EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral

Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

VERY LARGE TELESCOPE

HARPS EDPS-GUI tutorial

1 rev. 20260801

Issue 1

Date Aug 01 2026

Prepared:	L. Coccato	Aug 01 2026	.....
	Name	Date	Signature
Approved:			.....
	Name	Date	Signature
Released:			.....
	Name	Date	Signature

This page was intentionally left blank

Change record

Issue	Date	Section/Parag. affected	Reason/Initiation/Documents/Remarks
1	01/08/2026	all	First public release for 3.4.0.

This page was intentionally left blank

Contents

1 Introduction

1.1 Scope

This document describes how to reduce HARPS data with the `edps-gui` (Graphic User Interface), the dashboard of the ESO Data Processing System (`EDPS`), which is the recommended interface to reduce data from ESO telescopes. Details on the HARPS data reduction stream and how to configure the reduction to meet specific scientific needs are also given.

For a more extensive documentation on the `edps-gui` itself, consult the dedicated manual here.

For a description of the HARPS pipeline itself, consult the pipeline manual available at:
https://www.eso.org/sci/software/pipe_aem_table.html.

Note: this tutorial refers to:

- HARPS instrument pipeline named `espdr`, version 3.6.0.
- HARPS workflow: `harps.harps_wkf`
- `EDPS` version 1.7.1.
- `edps-gui` version 0.91.

Note that HARPS data are reduced by the ESPRESSO pipeline, i.e. `espdr`. Also, the eso-tk pipeline has to be installed as well if one wants to combine the reduced invididual spectra with the task **combine_science**.

The HARPS EDPS workflow supports also the reduction of data taken in POLARIMETRIC (both circular and linear polarization) and EGGS instrument modes. For POLARIMETRIC data, only extraction of 1D spectra is supported, not the computation of Stokes parameters.

Observations of the Sun (either HARPS or HELIOS) are currently not supported.

Graphical reports are currently unavailable.

1.2 What is `EDPS`?

The ESO Data Processing System (`EDPS`) is a framework to run ESO's data processing pipelines and it is meant to eventually replace the previous ESOReflex environment. The general principles of `EDPS` have been described by Freudling, Zampieri, Coccato et al. [2024, A&A, 681, A93]. Please refer to that paper if you have used `EDPS` for research resulting in a scientific publication.

Each of ESO's data processing pipeline consists of a series of standalone programs called *recipes*. Each recipe is designed to process certain type(s) of input data. The processing of these input data typically requires a range of auxiliary files such as calibration files. `EDPS` is designed to select appropriate input data for the different recipes of a pipeline, and execute them in sequence. This is done by specifying for each pipeline the workflow for organizing data and executing the recipes. Then, the workflow can be used to process a set of data fully automatically.

1.3 Main concepts

EDPS is an environment designed to execute the recipes of an instrument pipeline according to a series of instructions. The main concepts in EDPS are:

- **Workflow** and **reduction cascades**. A workflow is a series of instructions designed to reduce data with an instrument pipeline in potentially multiple ways, by carrying on a sequence of tasks. Each workflow can define multiple reduction cascades, depending on the scientific needs. For example, the same workflow can be used to process data following different strategies that trigger different reduction steps (e.g. in one strategy flux calibration can be omitted) or different end-points (e.g., combine different science exposures, or stop after the reduction of individual exposures without combining them). Each of these "strategies" defines a "reduction cascade".
- **Task**, **jobs**, and **recipes**. A task is an element in the workflow that performs a given step of the data reduction cascade. Tasks are often associated to a recipe of the underlying instrument pipeline. A jobs is a work unit in a processing environment, that runs a recipe on a set of input data with a set of recipe parameters. A single task can generate several jobs: for example, a "bias" task, can generate multiple jobs, each of the running the bias recipe on a different set of input files.
- **Dataset**. A dataset is a collection of files, that are needed to perform the data reduction as specified by the workflow. It consists, for example, of one or more science files plus the calibrations needed to process them. In EDPS, datasets have a hierarchical structure, which highlights the connections between the various files and tasks (e.g., task A is an input to task B).
- **Target** and **Target category**. The "target", or the "target task" is the end point of the reduction cascade. When specifying a target, EDPS will process all and only the files needed to execute it. For example, if my target is "science", and the science files need the bias files, EDPS will process only the biases that have been selected to process those science files; then it processes the science using the product of the bias reduction. However, if my target is bias, then EDPS will process all and only the bias files, regardless they are not used by any science. In this case, EDPS does not process the science, as it has already reached the end reduction point (e.g., process all biases). The "Target category" is a group of targets that have similar purposes. For example, the target category "science", includes all the tasks that deliver final scientific products, the target category "qc1calib" includes all and only the tasks that processes calibrations (e.g., bias, flat fields, standard stars).

1.4 Installation

1.4.1 Prerequisites

Prerequisites for a well functioning installation of EDPS and EDPS-gui are:

- Recent Firefox or Chrome browser, Python 3.11 or higher (but there are issues with Python 3.14).
- At least one ESO pipeline with EDPS workflow should be in your system. To install the desired ESO pipelines, follow the instructions in the ESO pipelines pages. NOTE: the `apptainer` installation method

is currently not supported. After the installation, the esorex command must be in the path. To test whether the installation was successful, type

```
esorex --recipes
```

A list of available recipes should appear.

- Install `graphviz`, `fv`, and `ds9`, which have to be included in the system path (defining aliases not enough). On linux, `Graphviz` can be easily installed via:

```
sudo apt install graphviz (Debian, Ubuntu)
sudo dnf install graphviz (Fedora)
```

Check the `Graphviz` webpage for installation instructions for other OS.

`fv` and `ds9`, are optional. To install them, follow the instructions in corresponding webpages. You can test whether these three packages are installed and their paths are correctly set by typing on a terminal:

```
dot -V
fv  -version
ds9 -version
```

1.4.2 Installation steps

To install EDPS follow these steps:

- Create a new Python virtual environment and activate it:

```
python3 -m venv edpsgui
. edpsgui/bin/activate
```

Make sure the python3 version is 3.11 or higher, but not 3.14.

- Install the required packages:

```
pip install --extra-index-url \
    https://ftp.eso.org/pub/dfs/pipelines/repositories/stable/src \
    edps edpsgui edpsplot adari_core
```

To run the `edps-gui` type from a terminal (with the active environment):

```
edps-gui
```

Important note. The first time `edps-gui` is executed, you will be asked to specify the directory where the reduction products (fits files and quality plots) will be stored. The default location is `$HOME/EDPS_data`. During the first execution, a configuration file named `application.properties` will also be saved in the directory (newly created) `$HOME/.edps`.

2 Reducing demo data

Follow this procedure to quickly reduce HARPS demo data. We assume that the `EDPS`, `edps-gui`, the HARPS pipeline and its associated demo data are installed in your system. For general instructions on how to install `EDPS` and the pipeline, see Section 1.4 or please visit: https://www.eso.org/sci/software/pipe_aem_main.html.

2.1 Setting the workflow

Proceed as follows:

1. If not done already, activate the `EDPS` virtual environment, defined during installation (Sect. 1.4).
2. Start the `edps-gui` dashboard by typing:

   ```
   edps-gui
   ```

   The `edps-gui` dashboard will start in a browser window (Figure 1).

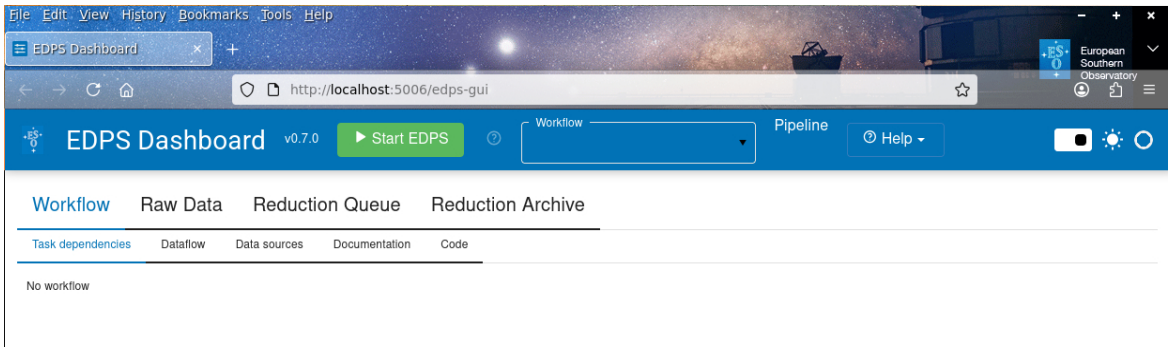

Figure 1: The empty `edps-gui` Dashboard; the underlying `EDPS` engine has not yet been started and no workflow has been loaded.

3. Optionally, before starting `EDPS`, one can specify new settings by pressing Help –> Settings (Figure 2).

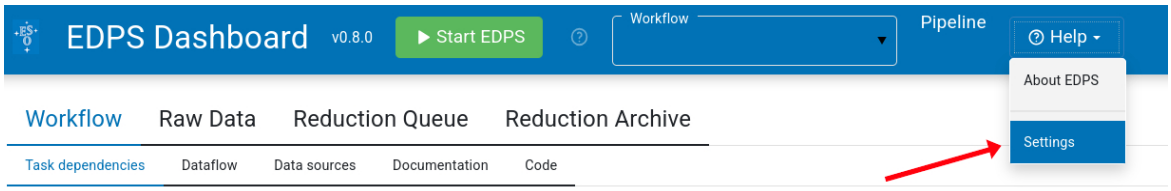

Figure 2: The “Help” –> “Settings” menu.

4. On the browser window with the dashboard, press the button ‘Start EDPS‘.
5. Choose the `harps.harps_wkf` workflow from the list in the ’Workflow’ field. The workflows offered in this selector depend on the installed pipelines. The graphic workflow representation will appear as in Figure 4.

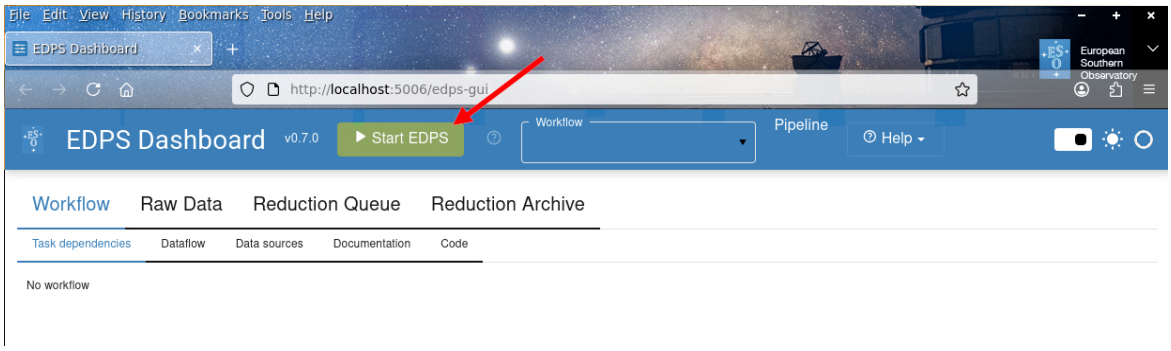

Figure 3: The “Start EDPS” button.

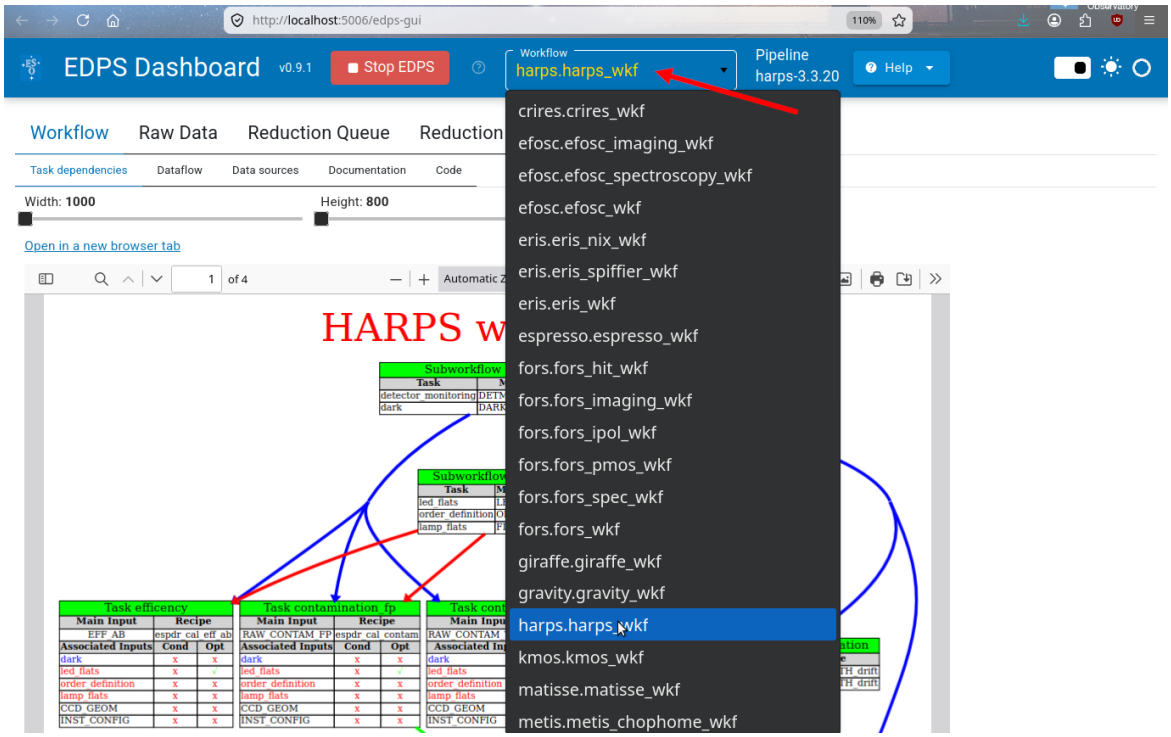

Figure 4: The `edps-gui` with the HARPS workflow loaded.

2.2 Selecting the input data

1. Press ‘Raw Data‘ to enter the corresponding tab, as in Figure 5.
2. Press ‘Select Inputs‘. A selection window will appear that allows to select data that are stored on a local disk (Figure 6).
3. (Optional). Select the reduction target, configure the workflow parameter and specify the association preferences. These steps are optional. For more information see Section **??**.
4. Press ‘Create Datasets‘. A list of datasets appears, one line for each set of science data (Figure 7).

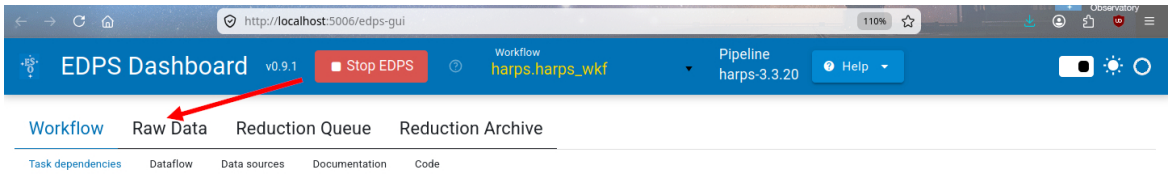

Figure 5: How to select RAW data Tab.

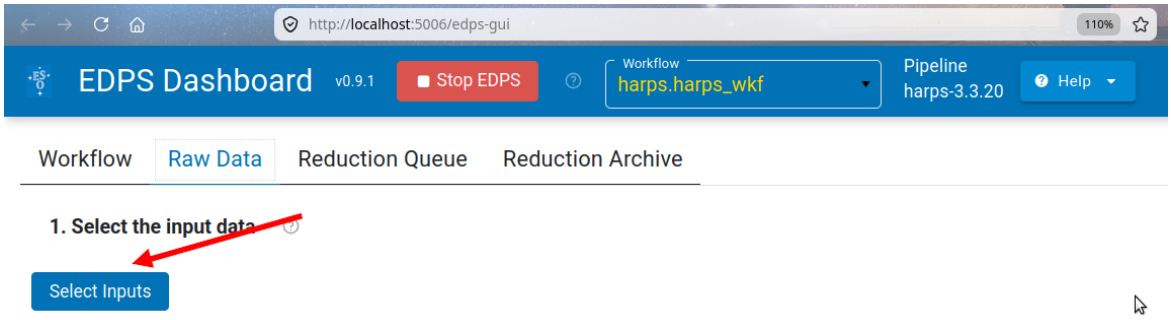

Figure 6: How to select input data.

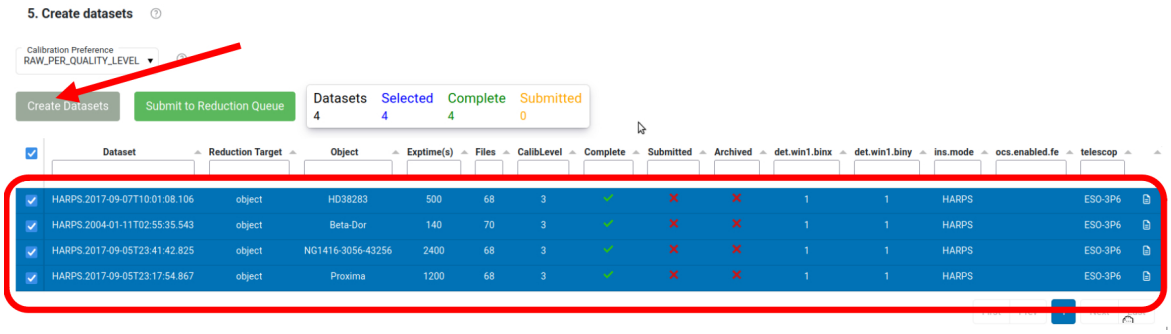

Figure 7: How to inspect the input data directory to create datasets.

5. Choose the datasets that should be processed (Figure 8)

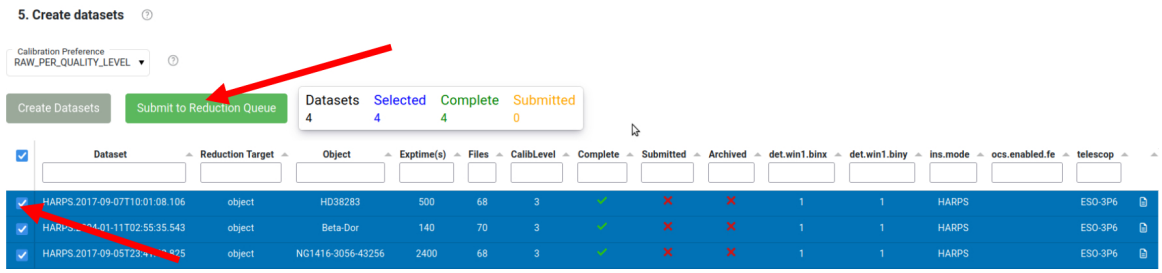

Figure 8: How to send the selected datasets to the Reduction Queue for processing.

and send them to the data reduction queue by pressing ‘Submit to Reduction Queue‘. Note that this action does not start the reduction automatically.

2.3 Start the reduction

1. Press the ‘Reduction Queue‘ tab (Figure 9).

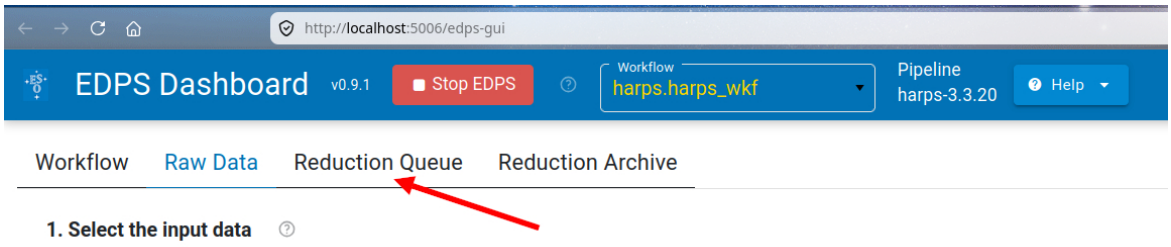

Figure 9: How to select Reduction Queue tab.

2. Select the datasets you’d like to reduce.

3. (Optional). Configure the workflow and recipe parameters by pressing the wheel button  to open the configuration editor. See Section 4.2 for more information on the configuration editor.

4. Press the ‘Reduce‘ button (Figure 10). The selected data will now be processed with the configured parameters.

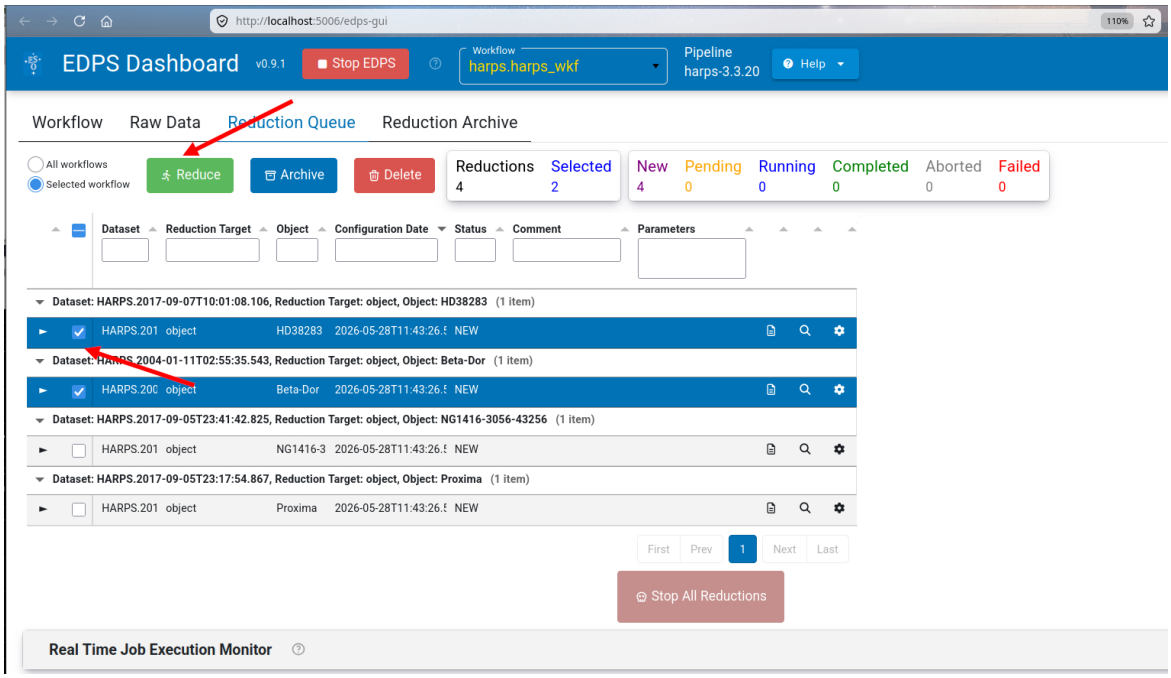

Figure 10: Reduce.

Congratulations! You reduced your first data with the `EDPS` dashboard! All the reduced data are saved in the EDPS_data directory specified when executing `edps-gui` for the first time.

2.3.1 Quality plots

It is possible to inspect the information on each job, such as quality plots showing the products (for the most important jobs and products), the list of inputs and output files, the recipe parameters and logs. All the information on the job processing can be inspected from the 'Reduction Queue' window. While quality plots are produced only for completed jobs, the other relevant information is available also for failed jobs.

The information associated for the main product can be inspected by pressing the magnifying glass symbol at the right side of each dataset. To inspect the information associated to other individual jobs (e.g., calibrations), proceed as follows:

- Expand the desired dataset by pressing the black arrow on its left. The list of jobs will appear with the associated status (COMPLETED, RUNNING, PENDING, MISSING, ABORTED, FAILED)
- Press the magnifying glass symbol at the right side of the job you want to inspect.

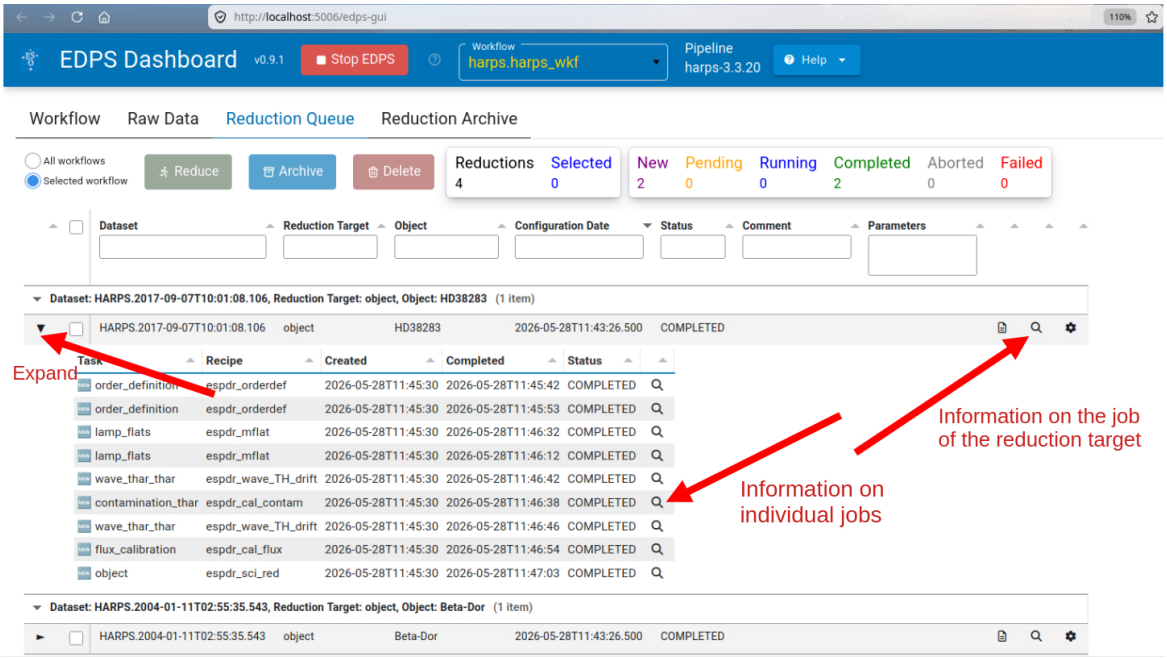

Figure 11: How to look for job information from the Reduction Queue tab.

Important note. The current version of the HARPS workflow (3.6.0) does not produce any plot. It is however possible to access other informations via the magnifying glass symbol, such as the list of input and output files (that can be visualized via fits viewers), the recipe parameters and logs.

2.4 Exporting the final products

Completed reductions can be 'Archived' (i.e. declared 'completed' because no more work is needed) and removed from the Reduction Queue. Additionally, even if all products for all tasks are saved in the EDPS_data directory, the most important products can be 'exported' to a desired location.

To do so, proceed as follows:

1. In the ‘Reduction Queue‘ tab, select the dataset and the dataset for which you want to export the final products, and press the ’Archive’ button.

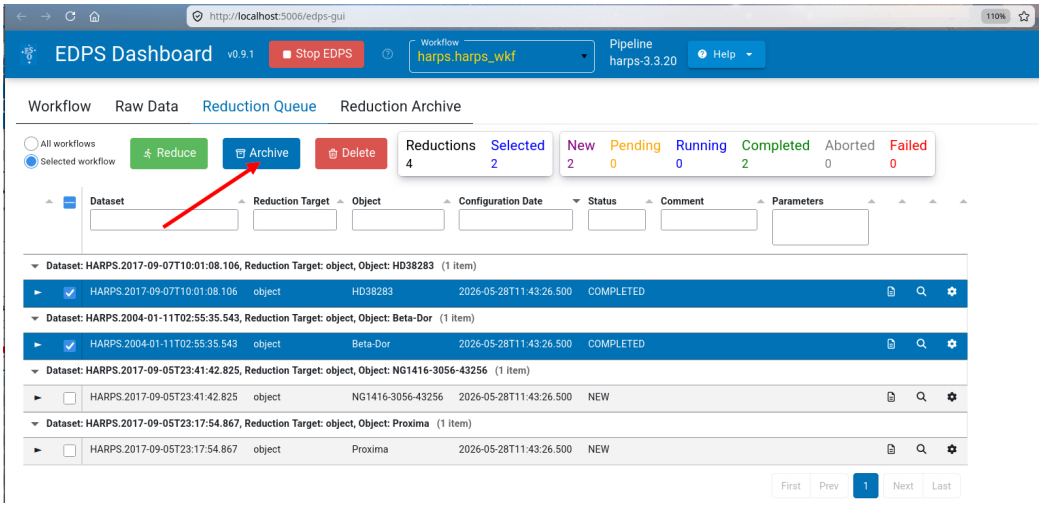

Figure 12: How to archive a completed reduction from the Reduction Queue tab.

2. Go in the Reduction Archive tab and click on the ’Export’ button. A new tab window appears where you can indicate the directory you want to copy your final products; finally press "Export" to copy the data.

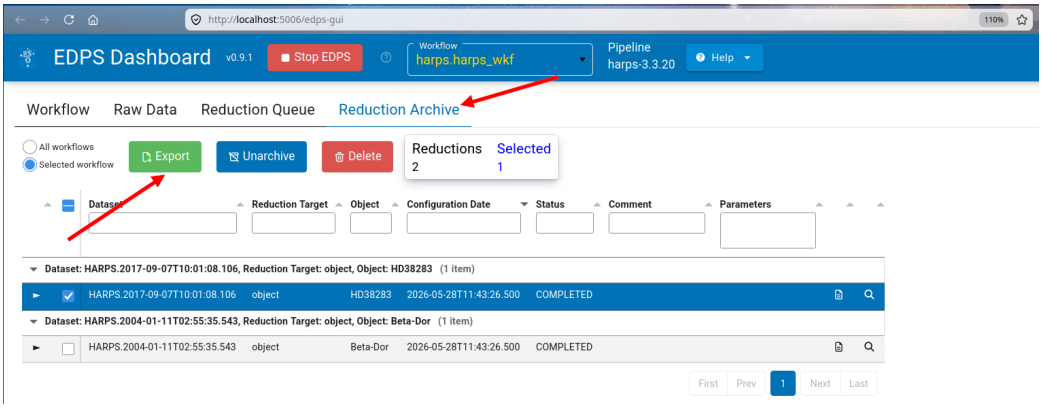

Figure 13: The reduction archive tab. This table contains all the different configurations of datasets that are declared "finished" and removed from the Reduction Queue. From this page, the user can export the most important files into a desired local directory.

Exported products are organized by ‘DATASET‘ (named as the first scientific exposure of the dataset), and ‘TIMESTAMP‘ (time of start of reduction)

The final products saved in the specified directory are:

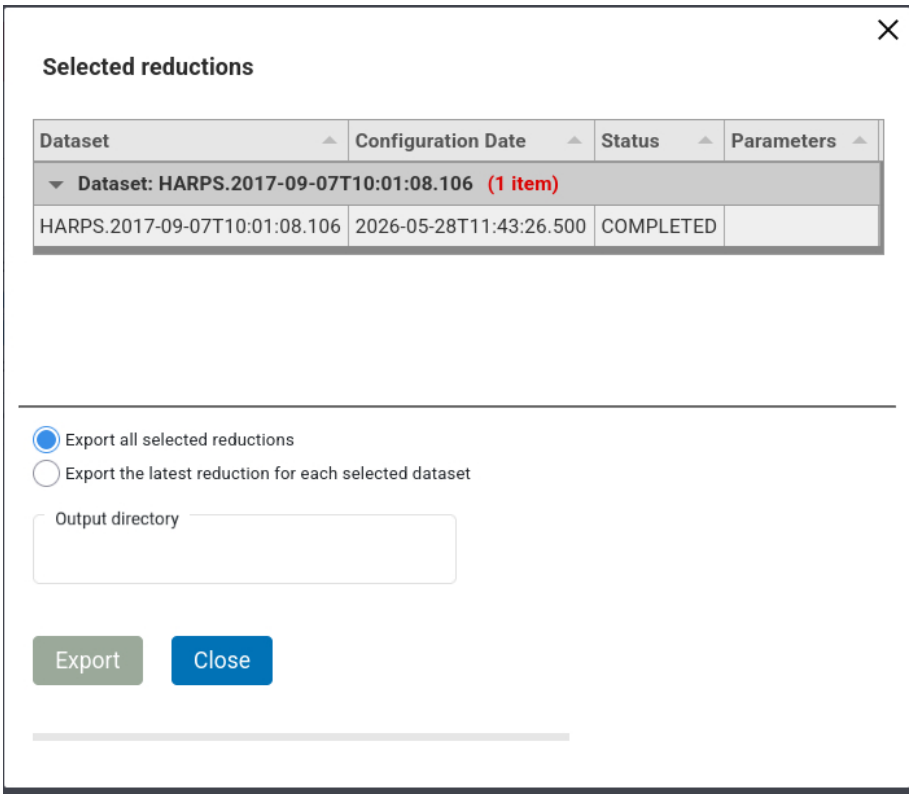

Figure 14: The EXPORT dialogue window, where the user can decide which reduced configuration to save and where.

- **Combined spectra** If the data are combined, the extracted combined spectrum is saved with the name:
  - SPECTRUM_COMBINED_<obs.targ.name>. Where obs.tar.name is the name of the target, as read from the header of the first spectrum in the stack. Note that the recipe `esotk_spectrum1d_combine` from the eso-tk package needs to be installed together with the `espdr` pipeline.

  Note that for polarimetric data, the combination is not done, only individual exposures are saved.

- **Individual exposures.** The individual exposures that contributed to the combination are saved in a sub-directory. The saved files are:
  - SPECTRUM_A_<exposure_name>.fits. Extracted spectrum on fibre A (target). Flux calibrated if
  - SPECTRUM_B_<exposure_name>.fits. Extracted spectrum on fibre B (sky or calibration unit). Not flux calibrated.

  For polarimetric data, the two spectra A and B show the different polarization channels of the same target. Please, compare the columns FLUX_EL of the two spectra to have them in the same units (electrons).

3 The HARPS data reduction flow.

The overall data flow of the HARPS pipeline is displayed in Figure 15.

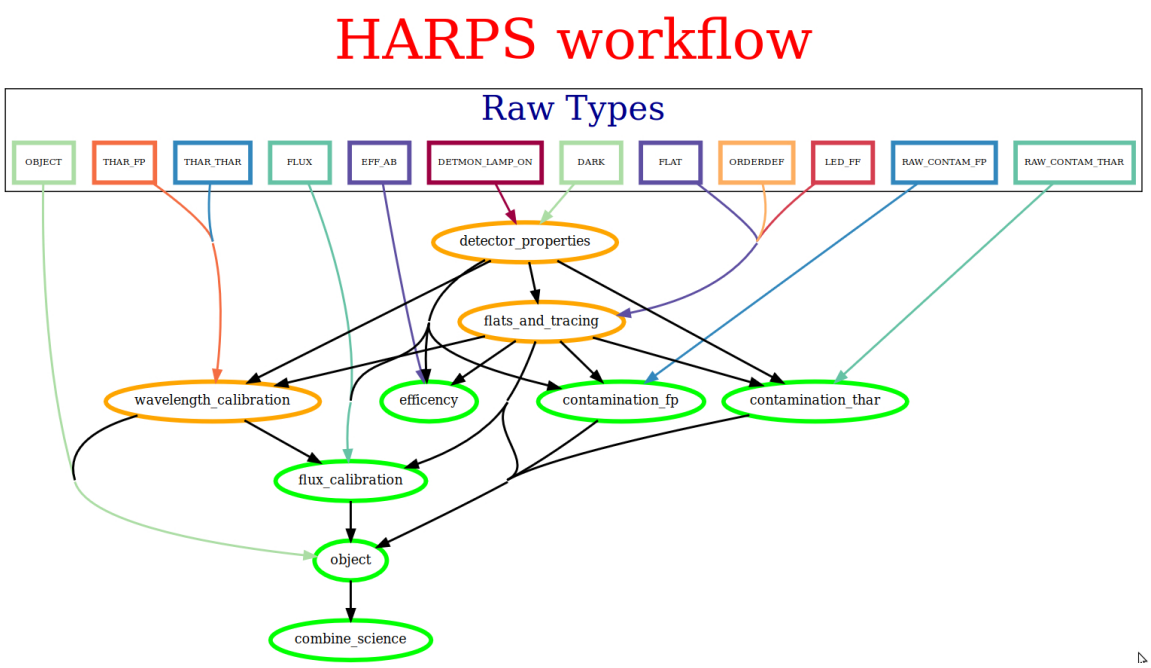

Figure 15: The data reduction cascade of the HARPS workflow.

The reduction cascade is organized in tasks, which represent well-defined steps in the process. Tasks can be grouped inside sub-workflows. Each task runs a recipe; the detailed description of the algorithms, input, outputs and recipe parameters used in each recipe are available in the pipeline manual. Here, we present only the description of most important features.

The `harps.harps_wkf` `EDPS` workflow is designed to execute the tasks that deliver the final reduced data cube for each dataset. It can be either the product of a single exposure, or the combination of multiple exposures. Only calibrations needed by the selected the scientific exposures are processed.

It is possible to set `EDPS` to perform the data reduction until a certain step of the reduction chain (e.g. to reduce only standar stars, or only flat fields). This is done by specifying the desired tasks in the field **Select reduction target** of the **Raw Data** tab.

The reduction steps of the `harps.harps_wkf` workflow are listed below. Before starting the reduction, the parameters of the recipes associated to each task can be configured by pressing the button  close to each dataset configuration. See for more info on the configuration editor 4.2

3.1 Bias and Darks

The subworkflow **detector properties** reduces raw biases and raw darks. Typically, the default parameters gives the best results. The bias reduction generates master biases (used only to process darks), and residuals (used only for data taken after 20 May 2026). The dark reduction generates hot pixel masks. If darks are not present, static calibrations of hot pixel masks are used.

3.2 Flats and Tracing

The subworkflow **flats and tracing** is responsible to determine the traces of the various orders on the detector, determine the order profile, the pixel-to-pixel efficiency variations, and the blaze function. These steps are carried by the following 3 tasks within the subworflow:

3.2.1 Led flats

The task **led_flats** runs the recipe `espdr_led_ff` to process led exposures and determine maps of bad pixels. In a typical dataset, led flat fields are not present and static calibrations that map the bad pixels (whose location is very stable) are used instead.

3.2.2 Order Definition

The task **order_definition** runs the recipe `espdr_orderdef` to trace the various orders on the detector by using thungsten lamps. Typically, the default values give already good results. In some rare occasions, the presence of strong cosmic rays makes the recipe to fail; there are no recipe parameters that deal with cosmic rays rejection, therefore cleaning the input files before processing is the only option if the problem occurs.

3.2.3 Flat Fielding

The task **lamp_flats** runs the recipe espdr_mflat and generates calibrations needed to correct for pixel to pixel variation and the blaze function. Typically, the default values give already good results. If "suspicious bumps" are seen in the masterflat or blaze function, it could be an indication that the intra-order background was badly subtracted (very rare). In this case, the recipe parameters that can be changed to improve the results are:

```
background_sw       : Background subtraction activation (on/off). [on]
bkgr_grid_size_x    : Grid size in x used to calculate the background,
                      between: 16 and 10000. [577]
bkgr_grid_size_y    : Grid size in y used to calculate the background,
```

3.3 Wavelength calibration

The subworkflow **wavelength_calibration** executes

- two tasks for data taken prior to 20/05/2026 **wave_thar_fp_drift wave_thar_thar_drift**, which both run the recipe `espdr_wave_TH_drift`.
- 3 tasks for data taken after 20/05/2026 **wave_fp_fp**, **wave_thar_fp** and **wave_fp_thar**, which run the recipes `espdr_wave_FP` and `espdr_wave_THAR`

They generate the wavelength solution to be applied to the science data using Thorium-Argon lamps and Fabry-Perot exposures.

Typically, the default values give already good results. In some rare occasions, the presence of strong cosmic rays makes the recipe to fail; there are no recipe parameters that deal with cosmic rays rejection, therefore cleaning the input files before processing is the only option if the problem occurs.

In some rare cases, the peaks of the emission lies are not enough intense and the recipe can miss some identifications. In the unfortunate event that none of the peaks that should be identified in both orders are detected, the recipe cannot "connect" the wavelenght solution between orders and it fails. The error message in the recipe log in this case is:

```
[ ERROR ] espdr\_wave_THAR: espdr_get_all_FP_ll_whole_image failed:
Input data do not match
```

In some cases, this situation can be avoided by changing the recipe parameter **fp_extraction_ksigma**.

3.4 Contamination Thar and Contamination FP

These two tasks determines the amount of mutual contamination between the two fibres when exposes with Thorium-Argon or Fabry-Perot lamps by running the recipe `espdr_cal_contam`. Typically, only data to determine the contamination from Thorium-Argon lamps are present. Default values give already good results.

3.5 Flux calibration

The task **flux_calibration** runs the recipe `espdr_cal_flux` to reduce flux standards for the flux calibration of data. Default values give already good results, however, given flux standard are taken seldomly in the HARPS calibration plan, it is common that a flux standard weeks apart from the data is associated. Therefore, while a relative flux calibration is still ok, the absolute flux calibration is very uncertain.

3.6 Object

The task **Object** runs the recipe `espdr_sci_red`, reduces science spectra by applying all the calibrations, corrects telluric absoprtion features (if requested), and computes the heliocentric radial velocity. Typicallt default values give the best results.

By default, spectra are not telluric corrected. This is because the telluric correction step for HARPS spectra is still sub-optimal and can leave residuals on the final 1D spectrum. To activate the telluric correction and assess whether its quality is good for the science needs, set the recipe paramters `telluric_corr_sw` to 1 in this task.

3.6.1 Sky subtraction

For very low S/N regime, readout limited or close to it, it is recommended to use the option smooth for sky subtraction, thus reducing the readout noise contribution from the step of sky subtraction. This can be done by setting the recipe parameter `sky_corr_method` to `smoothed` in the configuration editor.

Note: sky subtraction is automatically switched off for polarimetric observations.

3.6.2 Background intra-order contamination

The recipe parameter `background_sw` removes the intra-order diffuse background contamination (it does not have to be mis-interpreted by sky background, which is regulated by `sky_sub_method` and active only for OBJECT,SKY observations). It is evaluated on boxes of size `sci_bkgr_grid_size_x` × `sci_bkgr_grid_size_y` and then interpolated all over the frame. The diffuse background is proportional to the dispersed light inside the spectrograph (and thus, to a good approximation, to the total flux recorded in the detector). If the diffuse background is not measured correctly (as happens when is negligible), correcting for it will only add an additional source of noise to the flux. Fabry-Perot light contributes significantly to the inter-order background and as such exposures with FP on fiber B have the inter-order background correction flag by default at ON. In most cases, stellar light does not contribute significantly to inter-order background and as such exposures with SKY on fiber B have the inter-order background correction flag by default at OFF. If any exposure points to the SKY on fiber B and yet has a very large target flux in fiber A, the user should change the inter-order correction flag to ON.

3.6.3 Cosmic rays cleaning

The science recipe has two algorithms for cosmic ray cleaning. They user can decide to use none, one or both by setting the corresponding recipe parameter in the configuration editor. The parameters are:

- `ksigma_cosmic`. ksigma for removing cosmics on fiber A or SKY; Set it to -1 to deactivate it. Default: 3.5. The algorithm operates on the extracted spectrum and flags pixels that deviate more than a certain factor.
- `cosmic_detection_sw`. Use the LA Cosmic detection (van Dokkum 2001, PASP 113, 1420). Set it to 0 to disable, 1 to enable. `cosmic_detection_sw` to 1 or 0, respectively. Pixels that are flagged are ignored during the extraction of the one-dimensional spectrum. The tab "LACOSMIC" in the interactive window allows the user to specify the recipe parameters that control the algorithm. By default, the workflow switches on/off the algorithm and loads the optimal recipe parameters for a given observing mode. We refer the user to the pipeline manual for more information on the recipe parameters. The user might want to inspect the products with category CRH_MAP and CCD_CORR_SCIENCE to assess the quality of the flagging process. These products are available by pressing the magnifying glass of the corresponding job.

The general recommendation is to switch on both algorithms, but pay attention whether very intense targets or very intense exposures of fibre B (in particular with high binning modes), do generate too many false positive detections. In this case, it is recommended either to switch the LA Cosmic algorithm off, or to increase the `f_lim` `sigma_lim` thresholds, regulated by the corresponding recipe paramters.

If a cosmic ray is only partially detected, one might dilate the cosmic-ray mask by setting recipe parameters `post-filter-x` and `post-filter-y` parameters to 1 or 2 (higher values are not recommended).

The user has the option to provide a mask with cosmic rays detection (category CRH_MAP). If provided, it will switch off the execution of the LA Cosmic algorithm. In order to be used by the workflow and the recipes, the user-provided mask has to:

- be present amon the inputs.
- have the category `CRH_MAP` (header keyword HIERARCH ESO PRO CATG).
- have the same format of `CRH_MAP` produced by switching on the LA Cosmic algorithm. The convention is: pixels with value of 1 are cosmic rays, other pixels have value 0 (integers).
- have the header keyword ARCFILE of the same value of the science frame it is supposed to be associated to.

It is therefore recommended to first run the reduction with the LA Cosmic algorithm turned on, with the option `extra_products_sw`, and then edit the CRH_MAP produced by the workflow according to the needs. It is also possible to run a third-party cosmic ray detection algorithm on CCD_CORR_SCIENCE and record the flagged pixel into CRH_MAP. Note that the inclusion of an user-provided CRH_MAP replaces the LA Cosmic algorithm in the science recipe, but the "k-sigma clipping" algorithm can still be executed.

3.6.4 Radial velocity

The computation of radial velocity is a key-feature in the `espdr` pipeline. One might decide to fine-tune the recipe parameters to improve the calculation or to run a dedicated esoreflex workflow and recipe to execute only this step: they are available as part of the ESPRESSO-DAS pipeline, which is capable of dealing also with HARPS data. We refer the user to the ESPRESSO-DAS documentation for this option.

The recipe parameters that optimize the computation of radial velocity are: `rv_range` and `rv_step`. The general recommendation is to start with a large range `rv_range` and a course grid `rv_step` to locate the minimum. Then a fine-tuning of the range and grid are necessary to increase the precision of the measurement. However, M-dwarfs are particularly prone to bad convergence in the CCV computation if the RV range is large. It is not recommended to derive RVs using an RV range larger than 20 km/s for M dwarfs. When computing the radial velocity of the same target over a certain period of time, it is important to use the same template (mask_table_id) to remove systematic effects between measurements at different epochs.

3.7 Combine science

The task **combine_science** combines together science spectra taken within the same template (same header keyword `TPL.START`) by running the recipe `esotk_spectrum1d_combine`. The `esotk` needs to be installed. This task is not executed for polarimetric observations. Do not select this task if your science requires inspection of individual spectra.

3.8 Other tasks and workflow not associated to the scientific reduction

3.8.1 Efficiency

The task **efficiency** runs the recipe `espdr_cal_eff_ab` to correct for the relative efficiency between fibre A and B. During science reduction, the correction is done by using pre-processed calibrations provided by the archive, therefore this task does not enter in the reduction cascade of science data.

3.8.2 Detector properties

This is a subworkflow that contains the two following tasks. There tasks or their products are not used in the reduction cascade of scientific data.

- **Detector_monitoring**. This task runs the recipe `detmon_opt_lg_mr` to compute the linearity of the detector. The `detmon` pipeline has to be installed to run this task.
- **Dark** This task runs the recipe `espdr_mdark` to determine hot pixel mask. In a typical scientific dataset, raw darks are not present and static calibrations that map the hot pixels (whose location is very stable) are used instead.

4 Overview of all the data reduction configuration options

4.1 Selection of most appropriate calibrations

By default, EDPS associates raw calibrations to the reduction process. It is also possible to use pre-processed calibrations (a.k.a. master calibrations) if available, in order to speed up the reduction. The preference can be specified in the Raw Data tab, before creating the datasets.

Possible values of the Calibration Preferences are:

- **raw_per_quality_level**: At equal quality of reduction, association of raw calibrations is preferred. This is the default.
- **master_per_quality_level**: At equal quality of reduction, association of master calibrations is preferred.
- **raw**: Association of raw calibration is preferred, despite the quality of results.
- **master**: Association of master calibration is preferred, despite the quality of results.

When master calibrations are used, the reduction step needed to process raw calibrations are not executed. The reduction then moves directly to the process of scientific exposures.

For example, if reduction speed for a quick check is preferred over a high quality reduction, one can select "master". In this case, old master calibrations are associated even if there are raw calibrations closer in time (and therefore more likely to ensure better quality products).

The quality level that the selected calibrations deliver is indicated close to each dataset in the ‘Raw input‘ tab, under the colum ‘CalibLevel‘. CalibLevel=0 indicates that calibrations that follow the rules of the instrument calibration plans have been selected. The higher the number, the poorer the quality of the products.

4.2 Configuration of parameters: the configuration editor

The data reduction of each dataset can be configured according to the scientific needs using an appropriate configuration editor.

The EDPS workflows contain two types of parameters and they both have default values that can be modified to improve the data reduction: **workflow_parameters** and **recipe_parameters**. The current version of the HARPS workflow contains only one workflow parameter (IS_IDP, which is used only by ESO internal data products creation and can be ignored by general user cases).

Recipe parameters are specific to the individual recipes and can be configured per task. They are accessible in the ‘Reduction Configuration‘ editor, in the ‘Reduction queue‘ tab.

This editor allows to configure the data reduction for a given dataset by specifying the recipe parameters.

To open the editor, click on the wheel button  next to the dataset you desire to configure the reduction for. A window with the configuration editor appears as shown Figure 16.

The editor is divided into 4 parts, which can be accessed pressing the corresponding expansion arrow.

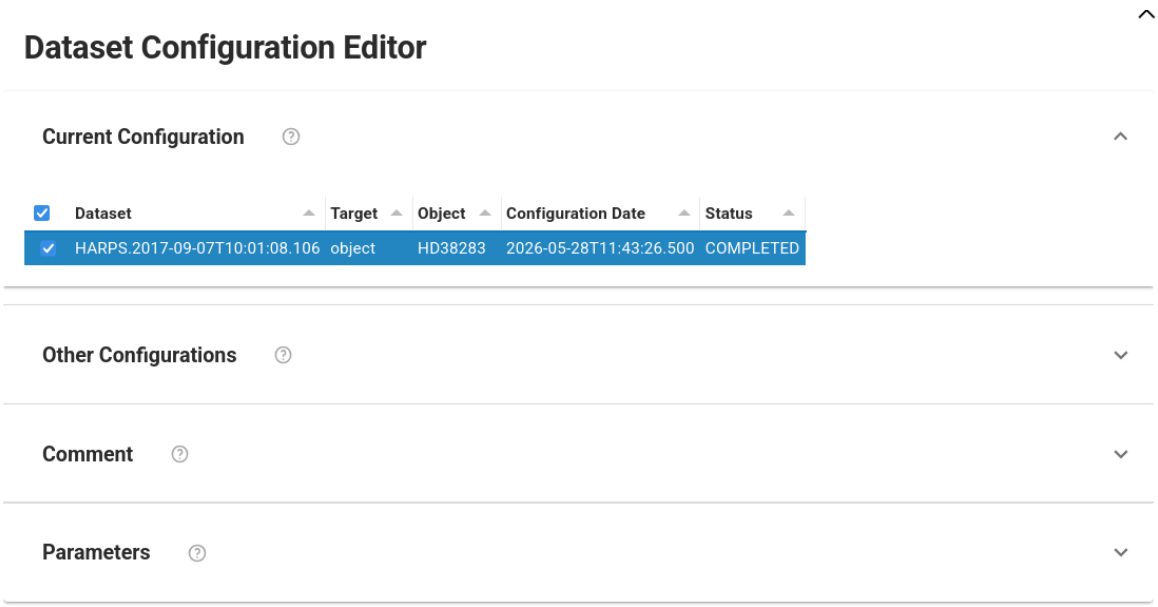

Figure 16: The Reduction Configuration editor. It contains 4 sections, that indicate the current configuration, list of other configurations to set, comments to insert, and the parameters to modify.

- **Current configuration.** It indicates the name of the selected configuration for a given dataset (Figure 17).
- **Other configurations.** It allows to specify other configurations, to which the changes shall be copied to (Figure 18.
- **Comment** It allows to specify a comment to describe the configuration. It is possible to append or replace a comment (Figure 19). Comments can be changed on all configurations. It is possible to save the comment for the current configuration only, or for all the selected configurations.
- **Parameters.** A window as in Figure 20 appears.

  The window allows to:

  – Select the parameter set. A pre-determined list of workflow parameters and recipe parameters for a given use case. For the majority of the cases, the "science" parameter set can be used.

  – Edit the workflow parameters. These are parameters that regulates the reduction strategy, e.g. whether to use a given calibration or not, or to trigger a certain reduction step. Note that if the changes imply that some files not in the dataset are needed, the reduction might fail. In case, go back to the raw data tab, edit the workflow parameters there, and recreate the datasets.

  – Edit the recipe parameters. These are parameters associated to the recipe of a given task. Note: the same recipe parameters can be configured differently for the tasks that run the same recipe. Default parameters are shown (albeit some parameters can be dynamic, e.g. ‘EDPS‘ changes their value depending on the type of input data).

  Change the values according to the needs and then select whether to save it to the current or the selected

configurations. Note, complete configurations cannot be modified, new configurations will be automatically created instead.

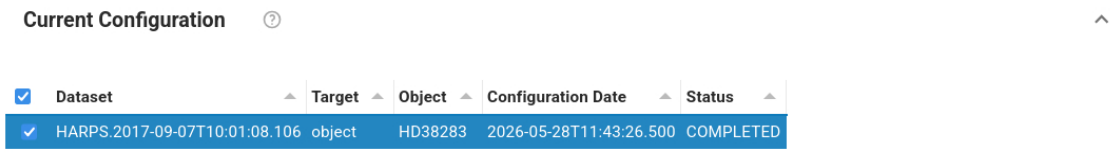

Figure 17: The first part of the Reduction Configuration Editor, that indicates the selected configuration.

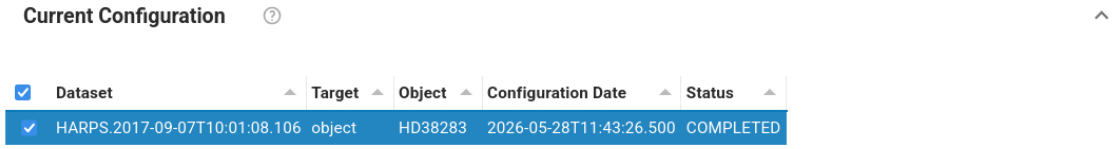

Figure 18: The second part of the Reduction Configuration Editor, that indicates other configurations for which we'd like to apply the changes.

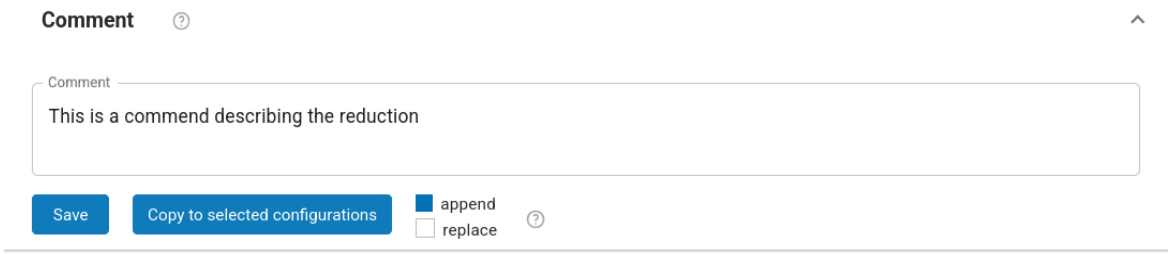

Figure 19: The third part of the Reduction Configuration Editor, that allows to specify a comment to the selected configurations.

4.2.1 Apply the same parameters to multiple datasets and configurations

A common user case is to apply the same set of optimized parameters to other datasets or other configurations. This is possible with the **Other configurations** tab of the configuration editor. To do so, proceed as follows:

- From the Reduction Queue tab, select the dataset/configuration that has the parameters you want to adopt for other reductions.
- Open the configuration editor by clicking on the weel-button on the right-hand side, at the end of the line of the selected configuration.
- If necessary, edit the parameters.

- On the **Other configurations** tabs, select the datasets or configurations you want to reduce with the same parameters of the "Current configuration". Only datasets/configurations present in the Reduction Queue can be selected.
- Go on the Parameters tab of the configuration editor and click on the button **Copy to selected configurations**. Selected configurations that were labelled with "NEW" will be updated, selected configurations that were labelled with "COMPLETED/FAILED/ABORTED" will not be updated, but "NEW" configurations will be created instead.
- If you have edited paramters on the 3rd step, please note that the original "Current configuration" will not be updated by pressing the button **Copy to selected configurations**; only those selected in the "Other configurations" tab will be updated. If you want the edited parameters to be copied also to the "Current configuration", then press the "SAVE" button (available only if the Current configuration is labelled as NEW) or "Create new configuration" button (in this case the Current configuration is not updated, but a "NEW" configuration is created instead).

The newly created or updated configurations are now ready for reduction.

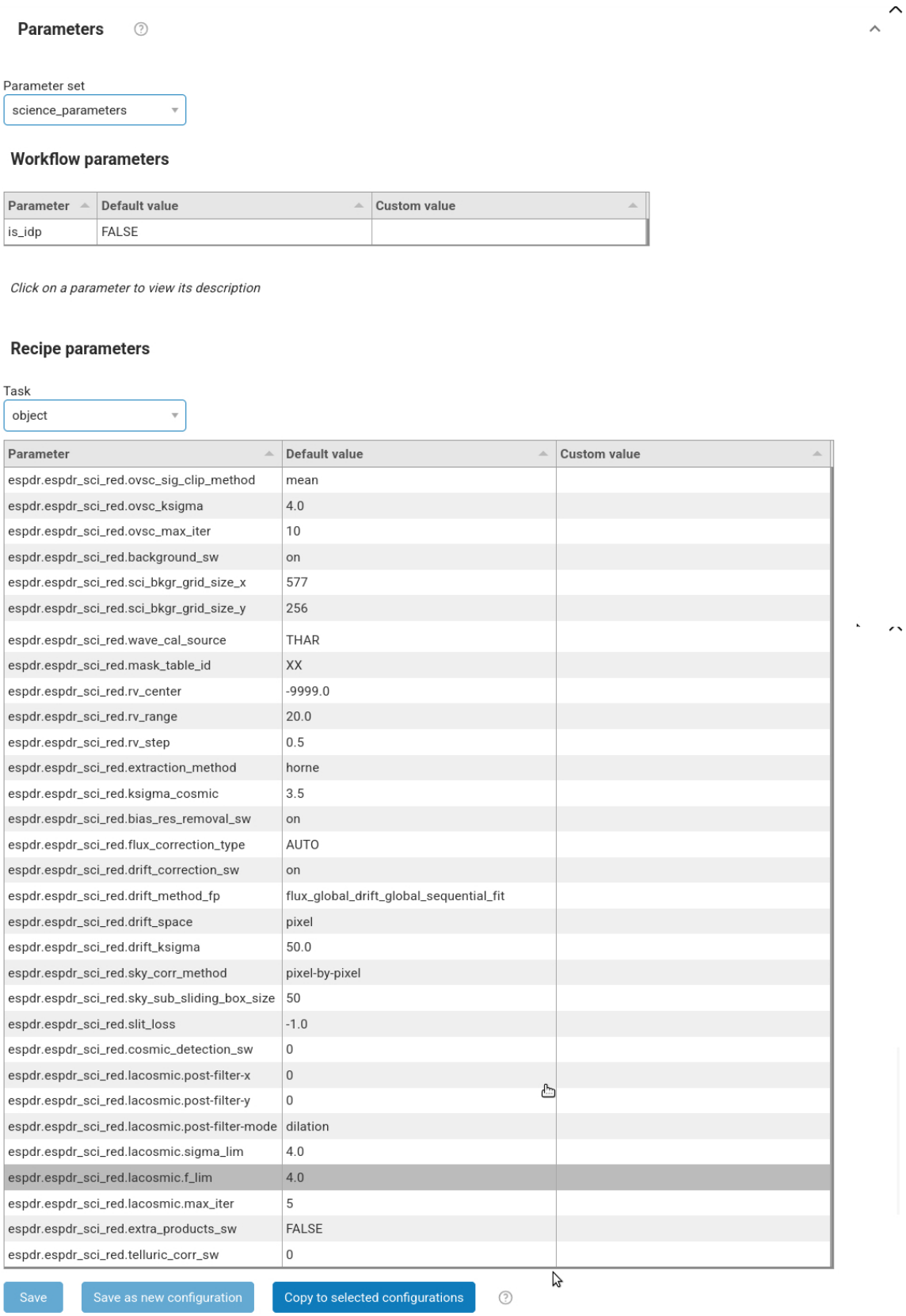

Figure 20: The fourth part of the Reduction Configuration Editor, that allows to specify the parameters sets and the recipe parameter per task. These settings can be applied to the "Selected Configuration" (Fig. 17) or to the "Other Configurations (Fig. 18).

5 List of workflow tasks

This is the list of all the tasks and associated recipes in the HARPS workflow. Only some of them are needed for scientific reduction, they are indicated by the flag "yes" (triggered by default) or "optional" (triggered only if requested by a workflow parameter). Other tasks are not used for scientific reduction (they are indicated by the flag "no"), they are mainly used for instrument monitoring and they can be executed only by specifying them as target. Note that, when a task is specified as target, all the tasks that generate the calibrations needed for it are automatically executed.

TASK	RECIPE	Used in science reduction	Notes
bias	espdr_mbias	yes	Computes master bias and residuals
combine_science	esotk_spectrum1d_combine	yes	Combines reduced 1D spectra of the same target
contamination_fp	espdr_cal_contam	yes	Computes mutual contamination of fibres with Fabry-Perot spectra
contamination_thar	espdr_cal_contam	yes	Computes mutual contamination of fibres with Th-Ar spectra
dark	espd_mdark	no	Computes masterdark and hot pixel table
detector_monitoring	detmon_opt_lg_mr	no	Computes detector linearity
efficency	espdr_cal_eff_ab	no	Computes fibres relative efficiency
flux_calibration	espdr_cal_flux	yes	Computes flux calibration
lamp_flats	espdr_mflat	yes	Computes flat-fielding and blaze-function corrections
led_flats	espdr_led_ff	yes	Computes bad pixels mask
object	espd_sci_red	yes	Reduces science spectra and computes radial velocity
order_definition	espdr_orderdef	yes	Traces the orders on the detector
wave_thar_fp_drift	espdr_wave_TH_drift	yes	Performs one step of the wavelength calibration
wave_thar_thar_drift	epdr_wave_TH_drift	yes	Performs one step of the wavelength calibration
wave_fp_fp	espdr_wave_FP	yes	Performs one step of the wavelength calibration
wave_thar_fp	espdr_wave_THAR	yes	Performs one step of the wavelength calibration
wave_fp_thar	epdr_wave_THAR	yes	Performs one step of the wavelength calibration

Table 5.0.0: HARPS pipeline tasks overview

6 Frequently Asked Questions

- **Q1) Where can I find the final reduced data?**

  Answer: all the products of all the datasets and the reductions are saved into the EDPS_data directory, specified when executing the `edps-gui` for the first time. One can decide to export only the final products for selected datasets and only for the desired reduction attempts into another location for further analysis. See Section 2.4 for further instructions.

- **Q2) How do I stop the application?**

  Answer: Proceed as follows:

  1. Press "Stop EDPS" in the Dashboard.
  2. Type Ctrl-C in the terminal where the application is running. If the application doesn't terminate, type Ctrl-C again.
  3. Alternatively, kill the 'panel serve' process on your system, for example:

     ```
     ps -e | grep panel # get the process ID of the gui (<pid>).
     kill -9 <pid>
     ```

- **Q3) I have closed the browser window where the application is running. How can I reopen the application?**

  Answer: Point your browser to: `http://localhost:5006/edps-gui`

- **Q4) Where can I find some data that I can use to test the application?**

  Answer: Install the 'datademo' package provided with the pipeline installation or download the "Demo Data" package from https://www.eso.org/sci/software/pipe_aem_table.html.

  Please note that the demo data can be large (tens of Gigabytes).

  A convenient script to download demo data for any pipeline is also available and can be used from the command line:

  ```
  curl -O https://eso.org/sci/software/apptainer/eso_download_demodata.sh
  bash ./eso_download_demodata.sh
  ```

- **Q5) How can I start the edps-gui if the following message appears?**

  ```
  Cannot start Bokeh server, port 5006 is already in use
  ```

  Answer: The panel server was not closed properly. Kill it by typing:

  ```
  ps -e | grep panel # get the process ID of the gui (<pid>).
  kill -9 <pid>
  ```

- **Q6) How do I get additional support on EDPS or data reduction in general?**

  Answer: For suggestions, questions, or feedback in general, please open a ticket with the EDPS Support team. This https://support.eso.org/new-ticket?ticket%5Bticket_field_13%5D%5Bdata%5D=227 should take you directly to a webpage for creating and `EDPS` feedback ticket, but in case you want to navigate there 'manually', go to https://support.eso.org, login, click on "Submit Helpdesk Ticket", and specify the Help topic: "Post Observations", "ESO Data Processing System [EDPS]".

- **Q7) I have a lot of disk space, but when I install `EDPS` with `pip` or an ESO pipeline with `Homebrew` I get the error message: `Cannot mkdir: No space left on device`. How do I fix it?**

  Answer: This depends on how much disk space is allocated to the `/home`, `/var`, and `/tmp` directories. The final solution would be to resize the space allocated to the in the organization of the filesystem. However, we list here few tricks that might do the job.

  – Clearing the pip .cache to make space for new packages. Type the command:

    ```
    pip cache purge
    ```

    before installing `EDPS`.

  – Redirect the cache, `Homebrew` temporary build directories into a partition with enough space. Set some of the following environmental variables in your `.bashrc` file:

    ```
    export HOMEBREW_CACHE=<path_to_new_cache_directory>
    export XDG_CACHE_HOME=<path_to_new_cache_directory>
    export HOMEBREW_TEMP=<path_to_new_temporary_directory>
    export TMPDIR=<path_to_new_temporary_directory>
    ```

    The first moves only the location of `Homebrew` cache, the second the cache of most applications (instead of the default `/home/username/.cache`), the third moves the directory where `Homebrew` builds, extracts, and saves temporary files (instead of the defaults `/tmp` and `/var/tmp`). The last changes the global system temporary directory and affects most of the linux commands.

  – As extreme measure, one can move the `/home/linuxbrew/.linuxbrew` directory somewhere else, and create a symbolic link in `/home/linuxbrew`. For example:

    ```
    cd /home/linuxbrew
    mv -f .linuxbrew <path_to_new_directory>
    ln -s <path_to_new_directory> .linuxbrew
    ```

    Important note: this operation might break some internal links. Recipes requiring external packages such as `telluriccorr` might not work (impacts on KMOS, XSHOOTER, FORS2, and MOLECFIT pipelines).