

Constraints on disk galaxy formation from **Tully-Fisher relation** and **weak lensing** of **SDSS galaxies**

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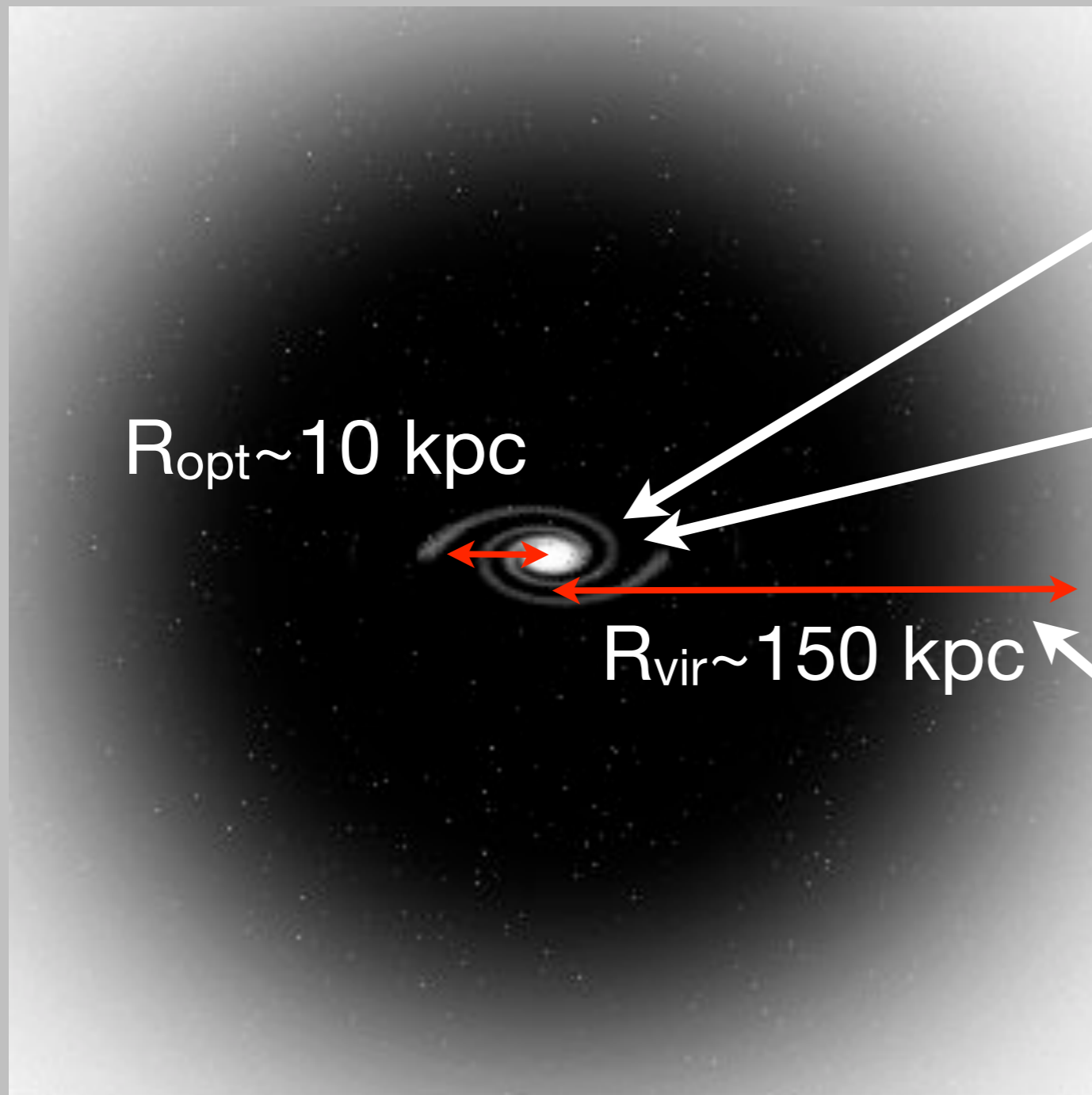
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Uros **Seljak** (UC Berkeley/LBL)

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Hsin-Yu **Chen** (UChicago)

TF relation + Weak lensing



kinematics $\rightarrow V_{\text{opt}}$ (TFR)

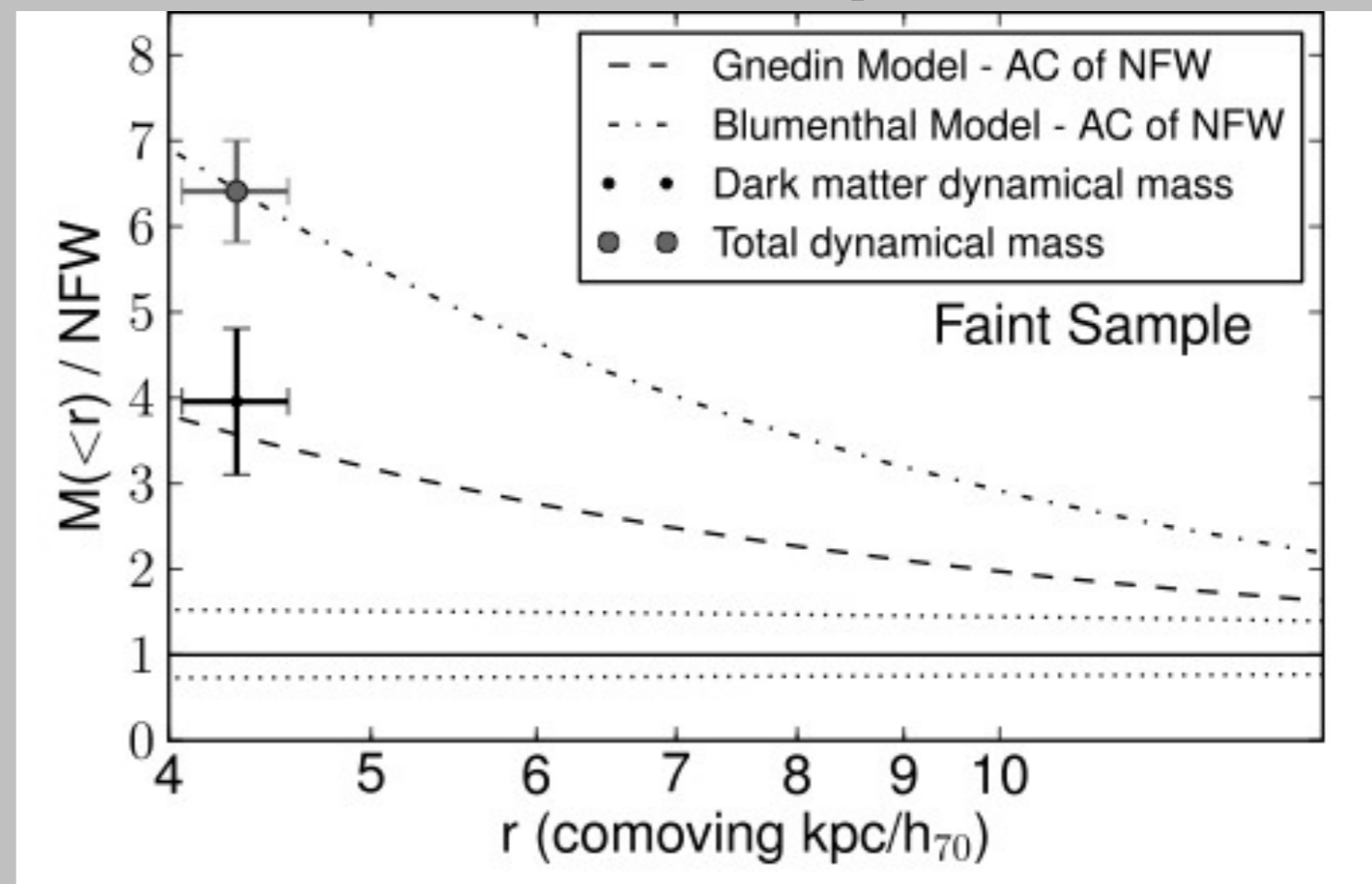
photometry $\rightarrow M_{\text{star}}, M_{\text{gas}}$

weak lensing $\rightarrow M_{\text{halo}}$

TF relation + Weak lensing

- Constrain **total mass profile** over $<R_{\text{opt}}$ to $\sim R_{\text{vir}}$
- Determine **direct measurement** of $V_{\text{opt}}/V_{\text{vir}}$
- Constrain **stellar IMF** and **halo response** (i.e., adiabatic contraction)
- Test **galaxy formation models** and **simulations**
- Lift **disk-halo degeneracy** in rotation curve modeling

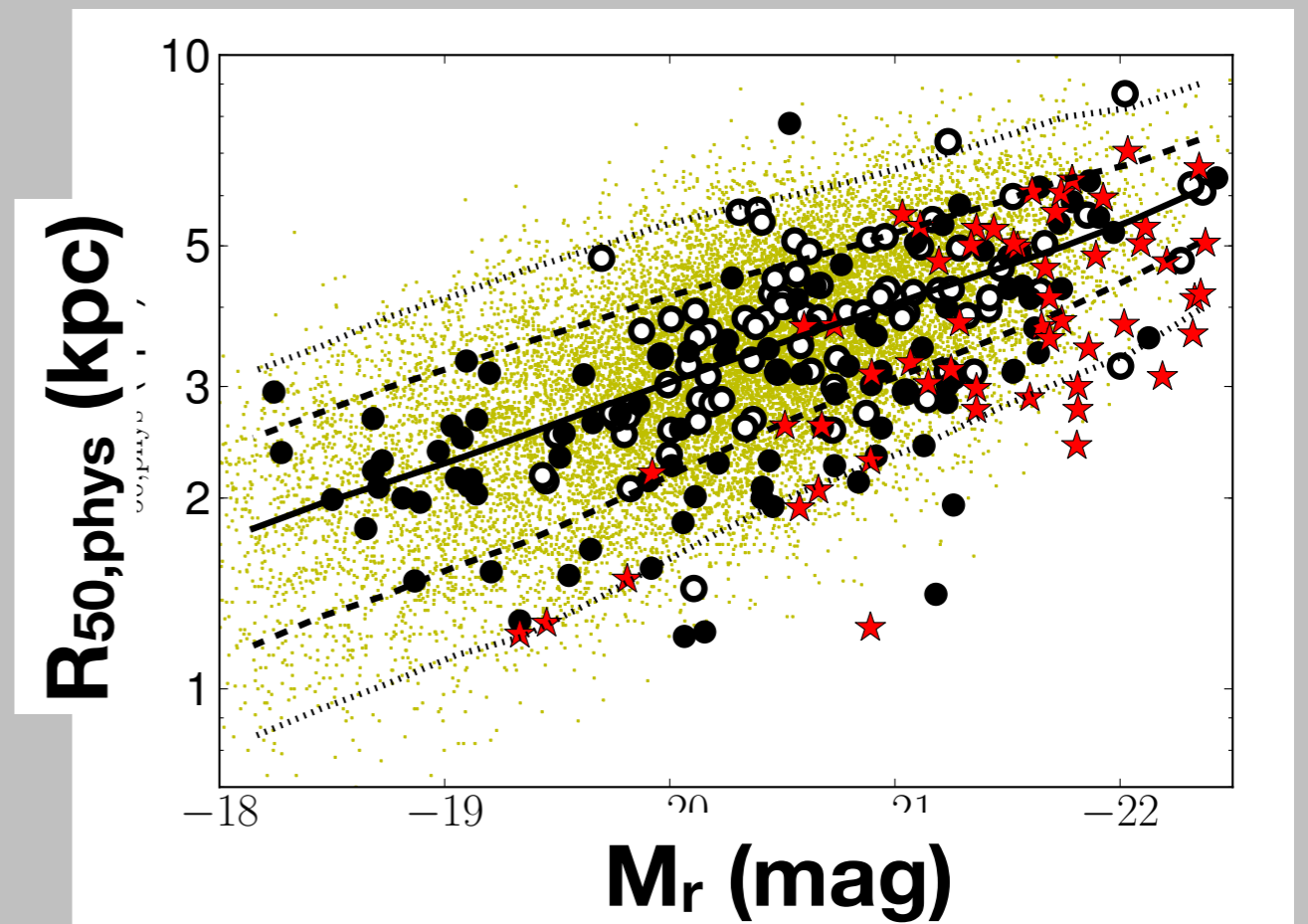
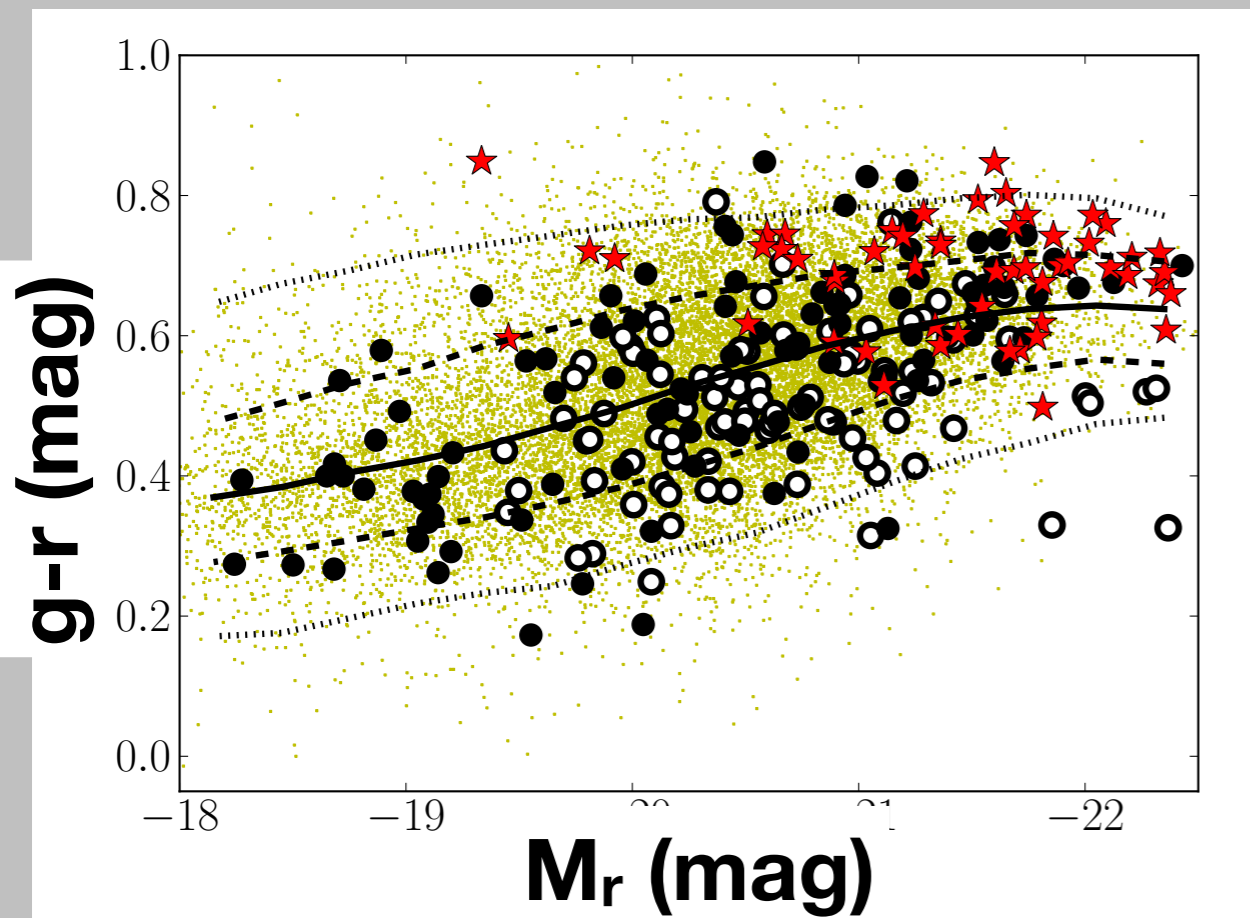
SDSS ellipticals



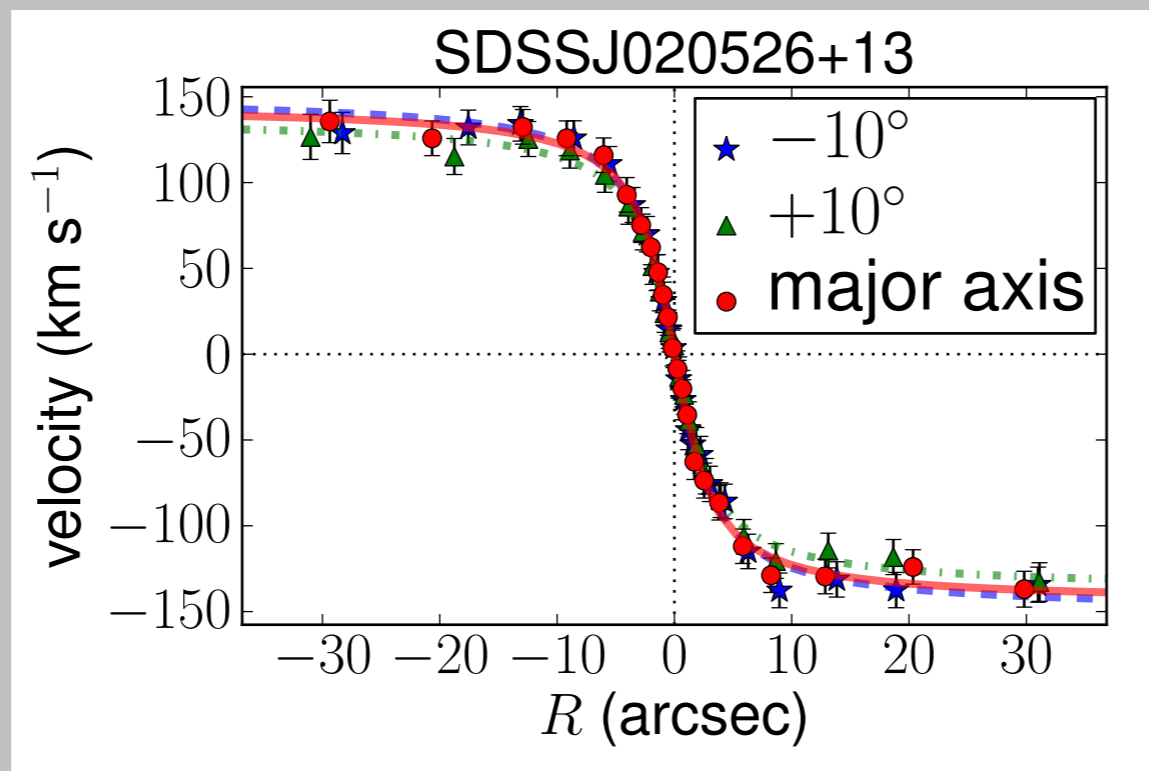
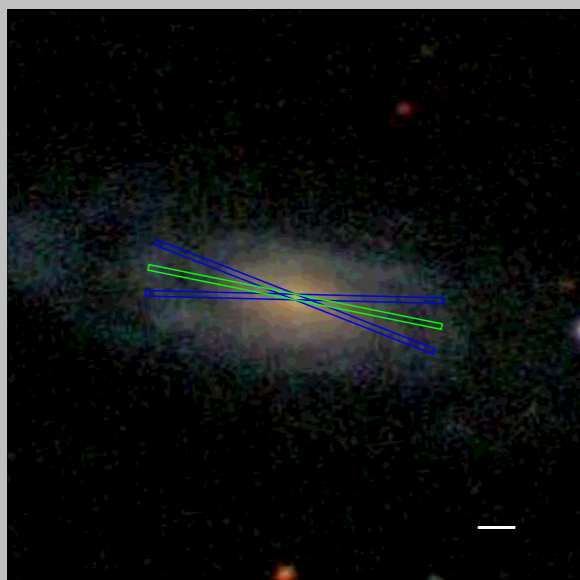
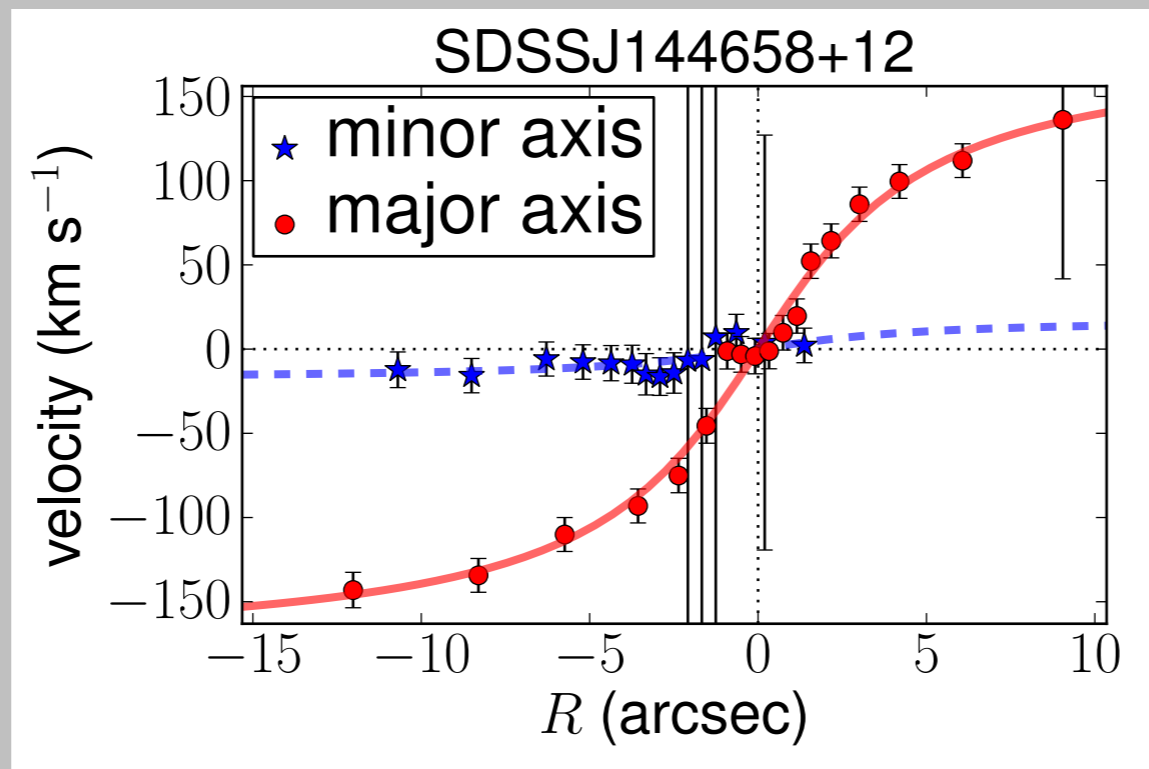
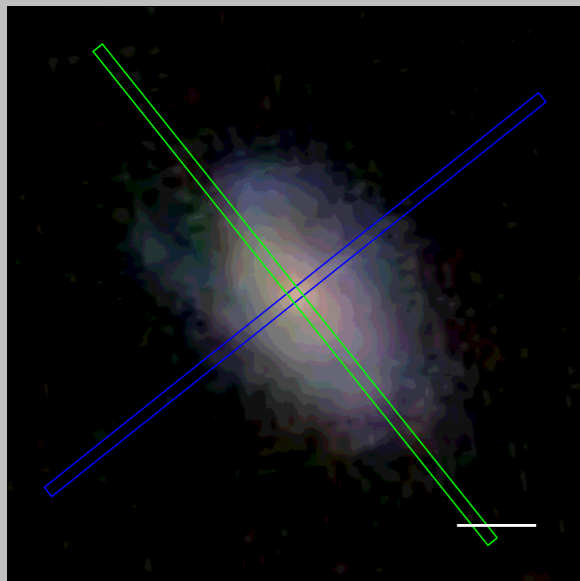
Schulz et al. (2010)

Sample selection

- TF sample must be *representative* subsample of lens sample
- **189 galaxies** in the TF sample
 - 99 galaxies from Pizagno et al. (2007)
 - 90 galaxies with new observations from APO 3.5m



Rotation curves

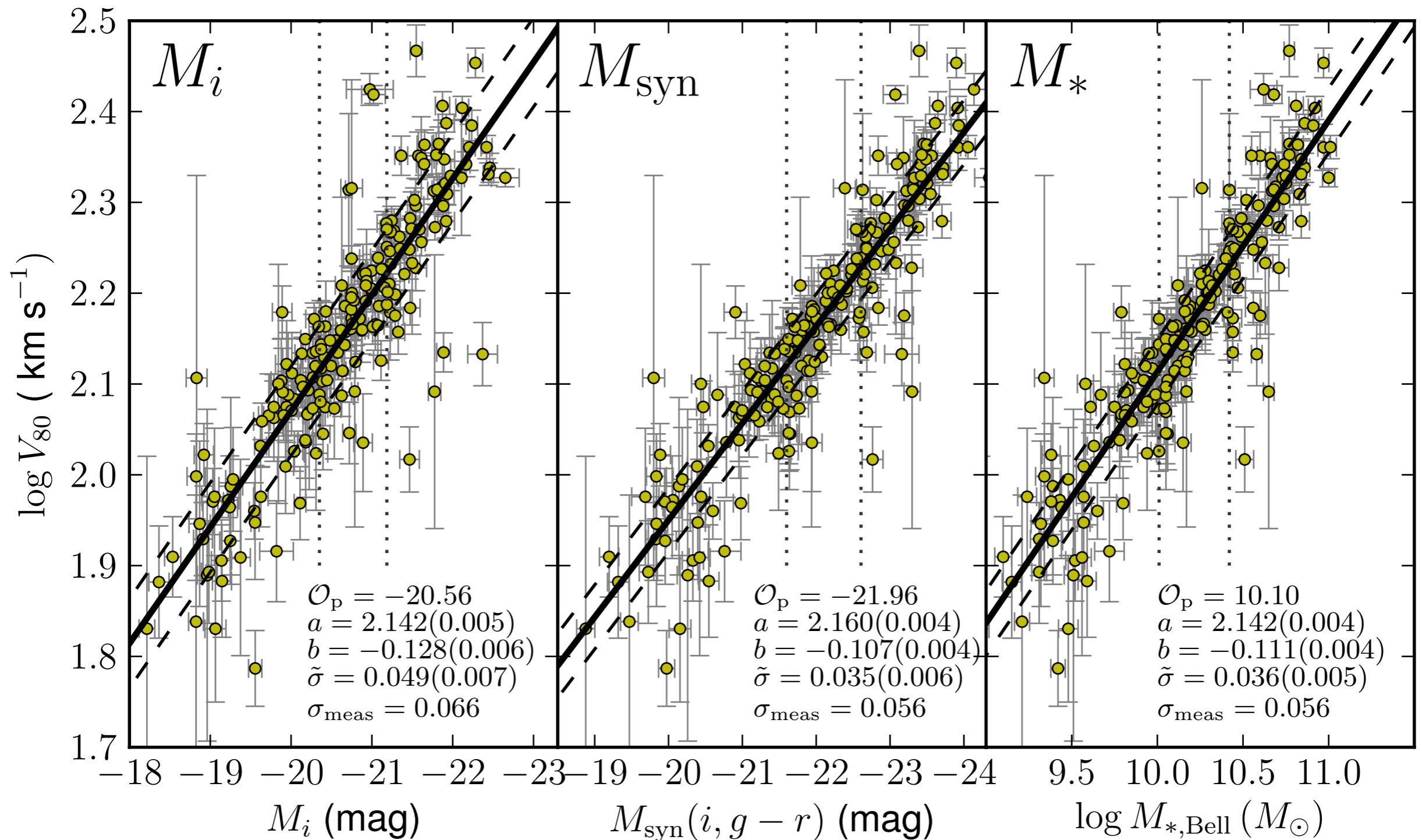


90 galaxies observed for **long-slit spectroscopy** with DIS at the 3.5m telescope at APO over 25 half-nights.

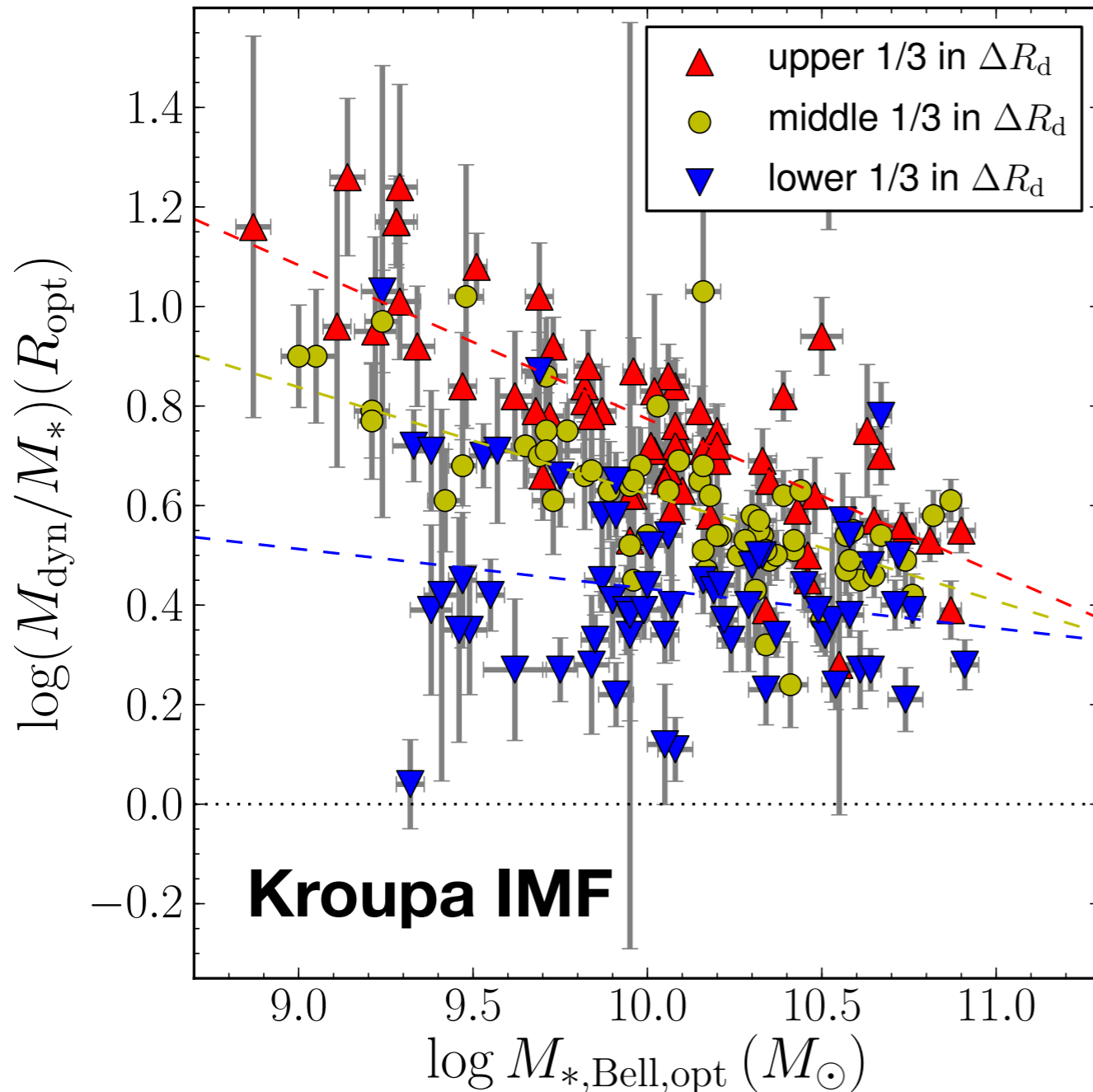
Arctangent model fits the observed rotation curves adequately for $\sim 99\%$ of the sample.

Determine rotation velocity \mathbf{V}_{80} .

Minimal-scatter TF relation



Dynamical-to-stellar mass ratios

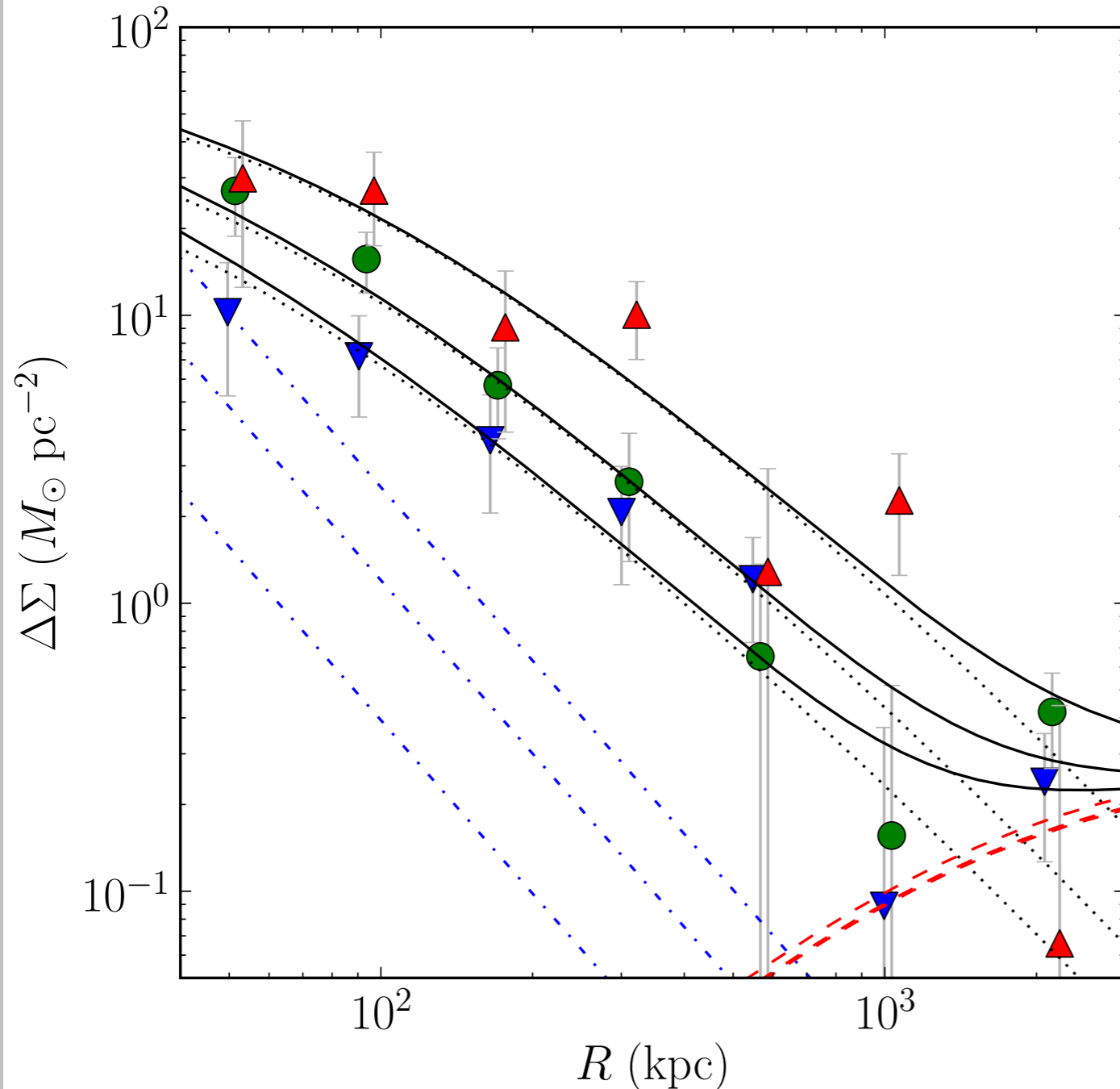


$M_{\text{dyn}}/M_{\text{star}}$ within the optical radius decreases from ~ 10 to 3 as stellar mass increases from $M_{\text{star}} \sim 10^9$ to $10^{11} M_{\text{sun}}$.

Larger disks have **higher $M_{\text{dyn}}/M_{\text{star}}$** at a **given stellar mass**.

The smallest disks have **low $M_{\text{dyn}}/M_{\text{star}}$** at **all stellar masses**.

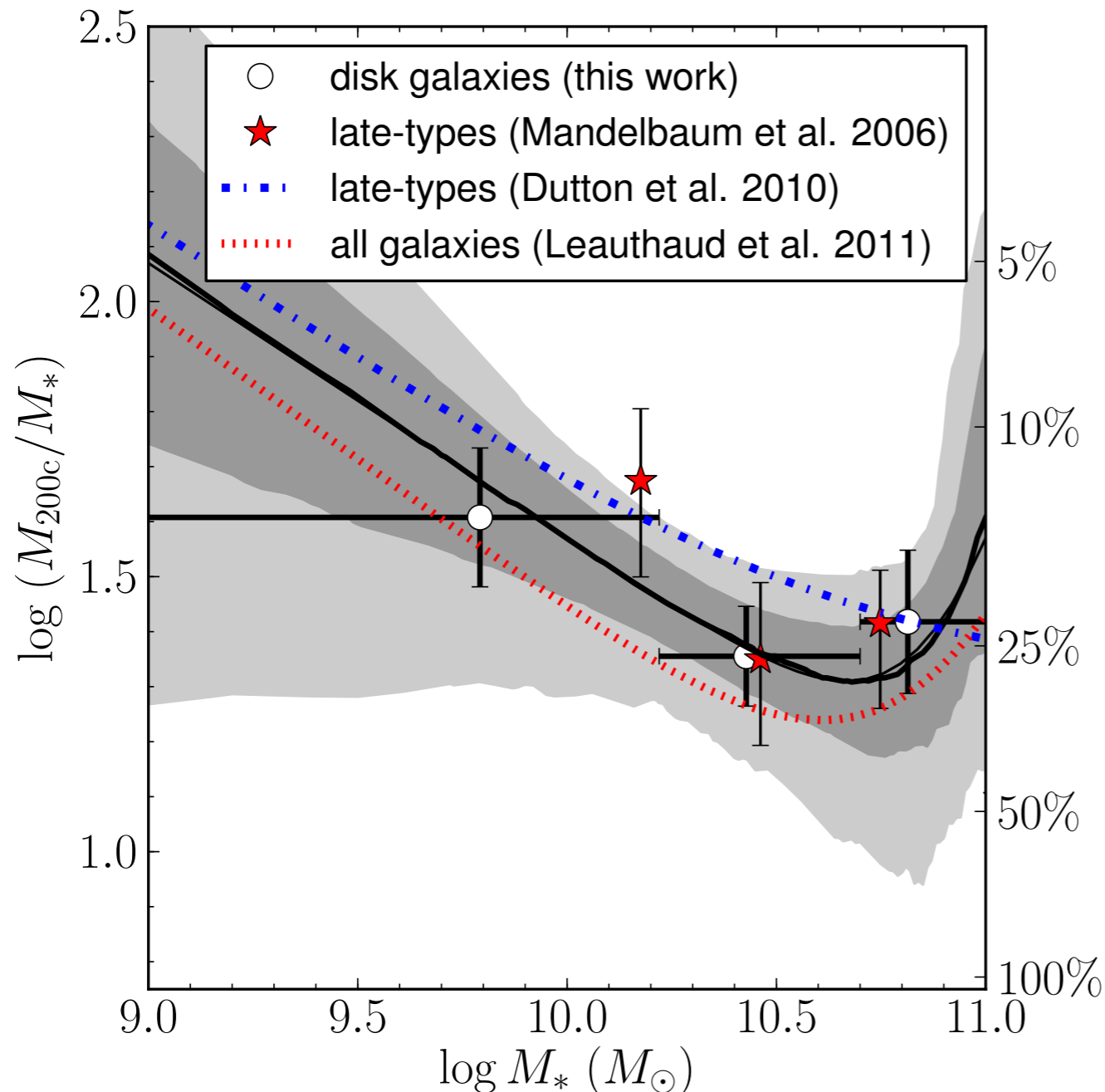
Weak lensing profile



Bins in **stellar mass** have **$N \sim 78, 47, 8 \times 10^3$ galaxies** and **$\langle \log M_* \rangle \sim 9.79, 10.43, 10.81$** (in units of M_{sun}).

Fits to NFW profiles give **halo virial masses** **$\langle \log M_{200c} \rangle$** **$\sim 11.40, 11.79, 12.23$** **$\pm 0.13, 0.09, 0.13$** (in units of M_{sun}).

Halo-to-stellar mass ratios



M_{200c}/M_{star} decreases from $\sim 10^2$ to a **minimum of ~ 20** at $M_{\text{star}} \sim 3 \times 10^{10} M_{\text{sun}}$.

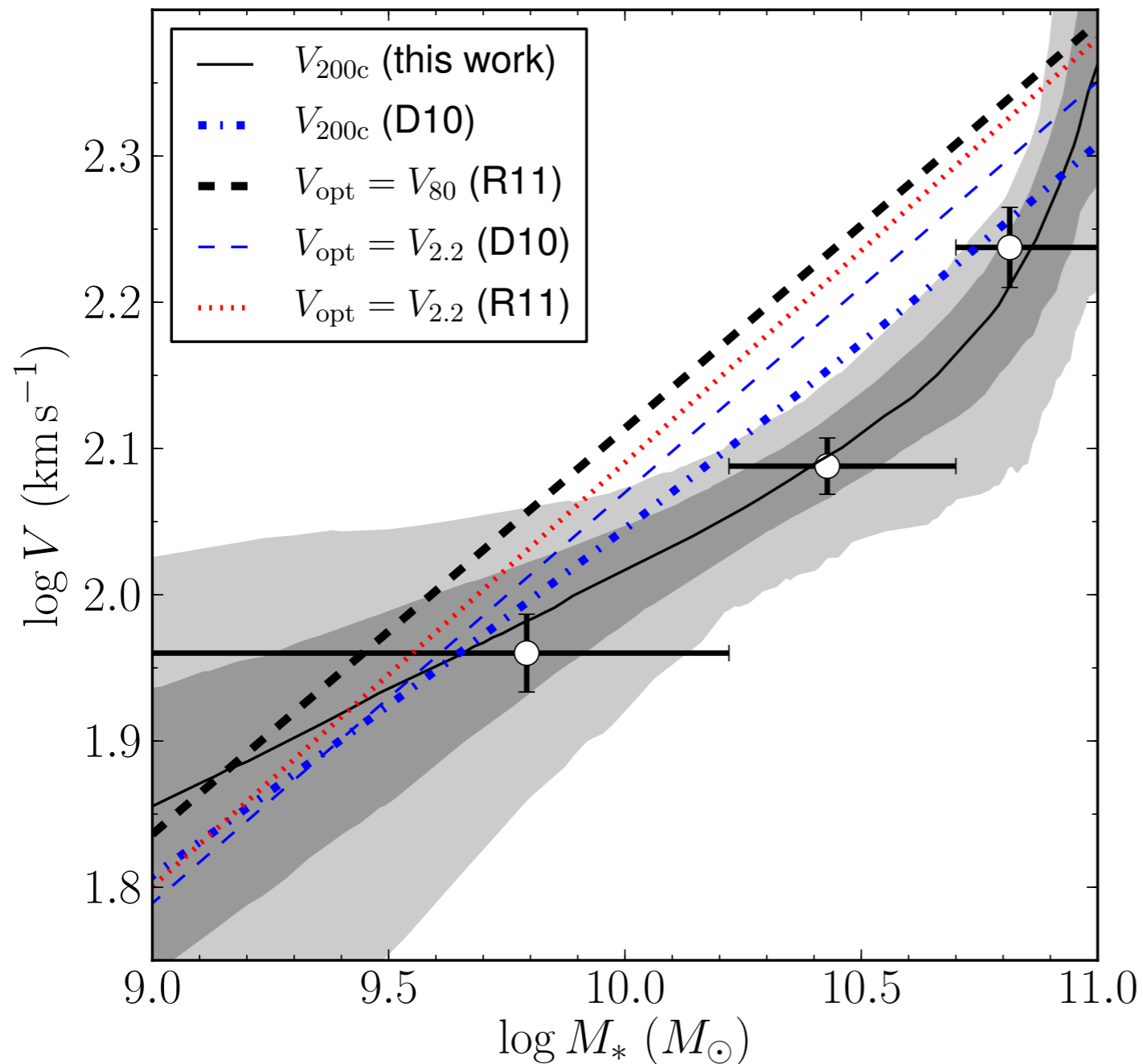
For our 3 stellar mass bins:

halo-to-stellar mass ratio
 $M_{200c}/M_{\text{star}} = \mathbf{41, 23, 26}$
 $\pm 5, 2, 3 (1\sigma)$

stellar conversion efficiency

$\eta_\star = (M_{\text{star}}/M_{200c})/(\Omega_b/\Omega_m)$
 $= \mathbf{15, 26, 23}$
 $\pm 5, 6, 8\% (1\sigma)$

Virial vs. optical velocities



- V_{200c} from **weak lensing**:

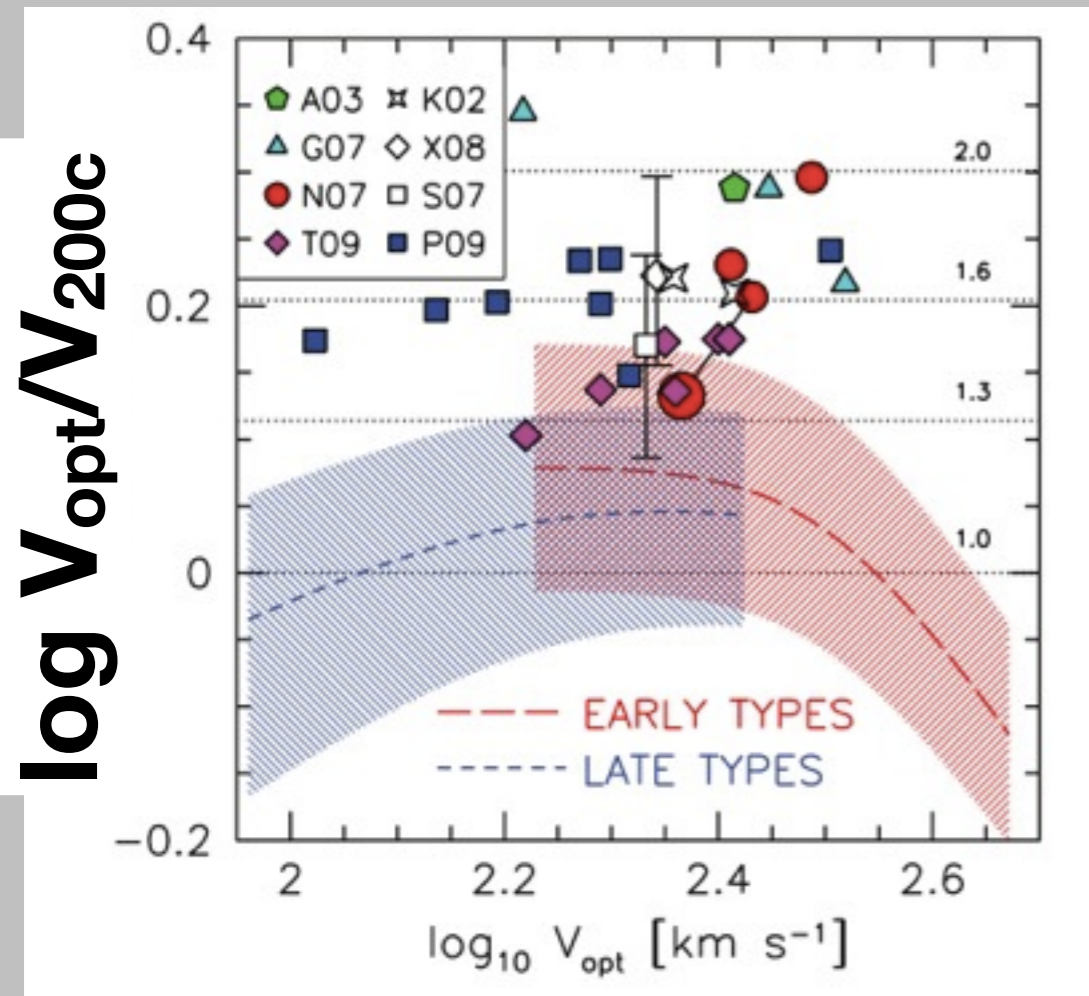
$$V_{200c} = (GM_{200c}/R_{200c})^2$$

- V_{opt} from **Tully-Fisher relation**:

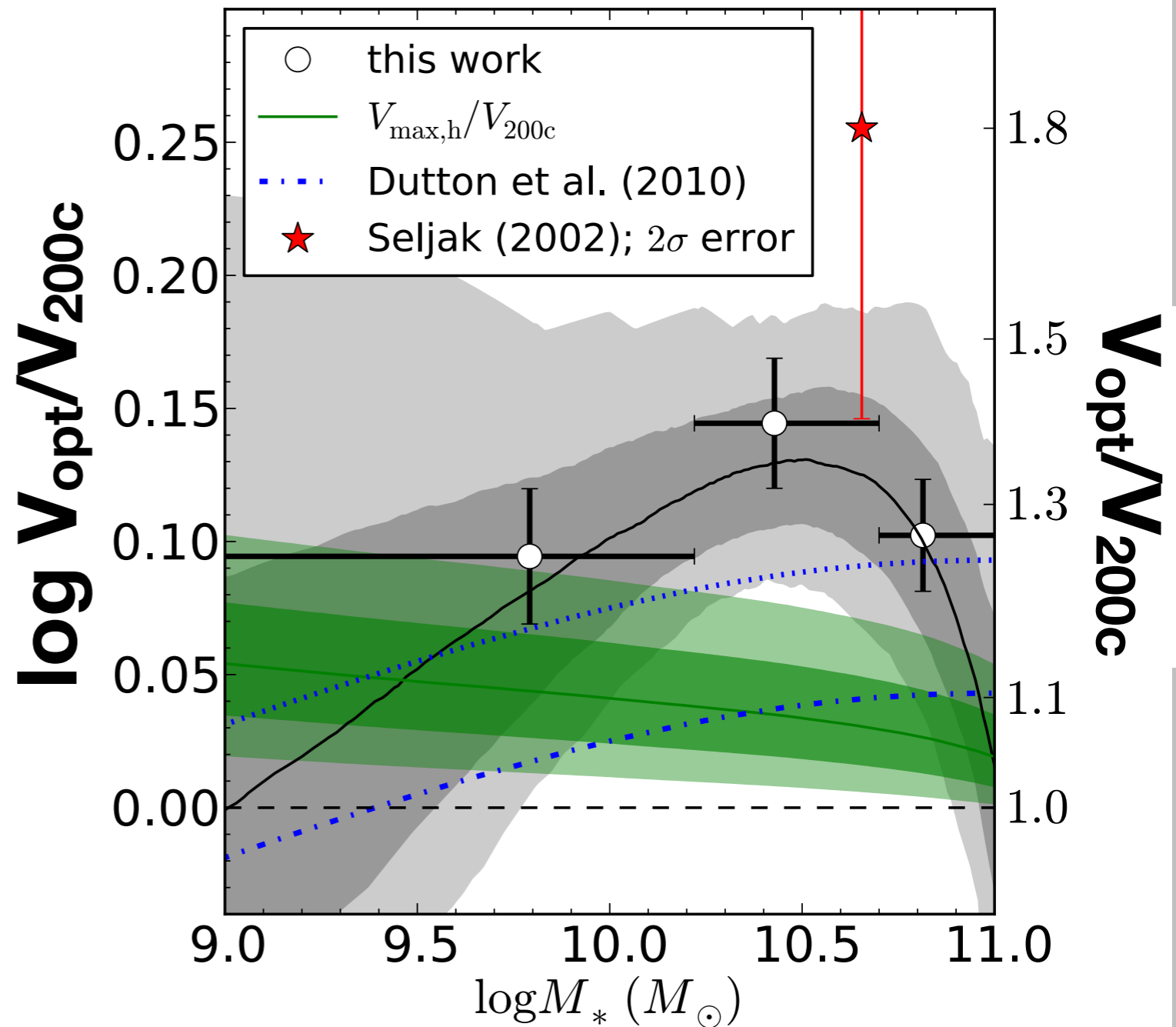
$$\log V_{80}(M^*) = 2.142 + 0.278 \times (\log M^* - 10.10)$$

Optical-to-virial velocity ratio

Dutton et al. (2010)

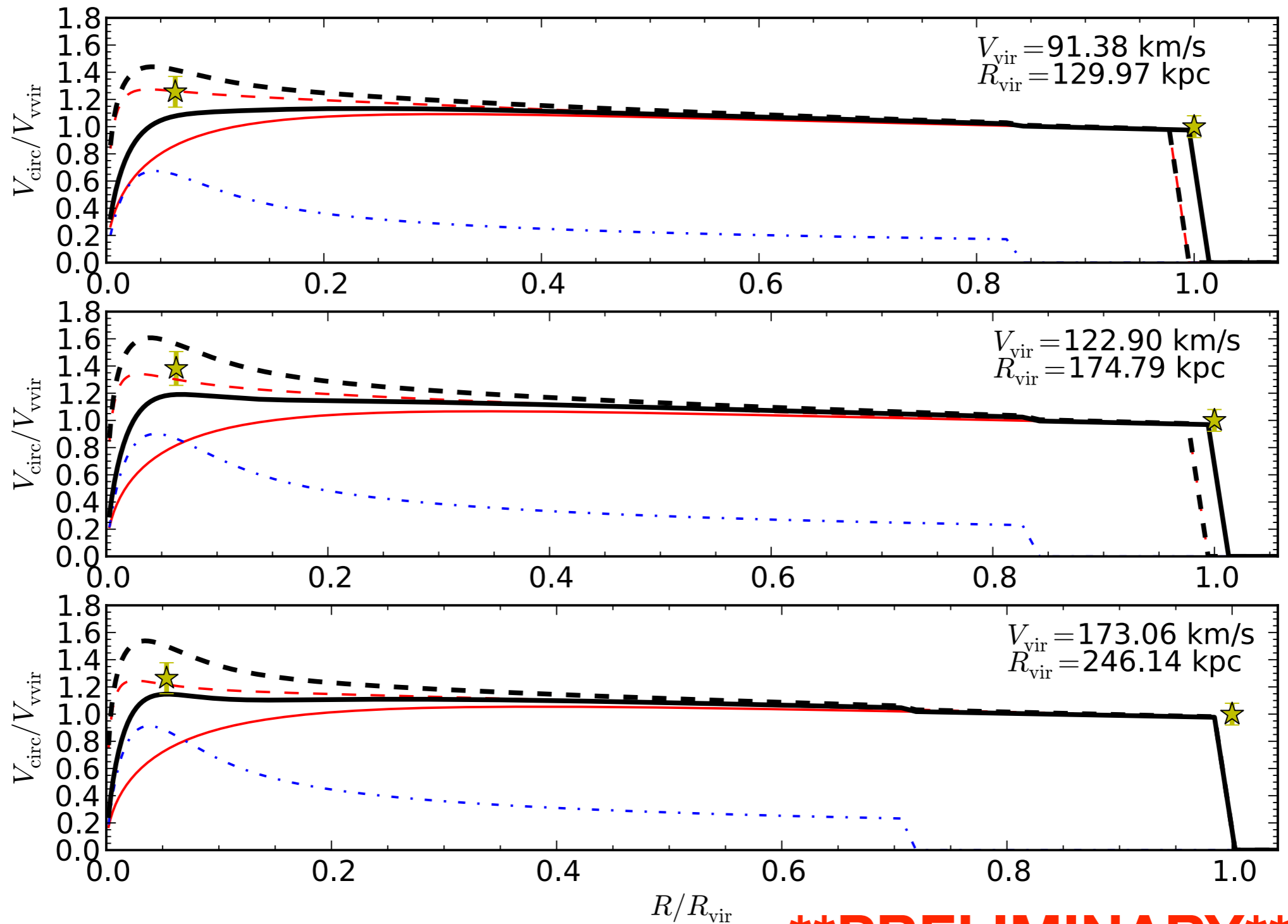


--> $V_{\text{opt}}/V_{200c} \sim 1$



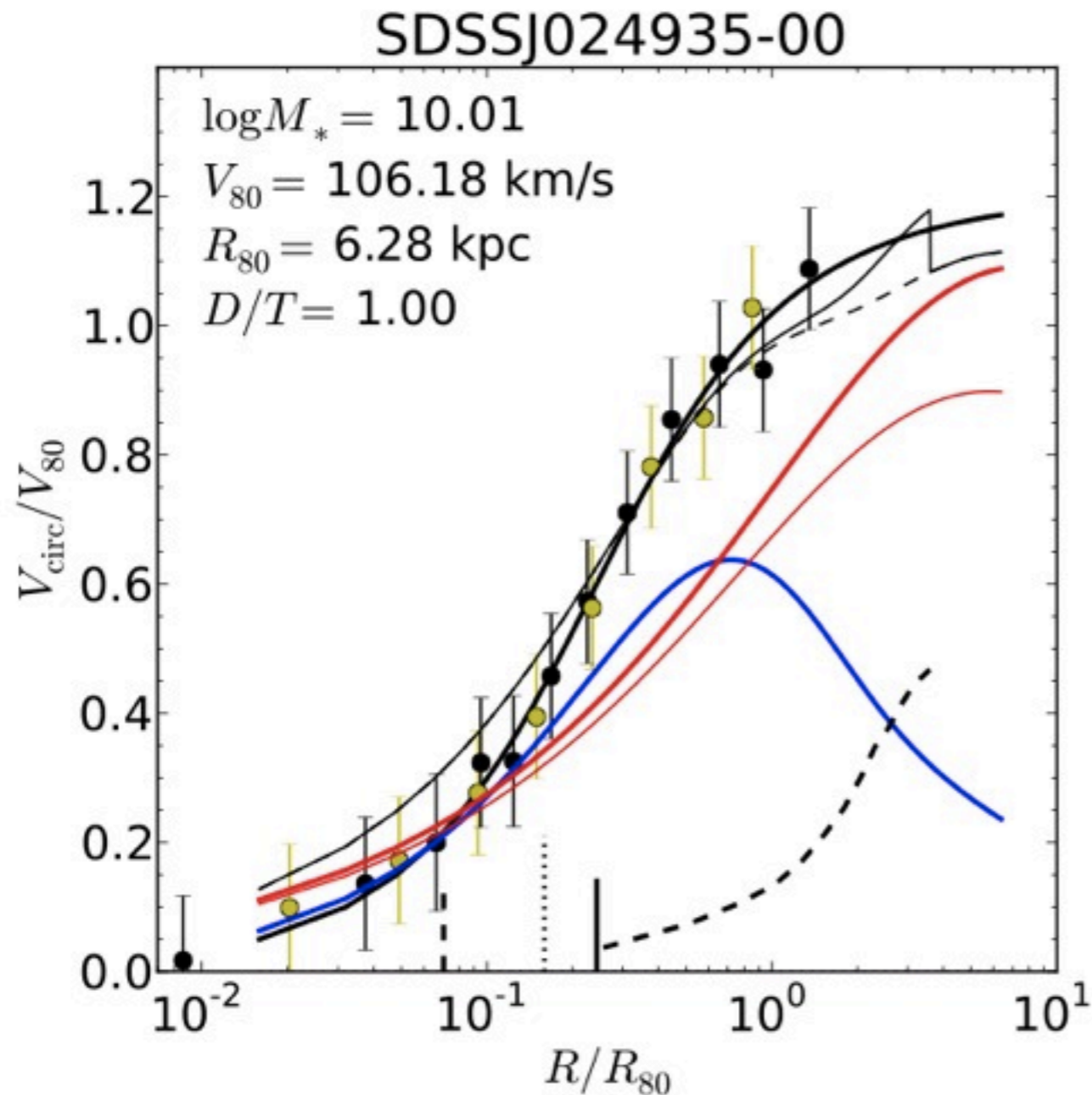
--> $V_{\text{opt}}/V_{200c} \sim 1.3$

Rotation curve modeling

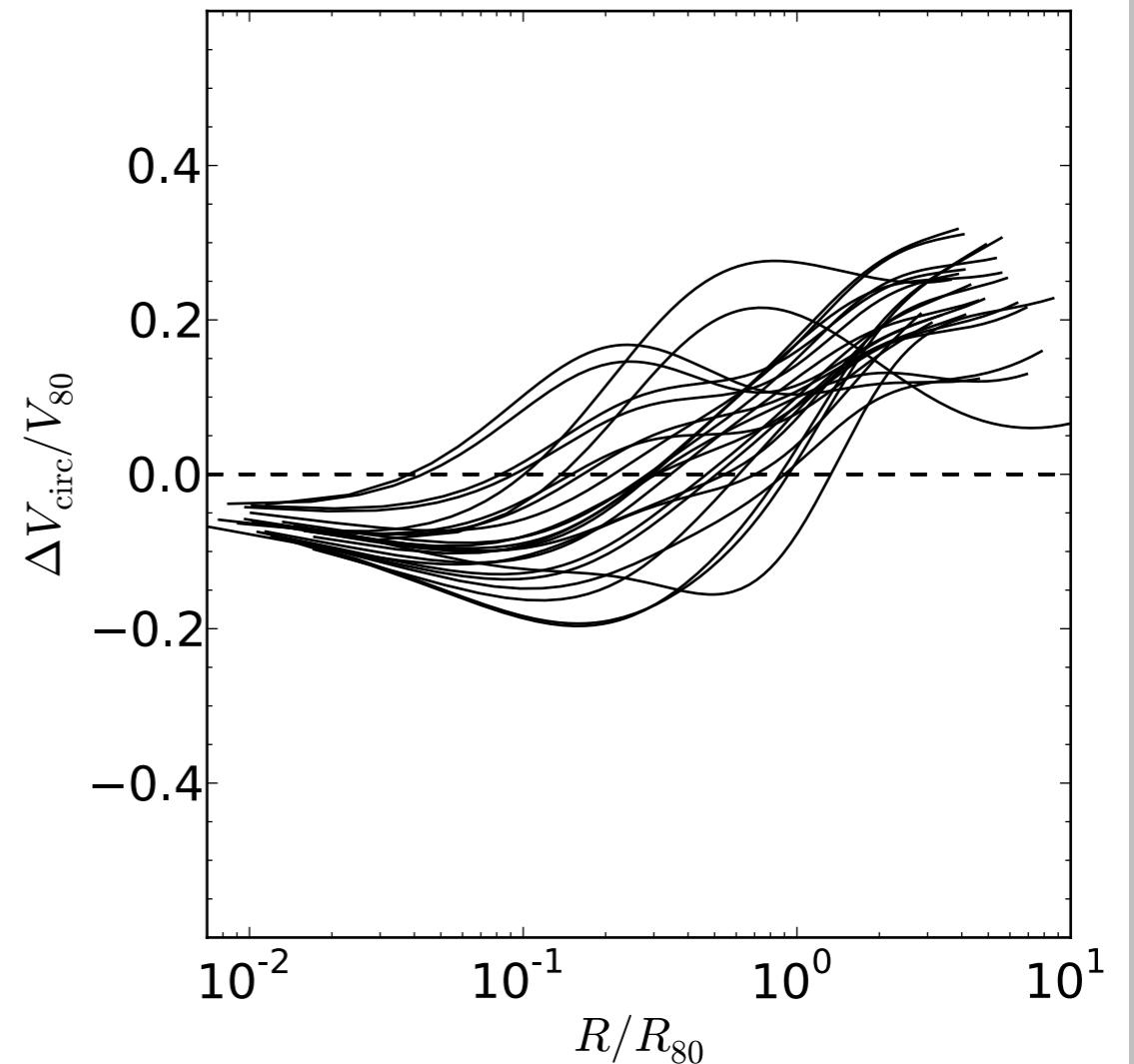


****PRELIMINARY****

Rotation curve modeling

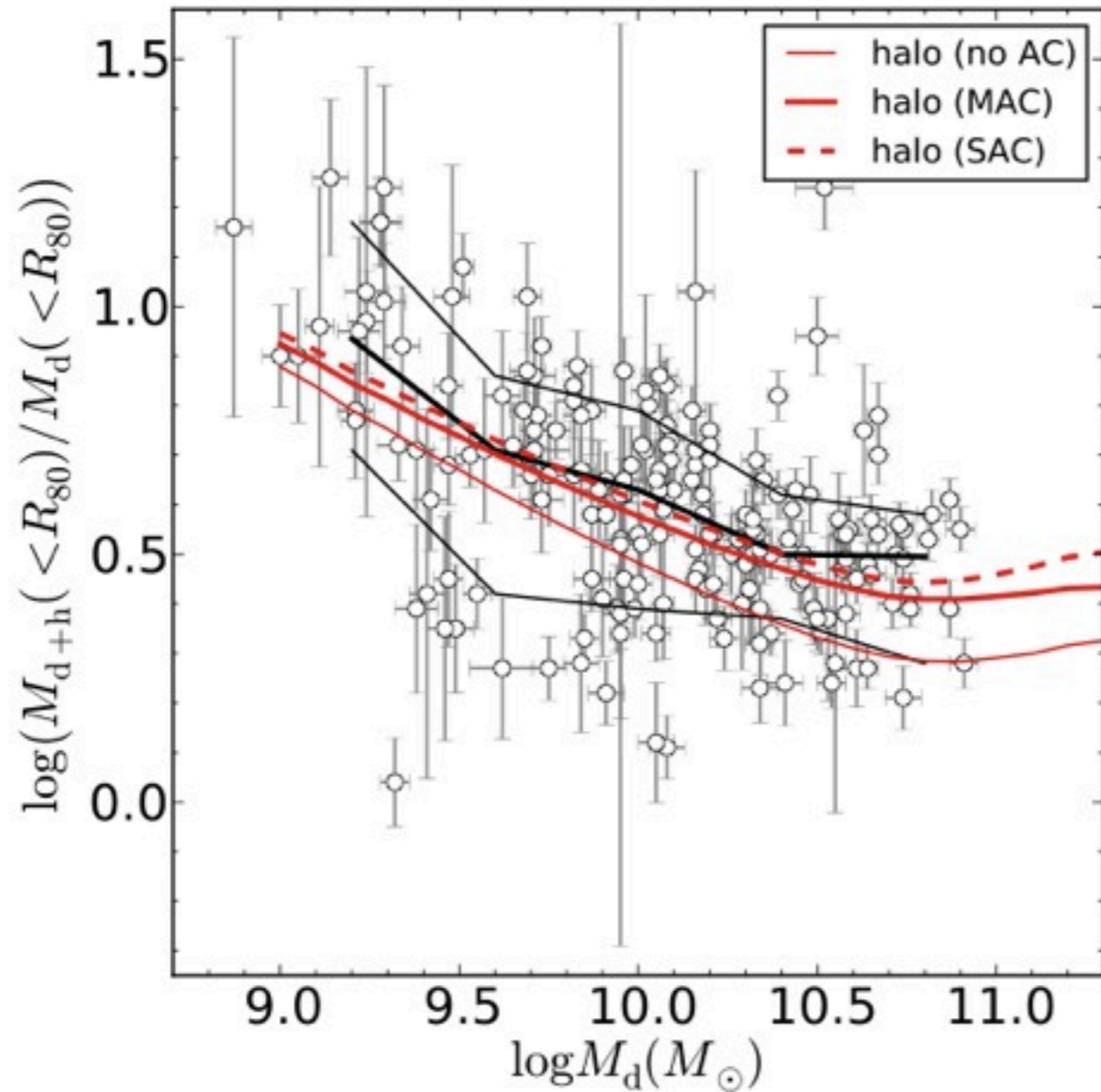


****PRELIMINARY****

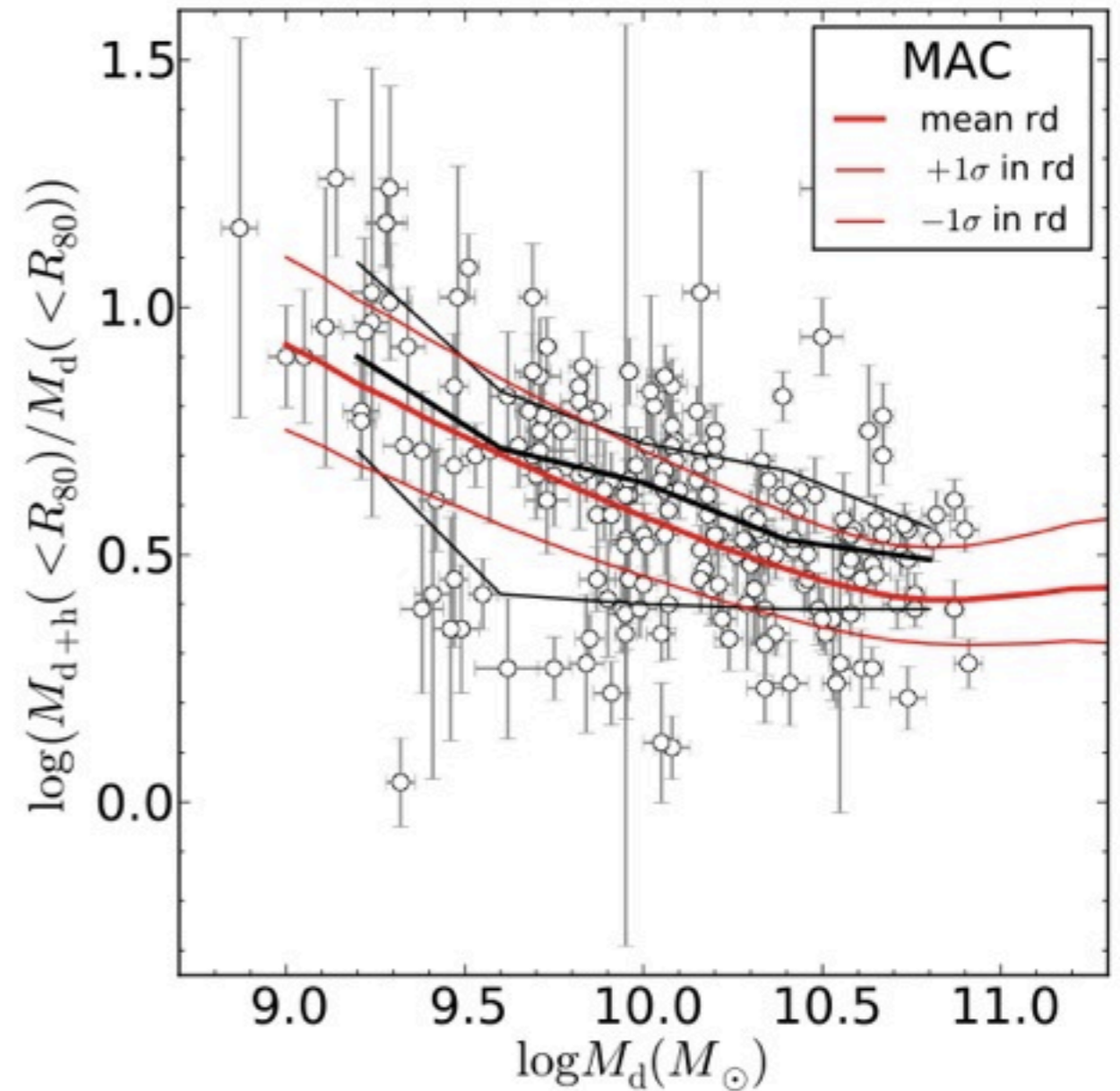


****PRELIMINARY****

Mass modeling



****PRELIMINARY****



****PRELIMINARY****

Summary

Available now:

- Tully-Fisher relation from SDSS galaxies at $z \sim 0.1$
[Reyes, R. et al. 2011](#)
 - Optical-to-virial velocities from TF + weak lensing
[Reyes, R. et al. 2012, *submitted*](#)
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Upcoming:

Constraints on **halo contraction** and **stellar IMF**

- rotation curve modeling (200 galaxies, individually)
- mass modeling (200 galaxies, together)