Astrofísica Galáctica e Extragaláctica (2017)

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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

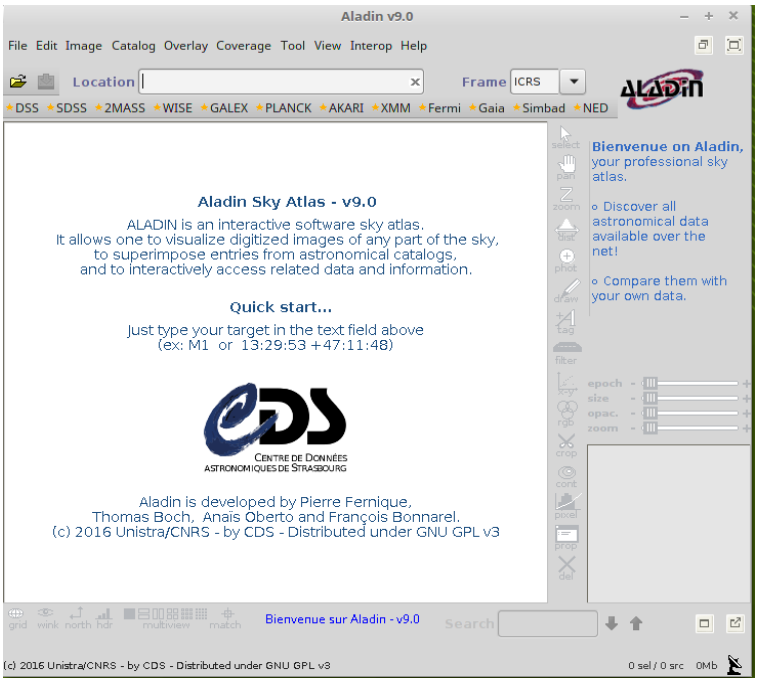
http://quiwi2.u-strasbg.fr/pub/fc/workflows/Pleiades.html

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. Aladin[1] is a software to retrieve and visualize astronomical images. Topcat[2] is an interactive graphical viewer and editor for tabular data. These tools can query and access astronomical data through technologies of the Virtual Observatory[3].

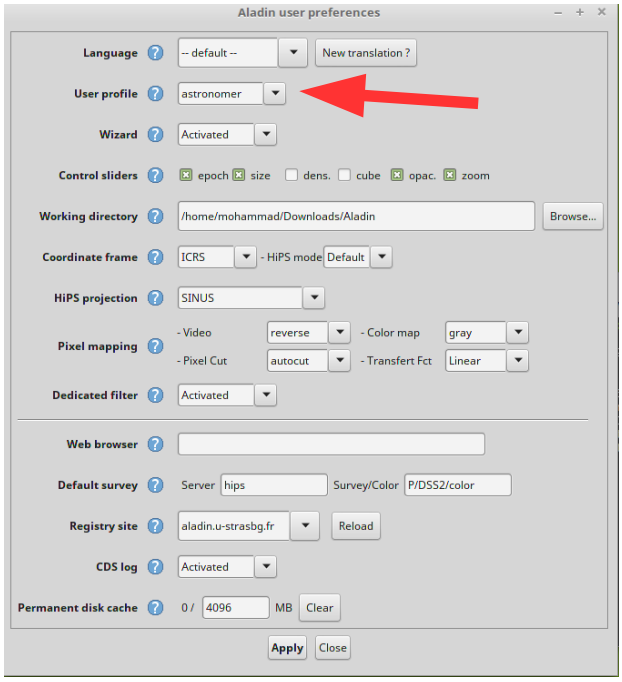
Note: If you don't have the softwares installed on your system, please see the instructions in page 17 of this file.

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



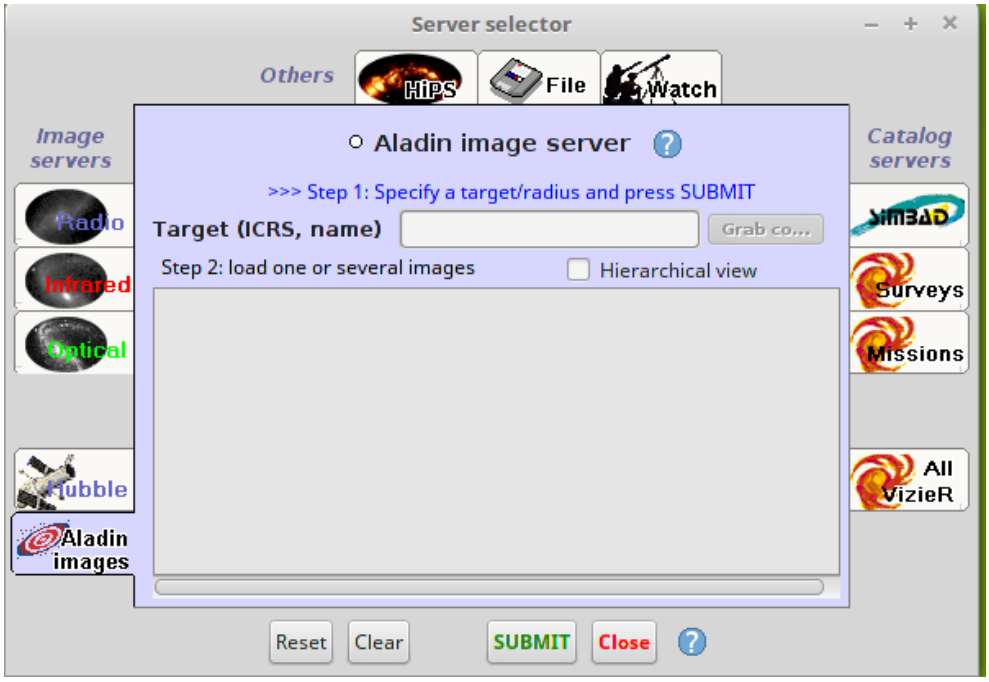
1- aladin.u-strasbg.fr
2- www.star.bris.ac.uk/~mbt/topcat
3- www.ivoa.net

2- Go to Edit ---> User preferences and select "User profile ---> Undergraduate". Restart Aladin.

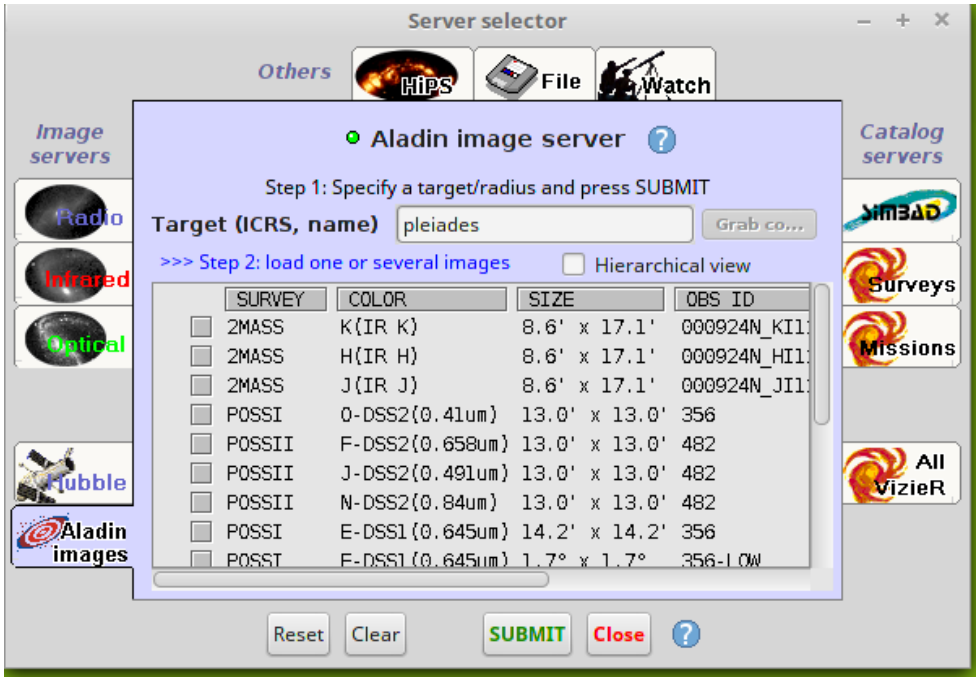


3- The new apparence will be like this:

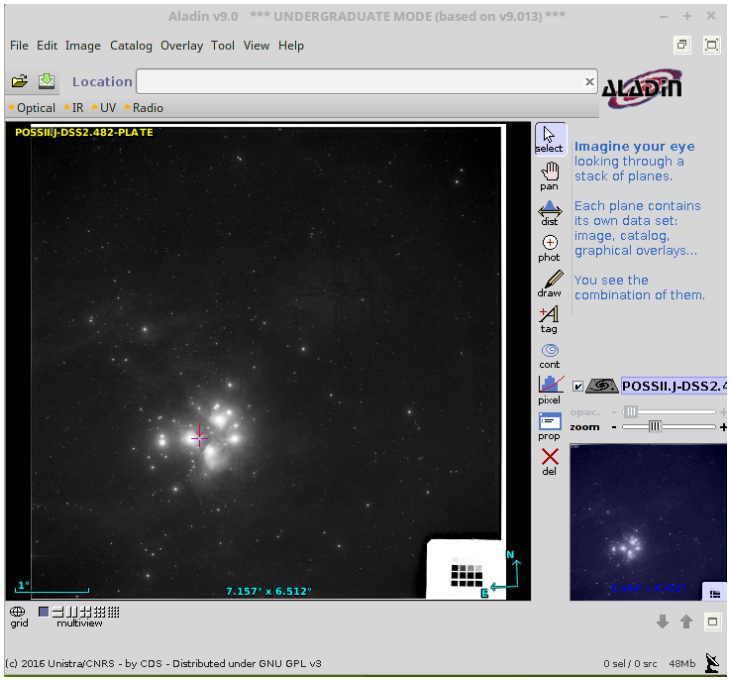
4- Go to File ---> Load astronomical image ---> Aladin image server



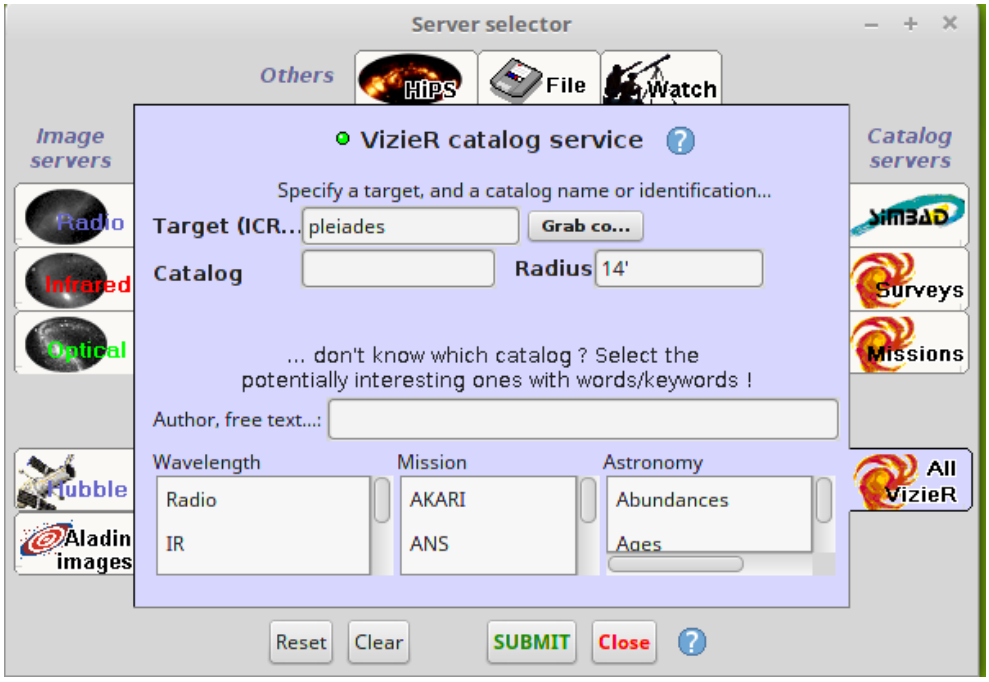
5- On the field “Target”, type '`pleiades`', and then click on the SUBMIT button.



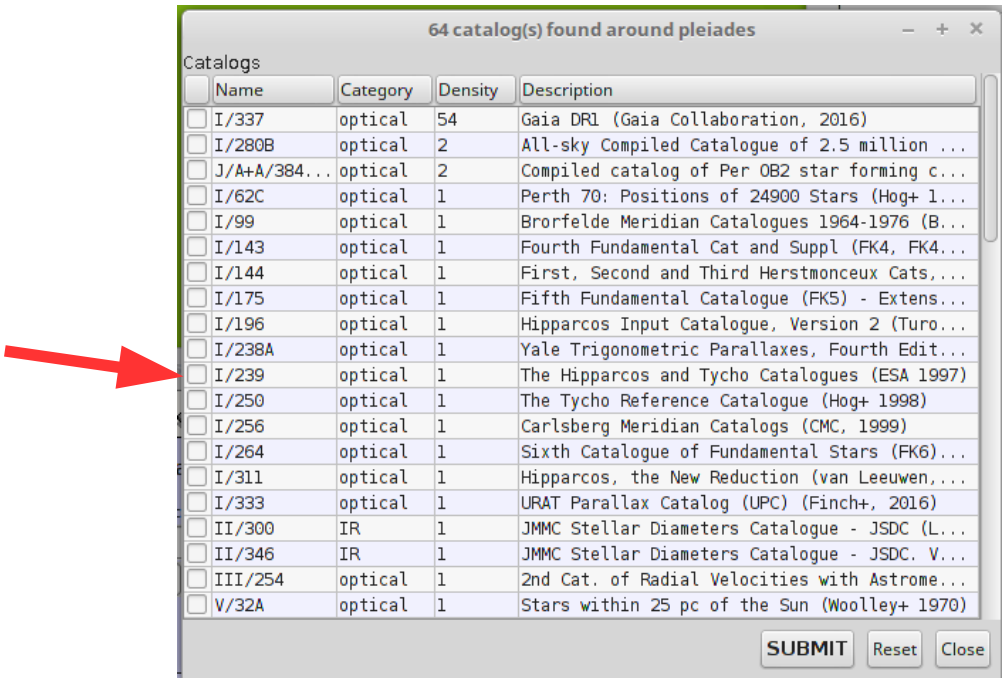
6- On the new window, select the item 'J-DSS2 (6.5º x 6.5º)' from the POSS II survey and click Submit. The image will be opened on the Aladin window.



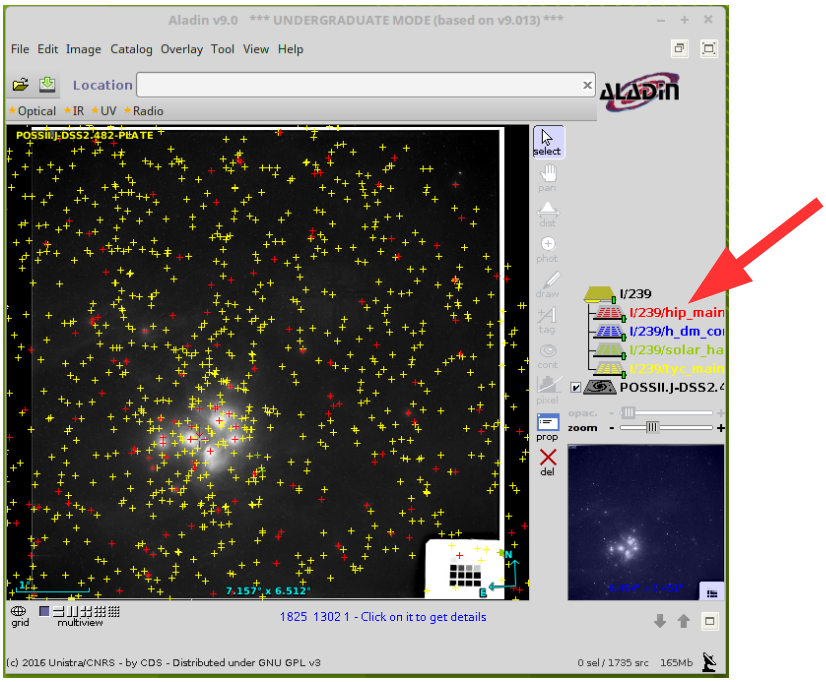
7- Go to File ---> Load Catalog ---> Vizier
A window will be opened.



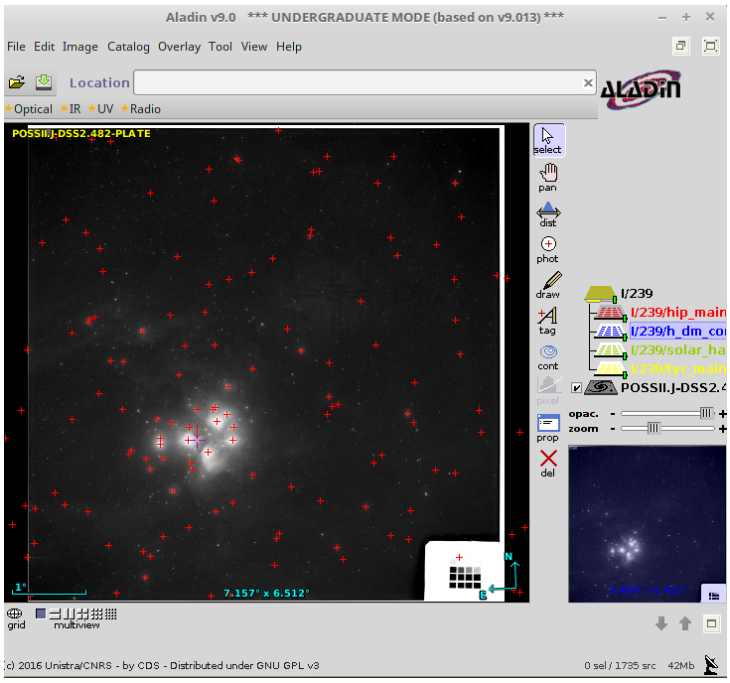
8- On the field “Author, free text”, type '`parallax`', and on the field “Radius”, type '`5 deg`', and then click on SUBMIT. A new window will be opened.



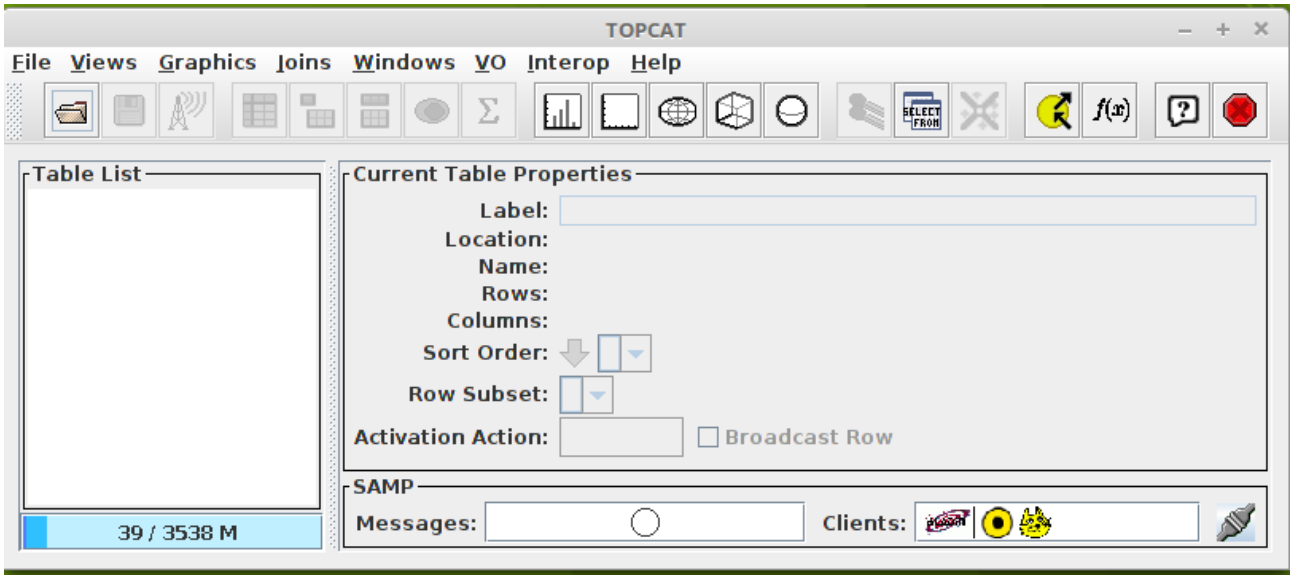
9- On the new window, select the item 'I/239' (it contains the parallaxes from the Hipparcos and Tycho Catalogues), and then click on SUBMIT. Points will be overlaid on the Pleiades image.



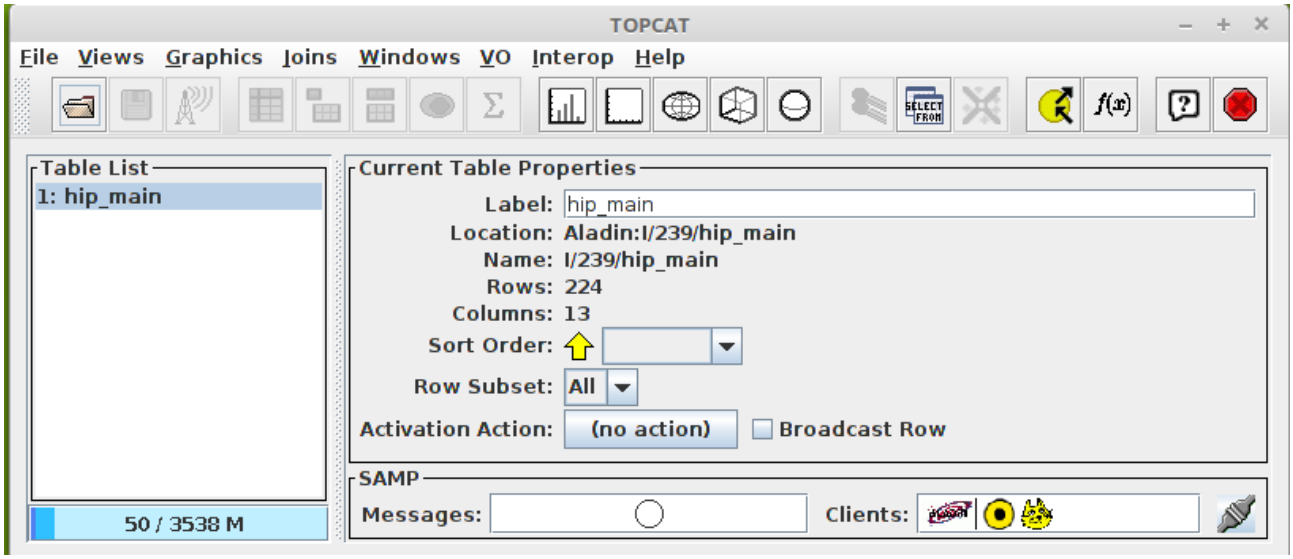
10- We will only use the data from Hipparcos, so go back to the main Aladin window, and deactivate the layers other than 'I/239/hip_main' (this is done by clicking their respective icons to toggle the layers on and off)



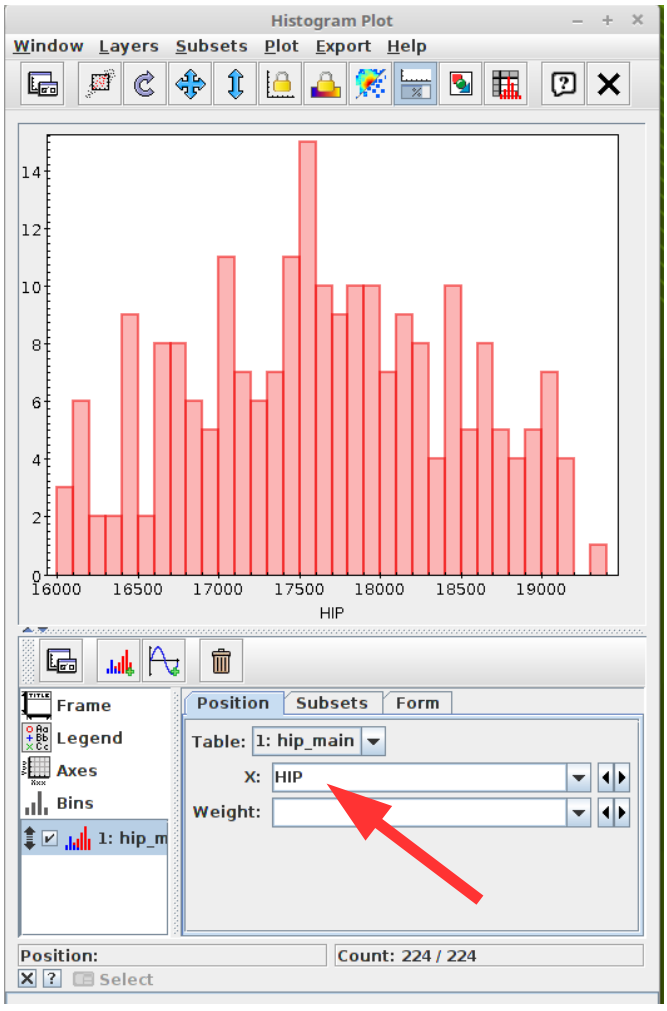
11- Open a terminal and run Topcat with this command: `topcat&`



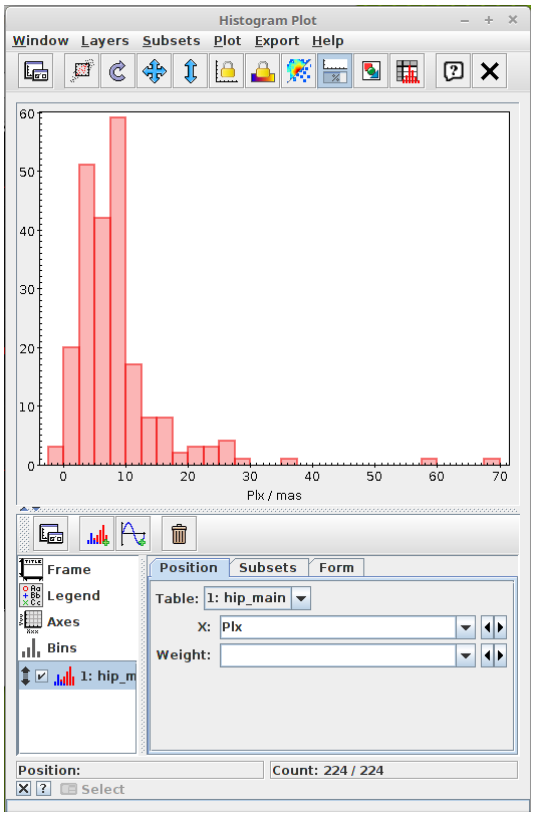
12- Go back to the Aladin main window, right-click the layer 'I/239/hip_main', and then click on 'Broadcast selected tables to… > topcat'.



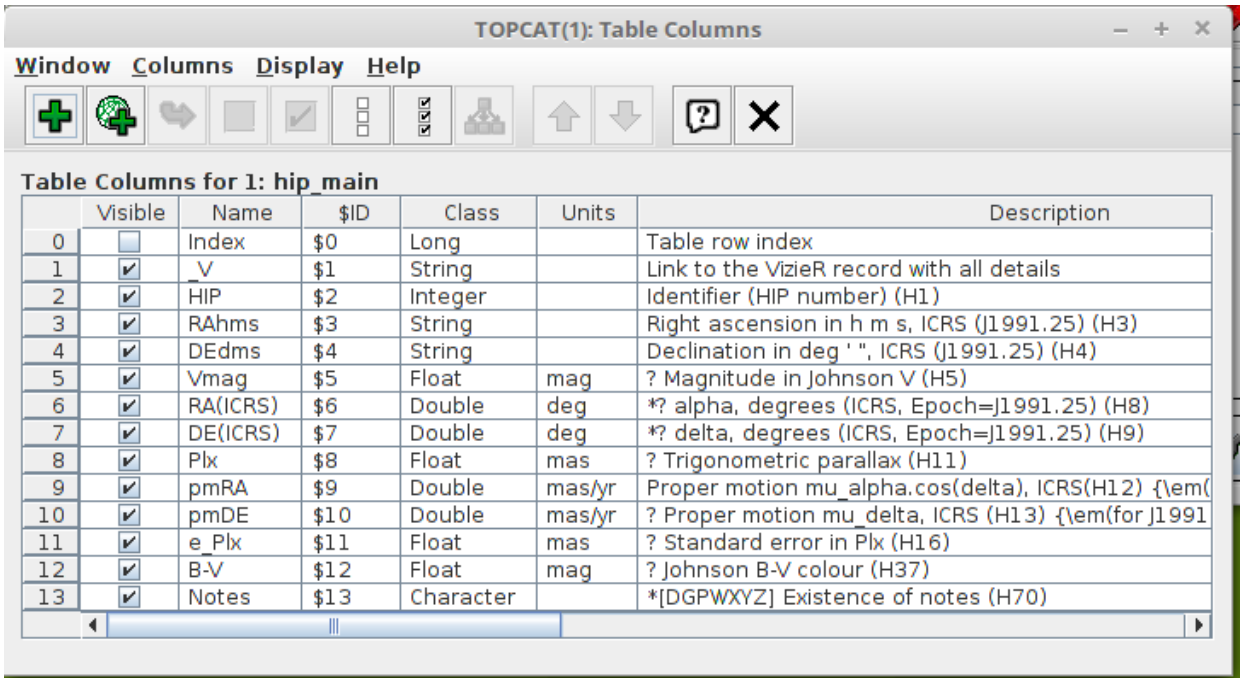
13- Let's plot the histogram of the parallaxes of the stars in the field of Pleiades. Go to the TOPCAT window, and click on Graphics > Histogram plot.



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).

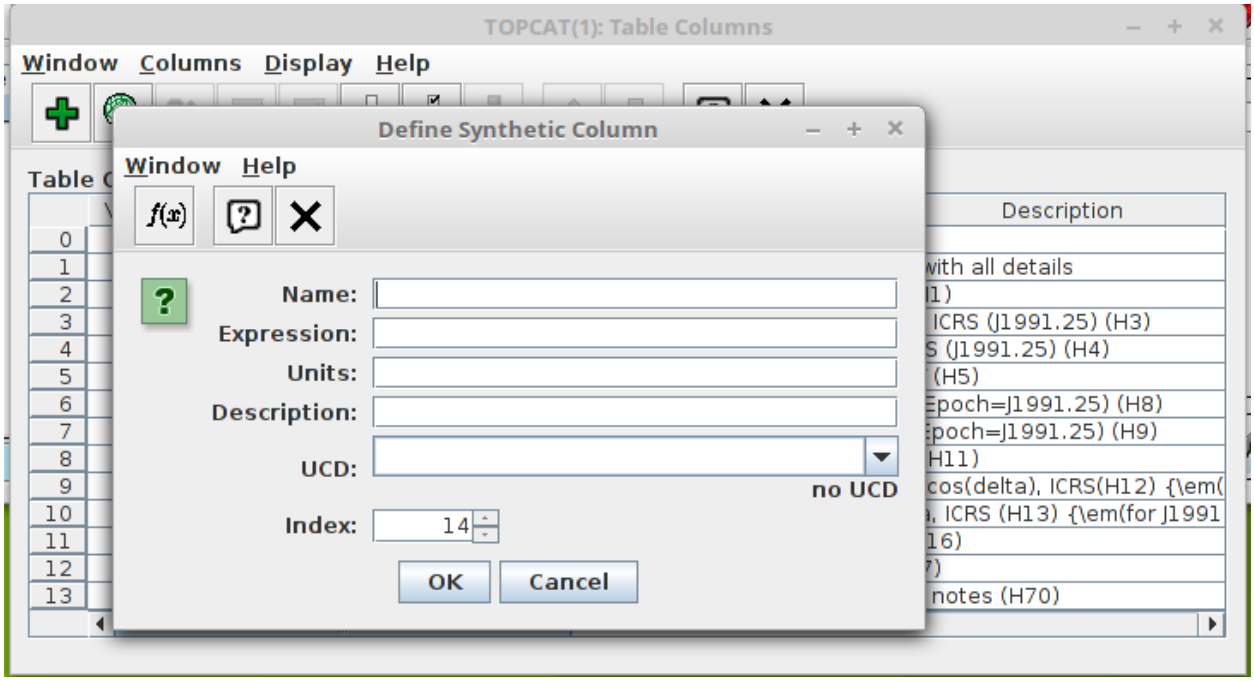


15- We will now correct for the reddening (extinction) of the cluster. First, go to the TOPCAT window and then Views ---> Column Info. We will add a column for corrected (B-V) color.

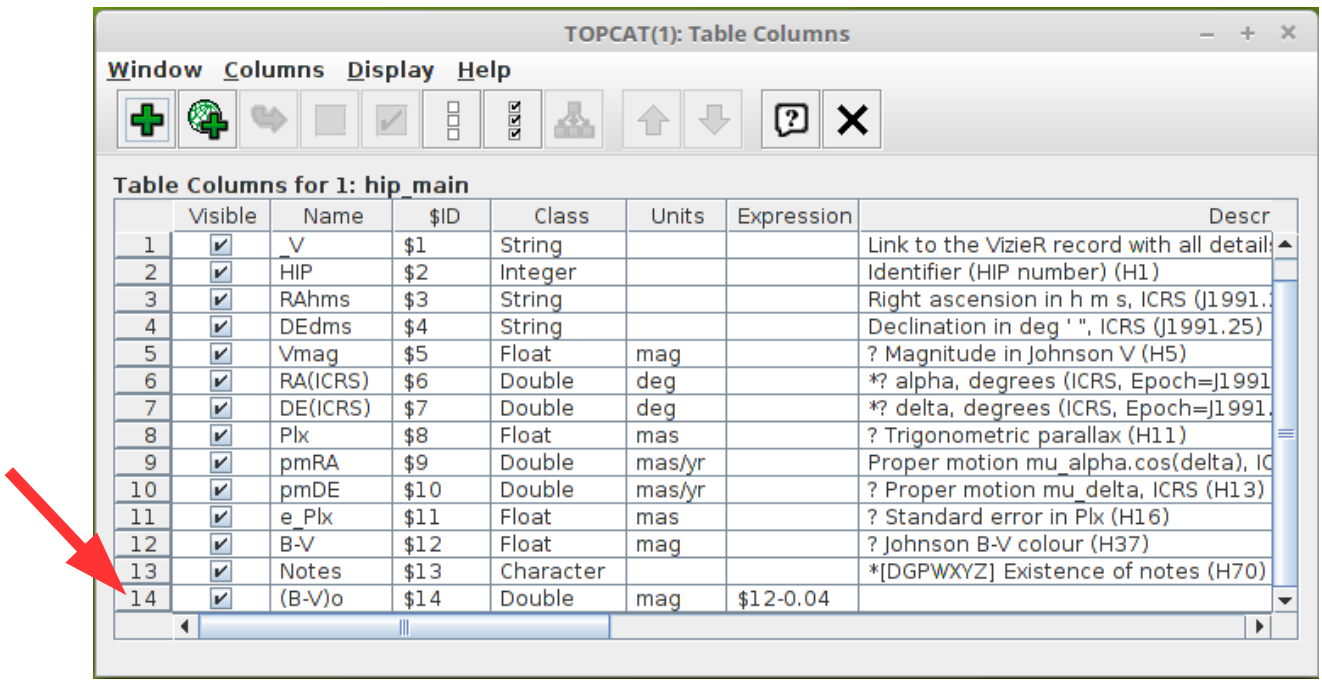


	Visible	Name	$ID	Class	Units	Description
0	☐	Index	$0	Long		Table row index
1	☑	_V	$1	String		Link to the VizieR record with all details
2	☑	HIP	$2	Integer		Identifier (HIP number) (H1)
3	☑	RAhms	$3	String		Right ascension in h m s, ICRS (J1991.25) (H3)
4	☑	DEdms	$4	String		Declination in deg ' ", ICRS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

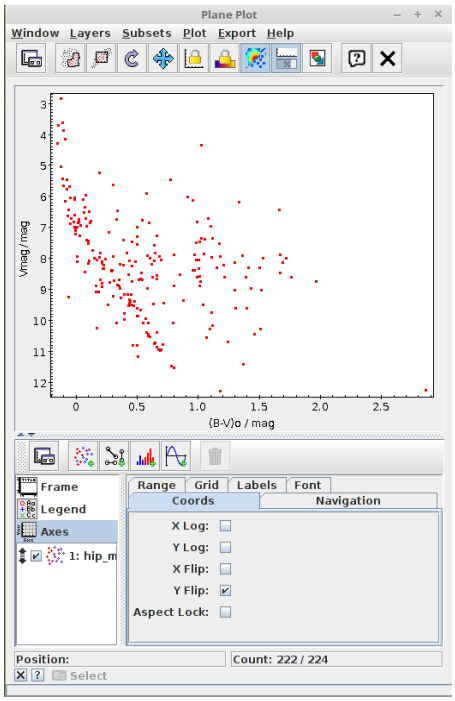
16- In the new window, go to the Columns > New Synthetic Column.



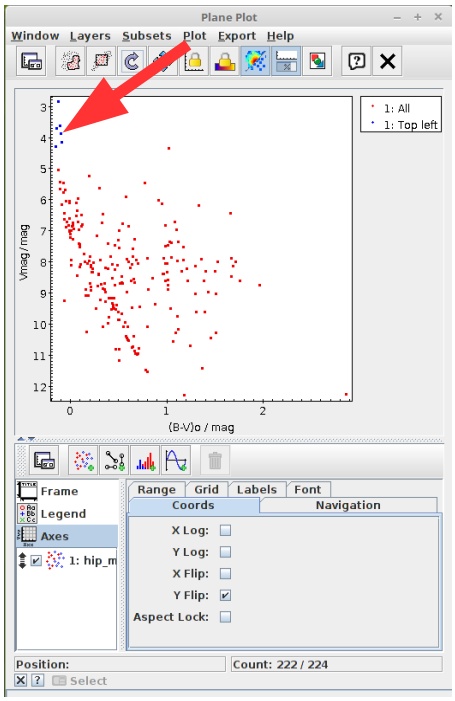
17- In the field “Name”, type '`(B-V)o`'. In the field “Expression”, we will put the values of (B-V) corrected for a reddening of -0.04 (value for the Pleiades cluster): this is done by typing '`$NUMBER -0.04`', where NUMBER = the number of the column (B-V) (you can check it on the TOPCAT: Table Column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



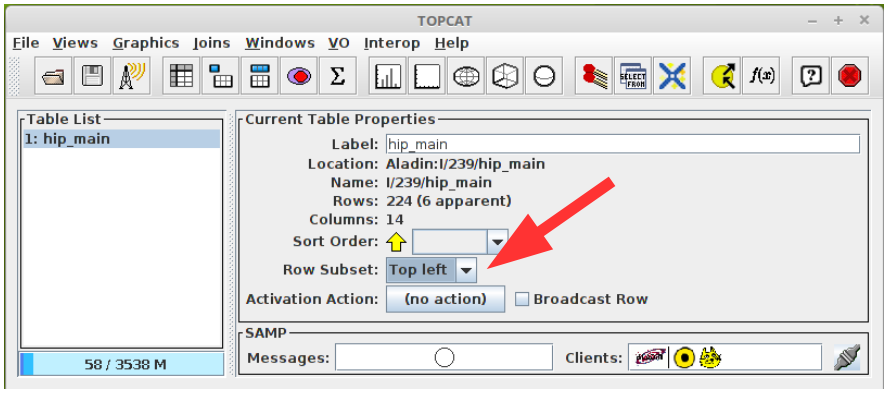
18- Now we will plot the color-magnitude diagram for our field of stars. This is done on the TOPCAT window. Go to Graphics > Plane Plot. On the new window, select '(B-V)o' for the X axis and 'Vmag' for the Y-axis, then click on Axes on the list on the left, and select 'Y flip'. You will clearly see the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



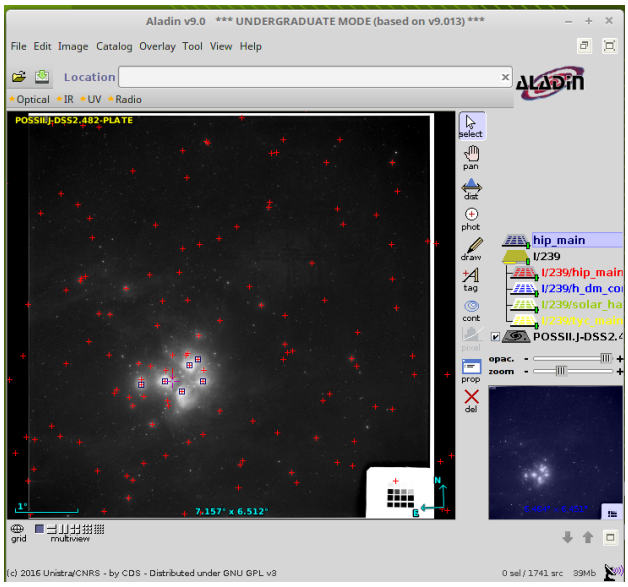
19- We can visualize a specific selection of stars from the CMD in the Aladin main window. In Plane Plot window, go to Subsets > Draw subset region. First, we will select only the stars on the top left region of the CMD. Draw a region that encircle these stars on the CMD plot, and then go to Subsets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



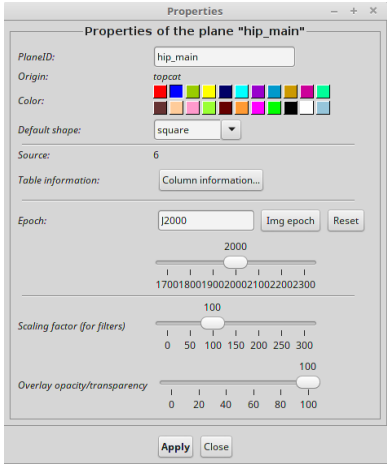
20- Now, go to the TOPCAT main window, and select the 'Top left' item on the "Row subset" list. Then go to File > Send table to… > Aladin.



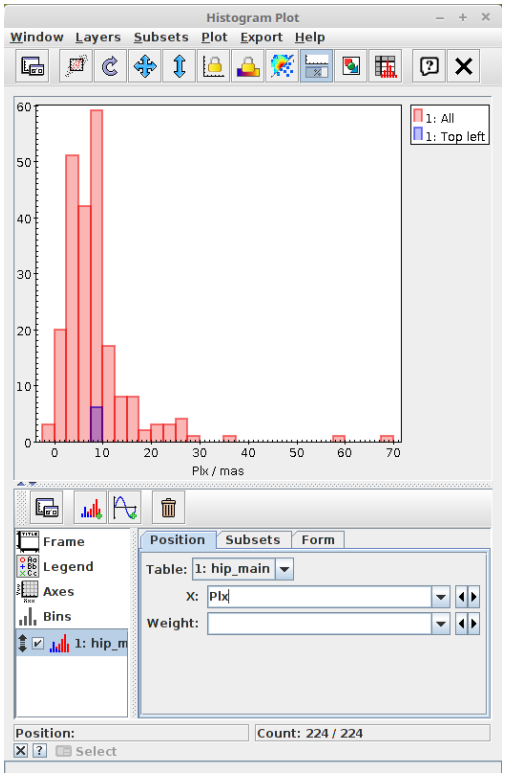
21- On the Aladin main window, you will see that a new layer was added.



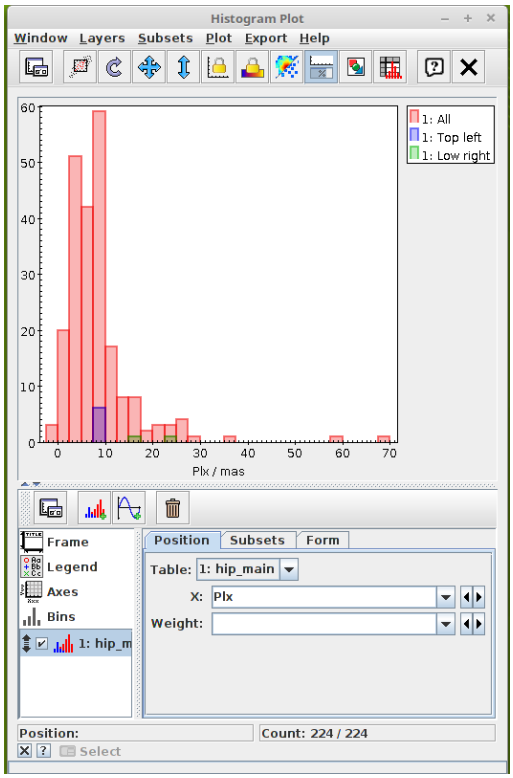
22- You can change its color to a more distinctive one by right-clicking the layer, going to Properties…, selecting the new desired color, and clicking on "Apply". Notice that most stars on the top left of the CMD are the brightest one from the Pleiades cluster.



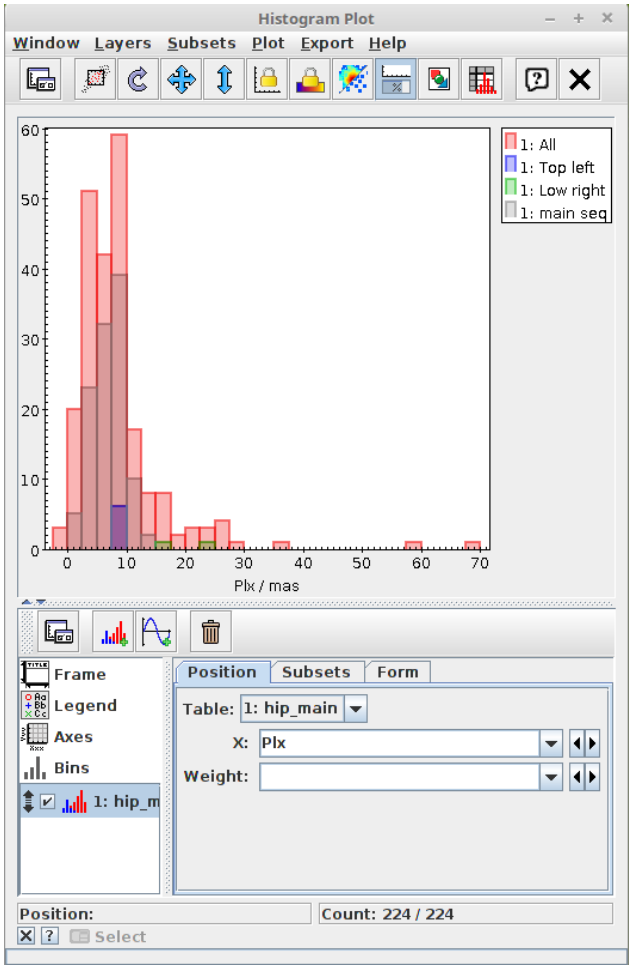
23- Go to the Histogram plot window, and you will also notice that the subset of stars you selected will be shown in the histogram of parallaxes.



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.

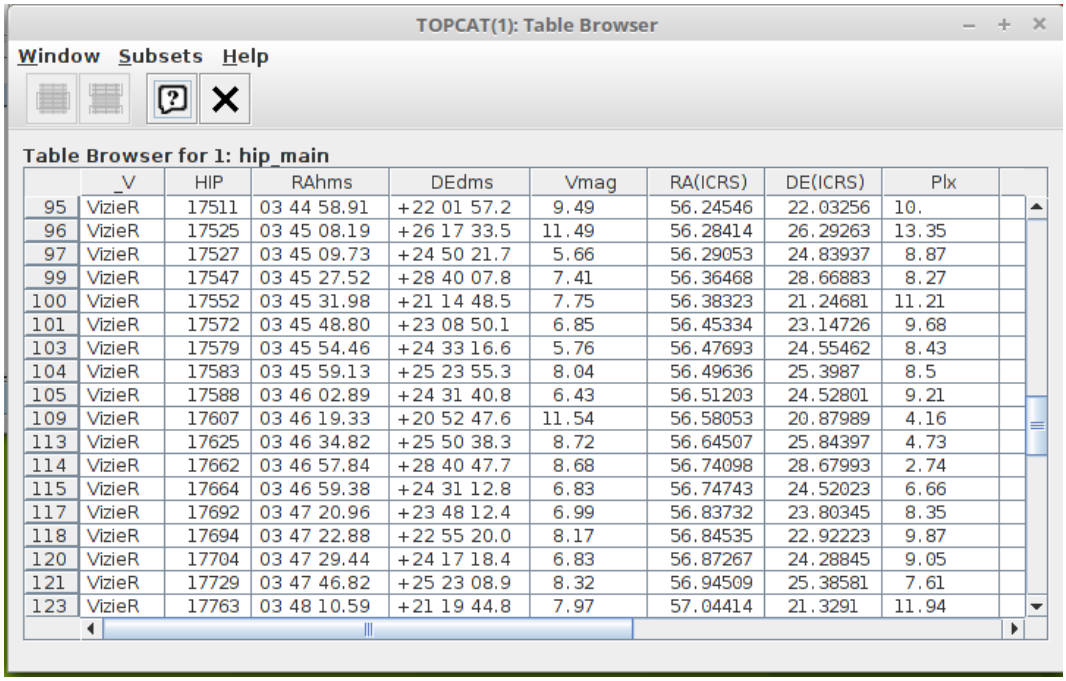


Question: How do you interpret the stars in the CMD showing (B-V)0 > 0.8?

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

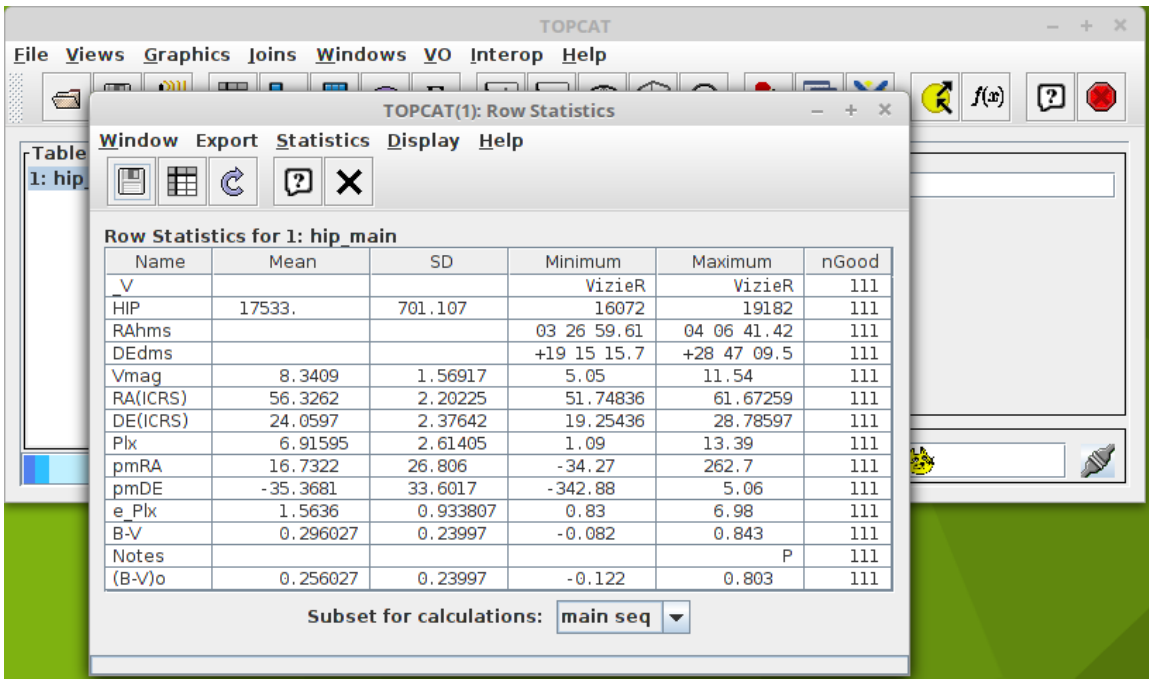
Question: Which regions you think are best to derive the mean radial velocity of the cluster?

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.



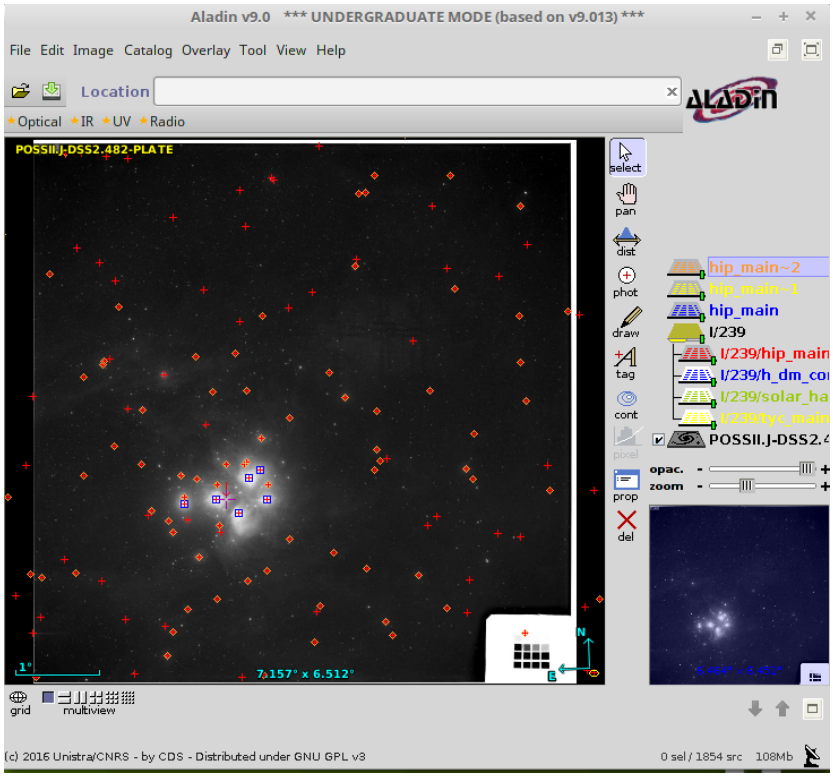
	_V	HIP	RAhms	DEdms	Vmag	RA(ICRS)	DE(ICRS)	Plx
95	VizieR	17511	03 44 58.91	+22 01 57.2	9.49	56.24546	22.03256	10.
96	VizieR	17525	03 45 08.19	+26 17 33.5	11.49	56.28414	26.29263	13.35
97	VizieR	17527	03 45 09.73	+24 50 21.7	5.66	56.29053	24.83937	8.87
99	VizieR	17547	03 45 27.52	+28 40 07.8	7.41	56.36468	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.



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

29- Final view on Aladin:

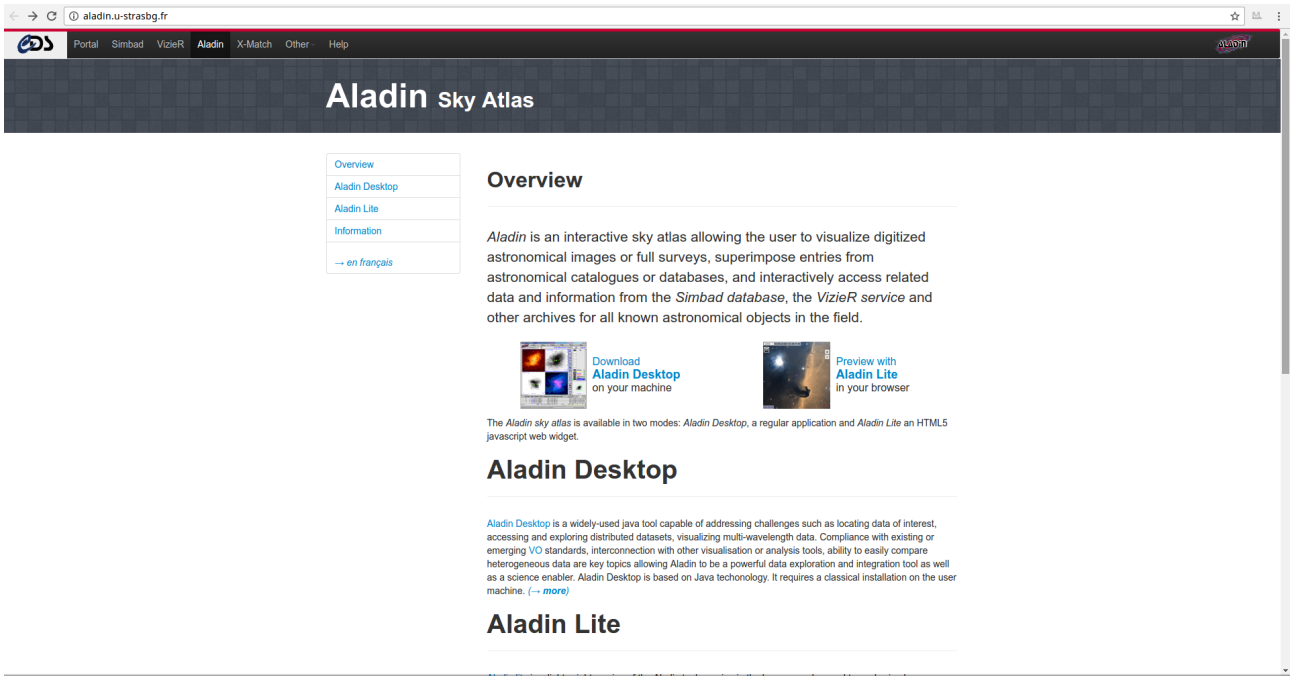


Question: What is your estimate of the mean parallax Pleiades clusters? Which subset you choose to derive this mean? (explain your choice)

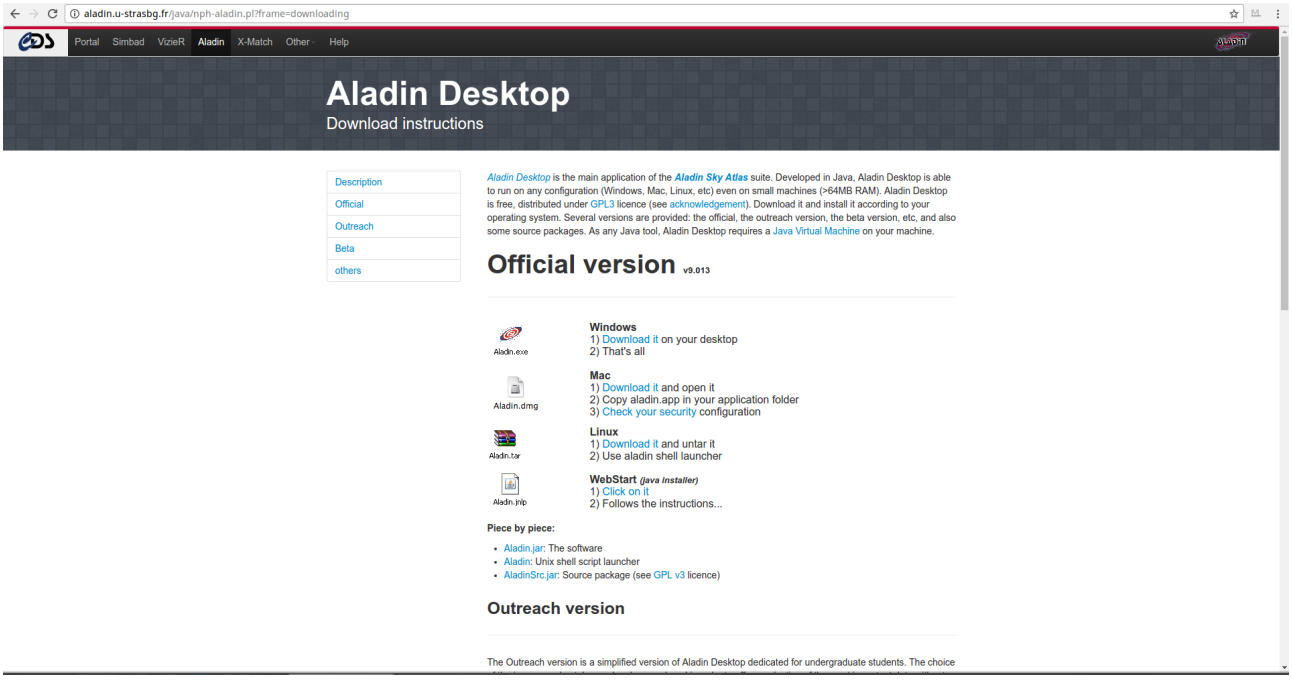
Question: What about radial velocities? Use what you have learned to estimate of the mean radial velocity of the cluster.

Download and Installing Aladin and Topcat:

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

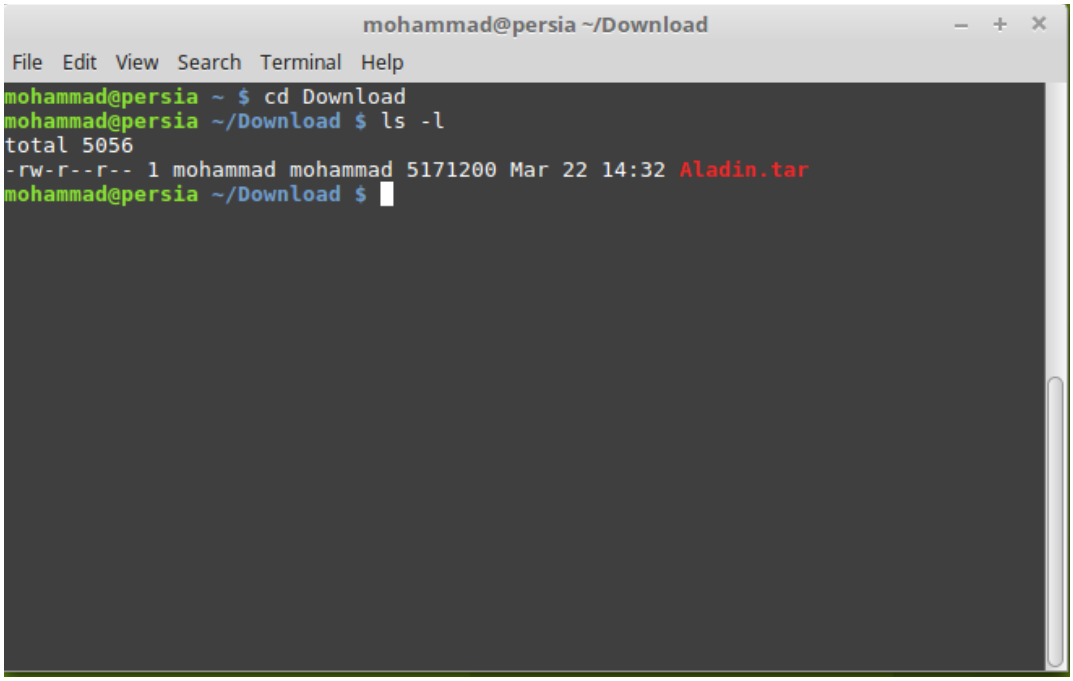


2- Click on "Download Aladin Desktop"



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

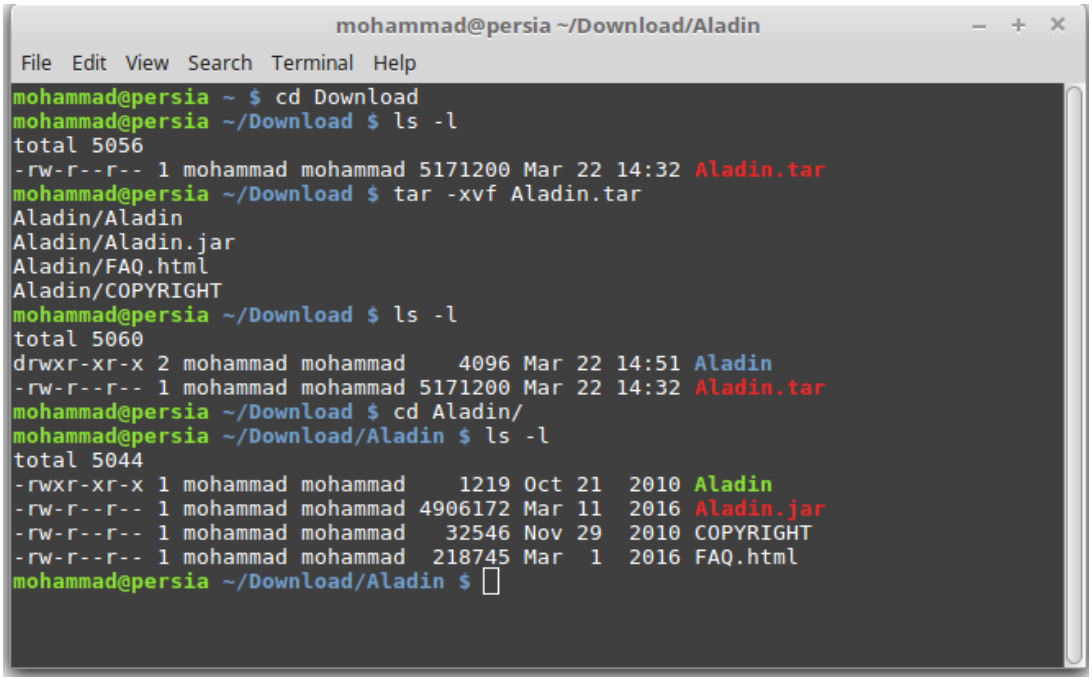
4- Open a terminal (Ctrl + Alt + T) and go to the directory where you saved the file. If you list the files you will find a file named “Aladin.tar”



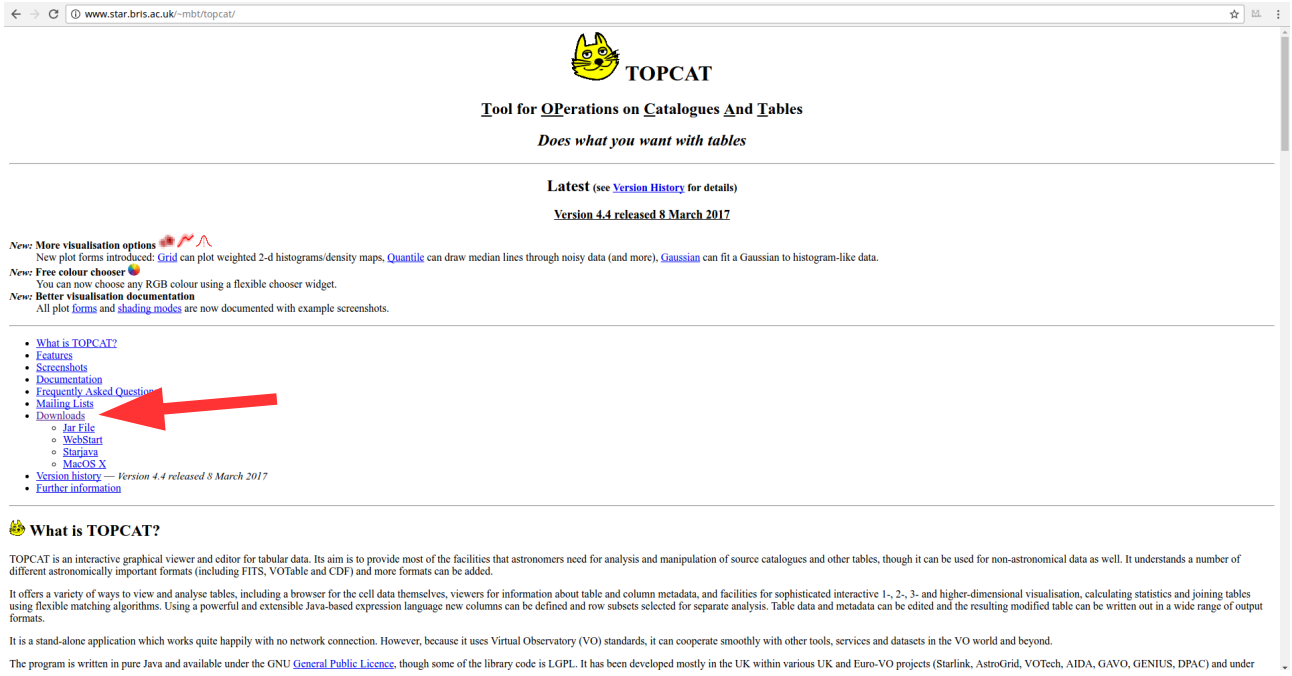
5- Extract Aladin.tar (command: `tar -xvf Aladin.tar`), then you will have a folder named “Aladin” containg four files:

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

where Aladin is an executable file.



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



7- Click on "Downloads"

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”.