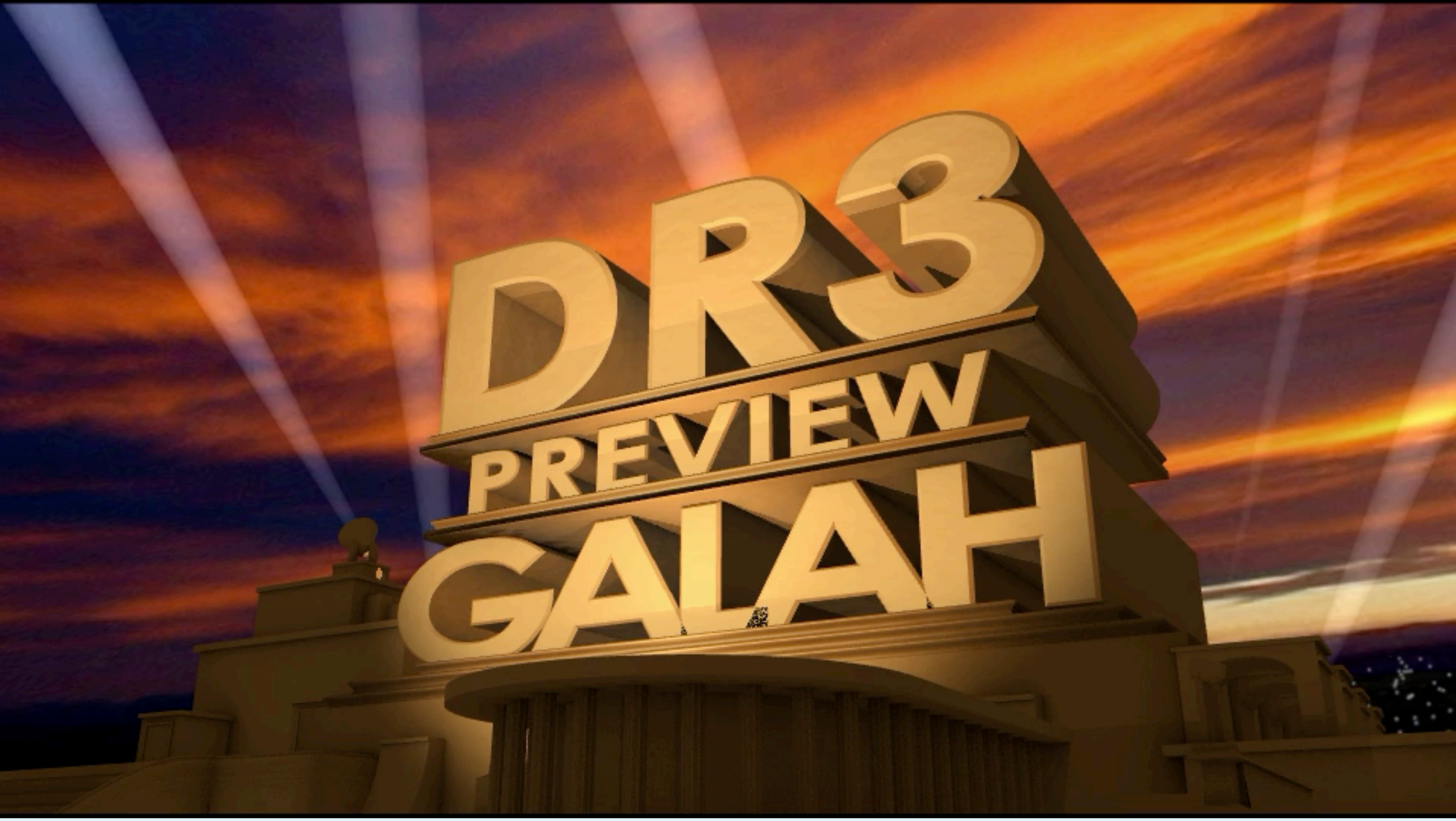


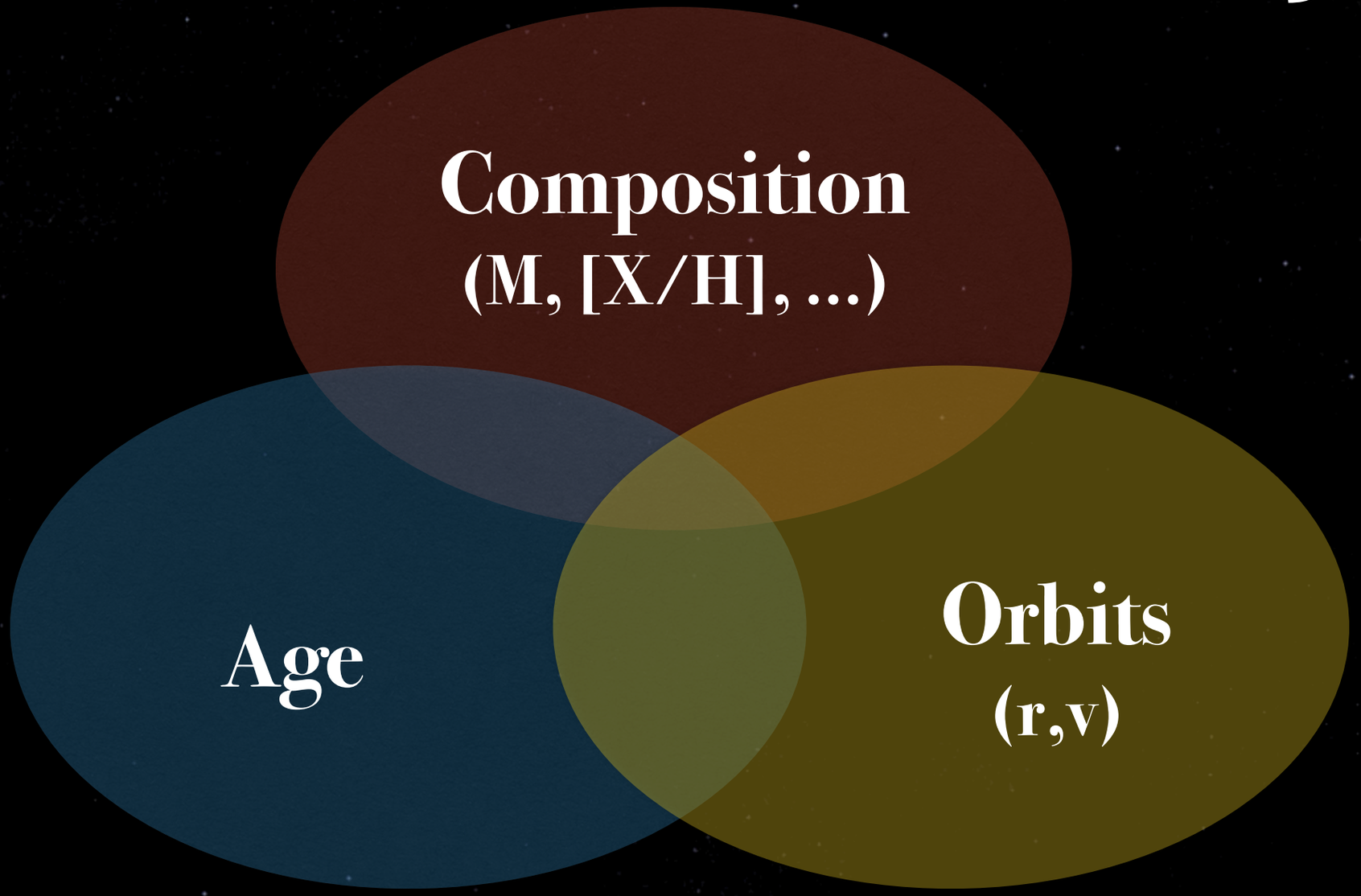
Sven Buder (MPIA Heidelberg)
& The GALAH Survey Collaboration

buder@mpia.de, @astro_sven

In June 2019 in a galaxy

that we call our Galaxy...

What intel on stars do we need to gather?

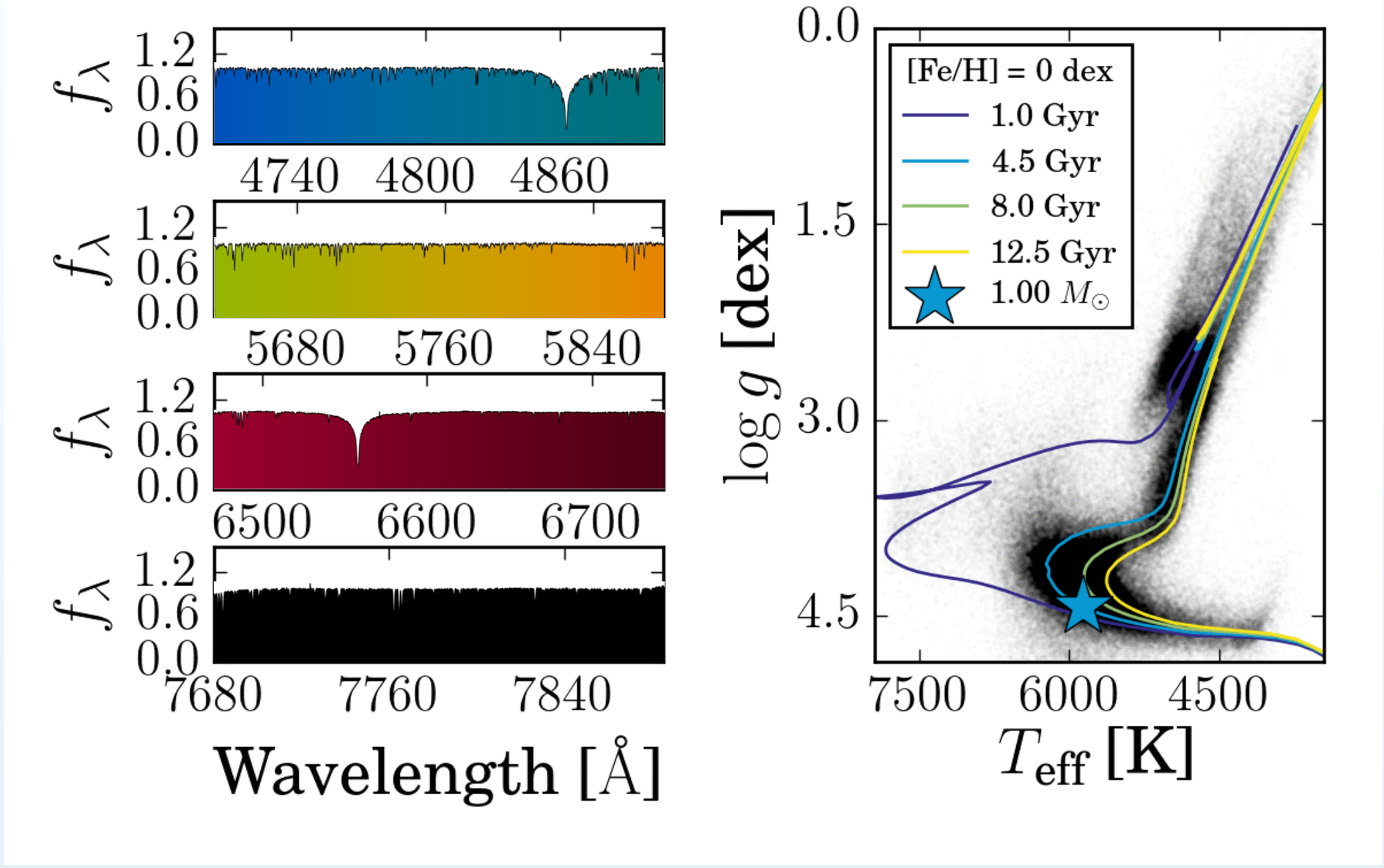


Episode MMXIX

THE RETURN OF THE GALAH

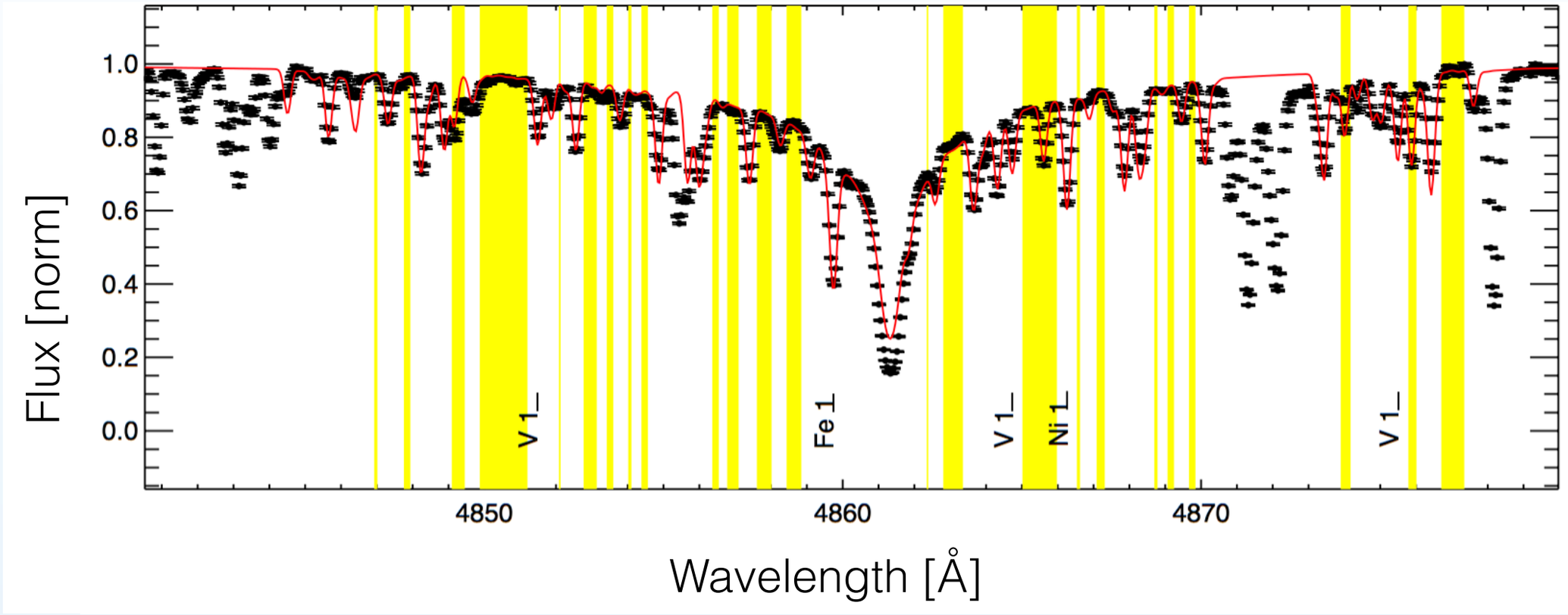
SURVEY (DR3)

Chemical Composition from Spectra



The information on the (chemical) composition of a star is hidden in its spectrum!

“Model-driven” stellar properties from spectra



Spectrum synthesis based on atmosphere models
(molecular+ionisation equilibrium, continuous+line opacities, radiative transfer)

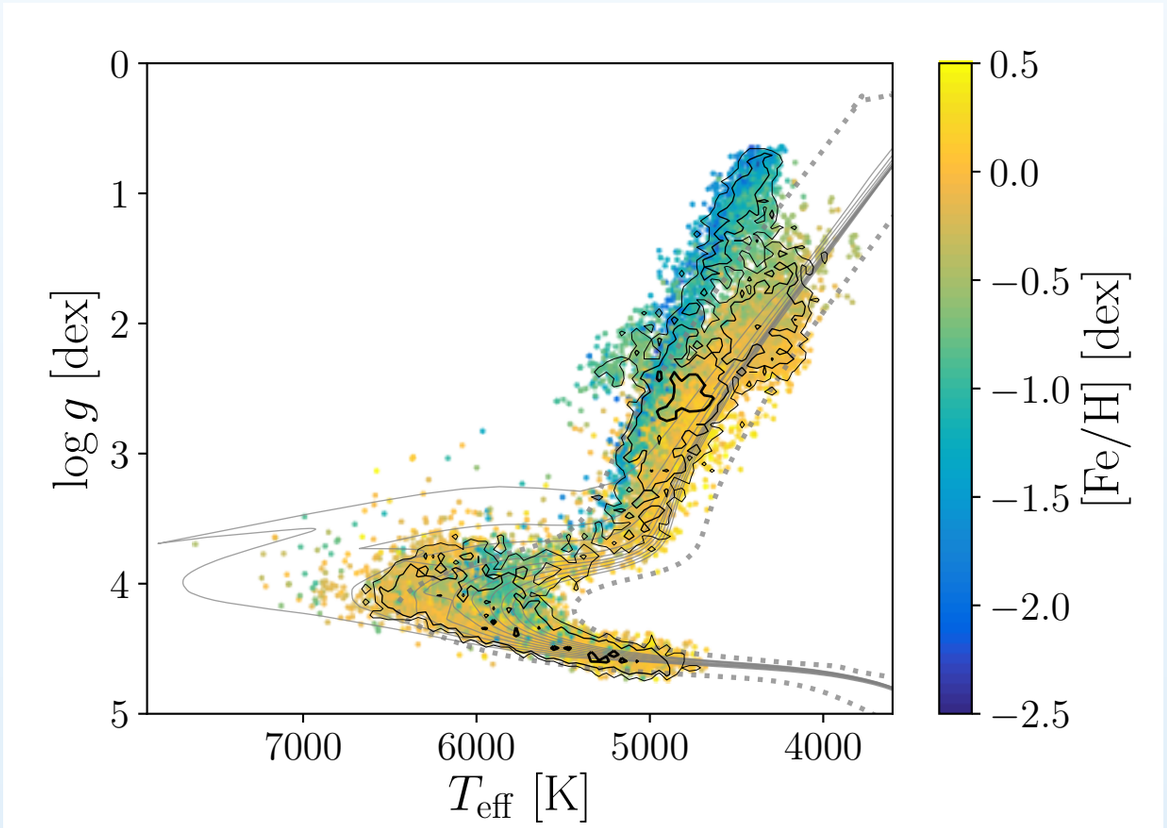
χ^2 **optimisation** of stellar parameters and element abundances

for GALAH: SME by Piskunov & Valenti (2017)

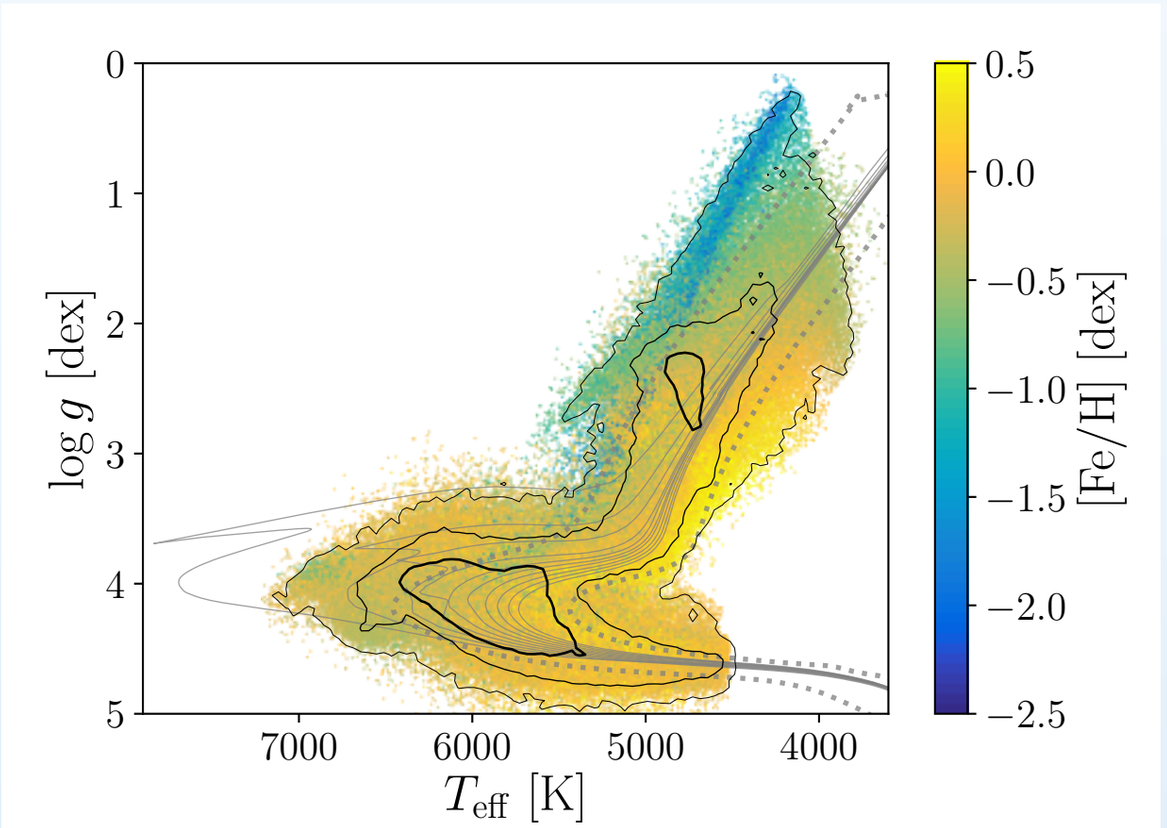
"Data-driven" stellar properties from spectra

Use linear algebra (e.g. quadratic model) to construct spectral flux **f** from stellar labels *l* (temperature, metallicity, …)

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



l_n fixed, train Θ_λ



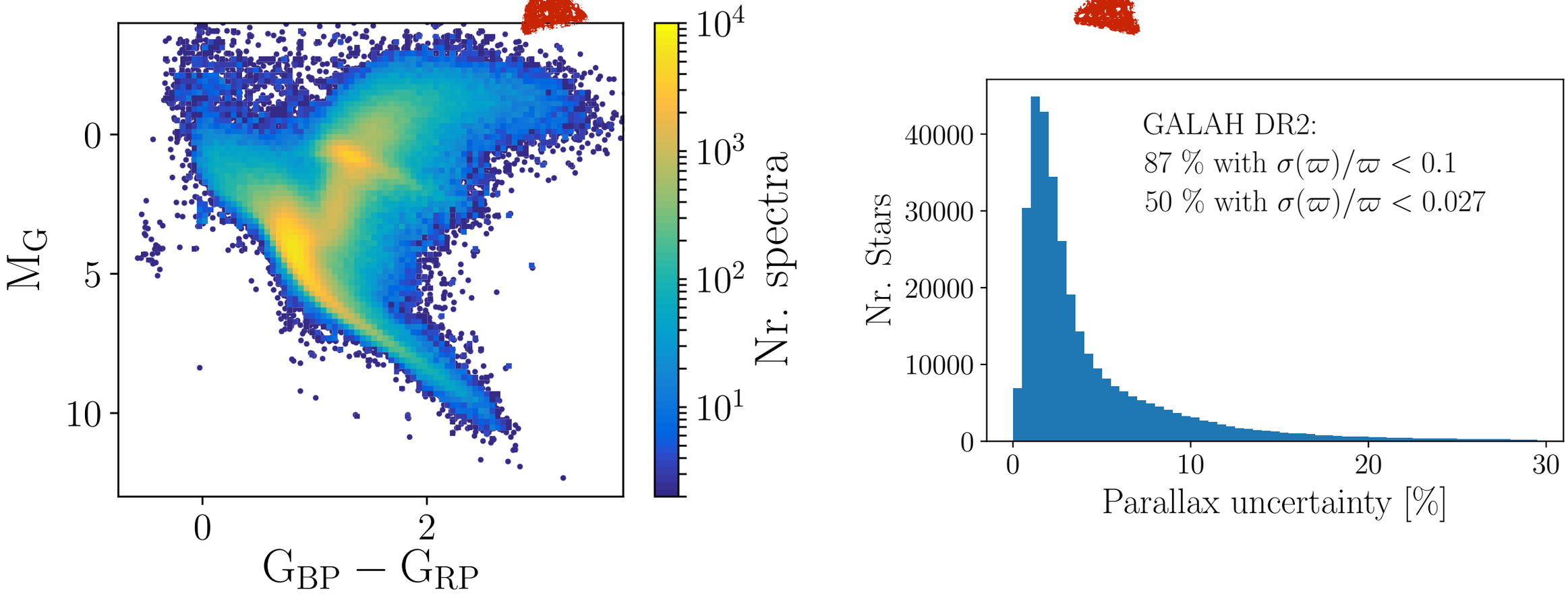
Θ_λ fixed, optimise l_n in 0.1s

For GALAH: *The Cannon* by Ness et al. 2015

Post Gaia DR2: At the sweet spot of Gaia

Gaia

GALAH



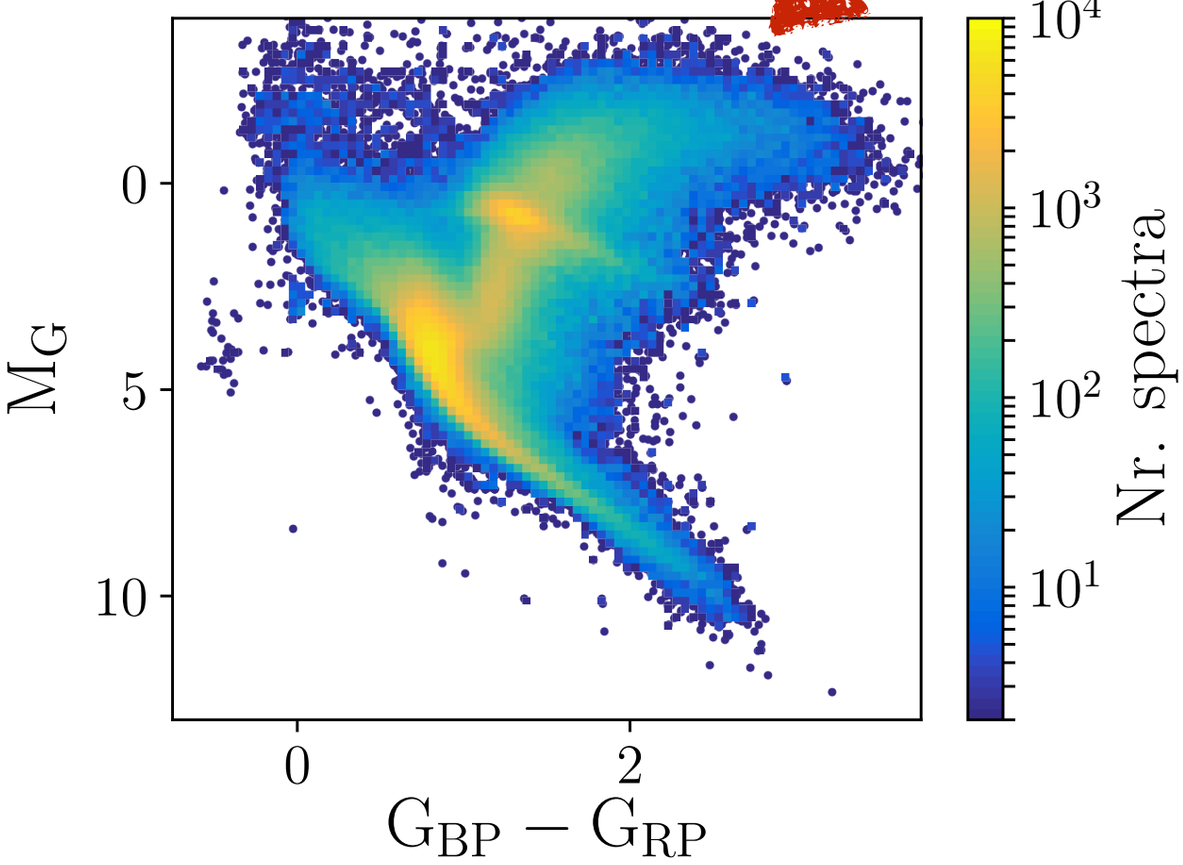
$$\log\left(\frac{L_{\rm bol}}{L_{\rm bol,\odot}}\right) = 0.4 \cdot (M_{\rm bol,\odot} - M_{\rm bol})$$

$$\frac{L_{\rm bol}}{L_{\rm bol,\odot}} = \left(\frac{\mathcal{M}}{\mathcal{M}_\odot} \cdot \frac{g_\odot}{g}\right)^2 \cdot \left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)^4$$

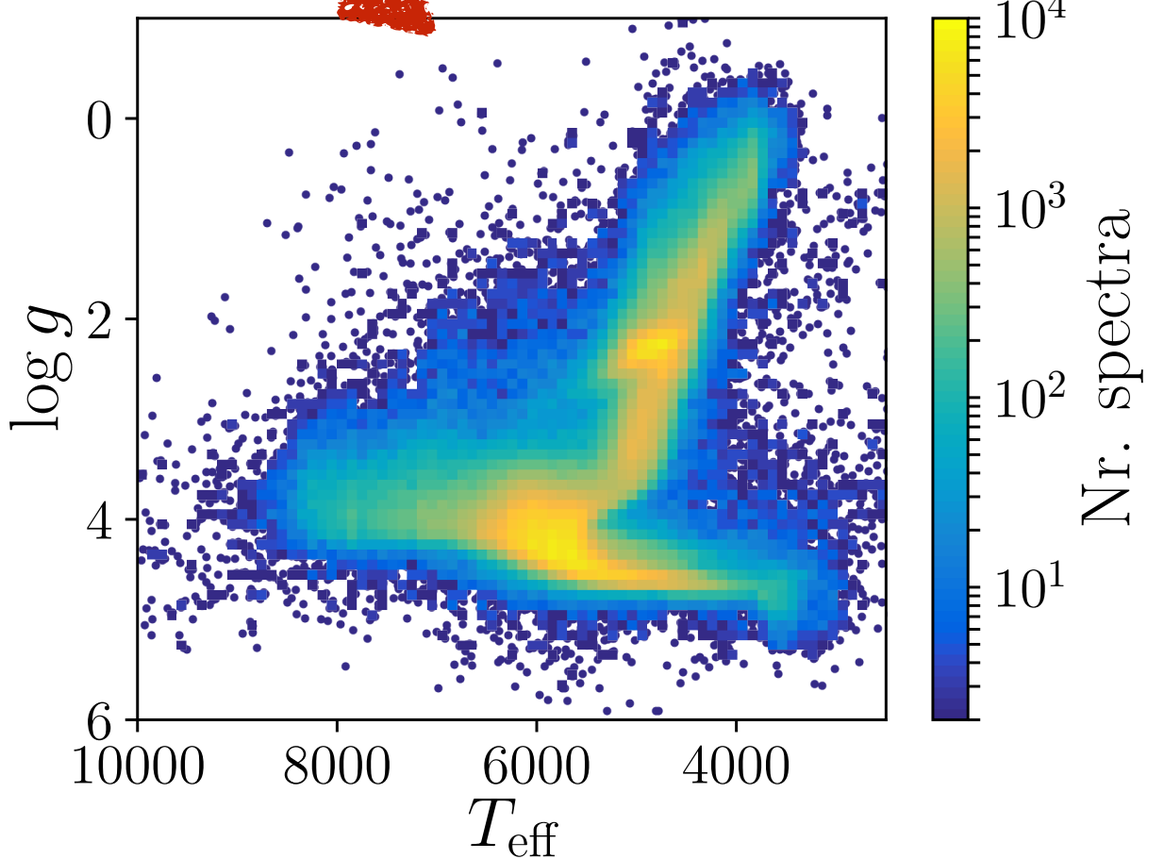
Sven Buder (MPIA)

Post Gaia DR2: At the sweet spot of Gaia

Gaia



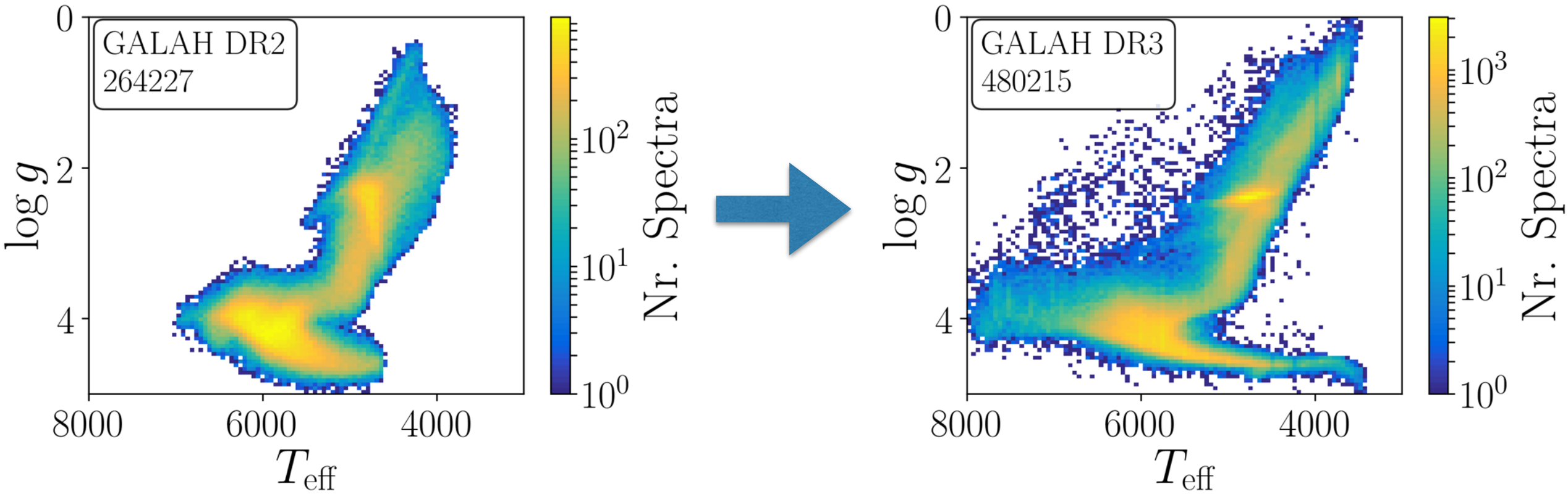
GALAH



$$\log\left(\frac{\mathcal{M}}{\mathcal{M}_\odot}\right) - \log\left(\frac{L_{\rm bol}}{L_{\rm bol,\odot}}\right) + 4\cdot\log\left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right) + \log g_\odot = \log g$$

Sven Buder (MPIA)

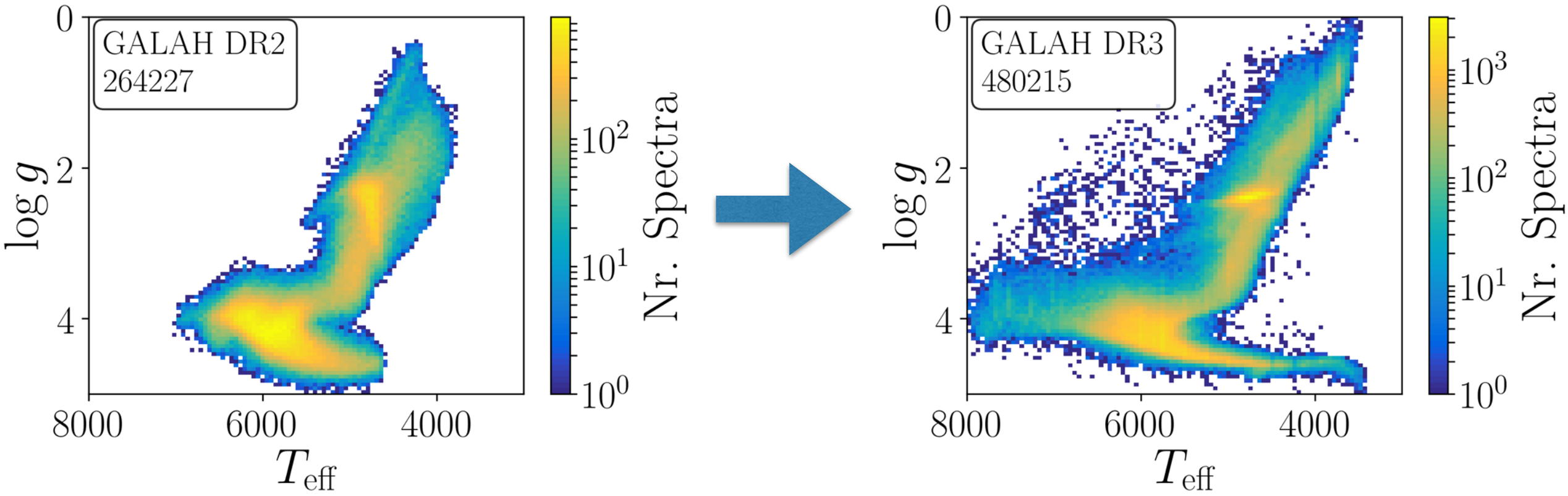
GALAH DR2 -> GALAH DR3



What has changed?

GALAH DR2: ~343k stars
GALAH DR3: ~650k stars

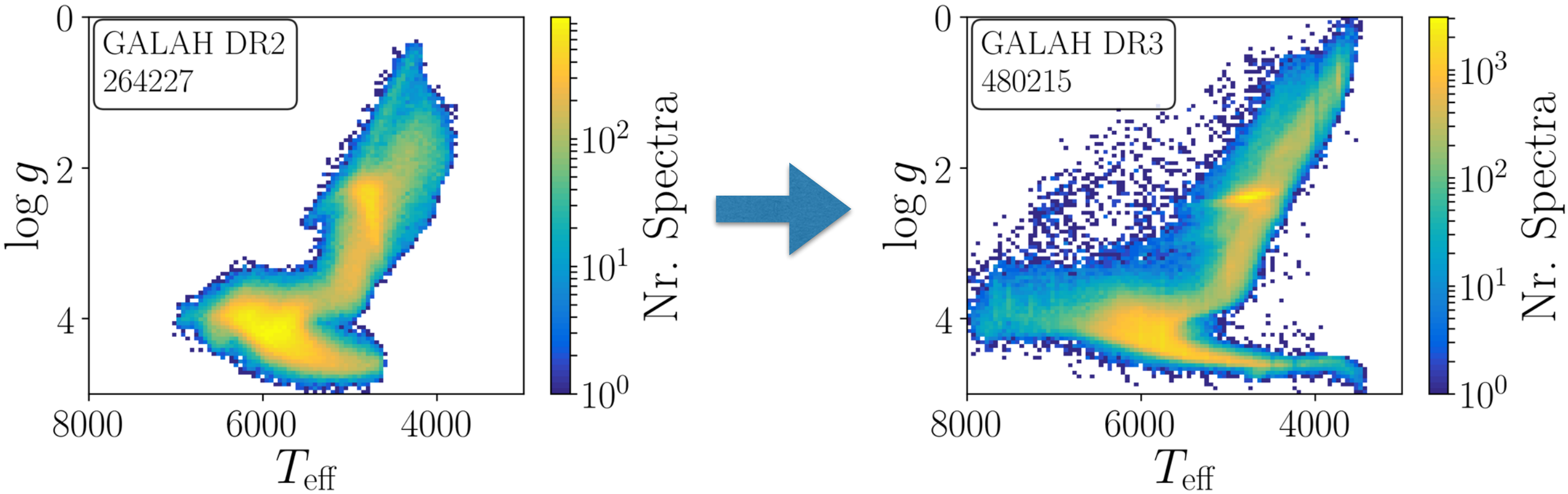
GALAH DR2 -> GALAH DR3



What has changed?

GALAH DR2: Using SME for ~10k stars + *The Cannon*
GALAH DR3: Using SME for all stars first

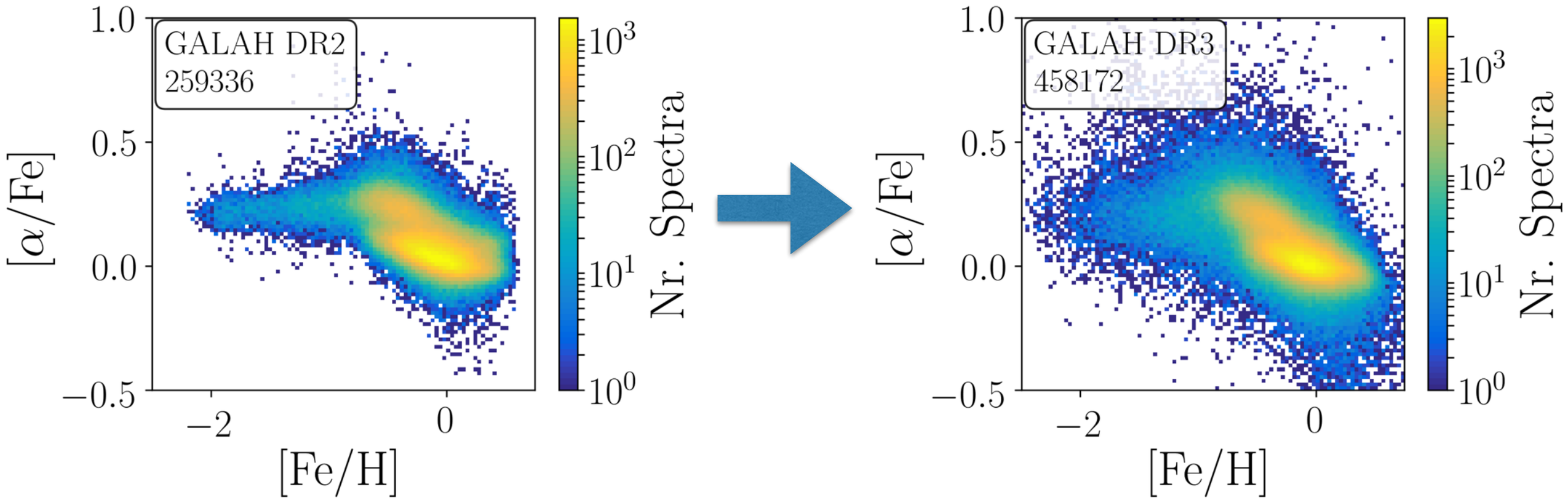
GALAH DR2 -> GALAH DR3



What has changed?

GALAH DR2: Constrain log *g* from spectroscopy
GALAH DR3: Constrain log *g* from M, T_{eff}, L_{bol}

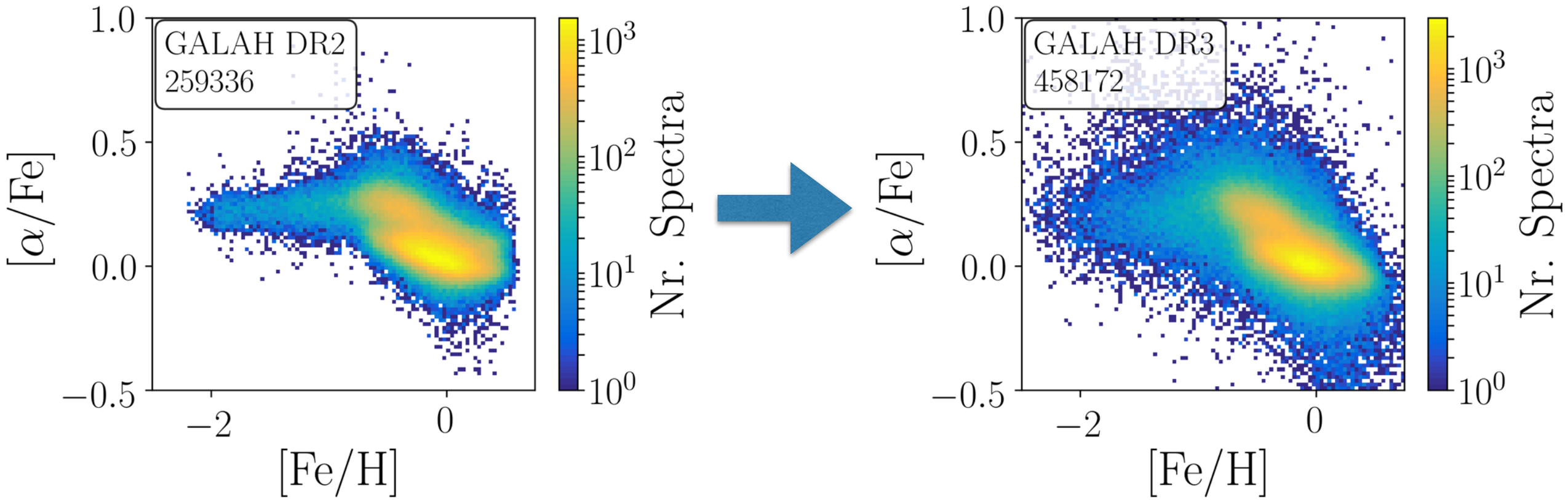
GALAH DR2 -> GALAH DR3



What has changed?

GALAH DR2: Possible dependence on training set
GALAH DR3: No data-driven limits on extrapolation

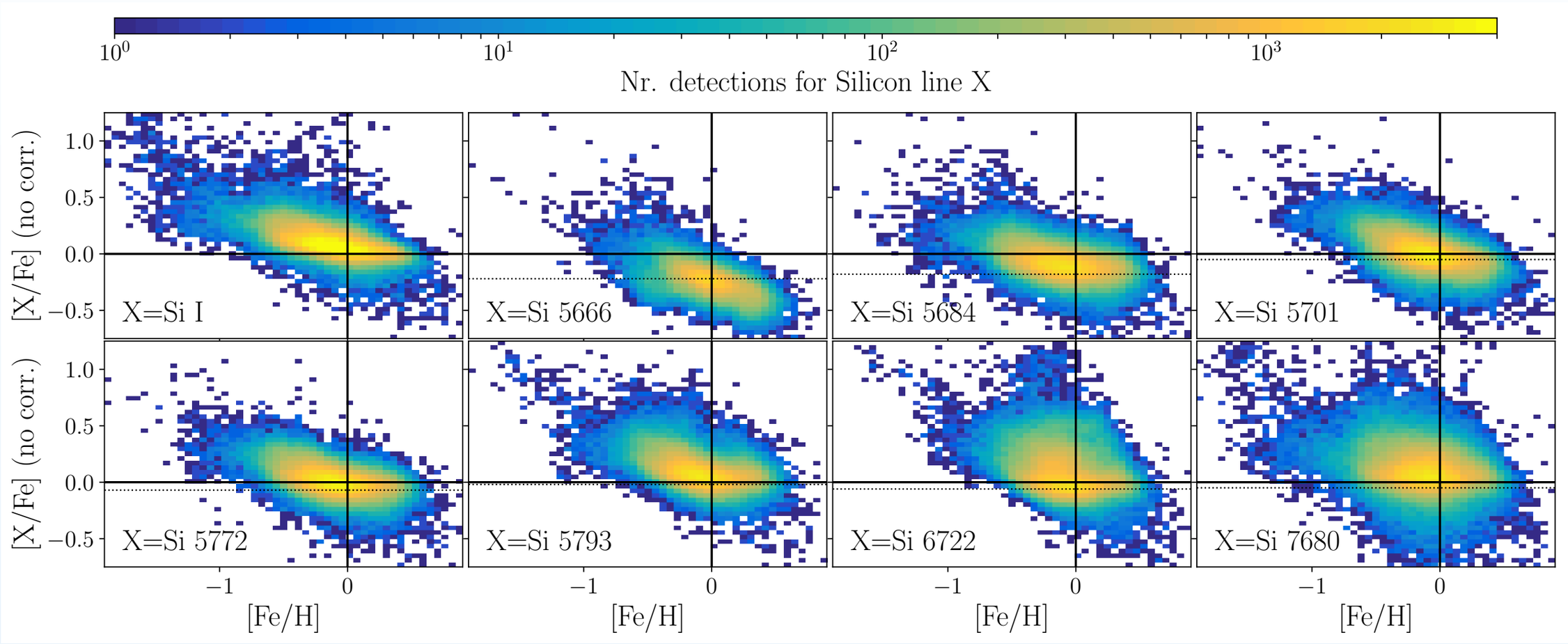
GALAH DR2 -> GALAH DR3



What has changed?

GALAH DR2: [α/Fe] from [Mg/Fe], [Si/Fe], [Ca/Fe], [Ti/Fe]
GALAH DR3: [α/Fe] from individual Mg, Si, Ca, Ti lines

GALAH DR2 -> GALAH DR3

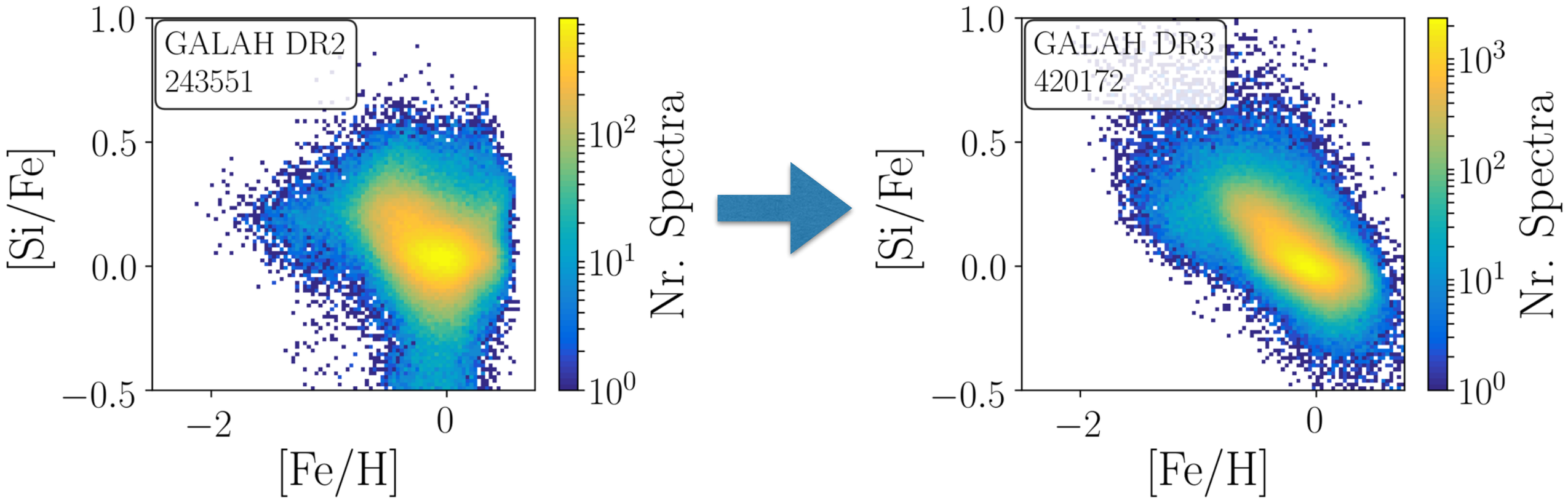


What has changed?

GALAH DR2: [X/Fe] simultaneous for all lines of X
GALAH DR3: [X/Fe] individually and then combined

See also *Gaia*-ESO analysis papers,
GBS papers (Jofre+) & Hawkins+2014

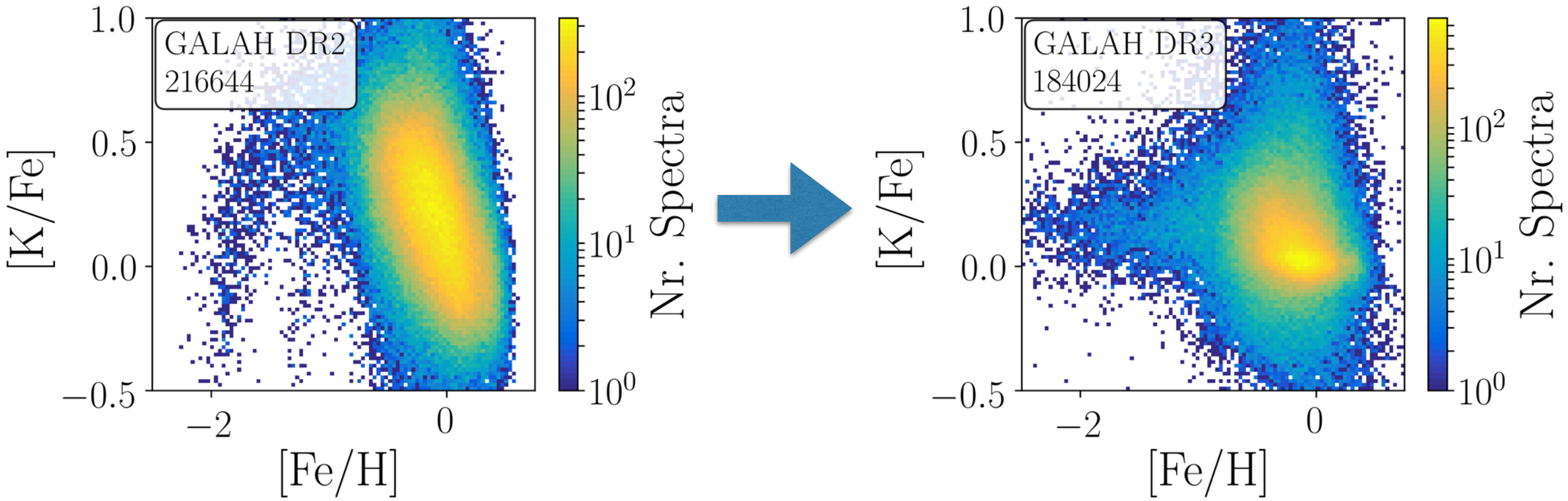
GALAH DR2 -> GALAH DR3



What has changed?

Better line selection

GALAH DR2 -> GALAH DR3

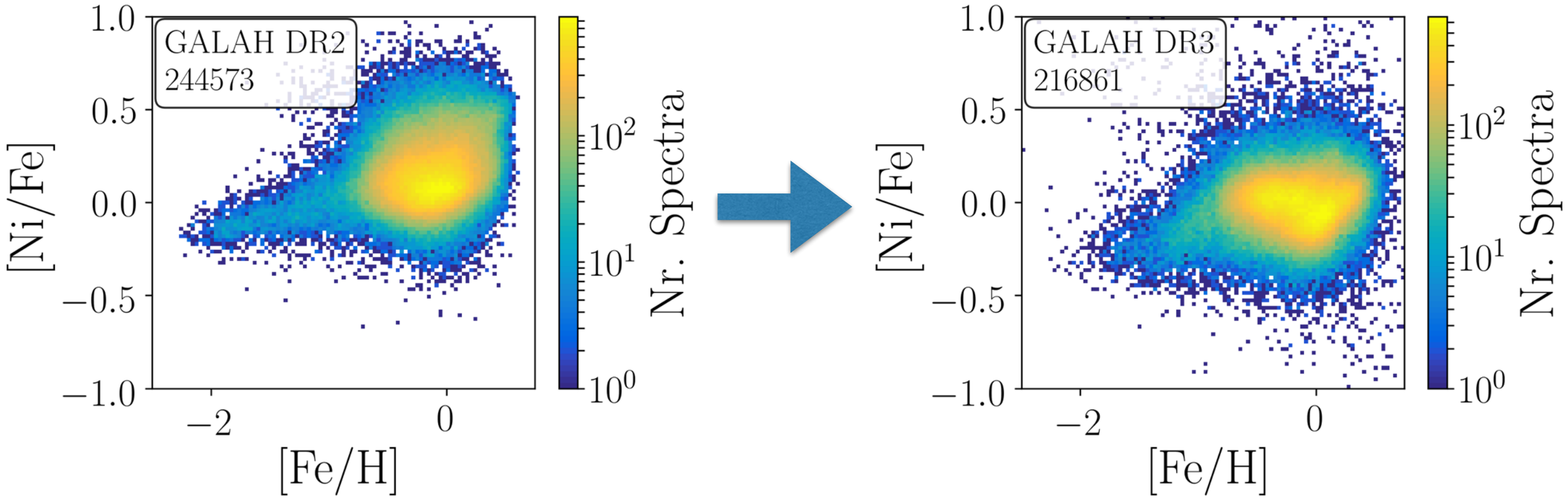


What has changed?

1D non-LTE for K (Reggiani)

Updates 1D non-LTE for 11 elements (Amarsi, Lind)

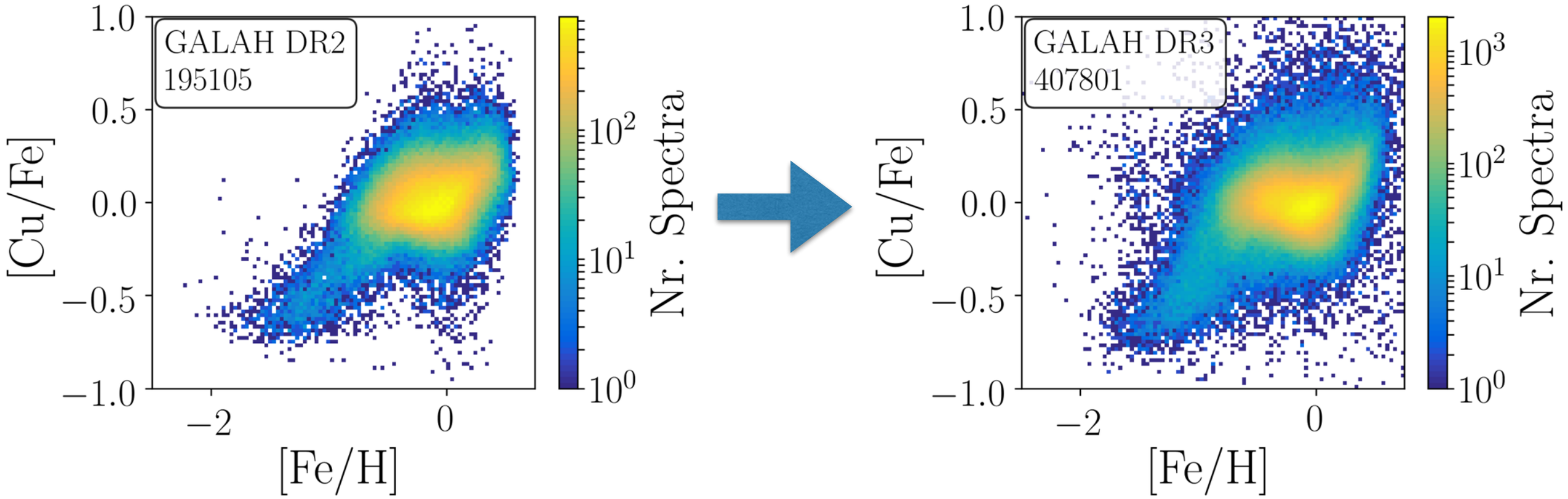
GALAH DR2 -> GALAH DR3



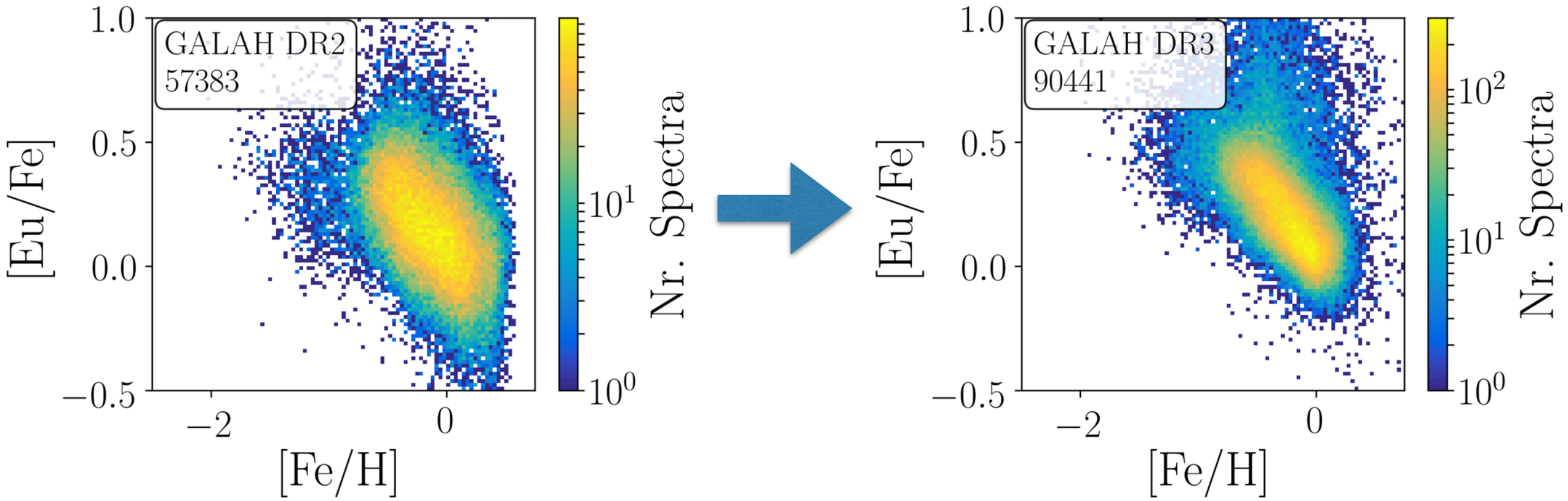
What has changed?

Better line selection

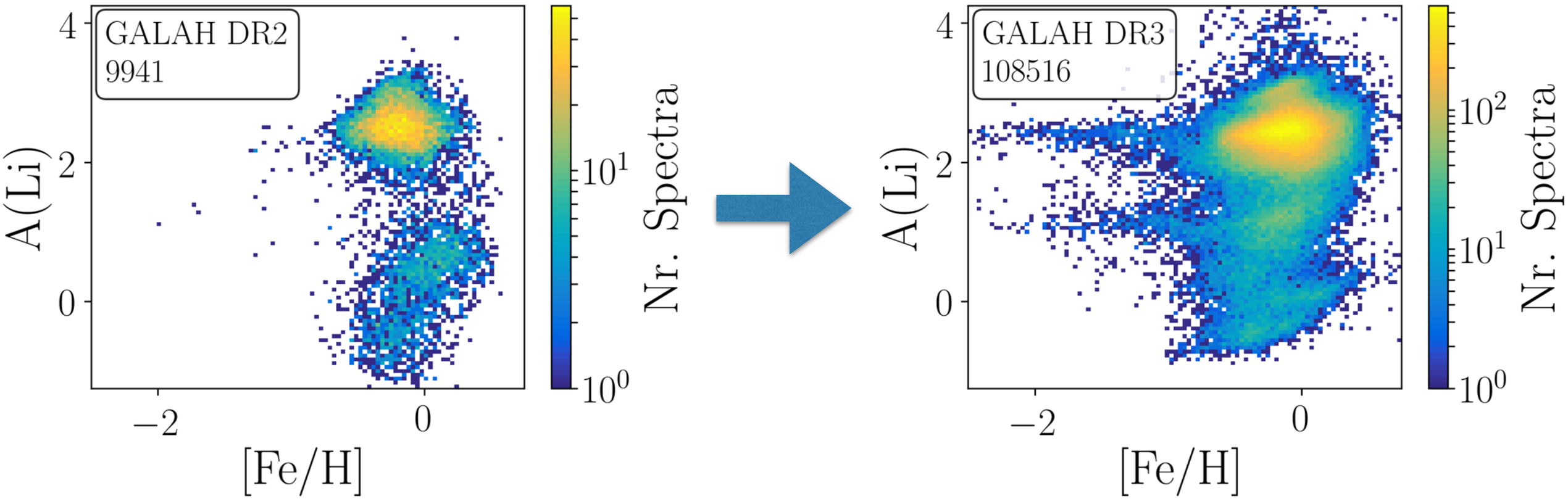
GALAH DR2 -> GALAH DR3



GALAH DR2 -> GALAH DR3



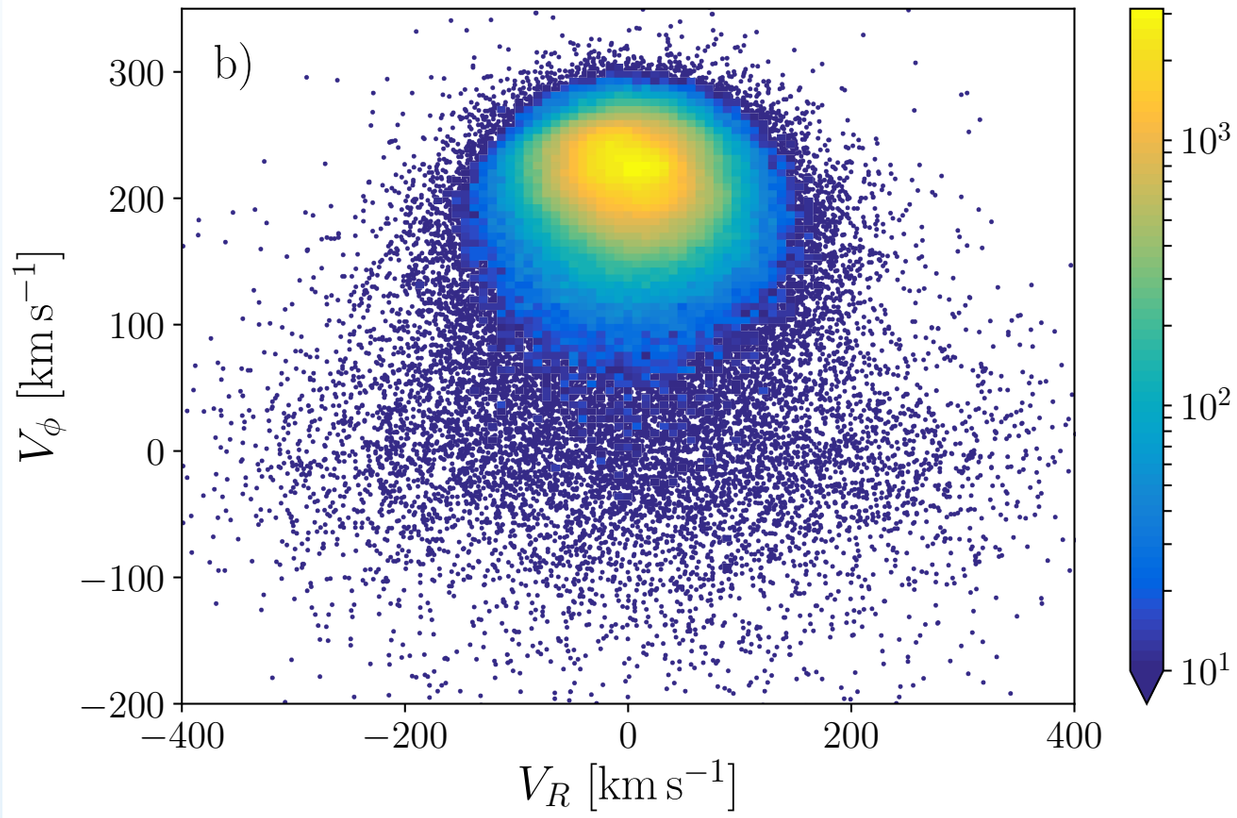
GALAH DR2 -> GALAH DR3

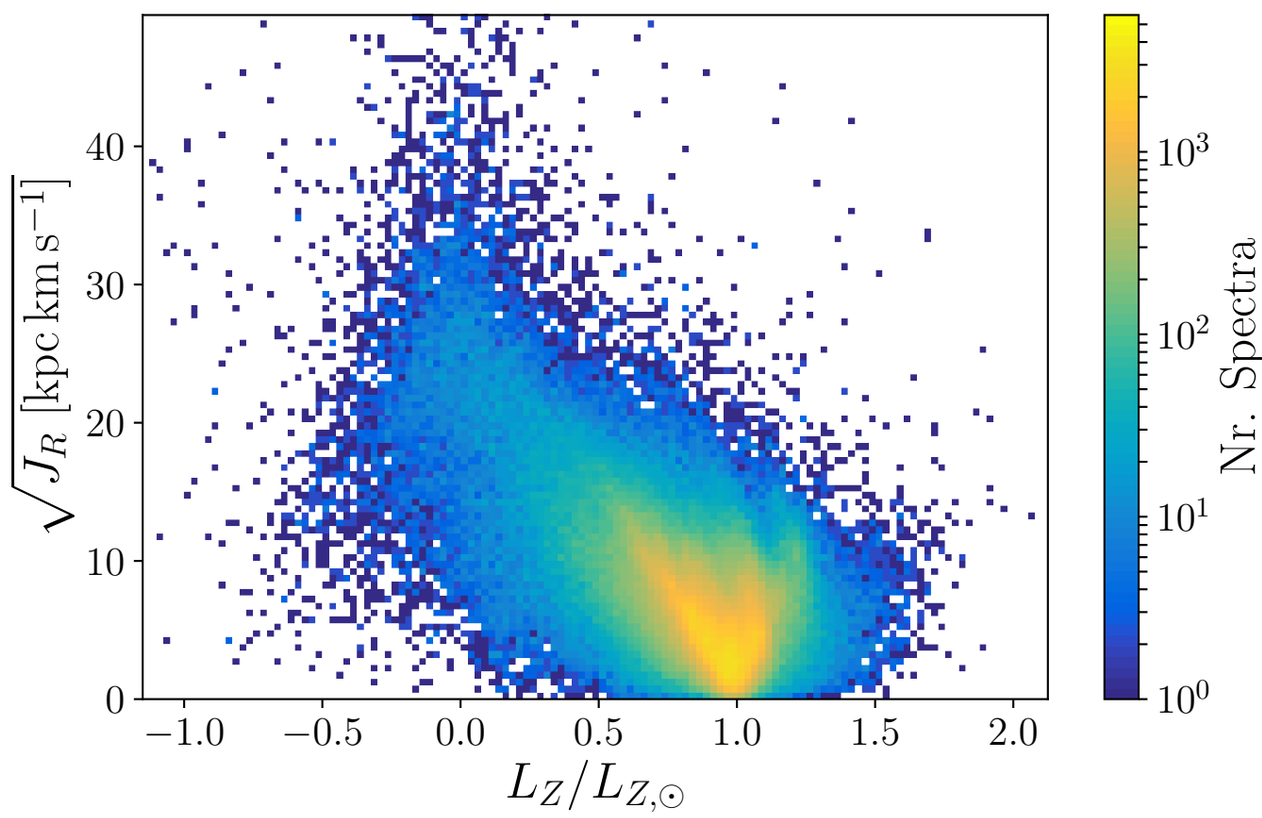


What has changed?

No dependence on training set

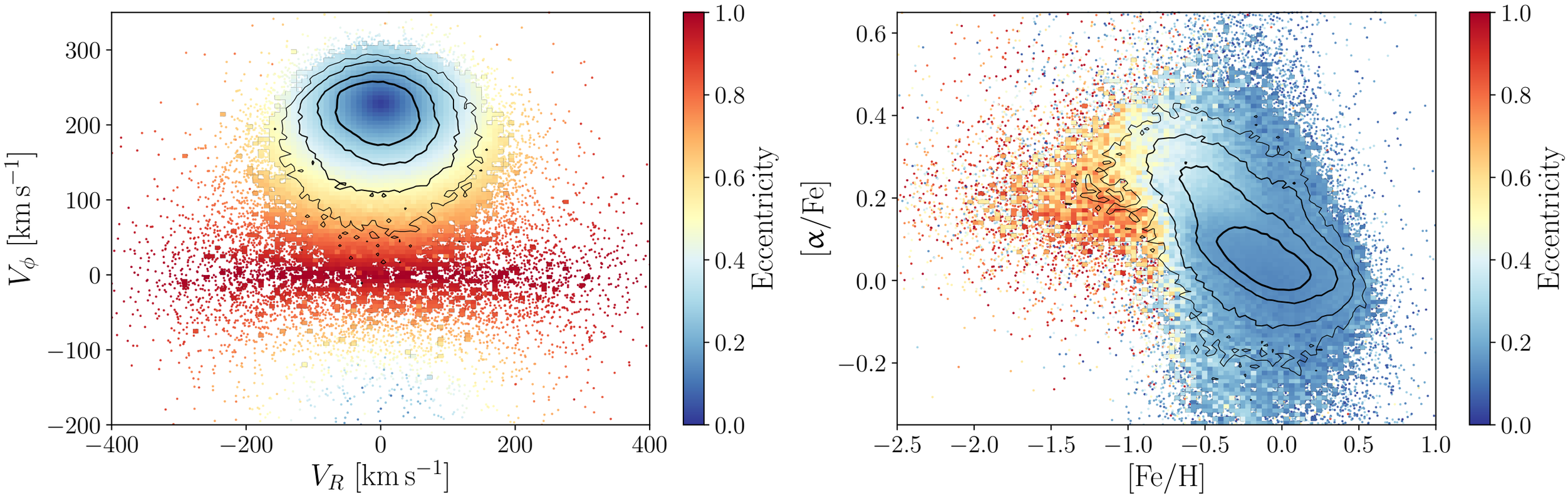
GALAH+Gaia: Chemodynamics!





Sven Buder (MPIA)

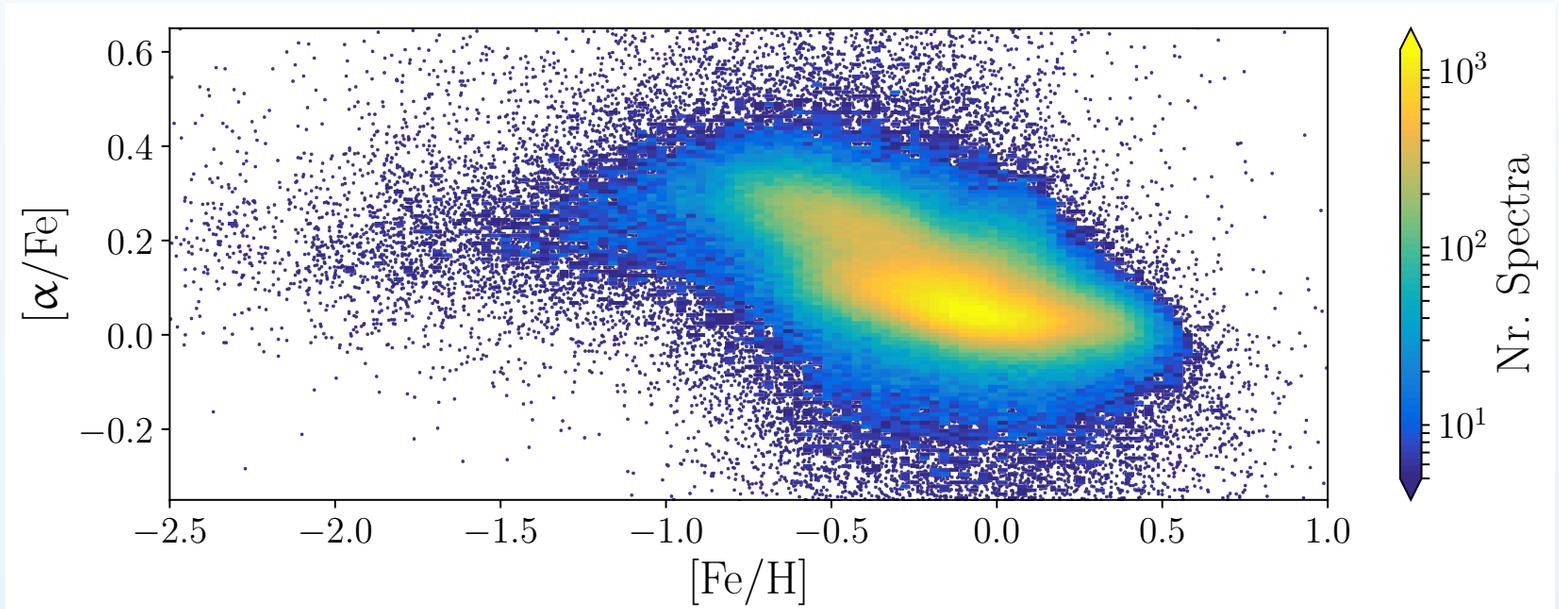
GALAH+Gaia: Chemodynamics!

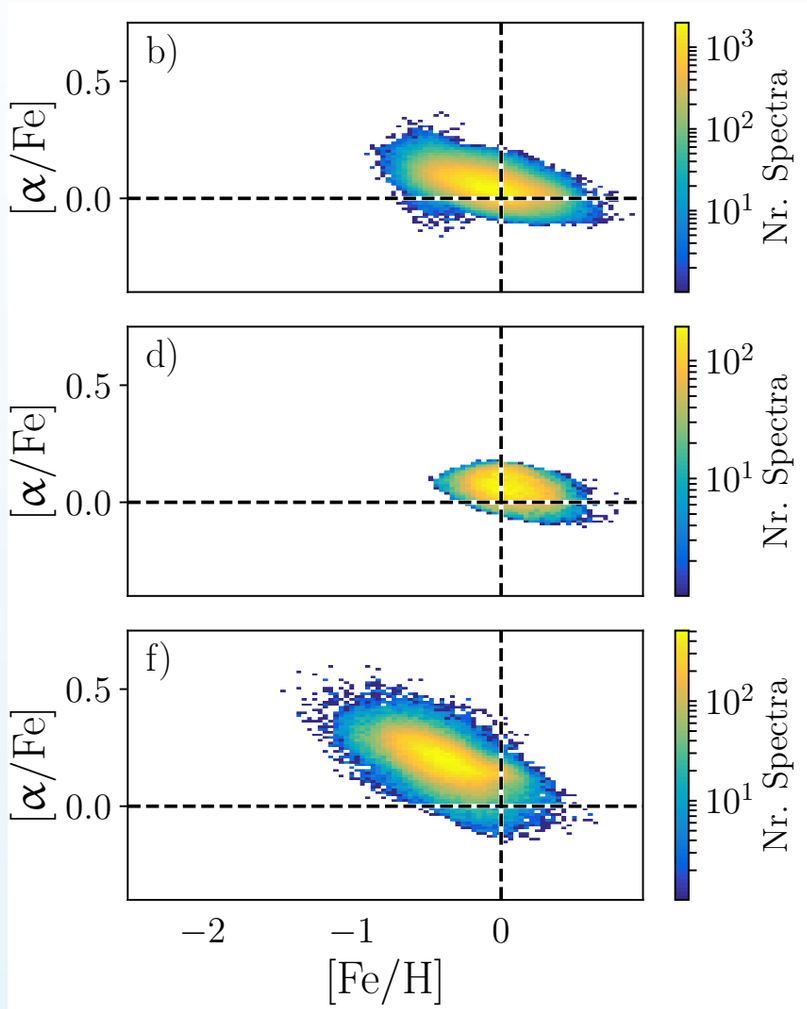


Sven Buder (MPIA)

Chemodynamic decomposition?

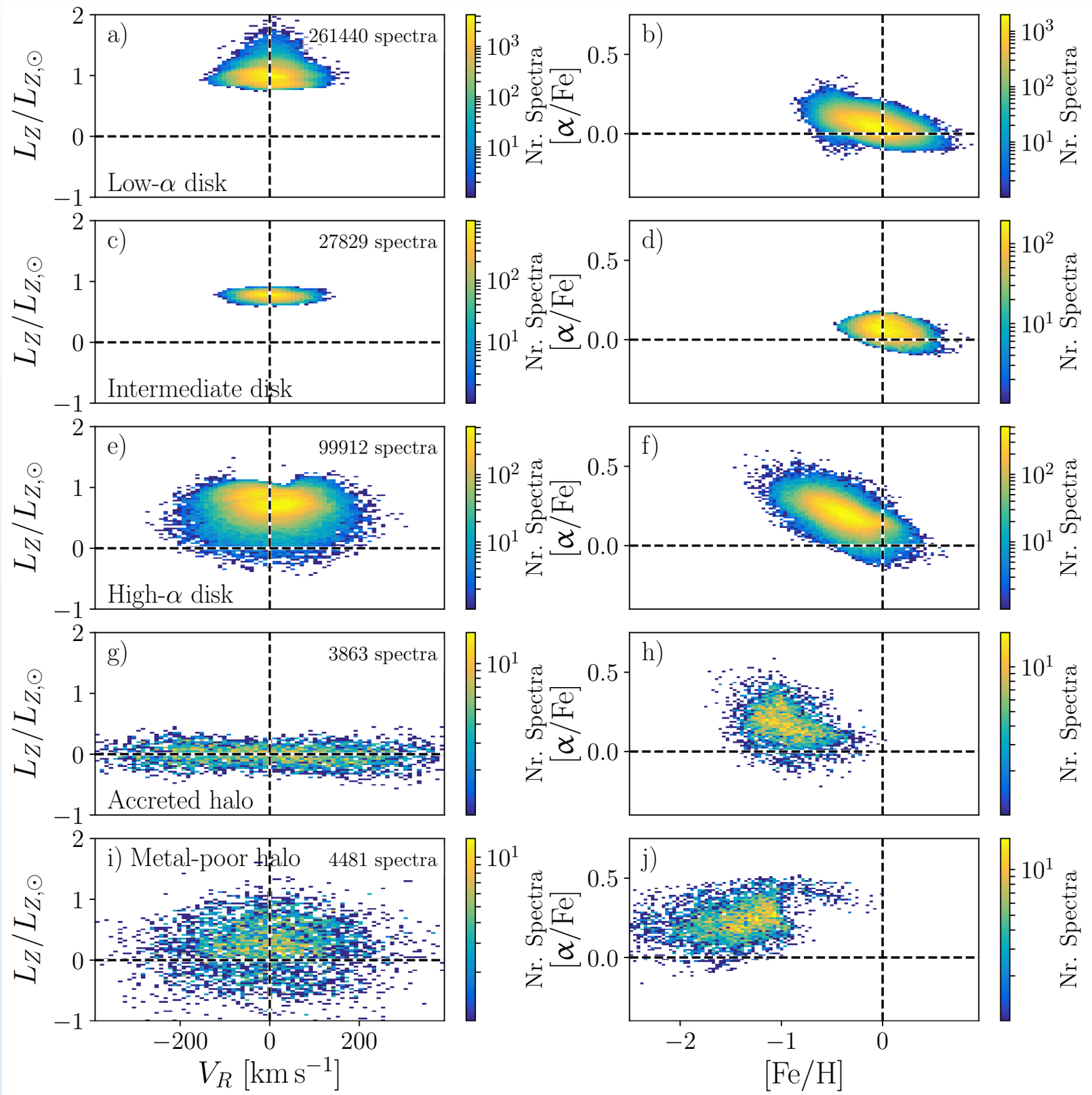
Gaussian Mixture Models to describe L_Z, V_R, [Fe/H], [α/Fe]





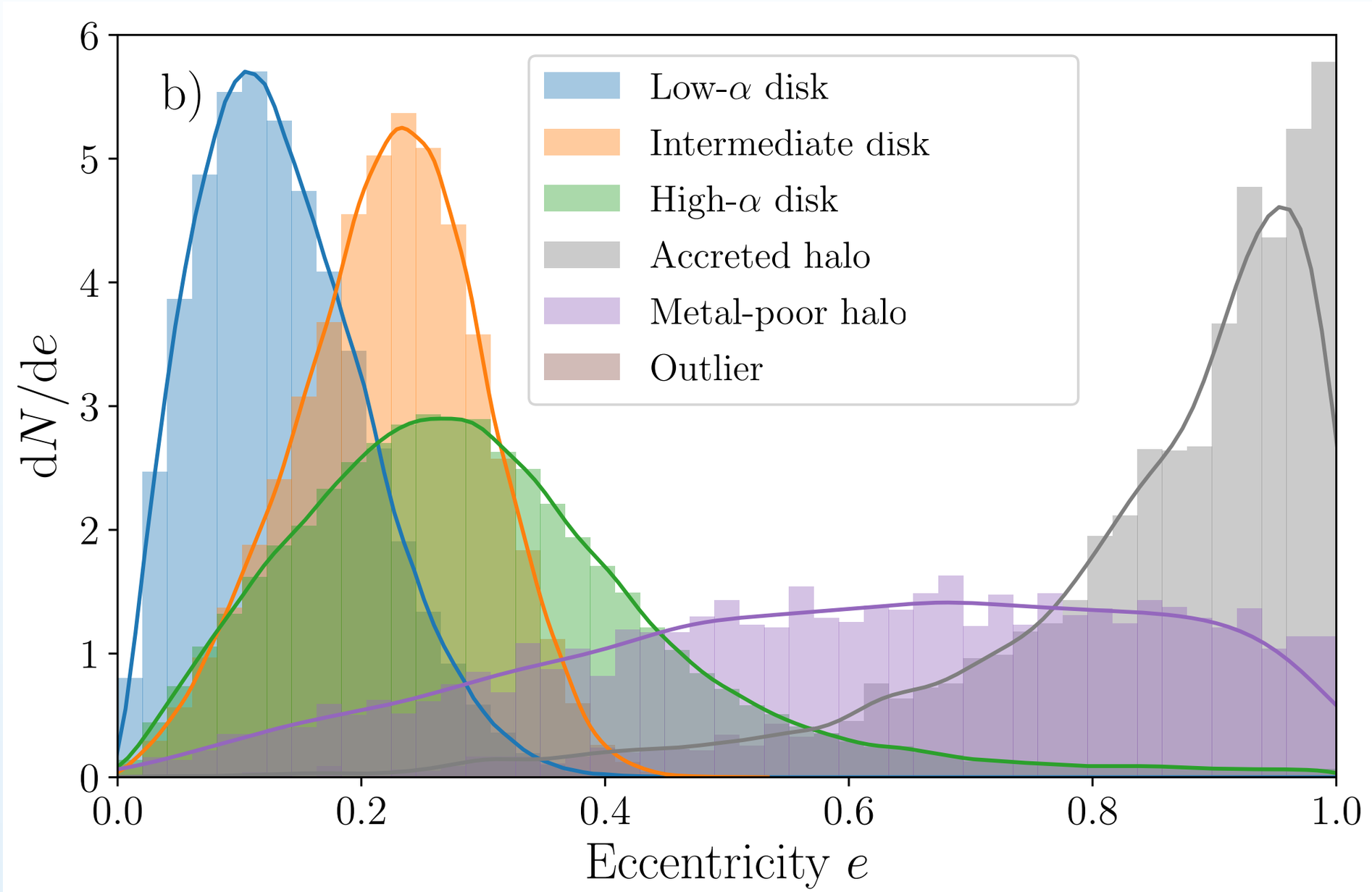
Sven Buder (MPIA)

Chemodynamic decomposition?



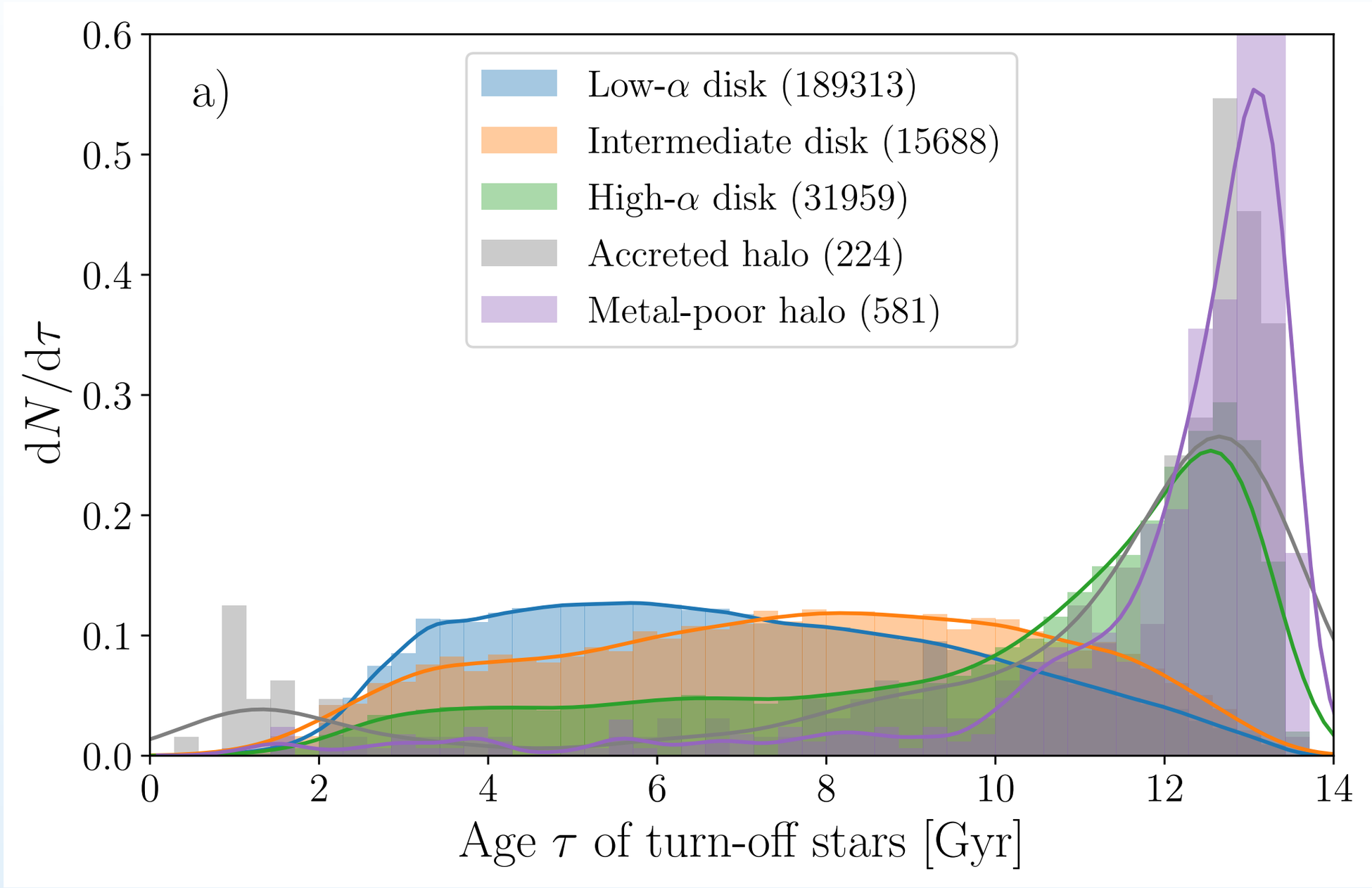
Sven Buder (MPIA)

Chemodynamic decomposition?



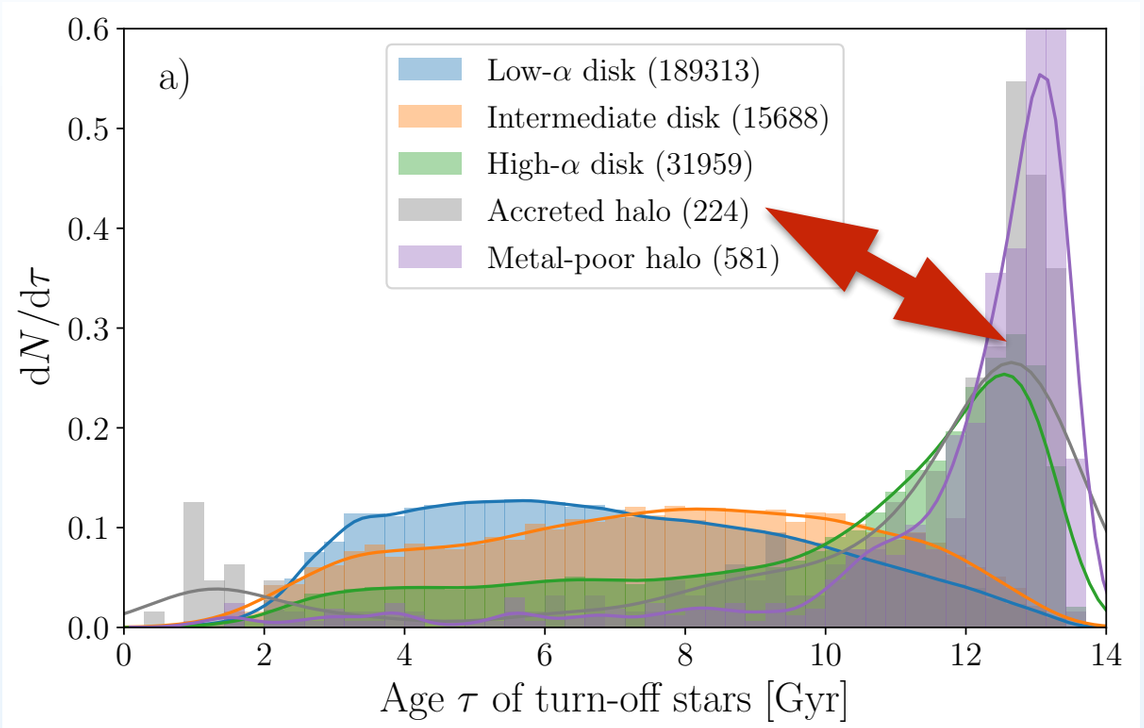
see also Schuster+2012,
Belokurov+2018, Mackereth+2019

Chemodynamic decomposition?

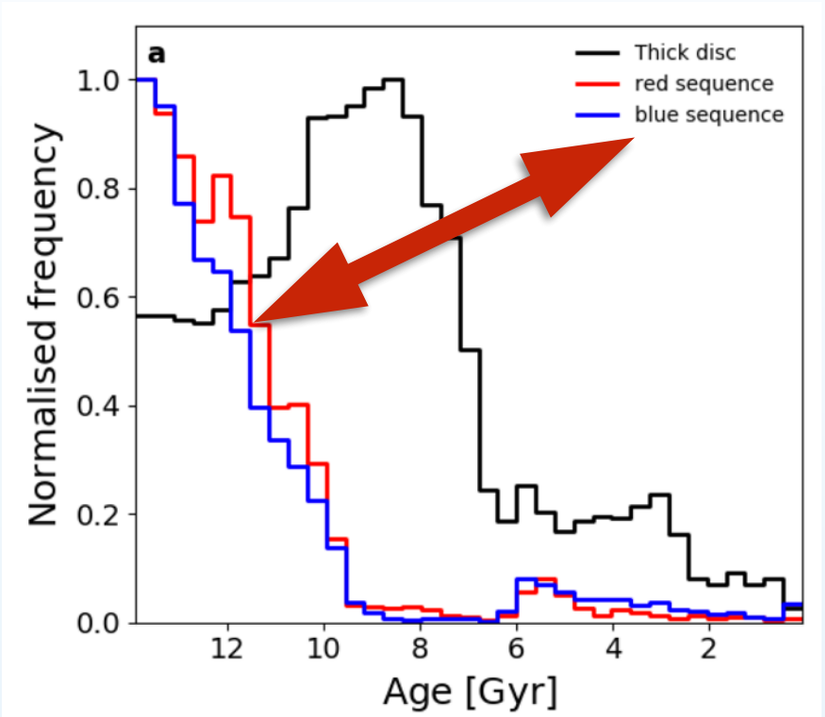


How old are the accreted stars?

Our study: old + coeval w/ old disk

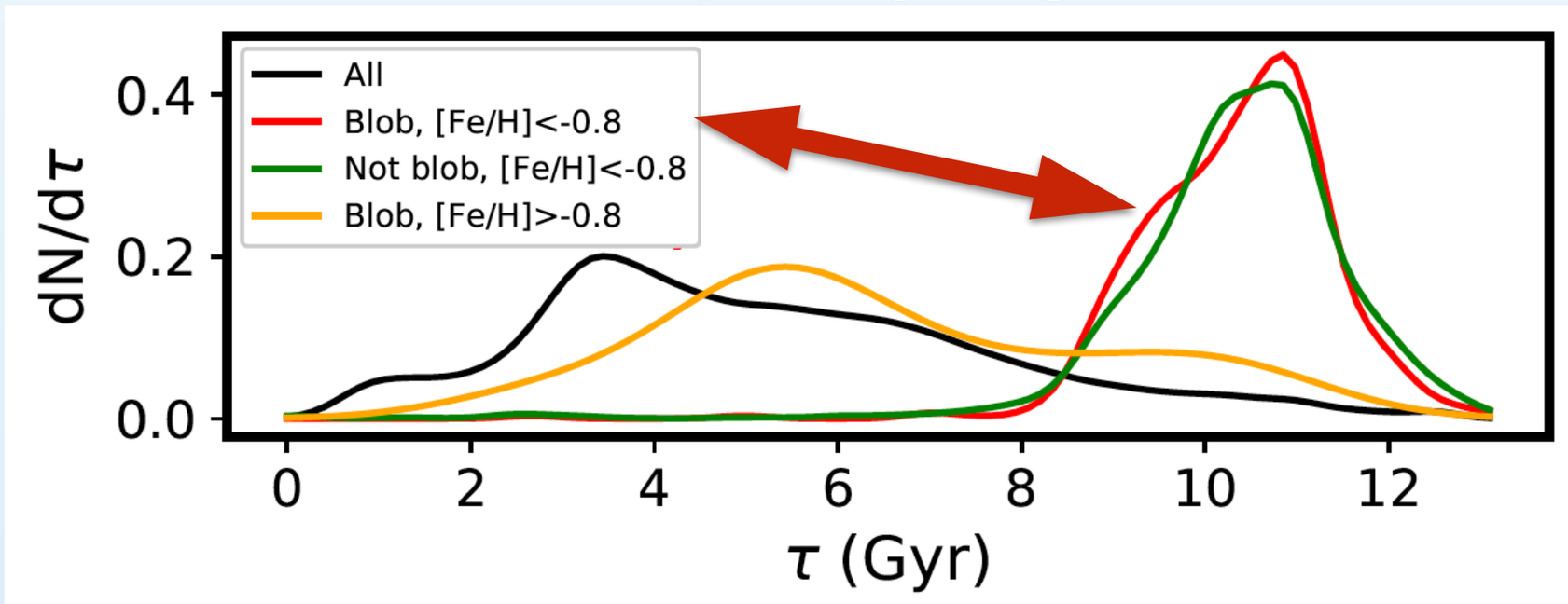


Gallart+2019: old



Schuster+2012: high-α halo 2-3 Gyr older than low-α halo

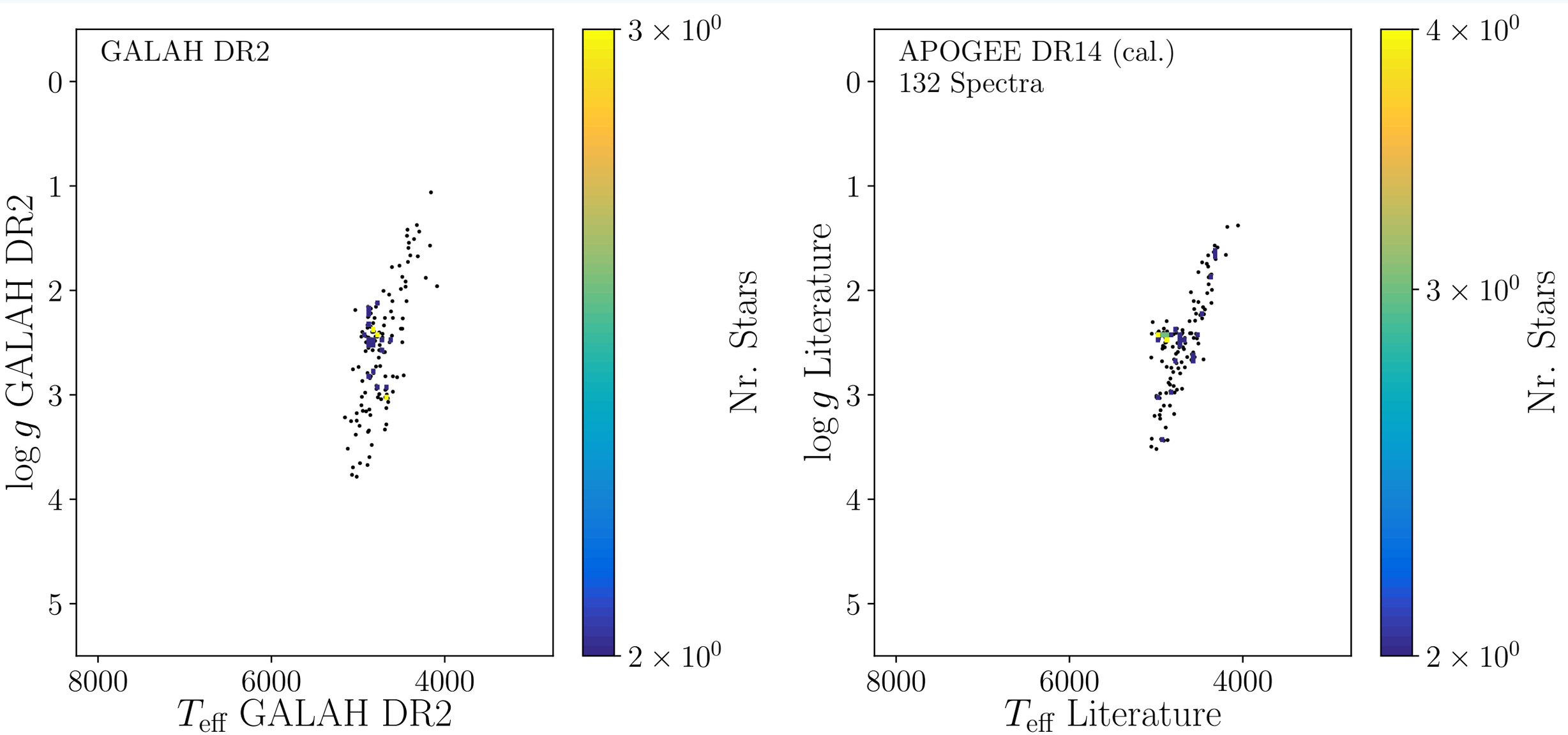
Das+2019: young + gradient



Sven Buder (MPIA)

GALAH DR2 vs. APOGEE DR14

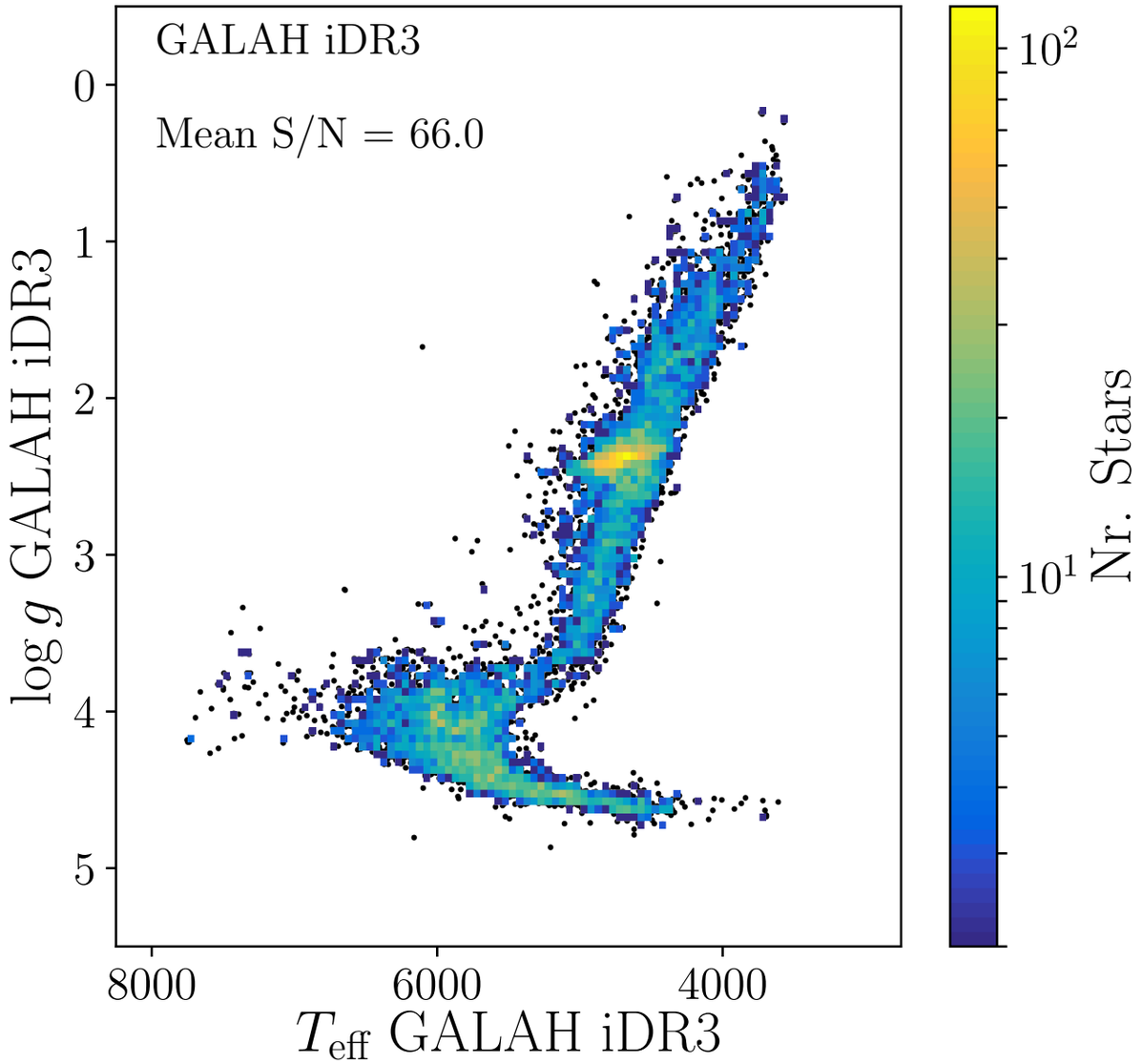
572 spectra (132 with sufficient quality/flags)

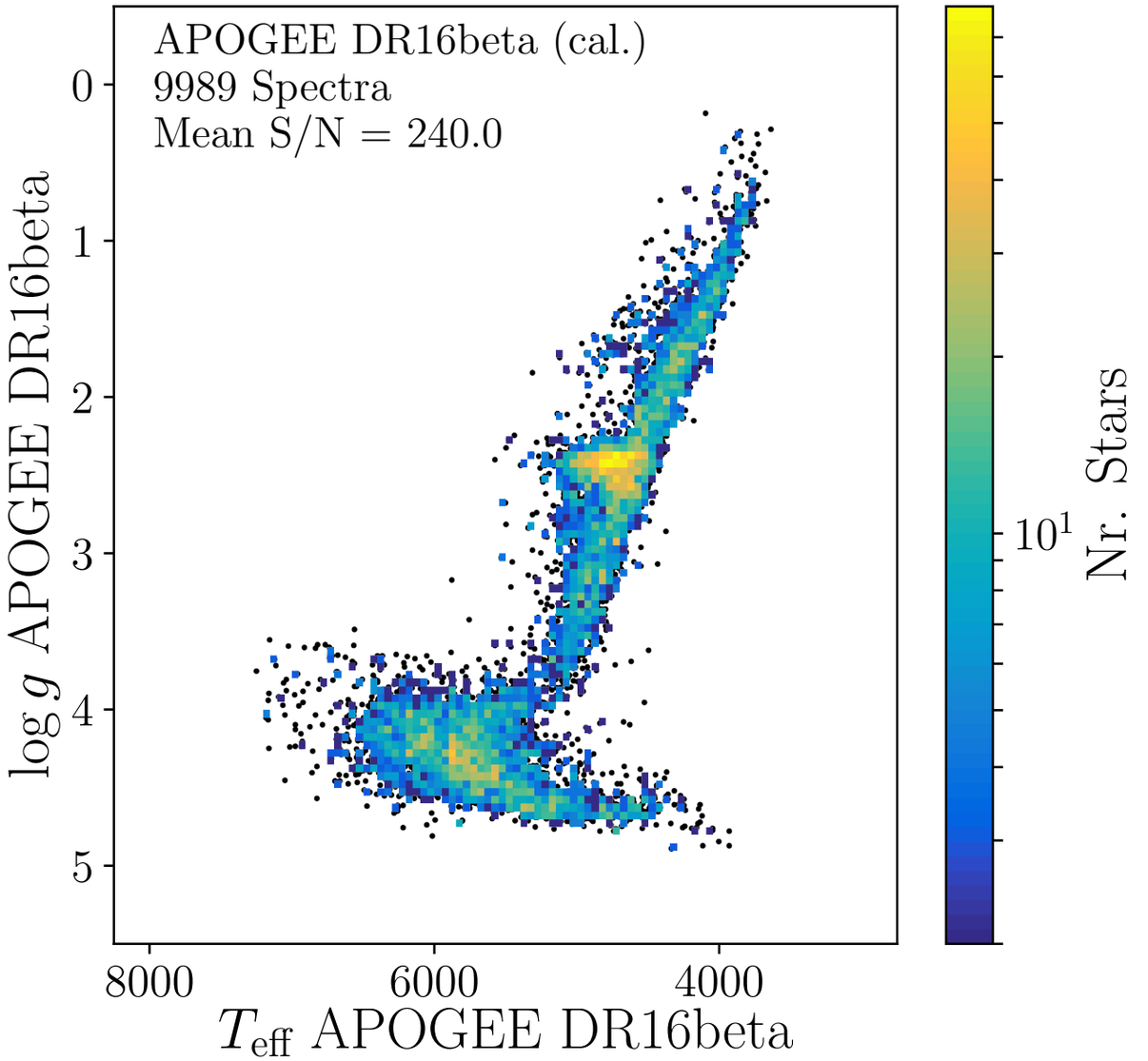


Sven Buder (MPIA)

GALAH DR3 vs. APOGEE DR16

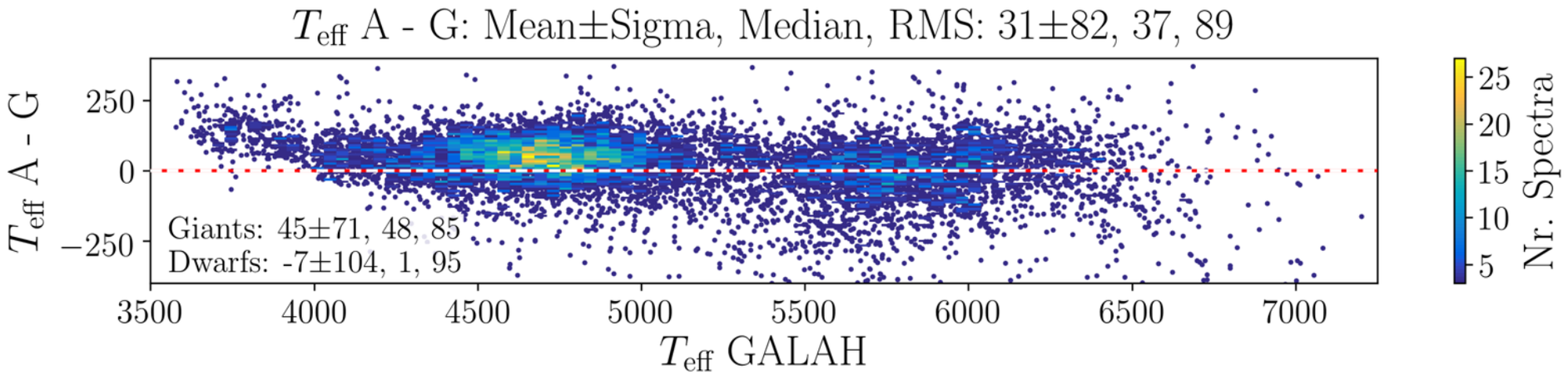
24348 spectra (9989 with sufficient quality/flags)





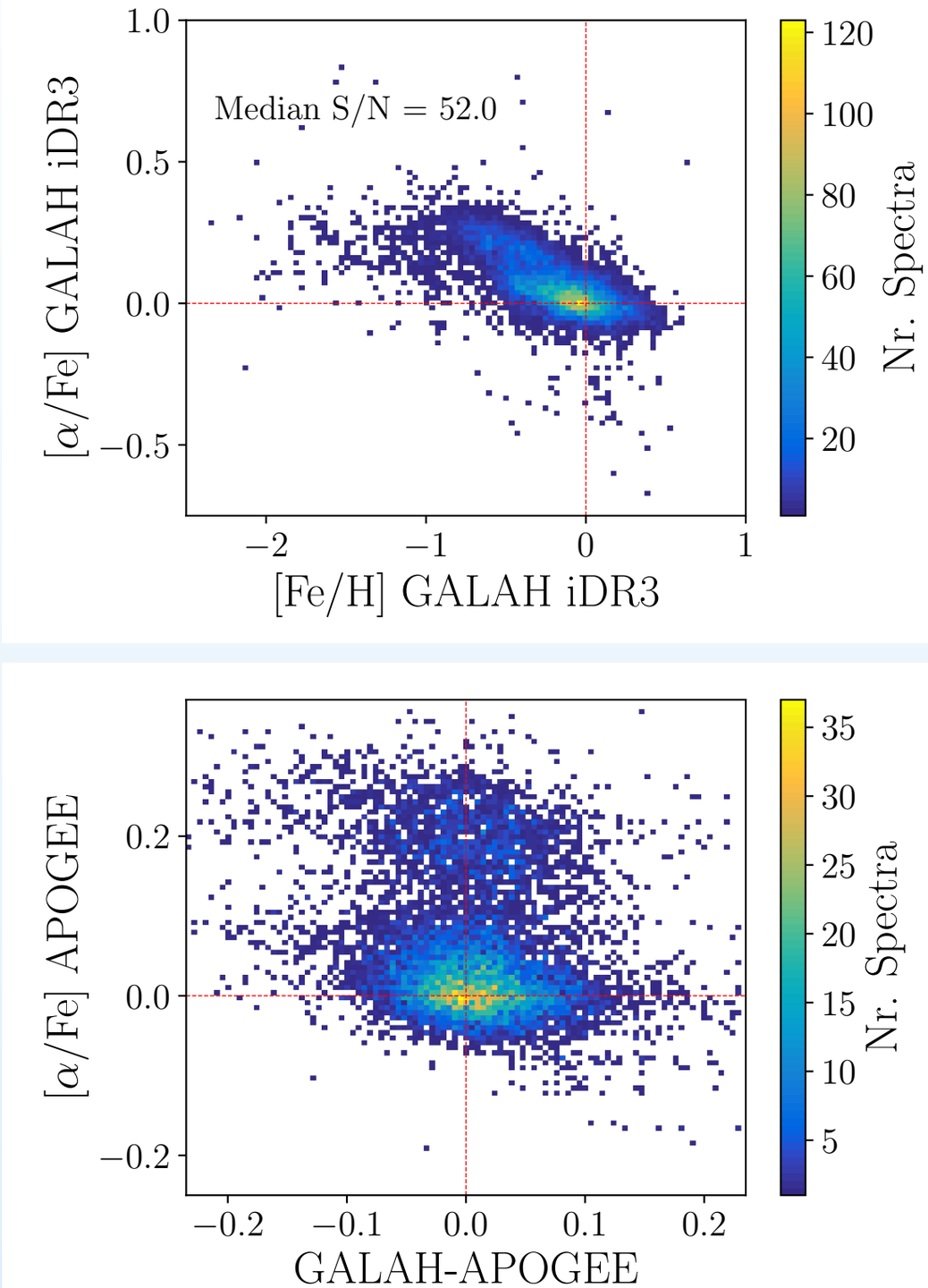
Sven Buder (MPIA)

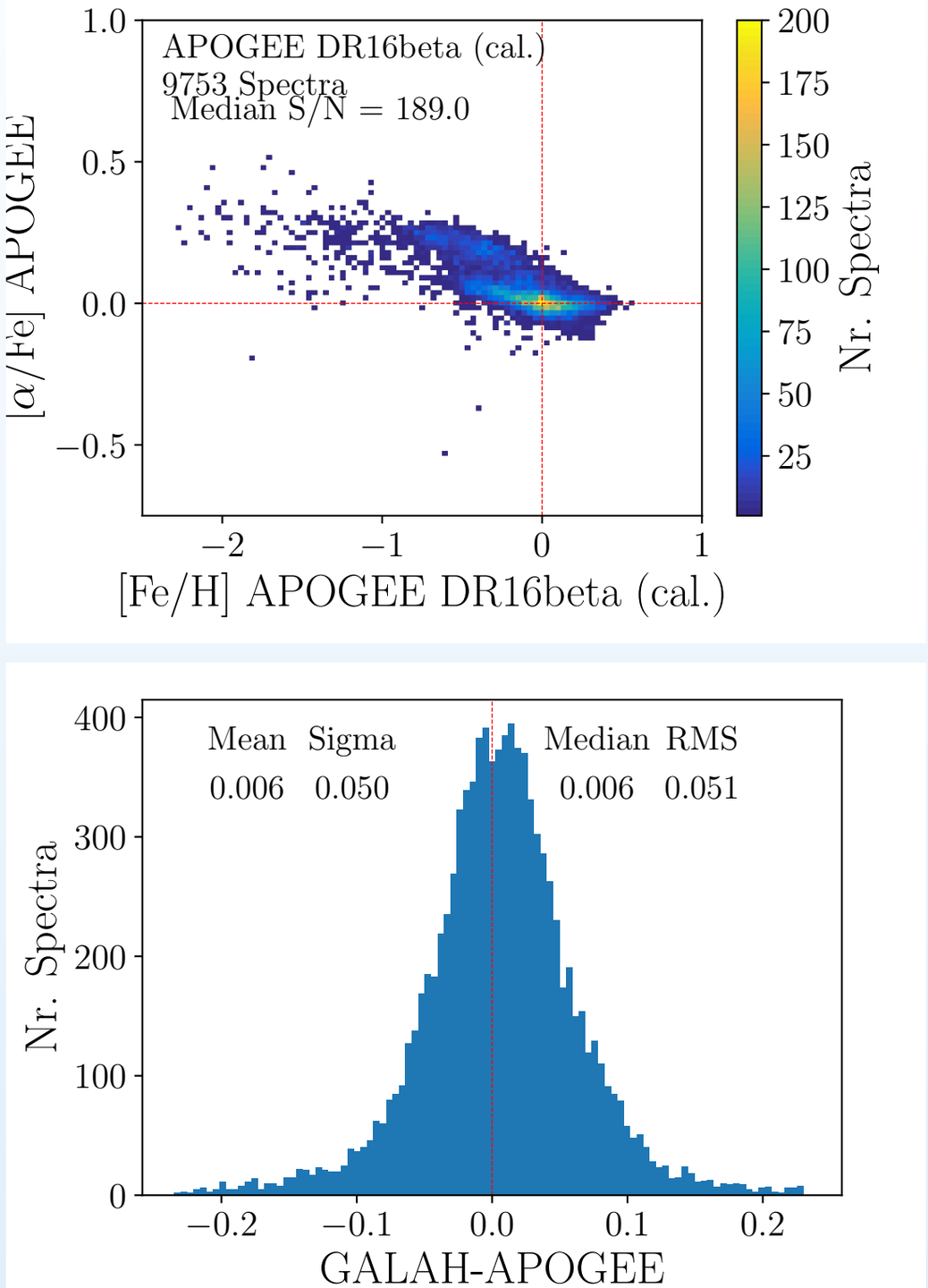
GALAH DR3 vs. APOGEE DR16



Sven Buder (MPIA)

GALAH DR3 vs. APOGEE DR16

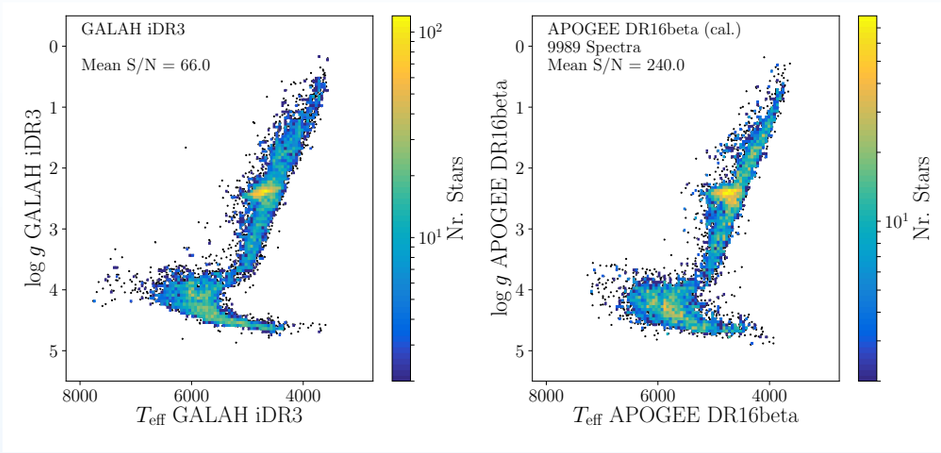


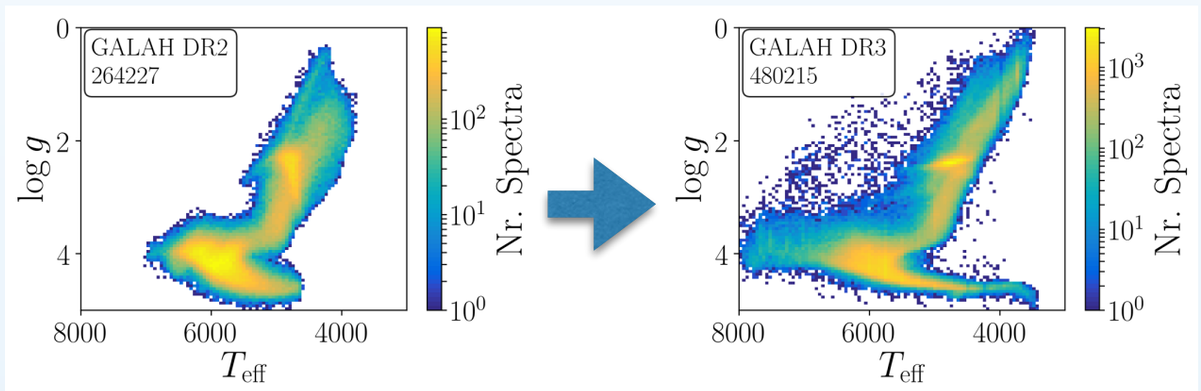


Sven Buder (MPIA)

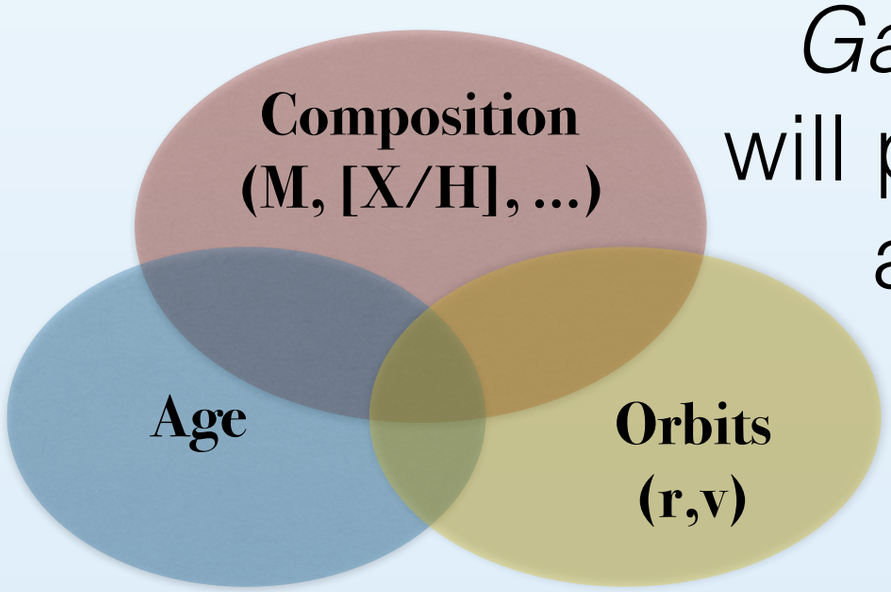
Take away

Spectroscopic surveys are making immense progress!

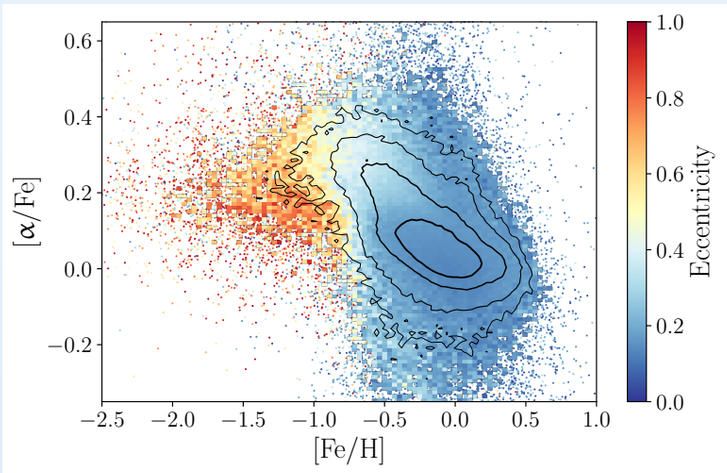




GALAH DR2 was quite OK, GALAH DR3 will be better+more: more stars, better accuracy, more+better abundances



Gaia DR2 + GALAH DR3 will provide chemodynamics and ages for the disk and



Sven Buder (MPIA)