Cold Dark Matter
vs
Modified Gravity

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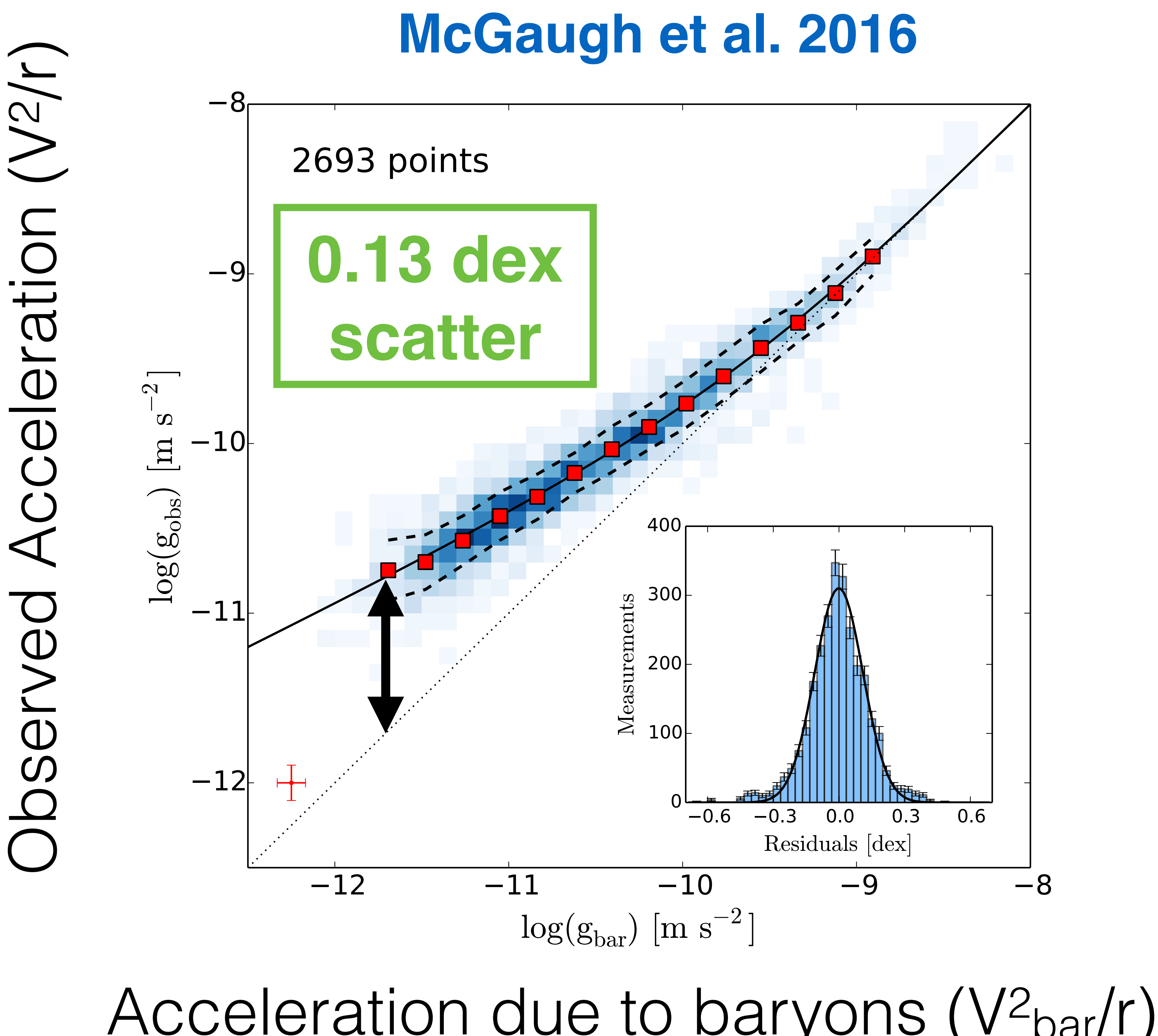
Questions

1. **What does the Radial Acceleration Relation tell us? Is the flattening at low g_{bar} supporting dark matter (DM) or modified gravity (MG)?**

2. What is the observational relation that most strongly supports DM / MG at dwarf scales?

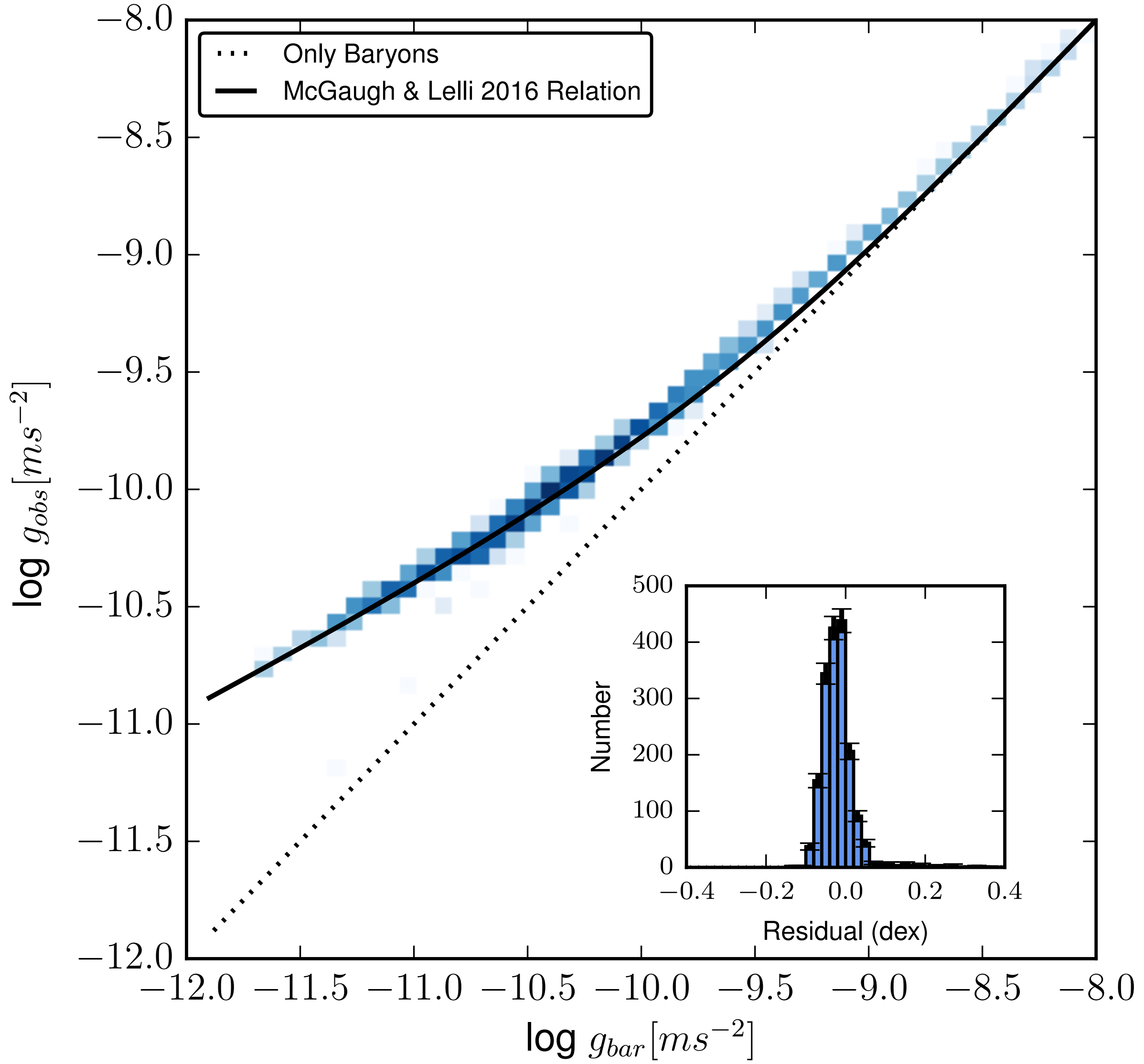
3. What could be a final test to prove/disprove DM/MG at dwarf scales?

Mass **D**iscrepancy **A**cceleration **R**elation

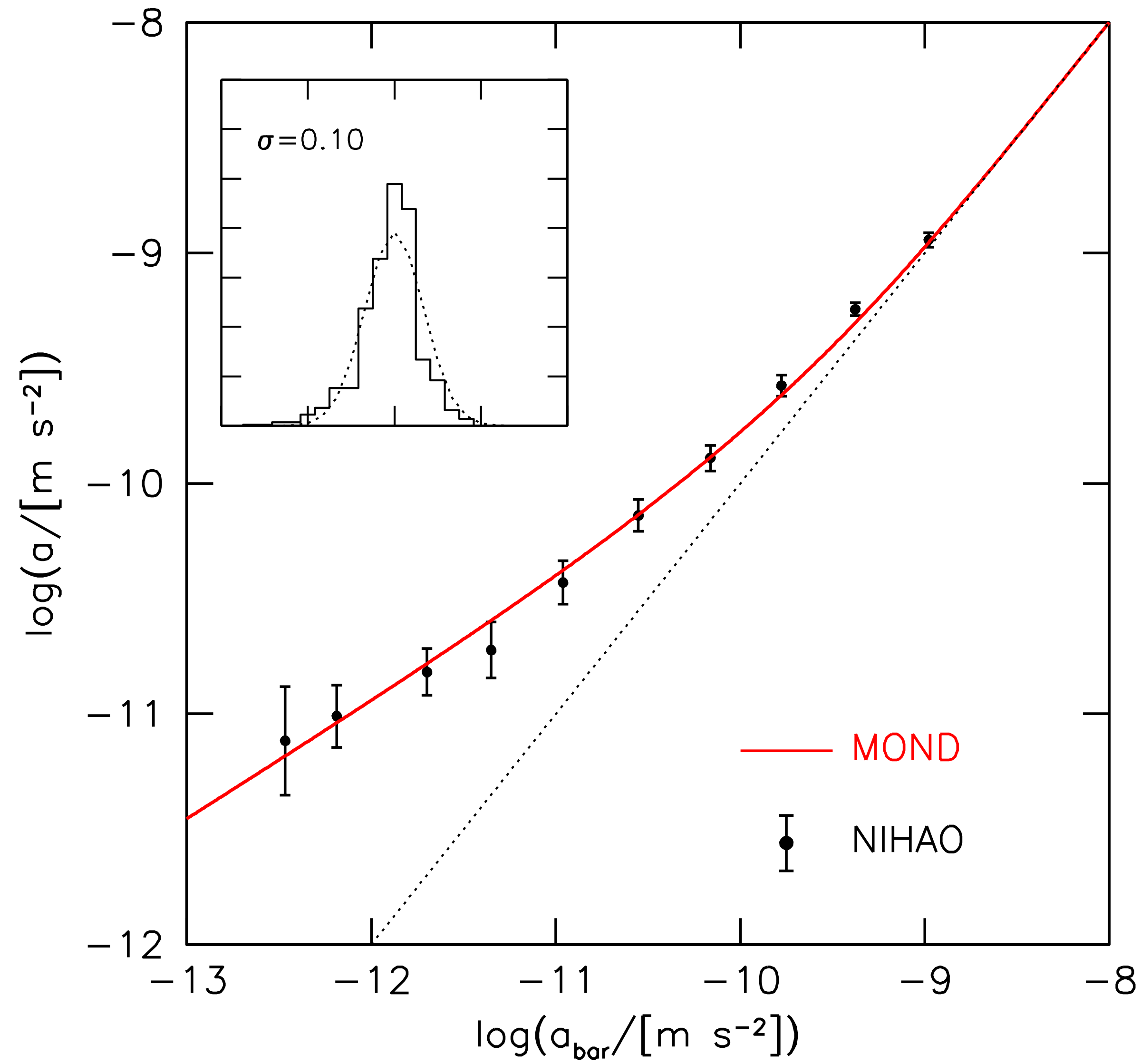


Mass **D**iscrepancy **A**cceleration **R**elation exists in LCDM galaxy formation simulations

Keller & Wadsley 2016



NIHAO simulations



MOND is based on 3 assumptions

Milgrom 1983

1. Rotation curves are flat at large radii

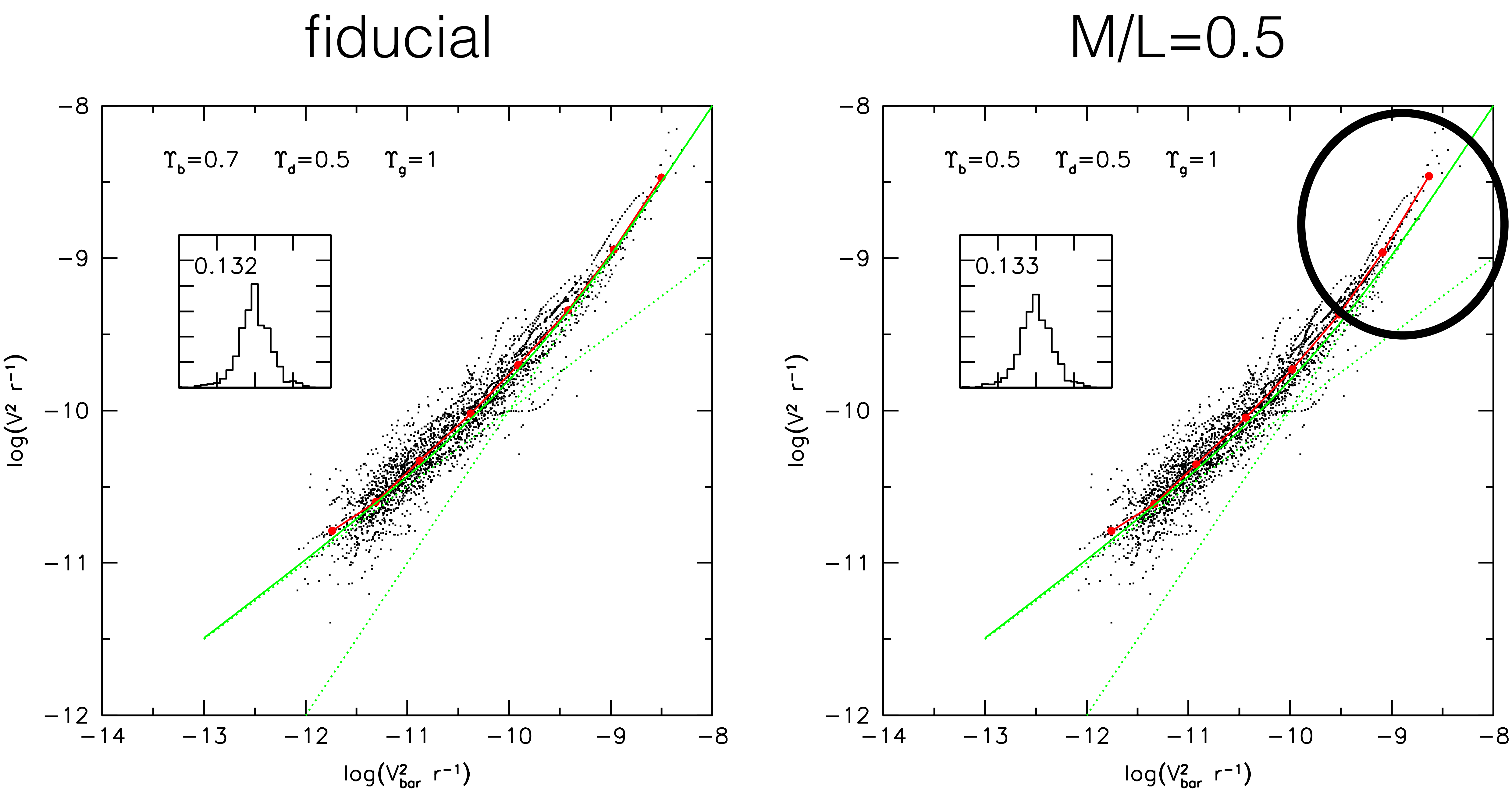
   $$a^2 = a_0\, a_{bar}$$
   $$V^4 = a_0\, G\, M_{bar}$$

2. Dark matter fraction is zero at high accelerations

   $$a = a_{bar}$$
   $$V = V_{bar}$$

3. There is a unique interpolation function between a_{bar} and a

Mass **D**iscrepancy **A**cceleration **R**elation Is Not Unique



Data from SPARC (same as used by McGaugh et al. 2016)

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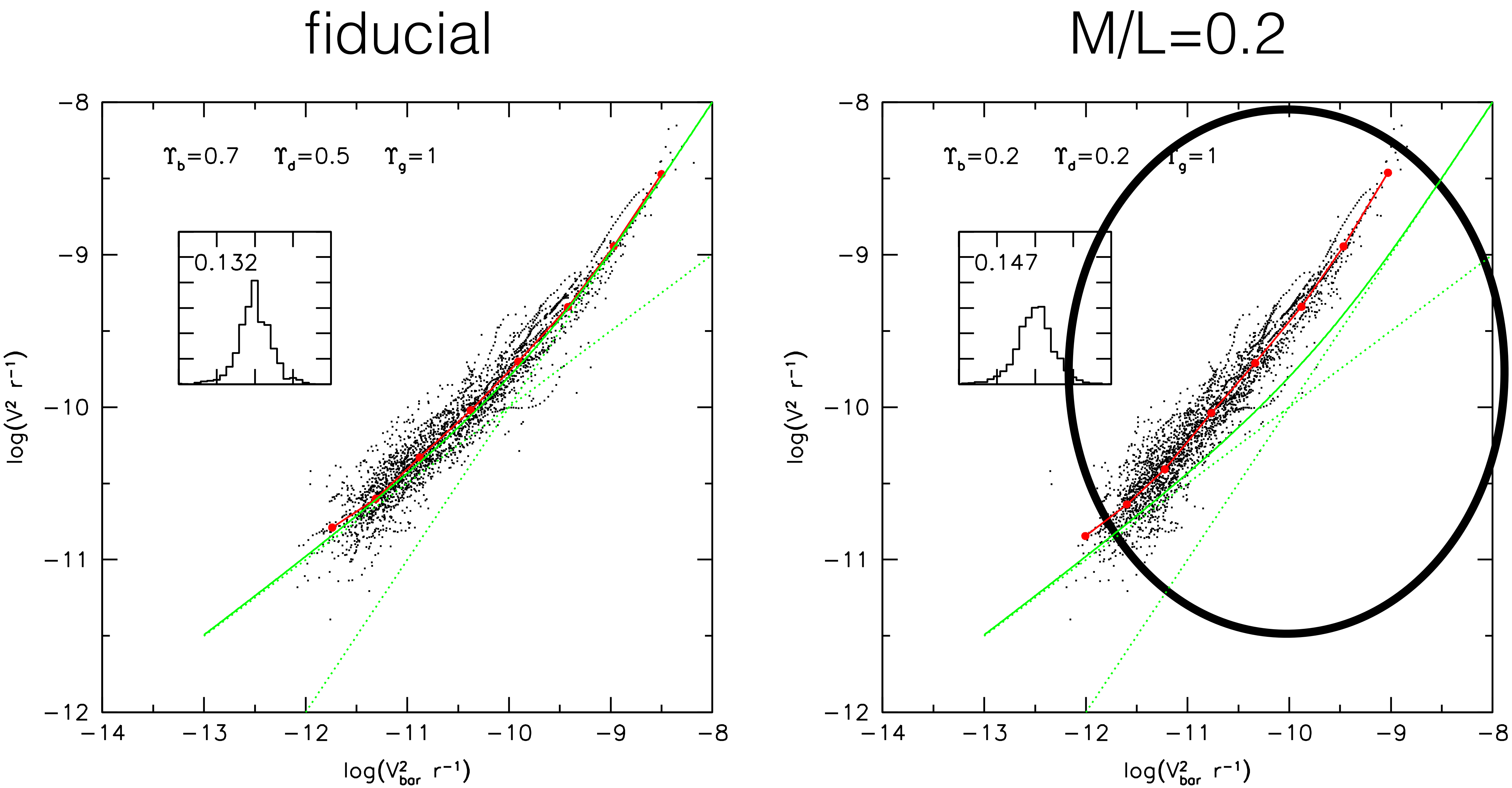

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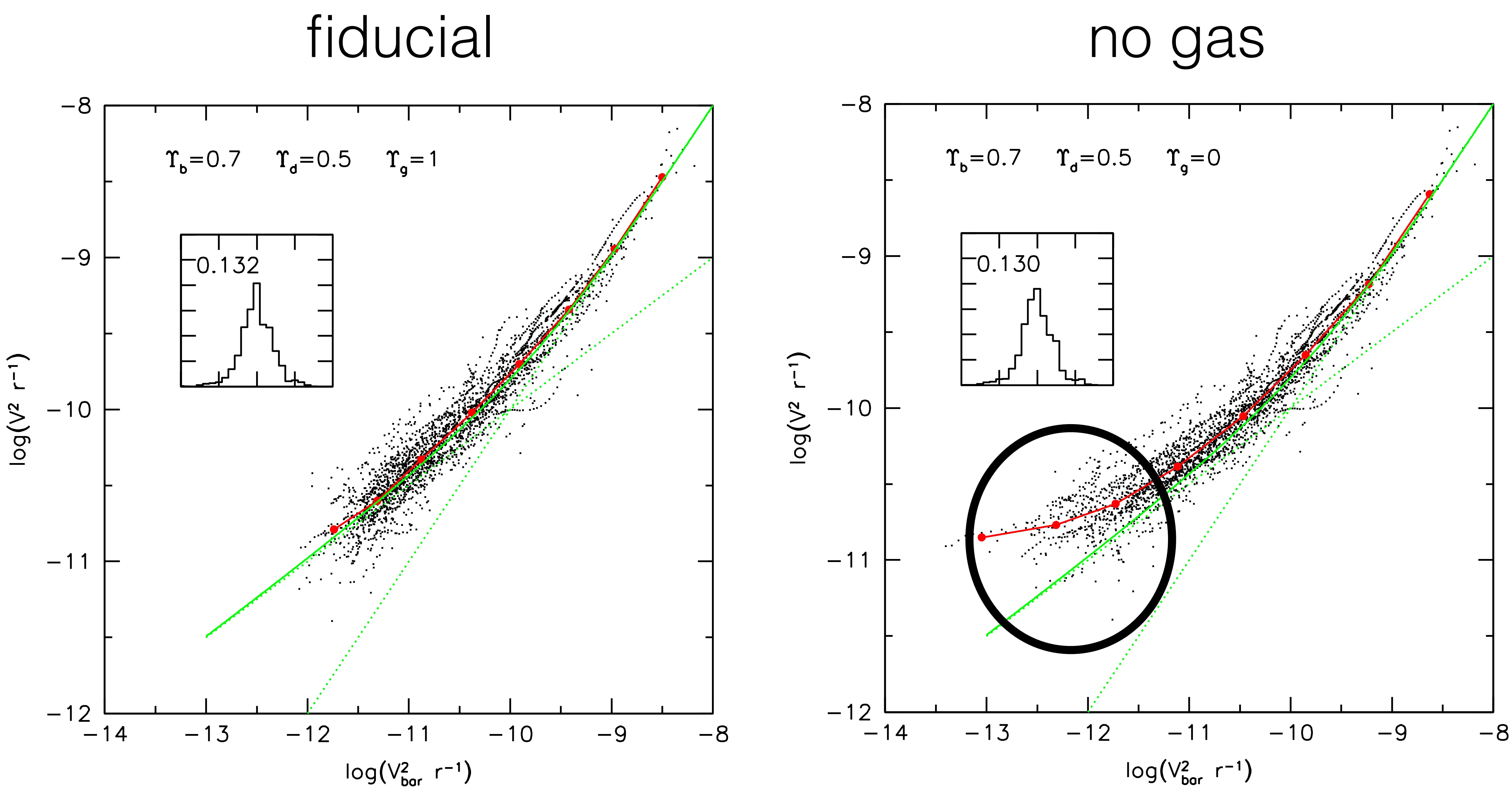

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   $$V^4 = a_0\, G\, M_{bar}$$

2. Dark matter fraction is zero at high accelerations

   $$\mathbf{a = a_{bar}}$$
   $$V = V_{bar}$$

3. There is a unique interpolation function between $\mathbf{a_{bar}}$ and $\mathbf{a}$

These are only **approximately** true

The fallacy of MOND is to assume they are a law of nature

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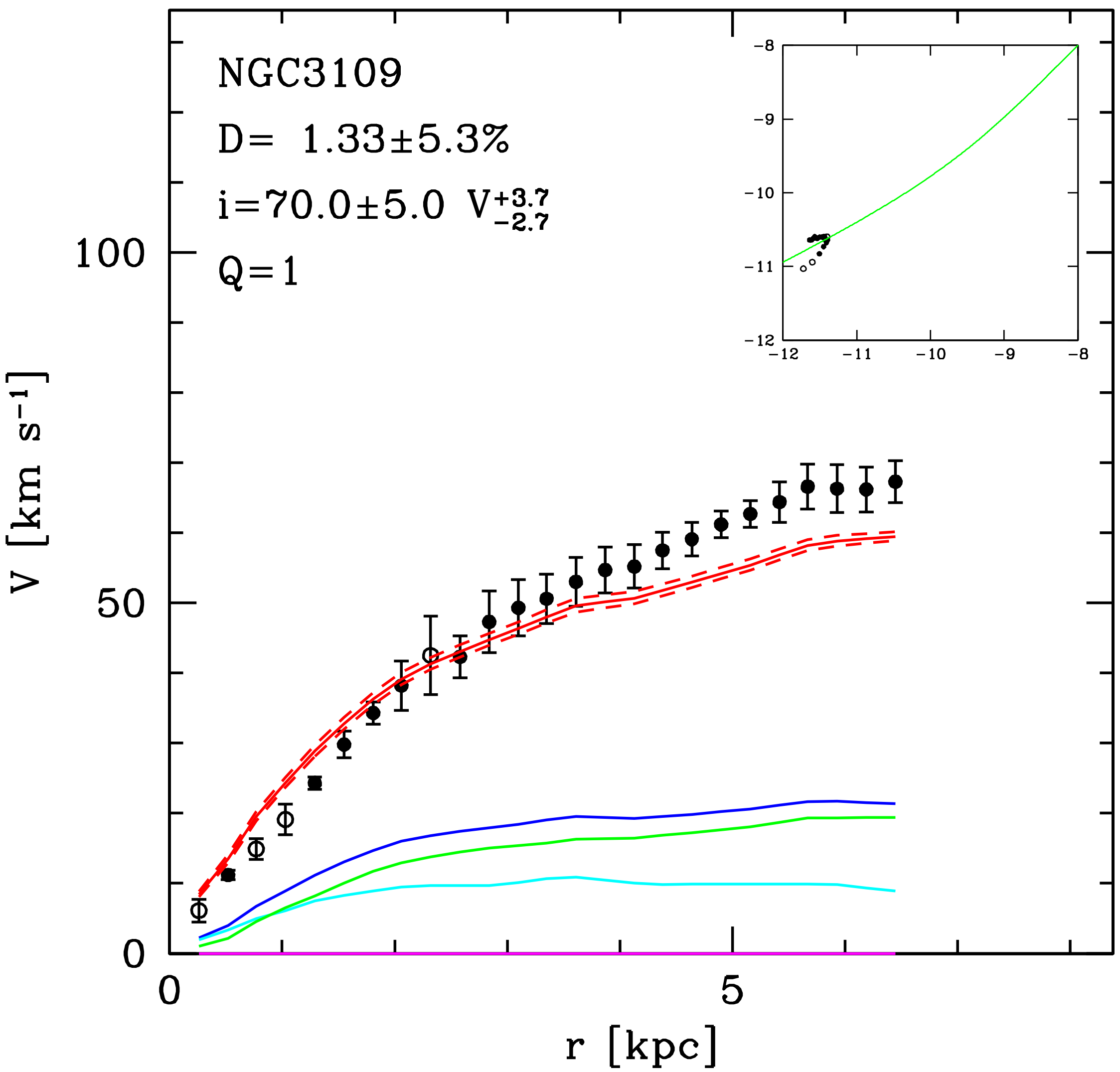
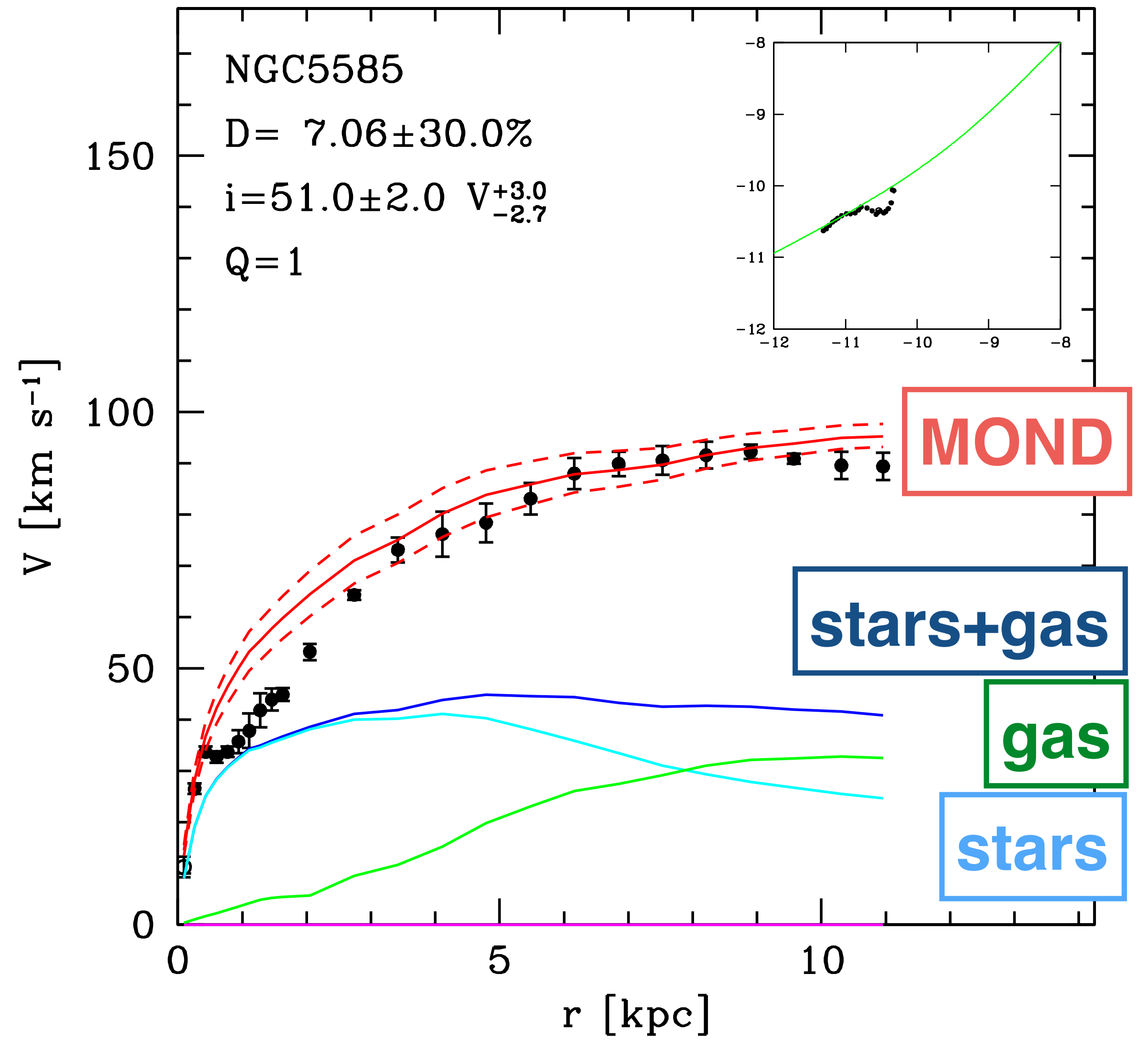
MOND over predicts rotation velocities at small radii





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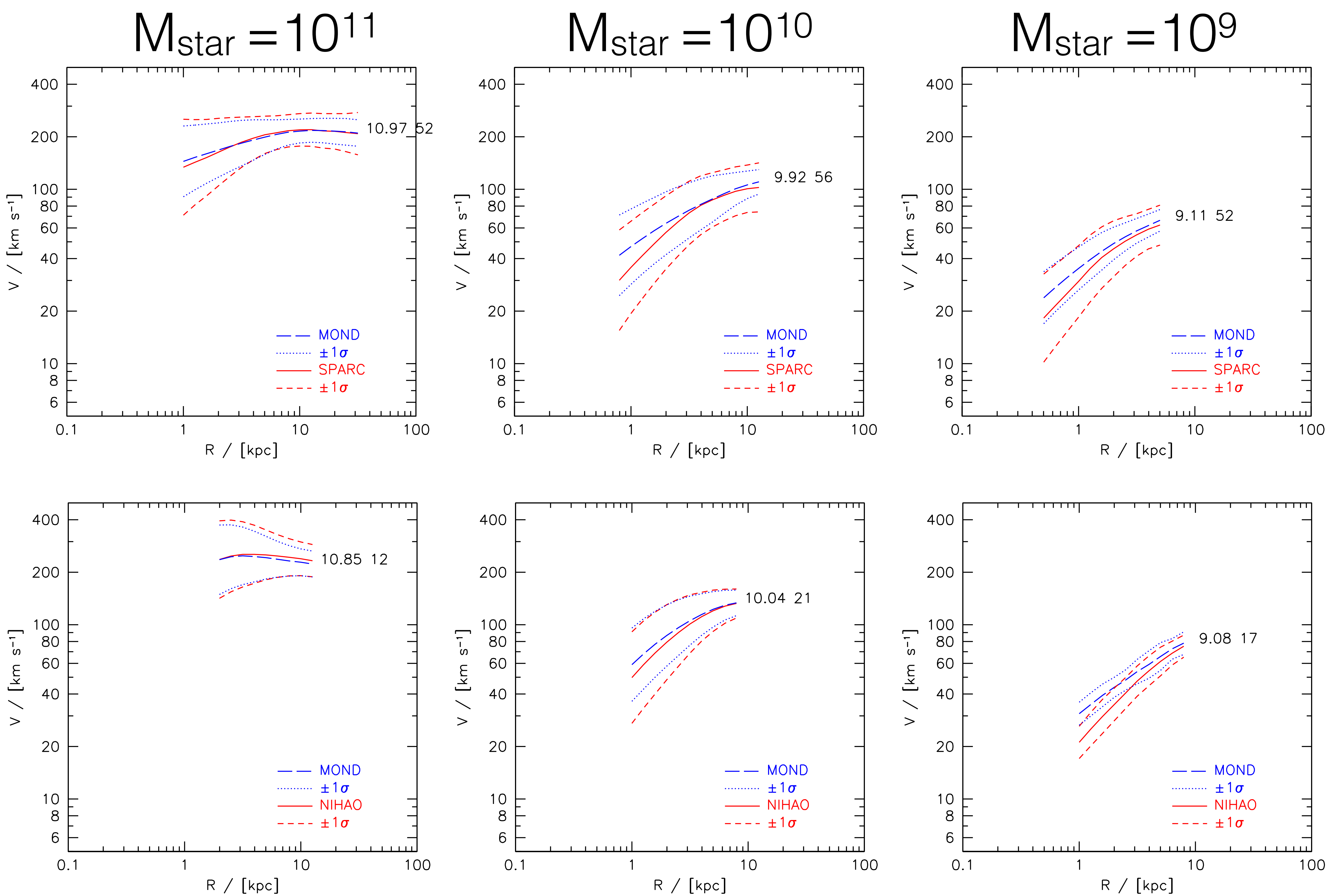
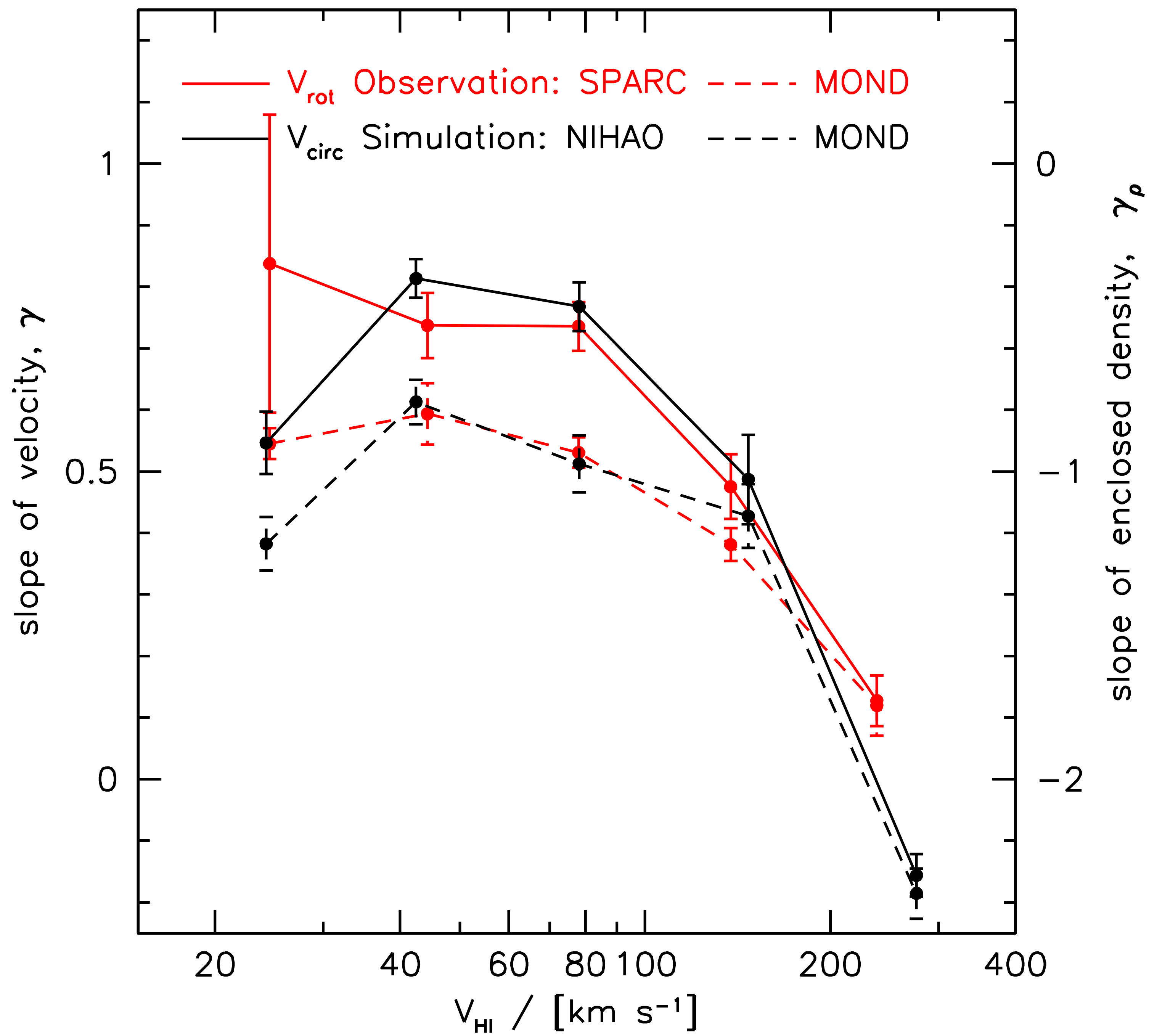


MOND over predicts rotation velocities at small radii

1-2 kpc



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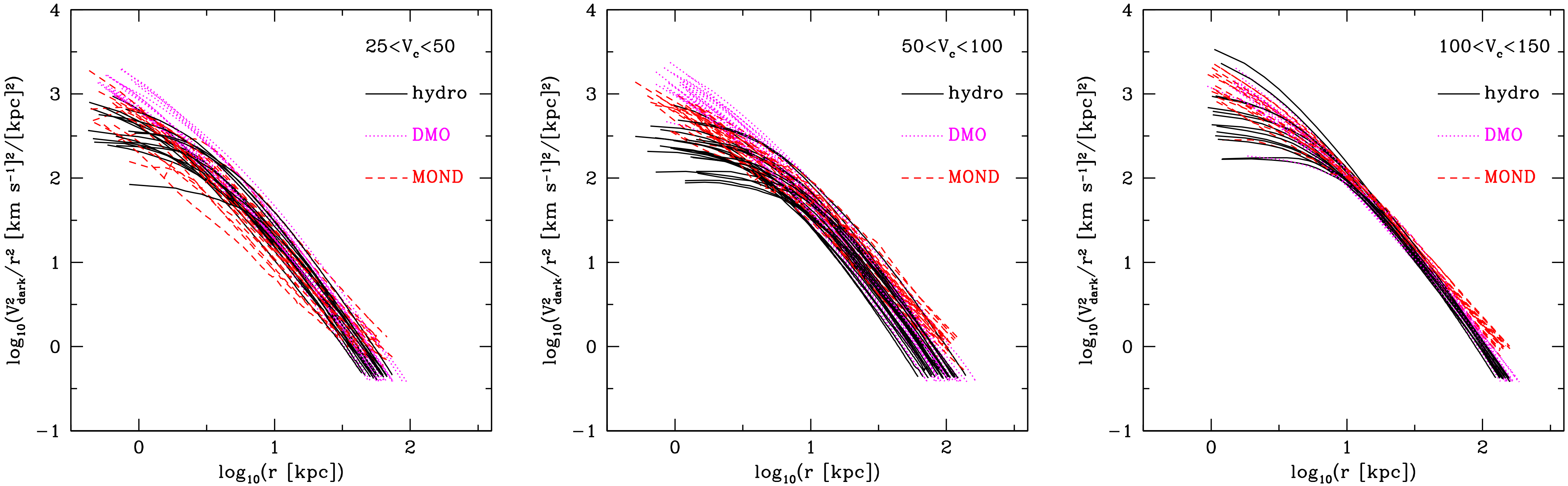
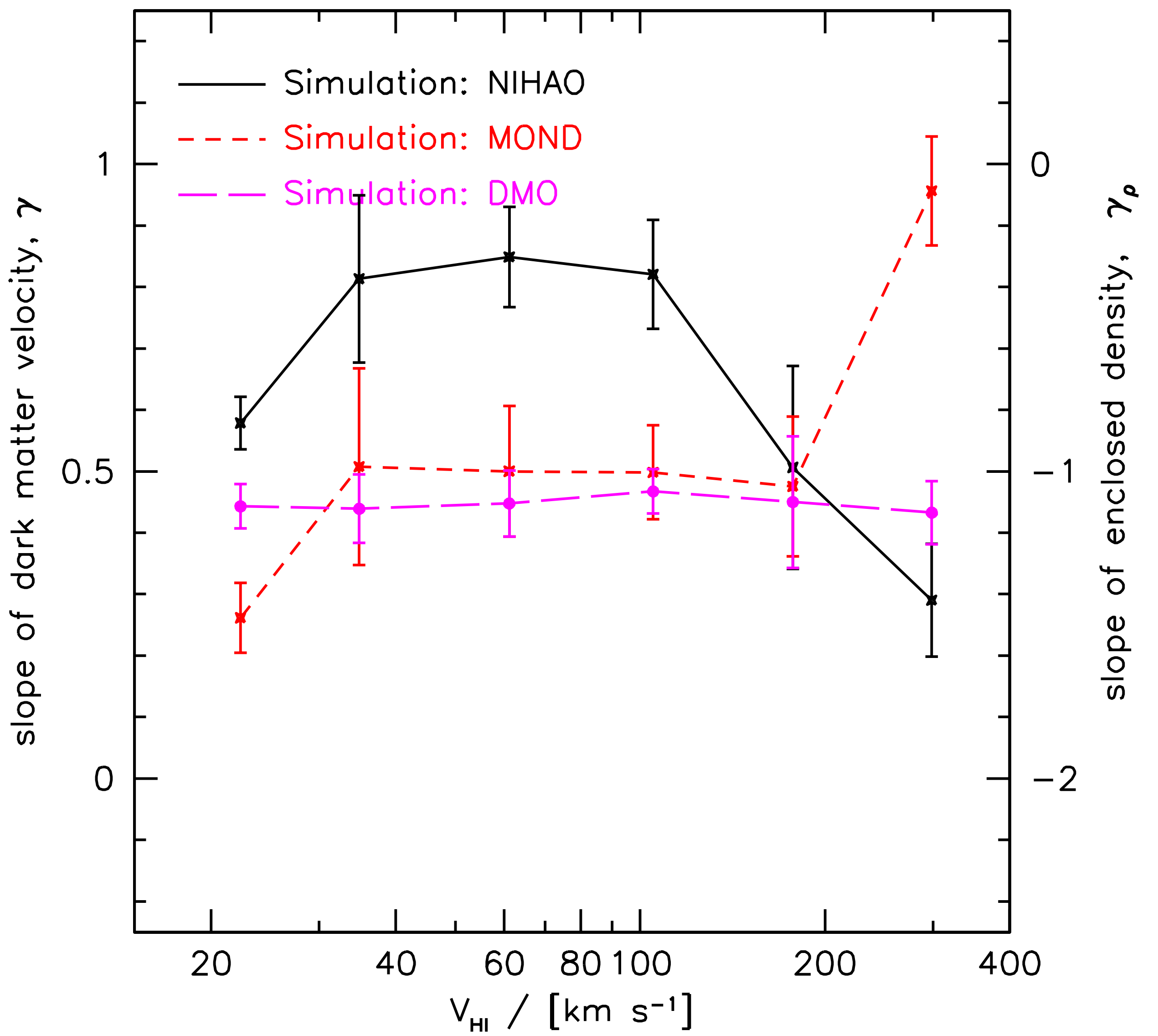
Enclosed Dark Matter density profiles



LCDM has more diversity at small radii

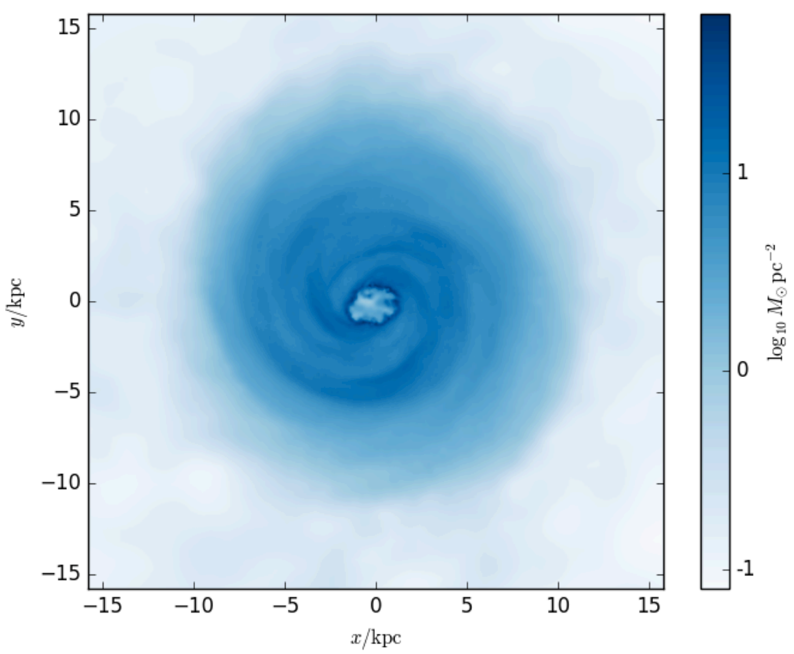
MOND predicts steeper density profiles

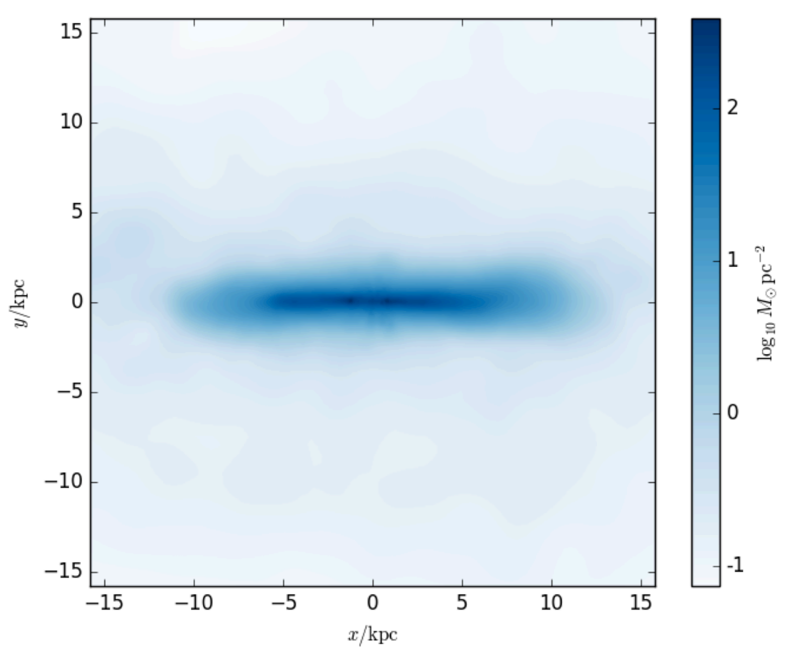
Enclosed Dark Matter density profiles



MOND predicts steeper density profiles ~ NFW like

Test Case: hollow baryon density profile





CDM: dark halo dominates. $V^2 > 0$

MOND: $V^2_{bar} < 0$ => ?