Motivation:

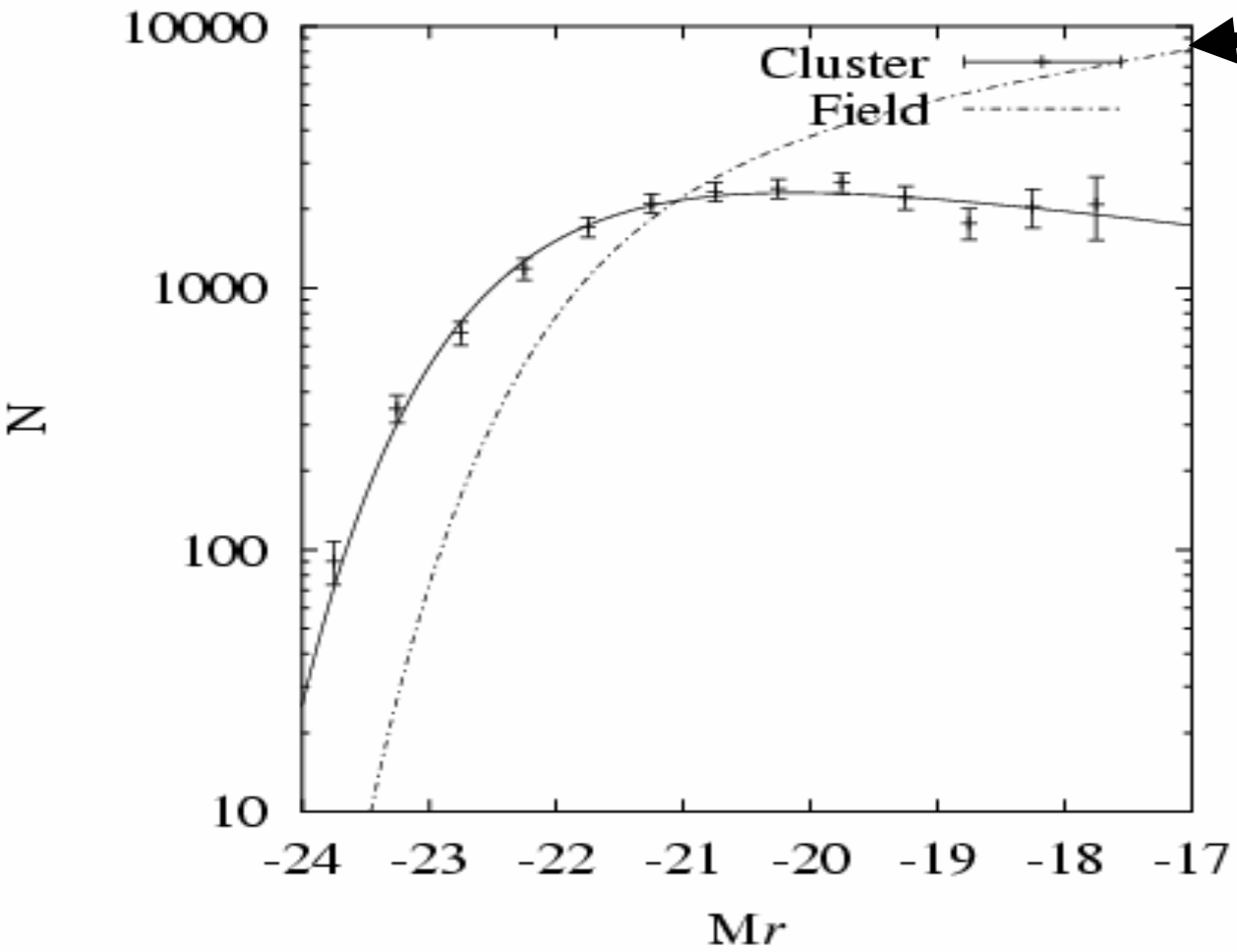
Why Red?

Why Early-type?

335 galaxy clusters selected from the SDSS DR2

All of them have σ>300km/s, Nmember>20

- (Goto et al. 2002, AJ, 123, 1807; Goto, 2005, MNRAS, 359, 1415)



Blanton et al. 2001

Band	M^*	α	Field M^*	Field α
u	-21.61 ± 0.26	-1.40 ± 0.11	-19.11 ± 0.08	-1.35 ± 0.09
g	-22.01 ± 0.11	-1.00 ± 0.06	-20.81 ± 0.04	-1.26 ± 0.05
r	-22.21 ± 0.05	-0.85 ± 0.03	-21.60 ± 0.03	-1.20 ± 0.03
i	-22.31 ± 0.08	-0.70 ± 0.05	-22.03 ± 0.04	-1.25 ± 0.04
z	-22.36 ± 0.06	-0.58 ± 0.04	-22.32 ± 0.05	-1.24 ± 0.05
r(spec)	-22.31 ± 0.13	-0.88 ± 0.07	...	...

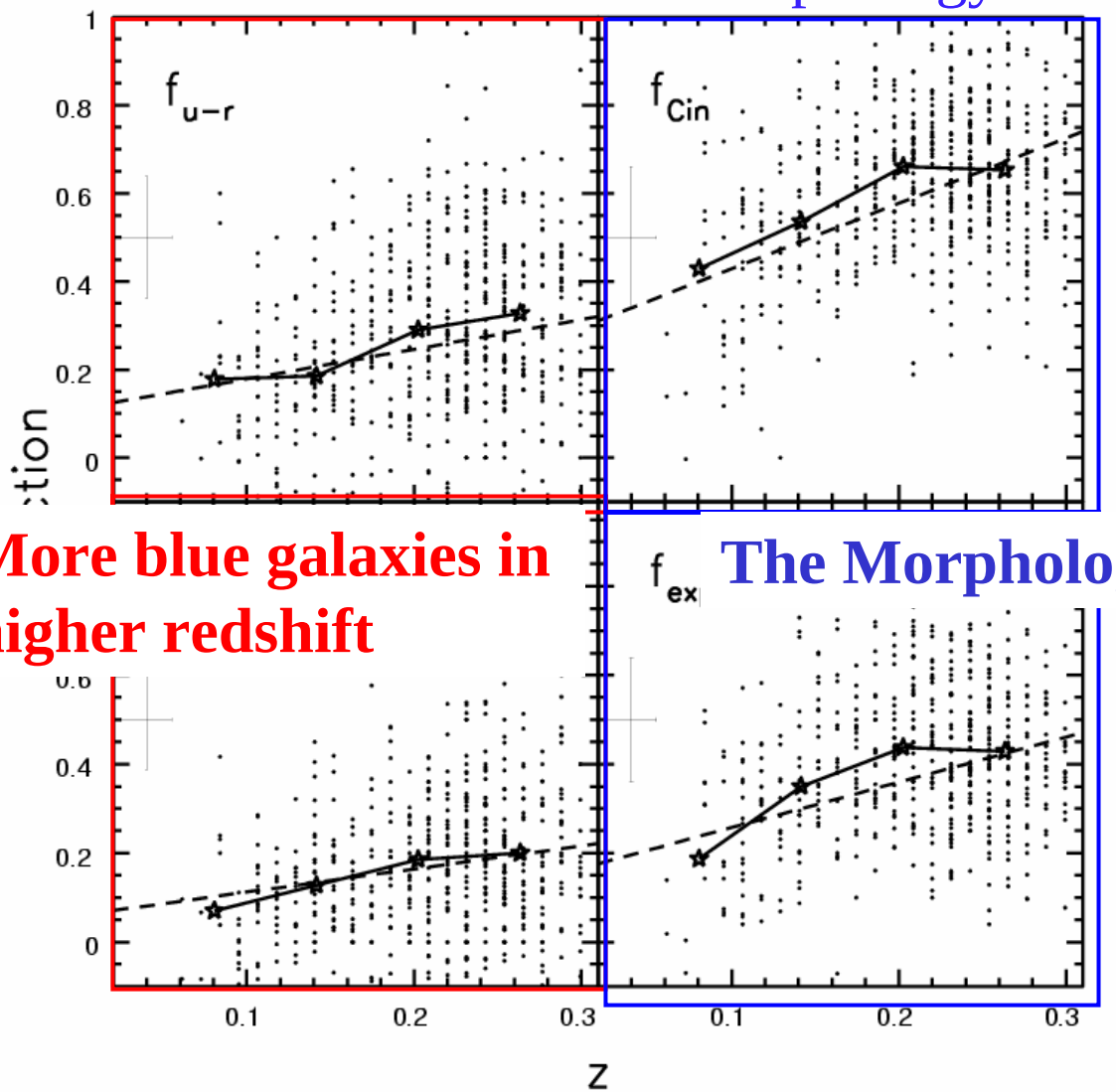
Note. The field values are from Blanton et al. (2001), whose parameters were shifted to match our cosmology. Galaxies within 0.75 Mpc are used.

Composite LFs from 205 SDSS clusters.

Goto et al. 2003, PASJ, 54 ,4

color

morphology



Morphological Butcher-Oemler effect in CE

(Goto, Okamura, Yagi et al. 2003, PASJ, 55, 755)

More blue galaxies in higher redshift

The Morphological BO Effect

Fig. 1. Photometric and morphological Butcher-Oemler effect from the 514 SDSS Cut & Enhance clusters. f_b, f_{Cin}, f_{exp} and f_{u-r} are plotted against redshift. The dashed lines show the weighted least-squares fit to the data. The stars and solid lines show the median values. The median values of errors are shown in the upper left corners of each panel. The Spearman's correlation coefficients are shown in Table 1.

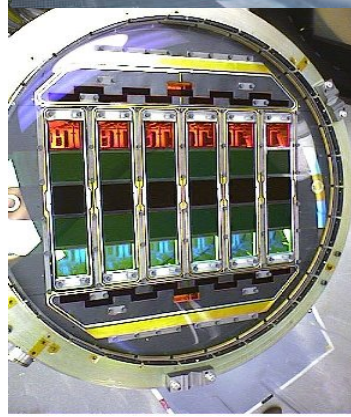
motivation:

Physics behind cluster galaxy evolution.

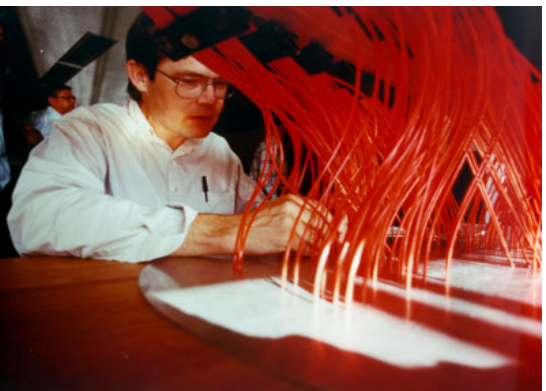
Index

- Critical environment in the SDSS at z=0
  - Morphology-Density Relation at z=0
  - The environment of passive spiral galaxies

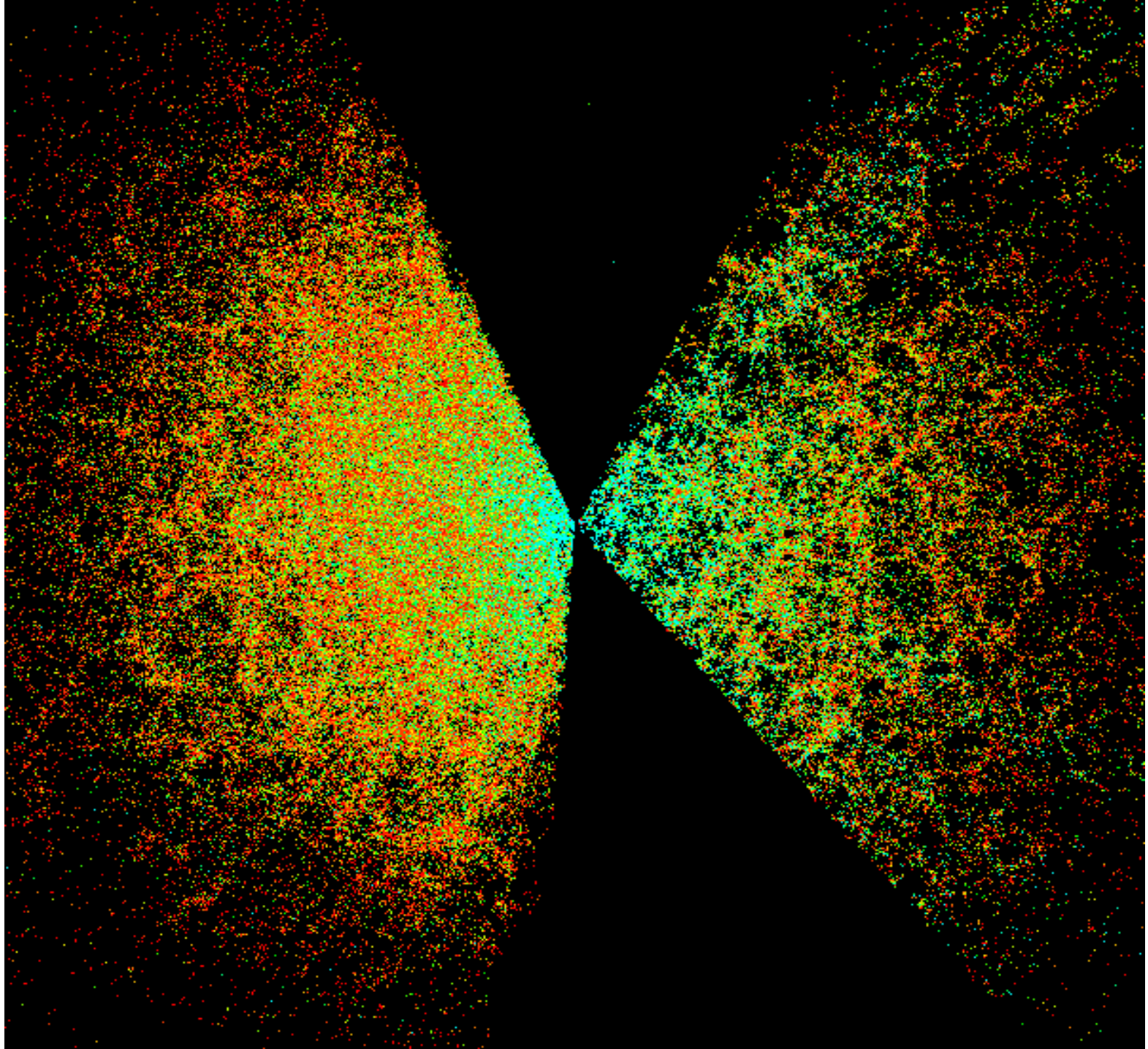
Sloan Digital Sky Survey (SDSS)



- SDSS will produce
  - Imaging of 10,000 sq.deg *r*~23.1
    In 5 optical bands (*ugriz*)
  - Spectra of $1.0 \times 10^6 \, galaxies$
    and $1.5 \times 10^5 QSOs$ in 5 years



Using 2.5m telescope at APO.

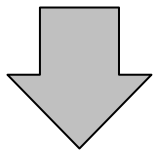


The Morphology-Density Relation with the SDSS

Correlation between morphology and environment
=> remarkable feature of galaxy population.

Previously (Dressler 1980, Postman 1984, Dressler et al 1997, Fasano et al 2000, Hashimoto et al 2000…)

- Eye-morphology
- Only cluster region
- Suffered from BG correction (no spectroscopy)



With SDSS

- All environment including field
- 3 dimensional density (No BG correction)
- Automated morphology

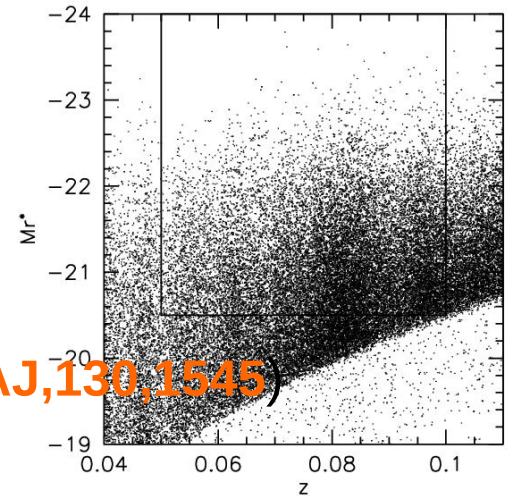
More information on the underlying physical mechanism

Analysis

- Sample
  - Mr<-20.5, z<0.1 in EDR

    (a volume limited sample with spectroscopic 7938 galaxies)
- Cluster Centric Distance
  - Distance to the nearest cluster within ±1000 km/s
- Galaxy Morphology
  - *Tauto* parameter

    (Concentration + Coarseness; **Yamauchi et al. 2005,AJ,130,1545**)



Tauto : Galaxy Classification

(Yamauchi et al. 2005, AJ, 130, 1545)

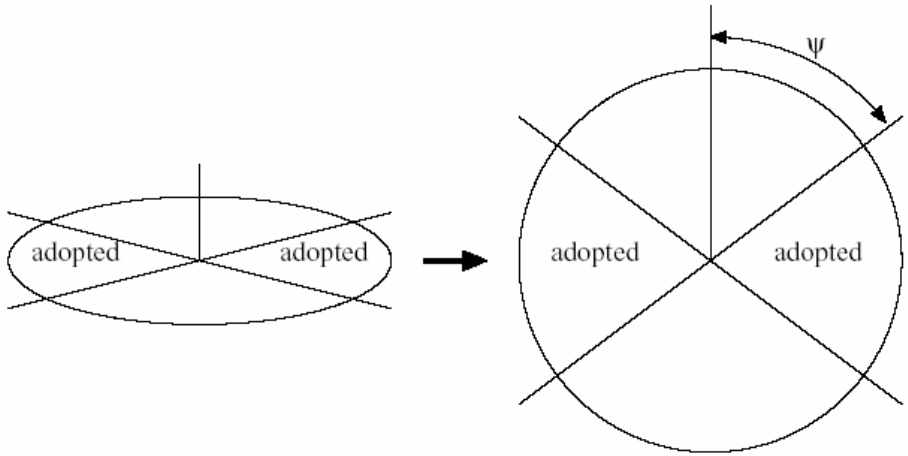


図 6: 短軸からの角度 ψ 内にあるピクセルは捨てる.

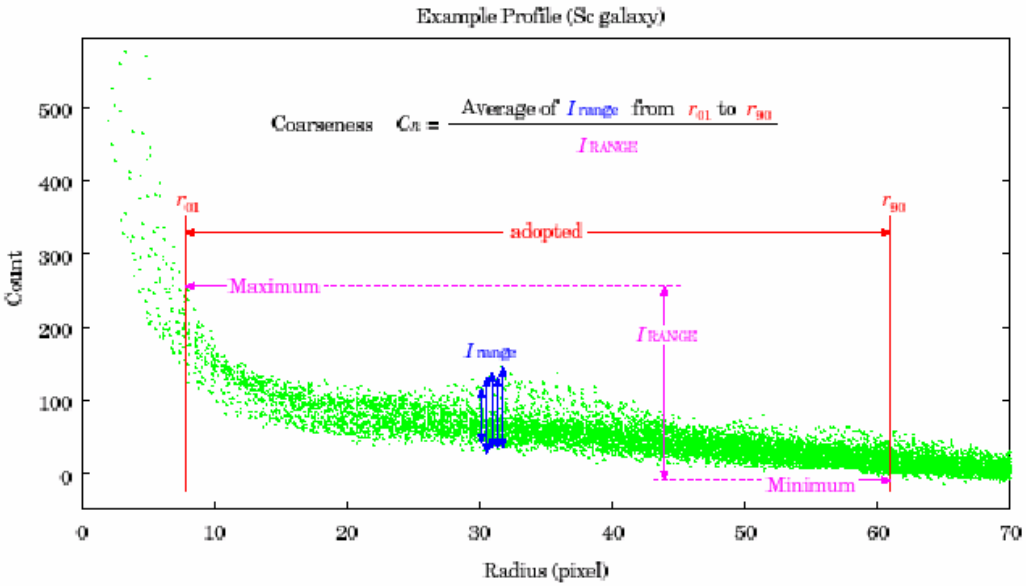
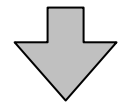


図 10: Coarsenessの算出方法. 緑のドットはCCDの各ピクセルのカウント値である.

concentration

+

coarseness



Tauto

Tauto vs eye-morphology

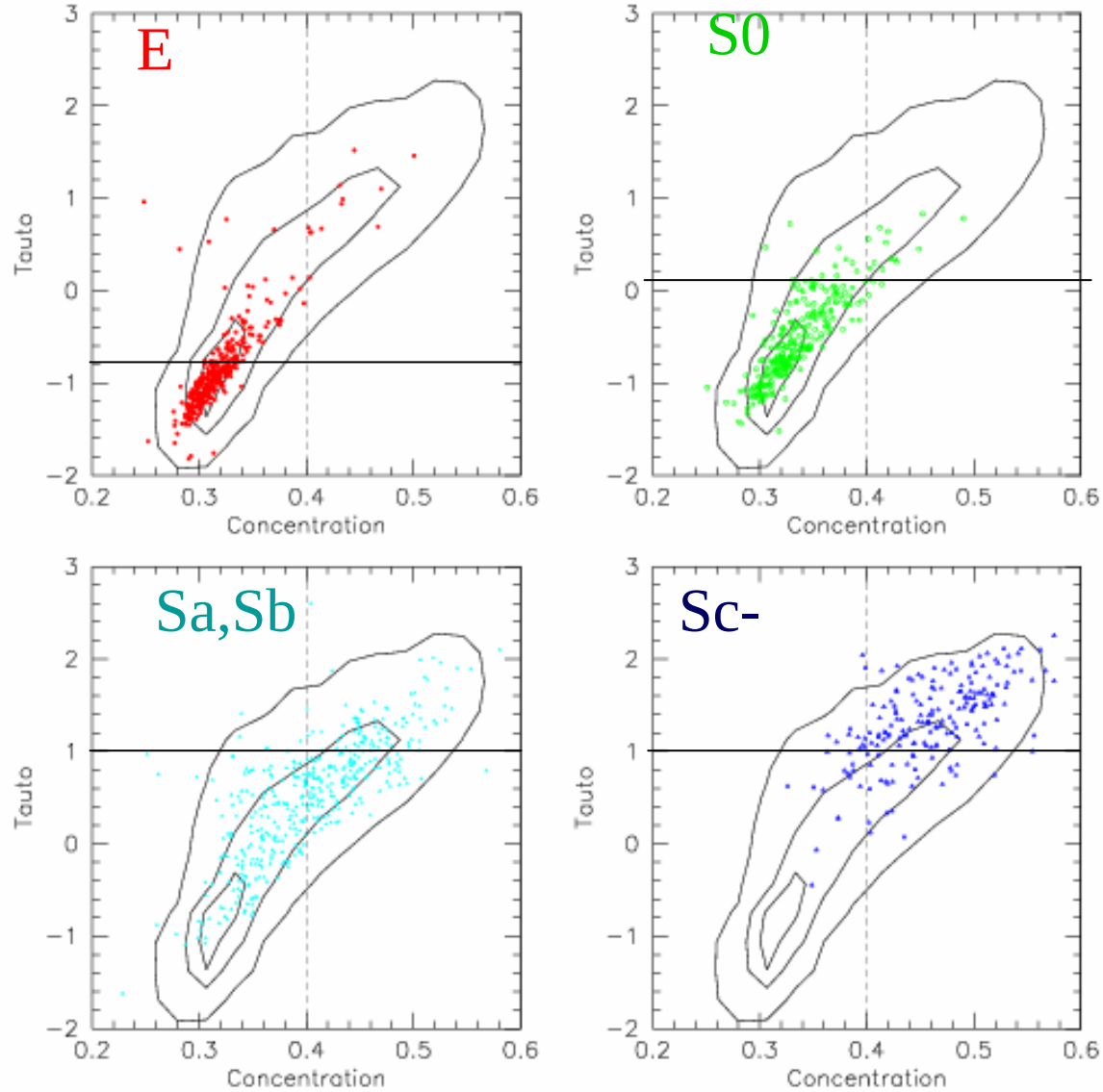


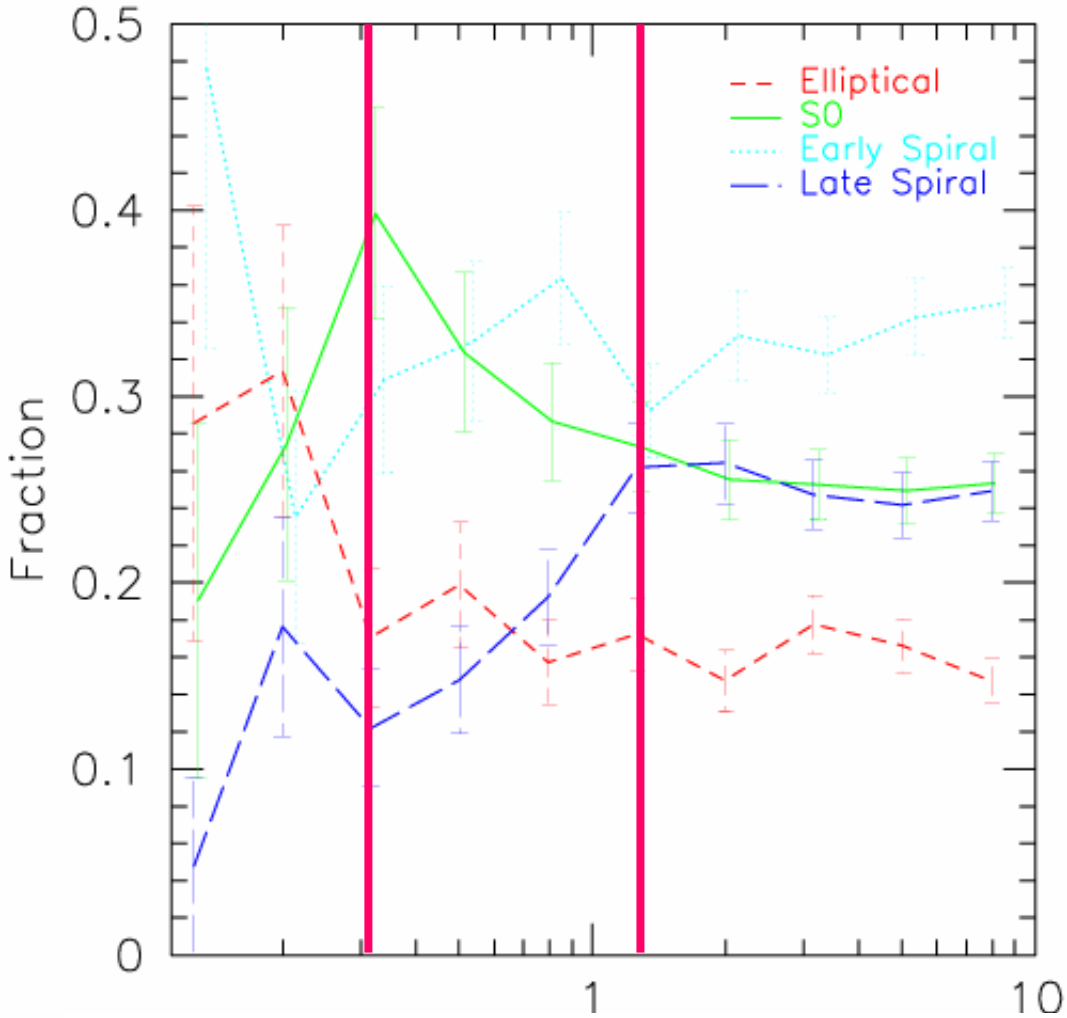
Table 1: Completeness and contamination rate of our four sample of galaxies classified by *Tauto* are calculated using eye-classified morphology.

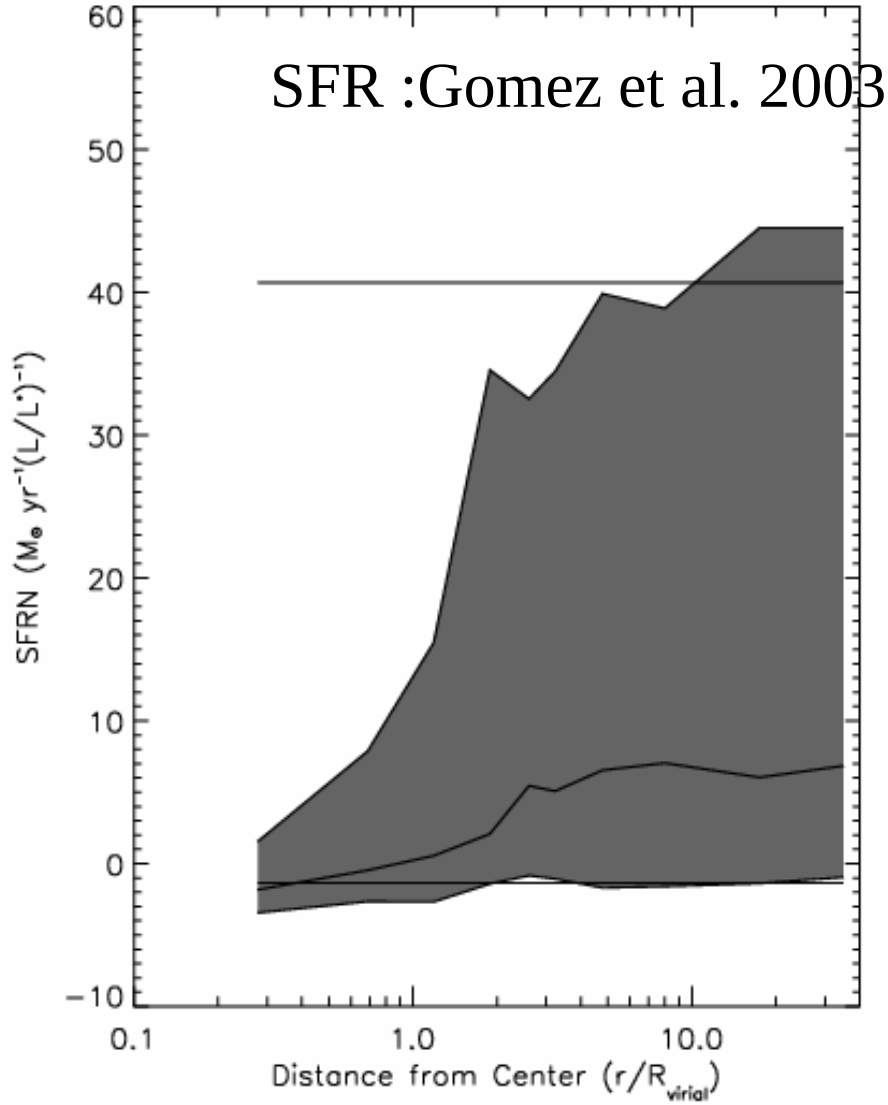
Type	Completeness (%)	Contamination (%)
Elliptical (*Tauto* $\leq$-0.8)	70.3	28.2
S0 (-0.8$\leq$ *Tauto* <0.1)	56.4	56.5
Early Spiral (0.1$\leq$ *Tauto* <1.0)	53.1	24.1
Late Spiral (1.0$\leq$ *Tauto*)	75.0	45.9

Fig. 8.— *Tauto* is plotted against *Cin*. The contours show distribution of all galaxies in the volume limited sample. A good correlation between two parameters is seen. The extension of the distribution to the upper left corner is due to the inclination correction of *Tauto*. Points in each panel show the distribution of each morphological type of galaxies classified by eye (Shimasaku et al. 2001; Nakamura et al. 2003). Ellipticals are in the upper left corner. S0, Sa and Sc are in the upper right, lower left and lower right panel, respectively.

Morphology Radius Relation

(Goto et al. 2003, MNRAS, 346, 601)





Two characteristic changes

→ two different physical mechanisms.

Fig. 1
against
dashed

Physical Size of Galaxies

(Goto et al. 2003, MNRAS, 346, 601)

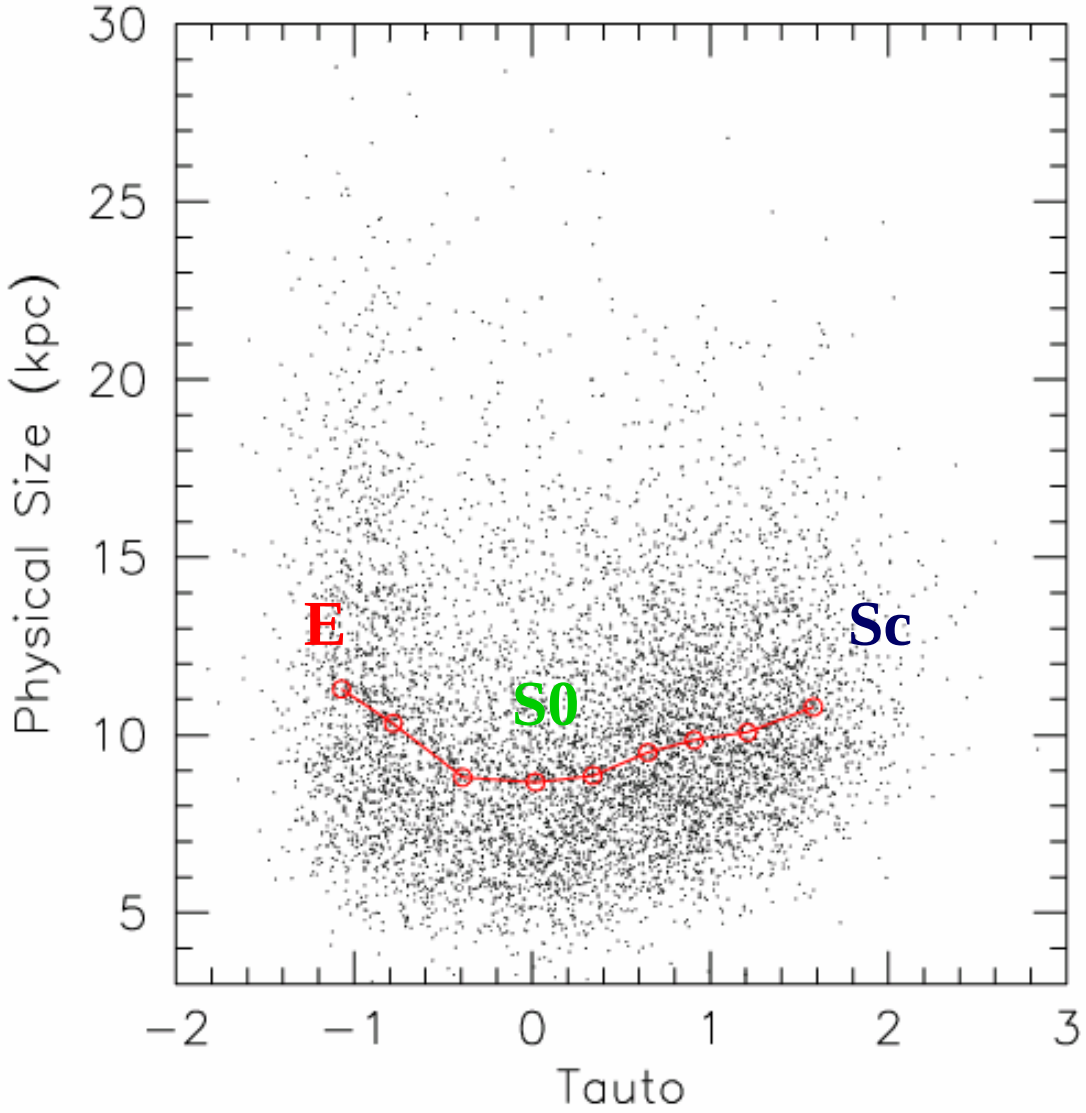
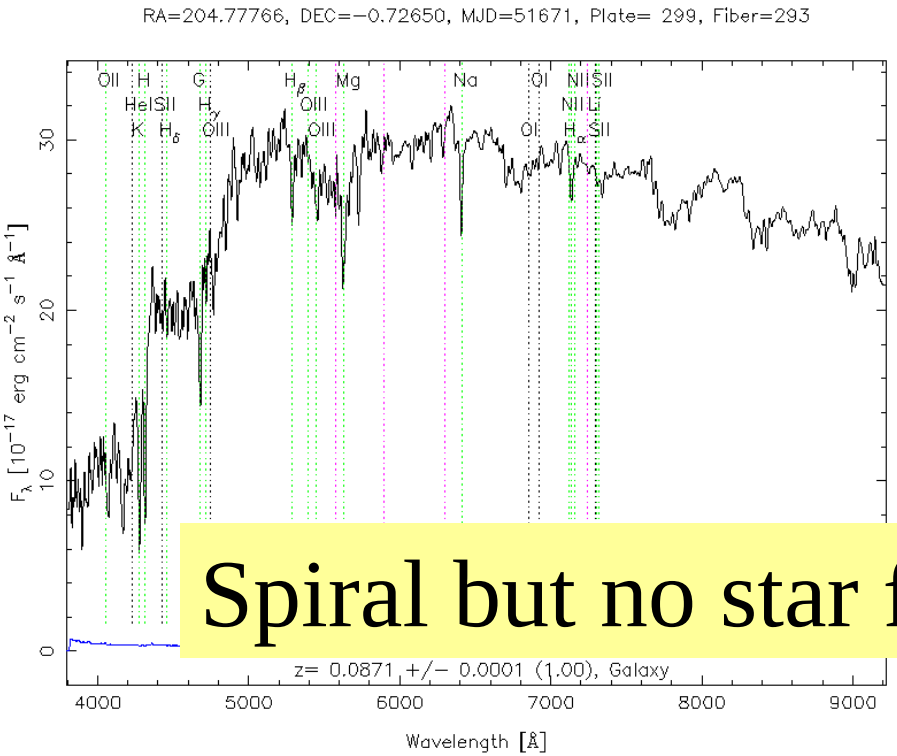


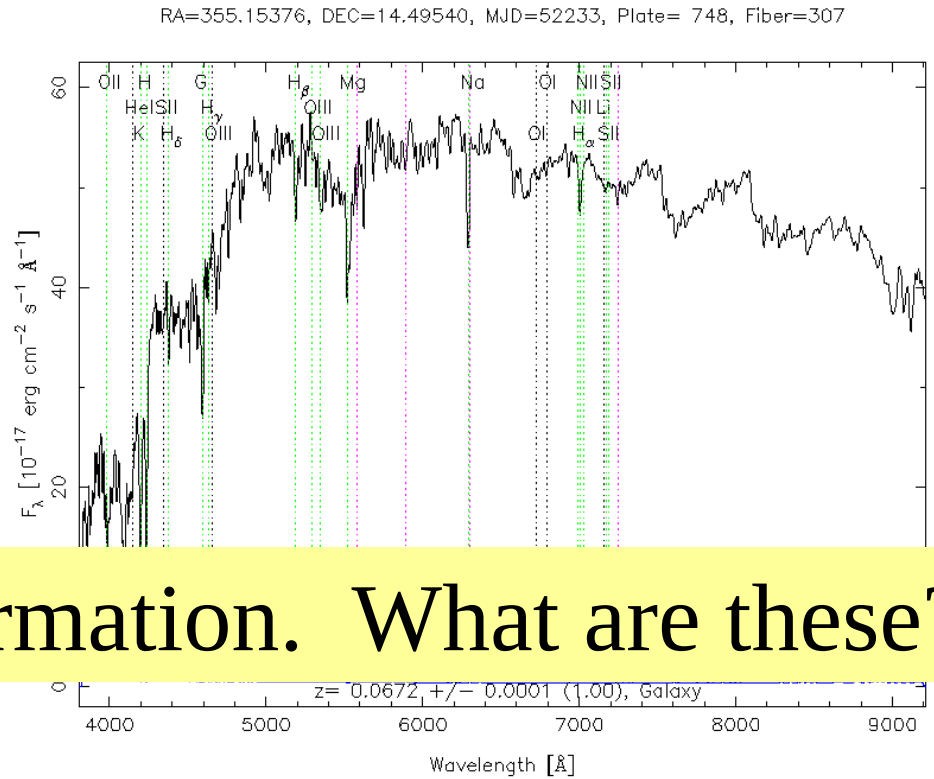
Fig. 17.— Physical sizes of galaxies are plotted against *Tauto*. Petrosian 90% flux radius in *r* band is used to calculate physical sizes of galaxies. A solid line shows medians. It turns over around *Tauto* ~0, correponding to S0 population.

S0 is smaller than Sc.
S0 is smaller than E.

Passive Spiral Galaxies in the SDSS

(Goto et al. 2003, PASJ, 55, 757)





Spiral but no star formation. What are these?

Passive Spiral Selection

- Cin>0.5
- No Hα & no [OII] (less than 1σ)
- 0.05<z<0.1, Mr<-20.5 (a volume limited sample)
- Seeing <2.0”

□73/25813(0.3%) passive spiral galaxies.

c.f. Active Spiral Galaxies

Cin>0.5, with both Hα and [OII]□1059/25813

Optical-IR color --- not dustier

PS do not look like dusty star forming galaxies.

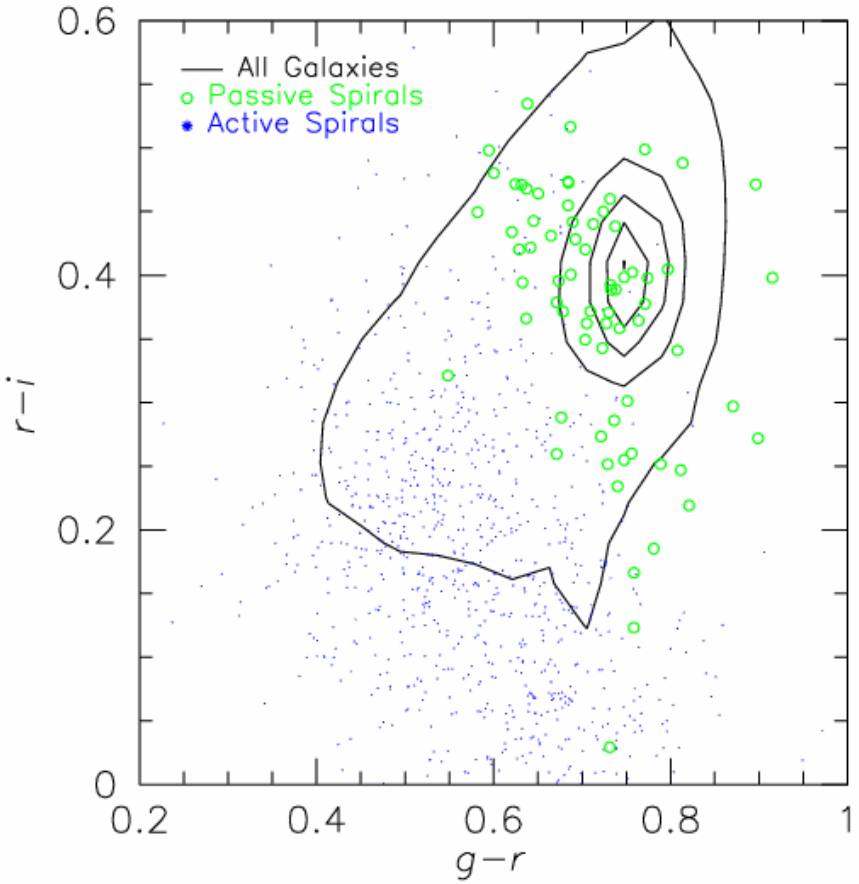
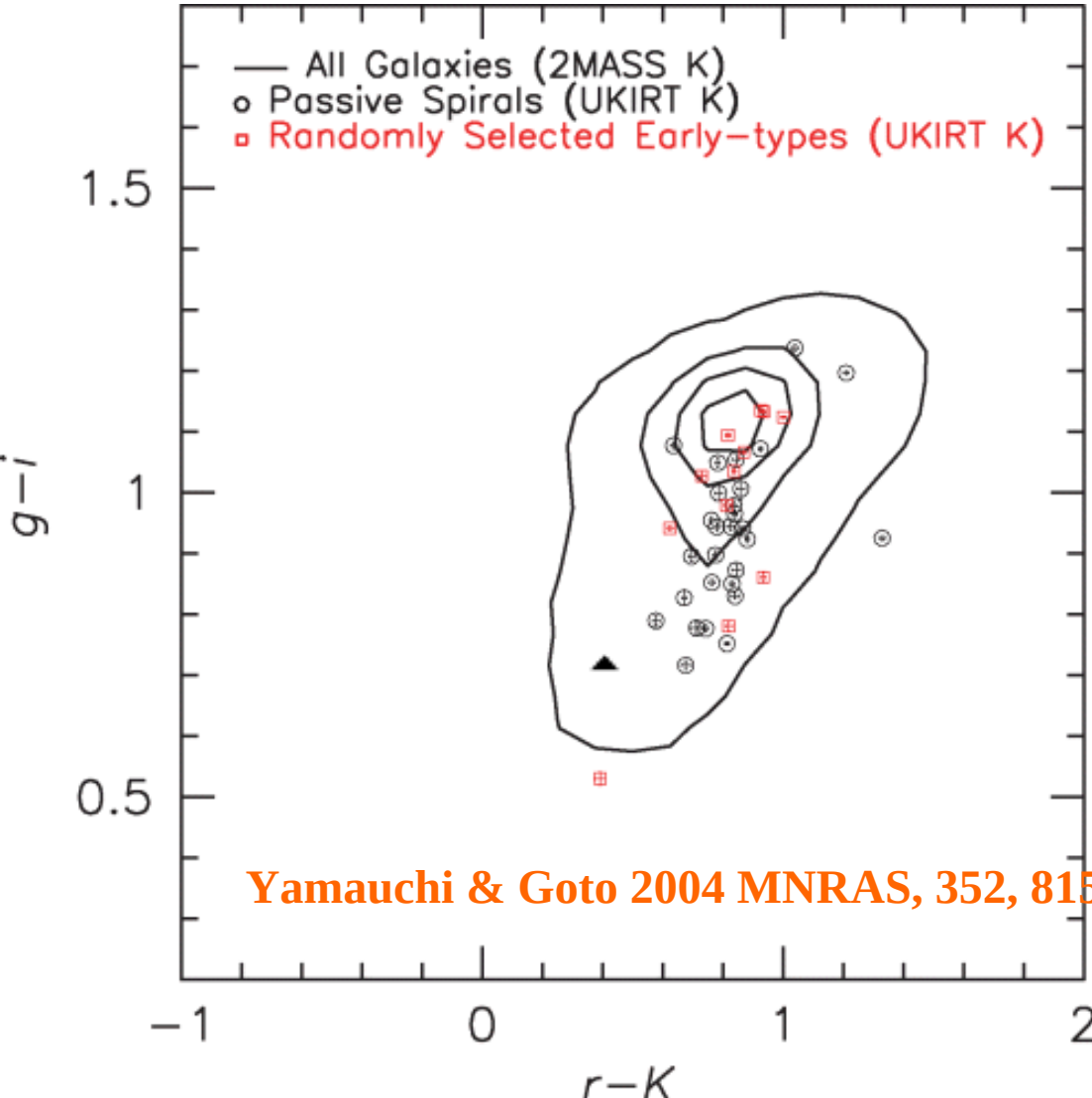


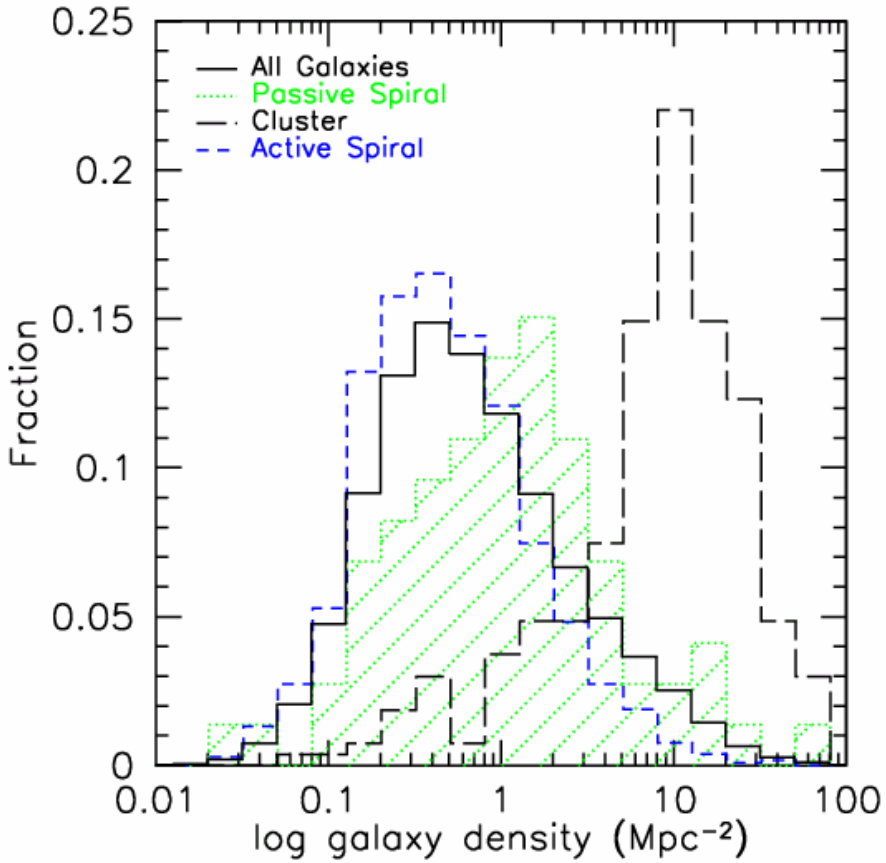
Fig. 9. The distribution of passive spirals in restframe $g-r-i$ plane. Contours show the distribu
all galaxies in our volume limited sample. Open circle and filled dots represent passive and activ
galaxies, respectively.



The Environment of Passive Spirals

(Goto et al. 2003, PASJ, 55, 757)

Passive spirals are cluster related.



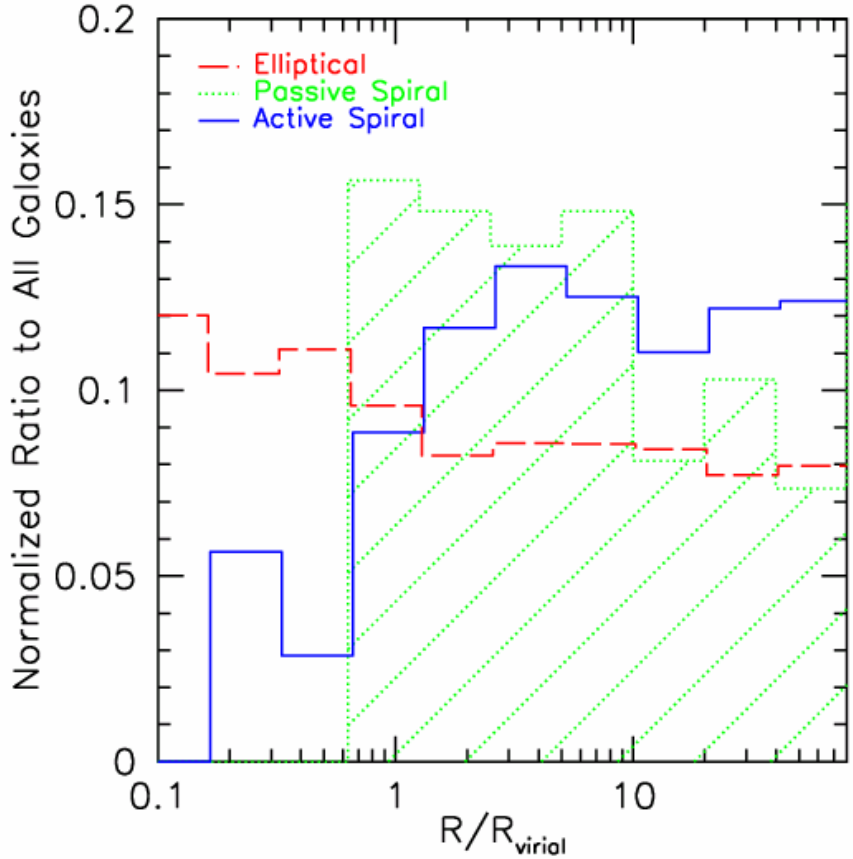


Fig. 7. The distribution of densities for passive spiral galaxies (hashed region) and all galaxies (solid line) in a volume limited sample. A Kolomogorov-Smirnov test shows distributions of passive spirals and all galaxies are from a different distribution. A long dashed line shows the distribution of cluster galaxies. A short dashed line shows that of active spiral galaxies.

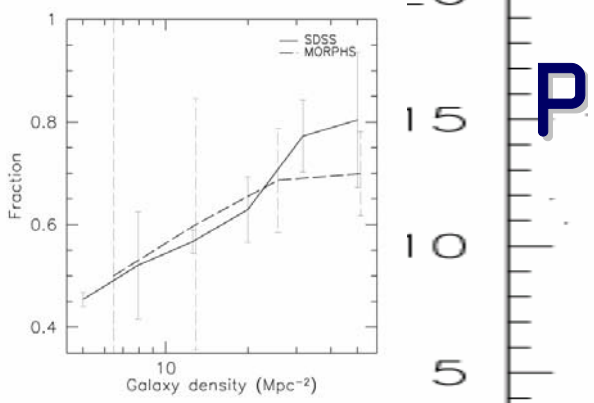
g. 8. The distribution of passive spiral galaxies as a function of cluster-centric-radius. A solid, dashed d dotted lines show the distributions of passive spiral, elliptical and active spiral galaxies, respectively. e distributions are relative to that of all galaxies in the volume limited sample and normalized to be 1 clarity. The cluster-centric-radius is measured as a distance to a nearest C4 cluster (Miller et al. 2003) within ±3000 km/s, and normalized by virial radius (Girardi et al. 1998).

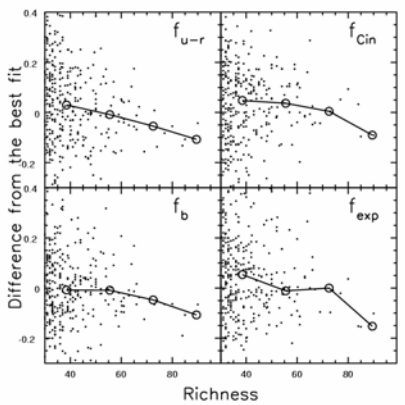
Passive Spiral Galaxies in the SDSS

(Goto et al. 2003,PASJ,55,757)

- Red optical color, but do not look dustier in *r-K*□no sign of dusty star formation.
- Passive Spirals live in cluster infalling region.

- Likely to be *a key population* in transition between blue/spiral and red/S0 galaxies as seen in BO effect and MDR.
- Quiescent truncation of SFR required. Merger/interaction is not likely to be responsible.





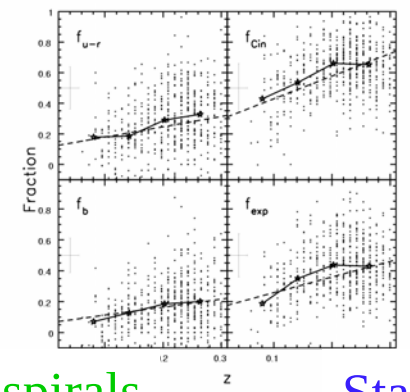


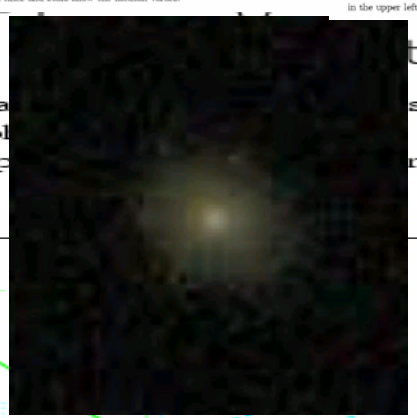
Fig. 18.— Comparison of the morphology-density relations of the SDSS(low redshift) and the MORPHS(high redshift). Fraction of elliptical galaxies are plotted against local galaxy density within 730 kpc. The MORPHS data are plotted in a solid line, and the SDSS data are plotted in a dashed line.

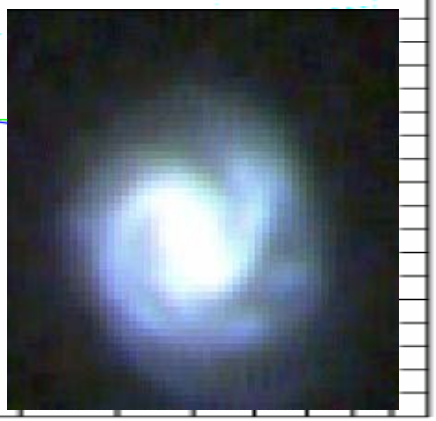
Fig. 4. The difference of the late type fractions from the best fit lines as a function of redshift are plotted against cluster richnesses. Solid lines and stars show the median values.

e spirals

Star-forming galaxies

Cluster Es could be much older.





merging

Stripping
strangulation

Core

Infalling

Field

R/R_{virial}

Fig. 15.— The morphology-radius relation. Fractions of each type of a galaxy is plot against cluster centric radius to the nearest cluster. short-dashed, solid, dotted and l dashed lines represent elliptical, S0, early-spiral and late-spiral galaxies, respectively.

Summary : z=0 with the SDSS

■ Morphology-Density Relation suggests the existence of two different physical mechanisms governing cluster galaxy morphology.

- Cluster infalling region (0.3<Rvir<2):
  S0 increase, SFR decrease, existence of passive spirals.
- Cluster core (Rvir<0.3):
  Elliptical increase.

■ Passive Spiral galaxies live in cluster infalling region (1<Rvir<10). Likely to be a galaxy population in transition between blue/spiral and red/S0.