# Data mining with Topcat and ADQL

## Creating a target list

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Research workshop on evolved stars
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# Overview

- Topcat
  - Basic overview
  - Table visualisation/manipulation
  - Visualisation tools
  - Crossmatching
- ADQL
  - Basic commands
- Exercise: the Pleiades open cluster
- Exercise: cross-match with ATLAS – creating our target list for photometry
- Exercise: some ADQL queries
- Creating our target list for spectroscopy
  - Defining the region of interest
  - ADQL query
  - Observational constraints

# TOPCAT

**Tool for OPerations on Catalogues And Tables**

***Does what you want with tables***

- Website: http://www.star.bristol.ac.uk/~mbt/topcat/
- Manual: http://www.starlink.ac.uk/topcat/sun253/
- Why TOPCAT?
  - Easy to use
  - Easy to learn
  - Easy to investigate data — good for exploratory analysis
  - Simple things obvious, complicated things documented
  - Easy to install and run
  - Fast
  - Copes with large data sets

TOPCAT

- What can we do with TOPCAT?
  - Read/write tables in multiple formats
  - View/edit data
  - View/edit metadata
  - Plot data
  - Crossmatch — efficient and very flexible
  - (Simple) Calculations
  - Access Virtual Observatory (VO) services
  - Trigger some event when a row is selected
  - Talk to other astro tools (SAMP)

# TOPCAT – start window

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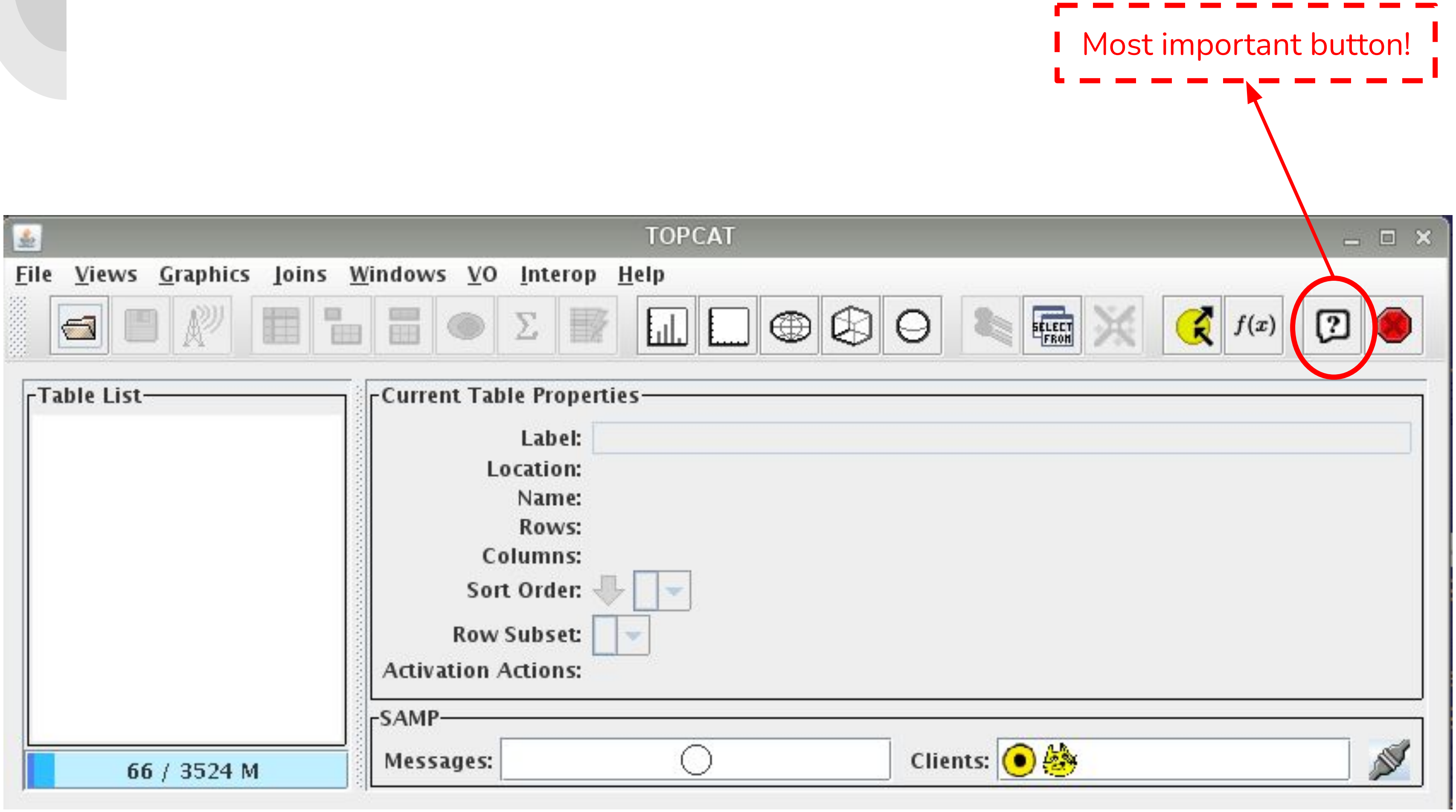
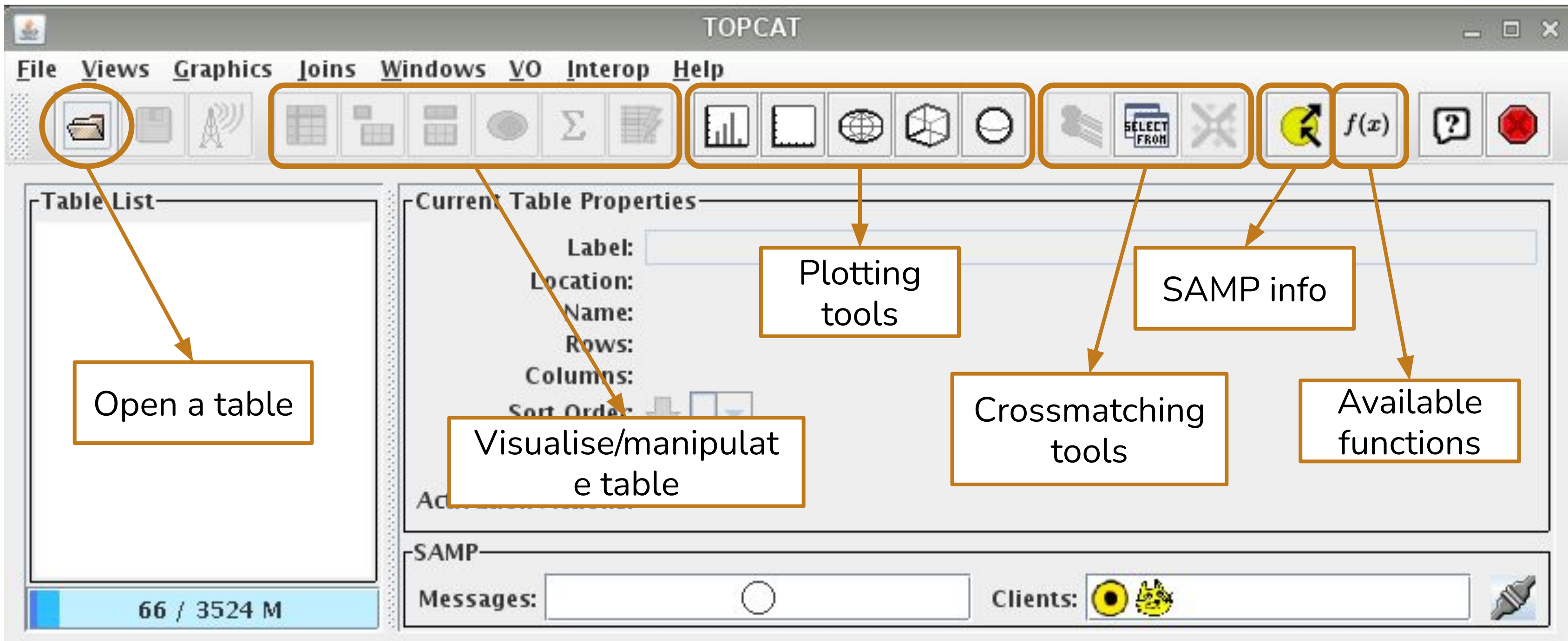
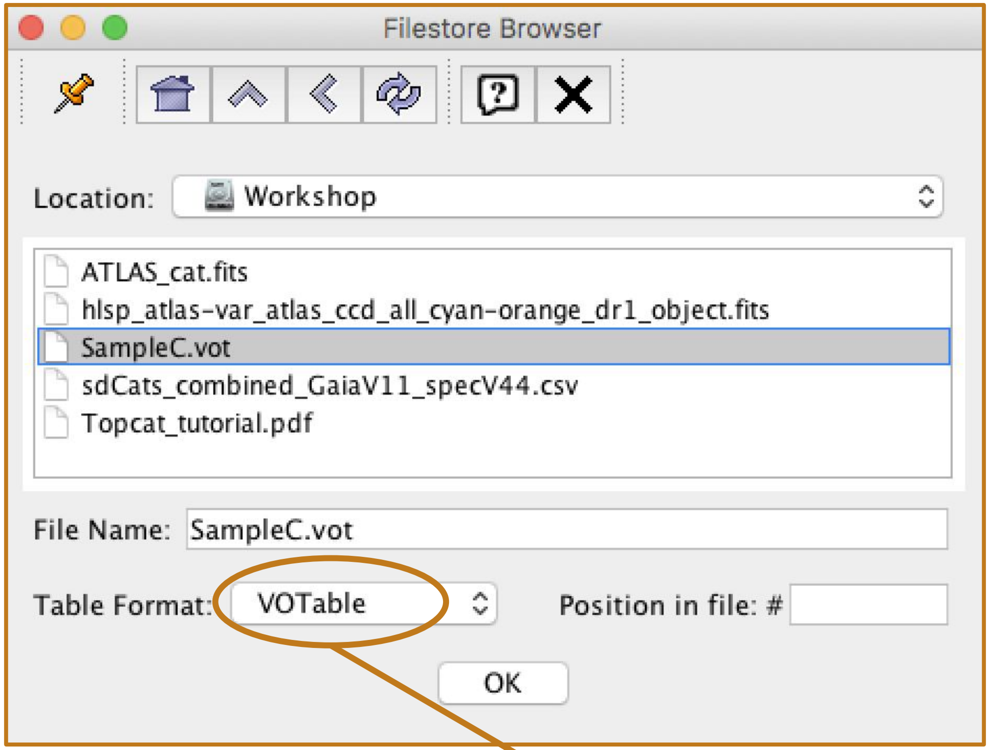


# TOPCAT – start window

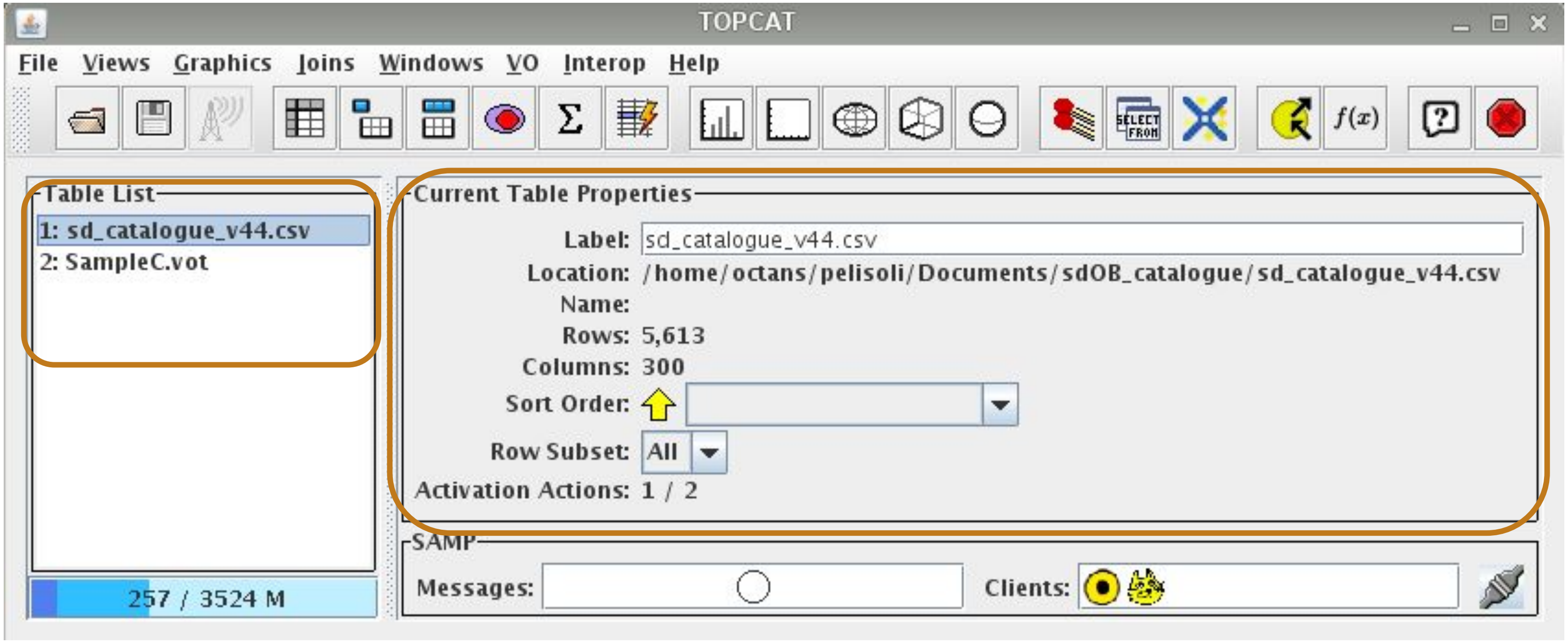


# TOPCAT – open a table

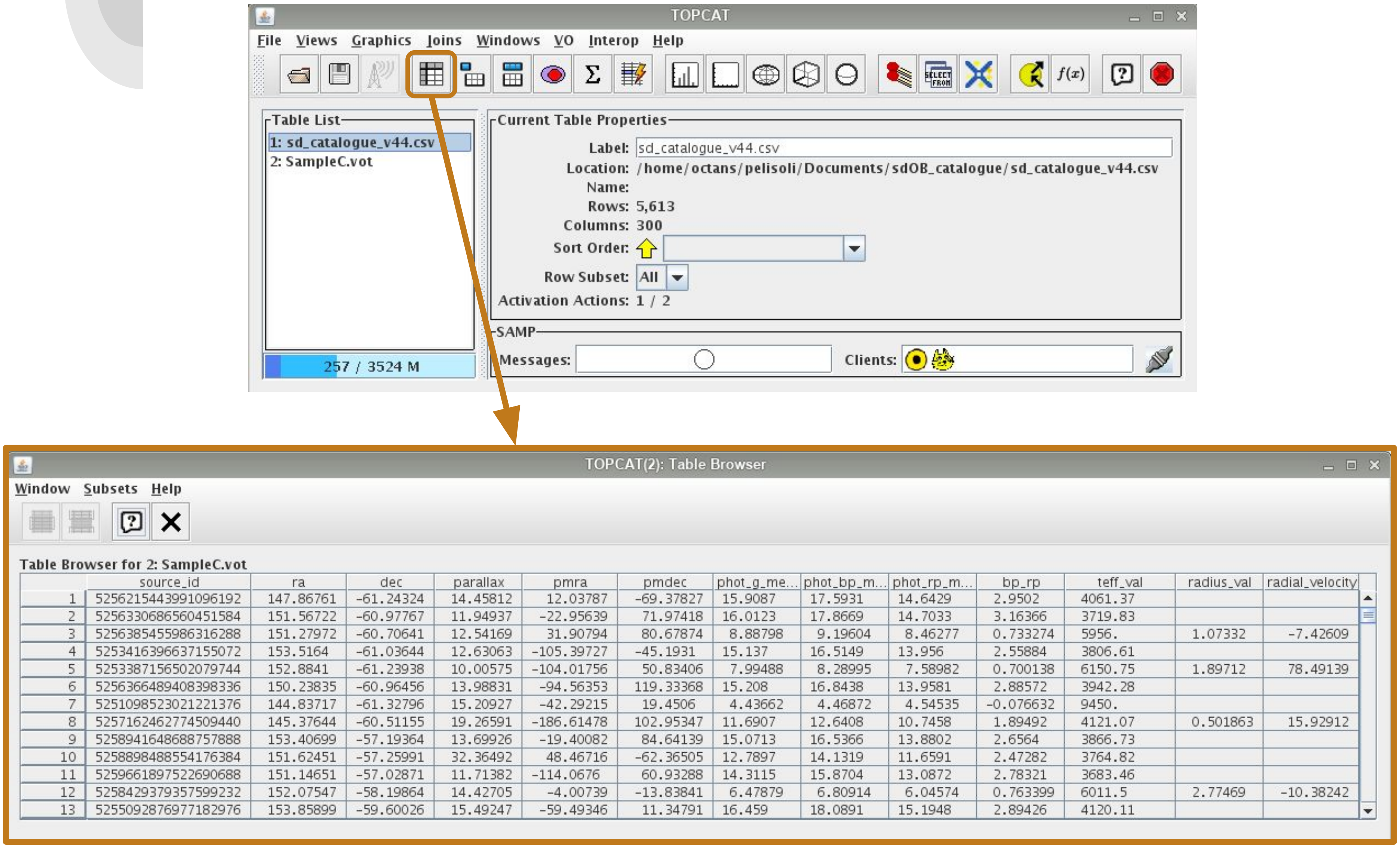



It's necessary to set the correct table format

# TOPCAT – tables

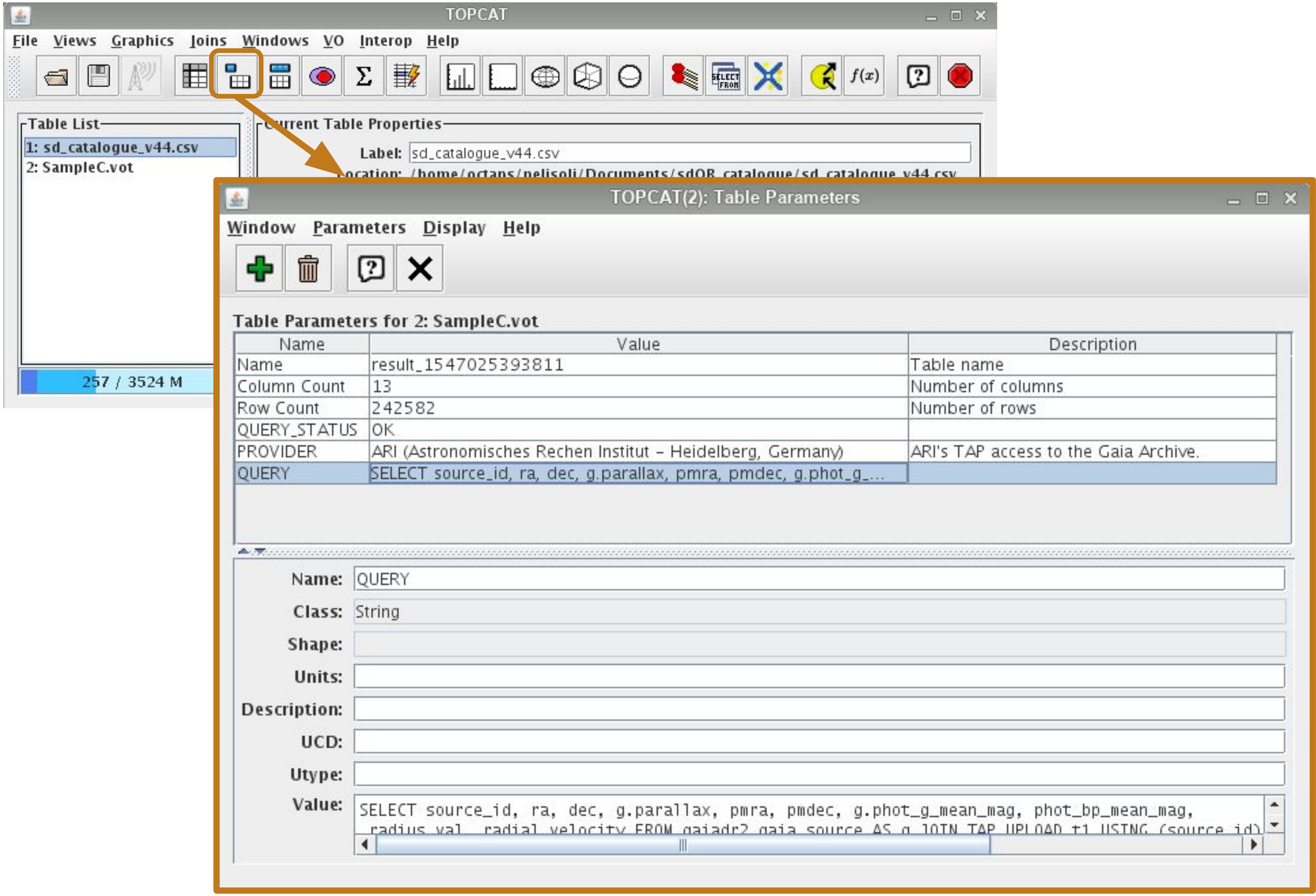


# TOPCAT – browse a table

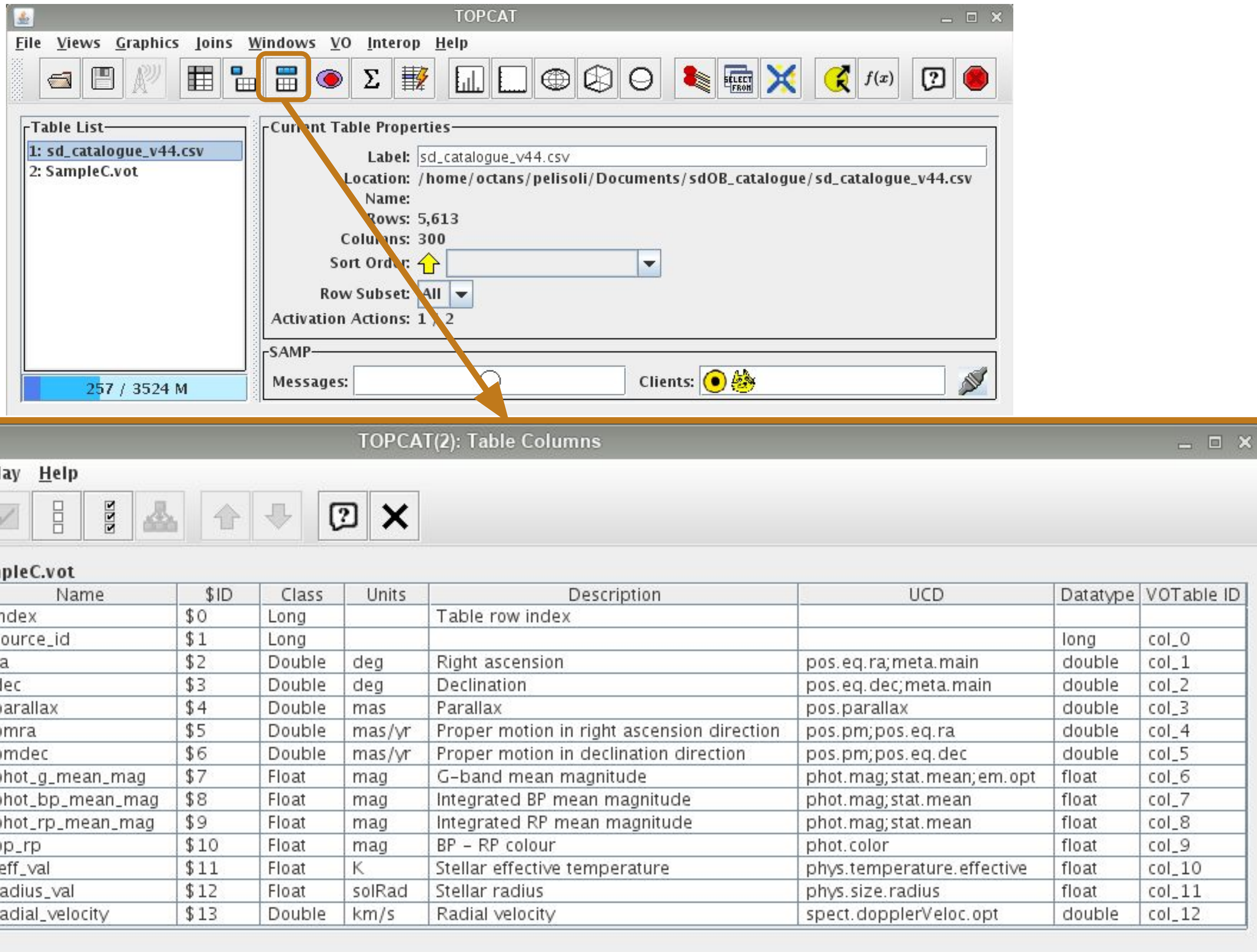



| | source_id | ra | dec | parallax | pmra | pmdec | phot_g_me... | phot_bp_m... | phot_rp_m... | bp_rp | teff_val | radius_val | radial_velocity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5256215443991096192 | 147.86761 | -61.24324 | 14.45812 | 12.03787 | -69.37827 | 15.9087 | 17.5931 | 14.6429 | 2.9502 | 4061.37 | | |
| 2 | 5256330686560451584 | 151.56722 | -60.97767 | 11.94937 | -22.95639 | 71.97418 | 16.0123 | 17.8669 | 14.7033 | 3.16366 | 3719.83 | | |
| 3 | 5256385455986316288 | 151.27972 | -60.70641 | 12.54169 | 31.90794 | 80.67874 | 8.88798 | 9.19604 | 8.46277 | 0.733274 | 5956. | 1.07332 | -7.42609 |
| 4 | 5253416396637155072 | 153.5164 | -61.03644 | 12.63063 | -105.39727 | -45.1931 | 15.137 | 16.5149 | 13.956 | 2.55884 | 3806.61 | | |
| 5 | 5253387156502079744 | 152.8841 | -61.23938 | 10.00575 | -104.01756 | 50.83406 | 7.99488 | 8.28995 | 7.58982 | 0.700138 | 6150.75 | 1.89712 | 78.49139 |
| 6 | 5256366489408398336 | 150.23835 | -60.96456 | 13.98831 | -94.56353 | 119.33368 | 15.208 | 16.8438 | 13.9581 | 2.88572 | 3942.28 | | |
| 7 | 5251098523021221376 | 144.83717 | -61.32796 | 15.20927 | -42.29215 | 19.4506 | 4.43662 | 4.46872 | 4.54535 | -0.076632 | 9450. | | |
| 8 | 5257162462774509440 | 145.37644 | -60.51155 | 19.26591 | -186.61478 | 102.95347 | 11.6907 | 12.6408 | 10.7458 | 1.89492 | 4121.07 | 0.501863 | 15.92912 |
| 9 | 5258941648688757888 | 153.40699 | -57.19364 | 13.69926 | -19.40082 | 84.64139 | 15.0713 | 16.5366 | 13.8802 | 2.6564 | 3866.73 | | |
| 10 | 5258898488554176384 | 151.62451 | -57.25991 | 32.36492 | 48.46716 | -62.36505 | 12.7897 | 14.1319 | 11.6591 | 2.47282 | 3764.82 | | |
| 11 | 5259661897522690688 | 151.14651 | -57.02871 | 11.71382 | -114.0676 | 60.93288 | 14.3115 | 15.8704 | 13.0872 | 2.78321 | 3683.46 | | |
| 12 | 5258429379357599232 | 152.07547 | -58.19864 | 14.42705 | -4.00739 | -13.83841 | 6.47879 | 6.80914 | 6.04574 | 0.763399 | 6011.5 | 2.77469 | -10.38242 |
| 13 | 5255092876977182976 | 153.85899 | -59.60026 | 15.49247 | -59.49346 | 11.34791 | 16.459 | 18.0891 | 15.1948 | 2.89426 | 4120.11 | | |

# TOPCAT – table metadata

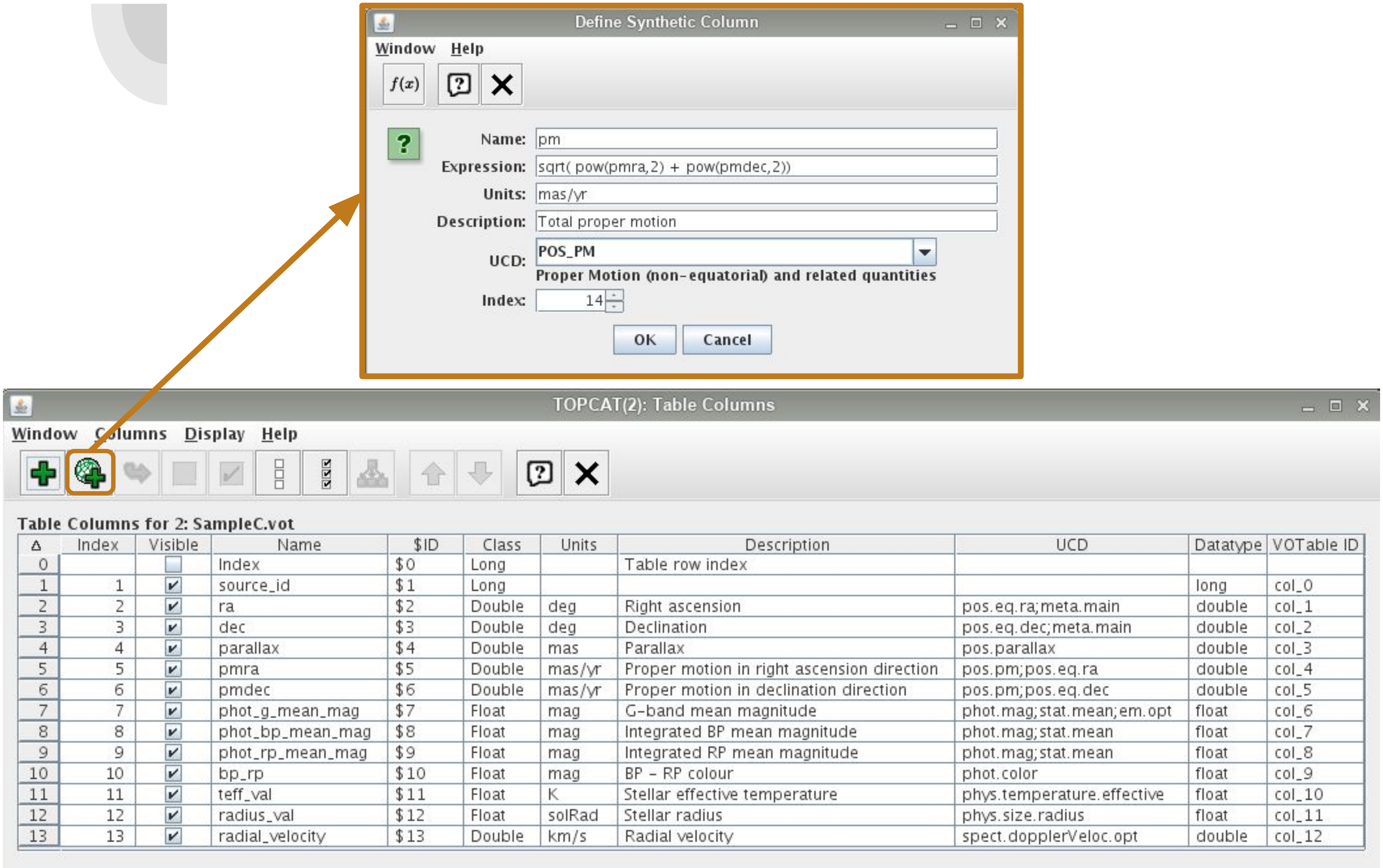


# TOPCAT – column metadata



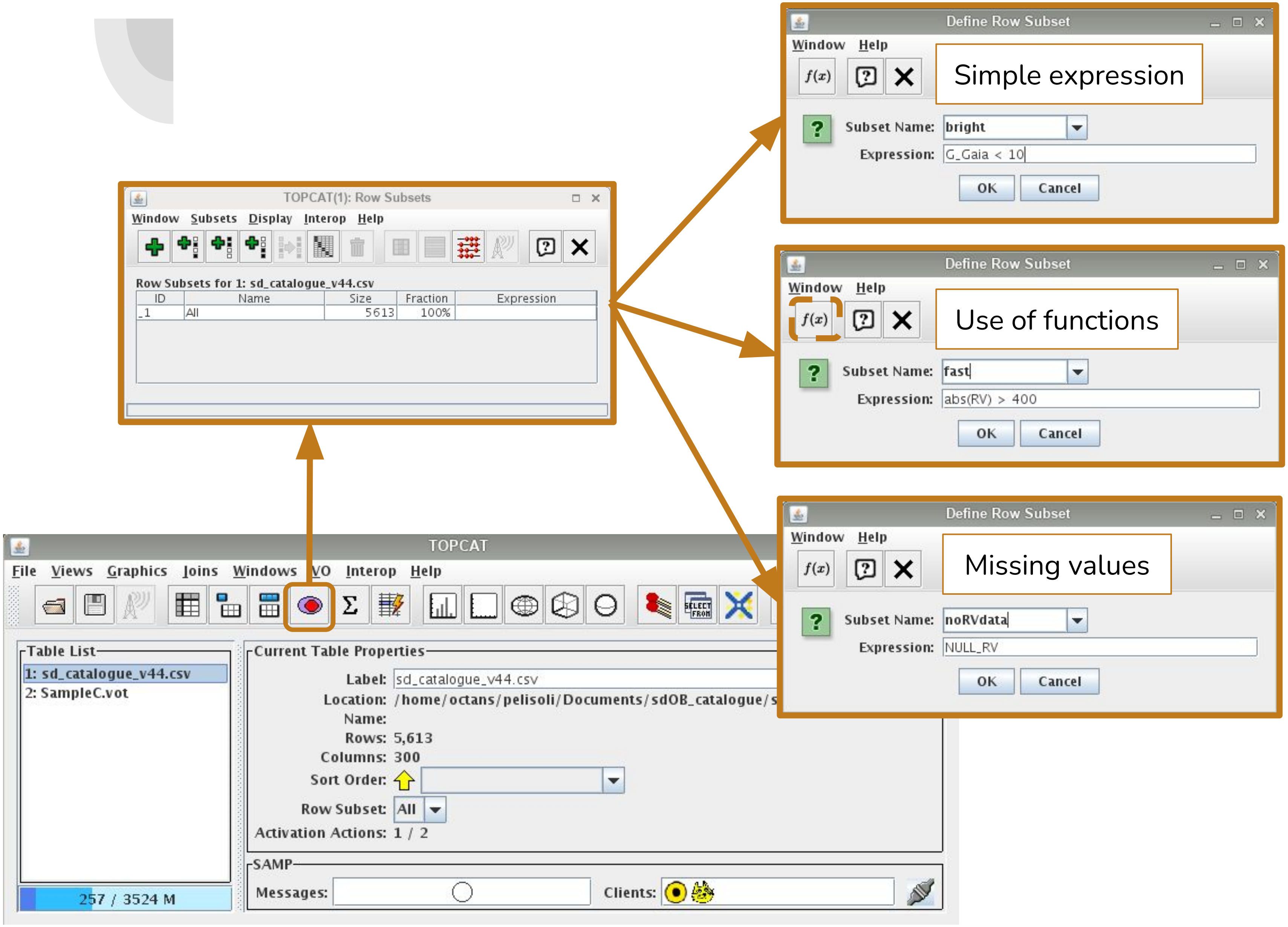

| Δ | Index | Visible | Name | $ID | Class | Units | Description | UCD | Datatype | VOTable ID |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | ☐ | Index | $0 | Long | | Table row index | | | |
| 1 | 1 | ☑ | source_id | $1 | Long | | | | long | col_0 |
| 2 | 2 | ☑ | ra | $2 | Double | deg | Right ascension | pos.eq.ra;meta.main | double | col_1 |
| 3 | 3 | ☑ | dec | $3 | Double | deg | Declination | pos.eq.dec;meta.main | double | col_2 |
| 4 | 4 | ☑ | parallax | $4 | Double | mas | Parallax | pos.parallax | double | col_3 |
| 5 | 5 | ☑ | pmra | $5 | Double | mas/yr | Proper motion in right ascension direction | pos.pm;pos.eq.ra | double | col_4 |
| 6 | 6 | ☑ | pmdec | $6 | Double | mas/yr | Proper motion in declination direction | pos.pm;pos.eq.dec | double | col_5 |
| 7 | 7 | ☑ | phot_g_mean_mag | $7 | Float | mag | G-band mean magnitude | phot.mag;stat.mean;em.opt | float | col_6 |
| 8 | 8 | ☑ | phot_bp_mean_mag | $8 | Float | mag | Integrated BP mean magnitude | phot.mag;stat.mean | float | col_7 |
| 9 | 9 | ☑ | phot_rp_mean_mag | $9 | Float | mag | Integrated RP mean magnitude | phot.mag;stat.mean | float | col_8 |
| 10 | 10 | ☑ | bp_rp | $10 | Float | mag | BP - RP colour | phot.color | float | col_9 |
| 11 | 11 | ☑ | teff_val | $11 | Float | K | Stellar effective temperature | phys.temperature.effective | float | col_10 |
| 12 | 12 | ☑ | radius_val | $12 | Float | solRad | Stellar radius | phys.size.radius | float | col_11 |
| 13 | 13 | ☑ | radial_velocity | $13 | Double | km/s | Radial velocity | spect.dopplerVeloc.opt | double | col_12 |

# TOPCAT – create new column

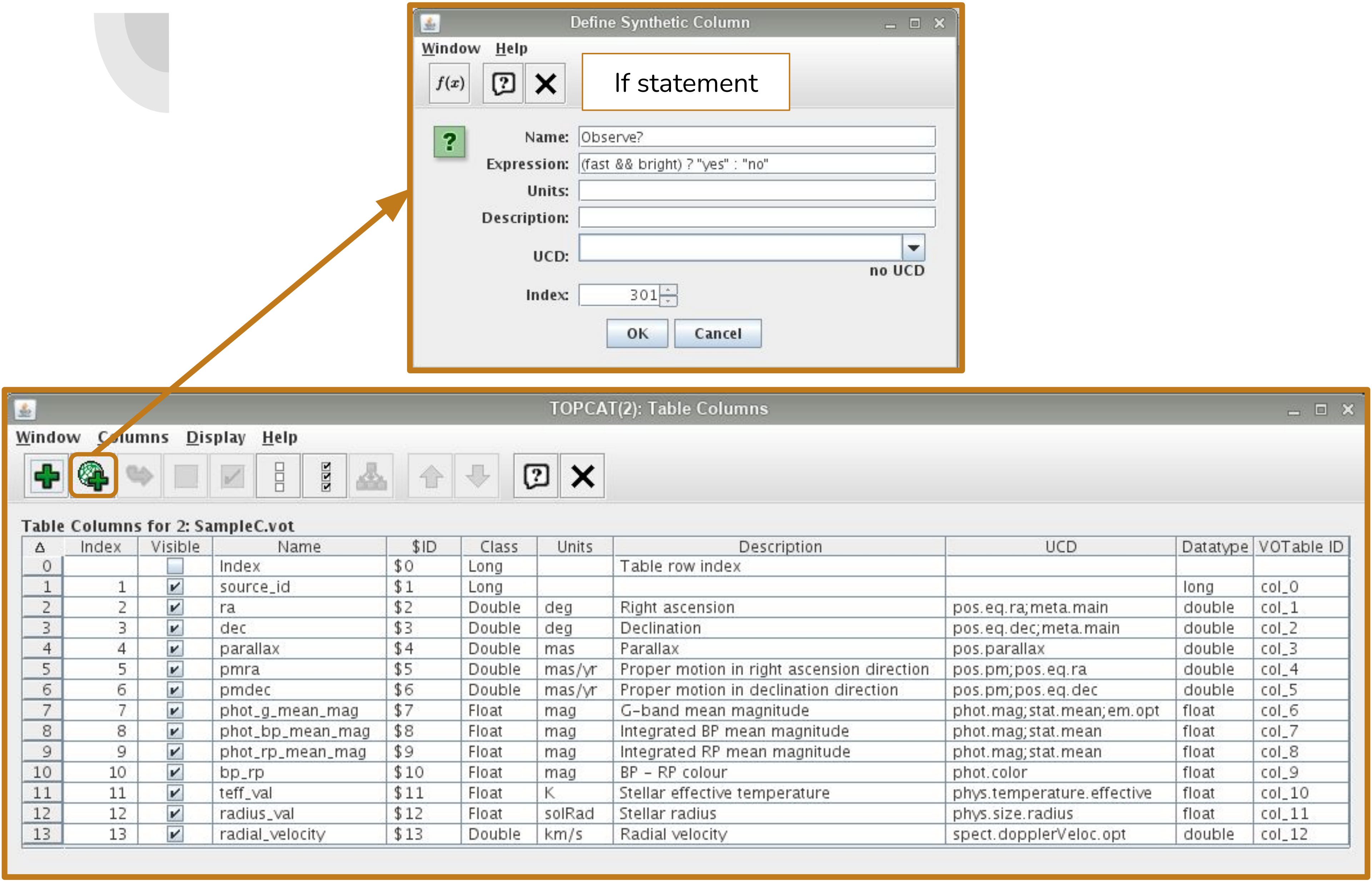



| Δ | Index | Visible | Name | $ID | Class | Units | Description | UCD | Datatype | VOTable ID |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | ☐ | Index | $0 | Long | | Table row index | | | |
| 1 | 1 | ☑ | source_id | $1 | Long | | | | long | col_0 |
| 2 | 2 | ☑ | ra | $2 | Double | deg | Right ascension | pos.eq.ra;meta.main | double | col_1 |
| 3 | 3 | ☑ | dec | $3 | Double | deg | Declination | pos.eq.dec;meta.main | double | col_2 |
| 4 | 4 | ☑ | parallax | $4 | Double | mas | Parallax | pos.parallax | double | col_3 |
| 5 | 5 | ☑ | pmra | $5 | Double | mas/yr | Proper motion in right ascension direction | pos.pm;pos.eq.ra | double | col_4 |
| 6 | 6 | ☑ | pmdec | $6 | Double | mas/yr | Proper motion in declination direction | pos.pm;pos.eq.dec | double | col_5 |
| 7 | 7 | ☑ | phot_g_mean_mag | $7 | Float | mag | G-band mean magnitude | phot.mag;stat.mean;em.opt | float | col_6 |
| 8 | 8 | ☑ | phot_bp_mean_mag | $8 | Float | mag | Integrated BP mean magnitude | phot.mag;stat.mean | float | col_7 |
| 9 | 9 | ☑ | phot_rp_mean_mag | $9 | Float | mag | Integrated RP mean magnitude | phot.mag;stat.mean | float | col_8 |
| 10 | 10 | ☑ | bp_rp | $10 | Float | mag | BP - RP colour | phot.color | float | col_9 |
| 11 | 11 | ☑ | teff_val | $11 | Float | K | Stellar effective temperature | phys.temperature.effective | float | col_10 |
| 12 | 12 | ☑ | radius_val | $12 | Float | solRad | Stellar radius | phys.size.radius | float | col_11 |
| 13 | 13 | ☑ | radial_velocity | $13 | Double | km/s | Radial velocity | spect.dopplerVeloc.opt | double | col_12 |

# TOPCAT – create subsets



# TOPCAT – create column based on subset




| Δ | Index | Visible | Name | $ID | Class | Units | Description | UCD | Datatype | VOTable ID |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | ☐ | Index | $0 | Long | | Table row index | | | |
| 1 | 1 | ✔ | source_id | $1 | Long | | | | long | col_0 |
| 2 | 2 | ✔ | ra | $2 | Double | deg | Right ascension | pos.eq.ra;meta.main | double | col_1 |
| 3 | 3 | ✔ | dec | $3 | Double | deg | Declination | pos.eq.dec;meta.main | double | col_2 |
| 4 | 4 | ✔ | parallax | $4 | Double | mas | Parallax | pos.parallax | double | col_3 |
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| 8 | 8 | ✔ | phot_bp_mean_mag | $8 | Float | mag | Integrated BP mean magnitude | phot.mag;stat.mean | float | col_7 |
| 9 | 9 | ✔ | phot_rp_mean_mag | $9 | Float | mag | Integrated RP mean magnitude | phot.mag;stat.mean | float | col_8 |
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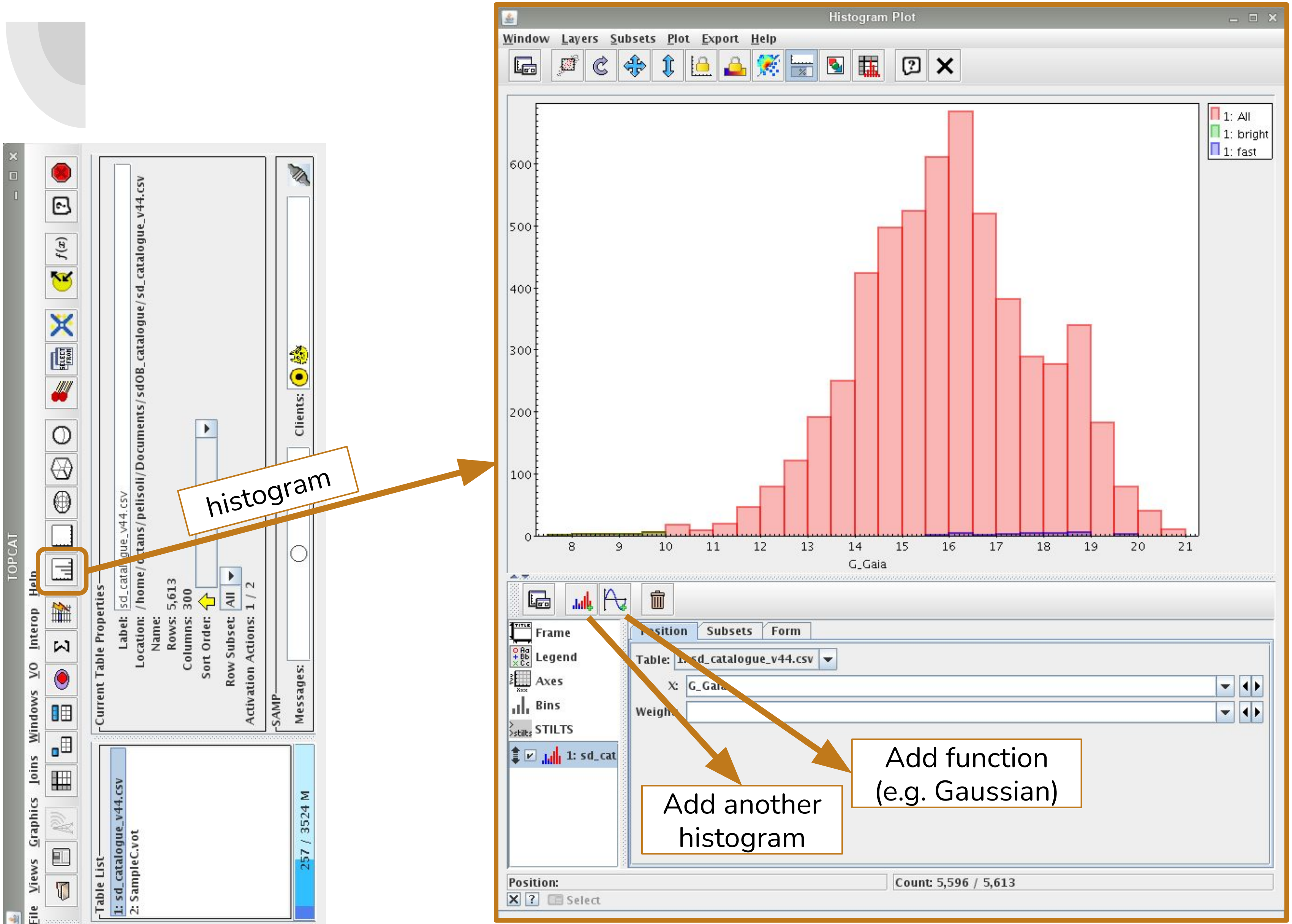
| 13 | 13 | ✔ | radial_velocity | $13 | Double | km/s | Radial velocity | spect.dopplerVeloc.opt | double | col_12 |

# TOPCAT – Visualisation tools



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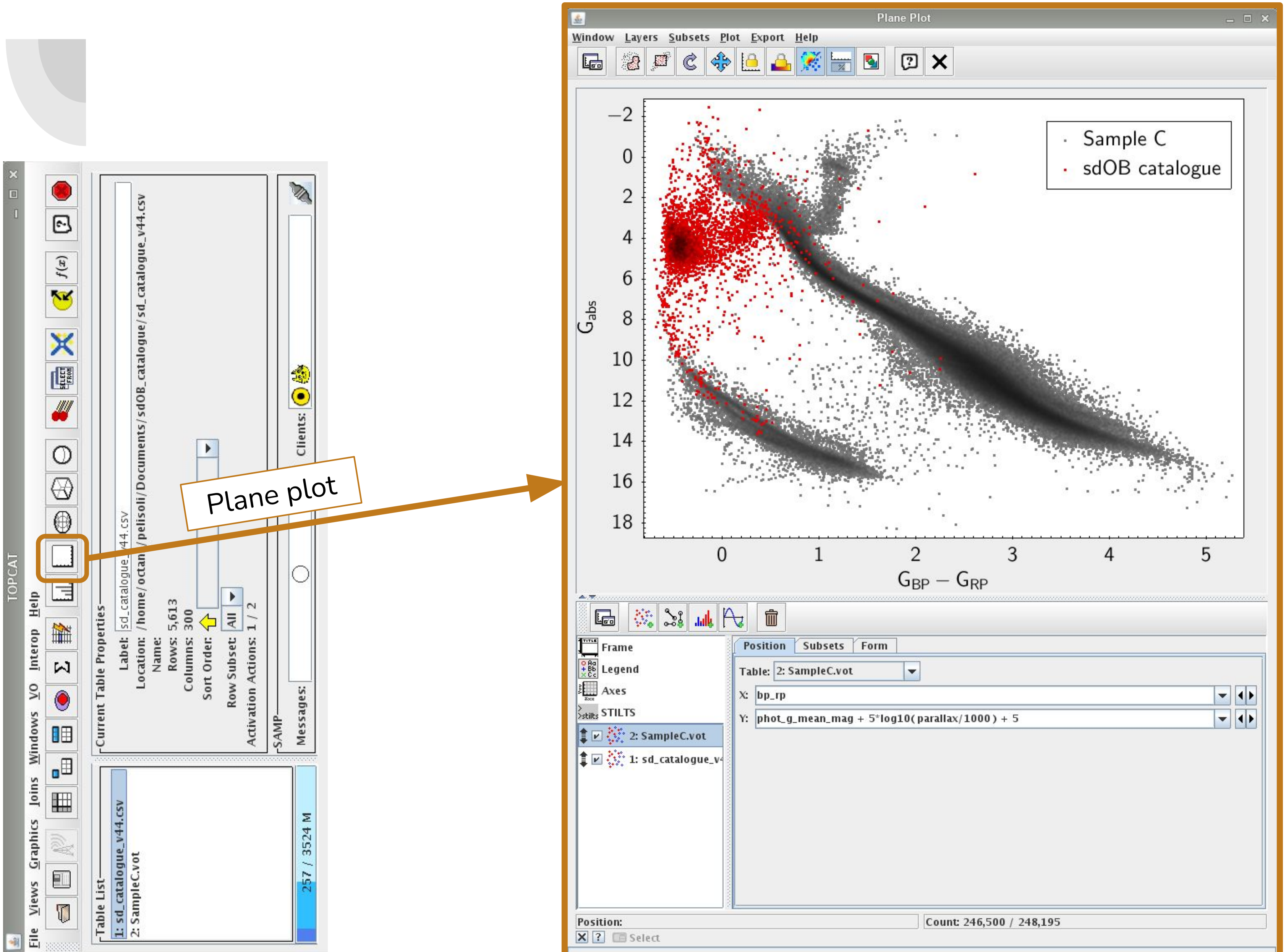

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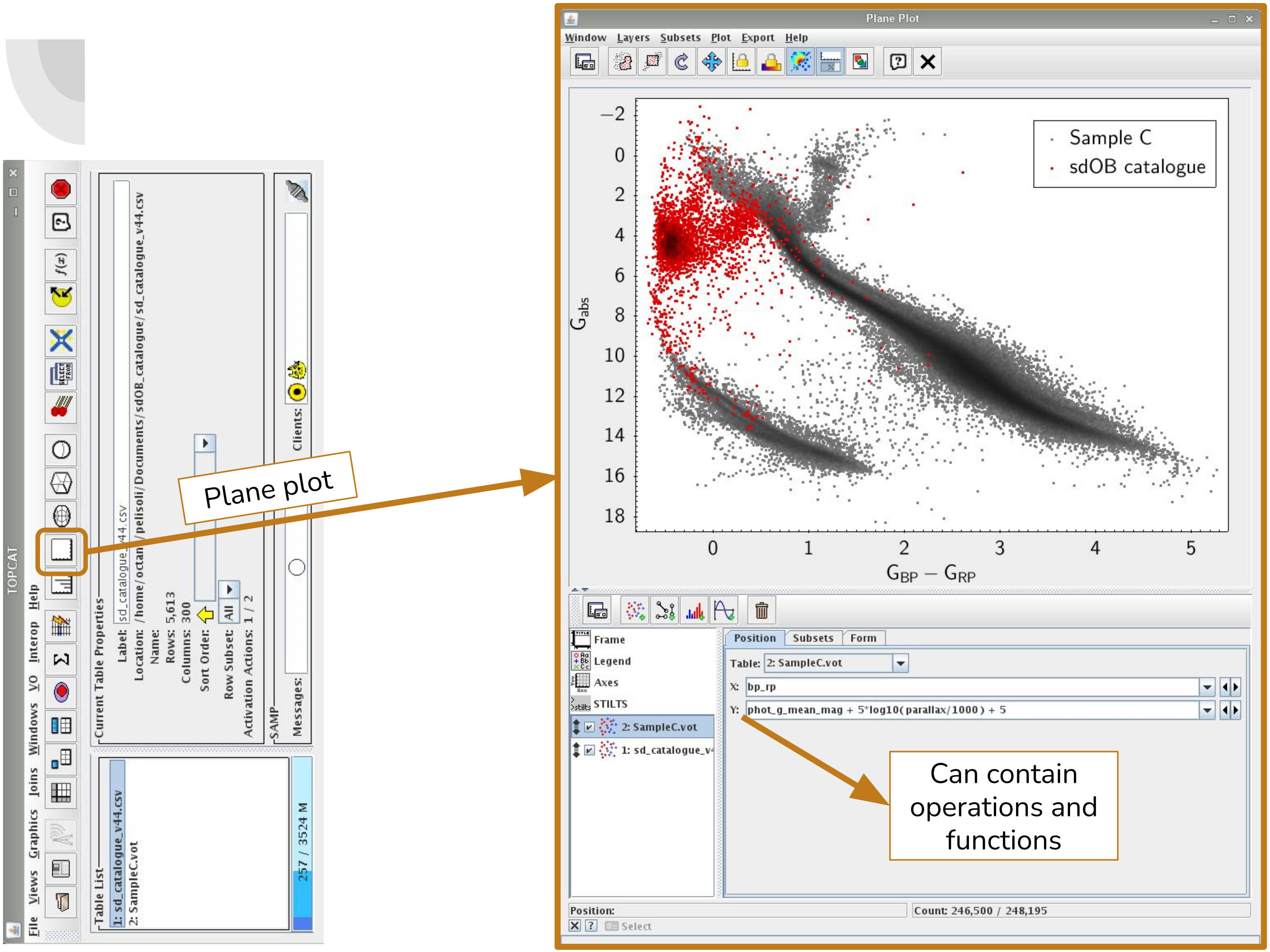

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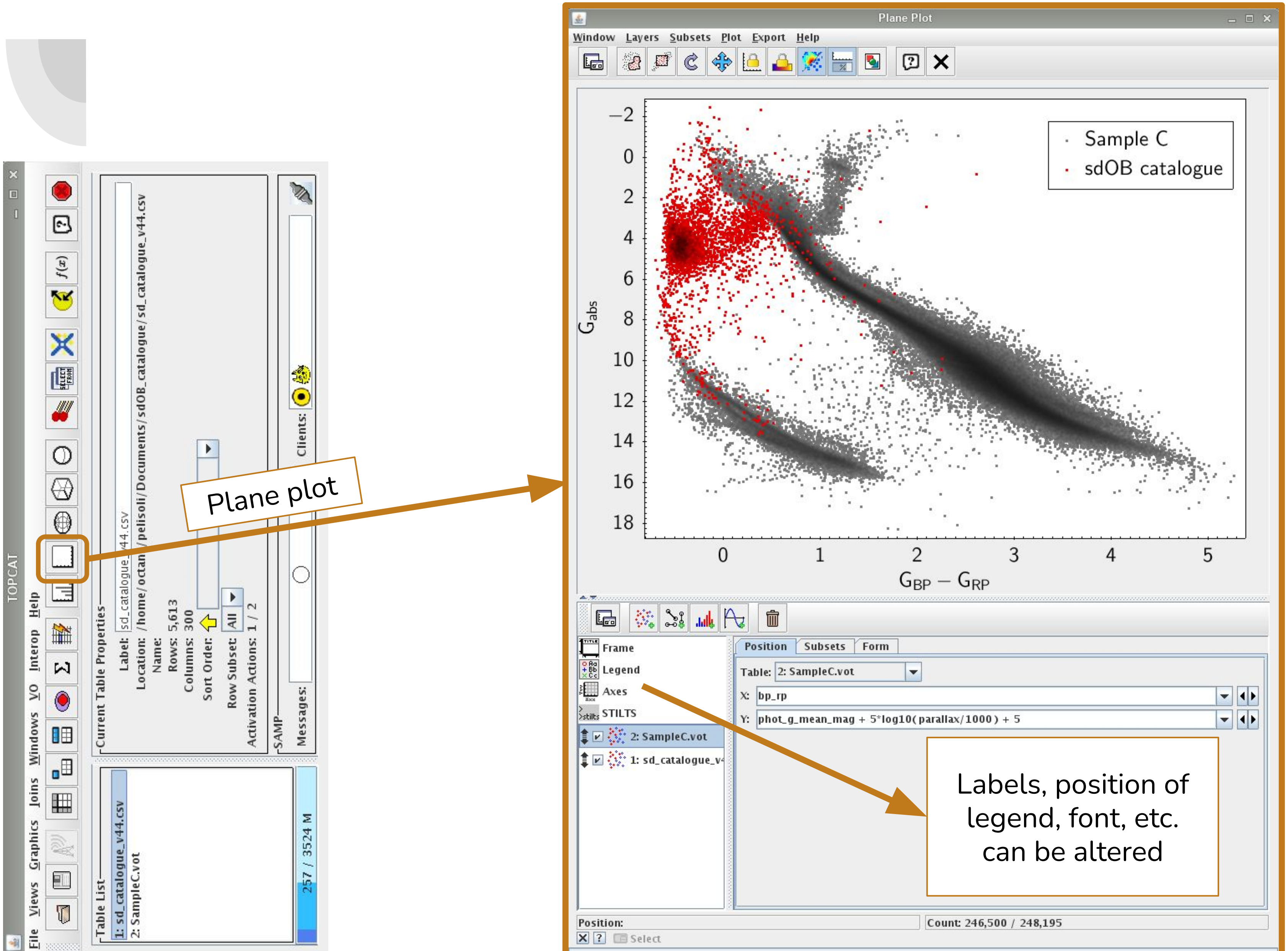

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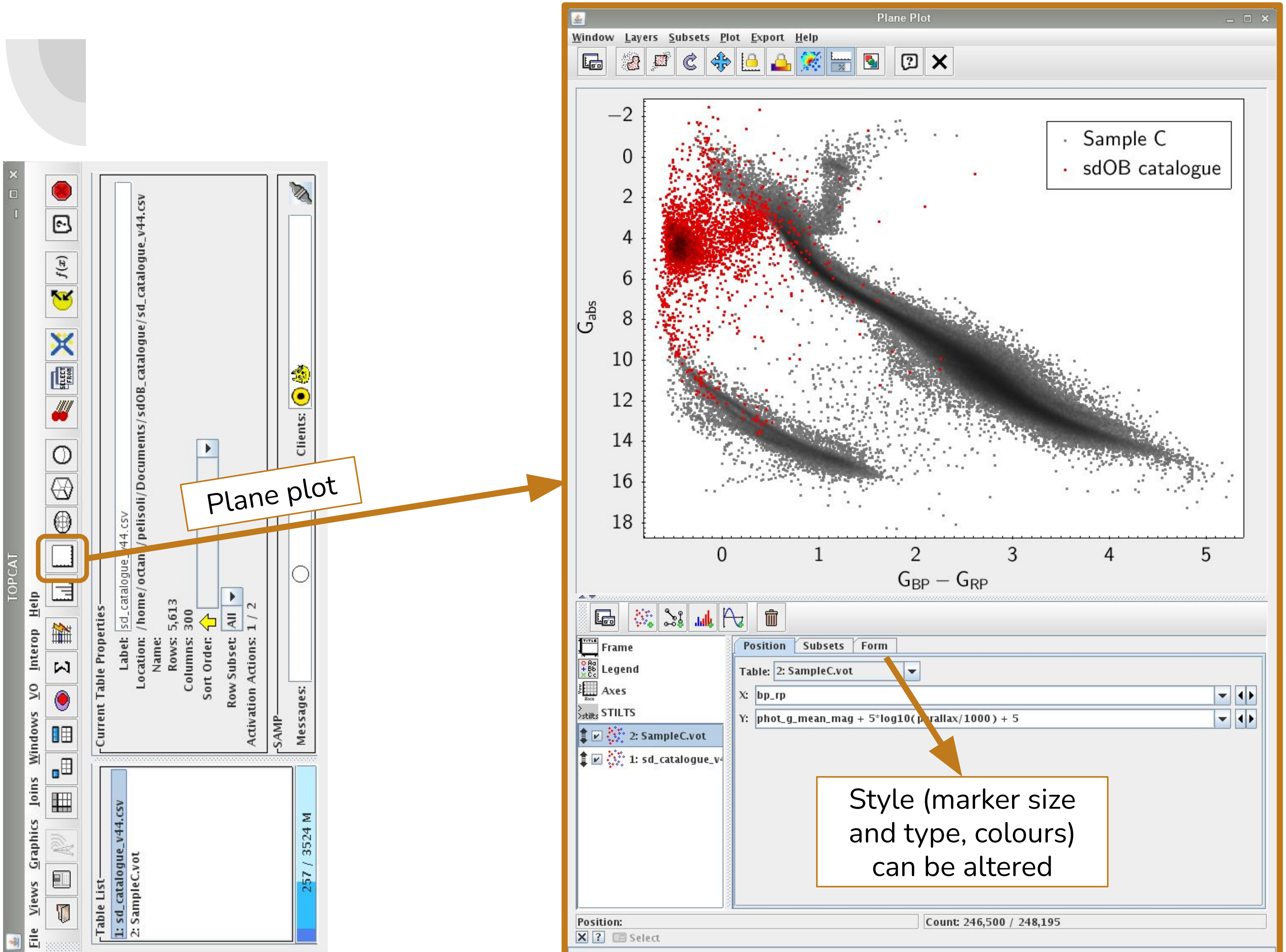

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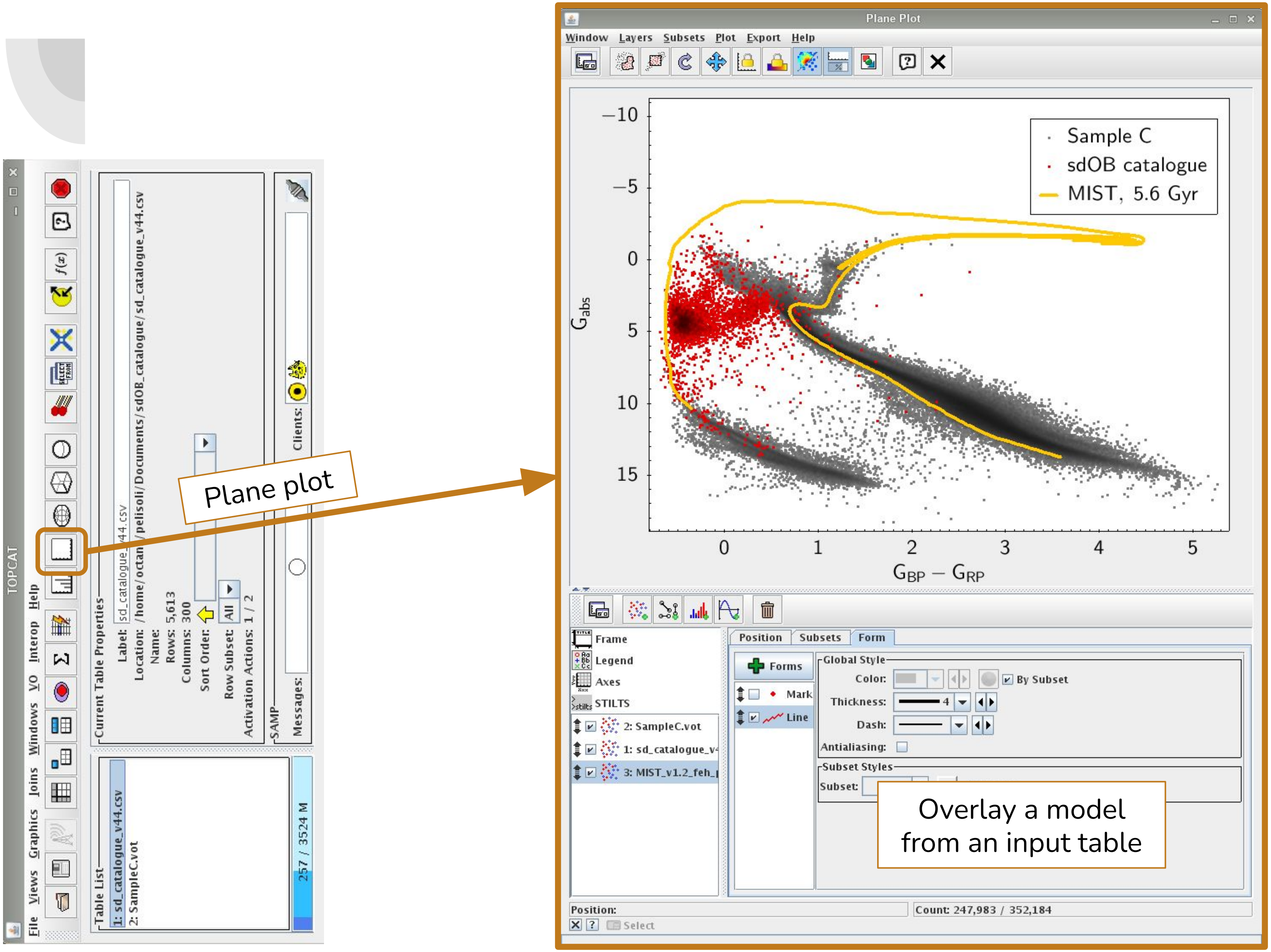

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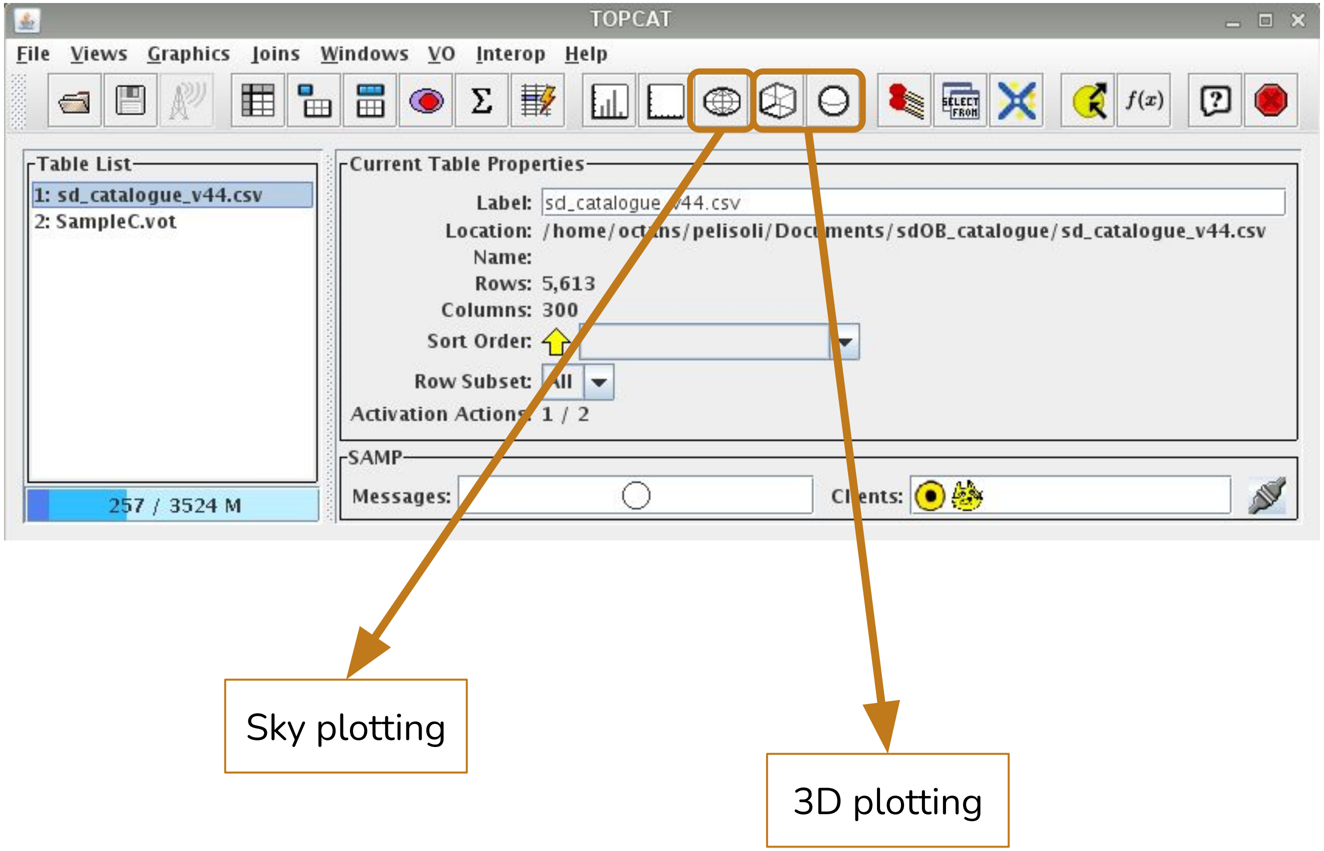
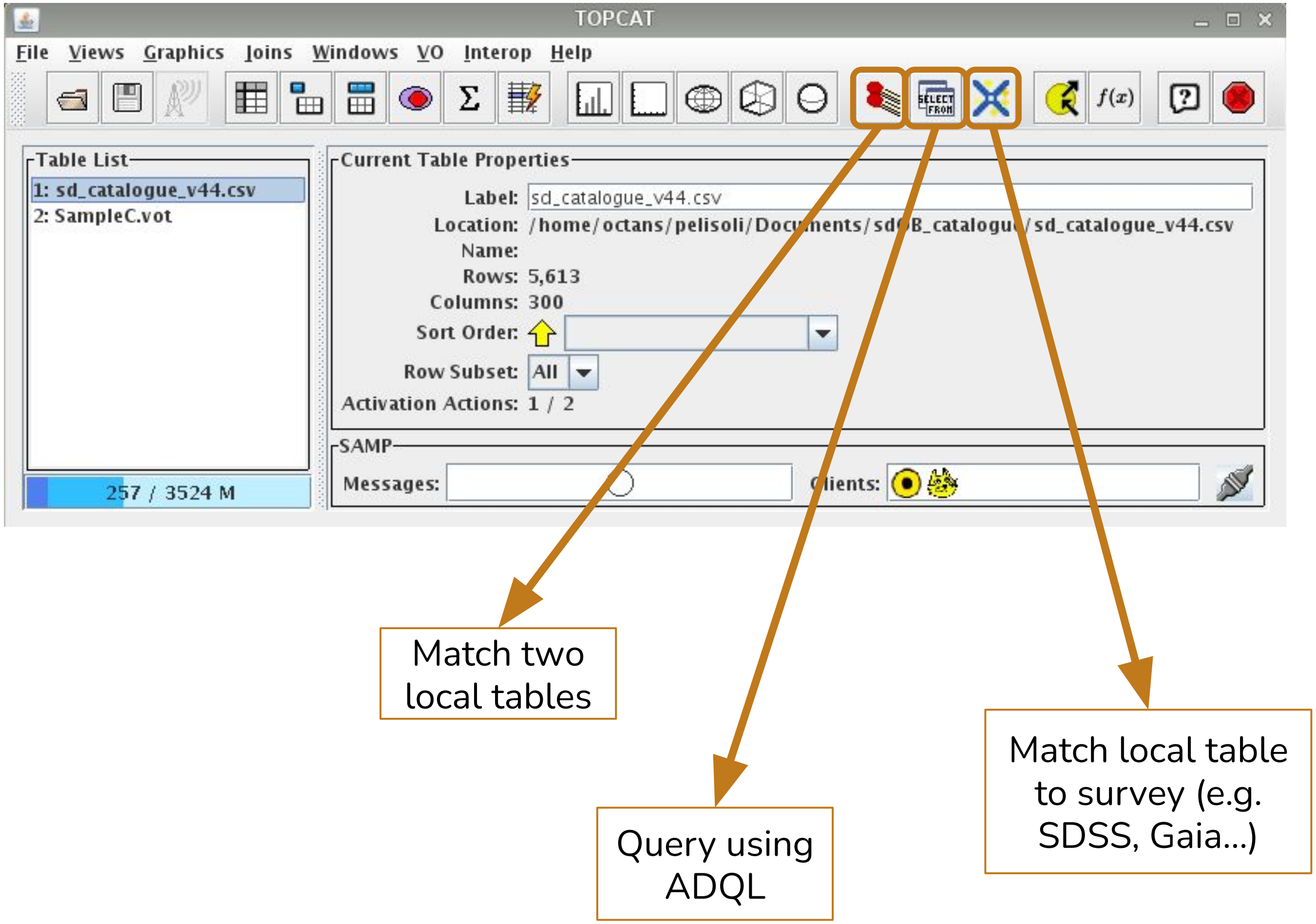


# TOPCAT – Crossmatching



# ADQL queries

- ADQL = Astronomical Data Query Language
- Useful tutorial http://docs.g-vo.org/adql-gaia/html/
- A dialect of SQL

Very basic summary of a query:

```
SELECT [TOP (number of rows)] [source table index].(variables you need)
FROM (table you're querying) [AS (table index)]
[WHERE (condition 1) AND (condition 2) OR (condition 3)]
[ORDER BY (variable)]
```

# ADQL queries – SELECT: ORDER BY

- Useful to select brightest, fastest, etc. from a table
- E.g.: 50 brightest stars in Gaia DR2

- E.g.: 20 highest proper motion stars in Tycho

# ADQL queries – SELECT: ORDER BY

- Useful to select brightest, fastest, etc. from a table
- E.g.: 50 brightest stars in Gaia DR2

```
SELECT TOP 50 source_id, phot_g_mean_mag, parallax, bp_rp
FROM gaiadr2.gaia_source
ORDER BY phot_g_mean_mag
```

- E.g.: 20 highest proper motion stars in Tycho

```
SELECT TOP 20 source_id, parallax, phot_g_mean_mag,
              SQRT(POWER(pmra,2)+POWER(pmdec,2)) AS pm
FROM gaiadr1.tgas_source
ORDER BY pm DESC
```

# ADQL queries – SELECT: WHERE clause

- WHERE introduces a logical expression, in a similar to other languages, with operators AND and OR.
- E.g.: stars brighter than 12, closer than 50 pc.

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```
SELECT source_id, phot_g_mean_mag, parallax, bp_rp
FROM gaiadr2.gaia_source
WHERE phot_g_mean_mag < 12.0 AND parallax > 20.0
```

# ADQL queries – SELECT: JOIN USING

- For joining two tables with a same column
- E.g.: get Gaia DR2 proper motions for stars with known `source_id`

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```
SELECT source_id, a.phot_g_mean_mag, a.parallax,
       a.bp_rp, b.pmra, b.pmdec
FROM TAP_UPLOAD.t6 AS a
JOIN gaiadr2.gaia_source AS b USING(source_id)
```

# ADQL queries – Geometries

- Useful for searching a radius around given coordinates
- E.g.: get Gaia DR2 proper motions for stars with *unknown* `source_id` (3" search)

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- Useful for searching a radius around given coordinates
- E.g.: get Gaia DR2 proper motions for stars with *unknown* `source_id` (3" search)

```
SELECT b.source_id, a.NAME_SDCAT, b.pmra, b.pmdec
FROM TAP_UPLOAD.t10 AS a
JOIN gaiadr2.gaia_source AS b ON 1=CONTAINS (
     POINT('ICRS', a.RAJ2000, a.DEJ2000),
     CIRCLE('ICRS', b.ra, b.dec, 3./3600.))
```

- Note: same thing could be done with a TOPCAT crossmatch, but that is not always the case (e.g. if a table is not listed for crossmatching).

# Exercise: Pleiades

**(Credit: Niall Deacon, Hawaii)**

**From the tutorial at**
http://andromeda.star.bris.ac.uk/topcat/tutorial/

- Open the VizieR load dialog ( ) **(click on "VO" at the top bar menu)**
- Search for all the objects within 3 degrees of the Pleiades in the Tycho-2 catalogue:
  - Check **Cone Selection** button
  - Object name `Pleiades`, **Resolve**
  - Radius 3 degrees
  - Catalogue Selection **Surveys** tab
  - Click on row Tycho-2 (Name column is ordered alphabetically)
  - Click **OK**
  - Loads 2 tables (2 tables in VizieR under that heading) - pick the one with most rows
- Visualise proper motions:
  - Open a scatter plot window
  - X = pmRA, Y = pmDE
  - Zoom in to find a cluster with non-zero motion
  - Draw a blob round it to create a new subset (click ; drag out the cluster region, click again)
- Draw colour-magnitude diagram:
  - Open a different scatter plot window
  - X = VTmag - BTmag, Y = VTmag, flip Y
  - See where the new cluster subset you identified sit in colour-magnitude space (main sequence?).
- Save the cluster identification:
  - Go to the Subsets window
  - Select the row corresponding to the cluster subset
  - Create a new boolean table corresponding to this subset by clicking the **To Column** toolbar button
  - Save the table.

# Creating our photometric target list

- Now that you have familiarised yourself with TOPCAT, we can create a list of targets for photometry!
- We want to observe hot subdwarf stars with suspected variability.
- We are going to use a table containing 40,000+ hot subdwarf and candidates:

http://www.astro.physik.uni-potsdam.de/~pelisoli/AstroWorkshop/sdCats_combined_GaiaV11_specV44.csv

- To identify candidate variables, we will use the ATLAS catalogue:

https://archive.stsci.edu/prepds/atlas-var/

(download the "Object Table" )

* This table is 7GB in size! If the download takes too long, download instead:

http://www.astro.physik.uni-potsdam.de/~pelisoli/AstroWorkshop/ATLAS_cat.fits

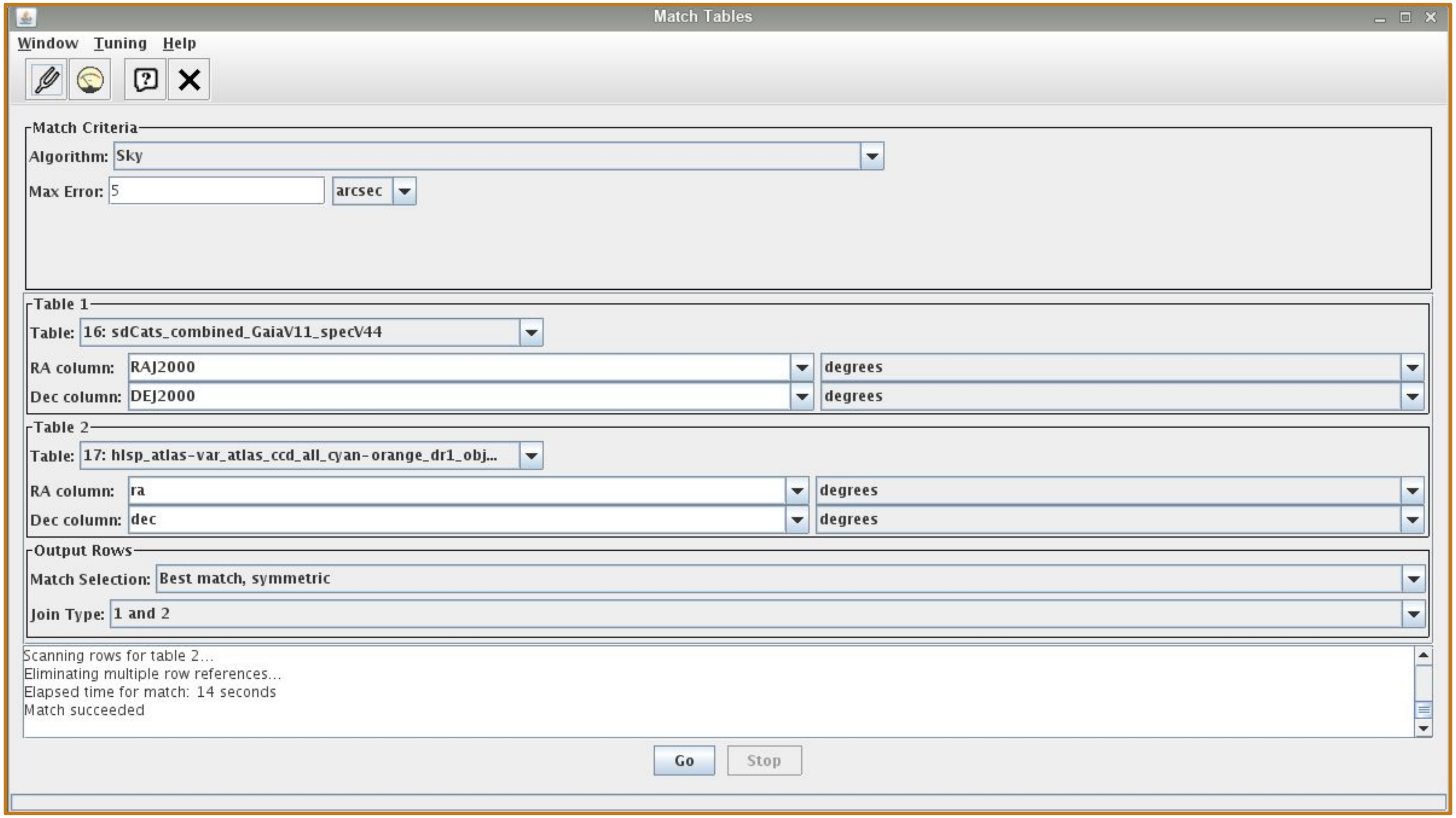
# Creating our photometric target list

- **Step 1:** import both tables to TOPCAT.
- **Step 2:** select only relevant columns from the ATLAS table.
  - There are 197 (!) columns in this table – they describe many parameters in the variability search algorithm run by ATLAS.
  - Using the column metadata shortcut, deselect all columns, then select only:
    - ATO_ID
    - ra and dec (we need those to do a crossmatch)
    - fp_period
    - fp_fitrms
    - fp_fitchi
    - CLASS (this is the type of variation ATLAS identified)

We are interested in short period binaries. These parameters describe the fitted period, root-mean-square, and chi-square of the short-period algorithm in ATLAS.

# Creating our photometric target list

- **Step 3:** cross-match both tables 



# Creating our photometric target list

- **Step 4:** create a subset with objects worth observing for our science case, taking into account the time and site constraints (for next week in Ondřejov).
  - You can use staralt: http://catserver.ing.iac.es/staralt/index.php

    (Ondřejov location: 14.781°E 49.915°N 500m, UT-offset +2)
  - We want objects that do have a short period determined.
  - Preferably objects whose period can be covered in one night.

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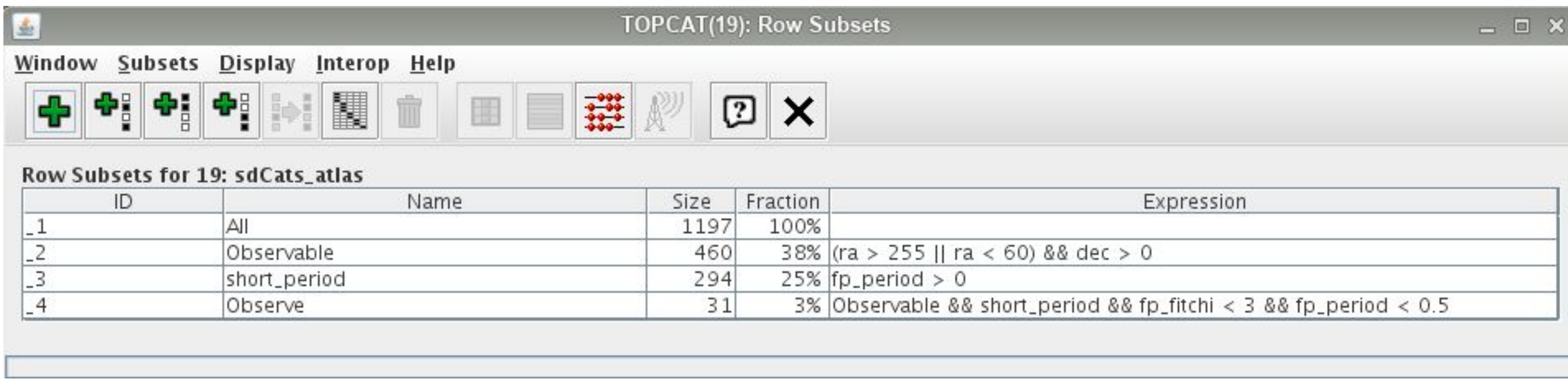



| ID | Name | Size | Fraction | Expression |
|---|---|---|---|---|
| _1 | All | 1197 | 100% | |
| _2 | Observable | 460 | 38% | (ra > 255 \|\| ra < 60) && dec > 0 |
| _3 | short_period | 294 | 25% | fp_period > 0 |
| _4 | Observe | 31 | 3% | Observable && short_period && fp_fitchi < 3 && fp_period < 0.5 |

# Creating our photometric target list

TOPCAT(19): Table Browser

Window Subsets Help

**Table Browser for 19: sdCats_atlas**

| | NAME_SDCAT | RAJ2000 | DEJ2000 | SPEC_SDCAT | phot_g_mea... | ATO_ID | fp_period | fp_fitrms | fp_fitchi | CLASS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1073 | | 331.33941 | 35.55149 | | 15.80169 | J331.3394+35.5514 | 0.08587 | 0.03249 | 1.20774 | NSINE |
| 943 | | 299.98457 | 50.61615 | | 17.09661 | J299.9845+50.6161 | 0.09119 | 0.07073 | 1.26616 | dubious |
| 997 | | 307.21987 | 6.16752 | | 14.81179 | J307.2199+06.1675 | 0.09422 | 0.02025 | 1.56105 | NSINE |
| 971 | | 303.32853 | 42.42771 | | 15.61423 | J303.3285+42.4276 | 0.09526 | 0.03289 | 2.42345 | dubious |
| 754 | | 267.15569 | 9.16338 | | 16.71258 | J267.1556+09.1633 | 0.09646 | 0.07756 | 1.39432 | SINE |
| 758 | | 267.90184 | 14.73861 | | 16.94822 | J267.9018+14.7386 | 0.09951 | 0.07587 | 1.65196 | dubious |
| 257 | | 30.59676 | 51.89702 | | 15.11298 | J030.5967+51.8970 | 0.1008 | 0.02152 | 1.25241 | NSINE |
| 1102 | | 343.38397 | 47.69991 | | 16.41222 | J343.3839+47.6999 | 0.1055 | 0.03974 | 0.8814 | NSINE |
| 1026 | | 316.00593 | 34.61008 | | 17.47401 | J316.0059+34.6100 | 0.11855 | 0.08564 | 1.9227 | dubious |
| 1105 | | 344.33419 | 49.65927 | | 17.56062 | J344.3341+49.6592 | 0.12966 | 0.08458 | 1.2062 | dubious |
| 189 | HS2035+0418 | 309.50381 | 4.48565 | sdB | 14.77305 | J309.5037+04.4856 | 0.13103 | 0.0249 | 1.46974 | dubious |
| 164 | KeplerJ184307+425918 | 280.77823 | 42.98835 | sdB+WD | 15.58791 | J280.7782+42.9883 | 0.13726 | 0.0395 | 2.02105 | dubious |
| 1024 | | 315.11791 | 59.65741 | | 16.3627 | J315.1179+59.6574 | 0.13772 | 0.05055 | 1.28395 | NSINE |
| 1129 | SDSSJ012458.96+475640.9 | 21.24568 | 47.94472 | sd | 16.92145 | J021.2457+47.9447 | 0.14013 | 0.07384 | 1.13479 | CBF |
| 792 | | 274.57916 | 6.89912 | | 17.27594 | J274.5791+06.8991 | 0.14707 | 0.10659 | 1.93357 | NSINE |
| 226 | | 0.63041 | 42.88611 | | 14.33737 | J000.6304+42.8861 | 0.15578 | 0.02251 | 1.6455 | SINE |
| 1077 | | 333.07139 | 52.02175 | | 17.46384 | J333.0713+52.0217 | 0.16019 | 0.10316 | 1.74243 | dubious |
| 212 | PG2259+134 | 345.44094 | 13.64374 | sdB | 14.51706 | J345.4409+13.6437 | 0.16346 | 0.02577 | 1.8531 | NSINE |
| 817 | | 280.39493 | 38.99883 | | 15.85566 | J280.3949+38.9988 | 0.1655 | 0.04998 | 2.95899 | SINE |
| 1184 | SDSSJ192059.78+372220.0 | 290.24908 | 37.37222 | sdB+dM | 15.77123 | J290.2490+37.3722 | 0.16896 | 0.03841 | 1.64564 | SINE |
| 215 | FBS2304+440 | 346.62686 | 44.31354 | sdB | 14.30496 | J346.6269+44.3135 | 0.17589 | 0.03356 | 2.88013 | CBF |
| 1115 | | 352.34433 | 32.23316 | | 16.92967 | J352.3443+32.2331 | 0.17644 | 0.07152 | 1.09889 | NSINE |
| 219 | Pn23I1-18 | 351.71858 | 12.50608 | sdB | 14.3078 | J351.7186+12.5060 | 0.21191 | 0.02353 | 2.7015 | IRR |
| 975 | | 304.26974 | 53.71505 | | 16.33385 | J304.2697+53.7150 | 0.21286 | 0.04614 | 1.39473 | SINE |
| 1074 | | 331.66585 | 32.72679 | | 16.962 | J331.6658+32.7267 | 0.22041 | 0.06343 | 1.14331 | NSINE |
| 229 | | 4.23059 | 51.23049 | | 16.35795 | J004.2305+51.2304 | 0.27096 | 0.04629 | 1.17926 | NSINE |
| 842 | | 284.85281 | 7.85064 | | 15.80786 | J284.8528+07.8506 | 0.29756 | 0.05785 | 2.25908 | SINE |
| 245 | | 18.47086 | 50.08699 | | 14.97042 | J018.4708+50.0870 | 0.31029 | 0.0239 | 1.37276 | NSINE |
| 211 | GALEXJ22392+1819 | 339.80672 | 18.3295 | sdB | 14.07094 | J339.8067+18.3294 | 0.36676 | 0.01961 | 1.88989 | PULSE |
| 1018 | | 312.41318 | 30.08182 | | 13.5045 | J312.4131+30.0818 | 0.42977 | 0.02234 | 2.12267 | SINE |
| 925 | | 296.70749 | 39.99371 | | 14.39431 | J296.7074+39.9936 | 0.45116 | 0.02622 | 2.38232 | SINE |

# Creating our photometric target list

- To determine the best targets, you can also inspect the light curves and perform a period search.
- At http://www.astro.physik.uni-potsdam.de/~pelisoli/lightcurves/ATLAS/dat/ you can find a Jupyter notebook containing instructions, as well as the code, to perform a Lomb-Scargle periodogram and phase-fold the data.

The data is available in this same directory.

# Exercise – ADQL queries in TOPCAT

- Draw the Gaia DR2 HR diagram
  (absolute magnitude $M_G$ = G - 5 log(d[pc]) + 5
  as a function of colour $G_{BP}$ - $G_{RP}$)
  for 100.000 stars closer than 100 pc.
    - Which variables do you need to select?
    - From which table?
    - How to limit this for 100.000 stars?
    - How to limit this to d < 100 pc?
- Inspect this diagram. Is there something odd with it? Why?

# Exercise – ADQL queries in TOPCAT

- Retrieve the variables `parallax_over_error`, `phot_bp_mean_flux_over_error`, `phot_rp_mean_flux_over_error`, `phot_bp_rp_excess_factor`, `astrometric_chi2_al`, `astrometric_n_good_obs_al`, and `astrometric_excess_noise` for the stars in the table resulting from your previous query. Hint: use JOIN USING.
- Create a subset with objects showing `parallax_over_error < 5`.

  How does the HR-diagram look like with only these objects?

- Now you know how important quality control parameters are!
- Use the following conditions to further improve your HR-diagram:

parallax_over_error > 10

astrometric_excess_noise < 1.0

phot_bp_mean_flux_over_error > 10

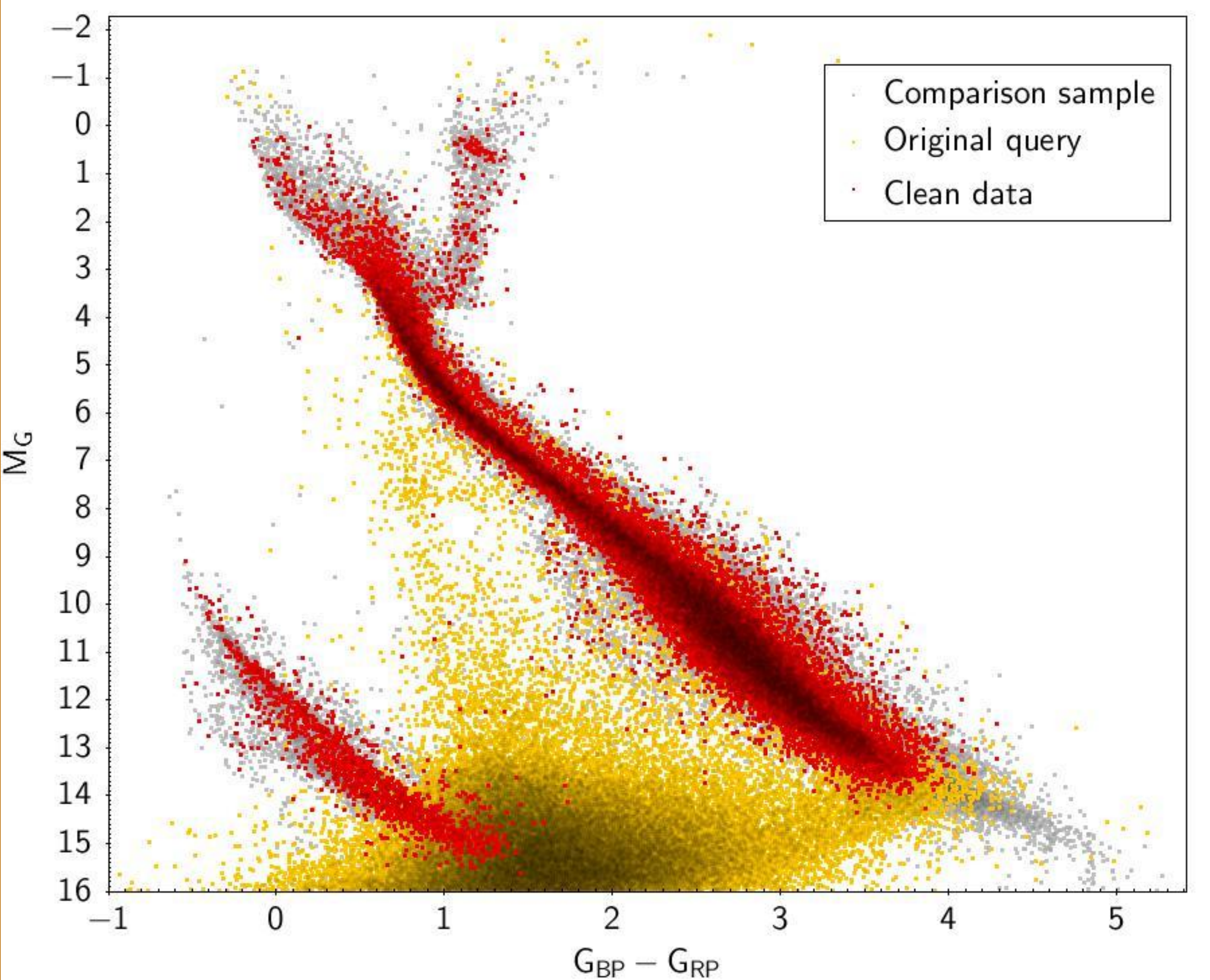
phot_rp_mean_flux_over_error > 10

phot_bp_rp_excess_factor < 1.3+0.06*power(bp_rp,2)

phot_bp_rp_excess_factor > 1.0+0.015*power(bp_rp,2)

astrometric_chi2_al/(astrometric_n_good_obs_al-5)
< 1.44*max(1, exp(-0.4*(phot_g_mean_mag-19.5)) )

Check out this paper: [https://arxiv.org/abs/1804.09366](https://arxiv.org/abs/1804.09366) if you want to understand more about where all of these parameters come from.


Comparison sample
Original query
Clean data
$M_G$
$G_{BP} - G_{RP}$
−2
−1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
−1
0
1
2
3
4
5

# Creating our spectroscopic target list

- Now that you have familiarised yourself with TOPCAT, ADQL, and some Gaia DR2 parameters, it is time to create our list of targets for spectroscopy!
- We want to observe bright candidate hot subdwarf stars identified in *Gaia*. Spectra can confirm (or rule out) their nature.

  **Step 1:** identify the position of these stars in the HR-diagram.

  **Step 2:** define a colour-cut.

  **Step 3:** do a query in *Gaia* recovering stars within your colour cut, also using quality control parameters.

  **Step 4:** validate your query. Does the result make sense?

  **Step 5:** observational constraints (brightness, RA and DEC).

# Creating our target list - STEP 1

- Plot the HR-diagram for the comparison sample

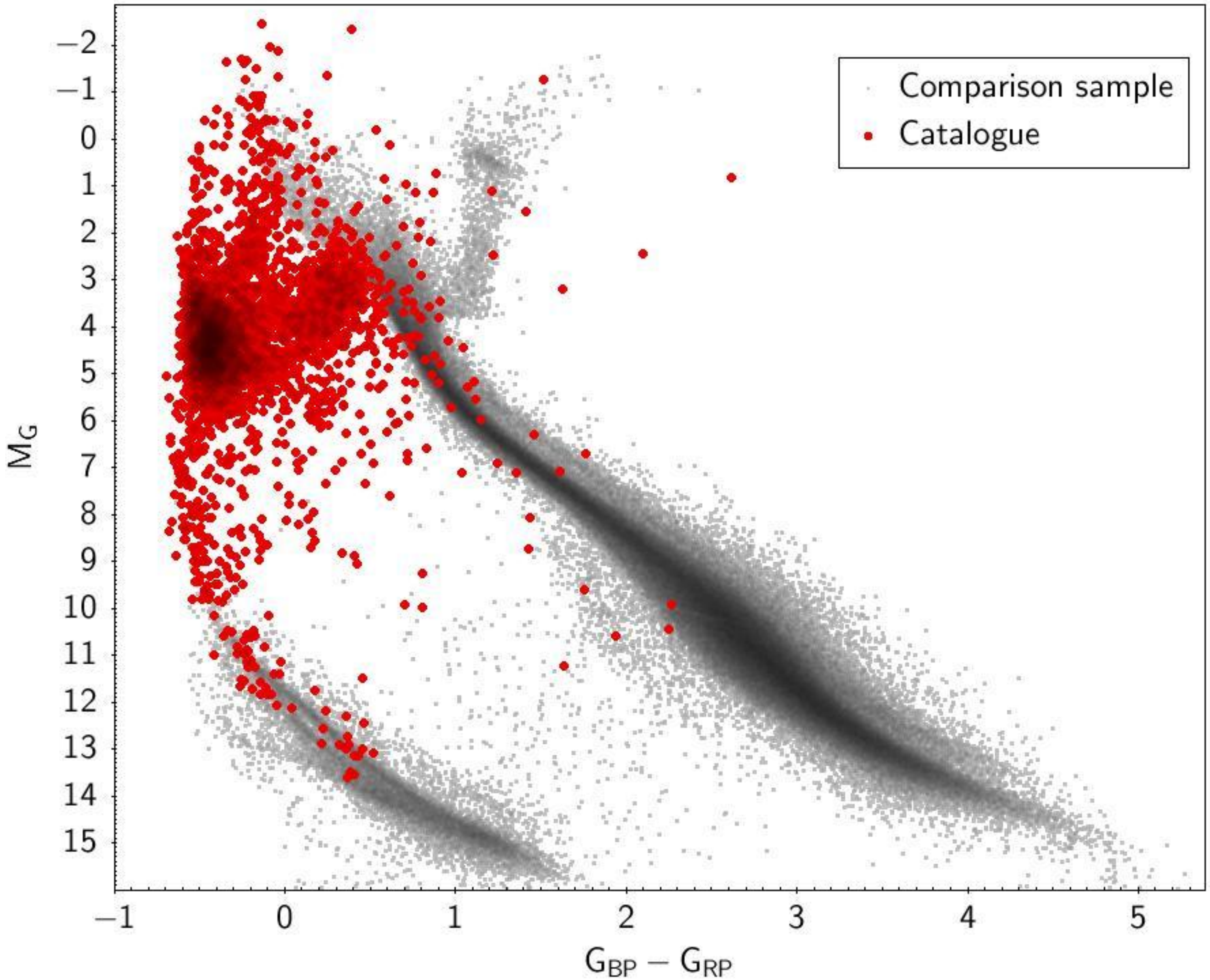
  Sample C:
  http://www.astro.physik.uni-potsdam.de/~pelisoli/AstroWorkshop/SampleC.vot

- Overplot the known hot subdwarfs from Prof. Geier's catalogue

  Catalogue:

  www.astro.physik.uni-potsdam.de/~pelisoli/AstroWorkshop/sd_catalogue_v44.csv

# Creating our target list - STEP 1

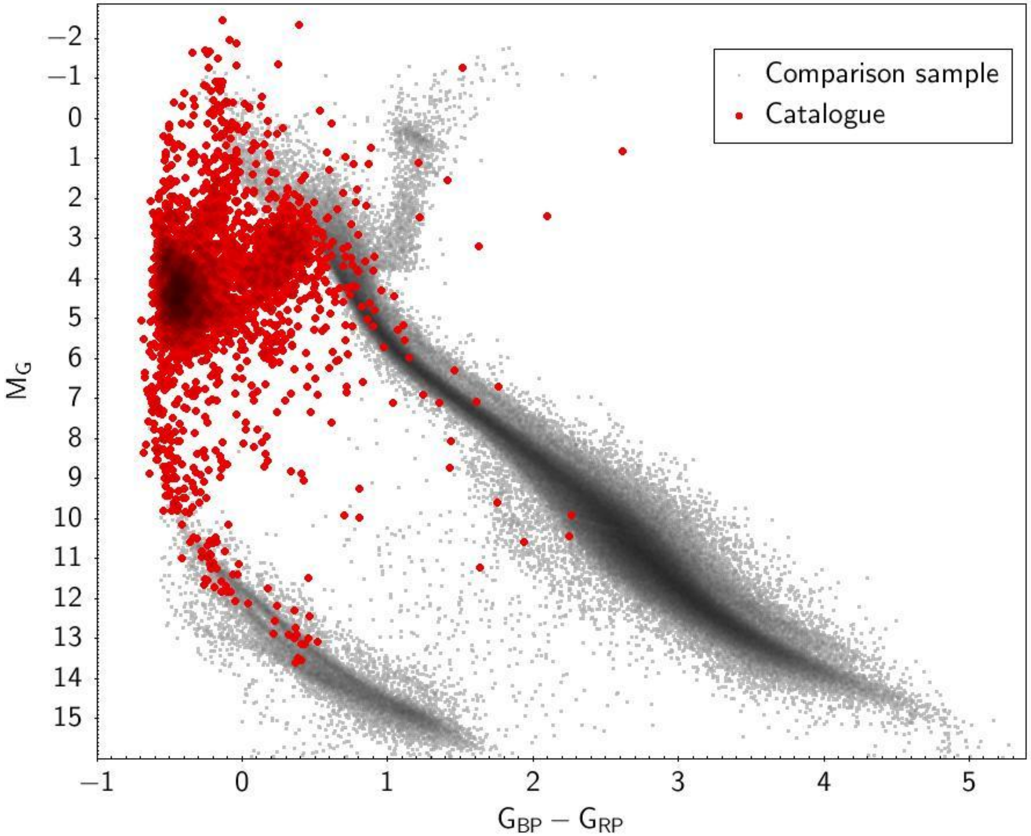


# Creating our target list - STEP 2

- Define a colour-cut. Where to these stars concentrate?

$$?? < M_G < ??$$

$$?? < G_{BP} - G_{RP} < ??$$

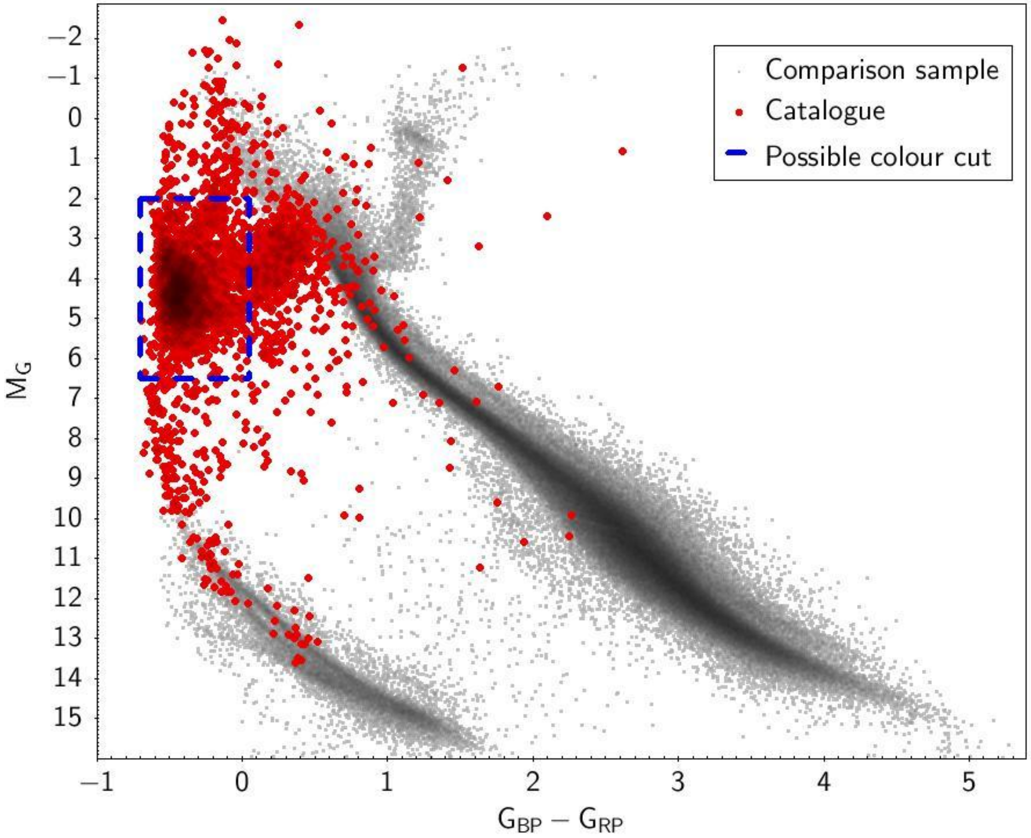


# Creating our target list - STEP 2

- Define a colour-cut. Where to these stars concentrate?

$$?? < M_G < ??$$

$$?? < G_{BP} - G_{RP} < ??$$

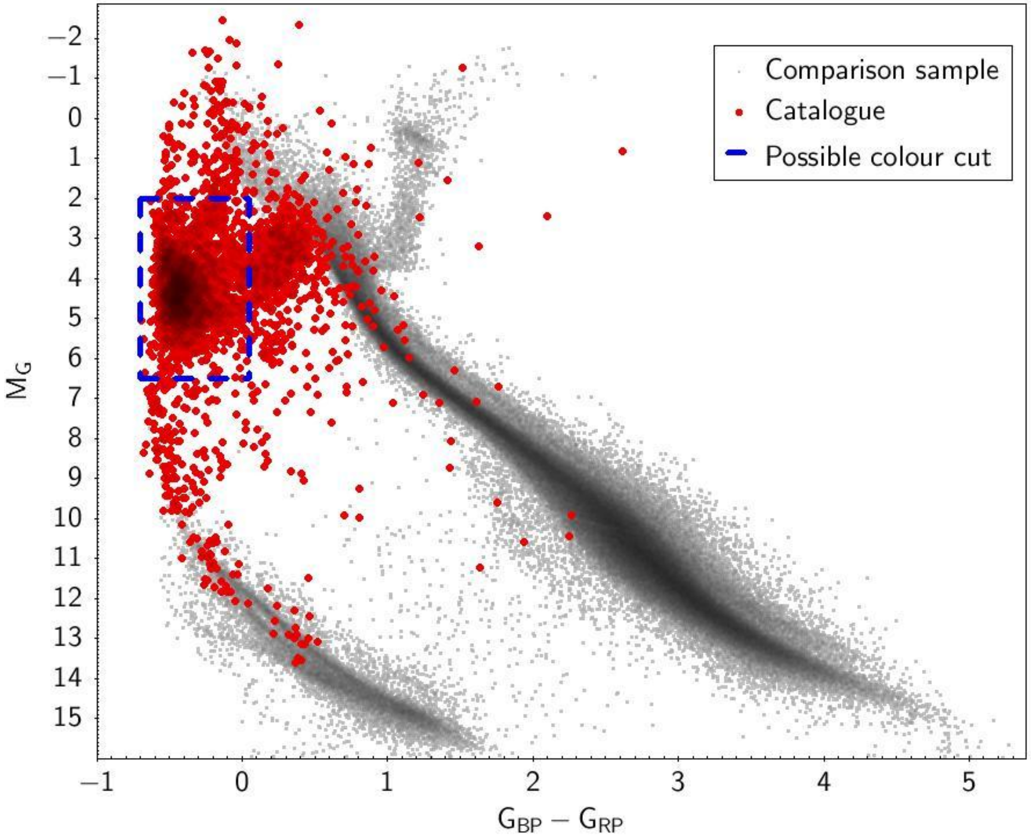


# Creating our target list - STEP 2

- Define a colour-cut. Where to these stars concentrate?

$$2 < M_G < 6.5$$

$$-0.7 < G_{BP} - G_{RP} < 0.05$$



# Creating our target list - STEP 3

- Write an ADQL query in *Gaia* recovering stars within your colour cut, also using quality control parameters:

```
parallax_over_error > 5

astrometric_excess_noise < 1.0

phot_bp_mean_flux_over_error > 10

phot_rp_mean_flux_over_error > 10

phot_bp_rp_excess_factor < 1.3+0.06*power(bp_rp,2)

phot_bp_rp_excess_factor > 1.0+0.015*power(bp_rp,2)

astrometric_chi2_al/(astrometric_n_good_obs_al-5)

    < 1.44*max(1, exp(-0.4*(phot_g_mean_mag-19.5)) )
```

# Creating our target list - STEP 3

- Write an ADQL query in *Gaia* recovering stars within your colour cut, also using quality control parameters.

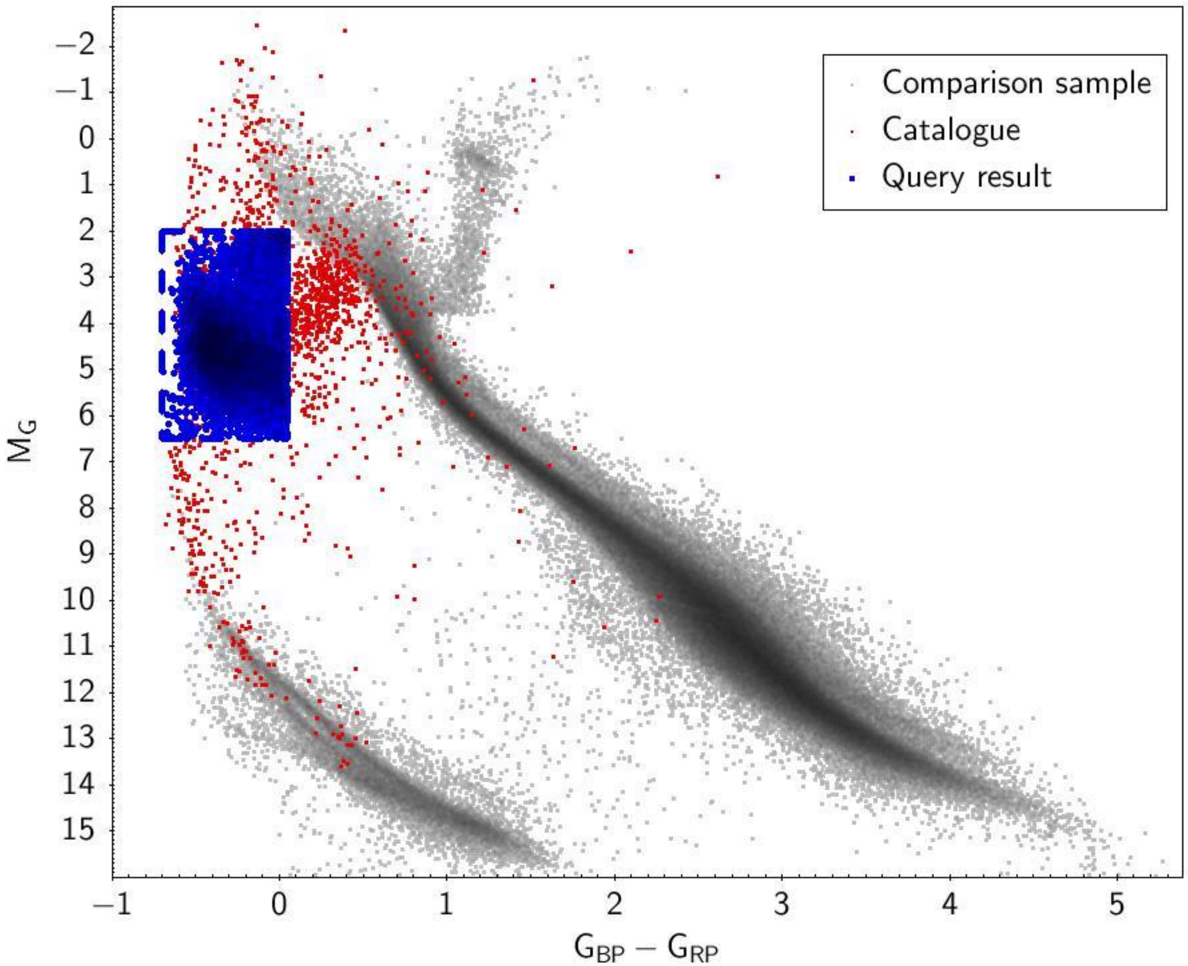
```
SELECT source_id, ra, dec, parallax, phot_g_mean_mag, bp_rp
FROM gaiadr2.gaia_source
WHERE parallax_over_error > 5
AND phot_bp_mean_flux_over_error>10
AND phot_rp_mean_flux_over_error>10
AND phot_bp_rp_excess_factor < 1.3+0.06*power(phot_bp_mean_mag-phot_rp_mean_mag,2)
AND phot_bp_rp_excess_factor > 1.0+0.015*power(phot_bp_mean_mag-phot_rp_mean_mag,2)
AND ( astrometric_chi2_al/(astrometric_n_good_obs_al-5)<1.44
    OR
astrometric_chi2_al/(astrometric_n_good_obs_al-5)<1.44*exp(-0.4*(phot_g_mean_mag-19.5)) )
AND bp_rp > -0.7 AND bp_rp < 0.05
AND 5+5*log10(parallax/1000)+phot_g_mean_mag < 6.5 and
5+5*log10(parallax/1000)+phot_g_mean_mag > 2.0
```

# Creating our target list - STEP 4

- Overplot the result of your query on the HR-diagram. Is everything where it is supposed to be?

# Creating our target list - STEP 4

- Overplot the result of your query on the HR-diagram. Is everything where it is supposed to be?



# Creating our target list - STEP 4

- Make a sky-plot of the objects in your query. Anything weird?

# Creating our target list - STEP 4

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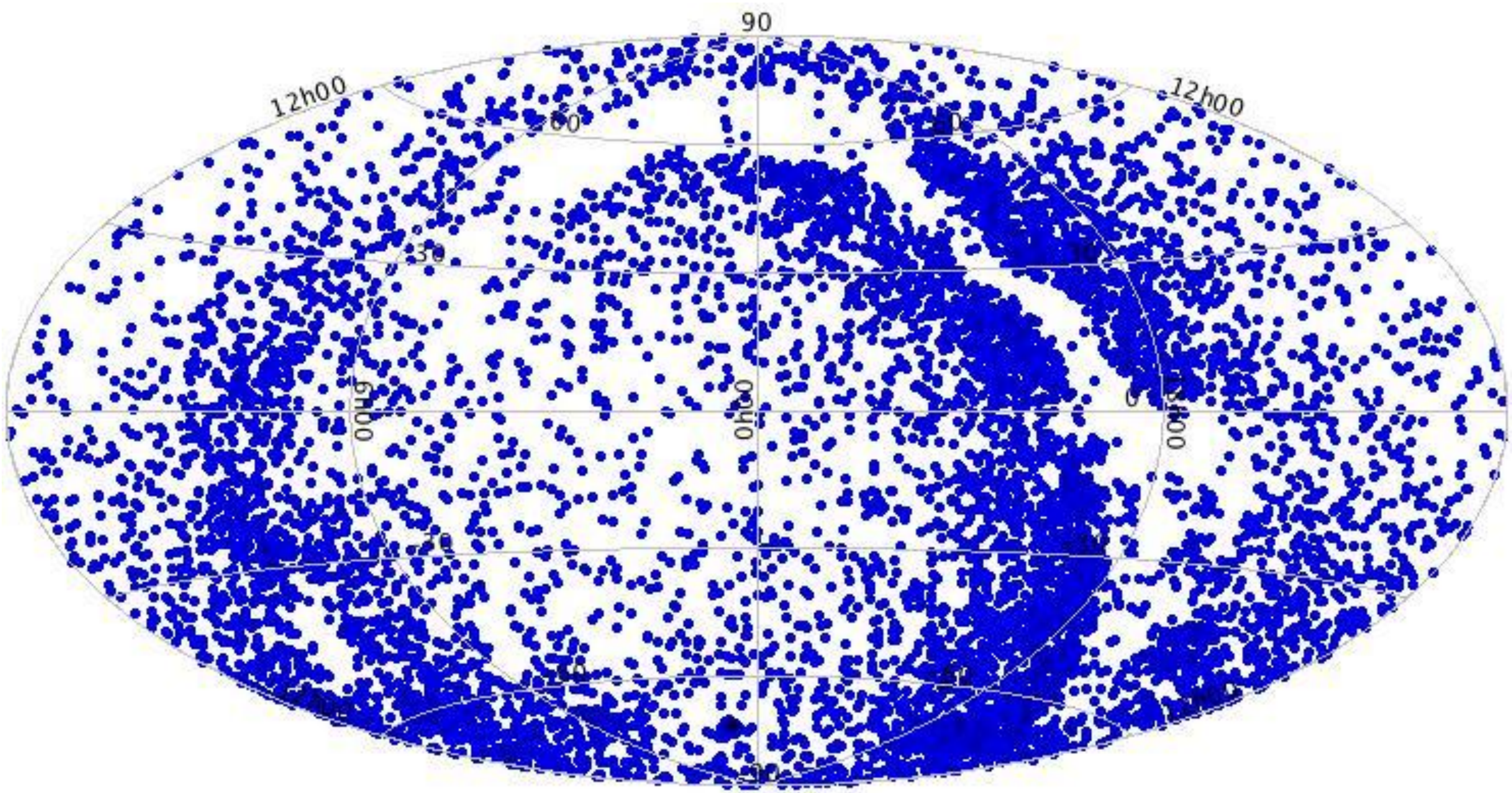


# Creating our spectroscopic target list

- Congratulations! You have done some proper science.

  However, you were too slow... "someone" has already published a catalogue of candidate hot subdwarfs in *Gaia*:

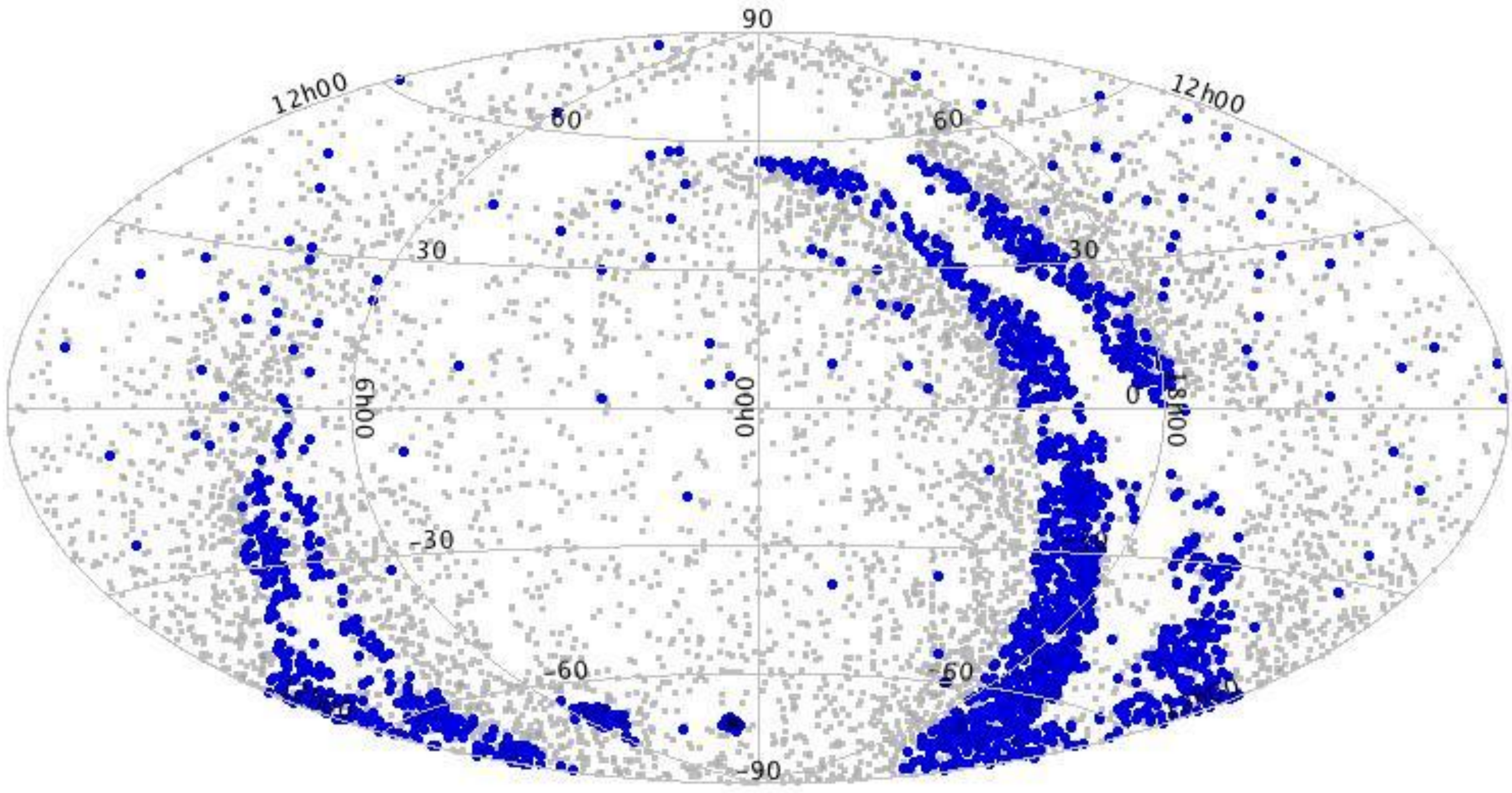
  Geier et al. 2019:

  The population of hot subdwarf stars studied with Gaia. II. The Gaia DR2 catalogue of hot subluminous stars

  http://www.astro.physik.uni-potsdam.de/~pelisoli/AstroWorkshop/sd_catalogue_gaia_v11.csv

  There are things taken into account in the published catalogue that we did not discuss here (e.g. problems in crowded areas), so, from here on, we will use the published catalogue.

# Crowded areas are problematic




In blue = in our query, but not in the final catalogue. Essentially the disc and the Magellanic clouds! These regions need stricter quality control cuts.

# Creating our spectroscopic target list

- Open the catalogue in TOPCAT.
- What is the brightness constraint for our telescope?
- What is the declination constraint given our location?
- What is the constraint in right ascension for this time of year?
    - You can use staralt again.

      Our locations is approximately: 12.97°E 52.41°N 32m UT+2

# Creating our spectroscopic target list

- Open the catalogue in TOPCAT.
- What is the brightness constraint for our telescope?
- What is the declination constraint given our location?
- What is the constraint in right ascension for this time of year?

| NAME_SDCAT | RAJ2000_HMS | DEJ2000_HMS | SPEC_SIMBAD | SPEC_SDCAT | G_GAIA | BP-RP_GAIA |
|---|---|---|---|---|---|---|
| | 00:54:35.22 | 19:11:18.32 | A1Vn | | 6.1981 | -1.8391 |
| | 00:09:20.15 | 79:42:52.44 | A7IV | | 6.6357 | -3.1425 |
| | 20:10:45.14 | 20:29:12.74 | B8V | | 7.4272 | -0.0909 |
| | 22:02:56.66 | 44:39:00.53 | | | 7.579 | -0.252 |
| | 21:49:48.89 | 34:55:00.57 | A0 | | 7.9073 | 0.1132 |
| | 01:53:19.25 | 43:23:21.98 | A2 | | 8.3128 | 0.202 |
| | 19:27:09.59 | 16:26:27.48 | A2 | | 9.013 | 0.1901 |
| | 19:03:01.82 | 42:32:46.14 | A2 | | 9.1905 | 0.2682 |
| | 23:01:16.37 | 44:29:48.04 | A3 | | 9.228 | 0.2118 |
| | 19:24:19.22 | 31:55:35.58 | A0 | | 9.2762 | 0.0005 |
| | 21:09:47.38 | 20:12:29.18 | B5 | | 9.4754 | -0.1932 |
| | 19:36:22.02 | 19:38:21.50 | A0 | | 9.5522 | 0.1759 |
| | 20:04:08.90 | 16:59:57.27 | G5 | | 9.6318 | 0.379 |
| FB179 | 21:59:41.98 | 26:25:57.40 | sdO6 | sdO | 9.6508 | -0.4614 |
| | 20:46:17.78 | 28:52:47.31 | A0 | | 9.7432 | 0.2434 |
| | 20:35:52.47 | 31:01:34.93 | A0 | | 9.7728 | 0.1405 |
| | 19:56:33.68 | 29:13:26.66 | A0 | | 9.8662 | 0.2232 |
| | 20:10:56.20 | 22:37:18.64 | A0 | | 9.8978 | 0.1707 |
| | 21:04:55.58 | 46:32:31.16 | B9V | | 9.9396 | 0.1792 |
| BD+37442 | 01:58:33.43 | 38:34:23.85 | sdOHe | sdO | 9.9485 | -0.3984 |