

Automated morphologies, the way to future?

followed by

Do sizes of ETGs care about environment?

Marc Huertas-Company

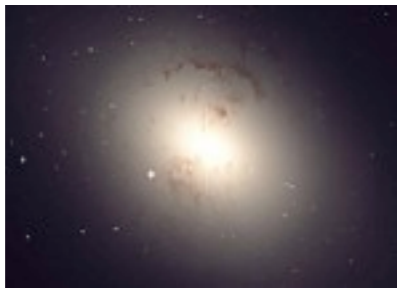
Simona Mei, Francesco Shankar, L. Delaye, J.A.L Aguerri, M. Bernardi, M. Povic, C. Lidman, P. Cerulo, A. Raichoor, R. Licitra, M. Berthiaud, R. Sanchez-Janssen ...

# Why (morphologically) classifying galaxies?



Complex problem

BOX I



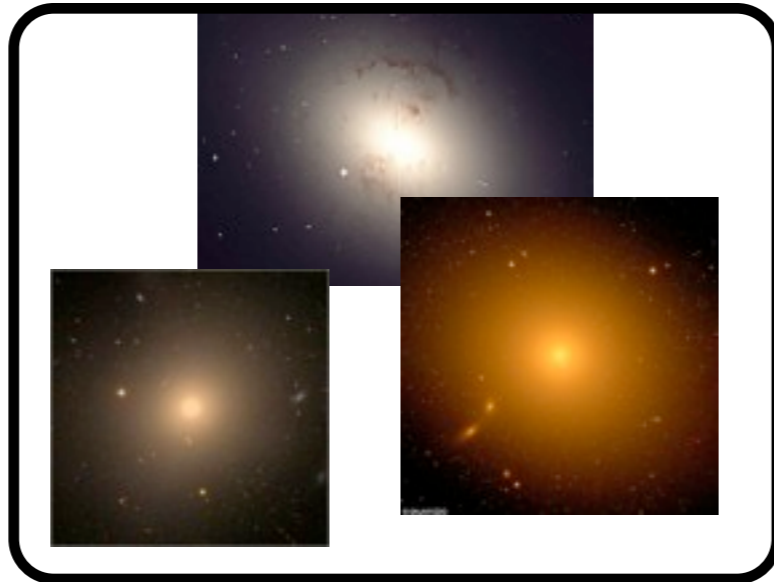
BOX II



BOX I



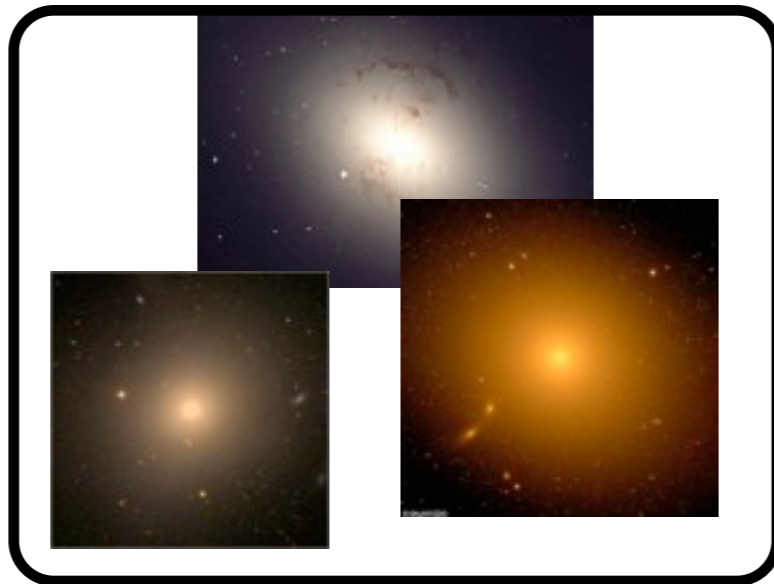
BOX II



BOX I



BOX II



“Objects in the same box experienced the same physics”

# BOX I



E0



E3



E7



S0



Sa



Sb



Sc



SBa

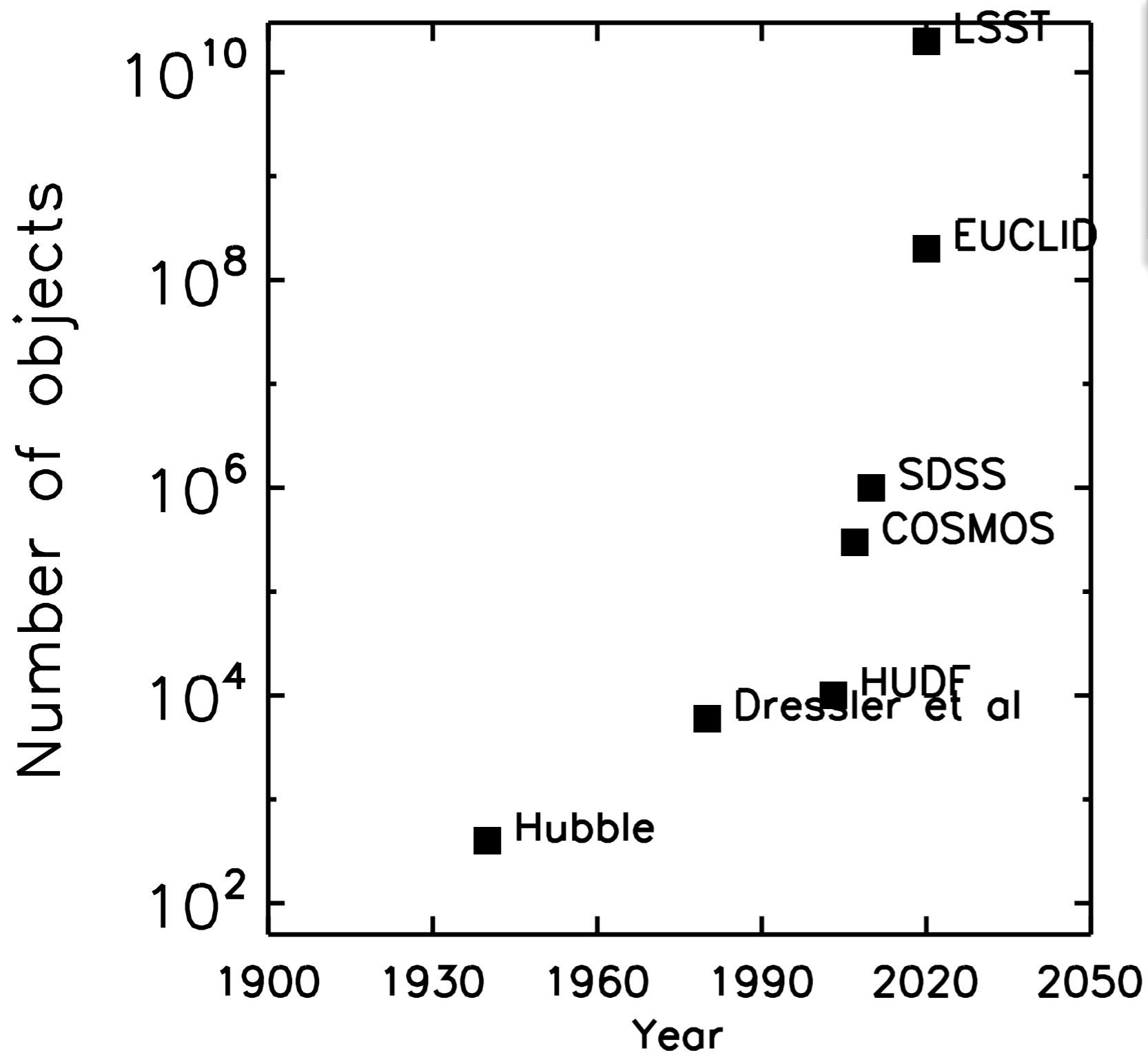


SBb



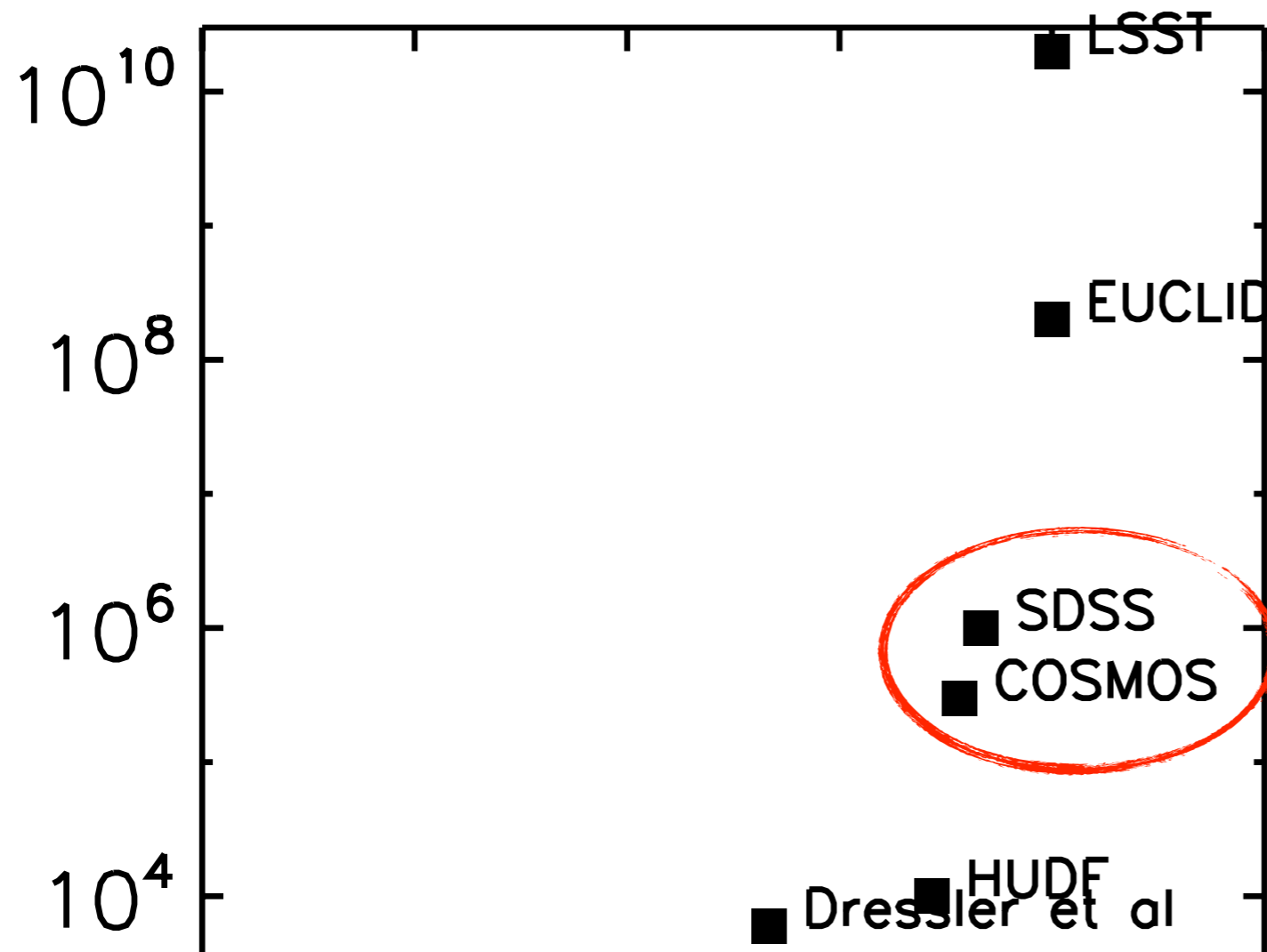
SBc

the  
X  
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e  
,



We do have a  
problem

Number of objects



We do have a problem

*Citizen science limit ?*



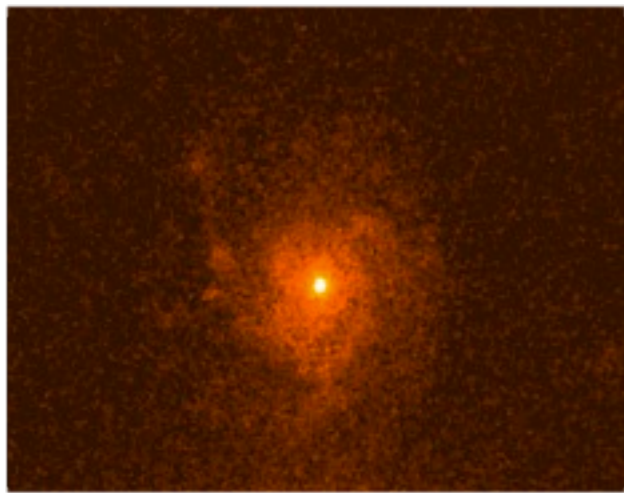
**Karen Masters** @KarenLMasters

10 Mai

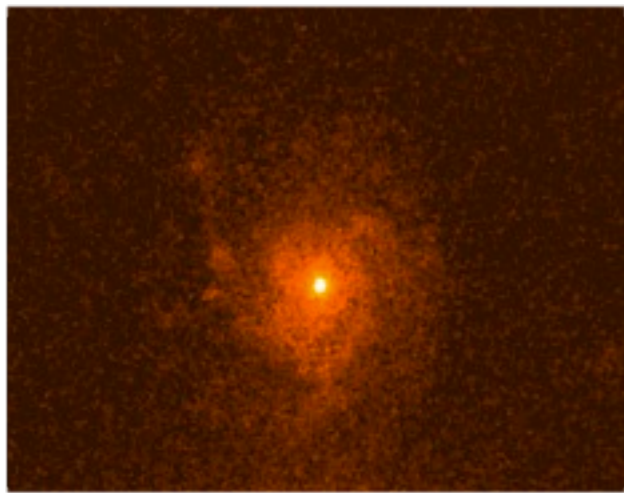
@PenguinGalaxy @thebamf I have calculated #euclidmission well resolved galaxy images would take ~70 yrs of @galaxyzoo #needtocheckfigures



A lot of skepticism still ... not to be scared by catastrophic errors!

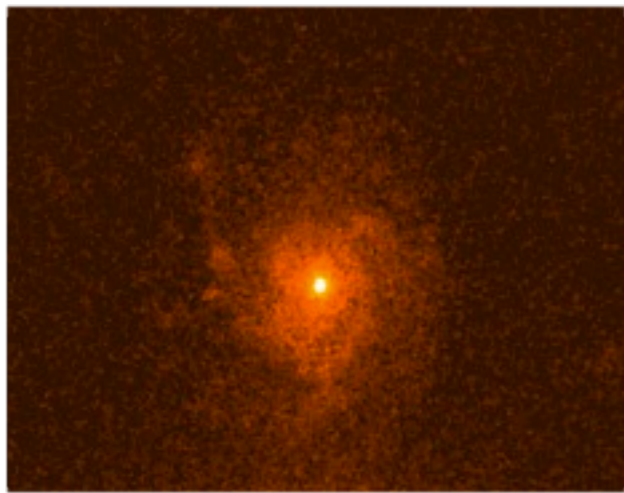


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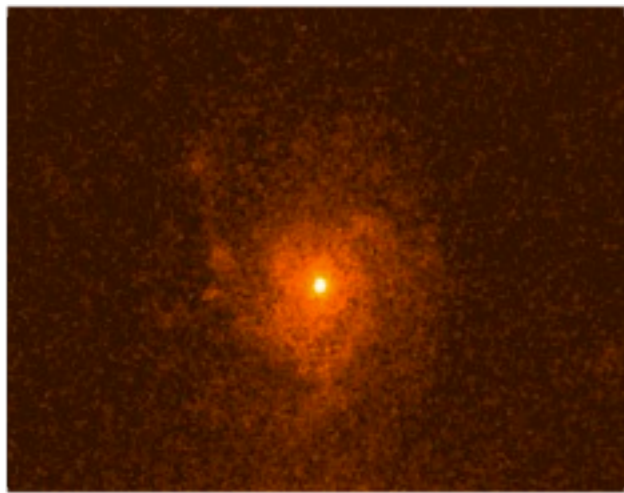
$z_{\text{phot}}=0.5$

A lot of skepticism still ... not to be scared by catastrophic errors!

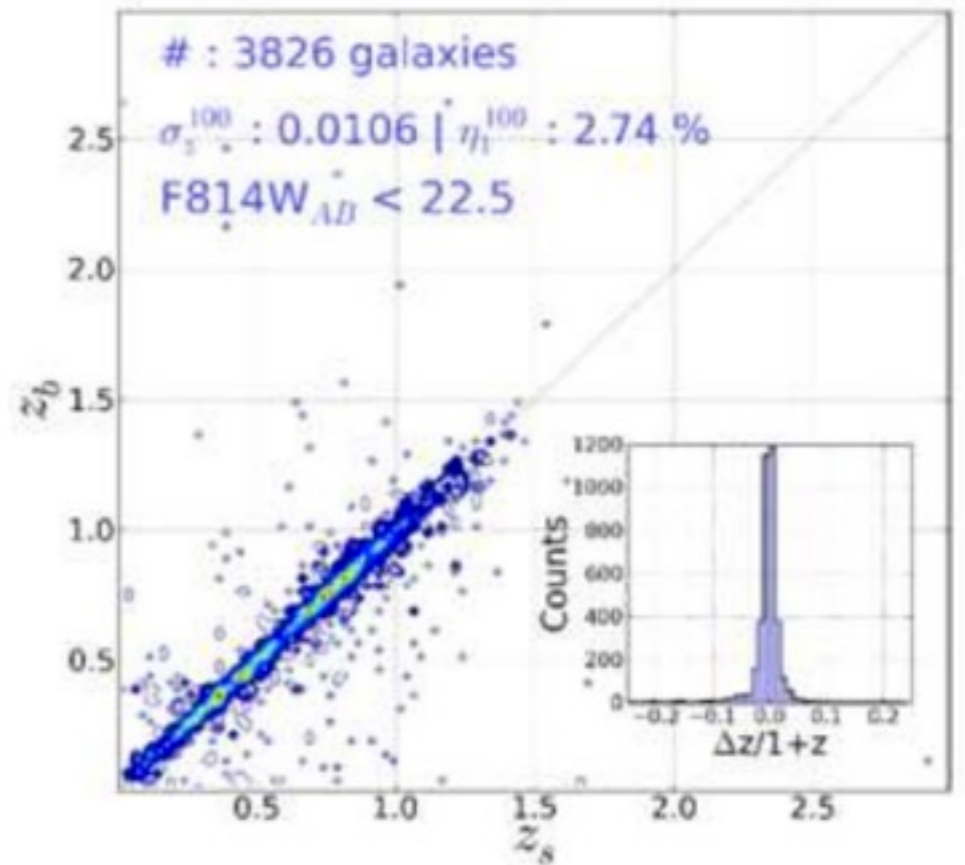


$z_{\text{phot}}=0.5$   
 $z_{\text{spec}}=0.2$

A lot of skepticism still ... not to be scared by catastrophic errors!

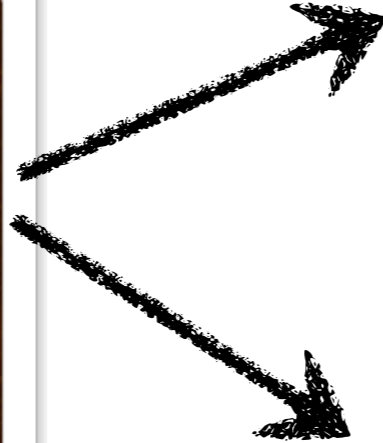
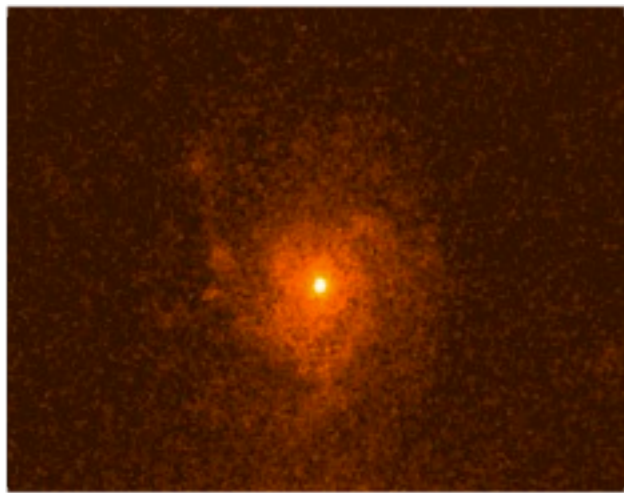


$z_{\text{phot}}=0.5$   
 $z_{\text{spec}}=0.2$



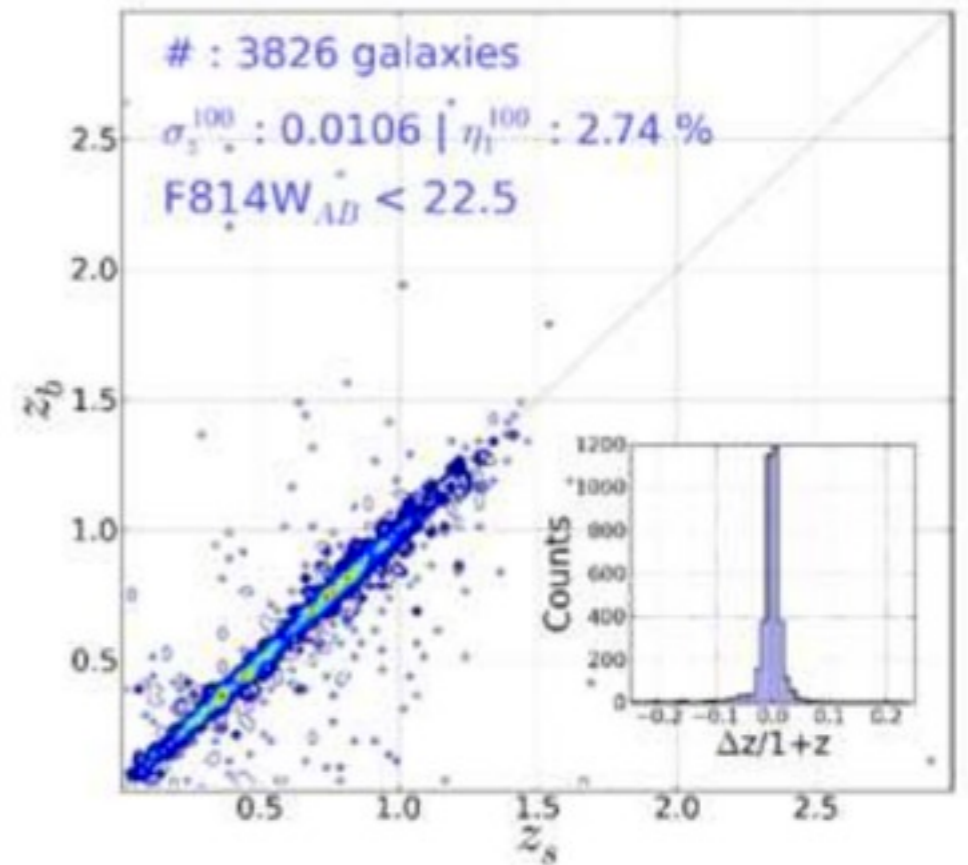
Molino+13

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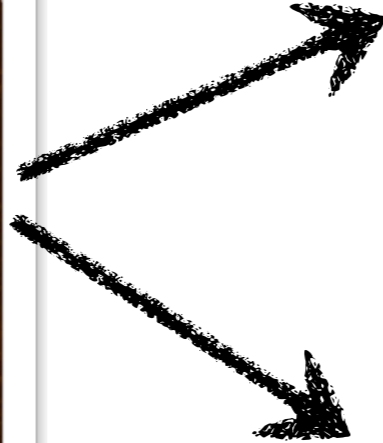
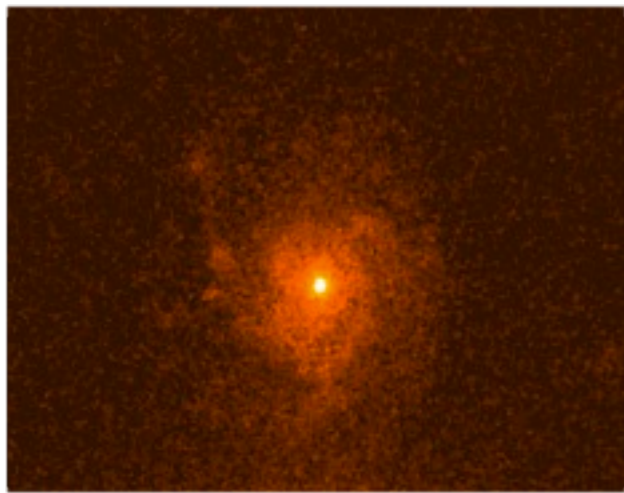
$z_{\text{phot}}=0.5$   
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ETG



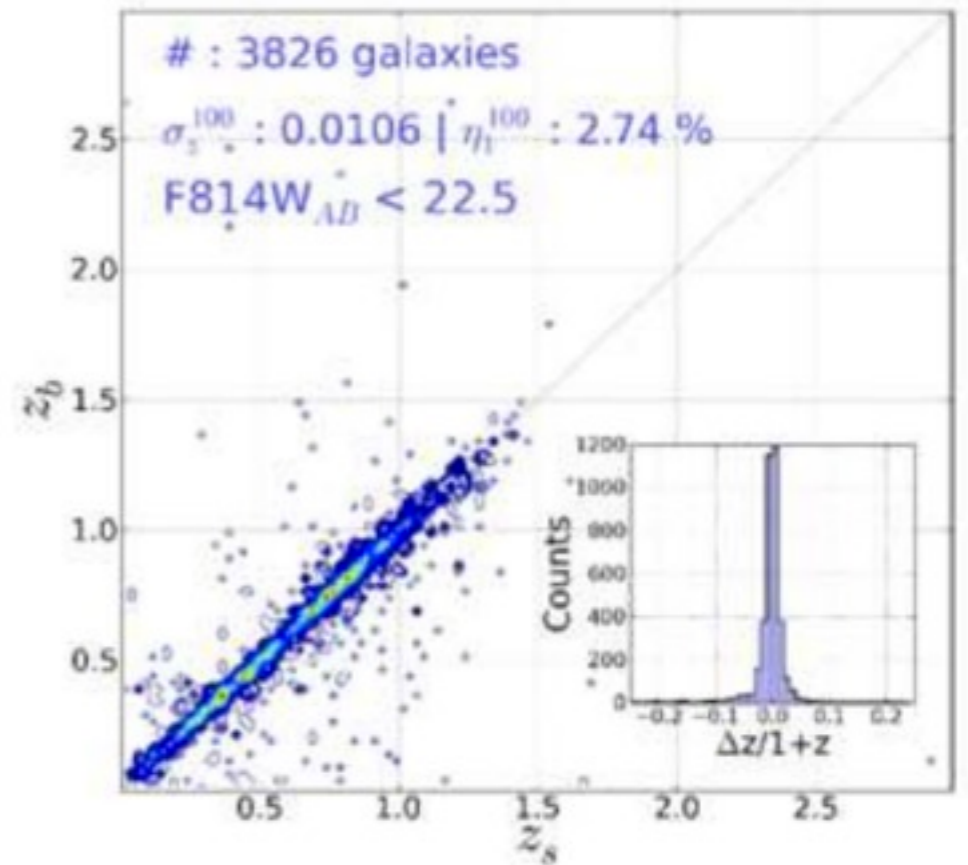
Molino+13

A lot of skepticism still ... not to be scared by catastrophic errors!



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ETG



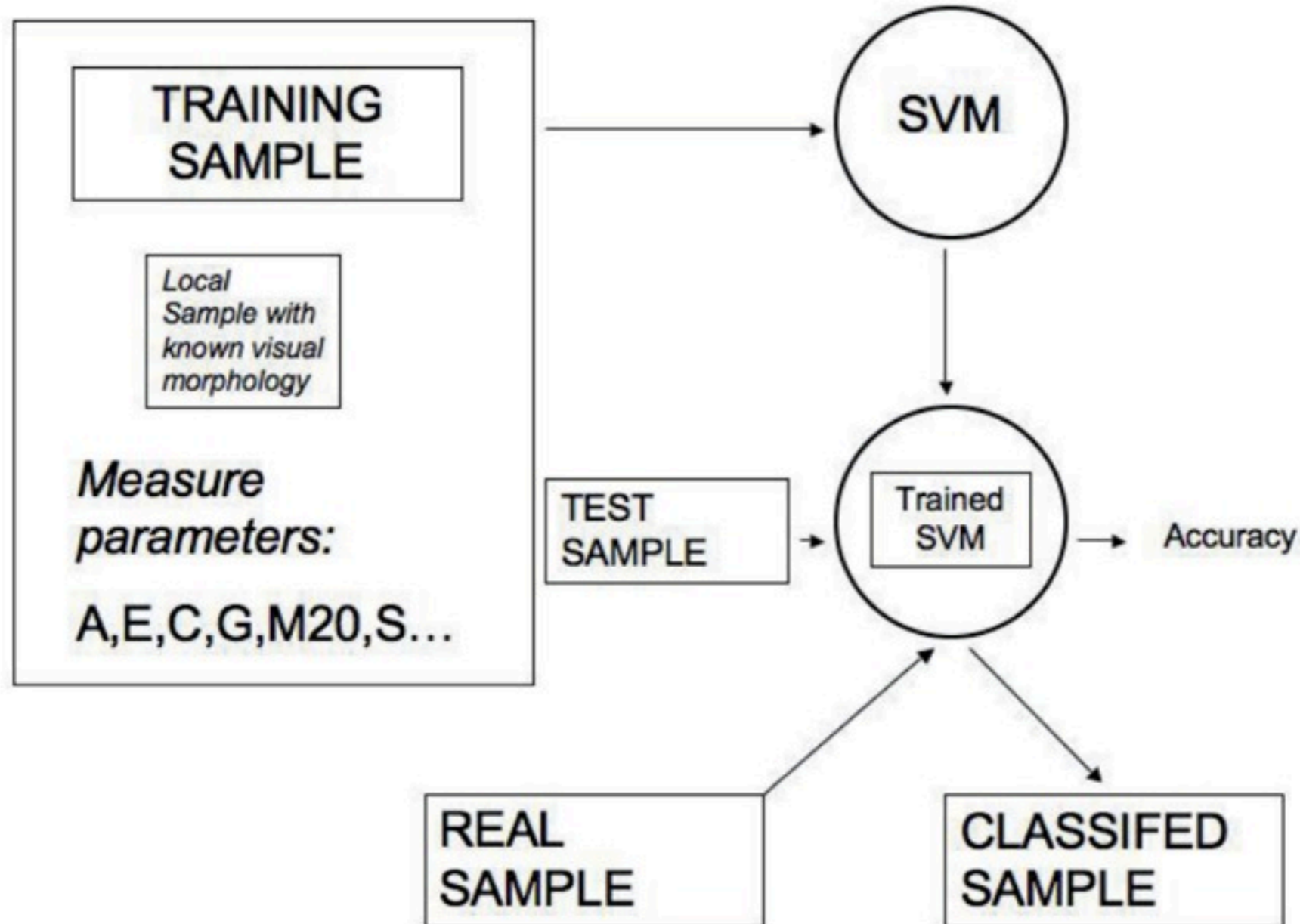
Molino+13

everything is on statistics...

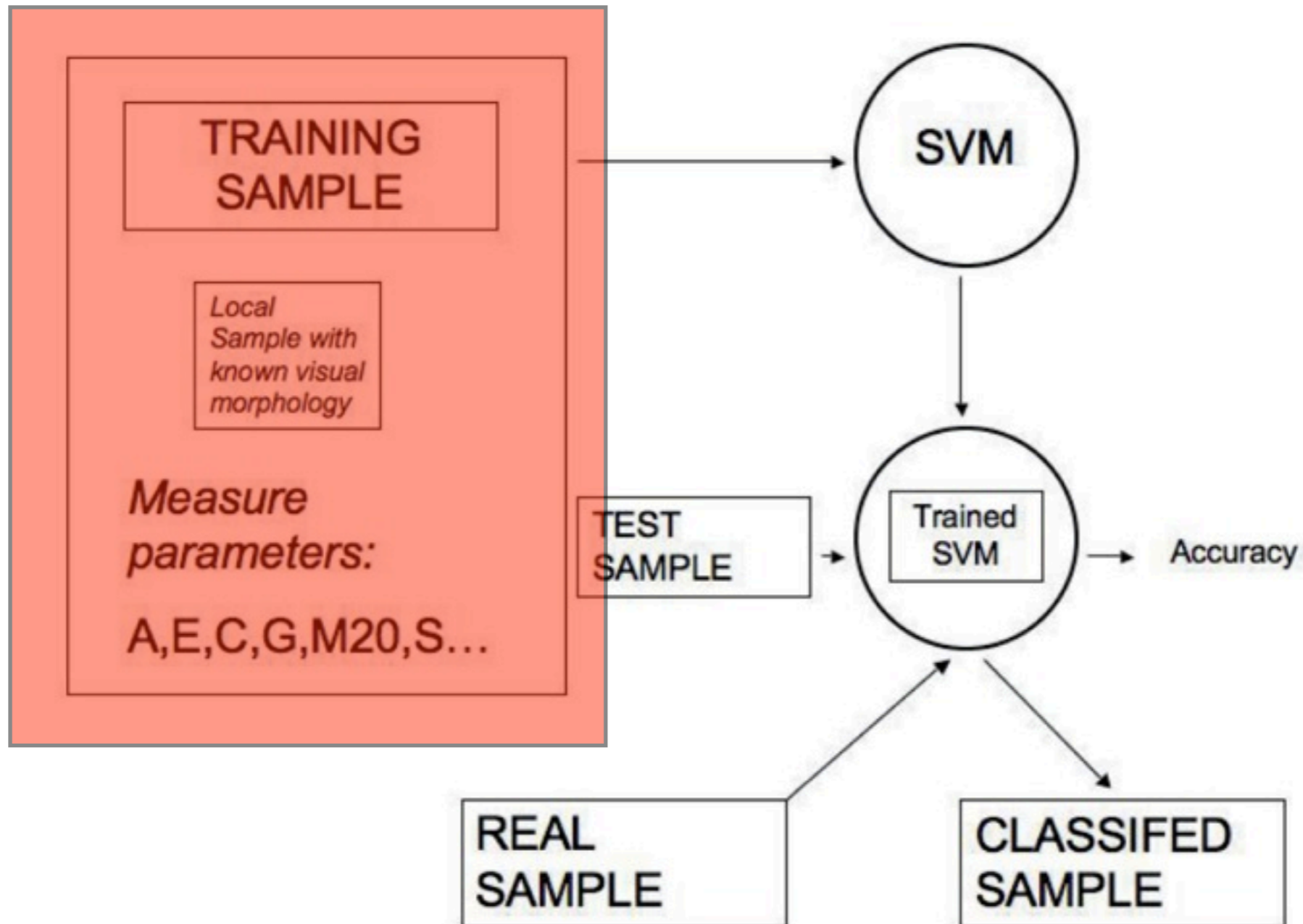
A lot of nice properties though ...

accuracy  
errors  
fast  
reproducible  
probability  
objective







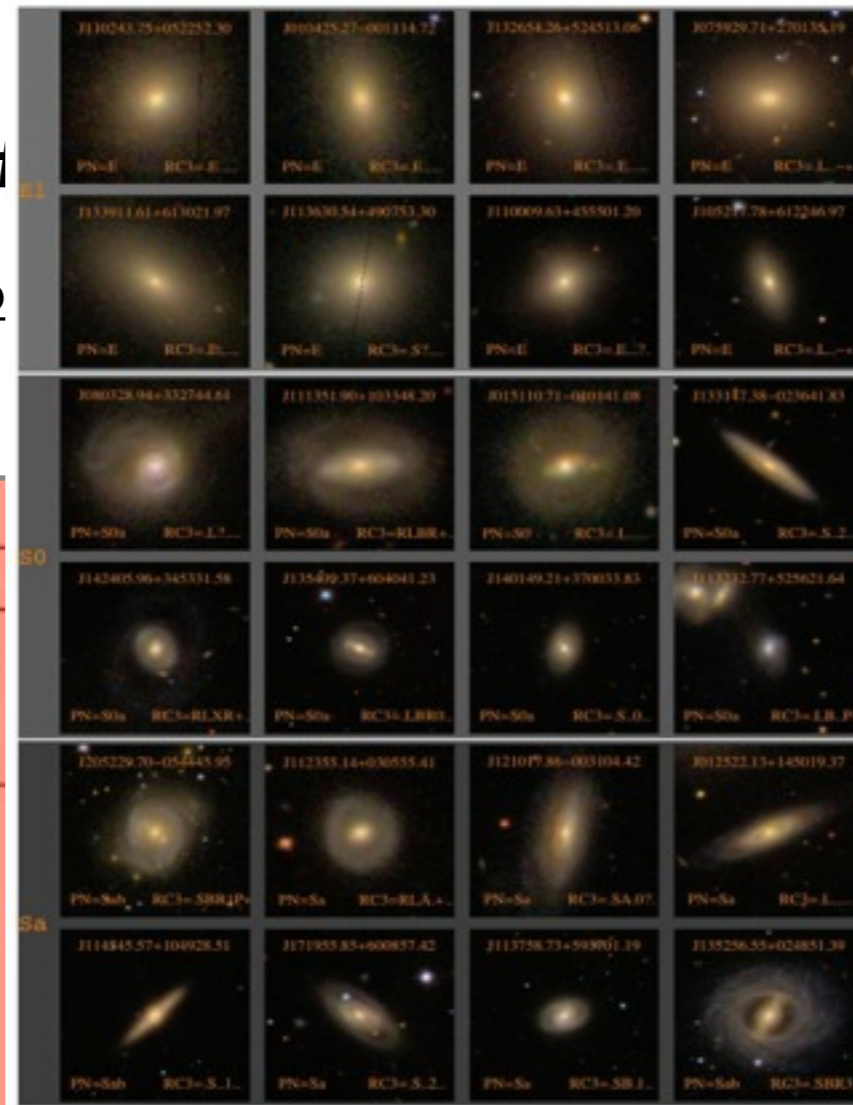




MH

<http://gepicom04.o>

Nair&Abraham+10



TRAINING SAMPLE

Local Sample with known visual morphology

Measure parameters:

A,E,C,G,M20,S...

TEST SAMPLE

Trained SVM

Accuracy

REAL SAMPLE

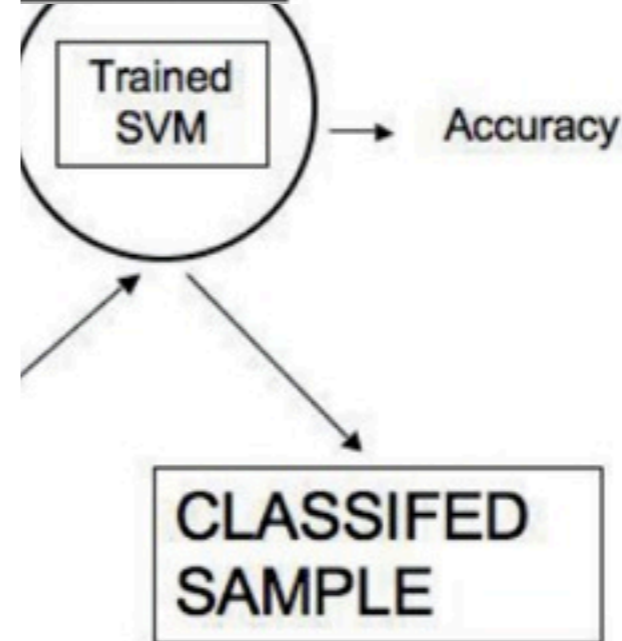
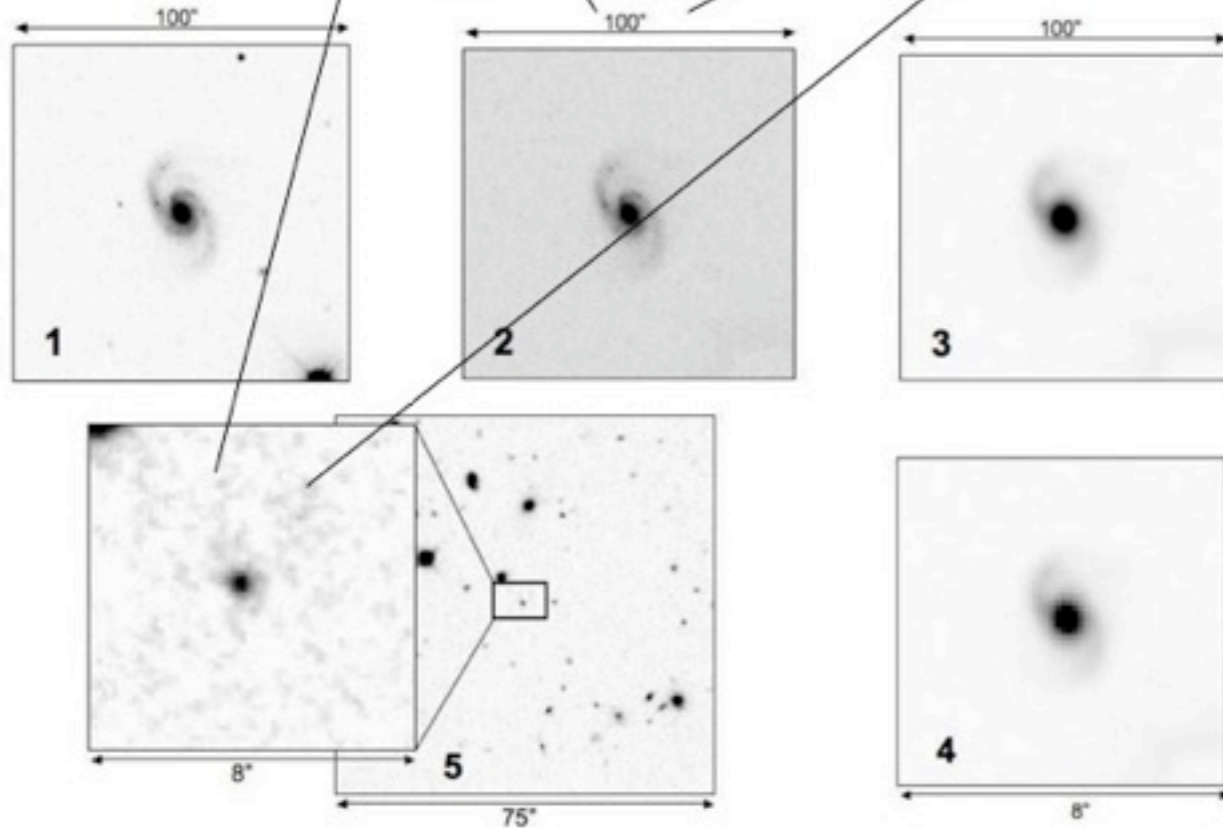
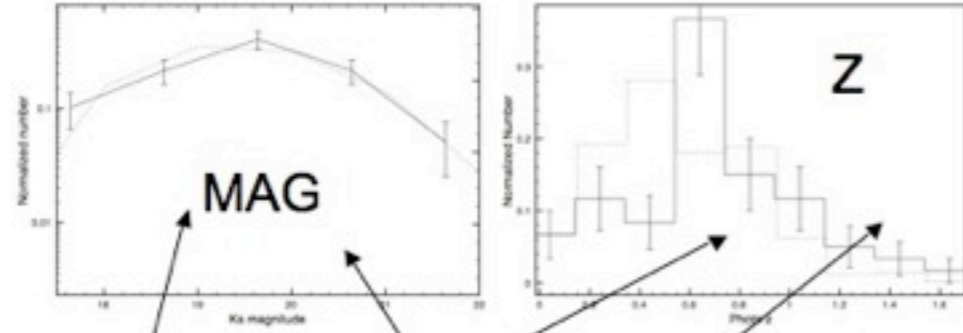
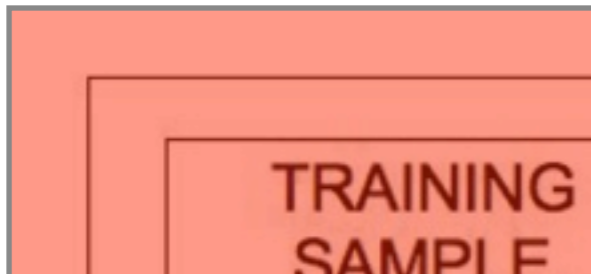
CLASSIFIED SAMPLE



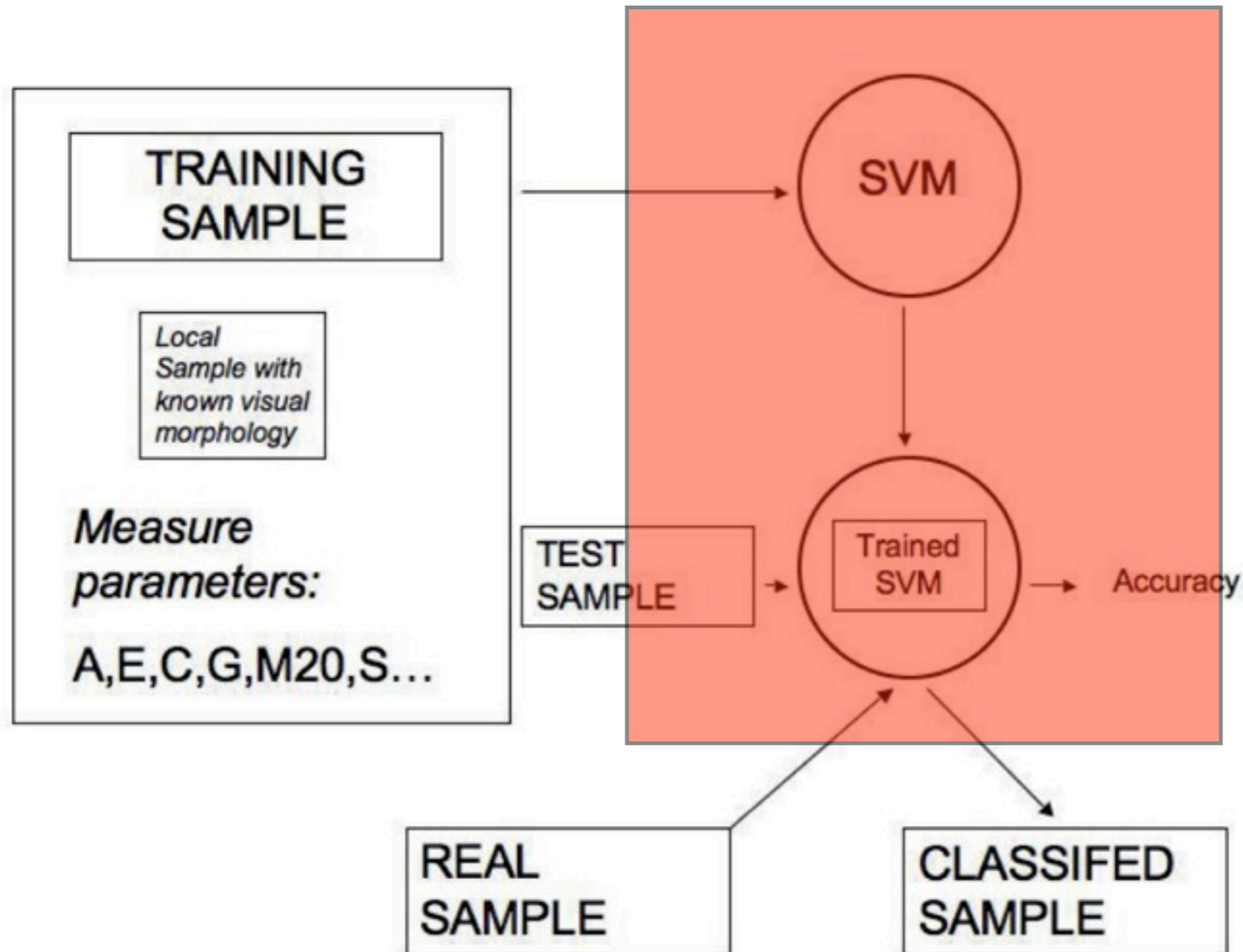
MH

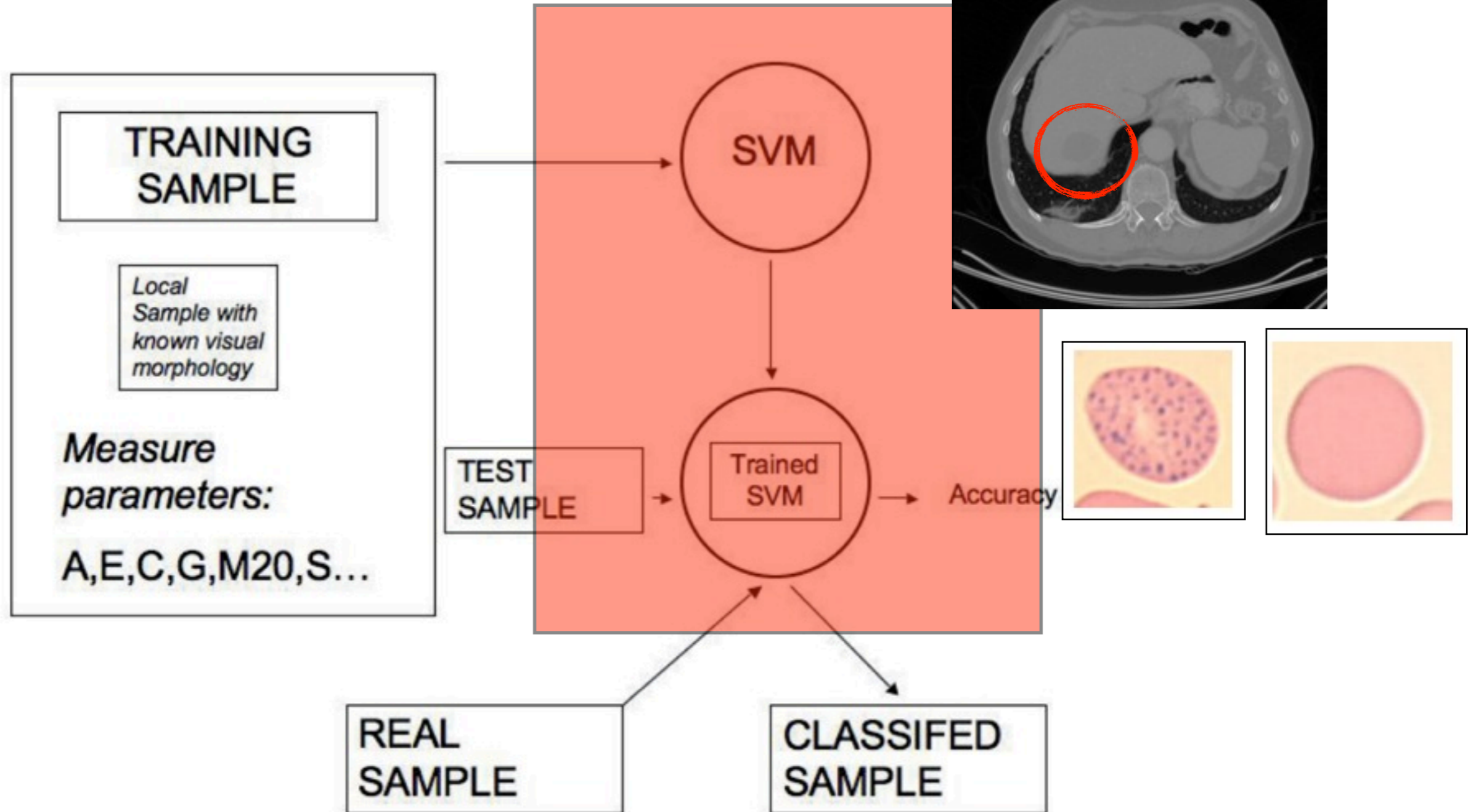
<http://gepicom04.o>

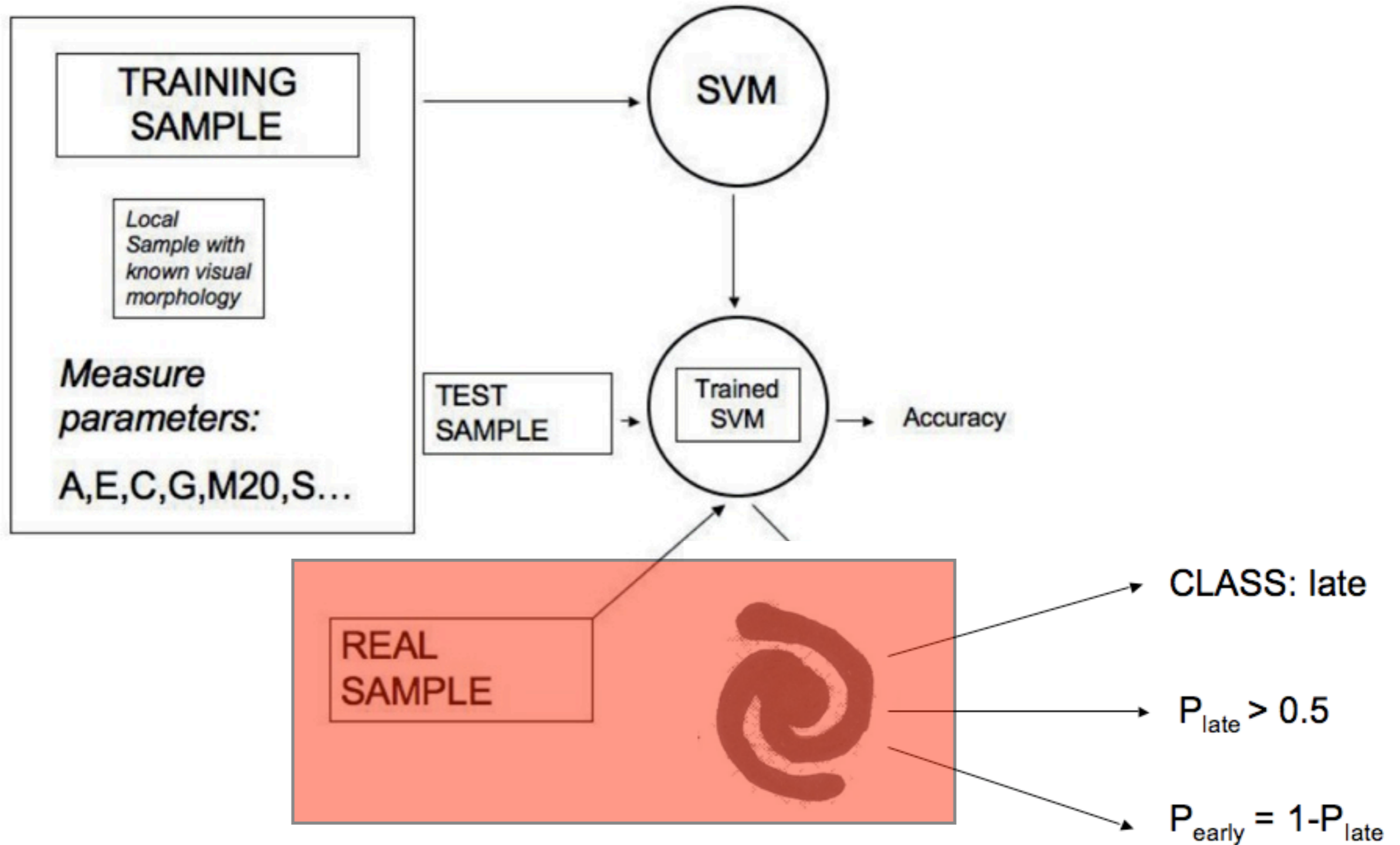
Nair&Abraham+10







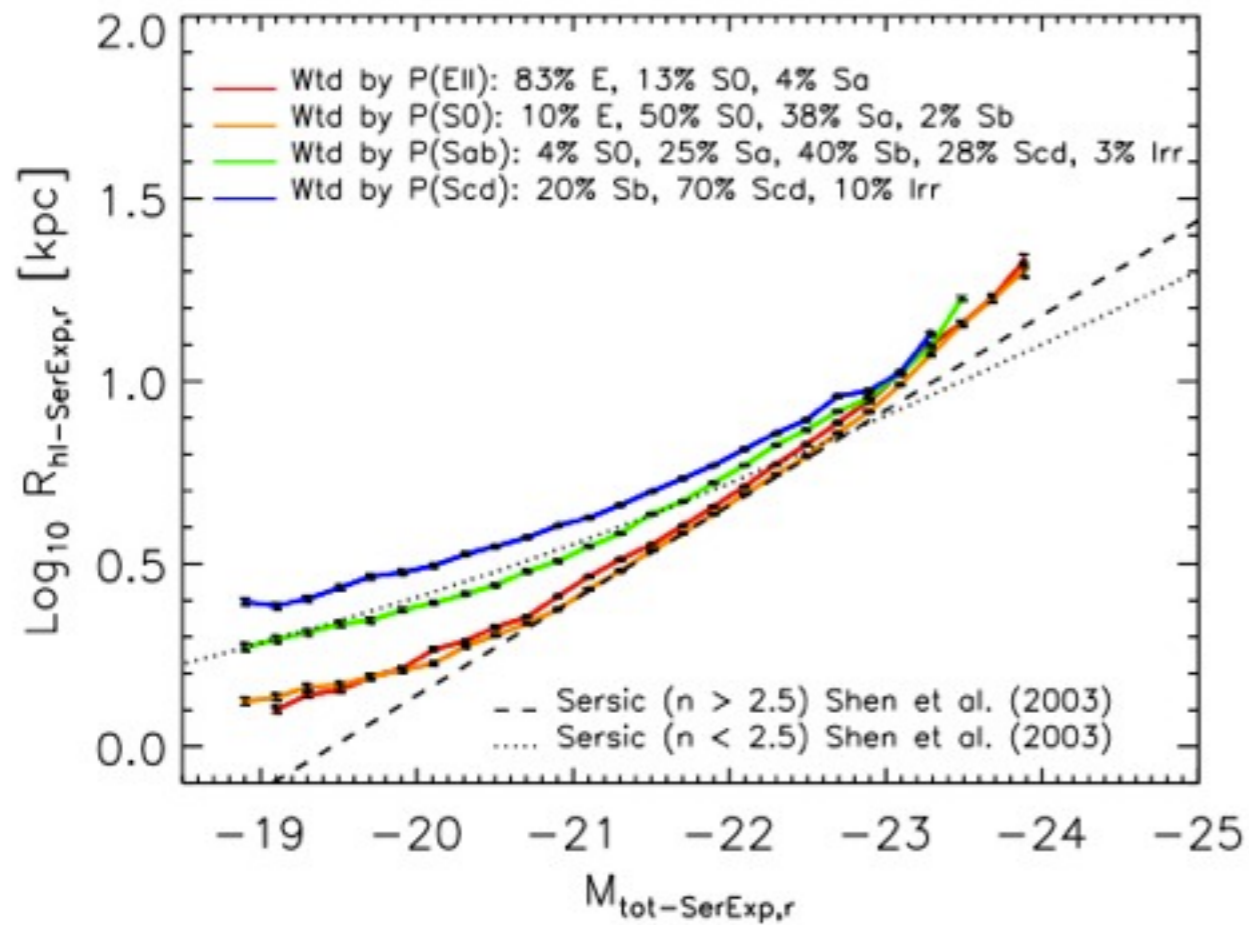




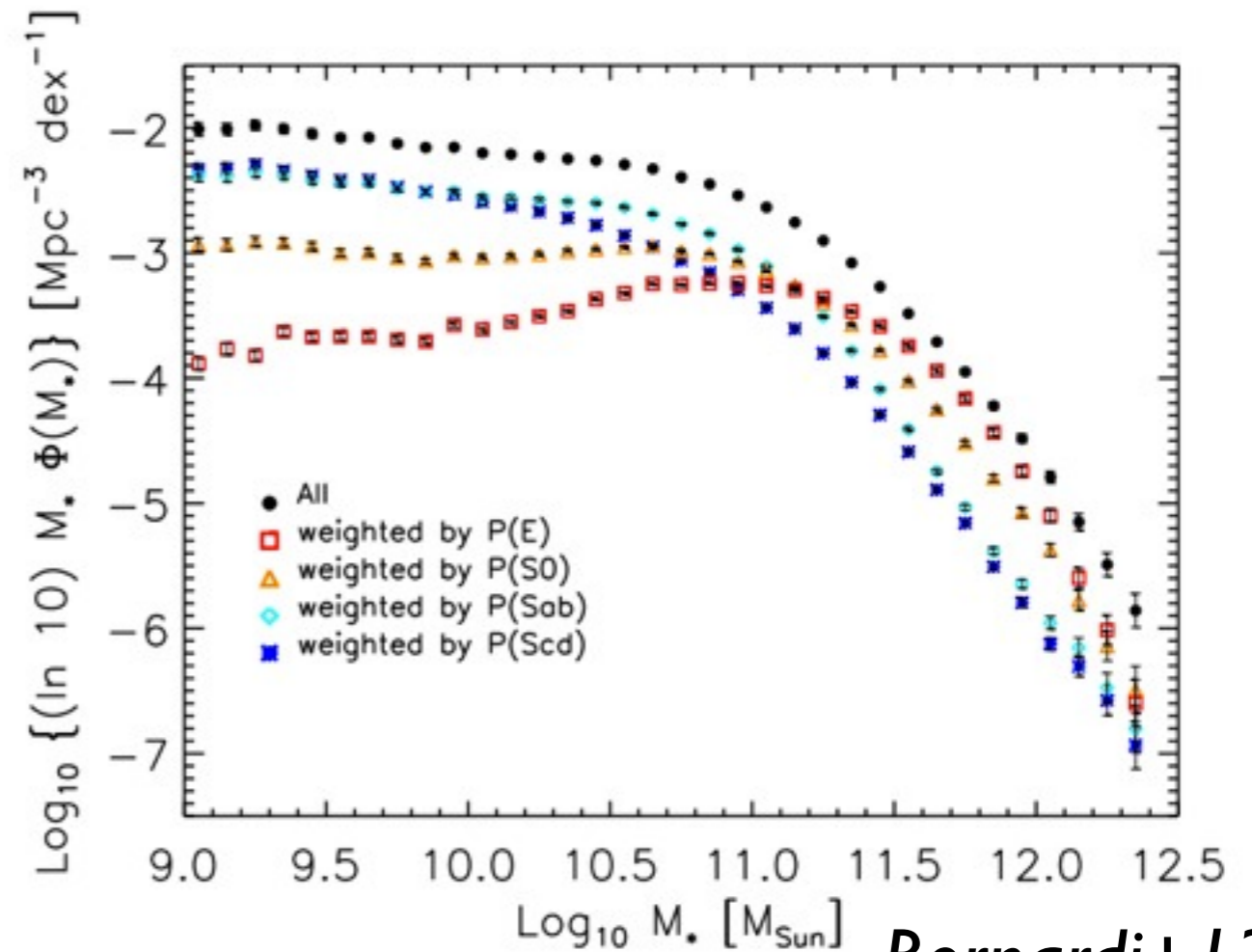
# Some examples

# Some examples

- $z \sim 0$  - SDSS - Bayesian classification of  $\sim 1e6$  galaxies - [gepicom04.obspm.fr/sdss\\_morphology/Morphology\\_2010.html](http://gepicom04.obspm.fr/sdss_morphology/Morphology_2010.html)



*Bernardi+13a*

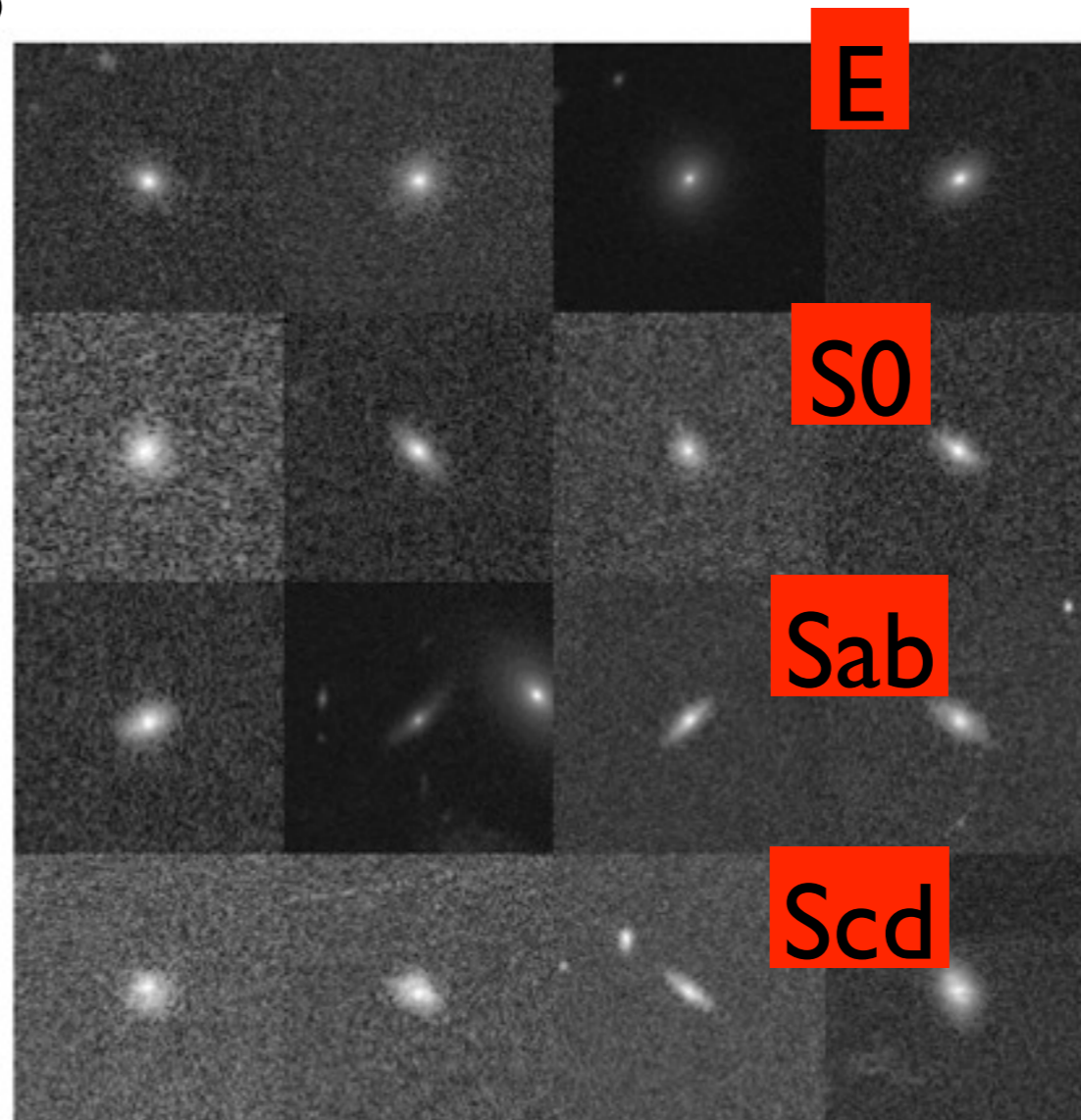


*Bernardi+13b*



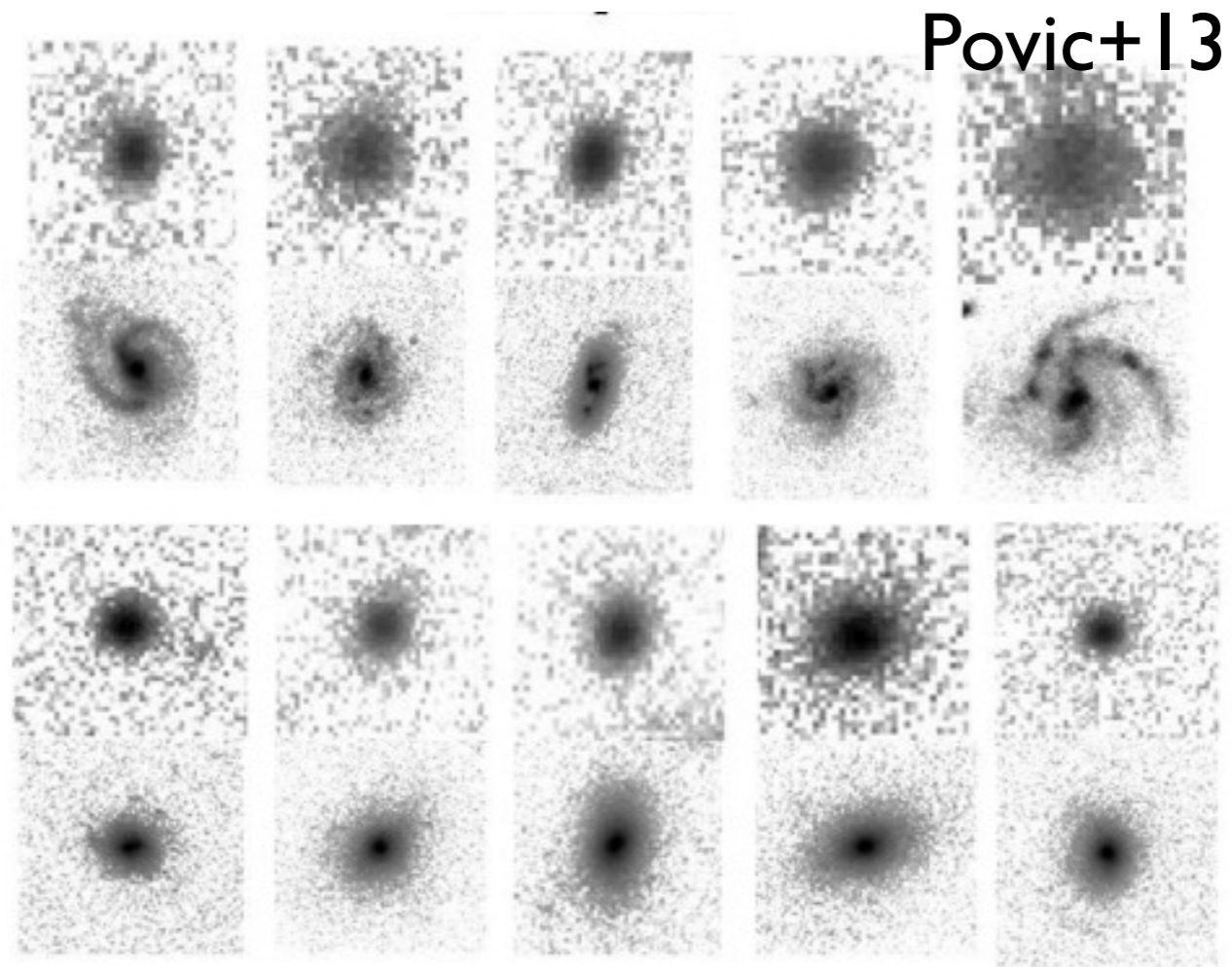
# Some examples

- $z < 1$  - COSMOS



*MHC+13a*

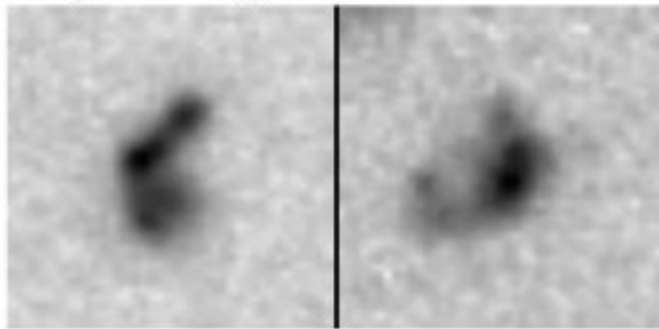
# Some examples



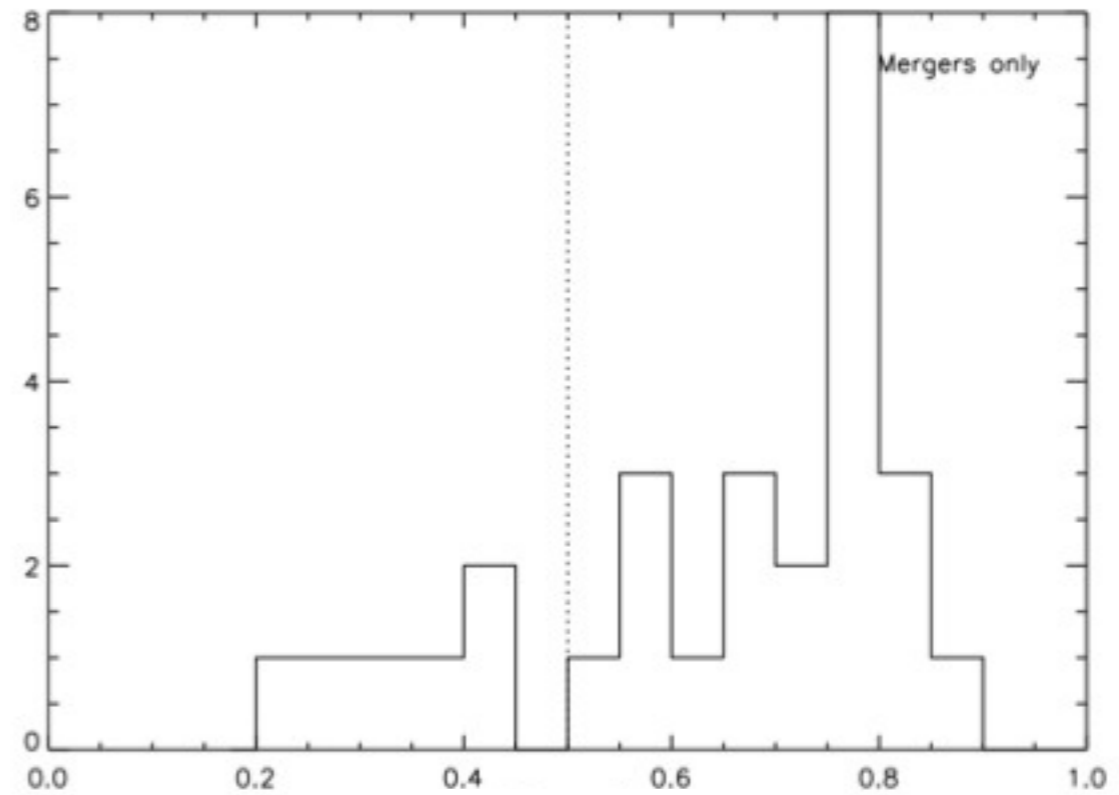
- $z < 1$  - ALHAMBRA / NGVS (low resolution)

# Some examples

Major mergers



*Kaviraj+13*



P(merger)

- $z > 1$  - WFC3-ERS

# SIGnALS: **S**upervised **I**ntelligent **G**alaxy **C**lassification for **L**arge **S**urveys

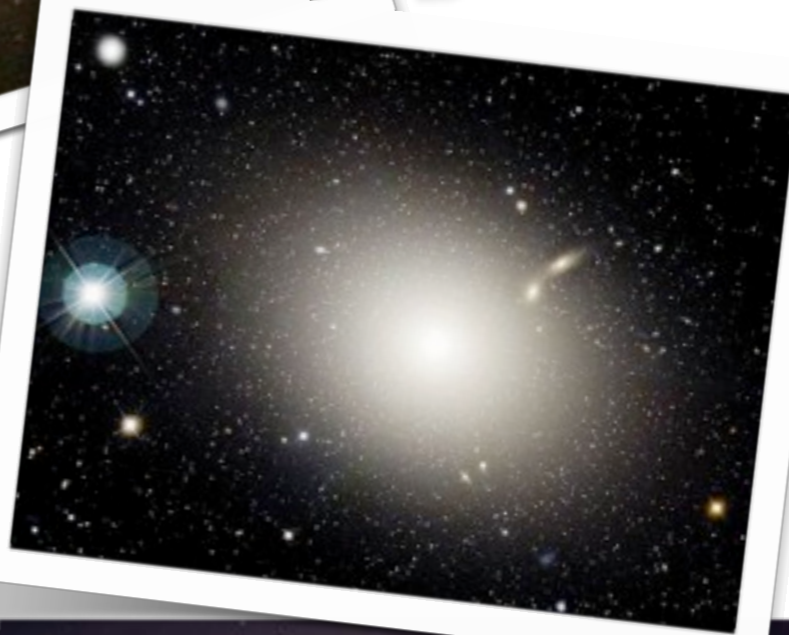
- **Objective:** set of general and versatile tools to classify galaxies in large surveys
- **Methods:**
  - Systematic tests of **different machine learning techniques**
  - Look for the **optimal way to classify galaxies**, given the data available (beyond morphology) without a priori

# (Ideally) what nice properties we want?

- allow the **discovery of new objects** which are expected in future surveys with a reduced human intervention.
- need to be able to recover known and **physically meaningful classes**.
- general enough so that they can **easily be exported to different datasets/situations**.
- provide clean and **controlled error measurements**.
- **probability** based



# “ETGs”



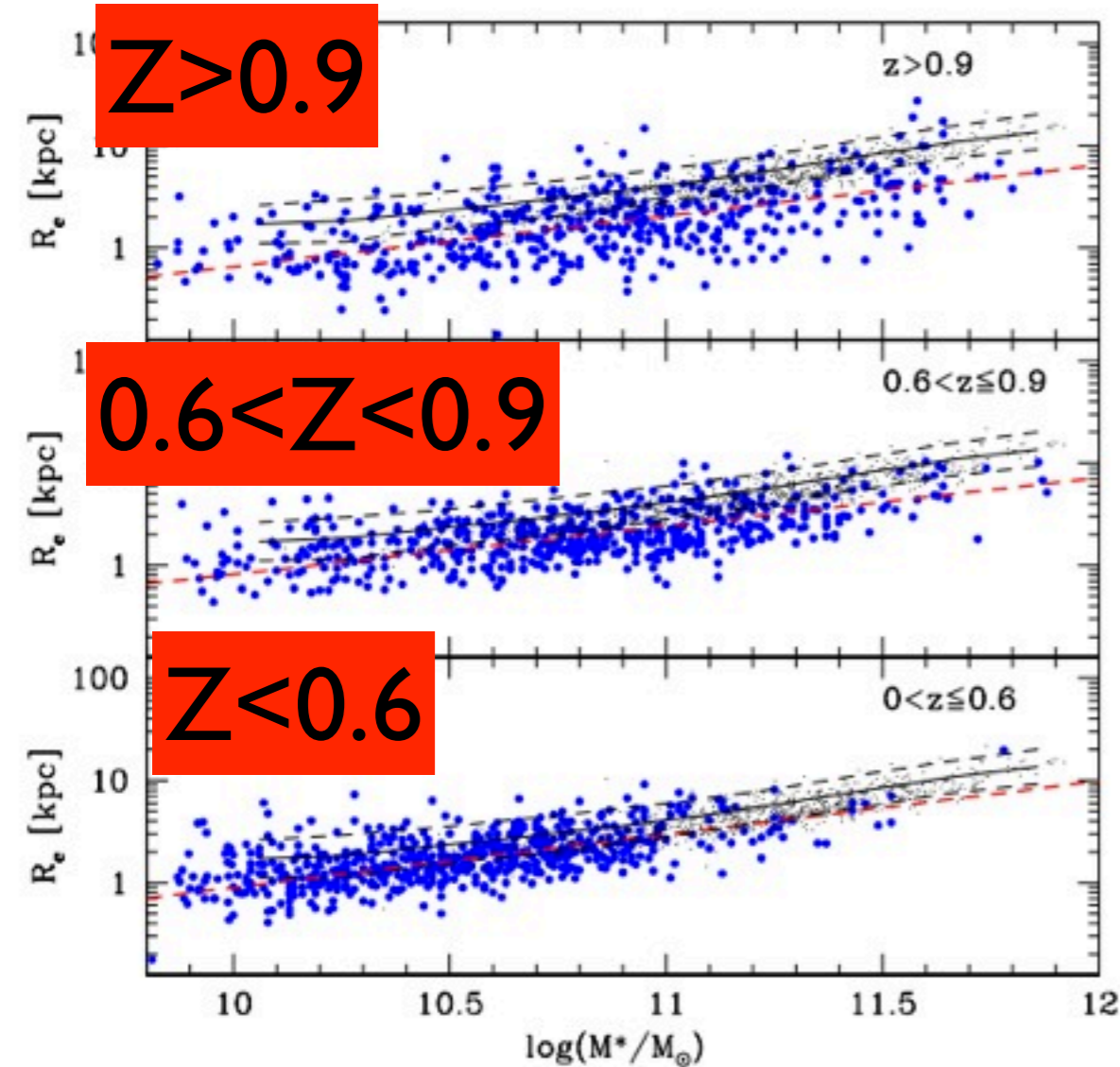




Courtesy: P.A. Duc

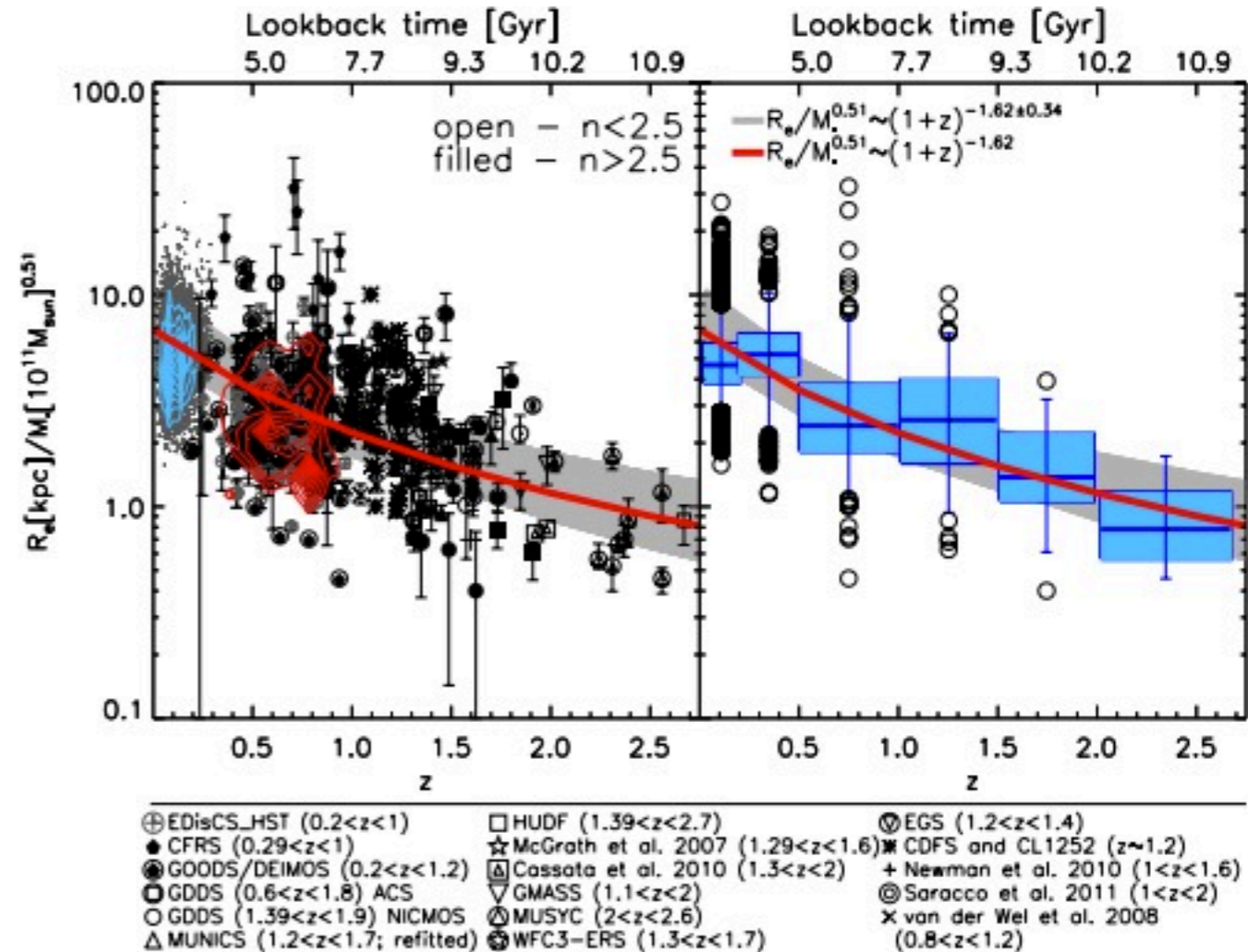


# strong size evolution at fixed stellar mass



Cimatti+12

Damjanov+11



## Number density at z~0?

(Poggianti+13 Trujillo+13, Damjanov+13, Quilis+13..)

## Amount of individual growth? Mergers?

(Newman+12, Bluck+12, Diaz-García+13...)

## Effect of new arrivals?

(Carollo+13, Poggianti+13...)

See talks by  
Damjanov,  
Cappellari, Barro ..

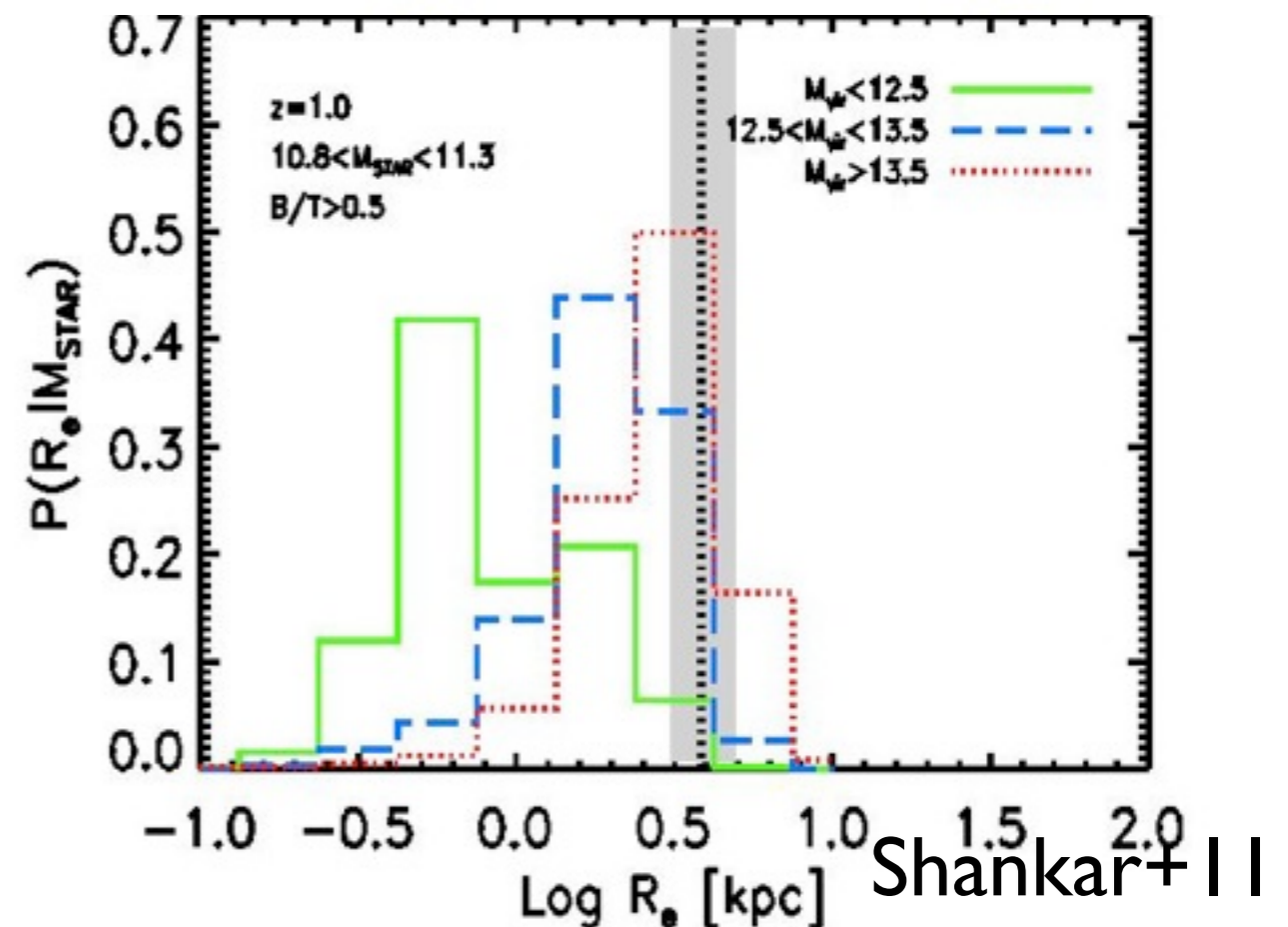
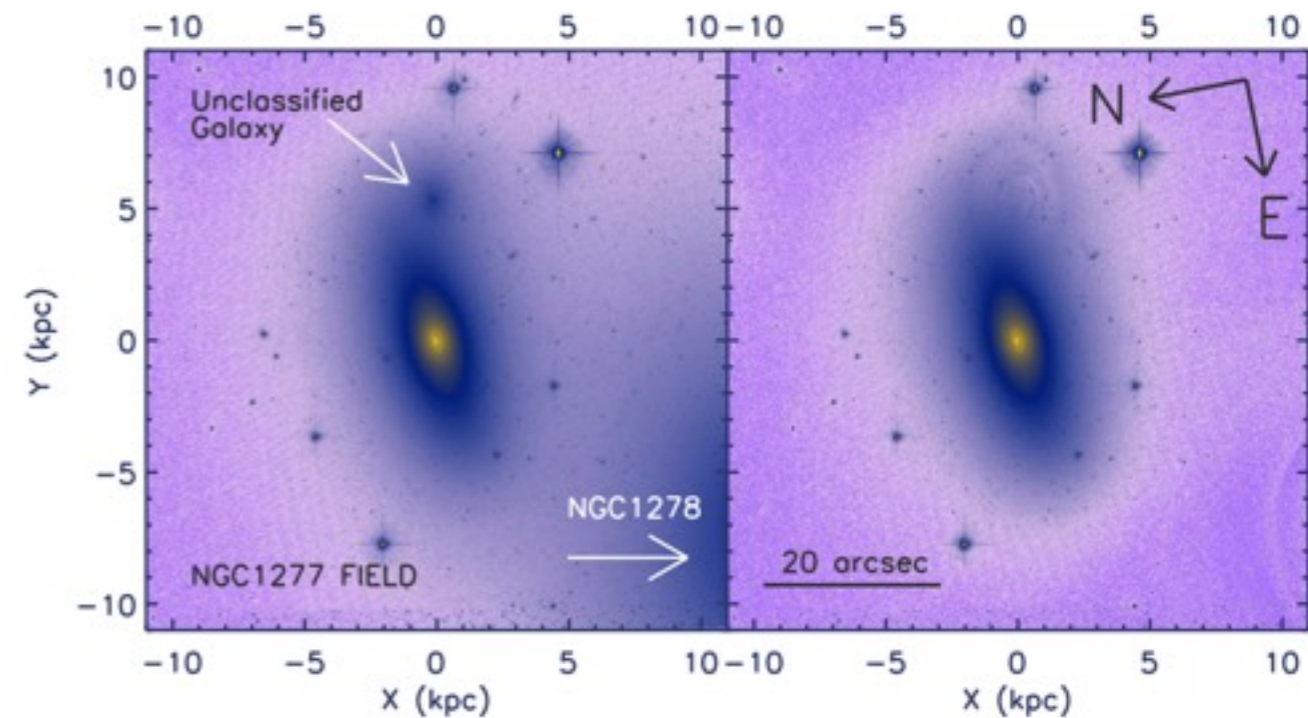


# Environment can put additional constraints on the mechanisms of mass assembly

Trujillo+13

High dense environments are natural places to look for relics/compacts (valentinuzzi+10, poggianti+13, Trujillo+13)

If size evolution is driven by mergers we could naturally expect a correlation with environment (see Ferrarese's talk)



# The data

## Field

$M_h < 10^{13}$

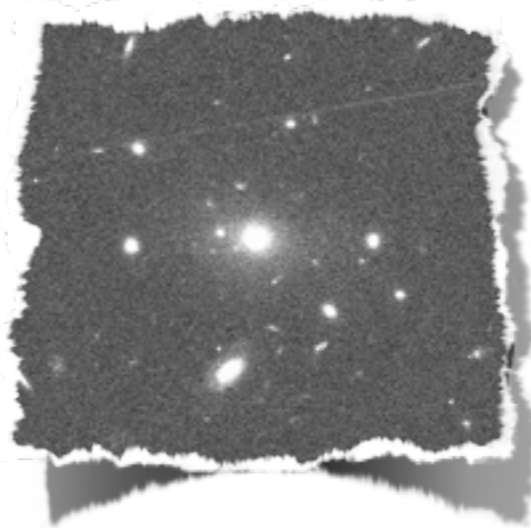


SDSS  
COSMOS  
GOODS-S  
CANDELS

$0 < z < 1.5$

## Groups

$10^{13} < M_h < 10^{14}$



1. SDSS (Yang+07)
2. ~70 X-ray detected groups in COSMOS + WL mass (Finoguenov+2007, Leauthaud+2010, Georges+12)

$0 < z < 1$

## Clusters

$M_h > 10^{14}$

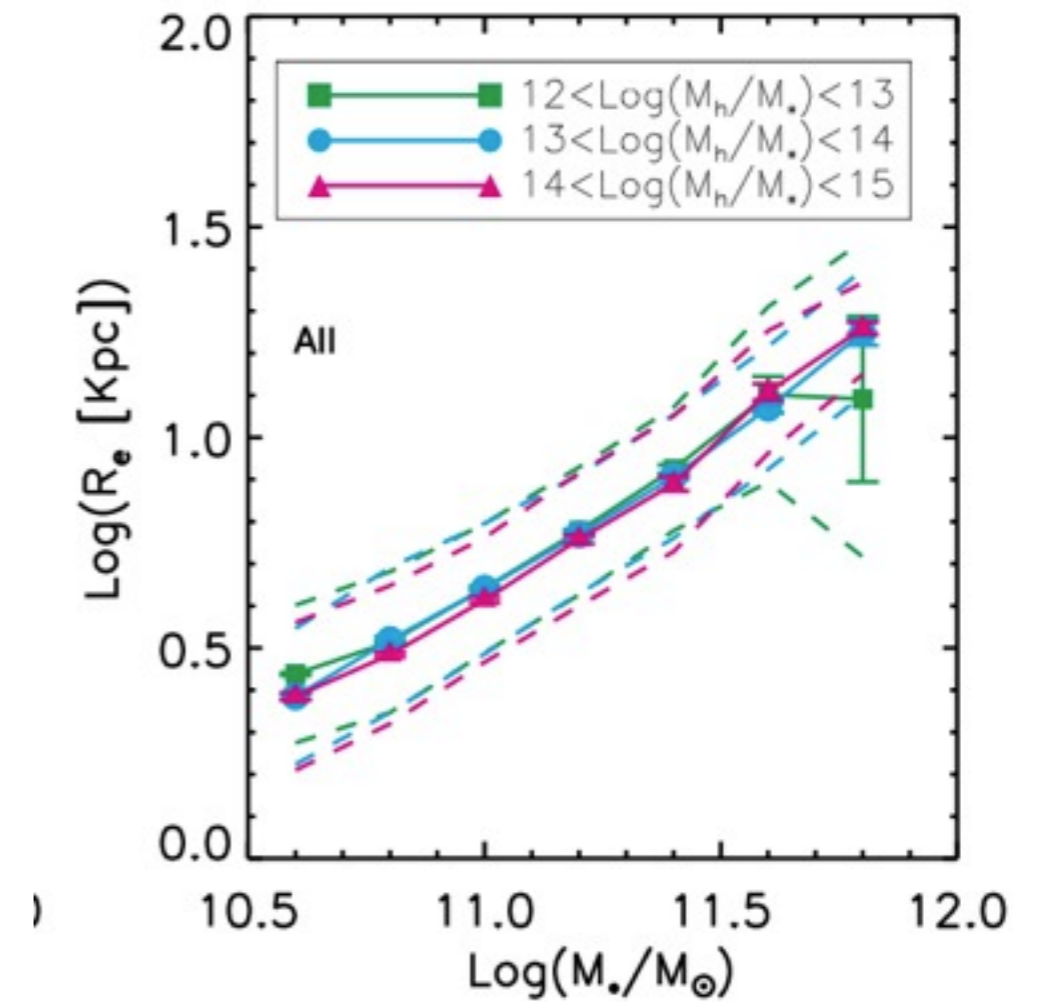


1. SDSS (Yang+07)
2. HAWK-I cluster survey (lidman+13)  
9 massive clusters with 20-100 spectroscopically confirmed members

$0 < z < 1.6$

*MHC+I3a,b*  
*Delaye,MHC+I3*

MHC+13a,b  
Delaye, MHC+13

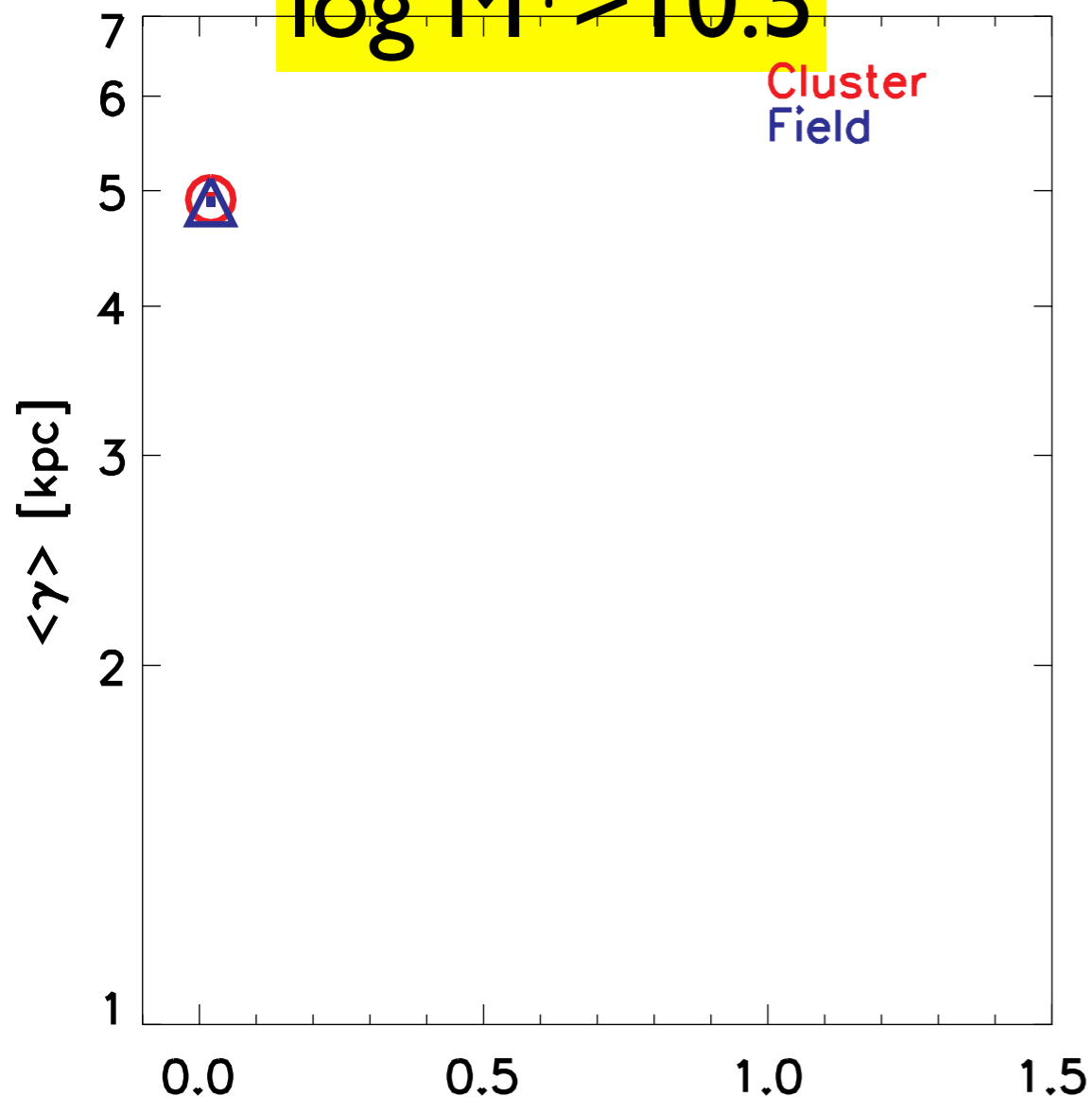


At  $z \sim 0$ , clusters and field galaxies lie on the same relation (see also Poggianti+13, Maltby+10, Diaz-García+13)

MHC+13a,b

Delgado-García+13

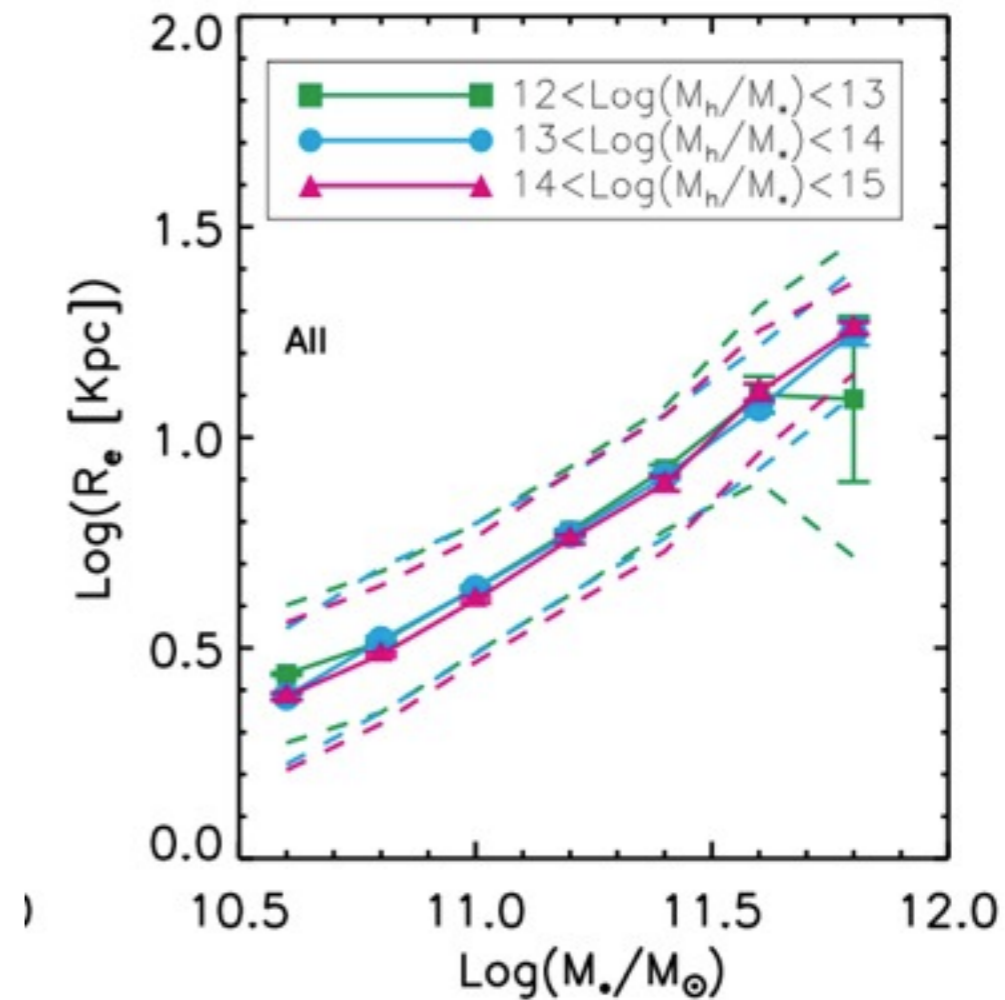
$\log M^* > 10.5$



○ Clusters

□ Groups

△ Field



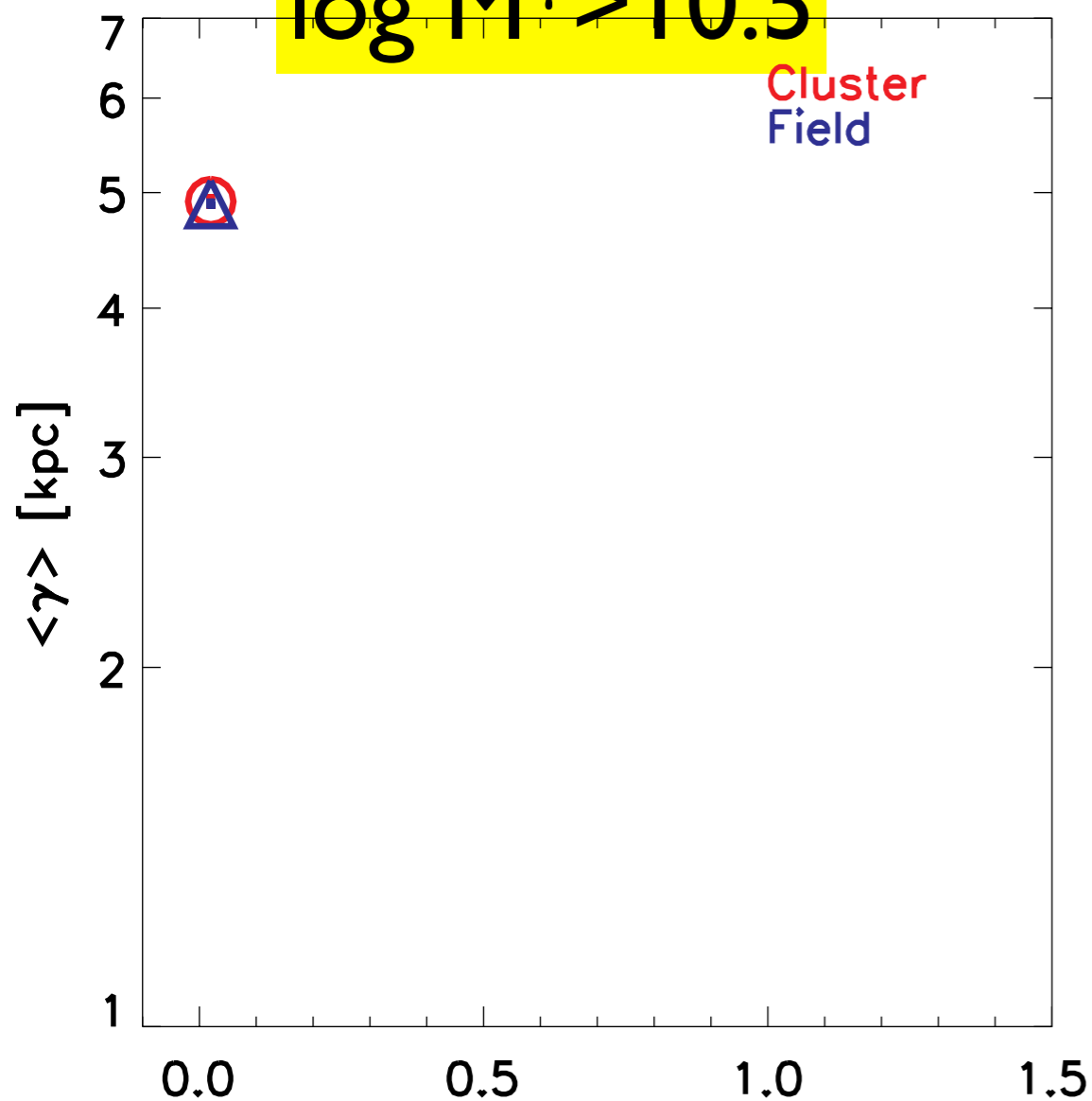
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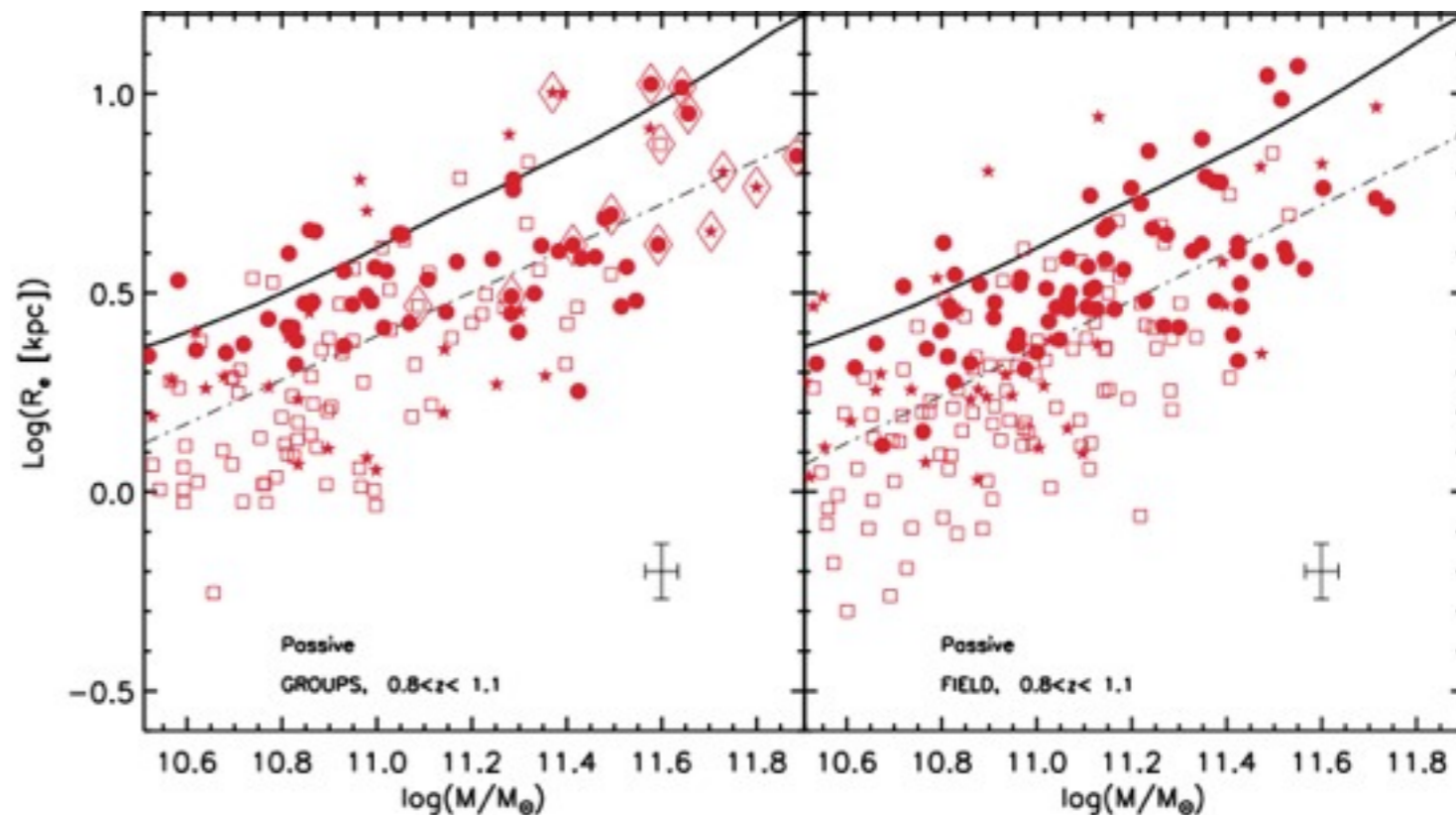
MHC+13a,b

Delaye, MHC+13

$\log M^* > 10.5$



Cluster  
Field



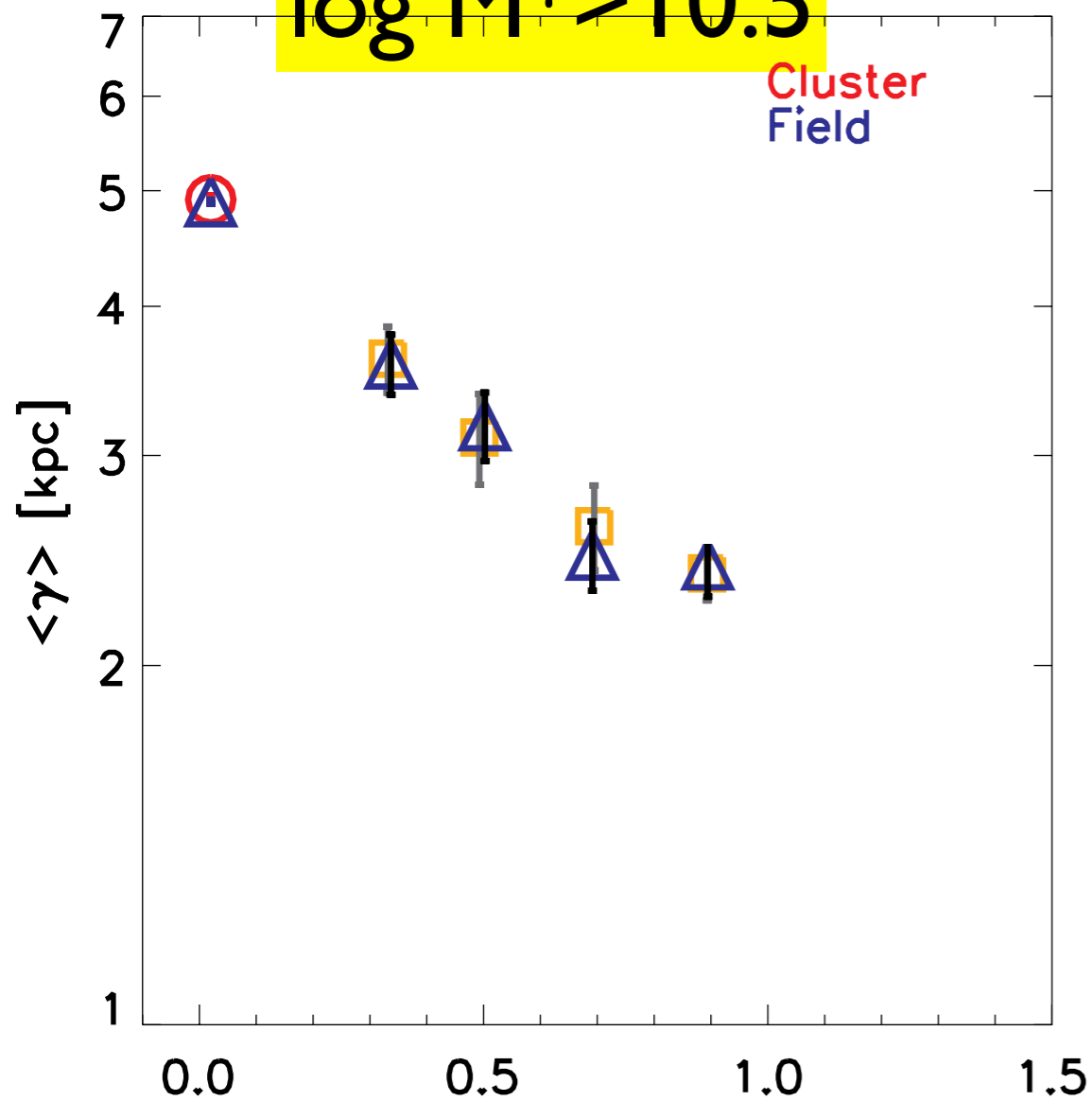
At  $z < 1$ , no significant difference between group and field galaxies



MHC+I3a,b

Delaye, MHC+I3

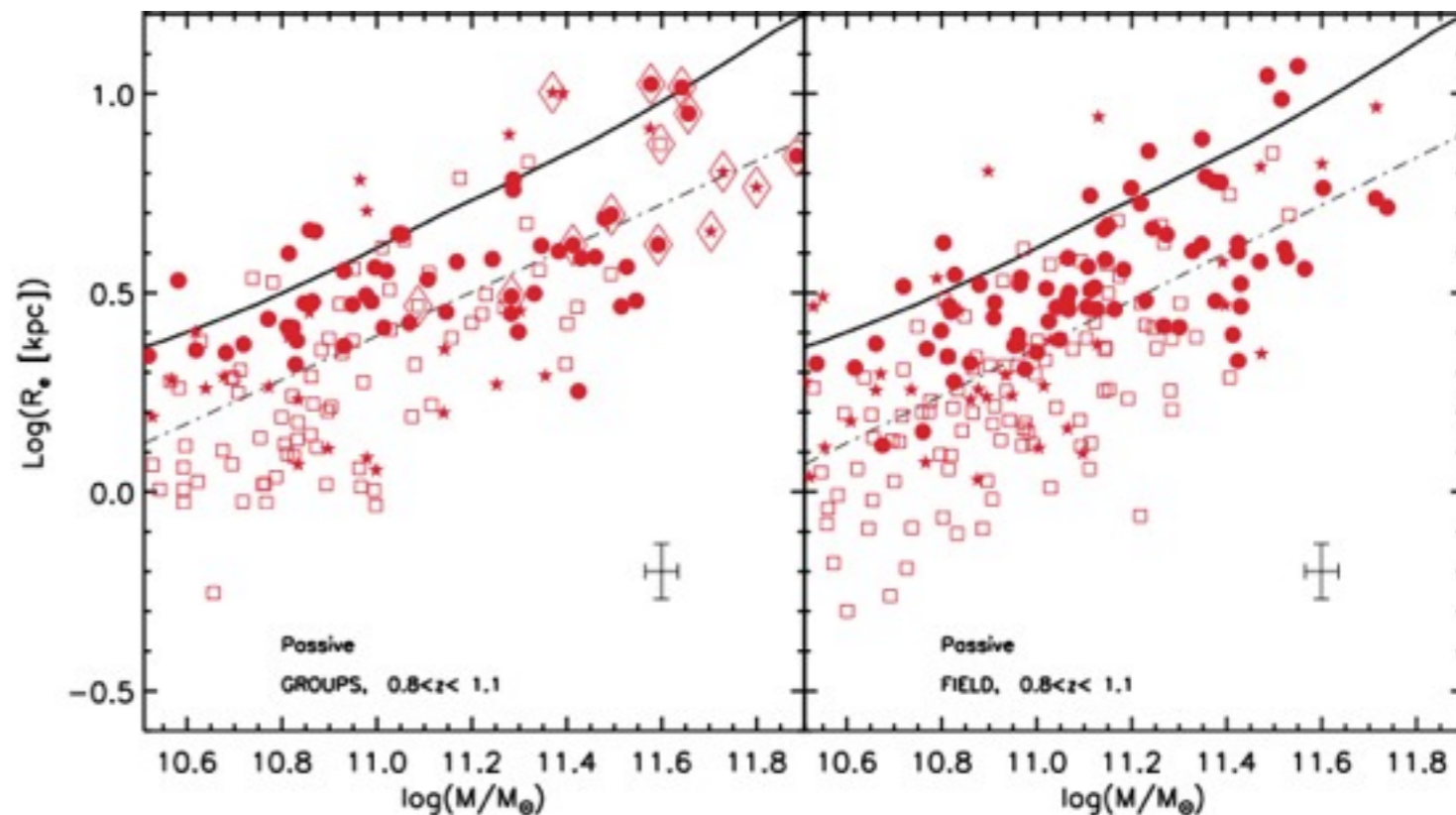
$\log M^* > 10.5$



○ Clusters

□ Groups

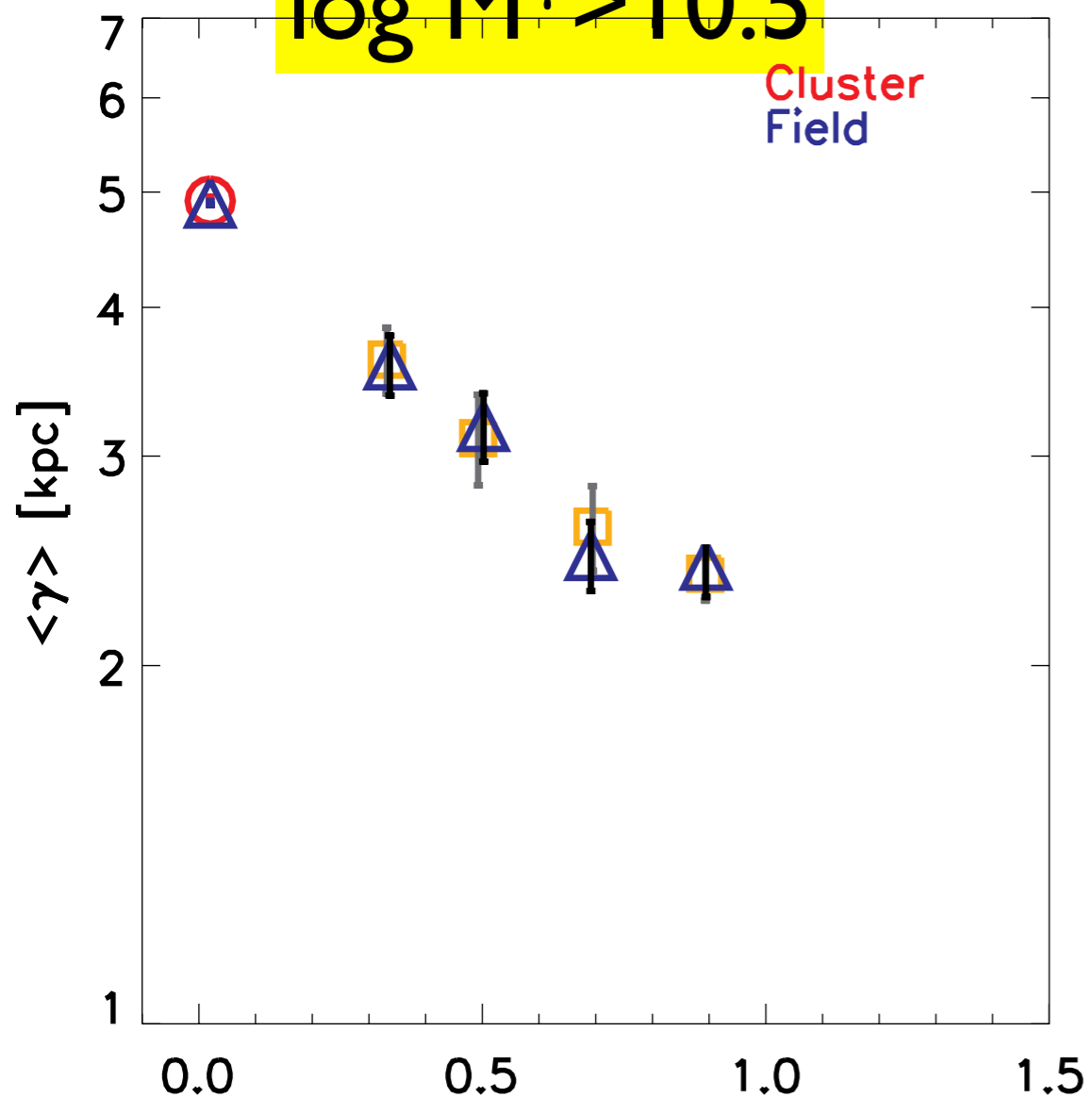
△ Field



At  $z < 1$ , no significant difference between group and field galaxies

MHC+13a,b  
Delaye,MHC+13

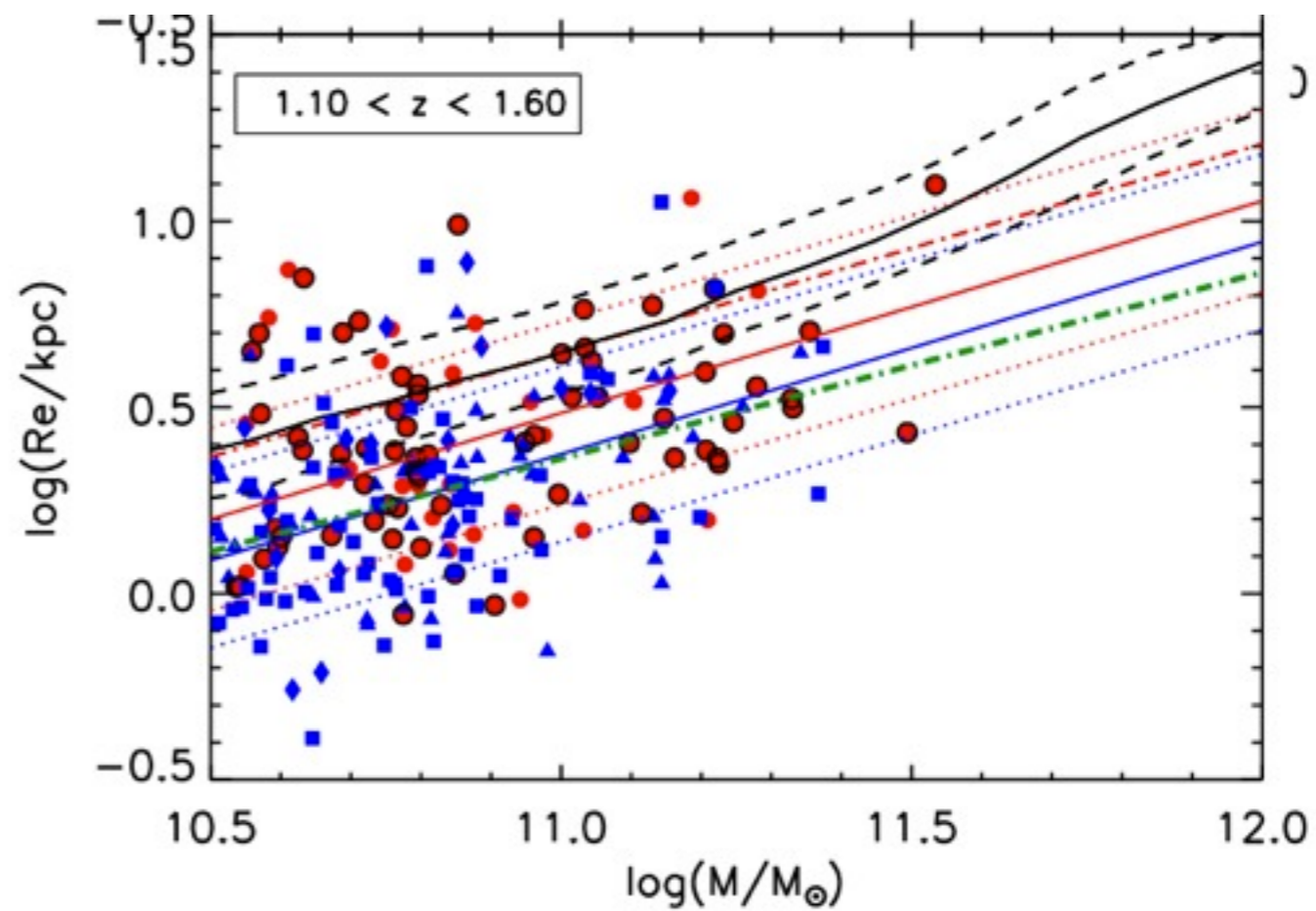
$\log M^* > 10.5$



○ Clusters<sup>redshift</sup>

□ Groups

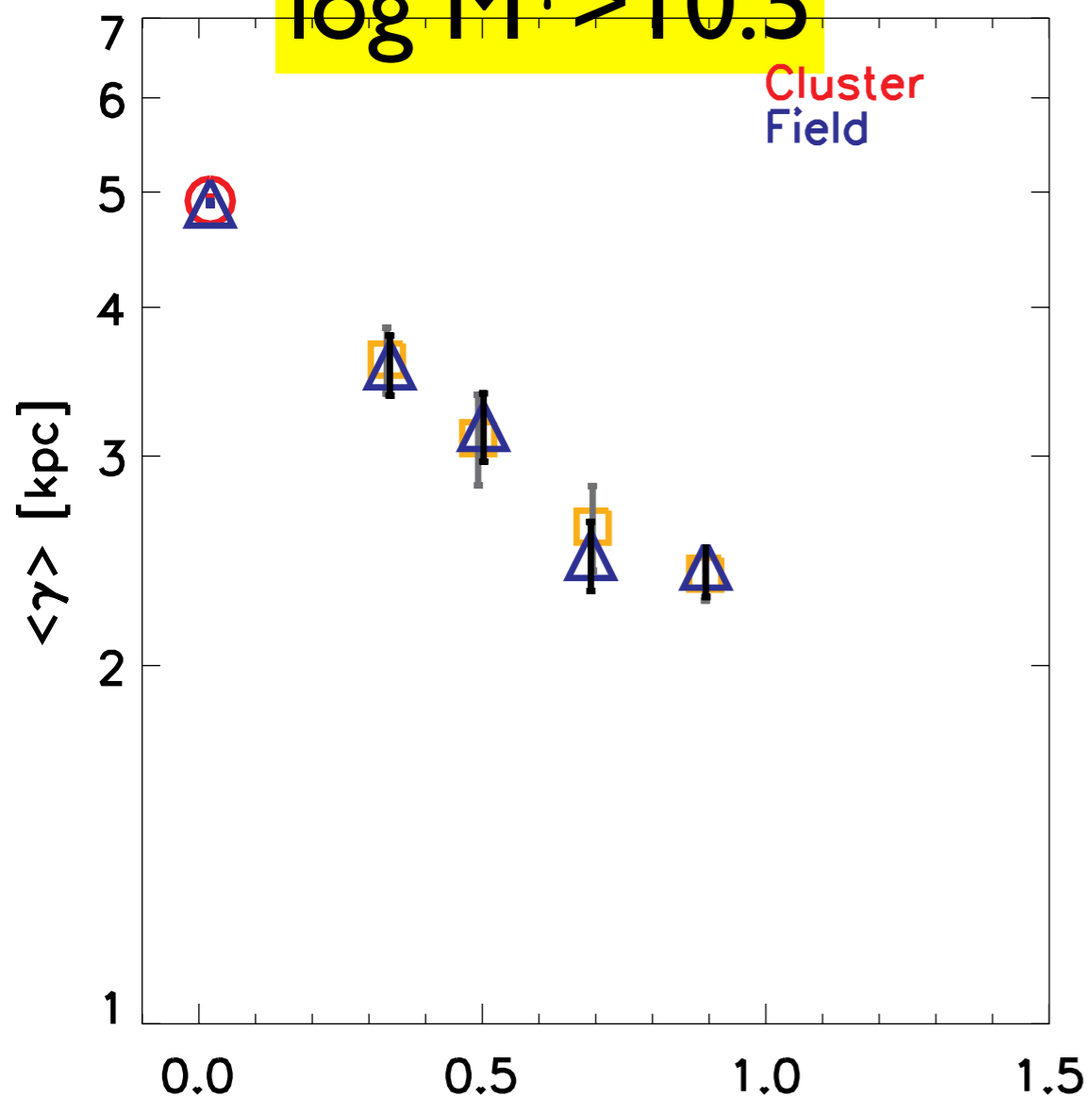
△ Field



MHC+13a,b

Delaye, MHC+13

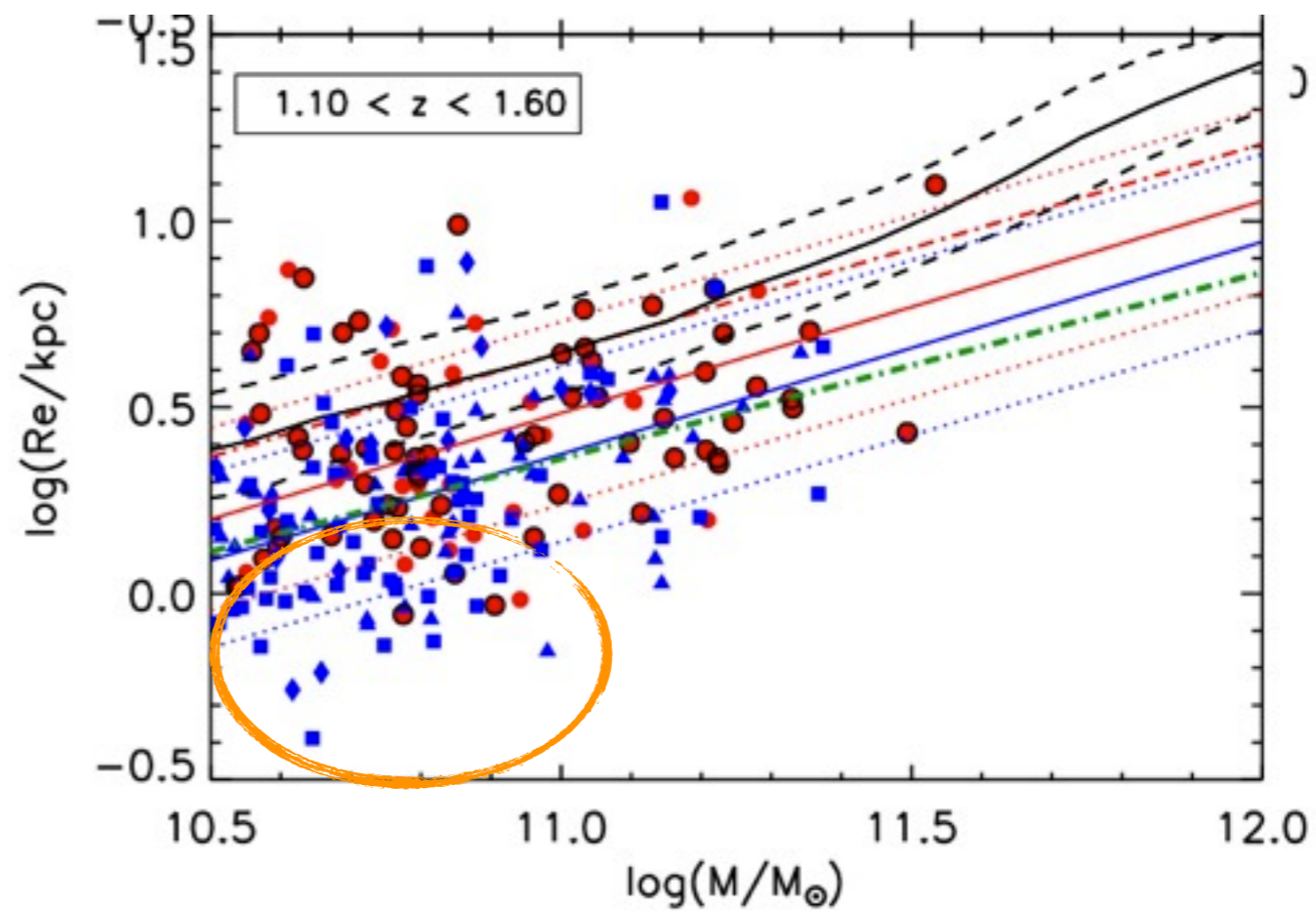
$\log M^* > 10.5$



○ Clusters<sup>redshift</sup>

□ Groups

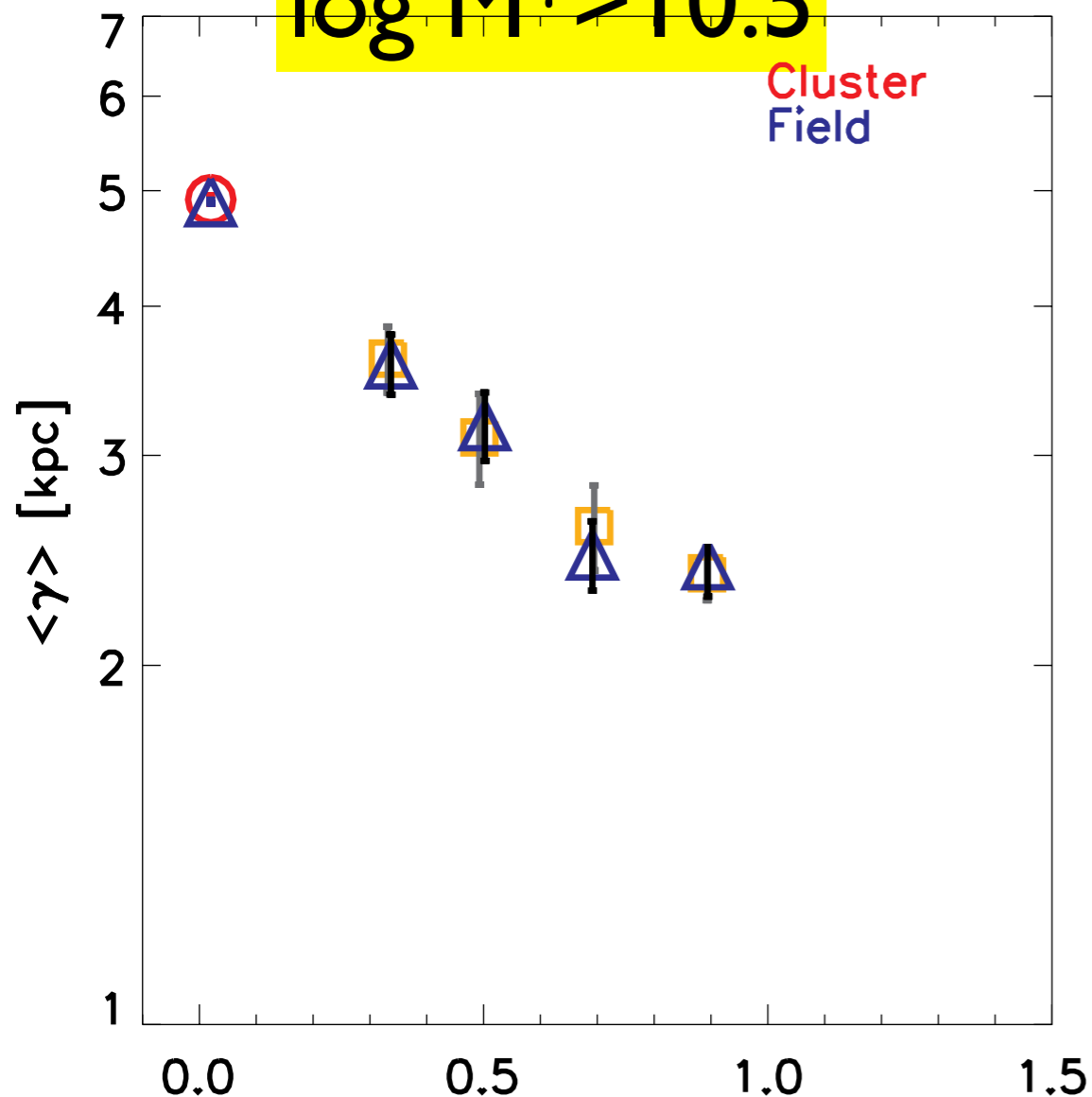
△ Field



MHC+13a,b

Delaye, MHC+13

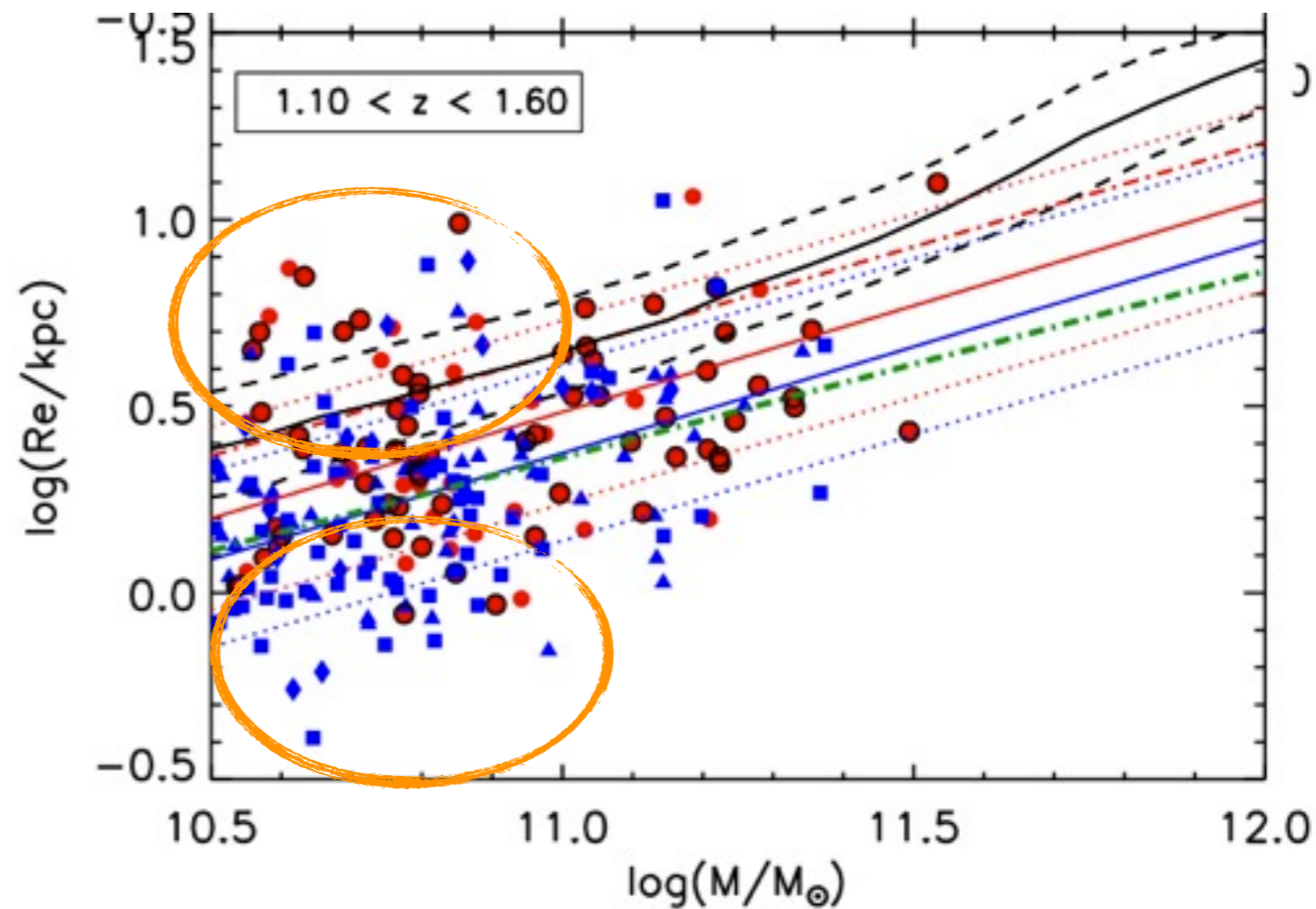
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○ Clusters

□ Groups

△ Field



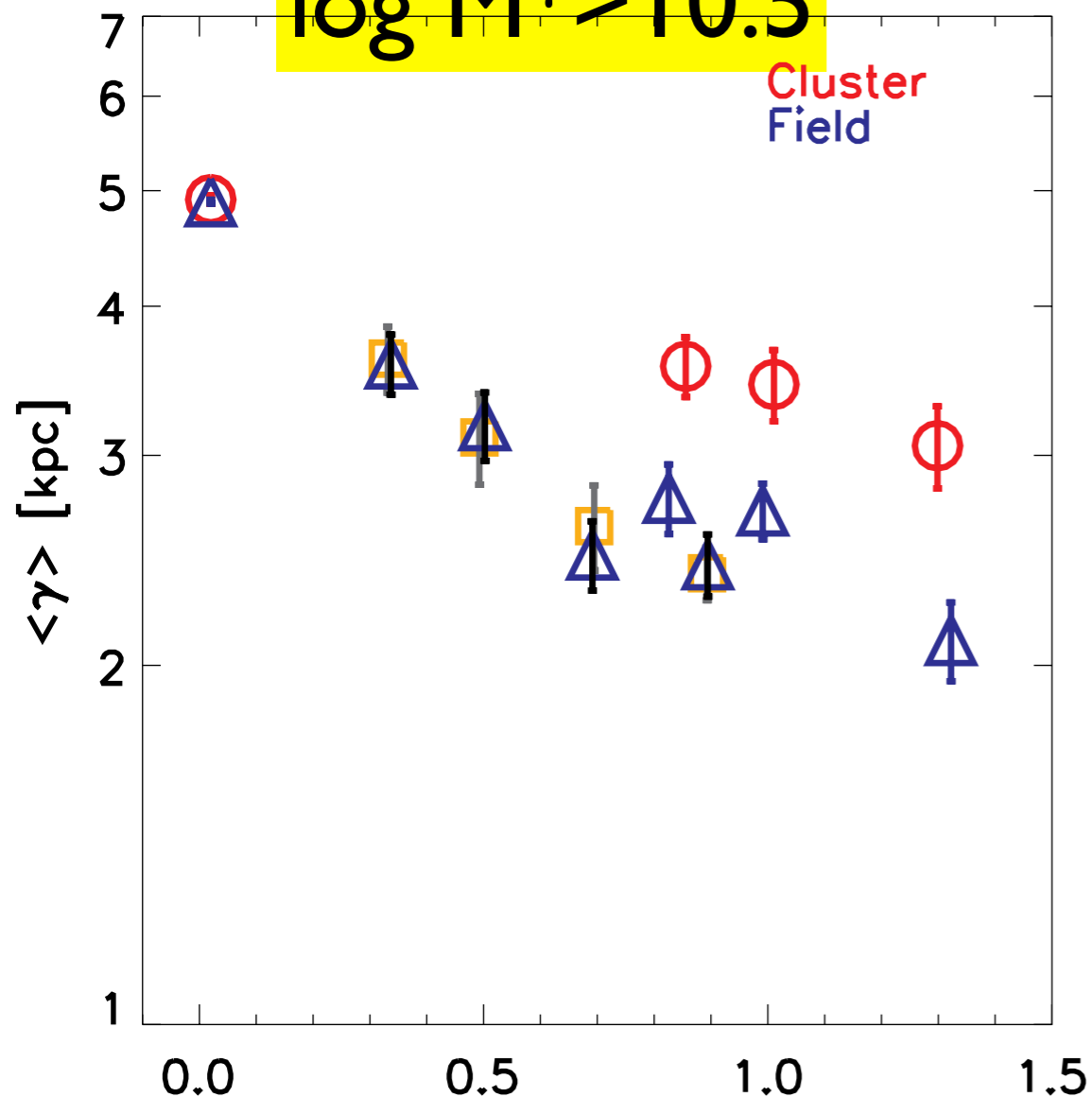
At  $z > 1$ , cluster galaxies appear to be on average **~30%** larger than field galaxies (see also Papovich+12, Strazzullo+13)



MHC+13a,b

Delaye, MHC+13

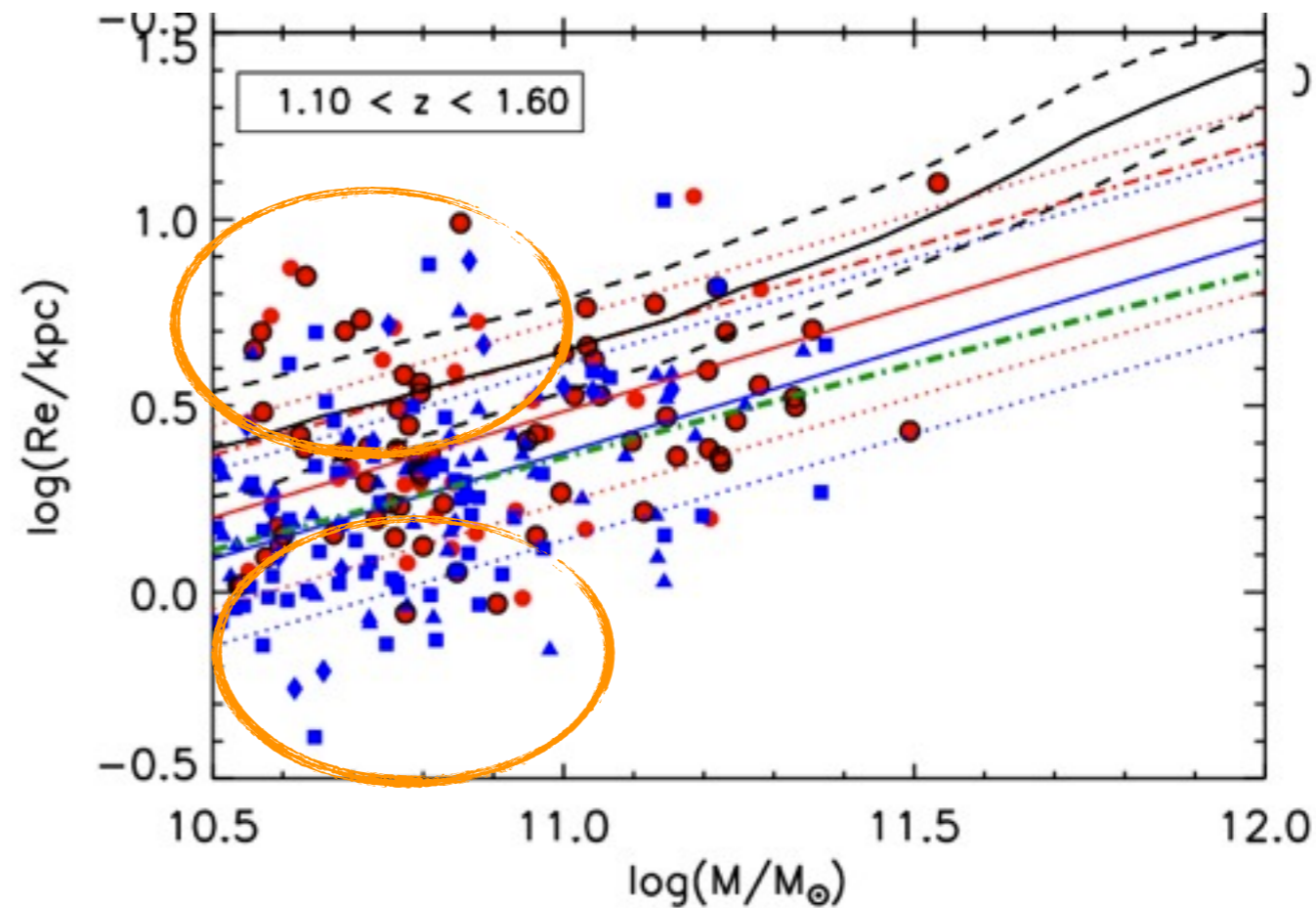
$\log M^* > 10.5$



○ Clusters

□ Groups

△ Field

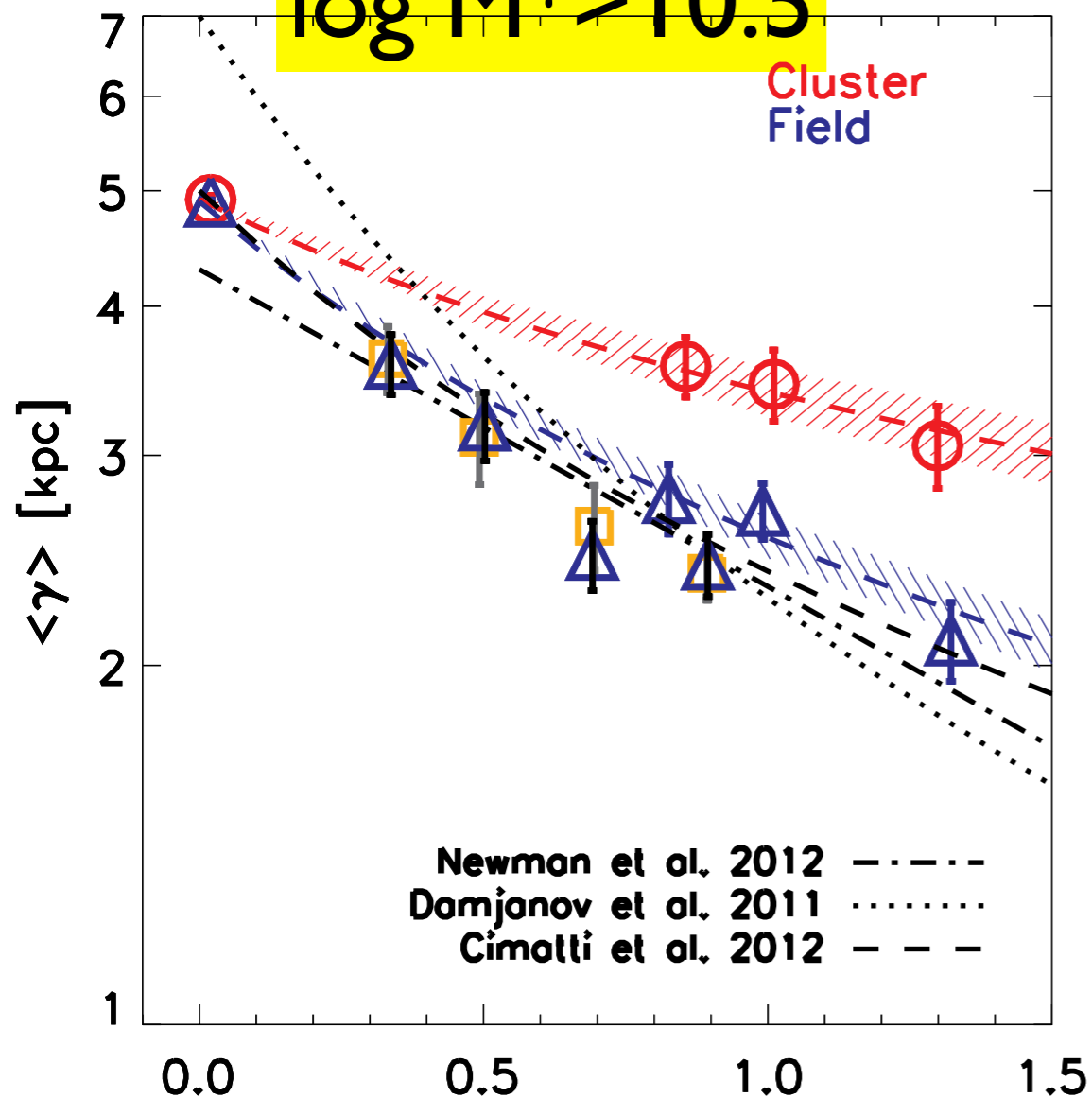


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MHC+13a,b

Delays, MHC+13

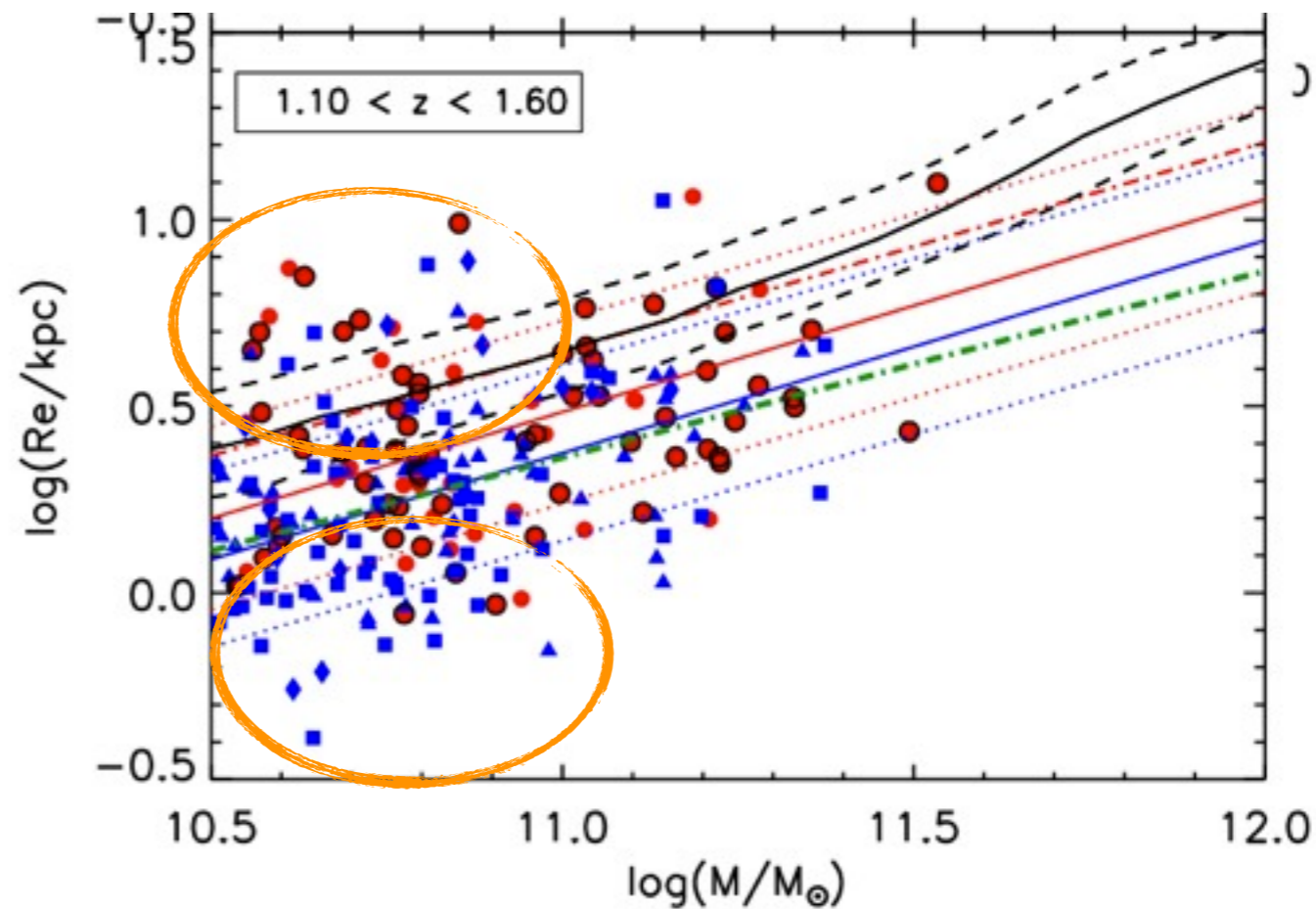
$\log M^* > 10.5$



○ Clusters

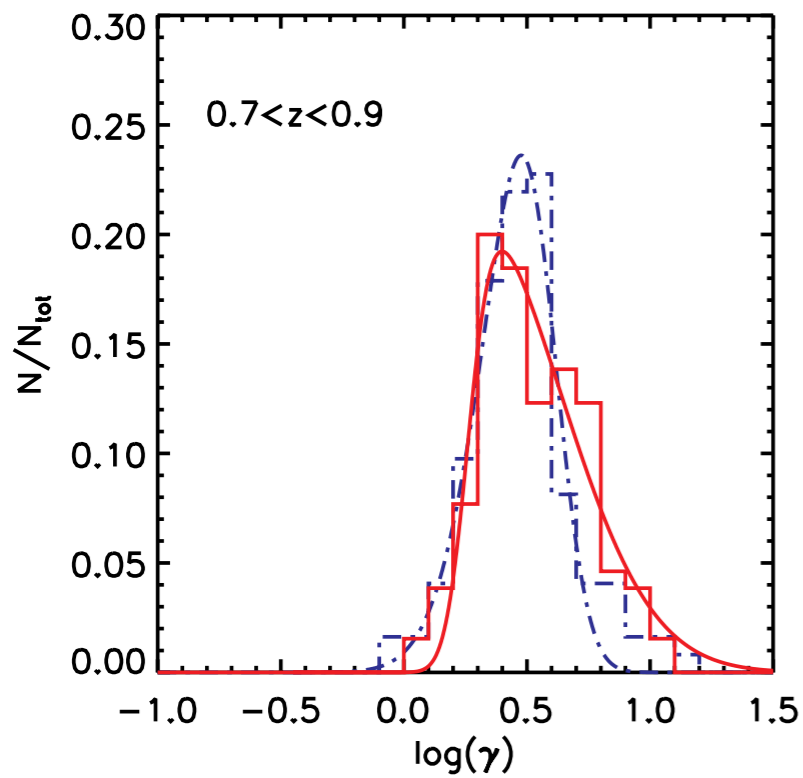
□ Groups

△ Field

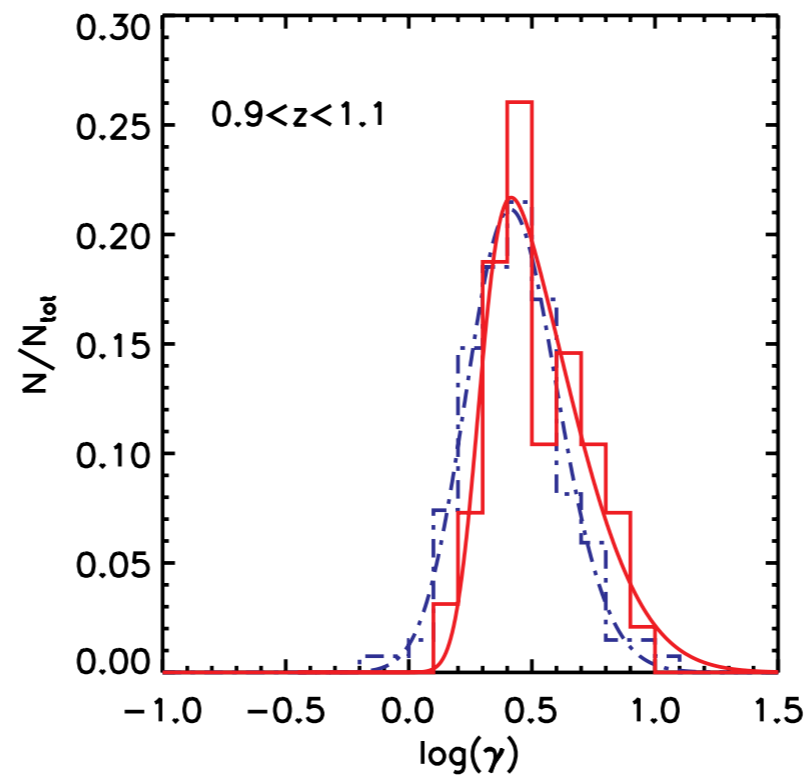


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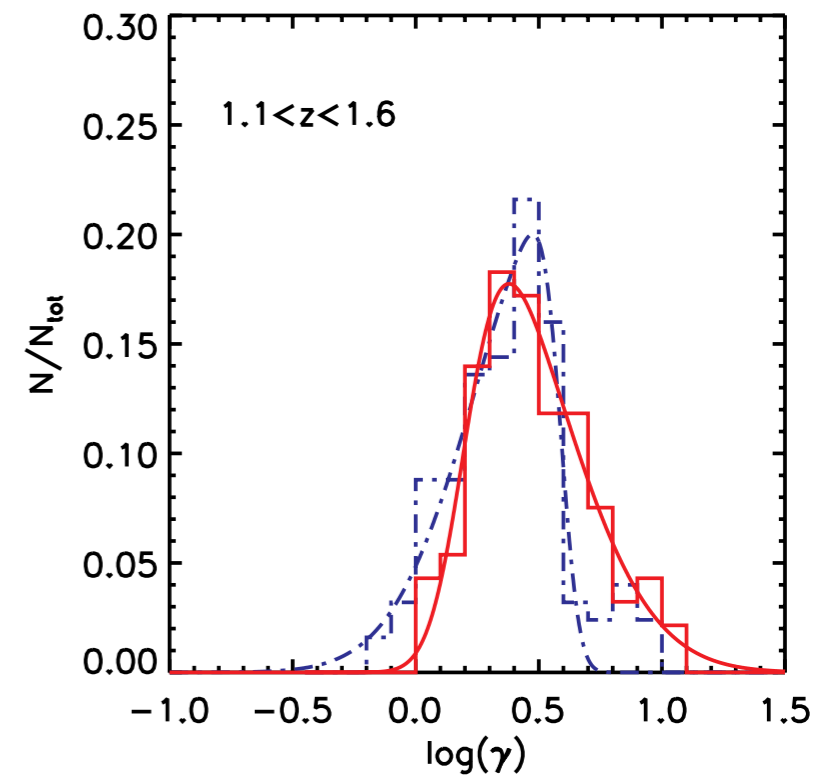
**$0.7 < z < 0.9$**



**$0.9 < z < 1.1$**



**$1.1 < z < 1.6$**



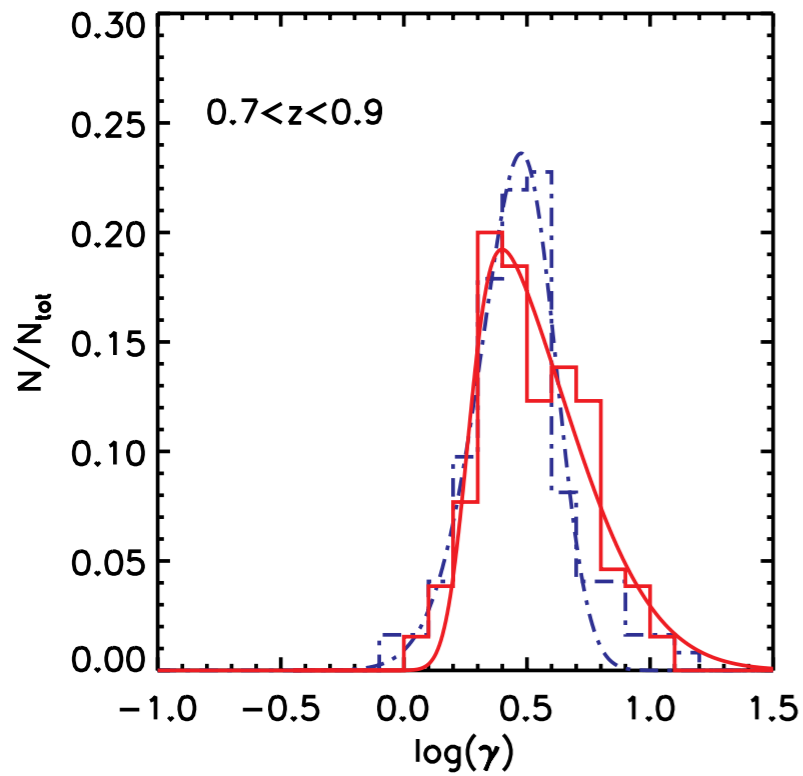
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**Clusters**

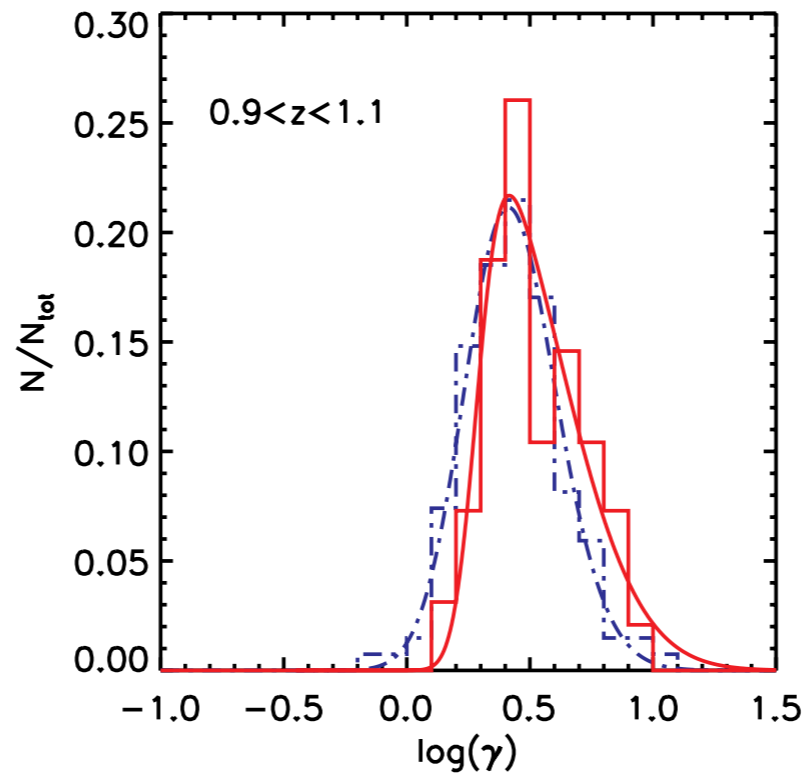
.....

**Field**

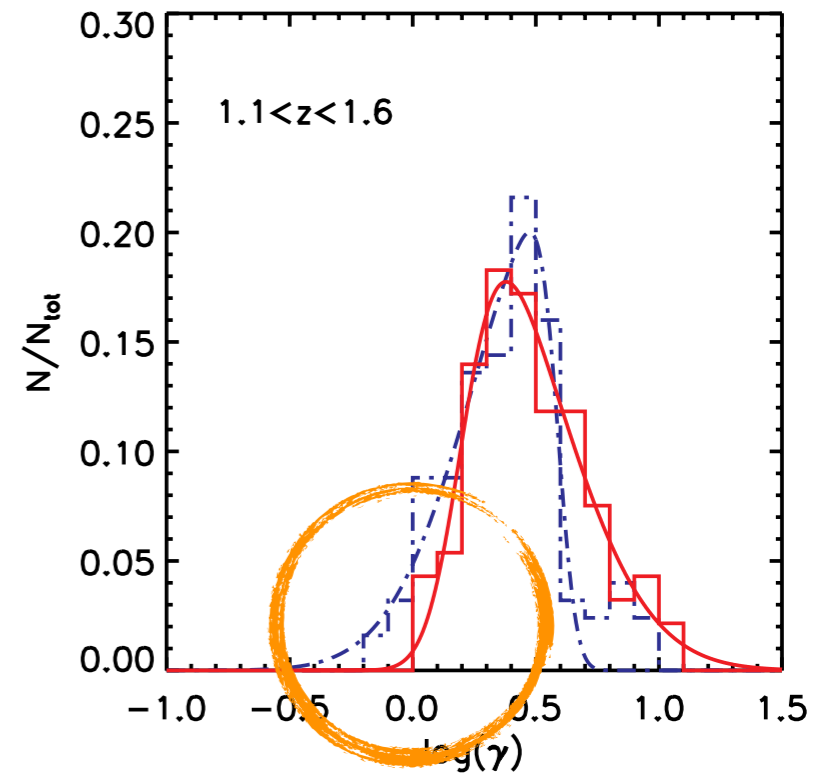
**$0.7 < z < 0.9$**



**$0.9 < z < 1.1$**



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—

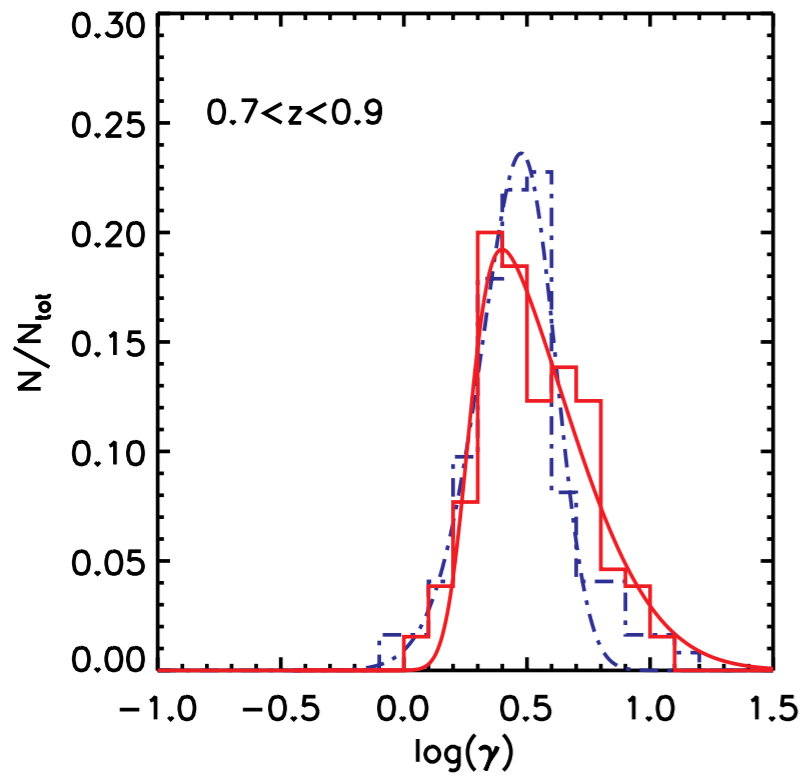
**Clusters**

⋯

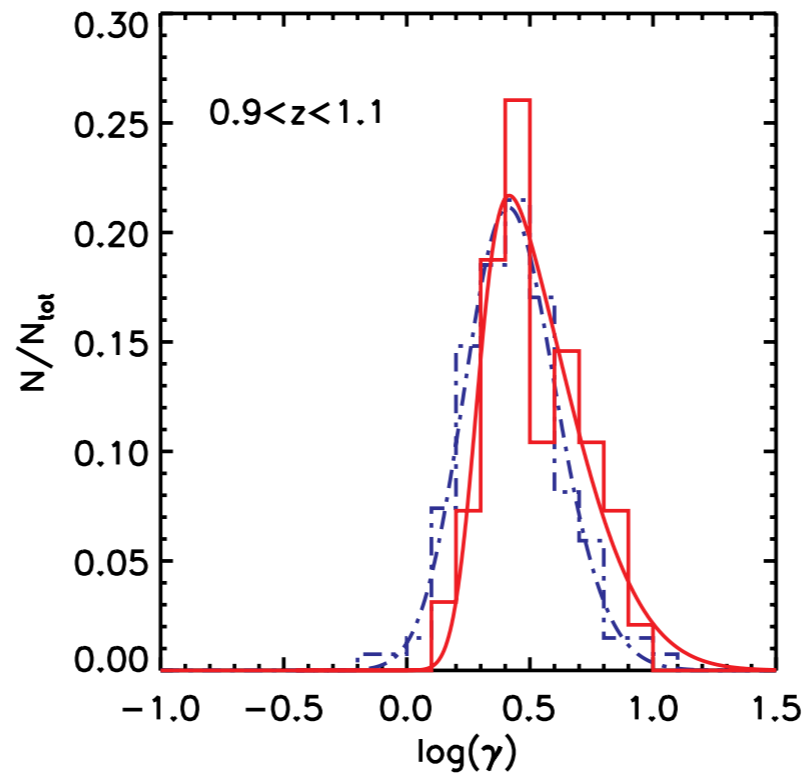
**Field**



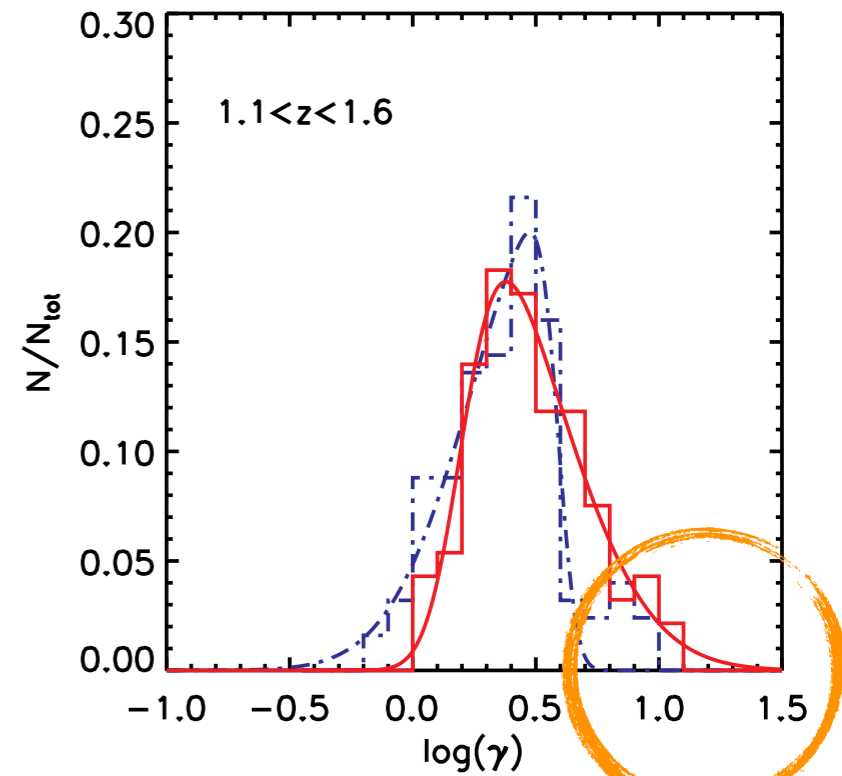
$0.7 < z < 0.9$



$0.9 < z < 1.1$



$1.1 < z < 1.6$



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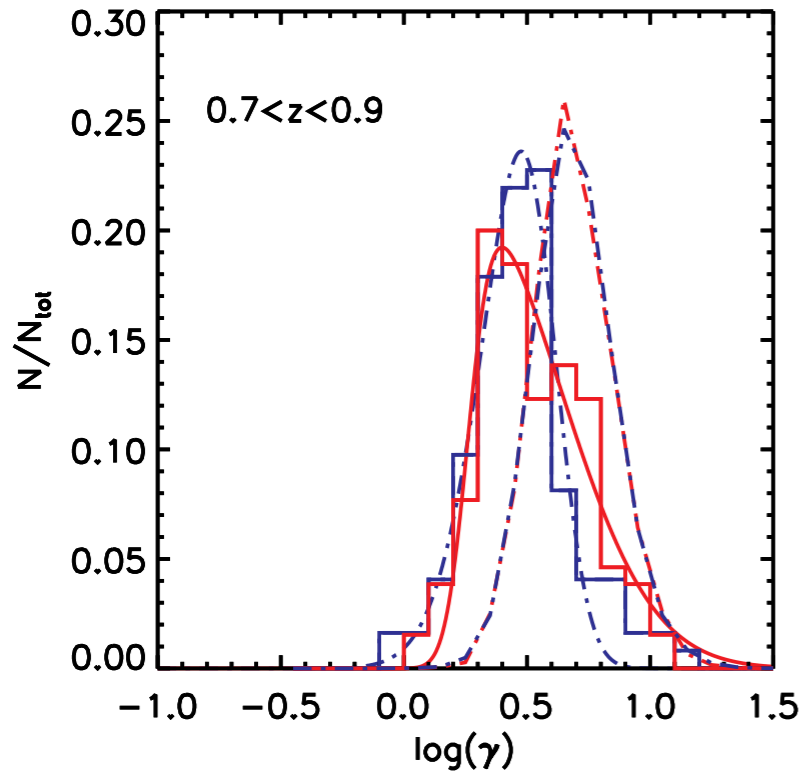
Clusters

⋯

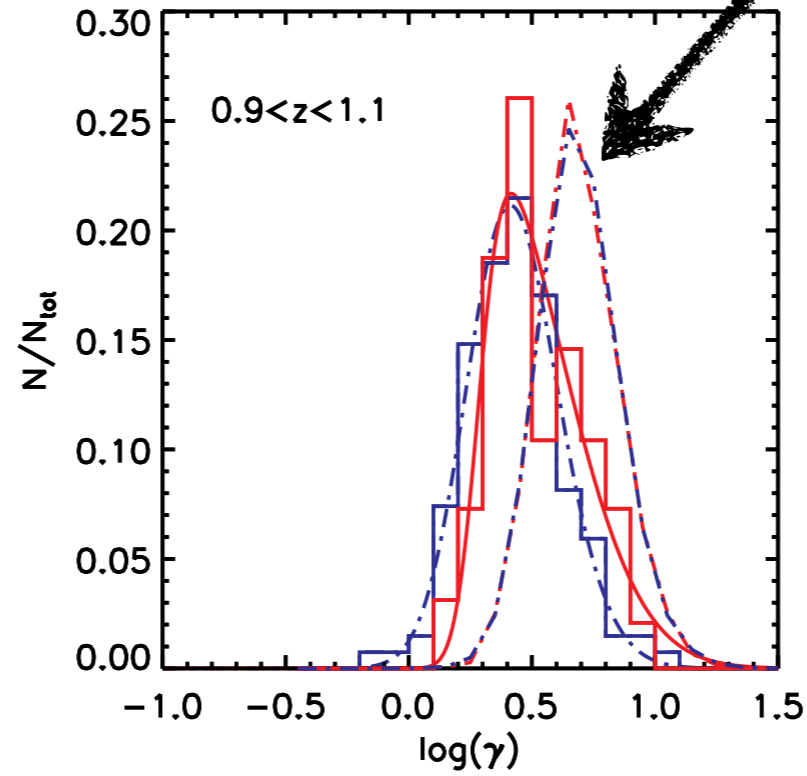
Field

SDSS

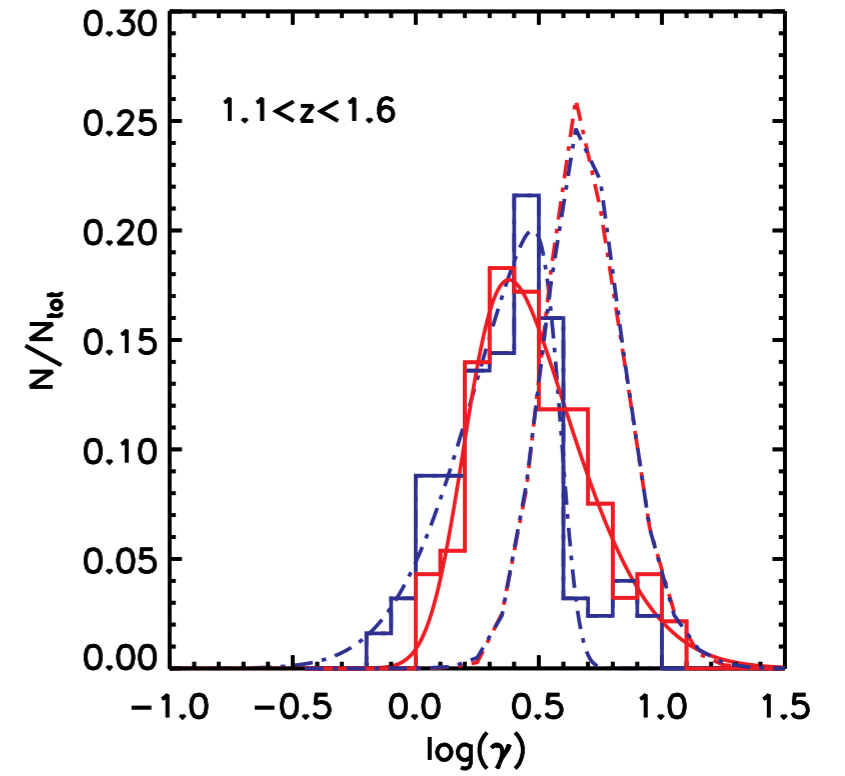
$0.7 < z < 0.9$



$0.9 < z < 1.1$



$1.1 < z < 1.6$



—

Clusters

⋯

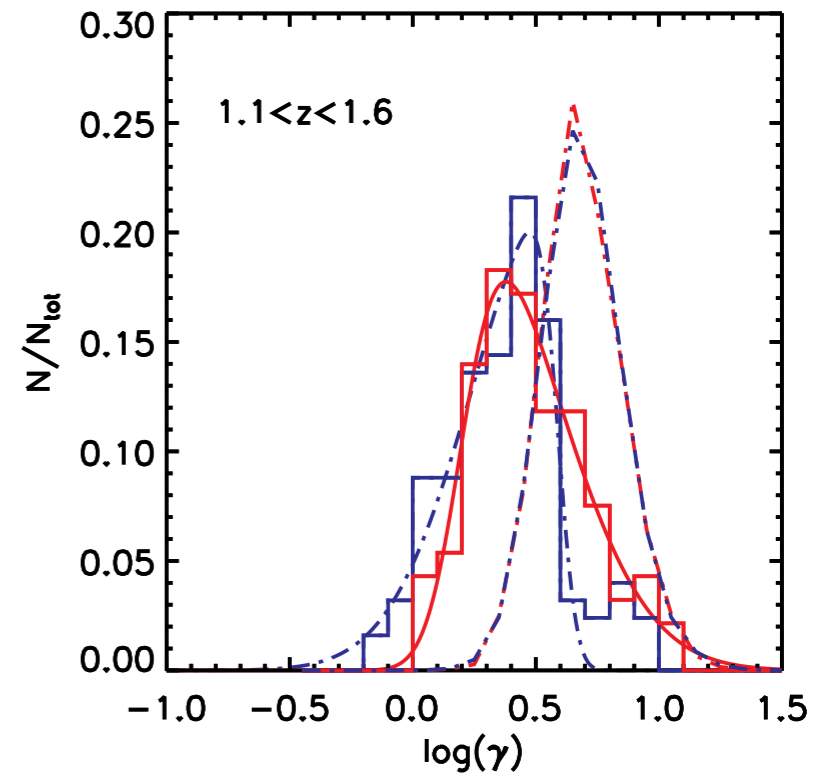
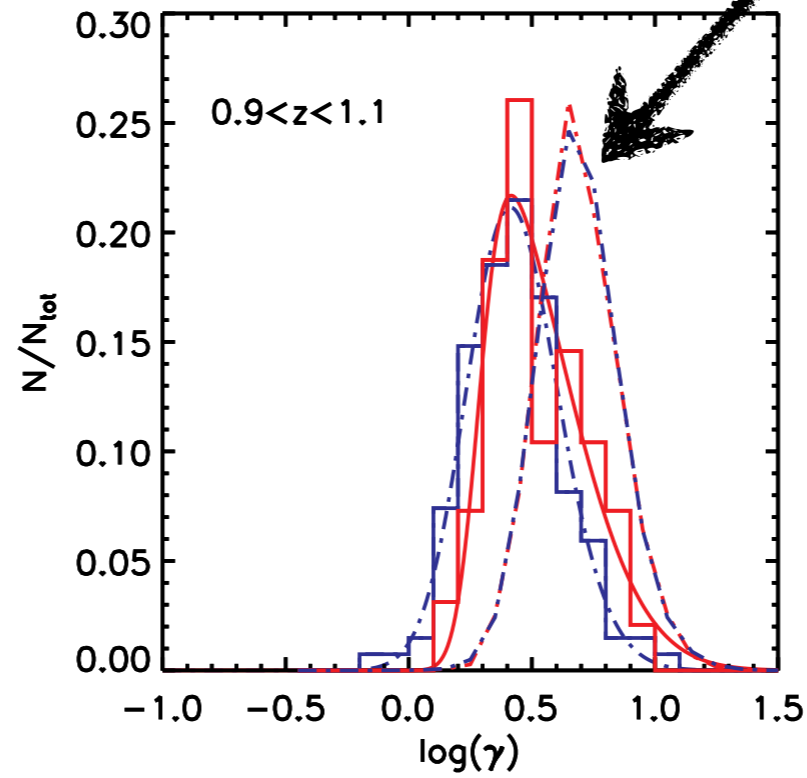
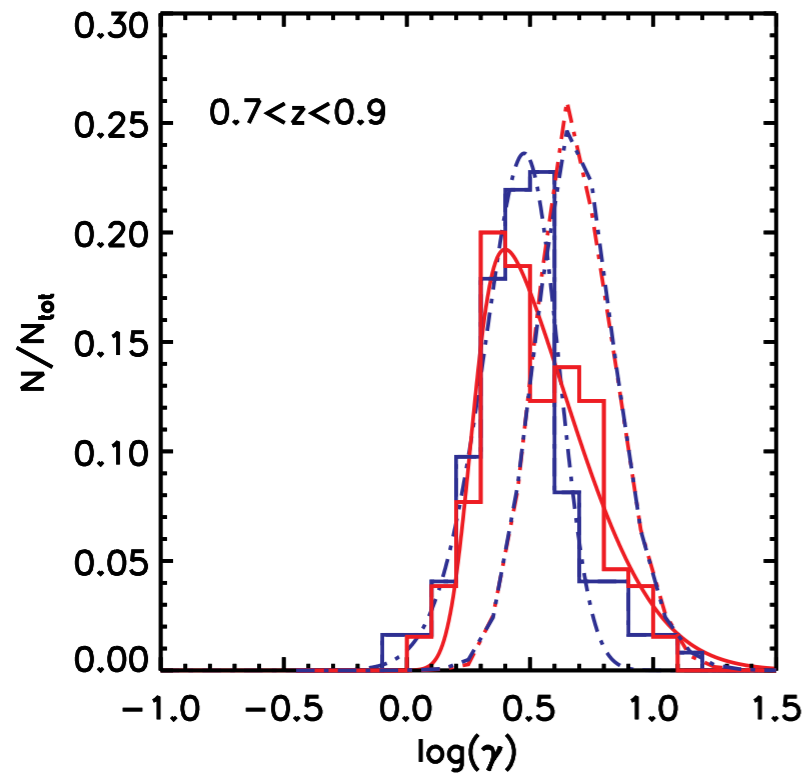
Field

SDSS

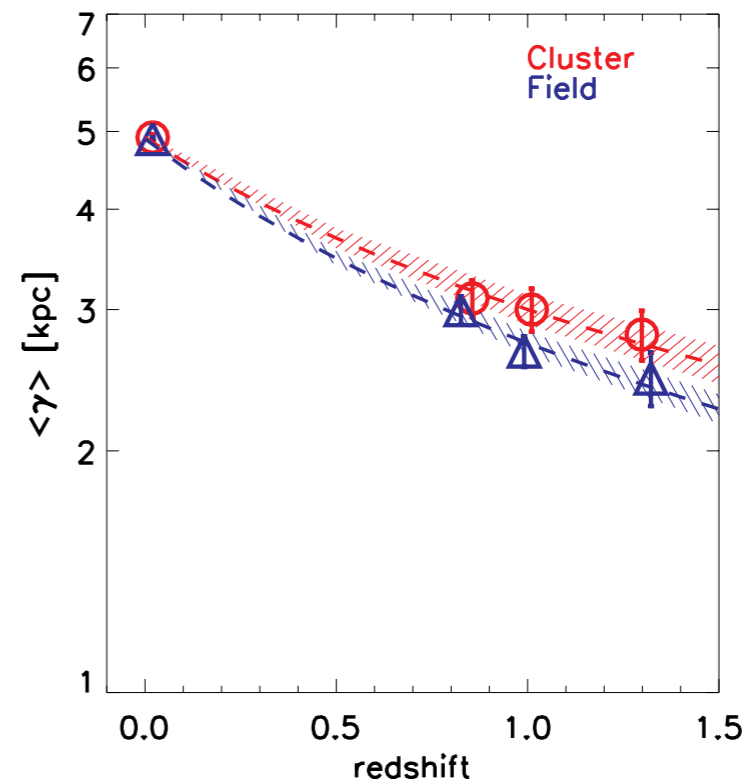
$0.7 < z < 0.9$

$0.9 < z < 1.1$

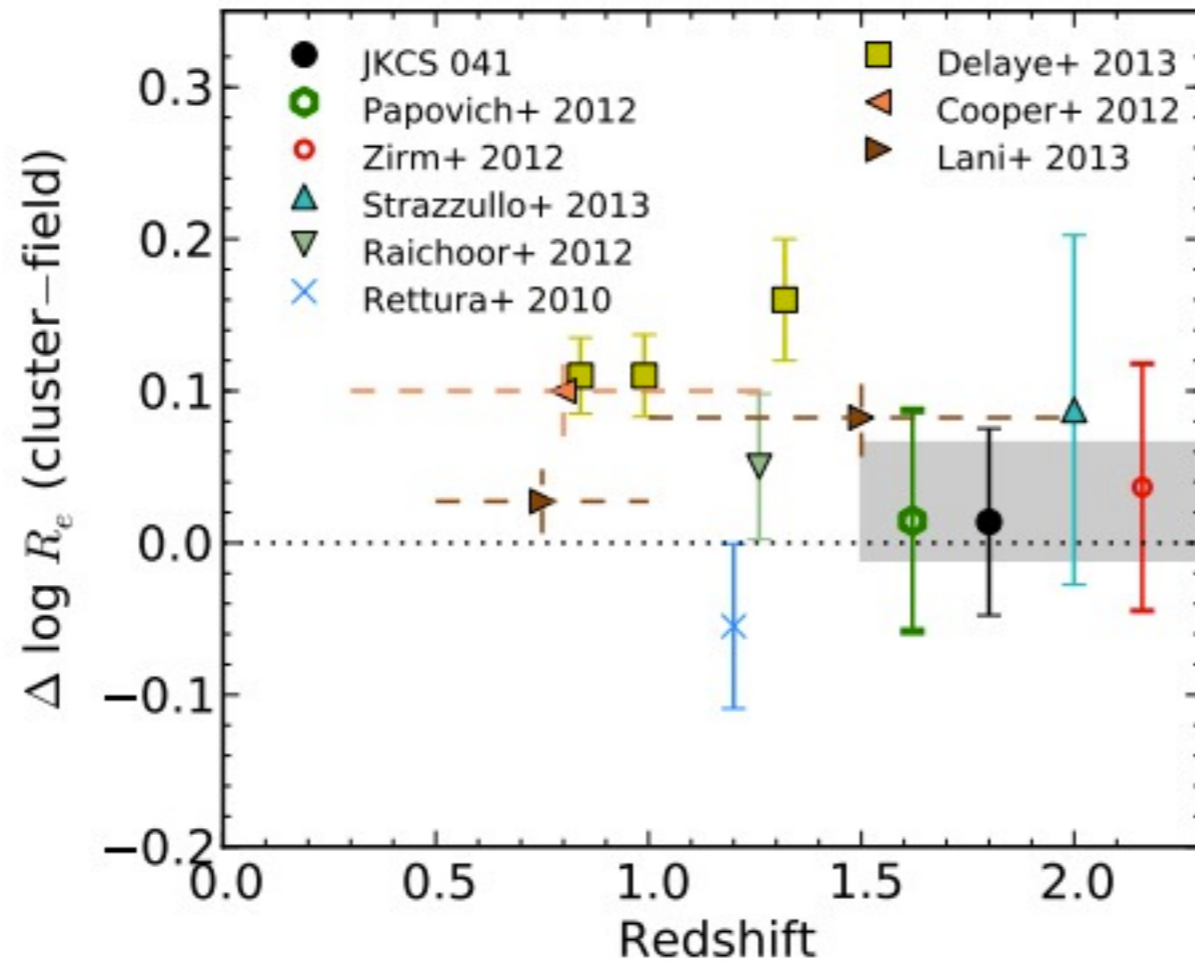
$1.1 < z < 1.6$



Clusters  
Field



There seems to be a **small** trend  
at  $z > 1$ ...



Newman+13



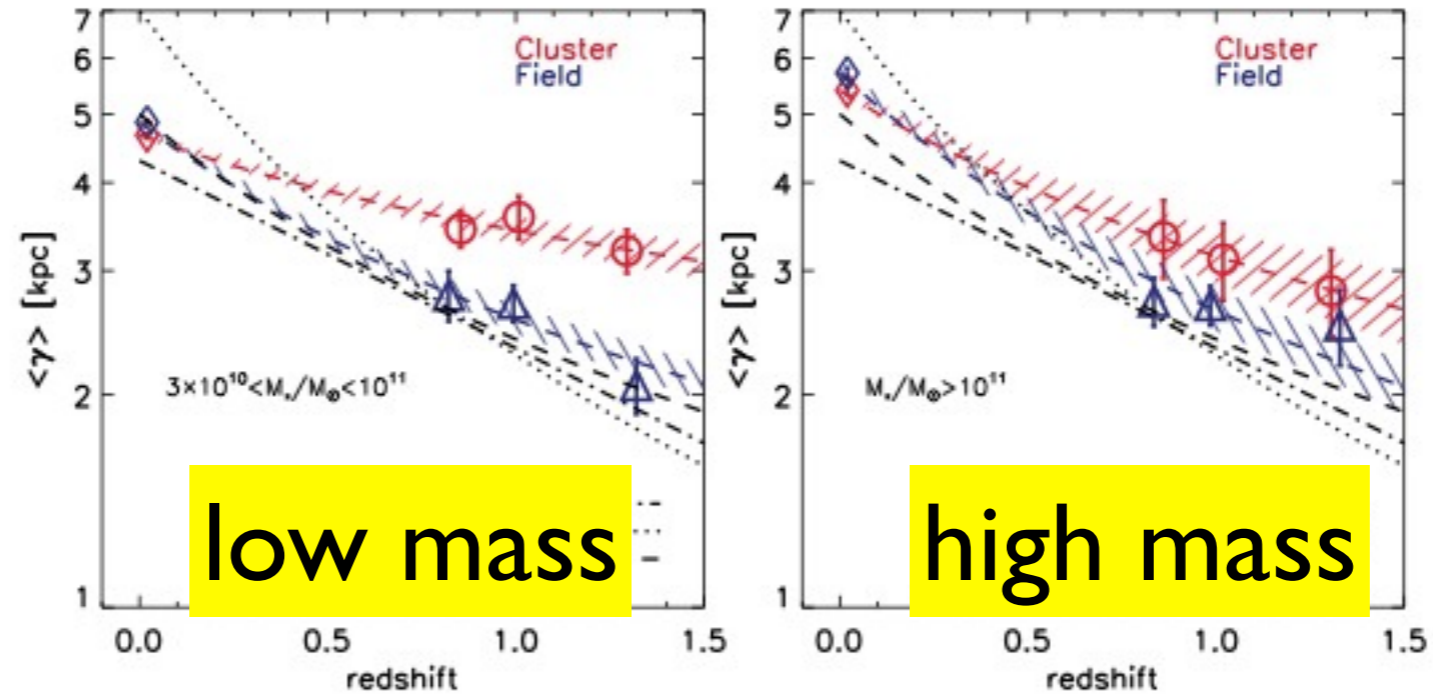
Is this telling us something about the physics?

Is this telling us something about the physics?

Mergers?

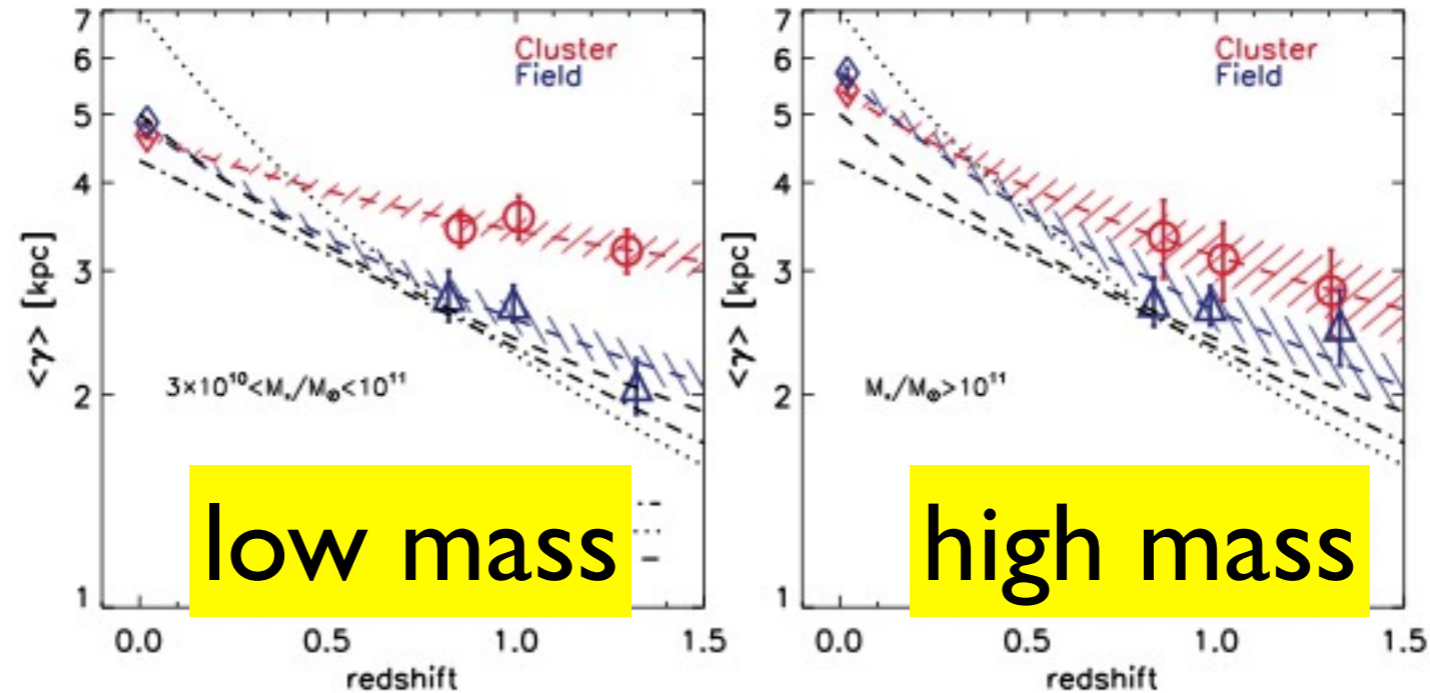
# Is this telling us something about the physics?

Mergers?

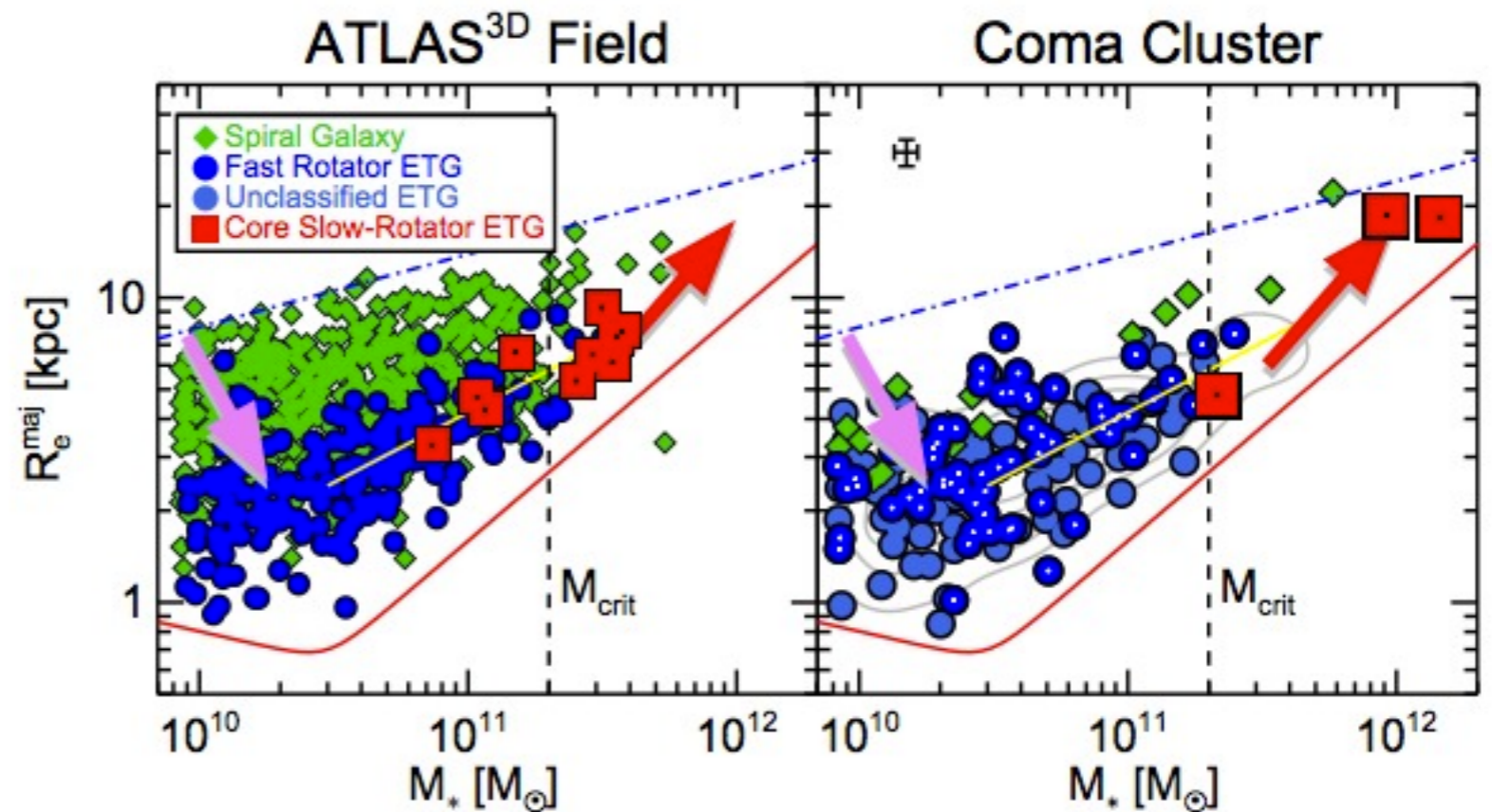


# Is this telling us something about the physics?

Mergers?



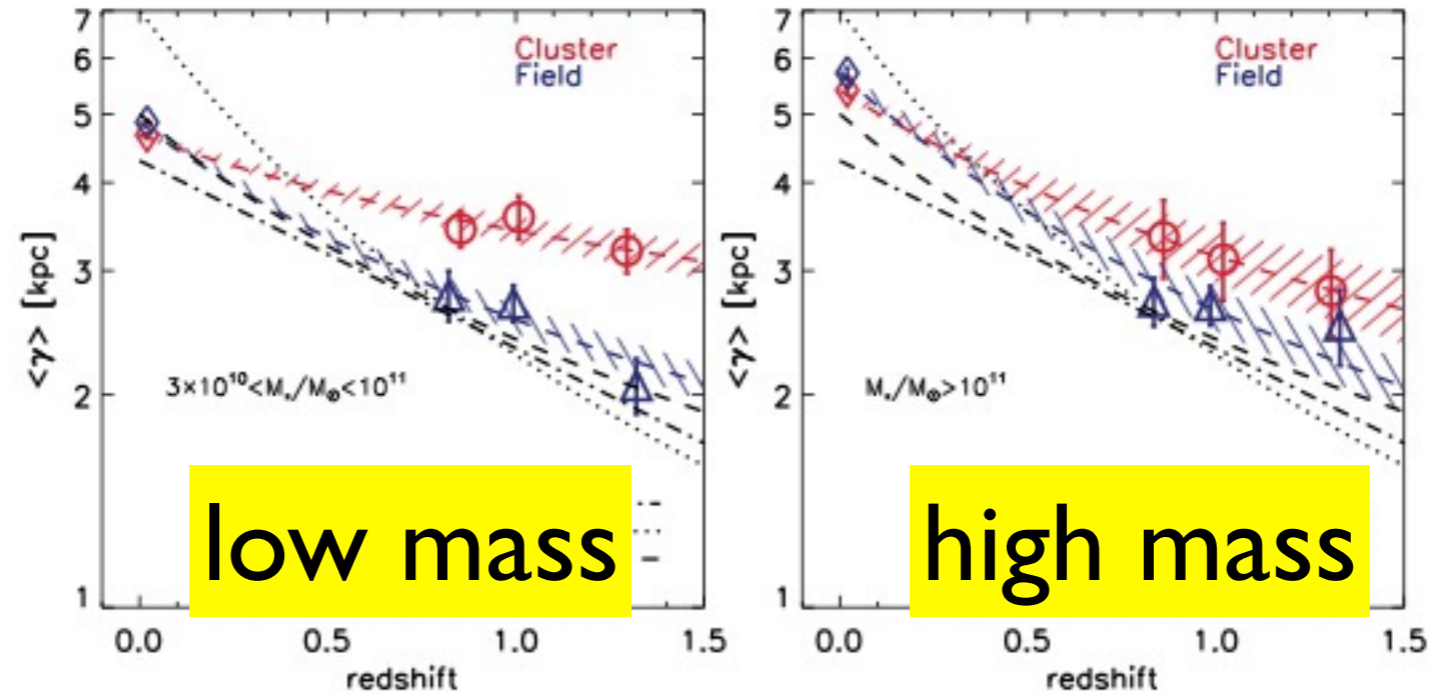
Accelerated  
quenching in  
dense  
environments?





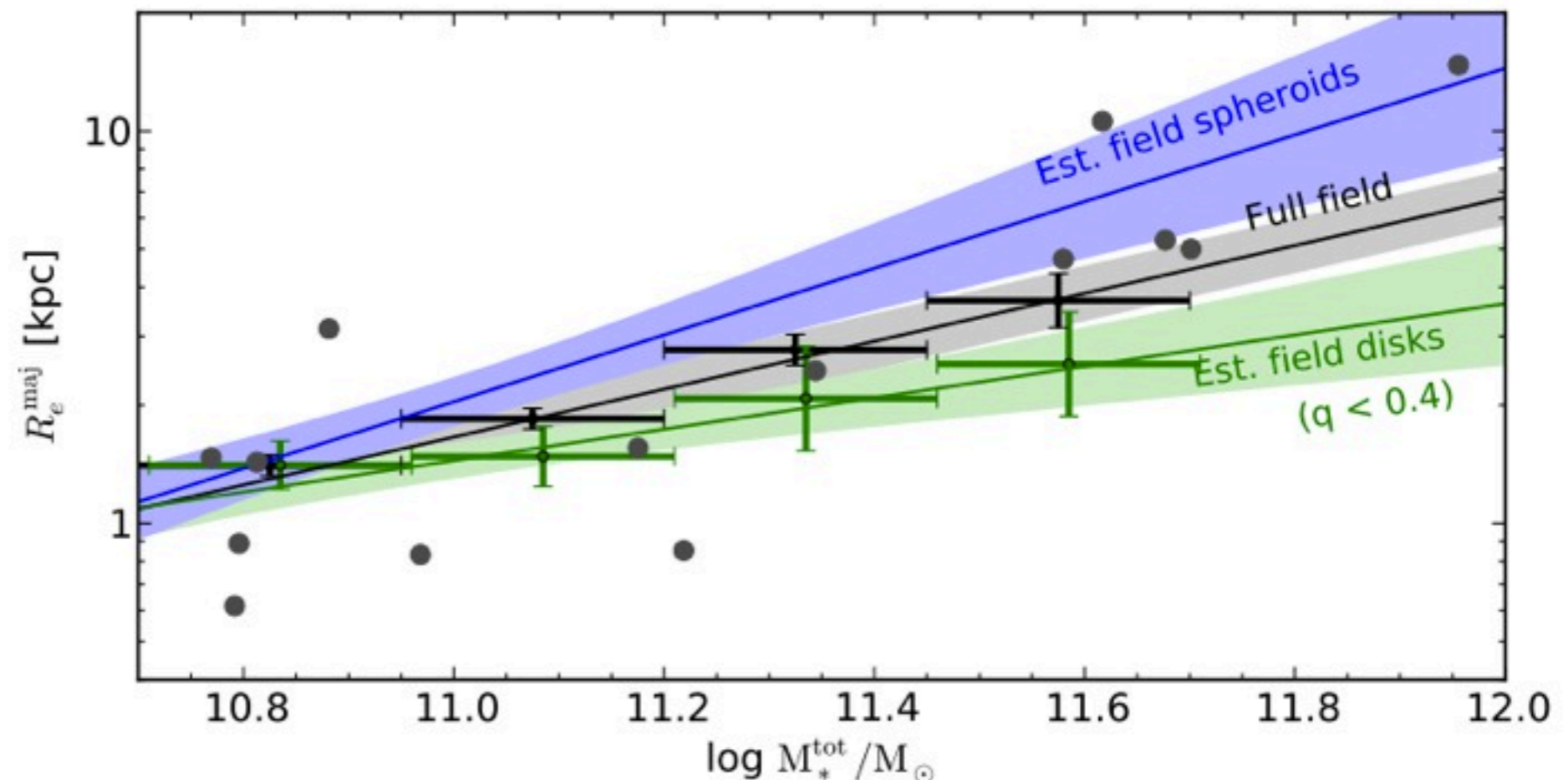
# Is this telling us something about the physics?

Mergers?



Accelerated  
quenching in  
dense  
environments?

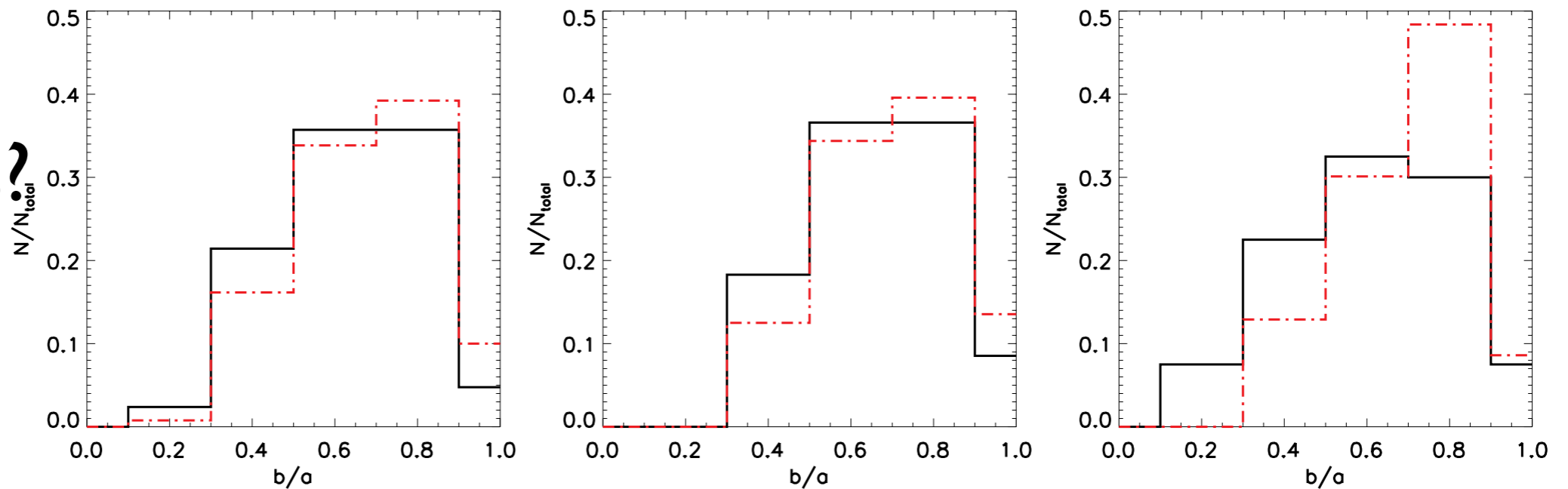
Morphological  
mixing?



Newman+13 (see also Huertas-Company+13, Bernardi+13, van der Well+10...)

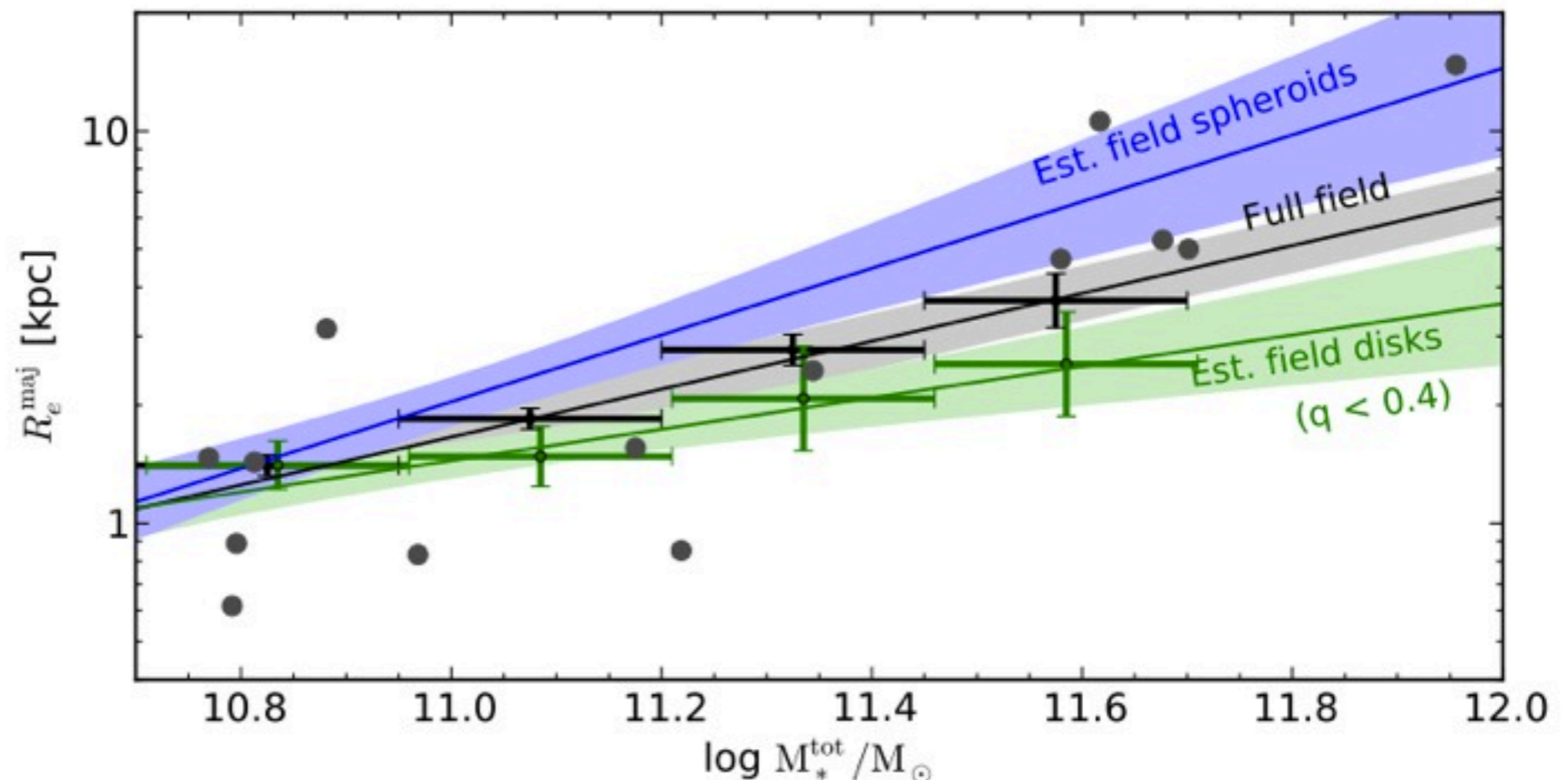
# Is this telling us something about the physics?

Mergers?



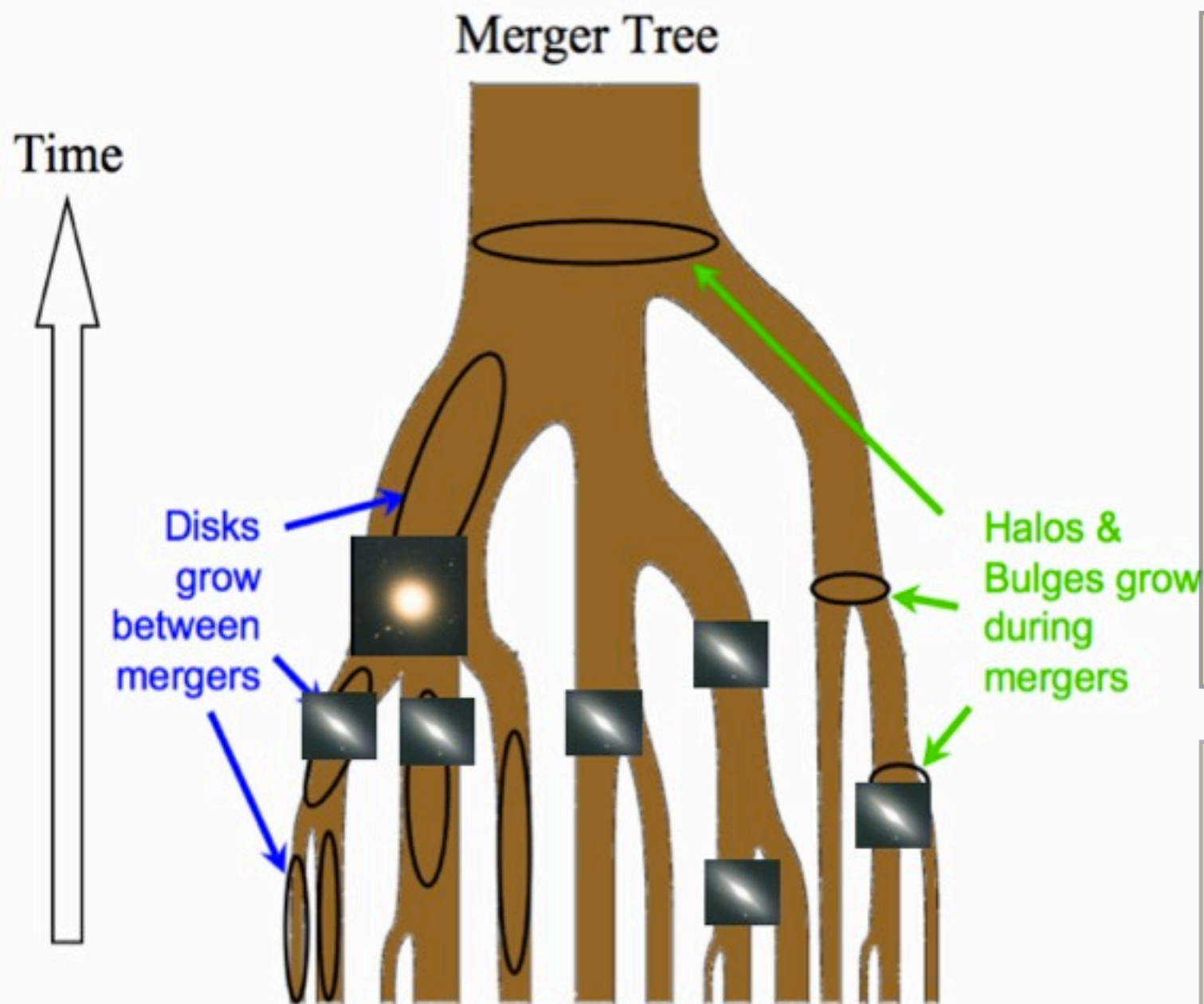
Accelerated  
quenching in  
dense  
environments?

Morphological  
mixing?



Newman+13 (see also Huertas-Company+13, Bernardi+13, van der Well+10...)

# What can we learn from models?



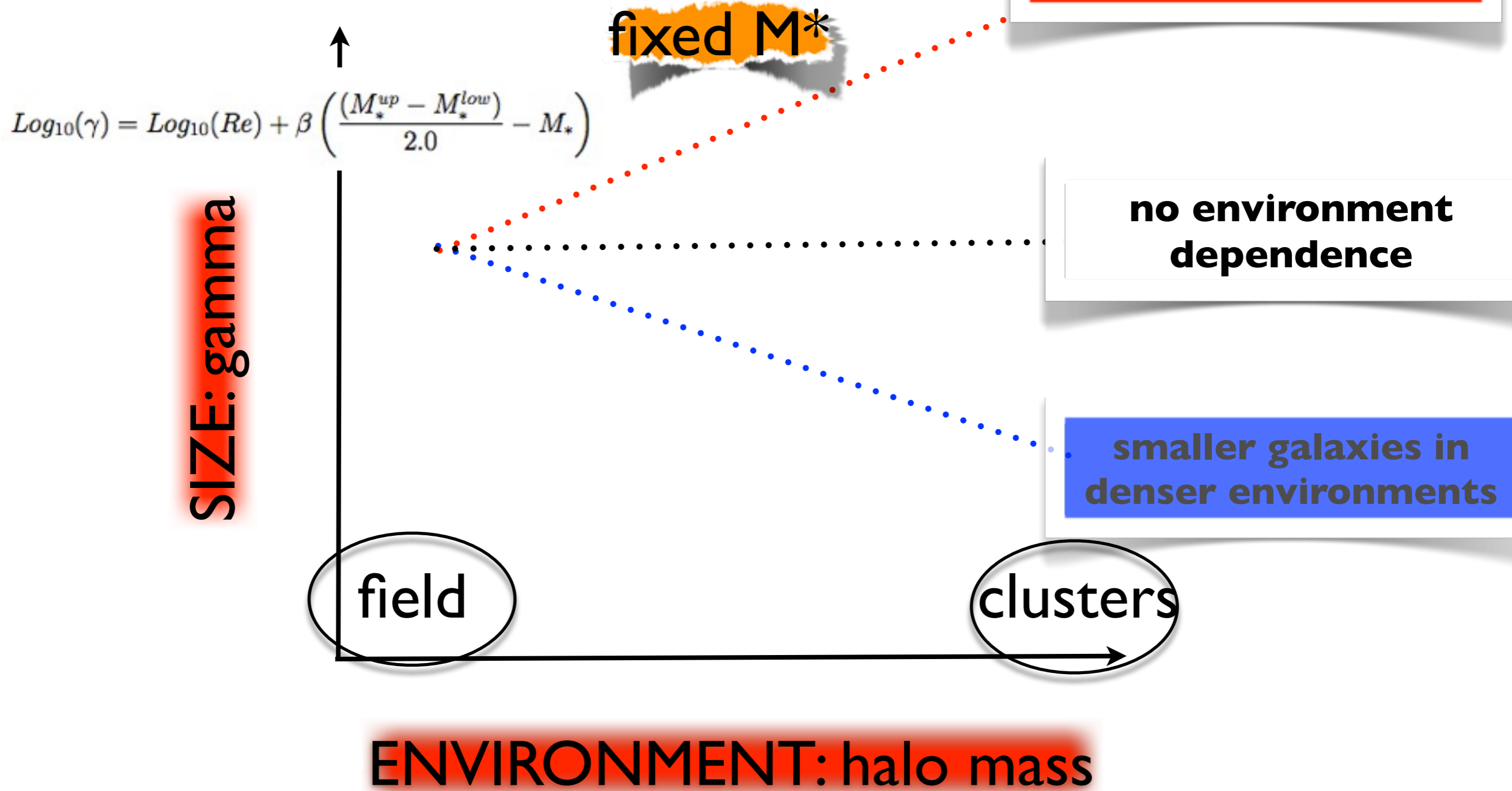
**1. SEMI-ANALYTIC MODELS:** EVOLVE GALAXIES ALONG THE DARK MATTER MERGER TREES FOLLOWING MANY PHYSICAL RECIPES

*many parameters/degeneracies*

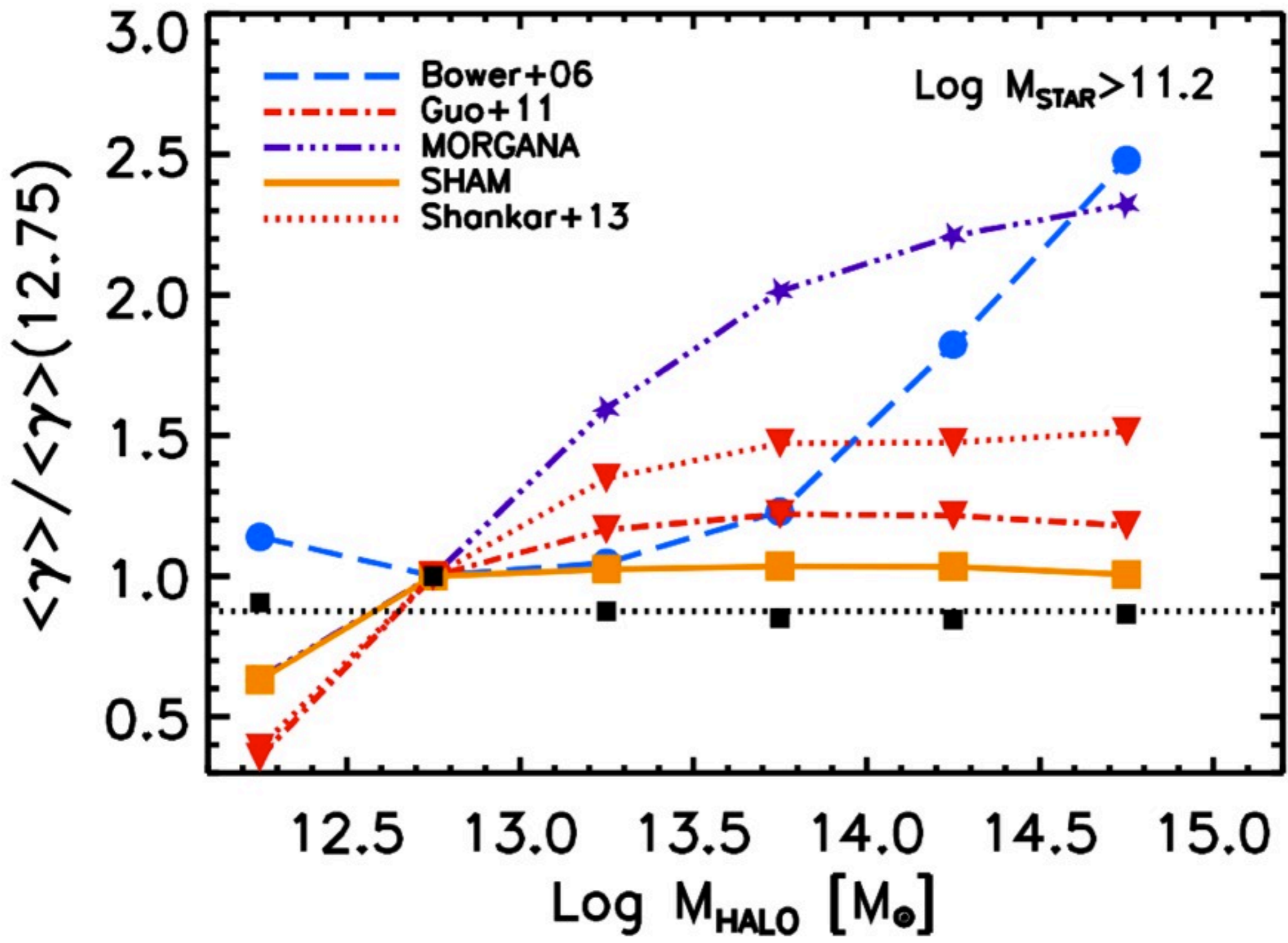
**2. MODELS FROM ABUNDANCE MATCHING:** GALAXIES ARE ASSIGNED EMPIRICALLY FROM STELLAR MASS FUNCTION AND CLUSTERING TO MATCH THE CORRELATION FUNCTION AND MASS FUNCTIONS

*Correlation and mass functions are properly reproduced by definition*

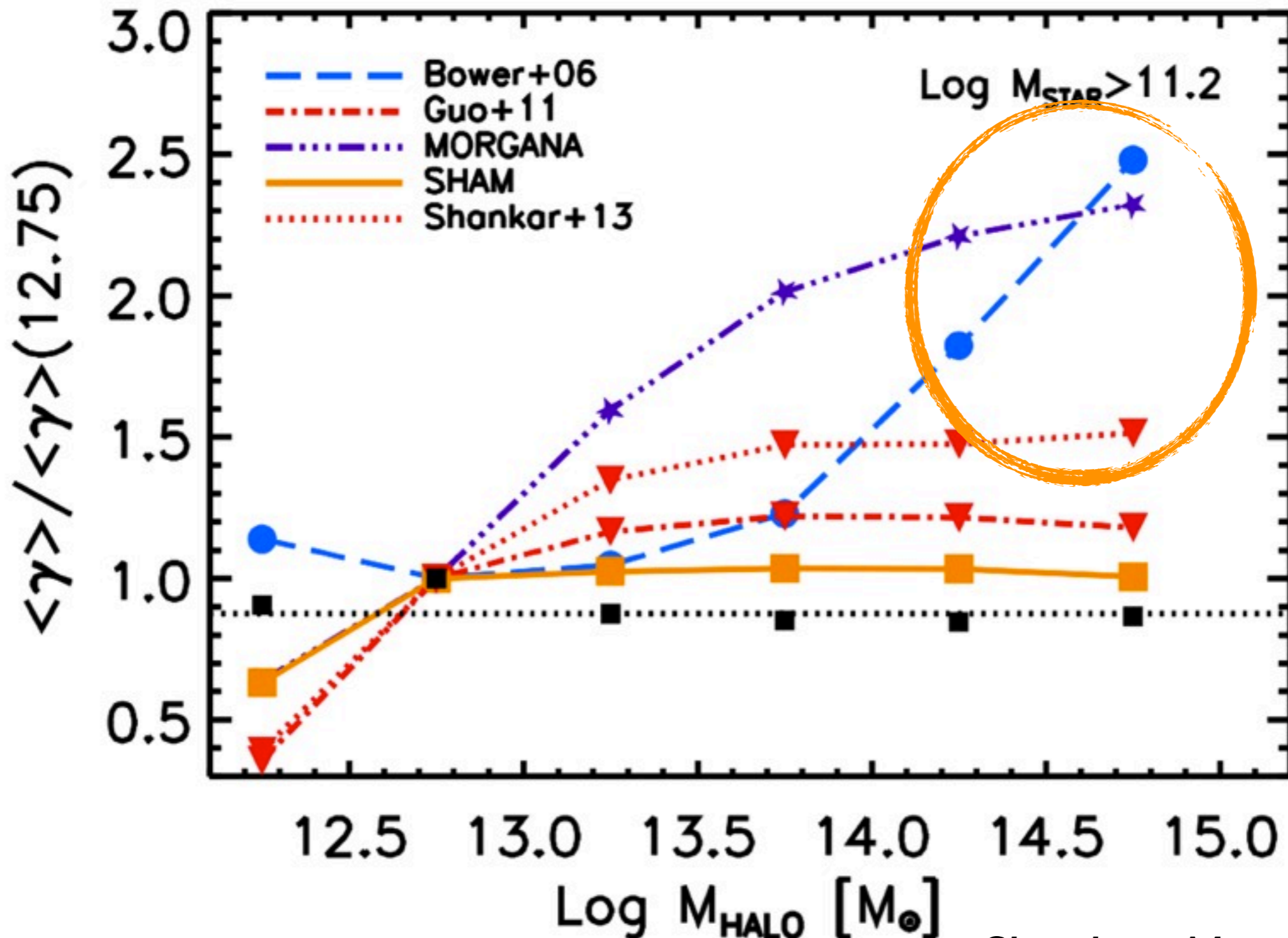
# The gamma/halo-mass plane







SAMs with strong disk instabilities (bars) and/or high merger efficiency and gas dissipation seem disfavored



Shankar, Mei, MHC+13

# Take away messages

- automated algorithms seem to be the way to go to classify future large surveys.
- First because of the increasing number of objects but also because they have nice properties for scientific purposes.
- huge number of visual classifications for training!

- Mass-size relation universal for all environments?
  - At  $z \sim 0$ , sizes of  $\sim 10^{11}$  ETGs are independent of large scale environment (cluster vs. field) (MHC+13b)
  - No difference seen either at the group scale at  $z < 1$  (MHC+13b)
  - ETGs in massive clusters at  $z \sim 1$  are  $\sim 30-50\%$  larger than the same galaxies living in the field (Delaye+13)
    - Difference driven by tail of low mass galaxies (physics? selection?)