Galaxy Color and Structure Dependence in the Scatter of the Fundamental Plane of Early-type Galaxies

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KIAS

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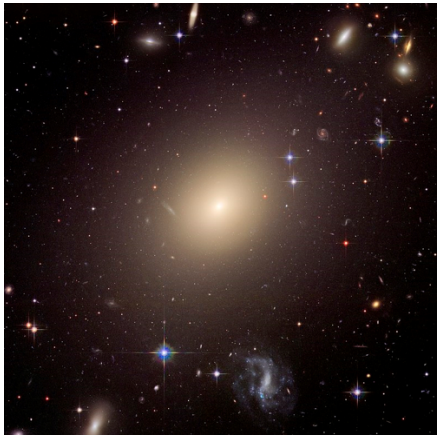
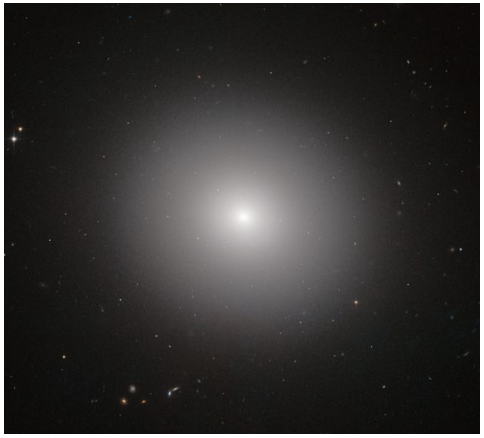
SSG Workshop

Introduction





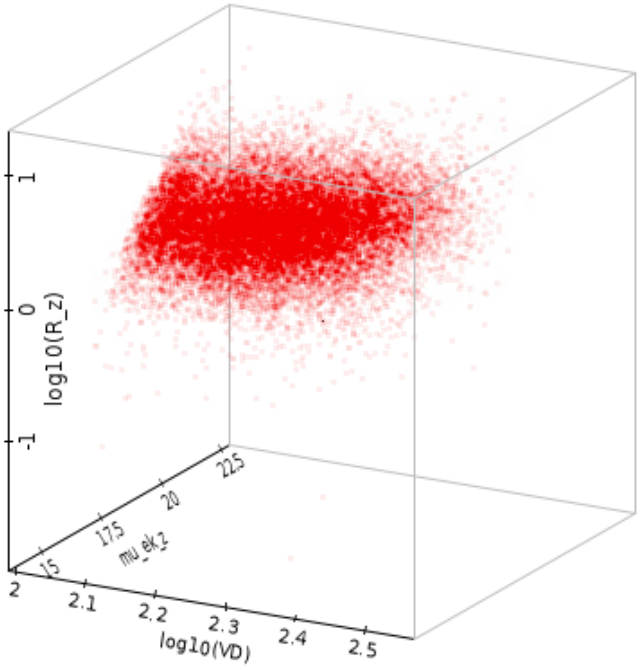
Virialized ETGs

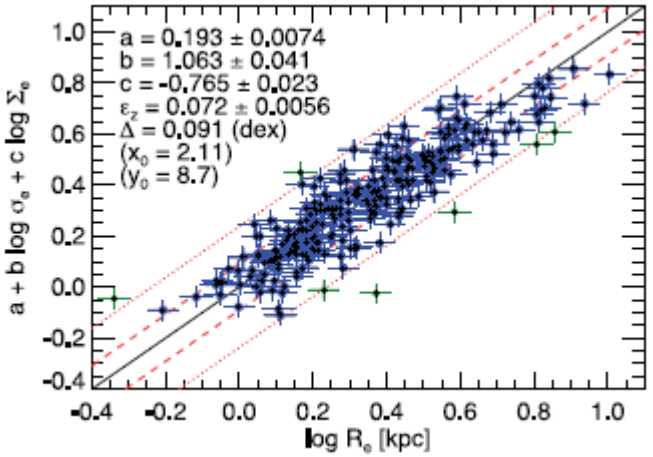
$$\sigma^2 \propto \frac{GM_{\rm dyn}}{R} \propto \frac{M_{\rm dyn}}{L} IR$$

Fundamental Plane

$$\log_{10} R_e = a \log_{10} \sigma_0 + b\mu_e + c$$

Introduction





Cappellari et al. 2013

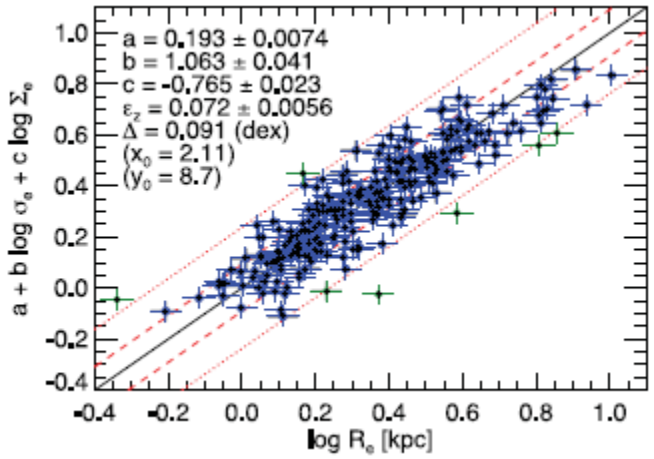
$$\log_{10} R_e = a \log_{10} \sigma_0 + b\mu_e + c$$

Used for studying **galaxy evolution (or merger) histories**

Used as a **standard ruler → distance measurements**

Introduction

$$\log_{10} R_e = a \log_{10} \sigma_0 + b\mu_e + c$$



Cappellari et al. 2013

Scatters of FP in previous studies using large survey data
(in the optical bands and in the direction of R_e)

: ~0.08 – 0.09 dex (~19 – 20%)

(Bernardi et al. 2003; Hyde & Bernardi 2009; La Barbera et al. 2010; Cappellari et al. 2013)

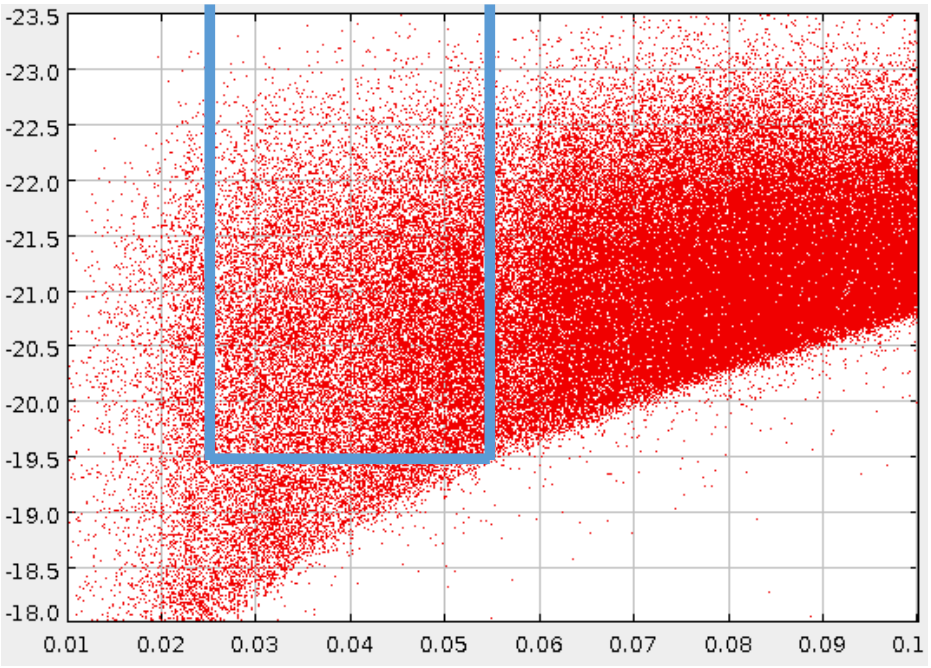
Can we reduce the scatter of FP?

Is there a subpopulation of ETGs having a small scatter?

Sample

SDSS galaxies classified as early types

in the KIAS value added catalog



$0.025 < z < 0.055$

$M_r < -19.5$

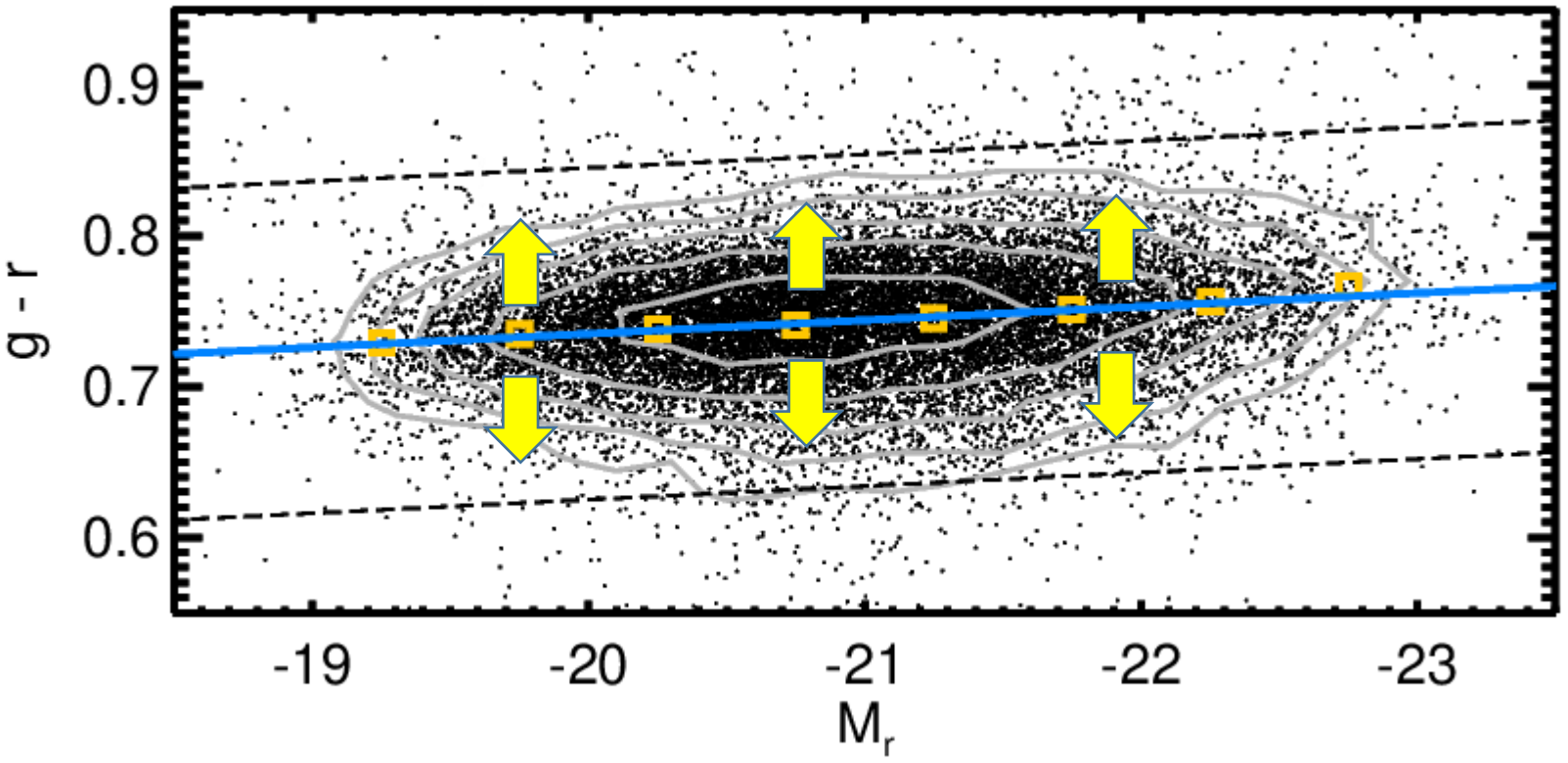
~16,000

Structure parameter: inverse concentration index (C_{inv})

$C_{inv} = R_{50}/R_{90}$, where R_{50} and R_{90} are the radii from the center containing 50% and 90% of the Petrosian flux, measured in i band with seeing correction.

Sample

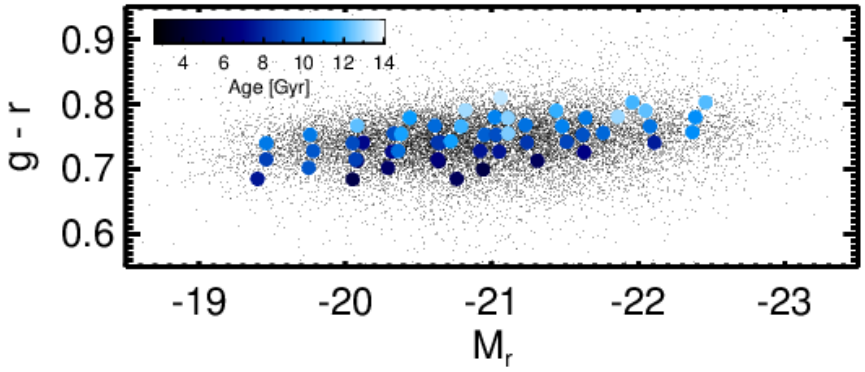
Color-magnitude diagram (CMD)



Early-type galaxies form a red sequence in the CMD.

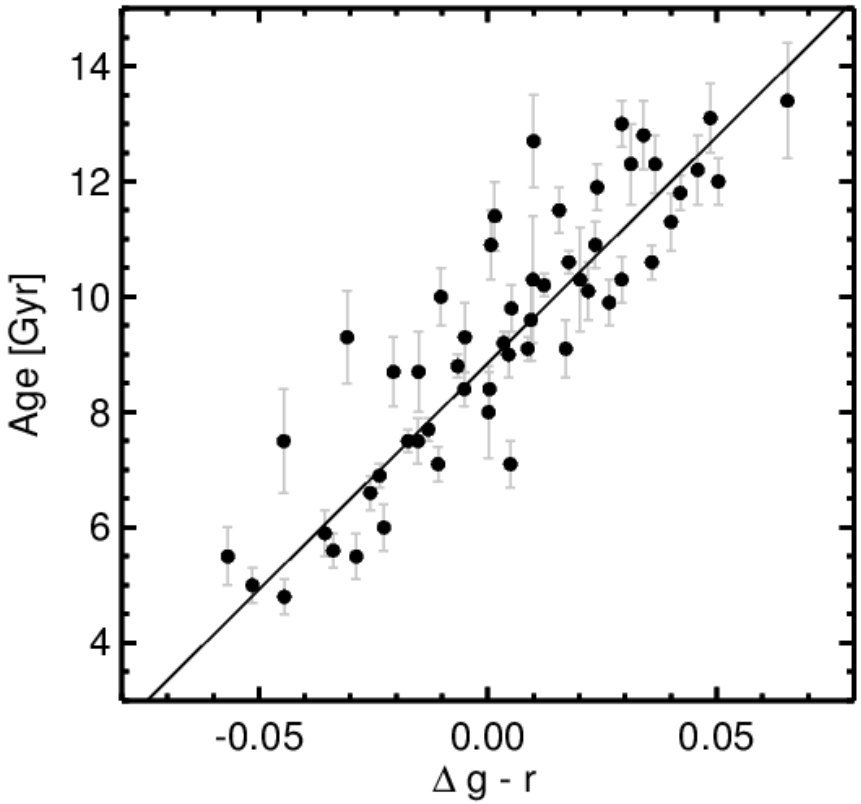
Use of the deviation of g-r (Δg-r) to make subpopulations

Sample



Δg-r vs age

Age information from the quiescent SDSS galaxies in Graves et al. (2009).



Δg-r is a very indicator of the age of ETG.

FP Fitting Method

Method in Cappellari et al. (2013)

Chi-square minimization after trimming outliers

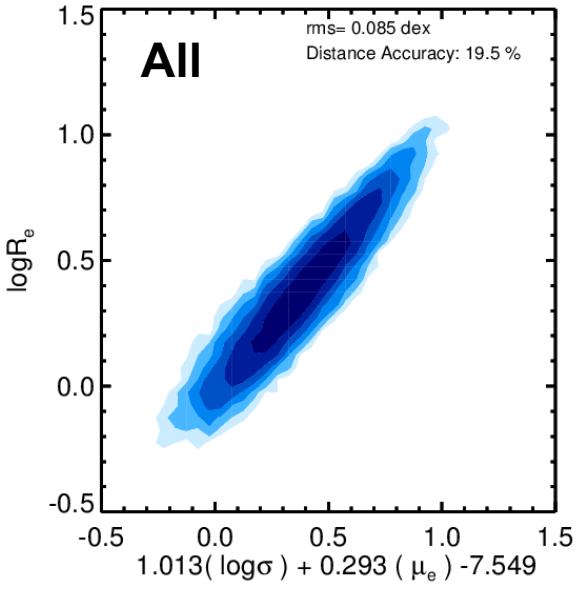
(Least trimmed squares robust fits)

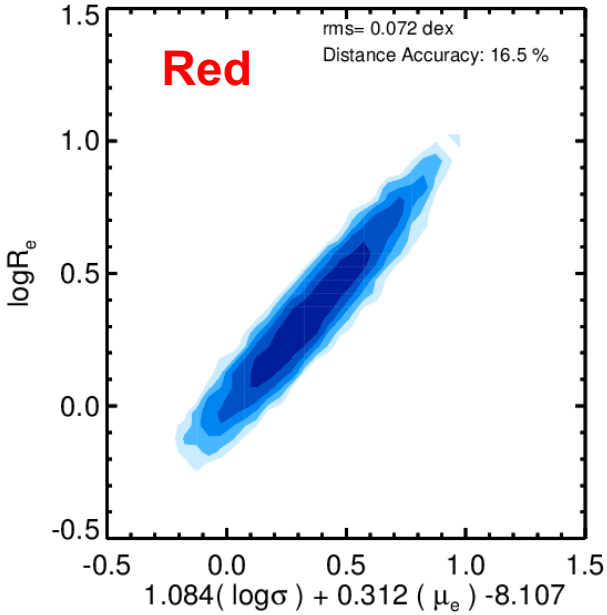
$$\chi^2 = \sum_{i=1}^{n} \frac{(ax_i + by_i + c - z_i)^2}{(a\Delta x_i)^2 + (b\Delta y_i)^2 + (\Delta z_i)^2 + \varepsilon^2}$$

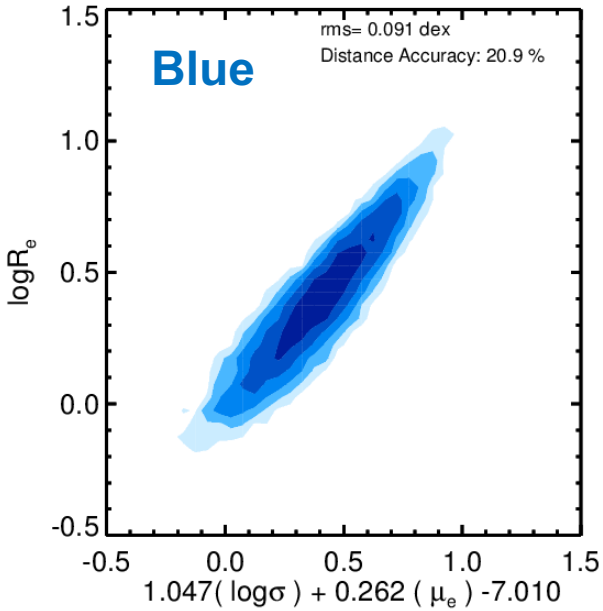
ε : intrinsic scatter

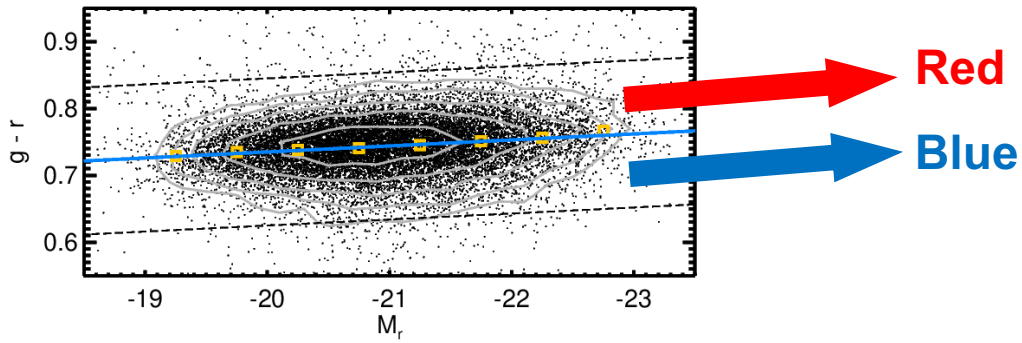
Results

$$\log_{10} R_e = a \log_{10} \sigma_0 + b\mu_e + c$$

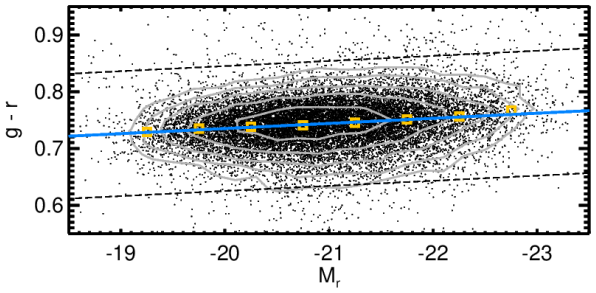




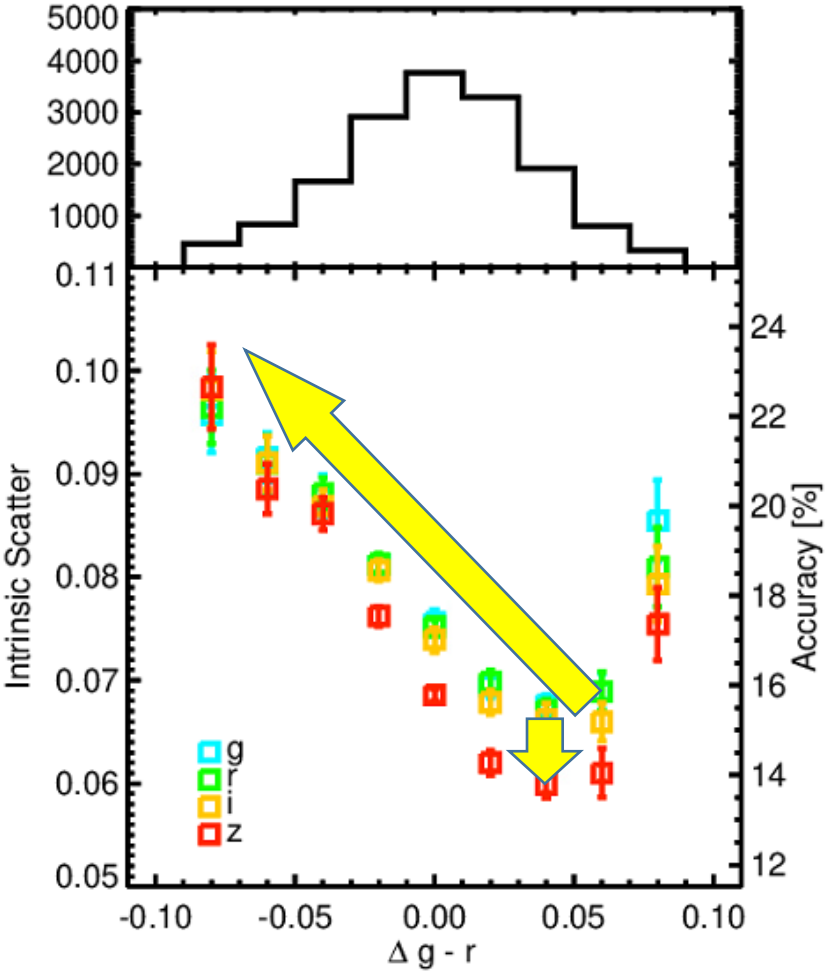




Results



FP scatter vs Δg-r

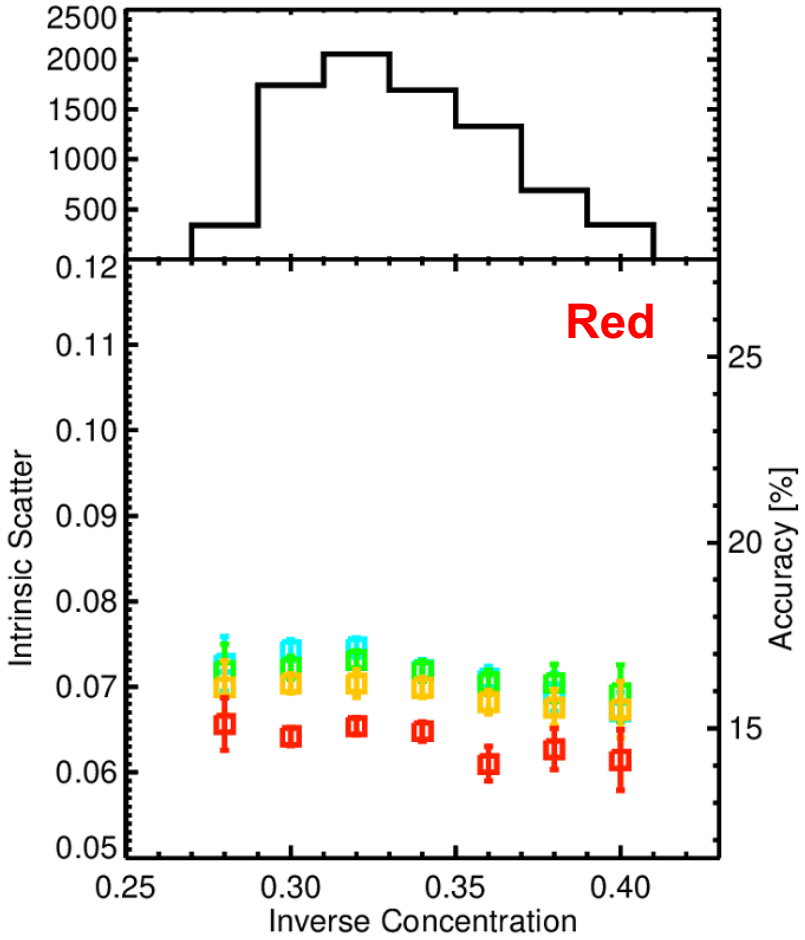


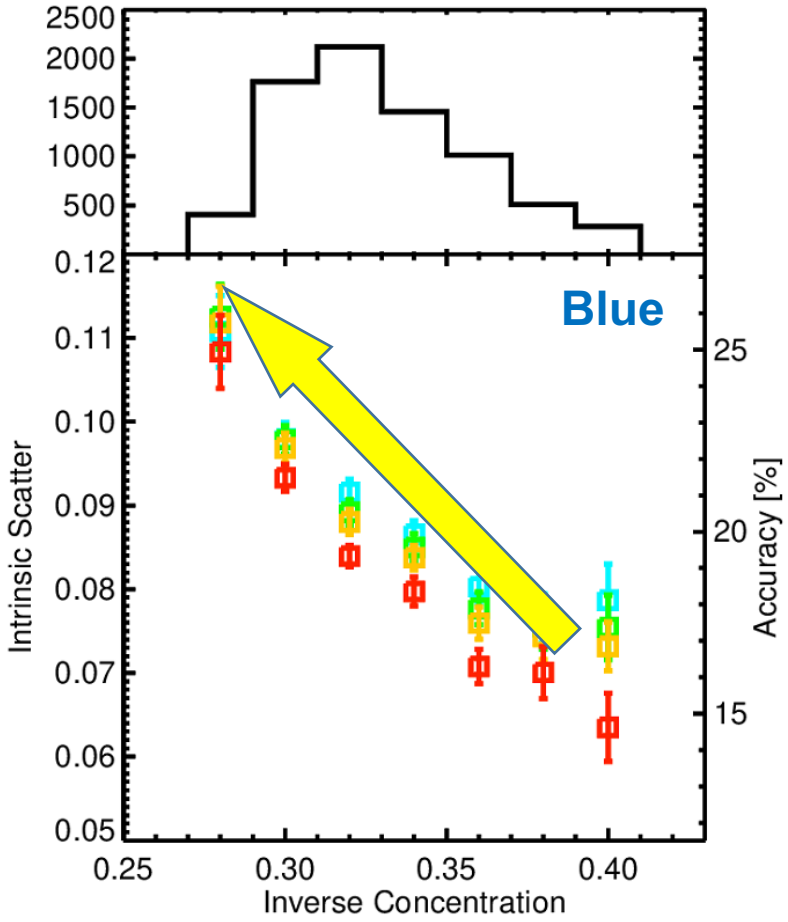
Younger (bluer) ETGs have larger scatters in FP.

The redder band shows a smaller scatter.

Results

FP scatter vs Compactness



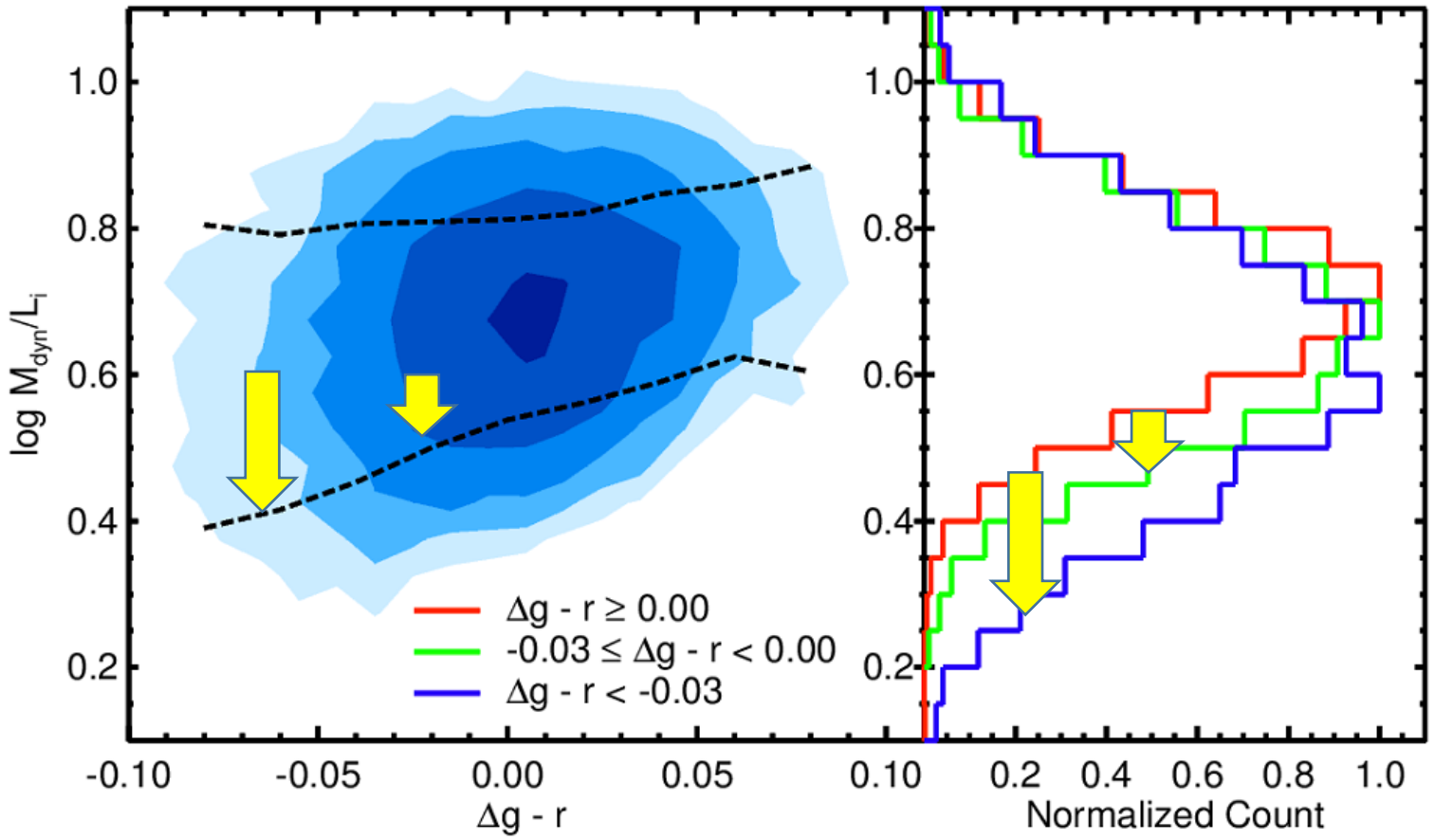


FP scatters of red (old) ETGs are not dependent on the compactness of the structures.

Young (blue) and more compact ETGs have larger scatters in FP.

Results

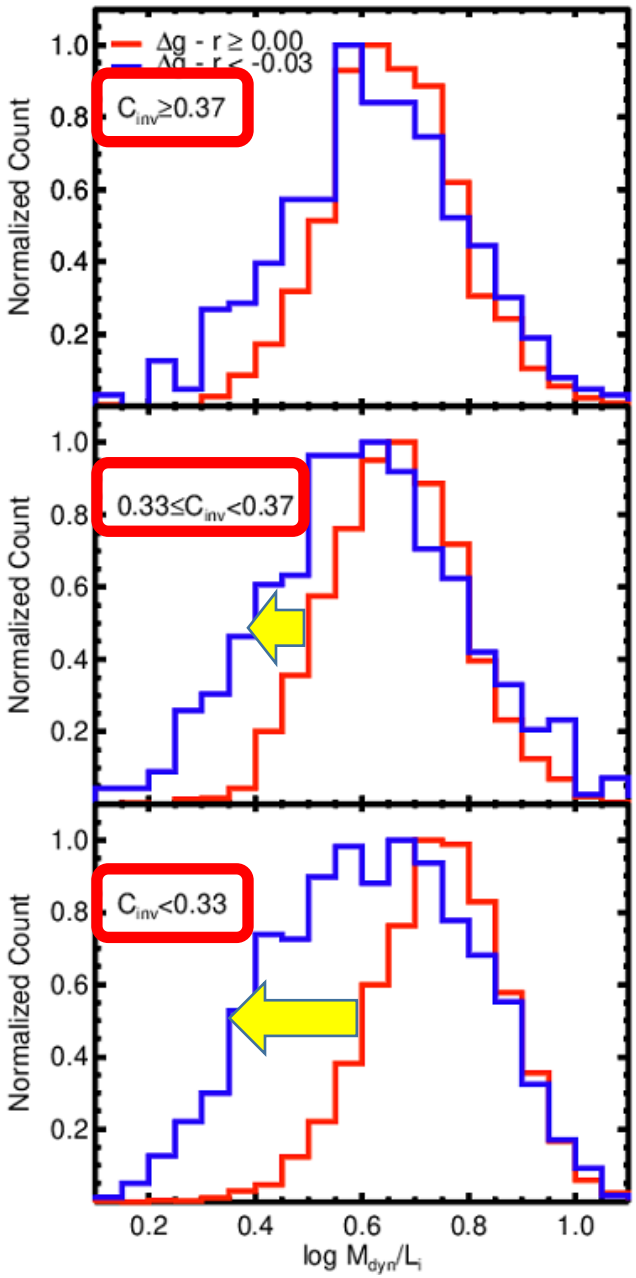
M/L scatter vs Δg-r



Bluer ETGs are more scattered into lower M/L.

(more light for a given dynamical mass)

Results



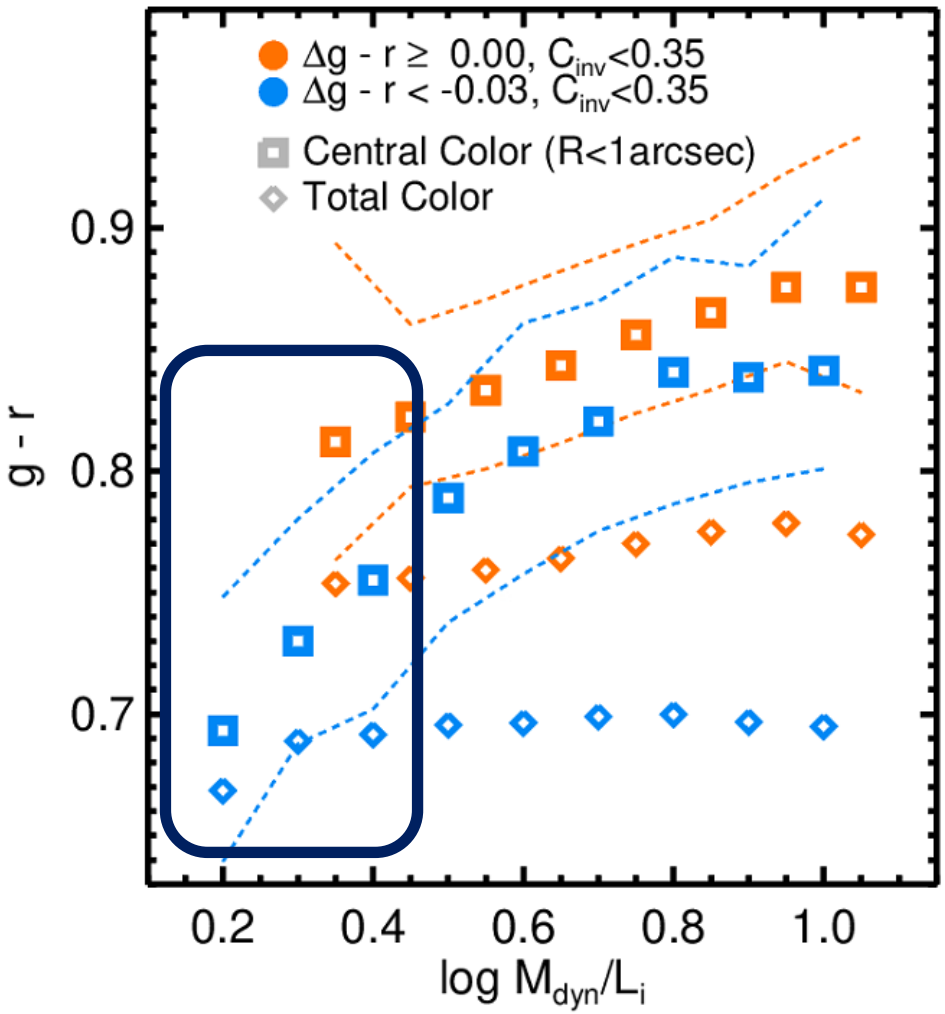
M/L scatter vs Compactness

Young (blue) and more compact ETGs are scattered into lower M/L.

(more light for a given dynamical mass)

Results

Central color vs M/L



Blue compact ETGs with lower M/L have blue centers

Discussion

The reason for the galaxies with the large scatter in M/L and their properties: gas-rich mergers

Gas-rich mergers make gas funnel into the central regions and starburst there.

→ **More compact structures, Younger ages and more light** in the central regions of ETGs

(see Robertson et al. 2006 and Hopkins et al. 2008)

Summary

Younger (bluer) and more compact ETGs have a larger scatter in FP.

This is due to the fact that their M/L values are more scattered into low M/L.

Gas-rich mergers can well explain our results.