CEFCA's Science Archive User's Manual

DRAFT VERSION

Version 1.18 (19/11/2019)

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Chapter 1

Introduction

This is the user's manual of CEFCA's Science Web Portals, ie. the websites that you use to access to the public data of the main surveys carried out by CEFCA like J-PLUS, mini-JPAS and J-PAS.

WARNING Although in the manual we are using images corresponding to one of the web portals (in this case, mini-JPAS), 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) we will warn you about this.

WARNING The manual tries to be as updated as possible with respect to the modifications done in the website and the archive but it is possible that some inconsistencies still remain.

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 available:

`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 is based on a database whose content is the following:

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 image in the rSDSS band as reference image. The "dual mode data" has the following characteristics:

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

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

1.3 Getting help

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

- Front page of the web portal (e.g. mini-JPAS, J-PLUS DR1).
- Clicking on the icon in the upper right corner (to go to the front page).
- Clicking on the icon to download this manual.
- There is a specific help page on ADQL queries. You can access to it through this link. There is also a link within the list of Services (see Section 2.1.2) and, of course, in the VO Asynchronous Queries (ADQL) main page (upper right corner).

1.4 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 desktop computer, a laptop or a mobile device. Even more, **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 2.5).

1.5 About this manual

Along 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 it is prone to produce an error.
- **REMEMBER** This is a particular warning to remind you some action that should be done.

On the other hand, in the description of the different windows, for clarity, are indicated only those parts of the window that are not obvious or those in which to put the attention.

Besides, the manual uses hyperlinks internally and also externally.

TIP The icons of the services, like this one Sky Navigator, will bring you to the corresponding webpage.

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.

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

1.6 Acknowledgements

The author of this manual is by no means the author of the archive and the website, which have been designed, constructed and are maintained by CEFCA's software engineers **Tamara Civera** and **Javier Hernández**, to which I am highly grateful for having done such a great work.

Of course, I am also very grateful to the rest (current and past) of the UPAD Team: **David Cristóbal (former head of the UPAD), Juan Castillo, Luis Cuesta, Alessandro Ederoclite (former UPAD member), Antonio Hernán Caballero, Ángel López, Alberto Moreno, David Muniesa, Héctor Vázquez Ramió**.

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 here.

Chapter 2

Science Data Access Web Portal

2.1 General information

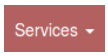
2.1.1 Access Page

Figure 2.1 is a the front 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.

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:

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



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


Link to the front page.


Link to this manual.


Link to CEFCA Catalogues' Web 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 log in to a new session or log out from the current one.

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.

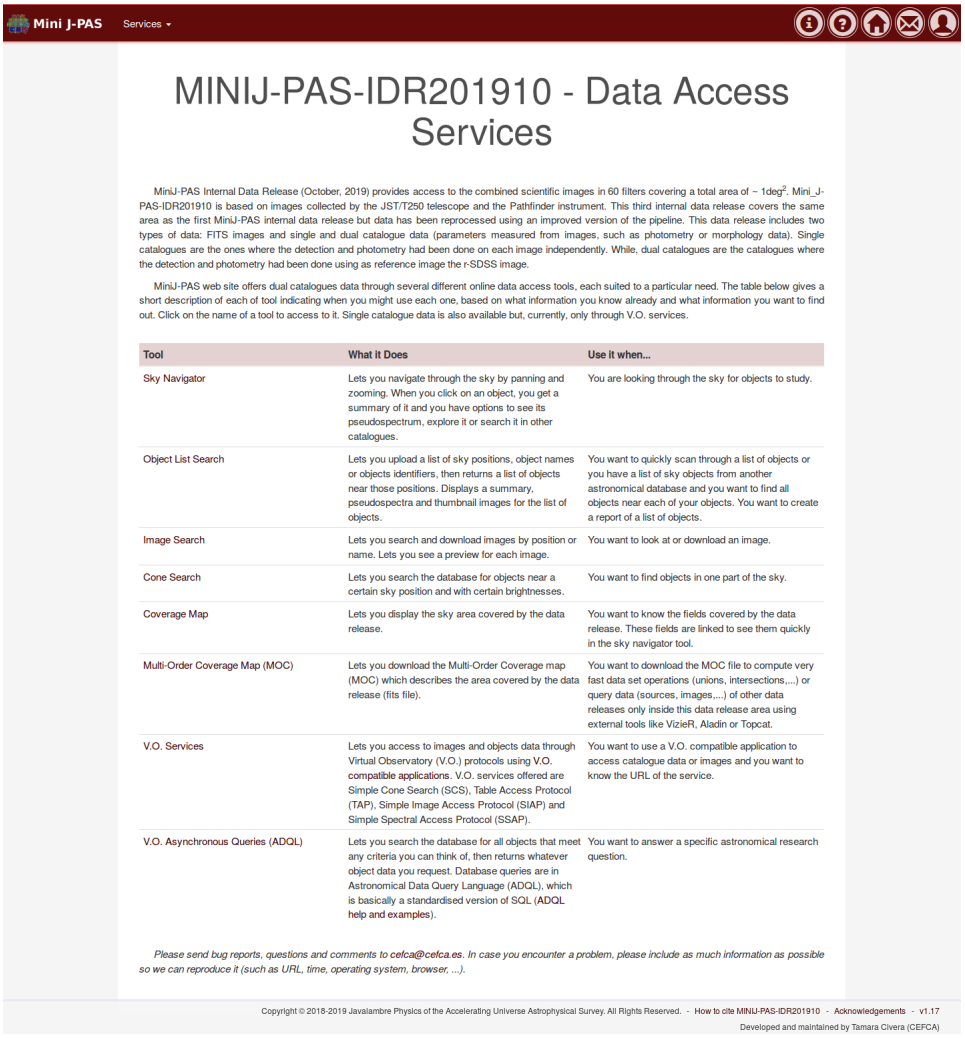


Figure 2.1: mini J-PAS Archive front page.

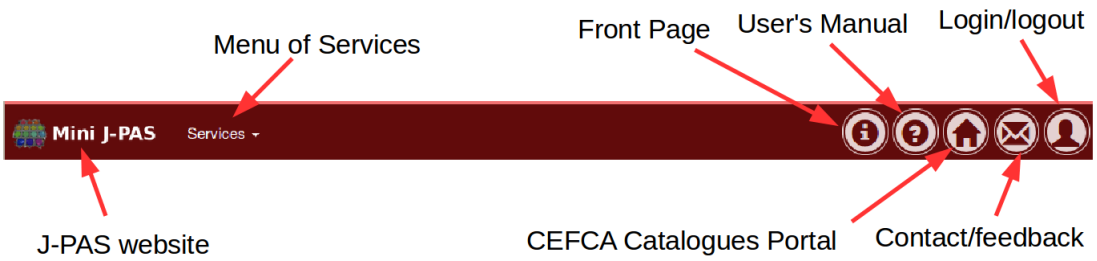


Figure 2.2: Main navigation bar.

- A link to the text to be used to cite when using data from the CEFCA Catalogues' Web Po
- 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 2.3: Menu of available services.

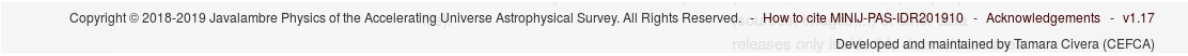


Figure 2.4: Common footer of the webpages.

2.2 Services

2.2.1 Sky Navigator

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

You should use this service if:

- you want to know the basic information about particular objects like:
  - visual morphology,
  - Spectral Energy Distribution (SED),
  - basic data from the database,
  - the list of tiles from which the photometry has been derived,
- you want to check the surrounding of a given object.

Figure 2.5 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] http://aladin.u-strasbg.fr/AladinLite/

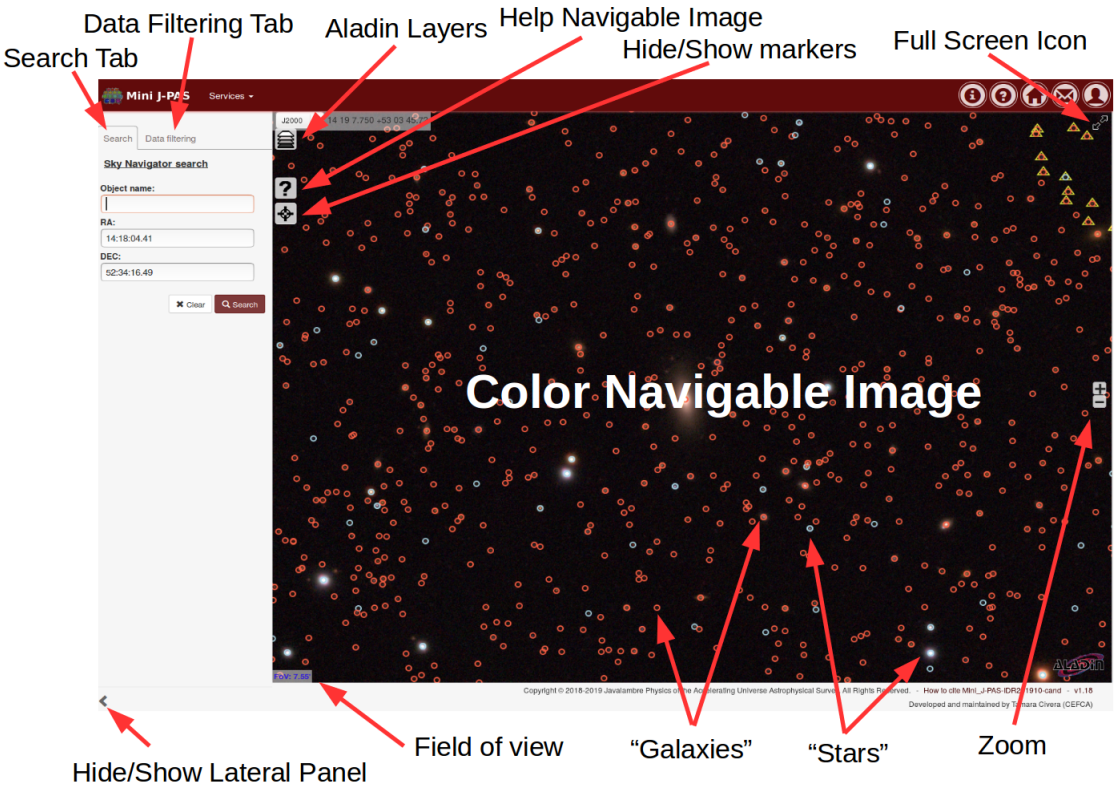


Figure 2.5: Sky navigator description.

image made from J-PLUS images and you will see blue and red circular markers indicating "stars" (unresolved objects) and "galaxies" (resolved objects), respectively.[2] For field of views larger than $\sim 15'$ the markers are not shown.

The main characteristics of this tool are:

- You can navigate in the image scrolling the image (keep pressed the left-button of the mouse and moved around) and zooming in and out (mouse wheel or pressing icons "+"/"-" in the right side).
- The size of the current field of view is shown in the lower left corner.
- You can make the image full screen 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 markers.
  - to create a PNG image of the current view.

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

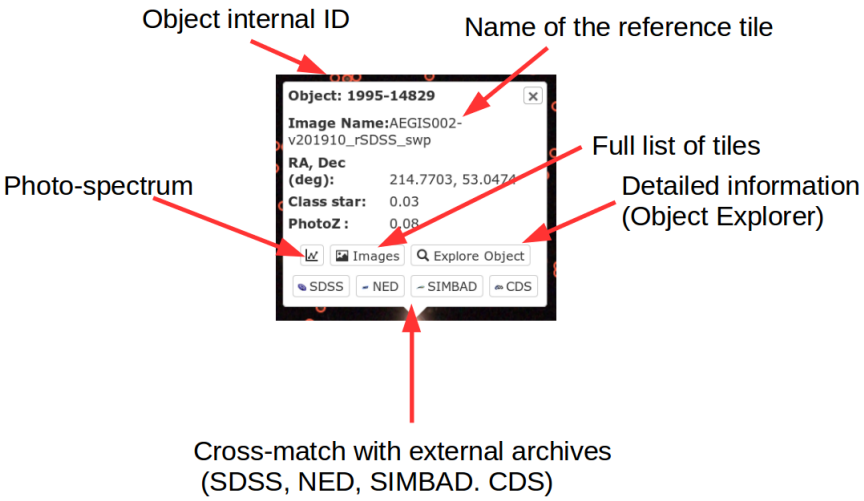


Figure 2.6: Description of the pop-up window that appears when clicking on the marker of an object.

- You can click on any marker and a pop-up window (Figure 2.6) with this additional information about the object will appear:

  Object Internal ID

  Equatorial coordinates

  Name of the original tile

  This button will show the SED of the object (Figure 2.7).

  Images Press to show the list of tiles in which the object has been found (see Service 2.2.4).

  Explore Object Press to open the Object Explorer with detailed information (see Service 2.2.2).

  In addition, an ellipse will be drawn 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 and checking or unchecking the corresponding checkboxes of overlay layers.

Lateral Panel In the lateral panel of the different services 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

[3]This will be resolved by Sesame.

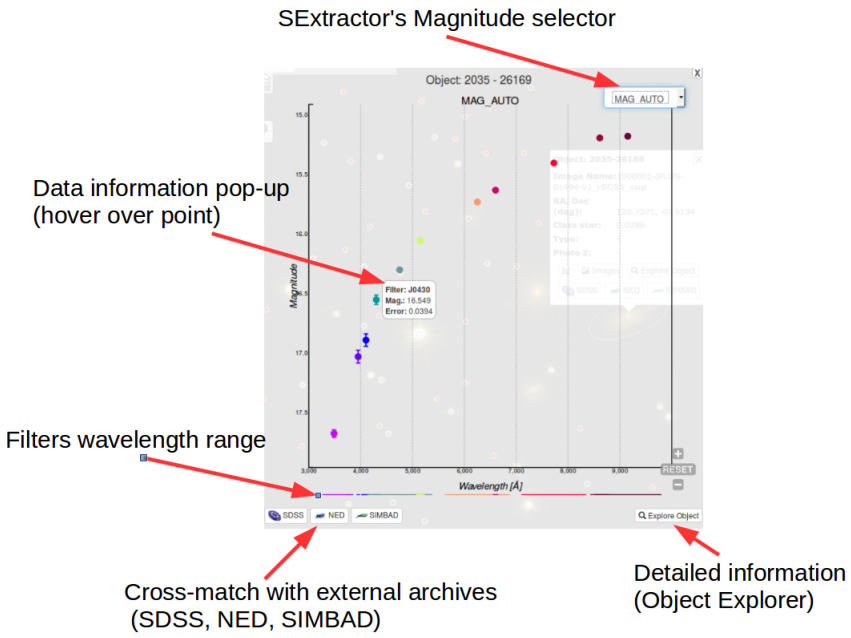


Figure 2.7: Description of the pop-up window showing the photo-spectrum.

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 2.8) 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".
- 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.

2.2.2 Object Explorer

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

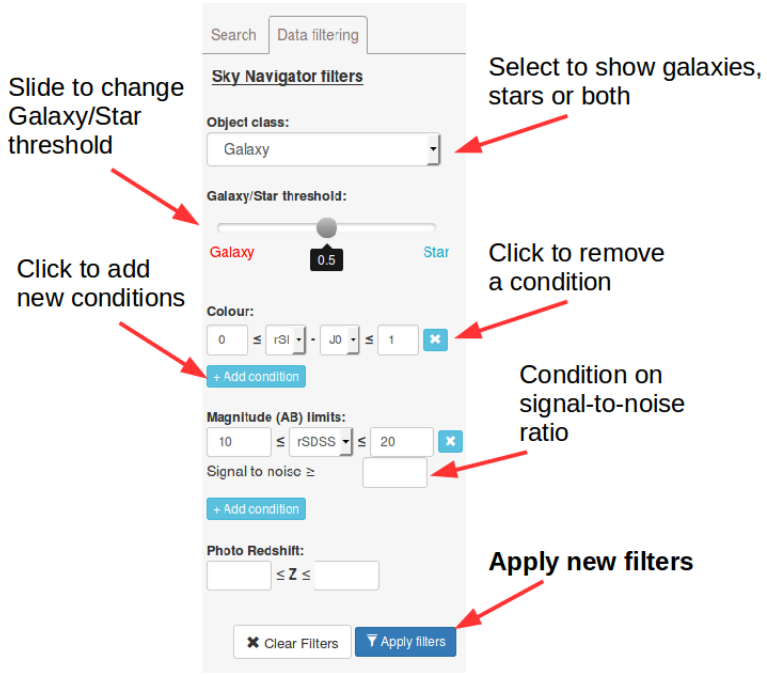


Figure 2.8: Description of the Data filtering tab.

Figure 2.9 shows a screenshot with information about some non self-explanatory options. The blue lines split the full area in five blocks identified with capital letters to help in the description.

Here you have a more detailed description of the page:

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

Coordinates Equatorial coordinates in sexagesimal and decimal format.

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

Photo-redshift information To be added.

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

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:

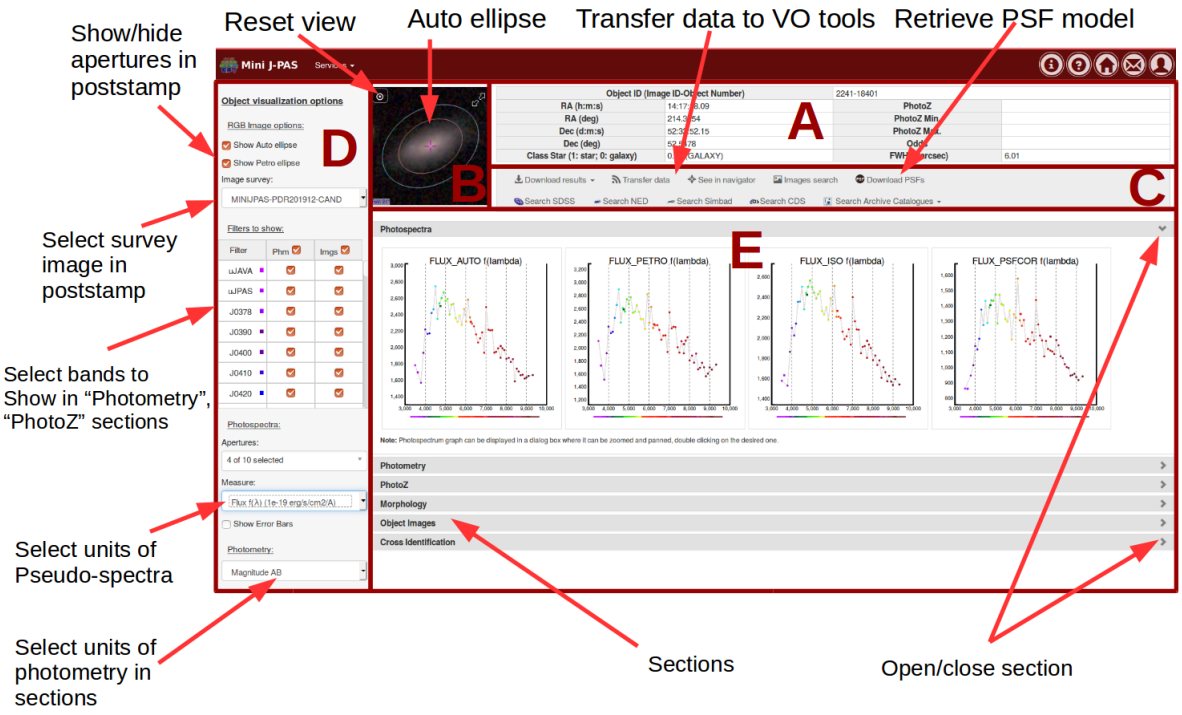


Figure 2.9: Description of Object Explorer.

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.

VOT 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 transfers information to VO compliance tools like TOPCAT or Aladin.[4] The information that is sent consists on the tabular data of the 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 tiles where the object was found in the Image Search service. TIP If any of the original tiles has been flagged as having a problem this is shown adding a warning signal in the button Images search.

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

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' Web 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 use 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 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.

Measures Here you can select the units used in the "Photo spectra" section and the "Photometry" section. The possibilities are:

- AB Magnitudes
- $f(\lambda)$, in units of $10^{-19}\,\mathrm{erg\,s\,cm^{-2}\,\AA^{-1}}$.
- $f(\nu)$, in units of $10^{-30}\,\mathrm{erg\,s\,cm^{-2}\,Hz^{-1}}$.

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

Photo-spectra Show the 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 of the photo-spectra using the menus in the bottom of the lateral panel. TIP You can select the apertures shown in this section using the menu "Apertures" of the section "Photospectra" of the lateral panel.

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").

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

PhotoZ Show information related to the photometric redshift (these parameters are analogue to the ones used in ALHAMBRA catalogues).

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. WARNING Be aware that due to the high number of cutouts they are not shown automatically. You can show them clicking on the Load png cutouts or the Apply.

Cross-identification This section performs a cross-match using the coordinates of the object with a series of all sky surveys available through the Virtual Observatory (VO). Again, with the Download results button you can retrieved the information of the cross-match in different formats. WARNING You need to click on the available external archives to launch the cross identification against the catalogues in that archive.

2.2.3 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 2.10 shows the main window of this service. For the purpose of the following description the window has been divided in three blocks labelled with blue capital letters.

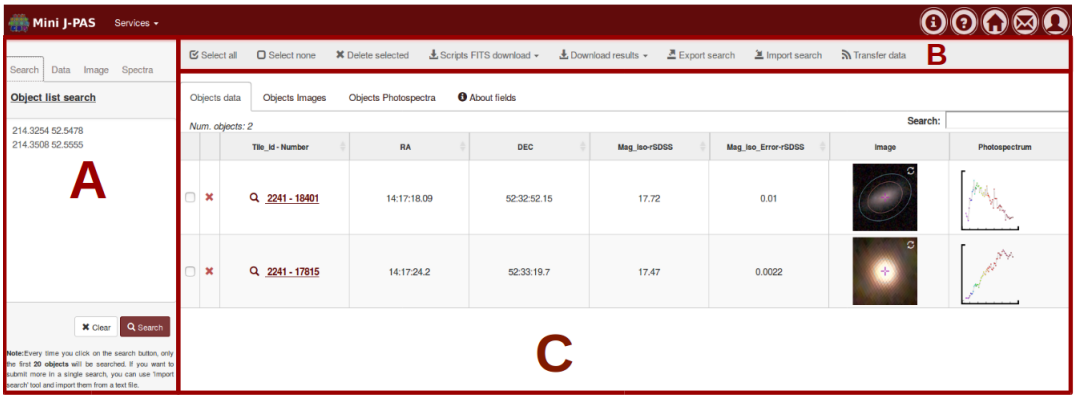


Figure 2.10: Screenshot of the Object Search List service. The division with the red lines and the labels with red letters are used in the text to help in the description.

Let's start with the description block by block:

Block A This block contains 4 tabs with different purposes:

[6] These parameters are related to the semi-axis of the isophote but they are not. See `SExtractor`'s Manual for a detailed description

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.:

  ```
  14:17:18.09 52:32:52.15
  214.3254 52.5478
  ```

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

  ```
  UGC4176
  ```

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

  ```
  2241 18401
  2241 - 18401
  ```

- 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 it described page 21.

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

Data This tab (leftmost image in Figure 2.11) 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 2.11) 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.

[7] No more than 20 objects. For longer lists of objects, you can use the Import search feature describe in page 21.

[8] If not search radius is provided a default 3” radius is used.

[9] Names are resolved by Sesame

Set default image view Reset all the changes made and returns to the default image configuration.

Copy images to data table If you arrive to this tab from a service different from the Object List, you can use this button to add the objects to your Object List.

Spectra This tab (rightmost image in Figure 2.11) 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 applied 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 images in which the objects have been found or just the cutouts, in FITS format in both 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 ~ 300 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 a open and listening VO tool.

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

Objects data This tab (Figure 2.12) 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 2.13) 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 2.14) 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.

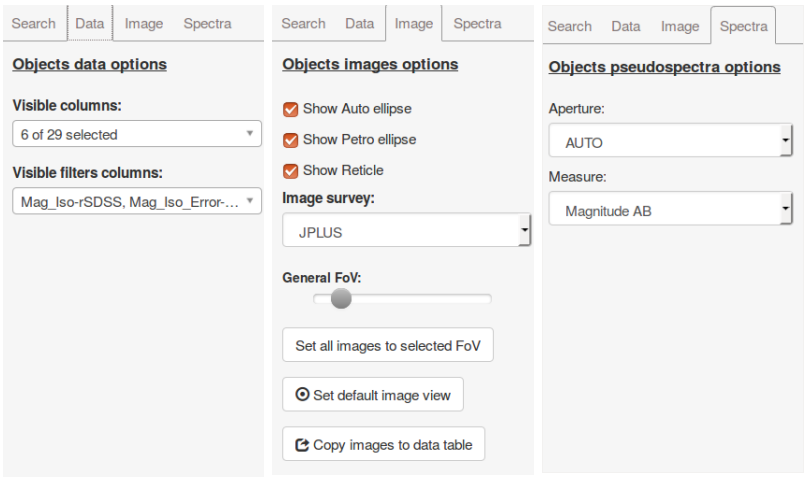


Figure 2.11: Screenshot of the additional tabs in the Block A of the Object List main screen. From left to right: Data tab, Image tab, Spectra tab.

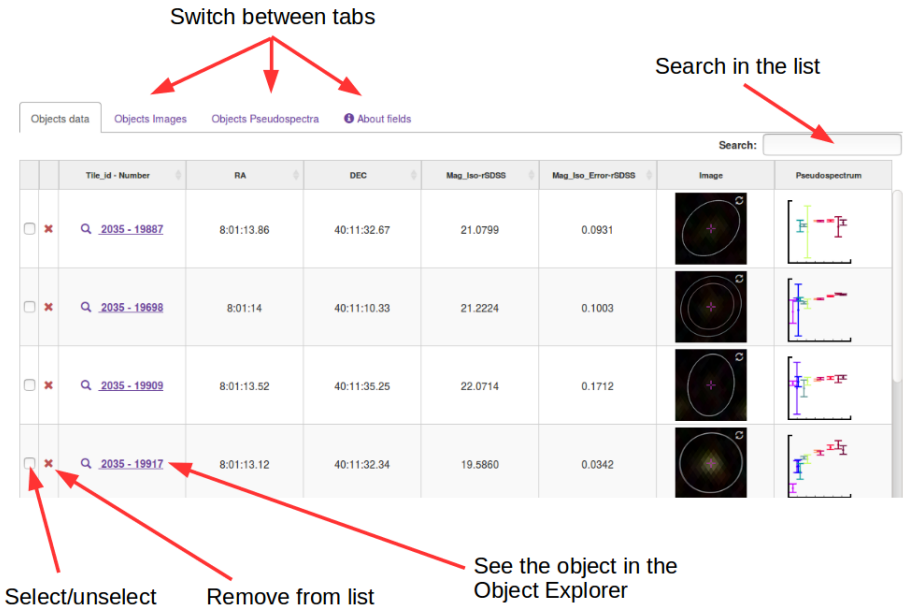


Figure 2.12: Screenshot of the Objects data tab.

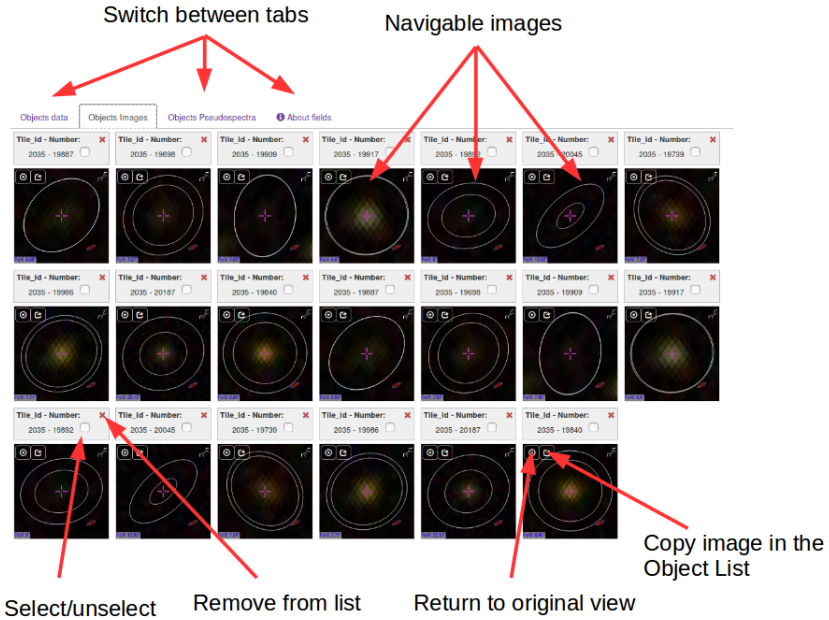


Figure 2.13: Screenshot of the Objects Images tab.

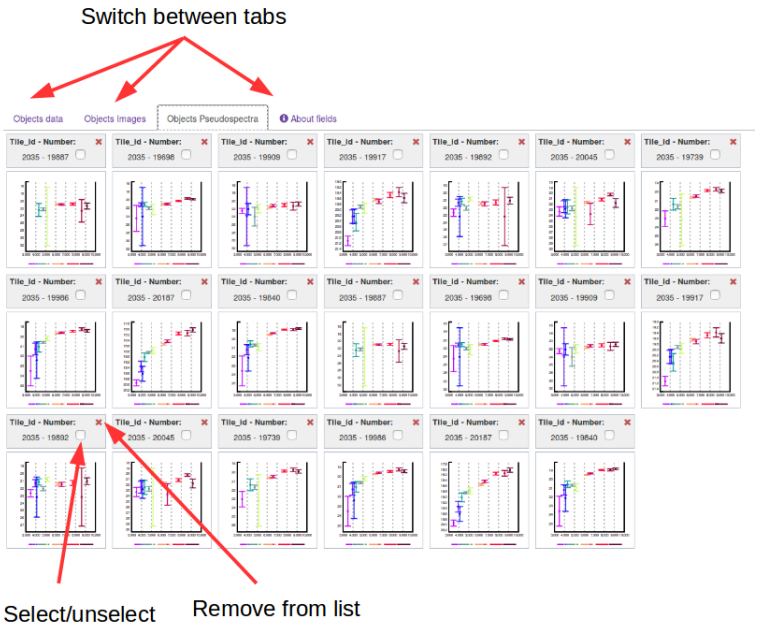


Figure 2.14: Screenshot of the Objects Pseudospectra tab.

2.2.4 Image Search

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

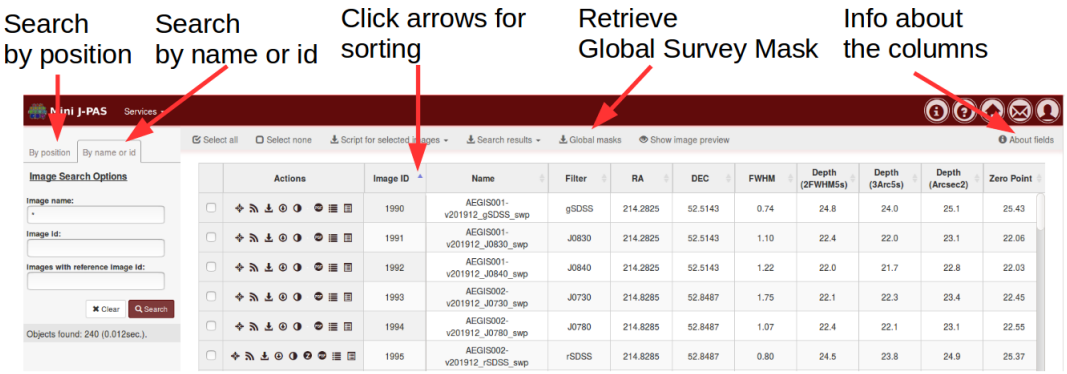


Figure 2.15: Screenshot of the Image Search main window with some useful indications.

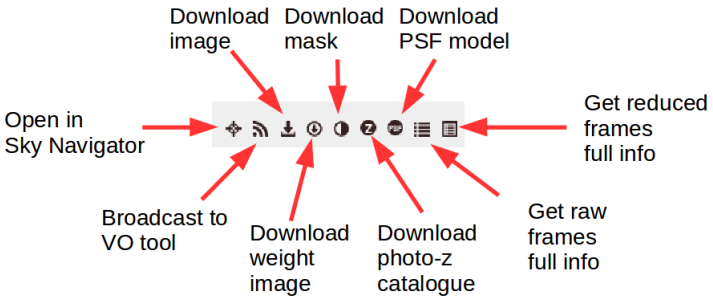


Figure 2.16: Detail of the Actions available.

Figure 2.15 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 tiles that falls 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 tiles are shown in all the filters but this can be changed using the menu Filter: .

By name or id This tab allows to search for tiles using internal database identifications like the actual name of the image, its internal id or by the internal id of the reference tile (i.e. the id of the tile 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 tiles in the J0395 filter.

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.

Download 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.

Download 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 tiles 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 tile.

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

- Open the Sky Navigator centered in the tile.
- Broadcast the image to any VO tool listening.
- Download the 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 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 reduced images available in the database (if available).

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

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 showed the kind of error affecting the image and clicking on a pop-up window will provide more information about the problem.

2.2.5 Cone Search

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

Figure 2.17 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.

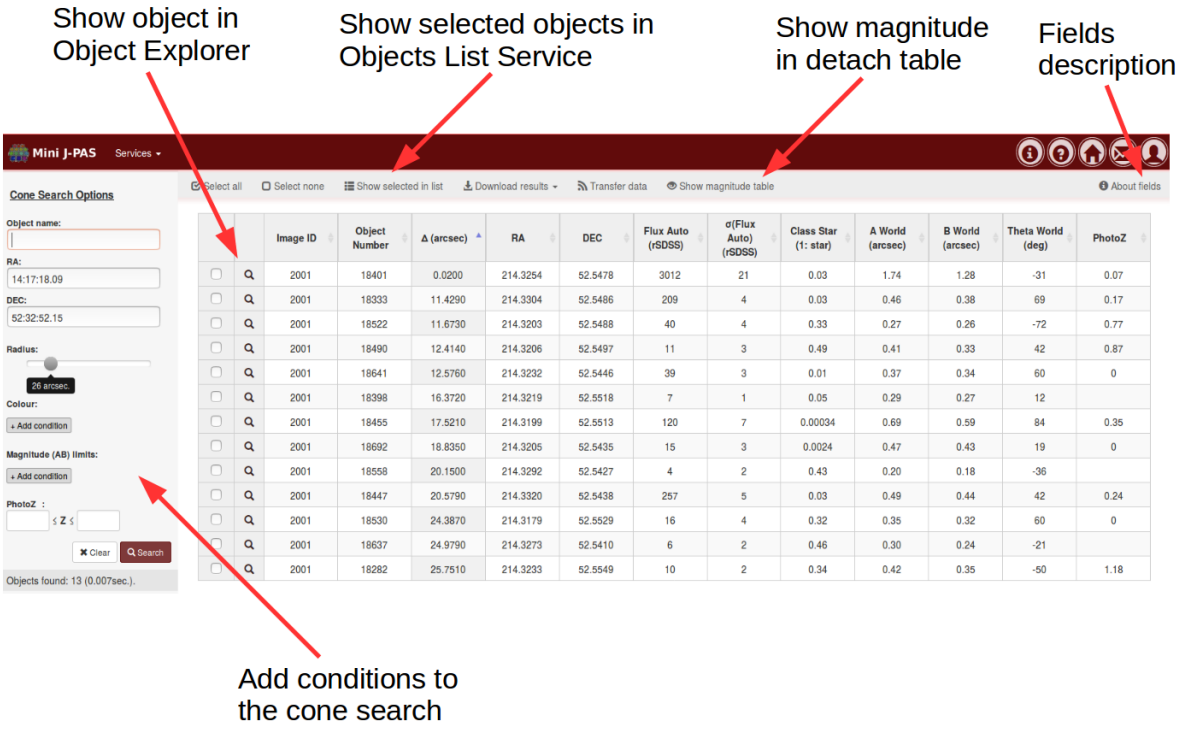


Figure 2.17: Screenshot of the main window of the Cone Search service with some useful indications.

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 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 Transfer data.

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.

2.2.6 Coverage Map

The Coverage Map service helps you to visualise the sky distribution of the pointings of the survey. Figure 2.18 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 tiles 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. With the box below you can focus on a given sky position either using coordinates or an object name[12].

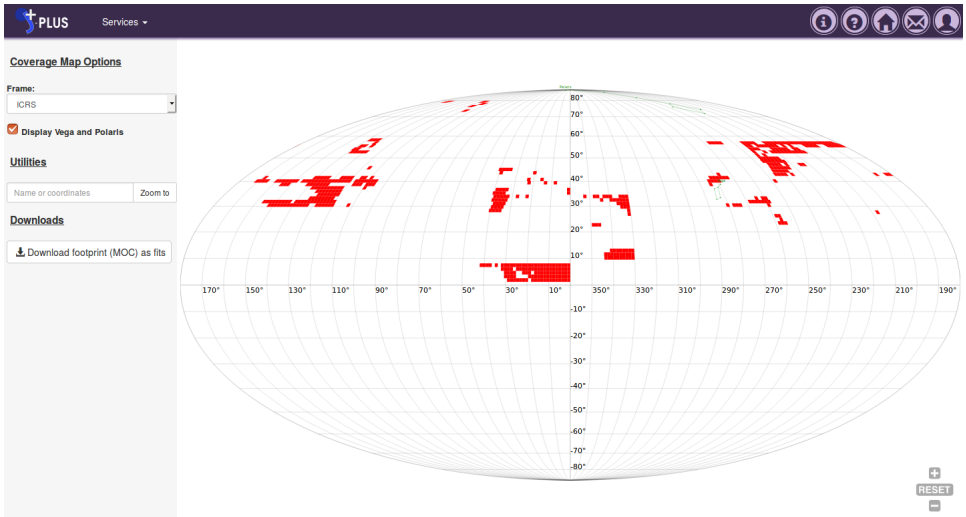


Figure 2.18: Screenshot of the main window of the Coverage Map service.

2.2.7 Multi-Order Coverage Map (MOC)

Multi-Order Coverage maps (MOC) 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.

2.2.8 V.O. Asynchronous Queries (ADQL Queries)

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.

[12]Resolved by Sesame.

The access is done using Astronomical Data Query Language (ADQL) which is in most of the aspects like MySQL, 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 Examples. In addition, we have included a quick tutorial on ADQL in the Appendix A of this manual.

Figure 2.19 shows a screenshot of the main window of this service.

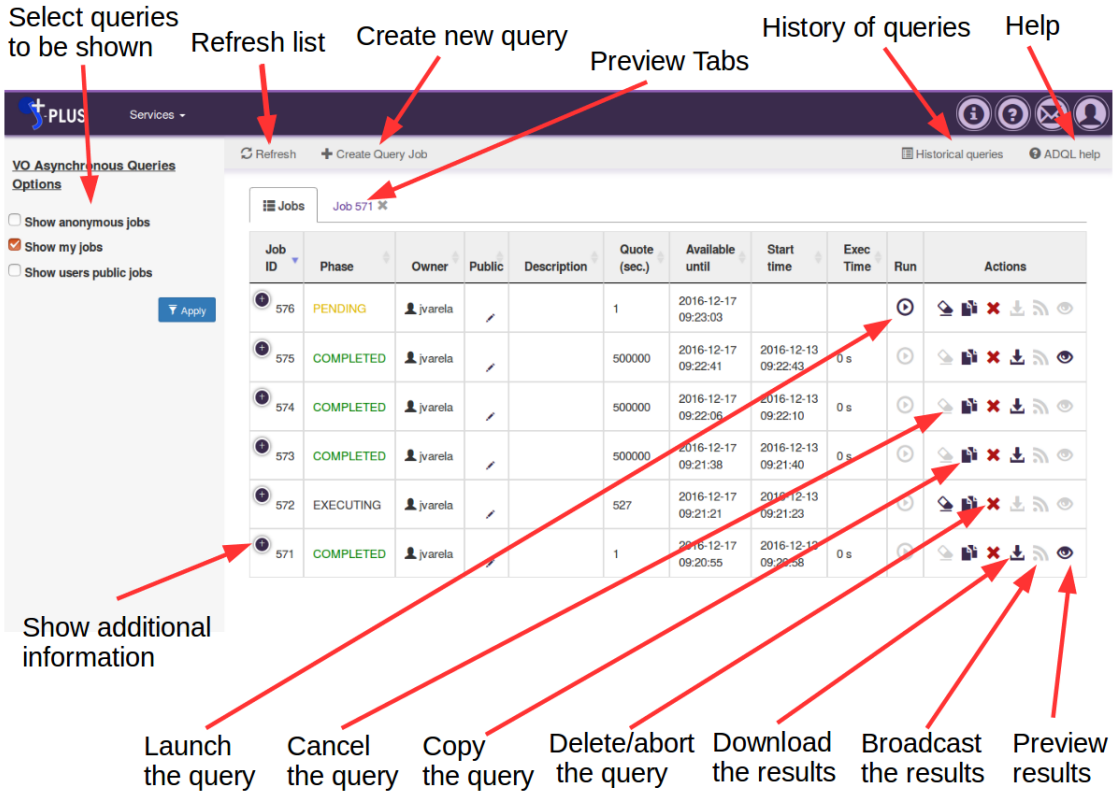


Figure 2.19: Screenshot of the main window of the VO Asynchronous Queries (ADQL) service with some useful indications.

Let's see the steps to launch a query[13]:

1. Click on the button + Create Query Job. This will open a new window (see Figure 2.20).

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.

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

3. Select the output format (**WARNING** this cannot be changed afterwards). You can select between FITS, VOTABLE, Comma Separated Values (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.

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 queue, press the in the "Run" column to send the job to the queue. At this point, the status in the "Phase" column will change from "PENDING" to "EXECUTING".

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.
    - to have a preview of the results. This will open a tab (see "Preview Tabs" in Figure 2.19) and the results will be shown in tabular form. **WARNING** This option only works when the selected output is CSV, TSV or VOTABLE, 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.

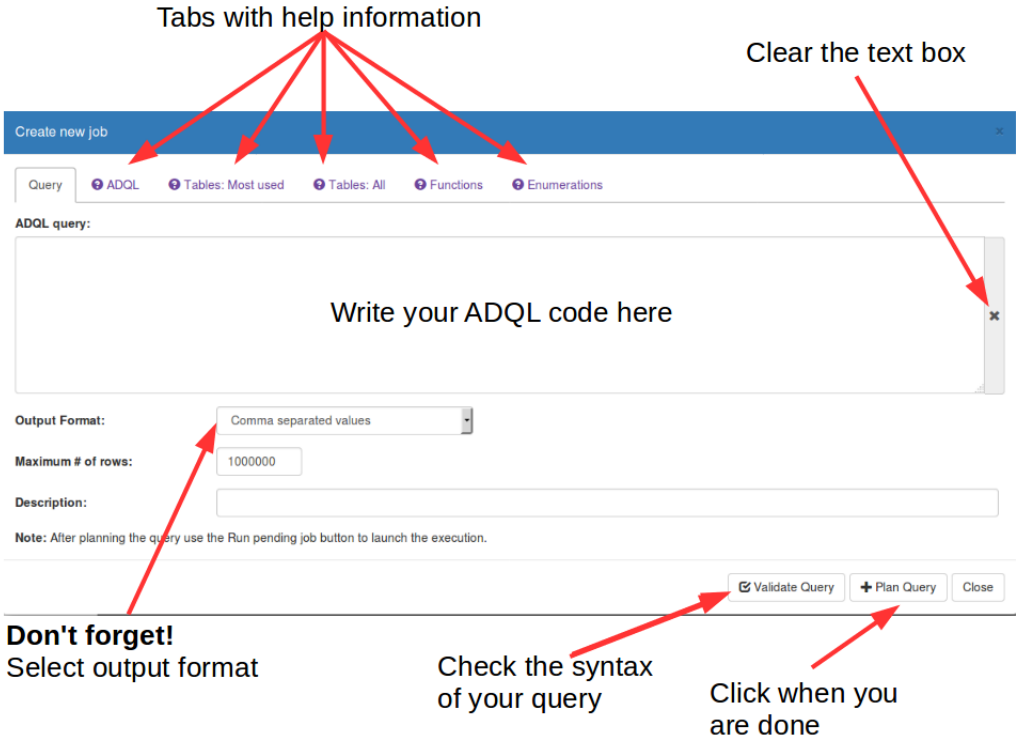


Figure 2.20: Screenshot of the main window used to create a new query.

2.2.9 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 V.O. services using the option V.O. Services in the Services menu.

Appendix A

Quick tutorial on ADQL Queries

A.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.

A.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/MySQL commands.

A.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]

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

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

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

As having said above, it is possible to retrieve expressions or functions which can involved 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
  minijpas.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
  minijpas.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
   minijpas.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.

A.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=2035 and  CLASS_STAR<0.1.
SELECT
   ALPHA_J2000,DELTA_J2000,MAG_AUTO
FROM
   minijpas.CalibratedMagABDualObj
WHERE
   TILE_ID=2035 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 Although this will change in the near future, right now the order of the bands in any array is determined by the order in the `minijpas.Filter` table and it is:

```
rSDSS, gSDSS, iSDSS, zSDSS, uJAVA, J0378, J0395, J0410, J0430,
J0515, J0660, J0861
```

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`. Ex.:

```
# Retrieve the coordinates and the (g-r) color using MAG_AUTO for
# objects in tile_id=2035 and  CLASS_STAR<0.1.
SELECT
   ALPHA_J2000,DELTA_J2000,
   MAG_AUTO[2]-MAG_AUTO[1] as g_r
FROM
   minijpas.CalibratedMagABDualObj
WHERE
   TILE_ID=2035 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 an enumeration called `minijpas`[2] which relates the name of the filter with the position in the array. The syntax is just `minijpas::filter` and it is used in substitution of the index position. Therefore, the previous example can be written like this, using the enumeration:

[2] `jplus` in the case of J-PLUS data

```
# Retrieve the coordinates and the (g-r) color using MAG_AUTO for
# objects in tile_id=2035 and  CLASS_STAR<0.1.
SELECT
  ALPHA_J2000,DELTA_J2000,
  MAG_AUTO[minijpas::gSDSS]-MAG_AUTO[minijpas::rSDSS] as g_r
FROM
  minijpas.CalibratedMagABDualObj
WHERE
  TILE_ID=2035 AND CLASS_STAR<0.1
```

A.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
   minijpas.TileImage
WHERE
   FWHMG<1
```

A.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. [3] Ex.:

=,>,<,<=,>=,!=,<> 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.:

[3] 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.

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

IS statements:

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

NOT statements:

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

LIKE statements can be used to match strings against patterns[4]:

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

Several conditions can be joined using[5] **AND**,**OR** or **XOR**.
These are several examples of uses of WHERE conditions:

```
# Simple WHERE
SELECT *
FROM minijpas.TileImage
WHERE
  tile_id=2509

# using "AND"
SELECT *
FROM minijpas.TileImage
WHERE
  ref_tile_id=2509 AND calib_procedure=3

# Using "OR"
SELECT *
FROM minijpas.TileImage
WHERE
  ref_tile_id=2509 AND
  (calib_procedure=3 OR calib_procedure=4)

# Using "IN"
SELECT *
FROM minijpas.TileImage
WHERE
  ref_tile_id=2509 AND calib_procedure IN (3,4)

# Using "NOT"
SELECT *
FROM minijpas.TileImage
```

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

```
WHERE
  NOT (ref_tile_id=2509 AND (calib_procedure IN (3,4)))

SELECT *
FROM minijpas.TileImage
WHERE
  (NOT ref_tile_id=2509) AND (calib_procedure IN (3,4)))

# Using BETWEEN
SELECT *
FROM minijpas.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
   minijpas.TileImage
WHERE
   name LIKE "%rSDSS%"
```

A.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 \magauto\ ascending.
SELECT
  ALPHA_J2000,DELTA_J2000,MAG_AUTO
FROM
  minijpas.CalibratedMagABSingleObj
WHERE
  TILE_ID=2035 AND CLASS_STAR>0.9
ORDER BY
  ALPHA_J2000 ASC, DELTA_J2000 DESC, MAG_AUTO ASC
```

A.3 JOIN ... ON|USING

Databases are commonly made of several tables which are related between them. For example, in the mini-JPAS 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 used aliases using AS, although this can 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 mini-JPAS 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
   minijpas.CalibratedMagABSingleObj t1
JOIN
   minijpas.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
   minijpas.CalibratedMagABSingleObj t1
JOIN
   minijpas.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 used RIGHT JOIN.

A.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 average[6].

For example:

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

[6] See this page for a full list of functions in MySQL. This is a reference list and it is not guaranteed that all these functions work as well in ADQL.

```
# 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
   minijpas.CalibratedFlambdaSingleObj t1
JOIN
   minijpas.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
   minijpas.CalibratedMagABSingleObj t1
JOIN
   minijpas.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
  minijpas.CalibratedFlambdaSingleObj t1
JOIN
  minijpas.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
```

A.5 Useful functions

A.5.1 ADQL Astronomical Functions[7]

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 ('FK4','FK5','ICRS','GALACTIC') and coordinates in regions are in degrees. Let's see these functions

POINT('coordinate system',ra,dec) [8] 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)
# Expressing the galactic center in galatic 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.)
```

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)
```

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

[8] 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.

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.[9] 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) This function returns the distance **in degrees** between the two points. The specification of the two points must be done through the function POINT. 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
   minijpas.CalibratedMagABDualObj


# 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
   minijpas.CalibratedMagABDualObj t1,
   minijpas.CalibratedMagABDualObj t2
WHERE
   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.
GROUP BY
   t1.number,t1.ALPHA_J2000,t1.DELTA_J2000
ORDER BY
   n_neighbours DESC
```

[9] **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 nor great circles.

TIP For practical purposes, it has been defined a non-standard ADQL function called **ARC_DISTANCE(ra1,dec1,ra2,dec2)** which takes as arguments directly the coordinates of the points without the need of using the POINT function explicitly.

CONTAINS(region1,region2) This functions 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
   minijpas.CalibratedMagABDualObj
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
   minijpas.CalibratedMagABDualObj t1,
   minijpas.CalibratedMagABDualObj 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
   minijpas.CalibratedMagABSingleObj as tcat
JOIN
   minijpas.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
```

A.5.2 Internal functions

Several functions have been defined internally in the database to help in some common computations, in particular conversion between different units to express the fluxes of the objects.

Here is the list of these functions:

ARC_DISTANCE(ra1,dec1,ra2,dec2) This function computes the angular distance between the points defined by the coordinates (ra1,dec1) and (ra2,dec2). This function is equivalent to DISTANCE but avoiding the need of using explicitly the POINT function.

Ex.:

```
# 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,
   ARC_DISTANCE(120.3,40.2,ALPHA_J2000,DELTA_J2000)
       AS distance
FROM
   minijpas.CalibratedMagABDualObj
WHERE
   ARC_DISTANCE(120.3,40.2,ALPHA_J2000,DELTA_J2000) < 1/60.
ORDER BY
   distance ASC
```

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.

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.

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

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

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

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

A.6 List of examples

Appendix B

Accessing the archive through external tools. V.O. 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 or SIAP, and VO-compliance tools like TOPCAT or Aladin.

B.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 to all the archives public through the VO Table Access Protocol (TAP).

In this section you will learn how to access the databases of the CEFCA Catalogues' Web Portal through TOPCAT:

1. Launch TOPCAT (Figure B.1, top).
2. Open the upper menu "V.O." and select "Table Access Protocol (TAP) Query" (Figure B.1, bottom).
3. In the "Table Access Protocol (TAP) Query" window (Figure B.2, left), introduce the URL of the mini-JPAS TAP Service[1] in the lower box ("Selected TAP Service") and press the button "Use Service".
4. If the connection is successful, you will be asked for your username and password (those of your personal account of the CEFCA Catalogues' Web Portal).
5. You will be brought to the tab "Use Service" (Figure B.2, right) and in the lower "ADQL Text" box you can introduce your query and launch it with the "Run Query" button.

TIP If you are using a terminal and you want load a file to an already running instance of TOPCAT you can use the command line argument `-running`. Eg.:

[1] `https://archive.cefca.es/catalogues/vo/tap/minijpas-pdr201912` for the PDR of mini-JPAS

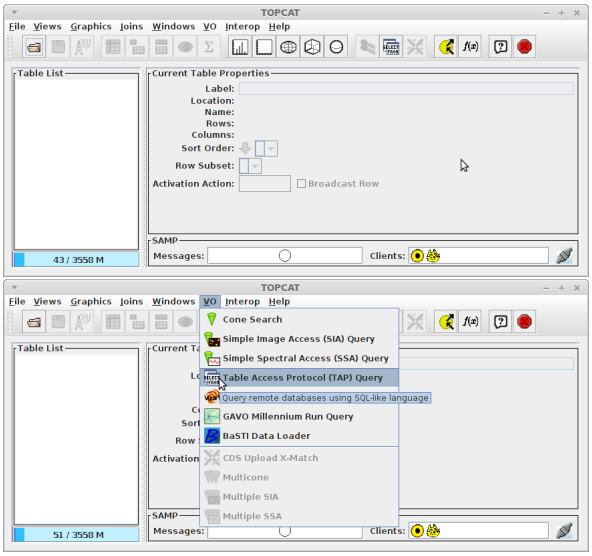


Figure B.1: TOPCAT main screen (top), and with the TAP selection (bottom).

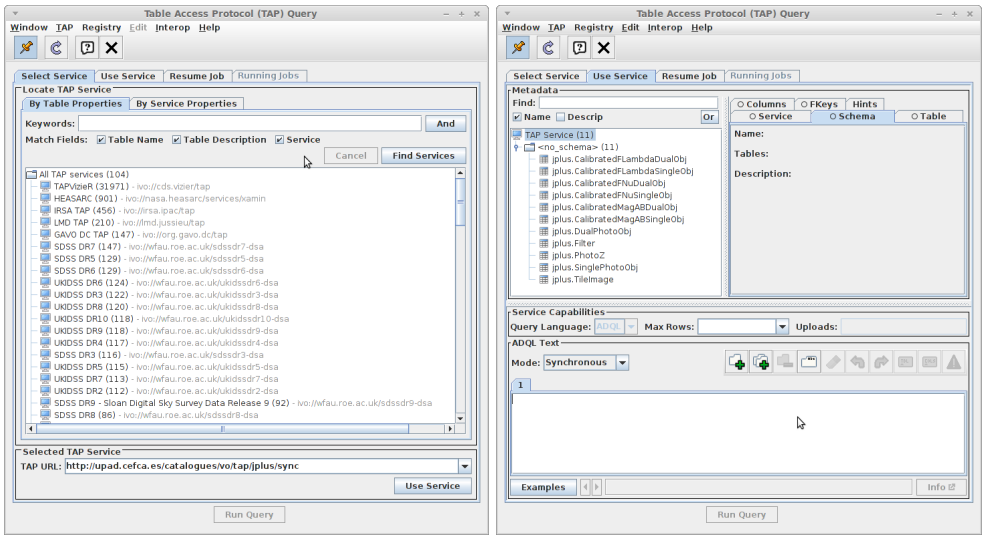


Figure B.2: TOPCAT TAP Query window for the “Select Service” tab (left) and for the “Use Service” tab (right) .

```
topcat -running myfits.fits
```

B.2 STILTS

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

The basic way to access the tables of any of the data releases stored in the CEFCA Catalogues’ Web Portal through STILTS is using the following script written by D. Cristóbal-Hornillos:

```
#!/bin/bash
```

```
version=minijpas-pdr201912
url=https://archive.cefca.es/catalogues/vo/tap/$version
user=$1
shift
query=$@
unset pass
function getpass {
   if [ -z "${pass+x}" ];
   then
       read -s -p Password: pass
   fi
}
getpass
stilts -Dstar.basicauth.user=${user} \     % $
       -Dstar.basicauth.password=${pass} \ % $
       tapquery\
       tapurl=${url}\
       adql="${query}" \
       ofmt=csv
```

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

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

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

```
./do_query_stilts your_cefca_archive_username 'adql_query'
```

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

B.3 curl

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

This an example of a script (written by D.Cristóbal-Hornillos and slightly modified by the author) which uses `curl` to connect to the archive:[2]

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

version=minijpas-pdr201912
url="https://archive.cefca.es/catalogues/vo/tap/${version}/sync"

user=$1
shift
```

[2]The `--insecure` option avoids an error with the certificate used at CEFCA website.

```
query=$@
curl -u ${user} --request POST \
  --location \
  --data REQUEST=doQuery \
  --data PHASE=RUN \
  --data FORMAT=votable \
  --data LANG=ADQL \
  --data "QUERY=$query" \
  --insecure \
  $url
```

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

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

Then, the script can be lauched with the syntax:

```
./do_query_curl.sh cefca_archive_username 'adql_query'
```

The output of this script will be always a VOTABLE.

B.4 Python

B.4.1 pyvo

Following is an example of a script that accesses the data using the pyvo module.

```
from pyvo.dal import TAPService

from pyvo.auth import authsession, securitymethods

import requests

user = 'xxx'
pwd = 'xxxx'

archive_url = 'https://archive.cefca.es/catalogues'

version = 'minijpas-pdr201912'

login_url = '{0}/login'.format(archive_url)

url_tap_service = {0}/vo/tap/{1}'.format(archive_url, version)

args = {'login': user, 'password': pwd, 'submit' : 'Sign+In'}
header = {"Content-type": "application/x-www-form-urlencoded",
          "Accept": "text/plain"}
```

```
pyvo.dal.tap.s = requests.Session()
response = pyvo.dal.tap.s.post(login_url, data=args, headers=header)

response.raise_for_status()

auth = authsession.AuthSession()

auth.creadentials.set(securitymethods.ANONYMOUS, session)

service = TAPService(url_tap_service, auth)

# Synchronous request.

resultset = service.run_sync("SELECT TOP 10 * FROM minijpas.TileImage")

# Asynchonous request.

resultset = service.run_async("SELECT TOP 10 * FROM minijpas.TileImage")
```

Appendix C

Description of the data

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

C.1 The databases

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

- The observed properties of all the detections made in the images.
- The characteristics of the images source of the detections.

In the ADQL Help and Examples service you can find the list of tables available in the database. Here you have a brief description of them:[1]

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 tiles. Except the magnitudes and the `FLAGS`, all the parameters are computed in the rSDSS image. The magnitudes columns and the `FLAGS` are arrays containing the values in the twelve filters. See Section A.2.2 for a detailed explanation on how to manage these arrays.

WARNING To avoid gaps between adjacent pointings and to help in the overall calibration of the images, adjacent J-PLUS pointings overlap. This means that for objects in these overlapping areas we have two independent measurements per filter. To avoid duplications in the main catalogue, only the best measurement is kept in this table. However, people interested in using the rejected values can obtain them from the tables **Duplicate...DualObj**, described below.

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

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.

[1] Tables' names can be preceded by a suffix referencing to the corresponding database, eg. `minijpas.MagABDualObj` to refer to the `MagABDualObj` table of the `minijpas` database.

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

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.

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

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

Duplicate...Obj Each of the previous tables have a complementary one with the preffix **Duplicate**, in which are stored the rejected measurement of the duplicated objects in overlapping areas.

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

REF_TILE_ID Remember that every pointing in J-PLUS is made of observations in twelve filters. In the construction of the dual-mode catalogues, the image or tile in the rSDSS filter is used as reference tile. This keyword makes reference to the identification of this rSDSS tile.

ZPT This is the Zero Point (ZP) of the image. This means that to compute the AB magnitude of an object you have to apply the formula:

$$m_{AB} = -2.5 \log_{10}(\text{Number of ADUs}) + ZPT \tag{C.1}$$

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

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

Spectrophotometric Standard Star (1) This procedure uses observations of a spectrophotometric standard star to calibrate the individual images. The zero point of the tile is inherited from the zero point of the individual frame that has been used as reference in the construction of the tile. **WARNING** In the EDR this procedure is used only to calibrate the data from the images obtained with the J0378 filter.

Photometric Standard Star (2) This is equivalent to the previous one but the photometry is not derived from a spectrum but from photometric observations.

SDSS Photometry (3) For those tiles 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. [2] **WARNING** In the EDR this procedure is used only to calibrate the data from the images obtained with the uJAVA and zSDSS filters.

SDSS Spectroscopy (4) For those tiles in which there are objects with spectra from SDSS is possible to derived synthetic photometry in all the filter from J0395 to J0861. From this synthetic photometry it is possible to derive zero points. **WARNING** In the EDR, this is the only procedure used to calibrate the data in all the filters except uJAVA, J0378 and zSDSS.

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. **WARNING** Not used in the EDR.

PanSTARRS (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) any image observed from the OAJ. **WARNING** Not used in the EDR.

TEXPOSED There are three keywords related with 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 individual images. It can be considered as the exposure time that would be needed in the conditions of the reference 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 tiles, 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.

[2] **WARNING** In fact, in order to minimize the uncertainties in the computation of the zero points, color terms are needed to be applied in all the broad bands to convert the photometry in SDSS photometric system to the photometry in the J-PLUS photometric system. These are not applied to the EDR and the IDR_201709, although the effects restrict to the uJAVA filter which is one of the two filters calibrated with the SDSS photometry (the other being the zSDSS but the color term uncertainties are much smaller).

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%.

KS Decay rate of the completeness for extended objects.

TileImageWithFlag This table is an extension of the **TileImage** table with three columns related with flags pointing out to possible issues with each tile. 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.

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.

C.2 The images

The images that are available in the archive are the original images from which the photometry has been derived, and the corresponding weight images. The main characteristics of the images are:

- The images are tiles or tiles which means that they have been constructed from the combination of a series of single exposures.

- Tiles have been constructed using the software SWarp.
- Single exposures have been background subtracted before combination. **WARNING** Be aware that this can affect your science.
- Tiles are artificial construction and their centres and dimensions are defined *a priori*. **WARNING** To ensure that actual images fall within the definition of the tile the sizes of the tiles are 9500×9500 pixels, which is a bit larger than the original frames. This has two consequences:
  - the centre of the tiles can be slightly offset with respect to the actual pointing of the original single frames.
  - the area of the tile with scientific data is smaller than the size of the tile so you will find a "frame" of pixels with zero flux.
- The exposure time of the tiles to be used in flux computations (ie. photometry) is 1 second. So, indeed, tiles 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 single frames 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 with 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 calibration of the tiles can be done in different ways:
  - Inheriting the calibration of the reference image.
  - When possible, comparing the photometry with external catalogues, in particular with SDSS.
- The zero points needed for calibration are available in the Image Search service.[3]. The zero points ZP are defined as:

$$m_{AB} = -2.5 \log_{10}(N_{ADU}) + ZP \tag{C.2}$$

[3] **WARNING** Due to technical reasons the zero points are not included in the header of the images.

where m_{AB} is the AB magnitude corresponding to a flux of N_{ADU}.

Zero points of the tiles can be computed in different ways and not all the calibration procedure are available for all the tiles. The calibration procedures used so far are:

Spectrophotometric Standard Star (SSS) . This consists on the observation of at least one spectrophotometric standard star at, at least, three airmasses from which the extinction and the photometric zero point of a given night can be derived. This procedure can be applied in those nights with stable transparency conditions.

Photometric SDSS (PhotSDSS) In this case, the instrumental flux of objects in images observed in broad band SDSS filters is compared with the photometry from SDSS. By construction, this calibration procedure can only be applied to images falling in the SDSS footprint and observed in filters uJAVA[4], gSDSDS, rSDSS, iSDSS and zSDSS. On the other hand, when this procedure can be applied, it can be done even in nights with variable transparency conditions in which it is not feasible to calibrate with a standard star.[5]

Spectroscopic SDSS (SpecSDSS) The calibration using spectra from SDSS allows to calibrate images taken in non SDSS filters, except J0378 which is outside the wavelength range of SDSS spectra. The procedure consists on computing the synthetic photometry of stars with SDSS spectra available to obtain the calibrated magnitudes of these stars in all the filters between J0395 and J0861. The zero points are computed from the comparison of the synthetic magnitudes with the instrumental magnitudes. Like the calibration with the photometry, in those cases in which there are spectra available there is no restriction to calibrate an image in variable sky conditions.

PanSTARRS In this case, the instrumental flux of objects in images observed in the broad bands g,r,i,z is compared with the photometry in the same bands from the PanSTARRS project.

The estimation of the uncertainties of the zero points $\sigma(ZP)$ will depend on the calibration procedure. In those cases in which the source is an external catalogue, the uncertainty is just the Root Mean Square (RMS) of the distribution of $m_{external} - m_{instr}$, where $m_{external}$ is the calibrated magnitude obtained from an external catalogue and m_{instr} is the instrumental magnitude, considering all the common objects with the external catalogue.

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

[4] uJAVA filter's passband is slightly different from that of SDSS which has an effect on the uncertainty of the calibration of this filter with this procedure.

[5] Due to the large FoV of T80Cam, the presence of even thin clouds can provoke spatial variations of the ZP which will result in high uncertainties.

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.

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 frames that have been combined.

HIERARCH OAJ PRO SWSCALE* These keywords provide the flux scale factors applied to each of the individual frames 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:

$$\text{noise} = \texttt{SNOIFIT} \cdot \sqrt{A} \cdot (\texttt{ANOIFIT} + \texttt{BNOIFIT} \cdot \sqrt{A}) \qquad \text{(C.3)}$$

Glossary

Astronomical Data Query Language is the language used by the International Virtual Observatory Alliance (IVOA) to represent astronomy queries posted to VO services. 28, 63

coadd See tile. 56

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. 5, 33, 53, 54, 57, 61

`PSFEx` is a PSF image characterisation code developed by Emmanuele Bertin. 59

`SExtractor` is a source extraction code developed by Emmanuele Bertin. 5, 12–15, 17–19, 54, 59, 61

`SWarp` is an image combination code developed by Emmanuele Bertin. 57

(HEALPix) Multi-Order Coverage map files are described here. 63

photo-spectrum is a spectrum in which the fluxes at different wavelengths come from independent photometric data instead of a single observed spectrum. 14, 17, 21

single-mode is the usual way of running `SExtractor`'s in which a single image is used to detect the objects and performed the photometry. See dual-mode for an alternative way of running `SExtractor`. 6, 54

tile (or **coadd**) is an image resulting from the combination of individual exposures. 11, 13, 24, 54, 56, 61

VO acronym of "Virtual Observatory". 47

VOTABLE is the table format defined by the IVOA. 16, 20, 25, 29, 33, 50

Acronyms

ADQL Astronomical Data Query Language. 6, 28, 31, 32, 34, 37, 38, 40, 42

ADU Analog-to-Digital Unit. 57

CDS Centre de Donnes astronomiques de Strasbourg. 17

CSV Comma Separated Values. 20, 25, 29, 33, 49

FITS Flexible Image Transport System. 16, 18, 20, 25, 29, 33

FoV Field of View. 18, 19, 58

FWHM Full Width at Half Maximum. 15, 59

ICRS Internation Celestial Reference System. 27

IVOA International Virtual Observatory Alliance. 61

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

JPEG Joint Photographic Experts Group. 25

J-PLUS Javalambre Photometric Local Universe Survey. 5, 12, 54

JSON JavaScript Object Notation. 20, 21

MOC (HEALPix) Multi-Order Coverage map. 27

NED NASA/IPAD Extragalactic Database. 17

OAJ Observatorio Astrofísico de Javalambre. 55

PanSTARRS Panoramic Survey Telescope and Rapid Response System. 55

PDF Portable Document Format. 16, 20

PNG Portable Network Graphics. 12, 18, 20

PSF Point Spread Function. 57, 59, 61

RMS Root Mean Square. 58, 59

SAMP Simple Application Messaging Protocol. 16

SDSS Sloan Digital Sky Survey. 17, 55, 57, 58

SED Spectral Energy Distribution. 11, 13

SIAP Simple Image Access Protocol. 47

SSS Spectrophotometric Standard Star. 58

STILTS Starlink Tables Infrastructure Library Tool Set. 48

SVG Scalable Vector Graphics. 20

TAP Table Access Protocol. 47

TOPCAT Tool for OPerations on Catalogues And Tables. 16, 47, 48

TSV Tabular Separated Values. 29, 33

VO Virtual Observatory. 16, 18, 21, 25, 26, 29, 61

ZP Zero Point. 54, 58