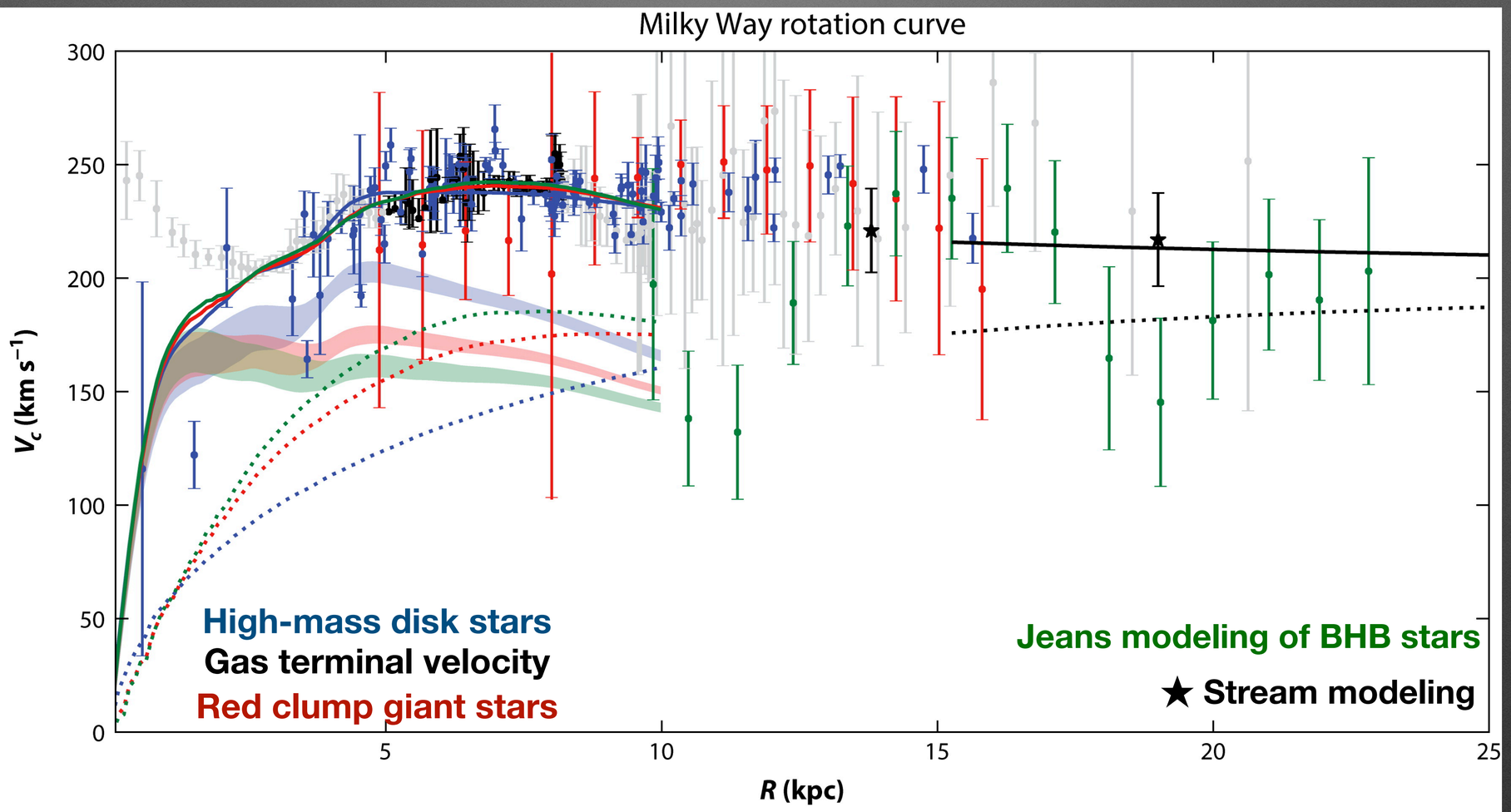
# Rotation Curve Tracers in Simulated Galaxies

Francisco J. Mercado (UCI)
Robyn Sanderson

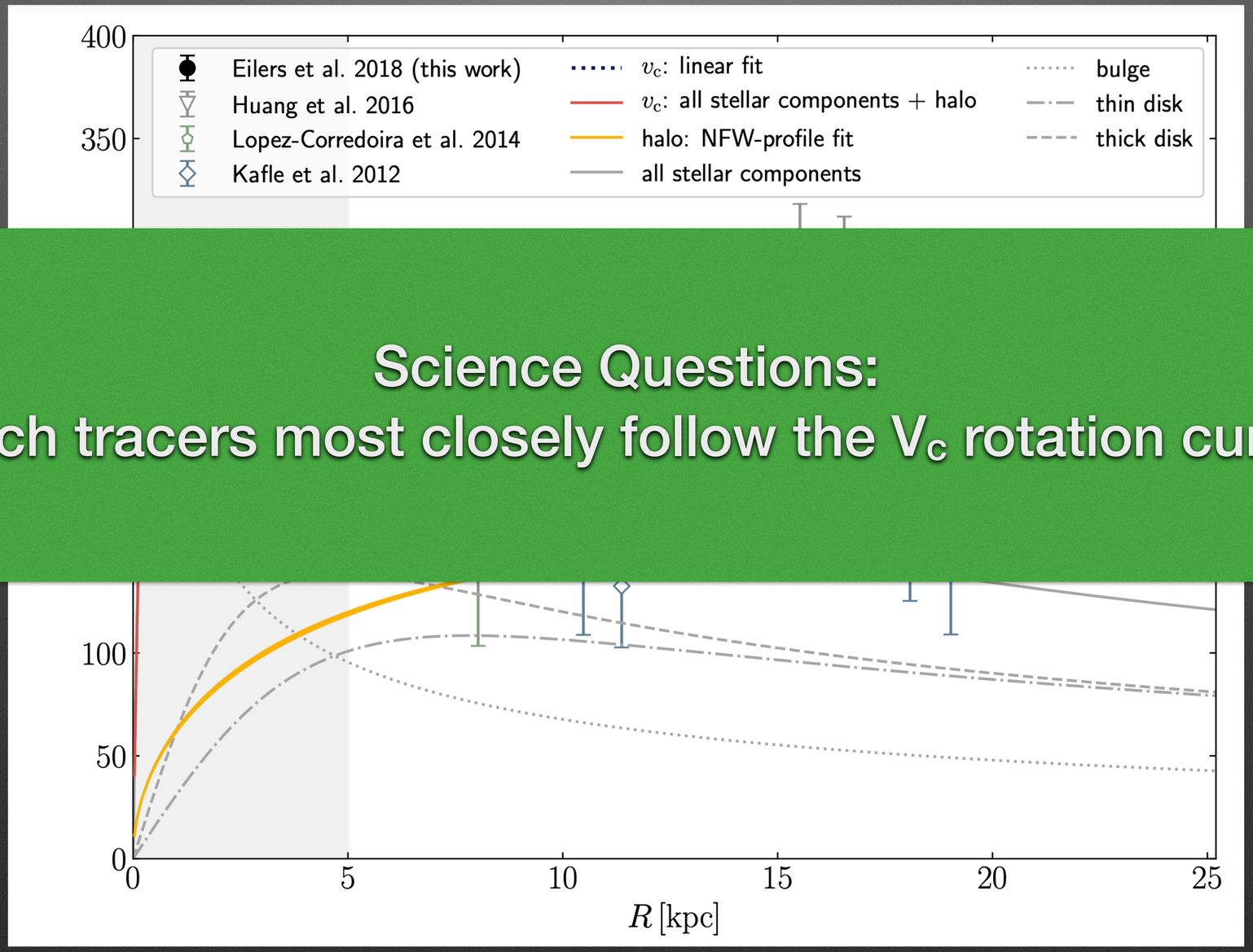
# The Rotation Curve Before Gaia




Bland-Hawthorn J, Gerhard O. 2016.
Annu. Rev. Astron. Astrophys. 54:529–96

$$v_c(r) = \sqrt{\frac{GM(<r)}{r}}$$

# Eilers et. al used Gaia data

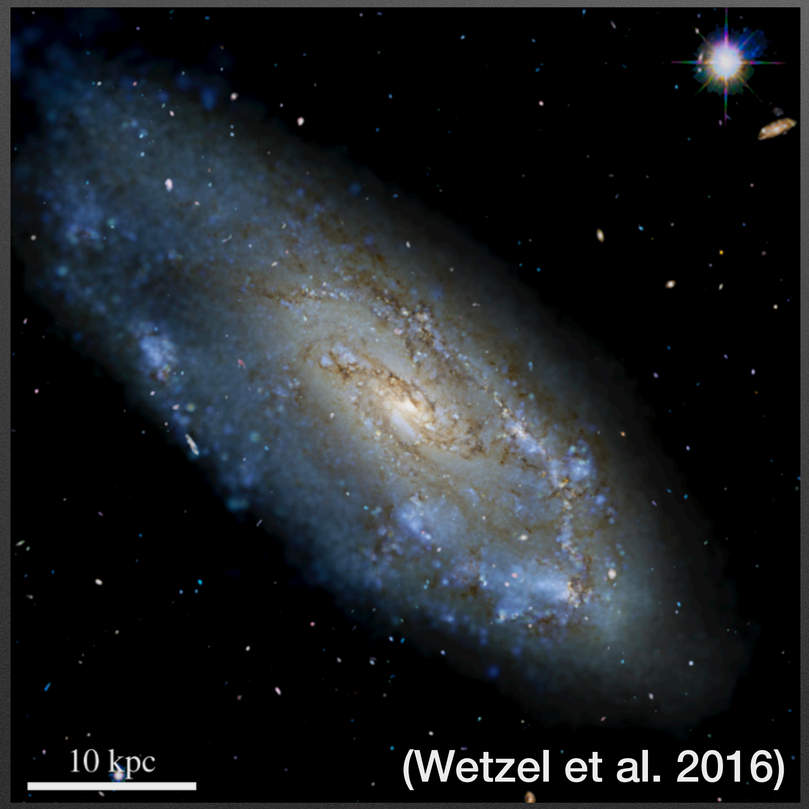



Science Questions:
Which tracers most closely follow the $V_c$ rotation curve?

# FIRE-2 Simulations

- 7 Isolated MW-like Halos (Latte) + 6 halos from simulated LG - like volume (Elvis) run with FIRE-2 physics

Latte

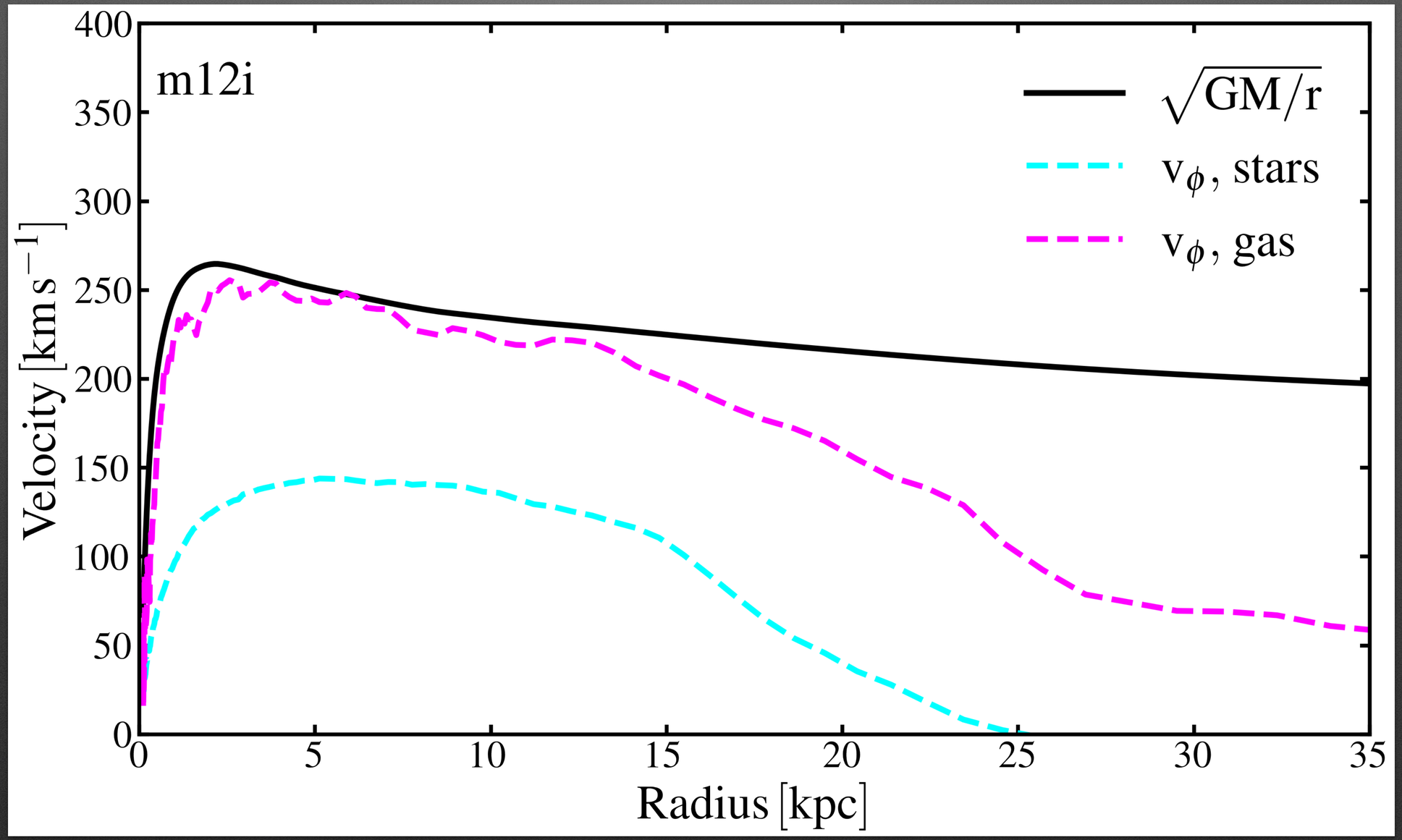



(Wetzel et al. 2016)

Elvis

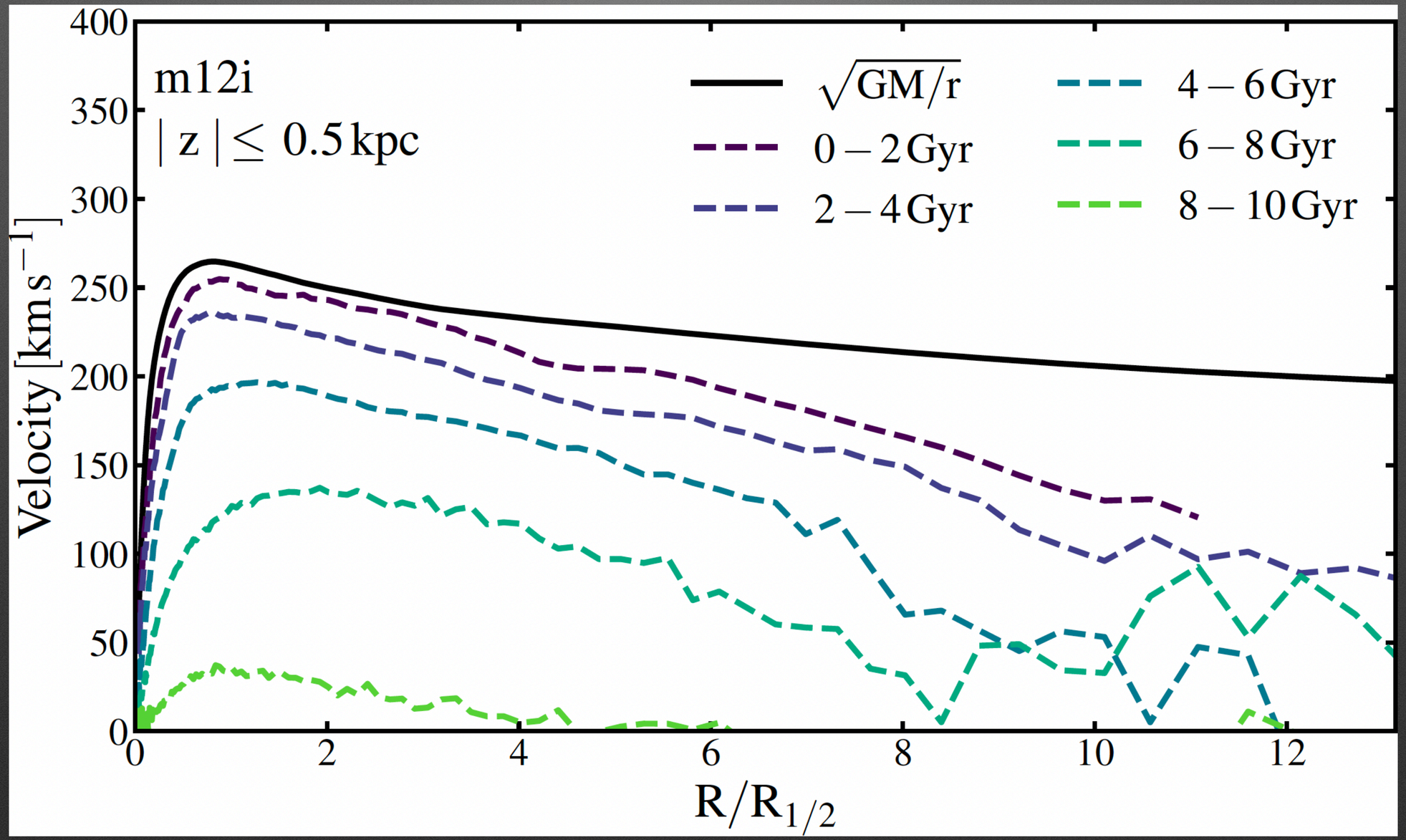
(Garisson-Kimmel et al. 2018)

# Stars vs Gas

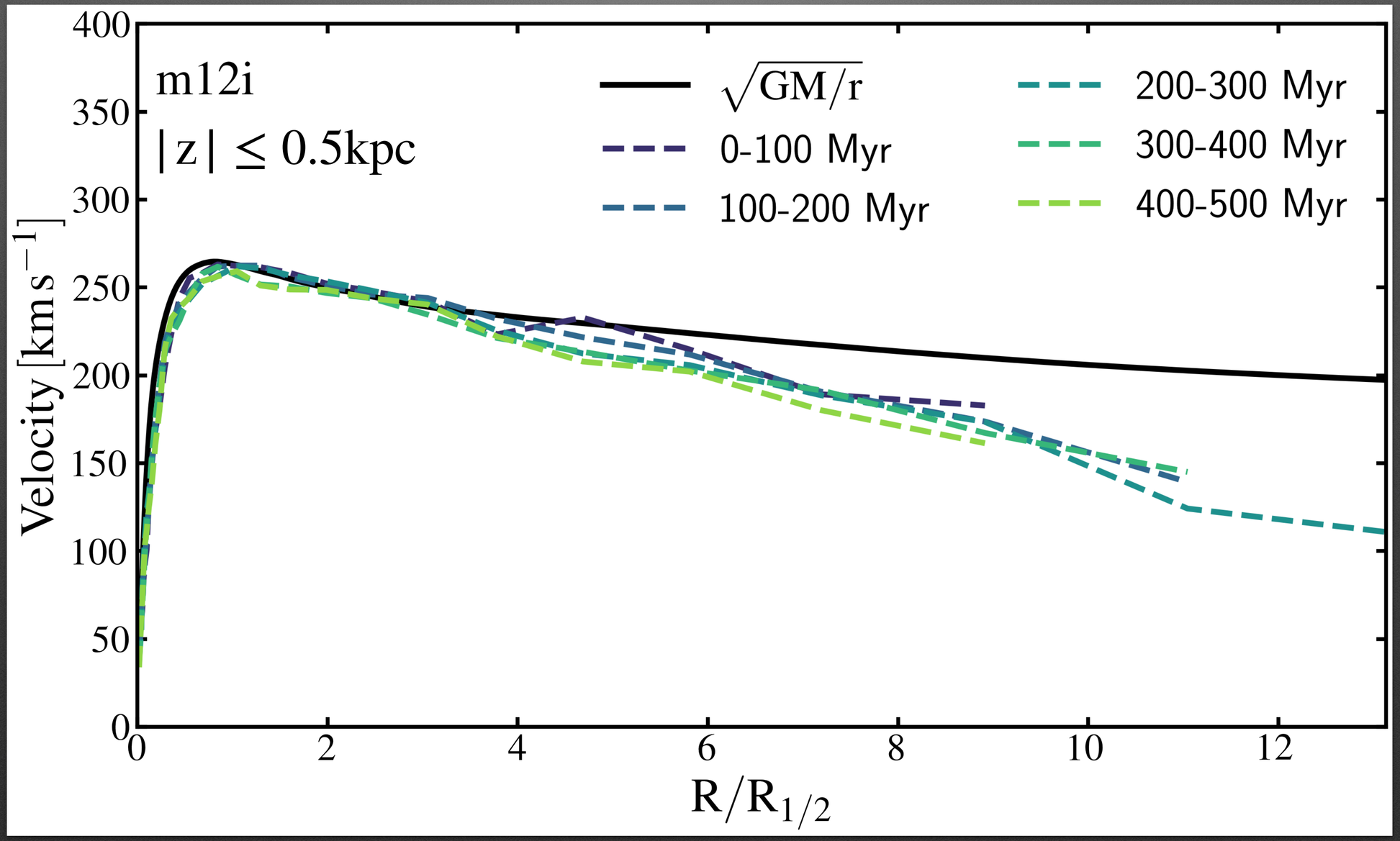

m12i
$\sqrt{GM/r}$
$v_\phi$, stars
$v_\phi$, gas
Velocity [km s$^{-1}$]
Radius [kpc]
0
50
100
150
200
250
300
350
400
0
5
10
15
20
25
30
35

# Stellar Component

# Younger Stars —> More Circular Orbits



# Youngest Stars —> Most Circular Orbits



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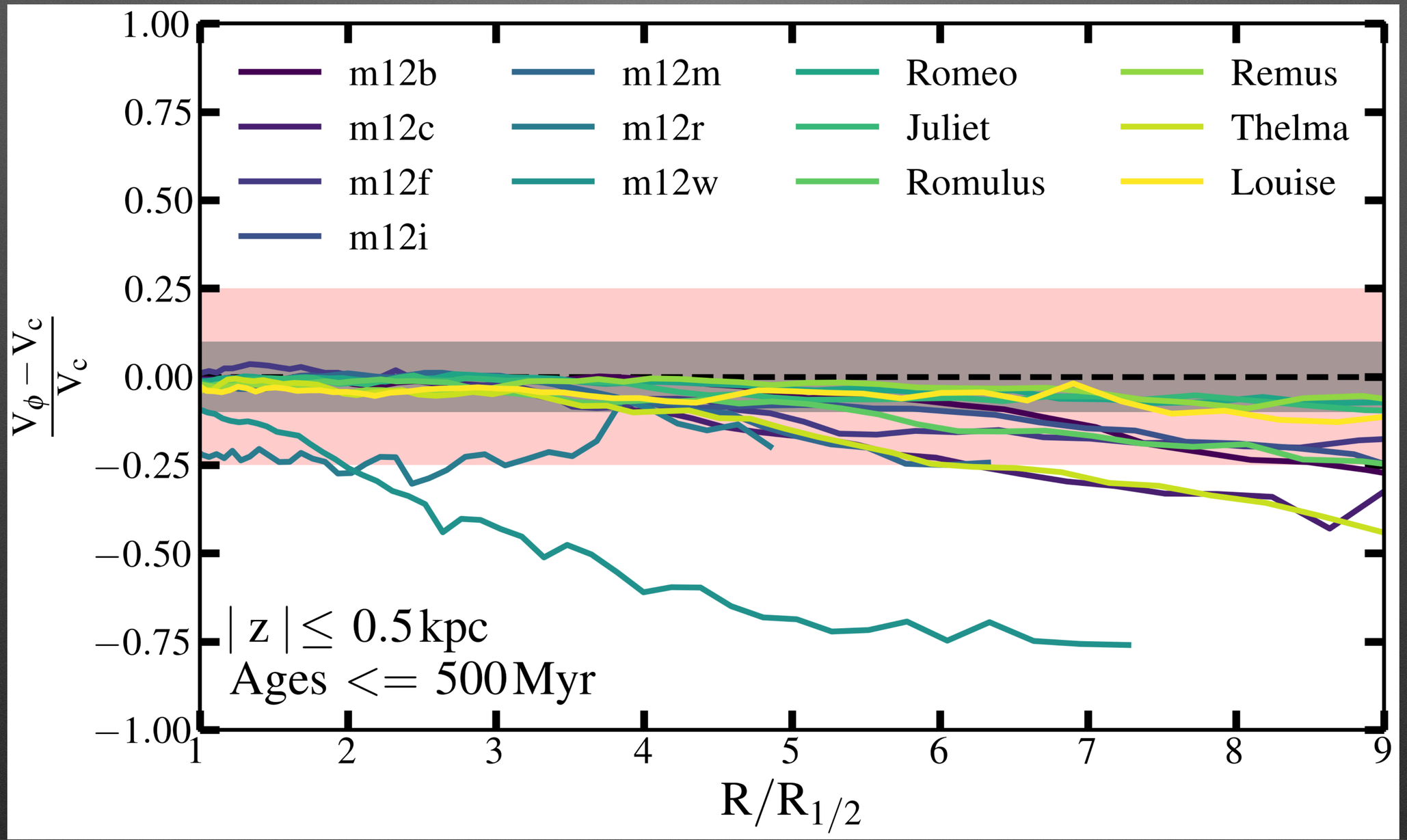
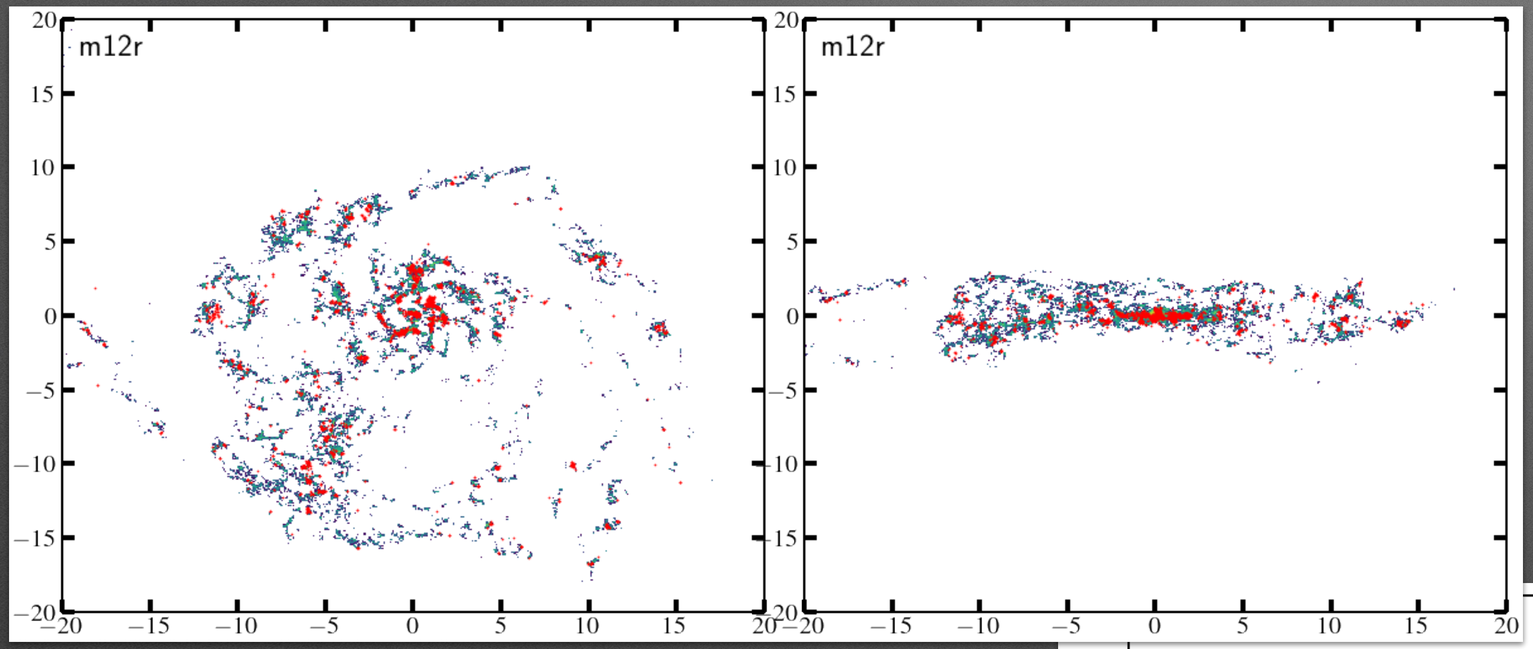
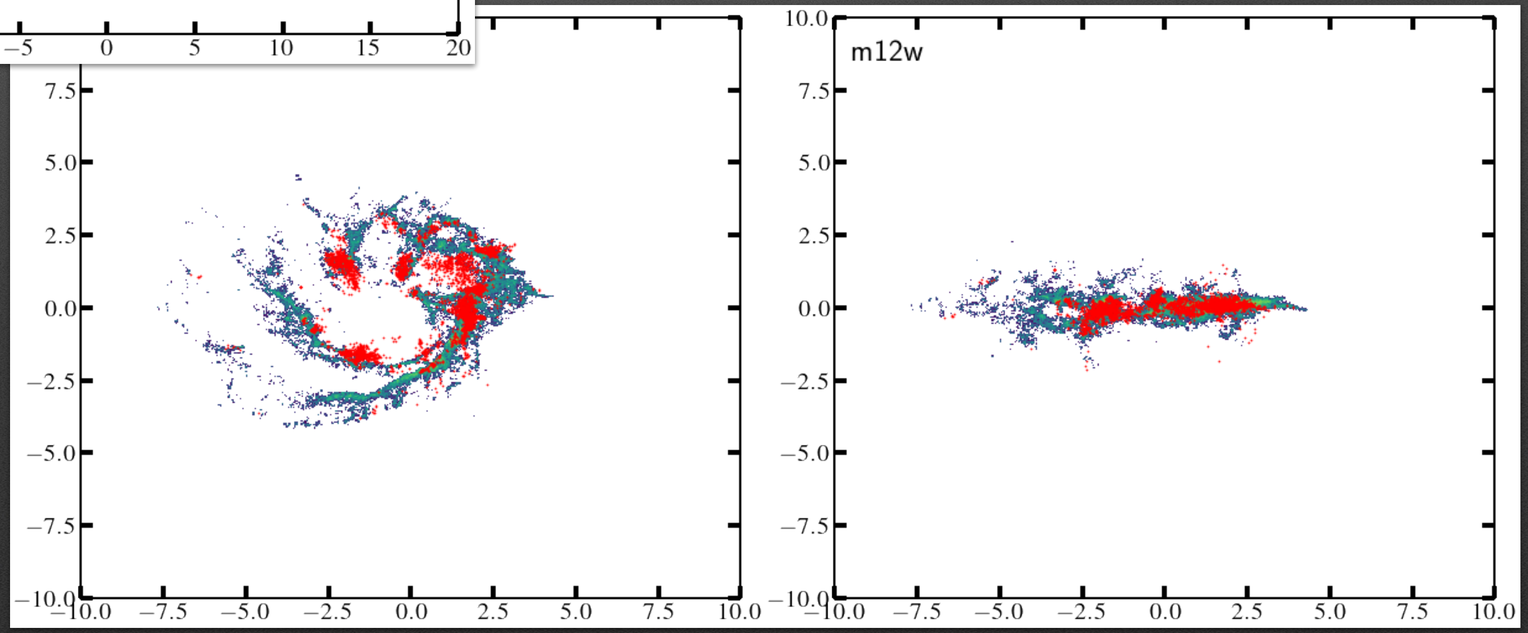
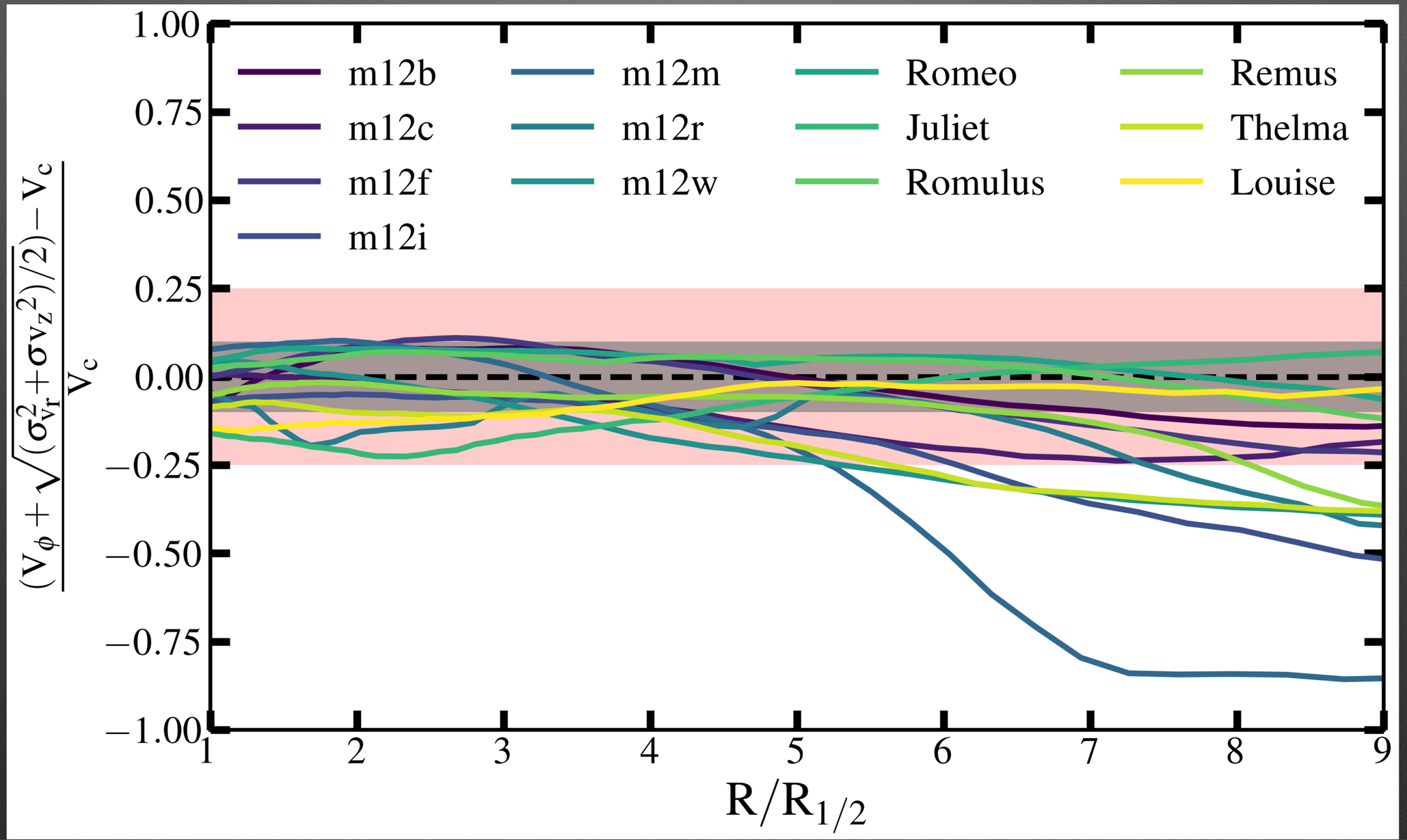


# Weird Cases: m12w & m12r

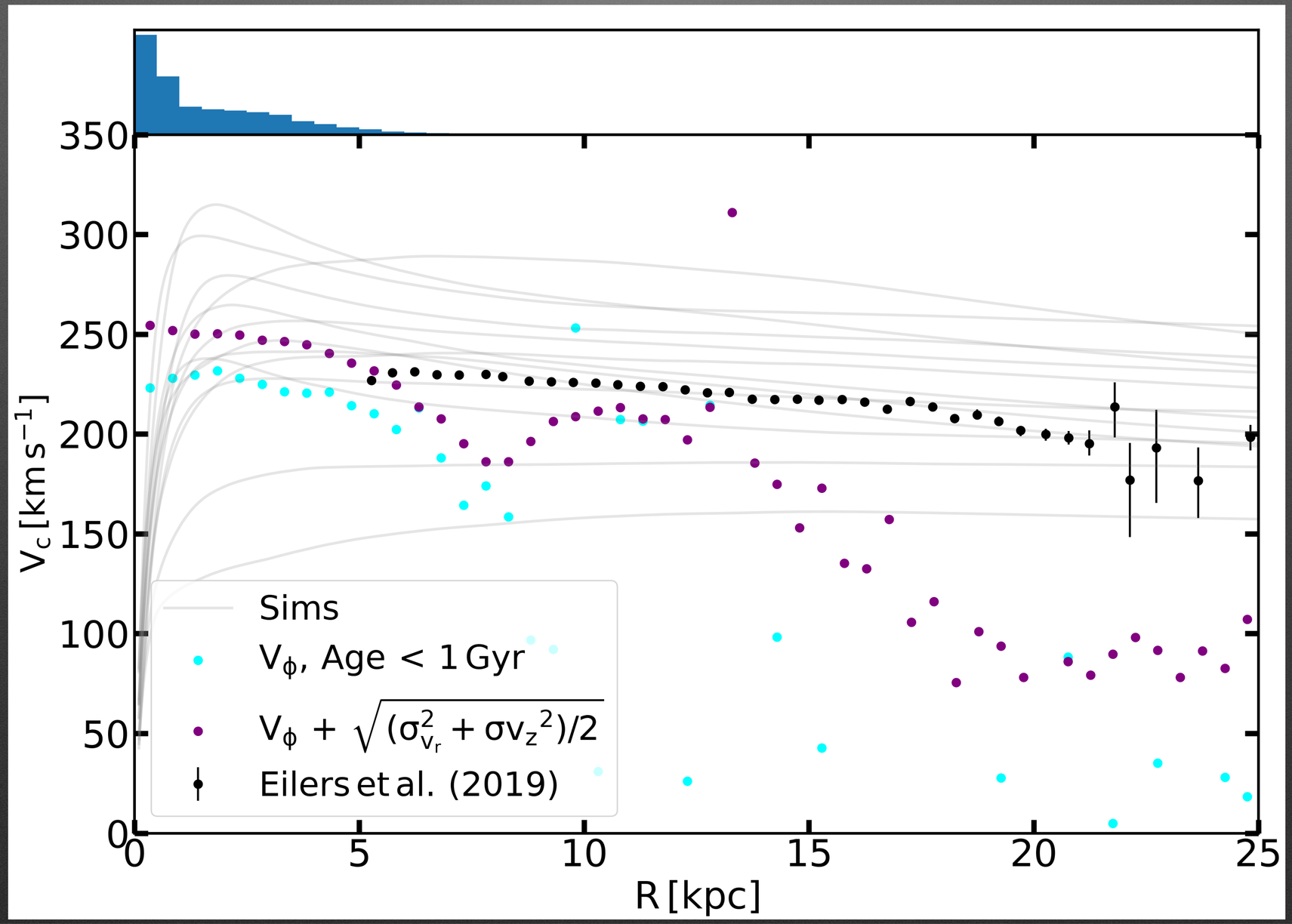


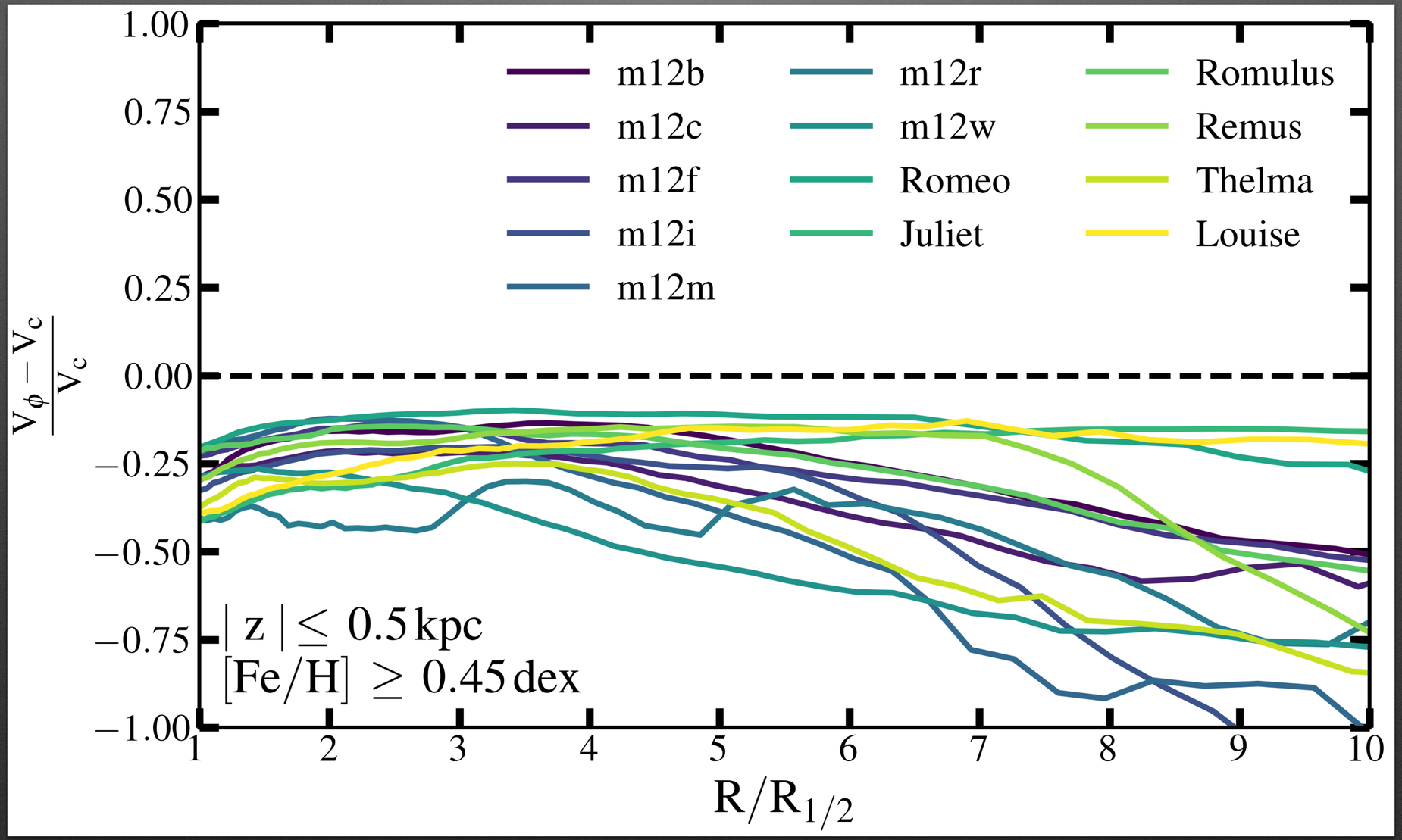
# Considering Asymmetric Drift



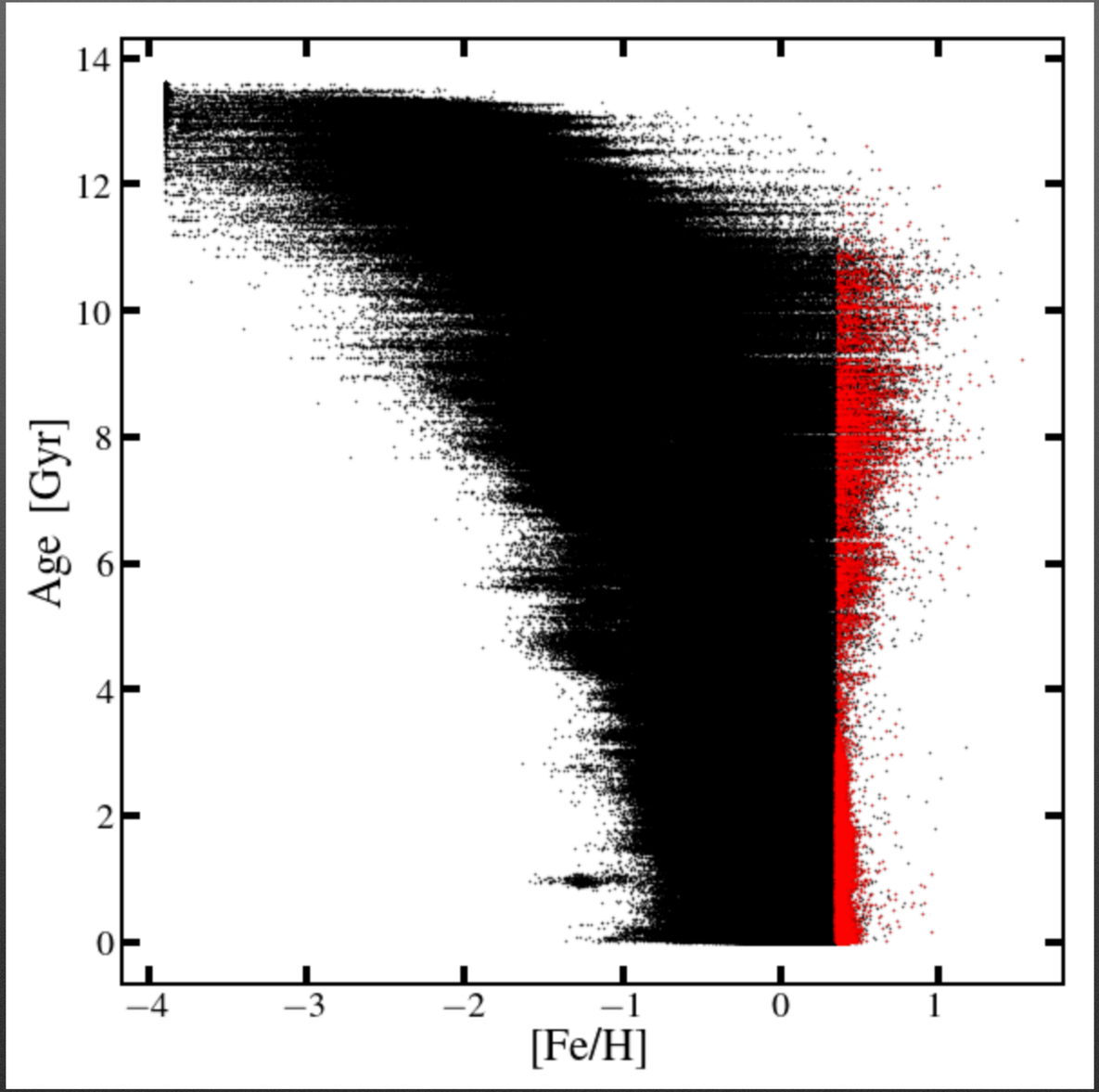
# A Look at Real Data: Apogee



# Cut on [Fe/H]

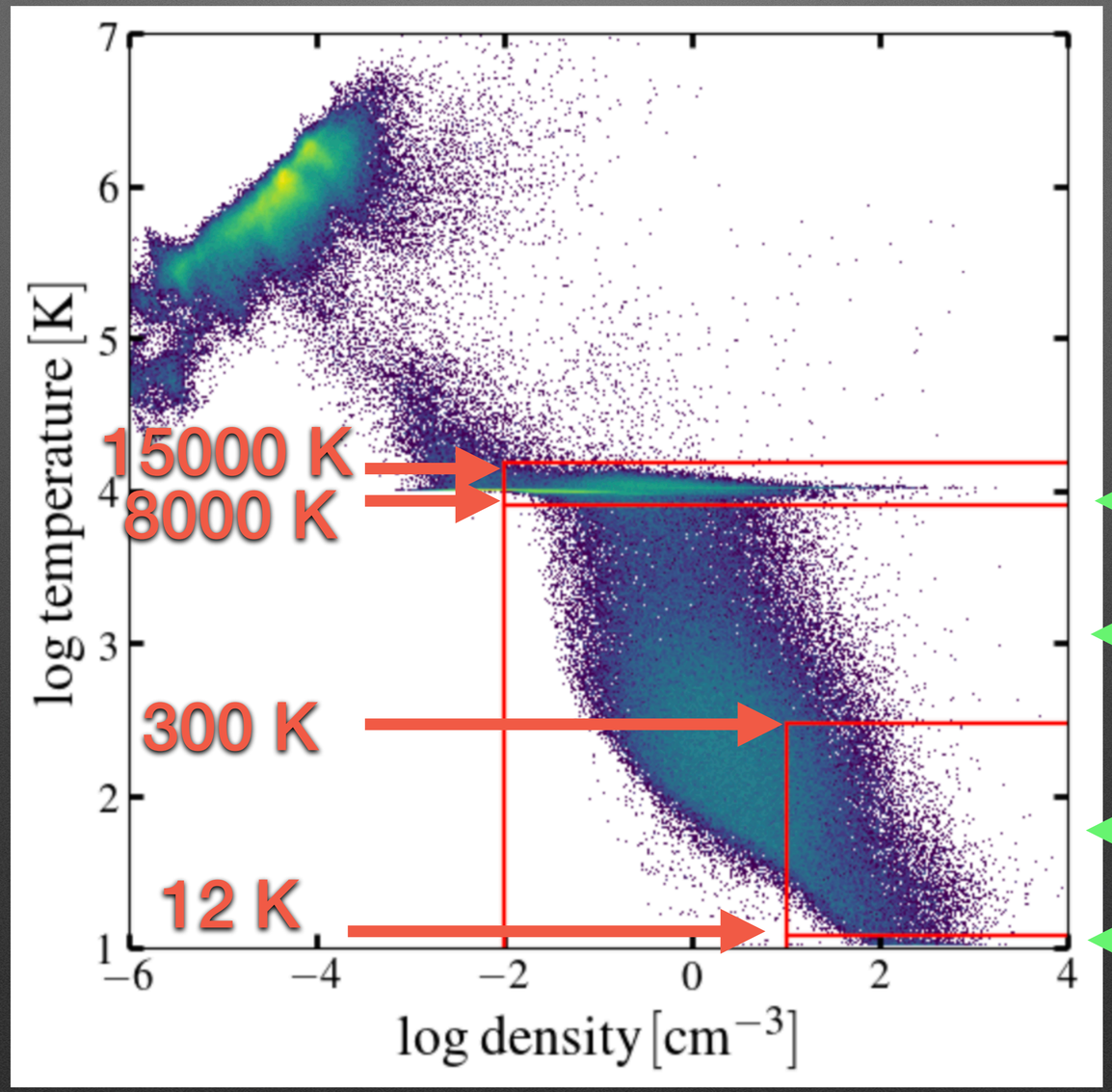

m12b
m12c
m12f
m12i
m12m
m12r
m12w
Romeo
Juliet
Romulus
Remus
Thelma
Louise
$|z| \leq 0.5\,\mathrm{kpc}$
$[\mathrm{Fe/H}] \geq 0.45\,\mathrm{dex}$
$\frac{V_\phi - V_c}{V_c}$
$R/R_{1/2}$
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
1
2
3
4
5
6
7
8
9
10

# Large Age S



# Gaseous Component

# Gas Cuts: Density & Temp




Cuts taken from Moreno+2019

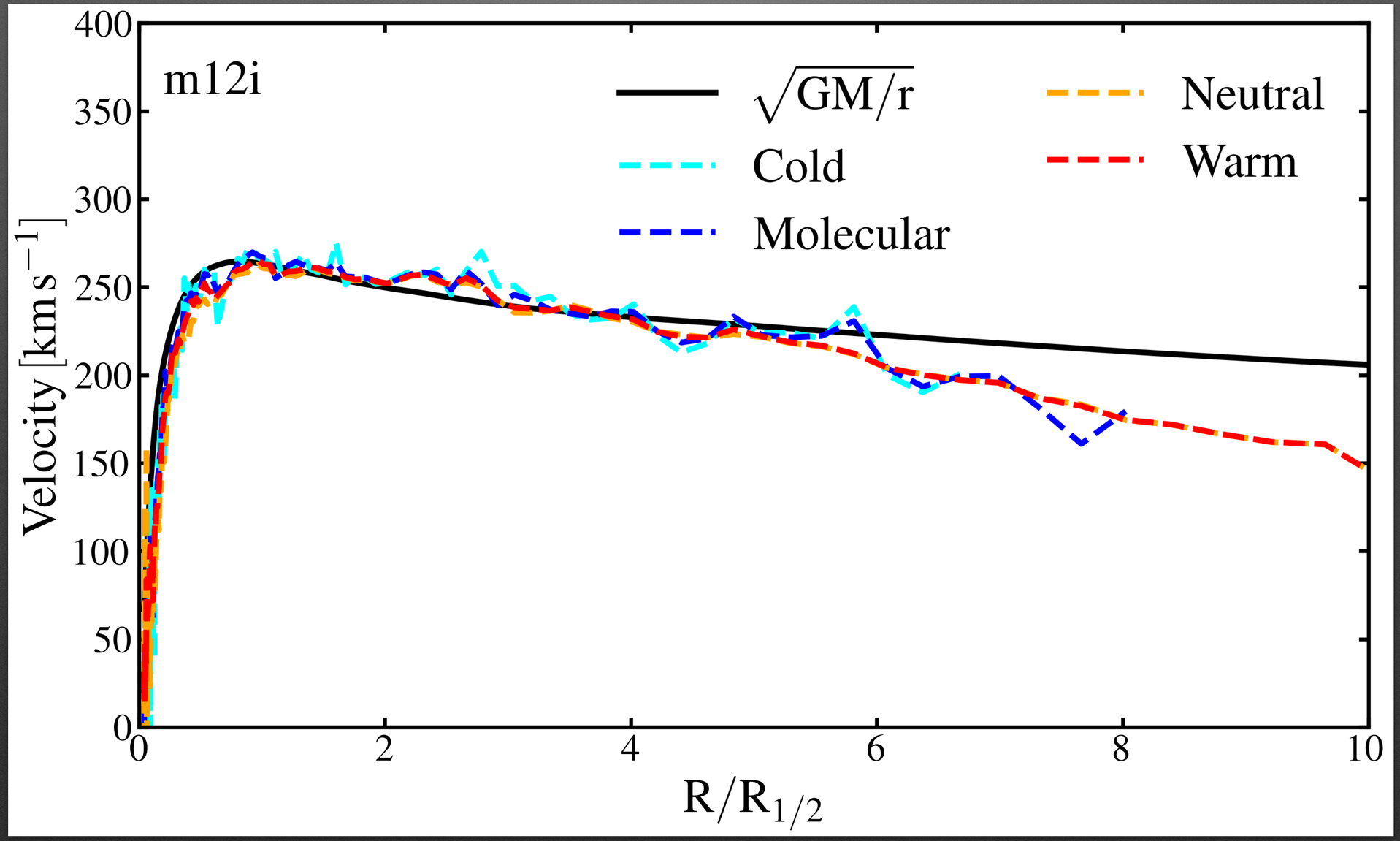
Warm

Neutral

Molecular

Cold

# Cold & Dens —> More Circular Orbits



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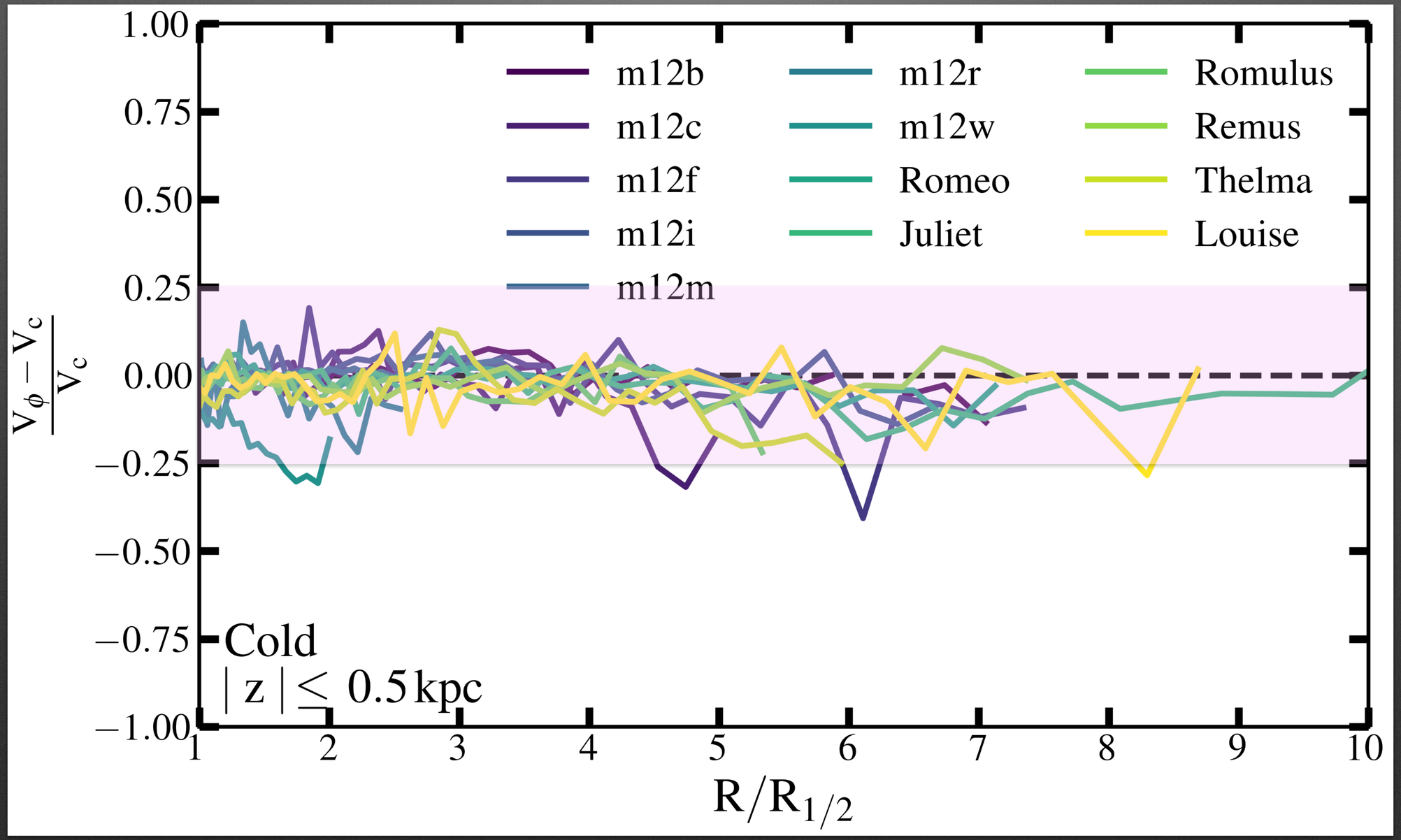

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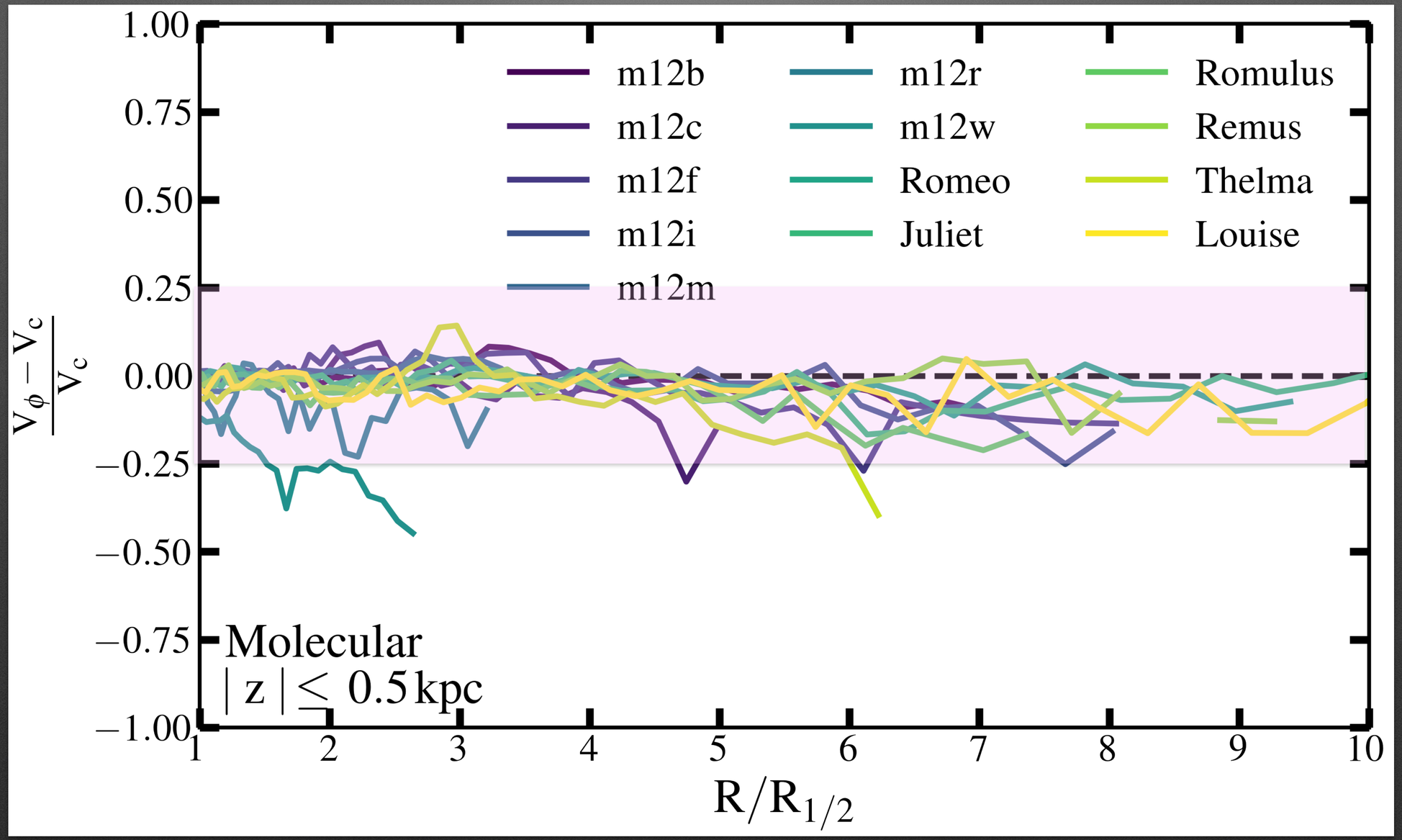

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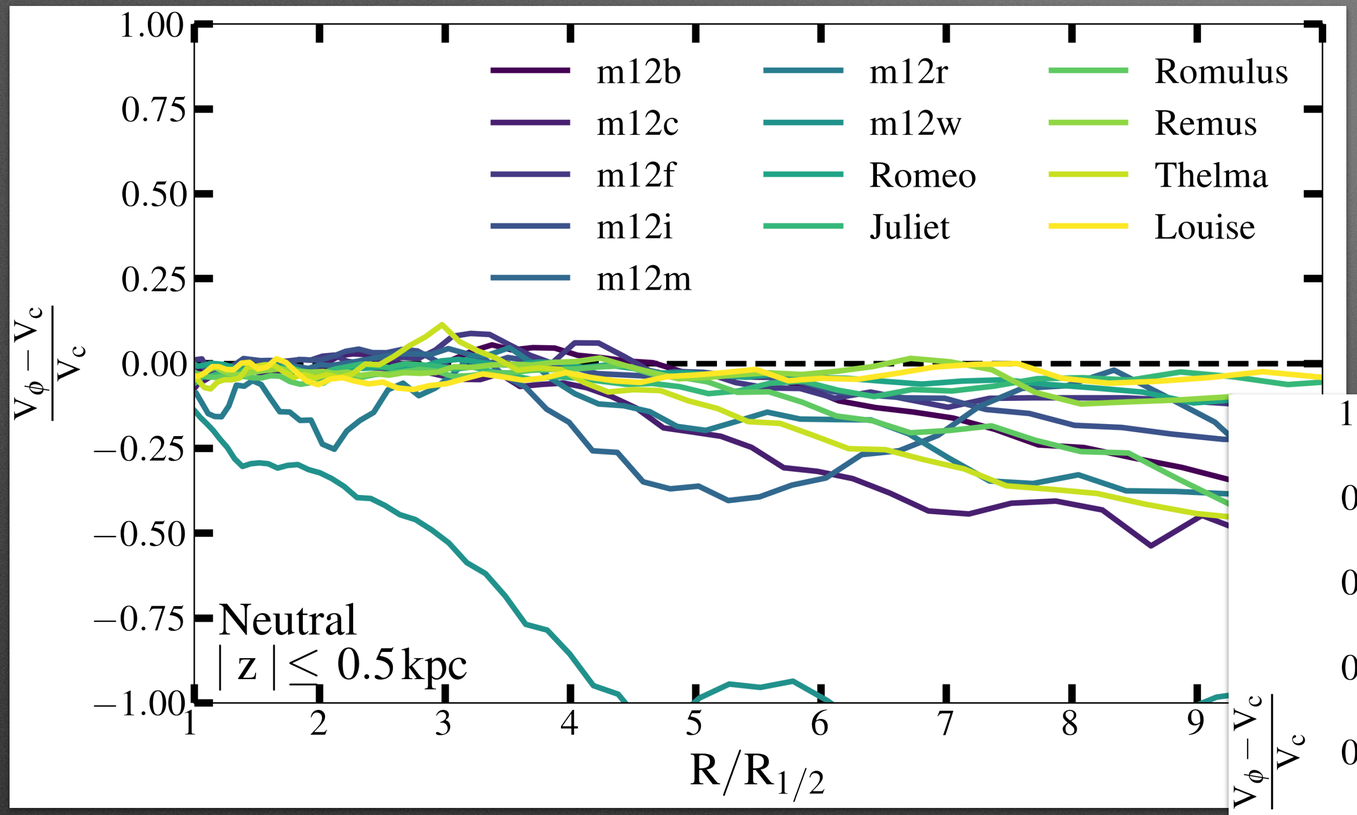


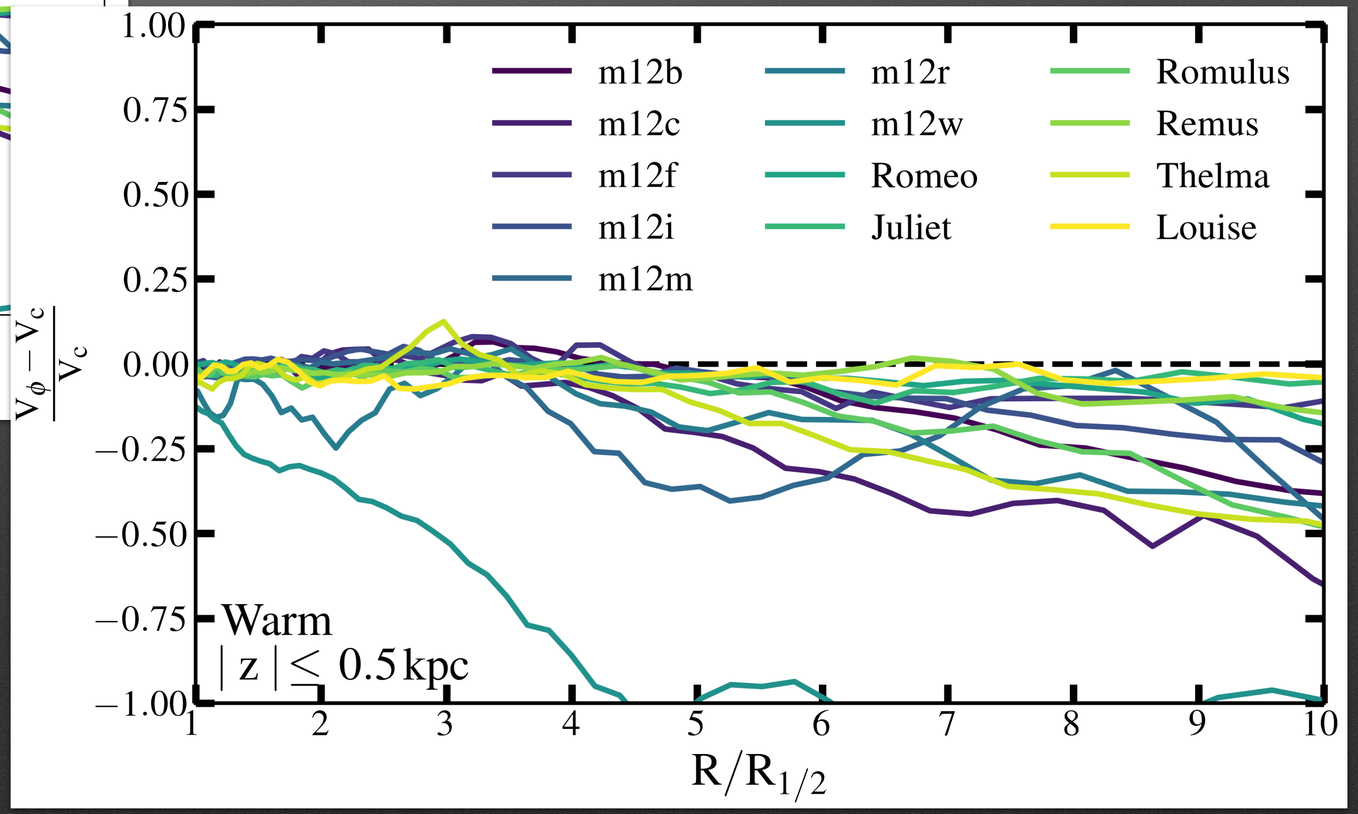

# Conclusions

- Young stars (age < 100 Myrs) tend to track the $\sqrt{(GM/R)}$ best out to a few times the stellar half mass radius within ~25%
- Galaxies that this doesn't work for either have disks that have not settled or have recently experienced mergers that significantly disrupt the disk
- Taking into account asymmetric drift works relatively well for all galaxies (even the weird ones)
- Seems like this method can work when applied to observational MW data
- Cold, dense gas also tracks $\sqrt{(GM/R)}$ relatively within ~25% large radii