

The GIRAFFE Archive: Reduced Spectra and Datacubes from the VLT FLAMES GIRAFFE Spectrograph

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Since 2003, the intermediate- and high-resolution multi-fibre spectrograph GIRAFFE, part of the FLAMES facility, has been producing 1D spectra in its multi-object configuration and 3D spectra using its integral field unit configurations. Raw data are available in the ESO archive. The GIRAFFE archive (<http://giraffe-archive.obspm.fr>) offers the community, via a web interface and the Virtual Observatory (VO), access to reduced scientific data. The web interface to the database allows the use of a large range of selection criteria, including individual target positions, magnitudes and signal-to-noise ratios, together with an interactive quick look at the reduced data. Two collections are available in the VO: the 1D spectra (summed in the case of integral field observations) and the 3D field observations.

FLAMES/GIRAFFE

The GIRAFFE spectrograph is part of the FLAMES facility (Pasquini et al., 2002) and combines high-resolution spectroscopy and multiplex capabilities with the Very Large Telescope (VLT) Unit Telescope 2. As a result of these properties, the scientific applications of GIRAFFE cover a wide range of topics, from stellar to Galactic and extragalactic studies. Since it started operations in spring 2003, GIRAFFE has been producing scientific data at the average rate of about 140 multi-object observations per month.

The multiplex capability of GIRAFFE relies on three different fibre systems that can be used to feed the instrument. These consist of a set of “Buttons” and are:

- Medusa (MED), where the 135 Buttons are composed of individual fibres, with

a circular 1.2-arcsecond aperture on the sky that can be deployed in the 25-arcminute diameter field of view (FoV);

- Integral field unit (IFU), where the set of Buttons is composed of 15 separate 4 by 6 micro-lens arrays (2 by 3 arc-seconds), also deployable in the FoV;
- Argus (ARG), a single central array (22 by 14 micro-lenses), with two available spatial scales giving a sampling of 0.52 and 0.3 arcseconds per micro-lens.

When data-mining multi-object observations, two different search levels are needed: a high level to retrieve full observational datasets and a low level to directly access individual object data. Raw data produced by GIRAFFE are distributed by ESO and are searchable in the ESO archive at the high level. The motivation of the GIRAFFE archive¹ is to provide advanced data products, searchable at both levels: high (Field) and low (Button).

Data processing

The data stored in the GIRAFFE archive are the result of automatic processing. Once publicly available, raw data are retrieved from the ESO archive and are reduced with the standard ESO pipeline. The calibration and science products are created according to the following steps:

- Using the reduction recipe `gimasterbias`, a master bias frame is produced for each night where the required number of raw bias frames are available;
- The reduction recipe `gimasterdark` is used to process raw dark frames, taken on an approximately monthly basis. Dark subtraction is applied only in the scientific reduction;
- Before using `gimasterflat`, raw flat-field frames are analysed to automatically detect broken fibres. The output fibre list is used as a parameter when running the recipe `gimasterflat`. The localisation and extracted flat fields are built for each set-up and slit for each night. In Medusa mode, the optimal extraction method is used for extracting these spectra;
- Using `giwavecalibration`, the slit geometry and wavelength solution are built for each set-up and slit, in two different runs of the recipe, for each night;

- Using gscience, each raw science exposure is reduced individually using the aforementioned calibration products. In Medusa mode, optimal extraction is used. For IFU and Argus data, the chosen output format for the datacubes is ESO3D (Kuntschner et al., 2012). The standard stars are processed as regular scientific frames. No flux calibration is performed on GIRAFFE data;
- The signal-to-noise ratios (SNR) are derived for the scientific spectra using the `DER_SNR` algorithm (Stoehr et al., 2008);
- In addition to the science products, sky subtraction is performed to compute the median sky from the dedicated fibres and subtract it from the spectra of all the fibres.

Only products from the science reduction are stored in the GIRAFFE archive. These products are:

- a FITS file in native format consisting of an image, where each column is an extracted calibrated spectrum;
- the errors on the flux, in FITS native format;
- the sky-subtracted flux, in FITS native format, when sky subtraction was possible;
- the concatenated reduction log (full calibration cascade);
- in the case of IFU and Argus modes, the ESO3D FITS datacube, containing 3D images of fluxes and errors for all the observed buttons.

Data pass through quality control prior to ingestion into the archive. The check is based on the statistics of the reduced spectra, the ambient temperature difference between the scientific observations and their matching calibration products, and the velocity dispersion of the wavelength solution. Only compliant reductions are ingested into the archive.

Web interface¹ and data mining

Different snapshots of the web interface illustrate this paper. For clarity, the specific parts of the figures, uniquely labelled with circled numbers, are referred to in the text and captions by bold numbers in parentheses.

Search interface

The form displayed in Figure 1 is a snapshot of the search interface. There are two search levels in the archive: Field, corresponding to full observations and Button, which corresponds to individual objects. Specifying this search criterion (1) is mandatory. The other search criteria are organised in five panels related to the object information, the exposure parameters, the fibre configurations, the instrumental set-up and the spectral characteristics. The criteria related to the objects are matched against information taken from the observations themselves: the celestial coordinates, object names and magnitudes stored in the archive are the ones provided by the original observer. The Target criterion (2) is optional and can be either a name, which will be automatically resolved into a position using Simbad, or right ascension and declination directly.

When Field is selected, the search is performed on the global parameters of each target: cone search on field centre positions, range of magnitudes, range of SNR, etc; however if Button is selected, the search is performed on the individual parameters of each MED spectrum: cone search on target positions, individual magnitudes and SNR.

The fibre buttons allocated to sky positions are not searchable in the database, provided that they were correctly flagged during the observation preparation. They are nonetheless part of the Field-related products. When the tick box specifying sky-subtracted data is checked (3), this criterion will propagate through the resulting pages and the related data products. This propagated information is indicated by a label on the corresponding pages, e.g., on Figure 5, (17).

Figure 2 shows a sketch of the browsing steps in the web interface, proceeding from the search form. The six coloured boxes in the flowchart stand for the different types of web pages in the interface and arrows represent the hyperlinks through which they can be browsed. Left and right columns respectively correspond to the Field and Button search levels. The three types of web page, from top to bottom, are:

- the query results, where all matching data are listed in a paginated table;

Figure 1. The GIRAFFE archive search interface is shown. The mandatory criterion Field/Button (1) must be specified. The other criteria are organised in five panels related to object information, exposure parameters, fibre configurations, instrumental set-up and the spectral characteristics. See text for details.

- the data product pages, which give details for individual data products (Field or Button);
- a dedicated visualisation tool which allows the user to explore both spatially and spectrally the content of the data (see section on SCubOX).

Query results

Once the desired criteria are given and the query is submitted (4), the list of matching data is displayed. The relevant parameters are listed in the different columns (Figure 3). On each row, the Observation ID can be clicked to access Field data product pages. In Button que-

ries, the content of the Object column links to the Button data product. The columns Observation ID, Magnitude and SNR can be sorted. Rows can be selected using tick boxes (5). The selection can be retrieved as a VOTable list (6) or the different files can be downloaded (7).

Download options

Data products can be downloaded from the web interface as shown in Figure 2, at different levels. Multiple download of selected products is possible from the query result lists (labels a and b in Figure 2), and files related to individual observations are available from the data product pages (c and d). The content of these downloads is the following:

- (a) The selection of rows in the Field query results allows the user to download the corresponding Field FITS files, in native format — see (7) in Figure 3.

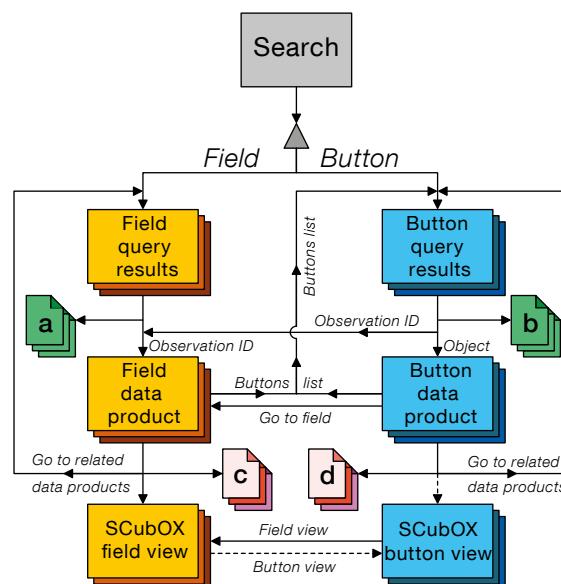


Figure 2. A flowchart of the browsing process in the web interface is shown. Horizontal boxes represent web pages and file icons stand for downloads. The different download options are detailed in the text. Labelled arrows represent hyperlinks, conditional when shown dotted.

Your query returned 187 fields

6 7

Download: select all unselect all VO list Download page 1 2 3 4 display 20 50 100 all results per page.

	Observation ID	Field name	ProgID	Field centre	Set-up	Mode	Argscale	Sim-Cal	# Fibres			Sky Sub	Exptime	Air mass	Seeing	Magnitude		SNR	
									obj.	sky	tot.				min	max	min	max	
1	GIRAF.2010-10-16T02:01:01.176	SMCF3	386.D-0541	00 48 32.4 -73 10 34	LR3	MED	--	YES	99	16	120	YES	2760	1.580	0.44	13.100	19.540	10.1	107.9
2	GIRAF.2010-10-05T04:05:18.822	SMCF1	386.D-0541	01 00 47.9 -72 11 07	LR3	MED	--	YES	112	15	132	YES	2760	1.489	1.15	12.790	20.260	-0.4	22.9
3	GIRAF.2010-10-16T03:08:26.846	SMCF4	386.D-0541	00 52 22.1 -72 45 14	LR3	MED	--	YES	111	16	132	YES	2760	1.508	0.50	12.640	19.720	7.7	113.9
4	GIRAF.2010-12-13T04:08:45.648	SMCF1	386.D-0541	01 00 47.9 -72 11 07	LR3	MED	--	YES	112	16	133	YES	2760	1.835	0.97	12.790	20.260	2.4	97.3
5	GIRAF.2010-10-15T03:17:32.282	SMCF2	386.D-0541	00 55 14.1 -72 28 51	LR3	ARG	1:1.67	YES	299	0	304	NO	2760	1.499	0.60	N/A	N/A	5.6	5.6
6	GIRAF.2008-07-24T05:59:31.428	NGC346	081.D-0364	00 58 48.1 -72 10 47	HR2	MED	--	NO	112	16	128	YES	2662	1.767	0.46	0.000	16.730	4.2	87.4
7	GIRAF.2008-07-25T08:39:37.880	Field2	081.D-0183	00 52 40.6 -72 29 00	HR15N	MED	--	YES	11	4	20	YES	2775	1.497	1.10	14.500	15.500	2.2	101.8

Figure 3. An example of a Field query result list is shown; only the first few rows are displayed. The Observation IDs in the first column, as shown by the cursor over the identifier, are links to the corresponding Field data product pages (see Figure 4). See text for details.

(b) The selection of rows in the Button query results gives access to the individual 1D spectra (reformatted into standard 1D FITS images).

Figure 4. An example of a Field data product page is displayed for the region around the globular cluster M55. Information related to the full observation is displayed and shows the fibre configuration (8) overplotted on the sky image using the Aladin Lite viewer: red squares represent object positions and blue squares stand for fibres allocated to blank sky positions. More details are given in the text.

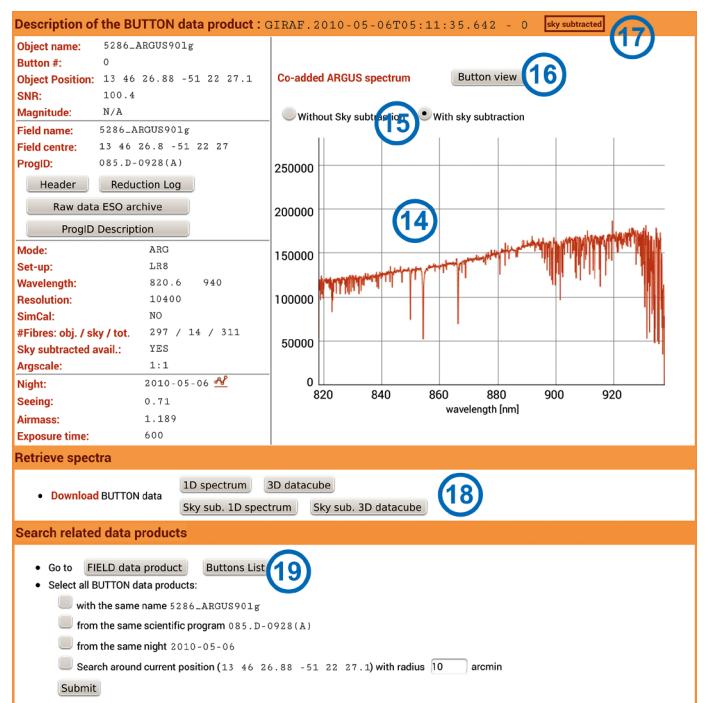
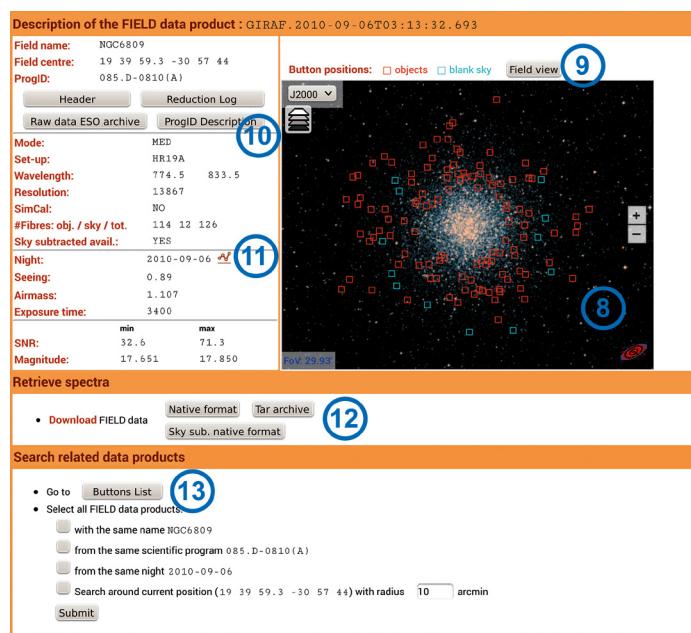
(c) From a Field data product page, the user can download several files: the reduced spectra in native format, the ESO3D cube if relevant, and their sky-subtracted version if available. The user can also download a tarball containing the reduced spectra and their corresponding error frames, an additional file containing the individual SNR, the full reduction log, the ESO3D datacube and the reconstructed images when relevant — see (12) in Figure 4.

(d) From a Button data product page, the user can download 1D spectra, with and without sky subtraction, and individual ESO3D cubes when relevant — see (18) in Figure 5.

Field data products

As shown in Figure 4, a Field data product page displays the fibre configuration in an Aladin Lite viewer (Boch & Fernique, 2014), distinguishing target-allocated buttons (red) from sky-allocated fibres, in blue (8). The interactive view can be zoomed and panned. Further interaction is available through the link Field view (9), further detailed in the section on SCubOX. This page also links to information available on the ESO website: the

Figure 5. Example of a Button data product page, for an Argus observation of NGC 5286 is shown. The spectrum (14) summed over the Argus array is displayed. In this example, sky-subtracted data were queried (17). See the text for more detail.



description of the observing programme (10) and the environmental conditions of the night (11). The link Buttons list (13) gives the content of the observation in terms of objects and allows the user to go to specific targets. The latter can also be accessed by clicking directly on their positions in the Aladin Lite viewer.

Button data products

The data related to individual targets are displayed in the Button data product pages (Figure 5). The 1D spectrum and its error bar are plotted in a dygraphs chart (14) and the user can zoom and pan to explore the spectrum. If sky-subtracted data are available, the plot can be switched from non sky-subtracted to sky-subtracted (15). In the case of IFU and Argus mode, where the button is composed of several fibres, the 1D spectrum is the sum over the different fibres. The details of the button spaxels (spatial pixels) can be explored with the Button view link (16), detailed in the next section. Two links (19) allow the user to go back to the Field level of the observation or explore the other Buttons.

Virtual Observatory access

The data are available in the Virtual Observatory in two collections, via the simple spectrum access (SSA) services, hosted by the VO-Paris Data Centre:

- GIRAFFE-1D: the 1D Button spectra (co-added in case of IFU and Argus);
- GIRAFFE-3D: the full Field reduced spectra.

The SSA services can be queried through VO tools or the VO-Paris Data Centre portal².

Exploring data products with SCubOX

A visualisation client, SCubOX (Spectral Cube Online eXplorer), is being developed to display spatial and spectral data via a web service. It has both Field and Button views.

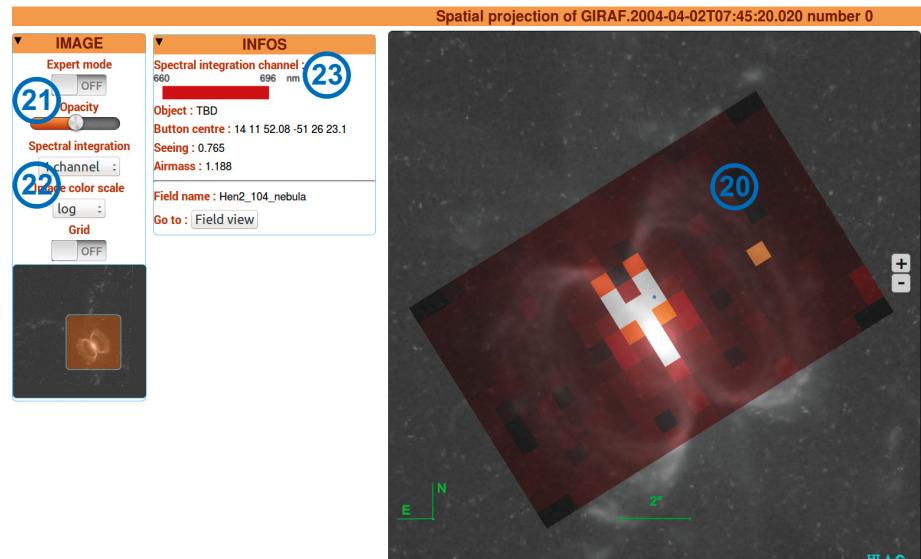


Figure 6. Example of a ScubOX Button view for an Argus observation of the Henize 2-104 planetary nebula. The cube is projected on the sky image and the different spaxels are displayed with a colour map based on the flux integrated over the wavelength axis (20).

Field view

The Field view combines the graphical displays of Field and Button data product pages in a single interface. Selecting targets in the Aladin Lite viewer loads their spectrum in the 1D dygraphs chart.

When buttons are composed of several spaxels, a link to the Button view is available.

Button view

This interface (Figure 6) plots the spatial projection of the datacube (20) over an image fetched from an online archive. The Hubble Legacy Archive is preferably checked (the source of the image is displayed in the lower-right corner). The opacity level of the projection can also be tuned (21). The spectral flux of the cube is integrated to produce the projected image: this integration can be done either on the full spectral range to produce a monochromatic image or the flux can be integrated on three equal spectral channels to produce a trichromatic red-green-blue image (22). The spectral channels are indicated in the INFOS box (23). An expert mode, allowing the display of the different spaxel spectra, is in progress.

Future developments

Several major capabilities as well as technical features will be implemented in the near future. The next objectives are the following:

- Use skycorr (Noll et al., 2014) to subtract the sky contribution;
- Offer the possibility to export the results of a query as a catalogue;
- Finalise the expert mode for SCubOX Button views allowing more versatility;
- Broaden the use of SCubOX and allow input 3D datacubes from different instruments to be accepted.

References

- Boch, T. & Fernique, P. 2014, in ADASS XXIII, ASP Conf. Series, 485, 277
- Kuntschner, H. et al. 2012, The Messenger, 150, 30
- Noll, S. et al. 2014, A&A, 567, A25
- Pasquini, L. et al. 2002, The Messenger, 110, 1
- Stoehr, F. et al. 2008, in ADASS XVII, ASP Conf. Series, 394, 505

Links

- ¹ GIRAFFE archive: <http://giraffe-archive.obspm.fr>
- ² VO-Paris Data Centre portal: <http://voparis-srv.obspm.fr/portal>