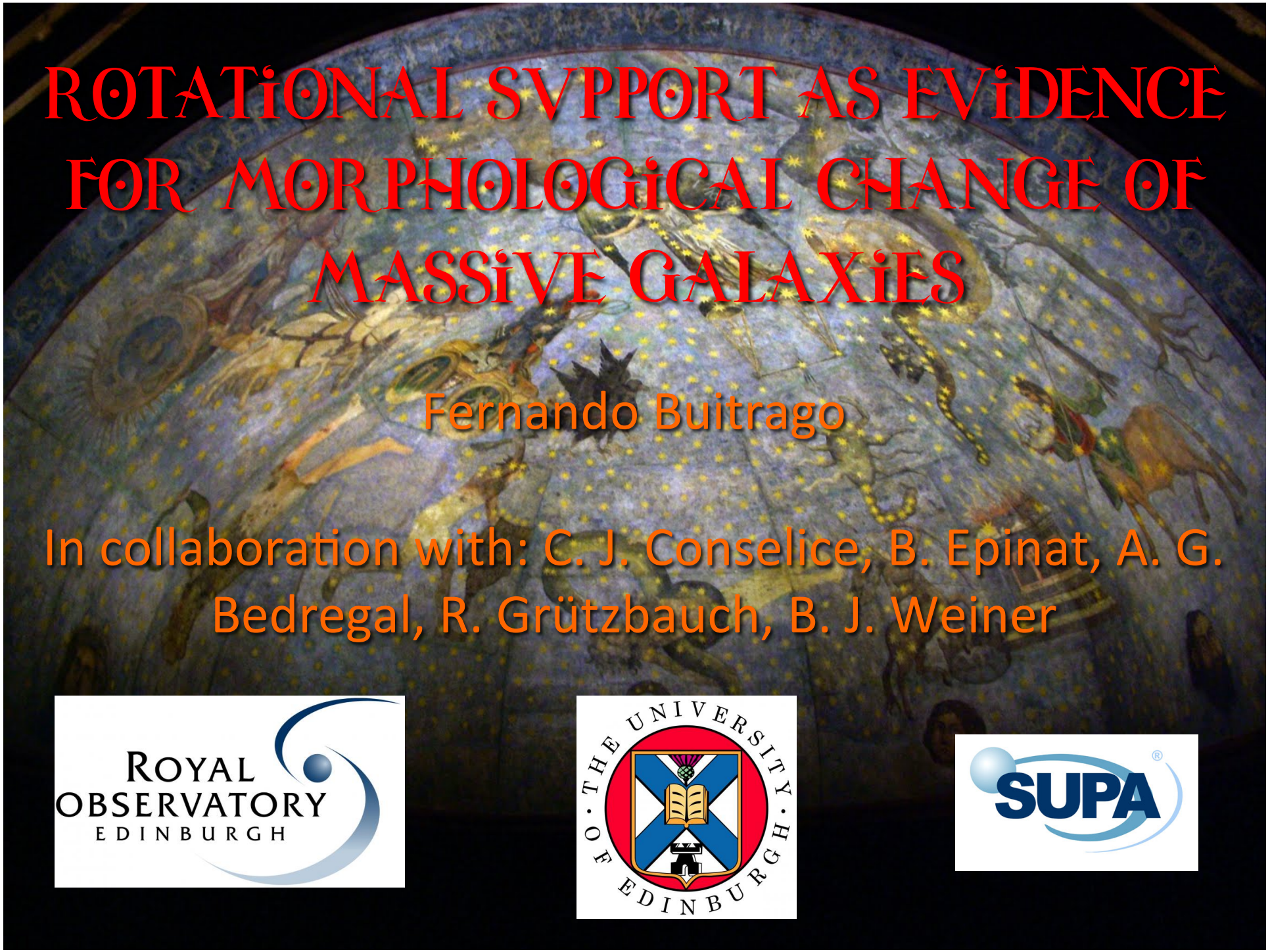
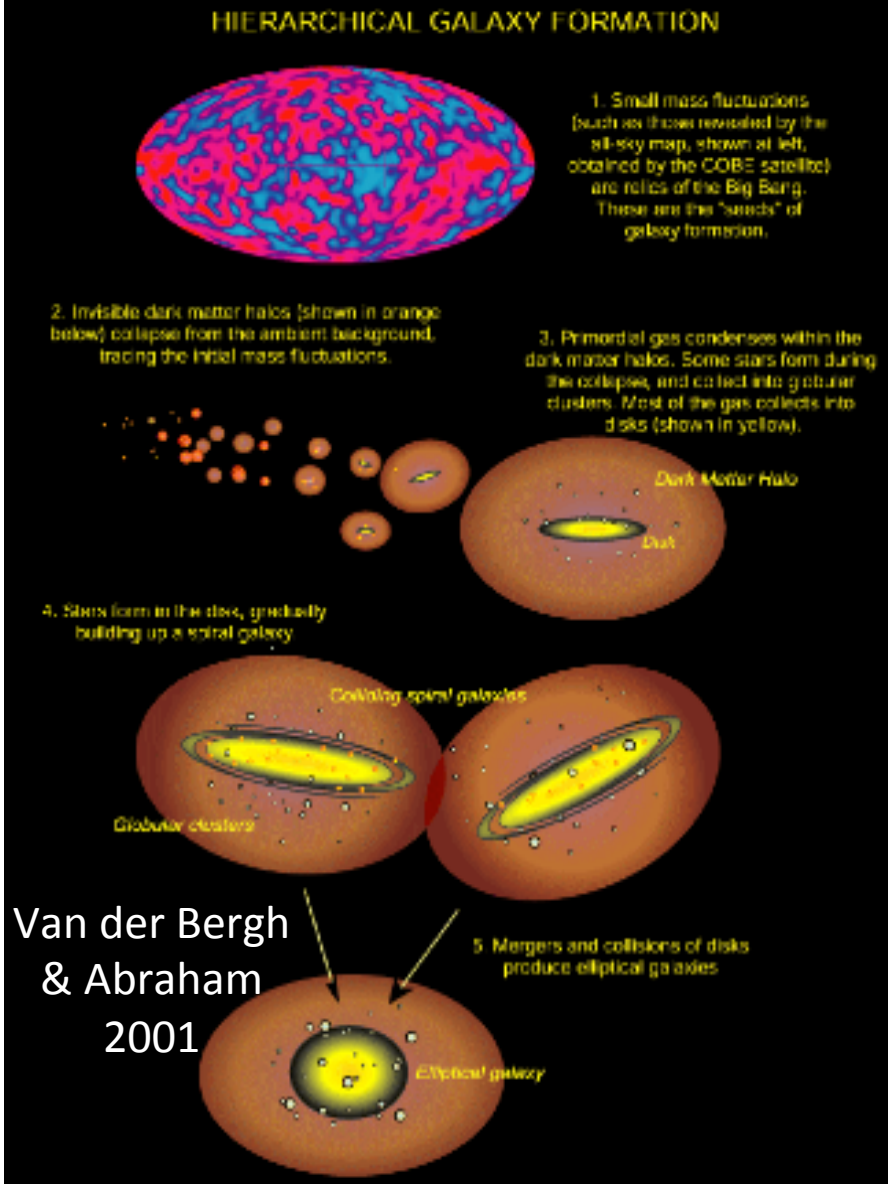

ROTATIONAL SUPPORT AS EVIDENCE FOR MORPHOLOGICAL CHANGE OF MASSIVE GALAXIES
Fernando Buitrago
In collaboration with: C. J. Conselice, B. Epinat, A. G. Bedregal, R. Grützbauch, B. J. Weiner
ROYAL OBSERVATORY EDINBURGH
THE UNIVERSITY OF EDINBURGH
SUPA

INDEX

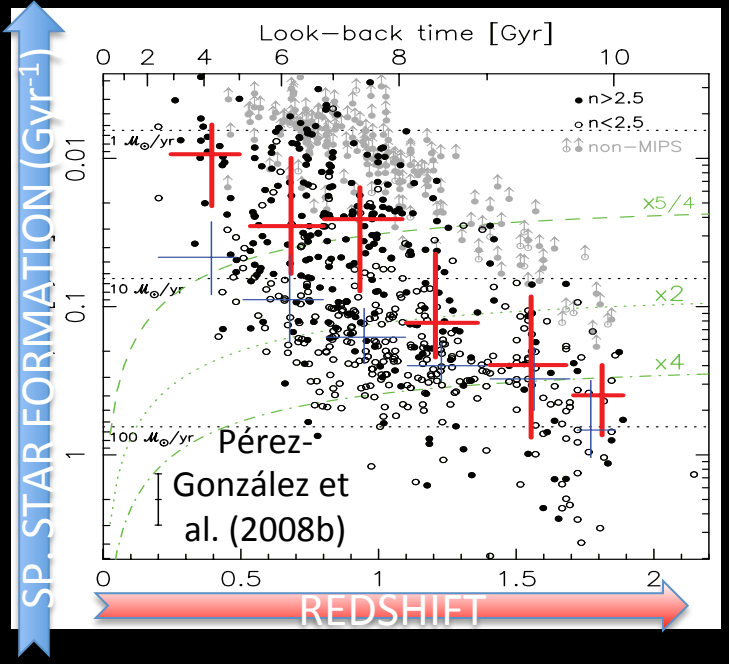
- Context: Evolution of massive galaxies with z
- Our sample
- Rotational support
- Tully-Fisher relation, dynamical masses, …
- Conclusions and future projects

MASSIVE GALAXIES IN ΛCDM

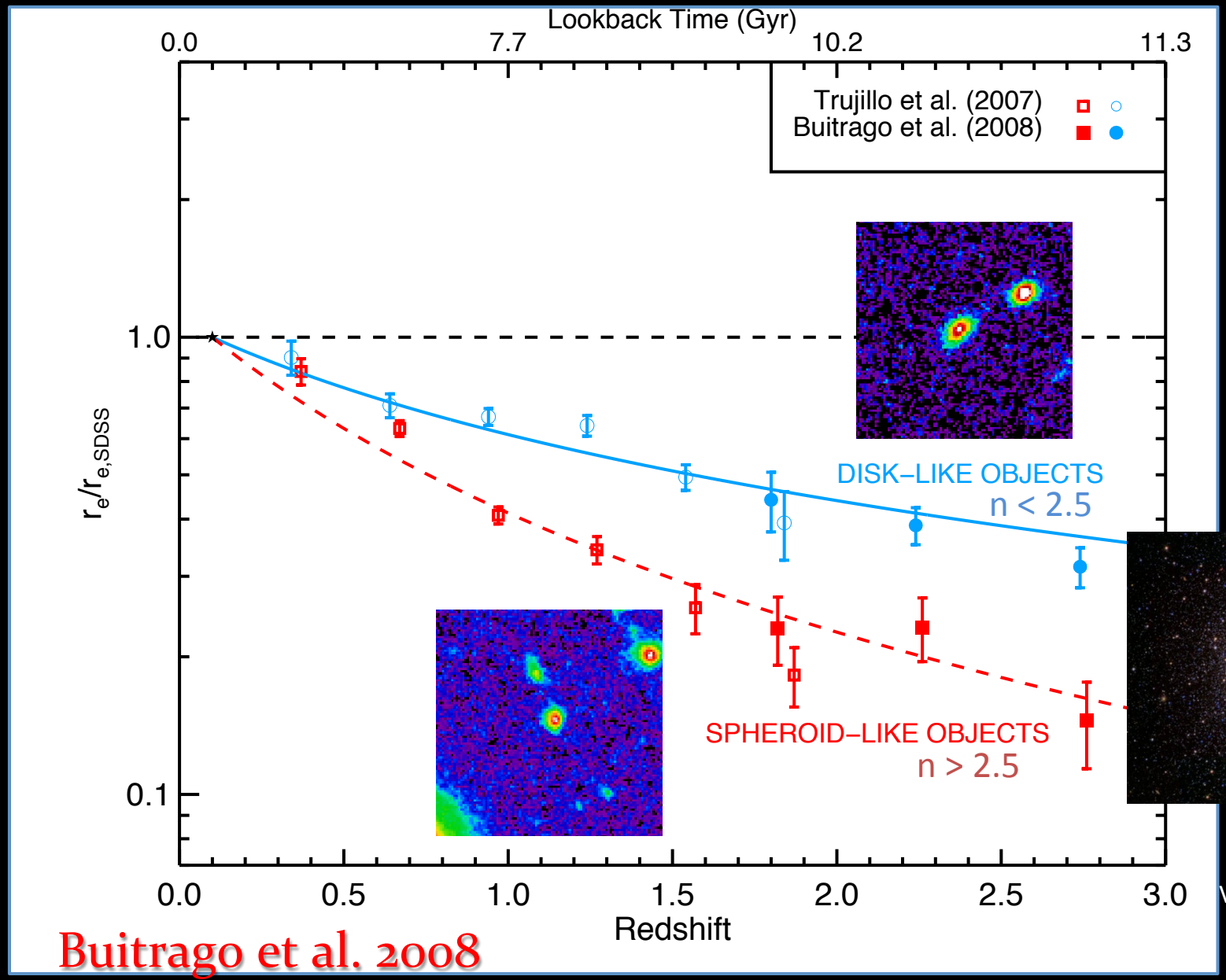


Van der Bergh & Abraham 2001

- Massive galaxies: $M_{stellar} > 10^{11} M_{\odot}$
- Already in place at high redshift ($z > 1$)
- Red, old and passive even at that epoch
- Two-phase formation: in situ formation and inside-out growth (Khochfar & Silk 2006, Hopkins et al. 2009, Oser et al. 12)
- "King of my castle" ➔ Large baryonic and DM dominates galaxy neighbours
- Galaxy main sequence, red sequence, quenching... ➔ Strong mass dependence
- Very luminous ➔ Easy to track at high-z



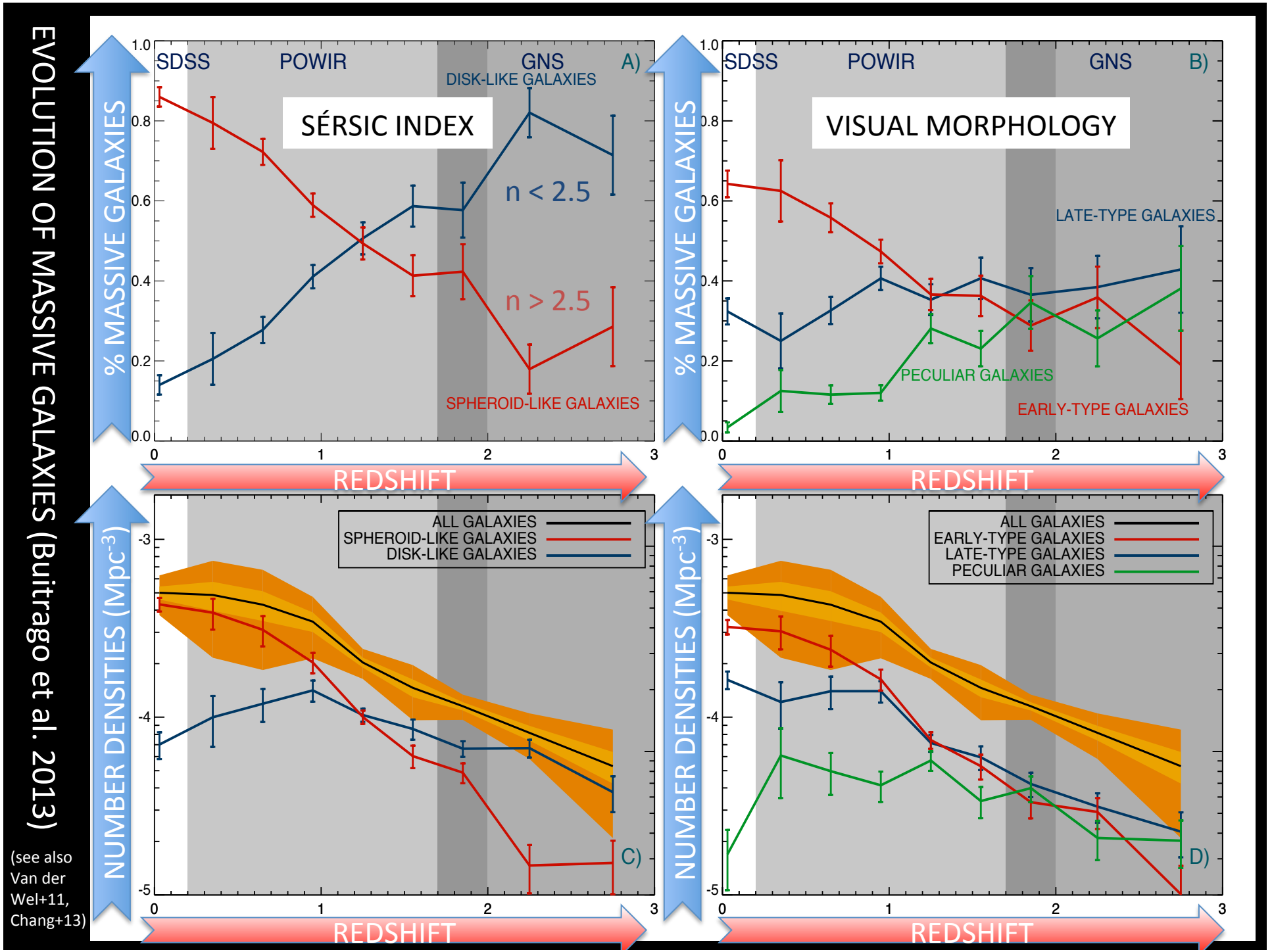
EVOLUTION IN SIZE



Buitrago et al. 2008

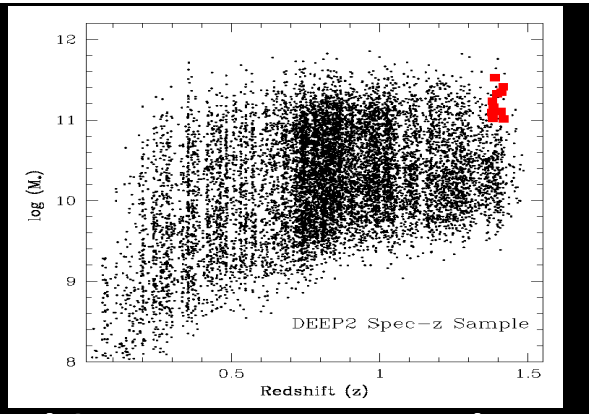
On average 3-5 times smaller than their local counterparts!

Van Dokkum et al. 2010, Bruce et al. 2012, Trujillo et al. 2014, …


EVOLUTION OF MASSIVE GALAXIES (Buitrago et al. 2013)
(see also Van der Wel+11, Chang+13)
% MASSIVE GALAXIES
SDSS
POWIR
GNS
A)
SÉRSIC INDEX
DISK-LIKE GALAXIES
n < 2.5
n > 2.5
SPHEROID-LIKE GALAXIES
REDSHIFT
B)
VISUAL MORPHOLOGY
LATE-TYPE GALAXIES
PECULIAR GALAXIES
EARLY-TYPE GALAXIES
NUMBER DENSITIES (Mpc^{-3})
ALL GALAXIES
SPHEROID-LIKE GALAXIES
DISK-LIKE GALAXIES
C)
ALL GALAXIES
EARLY-TYPE GALAXIES
LATE-TYPE GALAXIES
PECULIAR GALAXIES
D)

OUR SAMPLE

Buitrago et al. (2014)



- 10 massive galaxies with z_{spec}~1.4 (from DEEP2)
- Selected solely by stellar mass & $EW_{[OII]}$> 15 Å
- Observed with SINFONI@VLT (1.5 h per object)
- H-band for mapping Hα emission
- Objectives
  -Spectroscopic confirmation of the photometric scenario (galaxy kinematics)
  -Spatial information gives insight on the mass assembly (galaxy mergers)
- Caveats
  -Emission comes from ionized gas not from the stars (but not bad agreement if the system is relaxed, i.e., Förster-Schreiber+2011)
  -Is our sample biased towards star-forming objects? Certain SFR is not unusual (Cava+10,Bauer+11,Viero+12) and our equivalent widths are as expected (in HiZELS –Sobral+11– or in 3D-HST –Fumagalli+12–)

MODELLING (EPINAT+09,+10)

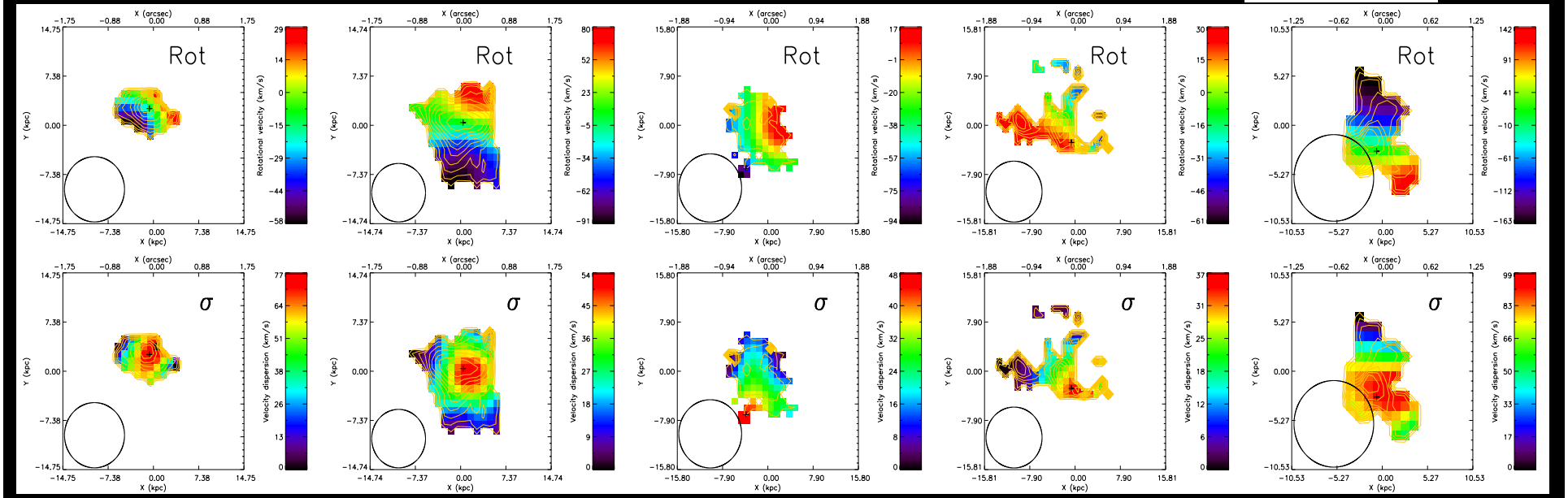
$r \le r_t$

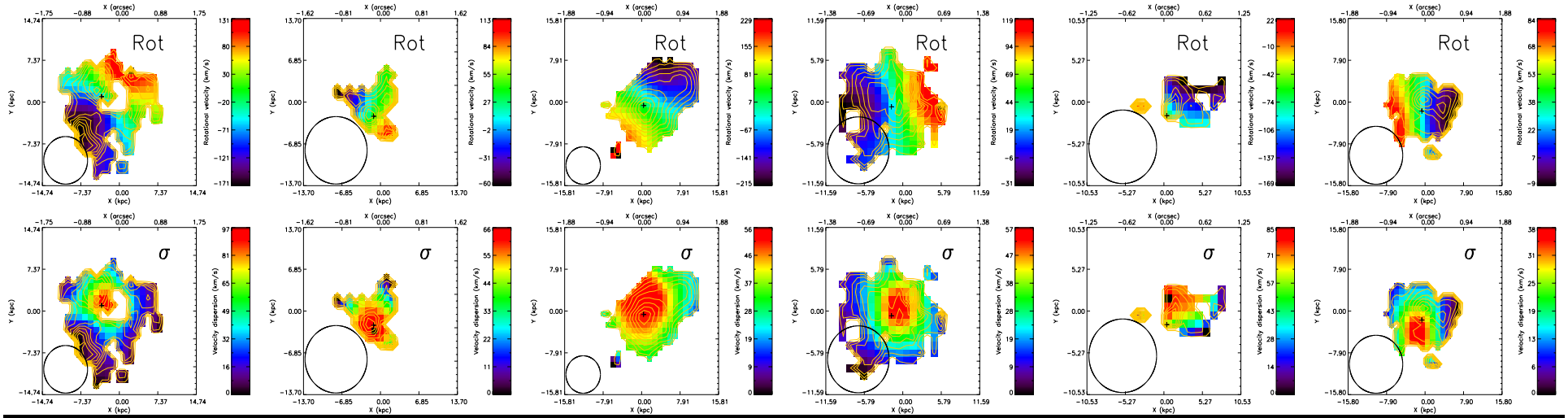
$$V(r) = V_t \frac{r}{r_t}$$

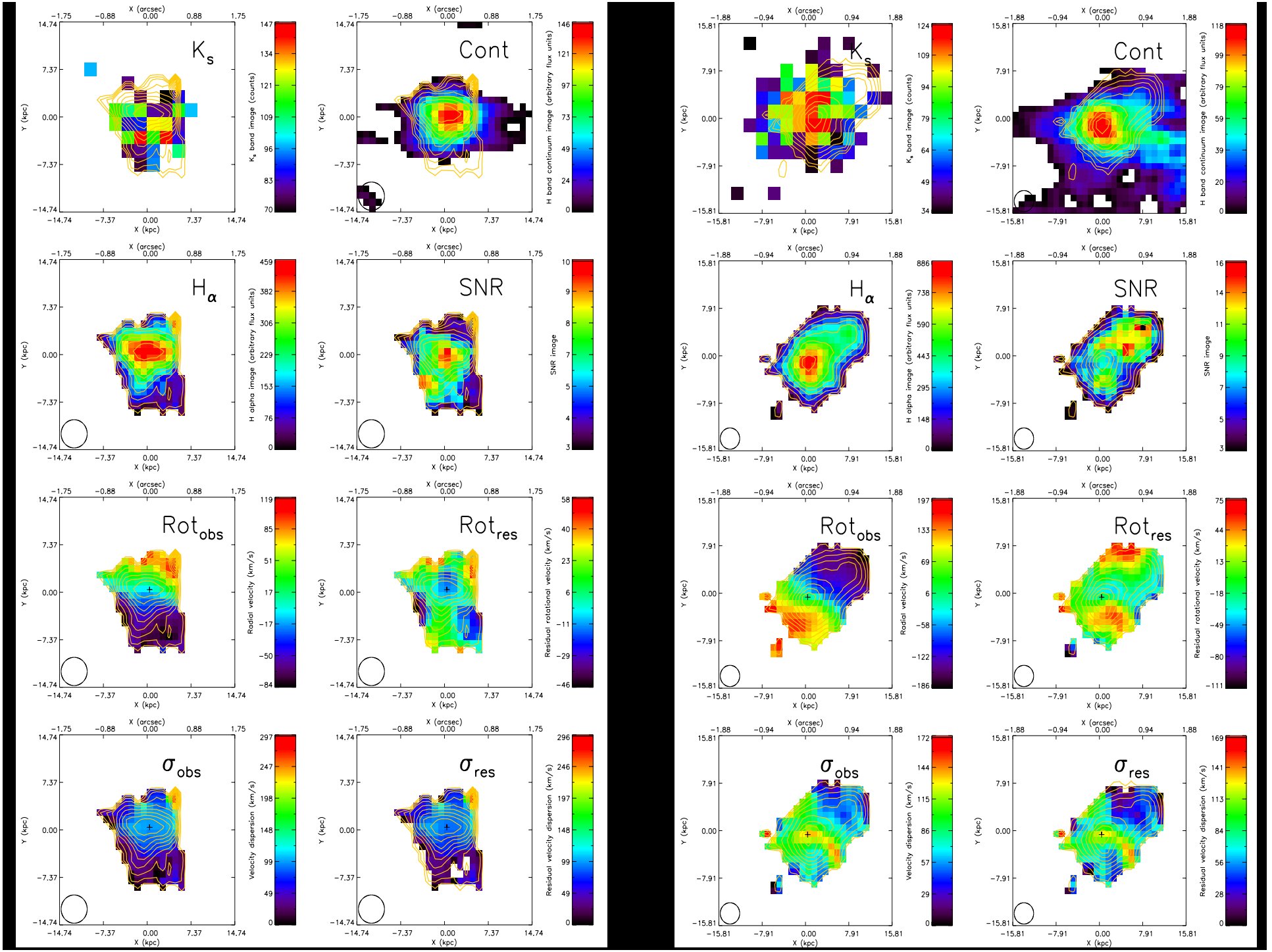
$r > r_t$

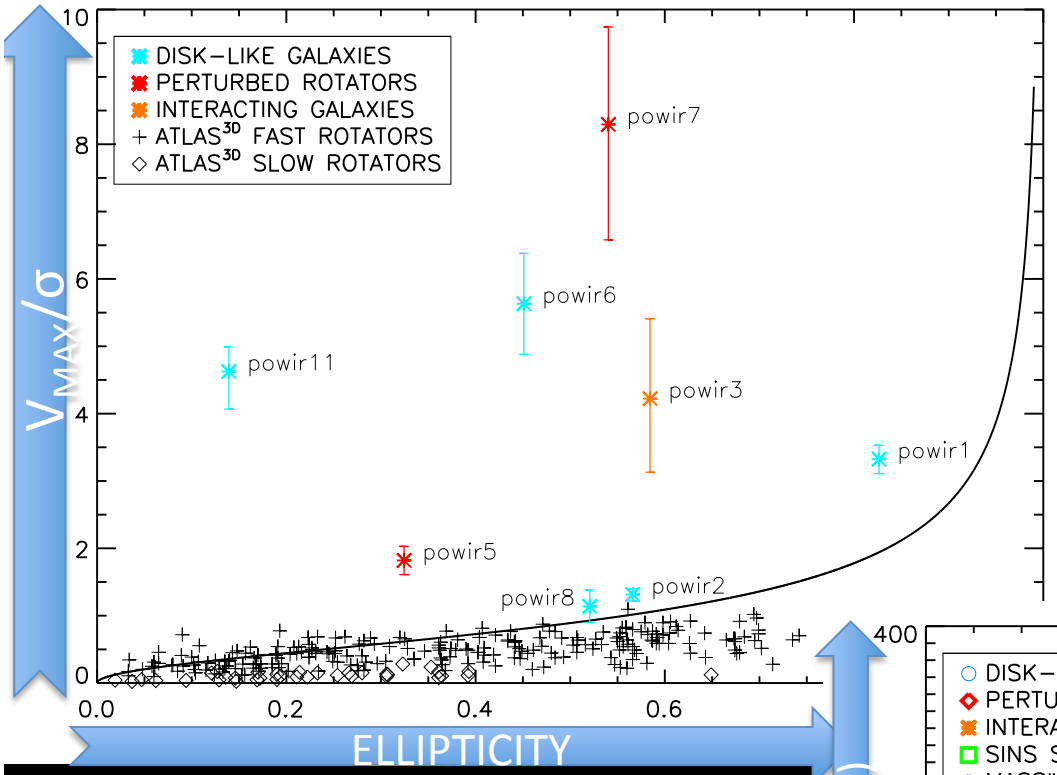
$$V(r) = V_t$$

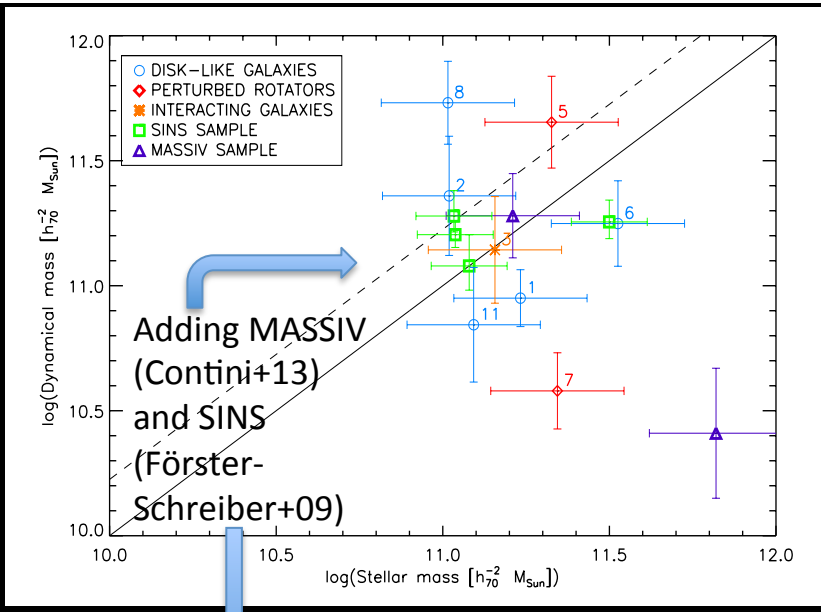
As in Wright +07,+09





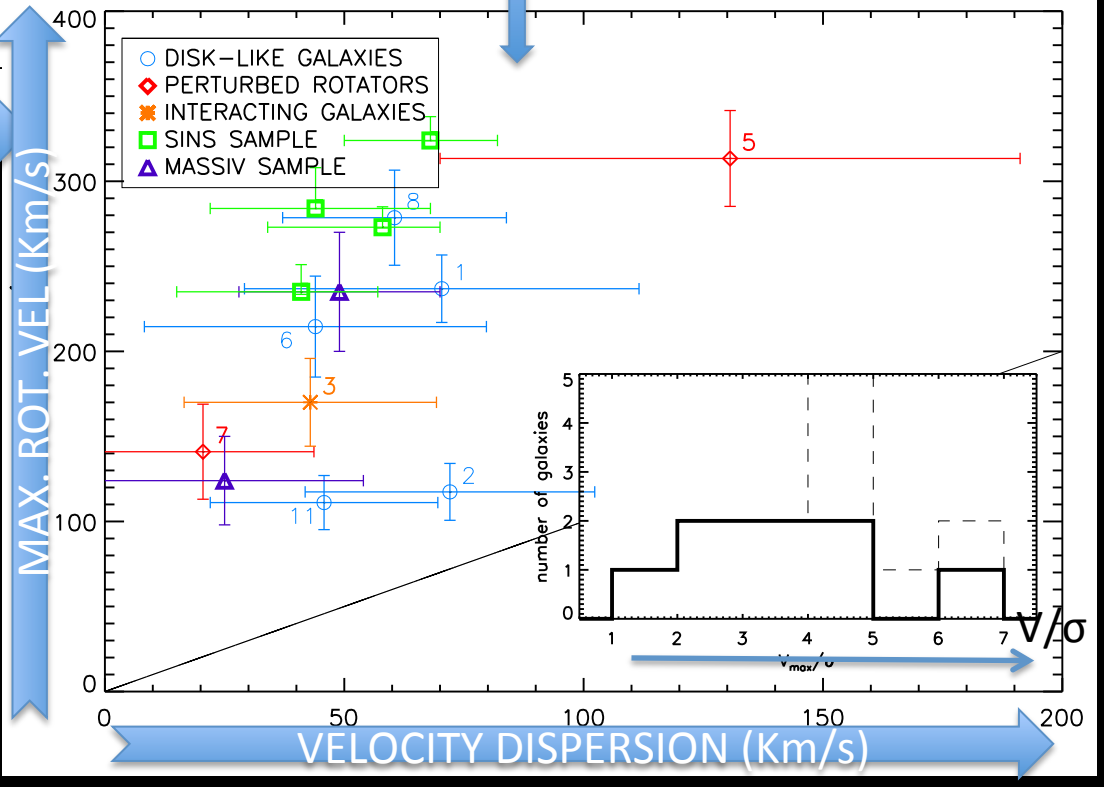

Ks
Cont
Hα
SNR
Rotobs
Rotres
σobs
σres
X (arcsec)
X (kpc)
Y (kpc)
Ks band image (counts)
H band continuum image (arbitrary flux units)
H alpha image (arbitrary flux units)
SNR image
Radial velocity (km/s)
Residual rotational velocity (km/s)
Velocity dispersion (km/s)
Residual velocity dispersion (km/s)



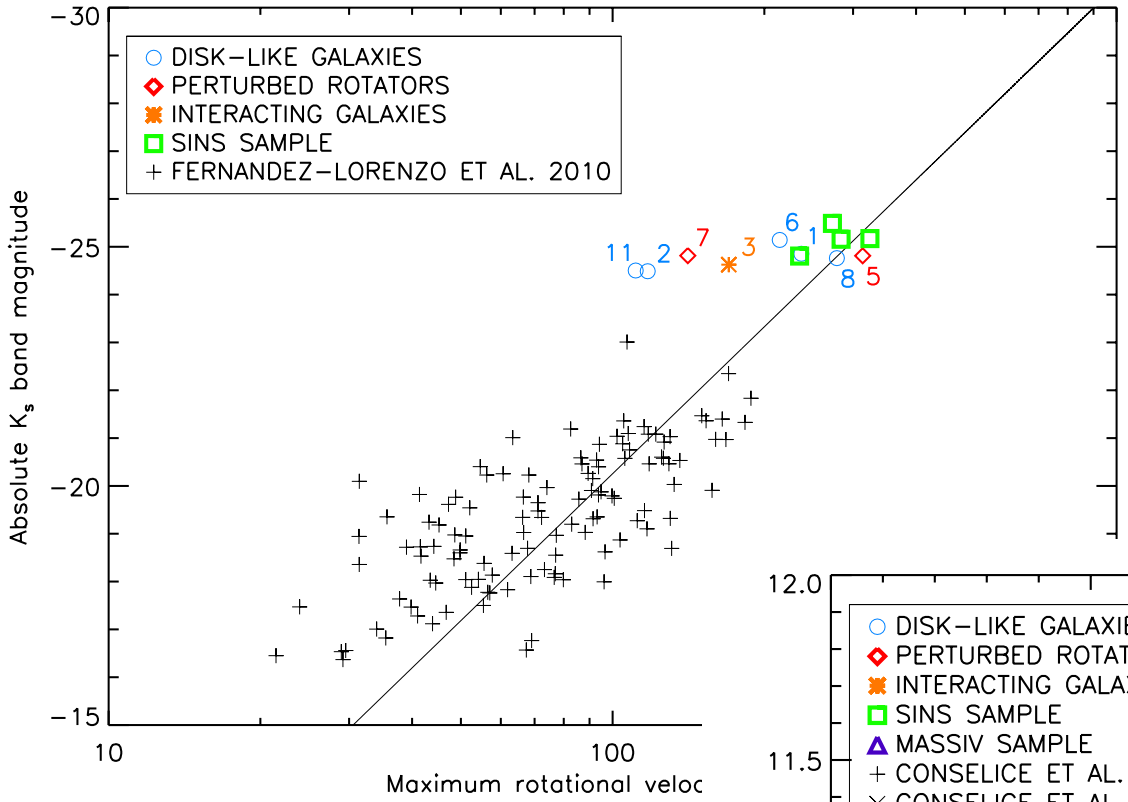


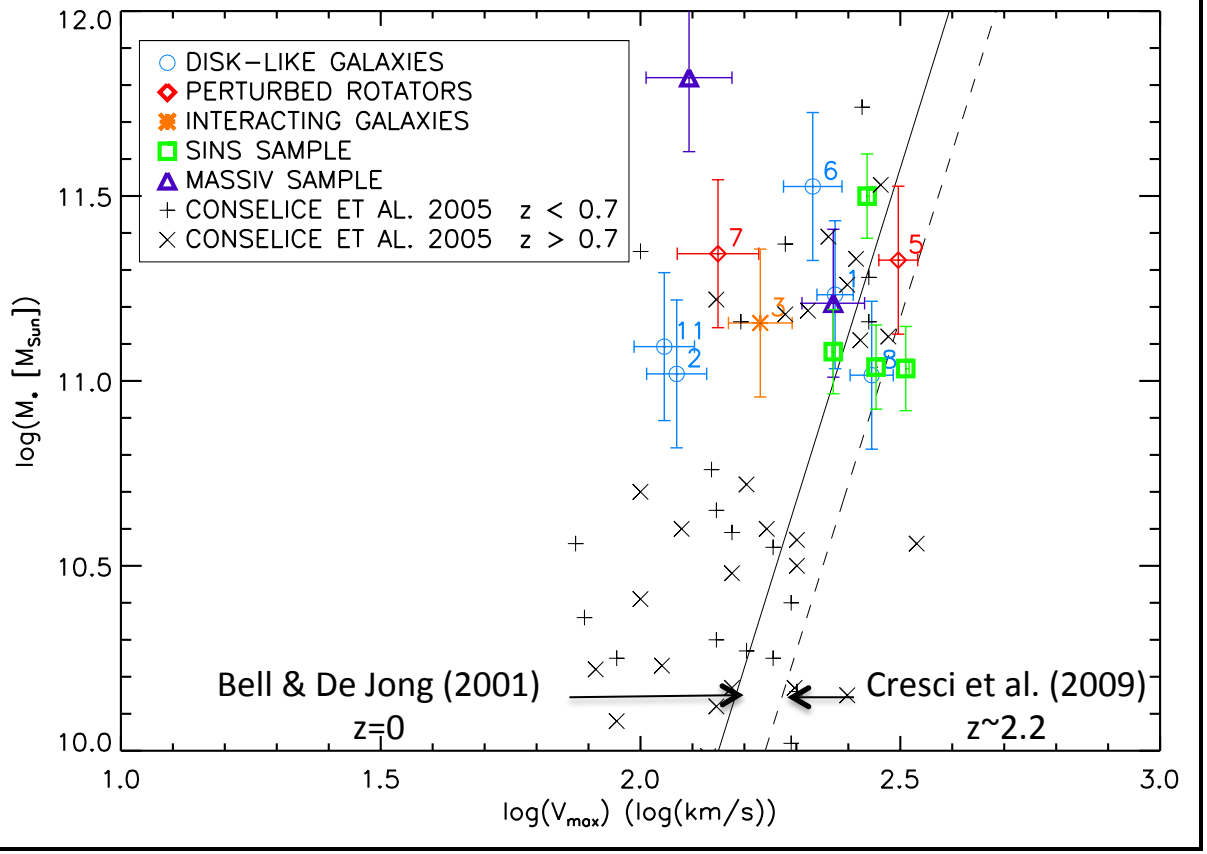
From Buitrago et al. (2014)

- ✓ 50% in our sample are compatible with being disks, while all are rotation dominated – this is not what it seen at low-z, both for spheroids and spirals



TULLY-FISHER RELATION





✓ Quite regular, extended and high rot. gradients: massive disks are stable very early (Epinat+12, Kassin+12) High mass protects? Morphological downsing

SUMMARY AND CONCLUSIONS

- Massive galaxies help us understanding ΛCDM
- Dramatic evolution with redshift → Morph. change
- First IFU sample of massive galaxies at z~1.4 (BEWARE: $EW_{[OII]}$> 15 Å)
  - 10 objects only, but careful selection and modelling
- Evidence for rotational support (BEWARE: Hα emission)
- Some hints minor merging, and two major ones
- Massive galaxies dynamically settled early on
- Future projects

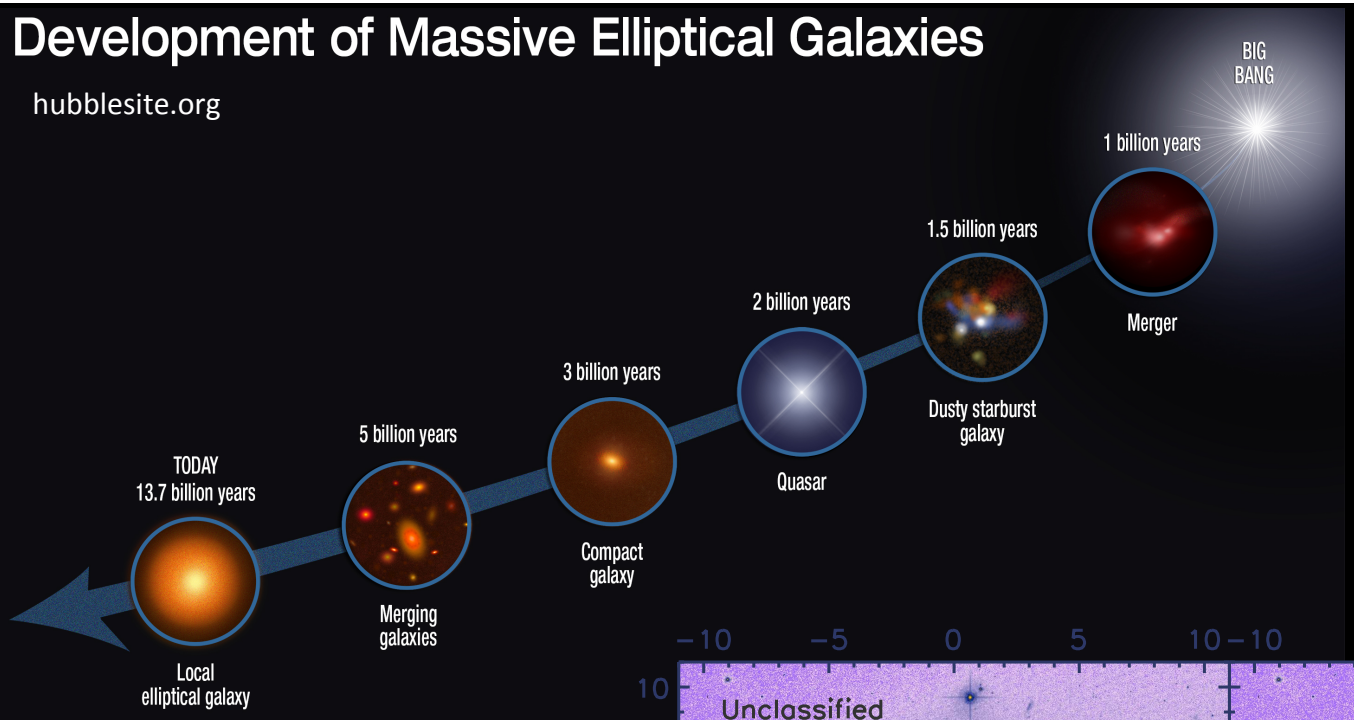
TAKE AWAY SLIDE

Massive galaxies: $M_{stellar} > 10^{11} M_{\odot}$

TIME

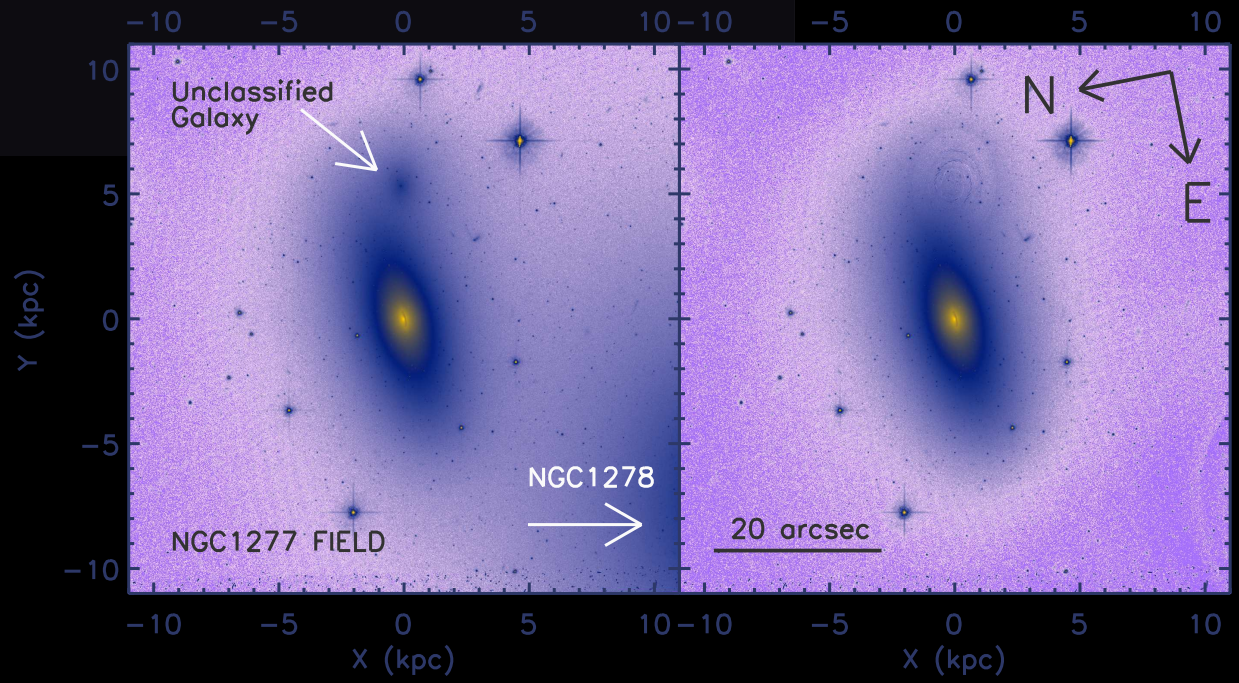
Development of Massive Elliptical Galaxies

hubblesite.org



Transition between disk-dominated to sph-dominated objects? Are internal disks in ellipticals(Falcón-Barroso+06, Krajnovic +08,+13, Oosterloo+10) a common feature at intermediate z?

KMOS for "local" galaxies in the HUDF (see Buitrago +14 in prep.), and using multiplex for testing satellite bombardment



From Trujillo et al. (2014) –> Relic (old & compact) massive galaxy at 73 Mpc –> V_{rot} ~300 km/s ; σ >300 km/s in Van der Bosch et al. (2012)