The Gaia-ESO Survey, its legacy, and new perspectives

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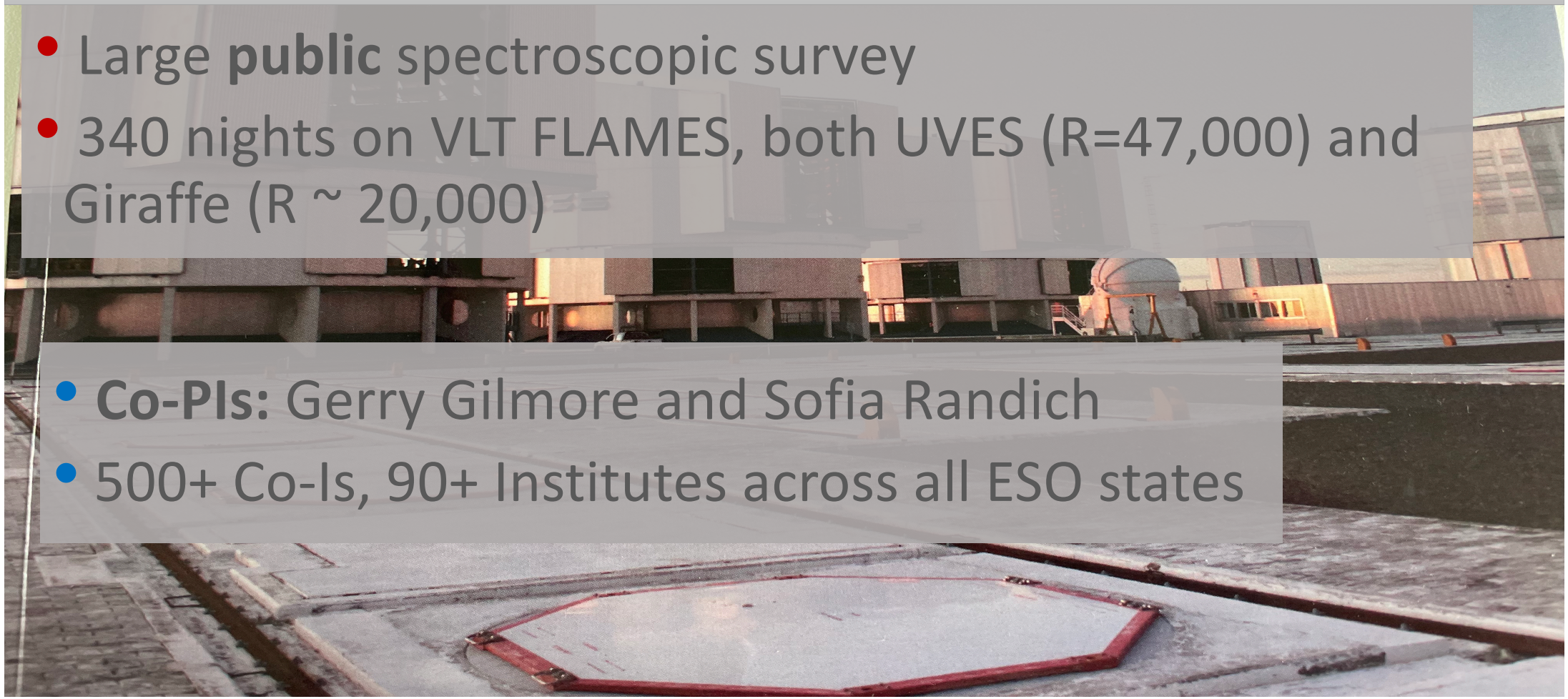
Gaia-ESO

From 2010 to 2023: a long journey across the sky



- Large **public** spectroscopic survey
- 340 nights on VLT FLAMES, both UVES (R=47,000) and Giraffe (R ~ 20,000)

- **Co-PIs:** Gerry Gilmore and Sofia Randich
- 500+ Co-Is, 90+ Institutes across all ESO states

The unique characteristics of Gaia-ESO

Observations and sample

- largest on a 8m class telescope →
- "only" 190,000 spectra, 114,000+ stars, but V=19
- all stellar-types: O to M, PMS to giants –by design-
- Instrument/grating optimized for the target type
- specific focus on open clusters well sampling the age-d_{Sun}-R_{GC}-mass space, sizeble samples of members

Advanced products (besides stellar parameters)

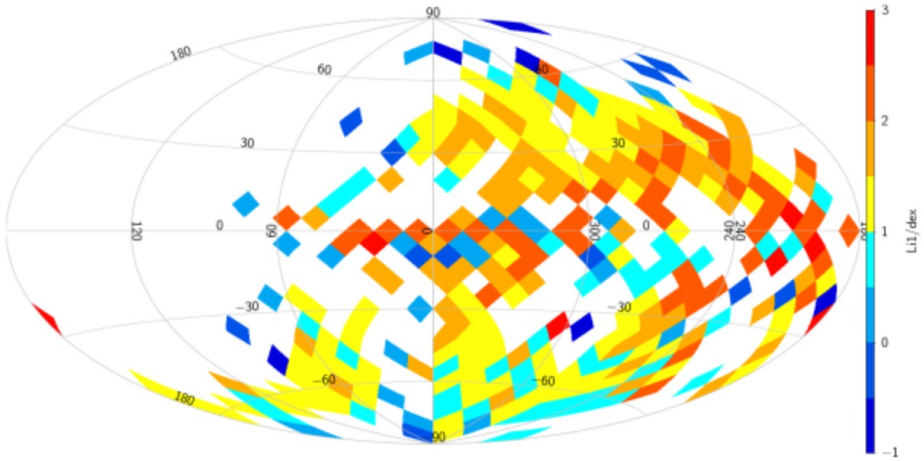
- RVs (down to 0.2 km/s) and vsini's
- abundances of up to 32 elements
- the broadest Li dataset
- mass accretion and stellar activity tracers
- cluster probability membership (GES+*Gaia*)
- a system of quality flags
- the UVES high res. sample remains of the highest quality

Strategy and methodology

- Gaia-ESO linelist – now widely used
- Involve many spectroscopic analysis methods –more methods means more information
- → systematic errors and random errors
- first that implemented a calibration strategy: internal and external calibrators
- final homogenization – boostrap everything onto *Gaia* benchmark stars

Final Data Release (5.1) of the Gaia-ESO Public Spectroscopic Survey

Published: 07 Jul 2023



+ CDS

Utilizing the UVES and GIRAFFE instruments, this comprehensive survey has encompassed all major components of the Milky Way, systematically studying 114,916 stars. The observed robust samples have enabled detailed observations of bulge, thick and thin disks, halo components, and open star clusters of various ages and Galactocentric distances.

The survey has provided an unprecedented, homogeneous overview of kinematic distributions and elemental abundances, significantly enhancing our understanding of Galactic and stellar evolution. Coupled with Gaia astrometry, this data helps quantify the formation history and evolution of Galactic populations across diverse stages, providing individual elemental abundances in each star, offering precise radial velocities for a 6-D kinematic phase-space, mapping kinematic gradients and abundances, and tracking the life cycle of open clusters as they populate the disk.

This final data release represents a valuable legacy dataset, enhancing the utility of the Gaia mission and ongoing ESO surveys.

European Southern Observatory

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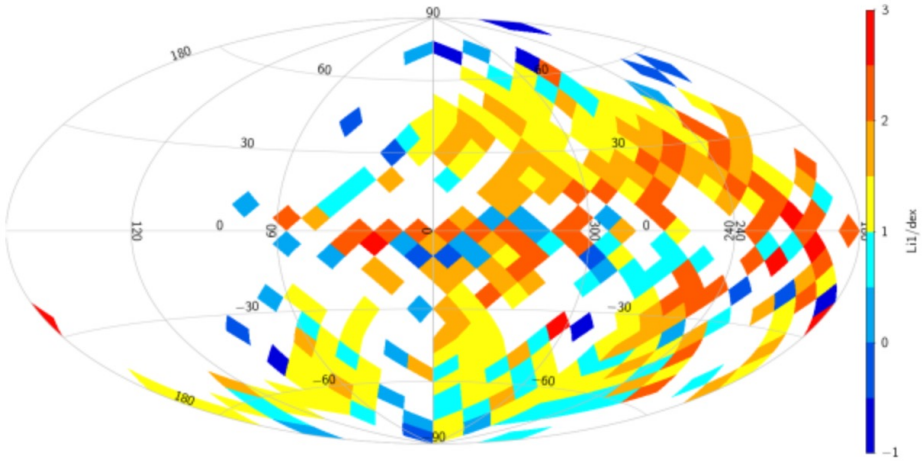

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Release – technical papers

European Southern

ESO — Reaching New Heights in Astronomy

Go!

The Gaia-ESO Public Spectroscopic Survey: motivation, implementation, GIRAFFE data processing, analysis, final data products★

G. Gilmore[1], S. Randich[2], C. C. Worley[1], A. Hourihane[1], A. Gonneau[1], G. G. Sacco[2], J. R. Lewis[†1], L. Magrini[2], P.

The Gaia-ESO Public Spectroscopic Survey: Implementation, data products, open cluster survey, science, and legacy.★

S. Randich[1], G. Gilmore[2], L. Magrini[1], G. G. Sacco[1], R. J. Jackson[3], R. D. Jeffries[3], C. C. Worley[2], A. Hourihane[2], A.

Worley et al. 2024
Hourihane et al. 2023
Franciosini et al. 20222
Bragaglia et al. 2022
Jackson et al. 2011
Heiter et al. 2021
Worley et al. 2021

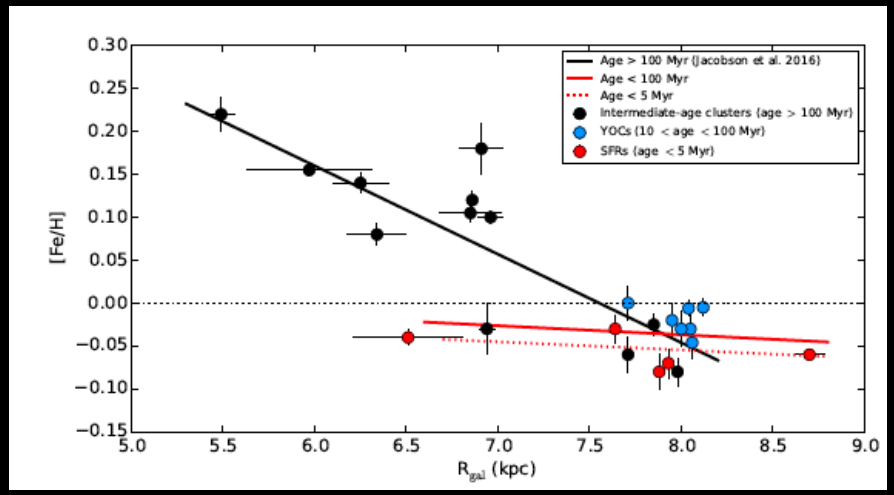
Franchini et al. 2018
Pancino et al. 2017
Stontuke et al. 2016
Smiljanic et al. 2014
Ruffoni et al. 2015
Damiani et al. 2014
Sacco et al. 2014

Results and impact on a variety of areas
(most of the topics covered in this symposium)

Focus on the thin disk, two recent results, topics not well covered in other talks, **enabled by the rich open cluster and abundance dataset**

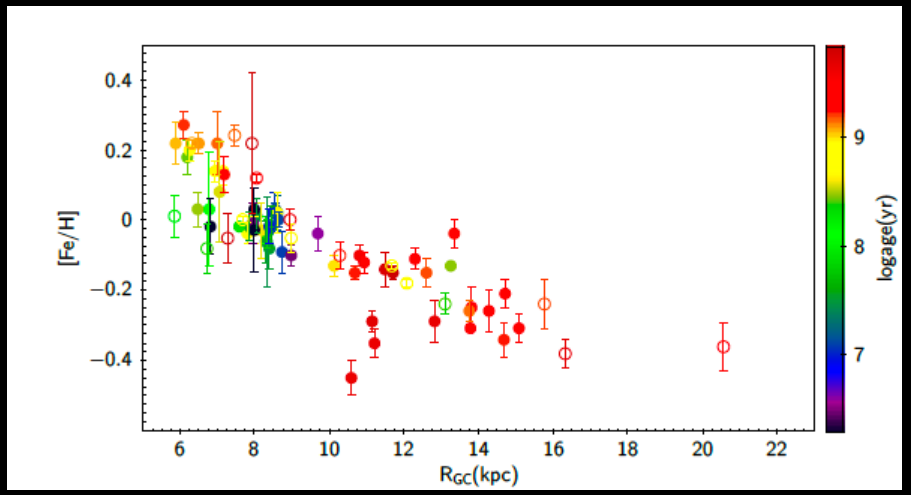
The [Fe/H] gradient of young clusters

Gaia-ESO DR4



Spina et al. (2017)

Gaia-ESO DR6



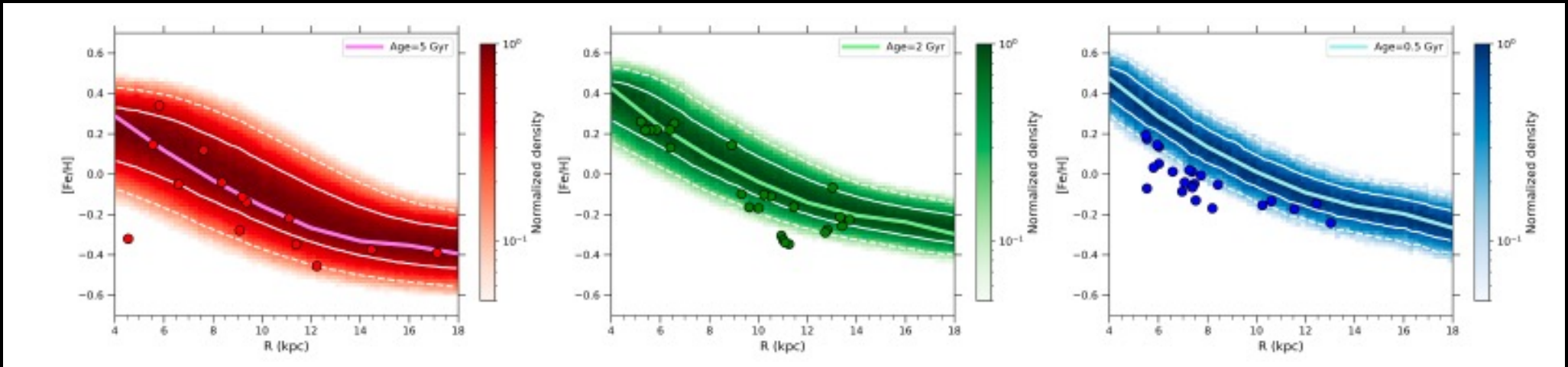
Randich et al (2022)

But see the caveats of Baratella et al. (2020), Magrini et al. (2023)

The [Fe/H] gradient of young clusters

two-infall + radial migration

Palla et al. 2024

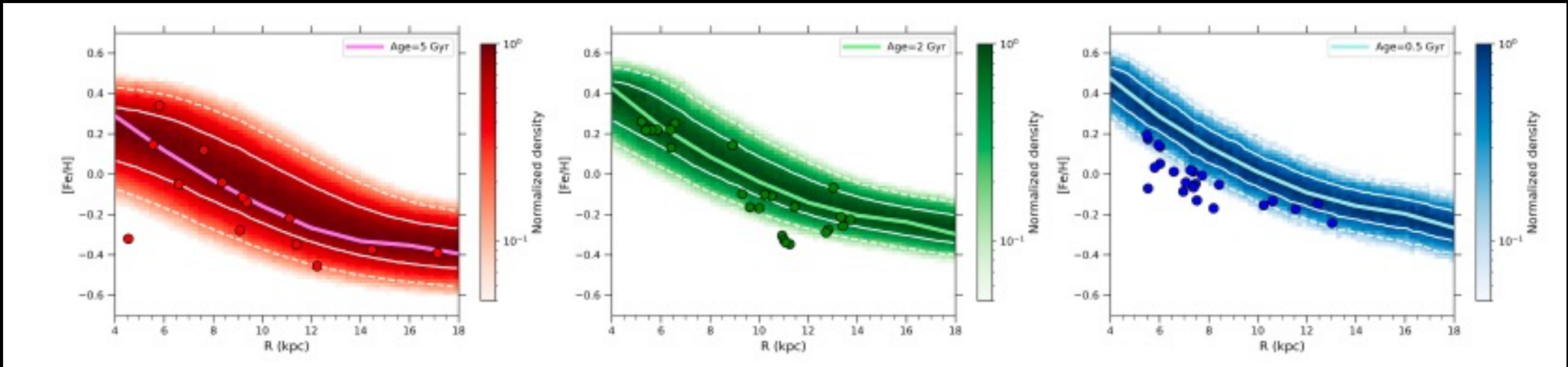


“clean“ dataset

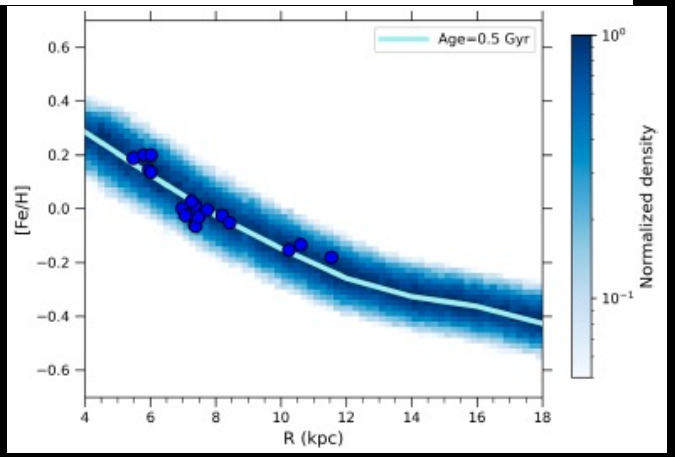
The [Fe/H] gradient of young clusters

two-infall + radial migration

Palla et al. 2024



Three-infall model needed: to explain the observed low metallic content in young clusters, a late gas accretion episode that triggered a metal dilution is proposed

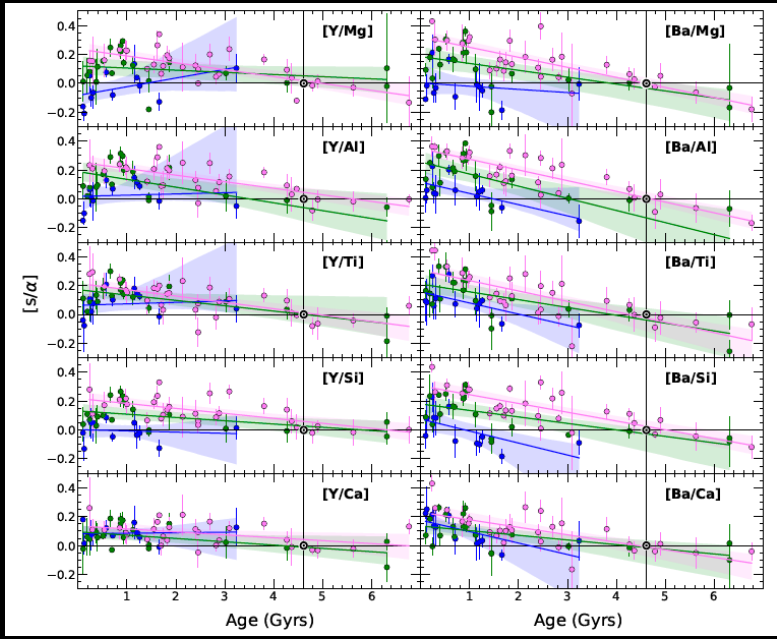


See also Spina+ (2017), Randich+ (2022), Magrini+ (2023), Spitoni + (2023)

Stellar ages and chemical clocks (see also the talk by Tautvaisiene)

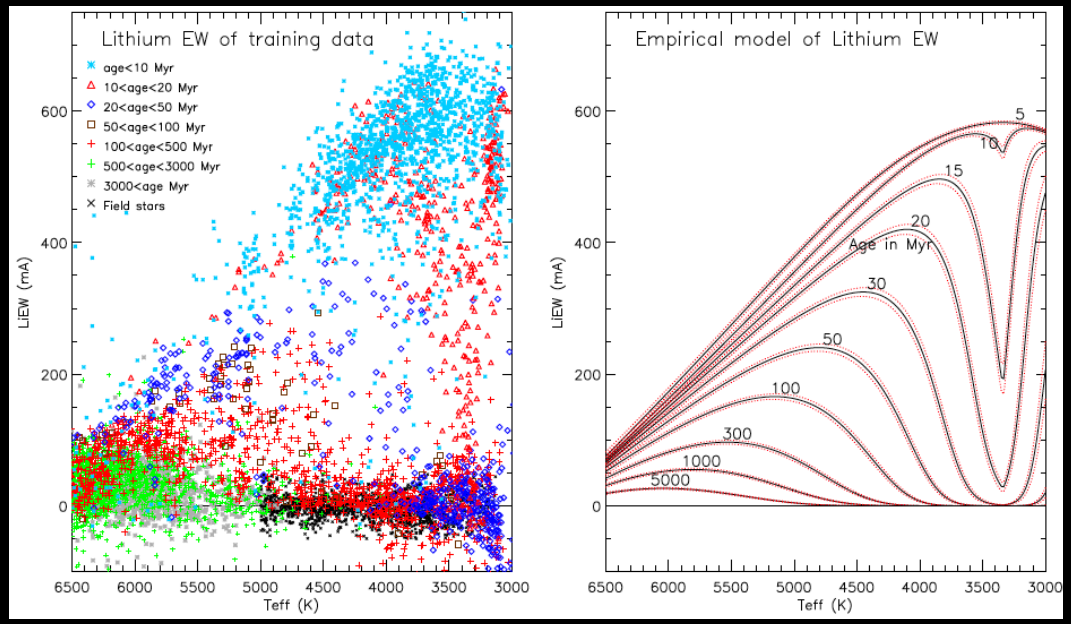
s/α

Viscasillas et al. (2022)



age-chemical clock relation, but dependence on the Galactocentric position

Jeffries et al. (2023)

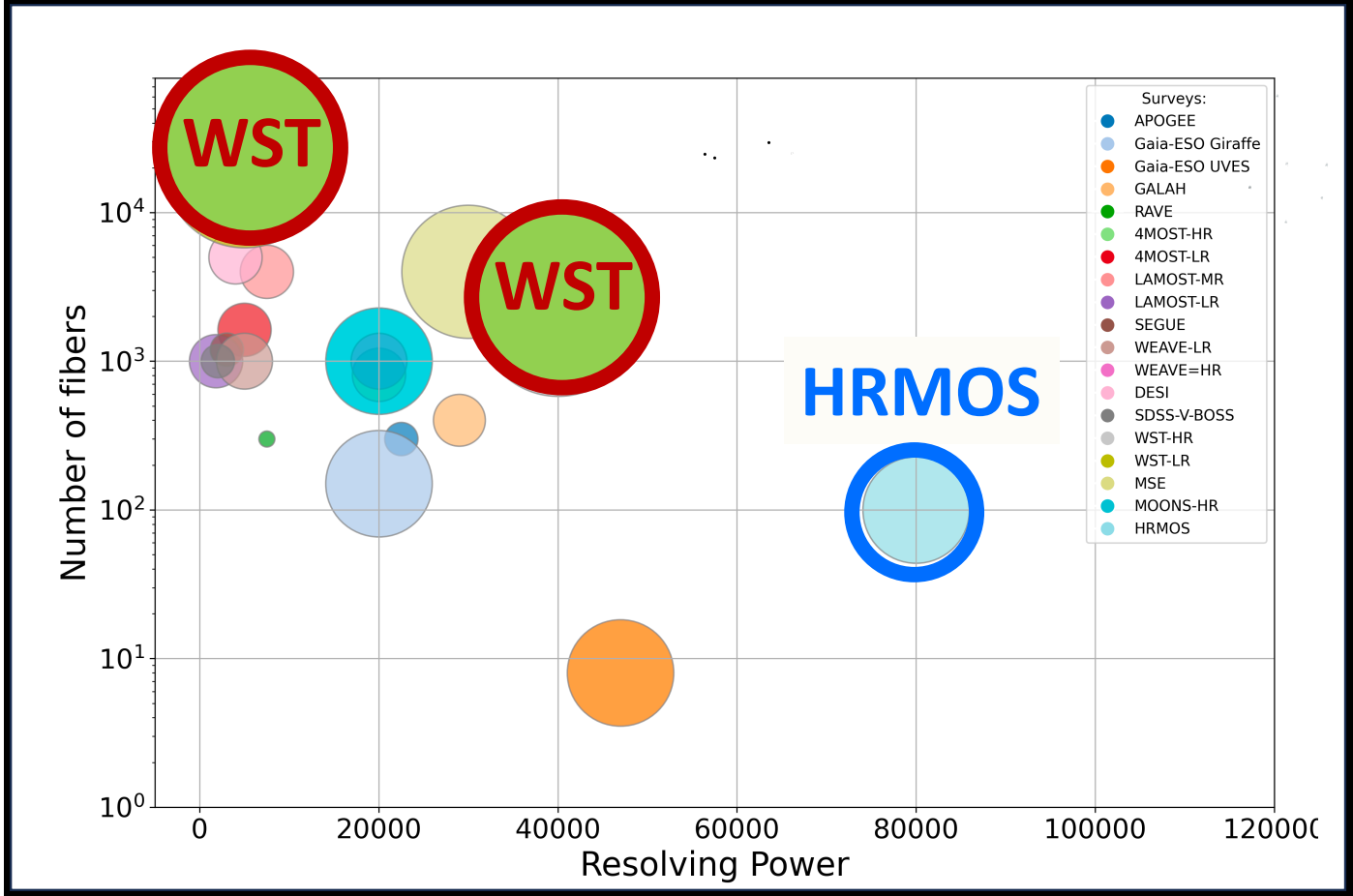


https://ascl.net/2307.043

the age probability distribution for a star with a given Li EW and Teff

What's next

What's next



- ☆ high res. MOS for the VLT -2030+
- ☆ new spectroscopic facility -2040+

- Complementary
- different timelines

The Wide-field Spectroscopic Telescope

Current baseline

PI: R. Bacon
Deputy: S. Randich

Telescope aperture (M1)	12 m seeing limited		
Telescope FoV	3.1 deg^2		
Telescope Spec. range	0.35-1.6 µm		
Operations	MOS and IFS simultaneous operations ToO implemented at telescope and fibre level		
Modes	MOS-LR	MOS-HR	IFS
FoV	3.1 deg^2	3.1 deg^2	3x3 arcmin^2 (mosaic on 9x9 arcmin^2)
Spectral range (simultaneous)	0.37-0.97 µm	0.37-0.97 µm 3-4 windows	0.37-0.97 µm
Spectral resolution	4000	40000	3500
Multiplexing	20000	2000	

https://www.wstelescope.com/

The WST science white paper v1, Mainieri et al, 2024, astro-ph
194 pages, 214 authors https://arxiv.org/abs/2403.05398
v2 foreseen in 2027-2028

3 Exoplanet, Stellar and Galactic Science Case

Authors Rodolfo Smiljanic,[11] Eline Tolstoy[12], Vanessa Hill[6], Tadafumi Matsuno[12], Georges

- three year concept study funded through Horizon
- it will be proposed at the ESO call for ideas for its next programme after the ELT
- challenge: science vision for the 2040+

A high resolution MOS for the VLT – HRMOS
www.hrmos.eu

PI: S. Randich
Co-PIs:
-O. Gonzalez (UKATC)
-E. Fernandez Alvar (IAC)
-S. Sousa (IA, Porto)

Current baseline (not frozen)

Resolution	R=80,000
Multiplex	40-80
Spectral range	Three windows centered at 390, 520, 660 nm (140 nm simultaneous)
RV precision	10 m/s

to be proposed at the upcoming call for VLT instrumentation

HRMOS

arXiv:2312.08270v1 [astro-ph.IM] 13 Dec 2023

White Paper
Science Motivation v.1

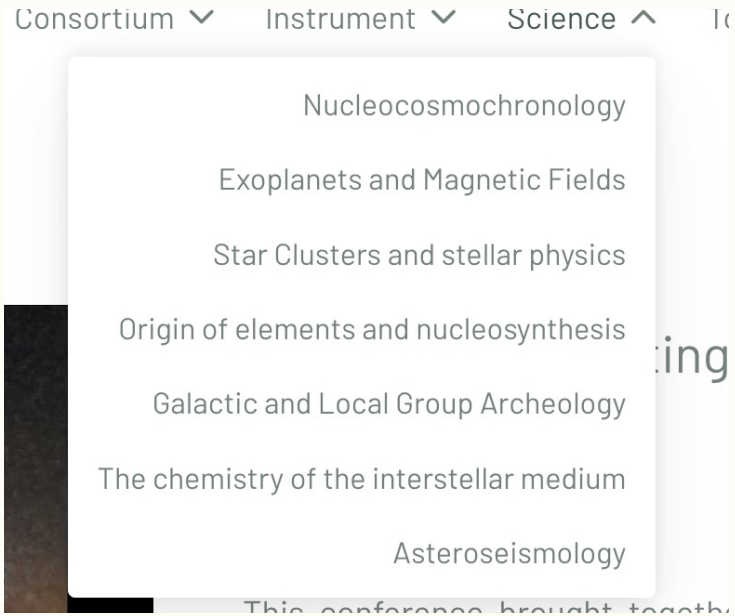
A new high-resolution multi-object spectrograph at the ESO VLT

December 14, 2023

Magrini, Bensby+, 2023

White Paper v2, in prep.
Foreseen in Spring 2025

Isotopes and more!



Summary

- Thanks to ***Gaia*** **and the ground based spectroscopic surveys** we are going through a **revolution**
- The **Gaia-ESO Survey** was a **precursor**
- **Gaia-ESO** final catalogue **public at ESO and CDS**
- This decade has plans in place for exponential growth of data + more mature community and new analysis methodologies
- **HRMOS** (2030+) and **WST** (2040+) appears key for a further step forward –**get involved! (page on websites)**
- In the meantime….**exploit the archives!**


Best Western