ESO Phase 3 Data Release Description

Data Collection	**AMBRE**
Title	**Stellar Radial Velocities, Atmospheric Parameters and Chemical Abundances from Spectra in the ESO Archive**
Release Number	**1**
Data Provider	**P. de Laverny**
Date	**29.03.2012**

Note: 2933 records of this catalog referring to data for which ESO does not hold the data property rights have been removed from the collection (ESO, 12 March 2014).

1. **Abstract -** *A short, broad overview of the project. Also touching on the instrument(s) and mode(s), and, of course, the method of analysis applied.*

The MATISSE/OCA-ESO project (called **AMBRE** hereafter: *Archéologie avec Matisse: aBondances dans les aRchives de l'ESO*) has been designed to automatically analyse the spectral archives of the FEROS, UVES, HARPS and FLAMES instruments with the MATISSE algorithm (Recio-Blanco et al., 2006, MNRAS 370, 141). Stellar radial velocity, atmospheric parameters (effective temperature, surface gravity, mean metallicity [M/H]) and enrichment in α-elements ([α/Fe]) are the main products of this analysis (see Worley et al., 2012, A&A 542A, 48, for a complete description). The analysis relies on a specific grid of synthetic spectra (de Laverny et al., 2012, A&A 544A, 126). The results of this analysis can be retrieved directly through the ESO Science Archive Facility[1].

2. **Overview of observations** - *selection criteria for spectra (instrument, mode, snr, presence of emission lines etc.), period of observations being covered.*

This first release concerns the FEROS data collected from 2005, October to 2009, December. The spectra were reduced by ESO with the corresponding automatic pipeline and then sent to the Observatoire de la Côte d'Azur (OCA, Nice) for ingestion into a dedicated pipeline (see Worley et al., 2012 and Sect.4 below). No a-priori preselection of the spectra was performed but, all along their analysis a number of spectra are rejected when failing a particular step of the process (presence of extreme emission lines preventing normalisation, failed determination of the radial velocity,...; see the description of the different flags in the section *Release Content* below and in Worley et al., 2012).

All FEROS spectra cover the domain 350 nm – 920 nm at a resolution of about 48 000. Before their ingestion into MATISSE, these spectra have been convolved at a lower resolution ($\Delta\lambda$ = 0.33Angstroem), sliced and resampled (total number of pixels = 11890). These steps were required in order to disregard the spectral regions affected by sky absorption and telluric features, those where the spectrograph has a lower efficiency or those containing spectral features less sensible to the stellar parameters (identified with preliminary MATISSE training vectors). This also optimizes the computation time. The spectral analysis with MATISSE was thus performed by considering the spectral ranges defined in Tab.2 of Worley et al. (2012) of the original FEROS spectra.

3. **Release content** - *Number of spectra, description of the parameters being derived.*

The total number of analysed FEROS spectra is 21551. They correspond to 6285 different objects. These spectra have been analysed with the pipeline described in Worley et al. (2012) and shown in

[1] http://www.eso.org/sci/observing/phase3/data_releases.html

Fig.1. The derived atmospheric parameters are then delivered if they are found within the extent of the MATISSE training grid (see Tab.8 of Worley et al., 2012). The adopted range for each parameter is: 3000K ≤ Teff ≤ 7625K; 1.0 ≤ log(g) ≤ 5.0; -3.5 ≤ [M/H] ≤ +1.0 and specific values of [α/Fe] (see Sect. 7.8 of Worley et al., 2012).

For each of the spectrum, whenever possible (55.5% of the total spectra have at least one AMBRE entry), the following parameters were estimated (please refer to Worley et al., 2012 for more detailed description):

Signal-to-Noise Ratio: mean of different estimates performed over different wavelength regions (selected because they are considered to be -almost- free from any lines). After the determination of the final atmospheric parameters (except for rejected stars), this SNR is then re-estimated owing to a better informed selection of line-free spectral regions (based on the reconstructed best fitting synthetic spectrum).

Emission lines flags: Emission features are automatically detected. If extreme emission lines are found, the spectrum is then rejected from the analysis (a total of 1455 spectra were rejected) . If some emission features are detected, the analysis is performed but the spectrum is flagged. When rejected because of extreme emission features, the spectra are flagged and all parameters have a null value.

Width of the absorption lines: The mean FWHM of absorption lines around 4500Angstroem is measured and a flag is provided if this mean FWHM is greater than the one of the training grid (FWHM>0.33Angstroem, probably a fast rotating star) or if it is smaller than a defined threshold (FWHM<0.11Angstroem, probably a very noisy spectrum). In this case, the default value of the FWHM is used in the analysis but the reported parameters could be uncertain.

Radial Velocity: The stellar radial velocity and its corresponding error (in km/s) is measured by cross-correlating the FEROS spectrum with a binary mask adapted to the corresponding stellar type. We also provide the FWHM (in Angstroem) of the cross-correlation function together with a flag grading the quality of the determined radial velocity (from '0' *very good* to '5' *very* bad, see Sect.5 for more details).

Effective Temperature and related errors: The stellar effective temperature (in K) as estimated with the MATISSE algorithm. We also provide the corresponding relative and external errors (in K). Internal errors are computed, for the corresponding SNR, from the theoretical expected errors of MATISSE (estimated from the training vectors) and the propagation of the radial velocity and normalisation uncertainties. External errors are estimated for a given type of stars by comparison with independent determinations as the ones found in the PASTEL database (Soubiran et al., 2010, A&A 515, 111; http://pastel.obs.u-bordeaux1.fr/). The range of possible effective temperature values is between 3000 and 7625K in the present release. Stars with effective temperature found ouside this range have been disregarded and this atmospheric parameter has a null value.

Stellar surface gravity and related errors: Same as the effective temperature (and its internal and external errors) but for the stellar surface gravity (*g* in cm/s2).The range of possible surface gravity values is between 1.0 and 5.0dex. Stars with surface gravity found ouside this range have been disregarded and this atmospheric parameter has a null value.

Mean metallicity and related errors: Same as the effective temperature (and its internal and external errors) but for the stellar metallicity (in dex and noted [M/H]). This metallicity index corresponds to all chemical species heavier than He. The adopted solar reference abundances are those of Grevesse et al. (2007, Space Science Review 130, 105). The range of possible [M/H] values is between -3.5

and +1.0dex. Stars with mean metallicity found ouside this range have been disregarded and this atmospheric parameter has a null value.

α-elements enrichment and related errors: Same as the effective temperature (and its internal and external errors) but for the stellar abundance of alpha-elements with respect to iron (in dex and noted [α/Fe]). Chemical species considered to be α-elements are O, Ne, Mg, Si, S, Ar, Ca and Ti. The range of possible α-elements enrichment values is between -0.4 and +0.4dex around the *standard* enrichment found in the galactic stars (i.e. [α/Fe]=0 for [M/H]≥0, [α/Fe]=+0.1 for [M/H]=-0.25, [α/Fe]=+0.2 for [M/H]=-0.5, [α/Fe]=+0.3 for [M/H]=-0.75 and [α/Fe]=+0.4 for [M/H]≤-1.0). Stars with [α/Fe] values found ouside this range have been disregarded and this atmospheric parameter has a null value.

Quality Flag: The overall quality of the atmospheric parameter determination of a given spectrum is checked owing to a χ^2 test based on its fit with the corresponding reconstructed synthetic spectrum together with a check if the derived parameters are found within the ranges defined at the beginning of Sect.3. We provide the $\log(\chi^2)$ and a flag grading the quality of the parameter determination (from '0' *very good* to '2' *very bad*, see Sect.5 for more details).

4. **Release notes** - *Short description of the reduction methods used quoting relevant publications, the calibration procedures (if any), quality control/tests and scientific verification. Explanation of quality flags. A comparison with previous releases if applicable.*

The adopted reduction pipeline is extensively described in Worley et al. (2012) and the different steps of the analysis are shown in Figure 1 below. This analysis pipeline determines the SNR, the radial velocity and carries out normalisation and cleaning of the spectra (such as comic rays removal) which are then analysed with the MATISSE algorithm (Recio-Blanco et al., 2006, MNRAS 370, 141). MATISSE has been trained with a grid of high resolution synthetic spectra (de Laverny et al., 2012, A&A submitted). These spectra were calculated using the MARCS stellar atmosphere models (Gustafsson et al., 2008, A&A 486, 451) and the Turbopectrum package (Alvarez and Plez, 1998, A&A 330, 1109) with subsequent improvements through the years. This grid spans the following stellar parameter ranges: 2500K ≤ Teff ≤ 8000K; -0.5 ≤ log g ≤ 5.0; -5.0 ≤ [M/H] ≤ +1.0 and α-elements enrichment as described above. A total of 16783 synthetic spectra covering the whole optical domain (3000-12000 Angstroem) has been computed at the OCA *Mesocentre* Computer Centre. VALD/atomic line lists (august 2009 content, see Kupka et al., 1999, A&AS 138,119) and molecular line lists (B. Plez, private communication) have been considered. Molecules included are CH, OH, MgH, SiH, CaH, FeH, C2, CN, TiO, VO, and ZrO. The learning phase of MATISSE consists of computing vectors from a linear combination of these synthetic spectra. An observed spectrum is then projected onto these vectors to derive its stellar atmospheric parameters.

Quality tests have also been performed from the estimated SNR, radial velocity and normalisation uncertainties and the theoretical expected errors of MATISSE (estimated from the training vectors). Then, a comparison between the FEROS spectra and the corresponding reconstructed synthetic spectrum at the derived parameters has been done and a χ^2 computed.

Finally, a comparison with external libraries has also been performed in order to compare the MATISSE stellar atmospheric parameters to literature values and to define some quality criteria. For that purpose, a list of comparison stars has been built from the PASTEL database (Soubiran et al., 2010, A&A 515, 111; http://pastel.obs.u-bordeaux1.fr/). Other key well known stars (the Sun, Arcturus, Procyon,...) and stellar samples from other comprehensive stellar studies (as S4N for instance, Allende-Prieto et al., 2004, A&A 420, 183) are also used to provide a crucial comparison of the MATISSE results. Unfortunately, very few comparison stars with published values of their [α/Fe] can be found in the literature (we used the sample stars of Bensby et al., 2003, A&A 410, 527, for that purpose).

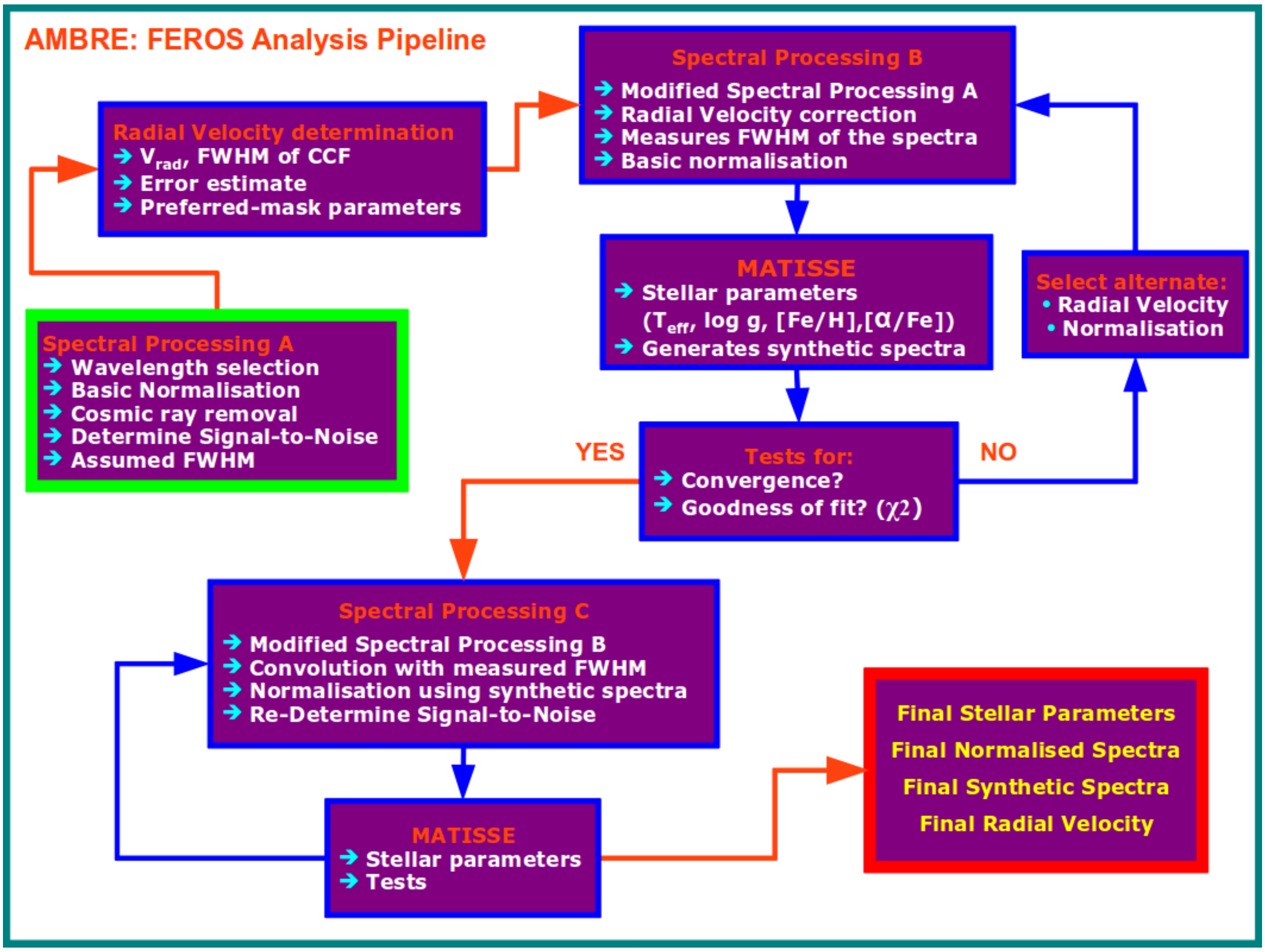

Figure 1: The FEROS Analysis Pipeline. The key stages are displayed in order of analysis. Spectral Processing A (SPA) and Spectral Processing B (SPB) carry out testing of spectra quality and preliminary parameter determination, including calculation of the radial velocity and spectral FWHM. In Spectral Processing C (SPC), robust iterative procedures are carried out resulting in the final stellar parameters and normalised spectra (see Worley et al., 2012, for a detailed explanation at each stage).

5. **Data format** - *In this case, the tabular format, list of columns, data format, description etc. Naming conventions used (if any).*

32 different parameters (when possible) are provided for each FEROS spectra. They are summarized in the table below and described more in details above in the *Release Content* section when necessary.

Column 1: **DP_ID** / format = '30A' / ESO data set identifier

Column 2: **OBJECT** / format = '25A' / Object designation as read in ORIGFILE

Column 3: **TARG_NAME** / format = '25A' / Target designation as read in ORIGFILE

Column 4: **RAJ2000** / format = 'real' in deg/ Telescope pointing (right ascension, J2000)

Column 5: **DEJ2000** / format = 'real' in deg/ Telescope pointing (declination, J2000)

Column 6: **MJD_OBS** / format = 'real' in Julian Day/ Start of observation date

Column 7: **EXPTIME** / format = 'real' in second/ Total integration time

Column 8: **SNR** / format = real / Signal-to-Noise Ratio as estimated by the pipeline

Column 9: **SNR_FLAG** / format = 'C' or 'R' / First crude estimate of the SNR ('C') from Spectral Processing A (see Fig.1) or refined value ('R') after the complete analysis (during SPC) once the final stellar parameters are obtained. If 'C', then the spectrum is not processed in SPC

Column 10: **EXTREME_EMISSION_LINE_FLAG** / format = 'Logical' / Detection of Extreme Emission Lines. If 'T', spectrum rejected.

Column 11: **EMISSION_LINE_FLAG** / format = 'Logical' / Detection of some Emission Lines. If 'T', analysis performed but Results Uncertain

Column 12: **MEANFWHM_LINES** / format = 'real' in Angstroem / Mean FWHM of absorption lines around 4500 Angstroem

Column 13: **MEANFWHM_LINES_FLAG** / format = 'Logical' / Flag on the Mean FWHM of absorption lines around 4500 Angstroem. If 'T', (FWHM < 0.11Angstroem or FHWM > 0.33Angstroem), the default value of the FWHM is used but Results might be Uncertain.

Column 14: **VRAD** / format = 'real' in km/s / Stellar Radial Velocity as estimated by the pipeline

Column 15: **ERR_VRAD** / format = 'real' in km/s / Error on the Radial Velocity

Column 16: **VRAD_CCF_FWHM** / format = 'real' in Angstroem / FWHM of the CCF between the spectrum and the binary mask

Column 17: **VRAD_FLAG** / format = 'I1' / Quality Flag on the radial velocity analysis (from '0' *very good* to '5' *very bad*; *NULL* value is '-99').

Column 18: **TEFF** / format = 'real' in K / Stellar Effective Temperature as estimated by the pipeline

Column 19: **ERR_INT_TEFF** / format = 'real' in K / Effective Temperature Internal Error

Column 20: **ERR_EXT_TEFF** / format = 'real' in K / Effective Temperature External Error

Column 21: **LOG_G** / format = 'real', *g* in cm/s^2 / Stellar Surface Gravity (log g) as estimated by the pipeline

Column 22: **ERR_INT_LOG_G** / format = 'real' in cm/s^2/ Surface Gravity Internal Error

Column 23: **ERR_EXT_LOG_G** / format = 'real' in cm/s^2/ Surface Gravity External Error

Column 24: **M_H** / format = 'real' in dex / Mean Metallicity [M/H] as estimated by the pipeline

Column 25: **ERR_INT_M_H** / format = 'real' in dex / Mean Metallicity Internal Error

Column 26: **ERR_EXT_M_H** / format = 'real' in dex / Mean Metallicity External Error

Column 27: **ALPHA** / format = 'real' in dex / α-elements over Iron Enrichment ([α/Fe]) as estimated by the pipeline

Column 28: **ERR_INT_ALPHA** / format = 'real' in dex / α-elements over Iron Enrichment Internal Error

Column 29: **ERR_EXT_ALPHA** / format = 'real' in dex / α-elements over Iron Enrichment External Error

Column 30: **CHI2** / format = 'real' / $\log(\chi^2)$ of the fit between the observed and the reconstructed synthetic spectrum at the MATISSE parameters

Column 31: **CHI2_FLAG** / format = 'I1' / Quality Flag on the fit between the observed and the reconstructed synthetic spectrum at the MATISSE parameters (from '0' *very good*, i.e. the parameters are found within the accepted ranges defined in Sect.3 and the $\log(\chi^2)$ is very small; to '2' *very bad:* most of the time, the derived parameters are found outside the accepted ranges; *NULL* value is '-99').

Column 32: **ORIGFILE** / format = '41A' / ESO filename of the original spectrum being analysed

6. **Acknowledgements** - *The acknowledgments to be included when using this data.*

When using data products provided in this release, acknowledgements should be given in the text to the OCA/ESO AMBRE project, referring to the publications Worley et al. 2012, A&A 542A, 48, and de Laverny et al. 2012, A&A 544A, 126, and to the MATISSE parametrisation algorithm (Recio-Blanco et al., 2006, MNRAS 370, 141).