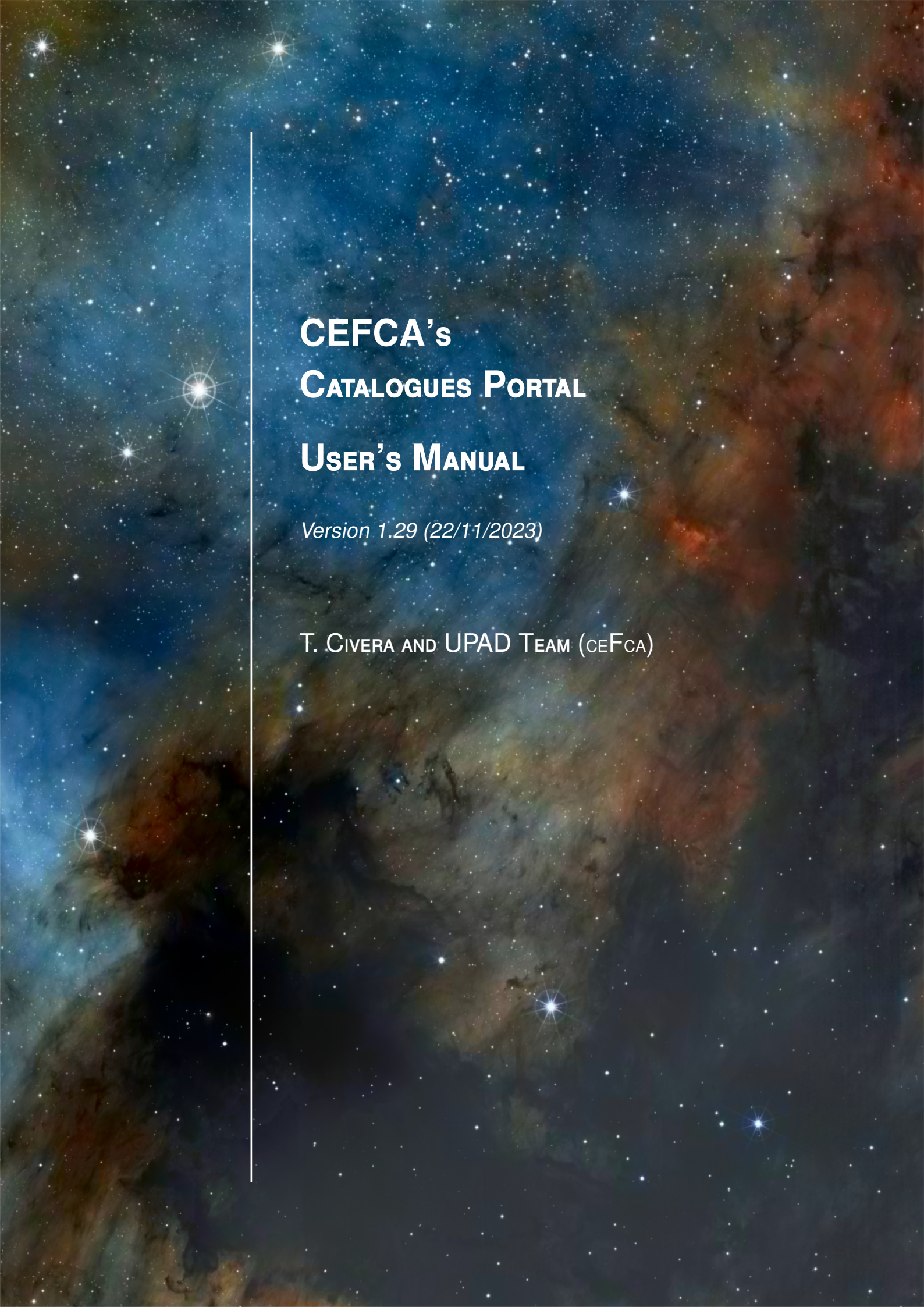

CEFCA's Catalogues Portal

User's Manual

Version 1.29 (22/11/2023)

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Contents

Chapter 1

Introduction

This is the user's manual of CEFCA's Catalogues Portals, ie. the web portals that you use to access to the public data of the main surveys carried out by CEFCA like J-PLUS, MiniJ-PAS and J-PAS.

WARNING Although in the manual we are using images corresponding to one of the web portals (in this case, J-PLUS), for the rest of web portals the layout is mainly the same with just a change in the color. In those cases in which there are particular differences between projects (mainly due to the different number of filters or different services offered), we will warn you about this.

1.1 Access to the website

The access to the website is done through the following URL:

https://archive.cefca.es/catalogues

At the moment of writing this version of the manual, the following data releases are publicy available:

https://archive.cefca.es/catalogues/jplus-dr3 For the J-PLUS DR3 (July, 2022).

https://archive.cefca.es/catalogues/jplus-dr2 For the J-PLUS DR2 (July, 2020).

https://archive.cefca.es/catalogues/minijpas-pdr201912 For the mini-JPAS Public Data Release (PDR) (December, 2019).

https://archive.cefca.es/catalogues/jplus-dr1 For the J-PLUS DR1 (July, 2018).

1.2 Content of the archive

The archive includes Coadd and reduced individual images and dual- and single-mode catalogue data which contain parameters measured from coadd images:

Reduced individual images It refers to science raw images processed/reduced by OAJ's pipelines.

Coadd images It refers to the images constructed from the combination of a series of reduced individual images.

Dual-mode data The main data of the archive is the so-called "dual-mode data". This data is the result of running `SExtractor` in Dual-mode on each pointing using the coadd image in the reference image (which is rSDSS in J-PLUS and mini-JPAS and expected to be iSDSS in J-PAS). The "dual mode data" has the following characteristics:

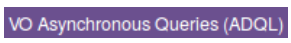
- only objects detected in the reference image appear in this catalogue;
- all the geometrical properties (as isophotal area or ellipticity) are derived from the reference image;
- the class star parameter is based on the reference image;
- the flux of each object in all the bands is measured in the same pixels (defined in the reference image);
- the PSF of each image is homogenised internally before performing any measurement although the detection is done on the original non-homogenised reference image.
- each detection has associated the photometry in all the bands.

Single-mode data This is an ancillary table that contents all the detections found in all the bands. In this table, all the detections are considered independent even if they come from the same object in different bands. This data can be accessed only via SCS or TAP services.

You can see a more detailed description in the Appendix 5.

1.3 Getting help

Apart from this user's manual you can get help from the following places:

- Data Access Services page of the web portal (e.g. J-PLUS DR3, Mini J-PAS PDR201912)
- Clicking on the  icon in the upper right corner (to go to the Data Access Services page).
- Clicking on the  icon to download this manual.
- There is a specific help page on ADQL queries. You can access to it through the list of Services (see Section 2.1.2) and, of course, in the 

main page (upper right corner).

1.4 About this manual

Within the manual particular typography is used for specific purposes:

- `THIS TYPOGRAPHY` is used for programming language keywords as well as for parameters of different software. In examples, programming keywords will be written in uppercase while words indicating input by the user will be written in lowercase.
- **TIP** This icon is used to point to features that are considered particularly useful and sometimes not obvious.
- **WARNING** This is used to point out a particular feature that is prone to produce an error.
- **REMEMBER** This is a particular warning to remind you of some action that should be done.

Some important points about this manual:

- The screenshots shown in various figures through out this manual may only focus on those parts that are not obvious or are discussed in the text. Therefore the full window may not be shown.
- The icons of the services, like this one Sky Navigator, will bring you to the corresponding webpage of the reference survey and data release used to create this manual (in this case, J-PLUS DR3).
- Be aware that since the web portal will be updated from time to time, it is possible that some features shown in this manual have changed or even disappeared. In such cases, please check the version; which is printed at the bottom right side of the CEFCA archives webpages and the first page of this PDF manual; clicking on it will show updates.
- Be also aware that some service and/or features could not be available for all the different surveys and data releases offered through the CEFCA Catalogues Portal.

Finally, for any comment or suggestion about this manual, you can contact us through the e-mail cefca@cefca.es.

1.5 Website display behaviour

The website of the archive is designed to adapt to the device used to access to it and, therefore, the display of the webpages will differ between using a PC computer or a mobile device.

WARNING the aspect of the website and how the information is displayed also depends on the size of the browser's window. For example, in tables with many columns, the number of visible columns will adapt to the width of the window. **TIP**

Whenever you see the symbol in the first column of a table, this means that there are hidden columns. If you click on the icon you will see the additional information not shown on the table and if you increase the width of the table whenever possible more hidden information will be shown as additional columns in the table.

TIP You can also hide/show the lateral panel using the small arrow in the lower left corner (see, for example, Figure 2.13).

1.6 Acknowledgements

This manual is based on the previous manual version 1.18 (19/11/2019) written by Jesús Varela.

The author of this manual and also the manager, designer and developer of the CEFCA Catalogues Portal, **Tamara Civera** (CEFCA's scientific software and database engineer), is very grateful to **Javier Hernández** (CEFCA's database engineer) and to **Juan Castillo** (CEFCA's hardware technician) for having done such a great work in the servers, databases and infrastructures on which the CEFCA Catalogues Portal runs. As well as to **Jesús Varela** (former head of the DPAD) who created this nice previous manual version on which this manual is based.

Of course, I am also very grateful to the rest (current and past) of the DPAD Team: **Héctor Vázquez** (current head of the DPAD), **David Cristóbal** and **Alessandro Ederoclite** (former heads of the DPAD), **Antonio Hernán**, **Ángel López**, **Alberto Moreno**, **David Muniesa**, **Héctor Vives** and **Mohammad Akhlaghi**.

I also acknowledge José Luis Lamadrid for his magnificent image of the NGC7000 Nebula[1] from which I have borrowed the background image of the front page.

And, finally, the acknowledgements extend to all CEFCA's staff, past and present, as well as to all the collaborators from other institutions which have made possible to have the data to be shared through this archive.

[1] You can see the original image in here.

Chapter 2

CEFCA Catalogues Portal

2.1 General information

2.1.1 Access Page

Figure 2.1 is a the Data Access Services page of the website with links to the main services of the site. You can see a brief description of the services and of the data. From this page you have access to all the available services for that particular survey data release.

WARNING Some of the services could be only available if you have logged in (to create an account see 2.2).

2.1.2 Main navigation bar

All the pages in this site share a common navigation bar in the top (Figure 2.2). In this bar you can find, from left to right:

J-PLUS This is a link to J-PLUS website with information about the site and the characteristics of the data release.

Services This button displays a list of the available services of the site (see Figure 2.3).

Link to the Data Access Services page.

Link to this manual.

Link to the main page of the CEFCA Catalogues Portal.

Link to the contact page, which can be used to ask for help or to provide feedback about the website or the data release.

Click on this icon to create a new account if you do not have an account in the CEFCA Catalogues Portal. This icon is only displayed if you are not logged in.

Click on this icon to log in to a new session. This icon is only displayed if you are not logged in.

Click on this icon to access to services related to your user account like edit your profile or log out. This icon is only displayed if you are logged in.

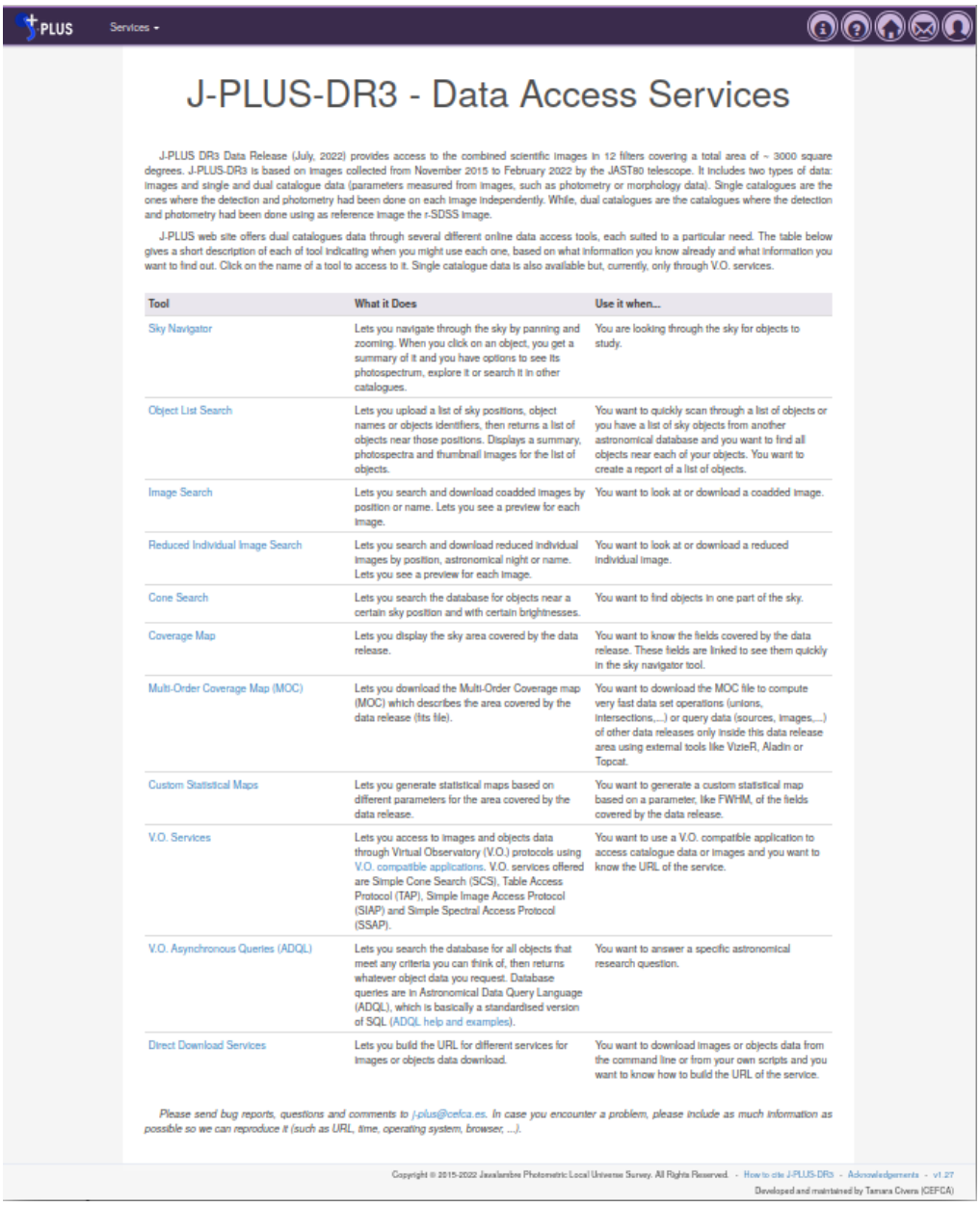


Figure 2.1: J-PLUS DR3 Archive Data Access Services page.

2.1.3 Footer

In the bottom of the webpages of the portal you will see a footer (see Figure 2.4) with the following useful information:

- Copyright information.

Figure 2.2: Main navigation bar.

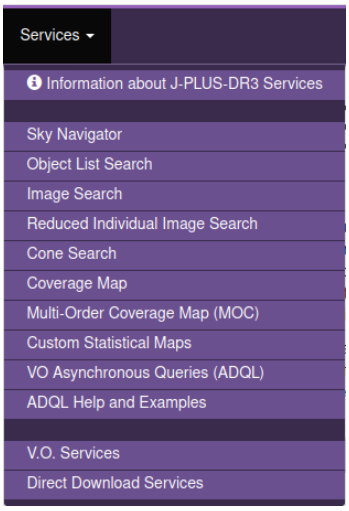


Figure 2.3: Menu of available services.

- A link to the text to be used to cite when using data from CEFCA Catalogues Portal.
- A link with the version of the webportal. **TIP** Clicking on this link you will be presented with the list of new features added to the current version. **TIP** The version of this manual is the same as the version of the webportal in which it is based upon.

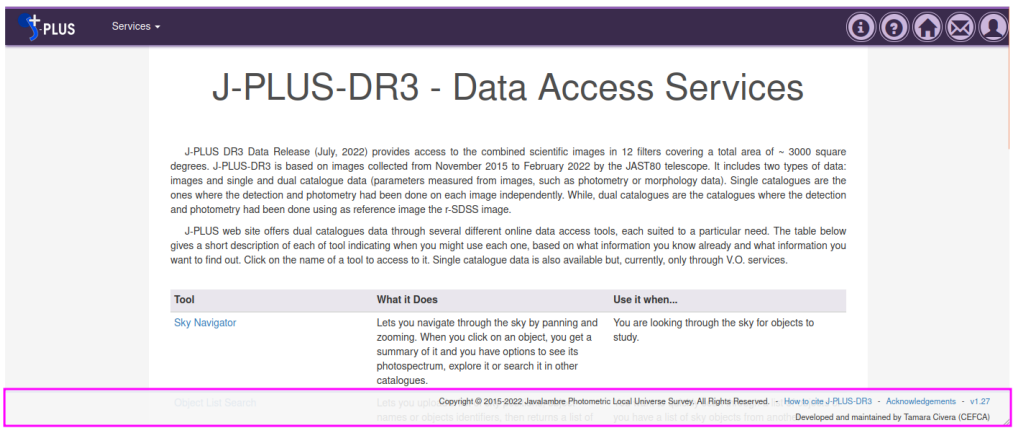


Figure 2.4: In pink, common footer of the webpages.

2.2 User account management

2.2.1 Creating a new user account

If you do not already have a user account, you can create one by clicking on the register icon on the top menu.

To start the registration, you must to introduce your e-mail address and click on the ”Next” button (see Figure 2.5).

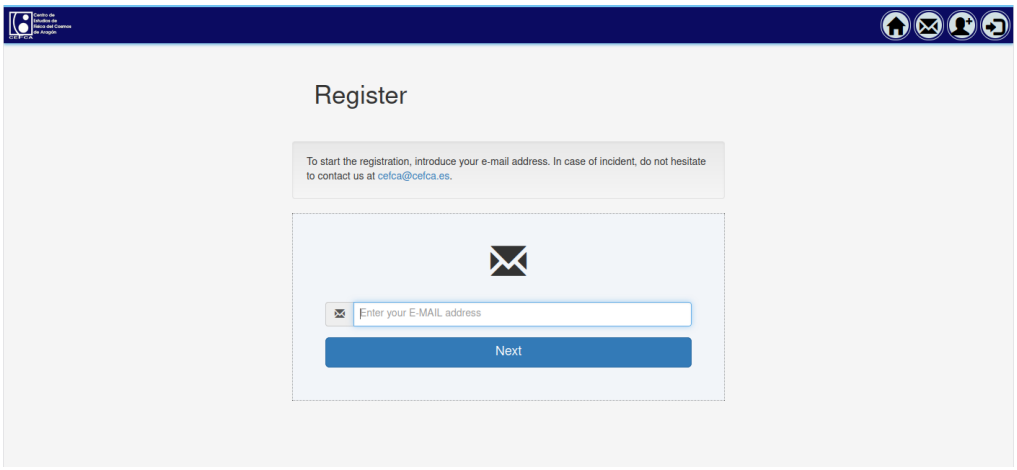


Figure 2.5: Registration page first step.

After clicking on the ”Next” button, the system checks if you already have a user account in the infrastructure, for example, if you have previously created an account at OAJ website. In that case, you only have to introduce the password of that account and describe your interests to access archival data also (see Figure 2.6).

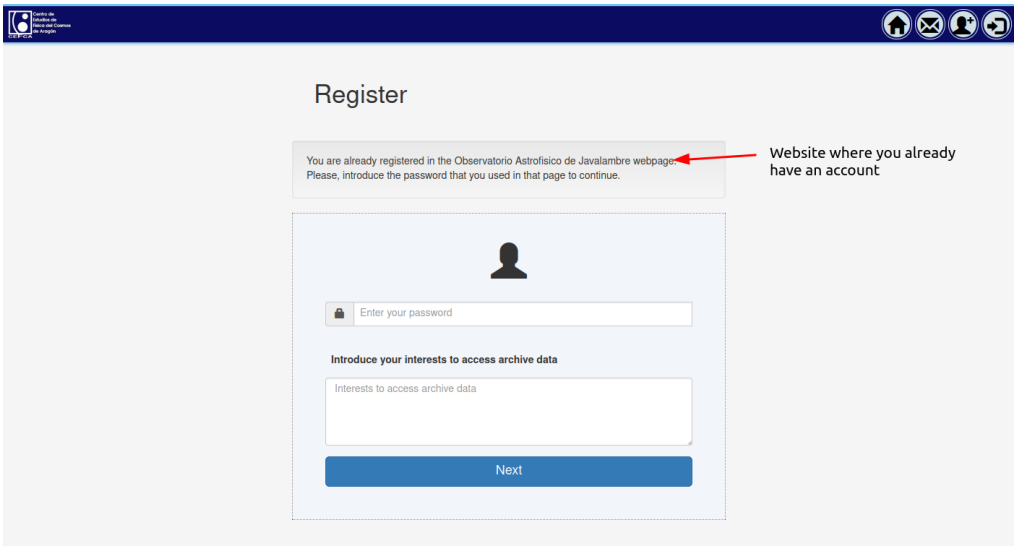


Figure 2.6: Registration page second step if you already have an account in the infrastructure.

The most common is not having a previous user account in the infrastructure. In that case, you have to fill your new user account data and your interests to access archive data (see Figure 2.7).

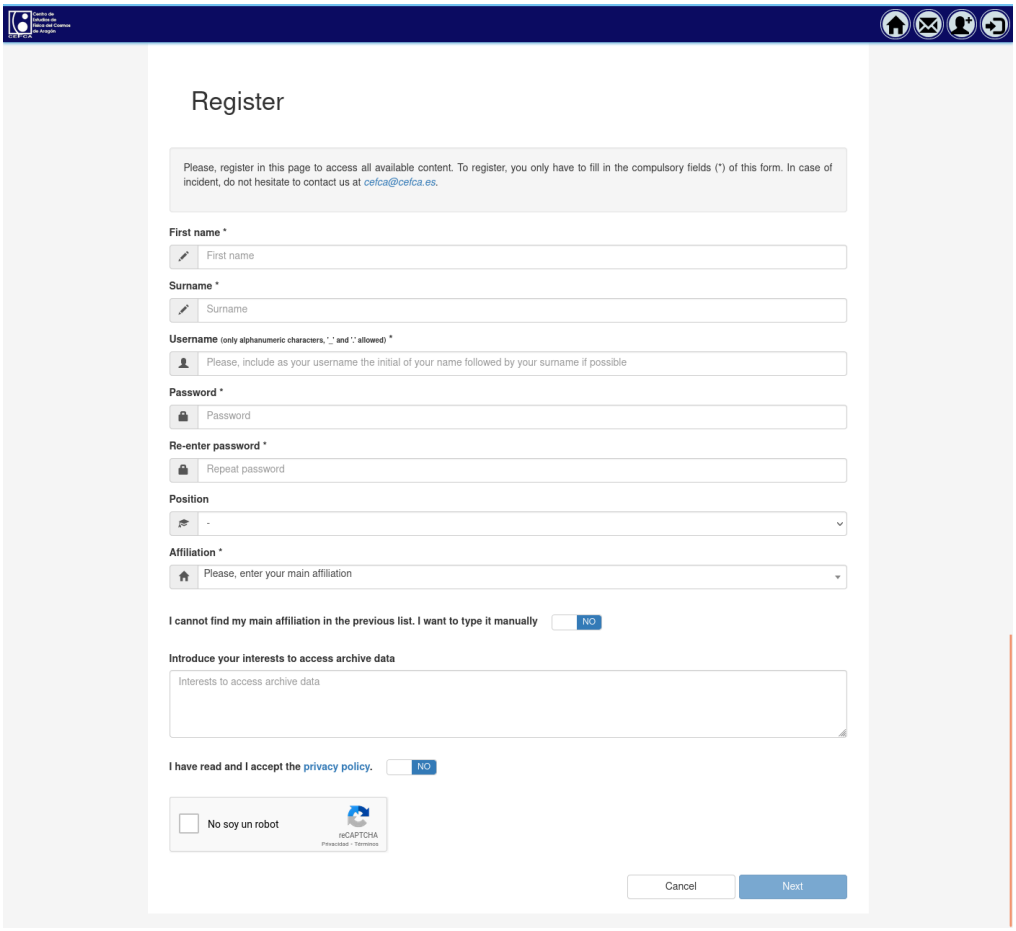


Figure 2.7: Registration page second step if you do not have an account in the infrastructure (the most common).

Once you send your data (Figure 2.6 or Figure 2.7), your account is automatically created and activated. To confirm it, a confirmation message is displayed in the screen (see Figure 2.8) and an email is sent to the email address you have used in the registration process.

2.2.2 Modifying your profile

You can modify your profile (first name, surname, email, position and affiliation) if you need it clicking on the user account icon and on the Edit my profile menu (see Figure 2.9).

2.2.3 Recovering your password

If you have lost your password, you can recover it clicking on the login icon on the top menu and then click on the link 'Lost password?' (see Figure 2.10).

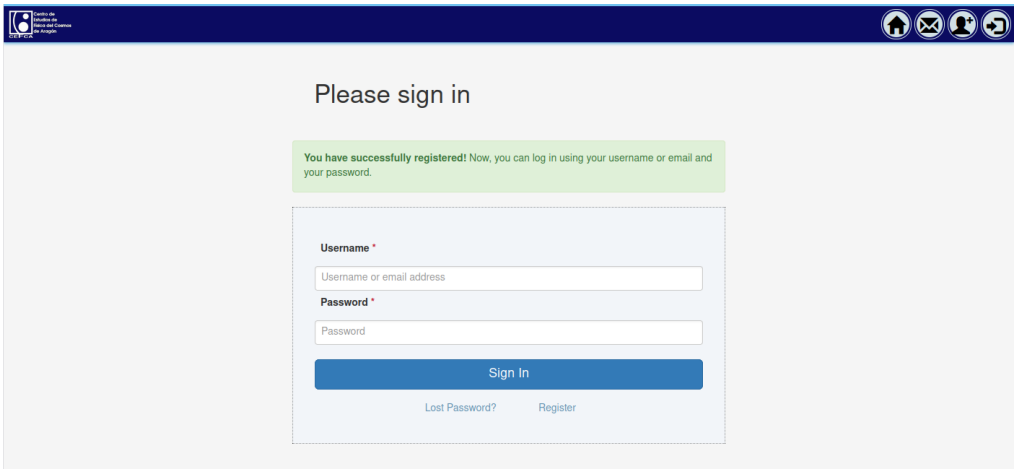


Figure 2.8: Confirmation message displayed when you register correctly.

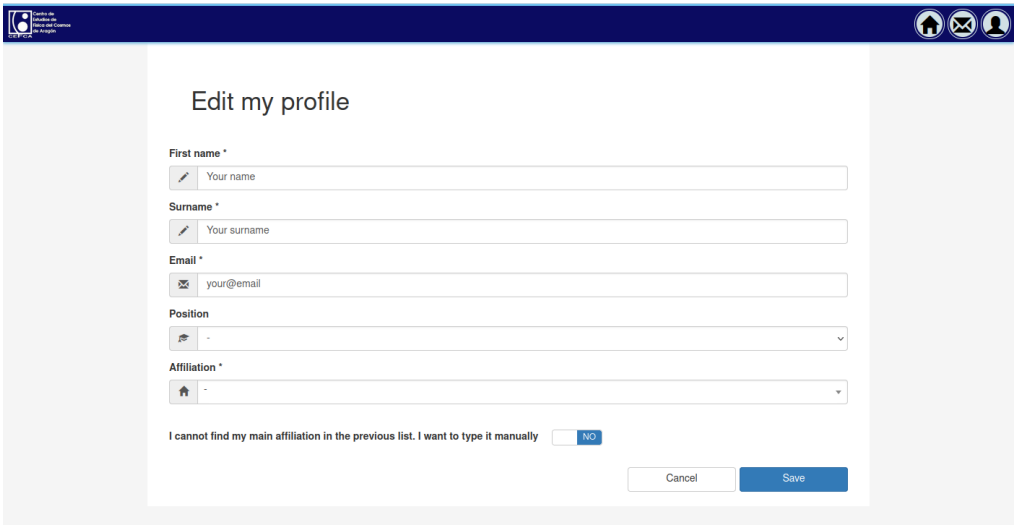


Figure 2.9: Edit profile page.

To recover the password you have to introduce your username or password and click on the 'Reset my password' button (see Figure 2.11). After clicking on the button, you are going to receive an email with the instructions to reset your password or cancel the request.

2.2.4 Modifying your password

You can modify your password clicking on the user account icon and on the Change password menu (see Figure 2.12).

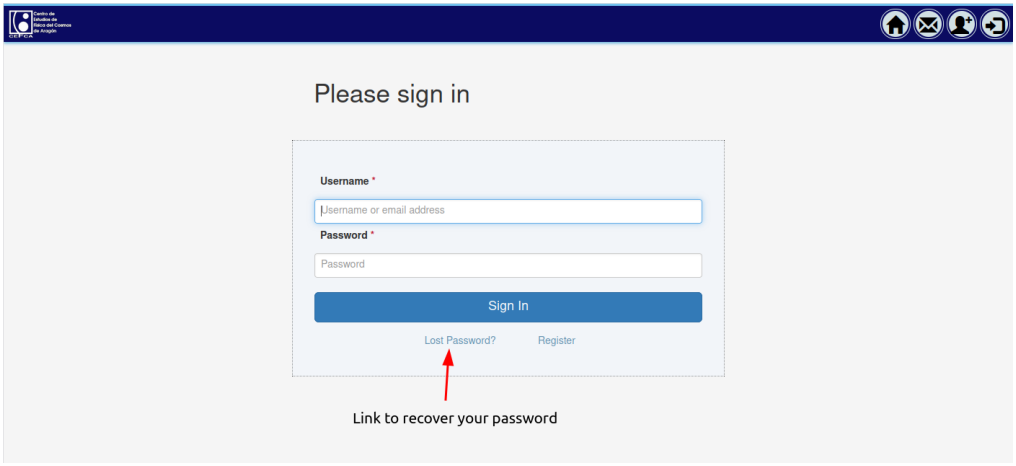


Figure 2.10: Link to recover your password if you lose it.

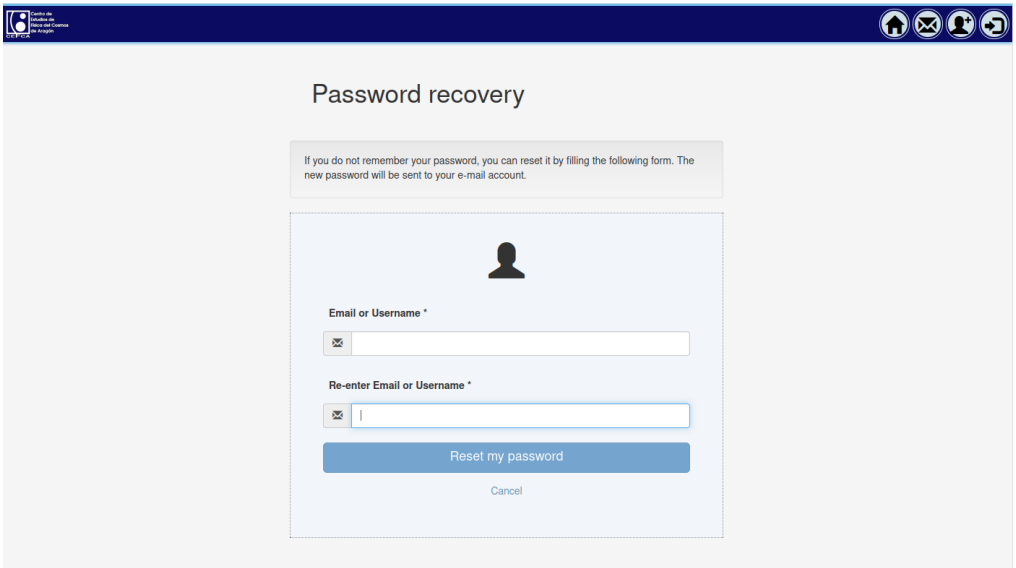


Figure 2.11: Password recovery page.

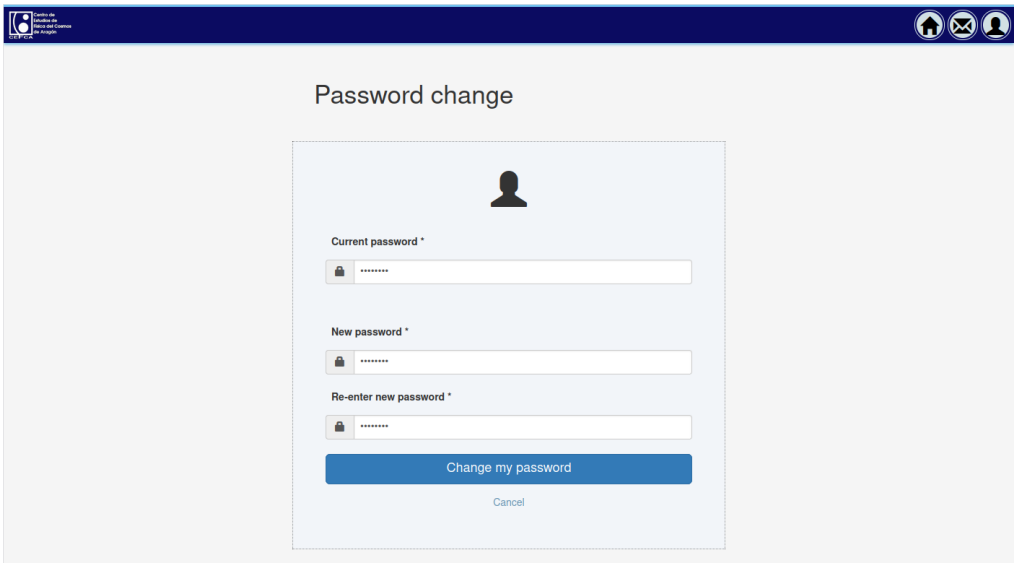


Figure 2.12: Password change page.

2.3 Services

2.3.1 Sky Navigator

The Sky Navigator is the most user-friendly service which allows navigation of the sky through color images of the survey and to easily get basic information of the objects stored in the archive.

You can use this service for in the following scenarios:

- You want to know the basic information about particular objects like:
  - visual morphology,
  - Photo-spectrum,
  - basic data from database,
  - the list of Coadd from which the photometry has been derived
- You want to check the surroundings of a given object.

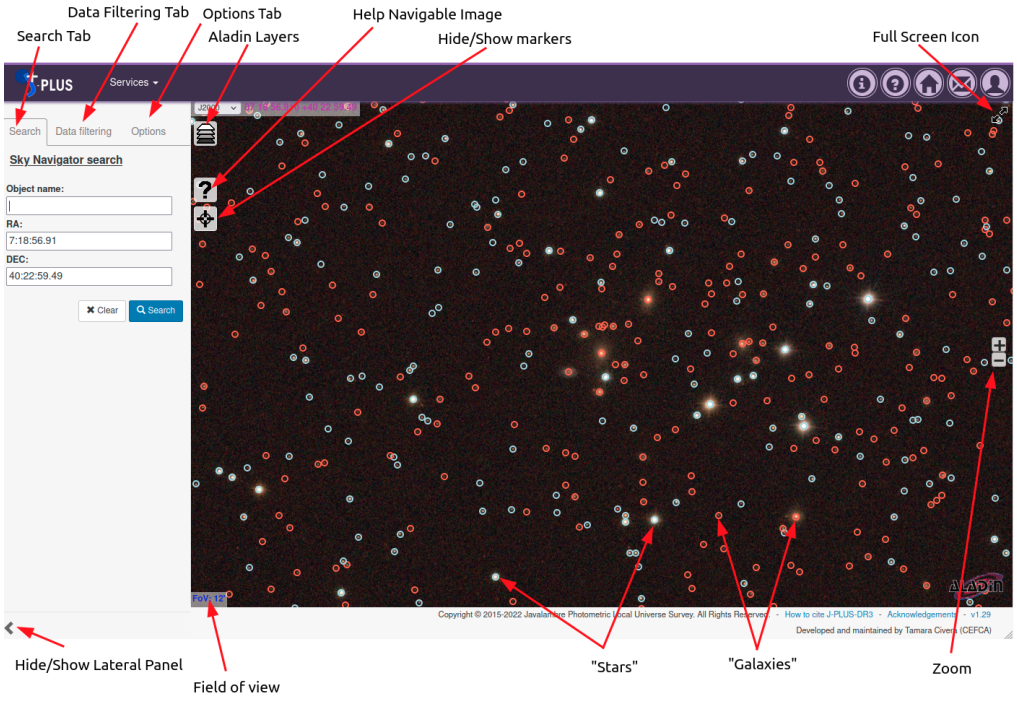


Figure 2.13: Sky navigator description.

Figure 2.13 shows the main screen of the Sky Navigator with some useful tips. Following is a brief description of the features of this service:

Navigable Image The navigable image is the main tool of the sky navigator. This tool is based upon "Aladin Lite"[1]. By default, the background image is a color

[1] https://aladin.u-strasbg.fr/AladinLite/

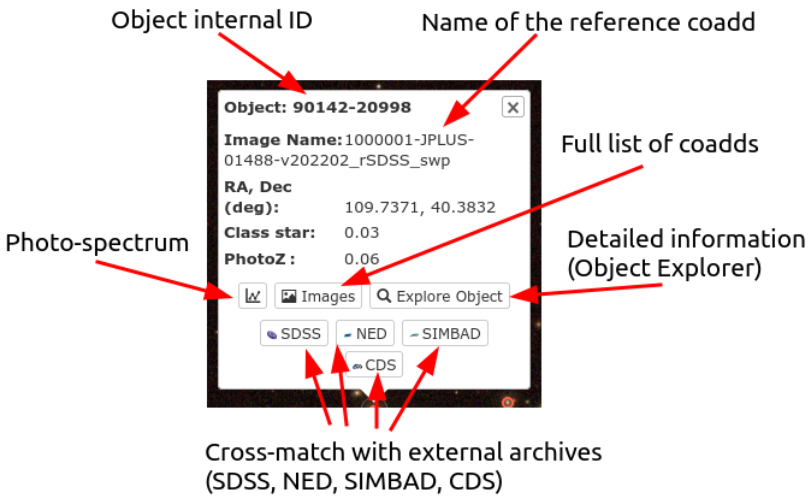


Figure 2.14: Description of the pop-up window that appears when clicking on the marker of an object.

image made from the survey images and you will see blue and red circular markers indicating "stars" (unresolved objects) and "galaxies" (resolved objects), respectively.[2] When the field of view (displayed on the bottom-left corner of the sky viewer) is larger than $\sim 15'$ the markers are not shown. Yellow triangles indicate that the objects are inside a mask (for example, if the object is affected by a star).

The main characteristics of this tool are:

- You can navigate in the image scrolling the image (keep pressing the left-button of the mouse and moved around) and zooming in and out (mouse wheel or pressing icons "+"/"-" in the right side). TIP Depending the level of zoom more or less objects are marked, this is because when you zoom in fainter objects are marked.
- The size of the current field of view is shown in the lower left corner.
- You can make the image full screen (within the browser) with the icon in the upper right corner.
- Clicking on the icon in the upper left corner you will see a pop-up window that allows:
  - to change the background image using images from several sky surveys observed in different wavelength ranges.
  - to change the colormap of the background image.
  - to hide or show the objects markers.
  - to show or hide the area covered by this data release and other footprints (when available).

[2]The distinction is made based on SExtractor's CLASS_STAR, with "star" having CLASS_STAR>0.5 and the rest considered "galaxies".

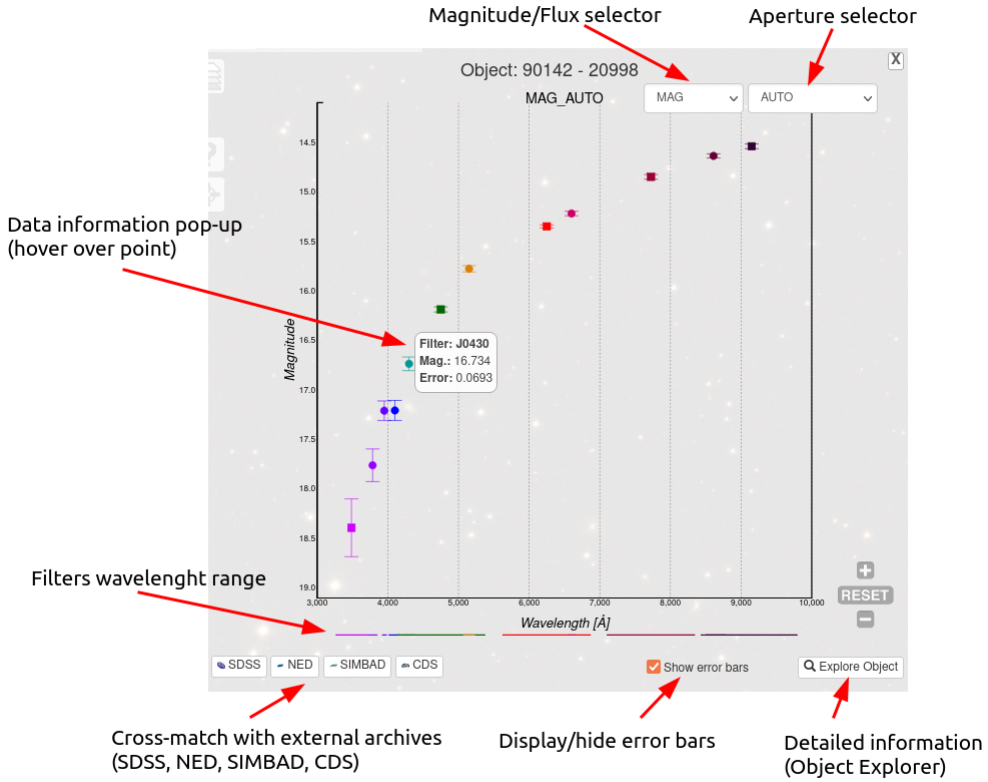


Figure 2.15: Description of the pop-up window showing the Photo-spectrum.

– to create a PNG image of the current view.

TIP Some of this options are also available on the Lateral Panel on the Tab 'Options'.

- You can click on any marker and a pop-up window (Figure 2.14) with this additional information about the object will appear:

  Object Internal ID

  Equatorial coordinates

  Name of the original Coadd

  Class star calculated by SExtractor

  Photometric redshift

  This button will show the Photo-spectrum of the object (Figure 2.15).

  Images Press to show the list of coadds in which the object has been found (see Service 2.3.4).

  Explore Object Press to open the Object Explorer with detailed information (see Service 2.3.2).

  In addition, an ellipse will be drawn over the background color image, showing the elliptical Kron aperture used to compute the SExtractor's MAG_AUTO.

TIP You can control whether to show or not the markers on the image clicking on the icon on upper left corner, clicking 'Show catalogue objects' on the Lateral Panel on the Tab 'Options' or on the icon on upper left corner and checking or unchecking the `catalogue` checkbox under 'Overlay layers'.

Lateral Panel In the lateral panel you will find tabs for different tasks. In the Sky Navigator you have two tabs:

Search This tab allows to move to a particular position in the sky. You can either introduce the name of an object in the "Object" box[3] or you can introduce equatorial coordinates. Coordinates can be introduced either in sexagesimal or decimal format. TIP You can also introduce the equatorial coordinates separated by a space in the "Object Name" box.

Data filtering This tab (Figure 2.16) allows to introduce different types of criteria for the objects to be marked in the navigable image. The criteria that can be applied right now are:

- Criteria on the star/galaxy separation. This is based on the `CLASS_STAR` parameter of `SExtractor` for the r band image. The menu allows to select the objects to be shown (only stars, only galaxies or both) while the slide allows to set the value of `CLASS_STAR` to separate between "stars" and "galaxies".
- Mark or not objects inside a mask with a yellow triangle.
- Criteria on the color indices. To introduce new criteria, click on the + Add condition button.
- Criteria on the total magnitude (`MAG_AUTO`) and the signal-to-noise ratio. To introduce new criteria, click on the + Add condition.
- Criteria on the photometric redshifts (when available).

REMEMBER Press the Apply filters to activate the new criteria.

Options This tab allows to change some sky navigator visualization options like:

- change the background image using images from several sky surveys observed in different wavelength ranges.
- hide or show the objects markers.
- show or hide the area covered by this data release and other footprints (when available).

2.3.2 Object Explorer

This tool is accessible through different services (e.g. the Sky Navigator) and presents detailed information of individual objects.

Figure 2.17 shows a screenshot with information about some non self-explanatory options. The pink lines split the full area within the figure in five blocks identified with capital letters to help in the description. A description of each is given below.

[3] This will be resolved by Sesame.

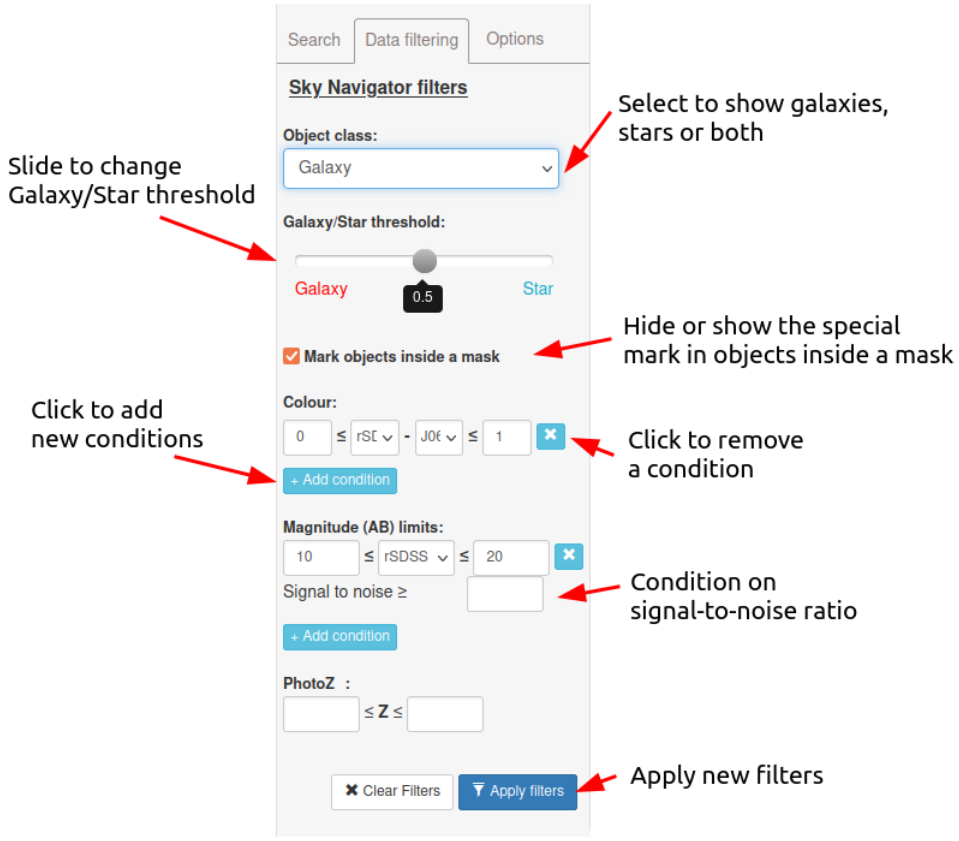


Figure 2.16: Description of the Data filtering tab.

Basic Info block (A) In the upper part you have a block with some basic information of the object:

Object identifier Identifier of the object composed by the reference rSDSS band image identifier and the NUMBER parameter of SExtractor.

Value Added Catalogue If the icon is displayed, the object has added value data associated. This data is displayed in the section "Added Value Data".

Coordinates Equatorial coordinates in sexagesimal and decimal format.

Class Star As provided by CLASS_STAR parameter of SExtractor (from the reference rSDSS band image).

PhotoZ Best point estimate of the photometric redshift from the default photometric redshift code.

PhotoZ Min., PhotoZ Max. Values that define the 68% confidence interval for PhotoZ with the default photometric redshift code.

Odds Probability that the actual redshift is within 3% of PhotoZ computed from the redshift probability distribution function (zPDF; see 5.2.3 for details).

FWHM Full width at half maximum in arcsec (as computed by SExtractor).

Figure 2.17: Description of Object Explorer.

Navigable Poststamp (B) The poststamp showed is navigable as any "Aladin Lite" image (ie. you can zoom in and out and move around). It shows the elliptical apertures used to compute the `MAG_AUTO` magnitude (cyan) and the `MAG_PETRO` magnitude (magenta). The ellipses can be hidden/shown through the checkboxes Show Auto ellipse and Show Petro ellipse in the lateral panel. The icon in the upper left corner resets the image to the original one.

Interaction buttons (C) In this block you can find links which perform different actions:

Download results This link allows to download the results presented in the explorer in different formats:

CSV Comma separated table. **WARNING** Be aware that the values of a given magnitude type (eg. `MAG_AUTO`) in the different bands are all in single column and separated by spaces.

FITS In FITS format the values of the different bands of a given magnitude types appeared grouped in an array.

VOTABLE VOTABLE format.

PDF PDF format of the Object Explorer webpage, including the poststamps. **TIP** The PDF contains a link to the original webpage which can be used for future references or to share the information with other people. **WARNING** The data stored in the PDF will correspond to the visible sections.

Transfer data This transfer information to VO compliance tools like TOPCAT or Aladin.[4] The information that is sent consists on the tabular data of the

[4]The applications must be open and listening through SAMP.

object as well as information of the cutouts and the full frame images in all the band and the URLs to access to them through SIA protocol.

See in navigator Show the object in the Sky Navigator.

Images search Show the list of original Coadd images where the object was found in the Image Search service. TIP If any of the original coadd images has been flagged as having a problem this is shown adding a warning signal in the button Images search.

Download PSFs This link allows to download PSF image models for that object in the bands selected.

Individual Images Show the list of original reduced individual images that compose the Coadd images where the object was found in the Reduced Individual Image Search service.

Search SDSS Search a cross-match in the SDSS catalogue.

Search NED Search a cross-match in NED.

Search Simbad Search a cross-match in Simbad.

Search CDS Search a cross-match in CDS.

Search Archive Catalogues Search a cross-match in other catalogues in the CEFCA Catalogues Portal.

Control panel (D) The lateral panel helps to control the output of different tools.

RGB image options Here you can control some configuration of the RGB poststamp.

Show Auto ellipse Check or uncheck the box to show or hide the aperture used for computing `MAG_AUTO` (cyan).

Show Petro ellipse Check or uncheck the box to show or hide the aperture use for computing the Petrosian magnitude or `MAG_PETRO` (magenta).

Image survey: With this menu you can change the background image used in the poststamp. By default, an RGB image made of given CEFCA's survey images is used but there are available several all-sky surveys in different wavelength ranges.

Filters to show These checkboxes control the bands that are shown in the Photometry (Phm) and the Photometric redshifts (PhZ) sections.

Photospectra Here you can select the apertures and the units used in the "Pseudo spectra" section and check or uncheck if you want to display the error bars. The units possibilities are:

AB Magnitudes

$f(\lambda)$ In units of $10^{-19}\,\mathrm{erg\,s\,cm^{-2}\,\AA^{-1}}$.

$f(\nu)$ In units of $10^{-30}\,\mathrm{erg\,s\,cm^{-2}\,Hz^{-1}}$.

Photometry Here you can select the units used in the "Photometry" section. The possibilities are the same of the Photospectra.

Full information Sections (E) This block contains several sections which provide a lot of detailed information in several ways:

Pseudo-spectra Show the pseudospectra or photo-spectra of the object using different types of SExtractor magnitudes, except the PSF_Matched magnitude which is computed as a part of the pipeline.[5] TIP When hovering over a point you get a pop-up window with the actual data. TIP You can change the units and the apertures displayed as well as displaying or hiding the error bars of the photo-spectra using the menus in the bottom of the lateral panel. TIP If you double click on a graph, it is displayed in a dialog box where it can be zoomed and panned.

Photometry Show the photometry in all the available apertures and types. In the columns of the aperture magnitudes, the number separated by underscores (eg. 1_5) corresponds to the diameter of the aperture in arcsecs (ie. 1_5=1.5").

PhotoZ Show information related to the photometric redshift. TIP If it is available, you can download the zPDF (see 5.2.3) clicking on the Download icon.

Morphology Right now these are just "geometrical" parameters like the isophotal area, the effective radius, the A and B SExtractor's parameters[6] and the position angle THETA.

Object Images TIP This section shows poststamps or cutouts in all the bands of the object. The cutouts can be downloaded either in PNG format or FITS format (with the proper astrometry). The Field of View (FoV) of the cutouts is controlled with the slide in the upper right corner. After changing the FoV you need to press the Apply button. TIP To visualize the images of the object for the different filters you have to click on "load png cutout" or on "apply" button.

Added Value Data This section shows the added value data associated to the object. TIP To load the added value data of the object you have to click on the different tabs that appear inside this section. WARNING This section is only displayed if the object has added value data associated to it.

Cross-identification This section performs a cross-match using the coordinates of the object. The different services used to perform these cross-matches are:

Simbad service

VizieR service The cross-match is performed on a preconfigured series of all sky surveys available in this service.

Other CEFCA Catalogues Portal surveys TIP If you click on the icon you can see all the information of the other survey object on its "Object Explorer" service.

[5] More details of the procedure can be found in Molino et al.(2014).

[6] These parameters are related to the semi-axis of the isophote. See SExtractor's Manual for a detailed description

TIP Again, to perform the different cross-matches you have to click on the different tabs that appear inside this section. **TIP** With the Download results button you can retrieved the information of the cross-match in different formats. **TIP** You can change the radius used to perform the cross-match with the slide in the upper right corner. After changing it you need to press the Apply button.

2.3.3 Object List Search

The Object List Search service is the easiest way to retrieve information for a list of objects. You can retrieve information for up to 1000 objects at once.

Figure 2.18 shows the main window of this service. For the purpose of the following description the window has been divided in three blocks labelled with pink capital letters.

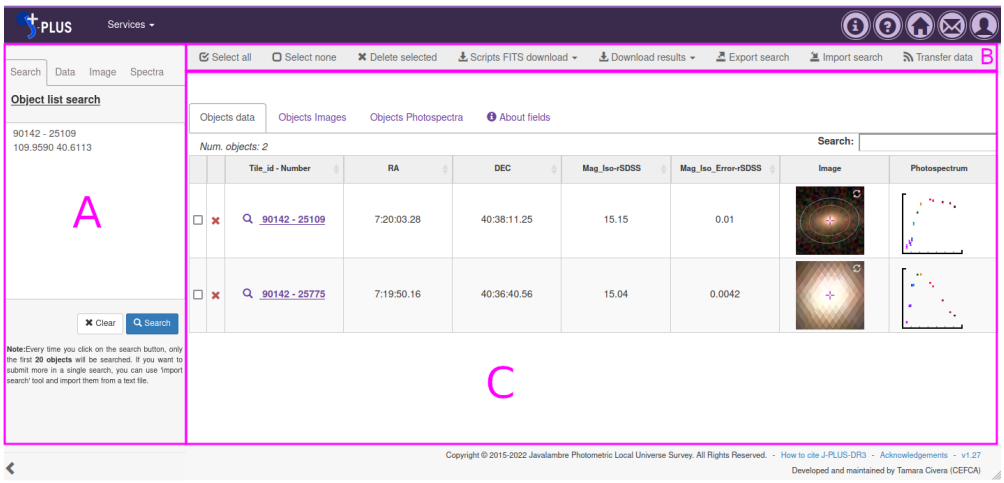


Figure 2.18: Screenshot of the Object Search List service. The division by the pink lines and the pink letters labels are used in the text to help in the description.

Let's start with the description block by block:

Block A This block contains 4 tabs with different purposes:

Search This is the main tab and the one in which you can insert a short list[7] of coordinates or objects names to be searched in the archive. TIP Hovering over the box will show a pop-up with instructions. The basic ones are:

- One object per line.
- Each object can be identified by equatorial coordinates (sexagesimal or decimal format) and a search radius in arc seconds[8]. Eg.:

  ```
  7:20:03.28 40:38:11.25 5
  110.0137 40.6365 5
  ```

- Its name (with no spaces)[9]. Eg.:

  ```
  J072003.27+403811.2
  ```

- By its internal identification made of the coadd id and the object id within the coadd, separated by a space or a dash. Eg.:

[7] No more than 20 objects. For longer lists of objects, you can use the Import search feature describe in page 28.

[8] If no search radius is provided a default 3" radius is used. The maximum radius allowed is 10"

[9] Names are resolved by Sesame

```
90142 25109
90142 - 25109
```

- It is possible to mix these different ways of identifying the objects in a single search.

TIP The searches are cumulative and the results of new searches are appended to the results of previous ones.

TIP If you want to search for more than 20 objects, use the Import search tool that is described page 28.

TIP With the Clear you can clear the searching box (not the list).

Data This tab (leftmost image in Figure 2.19) helps to control the columns that are visible in the table. The **Visible columns:** menu controls the parameters that are band-independent while the **Visible filters columns:** menu controls those parameters that are different from band to band.

Image This tab (central image in Figure 2.19) helps to control some parameters of the displayed image:

Show Auto ellipse Show/hide the elliptical Kron aperture used by SExtractor to compute MAG_AUTO.

Show Petro ellipse Show/hide the elliptical Petrosian aperture used by SExtractor to compute MAG_PETRO.

Show Reticle Show/hide small magenta cross in the centre of the image.

Image survey: Allow to change the background image among different sky surveys.

General FoV: Allow to set a given FoV to all the cutouts. First you have to set the value between 3" and 360" using the slide and then press the button Set all images to selected FoV.

Set default image view Reset the changes made on the FoV and central coordinates in all images and returns to the default image configuration.
TIP If you only want to reset the image of a particular object, you can go to the image in the Objects Images tab and click on the  icon.

Copy images to data table Makes a snapshot for each of the Objects Images tab images as they are currently displayed (FoV, central coordinates, survey image,...) and copies them to the images column of the Objects data tab.
TIP If you only want to change the snapshot of a particular object, you can go to the image in the Objects Images tab and click on the  icon.

Spectra This tab (rightmost image in Figure 2.19) helps to control the display of the photo-spectra of the objects. With the Aperture: menu you can choose the type of magnitude for the photometry, defined by different types of apertures, and with the Measure: menu you can choose the units of the photometry.

Block B This block contains a series of buttons to perform different actions regarding the data showed in the Block C. Let's see them in more detail:

Select all Use this button to select all the object in the list. Several actions apply only to selected objects.

Select none Use this button to uncheck the selected objects.

Delete selected Using this button you will remove from your list all the selected objects. A pop-up window asking for confirmation will appear before actually removing the items.

Scripts FITS download This button will allow to download either the full coadd images in which the selected objects have been found, their weight map images or just the cutouts, in FITS format in all cases. The download is made through the tools `wget` or `curl`, which are available in most of the Unix-like systems. After selecting one of the options you will retrieve a text file which is a script. The instructions on how to launch the actual download of the images are written in the same script. **WARNING** Be aware that full frame images are ~ 50 MB size each one.

Download results This button will allow you to download the data (all or part of it) of your object list in different formats:

CSV You will download the data of the table in CSV format.

FITS You will download the data of the table in FITS format.

VOTABLE You will download the data of the table in VOTABLE format.

PDF You will download the data of the table in PDF format. **TIP** The PDF file has links like the original webpage and they can be used to open the full list (first line of the PDF) or to see single objects in the Object Explorer.

OBJECT IMAGES This will allow you to download a ZIP file with PNG cutouts of all the objects (selected or not). **TIP** The cutouts include the coordinates of the centre and the size of the field of view.

OBJECT SPECTRA This will allow you to download a ZIP file with SVG cutouts of the photo-spectra of all the objects (selected or not).

Export search **TIP** Use this button if you want to keep your search (including the current view of the page) in a JSON format that can be imported afterwards with the Import search.

Import search **TIP** Use this button to recover a previous search that has been exported as JSON file or to perform a search like the one in the Search tab, ie. providing a list of objects or coordinates and a matching radius. **WARNING** There is a limit of 1000 objects.

Transfer data This button will transfer the data of your Object List to an open and listening Virtual Observatory (VO) tool.

Block C This is the main block showing the actual data. There are four tabs:

Objects data This tab (Figure 2.20) shows a summary table with information of each object, a cutout of the color image and a cutout of the photo-spectra.

TIP You can rearrange the order of the columns, clicking on the header of a column and dragging it to another position.

Objects Images This tab (Figure 2.21) shows an array of cutouts of all the objects. TIP These cutouts are navigable images so you can zoom in and out. TIP Remember that you can configure the cutouts using the Image tab in the lateral panel (Block A).

Objects Pseudospectra This tab (Figure 2.22) shows an array of cutouts of the photo-spectra of all the objects. TIP Remember that you can configure the photo-spectra using the Spectra tab in the lateral panel (Block A).

About fields This tab shows a brief description of the fields of the table.

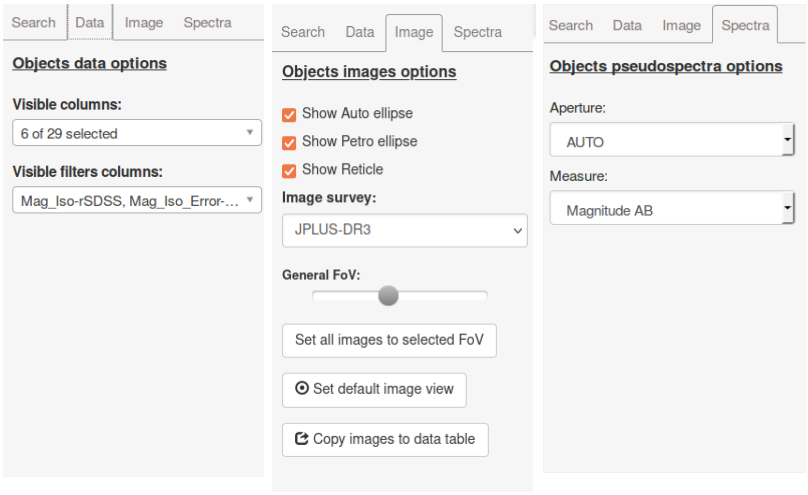


Figure 2.19: Screenshot of the additional tabs in the Block A of the Object List main screen. From left to right: Data tab, Image tab, Spectra tab.

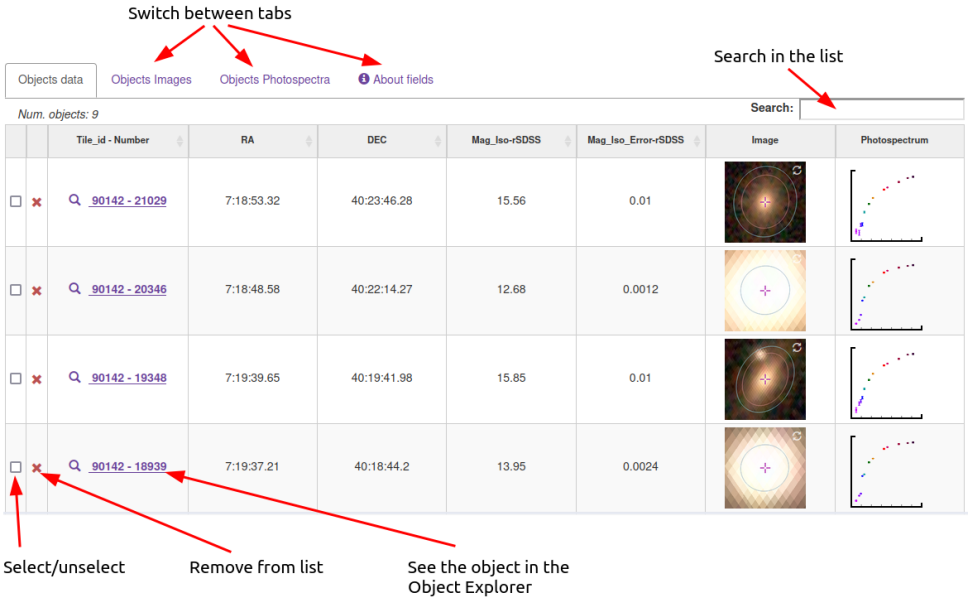


Figure 2.20: Screenshot of the Objects data tab.

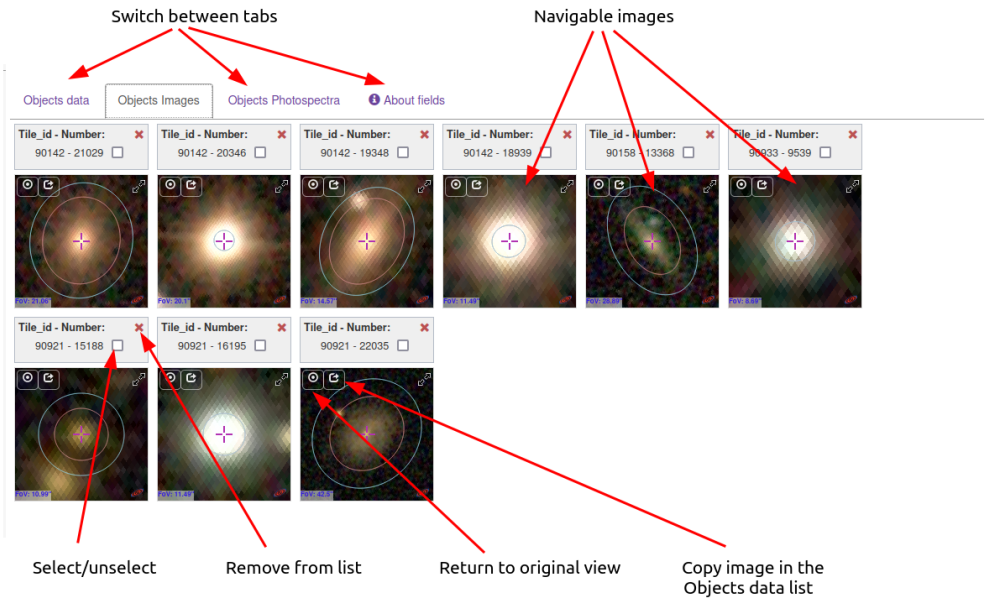


Figure 2.21: Screenshot of the Objects Images tab.

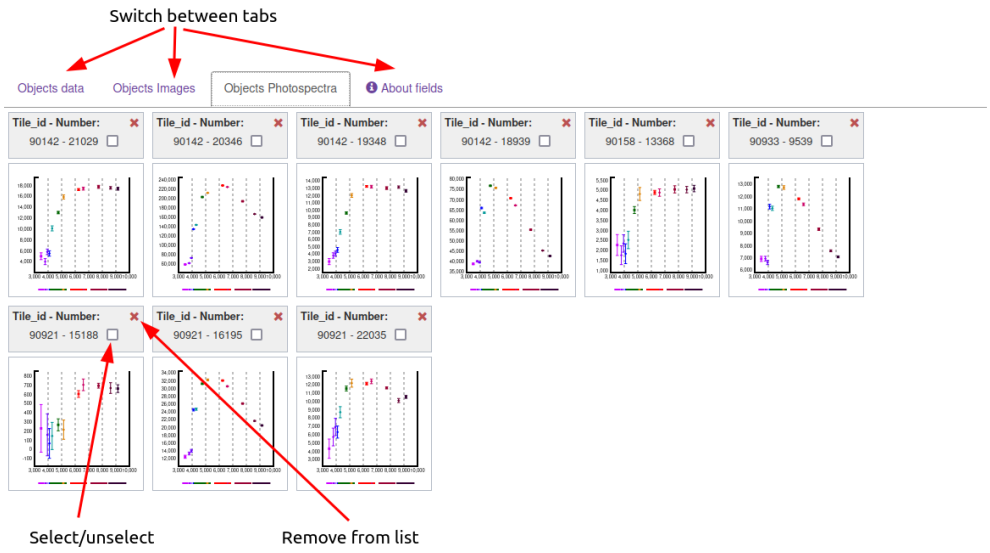


Figure 2.22: Screenshot of the Objects Pseudospectra tab.

2.3.4 Image Search

The Image Search service provides access to the original Coadd images from where all the data of the archive has been derived.

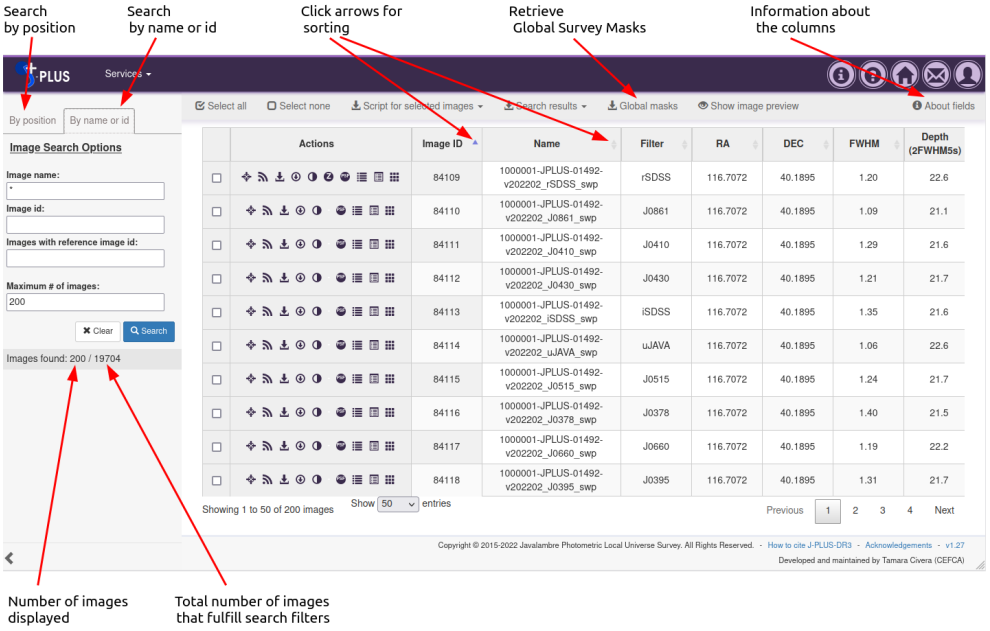


Figure 2.23: Screenshot of the Image Search main window with some useful indications.

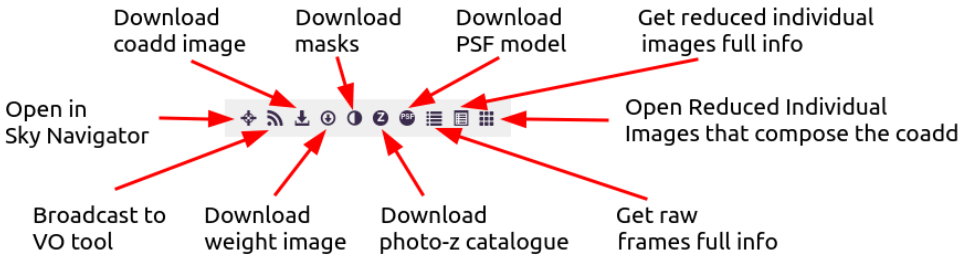


Figure 2.24: Detail of the Actions available.

Figure 2.23 shows a screenshot of the main page. Following is a description of the different parts of the window:

Lateral Panel The lateral panel provides two tabs to search for images in two different ways:

By position This tab allows you to search for all the coadd images that fall totally or partially in a box defined by the coordinates of its centre and the length of each side. The centre of the box can be provided as an object name

(which is resolved by Sesame) or by its equatorial coordinates. By default, the coadd images are shown in all the bands but this can be changed using the menu Filter:.

By name or id This tab allows to search for coadd images using internal database identifications like the actual name of the image, its internal id or by the internal id of the reference coadd (i.e. the id of the coadd image in the rSDSS filter). TIP When searching by image name it is possible to use the asterisk as a wildcard to match an arbitrary string. This is very useful to search for images in a given filter, e.g. '*J0395*' will search for all the coadds in the J0395 filter.

TIP In the Maximum # of images: field you can indicate the maximum number of images to display in case that the number of images which could fulfill the filters requirements should be large. WARNING If the field is empty no maximum number of images is set in the search, but be careful because if a large number of images is found the data display could be slow.

Upper menu In the upper menu you can find the following tools:

Select all Click to select all the images.

Select none Click to unselect all the images.

Script for selected images TIP If you want to download many images, select them and press this button. It will provide you with either a `wget` or `curl`[10] script to proceed to the download. After downloading the script, open it and follow the instructions written in it.

Search results Use this button to download the table with the data (not the images). The result can be downloaded in CSV, FITS or VOTABLE formats.

Global masks Clicking on this button you will download a tarball file with the global MANGLE [11] masks of the full survey (WARNING The icon is only visible when the masks are available).

Show image preview Clicking on this button you will see two preview images of the active row (that with purple background). The upper image is the color version of the pointing (and therefore doesn't change among coadd images of the same pointing) and the lower image is a JPEG preview of the original FITS image. TIP You can click on any of them to see a larger version.

About fields TIP Press this button to see a summary table describing the columns or fields that are shown in the table for each coadd image.

Table The table shows the main parameters of each coadd image (click on About fields for a brief description), except in the Actions column where you can find buttons or icons to perform the following actions:

[10] `wget` and `curl` are two common `*nix` command line downloaders.
[11] http://space.mit.edu/~molly/mangle/

- Open the Sky Navigator centered in the coadd image.
- Broadcast the image to any VO tool listening.
- Download the FITS image.
- Download the weight image (if available).
- Download the MANGLE masks of the image (if available). Several types of masks are provided in a tarball file.
- Download the PhotoZ catalogues in a tarball file (if available **WARNING** This action is only available in the coadd of the reference band).
- Download the PSF model (if available).
- Download a CSV table with all the information of the combined raw images available in the database (if available).
- Download a CSV table with all the information of the combined individual reduced images available in the database (if available).
- Open the Reduced Individual Image Search with the list of individual reduced images that compose this coadd image (if service is available in this survey data release).

TIP Clicking on the arrows next to the name of a column, you can sort (in ascending or descending order) the table using the values of that column.

TIP Sometimes, some problem can be detected in the images after uploading them in the archive. To keep consistency in the data releases, those images are not removed but are flagged and a warning signal beside the image ID is indication of a problem with the image. Hovering on the icon will show the kind of error affecting the image and clicking on a pop-up window will provide more information about the problem.

2.3.5 Reduced Individual Image Search

The Reduced Individual Image Search service provides access to the original reduced individual images used to generate the Coadd images from where all the data of the archive has been derived. **WARNING** This service is only available in those data releases that offer these images.

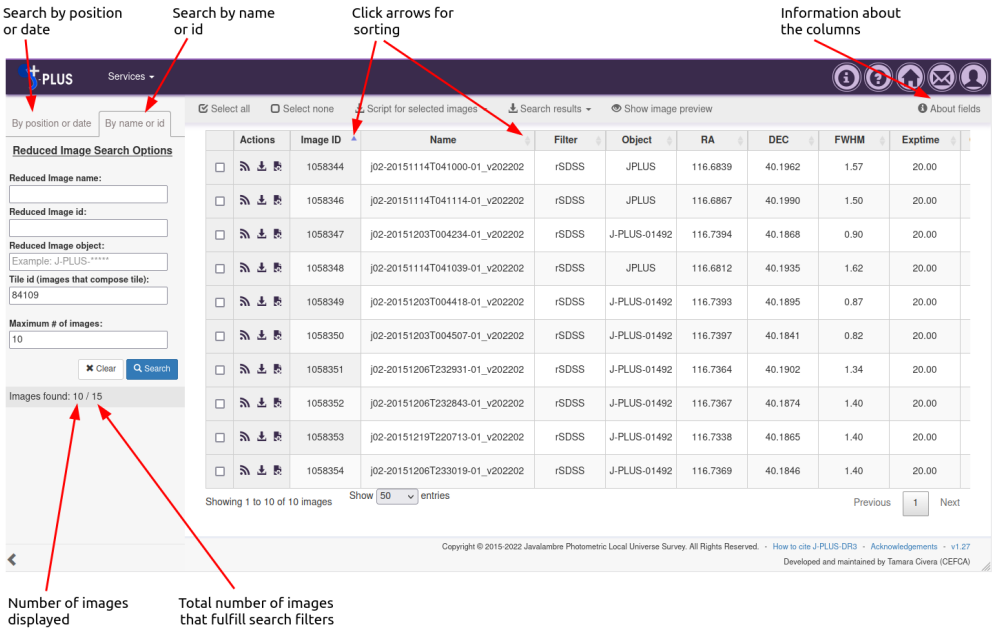


Figure 2.25: Screenshot of the Reduced Individual Image Search main window with some useful indications.

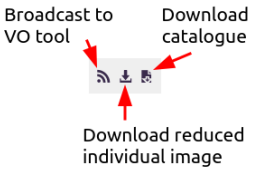


Figure 2.26: Detail of the Actions available.

Figure 2.25 shows a screenshot of the main page. Following is a description of the different parts of the window:

Lateral Panel The lateral panel provides two tabs to search for images in two different ways:

By position or date This tab allows you to search for all the individual reduced images that fall totally or partially in a box defined by the coordinates of its centre and the length of each side. The centre of the box can be provided as an object name (which is resolved by Sesame) or by its equatorial

coordinates. This tab also allows you to search by Astronomical observation night. By default, the individual reduced images are shown in all the bands but this can be changed using the menu Filter:.

By name or id This tab allows to search for individual reduced images using internal database identifications like the actual name of the image, its internal id or the name of object. It also allows to search all the individual reduced images that compose a coadd image searching by the coadd image id. TIP When searching by image name or object it is possible to use the asterisk as a wildcard to match an arbitrary string.

TIP In the Maximum # of images: field you can indicate the maximum number of images to display in case that the number of images which could fulfill the filters requirements should be large. WARNING If the field is empty no maximum number of images is set in the search, but be careful because if a large number of images is found the data display could be slow.

Upper menu In the upper menu you can find the following tools:

Select all Click to select all the images.

Select none Click to unselect all the images.

Script for selected images TIP If you want to download many images, select them and press this button. It will provide you with either a `wget` or `curl`[12] script to proceed to the download. After downloading the script, open it and follow the instructions written in it.

Search results Use this button to download the table with the data (not the images). The result can be downloaded in CSV, FITS or VOTABLE formats.

Show image preview Clicking on this button you will see a JPEG preview of the original FITS individual reduced image of the active row (that with purple background). TIP You can click on any of them to see a larger version.

About fields TIP Press this button to see a summary table describing the columns or fields that are shown in the table for each individual reduced image.

Table The table shows the main parameters of each individual reduced image (click on About fields for a brief description), except in the Actions column where you can find buttons or icons to perform the following actions:

Broadcast the image to any VO tool listening.

Download the FITS image.

Download the image objects catalogue in FITS format.

TIP Clicking on the arrows next to the name of a column, you can sort (in ascending or descending order) the table using the values of that column.

[12] `wget` and `curl` are two common `*nix` command line downloaders.

2.3.6 Cone Search

The Cone Search service allows to retrieve a list of objects within a certain angular distance of a given sky position.

Figure 2.27 shows the main screen of this service. As in other services, you can define the position on the sky using the name of an object (resolved by Sesame) or the equatorial coordinates of the position. The searching radius is set up with the slide up to 120". Finally, you have the possibility of adding additional criteria on colours, apparent magnitudes and redshift.

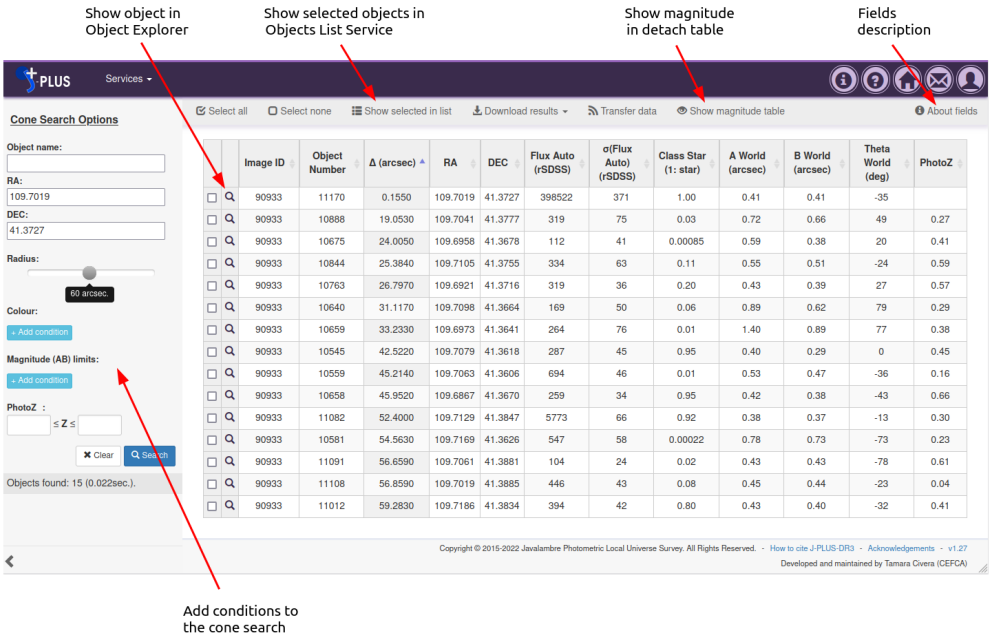


Image ID	Object Number	Δ (arcsec)	RA	DEC	Flux Auto (rSDSS)	σ(Flux Auto) (rSDSS)	Class Star (1: star)	A World (arcsec)	B World (arcsec)	Theta World (deg)	PhotoZ
90933	11170	0.1550	109.7019	41.3727	398522	371	1.00	0.41	0.41	-35	
90933	10888	19.0530	109.7041	41.3777	319	75	0.03	0.72	0.66	49	0.27
90933	10675	24.0050	109.6958	41.3678	112	41	0.00085	0.59	0.38	20	0.41
90933	10844	25.3840	109.7105	41.3755	334	63	0.11	0.55	0.51	-24	0.59
90933	10763	26.7970	109.6921	41.3716	319	36	0.20	0.43	0.39	27	0.57
90933	10640	31.1170	109.7098	41.3664	169	50	0.06	0.89	0.62	79	0.29
90933	10659	33.2330	109.6973	41.3641	264	76	0.01	1.40	0.89	77	0.38
90933	10545	42.5220	109.7079	41.3618	287	45	0.95	0.40	0.29	0	0.45
90933	10559	45.2140	109.7063	41.3606	694	46	0.01	0.53	0.47	-36	0.16
90933	10658	45.9520	109.6867	41.3670	259	34	0.95	0.42	0.38	-43	0.66
90933	11082	52.4000	109.7129	41.3847	5773	66	0.92	0.38	0.37	-13	0.30
90933	10581	54.5630	109.7169	41.3626	547	58	0.00022	0.78	0.73	-73	0.23
90933	11091	56.6590	109.7061	41.3881	104	24	0.02	0.43	0.43	-78	0.61
90933	11108	56.8590	109.7019	41.3885	446	43	0.08	0.45	0.44	-23	0.04
90933	11012	59.2830	109.7186	41.3834	394	42	0.80	0.43	0.40	-32	0.41

Figure 2.27: Screenshot of the main window of the Cone Search service with some useful indications.

The result of the search is shown in a table in which it is possible to select objects to add them in the Object List Search service using the Show selected in list button. Again, as in previous occasions, you can download the results in different formats using the Download results or broadcast the results to VO listening applications using the button .

You can use the button Show magnitude table to see a table with the different types of magnitudes in the different bands for the object in the active row.

2.3.7 Coverage Map

The Coverage Map service helps you to visualise the sky distribution of the pointings of the survey. Figure 2.28 shows the main screen of this service featuring a sky map with the observed regions marked with small red boxes. Hovering over the red regions you will see the names of the coadd images and the coordinates of their centres. Clicking on any red region will open the Sky Navigator centred in the corresponding pointing.

Using the Frame: menu you can select between using the ICRS or the galactic coordinates systems as well as displaying or hiding the complete survey footprint. With the box below you can focus on a given sky position either using coordinates or an object name[13]. Finally, you have the possibility of downloading the footprint of the observed regions as MOC file by clicking on the DR footprint (MOC) button.

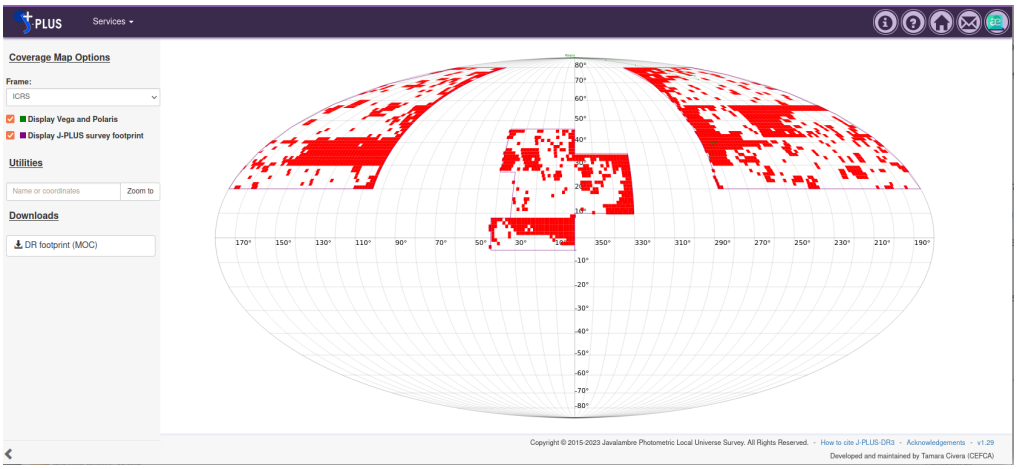


Figure 2.28: Screenshot of the main window of the Coverage Map service.

2.3.8 Multi-Order Coverage Map (MOC)

The Multi-Order Coverage Map (MOC) service allows you to download the Multi-Order Coverage map (MOC) with the footprint of observed regions of the data release. MOC maps are particular descriptions of the footprints of surveys that allow to carry out very fast operations (unions, intersections,...) on data sets or to query data (sources, images,...) of other data releases only inside this data release area using external tools like VizieR, Aladin or Topcat.

2.3.9 Custom Statistical Maps

The Custom Statistical Maps service allows you to generate custom statistical maps based on different parameters, like FWHM, for the area covered by the data release. Figure 2.29 shows the main screen of this service

Lateral Panel The lateral panel provides different options to generate the custom statistical map:

[13] Resolved by Sesame.

Source This option allows you to select if the source of the statistical map is Coadd images or reduced individual images (if this type of images are available in the data release).

Column This option allows you to select the parameter to create the map.

Filter(s) This option allows you to select if you want to generate the map for the images of all the different bands or for the images of a particular band.

Operation This option allows you to select the operation to perform.

Scale limits With this options you can indicate the scale limits.

Colour With this option, you can change the colour used to generate the map.

Format This option allows you to indicate the format. TIP To update the map displayed in the screen, you have to indicate as format "Visualize map" and the click on the Generate map button. TIP If you prefer to download the map, you have to select as format "Download PNG" (Portable Network Graphics (PNG)), "Download CSV" (Comma Separated Values (CSV)) or "Download FITS" (Flexible Image Transport System (FITS)) depending the format in which you want to download it.

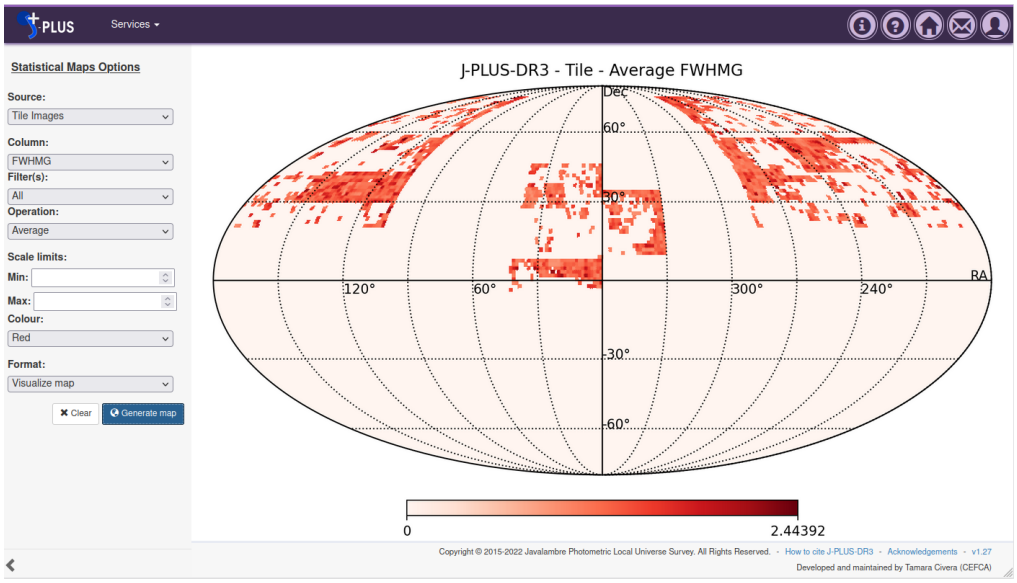


Figure 2.29: Screenshot of the main window of the Custom Statistical Maps service.

2.3.10 V.O. Asynchronous Queries (ADQL)

The VO Asynchronous Queries (ADQL) is the most powerful service available in the website and allows to directly retrieve data from the underlying database which contents all the available data currently in the archive.

The access is done using Astronomical Data Query Language (ADQL) which is in most of the aspects like SQL, with some additional features tailored for astronomical queries.

The "Asynchronous" means that the queries are not run immediately but they are sent to a queue and are processed once the previous queries have been processed.

In this section we will only describe how to access to the service and how to retrieve information through queries. To learn about ADQL you can refer to the help page available in the website accessible using the service ADQL help and Tables In addition, we have included a quick tutorial on ADQL in the Chapter 3 of this manual.

Figure 2.30 shows a screenshot of the main window of this service.

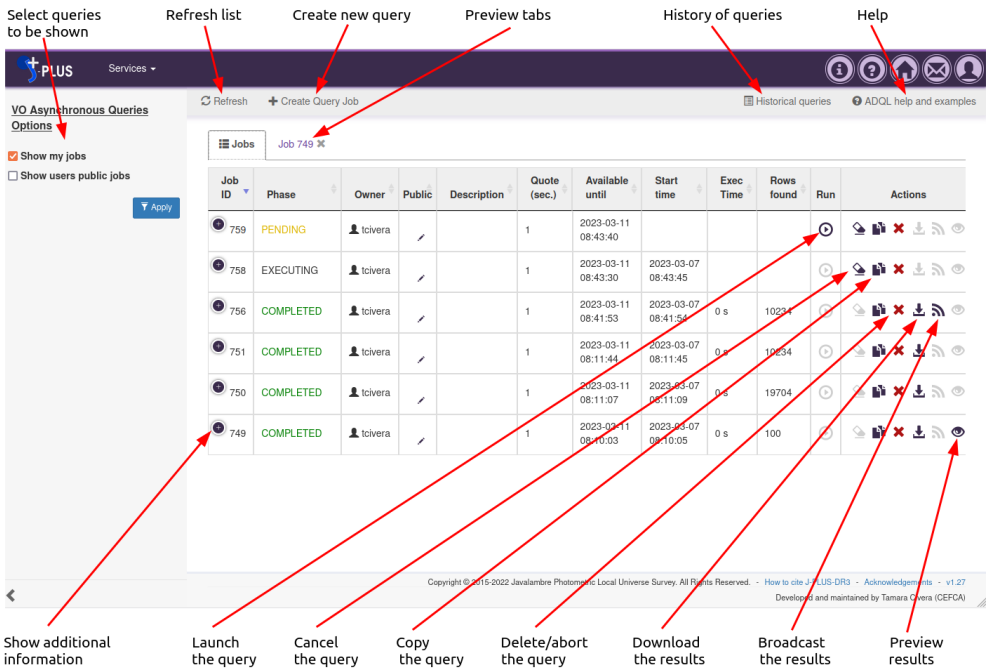


Figure 2.30: Screenshot of the main window of the V.O. Asynchronous Queries (ADQL) service with some useful indications.

Let's see the steps to launch a query[14]:

1. Click on the button ✚ Create Query Job. This will open a new window (see Figure 2.31).
2. Write in the box the ADQL query. There is no need to add ";" at the end of the sentences and you can break a line almost in any place in which you could put a space. TIP You can clear the text box using the button ✖ on the right side of the box.

[14] In the jargon of queue processing, each query is considered a "job", and in this manual "query" or "job" will be used interchangeably.

3. Select the output format (**WARNING** this cannot be changed afterwards). You can select between FITS, VOTABLE (text/xml), VOTABLE Binary2, CSV or Tabular Separated Values (TSV).

4. (Optional) Insert the maximum number of rows that you want to retrieved. Currently there is a hard limit of 1000000 rows [15].

5. (Optional) Write a description of the query that will appear in your list of queries.

6. Press the button Validate Query. This will check the syntax of the query and will raise an error or will show an OK.

7. If the validation is passed, press the + Plan Query button. This will close the window but **WARNING** this will not send the query to the queue. In the list of jobs, your new query will have the word "PENDING" in the "Phase" column and an estimation of the required time to run the query will appear in the "Quote" column.

8. To actually send the query to the execution queue, press the ⊙ in the "Run" column. At this point, the status in the "Phase" column will change from "PENDING" to "QUEUED" (waiting for a execution slot) or "EXECUTING" (execution already began).

9. If you don't want to send the job, you can cancel it using the icon in the columns of "Actions".

10. Depending on the length of execution of the query, the "EXECUTING" phase can be almost instantaneous or can last hours. The webpage will refresh from time to time but you can also force the refreshing using the button Refresh.

11. Once the job has been completed, it will appear the word "COMPLETED" in the "Phase" column or "ERROR" in case some error happened during the execution. Then you can perform several actions using the icons in the column "Actions":

    - to download the results.
    - to broadcast the result to VO application.
    - to duplicate the query. **TIP** This is a useful way to reuse or modify a query.
    - to delete the job. **TIP** It is recommended to delete the job after downloading the results to free up resources.
    - to have a preview of the results. This will open a tab (see "Preview Tabs" in Figure 2.30) and the results will be shown in tabular form. **WARNING** This option only works when the selected output is CSV, TSV or VOTABLE (text/xml), and the result will be limited to 300 rows. To not affect the performance of the browser, the number of open tabs is limited to 5.

[15] In 4.4.2 you can find an example of how to download more than 1000000 rows using PyVO library

WARNING Your jobs are going to be only available for 4 days, after this date (you can see it in "Available until" column), your job and the results are going to be automatically deleted.

TIP You can visualize the last 200 queries you have run with successful execution, although you have deleted the job, by clicking on the Historical queries button.

TIP If you want to share you query with all the CEFCA Catalogues Portal users, you can make it public by clicking on the icon on the "Public" column. You can revert this action, by clicking again in the same icon. **WARNING** It is going to be accessible by all users, only since it is available. **TIP** To see other users public queries, you have to select Show users public jobs option in the lateral panel and click on Apply button.

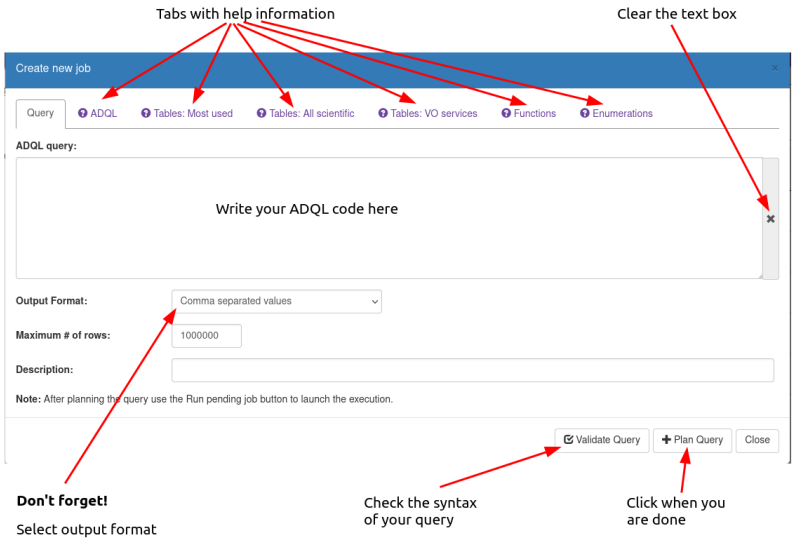


Figure 2.31: Screenshot of the main window used to create a new query.

2.3.11 V.O. Services

The archive provides access to the tabular data as well to the images through Virtual Observatory services. You can get a description of all the available VO services using the option V.O. Services in the Services menu. See section 4.

2.3.12 Direct Download Services

The Direct Download Services are very useful services accessible from the command line or from your own scripts using the indicated urls and parameters which allow you to retrieve images, cutouts, objects data and products.

Figure 2.32 shows a screenshot of the main window of this service. **WARNING** The list of services available can be different in each data release depending the data and products offered in that data release.

For each service the following information is given (see Figure 2.33):

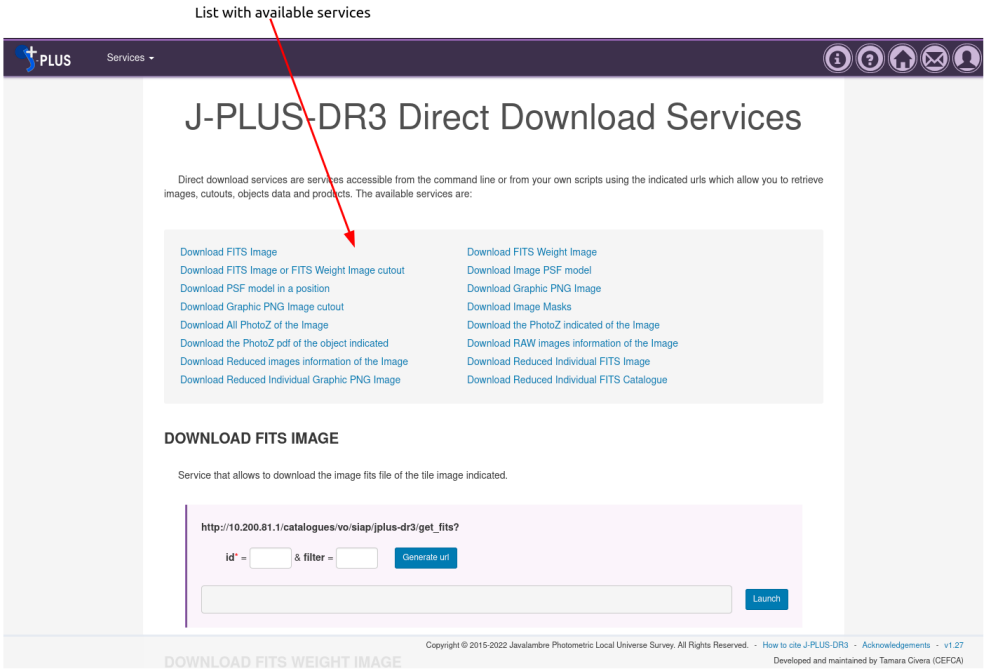


Figure 2.32: Screenshot of the main window of the Direct Download Services service.

Service explanation Short explanation of what the service allows to download.

Fixed service url Fixed part of the service url.

Url parameters Parameters you have or could to use in this service url. The parameters must be added at the end of the fixed url. TIP When hovering over a parameter name you get an explanation of the parameter. TIP The symbol * means that the parameter is compulsory. If it is not indicated, the parameter is optional. WARNING Sometimes the parameter has not the symbol *, but it could be compulsory depending on the values of the other parameters. To get more information about it, hover over the parameter name.

TIP You can probe the service url before using in your scripts, filling the parameters, clicking on Generate url button and then on Launch button.

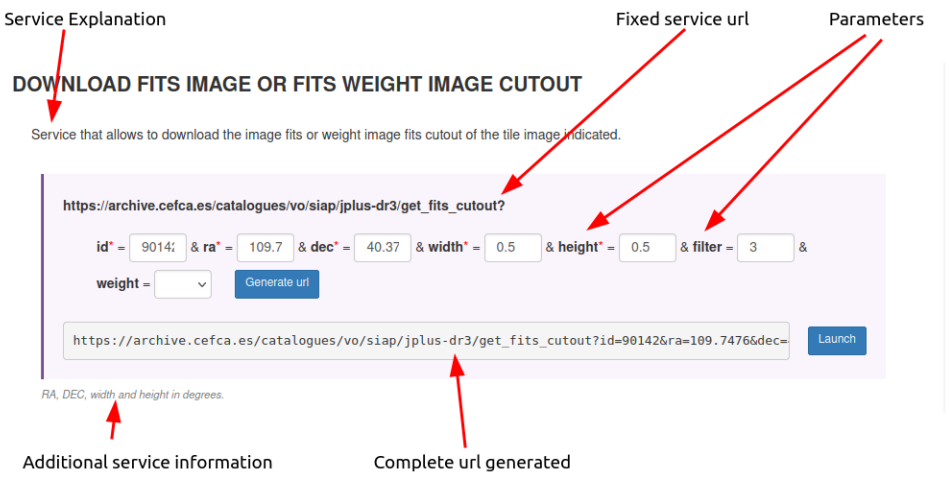


Figure 2.33: Screenshot of one of the Direct Download Services.

Chapter 3

Quick tutorial on ADQL Queries

3.1 Introduction

ADQL is the acronym of "Astronomical Data Query Language" which is the language used by the International Virtual Observatory Alliance (IVOA) to represent astronomy queries posted to VO services.

ADQL is based on the Structured Query Language (SQL), especially on SQL 92.

ADQL accepts only `SELECT` sentences and predefines a list of mathematics and geometric functions.

WARNING The different ADQL examples given in this chapter have been conceived for J-PLUS DR3 , although most of them with minimum changes can be applied to other surveys and data releases.

3.2 SELECT

The `SELECT` command is the basic command to retrieve information for the database.

In the following sections we will see different ways of using this command in combination with other ADQL/SQL commands.

3.2.1 SELECT ... FROM ... WHERE ...

This is the basis of most of the queries. The general syntax is:

```
SELECT [columns] FROM [table] WHERE [conditions]
```

where `columns` can be a comma separated list of fields (or expressions) to be retrieved or the asterisk (*) to retrieve all the columns; `table` is the table from which the data should be retrieved and `conditions` are the conditions that the elements of the table must fulfil to be retrieved. The `WHERE` block can be omitted if no condition must be applied.

These are some examples:[1]

[1] Although this is not necessary, the examples will be indented in a particular way to make them more readable. In all the cases, the queries could be written in one single line.

```
# Retrieve all the information in the table jplus.TileImage
SELECT * FROM jplus.TileImage

# Retrieve only the column "name" from the same table.
SELECT name FROM jplus.TileImage

# Retrieve the columns "name", "RA", "DEC", TILE_ID from the same
# table for those tiles with FWHMG < 1"
SELECT
   name, RA, DEC, TILE_ID
FROM
   jplus.TileImage
WHERE
   FWHMG < 1
```

As having said above, it is possible to retrieve expressions or functions which can involve fields or not. For example:

```
# Retrieve the number of records that fulfill the criteria
# function (count(*)) and write some text (quoted with single
# quotes).
SELECT
  'Number of records', count(*)
FROM
  jplus.TileImage

# Retrieve records and print the distance to a given point
# among other fields.
SELECT
  name,RA,DEC,DISTANCE(POINT('ICRS',RA,DEC),POINT('ICRS',120,40))
FROM
  jplus.TileImage
WHERE
  RA BETWEEN 100 AND 140
```

A useful tip is that it is possible to provide custom names or aliases to the fields or expressions to be retrieved. For instances, in the last example it would be useful to name the result of the `DISTANCE` function with a more appropriate name:

```
# Retrieve records and print the distance to a given point
# among other fields.
SELECT
   name,RA,DEC,
   DISTANCE(POINT('ICRS',RA,DEC),POINT('ICRS',120,40)) AS distance
FROM
   jplus.TileImage WHERE RA BETWEEN 100 AND 140
```

As can be seen, this is done just adding `AS alias` after the expression or the name of the field.

3.2.2 Arrays and Enumerations

Before continuing with the description of ADQL commands we need to make a stop to talk about arrays and enumerations.

In some tables, in particular in those containing Dual-mode photometry, the columns containing band-dependent values, like fluxes and magnitudes, are stored in arrays. This means that when retrieving these columns, instead of getting one column for each band we get one column with the twelve values.

Ex.:

```
# Retrieve the coordinates and MAG_AUTO for
# objects in tile_id=90142 and  CLASS_STAR<0.1.
SELECT
   ALPHA_J2000,DELTA_J2000,MAG_AUTO
FROM
   jplus.MagABDualObj
WHERE
   TILE_ID=90142 AND CLASS_STAR<0.1
```

WARNING Be aware that the output format that you select for retrieving the data will affect the way the elements of the arrays are presented. FITS and VOTABLE format can natively manage arrays, however, in CSV format the arrays are displayed as a space separated list of values and in the TSV format they are separated by commas.

WARNING The order of the bands can be different in every data release, for example the order of the bands in J-PLUS DR3 is:

```
rSDSS, gSDSS, iSDSS, zSDSS, uJAVA, J0378, J0395, J0410, J0430,
J0515, J0660, J0831
```

TIP The bands order is determined in the `jplus.Filter` table.

To access a particular value of an array you can specify it using the position of the element in the array, starting by 1 for `rSDSS` (J-PLUS DR3). Ex.:

```
# Retrieve the coordinates and the (g-r) color using MAG_AUTO for
# objects in tile_id=90142 and  CLASS_STAR<0.1.
SELECT
   ALPHA_J2000,DELTA_J2000,
   MAG_AUTO[2]-MAG_AUTO[1] as g_r
FROM
   jplus.MagABDualObj
WHERE
   TILE_ID=90142 AND CLASS_STAR<0.1
```

However, there is a more handy way to do it using the so-called enumerations. In our case, there is a single enumeration called `jplus` which relates the name of the filter with the position in the array. The syntax is just `jplus::filter` and it is used in substitution of the index position. Therefore, the previous example can be written like this, using the enumeration:

```
# Retrieve the coordinates and the (g-r) color using MAG_AUTO for
# objects in tile_id=90142 and  CLASS_STAR<0.1.
SELECT
  ALPHA_J2000,DELTA_J2000,
  MAG_AUTO[jplus::gSDSS]-MAG_AUTO[jplus::rSDSS] as g_r
FROM
  jplus.MagABDualObj
WHERE
  TILE_ID=90142 AND CLASS_STAR<0.1
```

Is it possible also to access to a subset of an array (array slice) using square brackes and indicating inside the lower-bound and upper-bound (both included) separated by a colon. . Ex.:

```
# Retrieve the coordinates and the values of the magnitude auto from fil
# objects in tile_id=90142 and  CLASS_STAR<0.1.
SELECT
   ALPHA_J2000,DELTA_J2000,
   MAG_AUTO[6:9]
FROM
   jplus.MagABDualObj
WHERE
   TILE_ID=90142 AND CLASS_STAR<0.1
```

3.2.3 SELECT TOP ... .

The TOP command can be used to limit the number of records to be retrieved. The syntax is:

```
SELECT TOP number ....
```

Only the number records that fulfil all the criteria will be retrieved.
Example:

```
# Retrieve the columns "name", "RA", "DEC", TILE_ID from the same
# table for those tiles with FWHMG<1"
SELECT TOP 10
   name,RA,DEC,TILE_ID
FROM
   jplus.TileImage
WHERE
   FWHMG<1
```

3.2.4 WHERE conditions

To retrieve records that fulfilled a series of conditions, we use the WHERE clause. Conditions can be any statement that returns TRUE (1) or FALSE (0) or NULL. [2] Ex.:

[2] Here you can find the full list of comparison operator in MySQL. Use it as reference since it is not guaranteed that all of them will work with ADQL.

`=,>,<,<=,>=,!=,<>` These are common mathematical comparison operators.

`IN` statements:

```
.... WHERE element IN (element1,element2,...)
```

You can reverse the selection adding `NOT` before the `IN`:

```
.... WHERE element NOT IN (element1,element2,...)
```

`BETWEEN value1 AND value2` statement. TIP This is a handy statement to impose a criterion in which a field must be between two values. Eg.:

```
.... WHERE ra BETWEEN 0 AND 180
```

`IS` statements:

```
.... WHERE dec IS [TRUE|FALSE|NULL]
```

`NOT` statements:

```
.... WHERE dec IS NOT [TRUE|FALSE|NULL]
```

`LIKE or ILIKE` statements can be used to match strings against patterns[3]:

```
.... WHERE string LIKE "pattern"
```

The difference between them is that `LIKE` is case sensitive and `ILIKE` is case insensitive.

Several conditions can be joined using[4] **`AND`**,**`OR`** or **`XOR`**.
These are several examples of uses of `WHERE` conditions:

```
# Simple WHERE
SELECT *
FROM jplus.TileImage
WHERE
  tile_id=90142

# using "AND"
SELECT *
FROM jplus.TileImage
WHERE
  ref_tile_id=90142 AND calib_procedure=9

# Using "OR"
```

[3] See MySQLreference for more information about the `LIKE` operator.
[4] Here you can find the list of logical operators in MySQL.

```
SELECT *
FROM jplus.TileImage
WHERE
  ref_tile_id=90142 AND
  (filter_id=1 OR filter_id=2)

# Using "IN"
SELECT *
FROM jplus.TileImage
WHERE
  ref_tile_id=90142 AND filter_id IN (1,2)

# Using "NOT"
SELECT *
FROM jplus.TileImage
WHERE
  NOT (ref_tile_id=90142 AND (filter_id IN (1,2)))

SELECT *
FROM jplus.TileImage
WHERE
  (NOT ref_tile_id=90142) AND (filter_id IN (1,2)))

# Using BETWEEN
SELECT *
FROM jplus.TileImage
WHERE
   ra BETWEEN 100 AND 150

# Using LIKE. In the pattern, the '%' means an arbitrary string
# while using "_" means one arbitrary character.
SELECT
   *
FROM
   jplus.TileImage
WHERE
   name LIKE '%rSDSS%'
```

3.2.5 ORDER BY ... [ASC|DESC]

Using `ORDER BY` it is possible to sort the output by a given field or expression. Adding `ASC` afterwards will sort in ascending way while `DESC` will do it in descending way.

Example:

```
# Select all the star-like objects in a given tile
# and sort the output by RA ascending, then by DEC descending
```

```
# and then by MAG_AUTO ascending.
SELECT
  ALPHA_J2000,DELTA_J2000,MAG_AUTO
FROM
  jplus.MagABSingleObj
WHERE
  TILE_ID=90142 AND CLASS_STAR>0.9
ORDER BY
  ALPHA_J2000 ASC, DELTA_J2000 DESC, MAG_AUTO ASC
```

3.2.6 OFFSET

Using OFFSET it is possible to specify the number of records to skip before starting to return records from the query. If a query contains both an ORDER BY clause and an OFFSET clause, then the ORDER BY is applied before the specified number of records are dropped by the OFFSET clause.

TIP This instruction can be very useful in big queries where the number of expected output records is bigger than the TAP maximum records limit or the limit indicated in the TOP clause. In that case, you can use this instruction to obtain your data in chunks by executing your query n times only changing the value of OFFSET until you get a result with a number of records less than the limit and then working with all the outputs files obtained. In these cases, it is strictly recommended to use OFFSET clause with ORDER BY clause.

WARNING If the total number of records is less than the value specified by the OFFSET clause, then the result set is empty.

```
# Obtaining the next 100000 records of the query in the table
# jplus.MagABDualObj
SELECT TOP 100000
  *
FROM
  jplus.MagABDualObj
ORDER BY
  TILE_ID, NUMBER
OFFSET
  100000
```

3.3 JOIN ... ON|USING

Databases are commonly made of several tables which are related between them. For example, in the J-PLUS DR3 archive there is a table for the information of each single object and another table for the tiles in which these objects were found. It can happen that we want to retrieve a table with information of each object and of the tiles in which they were found, so we need to combine the information of both tables. For this kind of jobs SQL-like languages provide the JOIN command and related ones.

The most simple combination of two tables is made with this syntax:

```
SELECT ...
FROM
  table1 AS t1
JOIN
  table2 AS t2
ON
  t1.field1=t2.field2
```

In this case, before applying any condition a table would be constructed matching `table1` and `table2` using the `field1` of the former and `field2` of the latter.

WARNING When using `JOIN` it is recommended to append each parameter with the name of the table it comes from using the syntax `table.field`.

TIP With tables it is also possible to use aliases using `AS`, although this can be omitted.

In those cases in which the joining fields have the same name in both tables there is an alternative with the `USING` keyword:

```
SELECT ...
FROM
  table1 AS t1
JOIN
  table2 AS t2
USING
  (field)
```

WARNING Don't forget to enclose the `field` name by parenthesis.

This is an example using the ADQL Service to include the name of the filters among the parameters retrieved from the single-mode catalogue:

```
SELECT TOP 10
   t1.NUMBER,t1.ALPHA_J2000 as RA,
   t1.DELTA_J2000 as DEC,t2.name as filter
FROM
   jplus.MagABSingleObj t1
JOIN
   jplus.Filter t2
ON
   t1.filter_id=t2.filter_id
```

Alternatively, with `USING`:

```
SELECT TOP 10
   t1.NUMBER,t1.ALPHA_J2000 as RA,
   t1.DELTA_J2000 as DEC,t2.name as filter
FROM
   jplus.MagABSingleObj t1
JOIN
   jplus.Filter t2
USING
```

```
(filter_id)
```

The JOIN parameter returns only those records in the first table that have a matching in the second table. However, we could be interested in retrieving also those cases in which there is no cross-matching. This is done using the LEFT JOIN command. The result of using LEFT JOIN is to retrieve all the rows of the first (left) table with the matches on the second table when available otherwise NULL values are returned. If we want to keep all the rows of the second (right) table we can use RIGHT JOIN.

TIP In the ADQL help and Tables service, in each table description, you have the section "FOREIGN KEYS" where you have some information that could help you to make your joins with others tables.

3.4 GROUP BY ... HAVING ...

The GROUP BY statement returns one line for each different value of the field or expression coming after, eg:

```
... GROUP BY filter_ID
```

WARNING The GROUP BY statement must be at the end of the query.

There are several functions that can be used to perform particular actions when using GROUP BY, like counting the number of records for each different group or computing basic statistics like the followings:

AVG function This function allows to obtain the average value in a column for a group of data lines. This function applies only to numeric data.

COUNT function This function allows to obtain a count of rows from a reference column values if it is not NULL.

SUM function This function allows to obtain the sum of values in a column for a group of data lines. This function applies only to numeric data.

MAX function This function allows to obtain the largest value of a column for a group of data lines.

MIN function This function allows to obtain the smallest value of a column for a group of data lines.

Some examples:

```
# Counting the detections on different bands in a given area
# of the sky
SELECT
   name as filter,COUNT(*)
FROM
   jplus.MagABSingleObj t1
JOIN
```

```
   jplus.Filter t2
ON
   t1.FILTER_ID=t2.FILTER_ID
WHERE
   t1.ALPHA_J2000 BETWEEN 11 AND 120 AND
   t1.DELTA_J2000 BETWEEN 39 AND 40
GROUP BY
   t2.name



# Computing the average flux of the objects detected in different
# bands in single-mode in the same area of the sky.
SELECT
   name as filter,COUNT(*),AVG(FLUX_AUTO)
FROM
   jplus.FlambdaSingleObj t1
JOIN
   jplus.Filter t2
ON
   t1.FILTER_ID=t2.FILTER_ID
WHERE
   t1.ALPHA_J2000 BETWEEN 11 AND 120 AND
   t1.DELTA_J2000 BETWEEN 39 AND 40
GROUP BY
   t2.name



# Estimating the depth of the catalogues as the
# average magnitude for objects with SNR=3+-0.1 in an
# aperture of 2".
SELECT
   name,COUNT(*),AVG(MAG_AUTO)
FROM
   jplus.MagABSingleObj t1
JOIN
   jplus.TileImage t2
ON
   t1.tile_id=t2.tile_id
WHERE
   (1.086/t1.MAG_ERR_APER_2_0) BETWEEN 2.9 AND 3.1
GROUP BY
   t2.name
```

With the statement `HAVING` it is possible to apply conditions on the records after performing the grouping. For example:

```
# Computing the average flux of the objects detected in different
# bands in single-mode in the same area of the sky and retrieved
# only those bands in which is larger than
# 10000 erg s^-1 cm^-2 A^-1.
SELECT
  name as filter,
  COUNT(*) AS number,
  AVG(FLUX_AUTO) as average
FROM
  jplus.FlambdaSingleObj t1
JOIN
  jplus.Filter t2
ON
  t1.FILTER_ID=t2.FILTER_ID
WHERE
  t1.ALPHA_J2000 BETWEEN 11 AND 120
  AND
  t1.DELTA_J2000 BETWEEN 39 AND 40
GROUP BY
  t2.name
HAVING
  AVG(FLUX_AUTO) > 10000
```

3.5 Common Table Expressions

The WITH operator creates a temporary named result set that can be referred to elsewhere in the main query. Using a common table expression can make complex queries easier to understand by factoring subqueries out of the main SQL statement.

For example:

```
# Obtaining images with wide filter
WITH wide_filter AS
  (SELECT filter_id FROM  jplus.Filter WHERE width > 999)
SELECT t.*
FROM
  jplus.TileImage t
JOIN
  wide_filter
USING
  (filter_id)
```

3.6 SET operators

You can combine the results of two queries with the same number of columns and compatible types for each column. The operators are the following:

UNION This operator combines the results of two queries, accepting rows from both the first and second set of results removing duplicate rows. TIP You can use `UNION ALL` to avoid removing duplicate rows.

EXCEPT This operator combines the results of two queries, accepting rows that are in the first set of results but are not in the second removing duplicate rows. TIP You can use `EXCEPT ALL` to avoid removing duplicate rows.

INTERSECT This operator combines the results of two queries, accepting rows that are strictly in both the first and second set of results, removing duplicate row. TIP You can use `INTERSECT ALL` to avoid removing duplicate rows.

Some examples:

```
# Obtaining objects in the data release with data in GAIA or
# Panstarrs
SELECT
  tile_id, number
FROM jplus.xmatch_gaia_dr3
UNION
SELECT
  tile_id, number
FROM jplus.xmatch_panstarrs_dr1
```

```
# Obtaining objects without data in GAIA
SELECT
  tile_id, number
FROM jplus.FNuDualObj
EXCEPT
SELECT
  tile_id, number
FROM jplus.xmatch_gaia_dr3
```

```
# Obtaining objects in the data release with data in
# GAIA and Panstarrs
SELECT
  tile_id, number
FROM jplus.xmatch_gaia_dr3
INTERSECT
SELECT
  tile_id, number
FROM jplus.xmatch_panstarrs_dr1
```

3.7 Type operations

The CAST operator returns the value of the first argument converted into the datatype specified by the second argument. The allowed convertion types are: INTEGER, SMALLINT, BIGINT, REAL, DOUBLE PRECISION, CHAR(number), VARCHAR(number) and TIMESTAMP. For example:

```
# Obtaining all reduced individual images observed in the
# night 2019/03/29
SELECT *
FROM
    jplus.ReducedIndividualFrame
WHERE
    OBSERVATION_DATE > CAST('2019-03-29T12:00:00' AS TIMESTAMP)
    AND
    OBSERVATION_DATE < CAST('2019-03-30T12:00:00' AS TIMESTAMP)
```

3.8 Useful functions

3.8.1 ADQL Astronomical Functions[5]

As an astronomical language, ADQL has some functions particularly tailored for astronomical computations.

First, we have a series of functions to define 2D regions or geometries. Regions are always attached to a coordinate system ('FK5','ICRS','GALACTIC') and coordinates in regions are in degrees. TIP If no coordinate system is indicated (''), by default 'ICRS' is used. Let's see these functions:

POINT('coordinate system',ra,dec) [6] Expresses a point in a given coordinate system. The output of this function is used as input of other functions like DISTANCE which are shown below. An example:

```
# A point with RA=120deg and DEC=30deg in ICRS
# equatorial system.
POINT('ICRS',120,40) or POINT('',120,40)
# Expressing the galactic center in galactic coordinates.
POINT('GALACTIC',0,0)
```

CIRCLE('coordinate system',ra_center,dec_center,radius) WARNING The radius is expressed in degrees. For example:

```
# A circle centered in RA=120deg and DEC=30deg in ICRS equatorial
# system and a radius of 1 arc second.
CIRCLE('ICRS',120,40,1./3600.)
```

[5] Much of the content on this section has been taken from this webpage.

[6] Although 'ra' and 'dec' words are used in the expression, in the case of galactic coordinates these coordinates will correspond to the galactic longitude and latitude.

BOX('coordinate system',ra_center,dec_center,width,height) **WARNING** The width and height are expressed in degrees. For example:

```
# A box centered in RA=120deg and DEC=30deg in ICRS equatorial
# system with a width of 1arc minute and a height of 1 degree.
BOX('ICRS',120,40,1./60.,1)
```

POLYGON('coordinate system',ra_1,dec_1,ra_2,dec_2,ra_3,dec_3,...) This defines a polygon made of great circles passing through the specified coordinates.[7] For example:

```
# A polygon defined by the coordinates (20,155),(80,155),
# (80,285), (80,285).
# Although this looks like J-PAS North footprint, it isn't
# because J-PAS footprint is not defined by great circles.
POLYGON('ICRS'20,155,80,155,80,285,80,285)
```

Now, these functions can be used together with the following ones to compute relations between them:

DISTANCE(POINT1,POINT2) or DISTANCE(RA1,DEC1,RA2,DEC2) This function returns the distance **in degrees** between the two points. The specification of the two points must be done through the function POINT or indicating the coordinates (in ICRS coordinate system). For example:

```
# Computing the distance of 1000 objects in the dual-mode
# catalogue to the galactic centre.
SELECT TOP 1000
   DISTANCE(POINT(''ICRS',ALPHA_J2000,DELTA_J2000),
            POINT('GALACTIC',0,0))
     AS galactocentric_distance
FROM
   jplus.MagABDualObj


# Computing the number of objects within 1 arcmin for the
# objects in one given tile (avoiding to count the same
# object) and sorting the output by the number of neighbours.
SELECT TOP 100
   t1.number,t1.ALPHA_J2000,t1.DELTA_J2000,
     COUNT(*) as n_neighbours
FROM
   jplus.MagABDualObj t1,
   jplus.MagABDualObj t2
WHERE
```

[7] **WARNING** Be aware that a sky region limited by constant declination side (ie. by a parallel) is not properly defined as a polygon with two contiguous vertices at equal declination since parallels are not great circles.

```
   t1.tile_id=2035 AND
   t2.tile_id=2035 AND
   t1.number != t2.number AND
   DISTANCE(POINT('ICRS',t1.ALPHA_J2000,t1.DELTA_J2000),
       POINT('ICRS',t2.ALPHA_J2000,t2.DELTA_J2000))<1/60.0
GROUP BY
   t1.number,t1.ALPHA_J2000,t1.DELTA_J2000
ORDER BY
   n_neighbours DESC


# The same example but using
# DISTANCE(RA1,DEC1,RA2,DEC2) format
SELECT TOP 100
   t1.number,t1.ALPHA_J2000,t1.DELTA_J2000,
     COUNT(*) as n_neighbours
FROM
   jplus.MagABDualObj t1,
   jplus.MagABDualObj t2
WHERE
   t1.tile_id=2035 AND
   t2.tile_id=2035 AND
   t1.number != t2.number AND
   DISTANCE(t1.ALPHA_J2000,t1.DELTA_J2000,
      t2.ALPHA_J2000,t2.DELTA_J2000)<1/60.0
GROUP BY
   t1.number,t1.ALPHA_J2000,t1.DELTA_J2000
ORDER BY
   n_neighbours DESC
```

CONTAINS(region1,region2) This function returns true if `region1` is inside `region2` (or equivalently, `region2` contains `region1`). The regions can be a `POINT()`, `CIRCLE()`, `BOX()` or a `POLYGON()`. For example,

```
# Perform a cone search around a given coordinate
# (eg.(120.3,40.2)) with a searching radius on 1 arc minute.
# WARNING: Using "*" in the SELECT will produce an error.
SELECT
   ALPHA_J2000,DELTA_J2000,
   DISTANCE(POINT('ICRS',ALPHA_J2000,DELTA_J2000),
            POINT('ICRS',120.3,40.2))
      AS distance
FROM
   jplus.MagABDualObj
WHERE
   1=CONTAINS(POINT('ICRS',ALPHA_J2000,DELTA_J2000),
     CIRCLE('ICRS',120.3,40.2,1/60.))
```

```
ORDER BY
   distance ASC


# Computing the number of objects within 1 arcmin for the
#  objects in one given tile (avoiding to count the same
# object) and sorting the output by the number of
# neighbours.
# In this example we use CONTAINS instead of DISTANCE.
SELECT TOP 100
   t1.number,t1.ALPHA_J2000,t1.DELTA_J2000,
     COUNT(*) as n_neighbours
FROM
   jplus.MagABDualObj t1,
   jplus.MagABDualObj t2
WHERE
   t1.tile_id=2035 AND
   t2.tile_id=2035 AND
   t1.number != t2.number AND
   1=CONTAINS(POINT('ICRS',t2.ALPHA_J2000,t2.DELTA_J2000),
         CIRCLE('ICRS',t1.ALPHA_J2000,t1.DELTA_J2000,1/60.))
GROUP BY
   t1.number,t1.ALPHA_J2000,t1.DELTA_J2000
ORDER BY
   n_neighbours DESC
```

INTERSECS(region1,region2) Returns true if `region1` and `region2` intersect.

AREA(region) This is a handy function that computes the area in square degrees of a region. Ex.:

```
# Compute the density (in deg^2) of detections in each band
# around the point (RA,DEC)=(120.3,40.2) within 10 arcmin.
SELECT
   tfilt.name as filter,
   COUNT(*)/AREA(CIRCLE('ICRS',120.3,40.2,10/60.)) as density
FROM
   jplus.MagABSingleObj as tcat
JOIN
   jplus.Filter as tfilt
ON
  tcat.filter_id=tfilt.filter_id
WHERE
   1=CONTAINS(POINT('ICRS',tcat.ALPHA_J2000,tcat.DELTA_J2000),
              CIRCLE('ICRS',120.3,40.2,10/60.))
GROUP BY
   filter
```

3.8.2 Internal functions

Several functions have been defined internally in the database to help in some common computations, for example, conversion between different units to express the fluxes of the objects or conversion of dates or functions to perform operations in array columns.

Functions related to conversion between different fluxes units

cefca_flambdatofnu This function converts a FLUX in units of 10^{-19} erg/s/cm^2/Å to units of 10^{-30} erg/s/cm^2/Hz. These units are the ones used internally by the database and have been chosen for being the most suitable for storage purposes.

cefca_fnutoflambda This function converts a FLUX in units of 10^{-30} erg/s/cm^2/Hz to units of 10^{-19} erg/s/cm^2/Å.

cefca_fnufluxtojansky This function converts a FLUX in units of 10^{-30} erg/s/cm^2/Hz to Jansky.

cefca_janskytofnuflux This function converts a FLUX in Jansky to units of 10^{-30} erg/s/cm^2/Hz.

cefca_fnufluxtomagab This function converts a FLUX in units of 10^{-30} erg/s/cm^2/Hz to AB magnitudes.

cefca_magabtofnuflux This function converts a FLUX AB magnitudes to units of 10^{-30} erg/s/cm^2/Hz.

Functions related to conversion between different time units

cefca_to_jd This function converts a 'time.epoch' (timestamp) to a astronomical Julian Date.

cefca_to_mjd This function converts a 'time.epoch' (timestamp) to a astronomical Modified Julian Date.

Functions related to array operations

arr_max This function returns the maximum value in an array.

arr_min This function returns the minimum value in an array.

arr_in This function tests if a value is present in the values of an array returning True if it is present.

arr_avg This function returns the arithmetic mean of the array elements.

arr_sum This function returns the sum of the array elements.

arr_count This function returns the number of array elements.

arr_map This function computes a new array by executing the expression indicated for each element of the input array.

array operations Basic math (+, -, *, /) can be done between numerical arrays and between numerical arrays and scalars. For example, to add arr1 elements to arr2 elements: arr1 + arr2

TIP In the ADQL help and Tables service you can find the complete list of functions available with all information about them.

3.9 List of examples

Chapter 4

Accessing the archive through external tools and VO protocols

In this appendix we will show different ways to access the data of the archive without using the web-based tool.

This is done thanks to the use of the VO protocols like TAP, SIAP, SCS or HiPS, and VO-compliance tools like TOPCAT or Aladin or python programming language.

4.1 TOPCAT

Tool for OPerations on Catalogues And Tables (TOPCAT) is a powerful tool to access and analyse astronomical data. Among many other things you can access all the archives through the VO Table Access Protocol (TAP) or SCS.

WARNING The TOPCAT version used in this manual is 4.8. With other version of the software some features could be different.

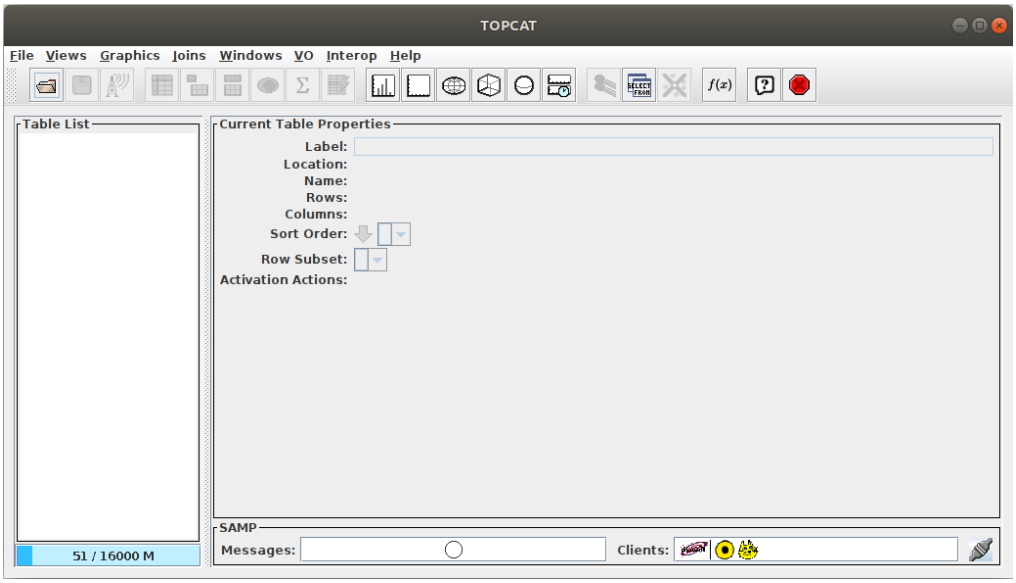


Figure 4.1: TOPCAT main screen.

4.1.1 TOPCAT: Accessing data through TAP service

In this section you will learn how to access the CEFCA Catalogues Portal data through TOPCAT using VO TAP service:

1. Launch TOPCAT (Figure 4.1).
2. Open the upper menu “V.O.” and select “Table Access Protocol (TAP) Query” (Figure 4.2).
3. In the “Table Access Protocol (TAP) Query” window (Figure 4.3), select in the list the TAP service you want to use or introduce the URL of the TAP Service in the lower box (“Selected TAP Service”) and press the button “Use Service”. **WARNING** In the list of TAP services, only public data releases are published. If the data release is private (for example an internal data release) you have to introduce the URL in the lower box. **TIP** You can find the url to use in the V.O. Services service. **TIP** To find the service in the list you can introduce the name of the data release in the keywords box and click on the ‘Find Services’ button.
4. For private data releases, if the connection is successful, you will be asked for your username and password (those of your CEFCA Catalogues Portal account).
5. You will be brought to the tab “Use Service” (Figure 4.4) and in the lower “ADQL Text” box you can introduce your query and launch it with the “Run Query” button.

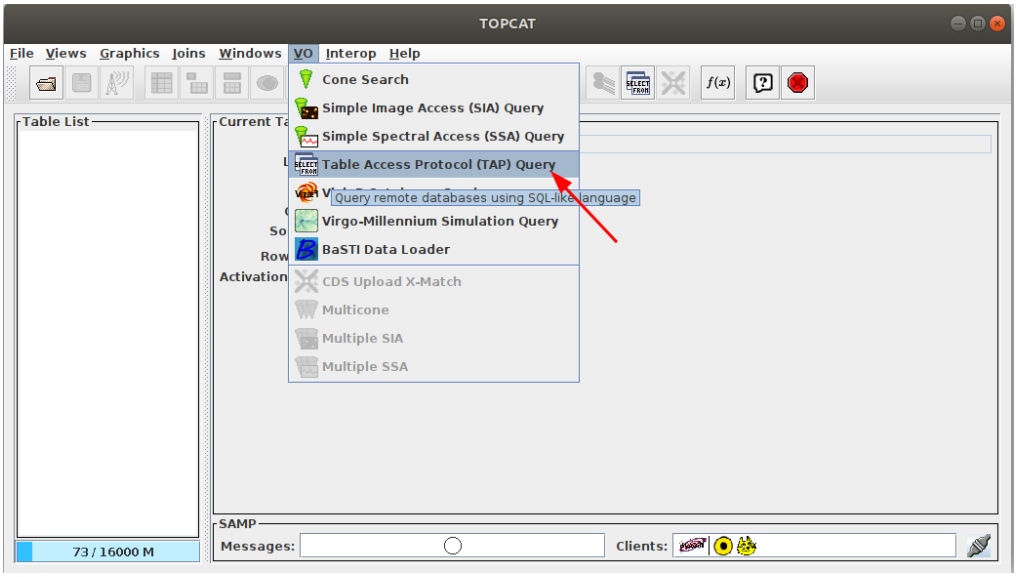


Figure 4.2: TOPCAT main screen with the TAP selection.

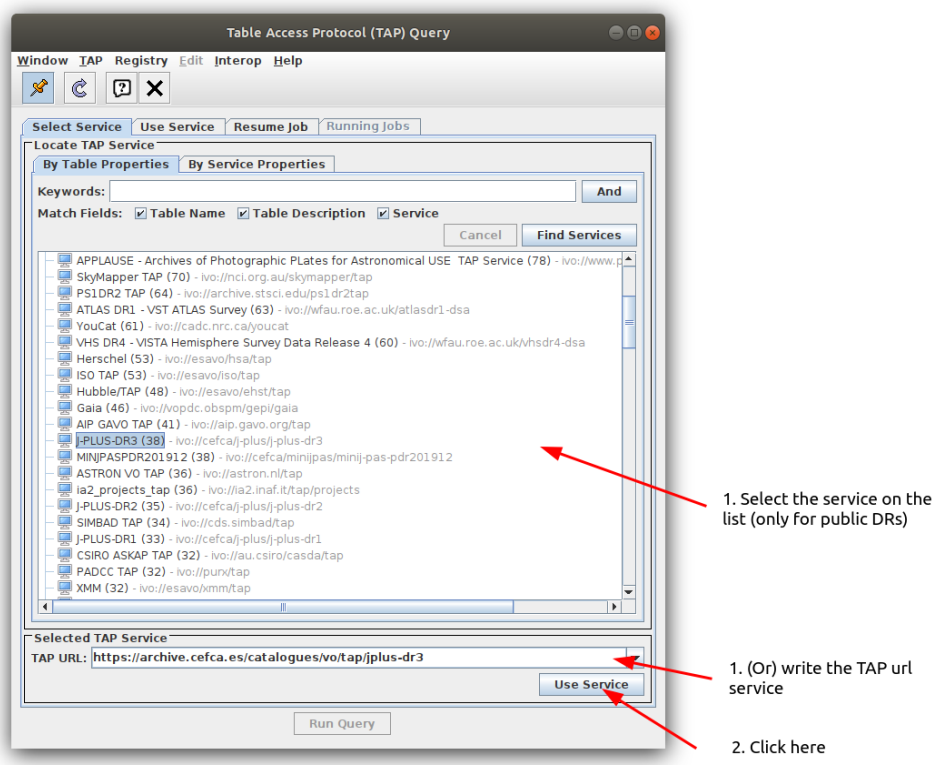


Figure 4.3: TOPCAT TAP Query window for the “Select Service” tab.

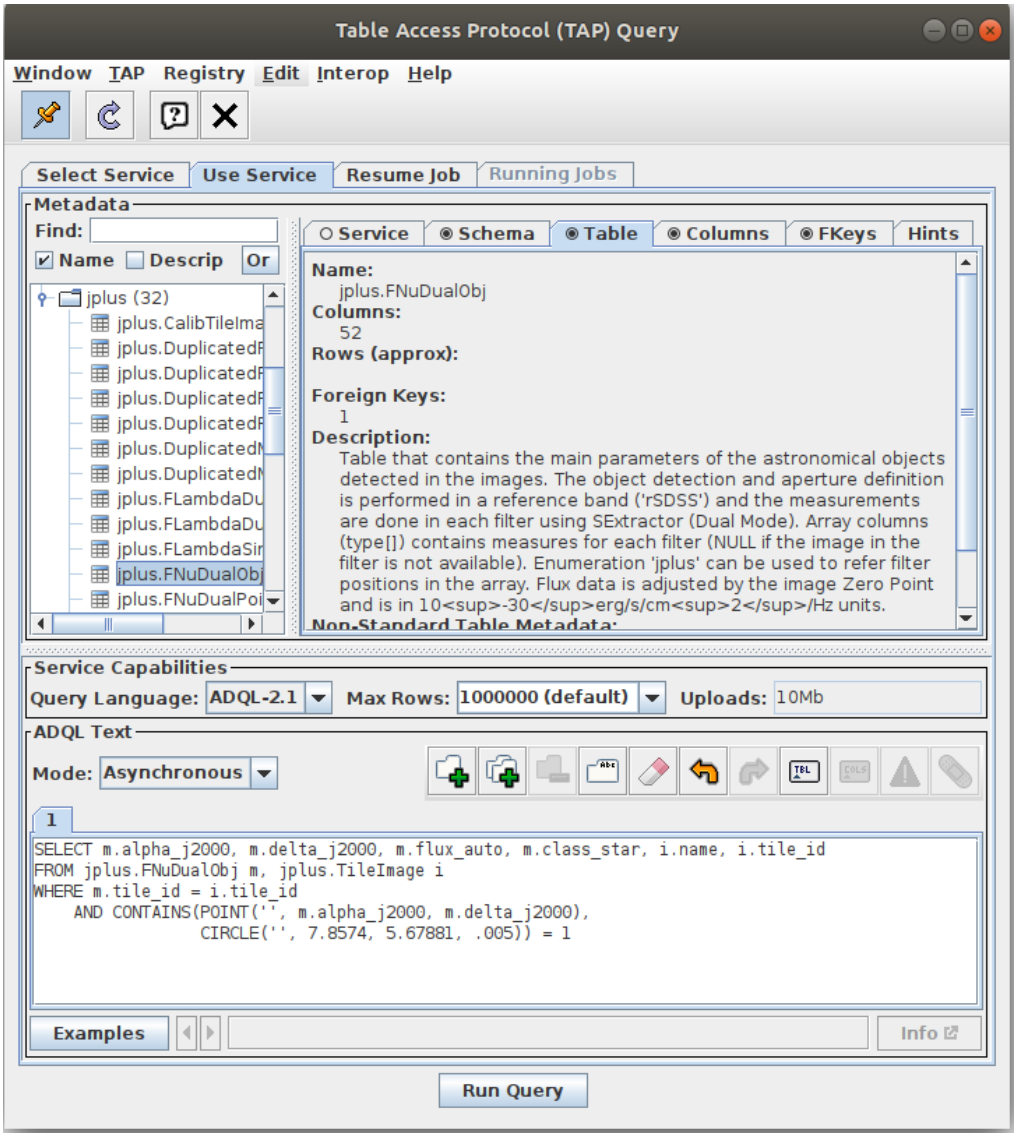


Figure 4.4: TOPCAT TAP Query window where you can introduce and execute your query.

4.1.2 TOPCAT: Accessing data through Cone Search service

In this section you will learn how to access the CEFCA Catalogues Portal data through TOPCAT using VO Simple Cone Search (SCS) service:

1. Launch TOPCAT (Figure 4.1).
2. Open the upper menu "V.O." and select "Cone Search" (Figure 4.5).
3. In the "Cone Search" window (Figure 4.6):
   a) Step 1 If the data release is public, click on the button "Find Services", select the data release in the resources list and then select the cone search service in the AccessURL table. **TIP** To find the service in the list you can introduce the name of the data release in the keywords box and click on the 'Find Services' button.
   b) Step 1 Other possibility is introducing the URL of the Cone Search Service in the lower box ("Cone URL"). **TIP** You can find the url to use in the V.O. Services service. **WARNING** If the data release is private, you have to use this method, because in the resources list only public data releases are published.
   c) Step 2 Introduce the RA, DEC and radius to perform your cone search and click on "OK" button.
   TIP For each cone search service there is a maximum radius allowed. You can find it in the V.O. Services service.
   TIP Verbosity is related to the number of columns returned. If you use verbosity "3 (maximum)" all the columns are going to be returned.
4. For private data releases, if the connection is successful, you will be asked for your username and password (those of your CEFCA Catalogues Portal account).

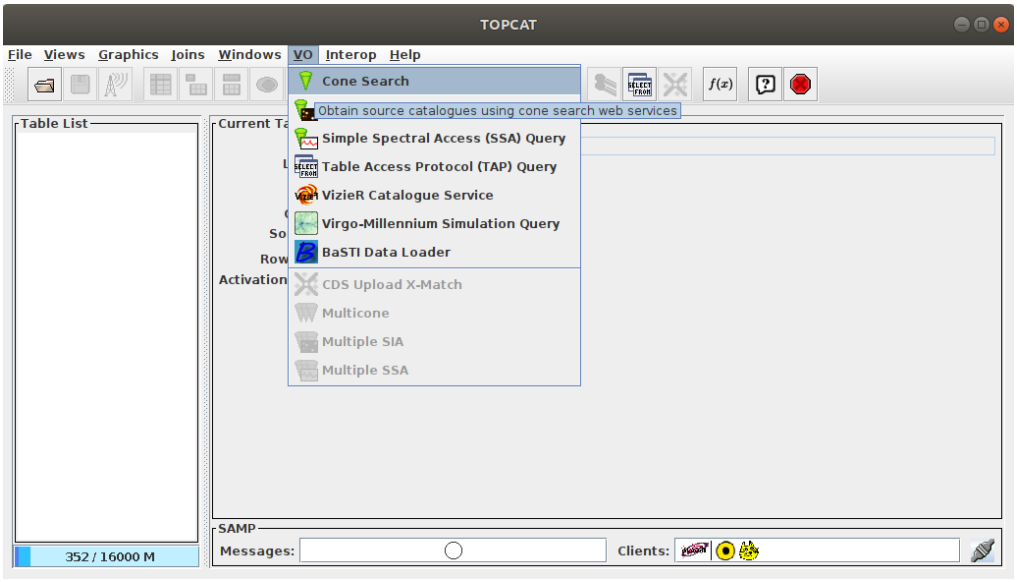


Figure 4.5: TOPCAT main screen with the Cone Search selection.

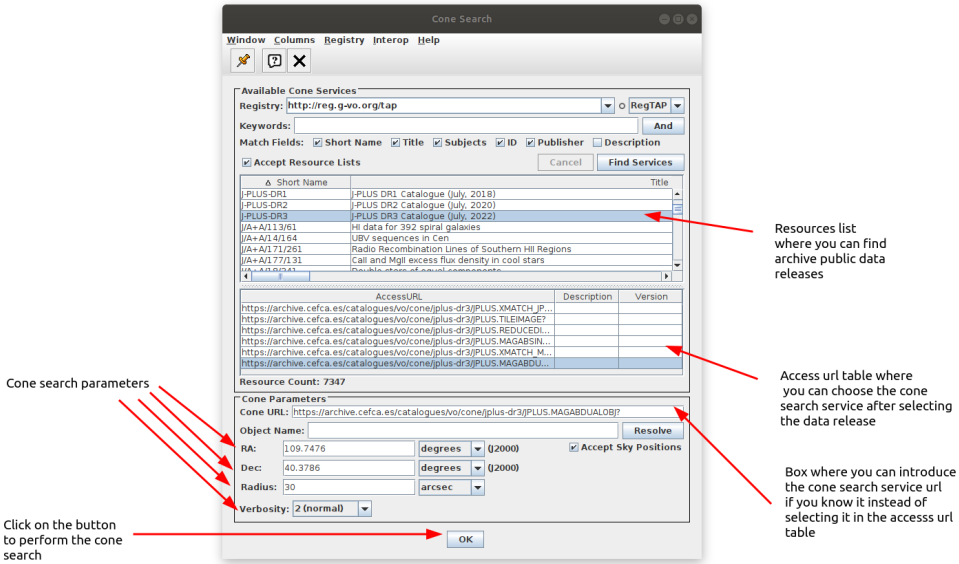


Figure 4.6: TOPCAT Cone Search Query window.

4.2 STILTS

Starlink Tables Infrastructure Library Tool Set (STILTS) can be considered as the command-line counterpart of TOPCAT.

4.2.1 STILTS: Accessing data through TAP service

The basic way to access the CEFCA Catalogues Portal data through TAP service and STILTS is using the following script:

```
#!/usr/bin/env bash

# Description how to use STILTS to execute a query
# Example of use:
#     ./do_query_stilts.sh user output.csv \
#                "SELECT TOP 10 * FROM jplus.TileImage"

url=https://archive.cefca.es/catalogues/vo/tap/jplus-dr3
user=$1
outputfile=$2
query=$3
unset pass
read -s -p Password: pass

java -jar -Dstar.basicauth.user=$user\
          -Dstar.basicauth.password=$pass \
  stilts.jar tapquery \
          tapurl=$url \
          adql="$query" \
          ofmt=csv \
          sync=false \
          out="$outputfile"
```

TIP You can download this script here.

WARNING The STILTS version used in this manual is 3.4. With other version of the software some features could be different.

Copy this text in a file (e.g. do query stilts.sh) and change the permissions to make it executable:

```
chmod u+x do_query_stilts.sh
```

Then you can perform a query running the command-line:

```
./do_query_stilts.sh user "output.csv" "adql_query"
```

REMEMBER The user you have to use is your CEFCA Catalogues Portal account's username.

WARNING The script is going to ask you a password, you have to introduce your CEFCA Catalogues Portal account's password.

TIP The output will be a CSV table. You can change the format of the output replacing the csv by other format (e.g. fits, votable,...), in the text 'ofmt=csv' of the script.

4.3 curl

It is possible to retrieve information of the archive using a simple HTTP query through a tool like curl.

4.3.1 curl: Accessing data through TAP service

The basic way to access the CEFCA Catalogues Portal data through TAP service and curl is using the following script:

```
#!/usr/bin/env bash

# Description how to use CURL to execute a query
# Example of use:
#     ./do_query_curl.sh user output.votable \
#                "SELECT TOP 10 * FROM jplus.TileImage"

url=https://archive.cefca.es/catalogues/vo/tap/jplus-dr3/sync
user=$1
outputfile=$2
query=$3
unset pass
read -s -p Password: pass

curl --user "$user:$pass" --request POST \
  --location    --data REQUEST=doQuery \
  --data PHASE=RUN \
  --data FORMAT=votable \
  --data LANG=ADQL \
  --data "QUERY=$query" \
  -o $outputfile \
  $url
```

Copy this text in a file (e.g. do_query_curl.sh) and change the permissions to make it executable:

```
chmod u+x do_query_curl.sh
```

Then you can perform a query running the command-line:

```
./do_query_curl.sh user "output.votable" "adql_query"
```

TIP You can download this script here.

REMEMBER The user you have to use is your CEFCA Catalogues Portal account's username.

WARNING The script is going to ask you a password, you have to introduce your CEFCA Catalogues Portal account's password.

TIP The output will be a VOTABLE table. You can change the format of the output replacing the votable by other format (e.g. fits, csv,...), in the text `FORMAT=votable` of the script.

4.4 Python

4.4.1 PyVO

PyVO[1] is a python library that lets you find and retrieve astronomical data using different VO protocols like TAP, Simple Image Access Protocol (SIAP) or SCS.

WARNING The PyVO version used in this manual is 1.5 With other version of the library some source code could not work.

PyVO: Accessing data through TAP service

The basic way to access the CEFCA Catalogues Portal data through TAP service and `PyVO` is using the following script:

```
# Imports
import pyvo.dal
from pyvo.auth import authsession, securitymethods
import getpass
import requests

# To avoid warnings
import warnings
warnings.simplefilter("ignore")

tap_url = "https://archive.cefca.es/catalogues/vo/tap/jplus-dr3"

# Login
user = input("Username:")
pwd = getpass.getpass("Password:")
archive_login_url = "https://archive.cefca.es/catalogues/login"
login_args = {"login": user, "password": pwd,
              "submit": "Sign+In"}
login_header = {"Content-type":
```

[1] You can read more about PyVO here.

```
                "application/x-www-form-urlencoded",
                "Accept": "text/plain"}

pyvo.dal.tap.s = requests.Session()
response = pyvo.dal.tap.s.post(archive_login_url,
                data=login_args,
                headers=login_header)
response.raise_for_status()
auth = authsession.AuthSession()
auth.credentials.set(securitymethods.ANONYMOUS, pyvo.dal.tap.s)

# Executing your query
service = pyvo.dal.TAPService(tap_url, auth)
resultset = service.run_async("SELECT TOP 5 * " \
          "FROM jplus.TileImage")
```

TIP You can download this python file here.

Other possibility is working directly with jobs. This option allows you to delete the job after obtaining the result which releases your user space in the server:

```
# Imports
import pyvo.dal
from pyvo.auth import authsession, securitymethods
import getpass
import requests

# To avoid warnings
import warnings
warnings.simplefilter("ignore")

tap_url = "https://archive.cefca.es/catalogues/vo/tap/jplus-dr3"

# Login
user = input("Username:")
pwd = getpass.getpass("Password:")
archive_login_url = "https://archive.cefca.es/catalogues/login"
login_args = {"login": user, "password": pwd,
               "submit": "Sign+In"}
login_header = {"Content-type":
                "application/x-www-form-urlencoded",
                "Accept": "text/plain"}

pyvo.dal.tap.s = requests.Session()
response = pyvo.dal.tap.s.post(archive_login_url,
                data=login_args,
                headers=login_header)
```

```
response.raise_for_status()
auth = authsession.AuthSession()
auth.credentials.set(securitymethods.ANONYMOUS, pyvo.dal.tap.s)

# Executing your query
service = pyvo.dal.TAPService(tap_url, auth)
job = service.submit_job("SELECT TOP 5 * " \
           "FROM jplus.TileImage")
job.run()
job.wait()
job.raise_if_error()
resultset = job.fetch_result()
job.delete()
```

TIP You can download this python file here.

As you can see this option is similar to previous one, and only the section '# Executing your query' has changed.

In these examples, the output format is votable which is directly read and load in the variable `resultset`, but you can also use other formats like FITS or CSV and save the result in a file.

For example, to obtain and save your data in FITS format you only have to replace '# Executing your query' section by:

```
# Executing your query
service = pyvo.dal.TAPService(tap_url, auth)
job = service.submit_job("SELECT TOP 5 * " \
           "FROM jplus.TileImage",
           maxrec=300, format="FITS")
dest_name = "result.fits"
try:
    job.run()
    job.wait()
    job.raise_if_error()
    with open(dest_name, "wb") as dest:
        response = pyvo.dal.tap.s.get(
               job.result_uri, auth=(user, pwd),
               verify=False)
        response.raise_for_status()
        dest.write(response.content)
finally:
    job.delete()
```

TIP You can download the complete python file of this example here.

Or to obtain and save your data in CSV format you only have to replace '# Executing your query' section by:

```
# Executing your query
service = pyvo.dal.TAPService(tap_url, auth)
job = service.submit_job("SELECT TOP 5 * " \
           "FROM jplus.TileImage",
           maxrec=300, format="CSV")
dest_name = "result.csv"
try:
    job.run()
    job.wait()
    job.raise_if_error()
    with open(dest_name, "w") as dest:
        response = pyvo.dal.tap.s.get(
               job.result_uri, auth=(user, pwd),
               verify=False)
        response.raise_for_status()
        dest.write(response.text)
finally:
    job.delete()
```

TIP You can download the complete python file of this example here.

PyVO: Accessing data through SCS service

The basic way to access the CEFCA Catalogues Portal data through SCS services and PyVO is using the following script:

```
# Imports
import pyvo.dal
from pyvo.auth import authsession, securitymethods
import getpass
import requests

# To avoid warnings
import warnings
warnings.simplefilter("ignore")

scs_url = "https://archive.cefca.es/catalogues/vo/cone/jplus-dr3/
JPLUS.MAGABDUALOBJ"

# Login
user = input("Username:")
pwd = getpass.getpass("Password:")
archive_login_url = "https://archive.cefca.es/catalogues/login"
login_args = {"login": user, "password": pwd,
              "submit": "Sign+In"}
login_header = {"Content-type":
```

```
                "application/x-www-form-urlencoded",
                "Accept": "text/plain"}

pyvo.dal.conesearch.s = requests.Session()
response = pyvo.dal.conesearch.s.post(archive_login_url,
                data=login_args,
                headers=login_header)
response.raise_for_status()
auth = authsession.AuthSession()
auth.credentials.set(securitymethods.ANONYMOUS,
       pyvo.dal.conesearch.s)

# Executing your search
result = pyvo.dal.conesearch(scs_url,
       pos=[109.7378, 40.3736], radius=0.003,
       verbosity=3)
```

TIP You can download this python file here.

PyVO: Accessing data through SIAP service

The basic way to access the CEFCA Catalogues Portal data through SIAP service and PyVO is using the following script:

```
# Imports
import pyvo.dal
from pyvo.auth import authsession, securitymethods
import getpass
import requests

# To avoid warnings
import warnings
warnings.simplefilter("ignore")

siap_url ="https://archive.cefca.es/catalogues/vo/siap/jplus-dr3"

# Login
user = input("Username:")
pwd = getpass.getpass("Password:")
archive_login_url = "https://archive.cefca.es/catalogues/login"
login_args = {"login": user, "password": pwd,
                "submit": "Sign+In"}
login_header = {"Content-type":
                "application/x-www-form-urlencoded",
                "Accept": "text/plain"}

pyvo.dal.SIAService.s = requests.Session()
```

```
response = pyvo.dal.SIAService.s.post(archive_login_url,
              data=login_args,
              headers=login_header)
response.raise_for_status()
auth = authsession.AuthSession()
auth.credentials.set(securitymethods.ANONYMOUS,
       pyvo.dal.SIAService.s)

# Executing your search
service = pyvo.dal.SIAService(siap_url)
resultset = service.search(
       pos=[137.4242, 37.6016], size=0.030)
```

TIP You can download this python file here.

TIP In the `Url` column of 'result' you have the different urls you have to use to retrieve the different types of images.

4.4.2 PyVO: Examples

Obtain more than 1 million rows

The limit of rows that TAP service returns is 1 million. So if you need to execute a query that returns more than this limit you can use the following or a similar source code that allows you to obtain dual mode catalogue data in coadd blocks:

```
# Imports
import pyvo.dal
from pyvo.auth import authsession, securitymethods
import getpass
import requests

# To avoid warnings
import warnings
warnings.simplefilter("ignore")

# TAP service url
tap_url ="https://archive.cefca.es/catalogues/vo/tap/jplus-dr3"

# Login
user = input("Username:")
pwd = getpass.getpass("Password:")
archive_login_url = "https://archive.cefca.es/catalogues/login"
login_args = {"login": user, "password": pwd,
               "submit": "Sign+In"}
login_header = {"Content-type":
              "application/x-www-form-urlencoded",
              "Accept": "text/plain"}
```

```
pyvo.dal.tap.s = requests.Session()
response = pyvo.dal.tap.s.post(archive_login_url,
              data=login_args,
              headers=login_header)
response.raise_for_status()
auth = authsession.AuthSession()
auth.credentials.set(securitymethods.ANONYMOUS,
       pyvo.dal.tap.s)

# Obtain all the reference tiles in the DR and the
# blocks of tiles

#    Change this number depending the number of
#    objects you expect by tile or coadd
num_tiles_per_block = 10

service = pyvo.dal.TAPService(tap_url, auth)

resultset = service.search("SELECT tile_id " \
     "FROM jplus.TileImage " \
     "WHERE filter_id = jplus::rSDSS")

ref_tiles = resultset["tile_id"]

blocks = int(len(ref_tiles) / num_tiles_per_block)
if len(ref_tiles) % num_tiles_per_block > 0:
    blocks += 1
print("Total reference tiles:", len(ref_tiles),
      "Blocks:", blocks)


# Your query
sql_base = "SELECT obj.TILE_ID, obj.number, obj.ALPHA_J2000, " \
           "obj.DELTA_J2000 AS DEC, obj.FLUX_AUTO," \
           "obj.FLUX_RELERR_AUTO,obj.class_star, " \
           "lephare.PhotoZ " \
    "FROM jplus.FNuDualObj obj, " \
           "jplus.PhotoZLephare lephare " \
    "WHERE obj.TILE_ID = lephare.TILE_ID AND " \
           "obj.NUMBER = lephare.NUMBER AND " \
           "lephare.photoz<0.35 AND lephare.photoz>0.05 AND " \
           "obj.tile_id IN ({0})"
file_dest_name = "block{0}.fits"

# Obtains your data in fits files
```

```
for i in range(blocks):
    grp = list(ref_tiles[
         i * num_tiles_per_block:(i+1) * num_tiles_per_block])
    adql = sql_base.format(",".join([str(x) for x in grp]))
    job = service.submit_job(adql, format="FITS")
    dest_name = file_dest_name.format(i)
    try:
        job.run()
        job.wait()
        job.raise_if_error()
        with open(dest_name, "wb") as dest:
            response = pyvo.dal.tap.s.get(job.result_uri,
                     auth=(user, pwd), verify=False)
            response.raise_for_status()
            dest.write(response.content)
    finally:
        job.delete()
    print("Done block", i)

print("All done.")
```

TIP You can download this python file here.

WARNING This source code generates a FITS file per block, so after executing it you have to join all the data. WARNING You should adjust the value of 'num_tiles_per_block' depending on your query and the expected number of objects returned by block to create a smaller number of blocks or to be sure that the number of objects returned is less than the limit.

Retrieve the fits cutouts of a set of objects

You can combine TAP service and the direct download services to obtain the fits cutouts of a set of objects:

```
# Imports
import pyvo.dal
from pyvo.auth import authsession, securitymethods
import getpass
import requests
from requests.auth import HTTPBasicAuth

# To avoid warnings
import warnings
warnings.simplefilter("ignore")

# TAP service url
tap_url ="https://archive.cefca.es/catalogues/vo/tap/jplus-dr3"
```

```
# Cutout service url
cut_url = "https://archive.cefca.es/catalogues/" \
"vo/siap/jplus-dr3/get_fits_cutout?" \
   "id={0}&ra={1}&dec={2}&width={3}&height={4}&filter={5}"

# Login
user = input("Username:")
pwd = getpass.getpass("Password:")
archive_login_url = "https://archive.cefca.es/catalogues/login"
login_args = {"login": user, "password": pwd,
               "submit": "Sign+In"}
login_header = {"Content-type":
              "application/x-www-form-urlencoded",
              "Accept": "text/plain"}

pyvo.dal.tap.s = requests.Session()
response = pyvo.dal.tap.s.post(archive_login_url,
              data=login_args,
              headers=login_header)
response.raise_for_status()
auth = authsession.AuthSession()
auth.credentials.set(securitymethods.ANONYMOUS,
       pyvo.dal.tap.s)

# Obtain the filters list

service = pyvo.dal.TAPService(tap_url, auth)

resultset = service.search("SELECT filter_id, name " \
     "FROM jplus.Filter")

filters = {}
for row in resultset:
    filters[row["filter_id"]] = row["name"]

# Obtain the objects of your interest with TAP

resultset = service.search("SELECT tile_id, number, " \
     "ALPHA_J2000, DELTA_J2000, KRON_RADIUS, " \
     "A_WORLD, B_WORLD, PETRO_RADIUS " \
     "FROM jplus.MagABDualObj " \
     "WHERE tile_id = 90142", maxrec = 5)

# For each object obtain the cutout in all the filters
for row in resultset:
```

```
    radius = row["kron_radius"]
    petro_radius = row["petro_radius"]
    if petro_radius > radius:
        radius = petro_radius
    width = radius * row["a_world"] * 1.15
    tile_id = row["tile_id"]
    number = row["number"]
    ra = row["alpha_j2000"]
    dec = row["delta_j2000"]
    for filter_id in filters:
        filter_name = filters[filter_id]
        url = cut_url.format(tile_id, ra, dec, width,
                 width, filter_id)
        response = requests.get(url,
               auth = HTTPBasicAuth(user, pwd))
        if response.status_code == 200:
            file_name = "{0}-{1}-{2}-cutout.fits".format(tile_id,
                      number, filter_name)
            with open(file_name, "wb") as f:
                f.write(response.content)
                print("Downloaded file: {0}".format(file_name))
        else:
            print("Error downloading data")

print("All done.")
```

TIP You can download this python file here.

Search for a set of objects whose coordinates you have in a file

TAP service lets you upload your own tables into the server for the duration of the query. These tables must be in a VOTABLE or FITS table format. So to search for a set of objects using its coordinates you can use this feature. For example, you can have a votable file called 'positions.votable' with the coordinates and identifiers in your external survey like this:

```
<?xml version="1.0" encoding="UTF-8"?>
<VOTABLE version="1.3"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xmlns="http://www.ivoa.net/xml/VOTable/v1.3"
        xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.3
        http://www.ivoa.net/xml/VOTable/VOTable-1.3.xsd">
  <RESOURCE name="Data" type="results">
    <TABLE ID="results" name="results">
      <FIELD ID="id" name="id" datatype="char" ucd="meta.id"
            arraysize="*">
```

```
        <DESCRIPTION><![CDATA[Object identifier]]></DESCRIPTION>
      </FIELD>
      <FIELD ID="ra" name="ra" datatype="double"
                ucd="pos.eq.ra;meta.main" unit="deg">
        <DESCRIPTION><![CDATA[Right ascension]]></DESCRIPTION>
      </FIELD>
      <FIELD ID="dec" name="dec" datatype="double"
                ucd="pos.eq.dec;meta.main" unit="deg">
        <DESCRIPTION><![CDATA[Declination]]></DESCRIPTION>
      </FIELD>
      <DATA>
        <TABLEDATA>
          <TR><TD>id1</TD><TD>110.5481</TD><TD>40.4684</TD></TR>
          <TR><TD>id2</TD><TD>107.1216</TD><TD>40.7678</TD></TR>
          <TR><TD>id3</TD><TD>-5.2122</TD><TD>-40.2323</TD></TR>
        </TABLEDATA>
      </DATA>
    </TABLE>
  </RESOURCE>
</VOTABLE>
```

And with TAP service you can search those objects by coordinates:

```
# Imports
import pyvo.dal
from pyvo.auth import authsession, securitymethods
import getpass
import requests
from requests.auth import HTTPBasicAuth

# To avoid warnings
import warnings
warnings.simplefilter("ignore")

# TAP service url
tap_url ="https://archive.cefca.es/catalogues/vo/tap/jplus-dr3"

# Login
user = input("Username:")
pwd = getpass.getpass("Password:")
archive_login_url = "https://archive.cefca.es/catalogues/login"
login_args = {"login": user, "password": pwd,
              "submit": "Sign+In"}
login_header = {"Content-type":
             "application/x-www-form-urlencoded",
             "Accept": "text/plain"}
```

```
pyvo.dal.tap.s = requests.Session()
response = pyvo.dal.tap.s.post(archive_login_url,
              data=login_args,
              headers=login_header)
response.raise_for_status()
auth = authsession.AuthSession()
auth.credentials.set(securitymethods.ANONYMOUS,
       pyvo.dal.tap.s)

# Obtain the objects list

service = pyvo.dal.TAPService(tap_url, auth)

resultset = service.run_async("SELECT Obj.tile_id, " \
       "Obj.number, Obj.MAG_AUTO, Pos.id, " \
       "DISTANCE(Obj.alpha_j2000, Obj.delta_j2000, " \
          "Pos.ra,Pos.dec) AS distance " \
     "FROM jplus.MagABDualObj AS Obj, " \
        "tap_upload.positions AS Pos " \
     "WHERE DISTANCE(Obj.alpha_j2000, Obj.delta_j2000, " \
           "Pos.ra, Pos.dec) < 5/3600.0",
     maxrec=2000, uploads={"positions": "positions.votable"})
```

TIP You can download this python file here and the example 'positions.votable' file here.

TIP Your file data is upload in a temporal table called 'tap_upload.{name_indicated}' where {name_indicated} is the one indicated in the uploads parameter:

'uploads={"name_indicated": "positions.votable"}'

Chapter 5

Description of the data

In this chapter we present an overview of the data that it is provided in each of the data releases stored in the CEFCA Catalogues Portal. This data can be split in two categories: the database and the images.

5.1 The database

The database contains all the information that can be stored in tabular form. This includes:

- The observed properties of all the detections made in the Coadd images.
- Crossmatches of the detections made in the Coadd images with other external surveys.
- The characteristics of the Coadd images source of the detections and, for some data releases, the characteristics of the reduced individual images.

In the ADQL help and Tables service you can find the list of all tables available in the database. Here you have a brief description of some of them:

jplus.MagABDualObj Most likely, this is the most important table in the database. It contains the photometry Dual-mode of all the objects detected in the rSDSS coadd images. Except the magnitudes and the `FLAGS`, all the parameters are computed in the rSDSS coadd image. The magnitudes columns and the `FLAGS` are arrays containing the values in the different filters. See Section 3.2.2 for a detailed explanation on how to manage these arrays.

In this table, the fluxes of the objects are stored in AB magnitudes.

jplus.FNuDualObj As the previous one but with the fluxes stored in units of $10^{-30}\,\mathrm{erg\,s\,cm^{-2}\,Hz^{-1}}$. In addition, errors in fluxes are stored as relative errors.

jplus.FLambdaDualObj Idem but with the fluxes stored in units of $10^{-19}\,\mathrm{erg\,s\,cm^{-2}\,\AA^{-1}}$. In addition, errors in fluxes are stored as relative errors.

jplus.PhotoZ{method} These tables contain the photometric redshifts of the astronomical objects. To obtain these redshifts the photometric information in table jplus.FNuDualObj is used. Different methods can be used to compute these redshifts:

`LEPHARE` This data is stored in jplus.PhotoZLephare table. The LePhare code[1] computes photometric redshifts using the template fitting method. We use a custom version of LePhare with templates obtained via stellar population synthesis (see Hernán-Caballero et al. (2021) for details). Some important columns are:

`PHOTOZ` Best photometric redshift solution (maximum of P(z)).

`PHOTOZ_ERR` Uncertainty in PHOTOZ.

`SPARSE_PDF` (Only available in some data releases). This column encodes a sparse representation of the full redshift probability distribution function (zPDF), which samples the z=[0,1] interval with a constant step of 0.005 (therefore contains 201 elements). In order to retrieve the full zPDF from its compressed representation a zPDF decompression software is given (to download it see table help at ADQL help and Tables).

jplus.MagABSingleObj This table contains the photometry of running `SExtractor` in Single-mode in all the tiles. **WARNING** Be aware that the photometry in different bands of the same object appears as independent measurements.

jplus.FNuSingleObj As the previous one but with the fluxes stored in units of $10^{-30}\,\mathrm{erg\,s\,cm^{-2}\,Hz^{-1}}$. In addition, errors in fluxes are stored as relative errors.

jplus.FLambdaSingleObj Idem but with the fluxes stored in units of $10^{-19}\,\mathrm{erg\,s\,cm^{-2}\,\AA^{-1}}$. In addition, errors in fluxes are stored as relative errors.

jplus.TileImage This table contains the information about the Coadd images. Here you have some longer explanations about some of the fields:

REF_TILE_ID Remember that every pointing in the survey is made of observations in all the different filters. In the construction of the Dual-mode catalogues, the coadd image in the rSDSS filter is used as reference coadd image or tile. This keyword makes reference to the identification of this image.

ZPT This is the Zero Point (ZP) of the image. This means that to compute the AB magnitude of an object the following formula has been applied:

$$m_{AB} = -2.5\log_{10}(\text{Number of ADUs}) + ZPT \tag{5.1}$$

WARNING You don't need to apply any correction by exposure time.

[1] More details of the LePhare code can be found in Arnouts & Ilbert (2011).

CALIB_PROCEDURE Many coadd images can be calibrated using different procedures. Of course, these procedures should provide the same zero point, however, this is not always like this and a single procedure has to be chosen to calibrate the data that is uploaded to the archive. The different procedures that can be used are:

Spectrophotometric Standard Star (1) This procedure uses observations of a spectrophotometric standard star to calibrate the individual images. The zero point of the Coadd image is inherited from the zero point of the reduced individual image that has been used as reference in the construction of the coadd image.

SDSS Photometry (3) For those coadd images falling in the footprint of photometric SDSS observations it is possible to calibrate the images through a direct comparison. This can only be done for the broad band filters, with the caveat that the uJAVA is known to be different from the u filter of SDSS.

SDSS Spectroscopy (4) For those tiles in which there are objects with spectra from SDSS is possible to derive synthetic photometry in most of the filters. From this synthetic photometry it is possible to derive zero points.

Stellar locus (5) This procedure consists on comparing the distribution of stars in color-color diagrams in instrumental magnitudes and compare the location in this diagram with the expected location from theoretical assumptions or with the position of well calibrated fields.

PanSTARRS Photometry (7) In December, 2016, PanSTARRS made public its first data release (DR1) which covers all the sky visible from the OAJ in the photometric bands g, r, i, z, y. This data is used to calibrate in the four band in common (g,r,i,z).

Stellar and White Dwaft Loci (8) In this method, the dust de-redened locus of main sequence stars, selected using the color-magnitude diagram from the Gaia satellite astrometry and photometry, is used to homogenize the photometry. The absolute calibration was computed by matching the theoretical and the observational locus of the white dwarfs in the survey (López-Sanjuan et al. (2019)). Since J-PLUS DR2, an additional correction to account for the systematic impact of the metallicity in the position of the stellar locus was applied (López-Sanjuan et al. (2021)).

Gaia and White Dwarf Locus (9) In this method, the synthetic photometry of main sequence stars obtained from Gaia low-resolution spectra is compared with the instrumental magnitudes to derive the zero point of the images. Magnitude and color transformations between both systems were applied (López-Sanjuan et al. (2023)). The absolute calibration was computed by matching the theoretical and the observational locus of the white dwarfs in the survey.

WARNING Not all the calibration methods are used in a particular data release. The enumeration `calibration_method` contains the calibration methods used in that data release.

WARNING The codes indicated could be different, you can check them in the enumeration `calibration_method`.

TIP The table jplus.CalibTileImage contains all the calibration data of the coadd images. For each image, this table contains the zero point and error obtained using the different calibration methods available for that data release.

TEXPOSED There are three keywords related to the exposure time. This keyword stores the sum of the exposure times of all the individual images that have been combined in the tile.

EFECTIME This keyword stores the "effective observed time". This is a weighted exposure time that takes into account the differences in transparency conditions of the different reduced individual images. It can be considered as the exposure time that would be needed in the conditions of the reference reduced individual image to reach the same depth as the actual tile.

EXPTIME This is the exposure time that enters in the computation of fluxes and magnitudes. In the case of coadd images, this exposure time has been set to 1 second.

DEPTH2FWHM5S This keyword stores an estimation of the depth of the image consisting in computing the AB magnitude corresponding to an object with a signal-to-noise of 5 within an aperture of two times the FWHM.

DEPTH3ARC5S Idem but within an circular aperture of 3 arc seconds of diameter.

DEPTHARCSEC2 Idem but within an aperture of 1 square arc second.

M50S Magnitude at which completeness for point-like sources is 50%.

KS Decay rate of the completeness (for point-like sources) assuming a the following Fermi-Dirac function to describe it:

$$f_c = 1 - \frac{1}{e^{-k_s(m-m_{50s})}+1}$$

where f_c is the completeness at magnitude r, k_S is the decay rate (ie. `KS`) and m_{50s} (column `M50S`) is the magnitude at which the completeness is 0.5.

M50G Magnitude at which completeness for extended sources is 50%.

KG Decay rate of the completeness for extended objects.

jplus.TileImageWithFlag This table is an extension of the **jplus.TileImage** table with three columns related to flags pointing out to possible issues with each coadd image. The additional columns are:

FLAG This column has the value `NULL` for images with no known problem and a numerical flag which correspond to a list of possible issues (see enumeration **jplus_img_flag**.)

FLAG_COMMENT When the **FLAG** column is not `NULL`, this column can contain a comment providing more information about the problem found on the image.

FLAG_UPDATE_DATE This columns provides the last date in which the image was flagged.

WARNING This table is only available in those data releases with issues in the coadd images.

jplus.Filter This is a simple but important table containing the list of filters. You will need this table to derive the filters' names from the numerical identifications used in the main tables. You can also retrieve information about the central wavelength of the filters and their widths.

jplus.ReducedIndividualFrame This table contains the information about the Reduced individual image used to create the coadd images. Here you have some longer explanations about some of the fields:

TILE_ID This column contains the identifier of the coadd image in which this image has been used to compose it.

OBSERVATION_DATE This column contains the date and time when the exposure was started.

EXPTIME This is the exposure time of the image in seconds.

WARNING This table is only available in some data releases.

jplus.xmatch_{survey} These tables contain crossmatches of the dual mode objects with other surveys. In the ADQL help and Tables you can find the complete list of these tables and in the description of each of them which radius has been used to execute the cone search to perform the cross match. Here you have some longer explanations about some of the common fields:

TILE_ID and NUMBER These columns contain the identifier of the object in the jplus.{MagAB/FNu/FLambda}DualObj tables.

angDist This column contains the distance of the object in the external survey to the survey matching object.

WARNING The xmatch tables can be different in each survey data release.

ivoa.Obscore This is a standard table defined by International Virtual Observatory Alliance (IVOA) that contains a list of the different images and products offered in this data release. Some important columns are:

DATAPRODUCT_SUBTYPE This column indicates if the image is a coadd image ('coadd') or an individual reduced image ('reduced individual').

S_RA Central right ascension, ICRS.

S_DEC Central declination, ICRS.

S_FOV Diameter (bounds) of the covered region.

FILTER Name of the filter used for this observation.

ACCESS_FORMAT Format of the file that you can download in the url indicated in the ACCESS_URL column. The two possible formats are:

image/fits This format means that the url points directly to the fits image.

application/x-votable+xml; content=datalink This format means that the url points to a VOTABLE file where you can find the url of the image and other products related to it.

ACCESS_URL The url where you can download the image or the file with the url of the image and other products related to it (see ACCESS_FORMAT column).

5.2 The images

The images available in the archive are the Coadd images from which the photometry has been derived, and the corresponding weight images. In some data releases, the reduced individual images used to compose these coadd images are also available.

5.2.1 Coadd images

Coadd or Tile images have been constructed from the combination of a series of single exposures or reduced individual images. The main characteristics of the images are:

- They have been constructed using the software `SWarp`.
- Single exposures have been background subtracted before combination. **WARNING** Be aware that this can affect your science.
- Coadd images are an artificial construction and their centres and dimensions are defined *a priori*. **WARNING** In most of the data releases, to ensure that actual images fall within the definition of the coadd images the sizes of these images is a bit larger than the original frames. For example, in J-PLUS DR3 the size is 9500x9500pixels. This has two consequences:
  - the centre of the coadd images can be slightly offset with respect to the actual pointing of the original reduced individual images.
  - the area of the coadd image with scientific data is smaller than the size of the coadd image so you will find a "frame" of pixels with zero flux.
- The exposure time of the coadd images to be used in flux computations (ie. photometry) is 1 second. So, indeed, image fluxes are in units of ADU/s.
- The combination of the images is done considering one of the images as the reference image and the fluxes of the rest of the reduced individual images is normalised to the flux of this reference image before the combination. **WARNING** This means that:
  - for calibration purposes the transparency and those parameters related to it (like extinction, airmass, zero points,...) to be assumed are those of the reference image.

  - the effective exposure time (keyword EFECTIME) is the exposure time that would be needed to reach the same depth as the actual image observing only in the transparency conditions of the reference frame.

  The name of the reference image is stored in the header keyword HIERARCH OAJ PRO REFIMAGE.

- Dual-mode catalogues are derived from PSF homogenised images. These images are created and deleted on-the-fly and, therefore, they are not available.
- The zero points needed for calibration are available in the Image Search service or through TAP in the table jplus.TileImage . Zero points of the tiles can be computed in different ways and not all the calibration procedure are available for all the coadd images (see 5.1). **TIP** In the last data releases, zero points are already included in the header of the images.
- The coadd images with '.fz' extension are in FITS format compressed using FPACK [2]. **WARNING** An important point regarding 'fpack' compression is that the compression of coadd images implies a loss in information, although this lost is at the level of the noise of the images and should not affect the photometry of the sources. For this reason is not recommended to compress again an image that have been uncompressed. Instead, the original compressed image should be kept and when the uncompressed image is not needed anymore it should be removed, keeping always the original compressed image.
- This is a brief list of some important keywords in the header of the images:

  HIERARCH OAJ QC NC* These keywords provide a summary statistics of the counts in the image. These statistics are derived in boxes across the image and the results are stored in:

  NCMODE The mode of the distribution of mean values.

  NCMIDPT The median of the distribution of mean values.

  NCMIDRMS The rms of the distribution of mean values.

  NCNOISE The median of the distribution of rms values (noise).

  NCNOIRMS The rms of the distribution of rms values.

  HIERARCH OAJ PRO FWHM* These are keywords providing statistics on the distribution of FWHM of the PSF.

  FWHMSEXT Average value of the FWHM computed by SExtractor for bright not saturated stars, in units of arc seconds. **WARNING** SExtractor computes the FWHM assuming a Gaussian core.

  FWHMSRMS RMS value of the FWHM computed by SExtractor for bright not saturated stars, in units of arc seconds.

  FWHMMEAN Mean of the FWHM computed by PSFEx.

  FWHMBETA β parameter of the Moffat profile fitted to the PSF by PSFEx.

  FWHMnstars Number of bright non saturated stars used by PSFEx to model the PSF.

[2] You can read more about FPACK compression here.

Ellipmean Average ellipticity of the PSF model derived by PSFEx.

NCOMBINED Number of individual exposures combined.

TEXPOSED This is the sum of the individual exposure times.

EFECTIME This is the effective time, ie. the equivalent exposure time that would be needed to reach the same depth as the final image if it would be observed in the conditions of transparency of the reference image.

HIERARCH OAJ PRO SWCMB* These keywords provide the names of the individual reduced images that have been combined.

HIERARCH OAJ PRO SWSCALE* These keywords provide the flux scale factors applied to each of the individual reduced images that have been combined.

***NOIFIT** These three keywords provide a formula to compute the noise due to variations of the background in the image. To compute the expected noise in a given aperture of area A we have to apply the formula:

$$\text{noise} = \texttt{SNOIFIT} \cdot \sqrt{A} \cdot (\texttt{ANOIFIT} + \texttt{BNOIFIT} \cdot \sqrt{A}) \tag{5.2}$$

PHOTZPT ST magnitude zero point.

PHOTZPER ST magnitude zero point error.

PHOTZPMD Procedure to compute ST magnitude zero point (see 5.1).

5.2.2 Reduced individual images

Reduced individual images are the science raw images processed/reduced by OAJ's pipeline used to construct the Coadd images. **REMEMBER** These images are not available for all the different data releases.

The main characteristics of the images are:

- They are not normalized by the exposure time.
- They do not have the background subtracted. **TIP** Background model is included in the image file in a separate HDU.
- The reduced individual images have '.fz' extension and are in FITS format compressed using FPACK [3]. **WARNING** An important point regarding 'fpack' compression is that the compression of reduced individual images implies a loss in information, although this lost is at the level of the noise of the images and should not affect the photometry of the sources. For this reason is not recommended to compress again an image that have been uncompressed. Instead, the original compressed image should be kept and when the uncompressed image is not needed anymore it should be removed, keeping always the original compressed image.
- These images can be composed by different HDUs. These HDUs can be:

[3] You can read more about FPACK compression here.

IMAGE The processed image.

MASKED_PIXELS The pixels masks. The different codes of the mask are:

1 Bad pixel
2 Saturated pixel
4 Cosmic rays
8 Shuttle trac
16 Interpolation
32 Pixel in hole
64 Pixel in object

BACKGROUND_MODEL The background model that is subtracted when the coadd image is created. **REMEMBER** The reduced individual image has not applied this background model.

MASK_MODEL Model with the saturated objects masked before creating the background model.

- This is a brief list of some important keywords in the header of the image:

DATE-OBS Starting time of the observation.

DATE-END Endind time of the observation.

EXPTIME Exposure time in seconds.

HIERARCH OAJ QC NC* These keywords provide a summary statistics of the counts in the image. These statistics are derived in boxes across the image and the results are stored in:

NCMODE The mode of the distribution of mean values.

NCMIDPT The median of the distribution of mean values.

NCMIDRMS The rms of the distribution of mean values.

NCNOISE The median of the distribution of rms values (noise).

NCNOIRMS The rms of the distribution of rms values.

HIERARCH OAJ PRO {**type**}**CORR** These are keywords providing information about the corrections applied. **WARNING** All these keywords are not always present in the images. If a keyword is not in the header, it means that this correction is not applied in that individual reduced image.

OVSCCORR Indicates if overscan correction has been applied using the Master-Overscan to remove the bias level from the image.

BIASCORR Indicates if bias correction has been applied using the Master-BIAS to remove the bias level from the image.

FLATCORR Indicates if flat correction has been applied using the Master-FLAT.

ICORCORR Indicates if illumination correction has been applied to the individual reduced image.

FRINCORR Indicates if fringing pattern correction has been applied to the individual reduced image.

SBKGCORR Indicates if the correction using the superbackground has been applied to the individual reduced image.

HIERARCH OAJ PRO FWHM* These are keywords providing statistics on the distribution of FWHM of the PSF.

FWHMSEXT Average value of the FWHM computed by SExtractor for bright not saturated stars, in units of arc seconds. **WARNING** SExtractor computes the FWHM assuming a Gaussian core.

FWHMSRMS RMS value of the FWHM computed by SExtractor for bright not saturated stars, in units of arc seconds.

5.2.3 Redshift probability distribution functions (zPDFs)

The photometric redshift codes that we implement provide the probability distribution function $P(z)$ for the redshift of each source. This zPDF is sampled at N+1 redshift values distributed uniformly along the redshift search range [0, $z_{\max}$]:

$$z_i = \delta z \cdot i, \quad i = 0, 1, \ldots N \tag{5.3}$$

where $\delta z = z_{\max}/N$ is the distance between consecutive points. The zPDF is normalized so that the sum over the entire redshift search range is 1:

$$\sum_{i=0}^{N} P(z_i) = 1 \tag{5.4}$$

zPDFs are stored in a compressed form to save disk space and bandwidth. For some datasets, the Object Explorer tool (see 2.3.2) includes a download link for the zPDF of the individual source being shown (the $zPDF$ is decompressed on the fly and saved as a FITS table when the user clicks the link). This FITS table contains the fields:

tile_id Reference rSDSS band image identifier.

number The NUMBER parameter of SExtractor. **REMEMBER** The identifier of the object is composed by this tile_id and the number.

z Array containing the redshift values z_i in which the zPDF is sampled.

pdf Array containing the probability density $P(z_i)$ for each z_i.

TIP The same information can also be obtained in VOTABLE, CSV, or FITS format via the Direct Download Services (see 2.3.12).

For some datasets, the zPDFs are also available in their compressed form through the VO Asynchronous Queries (ADQL) service (see 2.3.10) or TAP protocol (see 2.3.11). Compressed zPDFs are stored in the "SPARSE_PDF" field of the relevant table (e.g. jplus.PhotoZLephare). In order to extract the zPDF from its compressed representation, the user needs to save the output from the ADQL query in FITS format and then use the python script provided in the table help (ADQL help and Tables). This script will add the column "PDF" to the FITS file, which contains the $P(z_i)$ values of the uncompressed zPDF.

WARNING The z_i values are not included in the FITS file. However, the user can easily generate them from Eq.5.3 using the δz and N values specified in the Description column for the "SPARSE_PDF" field at the ADQL help page of the relevant table.

Glossary

Astronomical Data Query Language is the language used by the IVOA to represent astronomy queries posted to VO services. 40, 99

Astronomical observation night is the period between 12:00UT of the day indicated and 12:00UT of the next day. 36

Coadd (or **tile**) is an image resulting from the combination of individual exposures. 5, 17–19, 23, 32, 35, 39, 85–87, 90, 92, 98

Dual-mode is a way of running `SExtractor`'s in which an image is used for detection and another image is used to perform the photometry. 6, 47, 85, 86, 91, 98

`HDU` An HDU (Header Data Unit) is the highest level component of the FITS file structure, consisting of a header and a data array or table.. 92

Hierarchical Progressive Surveys (HiPS) is a service based on the namesake protocol defined by the IVOA which allows one to access, visualize and browse seamlessly image and catalogue data. 99

`PSFEx` is a PSF image characterisation code developed by Emmanuele Bertin. 91, 92

`SExtractor` is a source extraction code developed by Emmanuele Bertin. 6, 18–21, 24, 27, 86, 91, 94, 97, 98

`SWarp` is an image combination code developed by Emmanuele Bertin. 90

SQL (Structured query language) is a programming language that allows retrieving information from a relational database. 40, 99

OAJ's pipeline refers to the software designed and implemented at CEFCA which automatically processed the images acquired at the Observatorio Astrofísico de Javalambre. More information here. 6, 92, 98

Photo-spectrum is a spectrum in which the fluxes at different wavelengths come from independent photometric data instead of a single observed spectrum. 17, 19, 24, 28, 97

Pseudospectrum See Photo-spectrum. 24

Reduced individual image refers to raw science images processed/reduced by OAJ's pipeline. 5, 23, 35, 39, 85, 89, 90, 92

Simple Cone Search (SCS) is a service based on the namesake protocol defined by the IVOA which offers the simplest access to astronomical catalogues. It allows you to retrieve catalogue data on objects within a given radius around a specified location. Viewed in 3D, the radius defines a cone of space. 69, 100

Simple Image Access Protocol (SIAP) is a service based on the namesake protocol defined by the IVOA which offers astronomical images within a specified position and radius. It allows you to retrieve images and cutouts of the specified size. Currently, versions 1.0 and 2.0 of the protocol are offered. 73, 100

Single-mode is the usual way of running `SExtractor`'s in which a single image is used to detect the objects and perform the photometry. See Dual-mode for an alternative way of running `SExtractor`. 6, 86

Table Access Protocol (TAP) is a service based on the namesake protocol defined by the IVOA which offers a flexible access to data tables. It allows you to retrieve catalogue data using as input a query in Astronomical Data Query Language (ADQL), which is basically a standardised version of SQL. 65, 100

Tile See Coadd. 90

VO acronym of "Virtual Observatory". 65, 66, 69

VOTABLE is the table format (XML format) defined by the IVOA (TABLEDATA Serialization). 22, 28, 33, 36, 41, 47, 73, 82, 90, 94

VOTABLE Binary2 is the binary format defined by the IVOA (BINARY2 Serialization). 41

Acronyms

ADQL Astronomical Data Query Language. 6, 40, 45, 47, 48, 52, 57, 98

ADU Analog-to-Digital Unit. 90

CDS Centre de Donnes astronomiques de Strasbourg. 23

CSV Comma Separated Values. 28, 33, 34, 36, 39, 41, 47, 72, 75, 94

DPAD CEFCA's Processing and Data Archiving Department. 8

FITS Flexible Image Transport System. 22, 24, 28, 33, 34, 36, 39, 41, 47, 75, 80, 82, 94

FoV Field of View. 24, 27

FWHM Full Width at Half Maximum. 21, 38, 91, 94

HiPS Hierarchical Progressive Surveys. 65

ICRS Internation Celestial Reference System. 38

IVOA International Virtual Observatory Alliance. 89, 97, 98

J-PAS Javalambre Physics of the Accelerating Universe Astrophysical Survey. 5

JPEG Joint Photographic Experts Group. 33, 36

J-PLUS Javalambre Photometric Local Universe Survey. 5

JSON JavaScript Object Notation. 28

MiniJ-PAS Survey carried out with JPAS-Pathfinder camera on the AEGIS field and J-PAS filters set. 5

MOC (HEALPix) Multi-Order Coverage map. 38

NED NASA/IPAD Extragalactic Database. 23

OAJ Observatorio Astrofísico de Javalambre. 12, 87

PanSTARRS Panoramic Survey Telescope and Rapid Response System. 87

PDF Portable Document Format. 22, 28

PNG Portable Network Graphics. 19, 24, 28, 39

PSF Point Spread Function. 23, 91, 92, 94, 97

RMS Root Mean Square. 91, 94

SAMP Simple Application Messaging Protocol. 22

SCS Simple Cone Search. 6, 65, 69, 73, 76

SDSS Sloan Digital Sky Survey. 23, 87

SIAP Simple Image Access Protocol. 65, 73, 77

STILTS Starlink Tables Infrastructure Library Tool Set. 71

SVG Scalable Vector Graphics. 28

TAP Table Access Protocol. 6, 65, 66, 71–73, 78, 80, 82, 83, 91, 94

TOPCAT Tool for OPerations on Catalogues And Tables. 22, 65, 66, 69, 71

TSV Tabular Separated Values. 41, 47

VO Virtual Observatory. 22, 28, 34, 36, 37, 41, 42, 73, 97

ZP Zero Point. 86

z**PDF** Redshift probability distribution function. 24