

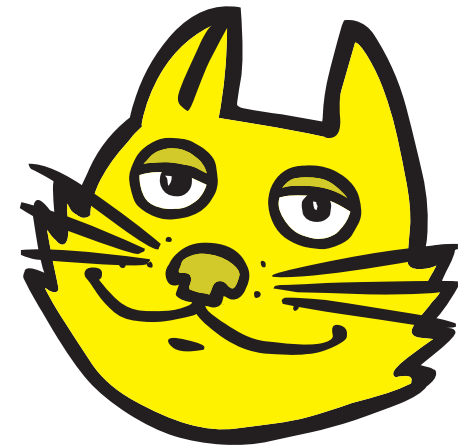
TOPCAT and Gaia DR3

Mark Taylor (University of Bristol)

Gaia DR3 Session
National Astronomy Meeting
Warwick

12 July 2022

\$Id: tcgaia.tex,v 1.27 2022/07/08 14:21:58 mbt Exp \$



Outline

TOPCAT

- Very short intro

Accessing Gaia Data from TOPCAT

- Database Queries (TAP/ADQL)
- Sky Region (Cone Search)
- Catalogue matching (CDS X-Match, TAP Upload, Pair match, pre-calculated)
- Ancillary Data (DataLink, Activation Actions)

DR3 Examples (*TOPCAT \geq v4.8-6 recommended if you try this at home*)

- Cluster identification using Proper Motions
- Galactic Extinction Map
- QSO Candidates
- XP Sampled spectra

TOPCAT

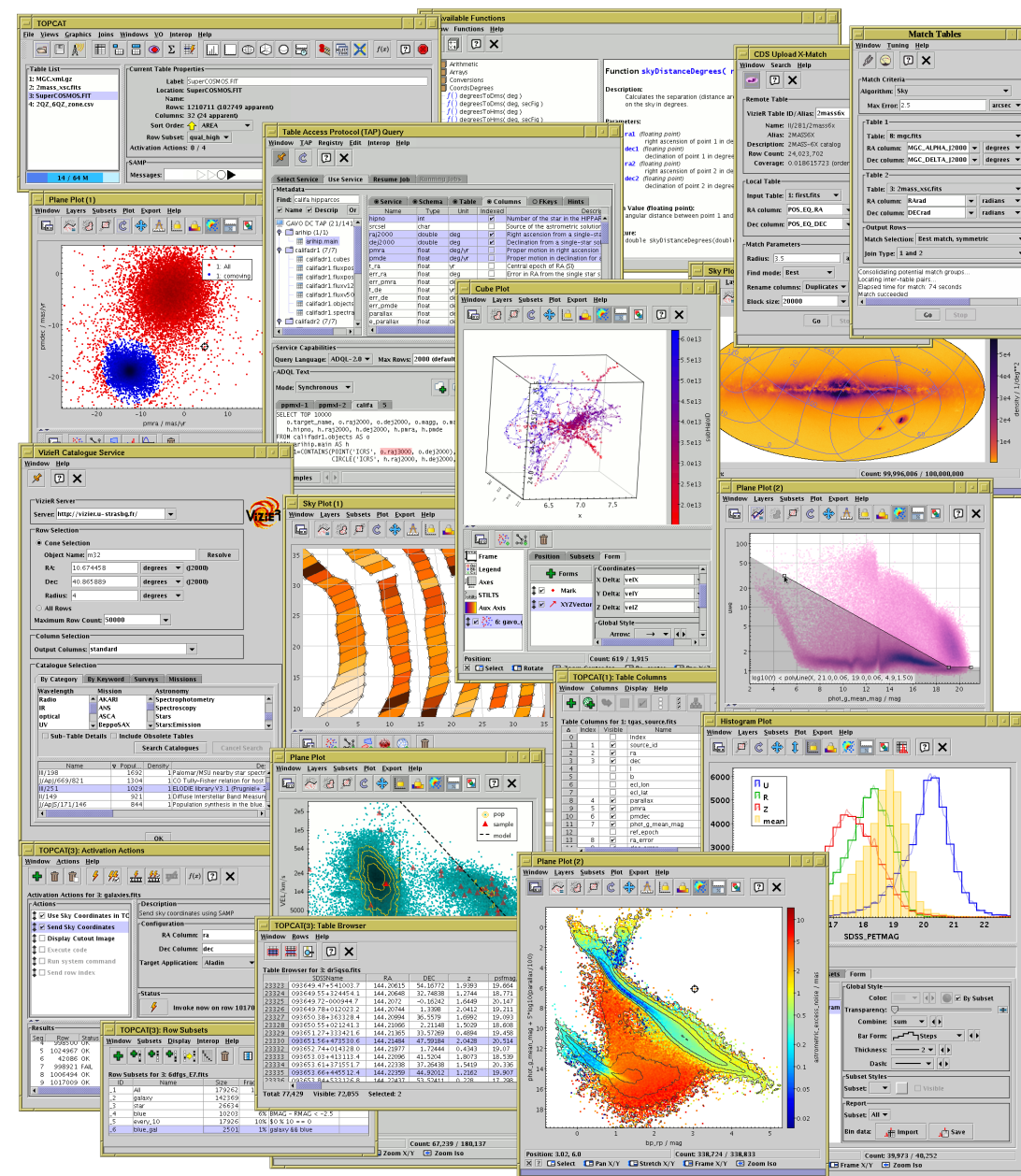
TOPCAT = Tool for OPERations on Catalogues And Tables

Capabilities:

- Does things with tables:
 - ▷ I/O, viz, selections, calculations, matching, ...
- Few Gaia-specific features ...
- ... but talks to the *Virtual Observatory*

See also STILTS

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



Data Access

There are lots of ways to get Gaia data!

Accessing DR3 data products from TOPCAT:

- Main `gaia_source` table:
 - ▷ Database query: TAP window
 - ▷ Positional query: Cone search window
 - ▷ Join with local data: X-Match window
- Other tables in database:
 - ▷ Database query: TAP window
 - ▷ Full table download (small-ish tables): Vizier window
- Ancillary tables:
 - ▷ DataLink access: Activation window
 - ▷ Database query (some services): TAP window

... or download externally, then load into TOPCAT

- ESA TAP web interface
- Bulk ECSV downloads

Full Database Access: TAP/ADQL



TOPCAT TAP window

- Browse column/table metadata
- Results loaded directly into topcat
- ADQL syntax highlighting
- ADQL editing features (multi-tab, undo/redo)
- Integrated table upload (`TAP_UPLOAD.t<n>` syntax)

DR3 has lots of tables!

Available TAP services:

- ESA Gaia catalogue
- ARI-Gaia
- GAVO DC
- VizieR
- ... and many more with (and without) Gaia data

The screenshot shows the 'Table Access Protocol (TAP) Query' window. The 'Metadata' section is active, displaying a list of tables on the left and a detailed view of the 'gaiadr3.gaia_source' table on the right. The table view includes columns for Name, Type, Unit, and Description. Below the metadata, the 'Service Capabilities' section shows 'Query Language: ADQL-2.0', 'Max Rows: 3000000 (default)', and 'Uploads: 100Mb'. The 'ADQL Text' section contains a query:

```
SELECT TOP 100000
  designation, source_id, ra, dec, parallax, bp_rp, phot_g_mean_mag,
  phot_g_mean_mag+5*log10(parallax/100) AS mag_g
FROM gaiadr3.gaia_source
WHERE parallax > 10
  AND parallax_over_error > 10
  AND astrometric_excess_noise < 1
```

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The screenshot shows the 'Table Access Protocol (TAP) Query' window. It has a menu bar with 'Window', 'TAP', 'Registry', 'Edit', 'Interop', and 'Help'. Below the menu are icons for home, refresh, help, and close. There are tabs for 'Select Service', 'Use Service', 'Resume Job', and 'Running Jobs'. The main area is divided into 'Metadata' and 'Service Capabilities'.

Metadata: A search box labeled 'Find:' is at the top. Below it are checkboxes for 'Name' and 'Descrip'. A tree view on the left shows a list of tables under the 'gaiadr3' schema, with 'gaiadr3.gaia_source' selected. On the right, a table shows the metadata for the selected table, with columns for Name, Type, Δ Unit, and Desc.

Name	Type	Δ Unit	Desc
rv_template_fe_h	float	'dex'	[Fe/H] of the template used
mh_gspphot	float	'dex'	Iron abundance from GSP-PH
mh_gspphot_lower	float	'dex'	Lower confidence level (16%)
mh_gspphot_upper	float	'dex'	Upper confidence level (84%)
phot_g_mean_flux	double	'electron'.s**-1	G-band mean flux
phot_g_mean_flux_error	float	'electron'.s**-1	Error on G-band mean flux
phot_bp_mean_flux	double	'electron'.s**-1	Integrated BP mean flux
phot_bp_mean_flux_error	float	'electron'.s**-1	Error on the integrated BP m
phot_rp_mean_flux	double	'electron'.s**-1	Integrated RP mean flux
phot_rp_mean_flux_error	float	'electron'.s**-1	Error on the integrated RP m
rv_template_teff	float	K	Teff of the template used to
teff_gspphot	float	K	Effective temperature from G
teff_gspphot_lower	float	K	Lower confidence level (16%
teff_gspphot_upper	float	K	Upper confidence level (84%
rv_time_duration	float	d	Time coverage of the radial v
ra	double	deg	Right ascension

Service Capabilities: Query Language: ADQL-2.0, Max Rows: 3000000 (default), Uploads: 100Mb.

ADQL Text: Mode: Synchronous. A toolbar with icons for save, copy, paste, undo, redo, and other editing functions is present. The query text area contains the following ADQL query:

```

SELECT TOP 100000
  designation, source_id, ra, dec, parallax, bp_rp, phot_g_mean_mag,
  phot_g_mean_mag+5*log10(parallax/100) AS mag_g
FROM gaiadr3.gaia_source
WHERE parallax > 10
  AND parallax_over_error > 10
  AND astrometric_excess_noise < 1
    
```

At the bottom, there are 'Examples' and 'Info' buttons, and a large 'Run Query' button.

Full Database Access: TAP/ADQL



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- ADQL editing features (multi-tab, undo/redo)
- Integrated table upload (`TAP_UPLOAD.t<n>` syntax)

DR3 has lots of tables!

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- VizieR
- ... and many more with (and without) Gaia data

The screenshot shows the 'Table Access Protocol (TAP) Query' window. It has a menu bar with 'Window', 'TAP', 'Registry', 'Edit', 'Interop', and 'Help'. Below the menu is a toolbar with icons for home, refresh, help, and close. The main area is divided into several sections:

- Select Service**: A list of metadata tables from the 'gaiadr3' schema, including 'commanded_scan_law', 'dr2_neighbourhood', 'frame_rotator_source', 'gaia_crf3_xm', 'gaia_source' (highlighted), 'gaia_source_lite', 'gaia_simulation', 'gaia_universe_model', 'galaxy_candidates', 'galaxy_catalogue_name', 'gold_sample_carbon_stars', 'gold_sample_fgkm_stars', 'gold_sample_obo_stars', 'gold_sample_solar_analogues', and 'gold_sample_spss'.
- Metadata**: A table showing details for the selected 'gaia_source' table. The columns are Name, Type, Unit, and Desc. The rows include: solution_id (long, Solution Identifier), designation (char(*), Unique source designation), source_id (long, Unique source identifier), random_index (long, Random index for use when), ref_epoch (double, yr, Reference epoch), ra (double, deg, Right ascension), ra_error (float, mas, Standard error of right ascen), dec (double, deg, Declination), dec_error (float, mas, Standard error of declination), parallax (double, mas, Parallax), parallax_error (float, mas, Standard error of parallax), parallax_over_error (float, Parallax divided by its standa), pm (float, mas.yr**1, Total proper motion), pmra (double, mas.yr**1, Proper motion in right ascen), pmra_error (float, mas.yr**1, Standard error of proper mo), and pmdec (double, mas.yr**1, Proper motion in declination).
- Service Capabilities**: Query Language: ADQL-2.0, Max Rows: 3000000 (default), Uploads: 100Mb.
- ADQL Text**: Mode: Synchronous. A text area containing the following query:

```
SELECT TOP 100000
  designation, source_id, ra, deg, parallax, bp_rp, phot_g_mean_mag,
  phot_g_mean_mag+5*log10(parallax/100) AS mag_g
FROM gaiadr3.gaia_source
WHERE parallax > 10
  AND parallax_over_error > 10
  AND astrometric_excess_noise < 1
```
- Run Query**: A button at the bottom right.

Full Database Access: TAP/ADQL



TOPCAT TAP window

- Browse column/table metadata
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- VizieR
- ... and many more with (and without) Gaia data

Table Access Protocol (TAP) Query

Window TAP Registry Edit Interop Help

Select Service Use Service Resume Job Running Jobs

Metadata

Find: gold

Name Descrip Or

GAIA (6/227)

gaiadr3 (6/88)

- gaiadr3.gold_sample_carbon_stars
- gaiadr3.gold_sample_fgkm_stars
- gaiadr3.gold_sample_oba_stars
- gaiadr3.gold_sample_solar_analogues
- gaiadr3.gold_sample_spss
- gaiadr3.gold_sample_ucd

Service	Schema	Table	Columns	FKeys	Hints
Name	Type	Unit	Description		
source_id	long		Unique source identifier (unique		
teff_gspphot	float	K	Effective temperature from GSP-P		
logg_gspphot	float	log(cm.s**-2)	Surface gravity from GSP-Phot Ae		
mh_gspphot	float	'dex'	Global metallicity from GSP-Phot A		
ag_gspphot	float	mag	Extinction in G band from GSP-Ph		
ebpminrp_gspphot	float	mag	Reddening E(BP-RP) from GSP-Ph		
alphafe_gspspec	float	'dex'	Median abundance of alpha-elem		
teff_gspspec	float	K	Median value of the effective tem		
logg_gspspec	float	log(cm.s**-2)	Median value of logarithm of the		
mh_gspspec	float	'dex'	Median global metallicity [M/H] fr		
radius_flame	float	solRad	Radius of the star derived from F		
lum_flame	float	solLum	Luminosity of the star from FLAME		
mass_flame	float	solMass	Mass of the star from FLAME usin		
age_flame	float	Gyr	Age of the star from FLAME using		
evolstage_flame	int		Evolutionary stage of the star de		
radius_flame_spec	float	solRad	Radius of the star from FLAME us		

Service Capabilities

Query Language: ADQL-2.0 Max Rows: 3000000 (default) Uploads: 100Mb

ADQL Text

Mode: Synchronous

```
1
SELECT TOP 100000
  designation, source_id, ra, dec, parallax, bp_rp, phot_g_mean_mag,
  phot_g_mean_mag+5*log10(parallax/100) AS mag_g
FROM gaiadr3.gaia_source
WHERE parallax > 10
  AND parallax_over_error > 10
  AND astrometric_excess_noise < 1
```

Examples Info

Run Query

Sky Region Access: Cone Search



TOPCAT Cone Search window

- Loads all Gaia sources in a given part of the sky
- Operation:
 - ▷ **VO|Cone Search** menu item
 - ▷ **Keywords:** “gaia” → **Find Services**
 - ▷ Select service **ARI-Gaia**
 - ▷ Fill in:
 - **Object Name** or **RA/Dec**
 - **Radius**
 - ▷ **Verbosity** selector controls which columns are included

The screenshot shows the TOPCAT Cone Search window with the following configuration:

- Registry:** `http://reg.g-vo.org/tap`
- Keywords:** `gaia dr3`
- Match Fields:** Short Name, Title, Subjects, ID, Publisher, Descr
- Accept Resource Lists**
- Find Services** button

Short Name	Title	
ARI-Gaia	ARI's Cone Search Service for the last Gaia Data Release (DR3)	Gaia B
ARI-Gaia	ARI's Cone Search Service for Gaia EDR3	Gaia B
GAIA DR3	Gaia DR3 at ESA	Gaia,
GAIA EDR3	Gaia EDR3 at ESA	Gaia,
I/355	Gaia DR3 Part 1. Main source	
I/356	Gaia DR3 Part 2. Extra-galactic	
I/357	Gaia DR3 Part 3. Non-single stars	

AccessURL	Description	Version
https://gaia.ari.uni-heidelbe...		

Resource Count: 13

Cone Parameters

- Cone URL:** `https://gaia.ari.uni-heidelberg.de/cone/search?`
- Object Name:** `ngc346`
- RA:** `14.771207` degrees (J2000) **Accept Sky Positions**
- Dec:** `-72.1759` degrees (J2000)
- Radius:** `0.75` degrees
- Verbosity:** `2 (normal)`

Resolve button

OK button

Data Access: Match Catalog X against Gaia

TOPCAT CDS Upload X-Match window

- Load X , then use **CDS X-Match** window
- Very fast, millions of rows while you wait
- Most, but not all columns from DR3 returned (some renamed)
- Understand match epoch (see [CDS X-Match service documentation](#))

TAP Upload match in TOPCAT TAP window

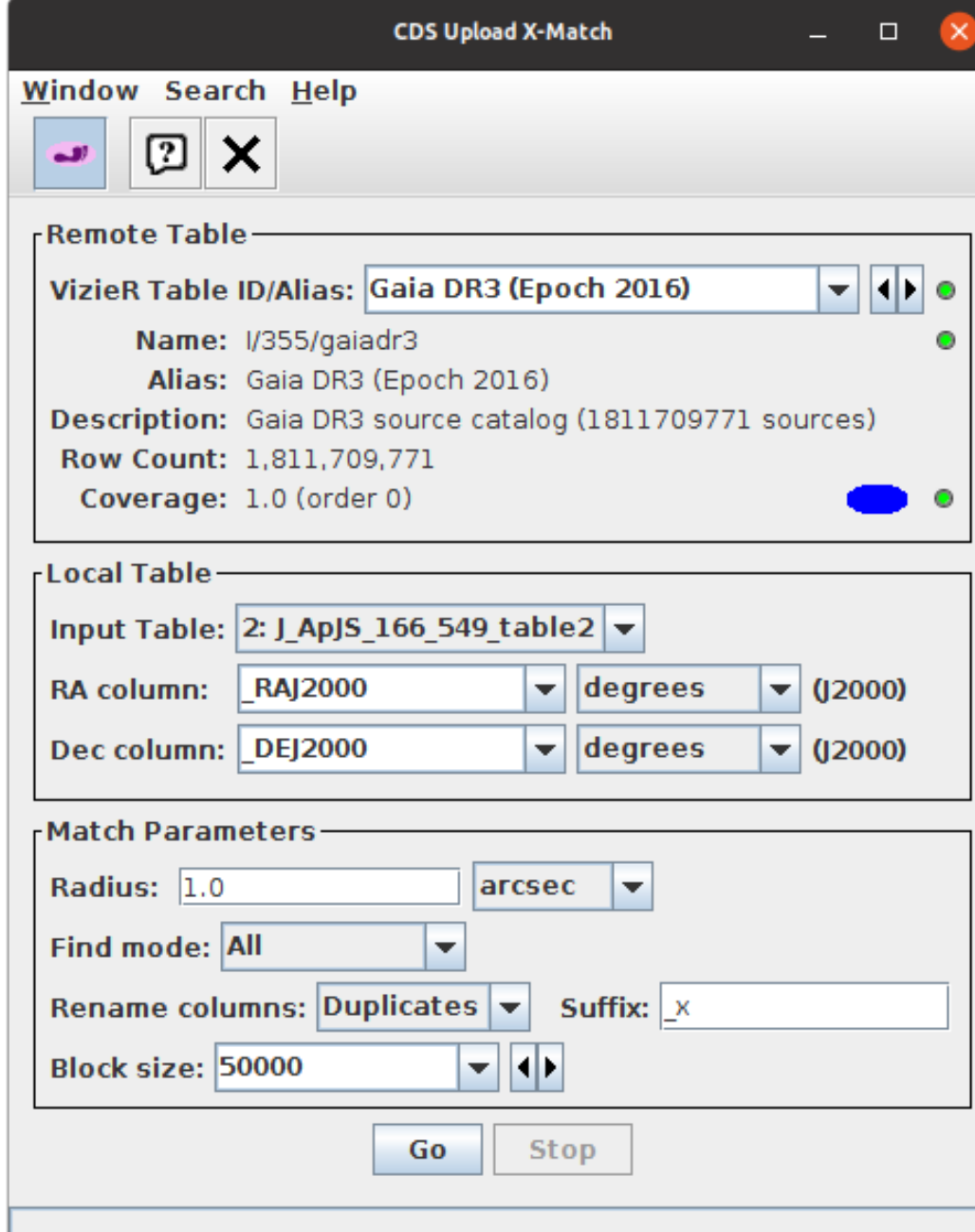
- Load X , then use `TAP_UPLOAD.t<n>` in ADQL
- Very flexible
- Upload table size limits apply

TOPCAT Pair Match window

- Load Gaia and X in same region, then match
- Suitable for matches in the same (sky?) region, \lesssim few million sources

Use pre-calculated archive match tables via TAP

- High-quality matches already done for large tables
- AllWISE, RAVE, SDSS DR13, APASS DR9, Pan-STARRS1, GSC 2.3, 2MASS, ...



CDS Upload X-Match

Window Search Help

Remote Table

VizieR Table ID/Alias: Gaia DR3 (Epoch 2016)

Name: I/355/gaiadr3

Alias: Gaia DR3 (Epoch 2016)

Description: Gaia DR3 source catalog (1811709771 sources)

Row Count: 1,811,709,771

Coverage: 1.0 (order 0)

Local Table

Input Table: 2: J_ApJS_166_549_table2

RA column: _RAJ2000 degrees (J2000)

Dec column: _DEJ2000 degrees (J2000)

Match Parameters

Radius: 1.0 arcsec

Find mode: All

Rename columns: Duplicates Suffix: _x

Block size: 50000

Go Stop

Data Access: Ancillary Tables

Background

- Ancillary data products are not all in the database
- Can't (mostly) access via TAP/ADQL, needs [DataLink](#)
 - ▷ sampled/continuous XP spectra, RVS spectra, epoch photometry, epoch RVs, GSPPhot/MSC MCMC samples
- Each row in the catalogue points to a [DataLink table](#) listing additional resources (via `designation/source_id` column)



TOPCAT Activation Window







- Configures {something} to happen when row/point clicked
 - ▷ Lots of options: load/plot table, view image/spectrum, message other tool, run command, ...
 - ▷ Includes **Invoke Service & View Datalink Table** (as long as designation column is SELECTed)
 - ▷ Various options from DataLink: load, plot, download, send tables
- Operates on ancillary data from one source at a time

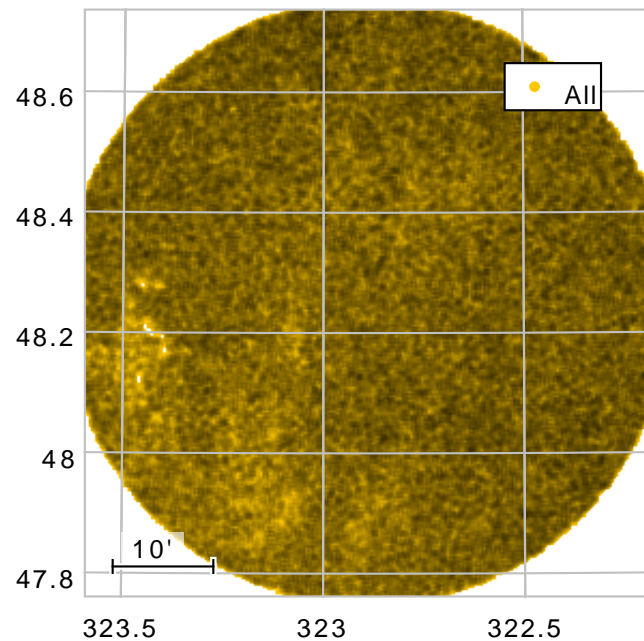
Seq	Row	Status	Message
5	80084	OK	https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4122597029
6	80089	OK	https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4122667123
7	123123	OK	https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+6133931765
8	85086	OK	https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4373306541

semantics	description	content_type	content_length	ID
1 #this	MCMC MSC, source Gaia DR3 4...	application/x-votable+xml		Gaia DR3 43733065
2 #this	XP mean sampled spectra, so...	application/x-votable+xml		Gaia DR3 43733065
3 #this	XP mean continuous spectra, ...	application/x-votable+xml		Gaia DR3 43733065
4 #this	MCMC GSP-Phot, source Gaia ...	application/x-votable+xml		Gaia DR3 43733065

Example: Cluster identification using Proper Motions







Identify members of open cluster NGC 7092 by proper motion clustering

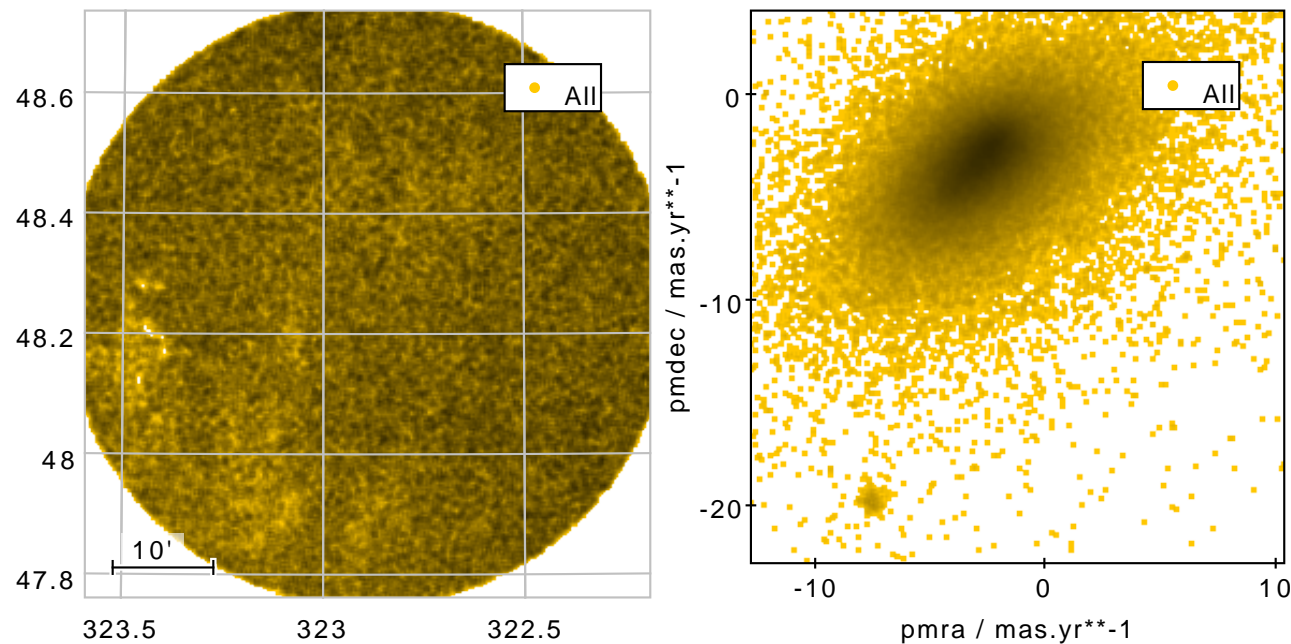
-  Cone Search NGC7092, $r=0.5^\circ$; returns $\sim 112\,000$ rows
-  Proper Motion space plot $pmra$ vs. $pmdec$
-  Make graphical selection of comoving objects
-  Sky Plot, see cluster positions (**Subsets** tab)
-  Colour-Magnitude diagram bp_rp vs. $phot_g_mean_mag$, view selection
-  Plot cluster $parallax$ histogram & Gaussian fit to determine mean distance ($\varpi \approx 3.3 \text{ mas} \Rightarrow r \approx 303 \text{ pc}$)



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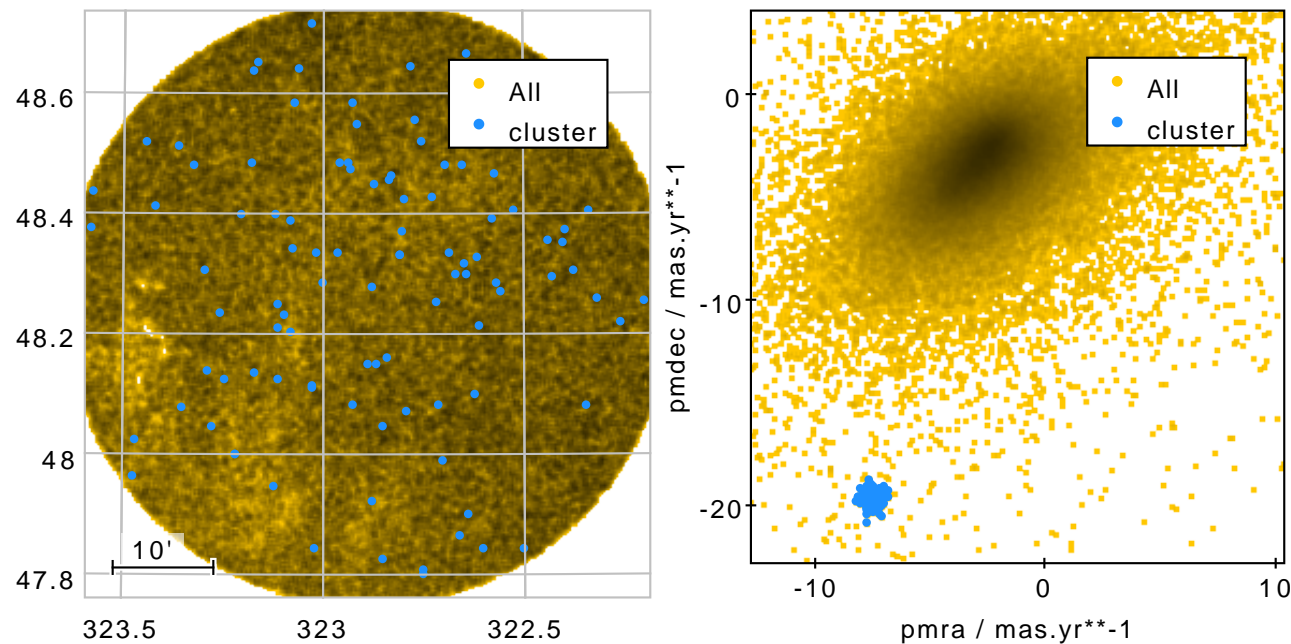
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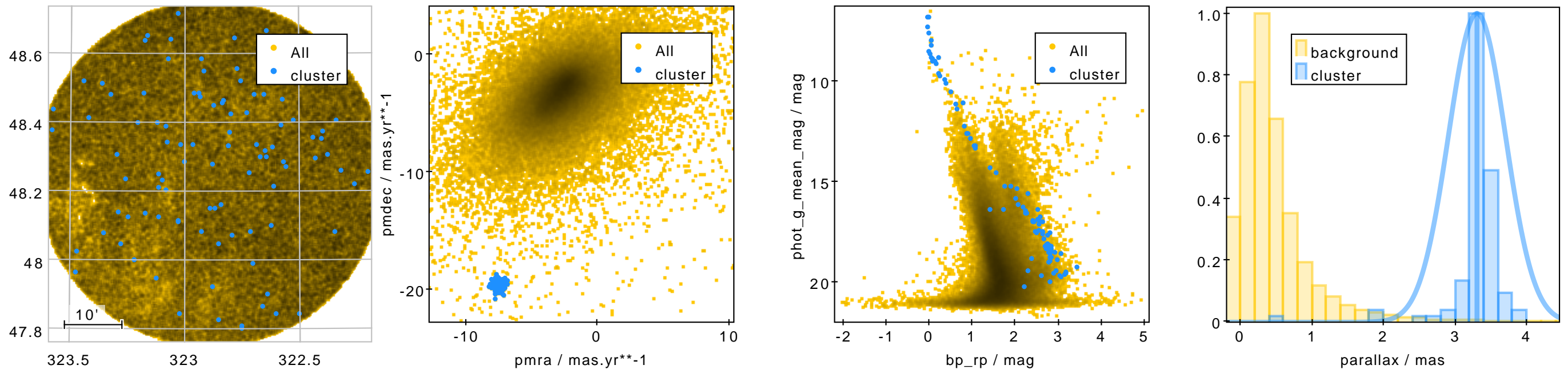
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Example: Galactic Extinction Map

Apsis calculates extinction maps (Delchambre et al. (2022), “Gaia DR3 Apsis III”)

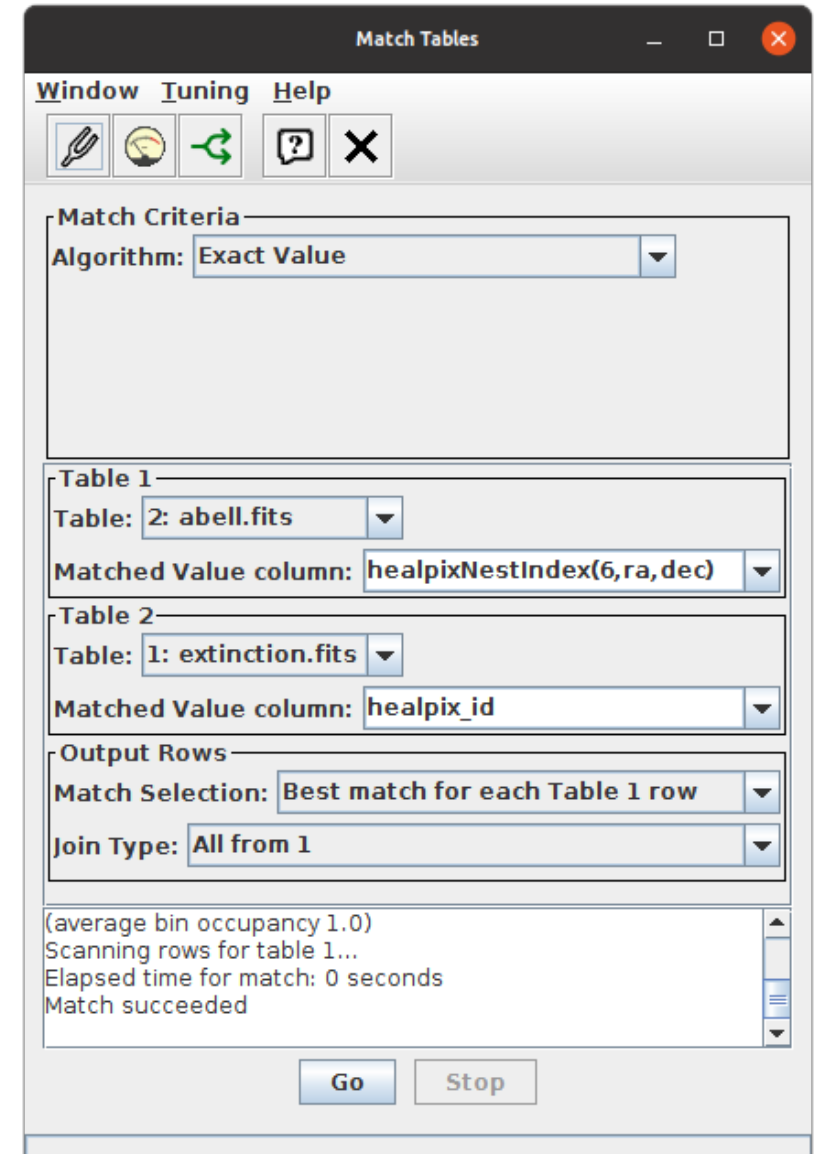
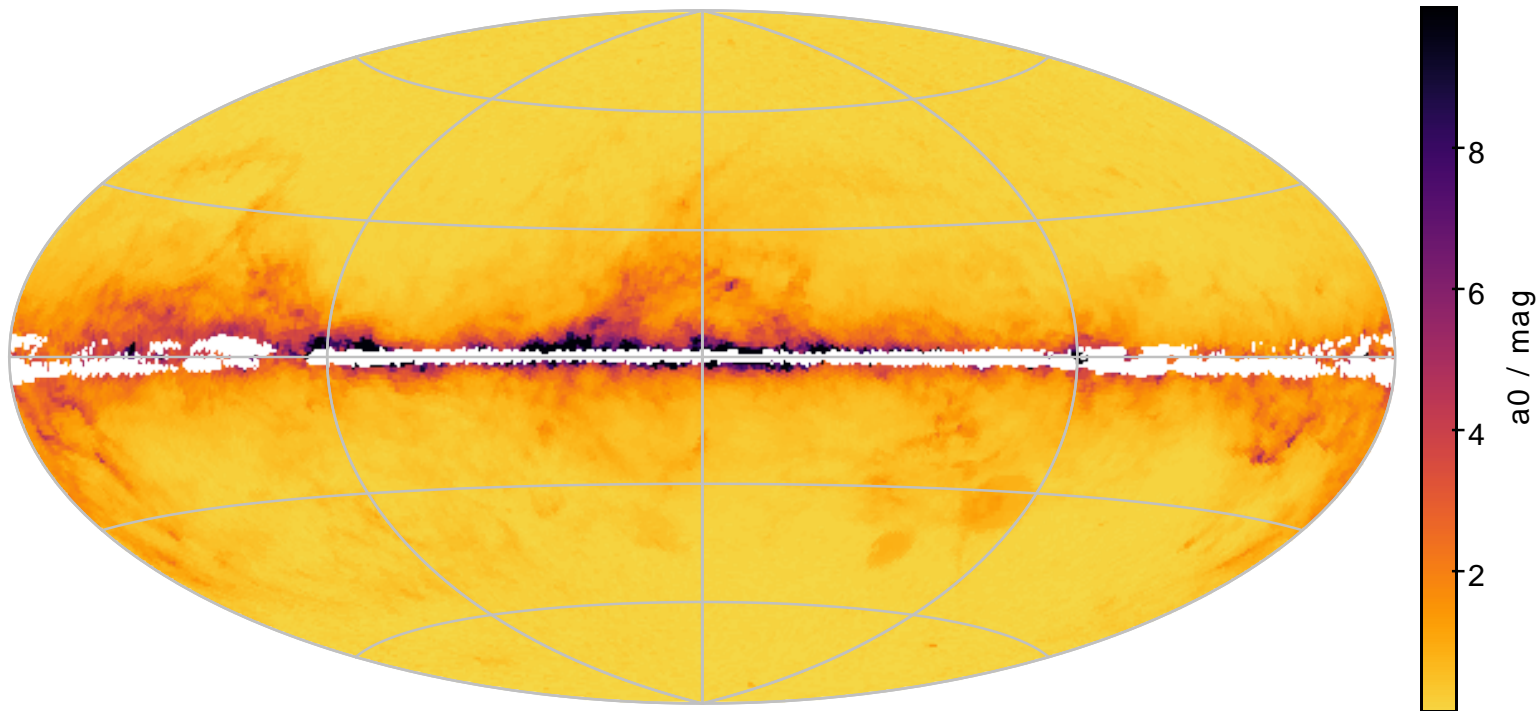
 Retrieve all HEALPix level 6 pixels from `total_galactic_extinction_map` ($49\,152 = 12 \times 4^6$ rows)

```
SELECT healpix_id, a0
FROM gaiadr3.total_galactic_extinction_map
WHERE healpix_level = 6
```

 Plot using HEALPix Layer Control

 Match HEALPix pixels against user table to find source extinction

- **Exact Value** match, `healpixNestIndex(6,RA,DEC)` vs. `healpix_id`



Match Tables interface showing configuration for matching tables. The window title is "Match Tables". The interface includes a menu bar (Window, Tuning, Help) and a toolbar with icons for edit, refresh, help, and close. The "Match Criteria" section shows the "Algorithm" set to "Exact Value". The "Table 1" section shows "Table: 2: abell.fits" and "Matched Value column: healpixNestIndex(6,ra,dec)". The "Table 2" section shows "Table: 1: extinction.fits" and "Matched Value column: healpix_id". The "Output Rows" section shows "Match Selection: Best match for each Table 1 row" and "Join Type: All from 1". The status bar at the bottom shows: "(average bin occupancy 1.0) Scanning rows for table 1... Elapsed time for match: 0 seconds Match succeeded". There are "Go" and "Stop" buttons at the bottom.

Example: QSO Candidates

See [Bailer-Jones et al. \(2022\)](#), “Gaia DR3: The Extragalactic Content”



Query `qso_candidates` table; need to join with `gaia_source` to get RA & Dec

```
SELECT g.ra, g.dec, q.redshift_qsoc,  
       q.gaia_crf_source, q.host_galaxy_flag, q.classlabel_dsc_joint, q.vari_best_class_name  
FROM gaiadr3.gaia_source AS g  
JOIN gaiadr3.qso_candidates AS q USING (source_id)
```

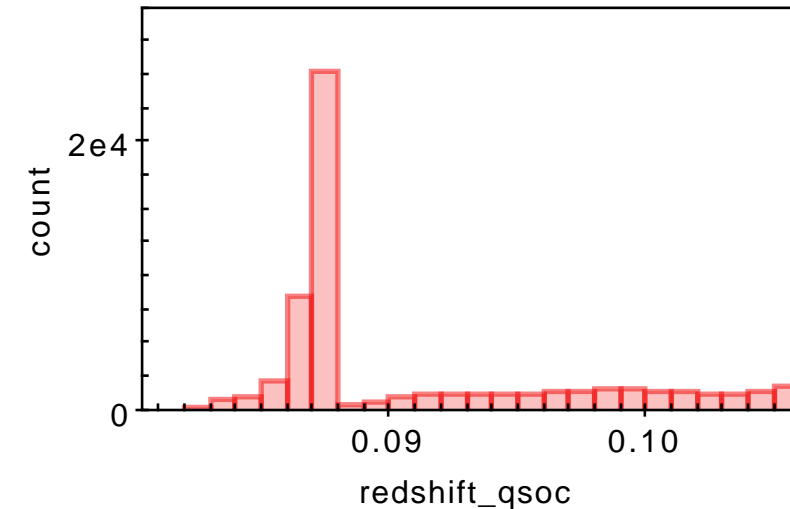
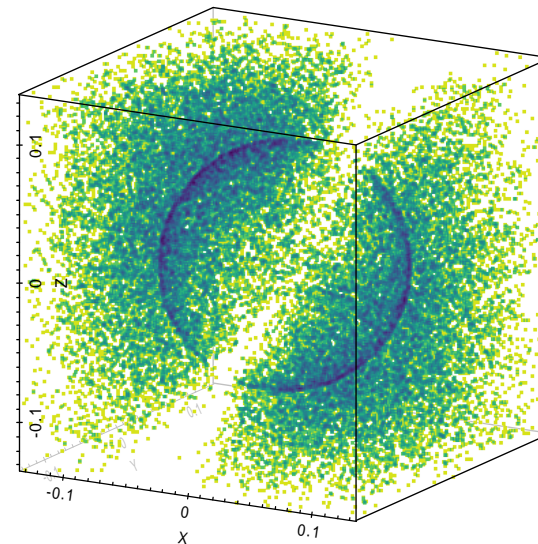
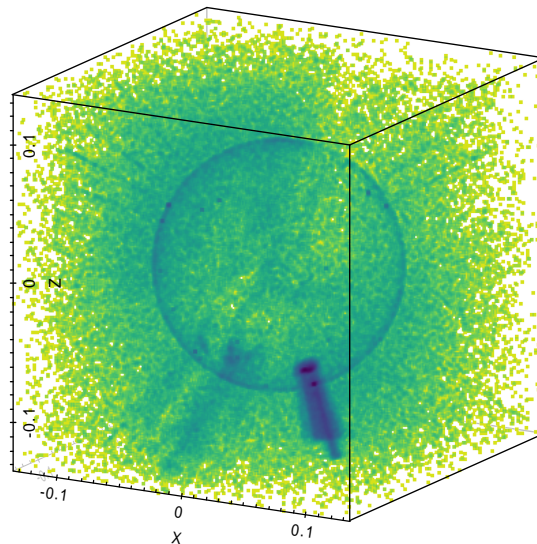


Plot in spherical polar coordinates using `ra`, `dec`, `redshift_qsoc`



Apply purity selection (Table 10 from Bailer-Jones et al., converting ADQL → TOPCAT expression language):

```
gaia_crf_source || host_galaxy_flag<6 || classlabel_dsc_joint=="quasar" || vari_best_class_name=="AGN"
```



Example: XP Sampled Spectra via DataLink

View XP Sampled spectra for points in a plot of interest



Query `gaiadr3.gaia_source` table to plot HR diagram:

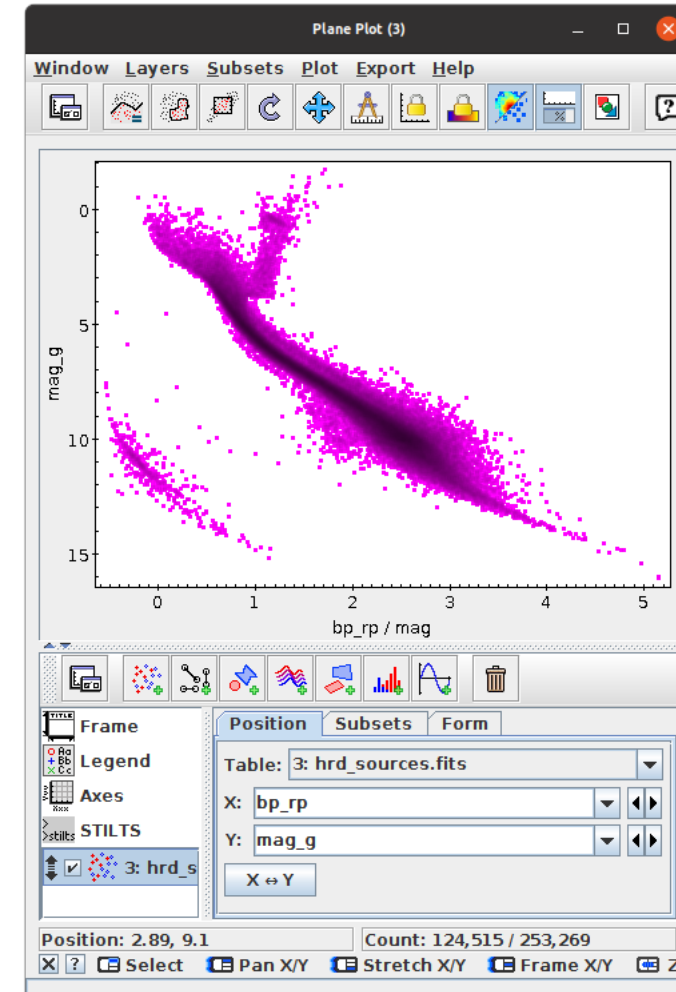
```
SELECT designation, source_id, ra, dec, parallax, bp_rp, phot_g_mean_mag,  
       phot_g_mean_mag+5*log10(parallax/100) AS mag_g  
FROM gaiadr3.gaia_source  
WHERE parallax > 10  
      AND parallax_over_error > 10  
      AND phot_bp_mean_flux_over_error > 10  
      AND phot_rp_mean_flux_over_error > 10  
      AND astrometric_excess_noise < 1  
      AND has_xp_sampled = 'true'
```

- ▶ Select on `has_xp_sampled` to ensure spectra are available
- ▶ Must **SELECT** `designation` (or sometimes `source_id`) to link rows with DataLink



Set up **Activation Action**

- ▶ Select checkbox for **Invoke Service**
- ▶ Service **Action** is **View DataLink Table**
- ▶ Select **XP mean sampled spectra** row of DataLink table
- ▶ Configure to **Plot Table** on DataLink load and **Auto-Invoke**
- ▶ Set up plot to taste
→ clicking on point in plot displays spectrum
(works best with TOPCAT v4.8-6 or later)



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View XP Sampled spectra for points in a plot of interest



Query `gaiadr3.gaiadr3.gaia_source` table to plot HR diagram:

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       phot_g_mean_mag+5*log10(parallax/100) AS mag_g
FROM gaiadr3.gaia_source
WHERE parallax > 10
      AND parallax_over_error > 10
      AND phot_bp_mean_flux_over_error > 10
      AND phot_rp_mean_flux_over_error > 10
      AND astrometric_excess_noise < 1
      AND has_xp_sampled = 'true'
```

- ▶ Select on `has_xp_sampled` to ensure spectra are available
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→ clicking on point in plot displays spectrum
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The screenshot shows the TOPCAT software interface. The main window, titled 'Plane Plot (3)', displays a plot of magnitude in the g-band (`mag_g`) versus the difference in magnitudes between the blue and red photometric bands (`bp_rp`). The plot shows a clear stellar main sequence. The 'Activation Actions' dialog box is open, showing the configuration for an activation action named 'TAP_4_gaiadr3.gaia_source, gaiadr3_gcns_main_1'. The 'Invoke Service' checkbox is checked, and the service action is set to 'View DataLink Table'. The configuration includes the name 'ancillary', a description, a base URL, and an IVOID. The status bar at the bottom of the dialog indicates that the action was invoked successfully on row 85086. The 'Results' panel at the bottom of the dialog shows a list of rows with their sequence numbers, row numbers, and status messages.

Seq	Row	Status	Message
5	80084	OK	https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4122597029
6	80089	OK	https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4122667123
7	123123	OK	https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+6133931765
8	85086	OK	https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4373306541

Example: XP Sampled Spectra via DataLink

View XP Sampled spectra for points in a plot of interest



Query `gaiadr3.gaia_source` table to plot HR diagram:

```
SELECT designation, source_id, ra, dec, parallax, bp_rp, phot_g_mean_mag,
       phot_g_mean_mag+5*log10(parallax/100) AS mag_g
FROM gaiadr3.gaia_source
WHERE parallax > 10
      AND parallax_over_error > 10
      AND phot_bp_mean_flux_over_error > 10
      AND phot_rp_mean_flux_over_error > 10
      AND astrometric_excess_noise < 1
      AND has_xp_sampled = 'true'
```

- ▶ Select on `has_xp_sampled` to ensure spectra are available
- ▶ Must `SELECT` `designation` (or sometimes `source_id`) to link rows with DataLink



Set up **Activation Action**

- ▶ Select checkbox for **Invoke Service**
- ▶ Service **Action** is **View DataLink Table**
- ▶ Select **XP mean sampled spectra** row of DataLink table
- ▶ Configure to **Plot Table** on DataLink load and **Auto-Invoke**
- ▶ Set up plot to taste
→ clicking on point in plot displays spectrum
(works best with TOPCAT v4.8-6 or later)

The screenshot shows the TOPCAT software interface. At the top, a 'Plane Plot (3)' window displays an HR diagram with mag_g on the y-axis and bp_rp on the x-axis. A point is selected on the plot. Below the plot, the 'TOPCAT(5): Activation Actions' window is open, showing the configuration for the selected point. The 'Actions' list includes 'Use Sky Coordinates in', 'Invoke Service', 'Send Sky Coordinates', 'Display HiPS cutout', 'Send HiPS cutout', 'Delay', and 'Execute code'. The 'Invoke Service' action is selected, and its configuration shows the 'Action' set to 'View DataLink Table'. Below this, the 'DataLink Table' window is open, displaying a table with columns: semantics, description, content_type, content_length, and ID. The table contains four rows, with the second row selected. The 'Row Detail' window is also open, showing the details for the selected row, including the 'access_url', 'content_type', 'content_length', 'description', 'semantics', and 'URL'. The 'URL' field is set to 'https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4373306541703685248&RETRIEVAL_TYPE=XP_S'. The 'Type' is set to 'TABLE', 'Guess' is checked, and the 'Action' is set to 'Plot Table'. The 'Auto-Invoke' checkbox is also checked.

semantics	description	content_type	content_length	ID
1 #this	MCMC MSC, source Gaia DR3 4...	application/x-votable+xml		Gaia DR3 43733065
2 #this	XP mean sampled spectra, so...	application/x-votable+xml		Gaia DR3 43733065
3 #this	XP mean continuous spectra, ...	application/x-votable+xml		Gaia DR3 43733065
4 #this	MCMC GSP-Phot, source Gaia ...	application/x-votable+xml		Gaia DR3 43733065

Row Link Type: Fixed Access URL
Row Detail:
access_url: https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4373306541703685248&RETRIEVAL_TYPE=XP_S
content_type: application/x-votable+xml
content_length:
description: XP mean sampled spectra, source Gaia DR3 4373306541703685248
semantics: #this
URL: https://gea.esac.esa.int/data-server/data?ID=Gaia+DR3+4373306541703685248&RETRIEVAL_TYPE=XP_S
Type: TABLE | Guess | Action: Plot Table | Auto-Invoke | Invoke
Result:

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View XP Sampled spectra for points in a plot of interest



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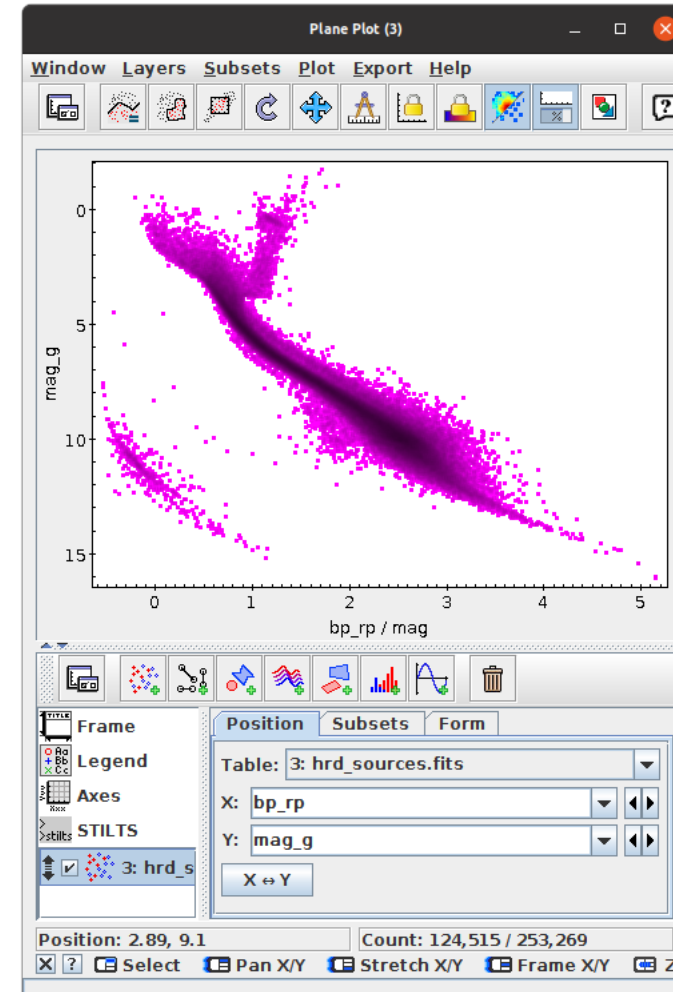
```
SELECT designation, source_id, ra, dec, parallax, bp_rp, phot_g_mean_mag,
       phot_g_mean_mag+5*log10(parallax/100) AS mag_g
FROM gaiadr3.gaia_source
WHERE parallax > 10
      AND parallax_over_error > 10
      AND phot_bp_mean_flux_over_error > 10
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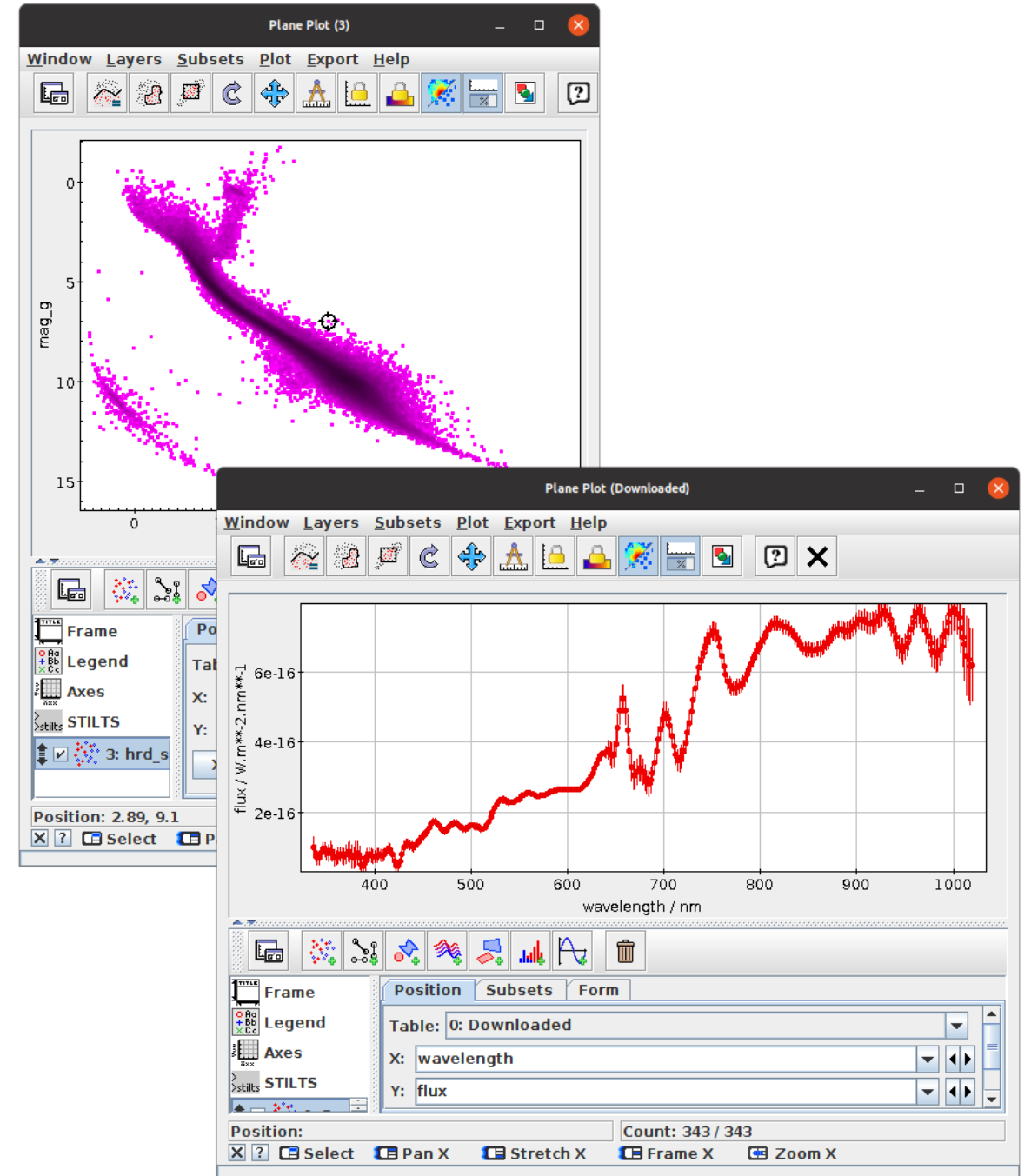
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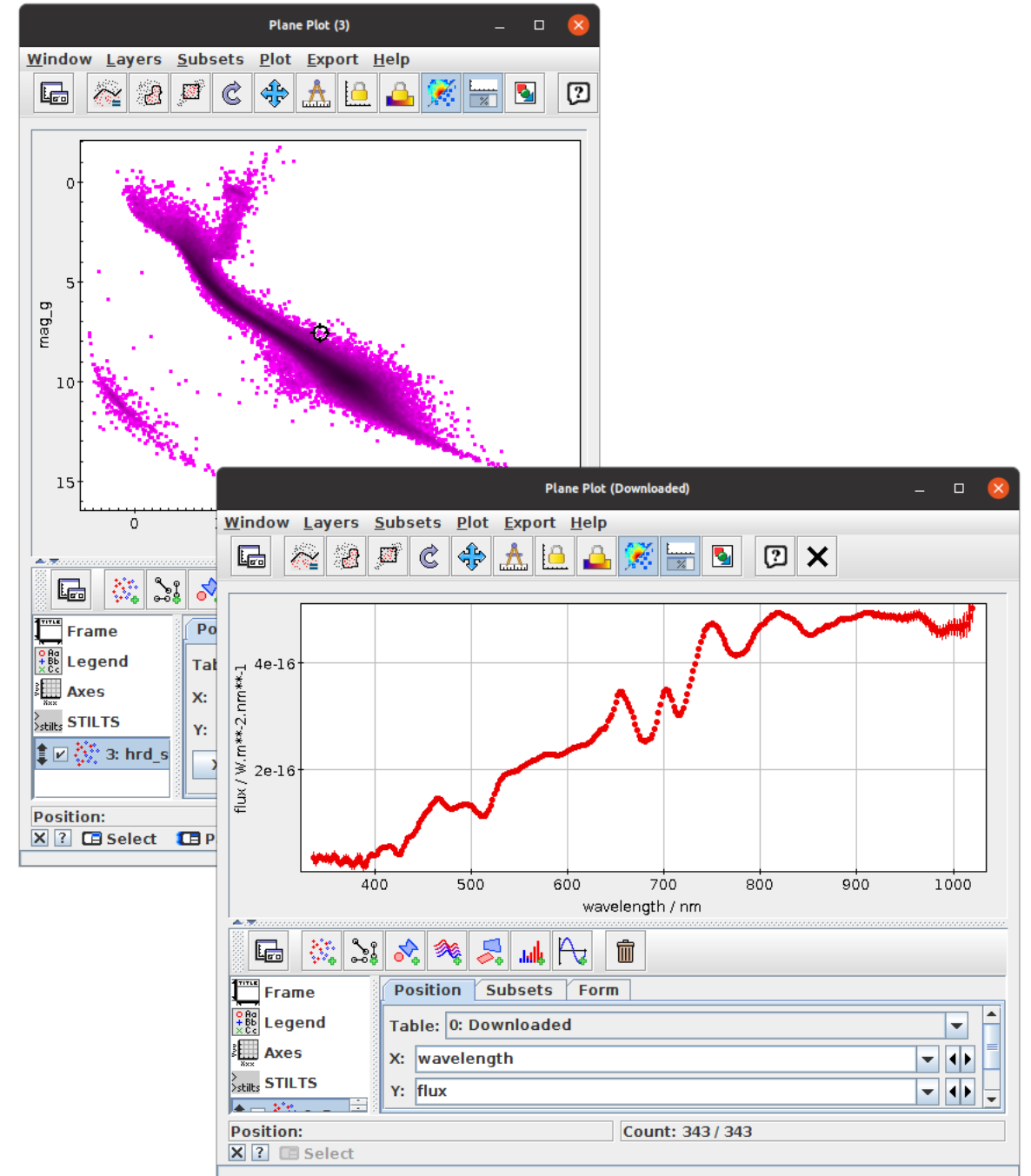
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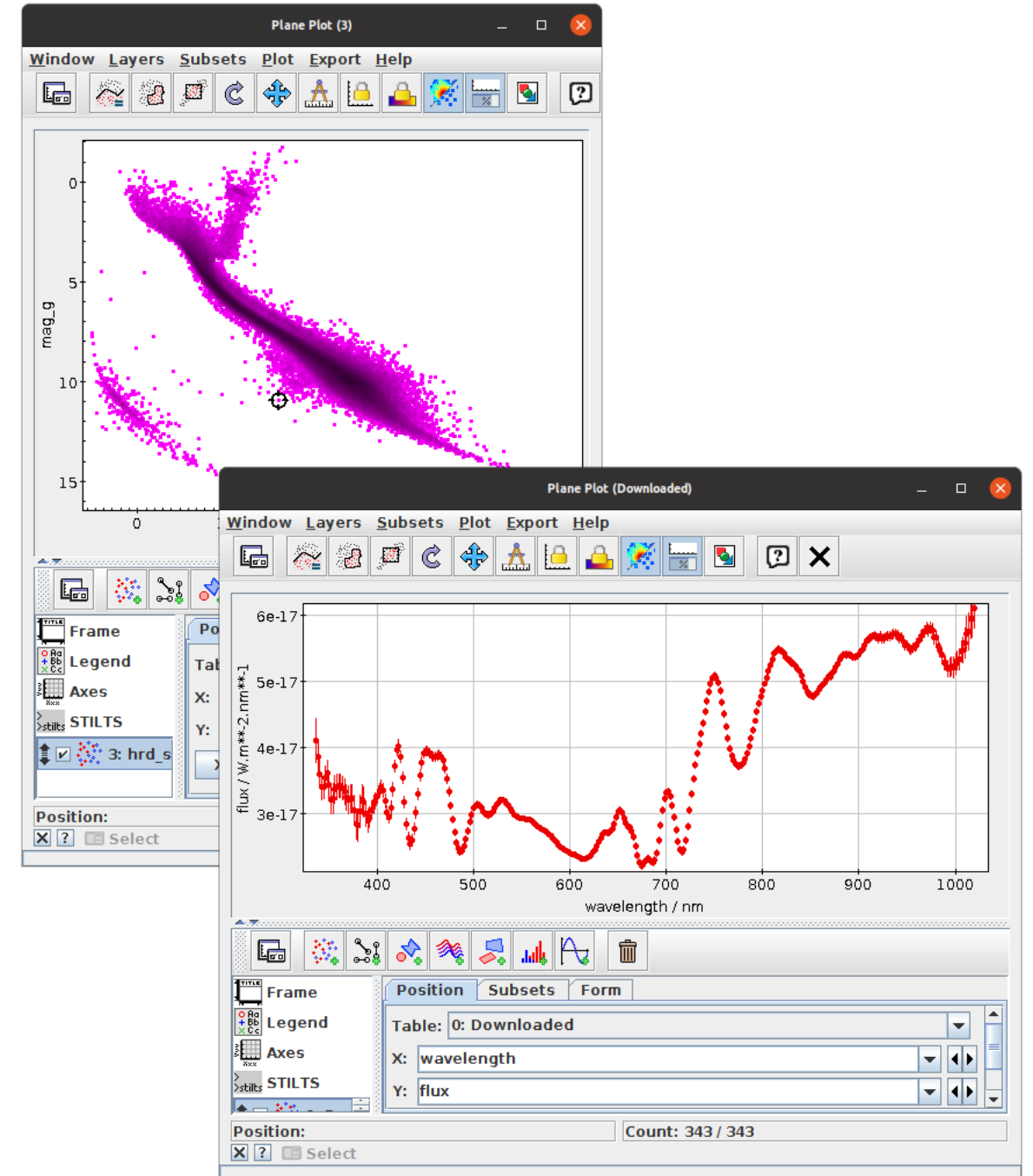
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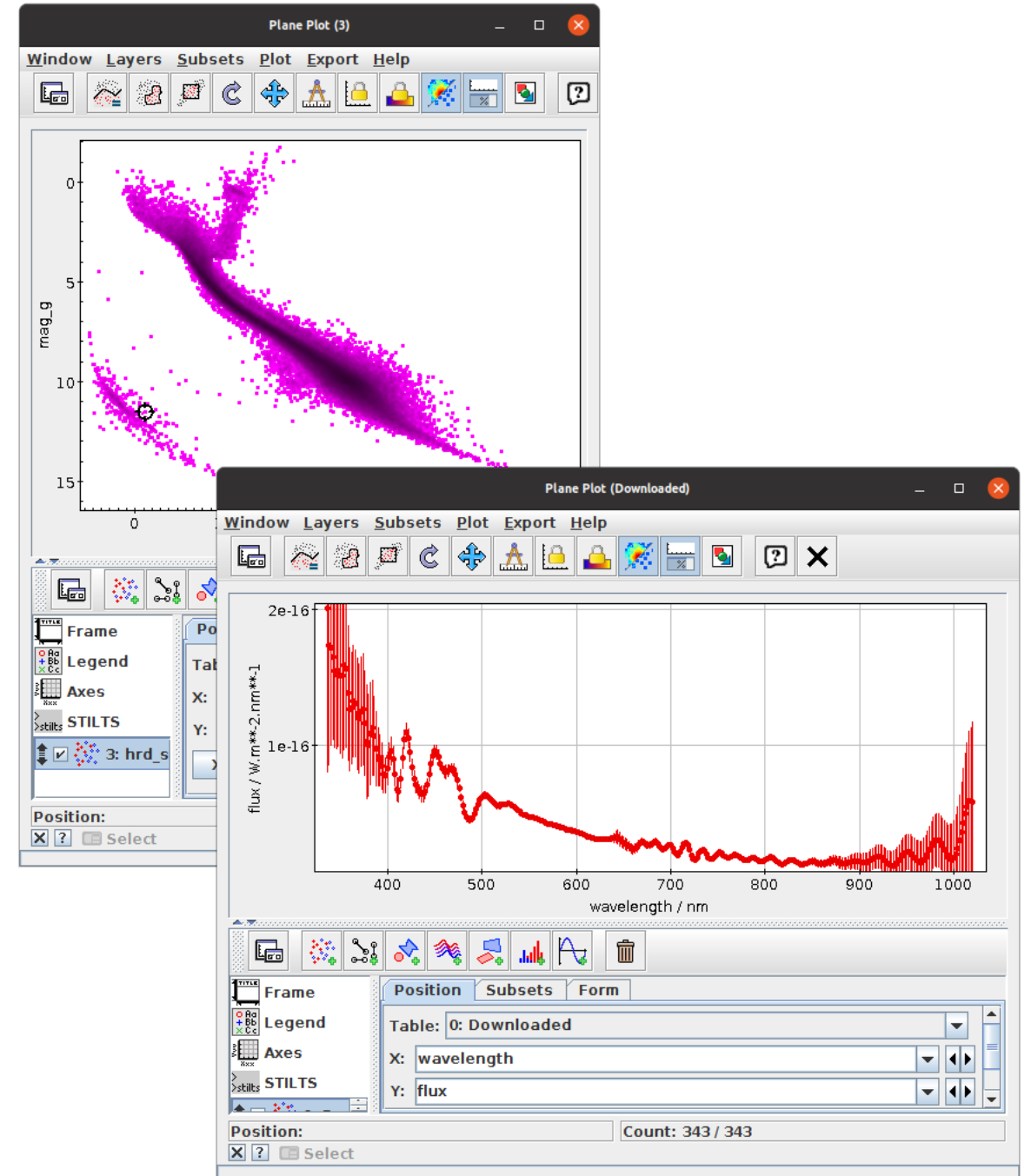
```
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Example: XP Sampled Spectra as Arrays

Some services provide ancillary data as arrays



Graphically choose some sources of interest (white dwarf region of HRD)



Set as **Current Subset**



Use subsetting table in a TAP upload match to `xp_sampled_mean_spectrum`
(use ARI-Gaia TAP service, not present at ESA)

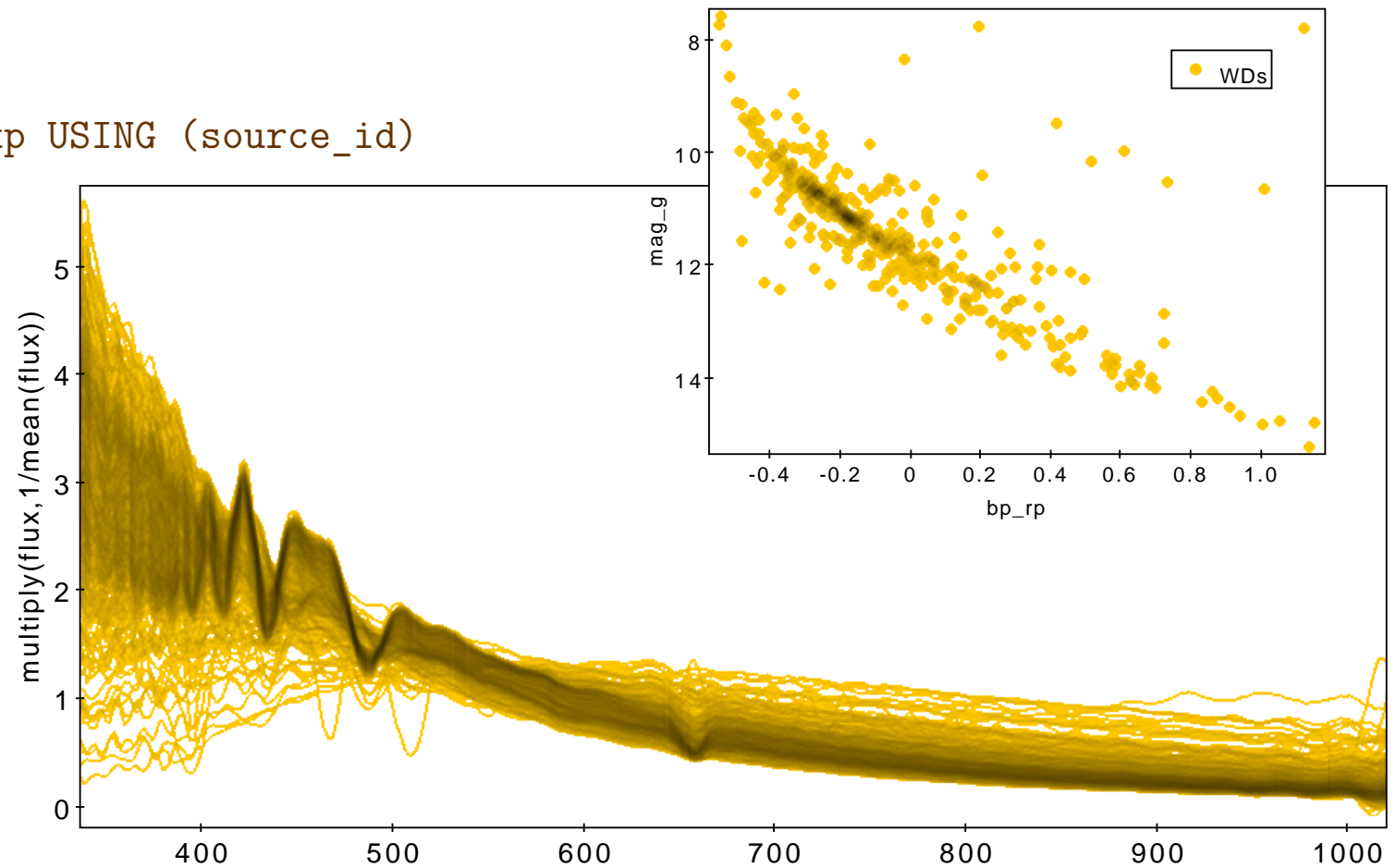
```
SELECT t.*, xp.flux, xp.flux_error
FROM tap_upload.t1 AS t
JOIN gaiadr3.xp_sampled_mean_spectrum AS xp USING (source_id)
```

*There are some other ways to get spectra as arrays too;
ESA archive RAW download, STILTS arrayjoin command*



Plot some or all spectra using **Array Pair Plot** layer control

- ▶ Normalise spectra e.g.:
`multiply(flux, 1./mean(flux))`
- ▶ Optionally provide fake wavelength values:
`add(multiply(sequence(343), 2), 336)`
- ▶ Optionally plot summary spectra
(mean/median/quantiles)



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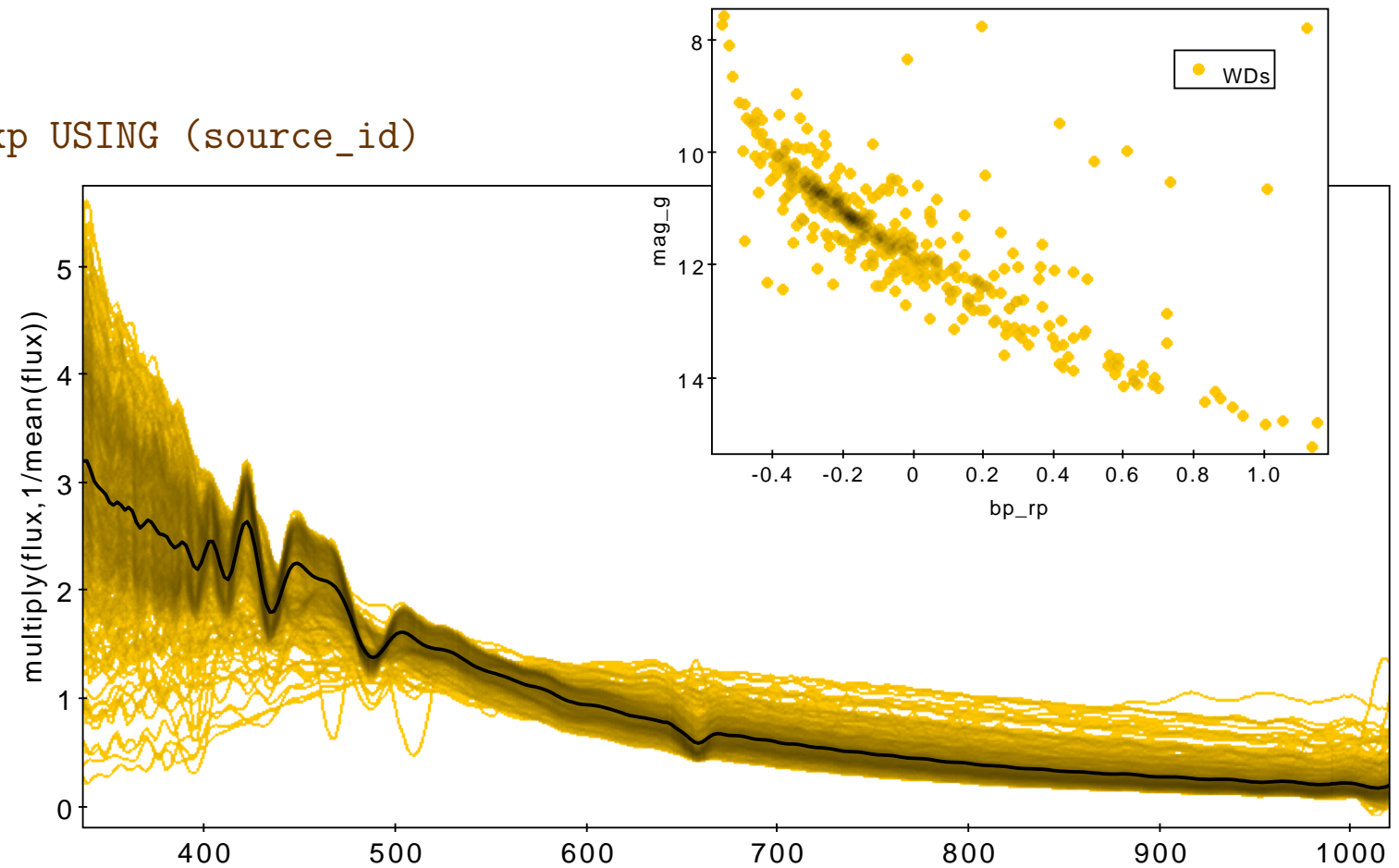
```
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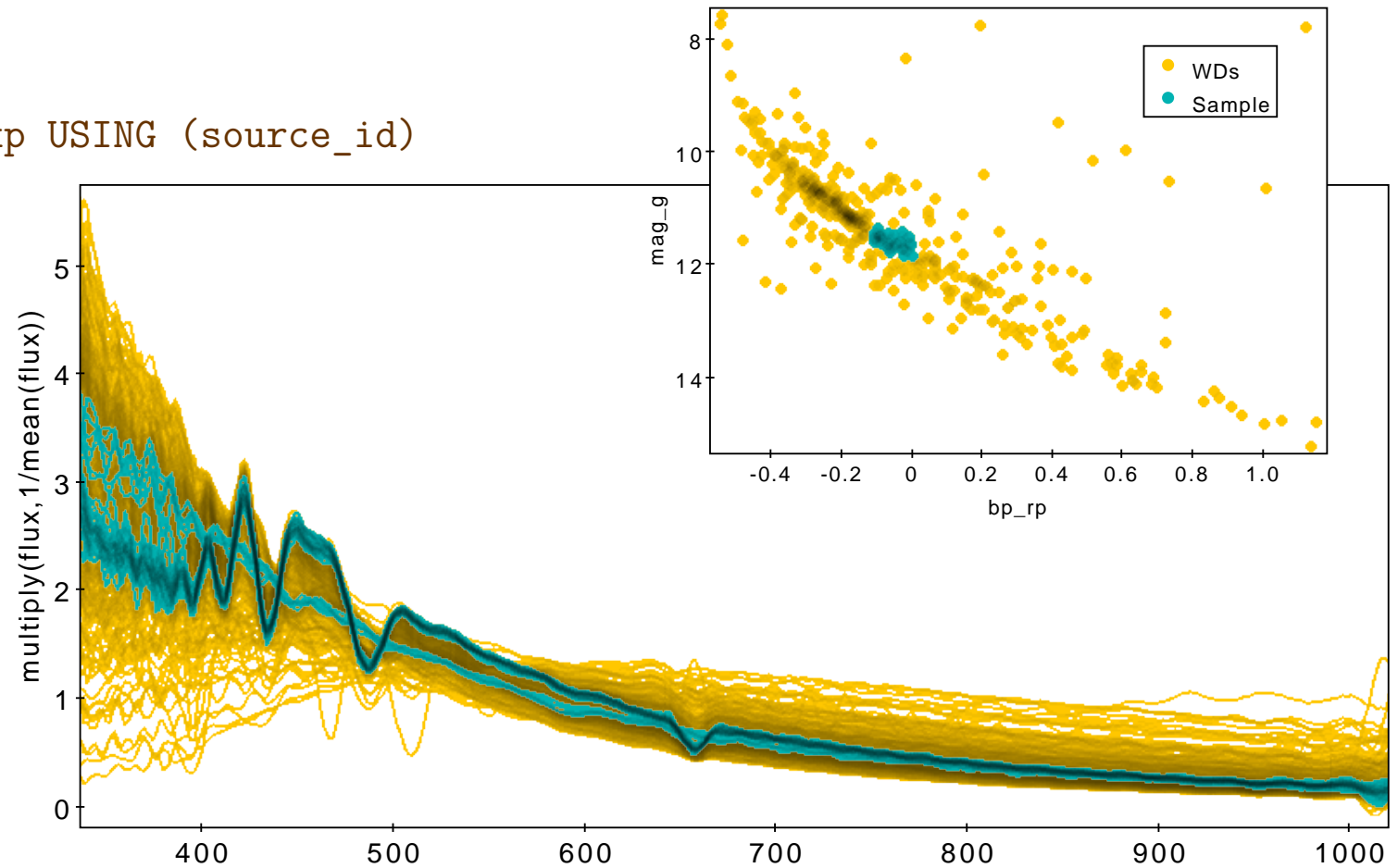
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Summary

TOPCAT's a good tool for working with Gaia DR3 data

- getting hold of it
- exploring it, analysing it
- comparing it to other data

Gaia DR3 is a fantastic data set to work with

Lots of features of both I didn't show here!

- Comprehensive [HTML](#) / [PDF](#) user manual
- **Help for Window**  button on every window
- Email support:
 - ▷ on list: topcat-user@bristol.ac.uk
 - ▷ in person: m.b.taylor@bristol.ac.uk
- Acknowledgement: [2005ASPC..347...29T](#)



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

- Downloads
- Documentation
- Tutorials

Enjoy Gaia DR3!