

# Mild velocity dispersion evolution of spheroid-like massive galaxies since $z \sim 2$

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*Cenarro & Trujillo, 2009, ApJ, 696, L43*

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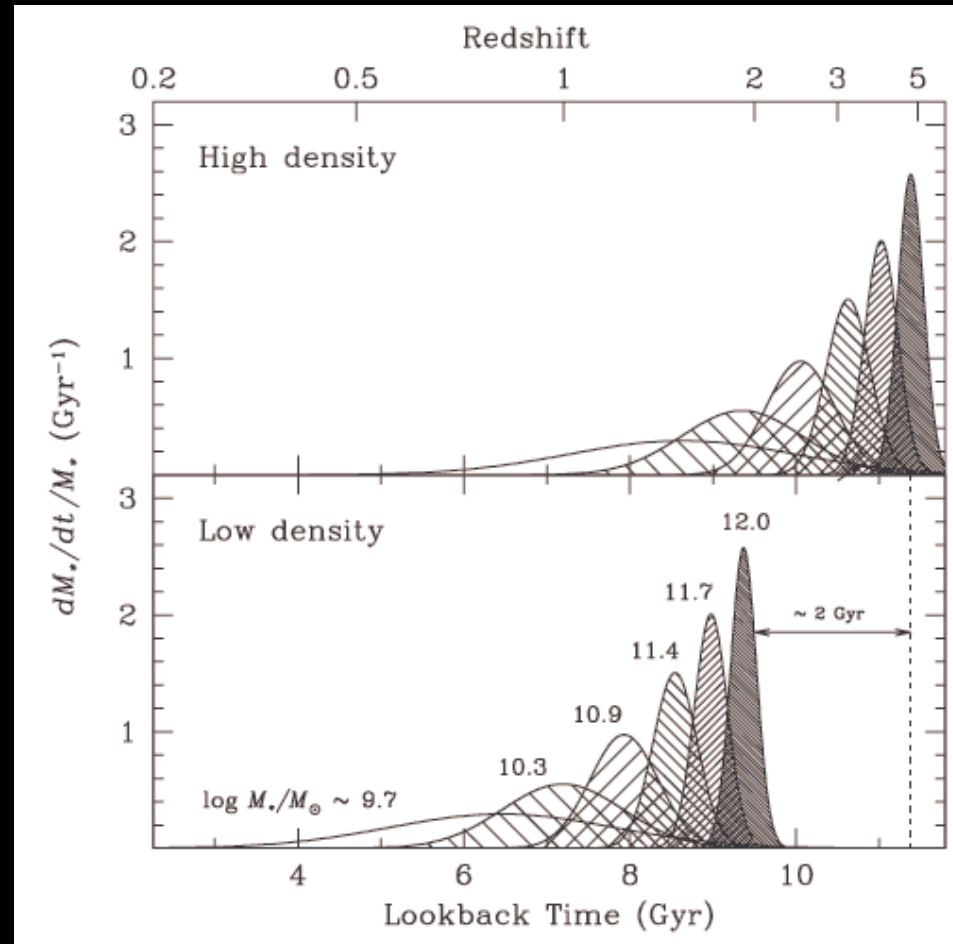


# Massive galaxies today



$M_* \geq 10^{11} M_{\text{sun}}$  galaxies:

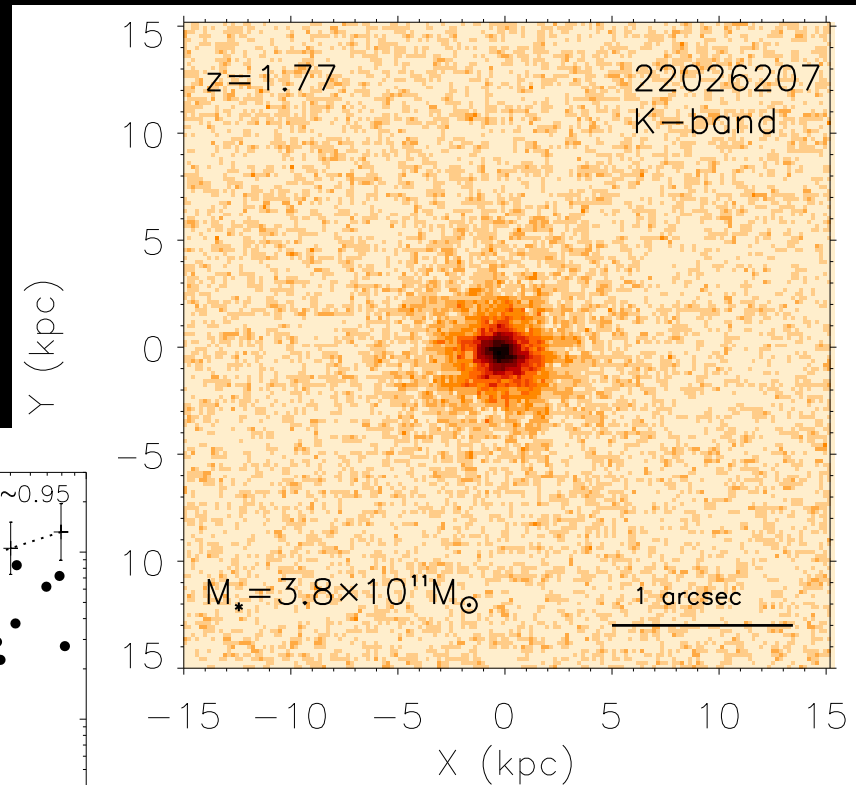
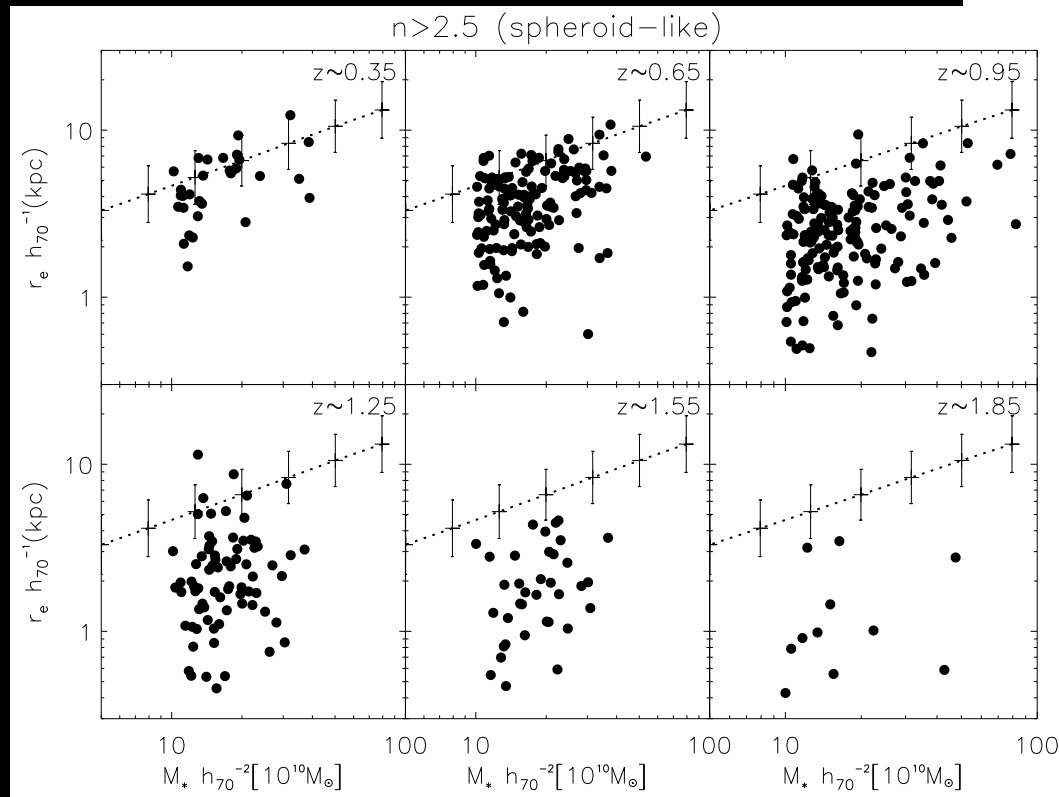
- **Morphological Type:** 75% early-type
- **Stellar populations:** old, metal rich, short formation time scale
- **Sizes:** big objects  $r_e \sim 5$  kpc



# Massive galaxies at $z \sim 1.8$

$M_* \geq 10^{11} M_{\text{sun}}$  galaxies:

- **Morphological Type:** mixed
- **Stellar populations:**  $\sim 1$  Gyr, metal rich?, short formation time scale?
- **Sizes:** compact objects  $r_e \sim 1.5$  kpc



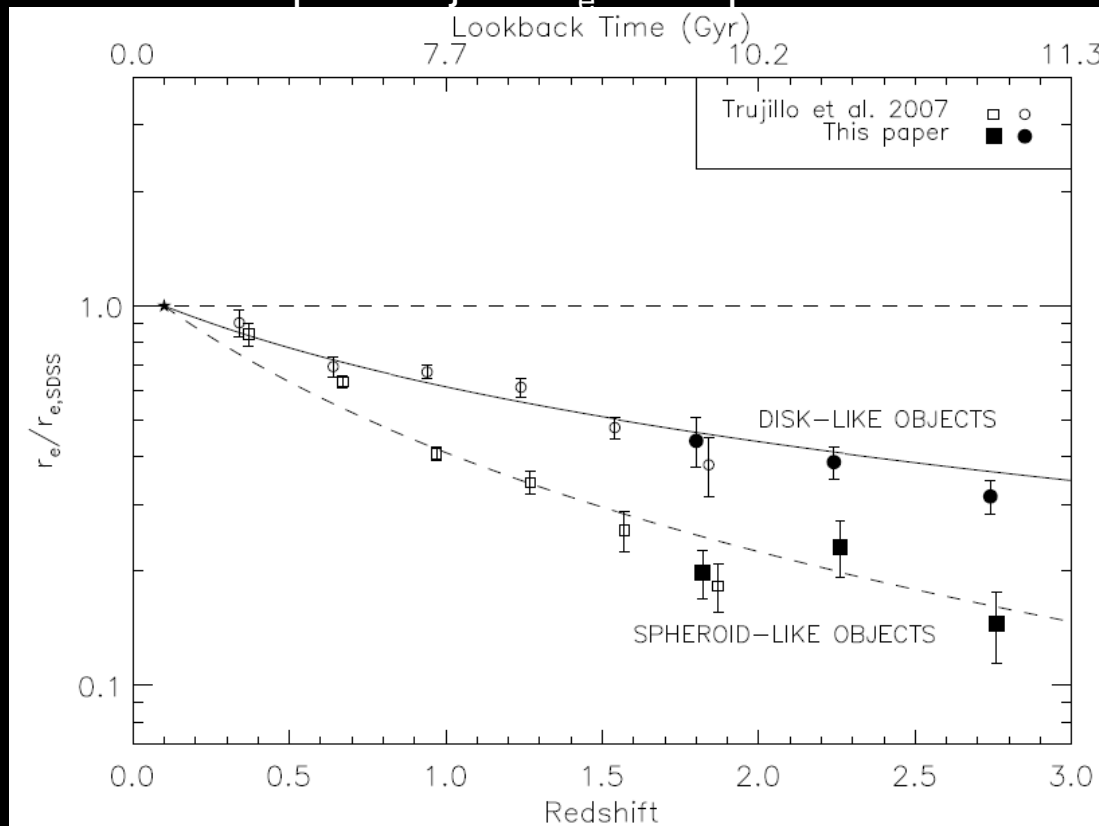
Conselice, Trujillo &  
Carrasco (2009; in prep)

Trujillo et al. (2007)

# Massive galaxies at $z \sim 1.8$

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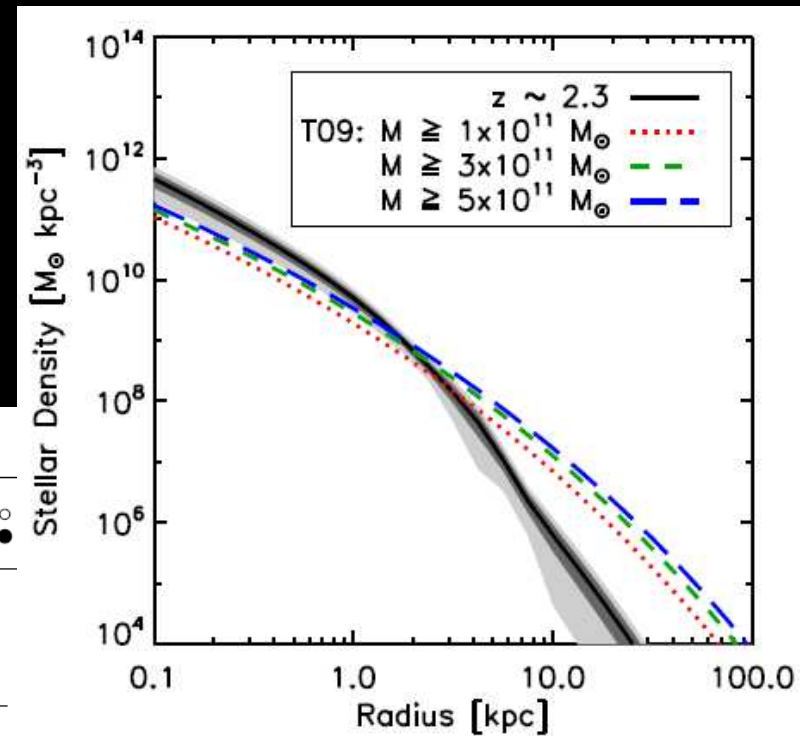
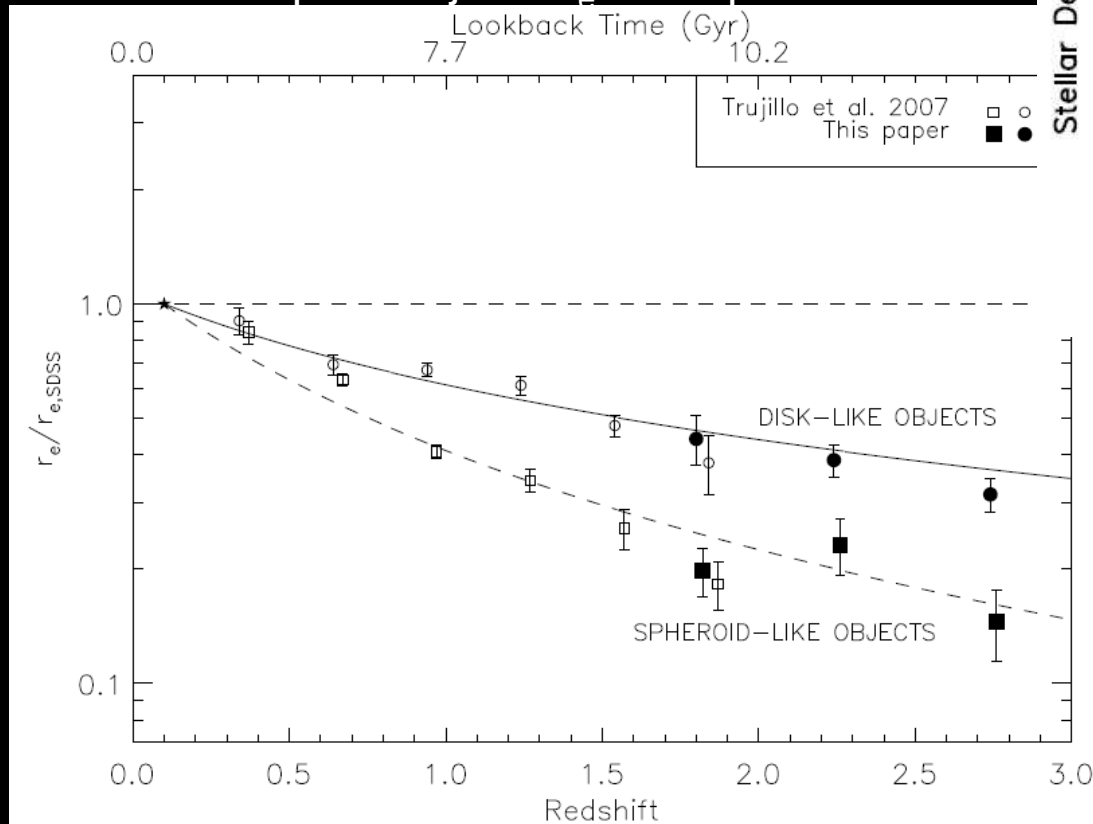


Stellar density at  $z \sim 2$ :  
 $\sim 2 \times 10^{10} M_{\text{sun}} / \text{kpc}^3$   
(Buitrago et al. 2008)

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$M_* \geq 10^{11} M_{\text{sun}}$  galaxies:

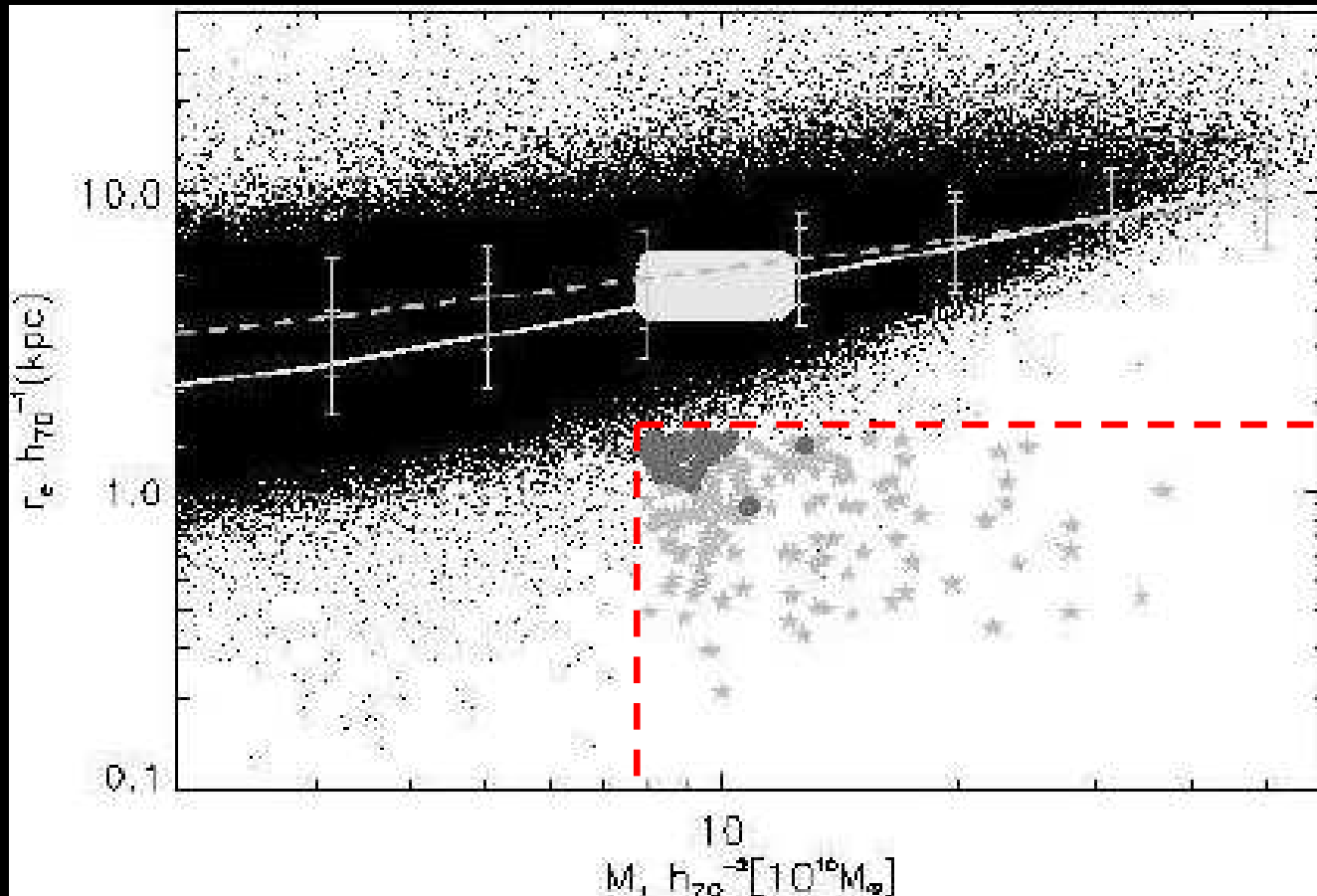
- **Morphological Type:** mixed
- **Stellar populations:**  $\sim 1$  Gyr, metal rich?, short formation time scale?
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Bezanson et al. (2009);  
Hopkins et al. (2009)

Stellar density at  $z \sim 2$ :  
 $\sim 2 \times 10^{10} M_{\text{sun}} / \text{kpc}^3$   
(Buitrago et al. 2008)

# Observational constraints: is there any compact massive galaxies at $z \sim 0$ ?



<0.03% of today massive galaxies are compact

Trujillo et al. (2009) (See also poster: S262 p:43)

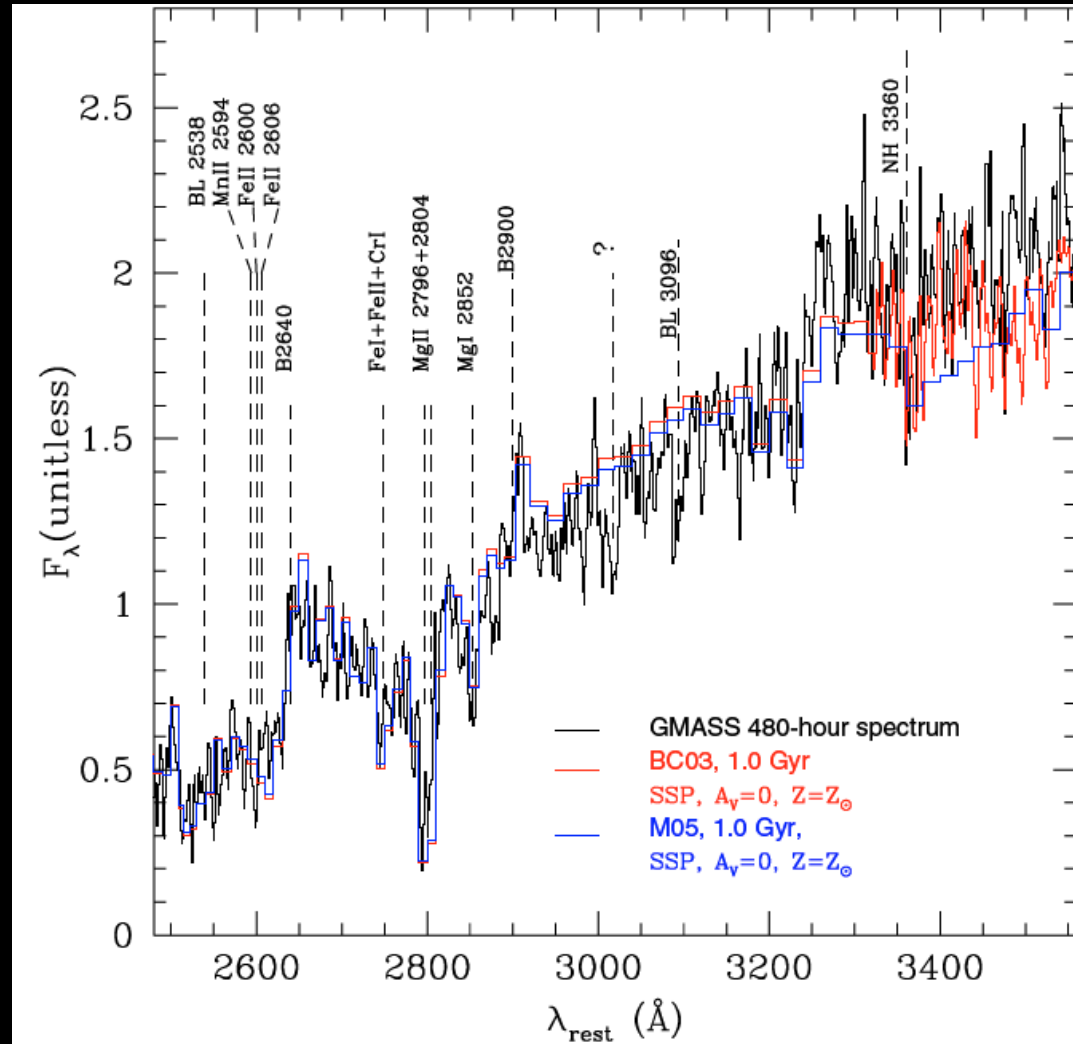
# Observational constraints: velocity dispersion evolution

$$\sigma \propto \sqrt{\frac{GM}{r_e}}$$

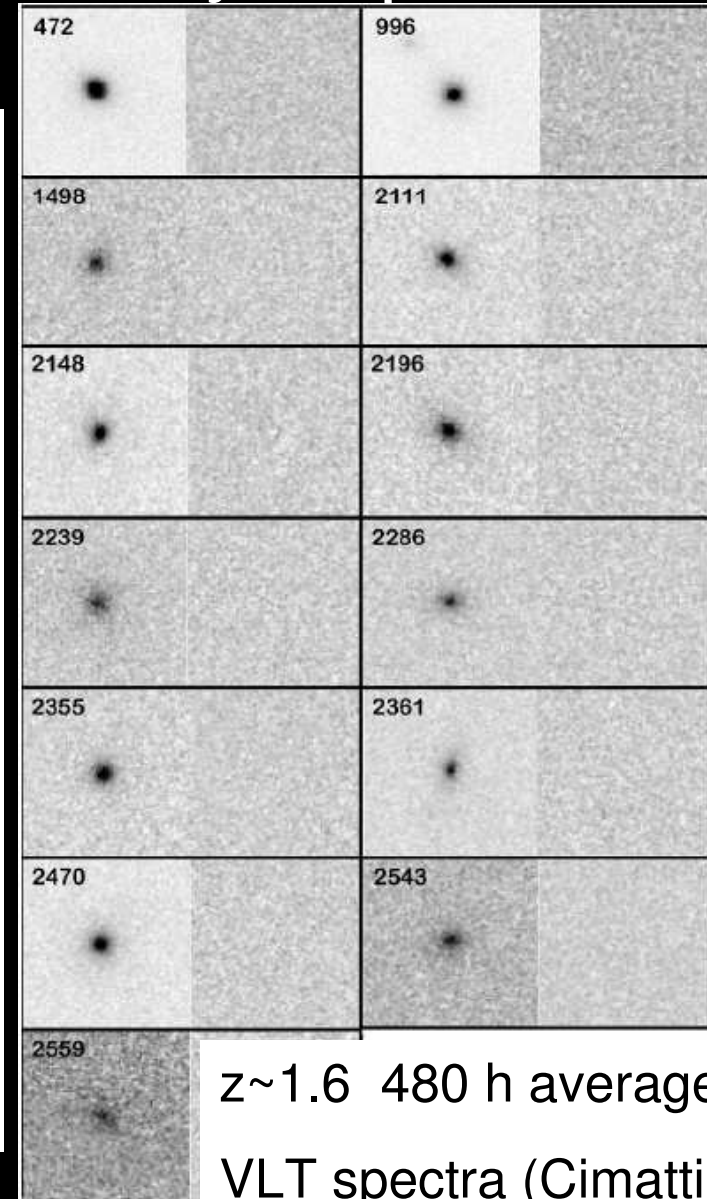
Naïve expectations at a fixed stellar mass:

$$- r_e(z=0) = 4 r_e(z=2) \Rightarrow \sigma(z=2) = 2 \sigma(z=0)$$

# Observational constraints: velocity dispersion evolution

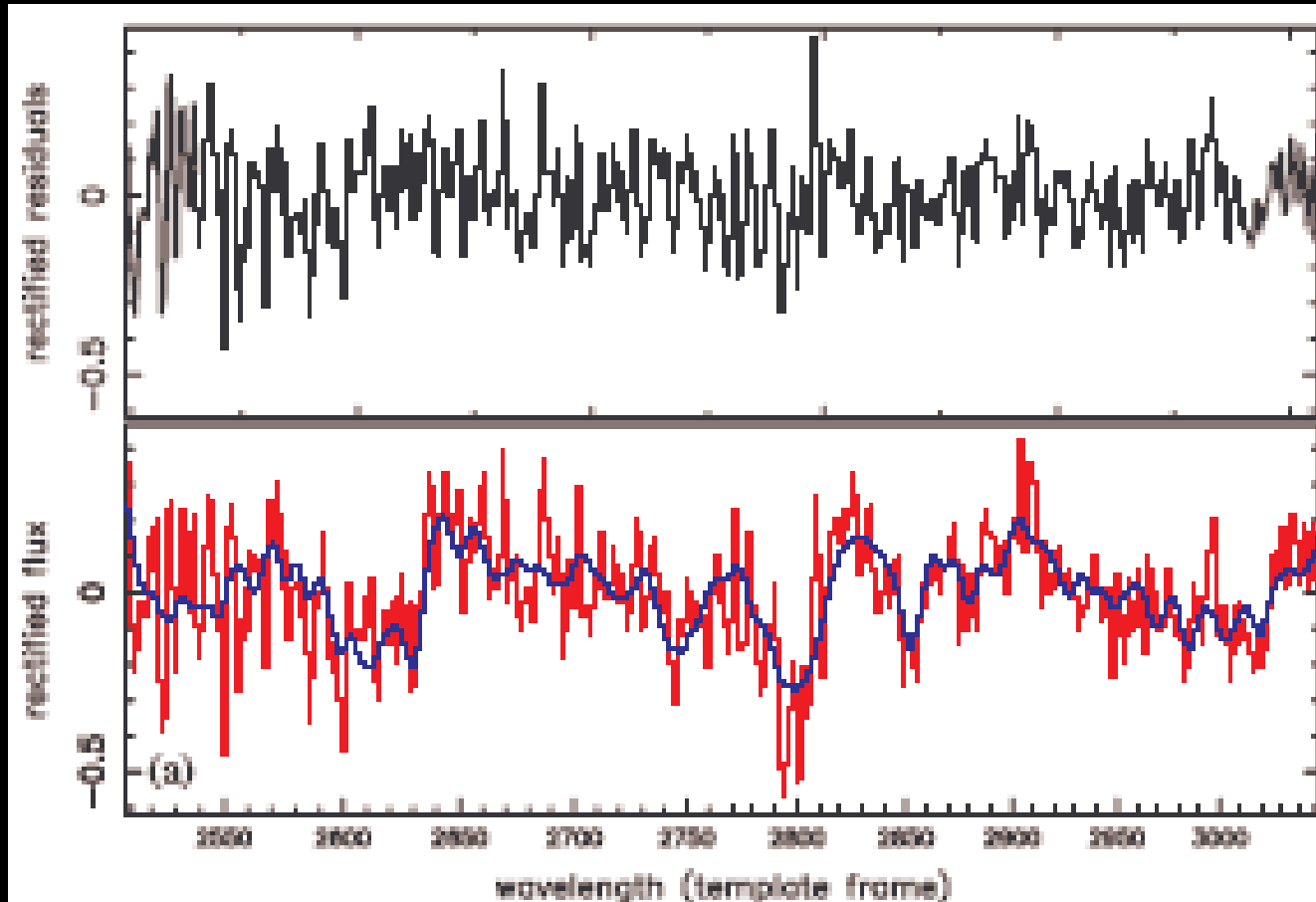


Cenarro & Trujillo (2009)



$z \sim 1.6$  480 h averaged  
 VLT spectra (Cimatti et al. 2008)

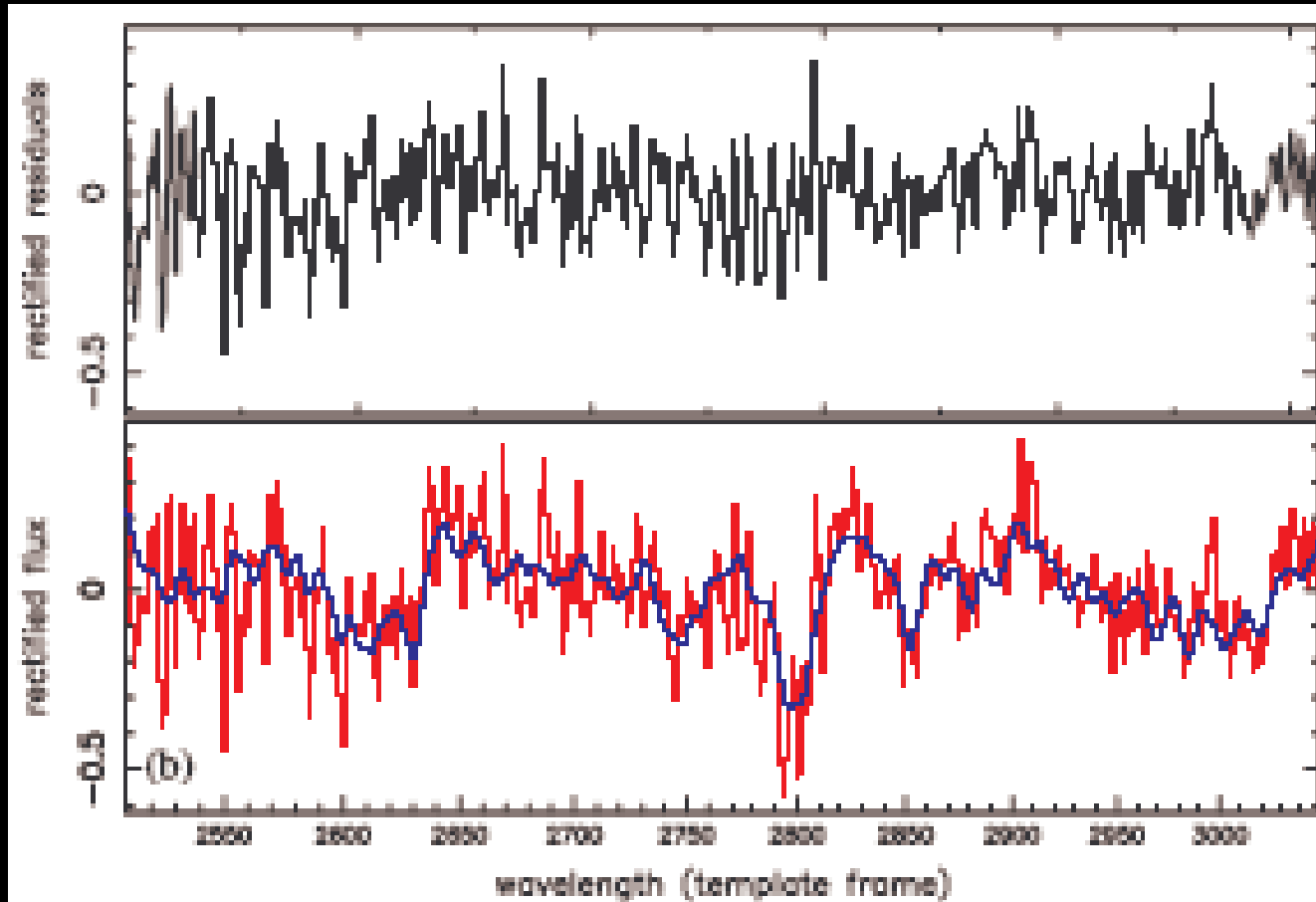
# Observational constraints: velocity dispersion evolution



Template:  
CoolCAT stars  
Spectral Range:  
2510-3050 Å  
 $\sigma_*$ (km/s):  
258±21

Cenarro & Trujillo (2009)

# Observational constraints: velocity dispersion evolution



Template:

BC03+NGSL  
SSP models

Spectral Range:

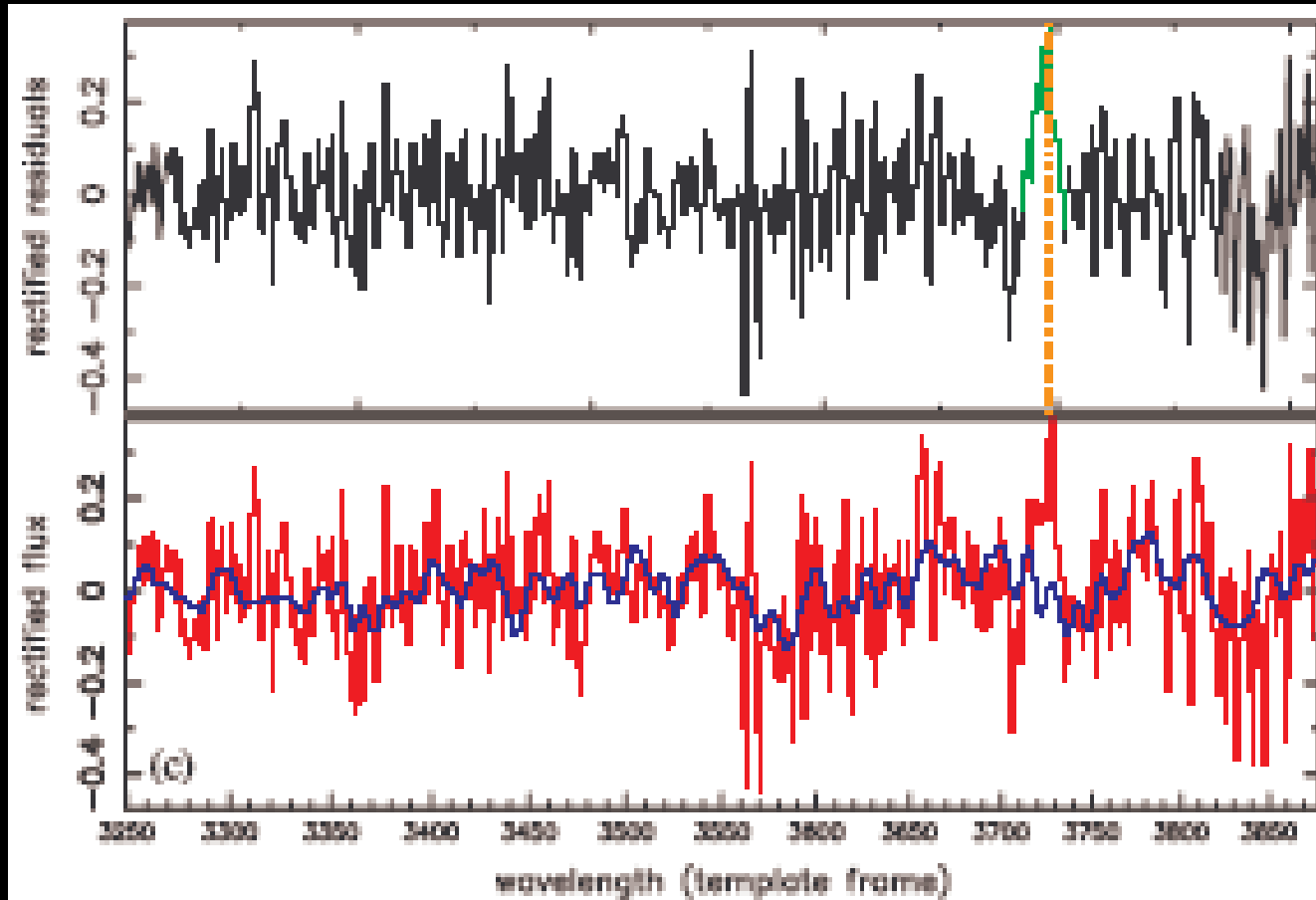
2510-3050 Å

$\sigma_*$ (km/s):

$236 \pm 18$

Cenarro & Trujillo (2009)

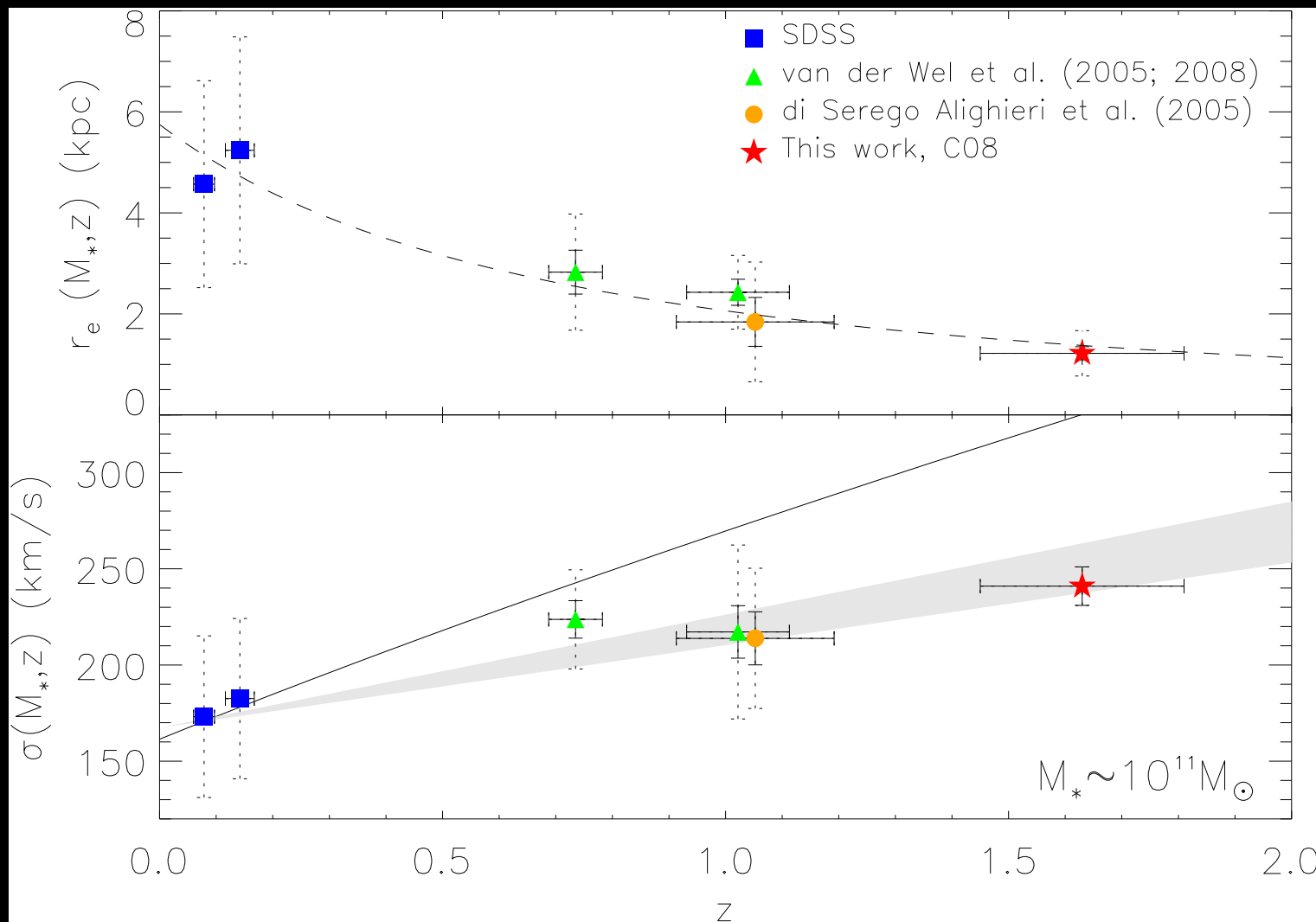
# Observational constraints: velocity dispersion evolution



Template:  
Keck/LRIS stars  
Spectral Range:  
3250-3880 Å  
 $\sigma_*$ (km/s):  
236±15

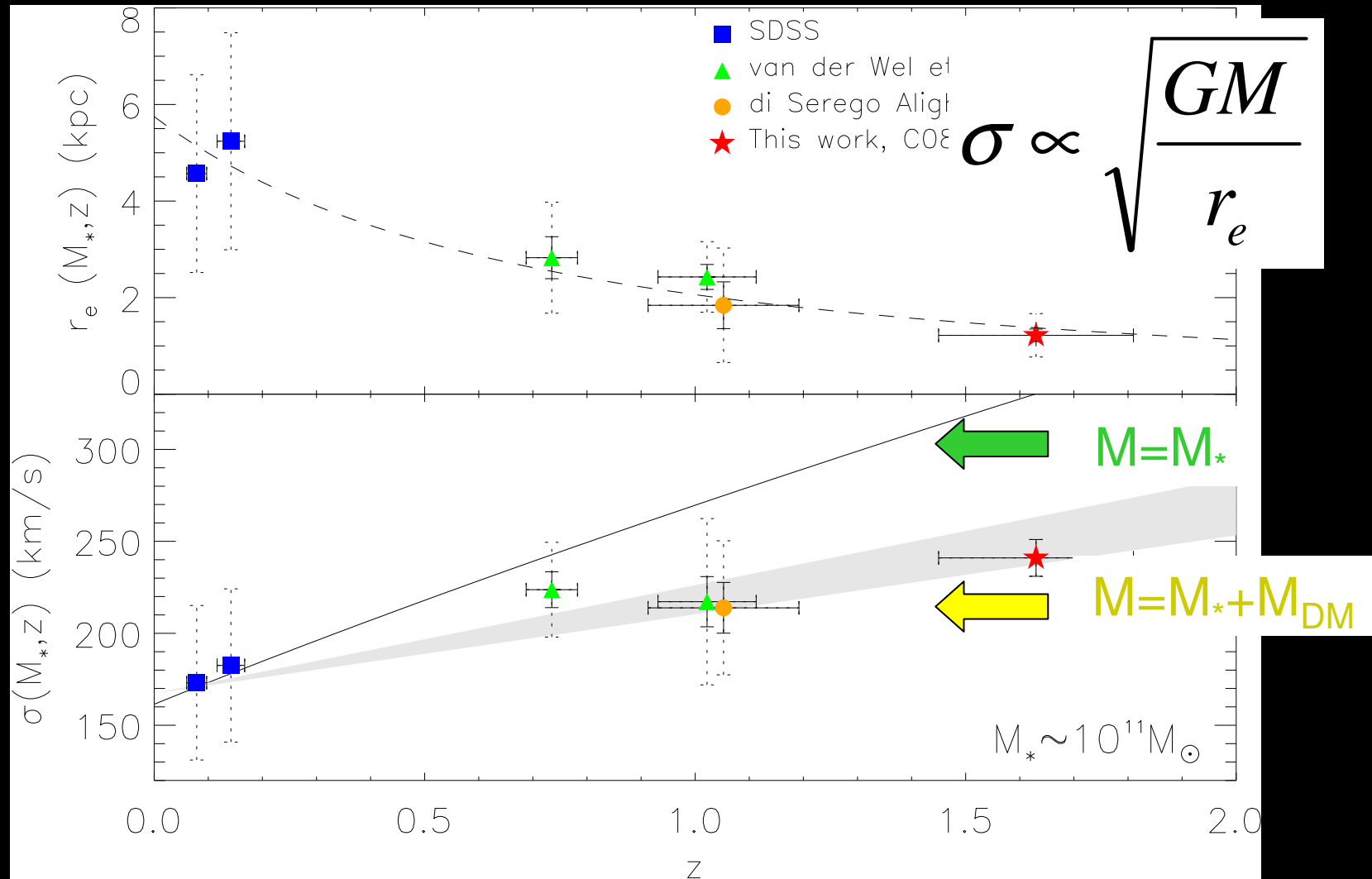
Cenarro & Trujillo (2009)

# Observational constraints: velocity dispersion evolution



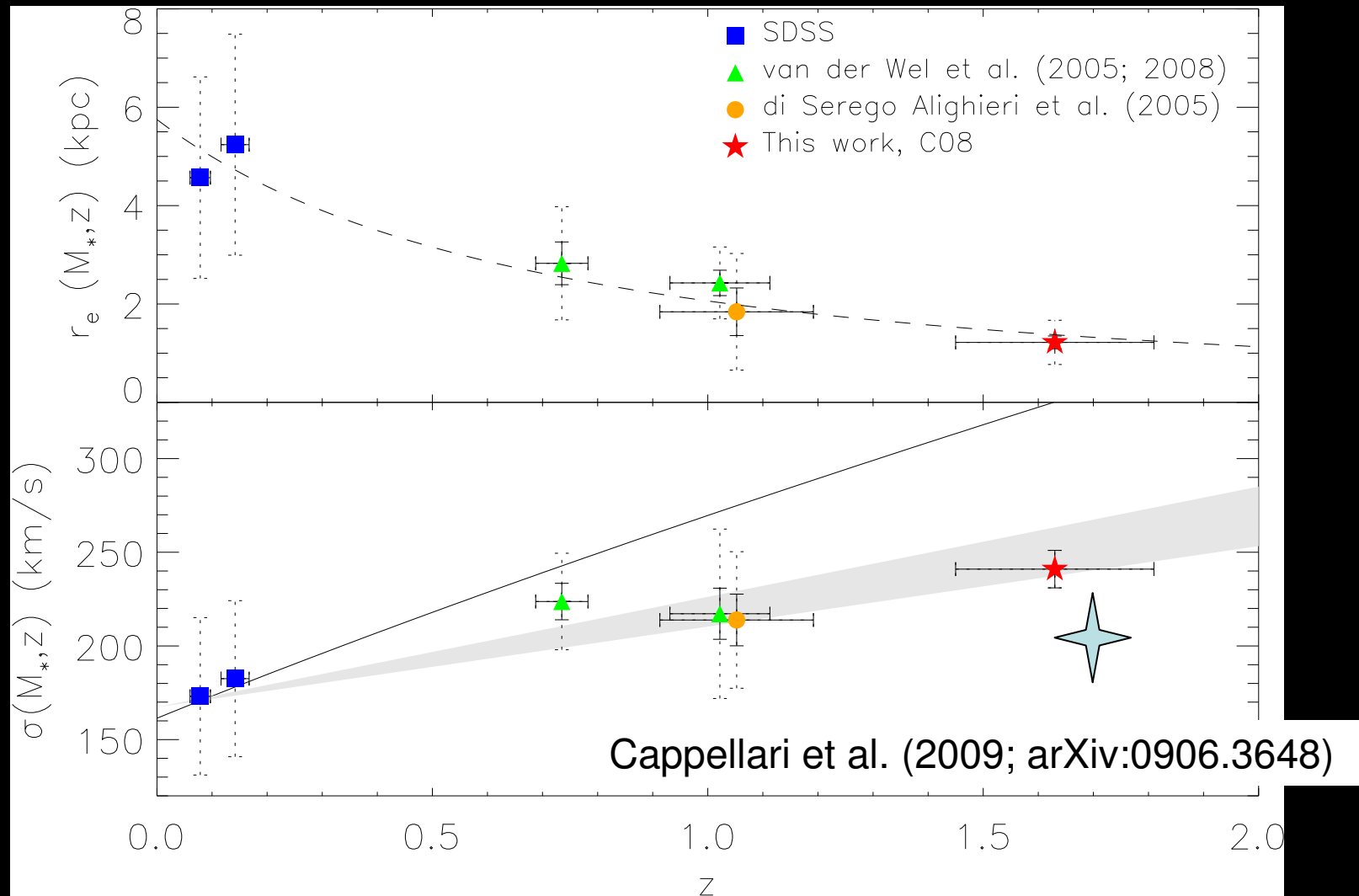
Cenarro & Trujillo (2009)

# Observational constraints: velocity dispersion evolution



Cenarro & Trujillo (2009)

# Observational constraints: velocity dispersion evolution



Cappellari et al. (2009; arXiv:0906.3648)

Cenarro & Trujillo (2009)

# Observational constraints: velocity dispersion evolution

Cenarro & Trujillo (2009):

1. Mild evolution of the velocity dispersion: at a fixed stellar mass only 1.3 larger at  $z \sim 1.6$ 
  - a) Compact massive galaxies are *really* massive
  - b) Important consequences on the IMF evolution
  - c) Progressive evolution of the dark matter in settling the velocity dispersion

# Open Questions:

Which mechanisms are transforming the compact massive galaxies into the local objects?

- AGN activity (**puffing-up**) model is unlikely to explain the evolution of the most massive galaxies
- Observationally mergers (at least major) seem to be very scarce to explain the observed evolution

Is **minor merging** the key?