



Astrofísica Galáctica e Extragaláctica (2017)

Dr. Paula Rodrigues Teixeira Coelho

Lab 1 - 28th March 2017 Study of the CMD and membership of stars in the Pleiades open cluster

Prepared by: Mohammad Reza Ghoreyshi

based on tutorials by Leonardo dos Santos

and EuroVO-AIDA WP5 case, originally developed by P. Padovani

<http://quiwi2.u-strasbg.fr/pub/fc/workflows/Pleiades.html>

Scientific context: In this tutorial we will investigate some properties of the Pleiades open cluster. We will use techniques of data mining to search for astrometric and photometric data available in literature. With these data we will be able to make an assessment of the stars which are members of the cluster, and which are not.

Tools: We will use two free software: Aladin and Topcat. Aladin¹ is a software to retrieve and visualize astronomical images. Topcat² is an interactive graphical viewer and editor for tabular data. These tools can query and access astronomical data through technologies of the Virtual Observatory³.

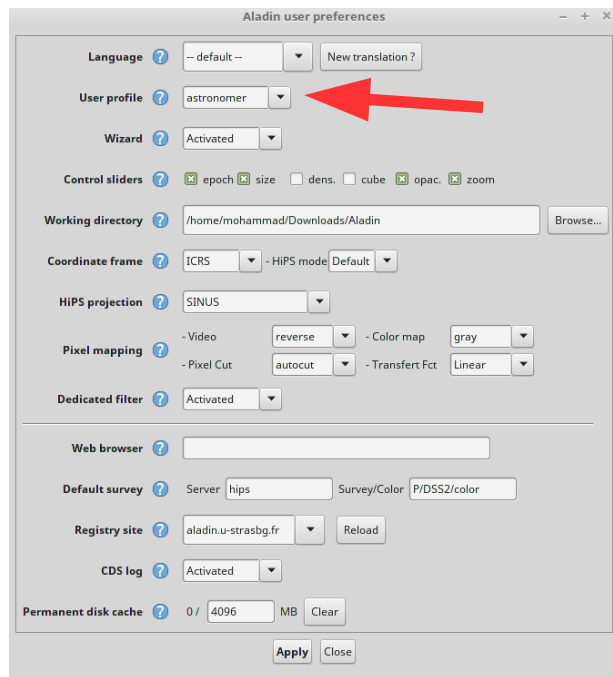
Note: If you don't have the softwares installed on your system, please see the instructions in page 17 of this file.

1- Open a terminal (Ctrl + Alt + T) and run Aladin with this command: `aladin&`
A window will be opened.

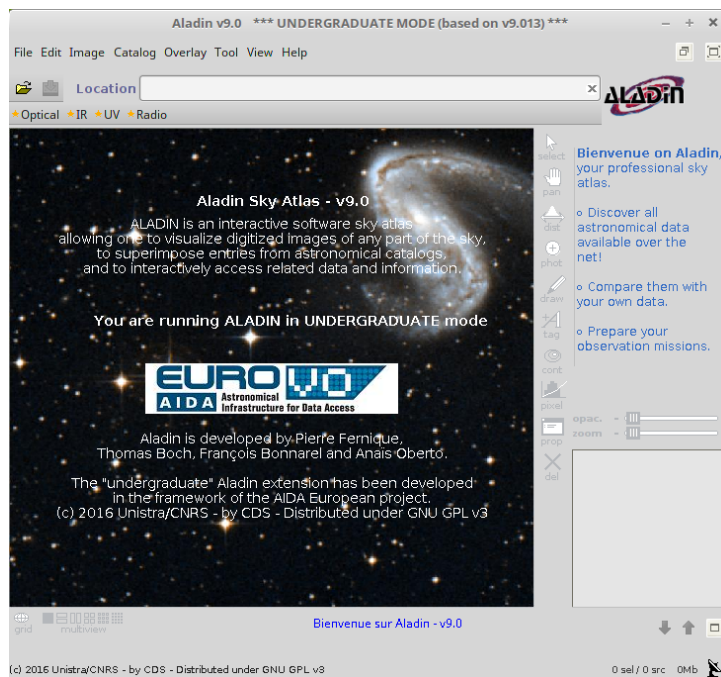


-
- 1- aladin.u-strasbg.fr
 - 2- www.star.bris.ac.uk/~mbt/topcat
 - 3- www.ivoa.net

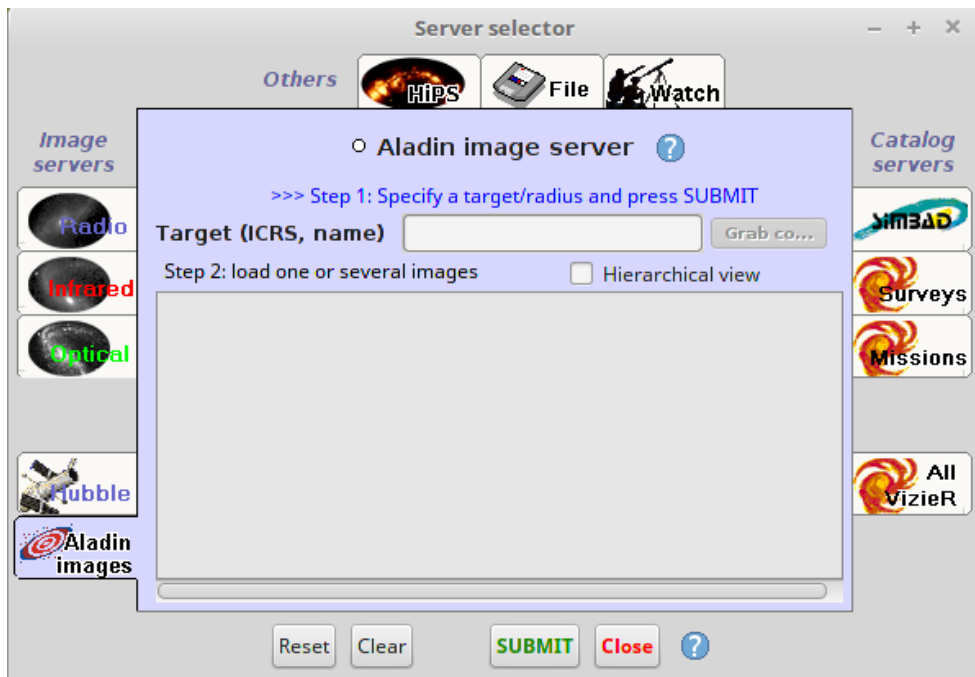
2- Go to **Edit** ---> **User preferences** and select “**User profile** ---> **Undergraduate**”. Restart Aladin.



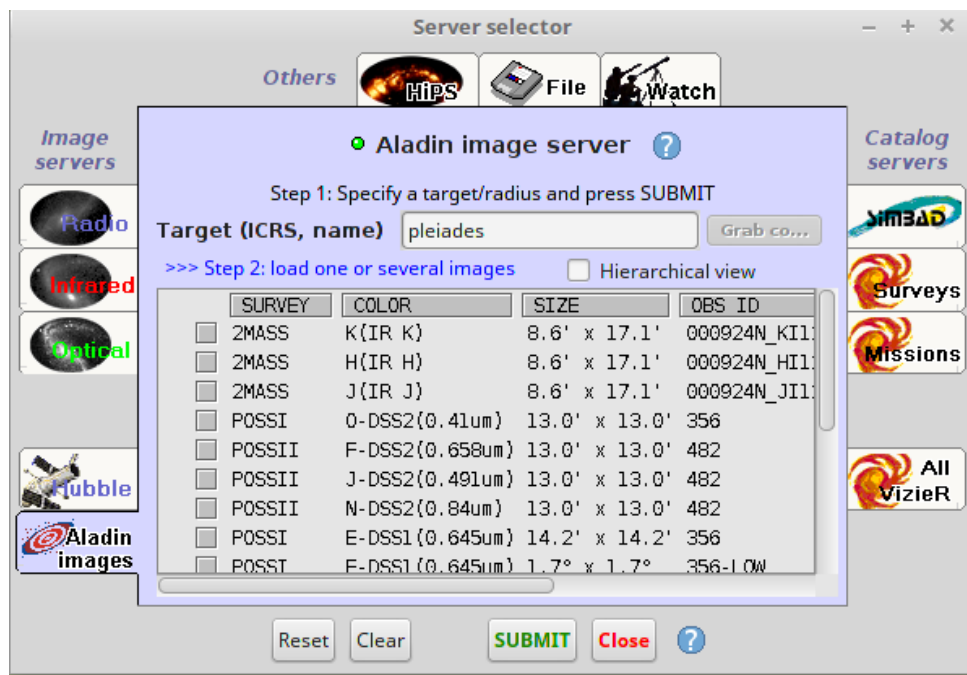
3- The new apparence will be like this:



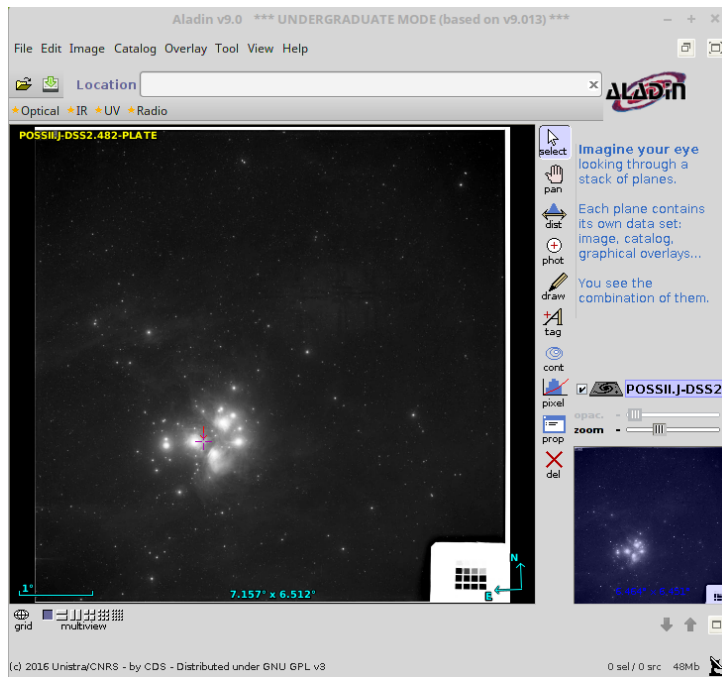
4- Go to File ---> Load astronomical image ---> Aladin image server



5- On the field “Target”, type 'pleiades', and then click on the SUBMIT button.



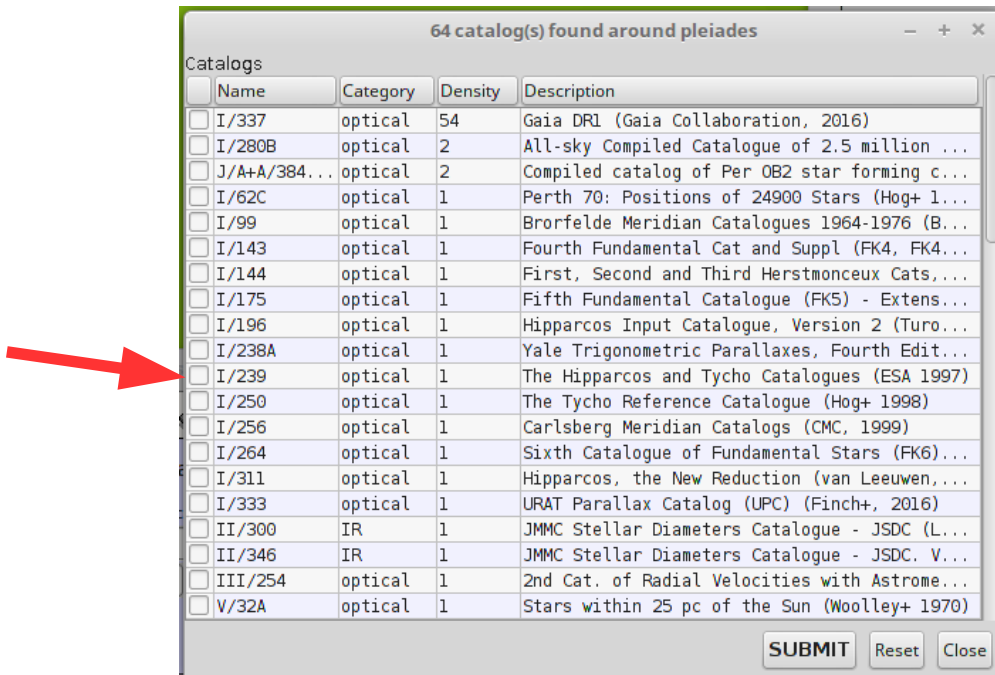
6- On the new window, select the item 'J-DSS2 (6.5° x 6.5°)' from the POSS II survey and click Submit. The image will be opened on the Aladin window.



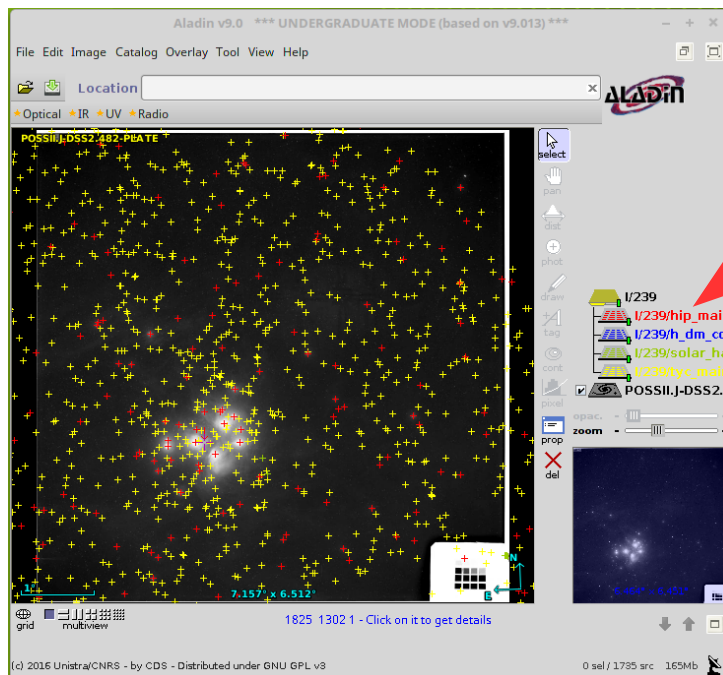
7- Go to **File** ---> **Load Catalog** ---> **VizieR**
A window will be opened.



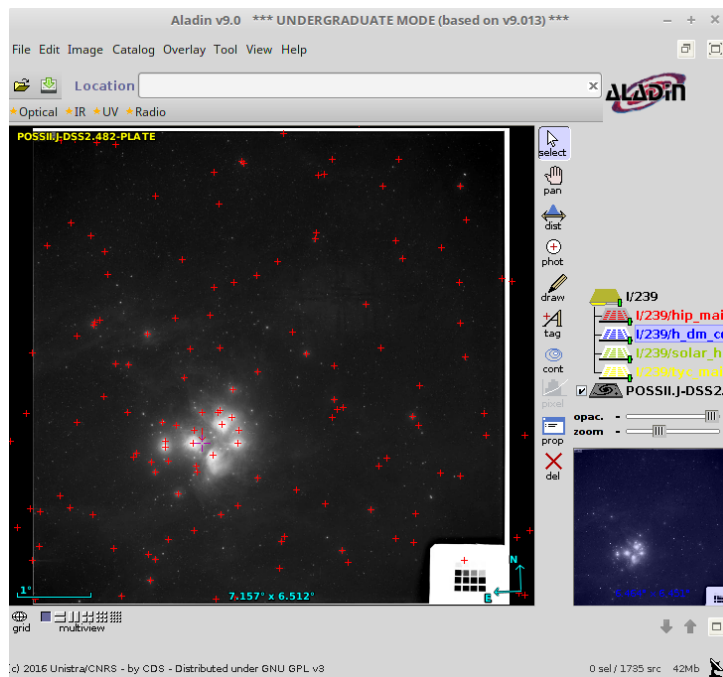
8- On the field “Author, free text”, type 'parallax', and on the field “Radius”, type '5 deg', and then click on SUBMIT. A new window will be opened.



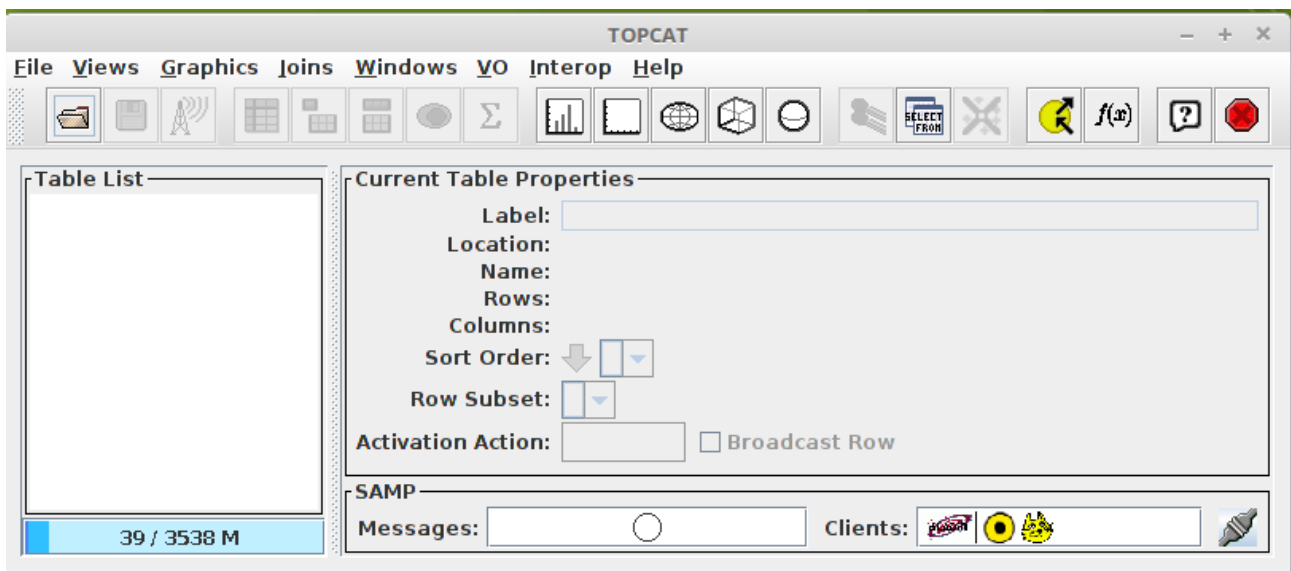
9- On the new window, select the item 'I/239' (it contains the parallaxes from the Hipparcos and Tycho Catalogues), and then click on SUBMIT. Points will be overlaid on the Pleiades image.



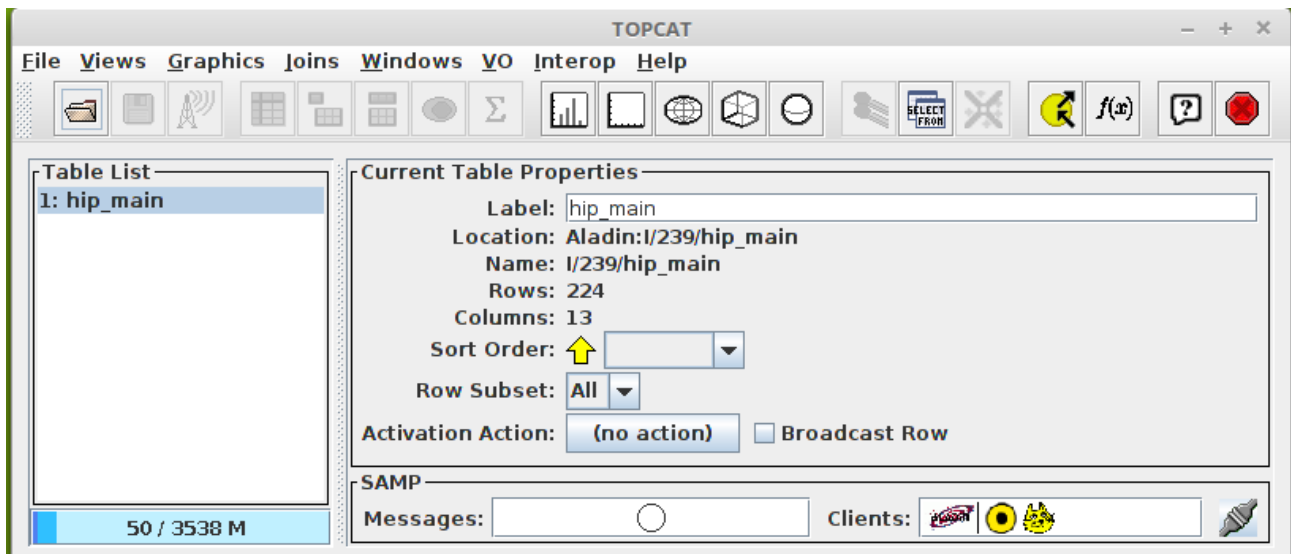
10- We will only use the data from Hipparcos, so go back to the main Aladin window, and deactivate the layers other than 'I/239/hip_main' (this is done by clicking their respective icons to toggle the layers on and off)



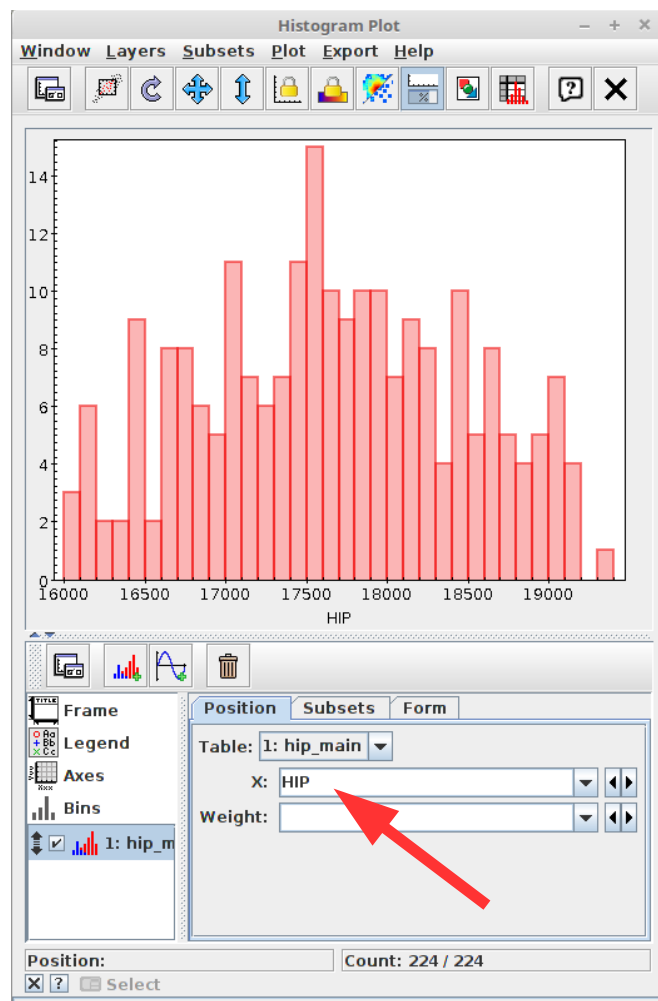
11- Open a terminal and run Topcat with this command: `topcat&`



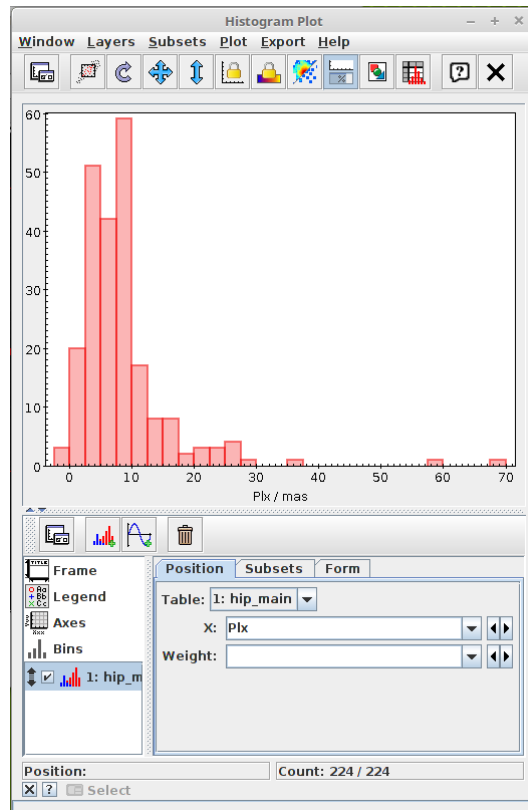
12- Go back to the Aladin main window, right-click the layer 'I/239/hip_main', and then click on 'Broadcast selected tables to... > topcat'.



13- Let's plot the histogram of the parallaxes of the stars in the field of Pleiades. Go to the TOPCAT window, and click on **Graphics > Histogram plot**.



14- Change “X” to 'Plx' (for parallax). You will notice that most stars have parallaxes between 0 and 20 mas (milli-arcsecond). Stars belonging to the Pleiades cluster are actually between 8 and 9 mas. The remaining stars are foreground (Plx < 8 mas) or background stars (Plx > 9 mas).



15- We will now correct for the reddening (extinction) of the cluster. First, go to the TOPCAT window and then Views ---> Column Info. We will add a column for corrected (B-V) color.

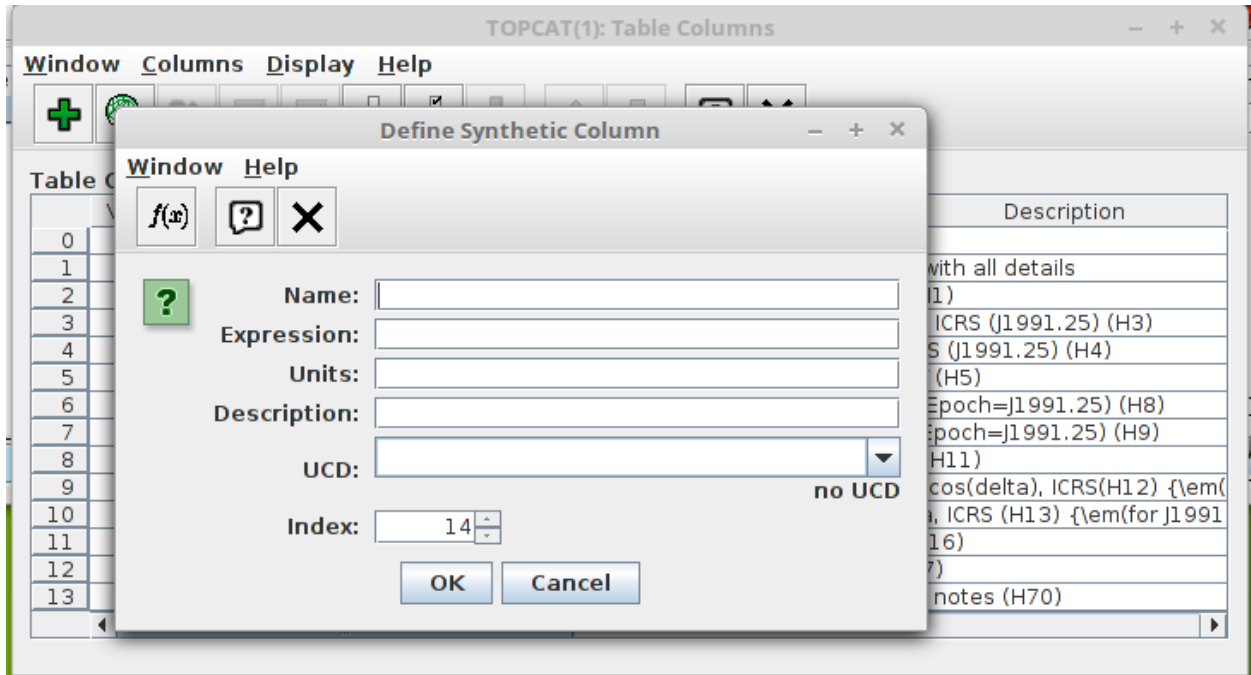
TOPCAT(1): Table Columns

Window Columns Display Help

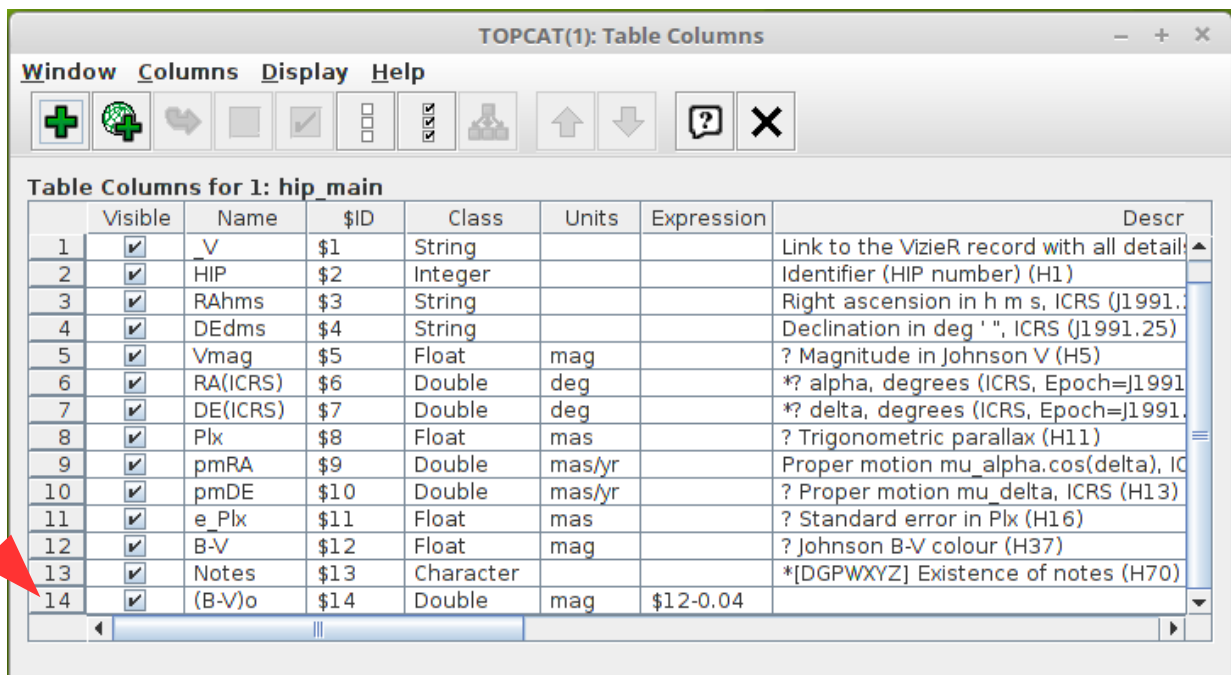
Table Columns for 1: hip_main

	Visible	Name	\$ID	Class	Units	Description
0	<input type="checkbox"/>	Index	\$0	Long		Table row index
1	<input checked="" type="checkbox"/>	_V	\$1	String		Link to the VizieR record with all details
2	<input checked="" type="checkbox"/>	HIP	\$2	Integer		Identifier (HIP number) (H1)
3	<input checked="" type="checkbox"/>	RAhms	\$3	String		Right ascension in h m s, ICRS (J1991.25) (H3)
4	<input checked="" type="checkbox"/>	DEdms	\$4	String		Declination in deg ' ", ICRS (J1991.25) (H4)
5	<input checked="" type="checkbox"/>	Vmag	\$5	Float	mag	? Magnitude in Johnson V (H5)
6	<input checked="" type="checkbox"/>	RA(ICRS)	\$6	Double	deg	*? alpha, degrees (ICRS, Epoch=J1991.25) (H8)
7	<input checked="" type="checkbox"/>	DE(ICRS)	\$7	Double	deg	*? delta, degrees (ICRS, Epoch=J1991.25) (H9)
8	<input checked="" type="checkbox"/>	Plx	\$8	Float	mas	? Trigonometric parallax (H11)
9	<input checked="" type="checkbox"/>	pmRA	\$9	Double	mas/yr	Proper motion mu_alpha.cos(delta), ICRS(H12) {\em(
10	<input checked="" type="checkbox"/>	pmDE	\$10	Double	mas/yr	? Proper motion mu_delta, ICRS (H13) {\em(for J1991
11	<input checked="" type="checkbox"/>	e_Plx	\$11	Float	mas	? Standard error in Plx (H16)
12	<input checked="" type="checkbox"/>	B-V	\$12	Float	mag	? Johnson B-V colour (H37)
13	<input checked="" type="checkbox"/>	Notes	\$13	Character		*[DGPWXYZ] Existence of notes (H70)

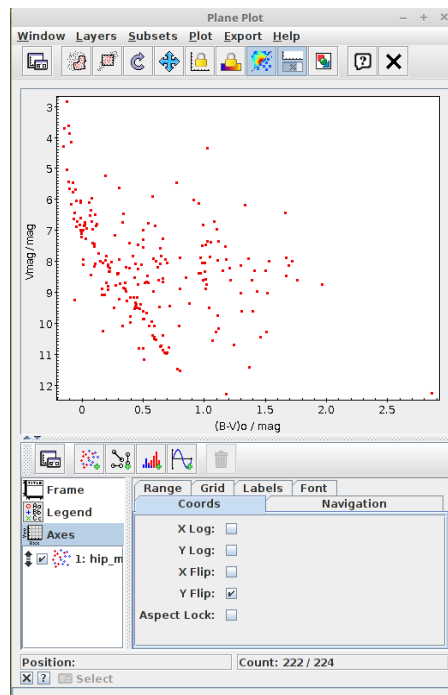
16- In the new window, go to the **Columns > New Synthetic Column**.



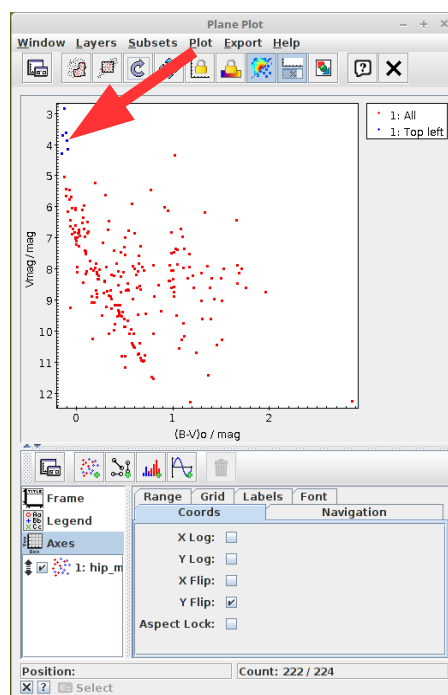
17- In the field “Name”, type '(B-V)o'. In the field “Expression”, we will put the values of (B-V) corrected for a reddening of -0.04 (value for the Pleiades cluster): this is done by typing '\$NUMBER - 0.04', where NUMBER = the number of the column (B-V) (you can check it on the TOPCAT: Table Column window). In the field “Units”, type 'mag' (for magnitudes). Then, click on OK. A new item will be added to the Table Column window.



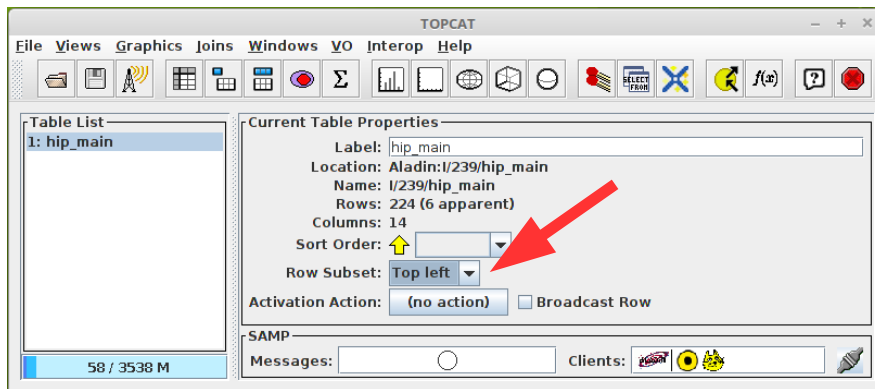
18- Now we will plot the color-magnitude diagram for our field of stars. This is done on the TOPCAT window. Go to **Graphics > Plane Plot**. On the new window, select '**(B-V)o**' for the X axis and '**Vmag**' for the Y-axis, then click on Axes on the list on the left, and select '**Y flip**'. You will clearly see the main sequence of the Pleiades cluster.



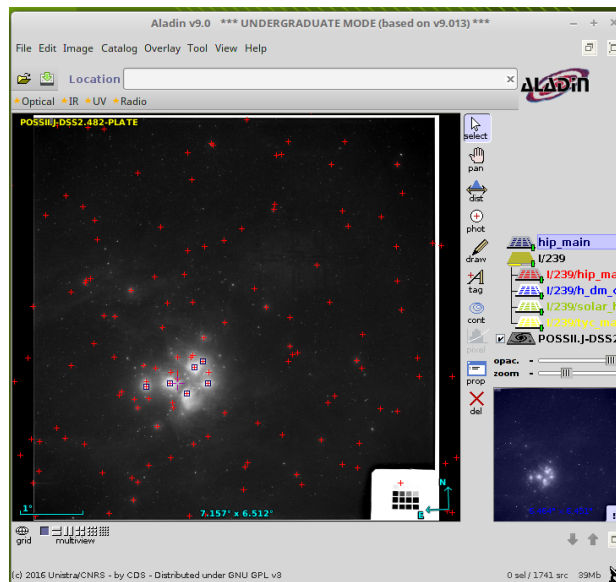
19- We can visualize a specific selection of stars from the CMD in the Aladin main window. In Plane Plot window, go to **Subsets > Draw subset region**. First, we will select only the stars on the top left region of the CMD. Draw a region that encircle these stars on the CMD plot, and then go to **Subsets > Finish Drawing Region**. On the “New Subset Name”, type '**Top left**' then click on “Add Subset”



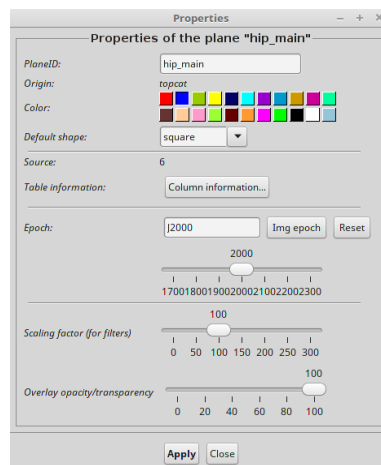
20- Now, go to the TOPCAT main window, and select the 'Top left' item on the “Row subset” list. Then go to **File > Send table to... > Aladin**.



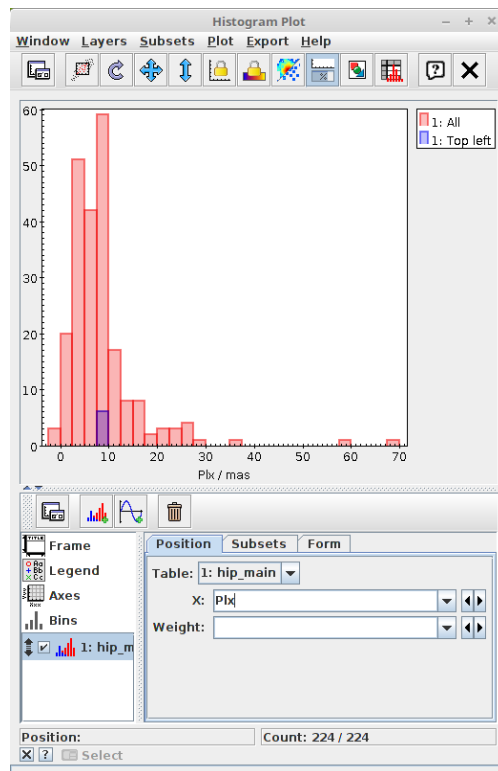
21- On the Aladin main window, you will see that a new layer was added.



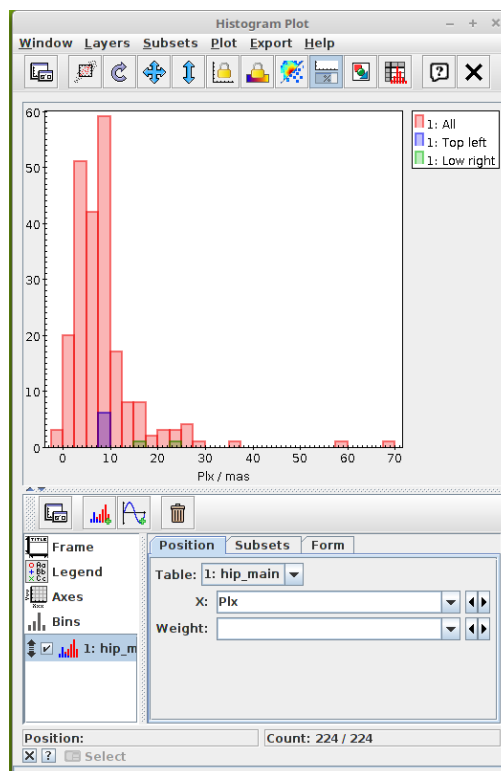
22- You can change its color to a more distinctive one by right-clicking the layer, going to **Properties...**, selecting the new desired color, and clicking on “Apply”. Notice that most stars on the top left of the CMD are the brightest one from the Pleiades cluster.



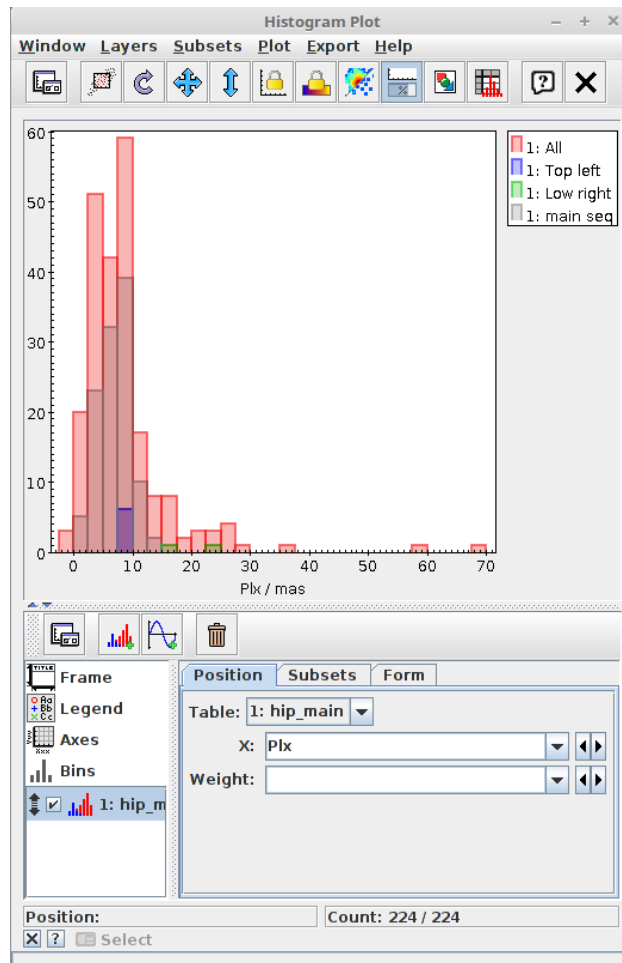
23- Go to the Histogram plot window, and you will also notice that the subset of stars you selected will be shown in the histogram of parallaxes.



24- Do the same you did for the top left region of the CMD, but instead this time do it for the lower right region. You will notice that the stars are mostly foreground stars that do not seem to be related to the Pleiades cluster.



25- Suggestion: do it for the main sequence too. Remember to check the histogram of parallaxes.



Question: How do you interpret the stars in the CMD showing $(B-V)_0 > 0.8$?

26- Repeat the process for different regions of the CMD.

Question: Which regions you think are best to derive the mean radial velocity of the cluster?

27- In TOPCAT, you can look at the values of the different subsets by selecting the subset name in the Main Window and double-clicking “hip_main” on the Table List.

TOPCAT(1): Table Browser

Window Subsets Help

Table Browser for 1: hip_main

	_V	HIP	RAhms	DEdms	Vmag	RA(ICRS)	DE(ICRS)	Plx
95	VizieR	17511	03 44 58.91	+22 01 57.2	9.49	56.24546	22.03256	10.
96	VizieR	17525	03 45 08.19	+26 17 33.5	11.49	56.28414	26.29263	13.35
97	VizieR	17527	03 45 09.73	+24 50 21.7	5.66	56.29053	24.83937	8.87
99	VizieR	17547	03 45 27.52	+28 40 07.8	7.41	56.36468	28.66883	8.27
100	VizieR	17552	03 45 31.98	+21 14 48.5	7.75	56.38323	21.24681	11.21
101	VizieR	17572	03 45 48.80	+23 08 50.1	6.85	56.45334	23.14726	9.68
103	VizieR	17579	03 45 54.46	+24 33 16.6	5.76	56.47693	24.55462	8.43
104	VizieR	17583	03 45 59.13	+25 23 55.3	8.04	56.49636	25.3987	8.5
105	VizieR	17588	03 46 02.89	+24 31 40.8	6.43	56.51203	24.52801	9.21
109	VizieR	17607	03 46 19.33	+20 52 47.6	11.54	56.58053	20.87989	4.16
113	VizieR	17625	03 46 34.82	+25 50 38.3	8.72	56.64507	25.84397	4.73
114	VizieR	17662	03 46 57.84	+28 40 47.7	8.68	56.74098	28.67993	2.74
115	VizieR	17664	03 46 59.38	+24 31 12.8	6.83	56.74743	24.52023	6.66
117	VizieR	17692	03 47 20.96	+23 48 12.4	6.99	56.83732	23.80345	8.35
118	VizieR	17694	03 47 22.88	+22 55 20.0	8.17	56.84535	22.92223	9.87
120	VizieR	17704	03 47 29.44	+24 17 18.4	6.83	56.87267	24.28845	9.05
121	VizieR	17729	03 47 46.82	+25 23 08.9	8.32	56.94509	25.38581	7.61
123	VizieR	17763	03 48 10.59	+21 19 44.8	7.97	57.04414	21.3291	11.94

28- In TOPCAT, click on the Main Window and go to Views ---> Column Statistics. It will show the statistics for the current selected subset.

TOPCAT

File Views Graphics Joins Windows VO Interop Help

TOPCAT(1): Row Statistics

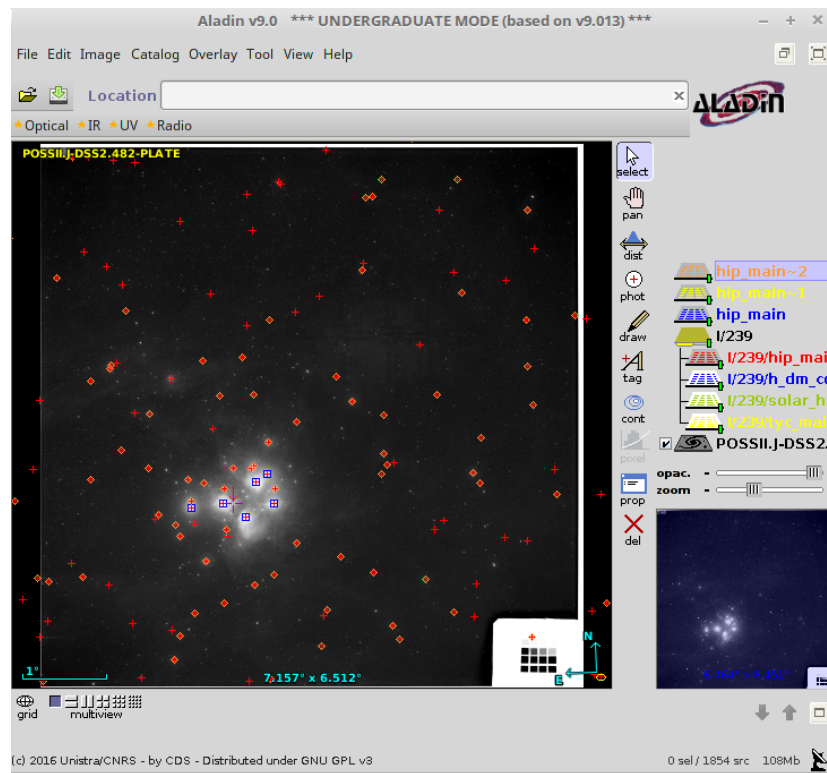
Window Export Statistics Display Help

Row Statistics for 1: hip_main

Name	Mean	SD	Minimum	Maximum	nGood
_V			VizieR	VizieR	111
HIP	17533.	701.107	16072	19182	111
RAhms			03 26 59.61	04 06 41.42	111
DEdms			+19 15 15.7	+28 47 09.5	111
Vmag	8.3409	1.56917	5.05	11.54	111
RA(ICRS)	56.3262	2.20225	51.74836	61.67259	111
DE(ICRS)	24.0597	2.37642	19.25436	28.78597	111
Plx	6.91595	2.61405	1.09	13.39	111
pmRA	16.7322	26.806	-34.27	262.7	111
pmDE	-35.3681	33.6017	-342.88	5.06	111
e_Plx	1.5636	0.933807	0.83	6.98	111
B-V	0.296027	0.23997	-0.082	0.843	111
Notes				P	111
(B-V)o	0.256027	0.23997	-0.122	0.803	111

Subset for calculations: main seq

29- Final view on Aladin:

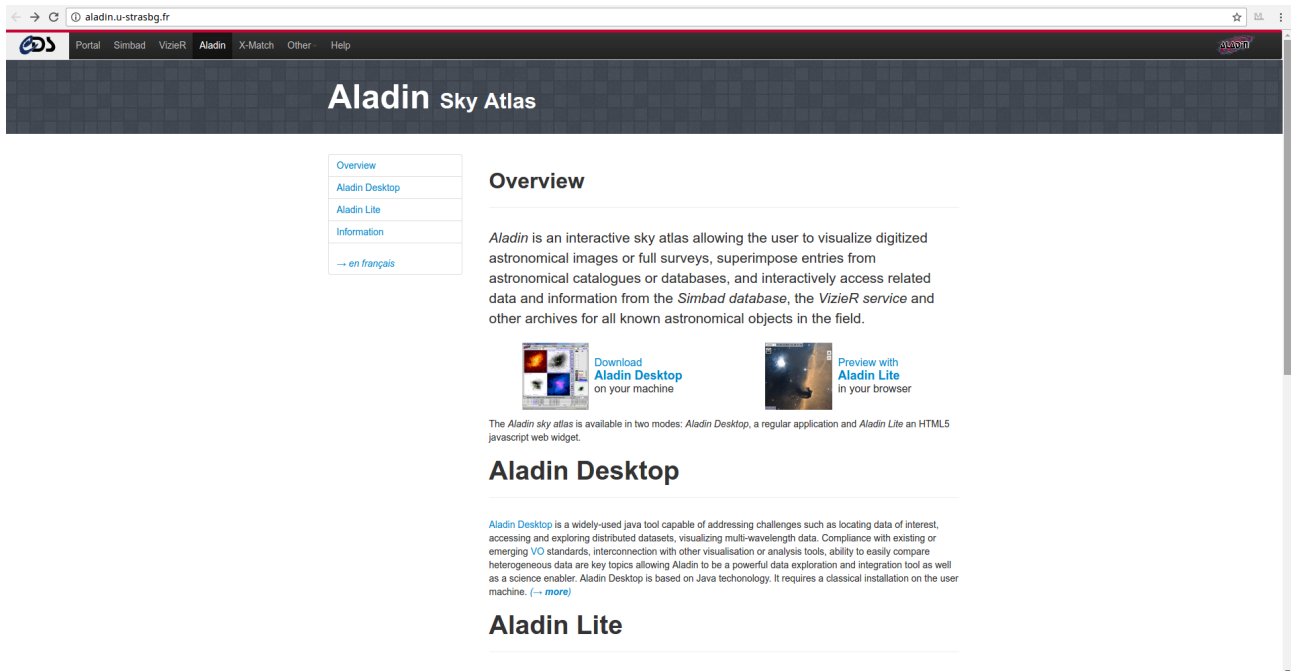


Question: What is your estimate of the mean parallax Pleiades clusters? Which subset you choose to derive this mean? (explain your choice)

Question: What about radial velocities? Use what you have learned to estimate of the mean radial velocity of the cluster.

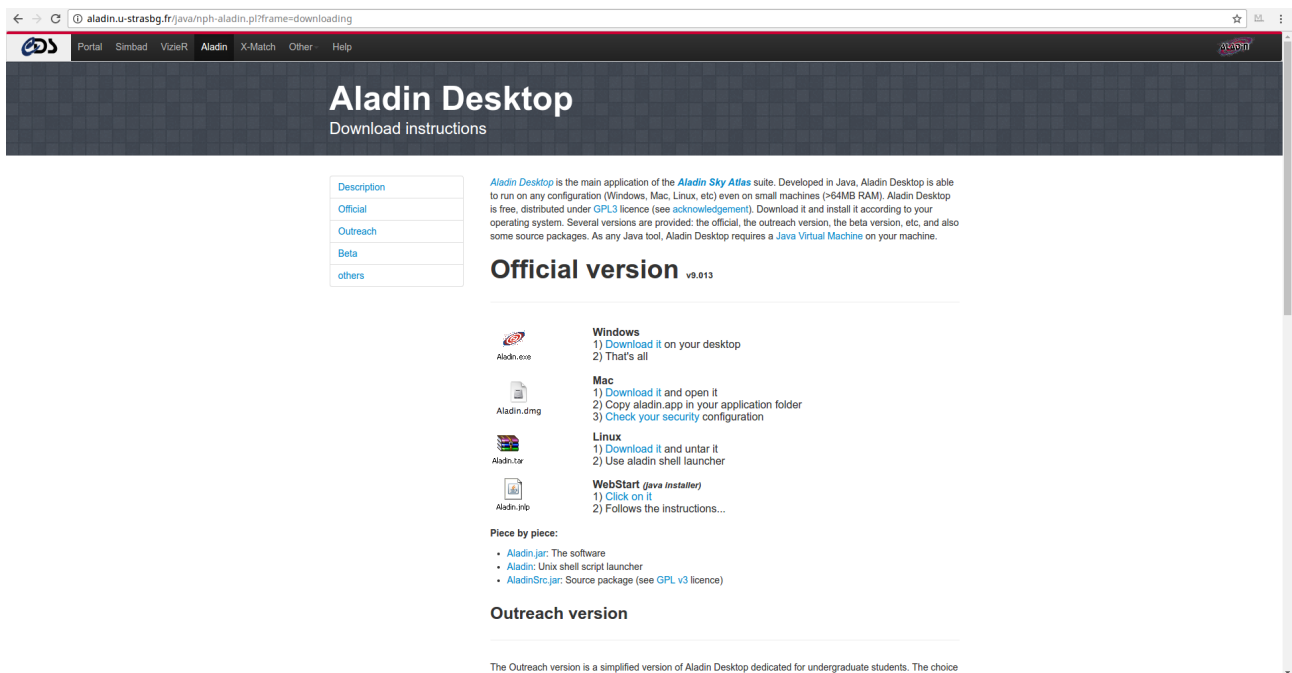
Download and Installing Aladin and Topcat:

1- Go to the website: aladin.u-strasbg.fr



The screenshot shows the homepage of the Aladin sky Atlas. The page has a dark header with the Aladin logo and navigation links: Portal, Simbad, Vizier, Aladin, X-Match, Other, and Help. The main content area is titled "Aladin sky Atlas" and features a sidebar with links to Overview, Aladin Desktop, Aladin Lite, Information, and a language switch to French. The main text under "Overview" describes Aladin as an interactive sky atlas for visualizing astronomical data. It includes two buttons: "Download Aladin Desktop on your machine" and "Preview with Aladin Lite in your browser". A note mentions that Aladin is available in two modes: Aladin Desktop and Aladin Lite. Below this, there are sections for "Aladin Desktop" and "Aladin Lite", each with a brief description of their capabilities.

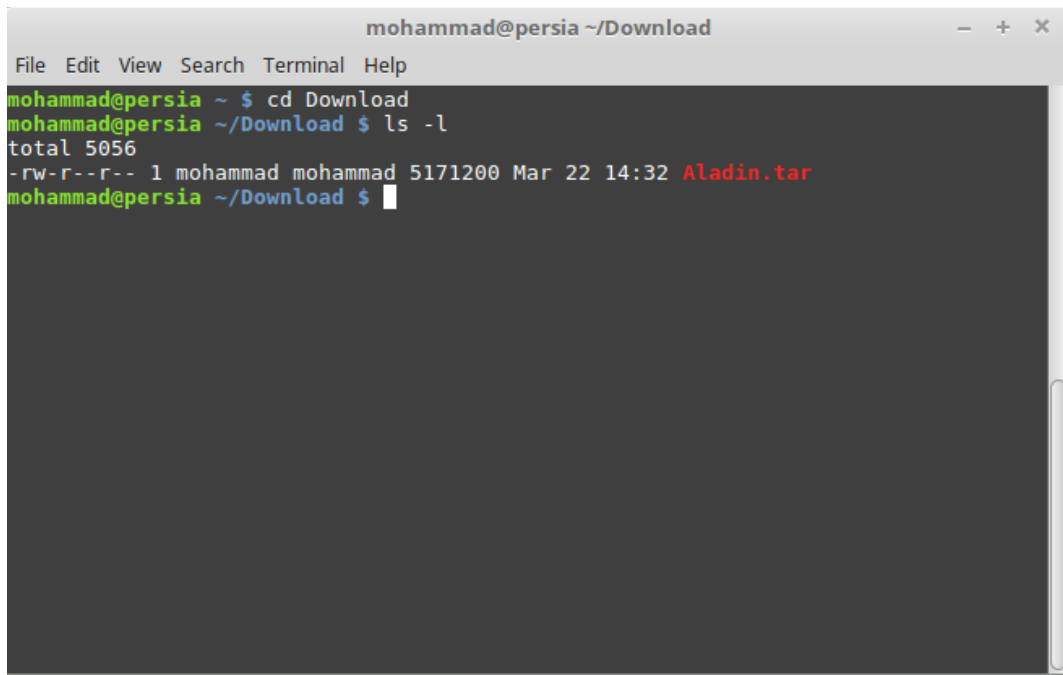
2- Click on “Download Aladin Desktop”



The screenshot shows the "Aladin Desktop" download instructions page. The header includes the Aladin logo and navigation links. The main heading is "Aladin Desktop" with the subtitle "Download instructions". A sidebar on the left contains links for Description, Official, Outreach, Beta, and others. The main content area starts with a paragraph explaining that Aladin Desktop is the main application of the Aladin Sky Atlas suite, developed in Java, and is free under GPL 3 license. It then lists the "Official version v8.013" with instructions for Windows, Mac, Linux, and WebStart (Java installer). Below this, it lists the "Outreach version" as a simplified version for undergraduate students.

3- Download your desired version according to your operating system. I do for “Linux”.

4- Open a terminal (Ctrl + Alt + T) and go to the directory where you saved the file. If you list the files you will find a file named “Aladin.tar”

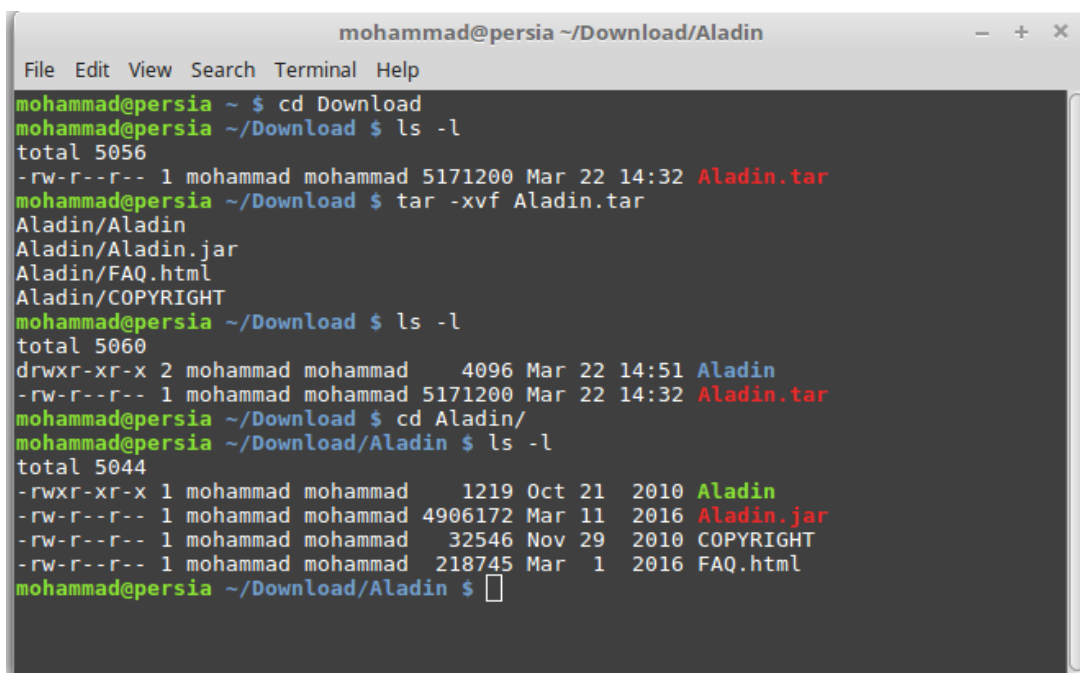


```
mohammad@persia ~/Download
File Edit View Search Terminal Help
mohammad@persia ~ $ cd Download
mohammad@persia ~/Download $ ls -l
total 5056
-rw-r--r-- 1 mohammad mohammad 5171200 Mar 22 14:32 Aladin.tar
mohammad@persia ~/Download $
```

5- Extract Aladin.tar (command: tar -xvf Aladin.tar), then you will have a folder named “Aladin” containing four files:

“Aladin”, “Aladin.jar”, “COPYRIGHT”, “FAQ.html”

where Aladin is an executable file.



```
mohammad@persia ~/Download/Aladin
File Edit View Search Terminal Help
mohammad@persia ~ $ cd Download
mohammad@persia ~/Download $ ls -l
total 5056
-rw-r--r-- 1 mohammad mohammad 5171200 Mar 22 14:32 Aladin.tar
mohammad@persia ~/Download $ tar -xvf Aladin.tar
Aladin/Aladin
Aladin/Aladin.jar
Aladin/FAQ.html
Aladin/COPYRIGHT
mohammad@persia ~/Download $ ls -l
total 5060
drwxr-xr-x 2 mohammad mohammad 4096 Mar 22 14:51 Aladin
-rw-r--r-- 1 mohammad mohammad 5171200 Mar 22 14:32 Aladin.tar
mohammad@persia ~/Download $ cd Aladin/
mohammad@persia ~/Download/Aladin $ ls -l
total 5044
-rwxr-xr-x 1 mohammad mohammad 1219 Oct 21 2010 Aladin
-rw-r--r-- 1 mohammad mohammad 4906172 Mar 11 2016 Aladin.jar
-rw-r--r-- 1 mohammad mohammad 32546 Nov 29 2010 COPYRIGHT
-rw-r--r-- 1 mohammad mohammad 218745 Mar 1 2016 FAQ.html
mohammad@persia ~/Download/Aladin $
```

6- Go to the website: www.star.bris.ac.uk/~mbt/topcat

www.star.bris.ac.uk/~mbt/topcat

TOPCAT

Tool for **O**perations on **C**atalogues **A**nd **T**ables

Does what you want with tables

Latest (see [Version History](#) for details)
Version 4.4 released 8 March 2017

New: More visualisation options
New plot forms introduced: [Grid](#) can plot weighted 2-d histograms/density maps. [Quantile](#) can draw median lines through noisy data (and more). [Gaussian](#) can fit a Gaussian to histogram-like data.

New: Free colour chooser
You can now choose any RGB colour using a flexible chooser widget.

New: Better visualisation documentation
All plot [forms](#) and [shading modes](#) are now documented with example screenshots.

- [What is TOPCAT?](#)
- [Features](#)
- [Screenshots](#)
- [Documentation](#)
- [Frequently Asked Questions](#)
- [Mailing Lists](#)
- [Downloads](#)
- [Jar File](#)
- [WebStart](#)
- [StarJava](#)
- [MacOS X](#)
- [Version history](#) — Version 4.4 released 8 March 2017
- [Further information](#)

What is TOPCAT?

TOPCAT is an interactive graphical viewer and editor for tabular data. Its aim is to provide most of the facilities that astronomers need for analysis and manipulation of source catalogues and other tables, though it can be used for non-astronomical data as well. It understands a number of different astronomically important formats (including FITS, VOTable and CDF) and more formats can be added.

It offers a variety of ways to view and analyse tables, including a browser for the cell data themselves, viewers for information about table and column metadata, and facilities for sophisticated interactive 1-, 2-, 3- and higher-dimensional visualisation, calculating statistics and joining tables using flexible matching algorithms. Using a powerful and extensible Java-based expression language new columns can be defined and row subsets selected for separate analysis. Table data and metadata can be edited and the resulting modified table can be written out in a wide range of output formats.

It is a stand-alone application which works quite happily with no network connection. However, because it uses Virtual Observatory (VO) standards, it can cooperate smoothly with other tools, services and datasets in the VO world and beyond.

The program is written in pure Java and available under the GNU [General Public Licence](#), though some of the library code is LGPL. It has been developed mostly in the UK within various UK and Euro-VO projects (Starlink, AstroGrid, VOTech, AIDA, GAVO, GENIUS, DPAC) and under

7- Click on “Downloads”

www.star.bris.ac.uk/~mbt/topcat/#install

Downloads

TOPCAT is written in the Java language using the Java 2 Standard Edition version 6, and should run on any Java SE 6 or more recent system. This means it can be run on a wide range of platforms, without requiring any recompilation - you just need to ensure that you have a suitable Java Runtime Environment (JRE). If you don't have Java installed, or have an unsuitable version, you can obtain the Java SE for Linux, Mac OS X, MS Windows and Solaris from [Oracle's web site](#) (you only need the "JRE" rather than the "JDK" download, unless you will be doing development work). Java SE Runtime Environments (sometimes called JVMs or Java Virtual Machines) for other platforms may be available from operating system vendors.

Note: Various open-source Java implementations (GNU's g1, OpenJDK-based implementations), sometimes bundled with Linux distributions, have not always worked well, at least historically, though OpenJDK seems to be a lot better recently. If you have one of these (try `java -version` to find out) and are experiencing trouble with TOPCAT, you are advised to get the Oracle implementation instead.

Having got Java, there are several ways to download TOPCAT, described in rough order of advisability in the following subsections. More information on how to run the program having obtained it can be found in SUN/253's section on [Invoking TOPCAT](#).

Standalone Jar File

The most convenient form for downloading is to pick up a single Jar file containing the required classes:

- [topcat-full.jar](#) (29.0M) - core facilities plus some optional extras
- [topcat-lite.jar](#) (22.4M) - core facilities

(Note: if you try to download these directly your browser may say something about a failed security check. Make sure that you save it to a file, for instance by right-clicking in Firefox).

On Unix-like operating systems, download one or other of these jar files and the startup script `topcat` into the same directory, then `chmod +x topcat`, and you can just run the command:

```
topcat
```

On non-Unix systems the script won't work, and you can use a command like:

```
java -jar topcat-*.jar
```

or invoke it in some other system-dependent way such as by clicking on it.

For many users, `topcat-lite` will provide all the features they need. The optional extras provided by `topcat-full` include:

- Treeview-like hierarchy browsing
- SoG image viewer (though you still need [JAI](#) for it to work)
- MySpace and SRB remote file browsing for table load/save

Even `topcat-full` lacks a few of the niche features (proper coordinate handling in SoG, NDF viewing in hierarchy view), since these require native libraries; for these you will need the Full StarJava installation described below.

WebStart

[WebStart](#) is a Java technology which enables one-click download, installation, updating and invocation of Java applications over the web. If you have Java's WebStart installed, you can install and invoke TOPCAT in one click from one of the following links:

- Webstart invocation: [topcat-full](#) (29.0M), [topcat-lite](#) (22.4M)

See the comments in the previous item for the difference between `topcat-lite` and `topcat-full`.

MacOS X

If you have an Apple Mac, you can pick up the following for easy installation:

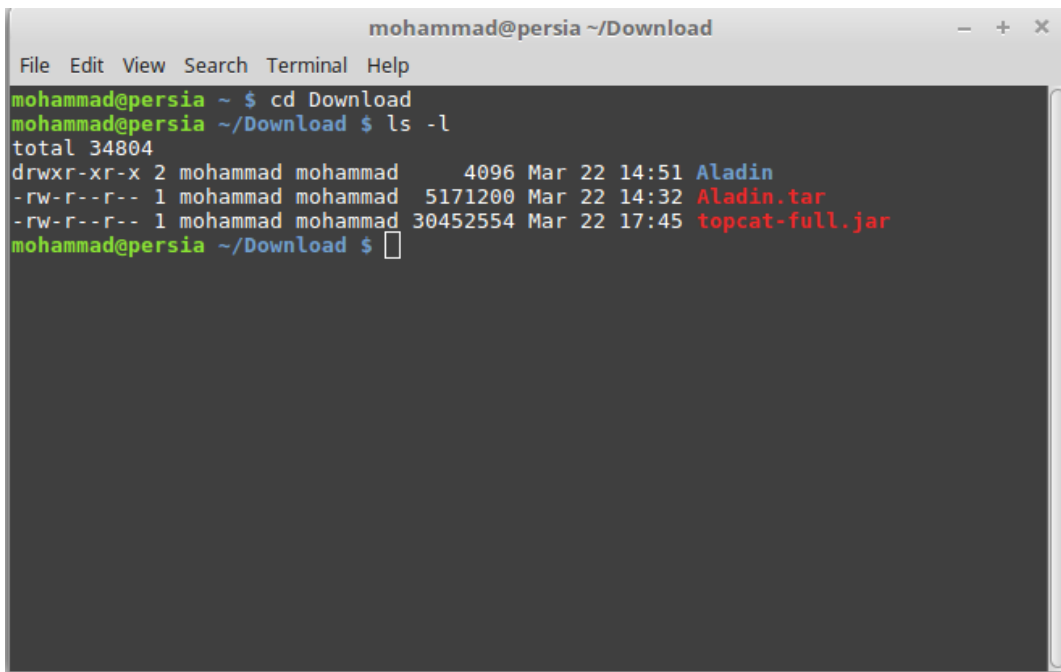
- [topcat-full.dmg](#) (35.2M)

A couple of FAQ entries are relevant: [how to set flags for memory usage etc](#) and [problem with "damaged" dmg file](#).

Full StarJava Installation

8- Select the desired version to download. I downloaded the first one.

9- Open a terminal (Ctrl + Alt + T) and go to the directory where you saved the file. If you list the files you will find a file named “`topcat-full.jar`”.



```
mohammad@persia ~/Download
File Edit View Search Terminal Help
mohammad@persia ~ $ cd Download
mohammad@persia ~/Download $ ls -l
total 34804
drwxr-xr-x 2 mohammad mohammad  4096 Mar 22 14:51 Aladin
-rw-r--r-- 1 mohammad mohammad 5171200 Mar 22 14:32 Aladin.tar
-rw-r--r-- 1 mohammad mohammad 30452554 Mar 22 17:45 topcat-full.jar
mohammad@persia ~/Download $
```