# ESO REFLEX: A GRAPHICAL WORKFLOW ENGINE FOR DATA REDUCTION


## ABSTRACT

Sampo is a project led by ESO and conducted by a software development team from Finland as an in-kind contribution to joining ESO. The goal is to assess the needs of the ESO community in the area of data reduction environments and to create pilot software products that illustrate critical steps along the road to a new system. Those prototypes will not only be used to validate concepts and understand requirements but will also be tools of immediate value for the community.

Most of the raw data produced by ESO instruments can be reduced using CPL recipes: compiled C programs following an ESO standard and utilizing routines provided by the Common Pipeline Library (CPL). Currently reduction recipes are run in batch mode as part of the data flow system to generate the input to the ESO VLT/VLTI quality control process and are also exported for use offline. Sampo has developed a prototype application called ESO Reflex that integrates a modern graphical user interface and existing data reduction algorithms. ESO Reflex can invoke CPL-based recipes in a flexible way through a dedicated interface.

ESO Reflex is based on the graphical workflow engine Taverna that was originally developed by the UK eScience community, mostly for work in the life sciences. Workflows have been created so far for three VLT/VLTI instrument modes (VIMOS/IFU, FORS spectroscopy & AMBER), and the easy-to-use GUI allows the user to make changes to these or create workflows of their own. Python scripts and IDL procedures can be easily brought into workflows and a variety of visualisation and display options, including custom product inspection and validation steps, are available.


REFLEX
The ESO Recipe Flexible Execution Workbench

SAMPO

## THE DATA REDUCTION NEEDS OF ESO

ESO is currently operating a large suite of instruments ranging from the optical to the infrared to the millimetre wavelength range. The responsibility for the quality of the scientific reduction of the data can only rest with the individual users but it is very difficult for users to be equally familiar with all of the different observational techniques spanned by the ESO instruments at a level where general-purpose tools like IRAF and ESO-MIDAS can be effectively used. Instrument specific software, implementing carefully tuned algorithms, is essential. Currently ESO aims to develop and export data reduction recipes for all VLT/VLTI instruments. These are based on the ESO Common Pipeline Library (CPL) and may be run offline using either the Gasgano graphical tool or the EsoRex command line tool. Recipes have the primary tasks of running as automatic pipelines within the data flow system and being used to create products suitable for quality control.

The challenge is to allow the user greater flexibility to interact with the data reduction process and to study data products, both intermediate and final, in order to optimize the quality of the results. In addition we aimed to reuse existing software as much as possible, both current pipelines and legacy software tools. We wished to embed the ESO recipes within a flexible environment without the need to recreate a complete and expensive new software system. This approach delivers a great improvement to the users for a modest cost.

## THE SAMPO APPROACH: ESO REFLEX

The Sampo project has concentrated on developing a graphical user interface to run ESO data reduction recipes. The result is a prototype application called ESO Reflex (Recipe Flexible Execution Workbench), in which the sequence of reduction steps is rendered and controlled as a graphical workflow. This approach allows users to follow and interact with the data reduction flow in an intuitive manner without the need for complex scripting. Figure 1 illustrates the look and feel of an ESO Reflex workflow. In this particular example, it is a reduction sequence to produce master calibrations for the FORS2 MXU mode.

ESO Reflex aims to provide most of the key elements for a scientific data reduction:

- Convenient ways to select and organise data, based on code from the Gasgano application, to cope with the complexity of the headers of modern data.
- CPL processor to include ESO recipes into workflows. This processor supports many extra features including different processor modes and control of parameter values.
- Processors through which Python and IDL scripts can be included within workflows.
- A particularly important use of scripts is to analyze intermediate products within the reduction process. To illustrate this concept we have developed several interactive tools. A screenshot of such a tool, in this case to iteratively check and refine the wavelength solution of 2D spectra is shown in Figure 2.
- The design of Taverna makes it very effective for building workflows that use Web Services such as those established within the Virtual Observatory. Experiments in this area are described in an accompanying poster.

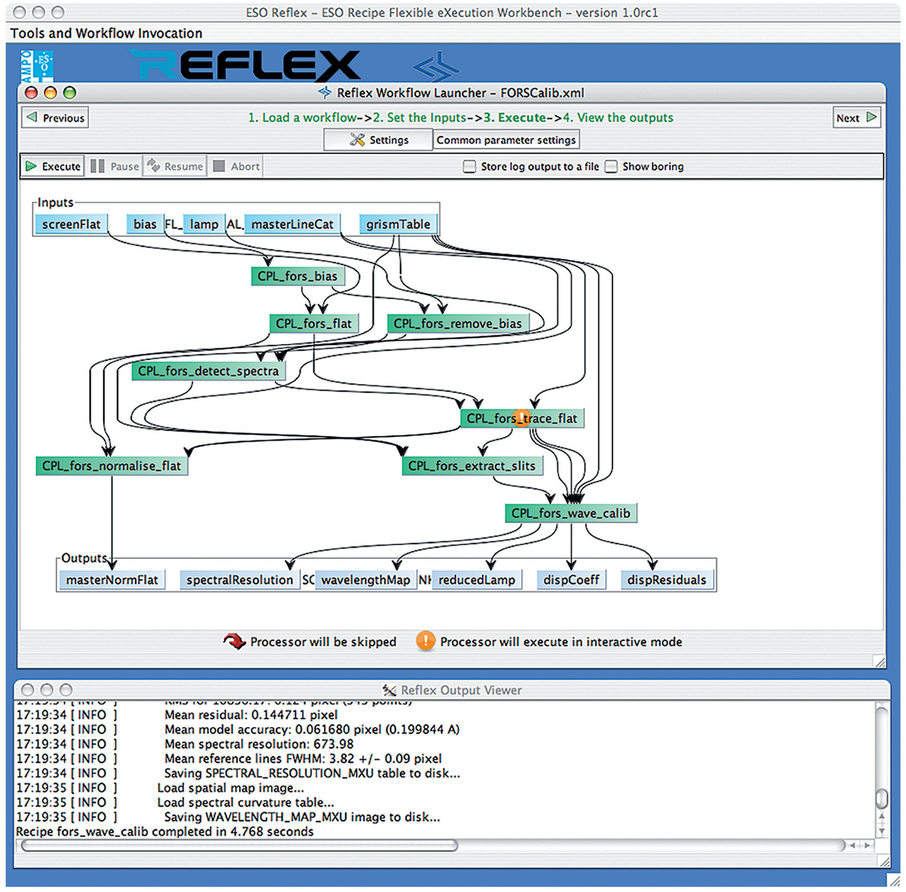


**Figure 1**
Example of a workflow with ESO Reflex: this case is based on FORS2 MXU calibration recipes. The input data are represented by the light blue boxes at the top. The data percolate through the processors in the middle section to produce the outputs at the bottom of the figure.
In this case the spectral tracing step has been switched into interactive mode to allow checking of the results and experimentation with the extraction parameters.

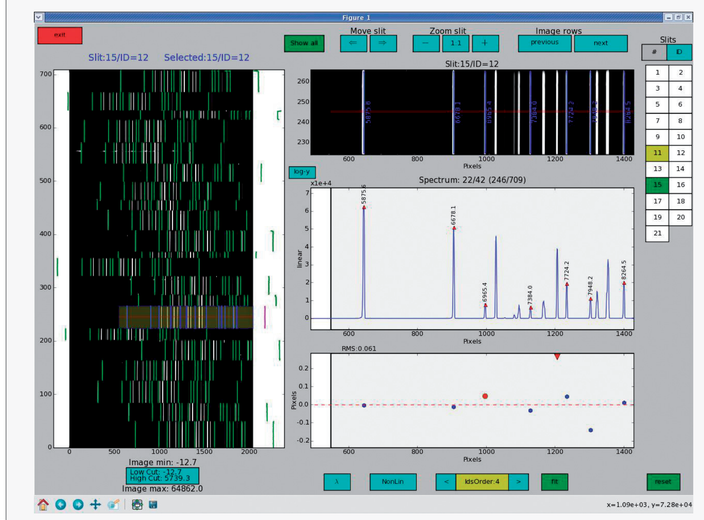


**Figure 2**
Screenshot of the Python tool to check and improve the wavelength solution of 2D spectra. Calibration spectral lines, either from an arc lamp or from the night sky, are displayed slit by slit and can be included or excluded when computing the wavelength solution with a polynomial fit, the order of which can also be set interactively.

## CURRENT STATUS AND FUTURE PLANS

At the time of writing ESO Reflex V1.0 BETA has recently been released internally at ESO. This incorporates many of the additional features and corrections that were identified in a beta testing campaign that involved both ESO internal astronomers, as well as potential users in the community. It also has a moderate level of documentation and testing. The feedback from test users was positive regarding the concept, but there remain several areas in which we feel further work is needed and there remain unexplored avenues of investigation. Examples we are currently working on include improved ways for ESO Reflex to process long lists of input files, batch processing without the GUI and enhancements to the user interface. Within ESO the adoption of ESO Reflex and the consequences for other aspects of observatory operations are currently being reviewed. On management approval we will consider wider distribution and support for the general community in the future.

## REFERENCES


Sampo project: http://www.eso.org/sampo/
ESO Reflex: http://www.eso.org/sampo/reflex/
CPL: http://www.eso.org/observing/cpl/
Taverna: http://taverna.sourceforge.net/
EsoRex: http://www.eso.org/observing/cpl/esorex.html



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