1 The Gaia-ESO Survey

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1.1 Abstract:(10 lines)

Gaia-ESO is a public spectroscopic survey, 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 FLAMES 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.

2 The Gaia-ESO survey: Scientific rationale (3 pages, +2pp figs)

How disc galaxies form and evolve, and how their component stars and stellar populations form and evolve, are among the most fundamental questions in contemporary astrophysics. This Gaia-ESO survey will contribute to those key questions, by revolutionising our knowledge of the formation and evolution of the Galaxy and the stars that populate it. Gaia-ESO is a high statistical weight ($\simeq 10^5$ stars) spectroscopic survey which samples all the main components of the Galaxy, from star-forming regions to ancient halo stars (Fig 1). This survey has enormous stand-alone value. However, its products will be even further enhanced by Gaia astrometry (2016) and Gaia spectrophotometry and improved stellar parameters (2018).

Understanding how galaxies actually form and evolve within our ΛCDM universe continues to be an enormous challenge[7,8]. Extant simulations of the aggregation of cold dark matter suggest that galaxies grow through a sequence of merger/accretion events[9]. However, theoretical models of galaxy formation, which necessarily involve modeling star formation and stellar evolution, rely more heavily on phenomenological models than on physical theory. Thus, these models require calibration with well-studied (nearby) test cases. For example, star formation involves turbulence, magnetic reconnection, collisionless shocks, and radiative transfer through a turbulent medium. Similarly, the treatment of convection, mixing, equations of state at high density, opacities, rotation and magnetic fields can all significantly affect stellar luminosities, radii, lifetimes at different evolutionary phases. We are also far from being able to simulate the coupled evolution of CDM and baryons from ab-initio physics. Observations are crucial to learning how galaxies and stars were formed and evolved, and what their structure now is[8]. Observations of objects at high redshifts and long look-back times are important for this endeavour, as is detailed examination of our Galaxy, because such "near-field cosmology" gives insights into key processes that cannot be obtained by studying faint, poorly resolved objects with uncertain futures. Just as the history of life was deduced by examining rocks, we expect to deduce the history of our Galaxy by examining stars. Stars record the past in their ages, compositions, and in their kinematics. For example, individual accretion and cluster dissolution events can be inferred by detecting stellar streams from accurate phase-space positions. Correlations between the chemical compositions and kinematics of field stars will enable us to deduce the history of star formation and even the past dynamics of the disc. The kinematic structure of the bulge will reveal the relative importances in its formation of disc instability and an early major merger. The study of open clusters is crucial to understanding fundamental issues in stellar evolution, the star formation process, and the assembly and evolution of the Milky Way thin disc[10].

Stars form in associations and clusters rather than singly[13]. Thus understanding star formation also implies studying cluster formation. Advances in infrared astronomy have opened up the study of the formation of stellar cores in dark clouds, and the period in which a core grows by accretion. We know that outflows of various types disperse most of the gas of a cloud, and that the great majority of groups of young stars then quickly disperse. More populous groups survive the dispersal as open clusters, and subsequently disperse through a combination of two-body scattering off other members of the group and tidal disturbance by the gravitational fields of external objects such as giant molecular clouds and spiral arms. It is possible that open clusters are the dominant source of field stars, a model we will test. They trace different thin disc components covering broad age and metallicity intervals, from a few Myr up to several Gyr, from $\sim 1/3$ to twice solar. Each cluster provides a snapshot of stellar evolution. Thus, observations of many clusters at different ages and chemical compositions, quantifies stellar evolution, allowing increasingly detailed theoretical models to be tested. Much stellar and Galactic astrophysics hinges on these crucial comparisons between cluster observations and the predictions of the models[11].

What is the scale of the challenge? The key to decoding the history of galaxy evolution involves chemical element mapping, which quantifies timescales, mixing and accretion length scales, and star formation histories; spatial distributions, which relate to structures and gradients; and kinematics, which relates to both the felt but unseen dark matter, and dynamical histories of clusters and merger events[21]. With Gaia, and calibrated stellar models, one will also add ages. Manifestly, very large samples are required to define all these distribution functions and their spatial and temporal gradients. Orbit space is (only) three-dimensional because generic orbits in typical galaxy potentials admit three isolating integrals. The number of objects required to determine the underlying probability density of objects grows rapidly with the dimensionality of the space. So in the present case, if we have ten bins along each axis in integral space, corresponding to a resolution in velocity as coarse as $\sim$ 6km/s, we have 1000 bins in integral space. Then we wish to distinguish at a minimum between young stars, stars of intermediate age and old stars, and similarly, between stars with solar abundances, stars with abundances similar to those of disc clusters and of halo clusters. Thus each of the age, [Fe/H], and [α/H] axes must be divided into at least three bins, giving us 27 000 bins in the minimal six-dimensional space. Even with perfectly adapted bin sizes, an estimate of the density of stars in this space will have Poisson noise of order unity unless we have in excess of 10^5 stars. Similarly, defining the information content in the open cluster system requires adequate sampling of the four dimensional (age, metallicity, position in the Galaxy, mass/density) parameter space. Even considering the inhomogeneous (mostly abundance) measurements available in the literature, only a new homogeneous survey of $\simeq 100$ objects, containing $\simeq 5 \times 10^4$ stars, will have sufficient statistical power (cf §4).

Thus progress in formation and evolution of the Galaxy and its component stars and populations requires a spectroscopic survey returning data for a sample of $\geq 10^5$ field stars and at least 100 open clusters. The Gaia-ESO Survey is that survey. It will also be the first survey yielding a homogeneous dataset for field and cluster stars, providing unique added value. We summarize below some of the scientific advances which it will deliver.

Open Cluster formation and dynamics: Theories of cluster formation range from the highly dynamic through to quasi-equilibrium and slow contraction scenarios. These different routes lead to different initial cluster structures and kinematics[11]. Subsequent evolution depends on many factors, including the initial conditions, star formation efficiency and tidal interactions. Whilst hydrodynamic and N-body simulations are developing, a fundamental requirement is an extensive body of detailed observations. A complete comparison requires precise position and velocity phase-space information resolving the internal cluster kinematics, ($\leq$ 0.5km/s), that can be provided by the spectroscopy proposed here[11]. Even more sophisticated studies will follow combination with Gaia astrometry. The velocity fields within the youngest clusters betray their formation history, whilst the kinematics of the older clusters and the age dependence of their mass functions test theories of cluster destruction.

Stellar evolution: Each star cluster provides a (near-)coeval snapshot of the stellar mass function. This survey contributes to testing stellar evolution models from pre-main sequence phases right through to advanced evolutionary stages. Much of the input physics in stellar models can be tested by its effects on stellar luminosities, radii and the lifetimes of different evolutionary phases. Homogeneous spectroscopy will provide estimates of stellar parameters and reddening for large samples of stars over a wide range of masses, in clusters with a wide range of ages and mean chemical compositions. Such data are essential in testing, calibrating, and refining both evolutionary tracks and stellar parameters derived from spectra[12] (Fig 3, top LHS). While of enormous stand-alone value, when later combined with Gaia astrometry, and supplemented by asteroseismology, these data isolate and probe all the theoretical uncertainties, whilst simultaneously identifying and quantifying important perturbing factors such as binarity, rotation, accretion and magnetic activity.

Halo substructure, Dark Matter, extreme stars: Recent surveys have revealed that the halos of both our own and other Local Group galaxies are rich in substructures[1,21,22] (Fig 2; Fig 3 lower RHS). These not only trace the Galaxy's past, but have enormous potential as probes of its gravitational field and hence as tracers of the still very uncertain distribution of dark matter[25]. High precision radial velocities for many stars at latitudes $|b| > 30^\circ$ will lead to the discovery of more substructures. Their abundance patterns will indicate clearly whether a given structure represents a disrupted object and of which type, or has formed dynamically by resonant orbit-trapping. The kinematics of streams will place tight constraints on the distribution of dark matter. The local dark matter mass distribution will be substantially better determined than the current result[6]. Furthermore, this large-number survey, with the metallicity-sensitive Calcium Triplet lines observed for every field star, will allow us to identify useful samples of rare kinematics or abundances for later follow-up[14].

Nature of the bulge: In simulations of galaxy formation, mergers tend to produce substantial bulges made of stars that either formed in a disc that was destroyed in a merger, or formed during a burst of star formation that accompanied the merger[27]. Such "classical" bulges are kinematically distinguishable from "pseudo-bulges" that form when a disc becomes bar unstable, and the bar buckles into a peanut-shaped bulge[7,8] (Fig 3, top RHS). In common with the great majority of late-type galaxies, the Galaxy's inner bulge appears to be a pseudo-bulge, but ΛCDM simulations suggest that it should also host a classical bulge, perhaps that observed at larger radii. By studying the kinematics and chemistry of K giants at $|b| > 5^\circ$ we will either confirm the classical bulge or place limits on it which will pose a challenge to ΛCDM theory. Our large survey will quantify elements of various species and their variation across the bulge region, substantially improving our knowledge of this fundamental, yet surprisingly under-studied, stellar population.

Thick Disc: Thick discs seem common in large spiral galaxies[26,15,20] (Fig 1). Are they evidence that the last major merger event occurred very much longer ago than is expected in standard cosmologies? Are they artifacts of thin disc dynamical evolution? Are they both or neither of these[16,23]? How did the metallicity of the ISM evolve at very early times? How does this vary with Galactocentric distance? Do major infall events occasionally depress the metallicity of the ISM[17]? We will determine quantitative kinematics and abundance patterns for large samples of thick disc FG stars over one outer radial and three vertical scale lengths to help elucidate these key questions in Galaxy formation and evolution. We supplement that with a survey of the rare but important very outer thin/thick disc K giant stars, extending to the warp, flare and Mon Stream[19] in the distant discs.

Thin Disc and Solar Neighbourhood: We will obtain UVES spectra for an unbiased sample of $\sim$5000 FG stars within $\geq$ 1kpc, for the first high-weight detailed determination of the kinematics-multi-element DFs (Fig 3, lower LHS). This covers both thin and thick discs, and all ages and metallicities. Using field stars and clusters, where ages are also known, we will survey the region from about 6 to $>$ 20 kpc Galactocentric radii, we will trace chemical evolution as a function of age and Galactocentric radius across a disc radial scale length. These are key inputs to models for the formation and evolution of the Galaxy disc. Current estimates suffer from poor statistics, inhomogeneous abundance determinations and absence of data at key ages and orbits[28]. Our survey will fill these gaps and provide a homogeneous abundance dataset from UVES spectroscopy. We will also address current disc structure, that which hosts the star formation. Spiral structure is fundamental to the dynamics of the disc: it dominates the secular rise in the random velocities of stars, and may even cause radial migration of stars and gas[18]. Currently, we are not even clear about the global morphology of our spiral structure, and the information we have on its dynamics largely relates to gas not stars. We will initiate a study of the kinematic distortion in the disc potential due to the bar/spirals by measuring some 1000s of radial velocities down key arm, inter-arm and near-bar lines of sight (Fig 3, top centre).

Impact of and relevance to Gaia The Gaia mission, scheduled for launch in 2013, is key to answering many of these questions. It will provide photometry and astrometry of unprecedented precision for most stars brighter than $V \simeq 20$, and obtain low-resolution spectra for most stars brighter than $V \simeq 16$. The first astrometry data release is likely to be $\sim$ 2016 for preliminary data, with spectrophotometry and first stellar parameters to follow some years later, and $\gtrsim$ 2021 for the full catalogue. While Gaia is remarkable, like all spacecraft it leaves for large ground-based telescopes what those do best. That is the spectroscopy we propose here. The Gaia-ESO spectroscopy complements and completes Gaia astrometry, and vice versa. Each project is intrinsically exciting, and each benefits from synergy with the other.

Gaia-ESO Survey legacy overview This VLT survey delivers the data to support a wide variety of studies of stellar populations, the evolution of dynamical systems, and stellar evolution. We complement Gaia by using GIRAFFE + UVES to find detailed abundances for at least 12 elements (Na, Mg, Si, Ca, Ti, V, Cr, Mn, Fe, Co, Sr, Zr, Ba) in $\geq 10^4$ field stars with $V \leq 15.5$ and for several other elements (including Li) for more metal-rich cluster stars. Depending on target S/N, and astrophysical parameters we typically probe the fundamental nucleosynthetic channels: nuclear statistical equilibrium (V, Cr, Mn, Fe, Co), and α-chain (Si, Ca, Ti). The radial velocity precision for this sample will be $\simeq 0.1\,\mathrm{km\,s^{-1}}$ to $\leq 5\,\mathrm{km\,s^{-1}}$, depending on target, with in each case the measurement precision being that required for the relevant astrophysical analysis. The data resolve the full phase-space distributions for large stellar samples in clusters. This makes it possible to identify, on both chemical and kinematic grounds, substructures that bear witness to particular merger or starburst events, and to follow the dissolution of clusters and the Galactic migration of field stars. The survey also supplies homogeneously determined chemical abundances, rotation rates and diagnostics of magnetic activity and accretion, for large samples of stars in clusters with precise distances, which can be used to challenge stellar evolution models. We are considerable effort in abundance calibration to ensure maximal future utility.

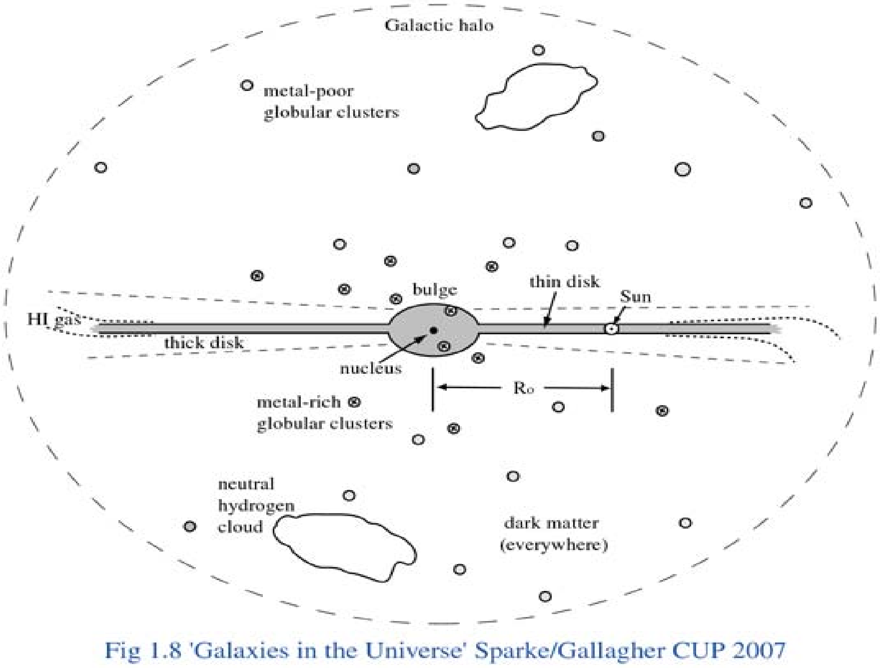

Figure 1: An overview of Stellar Populations in the Galaxy. The Gaia-ESO Survey will quantify kinematic and elemental abundance distributions in all stellar populations. In addition to bulge, halo and thick disc, it will provide precise data for a representative sample of open clusters in the thin disc, covering its whole age range, and a detailed determination of the population structure within one disc scale length of the Solar neighbourhood.

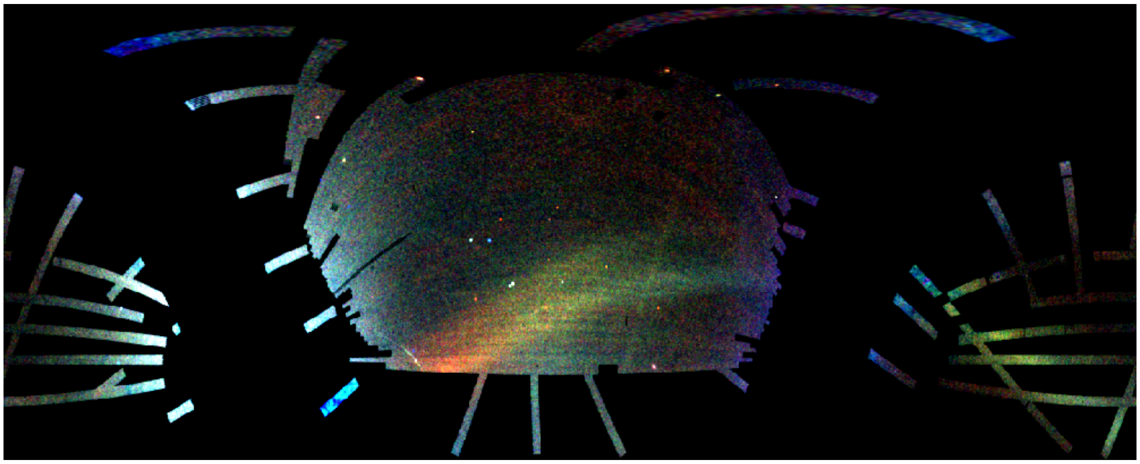

Figure 2: Gaia-ESO science at high Galactic latitudes and the outer Galaxy focuses on galaxy formation and assembly. This figure shows the “field of streams” image of the stellar distribution in the SDSS DR7 survey area[1]. Here turnoff stars are shown, colour coded by distance, with red being distant, blue closer. The wealth of halo structure, dominated by the complex tidal tails of the Sgr dSph galaxy, is evident.The Gaia-ESO survey will extend this photometric map to a multi-dimensional kinematics-abundance map.

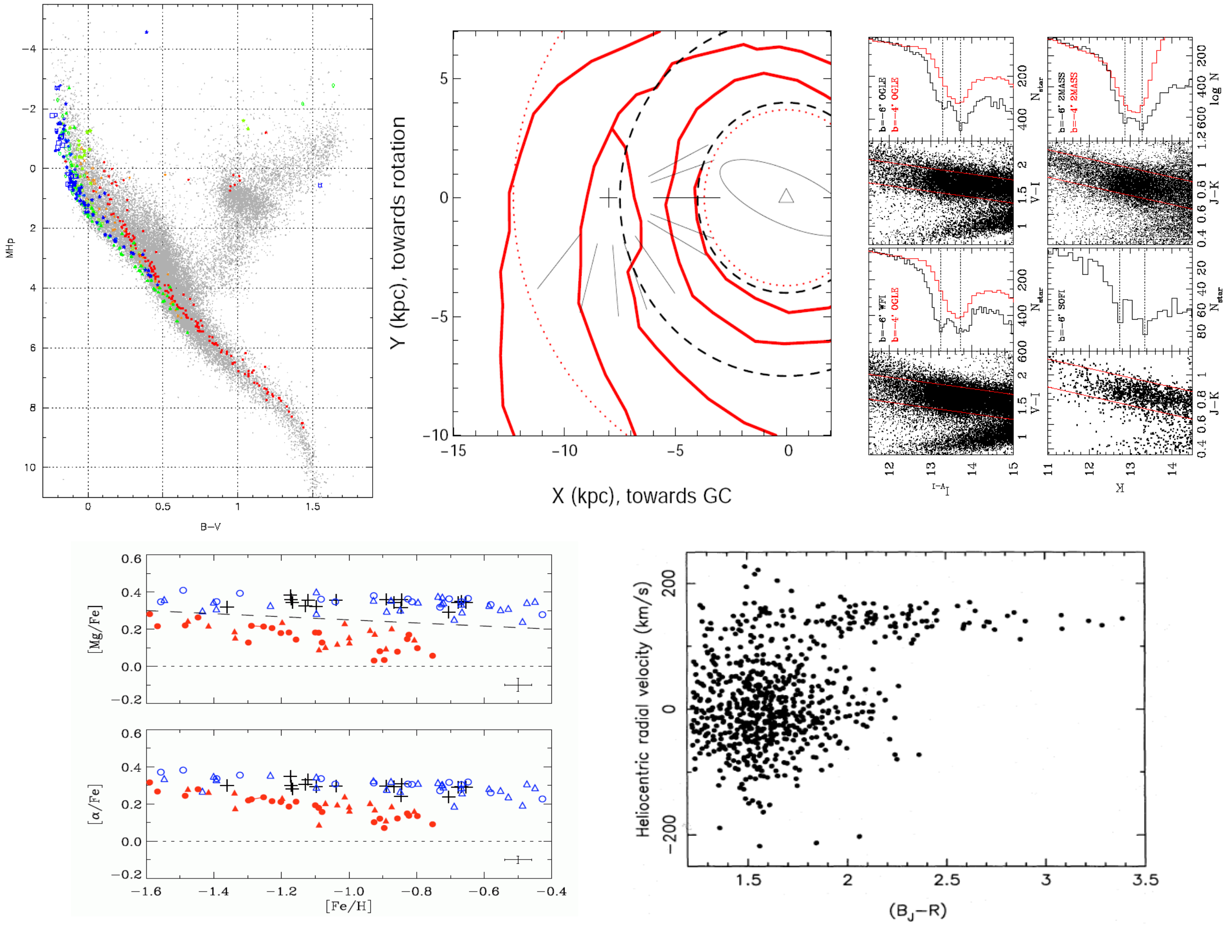

Figure 3: An illustration of some of the key Gaia-ESO science at low Galactic latitudes. Top left - open cluster CMDs from the revised Hipparcos reduction[2]. The clusters are colour-coded by age; precision membership, kinematics and abundance measurements will be provided here for a much larger cluster sample . Top centre - outline lines of sight probing the dynamics of spiral arms and the long bar, illustrating that dynamically-sensitive directions can be probed[18]. Top right: CMDs illustrating the complexity of the inner Galactic bulge - several major structural components are evident even in photometry[3]. Gaia-ESO will determine kinematics and elemental abundances for large samples, probing the complexity. Lower right - discovery data for the Sgr dSph galaxy[4]. This, the only galaxy yet discovered in phase space, illustrates the complexity in inner Galaxy lines of sight, and the potential discovery space. Lower left, elemental abundances for a small incomplete sample of nearby stars, illustrating the need for elemental abundances to characterise the history of stellar populations[5].

REFS: [1]Belokurov etal ApJ 642, L137 2006; [2]vanLeeuwen 2009 A&A 497 209; [3]McWilliam & Zoccali 2010 ApJ 724 1491; [4]Ibata, Gilmore, Irwin 1994 Nat 370 194;[5]Nissen & Schuster 2010 A&A 511 L10; [6]Kuijken & Gilmore 1989 MN 239 605;[7]Peebles 2011 Nat 469 305; [8]Kormendy etal ApJ. 723, 54 2010; [9]Komatsu etal 1001.4538;[10]Bland etal 2010 ApJ 713 166;[11]Jackson & Jeffries 2010 MN 407 465, Tan etal 2006 ApJ 641 L121, Proszkow etal 2009 ApJ 697 1020; [12]Soderblom 2010;[13]Elemgreen 2011 arViv1101.3113;[14]Tafelmeyer etal 2011 A&A 524 58; [15]Collins etal MN in press;[16]Qu etal 2011EAS 45 421;[17]Chiappini 2011 EAS 45 293;[18]Antoja etal 2010 hsa5conf 370;[19]Casetti-Dinescu et al 2010 AJ 139 1889;[20]Yoachim & Delcanton 2006 AJ 131 226;[21]Freeman & Bland-Hawthorn 2002 ARAA 40 487;[22]Beers & Christlieb 2005 ARAA 43 531;[23]Schoenrich & Binney 2009 MN 399 1145; [24] Ibata & Gilmore 1995 MN 275 605; [25]Helmi etal 2004 ApJ 610 L97; [26] Gilmore & Reid 1983 MN 201 73; [27]Abadi etal 2003 ApJ 597 21; [28] Nordstrom etal A&A 418 989.

3 Are there similar ongoing or planned surveys? (1 page)

There are no ongoing projects, only planned future surveys, which measure precise kinematics and stellar elemental abundances for large samples of stars. The future projects are Gaia, HERMES, & APOGEE. All other current or planned surveys use low-resolution galaxy redshift facilities, or narrow wavelength ranges, for kinematics and approximate “metallicity”. Several photometric surveys are underway or planned (VISTA, VST, SkyMapper, PSS) and will deliver valuable complementary data to our spectroscopy. There is a VLT Inner-Bulge LP underway (by a subset of our team), which will complement our survey in the very inner bulge.

Gaia: all-sky. This survey is complementary to, but is not dependent upon, Gaia. The Gaia RVS instrument will obtain spectra with ΔRV$\leq$ 10km/s (end of mission) for all stars with V$\leq$ 16, and with element abundances only to V=12. Gaia astrometry (first data release perhaps 2016), when combined with our spectra, will deliver more accurate abundances, robust distances and hence gradients, and, uniquely, for subgiants, ages: Gaia-ESO plus Gaia will calibrate stellar evolutionary models and will deliver the first ever age-abundance-kinematics distribution function for old stars. http://www.rssd.esa.int/index.php?project=GAIA&page=Science_Performance

SDSS I, II, & III: 2.5m, North. SDSS has published some 250K spectra providing velocities to $\sim 10-20$km/s, and [Fe/H] abundances to $\sim$ 0.25dex for stars with $14 \leq r \leq 19$. These studies complement the SDSS photometric analyses (cf Fig 2 above). SDSS spectra have provided only very limited information on the substructures prominent in the SDSS photometry, due to low precision and over-sparse spatial sampling. SDSS3 stellar spectroscopy continues, at $\sim$ 5 stars/sq deg. SDSS does not observe the Galactic thin disc and Bulge. www.sdss3.org/

SDSS-APOGEE: 2.5m, North, IR. APOGEE is a survey of Galactic stellar populations, to begin in 2012, aimed at obtaining high resolution (R = 30,000), high S/N ($\geq$ 100) spectra in the H band (1.5-1.7 microns) for 10^5 stars, primarily G-M giants, with $11 \leq H \leq 14$. APOGEE will study 50 high latitude Galactic halo fields, 65 bulge fields, and 110 low latitude disc fields, including 30 ‘key calibrator’ and some 200 other star clusters. We will observe several clusters in common with APOGEE, for calibration. www.sdss3.org/apogee.php

LAMOST: 4m, North. LAMOST is in transition from commissioning to full operations. It operates at SDSS resolution (R$\sim$ 1700), and will be able to observe very large numbers of Northern targets, incl clusters, at intermediate magnitudes and relatively low velocity precision, with no element abundances. We are in discussion with the LAMOST project, concerning possible complementary targeting.

AAT-HERMES: 4m, South. HERMES, to begin observations in 2013, aims to obtain precision multi-element abundances for 10^6 stars with V$\leq$ 14, from high S/N, R=30000 spectra, in 10^3 AAT nights. Our teams are coordinated, and surveys complementary, with HERMES restricted to brighter targets.
www.aao.gov.au/AAO/HERMES/

AAOmega: 4m, South. We have submitted an AAOmega large program, AEGIS, to complement this VLT survey. AEGIS is focused on low surface density relatively bright K Giant and BHB candidates for halo substructure. This brighter target survey is complementary to our Gaia-ESO survey, and optimises the 4m-very wide field plus 8m-deeper balance.

UKST-RAVE: 1.2m, South. RAVE is obtaining accurate radial velocities ($\leq$5km/s) and metallicities for $\sim 5.10^5$ stars with I$\leq$13. RAVE uses the Gaia CaT window, and will provide interesting UVES targets for this survey. www.rave-survey.aip.de/rave/

WOCS The WIYN Open cluster study is a survey carried out at the WIYN 3.5 telescope to obtain comprehensive photometric, astrometric, and spectroscopic data for a small number ($\sim$10) nearby clusters. Whilst some of the goals of this survey are in common with what we are proposing here, limiting magnitudes (V$\leq$ 16 for spectroscopy), the WOCS range of ages, stellar masses, distances, [Fe/H], and environments cover a very small subset of the parameter space that we plan to cover here.

4 Observing strategy: (1 page)

The Gaia-ESO Survey observing strategy has been designed to deliver the top-level survey goal. We will survey the Galactic inner and outer bulge, inner and outer thick and thin discs, the halo and known halo streams. We have particular focus on the local thin disc, as this study both complements Gaia astrometry, and will benefit most from the most precise Gaia data. We place special effort on open clusters at all ages and the solar neighbourhood field stars as tracers of both stellar and Galactic evolution.

Observation are restricted to $+10 \geq dec \geq -60$ whenever possible to minimise airmass limits. The primary source catalog for field stars is VISTA imaging, ensuring excellent recent astrometry, and adding maximal value to the VISTA surveys. The open clusters have been selected from the Dias et al. (2002, A&A 389, 871 -2010 version) and Kharchenko et al. (2005, A&A 440, 403) catalogues, and WEBDA database http://www.univie.ac.at/webda and the results of a monitoring programme carried out by the Geneva group. Only clusters with available photometry and membership information have been selected.

Bulge survey. Here the prime targets are K giants, including the red clump (I=15 typically). These dominate the relevant CMD selection. The analysis tests show that S/N=50 is needed to deliver $\log g$, while the typical giant will have S/N=100. Two GIRAFFE setups are needed. 4 OBs, to provide iron-peak elements: Fe, Cr, Mn, Co, Ni; alpha elements: Mg, Si, Ca, Ti; proton-capture elements: Sc, V.

Halo/thick disc survey. Primary targets are r=17-18 F stars, with the bluer, fainter F stars probing the halo, brighter, redder F stars probing the thick disc. SDSS photometry shows a clear thick disc/halo transition at $17 \leq r \leq 18; 0.2 \leq g - r \leq 0.4$ – we use the equivalent selection from VISTA. The spectrum analysis tests suggest that minimum S/N=30 for thick disc and halo FG stars delivers: iron-peak elements: Fe, Cr, Mn; alpha elements: Mg (all), Si, Ca, Ti (down to [M/H]$\simeq -1.0$); proton-capture elements: Sc. In both cases, this requires 2xHR21, 2xHR10, giving S/N=40 & 30. A single fposs setup is used, so fields can be completed in a single semester. In fields crossing known halo streams (eg Sgr) we will include stream K giant candidates.

Outer thick disc fields will have distant F stars as prime targets, like the halo. A well-defined low latitude sample, probes 2-4 kpc, more than a radial scale length. In addition, we will allocate 25% of the fibres to brighter candidate K giants, which probe the far outer disc, warp, flare and Mon stream, and will deliver excellent S/N.

Thin disc dynamics. We will target 4-6 fields to I=19 in the Plane to test spiral arm/bar dynamics. These require HR21 for RVs only. Several thousand RVs per line of sight will be obtained.

Solar Neighbourhood. We also dedicate UVES parallels for the field surveys to an unbiased sample of 5000 FG stars within 2 kpc of the Sun with detailed elemental abundances. UVES580 is adopted.

Open clusters –OCs. Cluster selection is optimized to fine-sample the age-[Fe/H]-radial distance-mass parameter space. OCs in all phases of evolution (except embedded), from $\sim 10^6$ Myr up to ~ 10 Gyr will be included, sampling different environments and star formation conditions. This will provide sufficient statistics to explore the dynamical evolution of clusters; the same sample will map stellar evolution as a function of metallicity for $0.1 \leq M/M_\odot \leq 100$, even for short-lived evolutionary phases, and provide a population large enough to throughly investigate metallicity as a function of Galactocentric radius and age. The total sample will include ~ 100 clusters. The young cluster (<100 Myr) sample will include: *i)* targets closer than ~ 1500 pc, the distance up to which Gaia will provide transverse velocity with precision better than internal velocity dispersion, as will our radial velocities, even for M stars; *ii)* massive clusters at larger distances, where only OBA stars will be targeted. The older sample also includes both nearby and very distant clusters. In the former we survey the whole population, down to the M dwarf regime, while in the latter we will observe RGB and clump giants, and early MS stars. For all clusters we will use GIRAFFE to target faint cluster members (down to V= 19), while UVES fibers will be fed with brighter or key objects (down to V= 16.5), to be used for accurate abundance determination or for which better precision in RV is required. Six GIRAFFE set-ups will be employed (HR03/05A/06/14A/15N/21). HR03/05A/06/14A contain a large number of spectral features to be used to derive RVs and characteristics (e.g., temperature, gravity, wind) of early-type stars; HR15N/21 are instead the most commonly used gratings for late-type stars; they access a large enough number of lines to derive RVs, as well as to retrieve key information on the star characteristics (e.g., temperature, Li, accretion rates, chromospheric activity, rotation). As to UVES, CD3 is most suitable both for early-type (520 nm setting) stars and late-type members (580 nm setting). We finally mention that all cluster FPOSS configurations will be observed at least twice to identify binaries.

5 Estimated observing time:

General assumptions. We are using UT2-FLAMES-GIRAFFE-UVES. We have ∼ 110 science targets from 130 fibres available in each 25arcmin fov with GIRAFFE, six-seven (one-two sky) with UVES. We have investigated the tradeoff between required S/N and the optimum number of GIRAFFE setups to ensure we can obtain the unique new information of radial velocities, elemental abundances, and dwarf/giant discrimination for field stars, down to very faint magnitudes. Astrometry out of the Plane is VISTA, so very good and very recent - we have no proper motion issues. Precise astrometry for the clusters is from 2MASS, and other high-quality astrometric studies, successfully used in our previous FLAMES cluster work. Our default ESO observing unit (OB) is 60 min, which corresponds to about 45 min exposure on target. For field stars parallel UVES exposures out of the Plane will be very efficient: we have 4-6 OBs per line of sight, allowing good S/N on the unbiased F/G field star sample to V≤ 15, sufficient distance for a fair sample of thin and thick disc. We invest considerable effort in calibrations, to ensure consistency with available (RAVE, Segue) and planned surveys, and especially with Gaia, and the ESO archive.

Required observing conditions. We have investigated possible lunar constraints using our faintest proposed targets for each grating setting in ETC v3.2.7a. Assuming a worst-case 1.2 arcsec seeing we find only a 10% improvement in SNR per pixel by adopting a 7-day lunar constraint for the faintest targets ($V \simeq 19$) at the HR15N/21 settings and a similarly small improvement for the faintest targets ($V \simeq 17$) at the HR03/05A/06/10/12/14A settings. Hence we do not request any lunar constraints. Whilst observations of even the fainter stars are insensitive to moon, they are obviously sensitive to seeing. For these we request 0.8 arcsec seeing and CLR conditions, as these push to the faint limits of what we propose. For cluster targets brighter than V∼ 15, observed to high S/N and less sensitive to seeing, we will instead request 1.2 arcsec + CLR.

Periods (88-93)	Time (h)	Mean RA	Moon	Seeing	Transparency
P88	470	6h	any	0.8	clear
P88	30	6h	any	1.2	clear
P89	470	18h	any	0.8	clear
P89	30	18h	any	1.2	clear
P90	470	6h	any	0.8	clear
P90	30	6h	any	1.2	clear
P91	470	18h	any	0.8	clear
P91	30	18h	any	1.2	clear
P92	470	6h	any	0.8	clear
P92	30	6h	any	1.2	clear
P93	470	18h	any	0.8	clear
P93	30	18h	any	1.2	clear

5.1 Time justification: (1 page)

Our targets are, in broad classes, inner Galaxy K giant (red clump) stars (550H); halo and outer thick disc F turnoff stars, with a minority halo K giant sample (960H); thin disc field K giants (150H); Galactic Open Clusters (1250H). 100H is dedicated to calibration targets. Very extensive tests show the optimum information content for the non-Plane GIRAFFE targets combines HR21 & HR10, with S/N=40-50 in each adequate to provide robust log(g) and elements beyond metallicity and alpha elements. These tests continue to ensure optimal selection. The goal in all survey fields is to determine the kinematic and multi-elemental abundance distribution functions with sufficient precision to make major advances.

◇ The Inner Galaxy - bulge, pseudo-bulge, inner thin and thick disks, Sgr dSph tails, ... *fields on a grid with* $5 \le b \le 30, -50 \le l \le +50$. *Stars are red clump giants, mean I=15. GIRAFFE settings HR21+HR10 with S/N=100, 50 respectively, deliver log(g) and Fe-peak, alpha, and proton capture elements. This implies 2xOB per setting most areas, 3xOB in high extinction. Minimum Goal to map area and complexity:* 2.10^4 *stars. 100 main bulge fields (x4OB) plus 20 inner bulge fields (x6OB) delivers 11,000+2200 stars (+600 UVES parallels) in 550H*

◇ The Halo & Thick Disk - gradients, streams, substructure, warp, flare, Mon stream... *infields with* $b \ge 20$ *targets are F stars, including halo and thick disk turnoffs. Selection at r=17.5 provides unbiassed samples of both.* *S/N*$\geq$*30 delivers iron-peak, alpha, and proton-capture tracers (cf §4). 4OBs per setup are implied. The absolute bare minimum number requirement to quantify assembly histories is 20,000stars, 800H. At lower latitudes and across (Sgr) halo streams 25% of fibres will be allocated to candidate K giants. The outer low-latitude special survey, of 4000 outer thick disk stars requires 160H. UVES parallels are local F stars. Total 960H*

◇ Thin disc dynamics - *selected fields with* $b \le 5$ *Radial Velocities for severalx1000 giants in sensitive lines of sight in the Plane will map bar/spiral distortion. I=19 K stars for RVs to 1km/s means HR21x1OB. Five fields x 3000RVs means 150H*

◇ Calibrations - *Ensuring the Gaia-ESO survay has maximal legacy impact is of key priority. Thus we have analysed the literature, the ESO archive, and other projects, to identify a set of open and globular custers which will cross-calibrate all major data sets uniformly. This is a big task, and requires 100H dedicated effort.*

◇ Younger open clusters - GIRAFFE + UVES: providing a minimum coverage of parameter space [§2,§4] requires several tens of clusters. We adopt a minimum of 40, of which 13 are massive clusters. The goal is both precision kinematics [resolving the (low) internal velocity dispersion], elemental abundances, and age-dependent astrophysical parameters. *Precision abundances are derived from parallel UVES spectra - for the young clusters integration times are dominated by Giraffe requirements. To deliver astrophysical parameters across all masses, young star accretion/activity indices, and the crucial Li*λ*6708 line (HR15N) a S/N greater than* ~ 30 *is required, implying 4 OBs for the faintest (V=19) M-type targets. For the same stars 1 OB with HR21 is needed to reach a S/N* ~ 10*, allowing us RV precision < 0.5 km/s. Considering the typical number of FPOSS setups (10-15), driven by cluster diameters and number of members, and repeated observations to identify binaries, 600H will be needed. 1 OB with the blue gratings is usually enough to reach high SNR for the hot bright stars in massive clusters. Considering typically two FPOSS setups per cluster and the six gratings, 150H are required to cover the massive clusters. The young cluster sample therefore requires 750H for 40 clusters, several x 1000 stars.*

◇ Older open clusters - GIRAFFE + UVES: providing a minimum coverage of parameter space, especially here age and Galactocentric radius [§2,§4], and comparison with the Solar Neighbourhood field sample requires many tens of clusters. We adopt a minimum of 60. *Integration times are set by UVES S/N on the red clump giants: 2xOB and 8xOBs/cluster for the closest* ($V_{\rm clump} \sim 13$) *and most distant clusters* ($V_{\rm clump} \sim 16.5$) *are needed. This allows a GIRAFFE (HR21) parallel study of the internal kinematics with velocity precision sufficient to resolve the low internal dispersion. For the closest clusters this will allow a full characterization of the MS population, critical for stellar evolution, and observations of Li in solar-type stars. With repeated observations for binaries and observations of 5-15 giants per cluster, this part of the program will require 500 hrs. The whole cluster program will require 1250 H, yielding* ~ 1000 *stars with the full UVES set of elemental abundances, and up to 30,000 member stars with precision kinematics and robust astrophysical parameters.*

6 Data management plan

The Gaia-ESO project will follow standard proven large-project management methods, with responsibilities and communications linked to work effort requirements and deliveries. The two Co-PIs are the point of contact to ESO, and are assisted by a steering group. A set of work packages matched to task requirements has been defined, with sub-packages as appropriate. Resources have been identified in each active participant group listed as Co-Is. All groups involved are active participants - the work will be distributed to teams with relevant expertise and appropriate resources, with clearly defined and agreed local responsibilities. Project coordination will involve kick-offs, regular telecons at Work Package (WP) level, and PI-WP lead level, with regular WP working meetings, and annual consortium meetings. We have a detailed Survey Implementation Plan, defining the activities related to data preparation and handling, target selection algorithms, data flow in and out of our working archive, WP responsibilities and interfaces, and lines of communication and responsibility. We also have a Survey Project Plan, defining internal responsibilities, and a Survey publication policy. These are overseen by the Steering Group, which acts as a project management board. We list the Steering Group below.

Name	Function	Affiliation	Country
Gerry Gilmore	Co-PI	Institute of Astronomy	UK
Sofia Randich	Co-PI	INAF Obs Arcetri	I
M. Asplund	Steering Group	MPA	D
J. Binney	Steering Group	Oxford	UK
P. Bonifacio	Steering Group	Paris	Fr
J. Drew	Steering Group	Herts	UK
S. Feltzing	Steering Group	Lund	Swe
A. Ferguson	Steering Group	Edinburgh	UK
R. Jeffries	Steering Group	Keele	UK
G. Micela	Steering Group	Palermo	I
I. Negueruela	Steering Group	Alicante	Sp
T. Prusti	Steering Group	ESA	ESA
H-W. Rix	Steering Group	MPIA	D
A. Vallenari	Steering Group	Padova	I

We will process all raw ESO data through the current ESO pipelines, as well as through our available special purpose pipelines. Where any potential improvements to the ESO pipelines are identified we will work with ESO to ensure these are understood and implemented for wider use.

6.1 Team members (working group leads):

The Gaia-ESO Survey project has excited such considerable enthusiasm in the European astronomical community, and contributes to such a wide range of astronomical interests, that we have over 250 confirmed active Co-I participants, with continuing requests. Current names are listed on the cover sheet.

We tabulate here the top-level data management tasks, the teams which have confirmed FTE support for those tasks, and the task coordinators. We have in place sufficient FTE effort for other survey tasks which are not data management, such as interface to Gaia, ISM analyses, production of a uniform suite of stellar atmosphere to support the spectrum analysis, and so on. We do not list those here.

Function	Contributing Groups	Coordinators
Survey Overview	Co-PIs	Gilmore, Randich (UK, I)
Management Overview	Steering Group	(see list above)
Cluster Membership Analysis	Vienna, MPIA, Palermo, Barcelona, Granada	E. Alfaro (Sp)
Auxiliary Data for Target Selection	Bologna, Vienna, Madrid, Geneva, AIP, ZAH Herts, Paris, Arcetri, Uppsala, Palermo, ROBelg	E. Paunzen (Austria)
Galactic Plane Field Selection	Paris, RUG, AIP, MSSL, Strasbourg	C. Babusiaux (Fr)
Cluster Stars Target Selection	Madrid, Arcetri, Vienna, Paris, RIT, Bologna Keele, IAC, Vilnius, Herts, Athens, RO Belg, Padova, Arcetri, Catania, Porto, Leuven, Nice, ZAH	A. Bragaglia (I)
Calibrators & Standards	Antwerp, Bologna, Madrid, Paris, MPA,	E. Pancino (I)
OB/fposs generation: Field survey Cluster survey	 Paris, ESO, Camb, Lund, AIP, ZAH Bologna, Arcetri, Padova, Palermo, IAC	 T. Bensby (Swe) E. Flaccomio (I)
Pipeline Raw Data: GIRAFFE Reduction UVES Reduction	 CASU, Keele Arcetri, Bologna	 M. Irwin (UK) Arcetri (I)
Radial Velocities	Camb, Keele, Arcetri, Antwerp, ZAH	Camb & Keele (UK)
Discrete Classification	Camb, MPIA, IAC, Madrid, MSSL, Porto, ZAH	C. Bailer-Jones (D)
GIRAFFE FGK Spectrum analysis	Paris, MPA, Lund, Uppsala, Nice, IAC, Vilnius Liege, Arcetri, Bologna, AIP, Ind, Madrid, IAA, Vienna, ESO, Rome, Porto, ZAH, Arcetri, Naples Catania, Padova	A. Recio-Blanco (Fr) & C. Allende Prieto (Sp)
UVES FGK Spectrum analysis	Paris, MPA, Lund, Uppsala, Nice, IAC, Vilnius Liege, Arcetri, Bologna, AIP, Ind, Madrid, IAA, Vienna, ESO, Naples, Porto, ZAH, Arcetri, Naples Catania, Padova	A. Korn (Swe) & R. Smiljanic (ESO)
Pre-Main Sequence Star Spectrum analysis	Madrid, Catania, Granada, Arcetri, Naples, Palermo, Zurich, Armagh	A. Lanzafame (I)
OBA Star Spectrum Analysis	Liege, RO Belg, AIP, OMA, Madrid, Paris, Armagh Uppsala, MPIA, Leuven, Herts	R. Blomme (Be)
Non-standard Objects	SRON, Nijmegen, Warwick, MPIA, Herts, ZAH, Leuven	tbc
Survey Parameter Homogenisation	all spectrum analysis groups	P. Francois (Fr)
Survey Progress Monitor	CASU	Co-PIs
Operational database	CASU/Cambridge	CASU
Survey Archive	AIP, RUG, Madrid, Vienna, ZAH, Edin	N. Hambly (UK)

6.2 Detailed responsibilities of the team: (1 page)

The Co-I teams have identified 20+FTE of dedicated effort for general survey implementation, with many more applying for future grant support, in addition to the several well-supported spectrum analysis teams. We are well aware of the realities and inefficiencies involved in a large distributed part-time team. However, the key and the time-critical tasks all have significant dedicated group effort identified. The spectrum analysis groups in particular are large and very well supported.

The tasks are distributed among working groups, each of which has membership who have confirmed their available FTE contribution of effort for a real contribution. The groups and individuals with special responsibility at task or team level are tabulated above. The tasks of the WPs are to implement the data flow, which we summarise in the section below. Most tasks are related to post-acquisition data reduction, described in the next section. The remaining key task is target selection and OB preparation.

Target identification, fposs and OB preparation Field star targets will be identified predominately from VISTA CMDs. This will be predominately VHS, with some VVV in the inner Galaxy. These data are processed and available at IoA Cambridge. [The VISTA VHS and VVV PIs are part of this project.] To ensure a stable selection function, selected potential target lists will be generated at the Cambridge CASU centre. At low latitudes in the Plane special fields are selected, using available microlensing data, and DENIS. Considerable dedicated effort is focused on optimal selection of open cluster members, using both model input and the best available detailed astrometric, multi-wavelength photometric and supplementary information. Calibration (open and globular cluster) targets are identified and will be observed. Several distributed groups are able to support fposs fibre allocation and OB generation, based on these target algorithms and data files, spreading this substantial workload viably. All OBs will be sanity checked and delivered to ESO under Co-PI responsibility.

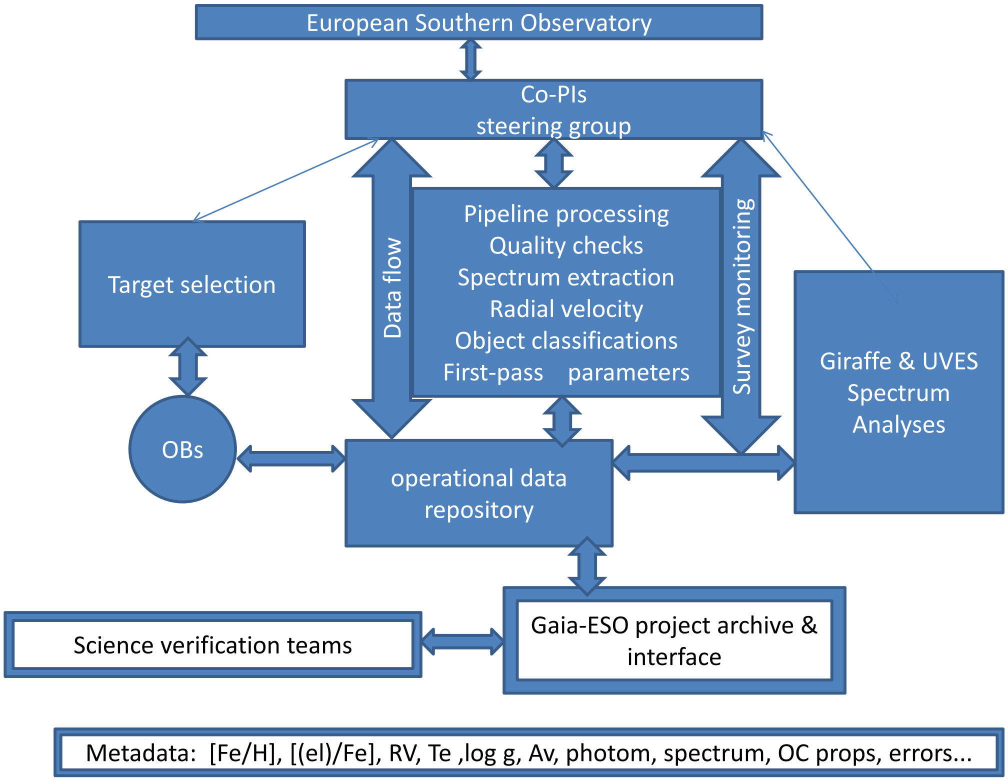

Figure 4: An overview of the Gaia-ESO Survey data flow system.

6.3 Data reduction plan: (1 page)

Target selection and OB development is described above. We consider here post-observation work.

Pipeline processing of raw data from ESO The Gaia-ESO project will utilise both an operational database and an internal archive, to hold all relevant information. Raw data are pipeline processed through the operational database, for delivery to the spectrum analysis teams. The operational database hosts the survey progress monitoring information, which is developed based on, and learning from, VISTA data reduction and monitoring experience. This keeps track of the status of all targets selected, through their several fposs allocations and GIRAFFE settings, the delivered S/N and quality flags in each, and the status of data processing and added-value product determination. This system, building on the operational VISTA (UKIDSS, etc) systems is hosted at CASU, Cambridge.

Radial velocity After pipeline processing to remove instrumental signature, we have extracted individual spectra. These are analysed (in one method, prior to extraction) to deliver radial velocities (& vsin*i* where relevant), and associated error functions, using two pipelines for GIRAFFE, one for UVES. This process generates a quality control flag, and preliminary object classification parameters.

Object classification Each spectrum, together with all its associated photometry from the target selection process, is then classified further, through dedicated systems (cross-correlation with templates, neural net, MPIA Gaia system) providing first-pass parameters for the spectrum analysis teams.

Spectrum analysis All extracted spectra are processed through general purpose pipelines, to refine astrophysical parameters, and deliver elemental abundances to a level appropriate for the relevant stellar type and available S/N. These pipelines manage, respectively, hot, warm, cool stars, as well as pre-main sequence stars, and GIRAFFE and UVES spectra. It is a strength of this Gaia-ESO Survey team that it includes a majority of Europe's spectrum analysis groups, which between them have available expertise in many complementary and special-purpose methodologies. All have agreed to adopt a fixed set of atomic data and model atmospheres for the analysis of FGK stars, and to optimise their local expertise appropriately. Very considerable coordination between the teams has been underway for some months. They are already operating as a coherent community. This range of analysis excellence will be applied to the various stellar and data types as appropriate. Sanity checking will then deliver, for each star target, a "best" set of parameters and abundances, with corresponding random and systematic errors, and an explicit analysis of the effect of alternative analysis assumptions. All these results will be archived for later analysis, both in the operational database, and the Survey archive.

Survey archive After abundance determination, the data are available for quality control, science verification, and preliminary analysis, by the survey team. This access and set of processes will be managed through an internal archive. This archive, building on expertise at AIP, Edinburgh and Madrid, will be VO compliant, and will serve the survey team with both survey and other available data (see details in Sect. 6.4).

Quality control, Calibration, Verification The reduced data will be sanity checked, the calibration targets analysed, errors assessed and verified. The output first-pass deliverables will now be available for internal Gaia-ESO science verification, and quick-look analysis. Following this process, checked deliverable data products will be returned to the archive and the operational database, and prepared for delivery to ESO.

Deliverable delivery The internal archive centre ensures all deliverables are appropriately formatted for ESO use, and documented. Following the agreed schedule, and Co-PI sign-off, value-added data are released to ESO, and to the Gaia-ESO Survey Co-Is for analysis.

6.4 Expected data products: (2 pages)

The survey will yield GIRAFFE/UVES spectra for $\simeq 10^5$ stars, a large fraction of which observed at two different epochs. Raw data will automatically be public. The products that we will deliver include both basic data, along with some ancillary information, and value added deliverables.
Regular data releases to ESO will include, for all targets with completed observations:

reduced, wavelength calibrated 1D spectra
the photometry (and additional membership information for the clusters) used to select the targets
open cluster relevant data (e.g. distance, age) and star identifications
object classification (for field stars)
radial velocity and error estimate
projected rotational velocity and error estimate (where relevant)

We aspire to three value added data-releases (equivalent to the EDPs in VISTA surveys) during the time of the project, including the final data-release. These will include a refined and expanded spectral analysis for all stars observed in earlier semesters where applicable, delivering,

for stars observed with GIRAFFE:
stellar astrophysical parameters: effective temperature, surface gravity
equivalent widths of absorption and emission lines (when present)
typically, stellar metallicity [Fe/H]
whenever possible [alpha/Fe]
lithium abundances for solar-type and cool stars in clusters
robustly determined errors on all parameters
measurements of chromosperic activity or accretion, for cluster members (where relevant)
quantitative mass loss estimates, for early-type stars
The GIRAFFE spectra should allow measurement of Mg, Ca, Ti and Fe for the majority of the F-G-K stars. For Bulge K giants also Si, Cr, Mn, Co and Ni, and possibly other elements, should be measurable.

for stars observed with UVES:
stellar parameters derived from the spectra
robustly determined errors on all parameters
elemental abundance estimates for some or all of the following elements (where stellar abundance and astrophysical parameters permit):
C, O, Na, Mg, Si, Ca, Sc, Ti, Cr, Mn, Fe, Ni, Zn, Y, Zr, Ba, La, Ce, Eu

We will also include selected matched multi-wavelength data for each source. The amount of such data will increase in volume with time during the survey as various on-going surveys will become public.

For the final data-release we will include all of the above for all stars. Aspirational date for this release is 18-24 months after completion of the observations. The final data release will include best values for all deliverables listed above. In addition, it will include

for open cluster members:
refined radial velocity for cluster members
average radial velocity for the cluster
refined membership classification
binarity flags
cluster mean metallicity determinations
cluster mean elemental abundances and dispersions (or limits).

Errors *Radial and rotational velocities*: the accuracy in radial velocity for cool cluster stars will be better than ~ 0.5 km/s for GIRAFFE spectra and than 0.1 km/s for stars observed with UVES (e.g., Jackson & Jeffries, 2010, MNRAS, 407). Similar accuracies will be obtained for K stars in the bulge, while for warmer, more metal poor targets in the halo and thick disk accuracies of the order of 1km/s will be obtained (Koposov, Gilmore etal 2011 ApJ in press). Typical uncertainties in $v\sin i$ will be of the order of 10 %.
Stellar parameters and elemental abundances A key strength of our consortium is the inclusion of many of the leading teams within Europe that work on elemental abundance determinations both in cool as well as in hot stars. Additionally, these groups are willing to put their own methodologies to the test in order for the consortium to provide very robust estimates of both systematic as well as random errors for both stellar parameters as well as elemental abundances.
Realistic typical errors for stellar parameters and abundances derived for the UVES spectra, given our data quality and complementary photometry, are delta(Teff) $\simeq$ 100K, delta(logg) $\simeq 0.2$, delta([Fe/H]) $\simeq 0.1$ and delta([X/Fe]) $\simeq 0.1$. Obviously the uncertainties will vary quite significantly from star to star and element to element but these should be typical values. The GIRAFFE errors will typically be $\simeq 0.15$ for [Fe/H] and [X/Fe], and $\simeq 0.1 - 0.3$ for [Li]. Cluster mean values much smaller, of course.

Data products in the Gaia context: The first results from the Gaia mission are expected in 2016 and the full catalogue is planned for publication in 2021. Even the first Gaia parallaxes will deliver vastly better determinations of the distances for most stars. Combining Gaia-ESO spectroscopic and Gaia data will refine the determination of stellar parameters, gravity in particular, for all our targets, enabling much improved internal precision. A primary motivation is determination of stellar ages, using calibrated stellar models (see below) for turn-off and sub-giant stars; this will provide for the first time a detailed and reliable chemical element-dynamics-age map for a significant portion of the Galaxy. The quality of kinematics as well as the ages based on the Gaia data will be unprecedented. Combined with the high-quality abundances provided through the Gaia-ESO survey provides a unique data-set.

The combined Gaia and spectroscopic data set for the clusters will allow calibration of stellar evolutionary models, which will allow determination of ages and masses and will impact upon a number of fundamental issues, e.g., the shape of the initial mass function and its universality; the timescale of star formation and star formation histories; the 'initial mass' to 'final mass' relation for white dwarfs etc. With these future ambitions in mind, we will ensure that the information content of all the data we deliver to ESO, as well as any additional data products provided through the Virtual Observatory, will be such that a full update of the analysis based on the Gaia data will be possible.

Additional legacy value: The Gaia-ESO survey will provide a spectroscopic dataset which will be unique due to the combination of number of measured chemical elements, survey depth, and the number and type of stars, from the metal poor old halo stars, to cool M dwarf members of young clusters.

For this reason, besides allowing us to address the top-level goals described in Sect. 2, this VLT survey delivers data of primary interest at many different levels to many communities,in addition to the 250+ researchers involved in this proposal. The data will support a wide variety of studies of stellar populations, the evolution of dynamical systems, and stellar evolution, along with detailed investigation of peculiar objects. We will detect objects such as VMPs, BHBs, WDs, CVs, dCs, emission line and high velocity stars, even compact galaxies, some QSOs. Large numbers of spectroscopic binaries will also be found. More generically useful data will also be achievable. For example, we aim to provide full 3D tomography of the local ISM, based on analysis of line of sight extinction, using of the order of 10^4 lines-of-sight.
Homogeneous determination of radial velocities, abundances, and stellar characteristics for such a large sample of clusters and cluster members represents a standalone unique dataset, that will allow the community to investigate a variety of outstanding topics. These include the still poorly-known mass accretion from the circumstellar disc onto young pre-main sequence stars, triggered star formation scenarios, binary fraction as a function of mass and cluster environment, use of lithium both as an age tracer and for a detailed investigation of internal mixing processes in stars, tracing of the local velocity field and the Galactic rotation curve. Available spectra of cleaned cluster sequences for clusters of different metallicities (in particular the metal-rich ones) will be of interest to the extragalactic community, allowing population studies in complex systems.

6.5 General schedule of the project: (1 page)

We anticipate approximately constant allocations (500H) each semester from P88 to P93. Our fields show some bias towards the RA range 15H to 20H, where the Galactic Plane runs north, but are overall fairly well distributed.

The data products delivered from the ESO-Gaia survey will be made public in three steps/categories. We will agree with ESO the exact timetable and content of these deliverables in the Survey Management Plan, with a goal to ensure we avoid major deliveries of OB and data products at the same times. Our ambitious aspiration involves:

- half-yearly deliveries to ESO of reduced data, target selection information, and first-pass astrophysical parameters, including accurate velocities and uncertainties, for all targets for which data collection is completed;
- these half-yearly data releases to occur one year following complete collection and delivery to the consortium of raw data for each included target ($t_0 + 13$months?);
- annual data releases to ESO of value added data products, including chemical abundances, complementary data as appropriate, and uncertainties, for all targets for which data collection is completed;
- annual data releases to start as for the half-yearly releases, at ($t_0 + 15$months?)
- a final data release, involving the full determinable set of astrophysical parameters for each individual target, and for the open clusters as systems, as specified above.
- the final data release to be no later than 24 months following final data taking
- in addition, we aspire to make available other value added products on a best-efforts basis, for release through standard VO access centres (eg CDS). These additional products will include parameters such as the line-of-sight extinction towards a target where determinable.

7 Envisaged follow-up: (1 page)

It is clear that the Gaia-ESO survey will discover many rare and extreme objects, meriting considerable follow-up, including extreme abundances, velocities, phase-space sub-structure, among very much more. Nonetheless, we do not request special access to follow-up for the Gaia-ESO team. All follow-up will be applied for competitively.

8 Other remarks, if any: (1 page)

The big themes in European astronomy require both space and ground based observations. To maximize the scientific output it is necessary to coordinate the efforts. ESO and ESA have recognized this coordination necessity in various topics which can and must be addressed both from the ground and in space. Joint working groups have been nominated for selected topics and the fourth such group was central to this proposal. This ESA-ESO working group (chaired by Catherine Turon) addressed the topic of "Galactic Populations, Chemistry and Dynamics". The report of the working group was published 2008 and remains up to date today. Many recommendations out of that study are of relevance to this proposal, but the key ones can be summarized in two words covering both space and ground: Gaia and spectroscopy. Gaia is being integrated for launch in 2013 and this public survey is aiming to start fulfilling the spectroscopic needs for our Milky Way. The planned spectroscopic data products will all be available to the community roughly in the same time frame as the first intermediate Gaia catalogue. This allows the European scientific community to address a multitude of galactic astronomy topics with the combined spectroscopic and Gaia data set.