Unveil the Sagittarius dwarf galaxy with the *Pristine* survey

MW-Gaia WG5 workshop
Breaking Barriers: Inspiring the Next Generation

Sara Vitali, Anke Arentsen, Elsa Starkenburg, Paula Jofré & Pristine collaborators
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The Sagittarius dSph

Discovered in 1994 by Ibata et al.

On-going merger with the Milky-Way

Core (~ 26.5 kpc, M~5x10^8 M⊙) + M54
+ stellar streams

High **extinction** and **contamination** from MW stars

Complex star formation history (SFH) -> different stellar populations (SPs)

Dominated by intermediate-age (8-10 Gyr) SP [Fe/H] ~ - 0.5
Presence of **old** (>10 Gyr) and **metal-poor** component [Fe/H] < -1.0

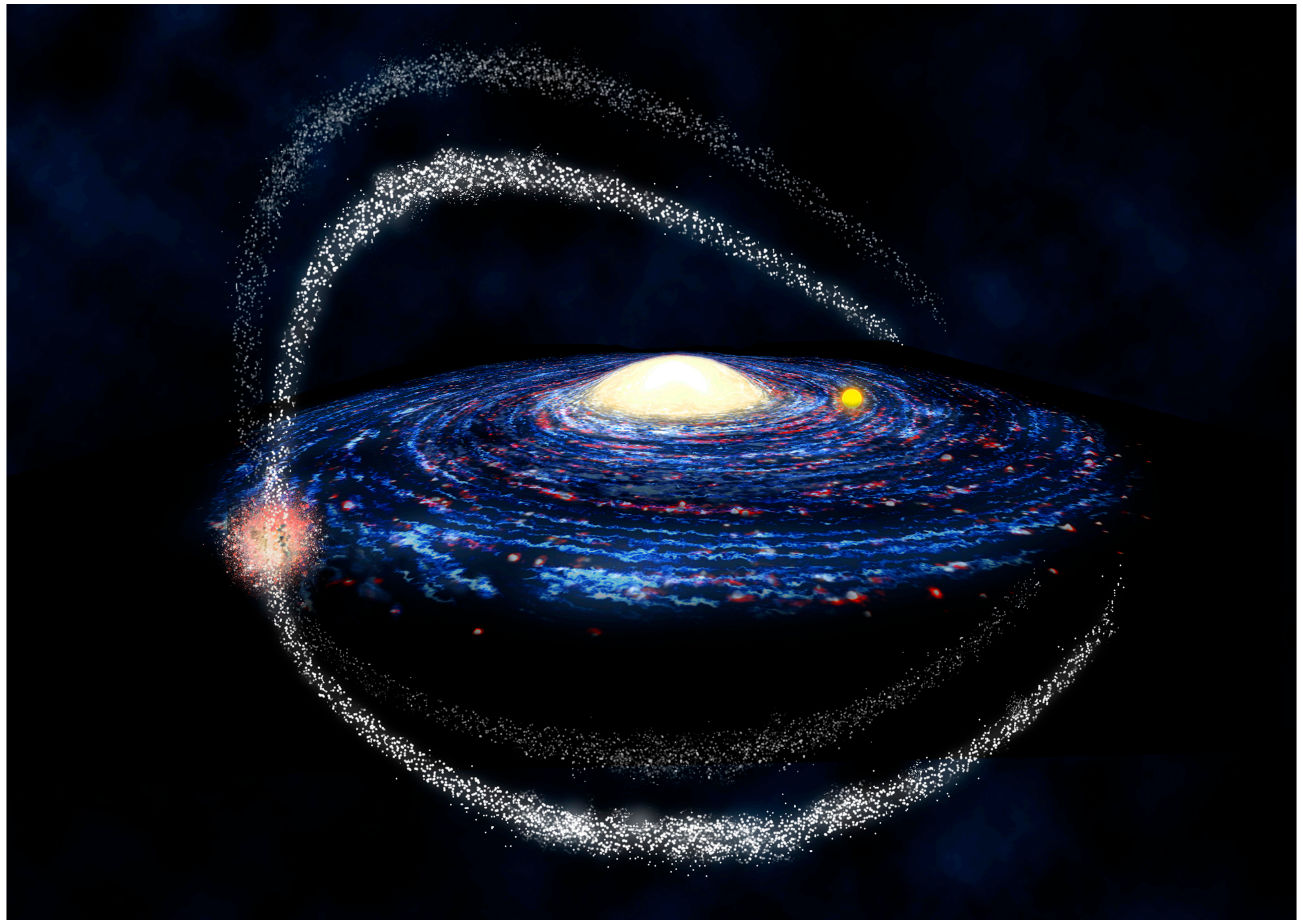


Image credit: Amanda Smith

→ **Metallicity analysis** for tracing back the history of the galaxy
`https://arxiv. org/abs/2204.12140`

The *Pristine* survey

Ongoing since 2016 (Starkenburg et al., 2016)

Photometric survey -> **CaHK** filter
+ broad-band photometry

Discriminatory power over -3.0 < [Fe/H] < -0.5
-> uncertainties of only ~ 0.2%

Study the **pristine stars** in and around the MW

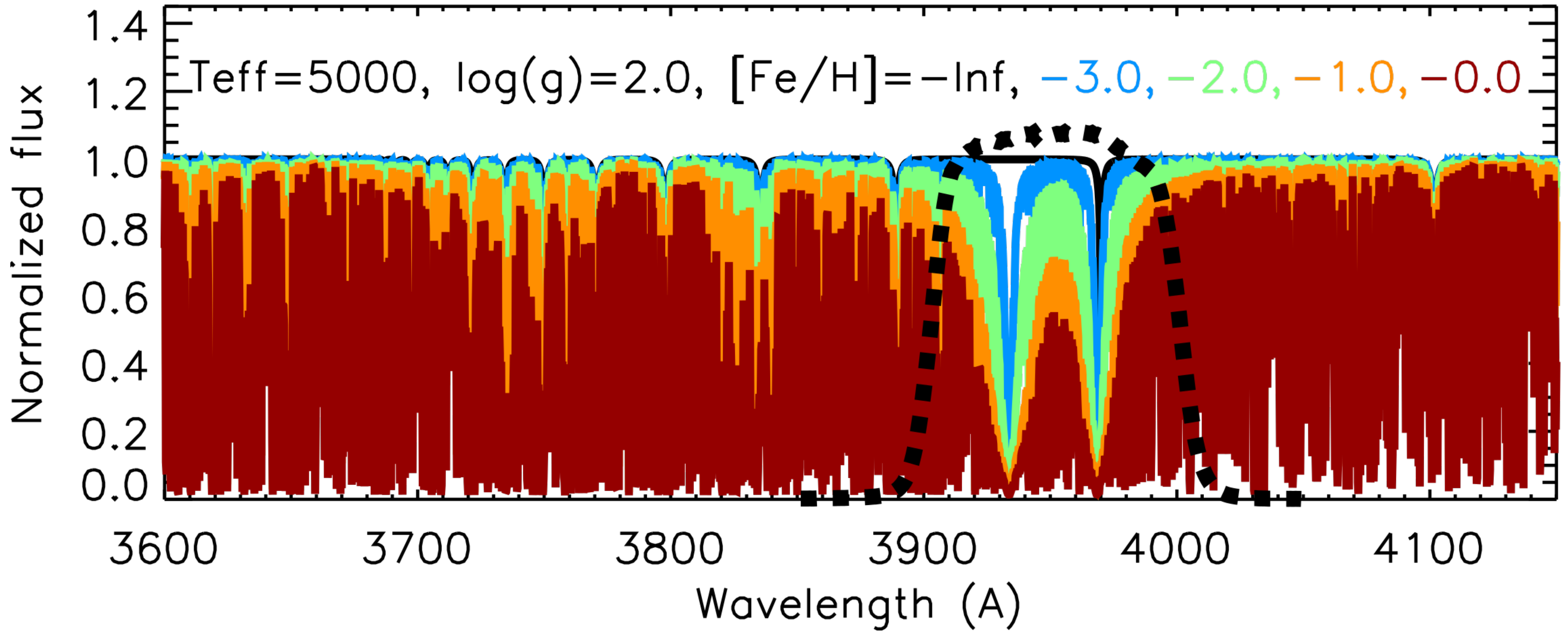
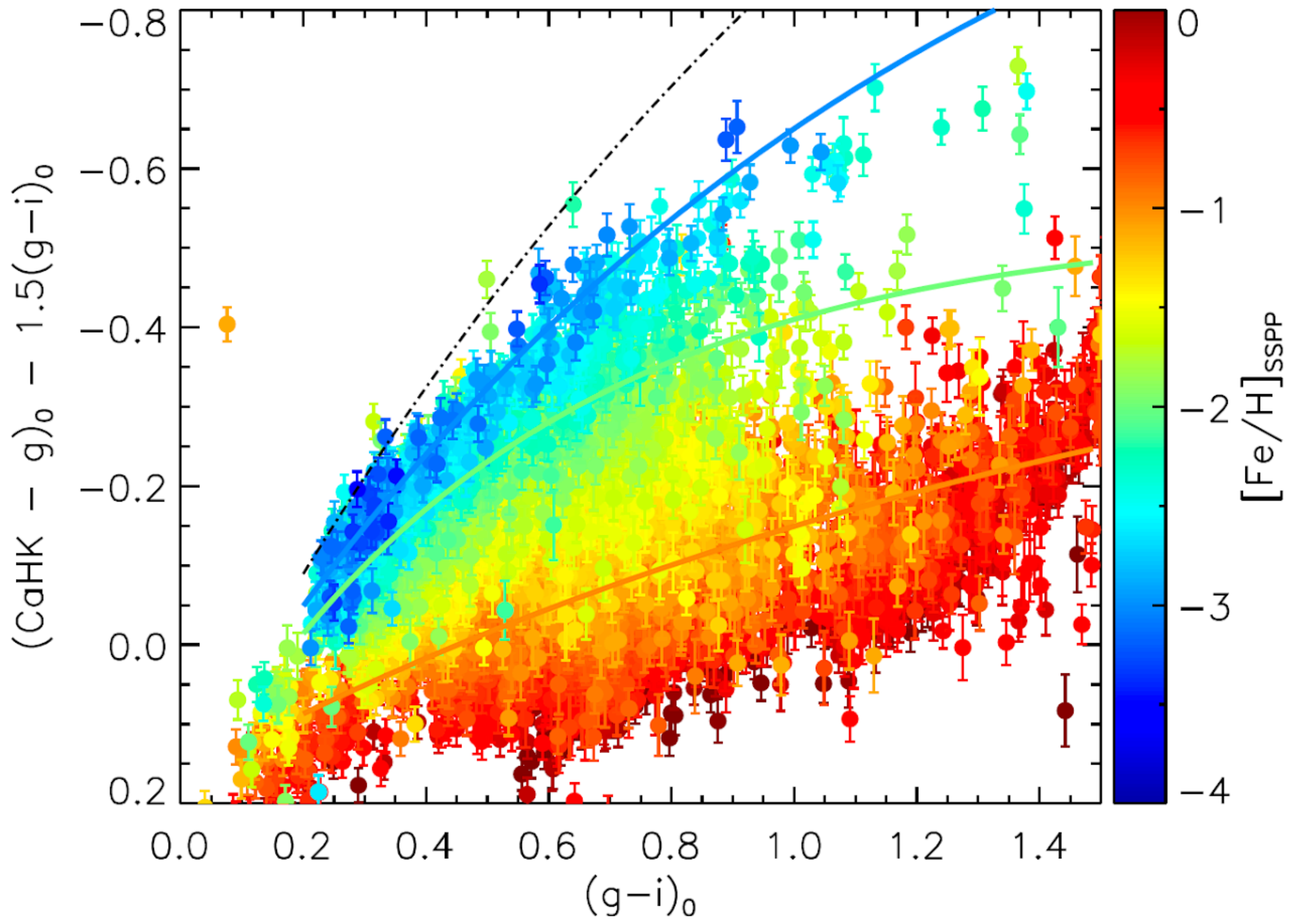


Image credit: E. Starkenburg



E. Starkenburg et al., 2017

The Pristine Inner Galaxy Survey (PIGS)

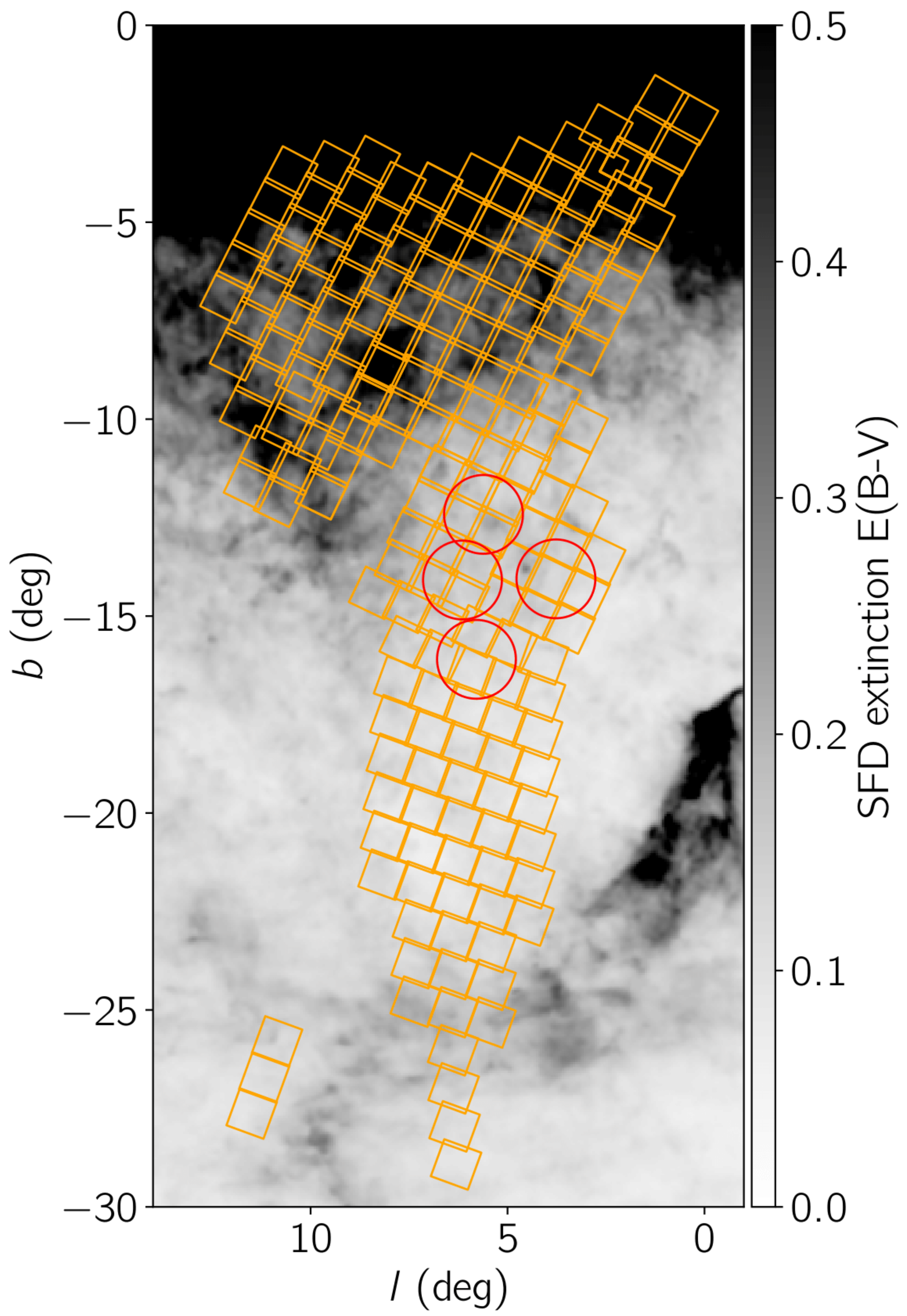
Sub-survey -> bulge (A. Arentsen et al., 2021)

Pristine photometry + ***Gaia*** G, BP and RP bands

Examine the most metal-poor star in the inner galaxy

δ ~ -30° -> **Sagittarius (Sgr) region**

Spectroscopic follow-up: low and medium resolution spectra (FERRE code)



Catalogues:

Photometry: PIGS + *Gaia G, BP* and *RP*
Extinction correction Schlegel map + color-dependent coefficients for *Gaia* EDR3 filters

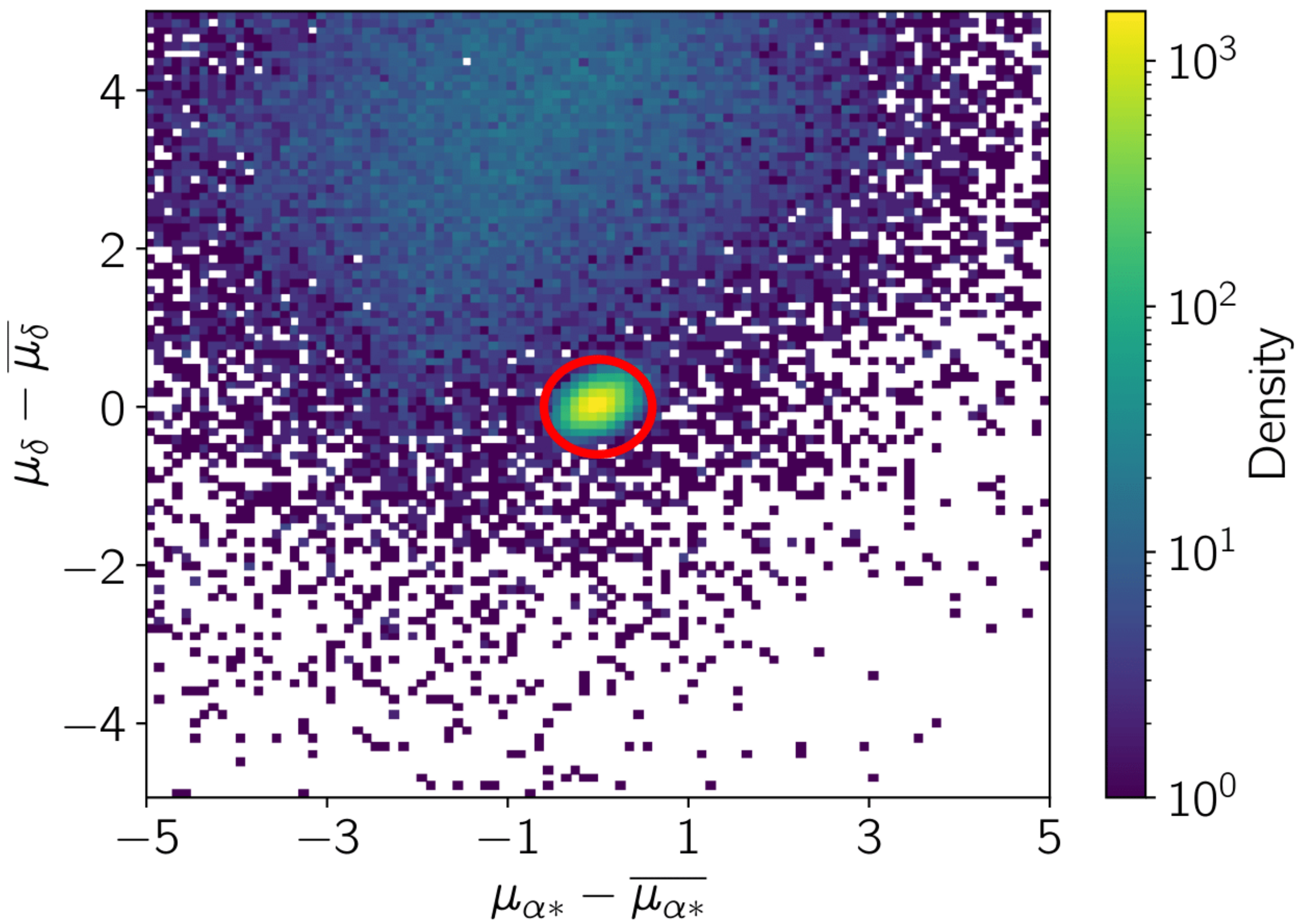
Astrometry: *Gaia* EDR3

Spectroscopy: PIGS, APOGEE DR17, a training sample from the *Pristine* halo survey (SEGUE + APOGEE)

Sgr-PIGS sample:

Cross-match of PIGS data with *Gaia* EDR3 (proper motions, parallaxes)

➡ Isolation of Sgr members



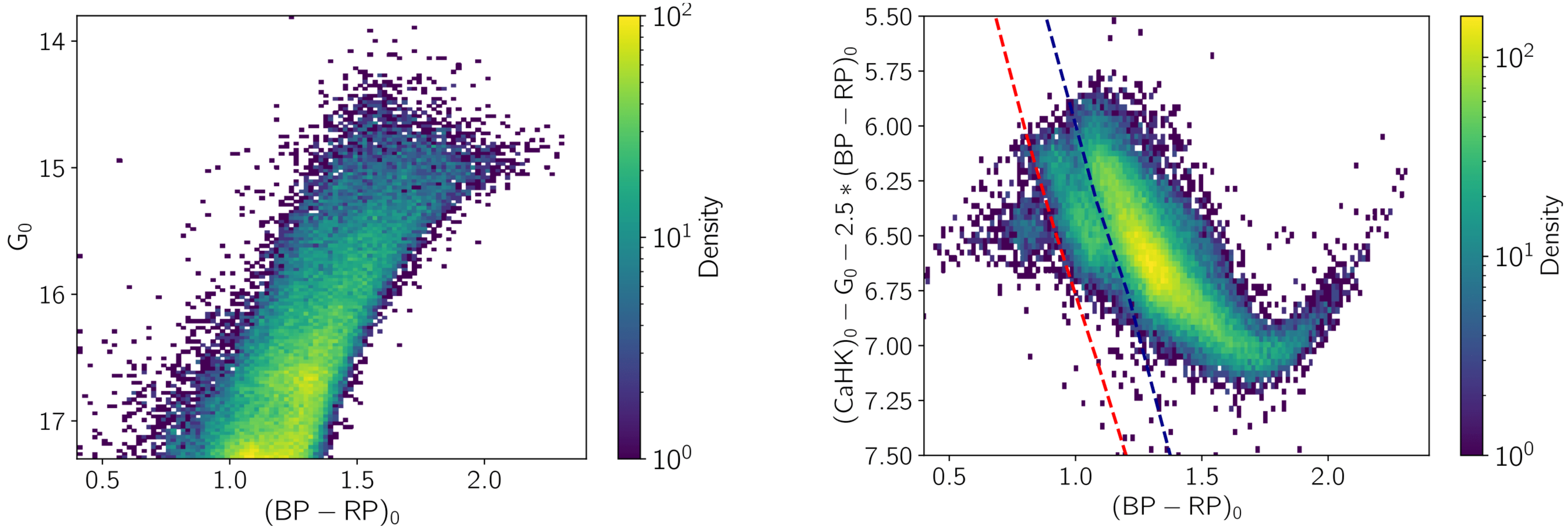
Member selection:

Astrometry: parallax & proper motions

Magnitude: *G<17.3*

Photometry: quality & variability

44785 members



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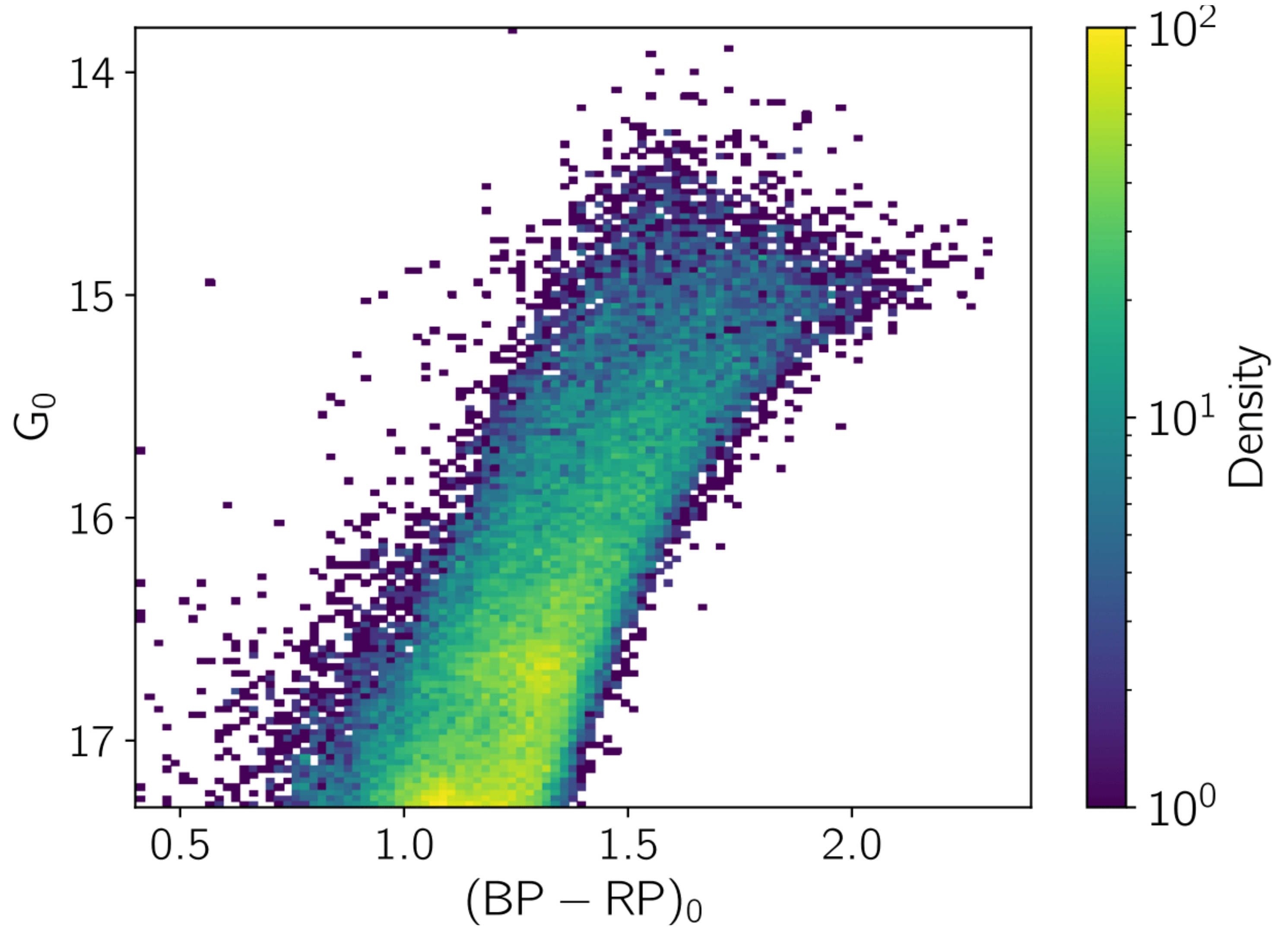
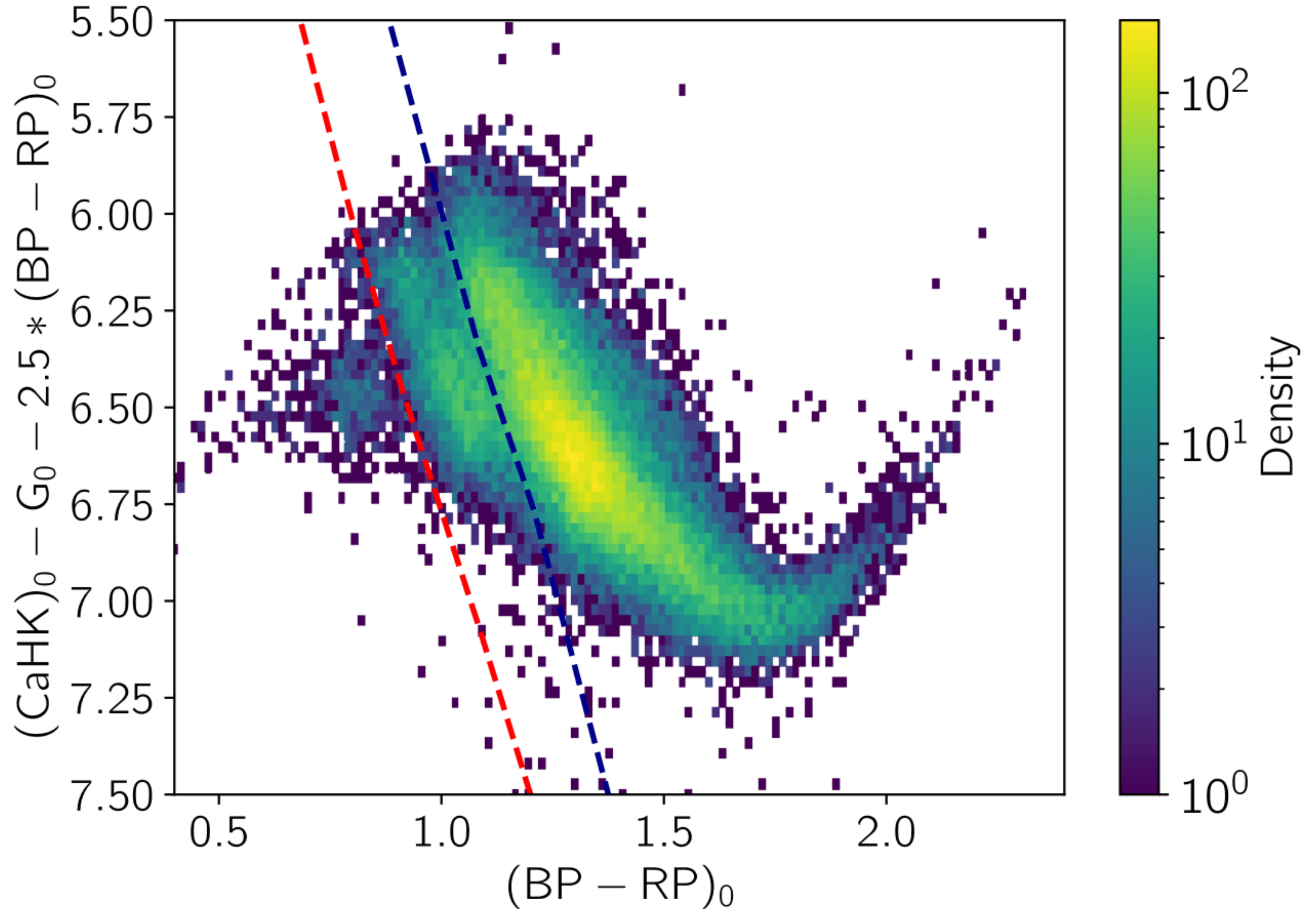
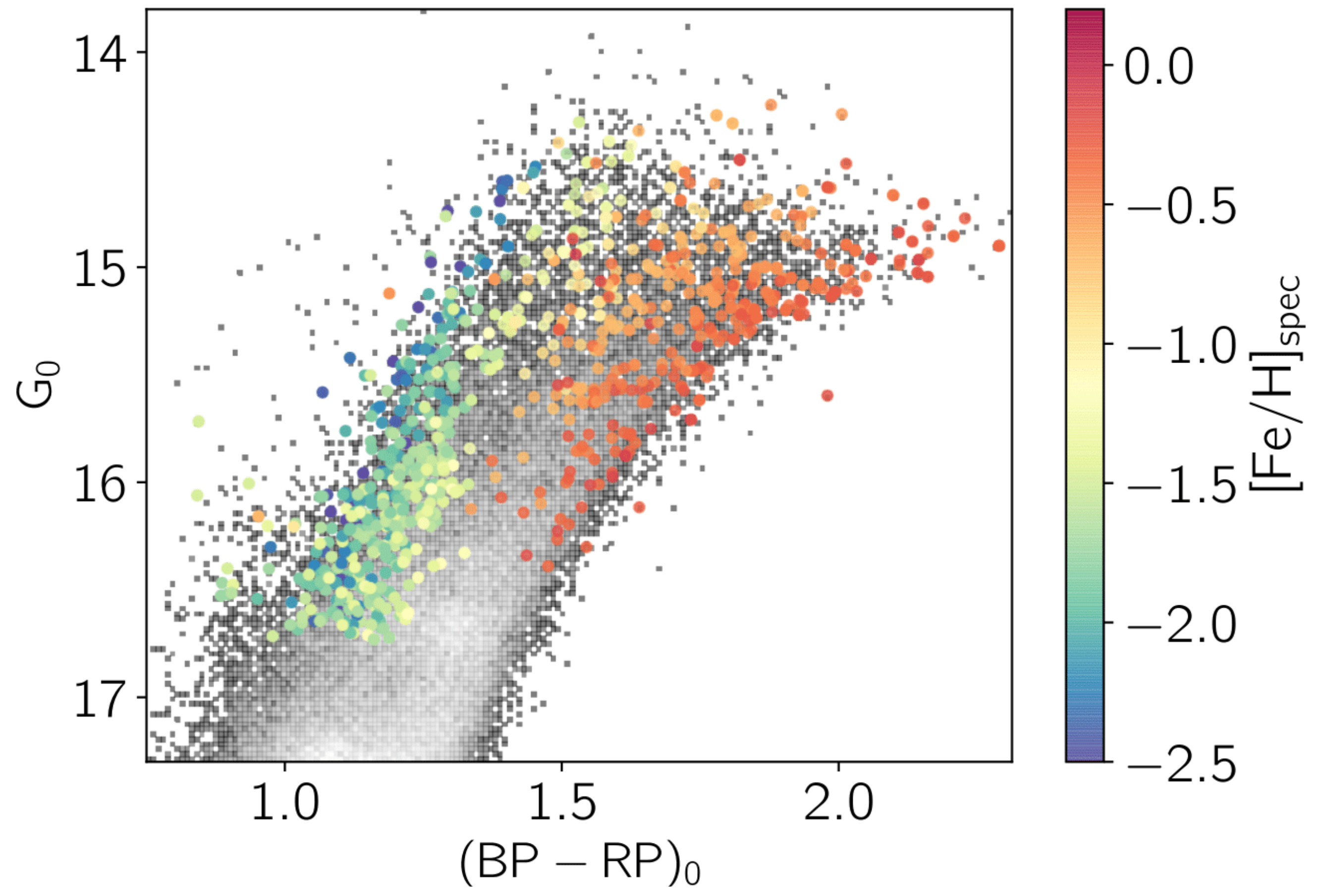
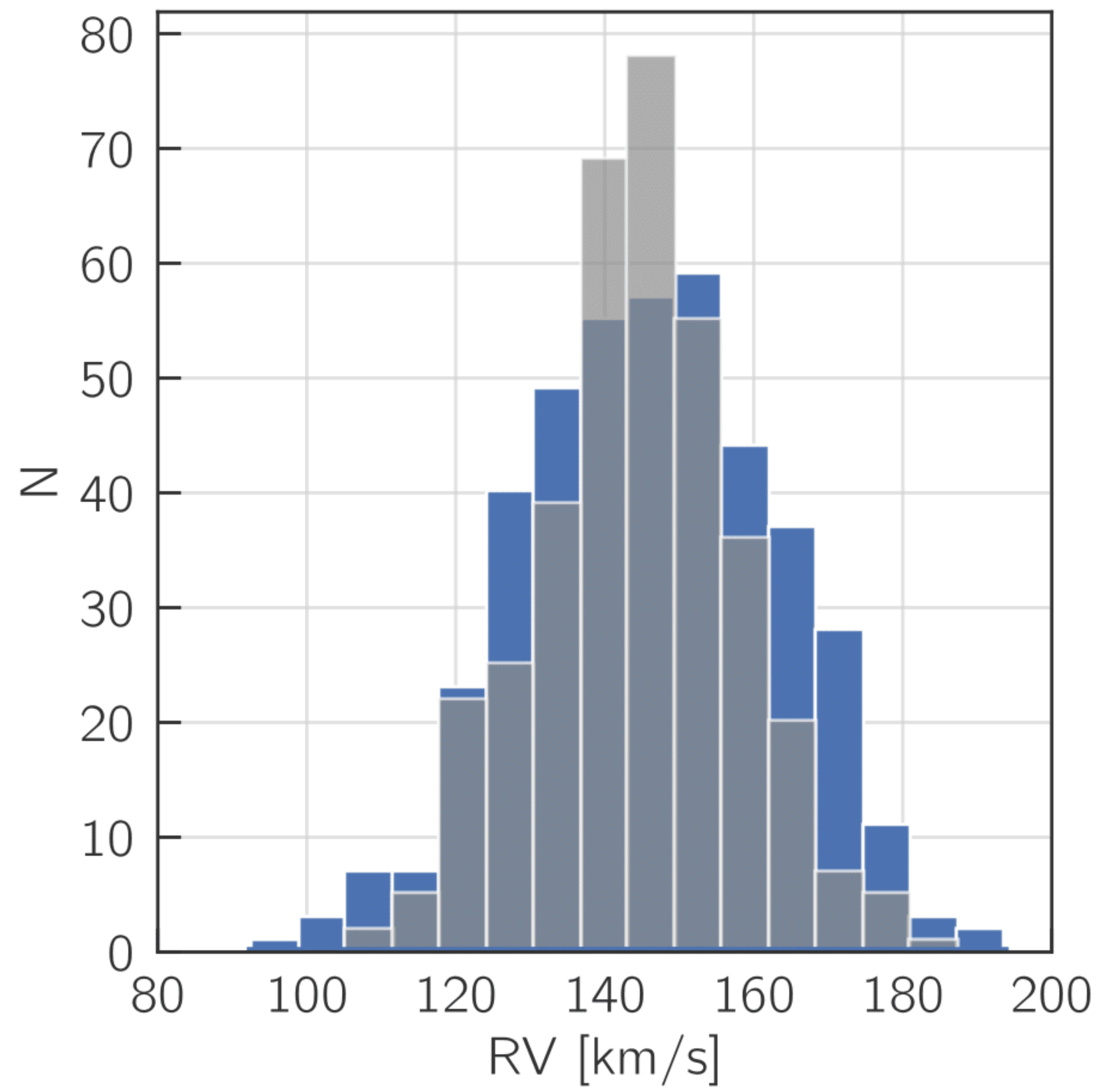
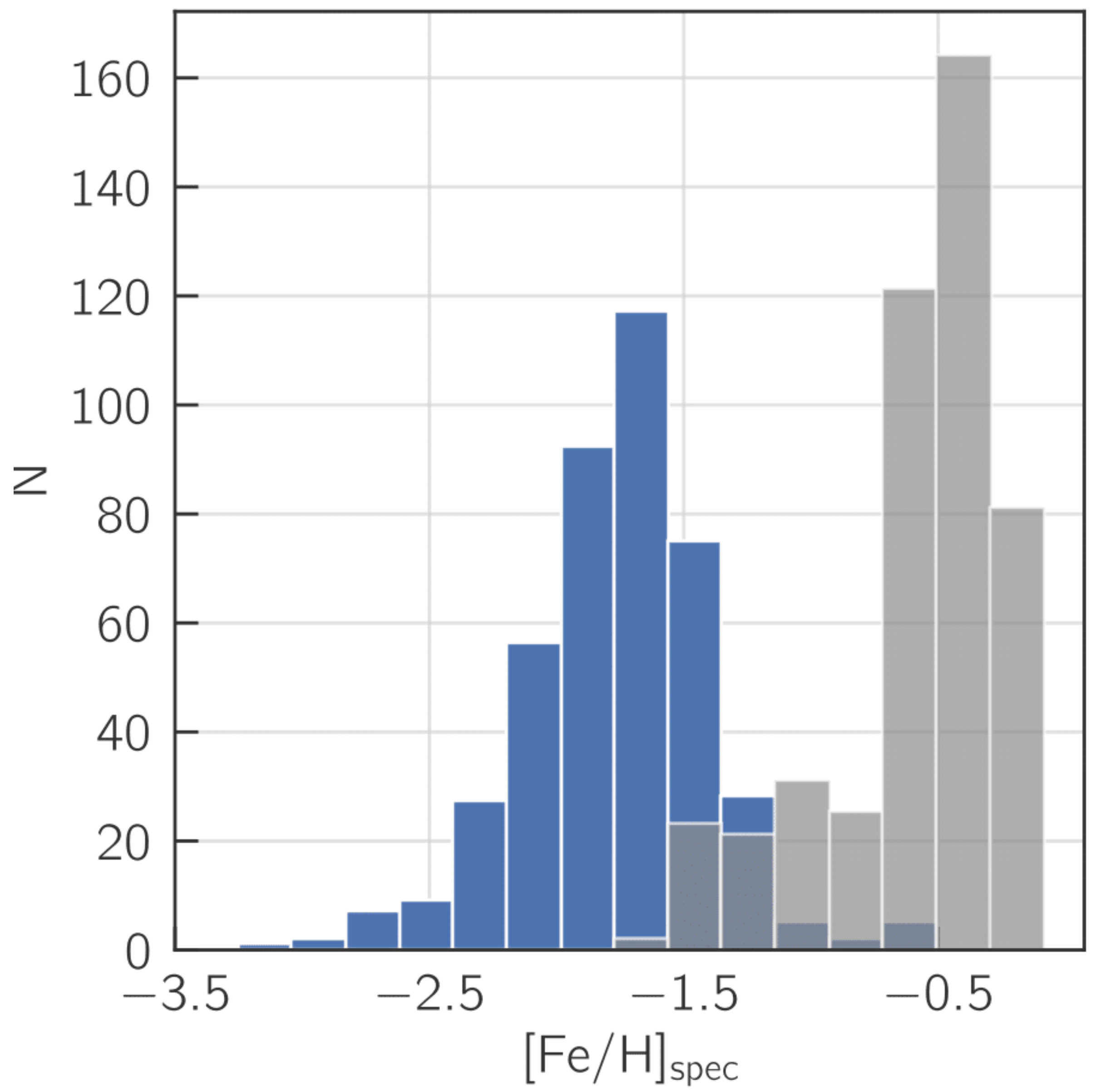




426 PIGS-spec candidates
568 APOGEE candidates







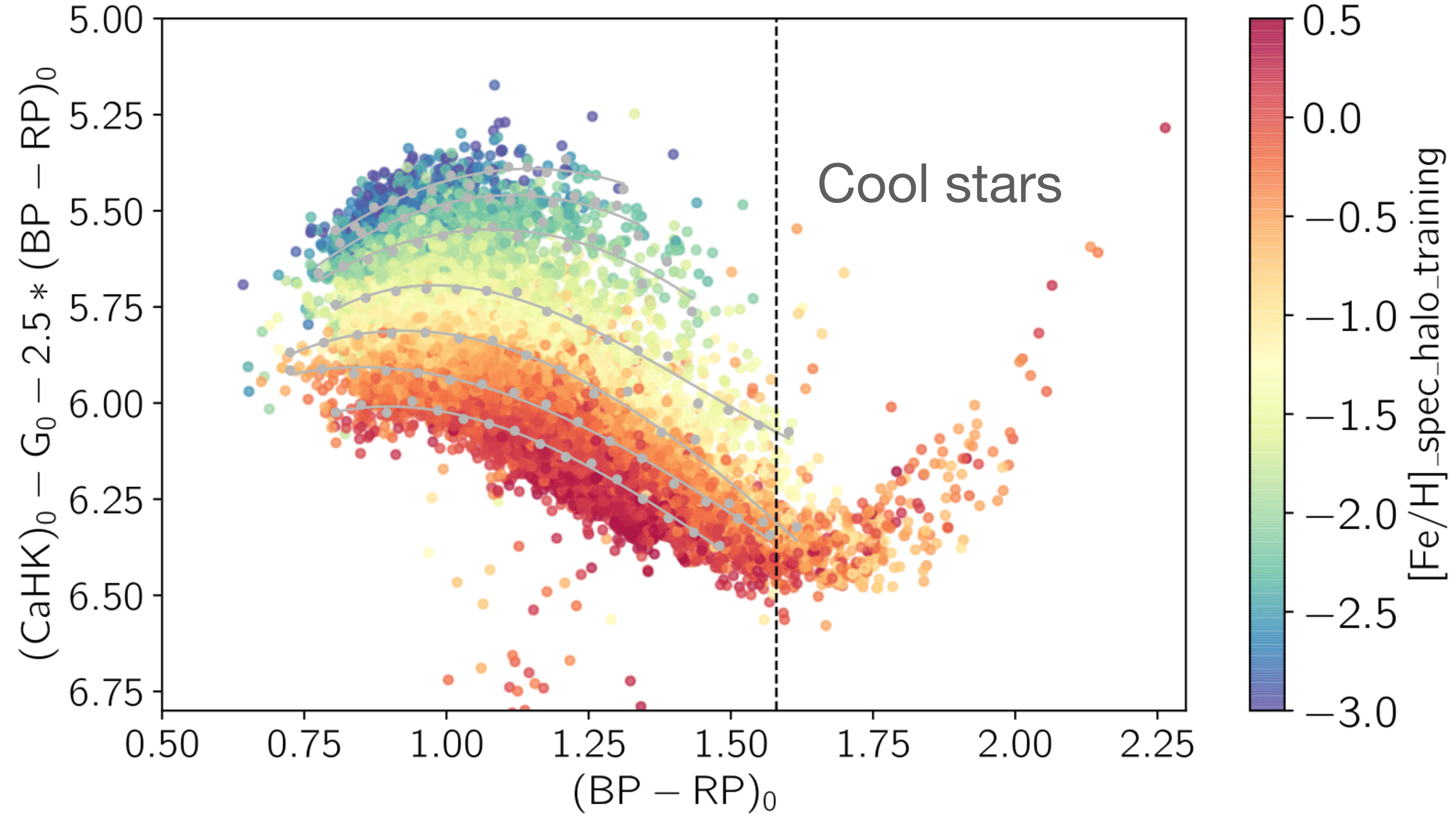
Metallicity analysis:

Calibration: Halo training sample -> +Lamost+APOGEE -> 2300 giants with -4.0 < [Fe/H] < +0.5

2nd 3rd order polynomials for *BP* and *RP* bins **metallicity separation**

Problem for **cooler** stars-> dependence on α abundances

different CaHK scale
-> **shift along y-axis**



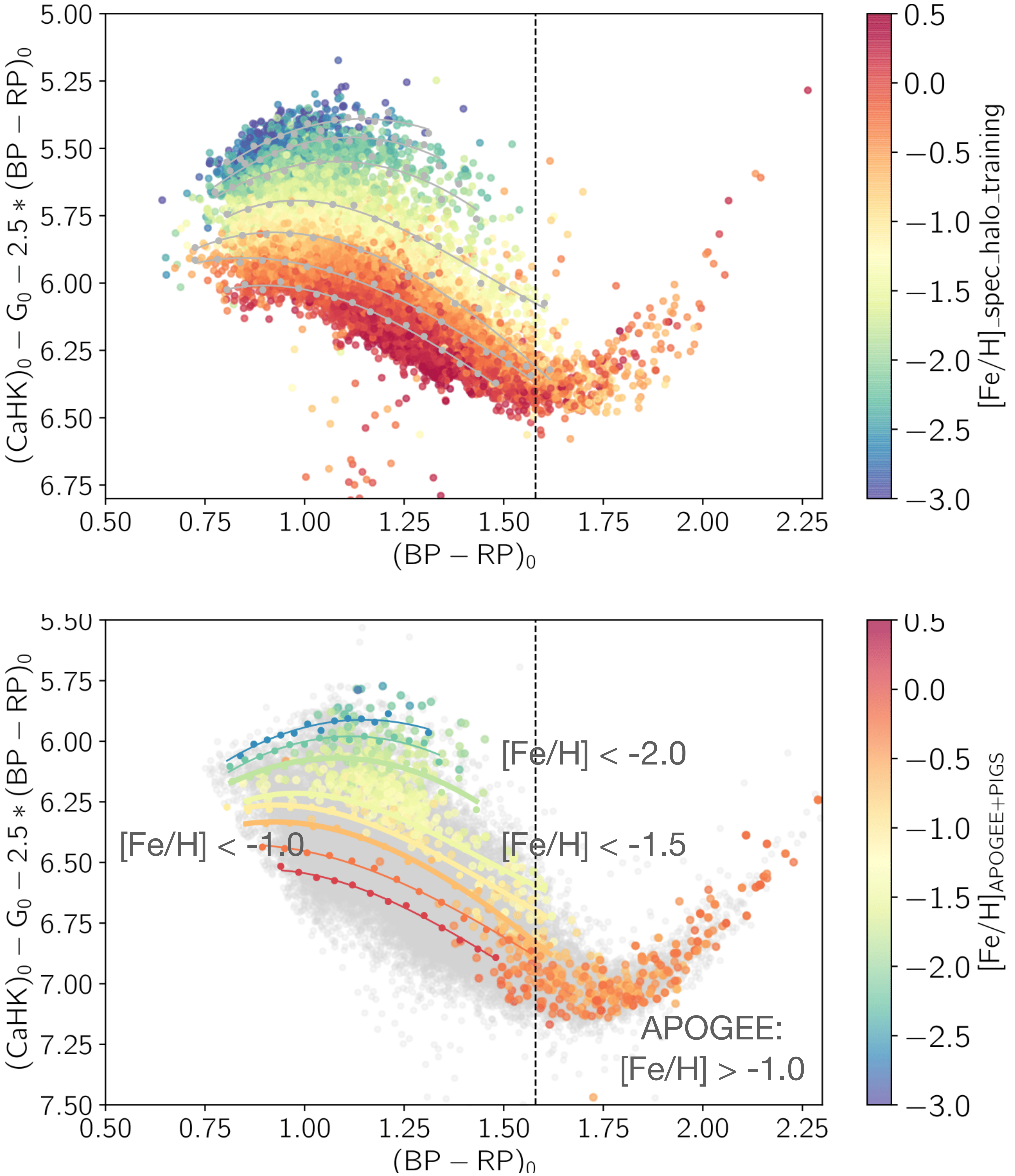
Metallicity separation:

Thanks to spectroscopic [Fe/H]

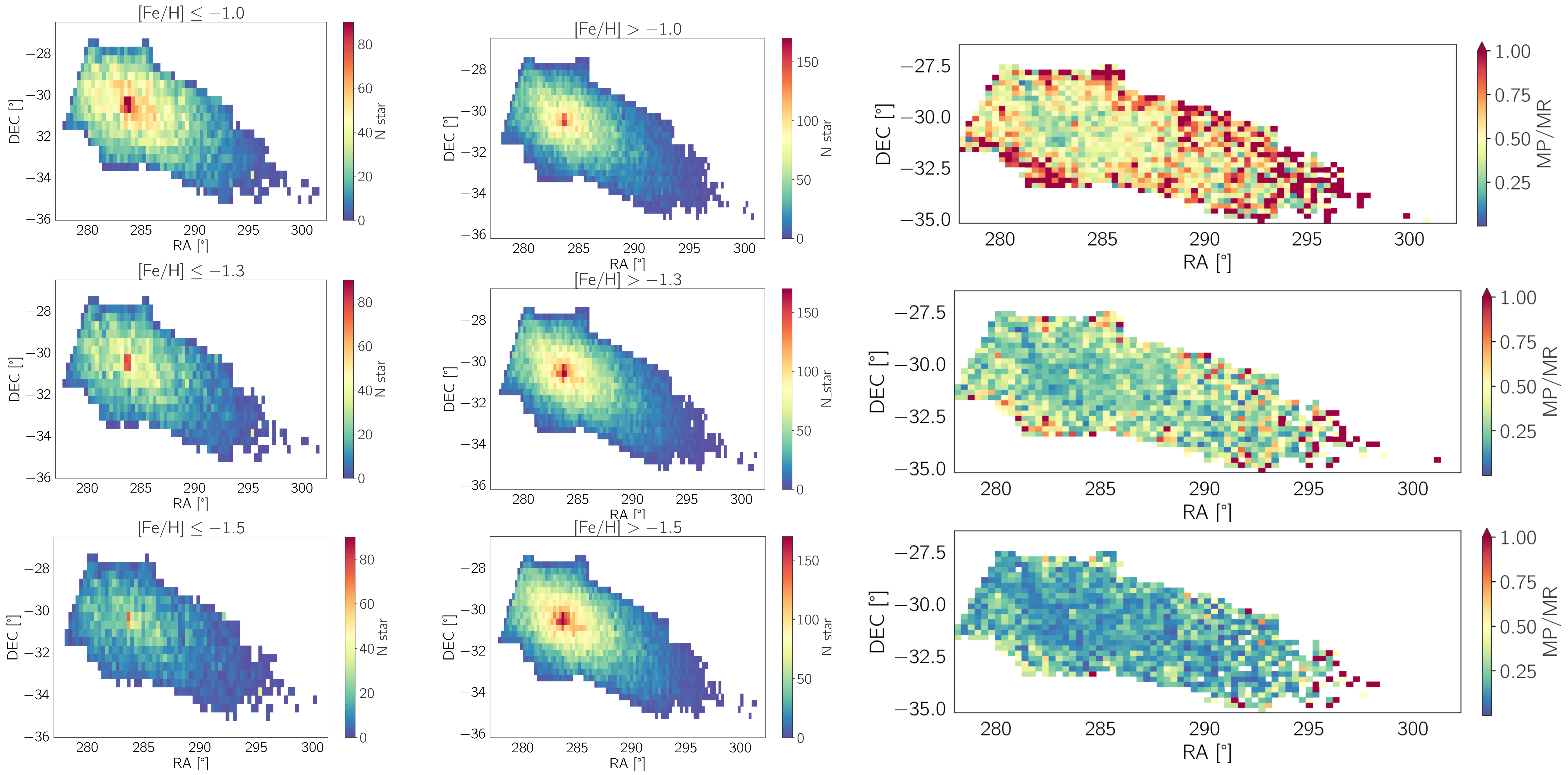
+0.52

Different **metallicity groups** 0.5 dex

Uncertainties on CaHK< 0.08

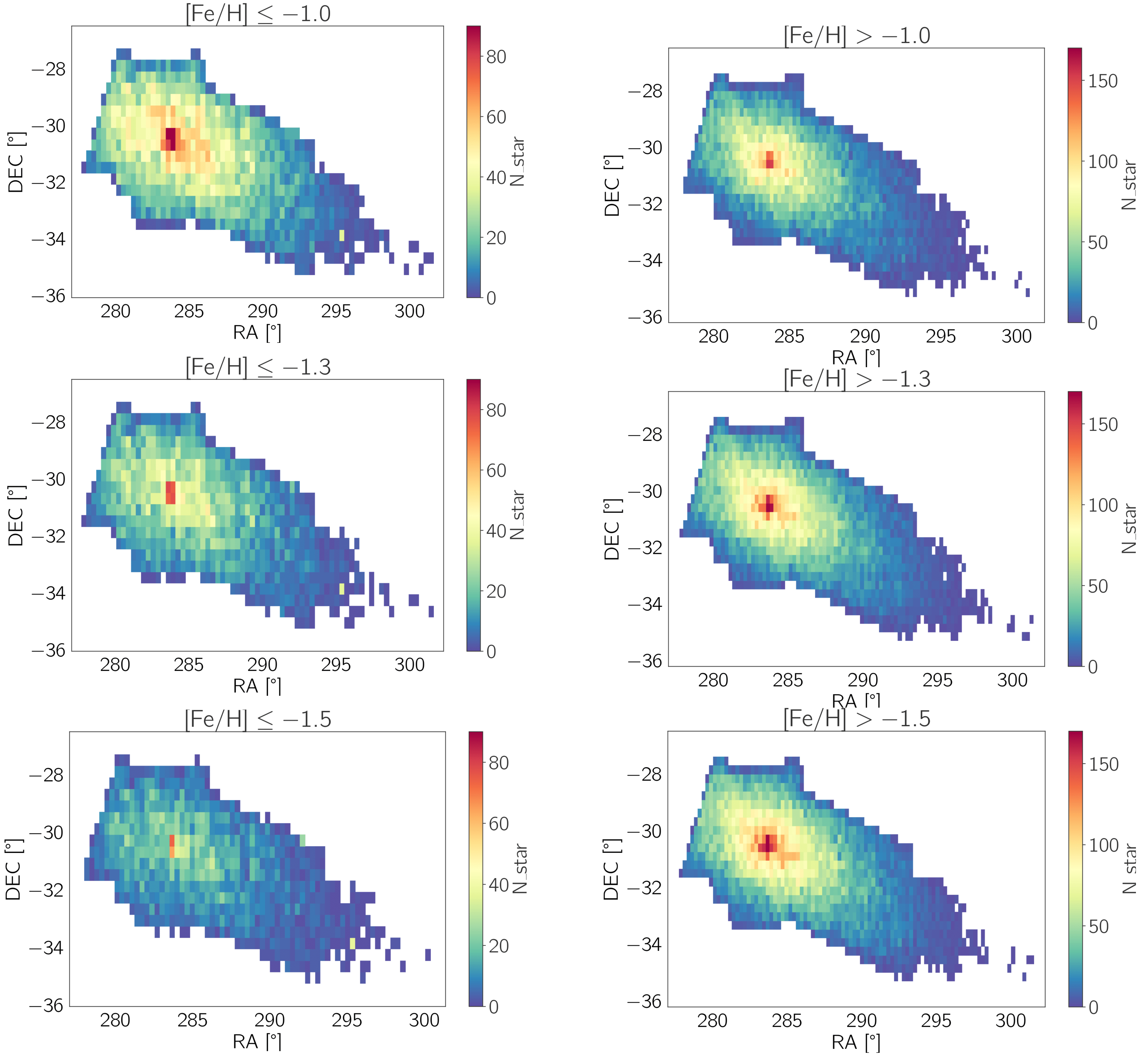


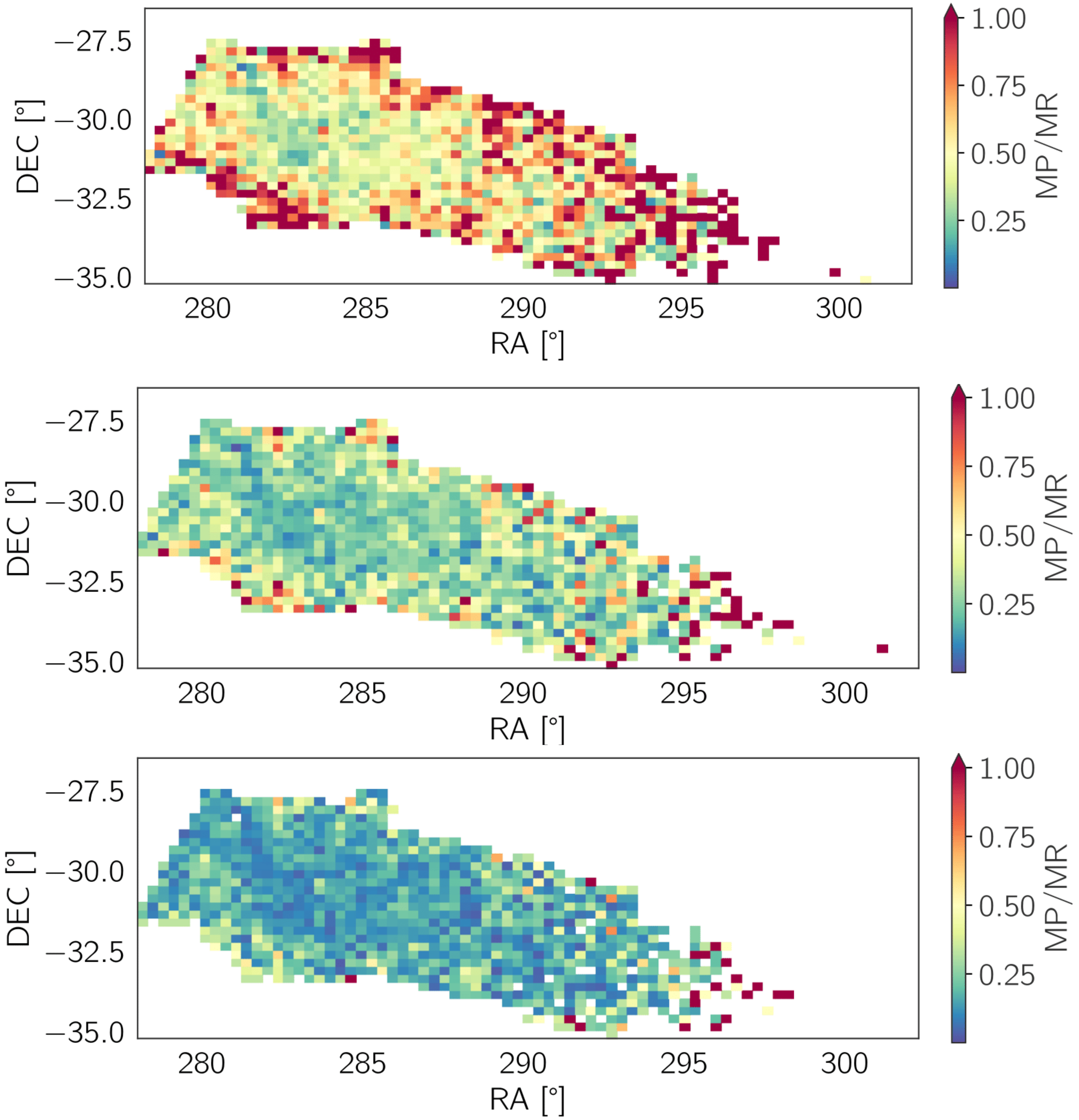
Spatial distributions: Density maps in binned RA and DEC



Spatial distributions: **Density maps** in binned RA and DEC

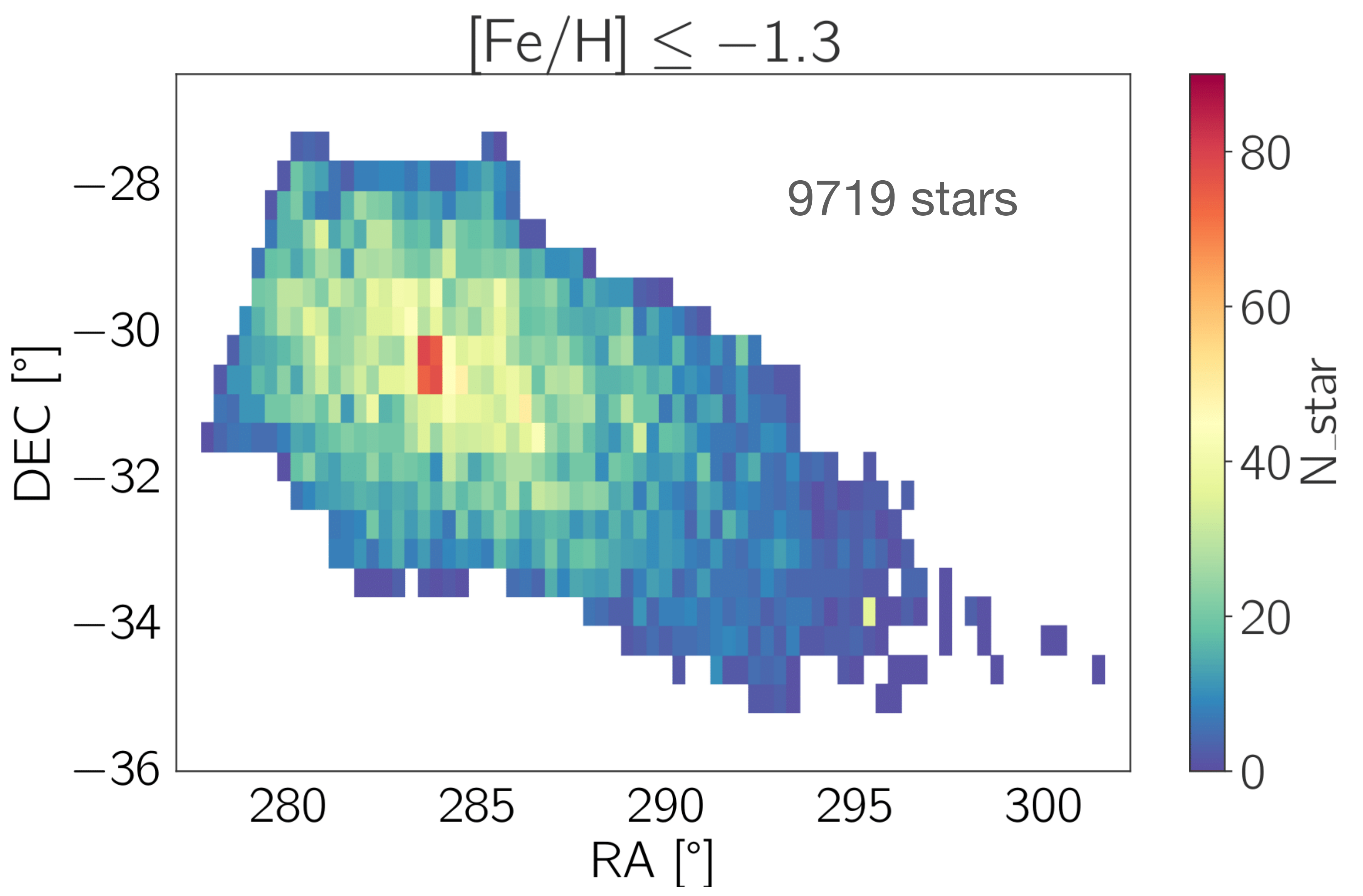
Relative number of **MP stars higher** at the **edges**



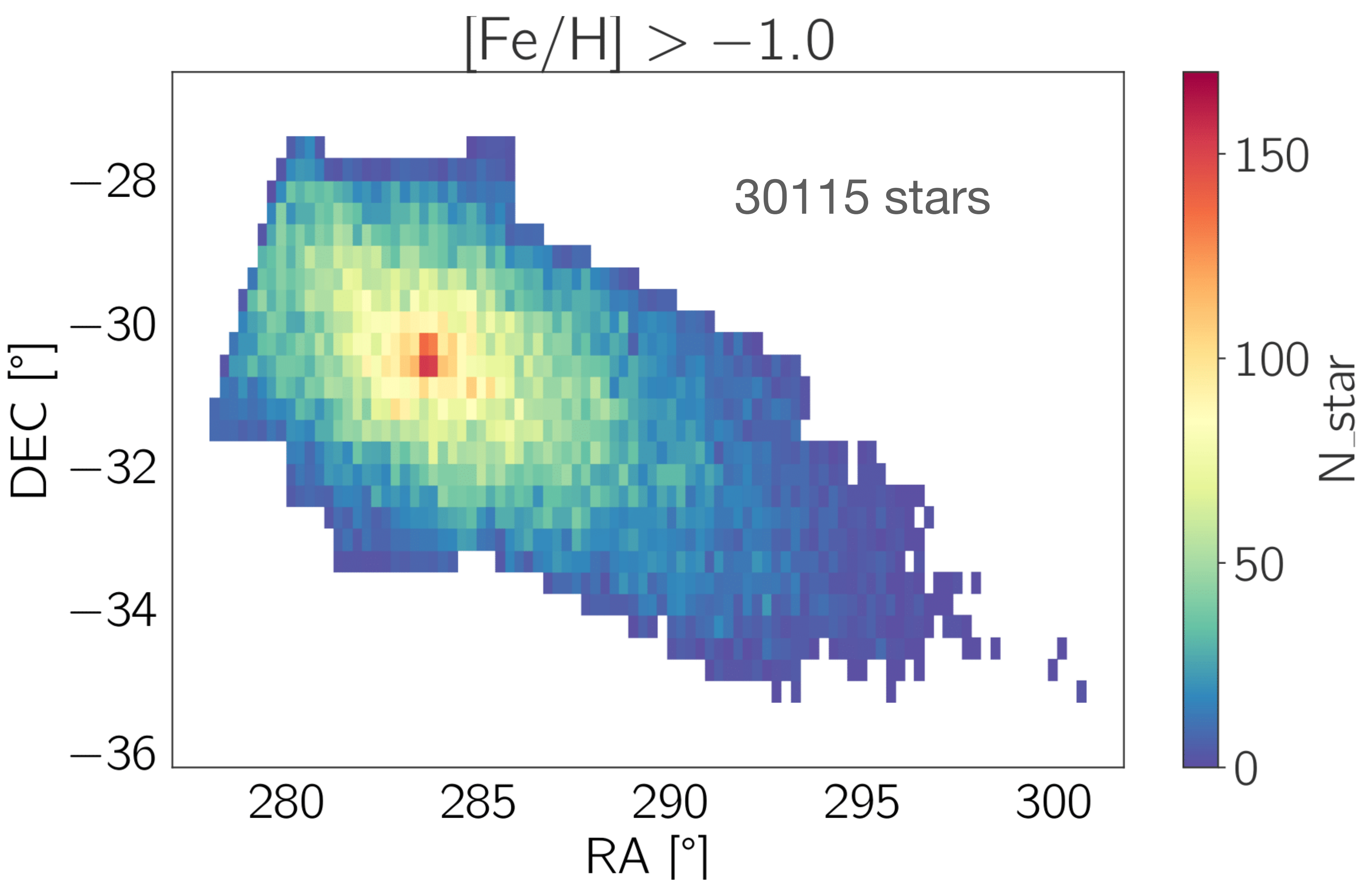


Metal-poor vs metal-rich:

metal-poor (MP): **[Fe/H] < -1.3**
metal-rich (MR): **[Fe/H] > -1.0**



Metallicity Gap



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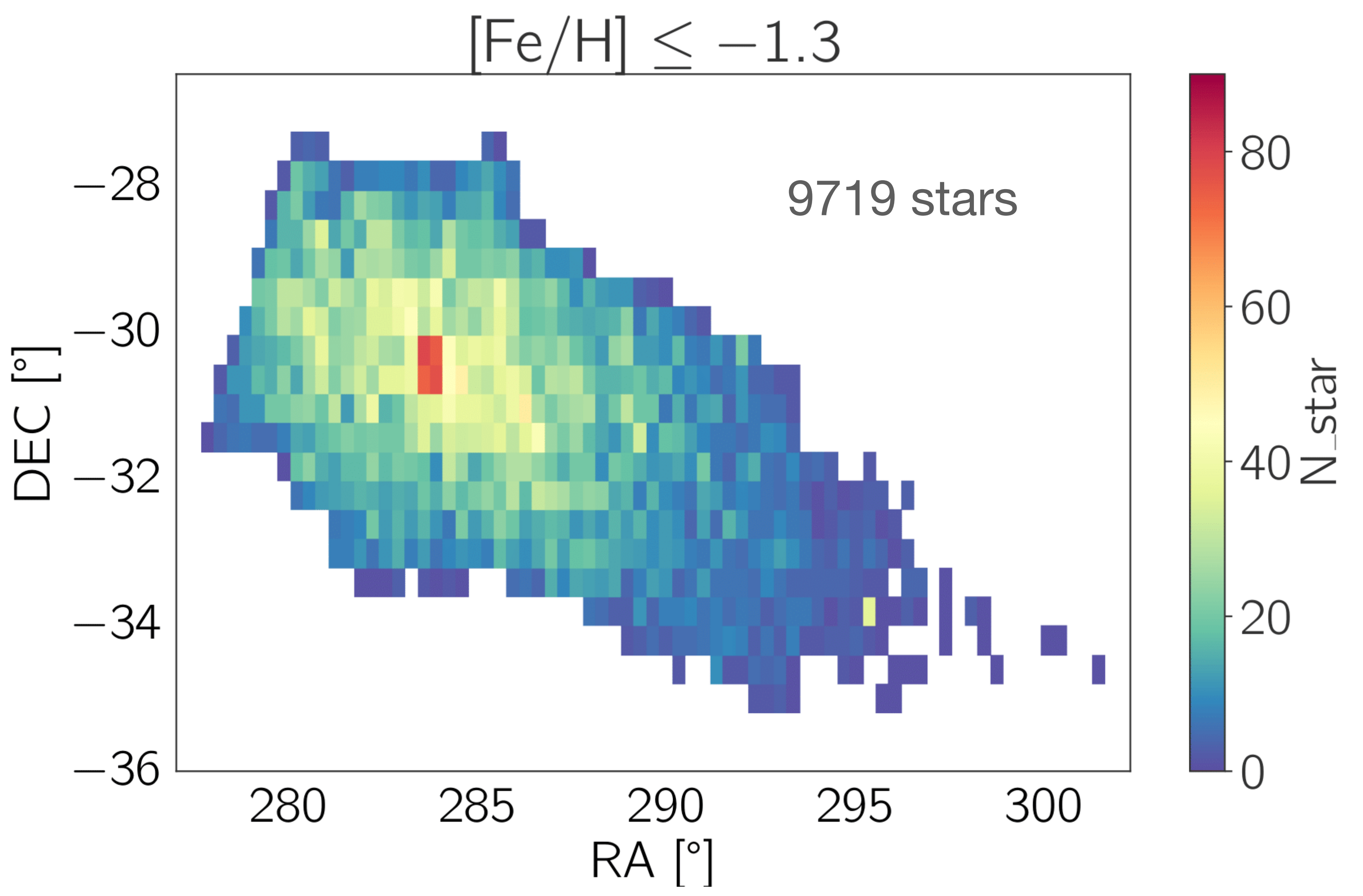

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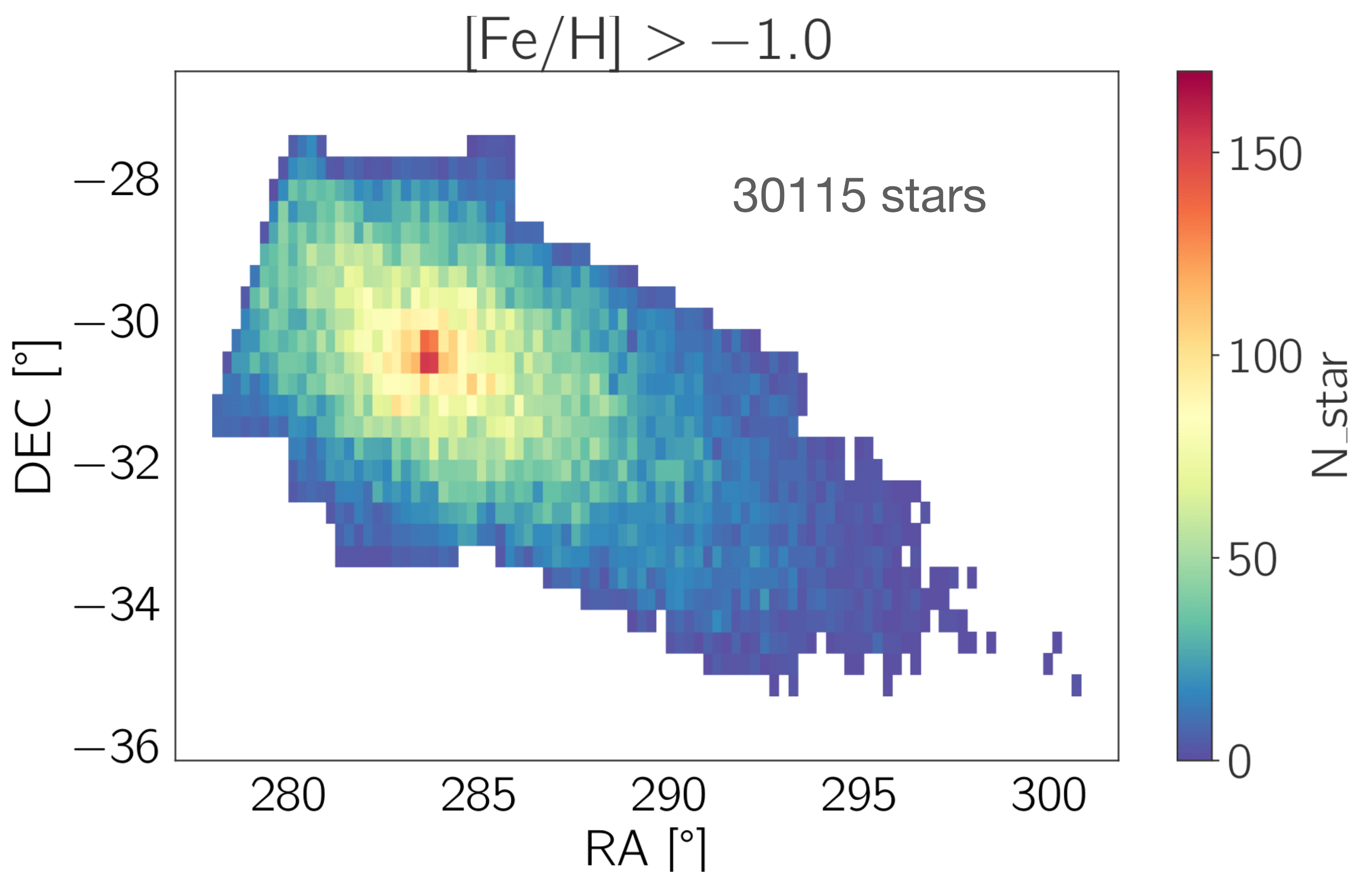

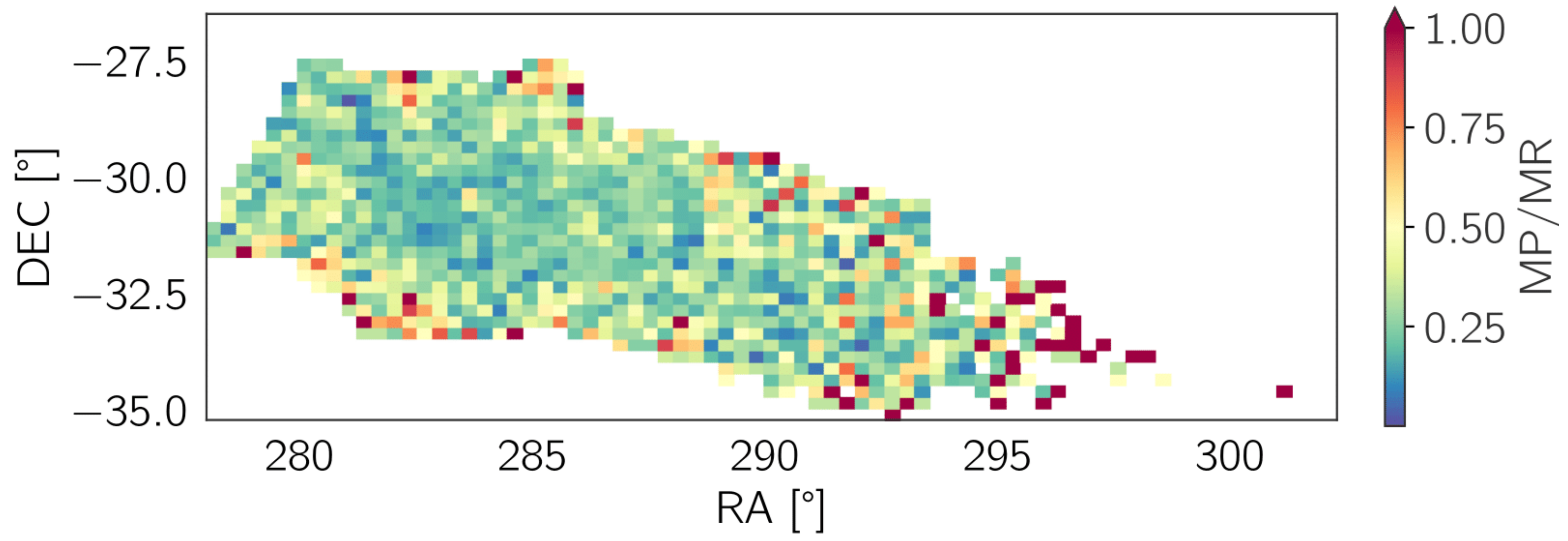

[Fe/H] ~ -1.3: Sgr alpha-knee

Models:

MCMC: Fitting of the stellar distribution of the different SPs

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$$N_i = A_0 exp(\frac{r_i}{r_e})$$

$$r_i = \frac{1}{1-e}(x_i \cos\theta - y_i \sin\theta)^2 + (x_i \sin\theta + y_i \cos\theta)^2)$$

Martin et al., 2018

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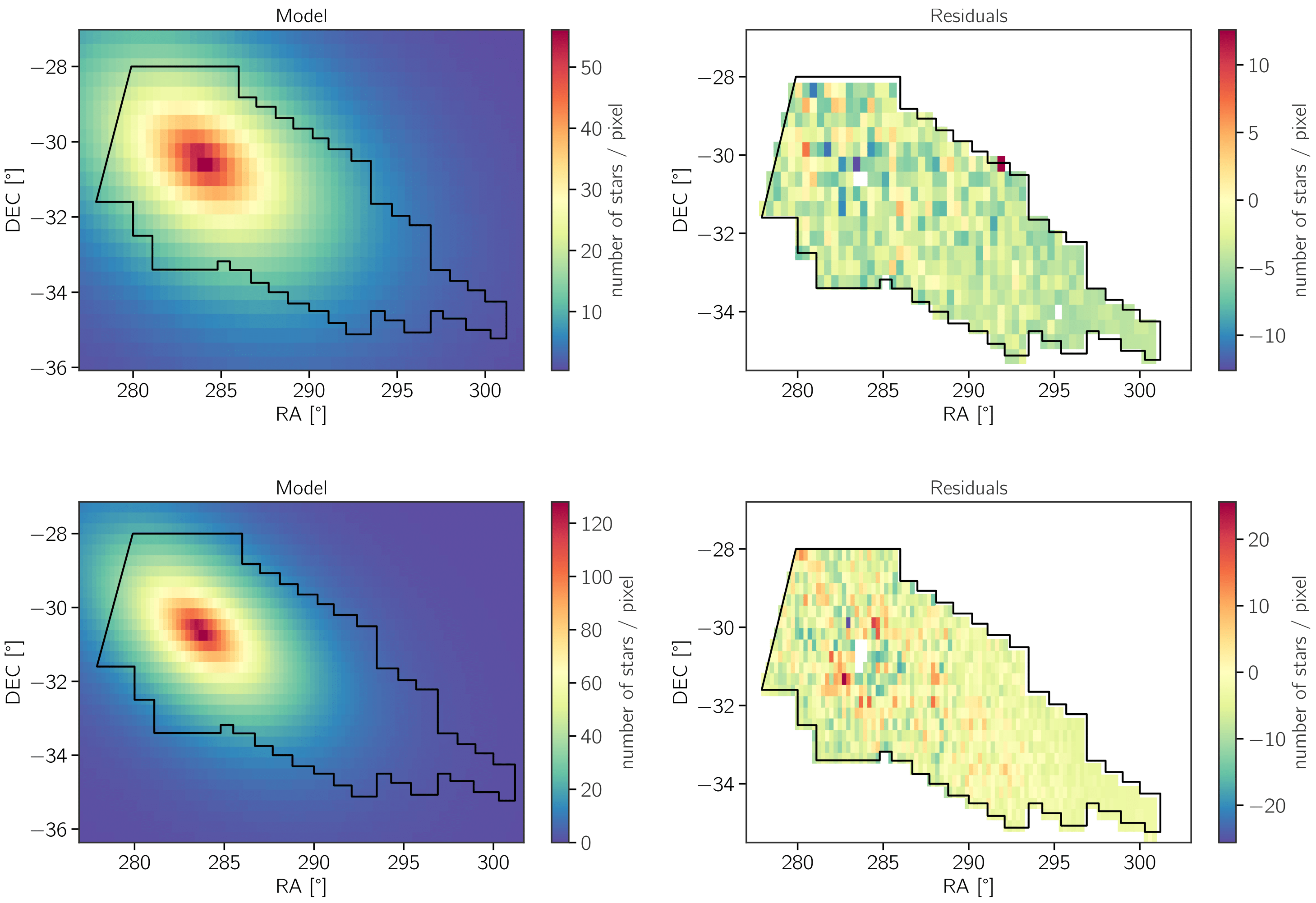

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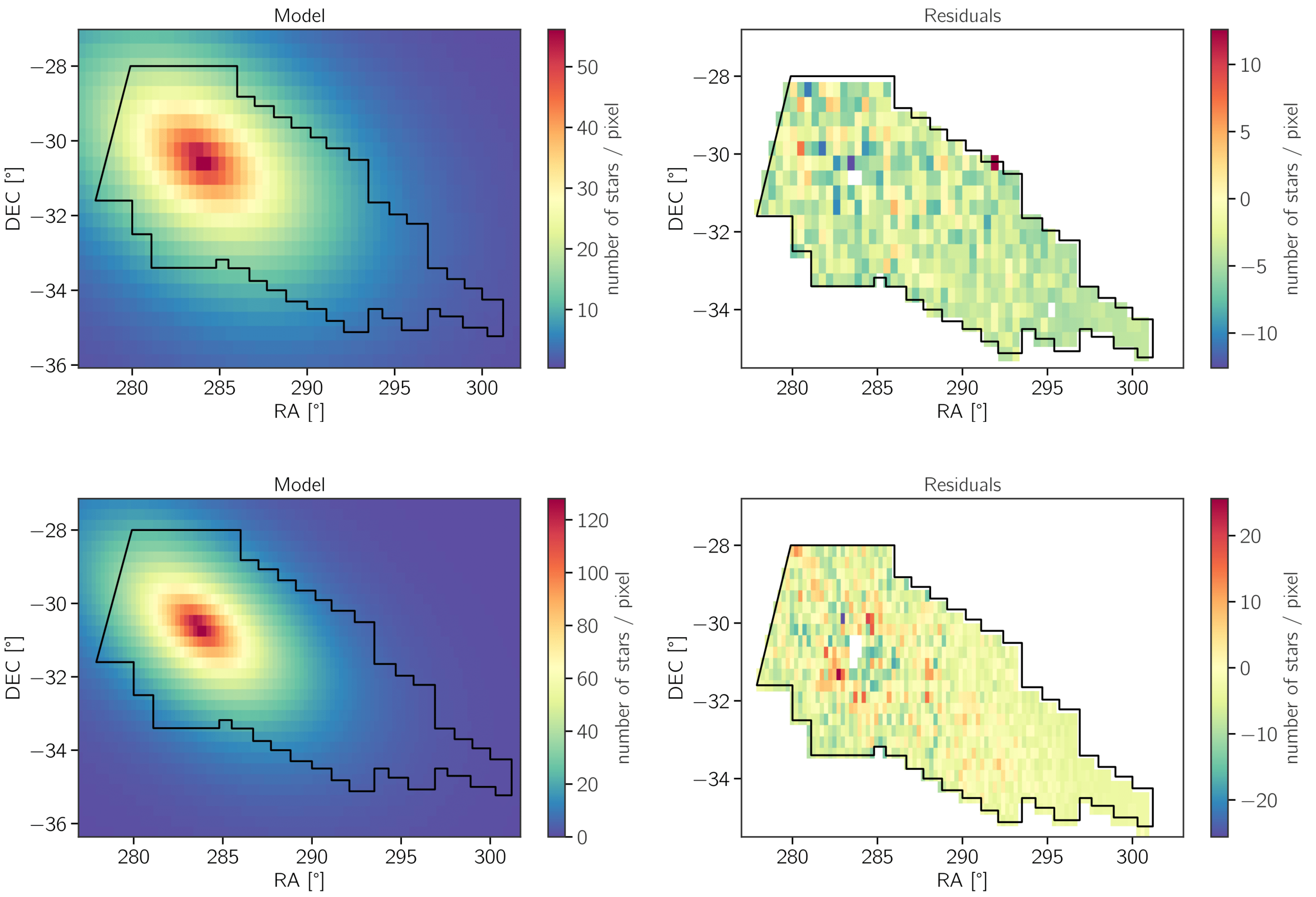
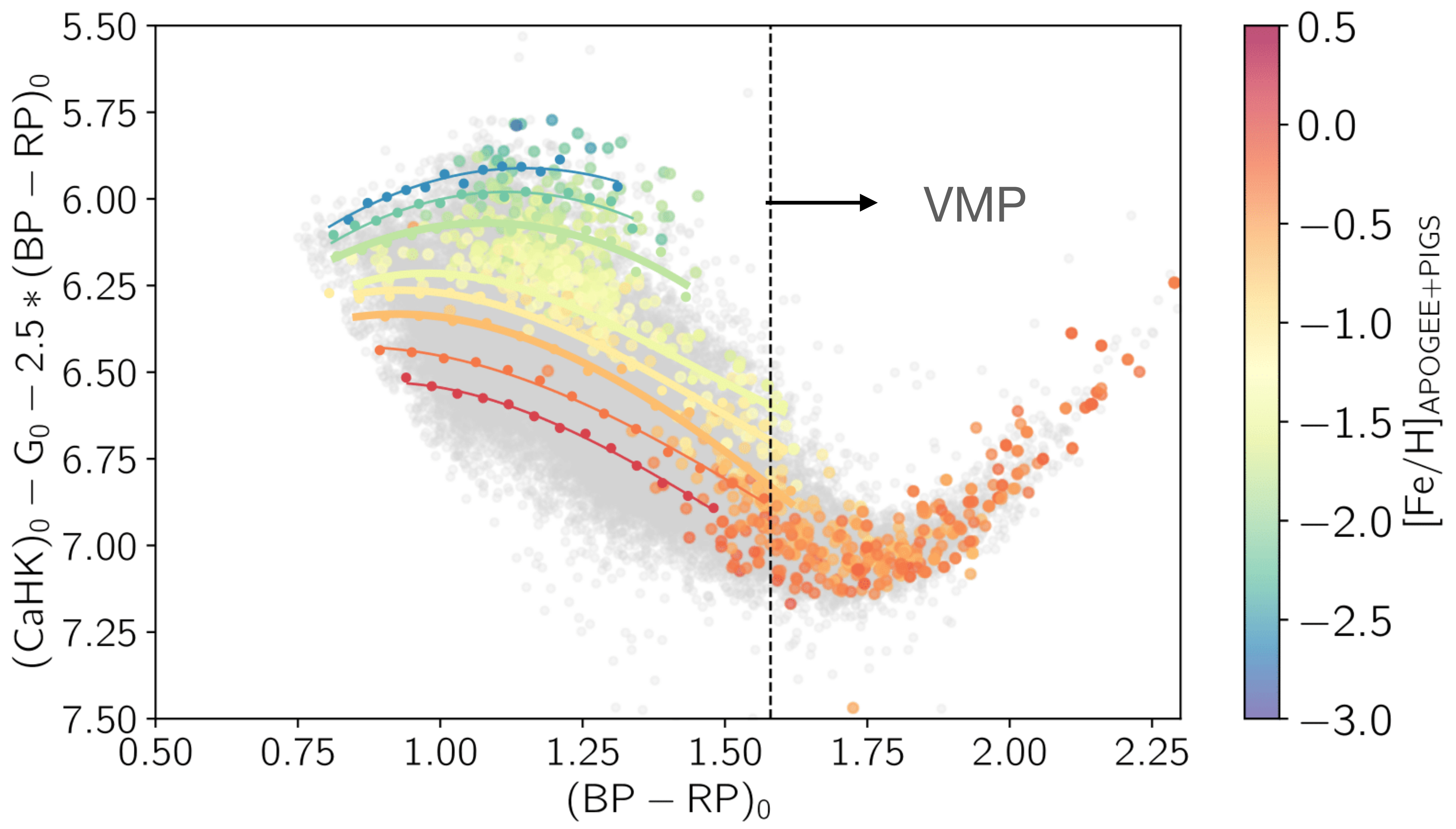
Metal-poor ([Fe/H] < −1.3)		
α_0(J2000)	δ_0 (J2000)	A_0
$284.083^{+0.014}_{-0.014}$	$-30.475^{+0.006}_{-0.006}$	$60.375^{+0.250}_{-0.247}$
r_e (deg.)	e	θ (deg.)
$4.085^{+0.022}_{-0.021}$	$0.566^{+0.003}_{-0.003}$	$-103.971^{+0.208}_{-0.206}$
Metal-rich ([Fe/H] > −1.0)		
α_0(J2000)	δ_0 (J2000)	A_0
$283.830^{+0.004}_{-0.004}$	$-30.493^{+0.002}_{-0.002}$	$126.008^{+0.222}_{-0.225}$
r_e (deg.)	e	θ (deg.)
$2.987^{+0.006}_{-0.006}$	$0.592^{+0.001}_{-0.001}$	$-107.289^{+0.067}_{-0.068}$



Very metal-poor (VMP) stars

Photometric selection: **[Fe/H] <-2.0**

1150 candidates
115 stars in common with PIGS



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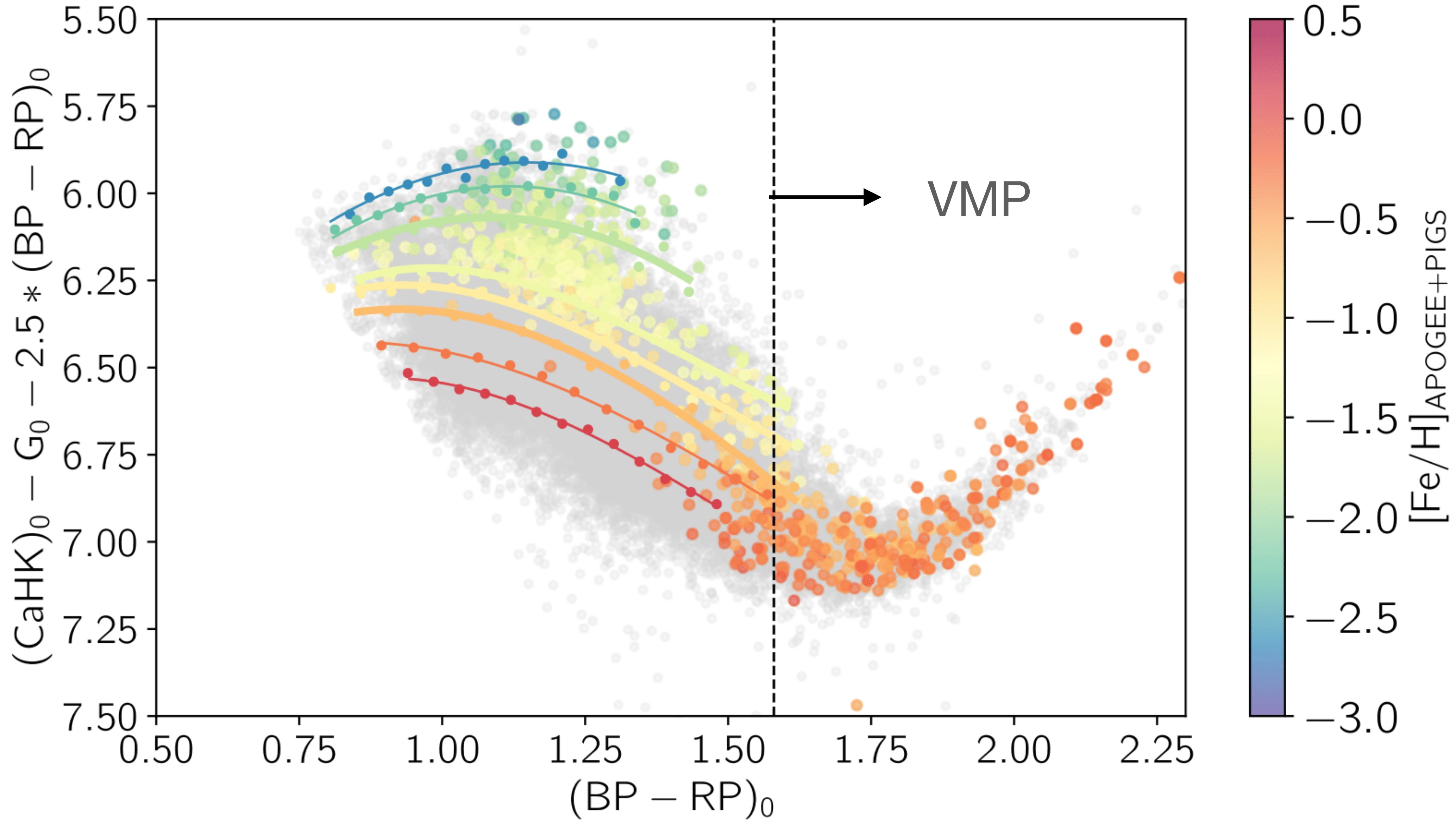

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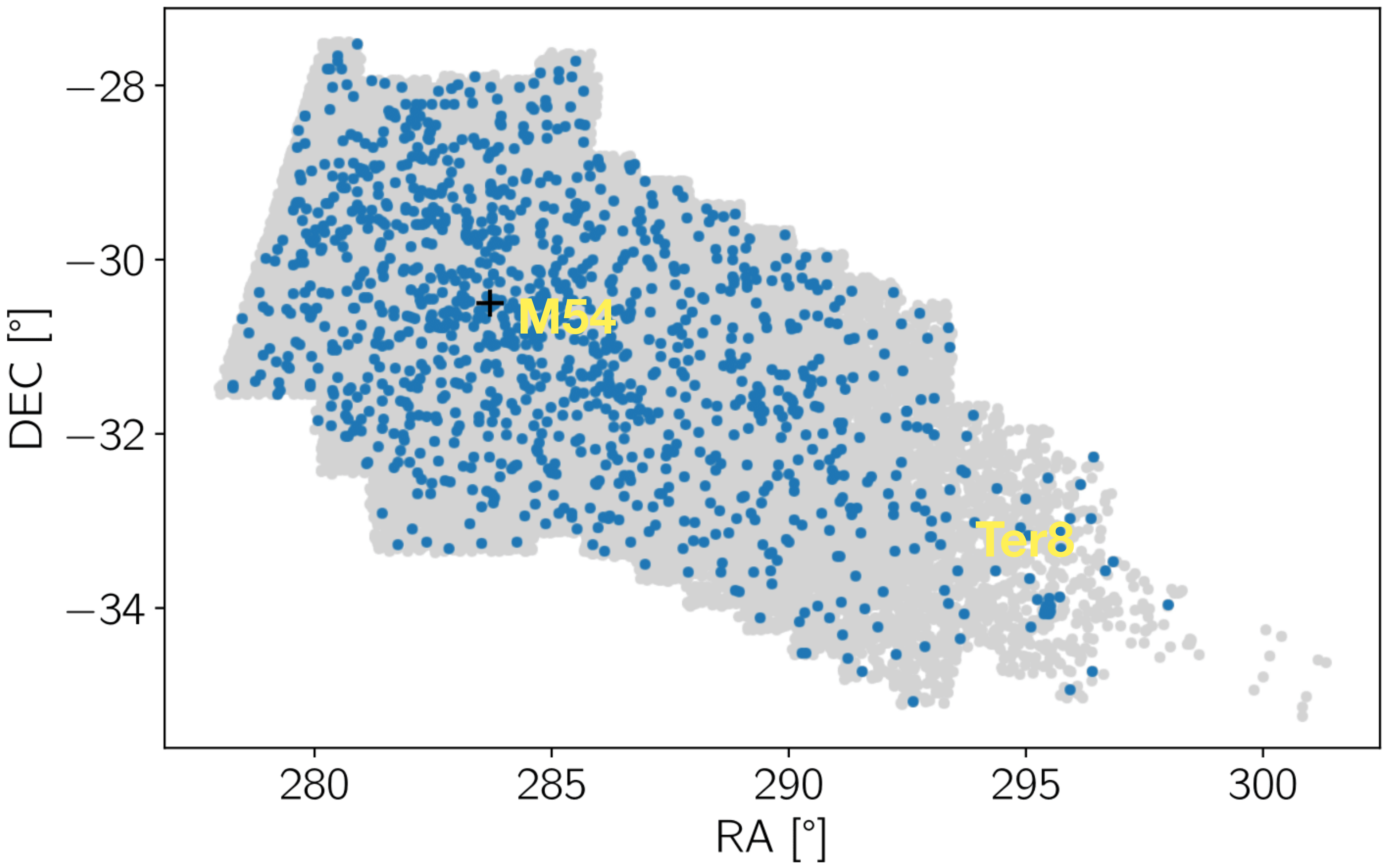

Mixed along the footprint

Left-over of ancient SP (≥10 Gyr)

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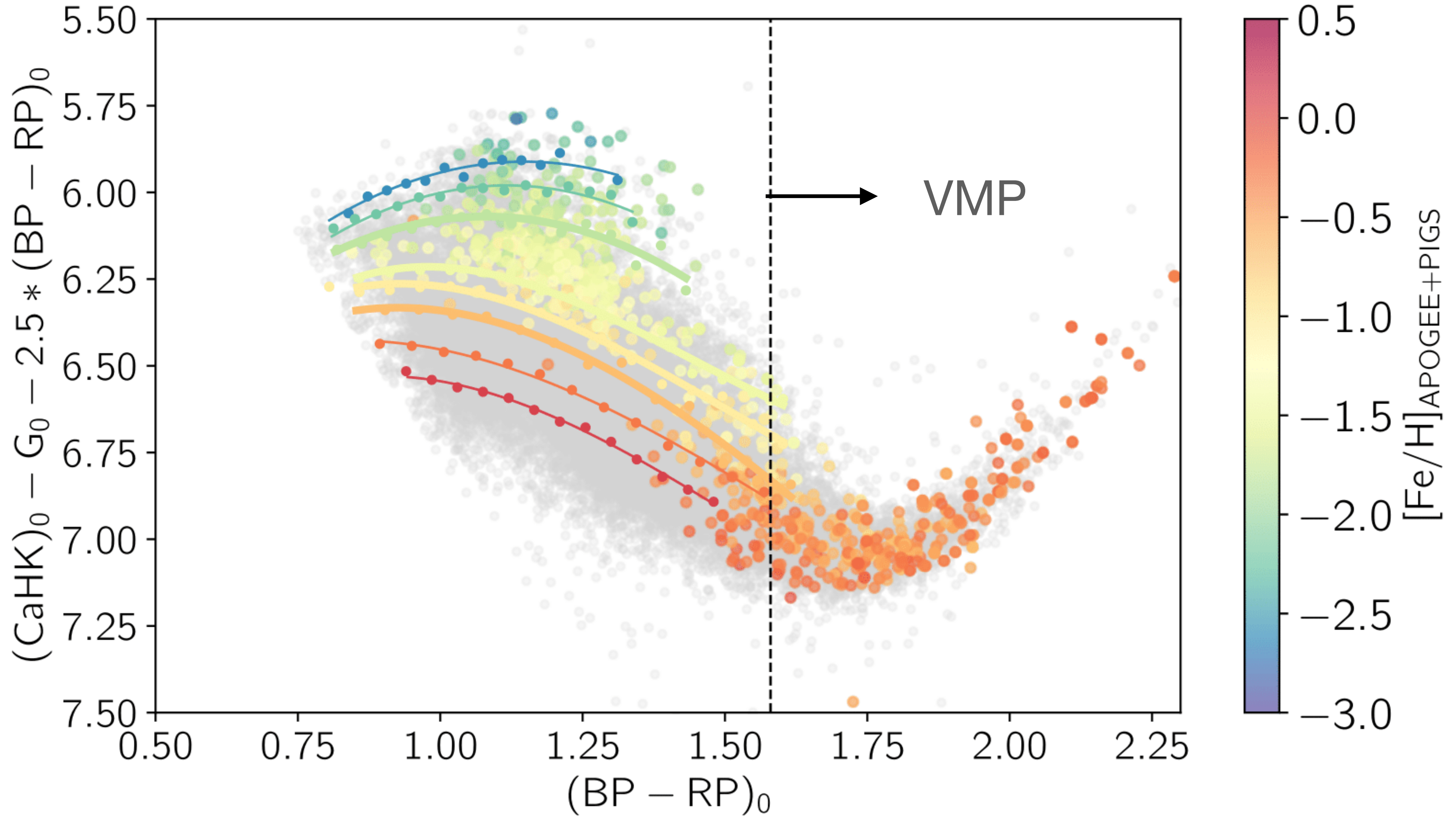

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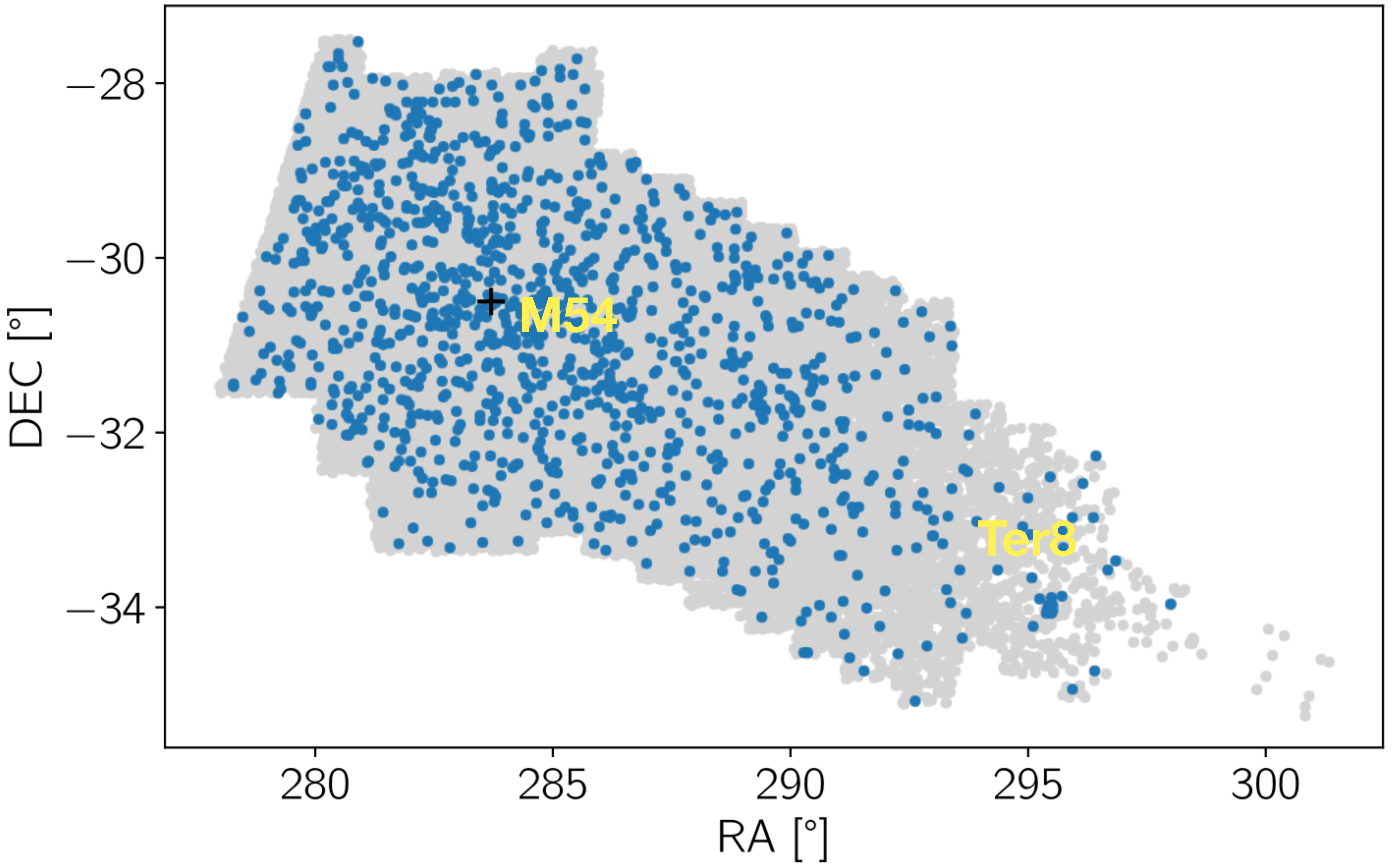

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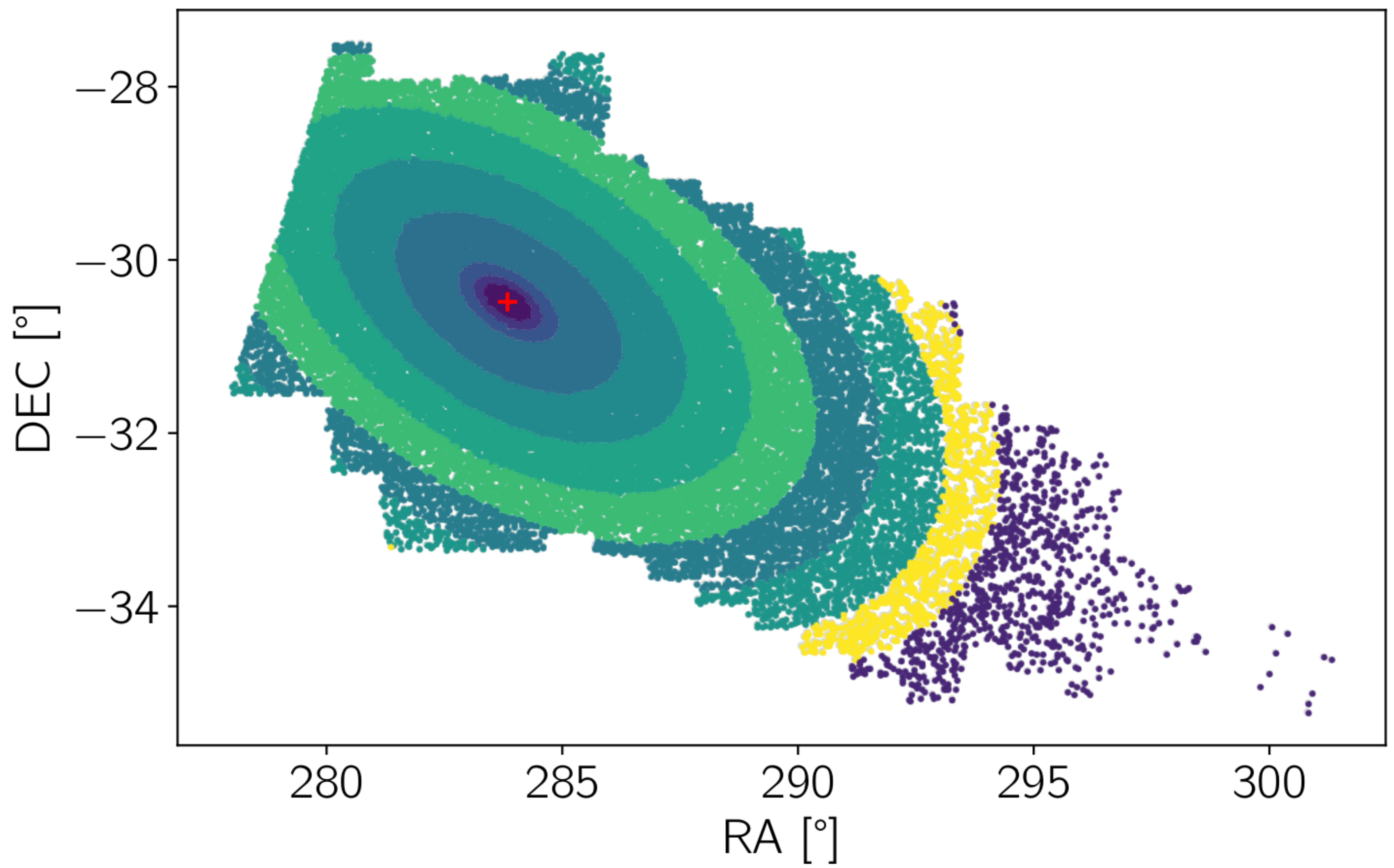
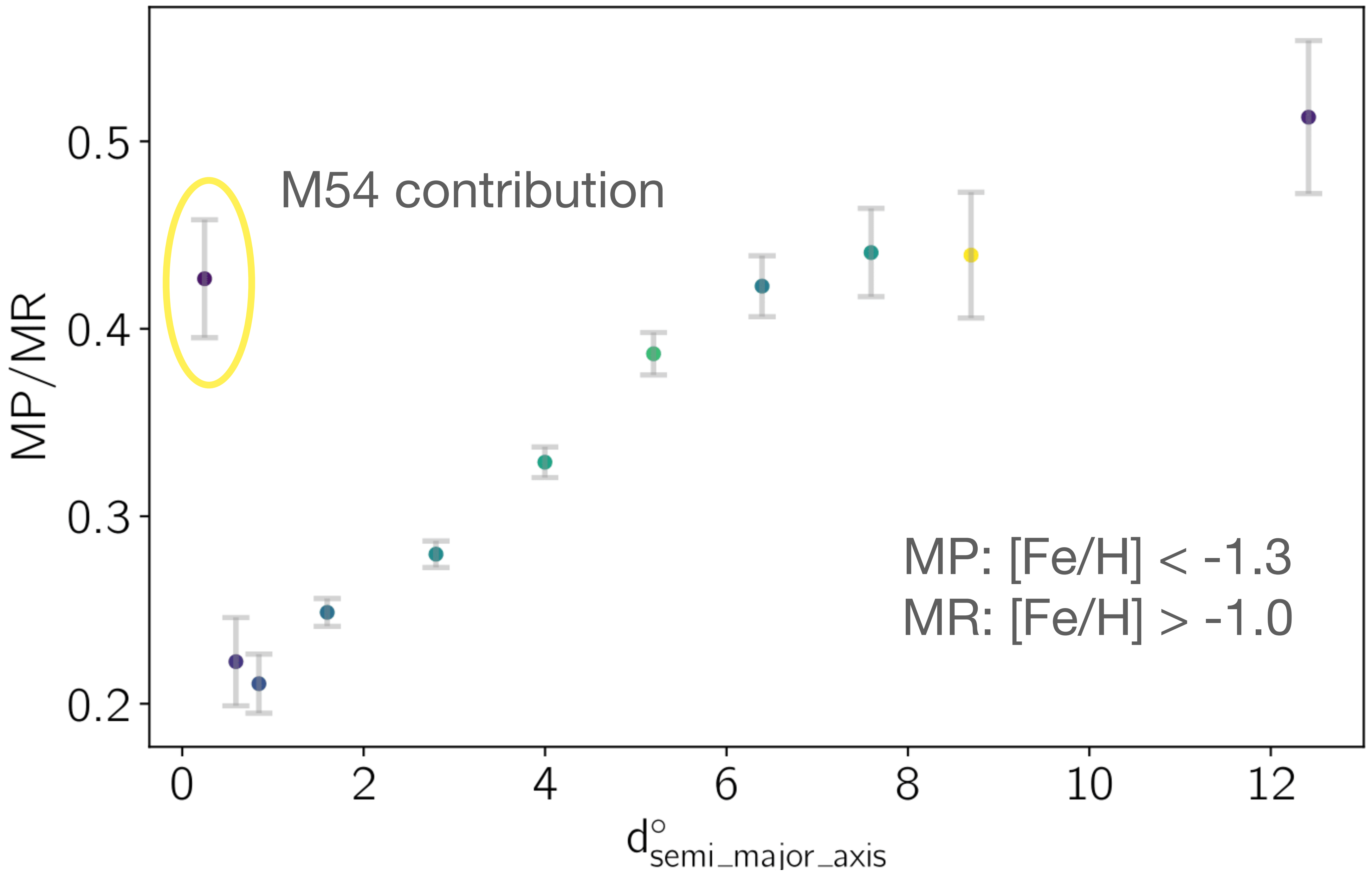
Largest VMP Sgr selection!!

Metallicity gradient

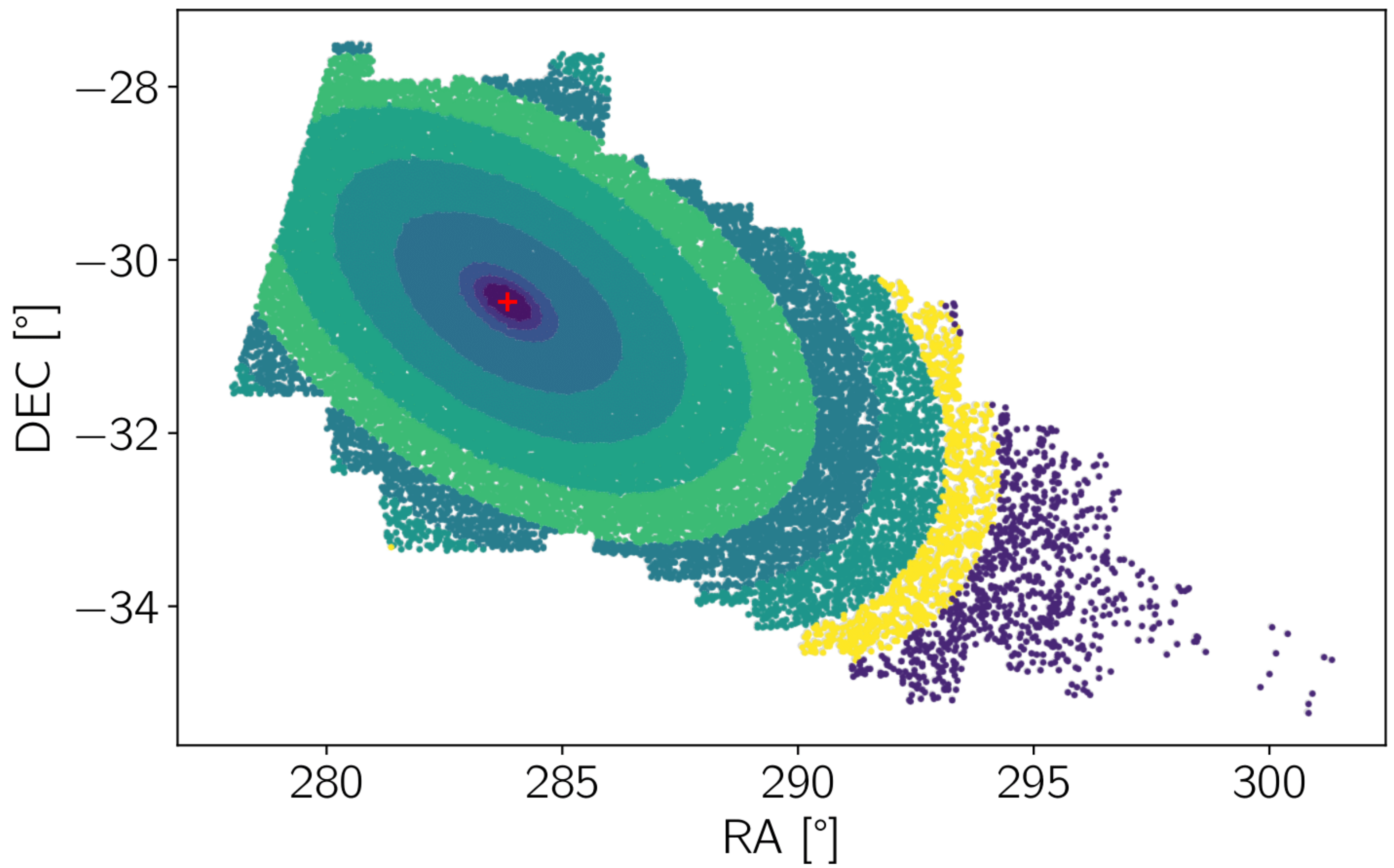


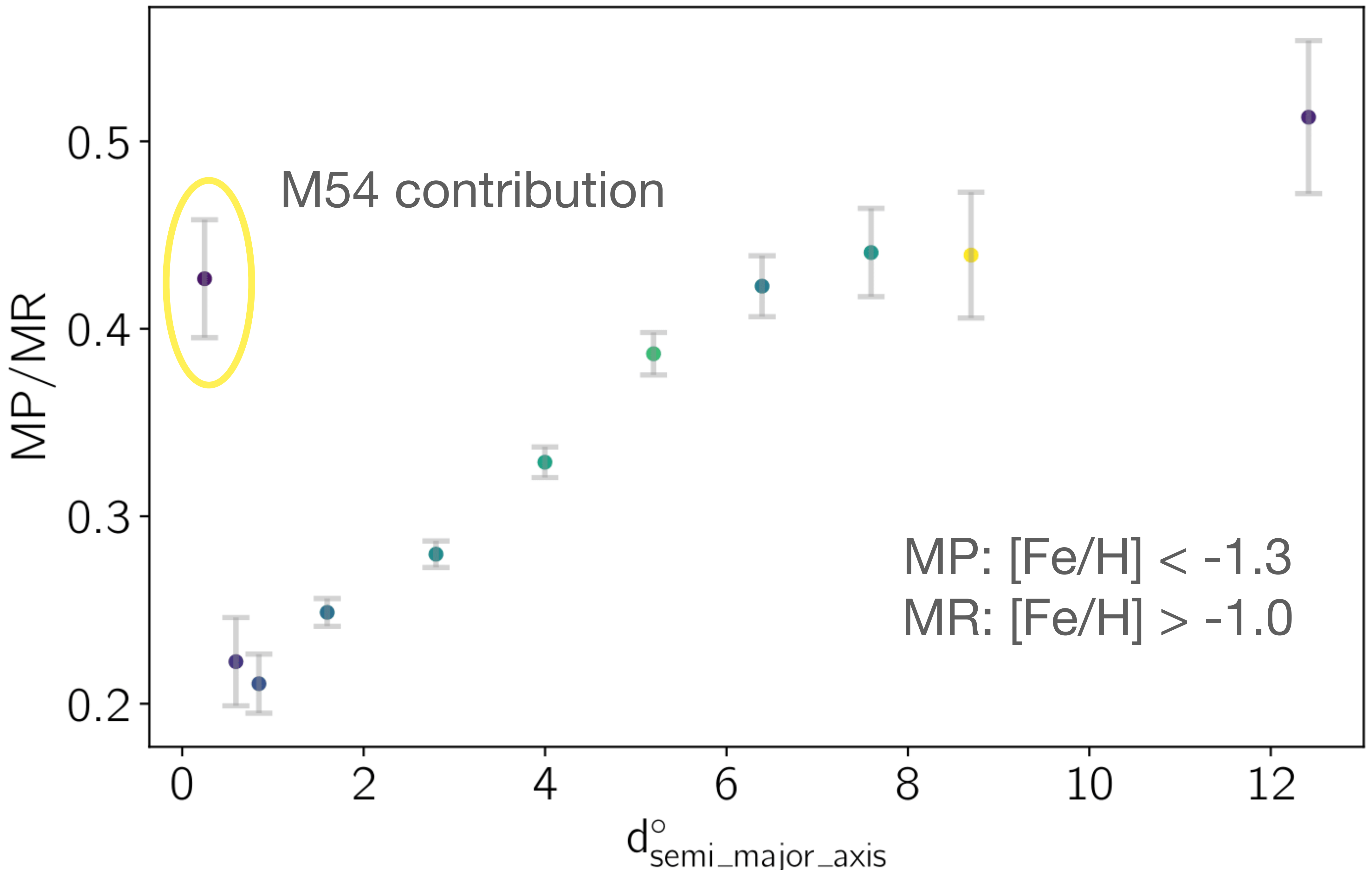


Negative gradient
Fraction of MP stars is higher at the outskirts

Metallicity gradient

★ Wide coverage!
12° / 5.5 kpc





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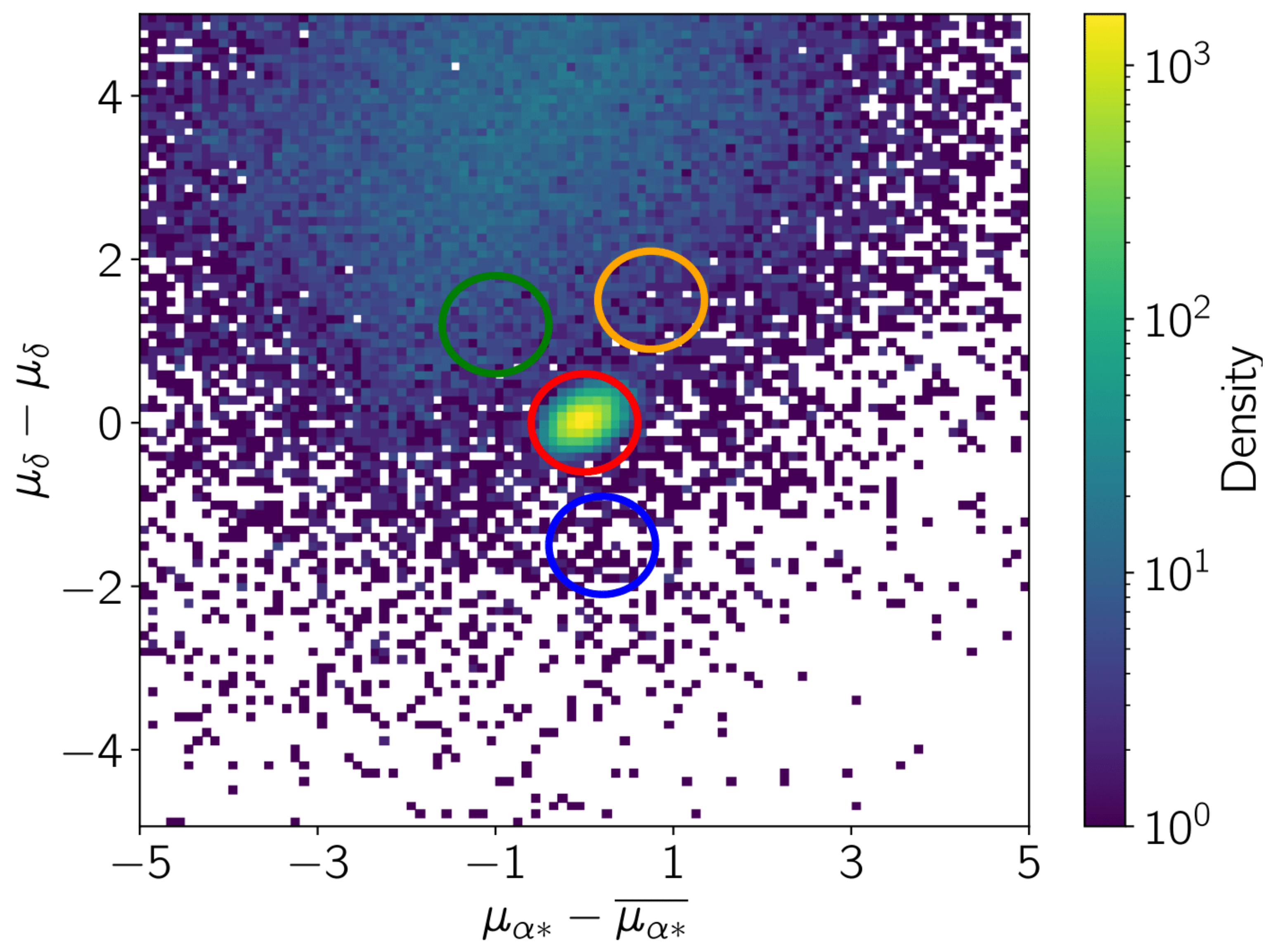

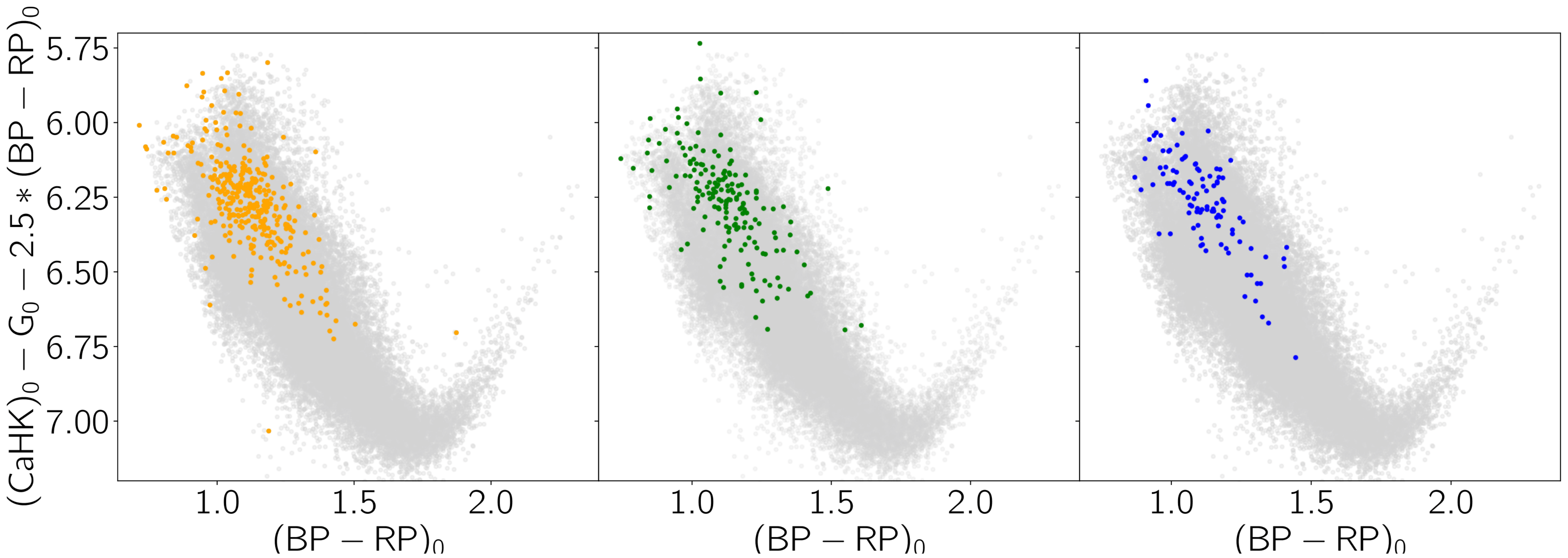

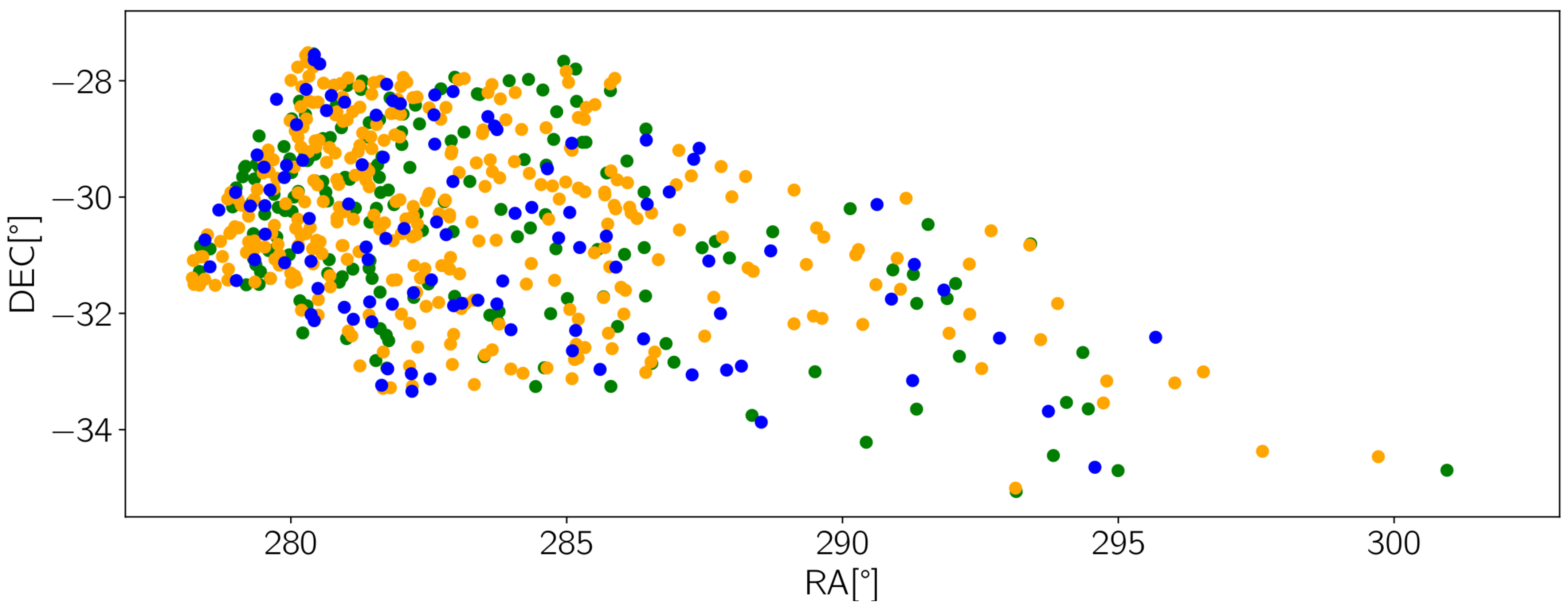

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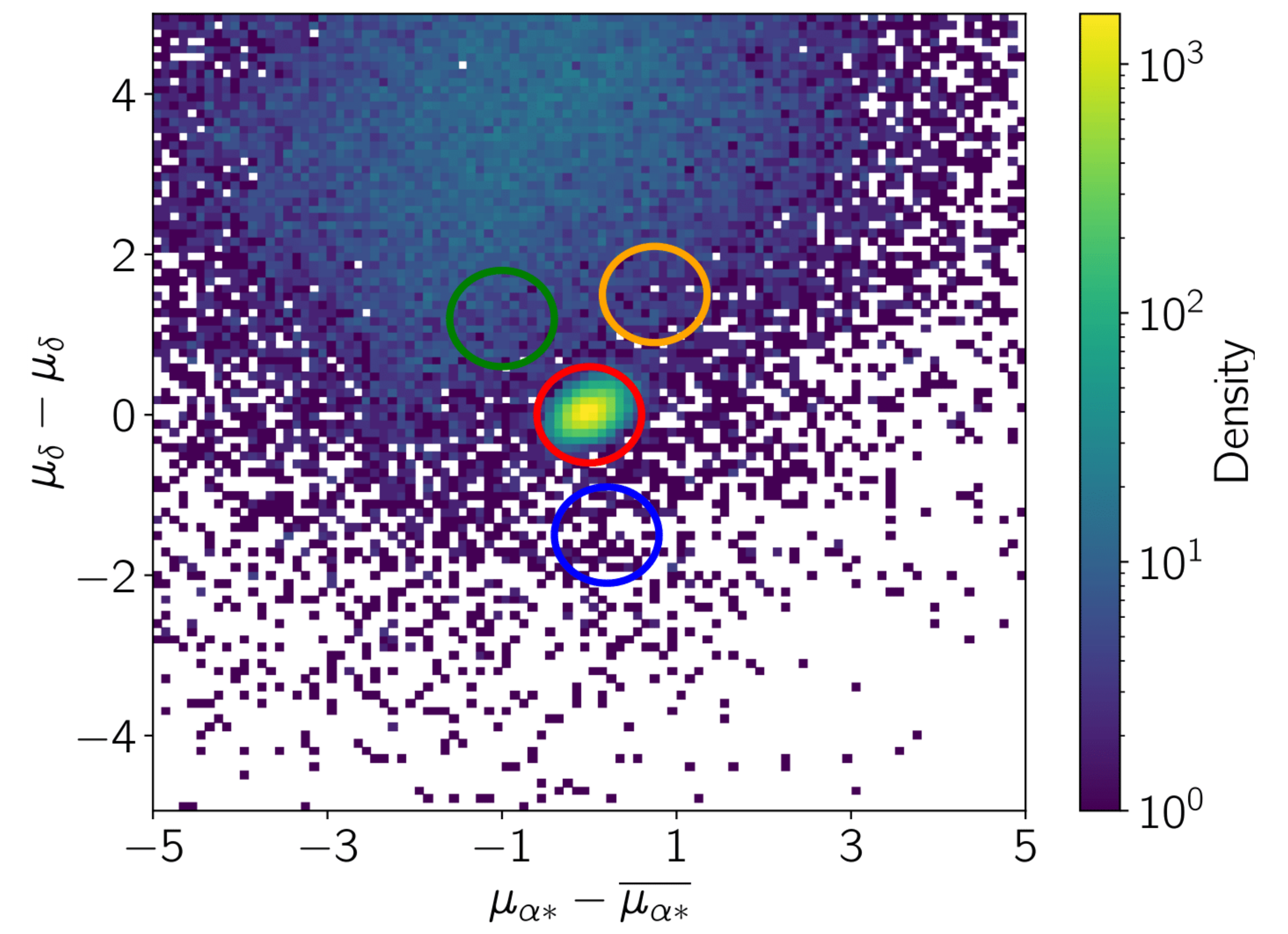

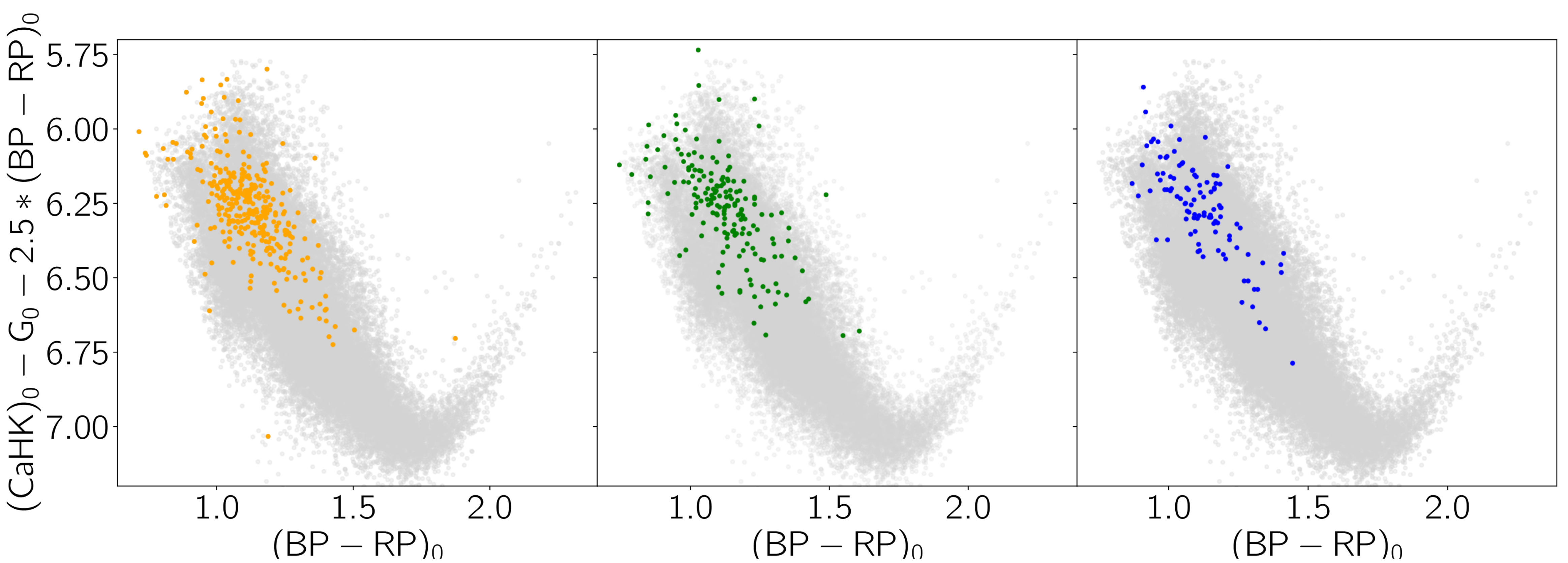

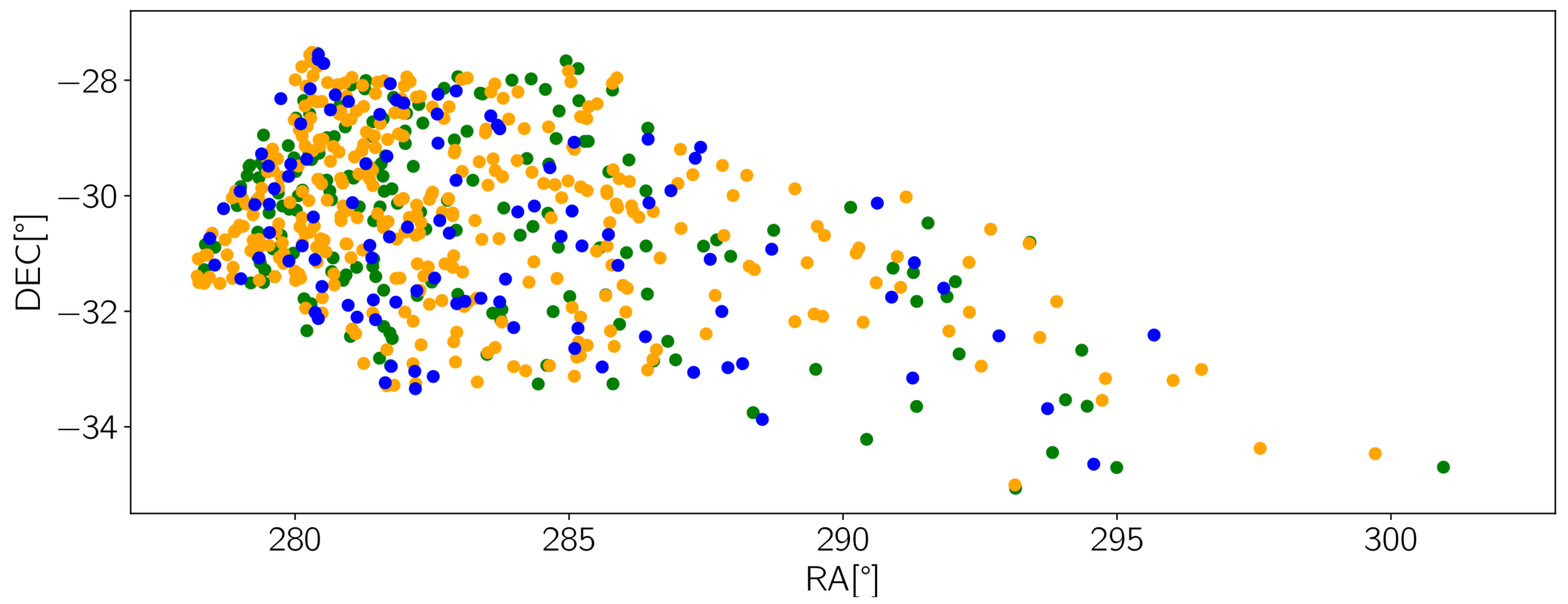

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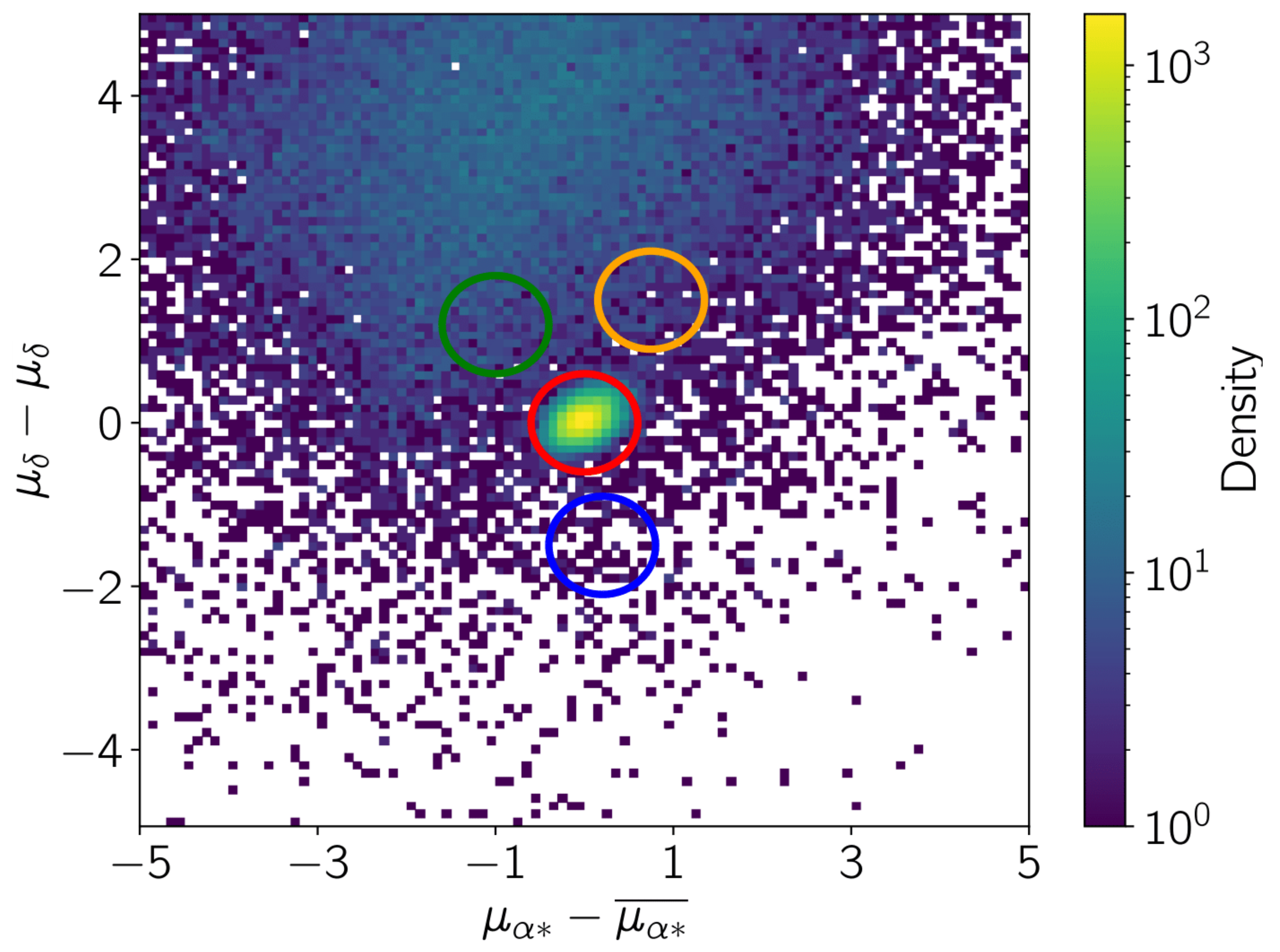

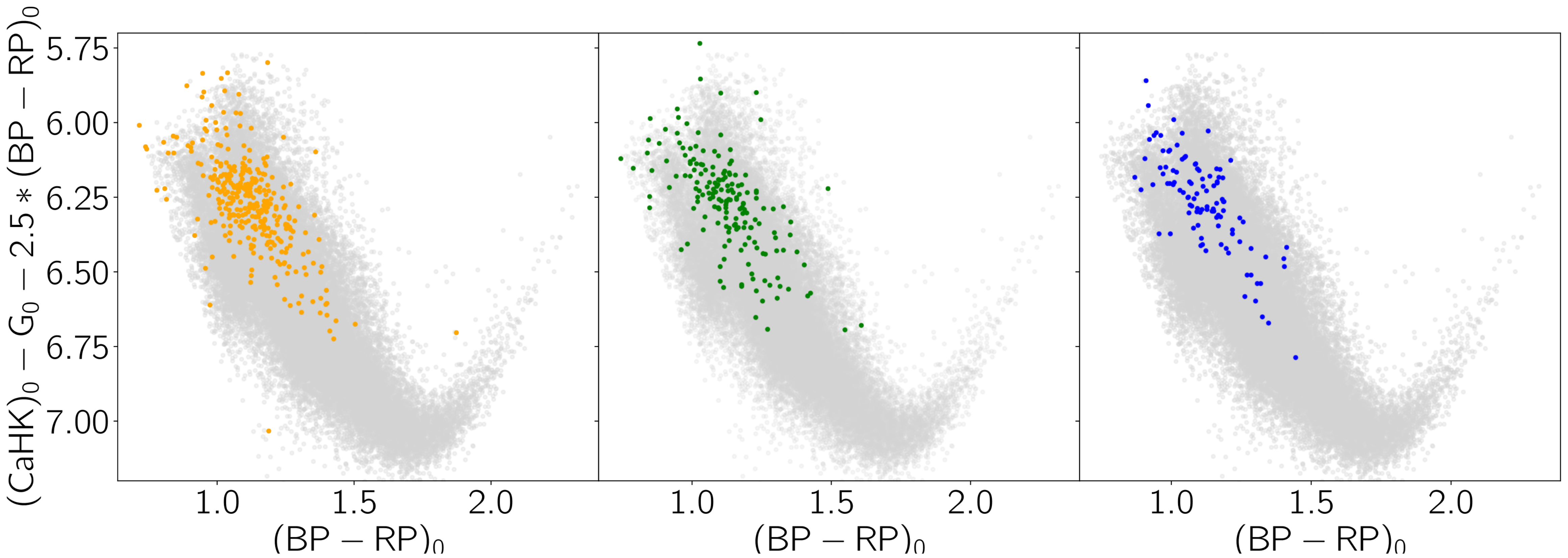

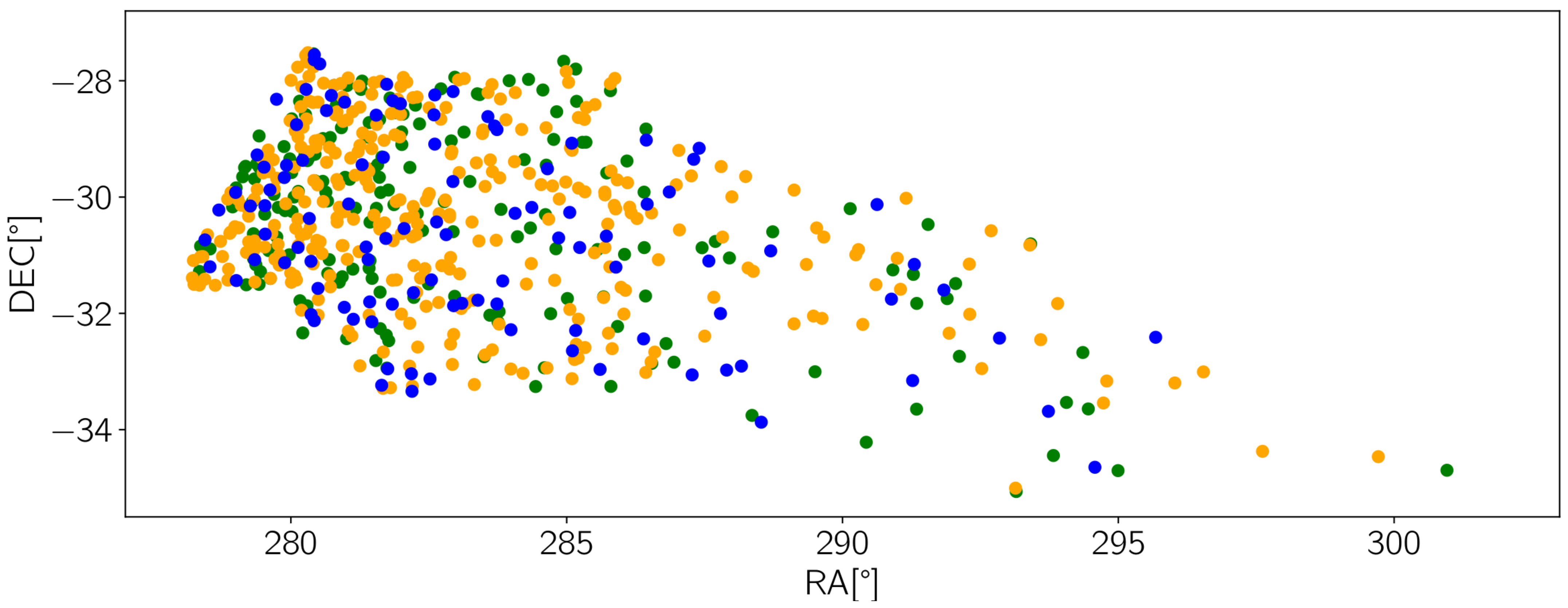

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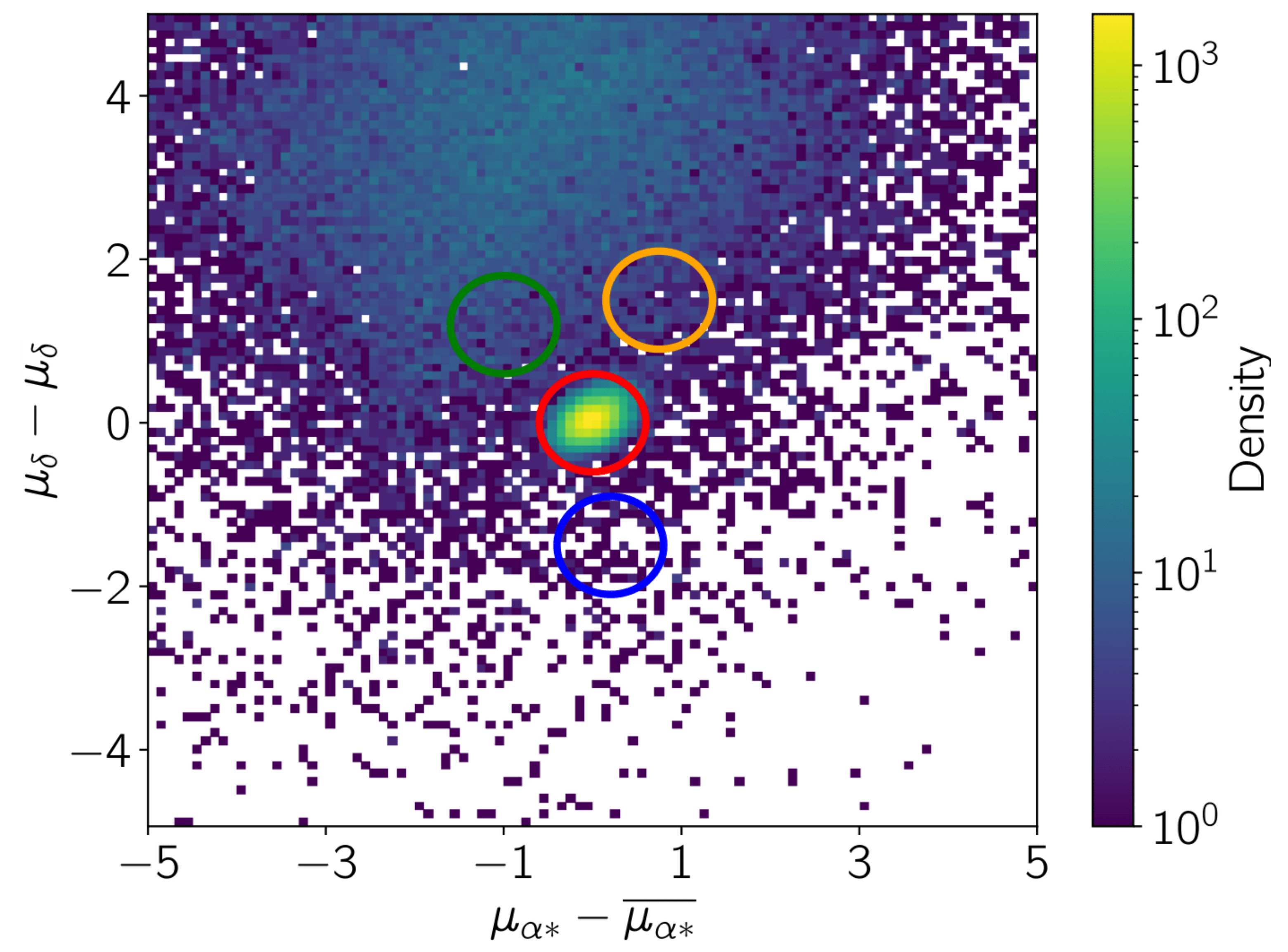
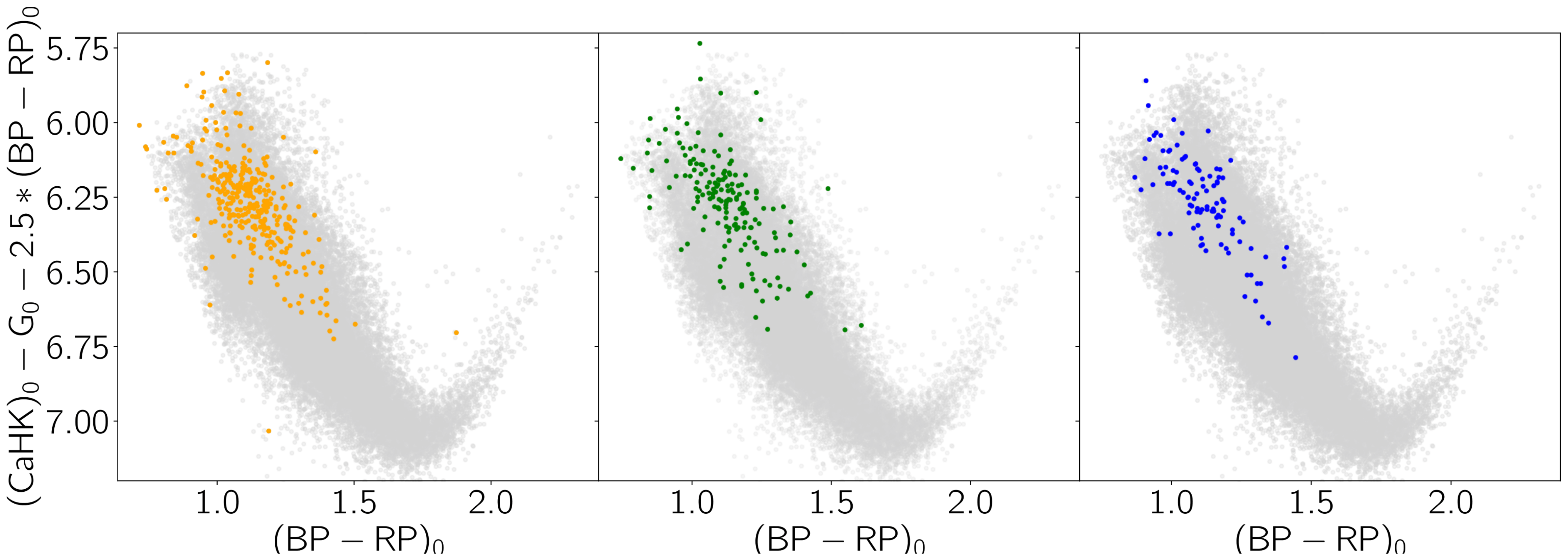
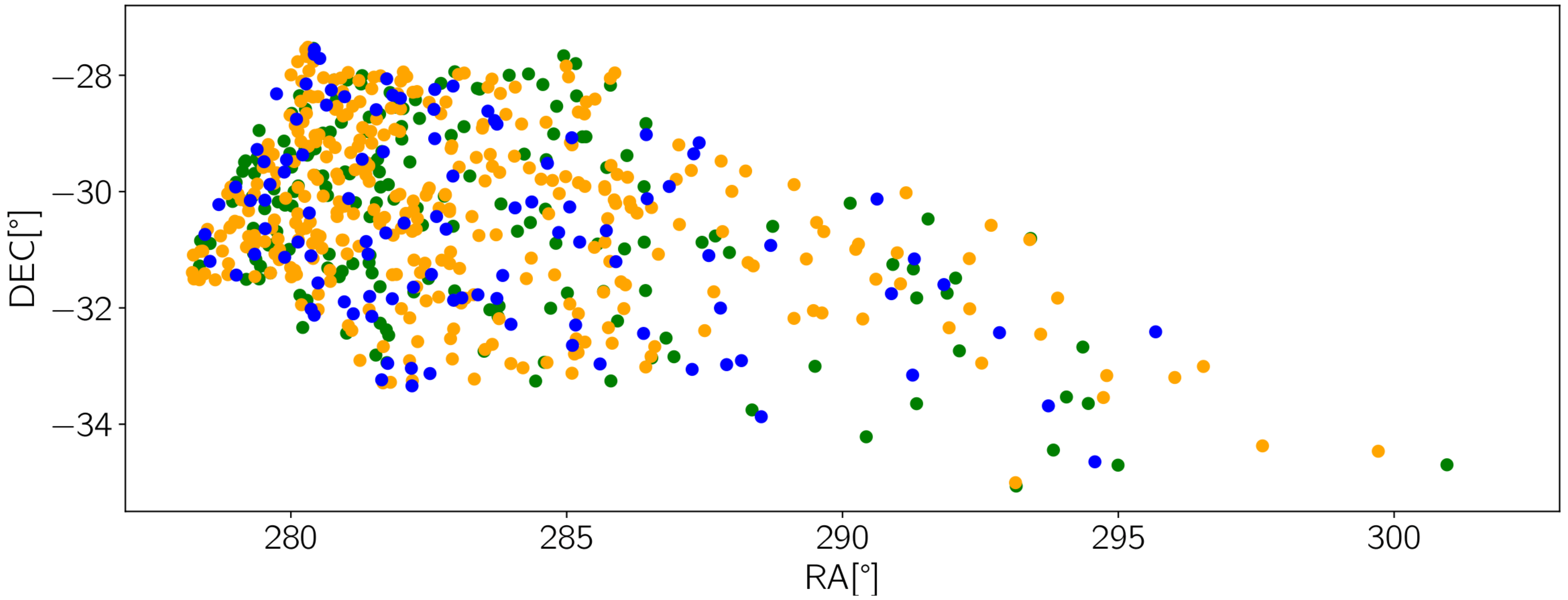
- Model fitting ⟶ approximation ⟶ parameters/real structure?







Conclusions

- Homogeneous investigation of 100° of Sgr region -> **division in different SPs**
- **Metallicity gradient** out to 12° along the Sgr core
- **MR** ([Fe/H] > -1.0) more **centrally** concentrated. **MP** ([Fe/H] < -1.3) more **diffuse**
- **Fitted models** -> different r_e
- **Outside-in** formation process
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Power and efficiency of ***Pristine* + *Gaia*** for investigate the history of Sgr dSph and

Important for the MW merging history

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High resolution spectroscopy -> elemental abundances
Much more with new Gaia release