The promise of the Gaia-ESO Survey for open cluster science

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Survey Co-PIs: Gerry Gilmore & Sofia Randich

350+ Co-Is (mostly from Europe, but not only) 90++ institutes

CREDIT AND THANKS!

1 The Gaia-ESO Survey

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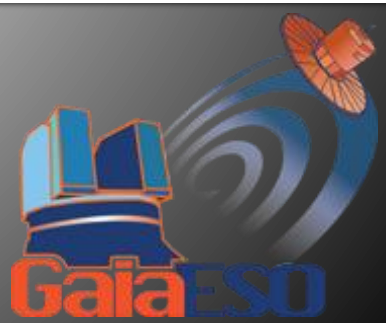
OUTLINE

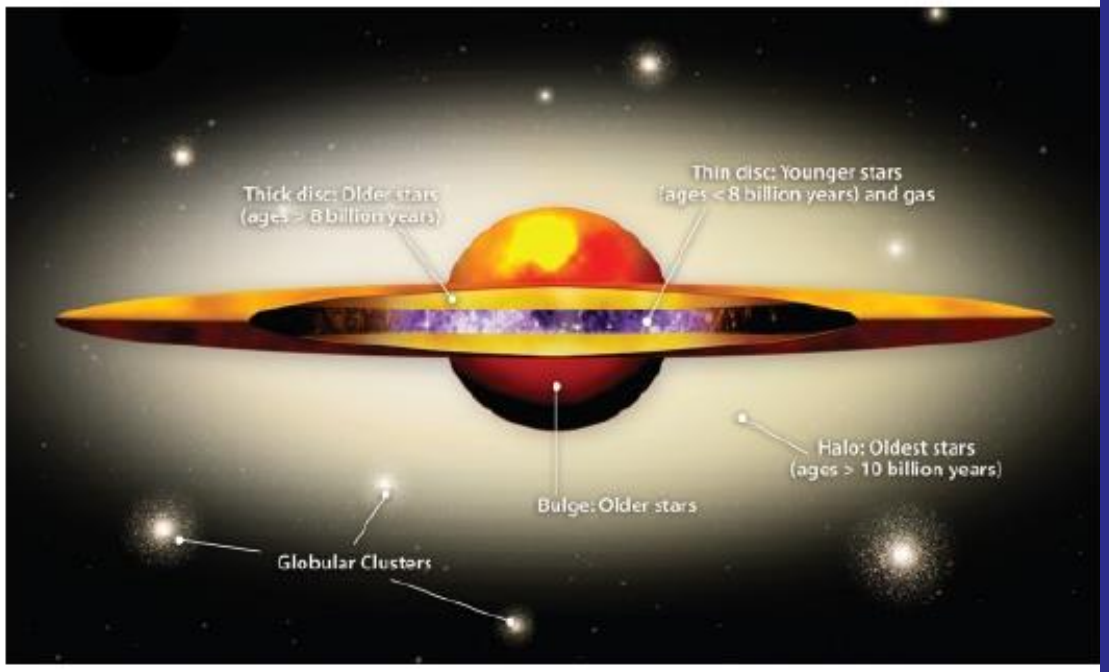
- Survey overview:
  - main characteristics and products
  - top level scientific goals (clusters)
  - targets (focus on clusters)
- Progress and status
- First results (focus on clusters)

Overview



GAIA-ESO SURVEY IN A NUTSHELL (1/3)

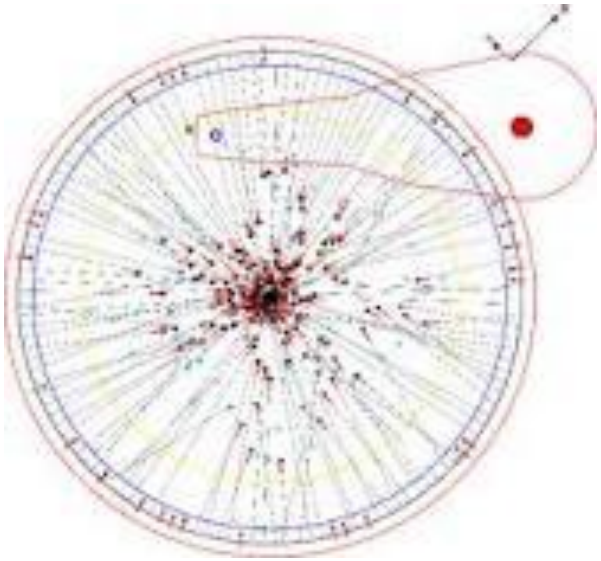
- Large **Public** Spectroscopic Survey – FLAMES
- **300 (240+60) nights** over **5 (4+1) years**; 12/2011 (P88) - 9/2016 (P97)++; VM



10^5 stars.
All populations of the MW:

- Halo
- Bulge
- Thick & Thin discs
- Open clusters

GAIA-ESO SURVEY IN A NUTSHELL (2/3)



Giraffe, 132 fibers

R=16000-25000, H3…H21

403-476…848-900

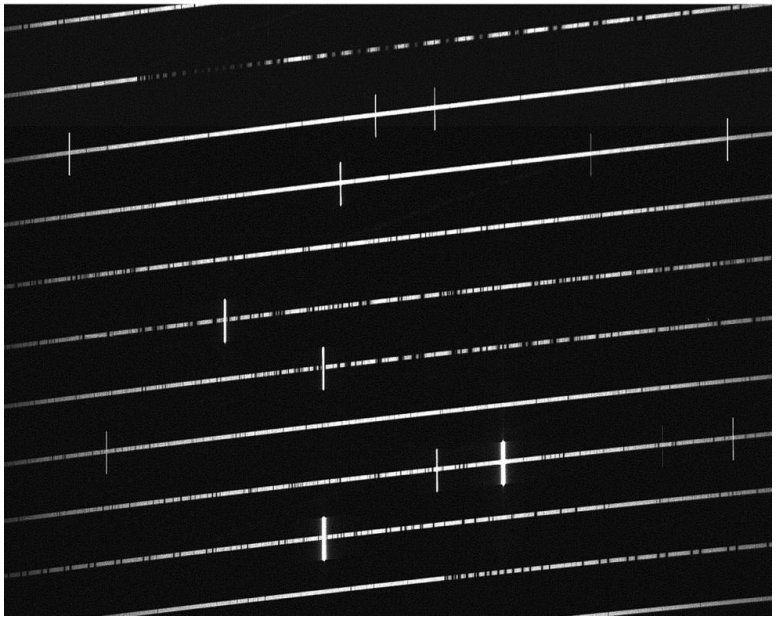
V<19, S/N > 10-15

UVES, 8 fibers

R=42,000, 520/580 nm

416-617/475-678

V<16.5, S/N > 30



GAIA-ESO SURVEY IN A NUTSHELL (3/3)

- **Giraffe and UVES spectra → Products**
  - RVs (→ to 0.2 km/s), variability, vsini
  - APs, [Fe/H], [X/Fe] (Li, α, Fe-peak, s-,..)
  - stellar properties (M_{acc}, $\dot{M}$, etc.)

Uniform analysis: → homogeneous overview of the distributions of **kinematics and element abundances** in the Galaxy

OPEN CLUSTER SCIENCE

- **Cluster formation and dynamics:** constrain theories of star formation through internal kinematics (complement Gaia pm & DANCe)
- **Stellar evolution:** spectroscopy to test, calibrate, and refine models (CMD → HRD)
- **Thin Disc** and Solar Neighbourhood: trace chemical evolution as a function of age and Galactocentric radius
- **+ Legacy science**

OCs IN THE GAIA-ESO SURVEY

PM

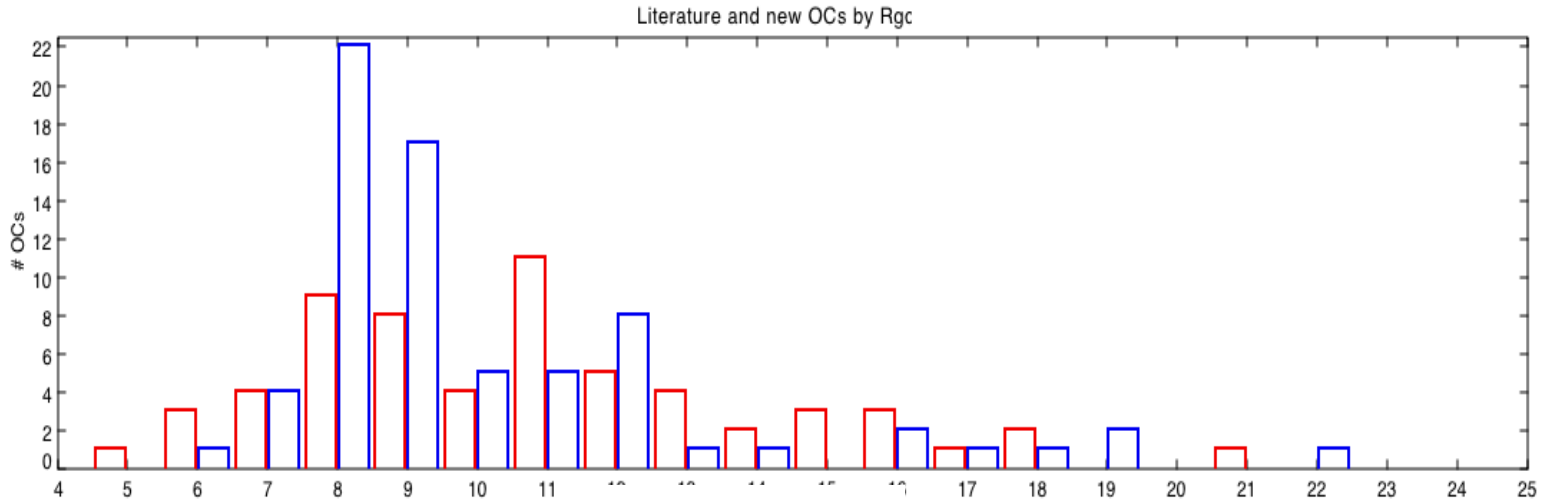
Yo

Master cluster list: ~90 clusters

Intermediate-age and old clusters (0.1 – 8 Gyr)

Both nearby (< 1.5 kpc) and distant ones, range in [Fe/H], density, mass, …

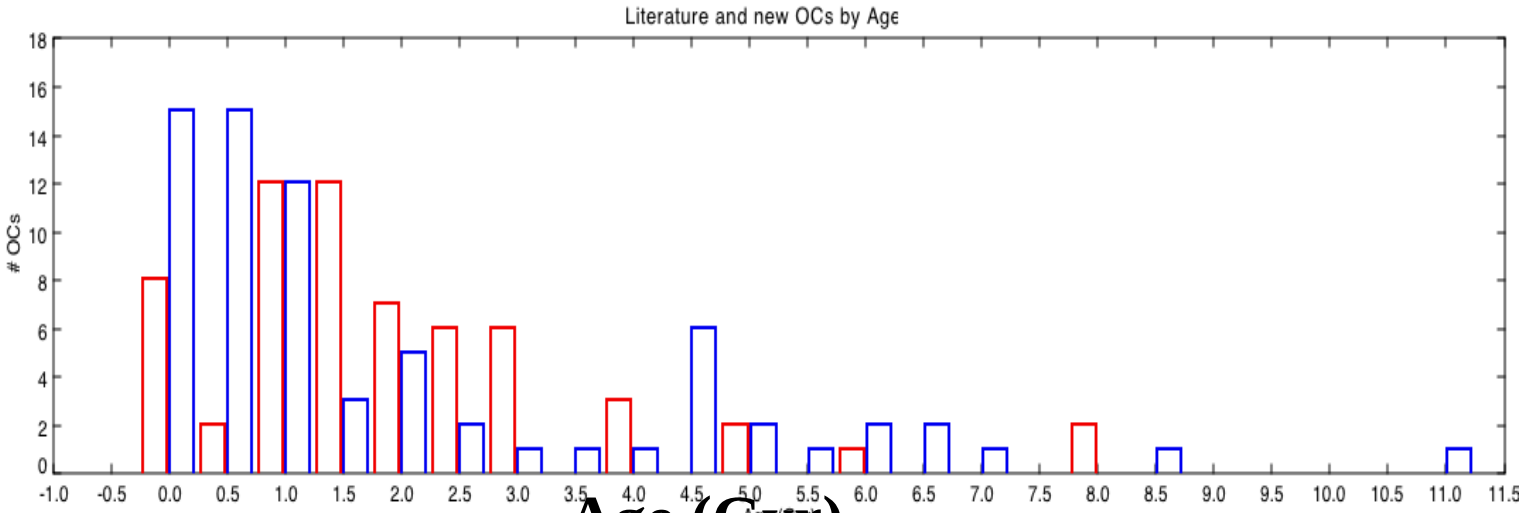
OCs IN THE GES



GES

Lit.

Rgc (kpc)

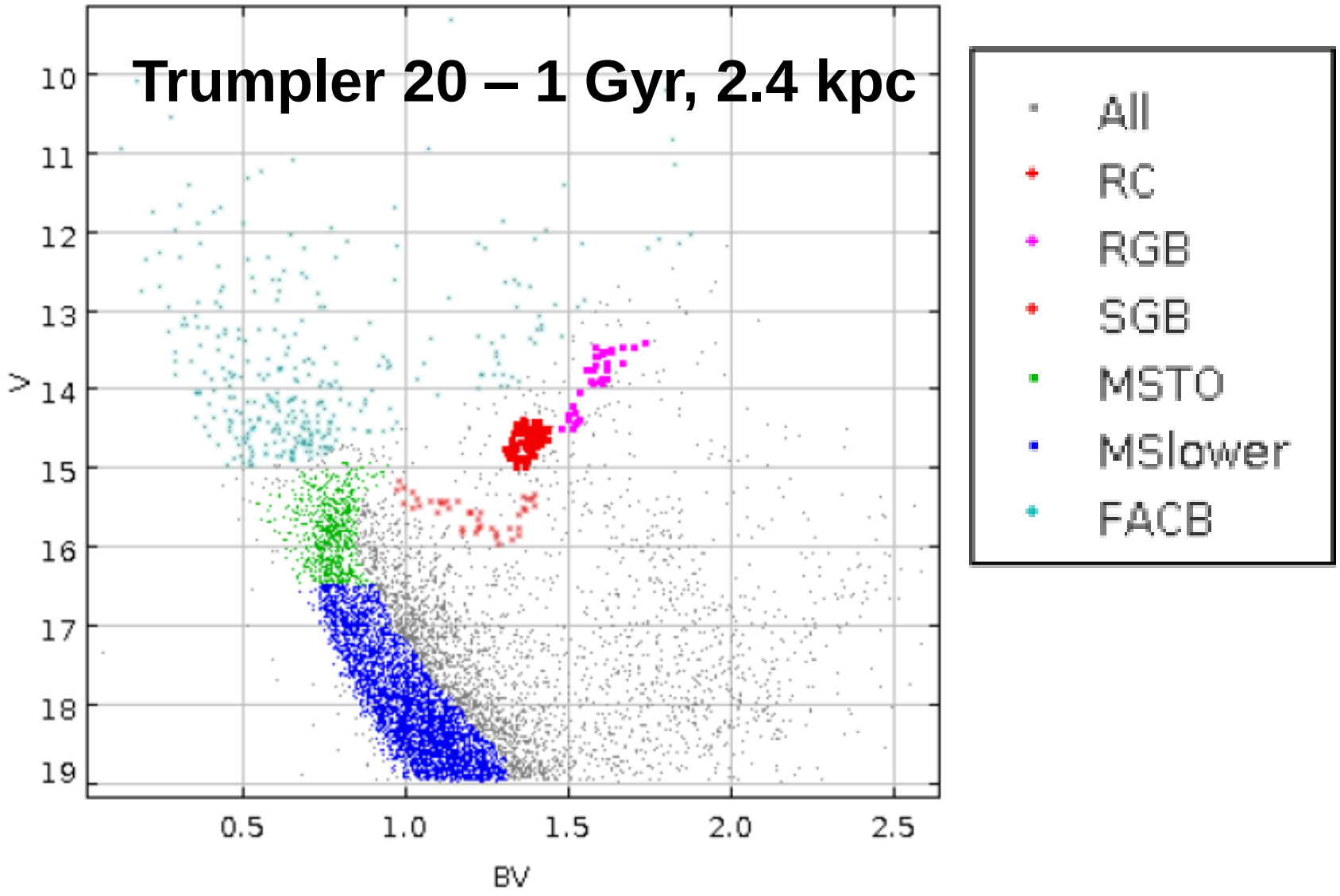


Age (Gyr)

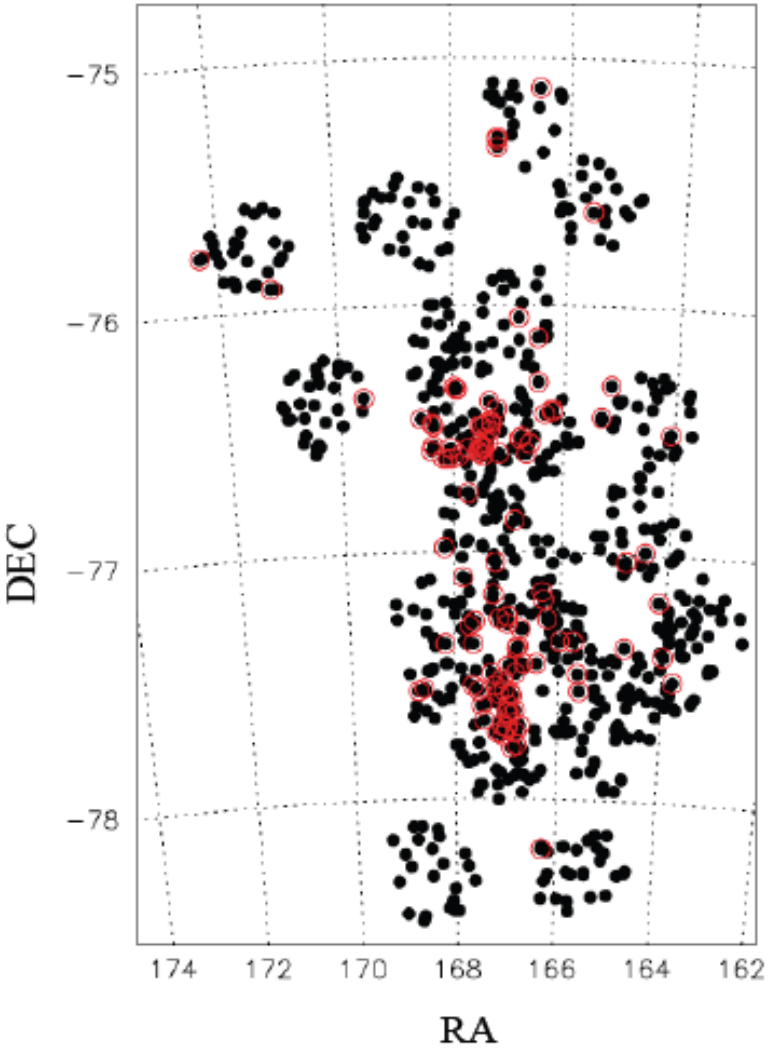
TARGET SELECTION IN OCs

- O → M dwarfs; (P)MS → evolved stars
- Devised as to optimize the top level science goals →
  - Giraffe: **unbiased,** not tailored on the individual clusters, also external regions, as complete as possible, or representative samples. Mainly based on photometry
  - UVES: **biased,** focus on high probability members

TARGET SELECTION IN OCs



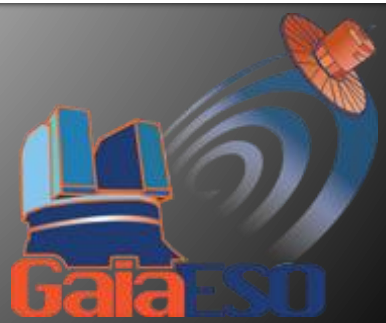
TARGET SELECTION IN OCs



- known members (140)
- phot. candidates (530) from 2MASS

Cha I (2-3 Myr, 160 pc) spatial selection

PROGRESS UPDATE



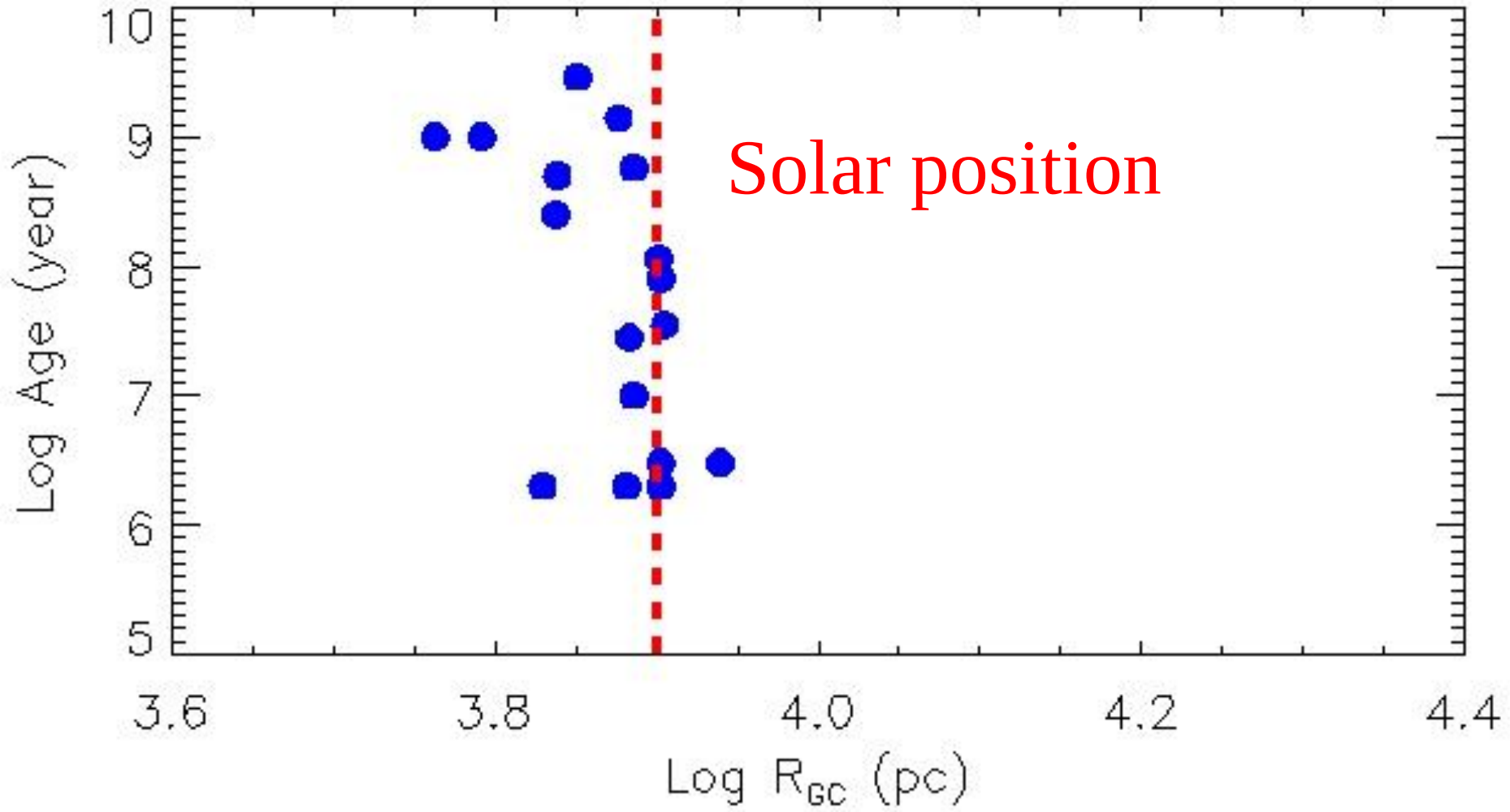
SURVEY PROGRESS

- ✓ 20 observing runs completed (100+ nights); about 85 % of time useful. **Large variety of targets** observed, including 17 clusters, several MW fields, several calibration targets (GCs, benchmark stars, COROT RGs, etc.)
- ✓ **7/2013:** first analysis cycle completed → internal release of APs and abundances for the first 6 month spectra
- ✓ **7/2013:** first 18 month spectra, along with RVs and photometry (iDR2)→ **second analysis cycle**

SURVEY PROGRESS

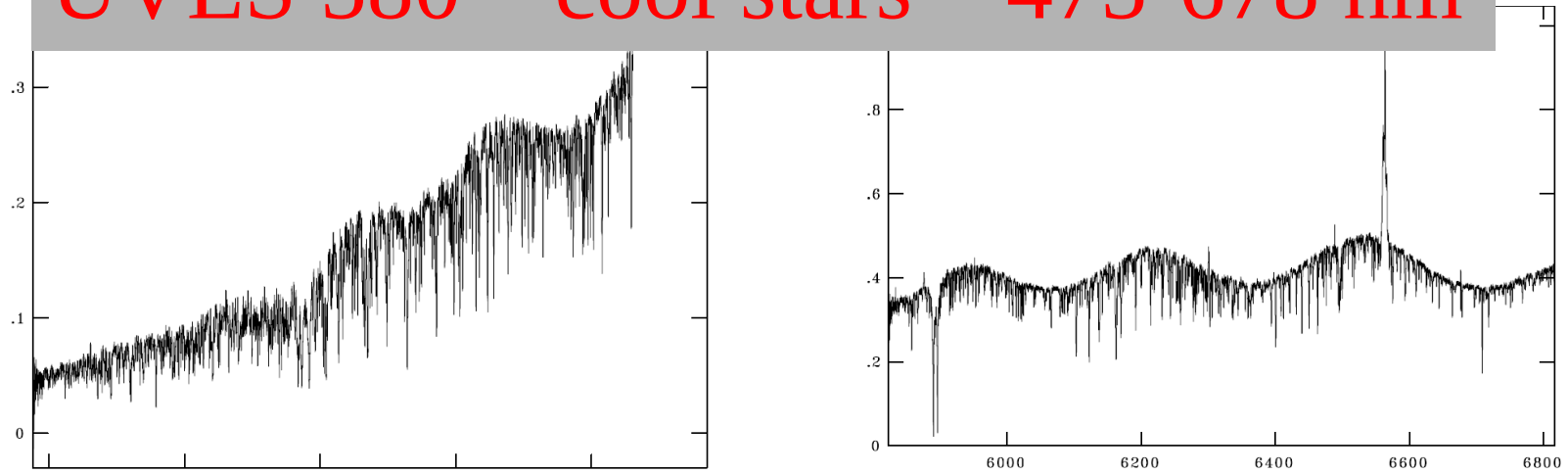
- ✓ **8/2013:** first release of spectra to ESO archive (6 month, good quality, completed targets →~4000 objects)
- ✓ **Beginning of 2014: completion of** iDR2 analysis → internal release of APs and abundances
- ✓ **7/2014 (?):** next release to ESO
- ✓ **4/2013:** first science consortium meeting

OBSERVED CLUSTERS

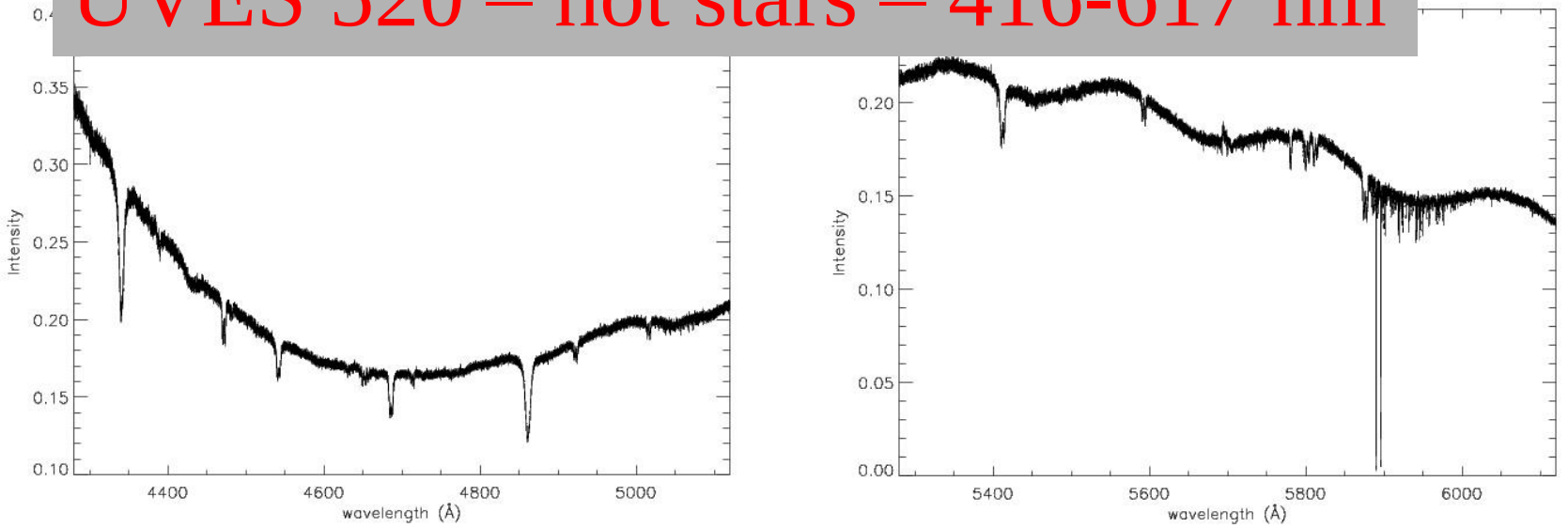


UVES SPECTRA

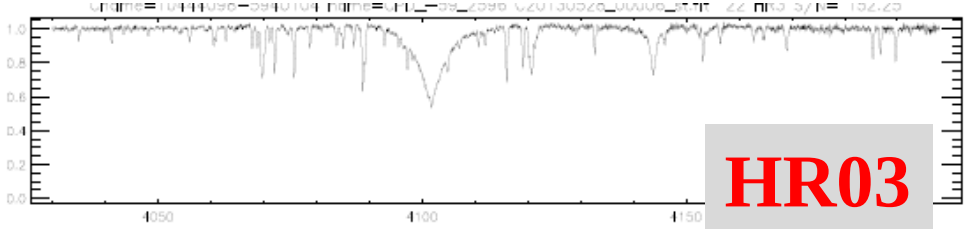
UVES 580 – cool stars – 475-678 nm



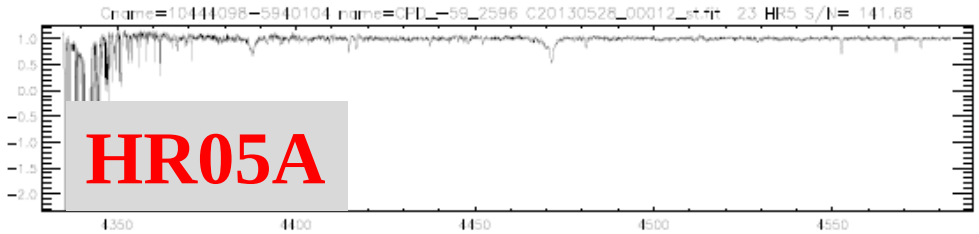
UVES 520 – hot stars – 416-617 nm



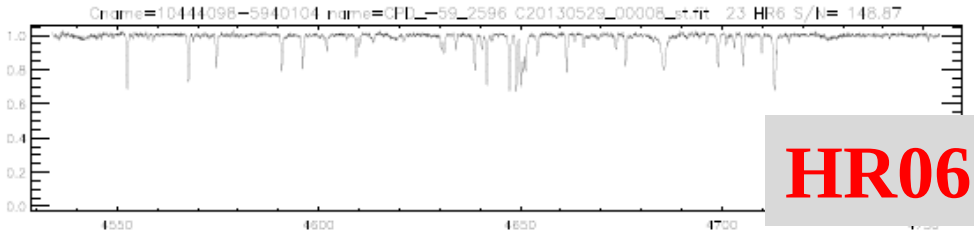
GIRAFFE SPECTRA



HR03



HR05A



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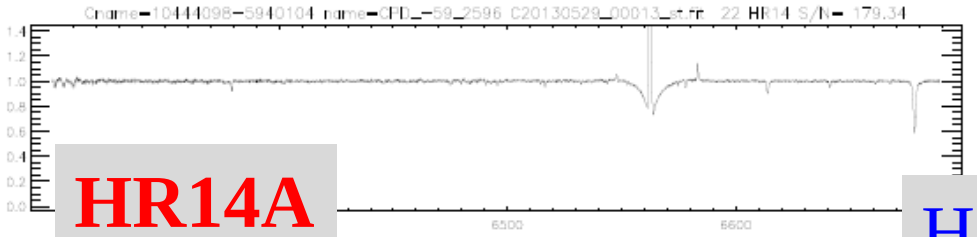
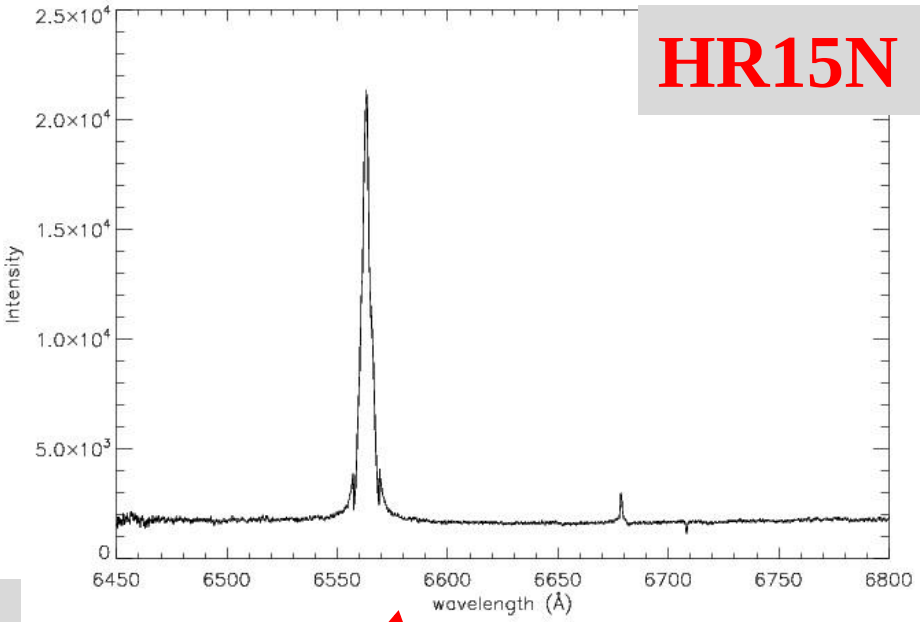


HR14A



HR15N

Cool (M-type) star in Cha I

Hot (40000 K) star in Carina

Results

PRESENTED AT THIS MEETING

R. Blomme - Massive stars

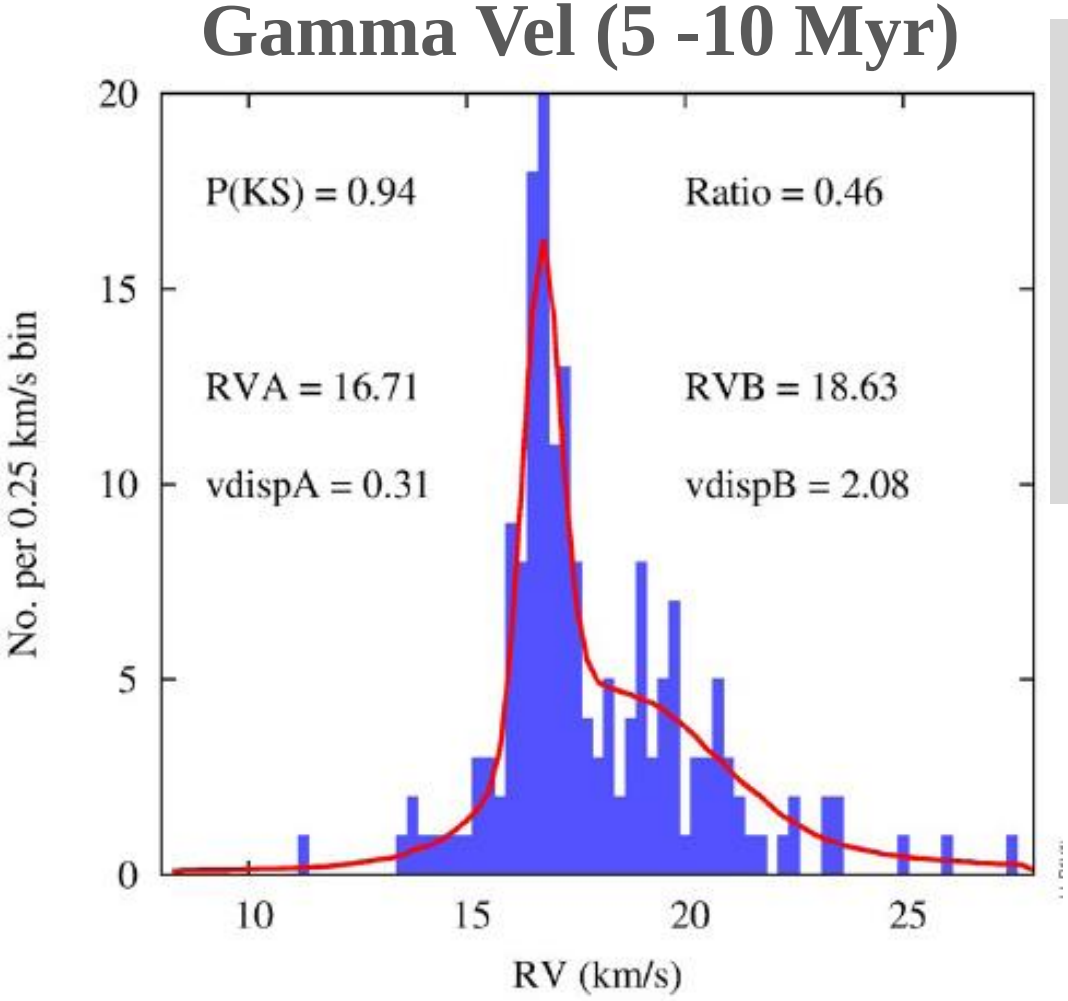
L. Magrini - Chemical tagging

T. Cantat-Gaudin - Radial gradient

R. Sordo - Stellar evolution

L. Sampedro - Membership in GES

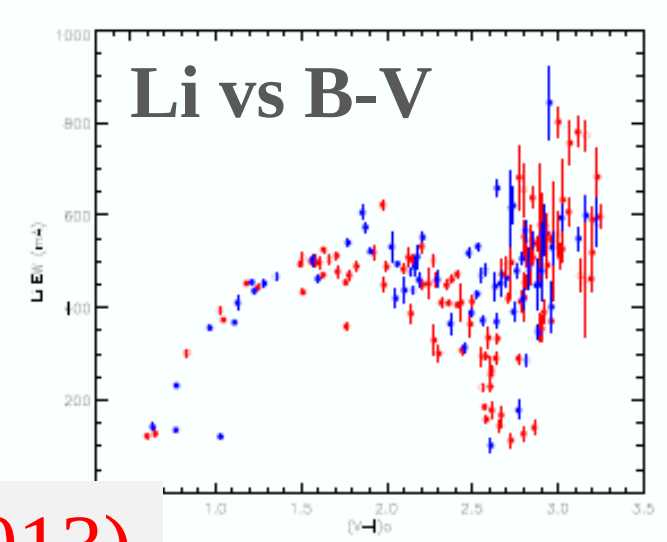
YOUNG CLUSTER KINEMATICS



RV precision (0.23 km/s)
unbiased selection

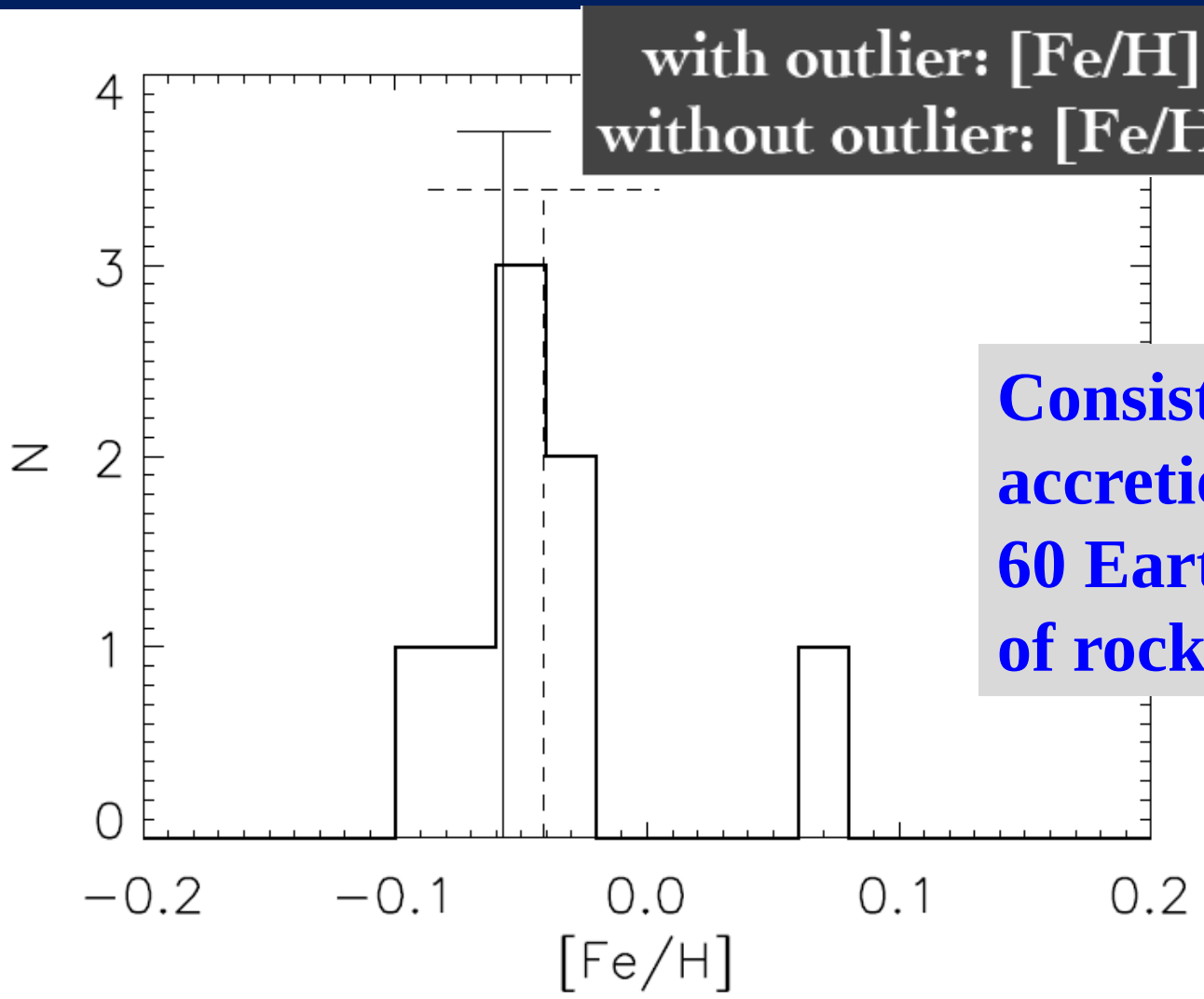
→

Double population



Jeffries et al., Franciosini et al (2013)

A METAL RICH STAR IN GAMMA VEL



Consistent with the accretion of 60 Earth masses of rocky material

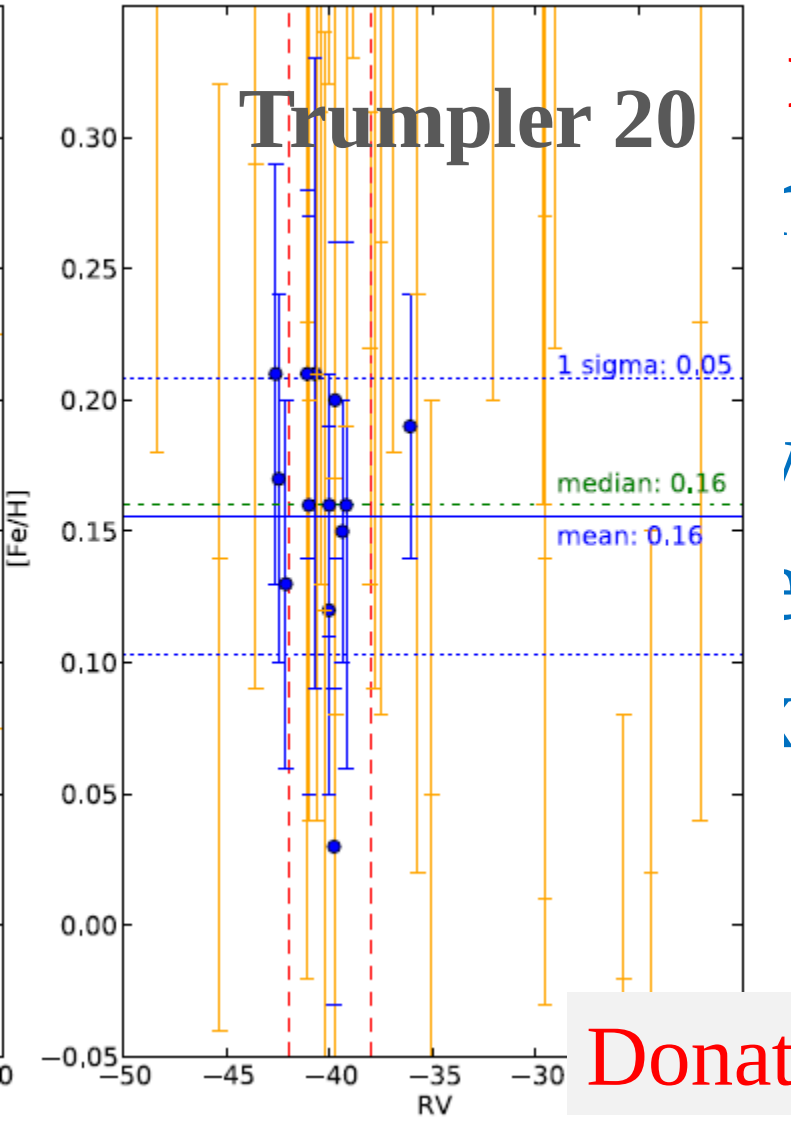
Spina et al. (2013)

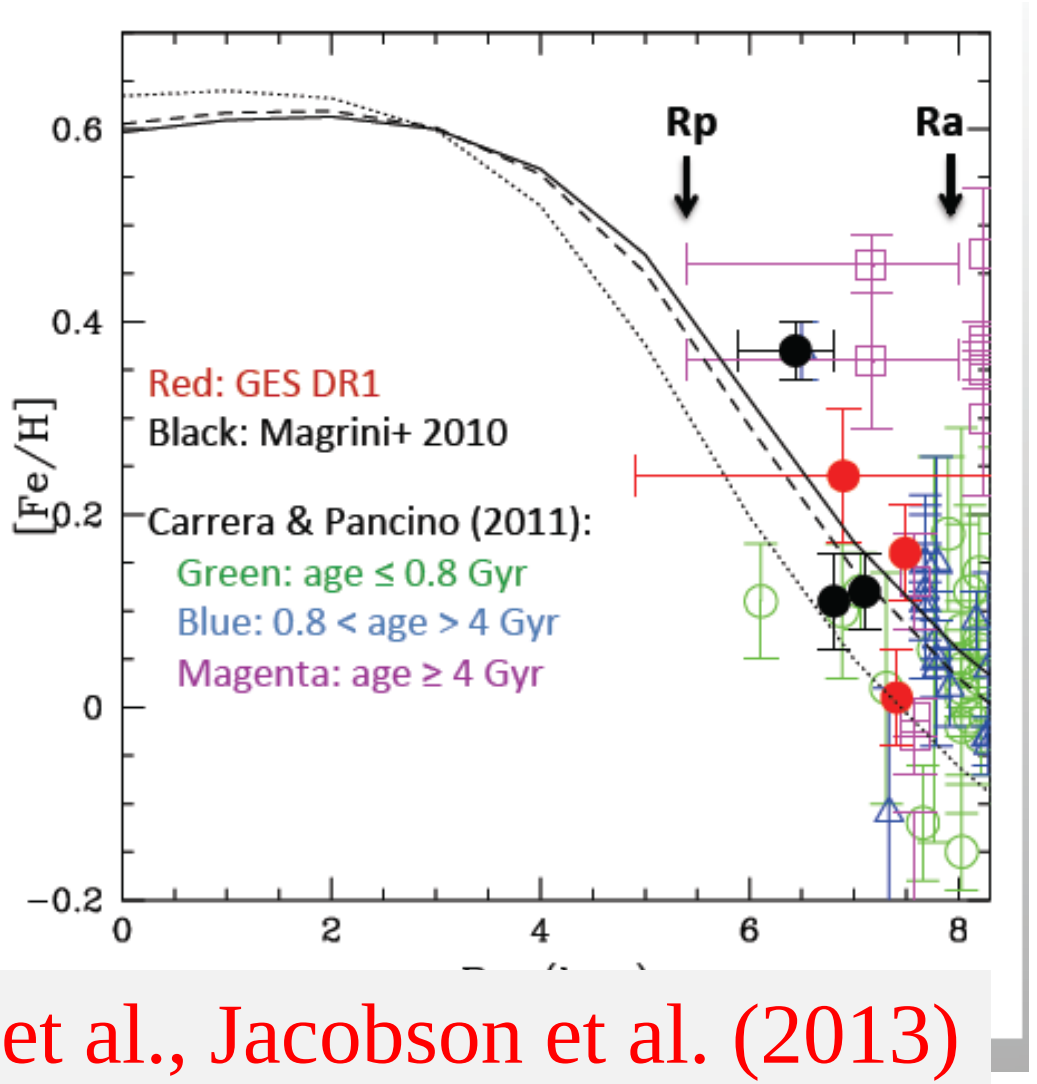
THE INNER RADIAL METALLICITY GRADIENT

Last 10-15 years several studies focusing on the gradient (Bragaglia, Carraro, Friel, Magrini, Pancino, Randich, Yong), but understanding of the disk gradient is:

-limited/biased by too small or too inhomogeneous cluster samples
-based on clusters with too few members/ too large errors
- largely ignoring possible radial migration effects

THE INNER RADIAL METALLICITY GRADIENT



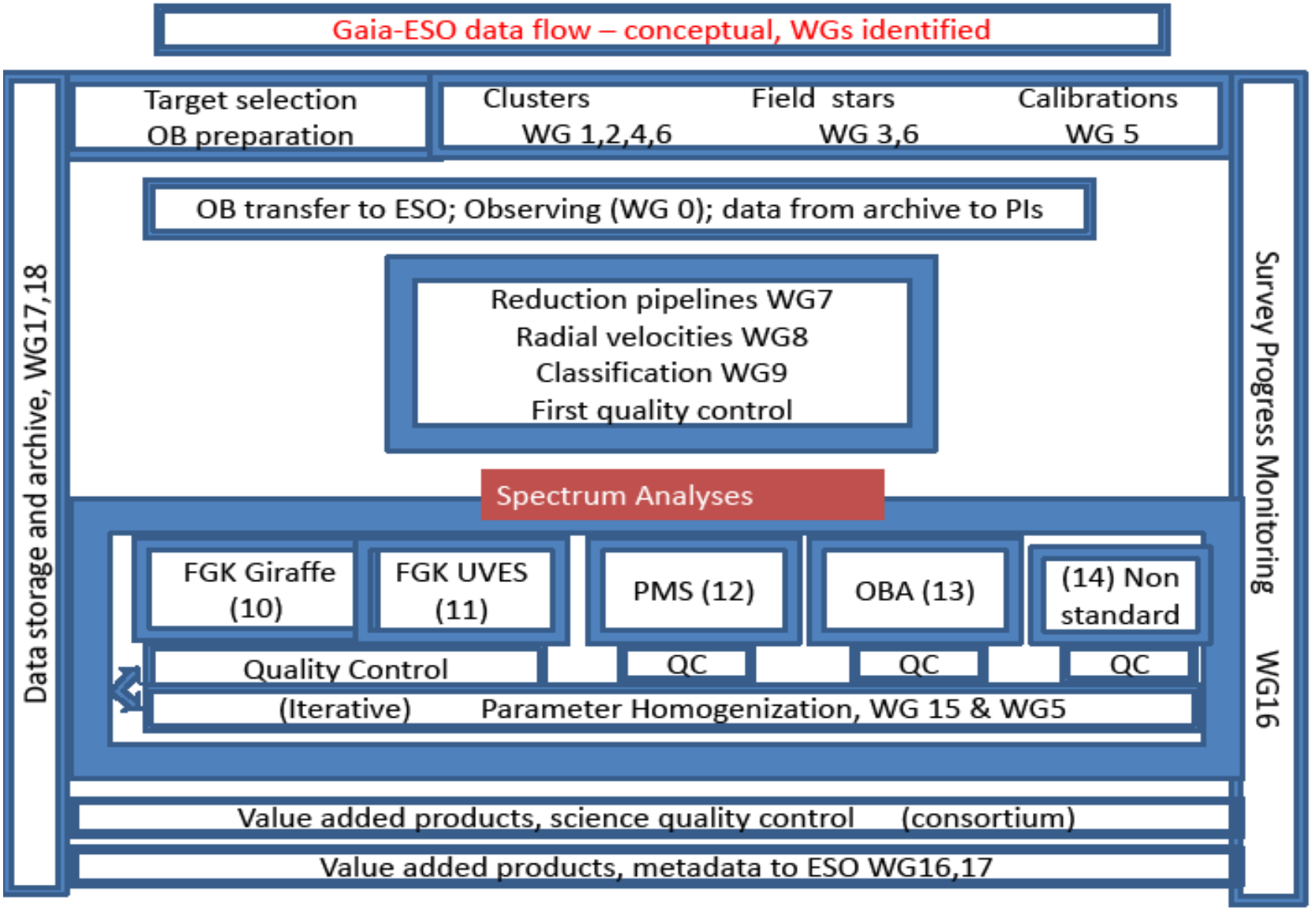


Donati et al., Jacobson et al. (2013)

SUMMARY

- GES is meeting its ambitious goals
- First results show the potential of the GES
- First science papers will appear over the next few months
- GES 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 AP, and chemistry for a very large number and variety of stars: core science plus legacy science

ORGANIZATION, DATA FLOW, ANALYSIS



SPECTRUM ANALYSIS

- Gaia-ESO explicitly includes all proven abundance methodologies (but same linelist and model atmospheres) → systematics + a wide range of techniques is essential to cover the range of stellar types →

homogeneization

- **Calibration targets:** internally consistent scale and understood external scale