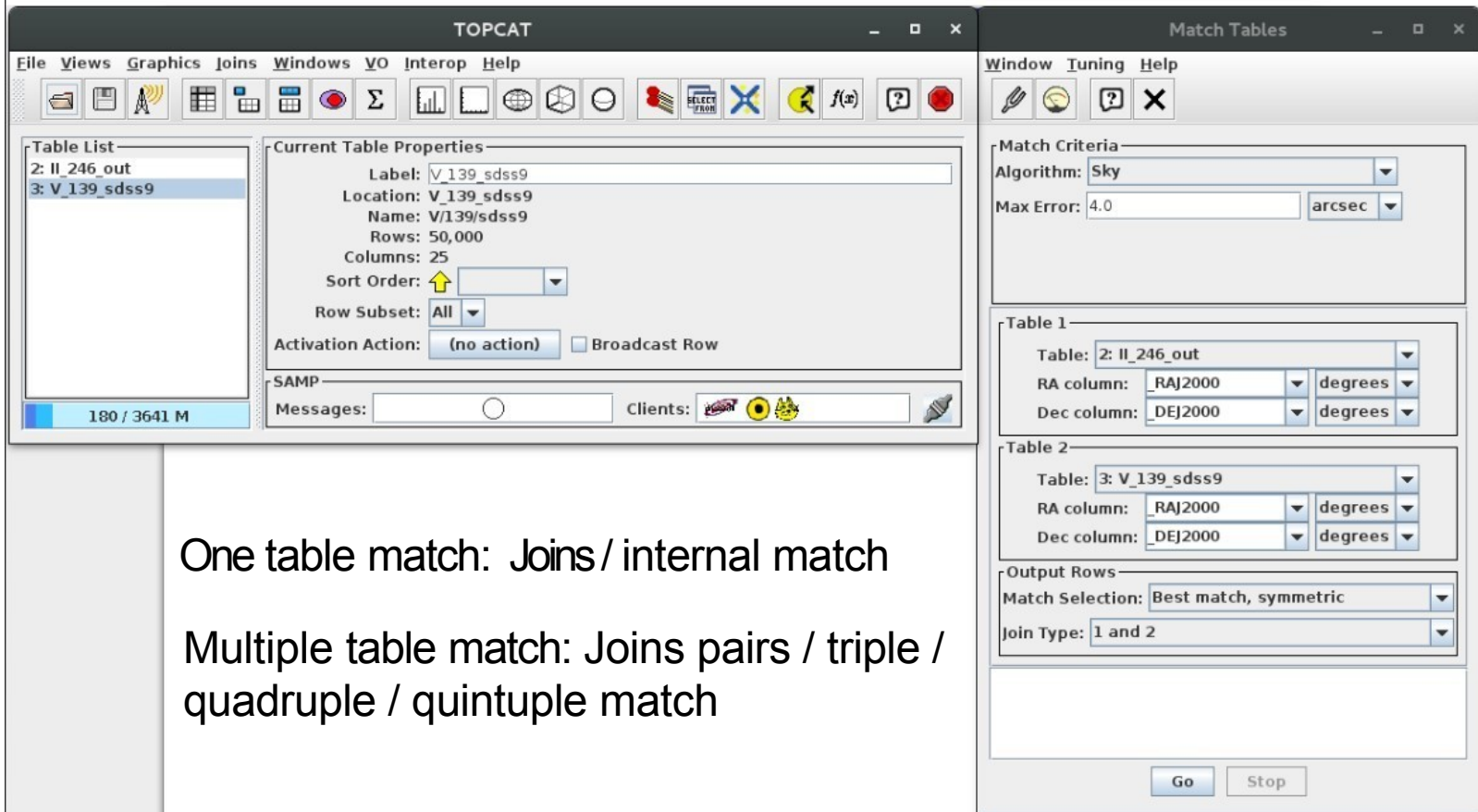
For large tables (> million rows) , the crossmatch can run out of memory.

Tip: Increase heap memory (run with `java -jar -Xmx2048M topcat-full.jar`) or use the `java -disk` option.

TOPCAT & STILTS

- **Crossmatching**  - How to x-match two **medium-size** catalogues?

TOPCAT → Joins / Pair match



The screenshot displays the TOPCAT software interface. The main window is titled 'TOPCAT' and features a menu bar (File, Views, Graphics, Joins, Windows, VO, Interop, Help) and a toolbar with various icons. On the left, a 'Table List' shows two tables: '2: II_246_out' and '3: V_139_sdss9'. The 'Current Table Properties' panel shows details for 'V_139_sdss9', including its location, name, row count (50,000), and column count (25). The 'Match Tables' window is open on the right, showing 'Match Criteria' (Algorithm: Sky, Max Error: 4.0 arcsec) and 'Table 1' (Table: 2: II_246_out, RA column: RAJ2000, Dec column: DEJ2000) and 'Table 2' (Table: 3: V_139_sdss9, RA column: RAJ2000, Dec column: DEJ2000). The 'Output Rows' section is set to 'Match Selection: Best match, symmetric' and 'Join Type: 1 and 2'. Buttons for 'Go' and 'Stop' are visible at the bottom of the 'Match Tables' window.

One table match: Joins / internal match

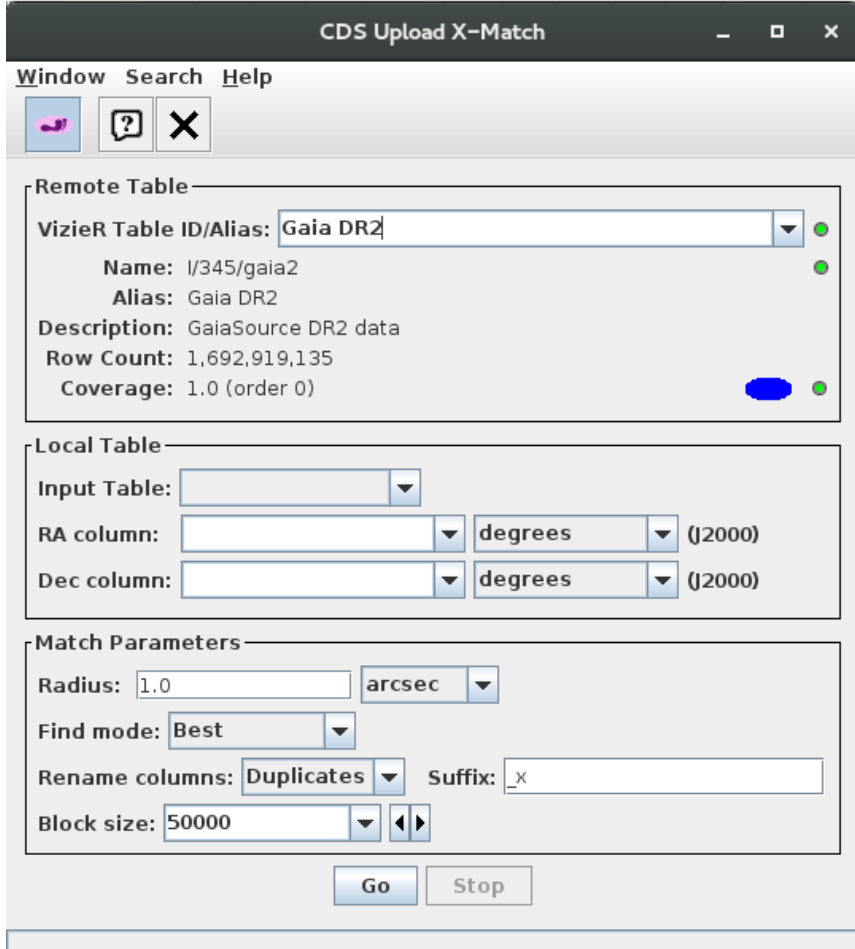
Multiple table match: Joins pairs / triple / quadruple / quintuple match

TOPCAT & STILTS

- **Crossmatching**  - How to x-match my catalogue with a large catalogue (in CDS) ?

TOPCAT → Joins → CDS Upload X-Match

- **Advantages: Efficiency**
- **Disadvantages:**
 - Only CDS catalogues
 - Only default columns (a problems if the needed columns are not selected by default. See next slide).




The screenshot shows the 'CDS Upload X-Match' window. It has a menu bar with 'Window', 'Search', and 'Help'. Below the menu bar are three icons: a red arrow, a question mark, and a close button. The main area is divided into three sections: 'Remote Table', 'Local Table', and 'Match Parameters'. The 'Remote Table' section shows 'VizieR Table ID/Alias' set to 'Gaia DR2', with details for Name, Alias, Description, Row Count, and Coverage. The 'Local Table' section has fields for 'Input Table', 'RA column', and 'Dec column', each with a dropdown menu. The 'Match Parameters' section includes 'Radius' (1.0 arcsec), 'Find mode' (Best), 'Rename columns' (Duplicates), 'Suffix' (_x), and 'Block size' (50000). At the bottom are 'Go' and 'Stop' buttons.

TOPCAT & STILTS

- **Crossmatching**  - How to x-match my catalogue with a large catalogue (in CDS) ?

Hot Stuff for One Year (HSOY) (Altmann+, 2017) [2017A&A...600L...4A](#) [ReadMe+ftp](#)
 1/339 [Post annotation](#) [Similar Catalogs](#)
 1.I/339/hsoy The HSOY catalogue (583001653 sources) (original column names in green) (583001653 rows)

Simple Constraint **List Of Constraints**

Query by **Constraints**  applied on Columns (Output Order: + -)
 Standard Original

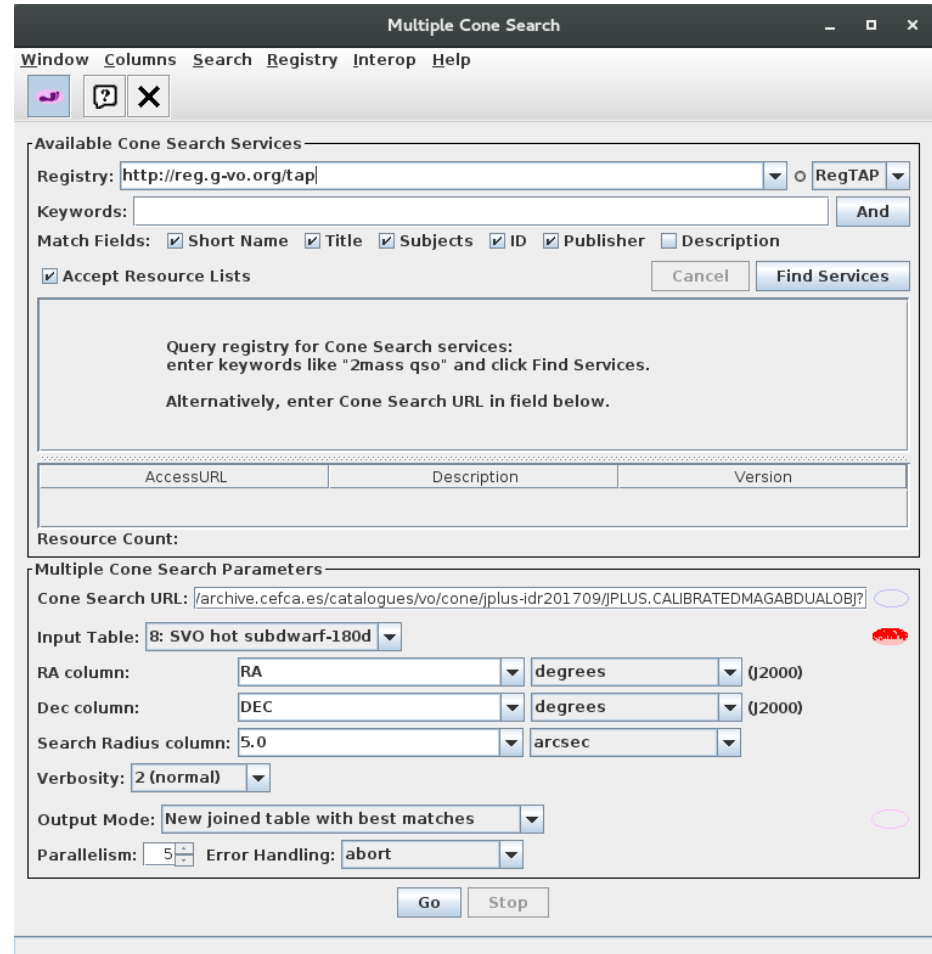
Show	Sort	Column	Clear	Constraint	Explain (UCD)
<input checked="" type="checkbox"/>	<input type="radio"/>	RAJ2000	<input type="text"/>	deg	(i) Right ascension, J2000.0, at epoch 2000 (raj2000) (pos.eq.ra;meta.main)
<input checked="" type="checkbox"/>	<input type="radio"/>	DEJ2000	<input type="text"/>	deg	(i) Declination, J2000.0, at epoch 2000 (dej2000) (pos.eq.dec;meta.main)
<input checked="" type="checkbox"/>	<input type="radio"/>	ipix	<input type="text"/>		(n)(i) PPMXL object identifier (ipix) (Note 1) (meta.id;meta.main)
<input checked="" type="checkbox"/>	<input type="radio"/>	comp	<input type="text"/>		[0/4] Disambiguation counter (where multiple DR1 objects match one PPMXL object) (comp) (Note 1) (meta.code.multip)
<input type="checkbox"/>	<input type="radio"/>	e_RAJ2000	<input type="text"/>	mas	Mean error: RA*cos(DE) at mean epoch EpRA (e_ra) (stat.error;pos.eq.ra)
<input type="checkbox"/>	<input type="radio"/>	e_DEJ2000	<input type="text"/>	mas	Mean error: DE at mean epoch EpDE (e_de) (stat.error;pos.eq.dec)
<input checked="" type="checkbox"/>	<input type="radio"/>	pmRA	<input type="text"/>	mas/yr	Proper motion in RA, pmRA*cos(DE) (pmra) (pos.pm;pos.eq.ra)
<input checked="" type="checkbox"/>	<input type="radio"/>	pmDE	<input type="text"/>	mas/yr	Proper motion in DE (pmde) (pos.pm;pos.eq.dec)
<input type="checkbox"/>	<input type="radio"/>	e_pmRA	<input type="text"/>	mas/yr	Mean error in pmRA (e_pmra) (stat.error;pos.pm;pos.eq.ra)
<input type="checkbox"/>	<input type="radio"/>	e_pmDE	<input type="text"/>	mas/yr	Mean error in pmDE (e_pmde) (stat.error;pos.pm;pos.eq.dec)

TOPCAT & STILTS

- Crossmatching  - How to x-match my catalogue with a large catalogue?

TOPCAT → *VO* → *Multicone*

- Disadvantages:
 - Slow



Multiple Cone Search

Window Columns Search Registry Interop Help

Available Cone Search Services

Registry:

Keywords:

Match Fields: Short Name Title Subjects ID Publisher Description

Accept Resource Lists

Query registry for Cone Search services:
enter keywords like "2mass qso" and click Find Services.
Alternatively, enter Cone Search URL in field below.

AccessURL	Description	Version
-----------	-------------	---------

Resource Count:

Multiple Cone Search Parameters

Cone Search URL:

Input Table:

RA column: (J2000)

Dec column: (J2000)

Search Radius column:

Verbosity:

Output Mode:

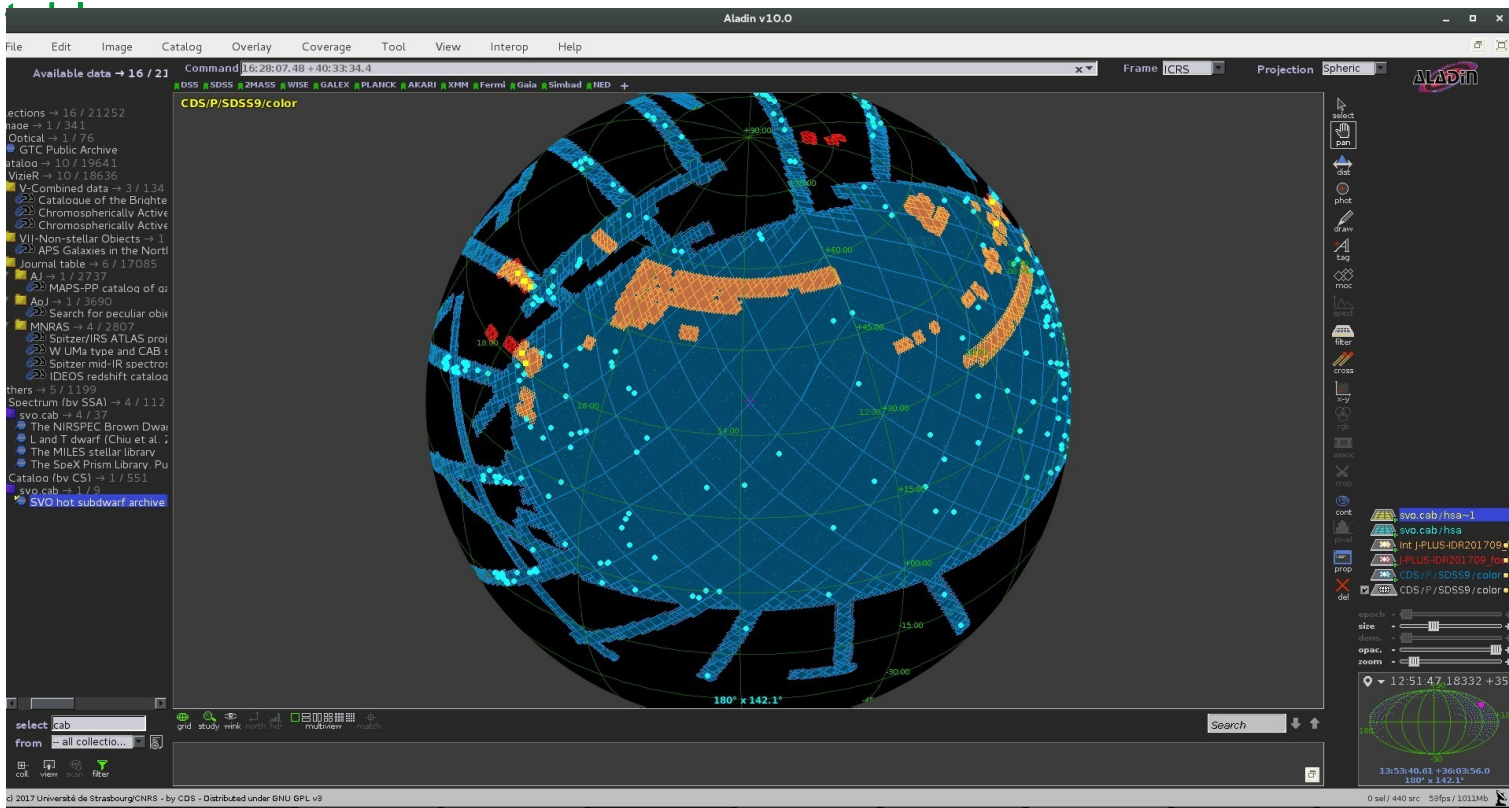
Parallelism: Error Handling:

TOPCAT & STILTS

- **Crossmatching**  - How to x-match my catalogue with a large catalogue?

Alternative (for non all-sky surveys)

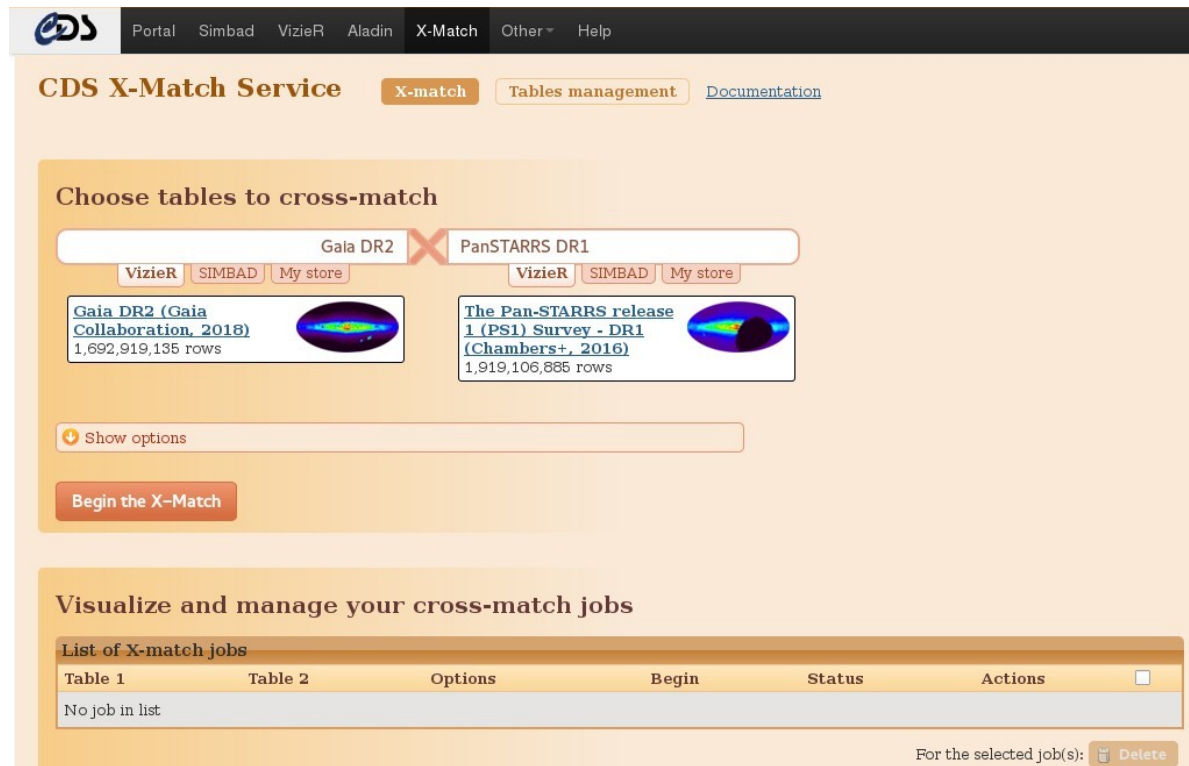
- Filter a table by MOC → X-match the filtered



TOPCAT & STILTS

- **Crossmatching**  - How to x-match two large catalogues (in CDS) ?

- **Disadvantages:**
 - No filtering
 - Large outputs



CDS X-Match Service

Choose tables to cross-match

Gaia DR2 PanSTARRS DR1

Gaia DR2 (Gaia Collaboration, 2018) 1,692,919,135 rows

The Pan-STARRS release 1 (PS1) Survey - DR1 (Chambers+, 2016) 1,919,106,885 rows

Show options

Begin the X-Match

Visualize and manage your cross-match jobs

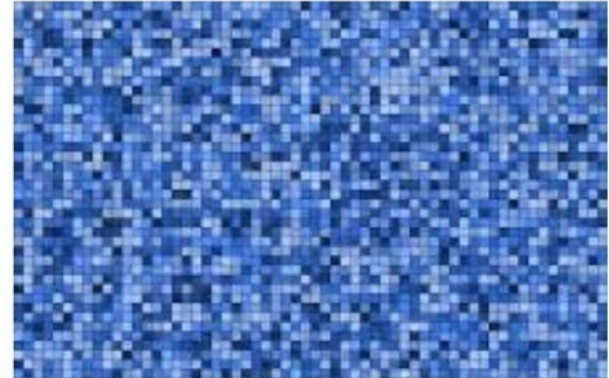
Table 1	Table 2	Options	Begin	Status	Actions
No job in list					

For the selected job(s): Delete

TOPCAT & STILTS

- Crossmatching  • - How to x-match two large catalogues (in CDS)?
(Alternative)

- STILTS



Tessellation

- Cross-match

```
java -jar stilts.jar tsnymatch2 ifmt1=votable in1=2mass.xml ifmt2=votable  
in2=sdss.xml ra1="RAJ2000" dec1="DEJ2000" ra2="RAJ2000" dec2="DEJ2000"  
error=10 find=all out=cross.xml ofmt=votable'
```

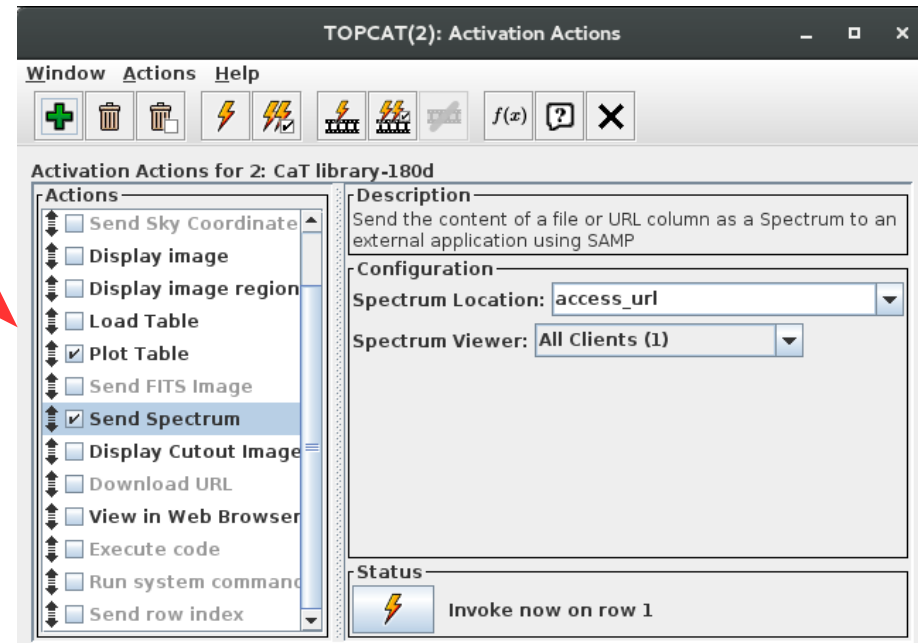
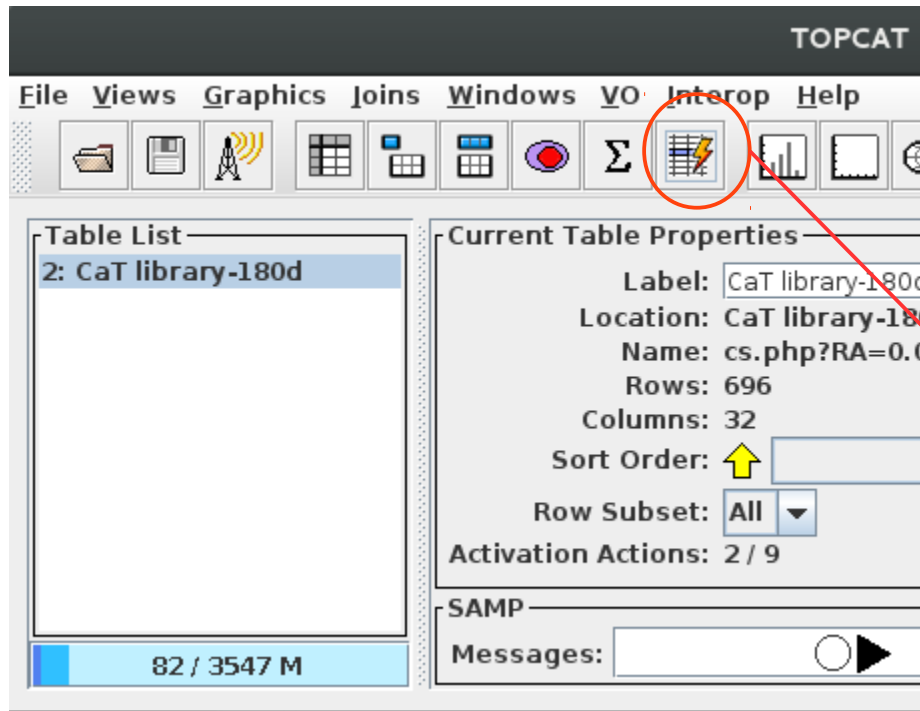
- Filtering

```
java -jar stilts.jar tpipe ifmt=votable in=cross.xml cmd="select  
zmag>12&&zmag<19.5&&rmag-kmag>(zmag+0.5)/2.5&&(rmag-  
kmag)<(zmag+10.5)/2.5&&e_Kmag>0" out=rmkz.xml ofmt=votable
```

TOPCAT & STILTS

• Activation actions and activation window

- The Activation Window lets you configure what happens when you click in a row of the table.
- A list of suggested Activation Actions is displayed in the top left panel.



TOPCAT & STILTS

Activation actions and activation window

- By clicking in a row, the associated spectrum is sent to the VO application (SPLAT-VO in this case).

TOPCAT(2): Table Browser

	RA	DEC	hd	teff	access_url
1	354.987	5.62639	222368	6136.	http://svo2.cab.inta-csic.es/vocats/v2/catlib/dl
2	352.3845	-4.53278	221148	4643.	http://svo2.cab.inta-csic.es/vocats/v2/catlib/dl
3	4.67459	-8.05306	1461	5816.	http://svo2.cab.inta-csic.es/vocats/v2/catlib/dl
4	7.97416	-5.26194	2857	7563.	http://svo2.cab.inta-csic.es/vocats/v2/catlib/dl

Starlink SPLAT-VO: Query VO for Spectra

Search parameters:
Simple Query
Object: RA: Dec:
Radius: 10.0 MAXREC:
Band:
Time:
Query Format: None
Wavelength calibration: None
Flux calibration: None

Query: <SERVER>?REQUEST=queryData&SIZE=0.16666666666666666
SEND QUERY

Query results:

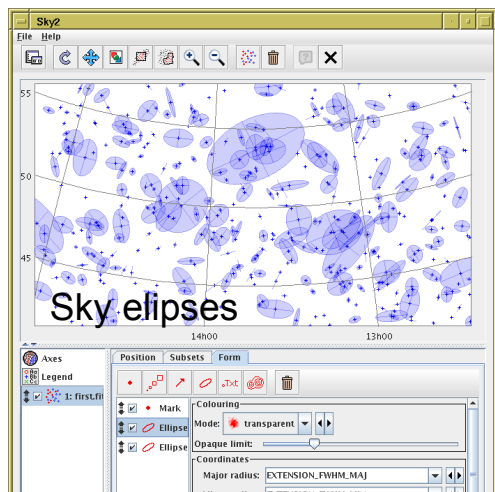
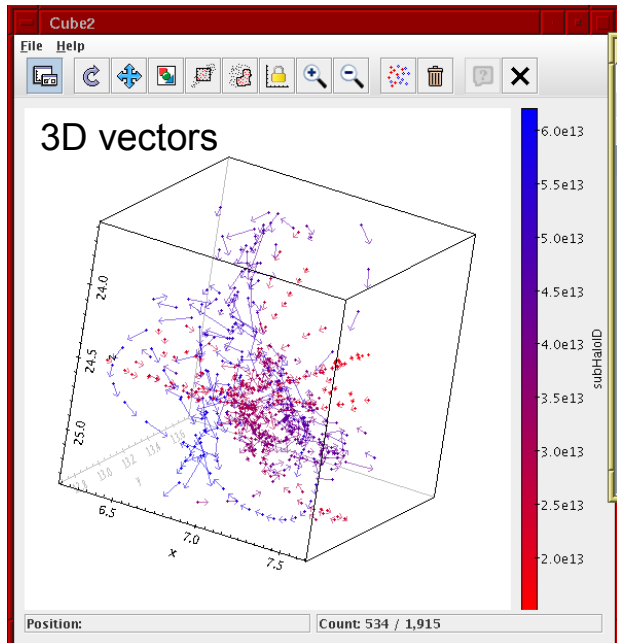
ID	access_url	service_def	error_message	description
1 HD 222368	http://svo2.cab.inta-csic.es/...			CaT spectrum (vot)
2 HD 222368	http://svo2.cab.inta-csic.es/...			CaT spectrum (ascii)
3 HD 222368	http://svo2.cab.inta-csic.es/...			CaT spectrum (fits)
4 HD 222368	http://svo2.cab.inta-csic.es/...			CaT error spectrum (vot)
5 HD 222368	http://svo2.cab.inta-csic.es/...			CaT error spectrum (ascii)

Starlink SPLAT-VO: plot

Displaying: HD222368
Axis 1: 133
X scale: 1.0
Y scale: 1.0
2-d compound coordinates

Plot showing flux (1.1 to 0.6) vs wavelength (100 to 700 nm).

TOPCAT: Visualization

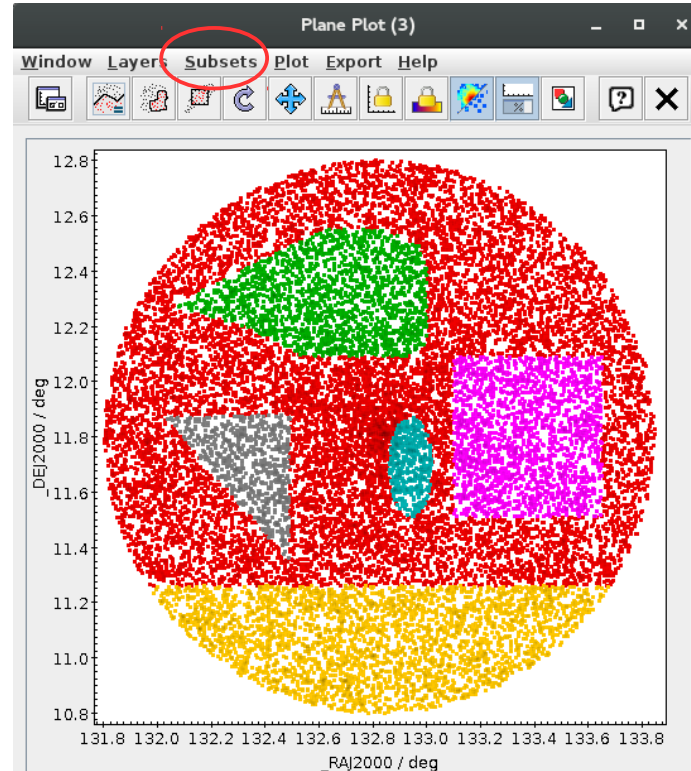


TOPCAT
File Views Graphics Tables Subsets Errors Help

- Table List:** Shows a list of tables including 'SuperCOSMOS_EIT' and 'SuperCOSMOS_FIT'.
- Current Table Properties:** Shows details for 'SuperCOSMOS_FIT', including location, name, rows, columns, and activation actions.
- Density Map:** A 2D color plot showing the distribution of data points.
- Scatter Plot:** A plot of '2MASS' vs 'BMAG' showing a clear correlation.
- 3D:** A 3D visualization of data points with color coding.
- Spherical Plot:** A plot on a spherical coordinate system.
- Cone Selection:** A dialog box for defining search cones based on RA, Dec, and Radius.
- Match Tables:** A dialog for matching data from different tables based on criteria like 'Max Error'.
- Line Plot:** A plot showing 'BMAG' vs 'epoch / year' over time.
- Axis Configure:** A dialog for customizing the axes of a plot.
- Plot Style Edit:** A dialog for configuring plot markers and colors.
- Table Columns:** A table showing the structure of a data table with columns like 'id', 'x', 'y', 'z', 'mag', etc.
- Row Subsets:** A table showing different subsets of the data based on various criteria.
- Table View:** A window for viewing and editing the data in a table.
- Histogram:** A histogram showing the distribution of data points.
- A3 Table View:** A window for viewing and editing the data in a table.
- Bin Placement:** A dialog for setting up bins for a plot.
- Input Coordinates:** A dialog for setting up coordinates for a plot.
- Right Ascension:** A dialog for setting up right ascension for a plot.
- Decination:** A dialog for setting up declination for a plot.

TOPCAT: What's new in Version 4.6-3? (released 9 May 2019)

- Among many other things (see full list at: <http://www.star.bris.ac.uk/~mbt/topcat/sun253/versions.html>)
- **Improvements to the Draw Subset:** Selection by free region, triangle, ellipse, polygon, below/above/right/left from a given position.



TOPCAT & STILTS

- More at:

- TOPCAT v 4.6-3

<http://www.star.bris.ac.uk/~mbt/topcat/sun253/sun253.html>

- STILTS v 3.1-6

<http://www.star.bris.ac.uk/~mbt/stilts/sun256/sun256.html>

- TOPCAT/STILTS advanced tutorial

<http://andromeda.star.bris.ac.uk/topcat/tutorial-asterics1/>