

# TGAS for dummies

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# Introduction

Gaia DR1 is twofold (Gaia Collaboration (Brown et al.) 2016, Summary description of Gaia DR1):

- ▶ TGAS: contains the astrometric single star solution for about 2M sources originally observed by Tycho and published in the Tycho-2 catalogue;
- ▶ position and G-magnitude of 1B sources.

The astrometric solutions are based upon the Tycho2 positions (epoch 1991.5) and the Gaia observations already available. The 5p-model (i.e. position at reference epoch, parallax and proper motion) was imposed, whether it was physically appropriate or not. Some statistical quality indicators are nevertheless present.

For processing or observational reasons, some Tycho2 stars are missing from TGAS:

- ▶ too poor astrometric solution;
- ▶ object too bright;
- ▶ too large proper motion, ...

# Application

Retrieve the parallax and its uncertainty for a list of Ba stars with known TYC identifiers (e.g. TYC 35-435-1).

Warnings:

- ▶ DR1 does not contain any spectral information yet so the selection of Ba stars has to take place outside the Gaia framework.
- ▶ TGAS supplies the parallax and its uncertainty but no guess of the extinction is provided yet.
- ▶ The observations will not be available for a long time so no processing with an alternative astrometric model is foreseen until then but other models will be considered in Gaia DR3+.

# Accessing the Gaia DR1 archive

Even though DR1 is accessible through CDS and several other mirrors, the main repository is at ESAC (Madrid):

<http://archives.esac.esa.int/gaia>



The screenshot shows the Gaia Archive website homepage. At the top, there is a navigation bar with the text "EUROPEAN SPACE AGENCY" and "ABOUT ESAC" on the left, and "SIGN IN" on the right. Below this is a dark red banner with the text "gaia archive" in white, the ESA logo, and a background image of the Gaia satellite. Underneath the banner is a horizontal menu with the following items: HOME, SEARCH, STATISTICS, VISUALIZATION, HELP, and DOCUMENTATION. The main content area has a white background with the heading "Welcome to the Gaia Archive". Below the heading is a red "DISCLAIMER" section stating that the archive is in prototype status and provides simulated data. This is followed by a paragraph describing the Gaia mission's goals. Below that is a section for acknowledgements. To the right of the text is a large circular graphic of the Gaia satellite. At the bottom of the page, there is a "Top Features" section with three icons: a magnifying glass for "Search", a globe for "Statistics", and a lifebuoy for "Help". To the right of these icons is a "SHARE" button with social media icons for Facebook, Twitter, and LinkedIn. The footer contains the copyright notice "COPYRIGHT 2000 - 2016 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED." and the version number "[v0.7.4]".

EUROPEAN SPACE AGENCY ABOUT ESAC SIGN IN

## gaia archive

HOME SEARCH STATISTICS VISUALIZATION HELP DOCUMENTATION

### Welcome to the Gaia Archive

**DISCLAIMER:** This archive is currently in **prototype status** and provides **simulated Gaia data**.

Gaia is an ambitious mission to chart a three-dimensional map of our Galaxy, the Milky Way, in the process revealing the composition, formation and evolution of the Galaxy. Gaia will provide unprecedented positional and radial velocity measurements with the accuracies needed to produce a stereoscopic and kinematic census of about one billion stars in our Galaxy and throughout the Local Group. This amounts to about 1 per cent of the Galactic stellar population.

If you use this service in your research, please include the following acknowledgement in any resulting publications:

*"This work has made use of data from the ESA space mission Gaia (<http://www.cosmos.esa.int/gaia>), processed by the Gaia Data Processing and Analysis Consortium (DPAC, <http://www.cosmos.esa.int/web/gaia/dpac/consortium>). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement."*

#### Top Features

SEARCH STATISTICS HELP

SHARE

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# Gaia Archive front end

So far, there are two ways to query the Gaia archive. The first approach offers a Simbad-like interface, convenient for one specific object or an area of the sky.

The screenshot shows the Gaia Archive search interface. At the top, there is a navigation bar with links for HOME, SEARCH, STATISTICS, VISUALIZATION, HELP, DOCUMENTATION, VOSPACE, and SHARE. The main header features the Gaia Archive logo and the ESA logo. Below the header, there are tabs for Simple Form, ADQL Form, and Query Results. The Simple Form tab is active, showing a search form with the following fields and options:

- Position:** Name (selected) or Equatorial
- Target in:** Circle (selected) or Box
- Name:** A text input field followed by a dropdown menu set to "Simbad".
- Radius:** A text input field set to "5" followed by a dropdown menu set to "arc min".
- Search in:** Gala Source (selected) or Tycho-Gaia Astrometric Solution (TGAS). A dropdown menu is set to "galadr1.gala\_source".
- Extra conditions:** A section with a dropdown arrow.
- Display columns:** A section with a dropdown arrow.
- Max. number of results:** A dropdown menu set to "500".
- Buttons:** Reset Form, Show Query, and Submit Query.

At the bottom of the page, there is a copyright notice: "COPYRIGHT 2000 - 2016 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED. (v0.7.4)".

This operation can be repeated for several objects stored in a file.

# Relational DataBase Management System

The Gaia data are stored in several rectangular tables (i.e. each row of a table has the same number of columns). A table represents a relation (in the mathematical sense) between the columns of that table. The rows of a table are independent. Relational algebra defines 3 operations to manipulate table(s)

- ▶ Projection ( $\pi$ ): generates a table with only a subset of the columns of the original table;
- ▶ Selection ( $\sigma$ ): generates a table with only the rows that satisfy a relation between some columns;
- ▶ Joint ( $\bowtie$ ): combines two tables into one where one column is common.

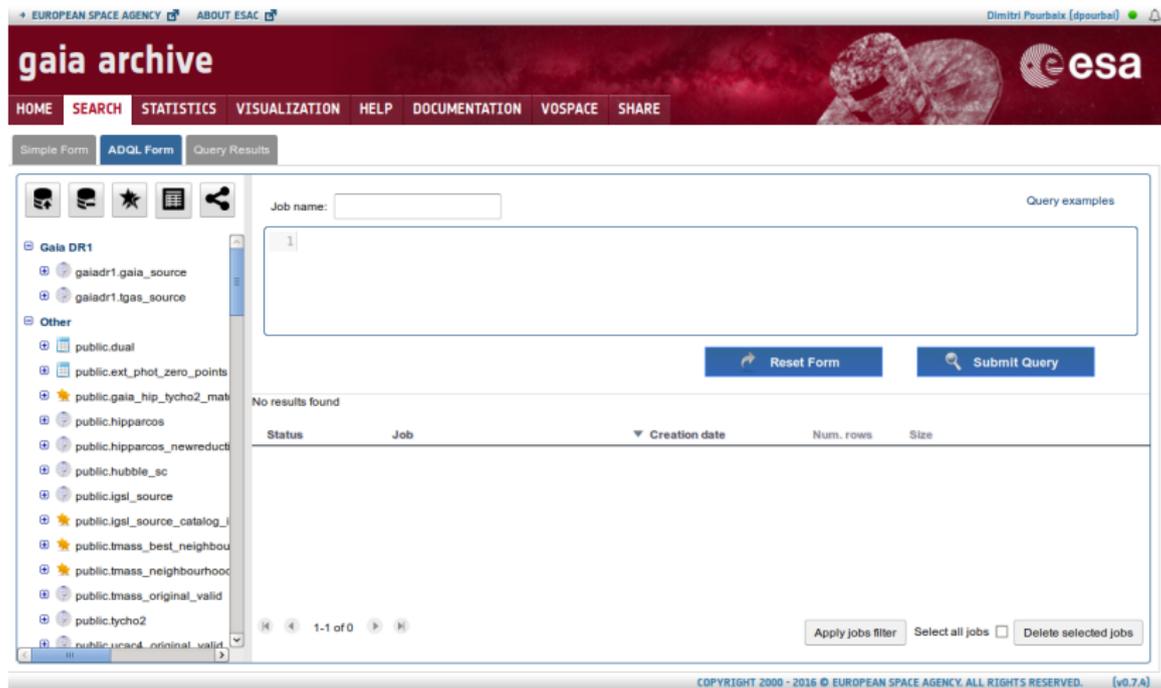
Our example becomes:  $\pi_{\omega, \sigma_{\omega}} (TGAS \bowtie XmTYC \bowtie BaList)$ .

The language commonly used to access such a database is Structured Query Language.

A general introduction to databases can be found in *Database System Concepts* by Silberschatz, Korth, & Sudarshan.

# Maximum power with ADQL

The Astronomical Data Query Language is a dialect of SQL-92. It makes it possible to build rather complex astronomical queries combining several tables.



The screenshot shows the Gaia Archive website interface. At the top, there is a navigation bar with the ESA logo and the text "gaia archive". Below this, there are tabs for "Simple Form" and "ADQL Form", with "ADQL Form" selected. The main content area is titled "Query Results" and contains a "Job name:" input field, a "Query examples" link, and a large text area for entering the query. Below the text area are "Reset Form" and "Submit Query" buttons. The results section shows "No results found" and a table with columns for "Status", "Job", "Creation date", "Num. rows", and "Size". The table is currently empty. At the bottom of the results section, there are controls for "Apply jobs filter", "Select all jobs", and "Delete selected jobs". The footer of the page contains the copyright information: "COPYRIGHT 2000 - 2016 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED. (v0.7A)".

Ref AQDL: <http://www.ivoa.net/documents/latest/ADQL.html>

## Server side versus client side

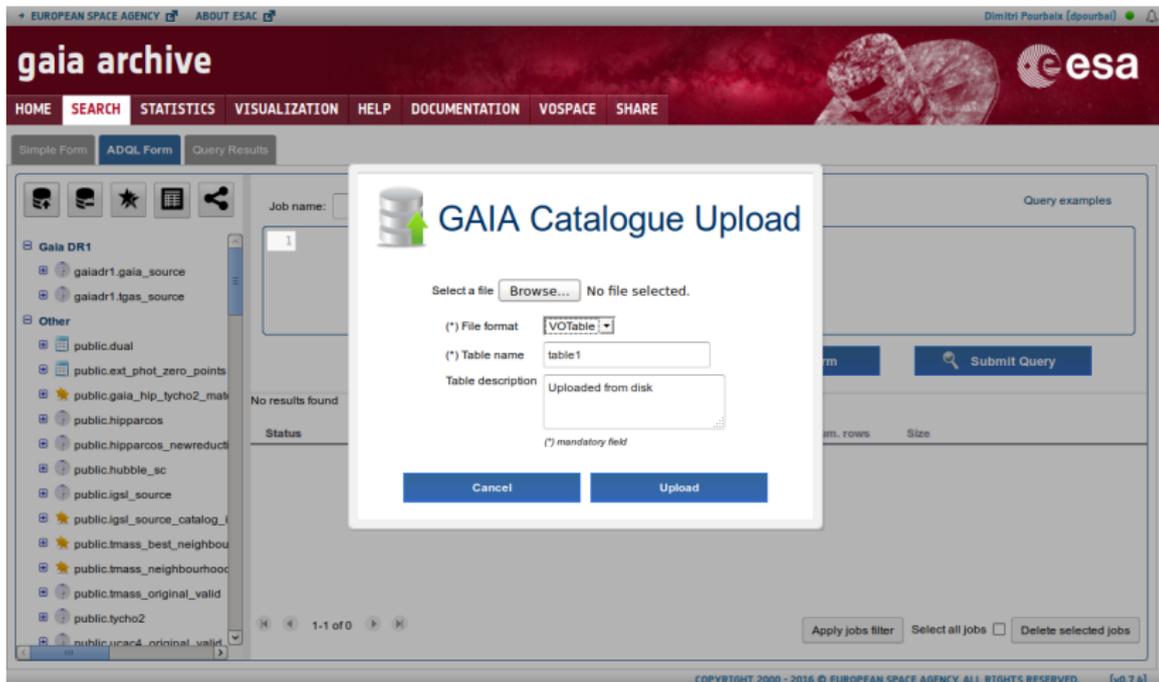
We are looking for TGAS stars with a specific TYC number. Two options are possible:

- ▶ Download the whole TGAS and take care of the cross-matching locally (client side);
- ▶ Upload the list to the server and let the server takes care of the cross-matching.

If several selections are considered, downloading TGAS once for all will be advantageous. However, in the case of TYC (as well as for HIP, GSC, UCAC, . . . ), cross-matching tables have been precomputed and stored on the Gaia Archive.

For TYC-like identifiers with a pattern, it is important to make use one uploads the exact same structure as the one adopted by the Gaia Archive: 'TYC 35-435-1', '0035-00435-1' and '0000 00435 1' are three distinct strings even if they might refer to the same TYC identifier.

# Uploading the targets



The screenshot shows the GAIA Catalogue Upload dialog box in the ESA Gaia Archive interface. The dialog box is titled "GAIA Catalogue Upload" and contains the following fields and options:

- Select a file:** A text input field with a "Browse..." button and the text "No file selected."
- (\*) File format:** A dropdown menu with "VOTable" selected.
- (\*) Table name:** A text input field with "table1" entered.
- Table description:** A text area with "Uploaded from disk" entered.
- Buttons:** "Cancel" and "Upload" buttons.

The background interface shows the "gaia archive" logo, navigation tabs (HOME, SEARCH, STATISTICS, VISUALIZATION, HELP, DOCUMENTATION, VOSPACE, SHARE), and a sidebar with a tree view of data sources. The main content area displays "No results found" and a "Submit Query" button.

The user can supply some new data through some new tables (VO-tables or CSV files).

# New DBMS entries

Once these tables are uploaded, they become part of the DMBS (user's working area) and can be used in any query.

The screenshot displays the Gaia Archive web interface. At the top, there is a navigation bar with the text "gaia archive" and the ESA logo. Below this, a menu contains links for HOME, SEARCH, STATISTICS, VISUALIZATION, HELP, DOCUMENTATION, VOSPACE, and SHARE. The interface is divided into two main sections: "Simple Form" and "ADQL Form", with "ADQL Form" currently selected. The "ADQL Form" section includes a "Job name:" input field, a large text area for the query (containing the number "1"), and two buttons: "Reset Form" and "Submit Query". Below the form, a message states "No results found". A table with the following headers is visible: "Status", "Job", "Creation date", "Num. rows", and "Size". The table is currently empty. At the bottom of the interface, there are navigation controls showing "1 - 1 of 0" and buttons for "Apply jobs filter", "Select all Jobs", and "Delete selected jobs". The footer of the page contains the text "COPYRIGHT 2000 - 2016 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED. [v0.7.4]" and a set of navigation icons.

The query can be typed or pasted in the upper window.

The screenshot shows the Gaia Archive query interface. At the top, there's a navigation bar with 'HOME', 'SEARCH', 'STATISTICS', 'VISUALIZATION', 'HELP', 'DOCUMENTATION', 'VOSPACE', and 'SHARE'. Below that, there are tabs for 'Simple Form', 'ADQL Form', and 'Query Results'. The 'ADQL Form' tab is active, showing a 'Job name' field with 'vpBa' and a large text area containing the following SQL query:

```

1 select tgas.source_id,xref.original_ext_source_id,parallax,parallax_error from user_gaiadr1.tgas_source tgas
2 join public.gaia_hip_tyc2 match_xref on xref.source_id = tgas.source_id
3 join user_dpourbal.batyc2 ba on ba.col1 = xref.original_ext_source_id
    
```

Below the query area are 'Reset Form' and 'Submit Query' buttons. A table below shows the job status:

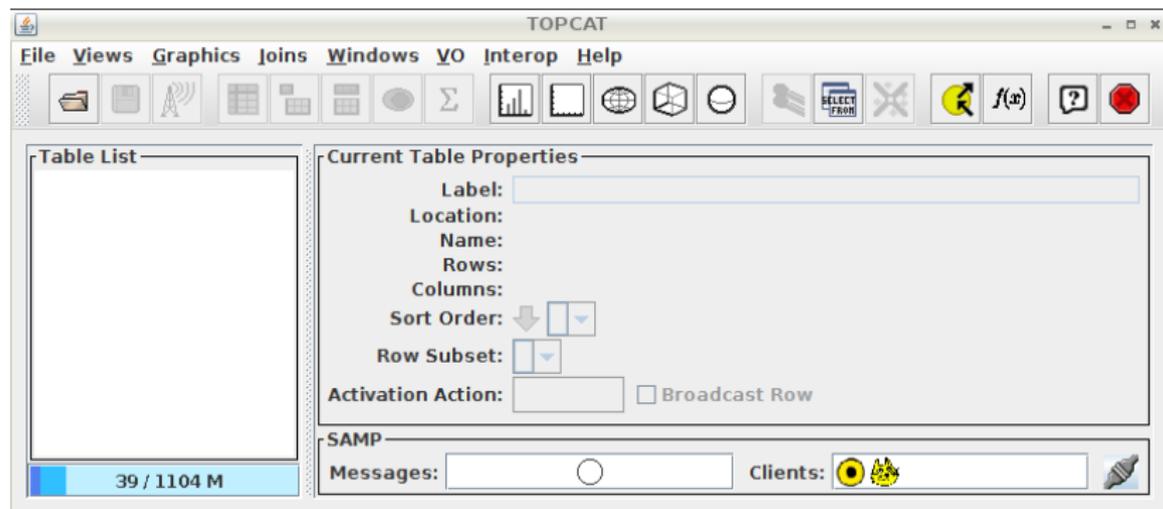
Status	Job	Creation date	Num. rows	Size
✓	vpBa	08-Sep-2016, 11:17:18	129	5 KB
✗	vpBa	08-Sep-2016, 11:16:48	0 KB	

At the bottom of the interface, there are navigation controls for the log (1-2 of 2) and buttons for 'Apply jobs filter', 'Select all jobs', and 'Delete selected jobs'.

Once the query is submitted, a new entry appears in the log. As soon as the query is completed ... or it crashes, the corresponding line of the log is updated (number of resulting rows, ...).

# TOPCAT

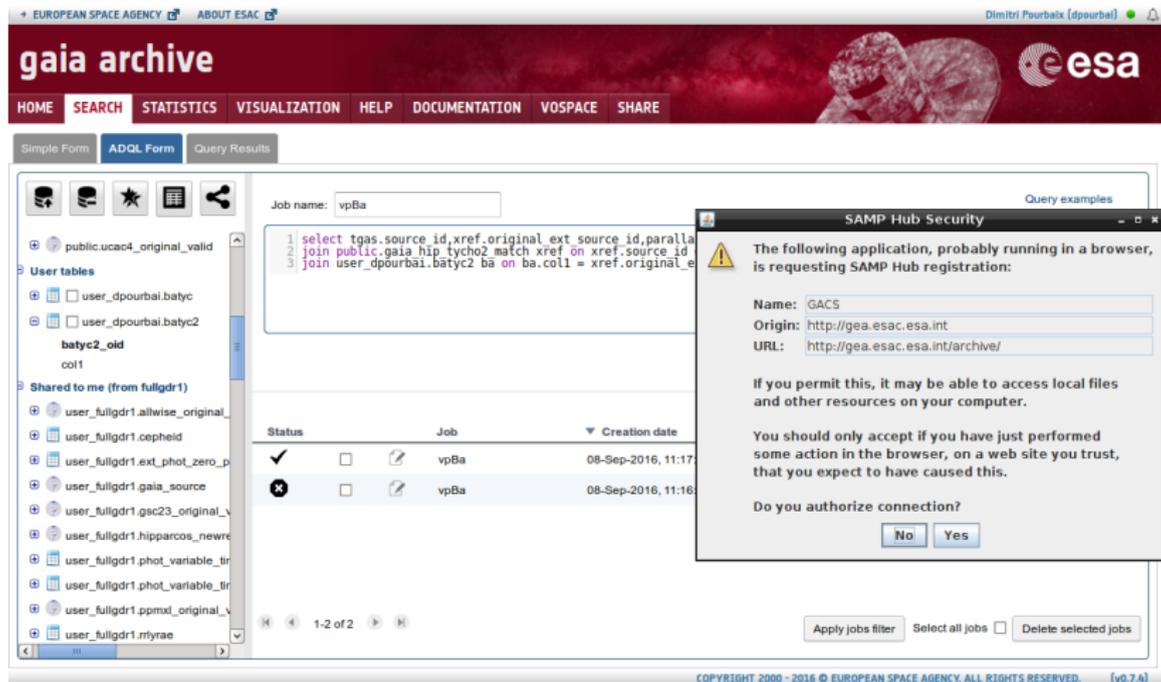
TOPCAT (<http://www.star.bris.ac.uk/~mbt/topcat/>) was designed to view and edit tabular data (regardless of Gaia). It was updated to communicate with the Gaia archive out of the box (4.3-3).



Make sure TOPCAT is running.

# Simple Application Messaging Protocol

Clicking on  establishes the connection between the server, browser and TOPCAT.



The screenshot shows the Gaia Archive website interface. At the top, there is a navigation bar with links for HOME, SEARCH, STATISTICS, VISUALIZATION, HELP, DOCUMENTATION, VOSPACE, and SHARE. Below this is a search form with a 'Job name' field containing 'vpBa'. A SQL query is displayed in a text area:

```
1 select tgas.source_id,xref_original_ext_source_id,parall
2 join public.gaia hip_tycho2 match xref on xref.source_id
3 join user_dpourbai.batyc2 ba on ba.col1 = xref.original_e
```

Below the query, there is a table showing the status of the jobs:

Status	Job	Creation date
✓	vpBa	08-Sep-2016, 11:17
✗	vpBa	08-Sep-2016, 11:16

On the right side of the interface, a security warning dialog box titled 'SAMP Hub Security' is displayed. The dialog contains the following text:

The following application, probably running in a browser, is requesting SAMP Hub registration:

Name: GACS  
Origin: http://gea.esac.esa.int  
URL: http://gea.esac.esa.int/archive/

If you permit this, it may be able to access local files and other resources on your computer.

You should only accept if you have just performed some action in the browser, on a web site you trust, that you expect to have caused this.

Do you authorize connection?

No Yes

At the bottom of the page, there is a footer with the text: COPYRIGHT 2000 - 2016 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED. [v0.7.4]

SAMP can also be used to establish a connection between TOPCAT and, say, a Python code (with SAMPy package).

# SAMP log in

A new dialog box opens and asks for the login and password on the Gaia Archive server.

The screenshot displays the Gaia Archive web interface in Mozilla Firefox. The main content area shows a search form with the job name 'vdba' and a SQL query: `select tps.source_id, sref.original_est_source_id, parallax, parallax_error from user_gaiaid1.tps_source tps join public.gaia_tps_tychos_match sref on sref.source_id = tps.source_id join user_djorbal.batyc2 ba on ba.col1 = sref.original_est_source_id`. Below the query is a table of jobs:

Job	Creation date	Num. rows	Size
vdba	08-Sep-2016, 11:07:18	129	9 KB
vdba	08-Sep-2016, 11:16:48		0 KB

Overlaid on the right side of the browser window is an 'Authentication' dialog box for 'gea.esac.esa.int'. It prompts for 'User:' (filled with 'djorbal') and 'Password:'. Below the dialog is a terminal window titled 'TOPCAT' showing the command `!load new table` and a 'Loading Tables' dialog box for 'SAMP/GACS:14733262380200'.

# View through TOPCAT

It is possible to directly view a sample of the table just transferred in TOPCAT.

The image shows a composite screenshot. On the left is the Gaia Archive website interface. The main content area displays a SQL query: `select tps.source_id,ref_original,est_source_id,parallax,parallax_error from user_gaiadr1.tps,source tps join hdbf1.gaiu_bip_tych2_mafcs_ara1 on ref_original,est_source_id join user_gaiadr1.hdbf1_b1 on ta_scl1 = ref_original,est_source_id`. Below the query, a table lists jobs with columns for Job name, Status, Job, Creation date, Num. rows, and Size. Two jobs named 'vblu' are listed, both with a status of 'OK' and a creation date of 08-Sep-2016. The bottom of the page includes the text 'COPYRIGHT 2006 - 2016 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED. [16.3.16]'. On the right is the TOPCAT Table Browser window. The title bar reads 'TOPCAT' and the window title is 'Table Browser for 1: 147232623002000'. The main area shows a table with columns 'source\_id', 'original\_ref', 'parallax', and 'parallax\_error'. The table contains 19 rows of data. Below the table is a terminal window titled 'LXTerminal' showing a series of shell commands and their outputs, including file paths like '/Downloads/index.djvu' and '/Downloads/index.pdf'.

# Export to CSV

Whereas one can directly access a TOPCAT table from, say, Java or Python, exporting to CSV might offer some more flexibility.

The image shows a screenshot of the TOPCAT software interface. The main window displays a query execution log with the following SQL query:

```
select tgas_source_id,xref.original_err_source_id,parall_x,parall_err error from user_gaiafr1.tgas_source tgas
join public.gaii_hybrid_match_xref on xref.source_id = tgas_source_id
join user_dpoirbat_bary2c_ba on ba.col1 = xref.original_err_source_id
```

The log shows a successful job named 'vofa' completed on 08-Sep-2016 at 11:17:18 with 128 rows and a size of 5 MB. Below the log is a table with columns: Status, Job, Creation date, Num. rows, and Size.

Overlaid on the TOPCAT window is a dialog box titled 'Export to CSV'. The dialog contains the following information:

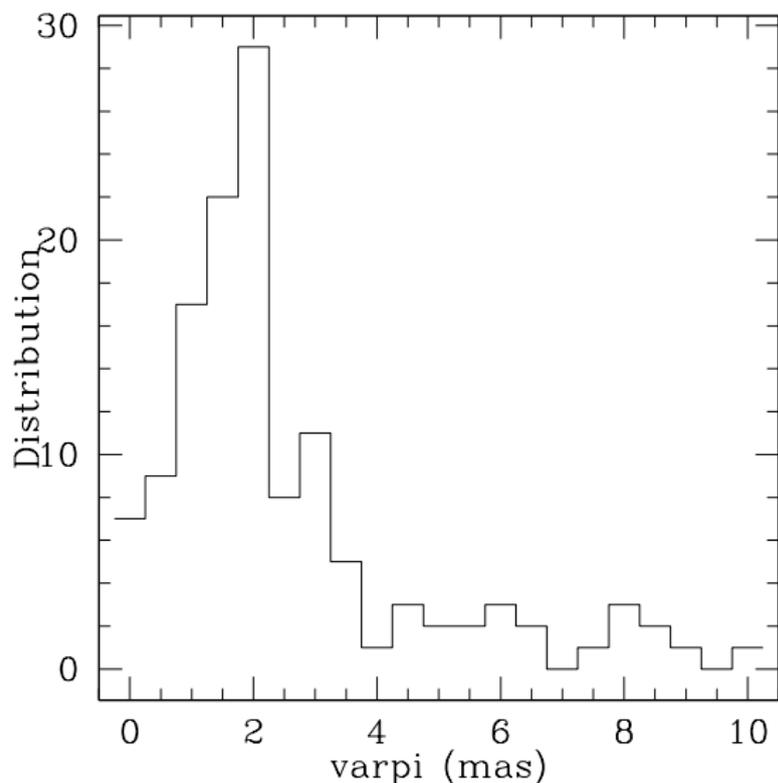
- Current Table: Multiple Tables | Session
- Table: 1:1473262380200
- Current Subject:
- Sort Order:
- Output Format: CSV+header
- Location: galT0AS.csv

The dialog also includes buttons for 'Filestore Browser', 'System Browser', and 'Cancel'.

In the background, a Mozilla Firefox browser window shows the Gaia Archive website. The browser's address bar contains 'gaia.archive.esa.int/archive'. The website header includes 'gaia archive' and navigation links like 'HOME', 'SEARCH', 'STATISTICS', 'VISUALIZATION', 'HELP', 'DOCUMENTATION', 'VOSPAC', and 'SHARE'.

## Results

Out of the original 557 TYC entries, only 129 turn out to hold a TGAS solution (see DR1 papers for the exact filtering criteria).



# Acknowledgement

This work has made use of data from the ESA space mission Gaia (<http://www.cosmos.esa.int/gaia>), processed by the Gaia Data Processing and Analysis Consortium (DPAC, <http://www.cosmos.esa.int/web/gaia/dpac/consortium>). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.