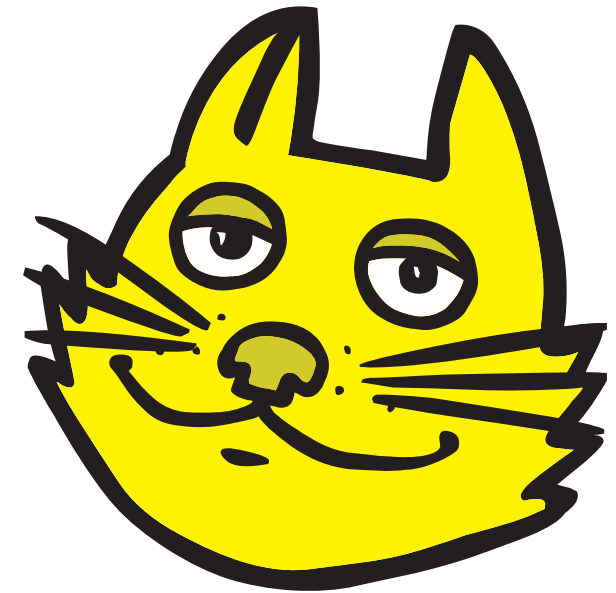


TOPCAT/STILTS Recent Developments

Mark Taylor (Bristol)

Astro-CC Tech Forum 1
Trieste

9 October 2025



`$Id: topcat.tex,v 1.21 2025/10/09 07:16:58 mbt Exp $`

TOPCAT

- Very short introduction

New ($\lesssim$ 12 months) features

- New axis scaling options: **asinh** & **symlog**
- Global variables
- TOPCAT/STILTS interoperability
- Parquet + VOParquet support
- HAPI
- Small body visualisation enhancements
- Multi-column sort
- MOC stuff: new MOC functions, MOC 2.0, mocshape
- File formats: CSV options

TOPCAT

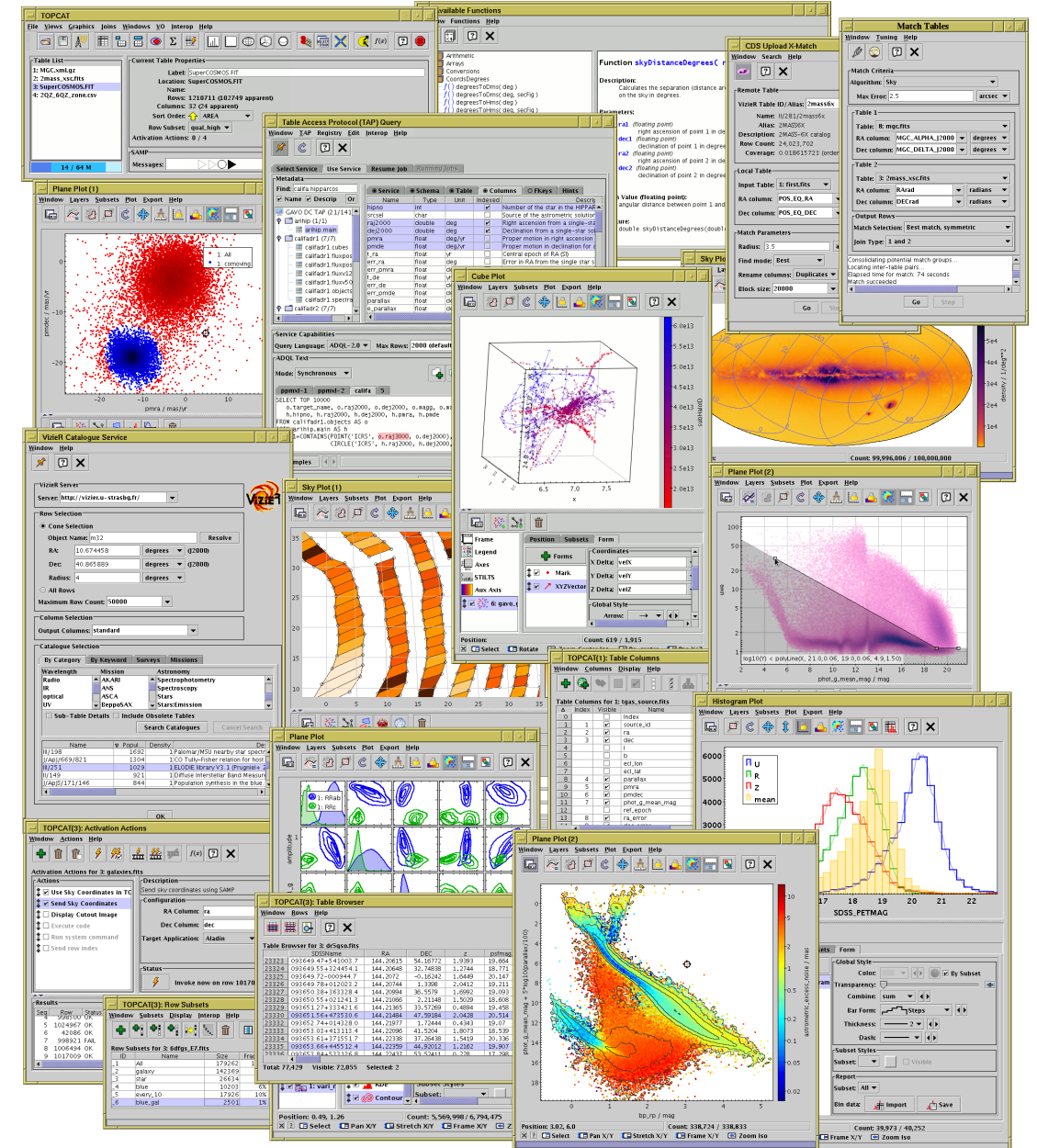
TOPCAT = Tool for OPerations on Catalogues And Tables

Capabilities:

- Does things with tables
- I/O, visualisation, selections, calculations, matching
- Virtual Observatory

See also STILTS

- Command-line/scriptable access to all TOPCAT capabilities (and more)



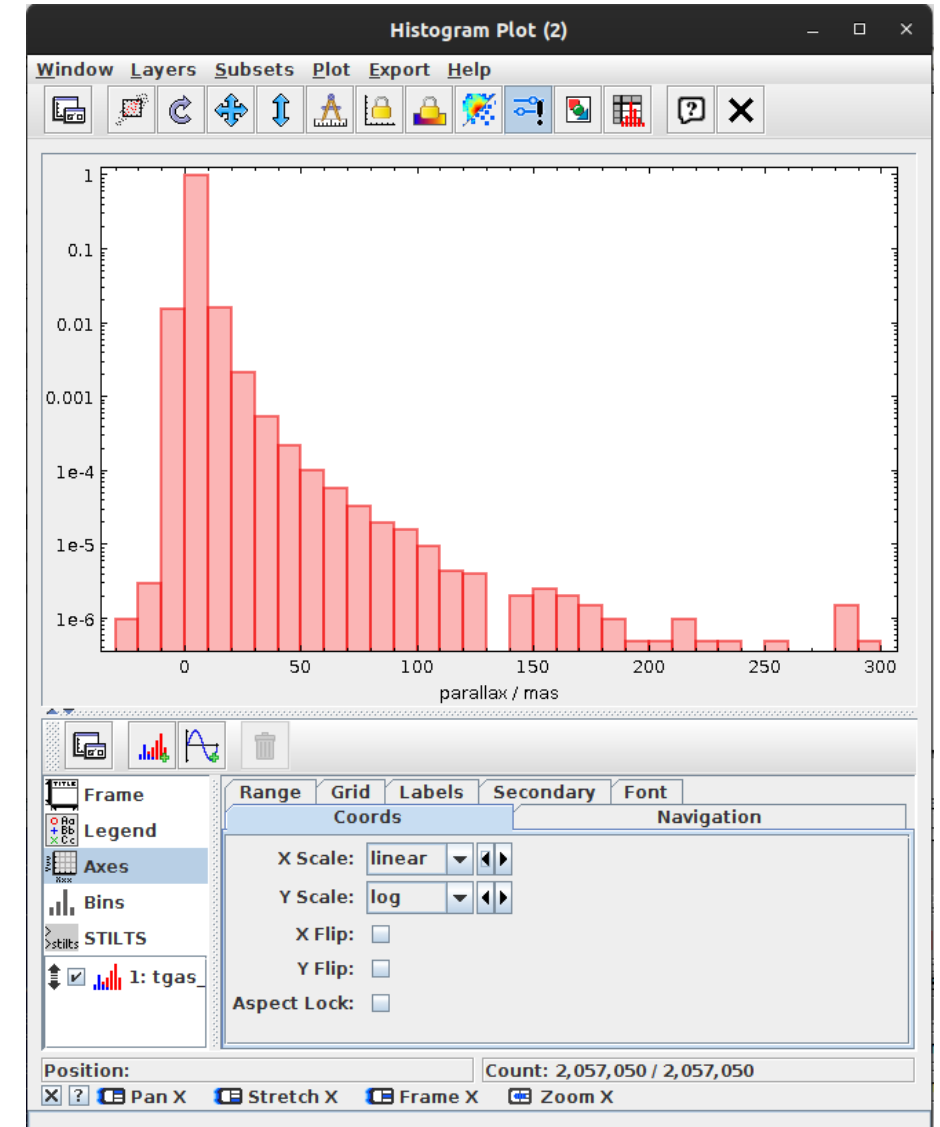
New Axis Scaling Options

Existing scaling options:

- **linear**: Small dynamic range, positive and negative values
- **logarithmic**: Large dynamic range, positive values only

New scaling options (v4.10-4, July 2025):

- **asinh**, **symlog**: Large dynamic range, positive and negative values
 - ▷ Linear near the origin, positive/negative logarithmic far from origin
 - ▷ **Asinh**: smooth transition, one parameter
 - ▷ **Symmetric Log**: sharp transition, two parameters



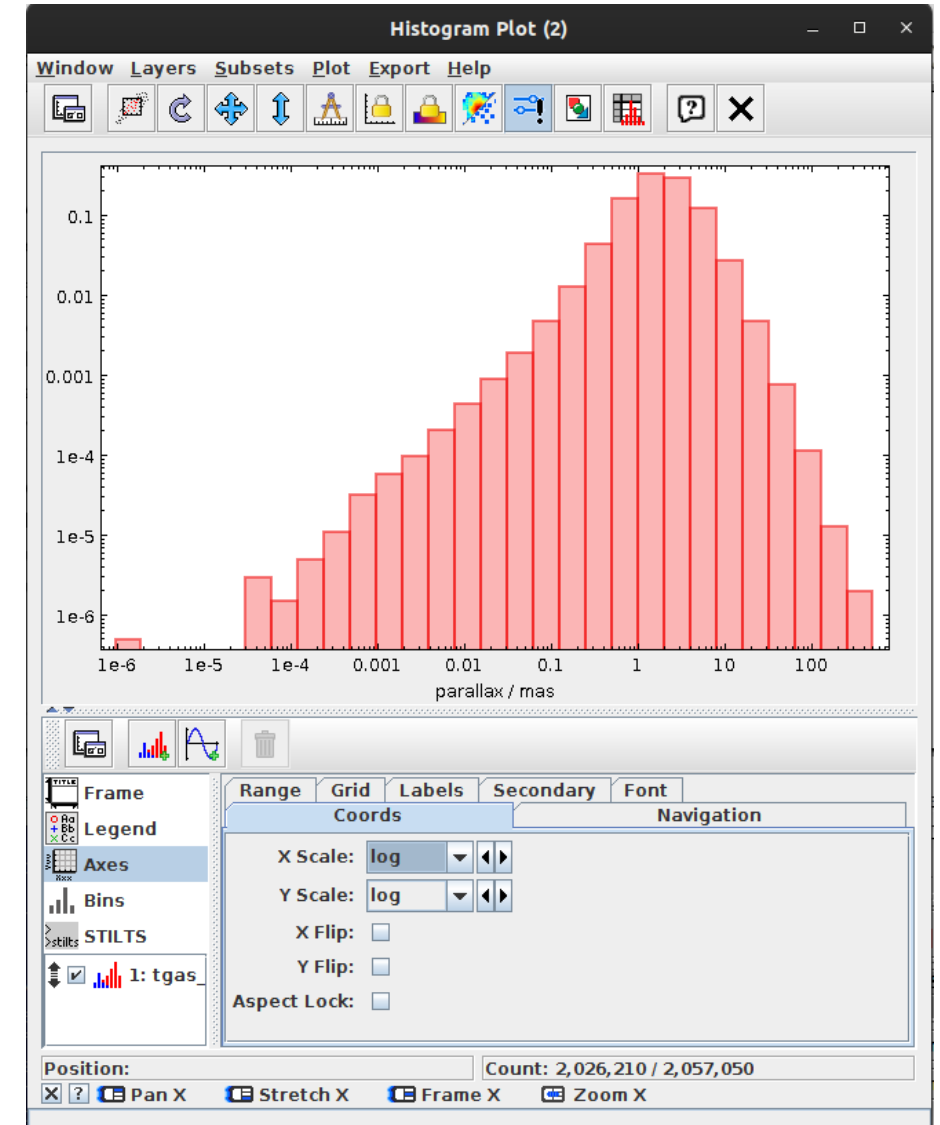
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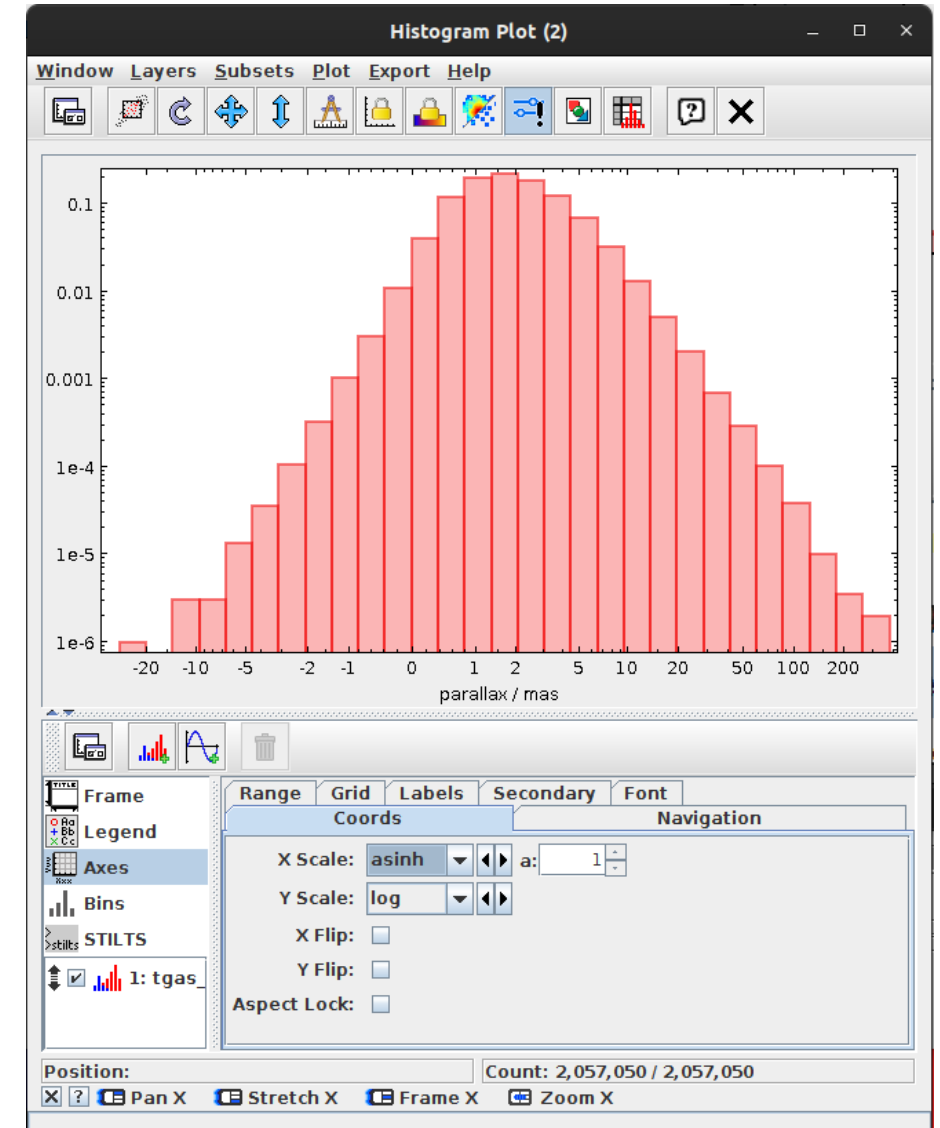
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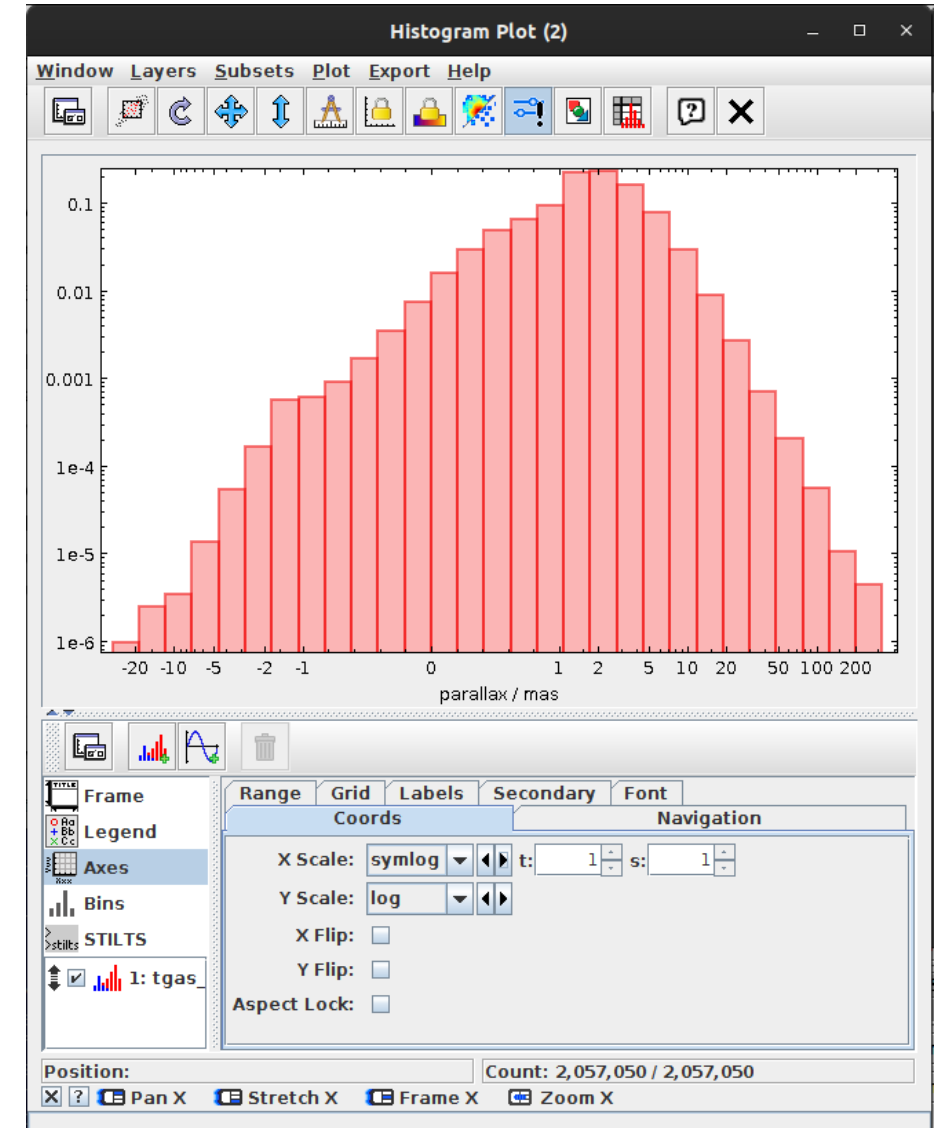
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Global Variables

Define independent values in expression language 

- Control via a slider widget
- Floating point or integer

Can be used (almost) anywhere in expression language:

- Column selection boxes in plots etc
- Algebraic row subset definitions
- Algebraic column definitions
- Function plot expressions

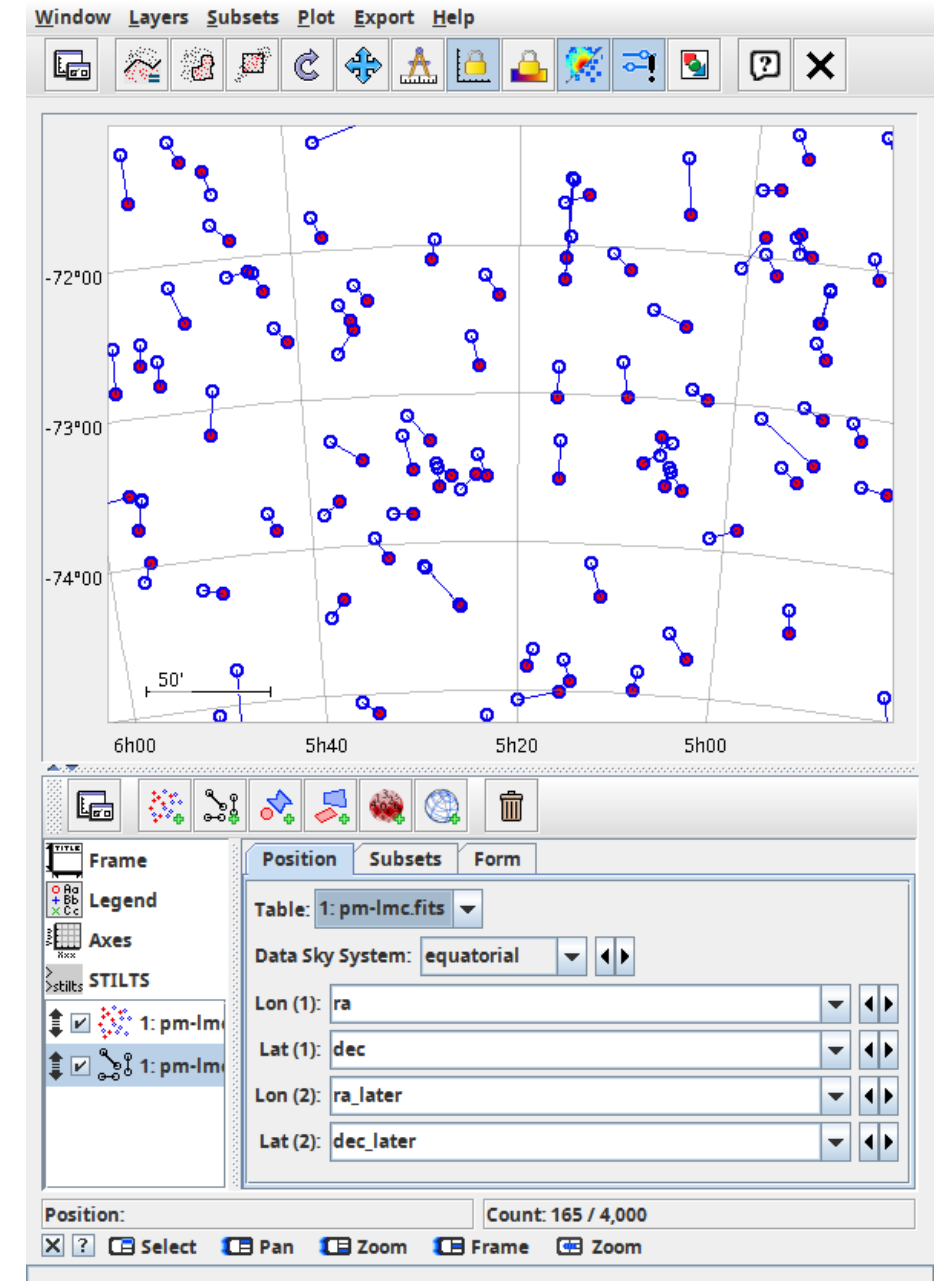
Plots update continuously when value (slider) is changed

Window Columns Display Export Help



Table Columns for 1: pm-lmc.fits

Δ	Name	Expression	Units	Visible	Class
0	Index			☐	Long
1	source_id			☒	Long
2	ra		deg	☒	Double
3	dec		deg	☒	Double
4	parallax		mas	☒	Double
5	pmra		mas.yr**-1	☒	Double
6	pmdec		mas.yr**-1	☒	Double
7	pm		mas.yr**-1	☒	Float
8	pos_later	epochProp(3000,array(ra,dec,parallax,pmra,pmdec,0))		☒	double[]
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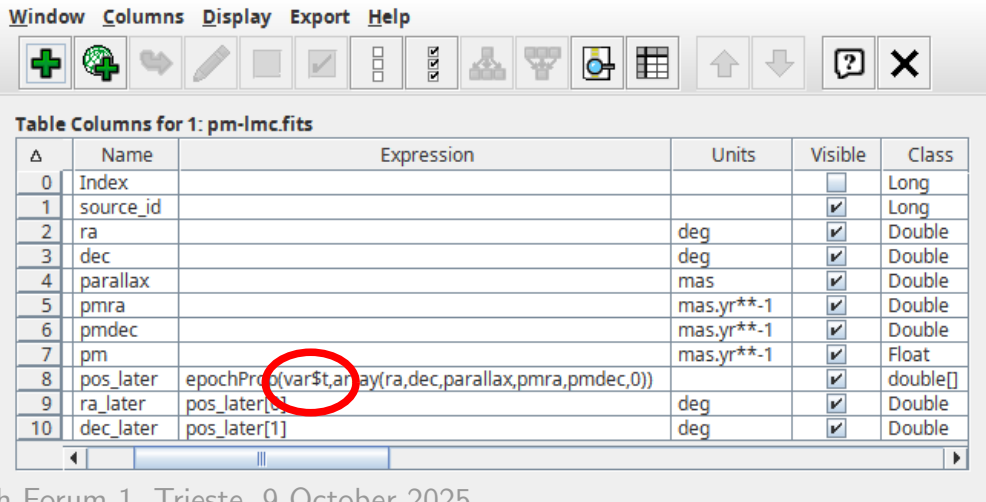
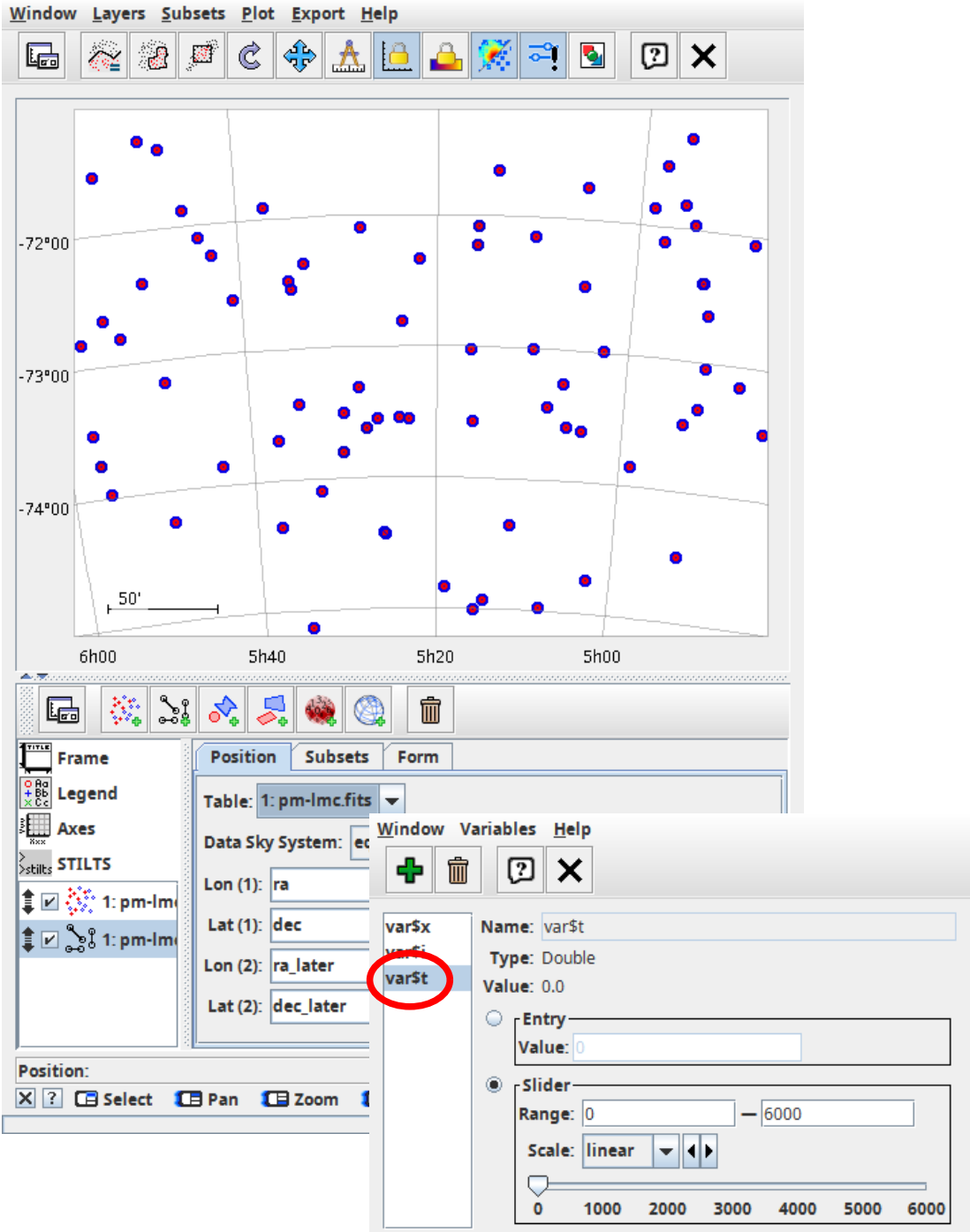


Table Columns for 1: pm-lmc.fits					
Δ	Name	Expression	Units	Visible	Class
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Since v4.10-4 (July 2025)



Global Variables

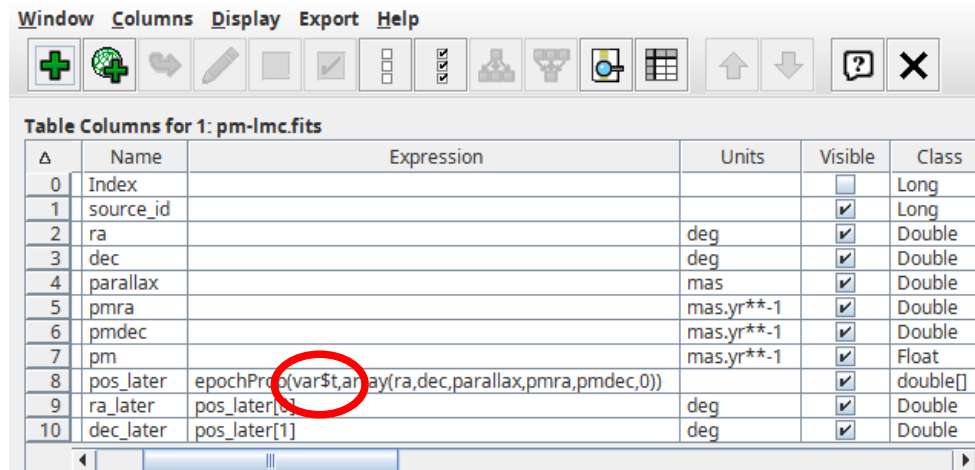
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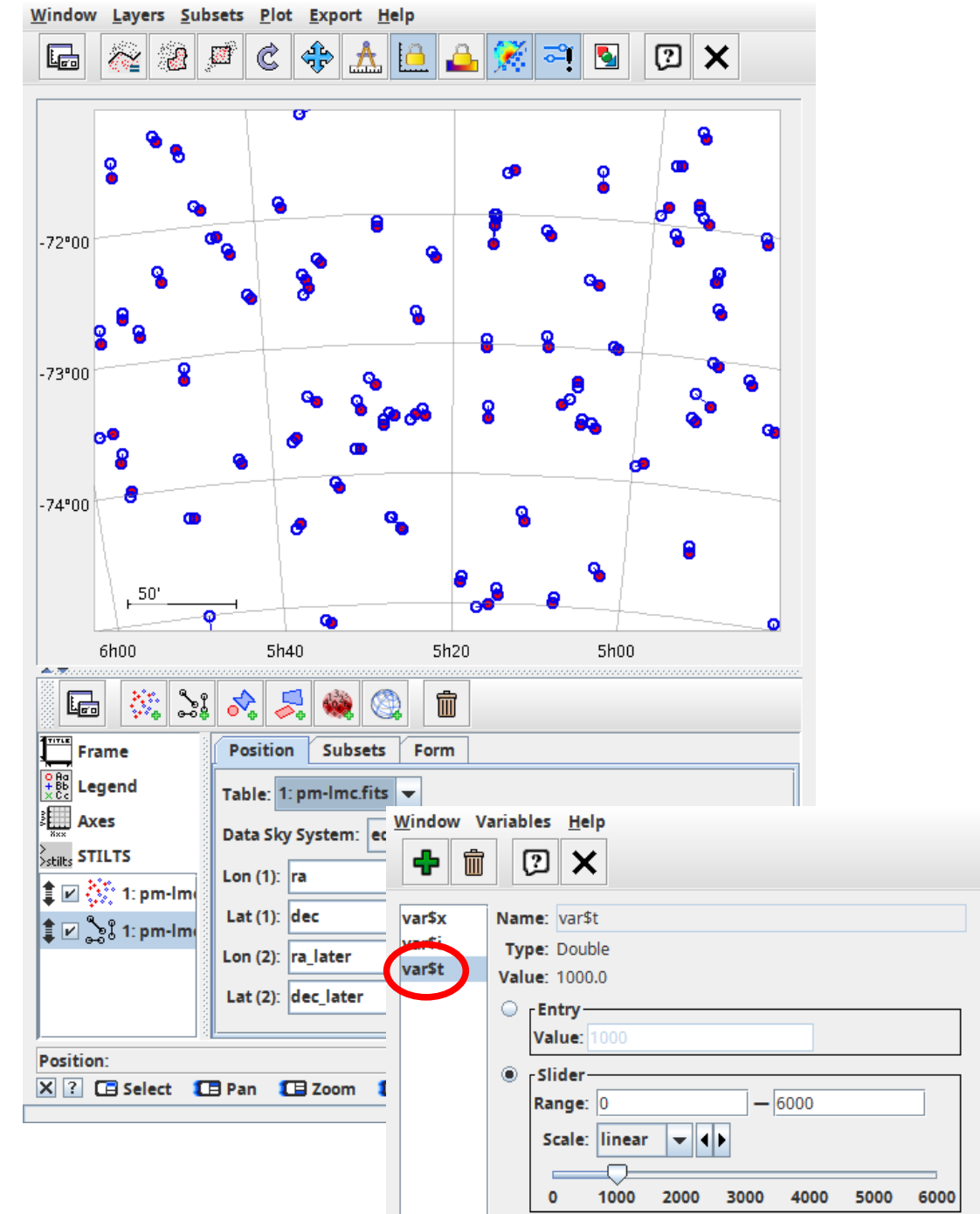
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Δ	Name	Expression	Units	Visible	Class
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WindowColumnsDisplayExportHelp











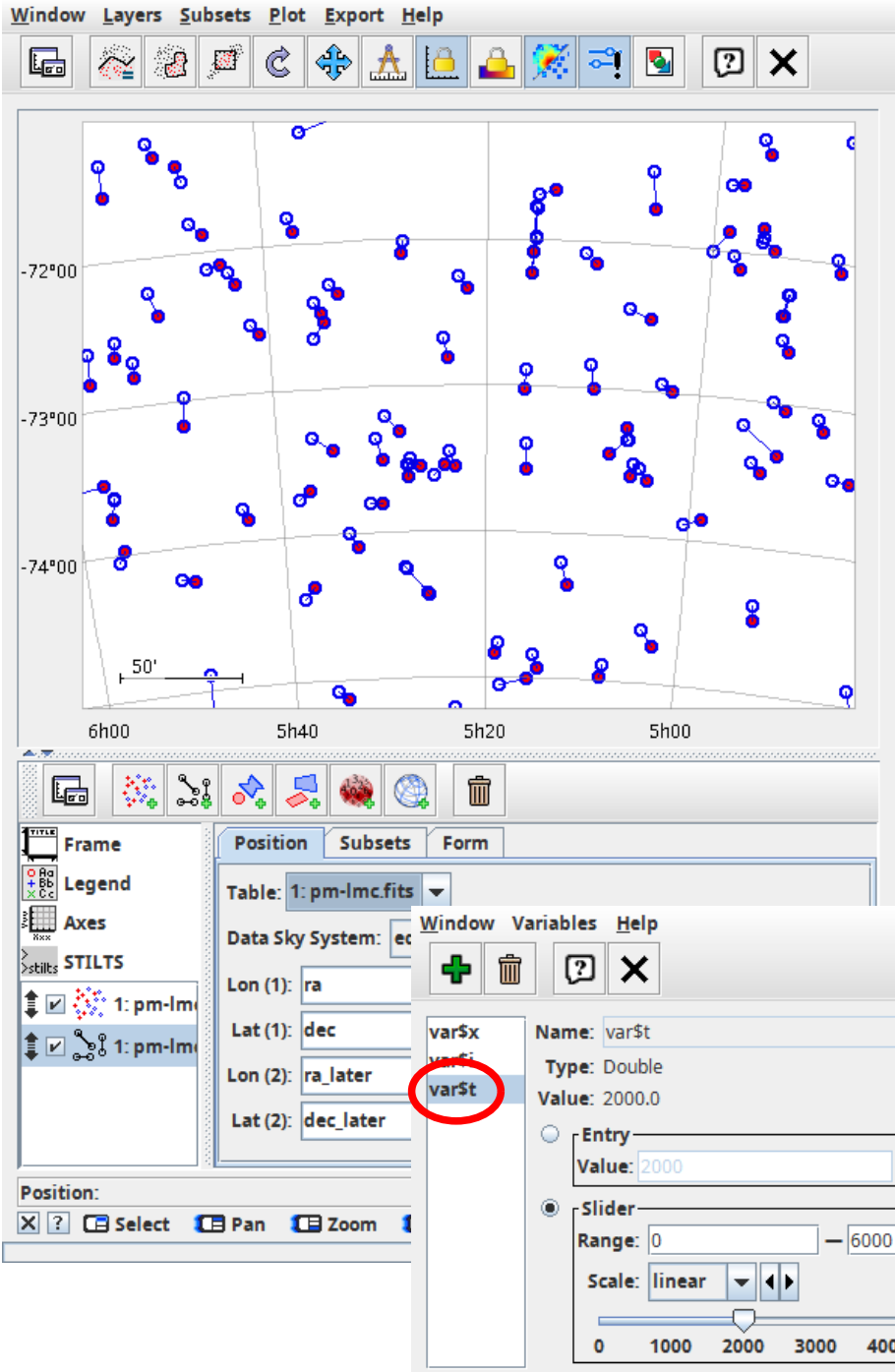




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Δ	Name	Expression	Units	Visible	Class
0	Index			☐	Long
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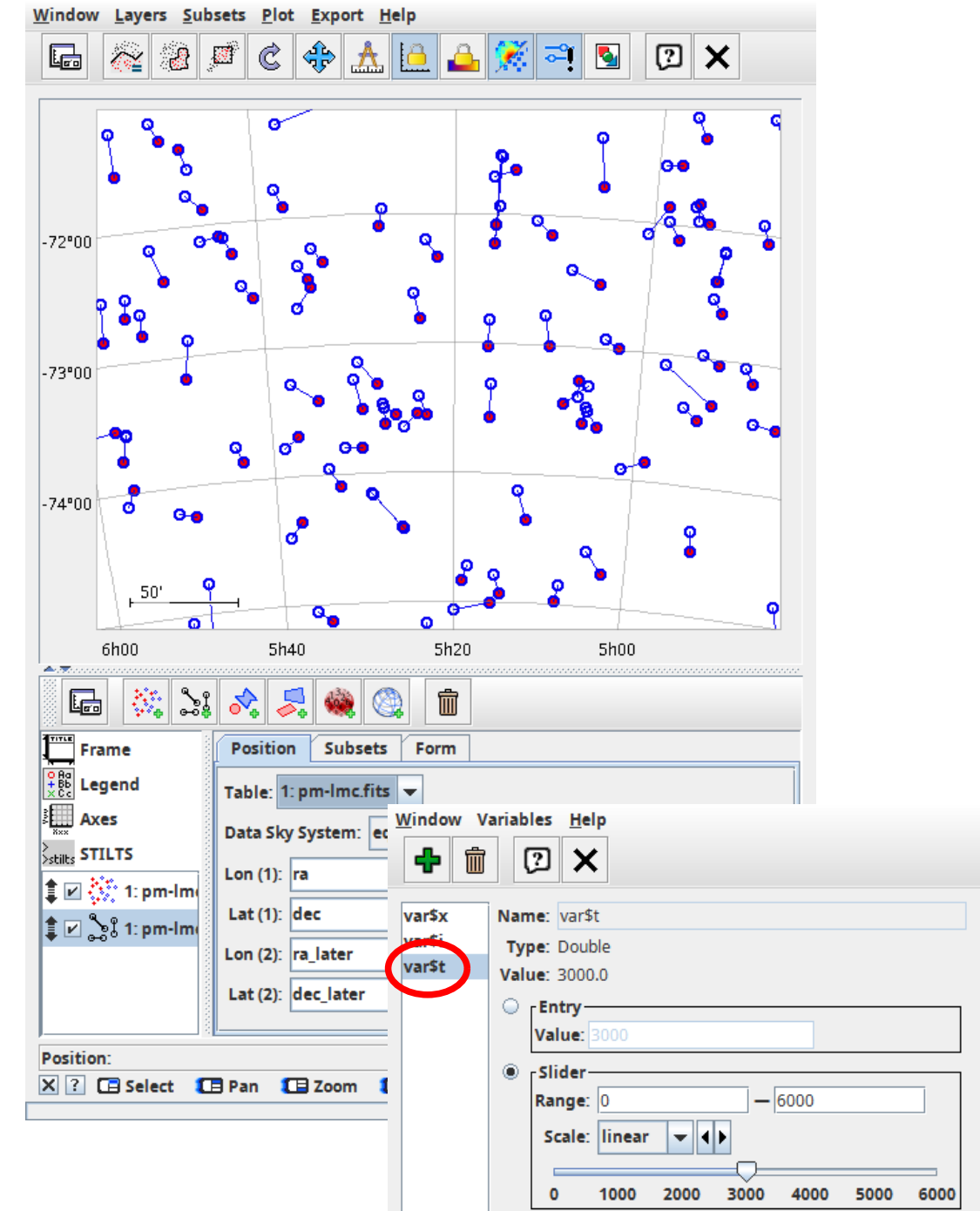
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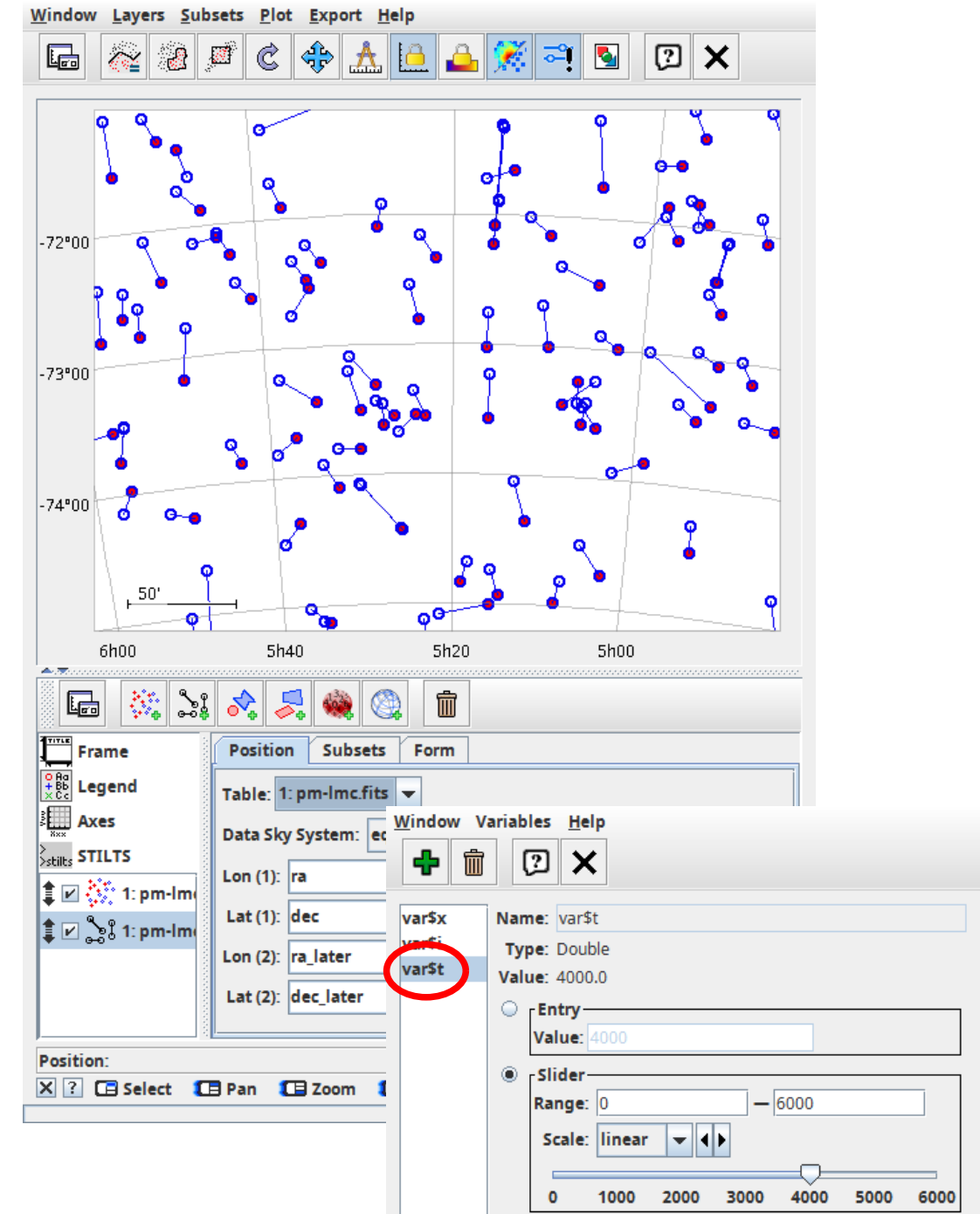
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5	pmra		mas.yr**-1	☒	Double
6	pmdec		mas.yr**-1	☒	Double
7	pm		mas.yr**-1	☒	Float
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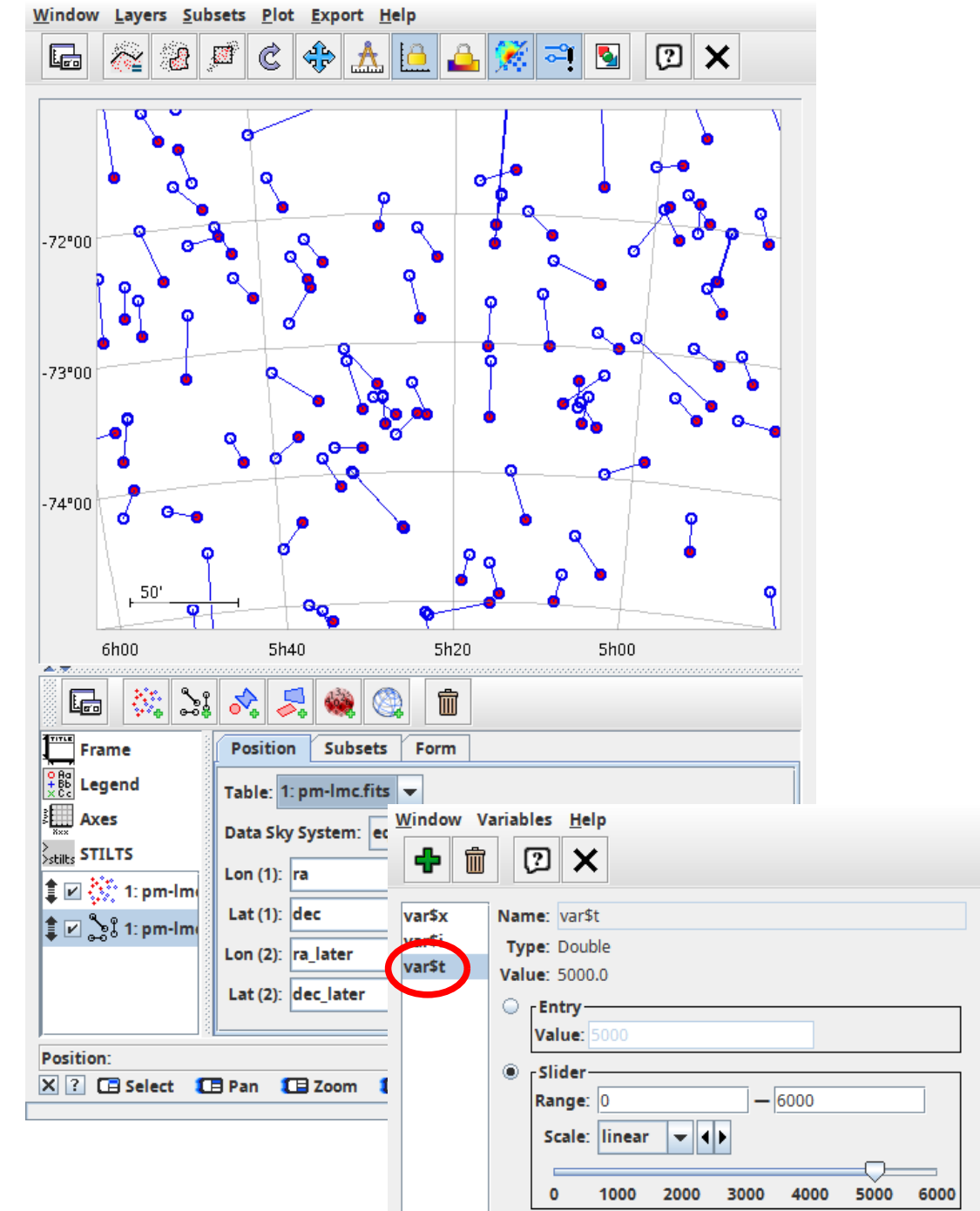
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Since v4.10-4 (July 2025)



TOPCAT/STILTS Interoperability

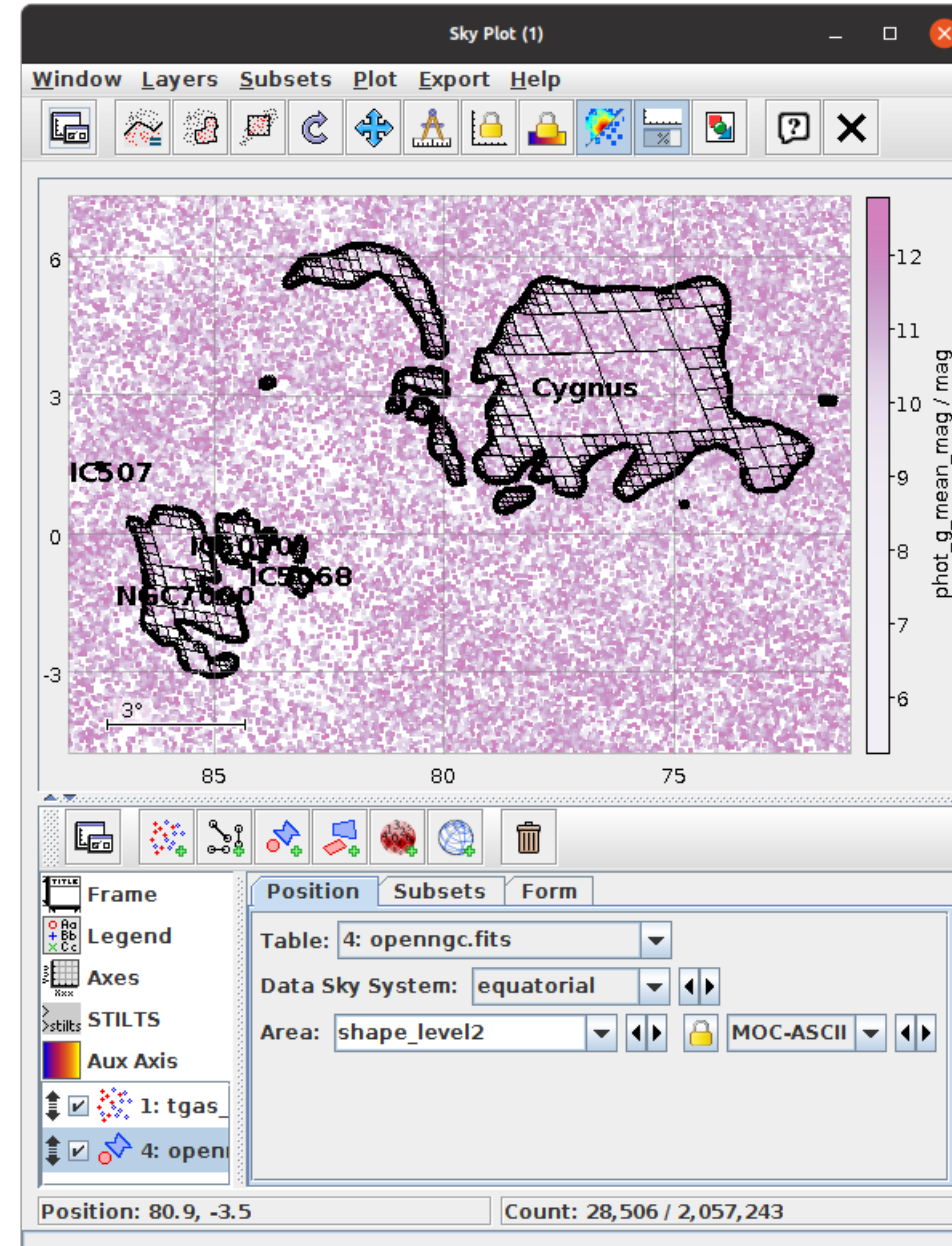
TOPCAT can tell you the STILTS command to duplicate the current action

Since version 4.5 (2017)

- All plotting windows

New at version 4.10-1 (Nov 2024)

- CDS Upload X-Match
- TAP
- Crossmatch
- Cone Search, SIA, SSA
- Multi-Cone, Multi-SIA, Multi-SSA



TOPCAT/STILTS Interoperability

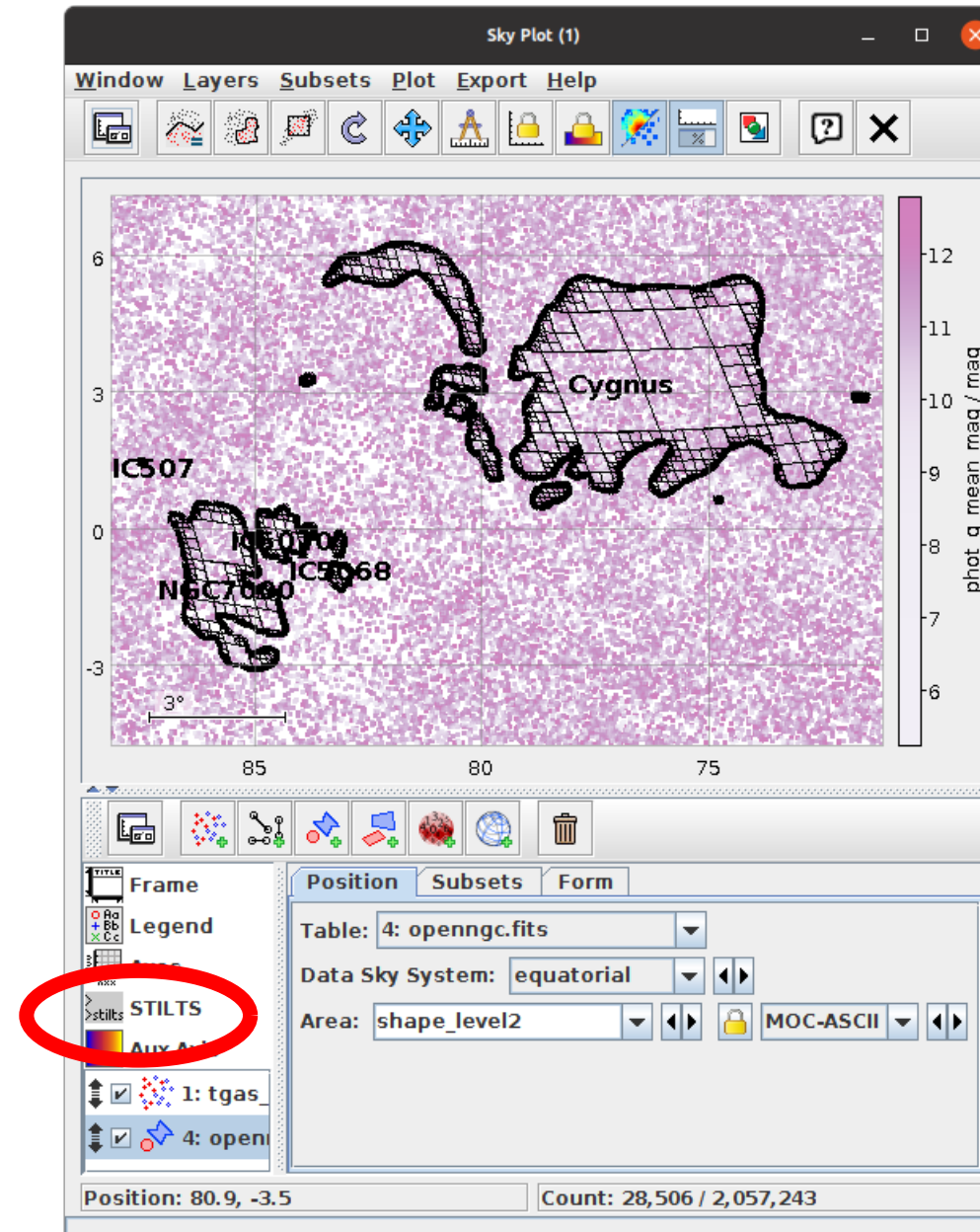
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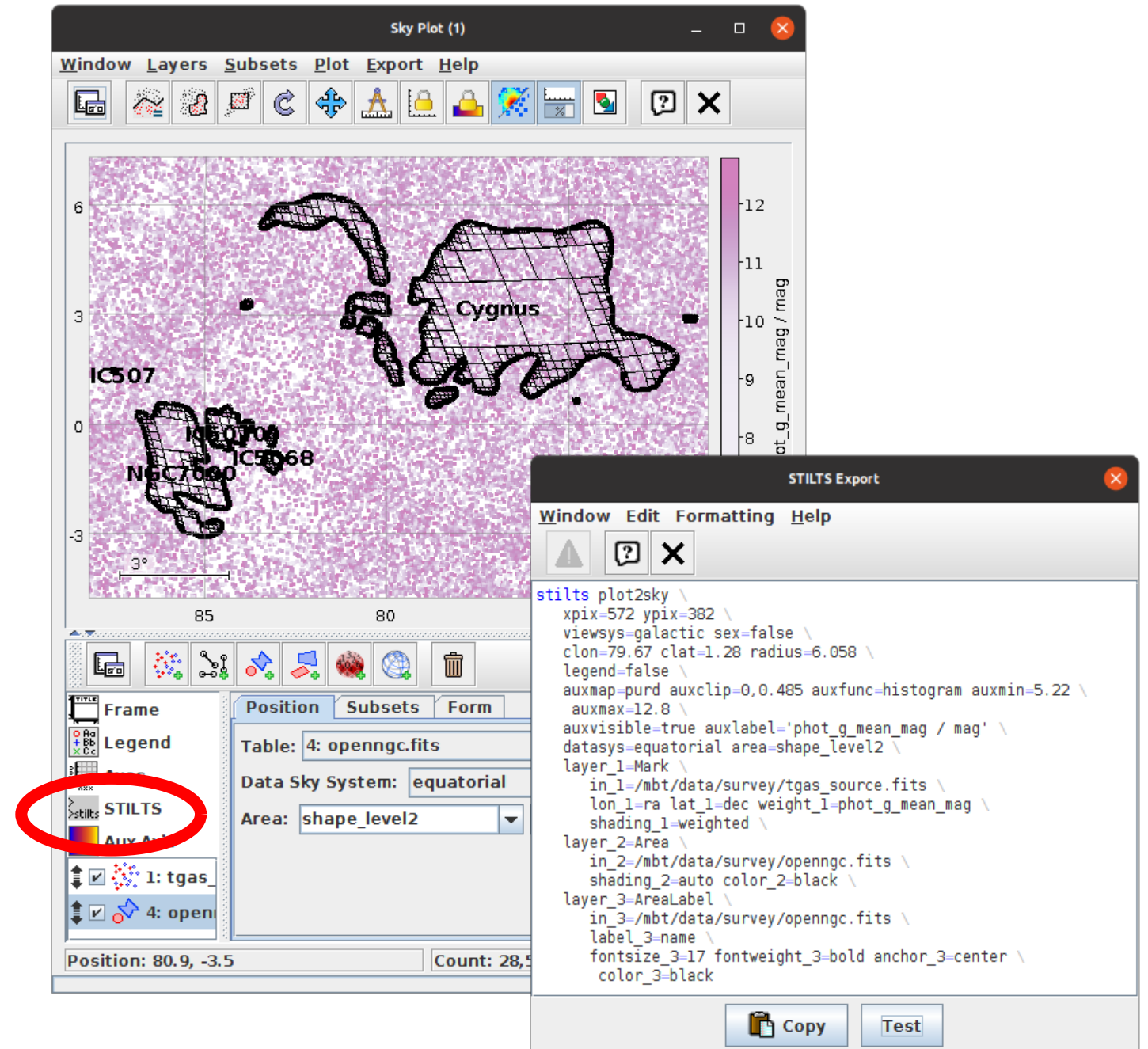
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The screenshot shows the 'CDS Upload X-Match' dialog box. It has a menu bar with 'Window', 'Search', and 'Help'. Below the menu bar are icons for a table, STILTS, help, and close. The dialog is divided into three main sections: 'Remote Table', 'Local Table', and 'Match Parameters'. The 'Remote Table' section shows 'VizieR Table ID/Alias' as 'Gaia EDR3 J2016' with a dropdown arrow and navigation buttons. Below this, it lists 'Name: GAIA_EDR3_J2016', 'Alias: Gaia EDR3 J2016', 'Description: GAIA_EDR3_J2016', 'Row Count: 1,811,709,771', and 'Coverage: 1.0 (order 0)'. The 'Local Table' section shows 'Input Table' as '9: ngc346.fits' with a dropdown arrow. Below this, it shows 'RA column: _RAJ2000' with a dropdown arrow and 'degree' unit, and 'Dec column: _DEJ2000' with a dropdown arrow and 'degree' unit. The 'Match Parameters' section shows 'Radius' as '0.1' with a dropdown arrow and 'arcmin' unit, 'Find mode' as 'All' with a dropdown arrow, 'Rename columns' as 'Duplicates' with a dropdown arrow and 'Suffix' as '_x', and 'Block size' as '100000' with a dropdown arrow and navigation buttons. At the bottom are 'Go' and 'Stop' buttons.

CDS Upload X-Match

Window Search Help

Remote Table

VizieR Table ID/Alias: Gaia EDR3 J2016

Name: GAIA_EDR3_J2016

Alias: Gaia EDR3 J2016

Description: GAIA_EDR3_J2016

Row Count: 1,811,709,771

Coverage: 1.0 (order 0)

Local Table

Input Table: 9: ngc346.fits

RA column: _RAJ2000 degree (J2000)

Dec column: _DEJ2000 degree (J2000)

Match Parameters

Radius: 0.1 arcmin

Find mode: All

Rename columns: Duplicates Suffix: _x

Block size: 100000

Go Stop

TOPCAT/STILTS Interoperability

TOPCAT can tell you the STILTS command to duplicate the current action

Since version 4.5 (2017)

- All plotting windows

New at version 4.10-1 (Nov 2024)

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CDS Upload X-Match

Window Search Help

Remote Table

VizieR Table ID/Alias: Gaia EDR3 J2016

Name: GAIA_EDR3_J2016

Alias: Gaia EDR3 J2016

Description: GAIA_EDR3_J2016

Row Count: 1,811,709,771

Coverage: 1.0 (order 0)

Local Table

Input Table: 9: ngc346.fits

RA column: _RAJ2000 degree (J2000)

Dec column: _DEJ2000 degree (J2000)

Match Parameters

Radius: 0.1 arcmin

Find mode: All

Rename columns: Duplicates Suffix: _x

Block size: 100000

Go Stop

TOPCAT/STILTS Interoperability

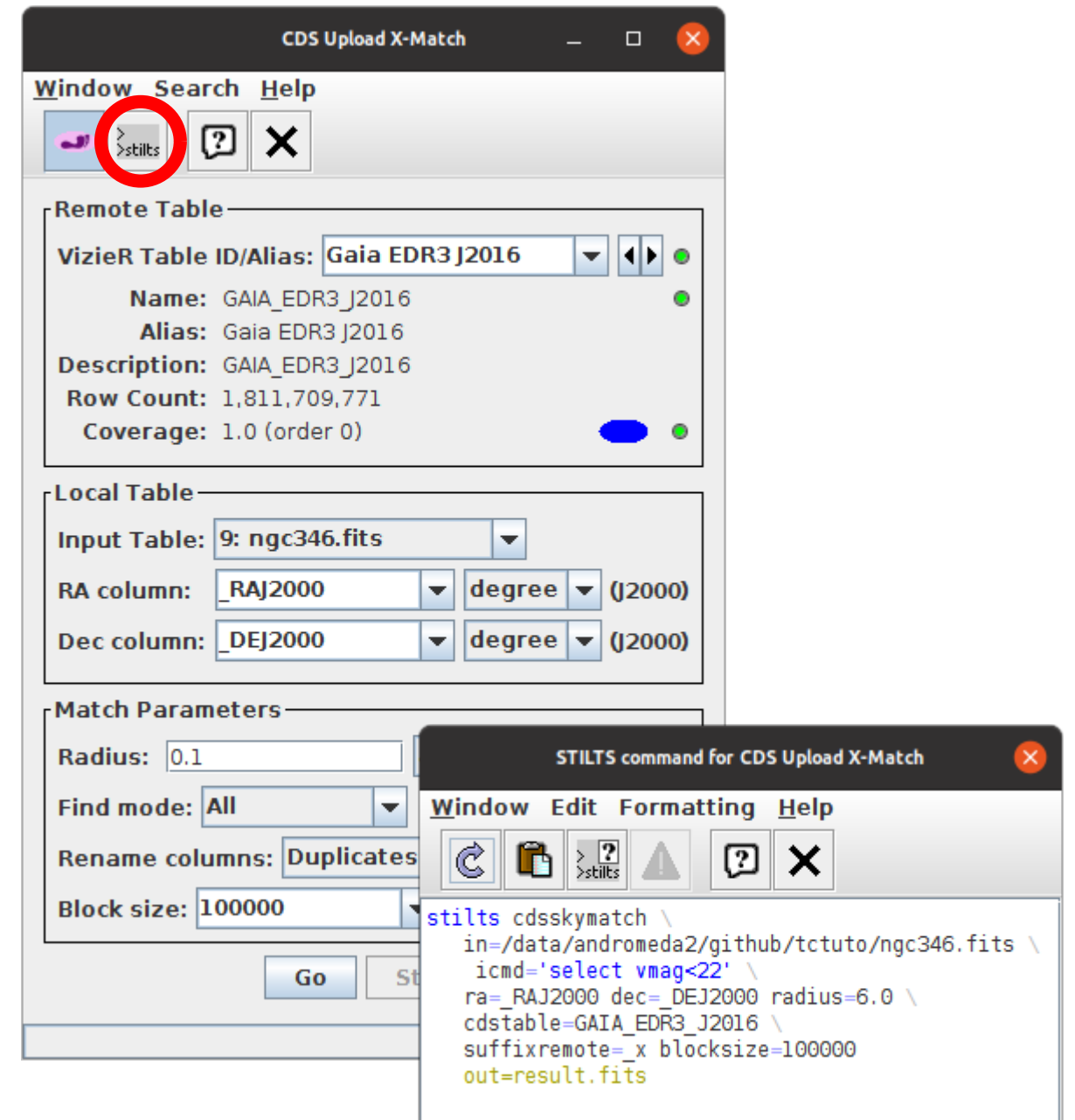
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- Multi-Cone, Multi-SIA, Multi-SSA



(VO)Parquet

Parquet is a “big-data”-friendly format (Spark, Hive, DuckDB, ...)

- TOPCAT/STILTS can read and write Parquet files
 - ▷ Support in place since v4.8-1 (2021), but various improvements/fixes over the last year
 - ▷ Parquet support currently not bundled with all versions (need `topcat-extra.jar` or DMG)
- Not as fast as some other software, but not too bad

VOParquet convention adds VOTable metadata to Parquet data

- IVOA Note [Parquet in the VO](#) January 2025
- Best of both worlds: Parquet efficiency + VOTable rich metadata
- TOPCAT supports VOParquet since v4.10-3 (March 2025)
- STILTS provides tools for VOParquet manipulation
 - ▷ [parqlint](#) VOParquet validator (useful if you're generating VOParquet files)
 - ▷ [parqlook](#) Tool for examining (VO)Parquet files

HAPI

Heliophysics Data Application Programmer's Interface

- **HAPI** is a service specification for time series data used (mostly) in Heliophysics

TOPCAT/STILTS support

- TOPCAT has a **HAPI load dialogue**
- TOPCAT/STILTS can be used to convert HAPI queries to other formats (VOTable, CSV, FITS, ...)
- Large/multi-chunk queries supported

Uses?

- Could be of interest for time series in the VO?
- Heliophysicists have their own client tools (e.g. Autoplot) but analysis in TOPCAT might be a useful complement

Since v4.9-1 (Feb 2024)

HAPI Query

Window HAPI Help

Service Selection

HAPI Server: VirES for Swarm

HAPI URL: <https://vires.services/hapi>

Chunk Limit: 1

Datasets

	Filter
CS_OPER_MAG	mag 20 / 101
GO_MAG_ACAL_CORR	
GO_MAG_ACAL_CORR_ML	
GRACE_A_MAG	
GRACE_B_MAG	
SW_FAST_MAGA_HR_1B	

Dataset Parameters

Include	Name	Type	Size	Units	
☒	Timestamp	isotime	24	UTC	Time stamp
☒	Latitude	double		deg	Position in ITRF - Latitude
☒	Longitude	double		deg	Position in ITRF - Longitude
☒	Radius	double		m	Position in ITRF - Radius
☒	B_FGM	double	[3]	nT	calibrated magnetic vector from FG
☐	B_NEC_raw	double	[3]	nT	calibrated and aligned magnetic ve

Dataset Metadata

Cadence: PT1S

Max Duration:

Resource URL: <https://doi.org/10.1186/s40623-021-01373-9>

Interval

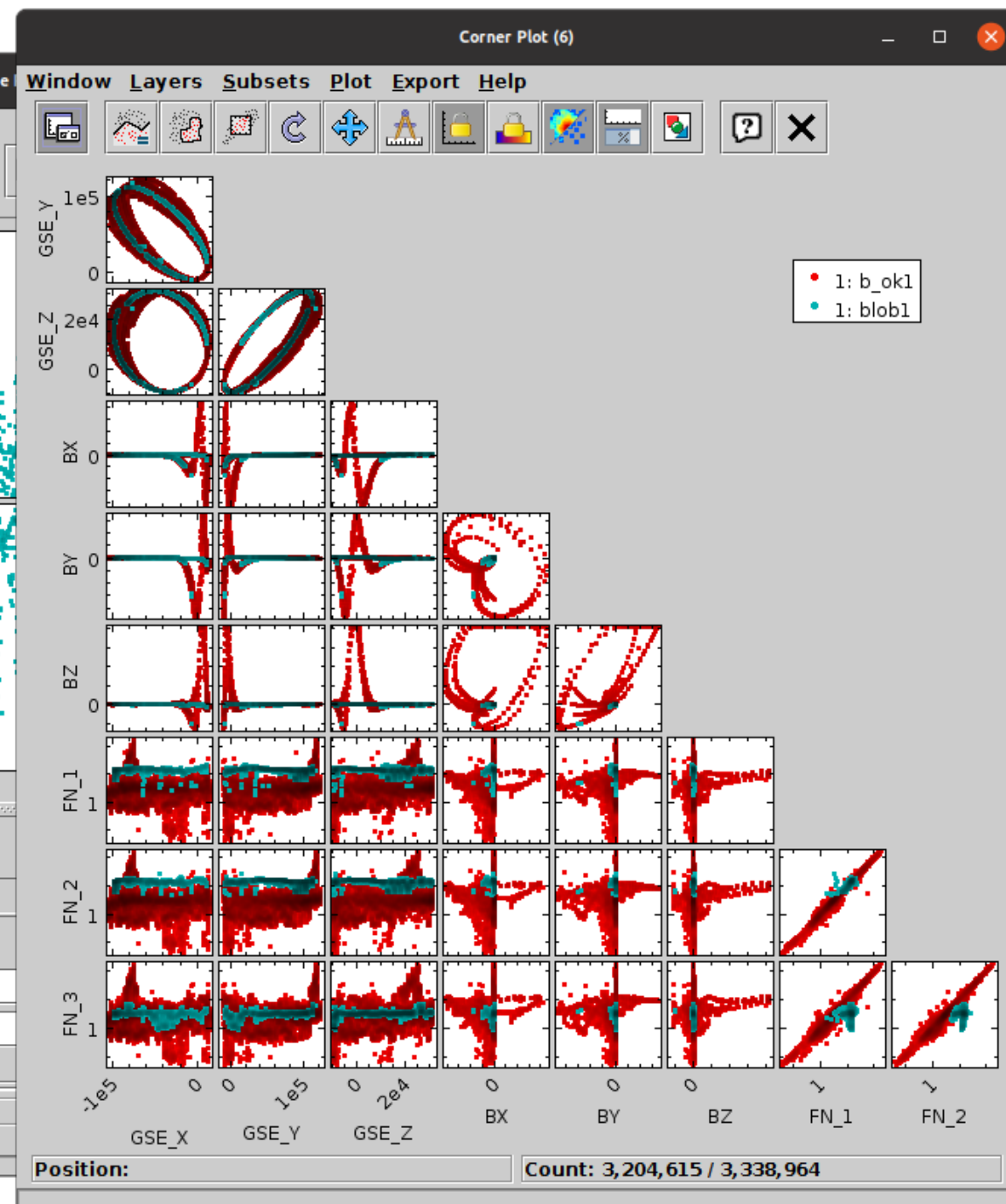
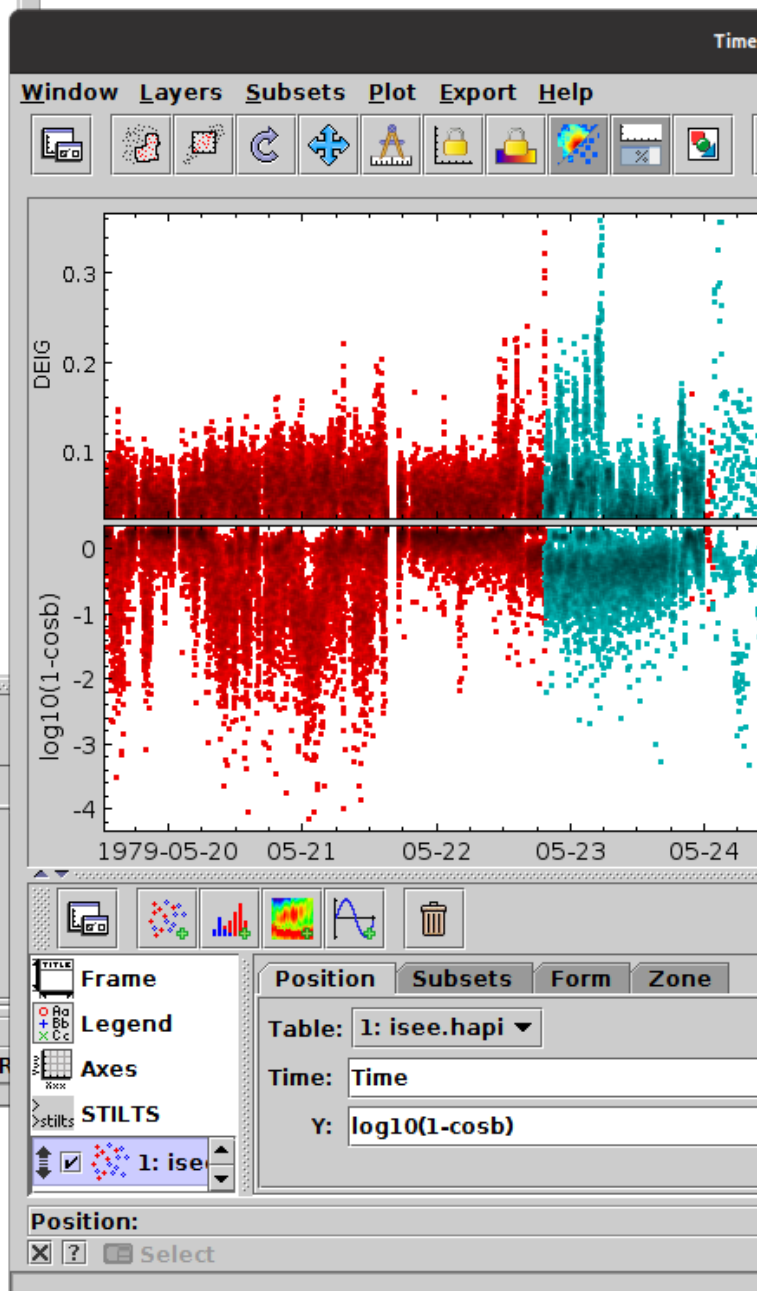
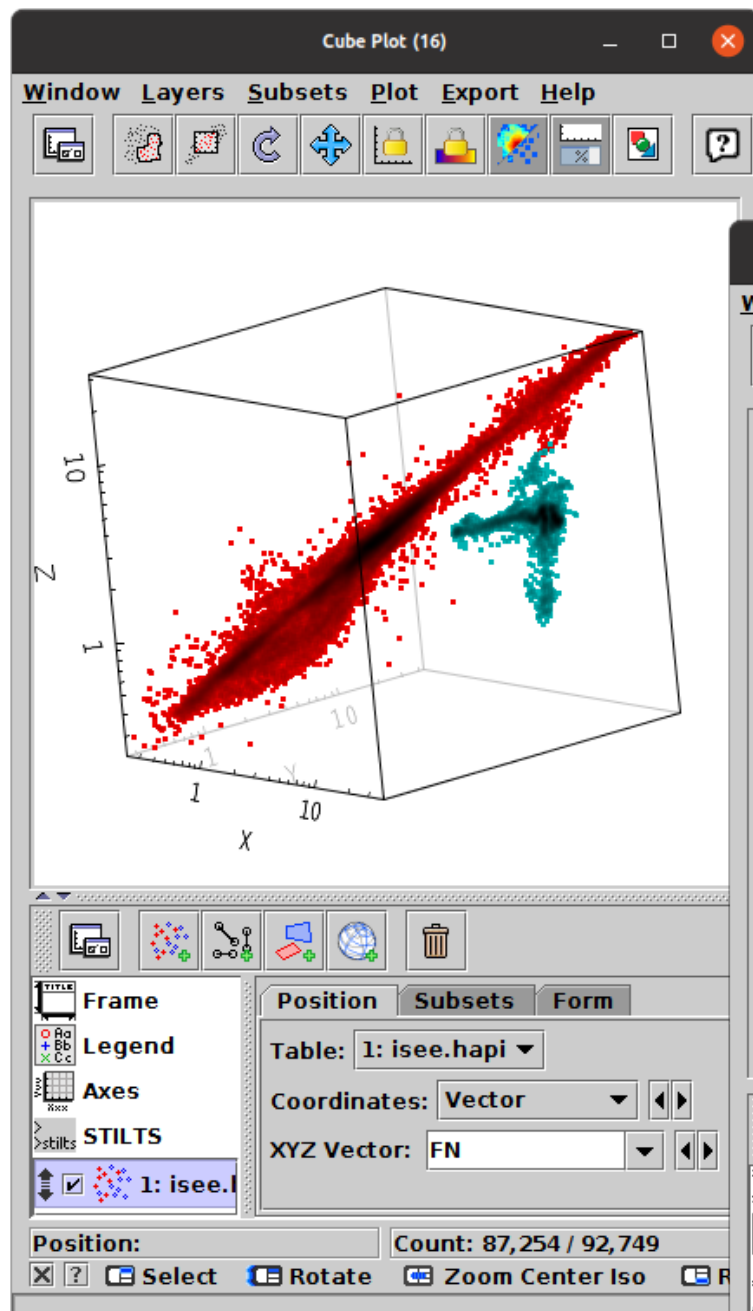
Start Date: 2010-04-08T17:00:00 >= 2008-01-01T00:00:04.787680Z

Stop Date: 2010-04-08T17:59:08 <= 2017-10-31T23:59:38.945023Z

2010 2012 2014 2016 1sec 1min 1hr 1day 1m 1yr

OK

Heliophysics Analysis Example



Small Body Visualisation

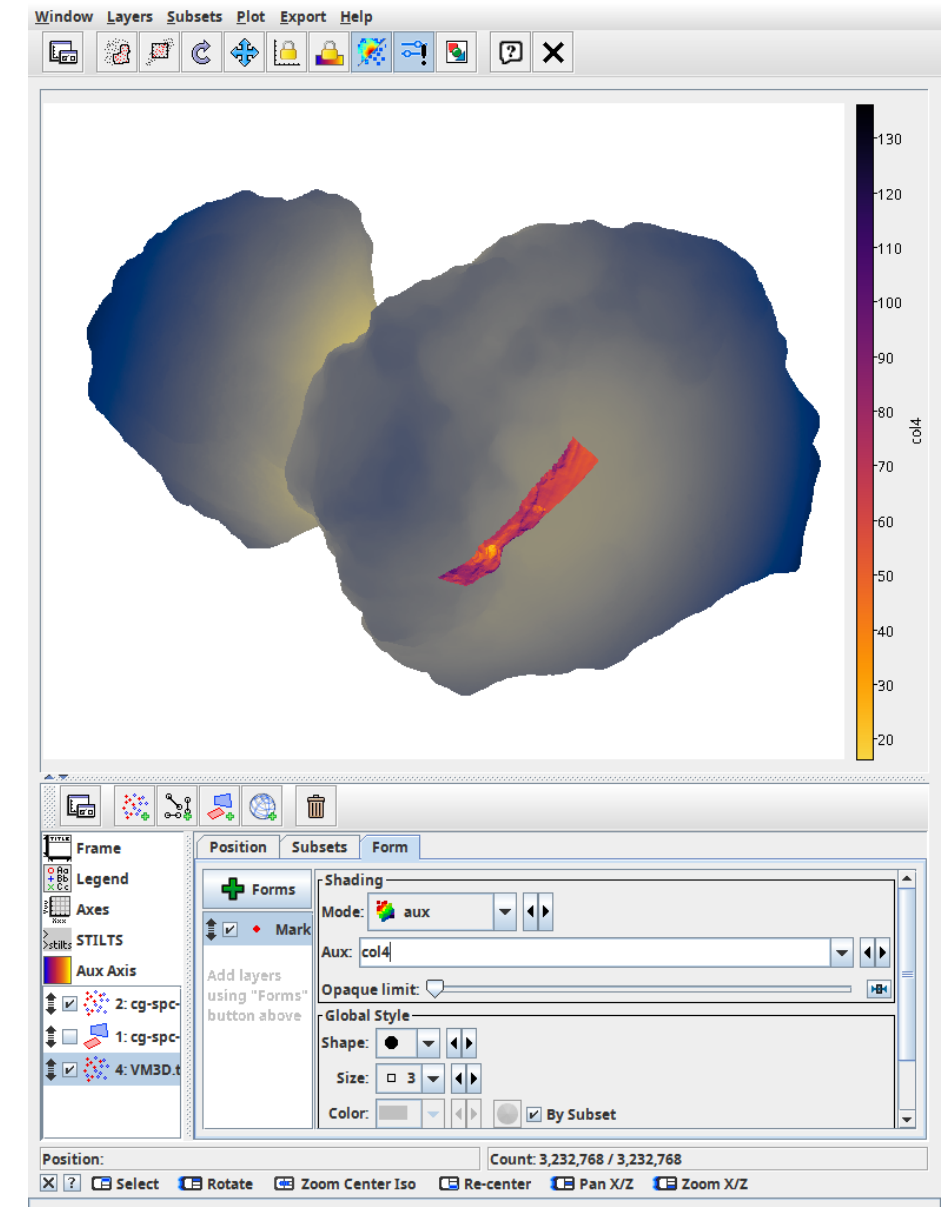
Requests from Stéphane Erard for SSO visualisation

- Isometric axes option in Cube Plot
- New shading modes **PAux** & **PWeighted**
 - ▶ additional colour-mapping variables having “private” map and no displayed scale
- Partial support for .ver format

For more details see Stéphane’s tutorial

- https://github.com/ept-vespa/tutorials/blob/master/surfaces/shape_models/shape_models.md

Since v4.10-3 (March 2025)



Multi-Column Sort

Sort table on multiple keys, which can be expressions

- Previous versions only allowed to sort on a single column
- Sort order affects table view, saved table etc.

The screenshot displays the TOPCAT software interface. The main window shows the 'Table List' on the left with '1: messier.xml' selected. The 'Current Table Properties' panel on the right shows details for 'messier.xml', including 'Location: /mbt/data/survey/messier.xml', 'Name: Messier', 'Rows: 110', and 'Columns: 12'. The 'Sort Order' is set to 'Ascending' (indicated by a yellow arrow icon) and a green plus sign indicates multi-column sorting. The 'Row Subset' is set to 'All'. The 'SAMP' section shows 'Messages: 0' and 'Clients: 2'. A 'Table Browser' window is open, displaying a table with 11 rows and 8 columns: Name, Con, NGC, Type, ID, RA, and DEC. The table lists Messier objects M1 through M11. The status bar at the bottom of the Table Browser shows 'Total: 110', 'Visible: 110', and 'Selected: 0'.

	Name	Con	NGC	Type	ID	RA	DEC
1	M1	Tau	1952	9	1	83.50208	22.016
2	M2	Aqr	7089	2	2	323.25208	-0.816
3	M3	CVn	5272	2	3	205.50083	28.383
4	M4	Sco	6121	2	4	245.7525	-26.533
5	M5	Ser	5904	2	5	229.5025	2.083
6	M6	Sco	6405	1	6	265.00042	-32.216
7	M7	Sco	6475	1	7	268.25375	-34.816
8	M8	Sgr	6523	4	8	270.75333	-24.383
9	M9	Oph	6333	2	9	259.75083	-18.516
10	M10	Oph	6254	2	10	254.25042	-4.1
11	M11	Sct	6705	1	11	282.75042	-6.266

Since v4.10-3 (March 2025)

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The screenshot displays the TOPCAT software interface. The main window shows the 'Current Table Properties' for 'messier.xml', which has 110 rows and 12 columns. The 'Sort Order' is set to 'Con' (ascending), indicated by a yellow arrow icon. The 'Row Subset' is 'All'. A 'Table Browser' window is open, showing a table with 110 rows and 8 columns: Name, Con, NGC, Type, ID, RA, and DEC. The table is sorted by 'Con' (ascending). The status bar at the bottom of the Table Browser shows 'Total: 110', 'Visible: 110', and 'Selected: 0'.

Table Browser for 1: messier.xml

	Name	Con	NGC	Type	ID	RA	DEC
31	M31	And	224	5	31	10.50292	41.266
32	M32	And	221	6	32	10.50292	40.866
110	M110	And	205	6	110	10.00167	41.683
2	M2	Aqr	7089	2	2	323.25208	-0.816
72	M72	Aqr	6981	2	72	313.25208	-12.533
73	M73	Aqr	6994	A	73	314.50375	-12.633
36	M36	Aur	1960	1	36	84.00042	34.133
37	M37	Aur	2099	1	37	88.00167	32.55
38	M38	Aur	1912	1	38	82.00167	35.833
41	M41	CMa	2287	1	41	101.5	-20.733
3	M3	CVn	5272	2	3	205.50083	28.383

Total: 110 Visible: 110 Selected: 0

Since v4.10-3 (March 2025)

Multi-Column Sort

Sort table on multiple keys, which can be expressions

- Previous versions only allowed to sort on a single column
- Sort order affects table view, saved table etc.

The screenshot displays the TOPCAT interface. The main window shows the 'Current Table Properties' for 'messier.xml', which has 110 rows and 12 columns. The 'Sort Order' is set to 'Con' (ascending) and 'NGC' (descending). A 'Table Browser' window is open, showing a table with 110 rows and 8 columns: Name, Con, NGC, Type, ID, RA, and DEC. The table is sorted by 'Con' and 'NGC'.

Table Browser for 1: messier.xml

	Name	Con	NGC	Type	ID	RA	DEC
110	M110	And	205	6	110	10.00167	41.683
32	M32	And	221	6	32	10.50292	40.866
31	M31	And	224	5	31	10.50292	41.266
72	M72	Aqr	6981	2	72	313.25208	-12.533
73	M73	Aqr	6994	A	73	314.50375	-12.633
2	M2	Aqr	7089	2	2	323.25208	-0.816
38	M38	Aur	1912	1	38	82.00167	35.833
36	M36	Aur	1960	1	36	84.00042	34.133
37	M37	Aur	2099	1	37	88.00167	32.55
41	M41	CMa	2287	1	41	101.5	-20.733
106	M106	CVn	4258	5	106	184.75	47.3

Total: 110 Visible: 110 Selected: 0

Since v4.10-3 (March 2025)

Multi-Column Sort

Sort table on multiple keys, which can be expressions

- Previous versions only allowed to sort on a single column
- Sort order affects table view, saved table etc.

The screenshot displays the TOPCAT software interface. The main window shows the 'Current Table Properties' for 'messier.xml', which has 110 rows and 12 columns. The 'Sort Order' is set to 'Con' (ascending) and '- parseInt(NGC)' (descending). The 'Row Subset' is 'All'. A 'Table Browser' window is open, showing a table with 110 rows and 8 columns: Name, Con, NGC, Type, ID, RA, and DEC. The table is sorted by 'Con' and '- parseInt(NGC)'. The status bar at the bottom of the Table Browser shows 'Total: 110', 'Visible: 110', and 'Selected: 0'.

	Name	Con	NGC	Type	ID	RA	DEC
31	M31	And	224	5	31	10.50292	41.266
32	M32	And	221	6	32	10.50292	40.866
110	M110	And	205	6	110	10.00167	41.683
2	M2	Aqr	7089	2	2	323.25208	-0.816
73	M73	Aqr	6994	A	73	314.50375	-12.633
72	M72	Aqr	6981	2	72	313.25208	-12.533
37	M37	Aur	2099	1	37	88.00167	32.55
36	M36	Aur	1960	1	36	84.00042	34.133
38	M38	Aur	1912	1	38	82.00167	35.833
41	M41	CMa	2287	1	41	101.5	-20.733
3	M3	CVn	5272	2	3	205.50083	28.383

Since v4.10-3 (March 2025)

MOC Updates

MOC 2.0 I/O now supported

- uses cds-astro MOCLib by Pierre Fernique

New functions in expression language:

- `mocUniq`, `mocUniqToOrder`, `mocUniqToIndex`, `mocSkyProportion`, `mocTileCount`

MOC writing commands in STILTS:

- New command `mocshape`
 - Can generate MOCs from points, circles, polygons, STC-S, UNIQ codes, other MOCs
- Existing command `pixfoot` can now exports ASCII-format MOCs

Since TOPCAT v4.10-3/STILTS v3.5-2 (March 2025)

File Formats

- CSV delimiter control

- You can (finally) read/write CSV files with non-comma delimiters

```
stilts tpipe in=data.tab ifmt='csv(delimiter=|)' out=data.fits
```

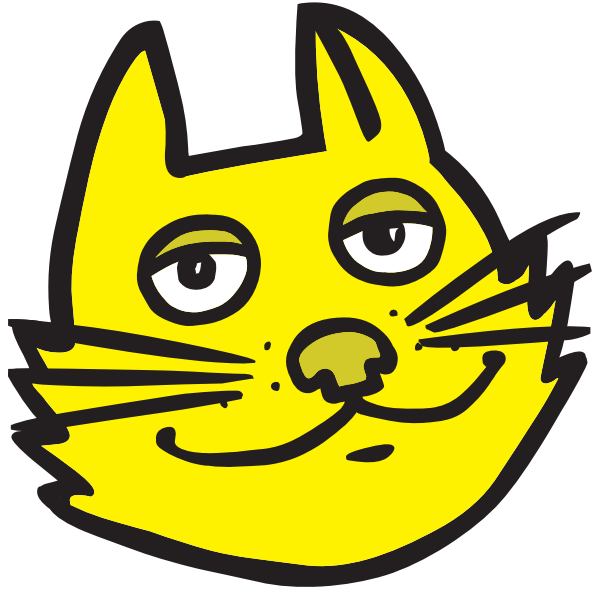
- CSV/ASCII type control

- Force integer/float type/length for columns in text-like tables

```
stilts tpipe in=cat.txt ifmt='ascii(notypes=short;int;float)' out=cat.vot
```

- Recent versions fix more or less serious bugs in CDF and Parquet I/O

Since TOPCAT v4.10-4/STILTS v3.5-3 (July 2025)



Thank you!

<http://www.starlink.ac.uk/topcat/>