

ESO Phase 3 Data Release Description

Data Collection	<GAIAESO/GaiaESO>
Release Number	<1>
Data Provider	<G.Gilmore, S.Randich>
Date	<22.10.2013>

Abstract

Gaia-ESO is a public spectroscopic survey¹ carried out with FLAMES, targeting $\geq 10^5$ stars, systematically covering all major components of the Milky Way, from halo to star-forming regions, providing the first homogeneous overview of the distributions of kinematics and elemental abundances. This alone will revolutionise knowledge of Galactic and stellar evolution: when combined with *Gaia* astrometry the survey will quantify the formation history and evolution of young, mature and ancient Galactic populations. With well-defined samples, we will survey the bulge, thick and thin discs and halo components, and open star clusters of all ages and masses. The UVES and Giraffe spectra will: quantify individual elemental abundances in each star; yield precise radial velocities for a 4-D kinematic phase-space; map kinematic gradients and abundance - phase-space structure throughout the Galaxy; follow the formation, evolution and dissolution of open clusters as they populate the disc, and provide a legacy dataset that adds enormous value to the *Gaia* mission and ongoing ESO imaging surveys.

Overview of Observations

The observations in this release of the Gaia-ESO survey² include those of the Galactic Bulge, Disc, and Halo designated as Milky Way (GE_MW) fields, Open Cluster observations designated as Cluster fields (GE_CL) and calibration observations of Globular Clusters designated as Standard GC (GE_SD_GC) fields. See Figure 1 for the location of these fields in the sky.

1 ESO programme 188.B-3002 described in 2012MsngR.147...25G
2. ESO programme 188.B-3002(A,B,C,D,E,F,G)

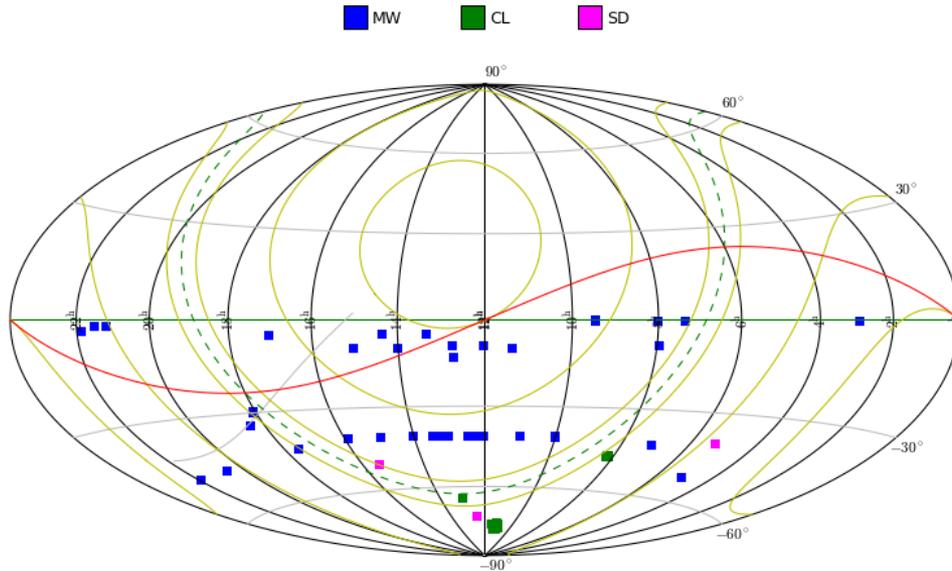


Figure 1: Location of target fields in the sky

The MW targets survey the Bulge, Halo, Thick Disc and Thin Disc populations of the Milky Way. Three primary setups were used for these observations: UVES 580 for brighter objects and Giraffe HR10 and HR21 for fainter objects.

For the Bulge survey observations of K giants were carried out for the brighter objects (gK stars) using UVES 580, otherwise Giraffe HR10 and HR21 were used. For the Halo/Thick disc survey, the primary targets are F+G stars, where bluer fainter F stars probe the halo, and brighter F/G stars probed the thick disc. The outer thick disc was probed using distant F/G stars, as well as K giants to sample the far outer disc. For the solar neighbourhood, G stars were observed using UVES 580 only.

The Standard fields included in this release are calibration observations of stars in the globular clusters NGC1851, NGC4372, NGC5927, which have observations in both the Giraffe HR10 and HR21 set-ups. For NGC1851 and NGC4372, UVES 580 observations are also included, whereas for NGC5927 the S/N did not meet our selection threshold for inclusion (see **Data Quality** section).

The open cluster survey aims to cover the age-metallicity-distance-mass parameter space. Depending on the stellar type, open cluster stars are observed with different Giraffe gratings (HR03/5A/6/8B/14A/15N), and two UVES settings (UVES520 and UVES580). The open clusters included in this data release are two young clusters: Gamma Vel (Age=5-10 Myr) and Chamaeleon I (Age=3-5 Myr), both observed using HR15N, UVES580, and one intermediate age cluster: NGC4815 (Age=0.5 Gyr) observed using Giraffe HR09B (A-type stars) and HR15N and UVES580. The faint cluster members were observed using Giraffe and the brighter stars using UVES. An overlap in magnitude between the two samples is present and a number of stars were observed both with UVES and Giraffe for calibration purposes.

For the nearby clusters ($d(\text{Gamma Vel}) \sim 350\text{pc}$), $d(\text{Cha I}) \sim 160\text{pc}$) the whole cluster population is sampled down to the M-dwarf regime. For the distant cluster ($d(\text{NGC4815}) \sim 2.5\text{kpc}$) red clump stars (UVES) and early-type main sequence and turn-off stars (Giraffe) are observed.

Within each cluster, target selection procedure was implemented slightly differ-

ently between Giraffe and UVES, but uniformly across clusters.

Namely, for Giraffe, in order not to bias the observations, we decided to basically rely on photometric membership. We used proper motions and other membership indicators (like e.g., X-ray emission) only to define the photometric sequences and the spatial extent of the clusters. In general, we did not use proper motions to select the targets, although in some cases they were employed to discard secure non-members. For UVES, which we aim to use to observe secure cluster members, when available, we did use membership information from the literature (e.g., V_{rad} , Li , $H\alpha$, ...).

The range of observations are restricted to $+10^\circ \geq \text{Dec} \geq -60^\circ$ whenever possible to minimise airmass limits. Figure 2 is the histogram of the seeing that was obtained, per object exposure, for the combined MW and CL dataset.

Figure 3 shows the range of observing conditions during which the observations were taken.

Figure 2: Histogram of seeing per exposure for MW, SD and CL fields.

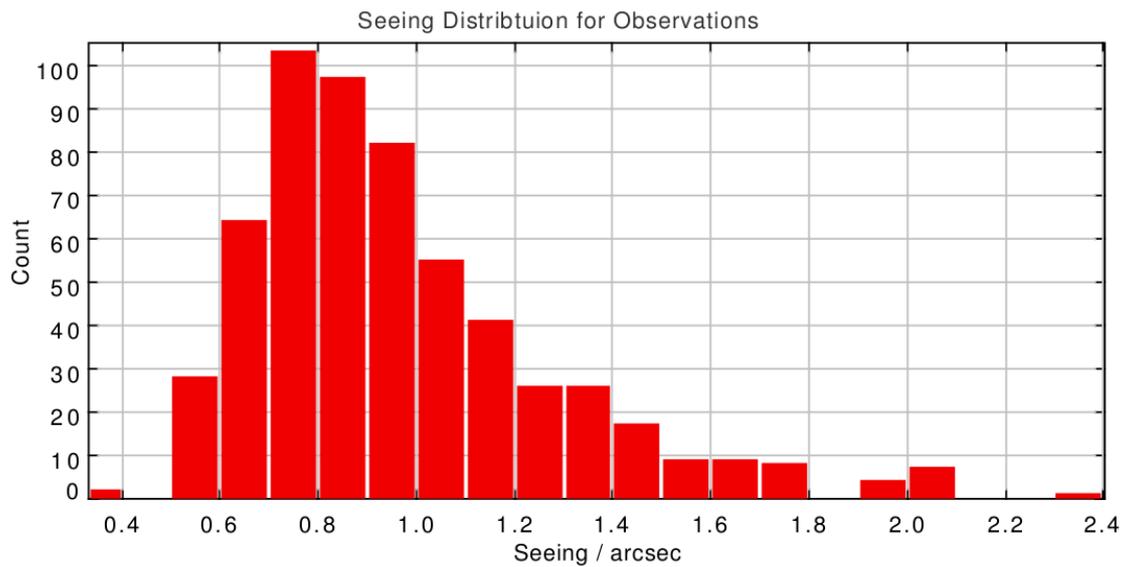
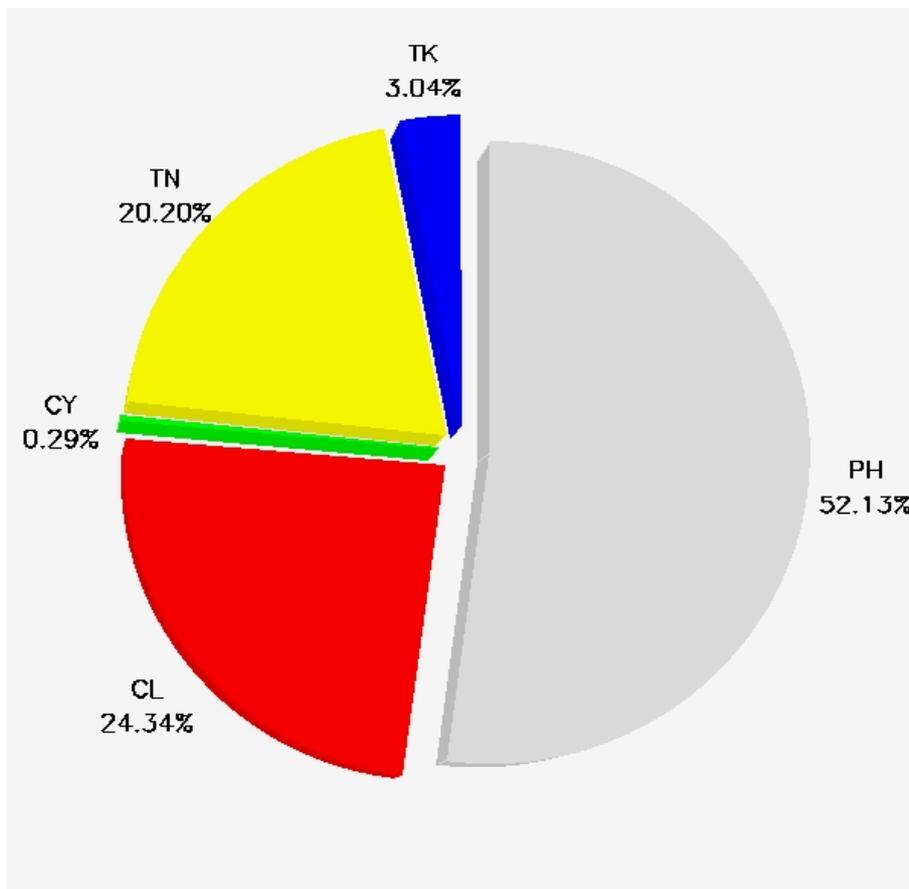


Figure 3: Percentages of observing conditions experienced during the observations : PH = Photometric, CL = Clear, CY = Cloudy, TN = Thin cirrus cloud, TK = Thick cirrus cloud. The percentage of observing time lost during the period due to weather was 26.51%, technical reasons: 2.12% and target of opportunity (ToO) observations: 3.34%.



The primary source catalogue for the Milky Way field stars is VISTA imaging, ensuring excellent recent astrometry, and adding maximal value to the VISTA surveys.

Photometry for the three open clusters comes from the literature and 2MASS. Astrometry is from 2MASS.

Release Content

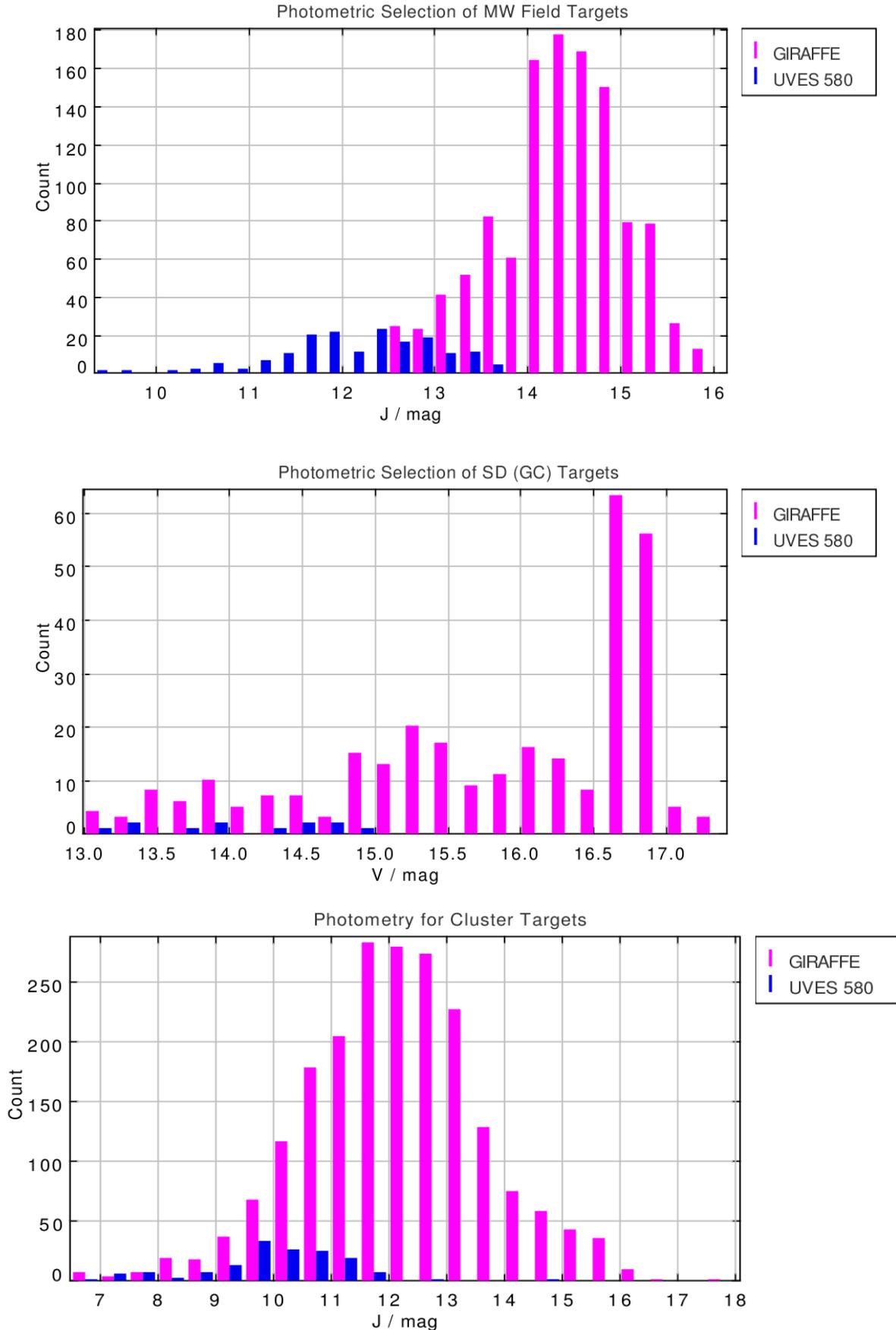
The observations in this data release are summarised in Table 1. The total number of data files submitted in this release is 5654 (size: 1357798 kB uncompressed) comprising spectra of 3834 unique targets. Figure 4 presents the histograms of the *V* and *J* magnitudes of the MW targets and the histogram of the *V* magnitudes of the CL targets.

Table 1: Observations Summary (31/12/2011-30/06/2012)

Field Type	Instrument	No. Objects	Grating	Spectral Range (Å)	Resolution ³	No. Spectra	Median S/N	No. Objects per field type
MW	Giraffe	1135	HR10	5339-5488	19800	1135	31	
			HR21	8484-8757	16200	1135	60	
	UVES	163	580	4771-6785	47000	326	78	
SD_GC	Giraffe	303	HR10	5339-5488	19800	303	40	
			HR21	8484-8757	16200	303	84	
	UVES	12	580	4771-6785	47000	24	60	
CL	Giraffe	2121	HR15N	6470-6650	17000	2029	74	
			HR9B	5143 - 5356	25900	113	19	
	UVES	143	580	4771-6785	47000	286	98	

³ <http://www.eso.org/sci/facilities/paranal/instruments/flames/inst/specs1.html> (Medusa), <http://www.eso.org/observing/etc/bin/gen/form?INS.NAME=UVES+INS.MODE=spectro>

Figure 4: Histogram of magnitudes of targets (V_{APASS} , J_{VISTA} for MW fields, literature V magnitudes for the SD and cluster fields, J_{2MASS} for clusters.)



Release Notes

Data Reduction and Calibration

The standard Gaia-ESO observing procedure is to divide each observing block into three exposures (except for Giraffe HR21 which is normally divided into two) - two long exposures which are then co-added to eliminate residual cosmic rays, and a short exposure (of a few seconds) which is taken for the purpose of obtaining a simultaneous arc lamp spectrum (simcal) with Giraffe for the wavelength calibration. Spectra from the short exposures are not co-added when creating the final spectra.

Departures from this observing pattern exist - in the case, for example, of periods of poor seeing when additional exposures of a field have been obtained with the aim of increasing the signal-to-noise ratio (S/N). Conversely, during occasional periods of exceptionally good seeing, only one exposure of a field may be taken.

Multi-epoch exposures are defined to be those composed of individual exposures originating from more than one night. A night is defined as the 24-hour period from noon-noon local time (16:00-16:00 UT).

Reduction Pipeline: Giraffe

The Giraffe data were reduced by a pipeline that was specially written at the Cambridge Astronomical Survey Unit (CASU). It performs all of the following steps:

- *Bias correction and 2D flat fielding.* The latter is done using test dome flats that are taken periodically as part of the instrumental health checks. Although these are not dispersed flat fields and, of course, flat fields are wavelength dependent, using these does take out a large amount of the pixel-to-pixel variation. (Unfortunately dispersed flat fields without the fibre feed in the light path are not available);
- *Localisation and tracing of the fibre spectra using fibre flat field images.* The optimal extraction profile fits are also done at this point;
- *Extraction of arc spectra, identification of arc lines and wavelength-solution calculation;*
- *Removal of scattered light, extraction and wavelength calibration of object spectra.* The spectra are wavelength calibrated using the arc solution and also shifted to the solar rest frame. For all but the HR21 setting the simcal lamp spectra are used to define a correction to the wavelength solution which is also applied here. For HR21 a similar correction is applied using a subset of well-studied night-sky lines;
- *Sky correction using combined sky fibres from the field.* For all but HR21 the combined sky spectrum is used as is and is subtracted from each object spectrum. For HR21, the sky spectrum is scaled by the relative fluxes of the sky lines to ensure cleaner sky removal;
- *Repeat exposures of the same objects are stacked and cosmic rays are removed.* These are then normalised by the fibre flat field to remove the large-scale wavelength-dependent variation in each fibre;

Reduction Pipeline: UVES

The UVES data were reduced at INAF-Arcetri, using the public ESO FLAMES-UVES pipeline (version 4.9.8) for the standard steps of the data reduction process (e.g. bias subtraction, flat-fielding and wavelength calibration) and a pipeline written at INAF-Arcetri for the sky-subtraction, barycentric correction, co-addition.

The reduction is performed in a semi-automatic way, following a reduction cas-

cade. Relevant raw data, including both calibration and science frames, are selected and inserted into the reduction path.

All acquired data are pipeline-reduced using the best possible master calibration products, which are produced starting from the best available day-time calibration frames. After quality checks (see Section 6) these are applied to the reduction of science data. The standard reduction steps followed are:

- *Bias subtraction;*
- *Flat-fielding;*
- *Tracing of the spectral order position;*
- *Wavelength calibration;*
- *Optimal extraction of science spectra (spectra are de-convolved for fibre cross talk and intra-order background is subtracted);*
- *Spectra are corrected for differences in fibre transparency;*
- *The orders are merged;*
- *The sky spectrum from the fibre allocated to the sky is subtracted from the target spectra. This step is performed both on the individual orders, and on the merged spectra. When more than one fibre is allocated to the sky, the median of the sky spectra is subtracted;*
- *Both single order and merged spectra are shifted to a Heliocentric reference system;*
- *Both single order and merged spectra of the same target are co-added;*
- *A median S/N ratio across the whole spectrum is calculated, for both CCDs;*
- *All co-added spectra are flagged for binarity;*
- *Final quality checks are performed on the spectra (see **Data Quality** section);*

Post-processing

The normalisation chosen to be applied to the spectra depends on the particular science goal of the analysis. The choice of continuum level in particular is an individual one which is left as a scientific choice for the end user. In this first release we deliver non-normalised spectra to ensure that no valuable information is lost from the spectra.

For the UVES echelle spectra, we have merged the spectral orders and deliver only the merged spectra in this first release.

Sky background spectra are not delivered since the stacked target spectra that we deliver comprise data from multiple exposures. Changing observing conditions, even from one exposure to the next on the same night, would render any averaged sky spectrum essentially meaningless.

Data Quality

The quality array ('QUAL') delivered along with the spectra in the data files codes data values as good quality (0) or bad quality (1). These code values are derived from weight maps where a value of '1' represents a bad pixel. Further quality control which is applied to the spectra is described below.

Quality Control: UVES

Quality control (QC) on the UVES data is performed in three steps:

- Check on the quality of the calibration frame by comparing the QC parameters, which are given as output by the ESO pipeline, with the typical values published on the ESO website. This approach allows us to verify the instrument stability (e.g. the stability of the bias frame or the precision of the wavelength calibration);
- Visual inspection of the final spectra aimed at discovering artifacts or other

anomalies (e.g., in the wavelength calibration). If this analysis identifies anomalies in one or more spectra, the whole workflow, since fibre allocation, is investigated. Once the problem is identified, the reduction is performed again to improve the quality of the spectra;

- Selection of S/N thresholds. (The S/N is the median value and is quoted per pixel.)

Quality Control: Giraffe

QC on the Giraffe data is carried out as part of the spectral template fitting which then assigns a basic classification.

The main criteria defining this classification are:

- the χ^2 of the fit;
- the S/N (calculated per pixel);
- the χ^2 of the pure continuum fit; and
- the distance to the best fit template.

The spectrum is marked as UNKNOWN instead of STAR when the continuum-only fit is better or almost as good as the template fit. The χ^2 and/or distance to the best-fit template are higher than a certain S/N-dependent threshold.

Quality Criteria:

The spectra included in this data release satisfy the following key criteria:

1. Observed prior to 30th June 2012;
2. Target observations are complete for the survey;
3. Above S/N limit:
 1. MW and SD: UVES S/N > 40 in both lower and upper CCDs; Giraffe spectra exist for the target in both HR21 and HR10, achieving HR21 S/N>30 and HR10 S/N >20
 2. CL: all of the clusters for which 70 % of the UVES targets have S/N > 40 in both lower and upper CCDs and 70% of the Giraffe spectra have S/N > 20 (Cha I, Gamma Vel, and NGC4815). Note that for each of the three clusters, spectra with S/N ratios below those thresholds are also delivered;
4. Preliminary Classification = STAR;
5. Observations are complete on all cluster targets, for all UVES and Giraffe settings during the required epoch;

Data Quality Figures

The following figures show key relations for the dataset submitted in this data release. The dataset is displayed in terms of S/N and magnitude (*V*, *J*). Similar figures are shown for the MW, SD_GC and CL fields.

Figure 5: Histograms of measured S/N for the different instrument set-ups. UVES580U and L refer to the UVES upper and lower CCD spectra, respectively.

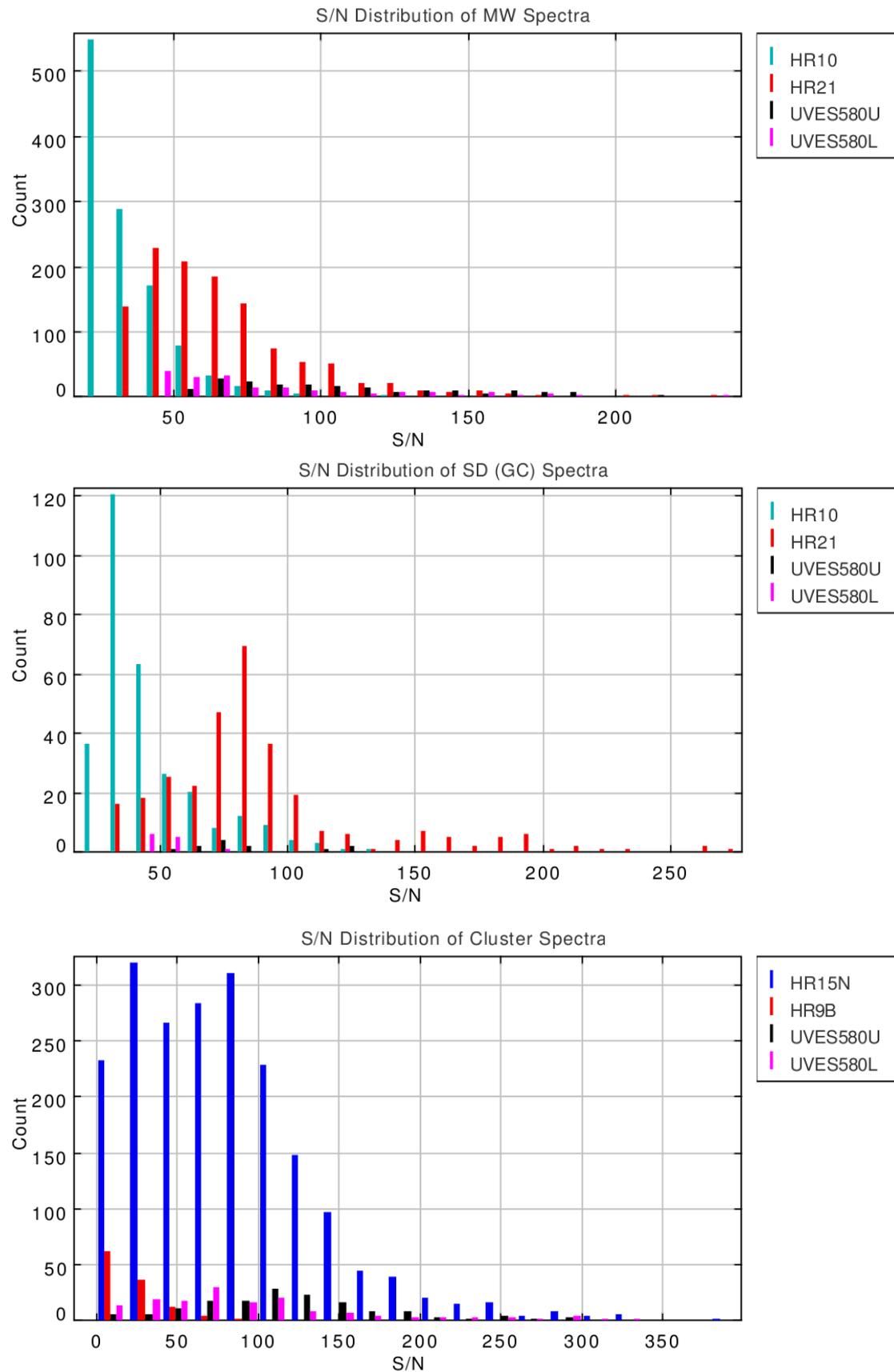


Figure 6: Comparison of S/N vs Magnitude (V, J) for MW and SD Fields

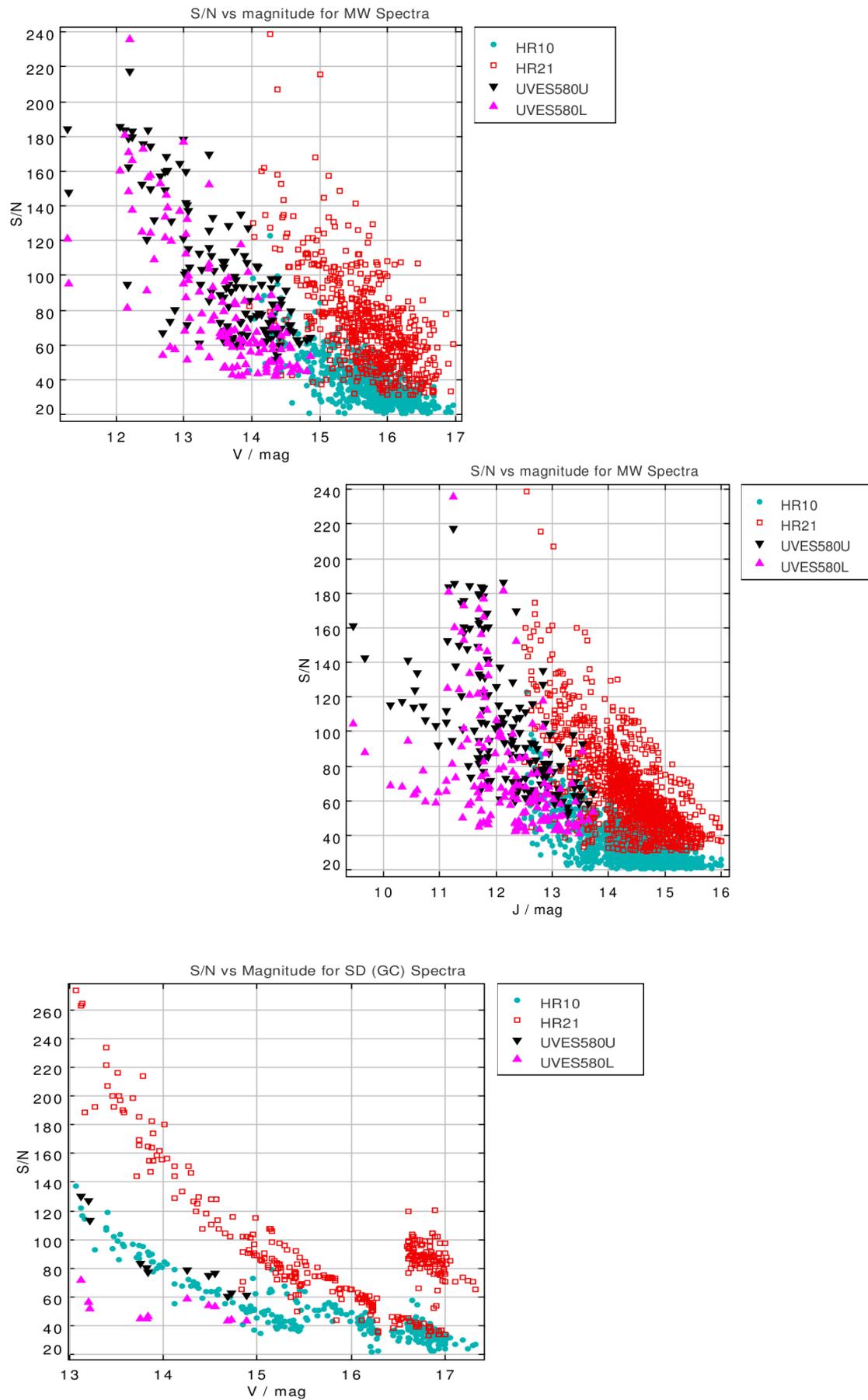
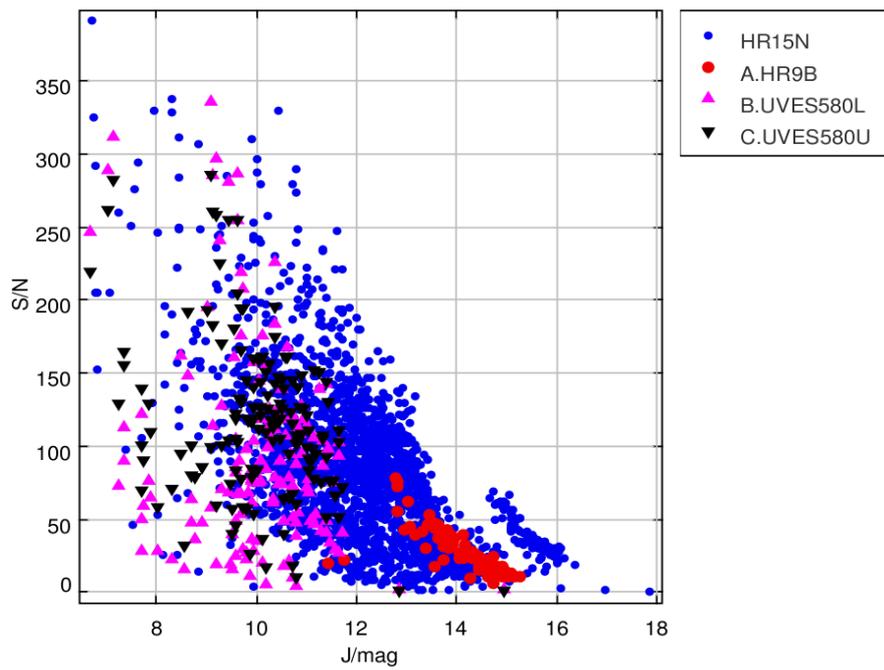
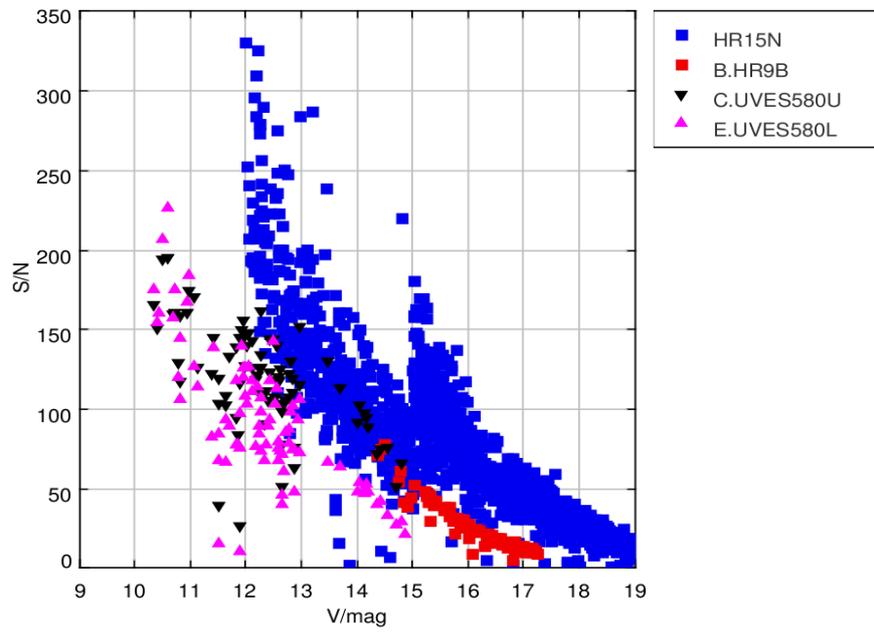


Figure 7: S/N vs. magnitude for the cluster stars. Note that the S/N vs. V plot includes fewer points, since V magnitudes are not available for Cha I.



Data Format

Files Types

The files provided for this release are in the format as specified in issue 5 of document GEN-SPE-ESO-33000-5335. This consists of a FITS file with a primary header unit containing no data and a binary FITS table extension containing the data. The header cards in the header unit of each extension contain the information requested in the above document.⁴ In addition, the primary and extension headers specify the type of the Gaia-ESO Survey field in the GES_TYPE keyword (values are listed in **Overview of Observations** Section). This keyword is intended to provide useful supplementary information on the field for the user – please note, however, that it is not currently a searchable field in the ESO archive. The wavelength array (WAVE), spectrum (FLUX), error array (ERR) and quality array (QUAL) are each provided in a single cell of the one row contained in the binary table.

The objects in each file have a name which is derived from the object's equatorial coordinates. This is formed by splicing the RA (in hours, minutes and seconds to two decimal places) and Declination (in degrees, minutes and seconds to one decimal place) as integers with the declination sign in the middle. Thus an object at 3h40m21.767s and -31°20'32.71" will have the name 03402177-3120327. The name of the file is of the form <prefix>_<name>_<expmode>.fits. The value of <prefix> will be either 'gir3' (Giraffe), 'uvl3' (UVES lower), or 'uvu3' (UVES upper). The value of <expmode> is derived from the central wavelength and grating for the instrument, e.g. H875.7.

Catalogue Columns

Not applicable.

Acknowledgements

Please use the following statement in your articles when using these data:
Based on data products from observations made with ESO Telescopes at the La Silla Paranal Observatory under programme ID 188.B-3002.

⁴ Please note that the SPEC_RES keyword in the primary header denotes the spectral resolving power, $\lambda/\Delta\lambda$, rather than the FWHM resolution.