SFGs & their Environment: Implications for Star Formation and Chemical Evolution

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1er Estallidos, Madrid Jan/03

¿Why Is it interesting at all?

The environment of Galaxies can affect their History of Star Formation (SFH)

e.g. Butcher & Oemler effect (c. 1978)

e.g. Morphology-density relation (Dressler & Co.)

From the *scale* of the HII regions in the *Milky Way*, SF regions in our *Local Group* to the SBs located in *galaxies in groups and clusters*, the *environment* is playing a key role.

Environment and star formation activity

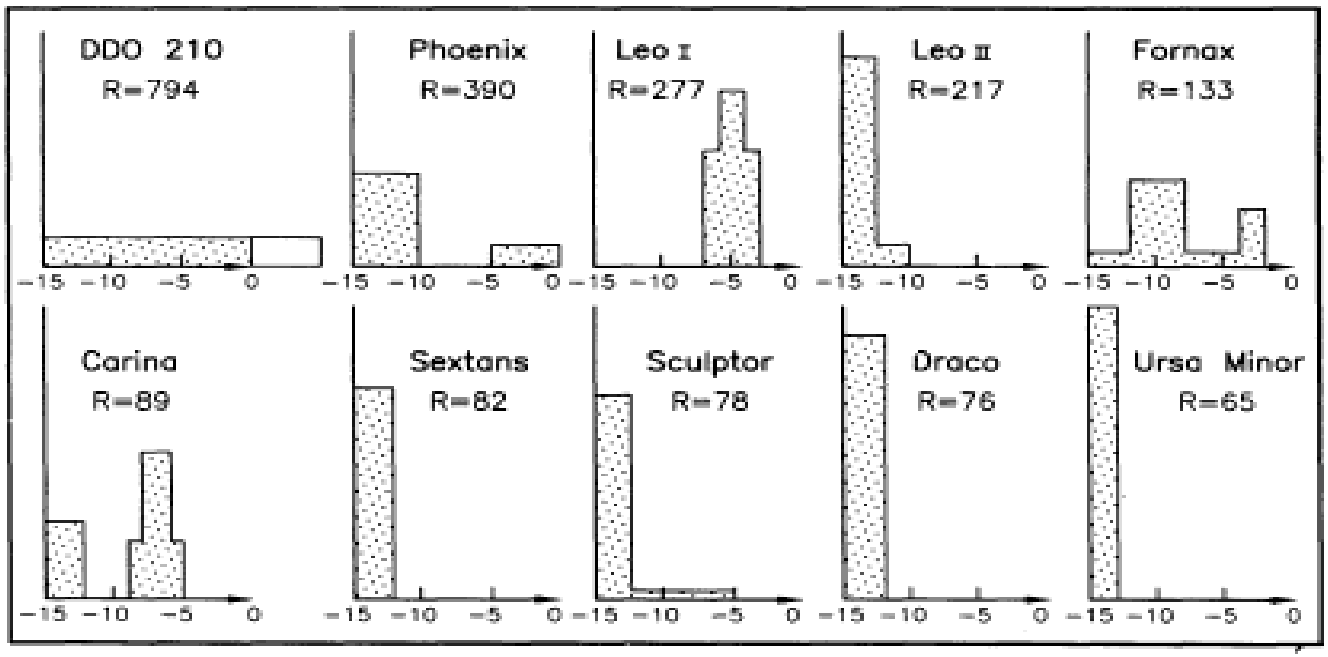
Selected ** NEARBY ** observational clues:

1.- Impact on the disk and bulge of the MW of objects/material from its very close environment ***(HVCs, infalling *s & g. clusters, "Big Dent" etc).***

2.- The tidal interaction of the Magellanic Clouds, & nearby dSph (Sag) with the Milky Way.

3.- The impressive pattern of the History of Star Formation of the galaxies belonging to our Local Group.

The Local Group: a Cartoon of SFH of dwarf galaxies
(van de Bergh 1989; 1994. Ap J 428, 617)



cartoons of star formation rate vs. time for Local Group dwarfs. Oldest stars were assumed to have an age of 15 Gyr. The
st Galactocentric distances *R*(kpc) started their existence with an intense burst of star formation. In most more distant dwa
ed at a more leisurely pace. The quoted Galactocentric distances were calculated from the heliocentric distances given in van

The history of star formation of LG galaxies changes in-out: Galaxies closer to the LG center MW--M31 show ``older´´ SFHs

Groups and Clusters:

Apparently there is a two-fold effect acting on gas rich disk galaxies.

Observational fact: **HI deficiency in spiral galaxies of nearby clusters (Virgo, Coma):**

Observations show high HI deficiency at environments with higher densities.

Should Chemical Evolution reflect this fact?

(Cayatte et al. 1990; Haynes et al. 1984; Solanes et al. 2001; Bravo-Alfaro et al. 2000; Skillman et al. 1995 ; Pilyugin, Mollá, Ferrini & Vílchez 2002)

HI in Virgo
Cayatte et al. (1990)

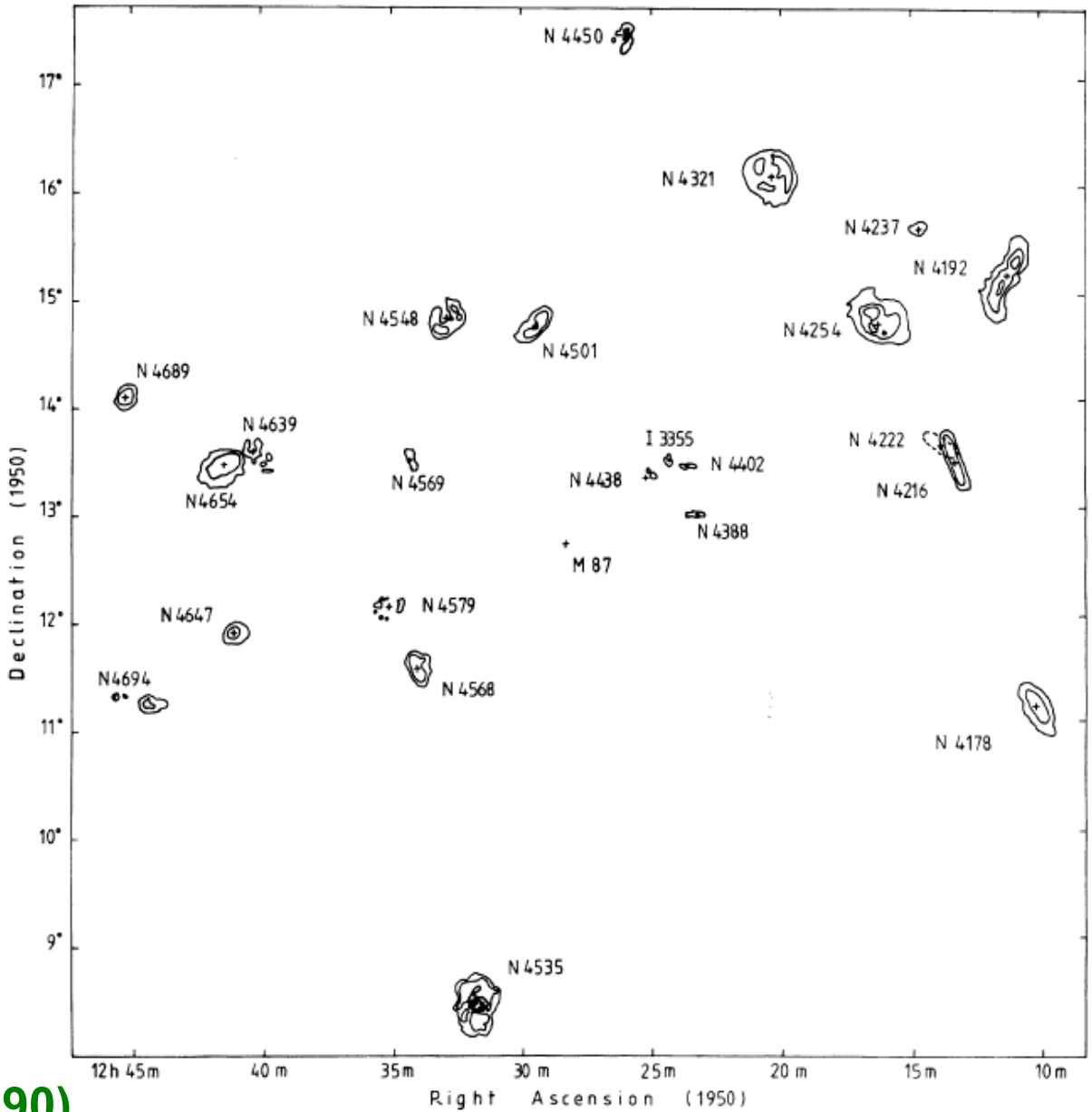
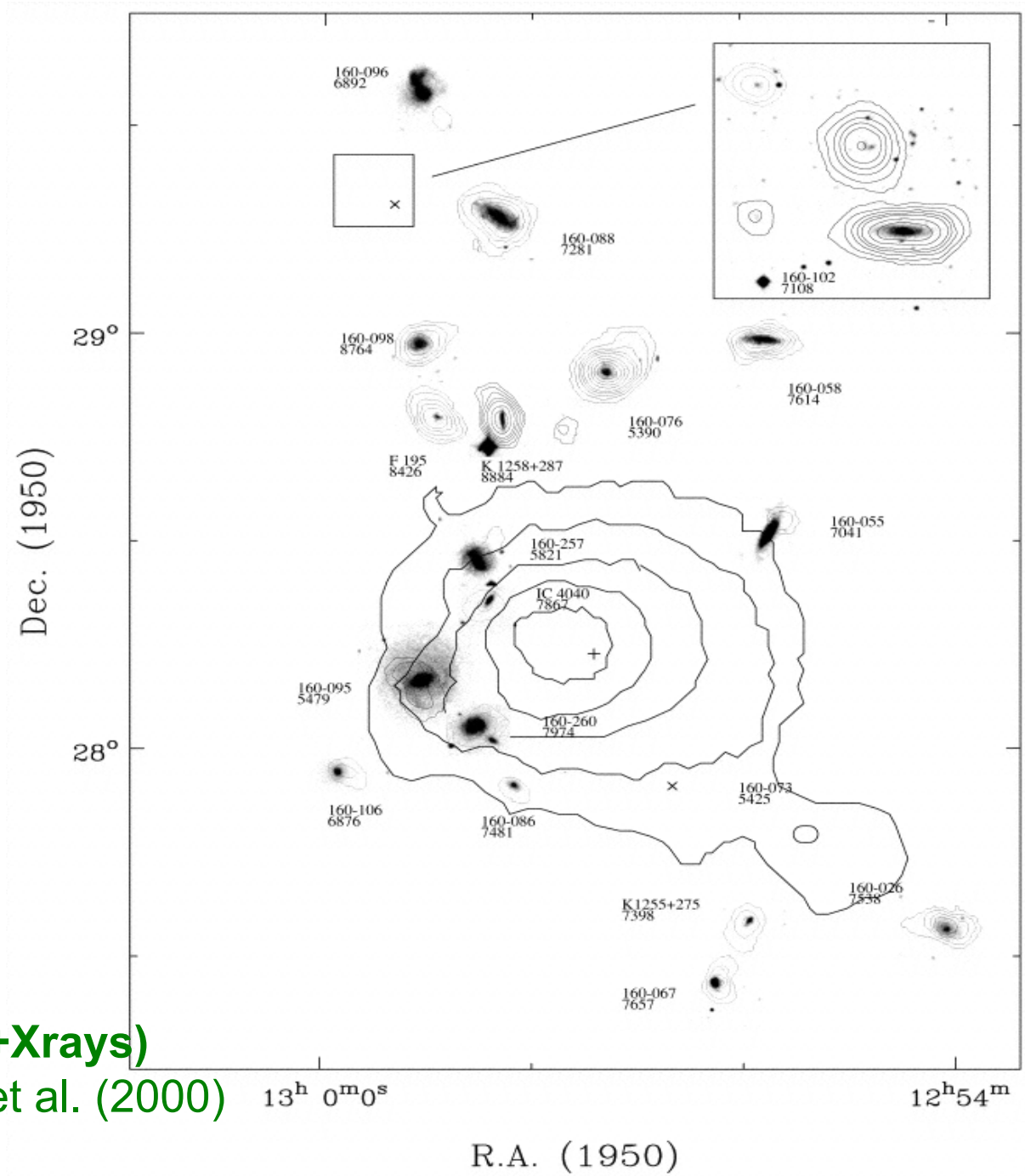
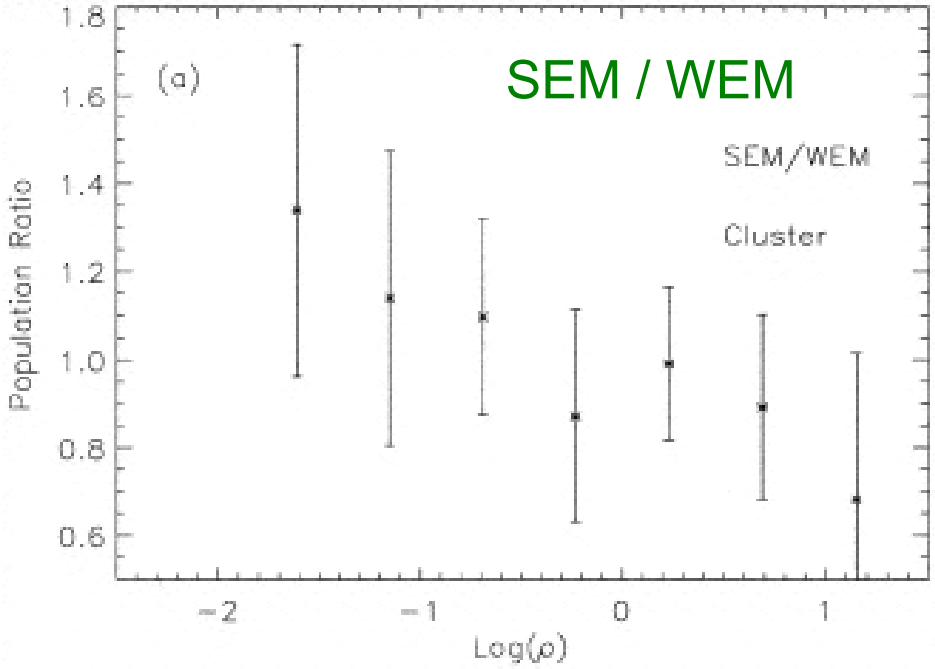


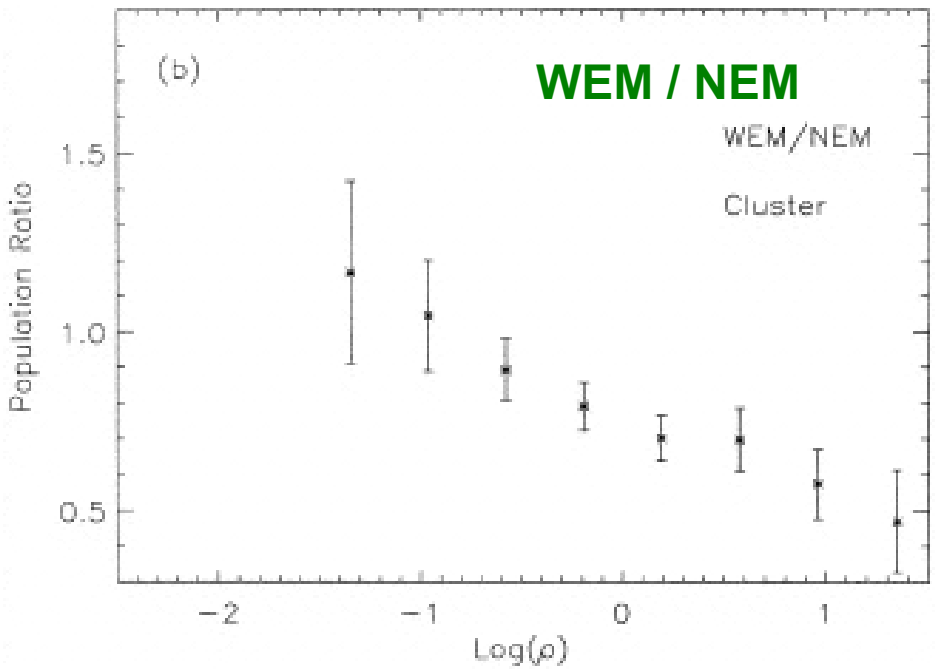
FIG. 23. Integrated neutral hydrogen maps of the brightest spirals in the Virgo Cluster center. Each map has been drawn at the galaxy position indicated by a cross and magnified by a factor of 5 compared with the scale in right ascension and declination. The first contour in each map corresponds approximately to a column density of 10^{20} atoms cm^{-2} (even if it is not the case in the maps published in Figs. 1–22 especially for NGC 4388, 4450, 4569, 4694).



HI in Coma (+Xrays)

Bravo-Alfaro et al. (2000)





Population ratio of the *emission line galaxies versus density of the environment* in LCRS (clusters)

SEM: Strong emission lines

WEM: Weak emission lines

NEM: No emission lines

LCRS: Las Campanas Redshift survey

Hashimoto et al. (1998)

A two-fold effect acting on gas rich disk galaxies :

1).- **Inhibition ** of further SF in very high density environments:

Gas removal, Ram pressure stripping, Harassment, [especially in clusters]

=> PUT GAS OUT => ***"Quenching" of SF***

(*ALSO:* even it may change the appearance and morphological type class)

(Koopman & Kenney 1996; Hashimoto et al. 1998; Iglesias-Páramo & Vílchez 1999; Verdes-Montenegro et al. 2001)

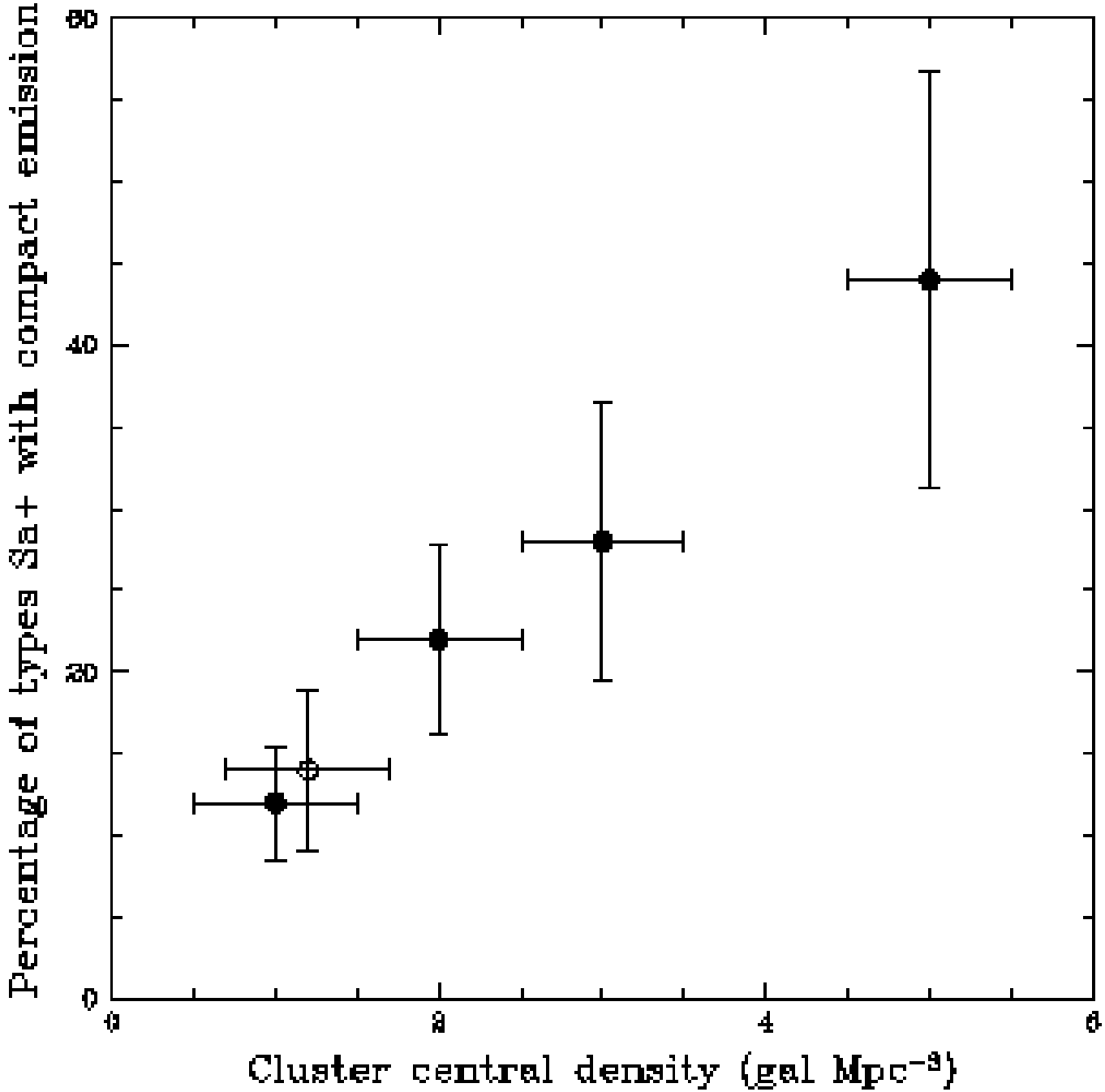
2) **Enhancement** of starbursts after a strong interaction, galaxy mergers; or subcluster merging

=> ***GAS is PILED UP:*** *inducing (circum)nuclear SBs; and/or tidal dwarfs in the outer parts*

(e.g. Moss & Whitle 1997; Vílchez & Iglesias-Páramo 1998; Rose et al. 2001)

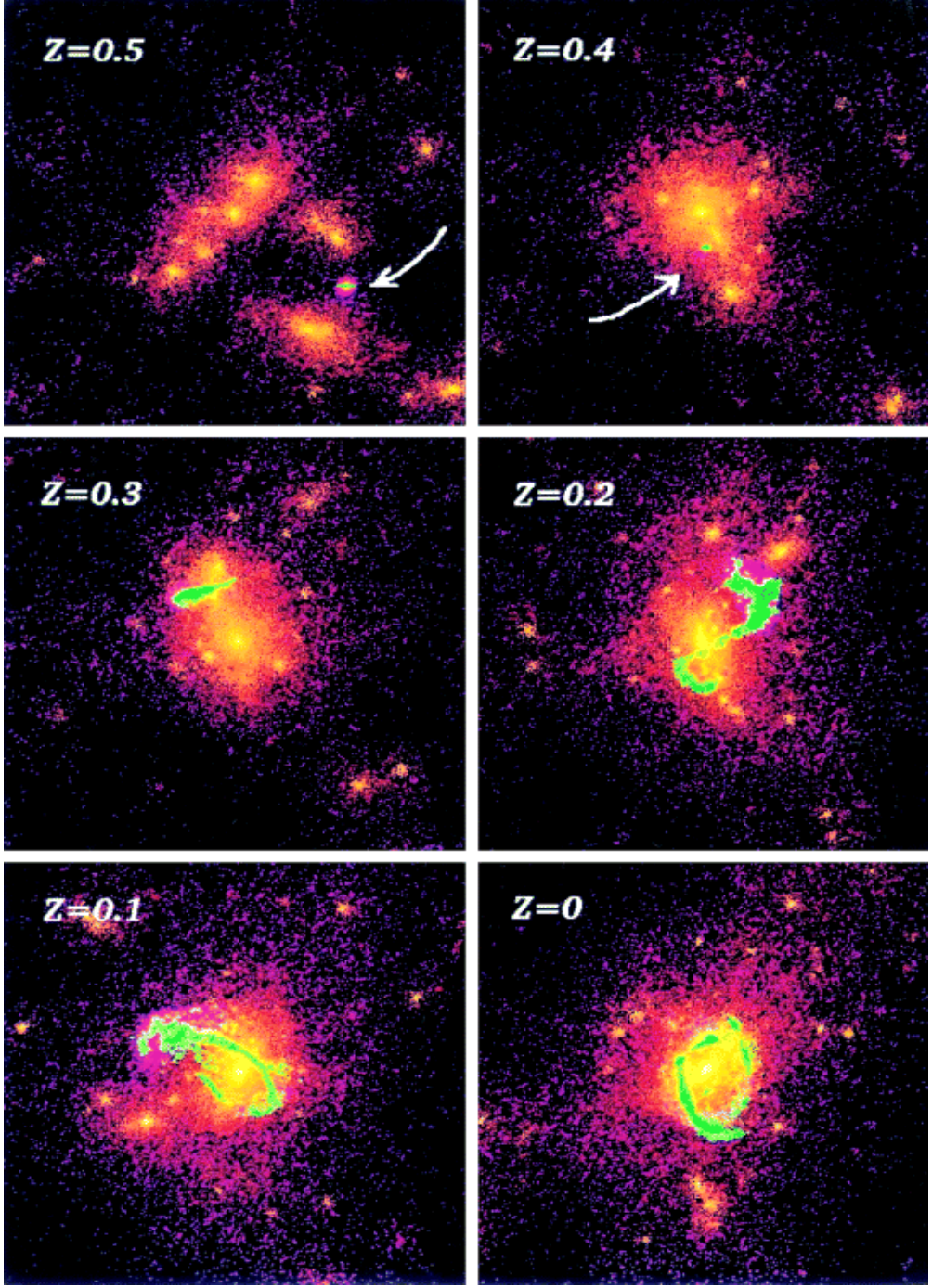
On average, the **present day SFR derived for groups of galaxies is similar or reduced with respect to the field**

>> Pionnering work: Larson&Tinsley (1978) suggested enhanced SF
>> Moles et al. (1994) studied SF in HCGs: similar/slightly higher rates
>> SF rates (Ha) derived for a large sample of HCGs
(Iglesias-Páramo & Vílchez (1999) ; Severgnini et al. 1999)



SBs in Clusters and Compact Groups

The percentage of early types with compact emission increases with cluster density (Moss & Whitle, 1997)



A quick look to the MODELS!!

Survival and/or destruction of disks (spiral) galaxies in clusters (Moore et al. 1998)

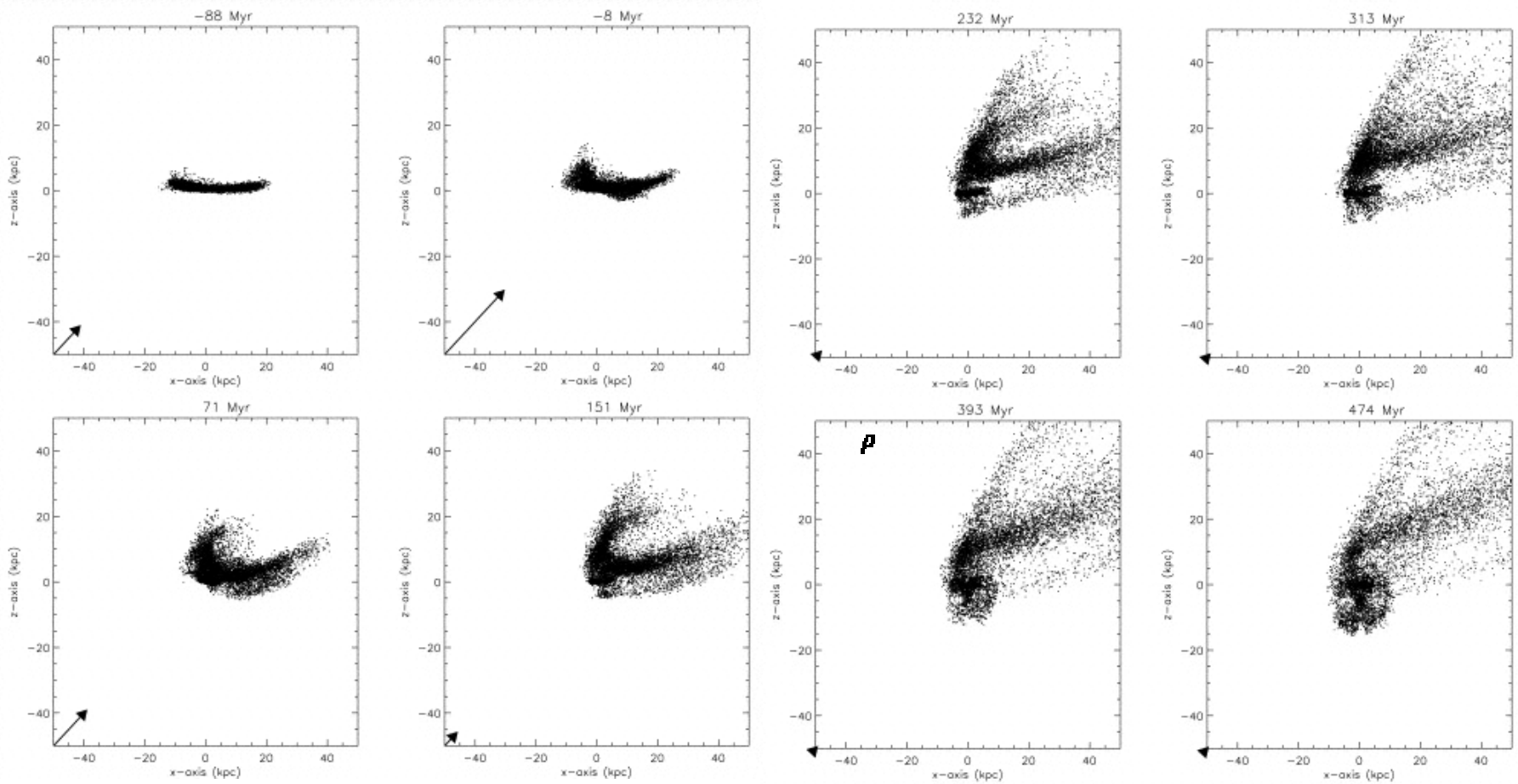
Particle distribution within a comoving **10-Mpc box centred on the forming cluster.** The redshifts of each frame are indicated.
Colors show density of Dark Matter in fractions of 10^6 times the mean density.

Green particles are star particles from the disc of high resolution model galaxy.

Initially the stars are confined to the disc, but at *z*=0 they are spread along the orbital path of the galaxy which has an apocentre of 1000 kpc and a pericentre of 250 kpc.

The virial radius of the cluster at z=0 is 2Mpc.

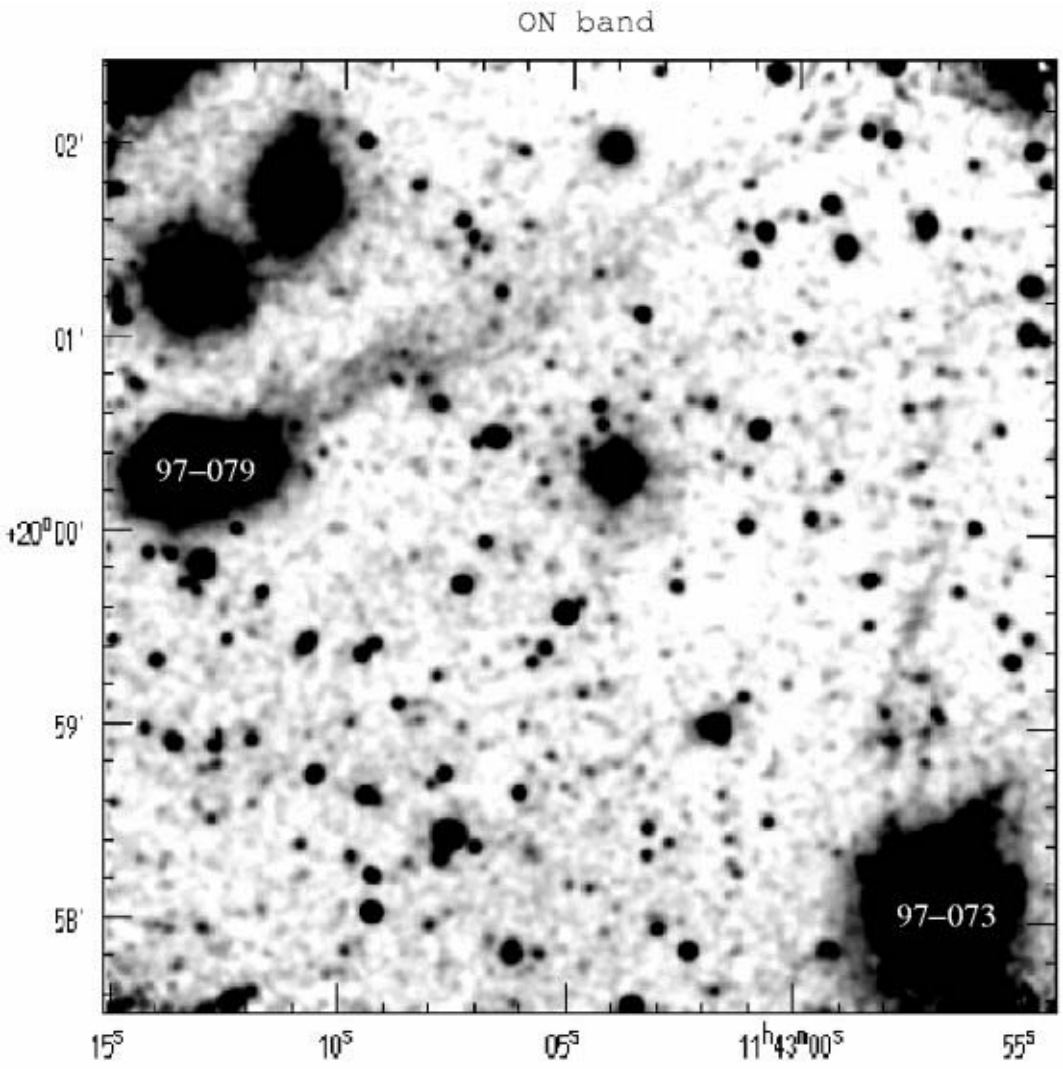
But , the incidence angle and the infall direction are crucial parameters (Vollmer et al. 2001 ApJ 561, 708)



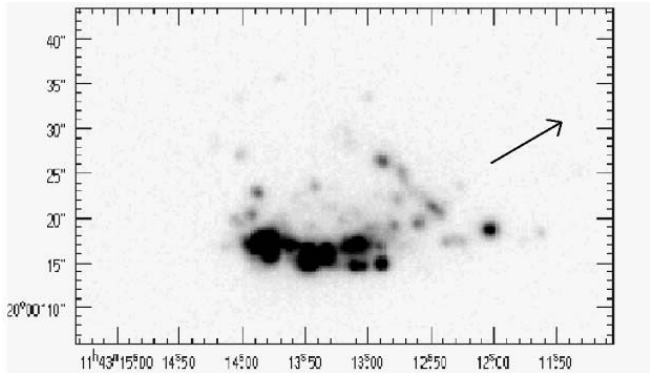
The galaxy is edge-on and is moving SW, i.e., the wind is coming from SE as indicated by the arrows of length proportional to ρv^2 .

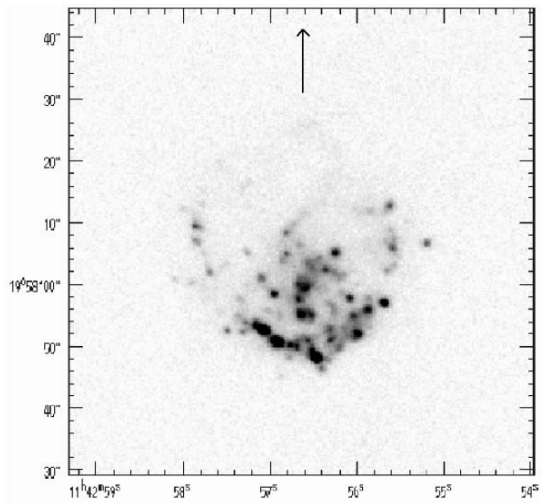
Some models predict that a variable amount of mass fall back into the galaxy.

Ram pressure: Detection of 75kpc Ha trails of two dIrr from our deep Halpha survey of A 1367



Iglesias-Páramo,Boselli, Cortese Vilchez, Gavazz i (2002) The Coma & A1367 survey in Ha





They are falling into the cluster for the first time (Gavazzi et al. 2001)

SF in dense environments: Summary

- "Surprisingly, the evolution with z of **the fraction of emission line galaxies in clusters has not been properly quantified so far**" (Poggianti, 2002)

- At **z>0, clusters have a population of active SF galaxies larger than the field**, though both SF populations increase with z (0<z<0.5; Balogh et al. 2002; Lewis et al. & 2dFGS)

- For **nearby clusters, it seems to exists a threshold for the decrease in EW(Hα) versus projected radius** (Mp < -19.5): fainter gals. in Virgo & Coma do not show any clear trend (Gavazzi et al 2002)

- The populat. of **SF dwarf galaxies in (nearby) clusters** with respect to the field **still under investigation: LF faint end**

We are carrying out a project to study SF & Chemical Evolution of galaxies in nearby groups and clusters:

i) Sample of compact groups (HCGs) with $z<0.02$

ii) Sample of nearby ($z<0.035$) Abell **Clusters**:

Virgo, Coma, A1367, Hércules, A634, A400, A2666, A539…

Virgo:

Spectroscopic survey of 22 BCDs & dIrrs	(Vílchez & Iglesias-Páramo 2003 & ongoing)
Deep Ha, R Imaging of BCDs	(Boselli, Iglesias-Páramo, Vílchez, Gavazzi 2002)
Chemical Evolution of Spirals vs. HI Deficency	(Pilyugin,Mollá,Ferrini,Vílchez 2002)

Coma & A 1367:

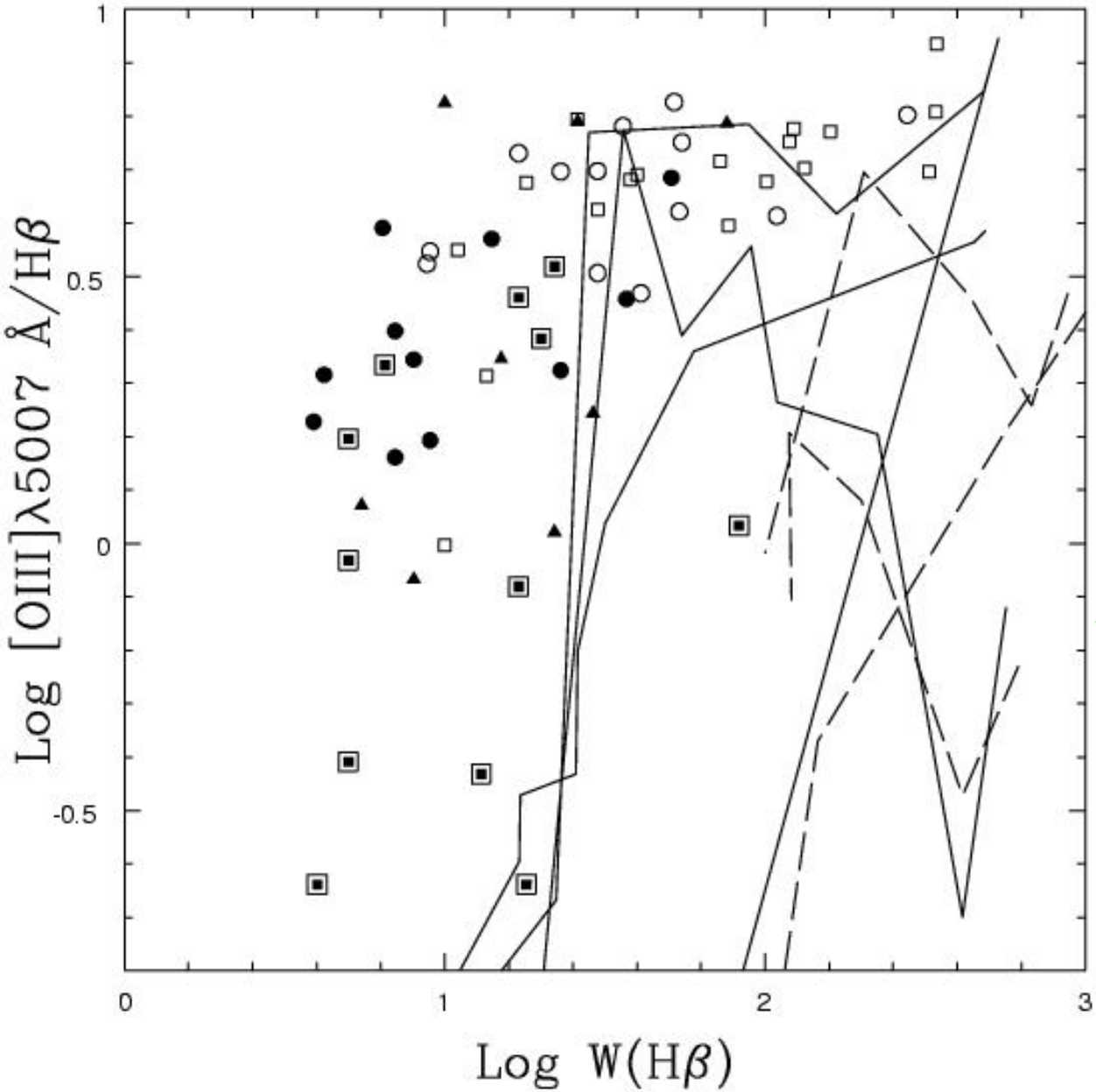
Deep Halpha survey: Halpha LF	(Iglesias-Páramo,Boselli,Vílchez,Gavazzi, 2002)
The r´ LF of A1367 & Coma vs. Field	(I-P,B,V,G A&A)
The spatial distribution of Sersic n-index of galaxies	(J.A. Aguerri,I-P,JMV,CMT)

Hércules:

Deep survey for dwarfs: optical spectra, photometry, HI	(I-P, Duc, Papaderos, JMV et al.)
VLA HI search for dwarf galaxy candidates	(W.v. Driel, I-P, P, Balkowski, V, et al.2003)
Deep B,V,i Halpha imaging. V band LF	(R. Sánchez, D Reverte, I-P, JMV, CMT ongoing)

A634: **Halpha & Cont. 1.5 deg2 WFC. LF** (D. Reverte PhD, JMV, I-P ongoing)

VIRGO Dwarf Galaxies: spectral properties

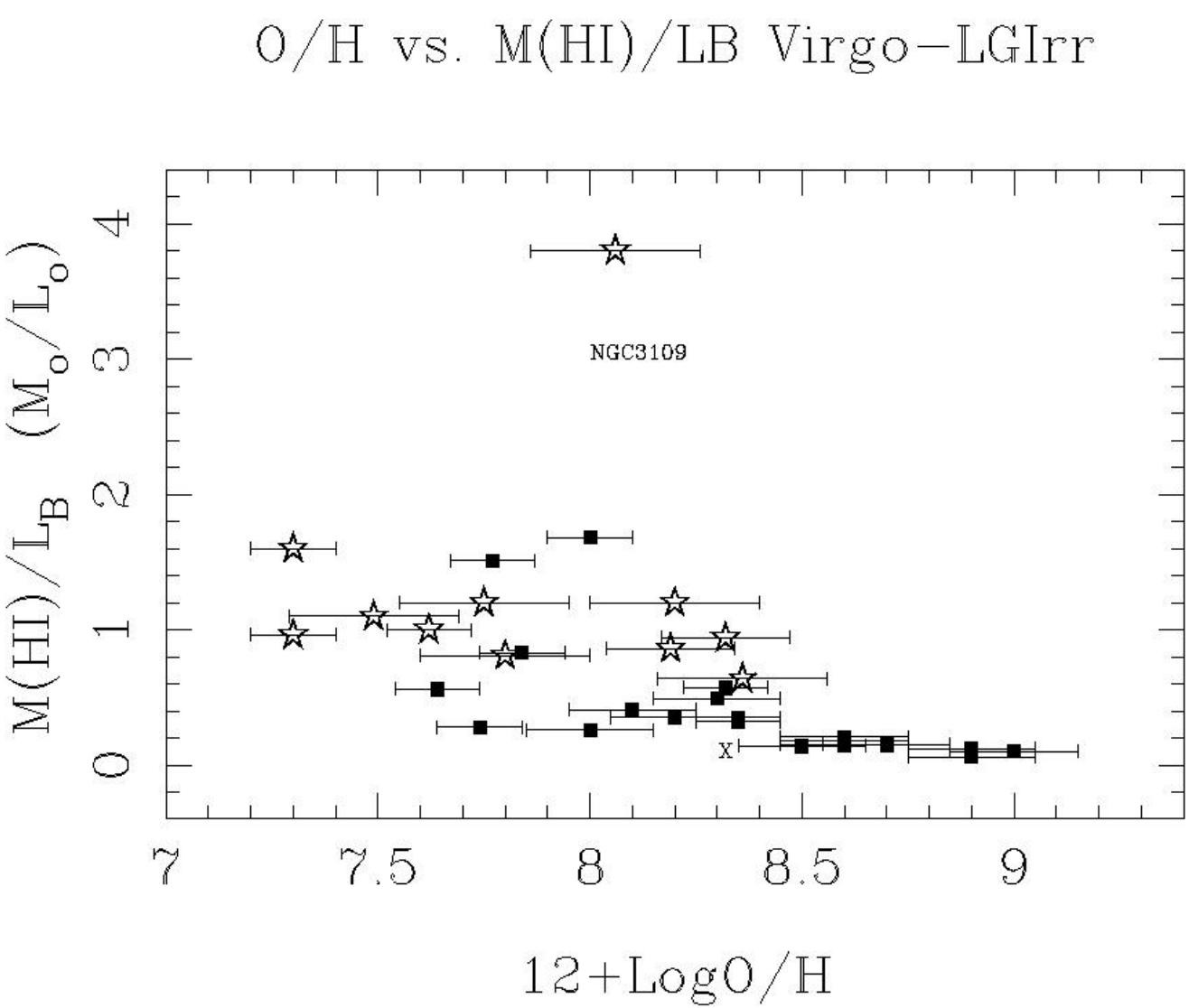


Do we have any evidence for a more evolved, underlying population ? :

Fading massive post-SBs or red /evolved dwarf galaxies with a new/recent SB ?

< Some show v. low EW(Hbeta)

Virgo galaxies: Chemical Evolution

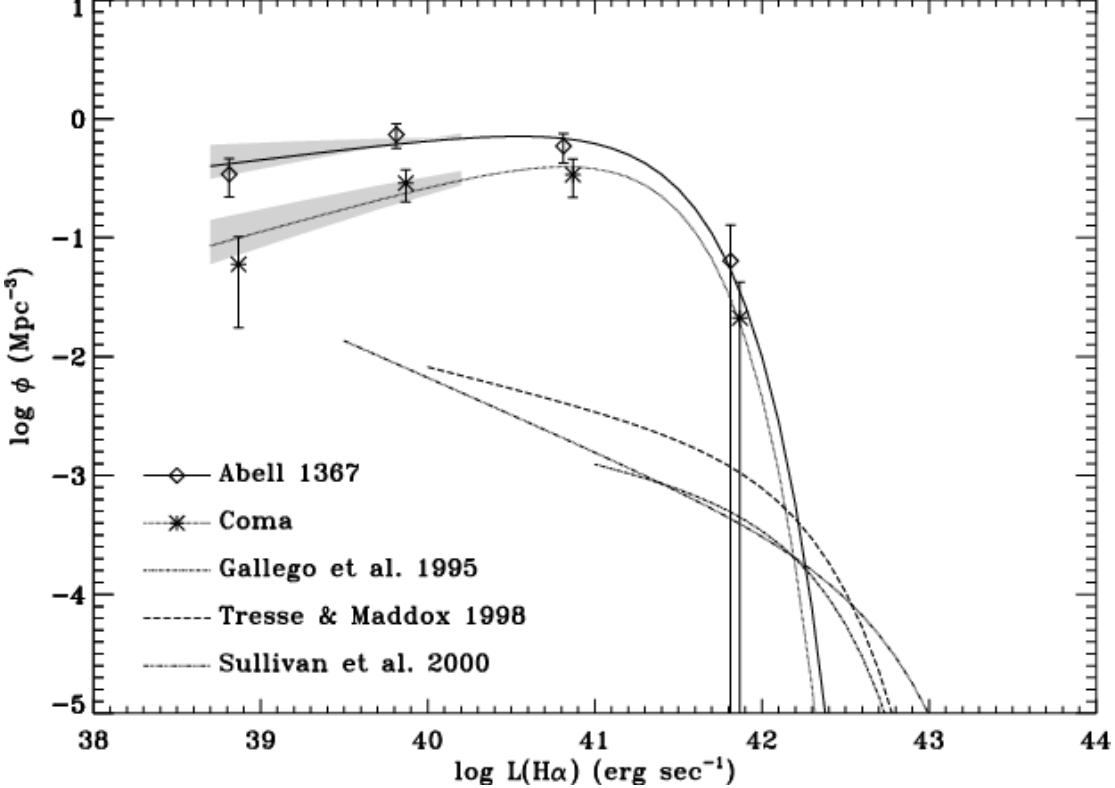


i) **HI deficient Spirals show similar O/H than field spirals of same Hubble Class. N/gives more clues about their chemical evolution**

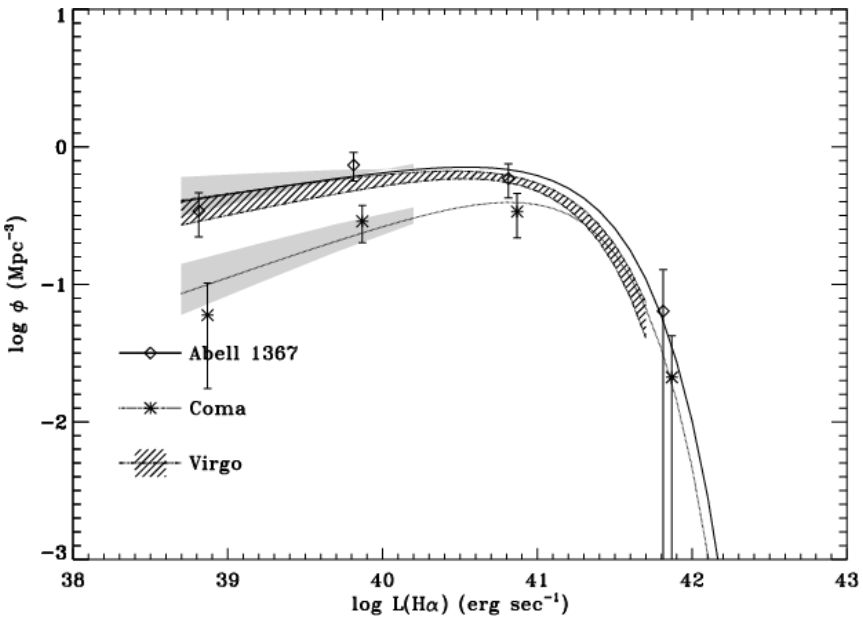
ii) **Dwarf galaxies follow the L-M relation with some O/H & N/O Enhancements.**

For standard yields & abundance, appear gas deficient with respect to Simple Close Box Model

Coma & A1367:
Luminosity Function



Comparison of the LFs of Halpha with the local field and the CFRS survey LF.



$$\phi(m) = \phi^* \cdot [10^{0.4(m^*-m)}]^{\alpha+1} e^{-10^{0.4(m^*-m)}}$$

Comparison of the Halpha LFs derived for Coma, A1367, Virgo The three nearby clusters show similar slopes

(Iglesias-Paramo et al. 2002)

Some questions & caveats about SF and Chemical Evolution of galaxies in dense Environments

>> At z>>>0 clusters show a population of active SF galaxies larger than the field and both populations increase with z. Is this behaviour just a consequence of the known morphology-density relation (MDR) evolving with z ?
Or is / are there other effect(s) on top of that ? :

Possibles ways out?:

- *i) It can be just MDR + a certain modulation by the effect of e.g. the galaxy infall rate into the cluster? Or + ram pressure stripping (overall)?*

- *ii) Possibly, there exists physically a "density threshold" in nº galaxies per Mpc^{-2} with Mb< -19 (Lewis et al. 2002, and the 2dFGS team)*

- *>>But we do not know what is the exact role/relevance of large scale structure in modulating the activity of SF and/or Metallicity Enrichment in clusters.*

Dwarf & Gas-rich Galaxies

>> They remain an *open question* for galaxy evolution in dense environments e.g. :

- **Is the *survival of SF dwarfs & disks* (Spirals) in clusters a real challenge for models?**

- **Last but not least: BETTER DATA! There are still many biases; e.g. most spectroscopic surveys do not detect extended emission, This is a critical point ! (see Rose et al 2002)**

- **BUT photometric (emission line) observations alone are loosing precious information too**

  => a combination of both techniques is needed for the deepest surveys at z>0