THE ASSEMBLY HISTORY OF DISK GALAXIES:

Evolution in The Tully-Fisher Relation to z∼1.3

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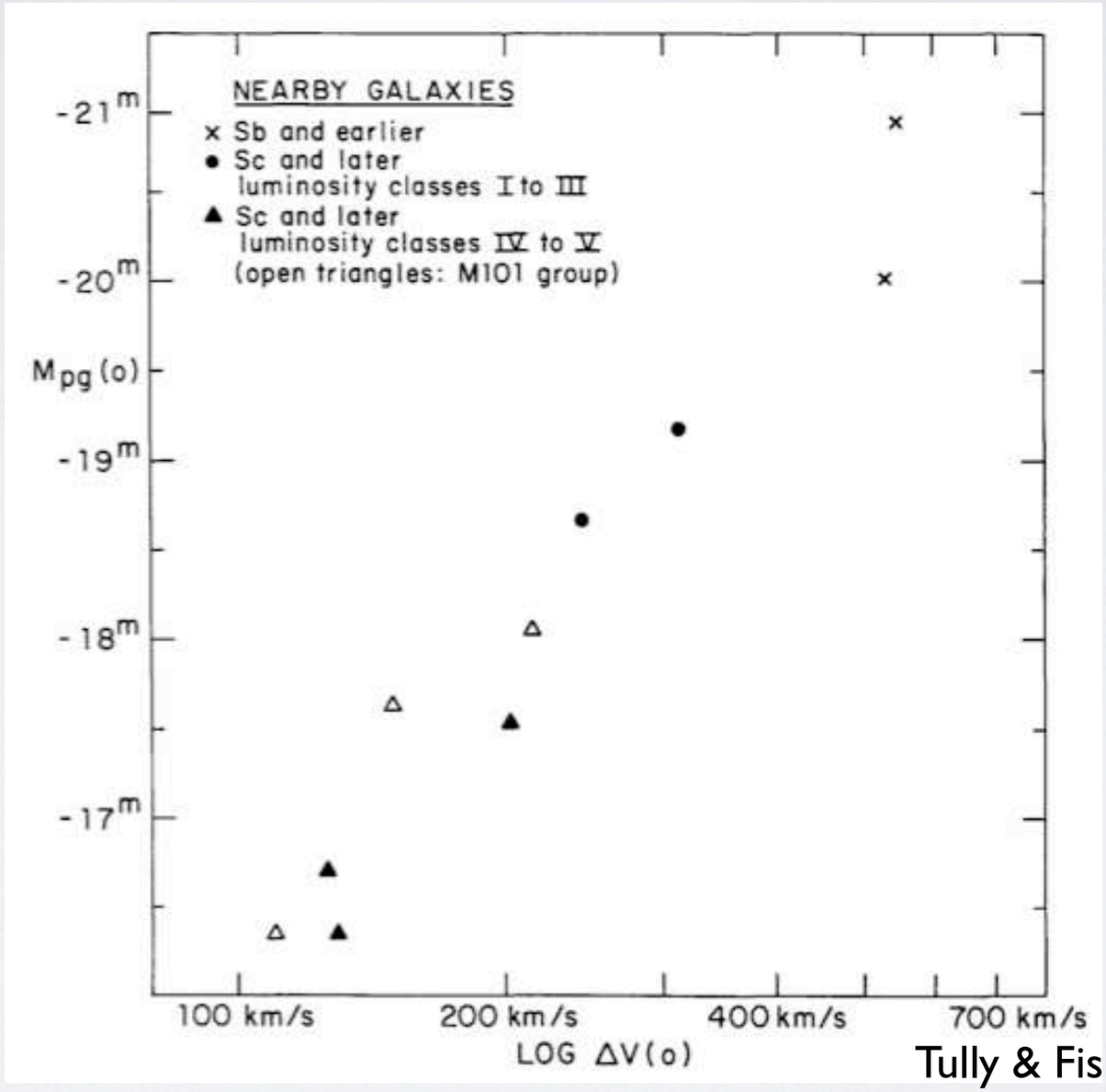
USING THE TULLY-FISHER RELATION TO CONSTRAIN OUR UNDERSTANDING OF DISK EVOLUTION

ABSOLUTE MAGNITUDE



Tully & Fisher, 1977

ROTATIONAL VELOCITY

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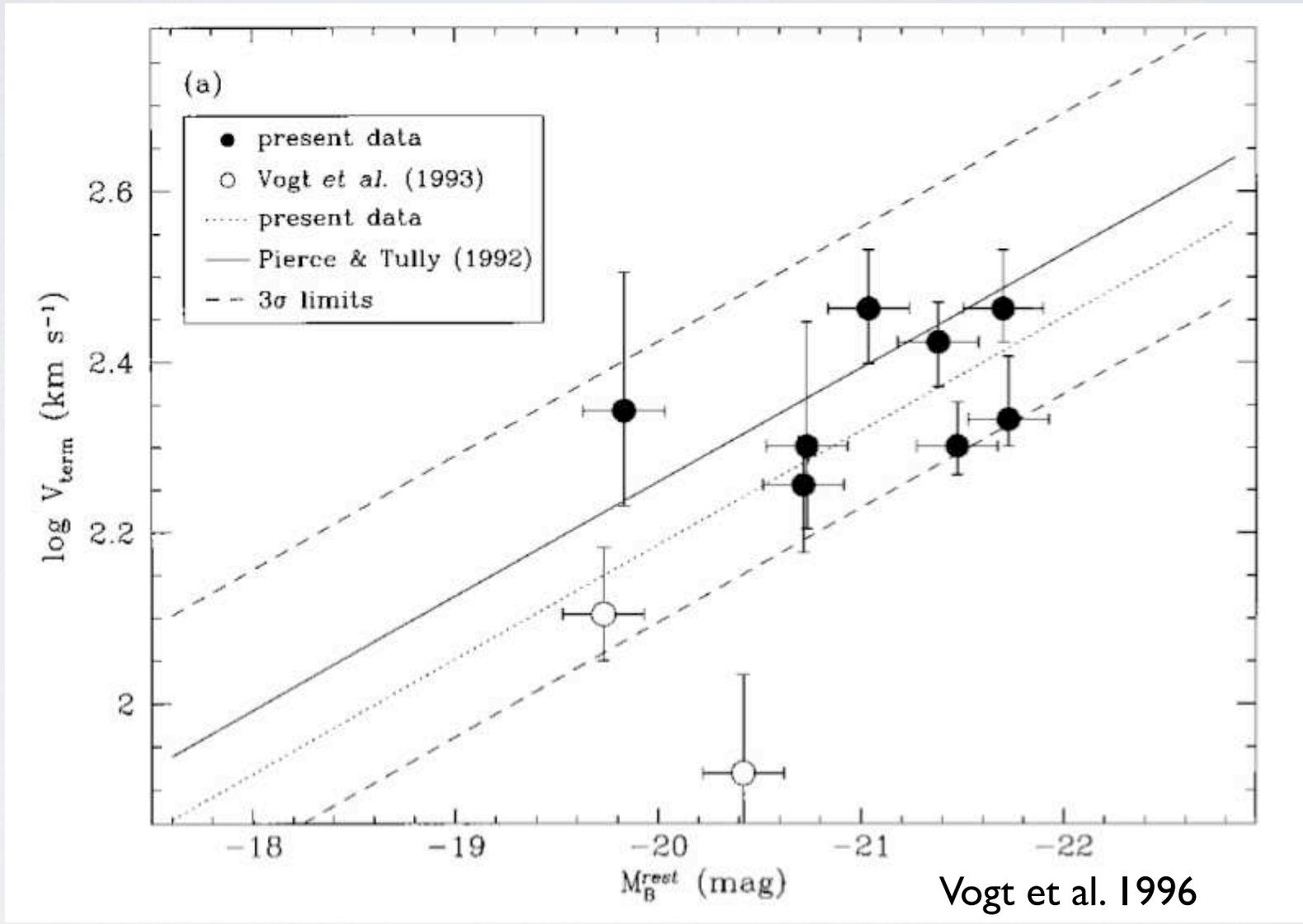
ABSOLUTE MAGNITUDE



Vogt et al. 1996

ROTATIONAL VELOCITY

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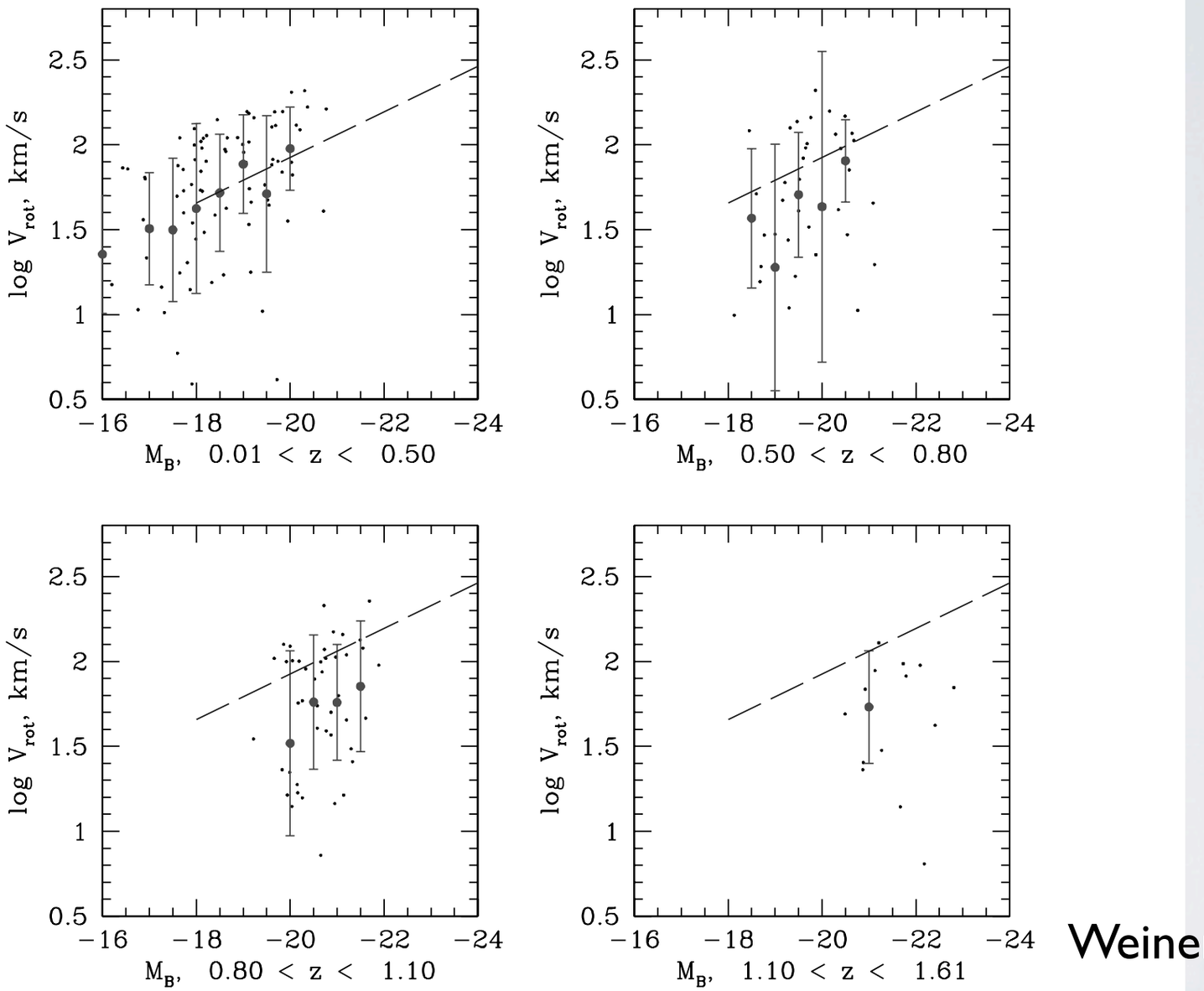
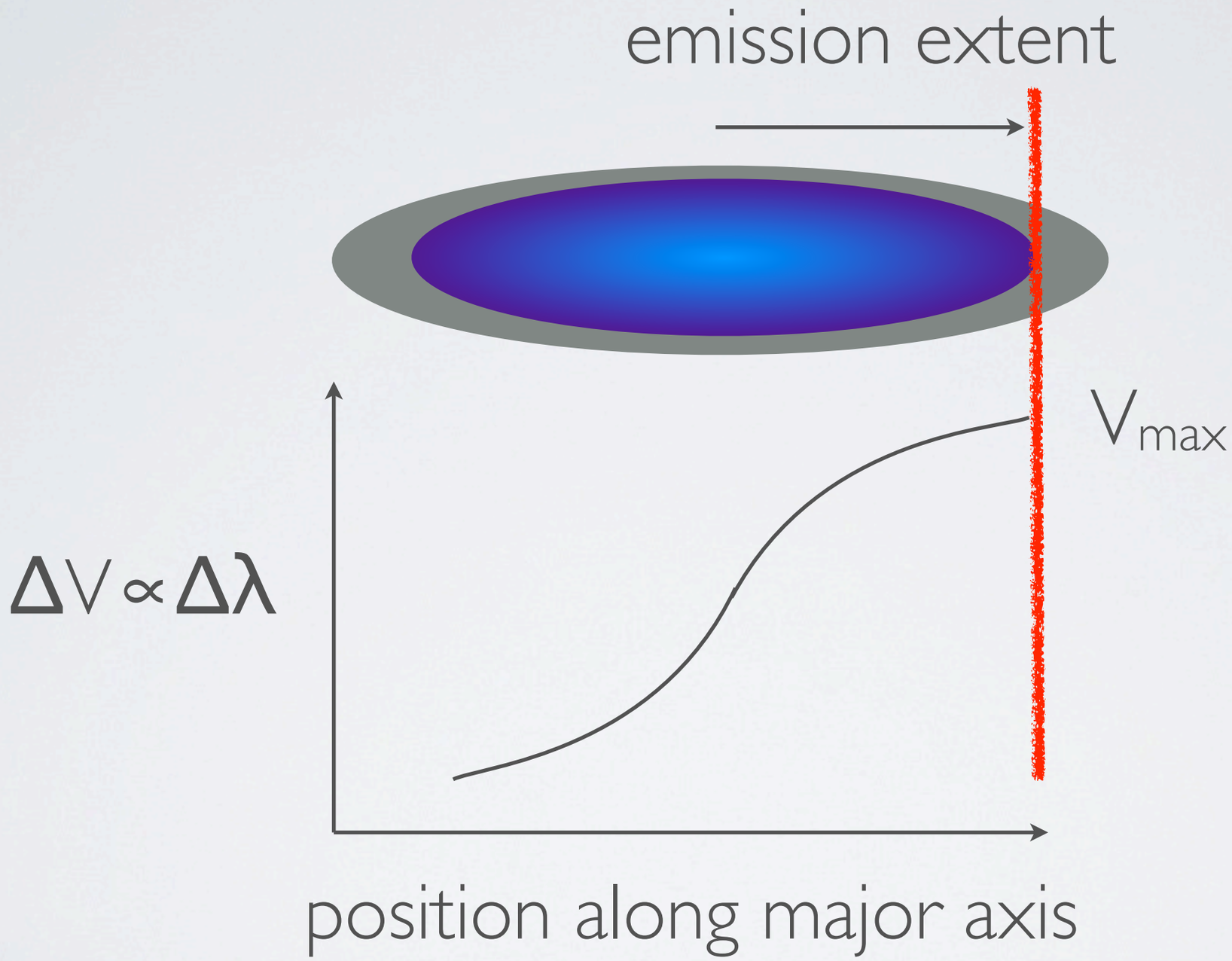


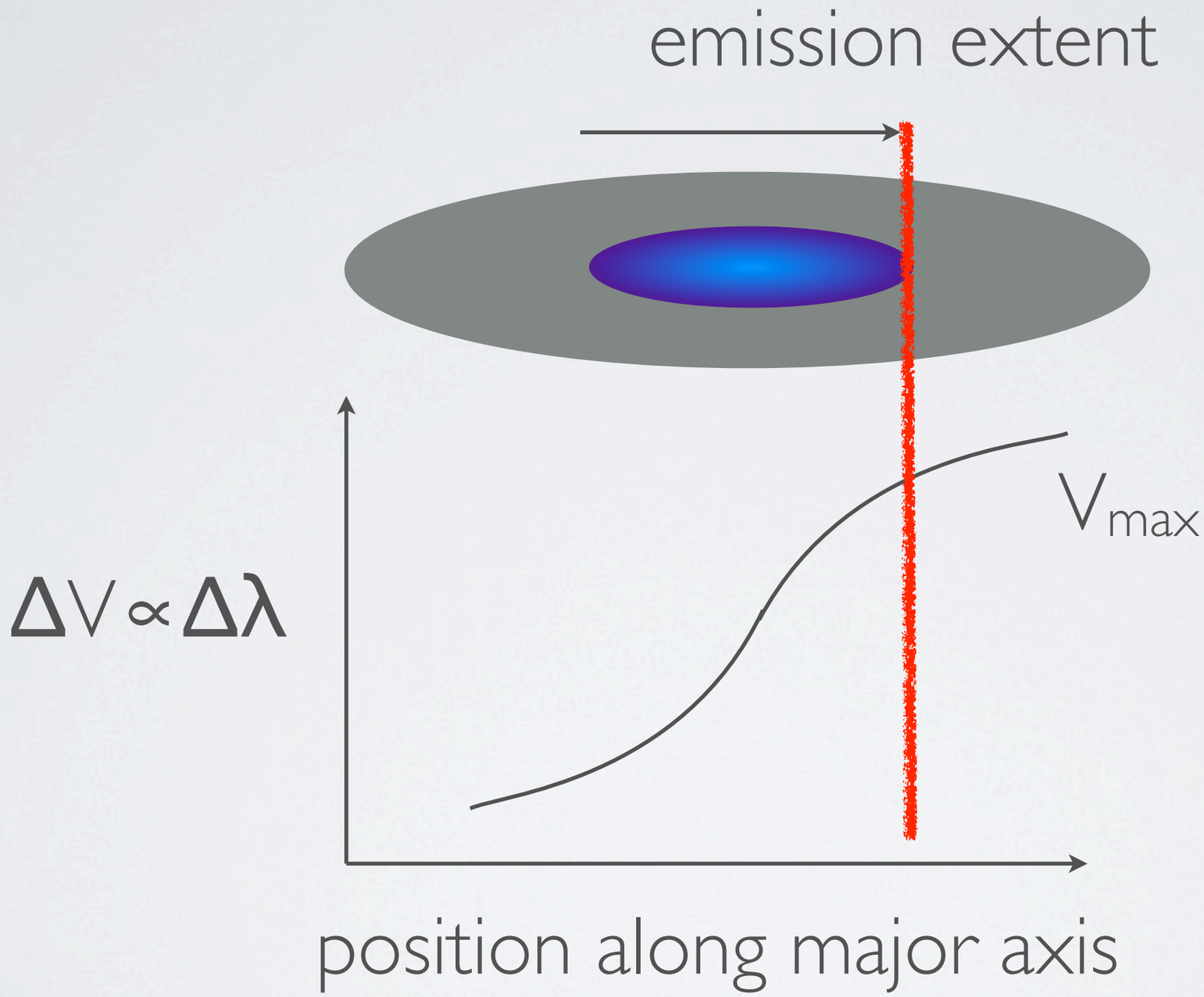
Weiner et al. 2006

ROTATIONAL VELOCITY

ROTATIONAL VELOCITY

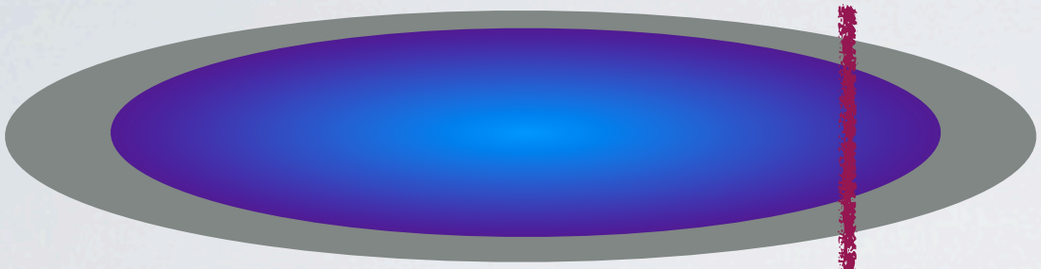


ROTATIONAL VELOCITY

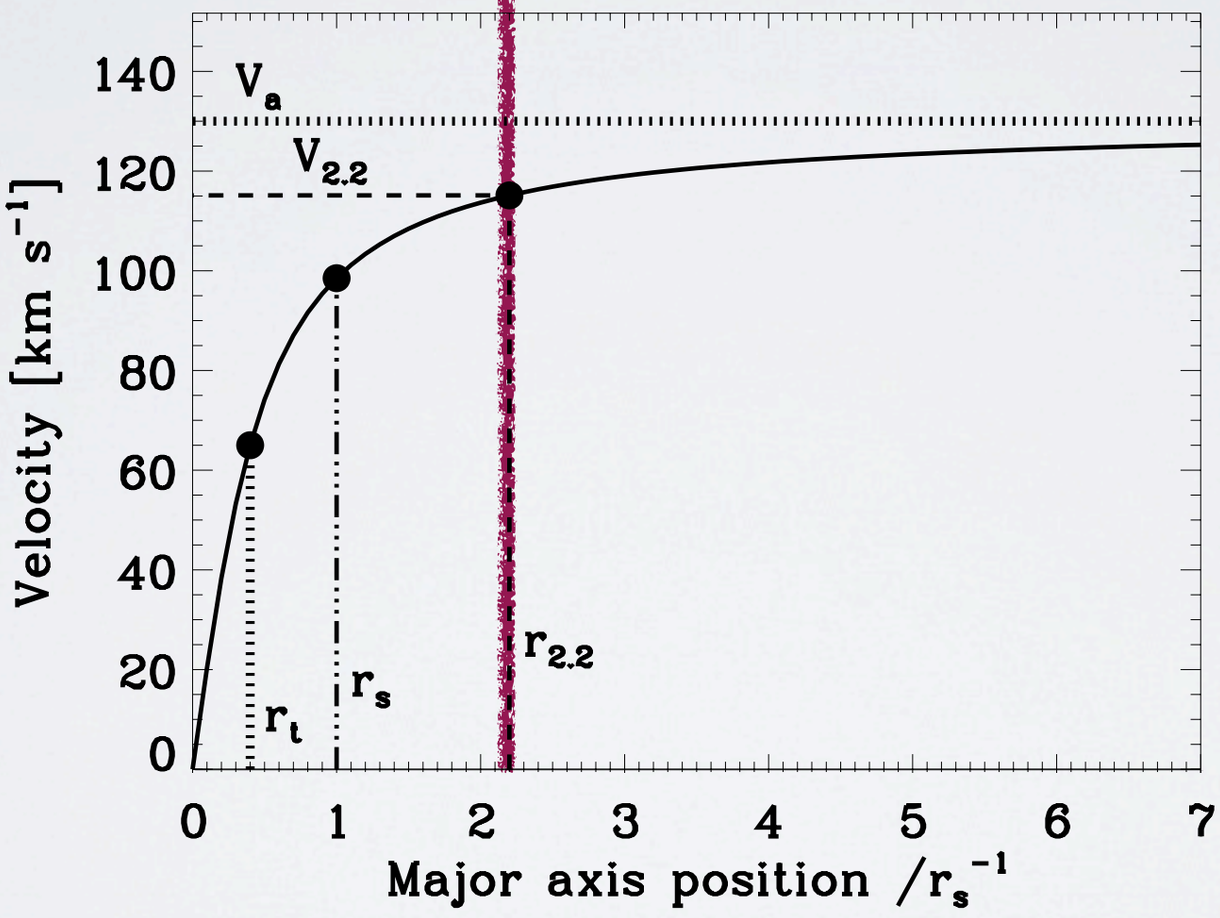


RADIAL VELOCITY

emission extent



$$V = V_0 + \frac{2}{\pi} V_a \arctan\left(\frac{r - r_0}{r_t}\right),$$



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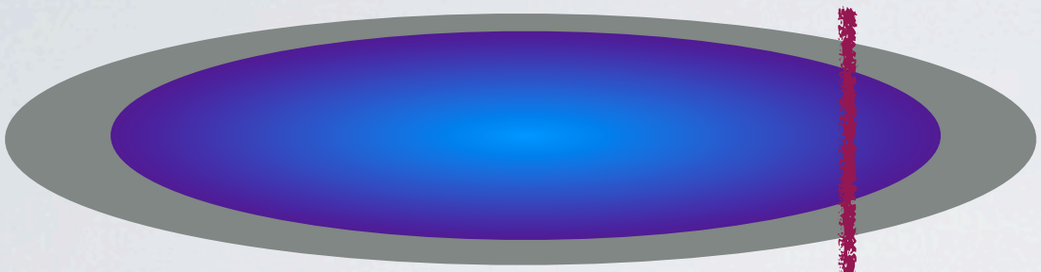
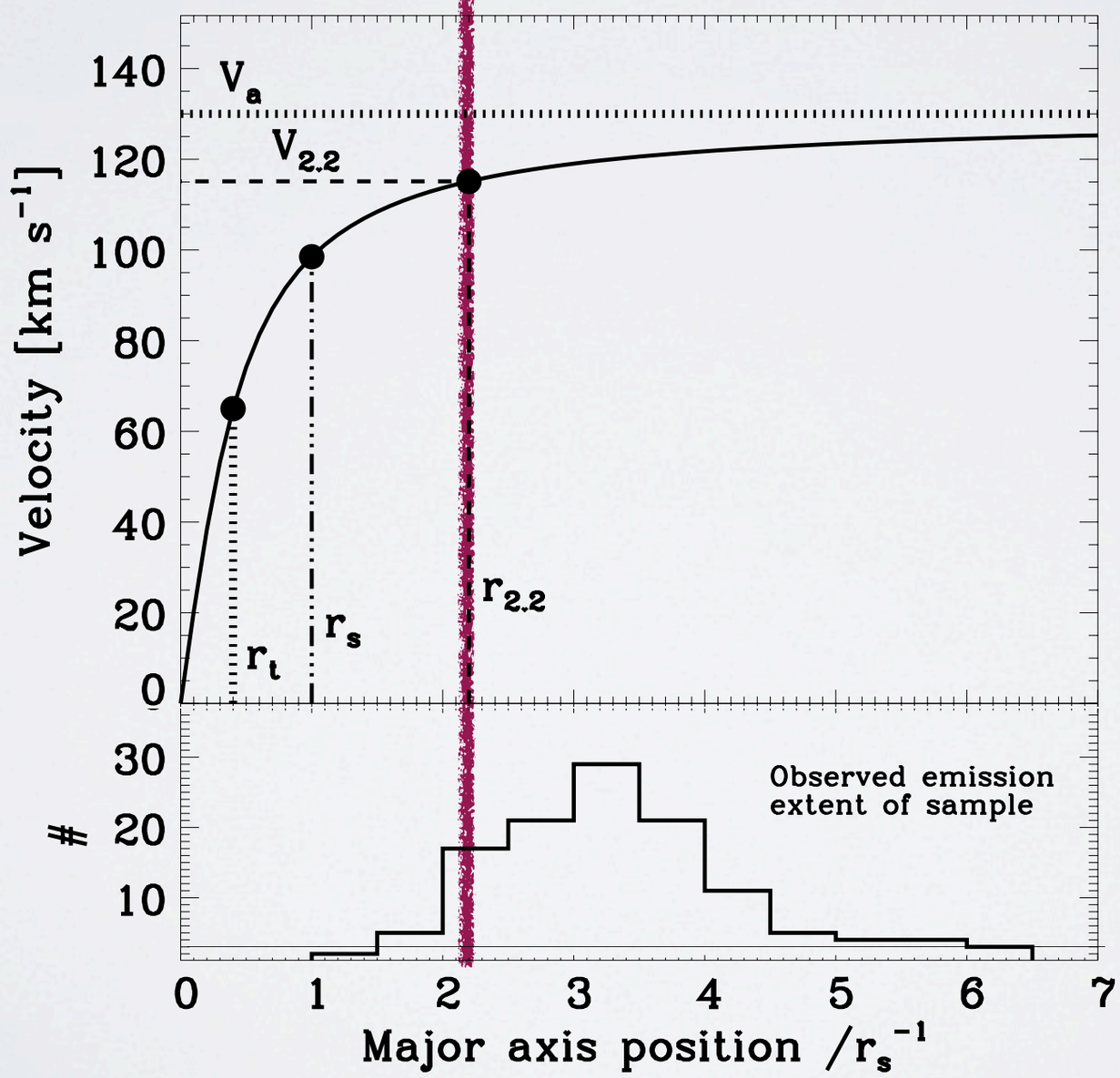


trace to $2.2r_s$ ($r_{2.2}$) on ~ 90% of our disks with extended emission!



THIS STUDY

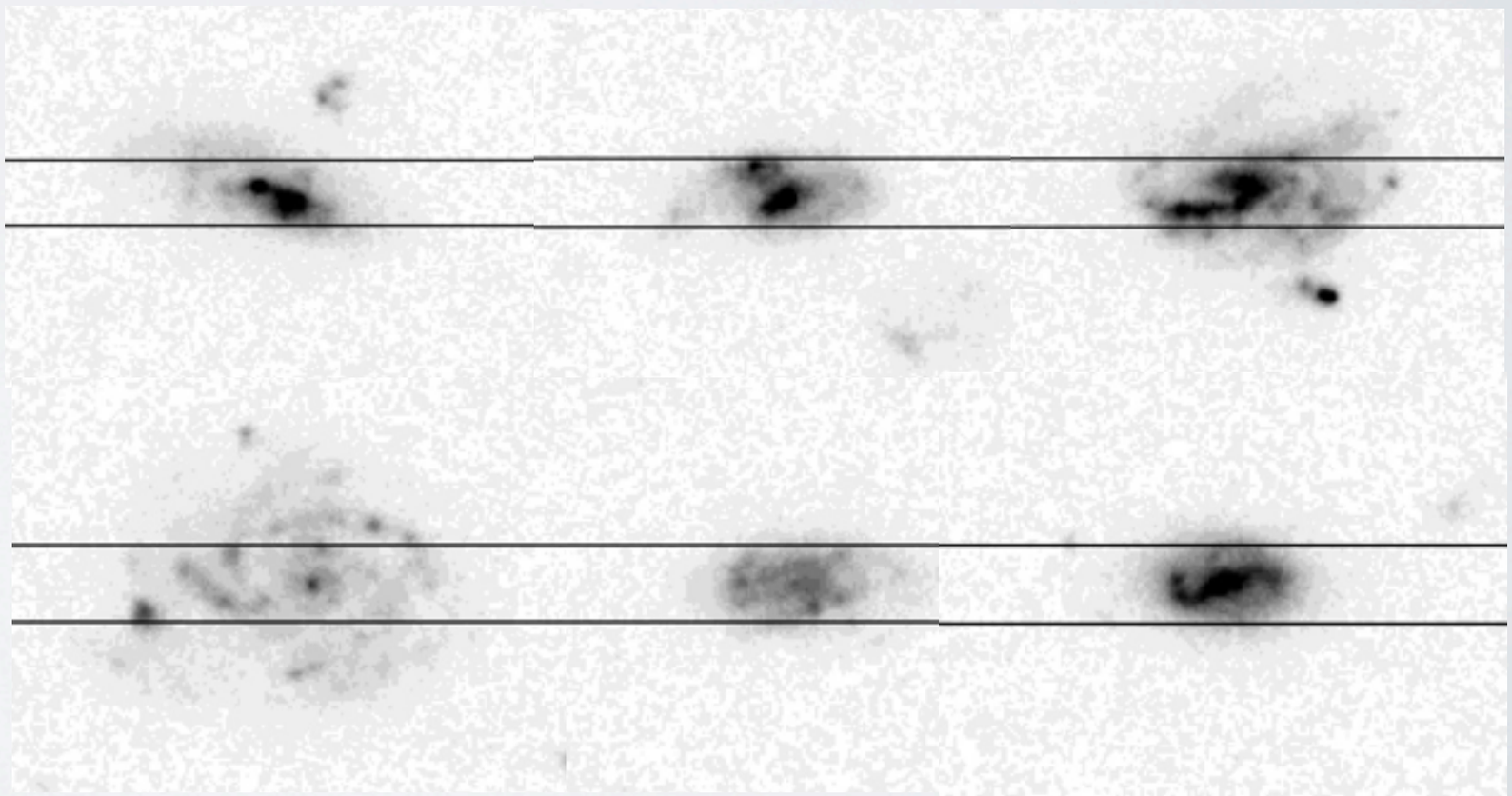
- 236 disks, including irregular and disturbed

- $0.2 < z < 1.3$

- $m_K < 22.3$, $M_* \sim 10^{8.5\text{-}11.5}\ M_\odot$

- GOODS fields- HST ACS B,V, i, z and ground-based K_s

- Keck II DEIMOS multi-slit spectra **6-8 hr integrations**



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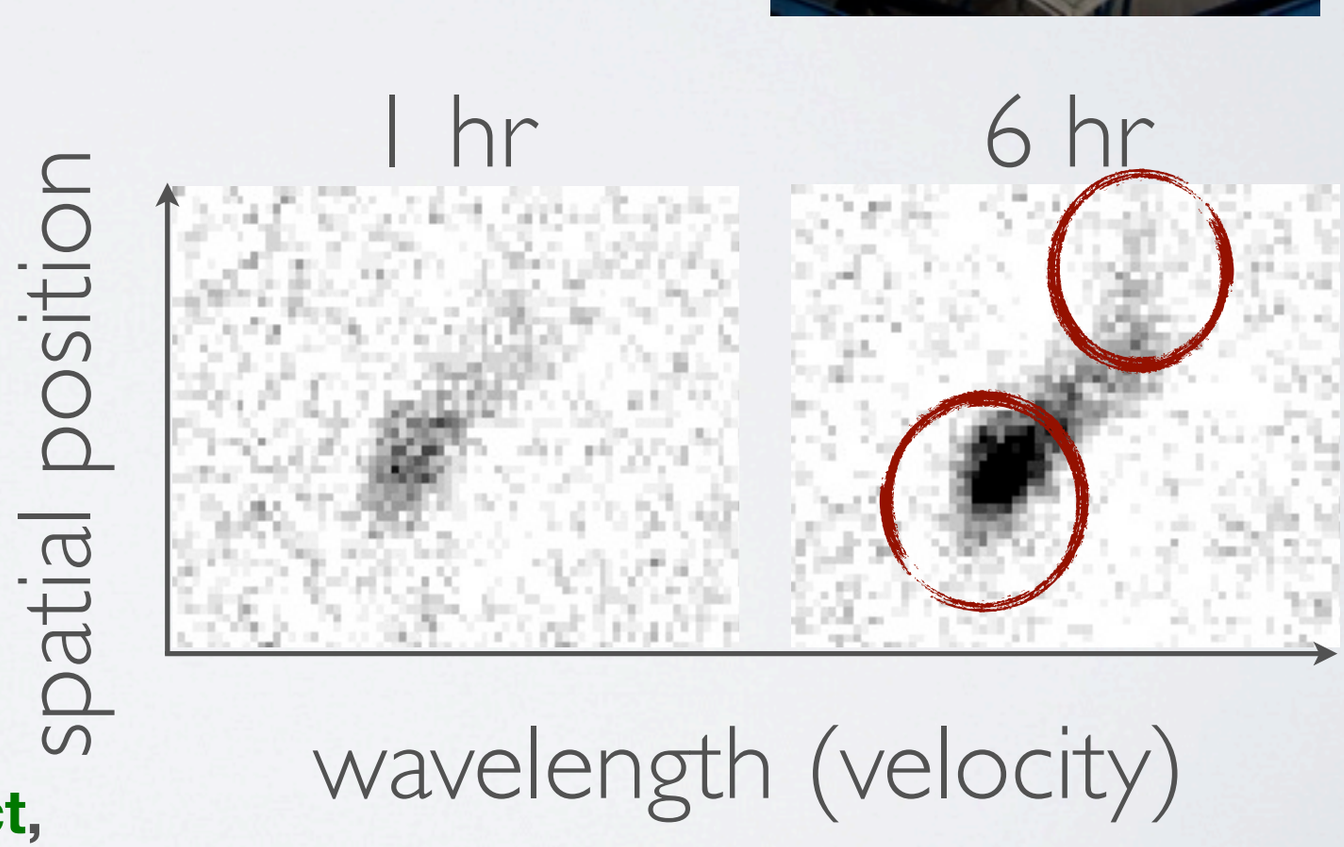
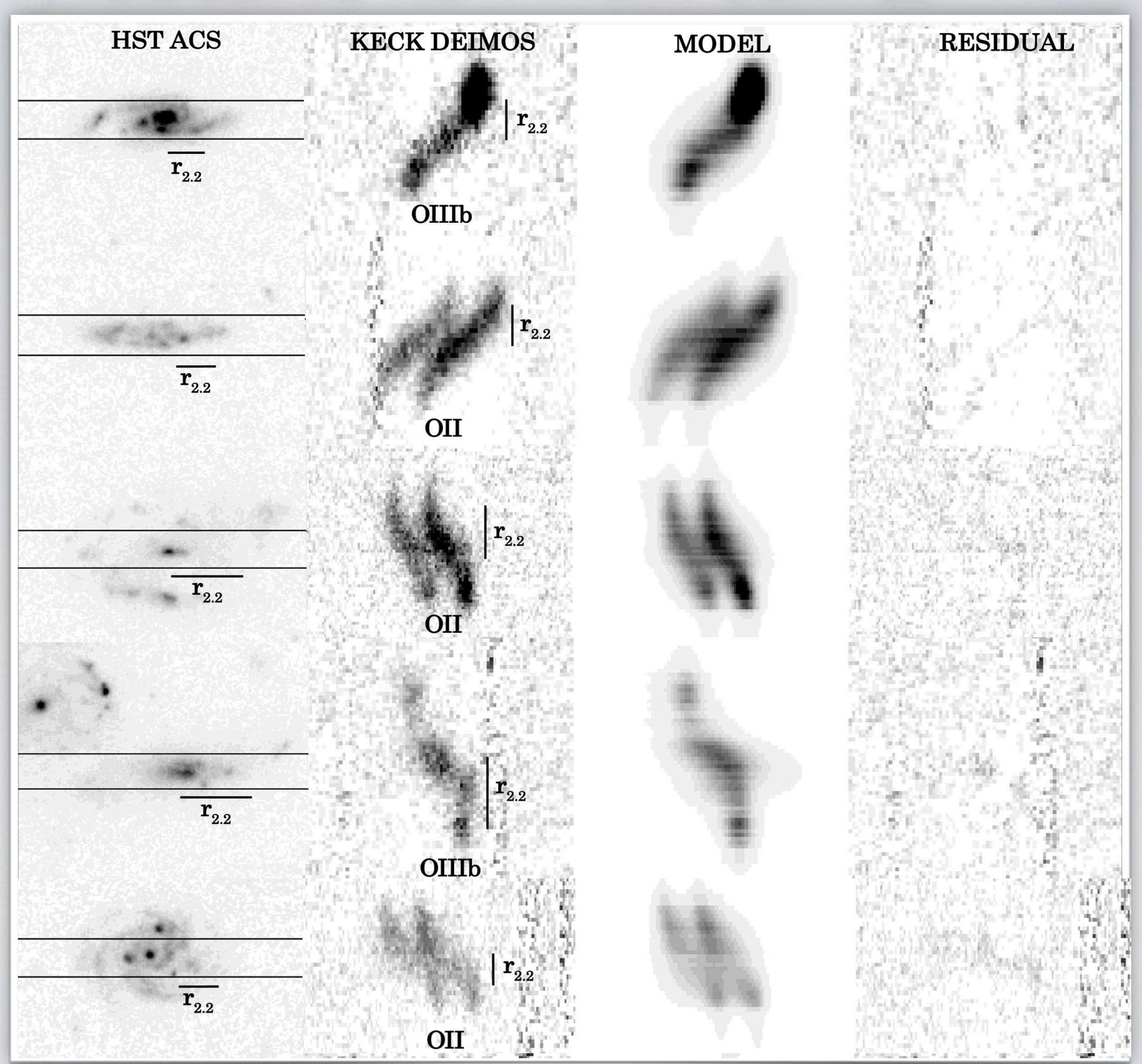
- GOODS fields- HST ACS B,V, i, z and ground-based K_s

- Keck II DEIMOS multi-slit spectra **6-8 hr integrations**

- **49 passive, 59 emission compact, 129 extended emission**



MODELING ROTATION CURVES



DISK SIZE AND PROJECTION

- **disk scale length: $r_{2.2}$**

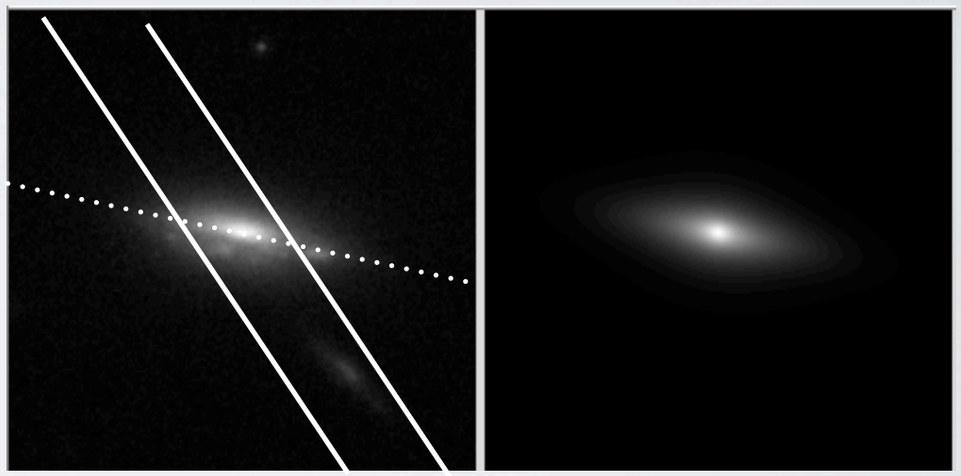
  Fit exponential disk
  (and BULGE when necessary)

- **inclination**

$$V_{corr} = \frac{V_{obs}}{(\sin i)} \qquad i = \cos^{-1}\sqrt{\frac{(b/a)^2 - q_0^2}{1 - q_0^2}}$$

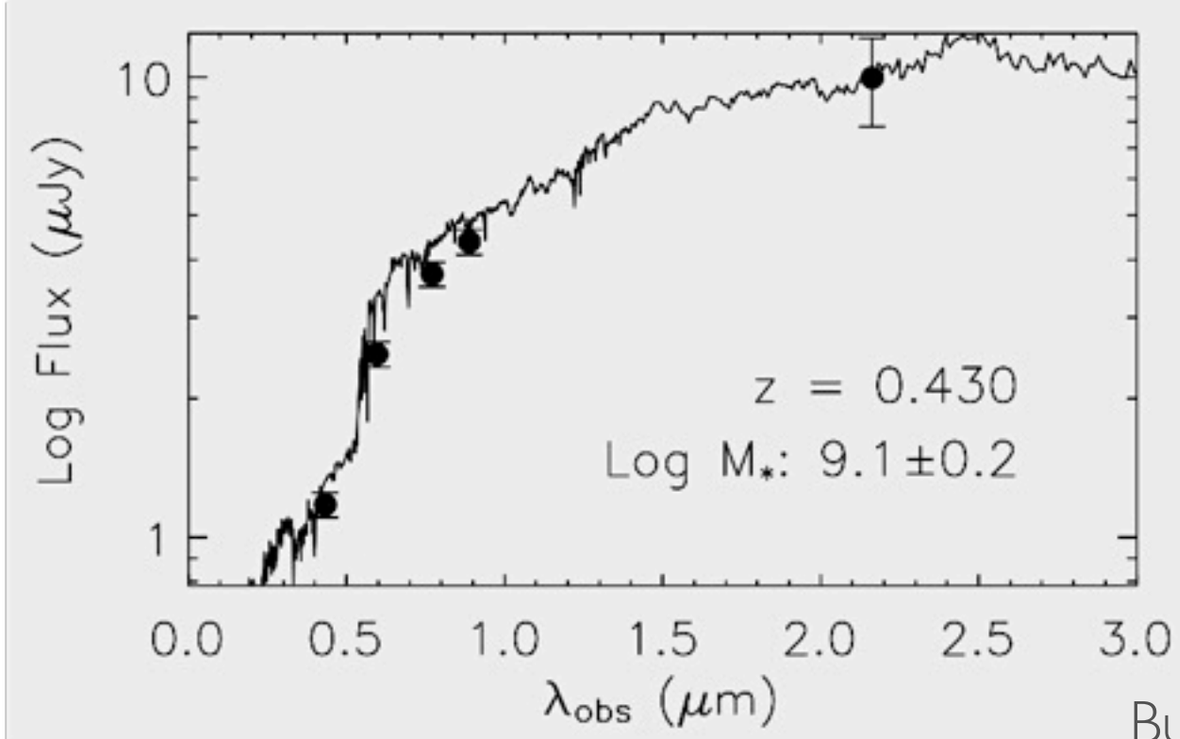
- **position angle offset between slit and major axis**

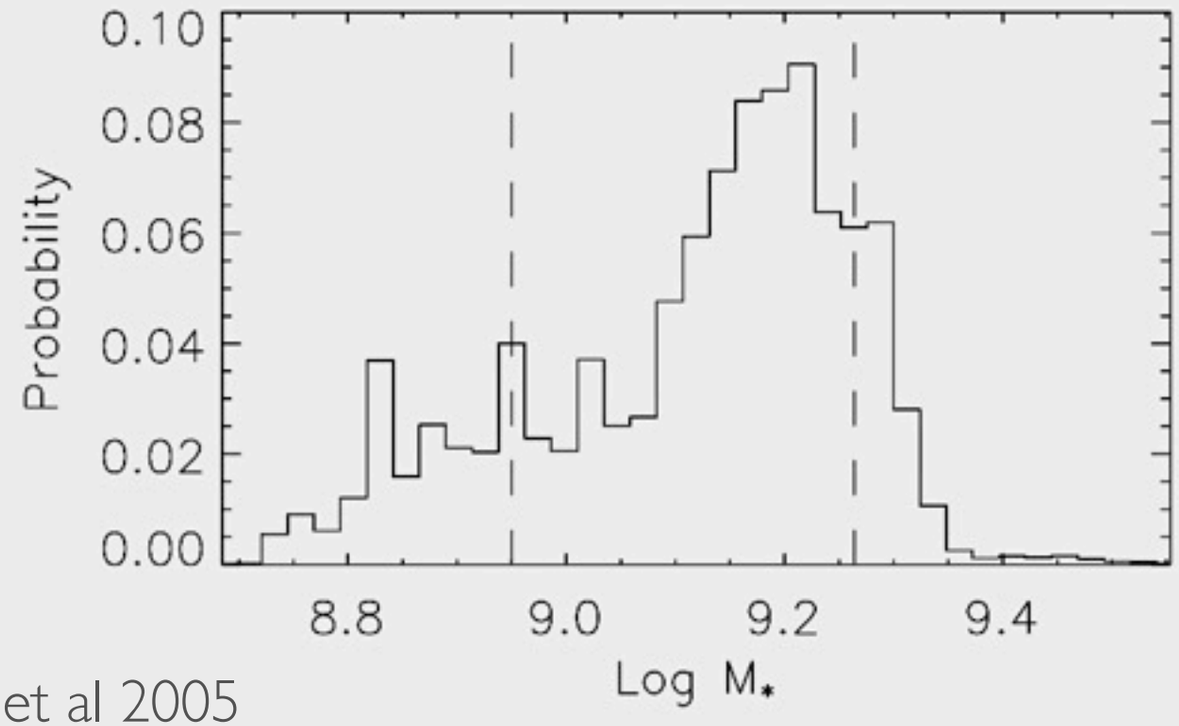
$$V_{corr} = \frac{V_{obs}}{\cos(\Delta PA)}$$



GALFIT
Peng et al. 2010

ABSOLUTE MAGNITUDE ⟶ STELLAR MASS

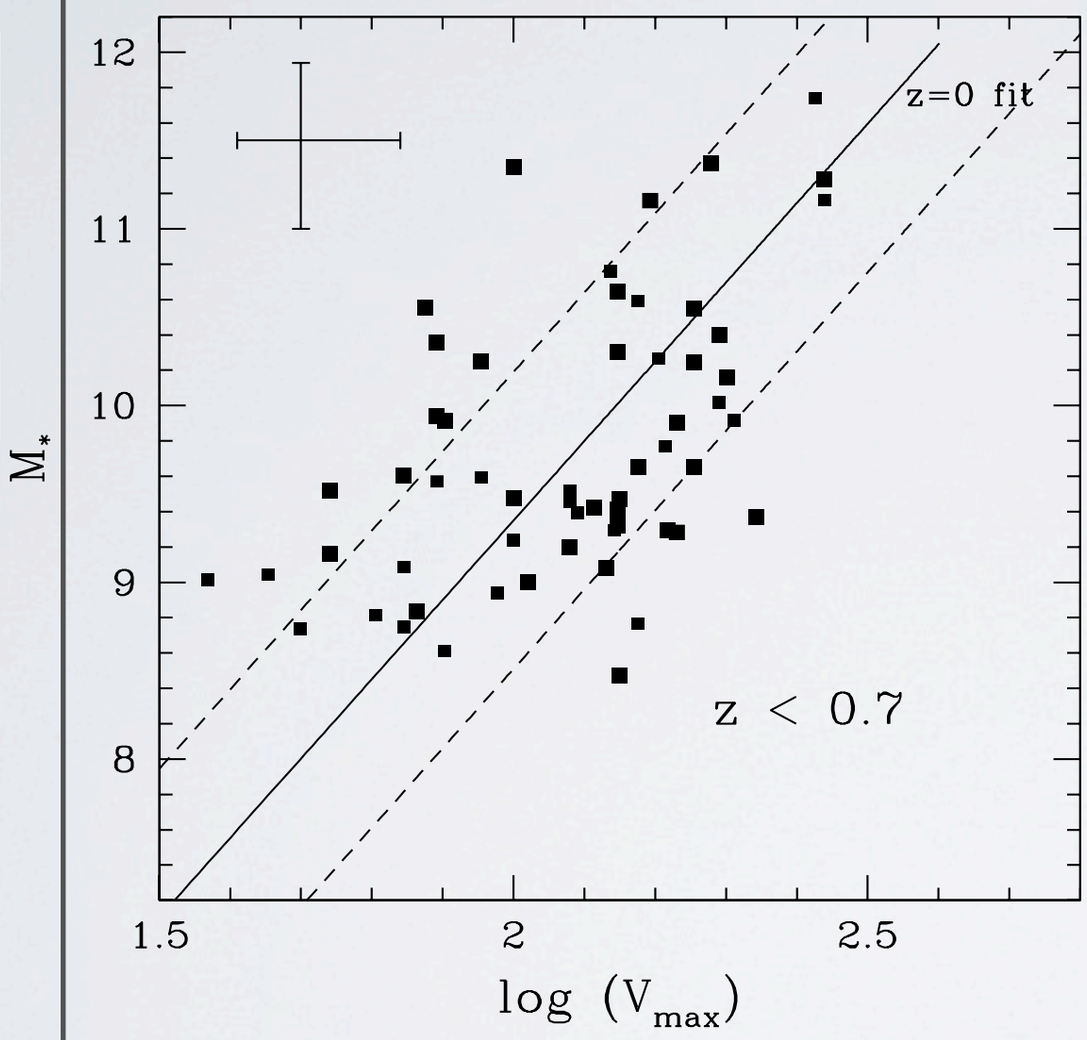


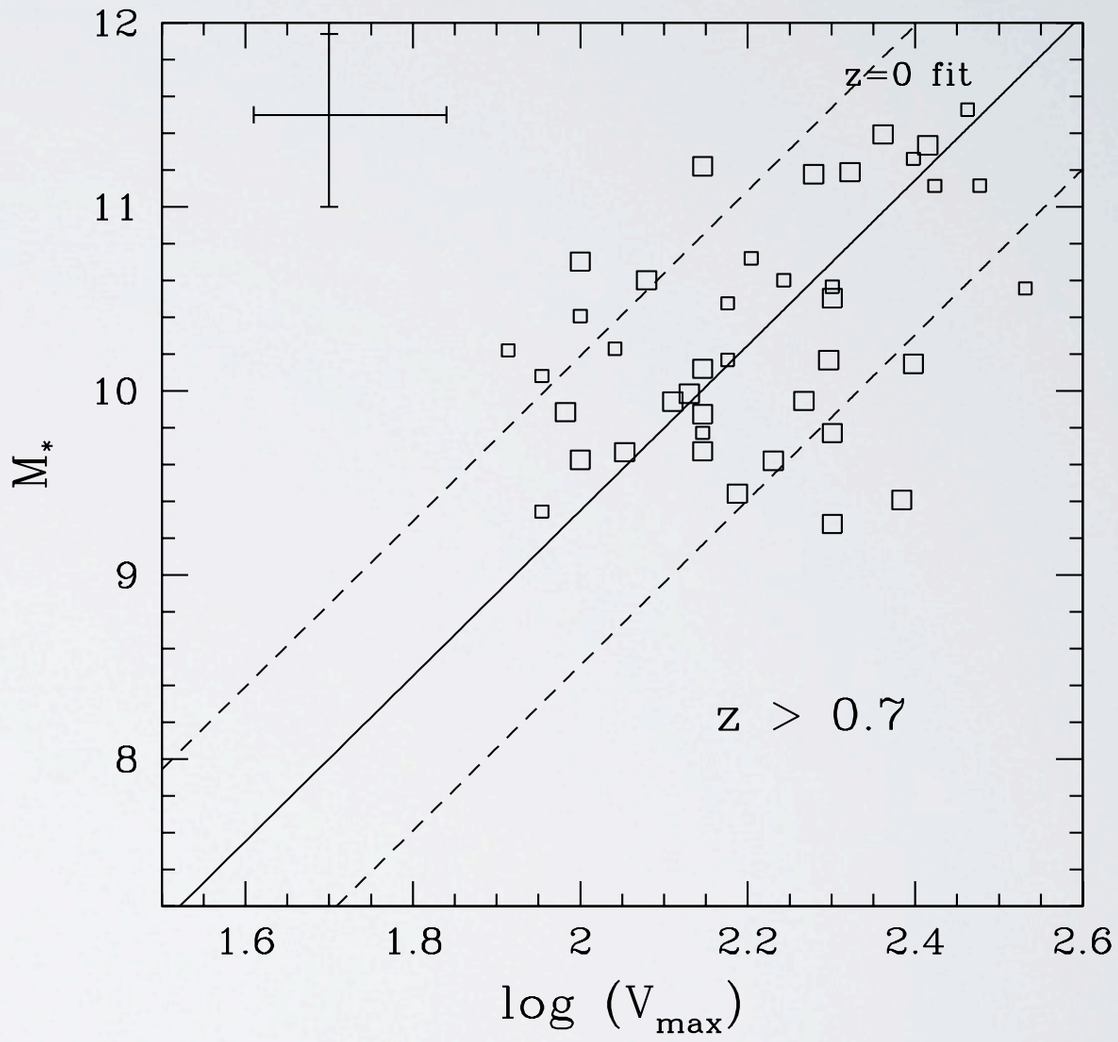


Bundy et al 2005

USING THE TULLY-FISHER RELATION TO CONSTRAIN OUR UNDERSTANDING OF DISK EVOLUTION

Stellar Mass





Conselice et al. 2005

ROTATIONAL VELOCITY

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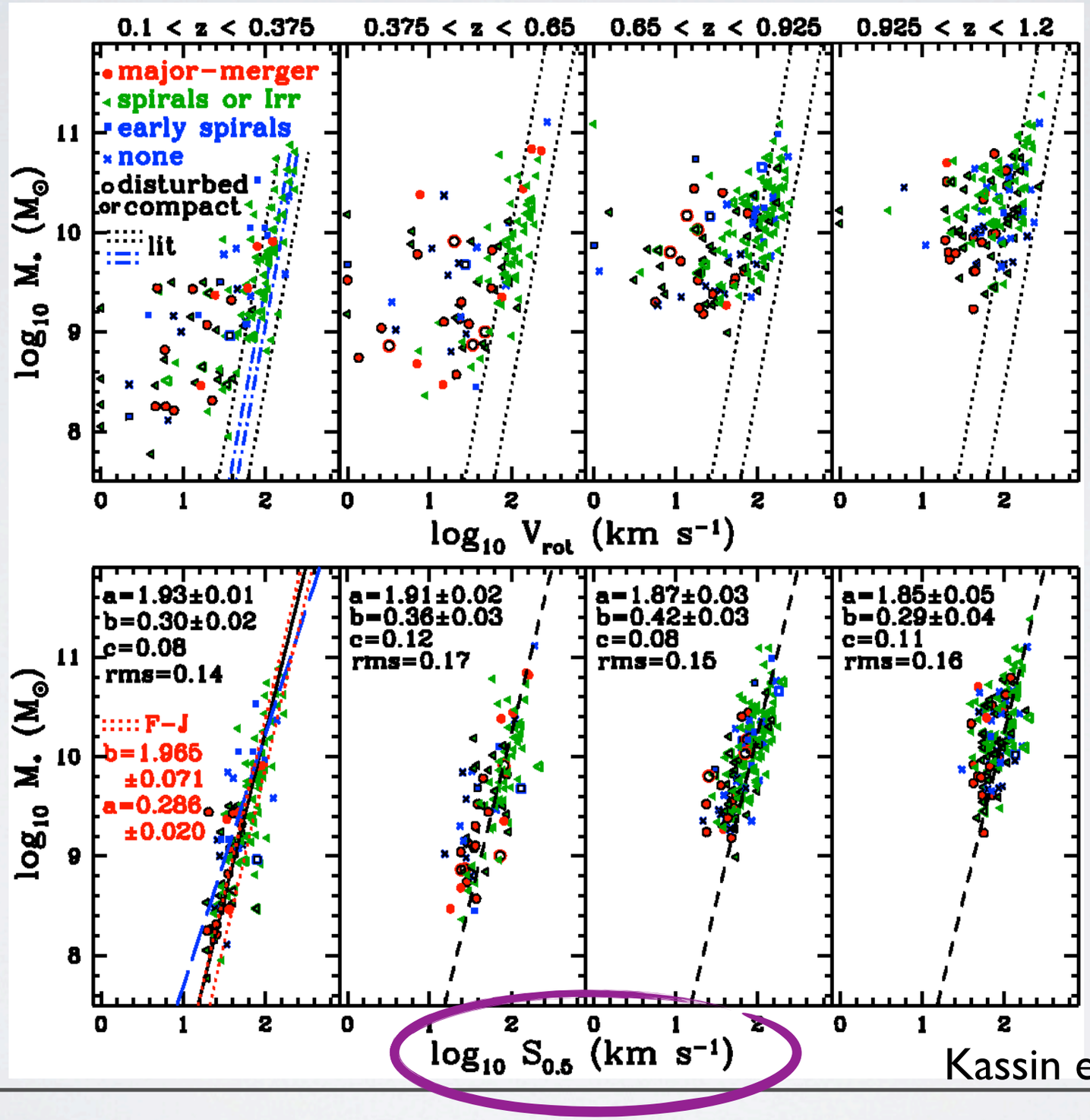
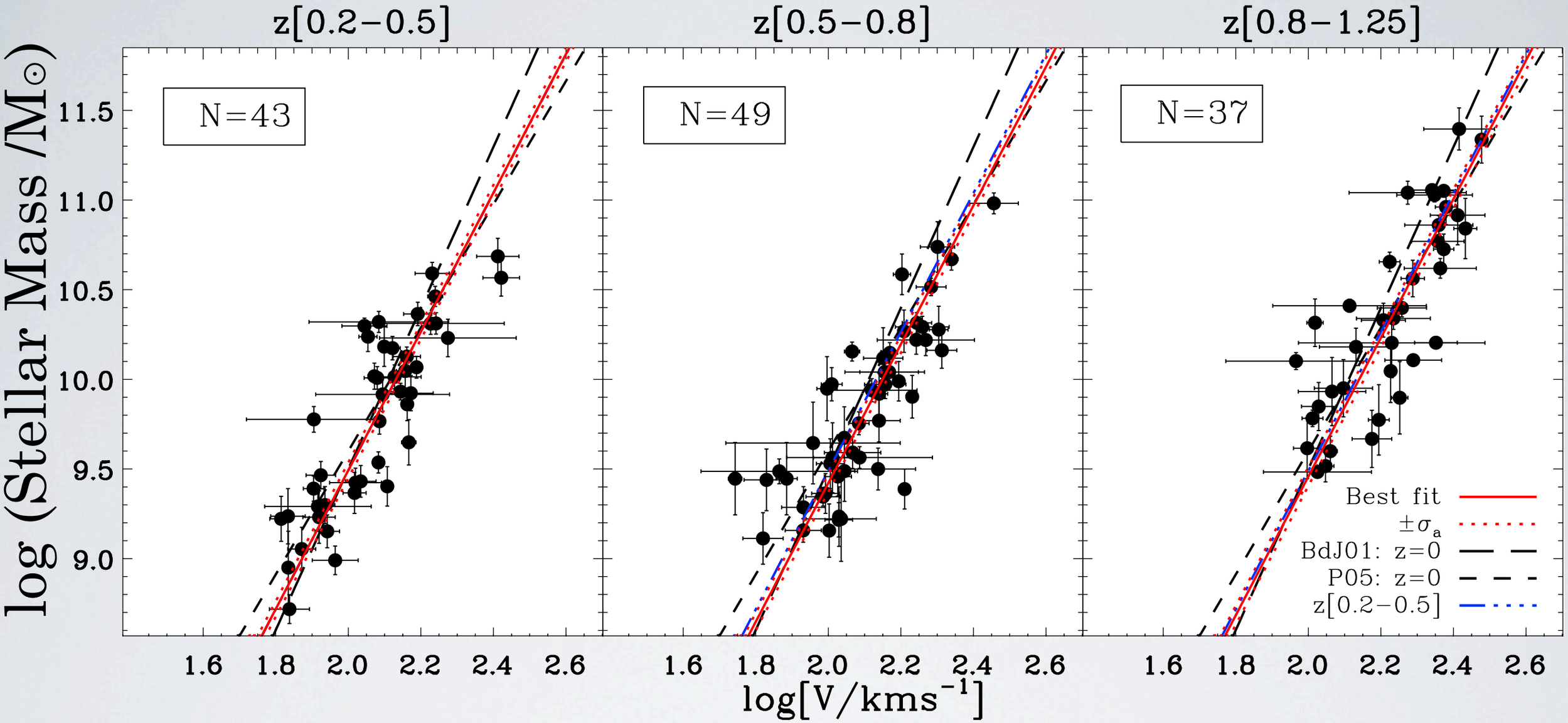


Kassin et al. 2007

~~ROTATIONAL VELOCITY~~ $\sqrt{(0.5V^2 + \sigma^2)}$

Miller et al. (submitted to ApJ)

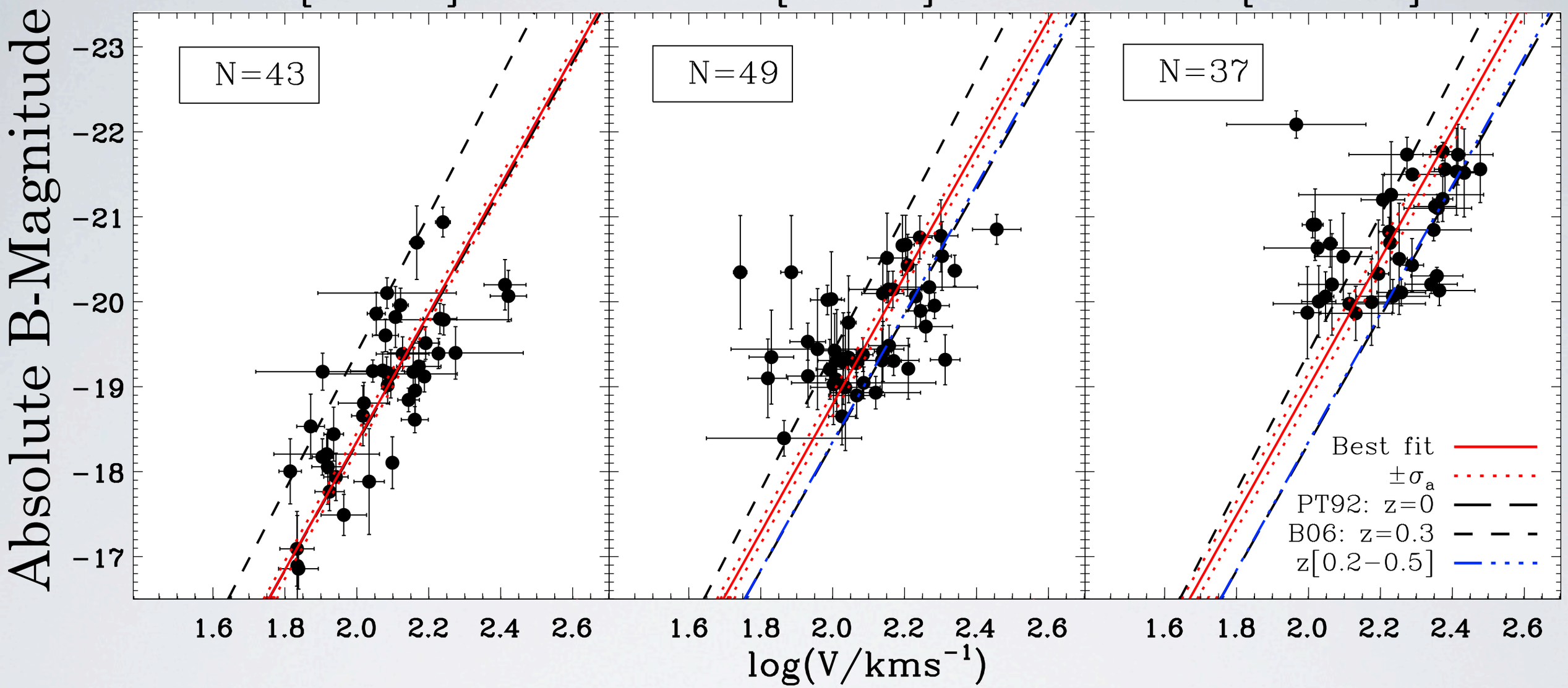


σ_{int} ~ 0.05 dex in V/km s^{-1}
~ 0.2 dex in M/M⊙

ΔM_* ~ 0.04 ± 0.07 dex
from ⟨z⟩~1 to ⟨z⟩~0.3

STELLAR MASS TULLY-FISHER RELATION WELL-ESTABLISHED AT z~1

Miller et al. (submitted to ApJ)



σ_{int} ~ 0.05-0.09 dex V/km s^{-1}
~ 0.4-0.7 mag

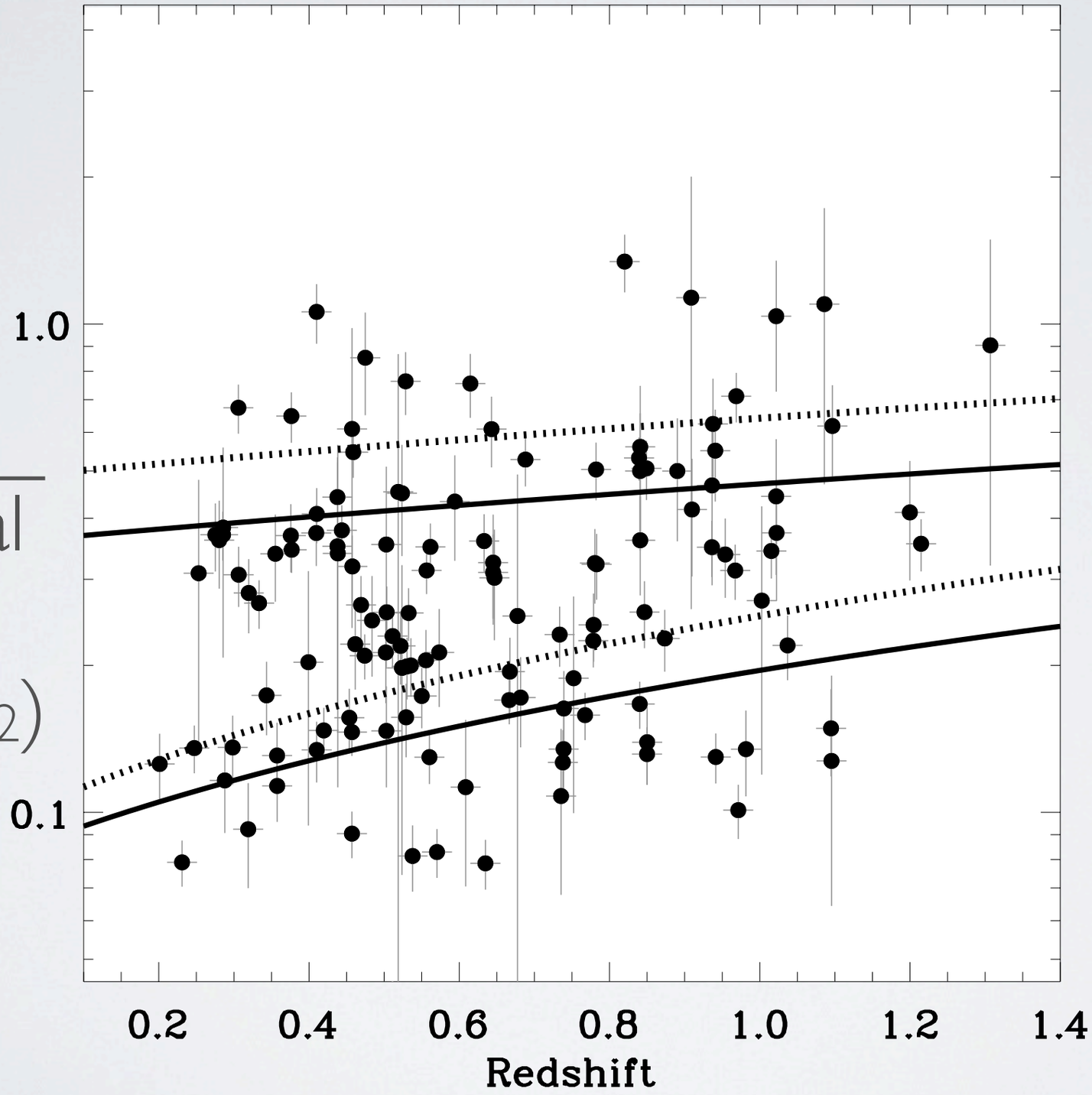
ΔM_B ~ 0.85 ± 0.28 dex
from $\langle z \rangle$~1 to $\langle z \rangle$~0.3

B-MAG TULLY-FISHER RELATION LESS FUNDAMENTAL AT z~1

LIGHT vs DARK

BARYONIC MATTER vs TOTAL MATTER

$$\frac{\text{Stellar Mass}}{\text{Dynamical Mass (within } r_{2.2})}$$

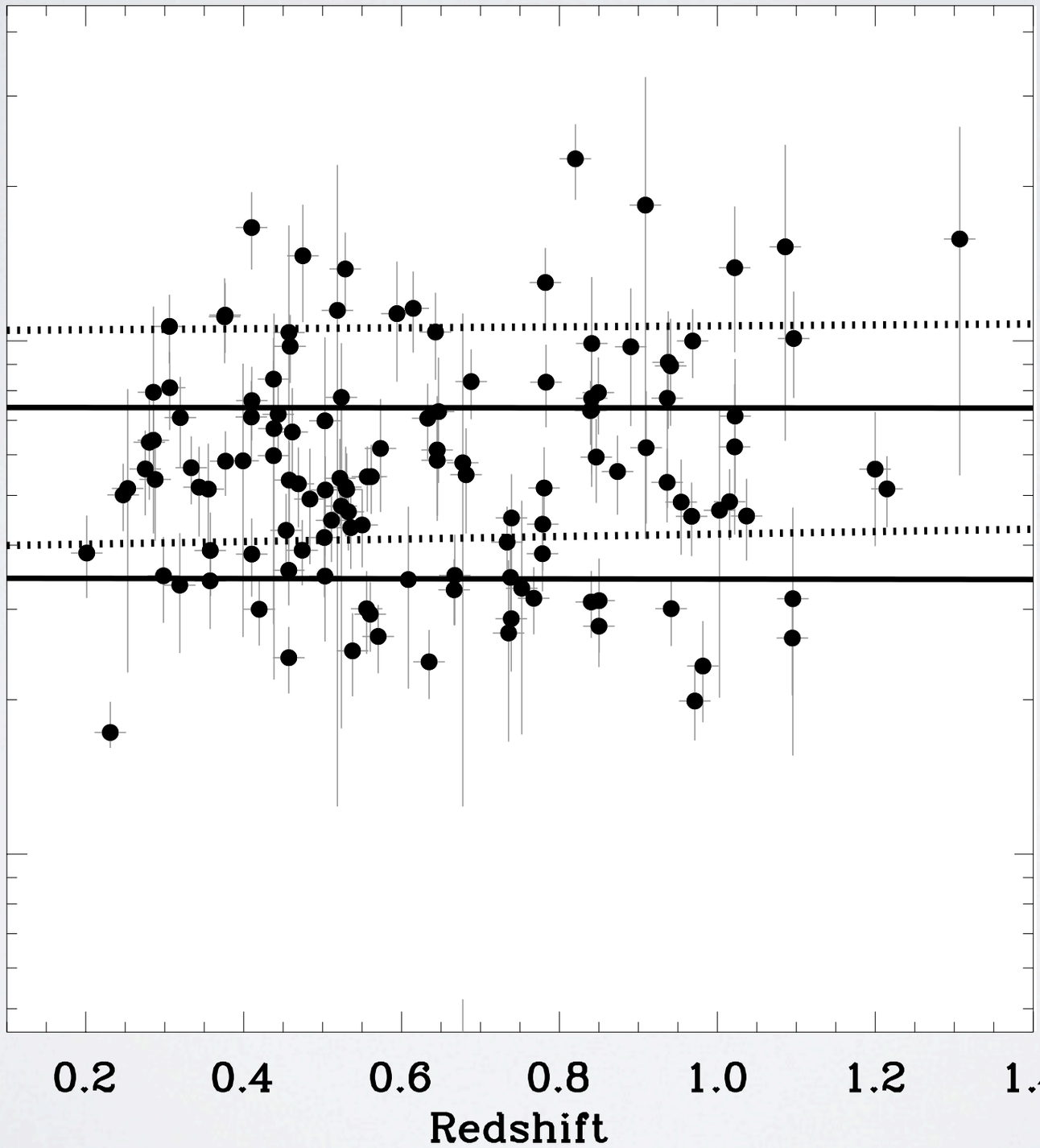


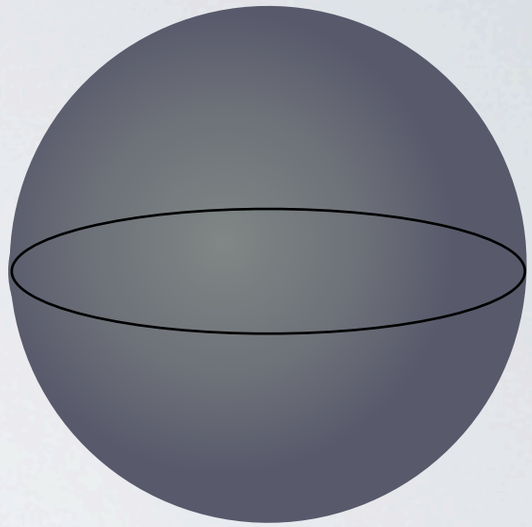
Miller et al. (submitted to ApJ)

LIGHT vs DARK

BARYONIC MATTER vs TOTAL MATTER

$$\frac{\textit{Estimated Baryonic Mass}}{\text{Dynamical Mass (within } r_{2.2})}$$





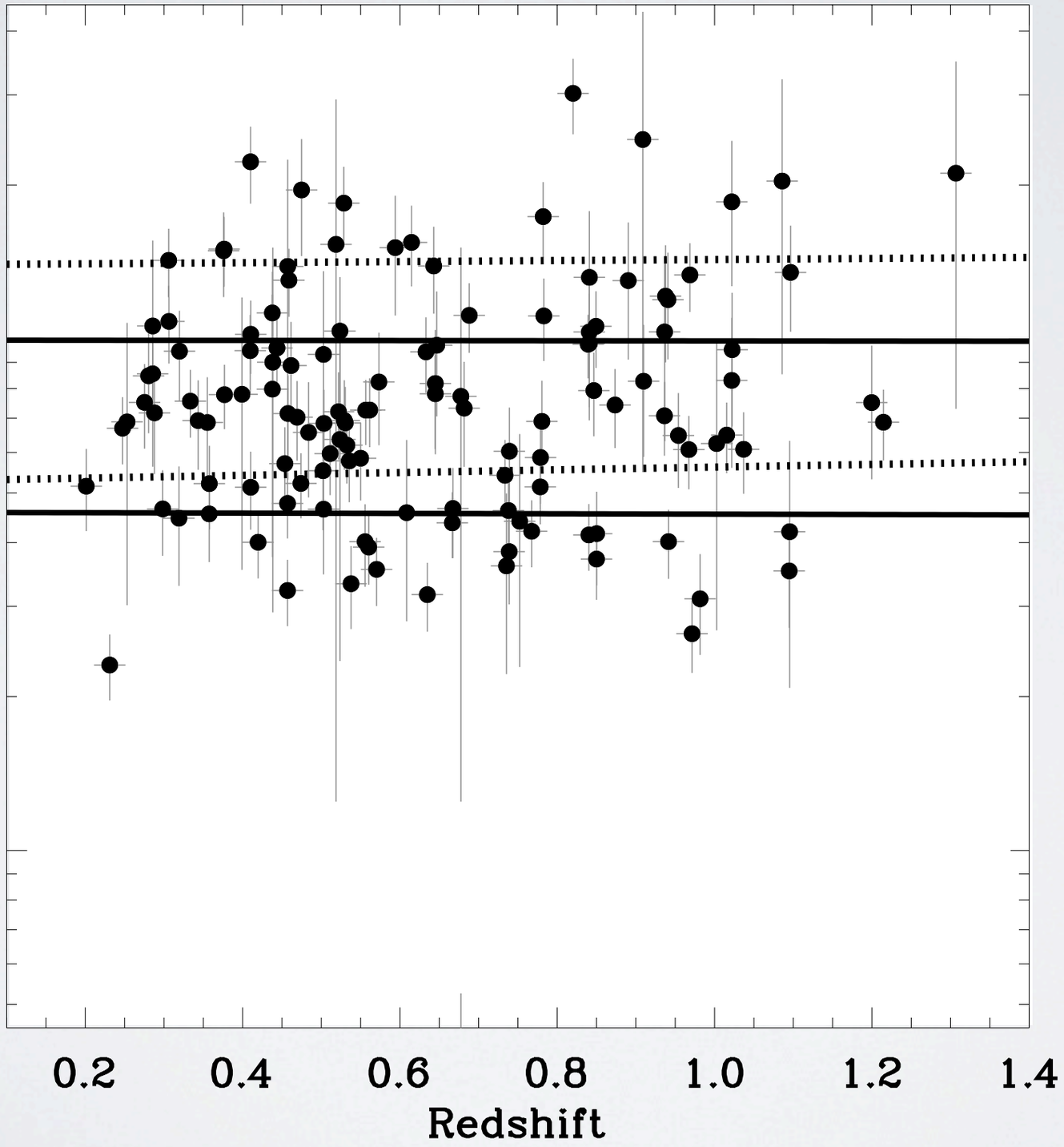
$$M_{2.2} \sim \frac{V^2_{2.2} R_{2.2}}{G}$$

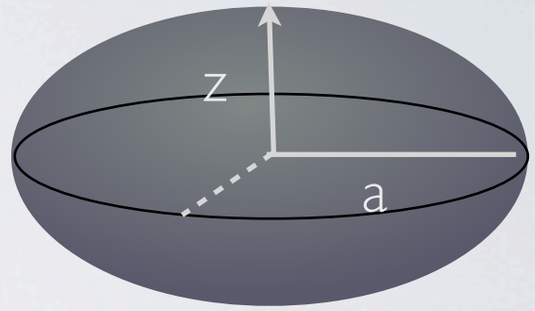
Miller et al. (submitted to ApJ)

LIGHT vs DARK

BARYONIC MATTER vs TOTAL MATTER

Estimated Baryonic Mass / Dynamical Mass (within $r_{2.2}$)



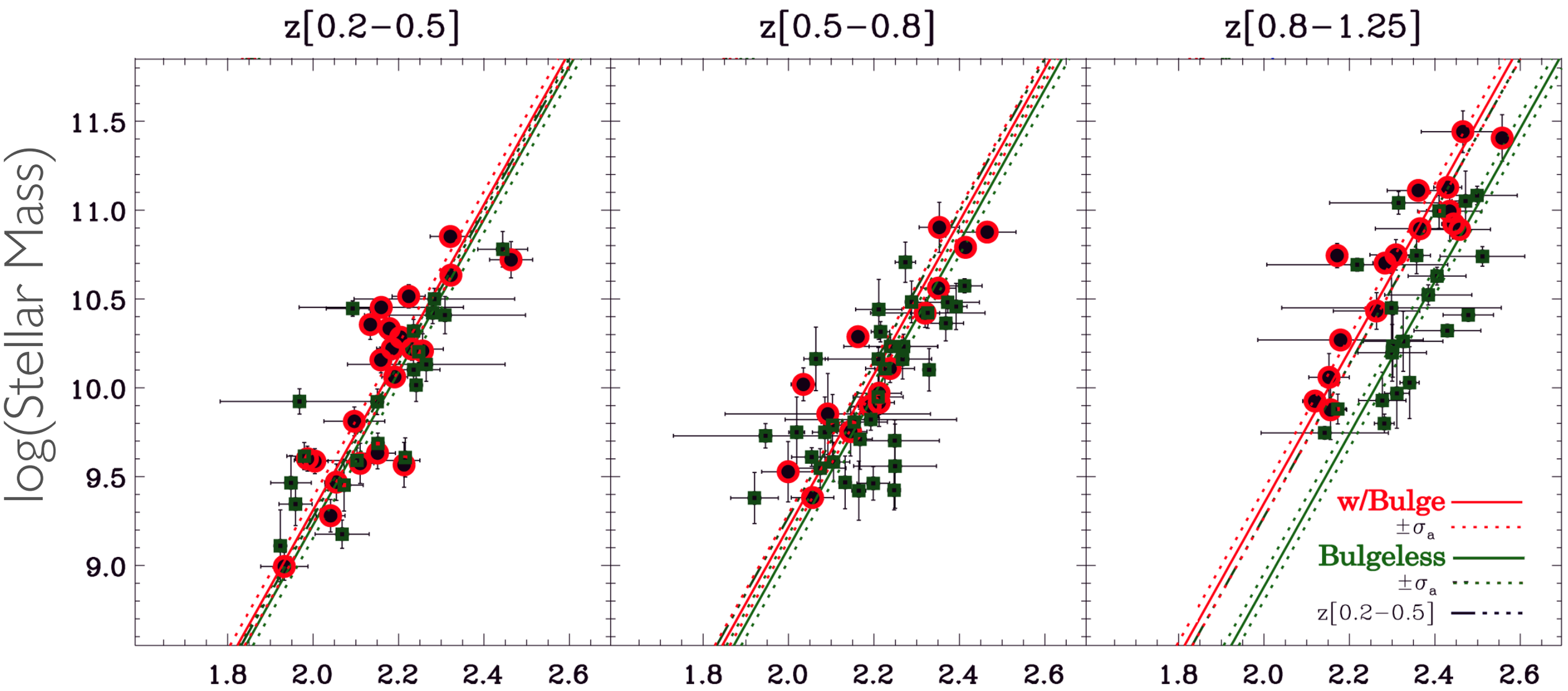


$q = z/a$

$M \sim f(q,\rho) \frac{V^2 R}{G}$

Miller et al. (submitted to ApJ)

EVOLUTION ***WITHIN*** THE TULLY-FISHER RELATION?



log V/(km/s)

Disks with a bulge ○

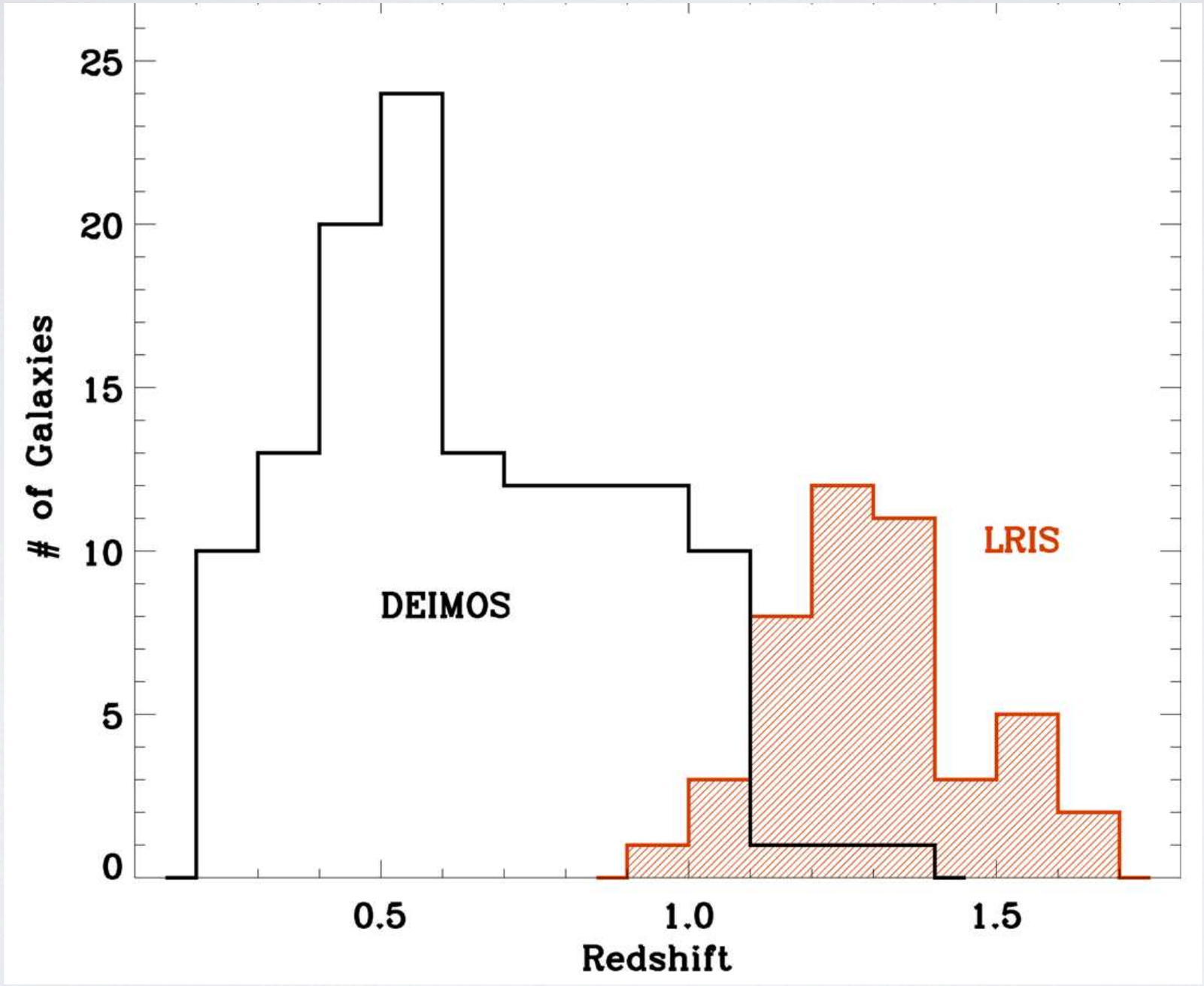
Disks without a bulge ■

Bulgeless disks offset in *stellar mass* or *velocity*?

Miller et al. (in prep)

PUSHING TO HIGHER REDSHIFT

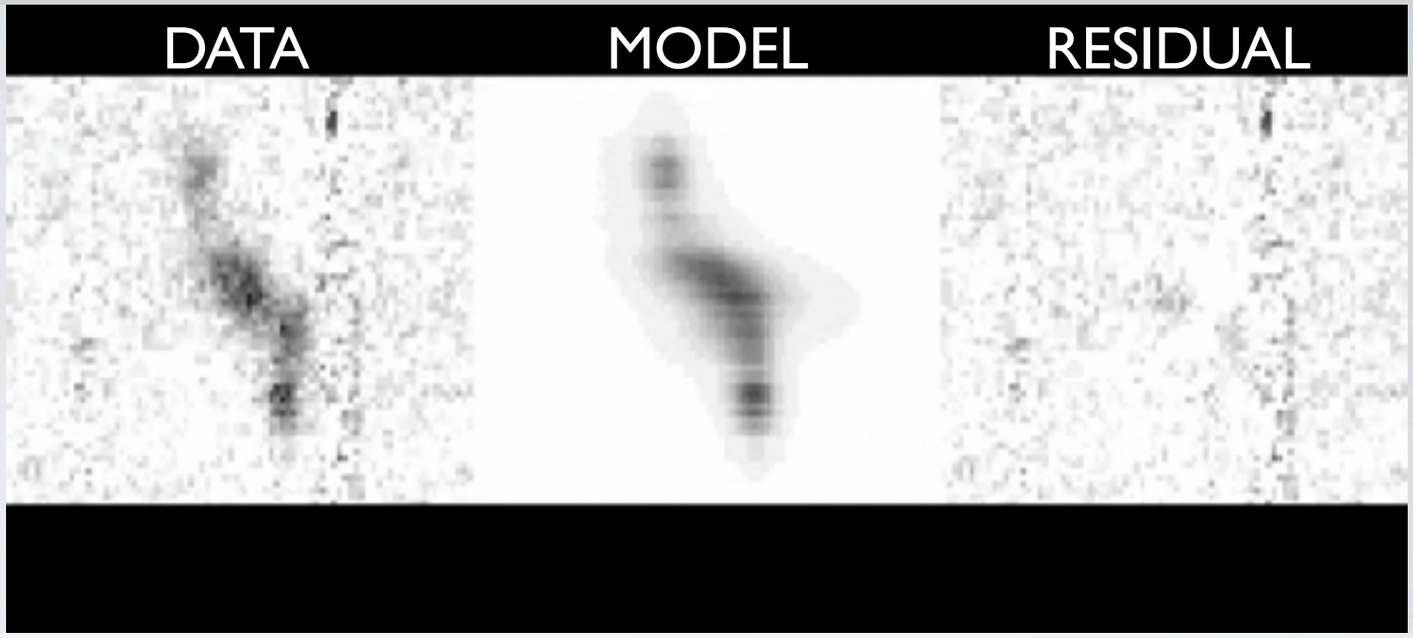
upgraded Keck I LRIS



Miller et al. (in prep)

SUMMARY

arXiv:1102.3911



- 129 new detailed rotation curves at z~1
- Tully-Fisher relation tightly in place at z~1
- No significant M_*-TF evolution: $\Delta M_* \sim 0.04 \pm 0.07$ dex from $\langle z \rangle \sim 1$ to $\langle z \rangle \sim 0.3$
  Some M_B-TF evolution: $\Delta M_B \sim 0.85 \pm 0.28$ mag from $\langle z \rangle \sim 1$ to $\langle z \rangle \sim 0.3$
- Baryons estimated to make up 50-100% of observable disk
- Bulgeless disks increasingly offset from the TF relation at high z?
  Pushing to higher redshift...

Sarah H. Miller