

# Characterising the **asteroseismic** **Red Clump** standard candle in *Gaia* **magnitude, colour,** **metallicity** and **alpha** abundance

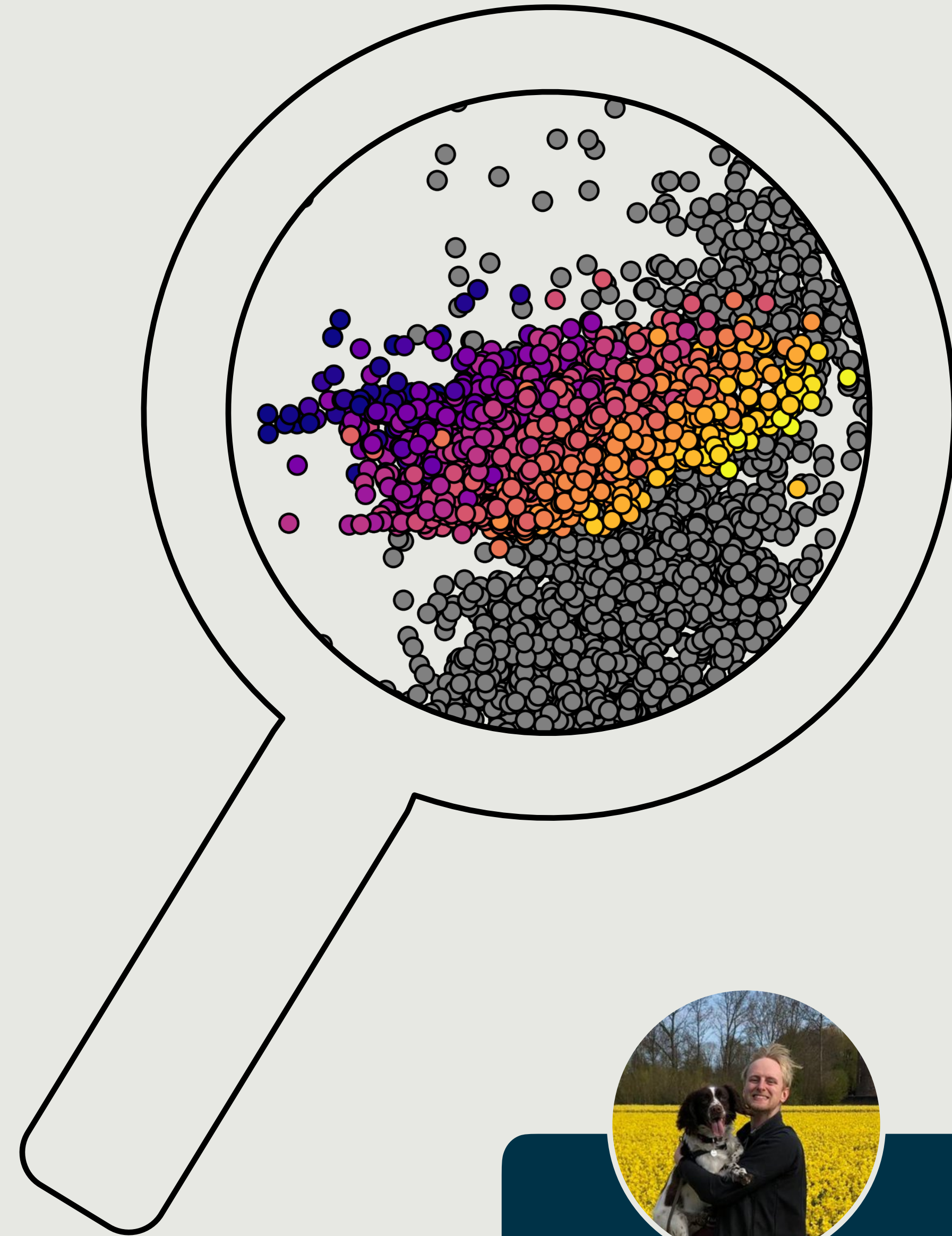
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**Oliver J. Hall** (he/him)

with Guy Davies, Keith Hawkins, Jos de Bruine and Alex Lytle  
(+you...? It's a work in progress!)

**MWGaia Workshop @ Aarhus University**

14 Jun 2022



[asteronomer.com](https://asteronomer.com)

[github.com/ojhall194](https://github.com/ojhall194)

@asteronomer



1.

The **Red Clump** is an important **standard candle**

2.

**Hierarchical Bayesian Models** let us characterise populations

3.

More **information** improves standard candle **precision**

1.

The **Red Clump** is an important **standard candle**

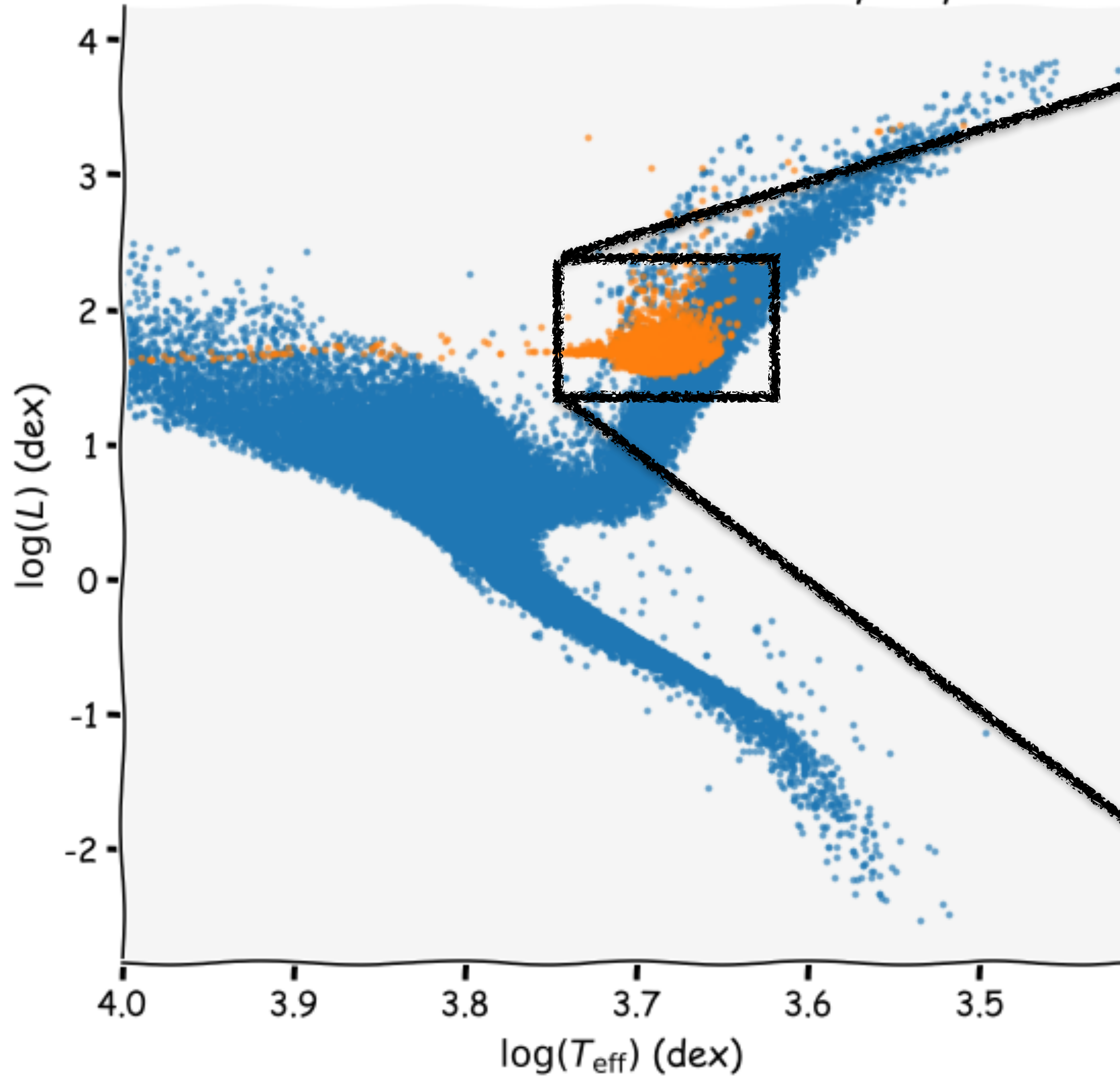
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**Hierarchical Bayesian Models** let us characterise populations

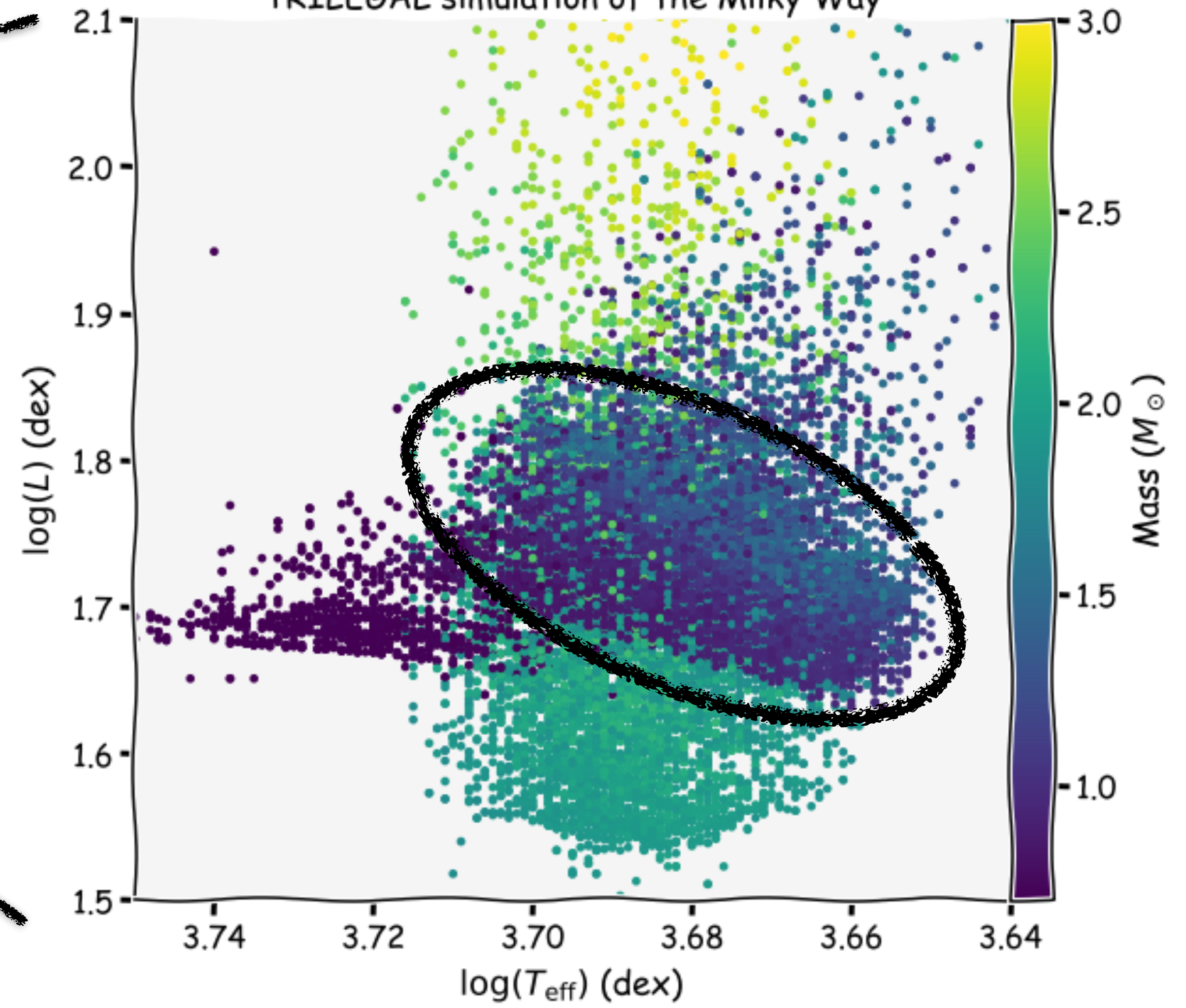
3.

More **information** improves standard candle **precision**

TRILEGAL simulation of the Milky Way



TRILEGAL simulation of the Milky Way



# The Red Clump standard candle has been used for, e.g.:

– Measuring **extinction** to known RC stars [see e.g. Sanders+22, Skowron+20]

– Mapping the **galactic bulge** in 3D [see e.g. Paterson+20, Coleman+20, Lopez-Corredoira+19]

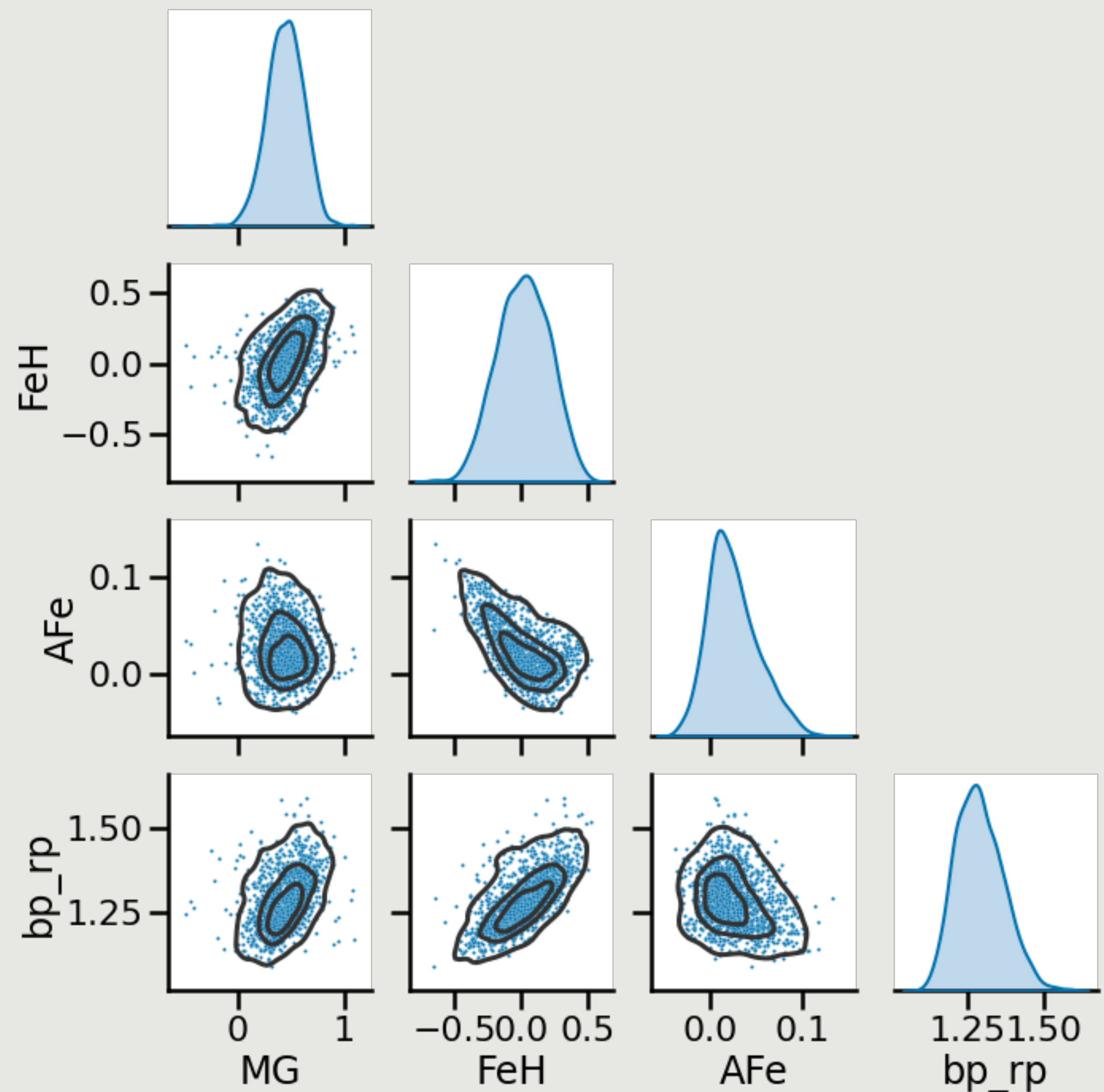
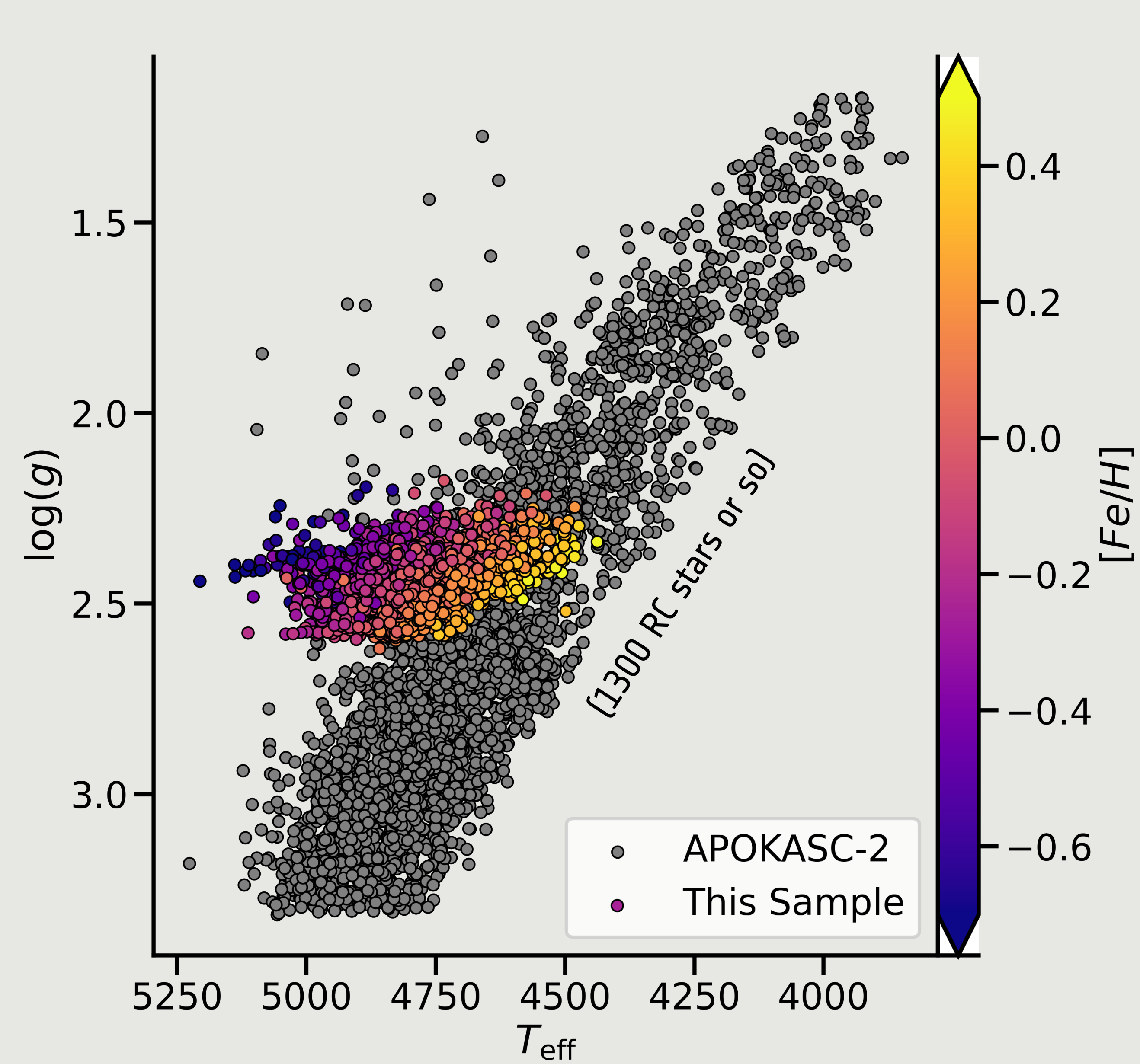
– Anchoring **models** of the **LMC** [see e.g. Choi+22]

– Constraining **stellar physics** in populations [see e.g. Hall+19, Casamiquela+21, Zinn+22]

– **Galactic archaeology** [see e.g. Miglio+20, Zinn+20, 22, Lu+22]

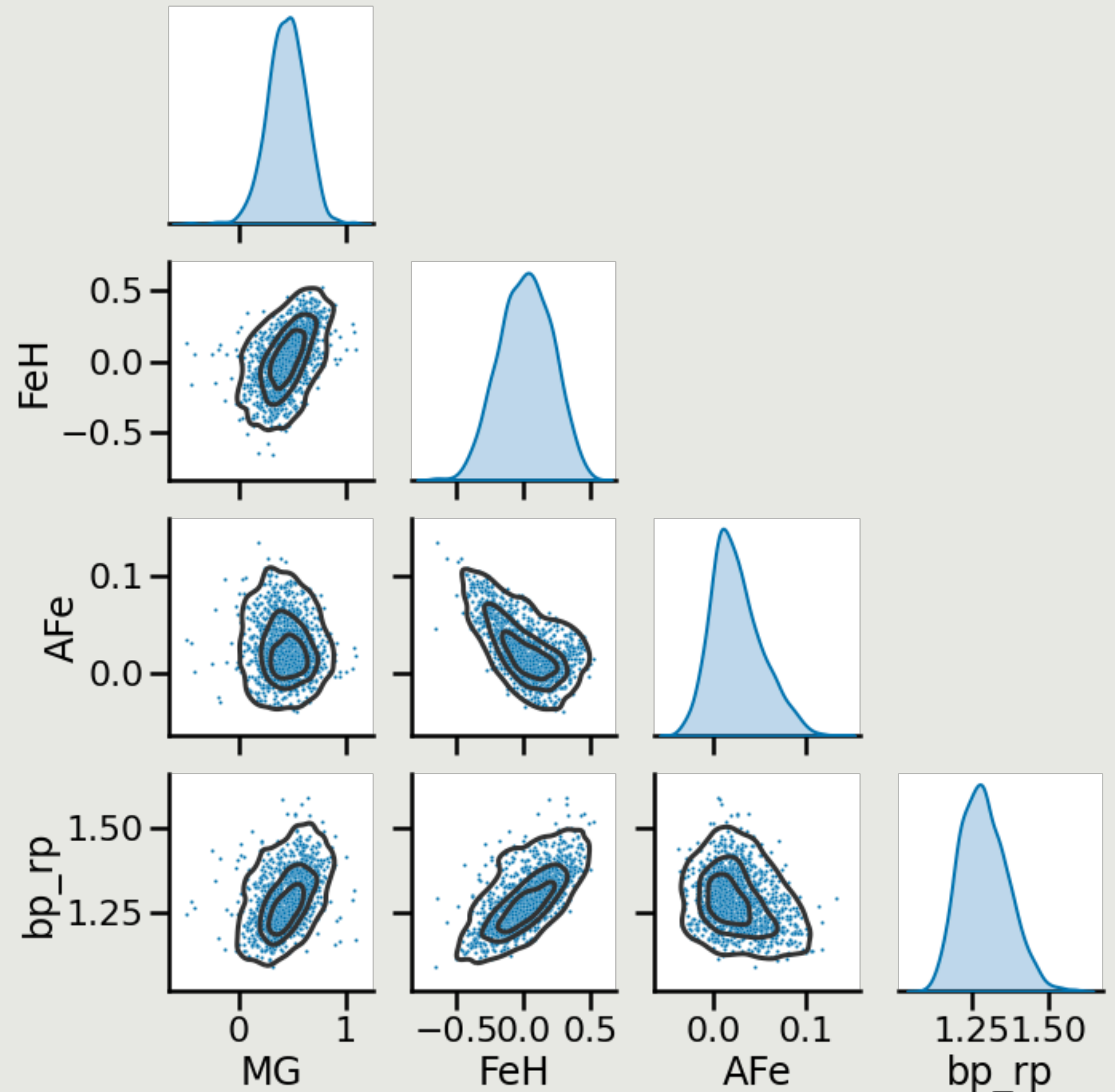
... and of course for **calibrating Gaia** [see e.g. Davies+17, Hawkins+17, Hall+19, Zinn+17, Zinn+19, Zinn+21, Chan+Bovy20]

Can we improve the **Red Clump's**  
**precision** by better **characterising**  
it as a **population**?



Stellar populations  
share **common**  
**properties**

Let's put them to  
work





1.

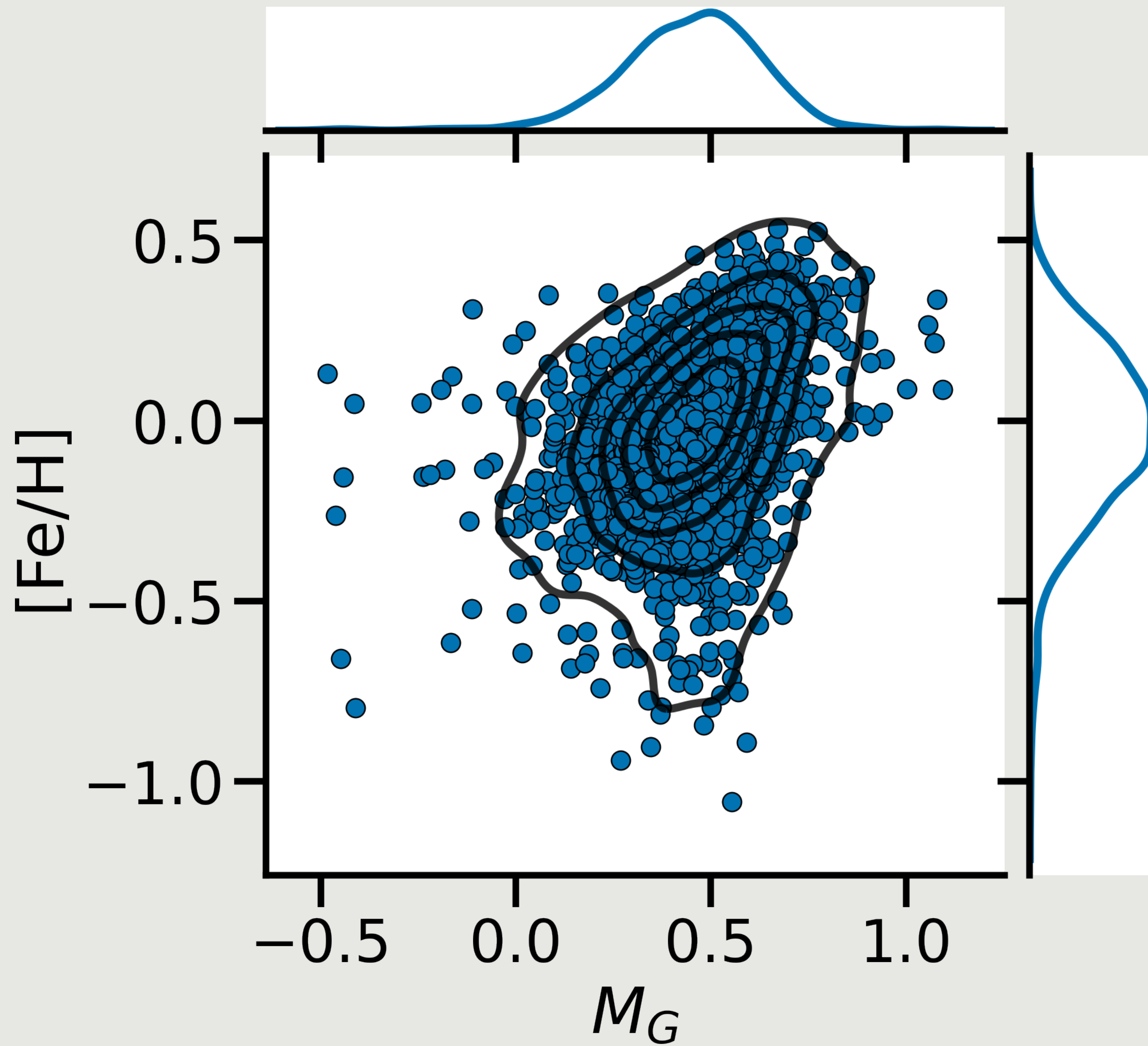
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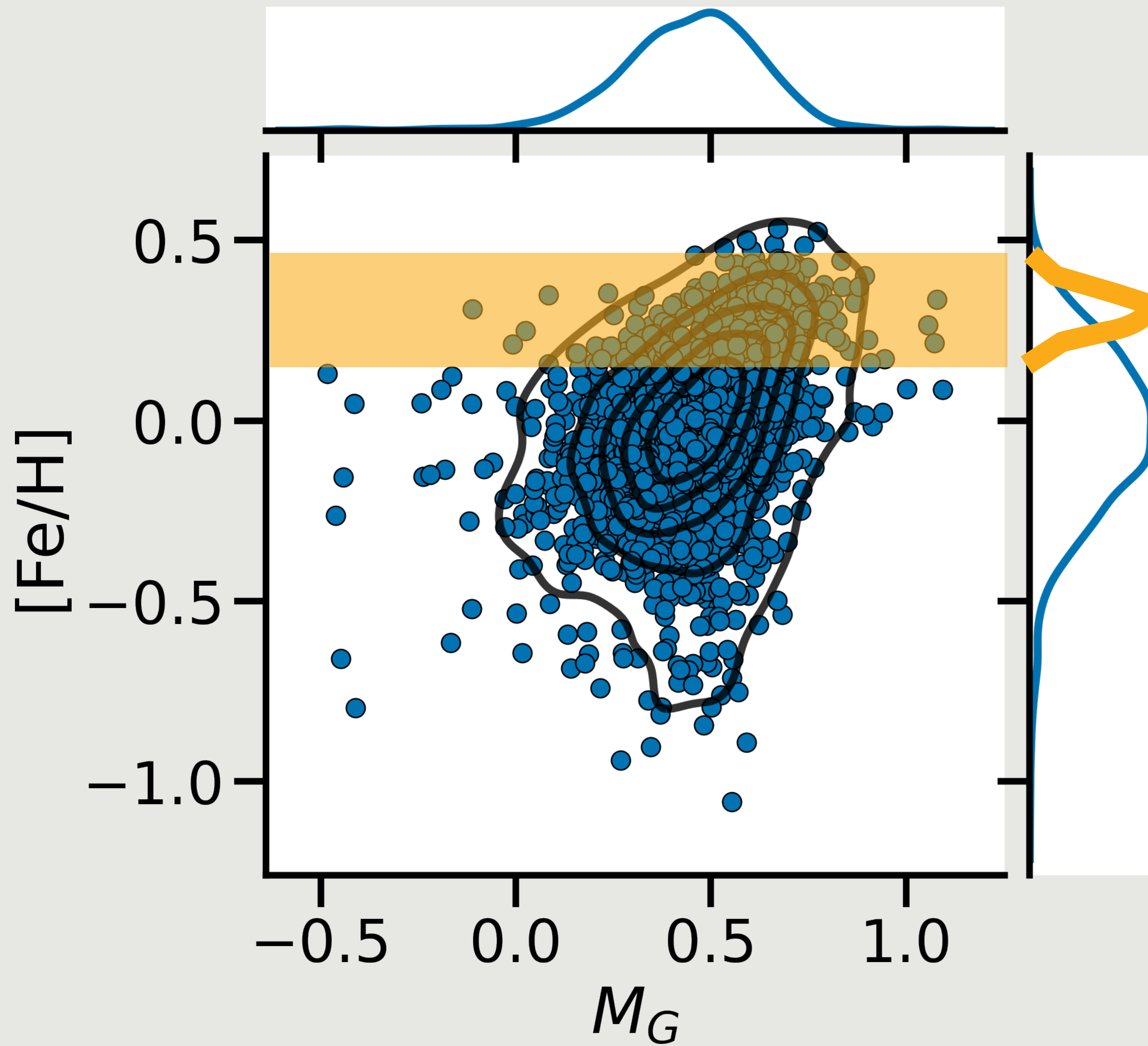
2.

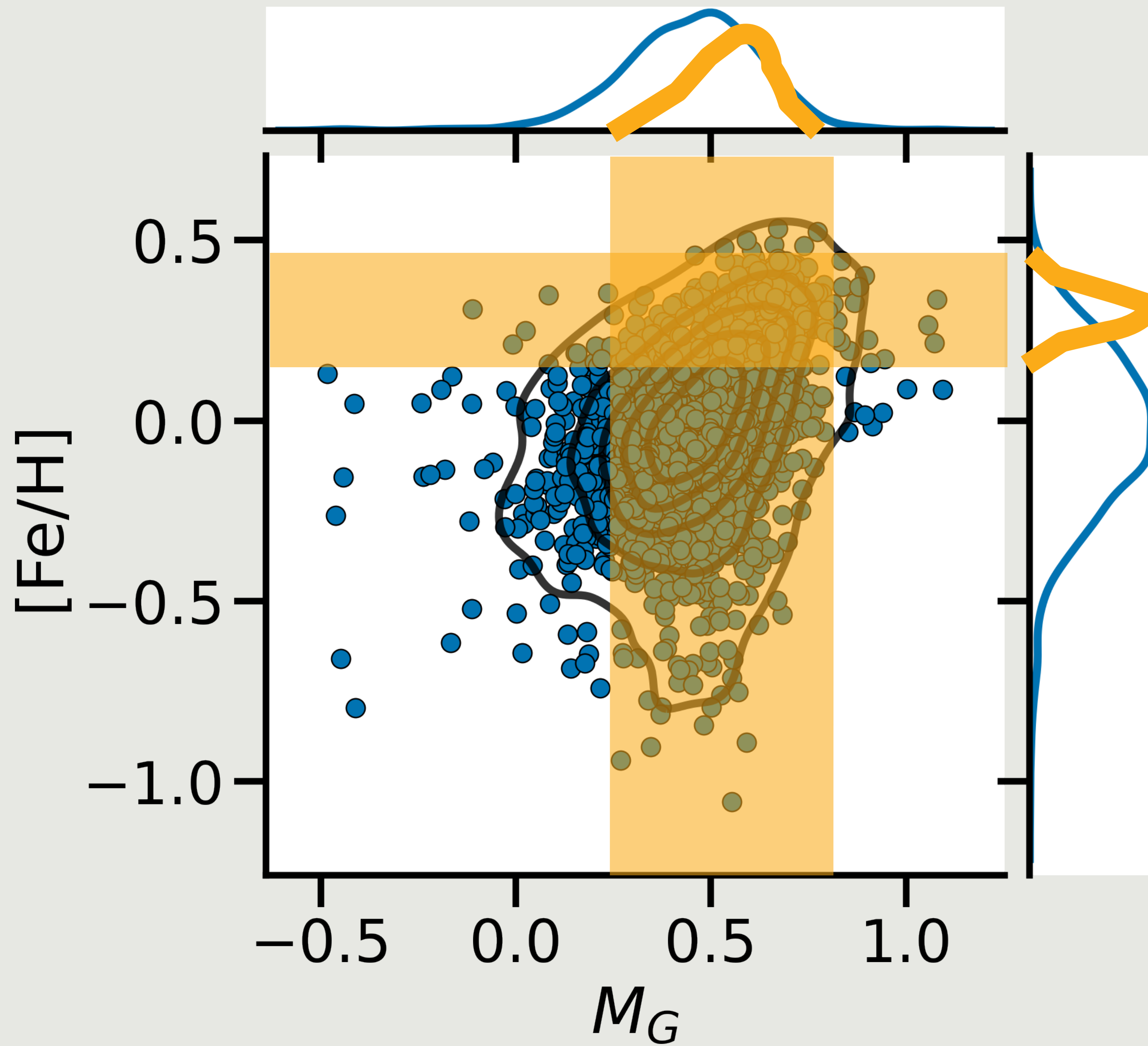
**Hierarchical Bayesian Models** let us characterise populations

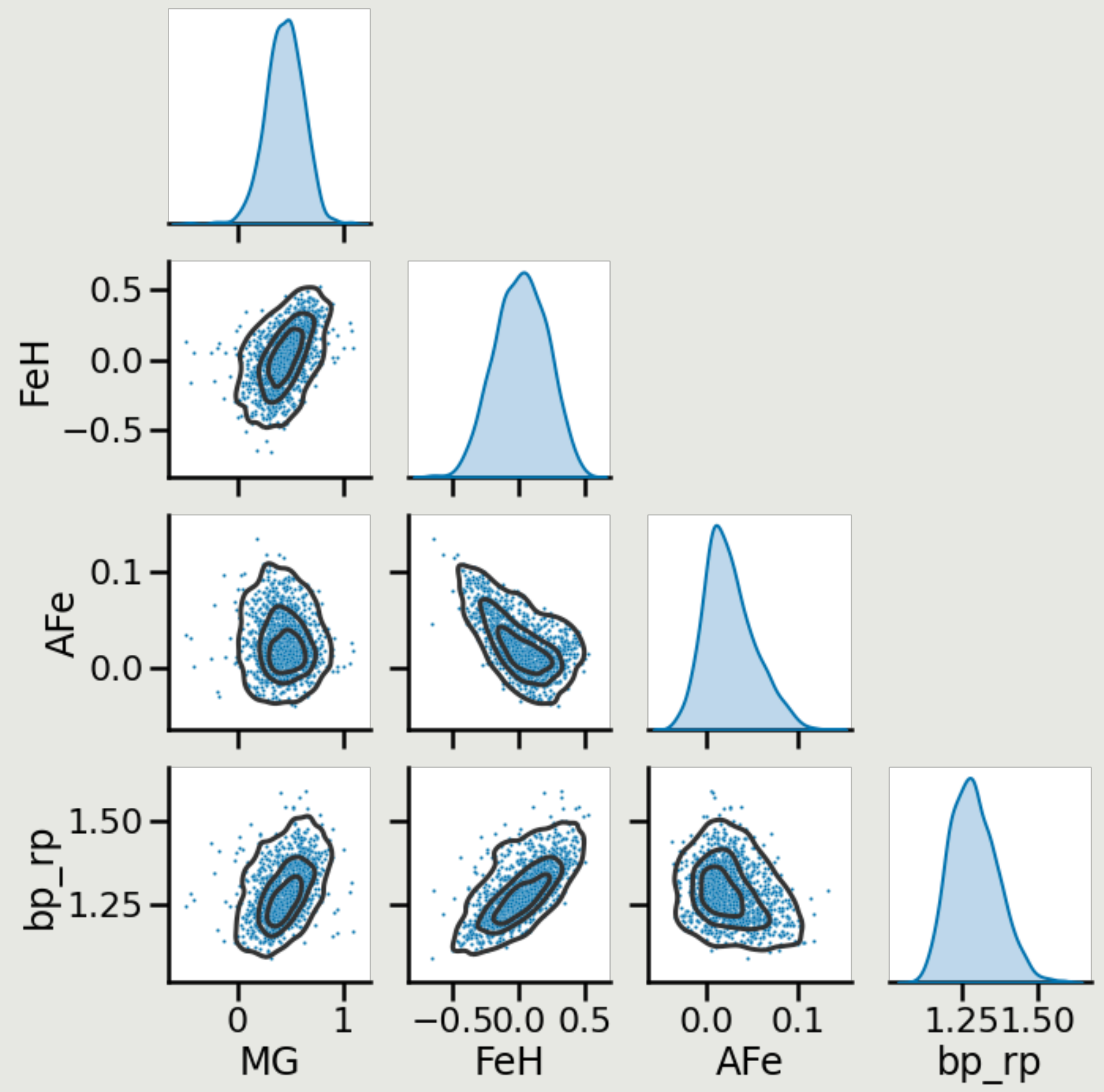
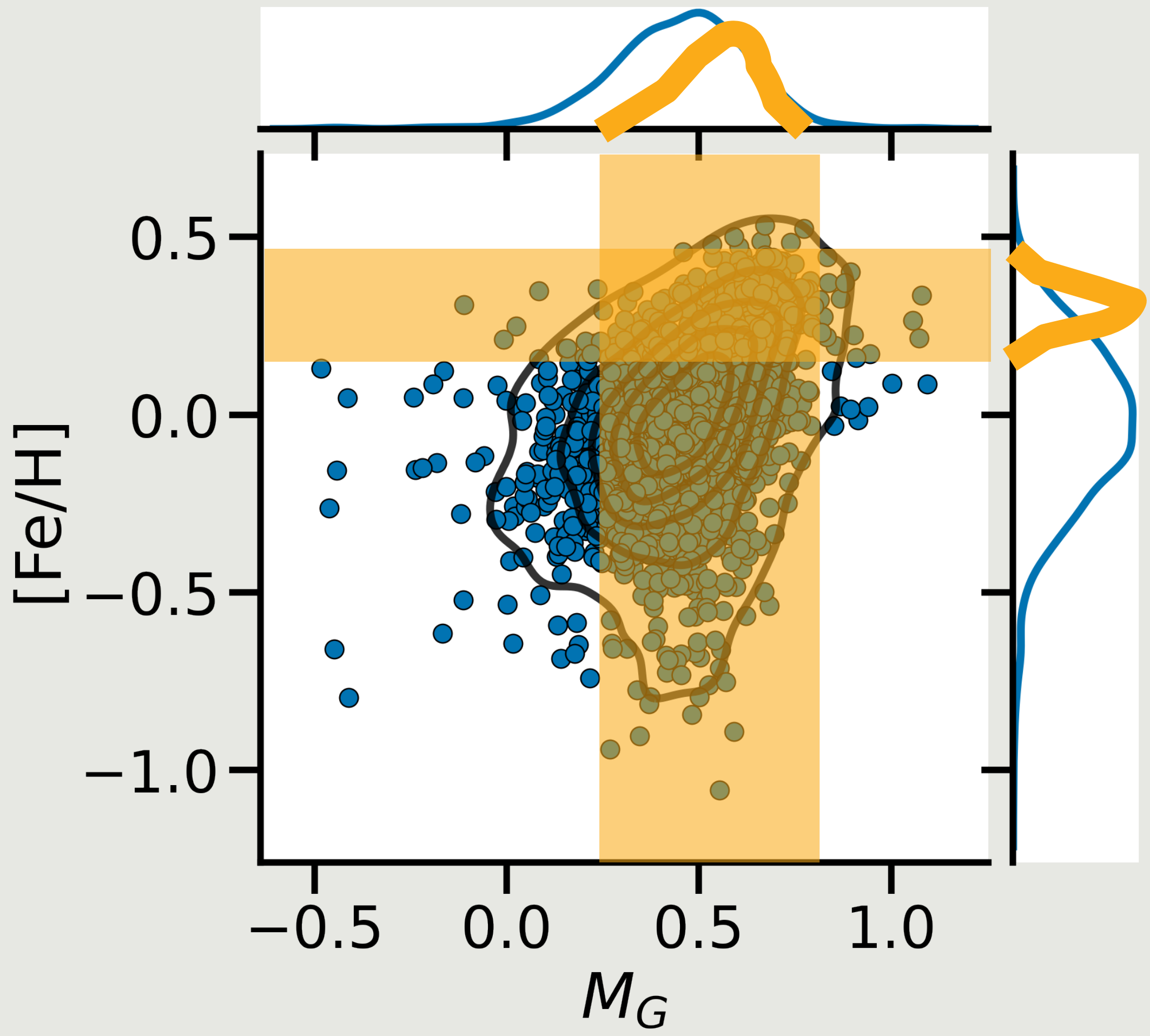
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More **information** improves standard candle **precision**

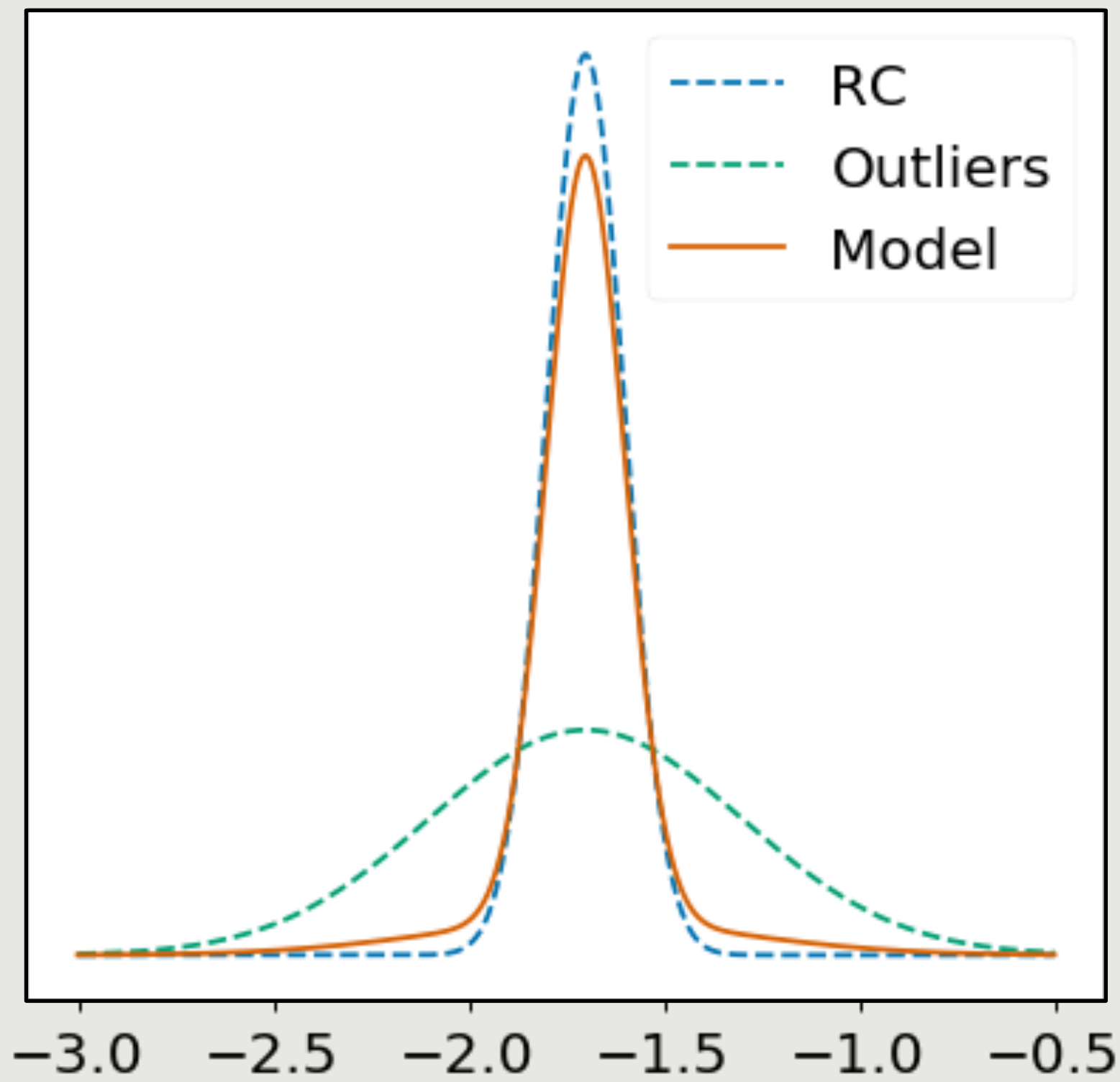




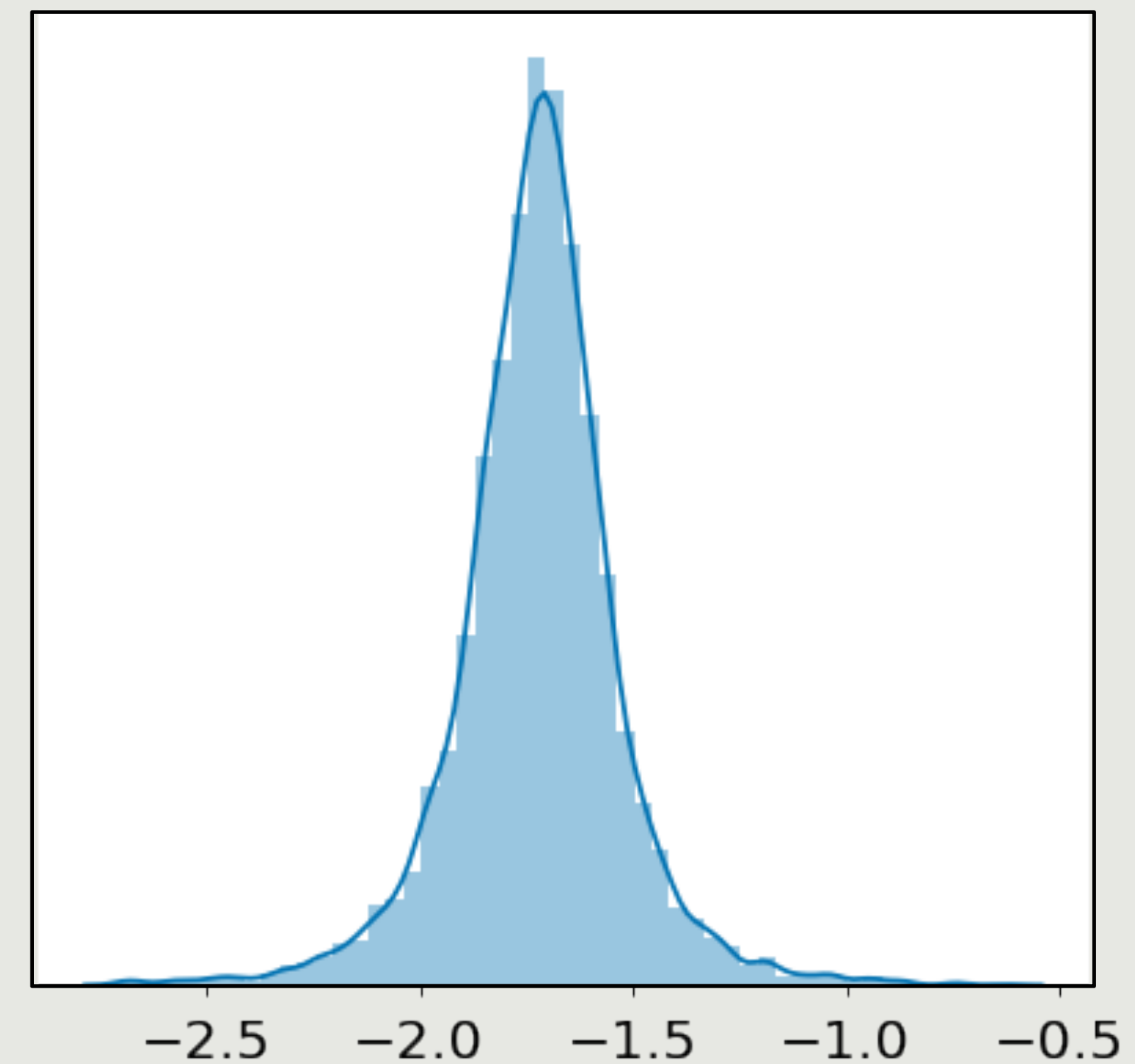




# Descriptive parameters

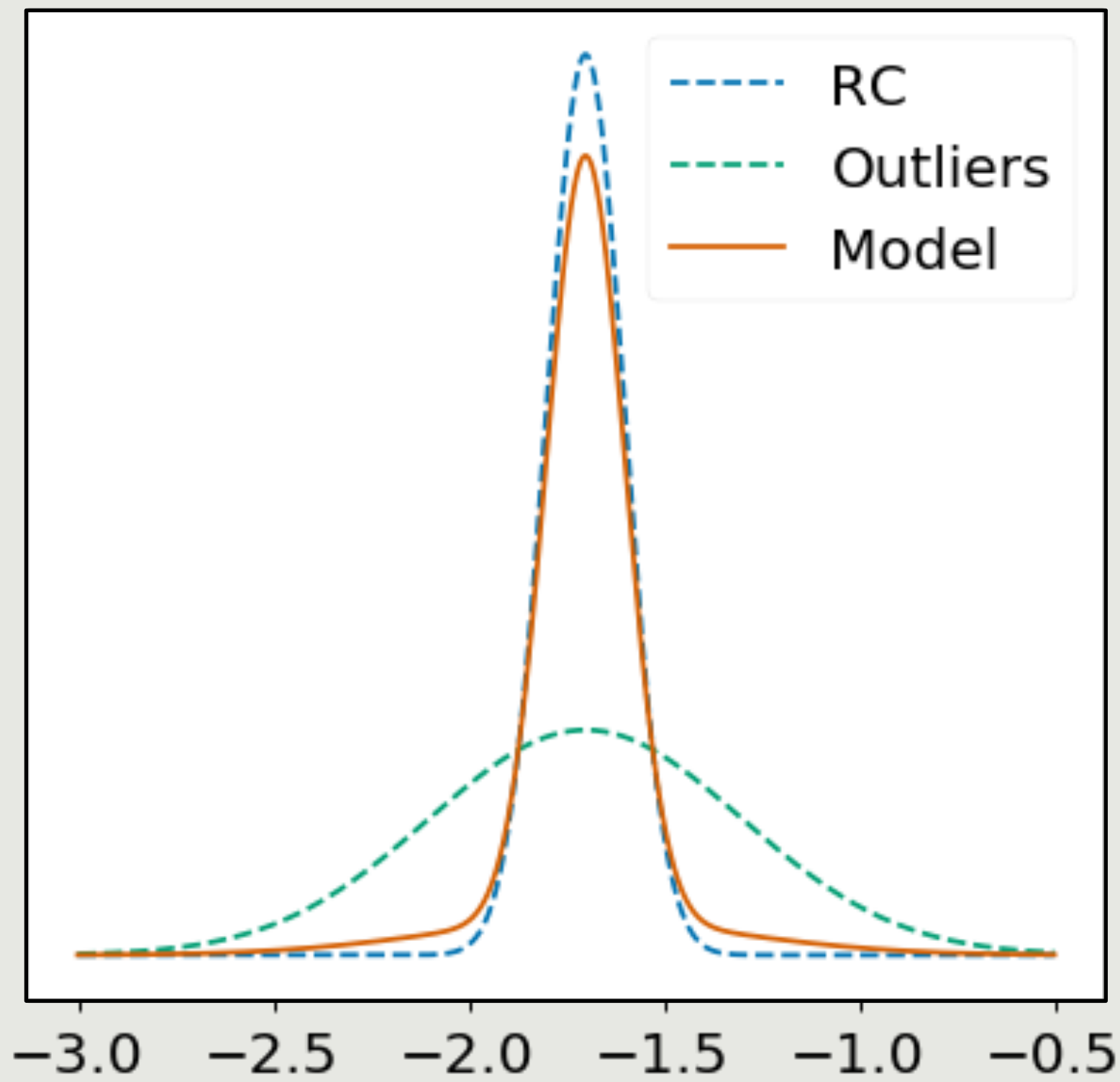


# Observed population



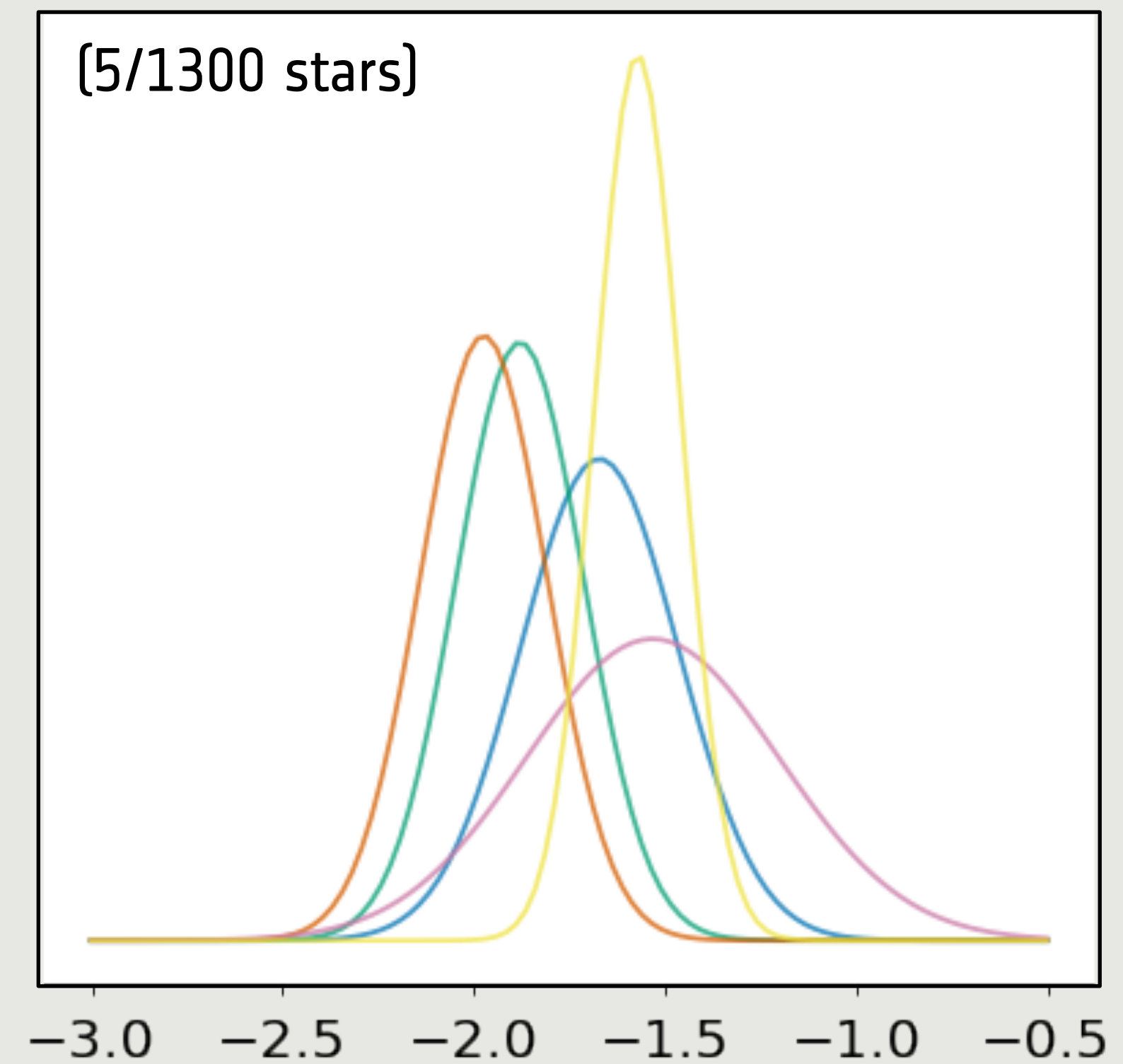
Seismic Absolute K-band Magnitude

# Descriptive parameters

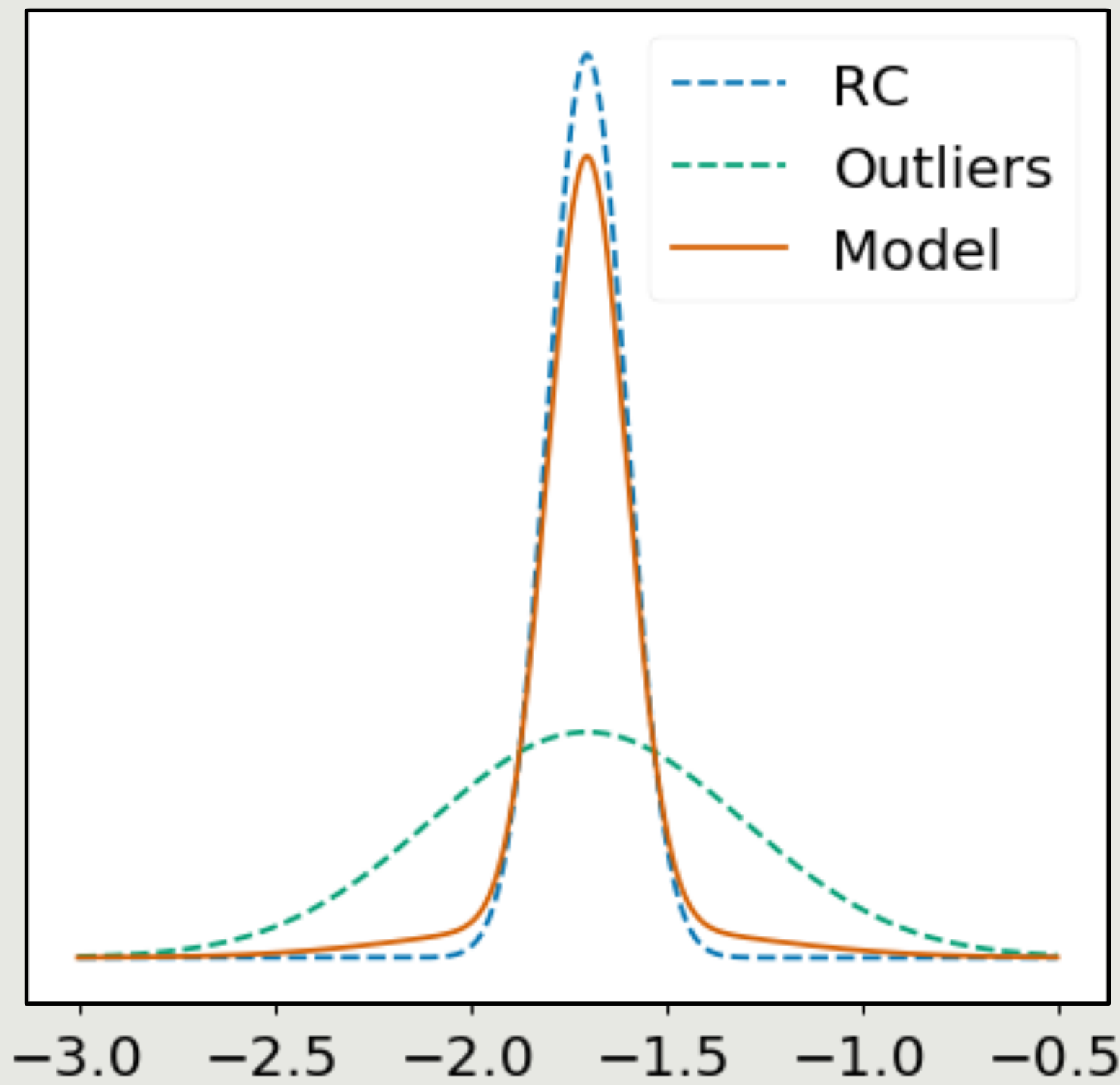


Seismic Absolute K-band Magnitude

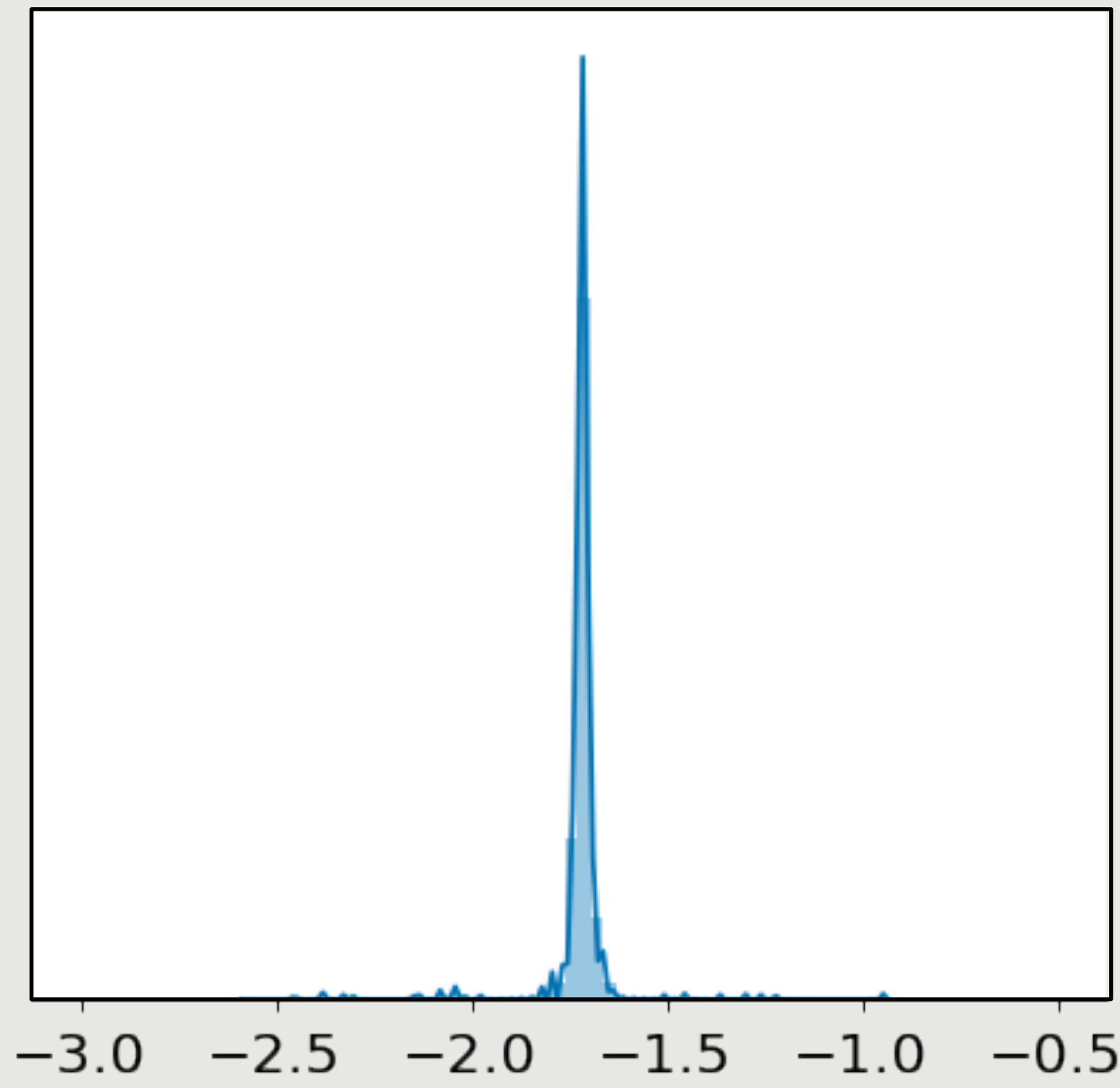
# Observed population



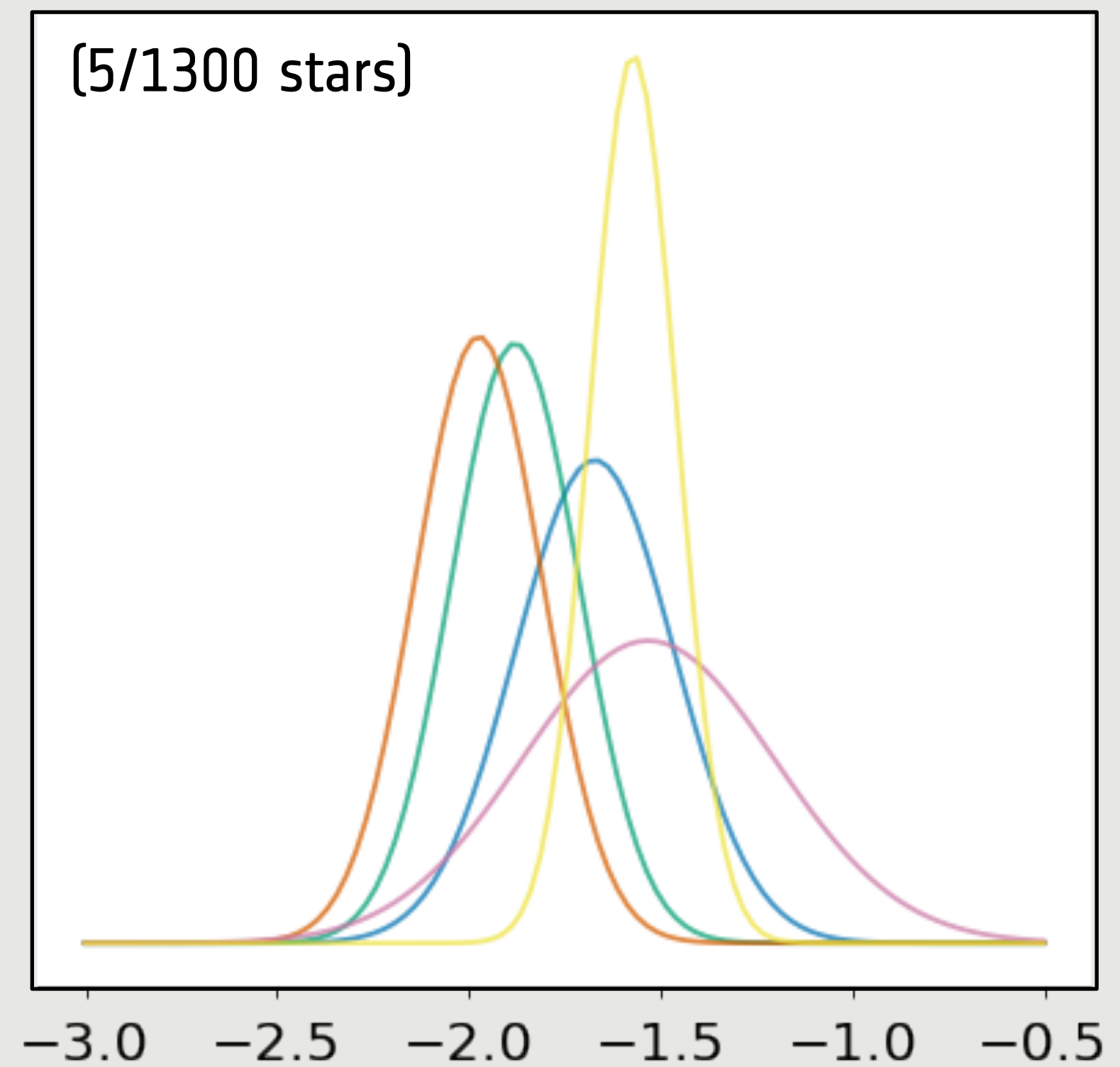
# Descriptive parameters



# Model ("true") population



# Observed population



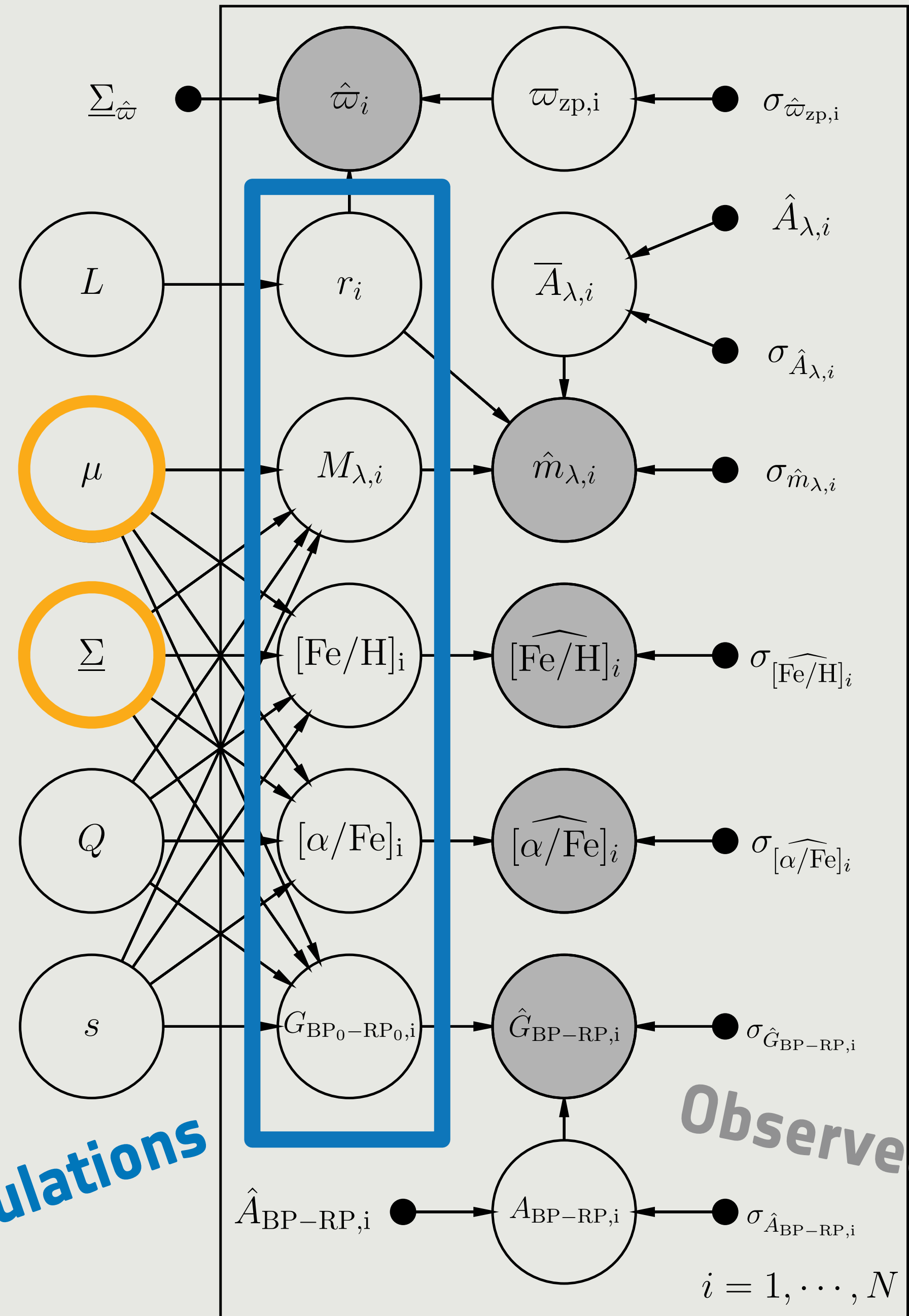
Seismic Absolute K-band Magnitude



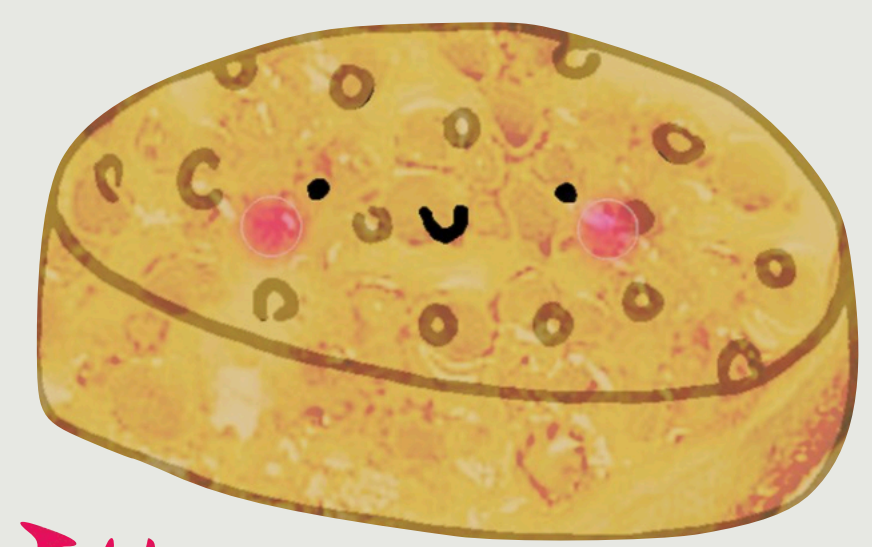
$M_\lambda$   
 $[\text{Fe}/\text{H}]$   
 $[\alpha/\text{Fe}]$   
 $G_{\text{BP}_0-\text{RP}_0}$

**Descriptive parameters**

(mean)  
 (covar.)



DO NOT BE AFRAID



THE CRUMPET OF COURAGE

Observed population

“true” populations



1.

The **Red Clump** is an important **standard candle**

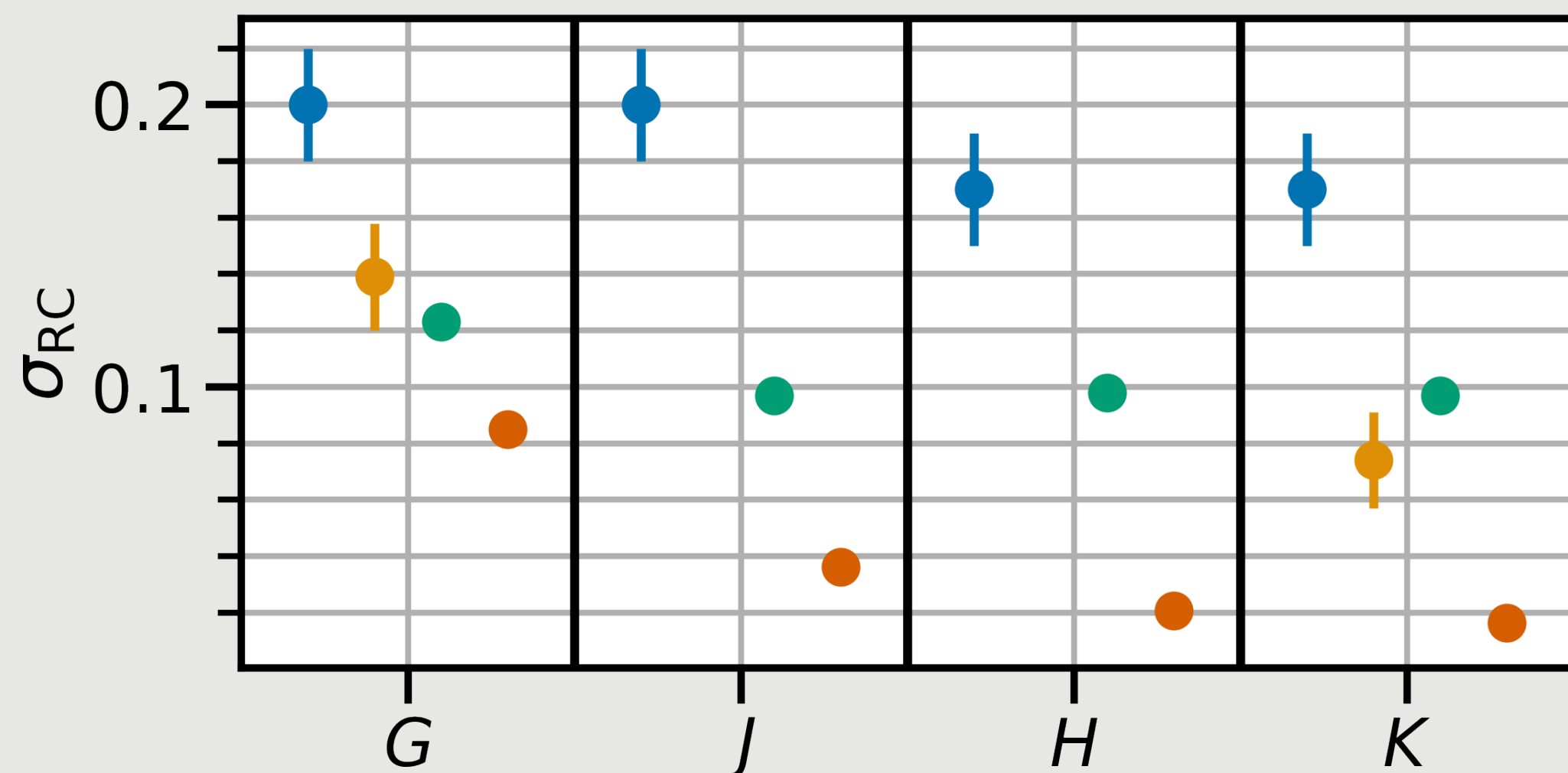
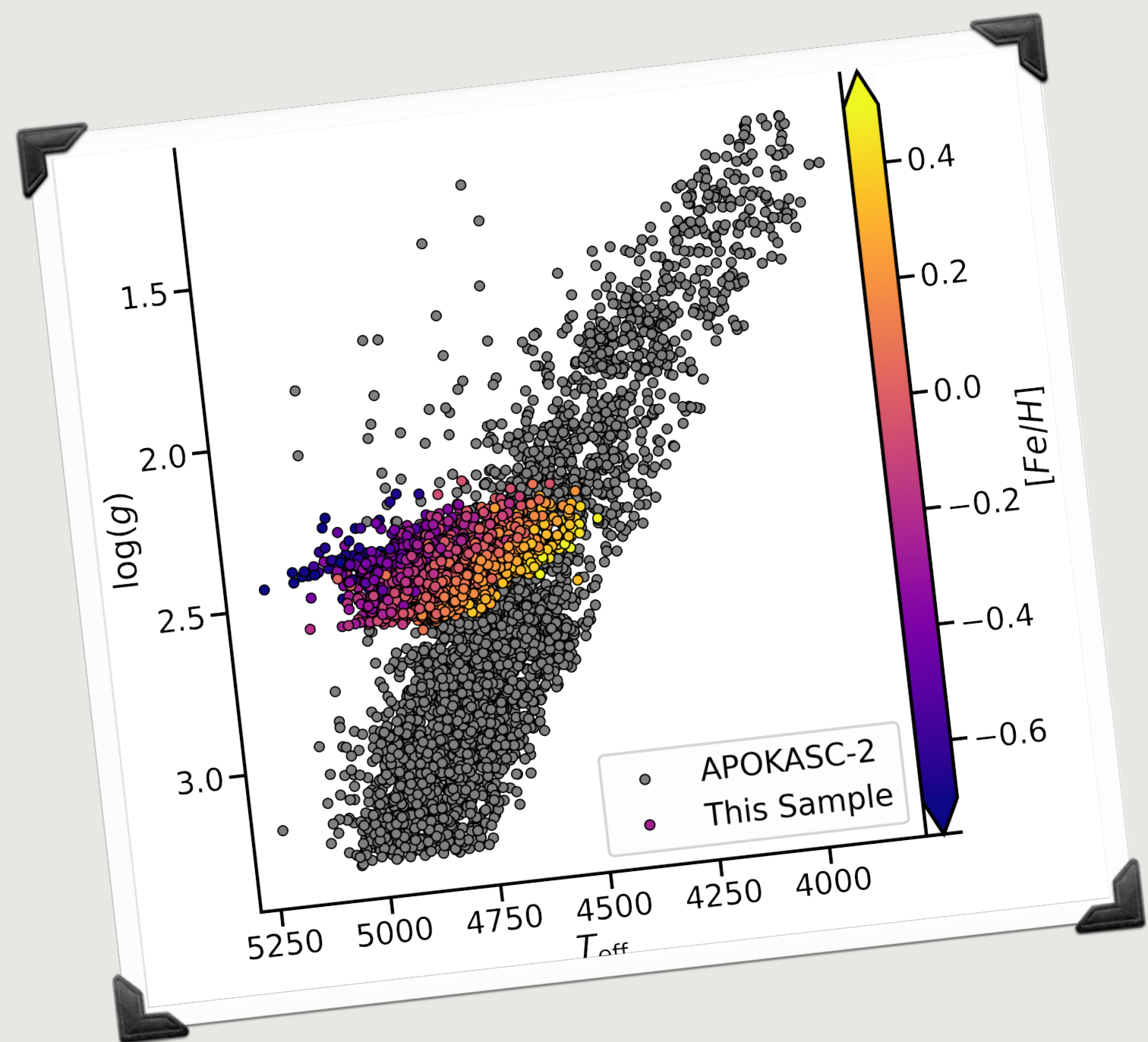
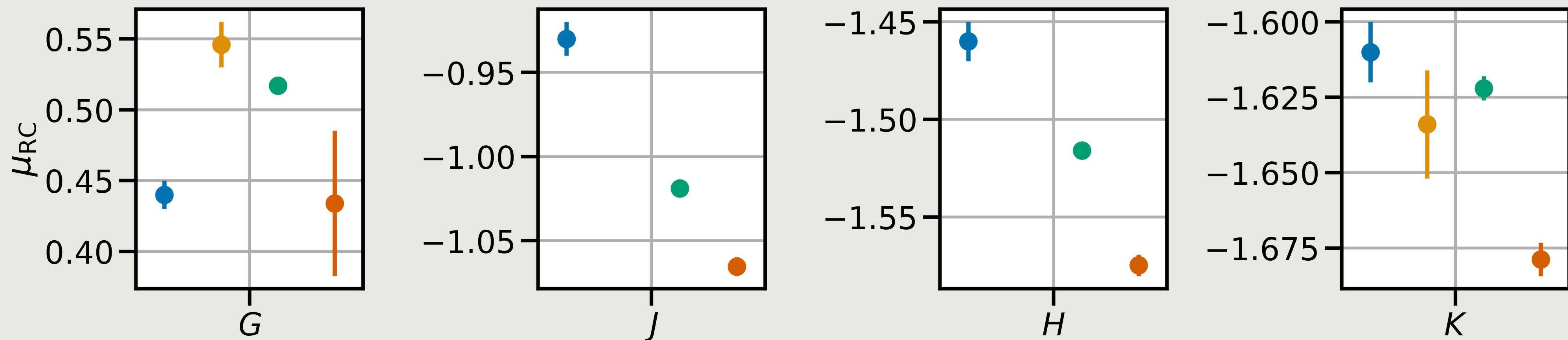
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**Hierarchical Bayesian Models** let us characterise populations

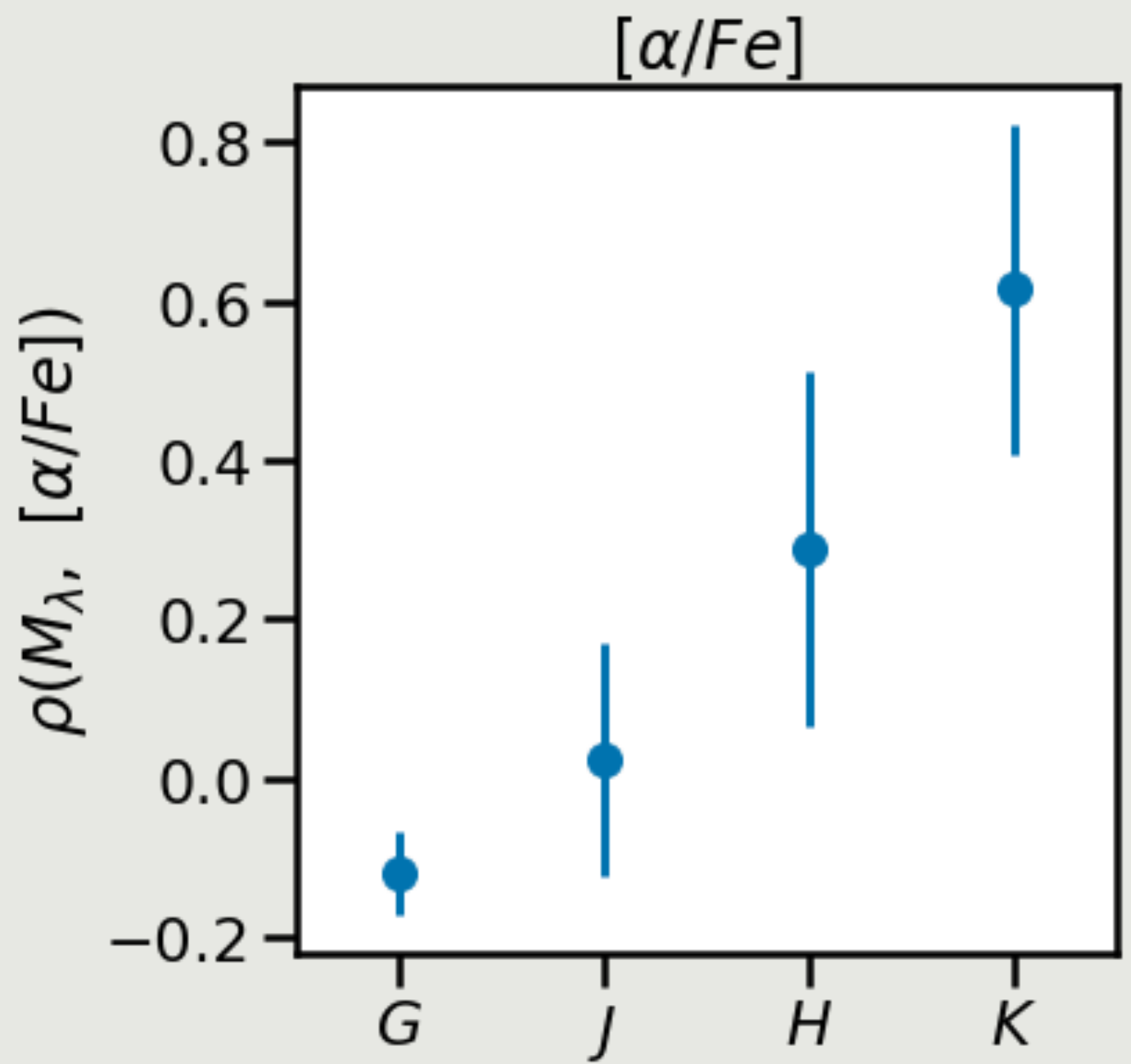
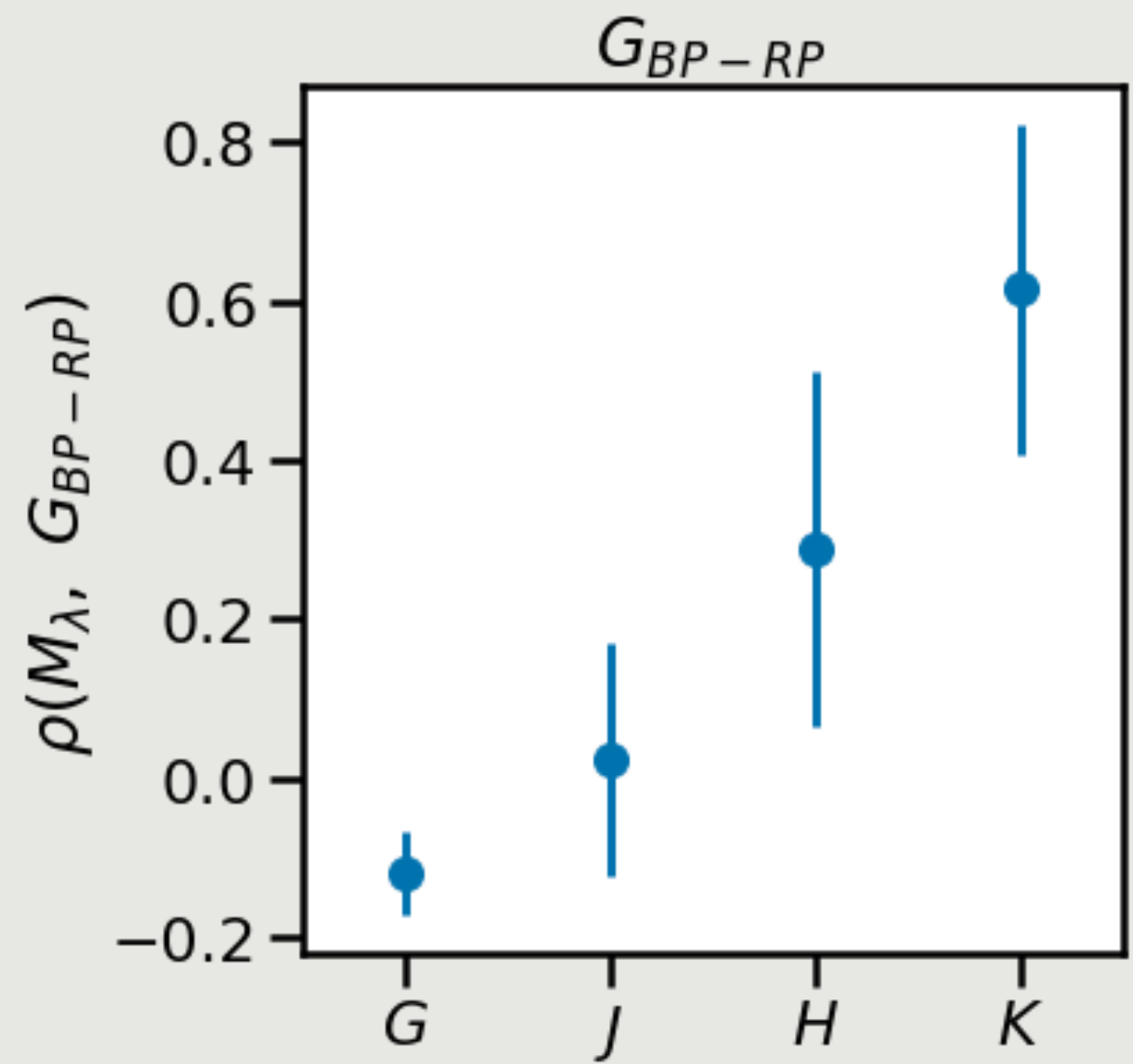
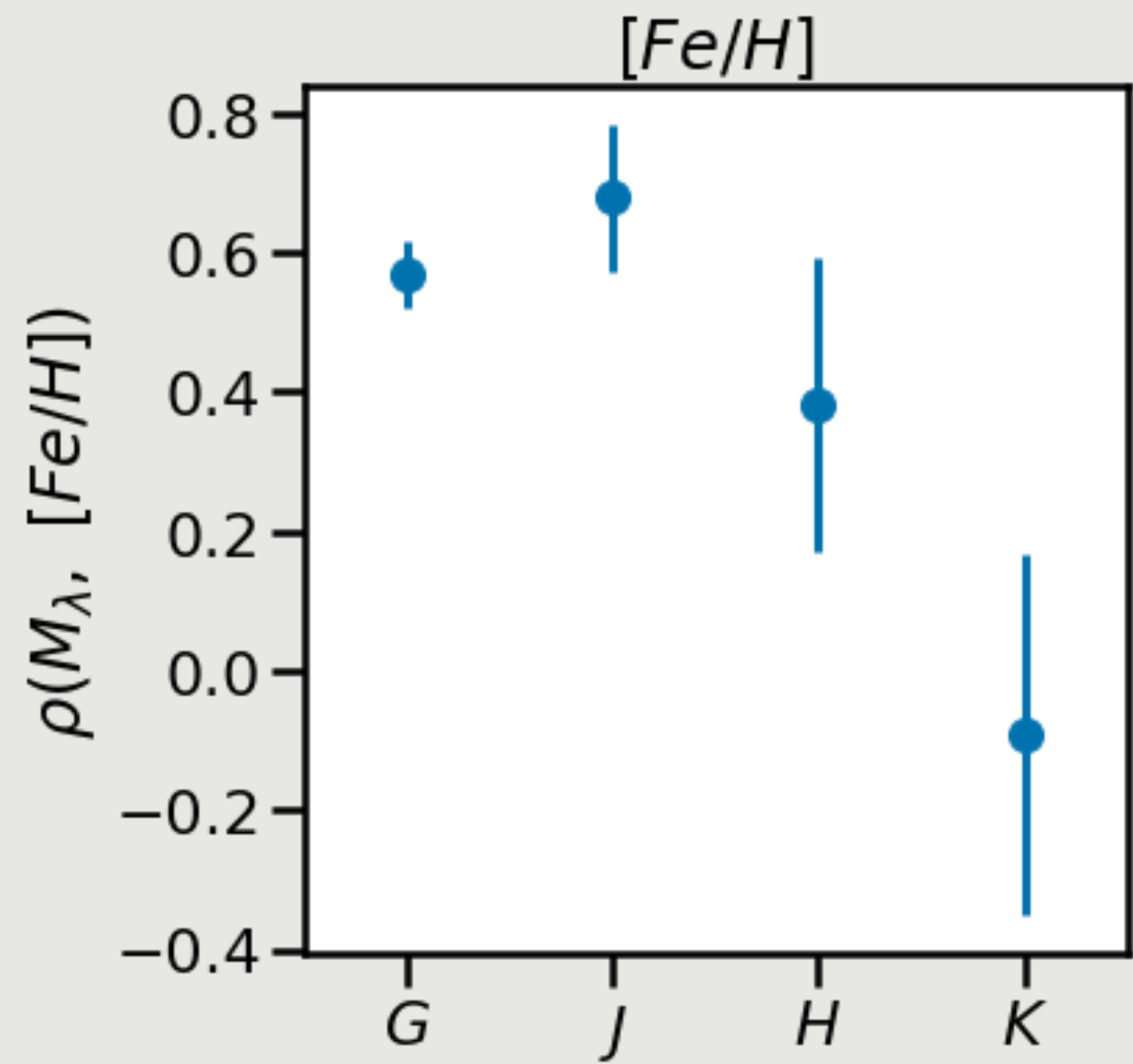
3.

More **information** improves standard candle **precision**

● Hawkins+17    
 ● Hall+19    
 ● Chan+Bovy19    
 ● This Work



IMPORTANT: This is magnitude spread \*decoupled\* from metallicity and colour (i.e. given perfect knowledge)



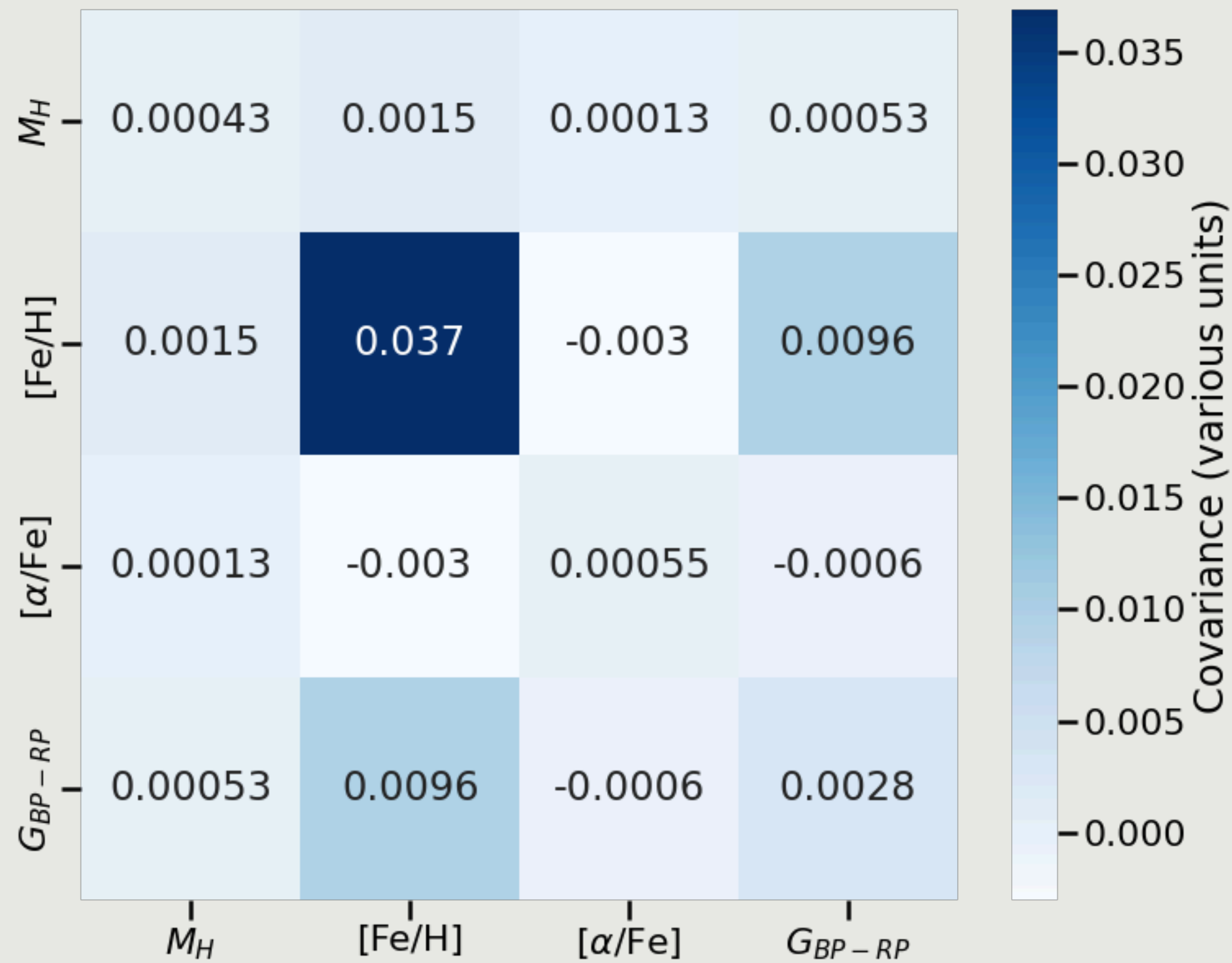
$\mu_T$

	$M_H$	[Fe/H]	[ $\alpha$ /Fe]	$G_{BP-RP}$
-	-1.6	0.018	0.025	1.2

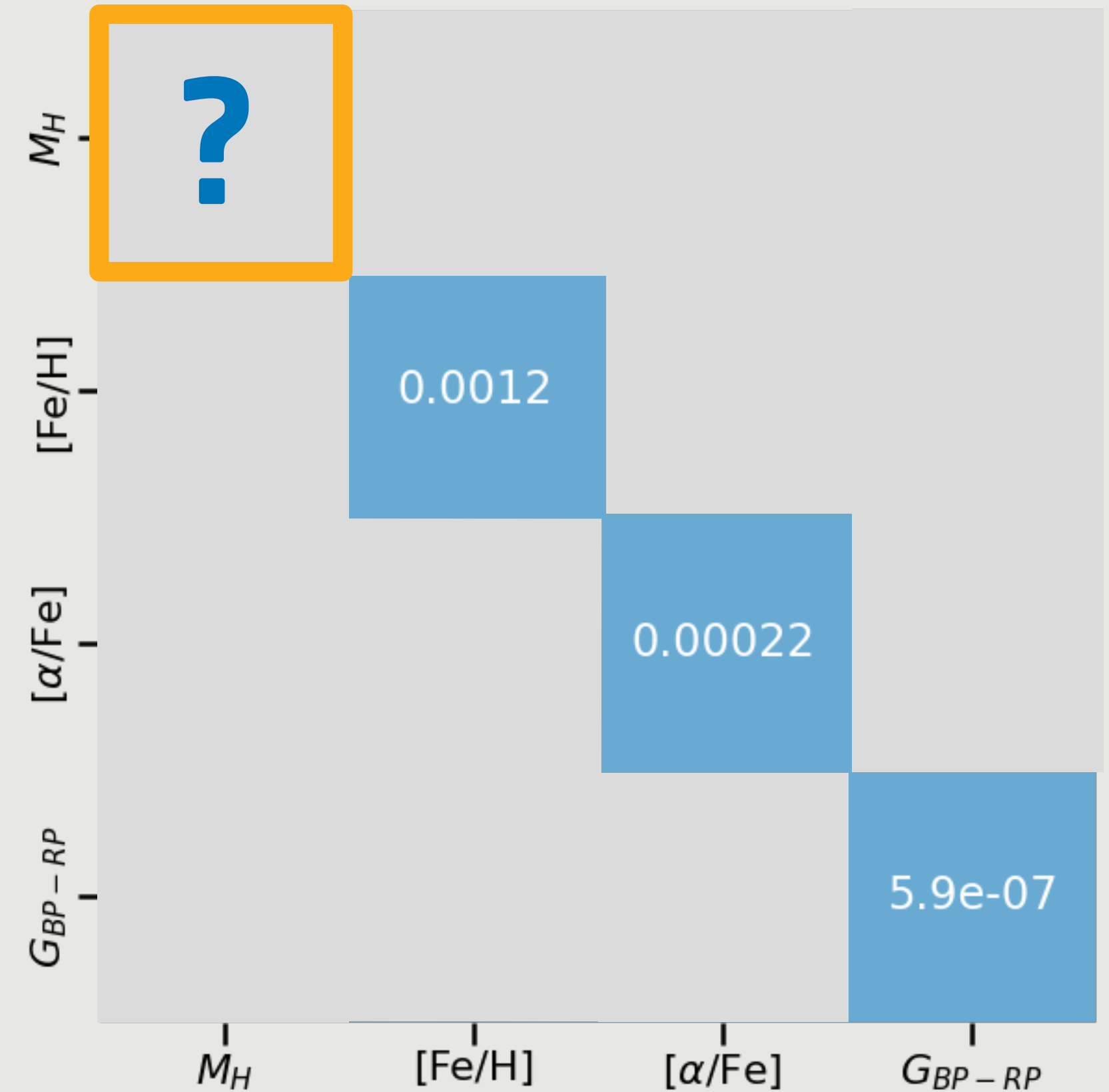
$\mu_{obs}$

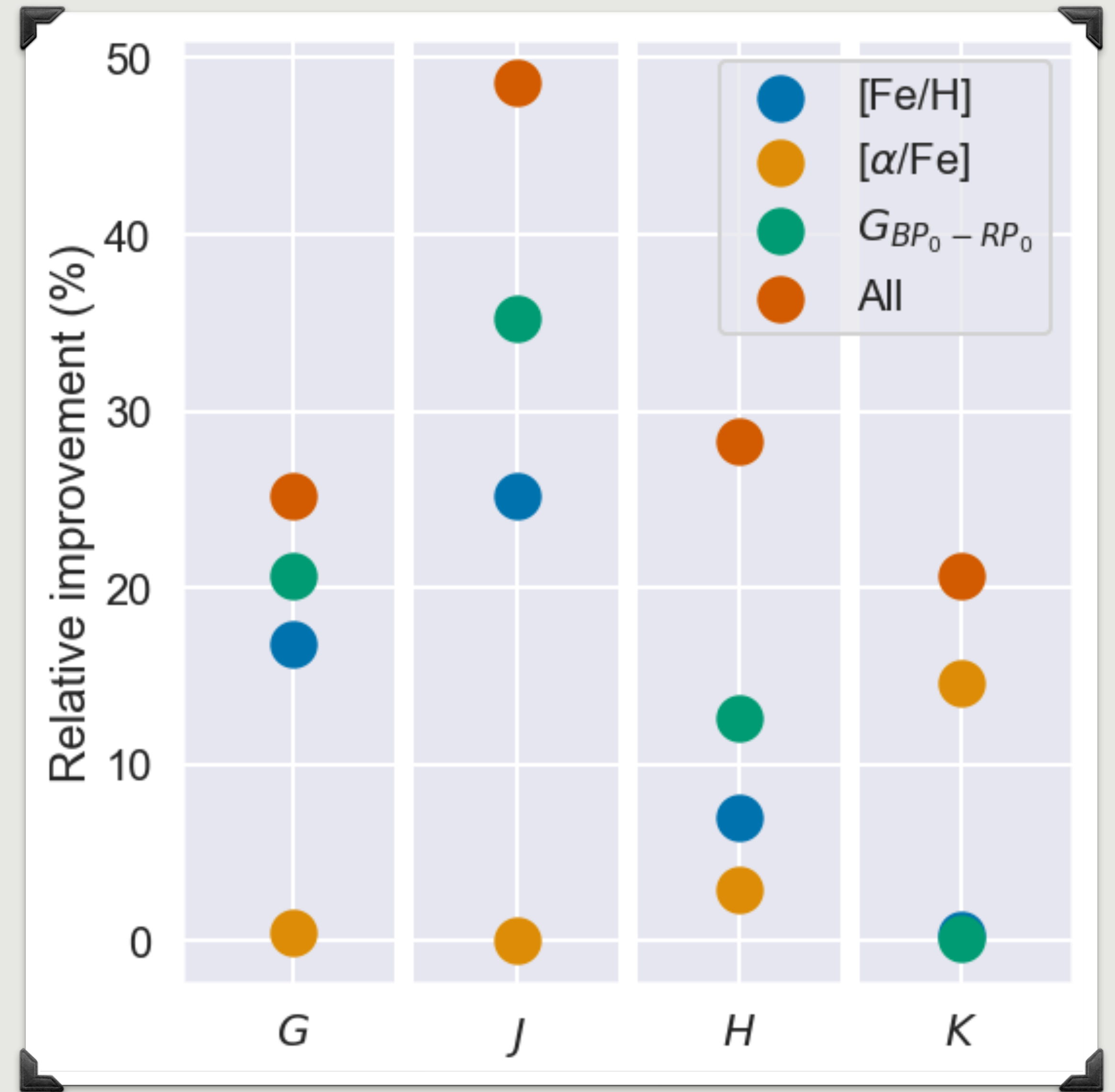
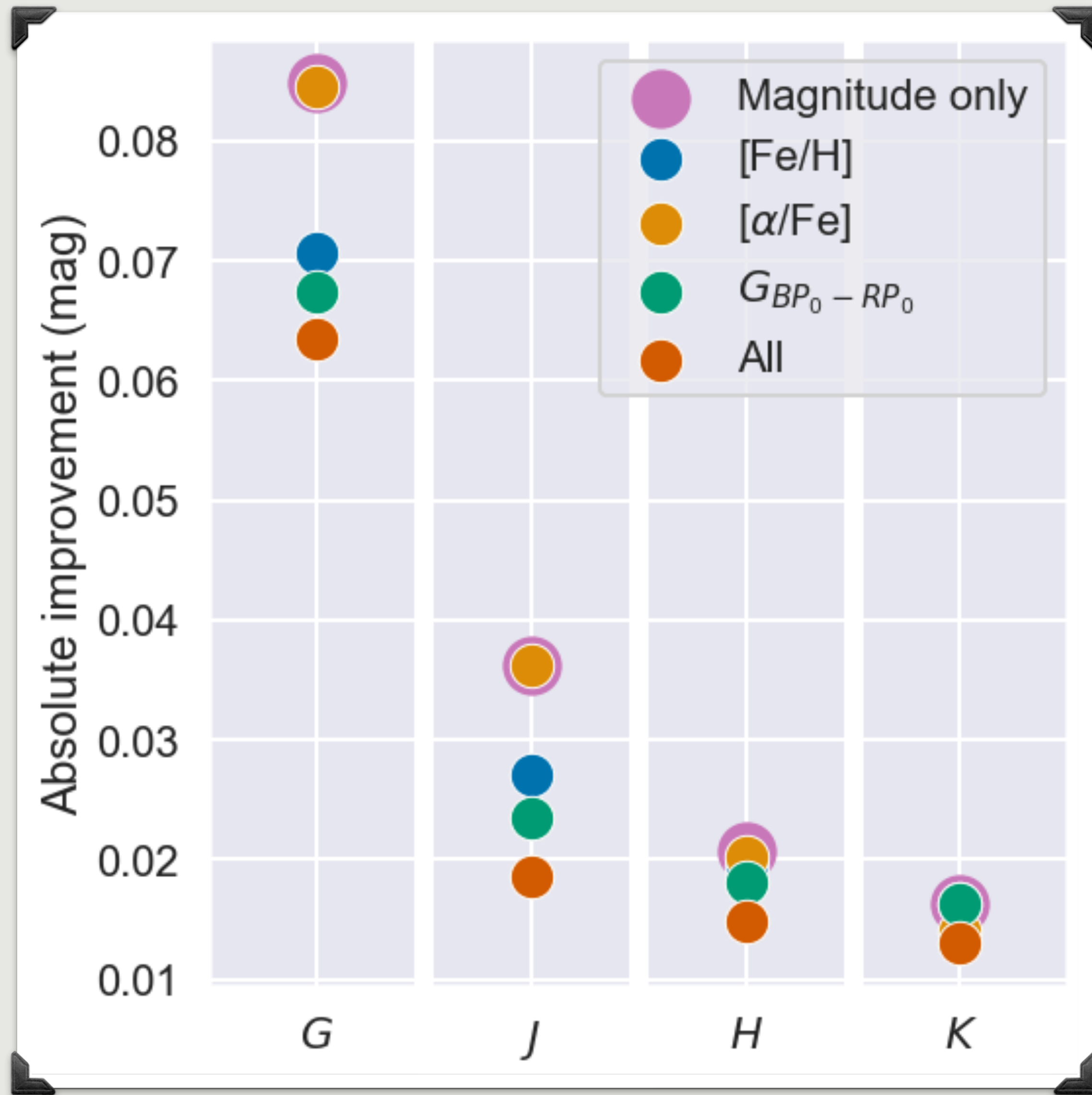
	$M_H$	[Fe/H]	[ $\alpha$ /Fe]	$G_{BP-RP}$
-	?	-0.26	0.19	1.2

$\Sigma_T$



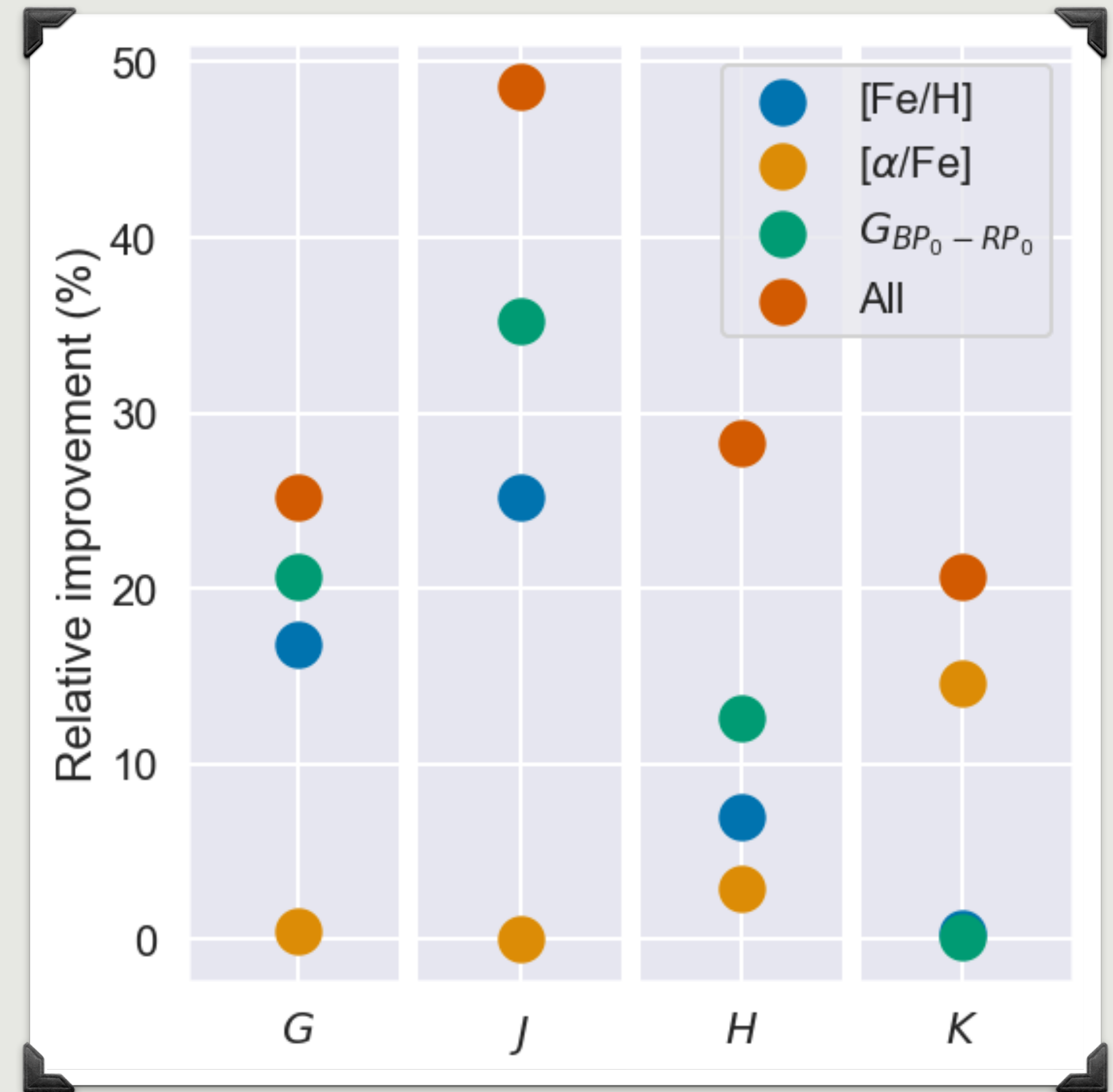
$\Sigma_{obs}$





# Summary

- The Red Clump **standard candle** is an important astronomical **calibrator**.
- Using Hierarchical Models and *Gaia* data we can **measure** the **covariances** **between parameters** in the Clump.
- Just including **metallicity** and **colour** data **improves** relative precision by **over 20%**.  
What more can we do with the full DR3?



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