Kinematic correlations in the solar neighborhood using RAVE ...

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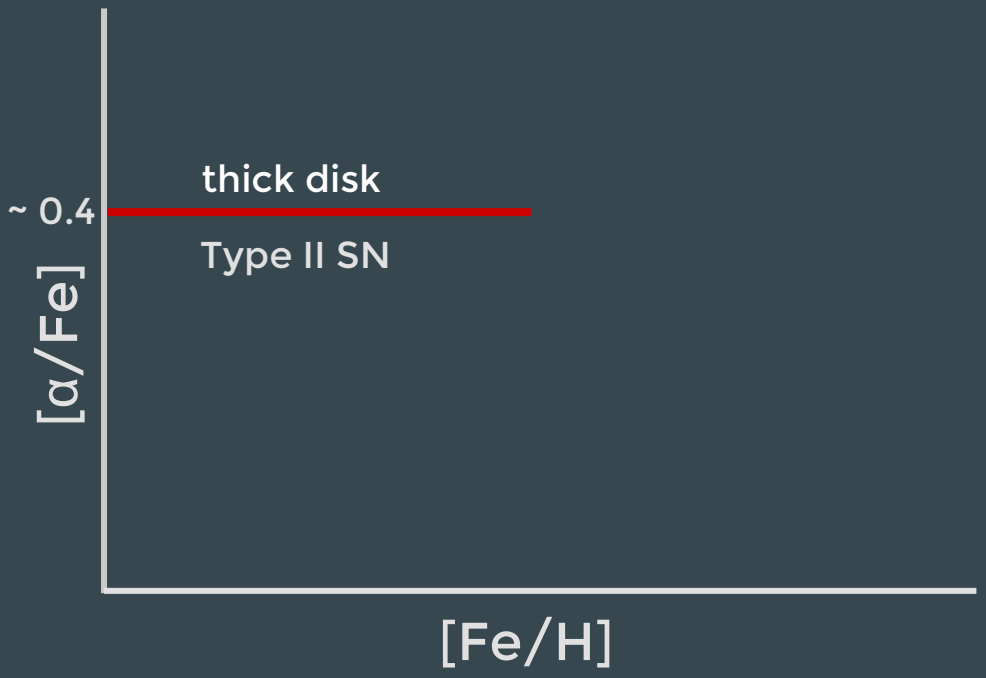
Wojno et al. 2016a - 2016MNRAS.461.4246W (arXiv:1603.09339)
Wojno et al. 2016b, in prep.

20.09.2016

Outline

1. Introduction / Motivation
2. RAVE selection function
    a. Target selection and observation strategy
    b. Two methods: field-by-field and healpix pixels
    c. RAVE mock catalog with Galaxia
        i. Application of selection function and uncertainties
        ii. Results
3. Chemical separation of disc components using RAVE
    a. Probabilistic method/model
    b. Results
    c. Further applications

Introduction / Motivation



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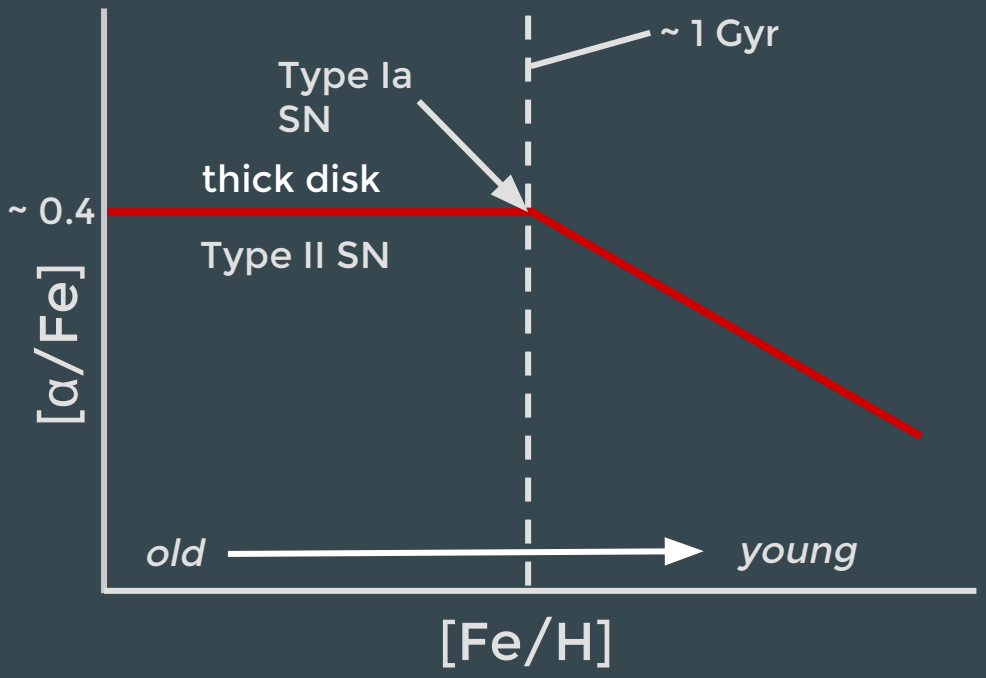

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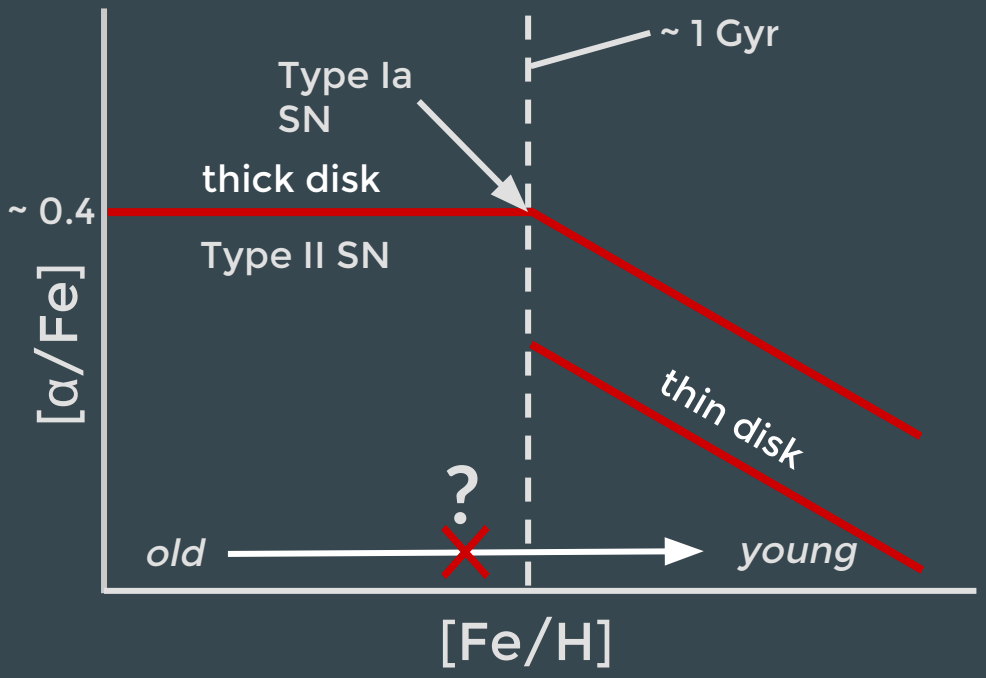

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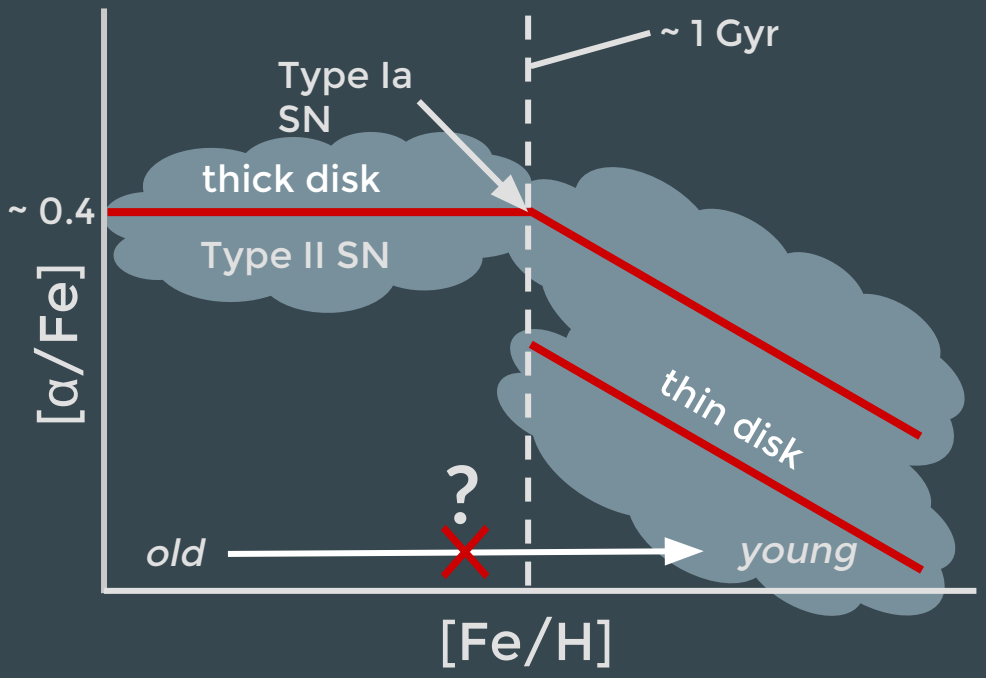

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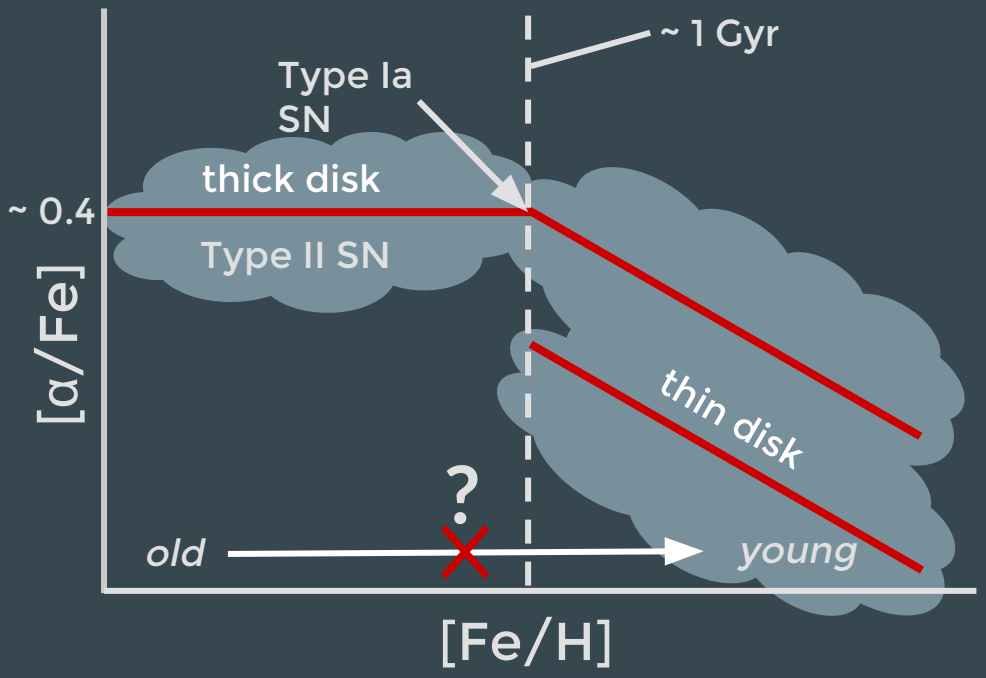
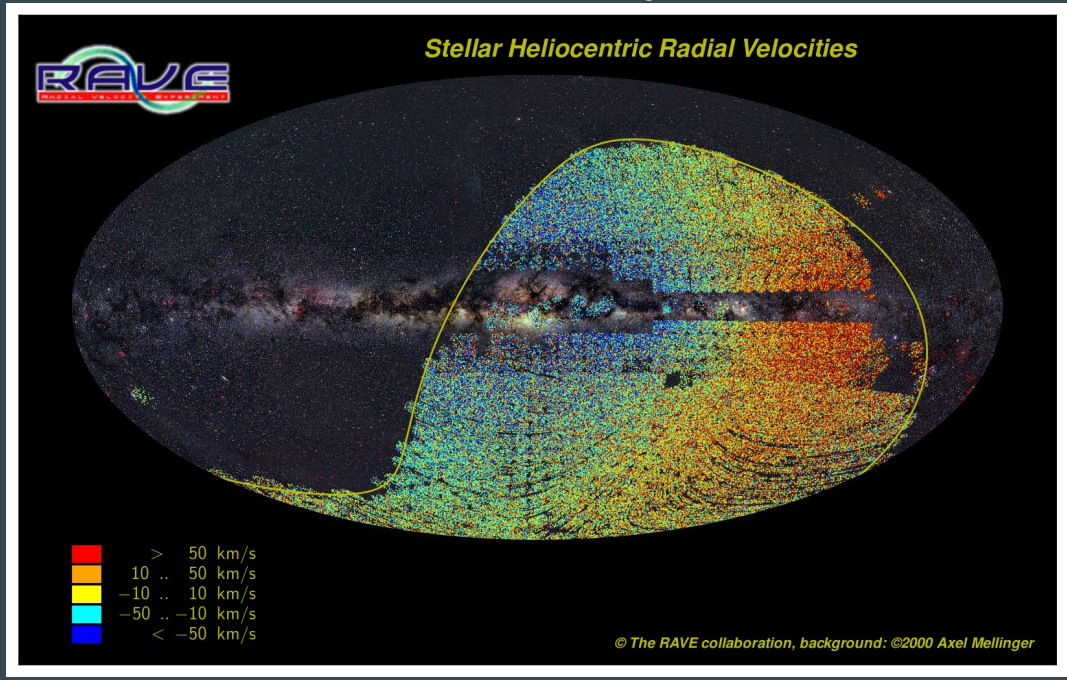


+ kinematics

- Evolutionary histories of thin/thick discs
- Origin of super metal rich (SMR) stars
- Impact/efficiency of radial migration

RAdial Velocity Experiment (RAVE) Survey

- > 500,000 spectra
- Observed 2003 - 2013 with 1.2m UK Schmidt Telescope (AAO)
- Medium resolution (R ~ 7500)
- Ca II triplet region



RAVE Data Release 5 (DR5) (Kunder et al. 2016)

520,781 spectra of 457,588 individual stars

- Radial velocities (σ_{RV} ~ 2 km s^{-1})
- Stellar parameters: Teff, log(g), [M/H]
- Chemical abundances: Mg, Al, Si, Ti, Fe, Ni
- Distance, parallax, age estimates
- Cross-matched with: Tycho2, UCAC4, PPXML, 2MASS, APASS, WISE

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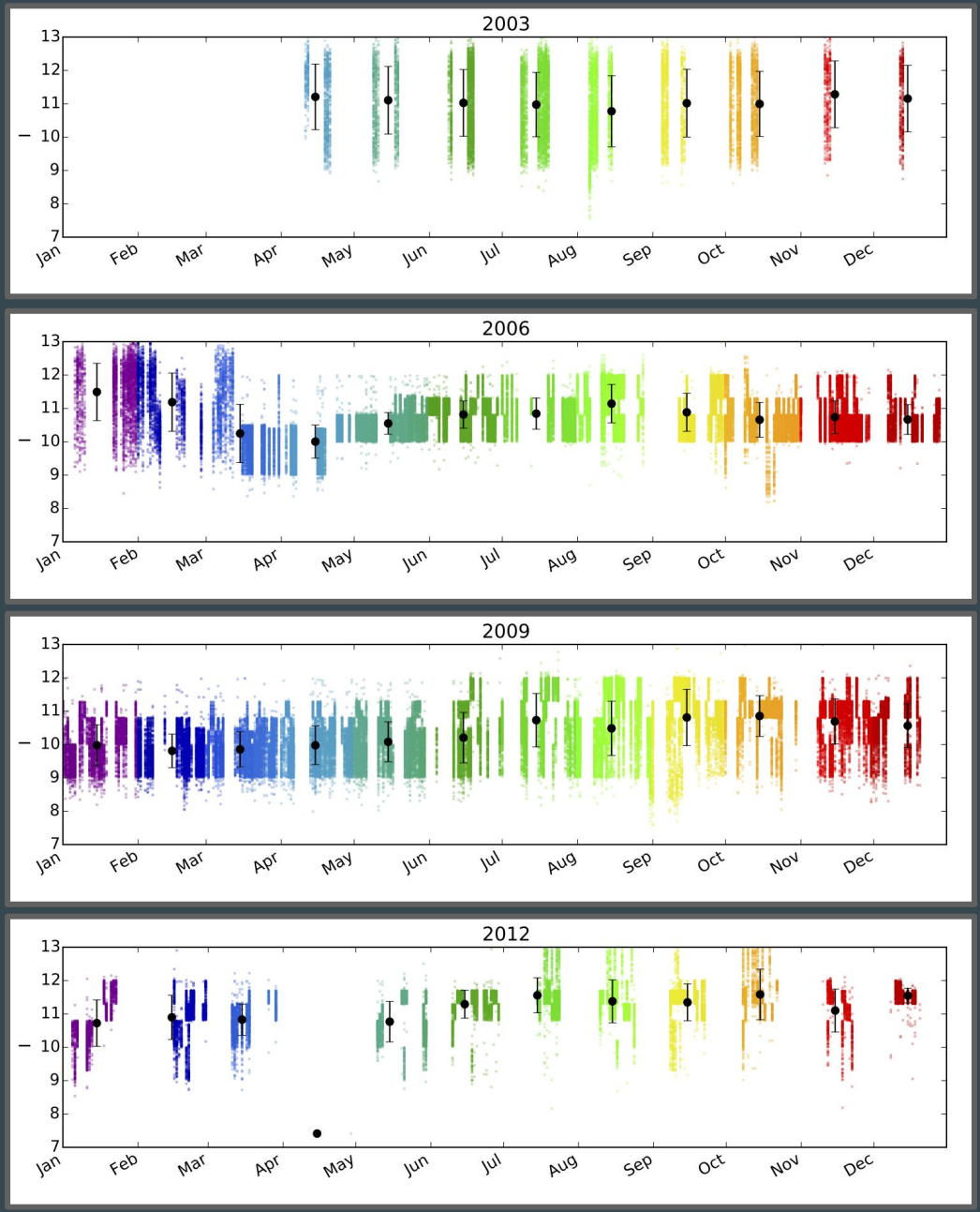
RAVE selection function



$$S \propto S_{select}(\ell, b, I, J - K_s)$$

Potential complications:

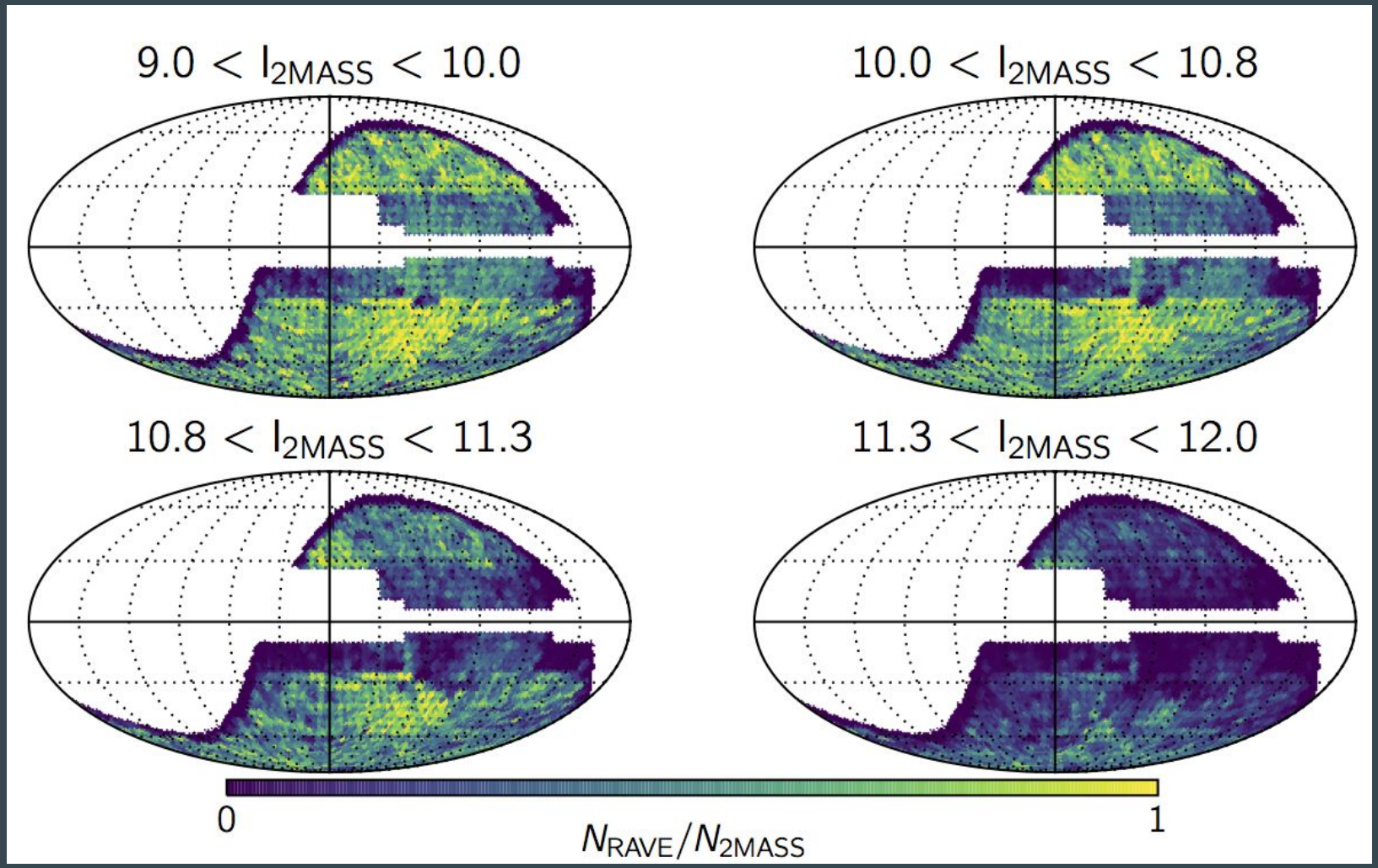
- Observing strategy
- Fiber positioning
- Spacing between fields as a function of time (overlap)
- Input catalog sources

→ two options:

1. Field-by-field
2. Equal areas on the sky (healpix) Gorski+05

RAVE selection function

$$S \propto S_{select}(\ell, b, I, J - K_s)$$



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RAVE selection function

RAVE mock catalog with Galaxia: Application of selection function and uncertainties

Galaxia all-sky catalog

(Sharma+11)

RAVE selection function

RAVE mock catalog with Galaxia: Application of selection function and uncertainties

Galaxia all-sky catalog

(Sharma+11)

Put into healpix pixels

(Gorski+05)

RAVE selection function

RAVE mock catalog with Galaxia: Application of selection function and uncertainties

Galaxia all-sky catalog

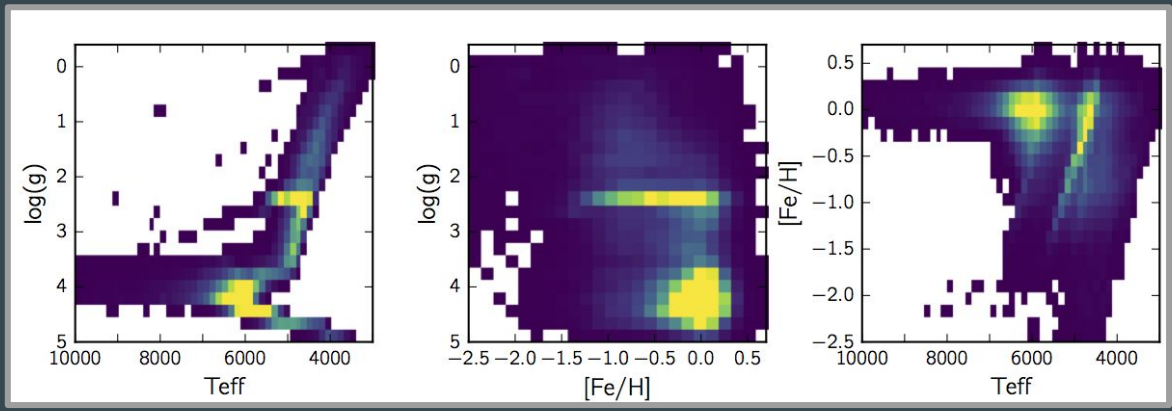
(Sharma+11)

Put into healpix pixels

(Gorski+05)

Apply RAVE selection function

$S_{select}(\ell, b, I, J - K_s)$



RAVE selection function

RAVE mock catalog with Galaxia: Application of selection function and uncertainties

Galaxia all-sky catalog

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Put into healpix pixels

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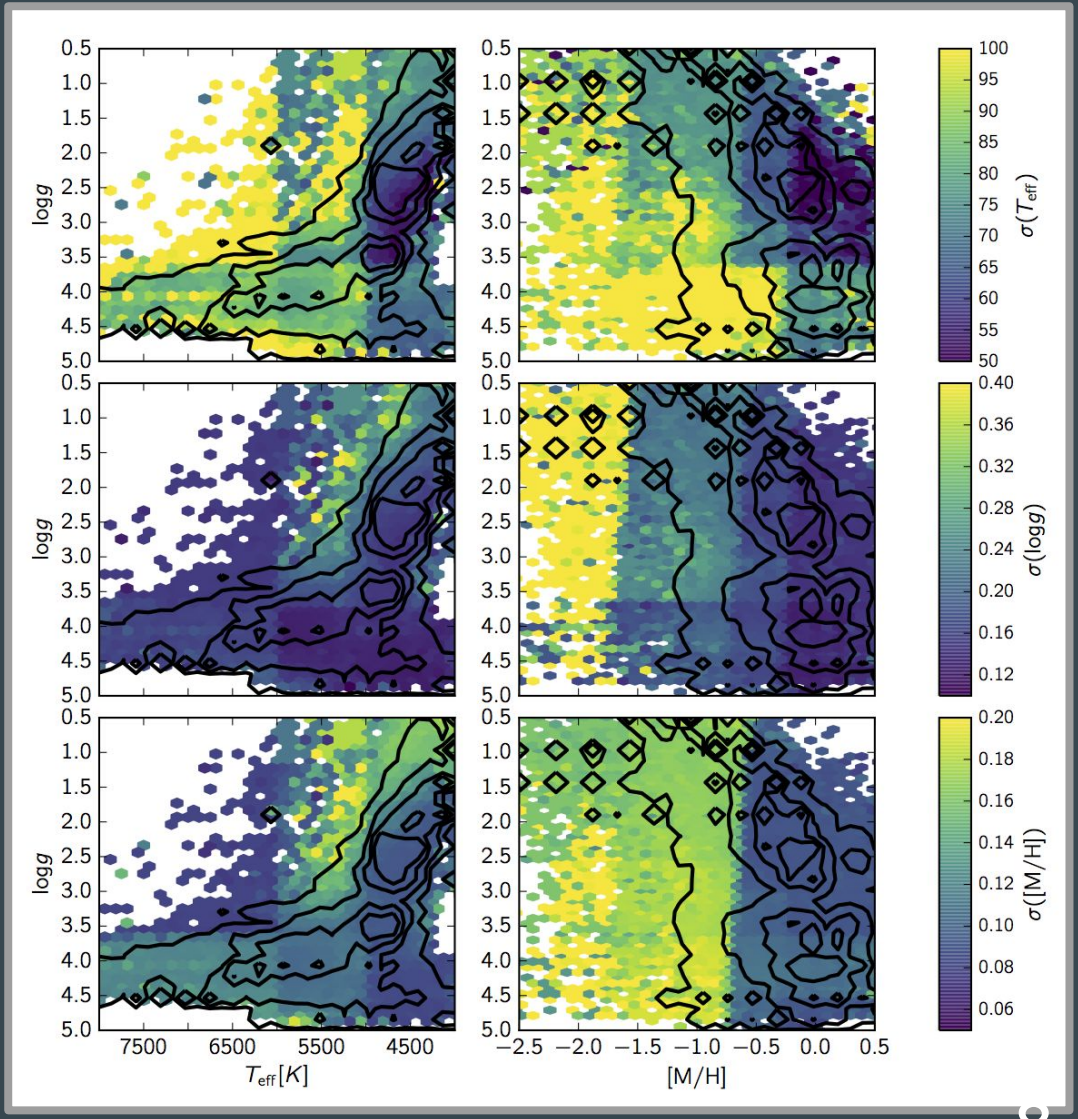
Apply RAVE selection function

$S_{select}(\ell, b, I, J - K_s)$

Apply RAVE-like errors



RAVE selection function

RAVE mock catalog with Galaxia: Application of selection function and uncertainties

Galaxia all-sky catalog

(Sharma+11)

Put into healpix pixels

(Gorski+05)

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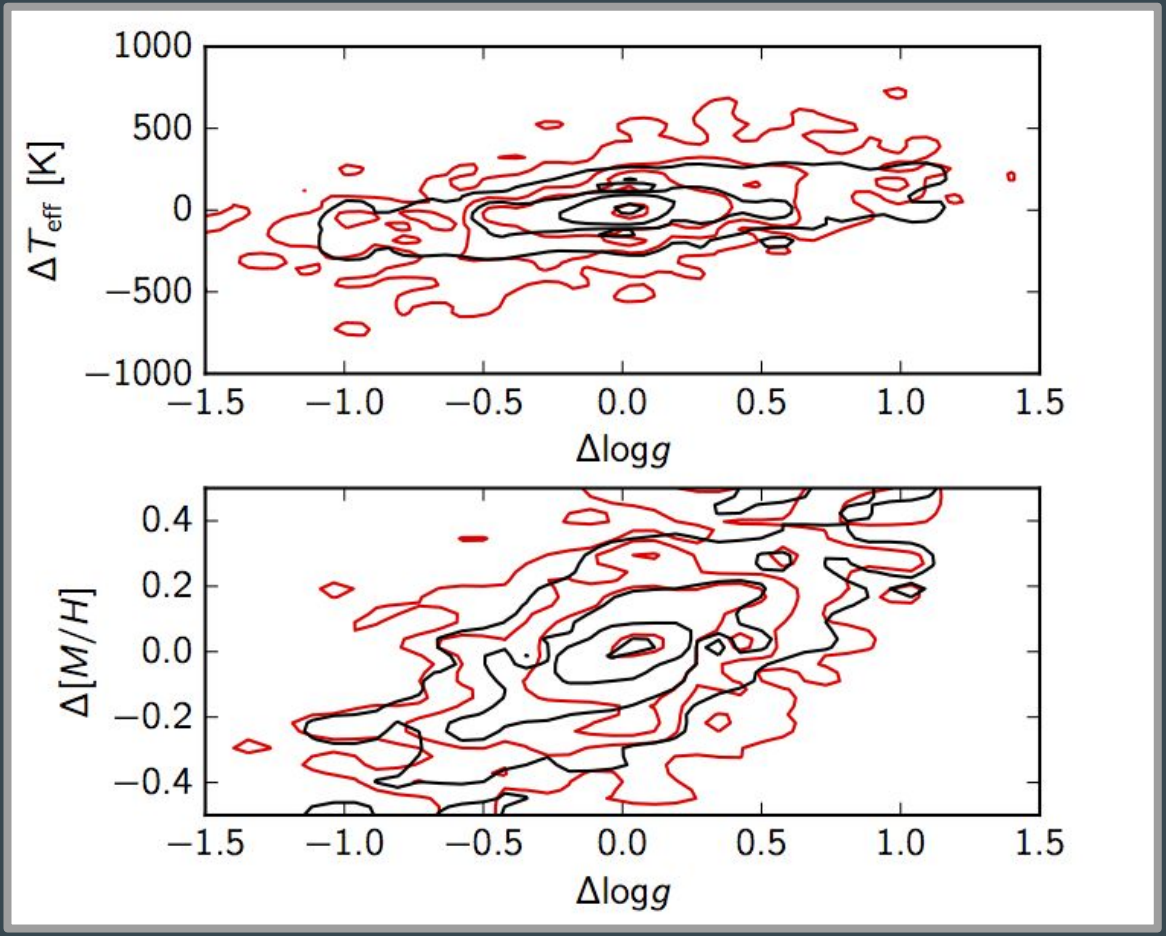


RAVE selection function

RAVE mock catalog with Galaxia: Application of selection function and uncertainties

Galaxia all-sky catalog

(Sharma+11)

Put into healpix pixels

(Gorski+05)

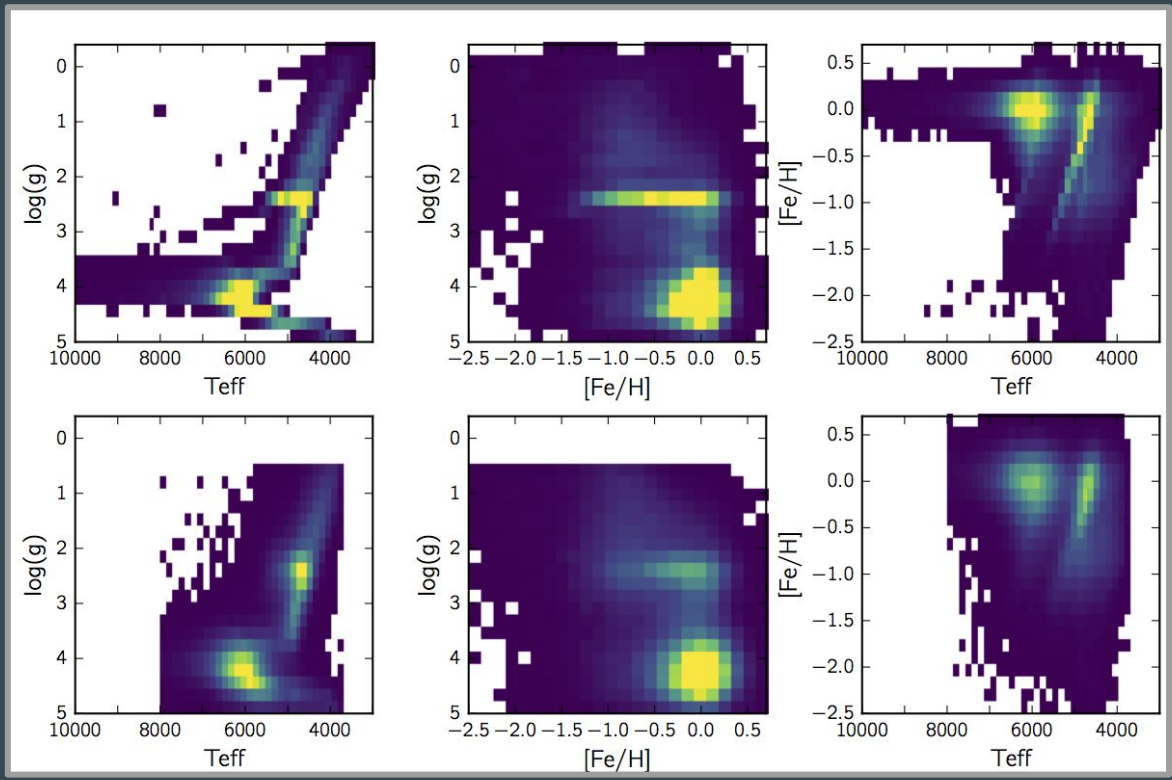
Apply RAVE selection function

$S_{select}(\ell, b, I, J - K_s)$

Apply RAVE-like errors

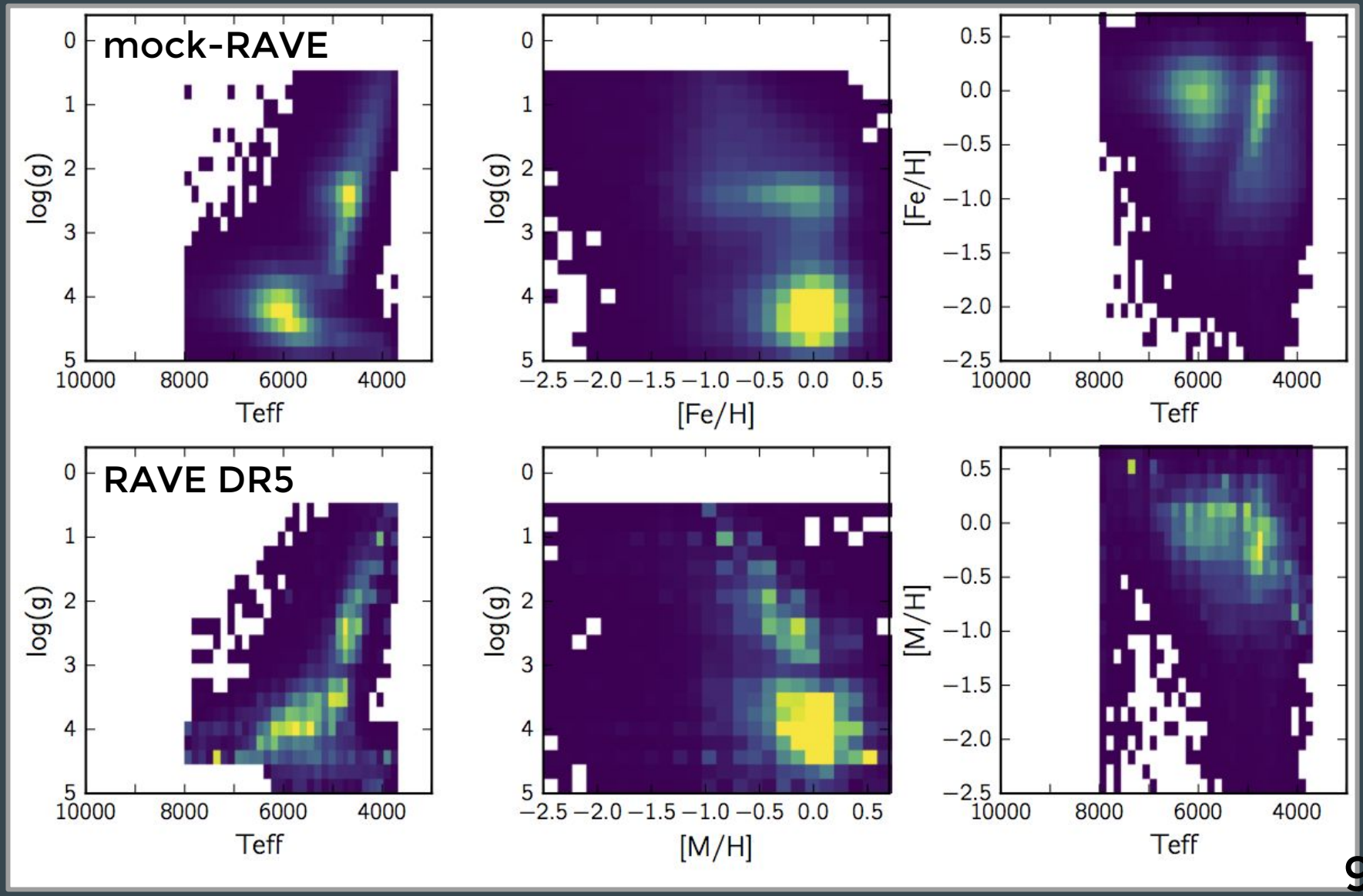
Apply pipeline selection function

$S_{pipeline}(T_{eff}, \log g, [M/H])$



RAVE selection function

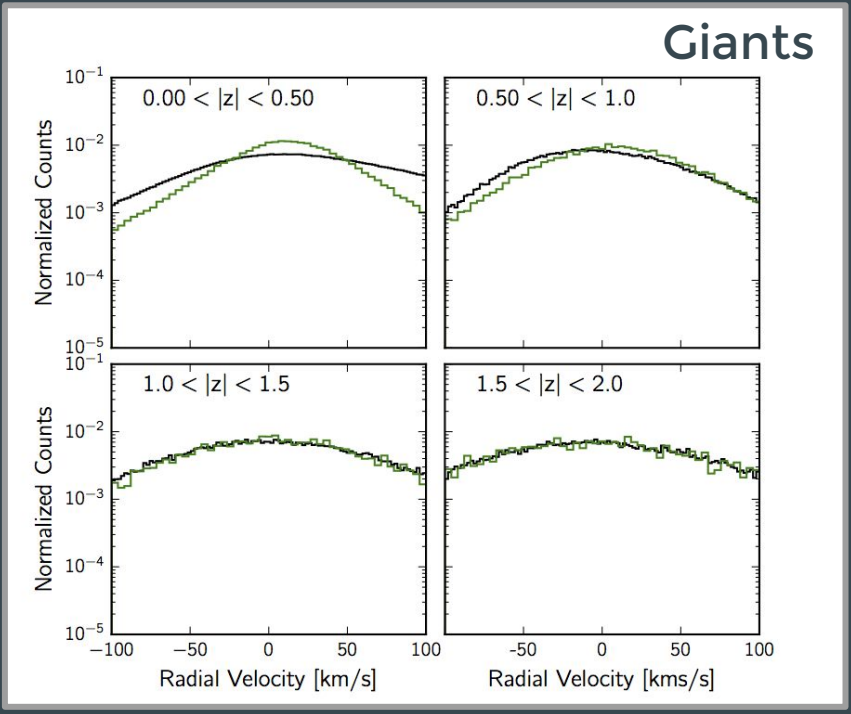
RAVE mock catalog with Galaxia:
Application of selection function and uncertainties



RAVE selection function

RAVE mock catalog with Galaxia

Results

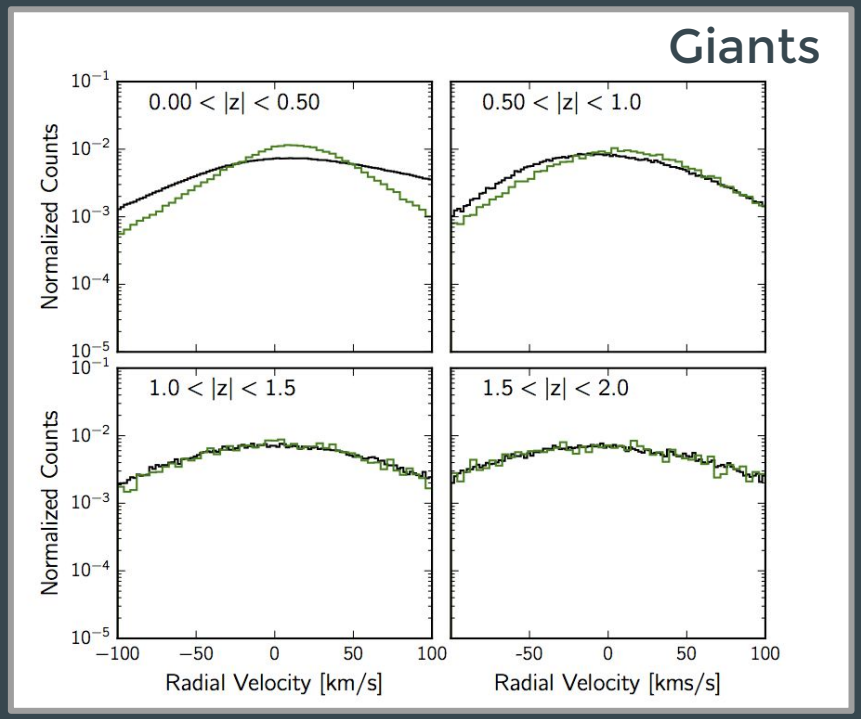


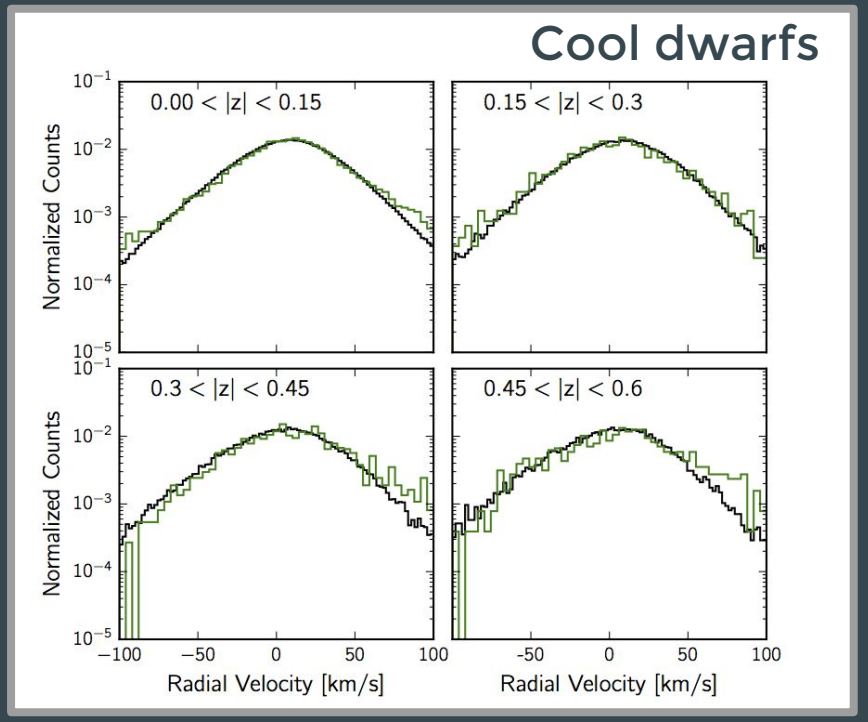
Definitions:

Giants: log(g) < 3.5

RAVE selection function

RAVE mock catalog with Galaxia Results





Definitions:

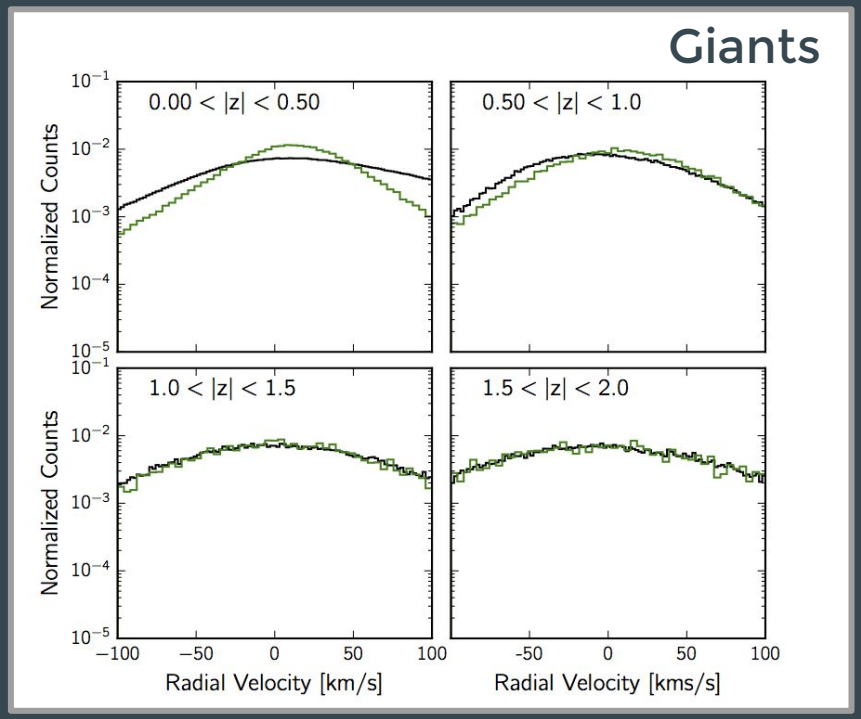
Giants: log(g) < 3.5

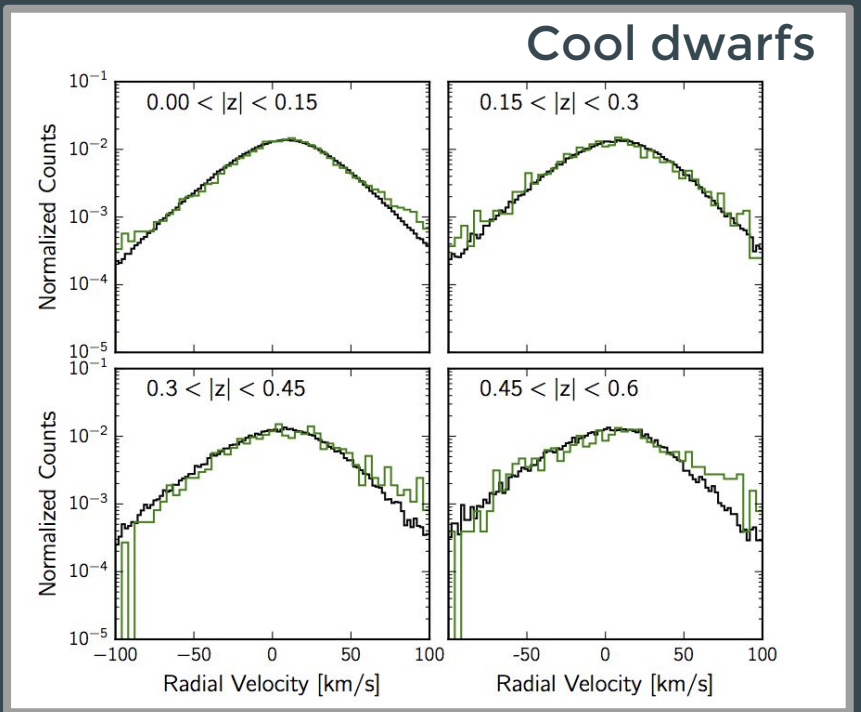
Cool dwarfs: log(g) > 4.2, T_{eff} < 6000 K

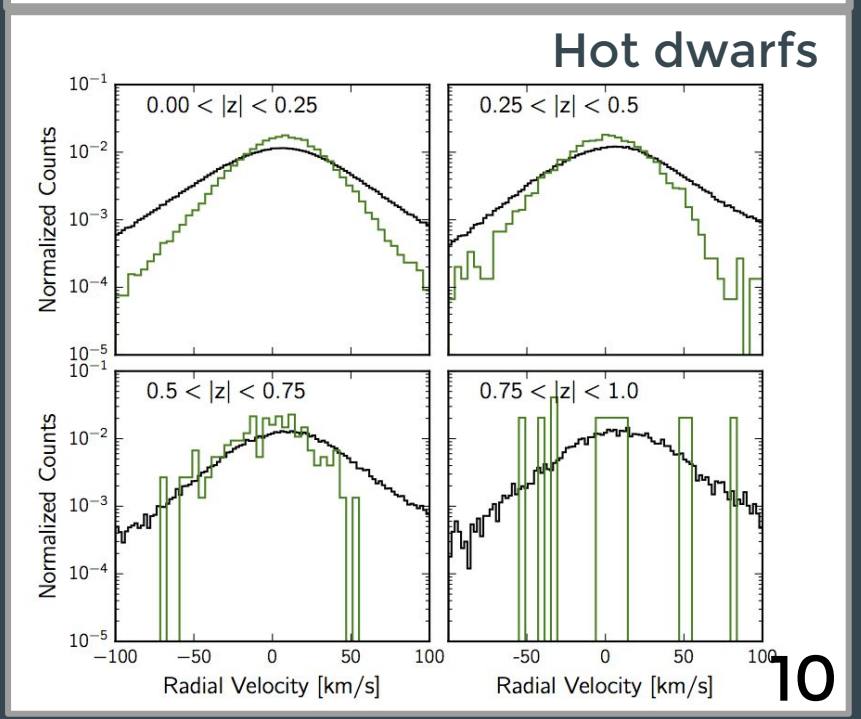
RAVE selection function

RAVE mock catalog with Galaxia

Results







Definitions:

Giants: log(g) < 3.5

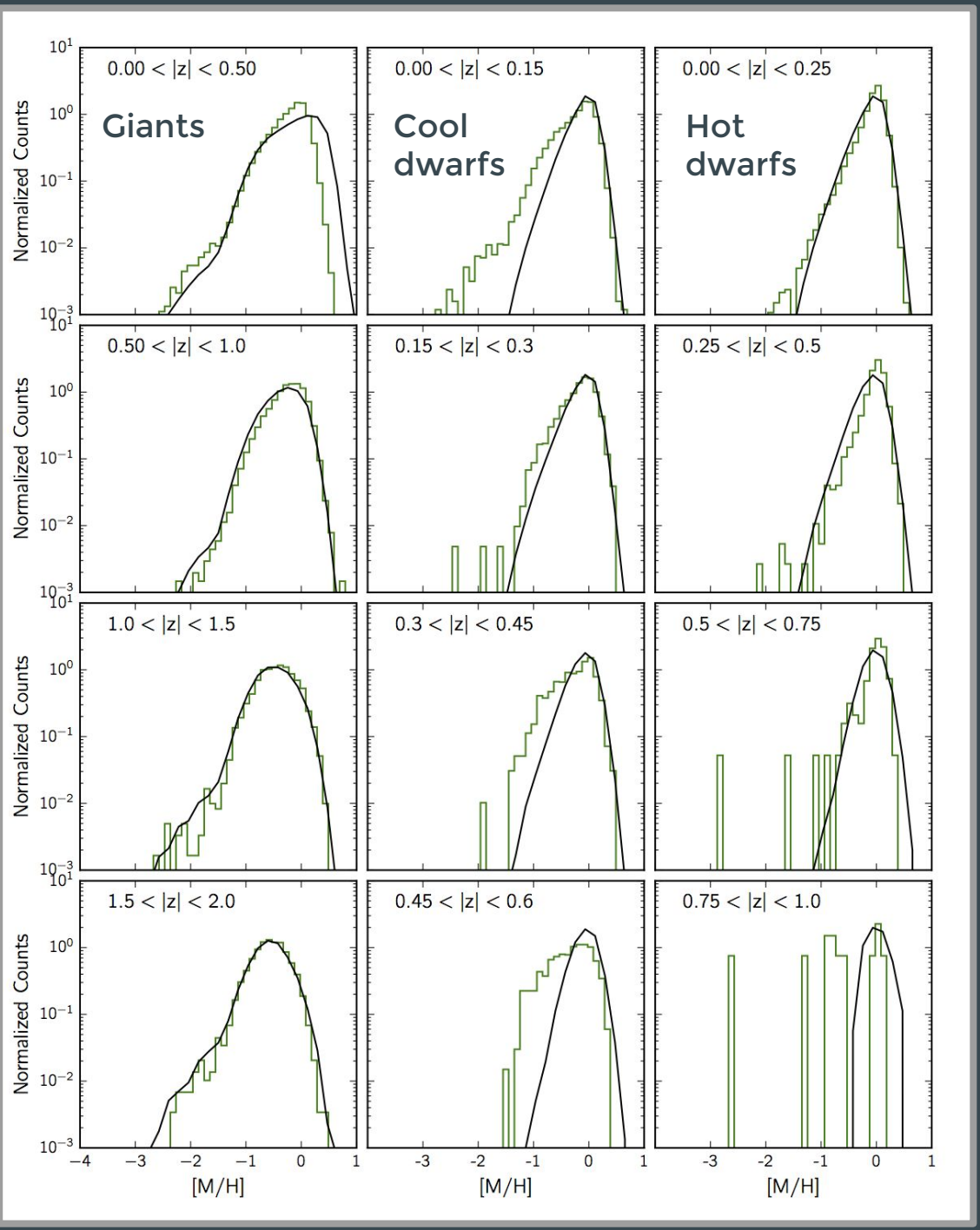
Cool dwarfs: log(g) > 4.2, T_{eff} < 6000 K
Hot dwarfs: log(g) > 3.5, T_{eff} > 6000 K

Definitions:

Giants: log(g) < 3.5

Cool dwarfs:
log(g) > 4.2, T_{eff} < 6000 K

Hot dwarfs:
log(g) > 3.5, T_{eff} > 6000 K



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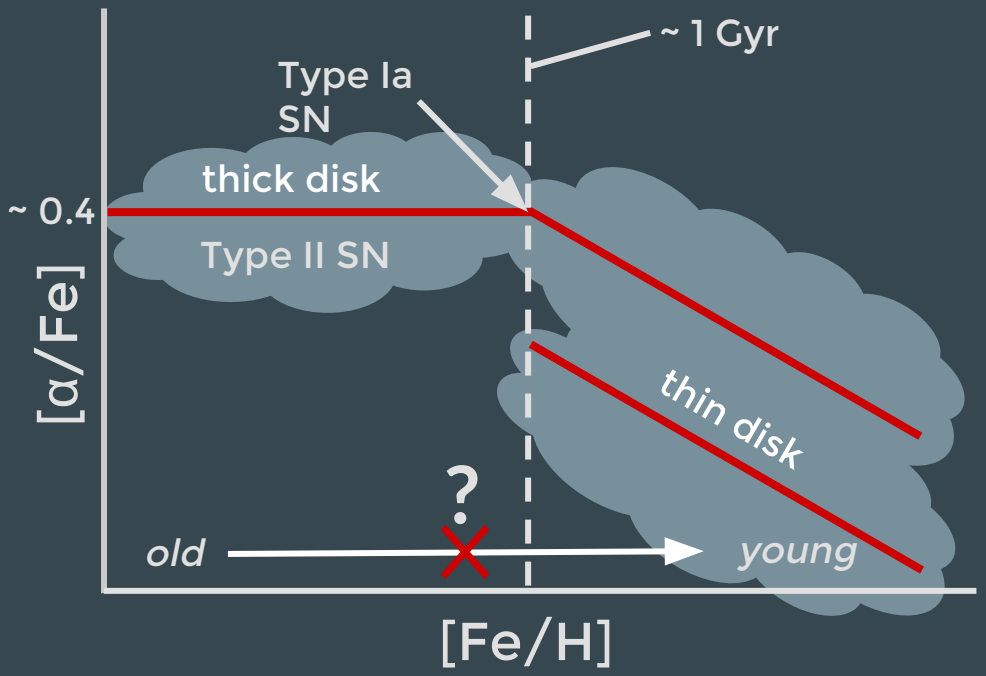
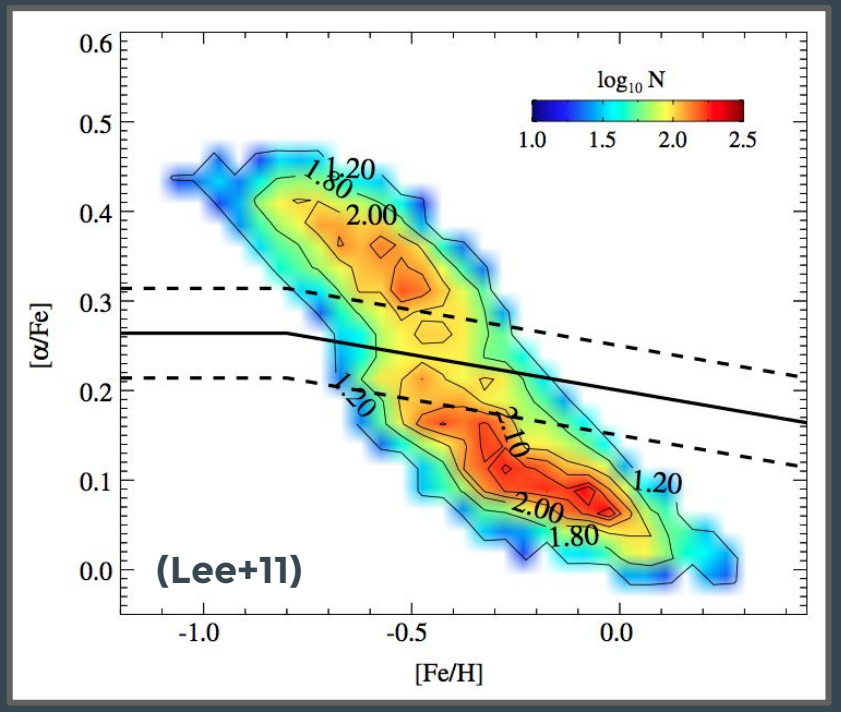
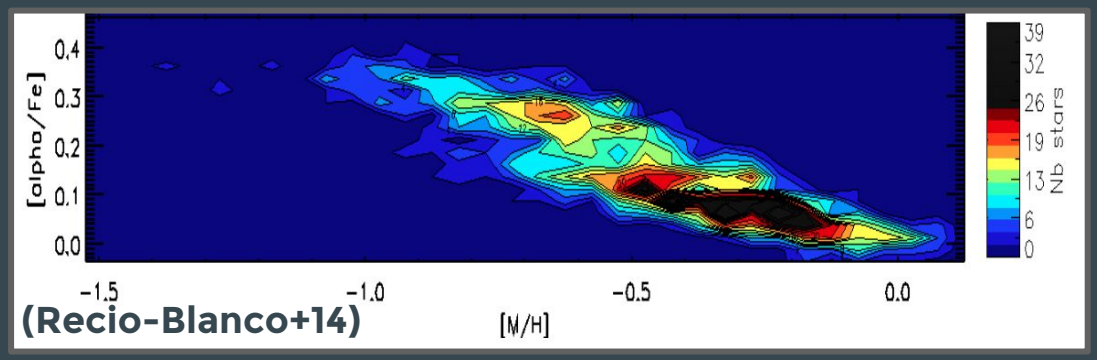
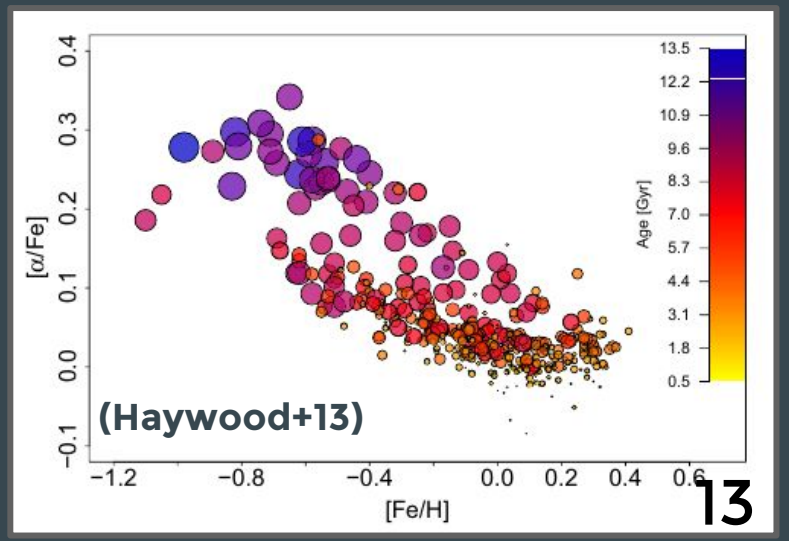
Chemical separation of disc components using RAVE





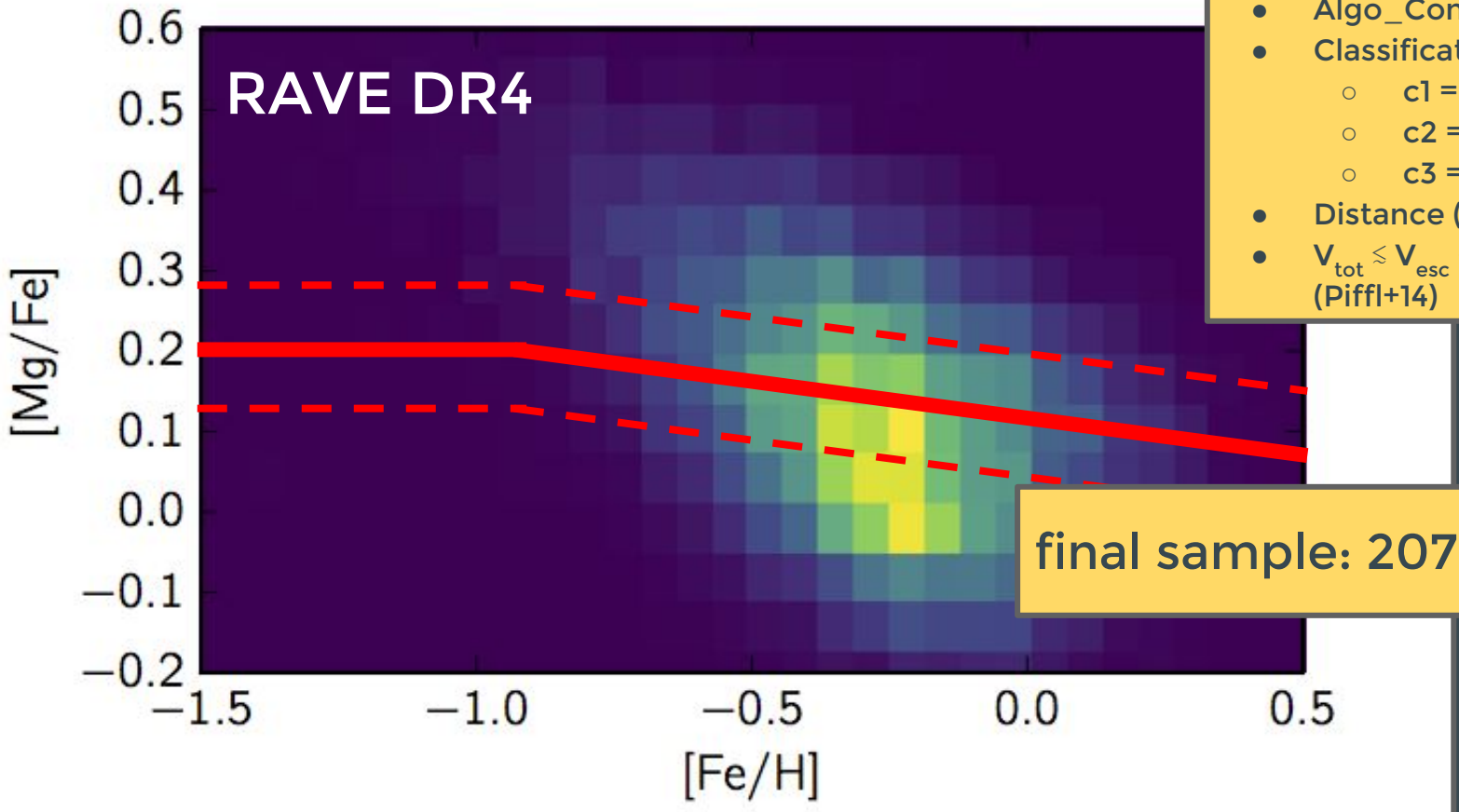




See also: Fuhrmann 11, Adibekyan+13, Bensby+14,Guiglion+15,Hayden+15,Kordopatis+15b

Chemical separation of disc components using RAVE

Probabilistic method



- SNR > 80
- CHISQ_c < 2000
- Algo_Conv_K ≠ 1
- Classification flags:
  - c1 = d,g,h,n,o
  - c2 = d,g,h,n,o,e
  - c3 = d,g,h,n,o,e
- Distance (DR5) < 1 kpc
- $V_{tot} \lesssim V_{esc}$ ~ 492 km/s (Piffl+14)

final sample: 20751 stars

RAVE DR4 abundance measurement errors ≈ 0.2 dex

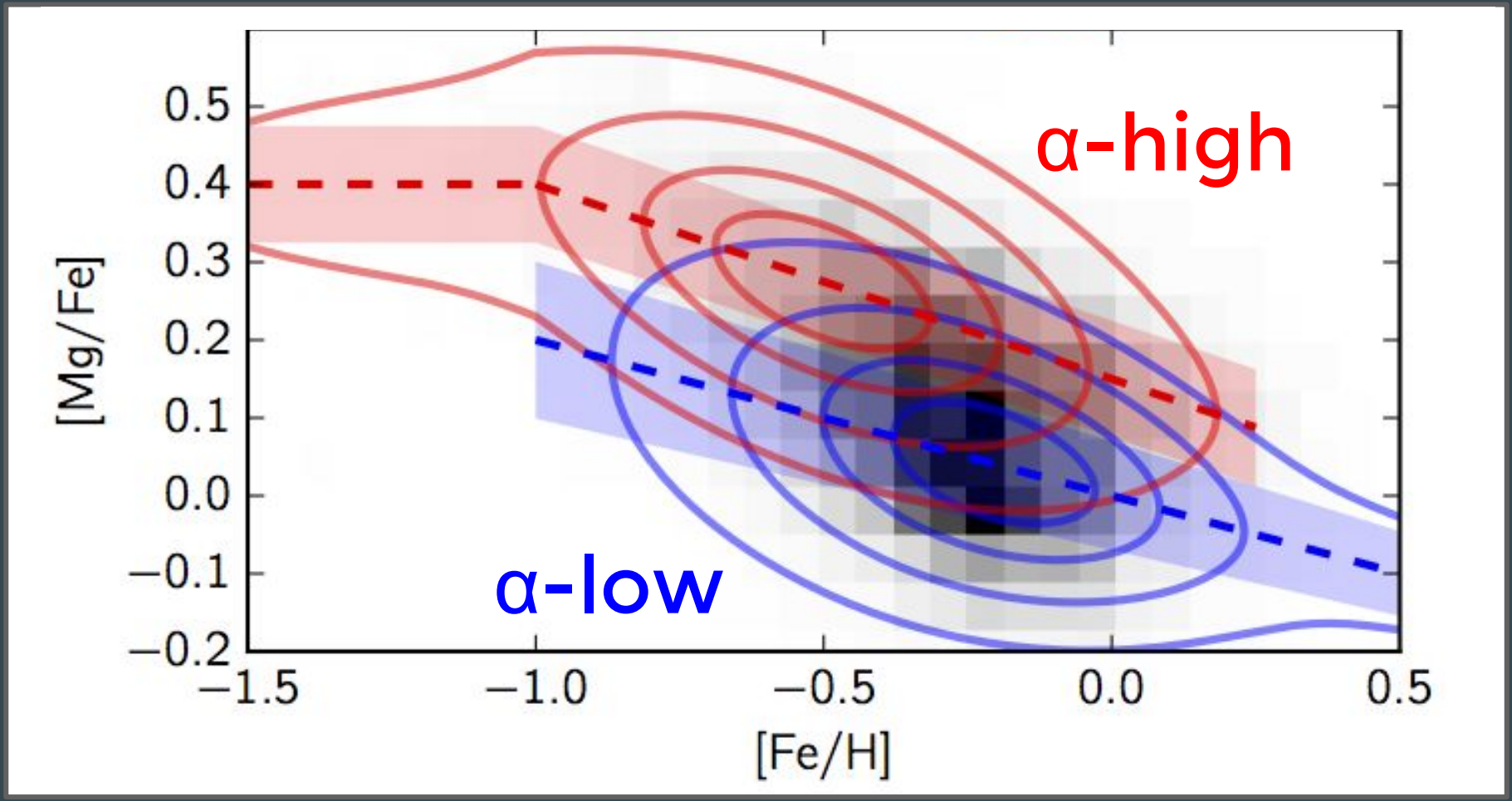
High-res surveys have separation of $\lesssim$ 0.2 dex

→ Need a different approach

Chemical separation of disc components using RAVE

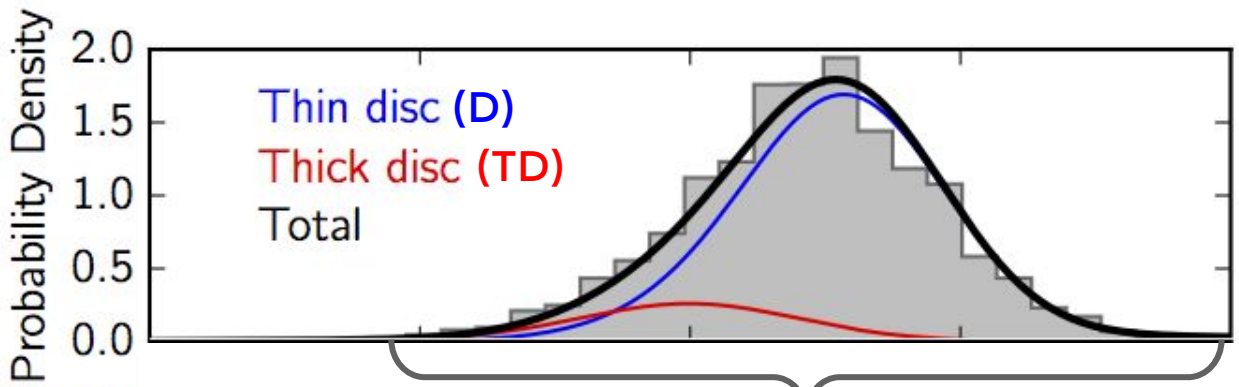
Probabilistic method

$$f([Fe/H], [\alpha/Fe]) = f_{[Fe/H]} \times f_{[Mg/Fe]}$$



Chemical separation of disc components using RAVE

Probabilistic method



MDF

$$f_{[\mathrm{Fe/H}]} = \sum_{i=1}^{n} \frac{a_i}{\sigma_{\mathrm{Fe},i}\sqrt{2\pi}} \exp\left(-\frac{([\mathrm{Fe/H}] - \mu_{\mathrm{Fe},i})^2}{2{\sigma_{\mathrm{Fe},i}}^2}\right)$$

D		TD	
a_1	0.8	a_1	0.9
$\mu_{Fe,1}$	-0.2	$\mu_{Fe,1}$	-0.5
$\sigma_{Fe,1}$	0.18	$\sigma_{Fe,1}$	0.2
a_2	0.15	a_2	0.08
$\mu_{Fe,2}$	-0.4	$\mu_{Fe,2}$	-0.8
$\sigma_{Fe,2}$	0.2	$\sigma_{Fe,2}$	0.4
a_3	0.05	a_3	-
$\mu_{Fe,3}$	0.2	$\mu_{Fe,3}$	-
$\sigma_{Fe,3}$	0.5	$\sigma_{Fe,3}$	-

Sum of 2 (TD) or 3 (D) Gaussians, based on high-res data (Kordopatis+15b)

Chemical separation of disc components using RAVE

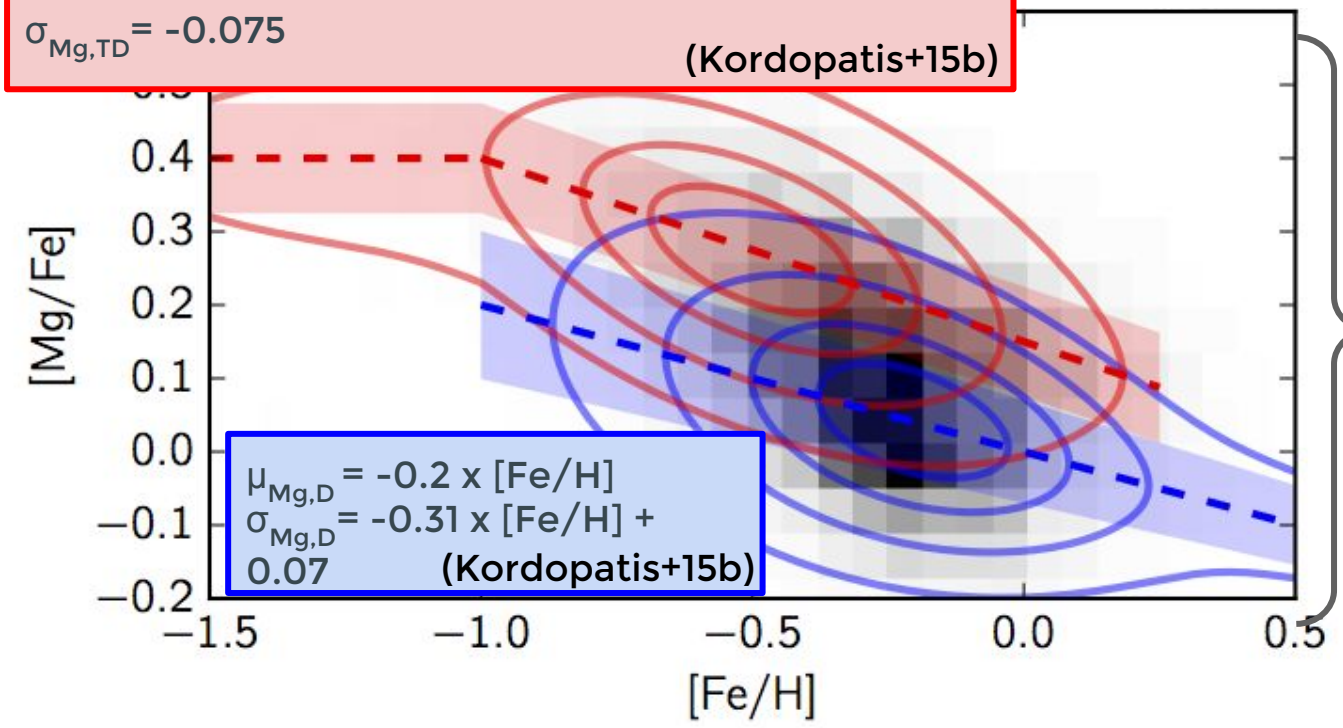
Probabilistic method

$$f_{[\mathrm{Mg/Fe}]} = \frac{1}{\sigma_{\mathrm{Mg}}\sqrt{2\pi}} \exp\left(-\frac{([\mathrm{Mg/Fe}] - \mu_{\mathrm{Mg}})^2}{2{\sigma_{\mathrm{Mg}}}^2}\right)$$

$\mu_{Mg,TD}$ = { -0.4 for [Fe/H] < -1.0; -0.25 x [Fe/H] + 0.15 otherwise

$\sigma_{Mg,TD}$ = -0.075

(Kordopatis+15b)



$\mu_{Mg,D}$ = -0.2 x [Fe/H]

$\sigma_{Mg,D}$ = -0.31 x [Fe/H] + 0.07

(Kordopatis+15b)

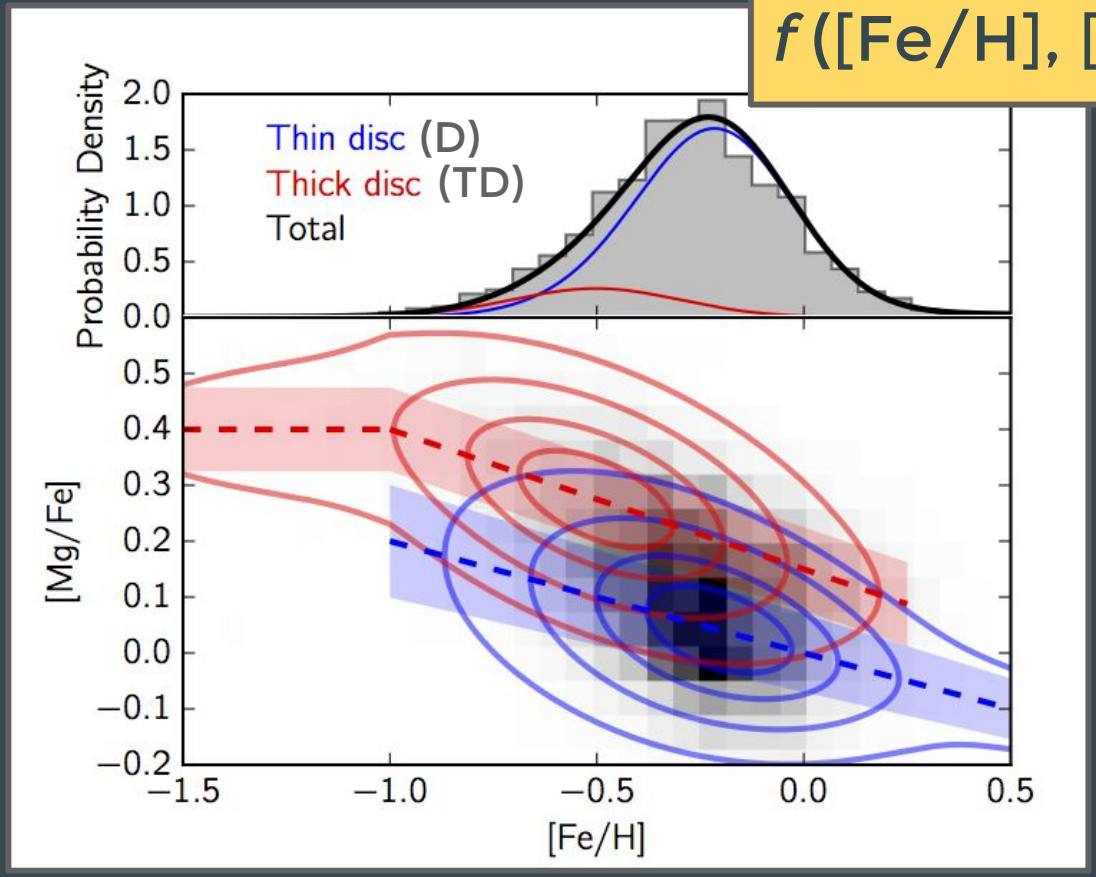
αDF

Single Gaussian for each component, $\mu_{[Mg/Fe]}$ and $\sigma_{[Mg/Fe]}$ functions of [Fe/H]

Based on high-res data

Chemical separation of disc components using RAVE

Probabilistic method



$$f([Fe/H], [\alpha/Fe]) = f_{[Fe/H]} \times f_{[Mg/Fe]}$$

MDF

Sum of 2 (TD) or 3 (D) Gaussians, based on high-res data

αDF

Single Gaussian for each component, $\mu_{[Mg/Fe]}$ and $\sigma_{[Mg/Fe]}$ functions of [Fe/H]

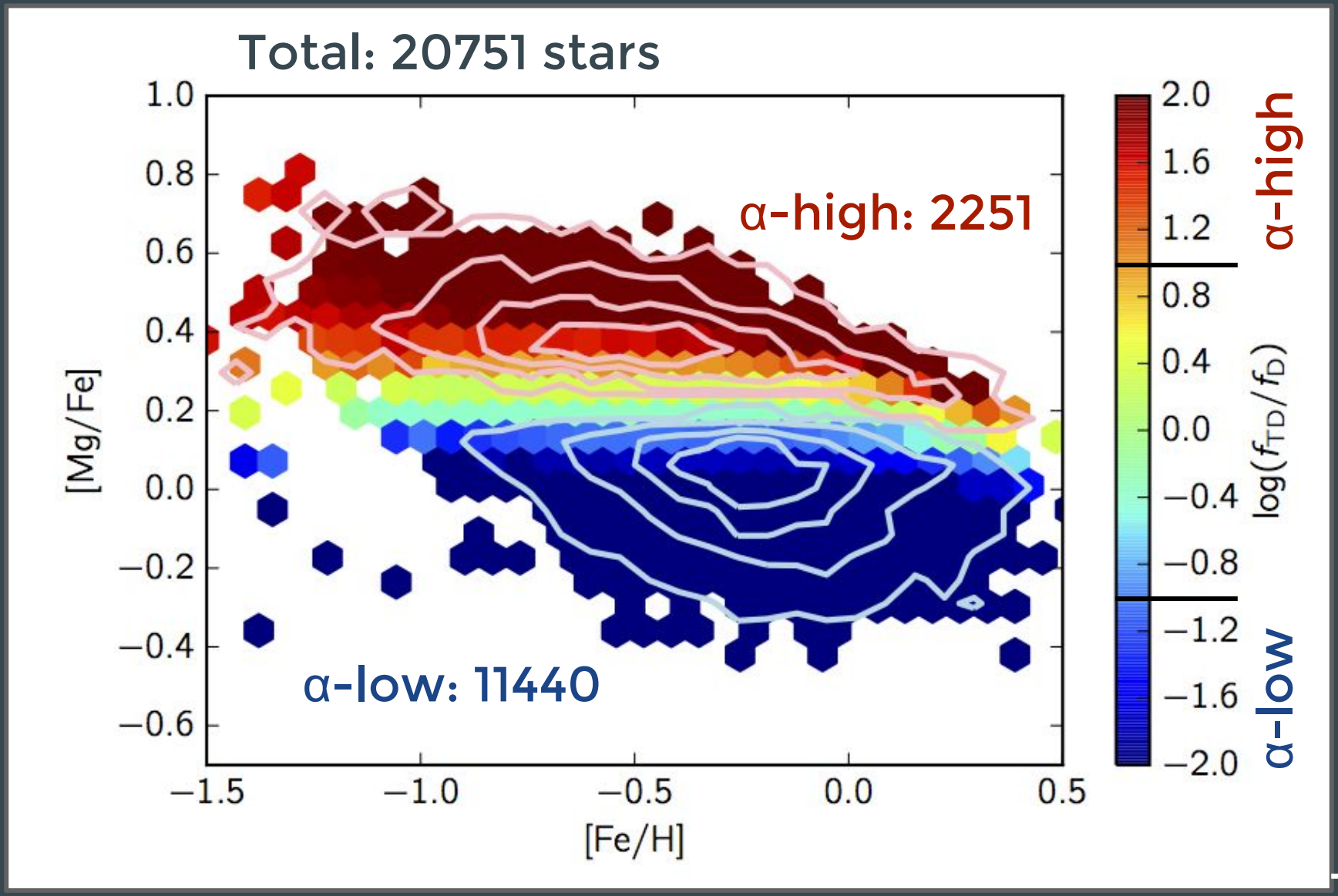
Based on high-res data

TD/D > 10 → thick disc (α-high)

TD/D < 0.1 → thin disc (α-low)

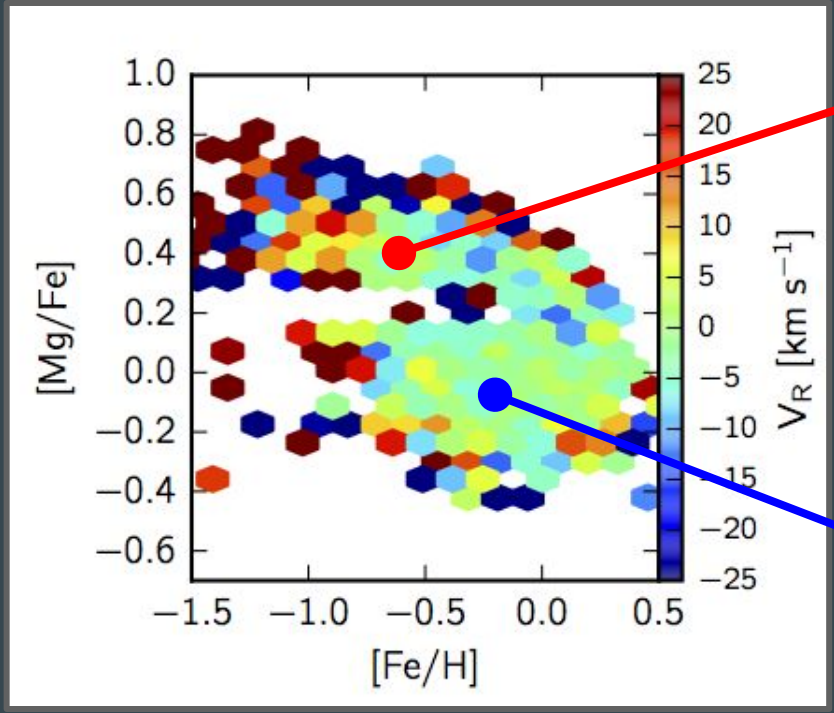
Chemical separation of disc components using RAVE

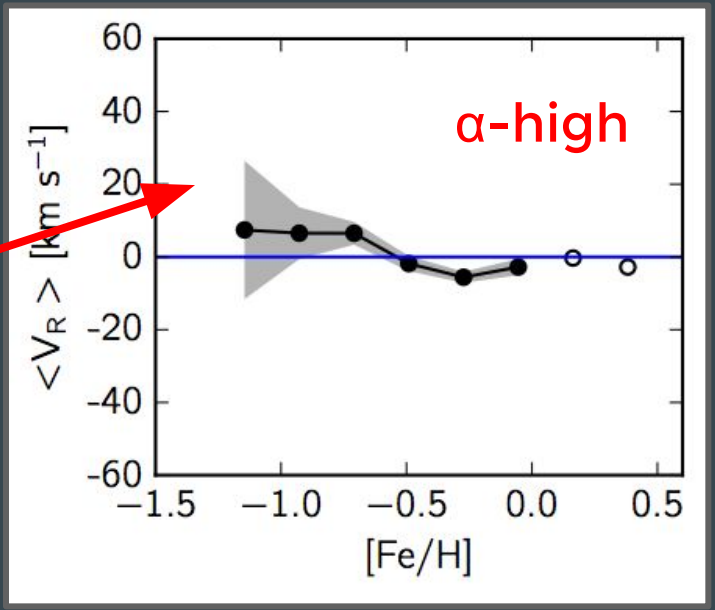
Probabilistic method

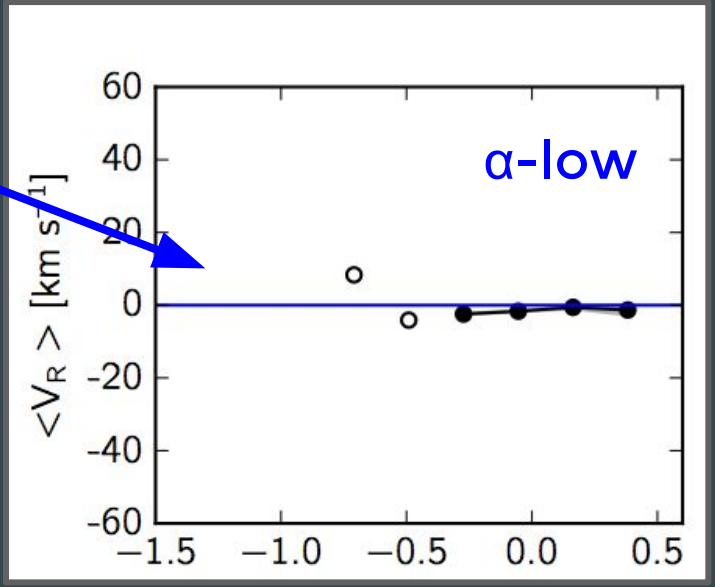


Chemical separation of disc components using RAVE

Results: kinematics



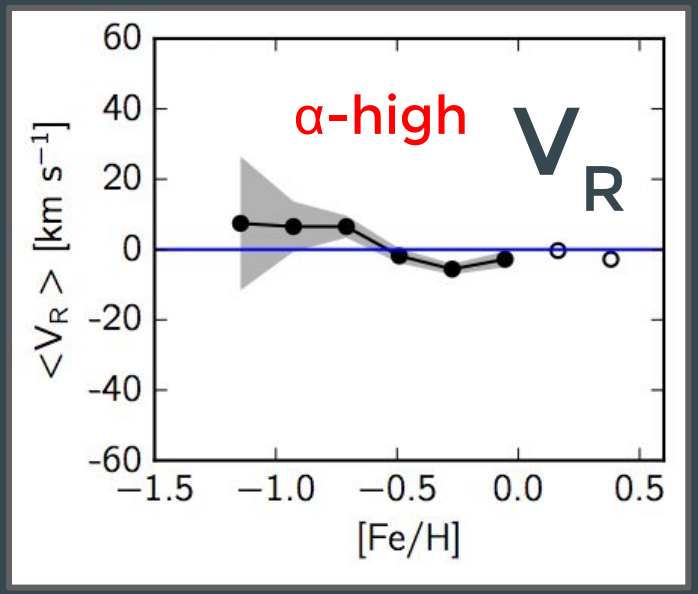


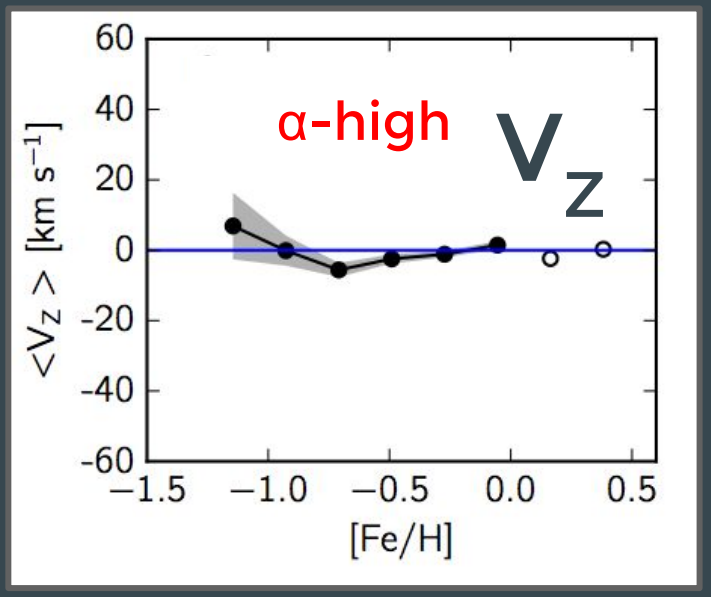


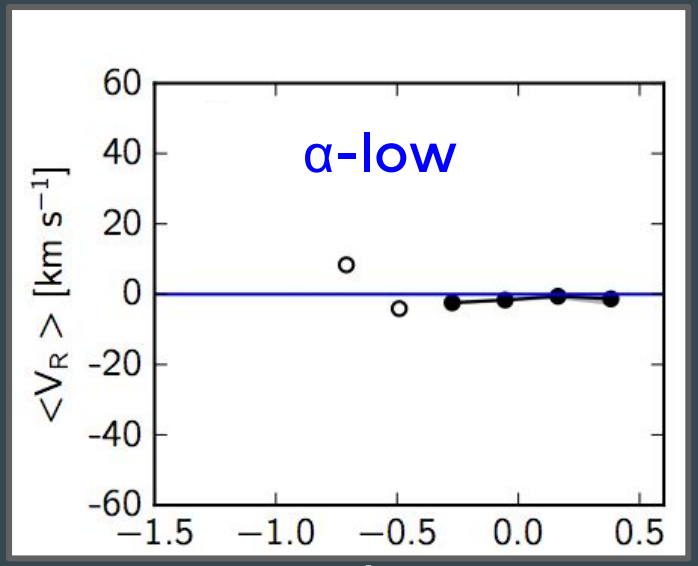
V_R

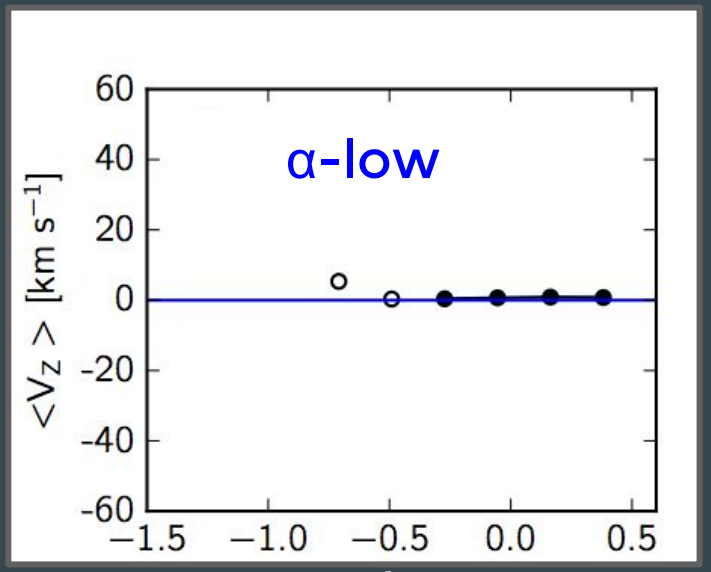
Chemical separation of disc components using RAVE

Results: kinematics



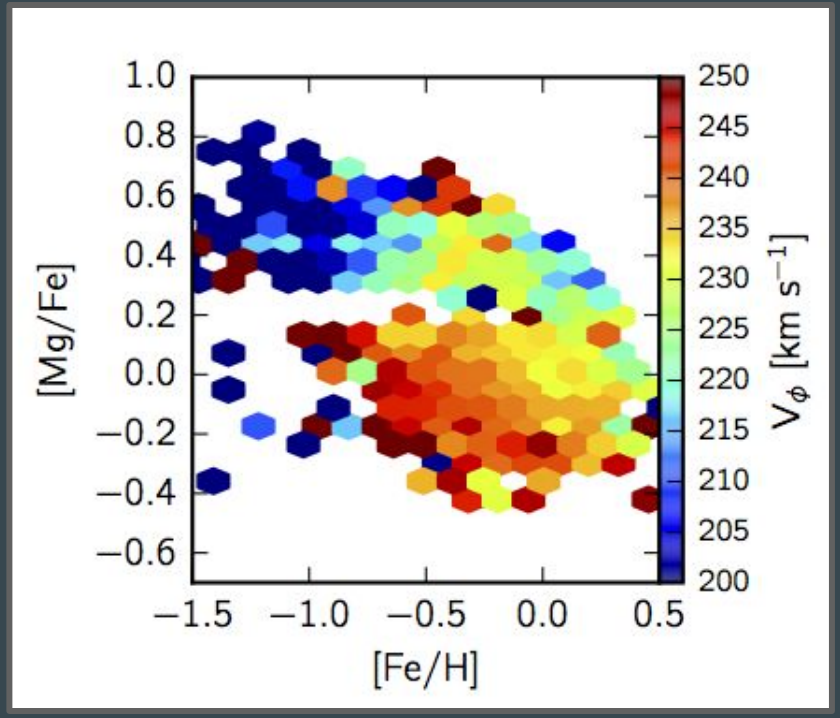


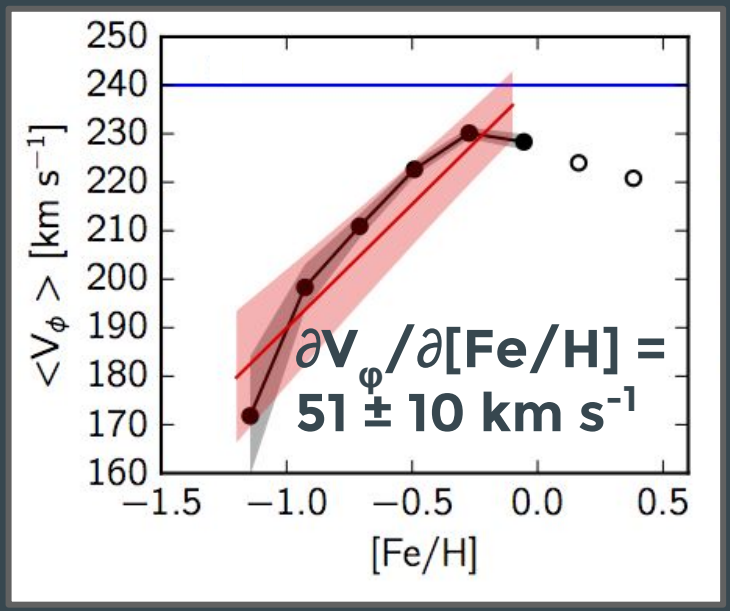


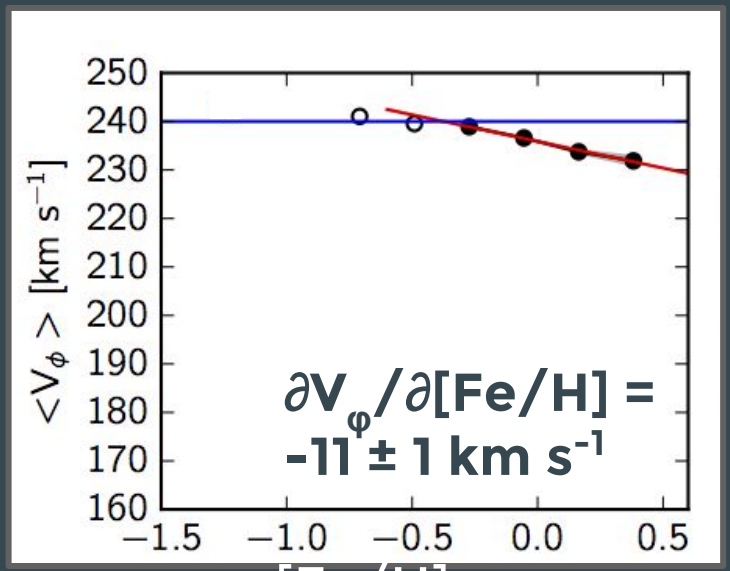


Chemical separation of disc components using RAVE

Results: kinematics



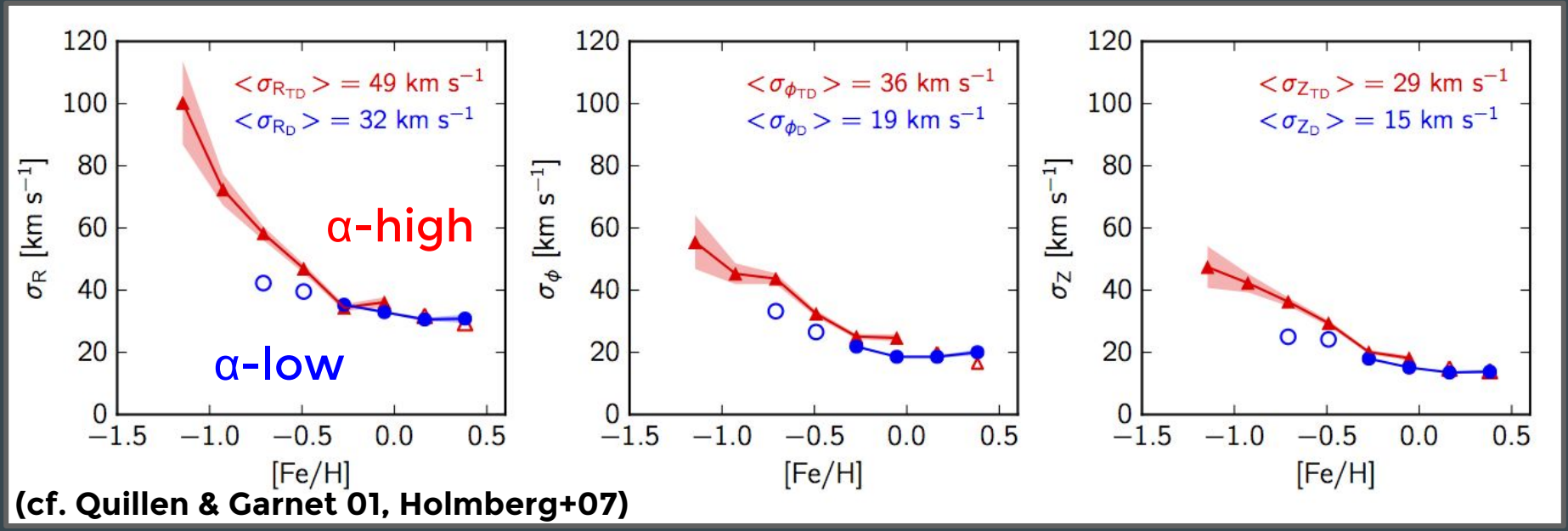




V_φ

Chemical separation of disc components using RAVE

Results: kinematics



(cf. Quillen & Garnet 01, Holmberg+07)

Results: scale lengths

$$h_R = \frac{2R\sigma_R^2}{V_c^2 - \langle V_\varphi^2 \rangle + \sigma_R^2 - \sigma_\varphi^2 - \sigma_Z^2}$$

h_R (D) = 4.8 ± 0.2 kpc

(cf. Robin+03, Juric+08, Bovy+12)

h_R (TD) = 3.4 ± 0.1 kpc

(cf. Bensby+11, Bovy+15)

Chemical separation of disc components using RAVE

Conclusions

- Two versions of the selection function(field-by-field and equal area)
- Mock-RAVE catalogue using Galaxia
  - Small kinematic biases, mostly to hot dwarfs
  - Metallicities relatively unbiased

- Chemically separated disc components
  - Not sensitive to reasonable estimates of thin/thick disc ratio
  - No difference between dwarfs/giants
  - Chemical thick disc scale length longer than thin disc
  - Method can be extended to other data sets where it is not possible to resolve two separate components a priori

Further applications

- RAVE-TGAS
  - Stellar parameters, chemical abundances for ~200k Tycho2 stars
  - Better distances, proper motions, will give better grasp on kinematics