The Role of Environment in the Growth of Disk Galaxies

- Evolutionary trends in the COSMOS field since z ~ 1 -

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SUMMARY

Goal: Study the evolution of structural & stellar components of large disk galaxies situated in different environments

Results: No strong environmental effects on large/massive disk galaxies in the range z<1, in particular:

1) the star formation rate (SFR) declines equally quickly with redshift in all density regimes and it also does not depend on the size of the bulge hosted by the disk.
2) in all environments the stellar populations of bulged systems are more mature than in late type disks.
3) A possible trend for the fraction of bulged systems to reach its present value more quickly in dense than in sparse regions may exist.

SAMPLE FACTS

- 1.7 deg^2 of HST *I*-band imaging in the COSMOS field
- structural measurements (non-parametric (*ZEST*) & Sérsic fits: Scarlata et al., '07; Sargent et al., '07)
- 27,000 disk galaxies with I_{AB} < 22.5, **divided into sub-classes** according to bulge-to-total ratio (*B/T*)
- **large** disk galaxies ($r_{1/2}$ > 5 kpc) **complete out to z~1**
- stellar mass & photo-z with $\sigma_{z/(1+z)}$ = 0.007 (Ilbert et al., '09)
- environmental density based on the zCOSMOS 10k sample (Kovac et al, '09; Lilly et al, '07)
- MIPS 24 μm counterparts/flux limits (Sanders et al., '07)

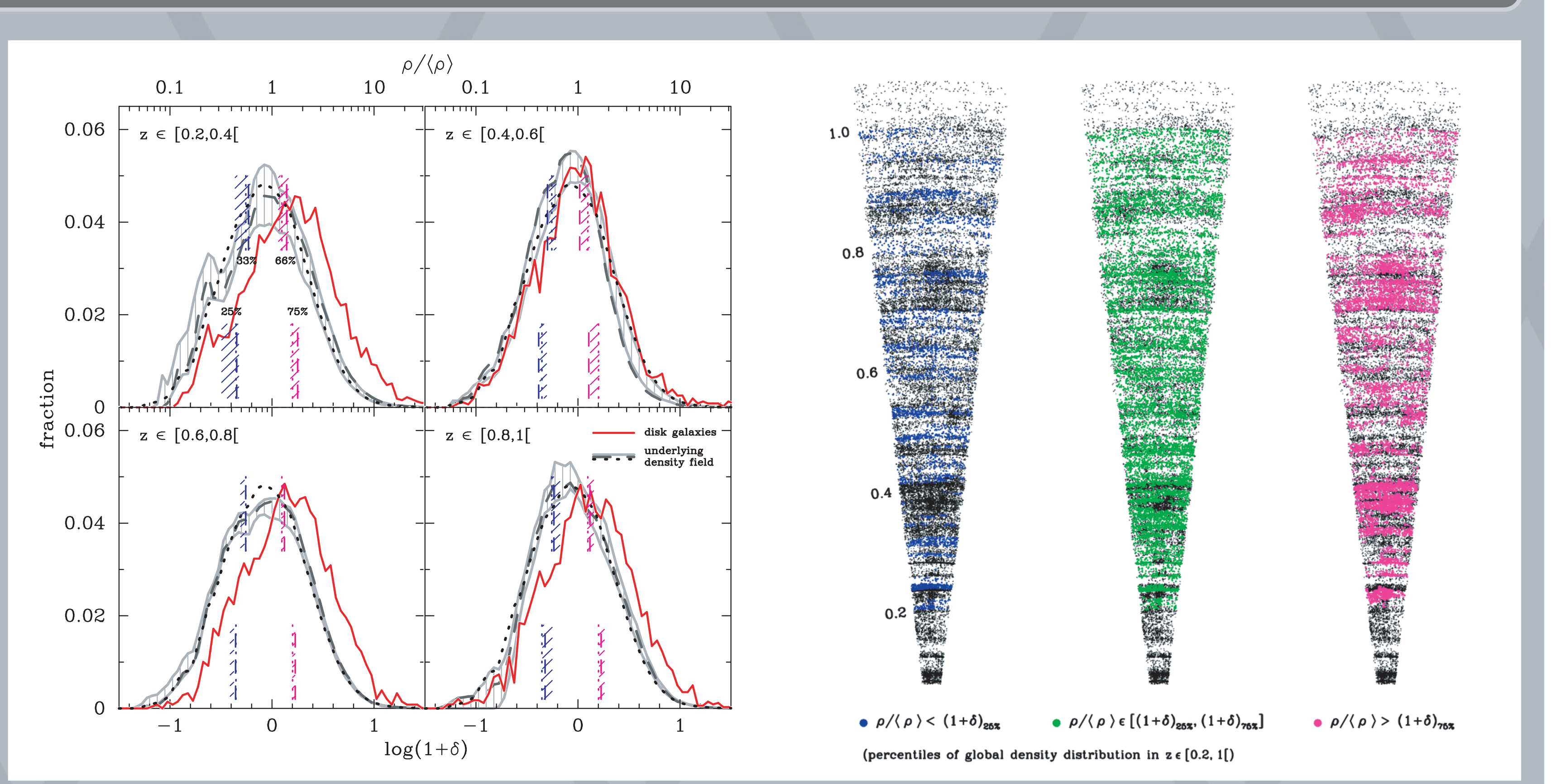

Fig. 1 (*left*) - Definition of density regimes using percentiles of the distribution of comoving overdensities: light grey - running bins of width Δz=0.2; dark grey - discrete bins; black - single bin 0.2<*z*<1. Red curve - density distribution of zCOSMOS galaxies. (*Right*) Density structures at 0.2<*z*<1 (collapsed in Dec.; angular scale increased tenfold).

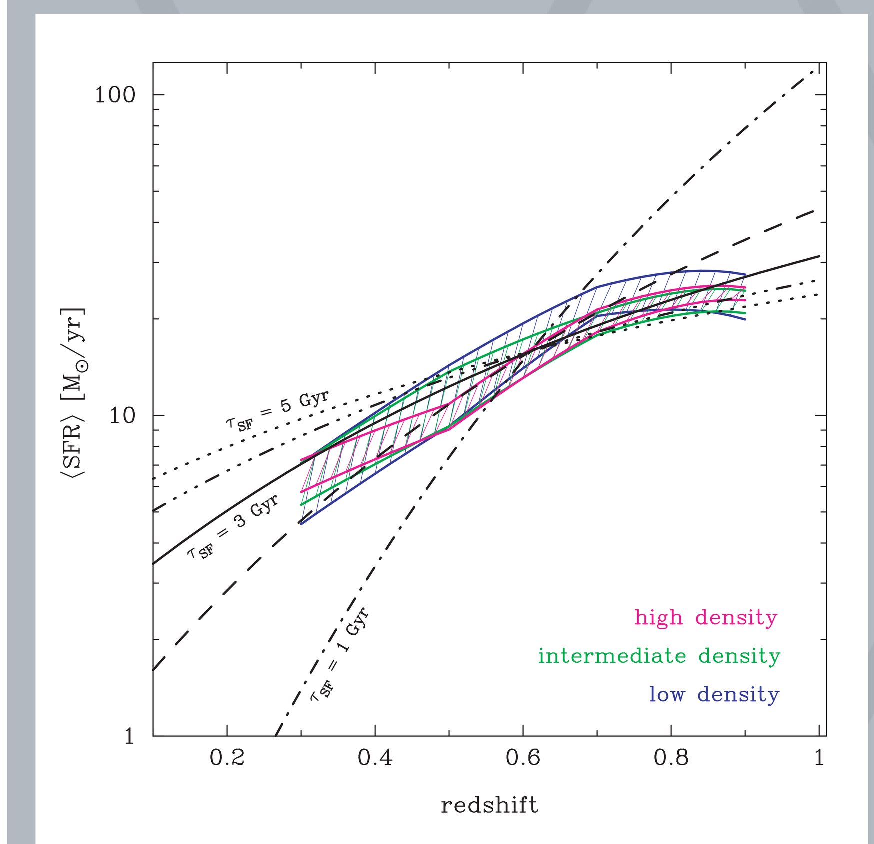

Fig. 2 - Evolution of the median SFR of large disk galaxies (including all *B/T* categories) in different environments since z~1. The black lines show the expected trend of the SFR in the case of exponentially declining star formation activity with time constants in the range 1 Gyr<τ_{SF}<5 Gyr (arbitrarily normalized to the centre of the studied redshift range). τ_{SF}~3 Gyr is favoured (cf. also Lilly et al., '98; Zheng et al., '07).

SF-RATE & MATURITY

Star formation rates are computed from total IR luminosities (Bell, '03) based on 24 μm fluxes assuming the IR SED of M82. Because not all galaxies have a mid-IR counterpart we derive the median value of the SFR & maturity parameter t_{SF}/t_H (Scoville et al, '07; t_H - Hubble time; t_{SF} = M_*/SFR;) with **survival analysis** (cf. Feigelson & Nelson, '85), thus accounting for upper limits in SFR from non-detections at 24 μm.

The evolution of the SFR with time is independent of the size of the bulge component. In Fig. 2 we show that it is also **independent of environment** & decreases by a factor ~5 from z~1 to 0.3.
Similarly the stellar populations of large early & late type disks mature at the same rate & almost unaffected by the density field (Fig. 3). However, **bulged disks are always more mature than late type** disk galaxies.

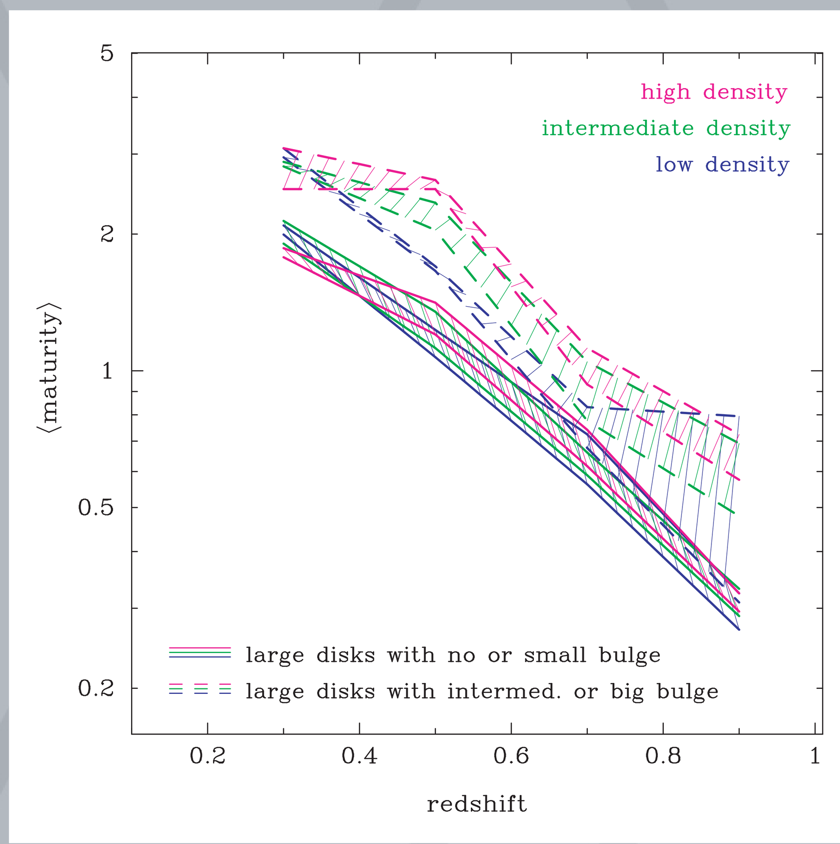

Fig. 3 - Evolution of the median maturity of large bulged (dashed lines) & bulgeless (solid lines) disk galaxies as a function of environment. At all redshifts the average late-type disk *has experienced significant star formation activity more recently* than the maturer, bulged disks. In both classes, the maturing of the stellar populations with cosmic time proceeds identically, regardless of environment

BULGE GROWTH

The fraction of disk galaxies with a prominent bulge increases by about **20% between z~1 & 0.2** (not shown here; note that the increase in the fraction of early type disk galaxies is smaller if they are defined by a cut in the Sérsic index). Superimposed on this observation there appears to be a trend for the fraction of bulged disk galaxies to rise to the low *z* value early on if the environmental density is high while in regions of low density it is **reached at later times** (see Fig. 4).

If confirmed (Sargent et al., '09), this finding could mean that:

i) externally induced secular evolution (Kormendy & Kennicutt, '04) transforms big disks more quickly in dense environments,
ii) bulges grow more quickly and are hence identified earlier in dense environments.

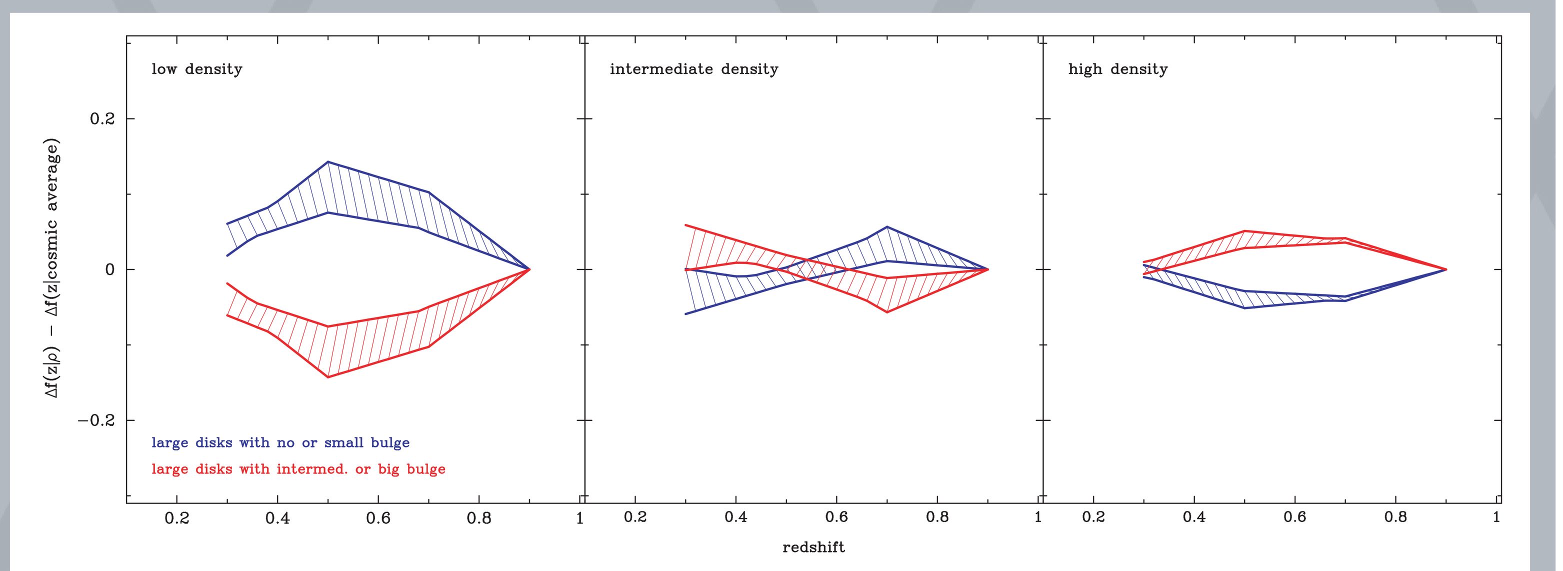

Fig. 4 - Relative timing of the increase in the fraction of significantly bulged disks (red) in 3 distinct density regimes, compared to the increase averaged over all environments at a given redshift, Δf(z|cosmic average). Negative values imply a *lag* in the build-up of the fraction in a specific environment.

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