

Observational constraints on the slope of the radial acceleration relation at low accelerations

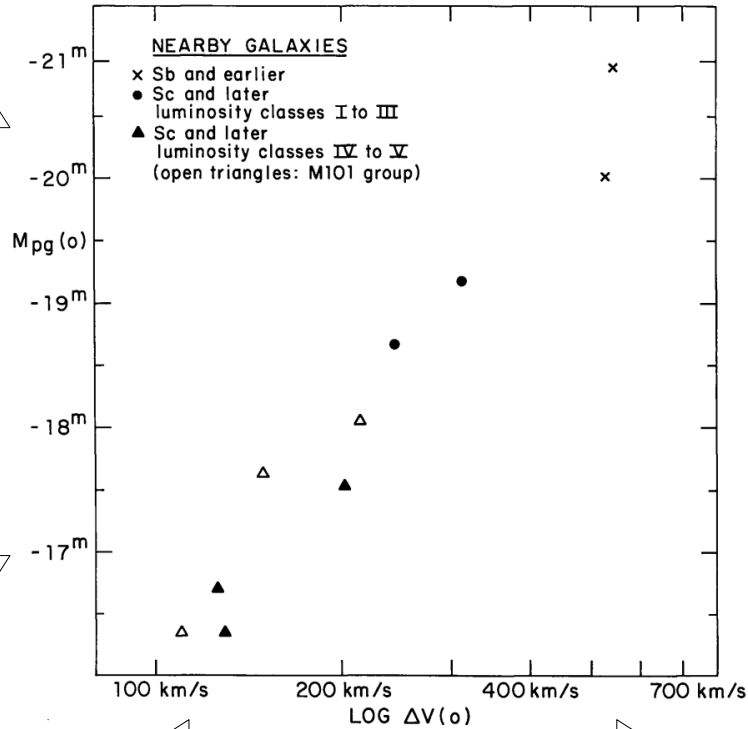
Kyle Oman (Durham ICC)

Margot Brouwer (Kapteyn Institute)

Aaron Ludlow (ICRAR)

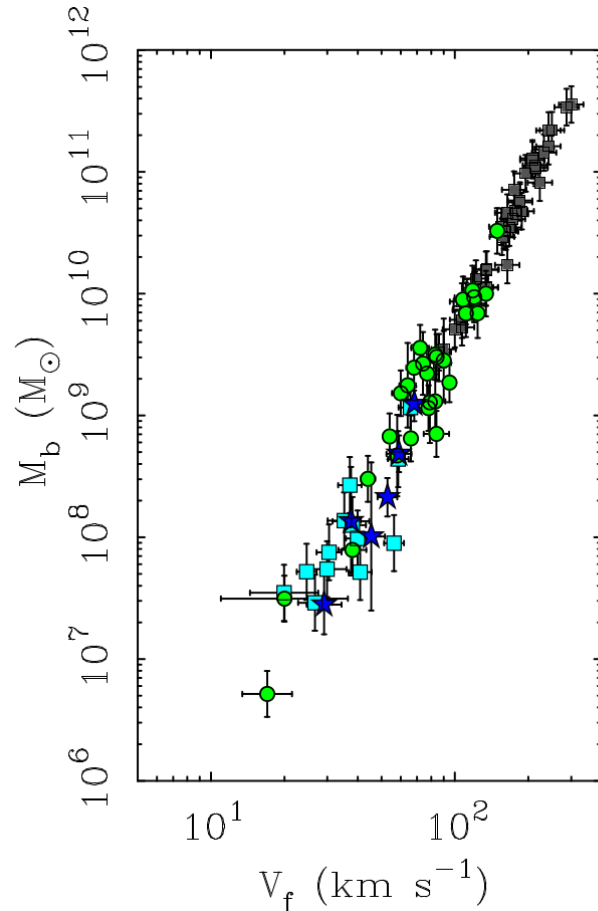
Julio Navarro (Victoria)

The Tully-Fisher relation



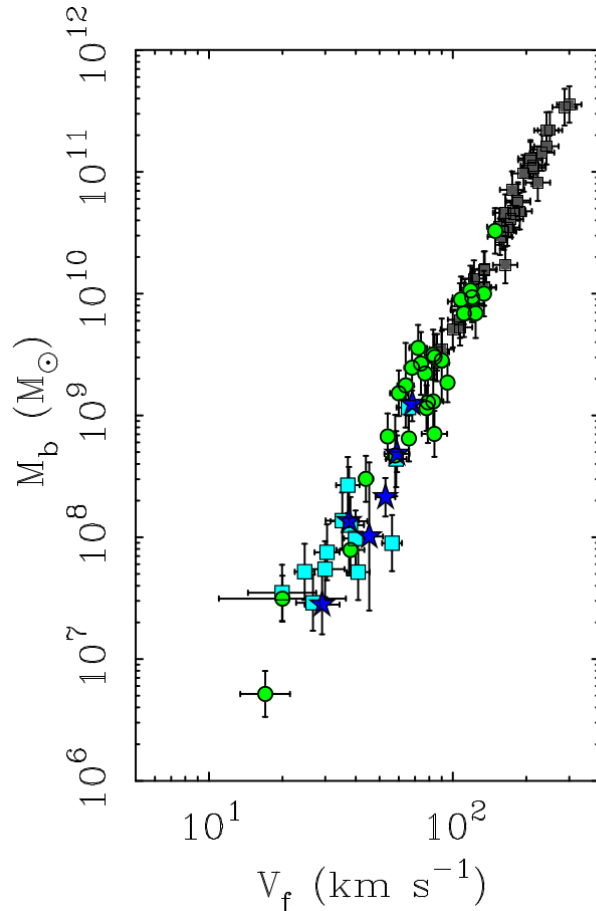
- Absolute magnitude vs. 21-cm line width.
- \approx stellar mass vs. dynamical mass.

The baryonic Tully-Fisher relation



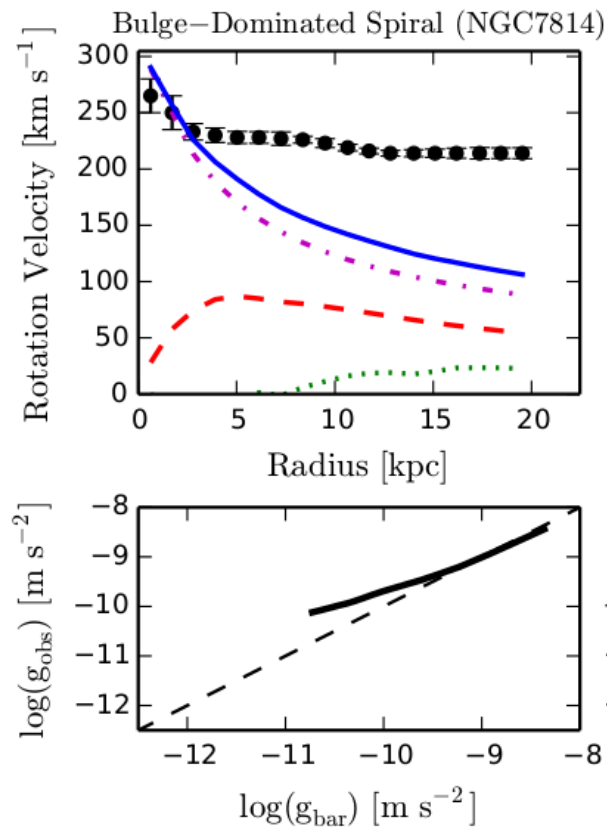
- Replaces the 21-cm line width with “V-flat”.
 - Spatially resolved observations allow better estimates of dynamical mass.
- Replaces absolute magnitude with $M_{\star} + M_{\text{gas}}$.

RAR: spatially resolved BTFR

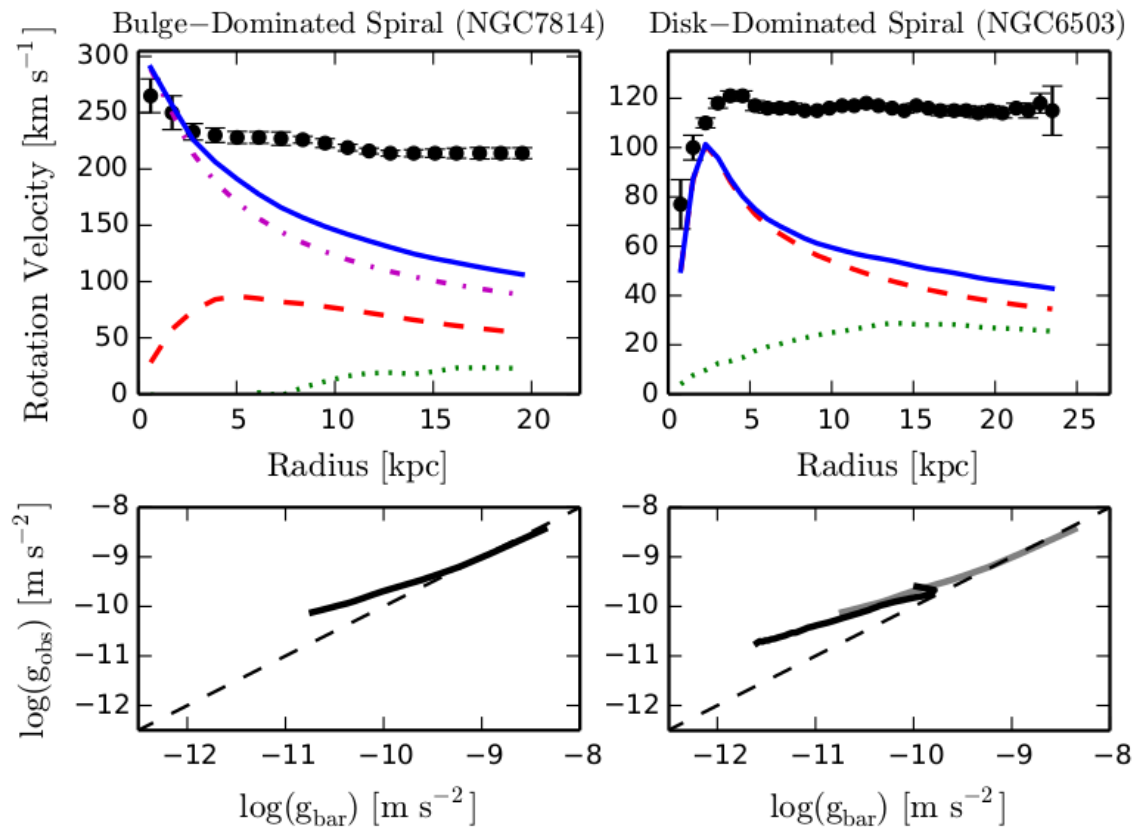


- Replace M_b with $g_{\text{bar}} = GM_b/r^2$
- Replace V_f with $g_{\text{obs}} = V_f^2/r$
- Plot a curve (implicitly a function of radius) for each galaxy, instead of a single point.
- Swap the axes.

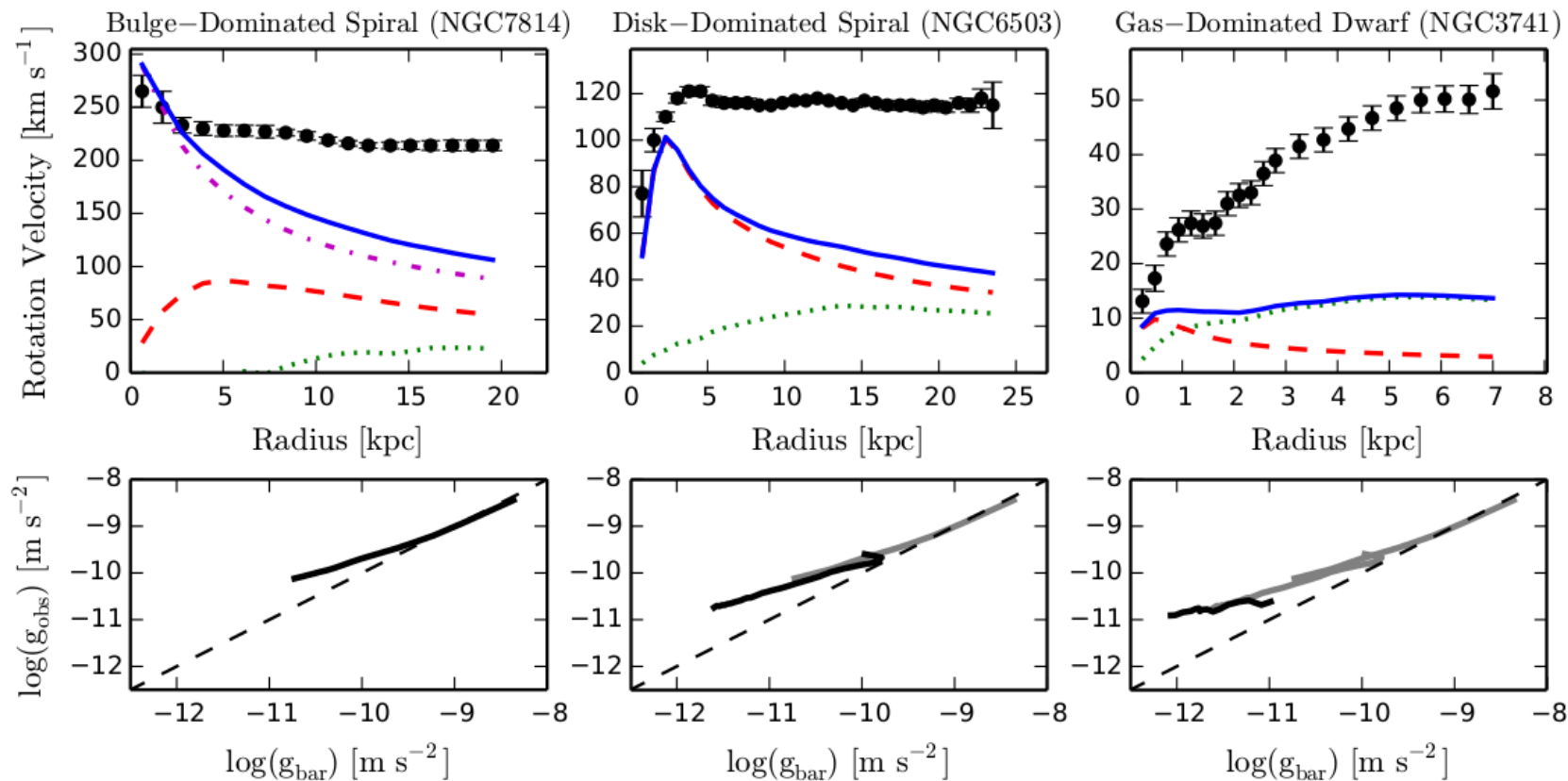
The radial acceleration relation



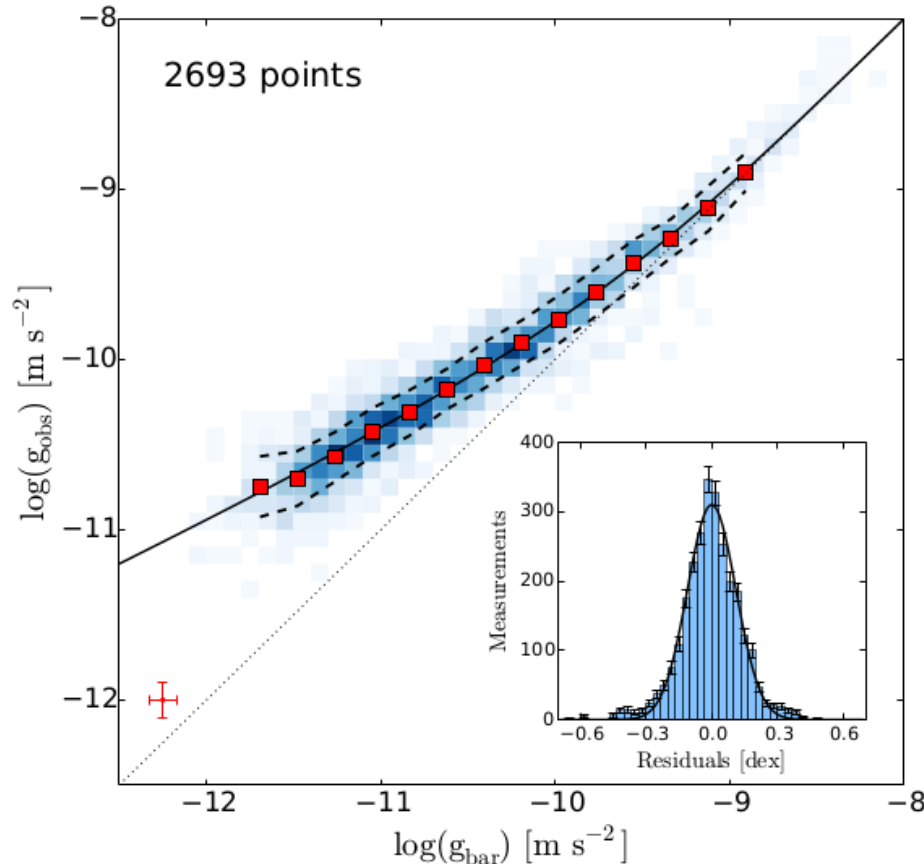
The radial acceleration relation



The radial acceleration relation



The radial acceleration relation

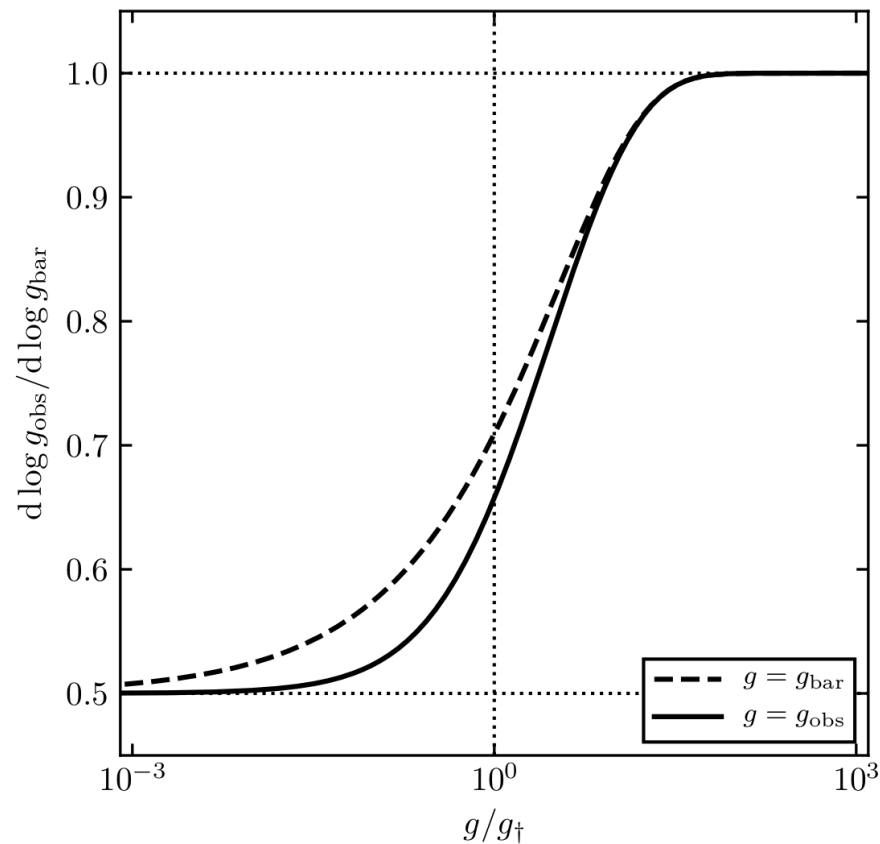
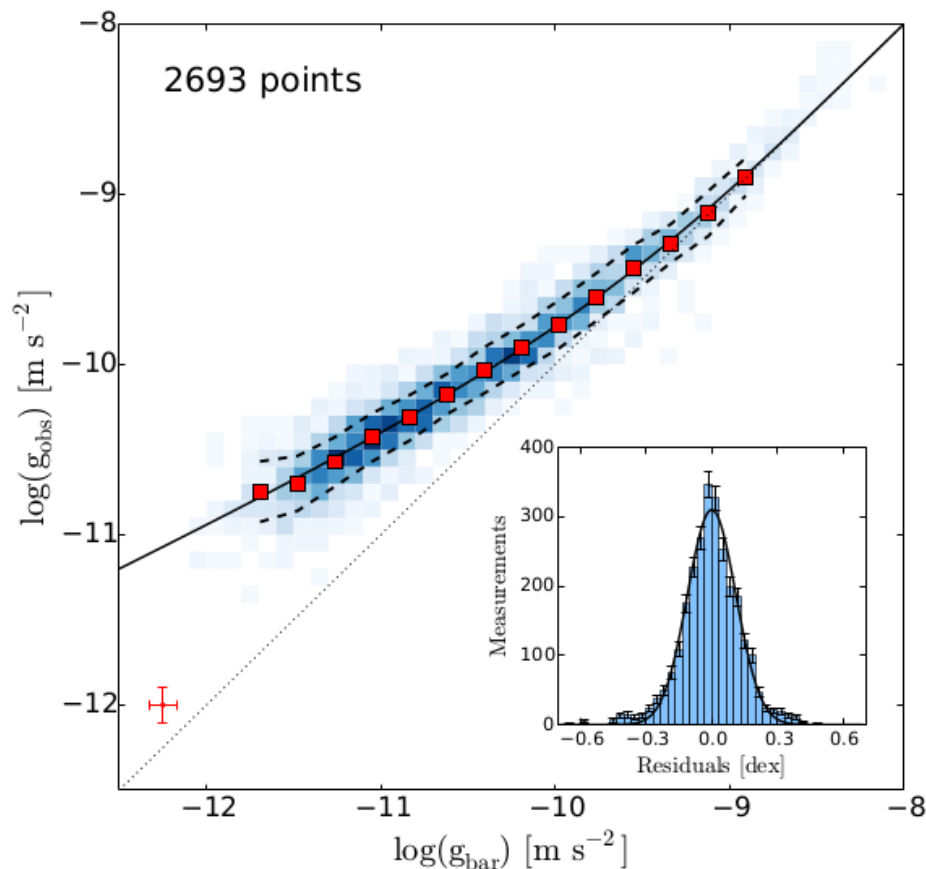


$$g_{\text{obs}} = \frac{g_{\text{bar}}}{1 - e^{-\sqrt{g_{\text{bar}}/g_{\dagger}}}}$$

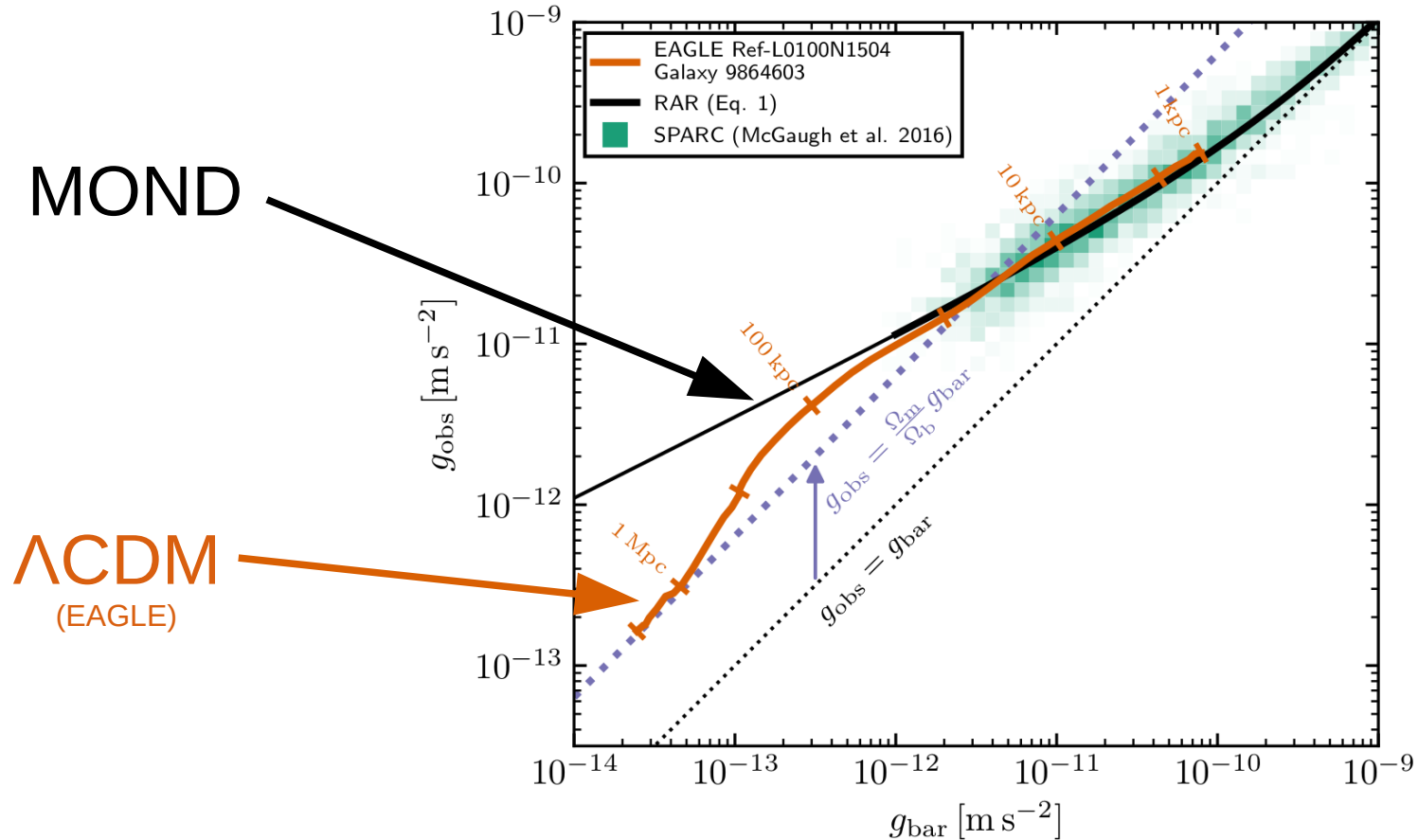
$$g_{\dagger} = 1.2 \times 10^{-10} \text{ m s}^{-2}$$

- A fundamental link between visible mass and mass inferred from motion?

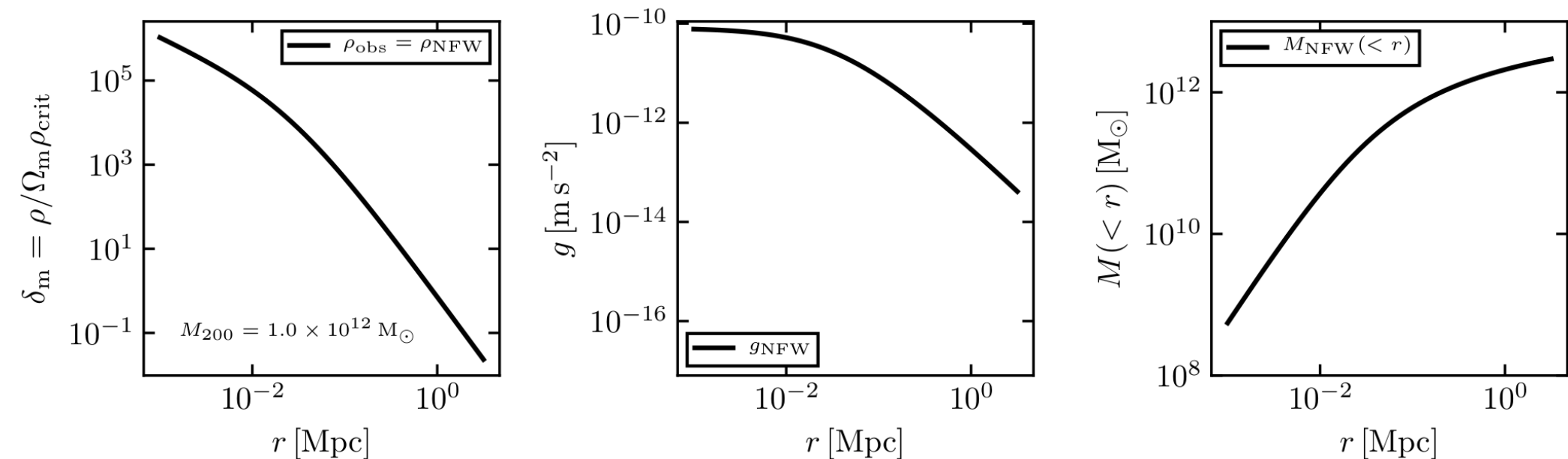
The radial acceleration relation



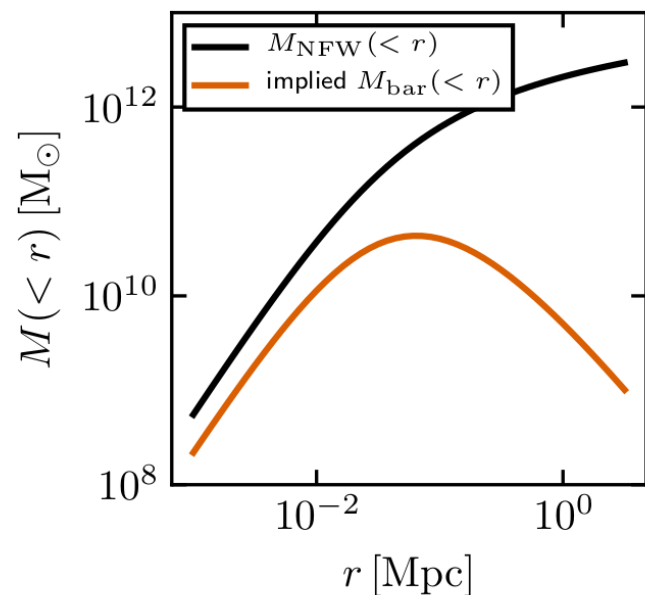
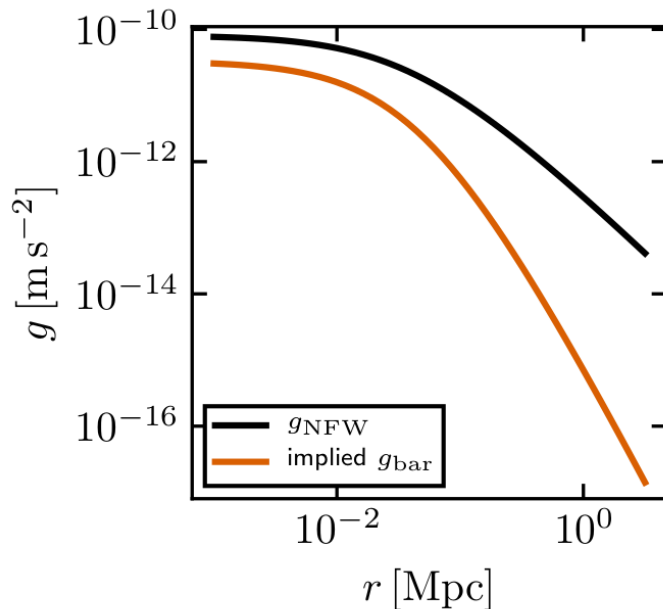
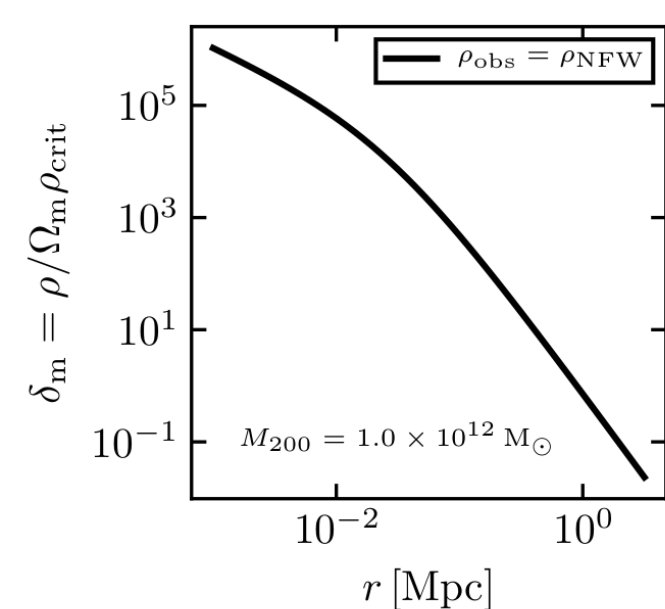
The low-acceleration RAR



The RAR as a predictor of baryons

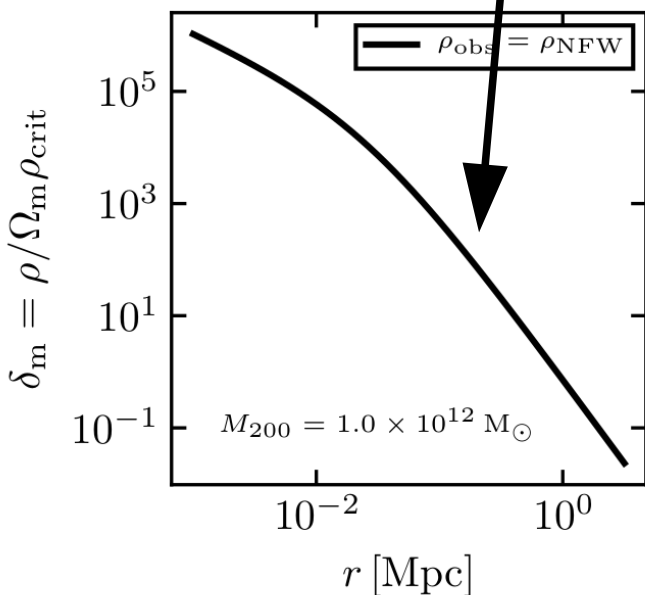


The RAR as a predictor of baryons

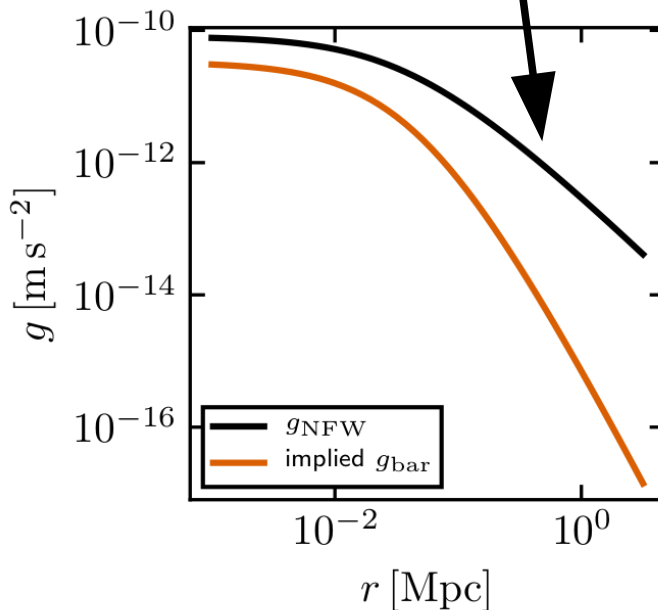


The RAR as a predictor of baryons

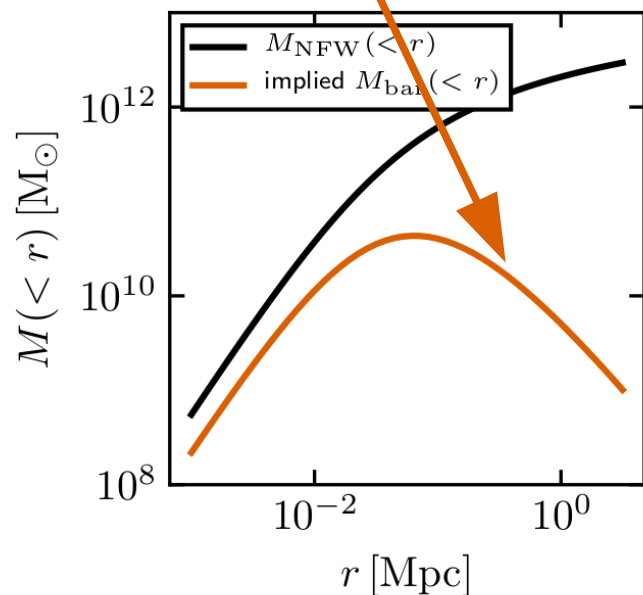
Steeper than $\rho \propto r^{-2}$



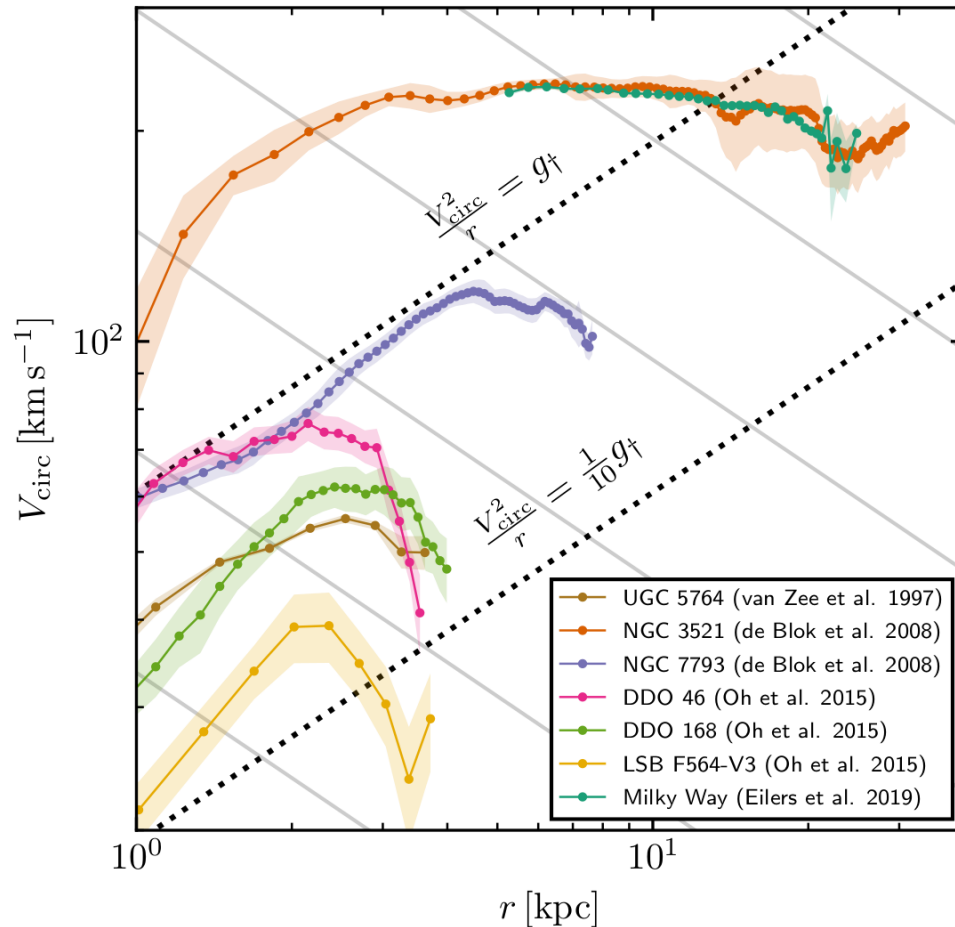
$g_{\text{obs}} \ll g_{\dagger}$



Declining cumulative mass (!?)

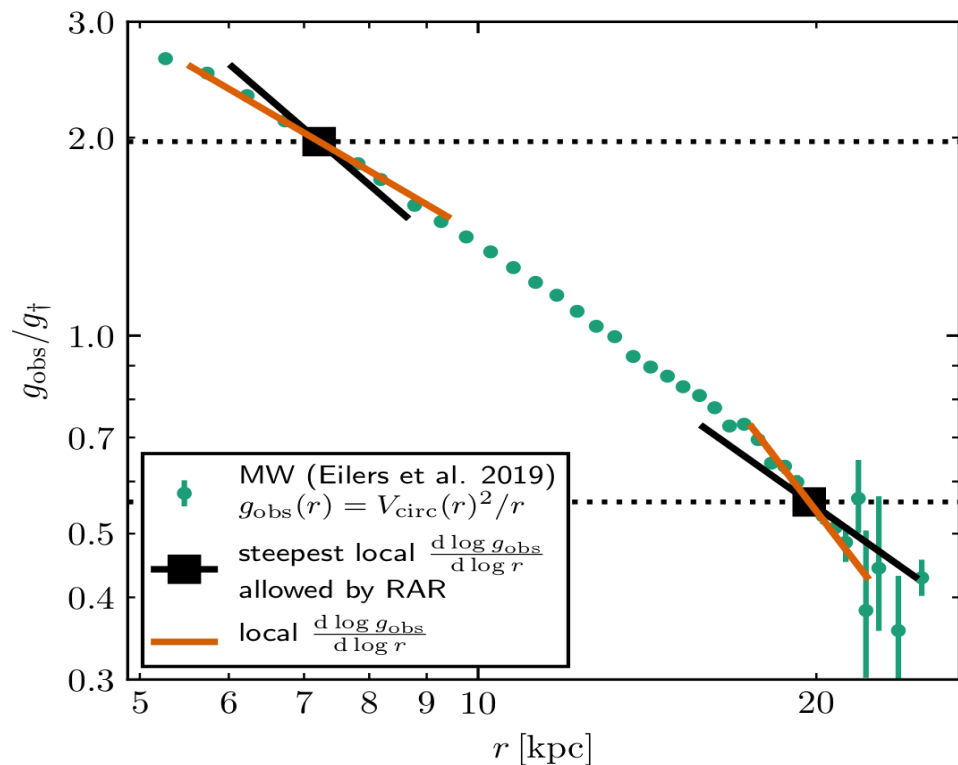


Constraints: rotation curves

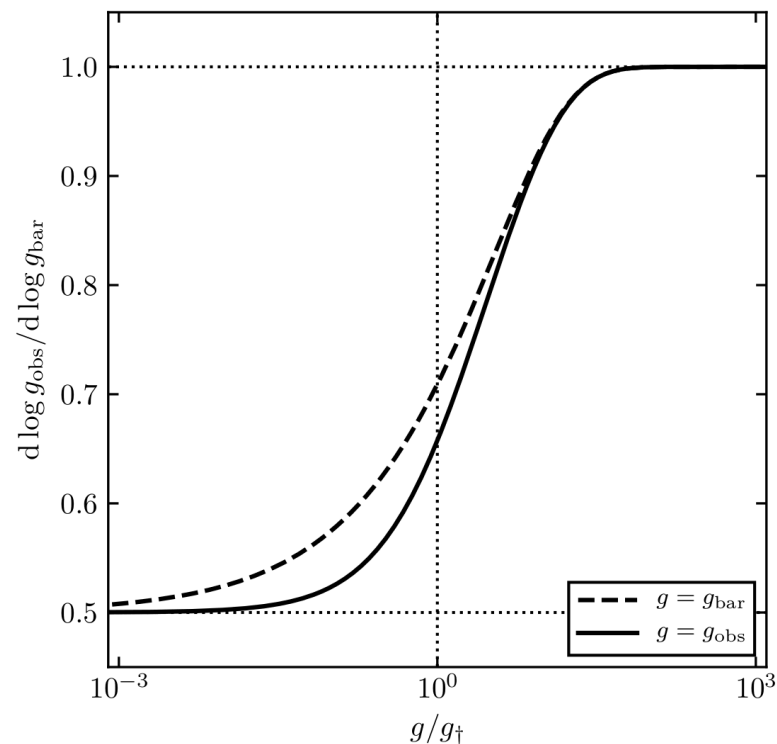
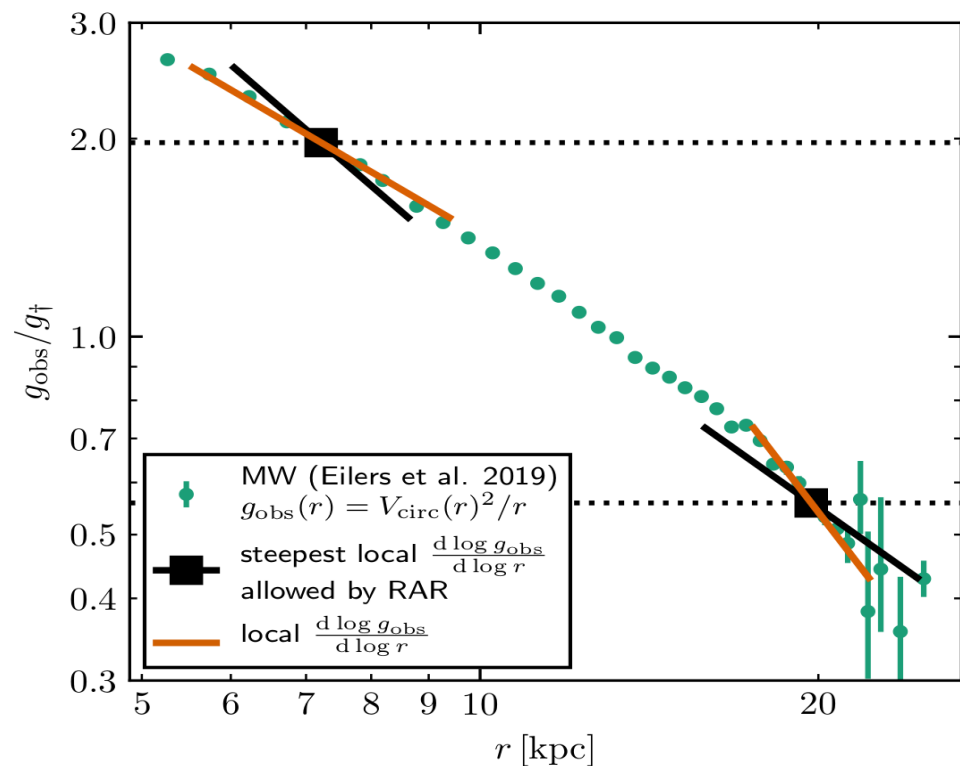


- Density profile steeper than isothermal == declining rotation curve
- Steeper than $V_{\text{circ}} \propto r^{-\frac{1}{2}}$ should be impossible (regardless of the RAR)

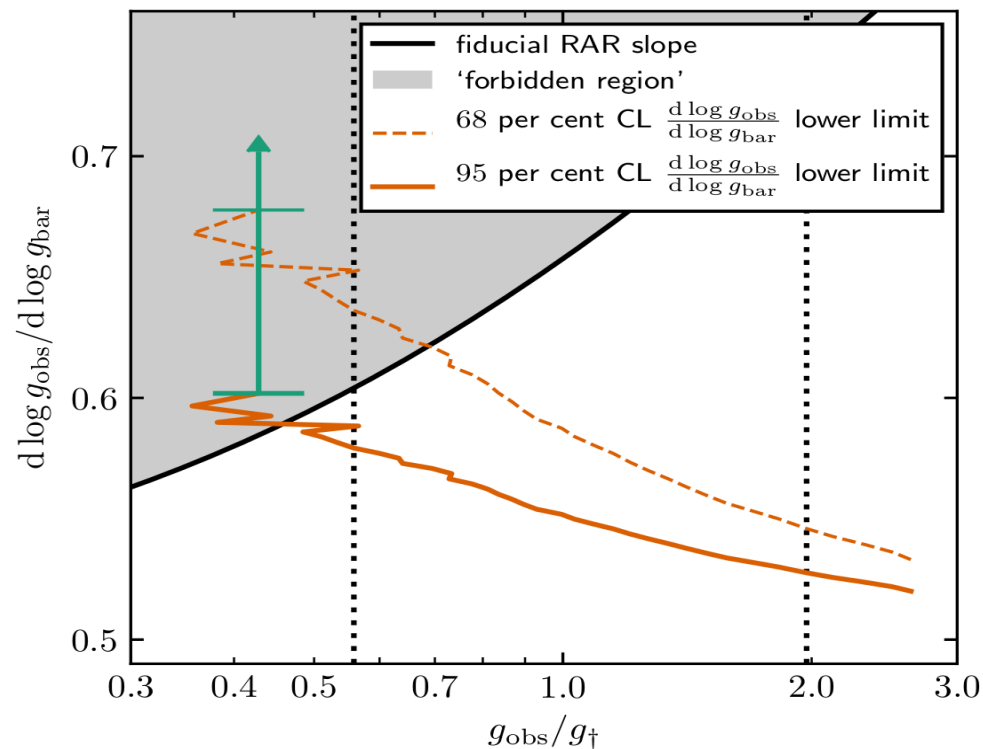
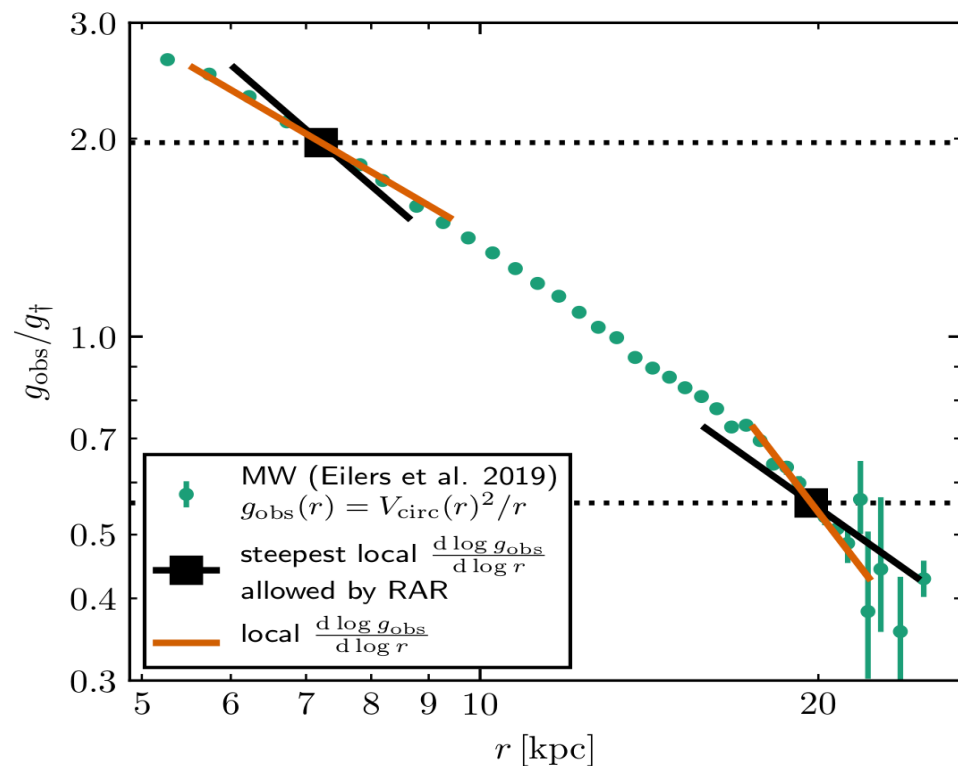
Constraints: Milky Way rotation curve



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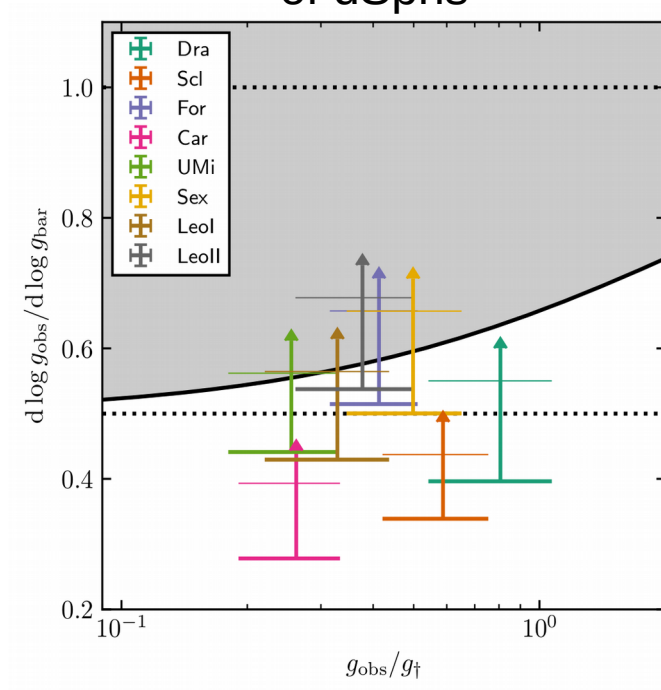


Constraints: Milky Way rotation curve



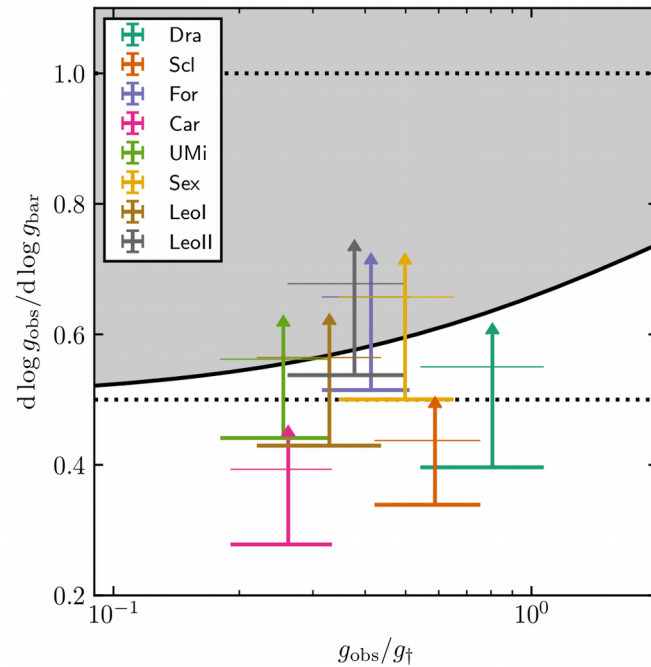
More constraints

Jeans modelling
of dSphs

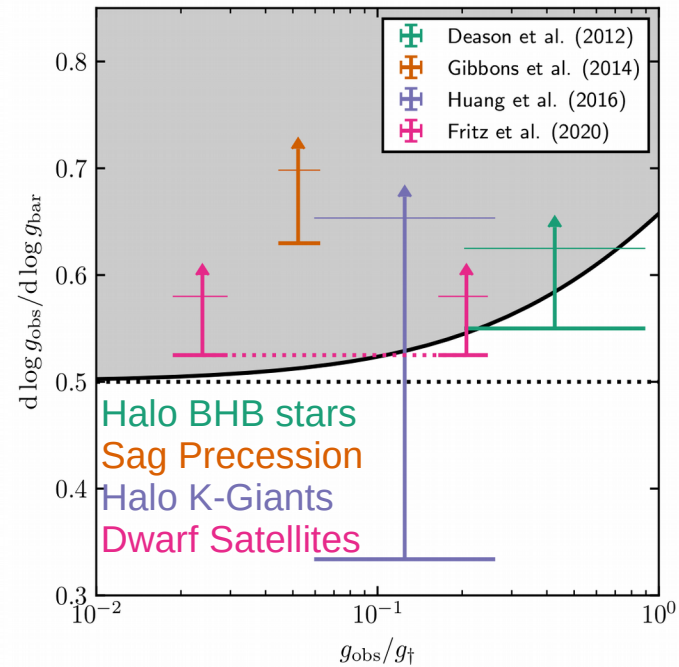


More constraints

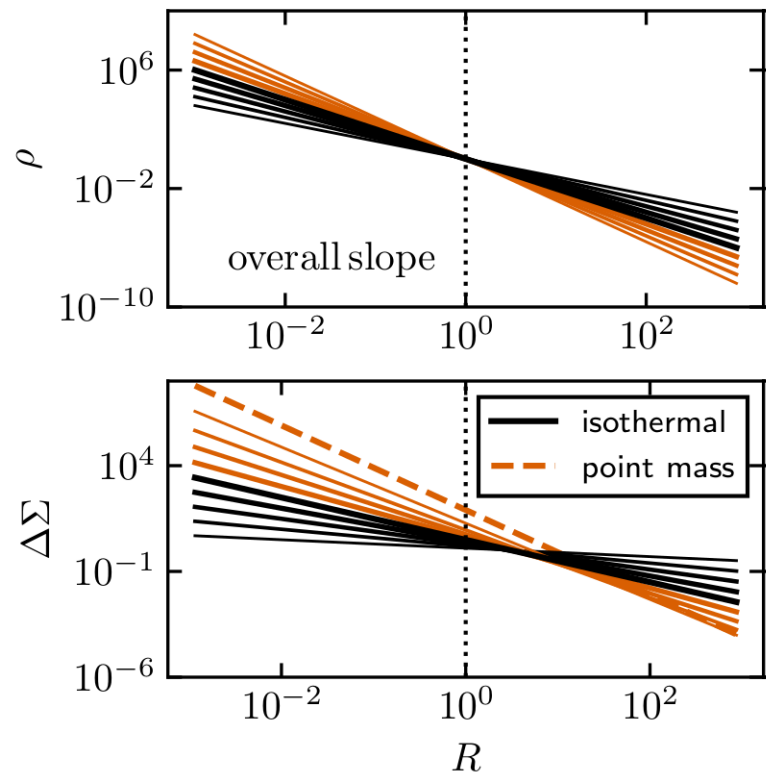
Jeans modelling of dSphs



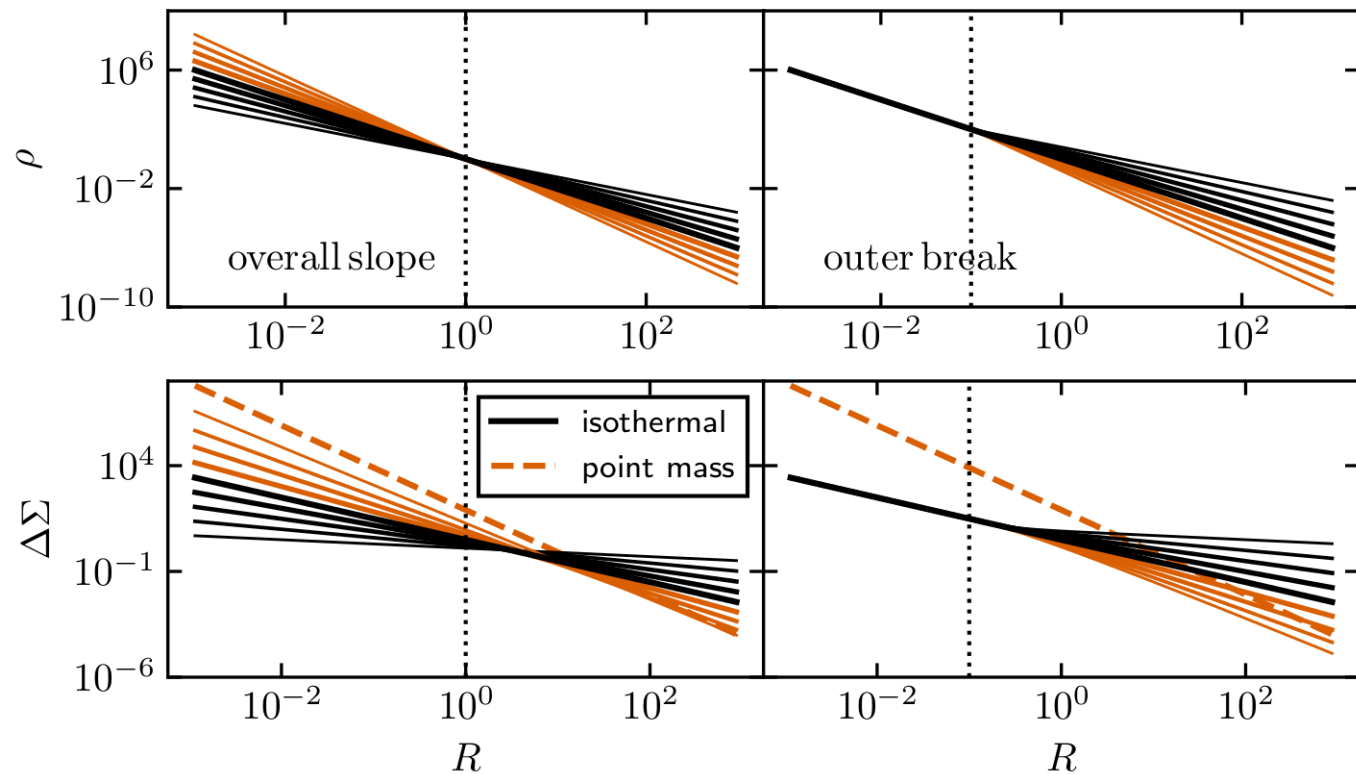
Outer Milky Way kinematics



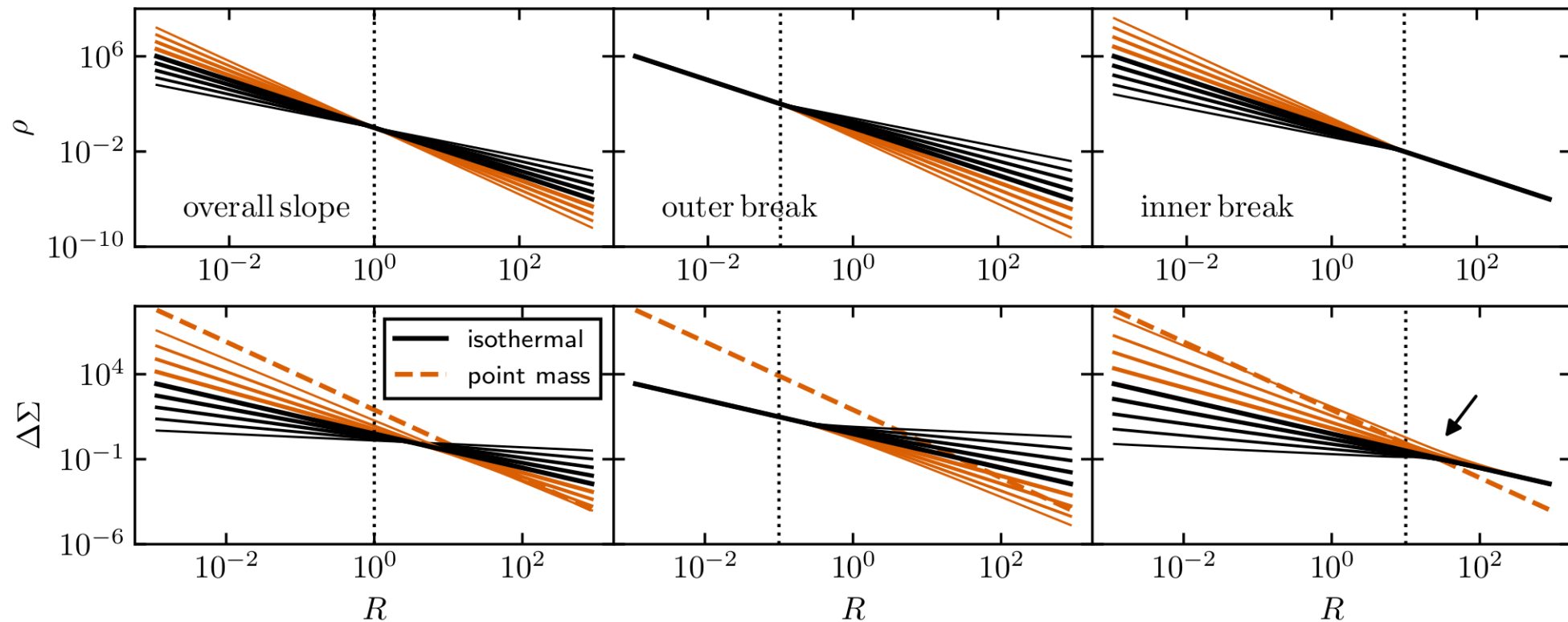
Galaxy-galaxy weak lensing



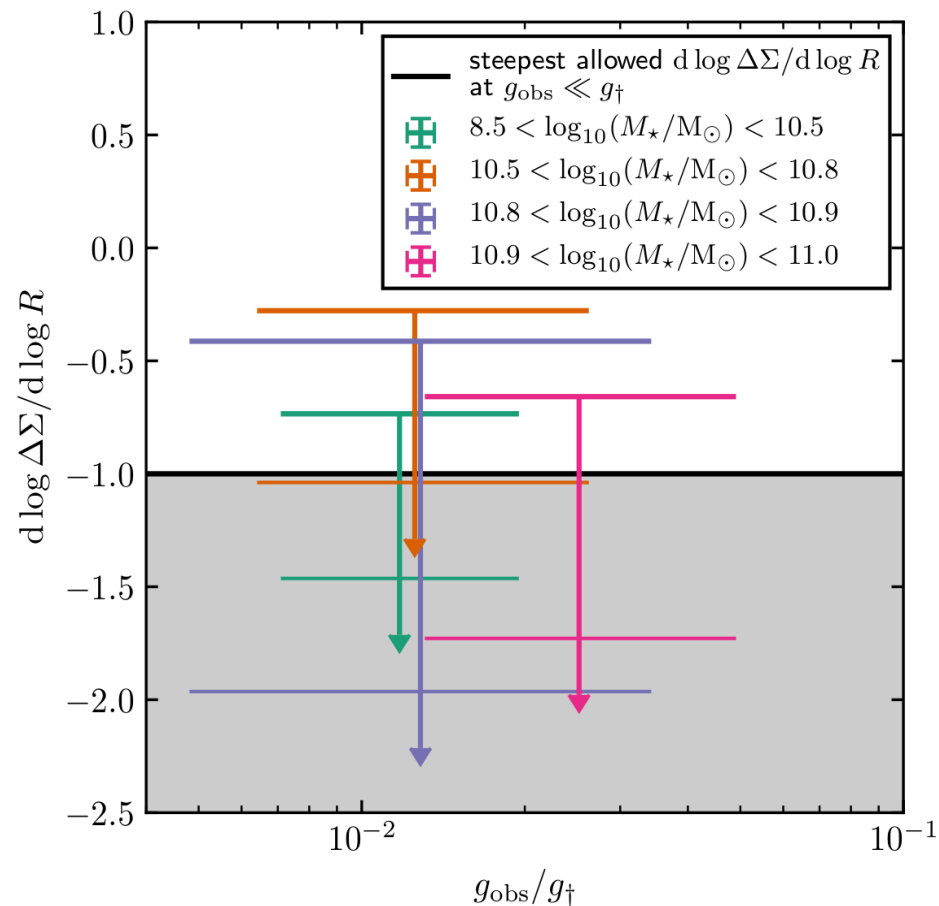
Galaxy-galaxy weak lensing



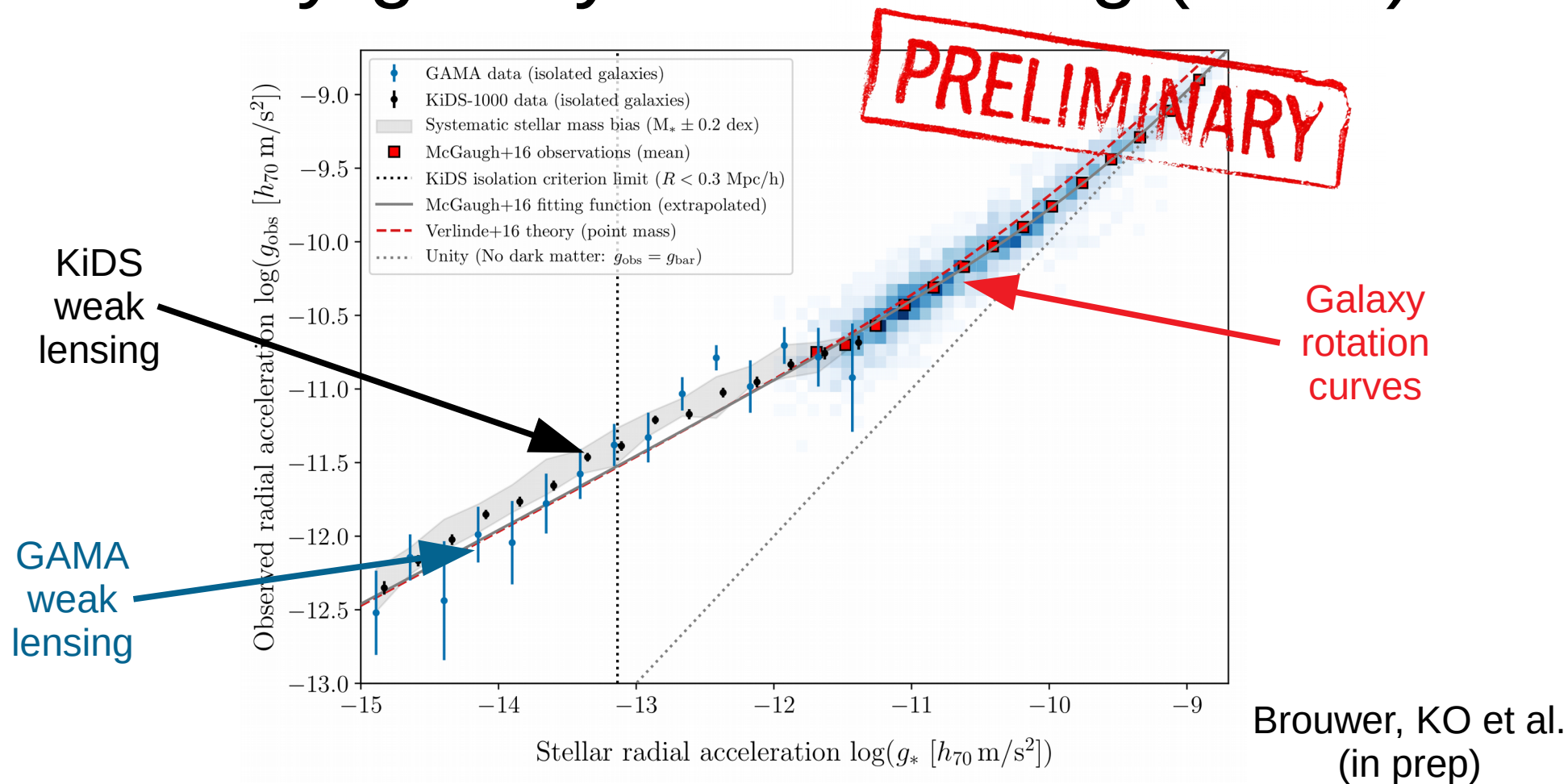
Galaxy-galaxy weak lensing



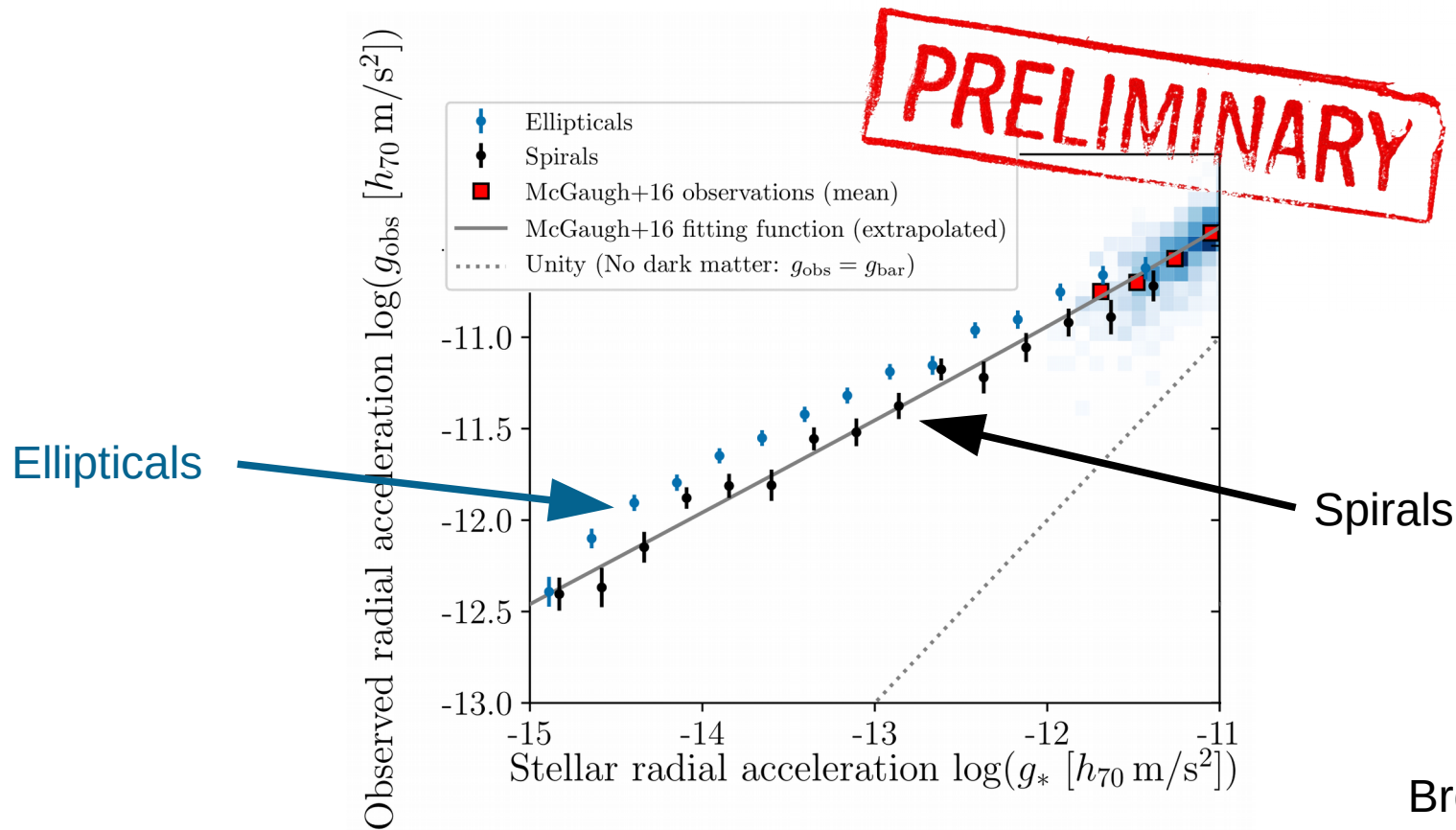
Galaxy-galaxy weak lensing (GAMA)



Galaxy-galaxy weak lensing (KiDS)



Galaxy-galaxy weak lensing (KiDS)



Brouwer, KO et al.
(in prep)

Summary

- All constraints point to weak evidence for a break to a steeper slope in the low-acceleration RAR
⇒ improve data and/or models.
- Weak lensing is promising, we are working on this (Brouwer, KO et al., in prep.).
- Strong constraints probably possible from the outer Milky Way with existing data & dedicated modelling.

Appendix: MOND & external fields

- The dSphs cannot be both on the RAR and consistent with its slope.

