VELOCITY DISPERSIONS OF COMPACT ETGs at z ~1.4: CONSTRAINTS ON INITIAL MASS FUNCTION

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1. Introduction

The stellar initial mass function (IMF), i.e. the mass spectrum of a stellar generation, is a key parameter in our understanding the galaxy formation and evolution. For example, many tests of galaxy formation models are based on stellar mass estimates that are derived assuming an IMF, currently supposed to be universal in time and space. Under the IMF universality assumption, it was found that at fixed stellar mass M_{star}, massive (M_{star}> $10^{10}M_{sol}$) ETGs show a remarkable (~ 2 order of magnitude) spread in their mean stellar mass density Σ ($\Sigma=M_{star}/(2\pi R_e^2)$, where R_e is the effective radius, i.e. the radius containing half of the total light) at least up to <z>=1.4 (see Fig. 1). However, very recently, differently from what is assumed, it was shown that the IMF of typical ($\Sigma<3000M_{sol}/pc^2$) local ETGs varies with their velocity dispersion σ. Despite the recent findings, two open questions still persist: is the IMF time independent? Densest ($\Sigma>3000M_{sol}/pc^2$) ETGs have the same IMF of typical ETGs?

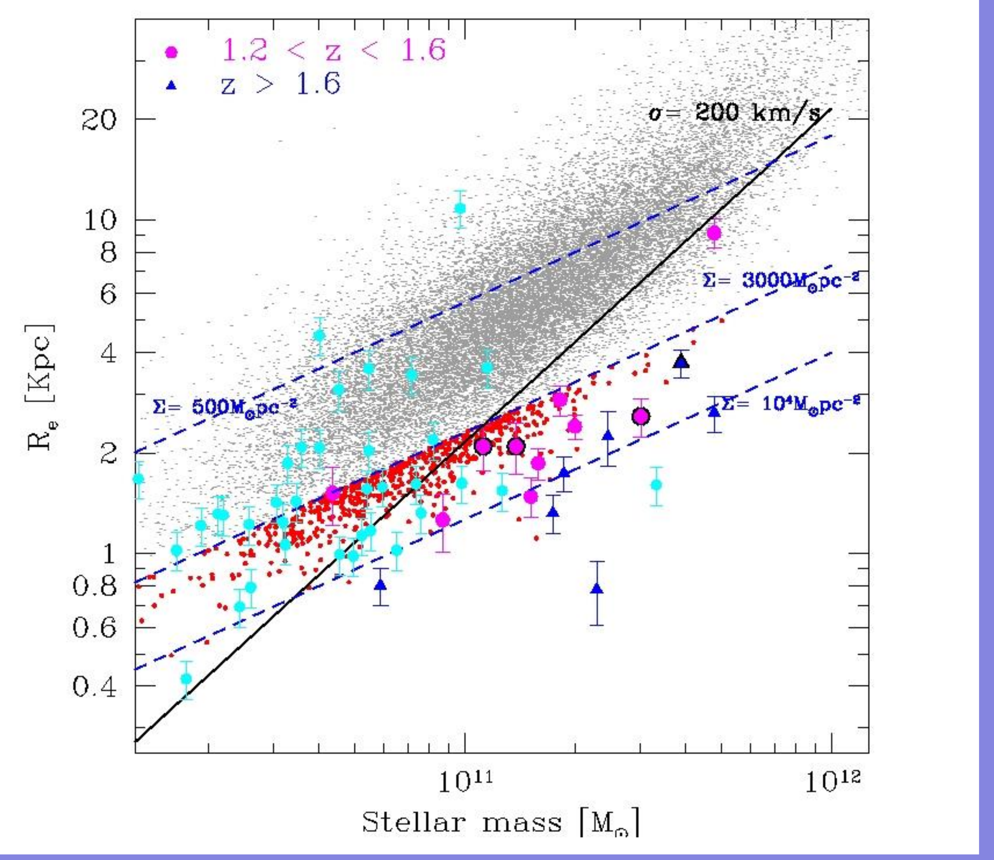

Fig 1: Size-mass relation (SMR) for local SDSS ETGs (grey and red points) and for ETGs at z~1.4 (cyan points). Magenta (blue) symbols are ETGs at <z> = 1.4 (1.8) with σ available. Black contours highlight the 4 ETGs presented here. Red points are local ETGs with $\Sigma>3000\ M_{sol}/pc^2$. Black line indicates line of constant velocity dispersion while blue one of constant Σ.

2. VLT-FORS2 spectra of compact high-z ETGs

We obtained VLT-FORS2 optical spectra (8-hours effective total integration time, Fig. 2) for 4 ETGs in the redshift range 1.2<z<1.9 to measure their velocity dispersions. HST/NIC2-F160W images (FIG. 3) allowed to derive their R_e (2.1 kpc < R_e < 3.4 kpc, Longhetti et al. 2007) while stellar masses were derived by fitting their SED ($1.1\times10^{11}M_{sol}$ < M_{star} < $4\times10^{11}M_{sol}$) (see Fig. 1 contoured points).

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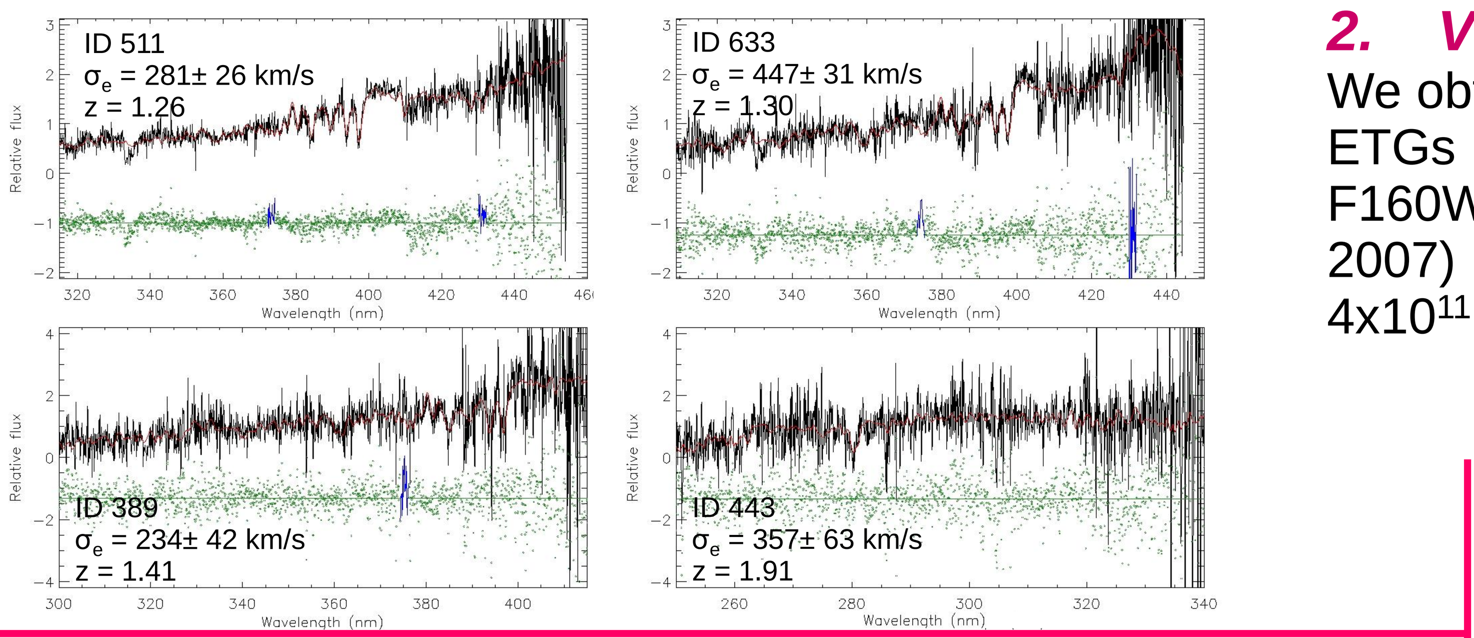


Fig. 2: VLT-FORS2 optical not rebinned and unsmoothed spectra for 4 dense ETGs at 1.26<z<1.9 (black lines). Red lines are the best fit models derived with the software ppxf (Cappellari et al. 2004). In each panel the ID, the velocity dispersion and the redshift are reported.

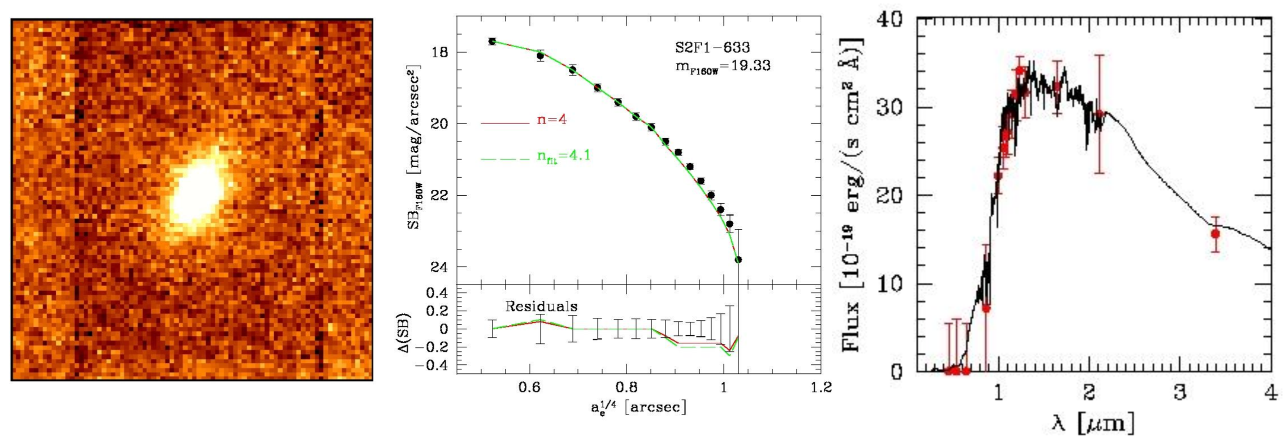


Fig. 3 From left to right: As example, NIC2 image for the ETG 633, its best-fit Sersic light profile model (green line) compared to the observed one (black points), and its best-fit model (black line) of the observed SED (red points).

2.1 The samples

High-z dense ETGs sample :
10 ETGs at 1.2<z<1.6 with $\Sigma>3000\ M_{sol}/pc^2$ and σ, R_e derived in F160W filter, and M_{star} available (magenta points Fig. 1). Since high-z ETGs show clear color gradients (Gargiulo et al. 2011, Gargiulo et al. 2012) we restricted the selection between z=1.2 and 1.6 in order to sample approximately the R-band rest frame.

Local dense ETGs sample:
Local SDSS ETGs with $\Sigma>3000\ M_{sol}/pc^2$ and σ, R_e derived in R band and stellar masses available (Bernardi et al. 2013). The stellar masses of both samples were derived with a Chabrier IMF.

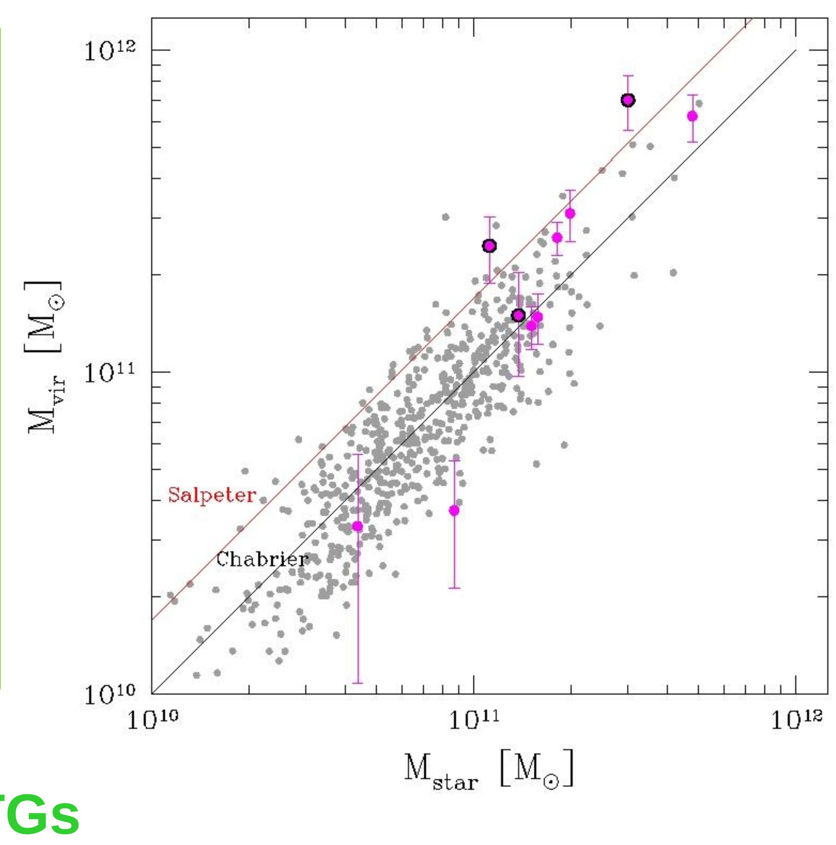
3 RESULTS

In Fig. 4 the virial masses M_{vir} ($\propto$ Re σ_e^2) of local (grey points) and high-z (magenta points) dense sample are reported as a function of M_{star} .

RESULT 1 : Structural and kinematics properties (i.e. R_e, σ_e, M_{star}) of our high-z dense ETGs are consistent with those of local dense ETGs.

M_{vir} of dense high-z ETGs progressively deviate from M_{star} → Massive dense ETGs have more massive IMF as local typical ETGs?

Fig. 4 M_{vir} vs. M_{star} derived with a Chabrier IMF for the high-z (magenta points) and local dense (grey points) sample. Solid lines set the one to one correlation for a Chabrier (black line) and for a Salpeter IMF (red line). Bear in mind that, on average, Salpeter IMF predicts stellar masses ~1.7 greater than that predicted by a Chabrier. Contoured points are the 3 ETGs at z~1.3 presented here.



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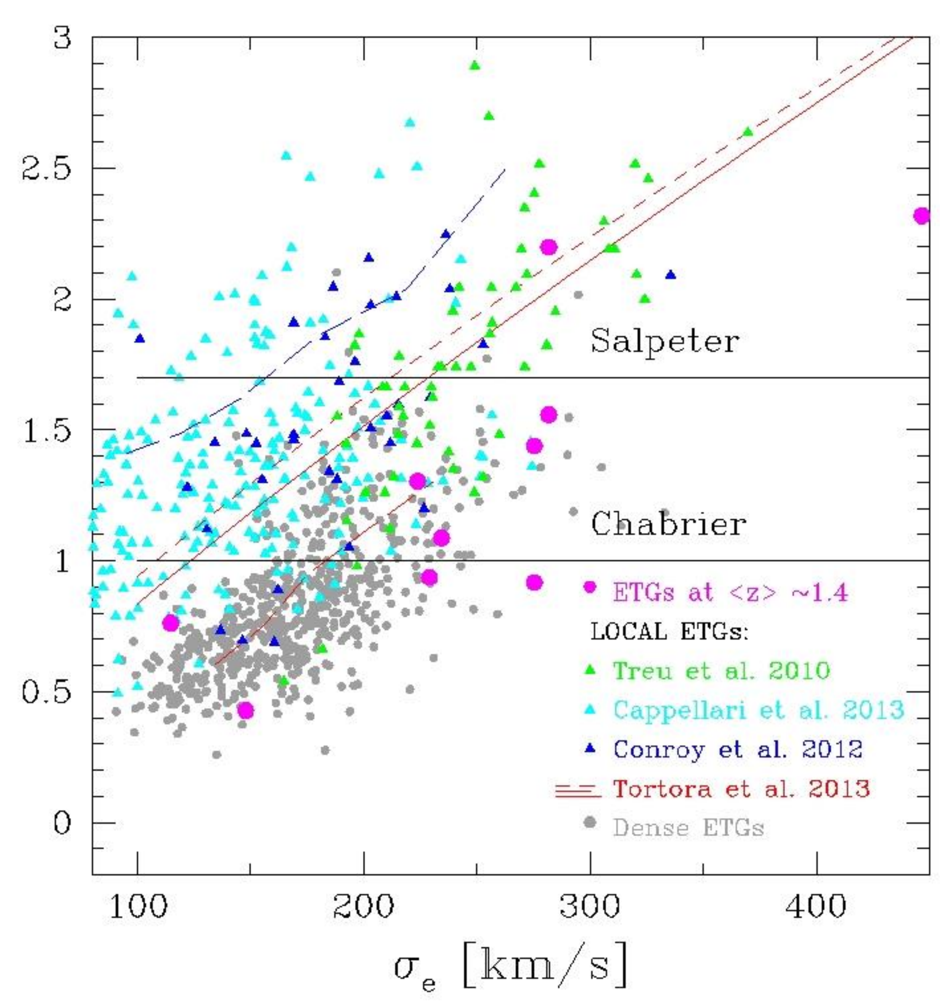

Fig. 5 The ratio Γ = M_{true}/M_{cha} vs σ_e for local ETGs (triangles + red lines). Magenta circles are the upper limit of Γ for high-z dense ETGs. Γ > (<) 1 indicates ETGs with true stellar masses greater (lower) than those predicted by a Chabrier.

3.1 IMF – σ trend in high-z dense ETGs

Recent local studies have shown that typical (Σ <~ $3000M_{sol}/pc^2$) ETGs with higher velocity dispersions have IMF more massive than those with lower σ. In Fig. 5 the ratio Γ = M_{true}/M_{cha} between the true stellar mass of typical local ETGs and those derived with a Chabrier IMF is plotted as a function of the σ within R_e, σ_e (triangles+red lines) (see also Ferreras et al. 2013, Spiniello at al. 2013, La Barbera et al. 2013). Assuming zero dark matter we derived the upper limit of the ratio Γ for high-z dense ETGs as $\Gamma_{up}= M_{vir}/M_{cha}$ (magenta points Fig 5).

RESULT 2: The IMF - σ trend of dense high-z ETGs is consistent with the IMF - σ trend of typical local ETGs.

3.2 Does the IMF – σ trend depend on mean stellar mass density and/or z?

At fixed σ_e the Γ of dense high-z ETGs is lower (~1.7 times) than the mean Γ of typical local ETGs → IMF evolution with z or sample selection effect?

In Fig. 5 grey dots are the $\Gamma_{up}= M_{vir}/M_{cha}$ of local dense ETGs.

FINAL RESULTS

The comparison of Γ_{up} of high-z and local dense ETGs shows that, at fixed velocity dispersion:

- **No significant (e.g Chabrier → Salpeter or viceversa) IMF evolution with redshift for ETGs;**
- **On average, dense ETGs have less massive IMF than typical ETGs at any redshift.**