The Metallicity Distribution Function of the disc with Gaia DR1+RAVE

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Importance of the MDF
(and link with V_ϕ)

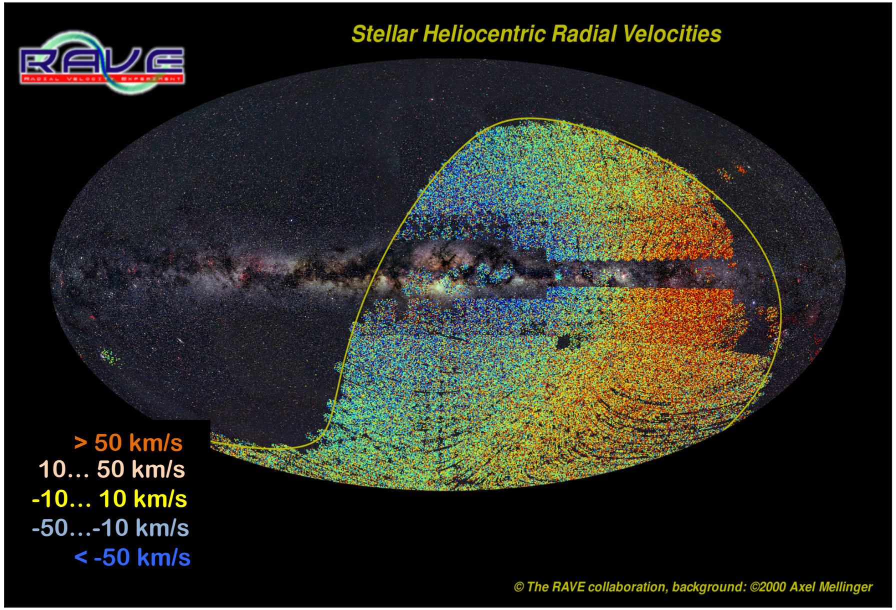
- Metallicity distribution function:
    - Radial and Vertical changes
  - ➢ Integrated star formation history
  - ➢ Hints of Radial migration (orbits desired)
  - ➢ Related to scale-lengths and scale-heights of the discs
    - Thick Disc formation scenarios
      - Cloud collapse?
      - Accretion of stars?

➔ How does the MDF change when Gaia-DR1 is taken into account?

RAVE: 5th public data release

Kunder, Kordopatis et al. 2017

- Intermediate resolution (R~7500)
- 457 588 stars,
- 520 781 spectra *(DR4: 482 430 stars)*
- 9 <I< 12 mag



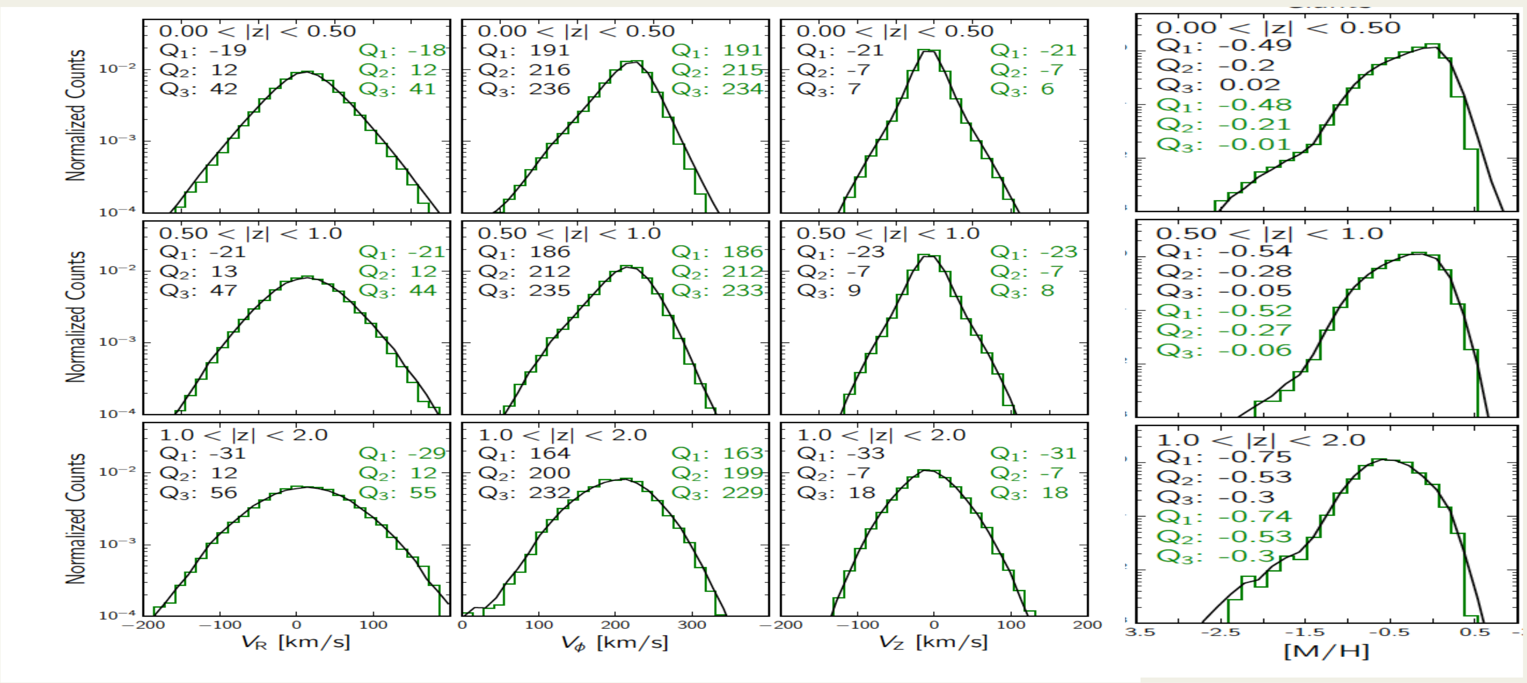
Database:

- ✓ **Radial velocities**
- ✓ **Spectral morphological flags**
- ✓ **T_{eff}, logg, [M/H]**
- ✓ **Line-of-sight Distances**
- ✓ ***Mg, Al, Si, Ti, Ni, Fe***
- ✓ **Photometry**: *2MASS, APASS*
- ✓ **Proper motions:** UCAC4, *UCAC5, HSOY, PPMXL, Tycho-2, TGAS*

RAVE DR5: selection function

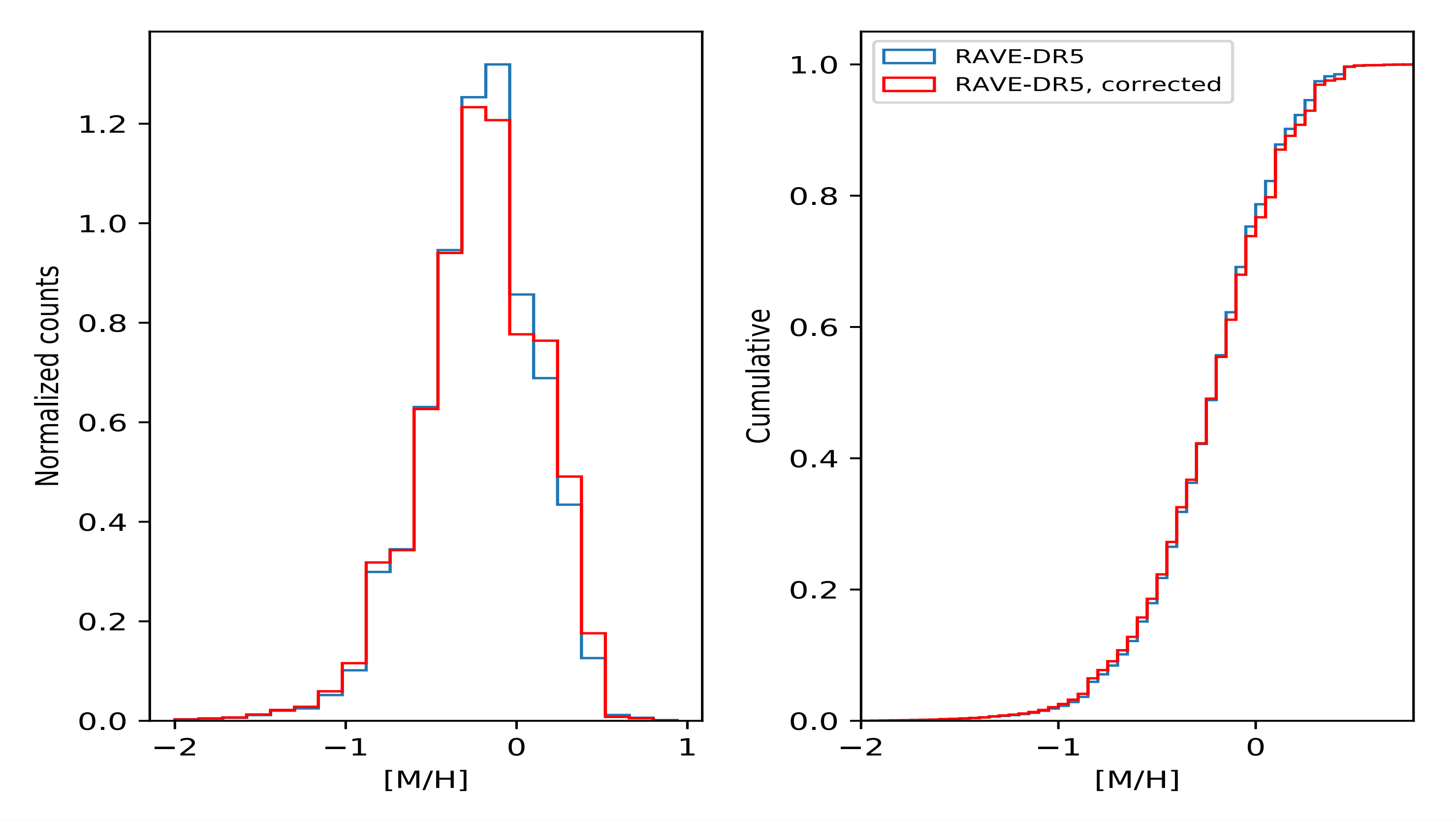
Wojno, Kordopatis et al. (2017)

Kinematically and chemically unbiased for 9<I<12



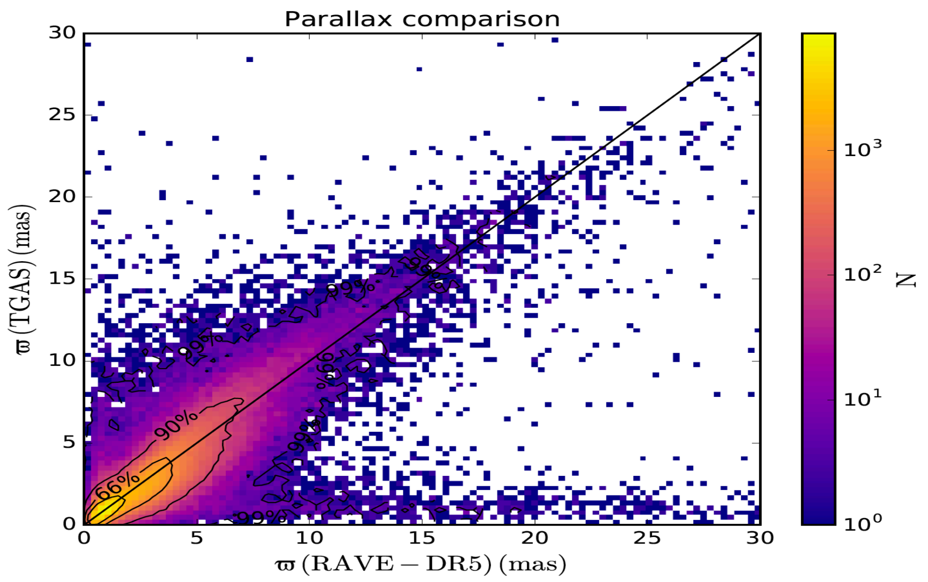
Parent sample
Mock RAVE

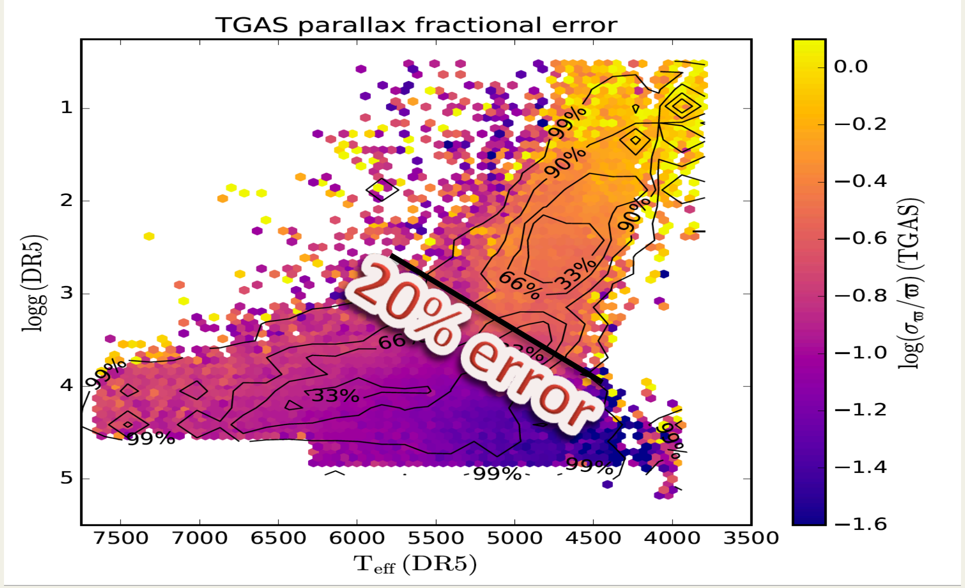
RAVE DR5: Corrected MDF



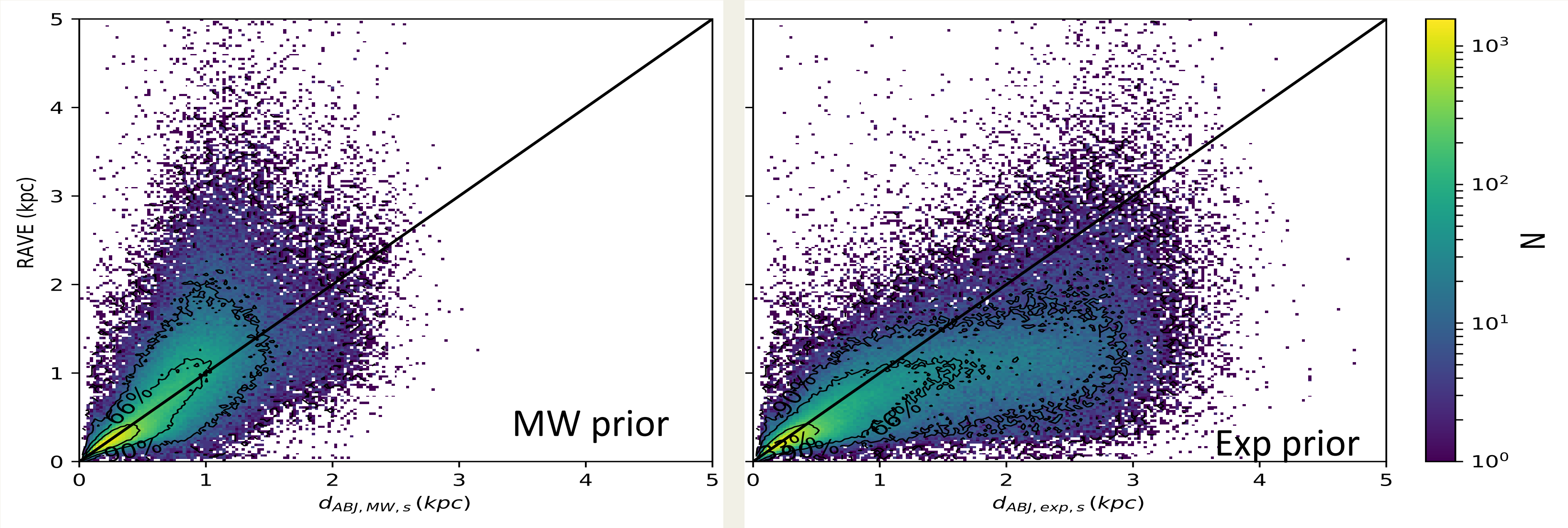
RAVE-TGAS catalogue

- *215 590 targets*





RAVE-TGAS catalogue
Astraatmadja & Bailer-Jones distances



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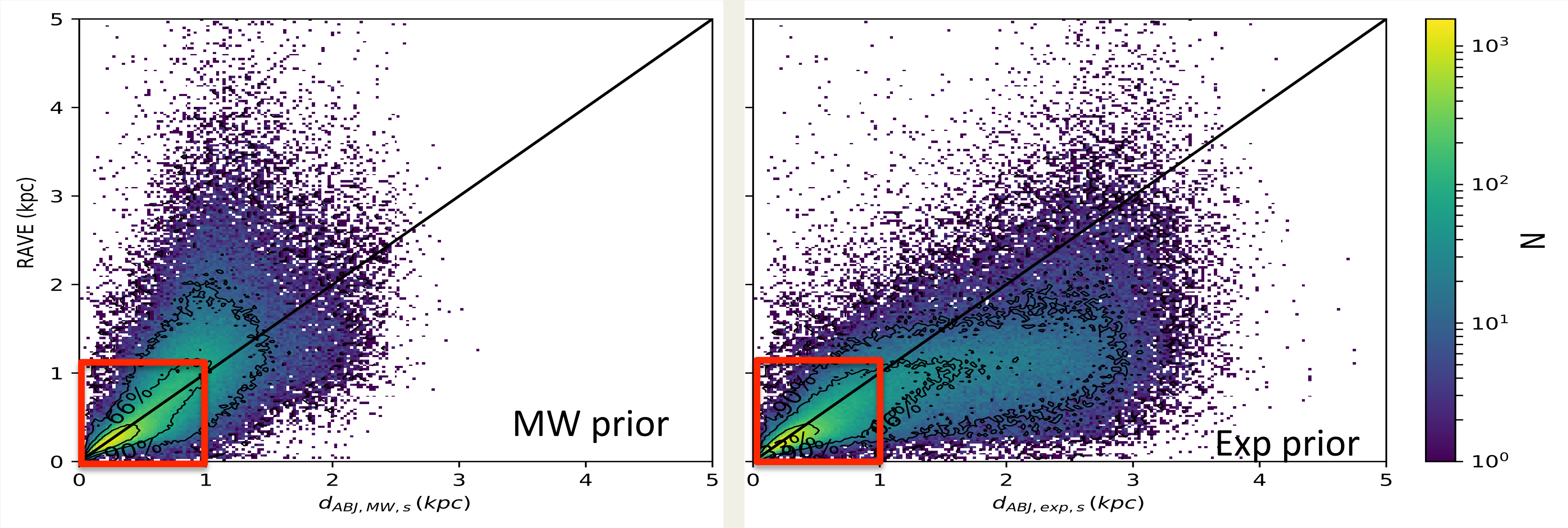

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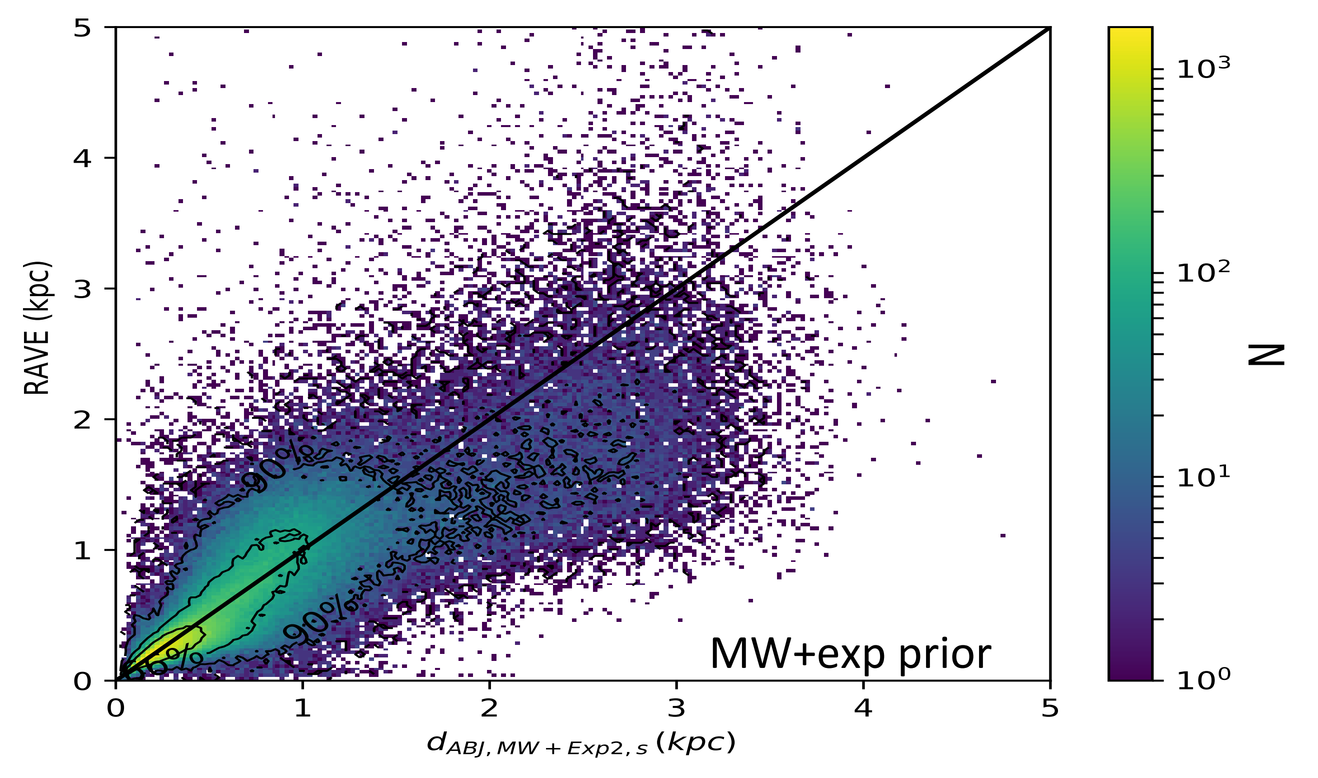
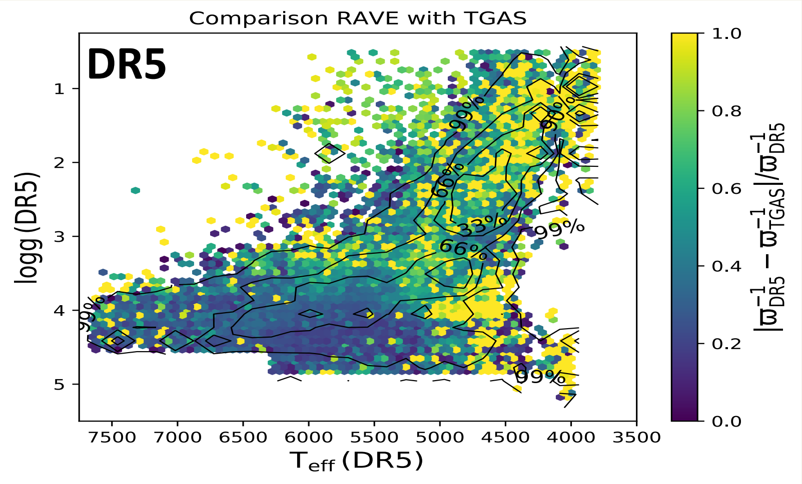
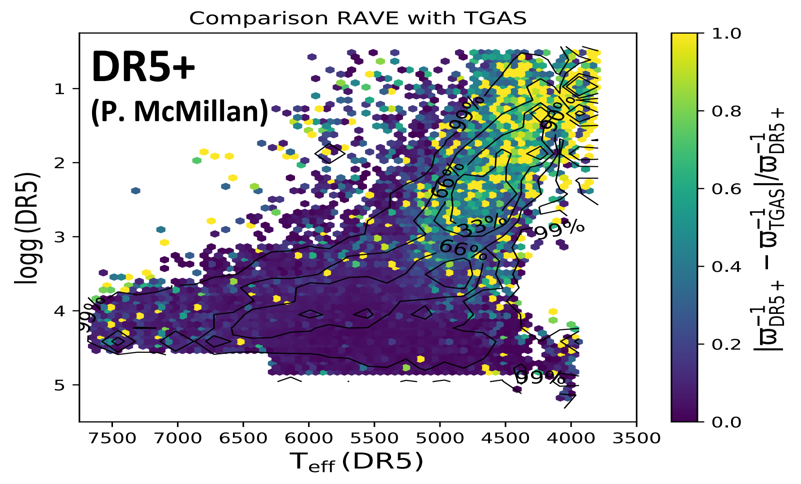


New distances for the RAVE-TGAS catalogue

- New distances *(c.f. P. McMillan's poster **C22**)*
  - ➔Use of T_{eff}, logg, [M/H] + ϖ + underlying Galactic model
    - ➢ 200% better than RAVE DR5 alone
    - ➢ 55% better than TGAS alone (logg<3.5)





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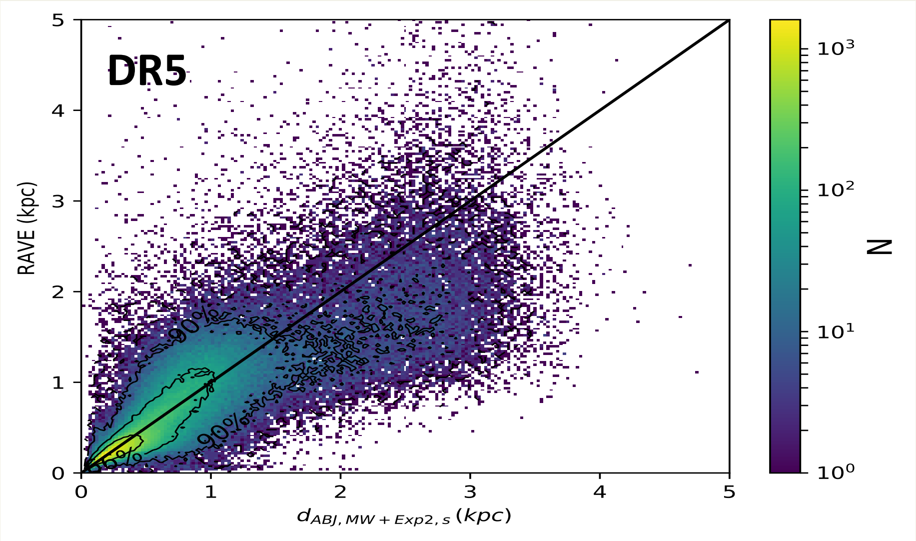
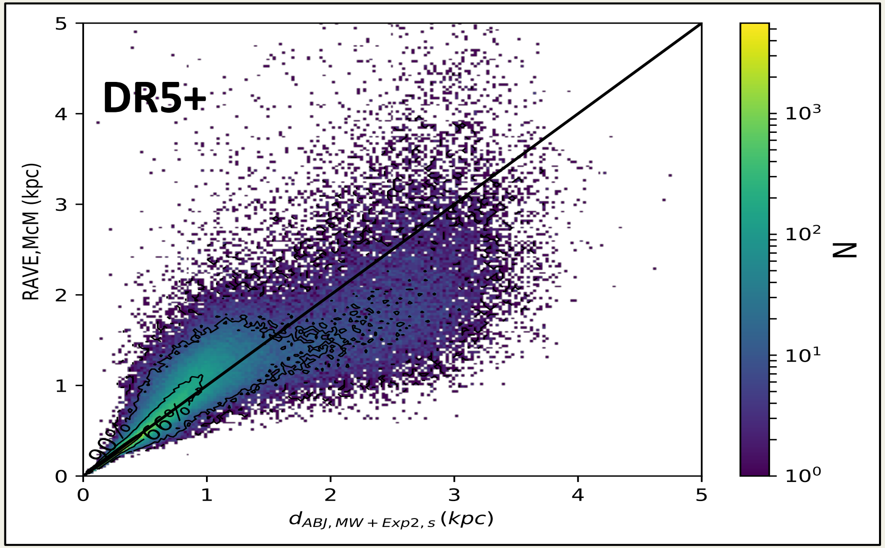
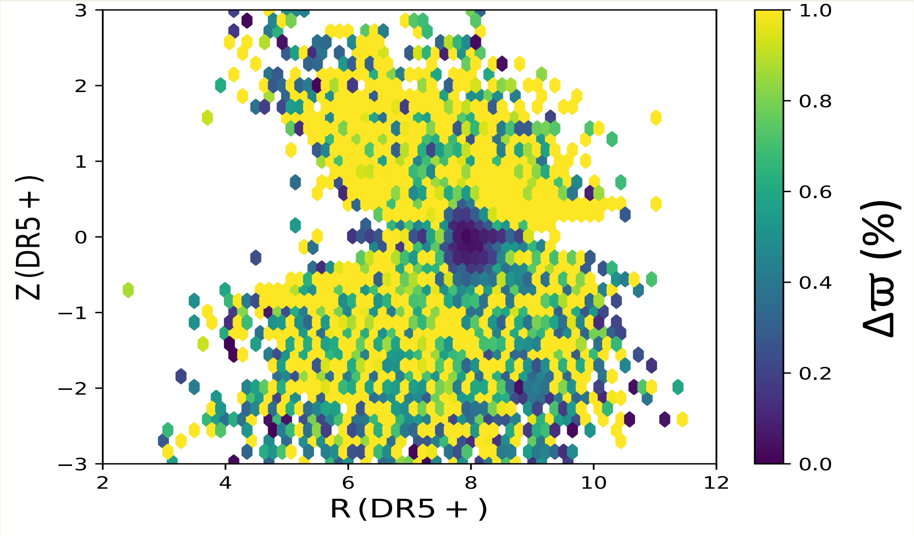
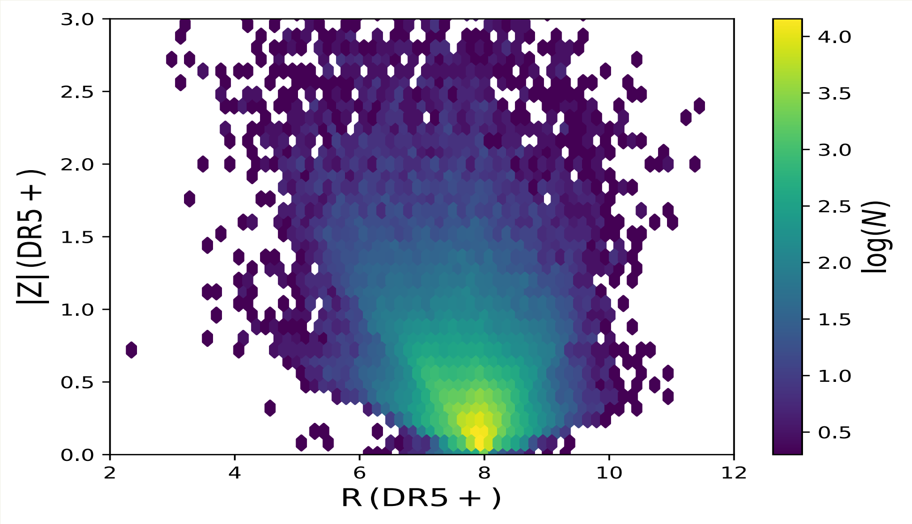




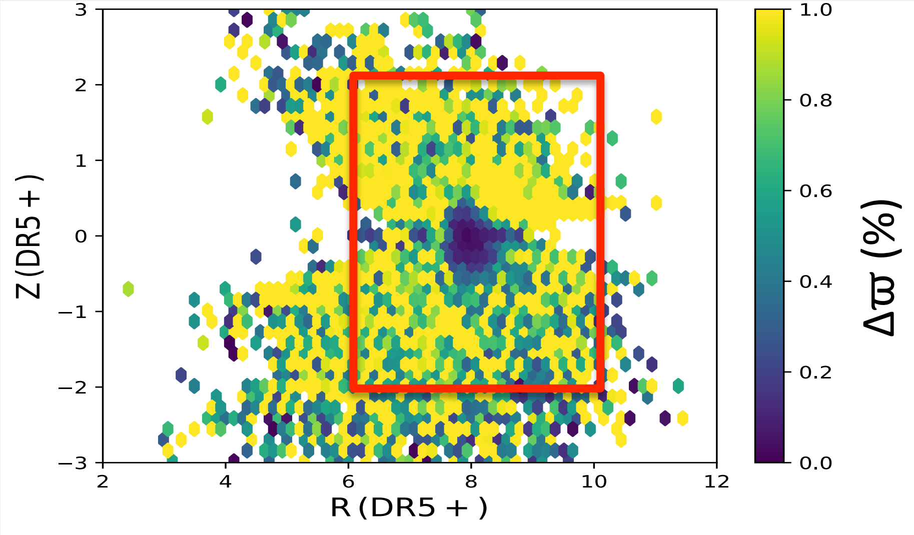
New distances for the RAVE-TGAS catalogue

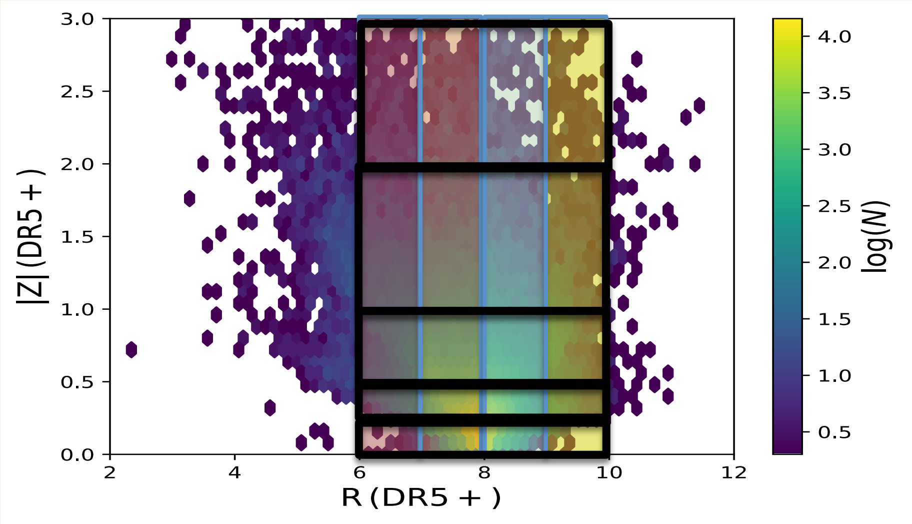




Metallicity Distribution Function

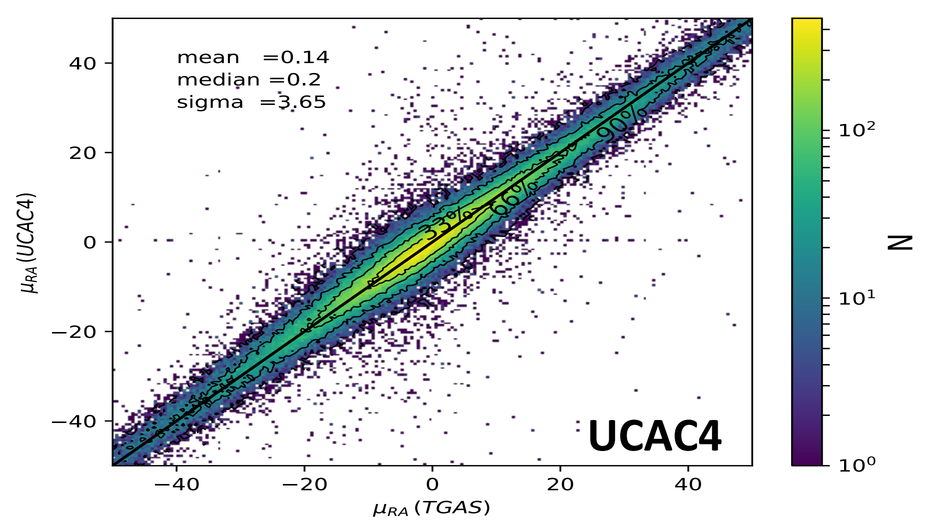
- 5 Radial distance bins:
  - 6<R<7 kpc, 7<R<8 kpc, 8<R<9 kpc, 9<R<10 kpc
- 5 Vertical bins:
  - 0<|Z|<0.25 kpc, 0.25<|Z|<0. 5 kpc, 0.5<|Z|<1 kpc, 1<|Z|<2 kpc, , 2<|Z|<3 kpc

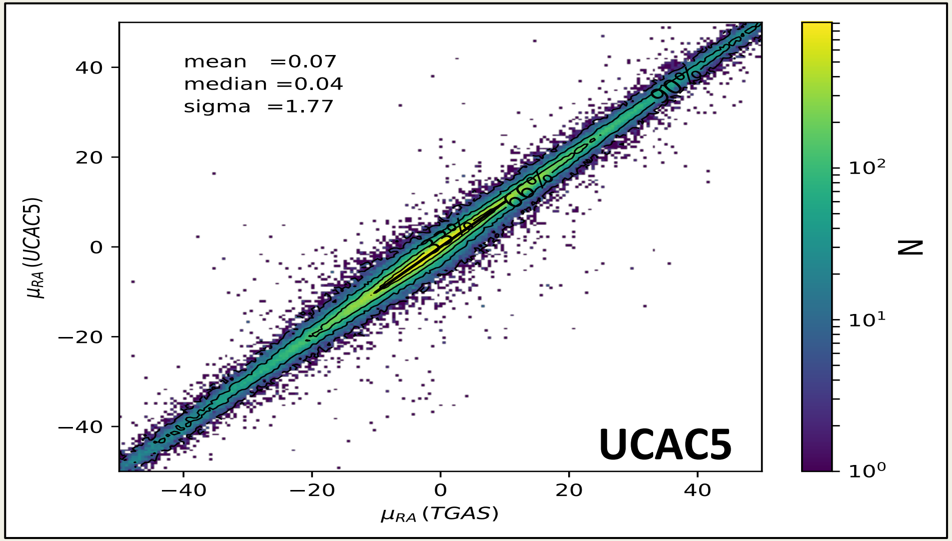




TGAS & UCAC5

- *UCAC5* (Zacharias et al. 2017): Improved p.m. for the TGAS stars, and new pm for the rest of the catalogue, based on Gaia-DR1 positions





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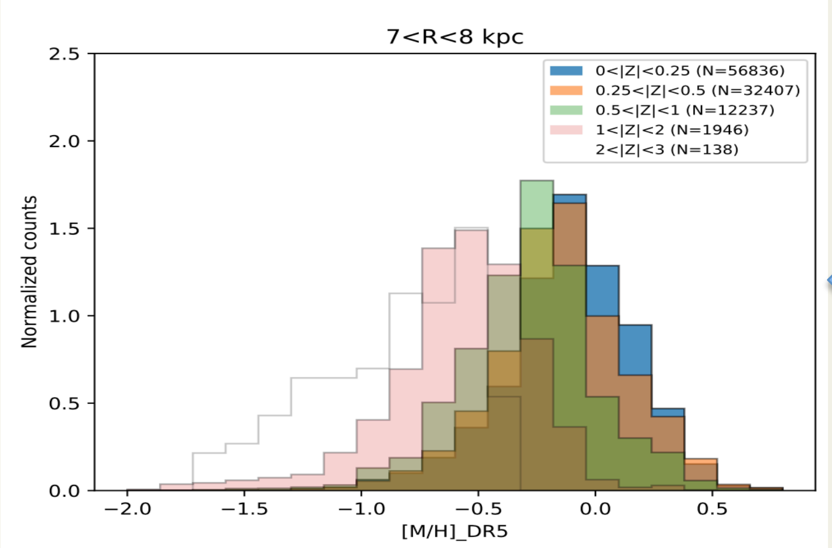
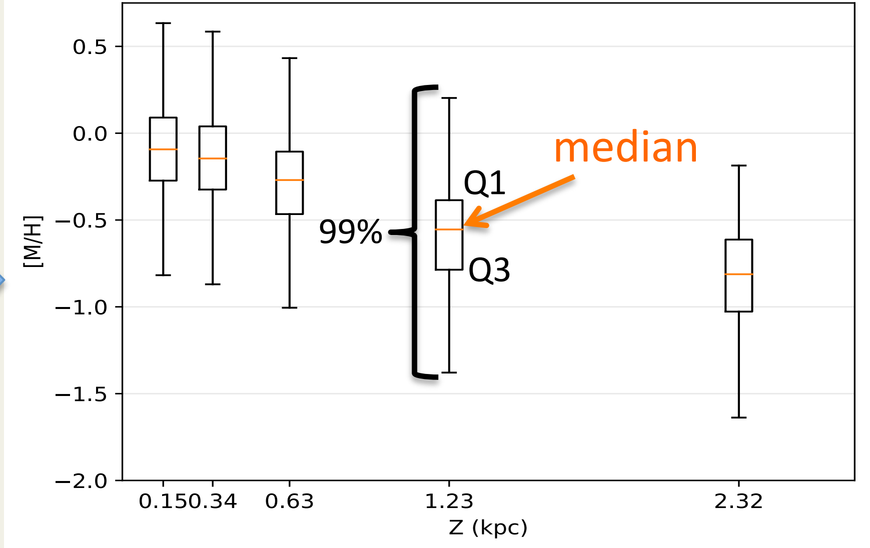
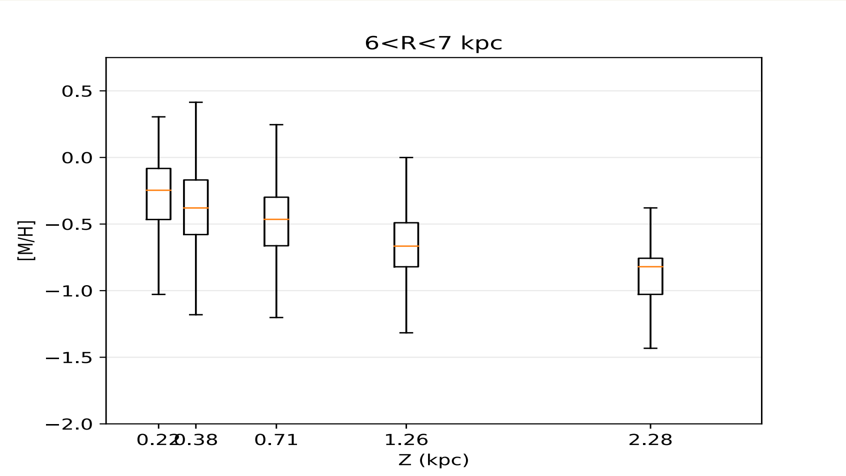
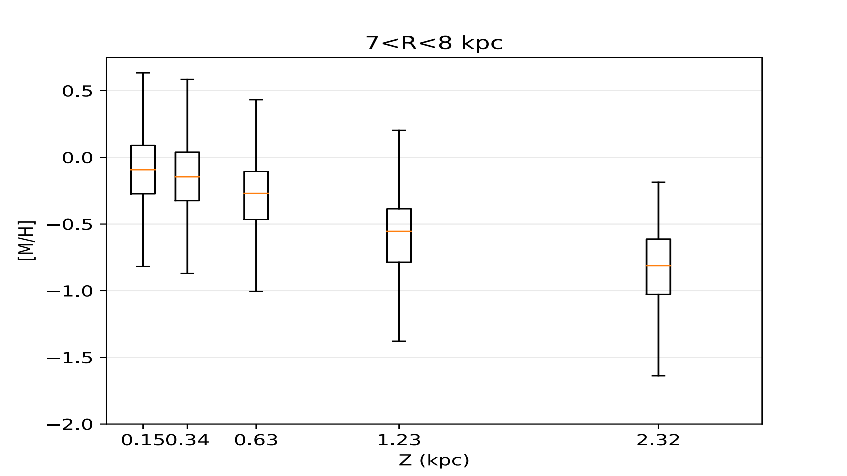


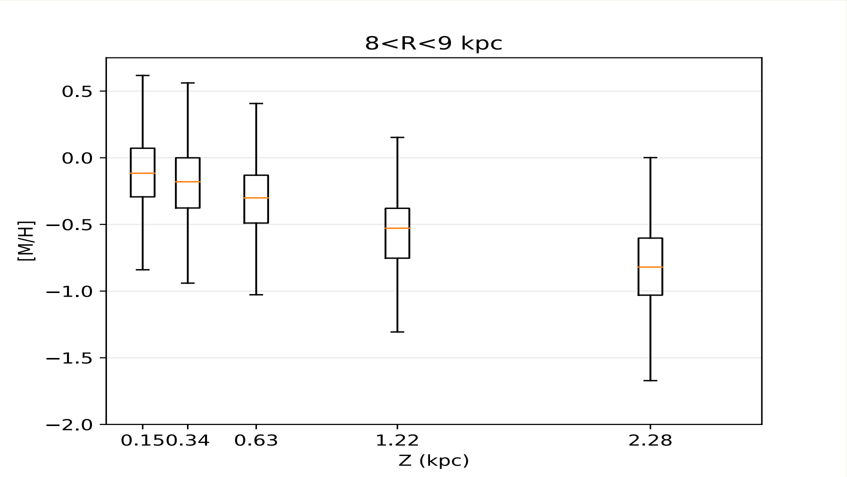


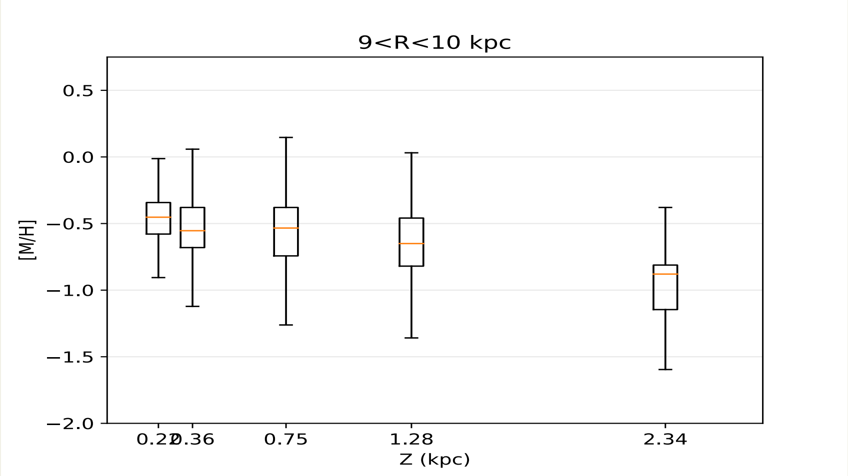
- MDFs are not Gaussian, even for a single population.
  - Multi-Gaussian decomposition,
  - chemical ([α/Fe]) decomposition,
  - kinematic decomposition

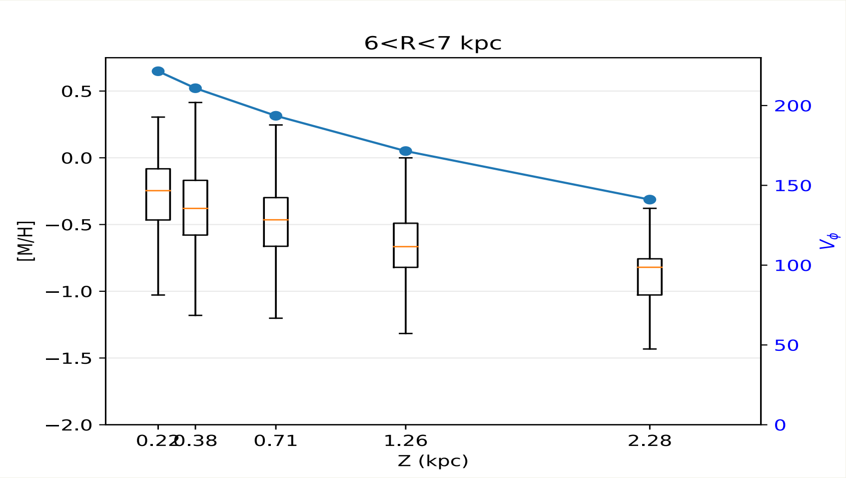


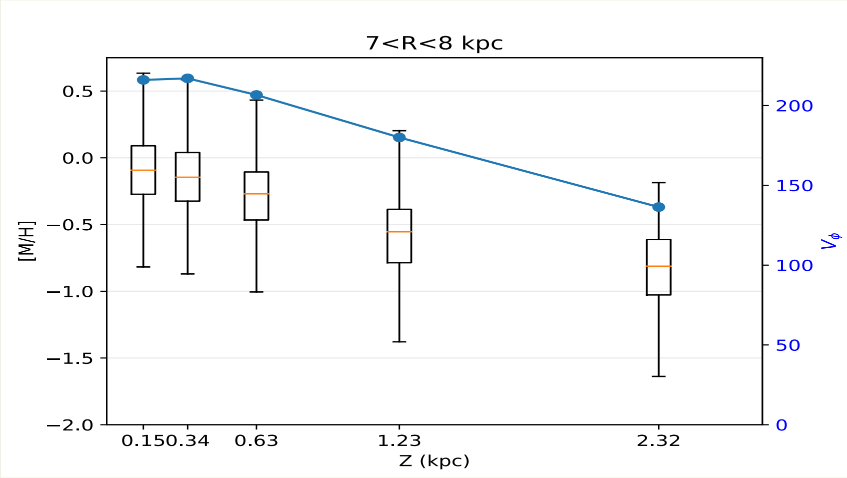


RAVE-DR5(McM) + UCAC5









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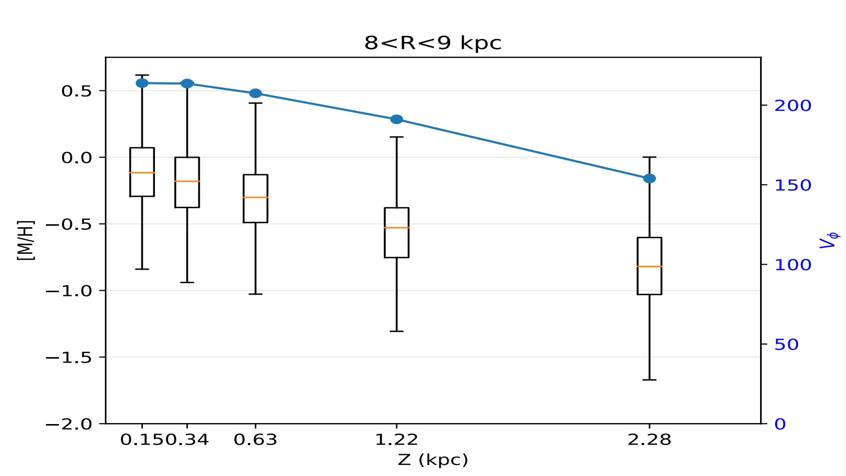
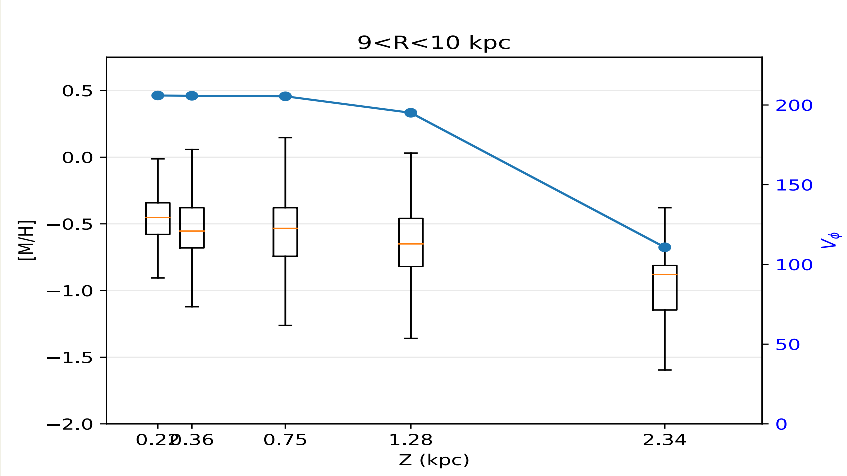
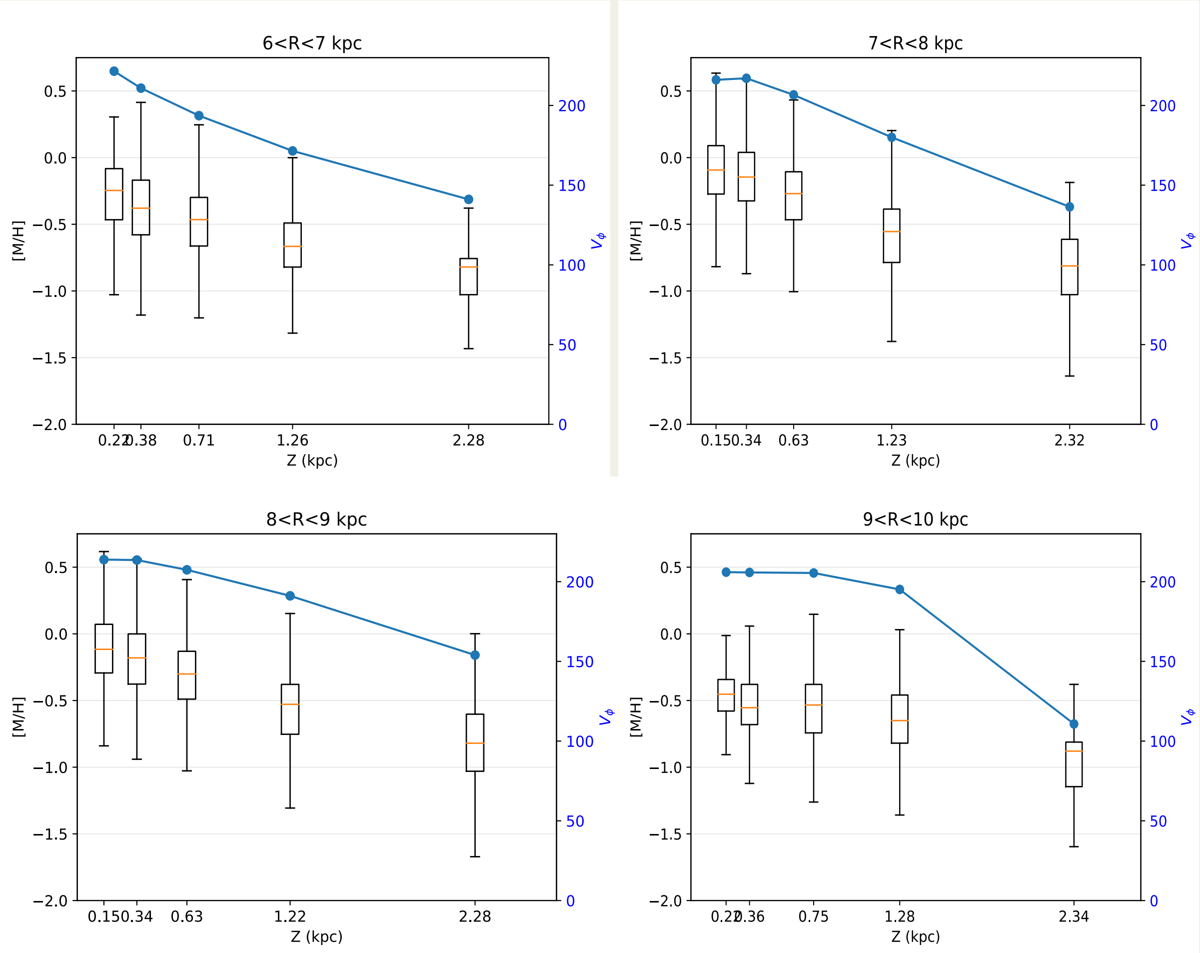
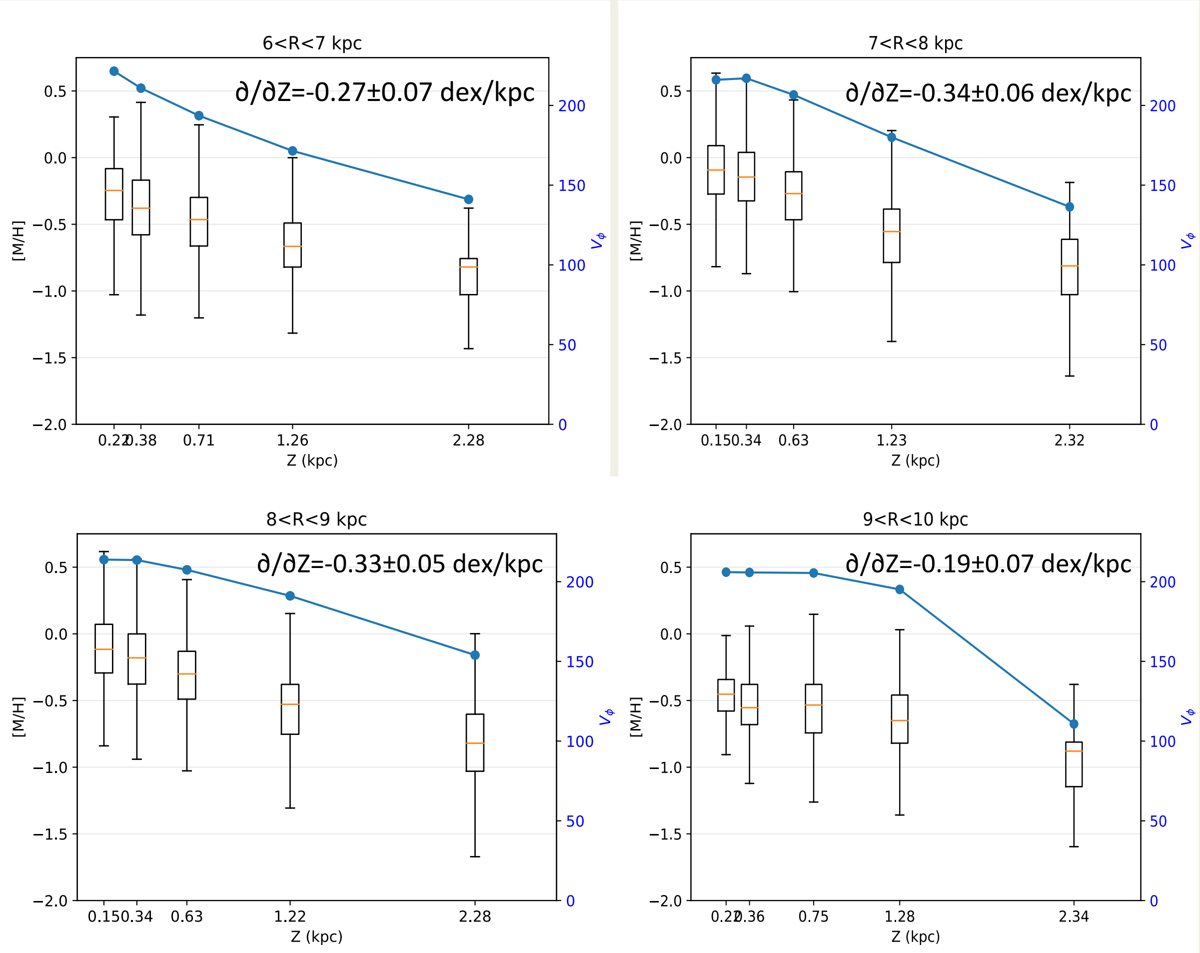




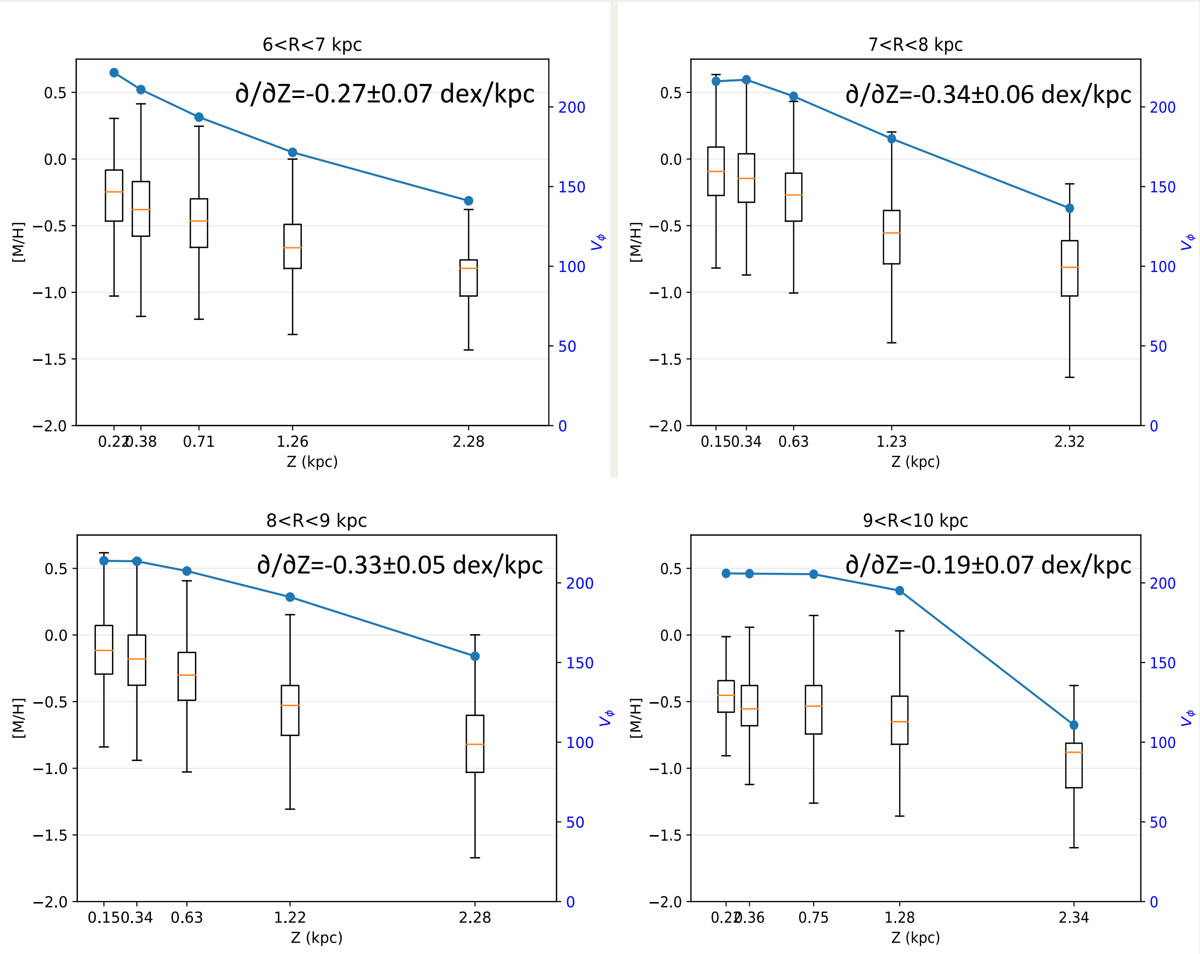


- MDFs at 7<R<8 kpc & 8<R<9kpc very similar



- MDFs at 7<R<8 kpc & 8<R<9kpc very similar
- outside this range biases exist, but vertical gradients excluding the closest bins agree

➔Schlesinger et al. 2014 (using SEGUE's G dwarfs): -0.243 ± 0.05 dex/kpc



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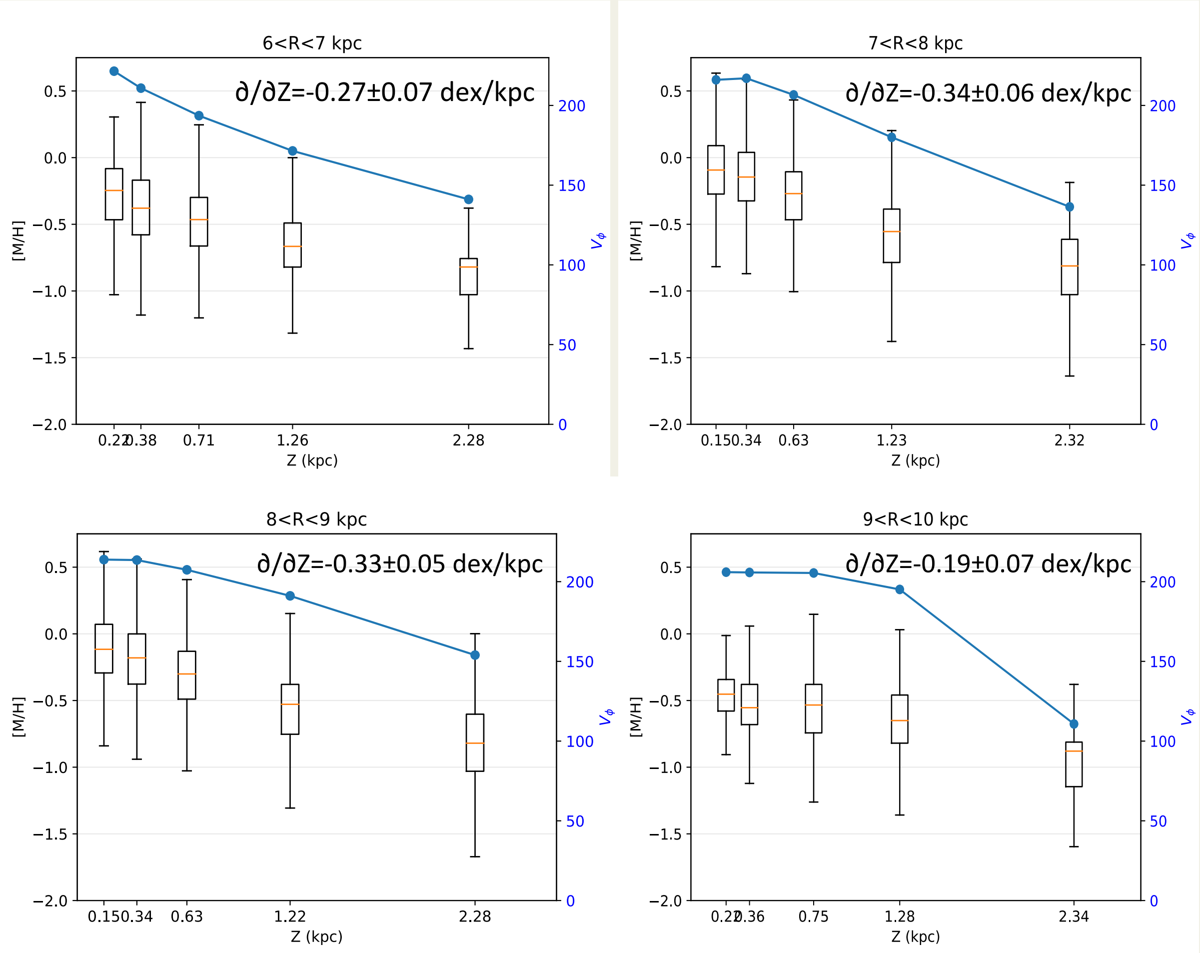
- signs of flaring of the thin disc at the outer regions



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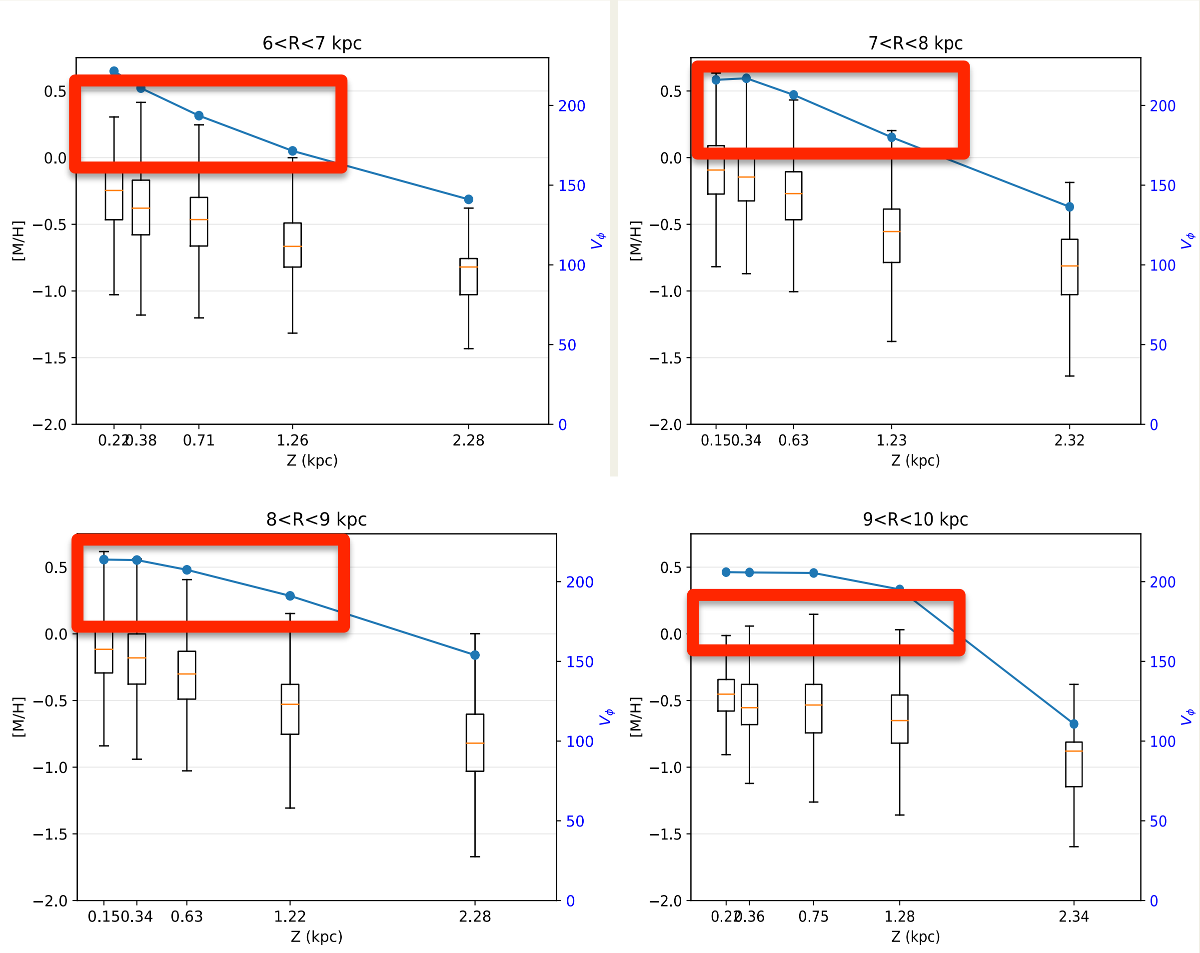
Compared to pre-Gaia results: smoother gradients, very well characterised correlations between V_ϕ and [M/H], no indication of inversion of the skewness (see Hayden et al. 2015), but need to correct for the selection function



SMR stars seen up to 1kpc from the plane, within 6<R<9 kpc
Stars with [M/H]~0.4 dex
➔ formed at very small Galactocentric radii

Super-Solar metallicity stars →Eccentricity determination

Same procedure as in Kordopatis et al. 2015

3 discs: $$\rho(R,z) = \frac{\Sigma_0}{2z_d} \exp\left[-\left(\frac{R_h}{R} + \frac{R}{R_d} + \frac{|z|}{z_d}\right)\right]$$

2 spheroids:

$$\rho(R,z) = \frac{\rho_0}{m^\gamma (a+m)^{\beta-\gamma}} \exp[-(m r_0/r_{cut})^2]$$

$$m(R,z) \equiv \sqrt{(R/r_0)^2 + (z/q r_0)^2}$$

Table 1. Parameters for the adopted mass model of the Milky Way.

Disc	Thick	Thin	Gas
Σ_0 ($M_\odot$ kpc^{-2})	7.30×10^7	1.11×10^9	1.14×10^8
R_d (kpc)	2.4	2.4	4.8
z_d (kpc)	1.0	0.36	0.04
R_h (kpc)	0	0	4
Spheroid	Dark halo	Bulge	
ρ_0 ($M_\odot$ kpc^{-3})	1.26×10^9	7.56×10^8	
q	0.8	0.6	
γ	−2	1.8	
β	2.21	1.8	
r_0 (kpc)	1.09	1	
r_{cut} (kpc)	1000	1.9	

(Dehnen & Binney 98, Binney12)

Super-Solar metallicity stars
→Eccentricity determination

Same procedure as in Kordopatis et al. 2015

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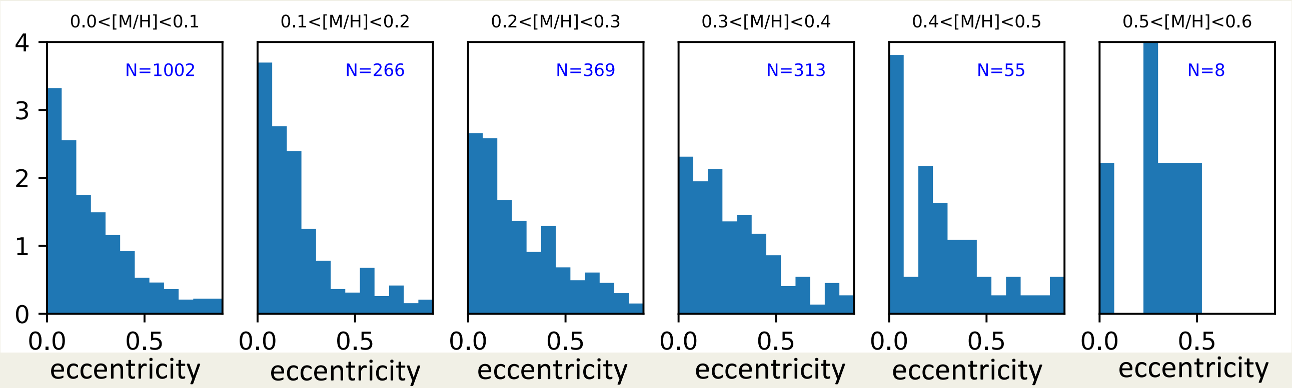
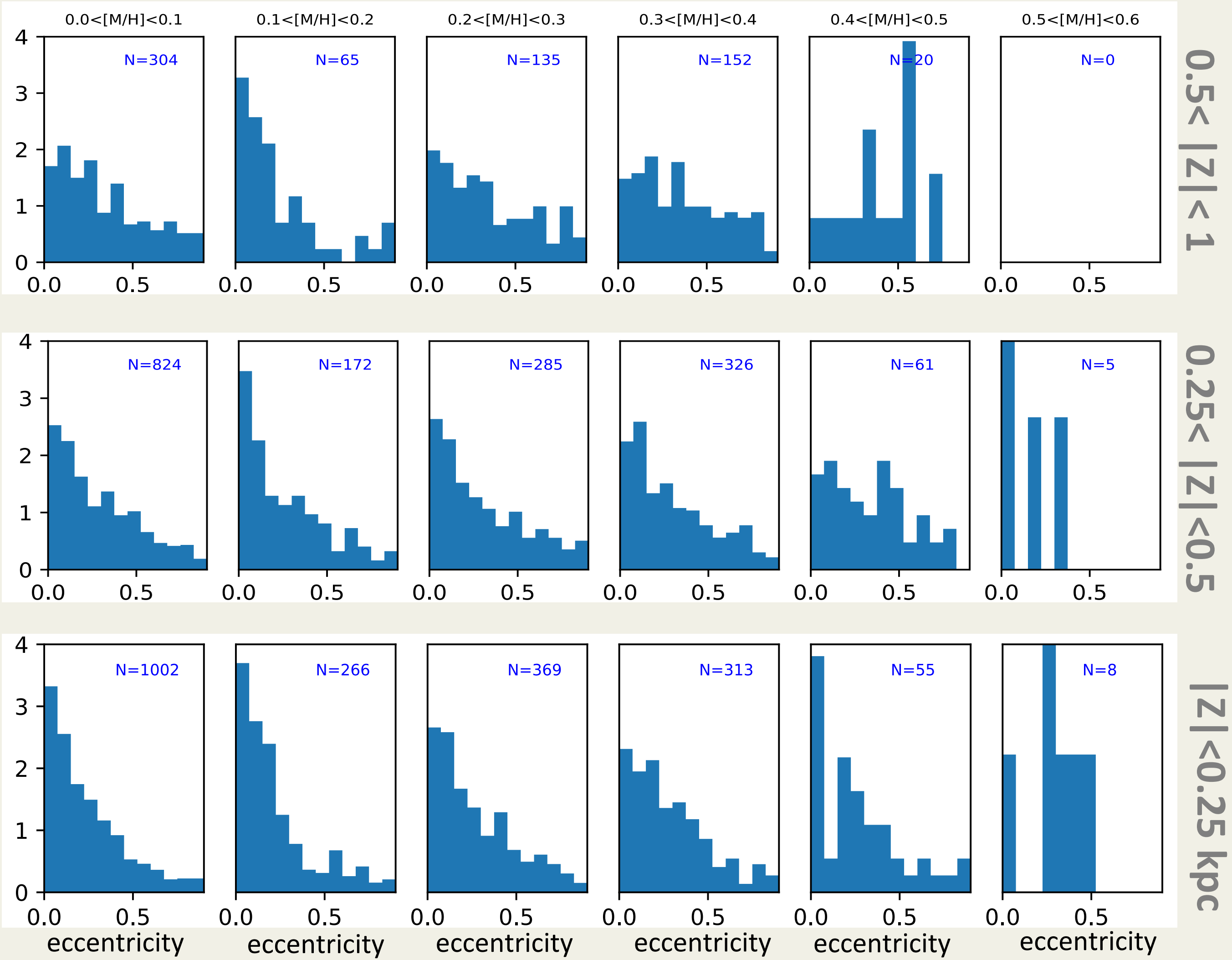
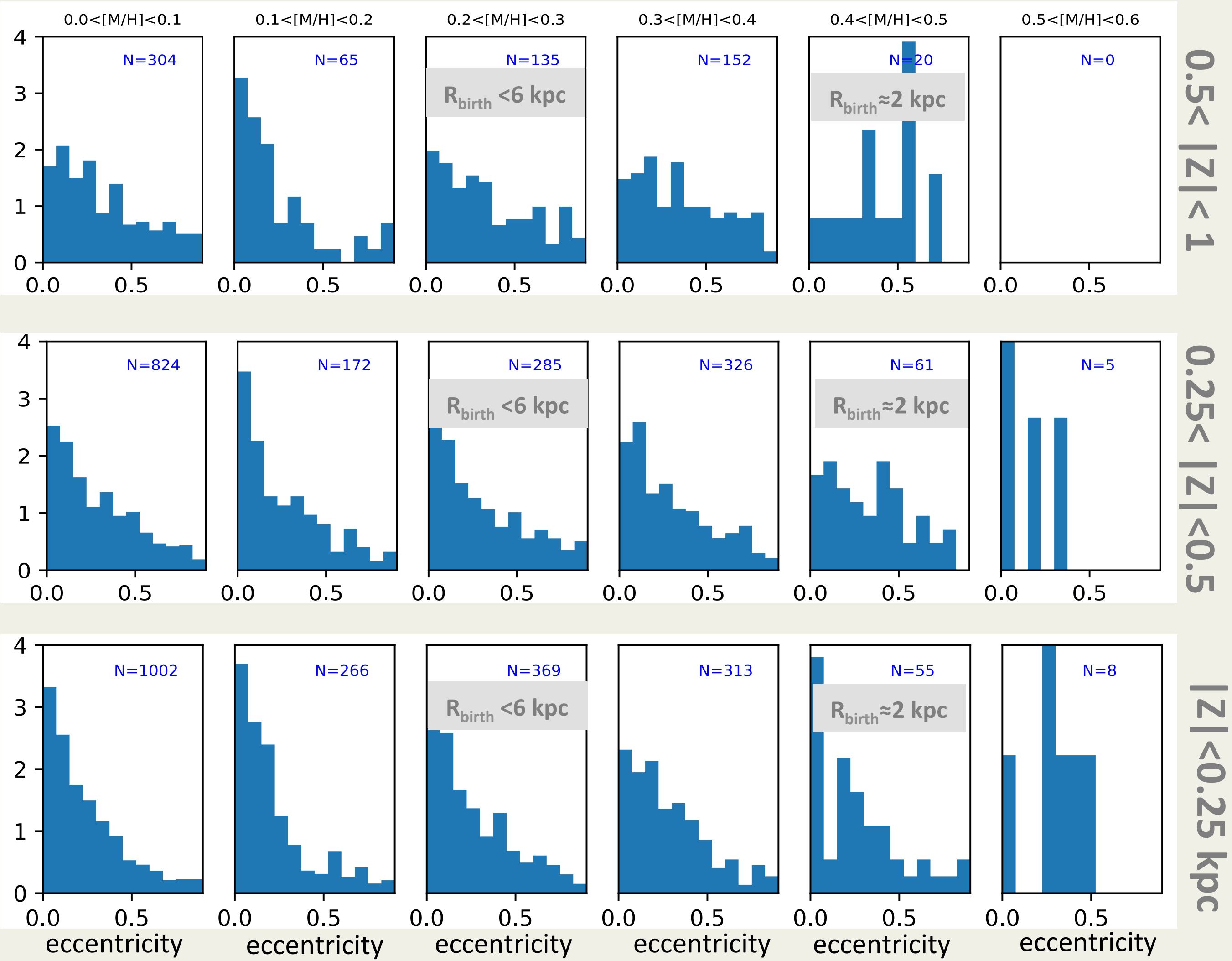


Distances DR5+

|Z|<0.25 kpc



Distances DR5+



- ISM's metallicity gradient: $\partial[M/H]/\partial R \sim -0.06$ dex kpc^{-1} *(Smartt & Rolleston97; Balser+11…)*

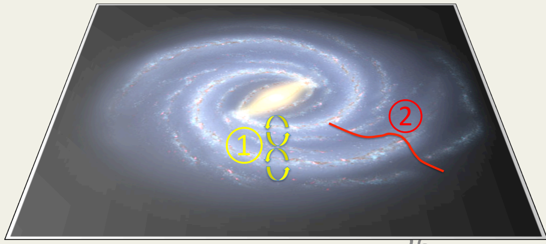
➢**Stars born well inside R_o.**

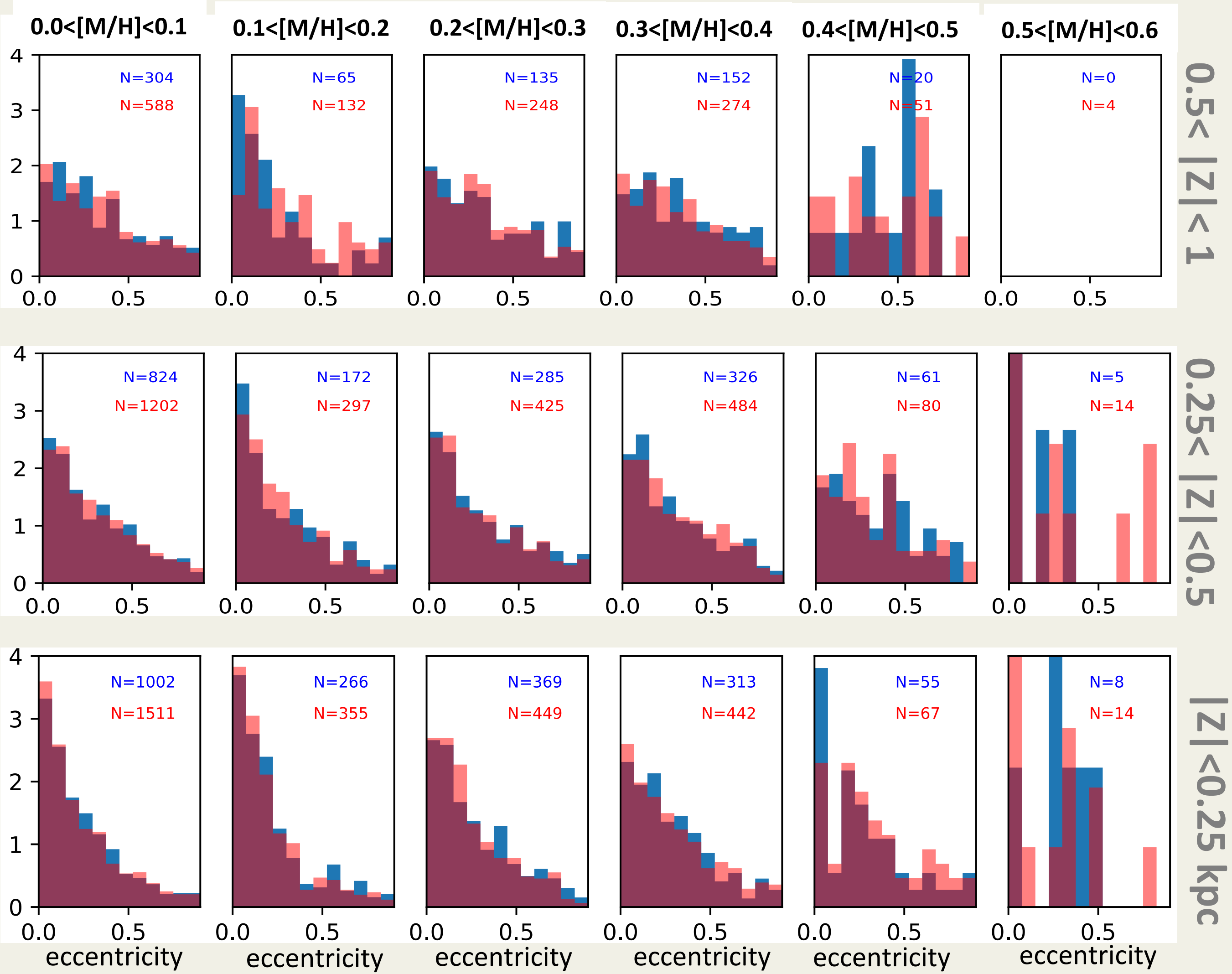
Radial migration: *(Sellwood&Binney02…)*

① Churning: Co-rotation resonances
Δe/Δt ~ 0

② Blurring: Lindblad resonances

➢ **Δe/Δt ≠ 0**





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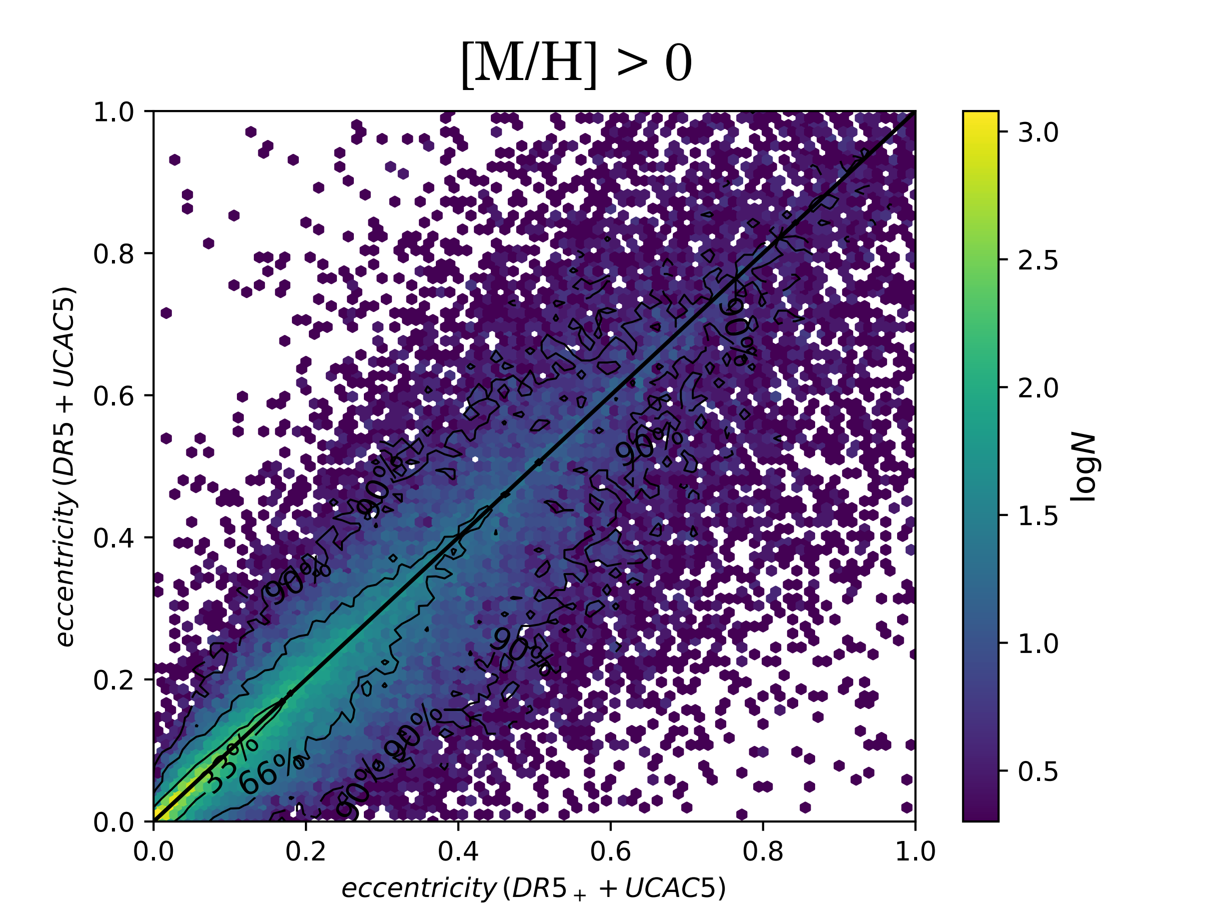
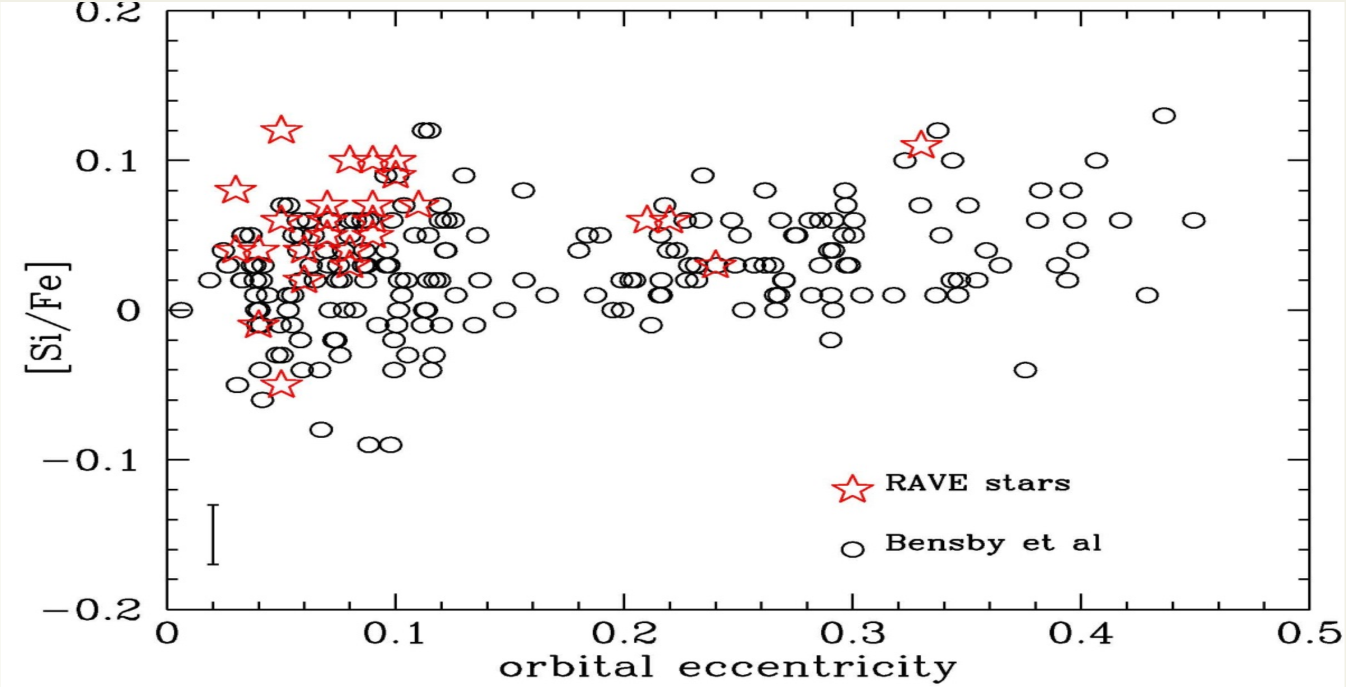

[M/H] > 0
eccentricity (DR5 + UCAC5)
eccentricity (DR5₊ + UCAC5)
logN
0.0
0.2
0.4
0.6
0.8
1.0
0.5
1.0
1.5
2.0
2.5
3.0
33%
66%
90%



Wyse, Hawkins, Kordopatis, Ruchti (in prep)

- ~40 stars observed with APO/ARCES (R=31 500)
- Hints of larger scatter in [Si/Fe] for lowest orbital eccentricity
  - Need larger samples, plus model predictions

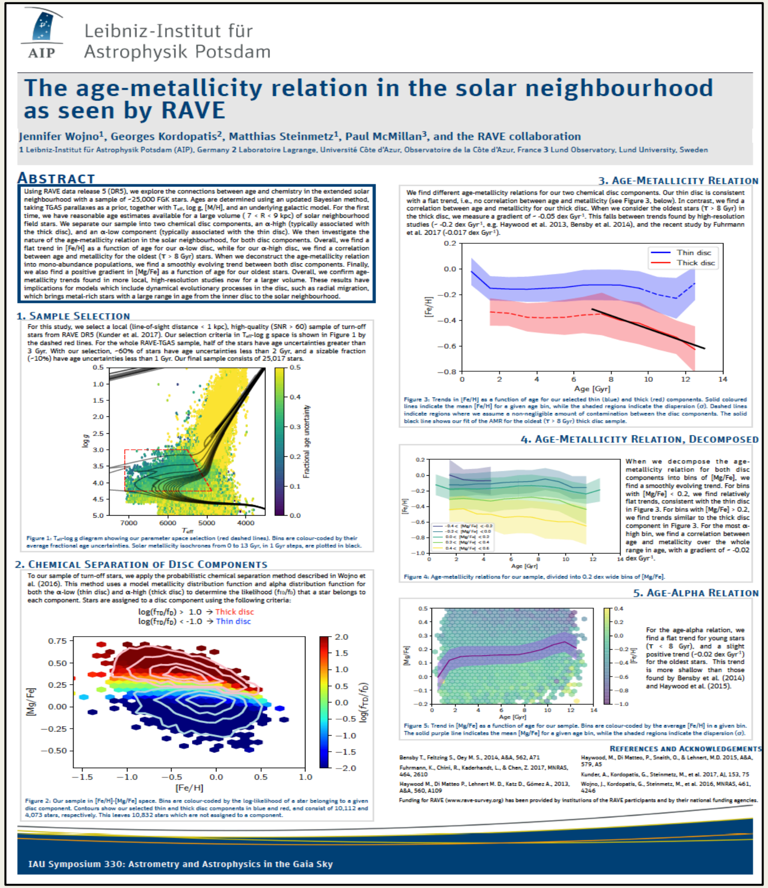
Conclusions

- New distances and updated pm allowed a re-analysis of existent data-sets
- General trends well identified in previous works
  - SMR stars on low-e confirmed
  - Correlation between [M/H]-V_{ϕ} confirms existence of thick disc in the inner disc and absence of it at the outer.
- Skewness study to be performed taking into account the completeness fraction.
- Decomposition into thin and thick disc & age analysis with RAVE data is difficult, but in progress (see J. Wojno's poster)

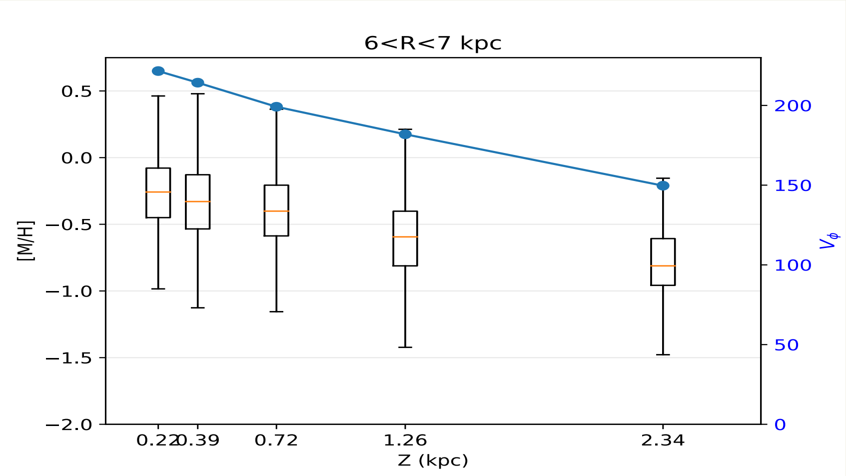
Ages + thin & thick disc decomposition

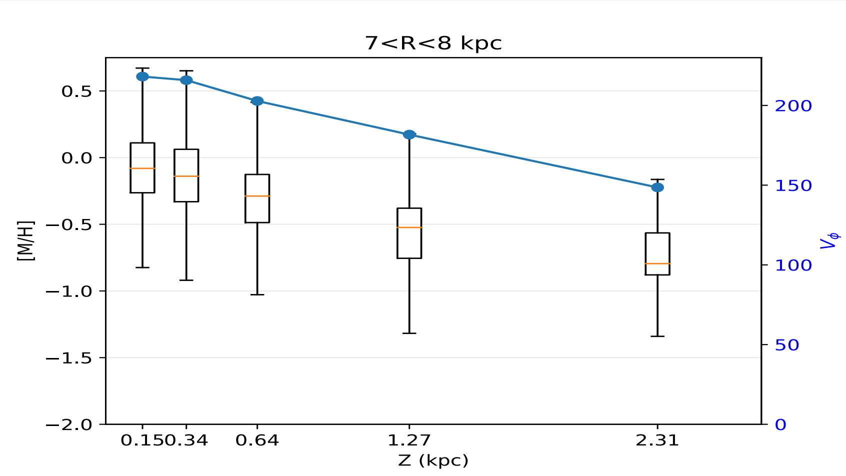
See **J. Wojno**'s poster **(C49)**

Ages by P. McMillan

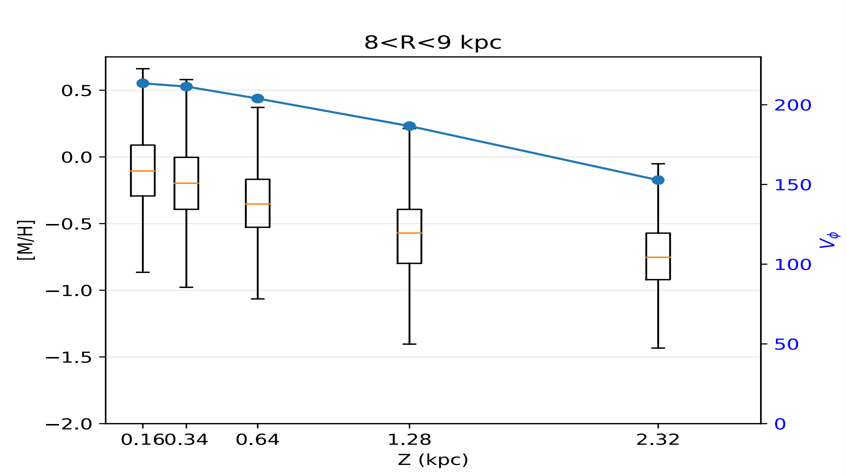


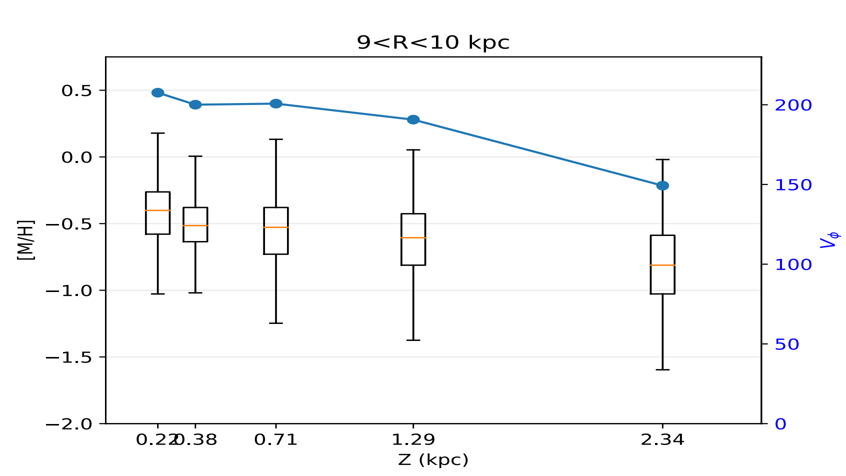
Thank you

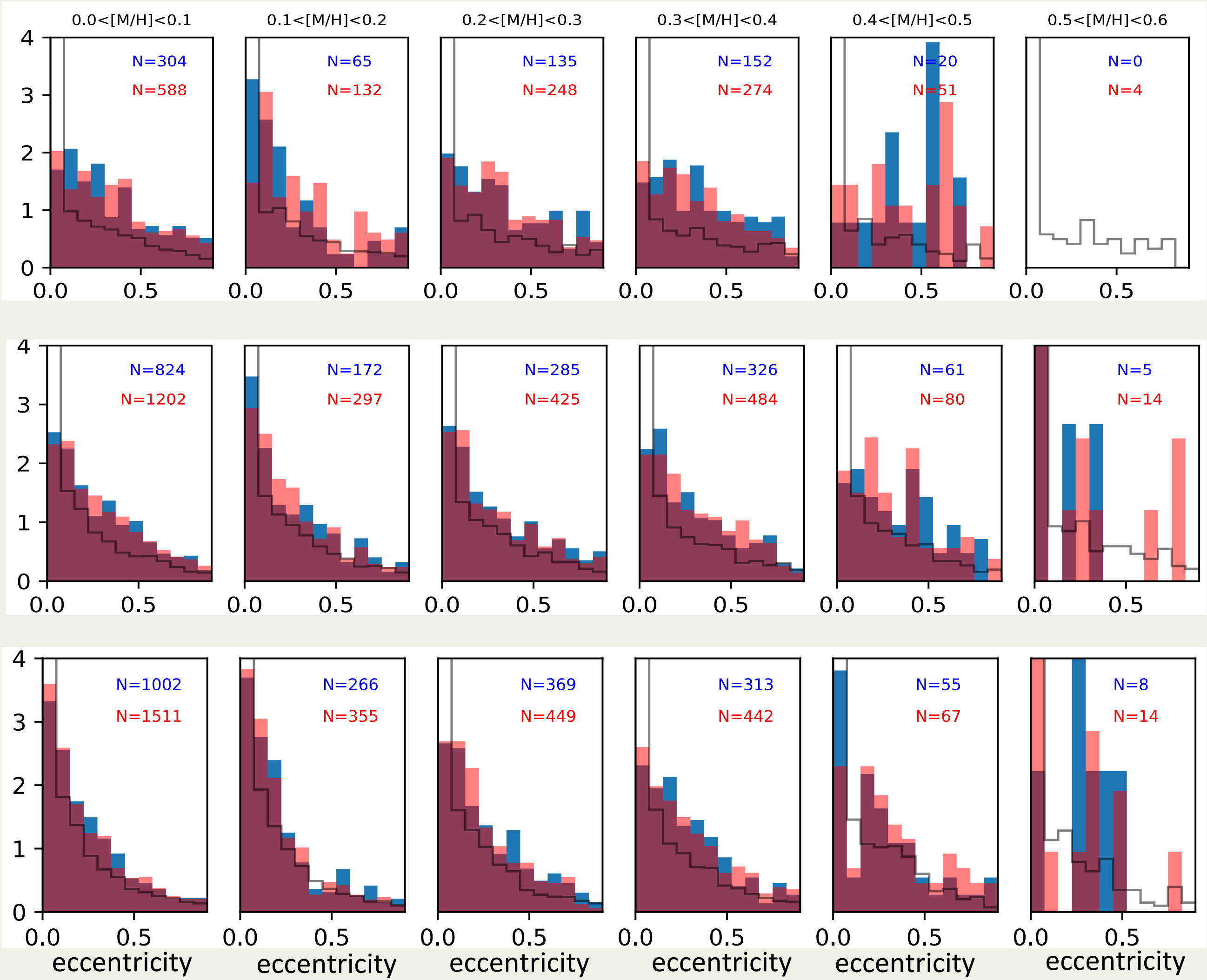




RAVE-DR5 + UCAC4







0.5< |Z|< 1

0.25< |Z|<0.5

Distances DR5+

Distances DR5

Cannon

|Z|<0.25 kpc