3D test particle simulations of the Galactic disks. The kinematical effects of the bar.

Giacomo Monari, Teresa Antoja & Amina Helmi

rijksuniversiteit groningen

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Motivation

- Understanding kinematical substructure in the MW
- Disentangle causes: external (e.g., accretion) and internal (e.g., non-axisymmetric components)
- Esp. in the thick disk and far from the plane
- Here we address internal causes: bar effects

Methods

- Test particle simulations
- 3D
- Thin and thick disk

Test particle simulations

(Monari, Antoja & Helmi 2013, arXiv:1306.2632)

- Integrated forward in time
- Rigid potential 3D
  - NFW halo
  - Thin and thick Miyamoto-Nagai disks (mass ratio 5:1)
  - Rotating Ferrers bar (Ω_b=50km/sec/kpc)

Simulations

(Monari, Antoja & Helmi 2013, arXiv:1306.2632)

ICs tracer populations:

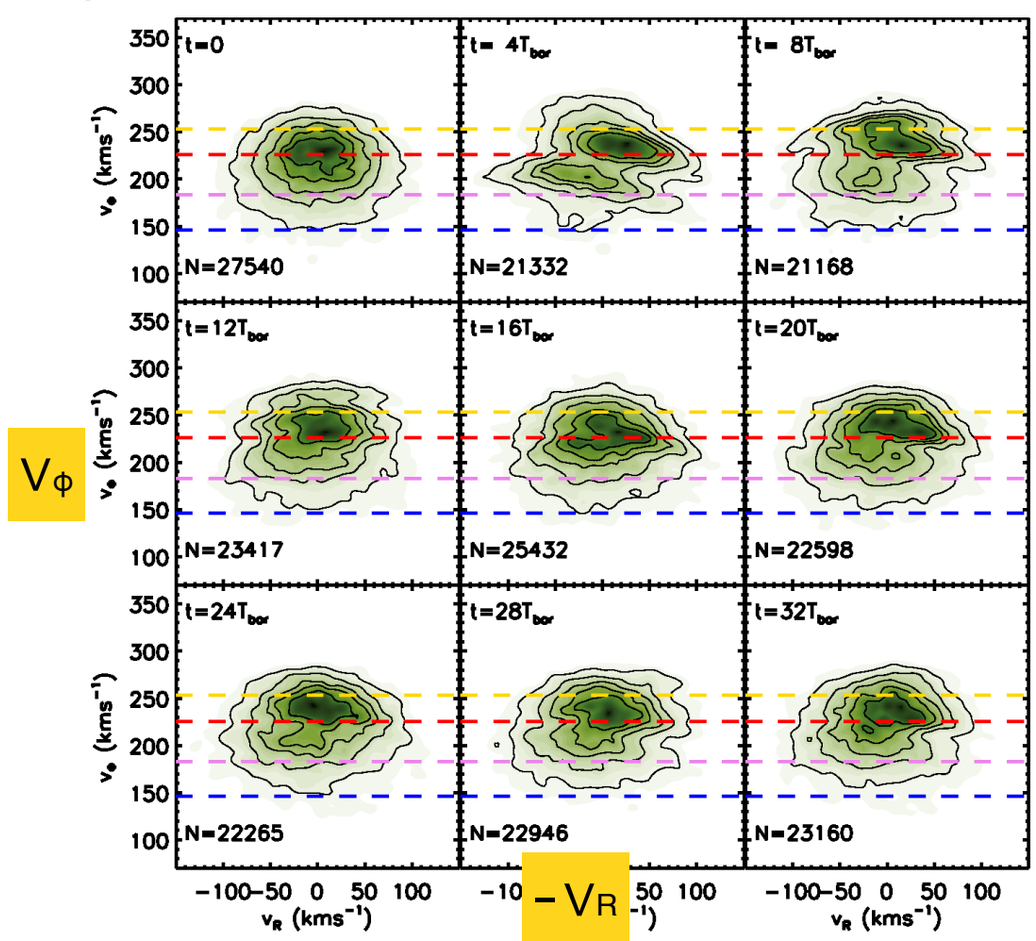
- Density: Miyamoto-Nagai disks ↔ potential
- Kinematics:
  - σ_R: smooth exp. fall off
  - σ_ϕ: epicyclic approximation
  - σ_z : vertical Jeans equation, assuming $\langle v_R v_z \rangle = 0$

THIN DISK	THICK DISK
$\sigma_R(R_0) \sim 45$km/sec	$\sigma_R(R_0) \sim 60$km/sec
$z_{thin} \sim 0.3$kpc	$z_{thick} \sim 1$kpc
$R_d = 3$kpc	$R_d = 3$kpc

Results: time evolution of SN

(Monari, Antoja & Helmi 2013, arXiv:1306.2632)

- After bar introduction kinematics SN strongly influenced, esp. in correspondence with OLR
- Transient effects for ~$10T_b$, then stable configuration
- $24T_b$~3Gyr default integration time.



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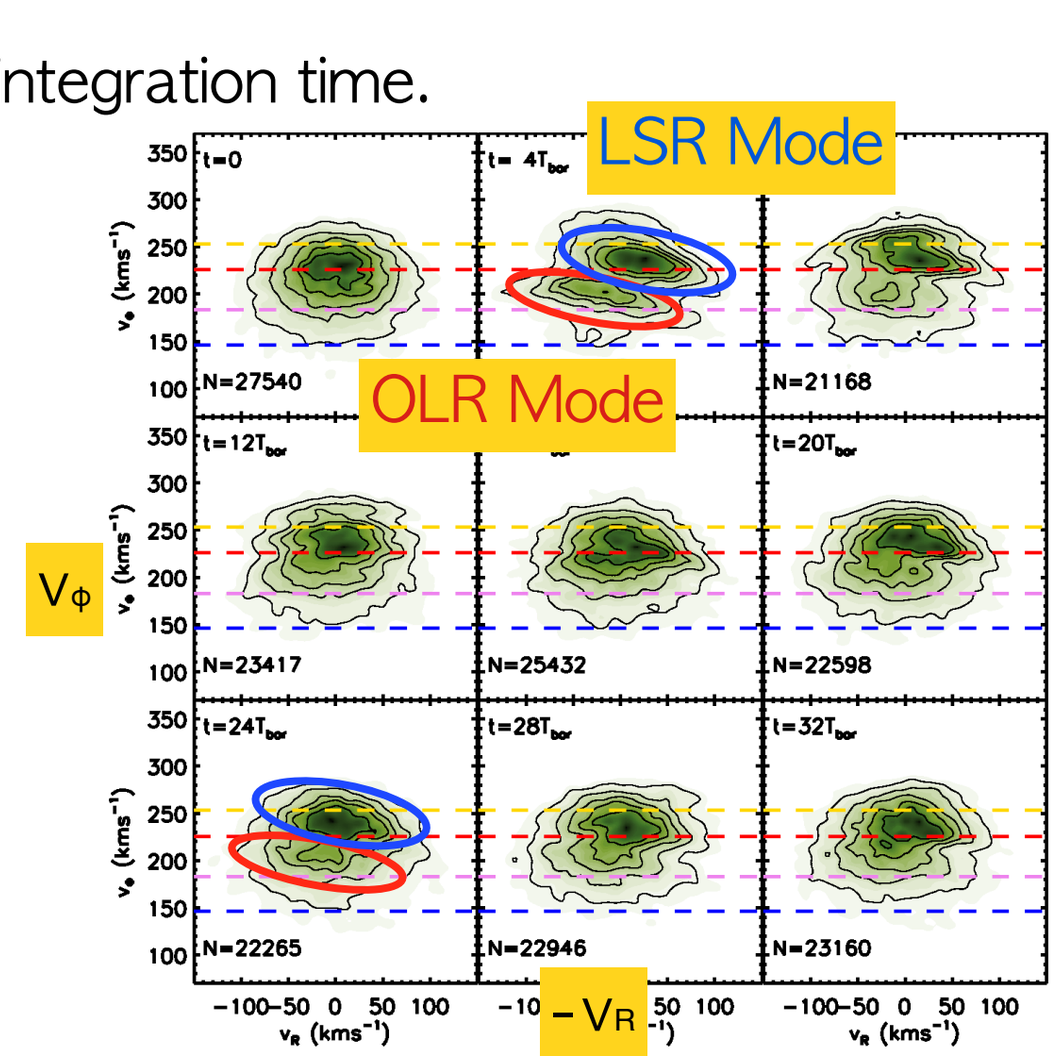

Results: Galactic plane

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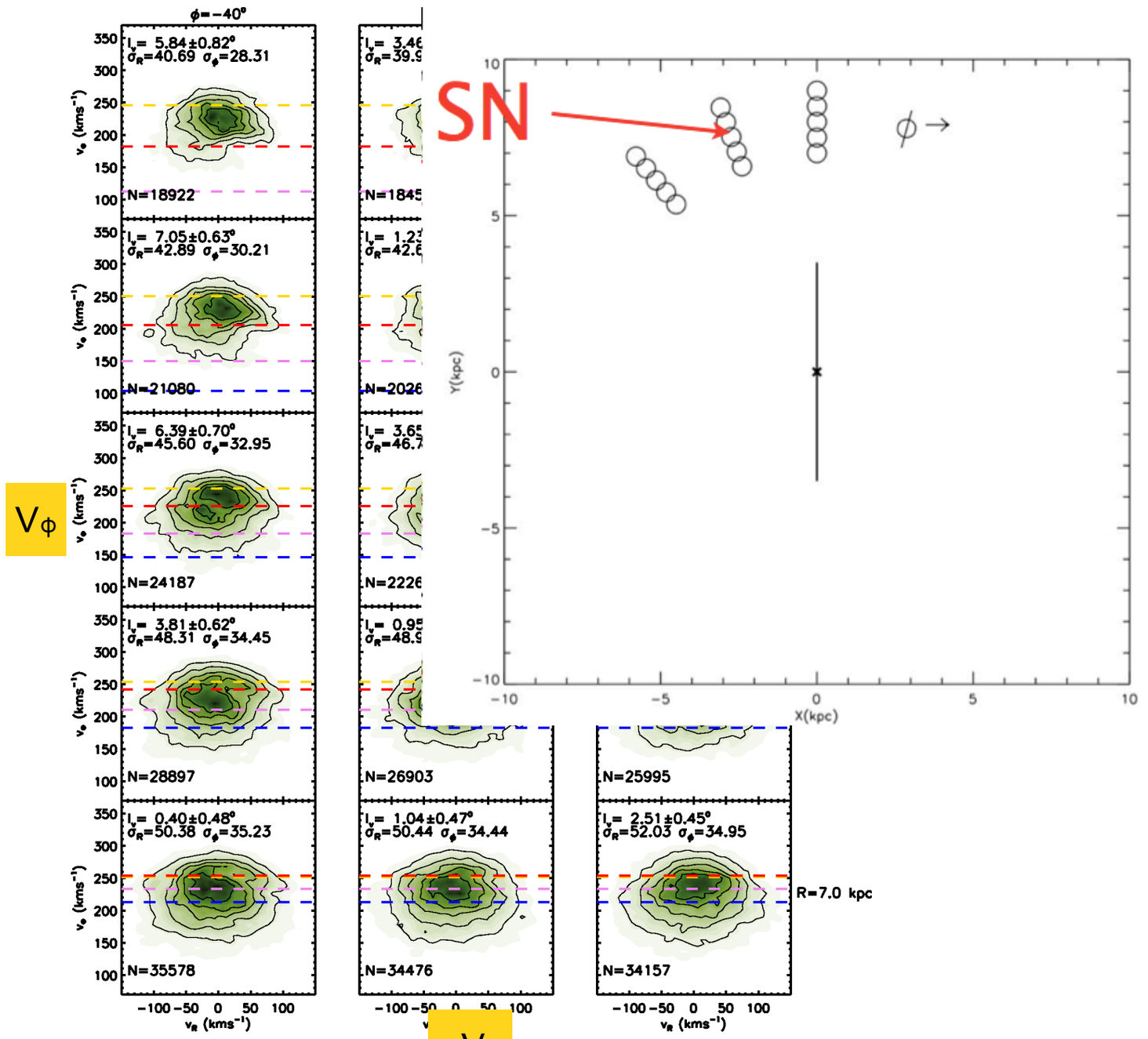
THIN DISK



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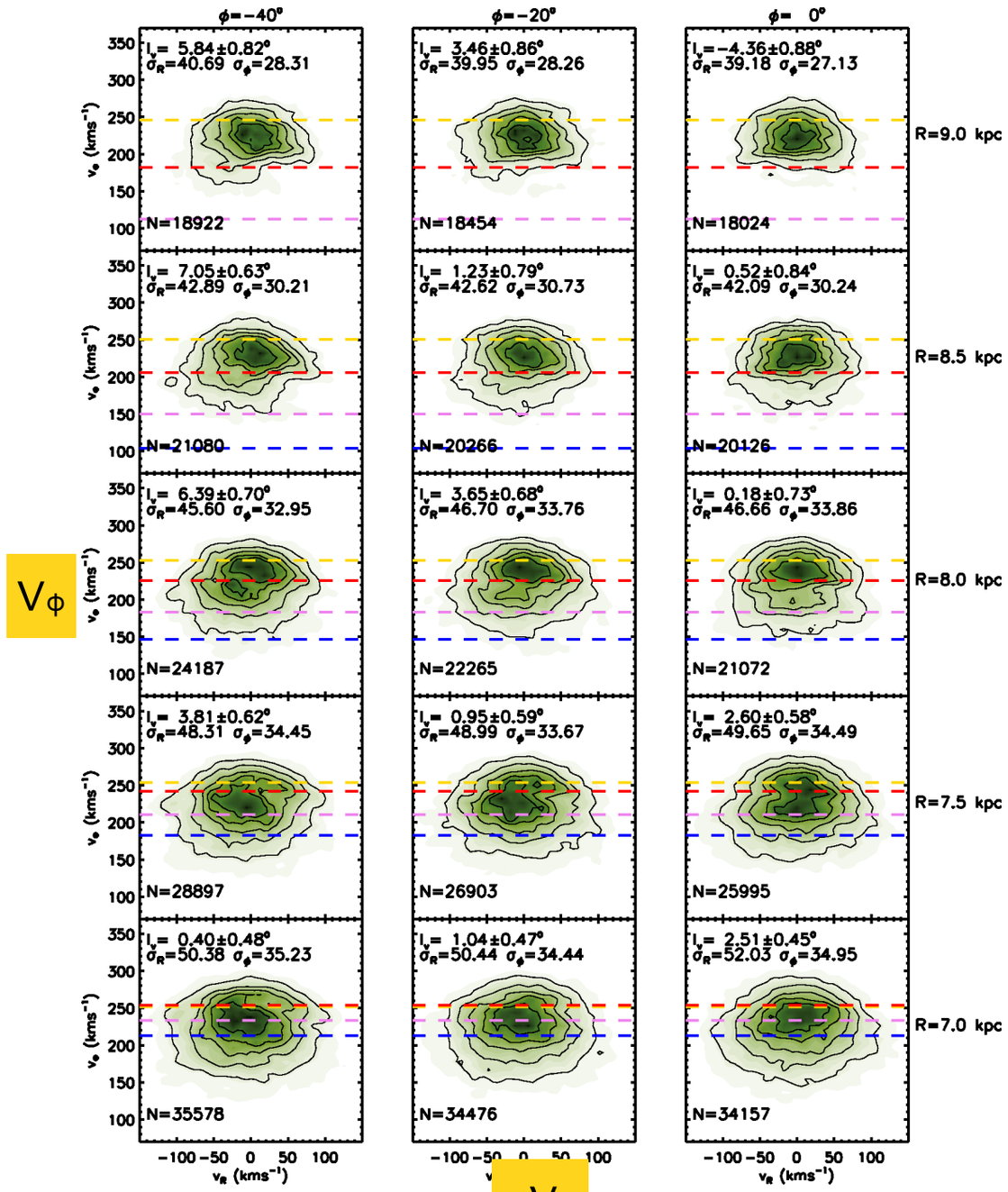

Results: Galactic plane

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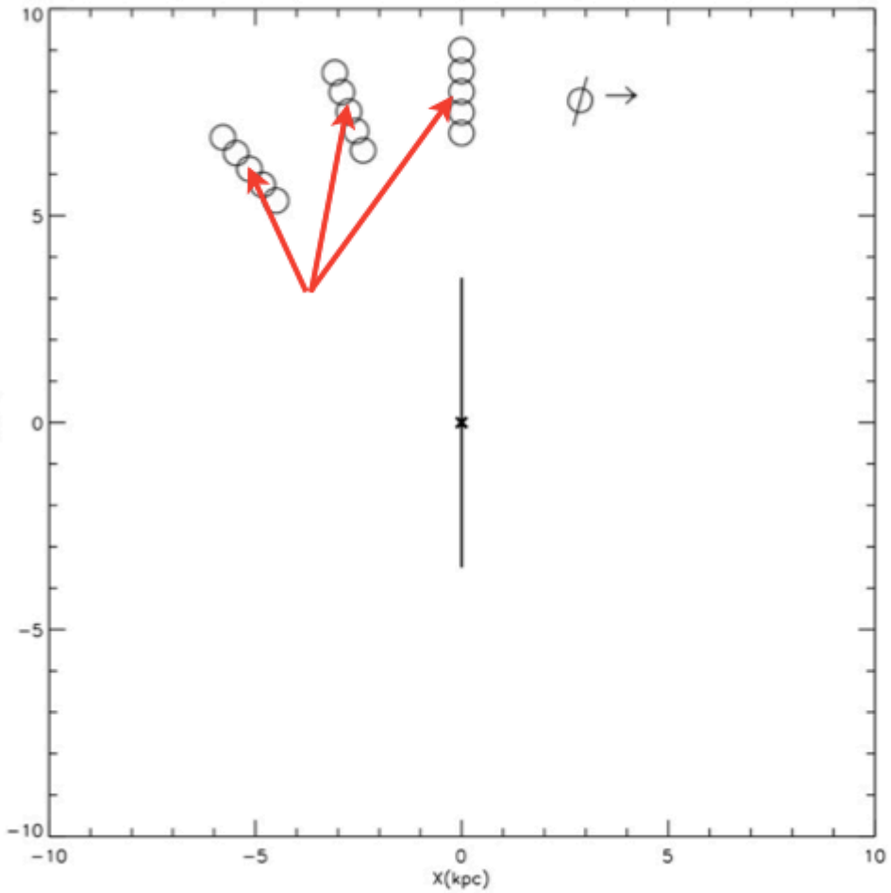
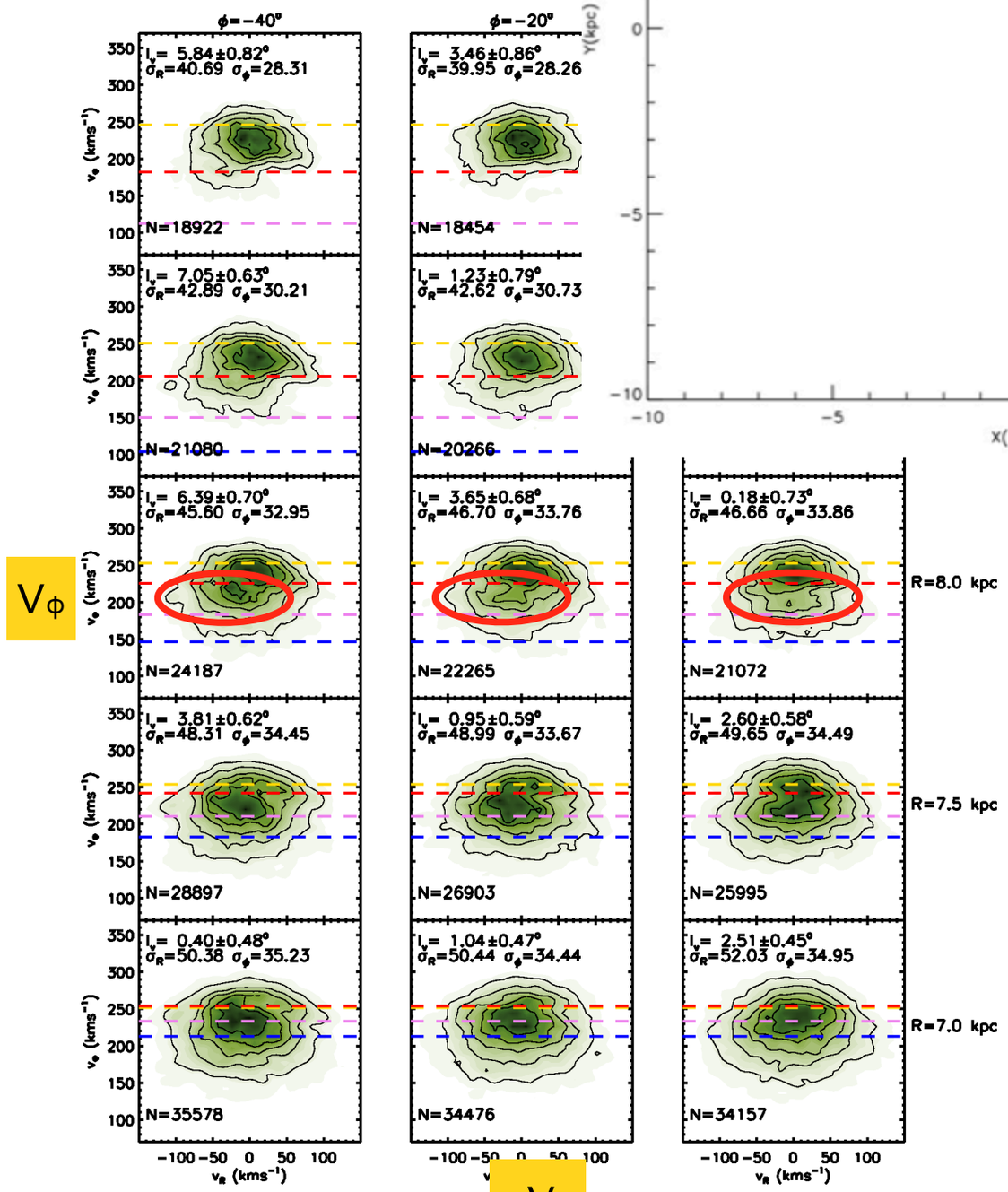
THIN D





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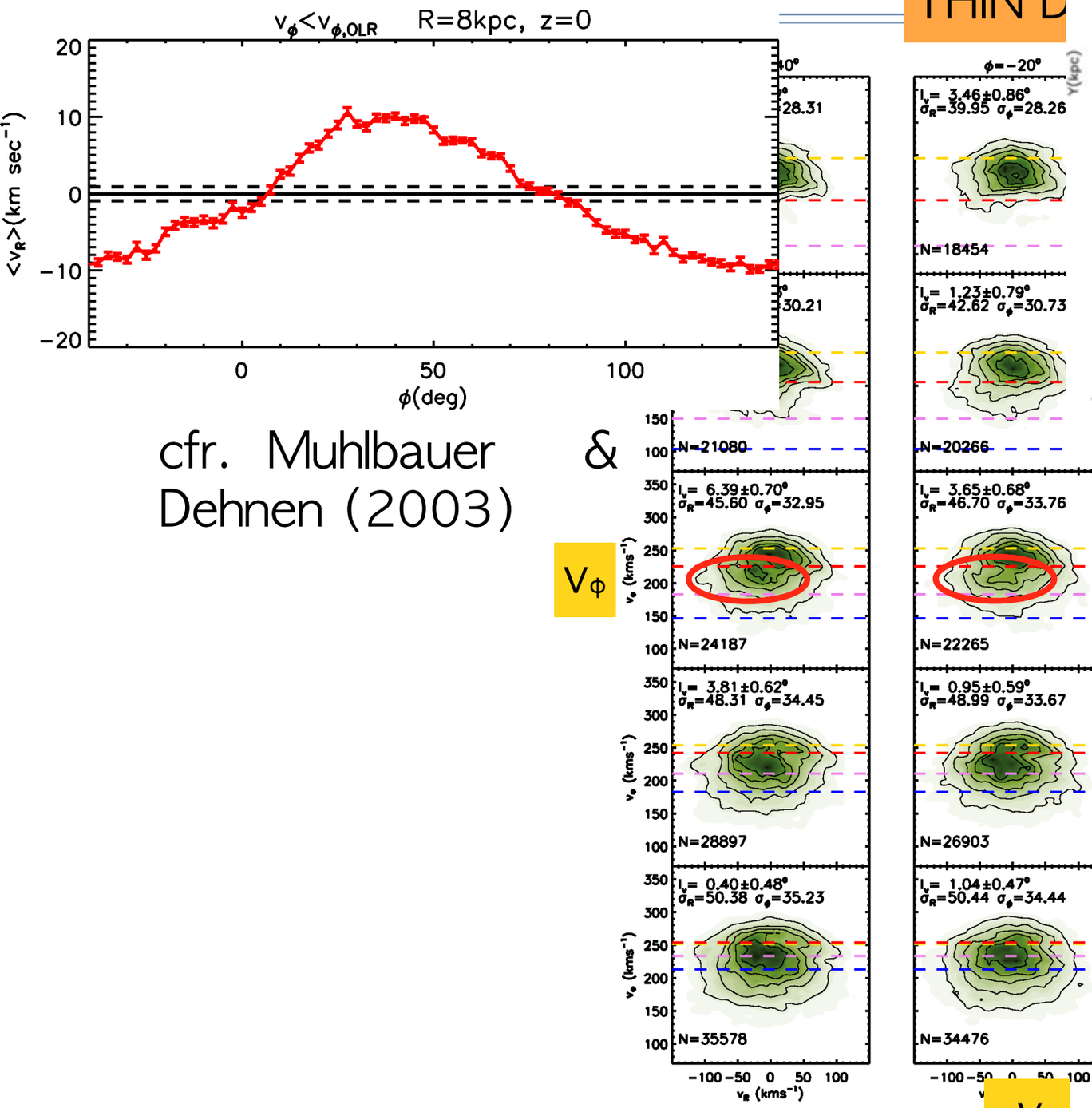
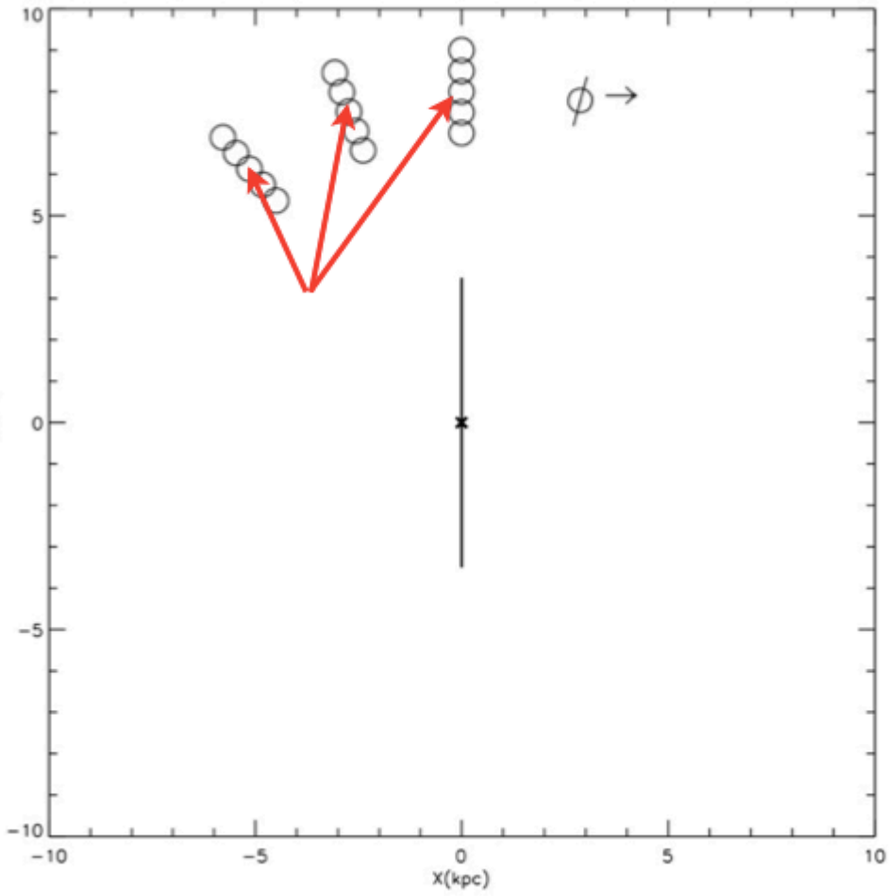




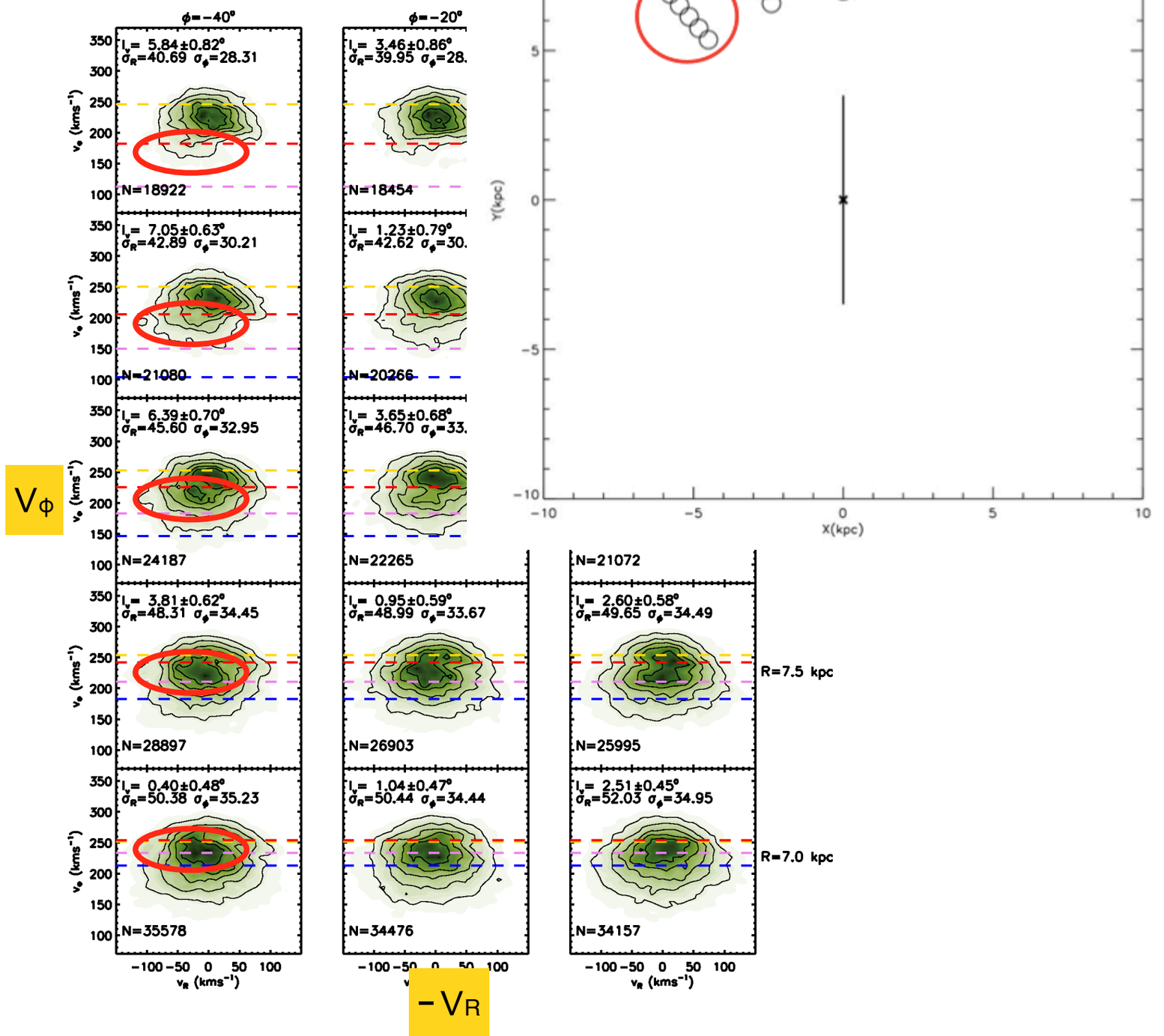
cfr. Muhlbauer & Dehnen (2003)

V_ϕ

$-V_R$

Results: Galactic plane

(Monari, Antoja & Helmi 2013, arXiv:1306.2632)



Results: Galactic plane

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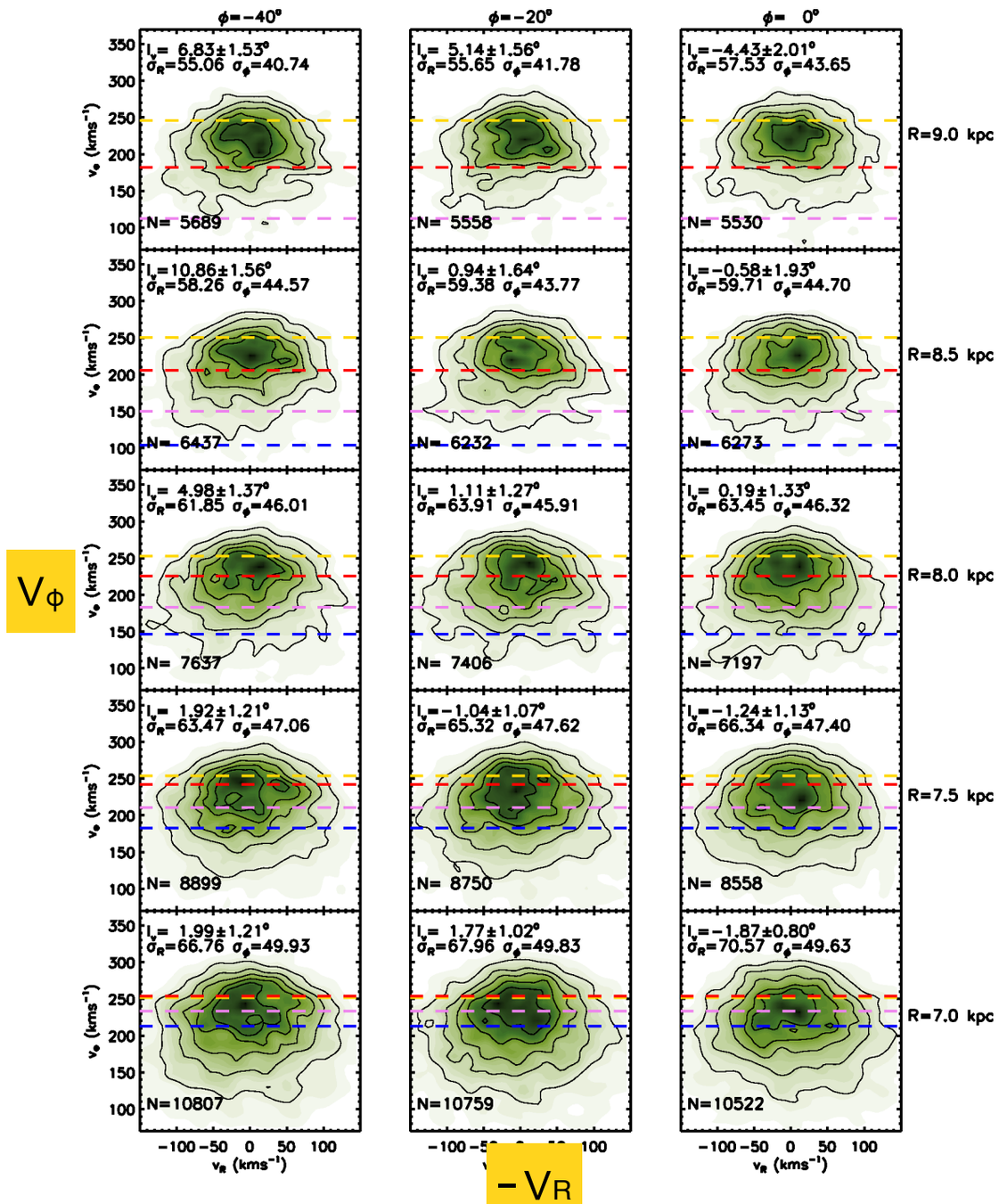
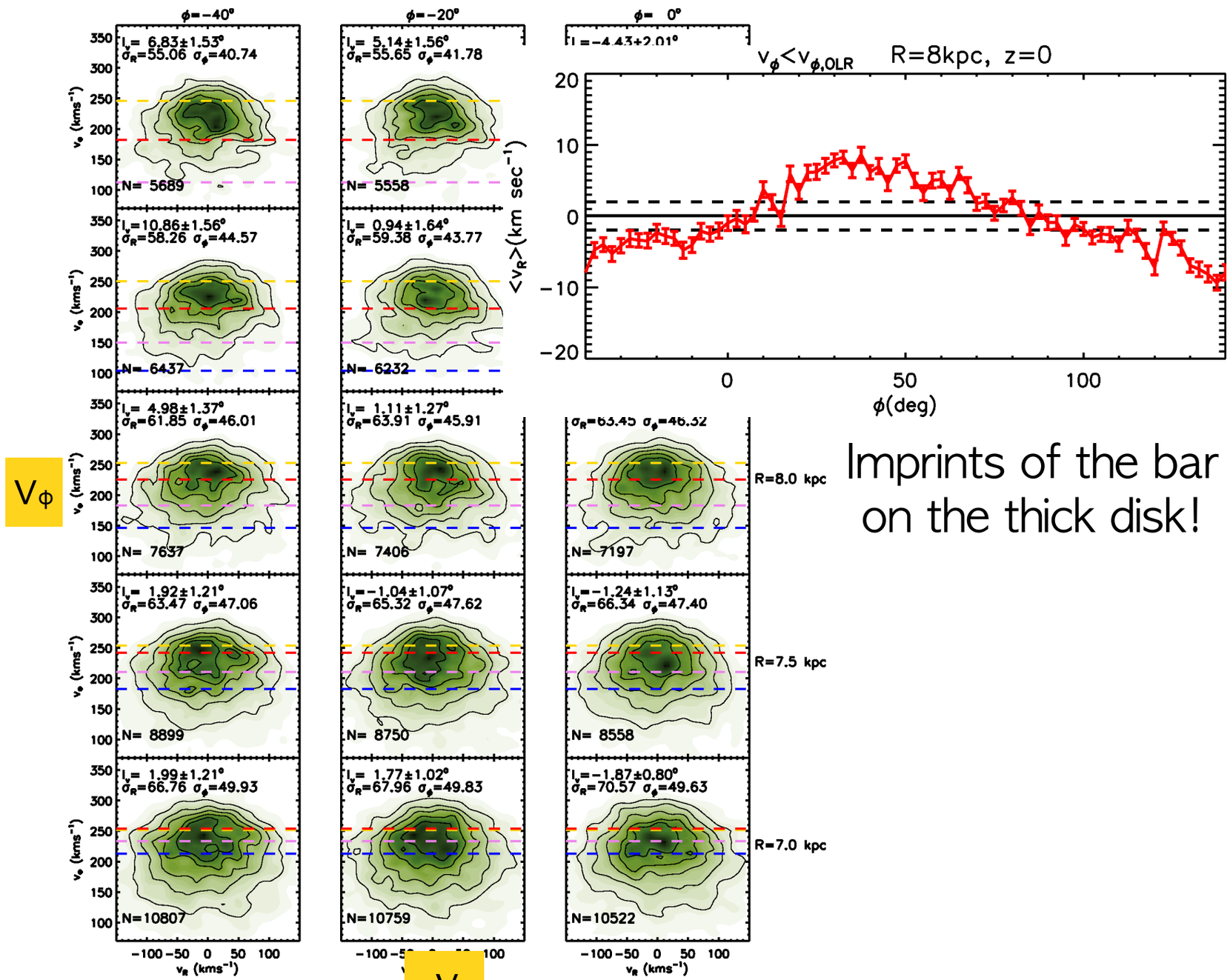
THICK DISK



Results: Galactic plane

(Monari, Antoja & Helmi 2013, arXiv:1306.2632)

THICK DISK



Imprints of the bar on the thick disk!

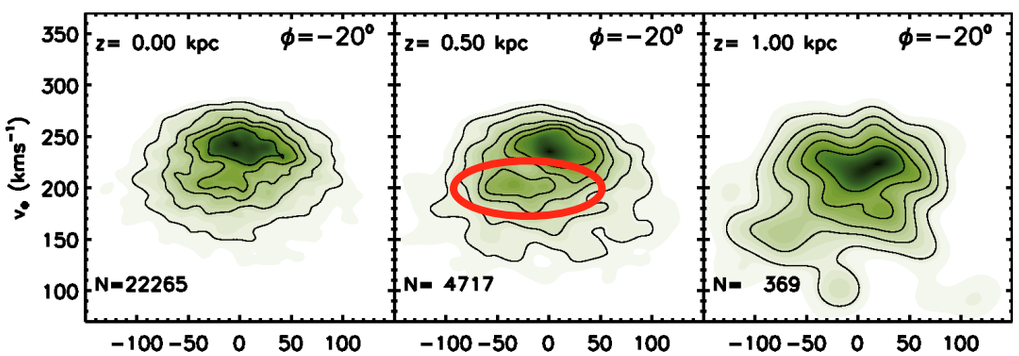
Results: above the Galactic plane

(Monari, Antoja & Helmi 2013, arXiv:1306.2632)

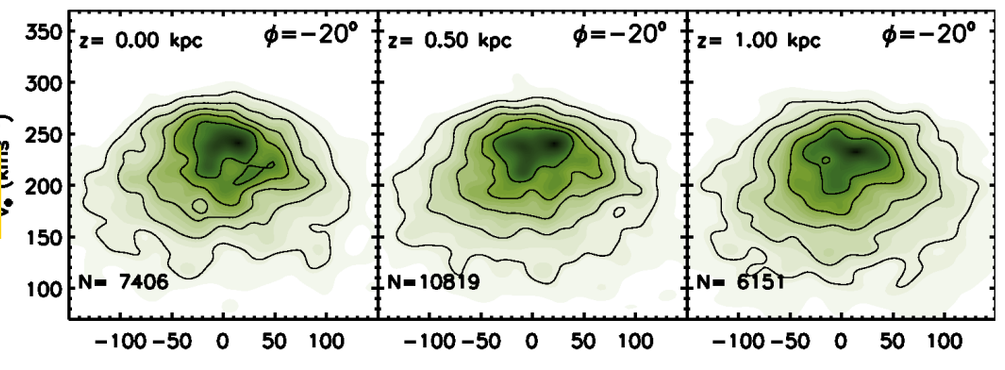
THIN DISK

THICK DISK

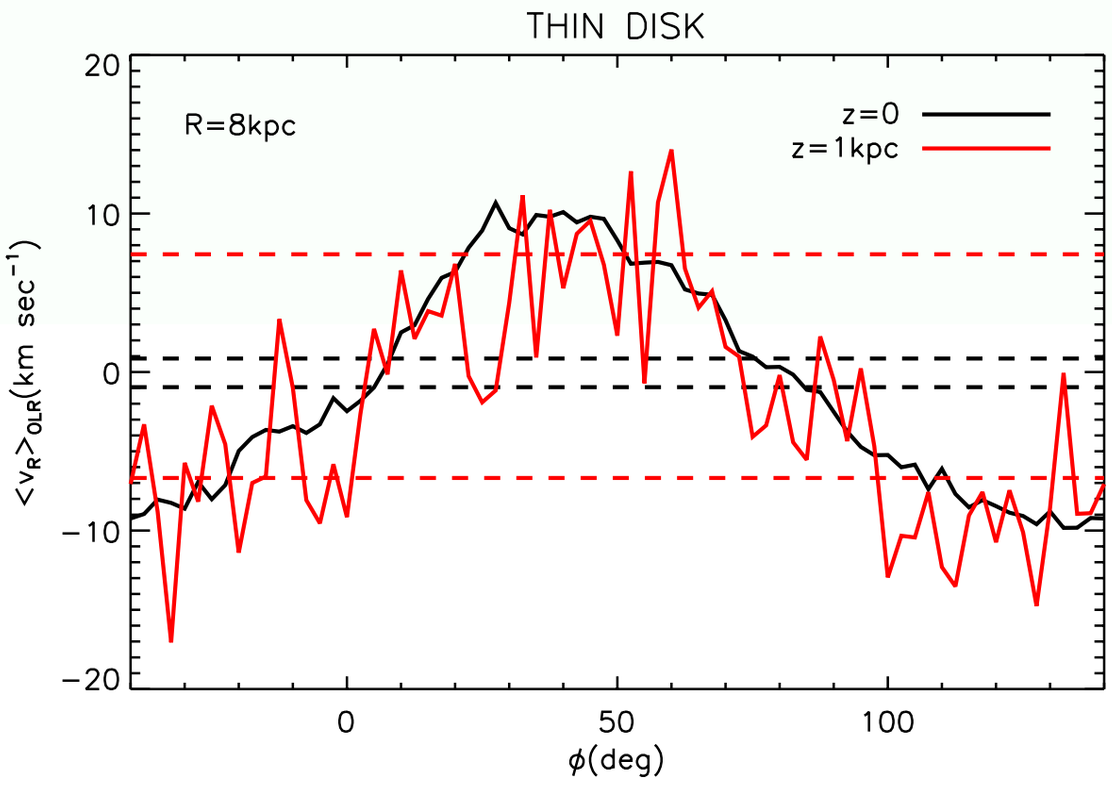
Vφ



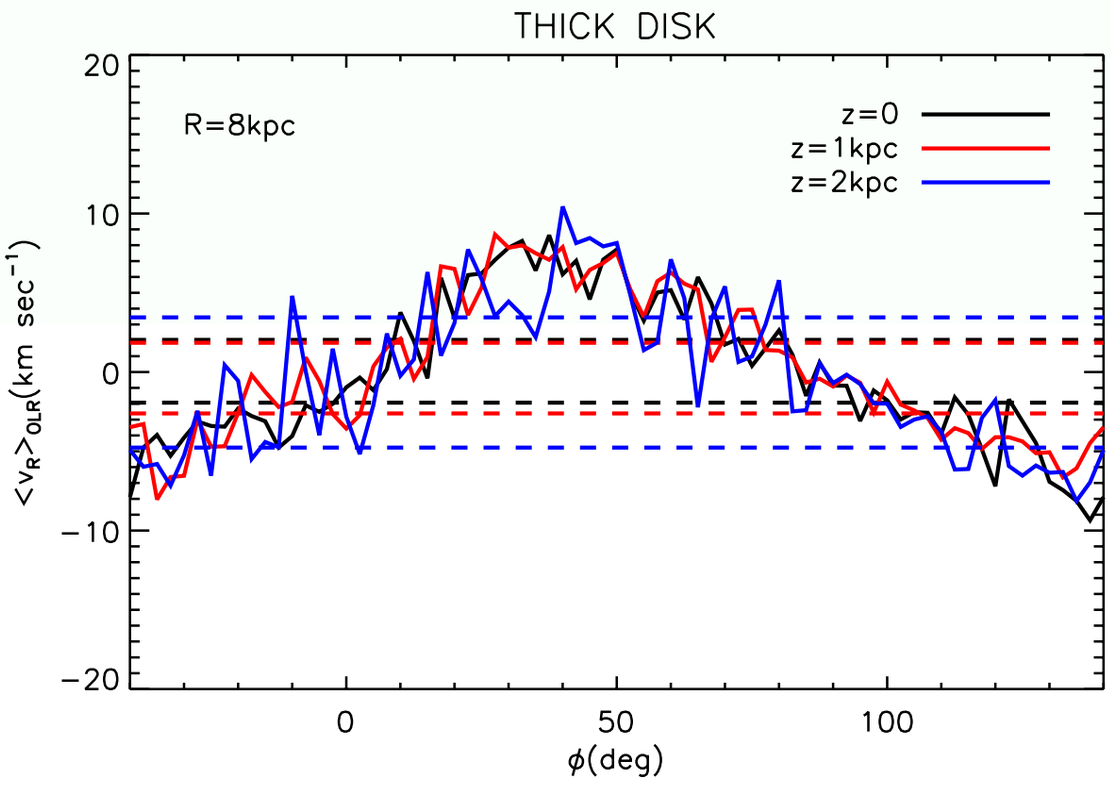
Vφ



−VR



−VR



Results: above the Galactic plane

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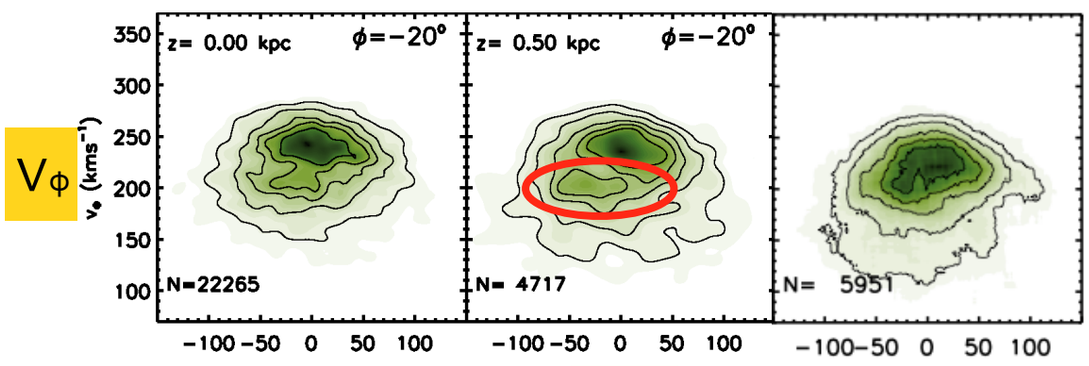
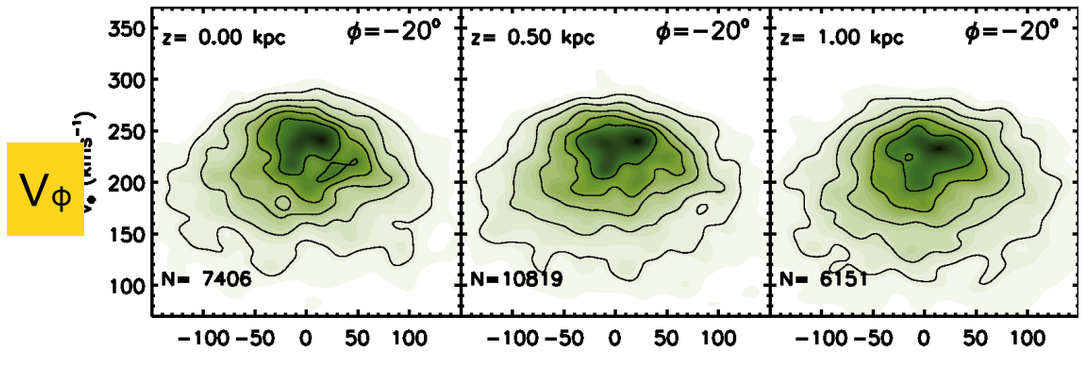
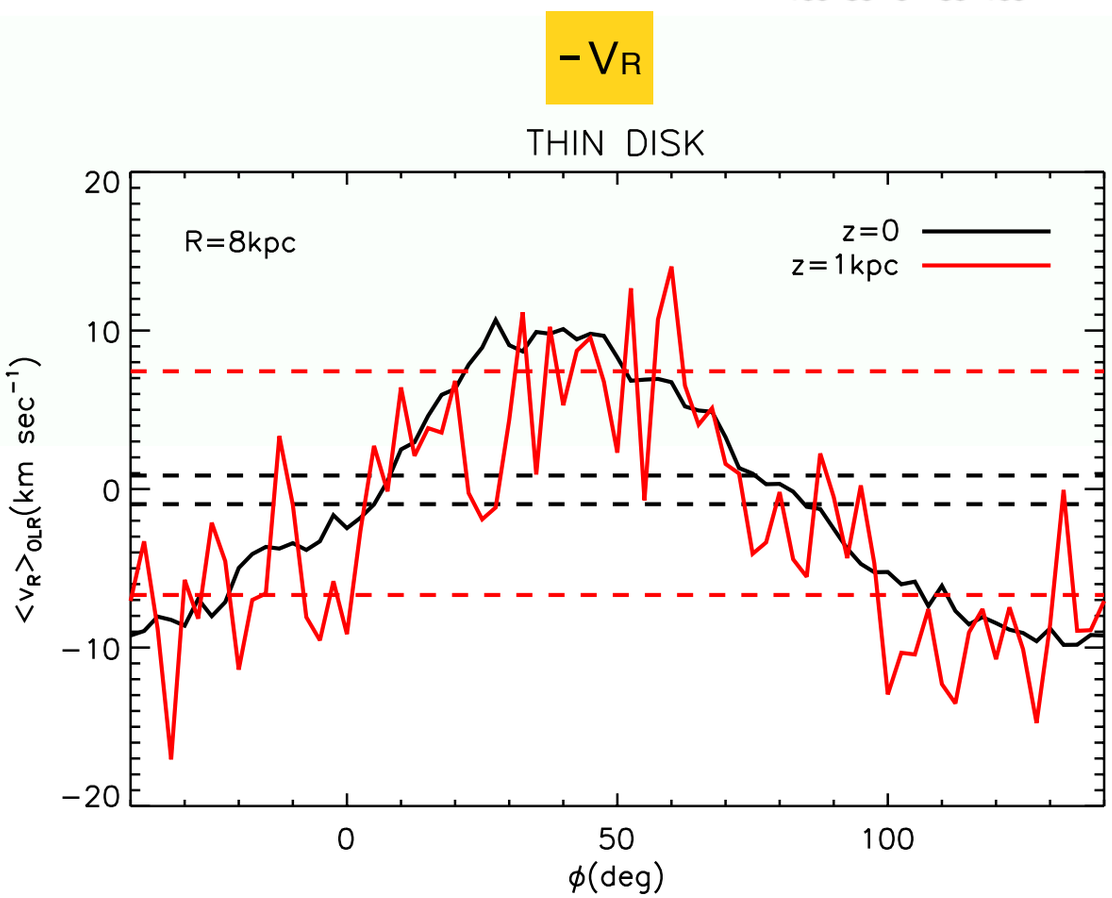
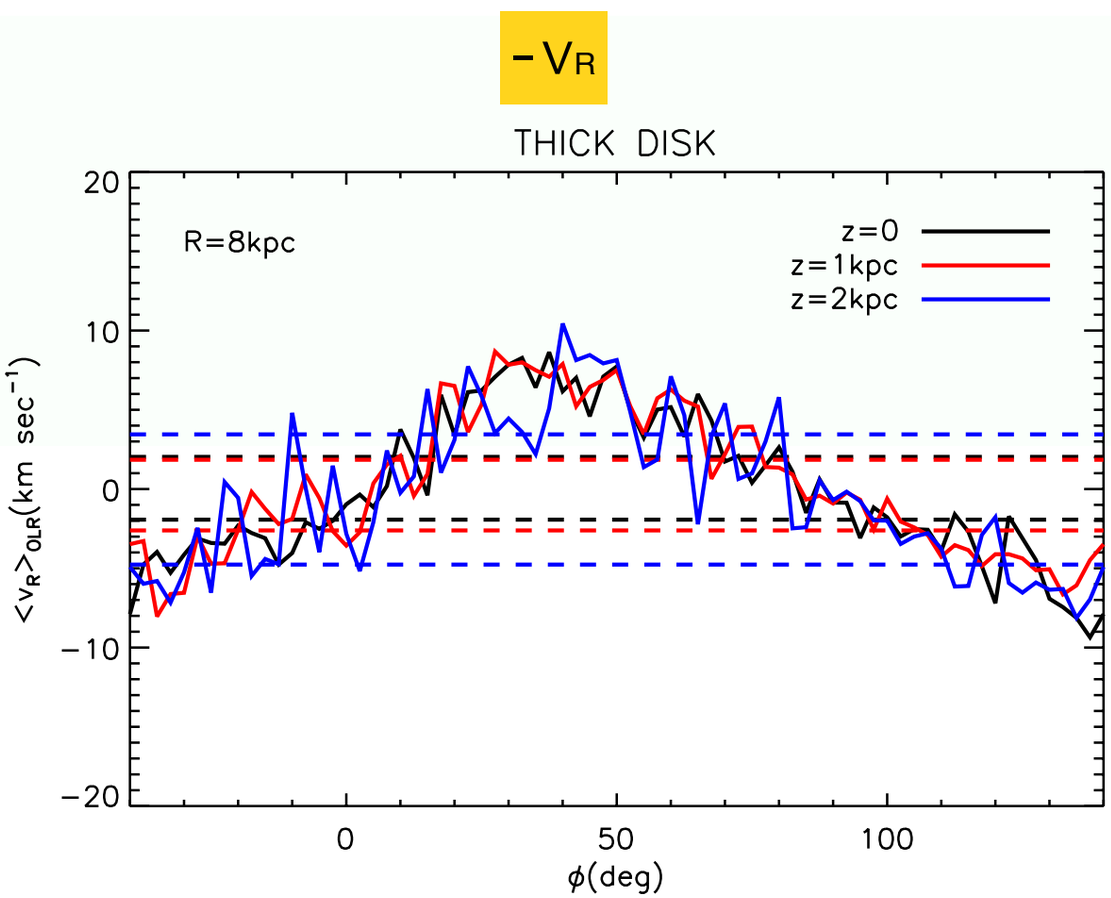
THIN DISK

THICK DISK









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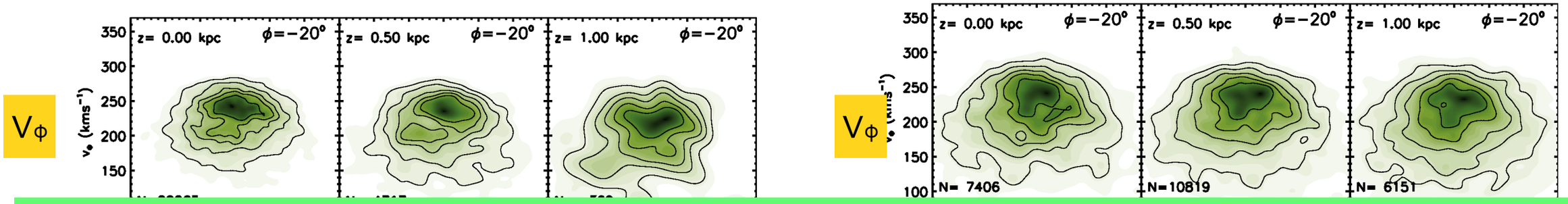
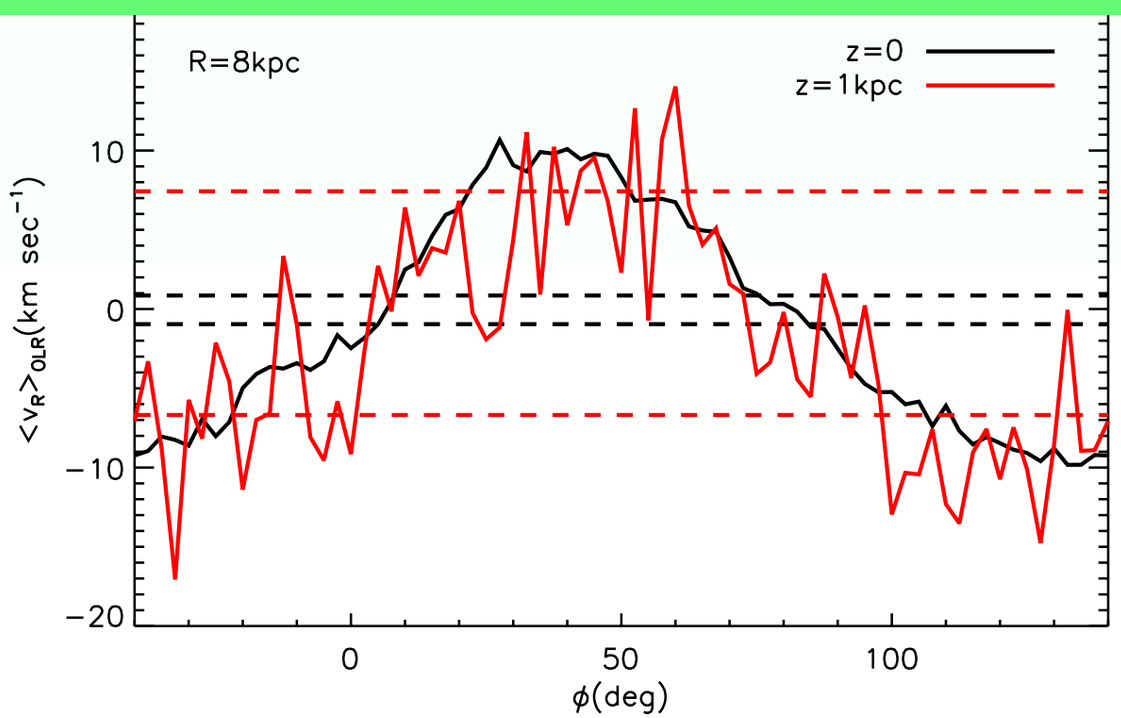
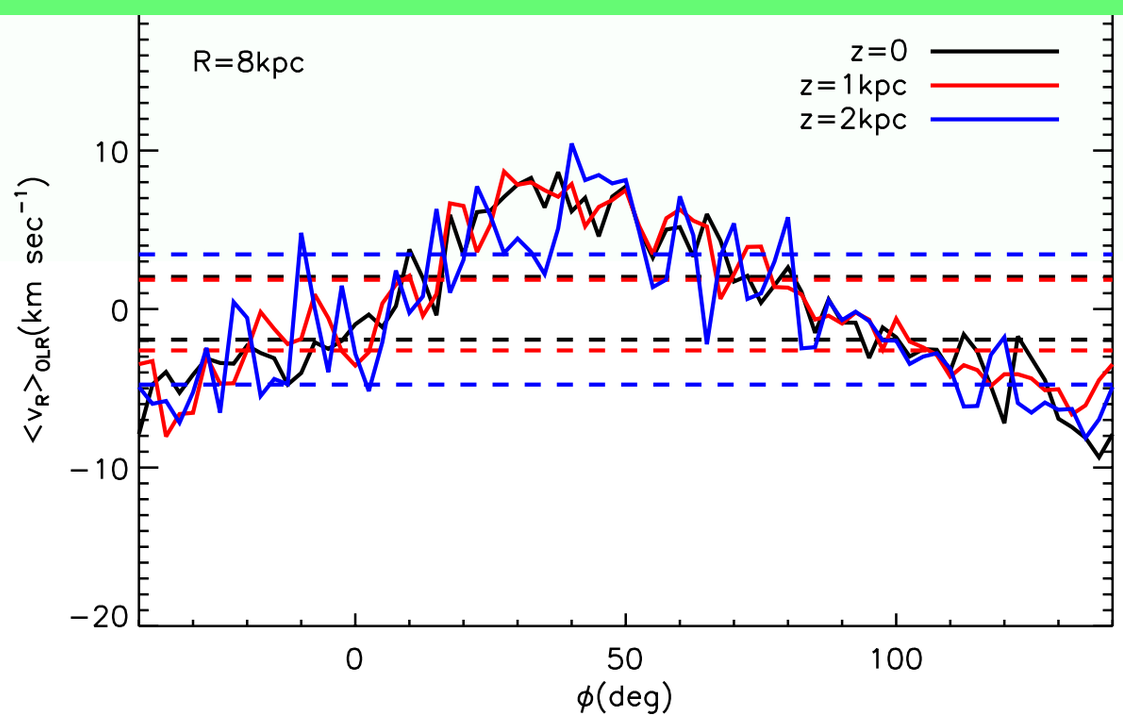


Antoja, Helmi & RAVE coll. 2012, MNRAS, 426, L1

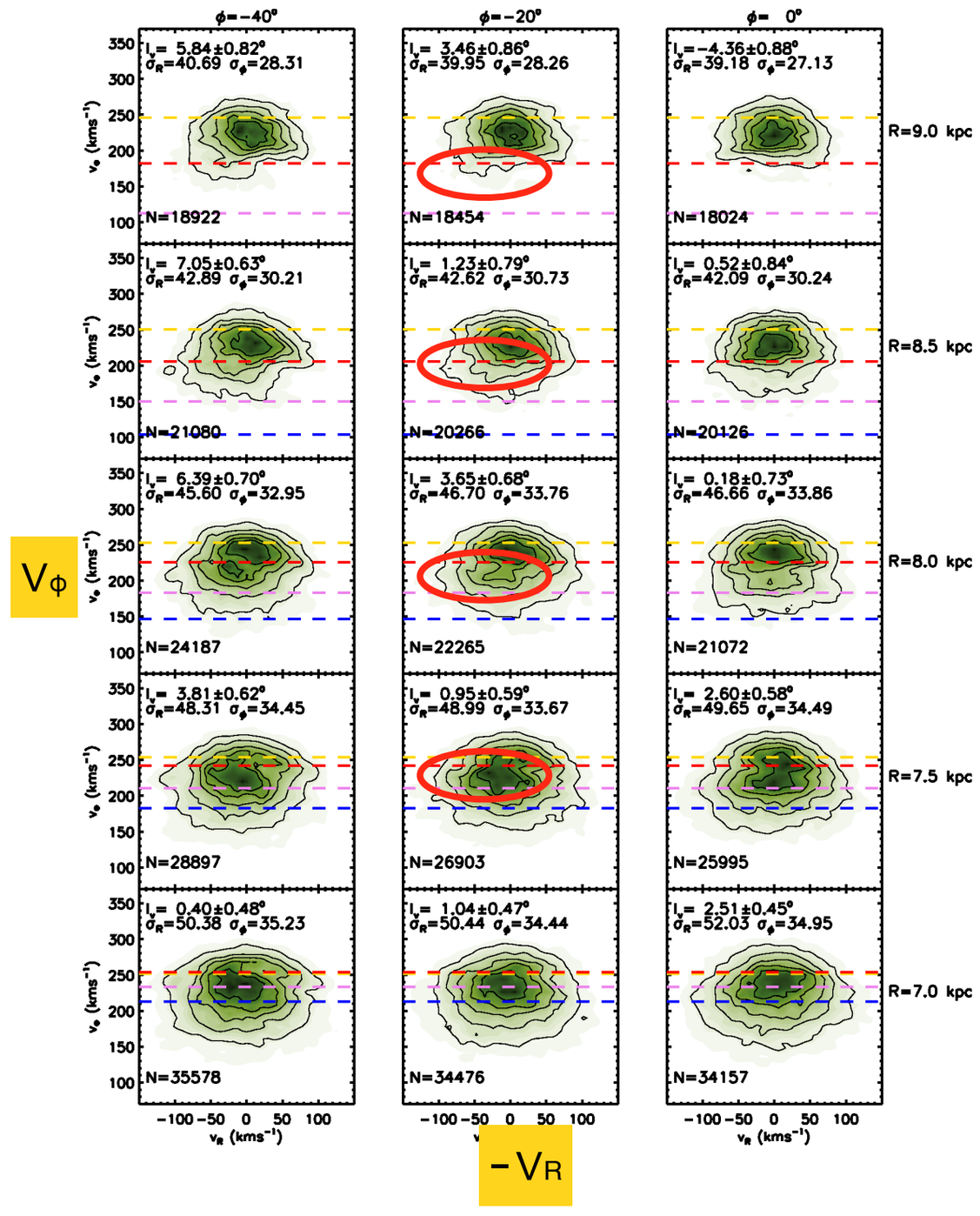
Moving groups extended on and above Galactic plane





The $\langle v_R \rangle$ gradient in the MW and the bar

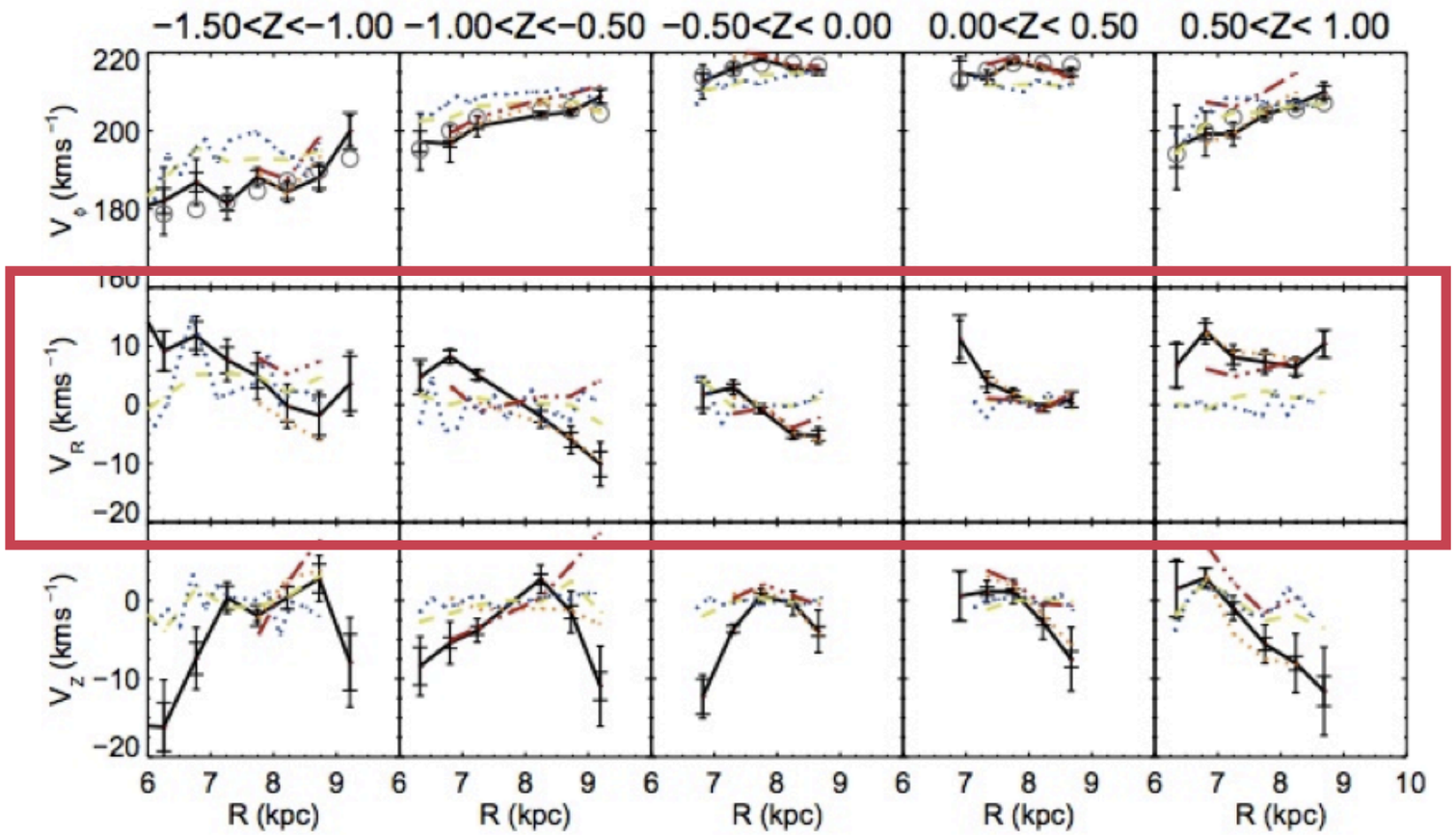
- Siebert et al. (2011); Williams et al. (2013): $d\langle v_R \rangle/dR \sim -3$km/sec/kpc from RAVE
- Bar creates $\langle v_R \rangle$ gradients nearby OLR
- For $\phi < 0$ and $R > R_{OLR}$ gradient is negative



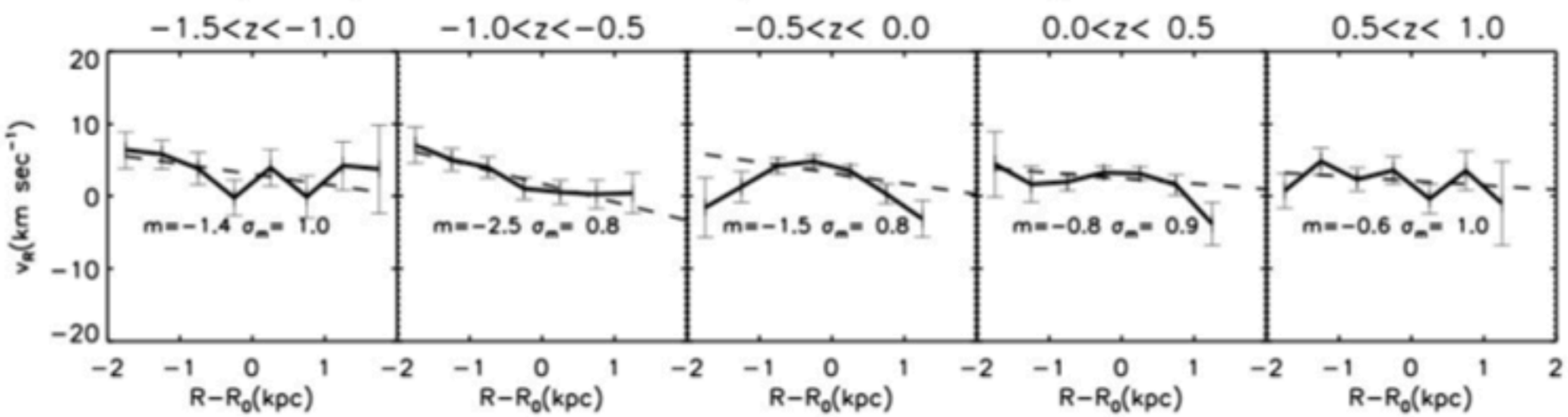
Conclusions

- 3D test particle simulations with bar, thin and thick disk
- Thick disk less affected by bar than thin, but significant substructure/imprints present
- Possible to trace bar effects z~1kpc thin disk, z~2kpc thick disk (akin Antoja et al., 2012)
- Bar induces large scale $d\langle v_R \rangle / dR < 0$, outside the OLR (cfr. Siebert et al. 2011, Williams et al. 2013)

The $\langle v_R \rangle$ gradient in the MW and the bar



Williams et al. 2013



Simulations