Evolution of Massive Galaxies via Semi-analytic and Halo Occupation Models
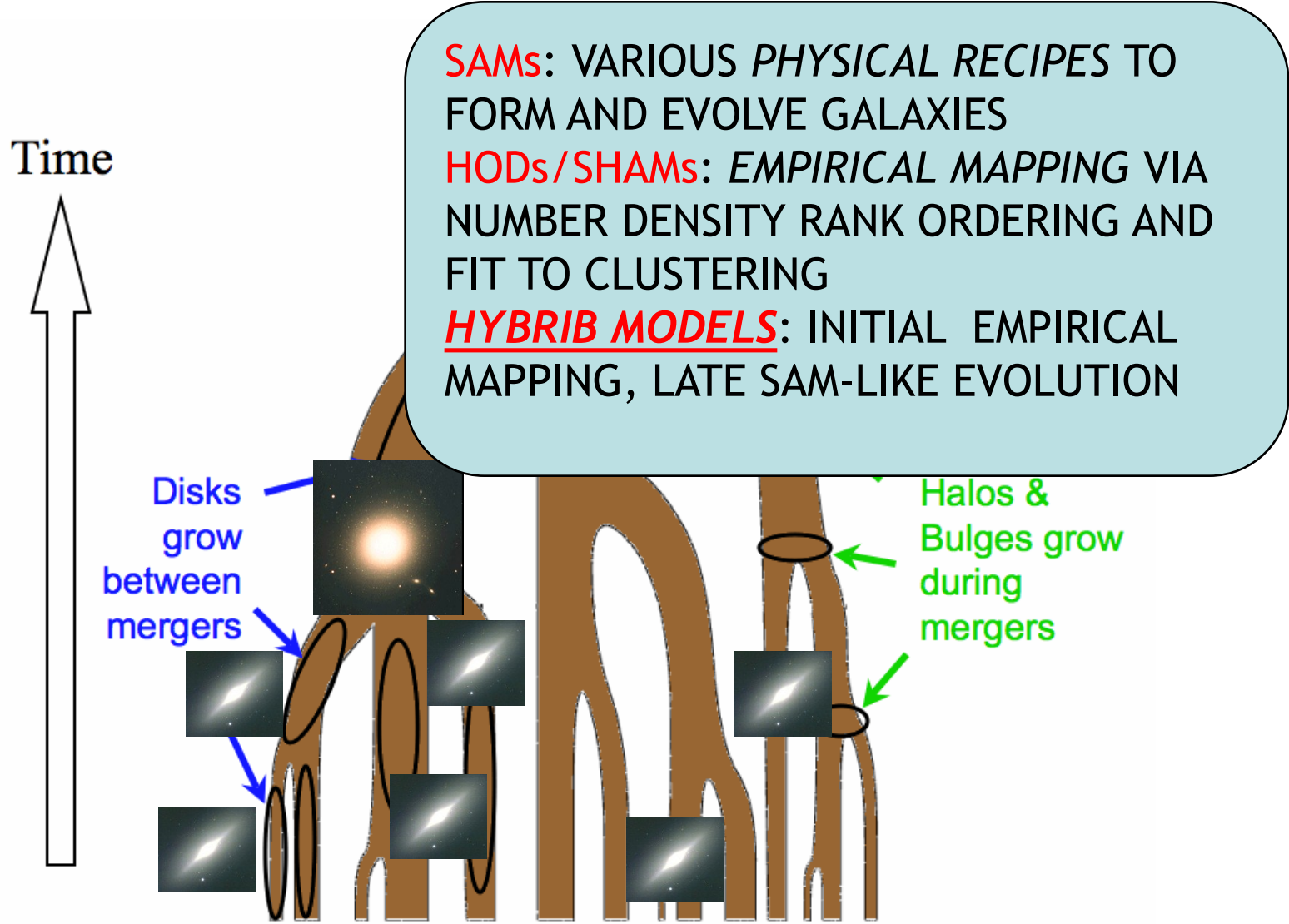
FRANCESCO SHANKAR

Bernardi, **Huertas-Company**, **Mei**, Sheth, Delaye, Fontanot, Licitra, Alimi, Corasaniti, Rasera, Cattaneo

Growing-up at high redshift: from proto-clusters to galaxy clusters

francesco.shankar@obspm.fr

HOW DOES ONE BUILD GALAXIES?
(see Chiang, De Lucia, Hirschmann, Stringer,…)

Time

Disks grow between mergers

Halos & Bulges grow during mergers

SAMs: VARIOUS *PHYSICAL RECIPES* TO FORM AND EVOLVE GALAXIES
HODs/SHAMs: *EMPIRICAL MAPPING* VIA NUMBER DENSITY RANK ORDERING AND FIT TO CLUSTERING
HYBRIB MODELS: INITIAL EMPIRICAL MAPPING, LATE SAM-LIKE EVOLUTION
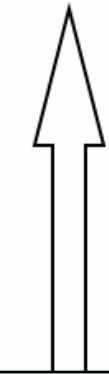
Whittle et al.

HOW DOES ONE BUILD GALAXIES?

(see Chiang, De Lucia, Hirschmann, Stringer,...)

Time

MODELS MAY INCLUDE:
-GAS ACCRETION
-GALAXY/BH MERGERS
-CLUMPY ACCRETION
-DIFFERENT BAR INSTABILITIES
-ADIABATIC EXPANSION
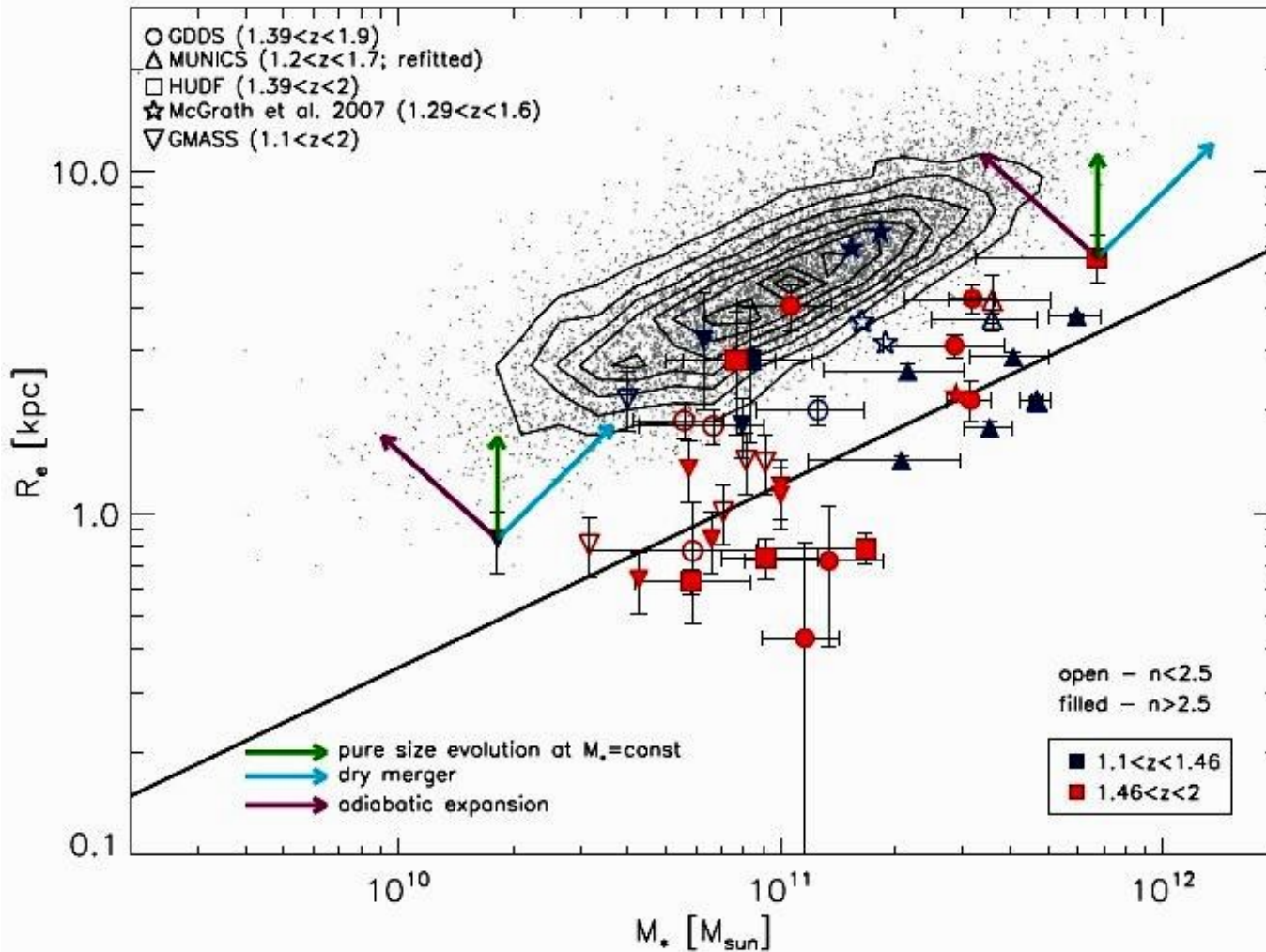-STELLAR/GAS STRIPPING
-FORMATION OF S0s, etc...

Disks

Halos &
Bulges grow
during
mergers

BUILD A GALAXY

MOCK CATALOGUE

WITH FULL STATISTICAL, STRUCTURAL, and SPECTRAL GALAXY PROPERTIES

TO COMPARE WITH DATA

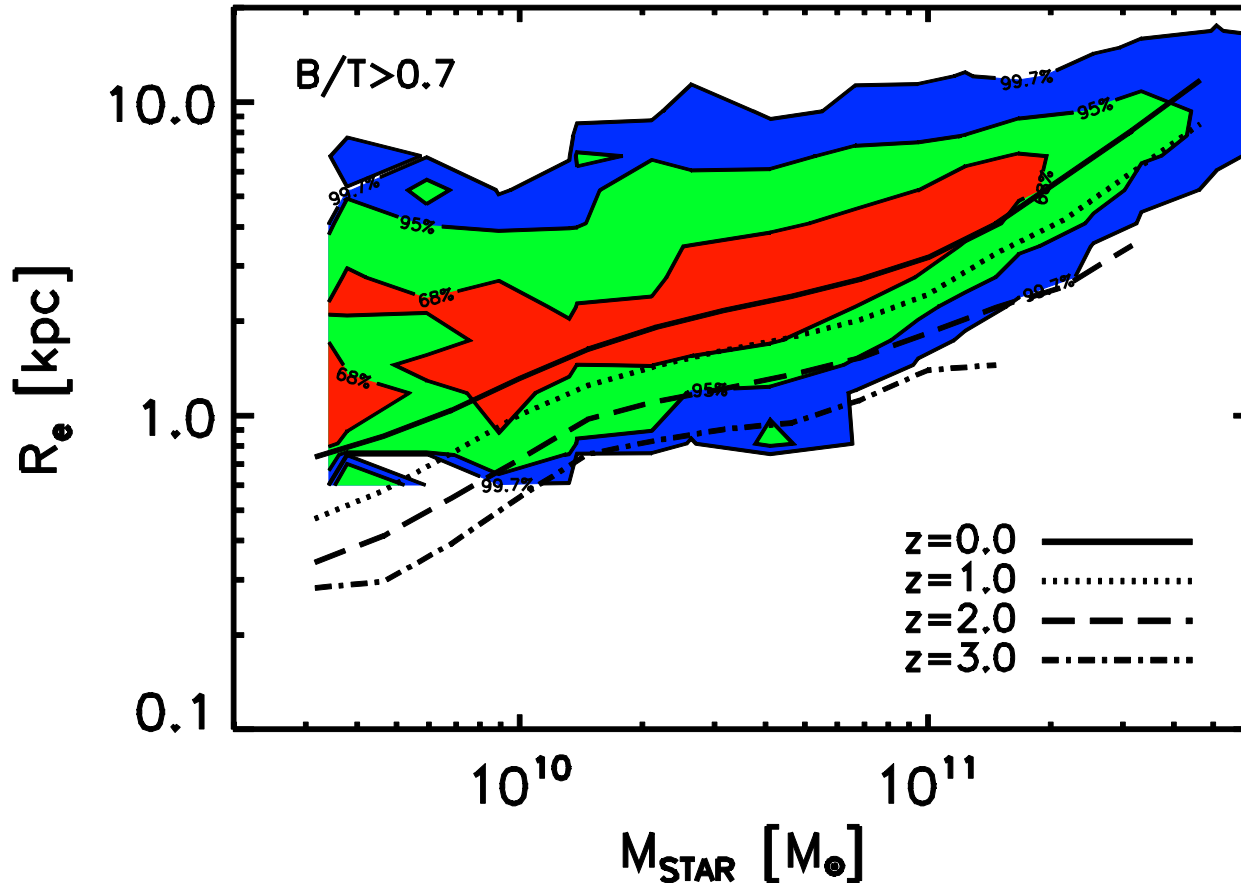Whittle et al.

I: Size Evolution of Galaxies

FS,.., Bernardi, Mei, et al. 2011

ETGs of fixed stellar mass at higher redshifts are MORE COMPACT!

(see Rettura, Huertas-Company… and posters by Delaye,…)

Damjanov et al..

I: Size Evolution of Galaxies

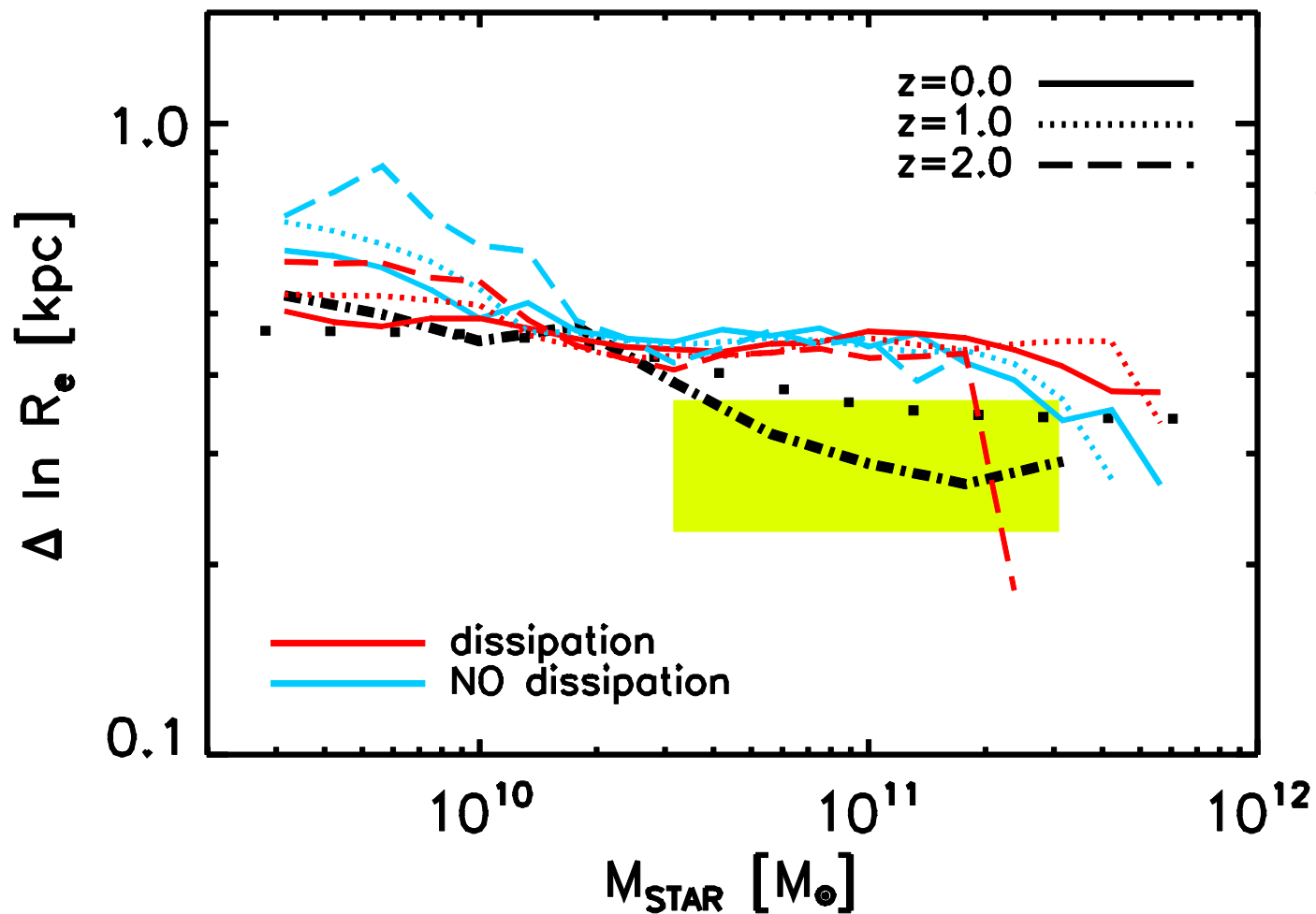FS,.., Bernardi, Mei, et al. 2011

ETGs of fixed stellar mass at higher redshifts are MORE COMPACT!

(see Rettura, Huertas-Company... and posters by Delaye,...)
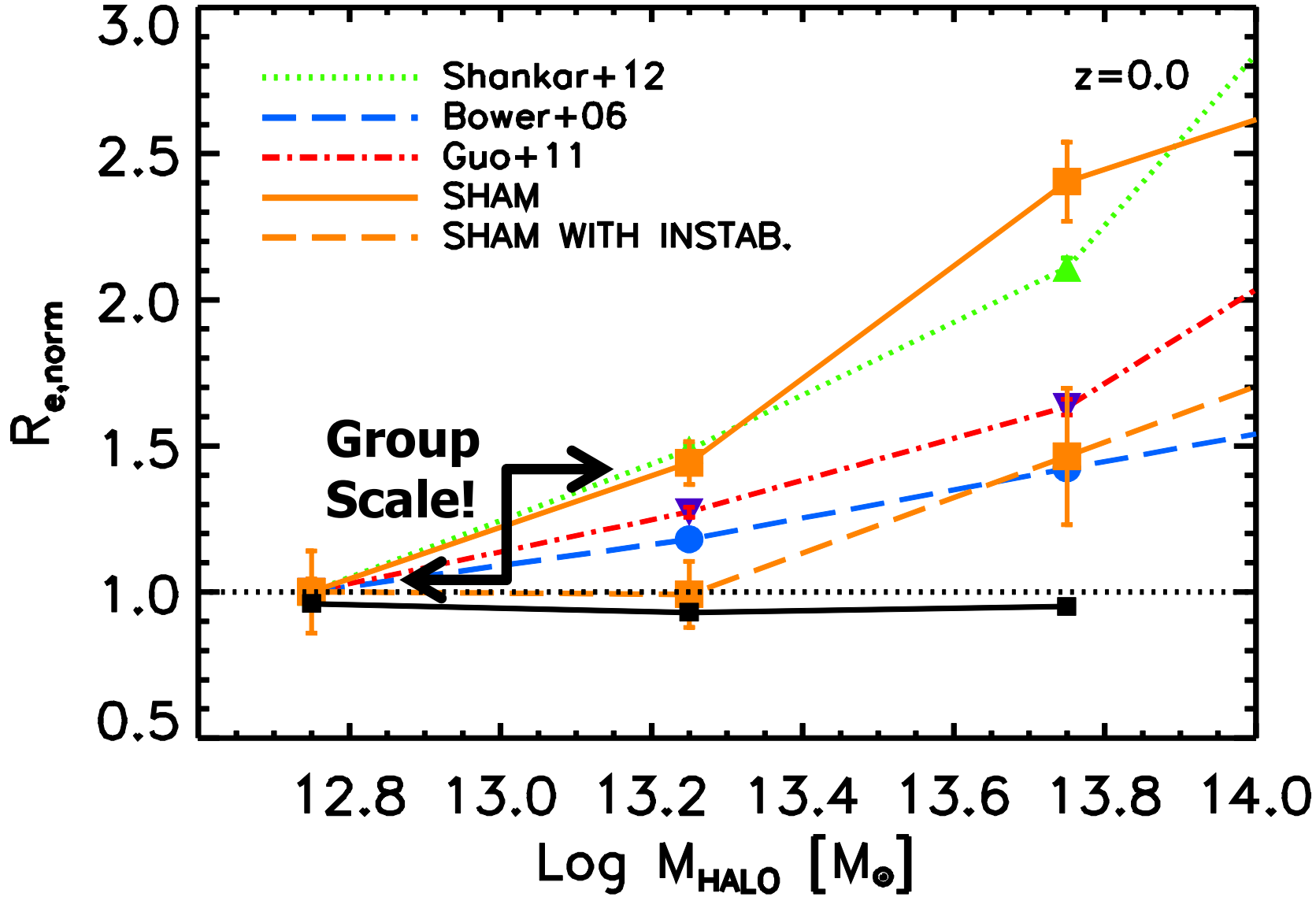
In models possibly <u>NOT</u> as compact as observed!

II: Scatter in scaling relations

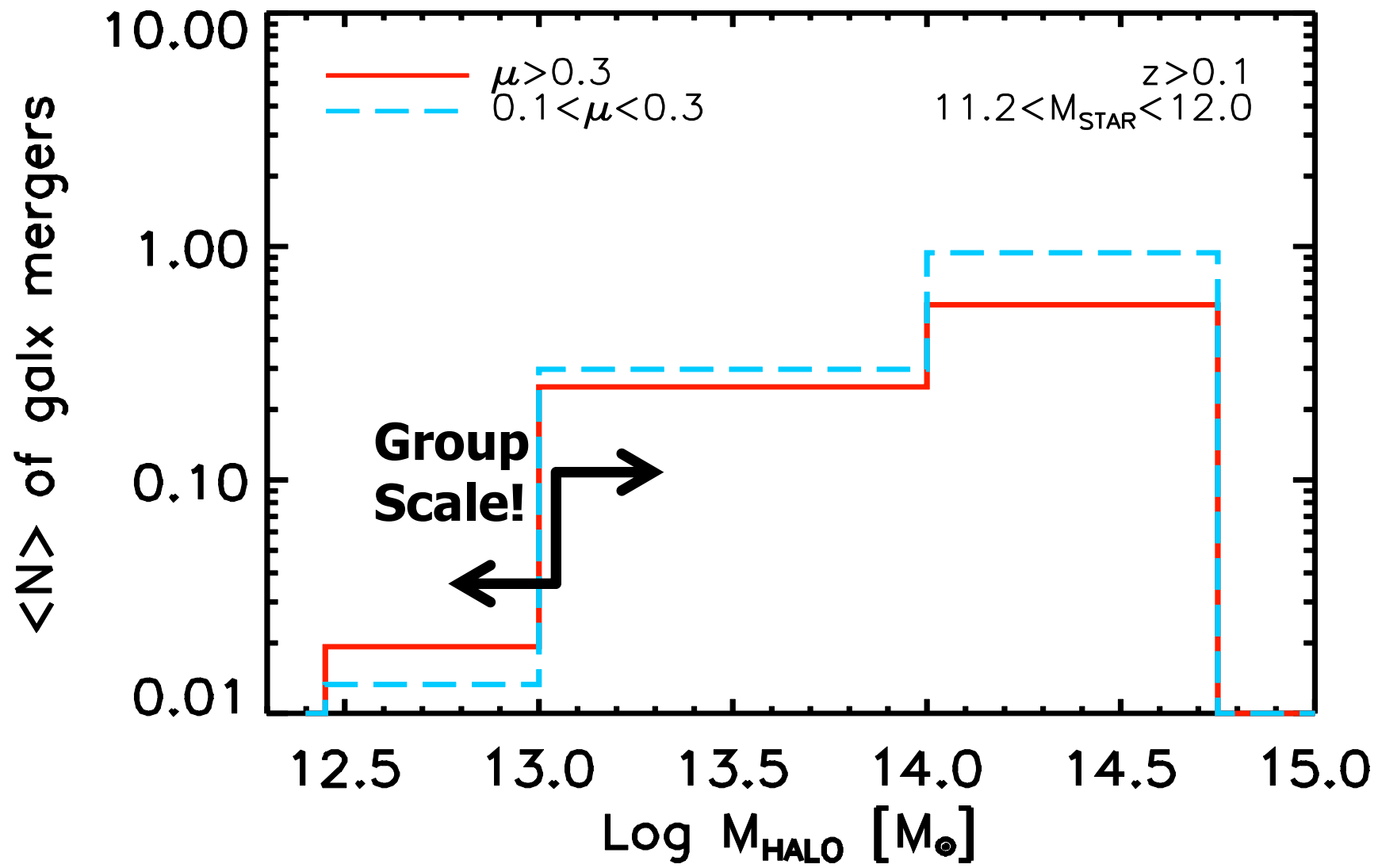**Larger scatter** by a factor of 2 at high masses predicted by Merger models!

FS et al. 2011

III: Role of Environment
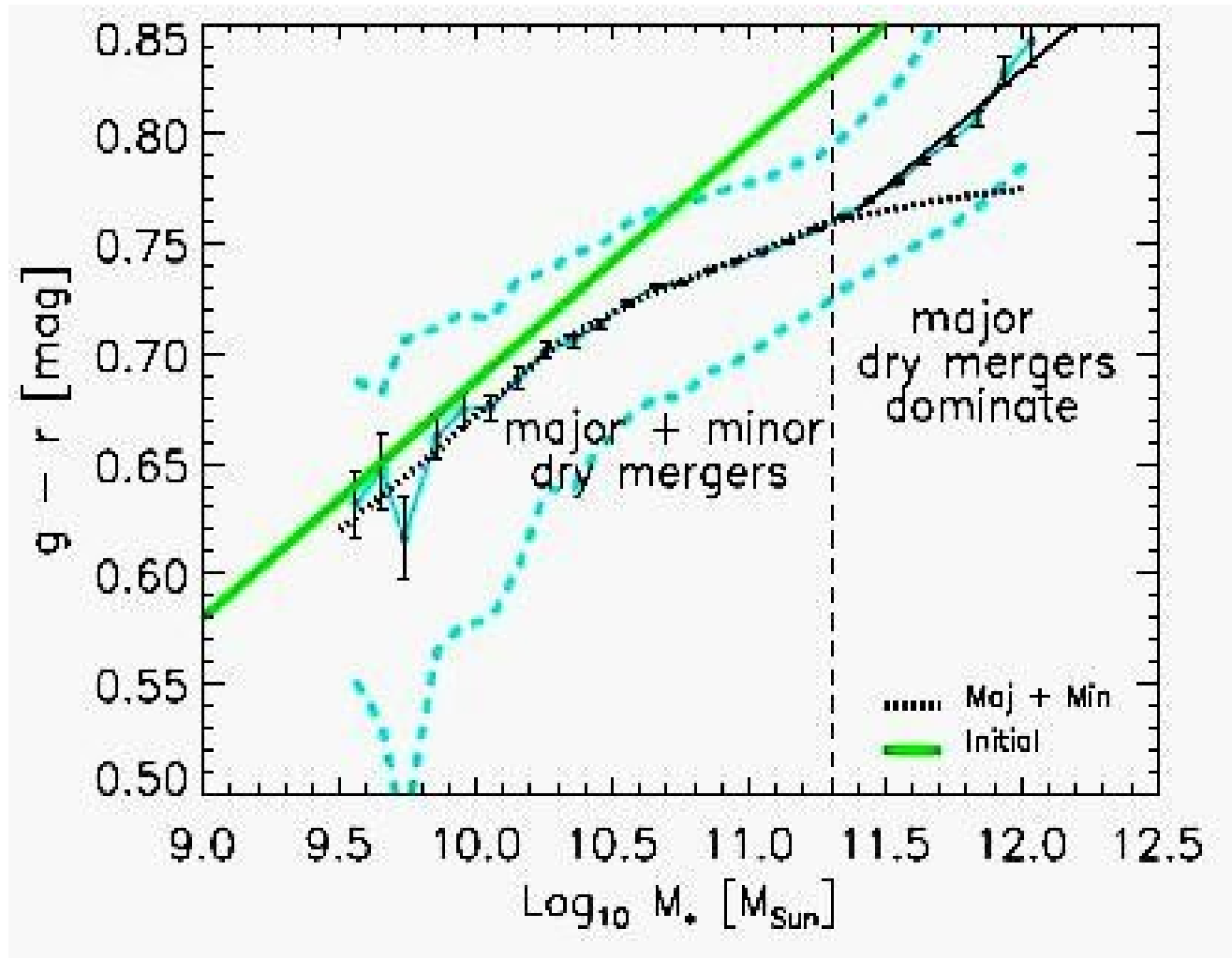
(see Bassett, Hatch, Huertas-Company, Muzzin, Patel, Rettura….)

FS et al. 2012, Huertas-Company, Mei, FS, et al. 2012

III: Role of Environment

(see Bassett, Hatch, Huertas-Company, Muzzin, Patel, Rettura....)

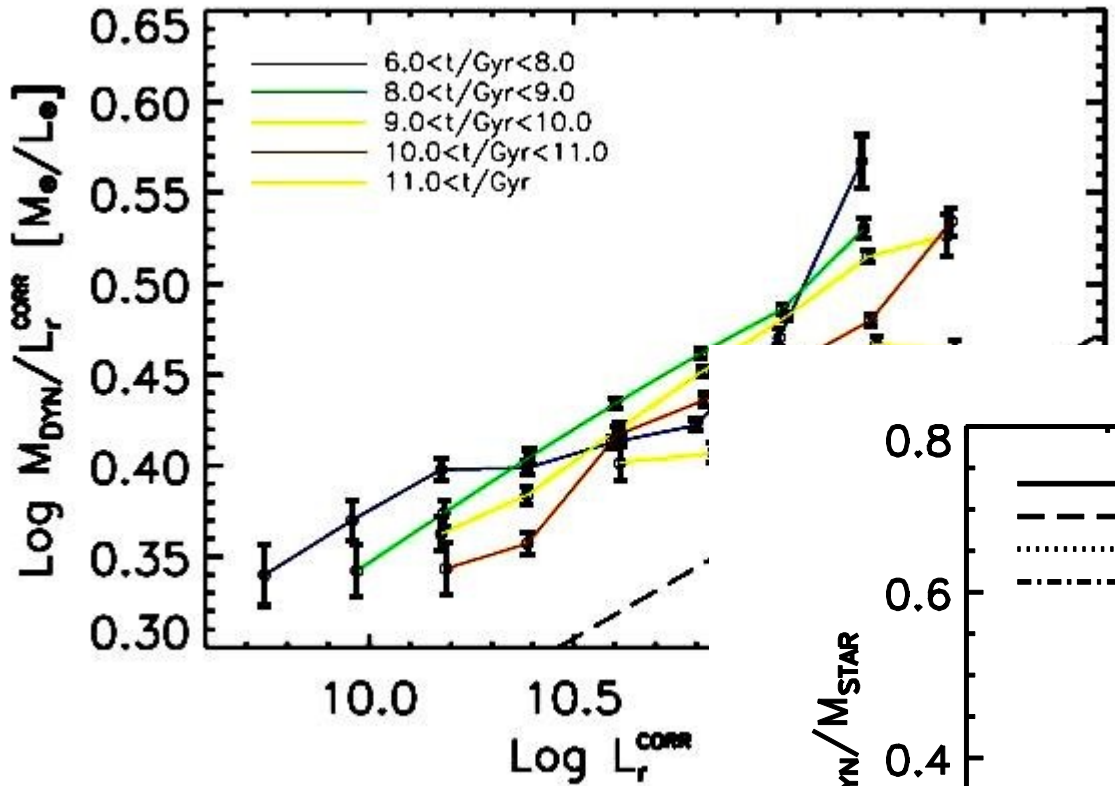FS et al. 2012, Huertas-Company, Mei, FS, et al. 2012

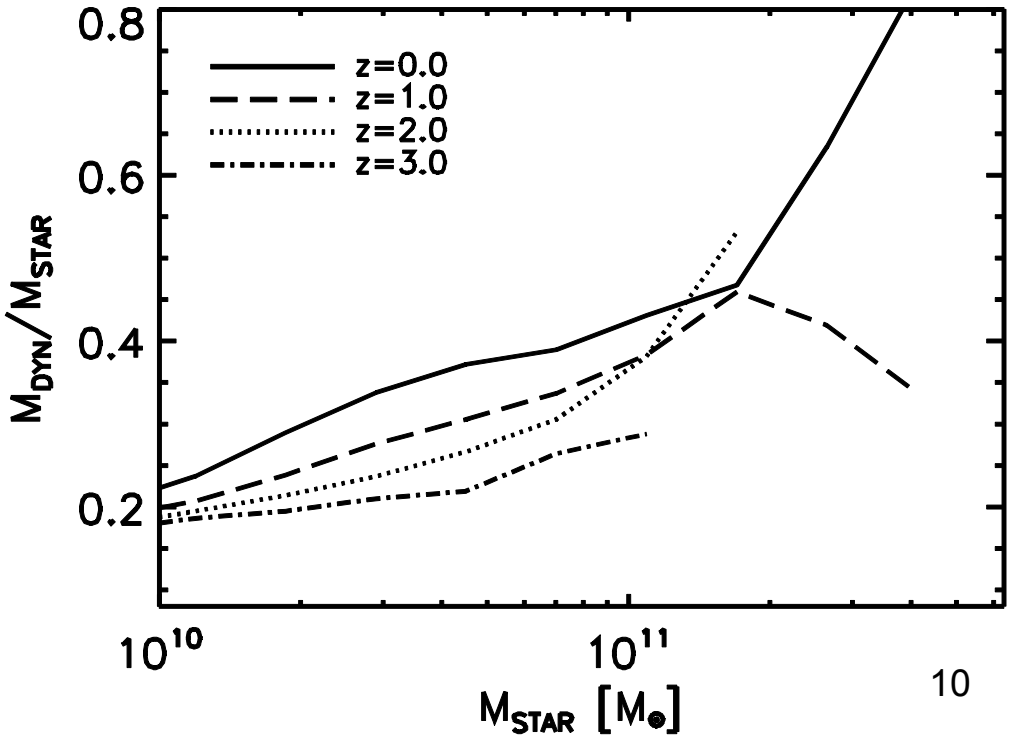# IV: Colour Evolution of Galaxies (see poster by Cerulo+)

Significant *Curvature* in the Color-Magnitude relation of early-type galaxies: sign of mergers?!?

Mei et al. 2006; Bernardi et al. 2011a,b
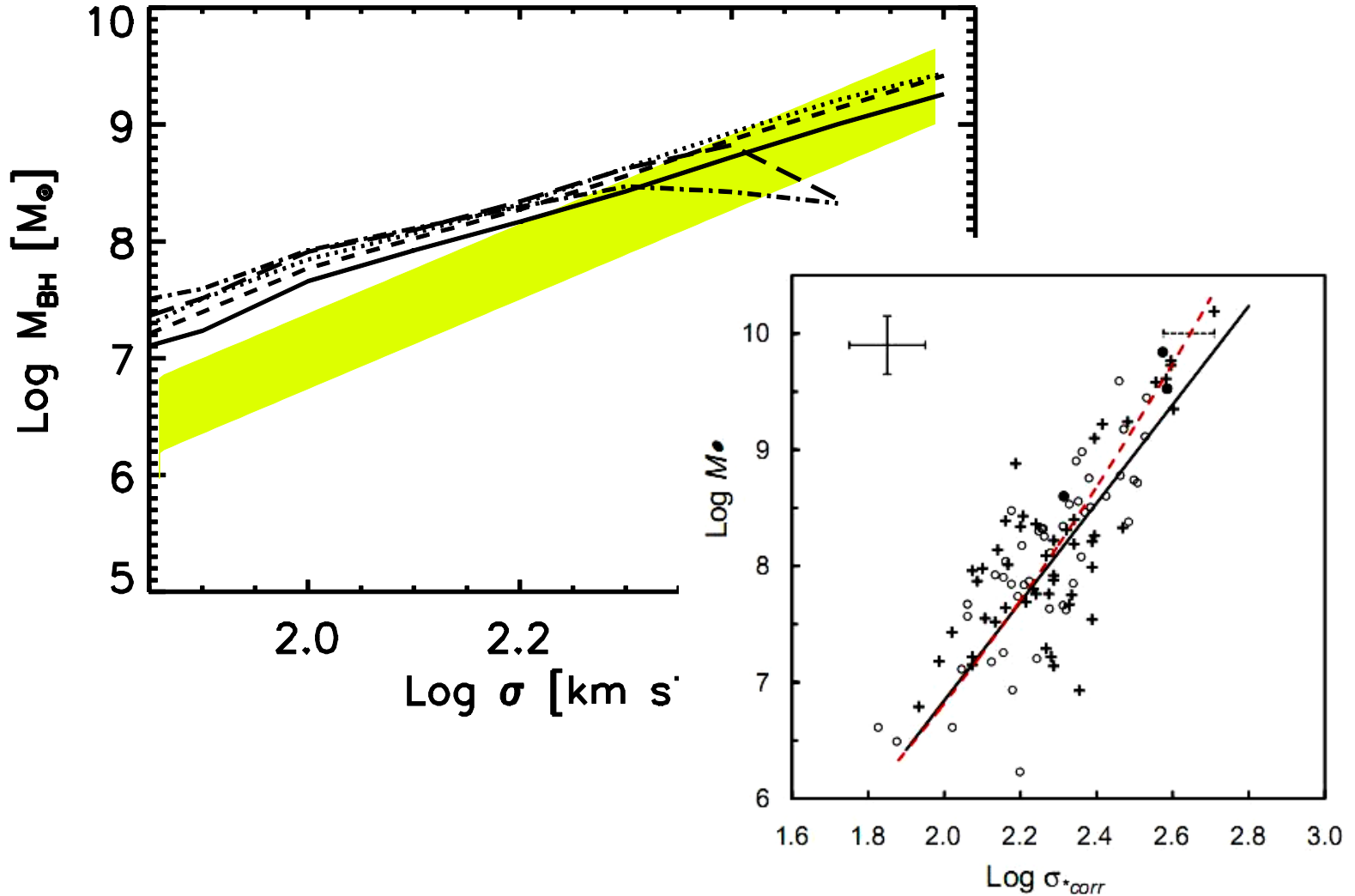
V: The Fundamental Plane and its evolution

$$\sigma^2 = k \frac{GM}{R}$$

FS & Bernardi 2009

VI: Evolution of the Mbh-sigma

Gaskell 2009

CONCLUSIONS

z-evolution weak and
Large Scatter

Clear significant signal
with Environment!

Strong non-linearities
in the CMR! Major Mergers?

Careful about velocity
Dispersions and BH masses!

francesco.shankar@obspm.fr