



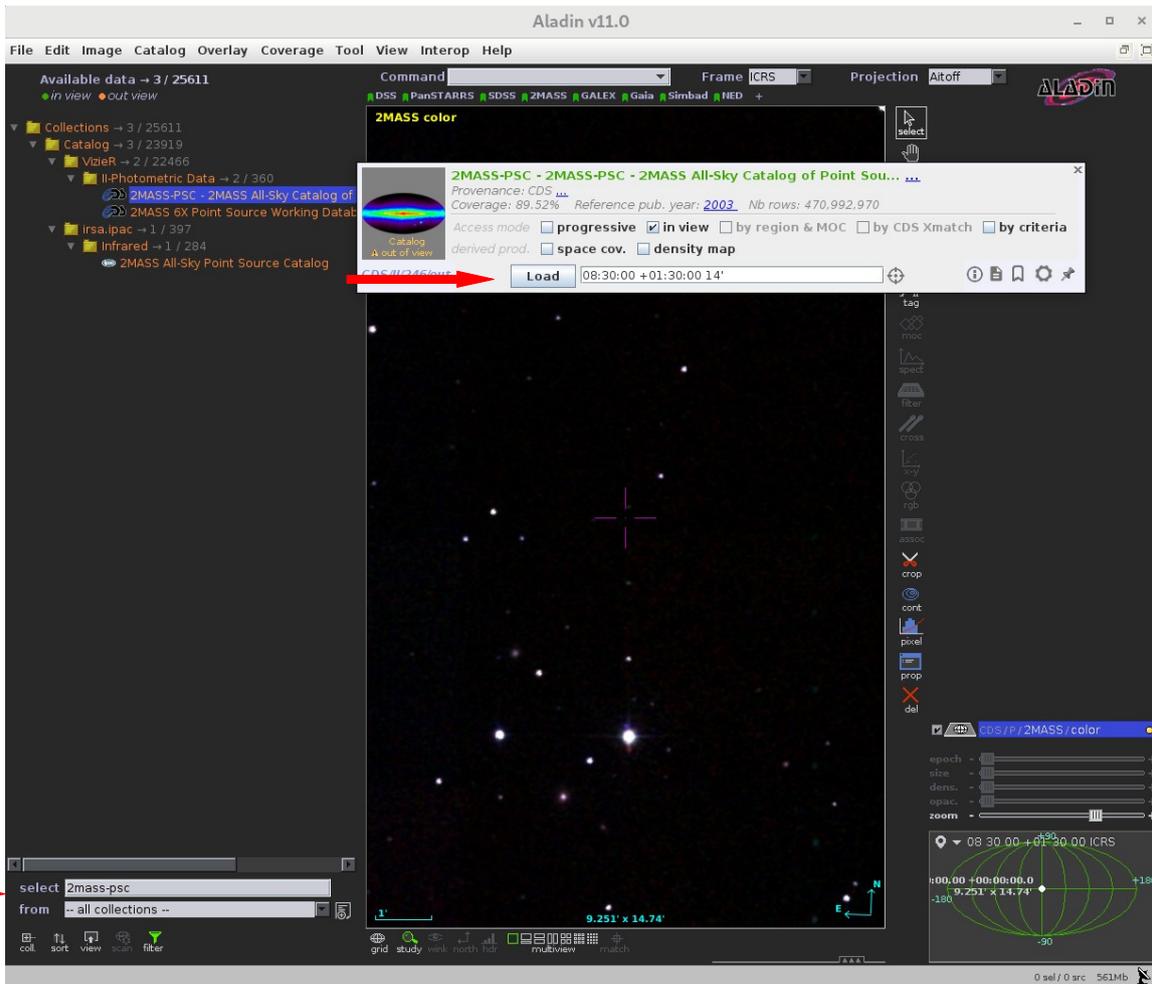
# Aladin



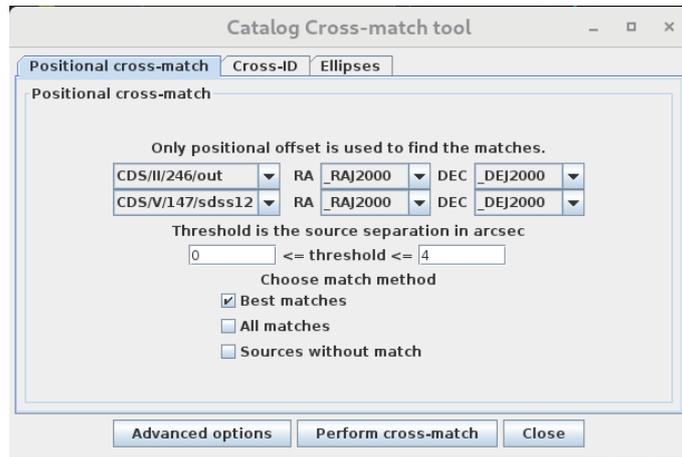
21<sup>st</sup> October 2020. Updated to: Aladin v11.024

## I) Science case: **Discovery of Brown Dwarfs mining the 2MASS and SDSS databases with Aladin.**

- **Scientific background:** Brown dwarfs are objects occupying the gap between the least massive stars and the most massive planets. They are intrinsically faint objects so their detection is not straightforward and, in fact, was almost impossible until the advent of global surveys at deep optical and near-infrared bands. We propose here to mine the 2MASS-PSC and SDSS-DR12 databases to identify T-type brown dwarfs through an appropriate combination of colours in the optical and the infrared, an approach that perfectly fits into the Virtual Observatory.
- **Workflow:** In this tutorial we will explore how to perform the download of data, cross-match of catalogs, sources selection and filtering with Aladin Sky Atlas.
  - Launch Aladin: Open a terminal and type: `java -jar Aladin.jar &`
    - Load a sky map (HiPS). On the left hand panel, go to the discovery tree and navigate through the folders: *Collections* → *Image* → *Infrared* → *2MASS* and click on “2MASS color J (1.23um), H(1.66um), K(2.16um)”. The sky map will be displayed in the central panel.
    - **Discovery:** Search 2MASS-PSC and SDSS-DR12 sources around RA:08h 30m DEC:01d 30m with a 14 arcmin radius.
      - On the left panel of the Aladin window, click on the **select** box located in the bottom corner and type “2MASS-PSC”. The discovery tree will open and show the available catalogs.
      - Click in the “2MASS-PSC - All-Sky Catalog of Point Sources” photometric catalog. A new window will pop up.
      - Write 08:30:00 +01:30:00 14' in the *position/radius* box next to the **Load** button and click on **Load**. Aladin will load in the main window a plane named *CDS/III/246/out* with 683 sources (you can see the number of sources on top of the right panel by placing the cursor on the name of the plane).

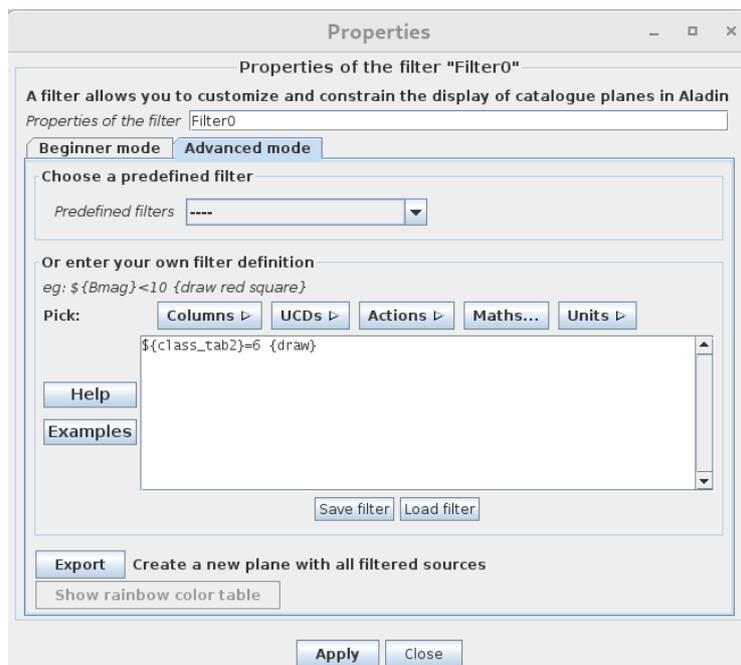


- If you wish you can modify the name of the plane, and colour and/or the shape of the symbols of this plane by doing the following:
    - Click on the **prop** button on the right panel of Aladin main window. A new window ("Properties of the plane...") will pop up.
    - Write "2MASS-PSC" in **Plane ID**.
    - Select the color and /or shape you wish.
    - Click on **Apply**.
  - Repeat the same steps for the SDSS-DR12 catalog. Select the SDSS-DR12 catalog in the *V – Combined data* folder. A new plane named *CDS/V/147/sdss12* will be loaded with 12404 sources.
- **Crossmatching:** Find common sources in 2MASS-PSC and SDSS-DR12 catalogs.
  - In the Aladin main window: *Catalog → Cross match objects*.
  - First catalog: 2MASS-PSC (CDS/II/246/out). Second catalog: SDSS-DR12 (CDS/V/147/sdss12). Default threshold (4 arcsec) and bestmatch option.
  - Click on **Perform cross-match**. A new plane ("XMatch") with 679 sources will be loaded.

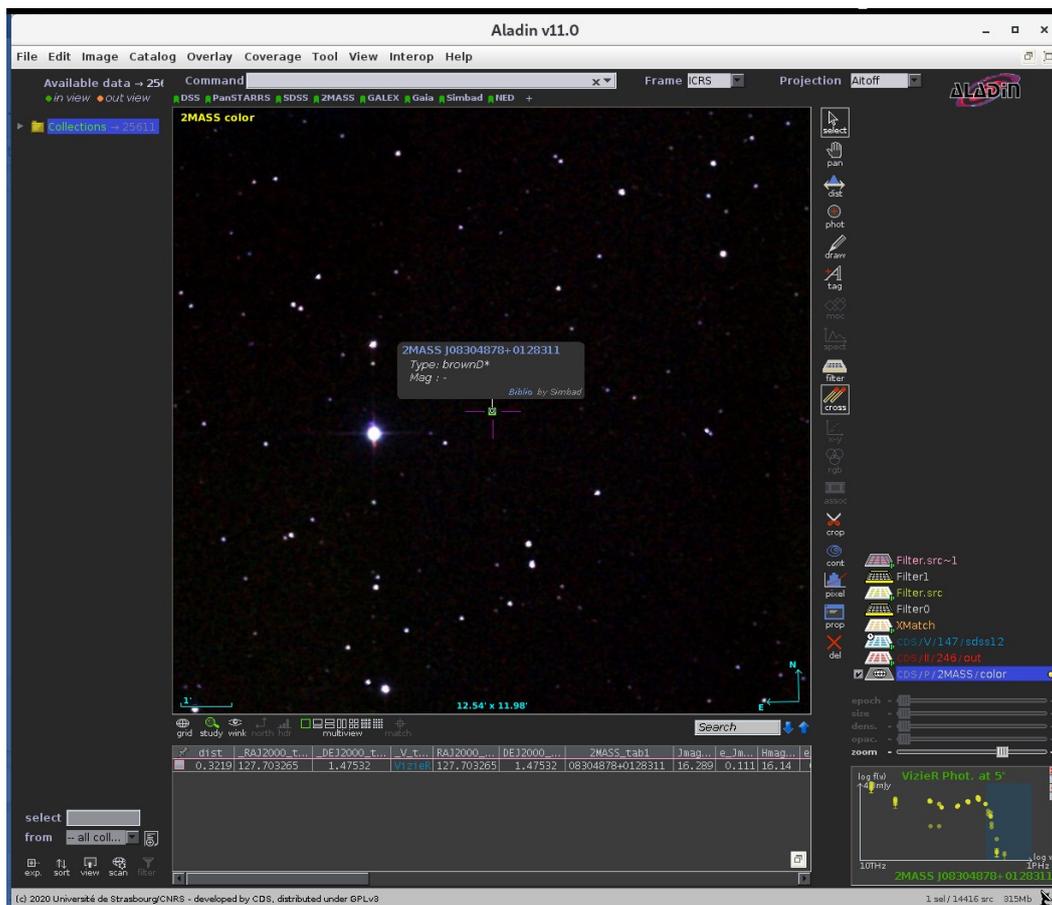


- **Filtering:**

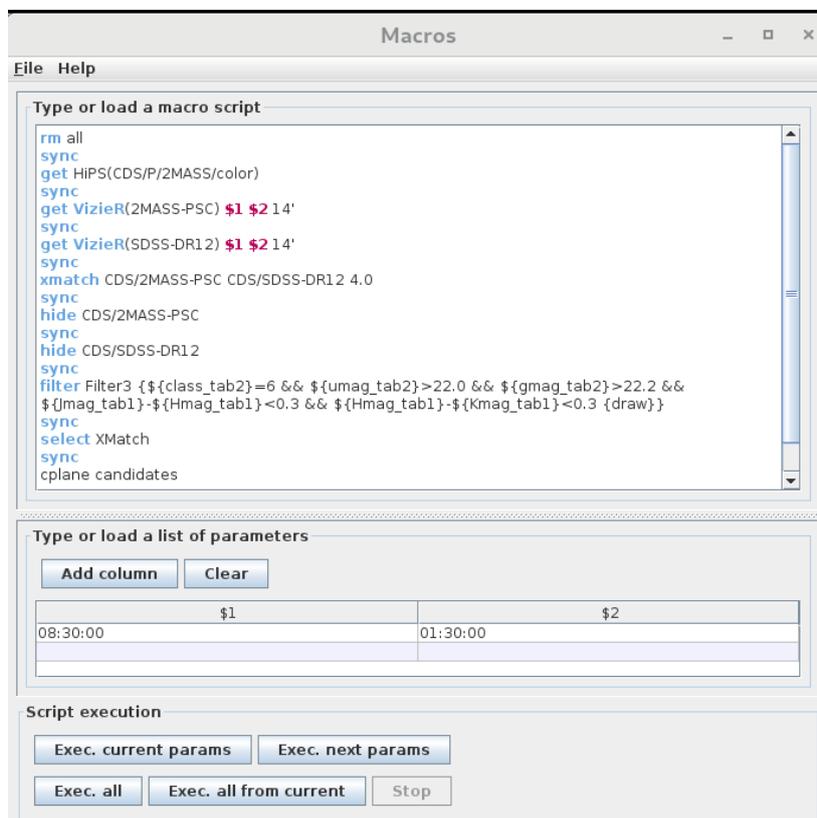
- In this step we will select point sources using the SDSS flag (class=6). "class" is a column of the SDSS- DR12 catalog that provides information on the type of object (3=galaxy, 6=star).
  - Click on the "XMatch" plane. The name of the plane would appear highlighted.
  - In the Aladin main window: *Catalog* → *Create a filter* (or click on the **Filter** button on the right panel of Aladin main window) → *Advanced mode* → *Columns* → *Columns in loaded catalog*. A new window ("Available columns") will pop up. Select the "class\_tab2" column from the Xmatch plane. The label of this column will be copied to the "Properties" window.
  - Complete the filter condition. It should be `#{class_tab2}=6 {draw}`
  - Click on **Apply**. Then click on **Export** to create a new plane with the filtered sources.



- A new plane “*Filter.src*” will be loaded in the Aladin main window. It contains 649 sources.
- Now, let's select sources with no detection in the u,g SDSS bands ( $u > 22.0$  &&  $g > 22.2$ , since brown dwarfs are cool objects not detected in the blue SDSS bands) and sources fulfilling the brown dwarf criteria provided by Burgasser et al. (2000, Apj, 531, L57):  $((J-H) < 0.3 \ \&\& \ (H-K) < 0.3)$ .
  - Click on the icons on the left of the names of the planes to hide them all but “*Filter.src*”.
  - Click on the “*Filter.src*” plane.
  - Repeat the same steps as in the previous filter. The filter condition now should be:
    - $\${umag\_tab2} > 22.0 \ \&\& \ \${gmag\_tab2} > 22.2 \ \&\& \ \${Jmag\_tab1} - \${Hmag\_tab1} < 0.3 \ \&\& \ \${Hmag\_tab1} - \${Kmag\_tab1} < 0.3 \ \{draw\}$
    - Click on **Apply**. Then click on **Export** to create a new plane with the filtered sources. A new plane “*Filter.src~1*” will be loaded in the Aladin main window. It should contain 1 source (RA\_2MASS:127.703265deg; DEC\_2MASS:1.475320deg). NOTE: You will get information on the source by clicking on it.



- **Analysis:** We can now use Simbad to confirm the brown dwarf nature of this object:
  - Place the cursor on the source.
  - After a few seconds a small window with basic information of the object will appear. If it does not, click on the right mouse button and select *Astronomical object exploration (Simbad & Vizier)*.
  - By clicking on the object name (in blue) a new tag will open in your browser with the information available in *Simbad* for this particular object.
- **Advanced scripting in Aladin:** Aladin has a script mode to build a list of commands to be processed. The workflow can be executed automatically for a list of targets.
  - If you closed Aladin, launch it again (java -jar Aladin.jar &). If your Aladin was still open, click on any plane, click right mouse button and select **Delete all planes**.
  - In the Aladin main window: *Tool* → *Macro Controller*
  - In the **Macros** window:
    - *File* → *Load script* → Load the script file “script\_aladin” available in the school web page.
    - *File* → *Load params* → Load the param file available in the school web page.
    - Click on the coordinates and then click on **Exec. current params**. You will get the source identified in previous workflows.



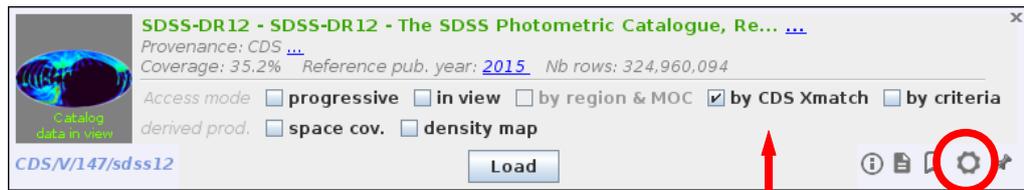
- More information on how to build scripts in Aladin can be found at Aladin main window: [Help](#) → [Help on script commands](#).
- 

NOTE: Before running each of the following examples, it is convenient to remove all loaded catalogs and images by clicking the right mouse button over any of the planes in the panel to the right in the main window and selecting **Delete all panels**.

## II) Other functionalities:

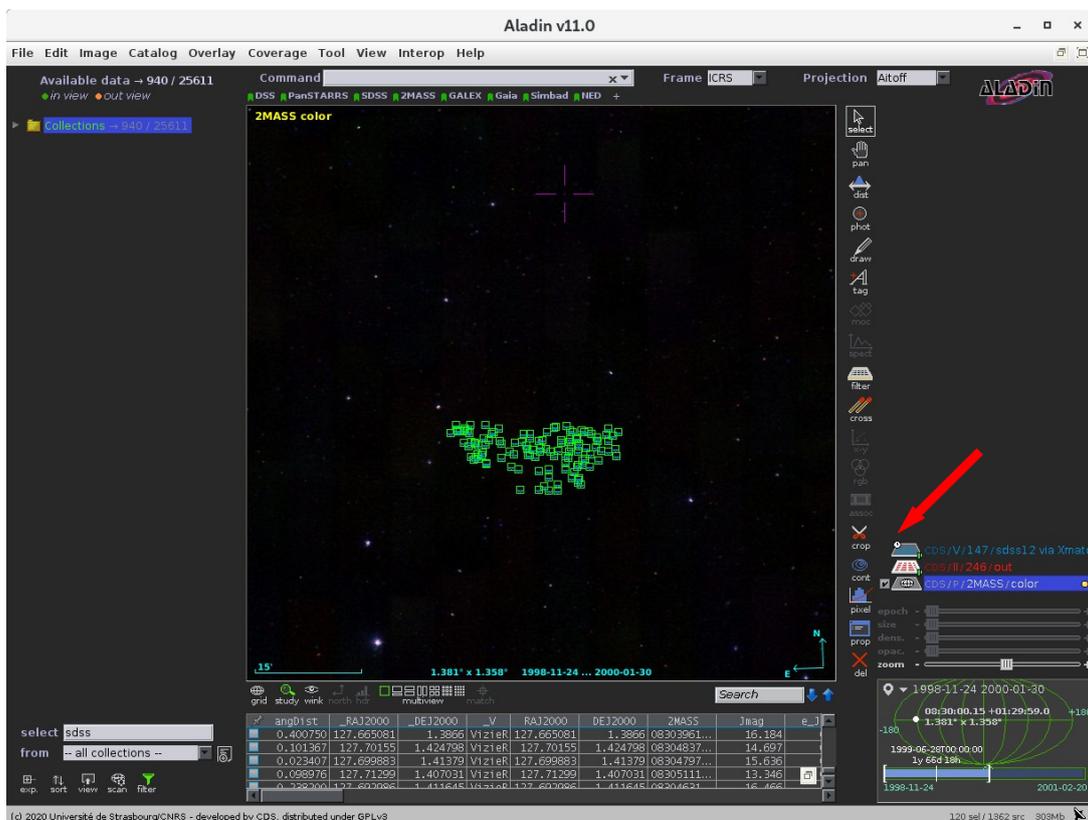
- **CDS-X match:** This option is suitable when we want to cross-match a catalog of sources with another VO catalog in different sky regions or when the region to load is too large, for example.
  - We will repeat the exercise described in the [Discovery](#) section of the science case using this time the CDS-X match option.
    - Load a sky map (HiPS). On the left hand panel, go to the discovery tree and navigate through the folders: [Collections](#) → [Image](#) → [Infrared](#) → [2MASS](#) and click on “2MASS color J (1.23um), H(1.66um), K(2.16um)”. The sky map will be displayed in the central panel.
    - Load 2MASS-PSC sources around RA:08h 30m DEC:01d 30m with a 14 arcmin radius as described above. For clarity, the steps are repeated here:
      - On the left panel of the Aladin window, click on the **select** box located in the bottom corner and type “2MASS-PSC”. The discovery tree will open and show the available catalogs.
      - Click in the “2MASS-PSC - All-Sky Catalog of Point Sources” photometric catalog. A new window will pop up.
      - Write 08:30:00 +01:30:00 14' in the *position/radius* box next to the **Load** button and click on **Load**. Aladin will load in the main window a plane named *CDS/II/246/out* with 683 sources (you can see the number of sources on top of the right panel by placing the cursor on the name of the plane).
    - Cross-match the 2MASS catalog loaded in the previous step with SDSS-DR12 in an alternative way:
      - On the left panel of the Aladin window, click on the **select** box located in the bottom corner and type “SDSS DR12”. The discovery tree will open and show the available catalogs.
      - Select the SDSS-DR12 catalog in the *V – Combined data* folder. A new window will pop up.
      - Select **by CDS-X match** and click **Load**. A new plane will be loaded in the main window with 679 sources resulting from the cross-match between 2MASS and SDSS-DR12. Note: In the pop up window, the previous to the last

symbol on the bottom right corner of the SDSS-DR12 window opens a new window where the configuration parameters of the cross-match can be changed.



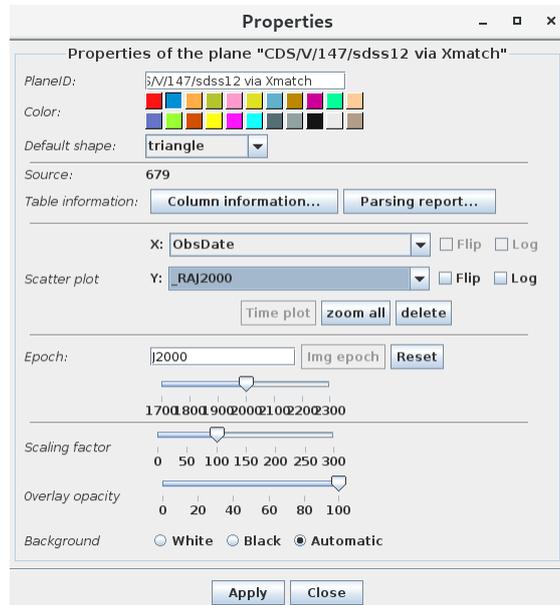
This will load a new plane called CDS/V/147/sdss12 containing 679 sources. As a result of the cross-match, it contains 2MASS and SDSS DR12 columns.

- The **time controller** allow us to visualize the sources in a catalog observed in a determined time range.
  - Note that the CDS/V/147/sdss12 plane shows a clock icon. This is because the SDSS DR12 catalog contains an epoch column. At the bottom of the right panel, under the plane stack, you can see the time range covered by the SDSS DR12 observations: 1998-11-24 to 2001-02-20.
  - To show sources observed between the first half of the covered interval, type 1998-11-24 2000-01-30 in the **Command** box, on top of the central panel. Press the **enter** button. 120 sources will be displayed in the central panel.

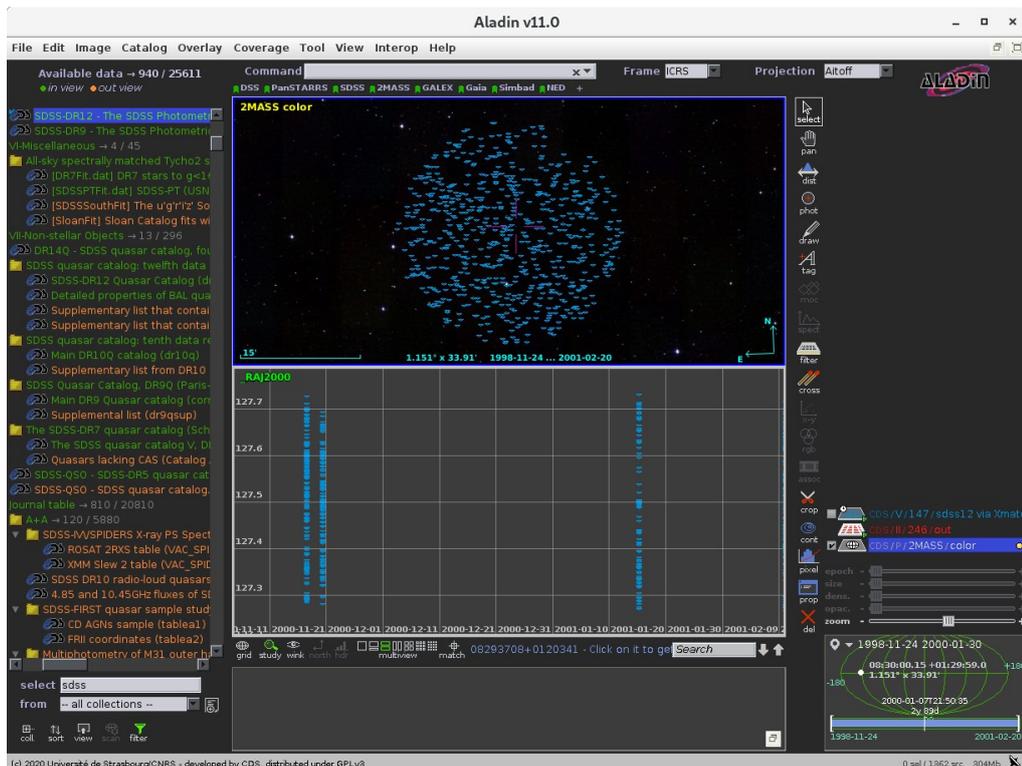


- You can create a new plane with the selected sources by clicking on the right mouse button in the central panel and selecting *Create a new plane with selected sources*. A new plane with this 120 sources will be created.

- The **time plot** shows the time distribution of the sources contained in the selected plane.
  - Select the CDS/V/147sdss12 plane. *Catalog* → *create a scatter/time plot*. A new window will pop up. Select “\_RAJ2000” to be displayed in the Y axis. The X axis is by default the epoch column, named “ObsDate”. Click **Apply**. A second panel with the time distribution will be displayed under the sky-view plane.

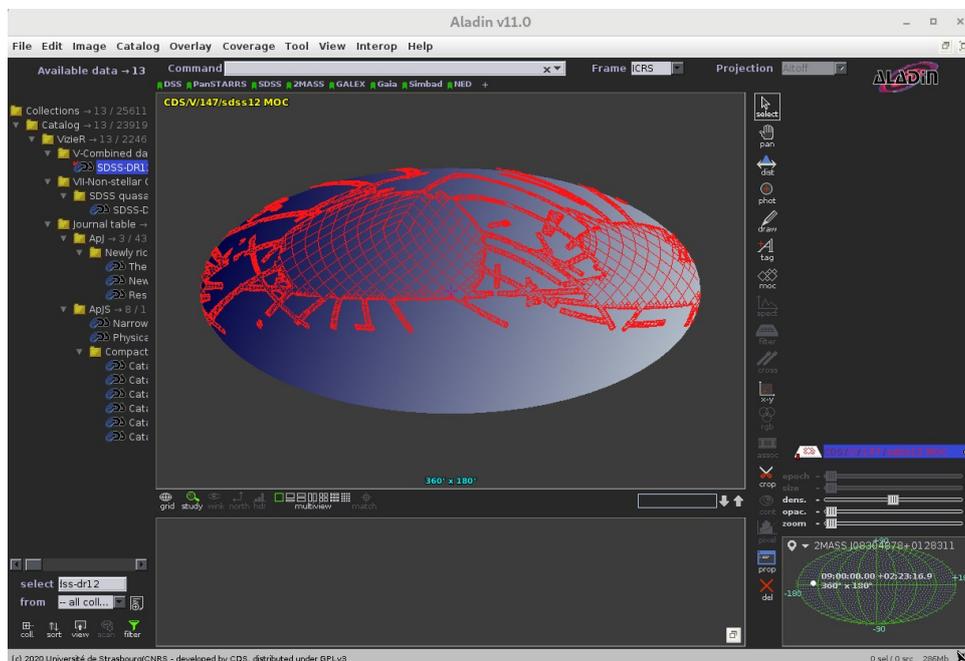


You can scroll on the time bar situated on the right panel at the bottom to control the displayed epoch in the plot.



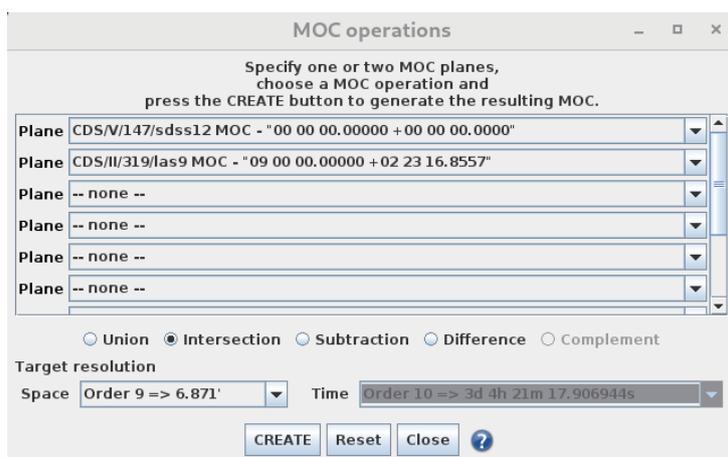
- **MOC** (Multi-object coverage). Used to describe sky regions (e.g. footprints) and provides a very fast mechanism to perform operations (union, intersection,...) between them.

- How to obtain the sky coverage of SDSS DR12:
  - On the left panel of the Aladin window, click on the **select** box located in the bottom corner and type “SDSS DR12”. The discovery tree will open and show the available catalogs.
  - Select the SDSS-DR12 catalog in the *V – Combined data* folder. A new window will pop up.
  - Select **space cov.**, deselect **by cone** and then click on **Load**. The footprint of the SDSS-DR12 catalog will be loaded in the main window.
  - Click on the “CDS/V/147/sdss12 MOC” panel. On top will appear the sky coverage: 14520 sq. deg., 35.198% of the sky.



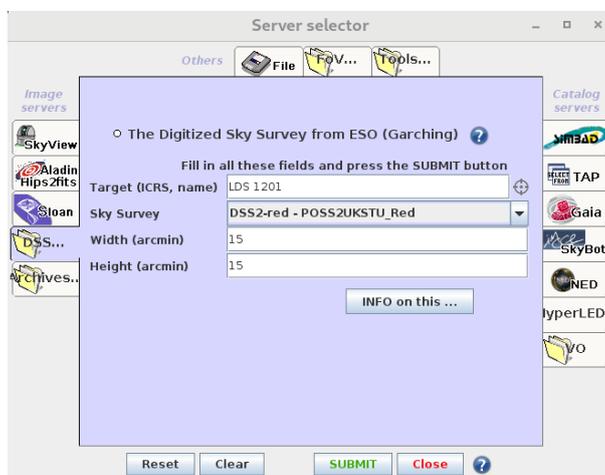
- How to obtain the region of the sky in common between SDSS DR12 and UKIDSS Large Area Survey9 (LAS9):
  - Repeat the same steps described to obtain the SDSS-DR12 MOC.
  - Repeat the same steps to obtain the UKIDSS LAS9 MOC. You must select the “UKIDSS-DR9 Large Area Survey”.
  - **Coverage** → **Logical operations**. A new window will pop up.
  - Select the CDS/V/147/sdss12 MOC and the CDS/III/319/las9 MOC and choose **Intersection**. Click on **Create**. A new plane with the coverage of the

intersection of both MOCs will be loaded in the main window with a sky coverage of 3654 sq. deg and 8.858% of the sky.



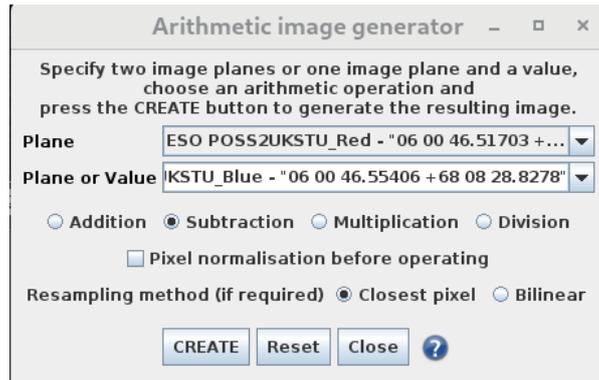
■ **Arithmetic operations between images.**

- *File* → *Open server selector*. A new window will pop up.
- On the left hand side, select *DSS label* and choose *DSS from ESO*.
- Write LDS 1201 in the **Target (ICRS, name)** box and select *DSS2-red – POSS2UKSTU\_Red* in the drop down of **Sky Survey**. Click on **Submit**. The corresponding image will be loaded in the main window.



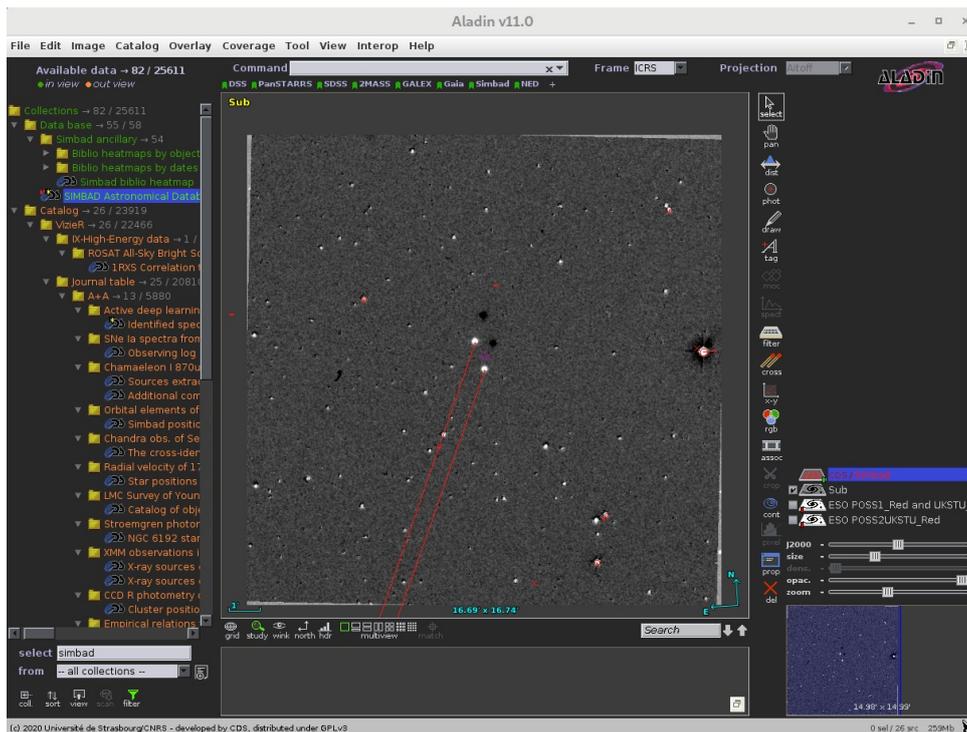
○ In the same Server selector window, select *DSS1 – POSS1\_Red and UKSTU\_Blue* and click on **Submit**. The corresponding image will be loaded in the main window.

- *Image* → *Arithmetic operation*. A new window will pop up.
- Select the previous loaded images and chose **Subtraction**. Then click on **Create**.



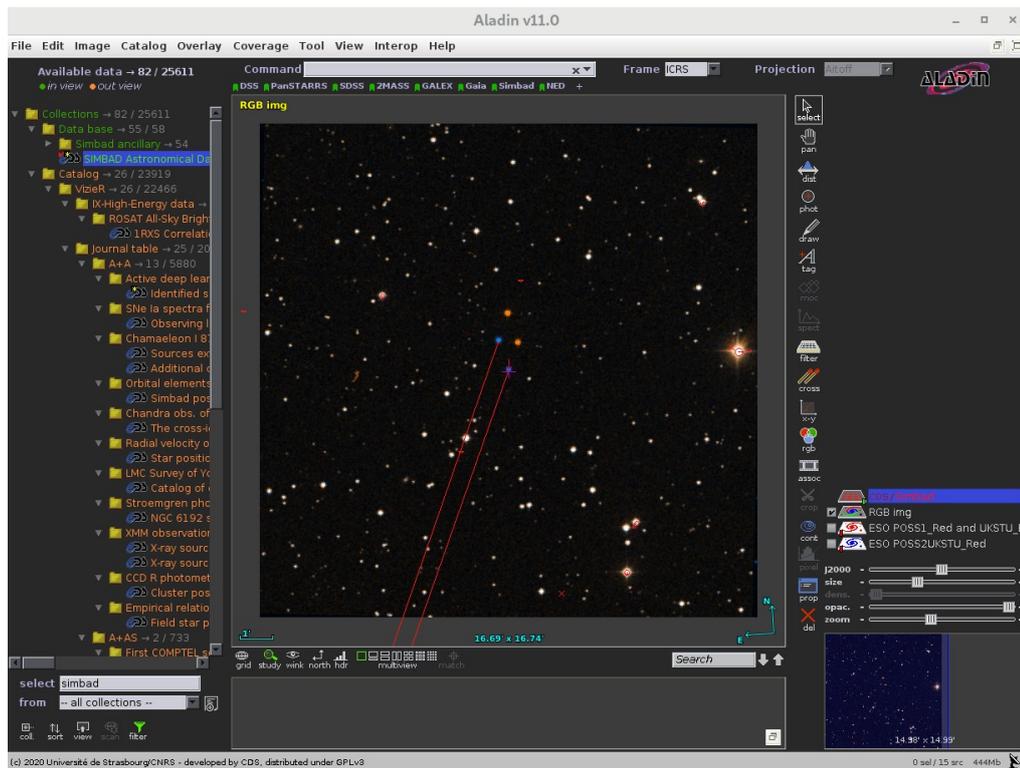
A new plane with the subtracted image will be loaded in the main window. In this case, a high proper motion binary system lies in the center of the image and the position of the components of the system at the epochs of the selected images can be clearly seen.

- On the **select** box located in the bottom corner type “Simbad”. Select the “SIMBAD Astronomical Database” and click **Load**. By default, the proper motions of the stars contained in *Simbad* are displayed.



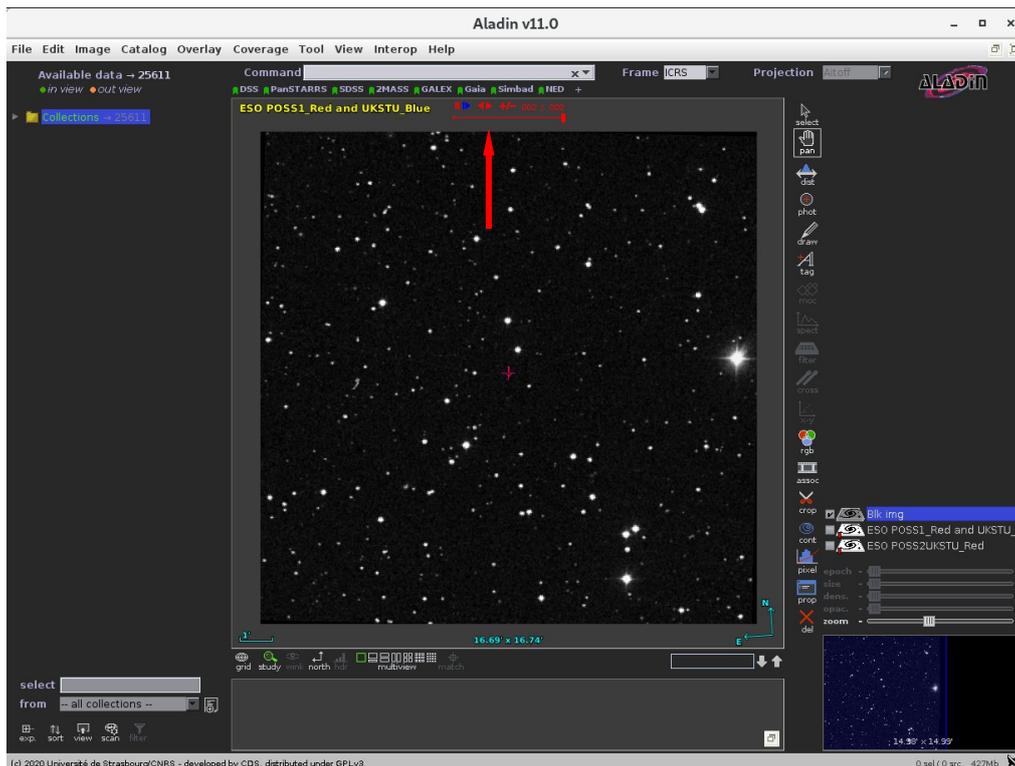
■ **RGB builder.** Compose an RGB image with Aladin.

- Repeat the first four steps in the example above.
- *Image* → *RGB image builder*. A new window will pop up.
- Select the two previous loaded images and click on **Create**. A new image with the resulting composed image will be loaded in the main window. In this case, a high proper motion binary system lies in the center of the image and the position of the components of the binary at the epochs of the selected images can be clearly seen. NOTE: Although the **RGB image builder** is meant to build a three color composed image (red, green and blue), it is also able to build it with only two images, as noted in this example.



- **Blink/movie** using images with Aladin.

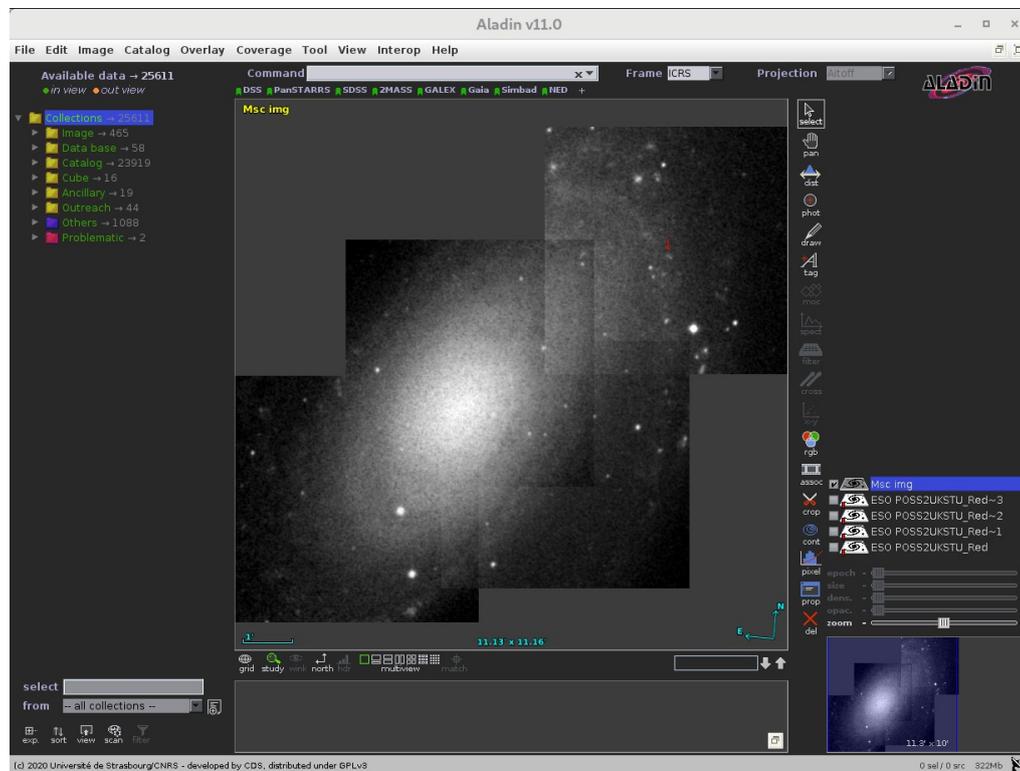
- Repeat the first four steps in the example above.
- *Image* → *Blink/movie generator*. A new window will pop up.
- Select the previous loaded images and click on **Create**. A new plane with the resulting movie will be loaded in the main window. On the top side of the central panel there are control buttons for the movie to stop, play, move forward/backward...



- **Mosaic builder** using images with Aladin.

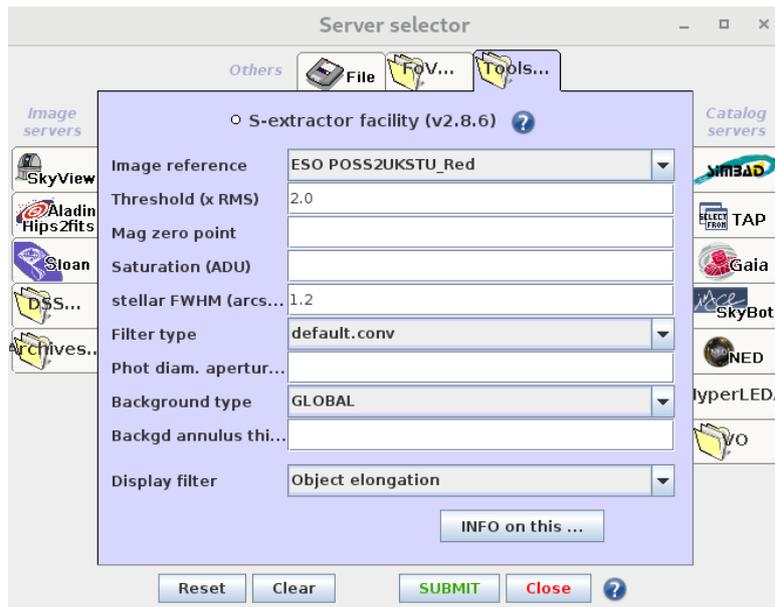
- *File* → *Open server selector*. A new window will pop up.
- On the left hand side, select *DSS* label and choose *DSS from ESO*.
- Write 09 55 55.63423 +69 01 55.9684 in the **Target (ICRS, name)** box and select *DSS2-red – POSS2UKSTU\_Red* in the drop down of **Sky Survey**. Change **Width** and **Height** to 5 arcmin. Click on **Submit**. The corresponding image will be loaded in the main window.
- Repeat the previous step with the following coordinates and the same width and height:
  - 09 55 32.07698 +69 04 51.2255
  - 09 55 08.96959 +69 02 57.2765
  - 09 54 49.20075 +69 07 25.5246

- *Image* → *Mosaic image builder*. A new window will pop up.
- Select each of the loaded images and click on **Create**. A new plane with the built mosaic will be loaded in the main window.

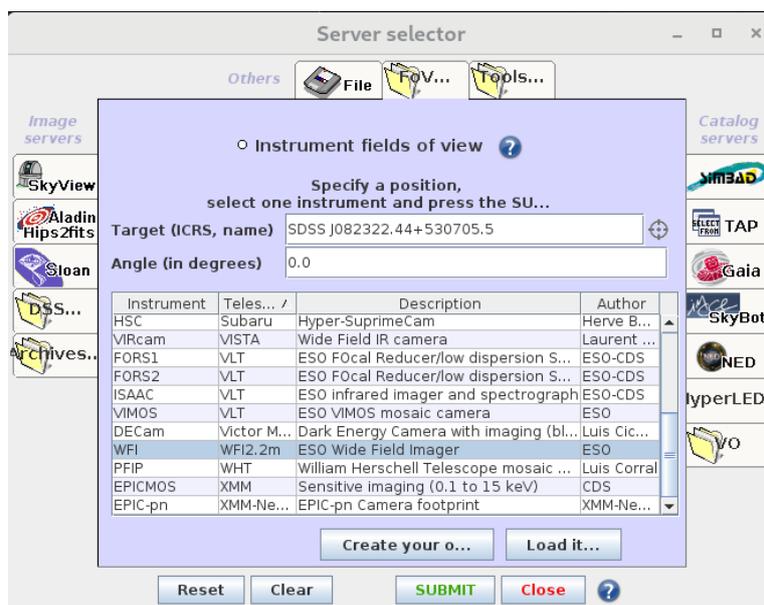


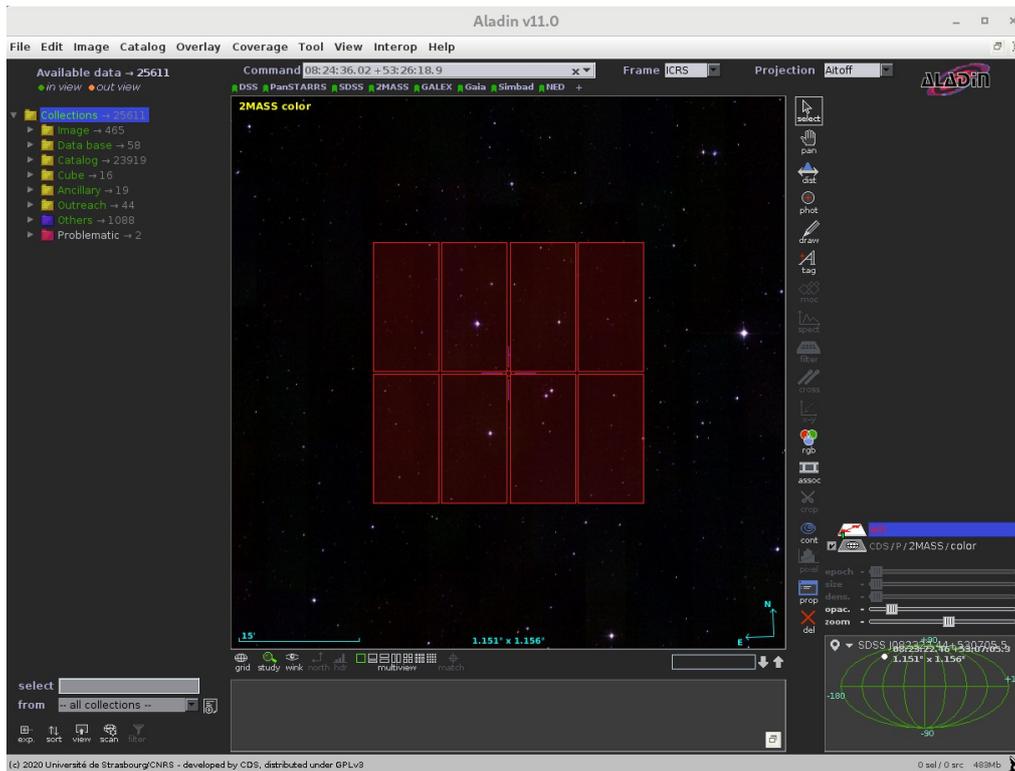
■ **SExtractor**: extract astrometry and photometry of a loaded image.

- *File* → *Open server selector*. A new window will pop up.
- On the left hand side, select *DSS* label and choose *DSS from ESO*.
- Write 00:10:15.02 -13:38:05.9 in the **Target (ICRS, name)** box and select *DSS2-red – POSS2UKSTU\_Red* in the drop down of **Sky Survey**. Click on **Submit**. The corresponding image will be loaded in the main window.
- *File* → *Open server selector*. A new window will pop up.
- Select *Tools* → *S-extractor* on the top labels.
- Select the loaded image in **Image reference** and click on **Submit**. A new plane with the extracted catalog will be loaded in the main window.



- Display instruments **Field of Views**, useful to check whether one or another instrument's FoV covers the desired region.
  - On top of the central panel, click “2MASS” just below the **Command** box. This will load the HIPS 2MASS survey.
  - Write SDSS J082322.44+530705.5 in the **Command** box to center the view around that object.
  - *File* → *Load instrument FoV*. A new window will pop up.
  - Write SDSS J082322.44+530705.5 in the **Target (ICRS, name)** box and select **WFI**. Click on **Submit**. A new plane with the WFI FoV will be loaded in the main window. Try to change the **Angle** in the FoV window to change the rotation of the displayed FoV.





■ Many other functionalities are available, like:

- Astrometric calibration: *Image → Astrometrical calibration*
- Visualization of 2, 4, 9 or 16 panels (images) with the possibility of matching views (unifying sizes and orientation): *View → Panels*
- Load a macro script for repetitive tasks: *Tool → Macro controller*
- Generate a MOC from a loaded catalog: *Coverage → Generate a spatial MOC based on*
- Export images: *File → Export the current view (EPS)...*
- Export planes: *File → Export planes (FITS, VOTable...)*
- ...

NOTE: We refer the user to the [F.A.Q](#) section of Aladin for details on these and other functionalities. A manual on the use of Aladin v10 is available [here](#) (in french).