



Transition Dwarf Galaxies in Nearby Groups of Galaxies

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S.Côté, A.Draginda (CFHT) , E. Skillman (U.of Minnesota),
& B. Miller (Gemini) 2009 (submitted to AJ)

Transition Dwarf Galaxies?

- Transition Dwarfs show characteristics of both:

Early-type dwarfs
(dwarf ellipticals & dwarf spheroidals)

-No on-going star formation

-No ISM

-Pressure-supported

dwarf Irregulars

*-Show star formation with
HII regions*

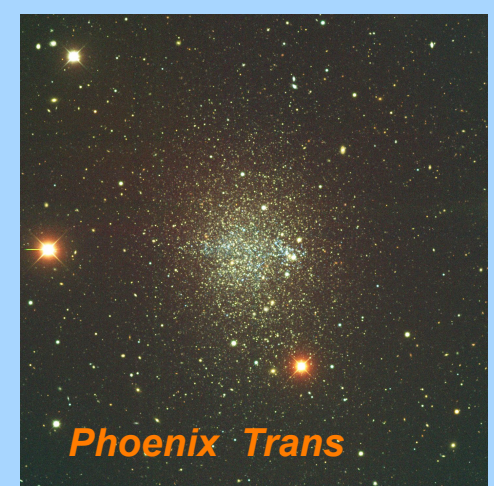
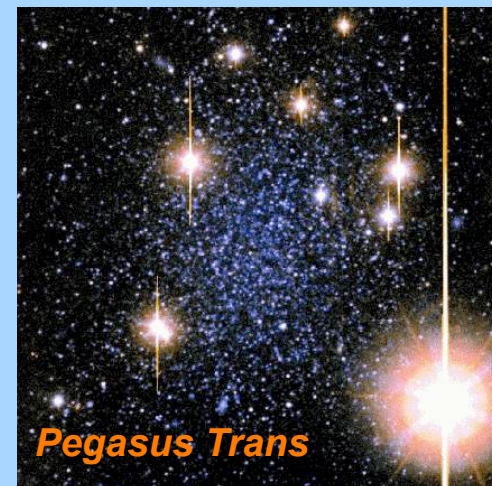
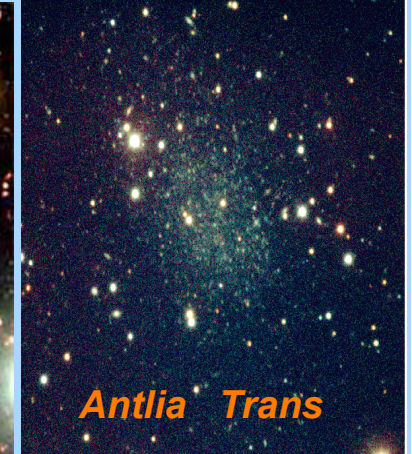
-HI rich

-Show appreciable rotation

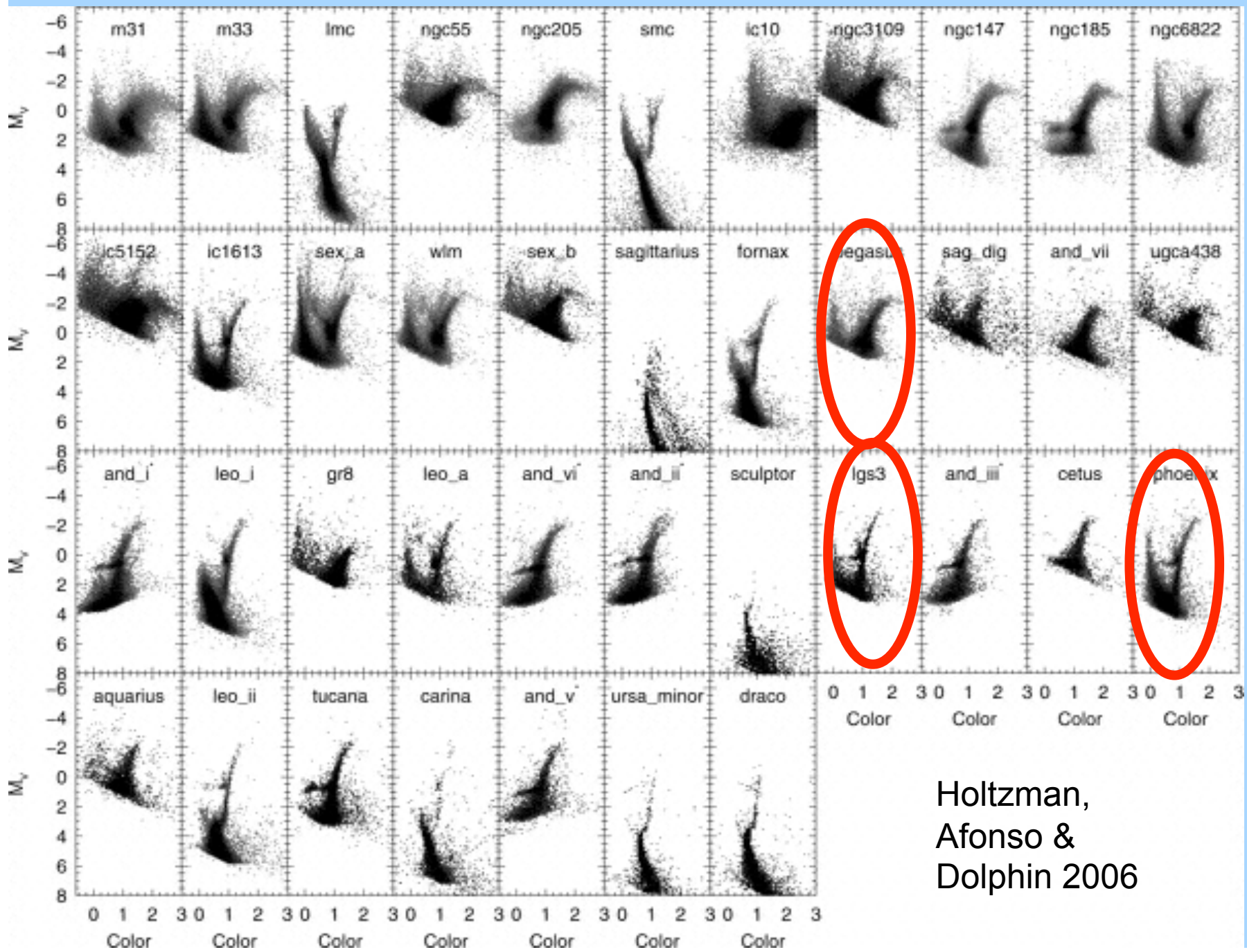
*“Mixed-morphology” dwarfs known since ddo210, Pegasus
(van den Bergh 1959). Discussed as “transition dwarfs” by
eg. Sandage & Hoffman 1991, Mateo ARAA 1998)*

***Warning! Not to be confused with dwarf galaxies – globular clusters
“transition objects”***

Transition Dwarf Galaxies?



Images from Massey et al 2007, NOAO Local Group Galaxies Survey Team



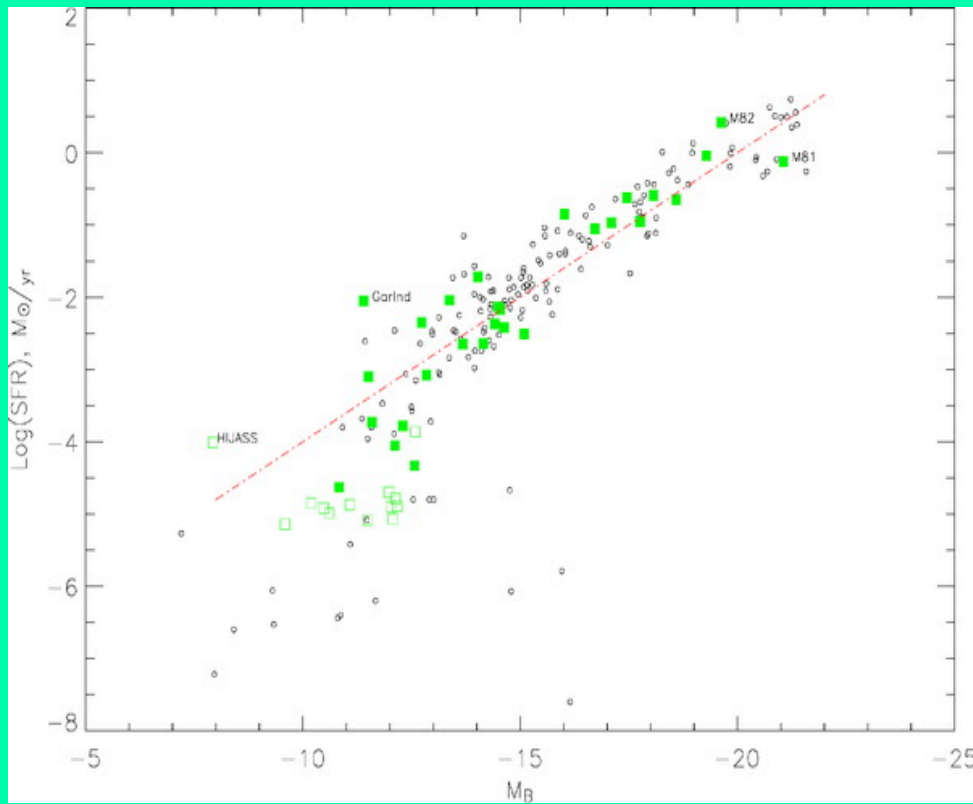
Holtzman,
Afonso &
Dolphin 2006

Transition Dwarf Galaxies?

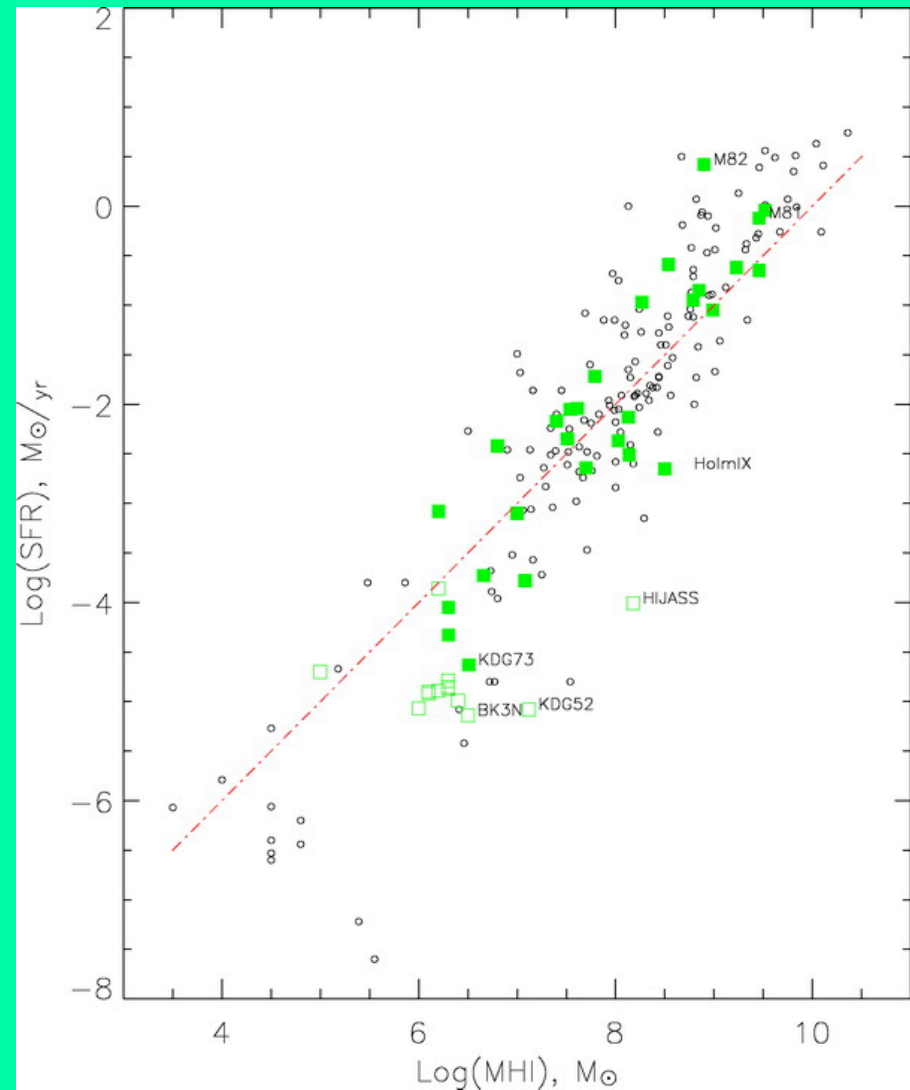
- Transition dwarfs have cold gas (HI) like dIs, but with no or much reduced star formation (as traced by $H\alpha$)
(*eg. Mateo 1998, Grebel, Gallagher, Harbeck 2003, Skillman, Côté, Miller 2003*)

Classifications based on optical morphology are too subjective

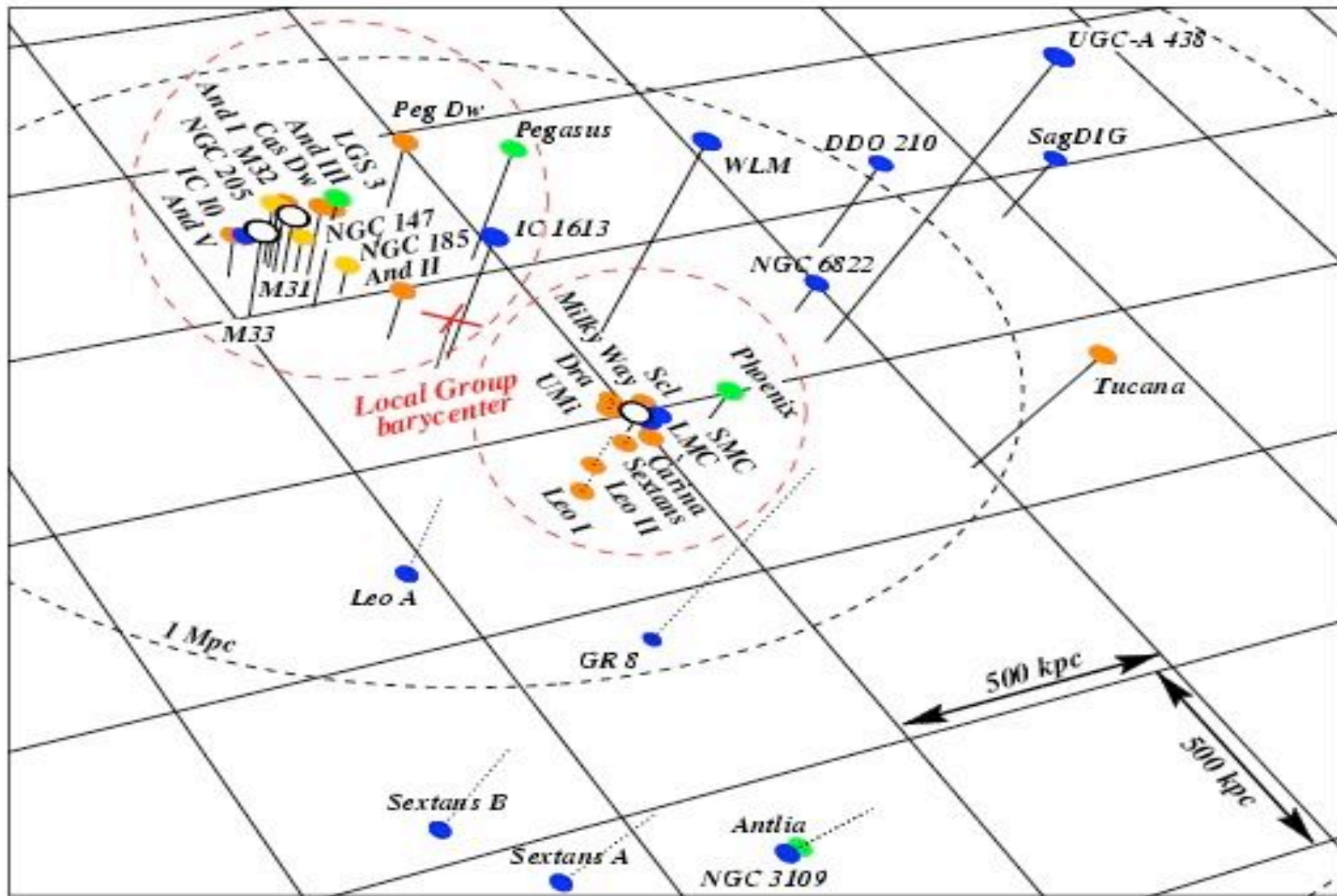
- They have been proposed as a “missing link” between the two classes of dwarfs
(*eg. Grebel, Gallagher, Harbeck 2003*)



Karachentsev & Kaisin 2007



Transition dwarfs detected in $\text{H}\alpha$ have much lower star formation rates for their absolute magnitudes, or for the HI mass.



(Image from E.K. Grebel 1999)

Morphology-density relation in the Local Group:

dSph, dEs are found in proximity to larger galaxies, dIs further away, transition dwarfs are in-between

H α imaging surveys

- H α survey of dIs in the Sculptor Group
1.5m Danish ESO with DFOSC, FOV 13'.6 x 13'.6
 $\mu_{\text{lim}} \sim 5 \times 10^{-17}$ erg/s/cm²/arcsec²
8 dwarfs observed + 4 from Miller (1996), van Zee (2000)
(Skillman, Côté, Miller 2003)

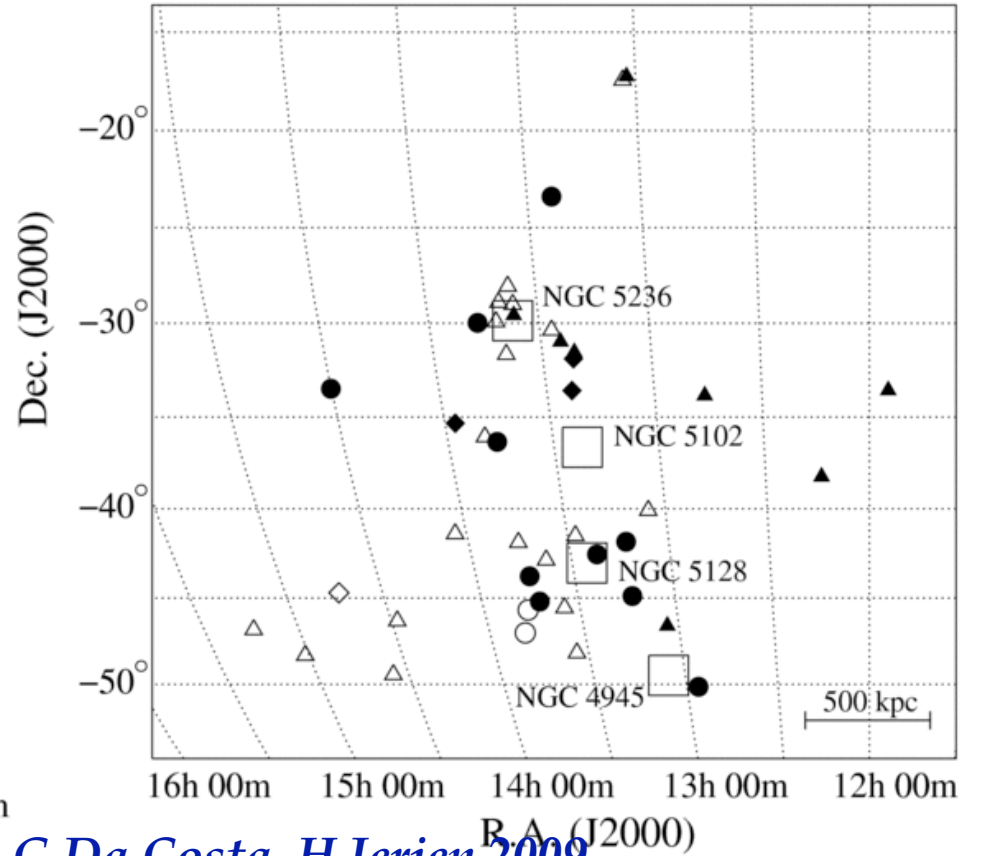
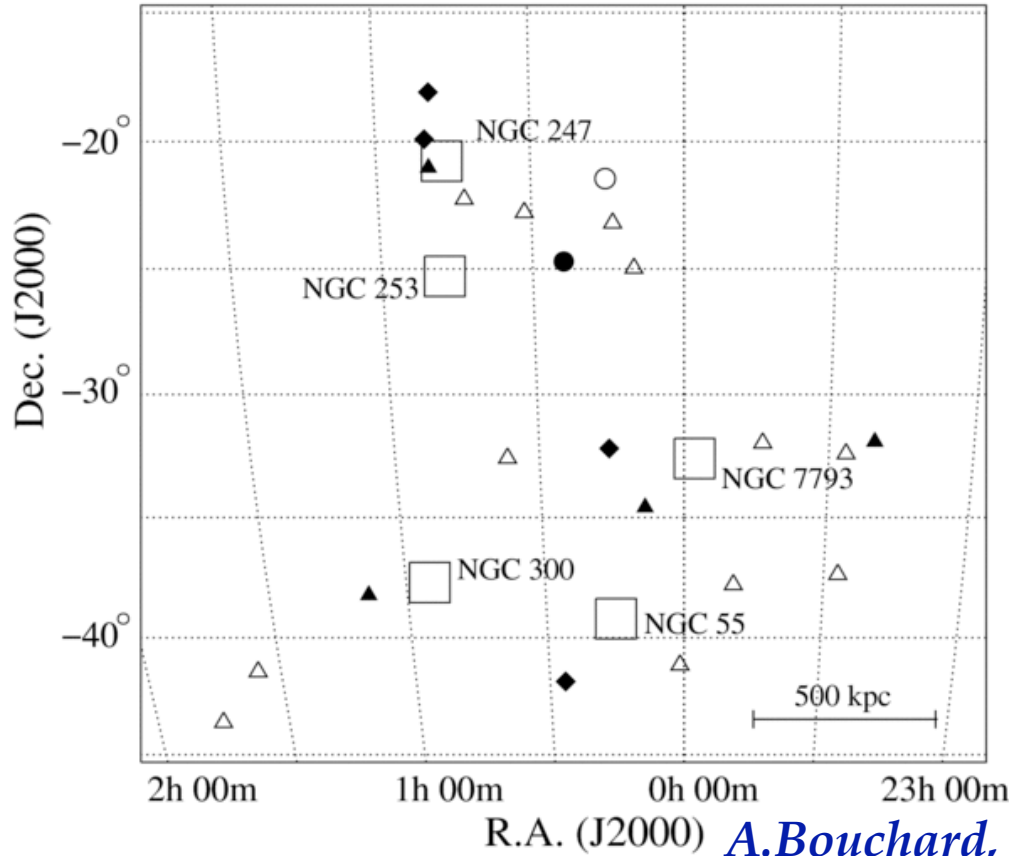
The Sculptor Group is a loose (low density) group, of late-type spirals

- H α survey of dIs in the Centaurus A Group
0.9m CTIO, FOV 13'.5 x 13'.5 $\mu_{\text{lim}} \sim 3 \times 10^{-17}$ erg/s/cm²/arcsec²
17 dwarfs observed + 1 from Bouchard et al (2009)
(Côté, Draginda, Skillman & Miller, submitted)

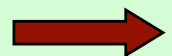
The Centaurus A Group is an "active" group, all the main members have been through a period of enhanced star formation

Sculptor Group 3.95 ± 1.6 Mpc

Centaurus A Group 4.35 ± 0.75 Mpc



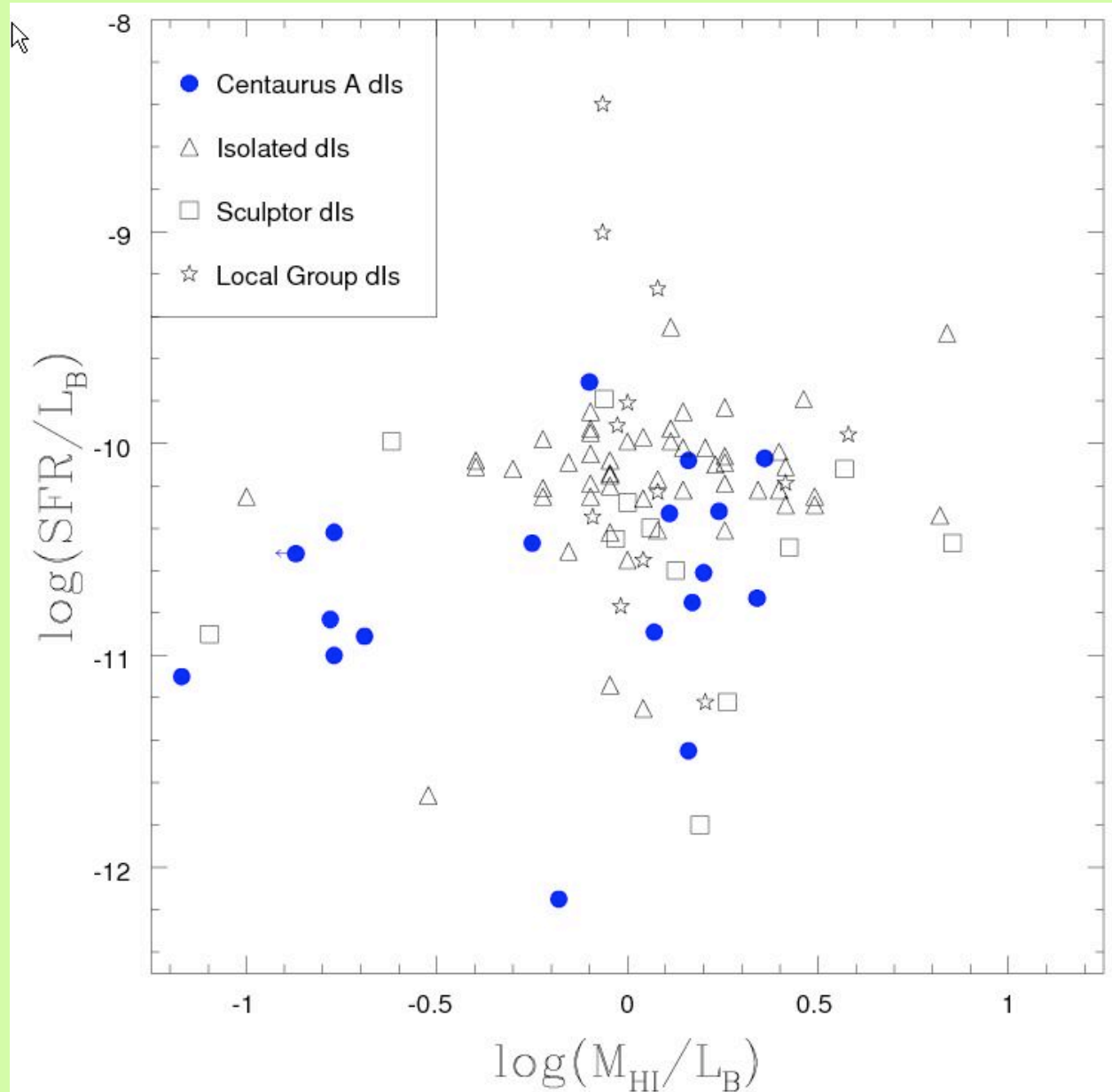
Do the Centaurus A dIs also have an elevated level of star formation? Are there more dwarf starbursts in this Group?



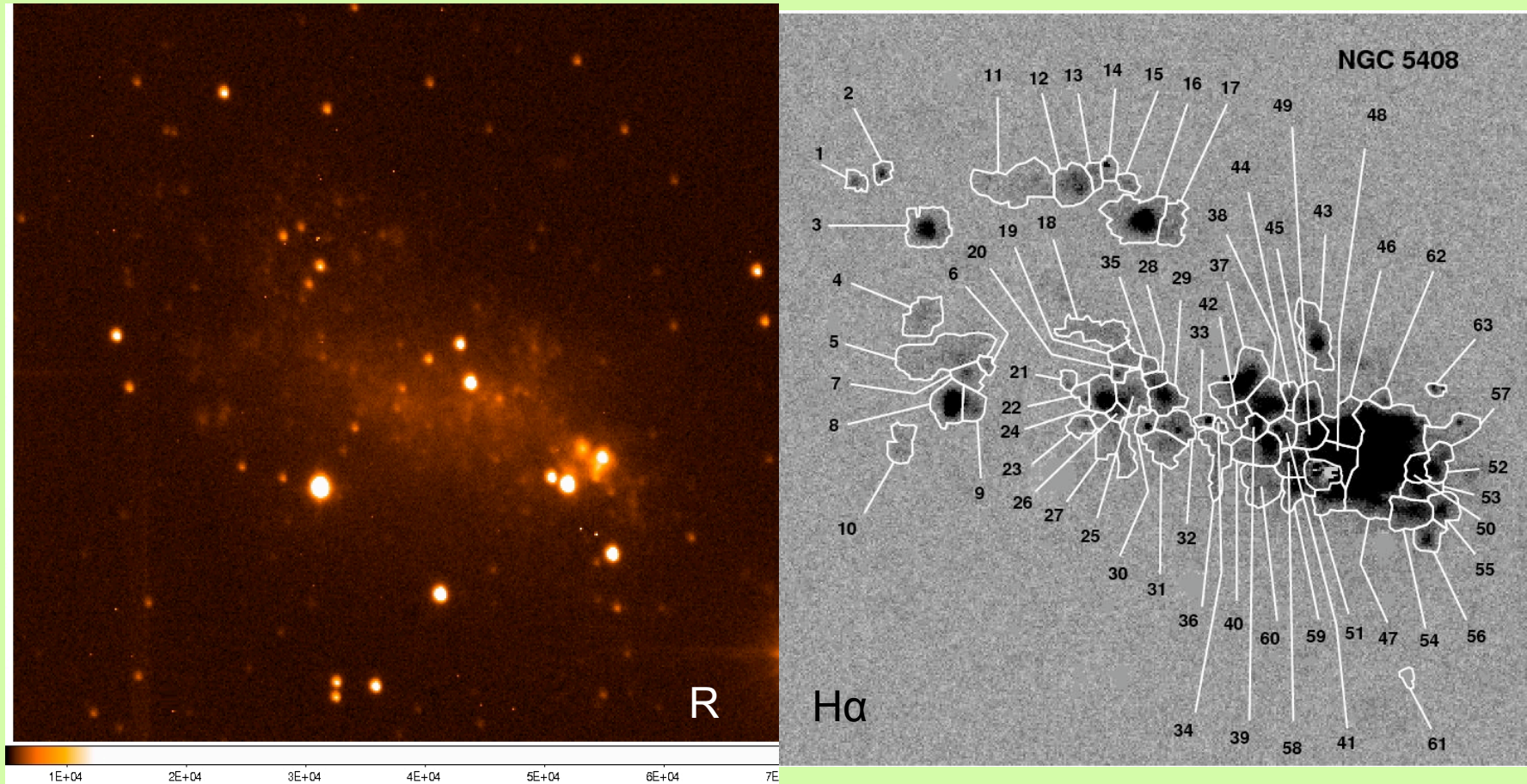
Is the star formation activity of the dwarfs influenced by their global group environment?

H α imaging surveys results

➔ *The Centaurus A dIs do not have enhanced star formation rates, compared to: the Local Group, the Sculptor Group, as well as Isolated dIs (from the sample of van Zee 2001).*



H α imaging surveys results



➔ *There is only one dwarf starburst in the Centaurus Group:*

NGC5408 $0.088 M_{\odot} / yr$

This is similar to what is found in the field

(J.Lee 2006, 11 Mpc survey finds $6 \pm 3 \%$ of dwarfs are starbursts)

H α imaging surveys results

➔ *Transition dwarfs are found in every group:*

5 in the Sculptor Group:

Sdig, DDO6, UGCA438, ESO294-G10, ESO540-G32

4 in the Centaurus A Group:

ESO269-G58, UGCA365, ESO384-G16, UKS1424-460

Adding to the 6 in the Local Group:

LGS3, Antlia, DDO210, Pegasus, Phoenix, Leo T

There are now distances determinations for most of these nearby dwarfs, from TRGB in CMD

(Karachentsev et al 2002, 2007)

The morphology-density relation in these groups can be investigated.

➔ *No correlation between SFR/area and Distance to nearest Spiral*

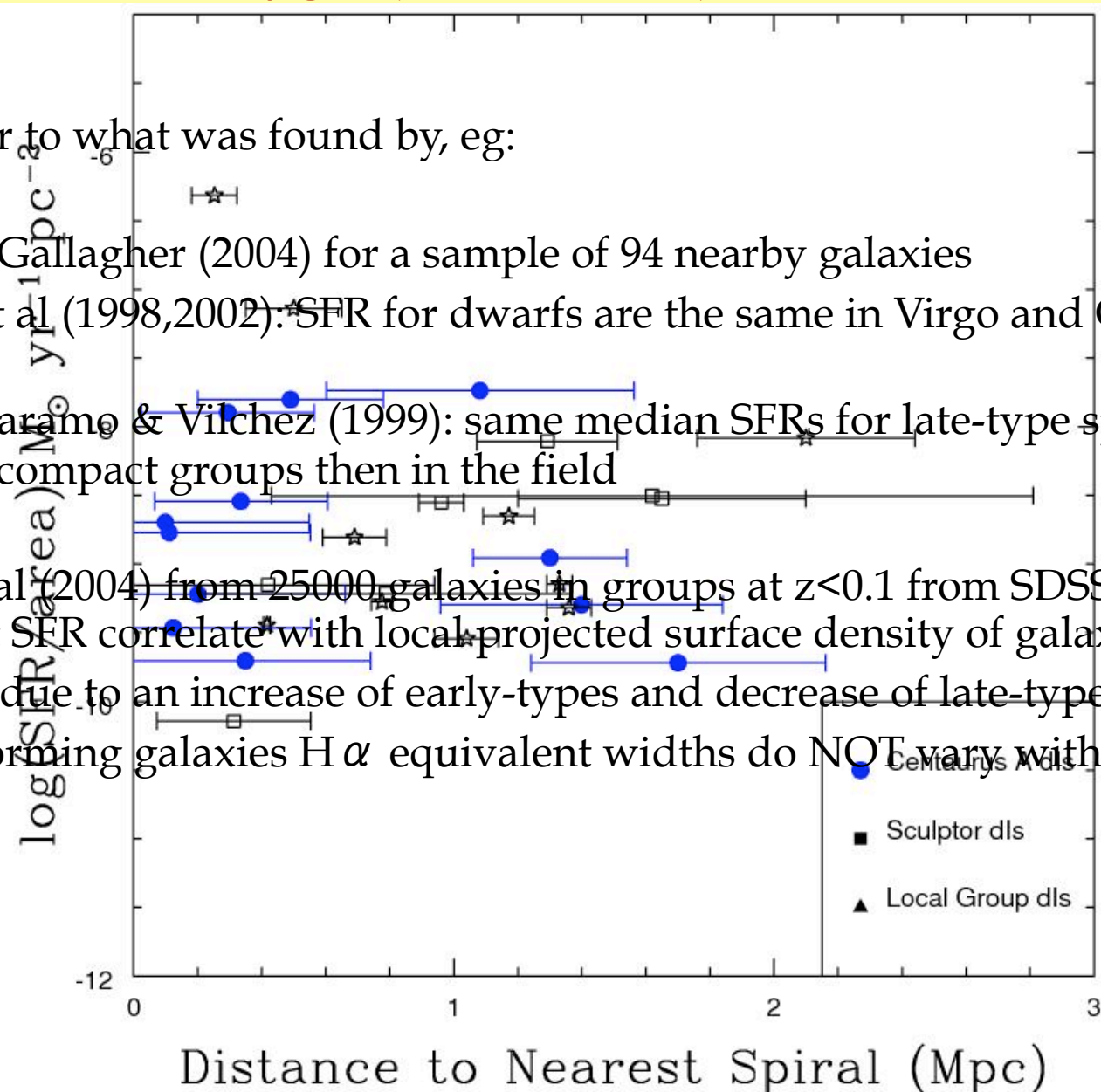
SFR of a dI in nearby groups does not depend on its local environment

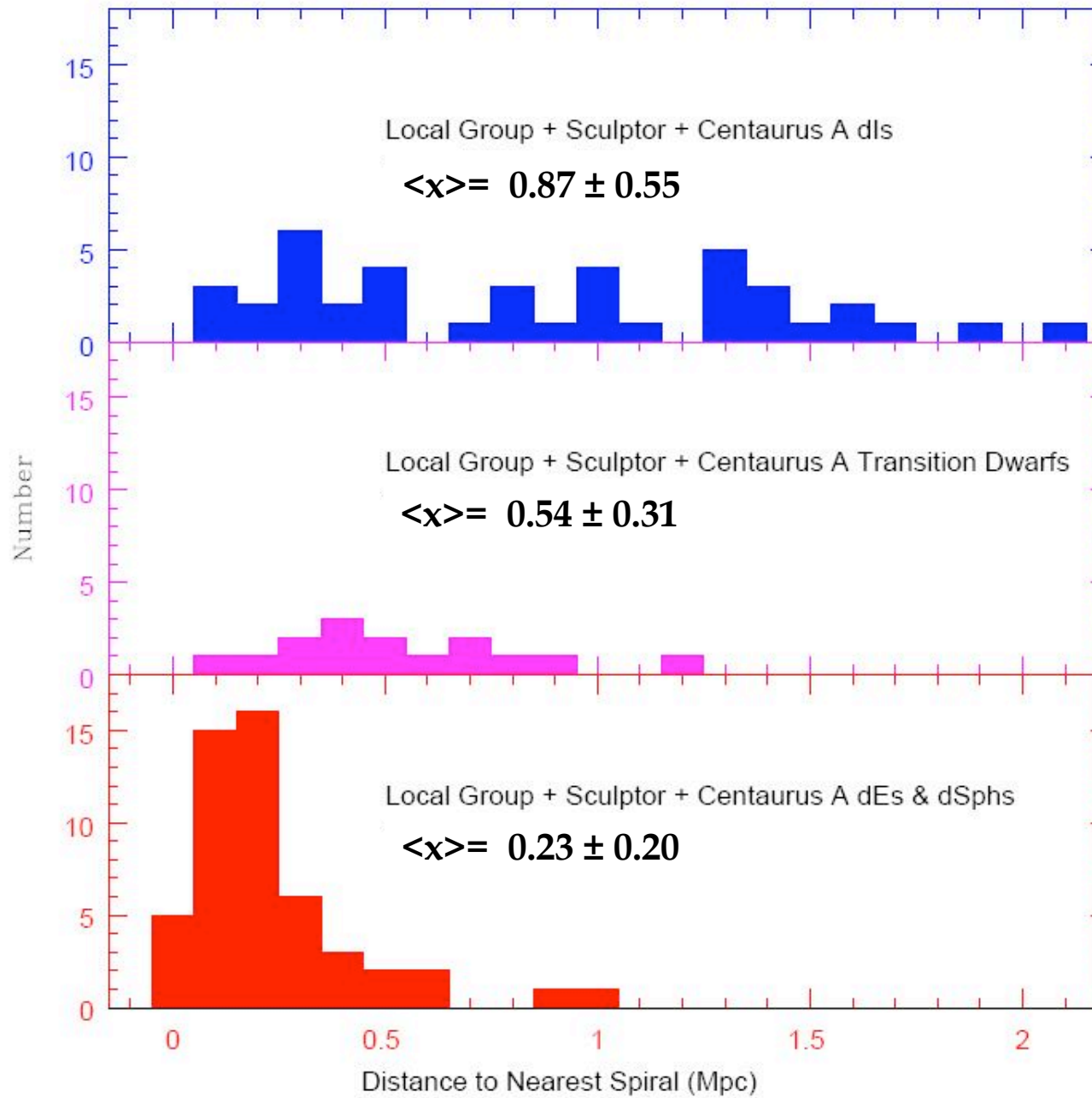
This is similar to what was found by, eg:

- Hunter & Gallagher (2004) for a sample of 94 nearby galaxies
- Gavazzi et al (1998,2002): SFR for dwarfs are the same in Virgo and Coma then in the field
- Iglesias-Paramo & Vilchez (1999): same median SFRs for late-type spirals in the middle of compact groups then in the field
- Balogh et al (2004) from 25000 galaxies in groups at $z < 0.1$ from SDSS and 2dFGRS, found that SFR correlate with local projected surface density of galaxies.

But this is due to an increase of early-types and decrease of late-types with density

The star-forming galaxies $H\alpha$ equivalent widths do NOT vary with environment





Transition dwarfs are at intermediate distances



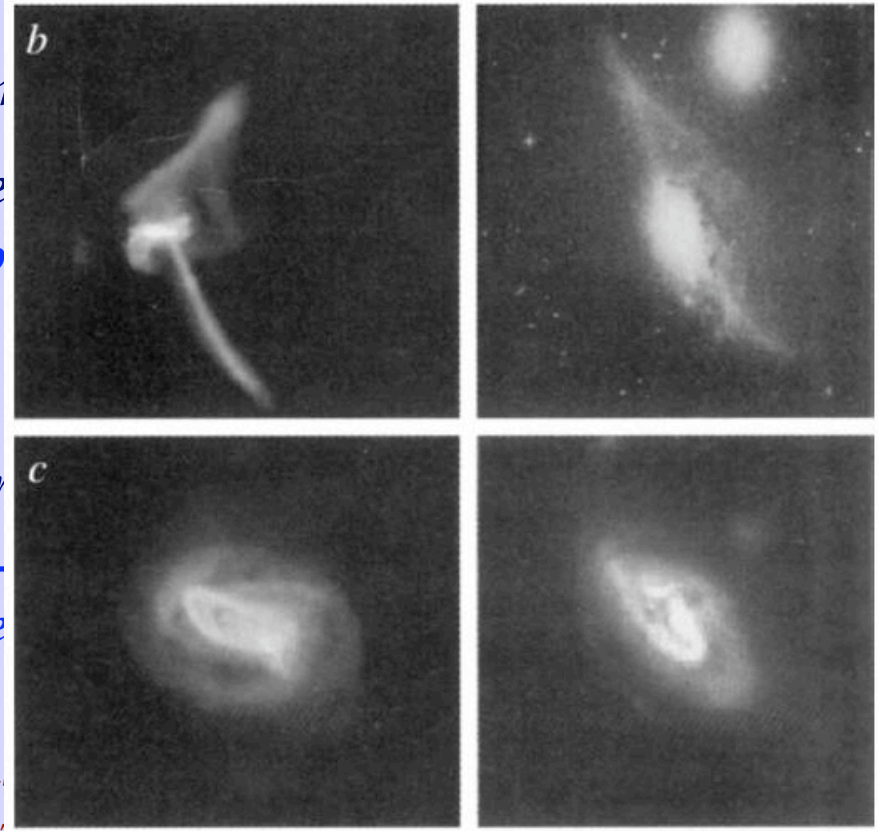
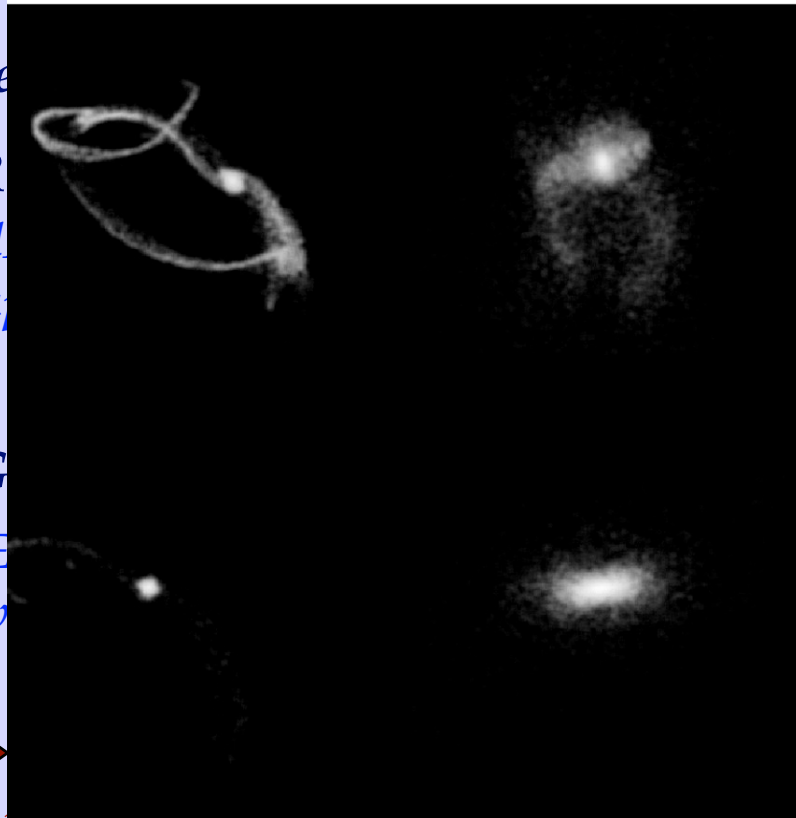
Their average distance is over half a Mpc

Transformation Mechanisms

The

- R
- d
- a

- G
- E
- v



morphology make them unlikely to have been produced by these mechanisms

- *CMDs of 5 Local Group transition dwarfs do not show any recent burst of star formation, except LGS3, Antlia in their inner regions (Piersimoni et al 1999)*
- *Stellar velocities of 18 Local Group dwarfs do not show any signs of streaming motions indicative of tidal disruption (Strigari, Bullock, Kaplinghat et al 2008)*

Transformation Mechanisms

One possibility:

Ram-pressure stripping...in an inhomogeneous Group IGM

$$n_{\text{halo}} \sim \sigma^2 n_{\text{gas}} / 3 v_{\text{dwarf}}^2 \text{ cm}^{-3} \text{ with } n_{\text{halo}} = \text{ambient gas density}$$

σ = velocity dispersion of dwarf

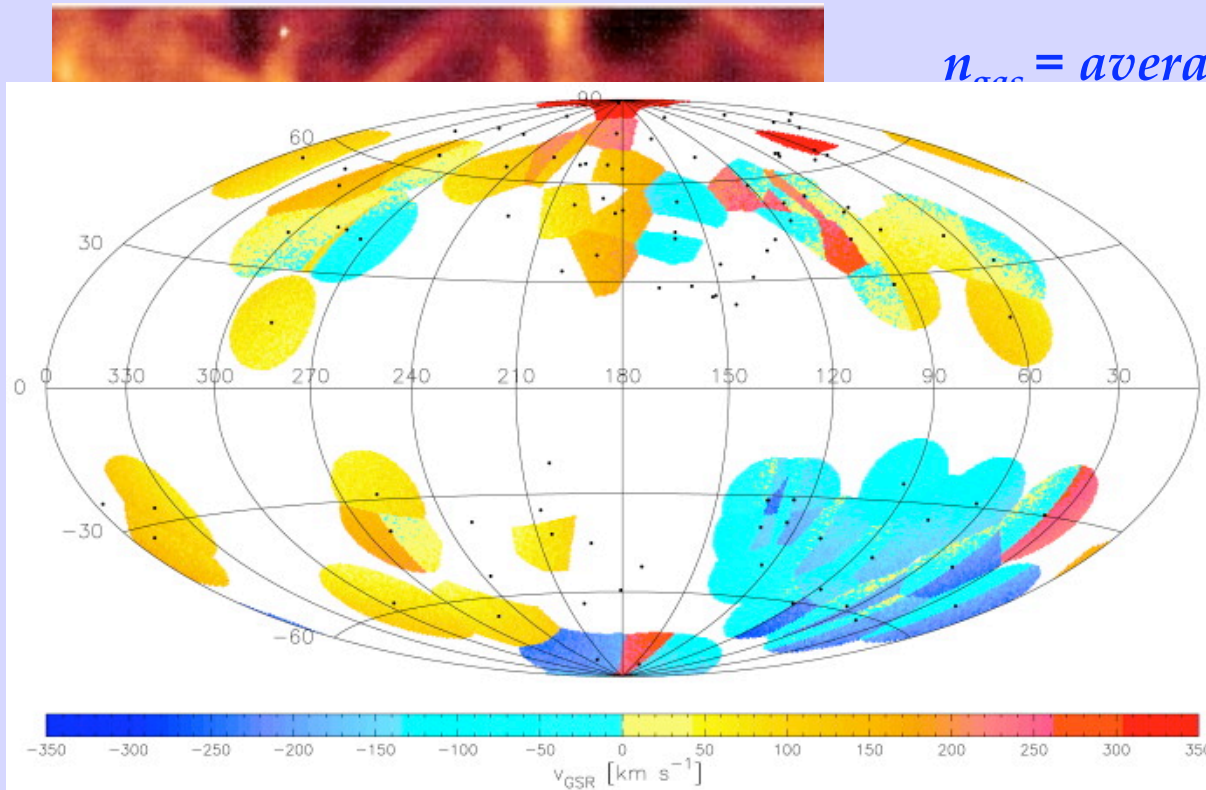
n_{gas} = average gas density of dwarf

v_{dwarf} = velocity of dwarf through medium

From FUSE UV OVI absorption lines observations, Sembach et al (2003) propose a hot low density $n \sim 10^{-4} \text{ cm}^{-3}$ Local Group medium

(1999)

Also: detection of inhomogeneous WHIM in X-ray (A.Soltan this conference)



Conclusions

- ➔ *The “active” Centaurus A group dIs do not show enhanced star formation. SFRs of dIs in nearby groups do not depend on their local environment*
- ➔ *Transition dwarfs are found in every nearby group (5 in the Sculptor Group; 4 in the Centaurus A Group)*
- ➔ *There is a Morphology-Density relation in nearby group, with transition dwarfs at intermediate distances between dIs & dSphs. Their average distance to their primary galaxy is quite large (0.54 Mpc)*
- ➔ *If transition dwarfs are the missing links between dIs and dSphs, one likely transformation scenario is ram-stripping through an inhomogeneous Group medium with regions of higher densities $n > 10^{-5} \text{ cm}^{-3}$*