RSS: Long-slit spectra processing and extraction v1.0

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Product and Specphot directories

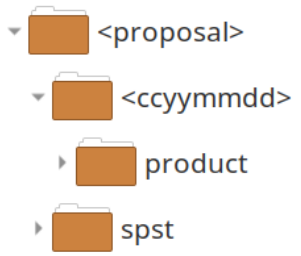
NOTE: This assumes the user is running a **Linux** operating system.

The procedure below is just one possible way to prepare the proposal product and specphot directories after receiving the relevant *SALT data available for download*-email for the observed product and requested specphot data, if relative flux calibration is required. Applicable specphot standards for the proposal is requested via the new Web Manager (or the old Web Manager) using the **Request spectrophotometric standards** tick box and **Request data** button at the bottom of the *Summary of executed observations* section.

Using a terminal (replace the variables <proposal>, <ccyymmdd>, <PIPT_login> and <PIPT_passwd> as applicable):

```
# Make proposal directory
mkdir <proposal>
cd <proposal>
# Make observation date directory
mkdir <ccyymmdd>
cd <ccyymmdd>
# Download proposal product tarball from the ftp location
wget --user=<PIPT_login> --password='<PIPT_passwd>' -c -t 100
ftp://saltdata.salt.ac.za/<proposal>.<ccyymmdd>_product.tar.bz2
# Untar proposal product tarball
tar jxvf <proposal>.<ccyymmdd>_product.tar.bz2
# If specphot data were requested, move up to proposal directory
cd ..
# Download spst directory from the ftp location
wget --user=<PIPT_login> --password='<PIPT_passwd>' -r -np -nH -c -t 100
ftp://saltdata.salt.ac.za/spst
```

The above procedure should produce the following directory structure:



Docker image setup

The **RSS: Long-slit spectra processing and extraction** app is distributed as a Docker image named **rsslsspectra**.

NOTE: This assumes the user is running a **Linux** operating system.

Using a terminal:

Install Docker (if not already installed):

```
# Update the package index files
sudo apt-get update
# Install Docker
sudo apt-get install docker.io
```

Get (pull) the **rsslsspectra** Docker image:

```
# Pull the latest rsslsspectra image from SAAO's Docker registry
# … this takes a few minutes depending on your internet speed …
docker pull registry.saao.ac.za/rsslsspectra:latest
```

If the `pull` command gives the message: "Got permission denied while trying to connect to the Docker daemon socket at unix:///var/run/docker.sock":

```
# Add the unprivileged user to the docker group
sudo usermod -aG docker ${USER}
```

After the `usermod` command restart computer / laptop before proceeding.

Run the **rsslsspectra** Docker image as a container (make sure to run the command as **1** line in the terminal):

```
docker run --rm -it --ipc host -v /home/${USER}:/home/${USER}:rw -v
/tmp/.X11-unix:/tmp/.X11-unix -e DISPLAY=$DISPLAY -u rssuser
registry.saao.ac.za/rsslsspectra
```

Overview

The RSS science product pipeline is integrated in SALT's daily data pipeline and reduces normal and frame transfer long-slit spectra. The additional products produced for object exposures by the science product pipeline, which are included in the data distribution to the user ftp locations, are at minimum: 2D bad pixel replaced, cosmic ray cleaned, CCD gaps filled, wavelength calibrated and rectified object exposures. If object exposures have an accompanying set of flat field exposures (or there is an archival set with the same instrument configuration) then the object exposures will also be auto gain corrected[1] and flat fielded.

The **RSS: Long-slit spectra processing and extraction** app is built to aid with the extraction of target spectra from the supplied reduced object exposures. The main window of the app contains a number of tabs that require user input as needed: The **Start** tab is a welcoming page which provides an *About* button that opens this document and a *Start* button that will take the user to the **Observation log** tab. On the **Observation log** tab the user must select a valid directory for the downloaded product data and, if relative flux calibration of the target spectra is required, a valid directory for the spectrophotometric (specphot) standards data - see **Product and Specphot directories**. After selecting a valid product directory, Block-id and Visit-id (if there are more than one), and a valid specphot directory, if required, the user may proceed to the **Reductions** tab or jump directly to the **Reduced log** tab. Pop-up prompts are displayed to guide the user to the next possible action. On the **Reductions** tab the user has the option to exclude some of the reductions mentioned above (if preferred) and accordingly re-reduce the exposures shown on the **Observation log** tab. The **Reduced log** tab shows the reduced exposures and the user needs to double-click an exposure to proceed to the **Long-slit spectrum** tab which will show an auto-extraction of the brightest spectrum near the centre (or bottom for frame transfer) of the exposure. The user may accept the auto-extracted spectrum or make adjustments to the extraction window parameters or select another spectrum in the 2D exposure. If available, the user will also have the option to select a specphot exposure, calculate and apply the resulting sensitivity function for a relative flux calibration of the target spectrum.

[1] The RSS CCDs have some electronics problems which can result in slight changes to the routinely obtained gain levels used for gain correction in the primary data reduction. An auto gain correction is applied to ameliorate any significant change in the gain levels.

Start tab

NOTE: The application window will load on the right hand side of the screen, leaving the left hand side open for **SAOImage ds9** (see the Observation log tab and Reduced log tab sections for more details on how **ds9** is utilised by the application).

On the **Start** tab the user may click the *About* button to view this document. The *Start* button takes the user to the **Observation log**.

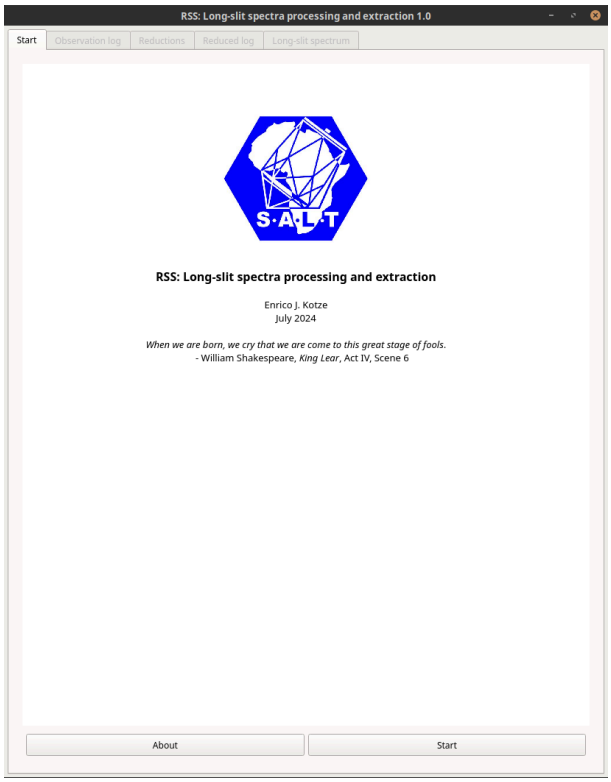


Fig. 1: Start tab

Observation log tab

On the **Observation log** tab the user has to select valid product and specphot (if relative flux calibration is required) directories (see **Product and specphot directories**).

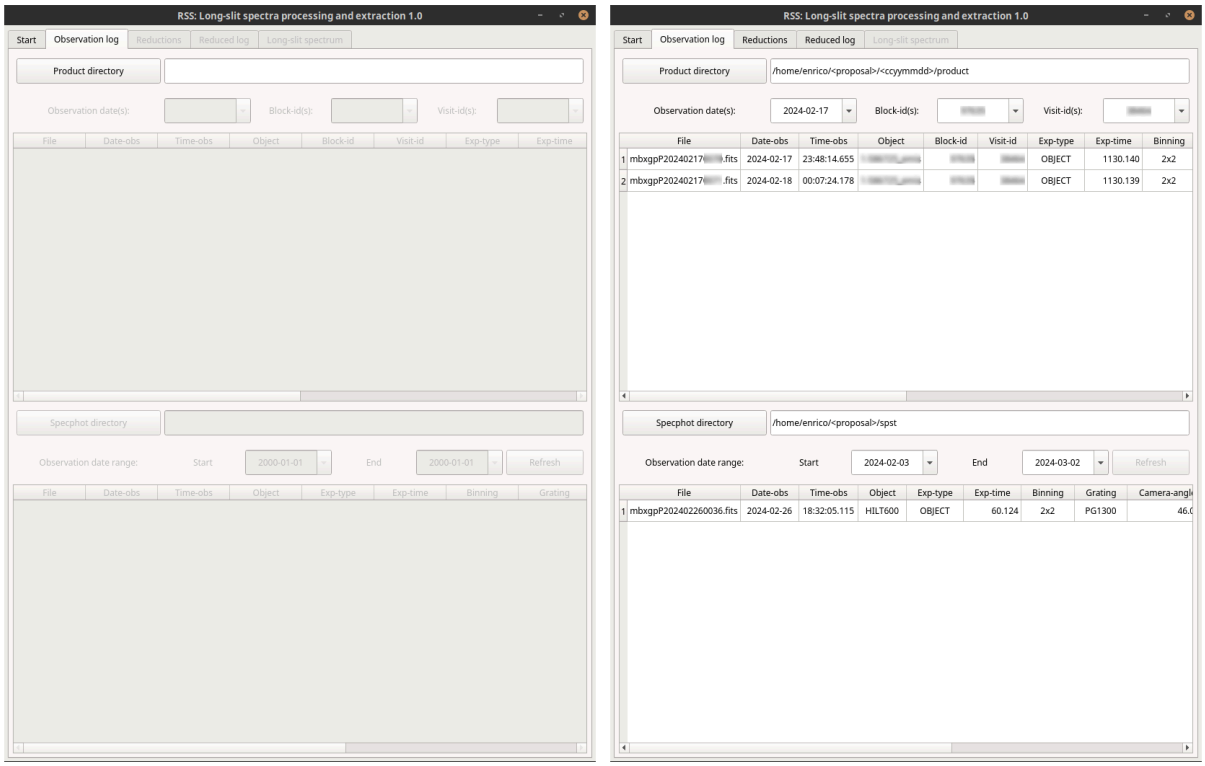


Fig. 2.1: Observation log tab. The left panel shows the tab before the product directory is selected and the right panel shows the tab after valid product and specphot directories are selected. Note that identifier fields have been blurred for confidentiality purposes.

If the product data for the observation date contains more than one block observation and/or more than one block visit then the user is prompted to select the one that must be processed. By default only applicable specphot files (that is, with the same instrument configuration as the block observation) within the date range of ±2 weeks of the observation date are displayed in the specphot table (+ range limit: yesterday). If none is found then the user may change the *Start* (limit: one year before observation date) and/or the *End* (limit: yesterday) of the *Observation date range* to include possibly older and/or newer applicable specphot files.

If a **File** field is double-clicked the exposure opens in **SAOImage ds9**. The **ds9** window is positioned to the left of the **RSS: Long-slit spectra processing and extraction** window.

NOTE: **Do not close the SAOImage ds9 window!** The first instance of **ds9** will be reused whenever a **File** field is double-clicked.

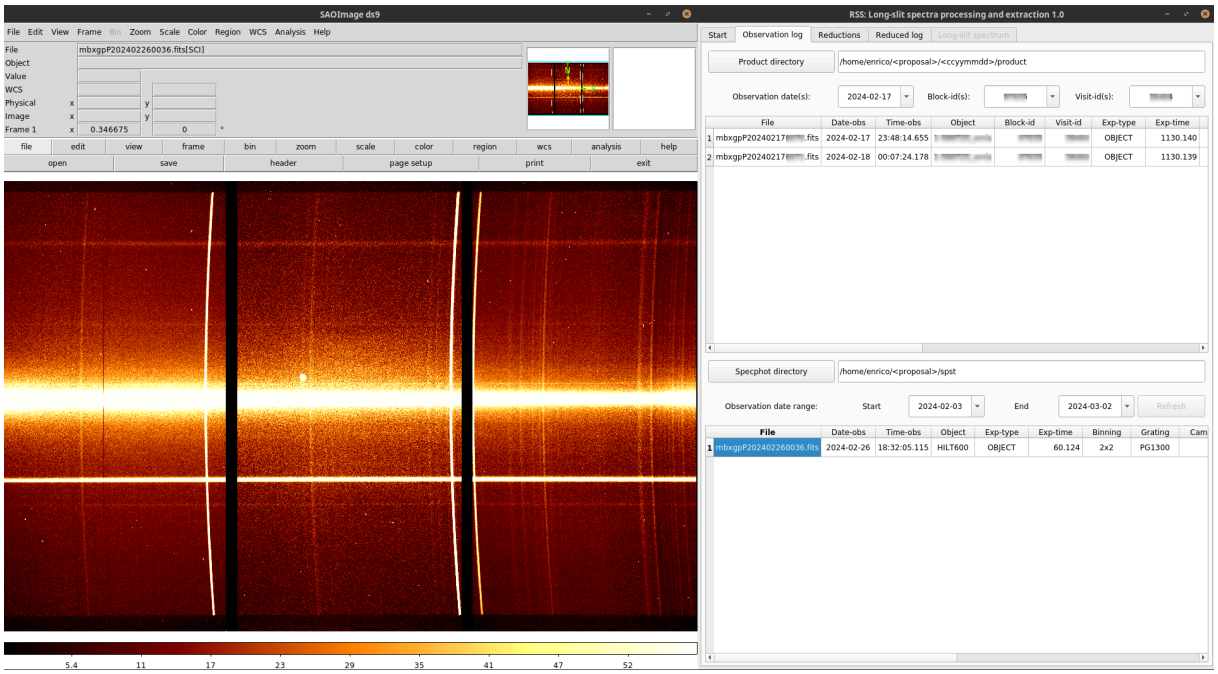


Fig. 2.2: Observation log tab and **ds9** window. The **ds9** window opened after the **File** field in the specphot table was double-clicked.

Reductions tab

The **Reductions** tab shows all the reductions applied by the daily pipeline run to the distributed product data. These may include bad pixel replacement, auto gain correction, flat fielding and cosmic ray cleaning. The CCD gaps filling and wavelength rectification (that is, applying the wavelength solution) are always applied.

The *Reduce product files* button re-reduces the product file(s) shown in the product table on the **Observation log** tab, and the *Reduce specphot files* button reduces the specphot file(s) in the specphot table on the **Observation log** tab. The user may untick any or all of the enabled daily pipeline applied reductions tick boxes or change the *Cosmic ray clean* parameters and (re-)reduce the product and/or specphot file(s) accordingly. Cosmic ray cleaning is done with Curtis McCully's Astro-SCRAPPY v1.0.8 (a Python package based on Pieter van Dokkum's L.A.Cosmic algorithm). The *About Astro-SCRAPPY v1.0.8* button will open its manual.

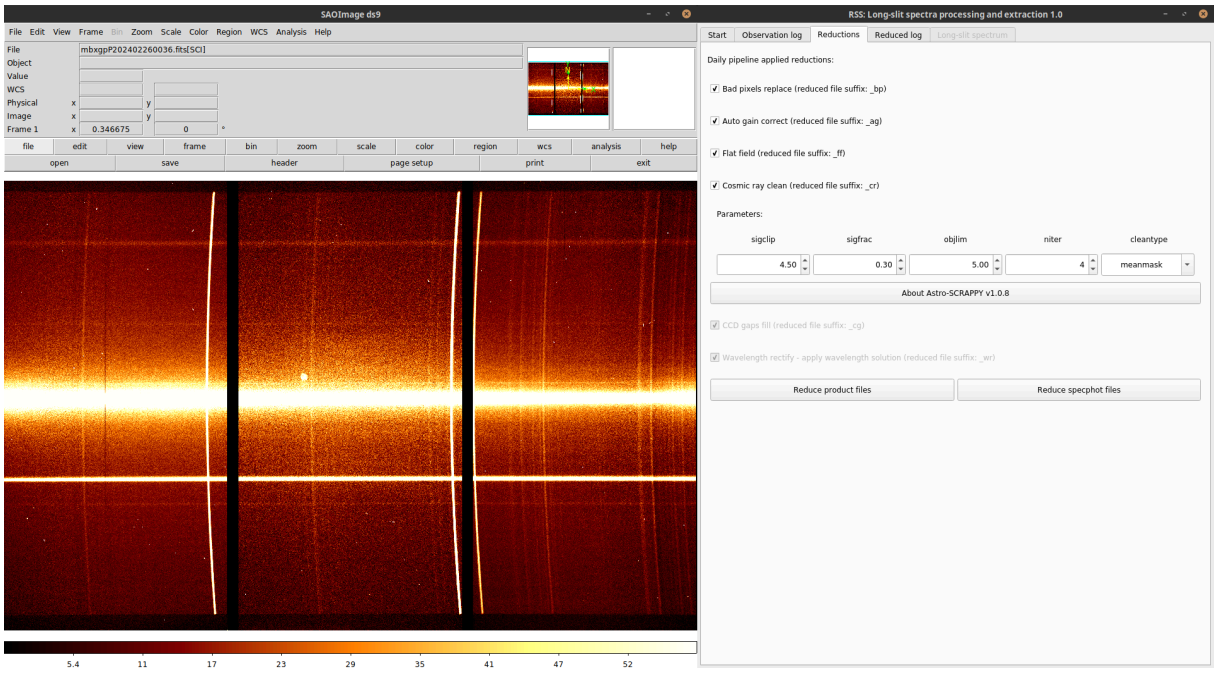


Fig. 3: Reductions tab and **ds9** window.

Reduced log tab

The **Reduced log** tab shows the reduced product and specphot files. Note the file suffixes the reduced files may have: _bp for bad pixels replaced, _ag for auto gain corrected, _ff for flat fielded, _cr for cosmic ray cleaned, _cg for CCD gaps filled and _wr for wavelength rectification.

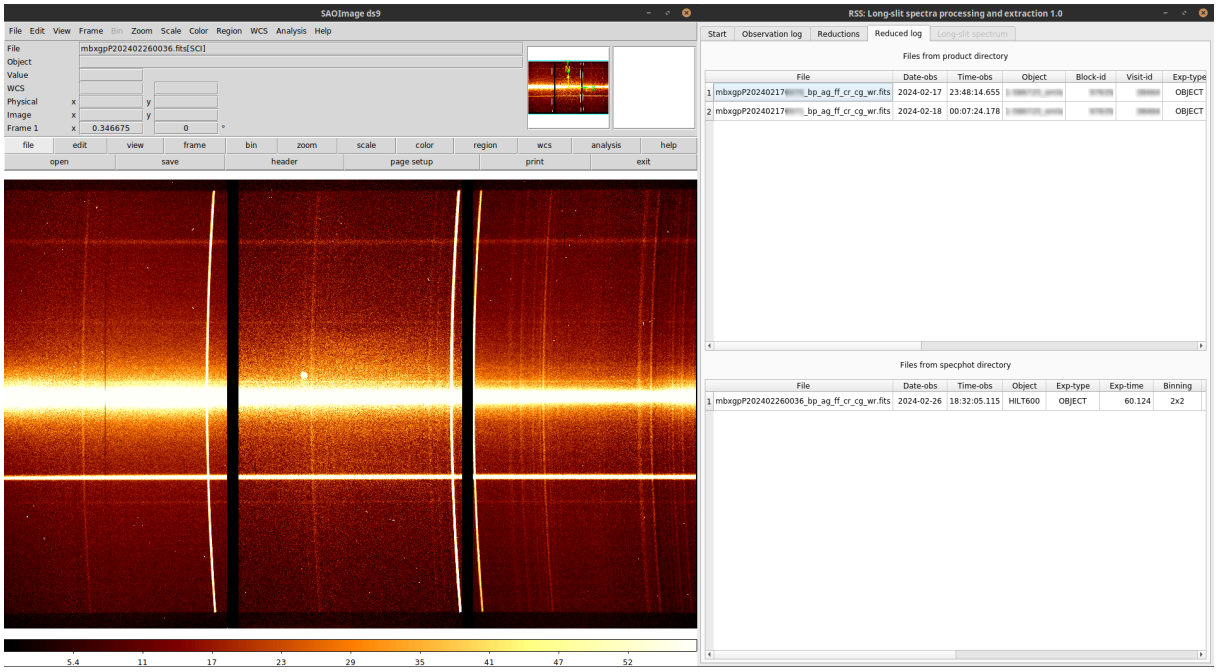


Fig. 4: Reduced log tab and **ds9** window.

If relative flux calibration is required, and **specphot** files exist, then these must be **processed first**. Double-clicking the **File** field of the reduced file to be processed will take the user to the **Long-slit spectrum** tab for the extraction of the target spectrum.

Long-slit spectrum tab

Specphot files

If relative flux calibration of the science target spectrum from a product file is required then the applicable **specphot** file **must be processed first**. Double-clicking the **File** field of a reduced **specphot** file on the **Reduced log** tab invokes an auto-extraction of the brightest spectrum closest to the centre of the 2D image which is then displayed on the **Long-slit spectrum** tab - see Fig. 5.1. Changing the auto-extraction is discussed in the **Product files** section.

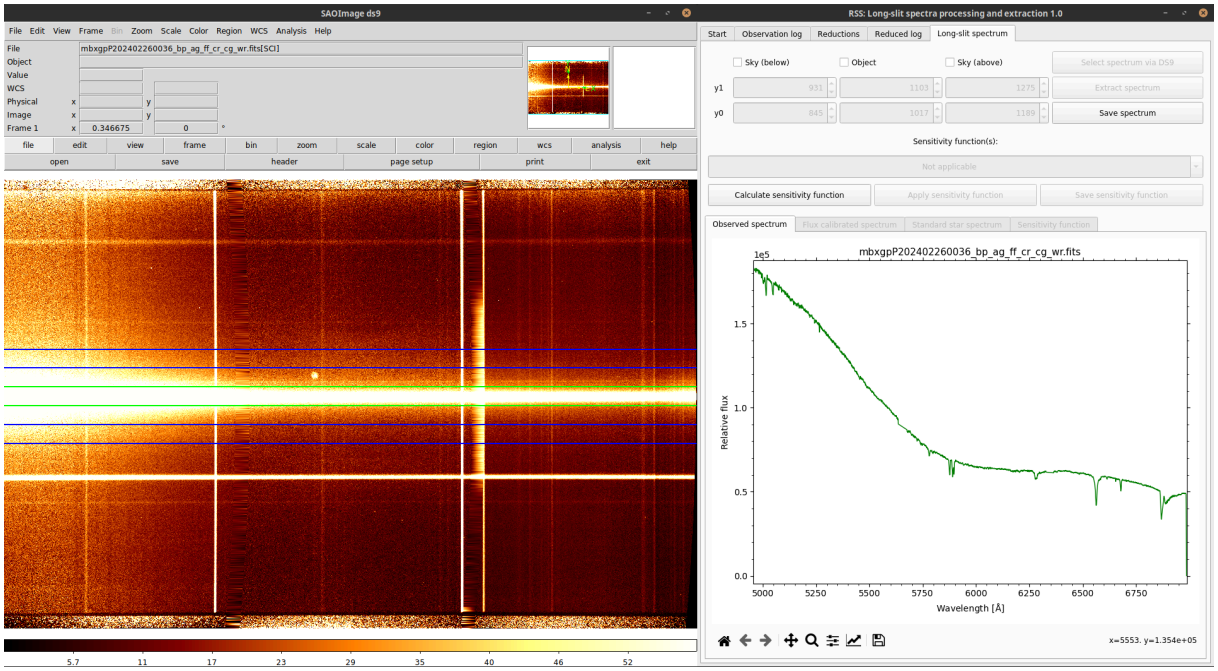


Fig. 5.1: Long-slit spectrum tab and **ds9** window for the selected specphot file. The windows for the auto-extraction of the specphot spectrum are shown in **ds9**: The **object** window is between the **green** lines and the **sky** windows (below and above the object window) are between the **blue** lines.

The *Calculate sensitivity function* button invokes the calculation of the sensitivity function and if successful then the **Sensitivity function** and **Standard star spectrum** tabs, as well as the *Apply sensitivity function* and *Save sensitivity function* buttons are enabled. The *Apply sensitivity function* button applies the calculated sensitivity function after which the **Flux calibrated spectrum** tab is enabled - see Fig. 5.2. The *Save sensitivity function* button saves the calculated sensitivity function and makes it available for the relative flux calibration of a science target spectrum from a product file.

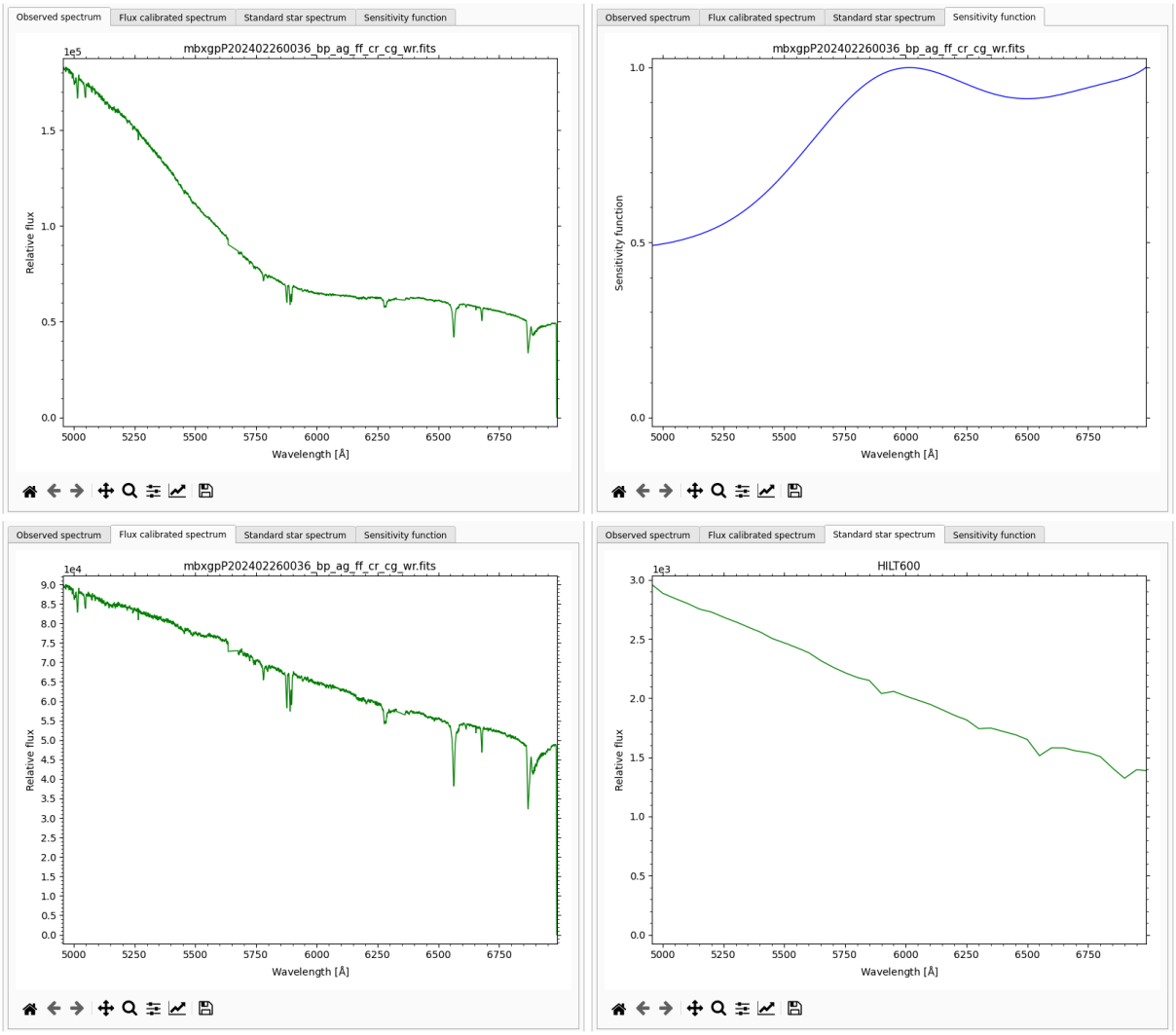


Fig. 5.2: Long-slit spectrum plot tabs for the selected specphot file. From top left clockwise: The observed spectrum, calculated sensitivity function, standard star spectrum (known) and flux calibrated observed spectrum after applying the calculated sensitivity function.

Product files

Double-clicking the **File** field of a reduced **product** file on the **Reduced log** tab invokes an auto-extraction of the brightest spectrum closest to the centre of the 2D image which is then displayed on the **Long-slit spectrum** tab - see Fig. 5.3.

If an applicable specphot file was processed, as described in the **Specphot files** section, then the *Sensitivity function(s)* dropdown box is enabled and the applicable sensitivity function file may be selected if relative flux calibration of the target spectrum is

required. The relative flux calibration is done by clicking the *Apply sensitivity function* button and the result is shown in the **Flux calibrated spectrum** tab - see Fig. 5.4.

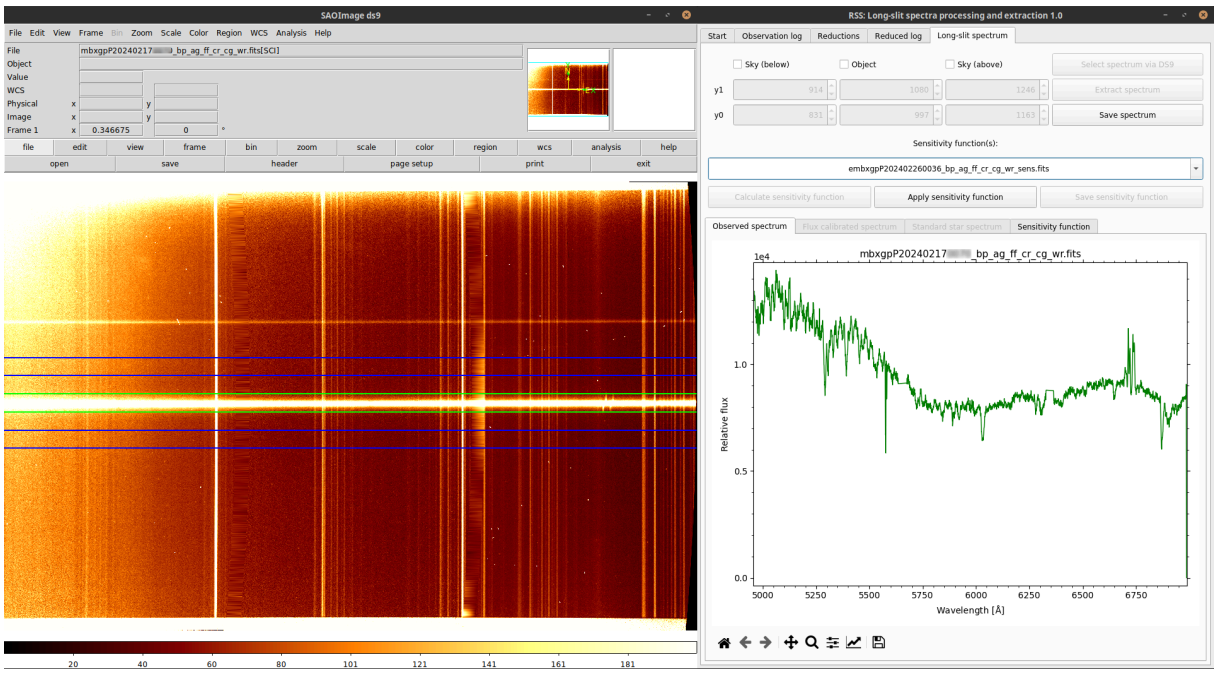


Fig. 5.3: Long-slit spectrum tab and **ds9** window for the selected product file. The windows for the auto-extraction of the product spectrum are shown in **ds9**: The object window is between the **green** lines and the **sky** windows (below and above the object window) are between the **blue** lines.

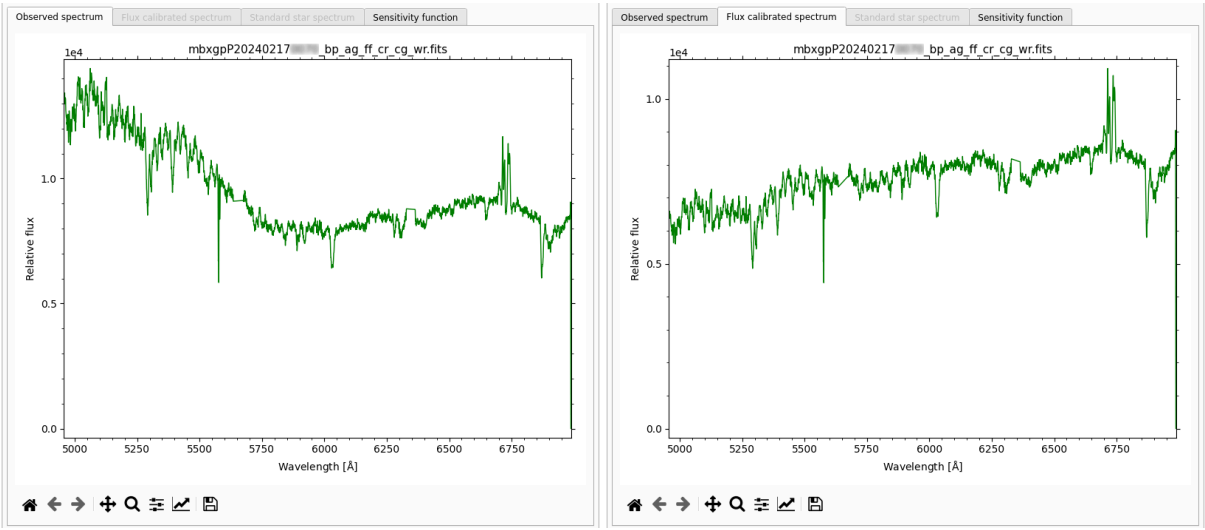


Fig. 5.4: Long-slit spectrum plot tabs for the selected product file. On the left is the observed spectrum, and on the right is the flux calibrated observed spectrum after applying the saved sensitivity function.

The auto-extraction may not be perfect due to, for example, sky windows overlapping with other spectra in the image or wrong target spectrum selection. If the auto-extraction needs to be changed, the extraction windows are changed depending on the type of change required:

1. To select a different target spectrum (for step a and b see Fig. 5.5, and for step c and d see Fig. 5.6):
    a. Tick the *Object* tick box. The *Select spectrum via DS9* button as well as the accompanying *y0* (window lower value) and *y1* (window upper value) spin boxes of the *Object* window are enabled.
    b. Click the *Select spectrum via DS9* button. The existing **green** and **blue** lines in the **ds9** window will disappear and the *Select spectrum via DS9* button text will change to *Confirm selection*.
    c. In the **ds9** window click once on the required target spectrum. A **red +** is shown at the position of the click. Make sure to do **just one click**.
    d. Click the *Confirm selection* button and the extraction will update automatically.

2. To make a small change in the windows:
    a. Tick the *Object*, *Sky (below)* or *Sky (above)* tick box to enable the accompanying *y0* (window lower value) and *y1* (window upper value) spin boxes of the window that needs a change.
    b. Change the window values using the spin (up and down) arrows or by typing the value directly in the spin box. The change is reflected in the **green** / **blue** lines in the **ds9** window depending on the affected window.
    c. The *Extract spectrum* button is enabled when a window value changes and must be clicked to re-extract the spectrum with the changed window(s).

The *Save spectrum* button saves the 1D extracted observed spectrum and flux calibrated spectrum, if it exists, to a two or three column text file: 1) Wavelength; 2) Observed flux; and 3) Calibrated flux, if relative flux calibration was done. Also, a multi-extension FITS file is saved with the original product FITS primary header and extension 1 as the observed spectrum and extension 2 as the flux calibrated spectrum, if it exists.

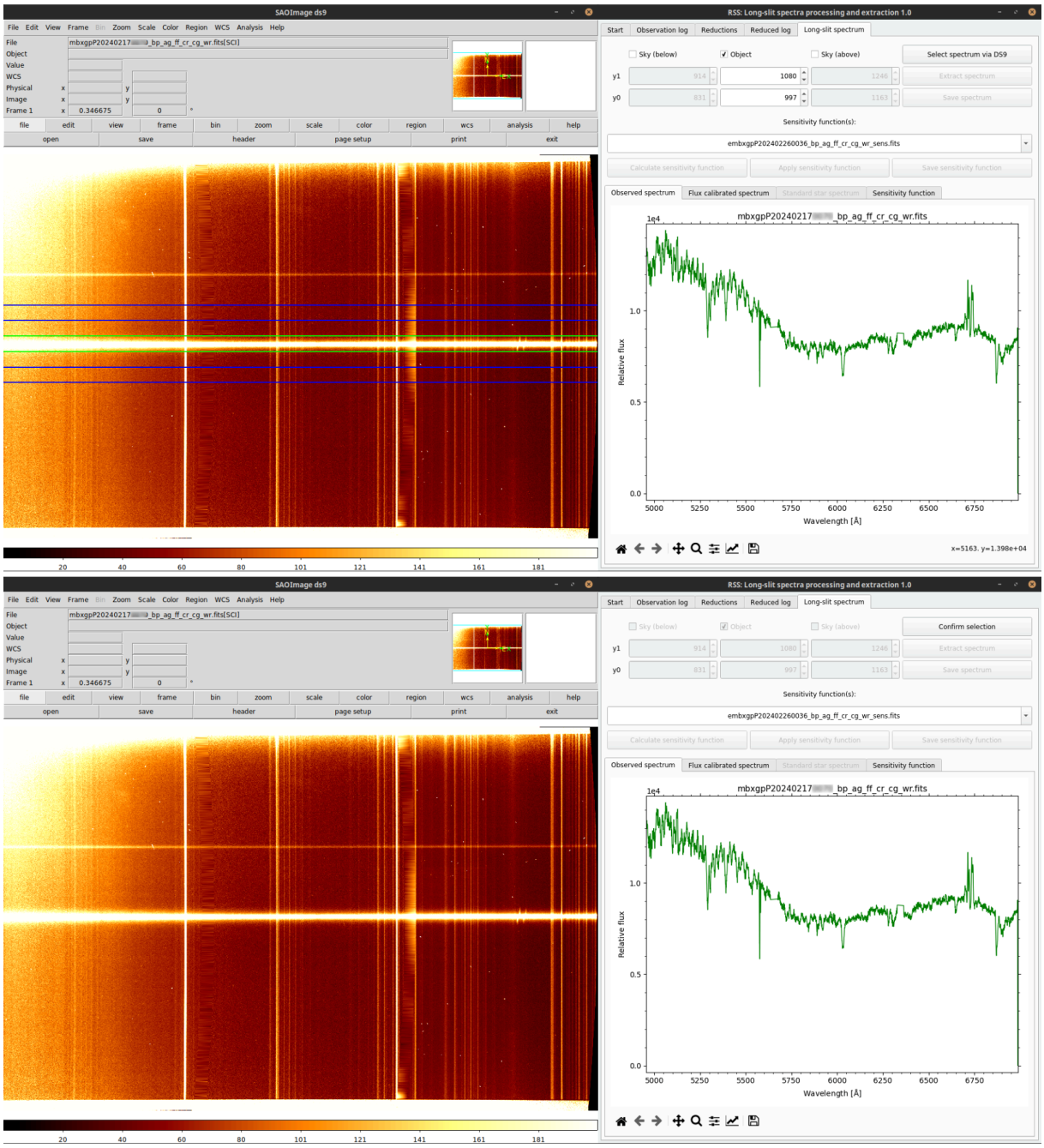


Fig. 5.5: Long-slit spectrum tab - Selecting a different target spectrum via **ds9** - step a and b. The ticked *Object* tick box and the enabled *Select spectrum via DS9* button can be seen in the top panel. In the bottom panel the **ds9** window is without the **green** and **blue** lines and the *Select spectrum via DS9* button text has changed to *Confirm selection* after clicking it.

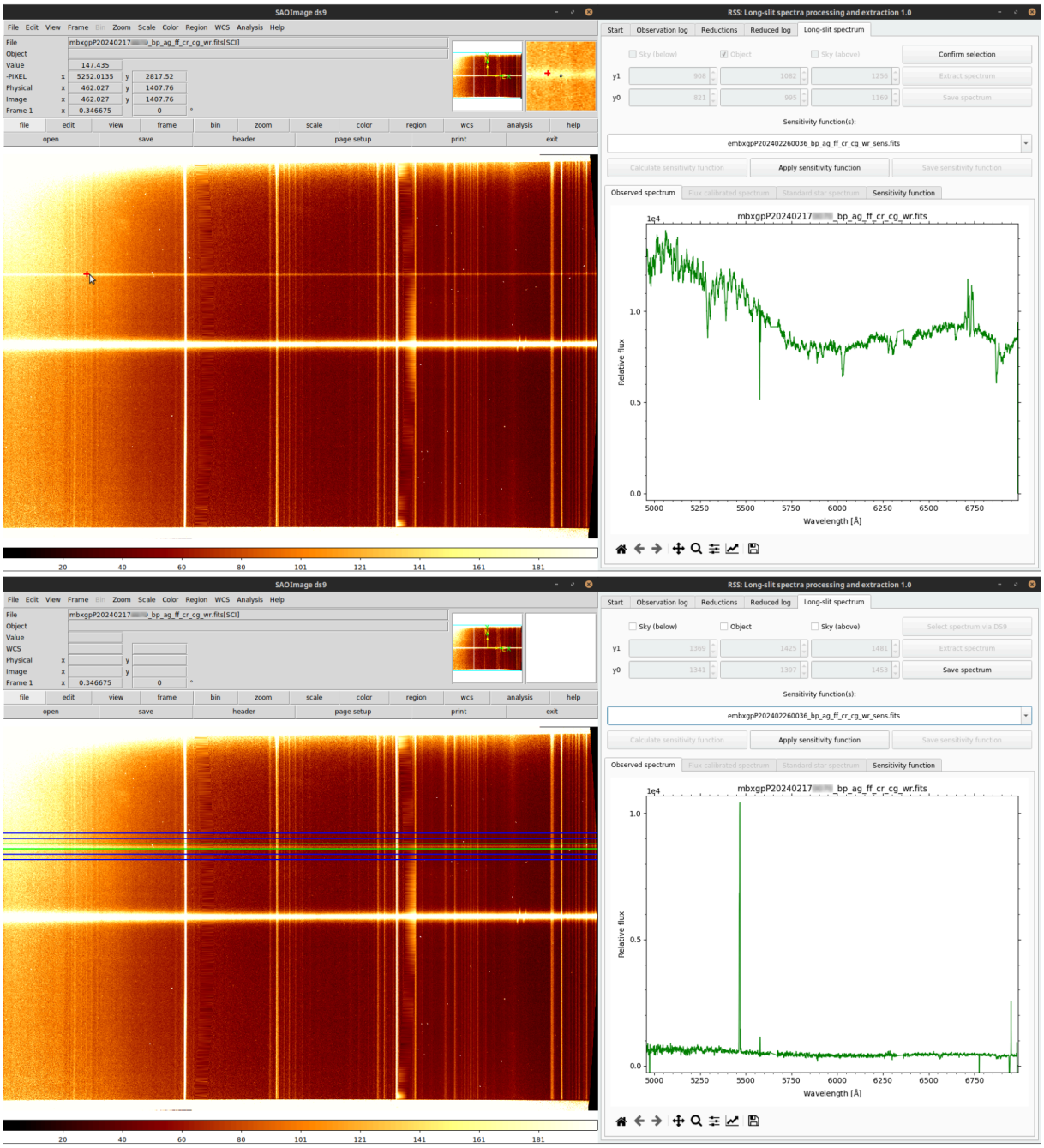


Fig. 5.6: Long-slit spectrum tab - Selecting a different target spectrum via **ds9** - step c and d. In the top panel the **red +** is shown on the **ds9** window at the selected position and the bottom panel shows the updated extraction after clicking the *Confirm selection* button.

Web links

NOTE: If the web link does not want to launch then copy it, open your favourite web browser, paste and go!

New Web Manager: https://wm-new.salt.ac.za/
Old Web Manager: https://www.salt.ac.za/wm/
Curtis McCully's Astro-SCRAPPY v1.0.8: https://pypi.org/project/astroscrappy/1.0.8/

The devil can cite Scripture for his purpose.
- William Shakespeare, *The Merchant of Venice*, Act I, Scene 3

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