SpecINTI and specINTI Editor V4

User Manuel

SpecINTI *and its graphical interface,* ***specINTI Editor****, form a software suite dedicated to the reduction of astronomical spectra. It supports data acquired with most spectrographs used by amateur astronomers, such as the Alpy 600, the Lhires III, the UVEX, the Star'Ex (HR and LR), the TinyStar'Ex (TSE), as well as any other instrument producing FITS files that comply with current standards.*

Developed in the Python language by Christian Buil and Valérie Desnoux, ***specINTI*** *and specINTI Editor are distributed free of charge as executables for Windows, macOS, and Linux.*

SpecINTI *is the processing engine. Fully self-contained, it operates on the basis of exchanges with scripts, and for this reason its direct use is reserved for developers.*

SpecINTI Editor *is the natural companion of* ***specINTI****. This graphical interface simplifies the entire workflow, from calibration through to the final analysis of spectra. It offers interactive wizards for high- and low-resolution reduction, an editor for configuration files, a generator for observation files, tools for displaying FITS images and spectral profiles, a dedicated module for computing the instrumental response, and more.*

The philosophy of this software suite is to reconcile scientific rigour, automation, and ease of use. The reduction procedures comply with the standards used by the main professional spectral databases, while offering a very wide range of parameters that allow the software to be adapted to a variety of instrumental configurations and to demanding analysis requirements.

Since ***version 4****,* ***specINTI Editor*** *has introduced new, and particularly powerful, operating modes that make the software easy to use from the very first contact, including for newcomers to the field.*

This document is the user manual for ***specINTI Editor****. It sets out the fundamental principles of use and describes the interface (the Windows environment is used here as the reference).*

A detailed, step-by-step guide has been written to teach you how to reduce spectra with the application. It relies on numerous worked examples. This spectral-reduction guide can be downloaded in PDF format from the following link:

https://buil.astrosurf.com/specinti4/guide_specinti_en.pdf

Installation

The official address of the website is: https://solex.astrosurf.com/specinti1_en.html

From there you can download the program and the accompanying files for the environment of your choice (Windows, macOS, Linux).

Unpack the downloaded “specinti_editor” file into the folder of your choice (this becomes the application folder). For macOS, see the procedure at the end of this document for authorising the execution of an unsigned application.

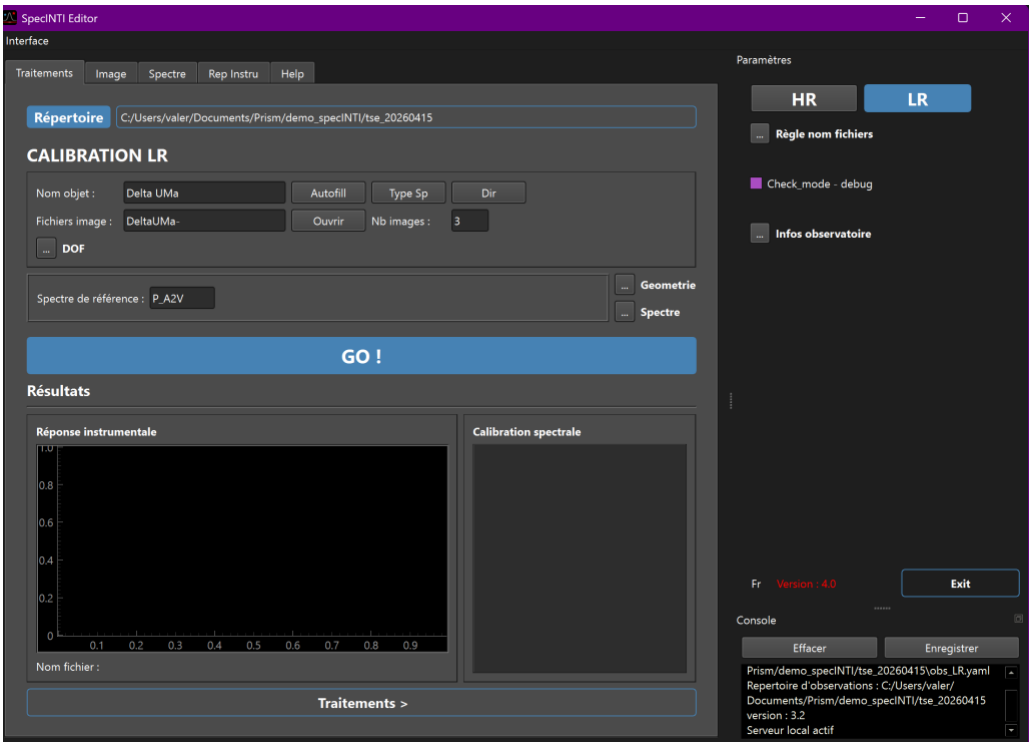
Copy the "specinti_inti.exe" software icon, which you have just installed in the folder, onto your desktop for quick access to the application.

This is a complete distribution comprising the reduction software itself (**specINTI**), its interface (**specINTI Editor**), and a number of accompanying files, including an automatically created directory named **_configuration**, which contains a set of scripts supplied by default for everyday use, referred to as **configuration files** in **specINTI** terminology. You will certainly go on to create configuration files tailored to your own needs (see the Processing Guide), which you should save in this same folder.

If you are already a specINTI user, remember to keep a copy of your current **_configuration** folder: this will allow you to retrieve your favourite configuration files and place them back into the new **_configuration** folder that is created automatically when this version is installed.

General overview

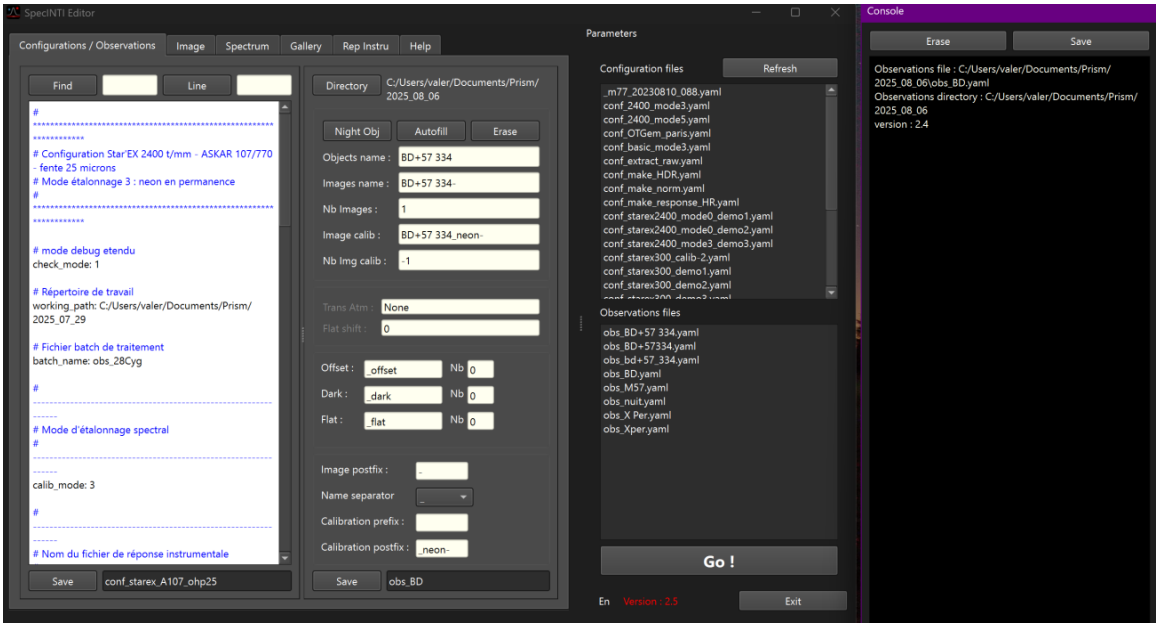
On startup, the window shown below appears; this is referred to as the **Standard Interface**.



A screenshot showing software, multimedia software, text, graphics software, automatically generated description

A simple menu, located above the tabs and labelled **Interface**, allows you to switch between **Standard Interface** mode (the current mode) and **Advanced Interface** mode, which provides manual editing of configuration files as well as the creation of observation files for reducing one or several objects (batch mode). The screenshot below shows the appearance of the **advanced**

interface, which, like the **standard interface**, is organised into a series of tabs, although some of the labels differ.



A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

Whichever interface mode is chosen, it is presented as two blocks (or docks): the Parameters block and the **Console** block. The main window can be resized. Both docks can also be resized independently and moved to the left or bottom of the window. The console can be undocked to become an independent, floating window. To re-dock a floating panel into the interface, double-click on its title bar.

The appearance of the interface depends on the operating system's theme. The examples shown here use the Windows 11 theme in dark mode.

The application remembers the interface layout and restores it automatically the next time it is launched.

The default language is French. To switch to English, click the **Fr** button located at the bottom of the interface, then restart the application.

If an internet connection is available, the application automatically checks the current version number on the software's website. If a more recent version is detected, the version number shown in the interface turns red.

Operating principle of specINTI

The **specINTI** processing pipeline relies on two files: the configuration file, which describes the reduction parameters, and the observation file, which allows one or several objects observed during the same night to be processed in batch mode. **SpecINTI Editor** is the interface that makes it easy to create and modify these two files.

A screenshot showing text, screen capture, software, number; AI-generated content may be incorrect.

We begin the description of the features by using the standard interface of **specINTI Editor**, which will be the most familiar to most readers.

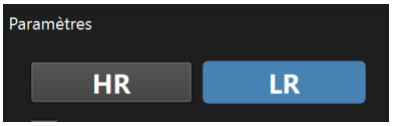
Standard interface – general points

The principle behind this interface is to hide the complexity associated with configuration and observation files. It thereby simplifies the use of the software, at the cost of a certain loss of flexibility. Reduction parameters are made available in floating boxes that can be edited on demand, rather than being entered directly as text.

With the standard interface, only one object can be processed at a time.

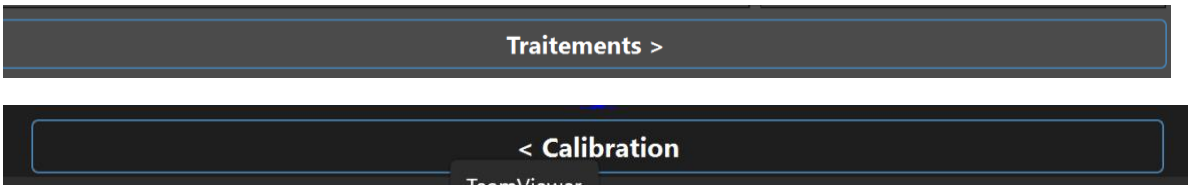
The software offers two reduction modes:

- **High Resolution (HR)**, for spectra acquired with a resolving power (R) generally greater than 5,000;
- **Low Resolution (LR)**, for spectra acquired at lower resolution.

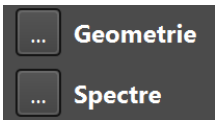


A screenshot showing text, screen capture, font, clock, automatically generated description

This distinction mainly concerns the automation of the reduction and the method used for spectral calibration (that is, the association of pixels with wavelengths). In HR mode, calibration is carried out from the spectrum of a neon source, whereas in LR mode it relies on the natural lines present in a reference stellar spectrum. For each of these two modes, a calibration stage and a processing stage are distinguished, the latter making use of the information obtained during calibration. To move from one stage to the other, click the button at the bottom of the tab.

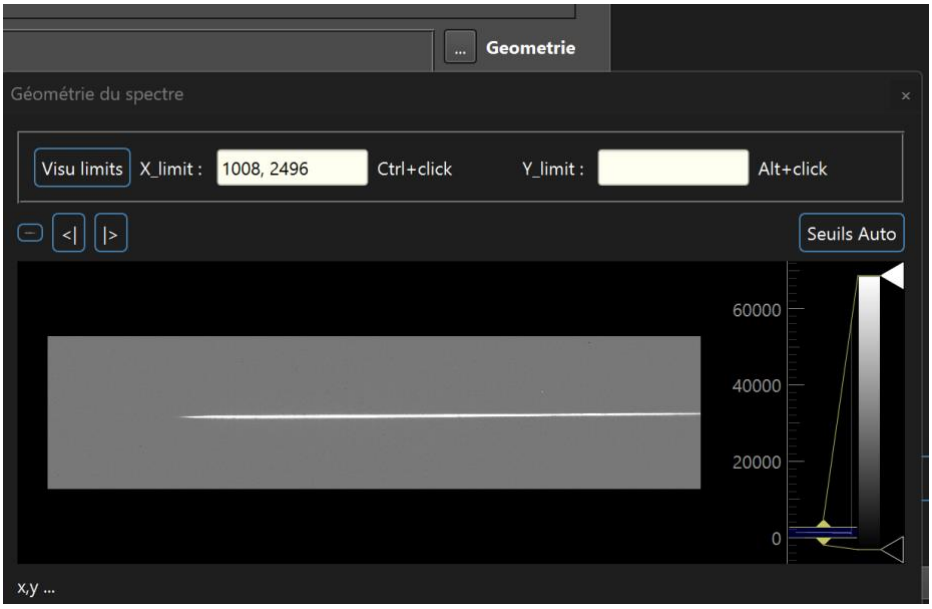


Each mode and each stage require a set of parameters that, in most cases, remain the same from one observation to the next, but which stay accessible at all times. Each group of parameters is identified by its name and by a small “…” button.



A screenshot showing screen capture, text, font, design, automatically generated description

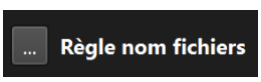
When you hover the mouse over this button, a floating window appears showing the corresponding parameters. To edit them, click the “…” button: the window then stays open. Once you have made the desired changes, close the window using its close box (the cross in the top-right corner). The new parameter values are saved automatically. Below is an example of the floating dialogue box for the spectrum geometry parameters.



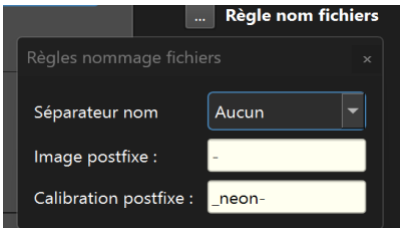
A few parameters specific to the **Processing** tab need to be adjusted according to your own habits. These are software usage rules common to all configurations of the **standard interface** (HR and LR, for example). See the right-hand side of the interface.

Naming rules

Before any operation, regardless of the observing mode, you must define the **naming rules** for your image files in order to benefit from **specINTI**’s automation features.



A screenshot showing text, font, screen capture, graphic, automatically generated description



A screenshot showing text, screen capture, software, font, automatically generated description

The **name separator** makes it possible to automatically locate image files from the object name alone, in a format compatible with **SIMBAD** (the Strasbourg astronomical database).

For example, for the object **delta Uma**:

- if the separator is **None**, the expected name is deltaUma;
- if the separator is **"_"**, the file name will be delta_Uma;
- if the separator is **"space"**, the file name will be delta Uma.

The **Image postfix** parameter defines the separator between the object name and the image number in the sequence. In most cases this is simply a hyphen (-).

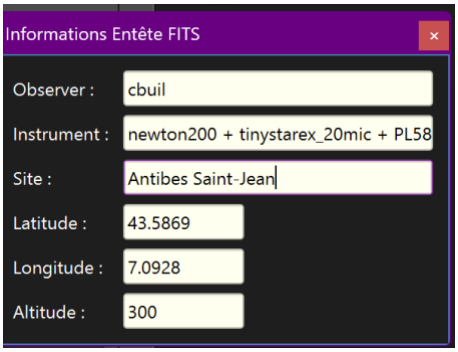
The **calibration image postfix** is free-form, but it is recommended to use the object name followed by _neon-. For example: deltaUma_neon- for calibration images acquired with an external neon lamp in HR mode.

These naming rules are particularly useful with the **Autofill** option, which automatically locates all the image files and calibration files from the object name alone, present in your directory.

Observation information

It is recommended to fill in the information relating to the observing site and the observer's name in the **Observatory information** section.

A screenshot showing text, font, screen capture, graphic, automatically generated description



A screenshot showing text, screen capture, software, font, automatically generated description

This information is added to the FITS header of the processed files and is compatible with the specifications of the **BeSS** database, a standard widely adopted by spectral databases.

The observer's and instrument's names must not contain special characters (accents, #, @, &, etc.).

Check_mode

This checkbox tells the software whether additional information should be generated and saved, in order to make it easier to diagnose a failed reduction or to analyse performance that falls short of expectations.

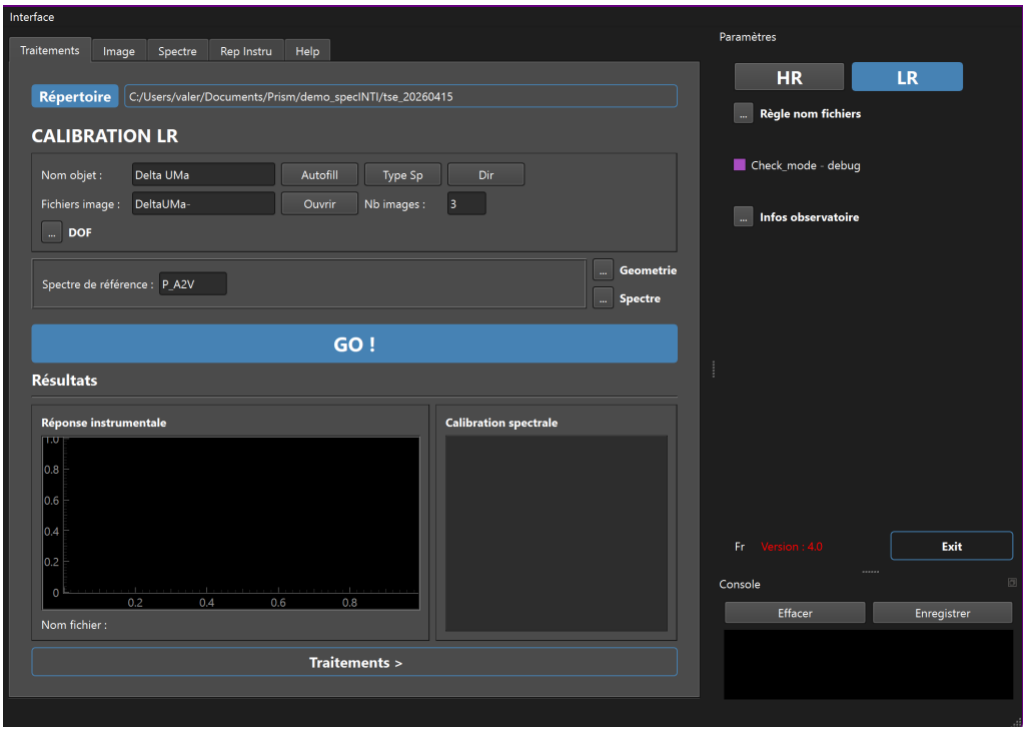
Standard interface in low resolution (LR)

The first operation to be carried out (at least once) is to calibrate the spectrograph you are working with: this consists of determining the spectral dispersion law, as well as the instrument's response to the incident flux. Let us therefore look at how the **specINTI Editor** interface is presented for carrying out this calibration, here in "low spectral resolution" mode.

Calibration stage

Click the large **"< Calibration"** button at the bottom of the **Processing** tab. In LR mode, calibration is carried out from the observation of a star of spectral type A. Thanks to **specINTI**'s algorithms, this operation requires neither a spectral calibration lamp nor a flat-field lamp, which is a significant technical simplification and a novel feature.

From the observation of this star alone, the software automatically determines both the spectral dispersion law and the instrumental response.



A screenshot showing screen capture, software, multimedia software, text, automatically generated description

Identifying the images

The first, very important, step is to select the **working directory**. Click the **Directory** button, then select the folder containing the data for the session you wish to process.

You then specify the name of the object whose spectrum you wish to extract. Since the data most often takes the form of a numbered sequence of images, two methods are available:

- **Enter the name of the observed object** (the **Object name** field), then click **Autofill**. If the naming rules have been correctly defined and followed, the generic image file name and the number of images are filled in automatically.

or

- **Click the "Open" button** to the right of the **Image files** field. It is then enough to select one of the files in the sequence to be processed. You must also manually indicate the number of images in this sequence.

If the image file contains the FITS keyword giving the object name, it is automatically entered in the **Object name** field. Otherwise, it must be entered manually. This name is used by **specINTI** for certain automatic calculations, in particular when querying the **SIMBAD** database.

DOF

To complete the definition of the files required for reduction, you must also indicate the **Dark**, **Offset**, and **Flat-field** (DOF) images used for pre-processing.

These images are generally reused for reducing objects observed over one or several nights, or even over several months. It is simply necessary to check that:

1. the windowing (cropping) of the images acquired during the observation is the same (identical *crop*);
2. the sensor temperature is the same as that of the science images.

Click the **"…"** button in the **DOF** section, then enter the generic name of the corresponding images. If these images were not acquired, leave the field blank or enter **"None"**.

The **"Nb"** buttons are used to specify the number of images in each series.

For example, if you have three offset images named o-1, o-2, and o-3 (FITS files located in the working directory), the generic name to enter is **o-** (do not forget the hyphen), and the number of images is **3**.

A distinctive feature of **specINTI** is that, during the first reduction run, it computes an average image for each category of DOF used. These images are saved in the working directory under reserved names:

- _offset for the offset image;
- _dark for the dark image;
- _flat for the flat-field image.

For subsequent reductions, these average images can be used directly. It is then enough to enter their name, as shown in the figure below, and to enter **0** as the number of images, since this is no longer a series.

Example where the offset image, like the dark, had already been synthesised, but no flat is used.

Dir

This small **"Dir"** button is very handy, as it allows you to quickly view all the FITS files present in the working directory. It is also possible to select one or several file names with the mouse and then copy and paste them directly into one of the input fields.

Spectral type

In low resolution, clicking the **"Type sp"** button causes **specINTI** to automatically determine the instrumental response by comparing the observed spectrum of a hot star (of spectral type A) with a corresponding reference spectrum.

To do this, the software uses spectra from the **Pickles** library, stored in the **_calib** subdirectory, which is created automatically when the software is installed.

The reference spectrum is selected according to the following steps:

1. The application automatically retrieves the spectral type of the observed object from the **SIMBAD** database (an internet connection is required).
2. It extracts a simplified spectral type.
3. If the star is not of type A, an error message is generated and the reduction is stopped, since the calibration would be likely to fail.
4. The software searches the Pickles library for the spectrum closest to the determined spectral type.
5. The name of the selected Pickles file is then shown in the **Reference spectrum** field.

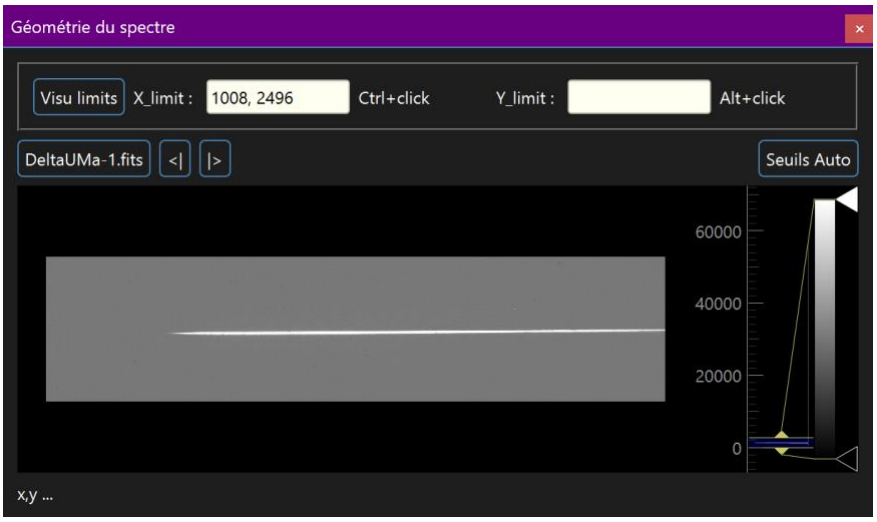
Geometry

For wavelength calibration, **specINTI** relies on detecting the Balmer lines and measuring their position.

One parameter is particularly important for ensuring reliable automatic detection: the limits along the x-axis, which define the region of the spectral trace within which the Balmer lines will be searched for and measured.

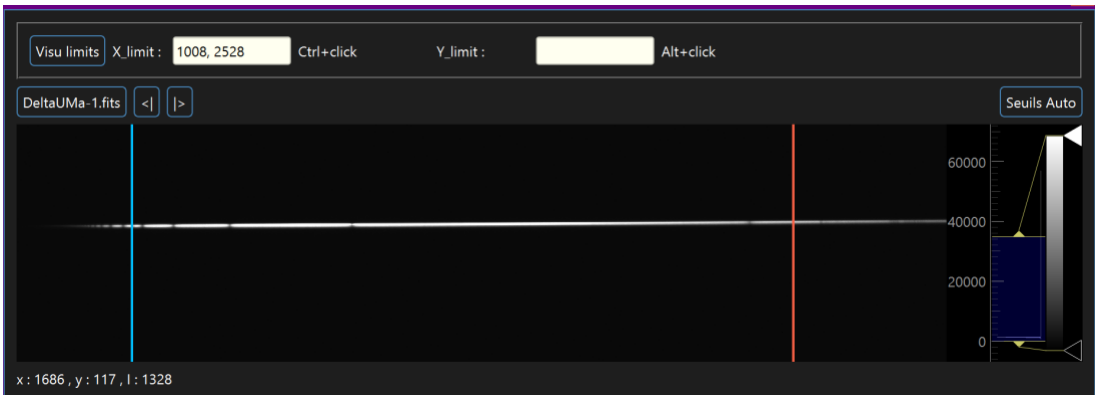
This parameter, named **X_limit**, is defined in the **Geometry** section.

Once correctly adjusted, these values can be kept for subsequent reductions, provided that the camera and its orientation remain unchanged.



*The **Geometry** dialogue box. The image is displayed and its thresholds, as well as the zoom and pan, can be adjusted.*

The **X_limit** values can be set directly with the mouse. Zoom in on the image, then set the limits by positioning the cursor between the first Balmer lines and, at the other end, after the Hα line but before the main telluric lines located in the red part of the spectrum. Use Ctrl+click to set these limits interactively with the mouse.

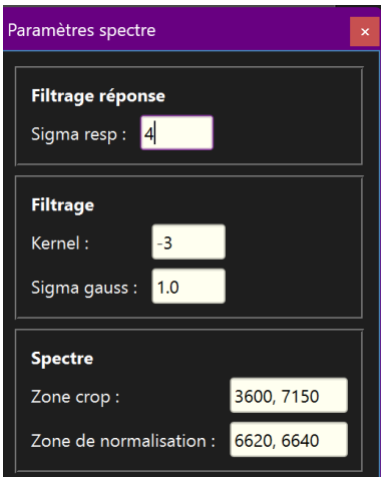


The portion of the spectrum in which the Balmer lines are searched for and measured lies between the two vertical lines, one blue, the other red. They are positioned with a Ctrl+click of the mouse.

A **Y_limit** zone can also be defined; this speeds up automatic detection of the position of the spectral trace by restricting the search area within the image. This option is particularly useful when the spectral image is not windowed and the wide part of the slit, known as the **photometric zone**, is present. To do this, simply Alt-click with the mouse, once below the spectral trace and once above it. Allow a generous margin above and below to make sure your spectrum always falls between these two limits.

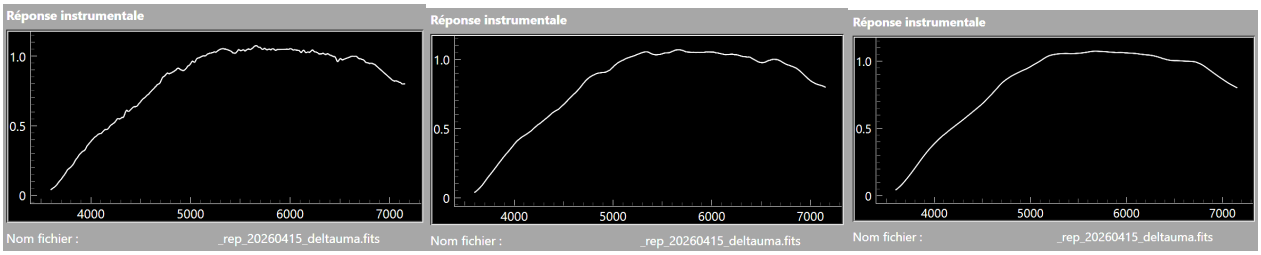
Spectrum

Only a few parameters remain to be checked or defined. They relate to the computed spectral profile, prior to it being saved.



One of the parameters derived from calibrating the instrument is its **response** to the **incident optical flux**. When evaluating this response, a filtering strength must be defined so as to obtain, in the end, a curve as a function of wavelength that faithfully represents this response, rather than noise or artefacts. This involves adjusting the **Sigma resp** parameter in the spectrum parameters dialogue box.

The higher the value, the smoother the resulting response profile. Its effect can be checked after processing by looking directly at the response curve displayed in the lower part of the **Processing** tab.



In the images above, from left to right: filtering at 1, filtering at 4, and filtering at 10. In this example, the value **4** offers the best compromise.

The **Filtering** section of the dialogue box also allows you to adjust the level of noise observed in the processed spectrum.

The **Kernel** parameter defines the processing kernel used to filter impulsive noise. It is recommended to keep the default value of **−3** (the negative sign is important), as this activates an algorithm that efficiently reduces this type of noise while very effectively preserving the fine detail of the spectrum (see the *User Guide* for further information).

The **Sigma_gauss** parameter controls the strength of a more conventional filter, based on convolution with a Gaussian function. The higher this value, the stronger the smoothing:

- A value of **0.5** produces a barely perceptible effect;
- A value of **1** corresponds to already significant filtering;
- A value of **2** produces marked smoothing that efficiently reduces noise but also reduces the fine detail of the spectrum.

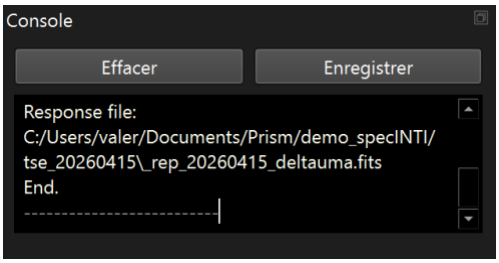
The best compromise between noise reduction and preservation of spectral resolution should therefore be chosen.

From this same dialogue box, it is also possible to restrict the spectral range processed (**Zone crop**) and to impose unit normalisation over a portion of the spectrum chosen by the user.

GO!

Once the data have been entered and the parameters defined or simply checked, click **GO!** to launch the calibration procedure.

The progress of the operations can be followed in real time in the **Console** window.

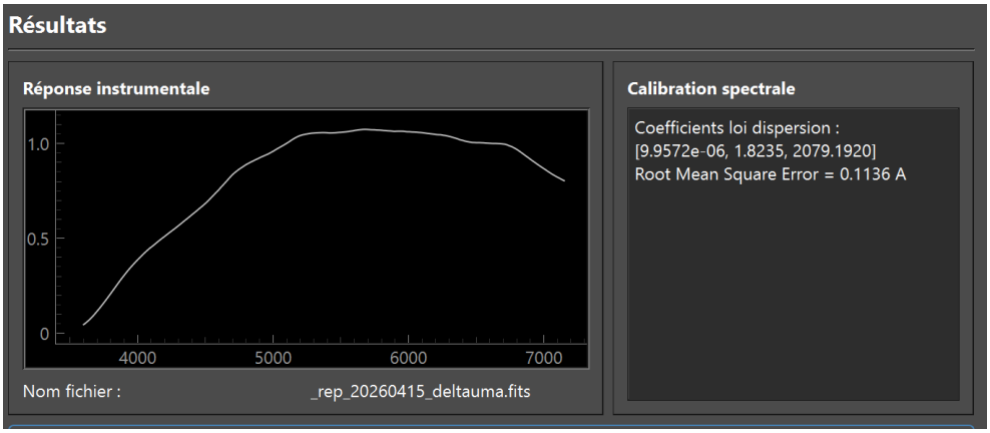


A screenshot showing text, screen capture, font, software, automatically generated description

At the end of the reduction, the instrumental response curve is displayed in the lower part of the **Processing** tab, and in the console, the name of the file under which it was saved, as well as the parameters of the dispersion law, are given in the form of the three coefficients **a**, **b**, and **c** of the second-degree polynomial:

$$\lambda(x) = a \cdot x^2 + b \cdot x + c$$

The mean error between this dispersion law and the position of the Balmer lines used for the calibration is also given.

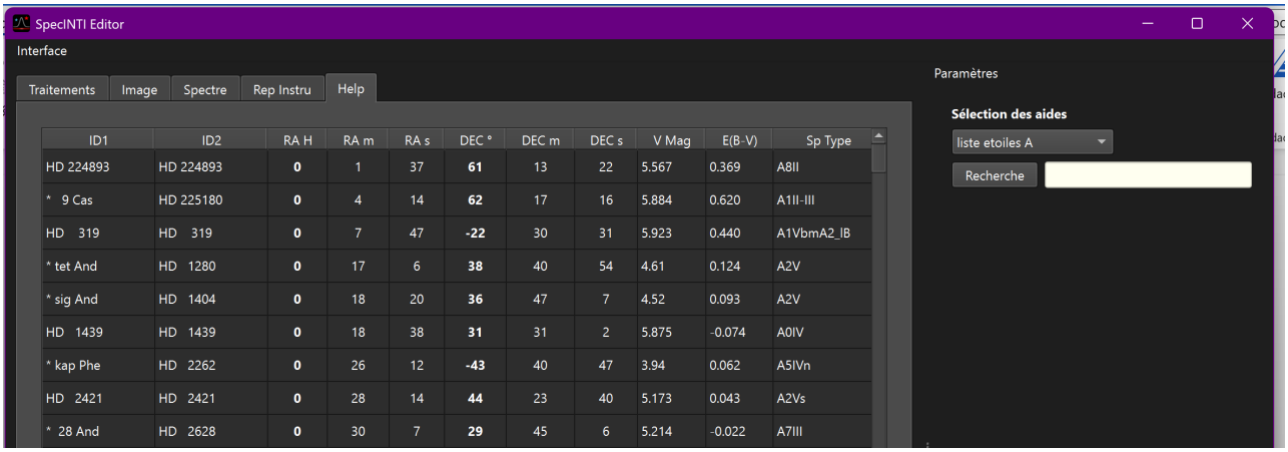


You have just determined the coefficients of the dispersion-law polynomial as well as the instrumental response. This information will now be used for subsequent reductions.

How long they remain valid depends on the stability of your instrumental setup. If you do not change any settings and make no alterations to the optical configuration, they can be kept for a long period of time. During the reduction stage for science targets, we will nevertheless see how to measure and compensate for a possible shift in the dispersion law caused by instrumental flexure, which can never really be entirely avoided in practice.

It is also worth noting that acquiring the spectrum of a type-A star at the start of the night, or even during the night, is not a demanding operation. It is, moreover, an excellent way of checking that the system is working correctly before starting an observing session.

A list of type-A stars that are bright enough and well distributed across the whole sky is available from the **Help** tab of the interface.

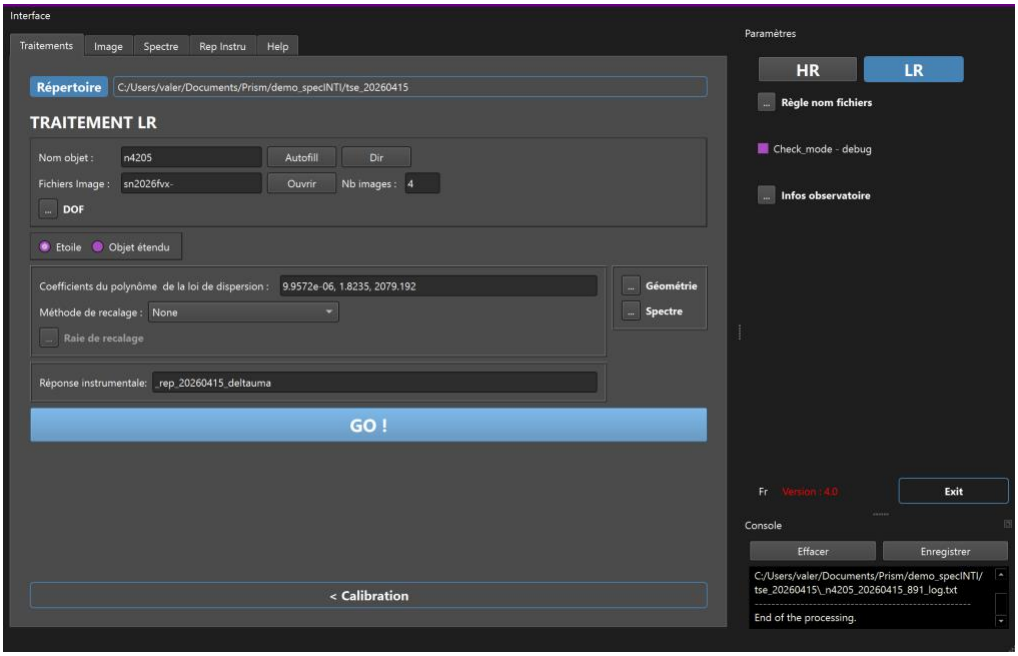


ID1	ID2	RA H	RA m	RA s	DEC °	DEC m	DEC s	V Mag	E(B-V)	Sp Type
HD 224893	HD 224893	0	1	37	61	13	22	5.567	0.369	A8II
* 9 Cas	HD 225180	0	4	14	62	17	16	5.884	0.620	A1II-III
HD 319	HD 319	0	7	47	-22	30	31	5.923	0.440	A1VbmA2_IB
* tet And	HD 1280	0	17	6	38	40	54	4.61	0.124	A2V
* sig And	HD 1404	0	18	20	36	47	7	4.52	0.093	A2V
HD 1439	HD 1439	0	18	38	31	31	2	5.875	-0.074	A0IV
* kap Phe	HD 2262	0	26	12	-43	40	47	3.94	0.062	A5IVn
HD 2421	HD 2421	0	28	14	44	23	40	5.173	0.043	A2Vs
* 28 And	HD 2628	0	30	7	29	45	6	5.214	-0.022	A7III

Processing stage

Now click the large **“Processing >”** button at the bottom of the tab, itself called **Processing**, to begin exploiting the night’s spectra. We are now in the routine operating phase of the instrument.

The appearance of the tab is fairly similar to that seen during the calibration stage. In particular, you will again find the input fields for the images of the object to be processed, the DOF, the geometry parameters, and the parameters relating to the spectrum.



*Layout of the **Processing** tab for reducing spectra acquired in low resolution.*

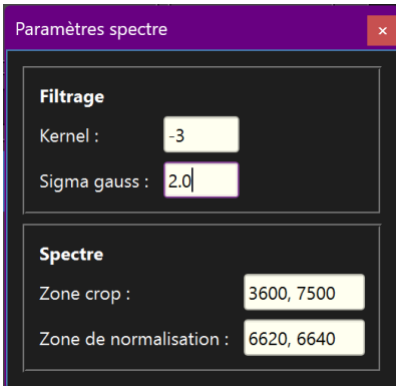
If the observed object is point-like, such as a star, select **Star** mode. This activates automatic computation of the binning zones (adding up the signal columns in the image) as well as the zones used to evaluate the sky-background level.

If the object is spatially extended, such as a nebula or a galaxy, select **Extended object** mode. **SpecINTI** then gives access to a floating **Binning** dialogue box, which allows you to manually adjust the binning width and the parts of the image used to evaluate the sky-background signal, column by column.

Note that the dispersion-law coefficients determined during the calibration stage are automatically carried over. They are transferred to the processing stage and remain stored until a new calibration is performed. The name of the instrumental-response file is likewise carried over automatically.

Bear in mind that if you are processing observations made on a different night from the one used to calibrate the instrument, you need to copy the DOF files and the instrumental-response file into the new working directory.

You should then check the geometry parameters and those relating to the spectrum. Adjustment of the instrumental-response filtering is no longer available at this stage. However, the median- and Gaussian-filter parameters can be freely adjusted according to the noise level and the desired result.



A screenshot showing text, screen capture, number, automatically generated description

In summary, no additional parameters are required to process the objects of an observing night once calibration has been carried out. Simply select the object to be processed, then click **GO!**

At the end of the reduction, the application automatically switches to the **Spectrum** tab, which displays the result.

Standard interface in high resolution (HR)

While the overall reduction procedure is similar in high and low resolution, a few differences should be noted.

In high resolution, using a spectral reference lamp is necessary in order to carry out the instrument's spectral calibration. This emission-line spectral source may be used before or after each acquisition sequence, or continuously, at the same time as the target is being observed, placed briefly at the entrance of the telescope.

Naturally, it also remains necessary to determine the instrumental response, by observing a reference star whose spectrum is otherwise known.

Calibration stage

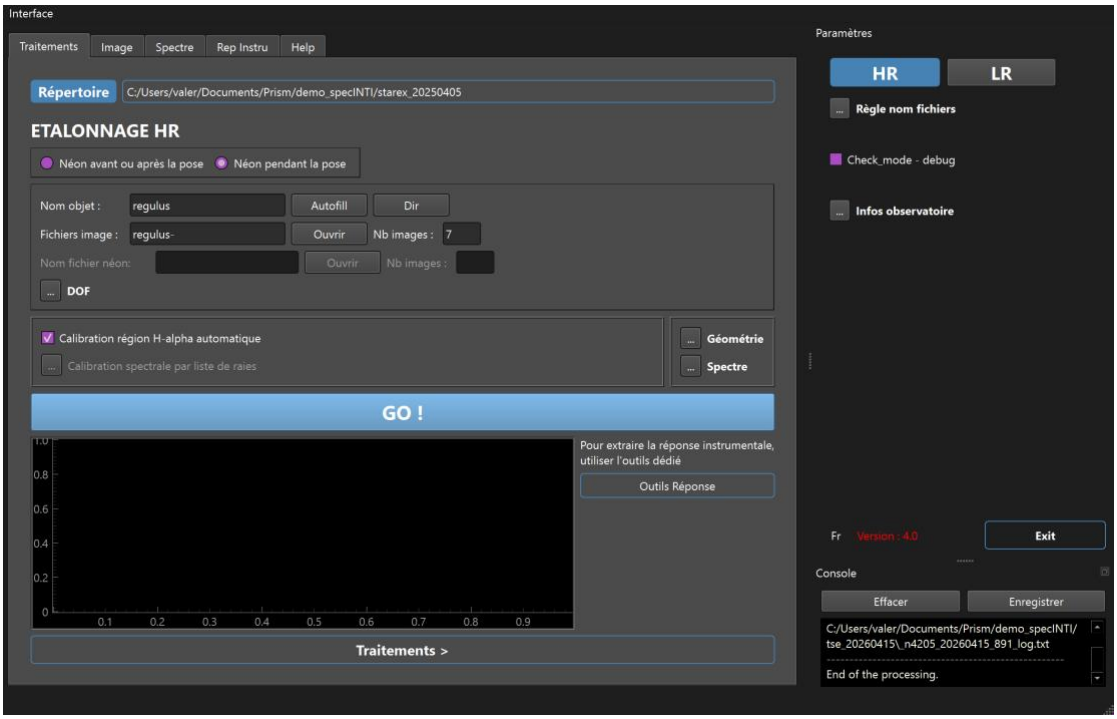
The star used to establish the instrumental response is preferably of spectral type A or B, bright enough to obtain a spectrum with a good signal-to-noise ratio in a relatively short time. The

principle is to compare the observed spectral profile of this object with its actual spectral profile taken from a spectral library.

The first step is therefore to extract the spectral profile from the raw two-dimensional images.

We assume that the spectral region observed is centred on the Hα line. In the illustrations that follow, we also assume that the spectral lamp illuminates the telescope's aperture for the entire duration of the exposure on the selected reference star (here the star Regulus). This is a neon lamp. Its emission lines therefore become superimposed on the spectral trace. This is known as the **side-by-side** ("lateral") calibration mode. This simultaneous acquisition of the target spectrum and the spectral lamp tends to provide a more accurate calibration (reducing the effect of differential flexure).

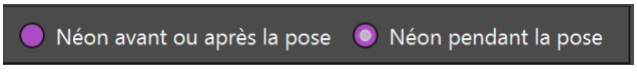
Switch to **HR Calibration** mode, as shown in the screenshot below.



*After selecting the **HR** option in the parameters, switch to **HR Calibration** mode by clicking the large "< Spectral calibration" button, which immediately becomes "**Processing >**".*

Method of using the neon lamp

In this example we use the side-by-side mode, which means that the **Neon during exposure** option must be selected (at the top of the **Processing** tab):



Naming the target object providing the reference spectrum

Enter the name of the star, then click **"Autofill"**, or select an image from the sequence directly, as described earlier in the section devoted to **LR** mode.

When the neon-lamp images are separate from the object images, choosing **Neon before** or **Neon after exposure** activates the **Neon file name** field. This is not the case here.

If you have entered the object name and the naming rules have been followed, clicking **“Autofill”** automatically fills in all the fields. Otherwise, use the **“Open”** buttons to select, in turn, an image from the object’s sequence, then an image of the neon lamp.

DOF

Enter the names of the **Dark**, **Offset**, and **Flat-field** images in the **DOF** section.

Spectral calibration

When the spectral range covers the region of the Hα line, **specINTI** has an algorithm that automatically detects the neon lines, measures their position, and identifies their wavelength in order to establish the dispersion law. All you need to do is tick the **Automatic H-alpha region calibration** box.

If the spectral range is different, untick the **Automatic Hα region calibration** box, then use the interactive line-identification tool for the reference lamp. This tool is presented further on.

Geometry

In high resolution, the spectral image generally shows several geometric distortions caused by the optical system and by the adjustments made. In particular, we distinguish:

- **Tilt**, which corresponds to the inclination of the spectral trace (a camera-orientation defect);
- **Slant**, which describes the mean inclination of the lines with respect to the vertical (a spectrograph-slit orientation defect);
- **Smile**, which describes the curvature of the lines (a natural effect in most spectrographs with a strongly dispersive element).

For stellar spectra, **specINTI** is able to automatically correct for **Tilt** and **Slant**. The **X_limit** coordinates are used only to delimit the zone within which the automatic search for **Tilt** is carried out (choose a relatively wide range, a few hundred pixels).

The **Smile** still needs to be computed, using the interactive tool in the **Geometry** window. Click the “@” button; a rectangle then appears at the centre of the image.

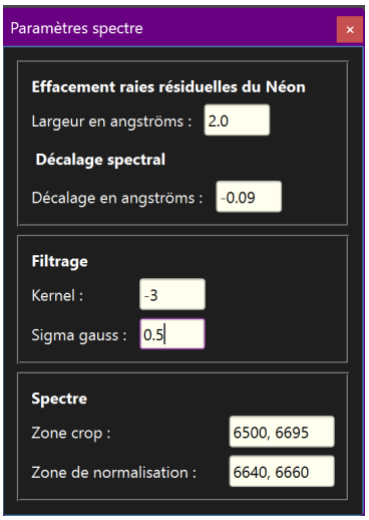
Using the mouse, right-click and drag to move the rectangle onto a neon line. If necessary, adjust its size using the diamond-shaped handle in its top-right corner.

As soon as the mouse button is released, the **Smile** value is computed and displayed. The value shown corresponds to the **radius of curvature**, expressed in pixels, of the selected line. A negative value means that the centre of the circle fitted to the shape of the line lies to the right of the image.

Click the window's close box to save the parameters.

Spectrum

This section again contains the filtering, **crop** (windowing), and normalisation parameters already presented in the section on LR mode.



A screenshot showing text, screen capture, display, software, automatically generated description

Two new parameters appear here, specific to high-resolution reduction.

Removing residual neon lines

When the neon lamp remains on during acquisition of the star's spectrum (side-by-side mode), and a value is assigned to the **Residual neon line removal** option, **specINTI** applies a cosmetic correction to possible artefacts at the locations where the lines of the spectral lamp overlap the trace of the spectrum under study. The affected areas are smoothed by linear interpolation over a width, in angstroms, that you specify (2 angstroms in the example above).

Spectral shift

At the end of processing, a spectral shift can sometimes be observed in the computed spectrum relative to the theoretical wavelengths. There are various reasons for this. You can compensate for this wavelength shift by entering a value in angstroms, including fractions of an angstrom. Beware here of a common mistake: applying this shift to a spectrum where it is needed, but then also applying it to subsequent spectra that do not need it, because you forgot to reset the **Spectral shift** field to 0. We will see another technique for this when discussing the advanced interface.

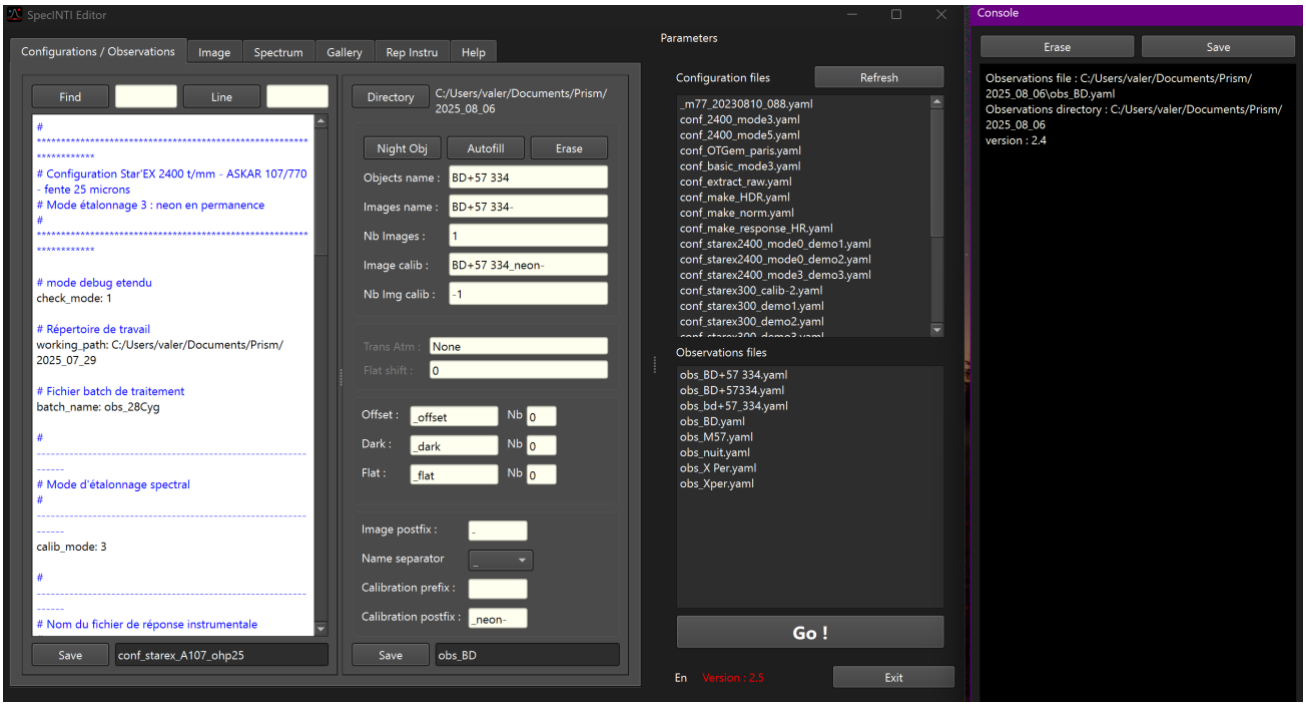
Processing stage

As in low resolution, the processing interface changes little. However, note the presence of a **Response tool**, which allows you to interactively evaluate and adjust the instrumental response from the observation of a standard star.

For a detailed description of this tool and how to use it, please refer to the **User Guide** document.

Advanced interface

This mode allows full manual editing of the configuration files, and hence the use of every parameter offered by **specINTI**.



A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

Configuration / Observations tab

The **Configuration / Observations** tab is the control tower of **specINTI Editor**'s advanced mode.

The relative size of the **Configurations** and **Observations** areas within the tab is adjustable. To change it, place the mouse pointer on the divider between the two areas, at the three dots, until the cursor changes appearance.

In the **Parameters** section of this tab, the upper part displays the contents of the **_configuration** directory, that is, all the **configuration files** you have created for your various reduction situations. The lower part shows the **observation files** associated with the objects of the current session, once they have been defined.

On the right-hand side of the window is the **Console**, which lets you follow the progress of the operations and view the information or error messages generated by the application.

To edit an existing configuration file, simply click on its name in the **Configuration files** list. It can then be edited like a plain text file in the editing area on the left.

The list of configuration files present in the **_configuration** directory, located within the application directory, is shown in the upper-right part of the tab, in alphabetical order, in the **"Configuration files"** section.

If you add a new file to this directory without restarting the application, click the **Refresh** button to update the list.

Select the desired configuration file with a single mouse click: its contents are then displayed as text in the editing area on the left. It can then be modified. To save the modified version of the configuration file (in **YAML** format), simply enter a new name, then click the **Save** button located at the bottom left of the tab.

When **specINTI** automatically updates certain keywords, these are shown in **green**.

The **Search** button, together with its input field, lets you search for a word or expression within the configuration file.

The **Line** button, together with its input field, lets you jump directly to a given line number.

The editing area for an **observation file** is located immediately to the left of the **configuration file** editor.

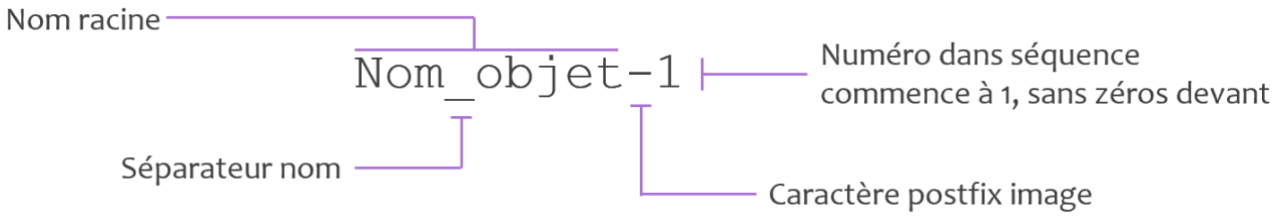
To carry out this editing work, first tell the software the path to your session using the **Browse** button. Note that you need to choose a **directory**, not a file.

The list of files with the **.yaml** extension present in this directory is then displayed in the **Observation files** section, as seen previously.

All fields can be edited manually, and it is possible to start from an existing file.

Naming rules

To make effective use of this editing tool, it is strongly recommended that you adopt a consistent naming convention.



A screenshot showing text, font, screen capture, line; AI-generated content may be incorrect.

Simply define the prefixes and postfixes for the image file names, as well as the character used to turn the object name into a file name.

Image file postfix

Indicates the character(s) separating the root name from the image number in a sequence.

Example:

- etoile-1
- etoile-2
- etoile-3

Here, the postfix is **-**.

Name separator

Defines how the object name is converted into a file name.

The available options are:

- **None**: EW Lac becomes EWLac
- **_**: EW Lac becomes EW_Lac
- **Space**: EW Lac stays EW Lac

The use of spaces in file or directory names is, however, discouraged.

Calibration file prefix

Indicates the character(s) placed before the root name of the calibration file.

Example:

- prefix: a
- resulting file: aetoile-1

This field can be left blank if no prefix is used.

Calibration file postfix

Indicates the character(s) added after the root name of the calibration file.

Example:

- postfix: _neon-
- resulting file: etoile_neon-1

List of objects

Enter the object names in a format compatible with **SIMBAD**.

Examples:

- EW Lac
- Altair
- HD 6226

SpecINTI can process a sequence of objects with different names automatically (very convenient for handling a large observing session). The object names must then be separated by commas, with or without spaces.

Example:

Altair, EW Lac, 60 Cyg, omi Cas

Offset, Dark, and Flat images

Enter the image names together with their postfix.

Examples:

- o-
- n300-
- f-

or directly the master images:

- _offset
- _dark
- _flat

The master images must be present in the observation-session directory.

Autofill function

Once the list of objects and the master images have been entered, click **Autofill**, provided your file names follow the convention defined earlier.

The following fields are then filled in automatically:

- List of images;
- Number of images per object;
- List of calibration images;
- Number of calibration images;
- Number of offset, dark, and flat images.

This very convenient function performs the following operations:

- replaces spaces in object names with the chosen separator to create the root name;
- automatically searches for and counts the images corresponding to each object;
- adds the prefixes and postfixes to build the calibration image names;
- counts the offset, dark, and flat images, or keeps the value **0** when only a single image is found, in accordance with the **specINTI** standard. In that case, the file is considered to be an already generated master image.

It is therefore strongly recommended to adopt the correct naming convention from the moment of acquisition, so that all the fields can be filled in automatically with a single click.

Examples of file names

Star images

- gamcas-1
- v442_and-1
- HD192685-1

Calibration images

With postfix:

- gamcas_neon-1
- v442_and_neon-1
- HD192685_neon-1

With prefix:

- agamcas-1
- av442and-1
- ahd192685-1

The following illustration shows an example of automatic filling after manually entering the list of objects and the master images.

A screenshot showing text, screen capture, software, multimedia software, automatically generated description

If you do not use a particular naming convention, or if you want to change a file name or a number of images, you can of course edit each field manually.

For example, if a calibration image is missing for a given object, it is possible to replace its name with that of another calibration file acquired at a nearby time.

You can also start from an existing observation file. To do this, click one of the files shown in the list on the right. This is useful for correcting an error or changing one or several parameters.

Once you have finished making changes, enter the name of the observation file and click **Save**. This file will also be saved automatically when the reduction is launched.

Tip

When changes are made in one of the fields of the **Observations** section, the profile file name is shown in **red**. This colour indicates that the file will be saved with the new changes the next time it is saved.

If you want to keep the existing version, simply change the file name. It then turns **white** again, indicating that a new file will be created.

“Obj Nuit” button

The **Obj Nuit** (“Night’s objects”) button is a tool designed to make it easier to build the list of objects observed during a night.

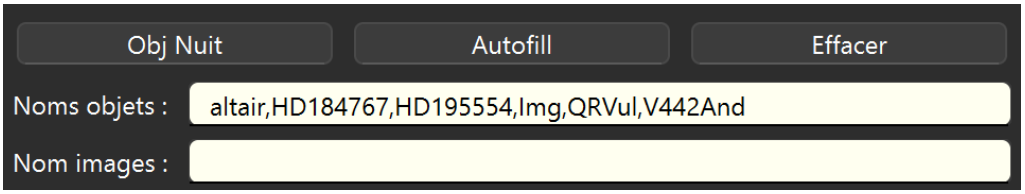
It works as follows:

- it searches for all files whose sequence number is **-1**;
- it extracts their root name;

- it automatically enters these names into the list of objects.

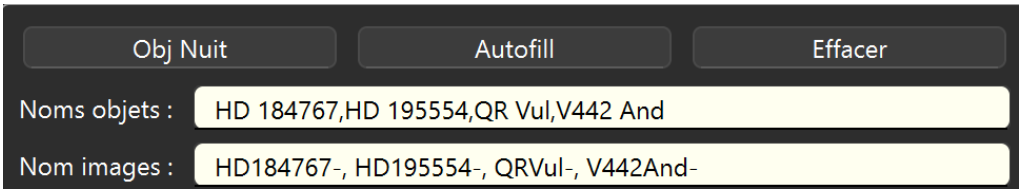
You then simply need to delete any irrelevant entries and add the necessary spaces to obtain names that conform to the **SIMBAD** nomenclature, as explained earlier.

For example, for a given observation directory, the algorithm might produce a list containing the following names:



A screenshot showing text, screen capture, font, automatically generated description

In this example, we remove **Altair**, already processed, and **Img**, which corresponds to a test image. We then add the necessary spaces to obtain names compatible with **SIMBAD**, and click **Autofill**.



A screenshot showing text, screen capture, font, number, automatically generated description

“Dir” button

The **Dir** button displays, in a window, the list of FITS files present in the current directory.

This function is particularly useful for quickly checking the name of the images, that of the instrumental response, or any other file used during reduction.

Advanced mode

Advanced mode gives access to two additional parameters:

- **Atmospheric transmission file list**: list of atmospheric transmission files associated with each object;
- **Flat shift list**: shift, in pixels, applied to the flat-field for a correction specific to each object.

By default:

- the lists are initialised to the value **None**;
- when an image file is not found, the corresponding number of images is set to **-1**.

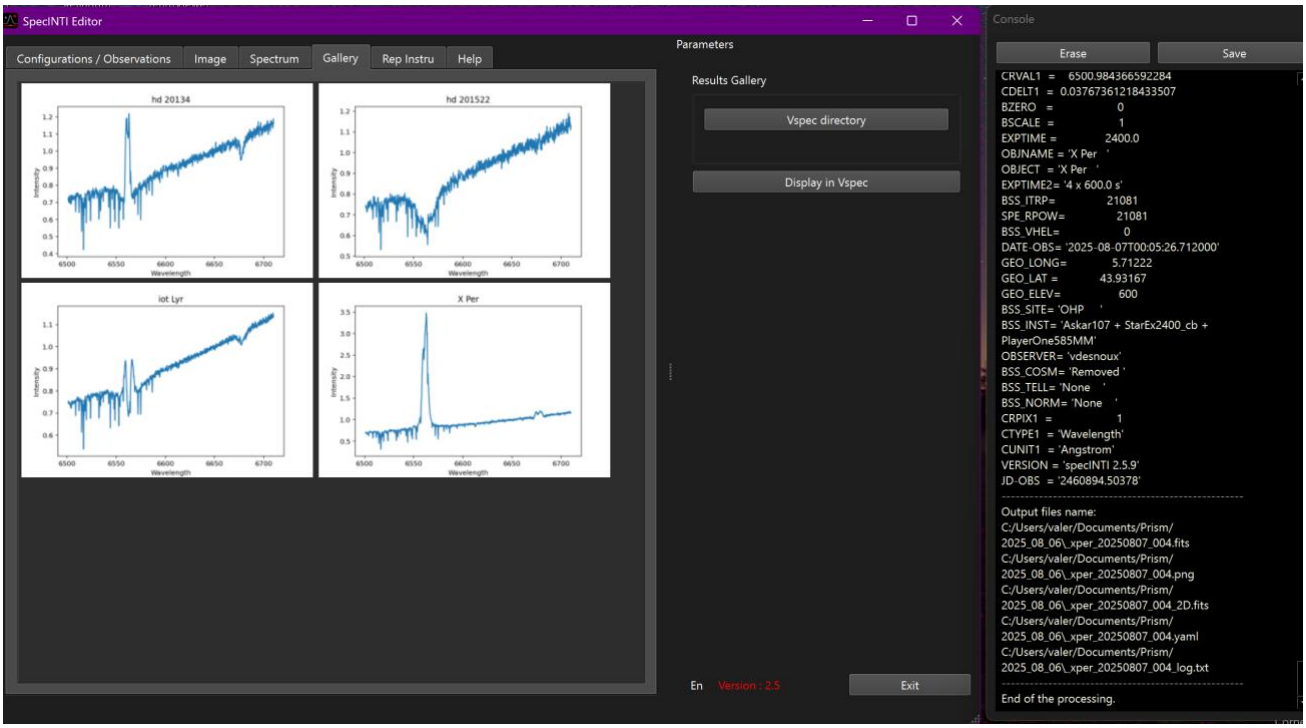
The **Go!** button runs the configuration script currently being edited in the **Configurations/Observations** tab.

Warning: this button automatically saves the changes made to the observation file. The name of the current observation file is also carried over into the configuration file, as the argument of the **batch_name** parameter. This update is also carried out when the observation file is saved.

During processing, the software automatically saves the observation file and the configuration file under the names given in their respective fields.

During processing, after clicking Go!, messages are shown in the console.

At the end of processing, the reduced spectra are shown in the **Gallery**. You can then double-click to open the selected spectrum in the **Spectrum** tab, or display all the spectra in Visual Spec.

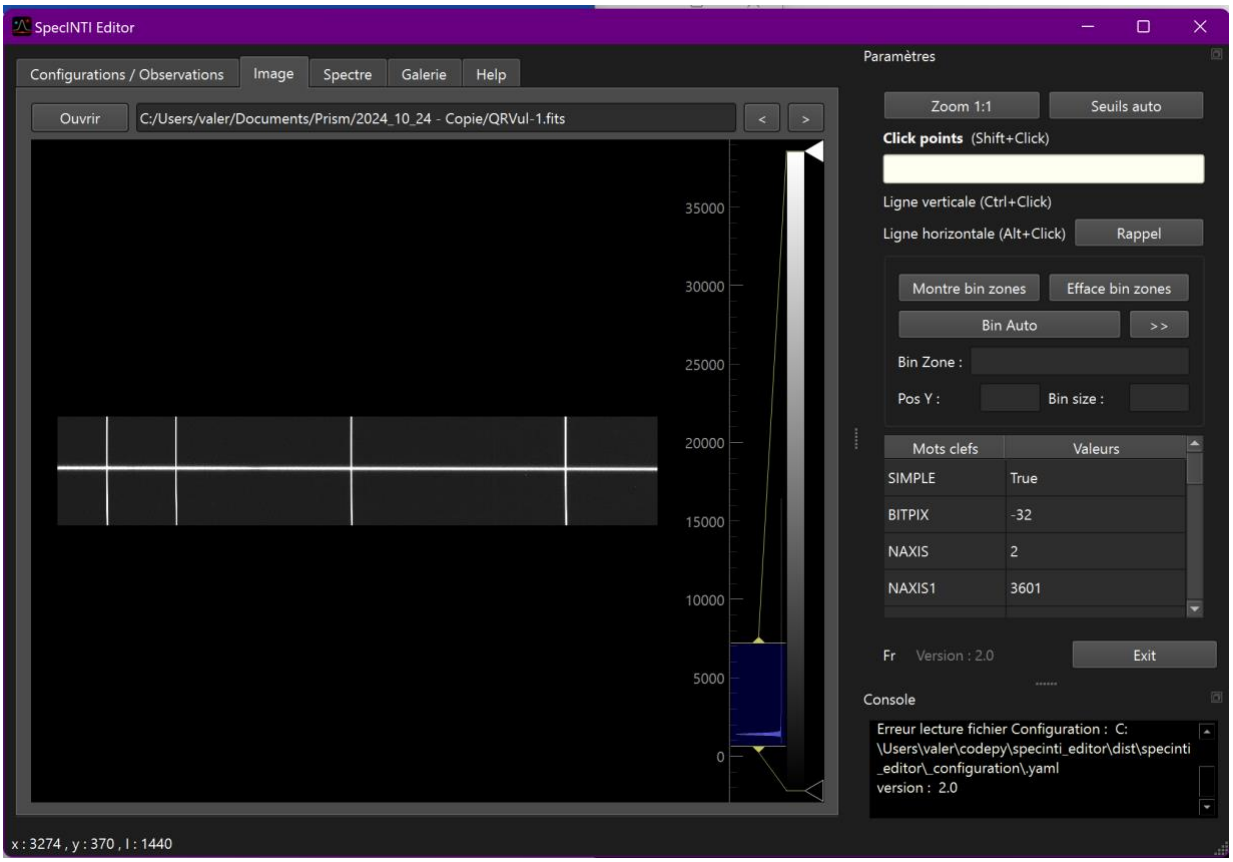


A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

The **Exit** button closes the application after saving the interface settings.

Image tab

This tab is used to display two-dimensional FITS images. It is used to check the quality of individual images, to compute the binning zones automatically or adjust them manually, to locate calibration lines, and to carry out various image-manipulation operations.



A screenshot showing text, screen capture, software, multimedia software, automatically generated description

Navigating the image

The image can be zoomed and panned using the mouse and its wheel.

The **Zoom 1:1** button restores the display to its native scale, with no zoom factor.

If the image has been panned or zoomed out a great deal, a right-click followed by the **View All** command automatically recentres the display.

Contrast and brightness

Contrast and brightness are controlled by two thresholds, a lower and an upper one, which can be adjusted directly with the mouse in the histogram to the right of the image.

Pixel information

The **x**, **y** coordinates, together with the intensity of the pixel under the pointer, are shown in the lower-left part of the window.

Context menu

A right-click opens the context menu provided by the **PyQtGraph** library, which in particular allows the image to be exported in **PNG** format.

Browsing a sequence

If the image belongs to a numbered sequence (name-1, name-2, …, name-n), the **<** and **>** buttons automatically display the previous or next image.

The field containing the image name can also be edited. After making a change, confirm by pressing the **Enter** key.

Marker lines

- **Ctrl + click** (*Command* + *click* on macOS) adds a yellow vertical line.
- **Alt + click** (*Option* + *click* on macOS) adds a red horizontal line.

To remove a line, click on it again while holding down the corresponding key (**Ctrl** or **Alt**).

The **Recall horizontal line** button retrieves the position of the last horizontal line onto another image.

Locating spectral lines

A **Shift + click** records the **x** position of a spectral line.

Each click adds the position after the previous ones in the **Click Points** text box, which remains fully editable.

To copy the entire contents of this box:

- **Ctrl + A**: selects all the text;
- **Ctrl + C**: copies it to the clipboard.

The positions can then be pasted into the **Configurations/Observations** tab, in the configuration-file editing area, after the appropriate keyword.

Automatic binning

The function activated by clicking **Auto binning** uses **specINTI**'s internal algorithms to:

- automatically detect the position of the spectral trace;
- locally straighten this trace by computing the **Tilt** angle;
- estimate the limits of the spectrum;
- automatically determine the binning zone of the spectrum, as well as the sky-background binning zones on either side.

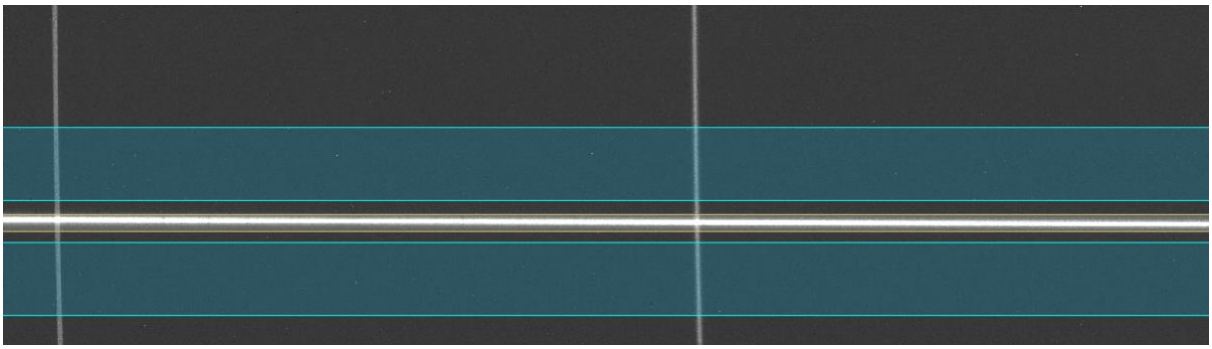
The following configuration-file parameters are then updated:

- **posY**: vertical position of the spectral trace;
- **bin_size**: width of the spectrum binning zone;
- **bin_zone**: width of the sky-background binning zones.

The **>>** button automatically transfers the **bin_size** and **sky** values into the configuration file. As a safety measure, the **posY** value is not transferred.

Graphical editing of the binning zones

The binning parameters can also be edited manually and displayed graphically using the **Show bin zone** button.



A screenshot showing screen capture, line, rectangle, parallel, automatically generated description

The display distinguishes:

- in **blue**, the sky-background binning zones;
- in **green**, the spectrum binning zone.

To modify a zone:

- click inside the zone to move it;
- bring the pointer close to one of its edges: the line turns red;
- click and drag this edge to adjust its position.

The corresponding numerical values are automatically updated in the associated fields.

The **Clear bin zone** button removes this overlay from the image.

FITS header

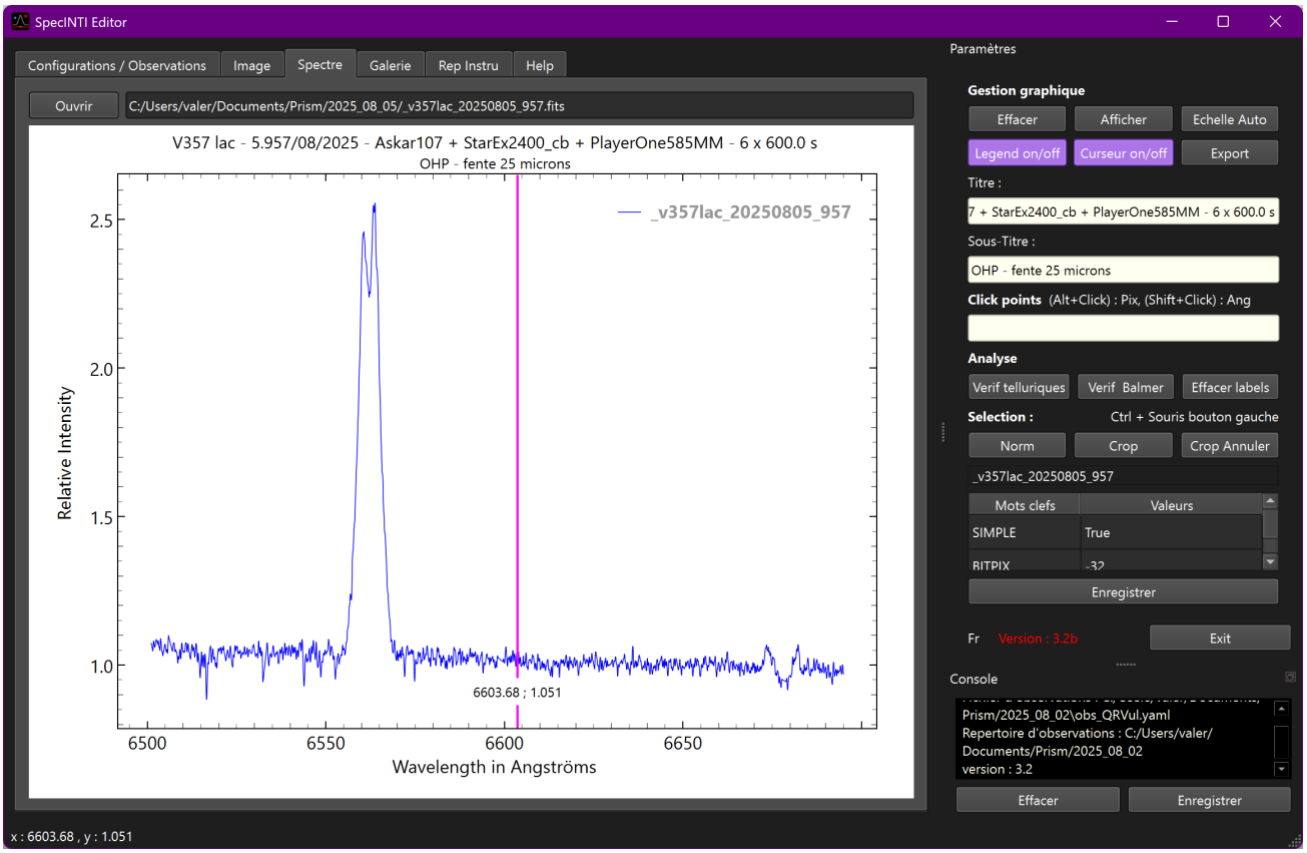
The FITS file header is shown in the lower part of the tab. It can be viewed but not edited.

Spectrum tab

This tab is used to display and analyse spectral profiles saved in **1D FITS** format.

Open a file using the **Open** button.

If a two-dimensional (image) FITS file is selected by mistake, a warning message is shown in the **Console**. The file's FITS header is also shown in the right-hand panel.



A screenshot showing software, text, multimedia software, computer icon, automatically generated description

It is perfectly possible to display several profiles one after another on the same graph, by clicking the **Open** button as many times as you wish. This overlaying of profiles is very useful for comparisons.

Navigating the graph

The mouse wheel zooms simultaneously along both the wavelength and intensity axes.

To zoom along a single axis, use the right mouse button:

- horizontal movement: zoom along the wavelength (x) axis;
- vertical movement: zoom along the intensity (y) axis.

At any time, you can return to automatic scaling by clicking the **Auto scale** button or the small **A** icon in the lower-left corner of the graph.

Legend and cursor

The legend and a vertical cursor are shown by default. They can be turned on or off using the **Legend On/Off** and **Cursor On/Off** buttons.

The legend can be freely moved with the mouse.

The vertical cursor can also be moved along the spectral profile. It shows, in real time, the wavelength and intensity values at the selected point.

Graph titles

When a file is opened, the software automatically builds a title from the information contained in the FITS header.

This title can be edited in the corresponding text box.

A second line, used as a **subtitle**, is also available. It is meant for permanent information, such as the observing site name or the slit width.

After any change to the title or subtitle, confirm the entry by pressing the **Enter** key.

Exporting the graph

Right-clicking within the graph area opens a context menu that allows you, among other things, to:

- Export the graph in **PNG** format;
- View the axis values.

The **Export** button provides the same functionality and directly offers to save the graph in PNG format.

The **Clear labels** button removes all labels, as well as any selection zones shown on the graph.

Saving a profile

The **Save** button lets you save the FITS profile under a different name. This is particularly useful for keeping several versions of the same spectrum, processed with different parameters, for later comparison.

The file name can also be entered or edited manually. Confirm the change by pressing the **Enter** key.

Editing the FITS header

Certain text fields of the FITS header can be edited directly in the grid on the right.

The editable keywords are:

- OBJECT
- OBJNAME
- BSS_SITE
- BSS_INST
- OBSERVER
- BSS_TELL
- BSS_NORM

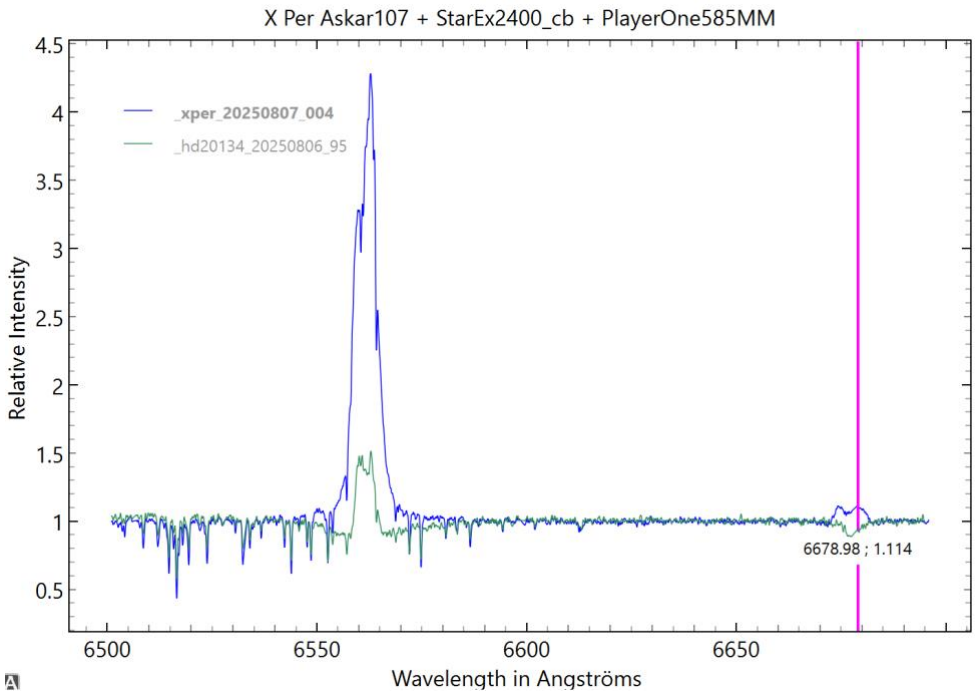
Changes are taken into account when the **Save** button is used.

Selecting a profile

When several spectral profiles are displayed simultaneously, you can choose the one to which subsequent operations will be applied.

To select a profile, click directly on its curve. It briefly flashes and its name appears in **bold** in the legend.

In the example below, the profile of **X Per** is selected. Its name appears in bold in the legend, and the values given by the vertical cursor, positioned on a helium line, show an intensity above the continuum: this line is therefore observed **in emission**.



A screenshot showing text, screen capture, line, diagram; AI-generated content may be incorrect.

The profile of X Per is selected; its name is shown in bold in the legend, and the vertical-cursor readings on the helium line clearly show a line value above the continuum, indicating that the line is in emission.

The **Spectrum** tab includes an analysis section that groups together tools for checking the quality of the wavelength calibration.

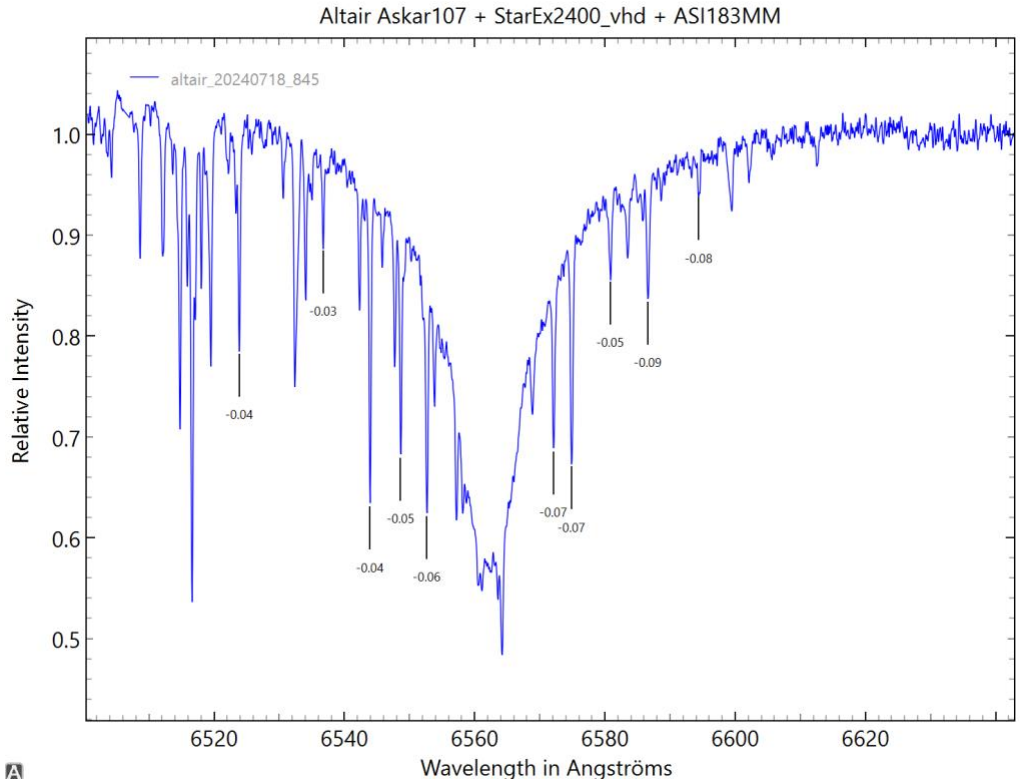
Two functions are available:

- **Check telluric**, intended for high-resolution spectra;
- **Check Balmer**, intended for medium- and low-resolution spectra.

Check telluric

This function displays the position of the main telluric lines on the spectral profile.

It allows you to quickly check the accuracy of the wavelength calibration of high-resolution spectra, by comparing the expected position of the atmospheric lines with their observed position.

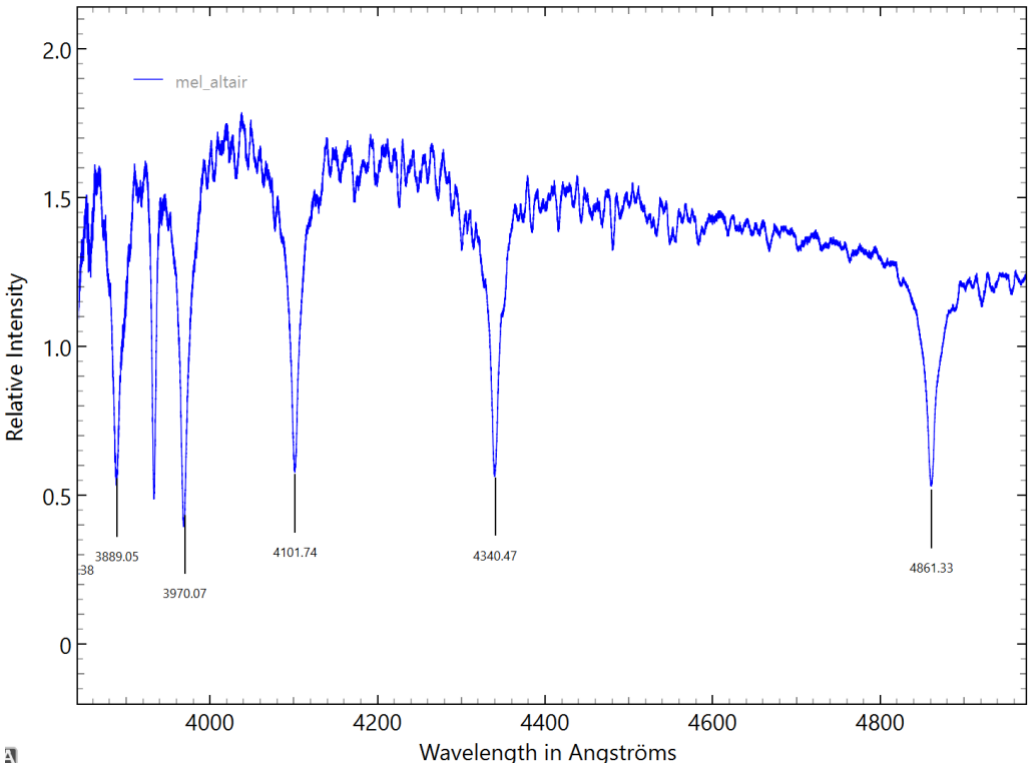


A screenshot showing text, screen capture, diagram, line, automatically generated description

Check Balmer

This function displays the position of the Balmer-series lines.

It is particularly useful for checking the wavelength calibration of spectra acquired at medium or low resolution, by confirming that the main hydrogen lines coincide with their theoretical position.

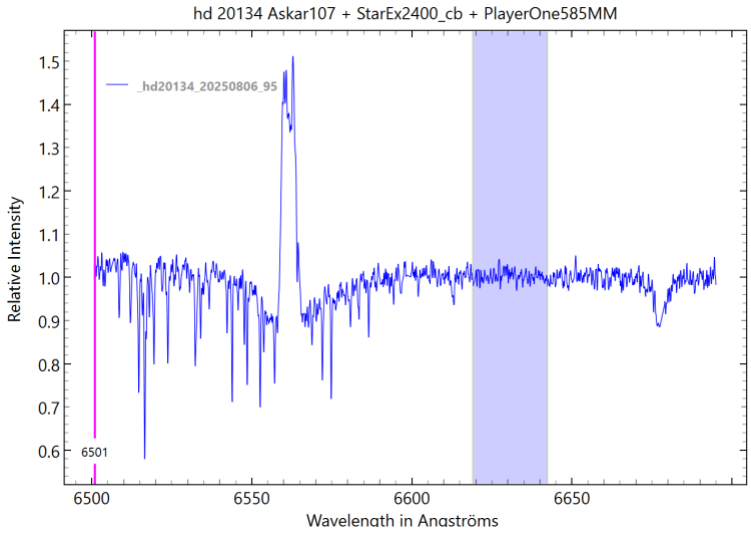


A screenshot showing text, line, screen capture, plot, automatically generated description

You can also perform intensity normalisation and isolate a portion of the displayed spectrum (*crop*), even though these functions are also directly available in the configuration file. These actions can be carried out interactively by selecting a region of the displayed profile with the mouse.

A portion of the spectrum is selected by holding **Ctrl + left-click** and then dragging the mouse to the end of the desired zone.

Once the selection has been made, you can click inside it to move it, or adjust its limits by dragging its edges with the mouse.

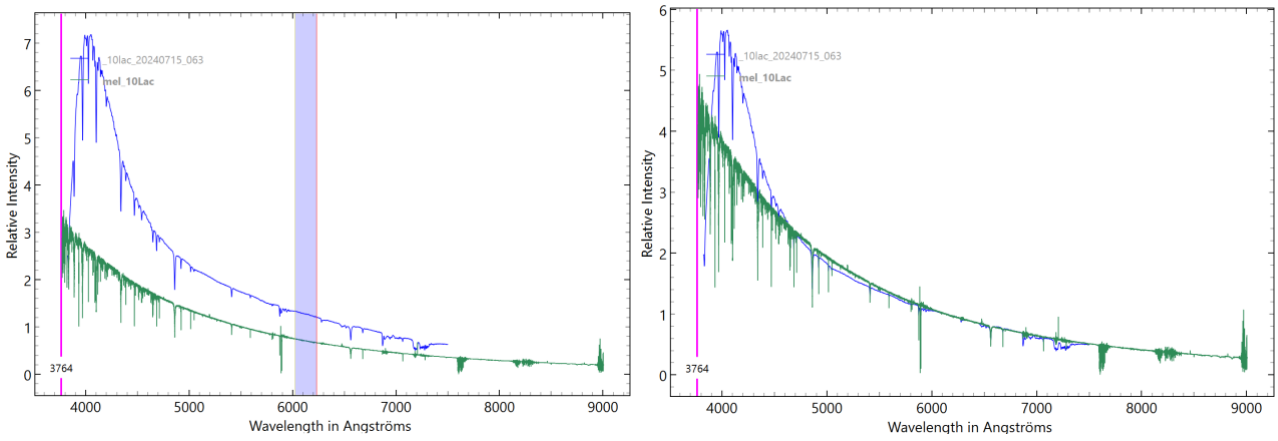


A screenshot showing text, screen capture, plot, line; AI-generated content may be incorrect.

The **Norm** function uses the selected zone to compute its mean intensity, then divides the whole spectral profile by this value.

After this operation, the selected region is therefore centred around the value **1**, which makes it easy to compare several spectra.

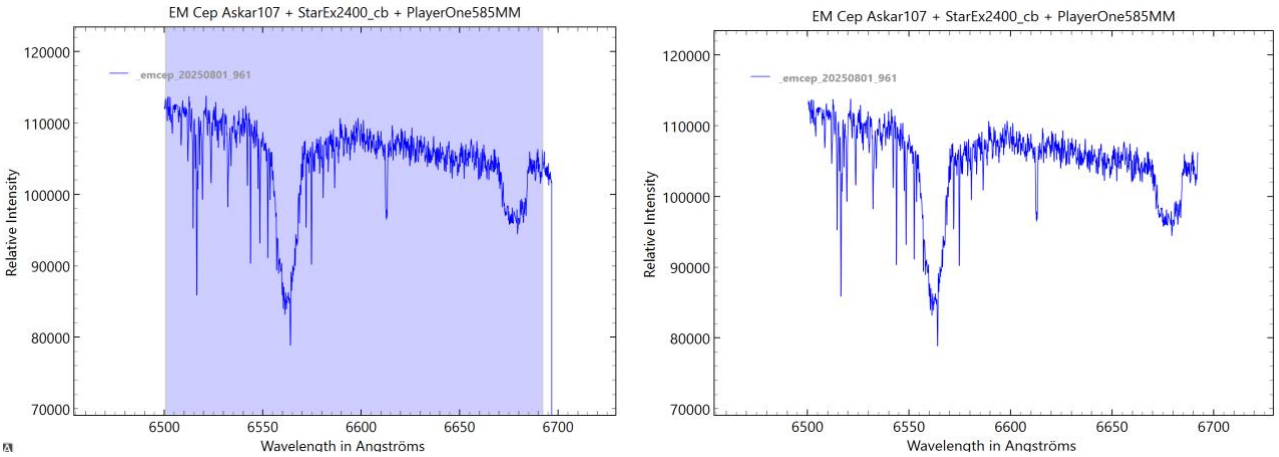
This function is particularly useful when several profiles are displayed simultaneously and are not represented on the same intensity scale.



The **Crop** function lets you quickly remove unwanted parts of the profile, in particular zero-value pixels at the ends of the spectrum, or any processing artefacts.

Select the portion of the spectrum to keep, then click the **Crop** button.

If you want to keep this change, remember to save the profile using the **Save** button.



Before and after the Crop, removing the zero-value pixels on the right.

If two spectra are displayed, **Crop** operates on the selected profile.

The last Crop operation can be undone using the **Crop Undo** button.

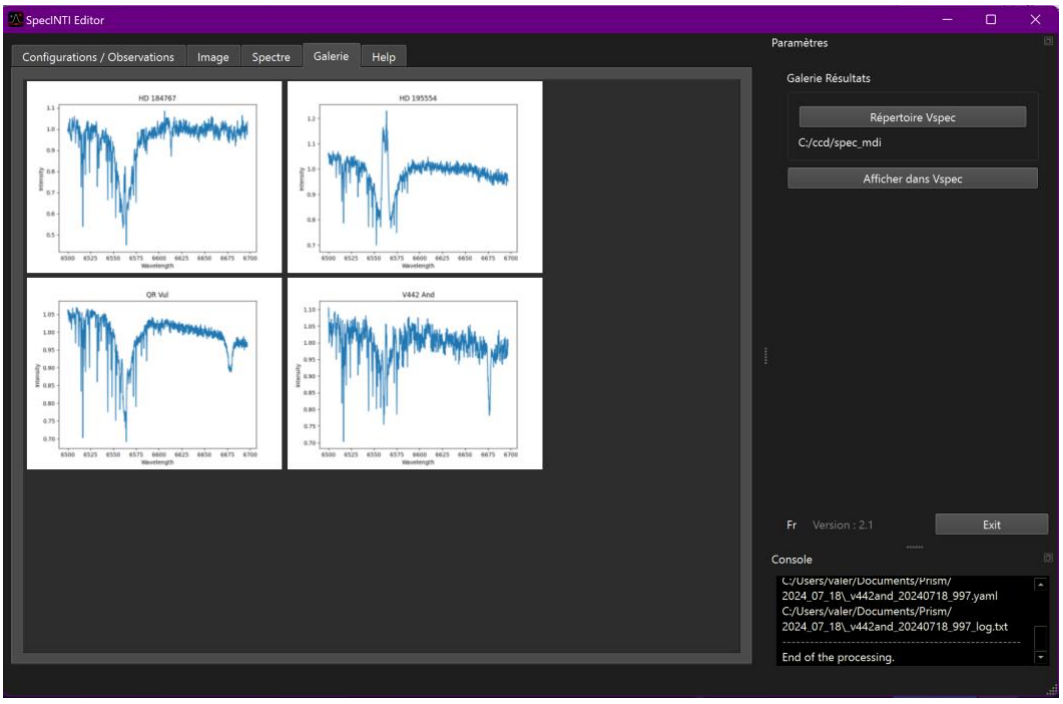
Gallery tab - (Advanced mode)

The **Gallery** tab displays, as thumbnails, the spectra generated by **specINTI** following reductions carried out from the configuration/observation tab, which allows batch processing.

Double-clicking a thumbnail automatically opens the corresponding spectrum in the **Spectrum** tab for detailed analysis.

It is also possible to open the spectra in **Visual Spec**. To enable this feature, you need to specify the path of the directory containing the **Vspec.exe** program.

This feature is available on **Windows** only.

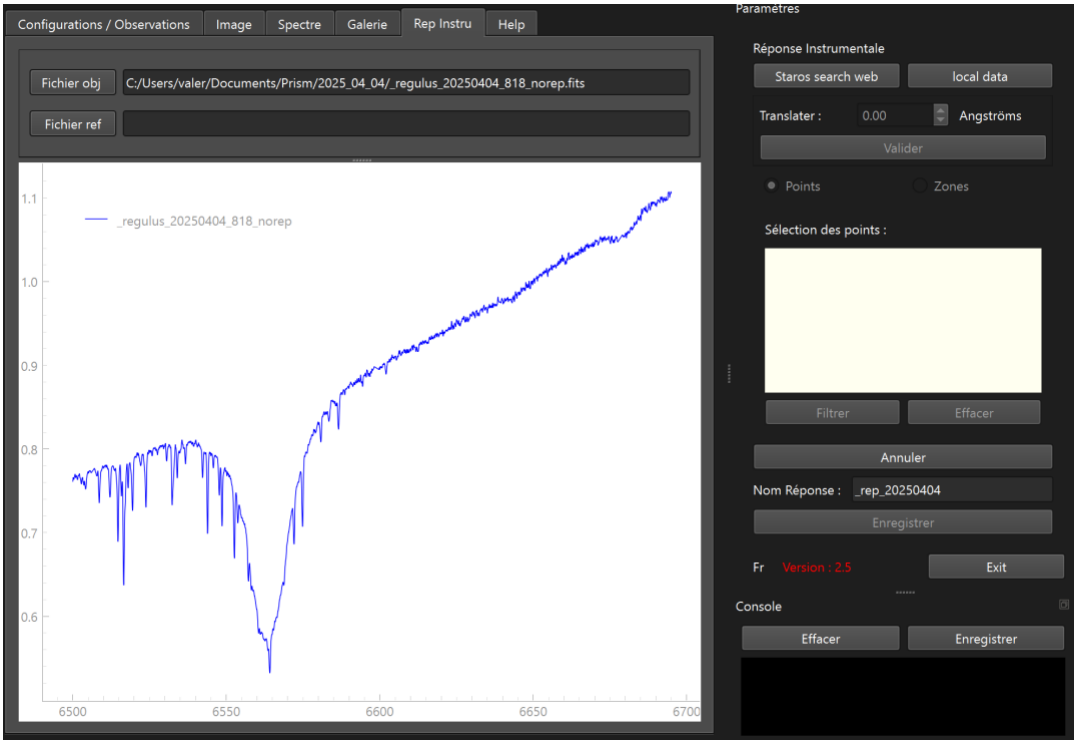


A screenshot showing text, screen capture, multimedia software, software, automatically generated description

Instrumental response tab

This tab is used to compute the **instrumental response** interactively and graphically.

Load the profile of the observed object using the **“Obj file”** button.



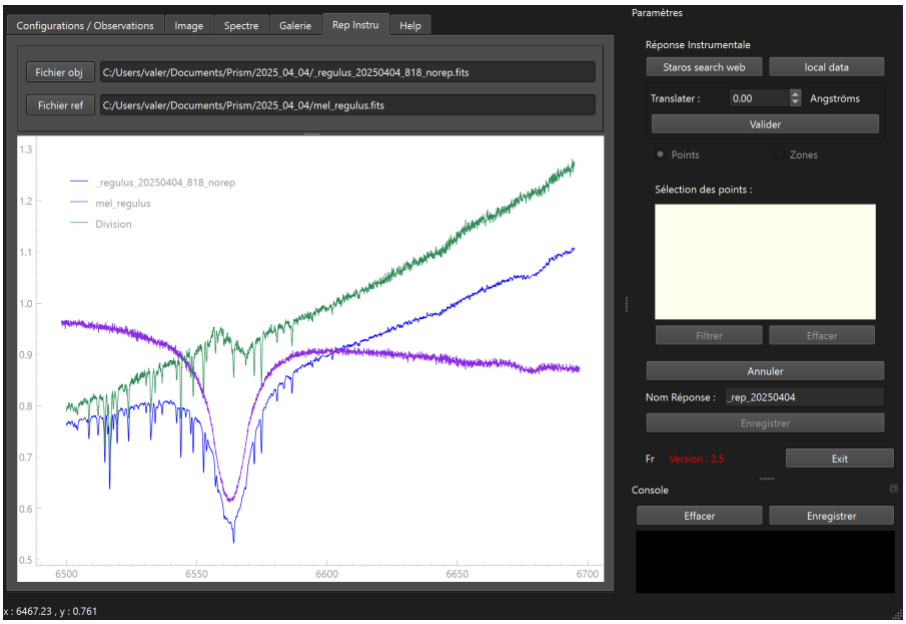
A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

Next, load the theoretical profile of the same object, which you can, for example, download from the **staros-search.org** website, accessible directly via the **“Staros Search Web”** button. You only need a user account to download the corresponding FITS file.

The reference file must be placed in the observations directory, that is, the same directory as the one containing the object’s profile. By convention, it is advisable to name it ref_object_name so that it can be easily found again.

It is also possible to use a local library of reference spectra. Its use is described at the end of this section, in the description of the **“Local Data”** button.

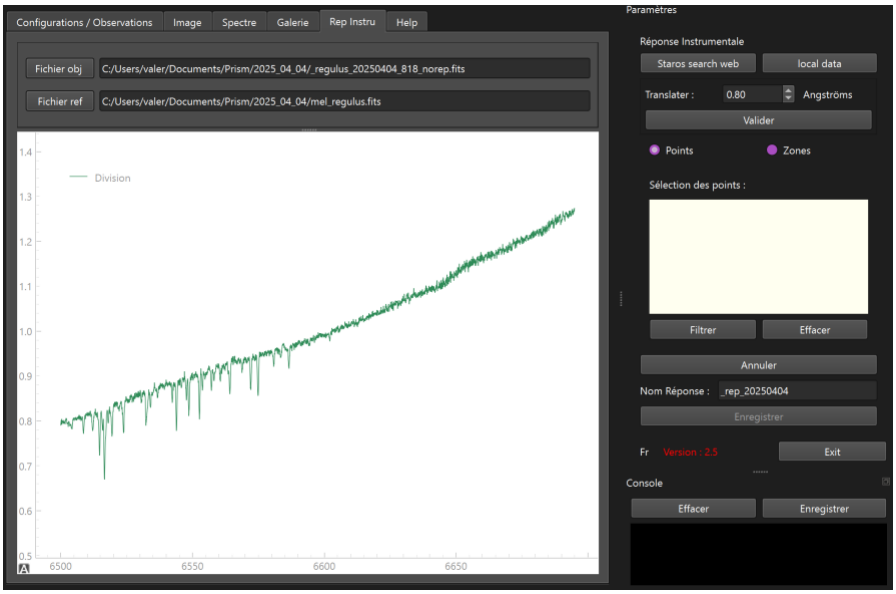
Once both files have been loaded, the interface automatically displays the ratio of the observed profile to the theoretical profile.



A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

In the right-hand panel, adjust the wavelength shift if necessary. This can be changed in steps of **0.1 Å** using the arrows, or by entering a value directly and confirming with the **Enter** key.

Once the shift has been correctly adjusted, click the **"Validate"** button. The display is then restricted to the result of the division, and the filtering tools are activated so that the instrumental response can be built.



A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

Building the instrumental response

To obtain a usable response curve, it is necessary to remove the telluric lines as well as noise-related fluctuations.

Two methods are available:

- **"Points" mode**, recommended for high-resolution spectra;

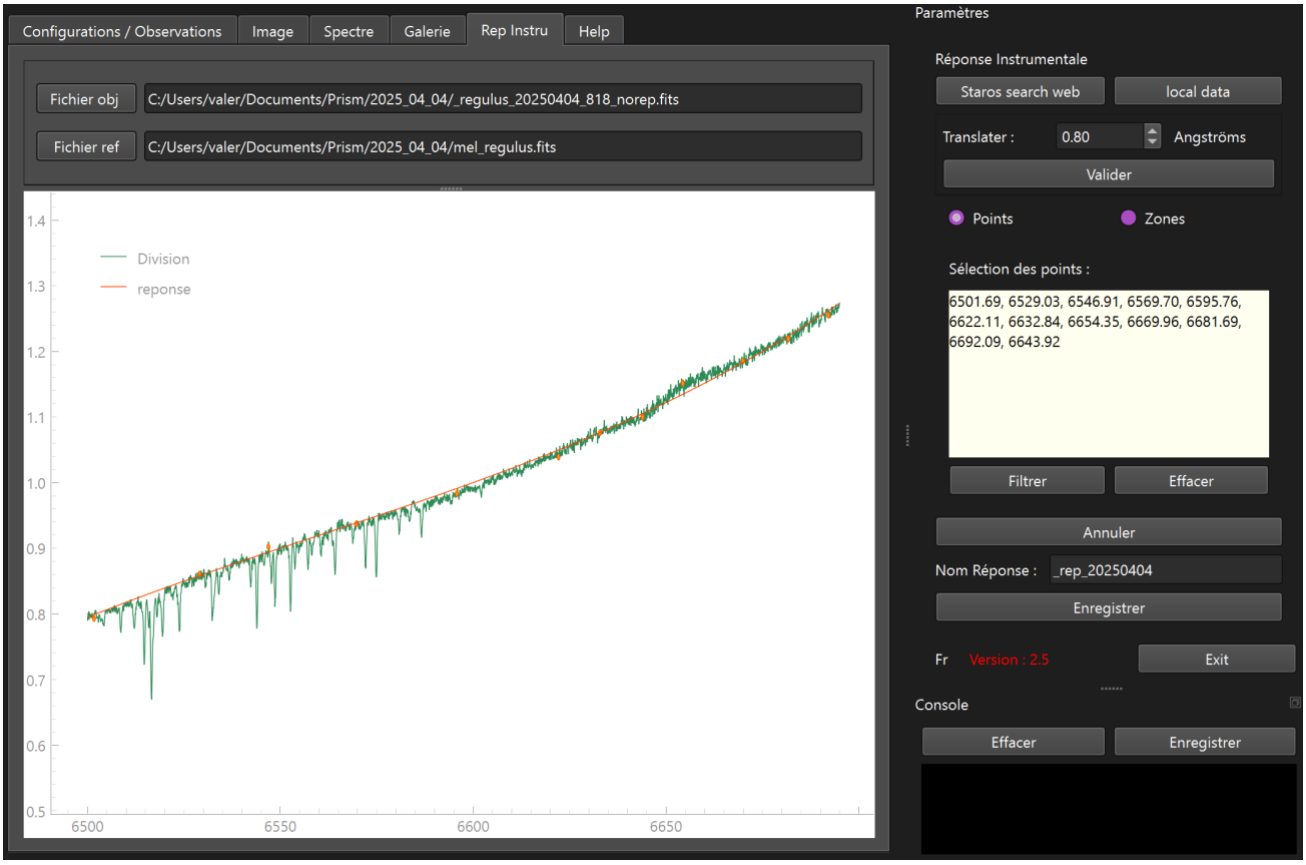
- **“Zones” mode**, suited to medium- and low-resolution spectra.

The difference between these two modes lies in the method used to build the response curve:

- in **Points** mode, a curve is fitted from a set of selected reference points;
- in **Zones** mode, the profile is filtered after excluding the regions disturbed by spectral lines.

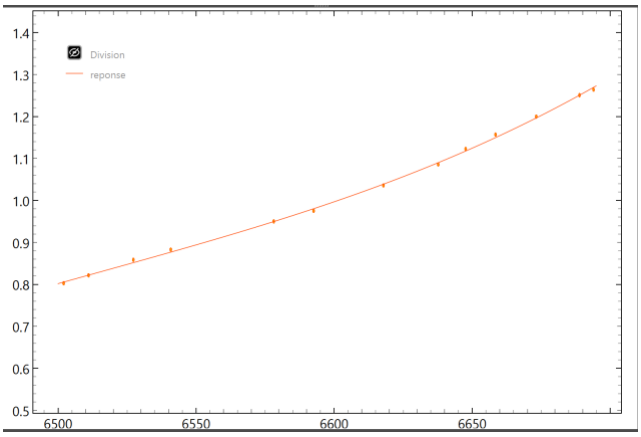
Points mode

Using the mouse, place points on the division curve while avoiding regions containing spectral lines. Once the points have been placed, click the **“Filter”** button to compute and display, in orange, the instrumental-response curve.



A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

If you click, in the legend, on the small green line in front of the name **Division**, you can hide this curve so as to more clearly view the instrumental-response curve.



A screenshot showing text, screen capture, line, plot; AI-generated content may be incorrect.

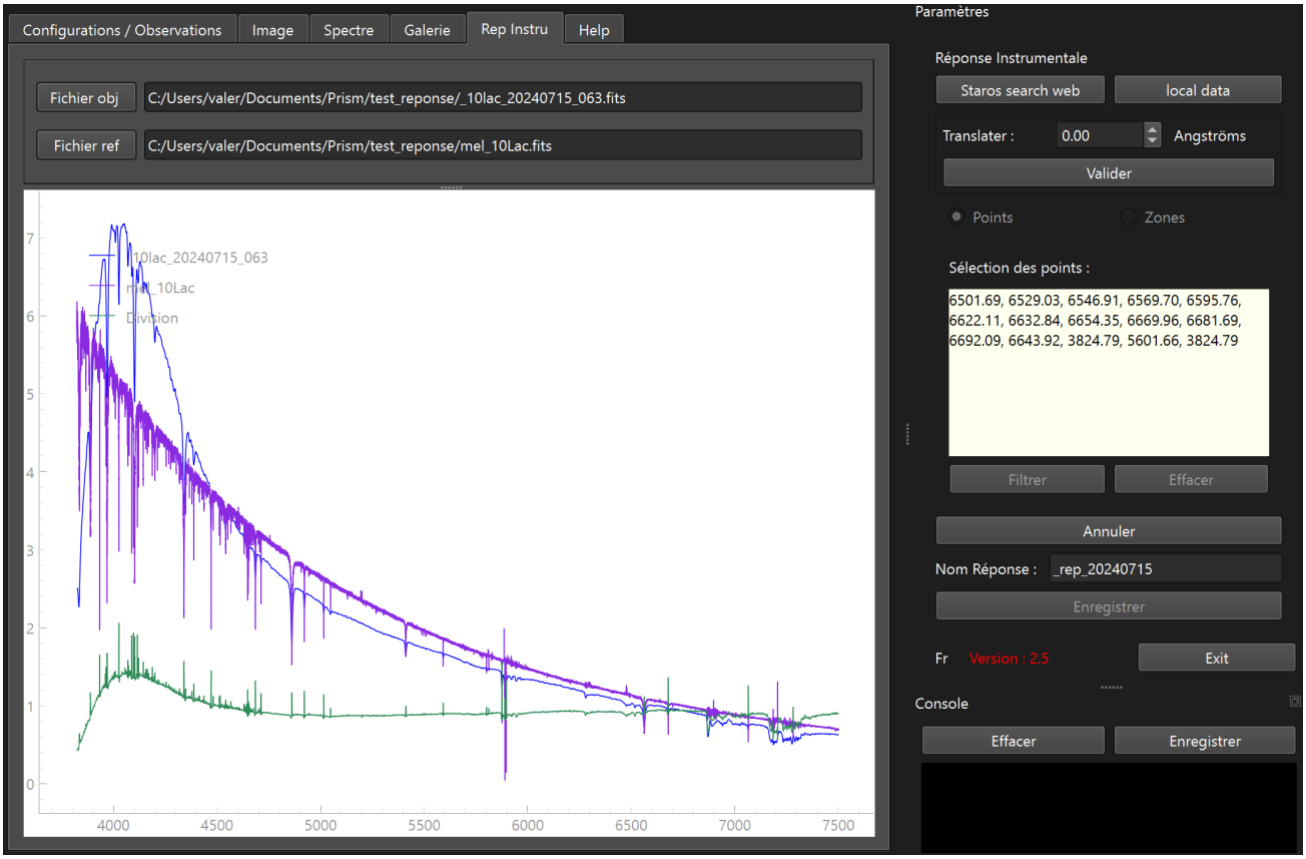
You can delete all the points and start placing them again using the **“Clear”** button.

The **“Cancel”** button lets you go back to the stage before the division was validated.

By default, the application suggests a file name made up of the prefix **rep_** followed by the object’s observation date. Click the **“Save”** button to save the computed instrumental response.

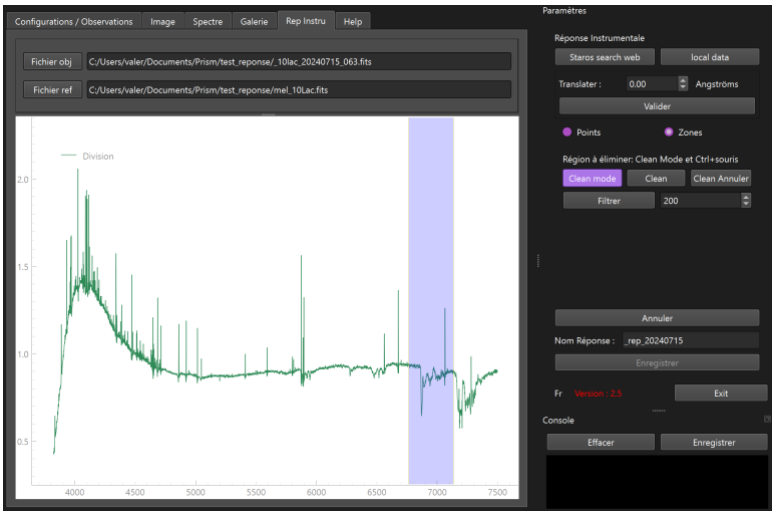
Zones mode

Before continuing, you can use the zoom functions to check whether a further adjustment of the wavelength shift is required.



A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

Then click the **“Validate”** button to confirm the division.



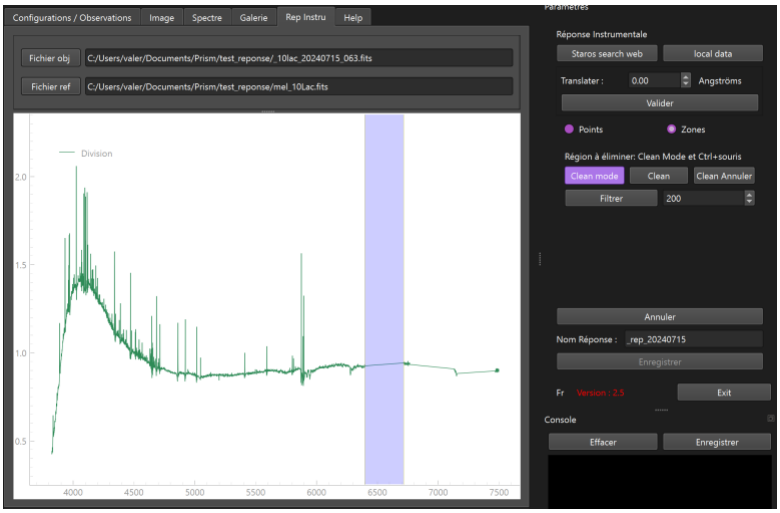
A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

Zones mode gives access to a **Clean** function. Clicking the **"Clean mode"** button makes a rectangular zone appear on screen. Its size and position can be changed directly with the mouse.

Place this zone over a region of the spectrum to be removed, then click the **"Clean"** button. As in the **Spectrum** tab, it is also possible to define a selection using **Ctrl + left-click** and moving the mouse.

Then move the zone and adjust its limits to remove the other disturbed regions. Once this cleaning step is finished, you can move on to filtering the curve.

The **"Crop Undo"** button lets you undo the last cleaning operation (*and only the last one*).



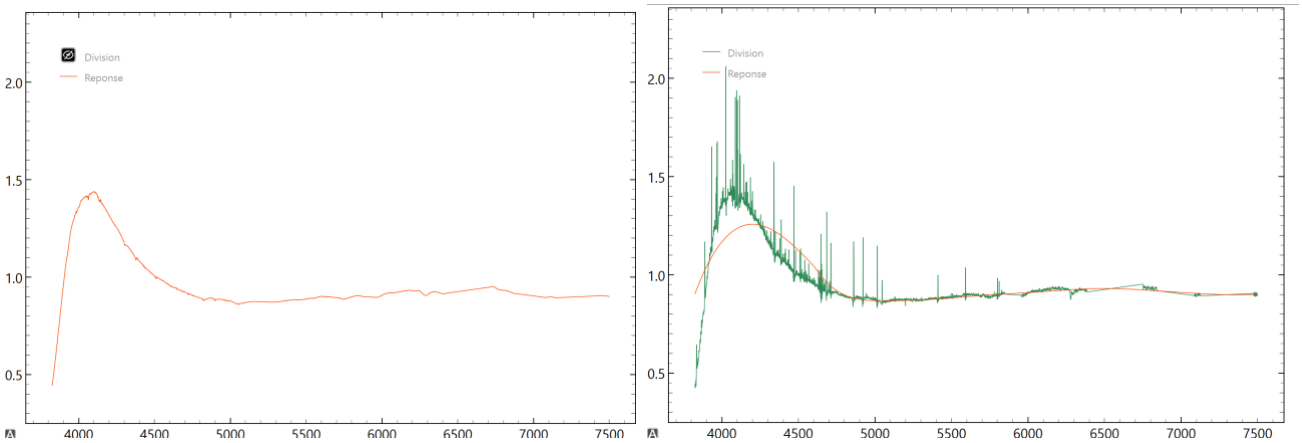
A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

Choosing the filtering

We must now filter this curve to remove residual spectral lines. The filtering value must be chosen carefully:

- too low a value will not sufficiently remove large-amplitude local variations;
- too high a value risks distorting the instrumental response, for example by shifting the maximum of the profile.

The example below compares filtering at **100** (on the left) with filtering at **2000** (on the right).



In this example, a value of **400** provides a good compromise between smoothing and preserving the shape of the profile.

To change the filtering, enter a new value or use the increment arrows, then click the **“Filter”** button again to recompute the instrumental response.

Selecting a local library

In some cases, the reference spectra of the **Melchiors** database are not suited to the user’s needs. For example, for work in the blue or near-ultraviolet, their spectral coverage may be insufficient. It may then be necessary to use a local library of reference spectra.

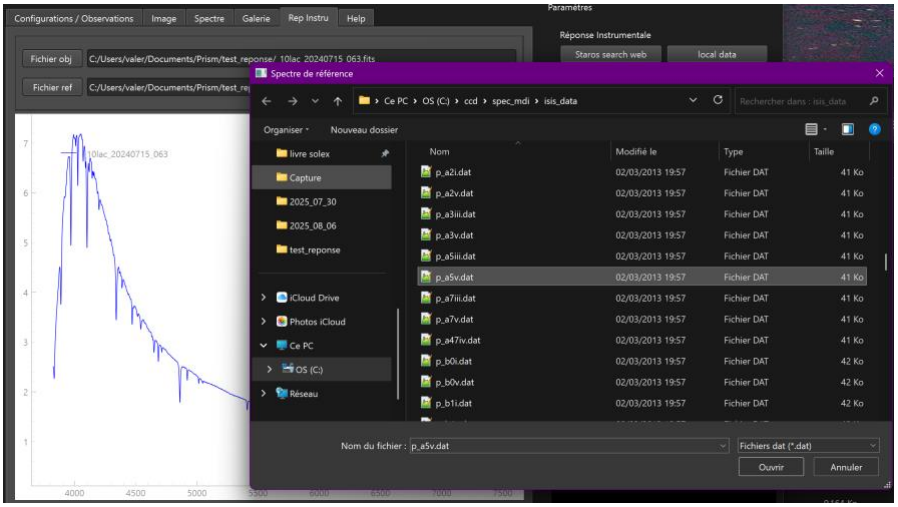
For example, you can download the database supplied with **ISIS**, which in particular contains the spectra of the **Pickles** library:

http://www.astrosurf.com/buil/isis/download/isis_database_v9.zip

Install this library in the directory of your choice.

To open a reference spectrum from this local library, do not use the **“Open”** button; instead, click the **“Local Data”** button.

Then browse the directory tree to the folder containing the local library.



A screenshot showing text, screen capture, software, multimedia software; AI-generated content may be incorrect.

Select the desired file. It may be in **.fits** or **.dat** format.

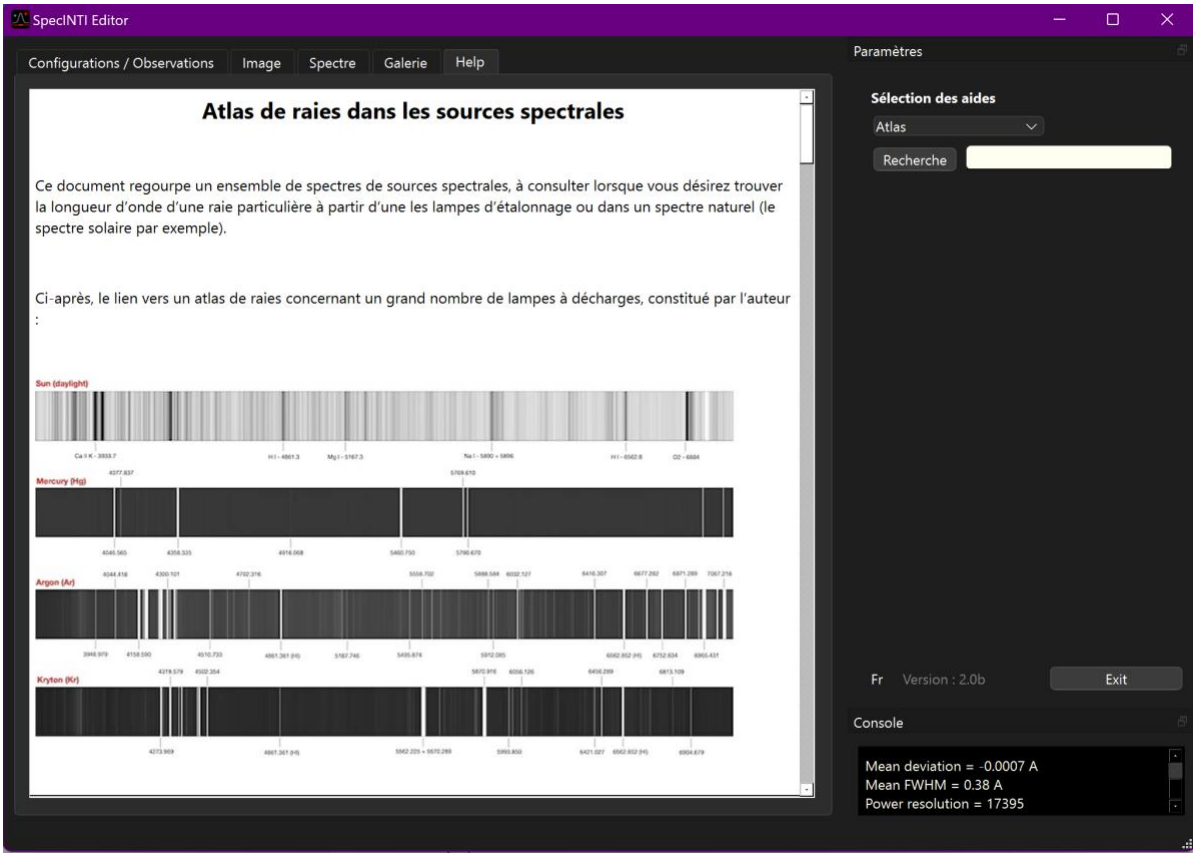
Once the spectrum has been loaded, continue the procedure as described in the previous sections.

Help tab

The **Help** tab is used to consult the documentation of **specINTI Editor** in the form of HTML or PDF files. It notably gives access to the reference manual, an atlas of spectral lines, various help documents, and lists of type-A or type-G stars.

To display a document, select it from the drop-down list on the right.

A text-search function is also available, using the **"Search"** button and its associated input field.



A screenshot showing text, screen capture, software, multimedia software, automatically generated description

Appendices

Appendix 1: running the application on macOS

To run an unsigned application on **macOS**, proceed as follows.

1. Copy the ZIP file into the directory of your choice.
2. Before unpacking it, open a **Terminal** window and enter the command:

sudo xattr -cr /path/to/specinti_mac.zip

Replace /path/to/ with the actual path to your ZIP file.

If the archive has already been unpacked, give directly the path of the directory containing the application:

sudo xattr -cr /path/to/specinti_mac/

3. The sudo command requires administrator privileges. The Terminal will therefore prompt you for your macOS account password.

Enter this password, then confirm with the **Enter** key. While typing, no characters are shown on screen: this is normal behaviour.

If the command runs successfully, the Terminal returns no message.

4. You can then unpack the archive (if this has not already been done) and launch the application.

The first time it starts, the loading time can be relatively long, taking up to around two minutes. It is therefore recommended to be patient. Subsequent launches will be much faster.

Appendix 2: restoring standard-interface configuration files

Standard Interface mode relies on the generation of configuration files with predefined names:

- _conf_LR_calib.yaml and _conf_LR_processing.yaml
- _conf_HR_calib.yaml and _conf_processing.yaml

These are present in the configuration folder. If these files are edited by mistake, or simply deleted, it is possible to restore the installed version.

Click the “Restore” menu and select the pair of altered files to restore: either the HR-mode files or the LR-mode files.