ESO Phase 3 Data Release Description

Data Collection	FEROS
Release Number	1
Data Provider	ESO Science Archive Facility
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Abstract

This is the release of reduced 1-D spectra from the FEROS[1] (Fibre-fed Extended Range Optical Spectrograph) at the ESO La Silla 2.2m telescope. The products were generated with FEROS pipeline run in a fully automated, unsupervised way. While the products undoubtedly contain scientifically valuable information, they cannot be considered to be "science grade" (also because of not carrying uncertainty estimates).

The data were reduced automatically using the FEROS Data Reduction Software (DRS) pipeline version fern/1.0. This pipeline is based on the ESO-MIDAS[2] FEROS context (an integrated component of ESO-MIDAS) plus a set of MIDAS command (PRGs), Perl and shell scripts developed from the set of PRGs in the "locproc"[3] directory of the ESO-MIDAS distribution. The version fern/1.0 thus refers to ESO-MIDAS version 15SEPpl1.0 plus the set of fern/1.0 tarball distribution, which will be bundled with the next MIDAS release. Before that, users can obtain this distribution via requesting it by sending email to usd-help@eso.org with subject "FEROS pipeline request."

The products come in the standard ESO 1-D FITS binary table format along with a gzipped TAR file containing selected output files generated by the pipeline.

Release Content

The release covers practically all FEROS science data since the so-called "FEROS Big Bang", i.e. the upgrade of FEROS to VLT standard, i.e. data acquired since November 2003 (ESO Period 72).

This release supersedes the release of FEROS data that used to be available with the "FEROS/HARPS pipeline processed data" service.[4] The differences with respect to this service are:
- Extended coverage. The "FEROS/HARPS pipeline processed data" service started in 2005-10, i.e. ESO Period 76, and contained several gaps, filled by the current release.

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[1] https://www.eso.org/sci/facilities/lasilla/instruments/feros.html.

[2] http://www.eso.org/sci/software/esomidas/

[3] The directory stdred/feros/locproc of the ESO-MIDAS distribution.

[4] http://archive.eso.org/wdb/wdb/eso/repro/form. This service remains active, but it no longer provides access to FEROS data; the only data accessible from there are pipeline processed HARPS polarimetry mode data and calibration data.

- Provision of the full combined and rebinned spectrum in the 1-D ESO data product standard FITS binary table format.
- The TAR file containing selected pipeline products is renamed to explicitly provide the pipeline version identifier.
- It is possible to query FEROS products simultaneously with data products from other Phase 3 releases.

All data have been pipeline-processed with version fern/1.0. Minor improvements were required to the package during the processing for the current release, thus version numbers in the headers of the file may differ in the place of the third version designator, e.g. 1.0.0, 1.0.1 or 1.0.3 etc. The differences between such versions is essentially cosmetic and all 1.0.x versions are referred to globally as fern/1.0 (or FERN_1.0 in the filenames).

The pipeline generates TAR files with several products and an HTML report (see "File structure" below). The pipeline-processed 1-D spectra are extracted from the TAR files, converted to the ESO standard spectroscopic format and then made available to the users via the ESO Archive user interface.[5]

The "FEROS" collection will be updated in regular intervals, roughly once per month. This timing is indicative; it may vary or may need to be adjusted according to operational requirements. Please note that most of the newly added data are proprietary; until the proprietary period expires (typically one year) only the PI and his/her delegates can download the data.

Release Notes

FEROS operates in a fixed configuration; in fact the instrument has no moving parts. An optical system delivers light either from the telescope and/or the calibration unit to a fibre-head, from which two optical fibres then carry the light to the instrument that is housed in a thermally controlled, vibration isolated room.

Science exposures of single objects are made with the object placed on one of the fibres (normally the fibre designated the OBJECT fibre) with the second fibre illuminated either by the sky (for subsequent sky-background subtraction during data reduction – **not** done by the automatic processing described here) or by a calibration lamp, usually the wavelength calibration lamp (to allow higher precision wavelength calibration, also **not** done by the automatic processing described here).

The primary products have been created with the following processing steps:
- The bias is subtracted (using the overscan regions) and bad columns are replaced by means of neighbouring columns.
- Orders are then first rectified i.e. straightened (MIDAS command RECTIFY/FEROS)

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[5] http://archive.eso.org/wdb/wdb/adp/phase3_main/form or
http://archive.eso.org/wdb/wdb/adp/phase3_spectral/form.

- Orders are then extracted using the *standard* (i.e. not the *optimum*) method.
- Extracted spectra are then flat-fielded.
- The flat-fielded, extracted spectra are then wavelength calibrated and rebinned to constant step in wavelength (0.03nm)
- Finally, the individual orders are merged into a single one-dimensional spectrum.

Data Reduction and Calibration

This Data Release is based on an **automated, non-supervised** reduction, based on the assumption that science data from each night can be calibrated by calibration data taken sometime during the 24hr period from mid-day Chilean local-time on the start of the night and mid-day the following day. The data are therefore processed on a night-by-night basis, processing first calibrations (i.e. raw files with header keyword HIERARCH ESO DPR CATG of 'CALIB'), typically bias, flat-field and wavelength calibration frames and then science (i.e. raw files with keyword HIERARCH ESO DPR CATG equal to 'SCIENCE').

The calibrations are processed in order to "initialize the DRS". The automatic processing assumes certain data-acquisition strategies to define a set of calibrations with which to initialize the DRS, typically either 5 bias frames, 10 flat-field frames and 6 wavelength calibration frames (a full DRS-Initialisation set of calibrations) or 2 bias frames, 2 flat-field frames and 1 wavelength calibration frames (a so called *Daily Health Check* [DHC] set of calibrations).

If for any reason the automatic pipeline is unable to successfully initialise the DRS it will then fail to reduce all science frames for that night.

The reduced data are **not** flux calibrated.

Data Quality

The pipeline does calculate some basic quality control parameters on the DRS-Initialisation wavelength solution, however these are not used anywhere, in particular there is no rejection of "bad" DRS-Initialisations on the basis of Quality (except in the sense that DRS-Initialisation data-sets too bad to result in successful reduction by the automated procedure fail to produce a result and are thus excluded form use for reducing science data in this way). These wavelength calibration basic quality control parameters are propagated through to the science products in the HIERARCH ESO PRO REC1 WLC QC keywords.

There is **no** quality control performed on the science products themselves.

Known issues

- Lamp aging and/or failure: the lamps used for the flat-field and wavelength calibrations age with use – they tend to fade slowly over their lifetimes, and their spectral energy distribution tends to evolve. Eventually the lamps fail. These changes mean that the exposure times used for the calibrations will not always be optimal and the

quality of the flat-fielding and/or wavelength calibrations will vary over time, sometimes affecting certain orders more than others.

- Low S/N in the bluest orders of flat-field lamp: If the scientific region of interest is the bluest orders, in some cases it may be better to consider the non-flat-fielded products (provided in the TAR files) in order to avoid adding noise from the low S/N flat-fields.
- Low S/N in the bluest orders of the wavelength calibration lamp: Low S/N in the bluest orders of the wavelength calibration frames means that few – if any – lines can be located for the wavelength calibration, in which case no wavelength calibration is computed for such orders and the wavelength calibration of the guess session is adopted.
- Seismic activity: the seismic nature of Chile means that FEROS is liable to have been affected by earthquake activity from time to time during its operational lifetime. Earthquakes have the possibility to cause changes in the alignment of the optical components and thus ultimately cause changes in the spectral format of the data recorded on the CCD and/or the focus of the instrument.
- Ripple effect in low S/N optimum extraction: The optimum extraction method produces a so-called ripple pattern in some low S/N spectra.
- The calculated barycentric correction stored in the header keyword "HIERARCH ESO DRS BARYCORR" of all FEROS product files in the SAF and applied to the rebinned science spectra is known to be of low precision and can result in a spurious ~1yr periodicity, see for example Mueller et al. (2013).

This first full reprocessing provides the first possibility to study such data issues over the lifetime (or at least a significant fraction of it to date) of FEROS, and may lead to future data-releases where the pipeline is improved to automatically cope with at least some of these issues.

Data Format

Files Types
The primary product is a rebinned, combined 1-D spectrum in FITS binary spectroscopic data format. [6] It is accompanied by a gzipped TAR file, containing selected products of the original pipeline processing.

The original file names of the products utilise the following scheme:
      Primary: FEROS.<date-obs>_DRS_<PipelineVer>_ESOSDP.fits
      TAR file: FEROS.<date-obs>_DRS_<PipelineVer>.tgz
where:
      <date-obs> is the start of the observation, in the ISO8601 restricted form (for example: 2010-04-01T22:33:44.555);
      <PipelineVer> is the value of the HIERARCH ESO PRO REC1 PIPE ID keyword (FERN_1.0 for this release).

I.e. the complete file names would be:
      FEROS.2010-04-01T22:33:44.555_DRS_FERN_1.0_ESOSDP.fits

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[6] http://www.eso.org/sci/observing/phase3/p3sdpstd.pdf.

FEROS.2010-04-01T22:33:44.555_DRS_FERN_1.0.tgz

The original file names of the products are recorded in the header of the primary spectrum file: keyword ORIGFILE stores the name of the spectrum file itself and keyword ASSON1 the name of the gzipped TAR file.

File structure

Primary file

The primary file comes as a binary FITS table in multi-column format. The columns are labelled as:

WAVE: Wavelength in Å.
FLUX: Arbitrary units.
ERR: Dummy.[7]

Wavelength is measured in air.

TAR file

The TAR file contains the following pipeline product files:

- r.FEROS.<date-obs>.000<i>.fits: PRO.CATG='PRERED_SCI': the C1, D1 and X1 products of the rectification of the spectra (MEF file with 3 extensions).
- r.FEROS.<date-obs>.<m>04<i>.fits: PRO.CATG='EXTR_SCI_<i>': Extracted spectra.
- r.FEROS.<date-obs>.<m>05<i>.fits: PRO.CATG='FFEX_SCI_<i>': Flat fielded extracted spectra.
- r.FEROS.<date-obs>.<m>06<i>.fits: PRO.CATG='REB_SCI_<i>': Rebinned, wavelength calibrated spectra.
- r.FEROS.<date-obs>.<m>06<i**+2**>.fits: PRO.CATG='REB_SCI_<i>': **Non-flat-fielded** rebinned, wavelength calibrated spectra.
- r.FEROS.<date-obs>.<m>08<i>.fits: PRO.CATG='RED_SCI_<i>': Final 1-D spectrum as a 40 extension MEF file, the first extension contains the full merged spectrum, the following 39 extensions contain the individual orders.
- r.FEROS.<date-obs>.<m>08<i**+2**>.fits: PRO.CATG='RED_SCI_<i>': **Non-flat-fielded** final 1-D spectrum as a 40 extension MEF file, the first extension contains the full merged spectrum, the following 39 extensions contain the individual orders.

Where:

- <i>=(1,2) for the two fibres, fibre-1 is the designated OBJECT fibre, fibre-2 the designated SKY fibre.
- <m>=(1,2,3) for the extraction mode, m=1 → Standard extraction, m=2 → Optimum extraction and m=3 → Standard extraction + comic ray detection.

The TAR file also contains an HTML summary page of the reduced products, including plots which may be useful for making a quick evaluation of the data quality. Point your browser to html/<yyyy-mm-dd>/<date-obs>/index.html.

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[7] FEROS pipeline currently does not provide error spectra. Presence of the error spectrum is, however, mandatory in the ESO Phase 3 spectroscopic data format, thus files do contain ERR column. This column is filled with NaN values.

We mention for completeness that the TAR files **may** also include two additional files:

- FFHV.<date-obs>.info: A simple text file listing the FEROS Fibre Head Viewer [FFHV] FITS image associated with the science exposure.
- FFHV.<mod-date-obs>.fits: the FFHV FITS image associated with the science exposure. Note that <mod-date-obs> does not include the milliseconds and that the DATE-OBS keyword in this file will generally differ from that of the science exposure, since the FFHV file is typically acquired at the end of the acquisition template, and thus before the start of the first FEROS science template of any OB.

Presence or absence of those two files for any given science file depends on numerous conditions, of no consequence for this dataset.

Additional notes

The value of the SNR keyword, required in the ESO Data Products Standard for spectroscopic data, is calculated using the "DER_SNR" algorithm described in Stoehr et al. 2008, Astronomical Data Analysis Software and Systems XVII, 394, 505.

The coordinates reported in the RA and DEC keywords may be off from the actual position of the source; in the vast majority of cases this offset does not exceed 2 arc minutes. It is however, unpredictable – it is believed to result from the nightly pointing correction of the telescope being performed with an instrument other than FEROS. Users who search for data by object coordinates (or by object name, which is translated to coordinates via the Simbad service) are advised to make sure that they use a sufficiently large search box.

Among the released spectra there are several "SolarSpectrum" products. Those observations were set up when available flatfield lamps had poor signal in the blue end of the spectrum, and the SolarSpectrum observations allowed for tracing of the blue orders. They were observed using science template and can be used scientifically either by someone wishing to study the Sun directly, or as a verification of the accuracy of the wavelength calibration.

The release includes reduced observations of standard stars.

Acknowledgements

All users of the ESO SAF are required to acknowledge the source of the data with an appropriate citation in their publications.

Since processed data downloaded from the ESO Archive are assigned Digital Object Identifiers (DOIs), the following statement must be included in all publications making use of them:

> *Based on data obtained from the ESO Science Archive Facility with DOI: https://doi.eso.org/10.18727/archive/24*

Publications making use of data which have been assigned an archive request number (of the form XXXXXX) must include the following statement:

> *Based on data obtained from the ESO Science Archive Facility under request number <request_number>.*