The effect of the environment on the gas and the stars of distant galaxies

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The effect of the environment on the gas kinematics and the structure of distant galaxies

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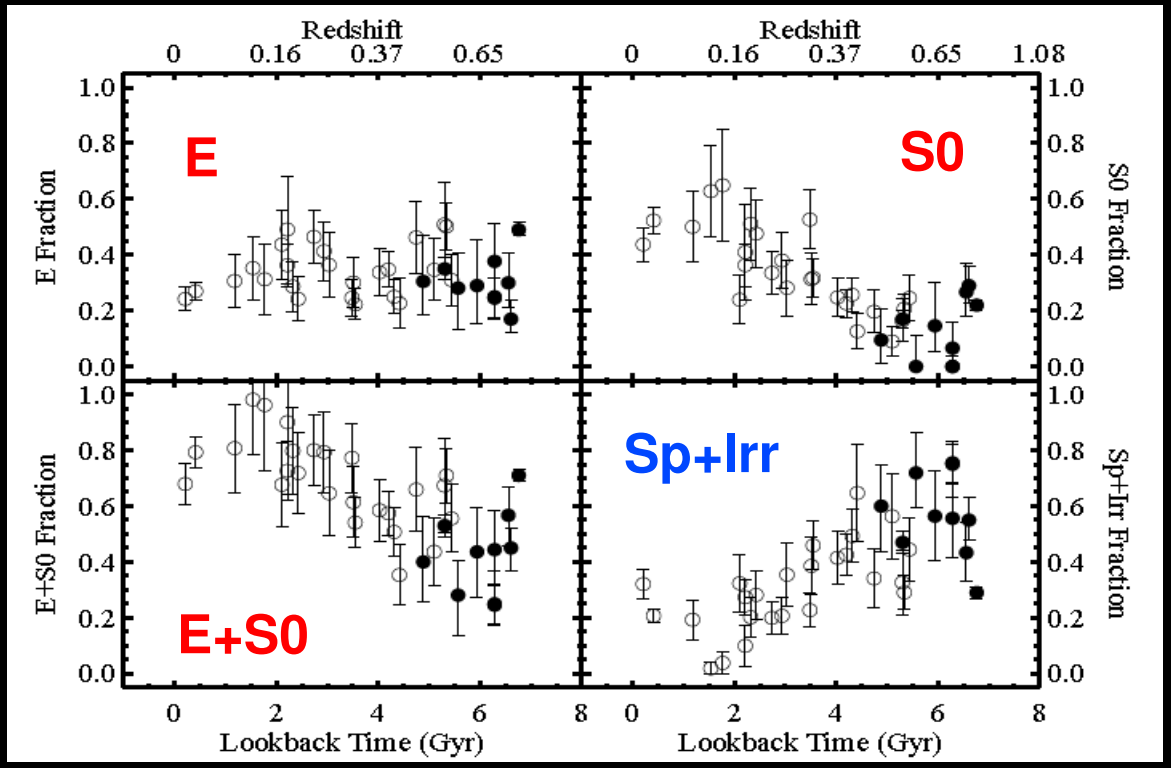
(Jaffé et al. 2011, MNRAS, 417, 1996)

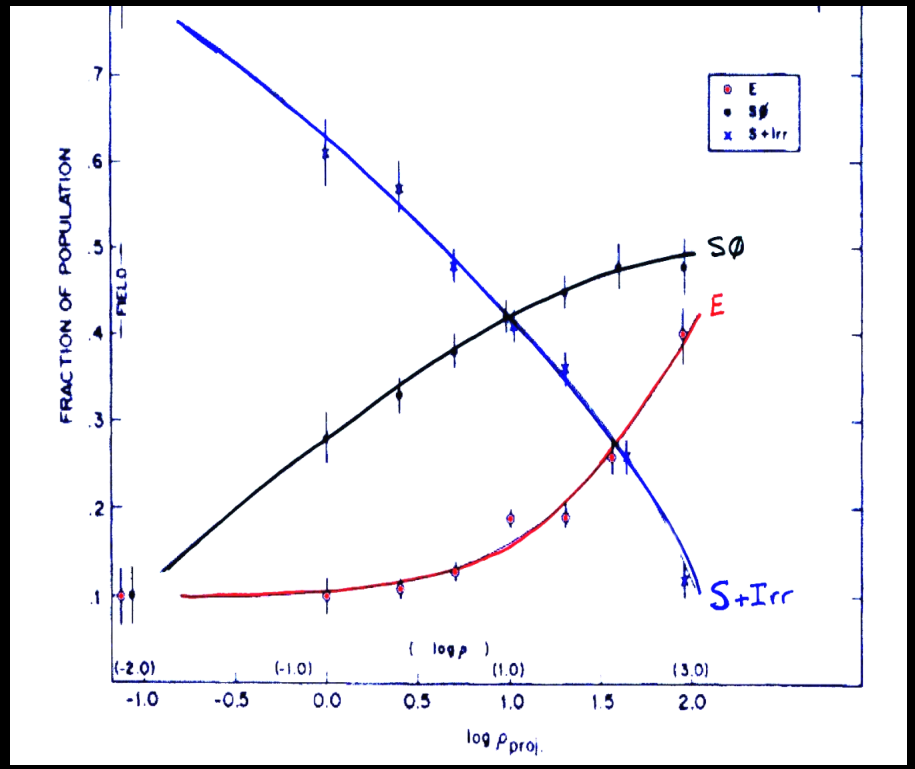
Galaxy Evolution
e.g. Morphology change & stellar population change

GEE

Environment
plays an important role in galaxy transformation!



Desai et al. (2007) – cf. Dressler et al. (1997)



Dressler (1980)

Spiral → → S0

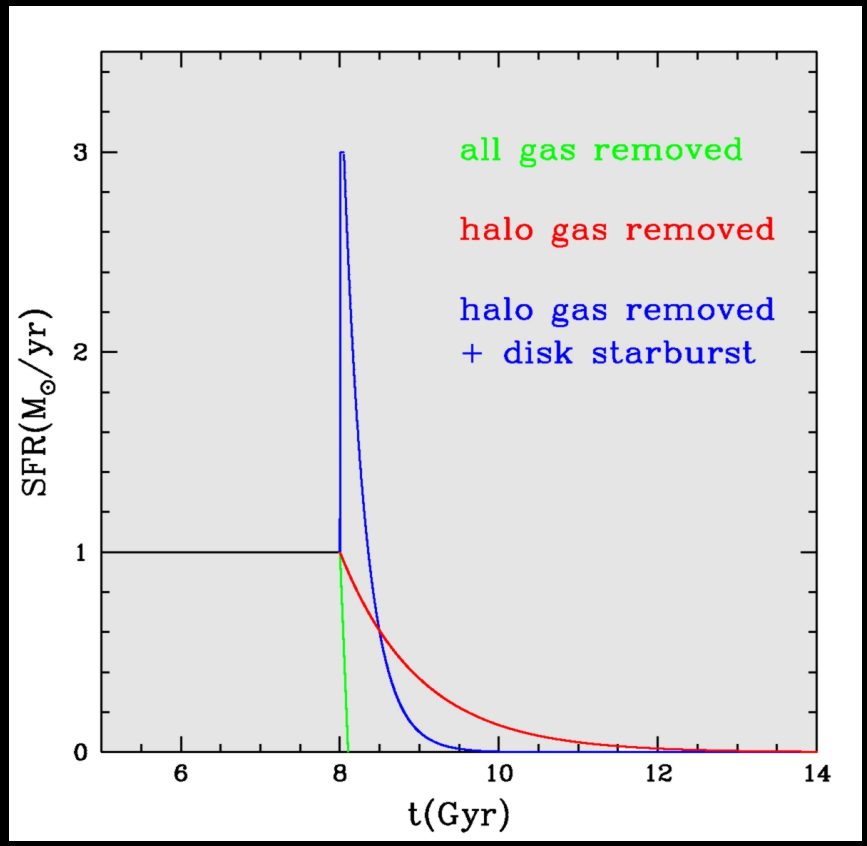
Spiral → → S0

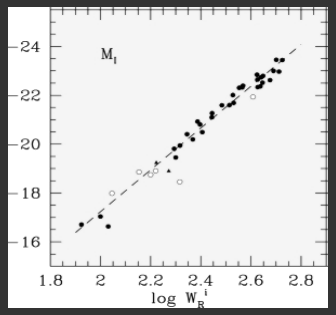
Possible mechanisms:

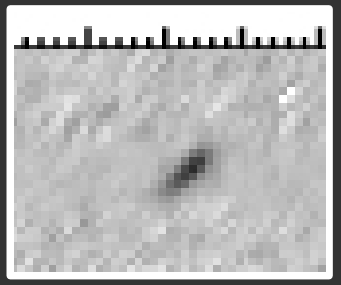
1) Ram-pressure stripping
   - of halo gas
     (e.g Larson et al. 1972, Bekki et al. 2002)
   - of disk gas
     (e.g Gunn & Gott 1972, Quilis et al. 2000)

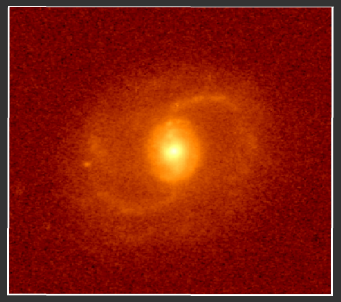
2) Galaxy-galaxy interactions
   - Unequal-M mergers (e.g Bekki 1998)
   - Harassment (e.g. Moore et al. 1998)

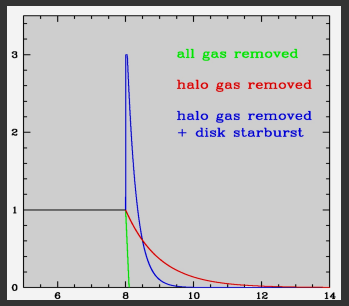
3) Cluster tidal field (e.g Bekki et al 2011)

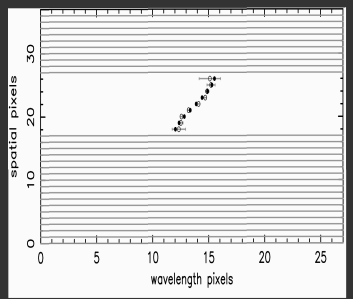












OUR APPROACH

Study:

→ Gas kinematics
→ Galaxy morphology (stellar structure)
→ Tully-Fisher relation
→ Star formation, Sizes, etc.

of galaxies up to z ~ 1
as a function of environment

ESO Distant Cluster Survey (EDisCS)

S. White (MPA-Garching, D)
A. Aragón-Salamanca (Nottingham)
R. Bender (Munich, D)
P. Best (ROE, Scotland)
M. Bremer (Bristol, UK)
S. Charlot (MPA, D & IAP, F)
D. Clowe (Bonn, D)
J. Dalcanton (U.Washington, USA)
B. Fort (IAP, F)
P. Jablonka (OPM, F)
Y. Jaffé (Nottingham, Padova)
G. Kauffmann (MPA, D)
Y. Mellier (IAP, F)
R. Pello (OMP, F)
B. Poggianti (Padova, I)
H. Rottgering (Leiden, NL)

P. Schneider (Bonn, D)
D. Zaritsky (U. Arizona, USA)
G. De Lucia (MPA, D)
V. Desai (Caltech, USA)
C. Halliday (Goettingen, D)
D. Maltby (Nottingham, UK)
B. Milvang-Jensen (Copenhagen, Denmark)
G. Rudnick (NOAO, USA)
R. Saglia (Munich, D)
L. Simard (U. Victoria, C)
S. Bamford (Nottingham, UK)
A. v.d. Linden (MPA, D)
I. Whiley (Nottingham, UK)
O. Johnson (ROE, Scotland)
J. Moustakas (U. Arizona, USA)
R. Finn (Siena College, USA)

Multi-λ survey of galaxies in 20 fields containing galaxy clusters at $0.4 < z < 1$

EDisCS

- Photometry (VLT/FORS2 + SOFI/NTT)

  White et al. (2005)

  10 "high-z" fields in VRIJK

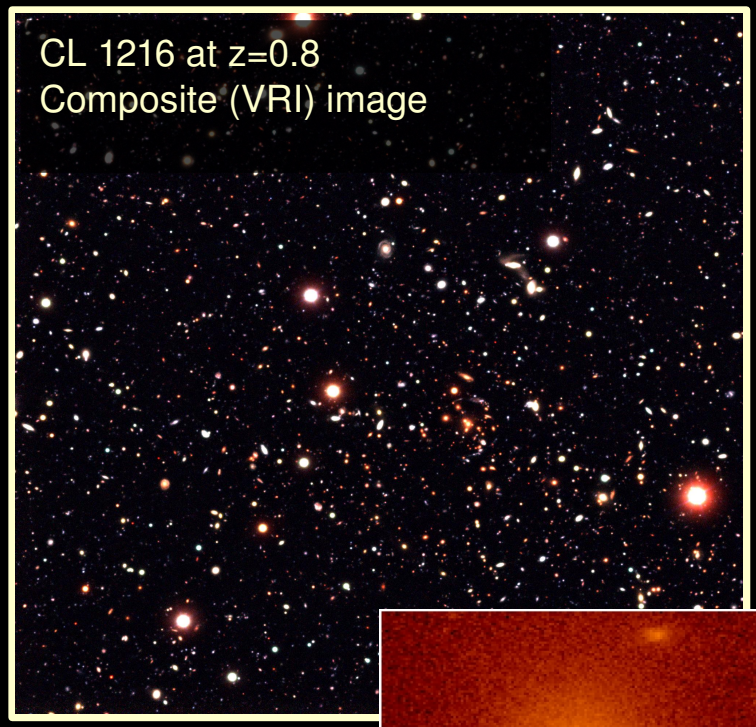
  10 "low-z" fields in BVIK

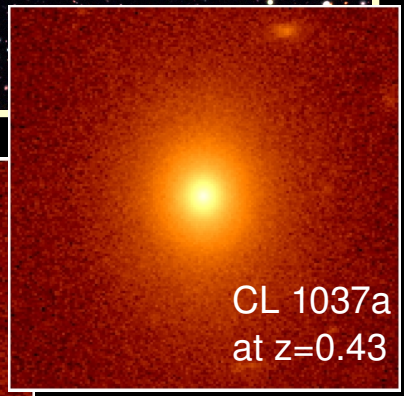
- Deep multi-slit Spectroscopy with VLT/FORS2 (MXU)

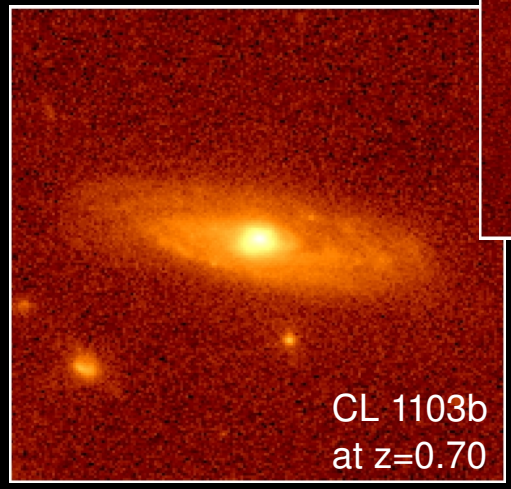
  Halliday+ 2004; Milvang-Jensen+ 2008

- Morphologies (10 fields have HST/ACS mosaic imaging)

  Desai et al. (2006)



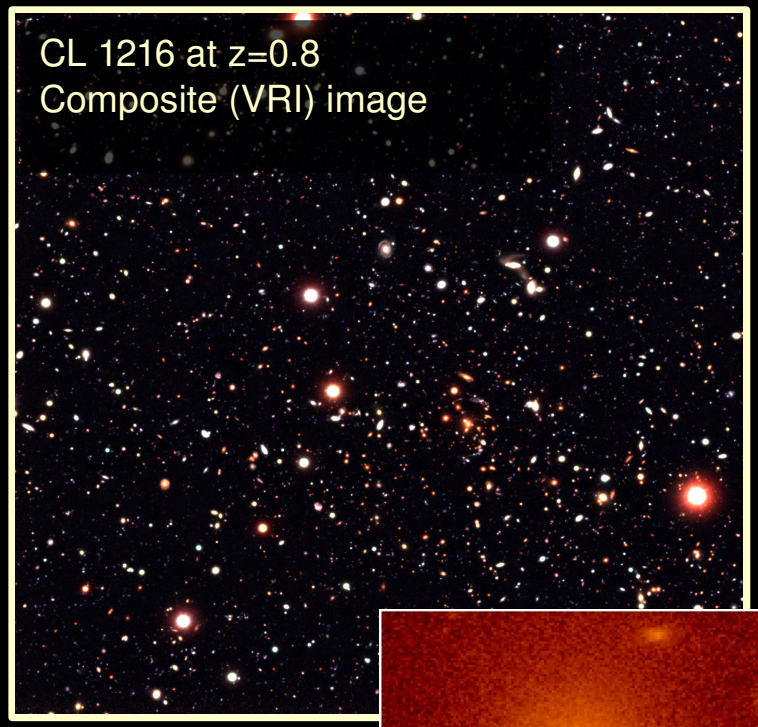




EDisCS

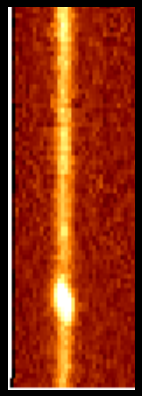
Wide range of environments!

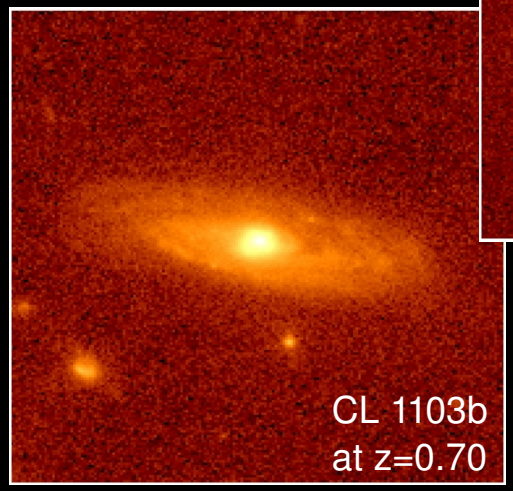
- 26 clusters + groups
- 150 km/s < vel. disp. < 1200 km/s
- + field galaxies

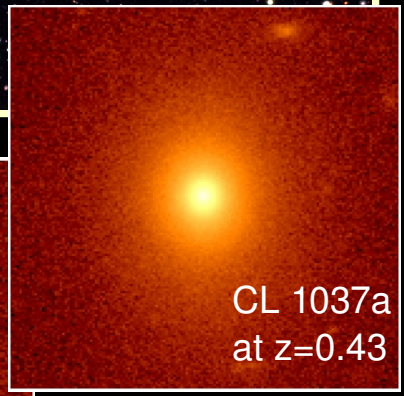


Our EDisCS sub-sample:

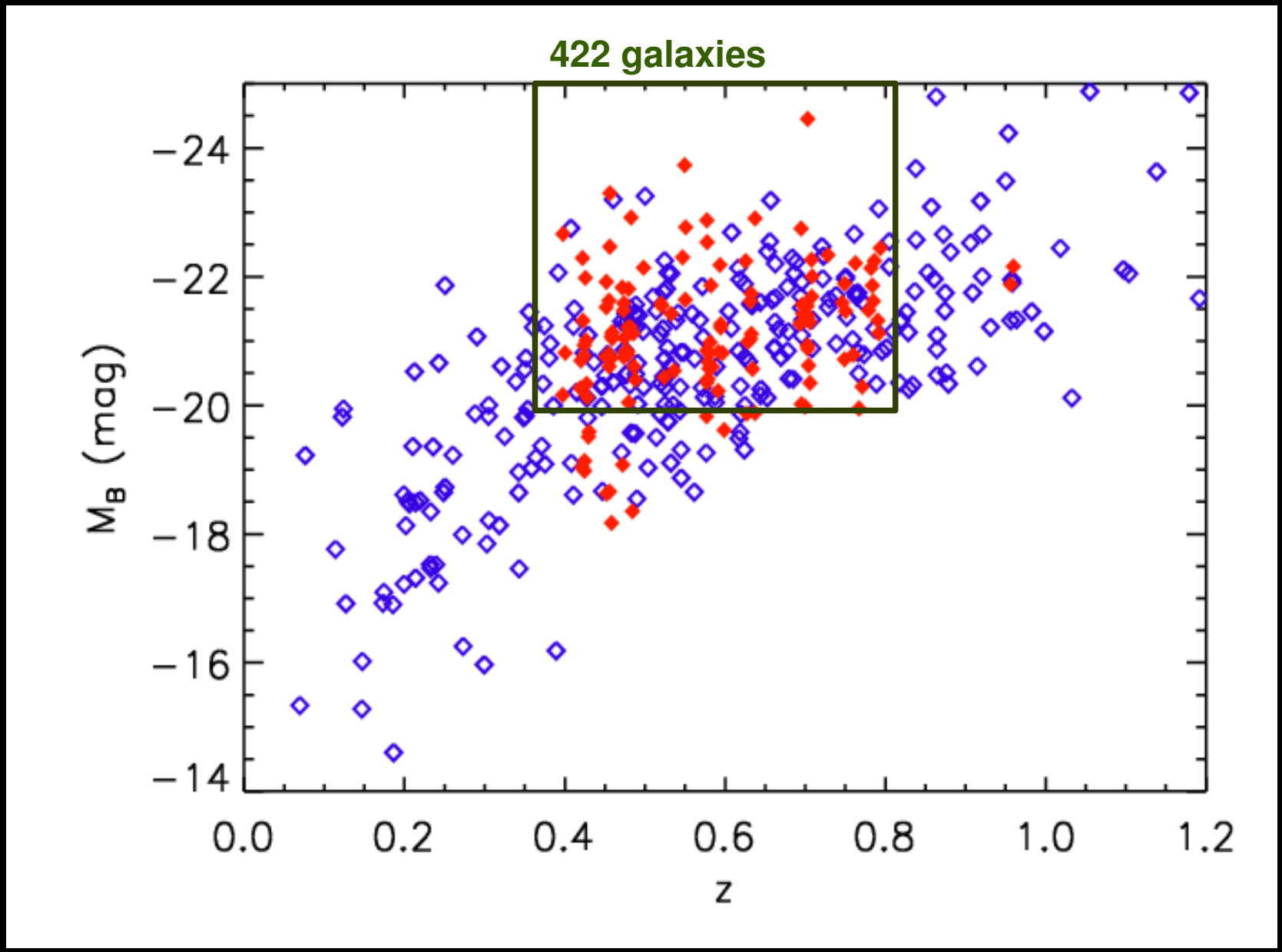
<u>422 galaxies</u> with measurable emission lines (in cluster, groups and field)







Our emission-line galaxy sample

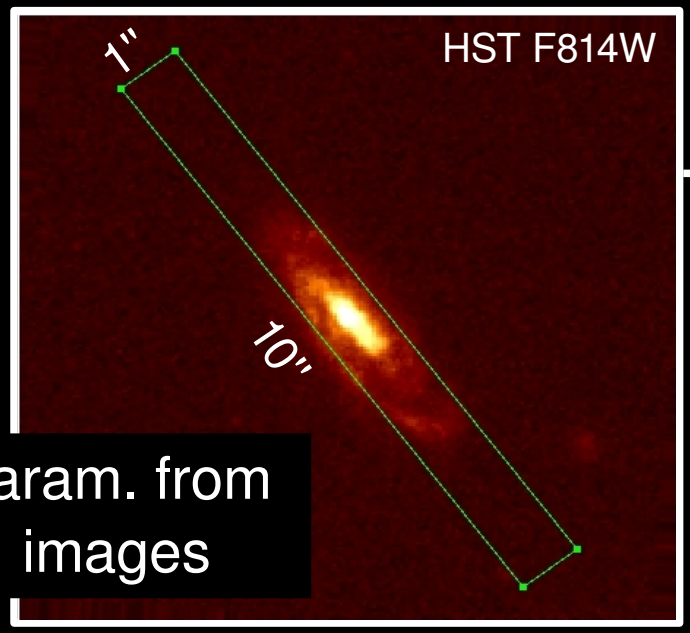


RESULTS

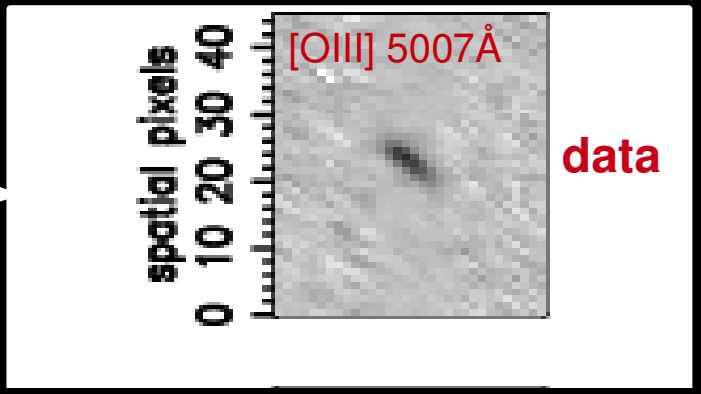
1) Gas kinematics & environment
- dynamical state
- rotation velocity (for TFR)

HOW? By fitting rotation curves to the emission-lines

Rotation curves at high z:



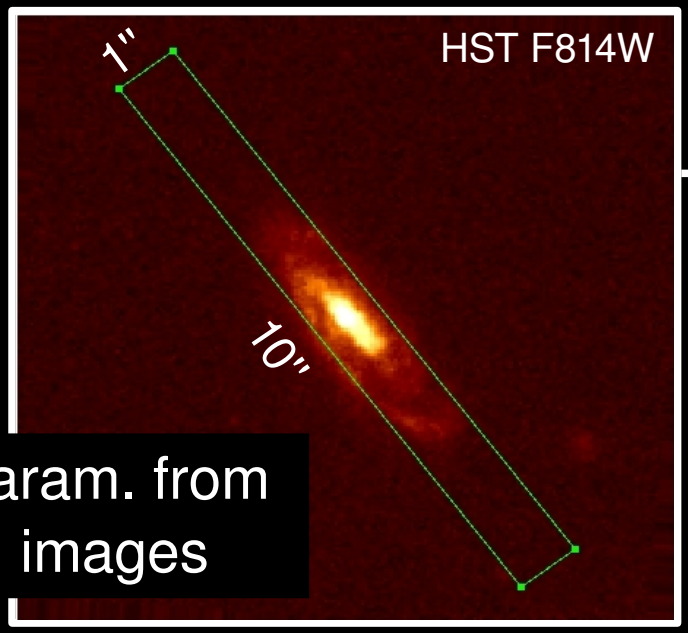
Structural param. from I-band VLT images



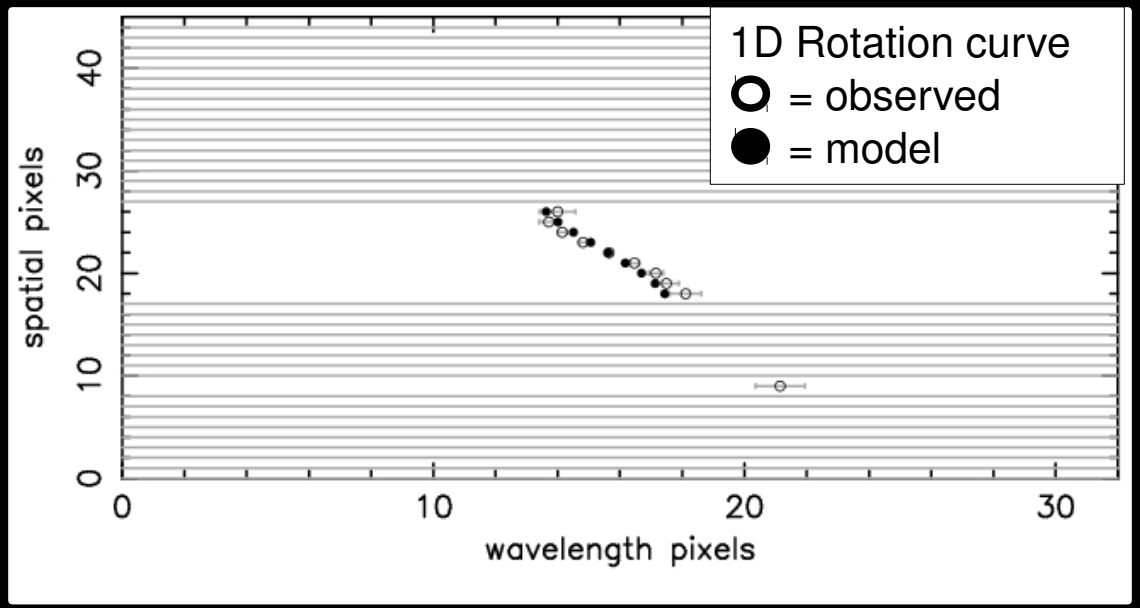
2D spectra of individual emission lines

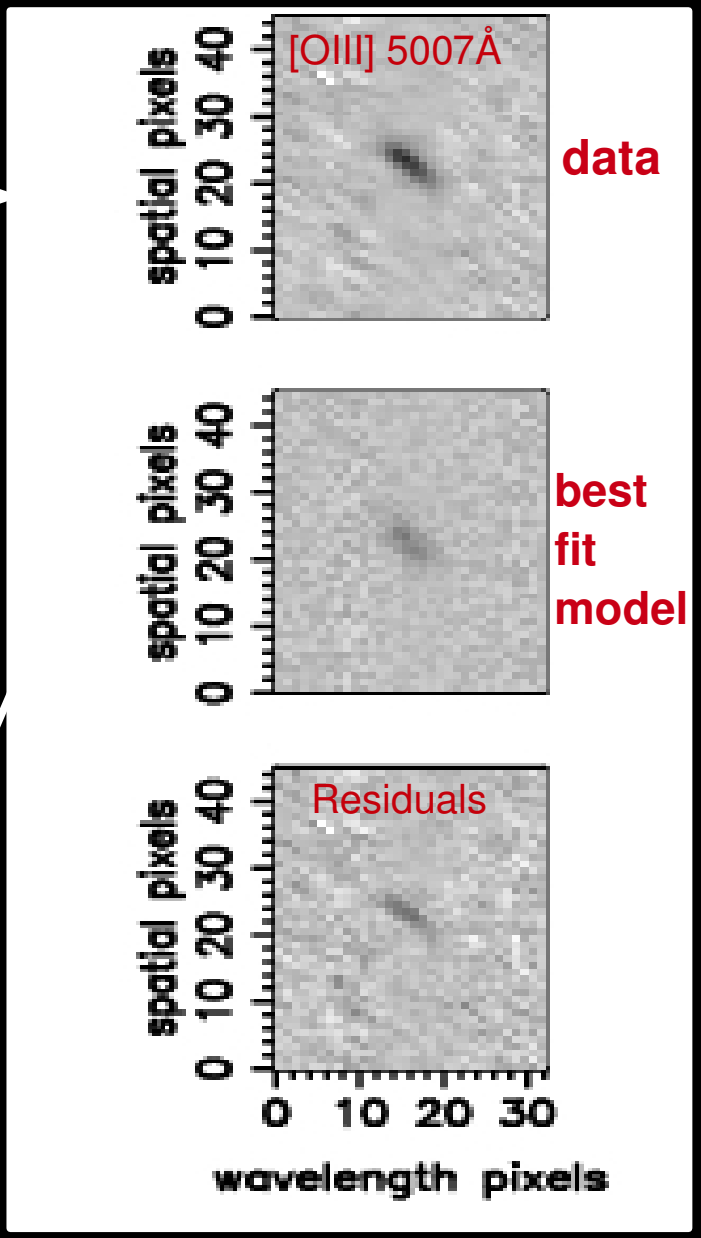
ELFIT2PY (Bamford +05)
Fits RCs to spatially resolved ELs of distant galaxies, assuming a *Courteau* RC and an exponential surface brightness profile

Rotation curves at high z:



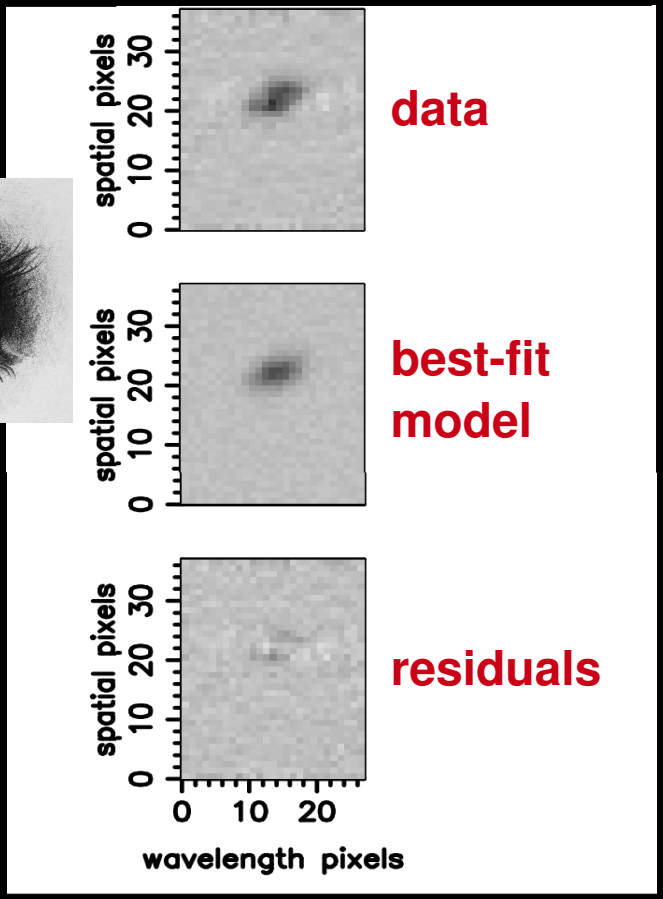
Structural param. from I-band VLT images

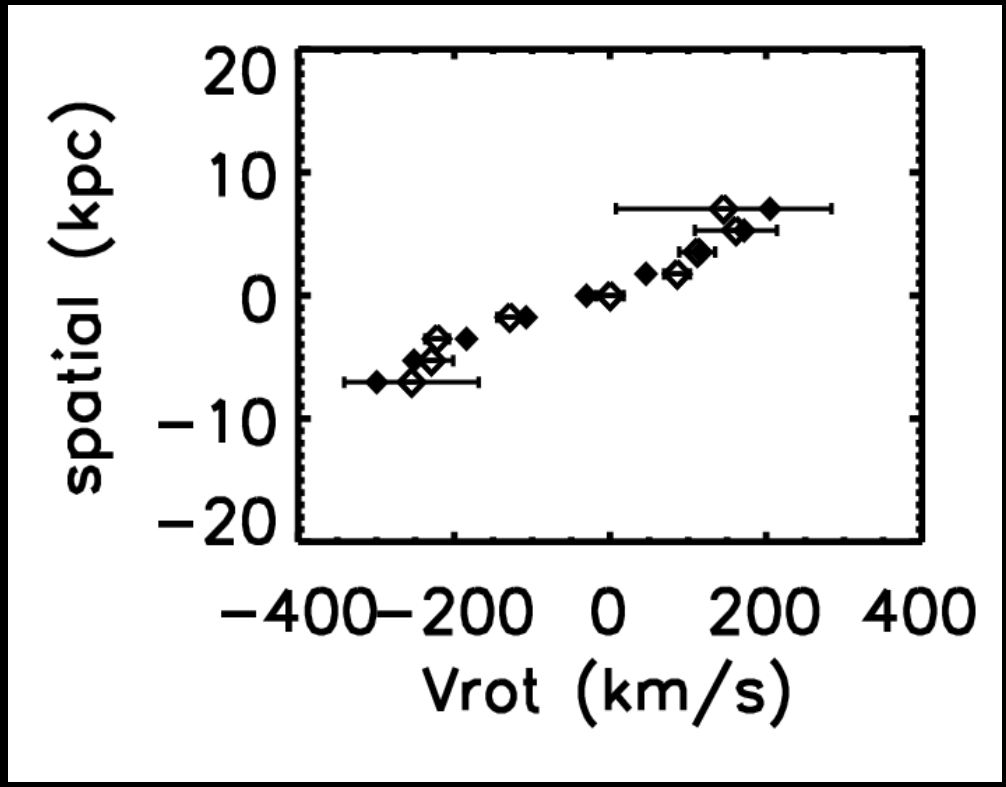




z = 0.474

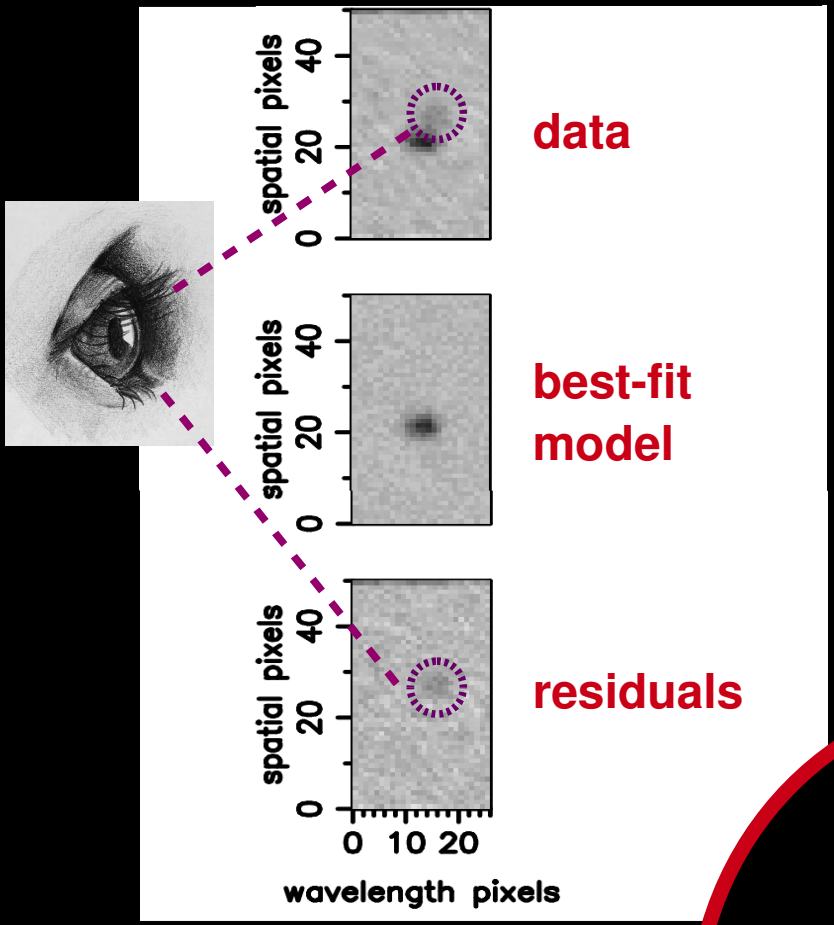
Good fits: 292/428 galaxies (68%)

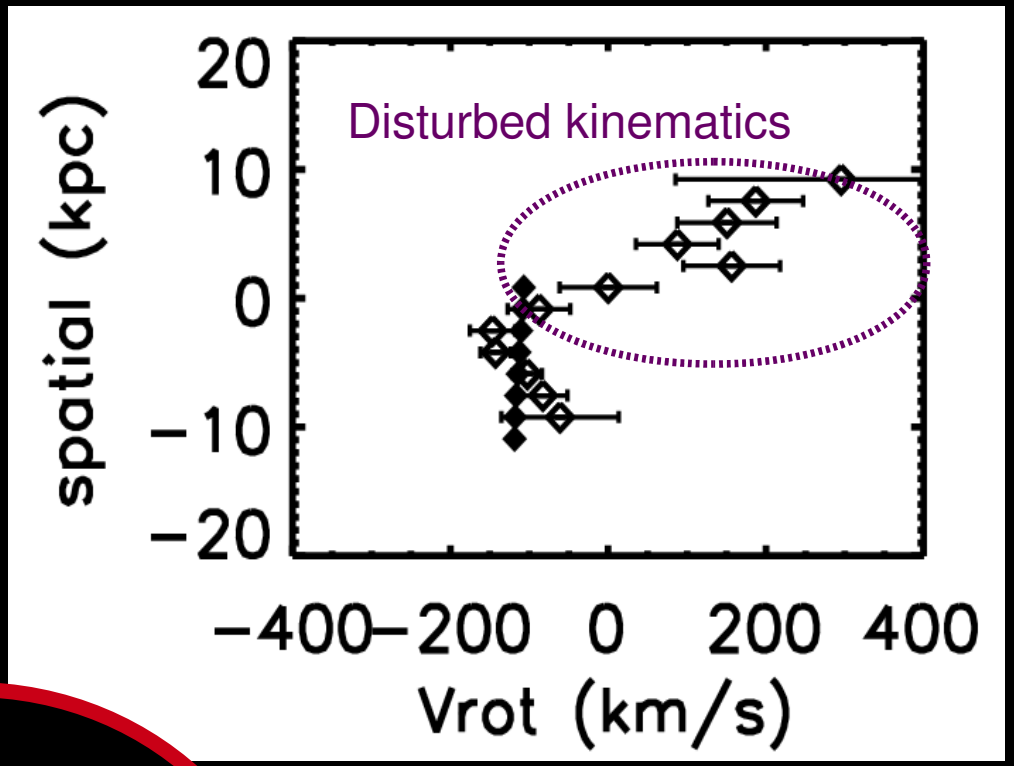




Line = [OII] doublet
z = 0.662
Inclination = 41.859
V_{rot} = 255.2 Km/s

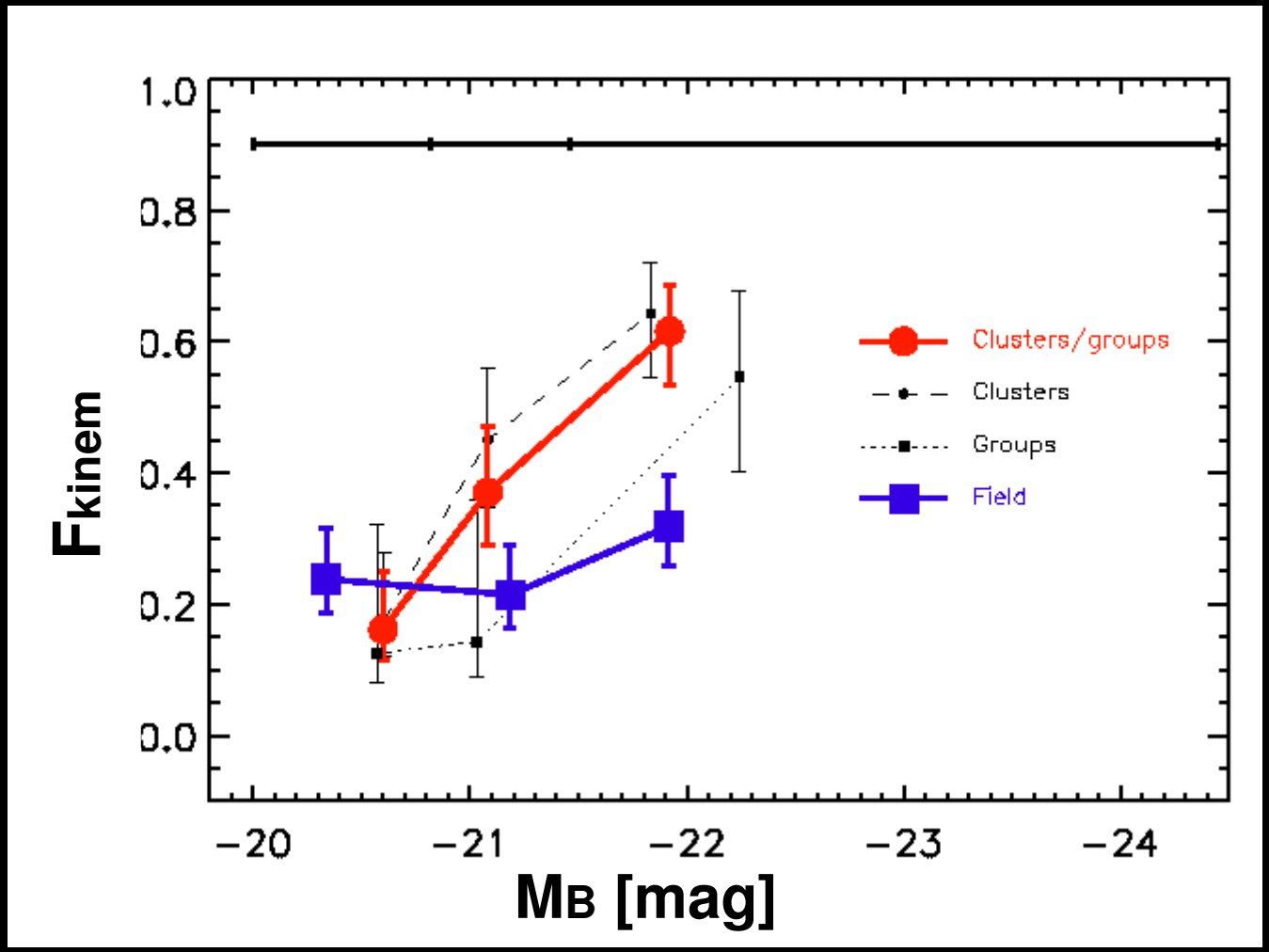
Bad fits: 136/428 galaxies (32%)





Line = [OII] doublet
z = 0.595
Inclination = 47.773
~~Vrot = 106.7 Km/s~~

Fraction of galaxies with disturbed gas kinematics vs. Mag

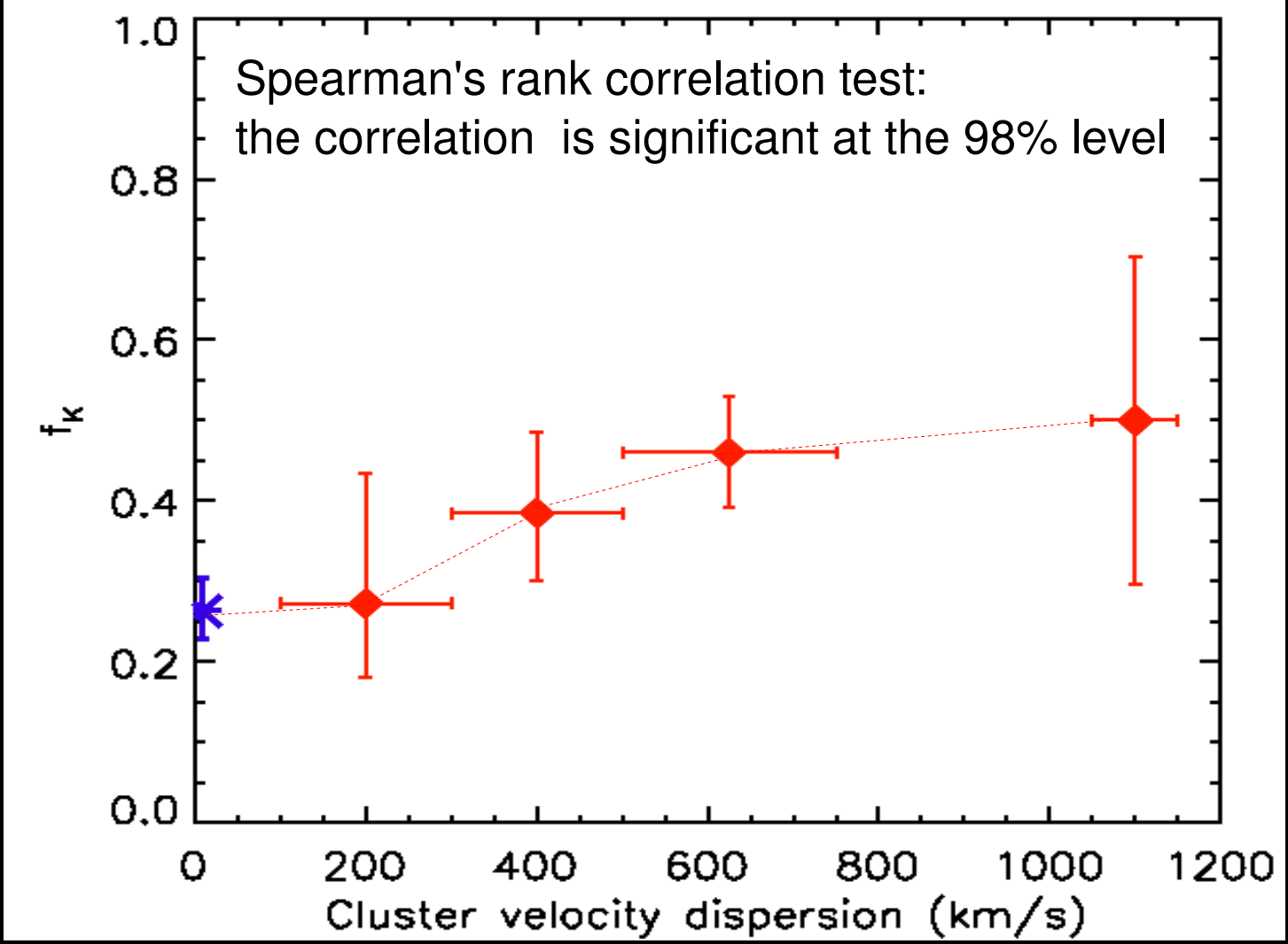


$$F_K = \frac{\text{No. Disturbed}}{\text{No. Total}}$$

More kinematically disturbed galaxies in clusters!

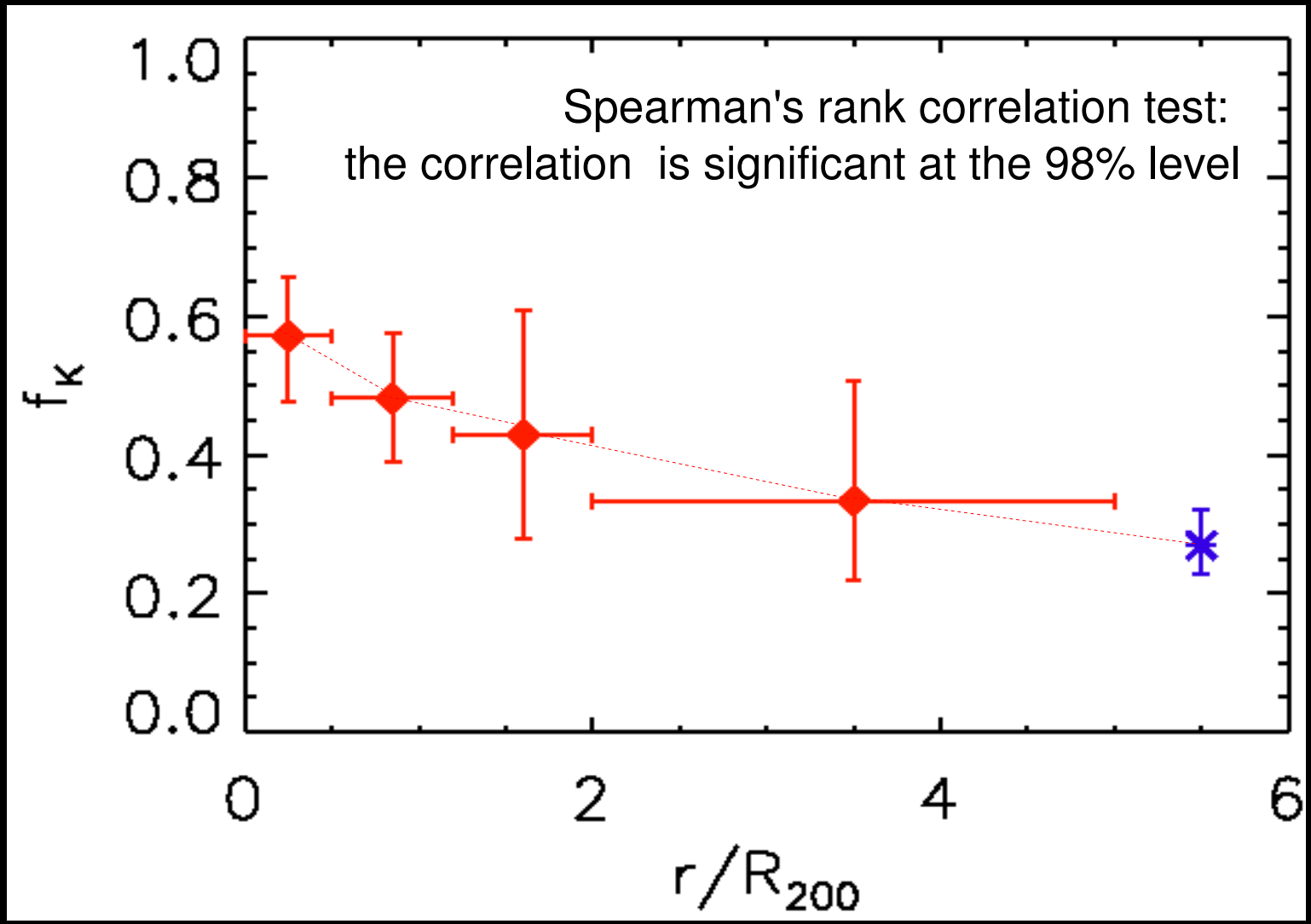
Fraction of galaxies with disturbed gas kinematics vs. environment

1) Cluster velocity dispersion (~cluster mass)



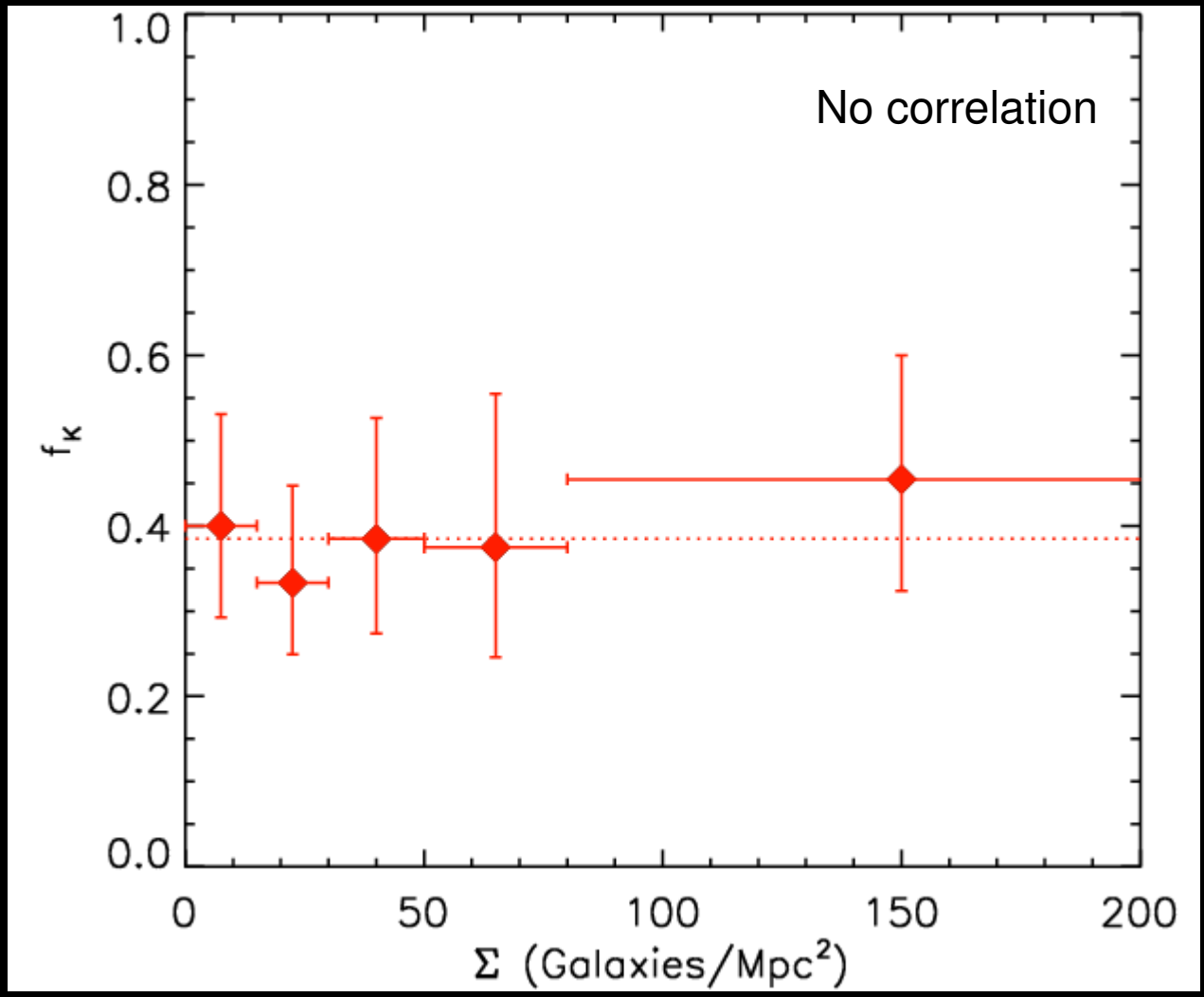
Fraction of galaxies with disturbed gas kinematics vs. environment

2) Distance from the cluster centre

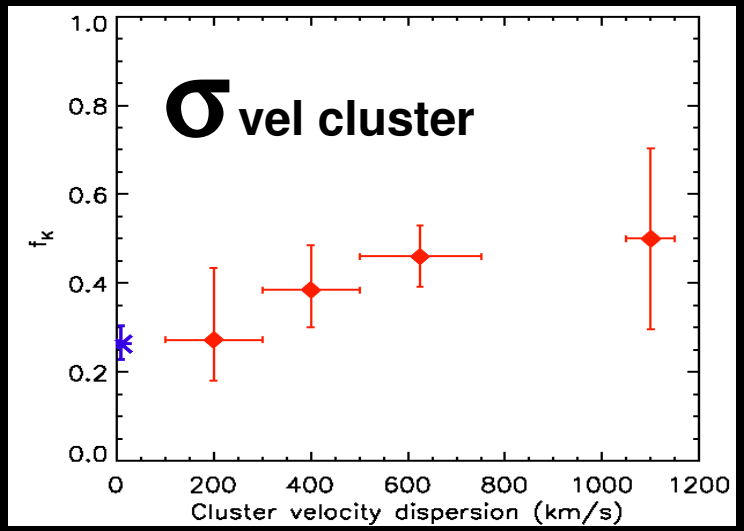


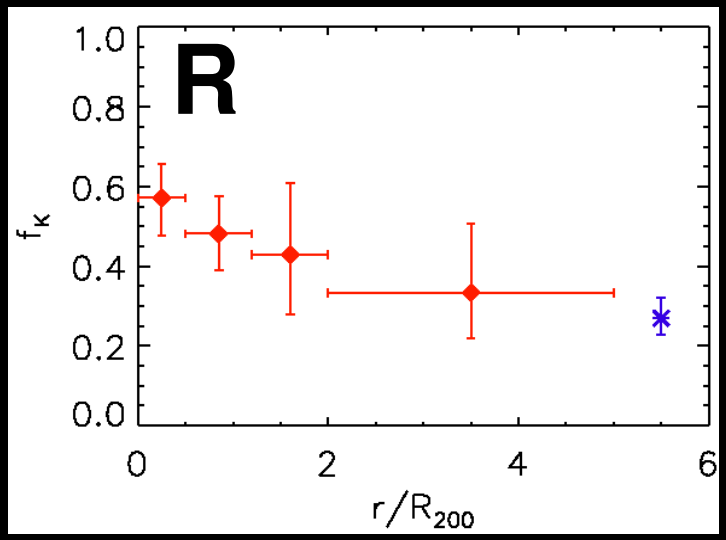
Fraction of galaxies with disturbed gas kinematics vs. environment

3) Projected galaxy density

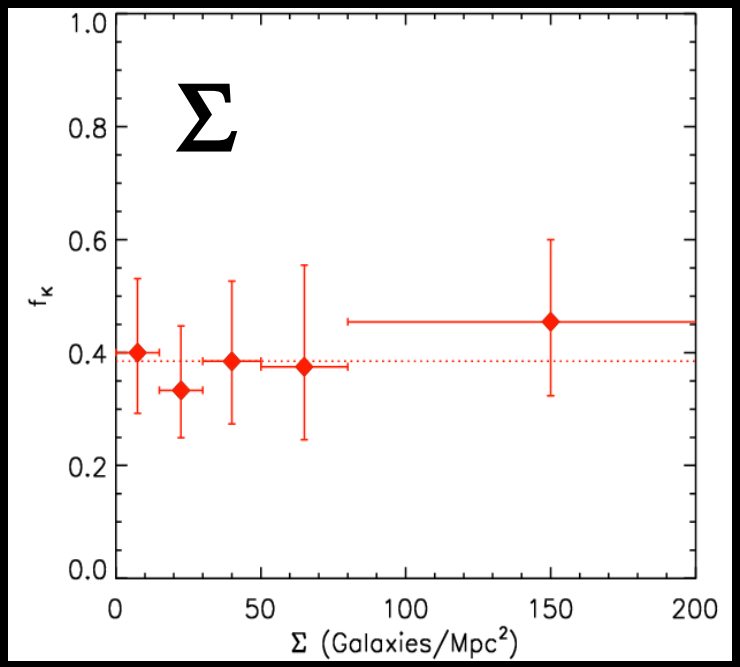


Fraction of galaxies with disturbed gas kinematics vs. environment:





Cluster environment (ICM?)

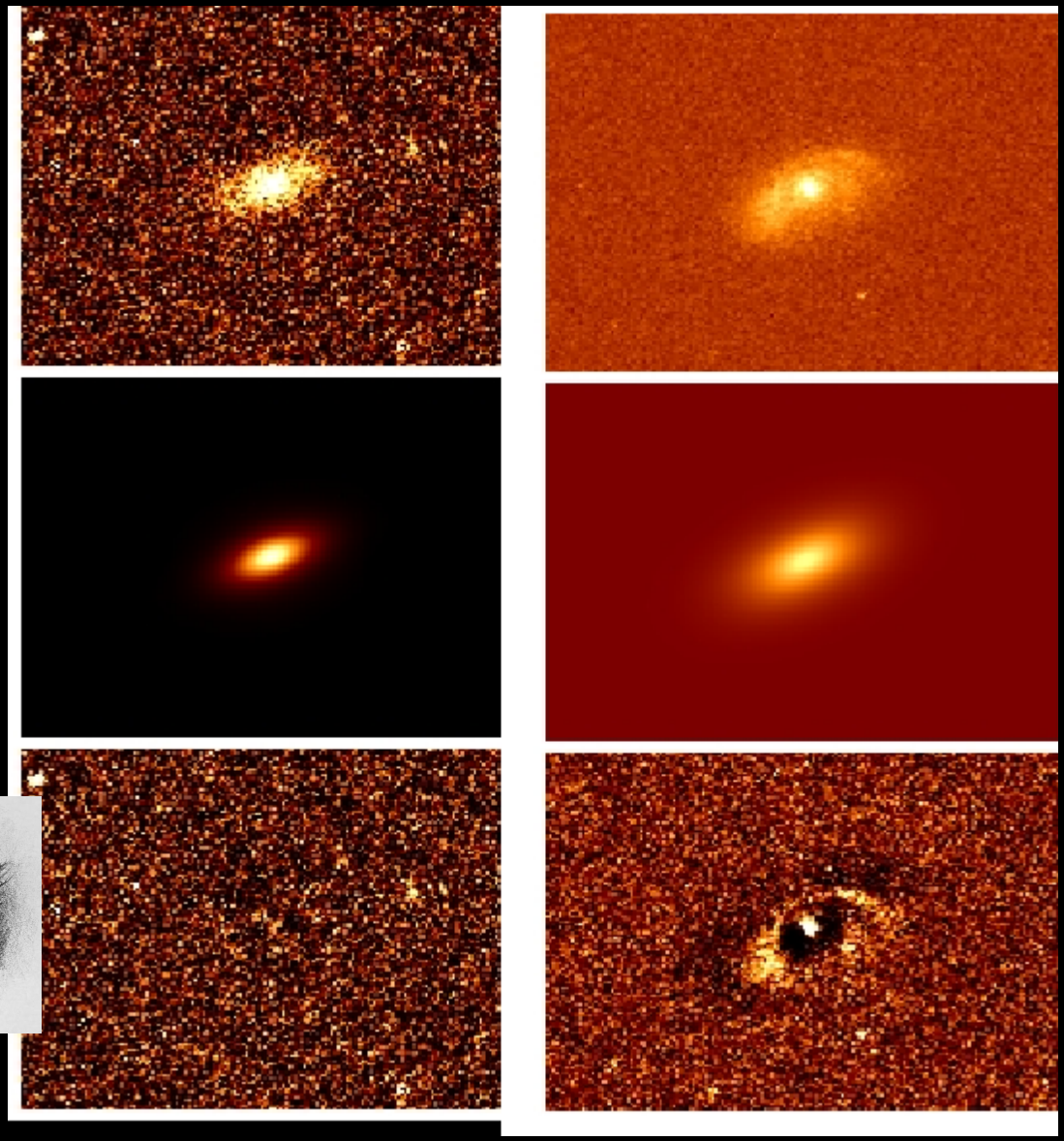


Galaxy density (mergers)

RESULTS

2) Galaxy morphology
& environment

Morphology disturbance with environment



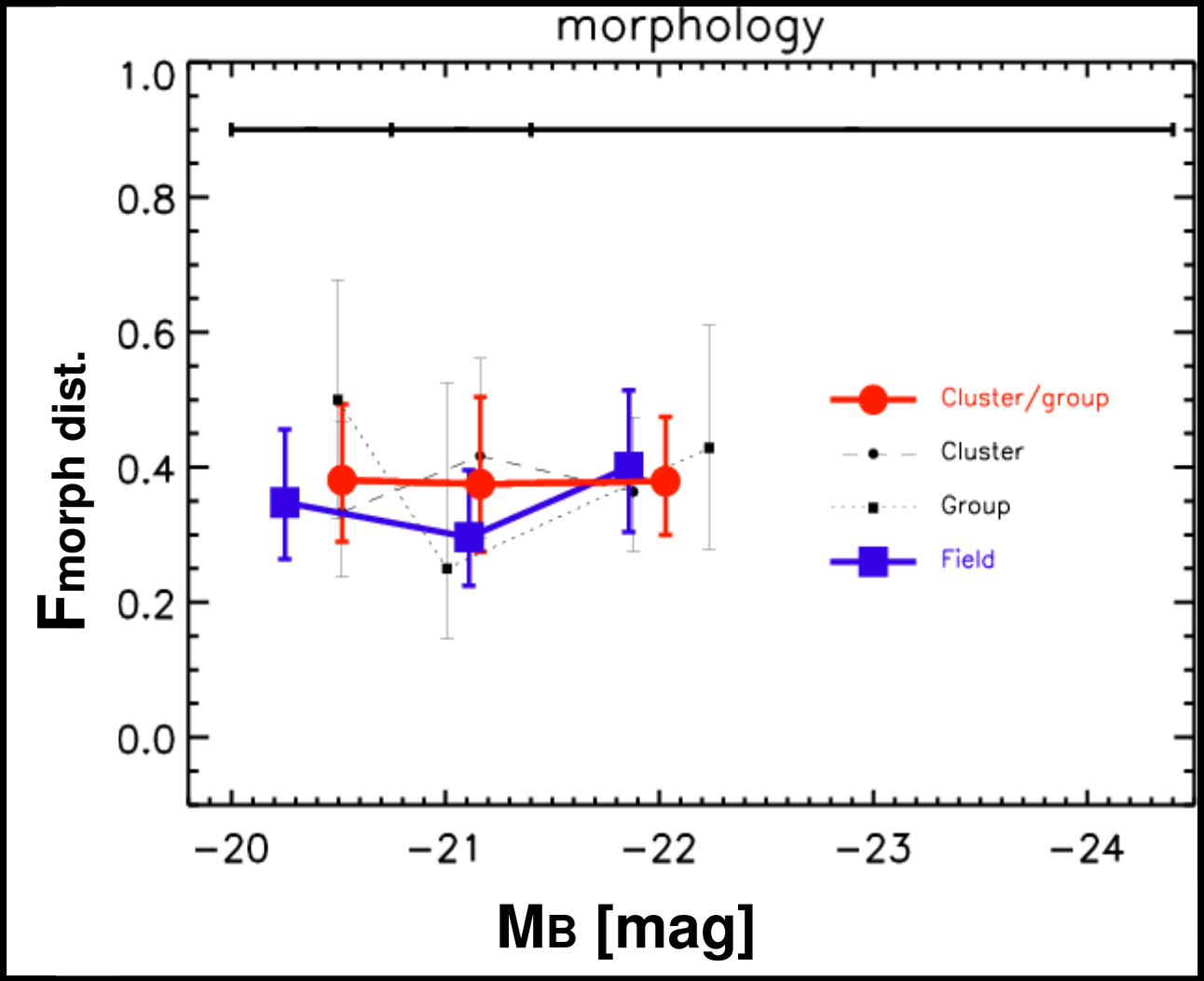
GOOD

DISTURBED

HOW?
By performing
Single-Sersic fits
to the HST F814W images

$$F_M = \frac{\text{No. Disturbed}}{\text{No. Total}}$$

Fraction of galaxies with disturbed morphologies vs. M_B and environment:



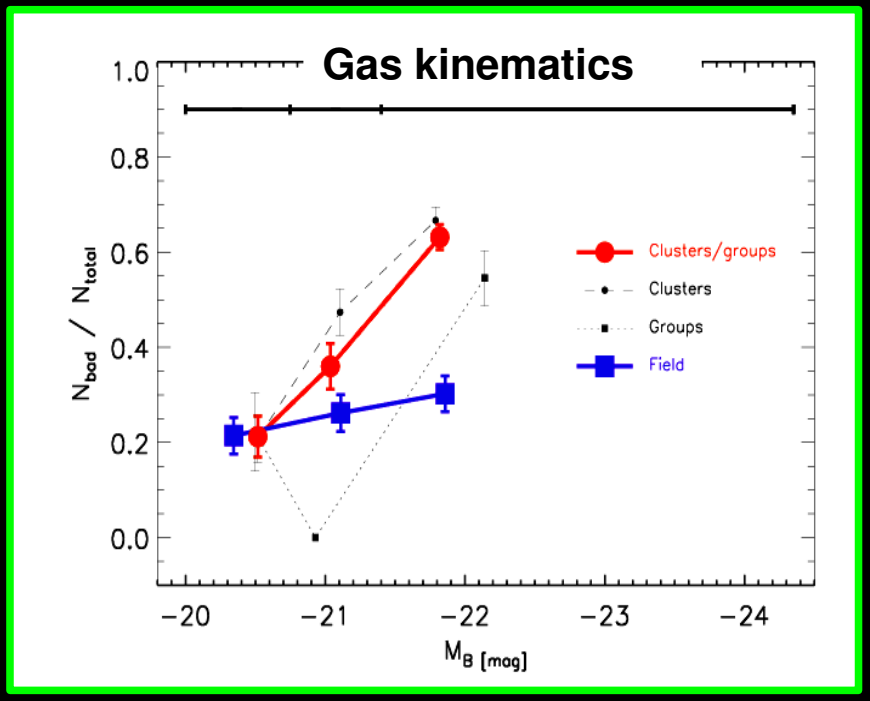
$$F_M = \frac{\text{No. Disturbed}}{\text{No. Total}}$$

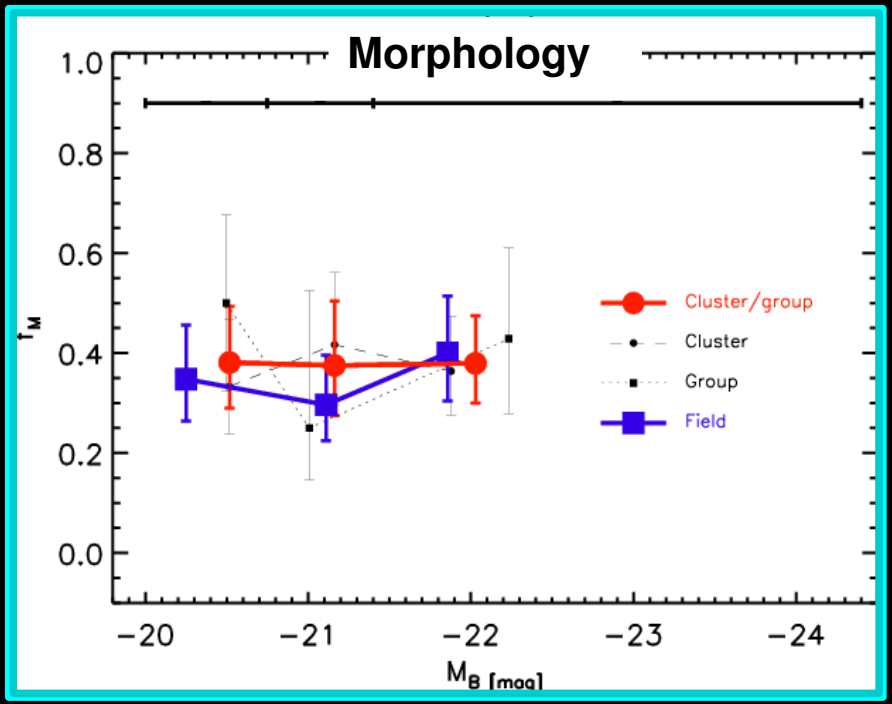
Fraction of galaxies with disturbed morphologies doesn't seem to care about environment!

Environmental effects on the GAS and STARS of distant galaxies

The physical mechanism acting on cluster galaxies has to be:

- strong enough to (significantly) disturb the gas
- but mild enough to leave the stars unaffected

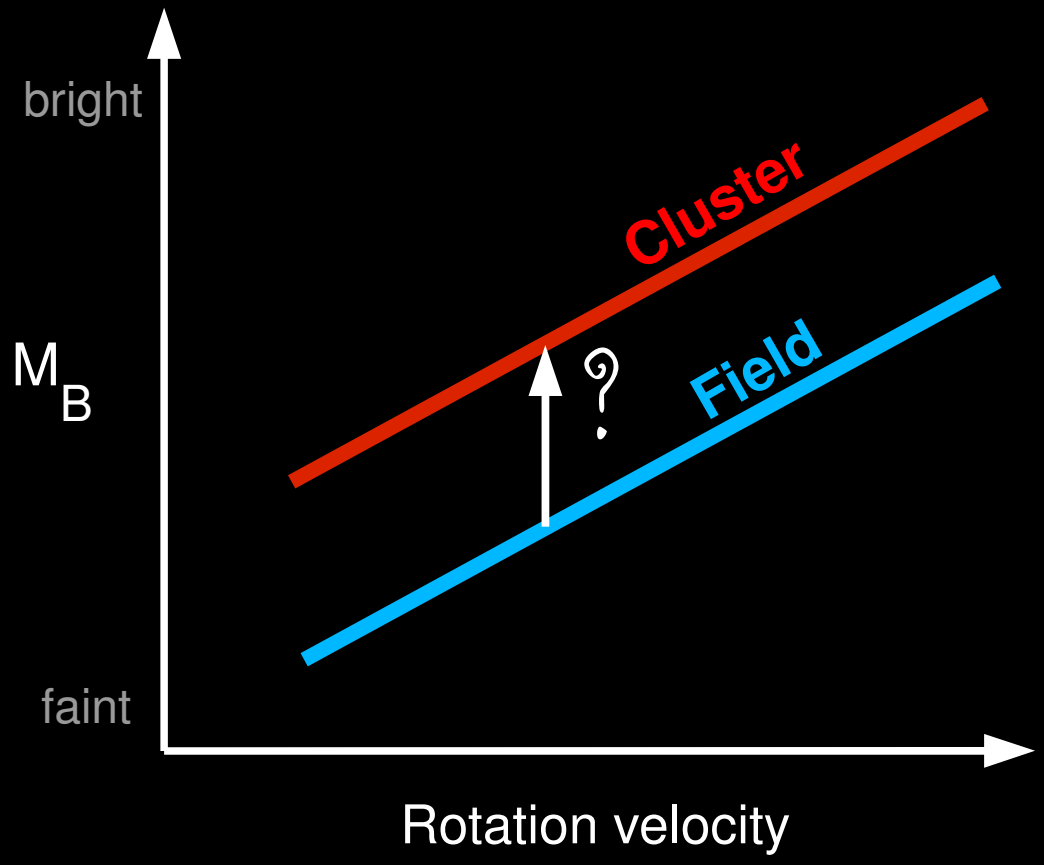


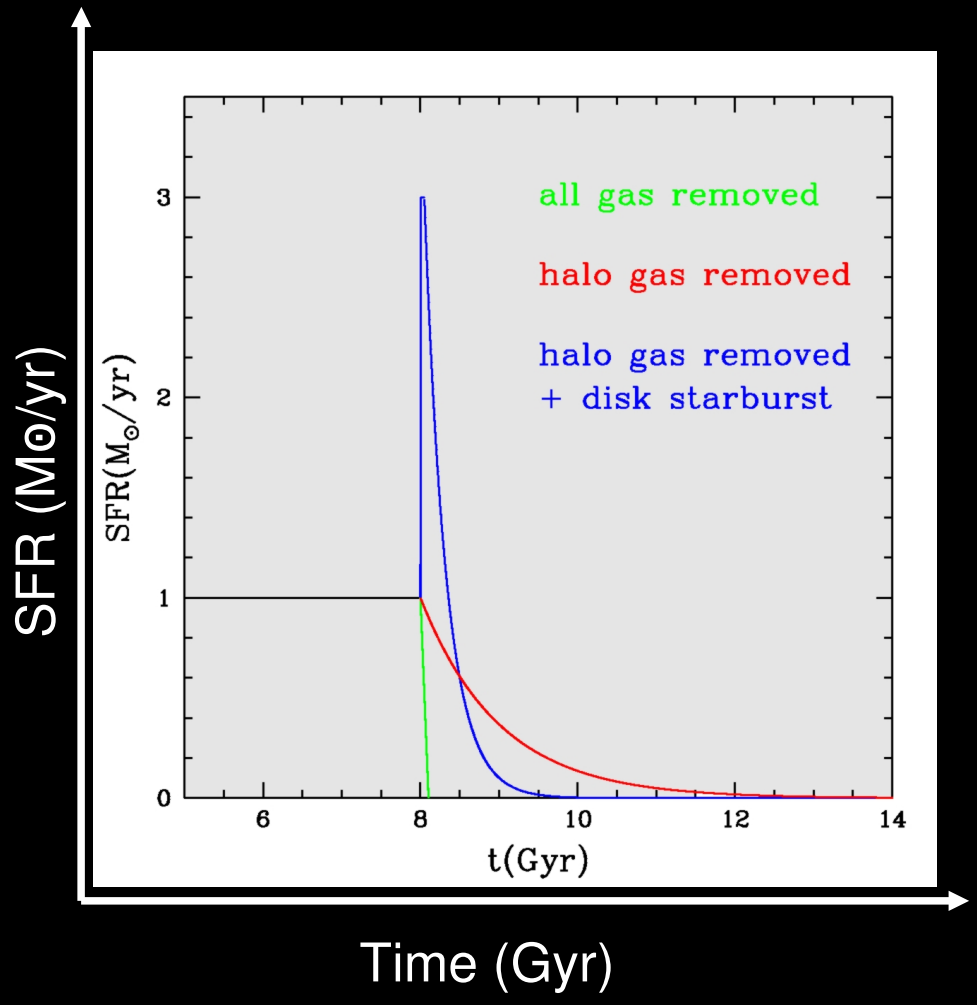


RESULTS

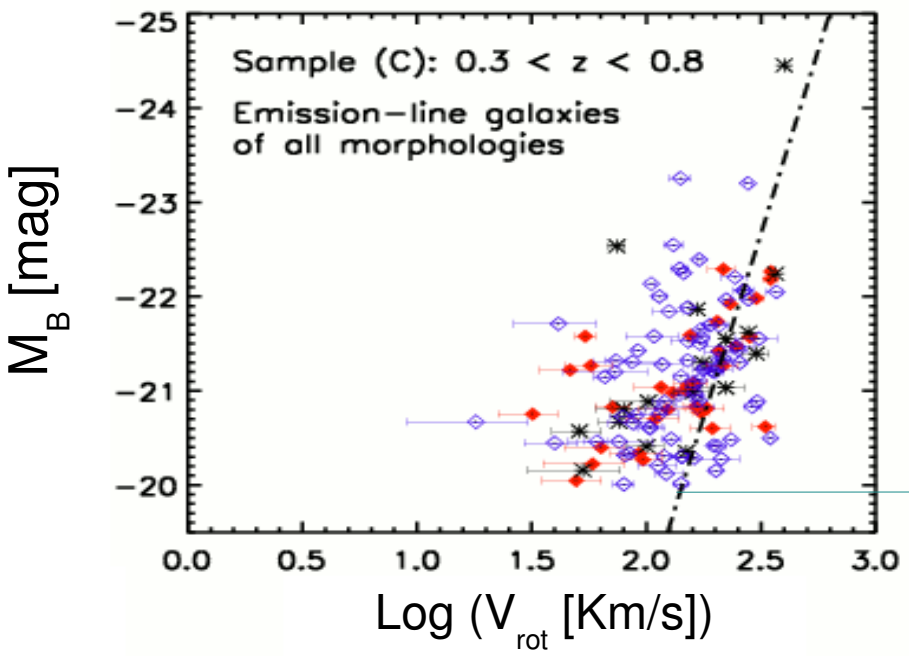
3) The Tully–Fisher relation as a function of environment

Can we see environmental effects in the TFR?





The TFR of emission-line galaxies at 0.3 < z <0.8

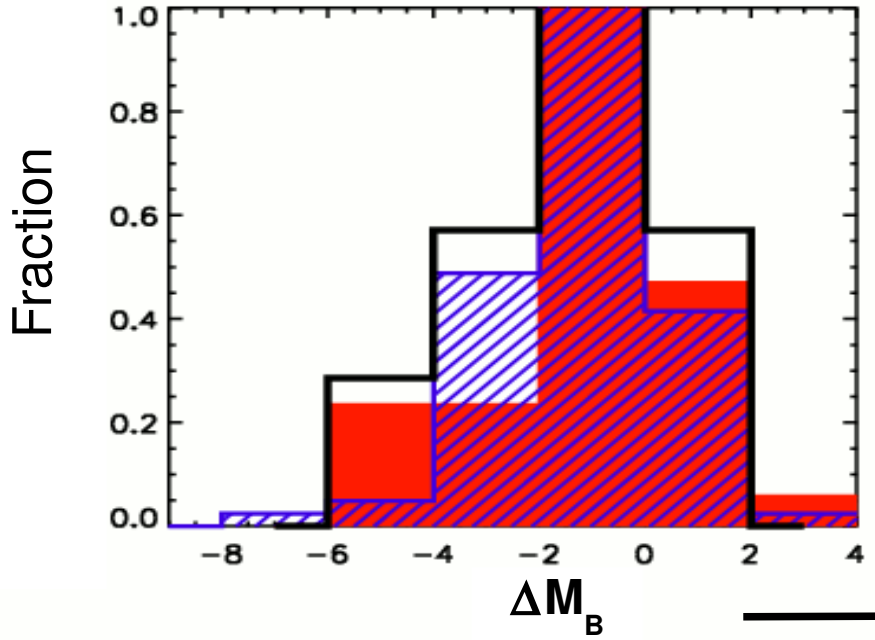


◆ field

◆ Cluster ($\sigma_{cluster}$ > 400 km/s)

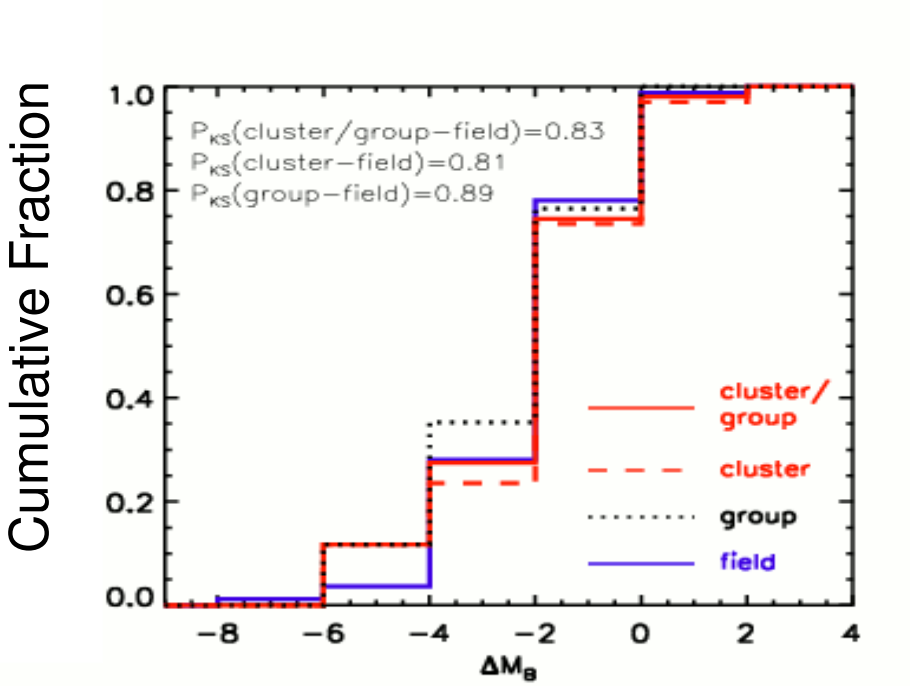
* groups ($\sigma_{cluster}$ < 400 km/s)

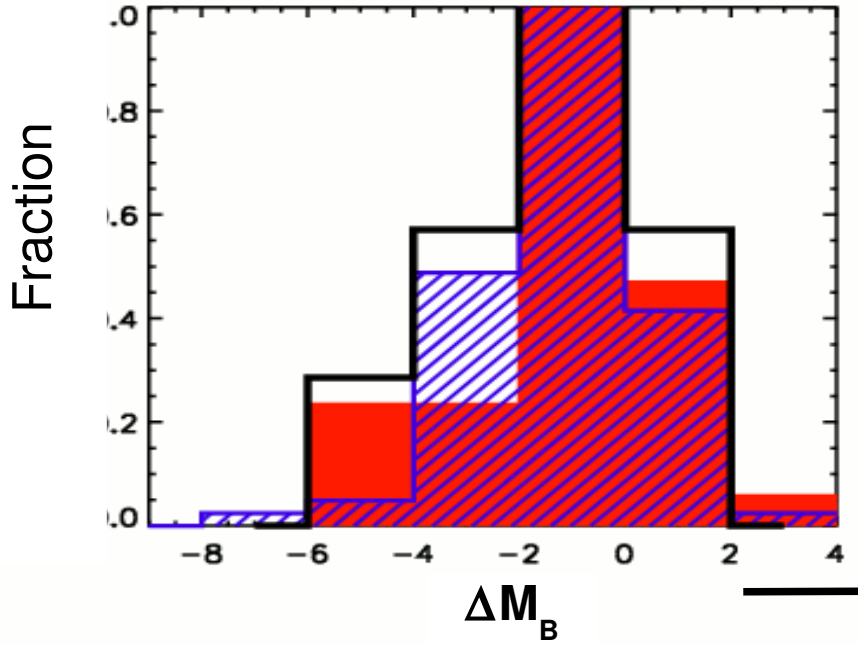
Local TFR (Tully et al. 1998)



$$M_B^{data} - M_B^{local}$$

The TFR of emission-line galaxies at 0.3 < z <0.8





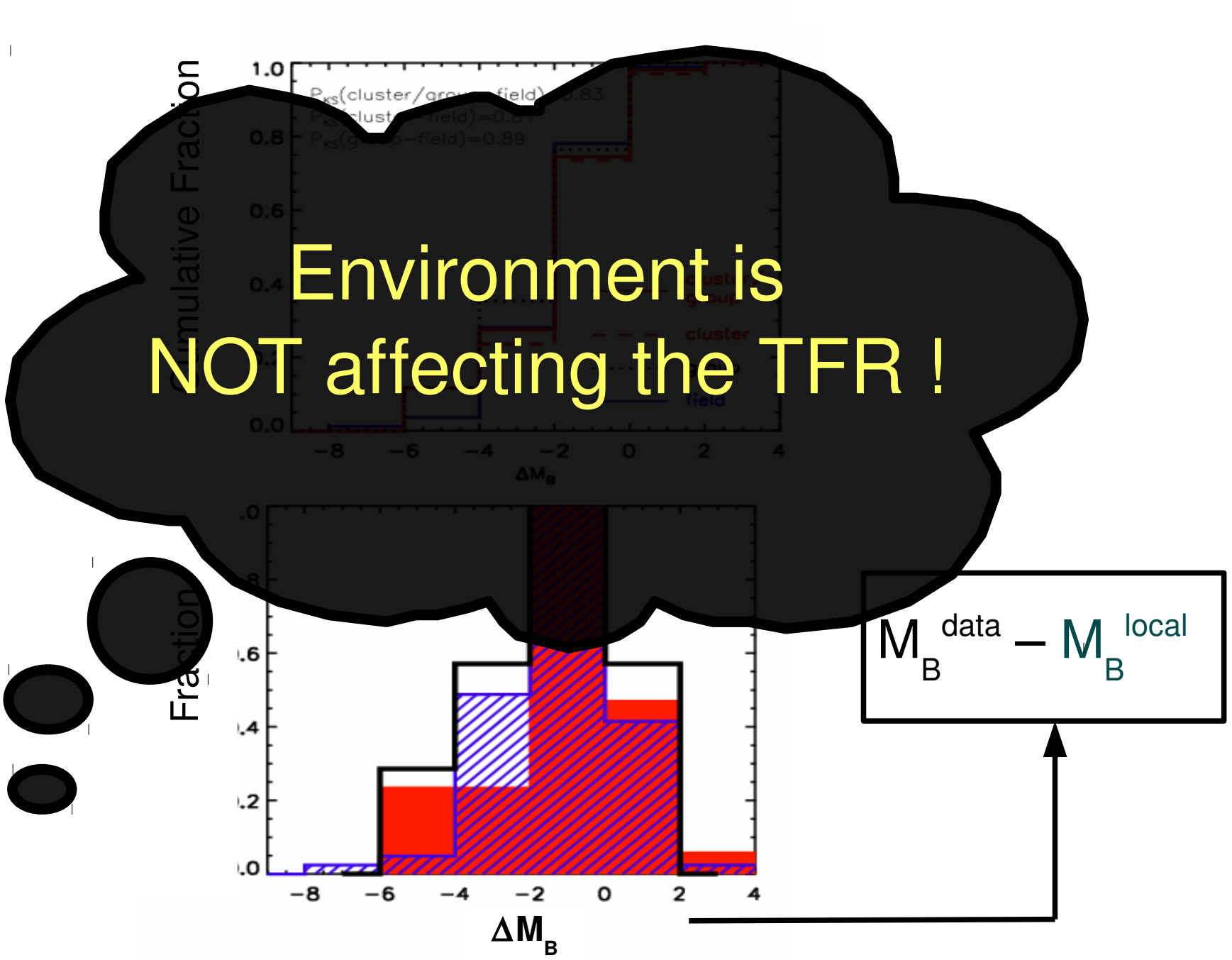
field

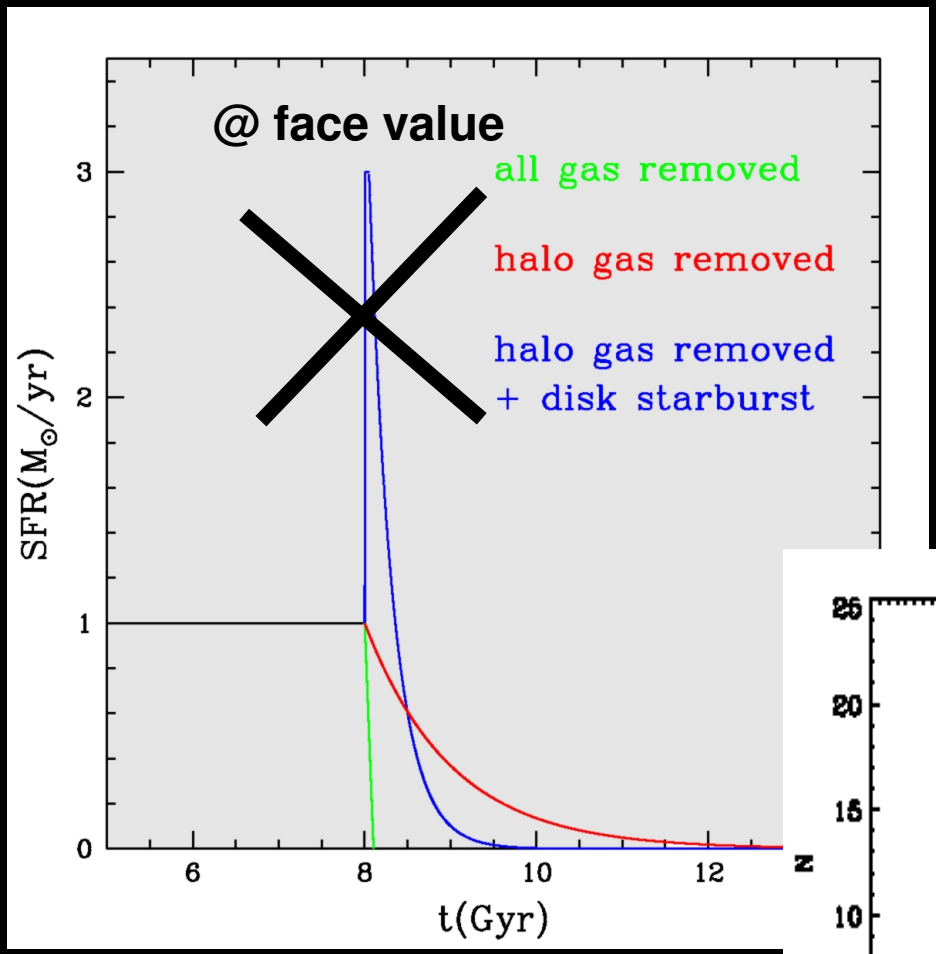
Cluster ($\sigma_{cluster}$ > 400 km/s)

groups ($\sigma_{cluster}$ < 400 km/s)

$M_B^{data} - M_B^{local}$

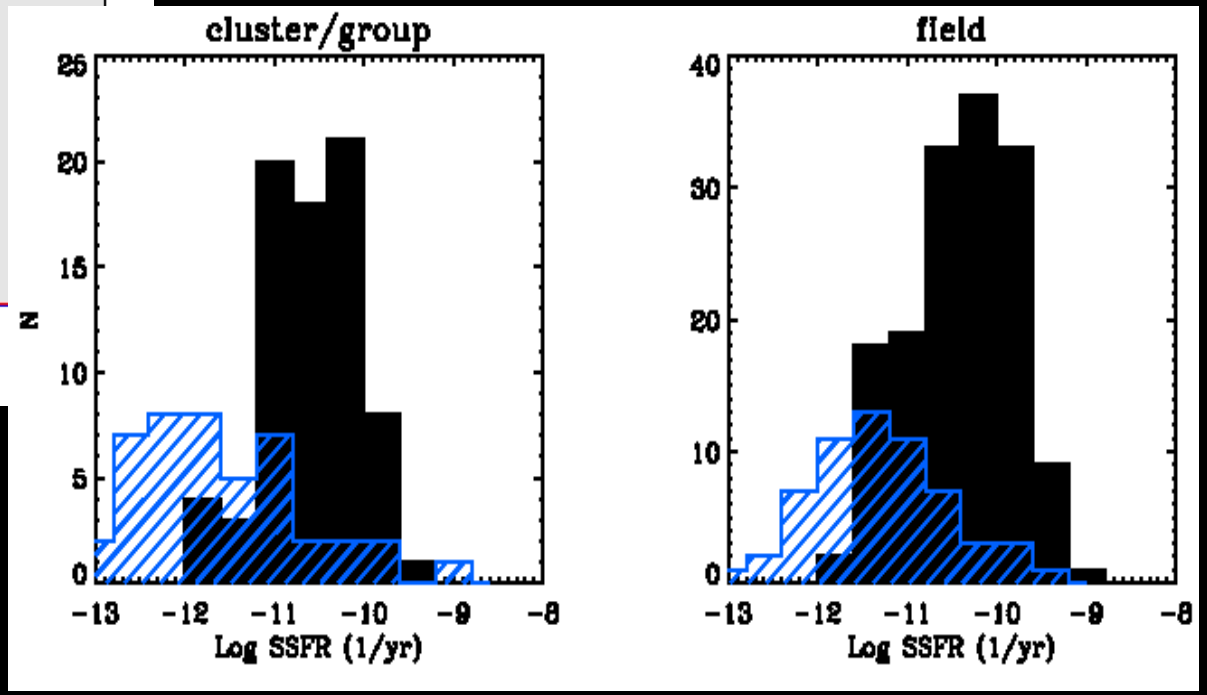
The Tully-Fisher relation at 0.3 < z <0.8





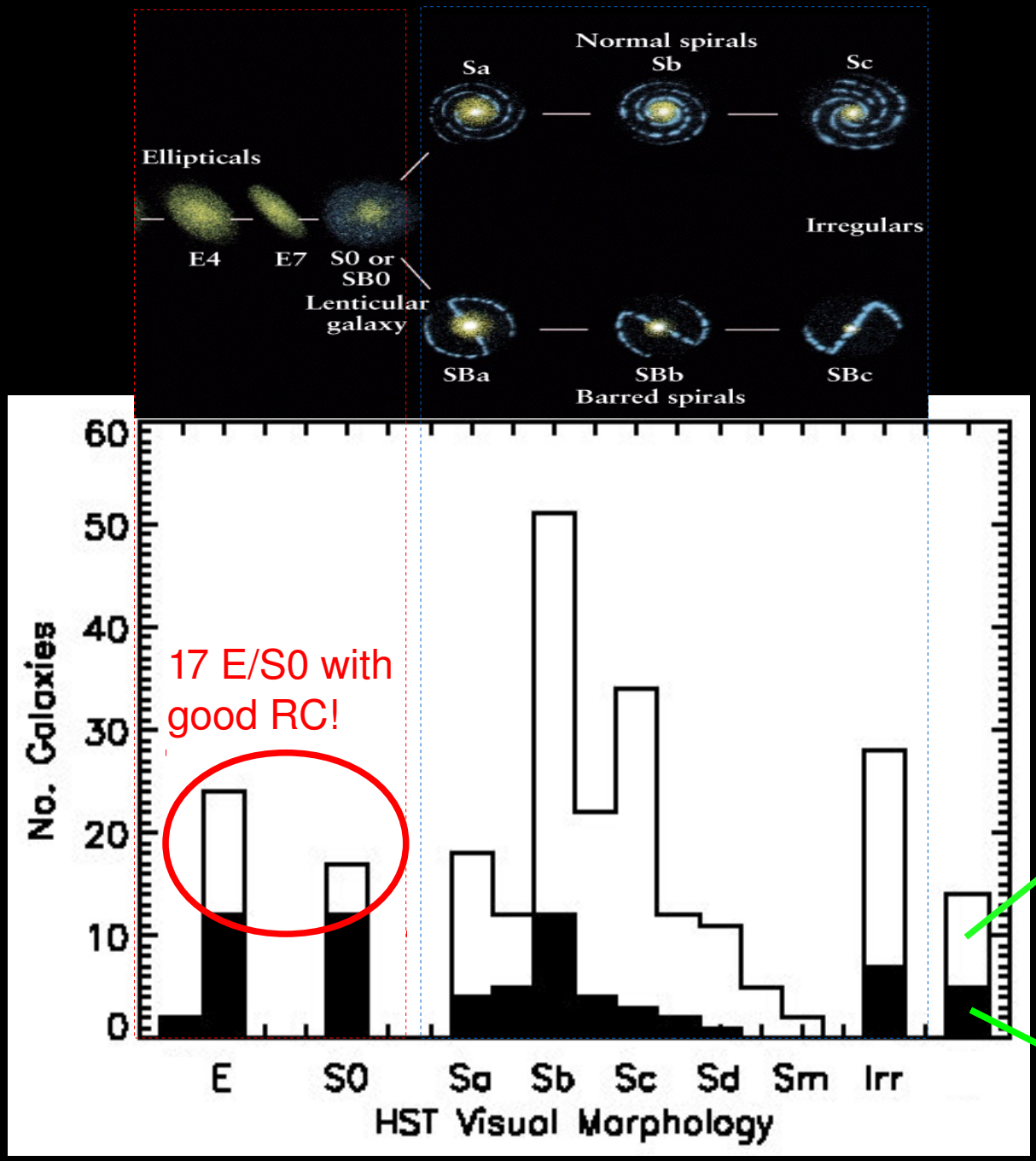
BUT.....

Do we not see it because of our inability to plot kinematically disturbed galaxies in the TFR?



No SF enhancement.
In fact, there is suppression!

A remark on the morphologies of our emission-line galaxies...



All EDisCS emission-line galaxies

Those with disturbed gas kinematics

CONCLUSIONS (1/3)

Previous work suggests that S transform into S0 but couldn't quite tell which mechanism is responsible. We looked at the morphologies & gas kinematics of distant galaxies in different environments, finding that:

- F_{Kin}
  - higher in clusters
  - increases with cluster velocity dispersion
  - decreases with distance from the cluster centre
  - not correlated with projected galaxy density
- F_{Morph} independent of environment

→ Cause of disturbance likely related to the ICM and not to galaxy-galaxy interactions.

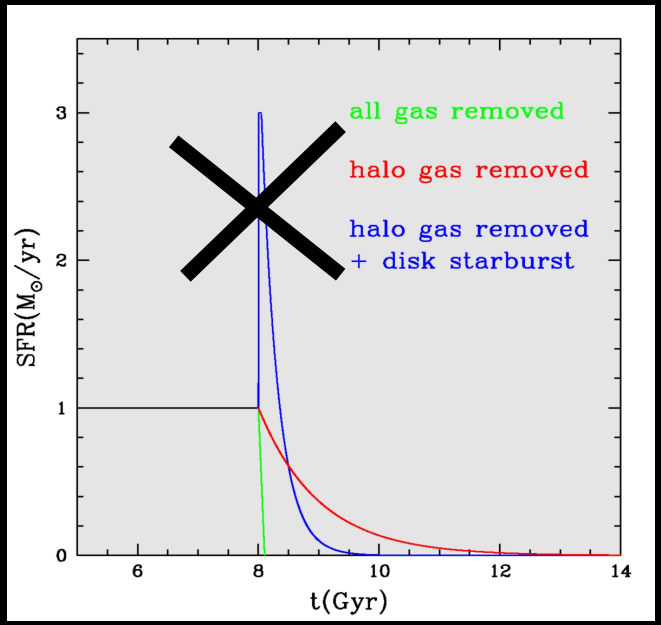
CONCLUSIONS (2/3)

Effect of environment on the TFR of emission-line galaxies:

- There is no significant difference in the cluster, group and field TFRs, at least for galaxies with no kinematical disruption

- kinematically disturbed galaxies present lower SSFRs

→ No SF enhancement in cluster environment.
→ Actually, truncated gas disks!



CONCLUSIONS (final)

If S are the progenitors of cluster S0s...
the mechanism responsible for the transformation:

- efficiently disturbs the SF gas
- reduces the SSFR
- removes gas from outskirts AND/OR concentrates it, building the bulges of S0s (results not shown)
- does not disturb the morphology

→ ICM wins over galaxy interactions in clusters

REF: Jaffé, Y. et al. 2011. MNRAS, 417, 1996

Grazie!