The Gaia-ESO Spectroscopic Survey

Survey Co-PIs

Gerry Gilmore
(IoA, Cambridge)
&
Sofia Randich
(INAF/Arcetri)

>300 CoIs

The Gaia-ESO Public Spectroscopic Survey

Gerry Gilmore[1,*]
Sofia Randich[2,*]
Martin Asplund[3,+]
James Binney[4,+]
Piercarlo Bonifacio[5,+]
Janet Drew[6,+]
Sophia Feltzing[7,+]
Annette Ferguson[8,+]
Rob Jeffries[9,+]
Giusi Micela[10,+]
Ignacio Negueruela[11,+]
Timo Prusti[12,+]
Hans-Walter Rix[13,+]
Antonella Vallenari[14,+]
Emilio Alfaro[15,‡]
Carlos Allende-Prieto[16,‡]
Carine Babusiaux[5,‡]
Thomas Bensby[7,‡]
Ronny Blomme[17,‡]
Angela Bragaglia[18,‡]
Ettore Flaccomio[10,‡]
Patrick François[5,‡]
Mike Irwin[1,‡]
Sergey Koposov[1,‡]
Andreas Korn[19,‡]
Alessandro Lanzafame[20,‡]
Elena Pancino[17,‡]
Ernst Paunzen[21,‡]
Alejandra Recio-Blanco[22,‡]
Giuseppe Sacco[2,‡]
Rodolfo Smiljanic[23,‡]
Sophie Van Eck[24,‡]
Nicholas Walton[1,‡]

1 Institute of Astronomy, University of Cambridge, United Kingdom
2 INAF–Osservatorio Astrofisico di Arcetri, Italy
3 Mount Stromlo Observatory, Australian National University, Canberra, Australia
4 Dept. of Theoretical Physics, University of Oxford, United Kingdom
5 GEPI, Observatoire de Paris, France
6 Centre for Astronomy Research, University of Hertfordshire, United Kingdom
7 Lund Observatory, Sweden
8 Institute for Astronomy, University of Edinburgh, United Kingdom
9 Astrophysics Group, University of Keele, United Kingdom
10 INAF–Osservatorio Astronomico di Palermo, Italy
11 Departamento de Física, Universidad de Alicante, Spain
12 ESTEC, ESA, the Netherlands
13 Max-Planck Institut für Astronomy, Heidelberg, Germany
14 INAF–Osservatorio di Padova, Italy
15 Instituto de Astrofísica de Andalucía-CSIC, Granada, Spain
16 Istituto Astrofísica de Canarias, Tenerife, Spain
17 Royal Observatory of Belgium, Brussels, Belgium
18 INAF–Osservatorio di Bologna, Italy
19 Dept. of Physics and Astronomy, University of Uppsala, Sweden
20 Dipartimento di Fisica e Astronomia, Università di Catania, Italy
21 Institut für Astronomie, Universität Wien, Austria
22 Observatoire de la Côte d'Azur, Nice, France
23 ESO
24 Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, Belgium
* Co-PI
+ Steering Committee member
‡ Working Group coordinator

The Gaia-ESO Survey Team
Co-PIs: G. Gilmore[1], S. Randich[2]

Gaia-ESO survey – context and motivations

(conclusions and key words of several talks)

- Chemistry **and** kinematics
- Ages
- Large (spectroscopic) datasets
- Uniform analysis (also across different populations)

GAIA + GB SPECTROSCOPY

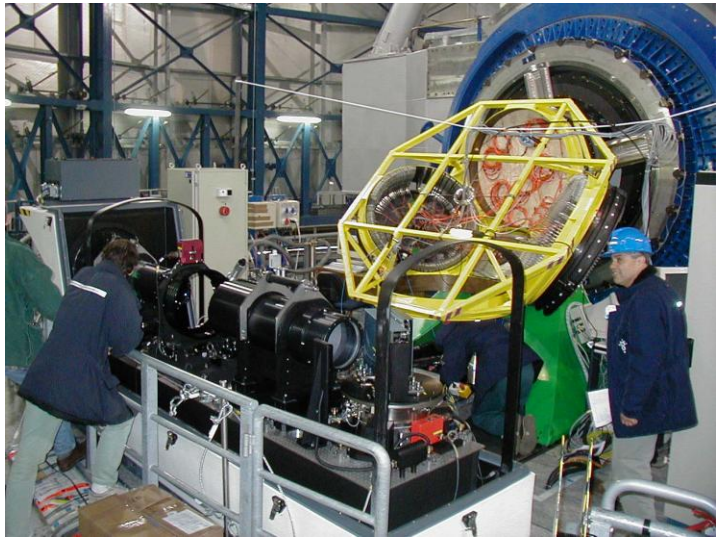
OUTLINE

- Survey overview
- Survey data products
- Core science
- Targets and strategy
- First light, spectra, “results”

Gaia-ESO survey (GES) overview (1)

- **Public** large spectroscopic survey with FLAMES@VLT
- Proposal approved in 6/2011, SMP in 10/2011, contract with DG signed in 2/2012
- **300 (240+60) nights** (30n/semester) over **5 (4+1) years**; start 12/2011 (P88), end 9/2016 (P97)++; visitor mode
- **All populations of the MW:** Halo; Bulge; Thick & Thin discs; open clusters and associations

Gaia-ESO survey overview (2)



Giraffe (130 fibers)
for faint targets (V<19)

UVES (8 fibers)
for 'bright' stars (V<16.5)

- **>10^5 Giraffe** spectra (R~16,000-25,000)
  → RVs, APs, [Fe/H], [X/Fe], stellar properties
- >**10^4 UVES** spectra (R~47,000)
  → precise multi element abundances
- + **ESO archive** exploitation/re-analysis

Survey data products

- 1D, λ calibrated, sky-subtracted spectra
- Radial and rotational velocities
- APs: T_{eff}, log g
- [Fe/H], [α/Fe], [X/Fe] (Li, C, O, Na, Mg, ..Ni, ..Ba, Y.)
- Average RV, [Fe/H], [X/Fe] for the clusters
- Stellar properties: e.g, accretion rates, mass loss
- Photometry used to select the targets
- Semester, annual, and final data releases
- First releases: 01/2013 and 06/2012

CORE SCIENCE

The formation and evolution of the MW and its component stars and stellar pops.

- The (dynamical) evolution of clusters: from birth to disruption
- Stellar evolution (ages, masses)
- Halo substructure, Dark Matter, Extreme stars (very low metallicity)
- Nature and formation of the bulge
- Formation and ev. of the thick and thin discs (field stars and clusters)

SAMPLE AND STRATEGY

What samples – 1. Field stars

GIRAFFE

- **Bulge:** mostly giant stars (clump and RGB), I=15
- **Halo /thick disc:** FG TO stars (17 < r < 18); giants in known streams, predominantly NGC and SGC
- **Thin disc** –only RVs for dynamics; I<19

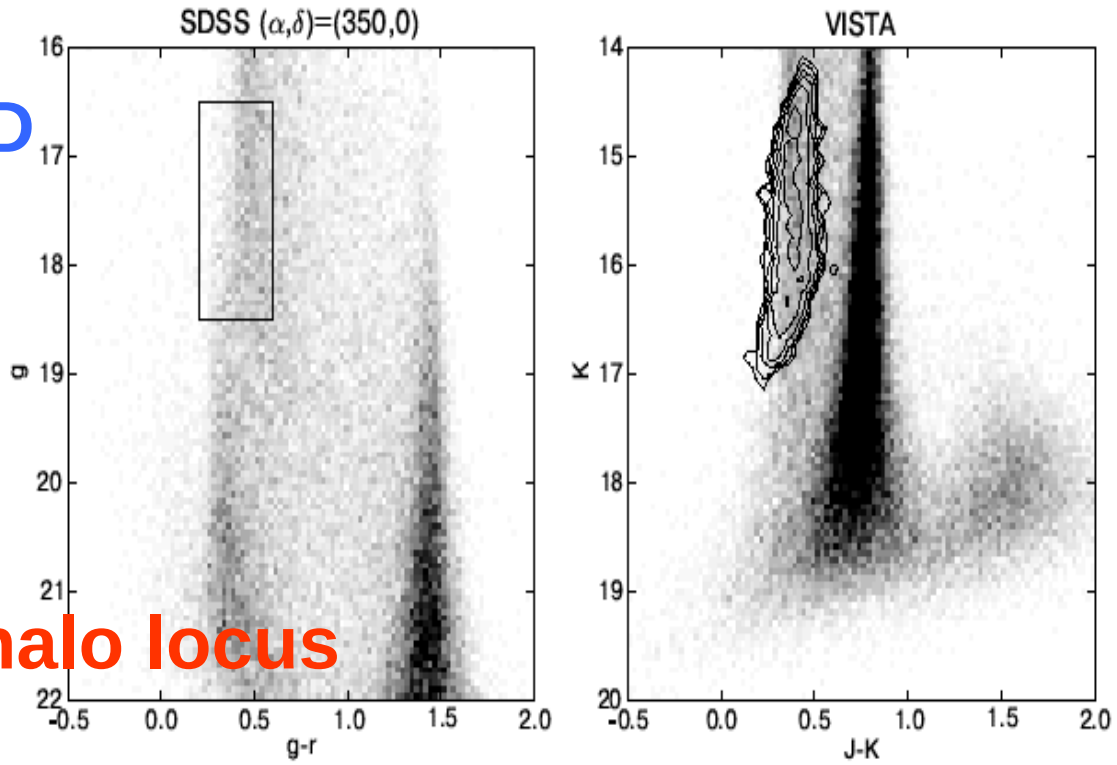
UVES parallel

- **Solar neighborhood:** complete unbiased 5000-star sample. Look at Mv~5.5, ➔ unbiased survey to 1kpc at V=15. Plus subgiants...
  At V=15, survey 2000 thin disk, 2000 thick disk, 1000+ halo

What samples – 1. Field stars

Selection based on CMDs using VISTA+ SDSS

Fix a box in the CMD with thick disc and halo turnoff



Select thick disk/halo locus

Implement in VHS

What samples – 2. Open Clusters

PMS clusters
(10-100 Myr)

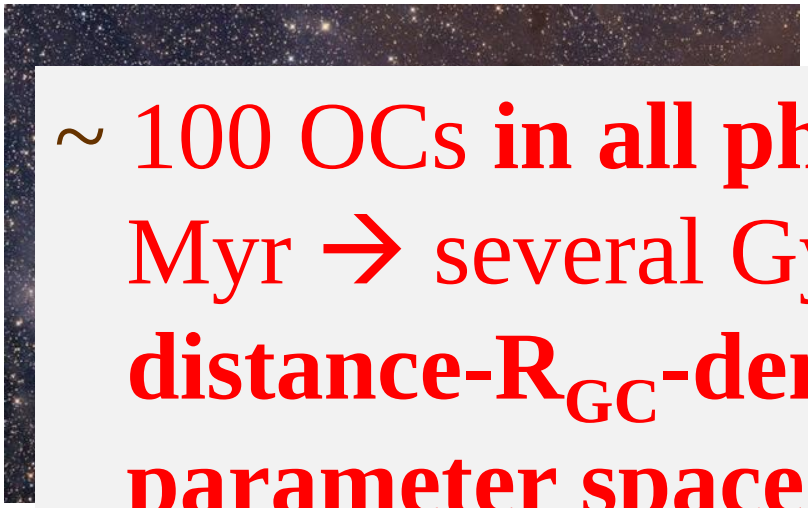
Very young clusters,
star forming regions,
associations

Intermediate-age
and old clusters
(100 Myr – 8 Gyr)

Nearby (< 1.5 kpc) and distant

Relevant populations covered

What samples – 2. Open Clusters



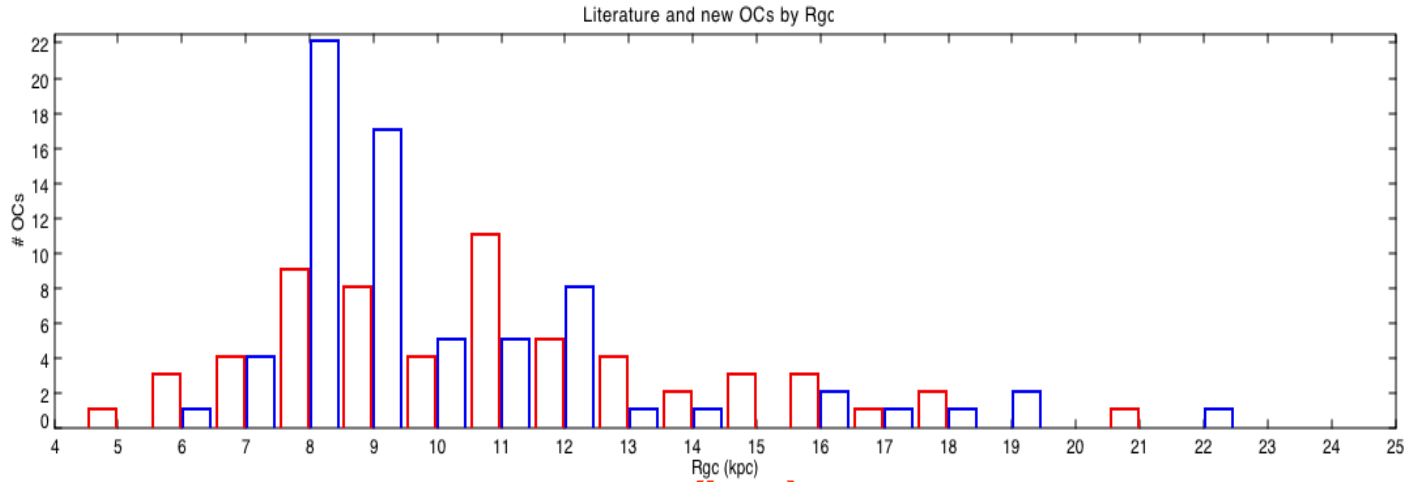
~ 100 OCs **in all phases of evolution** (~1 Myr → several Gyr), sampling the a**ge-distance-R_{GC}-density-mass-metallicity parameter space**

OB type stars → M dwarfs

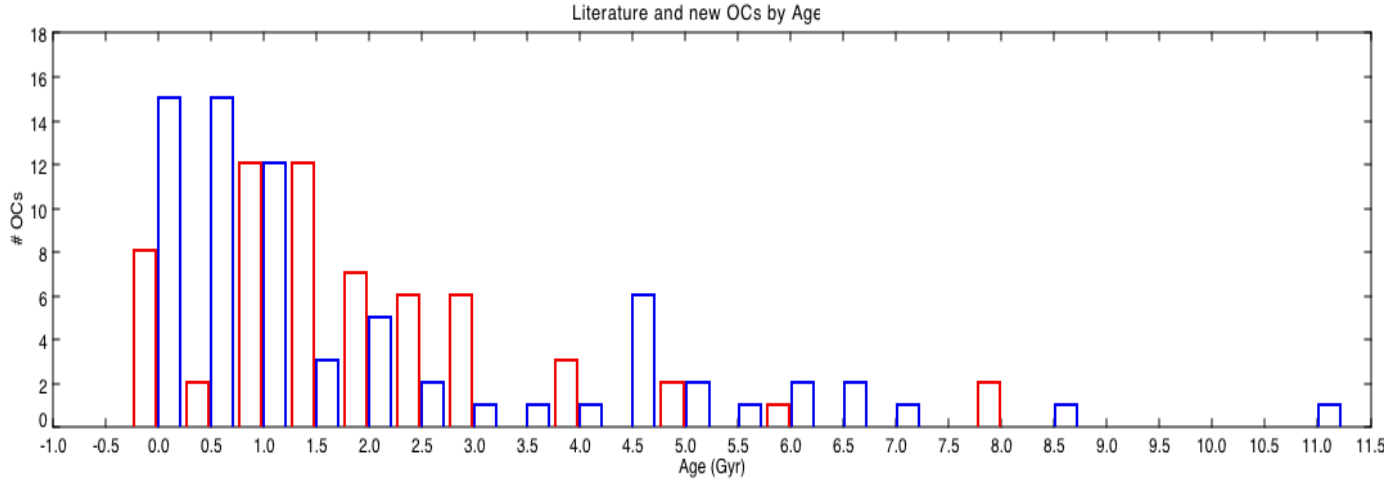
plus evolved stars (mostly clump giants)

Relevant populations covered

OCs in the Gaia-ESO survey



Rgc (kpc)



Age (Gyr)

GES

Literature

What samples/stars. 3 –calibration fields

- RV standards
- (Gaia) Benchmark stars
- COROT fields
- Targets observed by other surveys (e.g. Apogee)
- COROT fields
- Well studied open & globular clusters

Set-ups and spectral ranges

- **UVES:** CD3 -520/580 (416-617/475-678 nm) for hot/cool stars
- **Giraffe:** *Cluster/field stars:*

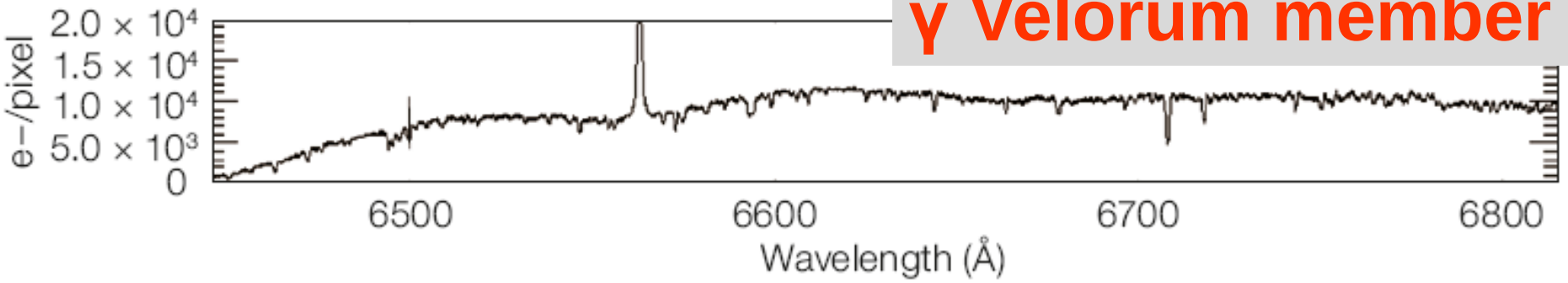
→ HR03/05A /06/09B/14A (403-476, 514-536, 631- 670 nm) for hot (down to A-type) stars: H lines, Si IV, He I, O II,…

→ HR10/15N/21 (534-562; 647-679; 848.4-900) for cool stars: Teff/gravity indicators, Hα, Li, Fe I and II lines, Ca IR triplet, a few other el. lines;

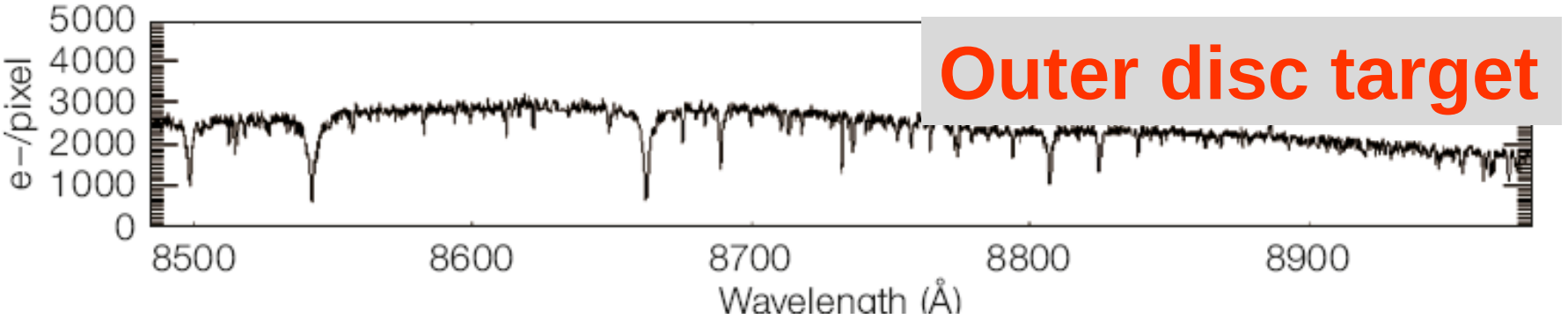
Observations

- ✓ First light: Dec. 31 2011-Jan 5 2012
- ✓ Another five runs carried out (30 nights in total)
- ✓ Five clusters completed covering different characteristics
- ✓ Several MW fields –thick disc, bulge

First spectra -Giraffe

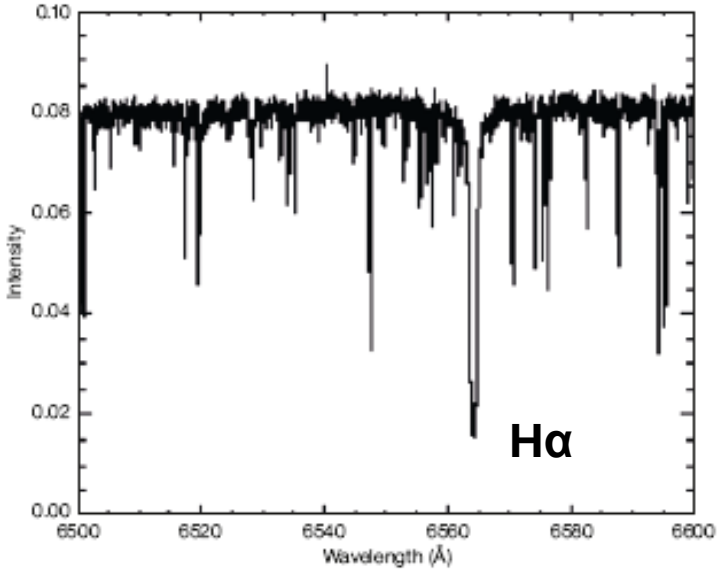


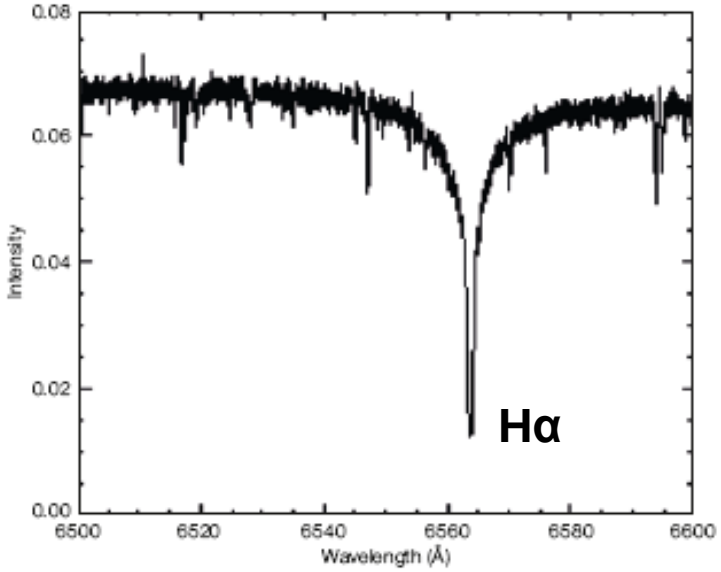
HR15N

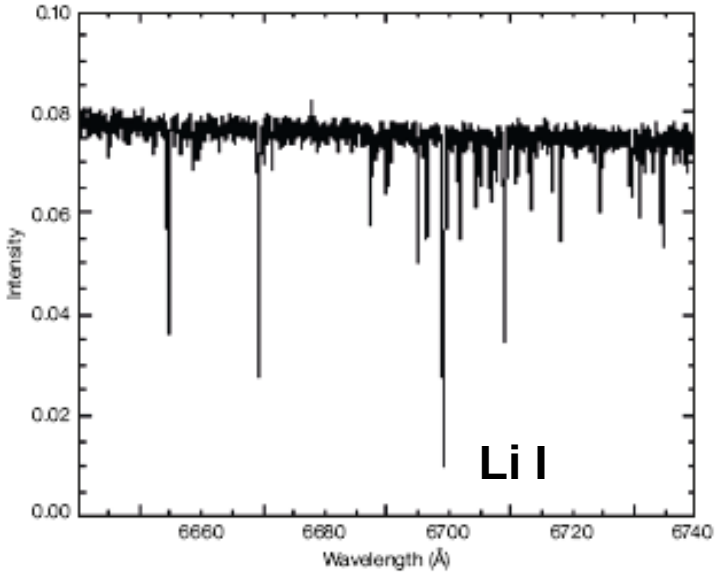


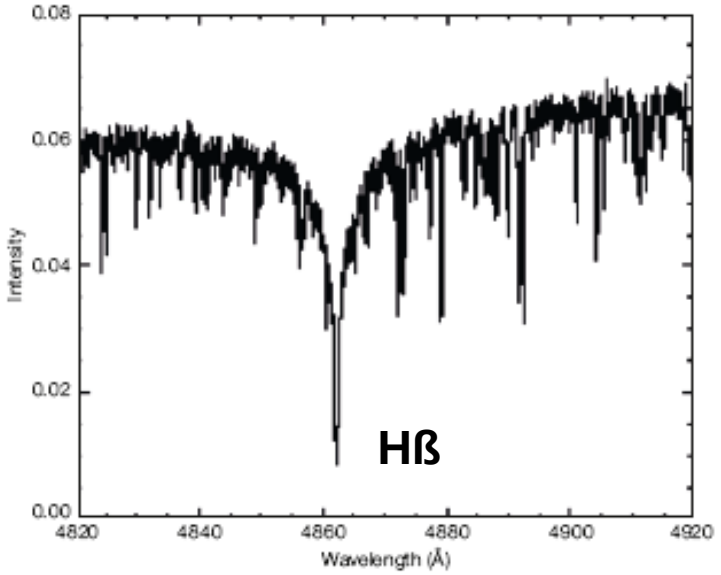
HR21

First spectra - UVES









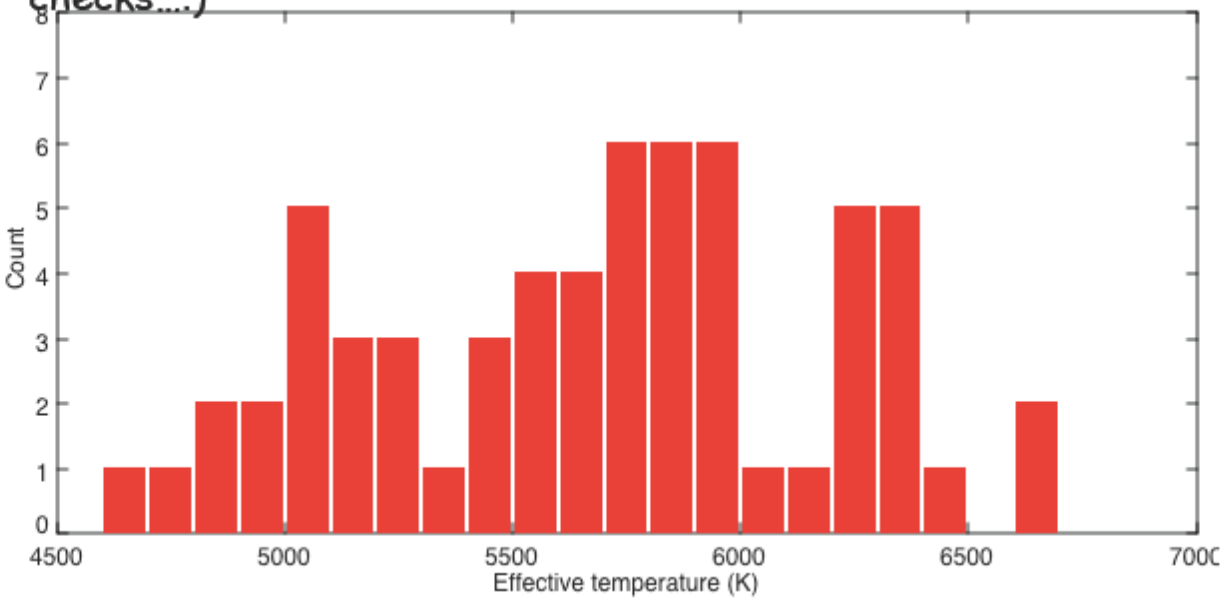
γ Vel member

MW target

First analysis results promising

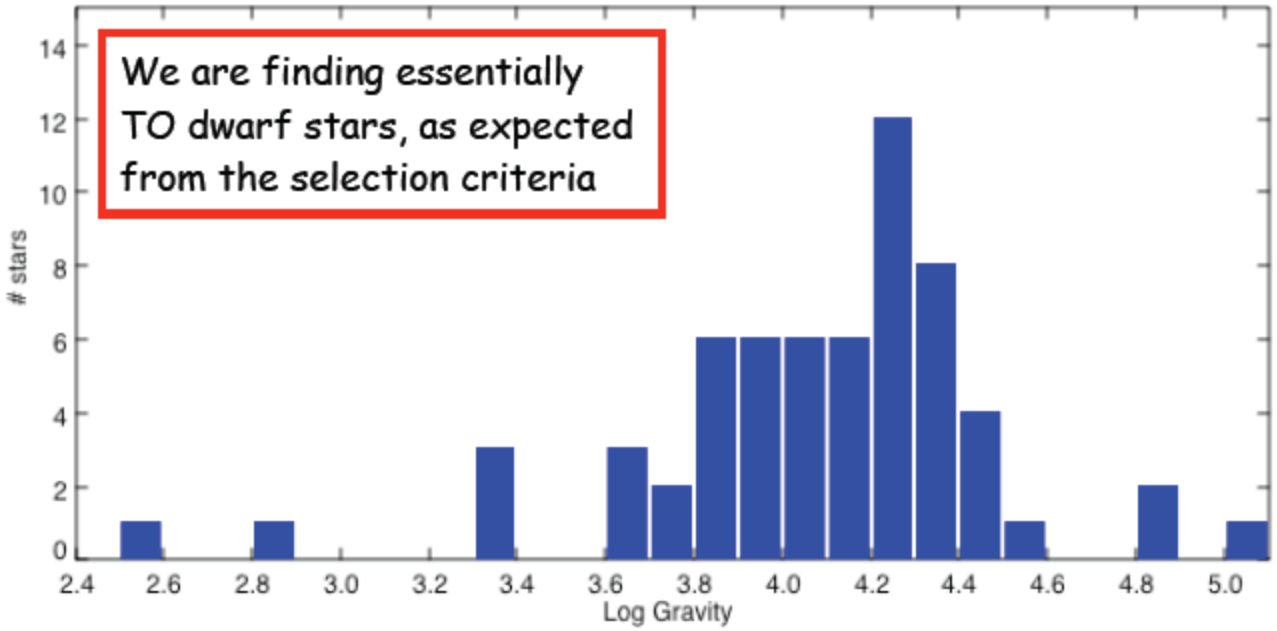
Run 1 and 2 results from MW UVES spectra

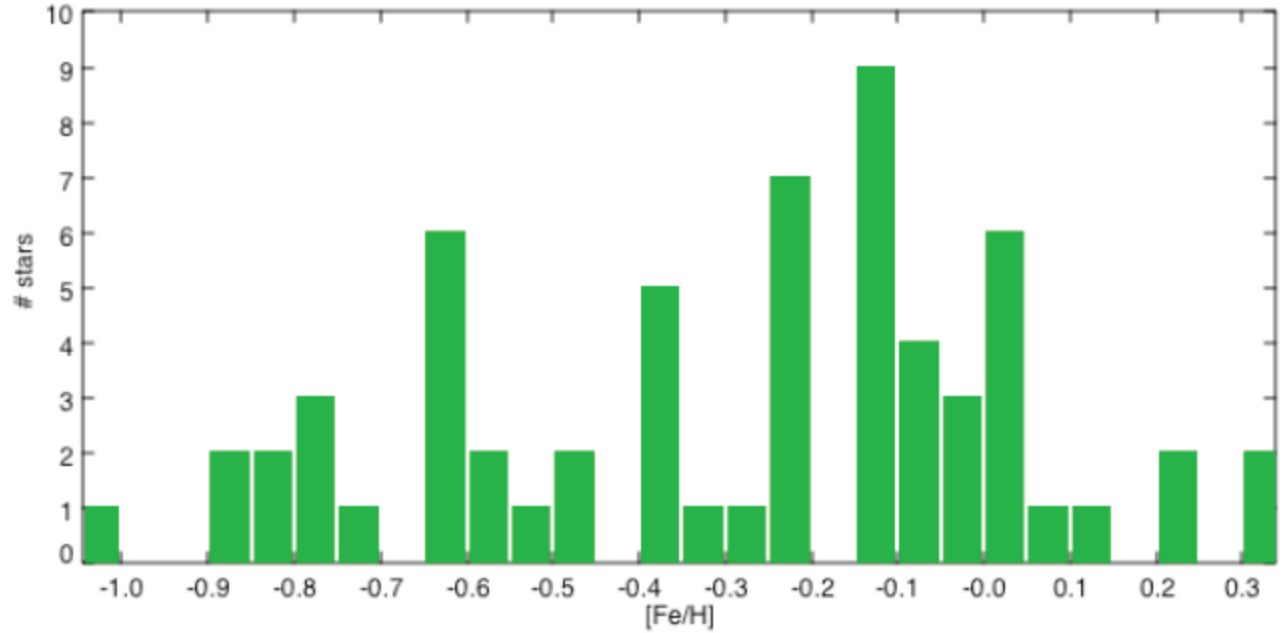
After solving some problems, the analysis of all MW fields taken in Run1-2 took ~2hrs CPU (preliminary analysis with few checks....)



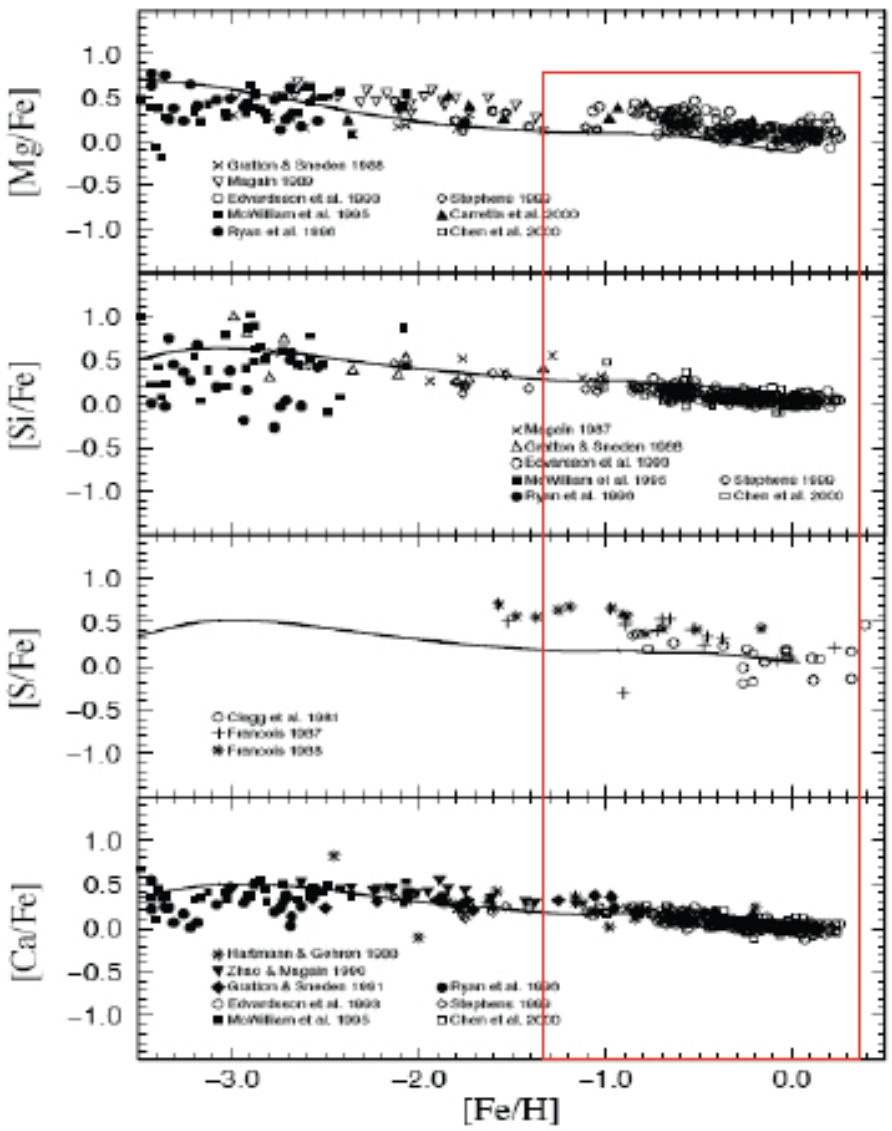
Courtesy Laura Magrini – Arcetri-Bologna-Padova-Indiana-ESO node

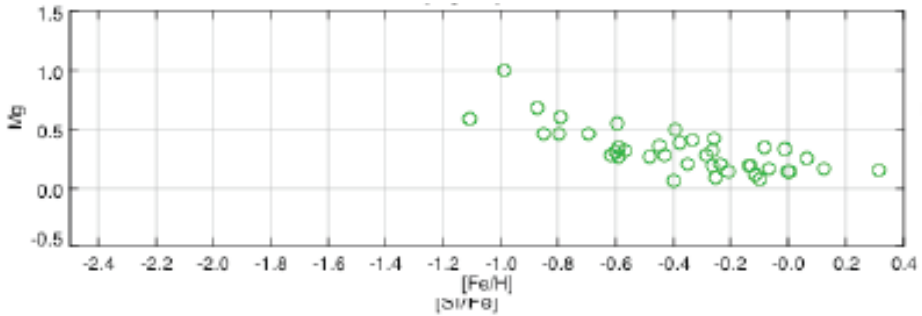
We are finding essentially TO dwarf stars, as expected from the selection criteria

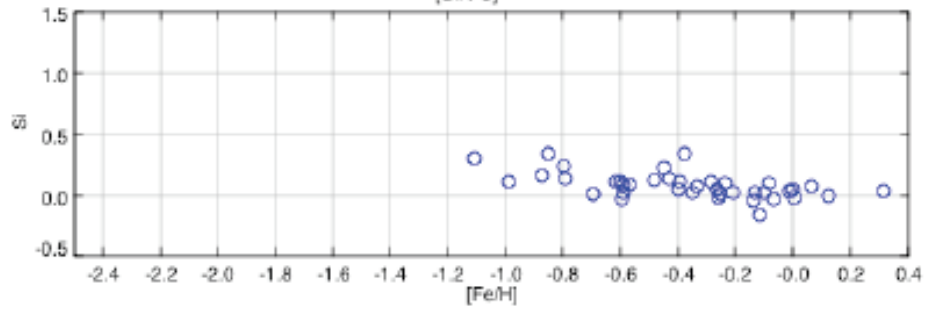


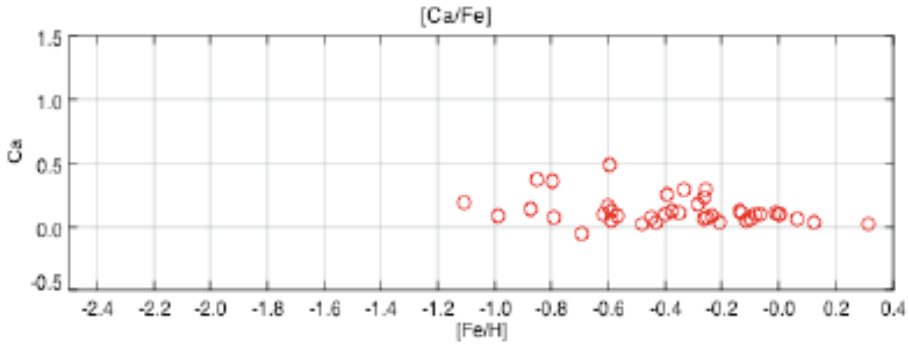


α elements


[Mg/Fe]
[Si/Fe]
[S/Fe]
[Ca/Fe]
[Fe/H]
−3.0
−2.0
−1.0
0.0
1.0
0.5
0.0
−0.5
−1.0


Mg
[Fe/H]
1.5
1.0
0.5
0.0
−0.5
−2.4
−2.2
−2.0
−1.8
−1.6
−1.4
−1.2
−1.0
−0.8
−0.6
−0.4
−0.2
−0.0
0.2
0.4


Si
[Fe/H]
1.5
1.0
0.5
0.0
−0.5
−2.4
−2.2
−2.0
−1.8
−1.6
−1.4
−1.2
−1.0
−0.8
−0.6
−0.4
−0.2
−0.0
0.2
0.4


[Ca/Fe]
Ca
[Fe/H]
1.5
1.0
0.5
0.0
−0.5
−2.4
−2.2
−2.0
−1.8
−1.6
−1.4
−1.2
−1.0
−0.8
−0.6
−0.4
−0.2
−0.0
0.2
0.4

Conclusions and perspectives

- Gaia-ESO Survey among the largest and most ambitious ground based spectroscopic surveys ever attempted by European astronomy –the largest on a 8m telescope

- First homogeneous overview of the distributions of kinematics and element abundances in the MW

- end data taking >2016++? – gives overlap with first Gaia data release. Combined → full 6D phase space f(x,y,z,v_x,v_y,v_z), plus stellar parameters, and chemistry for a very large number and variety of stars: core science plus legacy science

THANK YOU!