

# Demetra

## User documentation

### DC0030A

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# 1 Introduction

Demetra has been developed by Shelyak Instruments as an aid to operate the Alpy 600 spectroscope. Its purpose is to produce - within a single tool, from acquisition to data reduction - fully calibrated spectra.

It is designed to help everyone from beginners starting in spectroscopy to a full set of powerful tools for experienced users. It gives all the required tools in the field. Getting a calibrated spectrum requires the user to collect several sets of images. Demetra guides the user through this process, by listing for each observation all the required images.

Demetra is available in French and English.

The key features of Demetra are:

- All in one software: from raw spectra acquisition to final result.
- Observing session management: color coding for missing data, management of observations as data sets, integrated session log file...
- Open & standard image files format.
- Fully automated data processing... but also fully transparent step by step working (no hidden black box!).
- Useful tools available at the observing stage (real time profile display, saturation alert...).
- *Very flexible: you can use only part of the software (acquisition, session management, data reduction).*

## Recommended path to start working with Demetra

This documentation follows a step by step presentation. We recommend to follow this path:

- Install the software on your computer. The installation comes with some demo files.
  - Read the General Overview below, and learn to recognize the Demetra interface.
  - Play with the demo files, all the way through to the data reduction of these files.
  - Then, run your own observations, to produce your own fully processed files.
- Of course, you can jump directly to the chapter you want, but this documentation is written to help you follow the process from the beginning to the final result (calibrated spectrum).

## 2 Requirements

Demetra works under Windows 7 (or above), 64 bits.

If you want to acquire your own spectra using the Demetra acquisition software you will need to install the ASCOM platform. It is not required if you

only wish to manage and process existing images.  
You need an Alpy 600 spectroscope, or images coming from this instrument.  
Your acquisition camera must be connected under ASCOM platform (i.e. the appropriate ASCOM driver for your camera).

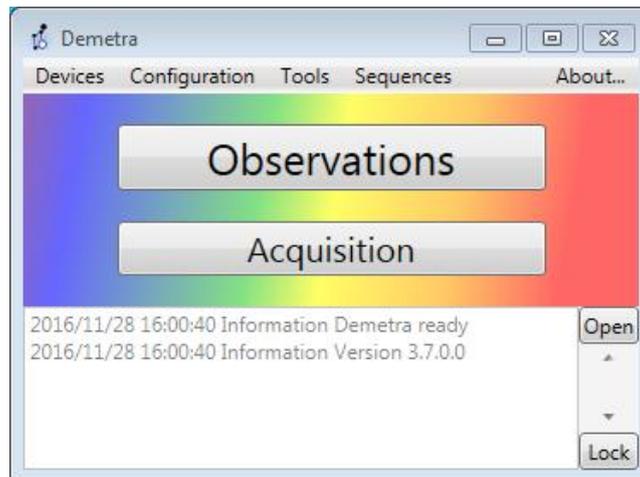
### 3 Installation

The installation is simple: just click on the .exe file, and follow the instructions.  
You can change the software language (to French or English) in the configuration menu. To take the change into account, you must then quit & restart Demetra.

Depending on your usage of Demetra, install the ASCOM platform (see above).  
Most of parameters are saved at the end of a working session: when you launch again Demetra, you'll recover your previous parameters.

### 4 General Overview

When you launch Demetra, you will see a small window with menus, two buttons (Observations and Acquisition) and a log area:



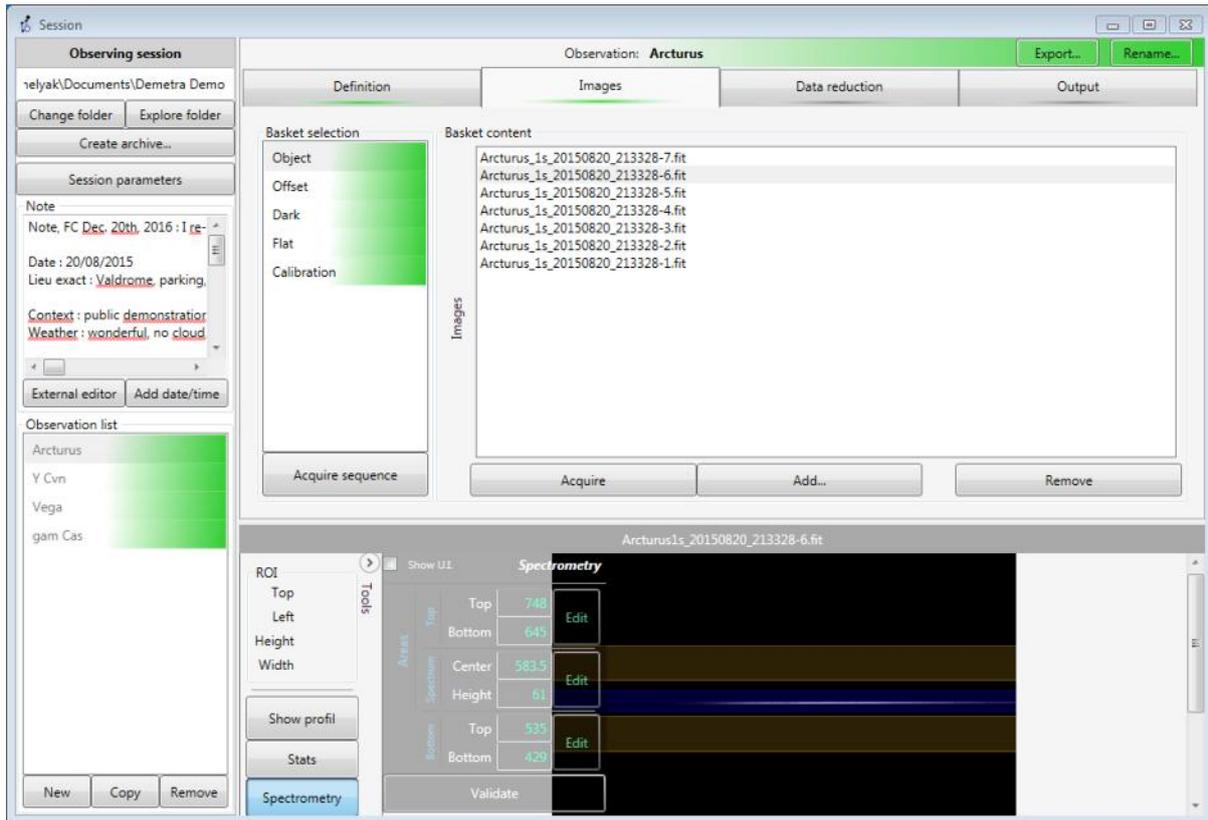
The log is useful for understanding what recently occurred. The complexity level of messages displayed in this area can be changed in the configuration menu, and the log can be exported in a text file (click on button « open »): it may help our support developers to understand some behaviors or difficulties.

Demetra is made of two modules: Observations and Acquisition.

Both modules can be used separately, but Demetra realizes its full potential when they are used together.

The main module is « Observations ». This manages the various observations

made in a complete observing session:

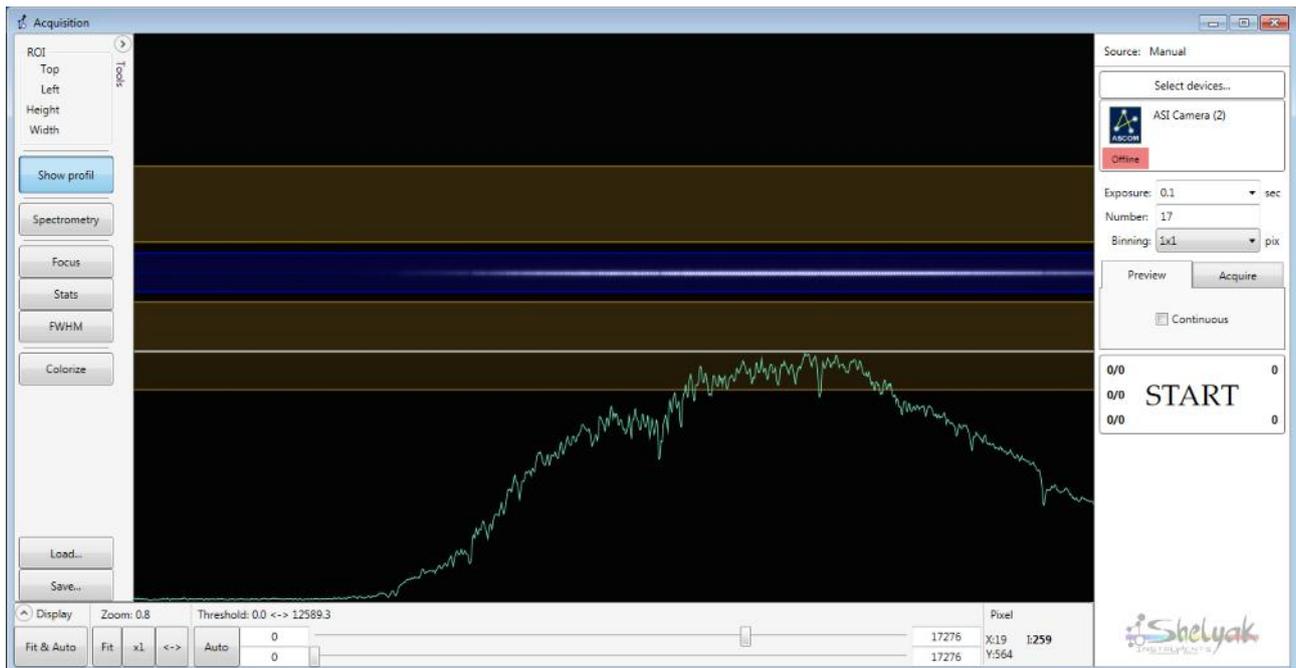


An **observation** is a set of data (images & parameters) related to a given astronomical target, that allows you to create a high quality spectroscopic profile.

An **observing session** is a set of observations. It is for instance an observing night, or a mission. The idea is that a session is made with a given instrument, at a given location (observing site) and by a given observer. When you change at least one of these parameter, you should open a new session.

All data for an observing session are stored in a **single directory**, which is defined at the top left area of the Observations window. You can change this directory: changing the directory means that you're changing to a new session (but it can also be used to re-open a previous session).

The « Acquisition » module manages the image acquisition from your Alpy 600. This controls the camera and the acquisition settings: such as exposure time, number of exposures, binning. It also provides useful visual functions such as a real time profile display, shown below:



Demetra utilizes a simple **color coding** for process all the stages to tell you where you must put your attention.

**Green** = all is fine, this is the normal status.

**Orange** = the process will work, but it is not optimal – you should examine closer.

**Red** = some key data are missing before you can proceed.

This is a general statement in Demetra: when everything is green, you have finished your spectroscopic observations, and *you can go to bed* !

The core of a Demetra observation is the **data reduction** process. Data reduction is the sequence of operations that must be performed on the raw data in order to extract a calibrated spectrum. With Demetra, the process is KING, and the images acquisitions must align with the process requirements. This may be surprising for amateur astronomers, but this ensures huge benefits in terms of fast processing, accuracy and standards.

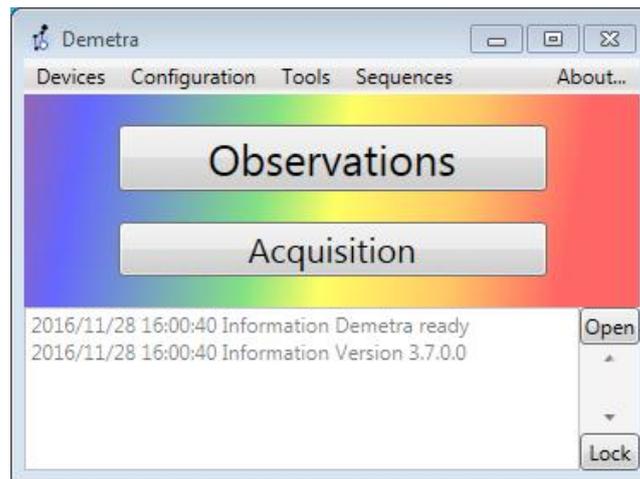
## 5 Quick start with the demo files

Using the Demo files is the simplest way to discover the Demetra interface, and run your first data reduction. You don't need to have a spectroscope connected to your PC for this step.

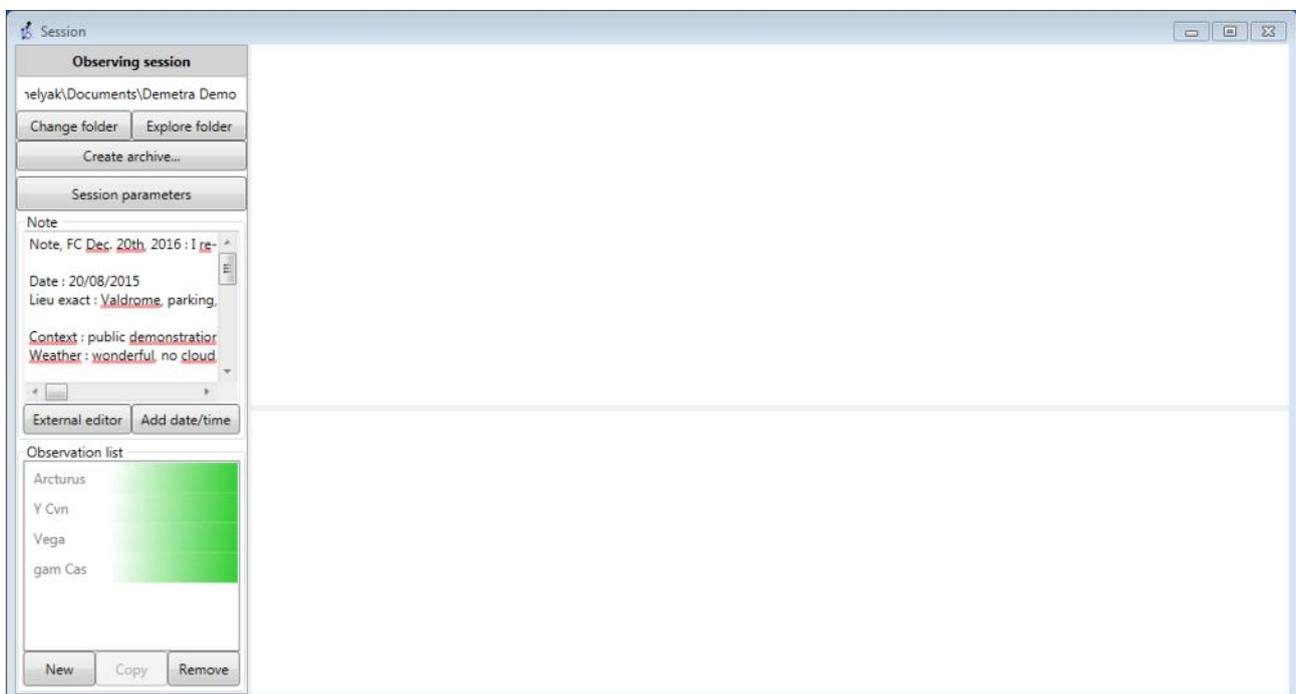
### 5.1 Discover the user interface

When you run Demetra for the first time, it opens the demo session folder, containing real observations.

Run Demetra. You will see the main window.



Click on the « Observations » button. You will see the demo session:

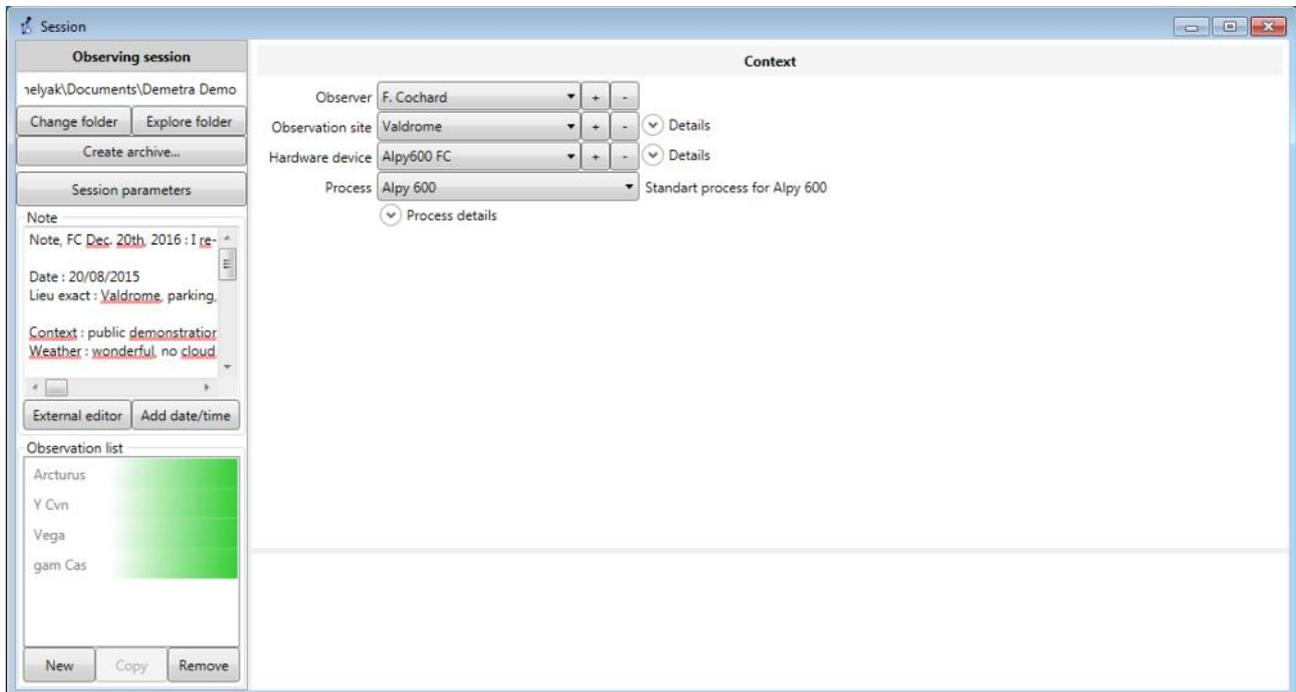


It contains a few observations of real stars: Arcturus, Y Cvn, Vega and gam Cas. But before going through these observations, let's have a look at the general parameters.

First, you will see that the demo files are located in a specific directory (like ...Documents\Demetra Demo). You can open this directory through a file explorer, but also directly from the button « Explore folder ». All the files of this session are in this directory.

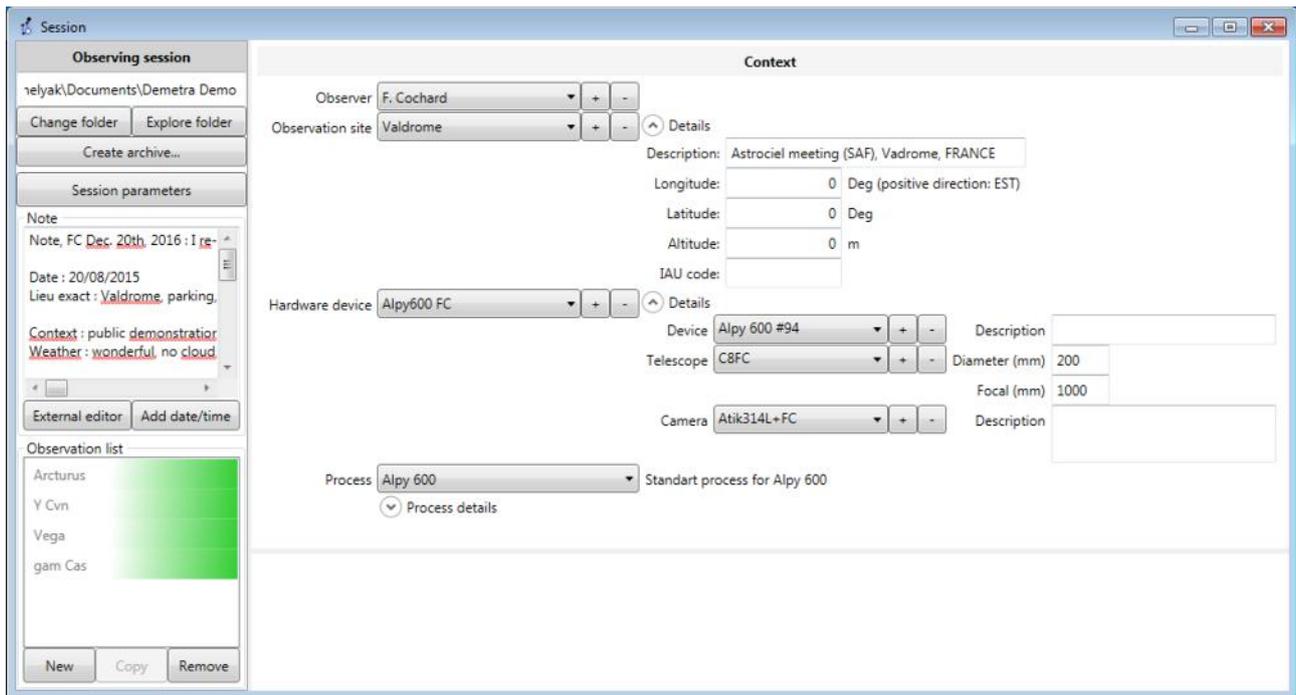
## 5.2 General parameters

Click on the « Session parameters » button, in the left top corner: Demetra shows the general parameters for the session: observer's name, observing site, instrument, and process (Alpy 600 in our case).

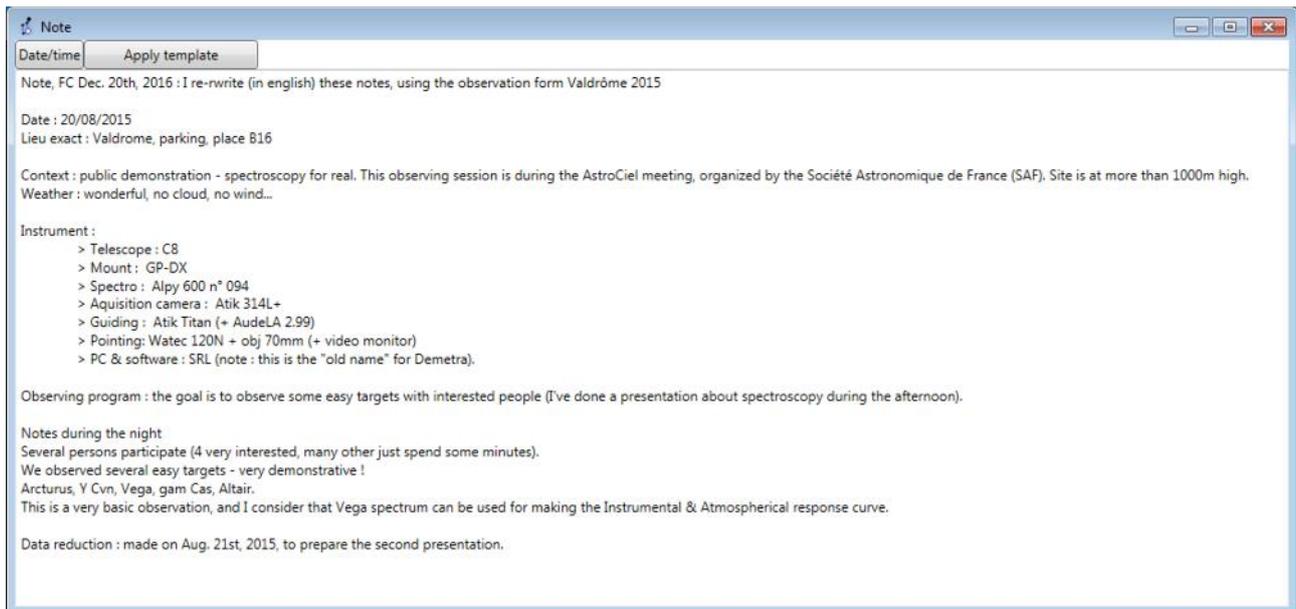


You can see the details of the site and the instrument, by clicking on « details » drop down button.

All these parameters may be edited. These details are recorded in the resulting FITS files header.



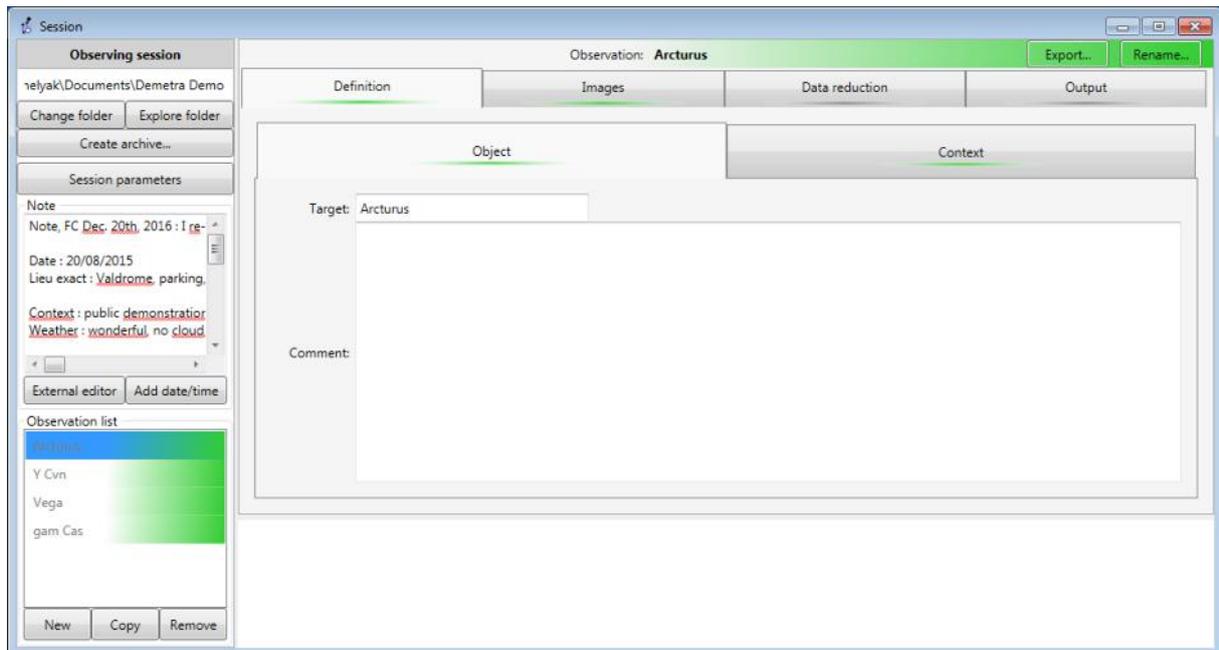
Below the « Session parameters » button, you will find the Notes area. This is the Observer's log file for the session. It shows all the details entered by the observer about the observing session. You can open the Notes file in a wider format by clicking on the button « External editor » button:



### 5.3 Playing with the observations

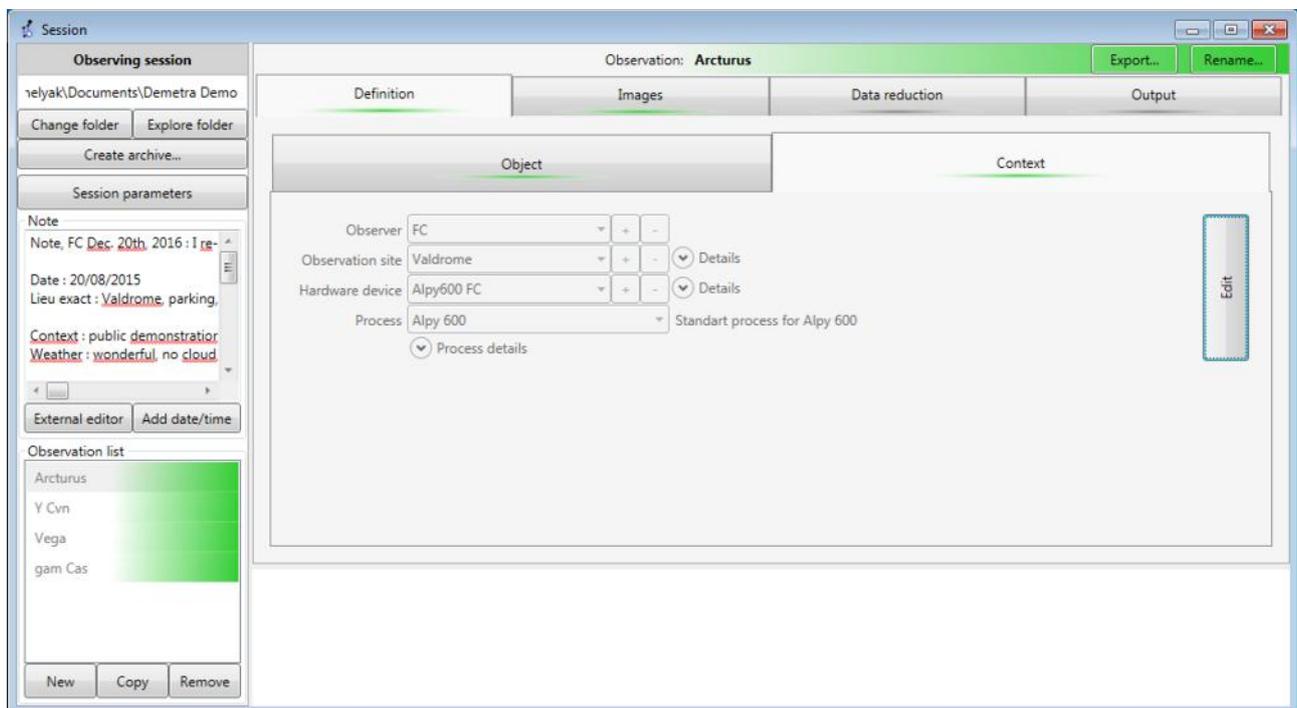
Now, let's look at the observations. As you can see, all four observations are green. It means that they are fully **complete**, with all data **needed** to **obtain** a good result.

Click on the first observation, Arcturus. The left part of the main Demetra window is now populated with several tabs:



All these tabs contain the various information and processing for this observation of Arcturus.

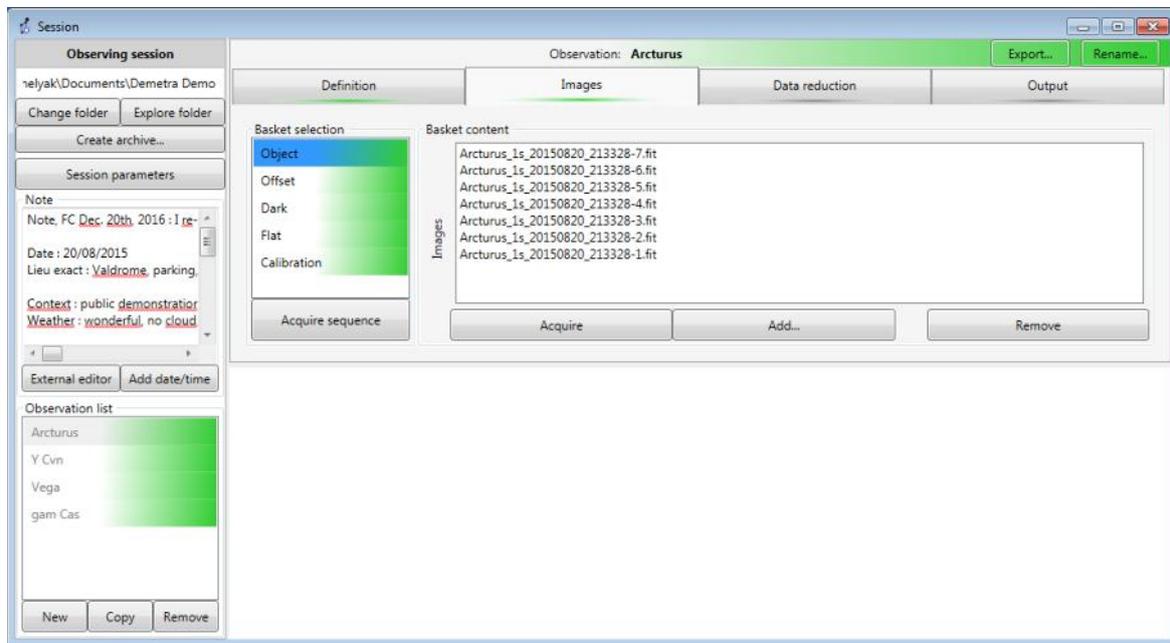
In the « Definition » tab, you have a description of the observed object (here, Arcturus – see picture above) and a copy of the context when the observation was made (Observer, Site, Instrument and Process):



These data are frozen, because they refer to already established observations. However, you can still edit them by clicking on the « edit » button on the right.

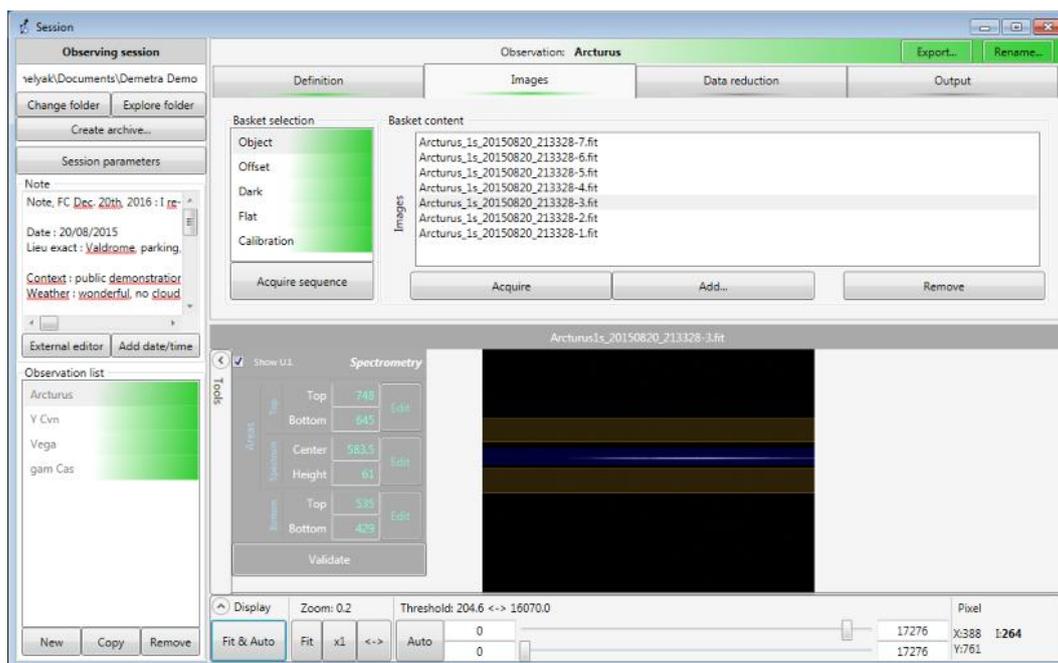
### 5.4 Images linked to an observation

The second tab, « Images » lists all the images linked to this observations:



You can see various « baskets of images »: Object (for target images), Offset (Bias), Dark, Flat and Calibration. Each basket contains a set of images. For instance, in the above picture, the Object basket contains 7 raw images of Arcturus spectrum. You can click on each basket to see the images contained inside.

Double-left-click on any of the Object image, for instance the image #3 ( Arcturus\_1s\_20150820\_213328-3.fit ). It opens in the bottom part of the screen. To display it properly, click on the button « Fit & auto », in the left bottom corner:



## 5.5 Image viewer

The Lower half of the frame is the viewer for Demetra. You can display the images in the way you want using the bottom row of buttons, and some intuitive mouse movements.

The Fit & Auto buttons displays the full image and tunes the visualisation thresholds to properly see the spectrum. You can do these to operations (fit and auto) with matching buttons. You can also display the image using the full wide of the image area, using the ↔ button. (This is useful, because a spectrum is usually a single line in the image frame). You can also display the image at full scale 1:1 (one pixel on the screen displays one pixel of the raw image).

In addition, you can zoom in/out the image using the mouse wheel whilst pressing the 'ctrl' key. And you can move the image by using ctrl key and moving the mouse with the left button depressed.

You can move the image vertically simply with the mouse wheel.

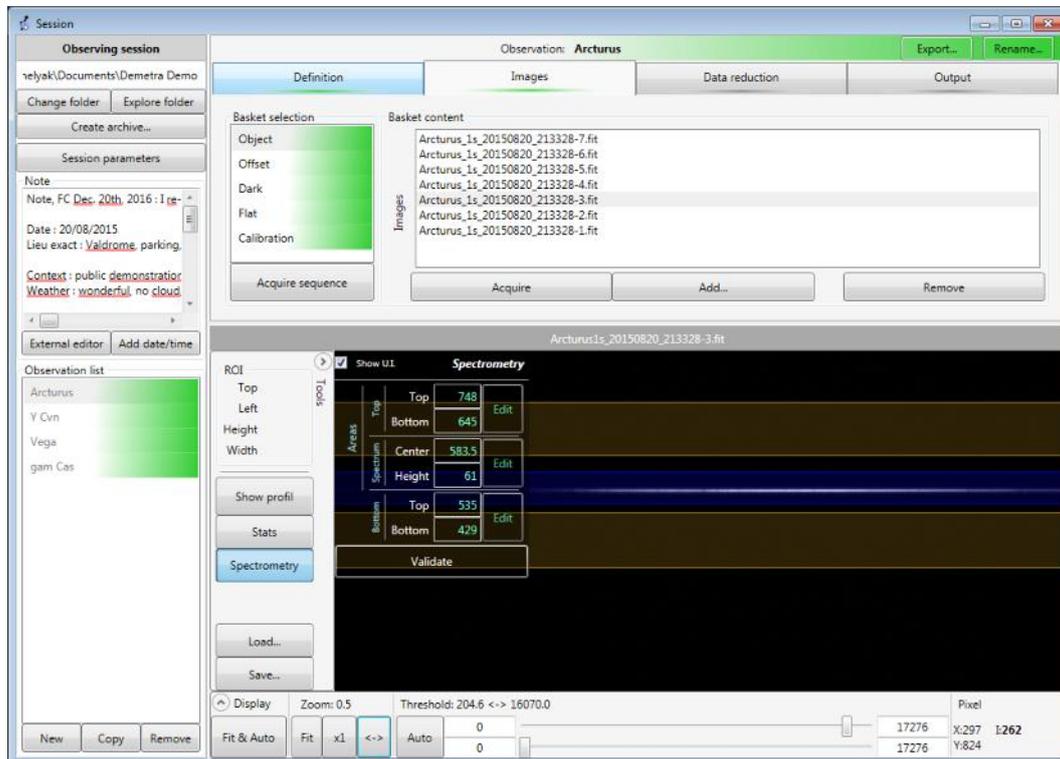
You have two scroll bars to change the visualization thresholds. On left and right of each of them, you have the min/max value displayed for each bar – you can edit them, of course.

In the bottom right corner of the frame, the X & Y position of the cursor is shown, as well as the intensity of the pixel under the cursor.

Three horizontal bands are displayed superimposed on the image. The blue shows the region where the star spectrum itself is located.

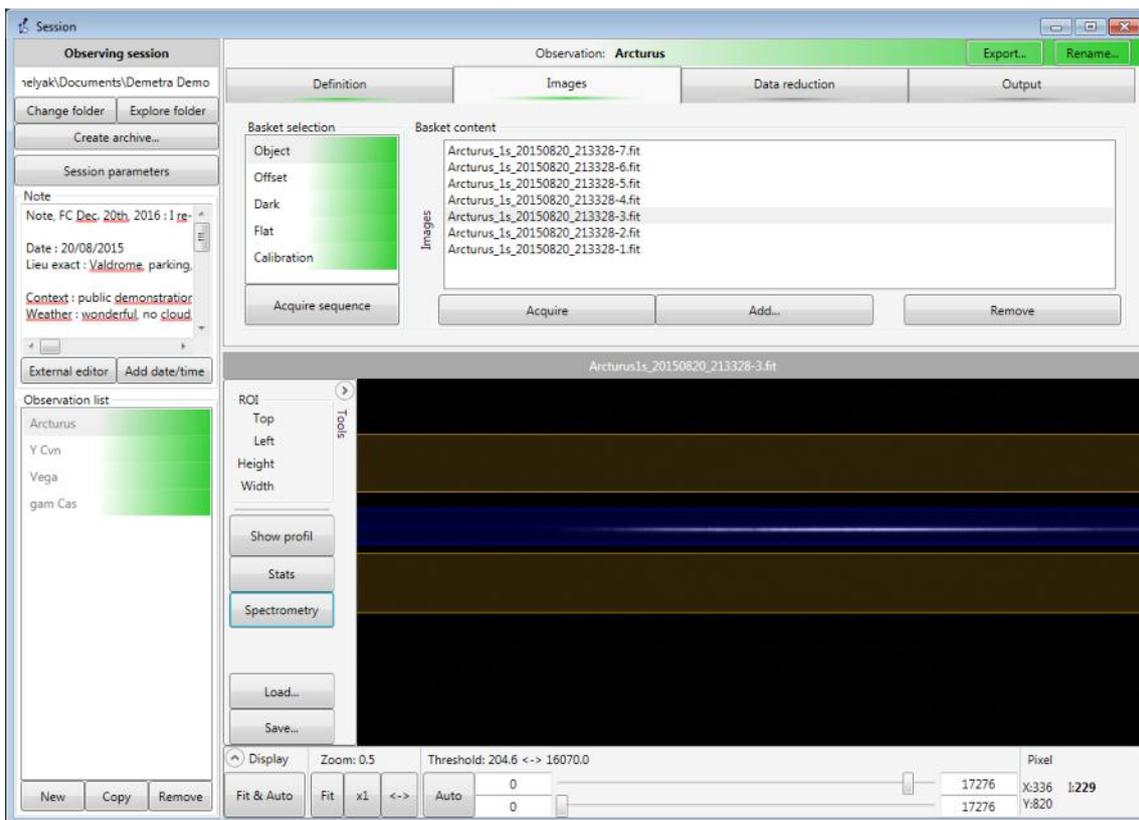
The two brown bands show the region of the sky background spectrum.

The three bands have been defined by the observer at the beginning of the observation. These bands are used during the data reduction, to extract optimally the star spectrum, and correct it from the sky background. These may be set with simple 'click and drag' edit commands. See below.

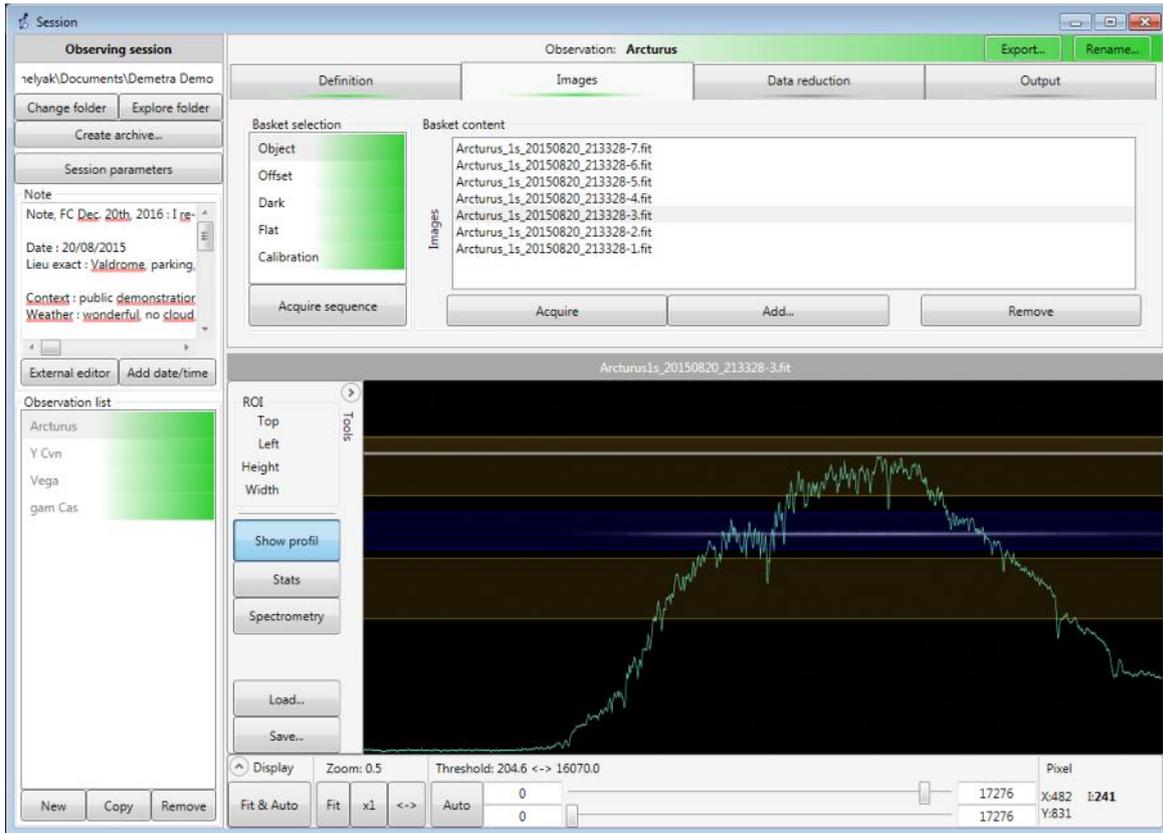


Let's continue with the image viewer. On the left of the image, you have a « Tools » bar. Click on it to display it:

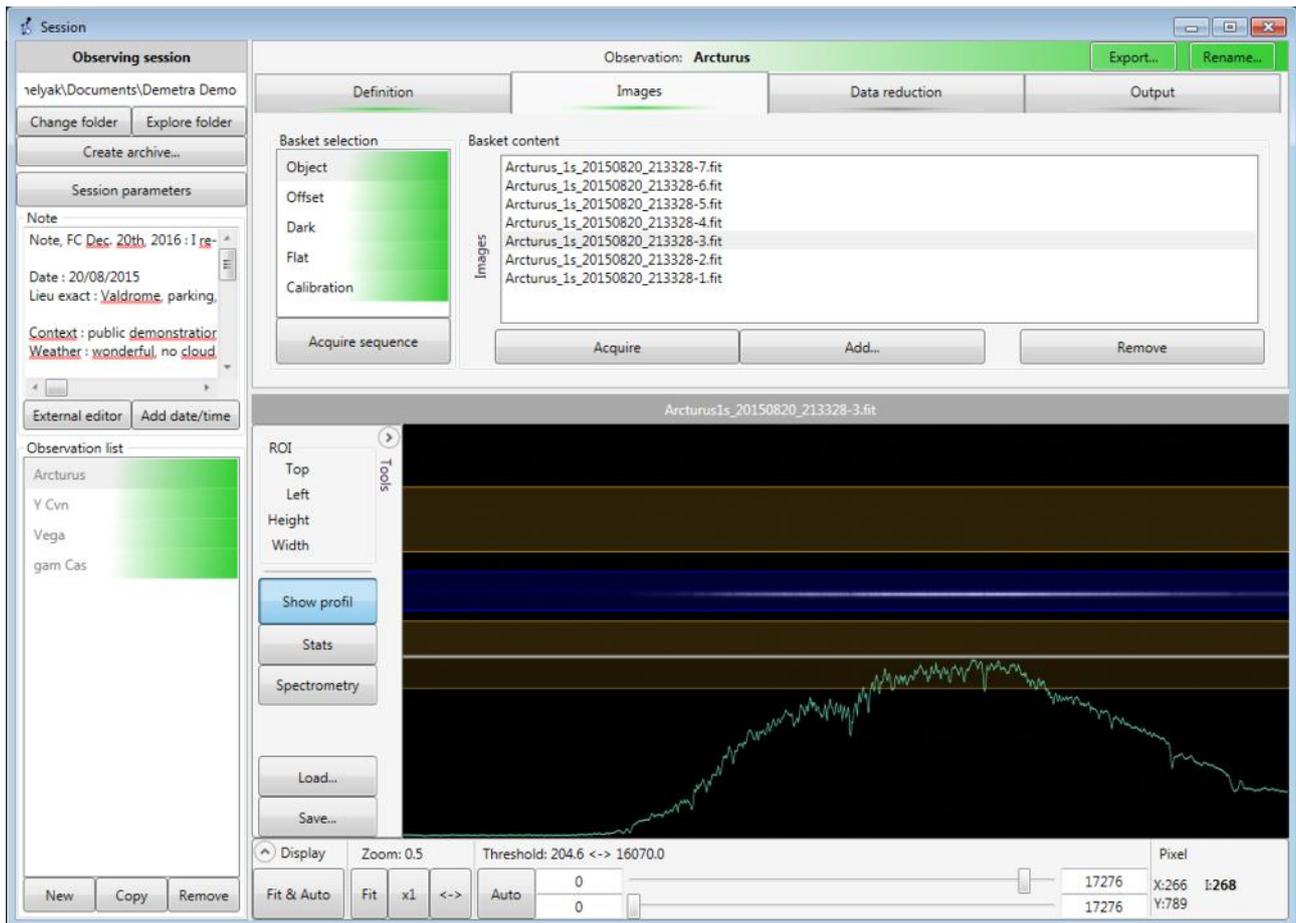
The spectrometry tool is already activated – this is the tool used to define the horizontal bands in the image (we'll come back to it later). When you deactivate it, it disappears from the the image:



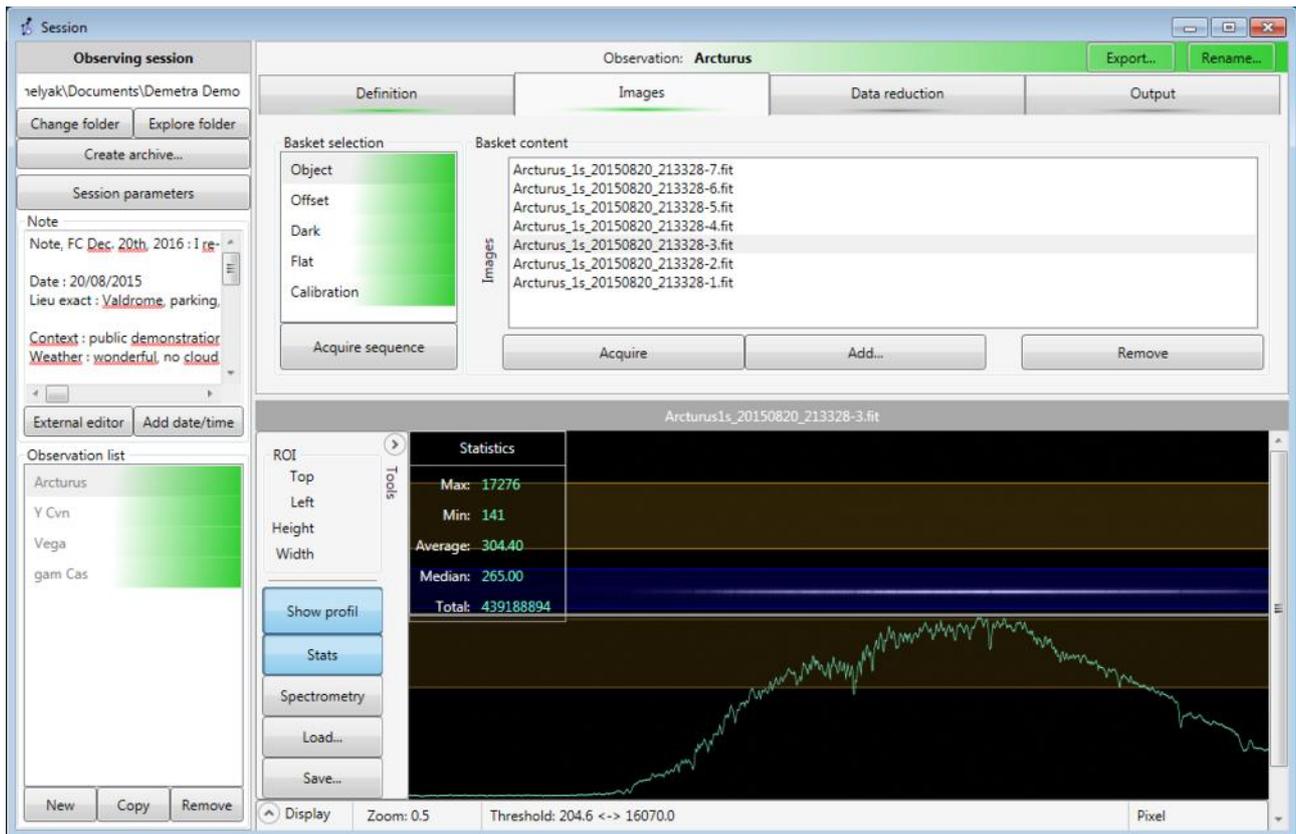
« Show profile » displays a quick profile of the spectrum:



This graph is simply calculated as the sum of each column in the blue area of the image. No more processing is made here, it is only provided to give a quick view of the spectrum profile. You can change the vertical size of the profile: just click-and-drag and drop the top white line of the profile area:

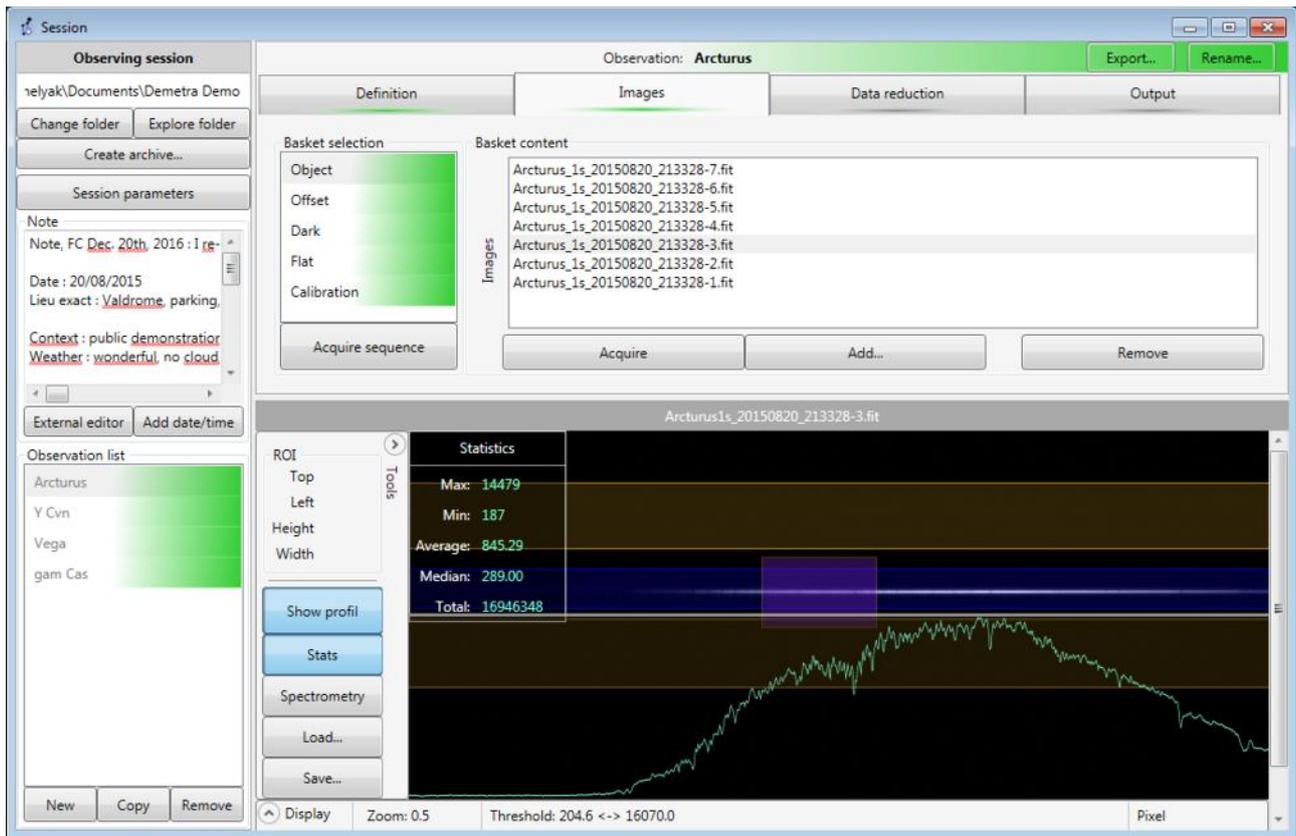


An important point here: most of the tools are displayed transparently above the image, but you can still see the image beneath. This is the « **Head-up display** » (HUD) style of Demetra.



Another tool is « Stats ». This displays key statistics *in the spectrum area* (blue horizontal band):

This blue area is that which contains most of the relevant information. It is therefore better to show statistics in this region instead of the whole image. However, if you need to show statistics – or even other information – for another region, then, you can select a rectangle anywhere you want to display that information. Simply construct a rectangle by click & hold, dragging the mouse and releasing the button at the opposite corner. The rectangle area is shown in purple superimposed on the screen, see below:



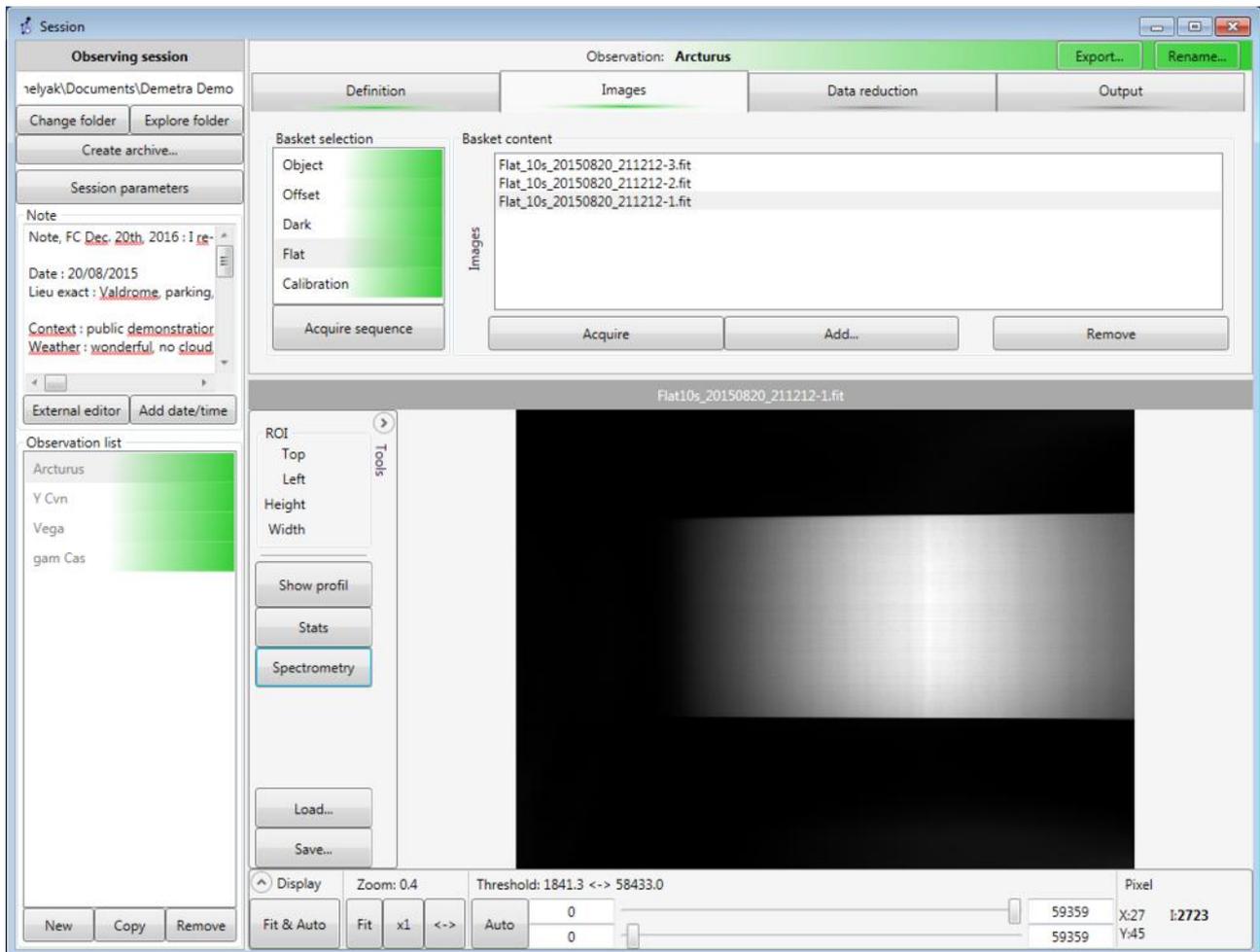
When the rectangle is selected, the statistics tool displays the statistics inside the rectangle, not in the blue horizontal band.

By right-clicking inside the rectangle, you have a choice of further options:

- Fit: displays the region in full size in the image area
- Thresholds: adapts the visualization thresholds to the region
- Statistics: show the statistics inside the area (same as in the stats tool)
- FWHM: measures the FWHM of the emission lines inside the region (works well if you select a small region around the line)
- Remove selection: cancels the rectangle

You can also cancel the rectangle by double-clicking anywhere in the image area, outside of it. Note that you need to erase the selection rectangle before creating a new one.

All these tools to manipulate images can be used on any of the available images. For instance, you can look at one flat image (on the picture below, we've deactivated all the tools):

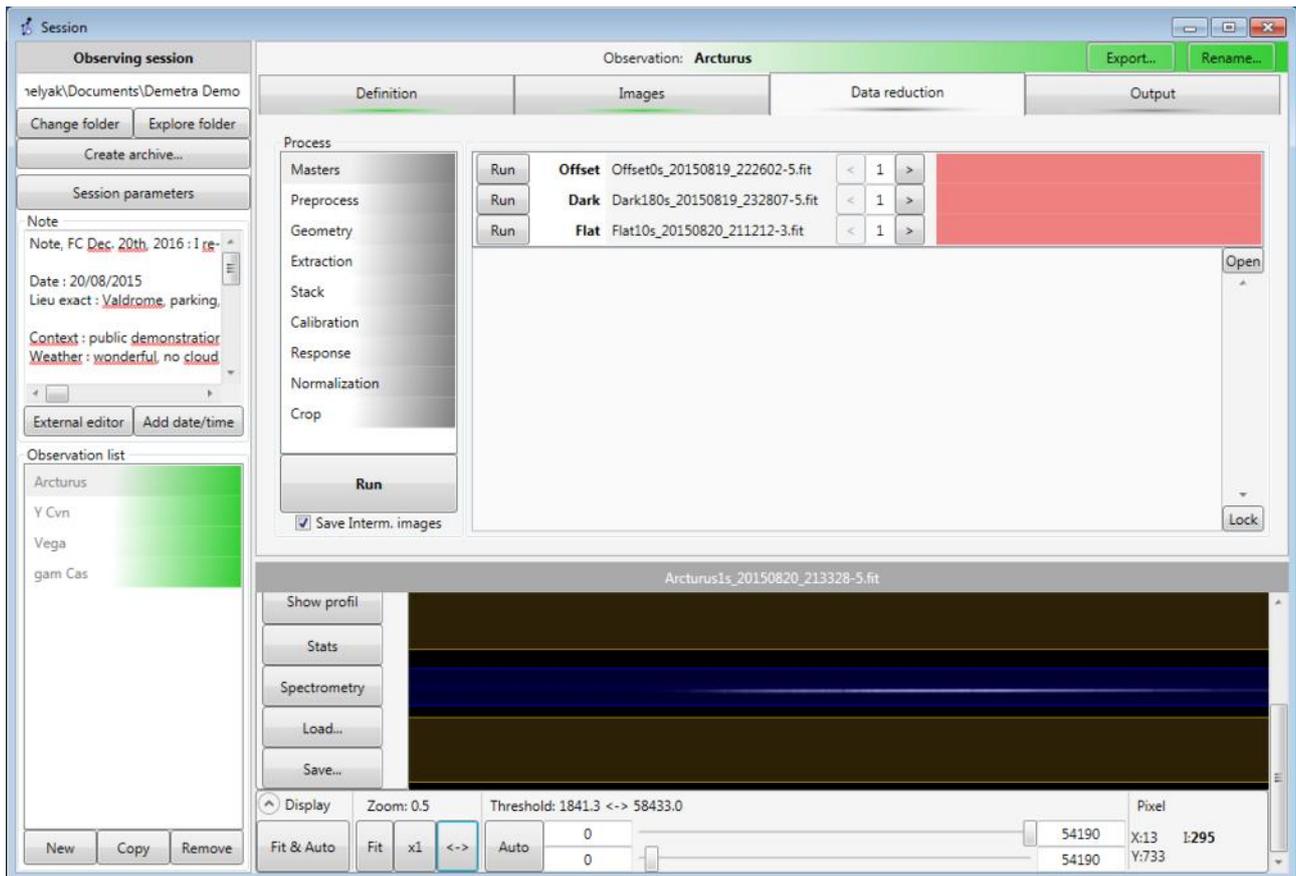


In the demo observations, all the baskets are green. This means that all baskets are properly filled with the required files. If one basket were empty, then it would be displayed red, as well as for the whole observation.

### **5.6 Data reduction**

When an observation is green, all required images are collected to run the data reduction. The data reduction is the sequence of operations that starts from the raw images and then transform them into a calibrated spectral profile. Demetra includes all the operations that perfectly matches the images acquired with an Alpy 600.

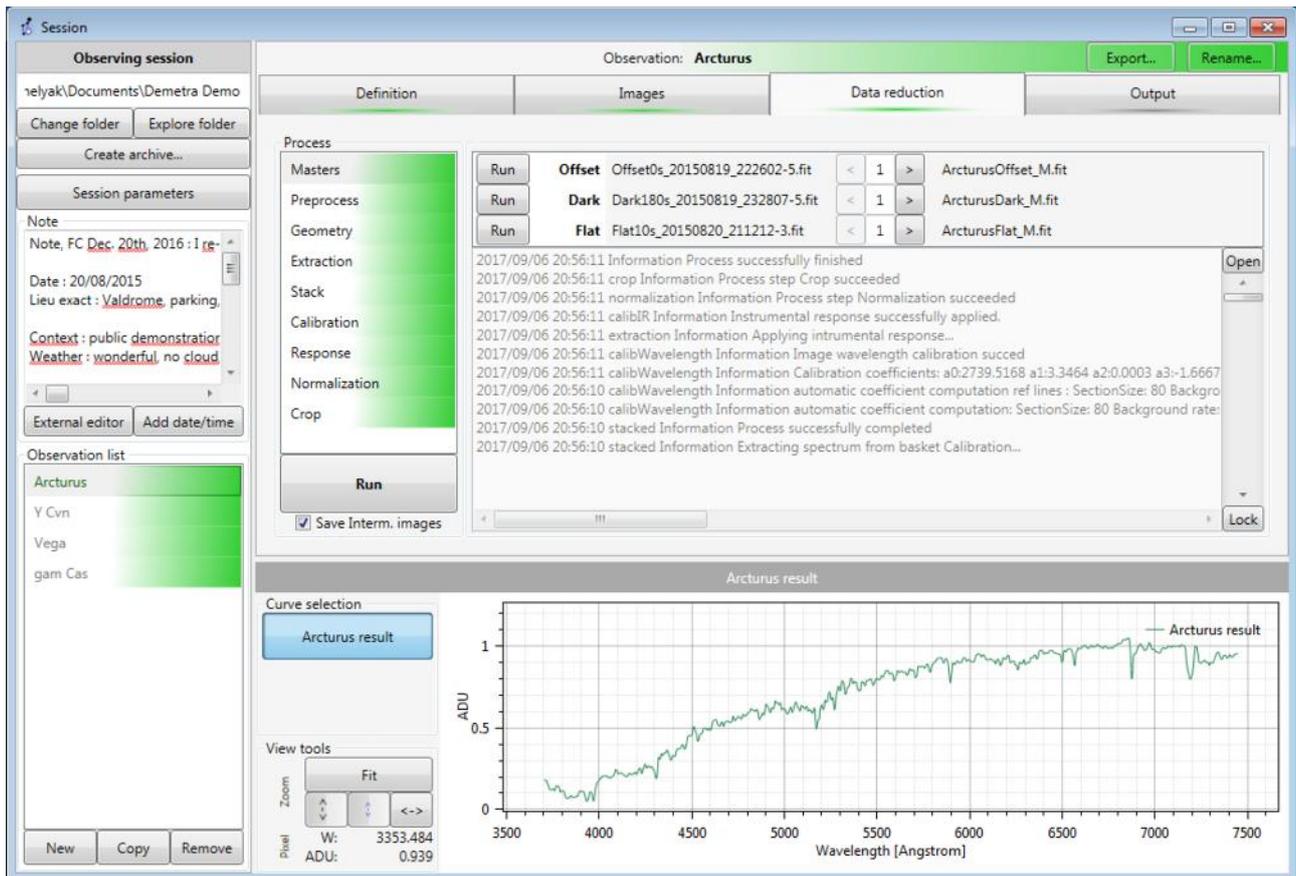
Then, we can now switch to the **Data reduction tab**.



In this new window, there is the list of all the data reduction steps (Masters, Preprocess, and so on). At this stage, all the steps are gray, which means that they are not yet completed.

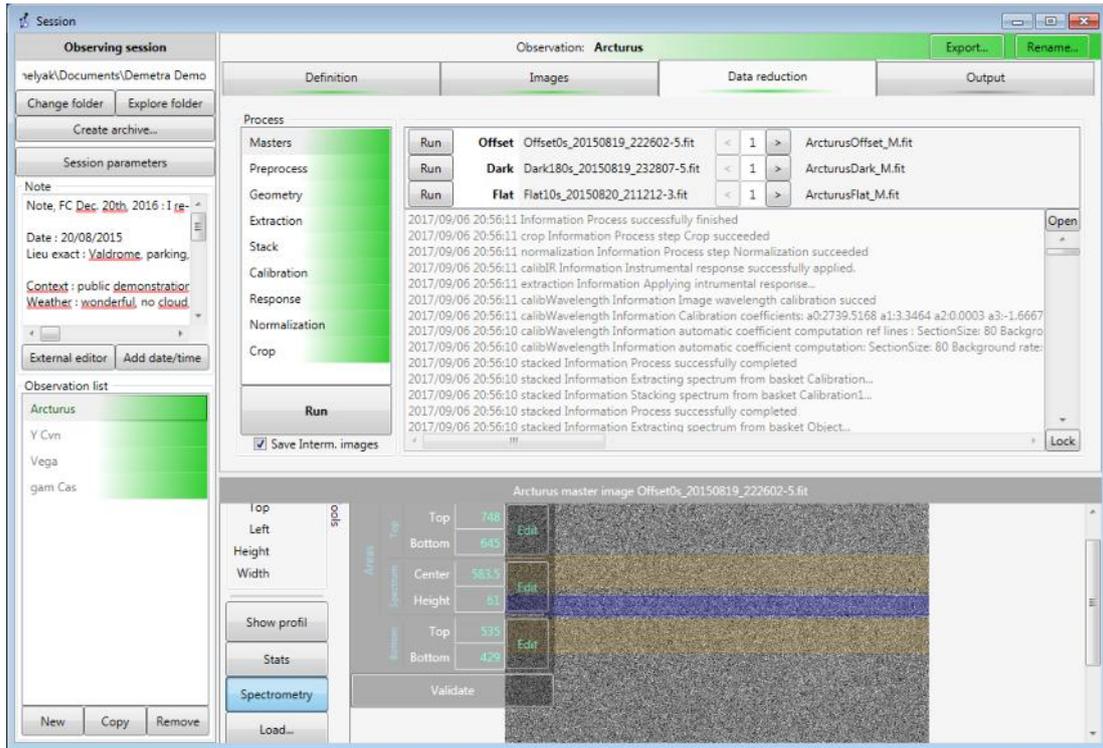
Demetra allows you to run these step one at a time, in sequence. But the entire process can also be done in one click: to do this, click on the button «Run», at the lower end of Process list.

All the steps will turn green, one after the other as the procedure progresses. At the end, when the whole data reduction is done (all steps are green), you will then see the calibrated spectrum in the image area:

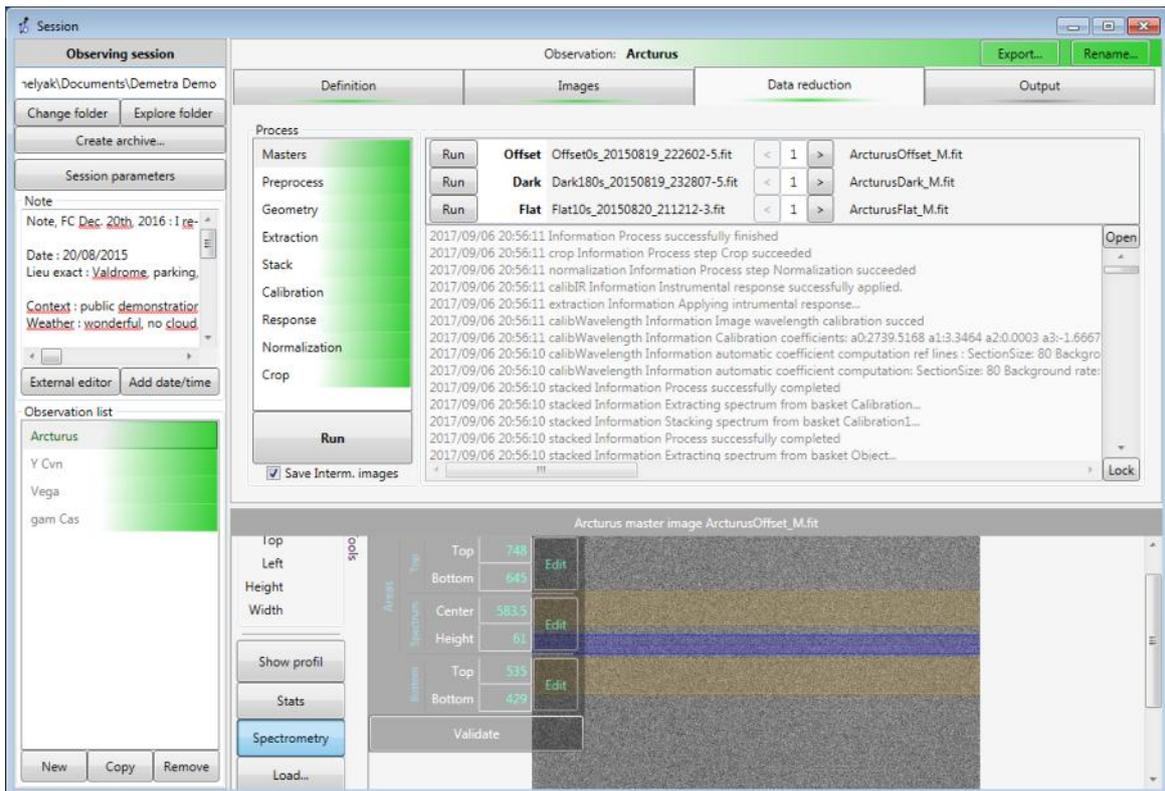


Even when a 1D profile is displayed in the bottom viewing area, you can play with the graph: fit, zoom, and so on. You can also select a rectangle in the graph, to zoom in the selected area. Note that you can zoom only horizontally or vertically with the mouse wheel – just put the cursor on the X axis or on the Y axis while rolling the wheel.

You can now go back to each step, and examine see its effect: each operation lists the images *before* and *after* the operation in the upper area of the Data Reduction window. To the left are the images input at the start of the process step and on the right are the resulting images. These 'results' then become the 'inputs' to the next stage of the process. And of course you can double-click on each image to display it in the bottom area. For instance, you can look at one offset image in the Master step (the first one):



And compare with the median resulting image (ArcturusOffset\_M.fit). We immediately see the effect of the Median operation: the result is much less noisy.



Here is a summary of operations made for each data reduction step:

- **Masters:** Demetra takes the raw bias, dark and flat images, and calculate the median of each serie. This improves the Signal to Noise Ratio (SNR) for these images.
  - **Preprocess:** Demetra corrects the star spectrum images from the bias, dark and flat. It also detects and manages any hot pixels. This retains only the signal from the target star, and removes most of the camera instrumental effect.
  - **Geometry:** Demetra applies a geometrical transformation to make the spectral image conform to the X & Y coordinates of the image. This corrects the raw image from optical distortions.
  - **Extraction:** Demetra extracts the spectral profile from each star spectrum image. This is the change from 2D images to 1D profile.
  - **Stack:** Demetra stacks all the spectral profiles. This improves the SNR of the result.
  - **Calibration:** Demetra uses the calibration images (from the ALPY lamp) to define the dispersion law of the spectrum, and applies it to the result. From now on, the spectrum horizontal axis is given in physical wavelength. Also, Demetra re-samples the spectrum to have a linear dispersion (necessary to share the result with others).
  - **Response:** Demetra corrects the spectrum from the instrumental response. This response must be calculated with a reference star (see below).
- Normalisation:** Demetra scales the spectrum according to a given wavelength area rescaled around the value 1. This avoids huge values for the spectrum, the Y axis now represents a relative energy (there is no physical unit in this axis).
- **Crop:** Demetra crops the profile to its useful spectral domain.

The whole data reduction process is a complex operation, but is made easy in Demetra because we give it all the information it needs to run it smoothly.

### ***5.7 Instrumental & atmospheric response correction***

One critical step in the reduction process is the instrumental correction. In a few words, the spectral profile measured for the target star is deeply affected by the instrument; for instance the grating of the spectroscope and/or the CCD sensor have their own spectral response. Also, the atmosphere changes the star spectrum significantly as seen from the Earth and this depends on the altitude of the object in the sky.

Instrumental & atmospheric correction is a complex subject, but the simplest way to do it is to observed a well known object under the same conditions are your target, and compare it with reference spectra. (Reference spectra are available in the literature and many are stored in Demetra's database). The

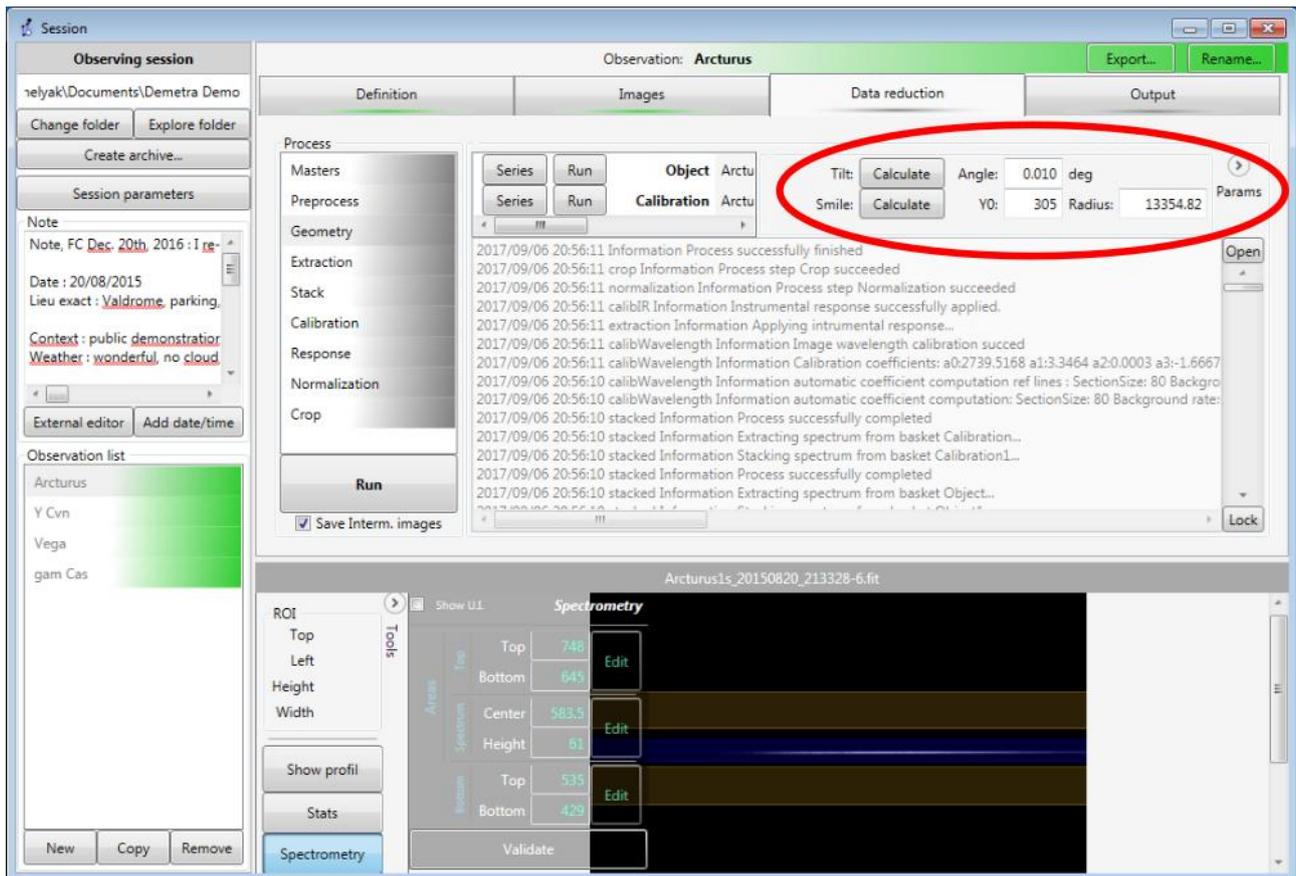
ratio between the theoretical and observed spectra produces your instrumental & atmospheric-response profile.

Demetra includes a tool to calculate this response profile – we'll see later on how to use it. At this point, just note that for the Arcturus demo observation reduction, Demetra uses a response profile named Vega\_Object\_C\_RI.fit. You can see it in the parameters of the « Response » step, and display it.

The screenshot displays the Demetra software interface for an observing session named 'Arcturus'. The 'Data reduction' tab is active, showing a list of process steps: Stack, Calibration, Response, Normalization, and Crop. The 'Response' step is selected, and its parameters are shown, including 'Response curve: Vega\_Object\_C\_RI.fit', which is circled in red. Below the process list, a log window shows the execution details of the response step. At the bottom, a graph titled 'Arcturus instrumental response' plots ADU (0 to 0.3) against Wavelength [Angstrom] (3000 to 7500). The graph shows a sharp peak at approximately 4000 Angstroms, with a secondary smaller peak around 4500 Angstroms. The legend indicates the curve is 'IR: Vega\_Object\_C\_RI.fit'.

## 5.8 Data reduction parameters

Some of the reduction steps use parameters input by the user: Geometry, Extraction, Calibration, Normalisation, Crop. These parameters can be edited at the right end of the process step display; click on the « Params » button. Here are for instance the parameters for the Geometry step:



These parameters are stored in the observation itself.

*As soon as you change a parameter, you must re-run the reduction steps.* Then, all the steps, from the one modified one, become gray again (they are considered as not yet done).

### **5.9 How data are stored**

Let's talk a little bit about the way the data are stored in Demetra.

First, it is key to mention that all raw images, which are pure FIT files (the FIT format is *the* standard for any astronomical image), are NEVER modified by Demetra. A raw image remains a raw image, and no change is applied after its acquisition.

All the **details** that define an observation (context, list of images, position of the horizontal bands, reduction parameters, and so on) are stored in an xml editable file. Its name contains the observation name, **appended** by .obs.srl. For the Arcturus observation, this name is Arcturus.obs.srl. You can find it in the session directory, and open it with any text editor (it is made for human reading). You can edit it ... but if you do so, there is a significant risk that you break the consistency of the file. Make sure to backup the file before any change.

All the images generated by Demetra during the data reduction are saved in

the same directory, with a file extension linked to its operation. For instance, the dark master image for Arcturus is named Arcturus\_Dark\_M.fit (\_M stands for Master).

If you don't want Demetra to save these intermediate files (to save room on the hard disk drive, for instance), then unselect the tick « Save interm. Images », below the reduction steps list, and re-run the reduction process. Note that if you do so, you cannot edit the process step by step anymore – because this edition requires to go back to intermediate images.

During the data reduction process, the log area is filled with all the details of this process. The same text is saved in the session directory under the name Arcturus.processlog.1.txt.

The resulting file of the data reduction – the actual result of the observation – is named Arcturus\_20150820213340.FIT. This name, automatically generated by Demetra is made up from the Observation name (Arcturus) and the date and time of the observation (Aug. 20<sup>th</sup> 2015, at 21h33).

Once the data reduction is done for Arcturus, the « Data Reduction » tab becomes green, and the observation name (in the observation list) is surrounded by dark green. This way, you can quickly see from the observations list which one is already processed and which aren't.

### **5.10 Output tab**

The last tab in the observation is the Output one. It is very intuitive, and allows you to show the result in several formats. When you're looking at an observation made after a long time, this is probably the most useful, the one which deals directly with the final result.

### **5.11 Other observations**

You have completed the data processing for Arcturus. You can now do the same for the other observations (Y Cvn, Vega and gam Cas). It gives a quick view of how differences are huge from one object to the other. Arcturus is a cool star (K type), Vega is a hot one (A type), Y Cvn is a carbon star, and gam Cas is a Be star, with high emissions in Balmer (hydrogen) lines.

## **6 Demetra folders**

Demetra works with a few key folders. It can be useful to understand them.

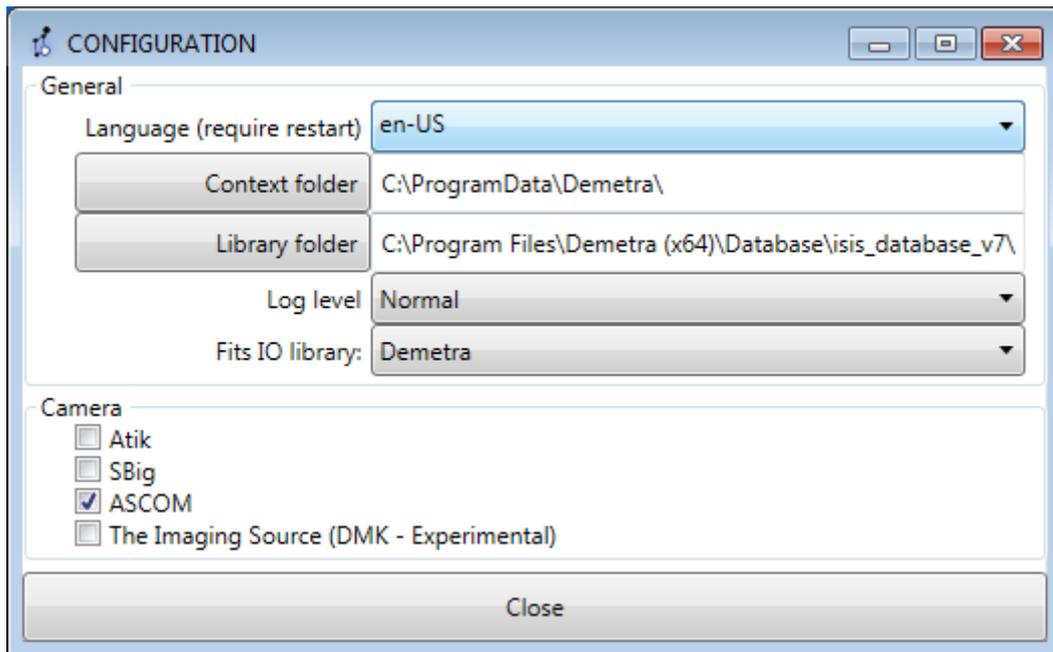
### **6.1 Installation folder**

Demetra software is installed in the directory <C://Programs/Demetra> (x64). Normally, you should never need to work in this directory.

### **6.2 Context folder**

Some data have to be recorded in a safe directory, to be reused at any time. For instance, the context information (observer, instrument, observing site...), or the calibration reference files. This directory is defined in the configuration

panel (main Demetra window). By default, it is in <C://ProgramData/Demetra>.



If you want to totally reset Demetra, you can simply remove this directory – be careful, you will lose all data you’ve updated since the Demetra installation. If Demetra cannot find this directory, or if it is empty, then it will re-create it with default values.

### **6.3 Library folder**

Demetra includes a library of reference spectra (required to create your own instrumental & atmospherical response curves). It is also defined in the Configuration panel (see above).

### **6.4 Session folder**

A Demetra observing session folder is equivalent to a folder on disk. This is necessary and important to keep observing data simple. If you want to archive a whole observation, then simply archive the matching directory. In some cases, you can use images that are available in another directory – for instance if you have a dark library somewhere else. In this case, Demetra copies the files you want to import into the session directory, so as to always comply to the rule: session = directory.

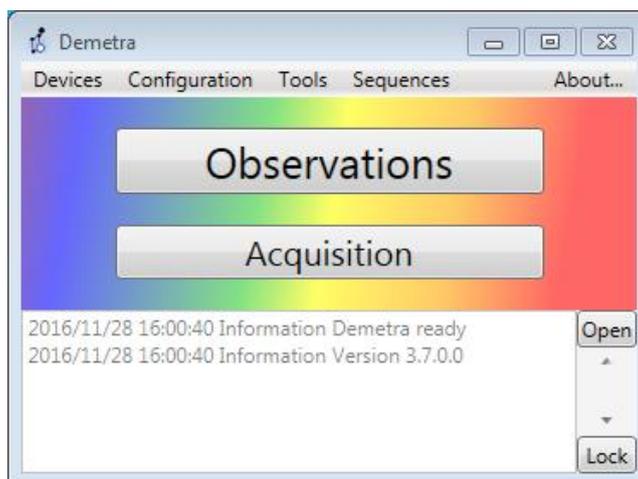
If you want to switch to a previous session, click on the « Change folder » button, in the top left corner of the Observations module. You will immediately recover the full context for this session.

## **7 Images acquisition**

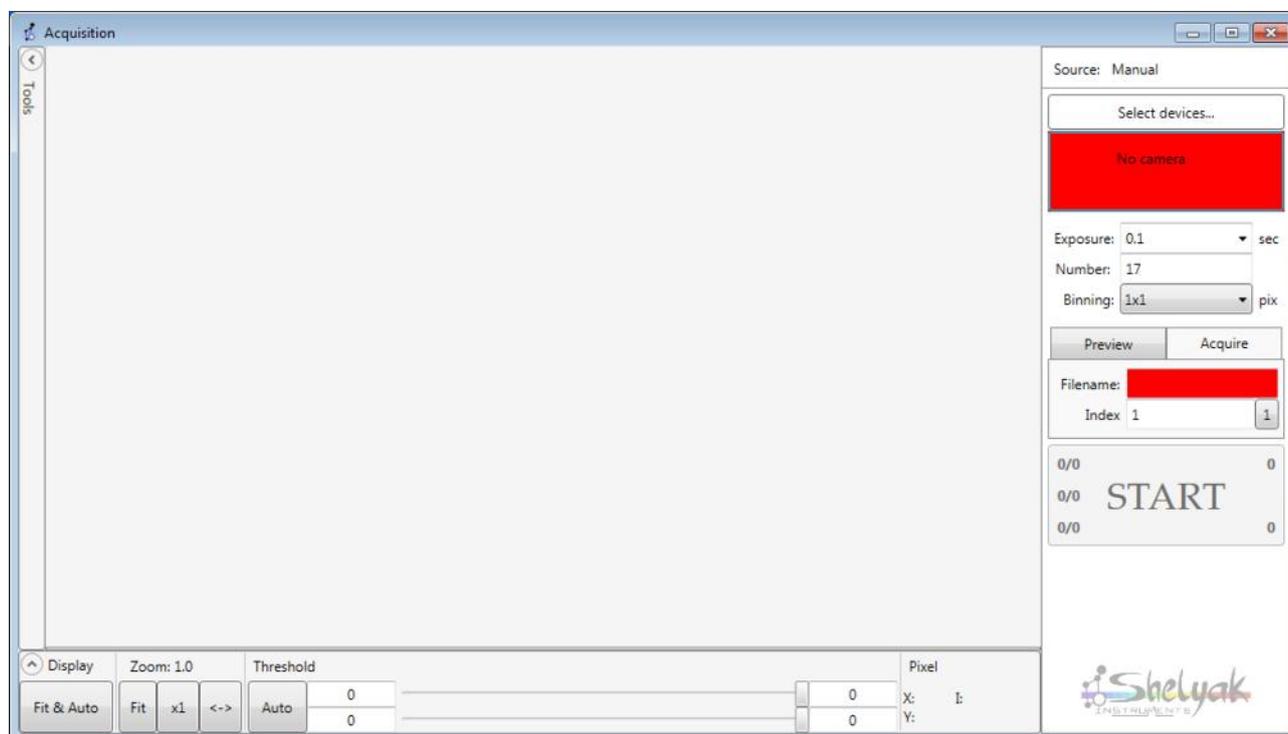
Demetra not only manages your observations and processes your spectra, it

also includes a tool for image acquisition. This tool specially fits the needs for spectroscopy. Let's look how it works.

In the main Demetra window, click on « Acquisition » button:



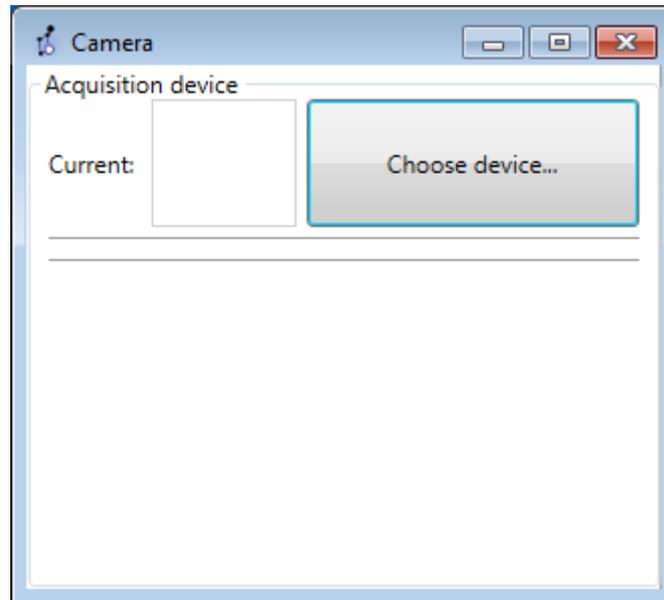
This opens a new window, with a wide display area:



You're already familiar with the style of display area: its interface is exactly the same as for the image viewer in the Observations module. The left panel is new: this is the camera control box. As usual in Demetra, the color coding is simple: when it's red, you pay attention!. When the red box under « Select Devices » is pressed a new pop-up box is displayed: this the camera connection. Being red, this button means there is no camera connected.

## 7.1 Connecting the camera

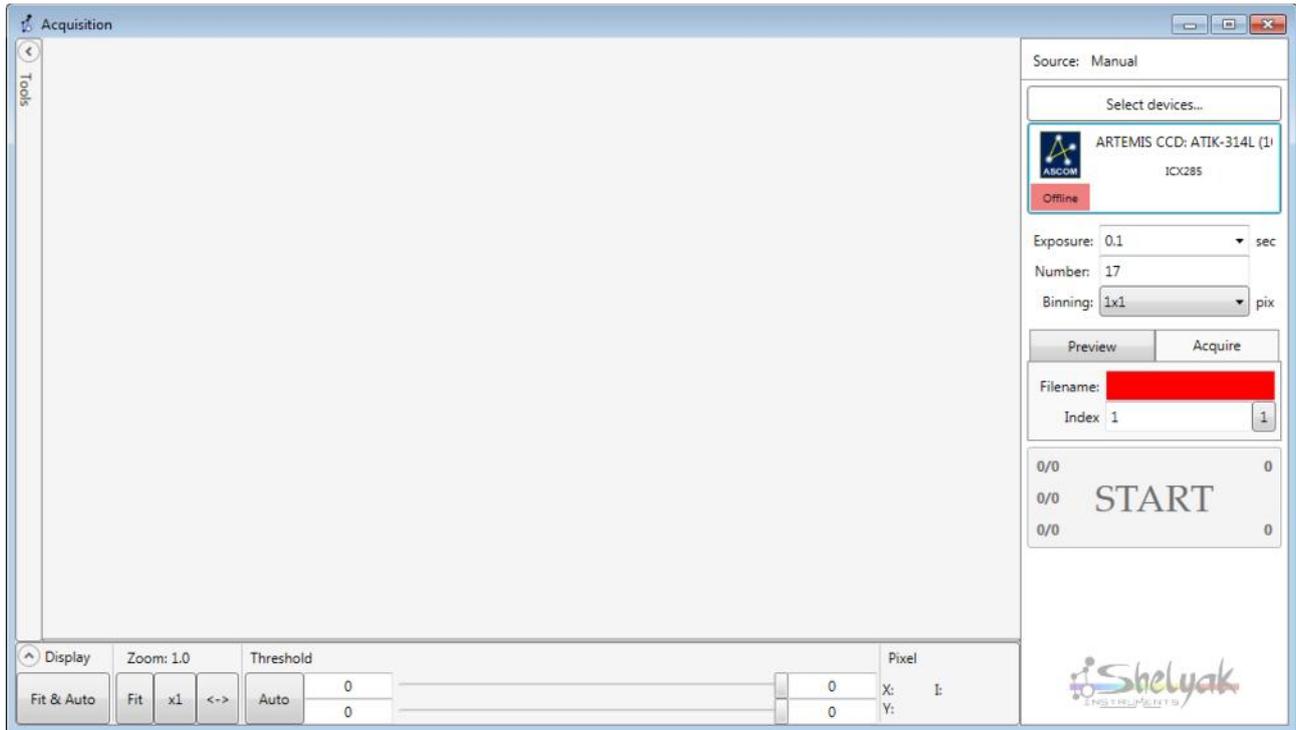
To connect your acquisition camera to your computer, and turn it on, click on the red button which opens the camera connection window:



Click on the « Choose device » button. You can select the ASCOM device:



Click on ASCOM, then on Connect. This opens the standard ASCOM connection window, in which you can select your camera. Go to the connection, and finish with OK. The camera is now connected and shown under the « Selected devices » area. In our case, we've connected an Atik 314 camera:



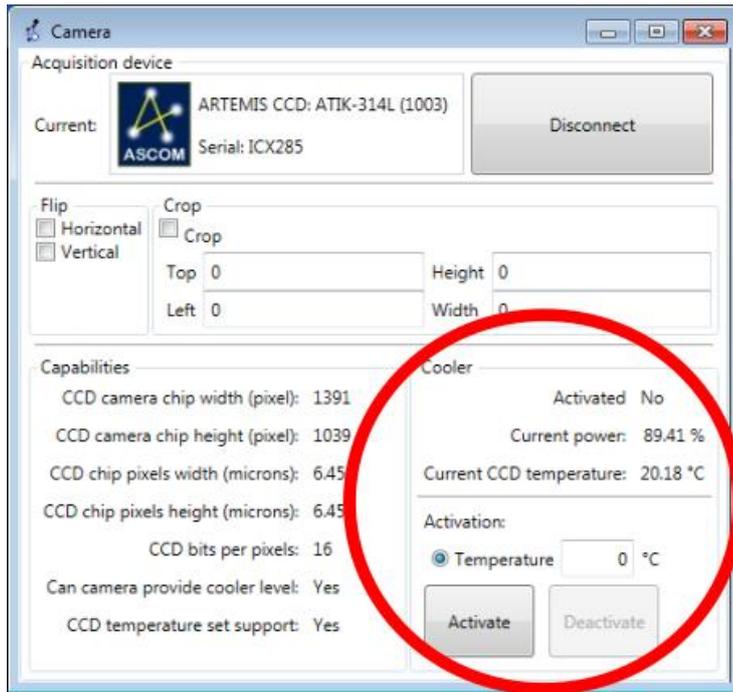
Once you've connected your camera, Demetra remembers it. Then, the next time you will connect again this camera to your computer and run Demetra, the camera will be automatically connected. The detailed process is this one: Demetra remembers the last connected camera, and at each start-up, it tries to connect it again. If the camera is actually present, then the connection is automatic.

Demetra remembers the last connected camera, and at each start-up, it tries to connect it again. If the camera is actually present, then the connection is automatic.

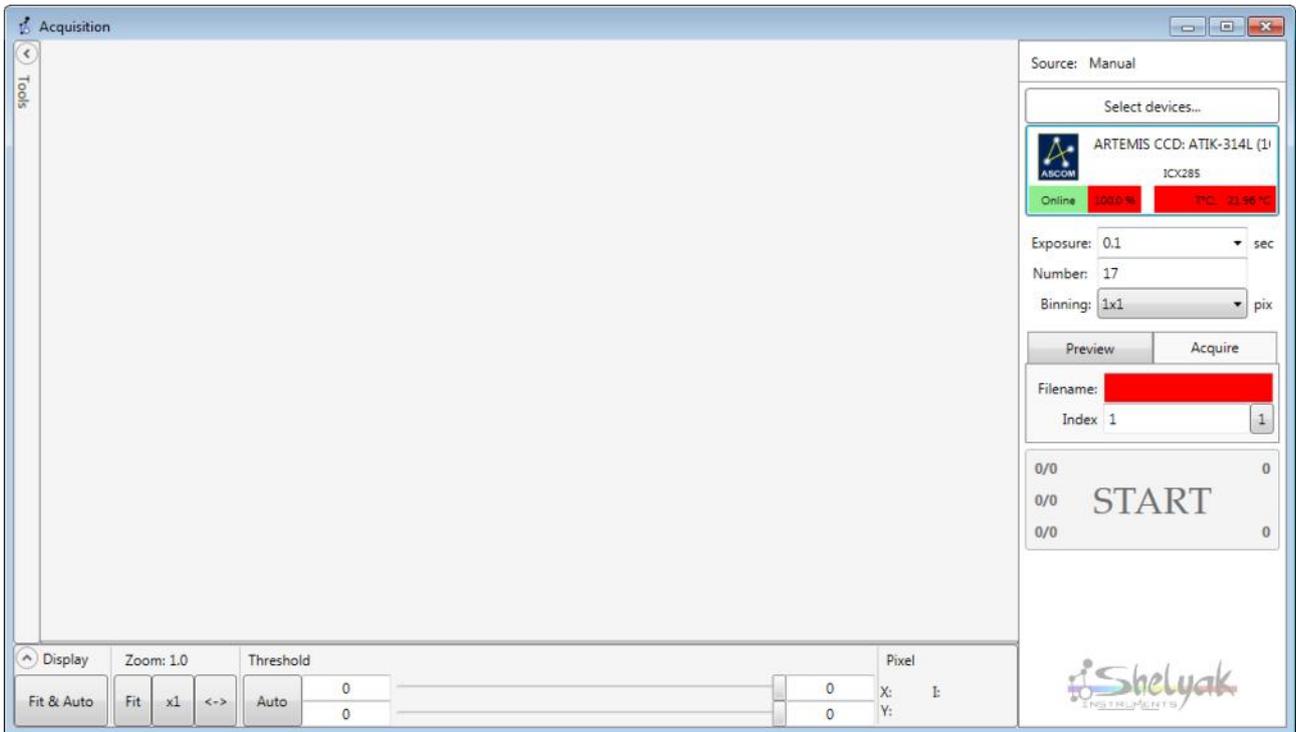
## **7.2 Camera temperature control**

As you can see above, there is still a red statement below the ASCOM logo. Again, it suggests to pay attention to this. The Atik 314 camera is a cooled camera. The red statement says that the camera cooling is off, which is not normal.

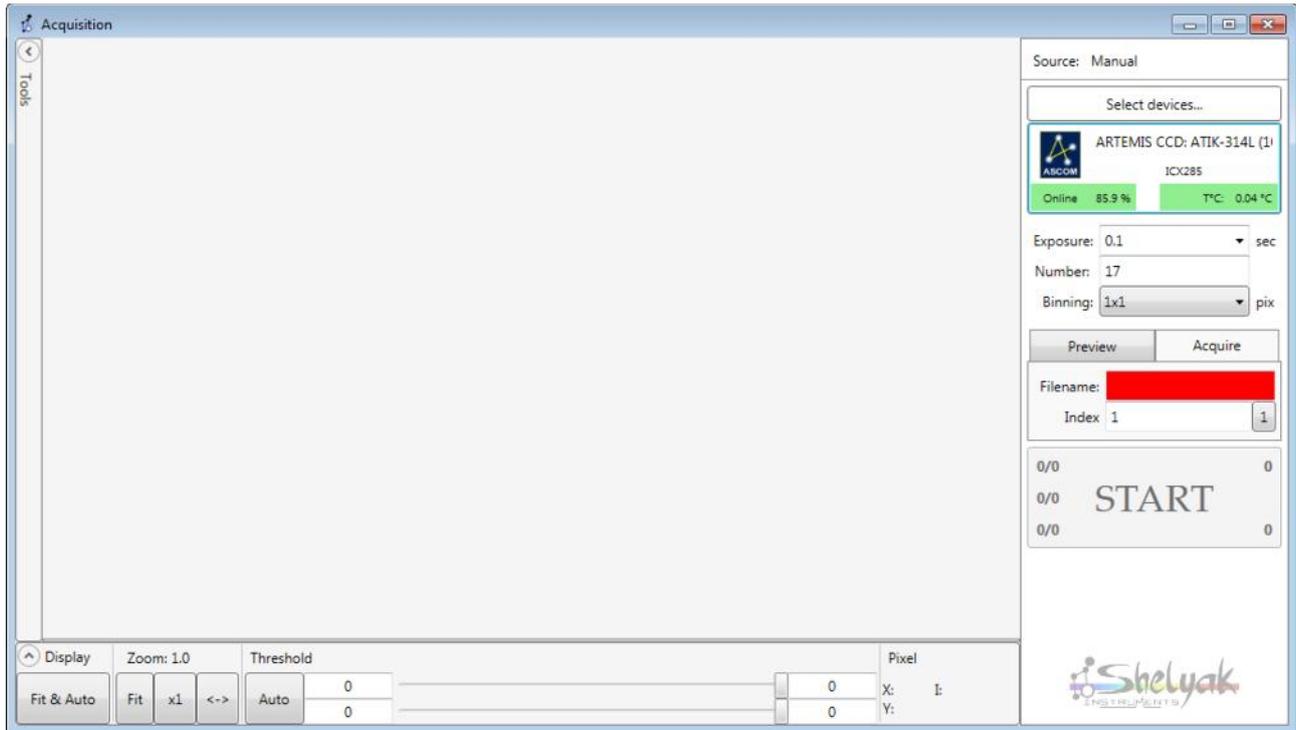
Go back to the camera connection window, select a target temperature for the camera, say 0°C, and click on « Activate » button:



Now, the acquisition window shows that the camera cooling is now on:



The cooling power and temperature remains red until the camera temperature target is reached. After a few minutes: everything becomes green.



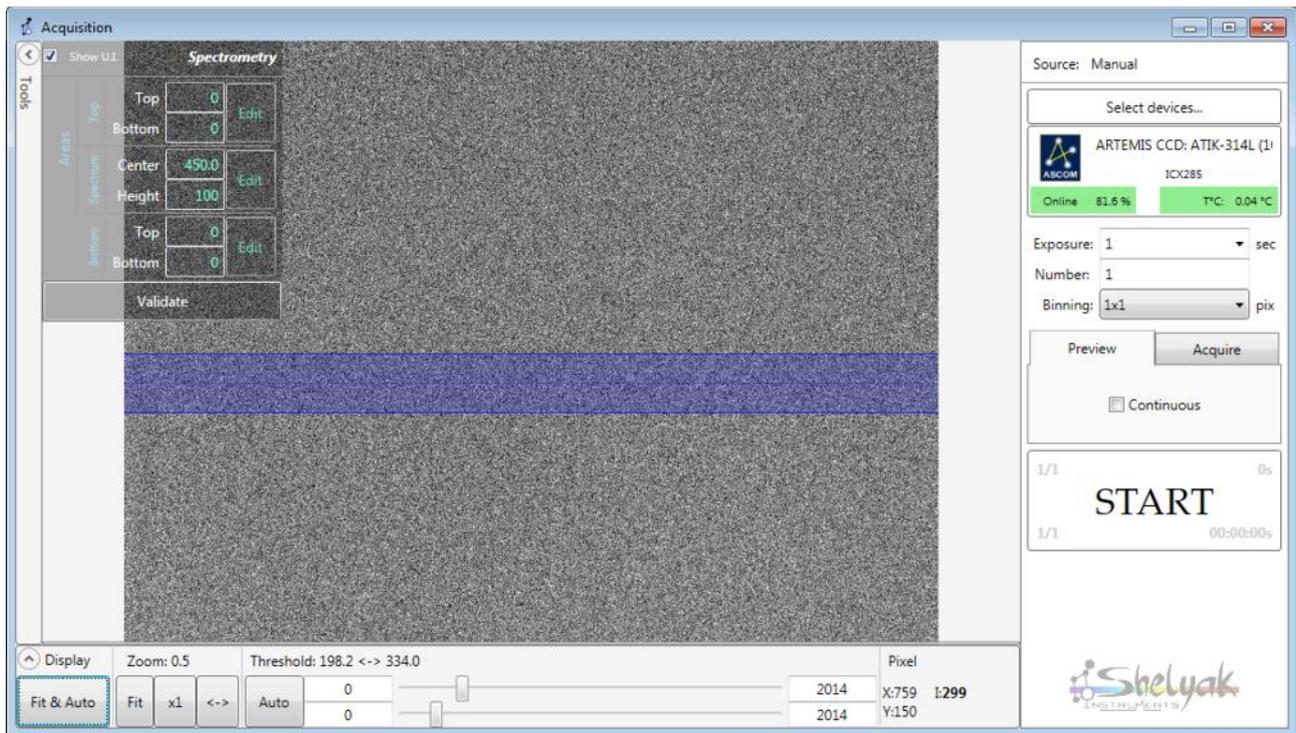
Of course, if during the observations, for any reasons the cooling fails and the target temperature is lost, then you would be immediately alerted by these red areas again.

The camera is now connected and fully operational: we can start with some acquisitions. As for any camera control software, you can select the exposure time (in seconds), the number of images you want to acquire, and the binning (default is 1x1).

Demetra includes a preview mode (the image is not saved), or to acquire (image is saved). If you want to acquire & save, give a root name for your file – the remaining red area in the acquisition module is because there is no file name. Usually, at the beginning, for tuning or testing the instrument, we start with preview images. Then, when all is Ok, we can acquire images.

In the preview mode, you can obtain a steady stream of continuous images; this is useful during tuning – for instance when you're focusing the camera.

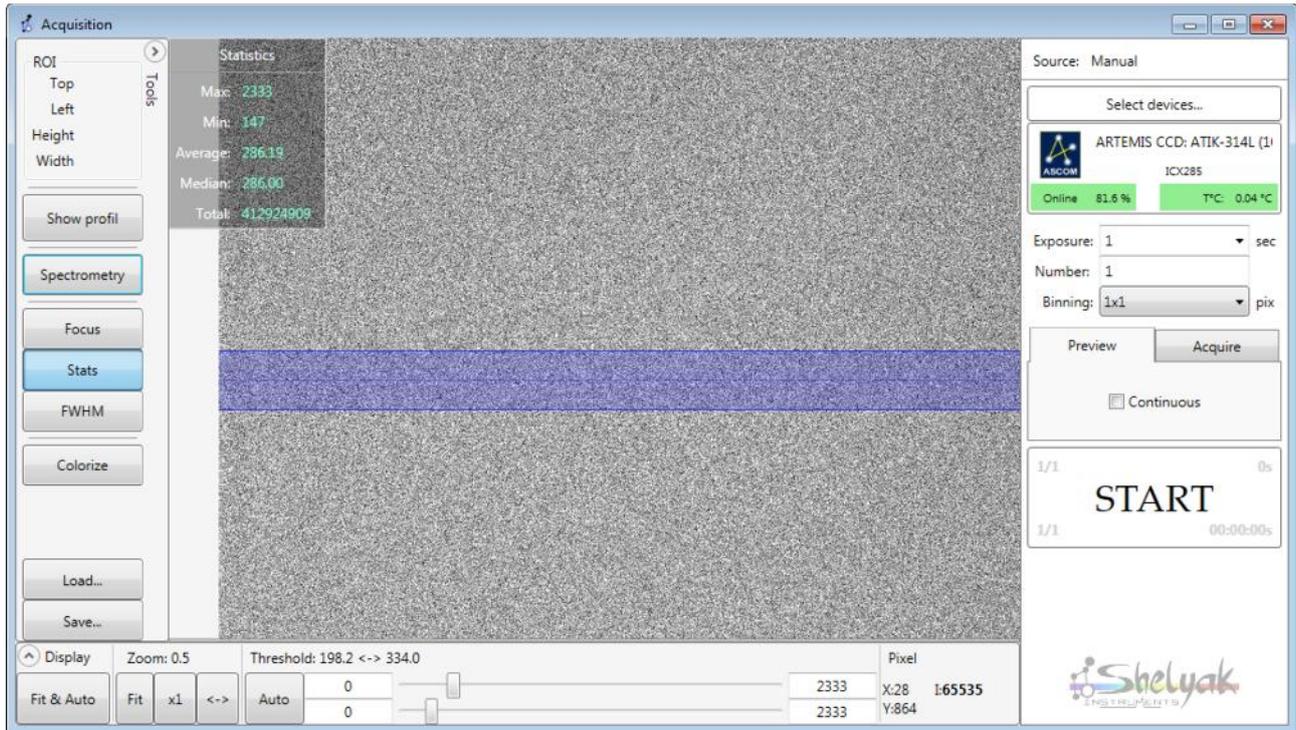
The image below is a dark preview image:



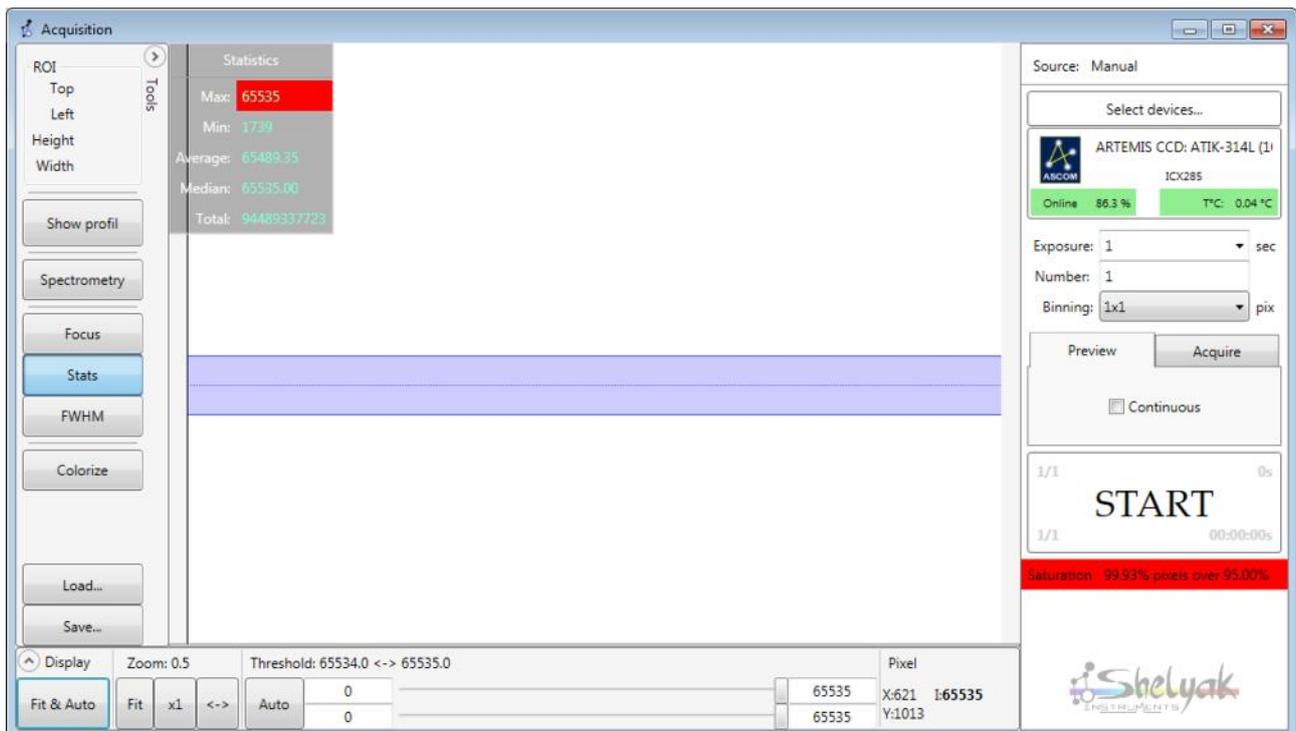
As already indicated, the viewing area of this window is the same as in the "observations" module. You can move or zoom the image, display tools, select an area in the image, and so on – please refer to section 5.5.

### **7.3 Saturation detection**

Let's do a quick example. Deactivate the Spectroscopy tool by clicking off the "Spectroscopy" button under "Tool", and activate the "Stats" button. Then, the stats for the blue band are displayed in HUD mode:



Now, let's make a saturated image – for instance, remove the camera from the spectroscope and launch a 1s exposure – for sure the image is saturated:



Demetra shows two areas red, indicating that the image is saturated! This function is useful during the observations: if at any time an image is saturated

– even partially – Demetra issues a clear warning.

### 7.4 Tuning your instrument

When you're familiar with the acquisition module, you can use it to tune your instrument: focusing the Alpy 600, putting the spectrum perfectly horizontal in the image, and so on. This is also the perfect tool to check, at the beginning of an observing session that everything works fine – you can check flat and calibration lamps, for instance.

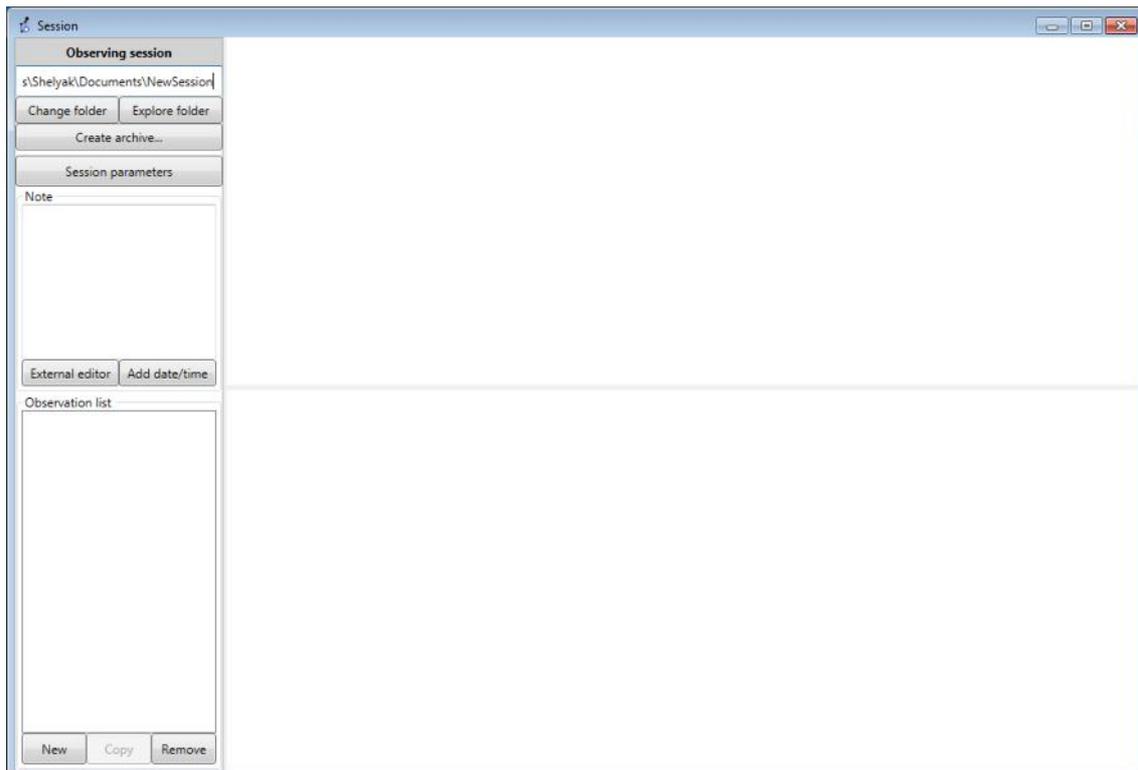
## 8 Make your own observations

You're now familiar with the way Demetra manages your observations and acquisitions. It is time to do your own observations. From now, you need to have an Alpy 600 spectroscope attached to your computer.

### 8.1 Create a new observing session

For Demetra, all the files from an observing session are stored in a specific directory. Then, creating a new observing session is easy: just **create a new empty directory**, and tell Demetra where this directory is. On top left corner of the Observations module, click on the « Change folder » session and select your new session directory (you can indeed create the directory at this point).

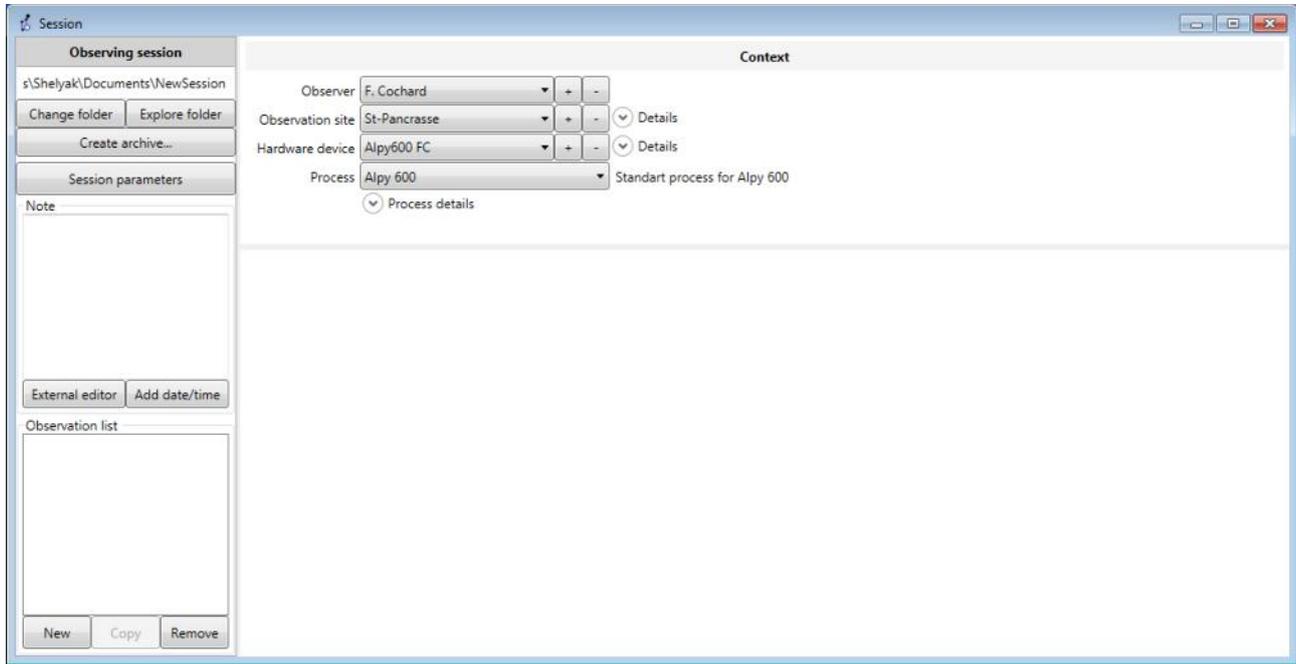
For instance, let's create a new folder called *NewSession* in the Document directory, and let's change Demetra session to this folder. Demetra is now blank:



You can check that the new session folder is empty by clicking on Explore folder.

## 8.2 General parameters

When you start a new session, the first thing to do is to setup the general parameters: Observer(s), Observation site, and Instrument (hardware device).



Demetra retains in its memory the previous data for each type of information (Observer, Site, Instrument): you can select them from the drop-down list for each item. You can of course create new entries (use button « + »), or delete an old one, no more useful (button « - »).

For Site and Instrument, you can (should!) add details, by clicking on the details arrows.

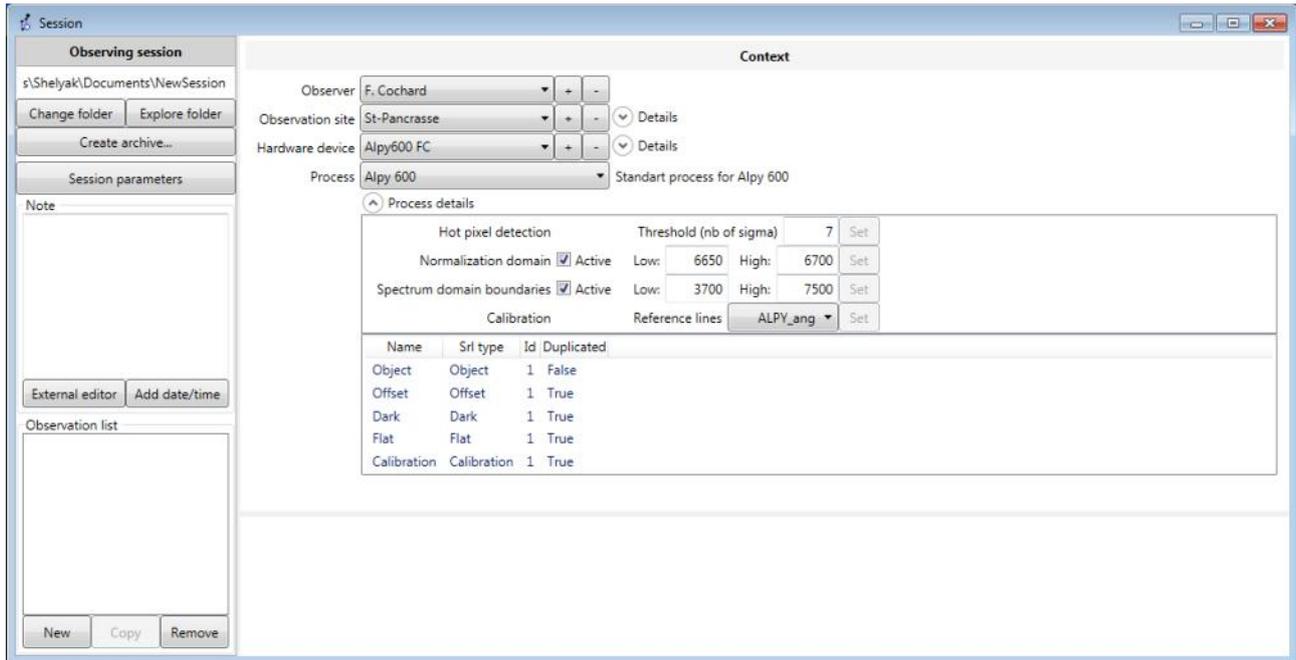
Filling the general parameters is important, because these data will be duplicated in all the FIT files generated by Demetra, during acquisition and/or data reduction.

## 8.3 Process selection

You can also choose the Process – but in our case, we're working with an Alpy 600, then you should keep the Alpy 600 process.

This is the Process which defines which images are required to go up to a valuable result. It defines the image baskets that are linked to each observation.

Look at the Process details (click on the « Process details » arrow):



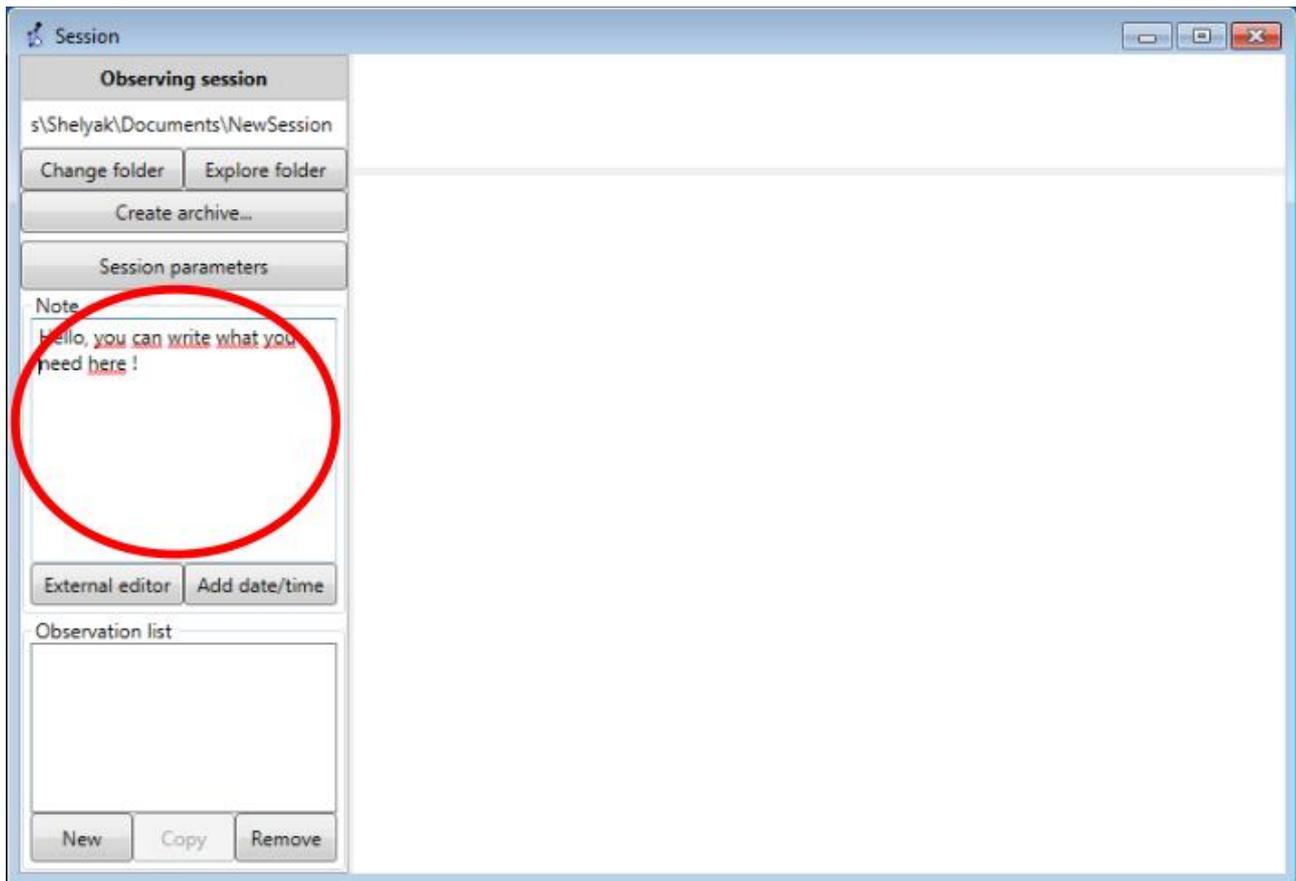
Some parameters are editable at this juncture. But these values should be Ok for an Alpy 600.

The threshold for hot pixel detection is used to create the list of hot pixels. All pixels above the dark master image median + 7 times the dark RMS are considered as hot. If you reduce this value, you'll detect more hot pixels, and if you increase it, you'll detect less hot pixels.

The normalization domain is the wavelength domain where the spectrum intensity will be considered equal to 1. At the end of the data reduction, the spectrum level is measured in this domain, and the whole spectrum is divided by this value – this is to prevent having huge values in the spectrum. This operation is done during the « Normalization » step of the reduction process. The spectral domain boundaries are the limits used for the crop operation (in the data reduction process). These values are the limits where the Alpy 600 is effective – outside, there is no useful signal.

### **8.4 Creating the log file**

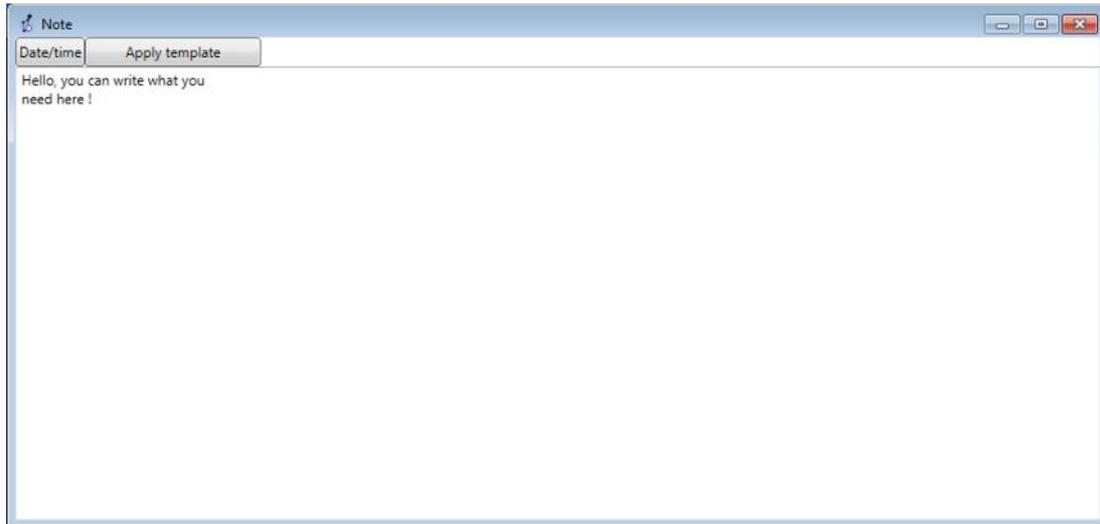
A log tool is embedded in Demetra. It is so important to be able to keep some notes during the observing sessions. You can write any comment at any time in the small notes window in the Observation tool:



Below this Notes area, there are two buttons. « External editor » opens the Notes in a full page editor, which can be more comfortable if you want to write copious notes!.

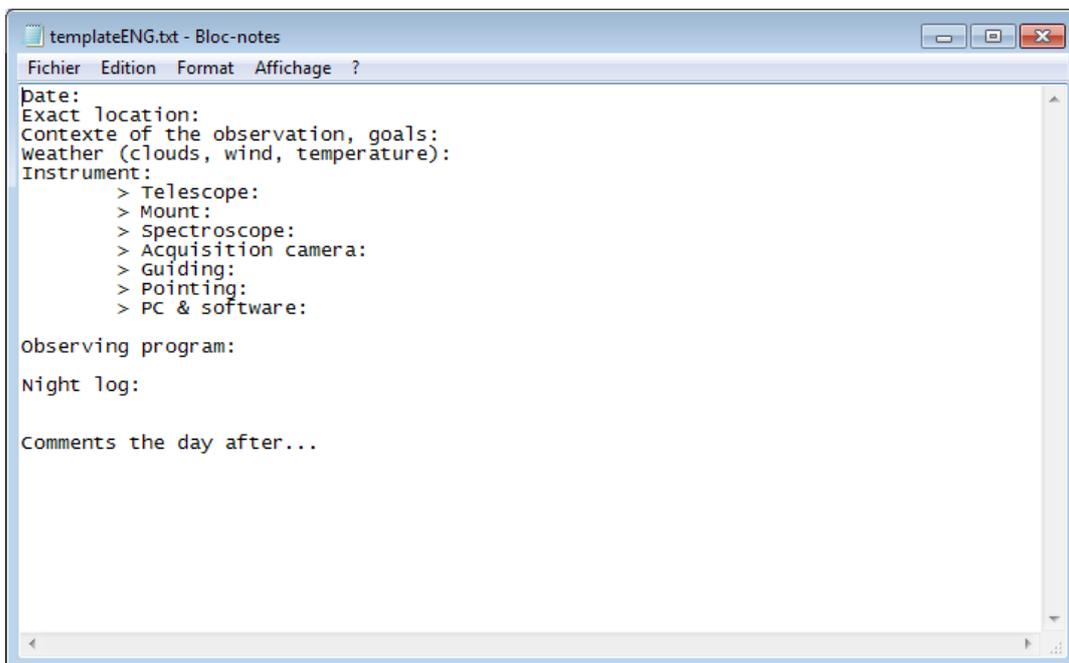
« Add date/time » is a quick tool to stamp what you write with date and time. Each time you click on it, current date and time are written where the cursor is. This is extremely useful for time-stamping events.

Open the external editor (by clicking on « External editor » button):

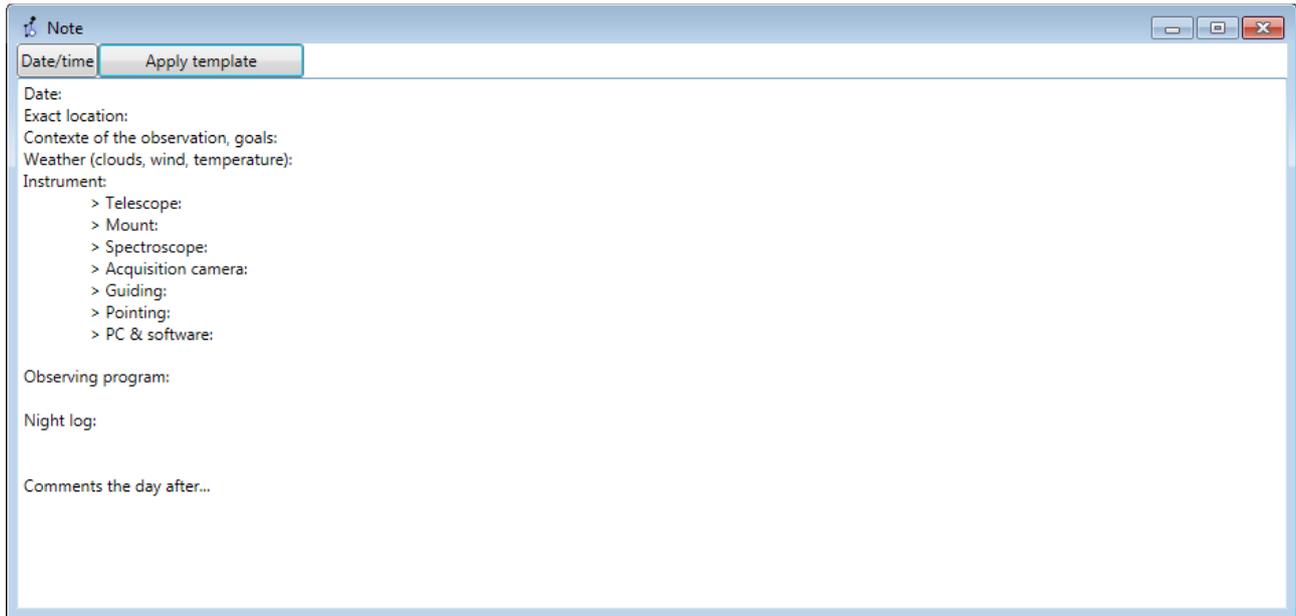


You will see, of course, exactly the same text as in the Observation window, and you still have the Date/time button.

In addition, you have another button « Apply template ». This makes Demetra load a pre-defined template file. For instance, you can predefine a text file with the following information:



This file must be stored (preferably, but not mandatory) in the <C:/ProgramData/Demetra> directory. Then, you can load it in Demetra, using the « Apply template » button, and fill it with the proper data. It is useful not to forget any important information to note:



There is no « save » button in the Demetra log file. This is because as soon as you write something in the notes window, it is written on the disk – no risk of forgetting to saving the file at the end of the night !

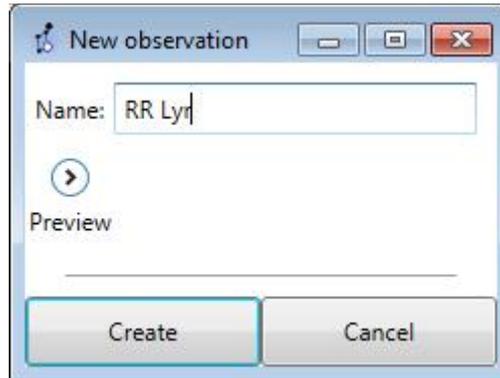
### ***8.5 Creating a new observation***

Everything is now ready for starting the observations.

At the beginning, the Observations list is empty. Click on « New » in the bottom corner of the Observations list: a new window pops-up, asking for an observation name. Give the name you want: the only condition is that it is unique (ie if you observe the same star 10 times in a row, then give an index to each of them: RRLyr-1, RRLyr-2, RRLyr-3, end so on).

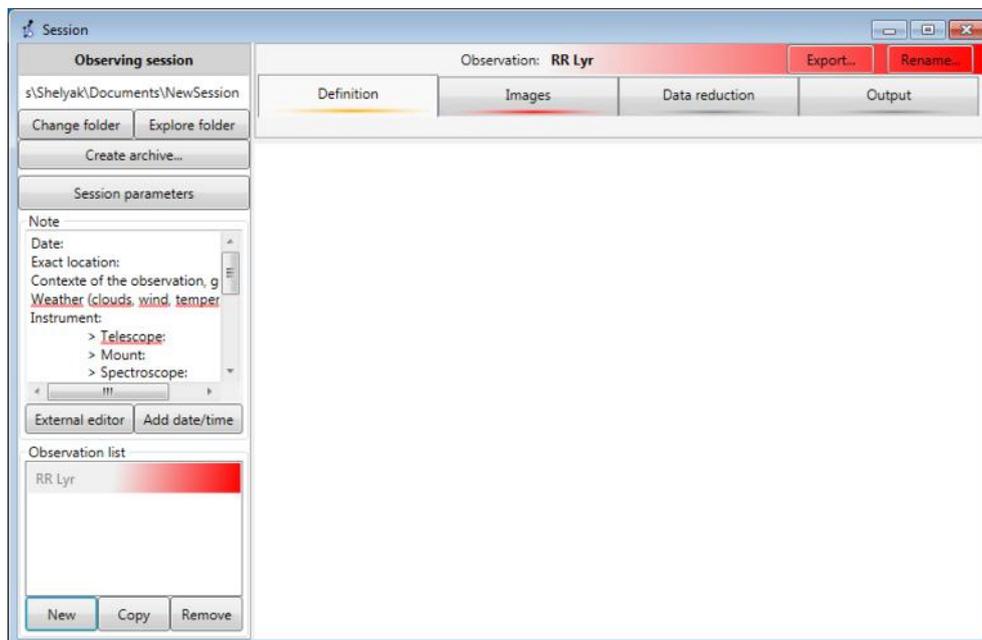
Be careful: an observation is a set of images & parameters that gives a consistent calibrated spectrum at the end of the process ; this is not a single image. If you decide to acquire 12 exposures of 300s for a single object – because you need such a total exposure time to get the right SNR – then, this is a single observation. In the above example ( RRLyr-1, RRLyr-2, RRLyr-3...), we're talking about successive observations i.e. we'll produce as many spectra as the number of observations. RR Lyrae is a good example of a star that requires, at some special instances to be observed many times, to show the quick evolution of the spectrum.

The name of the observation will be used for all the files created and linked to this observation.



If you click on Preview, you'll have a reminder of all the context parameters for the observation.

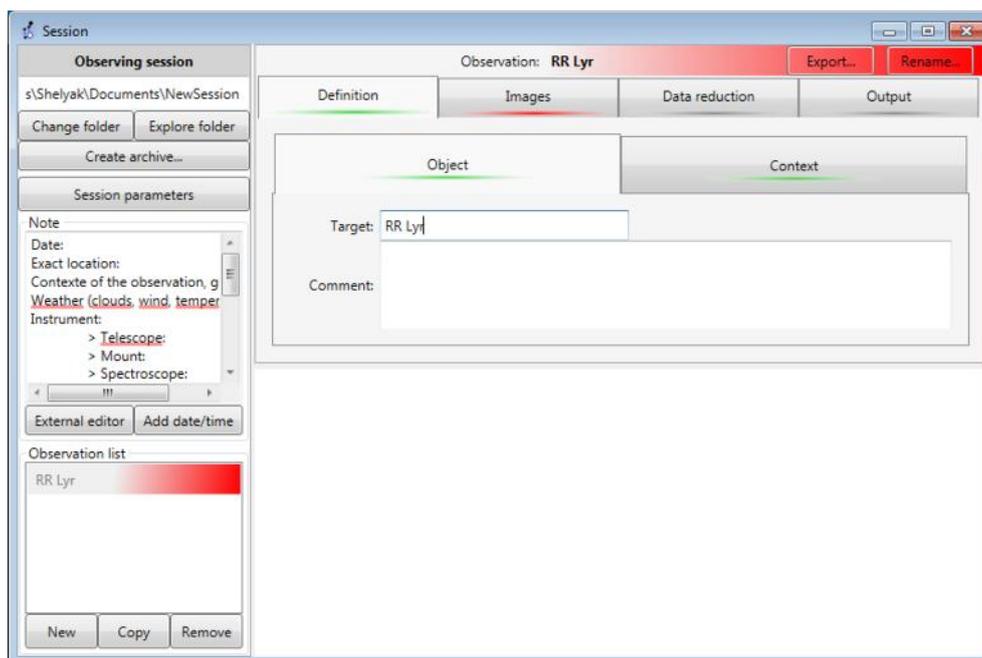
Click on « Create » to validate the observation name. You can now see the new observation in the main window:



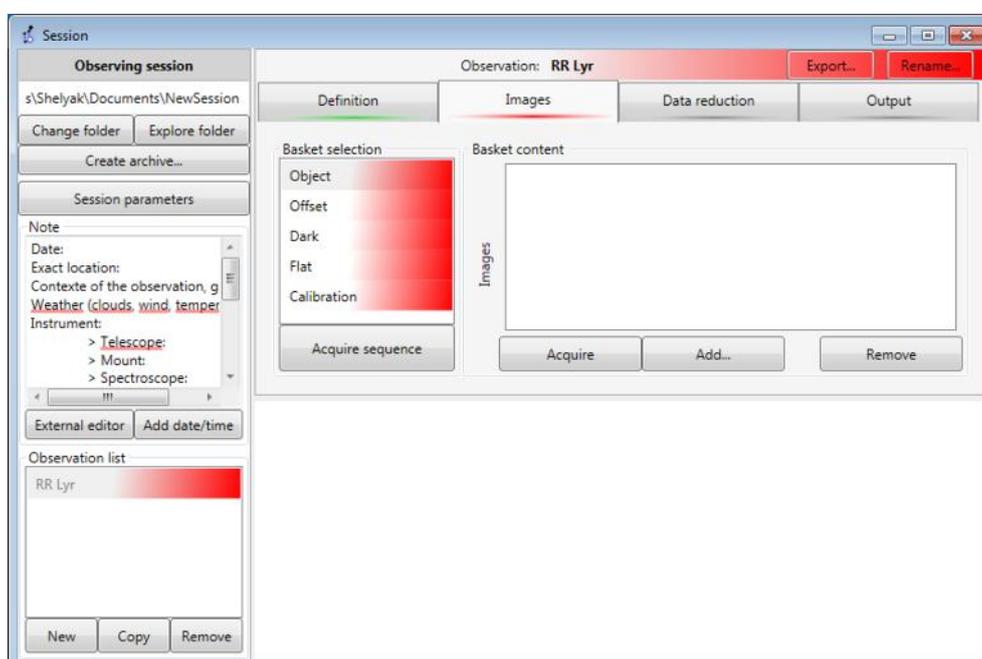
As you can see, the observation is RED, which means that elements are missing – this is normal, because we just created it. The color coding helps you to see where the missing elements are: the « Definition » tab is yellow, and the « Images » tab is red. This is where to put your attention.

In the Definition tab, the only missing data is the name of the target. This is usually the same as the observation, but it may differ (think about the RR Lyr time series above: observation names are different, but the target name is always RR Lyr).

Fill the Target name properly, and the « Definition » tab becomes green:



The, switch to the « Images » tab. Here, all the baskets are red:



Of course, this is normal again, because we've collected no image yet.

### **8.6 Add or acquire?**

There are two ways to put images in a basket: either you read it from your computer (if you already made the actual observation in the past), or you acquire it from the camera (which is the usual way to work with Demetra).

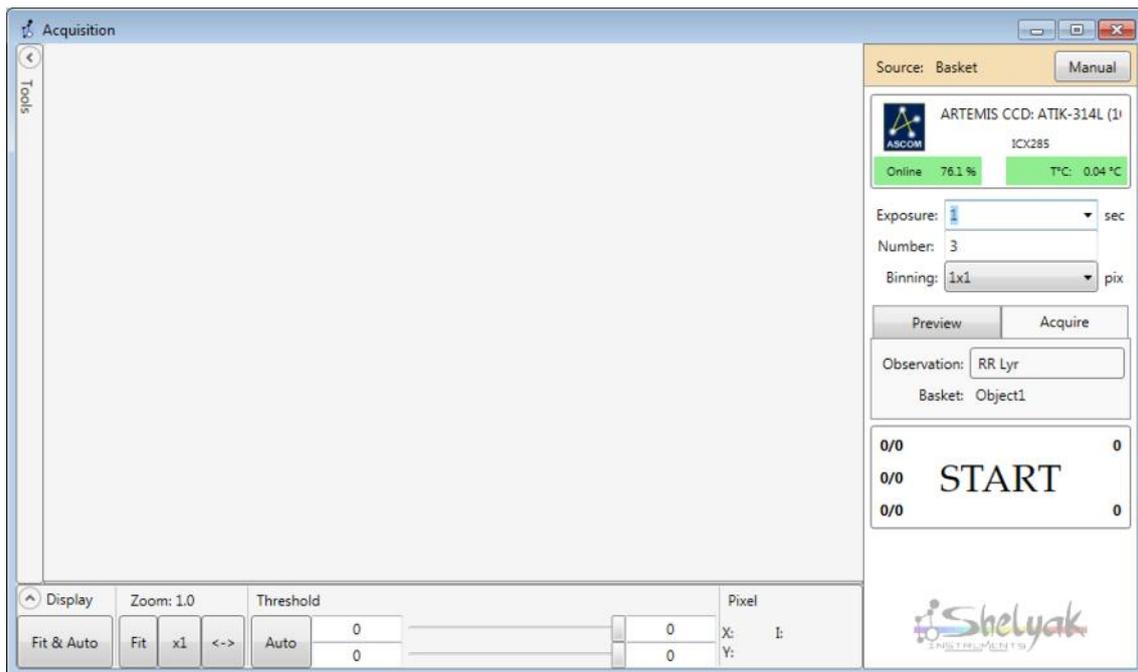
To add existing files from your computer, click on « Add... » button, and select

them from the correct folder. Reminder: if you select files that are not stored in the current session directory, then the files are be copied in the session folder.

There is no constraint on the files names: all the files that are in the basket will be processed by Demetra.

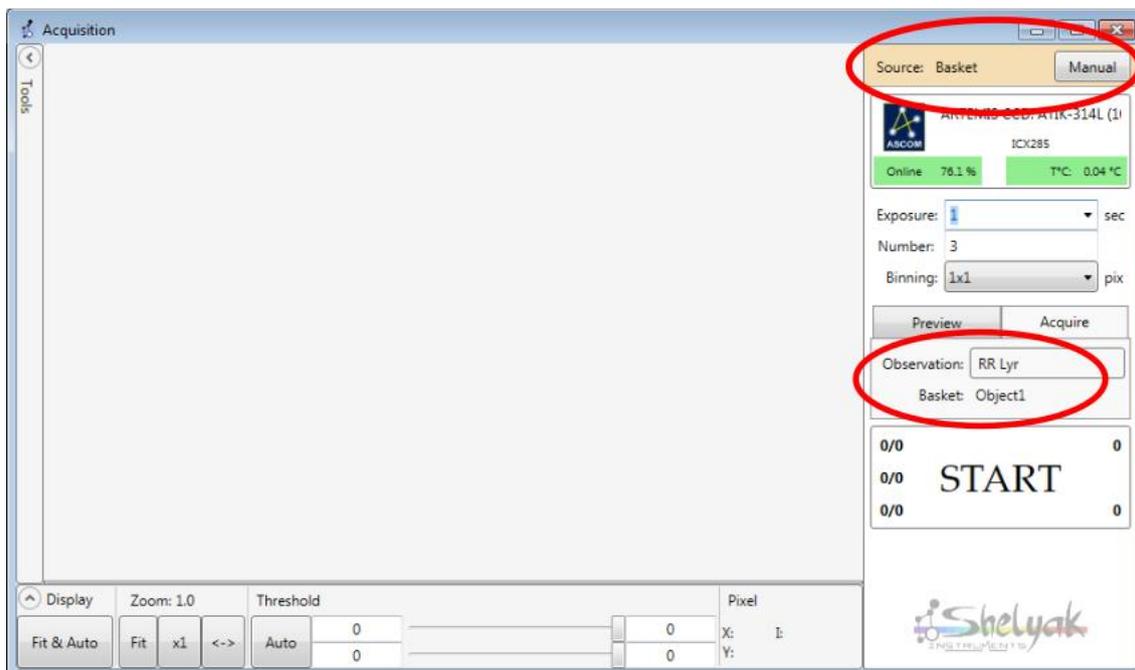
You must fill all the baskets, one after the other, before the whole observation area turns green.

Of course, if you want to acquire images from your Alpy 600, just click on "Acquire" button (for instance, in the Object basket). This opens the Acquisition module, of course:



We've seen in the chapter 7 how to use this acquisition module. But there are some differences with what was seen so far:

- In the top right corner, you can see the mention "source : basket". This means that the acquisition module is under the basket control and some data are prefilled.
- Above the start button, you have the name of the observation, and the basket that will be filled:



Thanks to this connection between Observation and Acquisition modules, when you'll launch the acquisition, they will be directly sent to the correct basket.

Some key tips here :

- The naming of the generated files is automatic (based on the observation's name), you don't need to care about this.
- If you want to recover the control of the acquisition module (from the observation), click on the "Manual" button, in the source area (top right corner).
- When you're in the acquisition module, you can switch back to the Observations by clicking on the Observation name (above the "Start" button).
- If you've put some files in a basket by mistake, you can always remove them – by clicking on "Remove" button under the files list of the basket (or select them, and press "Suppr" key).
- The only condition needed to make a basket green is to have at least one file in it. At this stage, Demetra does not make any control in the file itself.
- You can use the Acquisition module to get most of the images (Object, flat, calibration), and use the "Add" option for files which do not require to be made at each session (bias and darks).

We recommend to go up to the end of the first observation (ie, fill all the baskets of the first observation) before switching to the next observation – you will save time.

### **8.7 Blue band around the star spectrum**

As soon as you get your first star spectrum, you should define the "region of

interest" (ROI) around the spectrum, using the Spectroscopy tool (in the acquisition module). To do this, click on the 'Edit' button for the 'Spectrum Area' then 'click, drag and drop' the blue band that appears capturing the whole length of the spectrum. You should cover a vertical distance that included all the pixels that register a signal. You will notice that 'Validate' turns red. Click on 'Validate' to set this area.

### → **Image to come**

This ROI band is used for the "Show profile" and "Stats" tools (calculations are only made inside the blue band). Then, proper setup will make these tools working fine.

### **8.8 Yellow bands in the slit area**

While you're setting up the spectrum band ROI above, you should also set the two ROI for background sky bands depicted as yellow bands in the area of the image covered by the slit (this area is used to measure the sky background spectrum during the data reduction). The simplest way to see where is this area is, is to look at the flat image: the yellow bands must be inside the flat area, as big as possible, and not too close from the blue band, to prevent any side effect of the spectrum itself:

### → **Image to come**

### **8.9 Subsequent observations**

When the first observation is complete, you can begin the next one. You can repeat exactly the same operations (create a new observation), but you can save time by copying the first observation instead. When you copy an observation, most of the images can be copied directly in the new one : calibration, flat, darks, bias... indeed you can select the ones you want to copy:

### → **Image to come**

Of course, if several observations use partly the same files (darks, bias, flat, calibration), Demetra only copies the links to the files, but not the files themselves – the files are only once on the disk.

### **8.10 Reference star spectra**

During your night's observation, good technique mandates that you have to observe a reference star spectrum. This is needed to calculate the instrumental & atmospheric response. Ideally, a reference star is :

- close to your target (specially the height in the sky, to get the same atmosphere thickness),
- with the same magnitude range,
- a hot star (A or B type).

- the star should have a known spectrum and available in the Demetra reference libraries.

Demetra includes a reference spectra database. Make sure that you can find a spectrum in this database which matches with your reference star. Depending on the accuracy you expect, you can reuse the same reference for the whole session (low quality), or observe a reference star for each target (high quality).

### 8.11 Data reduction

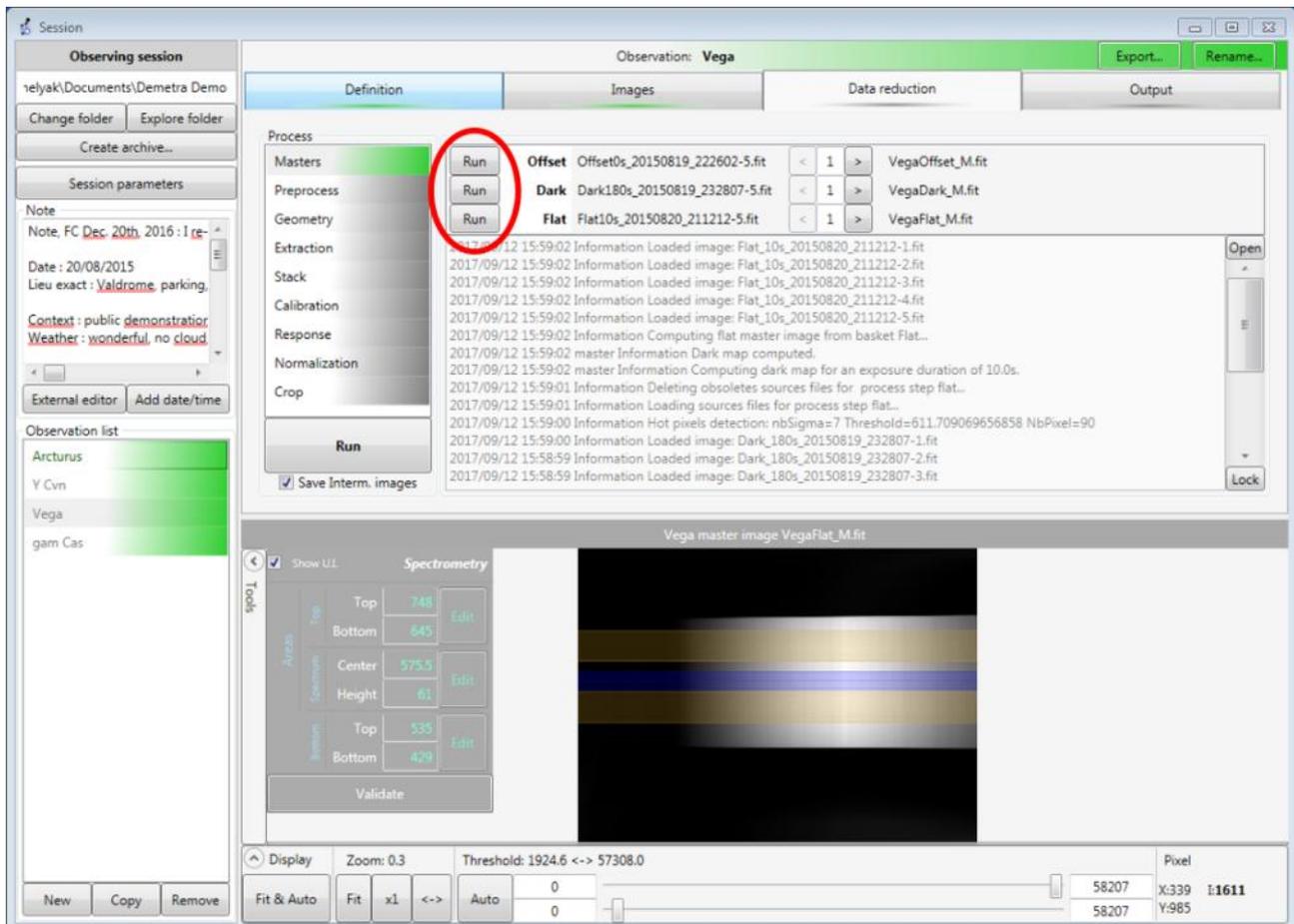
The first time you run a data reduction, we suggest to do it step by step : you'll understand in detail what happens, and you will setup properly the parameters at each step.

In the sections below (pictures), we re-use the demo session included in Demetra. But you should do the same with your own observations.

**You must start with the reference spectrum.** In our data, the reference star is Vega (A0 type).

#### a) Master images

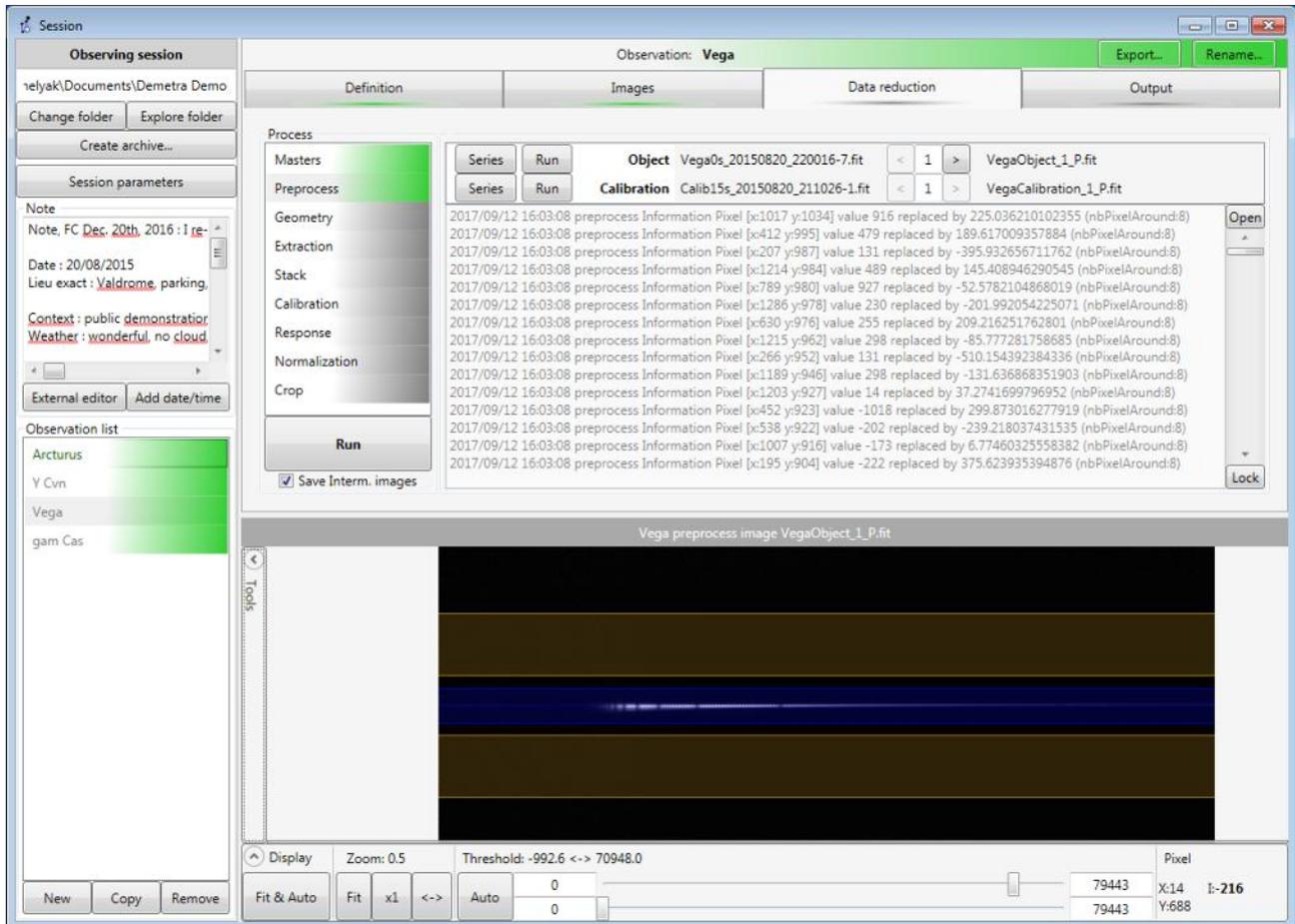
This step requires no parameters. You can run each line (bias, dark, flat) by pressing the individual "Run" buttons:



Use the flat image (see above) to check that the yellow bands are within the slit area.

## b) Pre-process

This step requires no parameter. You can run the pre-process for target (Object) and Calibration, again, by pressing the individual "Series" buttons:



The buttons "Run" launch the operation for a single image (the one selected alongside), and the "Series" launches the operation for the whole series of images. Of course, you can switch from one image to the next/previous one in the series with the left & right arrows.

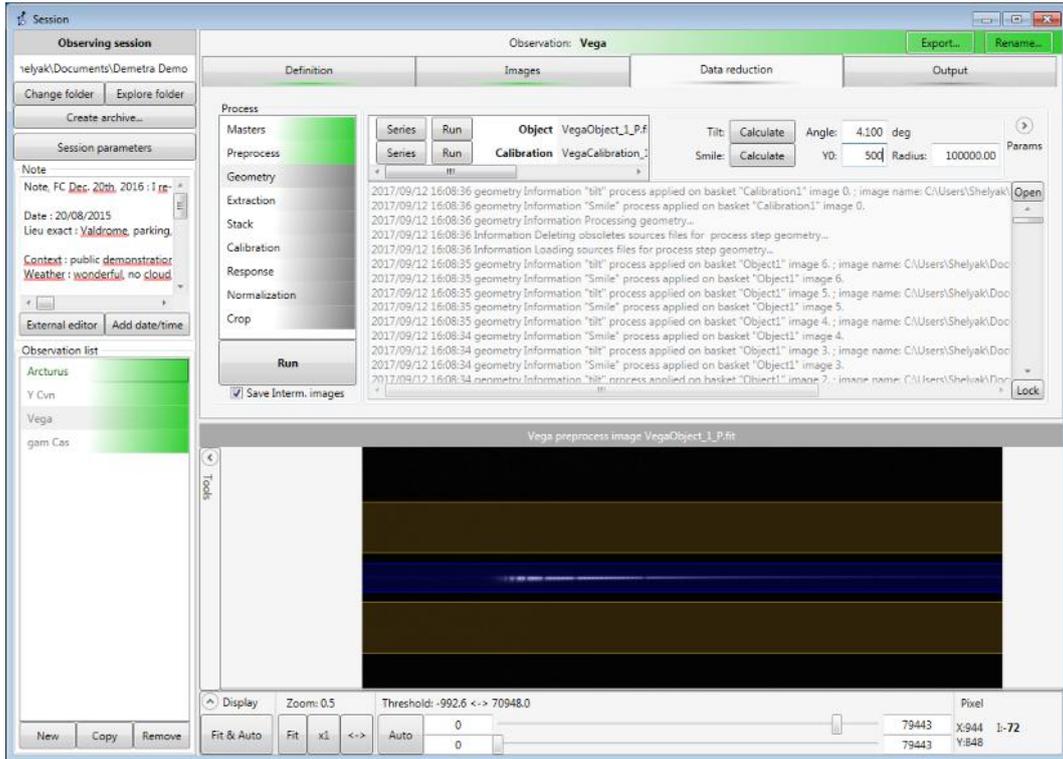
## c) Geometry

The Geometry step requires several parameters to be defined by the user: the tilt angle of the spectrum and the radius and Y position of the smile.

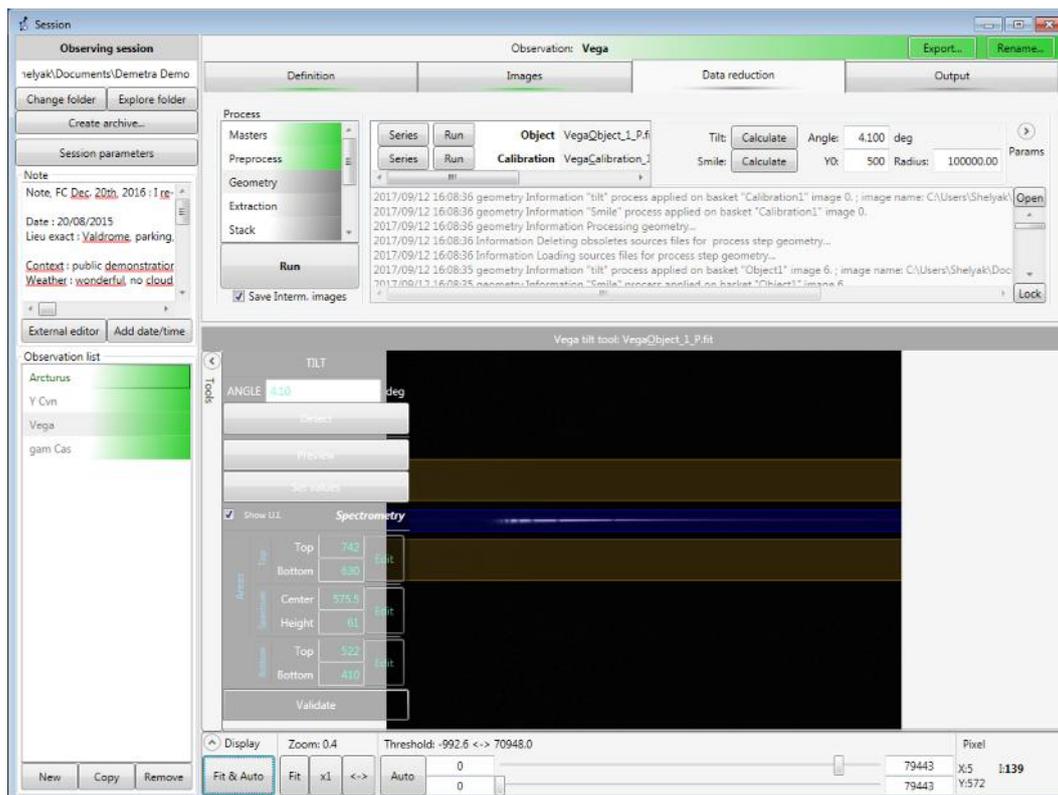
The tilt angle is the angle between the horizontal and the spectrum. Ideally, it should be null, but there is always a small remaining angle.

The "smile" is the optical effect that make calibration lines appear bent. We consider these to be arcs of circles.

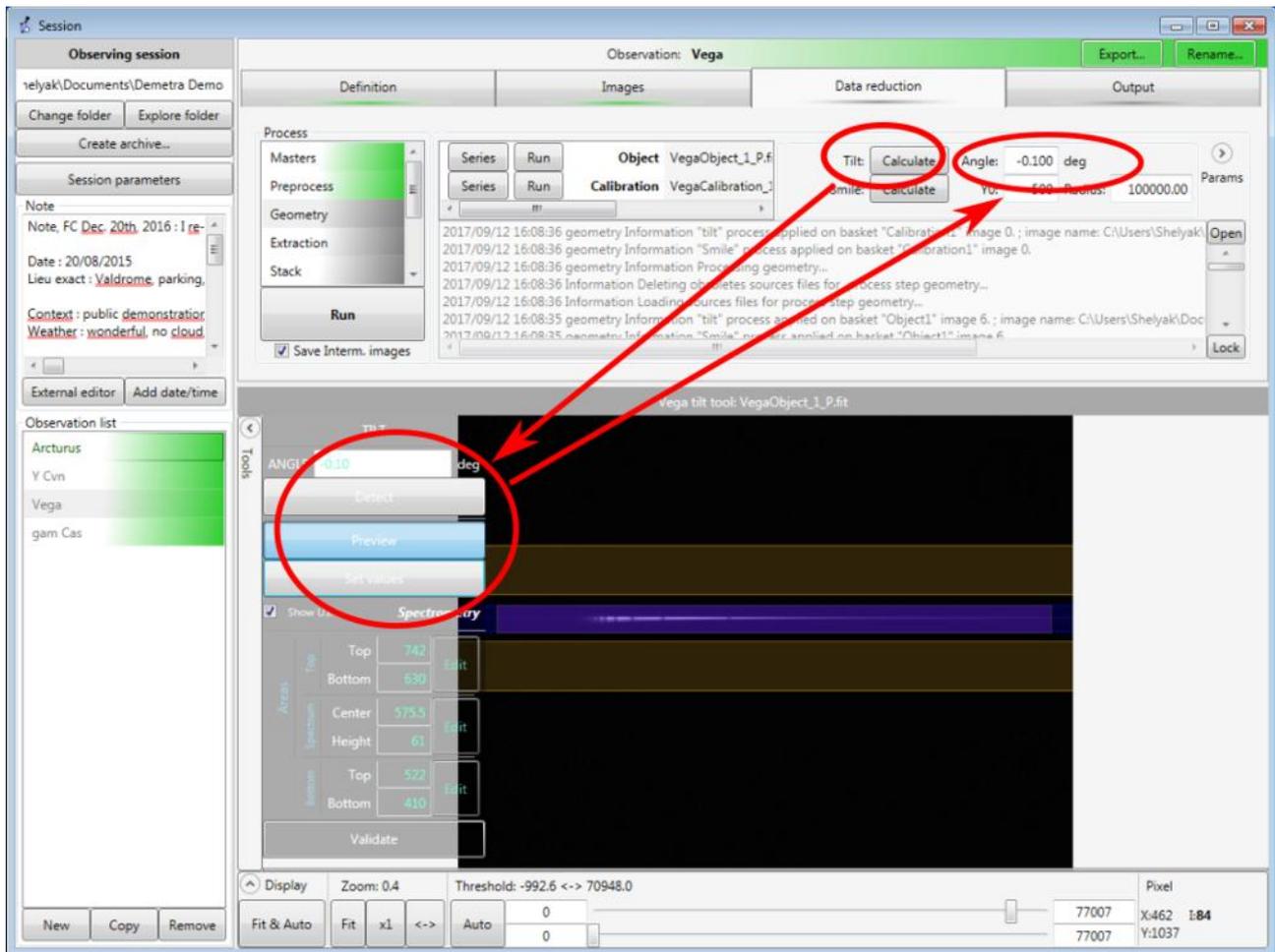
Click on the "Parameters" button, in the geometry step. There is one button to calculate the tilt, and another one to calculate the smile:



Click on "Calculate" for the tilt angle. This opens the spectrum image in the lower view area with a 'detection' dialogue box superimposed:



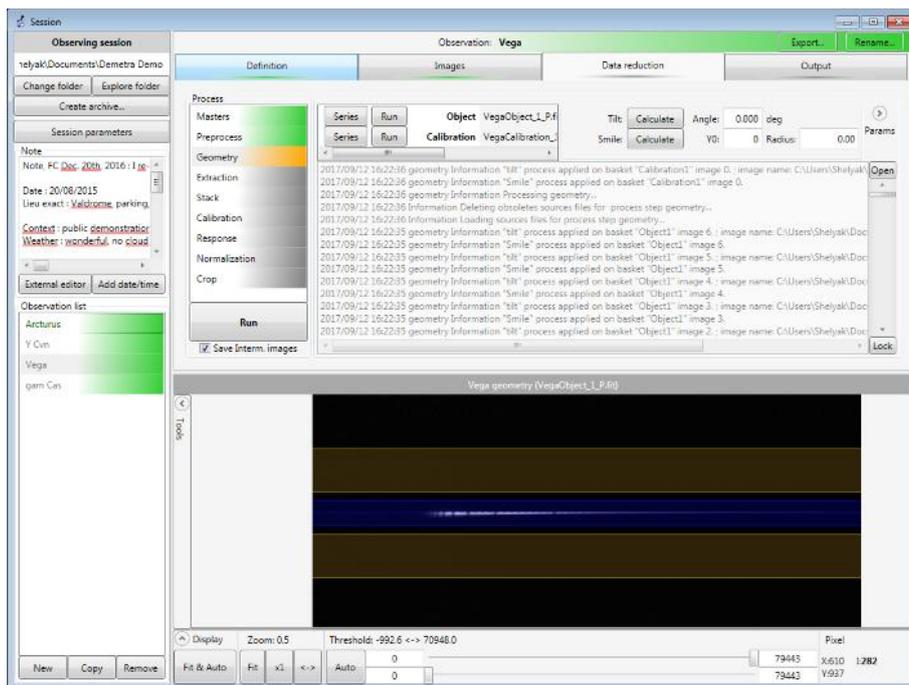
'Click and drag' to draw a rectangle around the spectrum, and click on the "Detect" button. This fills the angle value above the Detect button. You can preview the tilt correction effect by clicking on "Preview". If the result looks OK (the correction must put the spectrum horizontal), then click on "Set values" button. This sends the tilt value to the data reduction parameter (top right):



The principle is the same for the smile – except that it uses the Calibration (or lamp) image. Draw a rectangle around a bright, vertical emission line in the spectrum, then click on “Detect” button. If the value is Ok in “Preview”, click on “Set values”.

When all parameters are Ok and set, you can run the calculation of the Geometry step.

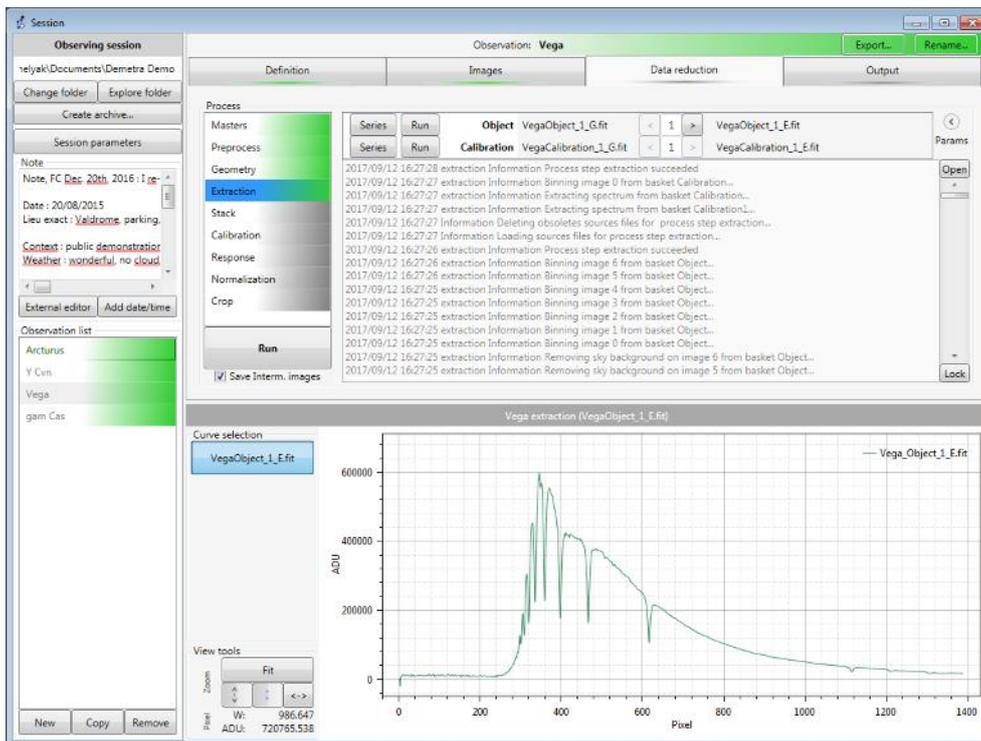
**Note:** if there is no value for tilt and smile parameters, the calculation of the Geometry step results in a yellow coloured step:



### d) Extraction

The only parameters for this step are the positions of the blue and yellow bands which should have been defined earlier in the process. However, you can edit them here, but normally they are Ok from the acquisition (see sections 8.7 and 8.8).

Run the extractions for each series (object and calibration). The result of this step is the 1D profile, with the X axis given in pixels:

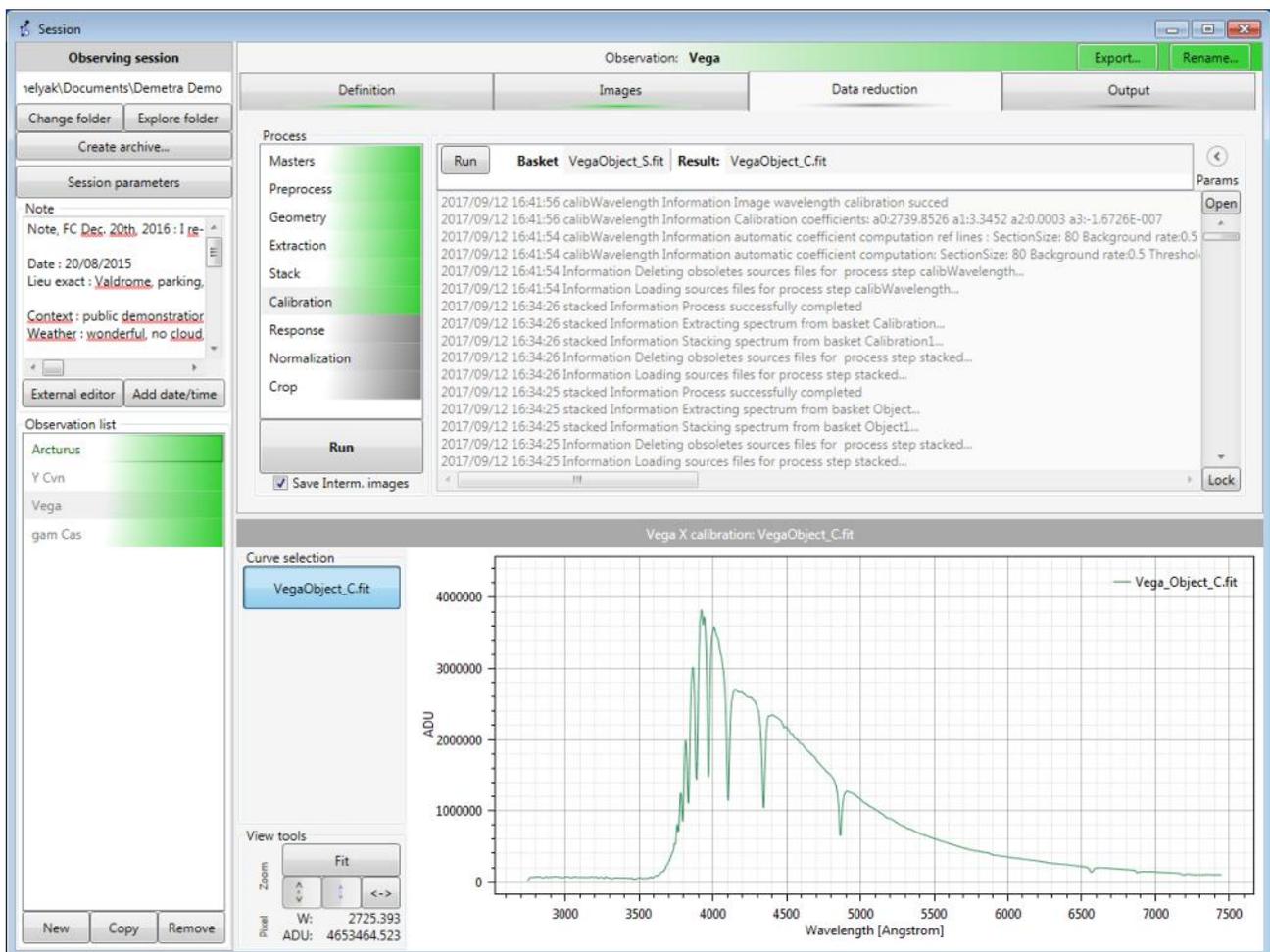


## e) Stack

The stack operation requires no parameters : this is a single addition of the previous spectra. The result is a spectrum with a better SNR, still in pixel units.

## f) Calibration

The wavelength calibration is fully automatic in Demetra! However the tool behind this process is very rich in functionality. Demetra uses the calibration processed image to automatically detect all the lines from the ALPY lamp spectrum. Then, it compares this list of detected lines with a list of expected lines, and calculates the best match. Demetra can then establish the link "pixel / wavelength" for each expected emission line. Then it can calculate the dispersion law, and convert the spectrum "in pixels" to a spectrum in physical wavelength. Most of the time, the calibration is very quick: just click on the "Run" button, and you will obtain a spectrum calibrated in Angströms:



If this operation fails (yellow/red step, or obviously a bad result), this is probably because Demetra has not been able to detect the expected lines in the calibration spectrum. This can be modified in the Calibration tool (click on the "Calibration" button, in Calibration step parameters).

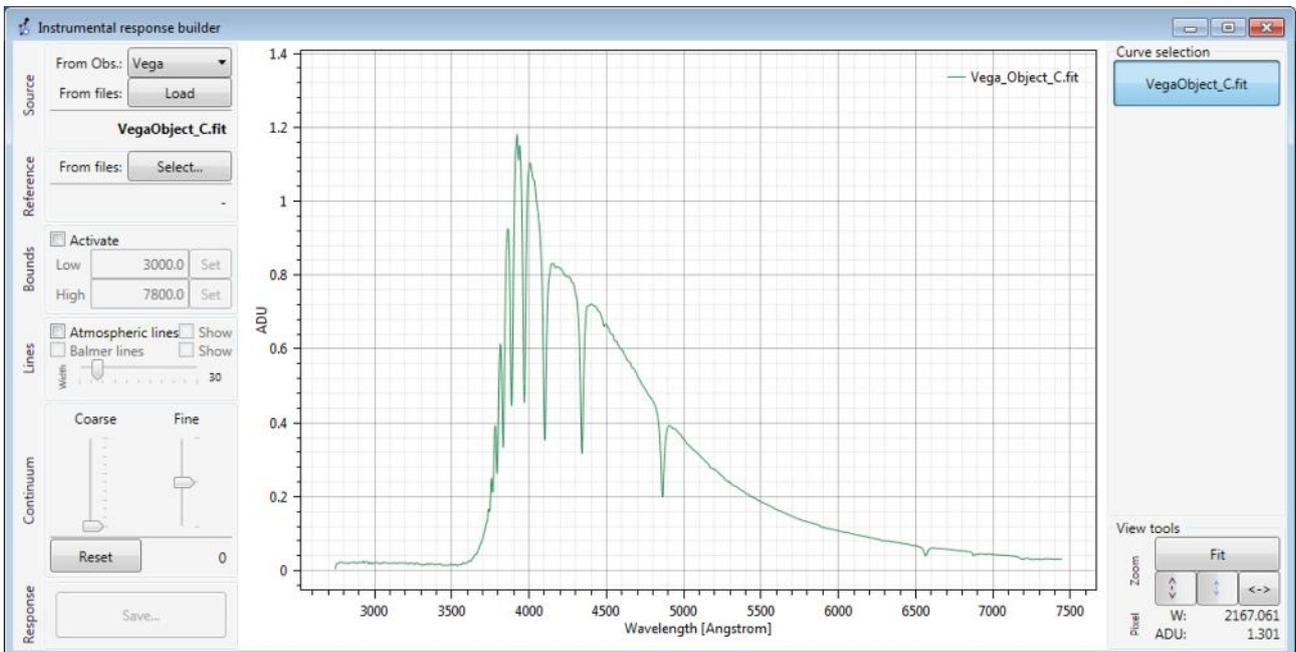
## g) Response

Demetra needs a response profile to correct the target spectrum from negative instrumental & atmospheric effects.

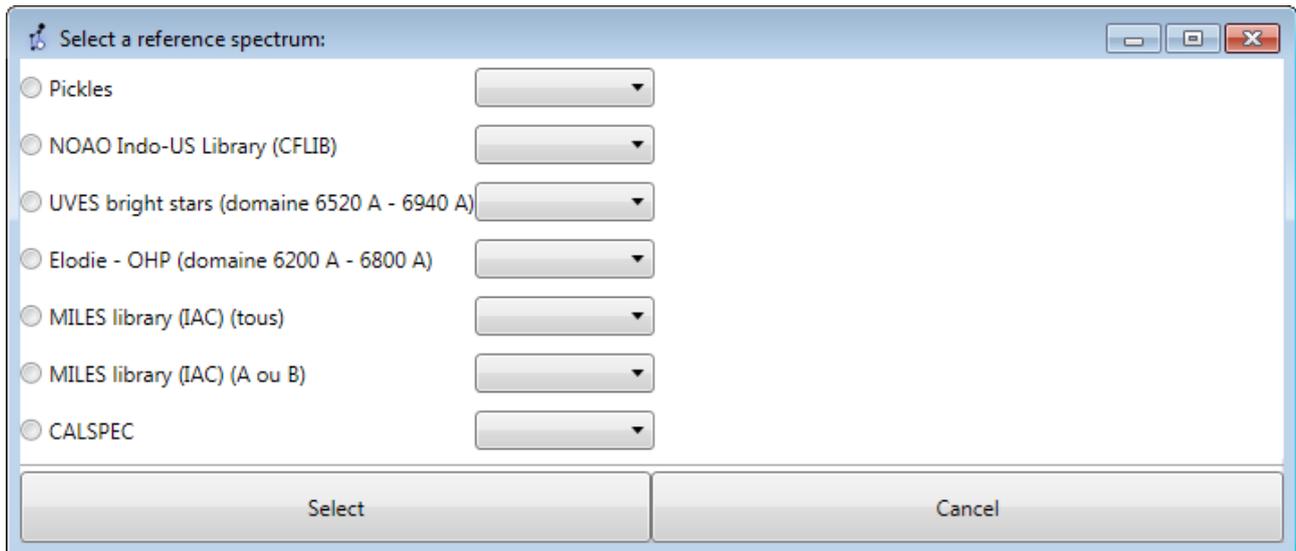
You can use the reference star observation to build this profile. Click on the "Construction I.R." button in the 'Response' window to open the tool. A separate window opens:



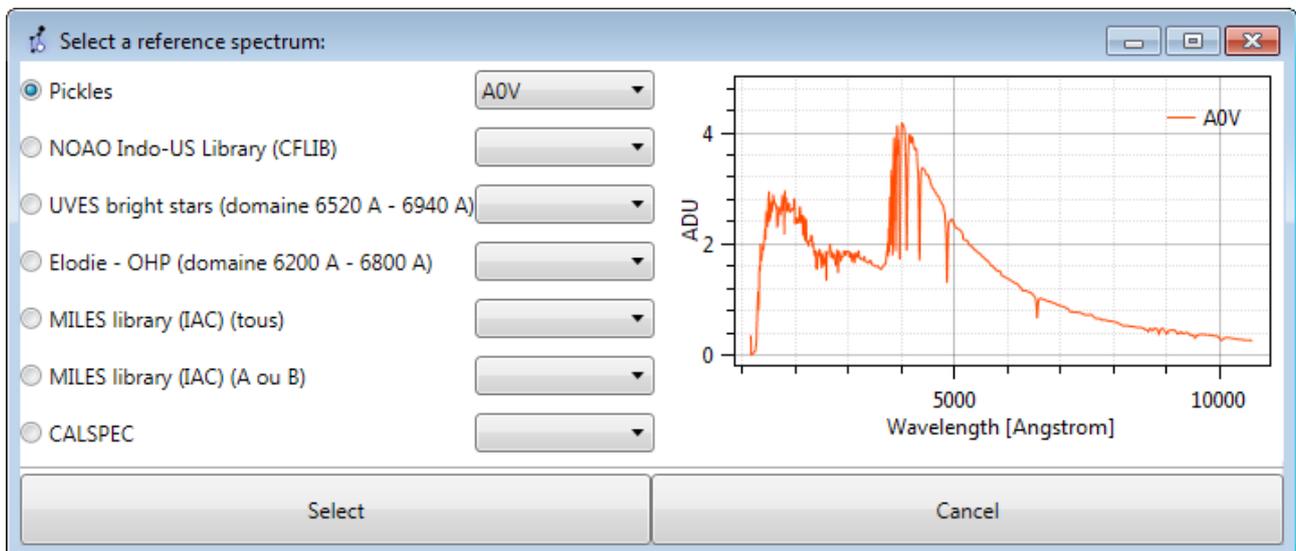
In top left drop-down menu, select the Observation you want to start with – in our case, Vega:



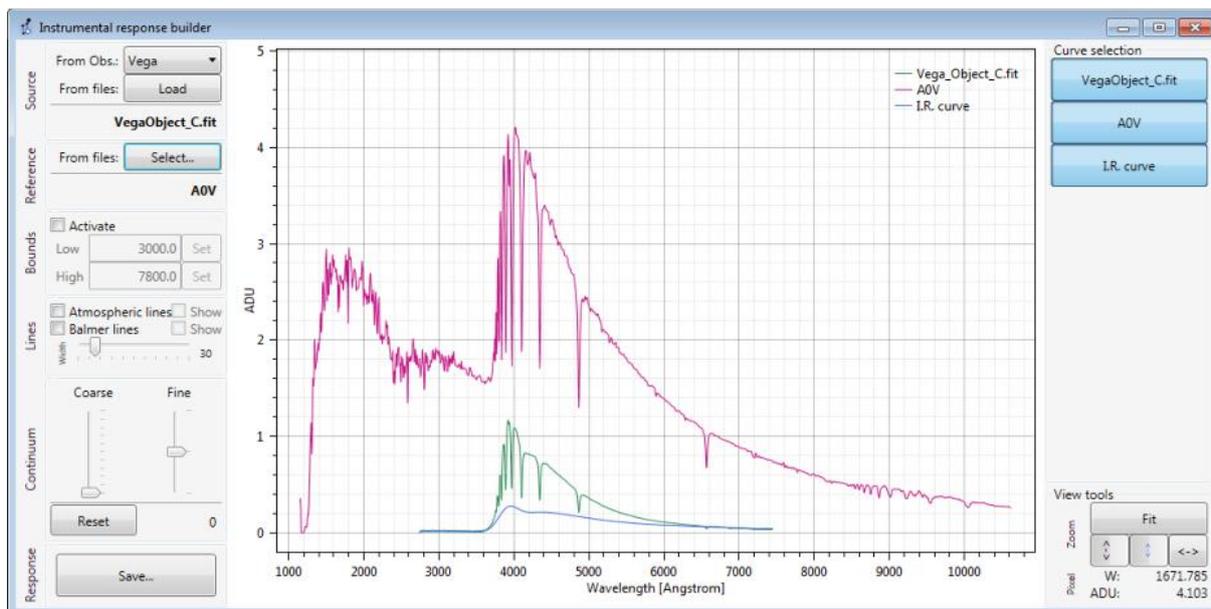
Then, in the "Reference" box, click on "Select" button which opens the reference spectra database:



As an example, select Pickles, and the open the list – choose A0V type (because Vega is an A0V star) to display the reference spectrum:



Click on Select to import this profile to the Response tool:

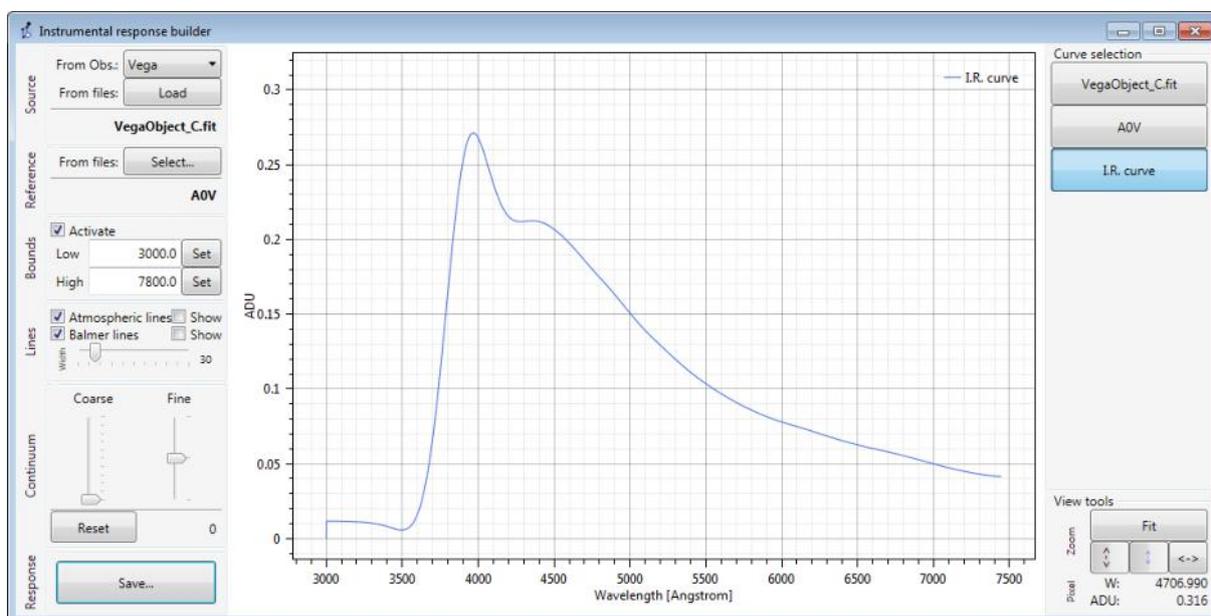


Now, you can see three spectra : yours (green), the reference one (purple), and the ratio between the two (blue). You can erase or display each spectrum with the buttons on the top right of the frame.

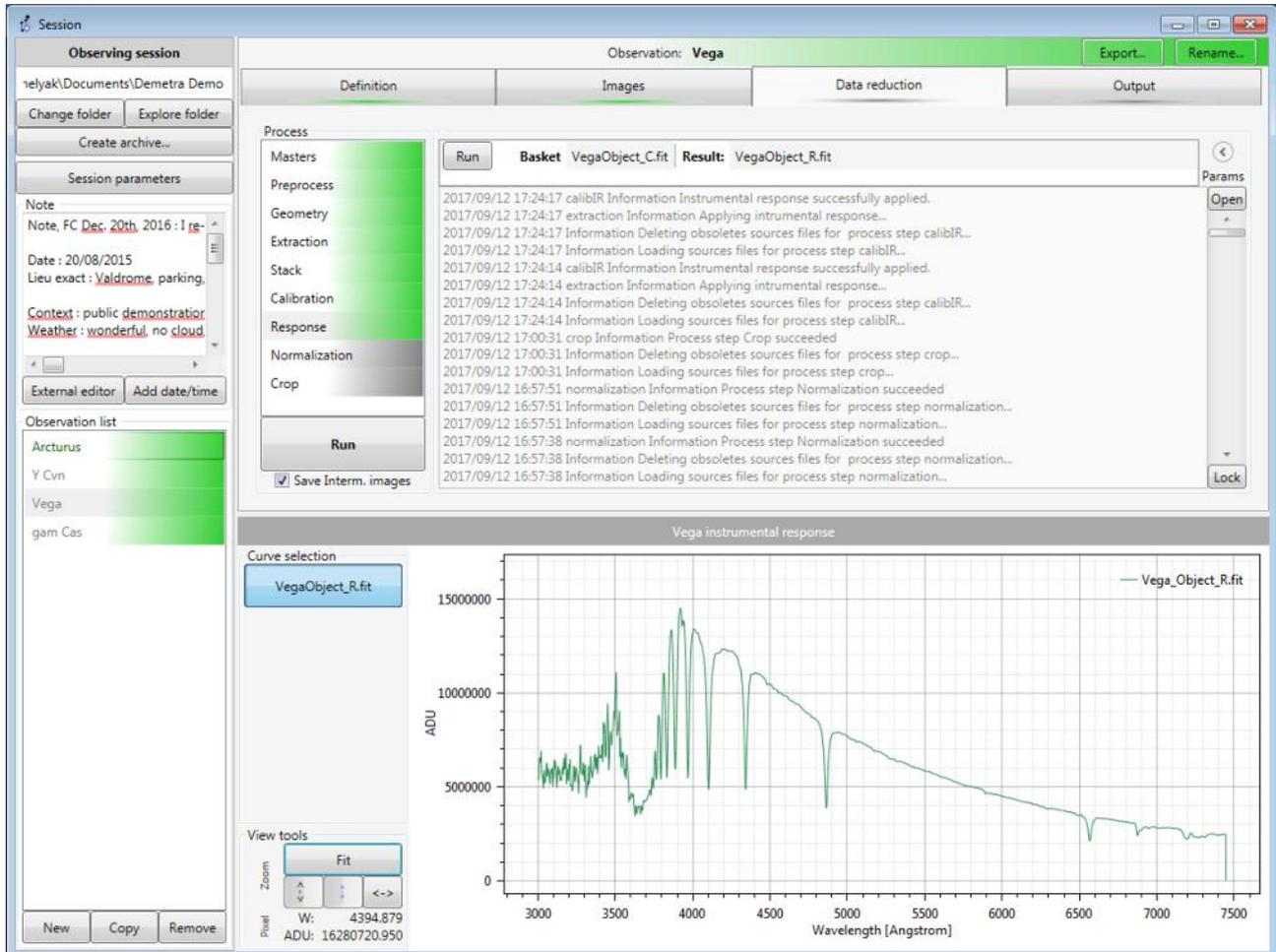
The response calculation takes care of the Balmer lines (deep absorptions in the profile) and of the telluric bands (on the right end). It also applies a filter, to smooth all noise effects in both spectra (yours and ref).

You can play with the different parameters, but the default values should be Ok.

The result is your response curve – just save it (an automatic name is proposed):



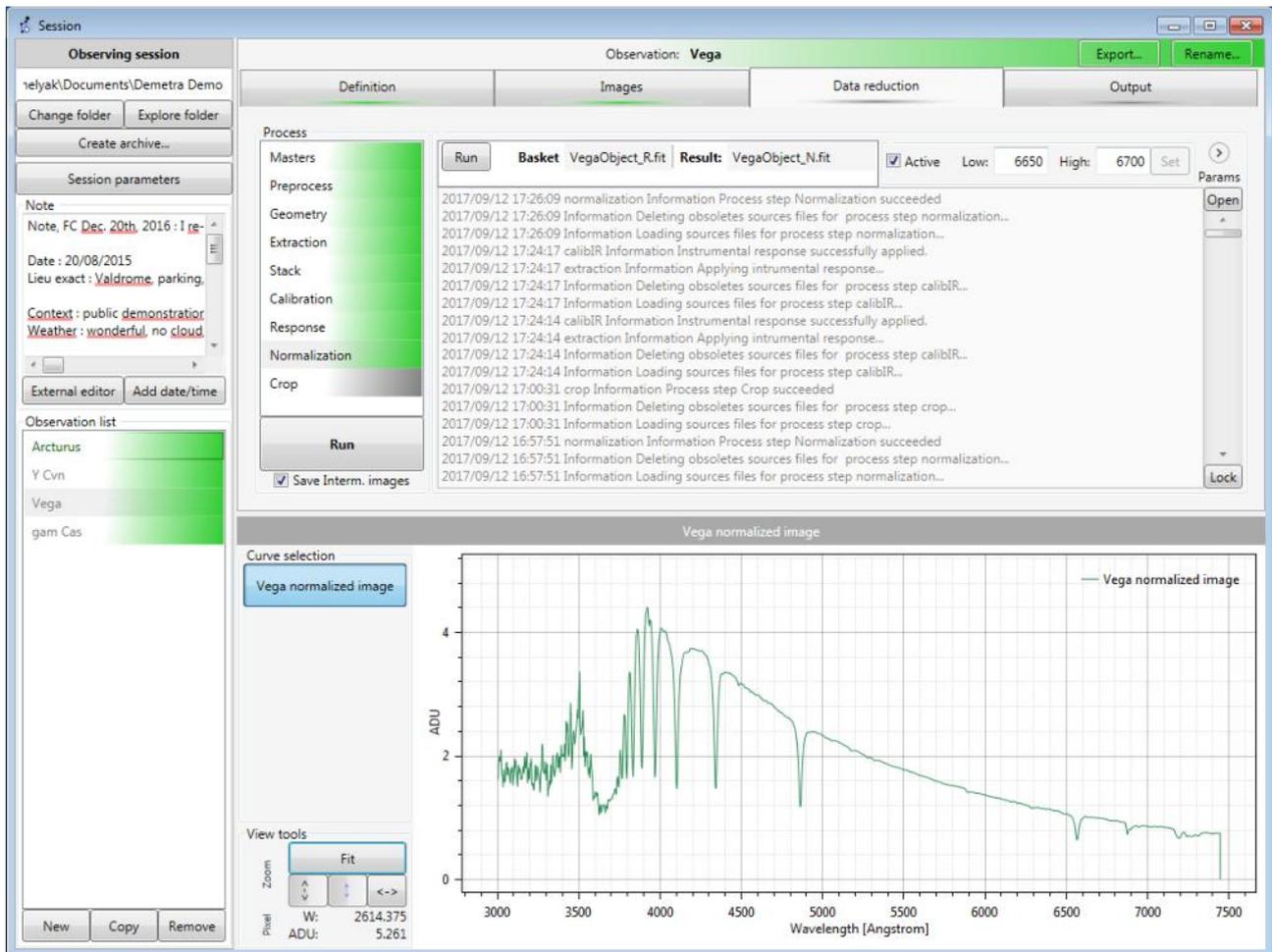
Close the Response tool window, and come back to the main Response step. Now, select the response file in Params, top-right – the one you just created. And run the step. The spectrum is now corrected from the instrumental & atmospheric response curve you just constructed:



Note : if you don't have the Response curve available (for instance because you did not observe a reference star), then select "No response" in the Response step parameters, and run the step – in fact nothing is changed (no response profile is applied).

## h) Normalization

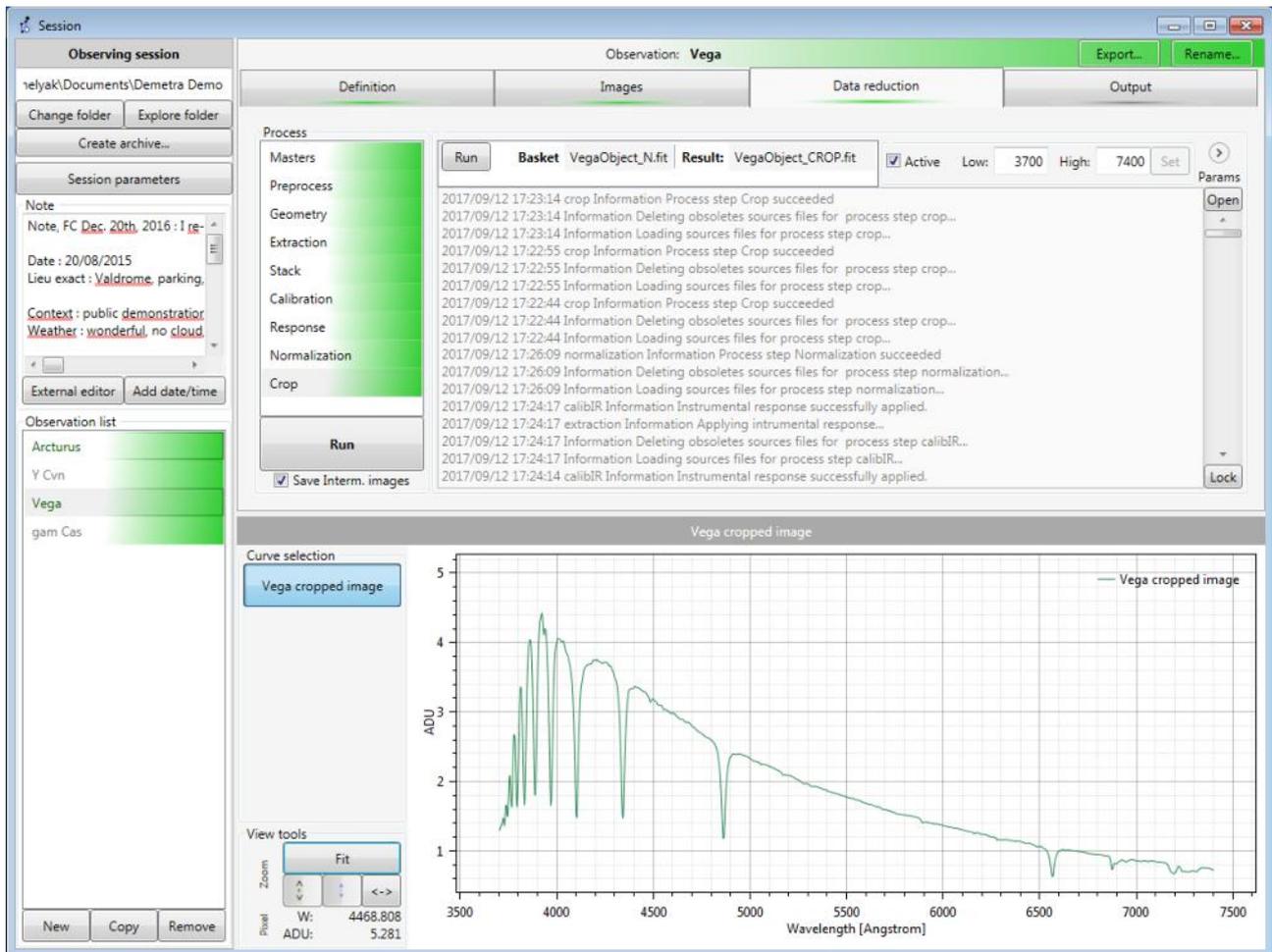
The parameters used for this step are the bounds for the spectral domain used to calculate the reference value (equal to 1) of the spectrum intensity. These parameters are defined in the process details, but can be edited here. Usually, you don't have to change these values. Then simply run this step. After this step, the intensity values have "normal" values (they were huge before):



## i) Crop

This last simple operation cuts the spectrum to the useful domain of the Alpy 600. The bounds of this domain are also defined in the process details, but can be edited here.

This is the last operation in the reduction process. The resulting spectrum is ready for analysis!



## 8.12 Publishing the result: Output tab

When the calculation is finished, you may want to publish the result for sharing with friends. This is the output tab purpose. This tab is also the one you will have to go to later on, when you want to come back on this observation, in few days... or years.

The data reduction process ends with creating the FIT file (compliant to BeSS FIT keywords requirement). Its name is made of the Target name, the date and time of the observation, and the .FIT extension. In our example, the result for Vega is: Vega\_20150820220026.FIT

In the Output tab, you can :

- Save the result in FIT format (it is already done automatically, but here you can select the file name you want).
- Export to a .dat file. This file is very basic, this is a single text file, with two columns : one for the wavelength, and the other for the intensity. Each line represents a point of the spectral profile. This basic file format is useful when you want to export data for calculation, for instance to Excel, Matlab, and so on.

- Of course, you can display the result.
- You can also open the FIT file in the Demetra Image viewer, to show all the details of the FIT header.
- Then, you can display the process log, which gives a lot of informations on how the data reduction process ran. Note : this process log is also saved on the disk in a text file.

### ***8.13 Data reduction for other observations***

When you've reduced the data for the reference star, you can repeat the same process automatically for all the observations of your session. This is the other real power of the Demetra software. The whole automated process becomes quickly repeatable without too much manual intervention. Because nothing changed during the session (tuning parameters, camera, and so on), all the parameters remain the same. Then calculation is immediate: you can run all of them in one click (the General "Run" button, below the reduction steps). The only point to note is that the acquisitions that follow may need to have their ROI redefined if you've placed the star on a slightly different place in the spectroscope's slit! But this can be done at the camera acquisition stage and is a minimal task.

## **9 Conclusion**

It is now your turn to run wonderful observations. Demetra will help you to make these observations fast and easy – and help you to concentrate on the most important factor: the science that you can do with your Alpy 600.

Share your results with the community !

François Cochard  
September 2017

End of the document.