Clues about Harassment in Coma and Virgo clusters.

J. Alfonso L. Aguerri, C. Muñoz Tuñón,
J. M. Vilchez

J. Iglesias Páramo

Evolution of galaxies in clusters

- The evolution of the galaxies depends on the environment. Galaxies in clusters have different evolutionary mechanisms
- Galaxies in clusters can evolved by:
  - Internal Evolution: Bars in discs, SpI=>Sp0
  - Fast encounters: t=1 Gyr;
  - Slow Encounters: groups, prepocesing
  - Gas striping: swept of cold gas by presure
  - Strangulation: swept of warm gas from halo
  - Interaction with the global potential

Evolution of galaxies in clusters

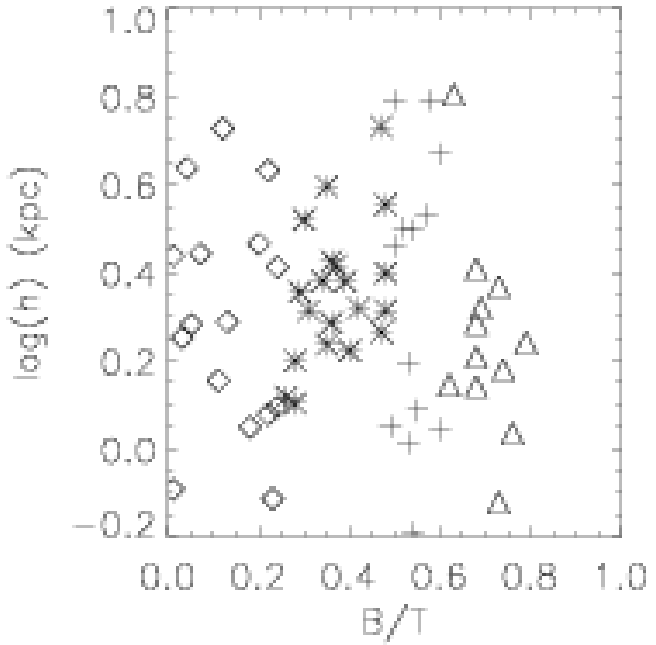
- The evolution of the galaxies depends on the environment. Galaxies in clusters have different evolutionary mechanisms
- Galaxies in clusters can evolved by:
  - Internal Evolution: Bars in discs, SpI=>Sp0
  - Fast encounters: t=1 Gyr; $\Delta E / E \approx r_g^{-2}; N \approx r_g^2$
  - Slow Encounters: groups, prepocesing
  - Gas striping: swept of cold gas by presure
  - Strangulation: swept of warm gas from halo
  - Interaction with the global potential

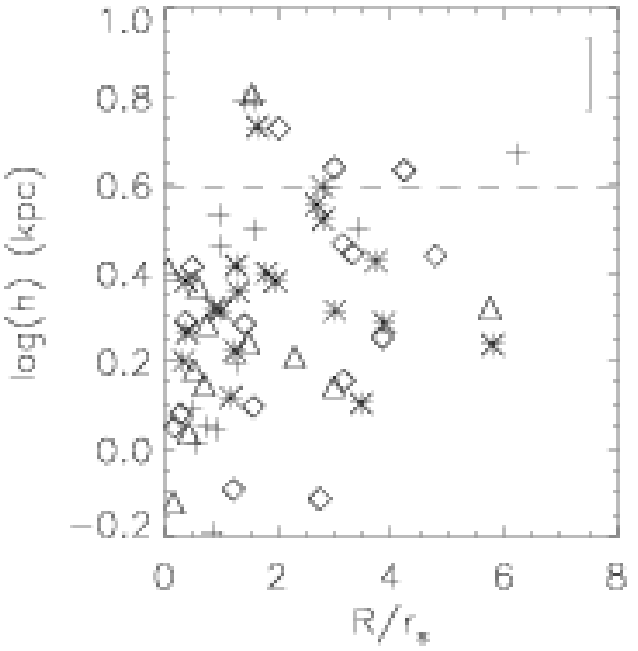
The harassment theory

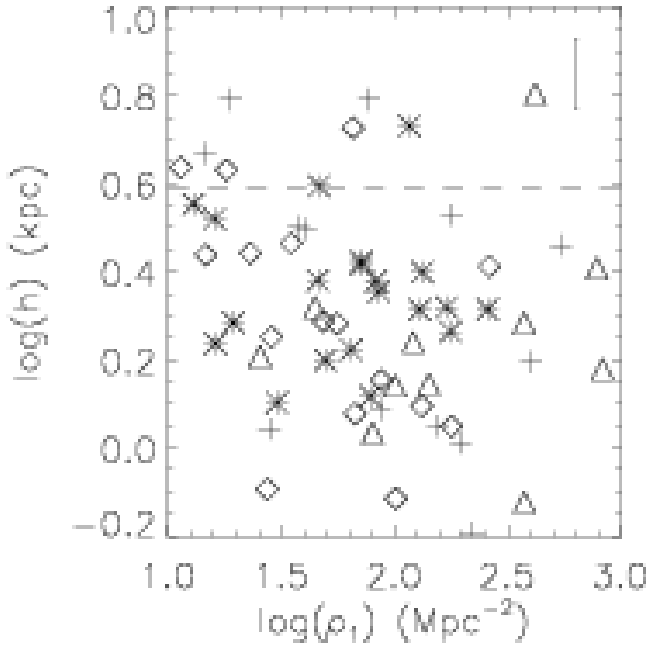
- The harassment theory tries to explain the morphological galaxy transformation in clusters due to fast encounters between galaxies and interactions with the global cluster potential.
- We try to find observational clues about this theory
  - Scales of discs in bright galaxies; Dwarf galaxies; Color of galaxies; Difuse light.

Coma Cluster

- We have analized the morphology of the galaxies in Coma with mr<17 in an area of 1 square degree.
- Bright galaxies:
  - The scale of the discs are smaller than field galaxies. Weak correlation with the postion. The mean log(h)=0.33 in cluster and 0.59 in field.
  - The bluest spirals are in the outer region in the cluster and they show the biggest disc scales. The mean log(h) for blue galaxies (B-R<1.5) is 0.57

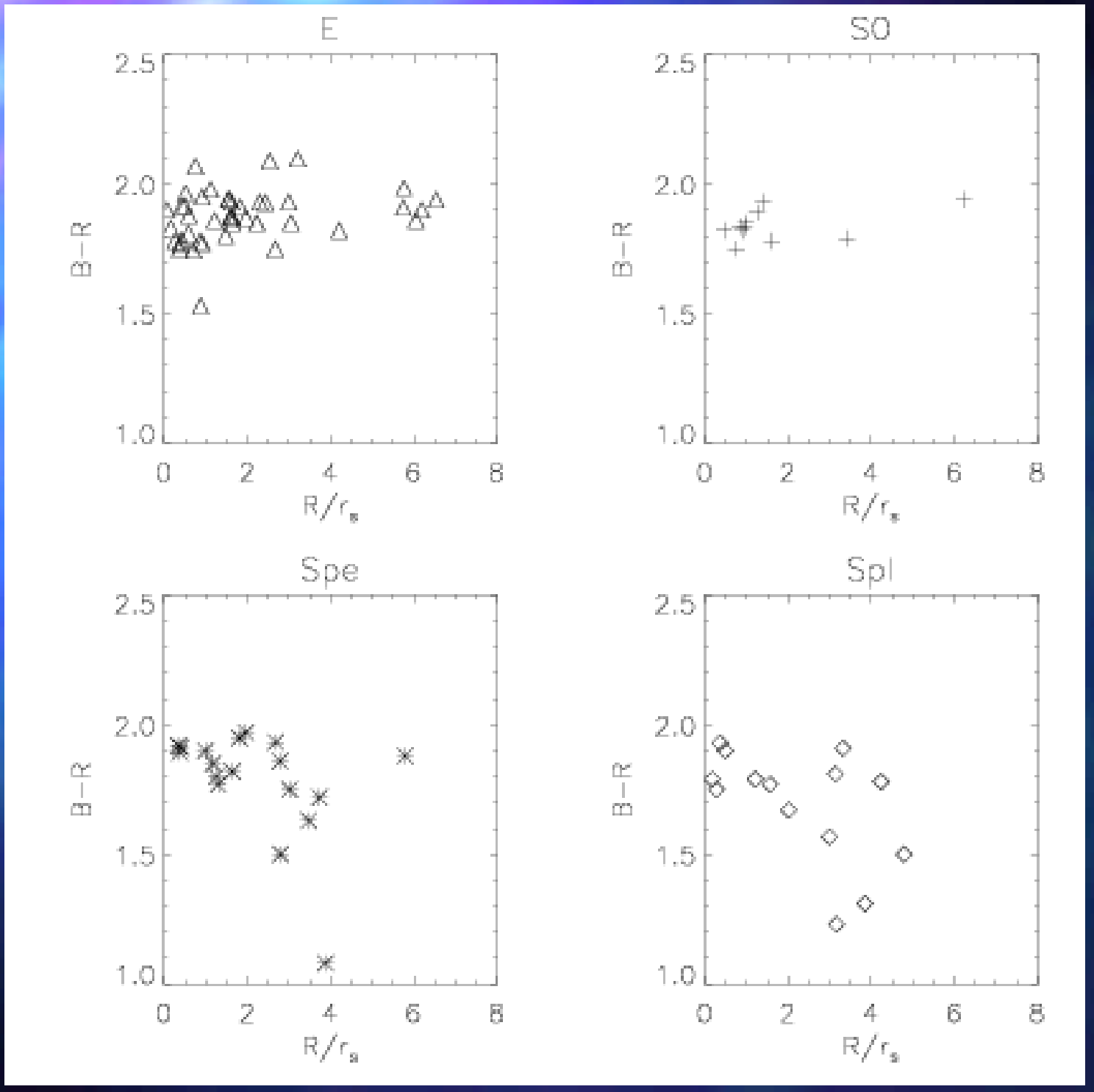

1.0
0.8
0.6
0.4
0.2
0.0
−0.2
log(h) (kpc)
0.0 0.2 0.4 0.6 0.8 1.0
B/T


1.0
0.8
0.6
0.4
0.2
0.0
−0.2
log(h) (kpc)
0 2 4 6 8
R/r*


1.0
0.8
0.6
0.4
0.2
0.0
−0.2
log(h) (kpc)
1.0 1.5 2.0 2.5 3.0
log(ρ1) (Mpc−2)

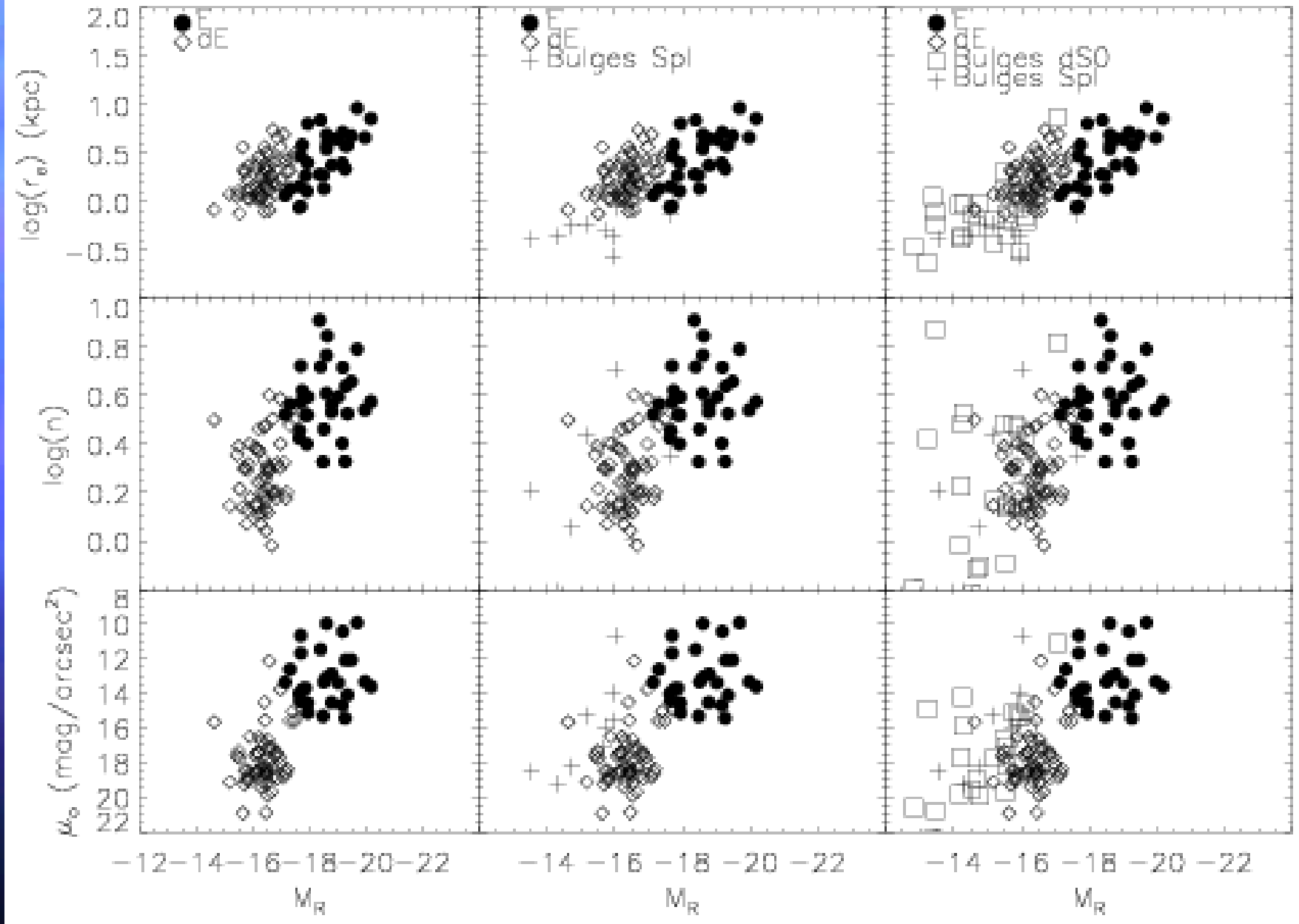
Coma Cluster

- We have analized the morphology of the galaxies in Coma with mr<17 in an area of 1 square degree.
- Bright galaxies:
  - The scale of the discs are smaller than field galaxies. Weak correlation with the postion. The mean log(h)=0.33 in cluster and 0.59 in field.
  - The bluest spirals are in the outer region in the cluster and they show the biggest disc scales. The mean log(h) for blue galaxies (B-R<1.5) is 0.57


E
S0
Spe
Spl
B−R
R/r_s
2.5
2.0
1.5
1.0
0
2
4
6
8

Coma Cluster

- Dwarf galaxies: Harassment predict that discs of late-type galaxies and LSB are destroyed and the galaxies evolve to dwarf galaxies.
- If this is correct dwarf spheroidal galaxies should be similar in scale to bulges of late-type galaxies.


E
dE
Bulges Spl
Bulges dS0
log(r_e) (kpc)
log(n)
μ_0 (mag/arcsec²)
M_R

Difuse light in clusters.

- Zwicky (1951) Excess of light between galaxies in Coma cluster.
- During many decades was asociated with: LSB galaxies; halos of the cDs; Intergalactic globular clusters
- Last years: Intercluster planetary nebulae; old stellar population.

Formation of the difuse light

- Encounter and mergers between galaxies disrrupt stars and gas and it is deposit in the intercluster medium
- LSB and late type galaxies can be destroyed by the global cluster potential.

Local Planetary Nebulae



Local Planetary Nebulae

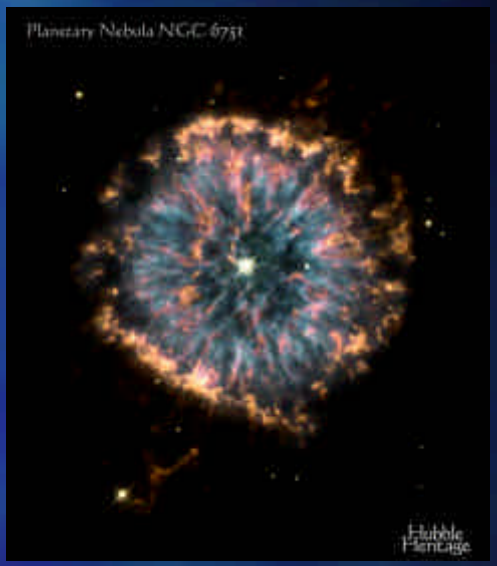




Local Planetary Nebulae



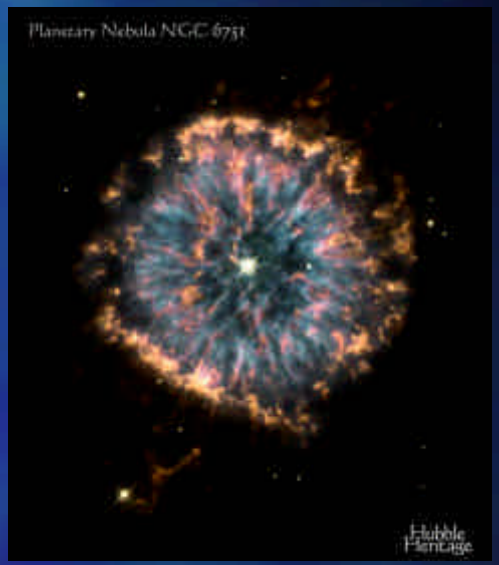


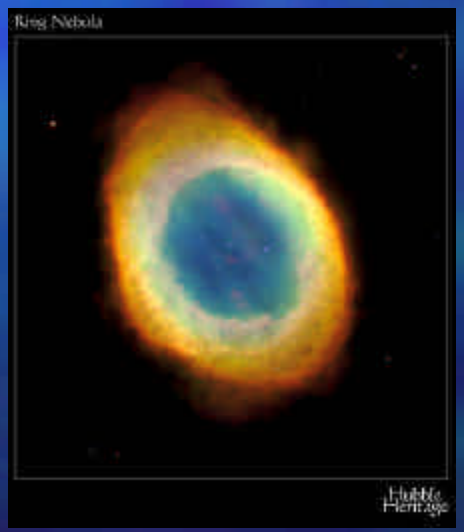


Local Planetary Nebulae

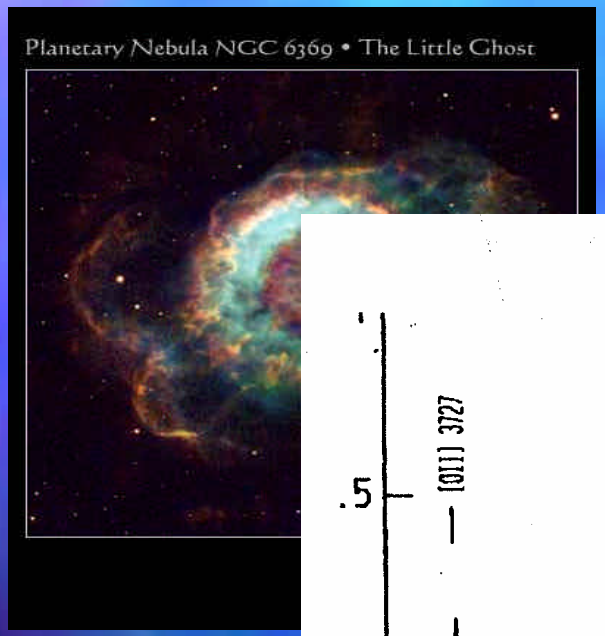


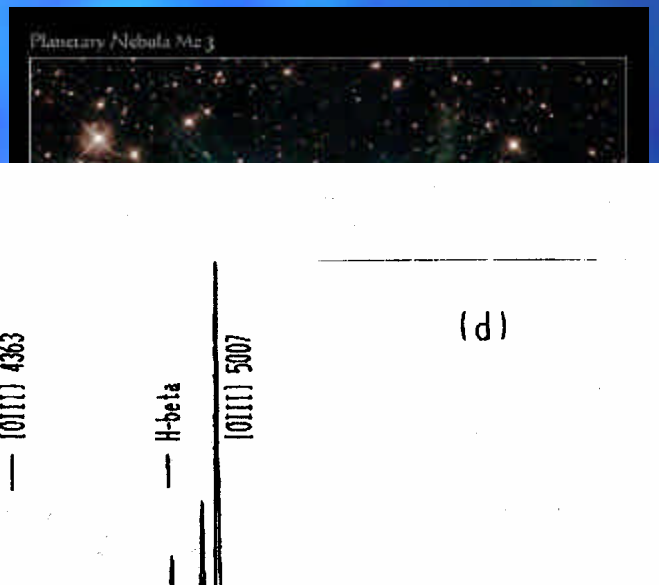


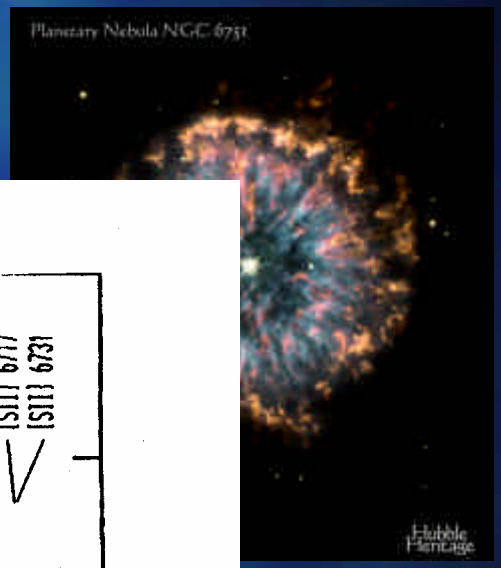


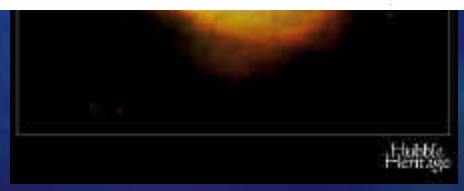


Local Planetary Nebulae

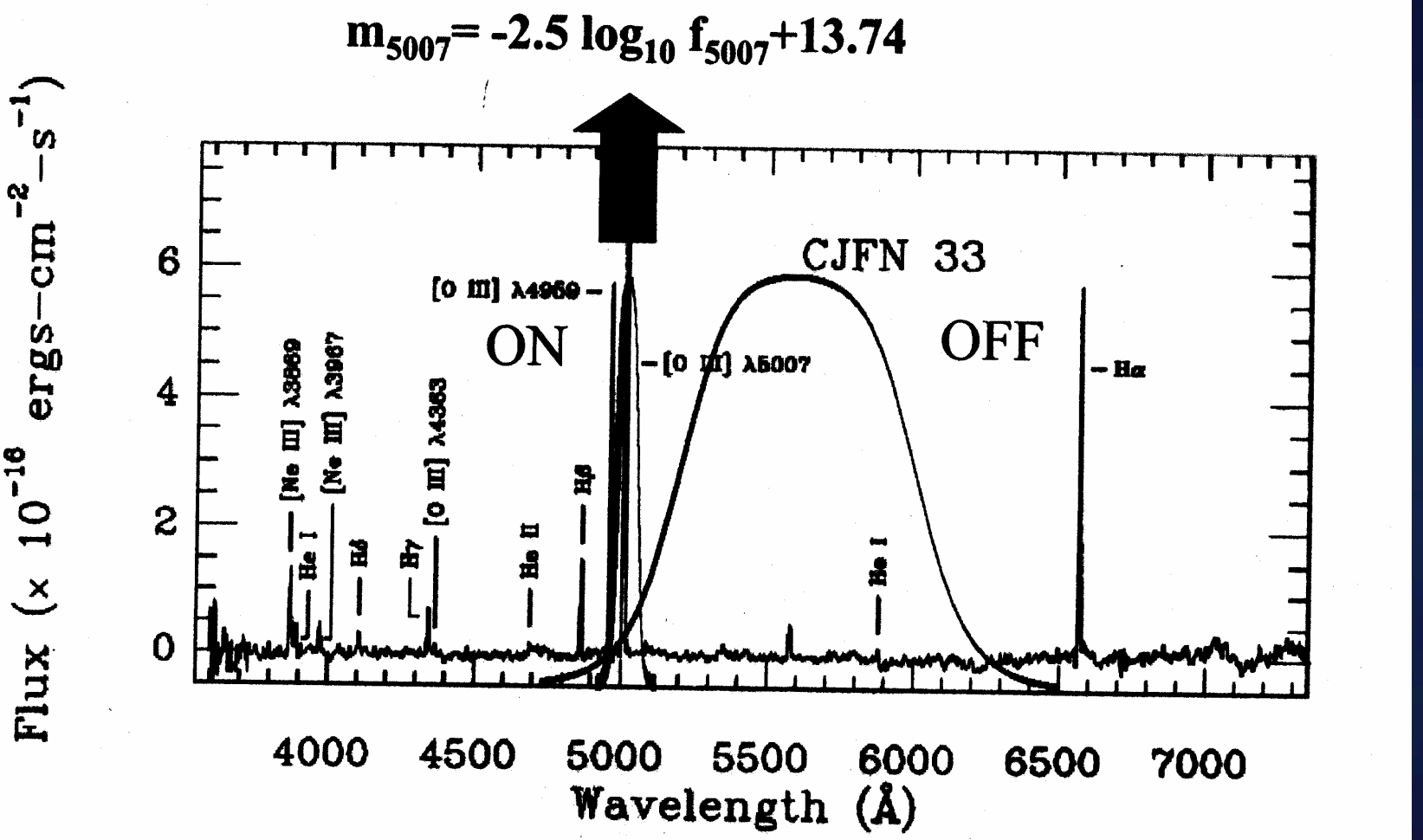




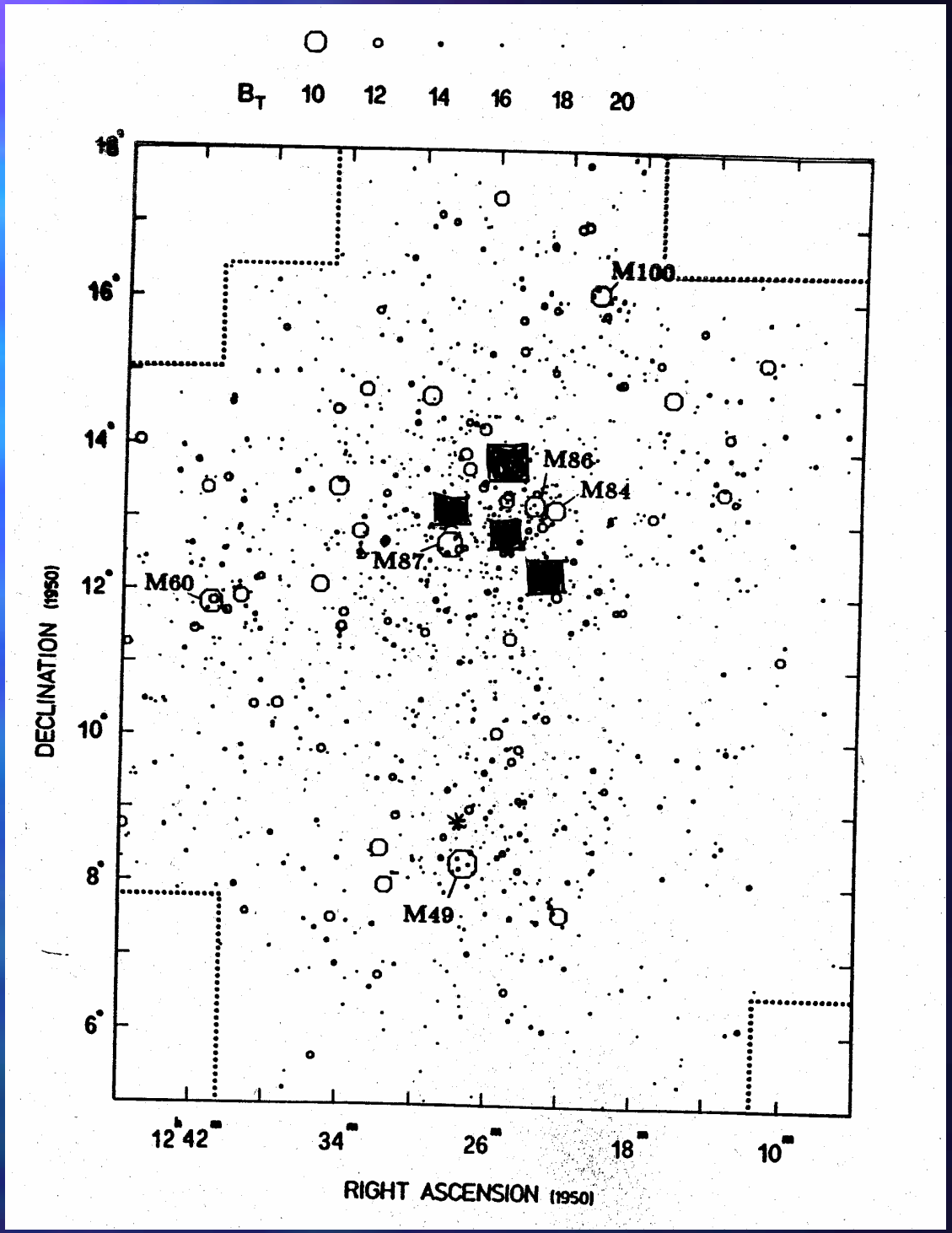




Observational technique



Virgo cluster



Previous studies

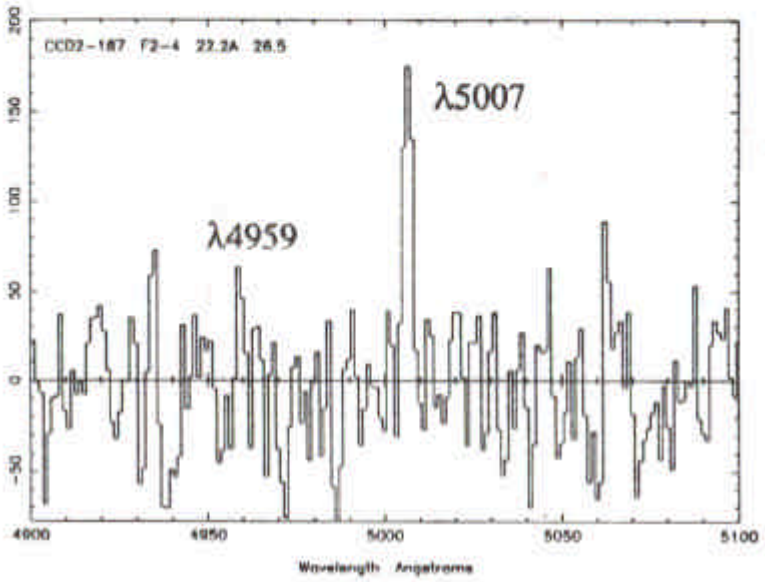
- Detection by “eye” of the candidates:
  - Feldmeier et al 2003: 68 candidates
  - Feldmeier et al 1998: 160 candidates
  - Mendez et al 1997: 11 candidates
  - ICPNe represents up to 50% of the light

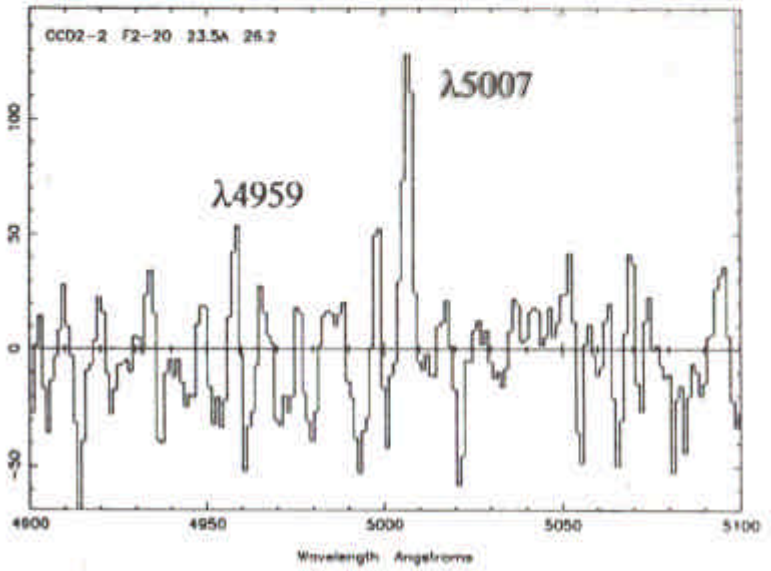
Spectroscopical confirmation

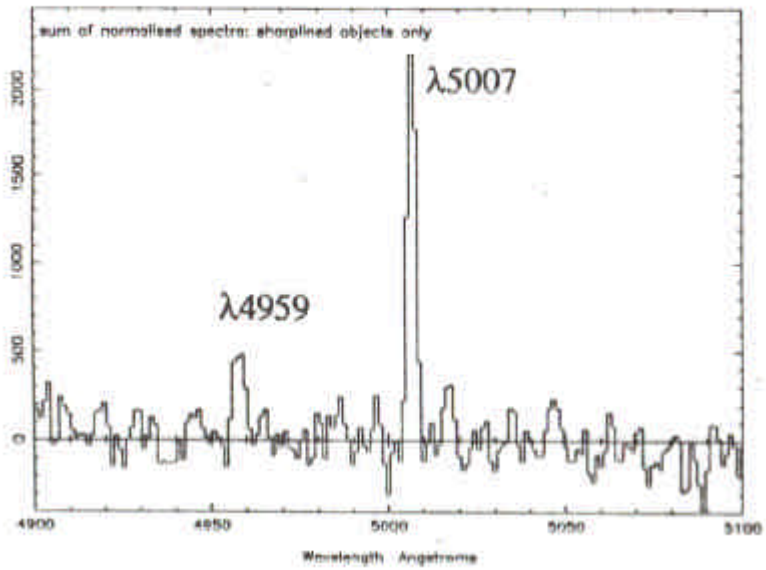
- Freeman et al 2000: Spectroscopical confirmation with 2dF of the samples from: Feldmeier, Jacoby and Mendez
  - 50% No detection or faint stars
  - 50% Emission objects: 25% Lyalfa z=3; 75% ICPNe

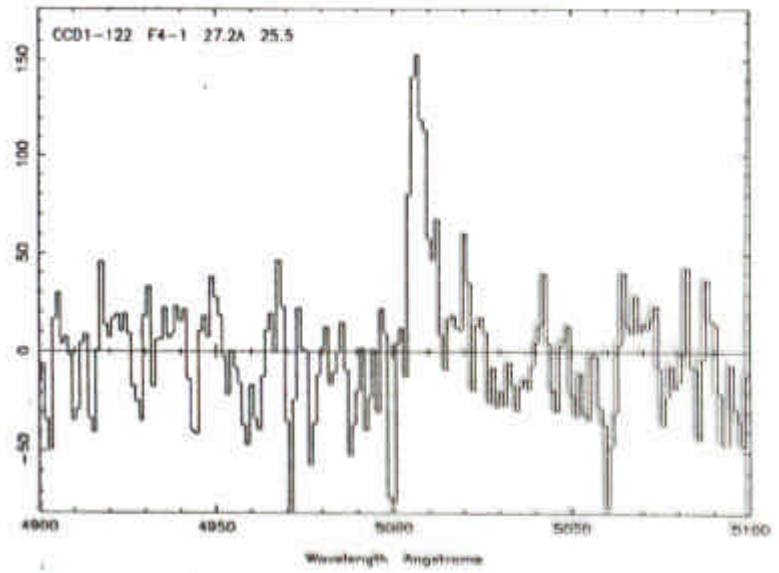
  Kudritzki et al 2000: Spectroscopy of ICPNe with VLT+FORS: No ICPNe, all Lyalfa at z=3.

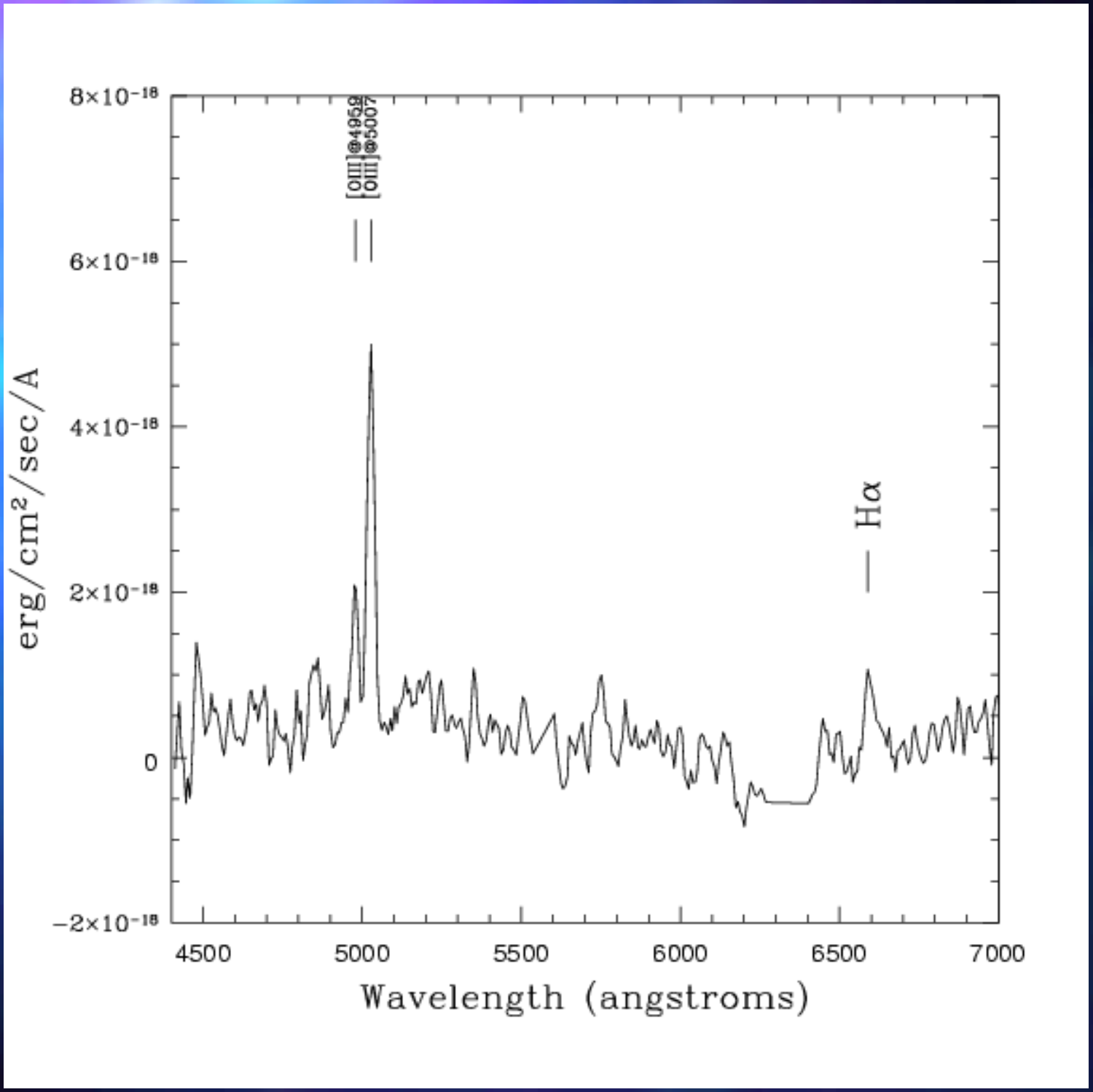
Arnaboldi et al (2002)





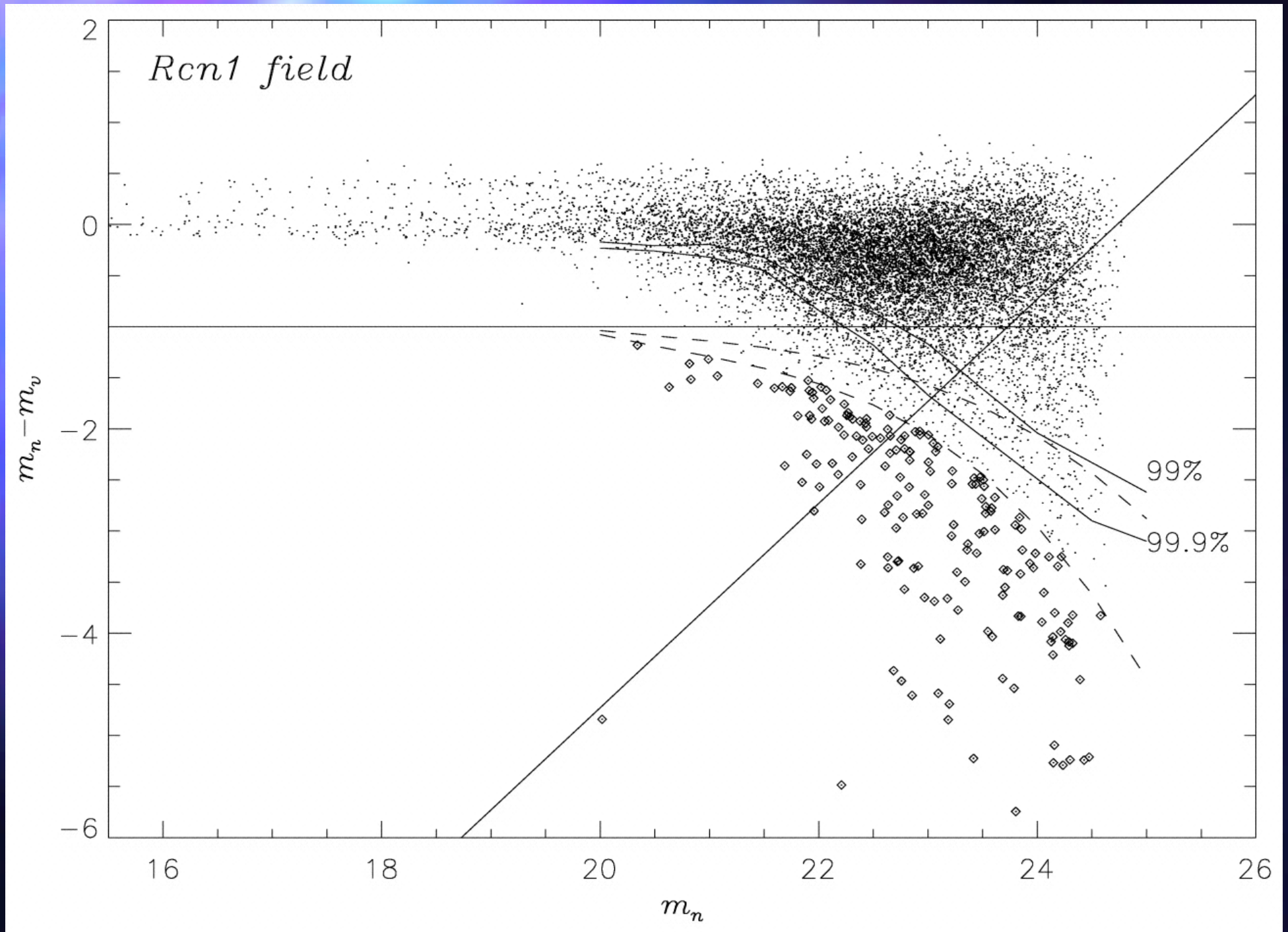




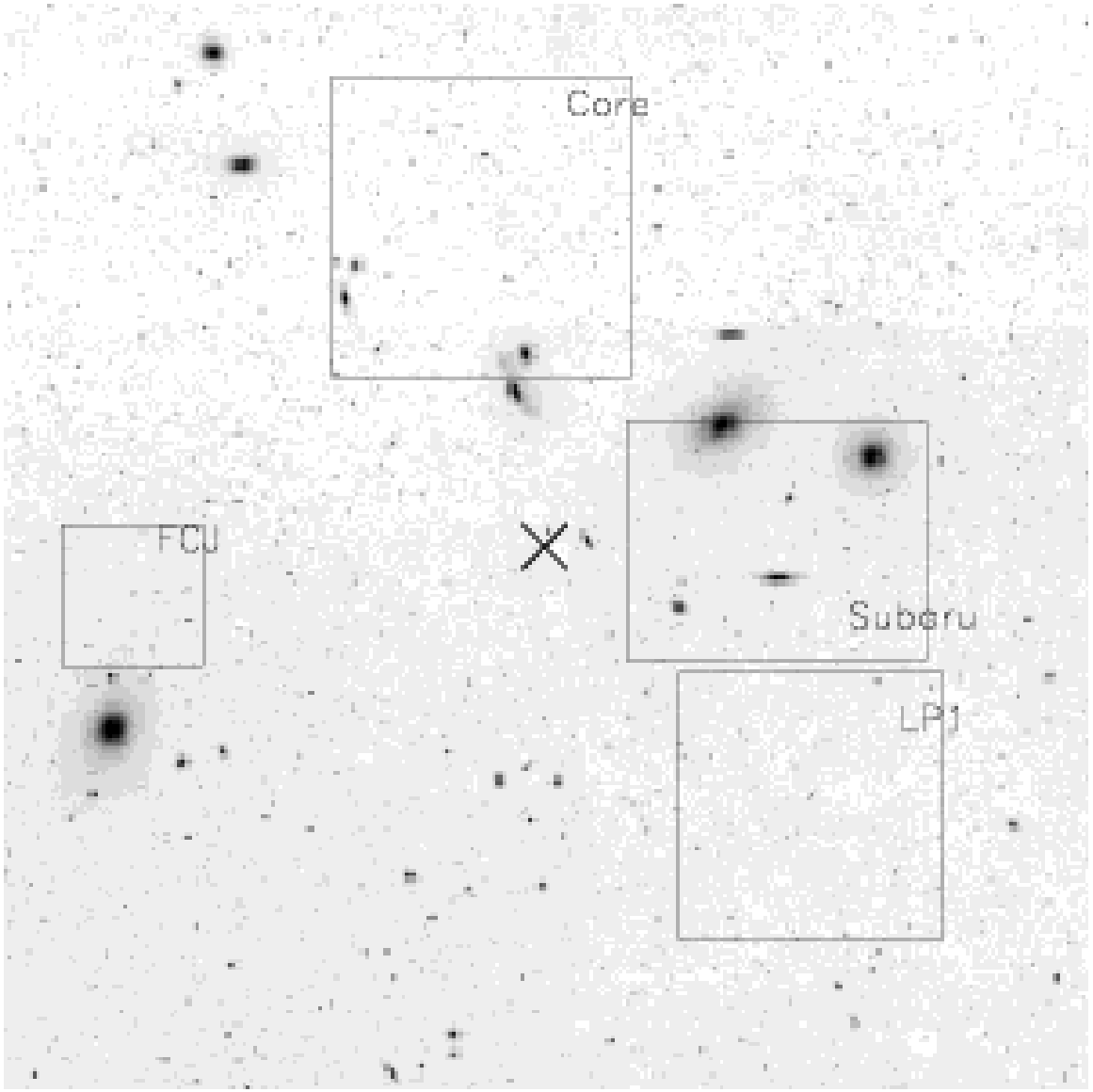

8×10⁻¹⁸
6×10⁻¹⁸
4×10⁻¹⁸
2×10⁻¹⁸
0
−2×10⁻¹⁸
erg/cm²/sec/A
[OIII]@4959
[OIII]@5007
Hα
4500
5000
5500
6000
6500
7000
Wavelength (angstroms)

Extraction technique

- Automatical extraction of the candidates
  - SExtractor
- Color magnitude diagrams (mo3-mV mo3)
  - ICPNe: mo3-mV<<0; EW>100A; mV<1sigma
- Point-like objects
  - PSF(ICPNe)=PSF(stars)


Rcn1 field
2
0
−2
−4
−6
16
18
20
22
24
26
$m_n - m_v$
m_n
99%
99.9%

Virgo Cluster Core



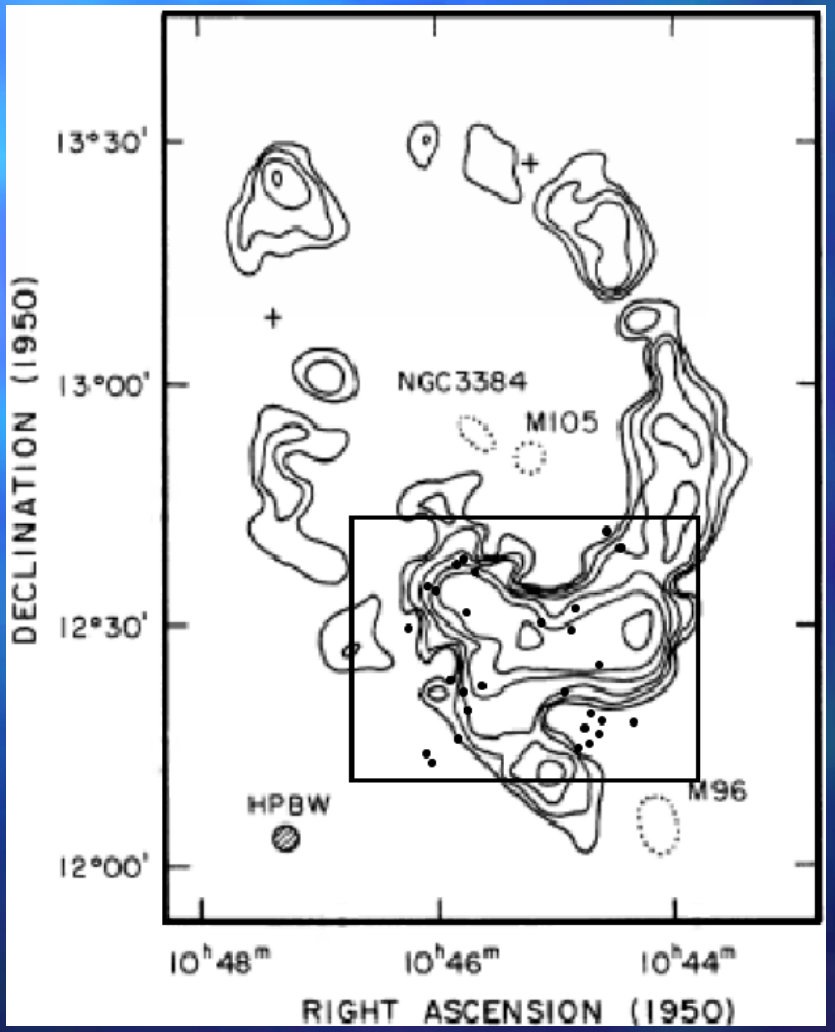
Difuse light in the Virgo Core

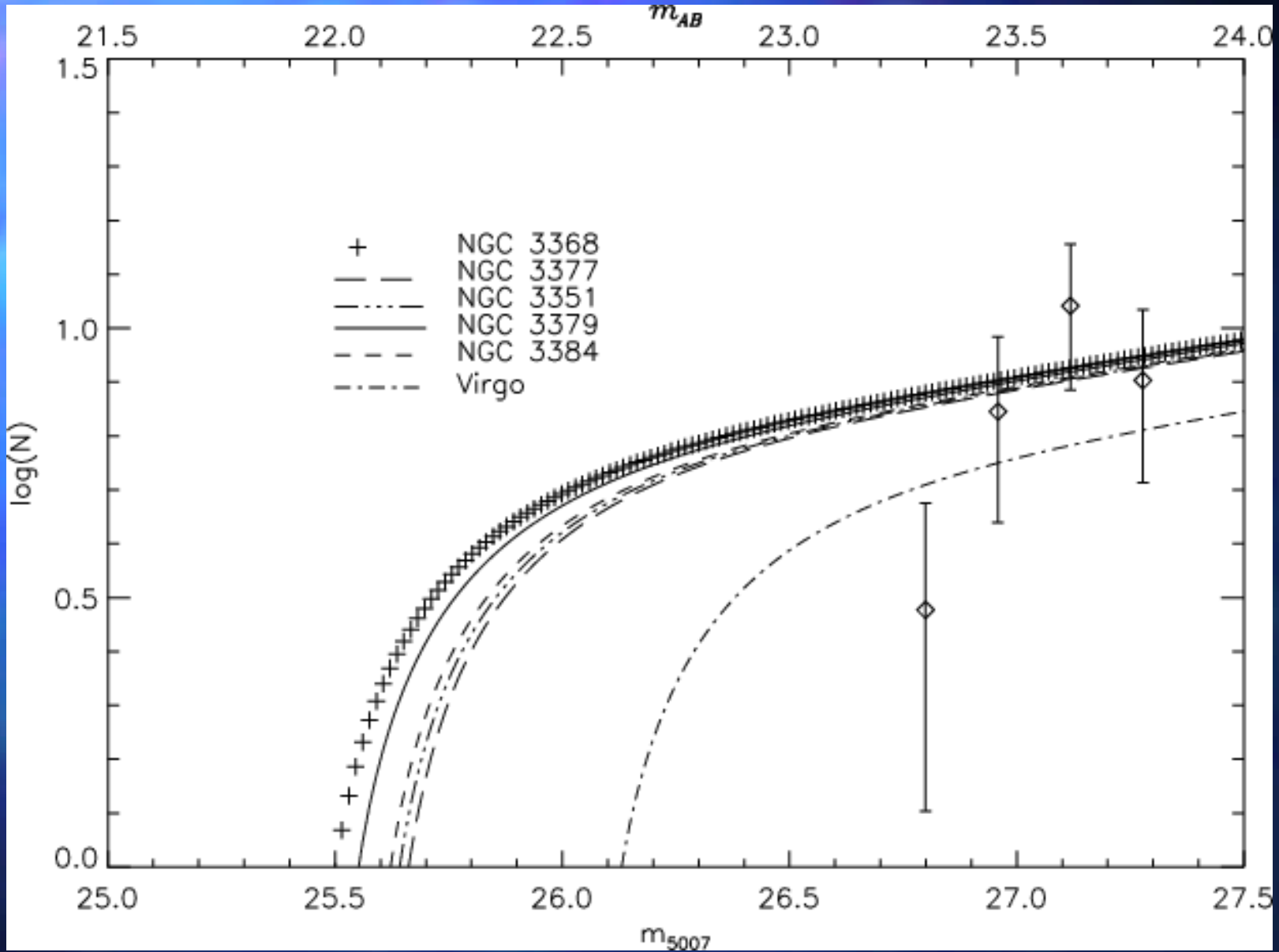
- The light from the difuse component is: difuse/(difuse+galaxies)
- The difuse light could be a local or global phenomenon.
  - Considering the global light of the galaxies
    - FCJ....17%; LPC....2%; Core.....5%
    - Mean in the Core region: 8%
  - Local light of the galaxies
    - FCJ....10%; LPC.....2%; Core.... 7%
    - Mean in the core region: 6%

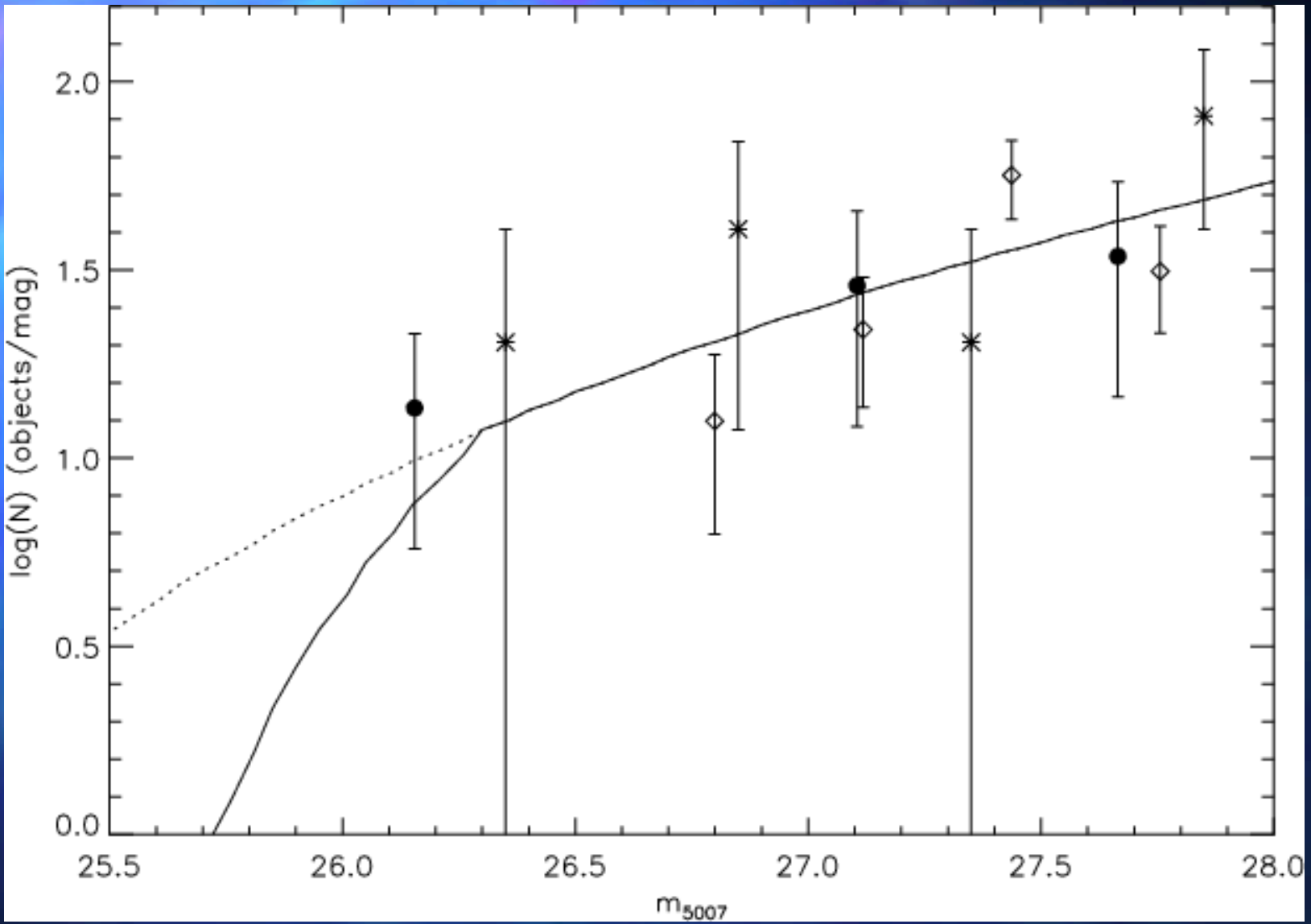
Difuse light in groups

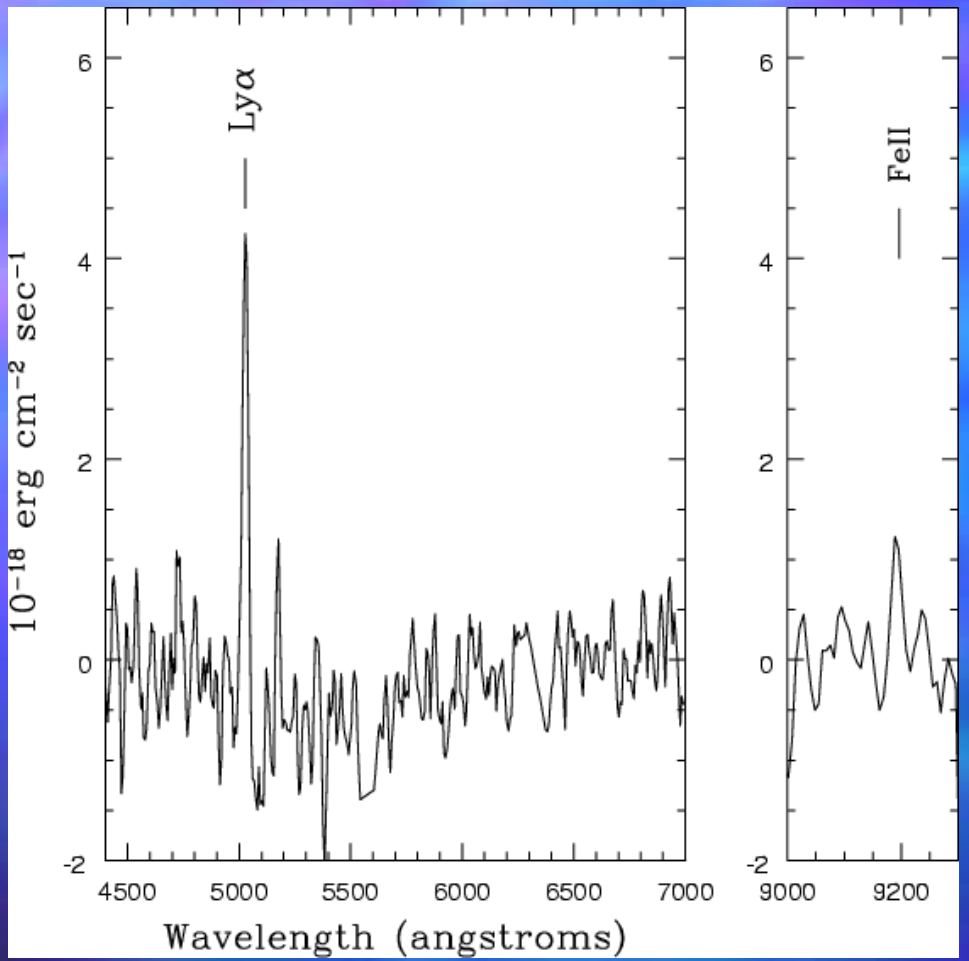
- Very few is know about the ICL in groups.
- If the ICL is due to galaxy collisions it should be less than in rich galaxy clusters
- Numerical simulations of groups predict that 5-25% of the total mass is in the IG.
- Only was previously studied M81. ICL=3%

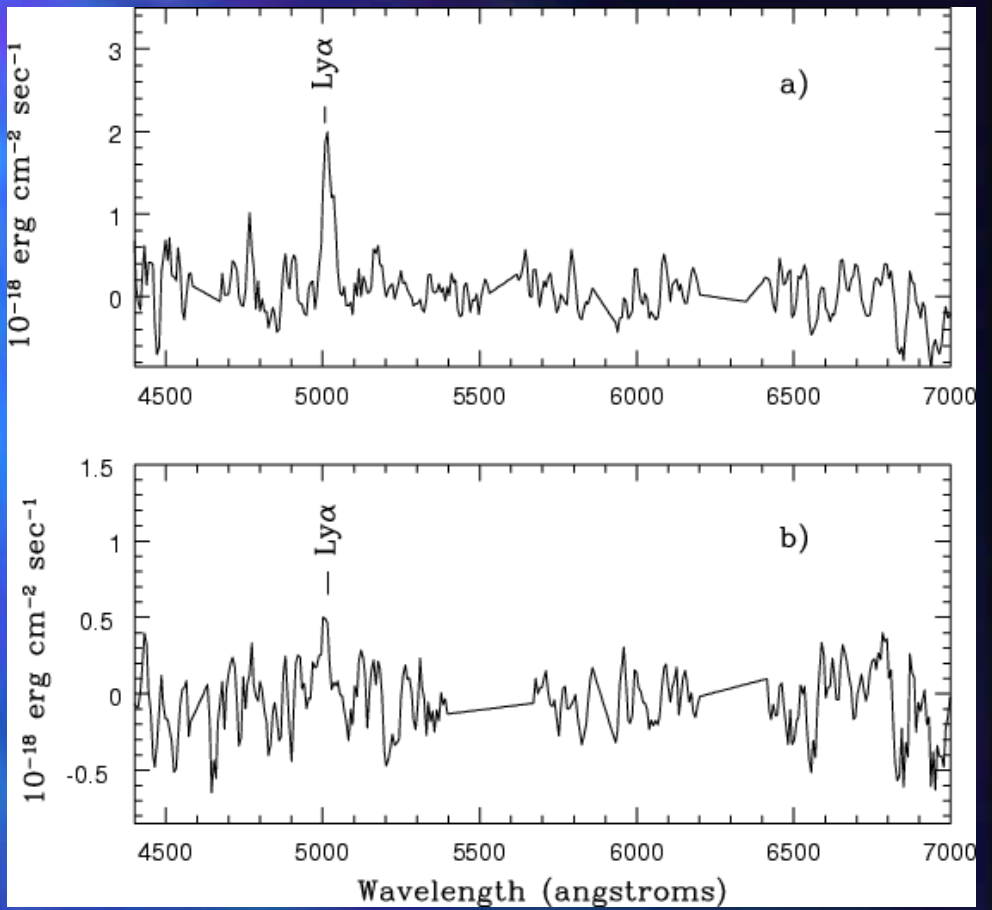
Intragroup light in Leo




m_{AB}
21.5
22.0
22.5
23.0
23.5
24.0
1.5
1.0
0.5
0.0
log(N)
NGC 3368
NGC 3377
NGC 3351
NGC 3379
NGC 3384
Virgo
25.0
25.5
26.0
26.5
27.0
27.5
m_{5007}


2.0
1.5
1.0
0.5
0.0
log(N) (objects/mag)
25.5
26.0
26.5
27.0
27.5
28.0
m5007


Lyα
FeII
10^{-18} erg cm^{-2} sec^{-1}
Wavelength (angstroms)


a)
b)
Lyα
10^{-18} erg cm^{-2} sec^{-1}
Wavelength (angstroms)

ICL in Leo group

- Considering an upper limit of 1IGPNe. The difusse component in Leo represent 1.6% of the total light.
- This field is used as blank field for contamination of Lyalfa galaxies in ICPNe in Virgo.

Future work

- Study the disc relation discovered in Coma in other clusters like A1367 and Hercules.
- Study the content of ICPNe in regions further from the Virgo cluster Core.
- Study the content of difuse light in more groups of galaxies.