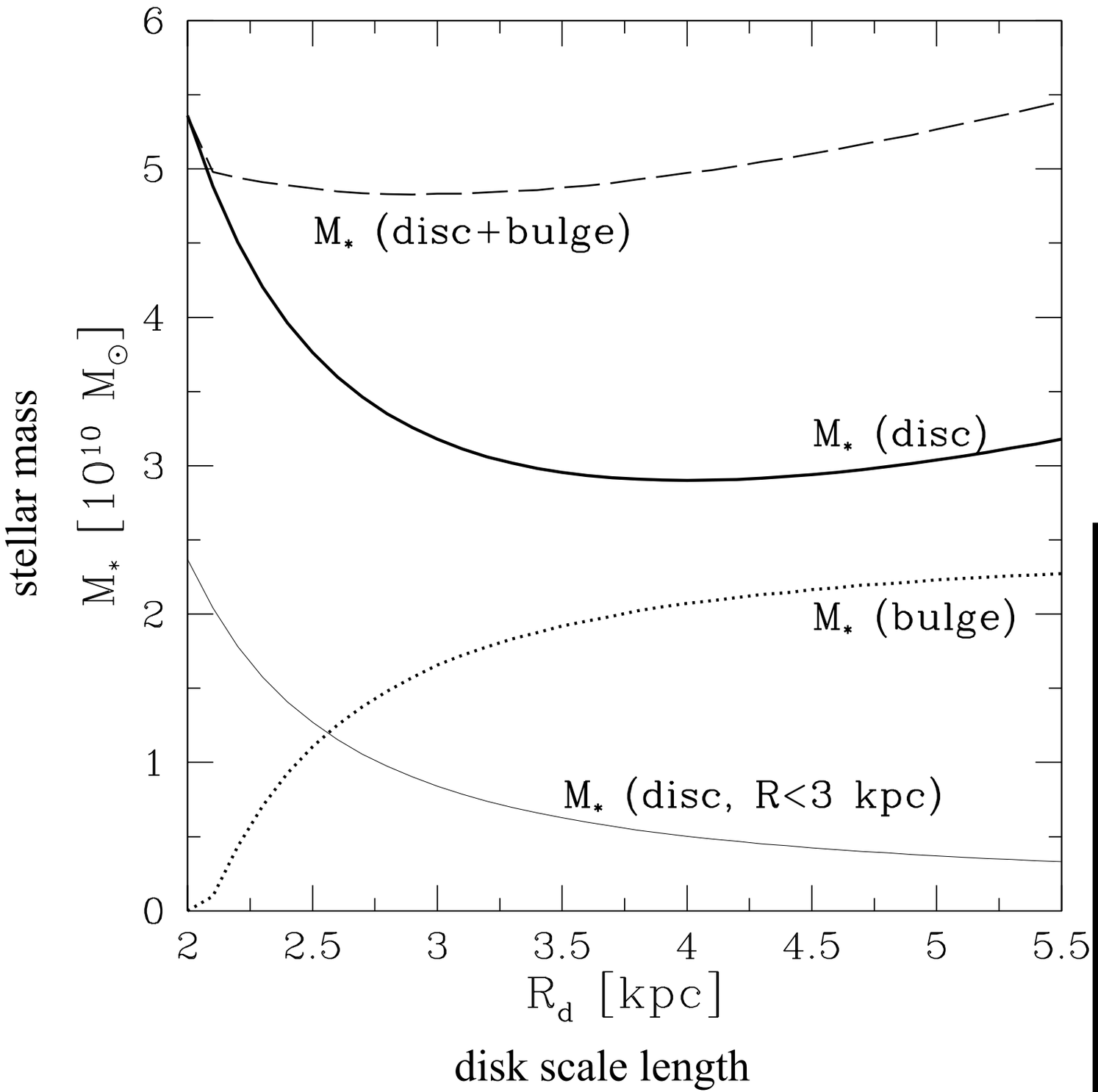
Big Questions

- Does Dark Matter exist?
  - "In 5 years, we'll know what the dark matter is."
    - I've heard this asserted by different people every few years since 1989.
- How do we explain the observed coupling between dark matter and baryons?

Saturday, March 14, 2009

Tuorla-Heidelberg Galaxy Model
Flynn et al. 2006, MNRAS, 372, 1149



Known properties

Local surface density

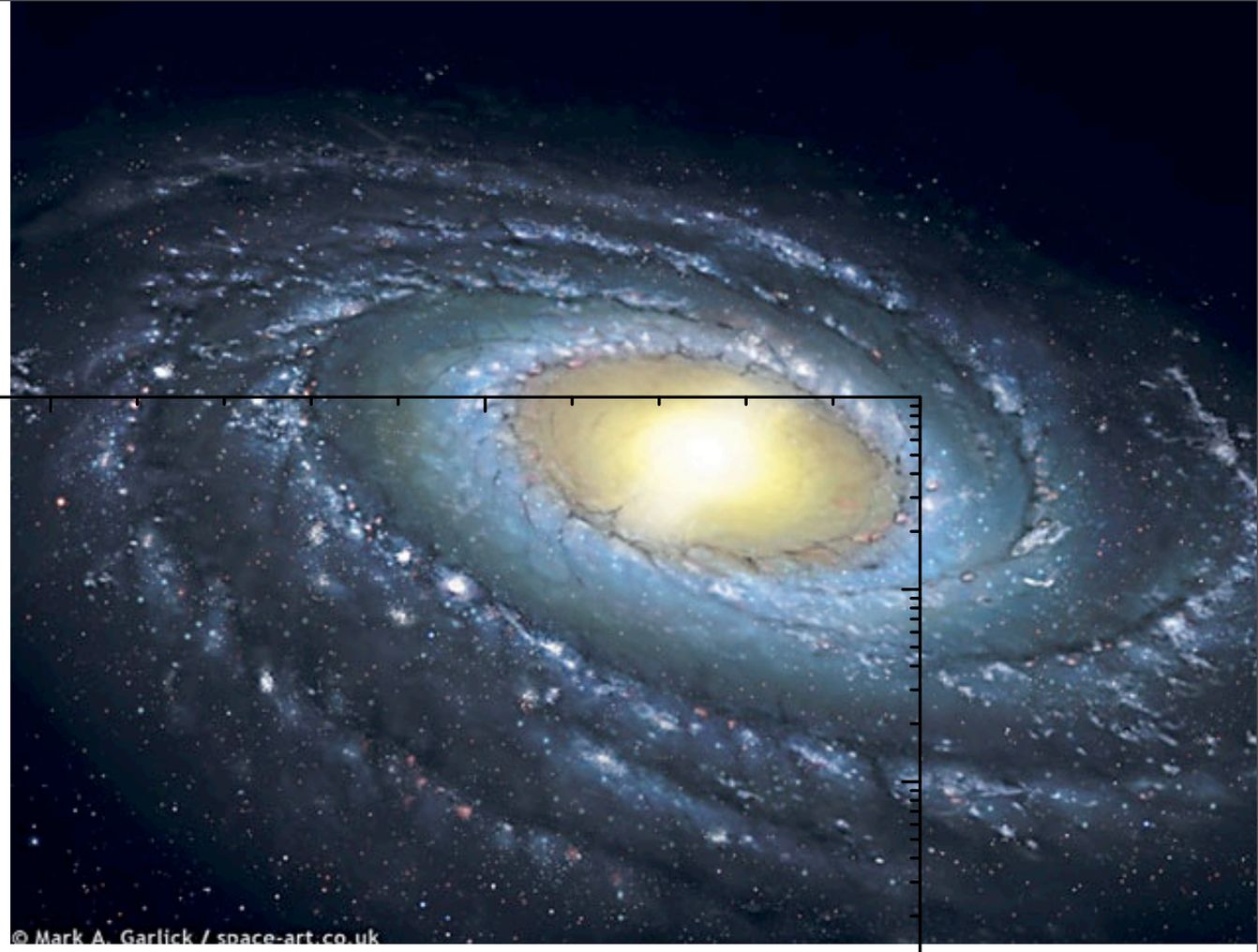
$$\Sigma_\star = 35.5\ \mathrm{M}_\odot\ \mathrm{pc}^{-2}$$

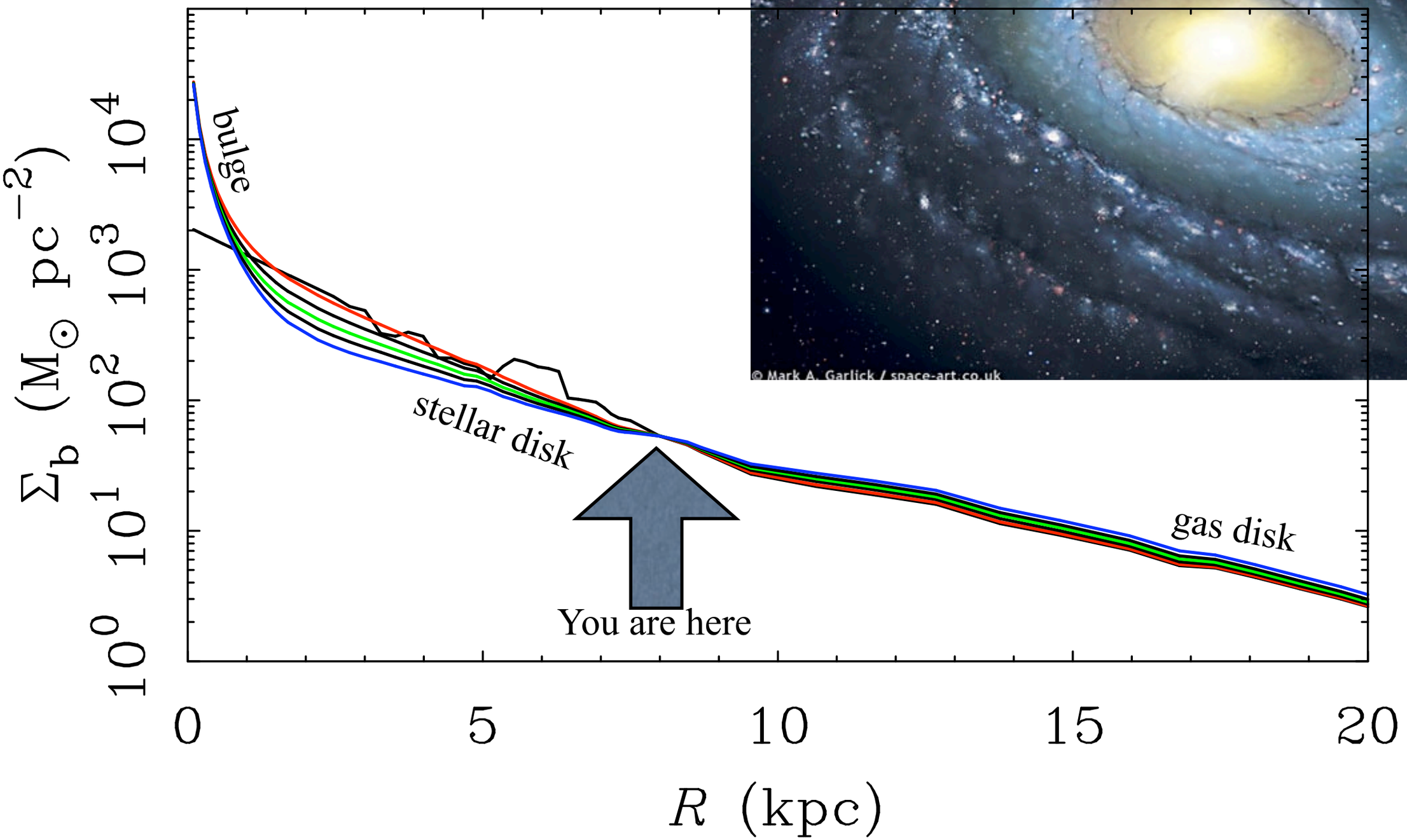
$$\Sigma_g = 13.2\ \mathrm{M}_\odot\ \mathrm{pc}^{-2}$$

$$\mathrm{M}_b \approx 6 \times 10^{10}\ \mathrm{M}_\odot$$

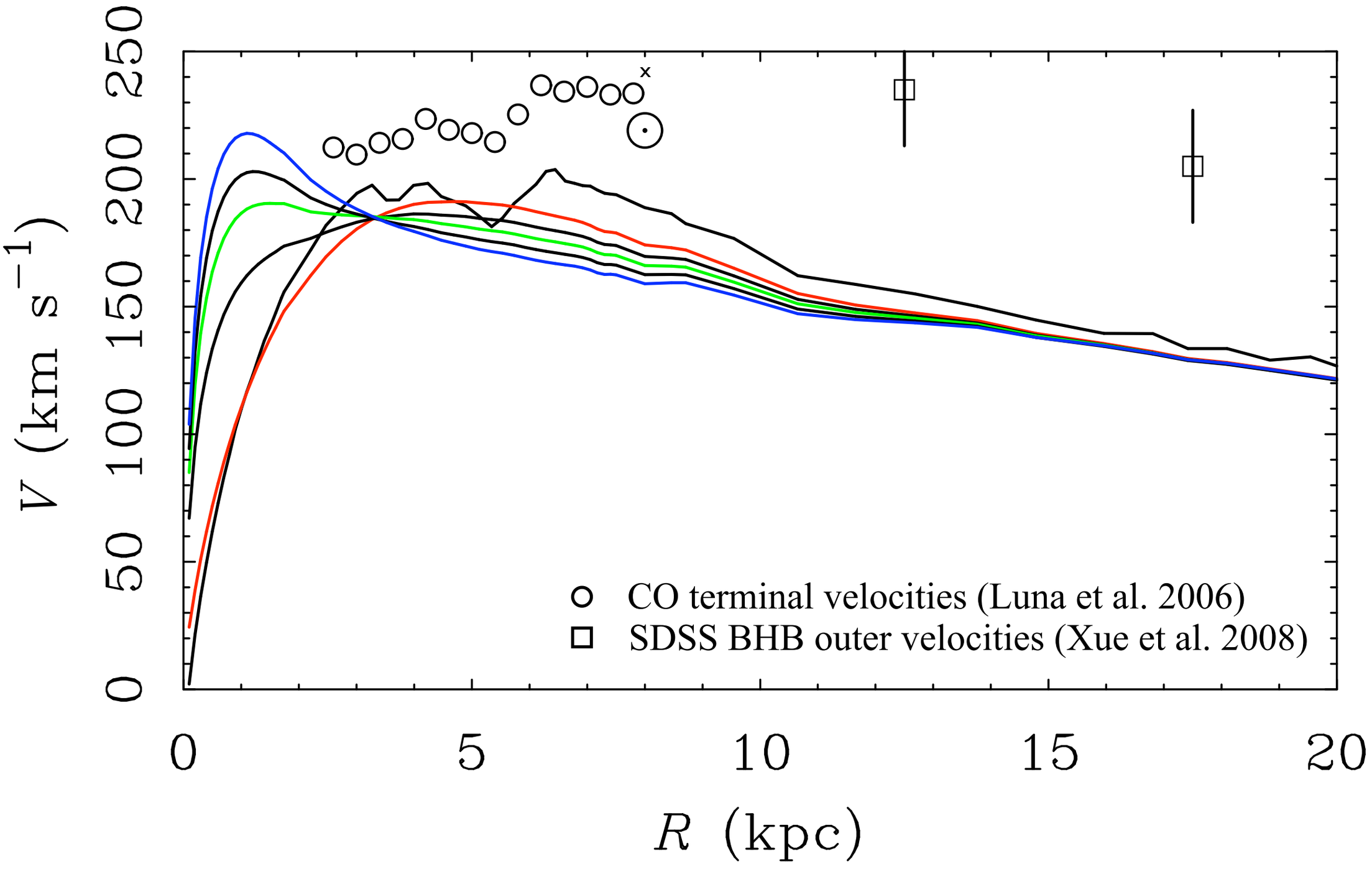
$$V(R = 3\,\mathrm{kpc}) \approx 200\ \mathrm{km\,s}^{-1}$$

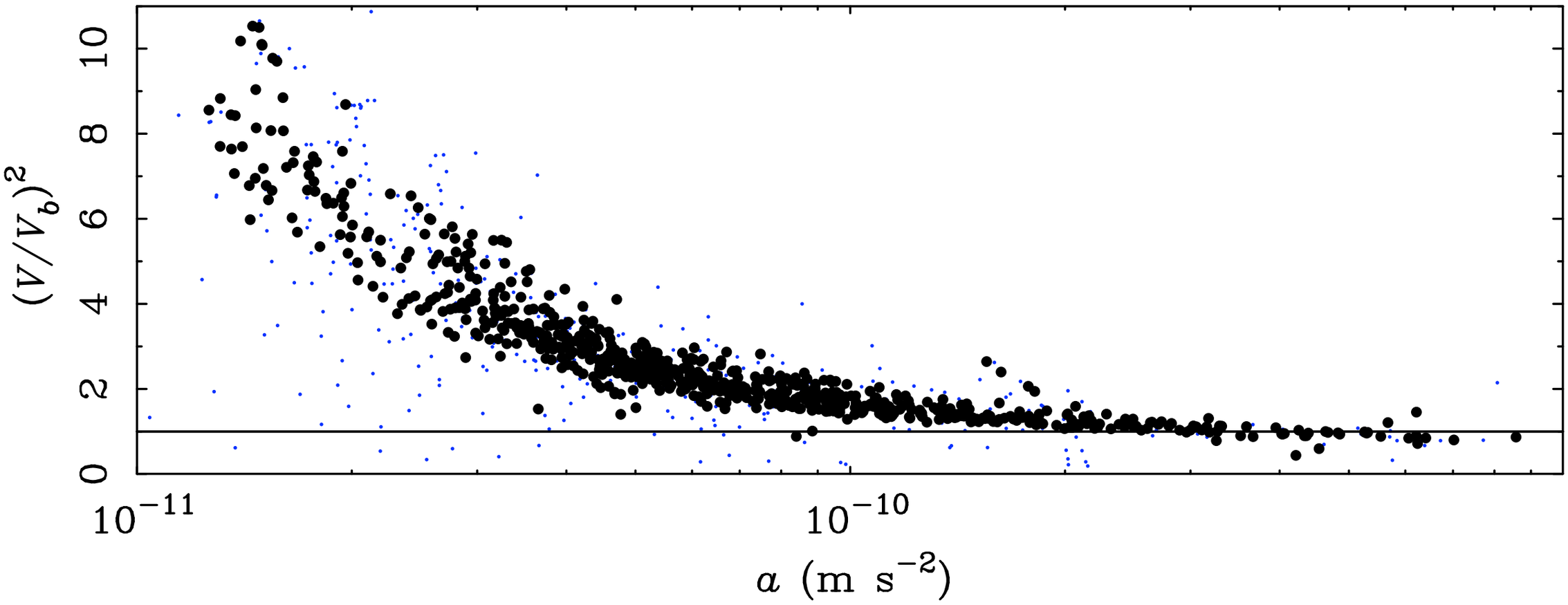
Inferred surface mass density
for scale lengths 2 - 4 kpc





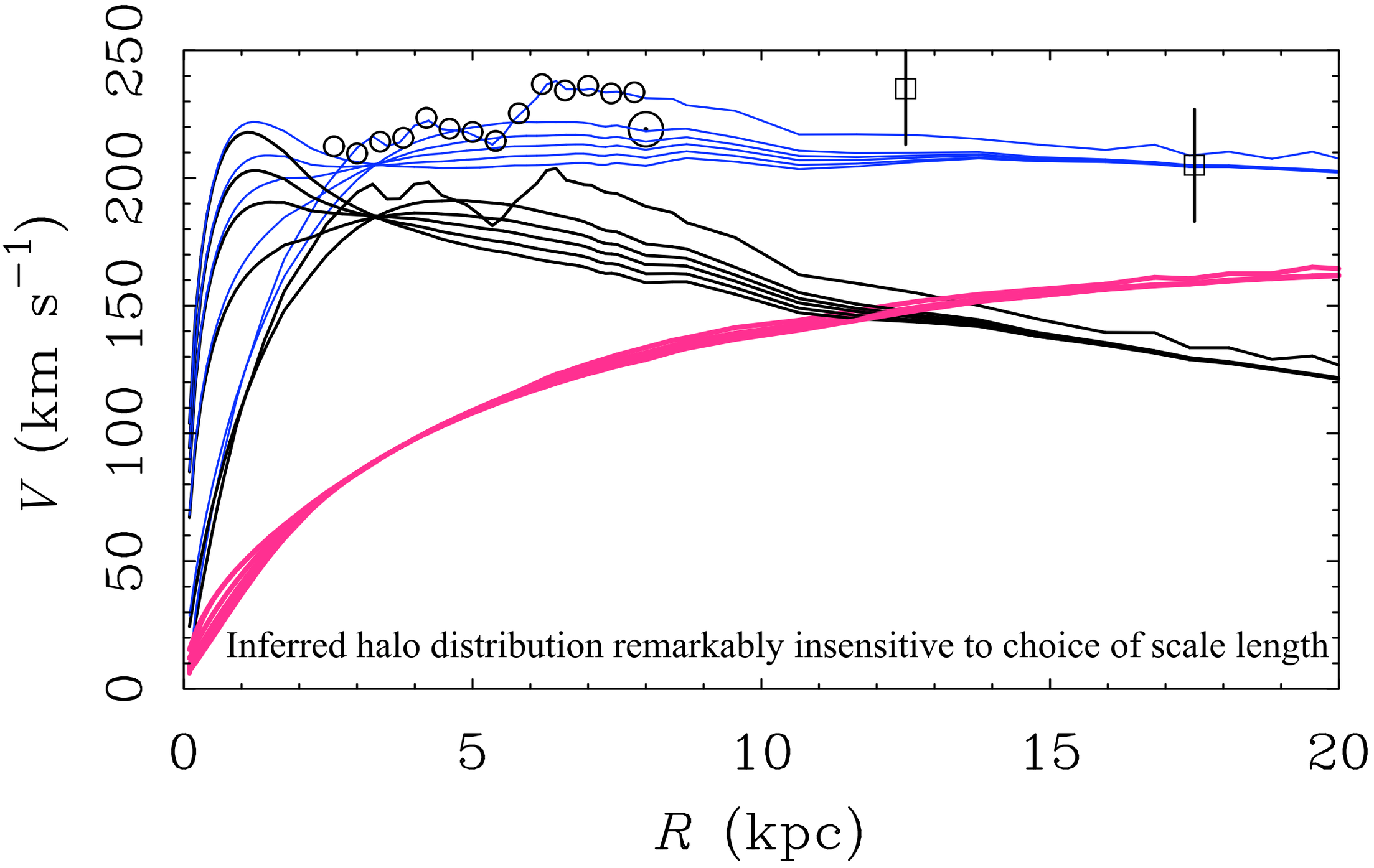
Inferred baryonic rotation curves
corresponding to preceding surface densities





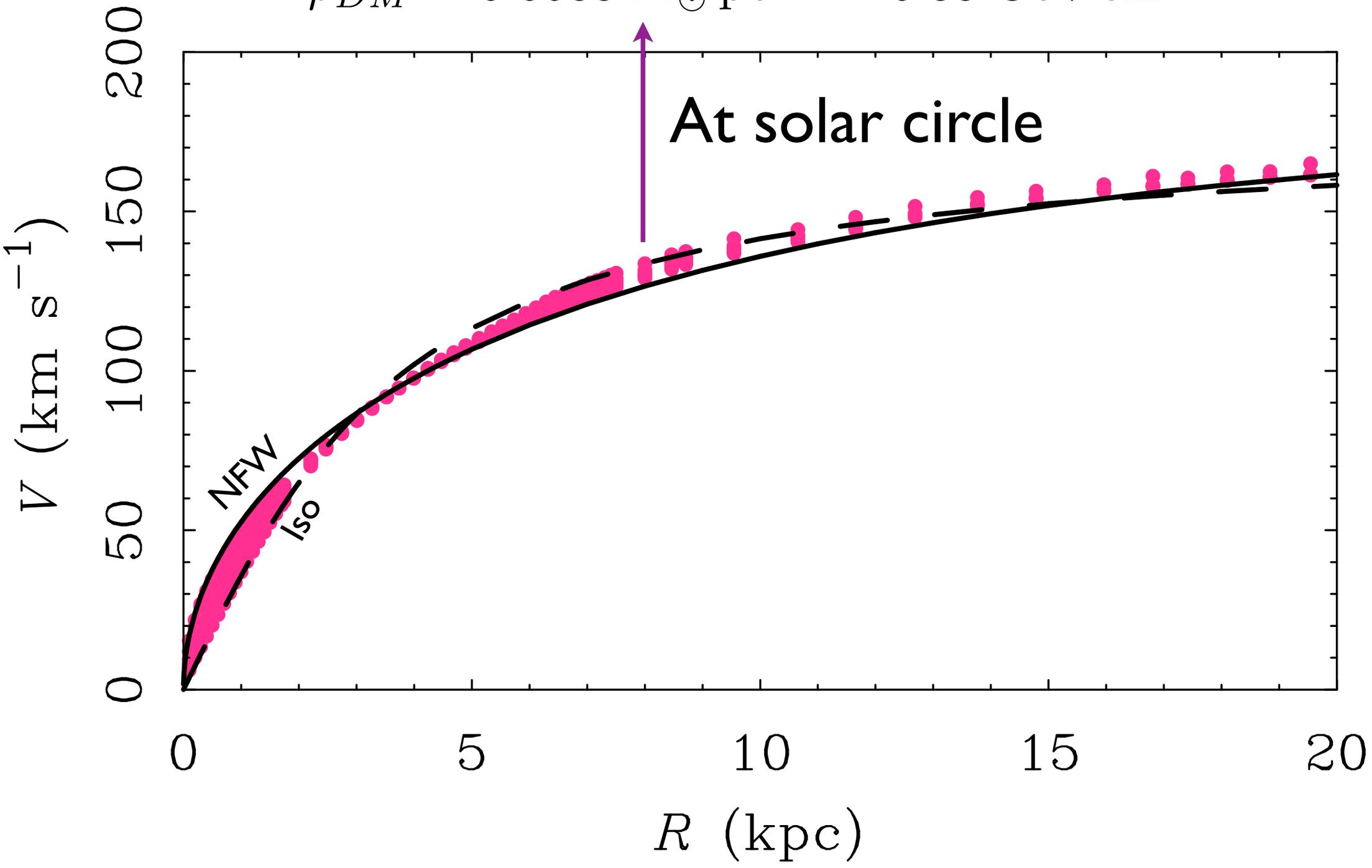
$$V^2 = \nu \left(\frac{a}{a_\dagger} \right) V_b^2$$

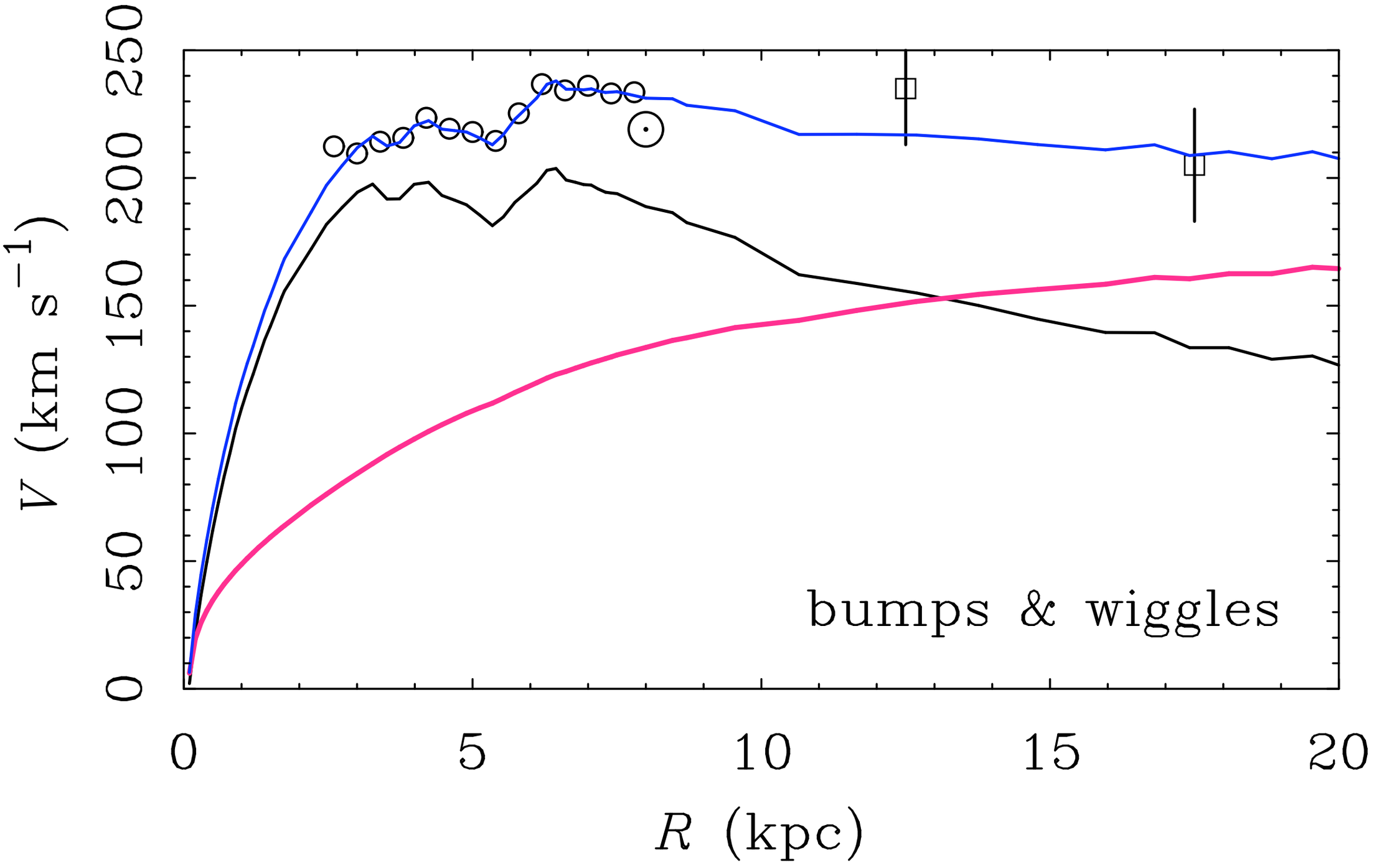
Spiral galaxies generally obey a mass discrepancy-acceleration relation (McGaugh 2005).
Can fit the data for this function.
Note that the mass discrepancy never appears above a critical acceleration $a_\dagger$


V (km s^{-1})
0
50
100
150
200
250
0
5
10
15
20
R (kpc)
Inferred halo distribution remarkably insensitive to choice of scale length

$V_{DM} \approx 130\ \mathrm{km\,s^{-1}}$ (circular support)

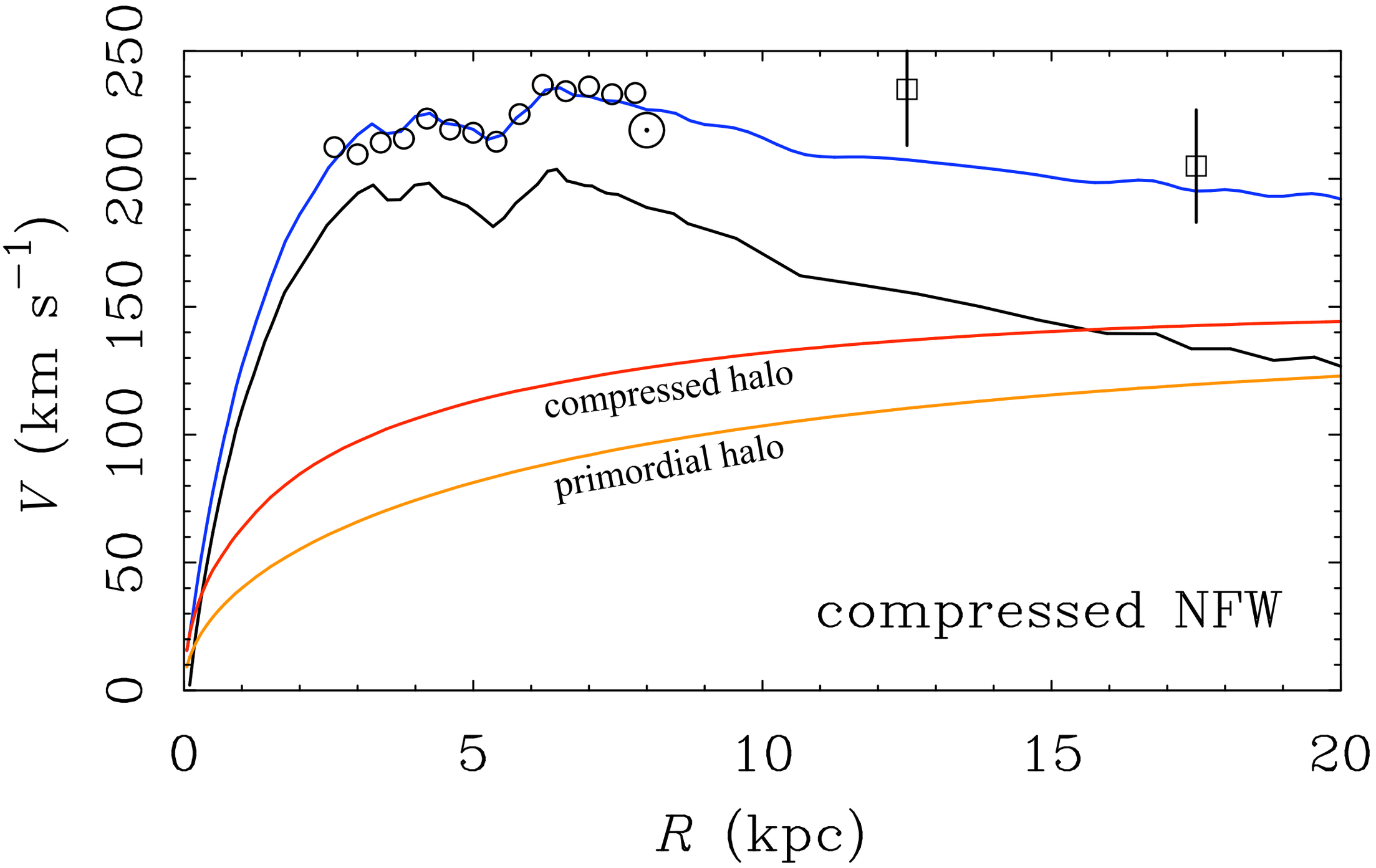
$\rho_{DM} = 0.0083\ \mathrm{M_\odot\,pc^{-3}} = 0.33\ \mathrm{GeV\,cm^{-3}}$




V (km s^{-1})
0
50
100
150
200
250
0
5
10
15
20
R (kpc)
bumps & wiggles

Primordial NFW halo
quite reasonable:

$$c = 7.1$$
$$V_{200} = 124\ \mathrm{km\,s^{-1}}$$



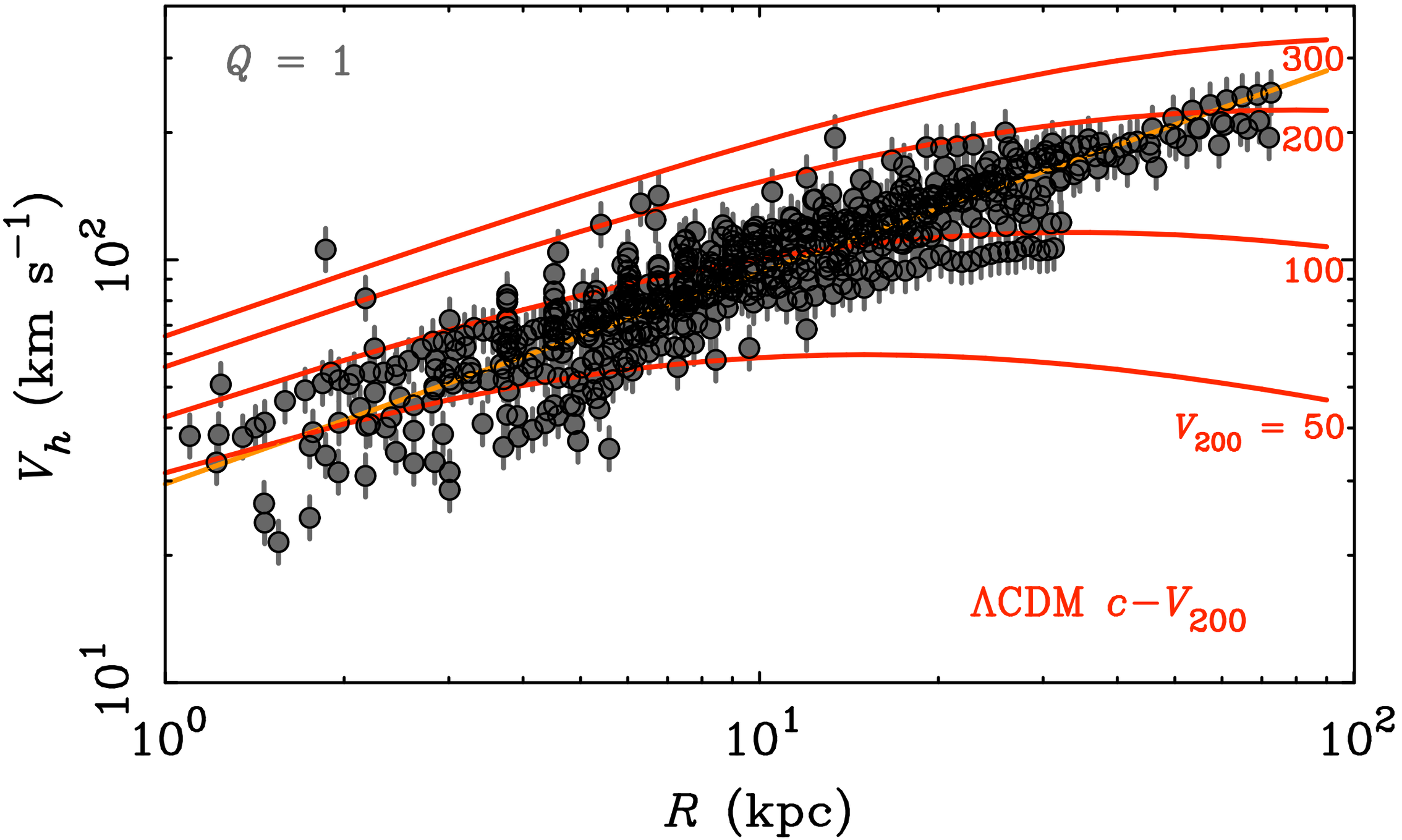
No problem having near-maximal disk if compression done right (Sellwood & McGaugh 2005)

The halo-only rotation curves of all spirals are strikingly similar (McGaugh et al. 2007)

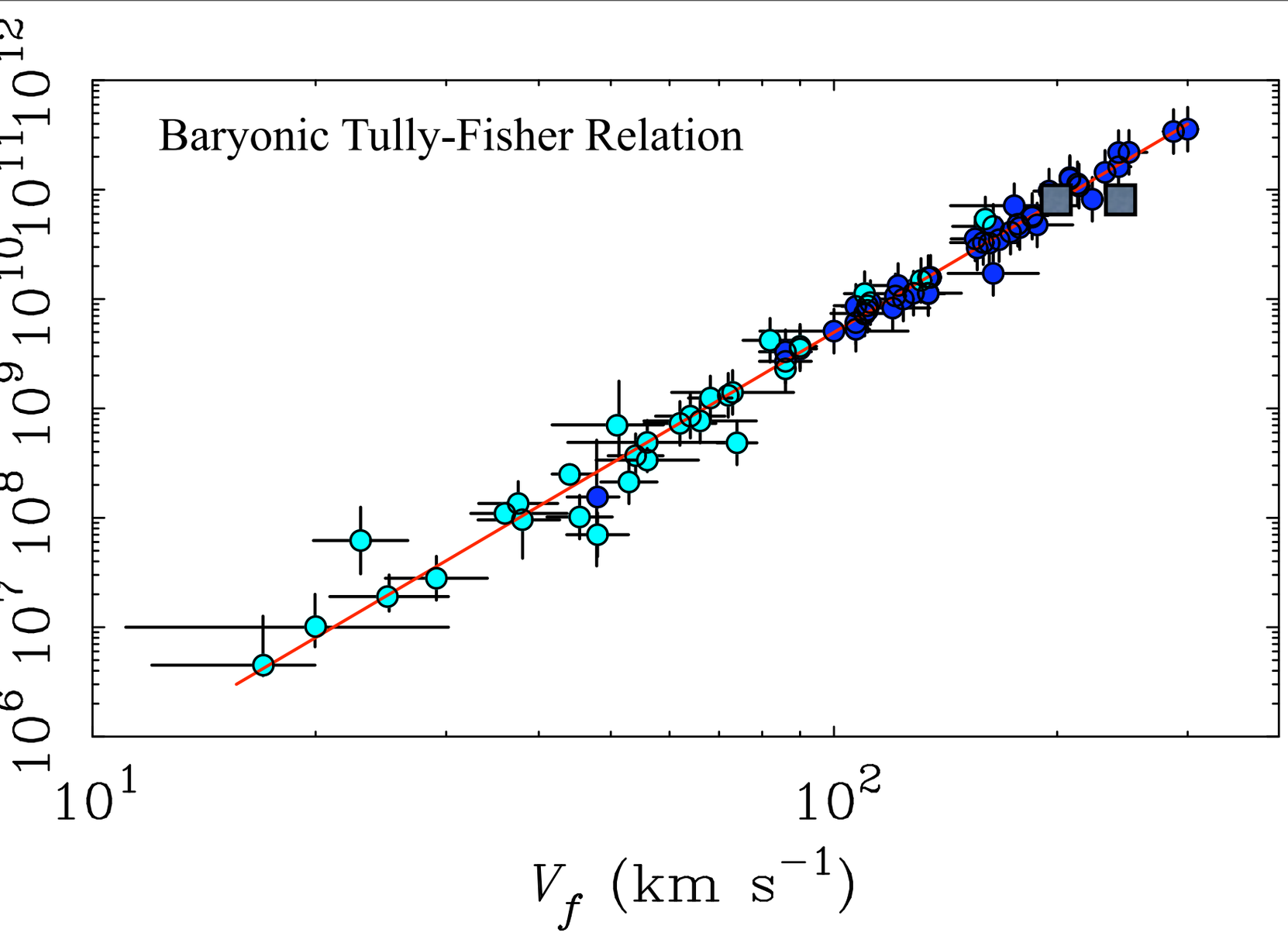
$$\log V_h = \frac{1}{2}\log R + 1.47^{+0.15}_{-0.19}$$

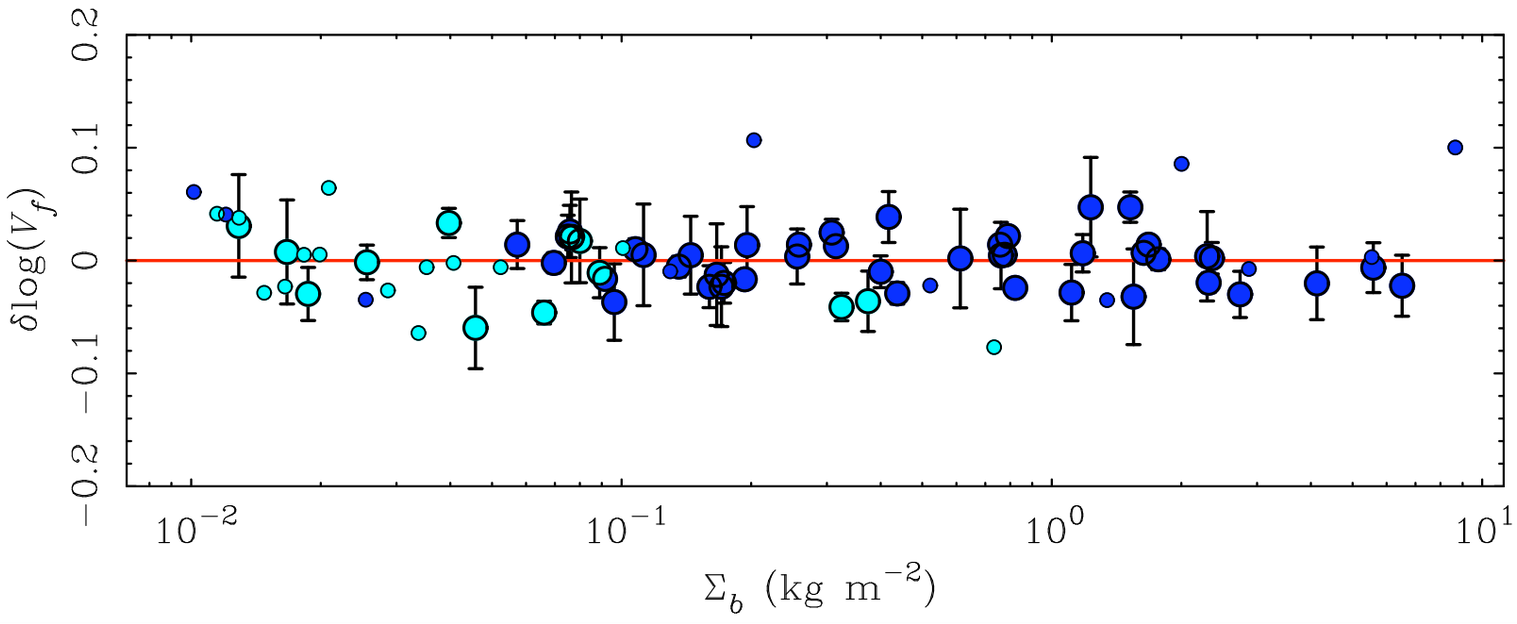
$$\rho = \frac{0.032}{R}\frac{\mathrm{M}_\odot}{\mathrm{pc}^3} = \frac{1.27}{R}\frac{\mathrm{GeV}}{\mathrm{cm}^3}$$

Densities are too low to be seen by Fermi

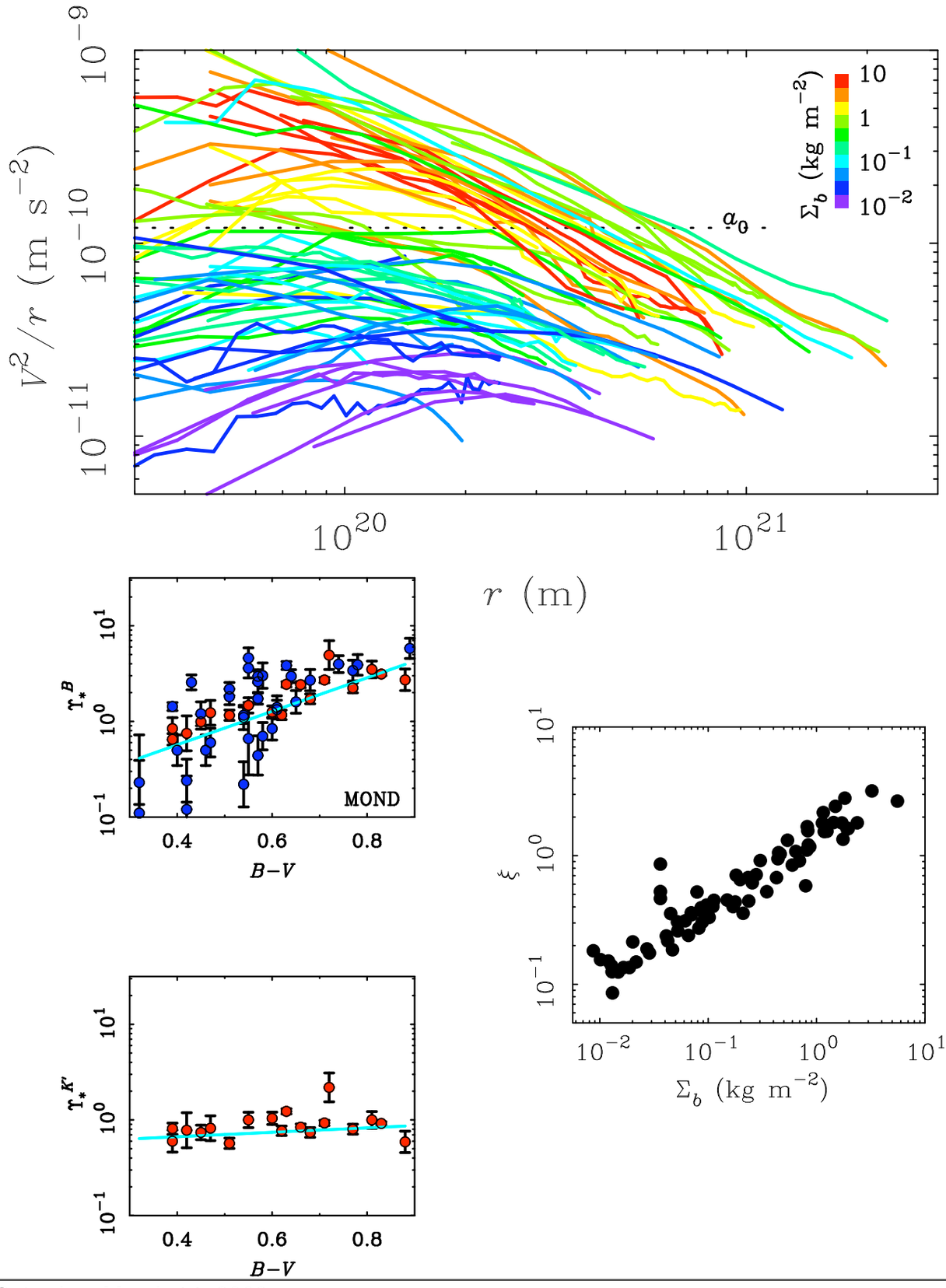


Lots of systematic regularities in spiral galaxy rotation curves





The Baryonic Tully-Fisher Relation and mass discrepancy-acceleration are empirical realizations of MOND predictions



Confirmed MOND predictions

- The Tully-Fisher Relation
  - ✔ Slope = 4
  - ✔ Normalization = $1/(a_0 G)$
  - ✔ Fundamentally a relation between Disk Mass and V_{flat}
  - ✔ No Dependence on Surface Brightness

✔ Dependence of conventional M/L on radius and surface brightness

✔ Rotation Curve Shapes

✔ Surface Density ~ Surface Brightness

✔ Detailed Rotation Curve Fits

✔ Stellar Population Mass-to-Light Ratios