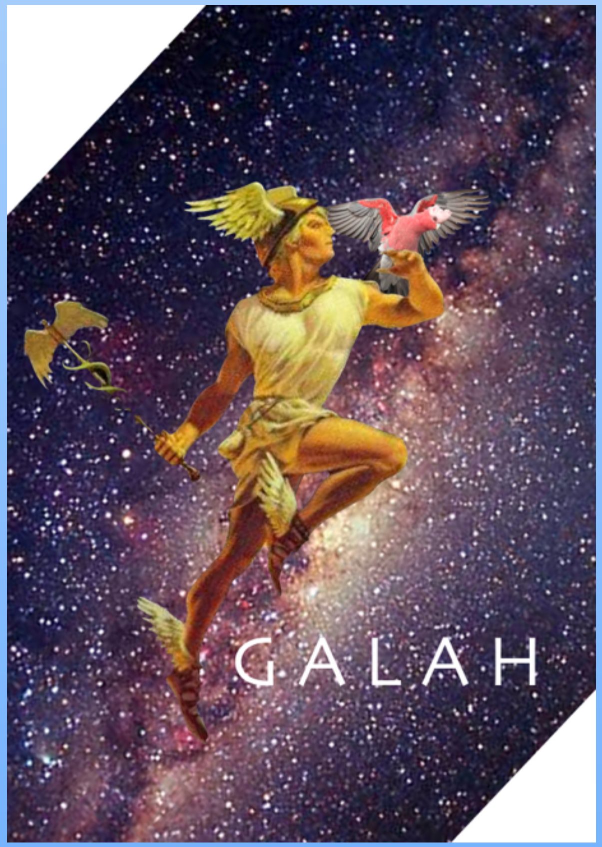
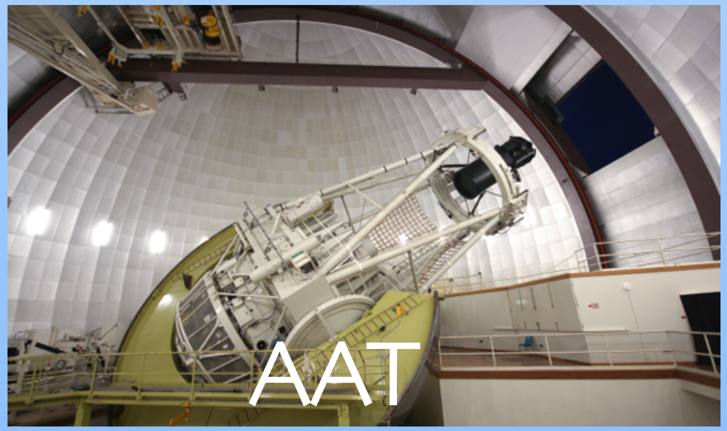
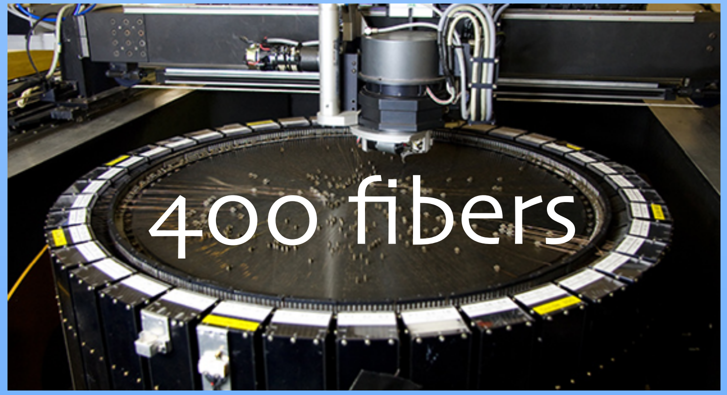
The GALAH Survey

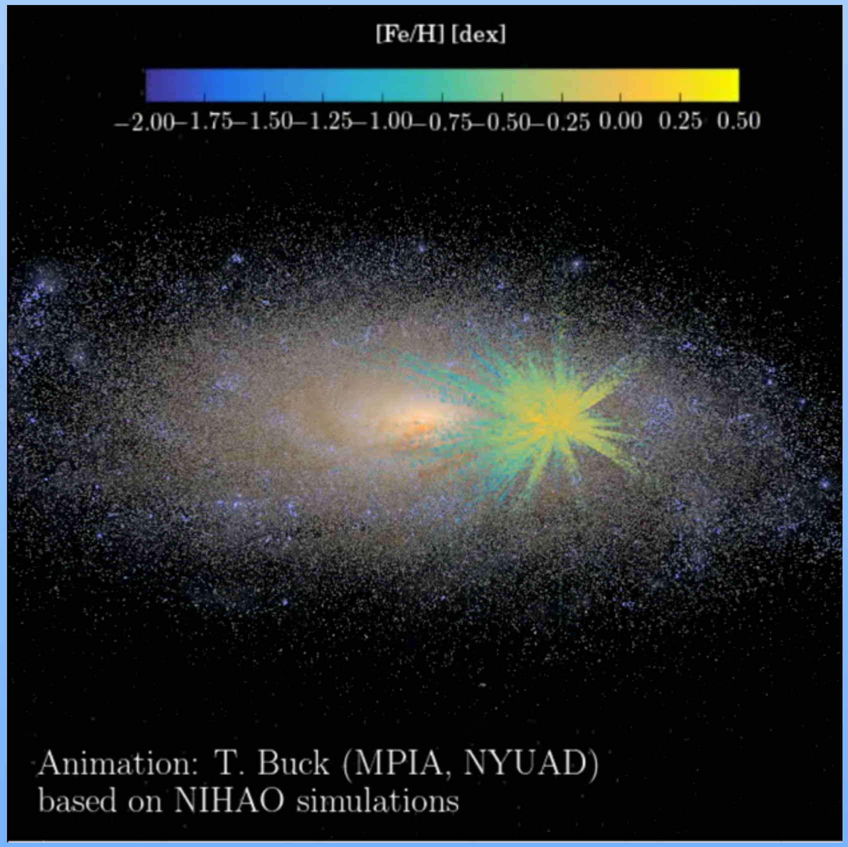
Forging connections in the solar neighborhood in the era of large scale stellar surveys

Sven Buder* (MPIA Heidelberg)
& the GALAH Survey team







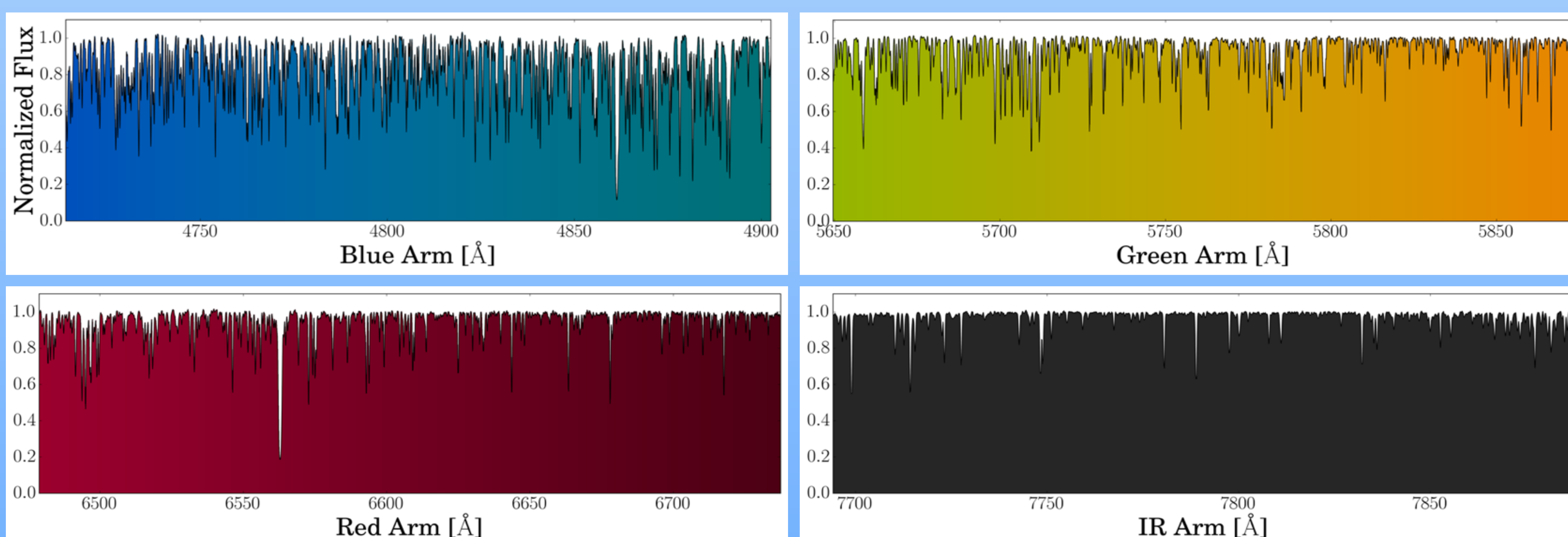


* I am member of GALAH, Gaia-ESO, and APOGEE: I care about them all and how we can improve!

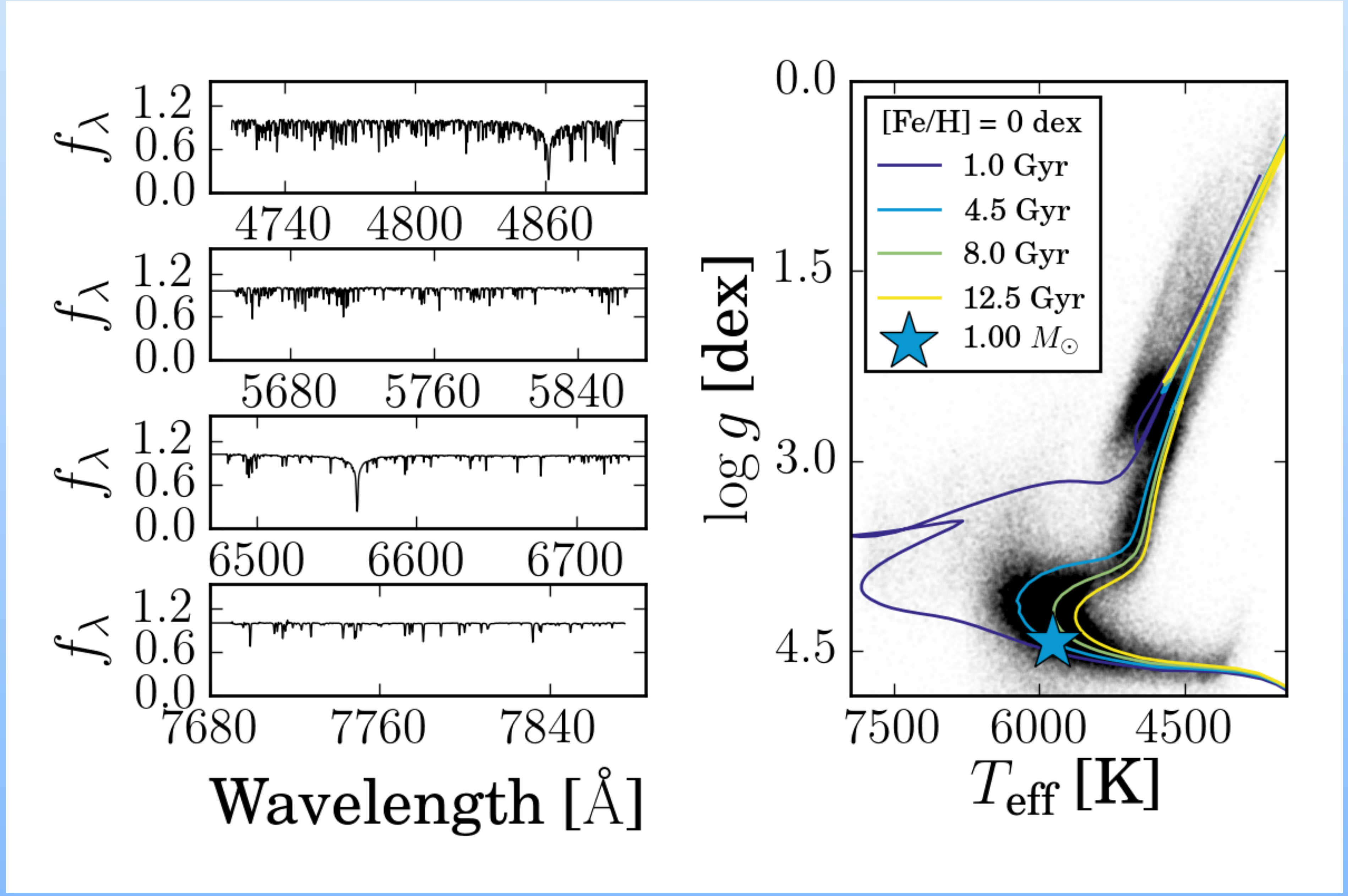
Science goals

- Distribution function of stellar properties ([Fe/H], chemical composition, age, position, orbits)
- Chemical tagging (with up to 30 [X/Fe])
- Improve understanding of stellar physics/evolution

Selection	12 < Vmag < 14	**R**	28000 (2dF HERMES)
Size	0.4 Mio. (aim: ≳ 1.0 Mio)	**λ**	~1000 Å (VIS incl. Hα,Hβ)



Up to 10^6 spectra



hot(ter) stars (v_{sini}), FGK dwarfs + giants, cool dwarfs (TiO!), pre-MS stars, emission stars, binaries, …
+ bad spectra

How to analyse 10^6 spectra?

Problem 1: time/computational costs

Stellar physics-driven data analysis takes ~ 1h per star (on-the-fly syntheses of spectra from stellar models)

Problem 2: data-driven analyses need training/calibration

Purely data-driven data analyses do not use stellar physics priors

Solution:

Combine physics-driven analysis for small representative set with data-driven analysis on whole sample:

Spectroscopy Made Easy (SME) by Piskunov & Valenti (2017)

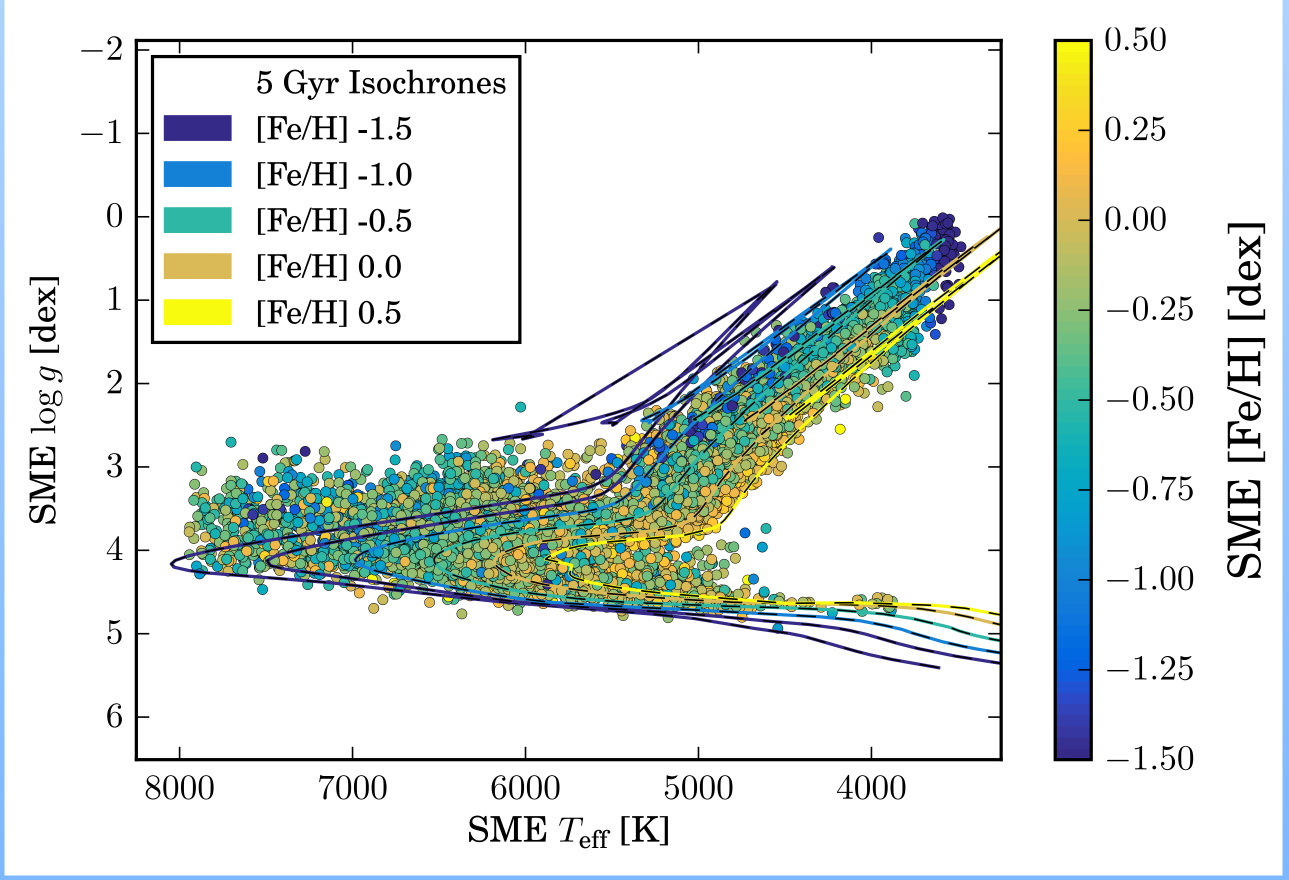
+

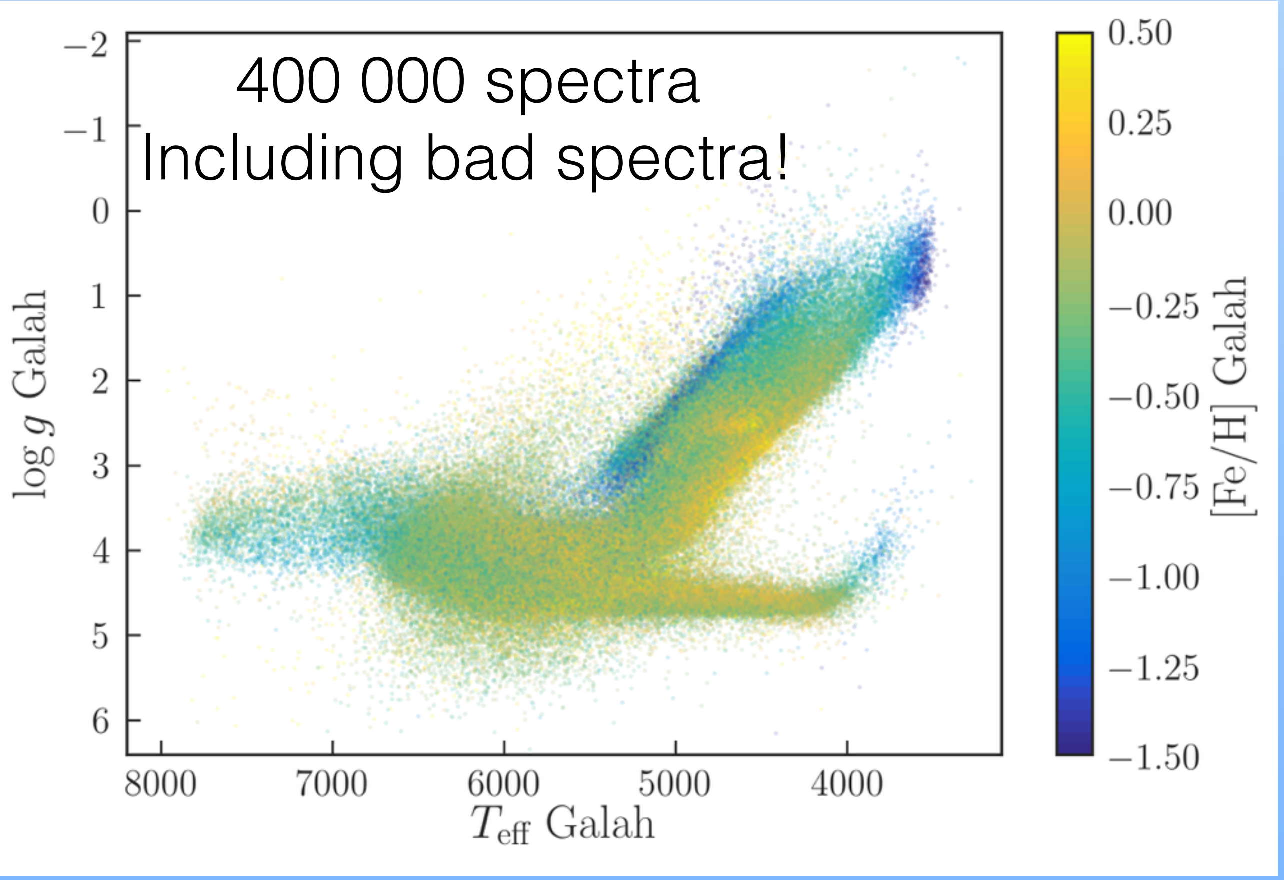
The Cannon by Ness et al. (2015)

THE CANNON (NESS ET AL. 2015)

Use linear algebra (e.g. quadratic model) to construct spectra from stellar labels (T_{eff}, log g, [Fe/H], …)

$$f_{n,\lambda} = \Theta_\lambda^T \cdot l_n + \text{noise}$$





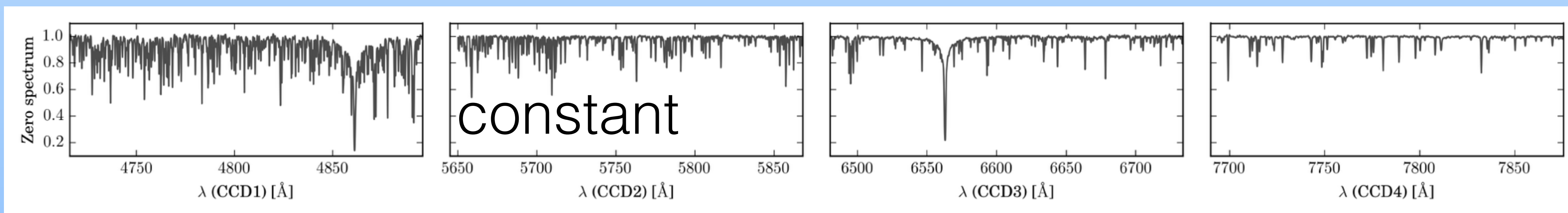
l_n fixed, train Θ_λ

Θ_λ fixed, optimise l_n

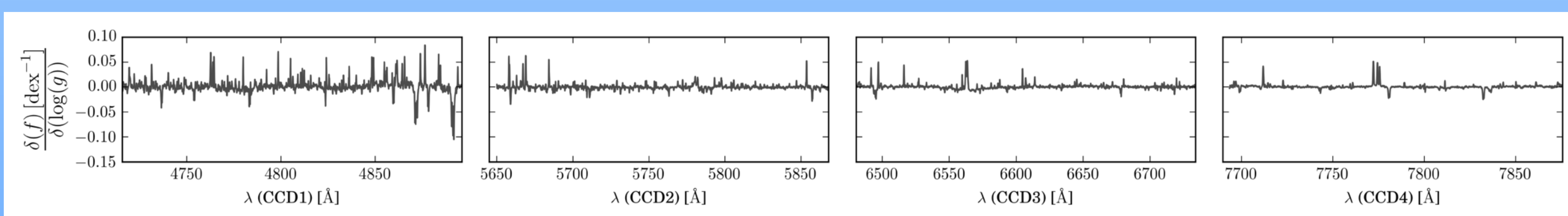
The Cannon (Ness et al. 2015)

Use linear algebra (e.g. quadratic model) to construct spectra from stellar labels (T_{eff}, log g, [Fe/H], …)

$$\mathrm{f}_{n,\lambda} = \Theta_\lambda^T \cdot l_n + \mathrm{noise}$$



linear coefficient for logg:



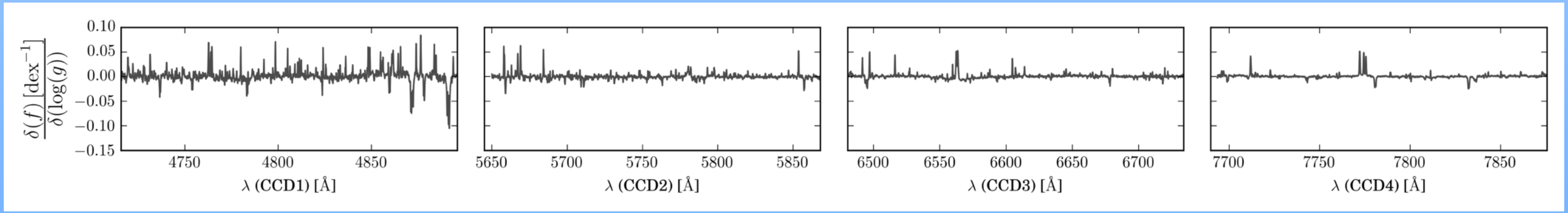
The Cannon (Ness et al. 2015)

Use linear algebra (e.g. quadratic model) to construct spectra from stellar labels (T_{eff}, log g, [Fe/H], …)

$$f_{n,\lambda} = \Theta_\lambda^T \cdot l_n + \text{noise}$$

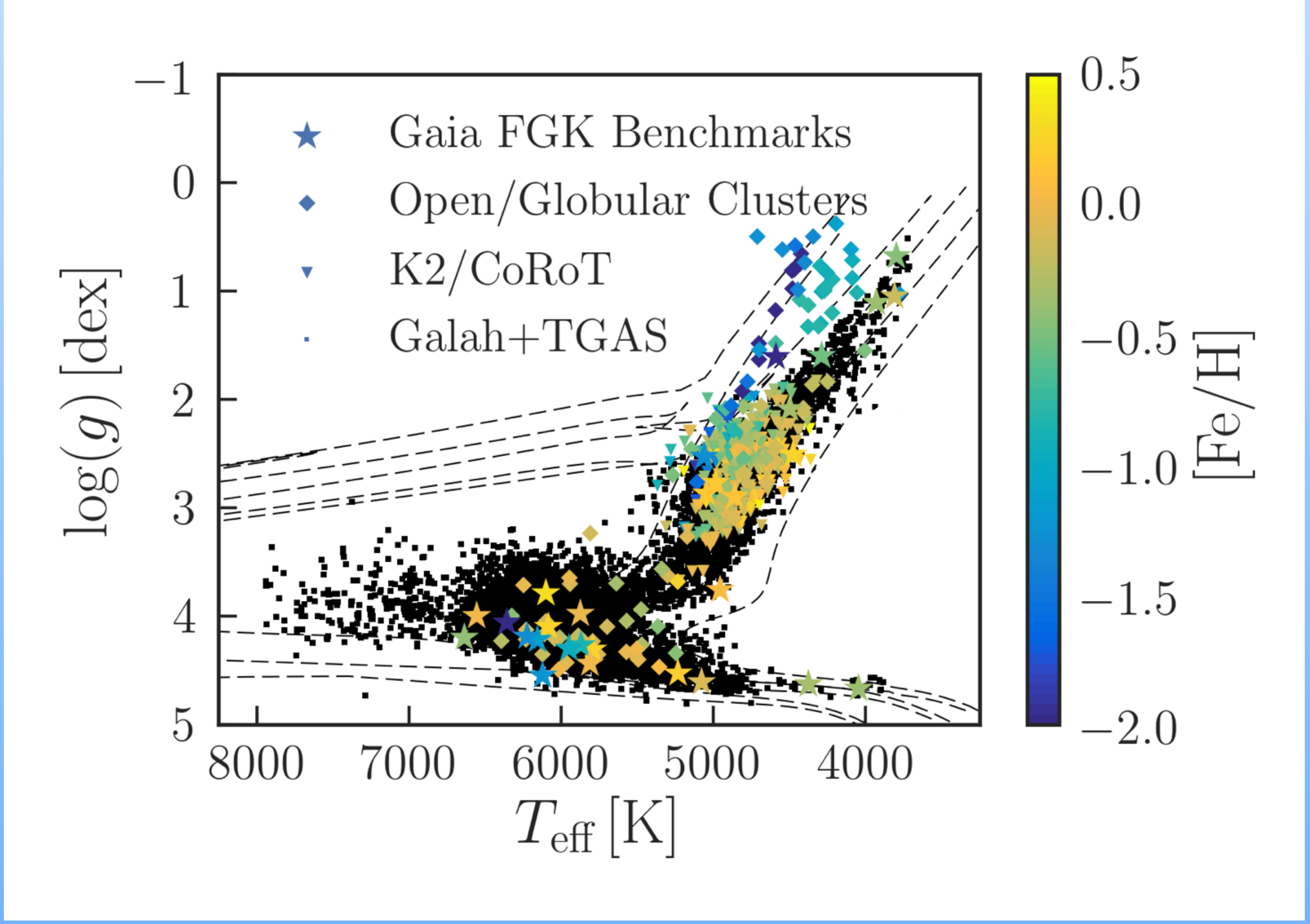
many properties can be used as a label:
… , v_{mic}, v_{sini}, [X/Fe], age, mass, E(B-V), A_K, BVRIJHK, …

linear coefficient for logg:



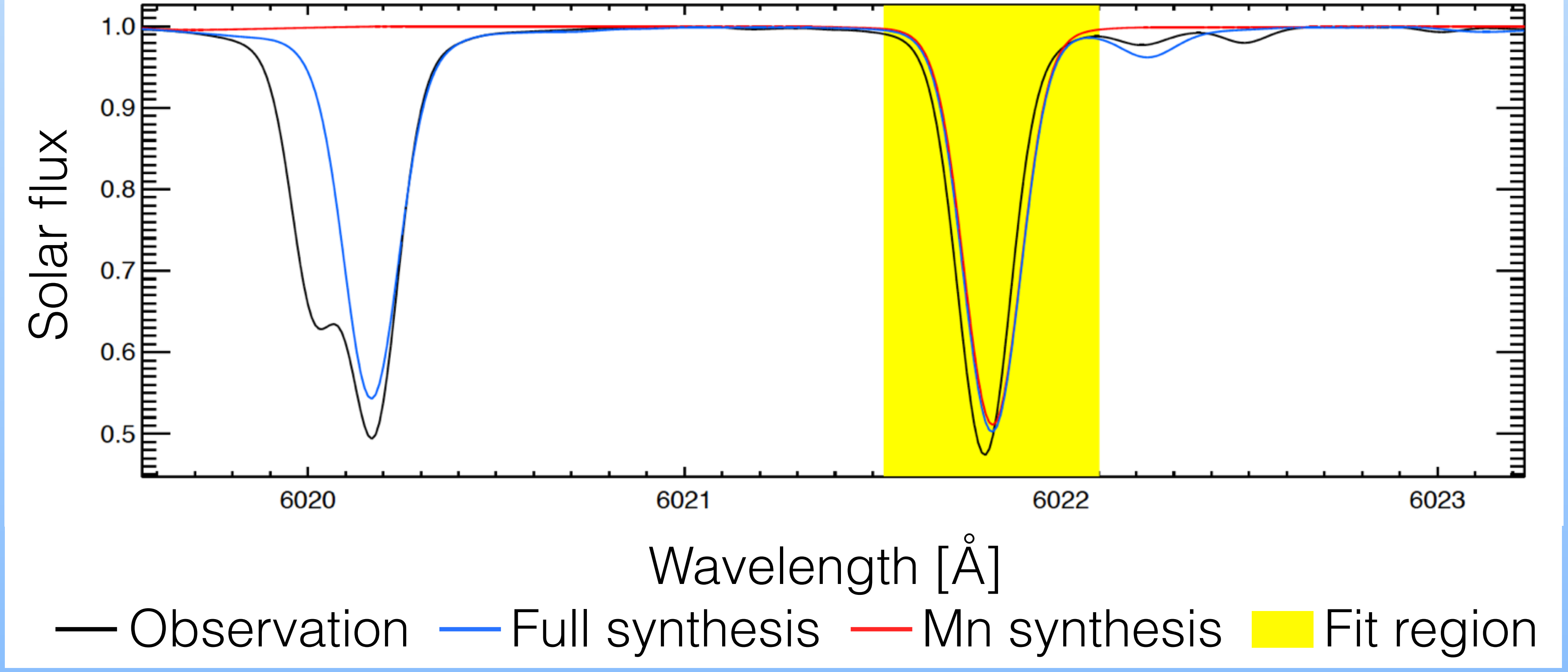
ACCURACY/PRECISION OF STELLAR PARAMETERS

validation/calibration with non-spectroscopic information



ACCURACY/PRECISION OF STELLAR ABUNDANCES

(First) quantification of influences as part of
GBS paper V: Jofré, Heiter, …, Buder, Gilmore, … (2017)



Continuum placement	Broadening parameters	Instrumental characteristics
Line data (λ, f-value)	Blends	Hyperfine structure

Accuracy/Precision of stellar abundances

Important for large scale automated analysis

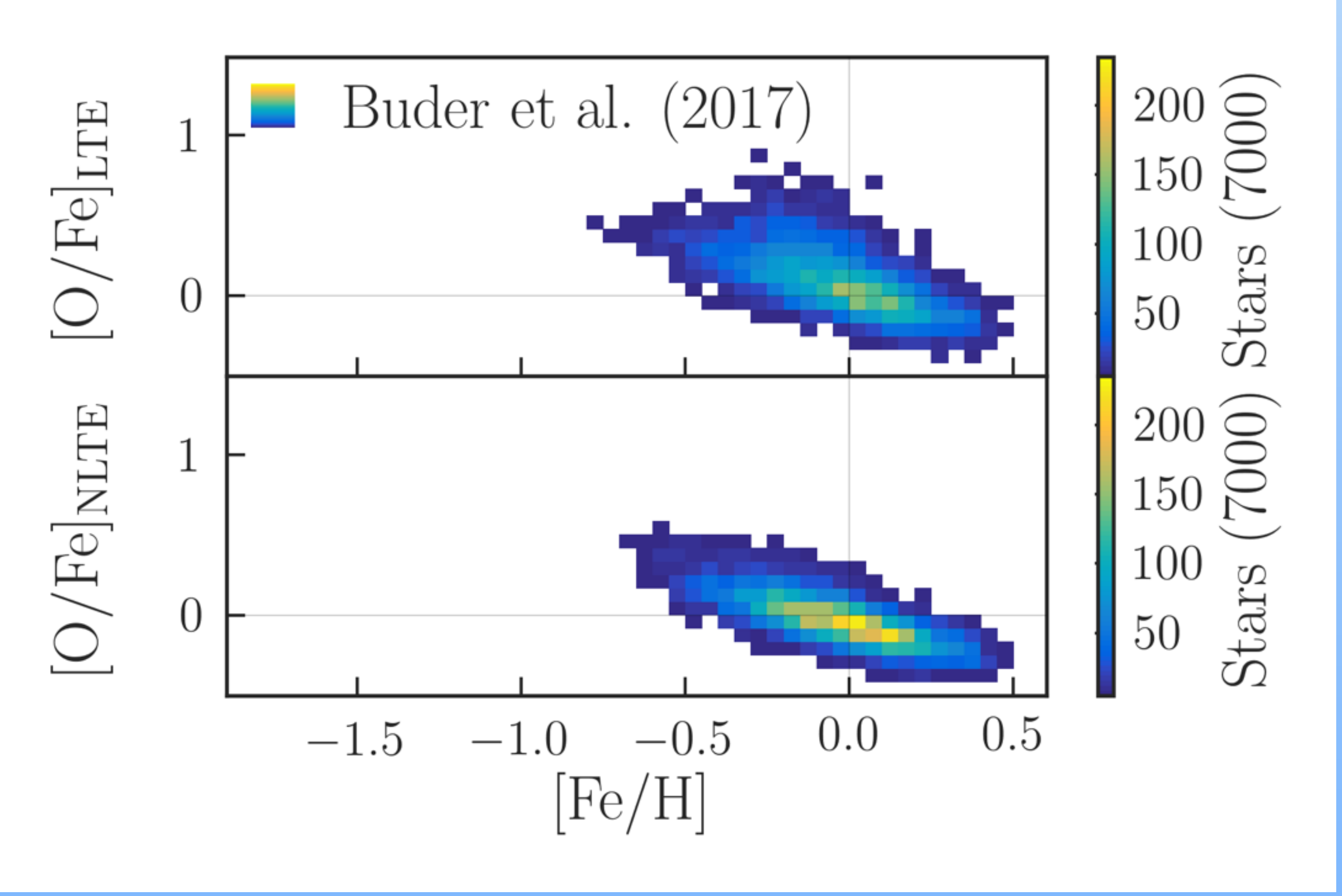
Tellurics

Sky, DIBs

Atmospheric structure

Level populations

Buder et al. (in prep)

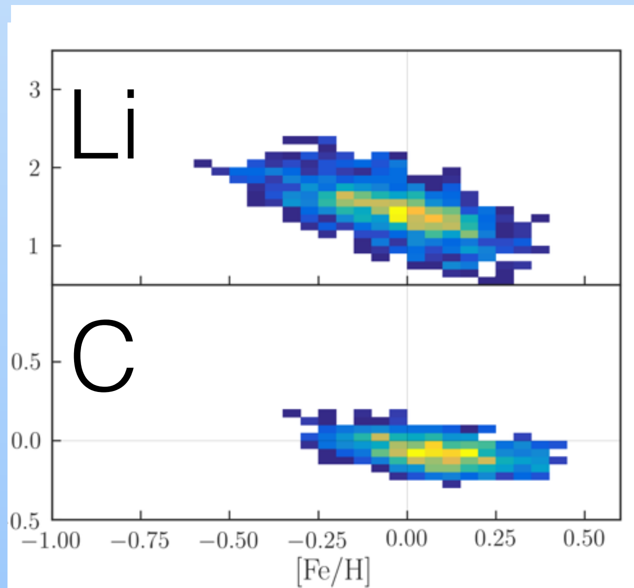


NLTE corrections by A. Amarsi (ANU -> MPIA)

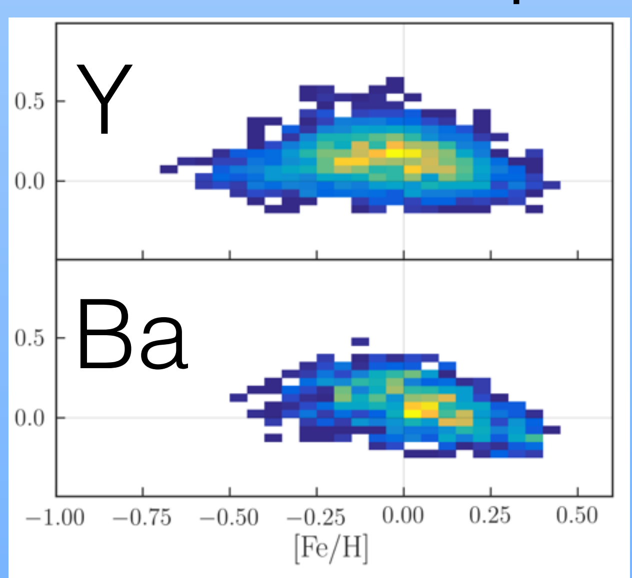
Abundances from the GALAH+TGAS dwarfs

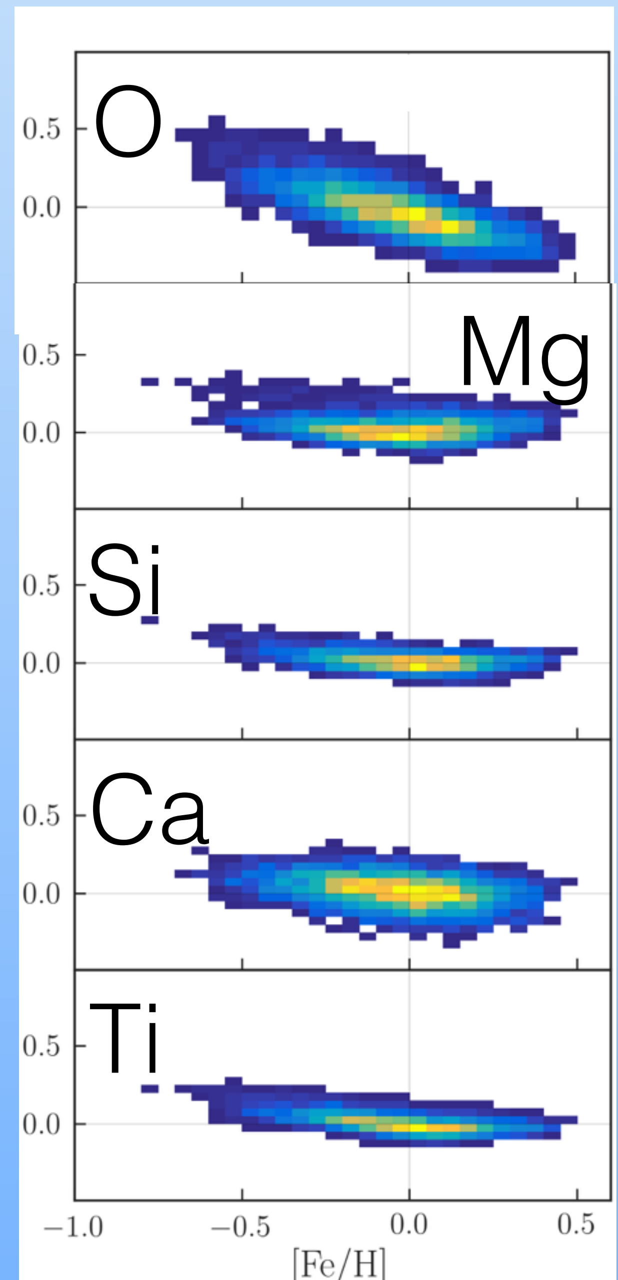
Buder et al. (in prep) based on homogenous study of Galah dwarfs in Gaia DR1 TGAS

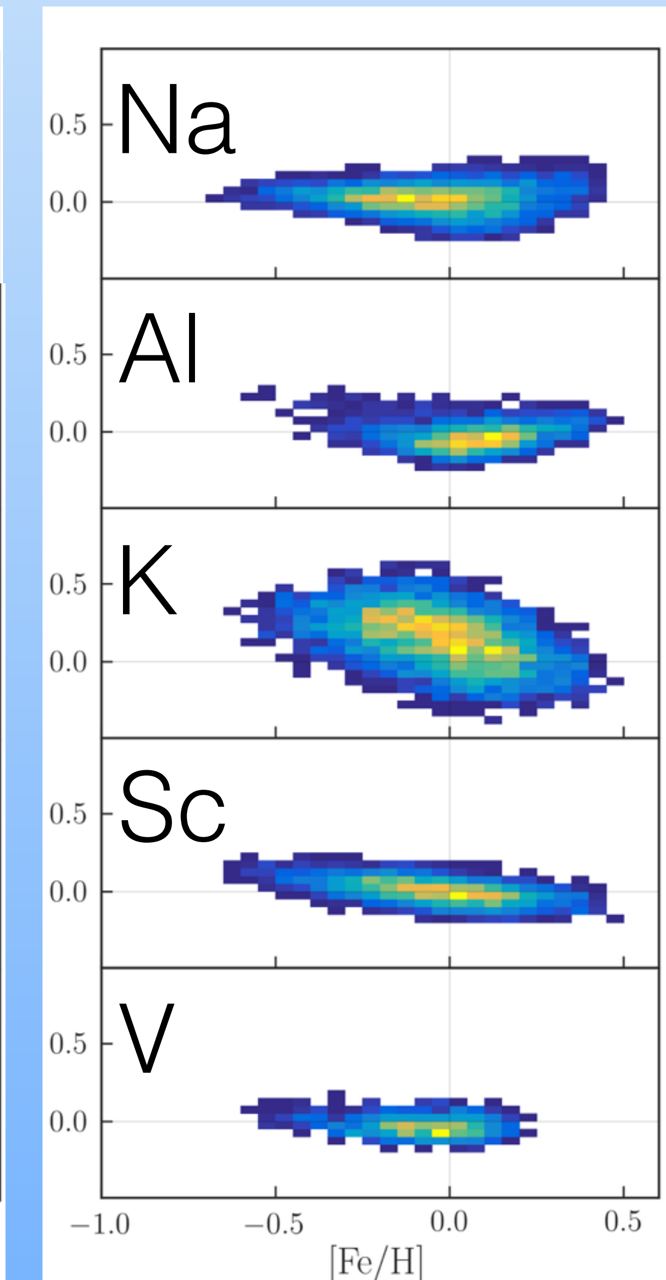
Light proton cap. Alpha odd-Z + iron-peak

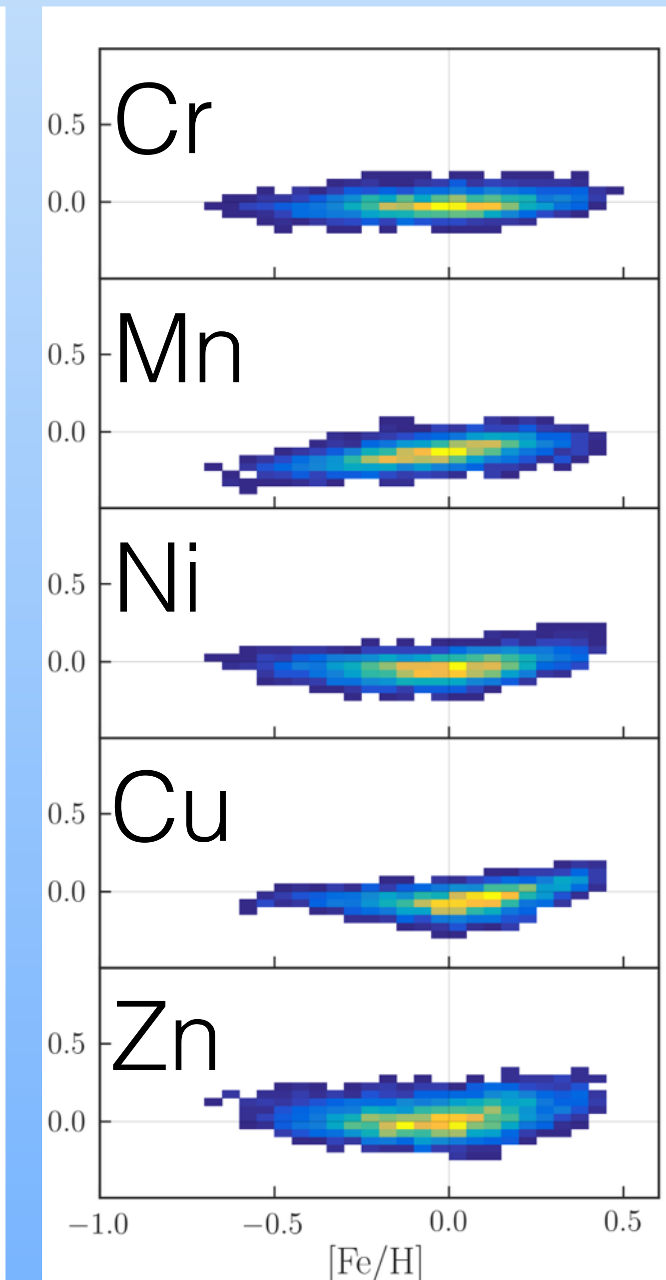


Neutron cap.



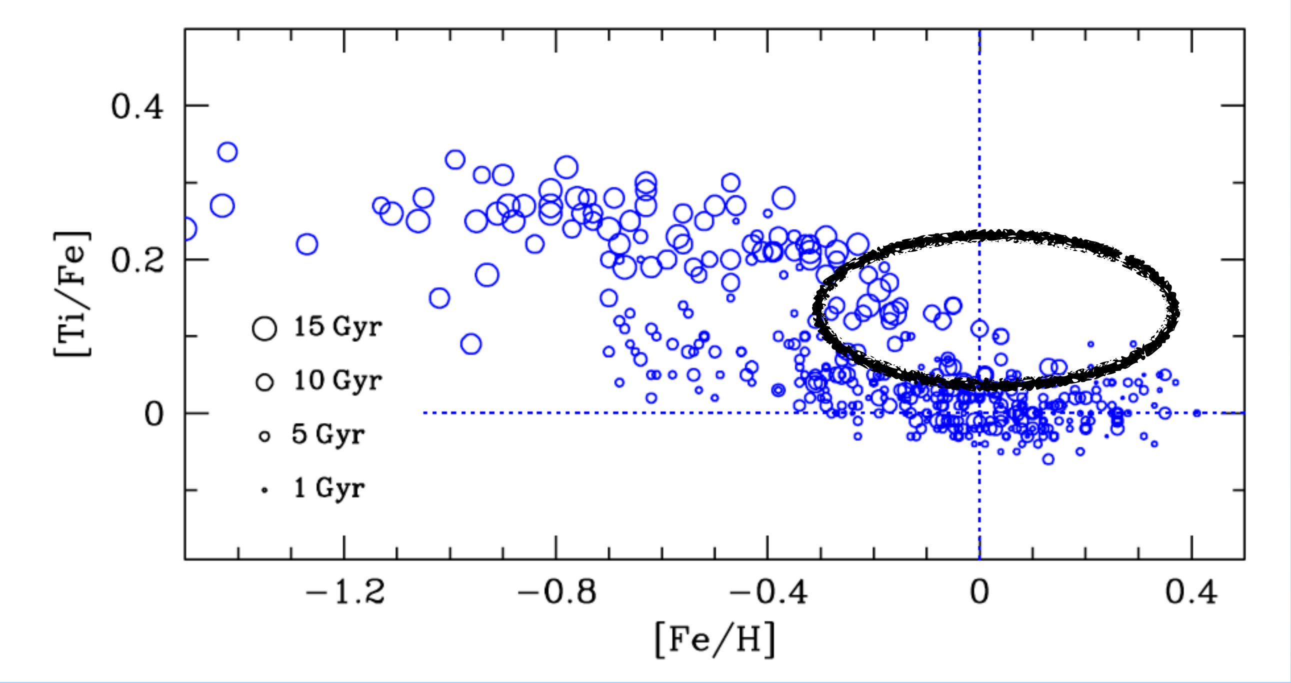






Almost all [X/Fe]: agreement with Bensby et al. (2014), Battistini & Bensby (2015, 2016)

[α/Fe] in our solar neighbourhood



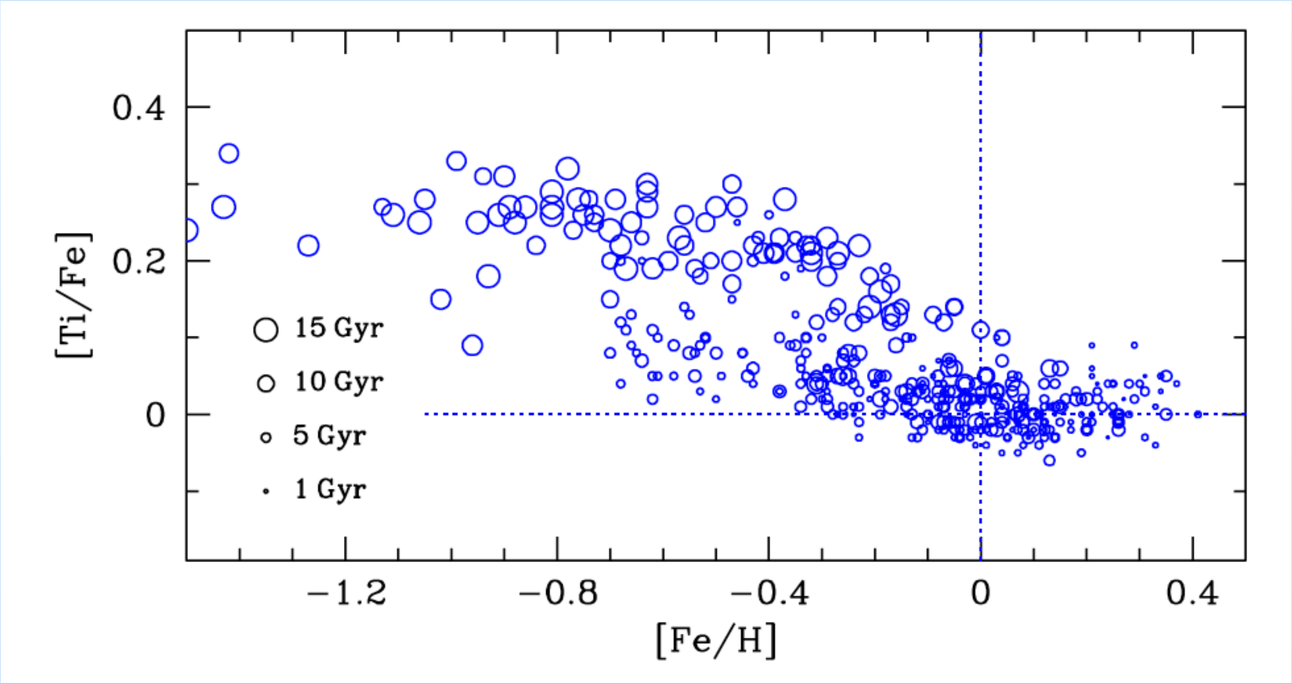
Bensby et al. (2014) - 714 dwarfs

Thick disk	**hαmr?***	**Thin disk**
α-enhanced		α-poor
old (> 8 Gyr)		young (< 8 Gyr)

different kinematics*

*Adibekyan et al. (2011)

[α/Fe] in our solar neighbourhood



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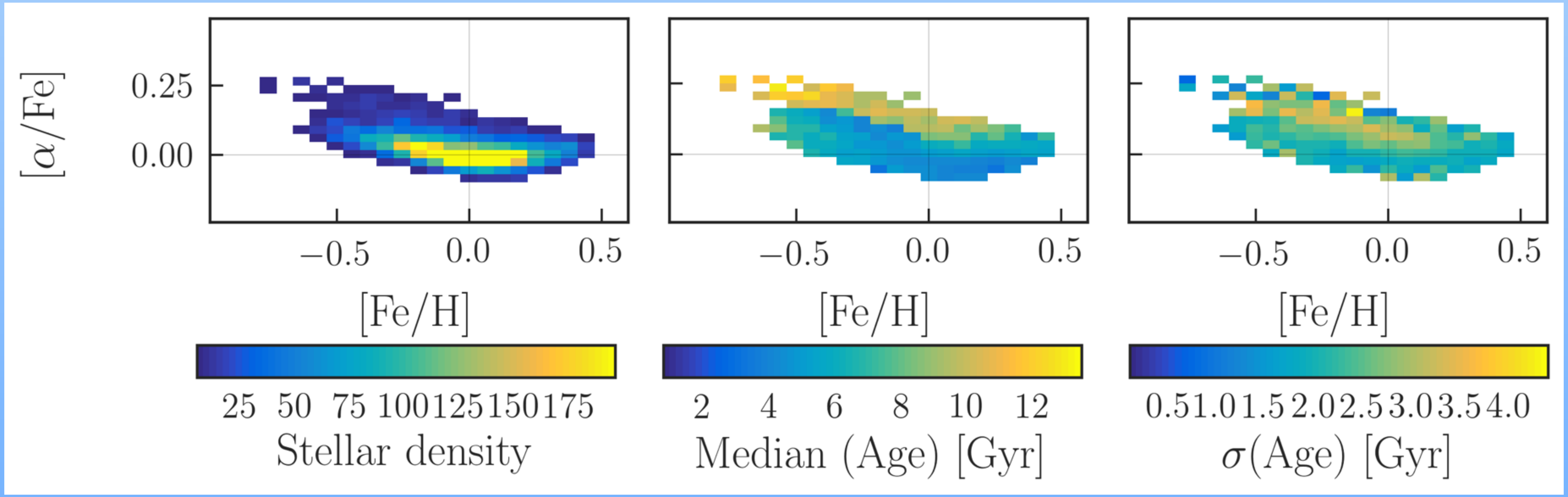


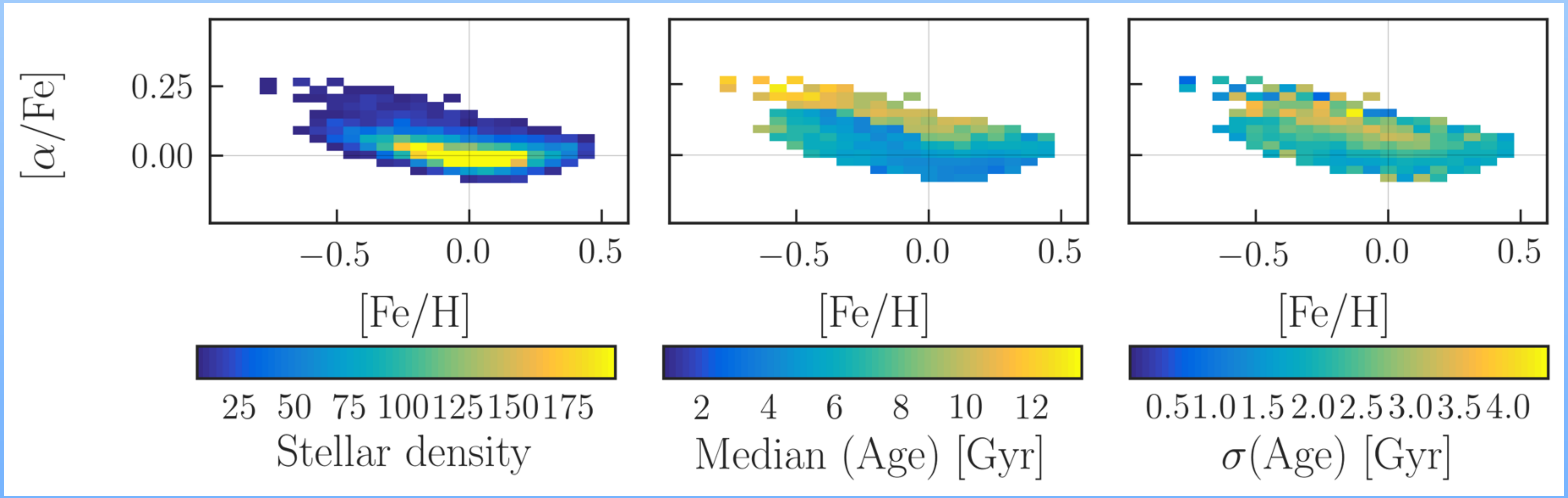
Buder et al. (in prep) ~8000 Galah+TGAS dwarfs (with preliminary age estimates)

[α/Fe] in our solar neighbourhood

α-elements trace SFH and show difference
in thin/thick disk dichotomy (yields)
global [α/Fe] vs. individual

Breakout Session?!

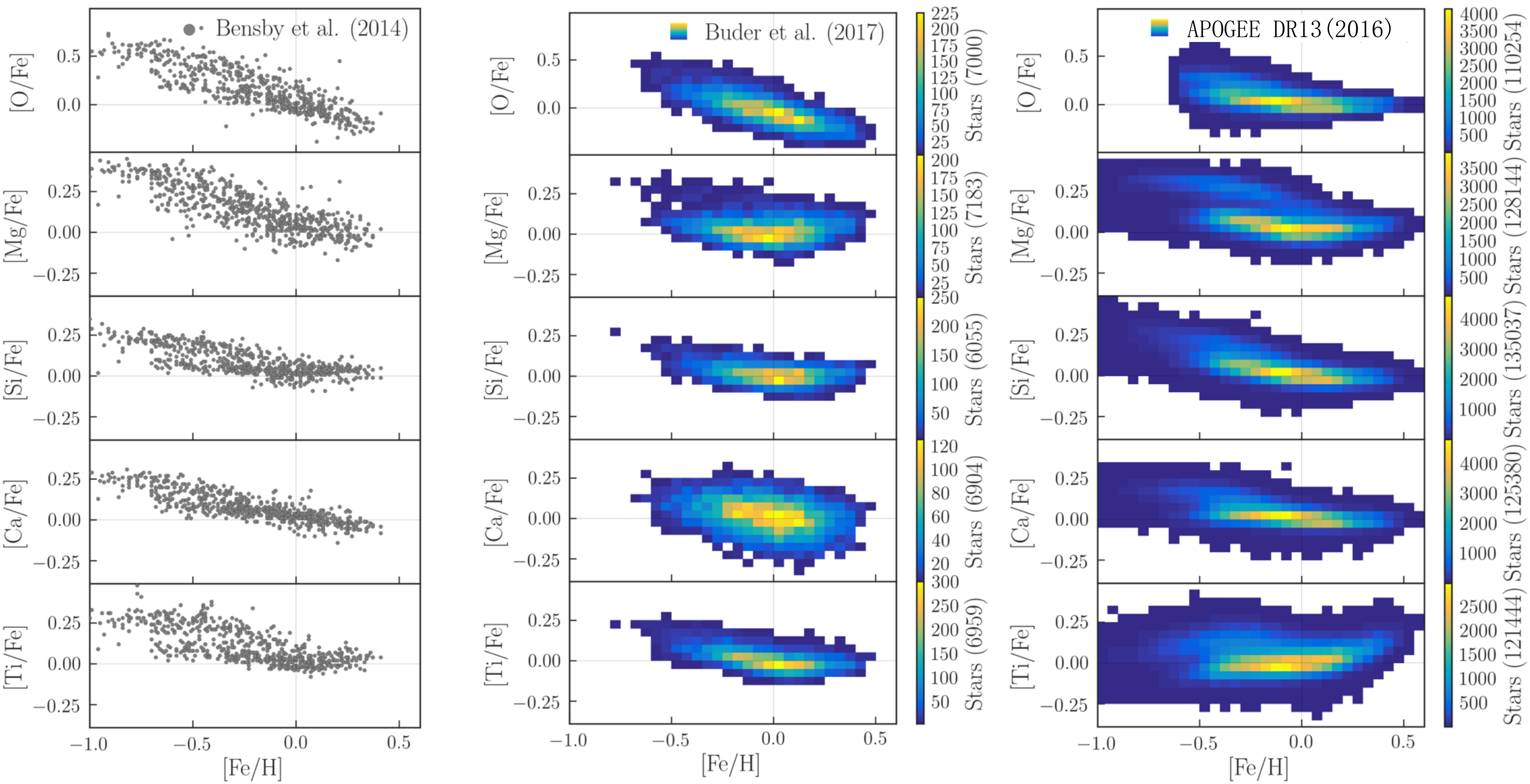
Element abundances: measurements vs. GCE models



Buder et al. (in prep) ~8000 Galah+TGAS dwarfs (with preliminary age estimates)

[α/Fe] from different elements & surveys

Bensby et al. (2014)	Galah+TGAS	APOGEE DR13
MS + TO @Rsun	MS + TO @Rsun	RGB
VIS, R > 40k, S/N > 150	VIS, R~28k, S/N ~50-100	IR, R~23k, S/N > 100



[α/Fe] from different elements & surveys

Why different?

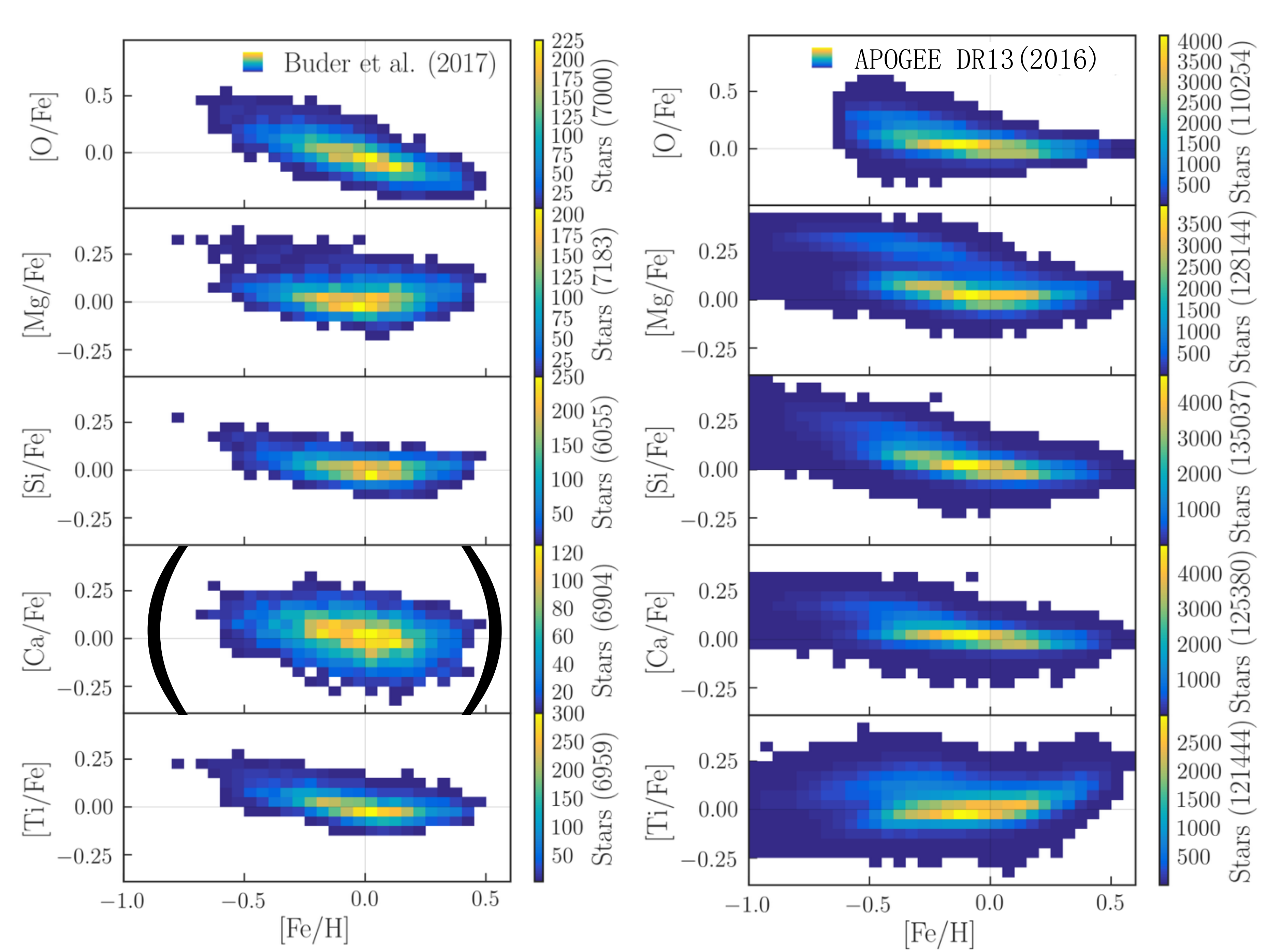
Selection (thin/thick)

Optical vs. IR?

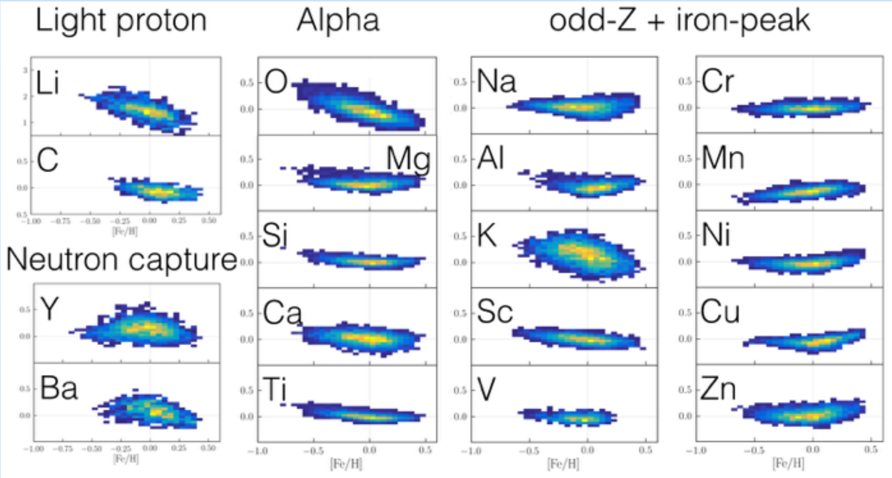
Dwarfs vs. giants?

What do GCE models predict for sub-supersolar regime?

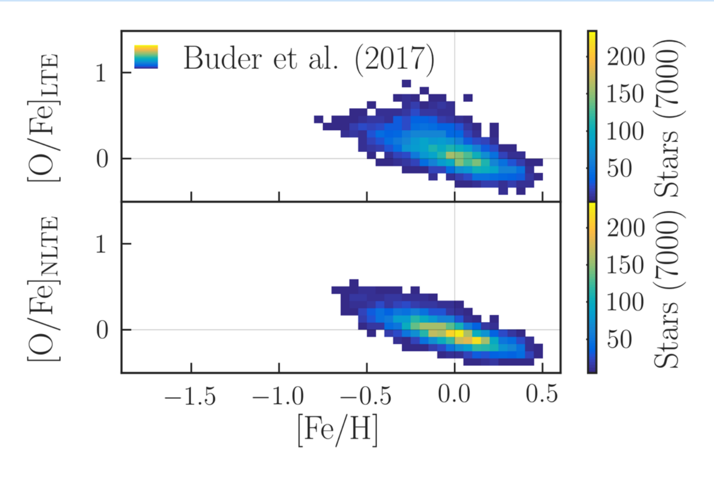
Galah+TGAS	APOGEE DR13
MS + TO @Rsun	RGB
VIS, R~28k, S/N ~50-100	IR, R~23k, S/N > 100



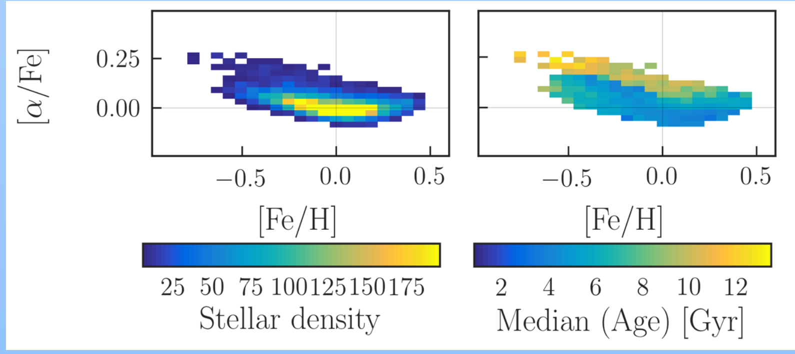
Forging connections with GALAH



Chemical tagging (1 Mio.★)

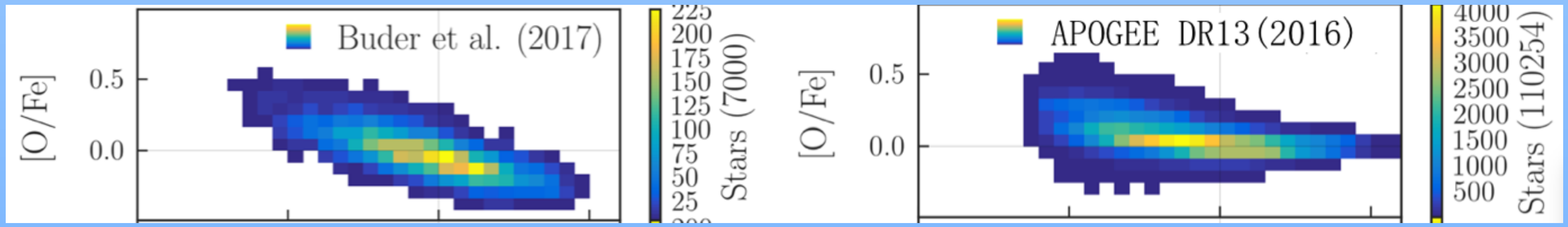


(3D) NLTE



[X/Fe]
+ages
+dynamics

Sven's
chemo-dynamic
sandbox



My idea for breakout session(s):
Stellar surveys vs. GCE for [α/Fe] (+25 [X/Fe])