

ESO Phase 3 Data Release Description

Data Collection	HARPS
Release Number	1
Data Provider	ESO La Silla Paranal Observatory Science Operations
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Abstract

This is the release of reduced 1-D spectra from the HARPS¹ (High Accuracy Radial velocity Planet Searcher) at the ESO La Silla 3.6m telescope. The release covers practically all HARPS science data in High RV Accuracy Mode (HAM) and High Efficiency Mode (EGGS).

All data were reduced automatically using the Data Reduction Software (DRS) pipeline developed by the HARPS Consortium. Data obtained before 29 May 2015 were processed with version 3.5 of the pipeline. Data obtained after that date with version 3.8 of the pipeline, configured in a way that the results are compatible with the results from version 3.5.

The products come in the standard ESO 1-D FITS binary table format² along with a TAR file containing all output files generated by the pipeline.

Release Content

The release covers practically all HARPS science data in HAM/EGGS modes since the beginning of the instrument operations (October 2003); the release does not contain HARPS data taken in the polarimetry mode.

This release supersedes the release of HARPS HAM/EGGS data that used to be available with the “FEROS/HARPS pipeline processed data” service.³ The differences with respect to this service are:

- Provision of the full combined and rebinned spectrum in the 1-D standard FITS binary table format.
- The TAR file containing all pipeline products is renamed to explicitly provide the pipeline version identifier.
- Possibility of simultaneous queries with data products from other Phase 3 releases.

The data were processed with two versions of the DRS pipeline:

- Version 3.5, installed at the Observatory on 7 October 2010.
- Version 3.8, installed at the Observatory on 29 May 2015; the pipeline is configured in a way that the results are compatible with the results from version 3.5.

Because of that, there are three batches of data in this release:

- Data obtained prior to 7 October 2010 were retrieved from the ESO Archive and re-processed in Garching with the version 3.5.
- Data obtained between 8 October 2010 and 29 May 2015 were processed with version 3.5 at the Observatory.
- Data obtained after 30 May 2015 were processed with version 3.8 (again, configured so that the results are comparable with data processed with version 3.5).

¹ <http://www.eso.org/sci/facilities/lasilla/instruments/harps.html>.

² <http://www.eso.org/sci/observing/phase3/p3sdpstd.pdf>.

³ <http://archive.eso.org/wdb/wdb/eso/repro/form>. This service remains active; it provides access to pipeline processed HARPS polarimetry mode data and HARPS calibration products.

The pipeline generates TAR files with several products (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.⁴

As the "HARPS" collection includes the data stream of new products generated at the observatory, its content grows as new data are acquired and processed. The archive ingestion of new HARPS data normally takes place the day following the observation so that the new files appear in the ESO archive no later than 48 hours after acquisition. This timing is indicative. It may vary or need to be adjusted according to operations requirements.

Release Notes

HARPS uses three operating modes:

- HAM: High Accuracy Mode (narrow fibre: ~1.0" on the sky, R~110000); data obtained in this mode have INS.MODE='HARPS';
- EGGS: high efficiency mode (wider fibre: ~1.4" on the sky, R~85000); INS.MODE='EGGS';
- HARPSPOL: polarimetry.

As mentioned above, polarimetric data are not part of this release, and will not be described here.

The HAM and the EGGS modes can be configured in the same manner, depending on the source of light available on the second fibre (fibre B). The pipeline has identical set of recipes for the two modes, and their extension explicitly recalls the mode name (e.g. obj_ONE_harps, obj_ONE_eggs).

For scientific observations the acquisition template name, fibre configuration, and reduction recipes are:

Acquisition name	Fibre A	Fibre B	Reduction recipe
obs_objA	STAR	DARK	obj_ONE
obs_objAB	STAR	SKY	obj_TWO
obs_thosimult	STAR	THAR	obj_TH
obs_wavesimult	STAR	WAVE	obj_WAVE

The last template and last recipes (obs_wavesimult and obj_WAVE) are used when the Fabry-Perot or the laser frequency comb illuminate fibre B.

Each one of these recipes performs:

- bias subtraction (via the overscan region), masking of bad columns and dark subtraction (via values stored in a database)
- order extraction (Horne optimal extraction + order geometry calibration) and generation of the 2D extracted spectra (e2ds)
- flat fielding (using the spectroscopic flats calibrations)
- wavelength calibration (using the latest valid ThAr spectra)
- order matching and generation of the one-dimensional (s1d) spectra
- cross correlation for RV computation and generations of the “ccf” and bisector (bis) files, unless prevented by the user by specifying RADVEL=-99999 in the acquisition template
- correction for the instrumental drift if fibre “B” was illuminated either by the ThAr hollow cathode lamp (recipe obj_TH) or by the FP or LFC (obj_WAVE recipe).

Data Reduction and Calibration

To achieve the best radial velocity precision all HARPS data must be calibrated using afternoon calibrations, acquired few hours before the science observations.

⁴ ESO Science Portal (<https://archive.eso.org/scienceportal/>) or ESO Archive Spectral Data Products Query Form (https://archive.eso.org/wdb/wdb/adp/phase3_spectral/form). Please note that most of the newly added data are proprietary; until the proprietary period expires (typically one year) only the PIs and their delegates can download the data.

Whenever a calibration has passed the pipeline quality control criteria, it is stored in a local “calibration database”. The pipeline will always use the calibrations closest in time and acquired before the science spectra from this database.

Data Quality

The pipeline performs basic quality control on the calibration and on the science data, both order by order and on the overall spectra.

In general, quality control criteria are based on the capability to model the data (flat fielding, wavelength solution), or on the comparison with reference data (instrumental drift, spectral envelope of the calibration sources).

Quality control information (PASSED/FAILED) is stored in the keywords “HIERARCH ESO DRS CAL QC” for calibrations and “HIERARCH ESO DRS DRIFT QC” for science data.

Calibration data that did not pass the quality control will not be stored in the local calibration database and therefore will not be used by the pipeline.

Known issues

As mentioned above, the data obtained prior to the October 2010 installation of DRS v.3.5 at the observatory were retrieved from the ESO Archive and reprocessed offline. The setup for this processing was slightly different from the observatory setup, and as a result the file directory structure (but not the content!) inside the TAR files for the data pre-October 2010 and post-October 2010 is different. The former have data in the root directory of the TAR file (i.e. “./”) while the latter have the data in the “./data/reduced/<YYYY-MM-DD>/” directory, with the date string showing the night of the observation.

Data Format

File Types

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

The original file names of the products utilise the following scheme:

Primary: HARPS.<date-obs>_DRS_<PipelineVersion>_ESOSDP.fits
TAR file: HARPS.<date-obs>_DRS_<PipelineVersion>.tar

where:

<date-obs> is the exposure start of the observation, in the ISO8601 restricted form (for example: 2010-04-01T22:33:44.555);

<PipelineVersion> is the value of the HIERARCH ESO DRS VERSION keyword (for example: HARPS_3.5).

I.e. the complete file names would be:

HARPS.2010-04-01T22:33:44.555_DRS_HARPS_3.5_ESOSDP.fits
HARPS.2010-04-01T22:33:44.555_DRS_HARPS_3.5.tar

The user may want to read the ORIGFILE header key in the spectrum file and rename the archive-delivered files.

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: The starting unit is ADUs, however the flux is scaled to match all the orders, and at the end it should be considered an “arbitrary unit”. If flux normalization is important, one should use the files with the “e2ds” extension and analyse the data order by order.
ERR: Dummy.⁵

TAR file

HARPS pipeline generates separate products for both HARPS fibres (labelled A and B), cross-correlating the observed spectra with template stellar spectra for various spectral types.

The TAR files contain several types of files, both FITS and non-FITS. Their content can be identified from their filenames. The root file name is “HARPS.<date-obs>”, where <date-obs> is the start of the observation in the “restricted ISO8601” format. This root name is appended with:

- “_s1d_<fibre>.fits” for 1-D extracted full spectrum, wavelength calibrated, in the solar system barycentric frame (the primary file of the release is the fibre A s1d file converted to the binary table format);
- “_e2ds_<fibre>.fits” for 2-D extracted spectrum, one row per order;
- “_bis_<sptype>_<fibre>.fits” for bisector from the cross correlation computed with the <sptype> mask;
- “_ccf_<sptype>_<fibre>.fits” for cross correlation function matrix for mask for <sptype>;
- “_ccf_<sptype>_<fibre>.tbl” for cross correlation function summary table (ASCII) with extracted radial velocity per each order;
- “_INT_GUIDE.fits” for integrated guiding image from the guide camera, used to confirm the correct centring of the star on the fibre. The image is integrated over the whole length of the scientific exposure.

where:

- <fibre> is either “A” or “B”; in science observations the A fibre is used for the object, while the B fibre is used for ThAr lamp, dark or sky exposure, depending on the observation setup.
- <sptype> is either one of “G2”, “K5” or “M2”, depending on which spectral mask was used in cross-correlation with the spectrum. The pipeline automatically selects one of the masks based on the object’s spectral type, as recorded in the “HIERARCH ESO DPR TYPE” keyword. The “G2” mask is used if the spectral type is G9 or earlier or no spectral type is recorded, the “K5” mask is used for all Kn spectral types, and the “M2” mask is used for spectral types of M0 or later.

For example, the filename of the cross-correlation function for the G2 mask would be:

HARPS.2010-04-01T22:33:44.555_ccf_G2_A.fits

etc.

Acknowledgements

Publications based on data obtained with the HARPS instrument should quote the following reference paper: Mayor, M., et al. 2003, The Messenger 114, 20.

According to the Data Access Policy for ESO data held in the ESO Science Archive Facility, all users are required to acknowledge the source of the data with 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/33>

⁵ HARPS 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 the ERR column, filled with NaN values.

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>.