The GES-CoRoT collaboration

First Results

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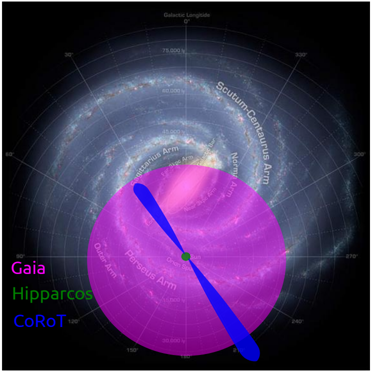
Gaia-ESO Survey

The GES aims to systematically cover all the major components of the Milky Way, providing the first homogeneous overview of the distributions of kinematics and elemental abundances.



- Thin and thick disk
- Halo
- Bulge
- Open Clusters (+GC)
- Very well defined selection criteria
- Homogeneity in kinematics and abundances

The Gaia-ESO Survey

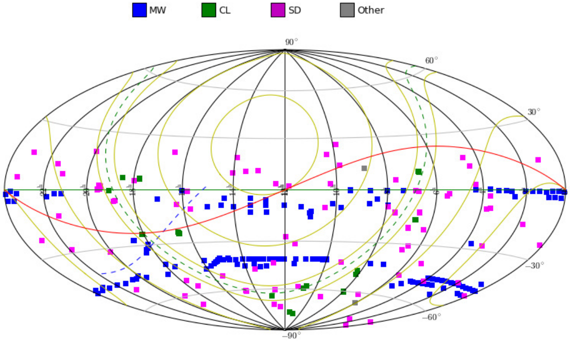
GES is a public spectroscopic survey of $\sim$ 100,000 stars.

Support of the ESA Gaia astrometric satellite, but will have numerous other uses.

- co-PIs: G. Gilmore (Cambridge) and S. Randich (Arcetri)
- $\sim$ 400 Co-Is from $\sim$ 90 Institutes across all ESO
- 19 WGs
- Stars are observed using the FLAMES spectrograph on the ESO VLT, UVES (3 setups) and GIRAFFE (8 setups) in parallels, at Paranal in Chile. UVES: 5,000 field stars and 2000 OC members. Accurate radial velocities and atmospheric parameters, plus detailed abundances of V, Cr, Mn, Fe, Co and α elements (Si, Ca, Ti). GIRAFFE: accurate radial velocities and atmospheric parameters. [Fe/H] and $[\alpha/Fe]$ + some element (Ca, Li)

Gaia-ESO Survey

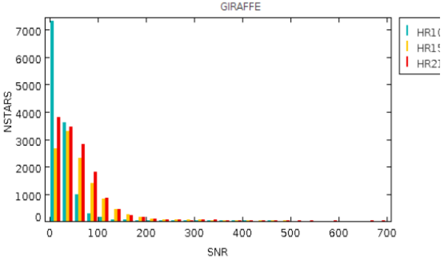
Stars are observed using the FLAMES spectrograph on the ESO VLT, in both FLAMES and UVES setups, at Paranal in Chile.



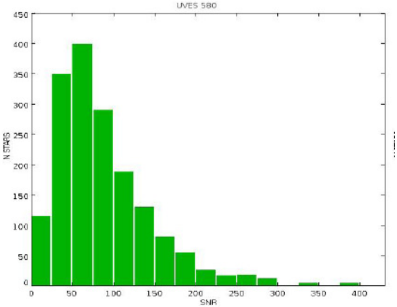
Status of the survey April 2014

Gaia-ESO Survey

SNR of spectra



SNR Giraffe spectra



SNR UVESspectra

Gaia-ESO Survey Aims

So far some of the most important GES aims are:

- Delivery of homegeneus atmospheric parameters, results of the effort and synchronization of more that 90 different nodes
- Creation of a benchmark catalogue of stars (Jofre et al.2014) suitable for Gaia
- Investigation of the major properties of the MW disks: matallicity gradients, etc (Recio Blanco et al 2013, Bergemann et al 2014)
- Integration of Asteroseismology in the calibration process and in the sample for investigatingMW archaeology

Galactic Archaeology

Some of the most important ingredients for investigating our Galaxy are:

1. Accurate element abundances
2. Accurate ages
3. Accurate distances

Solar like oscillating giants

What happens when combining asteroseismology with spectroscopic informations in a big survey?

1. Accurate element abundances → ASTEROSEISMOLOGY!!
2. Accurate ages + evolutionary status → ASTEROSEISMOLOGY!!
3. Accurate distances → ASTEROSEISMOLOGY!! (waiting for Gaia...)

Solar like oscillating giants are observed by ongoing surveys: GES, APOGEE, HERMES, RAVE, ...

Distances

Starting from the scaling equations it is possible to derive distance (i.e. Miglio et al. 2013) upto10 kpc:

- R from asteroseismology + Teff $\rightarrow$ L
- Apparent magnitude + Bol. Corrections + Extinction $\rightarrow$ l
- $d^2 \ \alpha \ \frac{L}{l}$
- uncertainty 10-15% (up to 5% with high quality data)

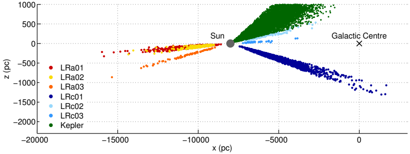
$$\log d = 1 + 2.5 \log \frac{T_{\rm eff}}{T_{\rm eff,\odot}} + \log \frac{\nu_{\rm max}}{\nu_{\rm max,\odot}} + \quad (1)$$

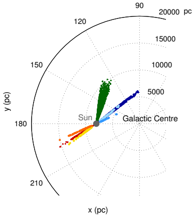
$$-2 \log \frac{\Delta\nu}{\Delta\nu_{\odot}} + 0.2(m_{\rm bol} - M_{\rm bol,\odot}), \quad (2)$$

d is expressed in pc, $m_{\rm bol}$= apparent bolometric magnitude, $M_{\rm bol,\odot}$= absolute solar bolometric magnitude.

Distances

From the radius determination it is possible to derive distance (i.e. Miglio, Chiappini, Morel et al. 2013):

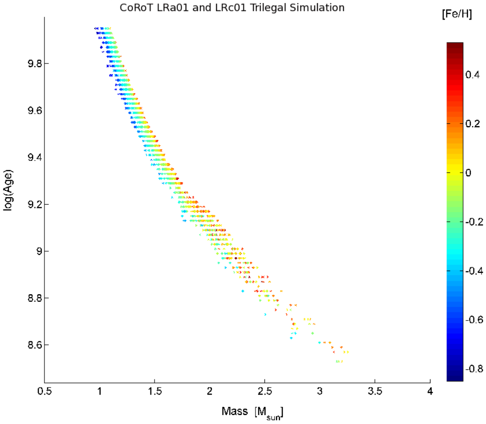




Ages

Mass + [Fe/H]→ Age (Miglio 2012). Reduced uncertainty when the evolutionary status is known.

MODEL DEPENDENT!!



Seismic log(g)

From the scaling relations it is possible to derive log(g).

$$\log g = \log g_{\odot} + \log\left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right) + \frac{1}{2}\log\left(\frac{T_{\rm eff}}{\mathrm{T}_{\rm eff,\odot}}\right). \quad (3)$$

- Weak dependence on Teff (Δ *Teff* of 200K $\rightarrow \Delta$ log(g) of 0.02 dex)
- High precision: uncertainty of $\sim$ 0.03 dex
- By fixing the surface gravity to the seismic value we increased the precision of the atmospheric parameters and abundances. UVES-GES: σ Teff = 40 K and σ[Fe/H] = 0.05 dex

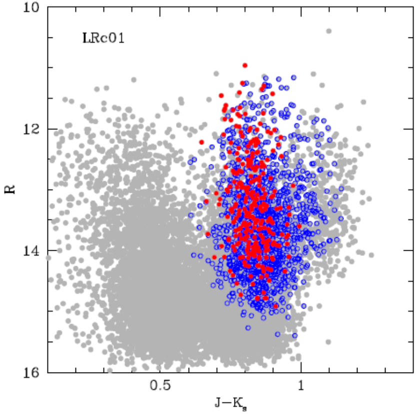
Conclusions for asteroseismology

Asteroseismology of Red Giants is a really useful tool for surveys:

- Improved ages (+ ev.status)
- Distances with an error of 10%
- Calibration sample for log(g), error of 0.03 dex
- A big sample: 20,000 RG stars from Kepler and CoRoT

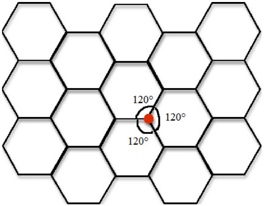
CoRoT-GES

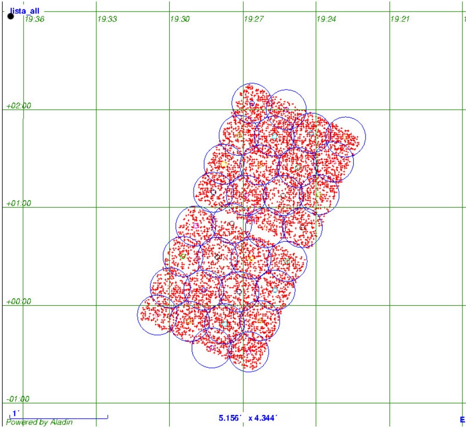
The CoRoT-GEScollaboration started in 2013. The CoRoT-RG group provided to GES a sampleof ∼ 1400 giants which present solarlike oscillations, plus a sample of photometrically selected giants (fiber filling) fora total of ∼5500 red giants candidates.



The LRc01 field

LRc01 field is 1 x 2.5 deg, FLAMES instrumental FOV is 25 arcmin. For covering the biggest number of targets we adopted an exagonal tessellation.

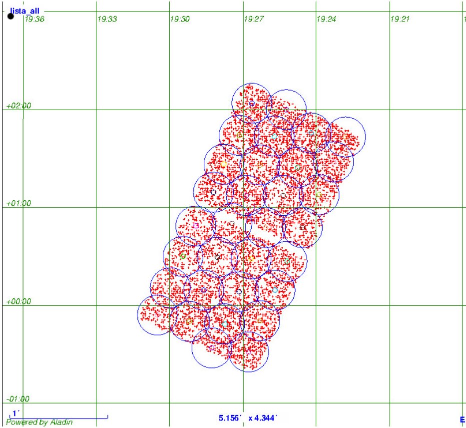




Status of observations

So far GES observed 13 field.

- UVES 55 targets with a SNR $\sim$ 100
- GIRAFFE: 1133 targets with SNR $\sim$ 50 (HR21, HR15N, HR10)

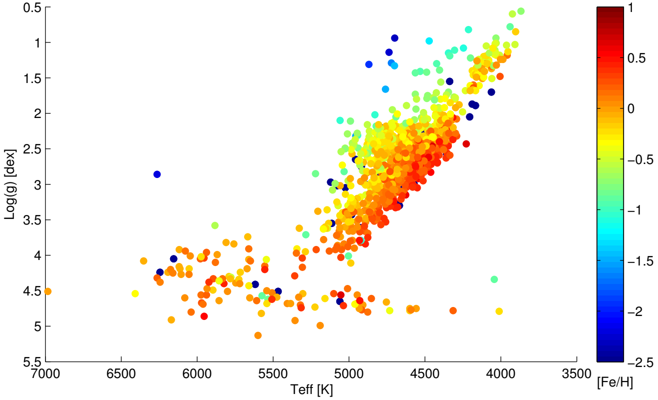


Data from spectroscopy

- more precise atmospheric parameters derived by fixing the log(g) to theseismic value
- GIRAFFE : Fe, Ti, Ca, Si, Mg, Mn, Co, Cr, Ni, V, Y, Zr, Li.
- UVES: alpha elements (O, Mg, Si, Ca, Ti), s-elements (Ba and Y), iron peak elements (Fe, Ni, Mn, Cr), and also Na, Al and Li. C CH C2 Swan (0,1) band head (very high SNR).

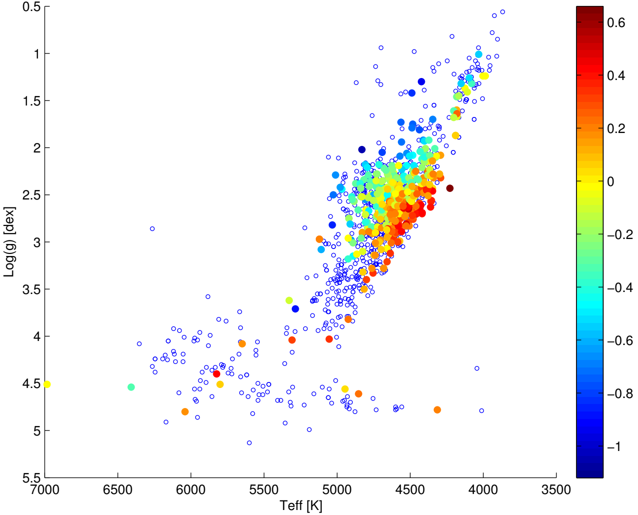
CoRoT stars in GES-DR2

First results for the CoRoT-GES DR2 - ∼1200 stars



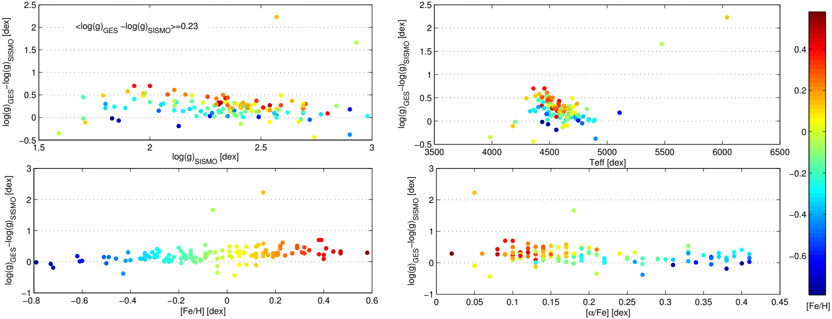
CoRoT stars in GES-DR2

First results for the CoRoT-GES DR2 -sismo for ∼500 objects



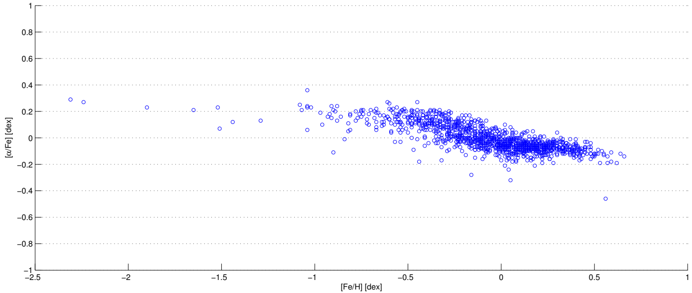
CoRoT stars in GES-DR2

Comparison of the homogeneized results with seismic log(g)



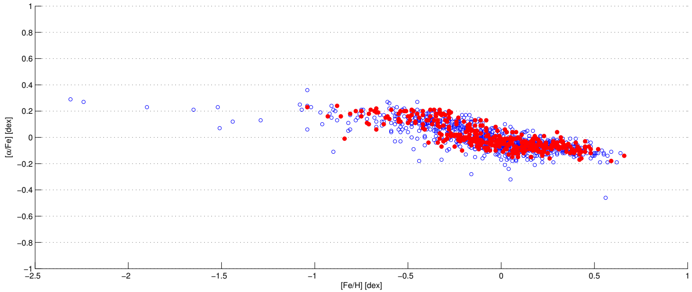
CoRoT stars in GES-DR2

First results for the CoRoT-GES DR2



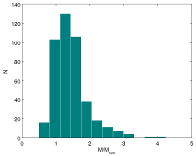
CoRoT stars in GES-DR2

First results for the CoRoT-GES DR2 - sismo available

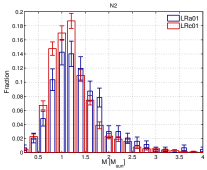


CoRoT stars in GES-DR2

Mass distribution (from scaling relation)

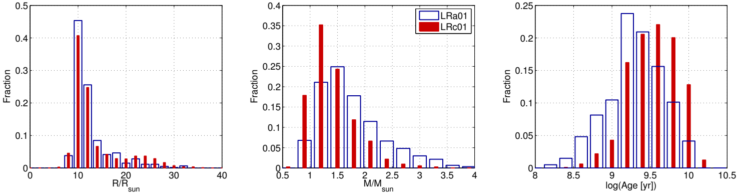


CoRoT-GES LRC01



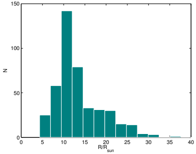
Miglio et al. 2013

TRILEGAL

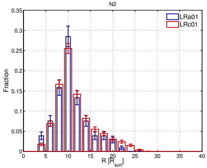


CoRoT stars in GES-DR2

Radius distribution (from scaling relation)

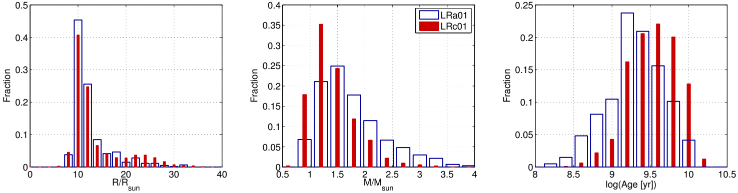


CoRoT-GES LRC01



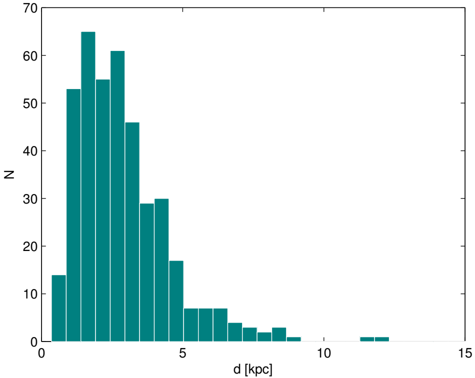
Miglio et al. 2013

TRILEGAL



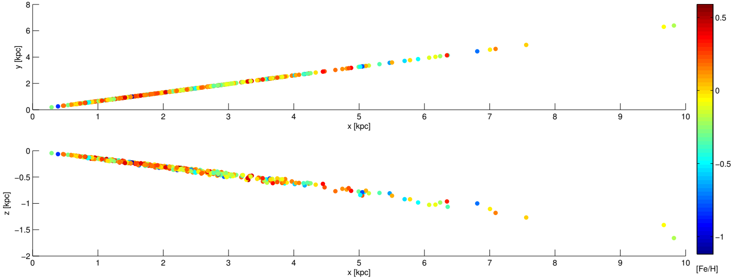
CoRoT stars in GES-DR2

Distances distribution



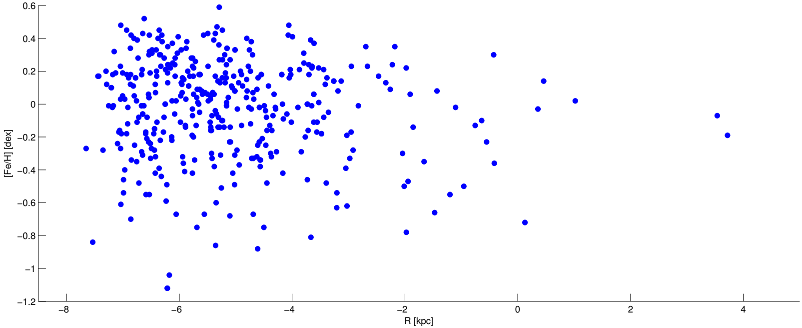
CoRoT stars in GES-DR2

Spatial distribution



CoRoT stars in GES-DR2

R vs [Fe/H]



CoRoT stars in GES-DR2

Projects on Galactic Archaeology

Project: Galactic archaeology: mapping and dating stellar populations by combining CoRoT asteroseismology of red giants with GES s

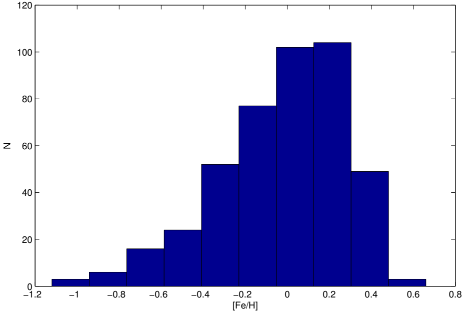
Proposers: M. Valentini, C. Chiappini, J. Montalban, A. Miglio, T. Morel and the CoRoT Red Giants group

Our understanding of the formation and evolution of the Galaxy is severely hampered by the lack of precise constraints on basic stellar p ages. Solar-like pulsating red giants represent a well-populated class of accurate distance indicators, spanning a large age range, whic disc. Using the new technique of Asteroseismology we have determined precise distances for ~2000 CoRoT space telescope stars spr disk (Miglio et al. 2013). GES performed an observational follow up of about ~1100 CoRoT RG stars towards the inner Galaxy, ~1000 c at high resolution with UVES. The subset of red giants observed with UVES are those for which it was possible to constrain their evolut sample we aim to abundances of elements (e.g. Li, Na, C) which are crucial to characterize internal mixing processes in giant stars. A b the red-giant phase will also be beneficial to our understanding of Galactic chemical enrichment, and to the interpretation of chemical al different populations. By complementing this highly strategic sample with chemo-dynamical constraints from GES spectroscopic analys ages, providing a gold standard for current and future surveys of the Milky Way.

Interested in joining this project: R. Smiljanic, G. Tautvaisiene, A. Drazdauskas, E. Stonkute, Šarūnas Mikolaitis

CoRoT stars in GES-DR2

Metallicity distribution of stars with seismic data



Conclusions

Asteroseismology is a powerful tool for deriving precise and accurate AGES, DISTANCES and ABUNDANCES.

- GES is observinga sample of ∼2000 CoRoT giants of LRc01
- Calibrations and homogeneization process (ongoing)
- Projects on Gal.Archaeology (M,R, Ages derived taking into account met.)
- Kepler: GES targets included in the Kepler K2 target list

The scaling relations

Thanks to two simple scaling equations these observables provide a DIRECT estimate of the Mass and Radius of the star:

$$\frac{M}{M_\odot} \simeq \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)^3 \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4} \left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)^{3/2} \quad (4)$$

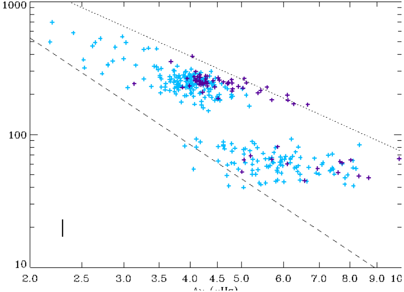
$$\frac{R}{R_\odot} \simeq \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right) \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-2} \left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)^{1/2} . \quad (5)$$

- Uncertainty on M $\sim$ 10%
- Uncertainty on R $\sim$ 3%
- Tests ongoing: interferometry (Huber et al. 2012); Hipparcos parallaxes (Silva Aguirre et al. 2012); OC NGC6791 (i.e. Miglio et al. 2012 and Sandquist et al.2013), eclipsing binaries, etc

Evolutionary status

Thanks to asteroseismology it is now possible to distinguish H-shell burning stars from those that are also burning He in the core.
Mosser et al 2011: CoRoT data (period separation of mixed modes vs $\Delta\nu$).

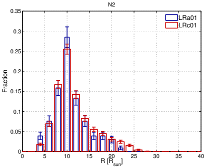
Unknown details of stellar evolution and structure!

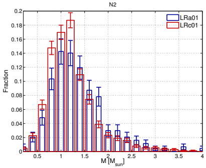


* Good quality light curves

Ages

Differences in mass and radius distributions in the two CoRoT fields are mainly due to the vertical gradient in the distribution of stellar masses (hence ages) in the disc (comparison with predictions of synthetic models of the Milky Way -TRILEGAL) - Miglio et. al 2013





TRILEGAL