Osservatorio Astronomico di Brera - Milan - INAF

JKCS041 cluster

Evolution of galaxies in the richest environments at z~2.2

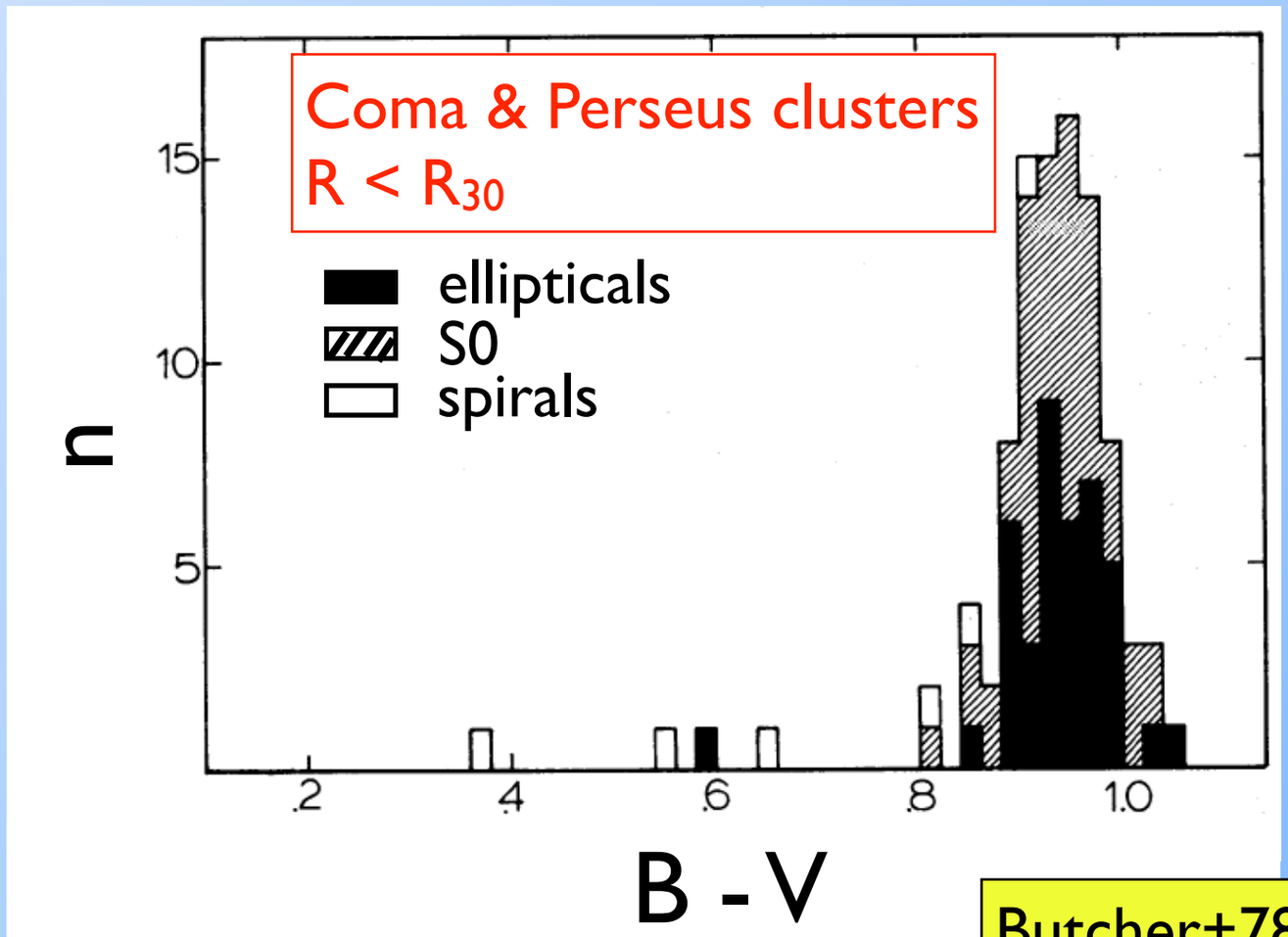
A. Raichoor & S. Andreon
(arxiv: 1110.6446)

GEE2 Meeting - 7/9 Nov. 2011

Star formation in clusters

Local Universe

- galaxies in cluster cores are virtually all quiescent
- →observe galaxies in clusters at increasing look-back time



Butcher+78

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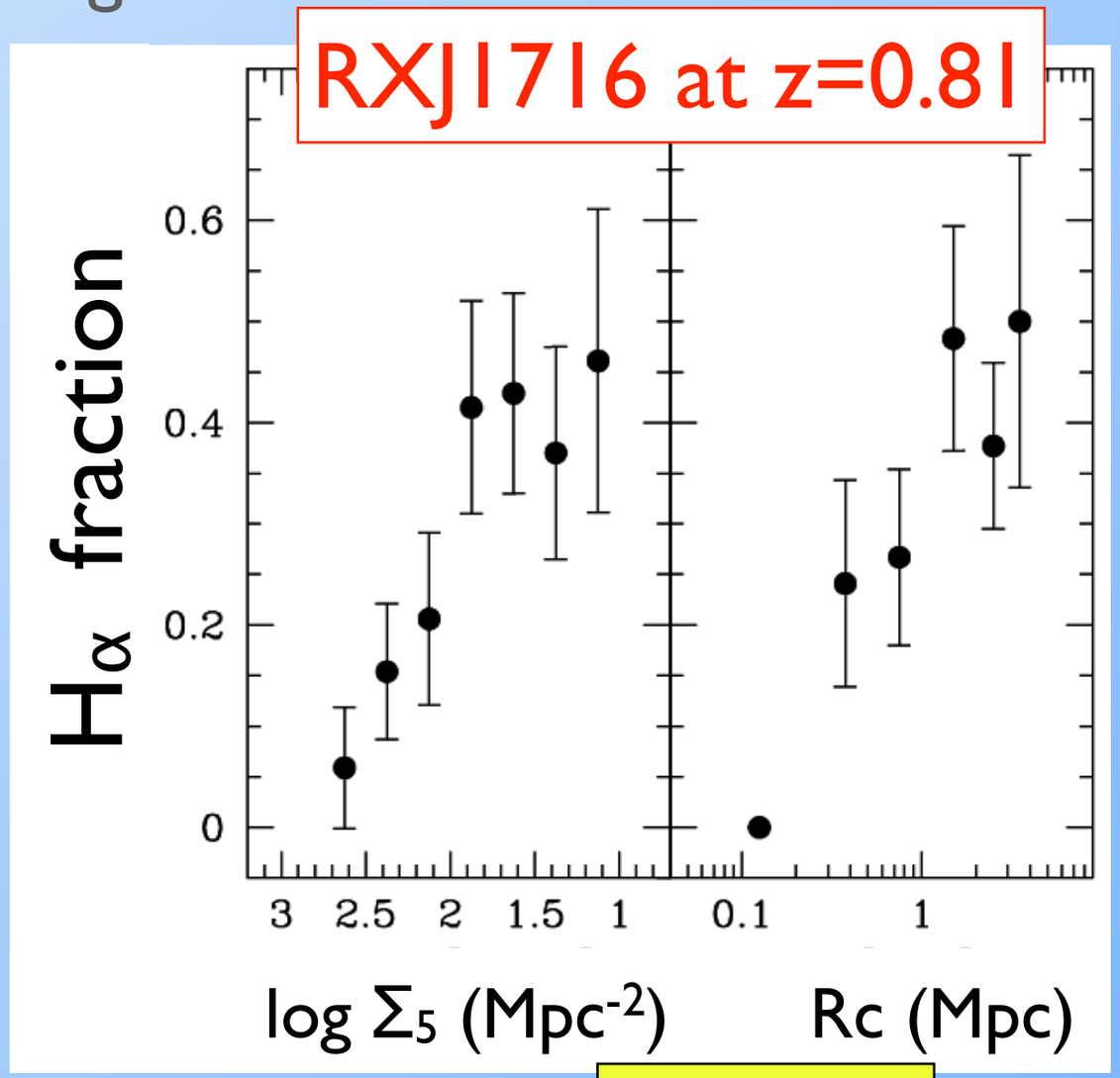
At z~1: core galaxies still quiescent

- Koyama+10 : z=0.81
- Sobral+11: z=0.84
- Patel+09: z=0.84
- Demarco+07: z=1.24



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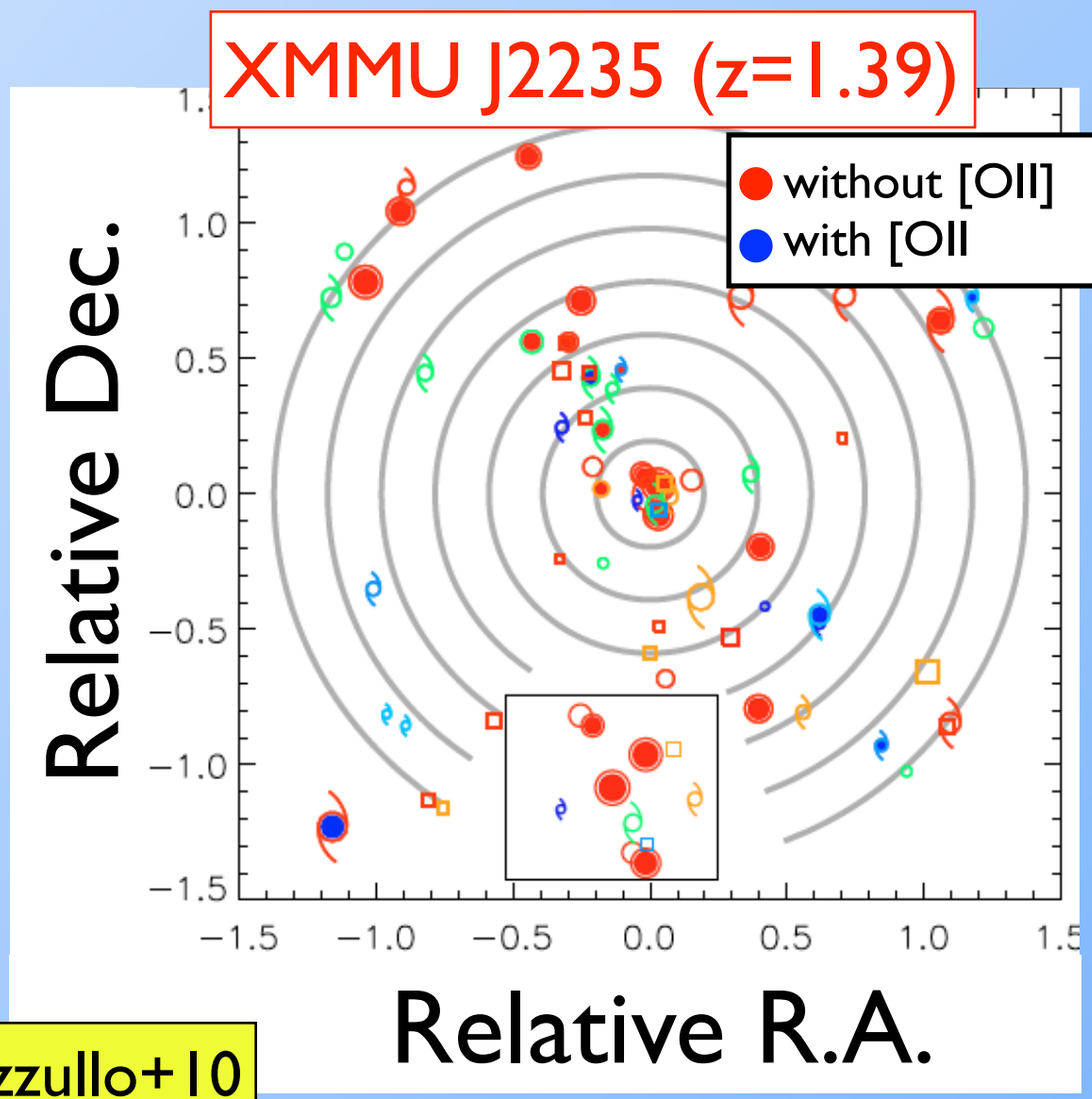
At z >1.4: in debate

- XMMU J2235 (z=1.39): no reversal
  (Lidman+08, Rosati+09, Strazzullo+10)



Strazzullo+10

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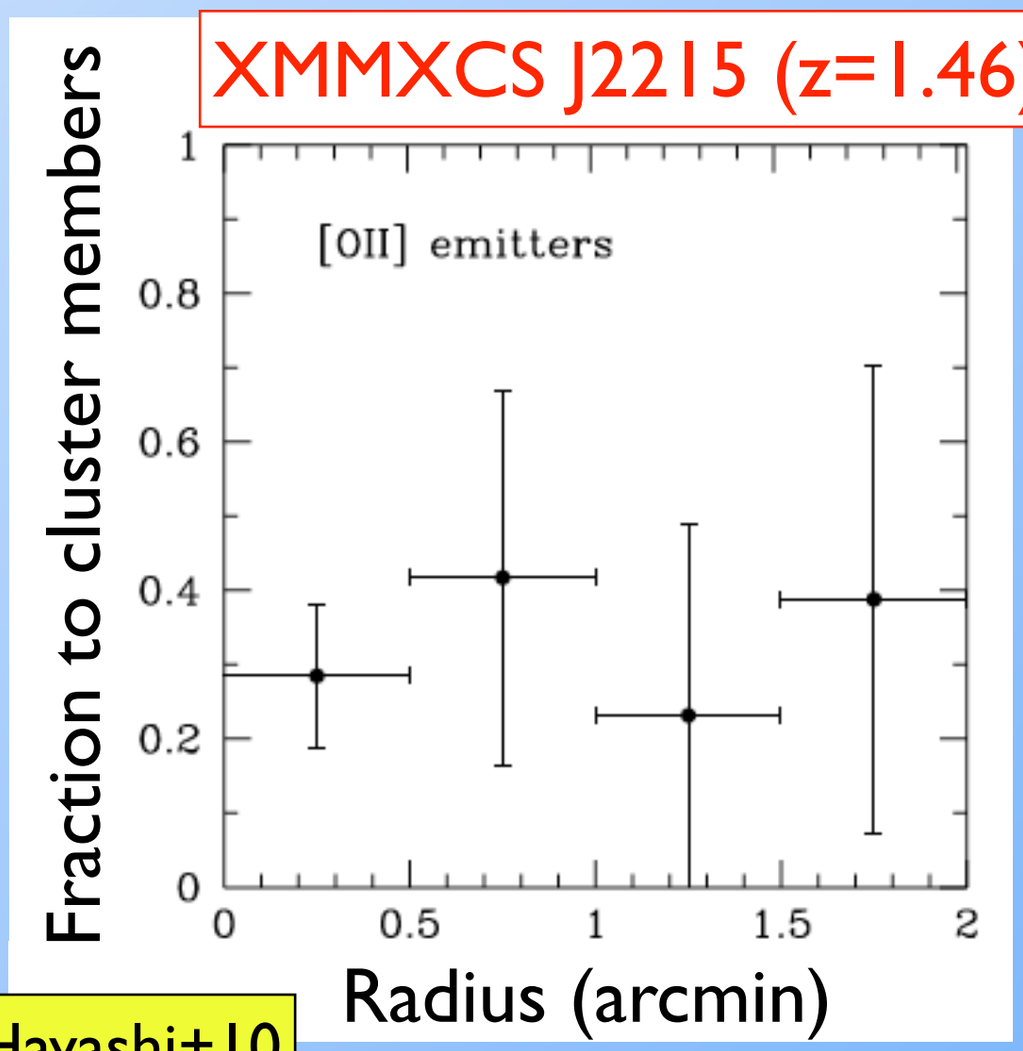
- XMMXCS J2215 (z=1.46): SF activity in cluster core (Hayashi+10, Hilton+10)



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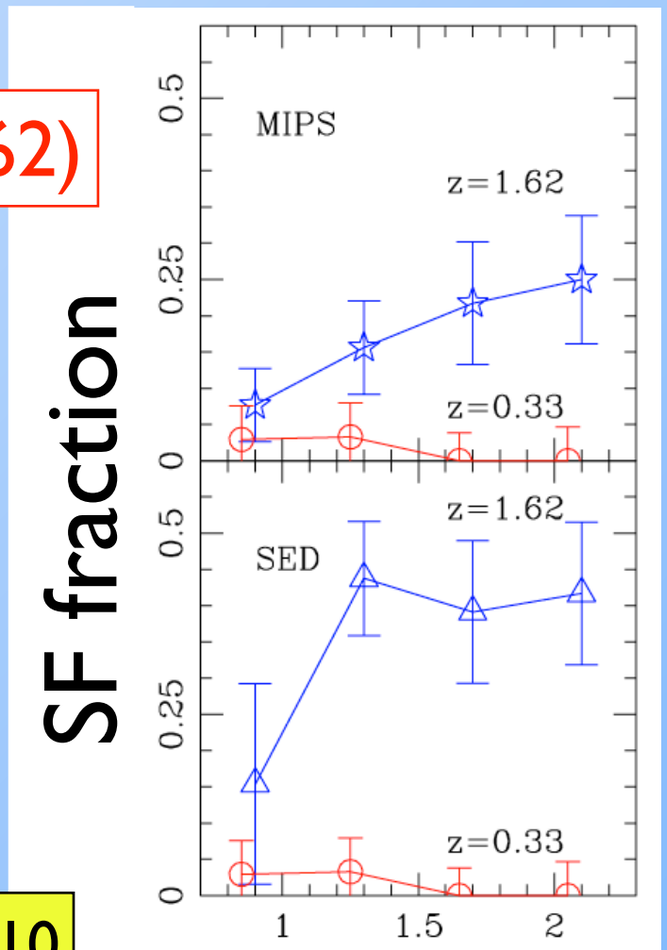
CIG J0218 (z=1.62)



Tran+10

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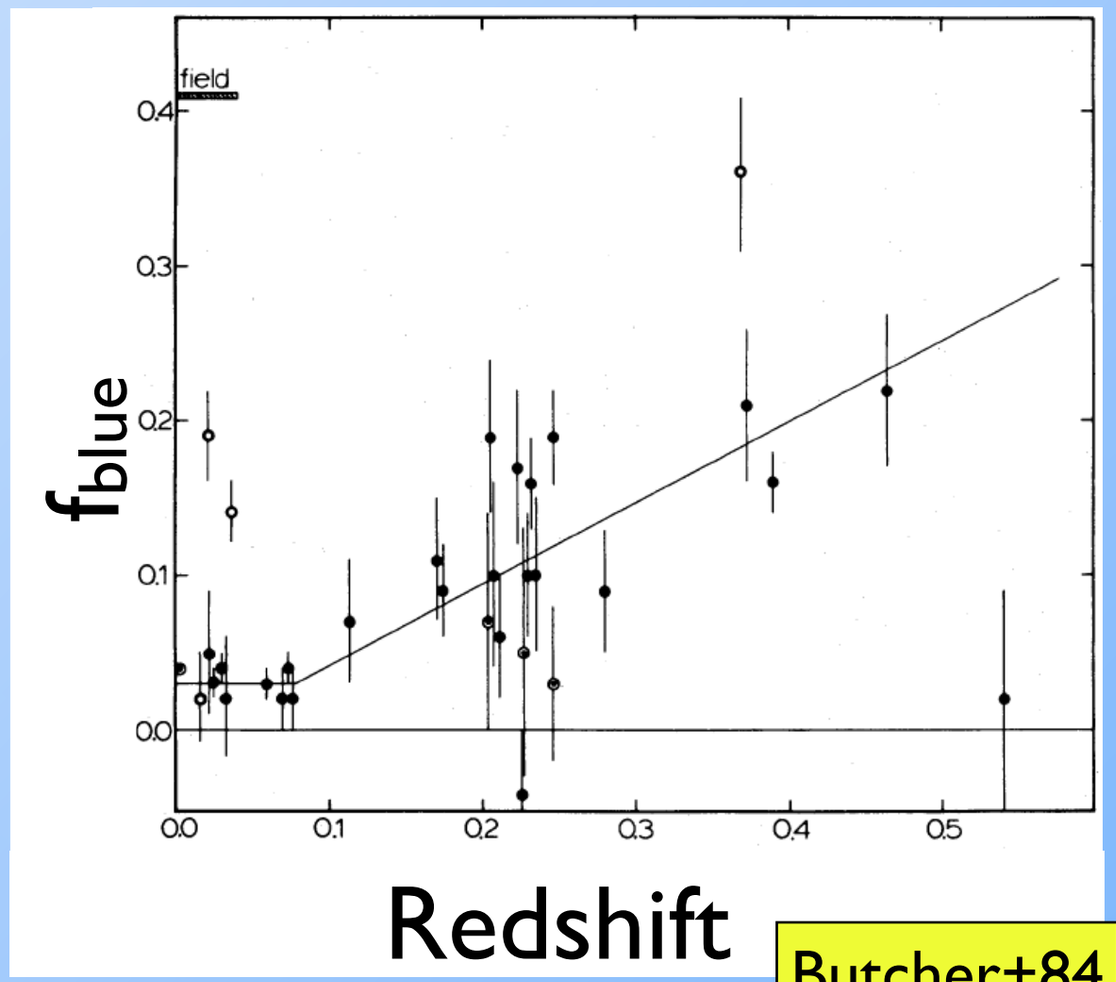
Butcher-Oemler effect

Butcher & Oemler (1984)

- clusters at higher redshift have a larger fraction of blue galaxies
- → accelerated evolution in clusters



Butcher+84

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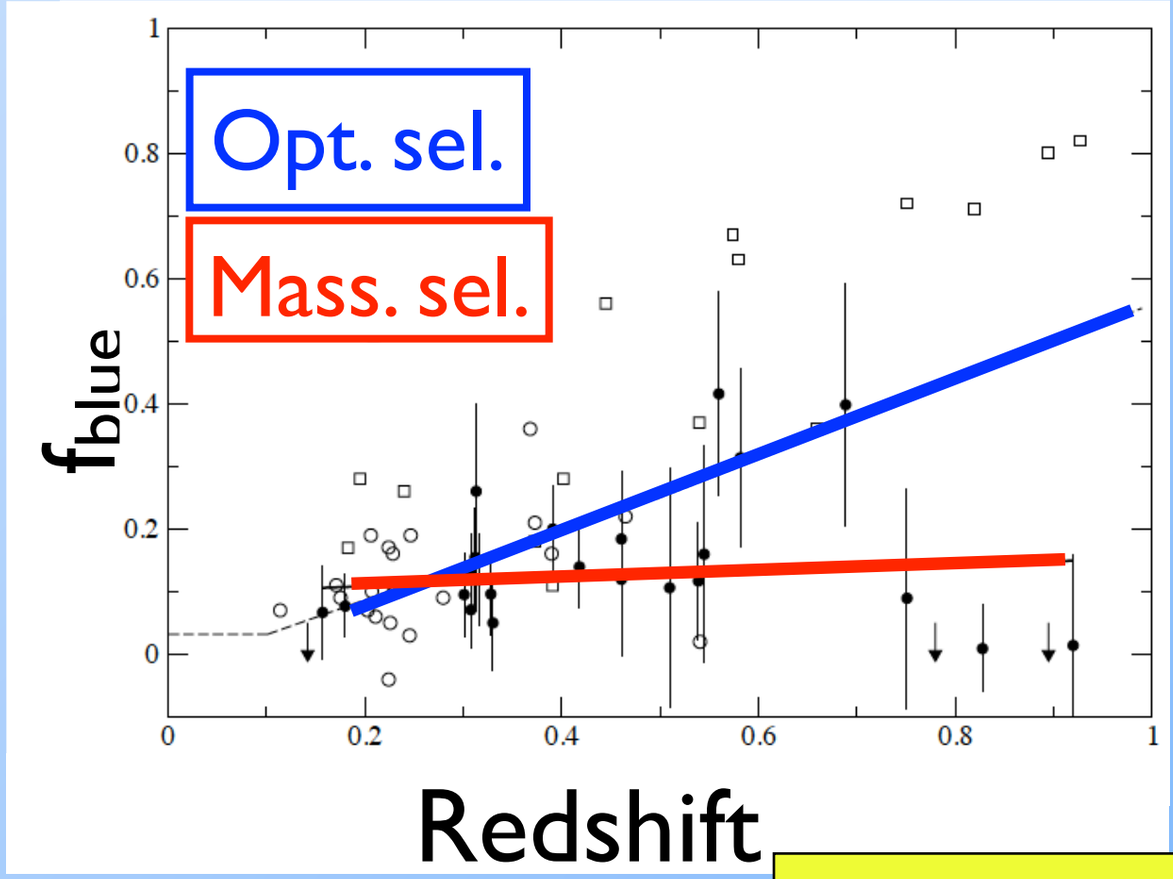
Methodological requirements

- mass-selected galaxy sample



DePropris+03

Butcher-Oemler effect

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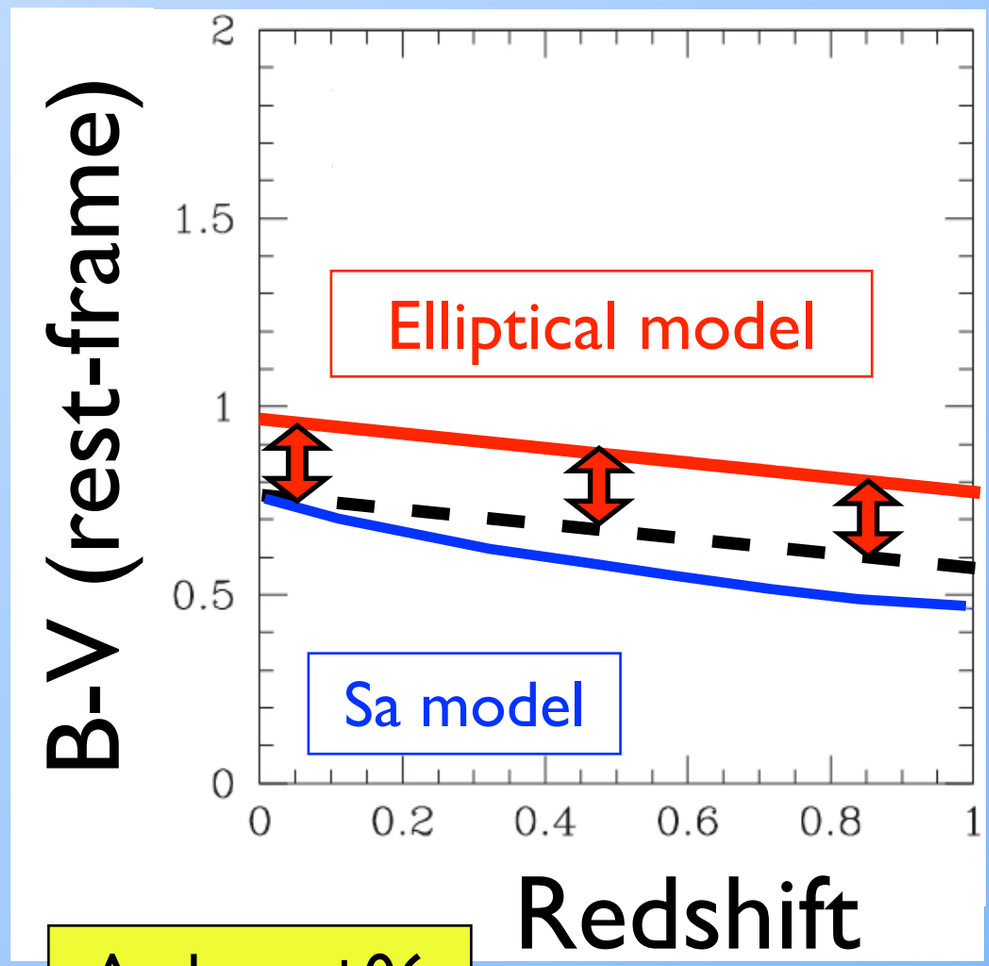
Methodological requirements

- mass-selected galaxy sample
- blue/red galaxy labeling:
  independent of redshift



Andreon+06

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Methodological requirements

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- blue/red galaxy labeling:
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- R < ... × R_{200} → scale with cluster radius

Name	z	r_{200} (Mpc)
XLSSC 024	0.29	1.0
XLSSC 028	0.30	0.8
XLSSC 009	0.33	0.5
XLSSC 010	0.33	0.8
XLSSC 016	0.33	2.0
XLSSC 006	0.43	1.7
XLSSC 012	0.43	1.5

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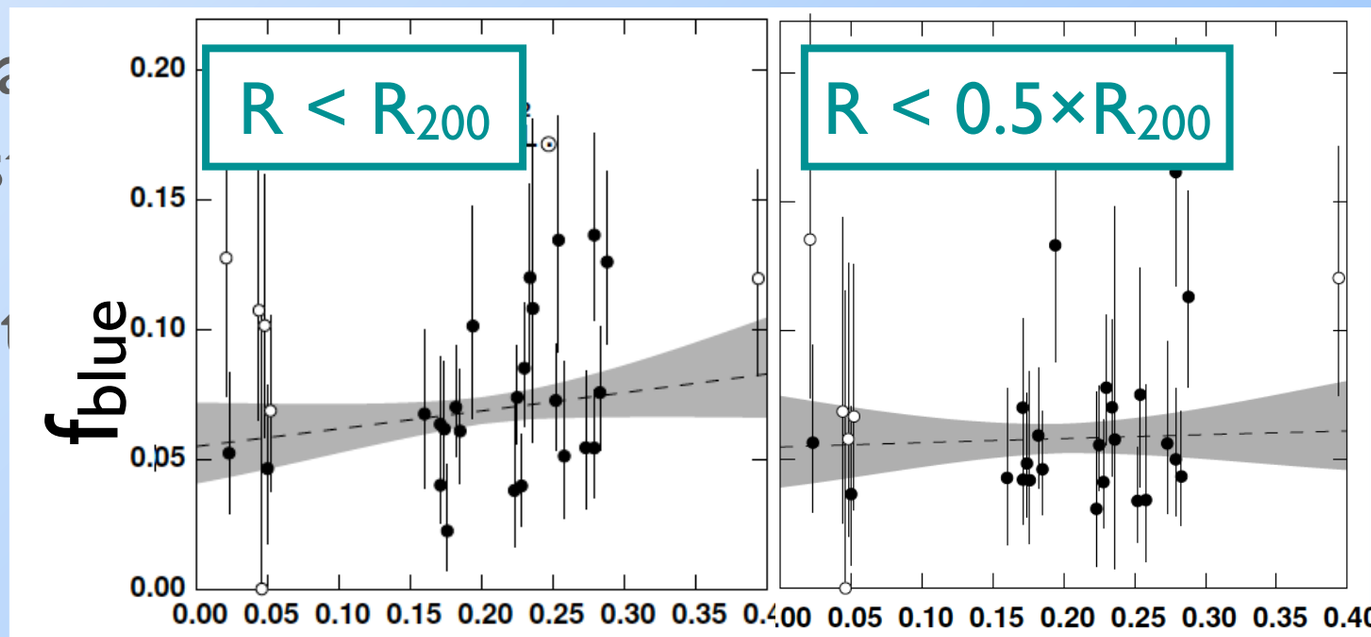

Recent results (M_{gal} > 4e10 M_o)

- weak/no evidence for a BO effect at z≤0.5 (Andreon+06, Haines+09)

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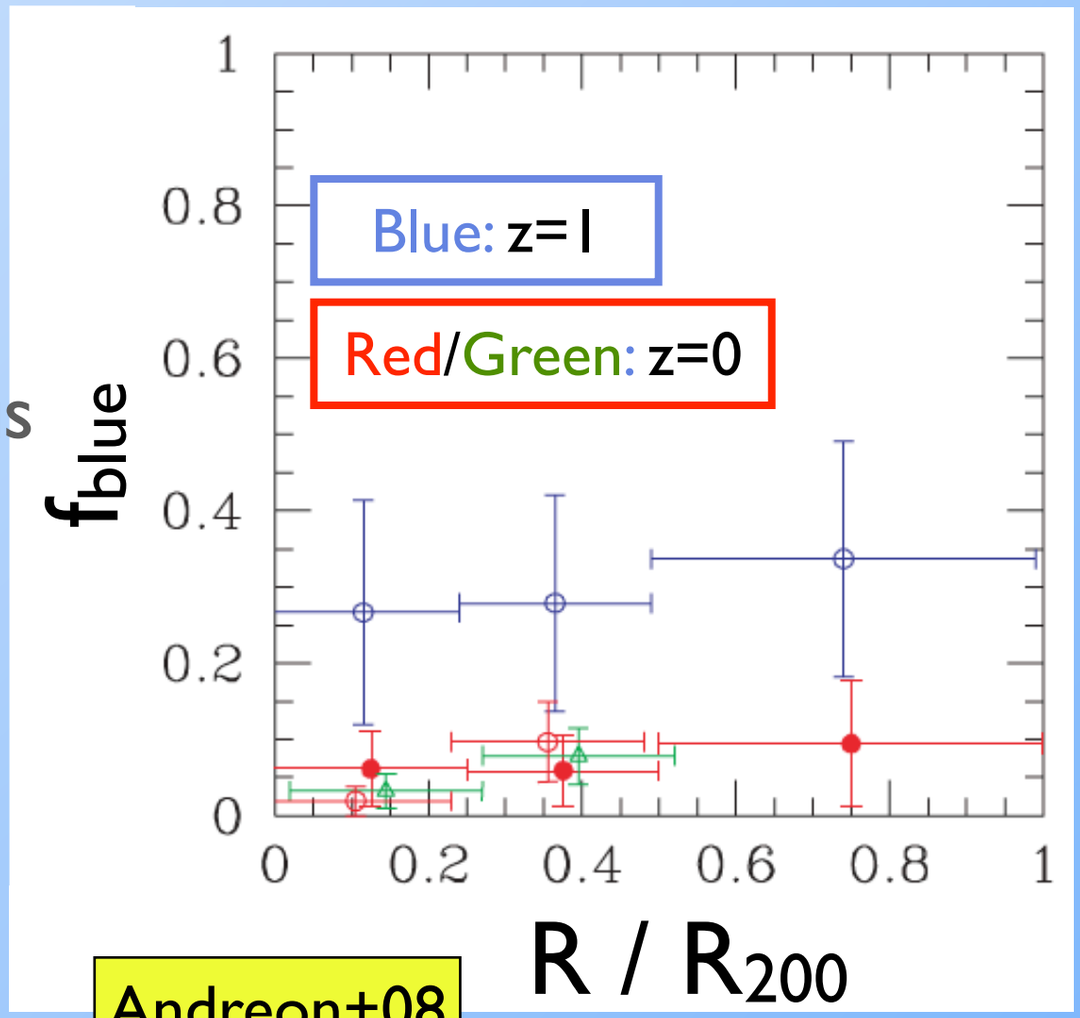
Recent results ($M_{gal} > 4e10\ M_o$)

- weak/no evidence for a BO effect at $z \leq 0.5$ (Andreon+06, Haines+09)
- possible blueing in excess to the one expected at z~1 (Andreon+08)



Andreon+08

JKCS 041 Cluster (z_{phot}=2.2)

Discovery (Andreon+09)

- Detected as red galaxies overdensity
- Extended X-ray source

CFHT/TERAPIX/WIRDS image
with Chandra X-ray image overlaid

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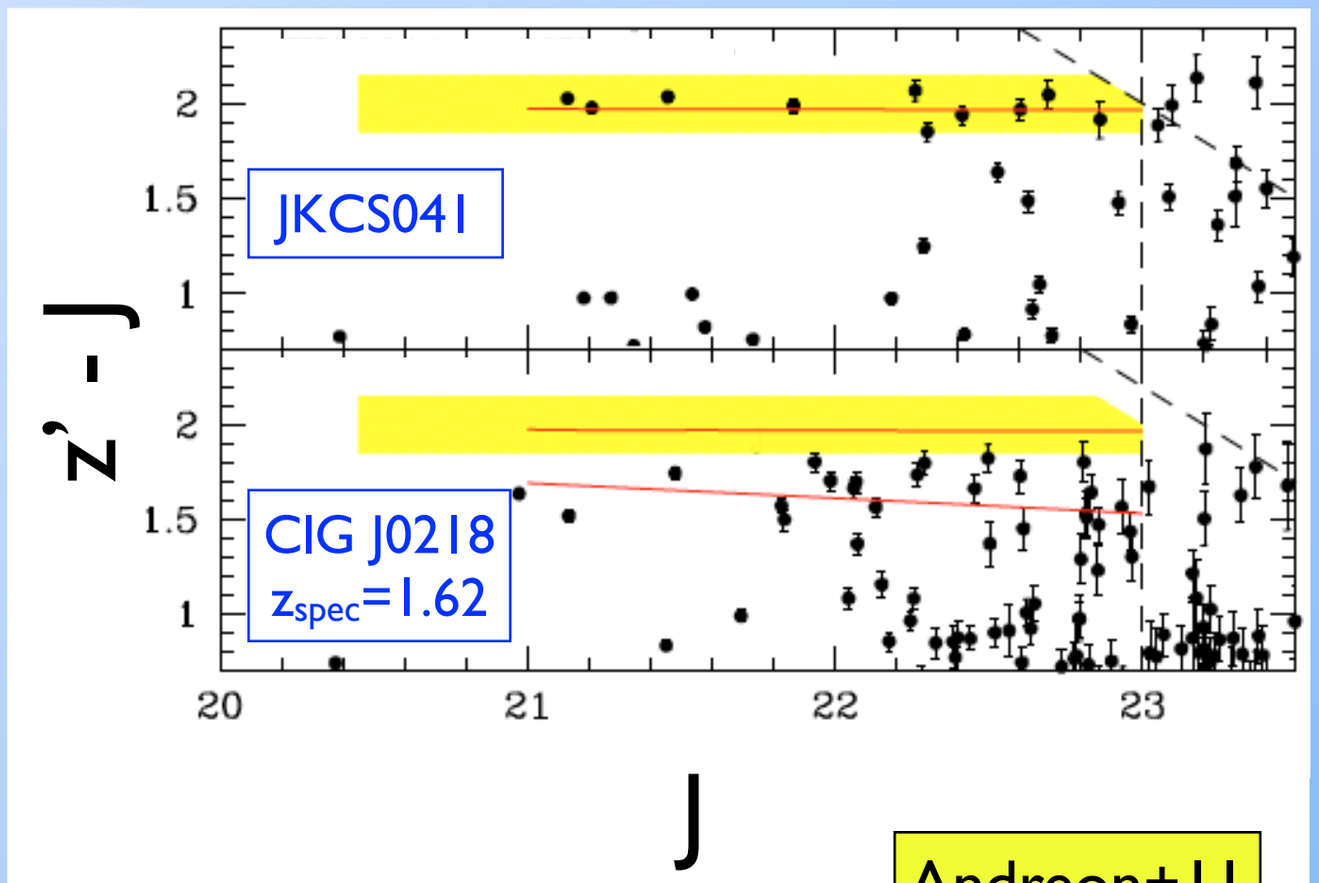

Andreon+11

JKCS 041 Cluster (z_{phot}=2.2)

Discovery (Andreon+09)

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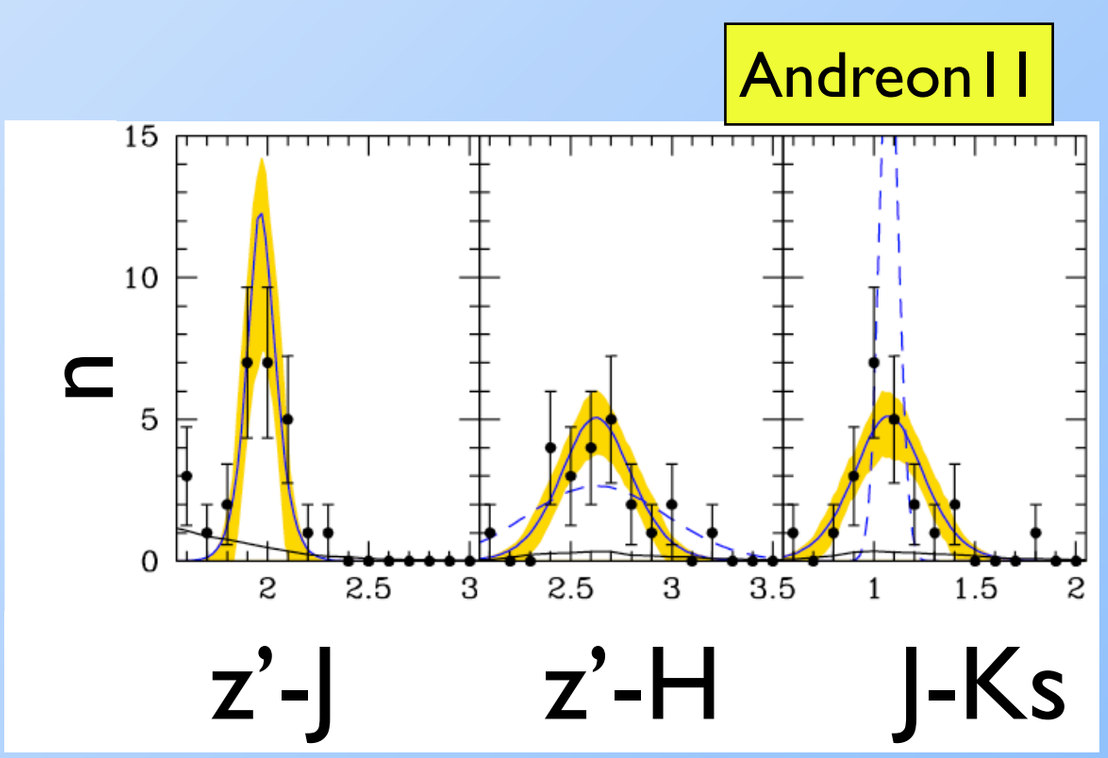
Properties

- well-defined red-sequence
  → z_{phot} = 2.2
- with a small scatter
  → spread in stellar age of 160±30 Myr



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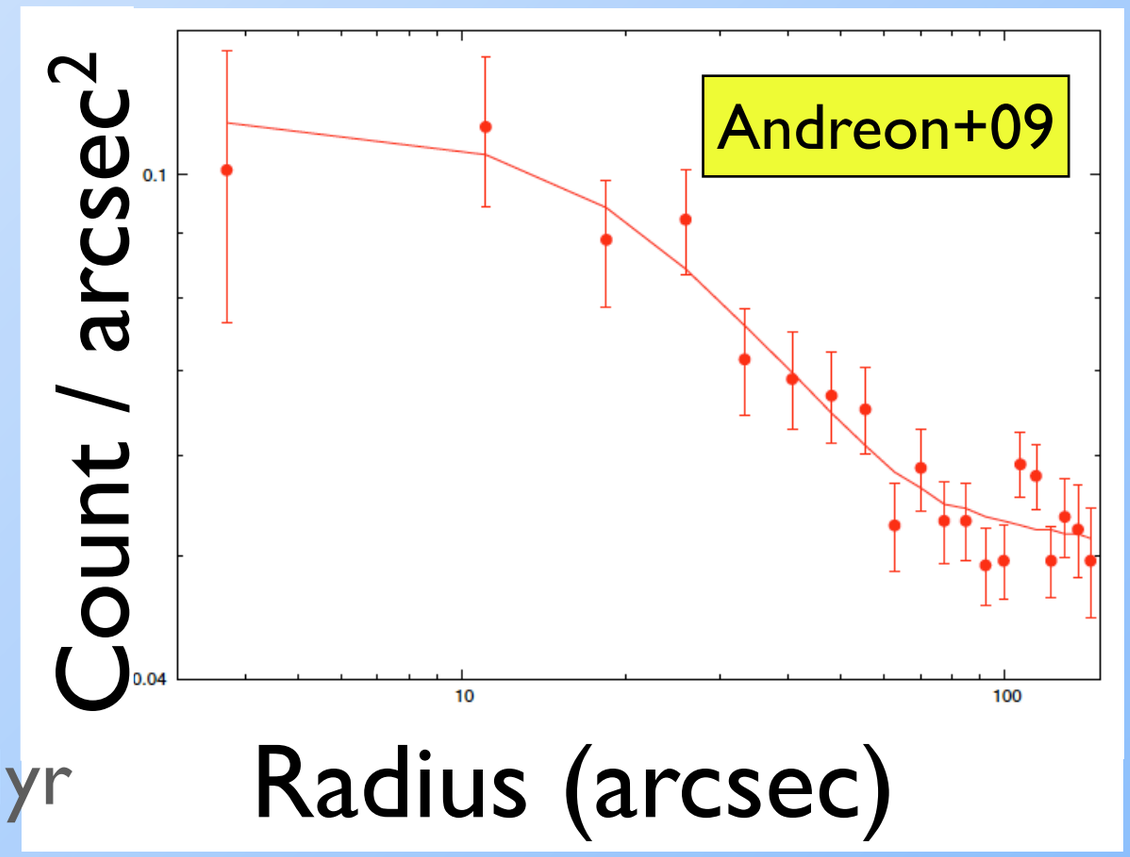
- X data (*Chandra*)
  → T=7.3 keV , M_{200}= 4.0e14 M_o,
  r200=0.76 Mpc



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all the properties of a mature cluster

Goal

Use JKCS 041 to study

- The star-formation activity and evolution of massive galaxies

→ radial profiles of the fraction of blue galaxies (Butcher-Oemler effect)

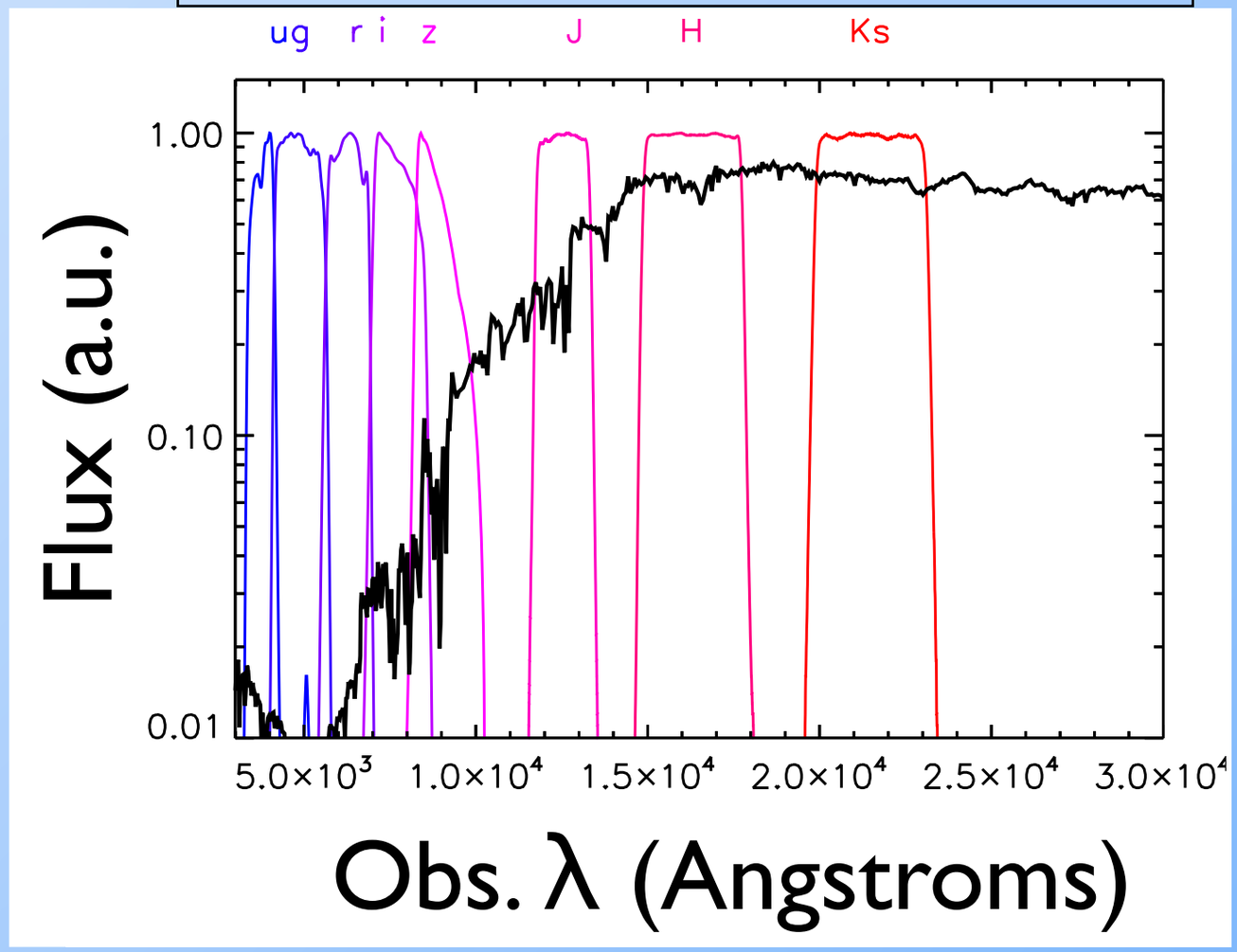
the fraction of star-forming galaxies

JKCS 041 analysis

CFHTLS/WIRDS data

- *u*g'r'i'z'JHK*$_s$ images
- Deep (50%: Ks=24.7) + seeing ~0.6-0.8”
- Mass-selected catalogues (Ks-band)

Ell. spectrum redshifted at z=2.2



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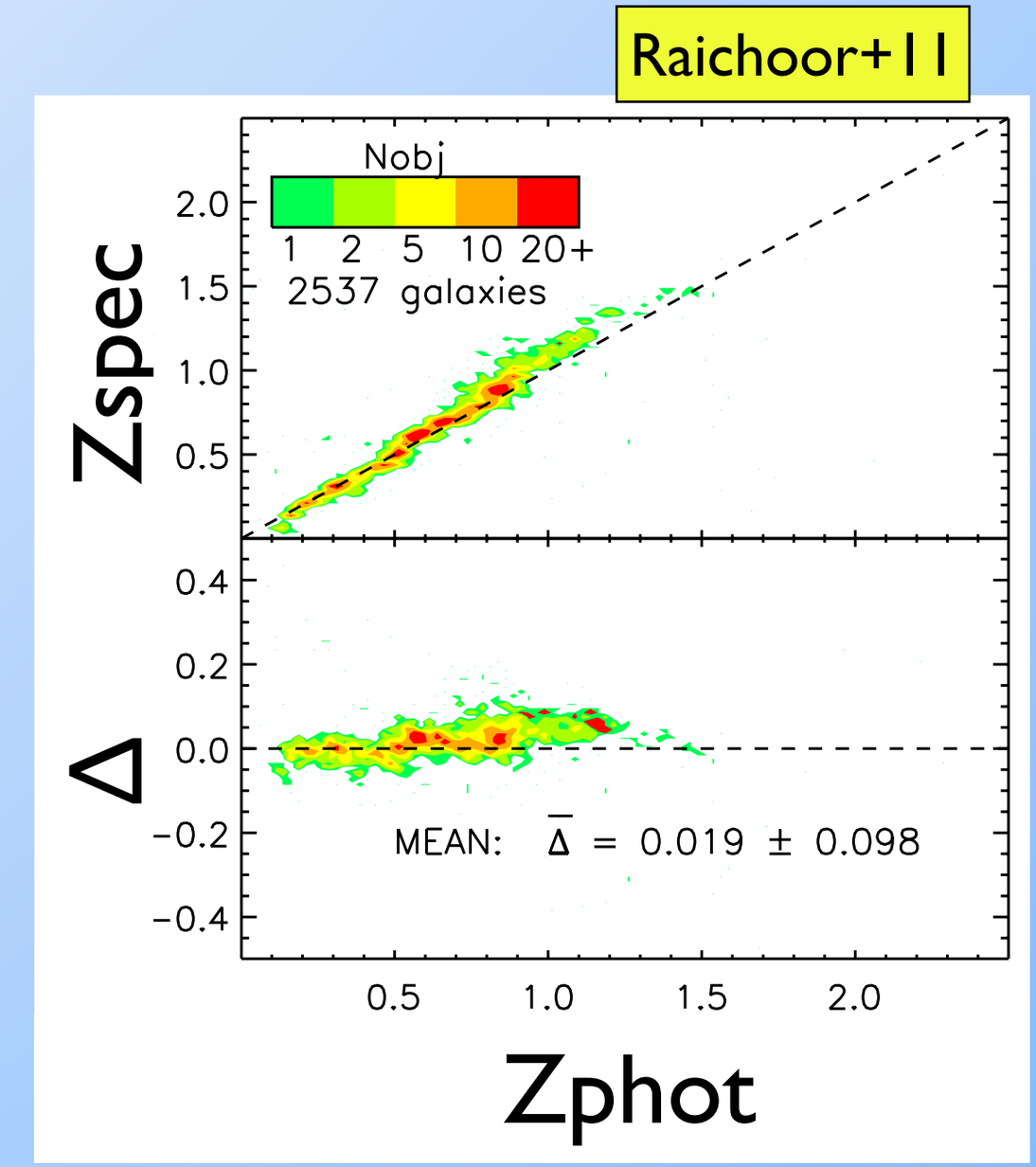
Photometric redshifts

- Eazy code
- VVDS for calibration



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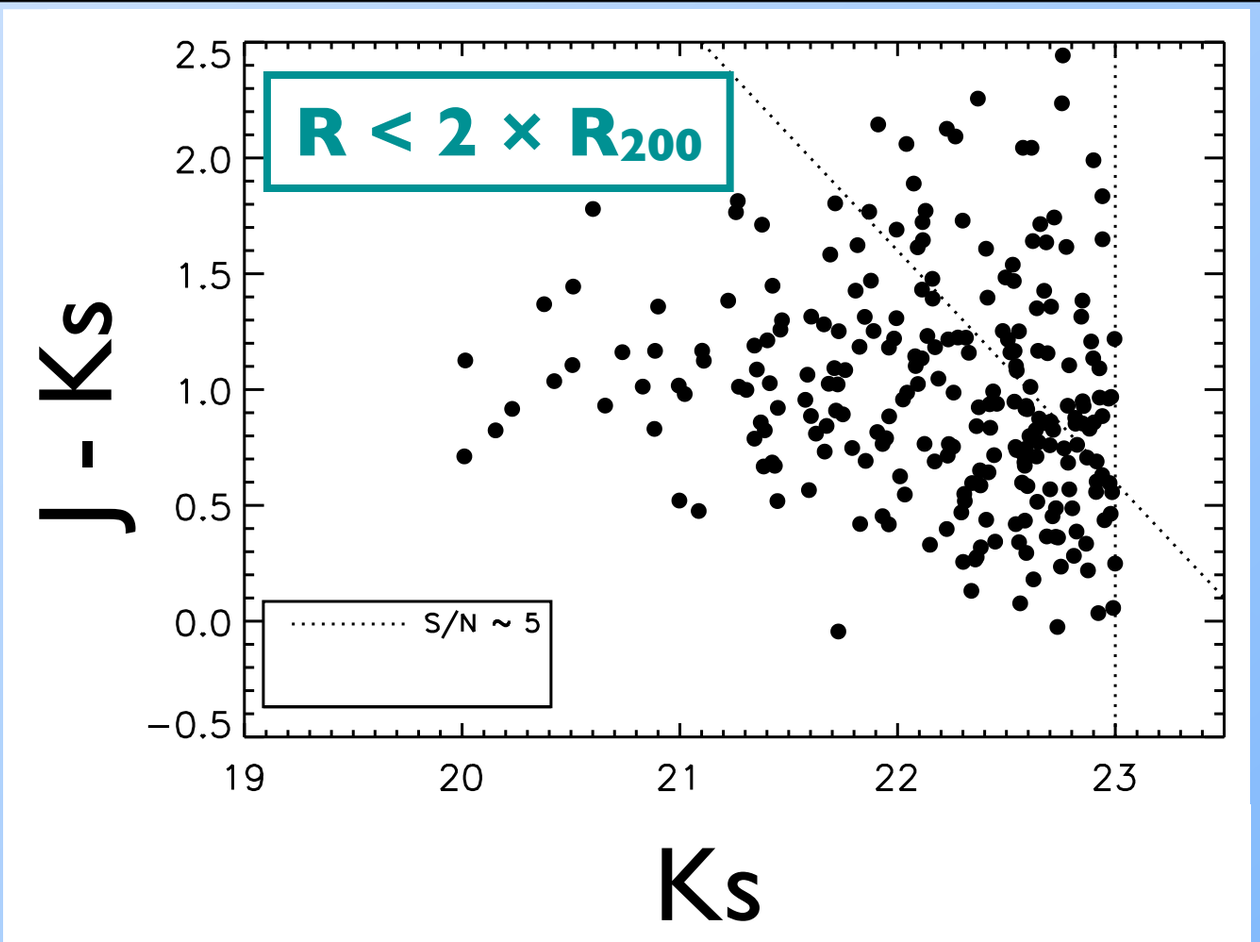
Pre-selection

- Using Eazy
  photometric redshift probability distributions p(z)
  → we reject obvious outliers

Fraction of blue galaxies

- (*J-Ks*) vs *Ks* CMD
  → probing Balmer break
- z_{phot} pre-selection
  (removes ~60% of objects within $2 \times R_{200}$)

JKCS 041 line of sight
(cluster AND residual background galaxies)



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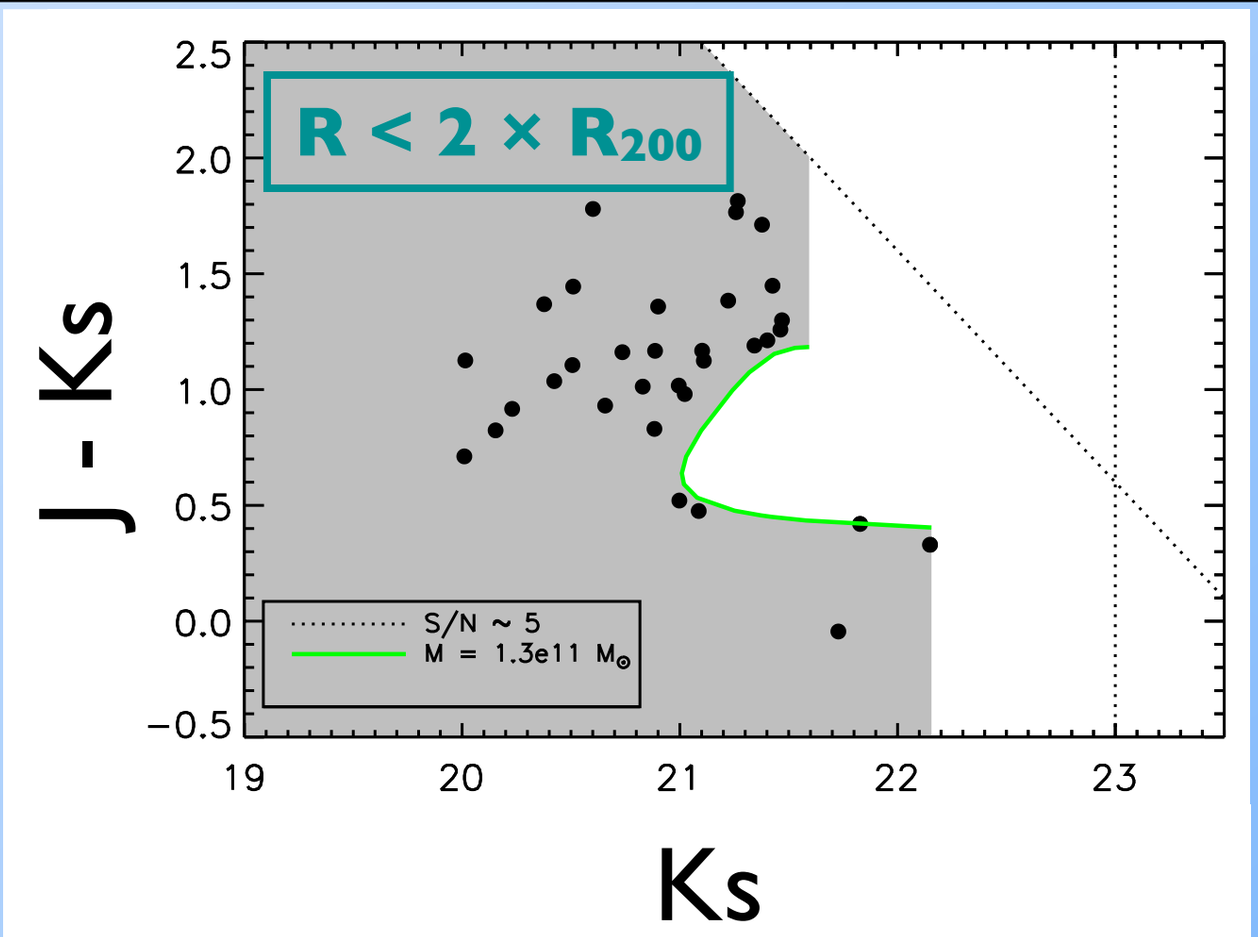

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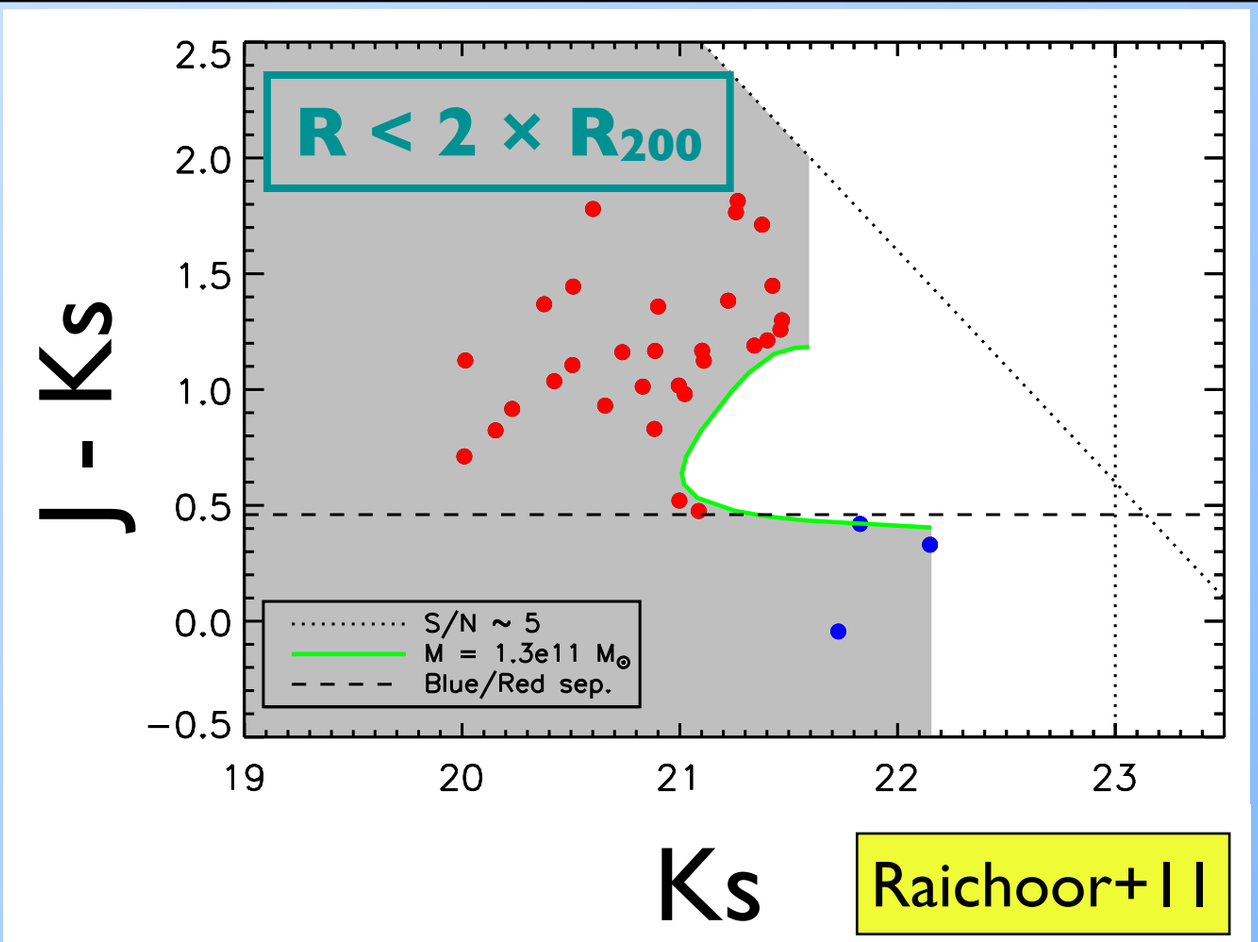

Raichoor+11

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- Background statistical subtraction:
  - large control area (~0.1 deg^2),
  - Bayesian method

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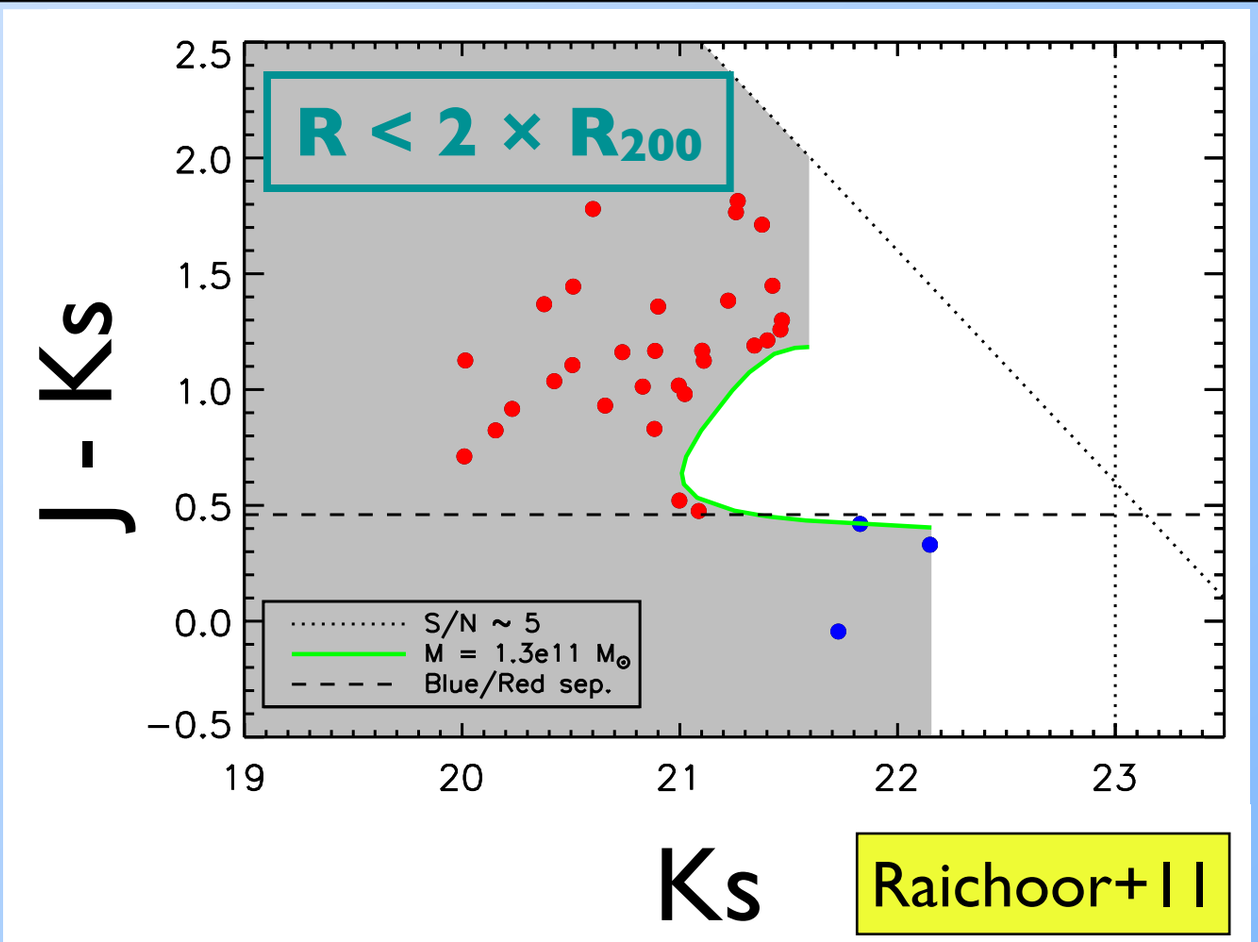

Butcher-Oemler effect

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Lower redshift sample

- A496 (z=0.03)
- RzCS 052 (z=1.02)

Cluster	r_{200} (Mpc)	σ_v (km s^{-1})	M_{200} ($10^{14} M_\odot$)
A496 [a]	1.85	721^{+35}_{-30}	7.5
RzCS 052 [b]	1.04	710^{+150}_{-150}	4.0
JKCS 041 [c]	0.76	-	$4.0^{+5.3}_{-3.3}$

(a) Rines et al. (2005) (b) Andreon et al. (2008a) (c) Andreon et al. (2009, 2011)

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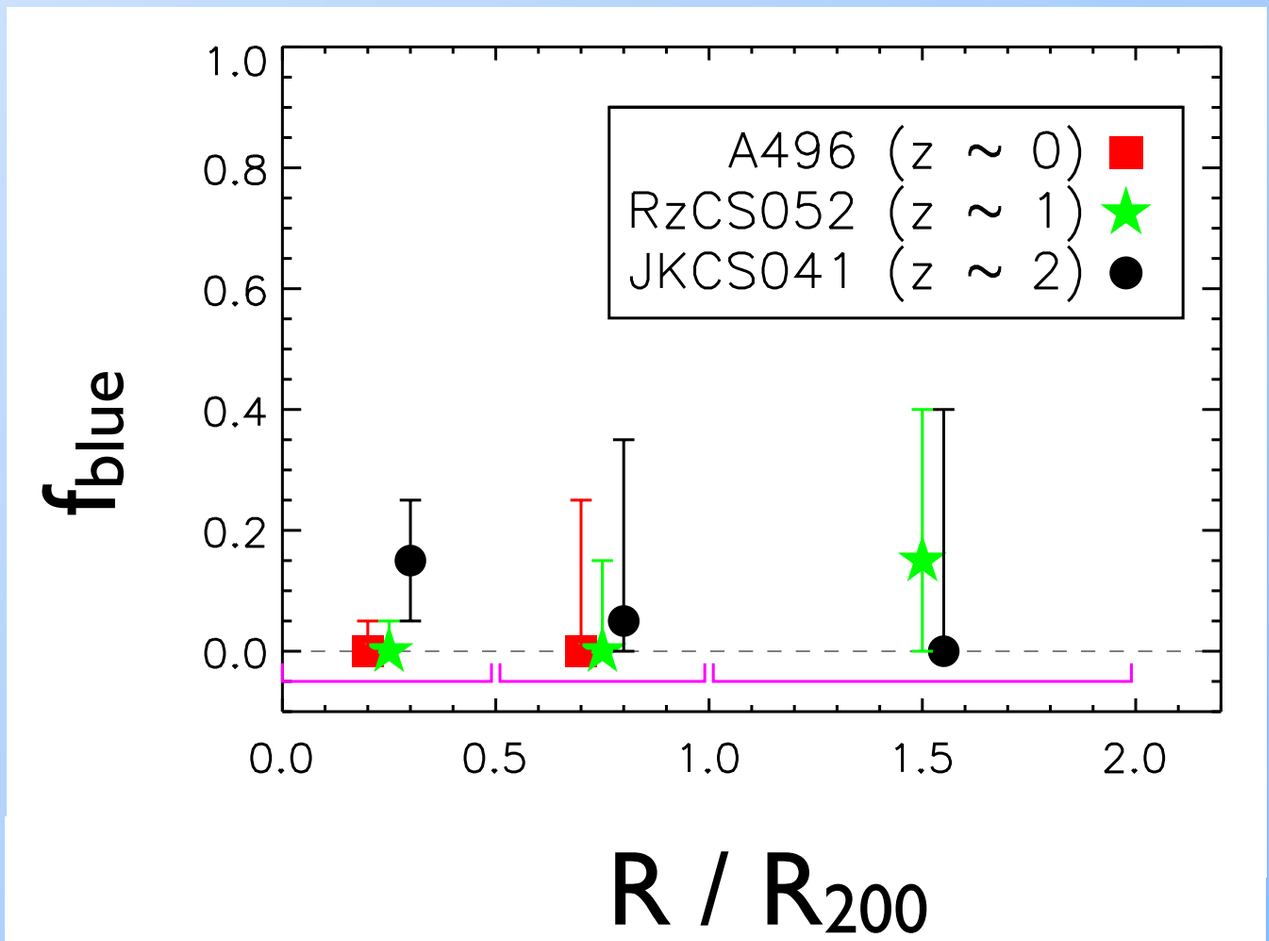
Same procedure

- A496: (u^*-r) vs r CMD
  RzCS 052: (i - z) vs z CMD
  → same rest-frame color probed
- Mass-selected sample: M > 1.3e11 $M_\odot$

Butcher-Oemler effect

No evidence for a Butcher-Oemler effect ($M > 1.3e11\ M_o$) between z=2.2 and z=0

Error bars: 68% conf. interval



Raichoor+11

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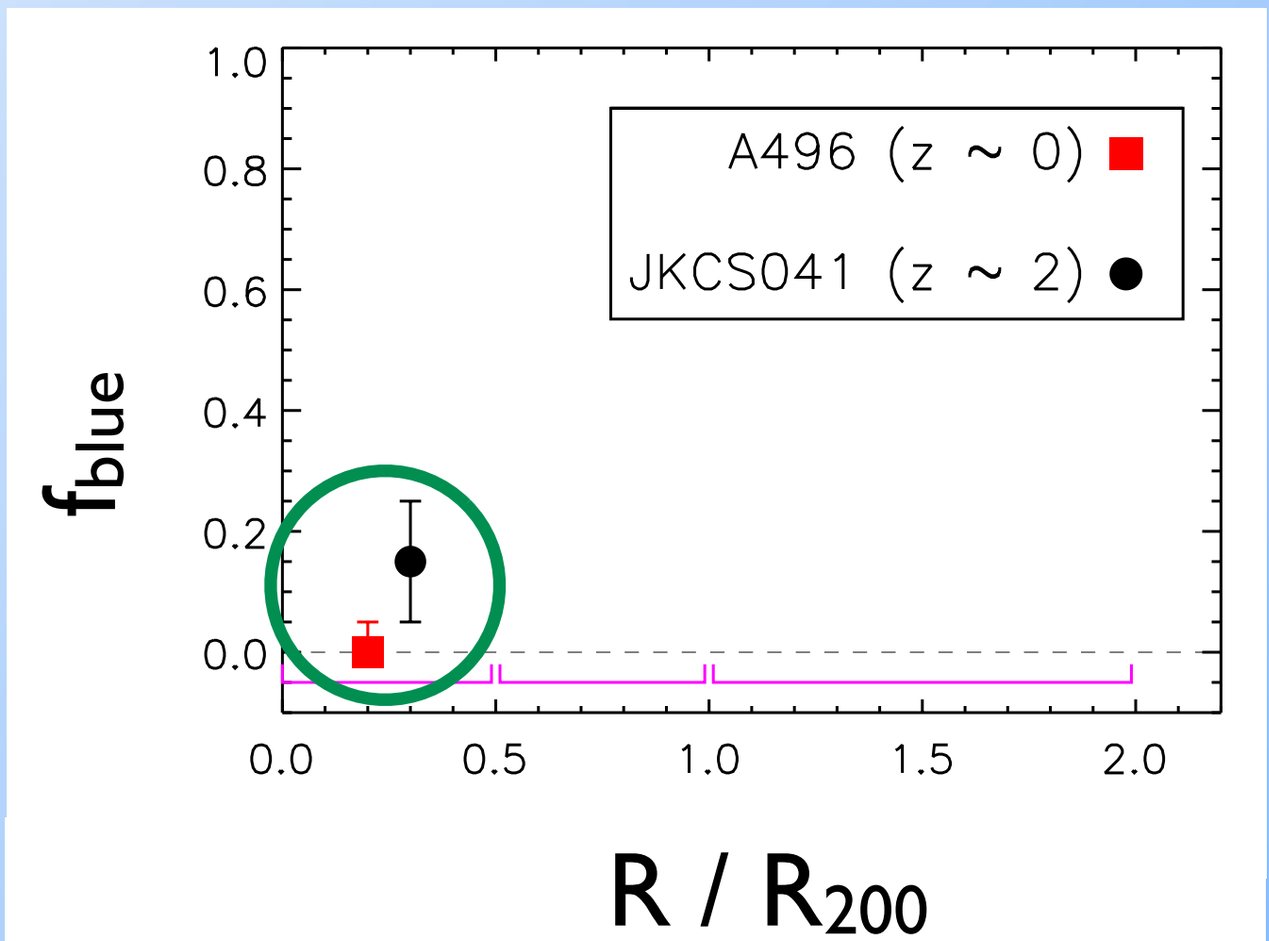

$\Delta f_{blue} = f_{blue}(z=2.2) - f_{blue}(z=0)$

$\Delta f_{blue} < 0.36$ with 95% probability

→

"slope of the Butcher-Oemler effect":

$\Delta f_{blue}/\Delta z < 0.16$

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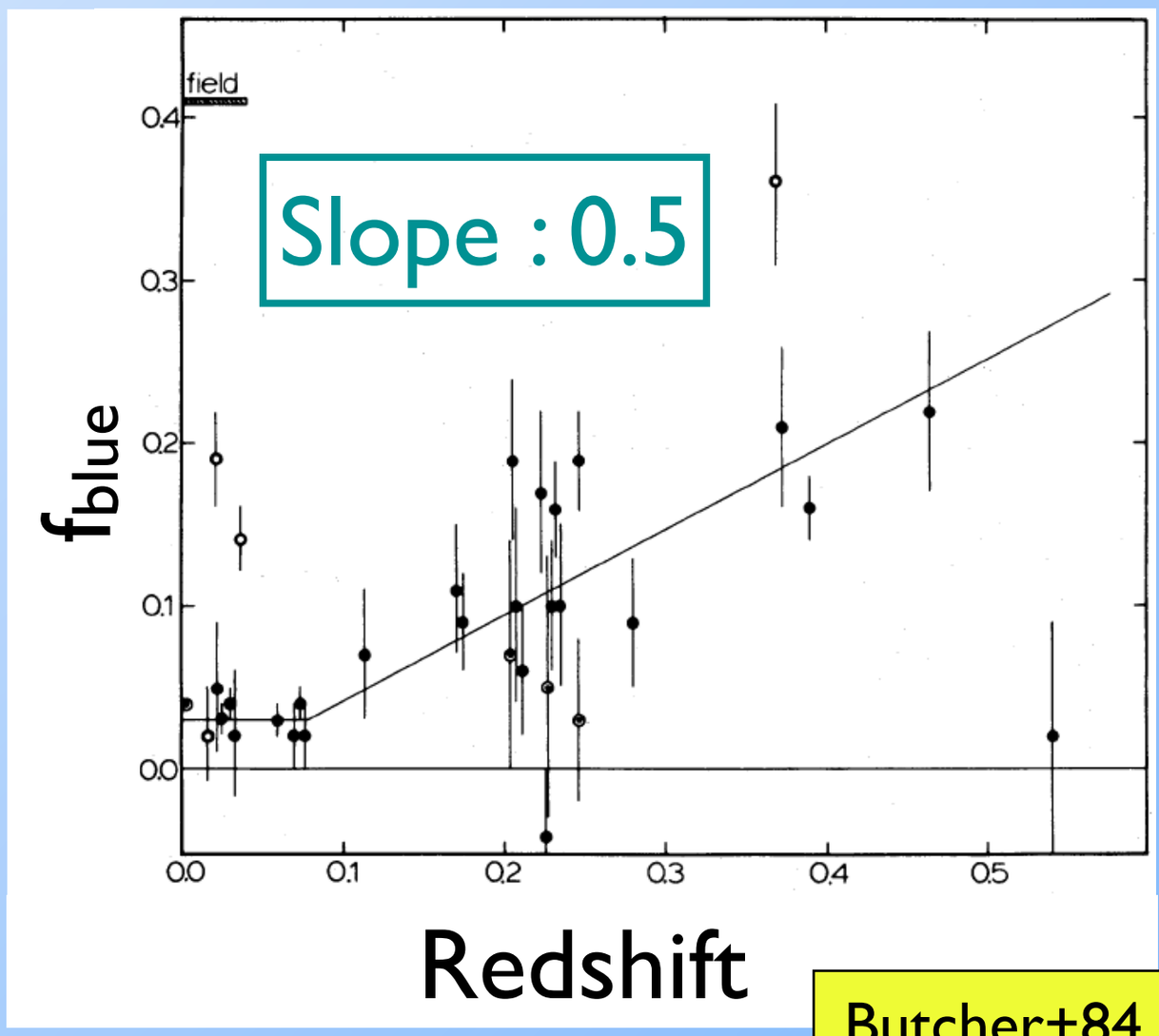

Butcher+84

Star-formation activity in JKCS 041

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Idea

- Same method, but
- Instead of classifying galaxies
  as **blue/red**,
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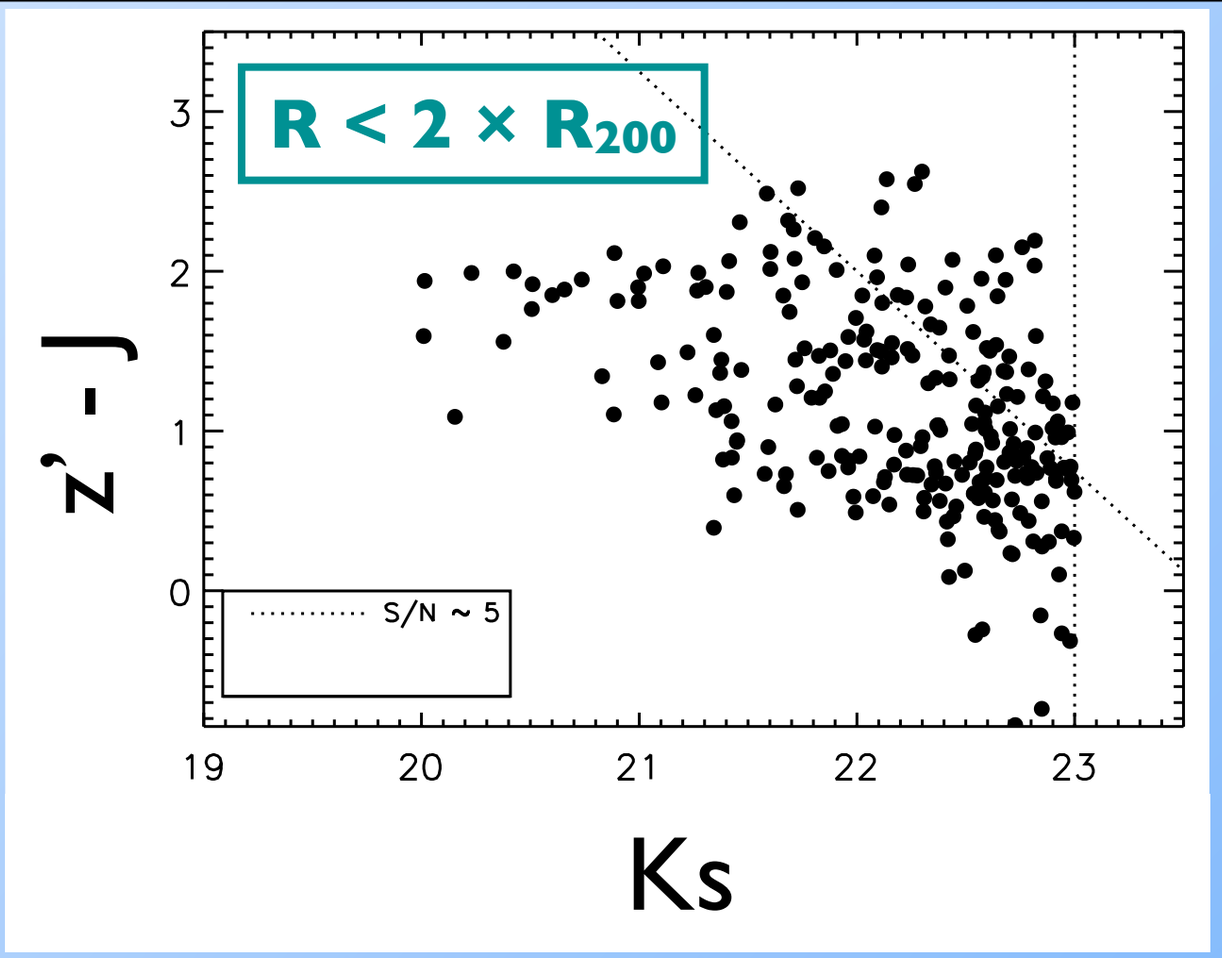
Technical points

- (*z'-J*) color → UV continuum slope

(not probing the Balmer break)

JKCS 041 line of sight
(cluster AND residual background galaxies)



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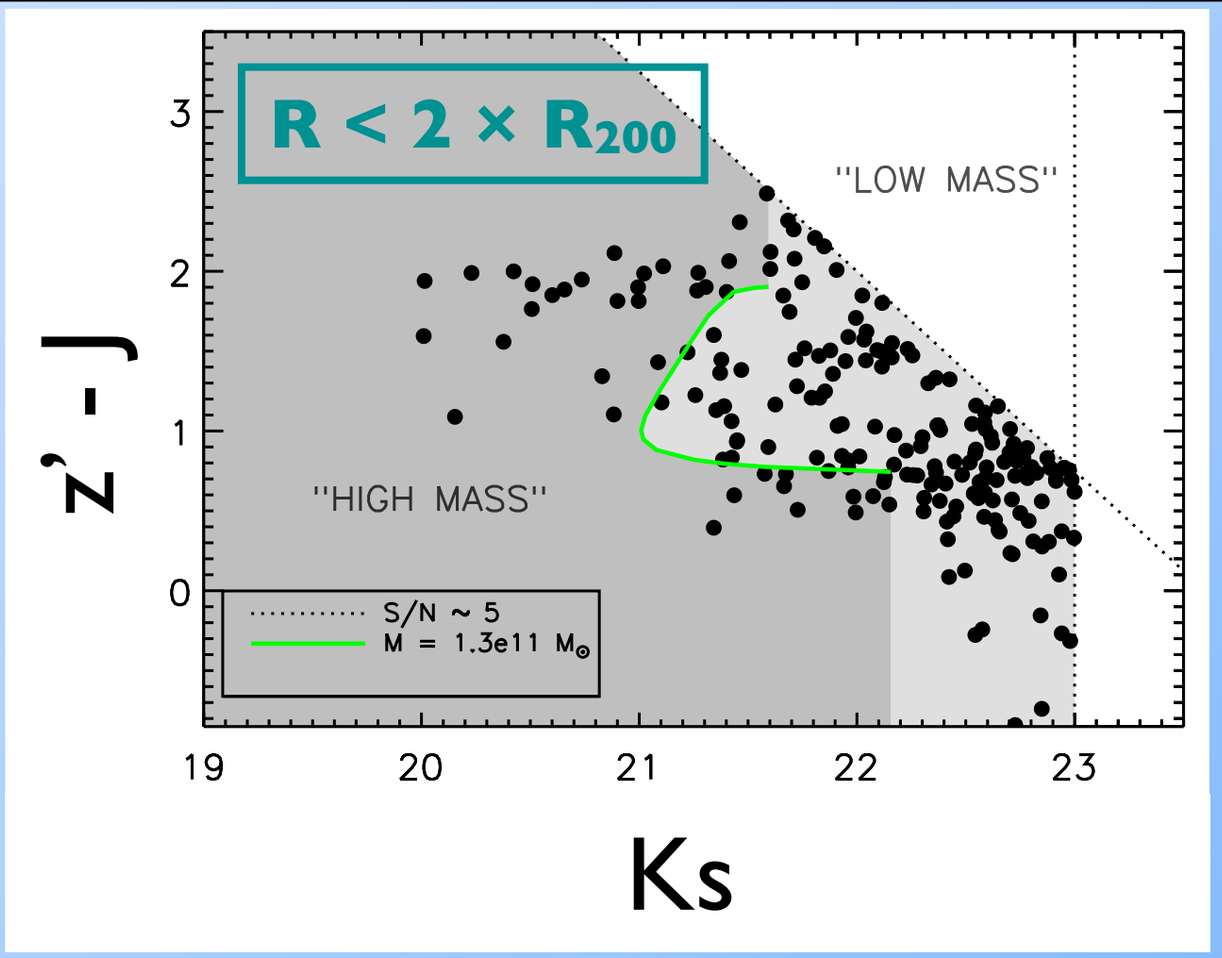

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- Star-forming/quiescent:
  SFR = 4 $M_\odot$ / yr (Kriek+09)

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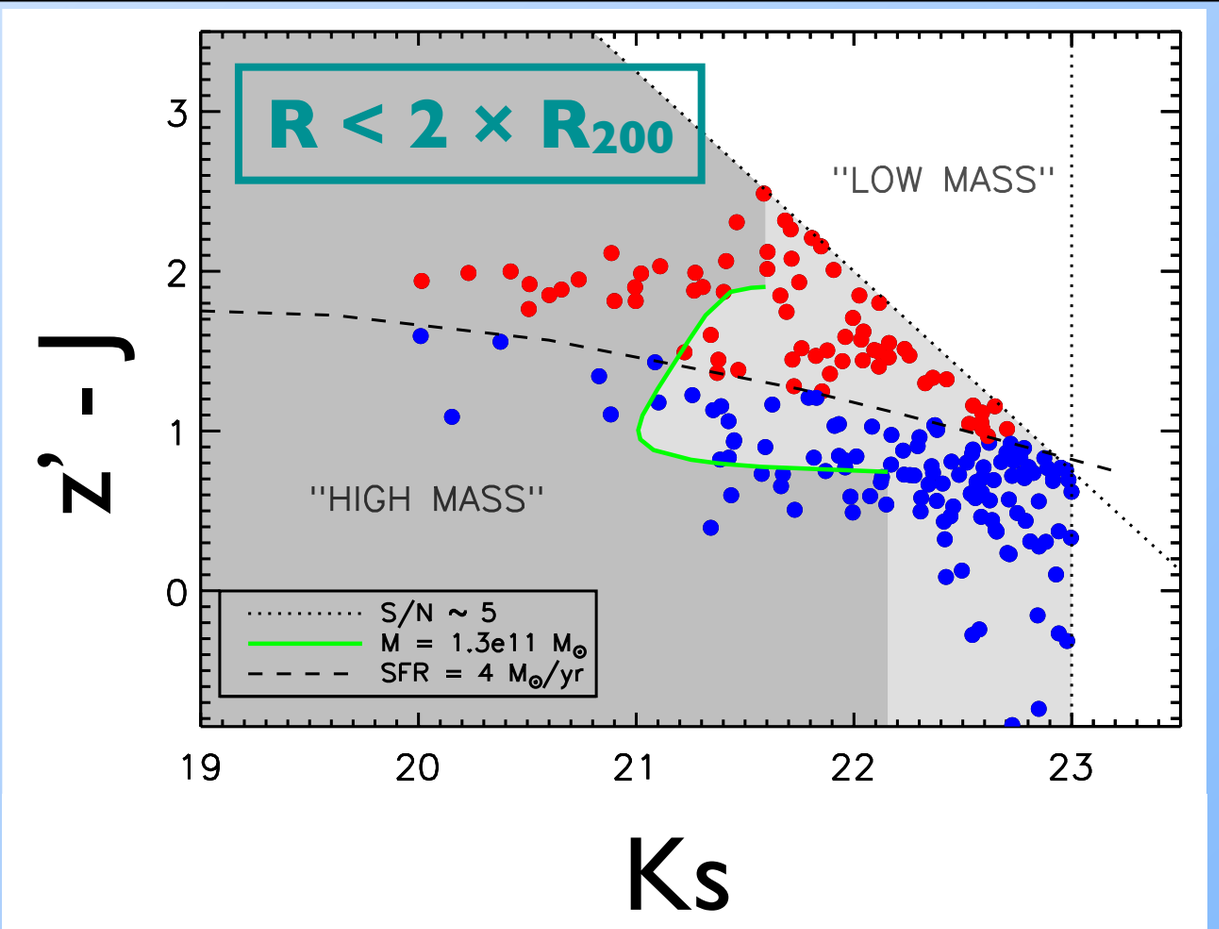
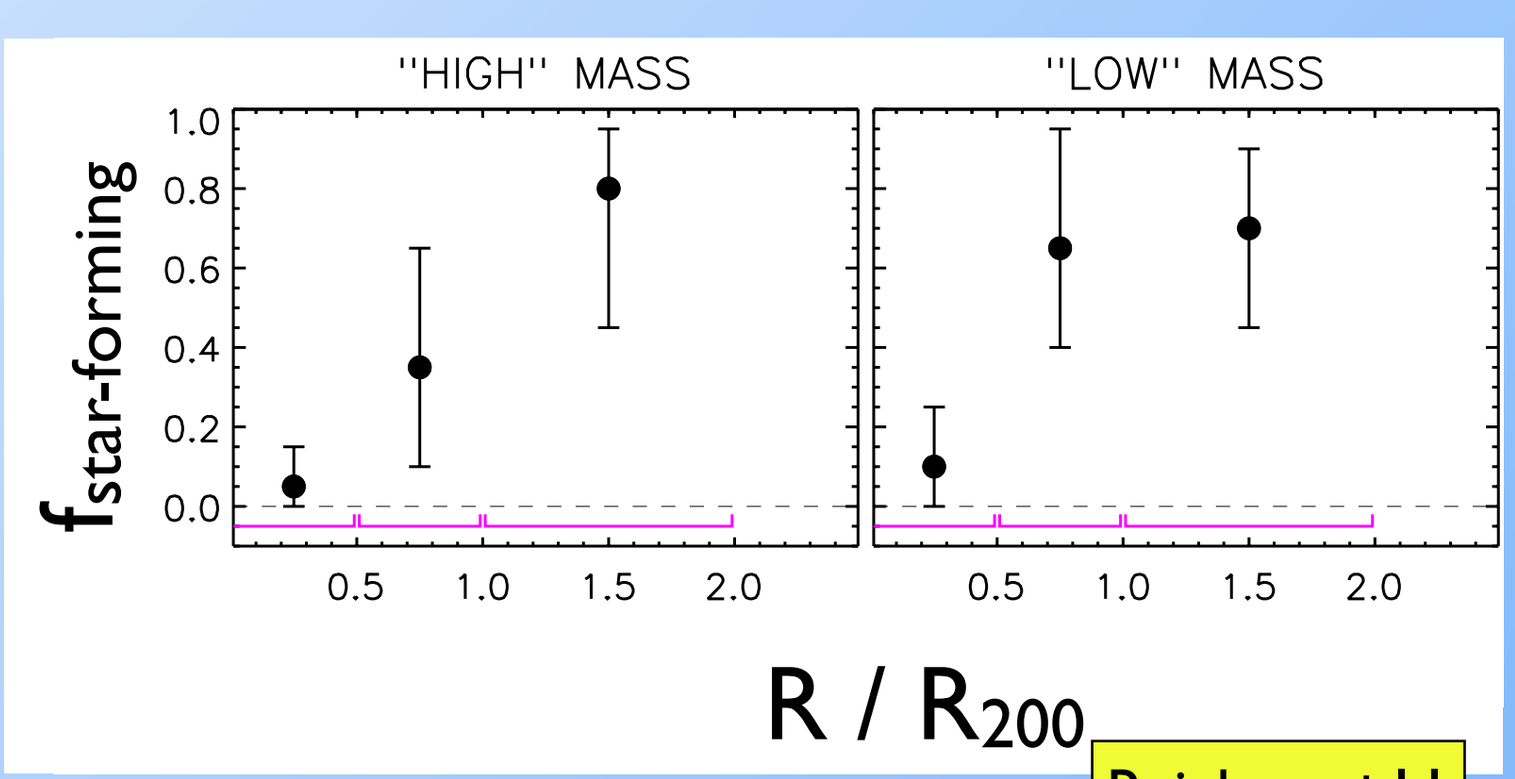


Raichoor+11

Star-formation activity in JKCS 041

The fraction of star-forming galaxies increases with increasing cluster-centric distance



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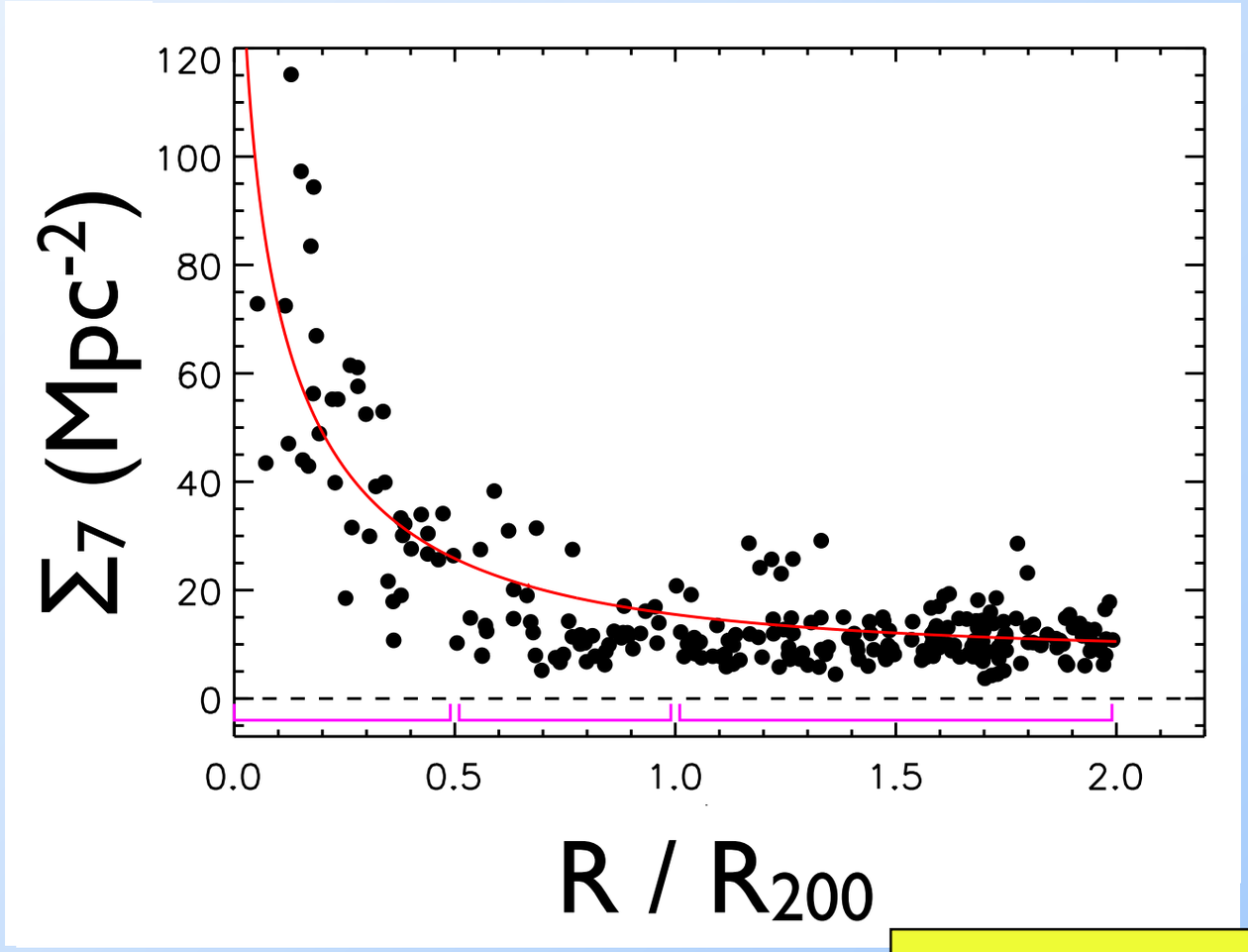


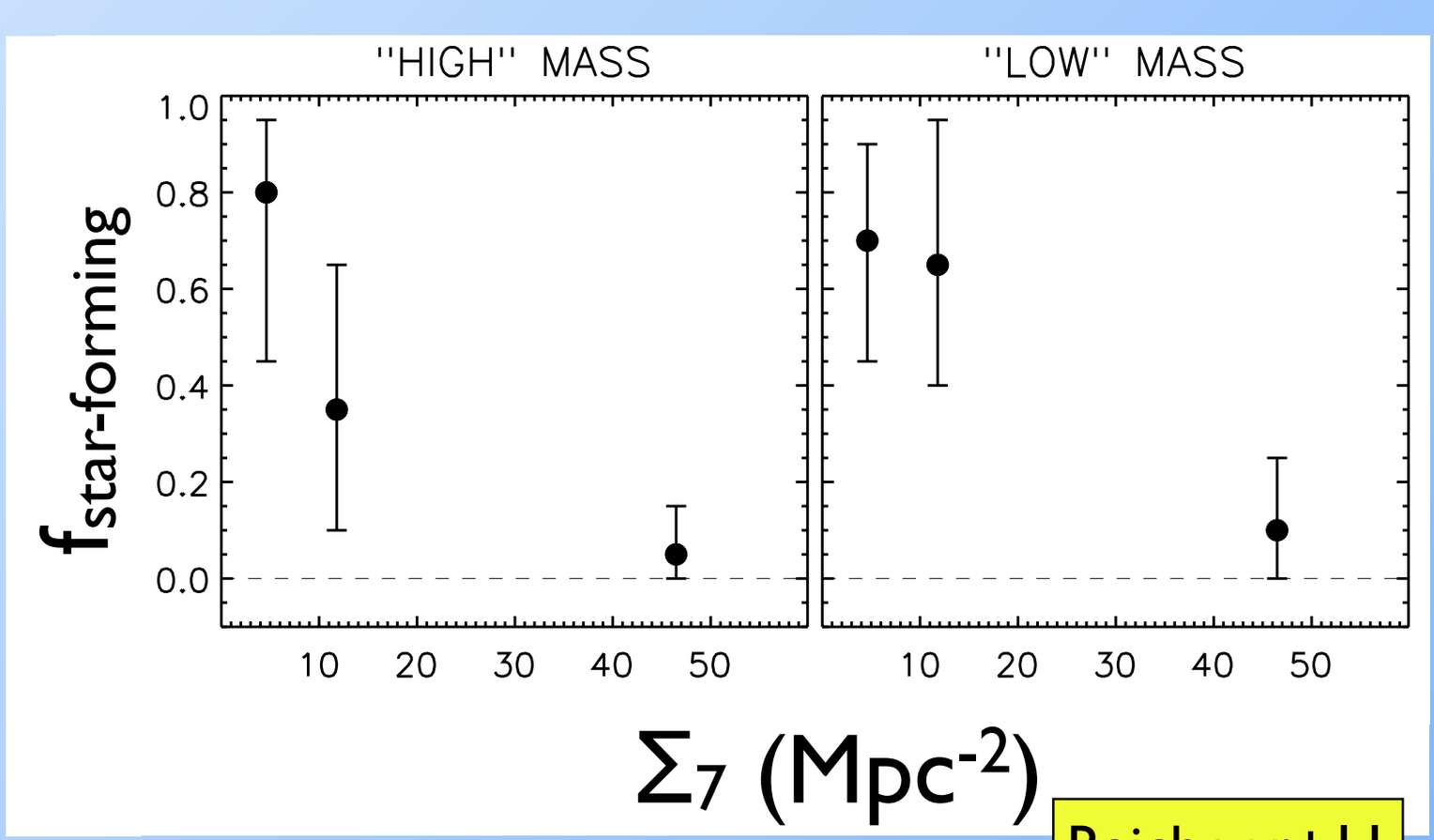
- Ks < 23
- z_{phot} pre-selection

Raichoor+11

Cluster-centric distance ~ local density

Star-formation activity in JKCS 041

The fraction of star-forming galaxies decreases with increasing local density



Raichoor+11

Conclusion

- **Butcher-Oemler effect**

  No evidence at $0<z<2$ ($M > 1.3e11\ M_\odot$), once accounted

  * for the younger age of stellar populations at high redshift
  * for the higher star formation rate there

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- **Andreon+08**

  Same study for A496 and RzCS 052, but for lower masses ($M > 4e10\ M_o$)

  → hint for a Butcher-Oemler effect at $0<z<1$

  → downsizing-like scenario.

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  * for the higher star formation rate there

- **Andreon+08**

  Same study for A496 and RzCS 052, but for lower masses (M > 4e10 M_o)

  → hint for a Butcher-Oemler effect at 0<z<1

  → downsizing-like scenario.

- **Star formation activity in JKCS 041**

  Galaxies in the cluster core are quiescent

  → in agreement with works on XMMU J2235 (z=1.39) and with Quadri+11 (z<1.8)

  → in disagreement with works on XMMXCS J2215 (z=1.46) and CIG J0218 (z=1.62)