

VirGO User Guide

Version 1.4.4-0

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1 Introduction

VirGO [6] [9] is the next generation Visual Browser for the ESO Science Archive Facility (SAF) developed in the Virtual Observatory Project Office (VOP), and is a plug-in for the open source (GPL) planetarium software Stellarium [7]. VirGO gives astronomers the possibility to easily discover and select data from millions of observations in a visual and intuitive way. It allows real-time access and graphical display of a large number of observations by showing instrumental footprints and image previews, as well as their selection and filtering for subsequent download from the ESO SAF web interface. It also permits the loading of external FITS files or VOTables, as well as the superposition of Digitized Sky Survey (DSS) images to be used as background. All data interfaces are based on Virtual Observatory (VO) standards which allow access to images and spectra from external data centers, and interaction with the ESO SAF web interface or any other VO applications.

The main ESO archive query form, a web interface, allows the user to search the ESO archive based on Target name or Coordinates, Observing Date or Programme ID, request the type of observations (Imaging, Spectroscopy, Interferometry etc) and the Category (Science or Calibration frames). The query may take anything from a few seconds to several tens of minutes, depending on the volume of the requested data that fulfill the user's requirements. The information is returned in the form of a table, listing the frames, as well as position, Programme ID, Exposure Time, Filter and other quantities and is followed by two tables summarising the total number of frames and exposure times, broken down by the various instruments or Exposure Time/Instrument/Filter.

VirGO proposes an alternative to this traditional querying form, providing a visual impression of the available data, their overlaps and the instruments footprints, while allowing for a real-time filtering of the resulting frames, before firing the query to the ESO archive. This solution implies many challenges in the field of the user interface design such as displaying and navigating through many observations simultaneously without confusing the observer or filtering out and selecting relevant observations in an intuitive way. An important aspect of VirGO is its capacity to access and handle large data collections on client and server sides, as well as to exchange data with other VO tools. These two features are achieved thanks to VO standards: the Simple Image Access/Simple Spectral Access (SIA/SSA) protocols for retrieving images and spectra from a variety of astronomical repositories through a uniform interface and the PLASTIC (Platform for Astronomy Tool InterConnection) protocol for communication with other VO Tools.

2 Installation

- If a previous installation of Stellarium exists, one may need to delete the `~/.stellarium` directory to restore the default configuration.
- On Linux: download the package, uncompress it and run `./VirGO.sh` in a console from the new directory. For example, issue the following commands on a terminal:

```
tar -xzf VirGO-1.4.4-linux32.tar.gz
cd VirGO-1.4.4-linux32
./VirGO.sh
```
- On MacOSX: download the .dmg file, open it and run the VirGO executable.
- On Windows: download the zip file, uncompress it and double click on `stellarium.exe`
- Optional: edit the `VirGO-1.4.4-{platform}/modules/VirGO/DataResources.ini` file to specify custom SIA/SSA services including settings such as the maximum query area.

2.1 Requirements

- A 32 bit linux machine (i86 architectures only) or MacOSX or Windows 32 bits.

- Hardware openGL acceleration. Most of the problems experienced by users are caused by buggy video drivers. In many case installation of recent graphic drivers resolves performance problems.
- Data requests through the data basket require an ESO user portal account.

3 Quick Start

3.1 Browsing Observations

Visual browsing of archive content through VirGO is mostly based on auto-generated positional queries. To trigger a query

1. choose the *Target Selection* tab
2. specify Simbad resolvable name or coordinates and press *Go!*
3. click on the *Download Observations from the SIA/SSA* button at the bottom of the screen (or press CTRL+E)

Upon successful completion of the on-line queries against the SIA/SSA services start exploring the result sets.

3.2 Bulk Retrieval

Registered ESO archive users may request many files at once through the data basket.

1. select several row in the List Browser window
2. right click on the selected rows to access pop up option Add ESO data...(n/m)
3. in the *Data Basket* tab press the *Submit request to ESO* button. This opens the online ESO request submission web form in the default web browser.

Step two is restricted to ESO science frames and two counters in the pop-up menu indicate the total number of selected items vs. the number of items to which this retrieval method is applicable.

4 The VirGO Graphical User Interface

4.1 Main window elements

VirGO is a plug-in for the “general public” software Stellarium and therefore benefits from all the standard features such as stars, planets and landscapes rendering, intuitive real time navigation, various projection modes etc. To this set of standard features, VirGO adds the necessary tools for browsing through the ESO data archive. Figure 1 gives an overview of the general look-and-feel of VirGO:

1. **The main Graphical Window** contains the dynamic view of the observations in the current field of view. Images with footprints and previews [10] as well as superimposed spectra can be visualised simultaneously, all on a multi-resolution Digitized Sky Survey (DSS) background if the user so desires (see further below).
2. **The List Browser** displays one summary line for each frame selected in the Graphical Window. The displayed information includes Observation Date, Exposure Time, Filter and Instrument. The existence of a preview is also indicated by the presence of a tick-box.
3. **The Info Window** contains detailed information about the observation currently selected in the List Browser. It also provides direct link to access the data sets and the preview images, if available.

4. **The View Selector** allows to choose which observations to show/hide by defining a set of constraints such as Observation Type (Images or Spectra), Processing Type (Raw data, Highly Processed data etc.), date or exposure time. The second part of this window is the Tree Browser containing a Telescope/Instrument/Filter tree reflecting which observations are currently loaded in VirGO. It gives a refined control of what to show/hide from the graphical window.
5. **The Target Selection** using either the Simbad name resolver or the exact coordinates.
6. **The Data Basket** lists the selected data to be requested from the ESO archive
7. **The VirGO Menu Bar** gives quick access to functionalities such as the download of observations from the ESO SIA/SSA servers; the activation of the DSS background, grid display etc.
8. Finally, **the Stellarium Menu Bar** provide the basic Stellarium functionalities.

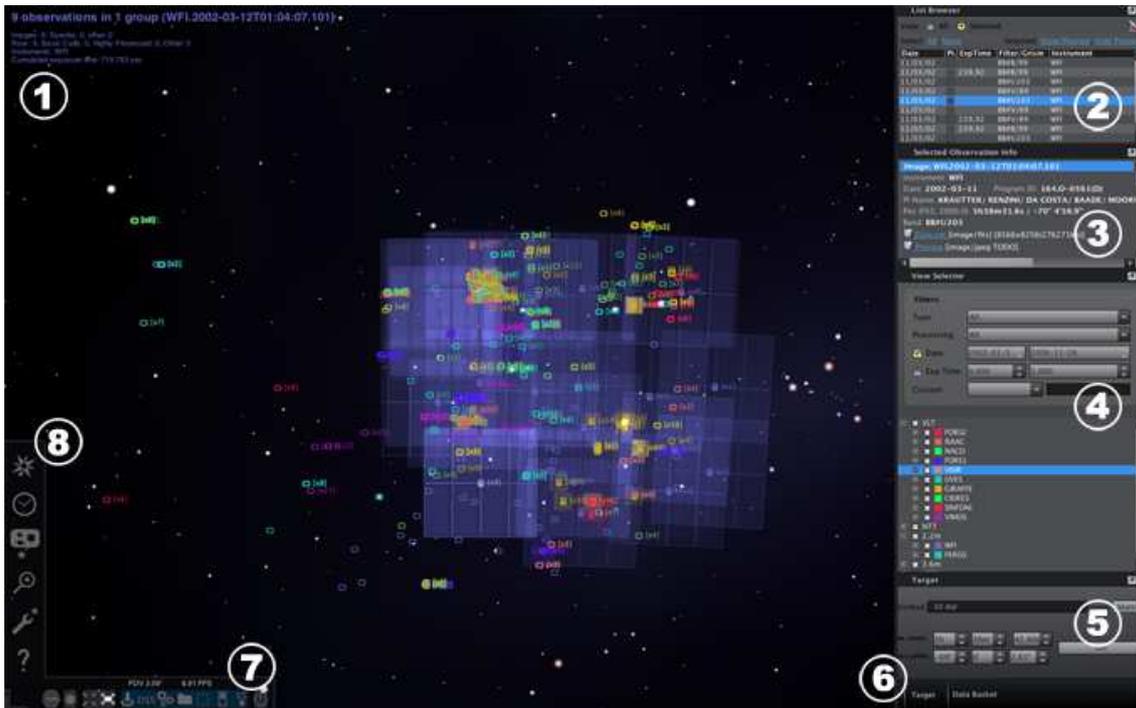


Figure 1. Overview of the VirGO interface

4.2 The main Graphical Window

The main window display a default sky background showing stars and sky images when zooming in. The images are based on a multi-resolution false-color JPEG version of the DSS originally created at STScI by processing and combining the original blue, red and near-IR DSS images (see Figure 2). The special version hosted at ESO was post-processed and indexed for use in VirGO.

To trigger a query, move and zoom to set the view to the desired sky location then click on the *Download observations from SIA/SSA* button from the button bar. The objects located in the displayed query area will then be downloaded. In the current release of VirGO (1.4), observational data are accessed from ESO Science Archive Facility servers using VO SIA/SSA services. The VOTables provided by those services are loaded by VirGO in streaming mode to allow a fluid interaction even when downloading large datasets. Note that for ESO servers, the maximum area of a query region is currently limited to a four square degree field for performance reasons.

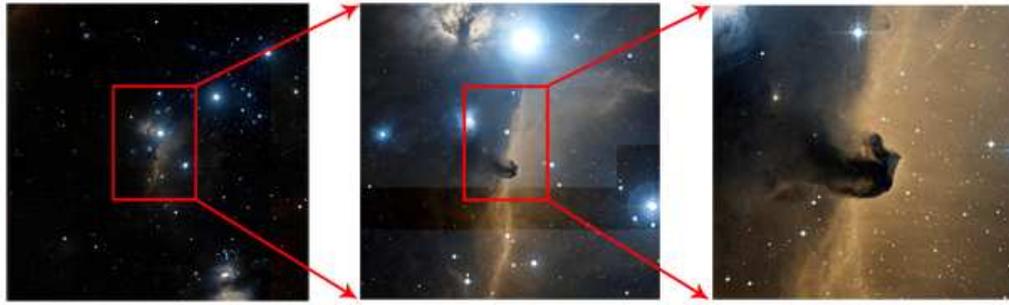


Figure 2. An example of the multi-resolution DSS background implemented in VirGO

The various observations are colour-coded depending on the instrument. The footprint of the images is also shown, whenever available. The various observations are grouped positionally if their footprint match. To select a group, click on the small icon at the centre of the group. Doing so, details about the selected group will appear at the top left of the Graphical Window, displaying the number of frames, the type of observation, the instrument, and the cumulative exposure time. The details of the selected group will also appear in the *List Browser* (see Section 4.1.2).

One can also select all the available data in a rectangular region drawn by the mouse (right-click and draw the region).

4.3 The List Browser

The list browser lists in tabular form frames displayed in the Graphical Window. The user can list either the selected frames (*View Selected*) or all frames displayed in the Graphical Window (*View All*). The table displays the observation date, the presence or absence of a preview in form of a tick-box (for images only), the exposure Time (*ExpTime*); the Filter (again for images only); and the instrument name. The observations can be sorted by any of the columns, by clicking on the column header.

4.4 The Info Window

By clicking on a specific row inside the *List Browser*, all the available information stored in the ESO SIA/SSA is listed in the *Selected Observation Info* frame. This same frame provides direct links to the data sets (and previews, whenever available).

4.5 The Viewer Selector

The various functionalities in the Viewer Selector window allow for the filtering of the observations loaded, based on the type of data, their processing level, a set of predefined keywords, as well as the telescope, instrument and filter or grism.

The available data types are Images (coming from the selected SIA services), Spectra (coming from the selected SSA services) and Other/Unknown datasets that could be e.g. VOTables with missing information loaded locally, files with unknown content or datasets from external VO services with insufficient information.

The processing type refers to data products that are raw, have had a basic calibration or are highly processed, i.e. science-ready products.

4.6 The Target Selection

In the field *Target* insert the name of the object. VirGO uses the SIMBAD name resolver [2]. Alternatively, type the coordinates of the desired target in the relevant fields (RA in hh mm ss; Dec in dd mm ss)

4.7 The Data Basket

By right-clicking on any entry or list of entries in the *List Browser*, the option *Add ESO data to Data Basket* appears. This action adds all data coming from the ESO SIA and SSA service in the *Data Basket*, where the following information is shown: the name of the file to be requested; the instrument, the filter, the exposure time and the type of observation (Image or Spectrum). Once the selected frames have been added to the *Data Basket*, a direct query to the ESO archive can be fired by clicking on *Submit request to ESO*. The list can be saved for later use. To clear the list, press the *Clear All* button.

4.8 The VirGO Menu

The most important functions of VirGO can be accessed in the button bar located in the bottom left corner.

- The button  enables/disables the display of the equatorial grid.
- The button  loads the names of the NGC/IC objects.
- The button  centers the current view direction on the selected target.
- The button  switches between full-screen and window mode.
- The button  triggers download of observations from the SIA/SSA; note that this will only download data from the sources which are currently activated in the *Data Source* list.
- The button  clears all the loaded observations from the *Graphical Window* as well as from the *List Browser*, and the *Info Window*.
- The button  opens the Data Sources window that allows to activate a list of predefined VO resources (both SIAs and SSAs), to add new VO resources in the list, and to load a local VOTable or FITS image.
- The button  enable/disable the display of the DSS multi-resolution background.
- The button  display the VirGO *Configuration Window* allowing the user to select the grouping scheme (e.g. footprint blending) and frame blending (depending on the number of superposed frames).
- The button  toggles between *Archive* and *Real-life Browsing* modes.
- The button  quit the application.

4.9 The Stellarium Menu

The Stellarium Menu allows to open the main Stellarium window:

- the *Location* window, where the user can select any virtual location from which to observe the sky in *Real-life browsing mode*

- the *Date/Time* window allowing for readjustments of the date and time
- *Sky and Viewing* options window
- the *Search* window that allows for target selection by Name (and uses the SIMBAD resolver); this is a somewhat duplicated functionality, as the *Target Selection* of VirGO does this same thing but also allows for positional search
- the *Configuration* window allows, among other functionalities, for language selection, running scripts, Navigation control etc
- the *Help* window displays information for all keyboard shortcuts and also shows a text log of all the actions performed in a given section

For detailed information on Stellarium, see the Stellarium User Guide [8].

4.10 Using other data sources

VirGO allows querying external VO services, i.e. other SIAs and SSAs external to ESO, listed under *Data Sources*. Apart from the two main ESO SIA and SSA servers, the following list of data sources is predefined (but deactivated by default) and can be activated in the *Data Source* panel:

- the ST-ECF Hubble Legacy Archive Images and high-level Spectra
- the HST preview and PR images
- a CFTH Image Search (provided by CADC)
- a Gemini Image Search (CADC)
- a CGPS Image Search (CADC)
- a JCMT Image search (CADC)
- XMM-Newton Science Archive (ESA)
- Galex (STSCI)
- ISO SIA and SSA (ESA)
- UKIDSS DR2 (ROE)
- zCOSMOS SSA (GAVO)

The right-hand side of the *Data Sources* panel displays information for any selected data source, namely the type (SIA, SSA), a short description of the service as well as the base URL for the service.

Any other SIA or SSA can be added to the list of querable sources, by following the easy steps presented below:

1. click on *Data Sources* and press *Add New Sources*
2. from the pull-down menu select the type of the data source (SIA or SSA)
3. specify the base URL of service (called *ParamHTTP Interface* in the registry) or a static web address; this information can be obtained by searching the EURO-VO Registry [5]
4. in order to make the newly added data source permanently available, tick the corresponding tick-box
5. specify the query region (ROI stands for "Region Of Interest")
6. *Save* your action

At any time newly added data sources can be edited (*Edit Source*) or completely removed from the list of Data Sources (*Remove Source*).

The user can also load a local FITS image or a catalogue in form of a VOTable. To do that, open the *Data Sources* window, *Add* a new source and select *Local FITS Image* or *Local VOTable* as source type. The file can also be made permanent by ticking the corresponding tick-box.

The list of Data Sources activated in the last VirGO session will be the one to be loaded when a new session of VirGO is launched. To restore the default list, just *Restore Default*.

4.11 Communication with other VO Tools

VirGO can communicate with other tools using SAMP, the Simple Application Messaging Protocol [11]. SAMP is a messaging protocol that enables astronomy software tools to share data and take advantage of each other's functionality.

Before using SAMP features, VirGO first needs to connect to a SAMP hub. A hub can be launched as an external program, and many VO applications also include an internal hub which is started automatically. Once a hub is running on the computer, VirGO will immediately detect it and connect to it and will get informed of the list of the other applications currently connected to the hub.

The current status of the SAMP connection is indicated by the change of the status of the interoperability icon located in the top right corner from  to  when connected to a hub. If another application is connected to the hub the icon changes to  and the SAMP transmission features are activated in the List Browser when right-clicking on a row.

From this point, selected FITS images can be sent to e.g. Aladin [1]; spectra to e.g. SPLAT [3] or VOSpec [6]; while lists of objects selected in the List Browser can be sent as VOTables to TOPCAT [4].

For example, let's assume that we are interested in an image that we selected in the main graphical window, and want to perform further analysis of it in Aladin. Instead of saving the image to a temporary file on the disk and loading it into Aladin manually, we now just have to click on the matching row in the List Browser and select *Broadcast/Send as image/fits to Aladin* in the context menu as showed in Figure 3.



Figure 3. Send a FITS image to Aladin using SAMP.

5 Use cases

We hereby illustrate some simple examples of the use of VirGO as an ESO archive browser and as a VO tool.

5.1 Querying popular fields

A user wants to know about all the available ESO observations within 1 square degree centred in the Chandra Deep Field South (CDF-S). Using the main ESO archive query form, the user will have to wait for about 28 minutes for all the frames (more than 31000) to be returned in the form of an html table (Figure 4). The same query using VirGO will only require a couple of minutes of the astronomer's life and will return the list in a visual form, like that shown in Figure 1, allowing the user to immediately see the overlaps between observations, to get a feeling of the depth of the exposures (using the footprint blending option) or to selectively look at the reduced data.

Mark	More	Release_Notes	RA [deg]	DEC [deg]	PL_Name	Program_ID	Instrument_Name	Filter/Grism	Exposure_Time [s]	Filename
<input type="checkbox"/>		GOODS_VIMOS_spectroscopy	53.070313	-27.842175	CESARSKY	171.A:3045(D)	VIMOS	MR	10799.94	GOODS_MR_NEW_2_B_Q2_29_1
<input type="checkbox"/>		GOODS_VIMOS_spectroscopy	53.071323	-27.798475	CESARSKY	171.A:3045(B)	VIMOS	LR_Blue	14400.00	GOODS_LRB_002_Q2_20_1
<input type="checkbox"/>		GOODS_VIMOS_spectroscopy	53.071356	-27.820814	CESARSKY	171.A:3045(D)	VIMOS	LR_Blue	14399.88	GOODS_LRB_003_NEW_2_Q3_45_1
<input type="checkbox"/>		GOODS_VIMOS_spectroscopy	53.071356	-27.820814	CESARSKY	171.A:3045(D)	VIMOS	LR_Blue	14399.88	GOODS_LRB_003_NEW_2_Q3_45_2
<input type="checkbox"/>		GOODS_VIMOS_spectroscopy	53.071360	-27.814937	CESARSKY	171.A:3045(B)	VIMOS	LR_Blue	14400.00	GOODS_LRB_002_Q2_16_1
<input type="checkbox"/>		GOODS_VIMOS_spectroscopy	53.072368	-27.822115	CESARSKY	171.A:3045(D)	VIMOS	MR	14399.98	GOODS_MR_NEW_2_1B_Q2_33_1
<input type="checkbox"/>		GOODS_VIMOS_spectroscopy	53.072719	-27.767697	CESARSKY	171.A:3045(B)	VIMOS	LR_Blue	14400.00	GOODS_LRB_002_Q2_29_1
<input type="checkbox"/>		GOODS_VIMOS_spectroscopy	53.073063	-27.834870	CESARSKY	171.A:3045(D)	VIMOS	MR	1200.00	GOODS_MR_NEW_1_D_Q2_30_1

Figure 4. Example output of the Advanced Data Products query form for ESO spectroscopy in the Chandra Deep Field South (CDF-S).

5.2 Proposal Preparation

A user preparing a proposal wants to know the available data in his/her favourite field or target, namely by instrument, exposure time and/or coverage. Once all the available frames have been loaded into VirGO, the list can be saved as a VOTable: in the **List Browser** click *View All* then *Select All* and then right-click inside the highlighted list in order to obtain the option *Save select as VOTable*. The list can be loaded (in form of a VOTable) in any other application capable of handling VOTables being connected simultaneously to the SAMP hub. TOPCAT, for example, can be used to filter the entire list, create subsamples and check, e.g., the Observing Dates or Exposure Times per filter (see Figure 5).

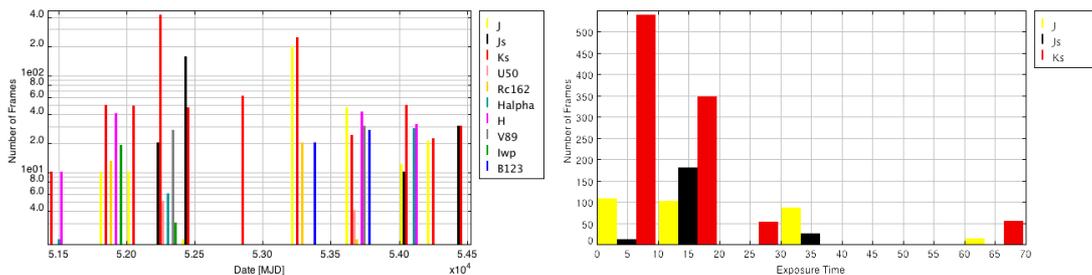


Figure 5. Date (MJD) and Exposure Time (in sec) histogrammes for a selected set of observations and for various filters. The histogrammes have been made using TOPCAT.

5.3 Search for variable stars in a globular cluster over years of observations

To search for variable stars in a globular cluster, one will need to check for observations taken over the years. VirGO allows for a quick view of the available observation for given periods of time by simply changing the Date intervals under **View Selector**.

5.4 What targets in the GOODS field have been spectroscopically followed up by ESO/GOODS?

A user wants to know which sources in the CDF-S field have been spectroscopically followed up by ESO/GOODS. The Advanced Data Products query form will again return an html list of files with the relevant information, like that shown in Figure 4. The same query using VirGO will return a visualisation of the available reduced spectra, shown in Figure 6. The user can then select an image to use as a background to identify the sources or, by zooming in, see the orientation of the slit (whenever available) or the number of spectra composing the final product per object, or even visualising individual spectra using other VO tools (shown here with SPLAT-VO) before requesting them to the archive.

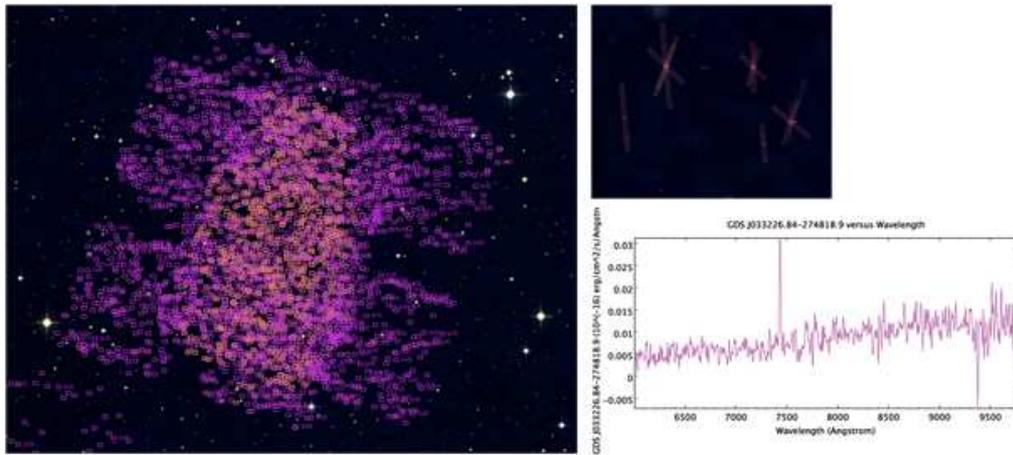


Figure 6. Output of VirGO from a search for spectroscopy in the CDF-S. Each object within a box has a spectrum, and zoom-in and visualisation of a selected spectrum using SPLAT-VO is shown.

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