



ESO Reflex

A graphical workflow engine for running recipes

ESO, Calibration Workshop, Garching
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Outline

- The ESO data reduction context
- The Sampo project
- ESO Reflex overview
- ESO Reflex in action
- Future plans

The Data Reduction Challenge

- As the volume and complexity of astronomical data increase, astronomers are faced with the challenge of a timely and accurate reduction of their own data.
- Archival research, data mining and Virtual Observatories allow easy access to a vast amounts of diverse data, an in-depth knowledge of which may be challenging for the average user.
- Two possible (and non conflicting) approaches:
 - Provide the user with reduced data
 - Provide the user with a (powerful, flexible and user-friendly) data reduction system

Reduced data at ESO

- QC processing of all pipeline-supported modes for VLT/MLTI Service Mode stream (virtually 100% of the data volume). These data are distributed to Pis.
- Similarly for HARPS and FEROS on La Silla and APEX.
- Advanced Data Products for selected datasets (eg, GOODS IR imaging and optical spectroscopy) are produced at ESO and ingested in the archive.
- Advanced Data Products are returned to ESO from the community (eg, Public Surveys, Large Programmes, etc.) and ingested in the archive.

Data reduction by individual users: the context

- ESO provides pipeline “recipes” for all VLT instruments
- They remove the instrumental signature and are used for quality control at ESO and distributed to the community
- All newer recipes are compiled C code using the CPL library and tools to run them offline are available (Gasgano and EsoRex)
- Many older general purpose reduction and analysis systems remain in wide use (MIDAS/IRAF etc)
- Many instrument-specific packages have been developed in the community (eg, Euro3D tools)
- Future developments will lead to enhanced data complexity

So - what is the best way forward for ESO in this area?

Sampo - background and organisation

- As part of Finland's joining fee a contribution "in kind" of 6 people for three years (18 FTE) was made available. Sampo started in January 2005.
- Aim: to assess the requirements for ESO data reduction and analysis software **infrastructure** over the next decade and beyond and perform a series of to assess different options and produce useful tools.
- Project Organisation:
 - Project Manager: Richard Hook (ESO/ST-ECF/DMD)
 - Project Scientist: Martino Romaniello (since January 2006)
 - Project Team (Finland):
 - Finnish National Coordinator (Ville Savolainen, CSC, 50%)
 - VO Specialist (Johan Lindroos, CSC)
 - Software Engineer (Pekka Jarvelainen, CSC, 50%)
 - System Architect (Marko Ullgren, Helsinki Observatory)
 - Two Software Engineers (Sami Maisala, Tero Oittinen, Helsinki Observatory)
 - One Consultant (Otto, Solin, Space Systems Finland)
- Project Oversight:
 - A Finnish Astronomical Advisory Group (FAAG) chaired by Juhani Huovelin.
 - An ESO Science Advisory Committee (SAC), chaired by the Project Scientist, representing the ESO Faculty.

Data reduction by individual users: the Sampo approach

- A data reduction system for the end user requires:
 - Modular recipes to provide access to intermediate products
 - Interactive tools, defined or customized by the user, to analyze intermediate and final data products
 - A user-friendly, intuitive and flexible interface
- Sampo, and specifically the ESO Reflex tool, tries to address the **interface issue**, with a focus on the use case of ESO data:
 - Common front-end interface to cope with the potentially large number of ESO instruments in a uniform and maintainable way (à la p2pp)
 - General invoker for CPL-based recipes
 - General invoker for Python scripts (hence PyRAF & PyMidas)

ESO Reflex? Taverna?

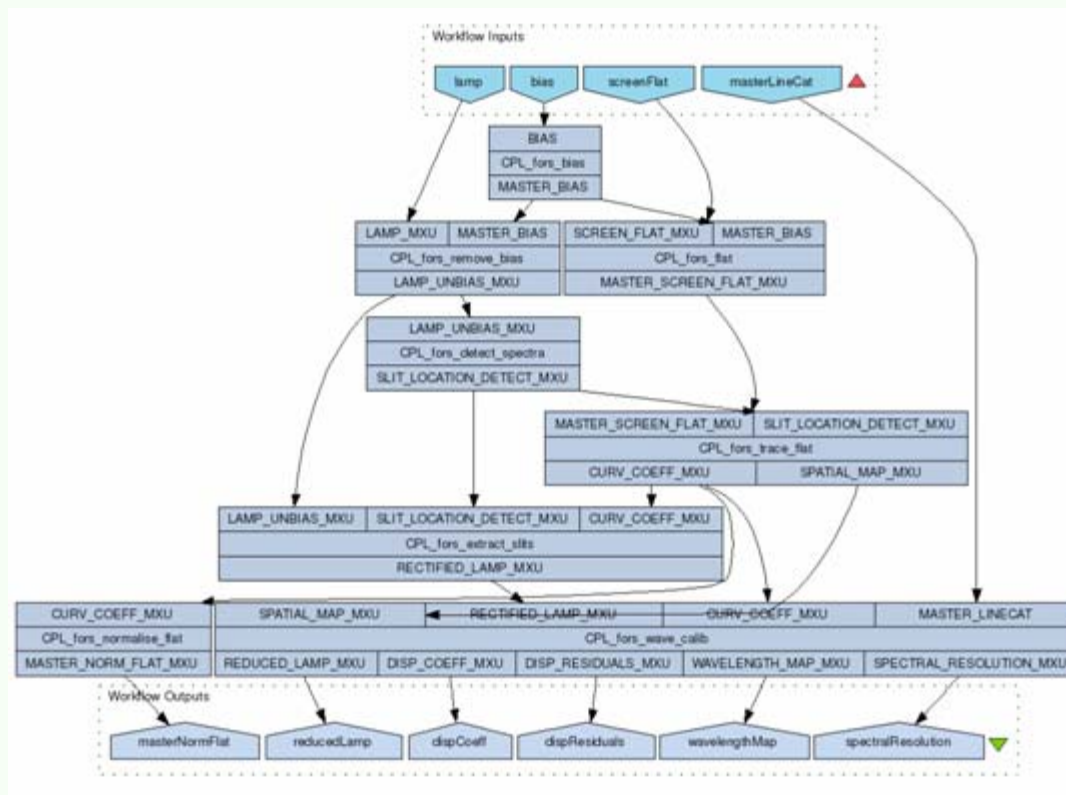
- ESO Reflex is a graphical **workflow engine** for executing CPL Recipes and other tools□
 - not instrument specific
 - easy inclusion of external tools and scripts
 - allows user interaction during execution
- ESO Reflex is based on Taverna
 - an open source Java workflow system developed for the molecular biology community in the UK
 - easy to use and adapt
 - suitable for science (rather than business applications)
- ESO Reflex is a pilot project to assess in detail the concept

From Taverna to ESO Reflex

- The Sampo project has developed Taverna further
 - to allow the execution of CPL Recipes
 - the recipe invocation mechanism
 - to ease the running of astronomical workflows
 - a completely new graphical user interface for launching the workflows
 - FITS file handling functionality
 - data classification
 - FITS viewing
 - to allow the incorporation of external tools
 - Python invoking mechanism, DS9, FV, Plastic...
 - also Web services (e.g. VO) at some stage

Advantages of Reflex: The Workflow Approach

- Modular sub-recipes are run in a sequence



Advantages of Reflex: Step-by-step execution

- In interactive mode the user can make changes to input data and parameters during execution

CPL Recipe "fors_bias" input configuration

Status: ✔ All required input frames in place, ready to execute Naming scheme: Overwr... ▼

Input frames Parameters Recipe info

File	CLASSIFICA...	TPL.ID	ORIGFILE	TPL.EXPNO	TPL.NEXP
▼ Displaying 5 files Unfiltered.					
▼ [pic] 60.A-9203(E)					
▼ [pic] 200115617 Calibration					
★ FORS2.2004-01-23T10:57:58.097.fits	BIAS	FORS2_img_...	FORS2_IMG...	1	5
★ FORS2.2004-01-23T10:58:39.008.fits	BIAS	FORS2_img_...	FORS2_IMG...	2	5
★ FORS2.2004-01-23T10:59:21.199.fits	BIAS	FORS2_img_...	FORS2_IMG...	3	5
★ FORS2.2004-01-23T11:00:02.505.fits	BIAS	FORS2_img_...	FORS2_IMG...	4	5
★ FORS2.2004-01-23T11:00:44.042.fits	BIAS	FORS2_img_...	FORS2_IMG...	5	5

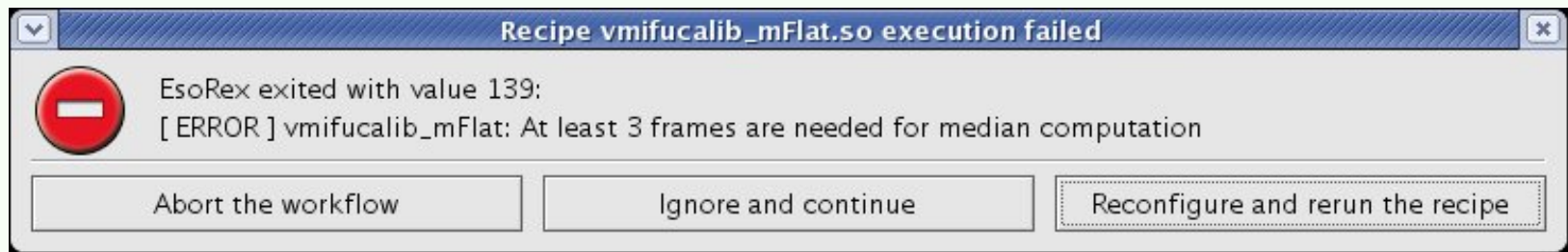
Use only selected frames

Execute recipe Abort workflow View (DS9) View (FV) Add/remove input frames

Advantages of Reflex:

Error detection and recovery

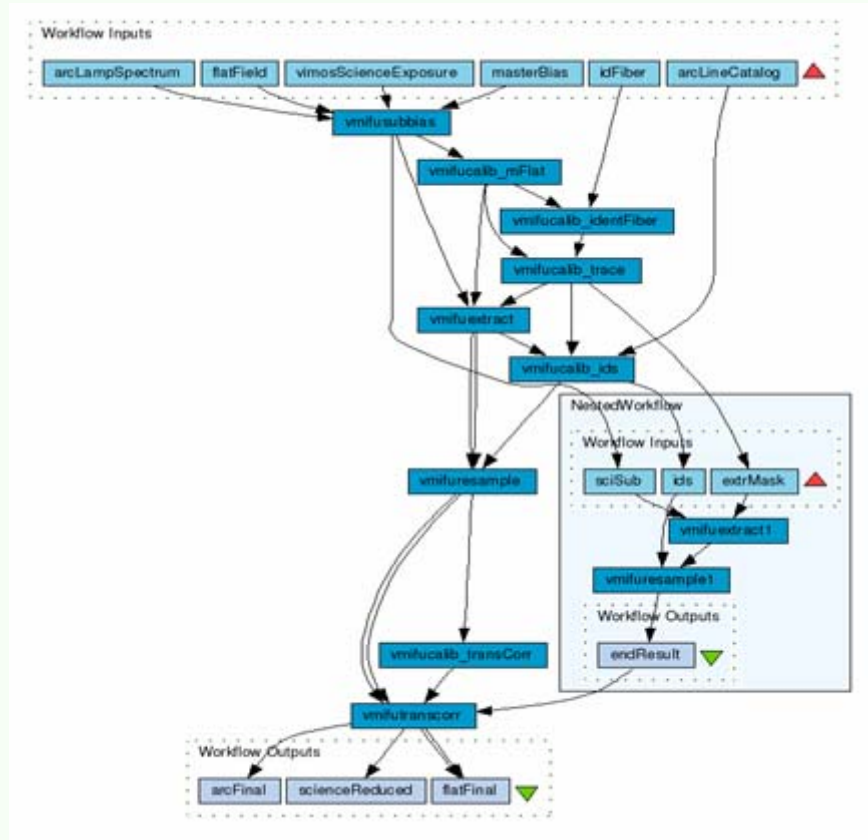
- Errors on during recipe execution are detected by Reflex



- Appropriate action can be taken by the user

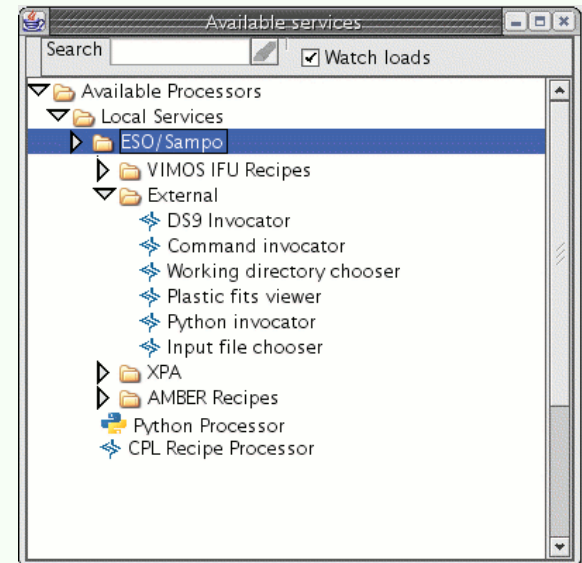
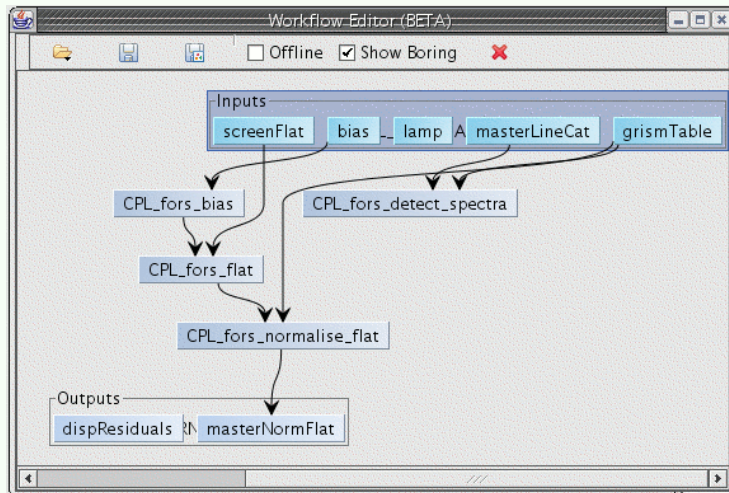
Advantages of Reflex: Parallel Execution

- The recipes on a parallel workflow execute in parallel
- Full advantage on multi-processor or multi-core machines



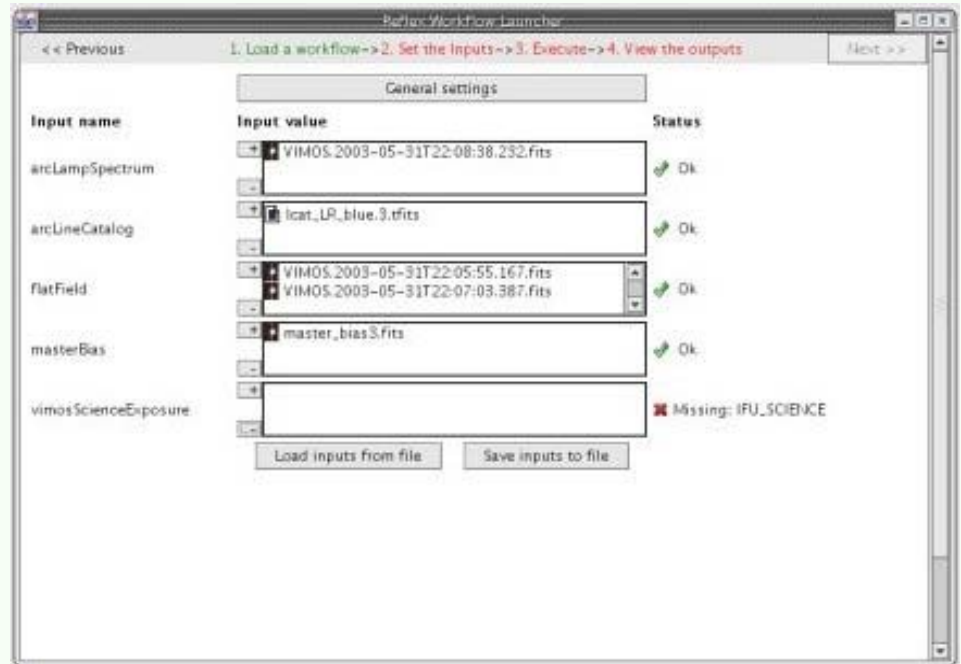
Advantages of Reflex: Customisability

- The user can easily modify the workflows
- Python scripts can be included in the workflows
- Any system command can also be invoked from the workflows



Advantages of Reflex: FITS-file handling (using Gasgano code)

- The instrument-specific *tags* of the FITS-files are automatically extracted from the FITS-headers
- Tag-checking: only compatible FITS-files are allowed in inputs





Reflex Workflow Launcher - fors_calib.xml

<< Previous **1. Load a workflow -> 2. Set the Inputs -> 3. Execute -> 4. View the outputs** Next >>

Settings

Load Show ports Show boring Show subworkflows Reset

Workflow Inputs

```

    graph TD
        subgraph Inputs
            masterLineCat
            lamp
            bias
            grismTable
            screenFlat
        end
        subgraph Processing
            CPL_fors_bias
            CPL_fors_remove_bias
            CPL_fors_detect_spectra
            CPL_fors_trace_flat
            CPL_fors_extract_slits
            CPL_fors_wave_calib
            CPL_fors_flat
            CPL_fors_normalise_flat
        end
        subgraph Outputs
            spectralResolution
            dispResiduals
            dispCoeff
            reducedLamp
            wavelengthMap
            masterNormFlat
        end

        masterLineCat --> CPL_fors_remove_bias
        masterLineCat --> CPL_fors_detect_spectra
        masterLineCat --> CPL_fors_extract_slits
        masterLineCat --> CPL_fors_wave_calib
        lamp --> CPL_fors_remove_bias
        lamp --> CPL_fors_detect_spectra
        lamp --> CPL_fors_extract_slits
        lamp --> CPL_fors_wave_calib
        bias --> CPL_fors_remove_bias
        bias --> CPL_fors_detect_spectra
        bias --> CPL_fors_extract_slits
        bias --> CPL_fors_wave_calib
        grismTable --> CPL_fors_remove_bias
        grismTable --> CPL_fors_detect_spectra
        grismTable --> CPL_fors_trace_flat
        grismTable --> CPL_fors_extract_slits
        grismTable --> CPL_fors_wave_calib
        screenFlat --> CPL_fors_remove_bias
        screenFlat --> CPL_fors_detect_spectra
        screenFlat --> CPL_fors_trace_flat
        screenFlat --> CPL_fors_extract_slits
        screenFlat --> CPL_fors_wave_calib
        screenFlat --> CPL_fors_flat
        screenFlat --> CPL_fors_normalise_flat

        CPL_fors_remove_bias --> CPL_fors_detect_spectra
        CPL_fors_remove_bias --> CPL_fors_extract_slits
        CPL_fors_remove_bias --> CPL_fors_wave_calib
        CPL_fors_detect_spectra --> CPL_fors_extract_slits
        CPL_fors_detect_spectra --> CPL_fors_wave_calib
        CPL_fors_trace_flat --> CPL_fors_extract_slits
        CPL_fors_trace_flat --> CPL_fors_wave_calib
        CPL_fors_extract_slits --> CPL_fors_wave_calib
        CPL_fors_flat --> CPL_fors_normalise_flat
        CPL_fors_normalise_flat --> masterNormFlat
    
```

Workflow Outputs

Rendering done.

Reflex Output Viewer

Clear

An example workflow - FORS/MXU calibration



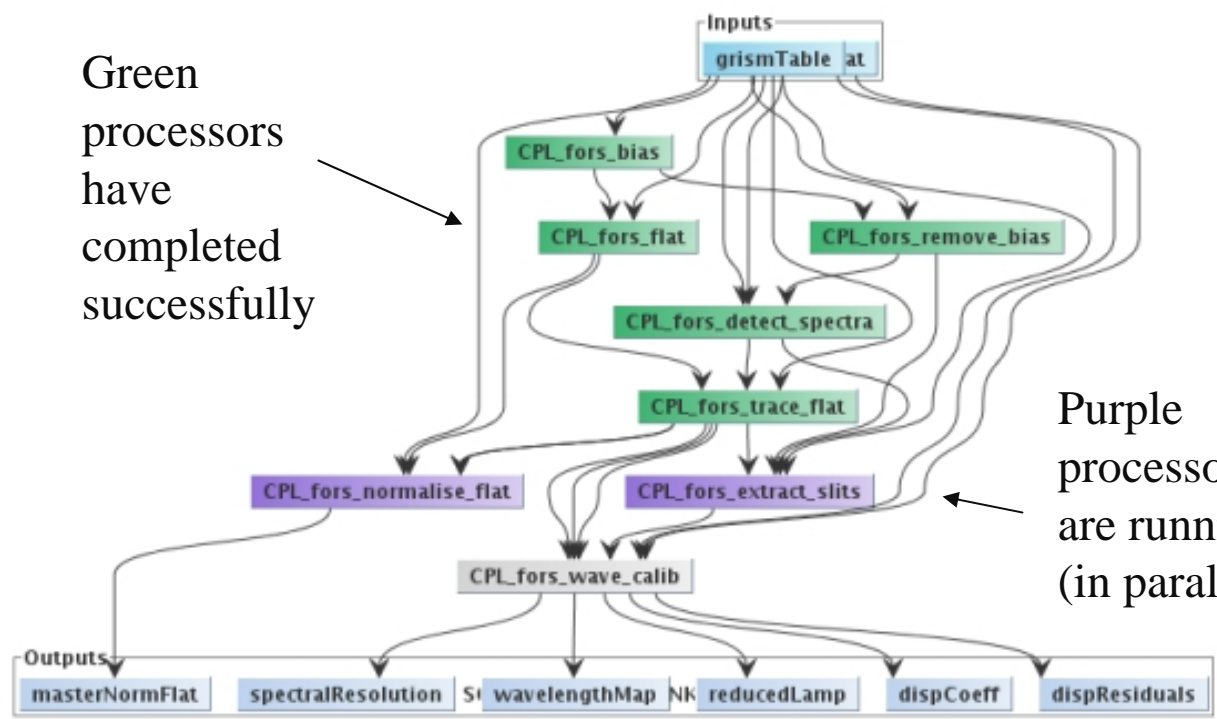
Reflex Workflow Launcher - fors_calib.xml

<< Previous **1. Load a workflow->2. Set the Inputs->3. Execute->4. View the outputs** Next >>

Settings

Execute Pause Resume Abort Store log output to a file Show boring

Green processors have completed successfully



Purple processors are running (in parallel)

An active workflow (FORS/MXU)

Reflex Output Viewer

```

18:23:49 [ INFO ]   endwavelength:
                  End wavelength in spectral extraction: 11000.000000
18:23:49 [ INFO ]   flux:
                  Apply flux conservation: TRUE
18:23:49 [ INFO ]   Check input set-of-frames:
Recipe fors_normalise_flat completed in 5.007 seconds

```

Current and Future Activities

- ESO Reflex is just being released to beta testers for a more detailed assessment
 - The release includes FORS/MXU and AMBER recipes
 - Interactive tools, featuring complex Python-based GUIs, are also included
- Based on the users's feedback ESO will decide the future course of action.