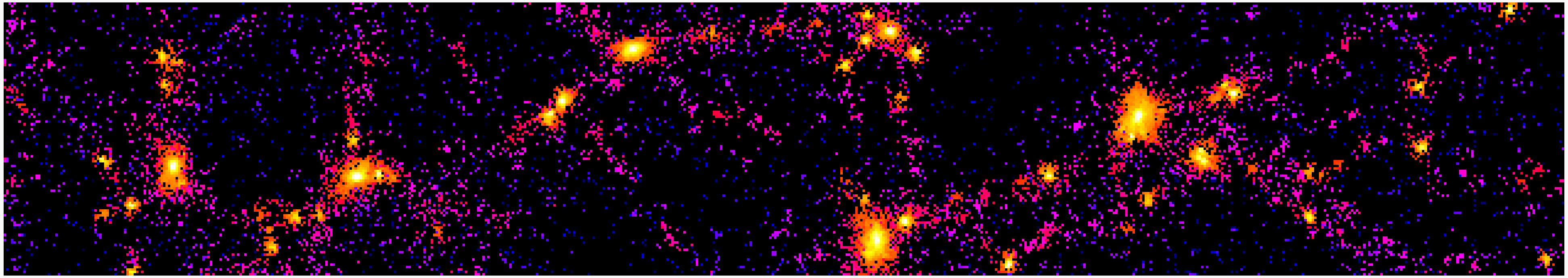
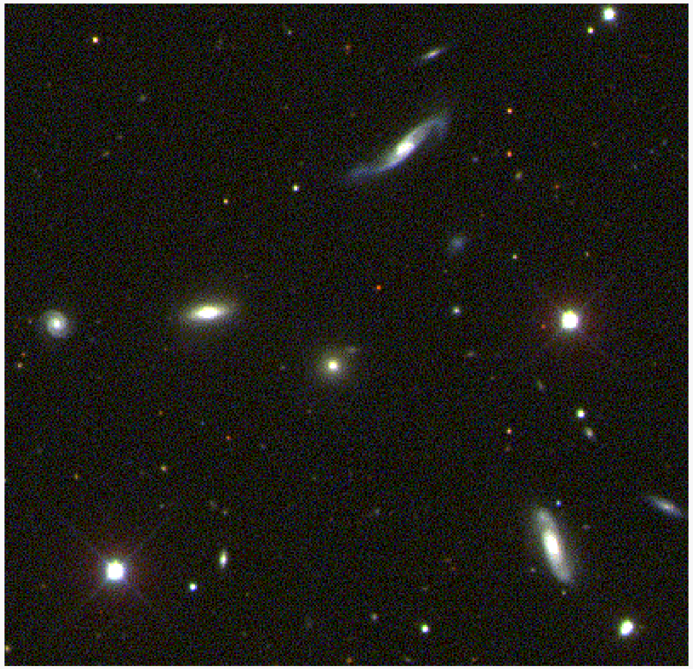


The optical and near-infrared properties of nearby groups of galaxies



Somak Raychaudhury

UNIVERSITY OF BIRMINGHAM

Plan of talk

- Statistically studying Groups of galaxies
- The GEMS survey
- Luminosity functions of groups and clusters
  - Optical and near-IR luminosity functions
  - mergers and galaxy evolution
- Star formation in groups in supercluster filaments

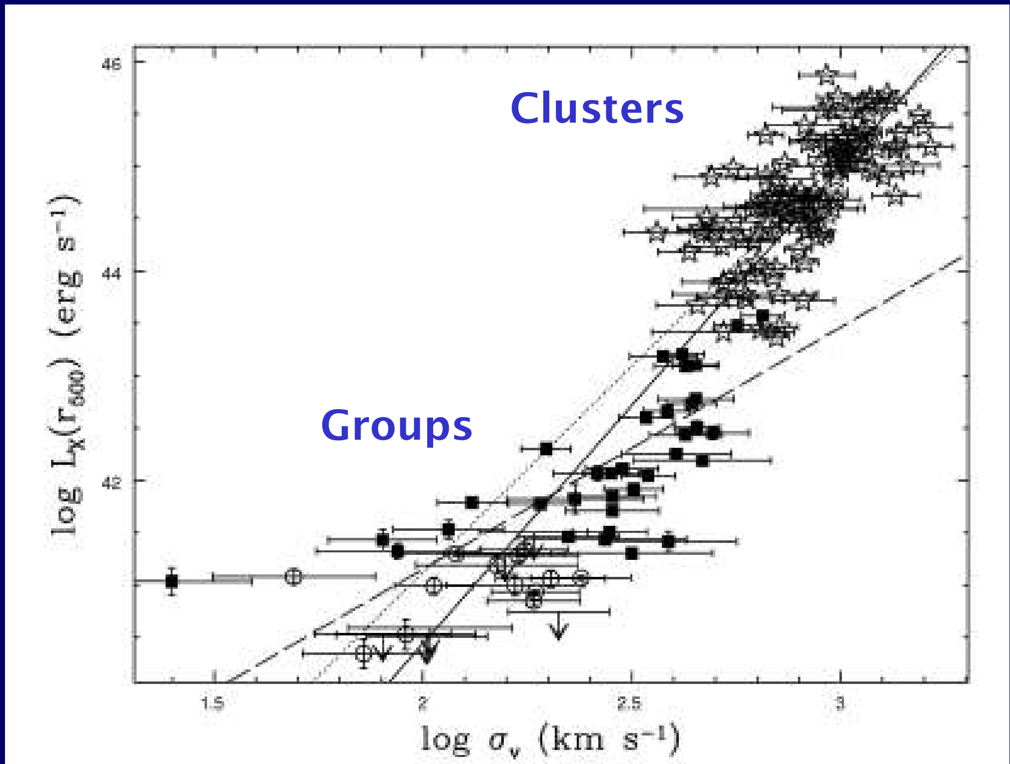
Collaborators:

Trevor Miles and Scott Porter (Birmingham)

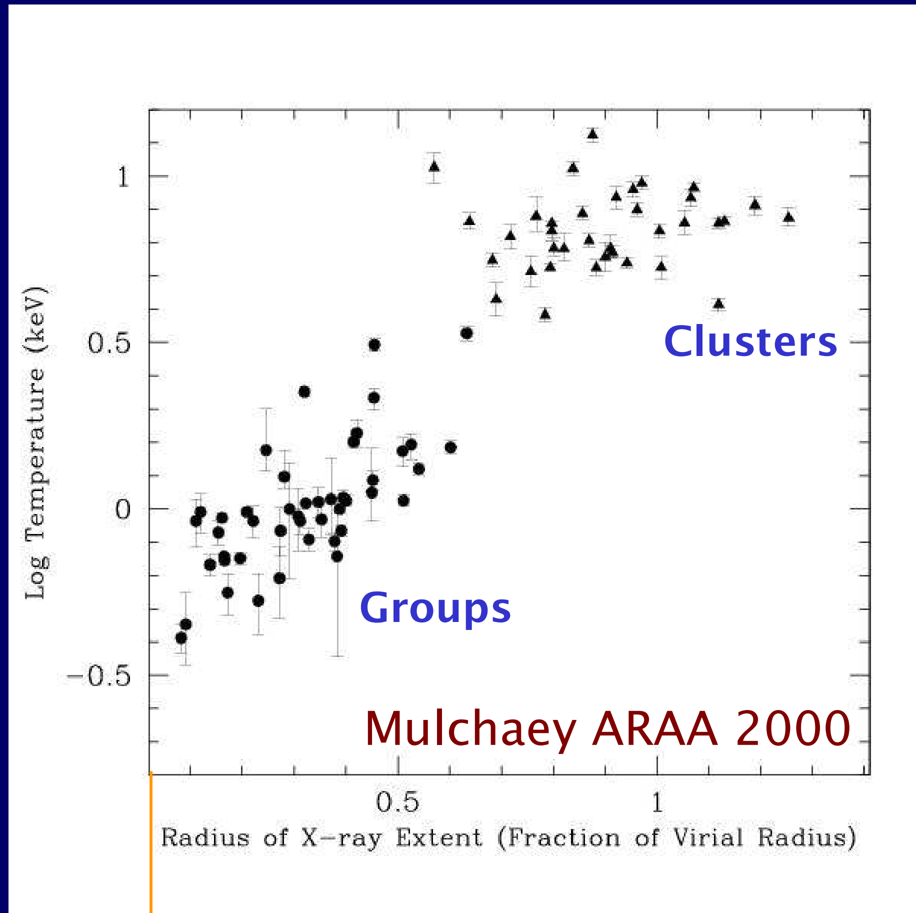
Trevor Ponman (Birmingham)

Duncan Forbes (Swinburne)

How is the group environment different from that in clusters?



Osmond and Ponman 2004

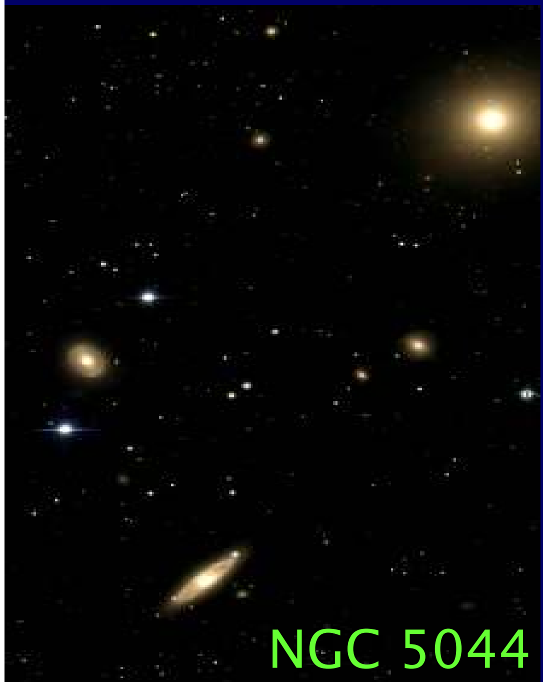


Nicastro et al. 2005 for the LG log T(k)=5.5-

Group Evolution Multi-wavelength Study [GEMS]

- 60 groups – sample selection:
  - We merged all available optical catalogues of groups (4000 of them)
  - Compared the groups to the ROSAT PSPC archive (X-ray integrations of > 10,000 s).
  - We have optical observations in three filters (B, R & I) for 25 groups – selection from colour-magnitude relation.
- Virial radius r_{500} derived from Temperature, following Evrard, Meitzler & Navarro (ApJ, 1996)
- Groups in a variety of evolutionary states

http://www.sr.bham.ac.uk/gems



GEMS: BRI Photometry

- 17 groups at INT 2.5m (La Palma)
  - Wide Field Camera 4 CCDs
  - 34 x 34 arcmin
  - 1 arcsec seeing in I-band
- 8 groups at ESO 2.2m (Chile)
  - Wide Field Imager 8 CCDs
  - 34 x 33 arcmin
  - 0.9 arcsec seeing in I-band

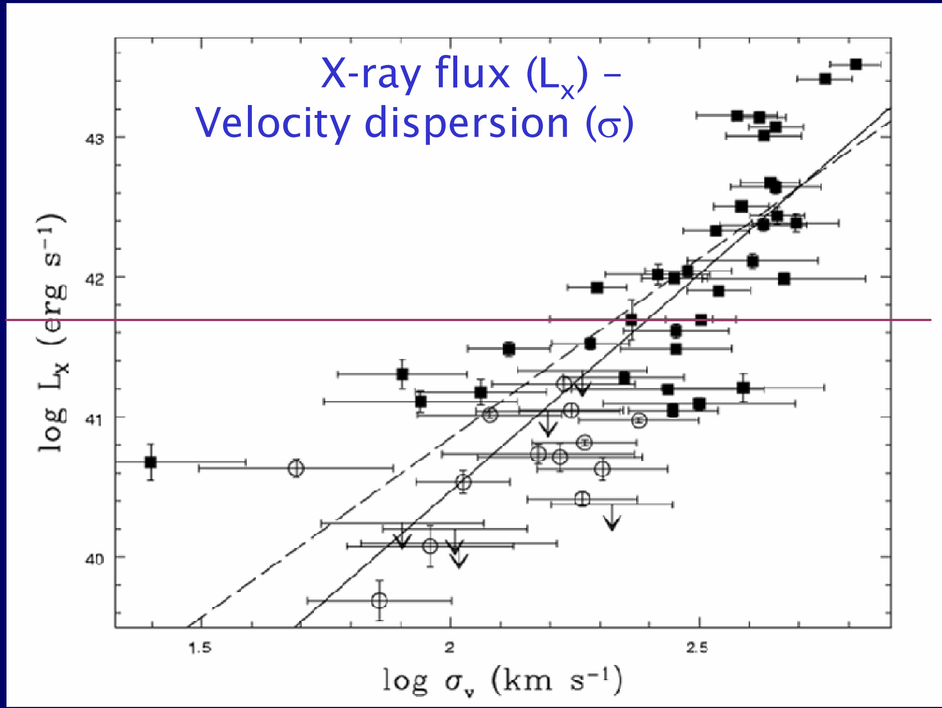
12 X-ray bright, 13 X-ray faint groups

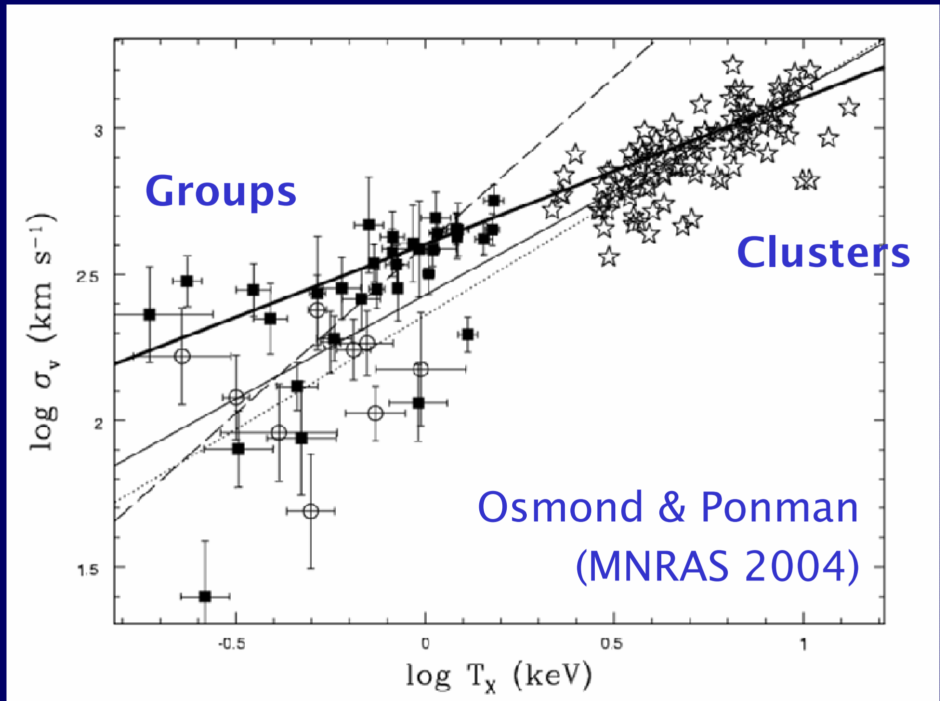
Reliable photometry down to M_B=–13

HI followup (Forbes, Brough, Kilborn),
XMM/Chandra followup (Birmingham)

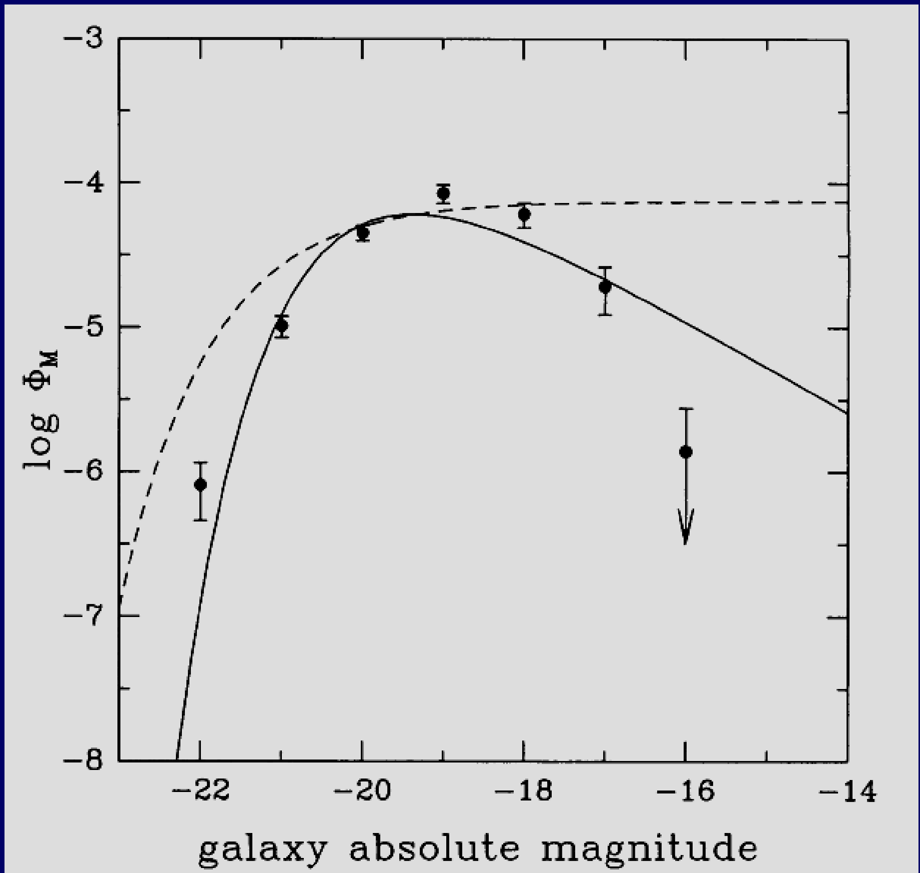
Divide groups into two classes

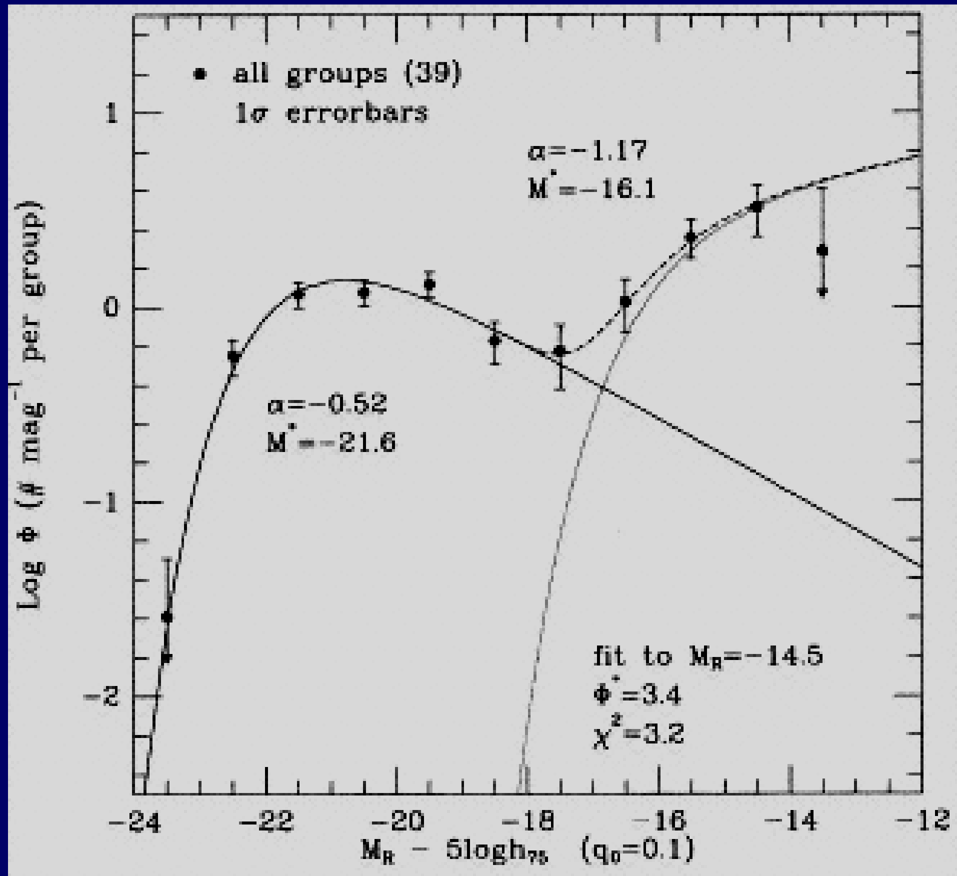
- According to X-ray flux (since temperature not so well determined)
- X-ray bright
  - $L_X > 10^{41.7} erg/s$
- X-ray dim
  - $L_X \leq 10^{41.7} erg/s$





Hickson Compact Group Luminosity Functions





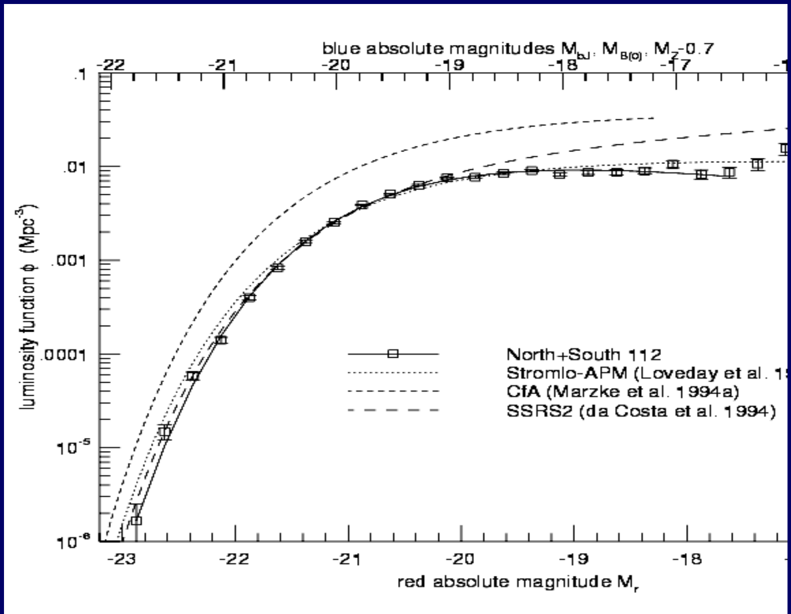
De Oliveira & Hickson (ApJ 1991) plates

Hunsberger, Charlton & Zaritsky (ApJ 1998) ccd

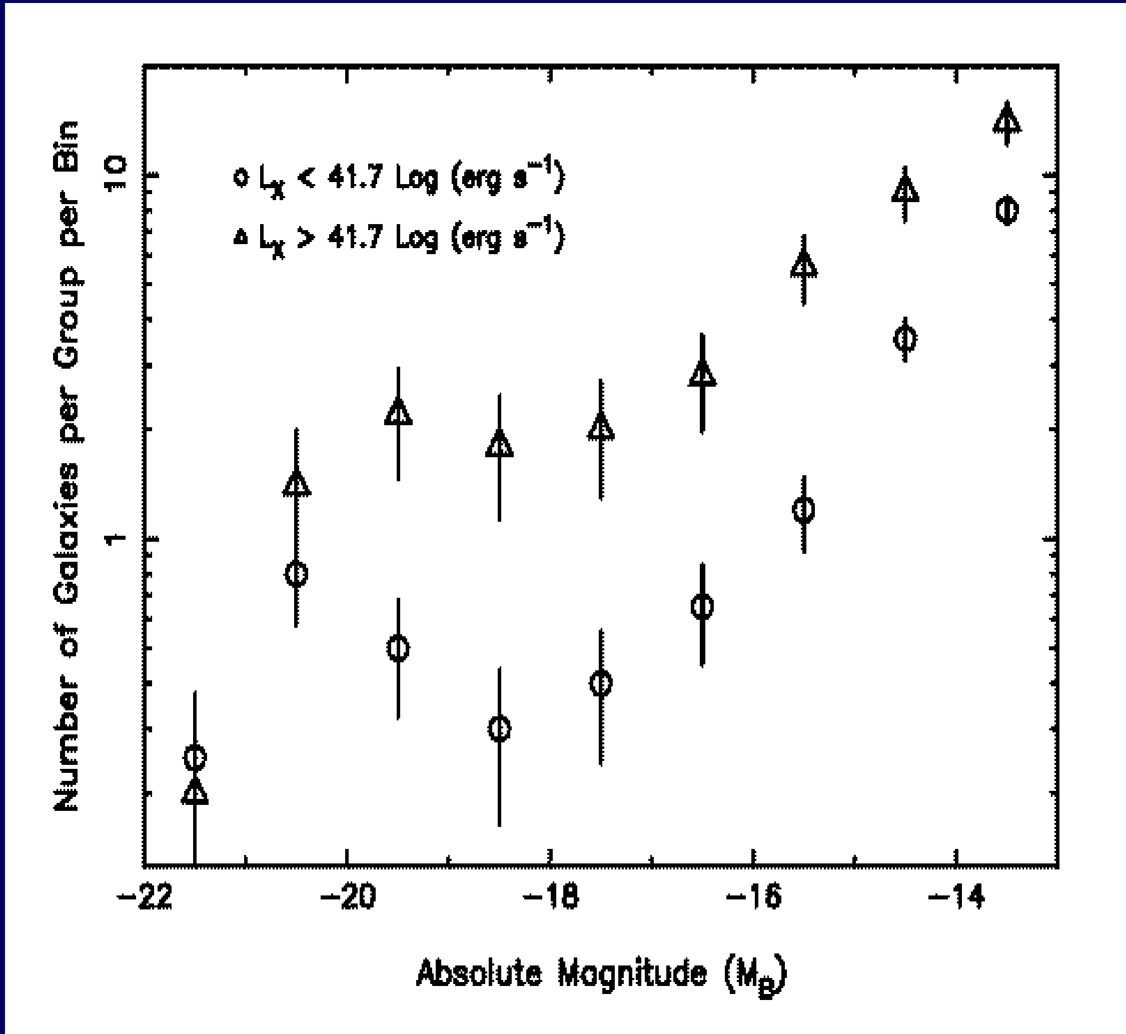
Composite LF of GEMS Groups

Compare:

LF of field galaxies (LCRS)



Lin et al. LCRS (ApJ 1996)



Miles Raychaudhury Forbes Goudfrooij Kozhurina-Platais 2004

Dynamical friction helps mergers

$$-\frac{dV}{dt} \propto \frac{M}{v^2}\rho$$

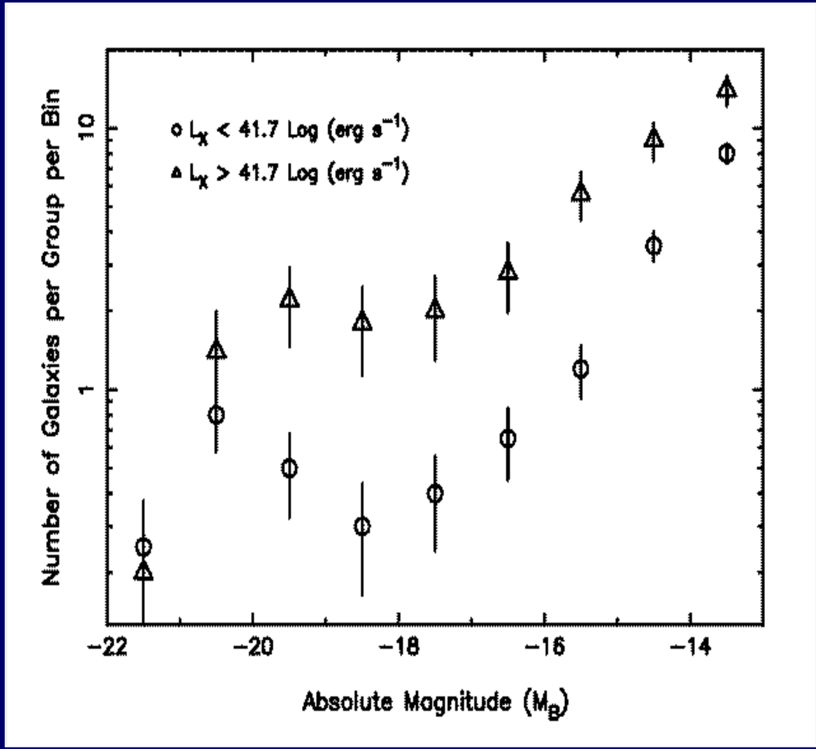
where:
M = mass of intruder galaxy
v = speed of intruder galaxy w.r.t medium

A low velocity dispersion environment is more conducive to tidal interaction and merger

Merger cross-section would be higher for more massive and larger galaxies

Intermediate-L galaxies are preferentially depleted due to mergers

- Tidal interaction and merger more effective in low-σ environment
- Mergers more likely between larger galaxies or between a large galaxy and a dwarf



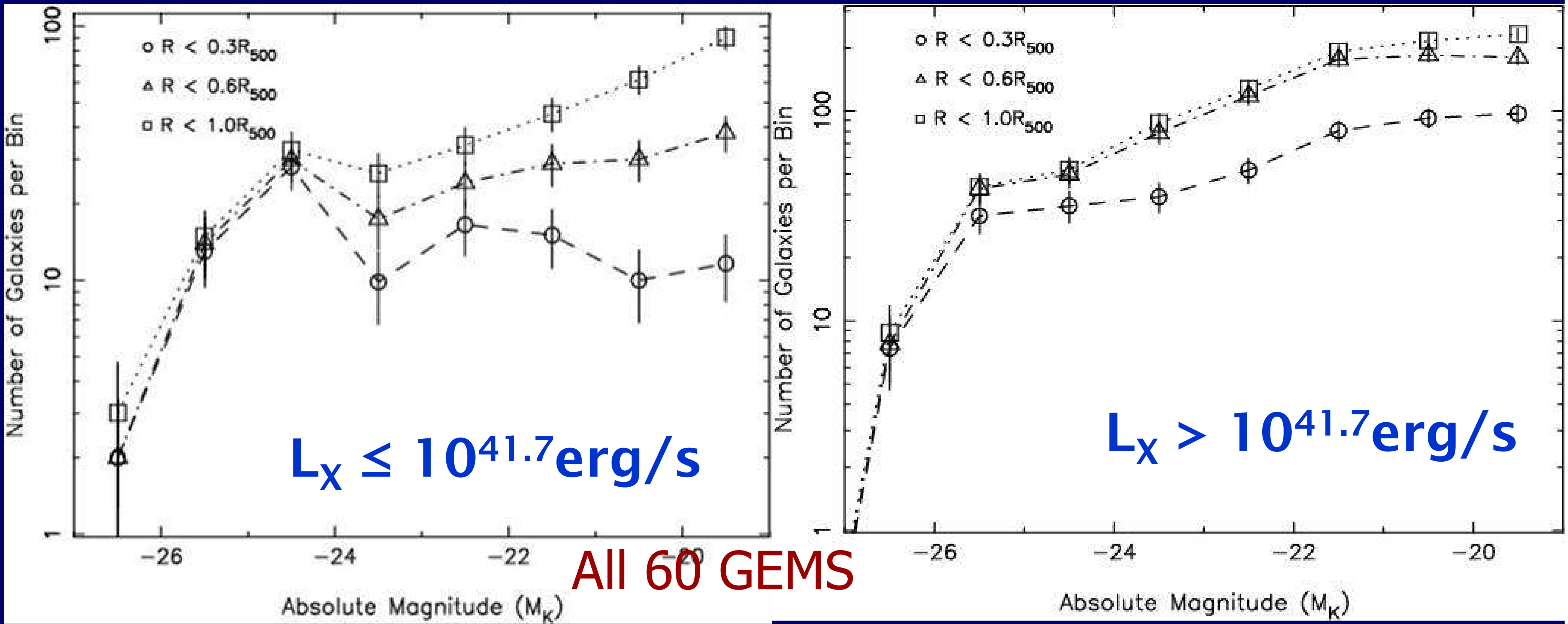
Also likely

- ❑ Star formation boosting B magnitudes?
- ❑ Varying mixture of LFs of sub-populations?

Could the dip be due to star formation boosting B magnitudes?

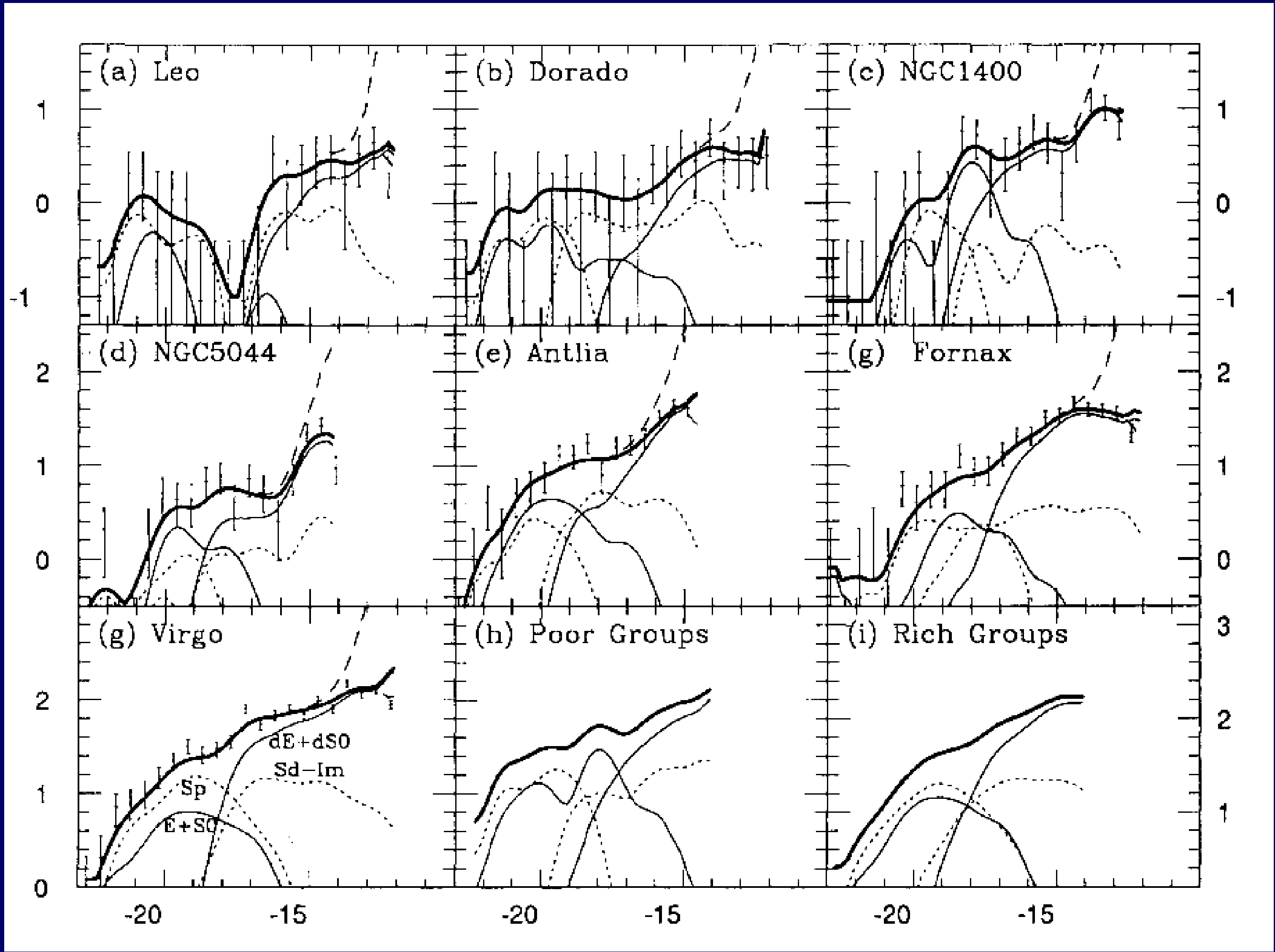
2MASS K-band

Miles Raychaudhury Russell 2005



- The dip is present in the near-IR
- **Goes away when averaged out to R_{500}**

The LF in Groups and Clusters



Ferguson and Sandage (AJ 1991)

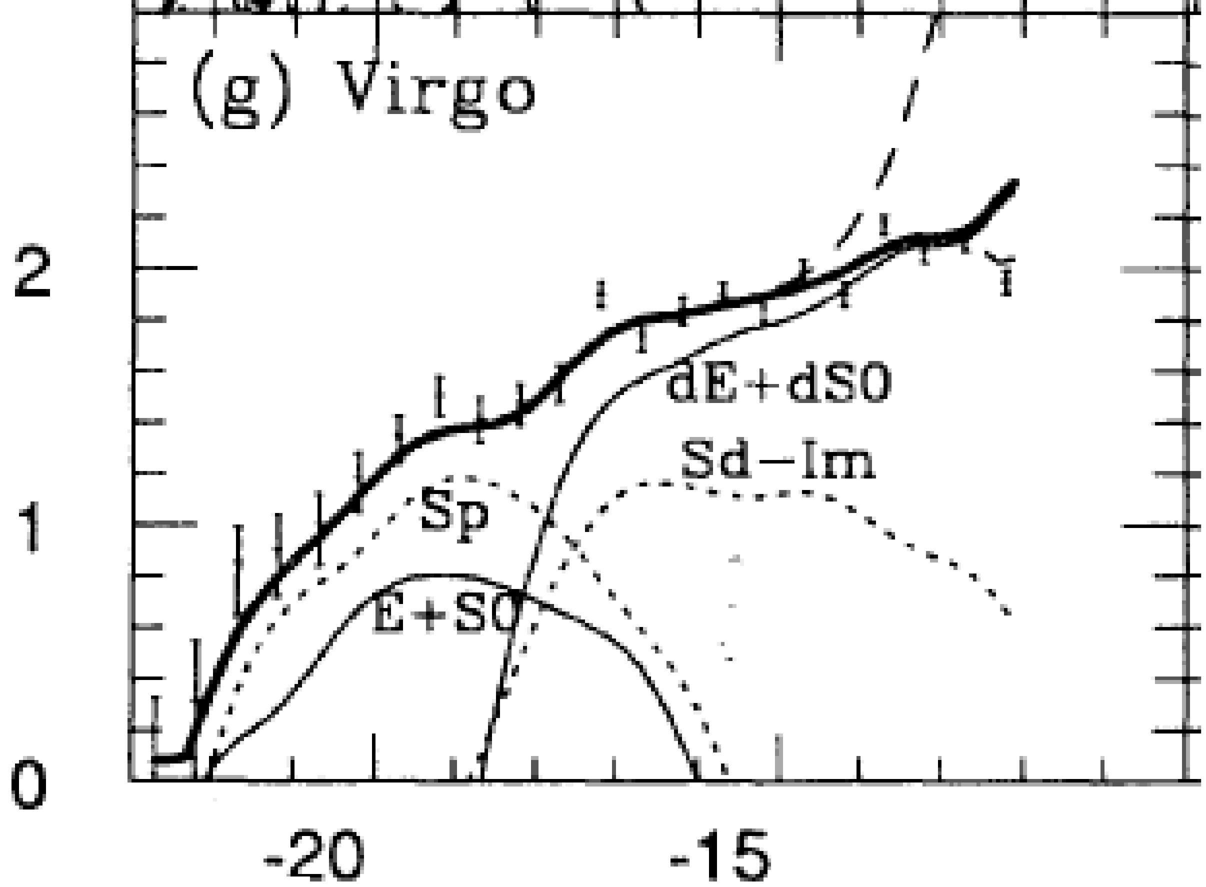
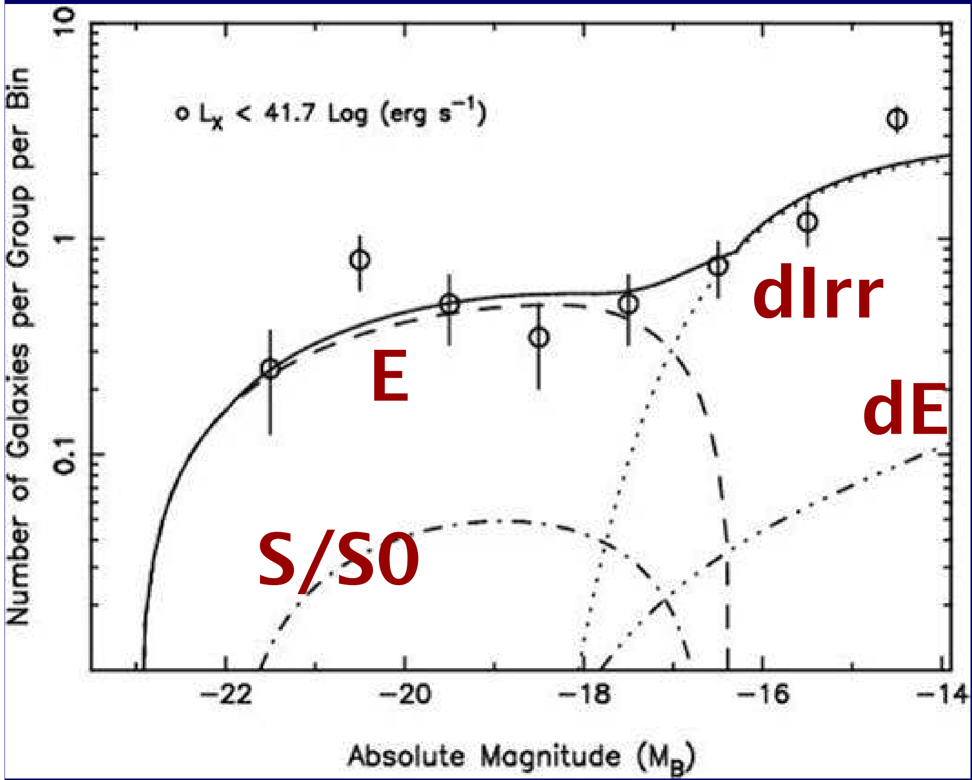
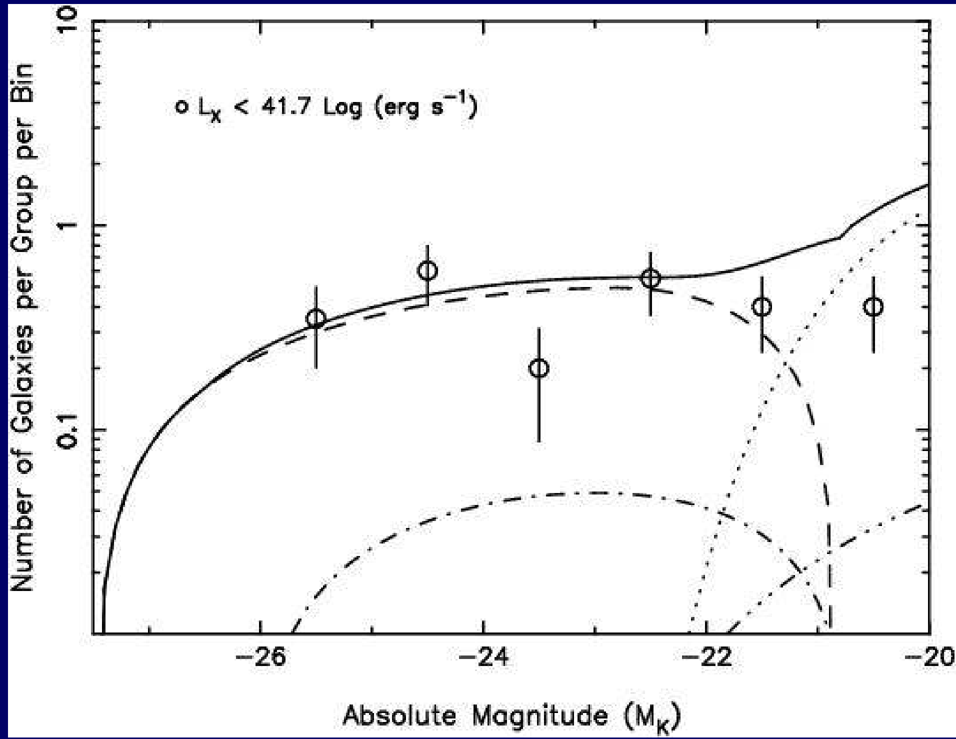
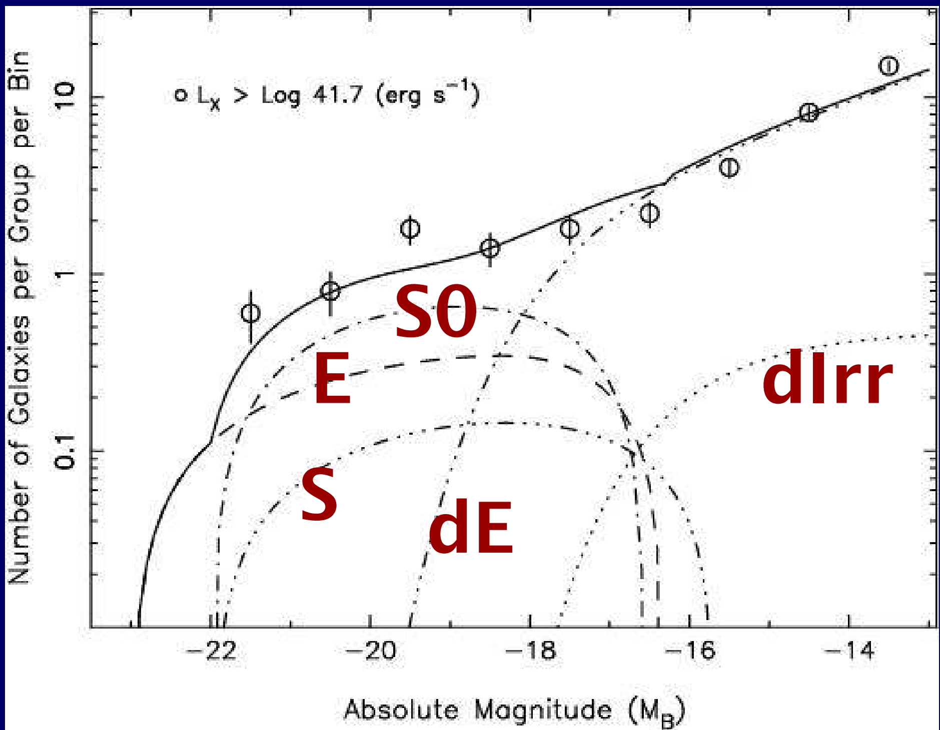


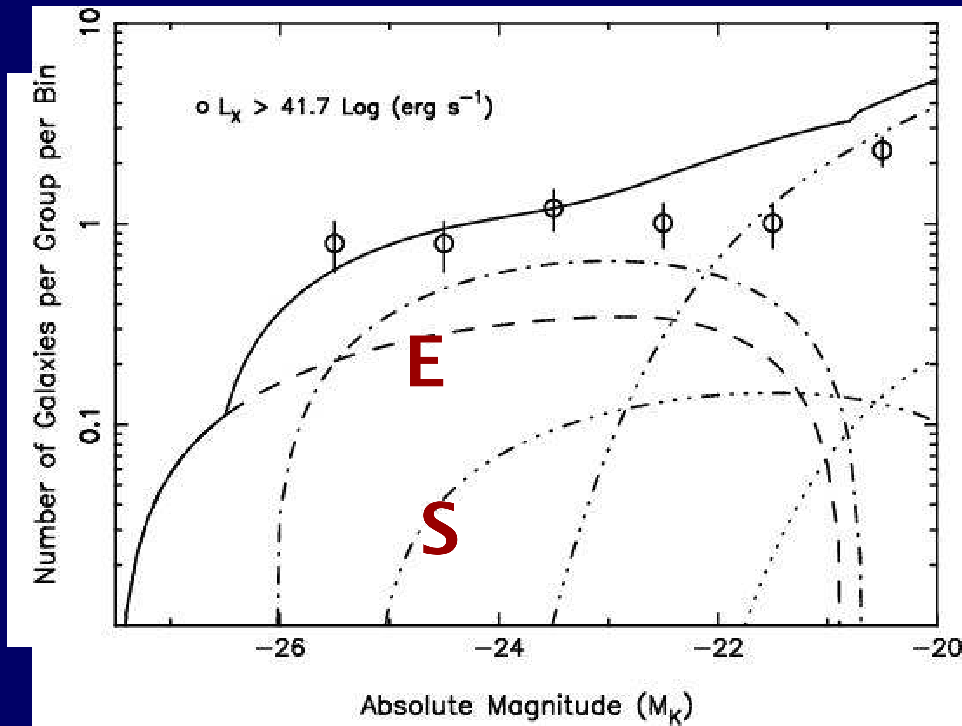
Table 1. Analytical functions and fixed parameters for the type-specific luminosity functions of Jerjen (2001).

Galaxy Type	Function	Parameter 1	Parameter 2
Elliptical	Gaussian	$\overline{M_B}$ = -18.3	$\sigma_{(M<\overline{M_B})}$ = 2.2 $\sigma_{(M>\overline{M_B})}$ = 1.3
S0	Gaussian	$\overline{M_B}$ = -18.9	σ = 1.1
Spiral	Gaussian	$\overline{M_B}$ = -18.3	σ = 1.4
dIrr	Schechter	M_B^* = -16.2	α = -1.0
dE	Schechter	M_B^* = -17.8	α = -1.4


Number of Galaxies per Group per Bin
Absolute Magnitude (M_B)
○ L_X < 41.7 Log (erg s^{-1})
E
dIrr
dE
S/S0
10
1
0.1
−22
−20
−18
−16
−14


Number of Galaxies per Group per Bin
Absolute Magnitude (M_K)
○ L_X < 41.7 Log (erg s^{-1})
10
1
0.1
−26
−24
−22
−20

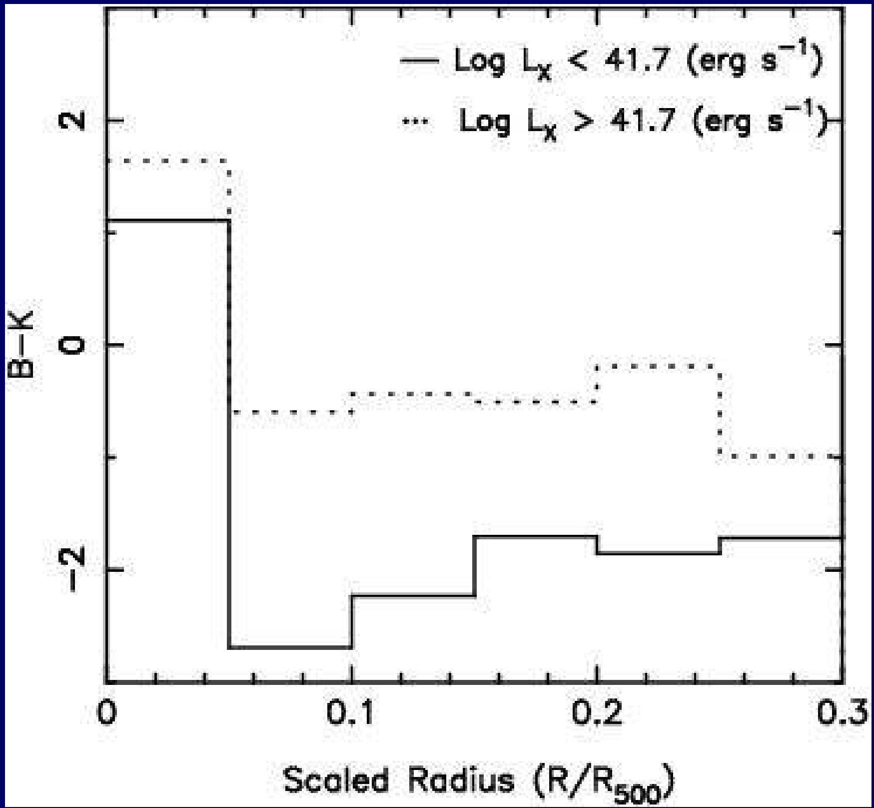

Number of Galaxies per Group per Bin
Absolute Magnitude (M_B)
○ L_X > Log 41.7 (erg s^{-1})
S0
E
dIrr
S
dE
10
1
0.1
−22
−20
−18
−16
−14


Number of Galaxies per Group per Bin
Absolute Magnitude (M_K)
○ L_X > 41.7 Log (erg s^{-1})
E
S
10
1
0.1
−26
−24
−22
−20

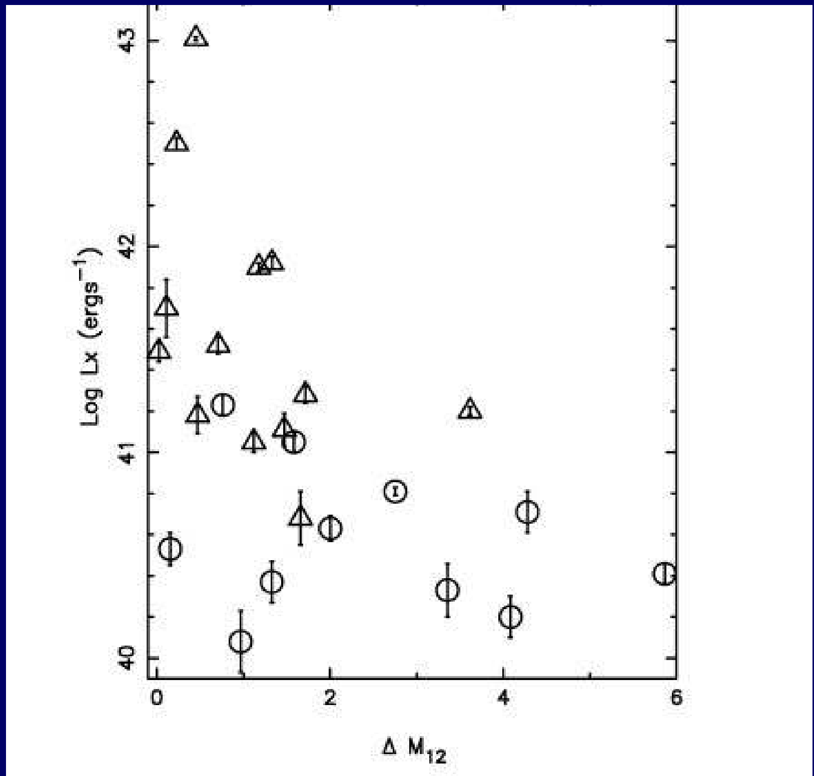
ic lu-

GEMS groups- brightest galaxies

Many groups with lower L_X (consequently lower σ) have higher ΔM

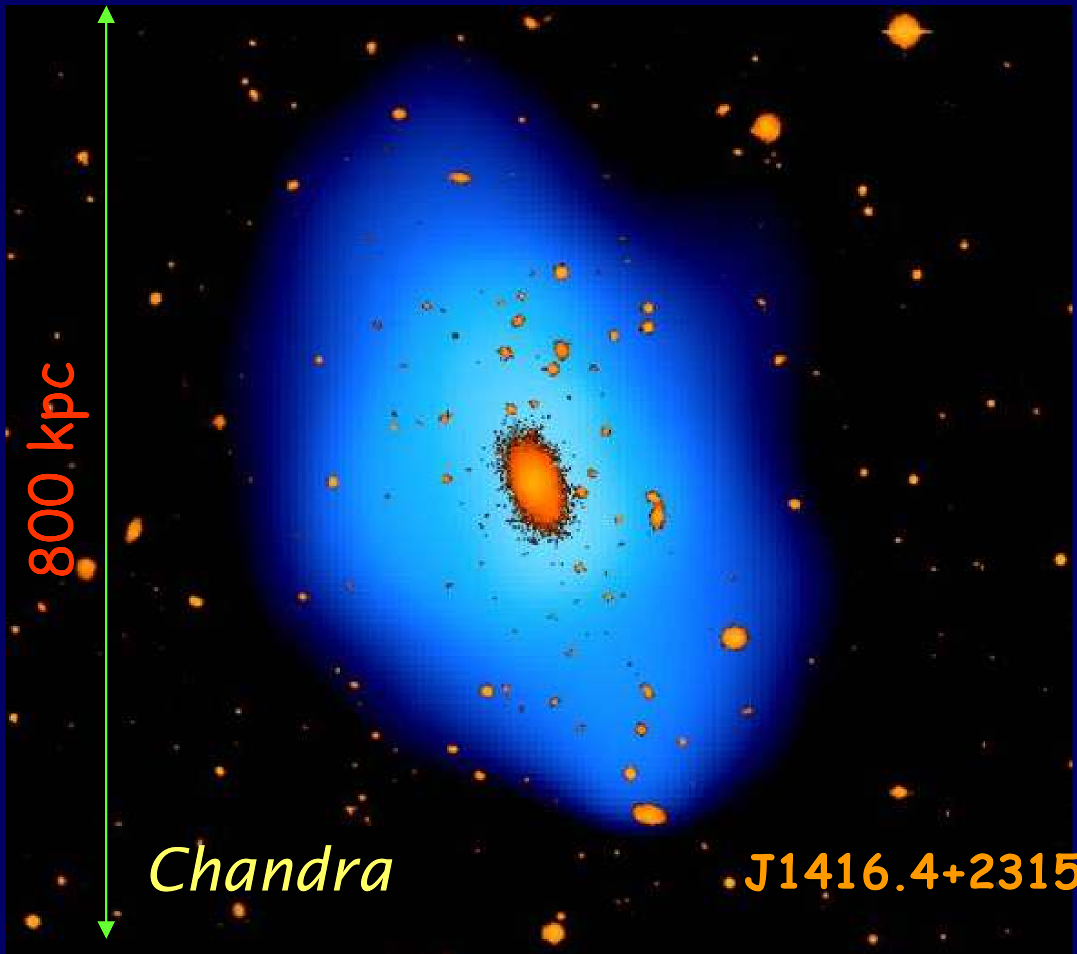


X-ray dim groups have very red central galaxies



Difference in magnitude between brightest and second brightest galaxies

Fossil groups:
end result of this kind of merger?

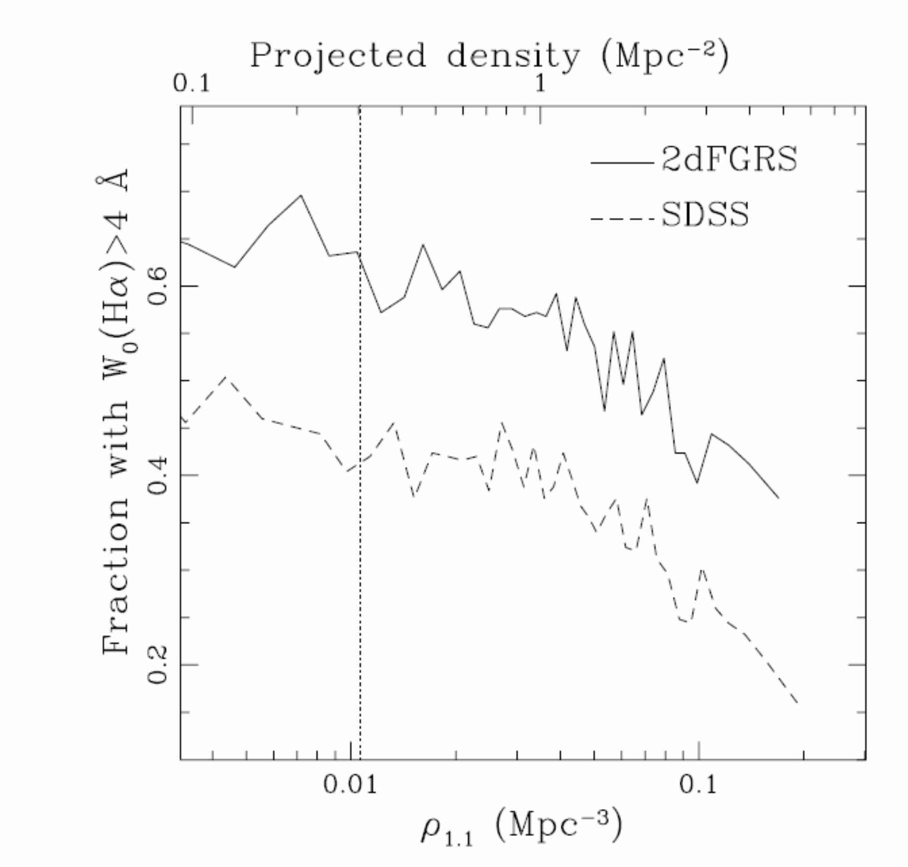


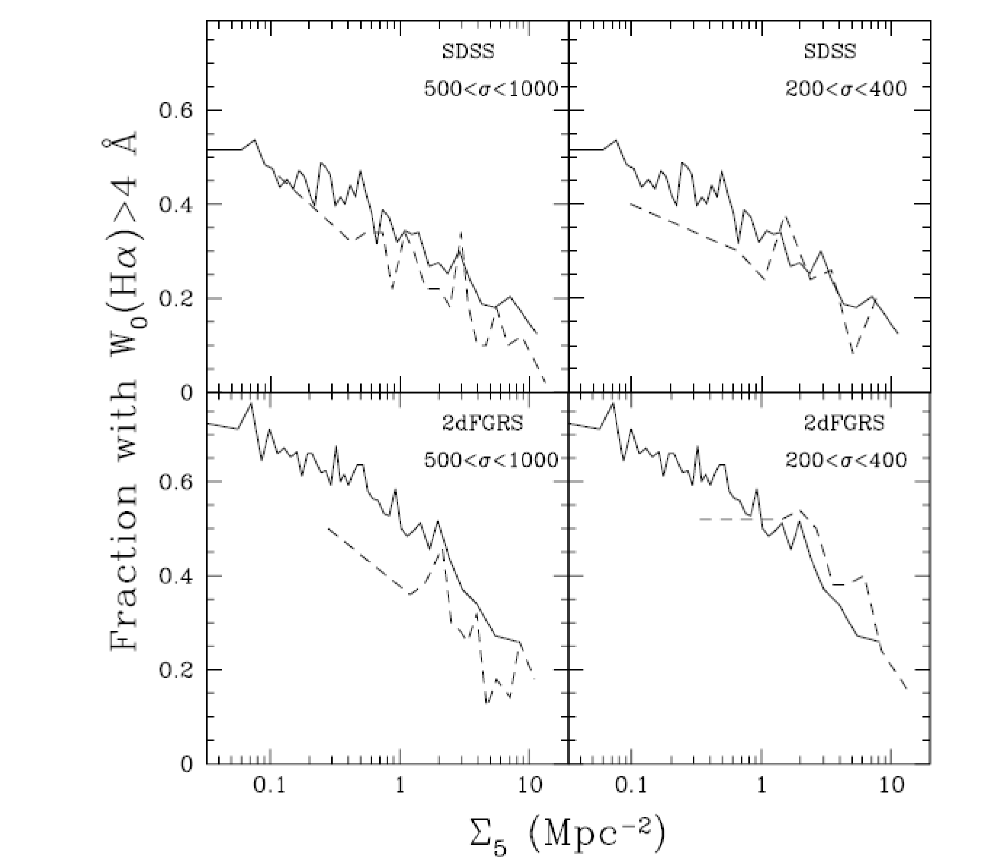
Khosroshahi et al. MNRAS 2005

Jones Ponman Forbes MNRAS 2003

- Isolated Elliptical Galaxy ($M_1 - M_2 > 2$)
- 70% of optical emission from dominant elliptical
- X-ray Luminosity and morphology is that of a poor group of galaxies rather than a single galaxy.

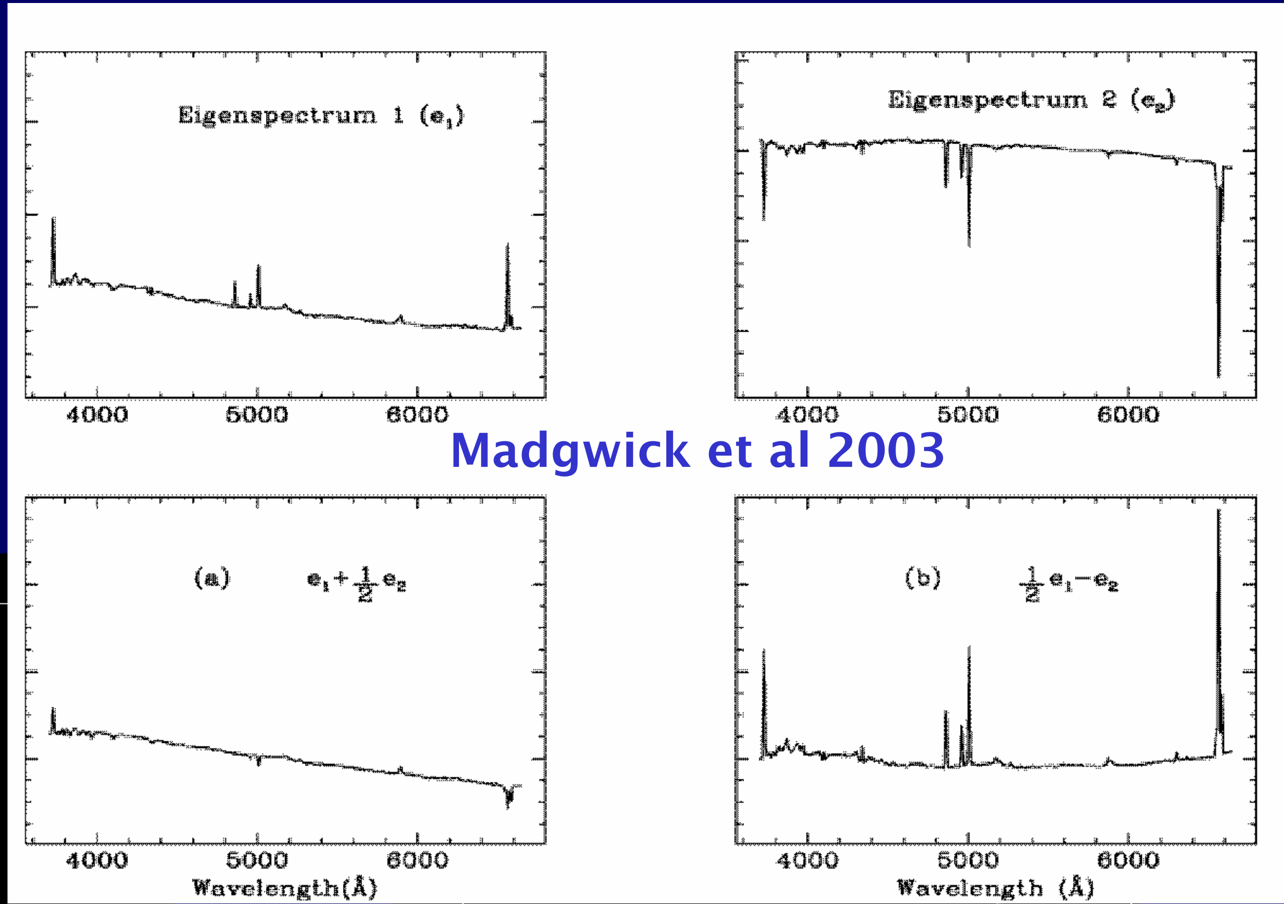
Star formation as a function of environment

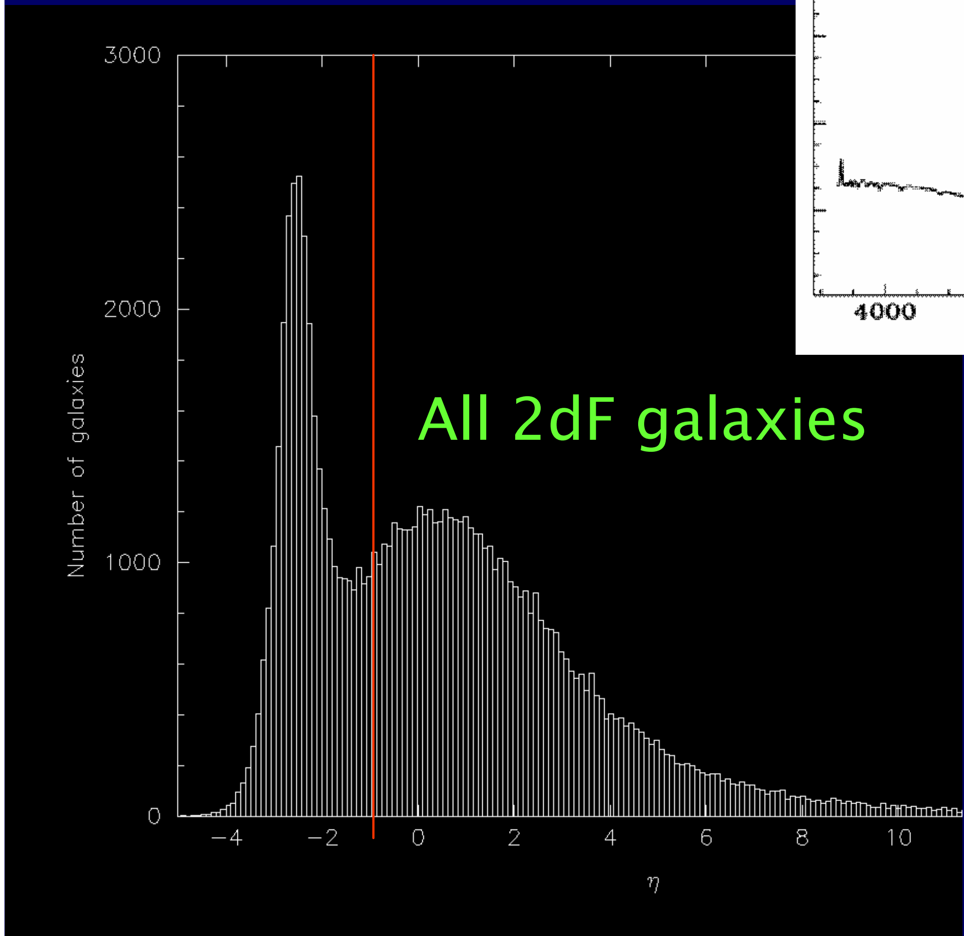


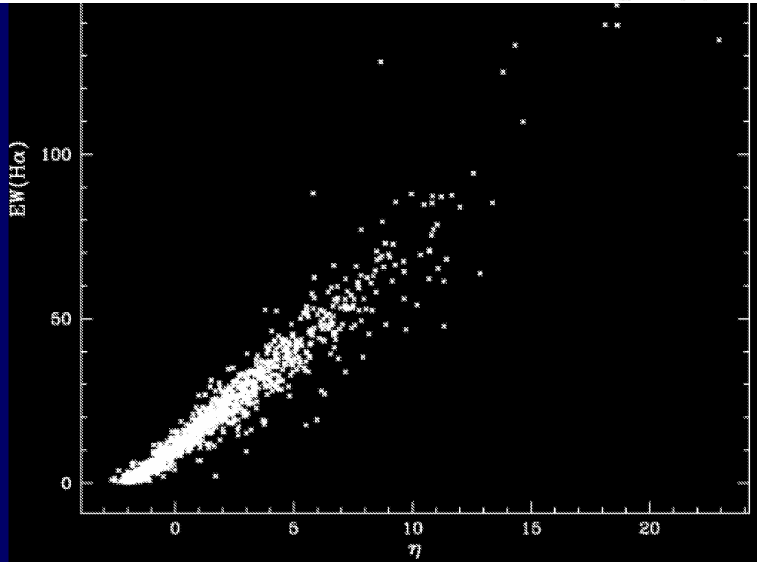


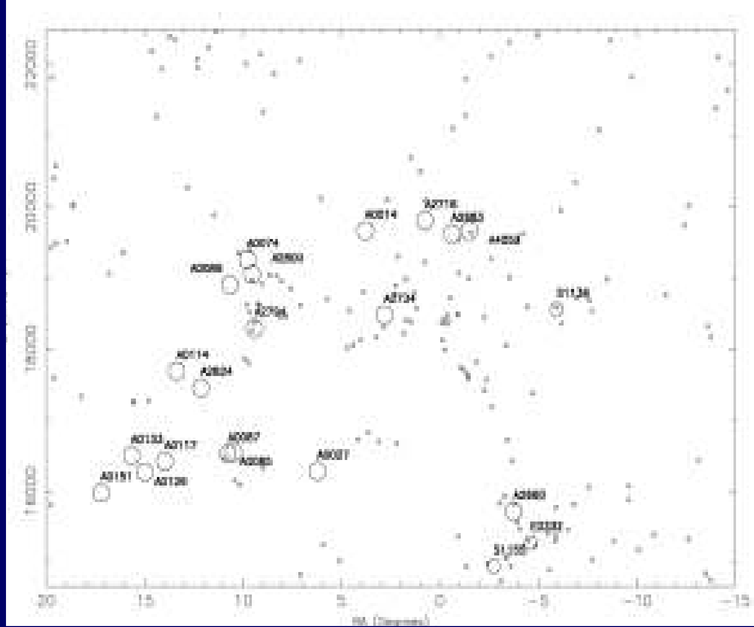
Balogh et al 2004, also Goméz et al 2003

The η Parameter is a star formation indicator





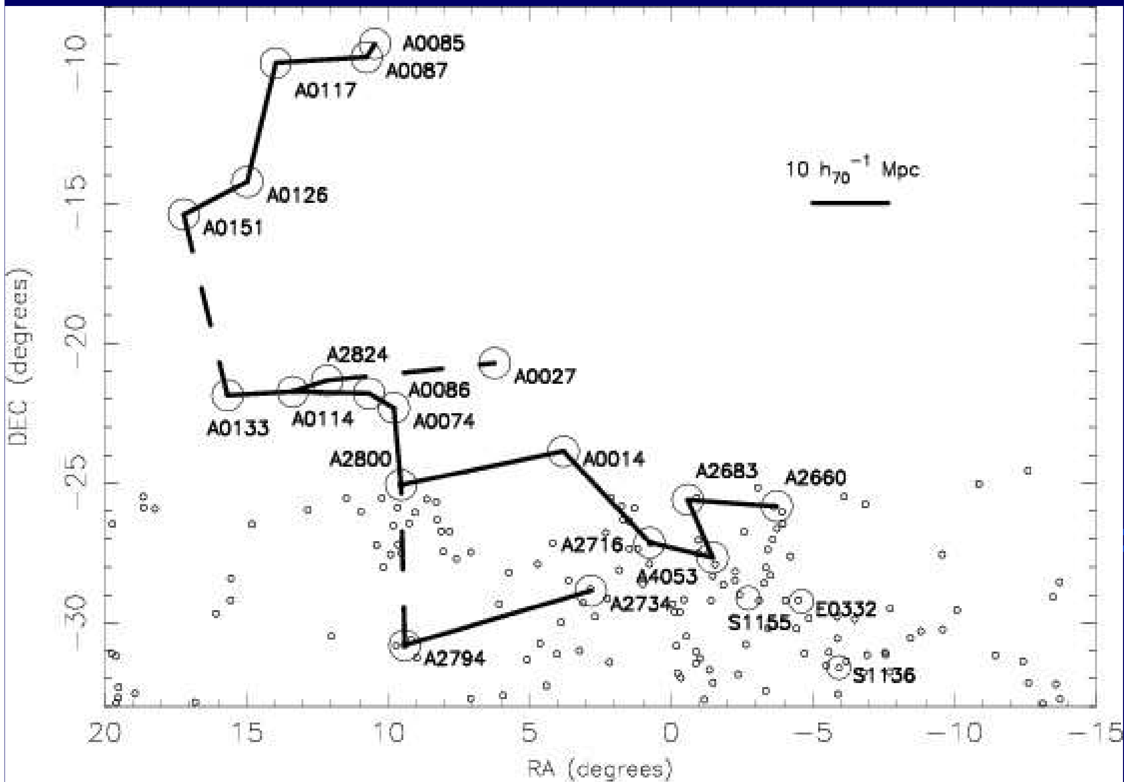


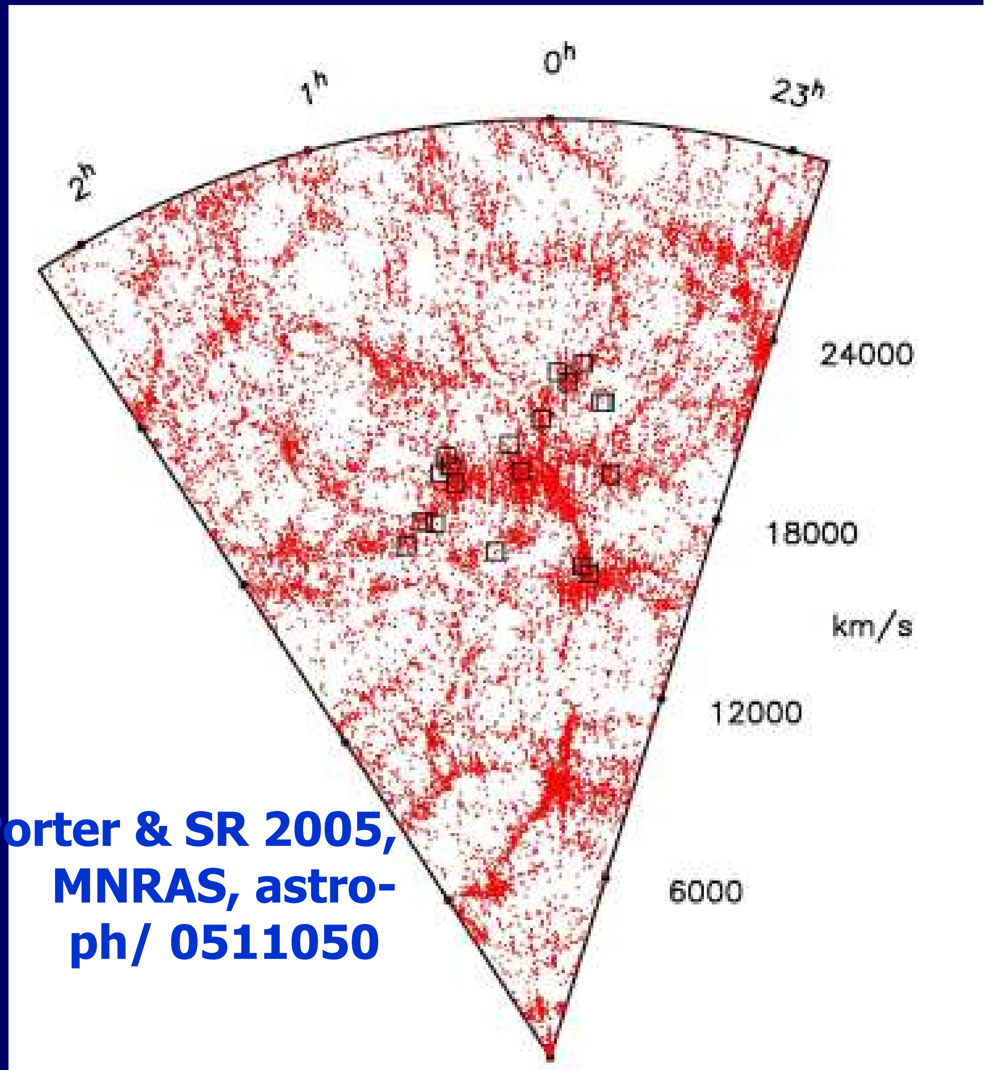


The Pisces-Cetus Supercluster at z=0.06

Part of the supercluster is in the 2dFGRS

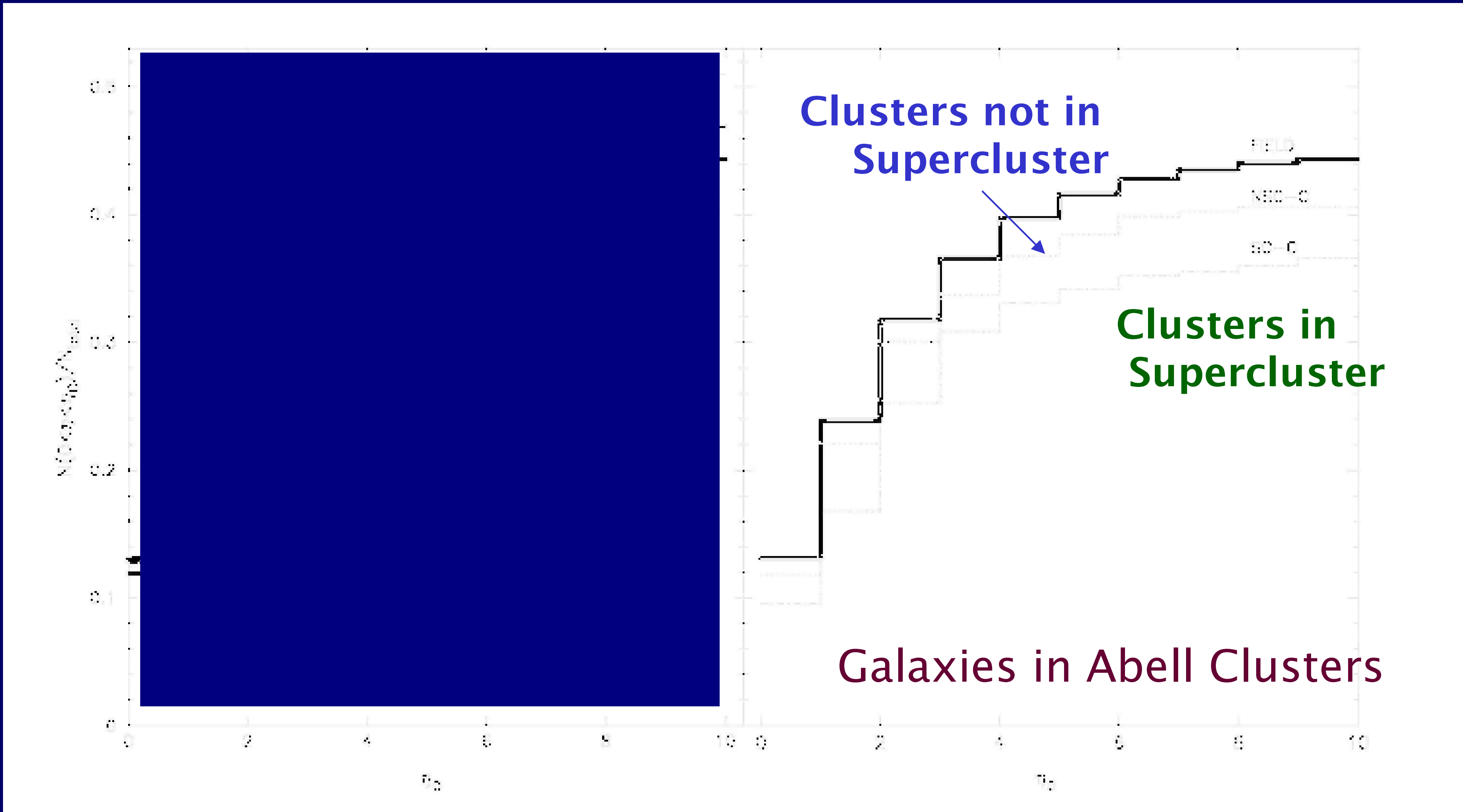
Little circles= 2PIGG groups (Eke et al 2004)





Porter & SR 2005, MNRAS, astro-ph/ 0511050

Enhanced star formation in the Pisces-Cetus SC



PG= Poor groups (2PIGG) 4 ≤ N < 10

Porter & SR 2005, MNRAS, astro-ph/0511050

Conclusions

- Merger-driven galaxy evolution is most important in dynamically sluggish poorer groups, even at z=0
- X-ray dim groups have
  - a deficit at intermediate luminosities in their optical and near-IR luminosity functions
  - a more centrally concentrated early-type galaxy population
- Star formation is enhanced in groups residing in supercluster filaments compared to that is “field galaxies”
  - Star formation is further enhanced as galaxies and groups stream down intercluster filaments, far outside the virial radii of clusters