The Fraction of Bars in the Local Universe

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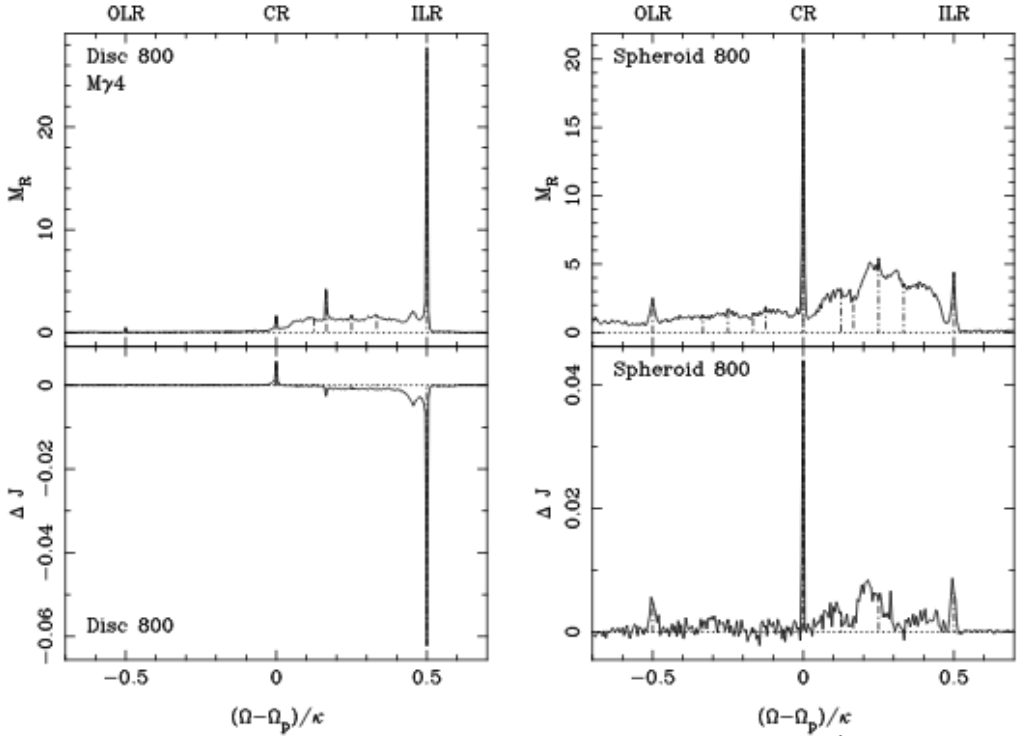
Outline of the talk

- Introduction: Properties of bars
- Observational parameters of the bars: length, strength, pattern speed, fraction
- Dependence of the bar fraction on the mass and environment
- Summary

Why are bars important?

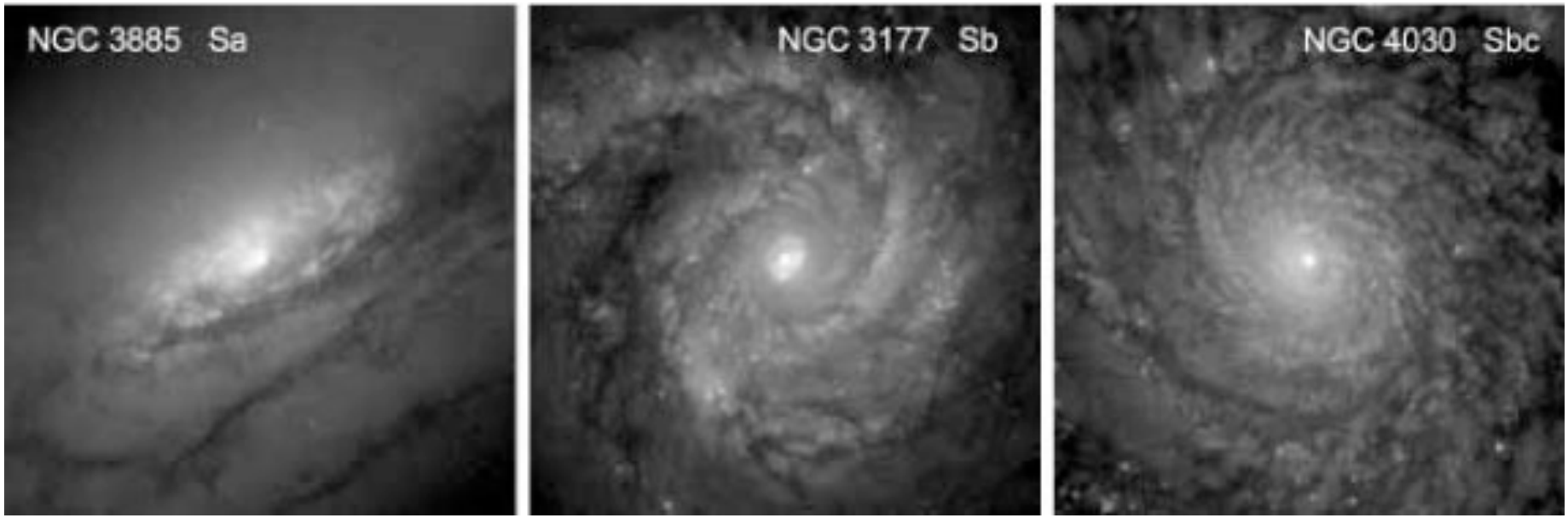
- Main drivers of secular evolution in galaxies
  - Redistribution of angular momentum between the barions and the dark matter.



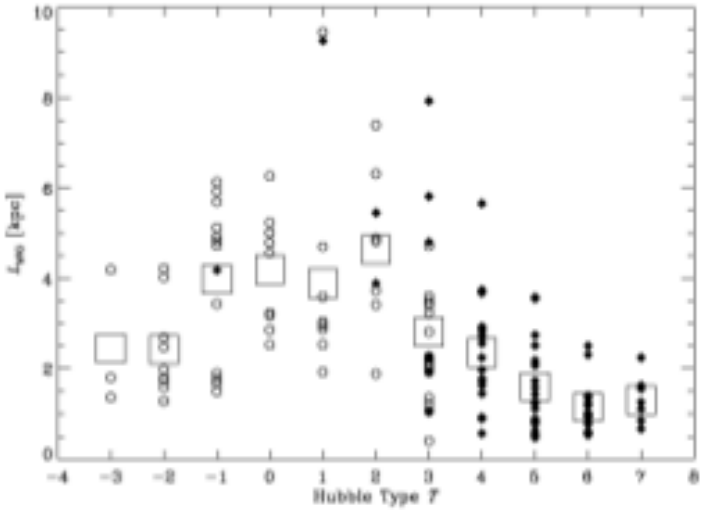
See e.g., Debattista & Sellwood 1998, 2000; Athanassoula et al. 20003; Martinez-Valpuesta et al. 2006; Villa-Bargas et al. 2009

Why are bars important?

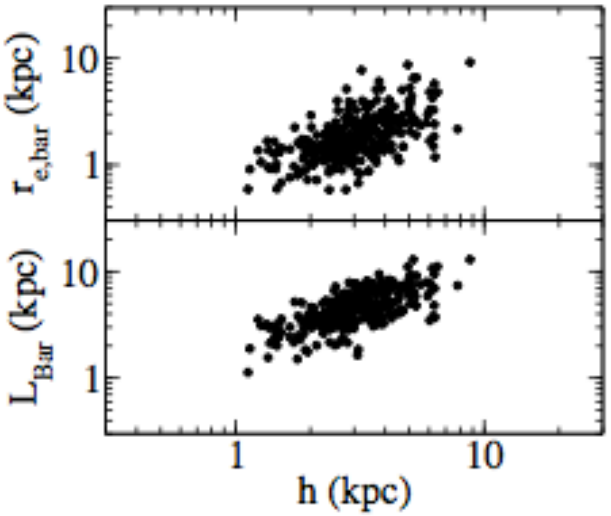
- Main drivers of secular evolution in galaxies
  - Related with the formation of pseudo-bulges (e.g. Kormendy 04; Carollo 97,99,01; Debattista+06)
  - Related with the stellar migration → age and metallicity redistribution (e.g. Sellwood & Binney 02; Roskar+12,13)



Bar parameters



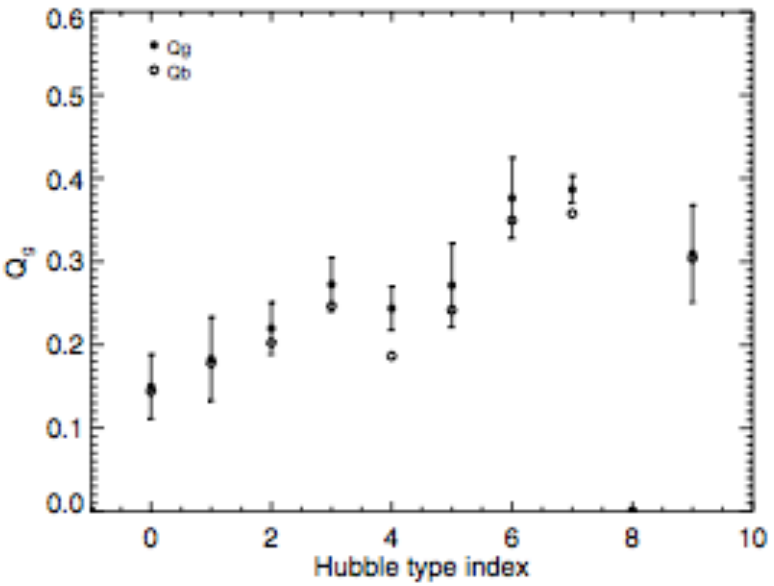
Erwin 2005



Gadotti 2011

- Observational parameters of bars
  - Length of the bar: visual (Kormendy79; Martin95); maximun ellipticity (Wozniak+95; Marquez +99; Laine+02; Marinova & Jogee 07; Aguerri+09); Structural decomposition (Prieto+97,01; Aguerri+01,03,05; Laurikainen +05,07,09; Gadotti 08,11; Weinzirl+09); Fourier analysis (Otha+90; Aguerri+02)
  - Correlation with other galaxy parameters: disc scale length, disc size, galaxy color, prominence of the bulge; Hubble type (see e.g. Aguerri+05; Marinova & Jogee 07; Gadotti 11; Hoyle+11; Elmegreen & Elmegreen 85; Aguerri+09; Erwin05; Menendez-Delmestre +07). In general, larger bars are in larger discs and S0 galaxies show larger bars than late-type ones.

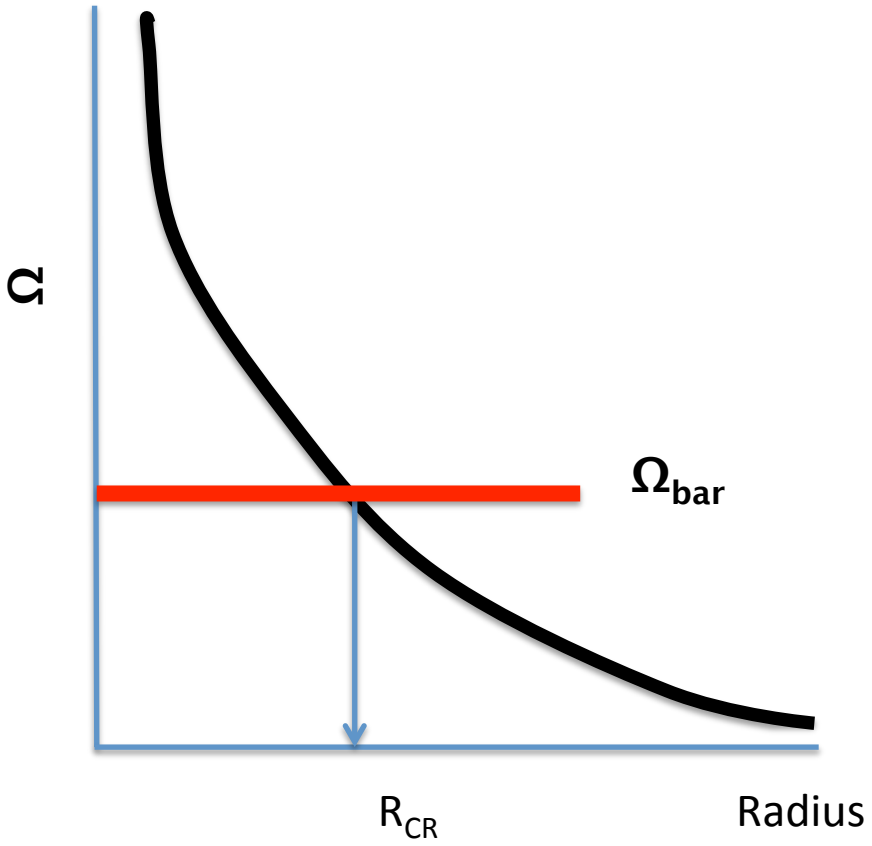
Bar parameters



Laurikainen et al. 2007

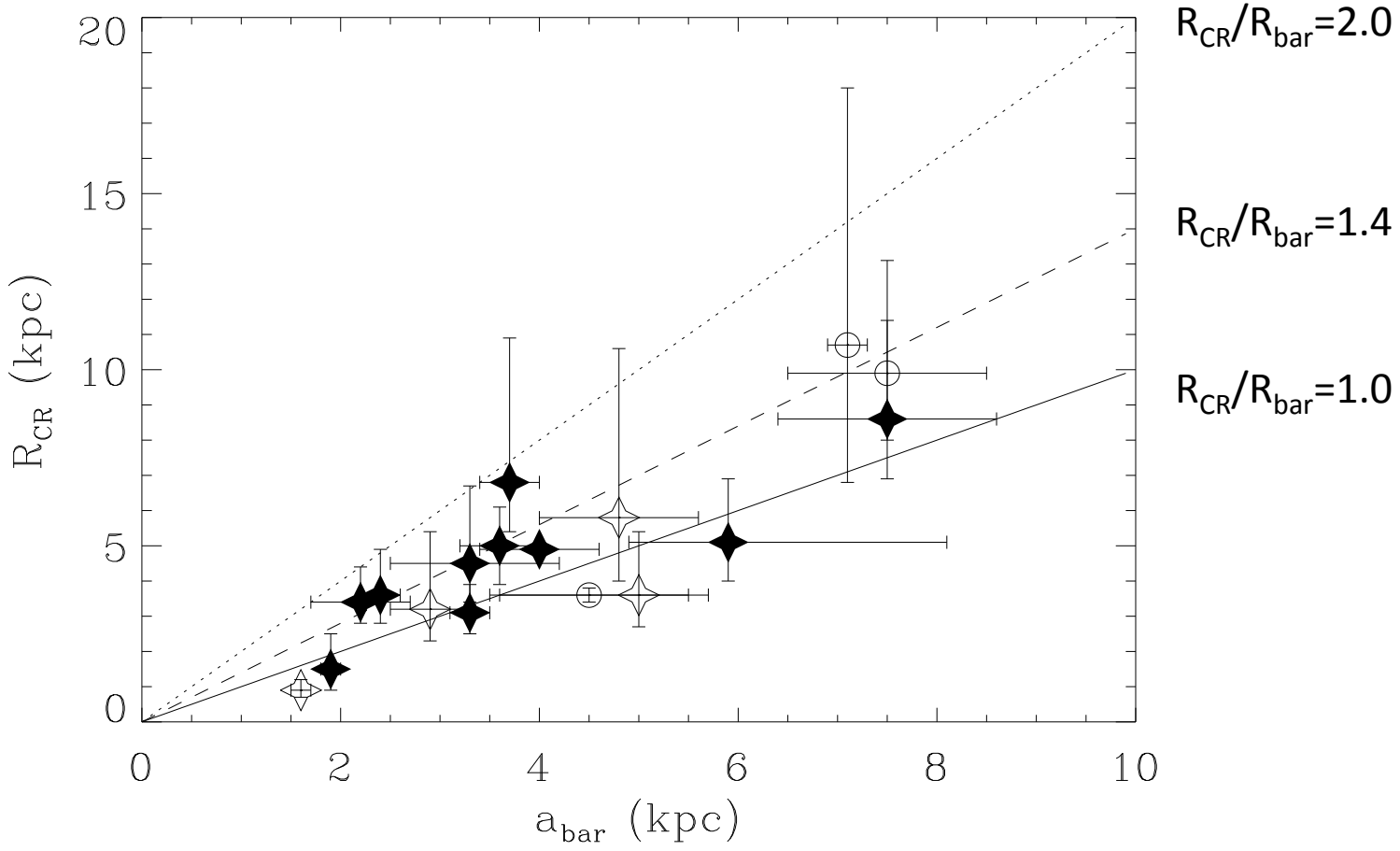
- Observational parameters of bars
  - Strength of the bar: Related with the torque produced by the bar
  - Measuring the torques of the potential (Combes & Sanders 81; Quillen+94; Buta & Block 01; Laurikainen+07; Salo+10); bar ellipticity (Martinet & Friedli 97; Aguerri 99; Whyte +02; Aguerri+09); fourier analysis (Ohta+90; Aguerri +02; Laurikainen+05)
  - In general, S0 galaxies show weaker bars than late-type ones (see Laurikainen+07; Aguerri+09; Buta+10)

Bar parameters

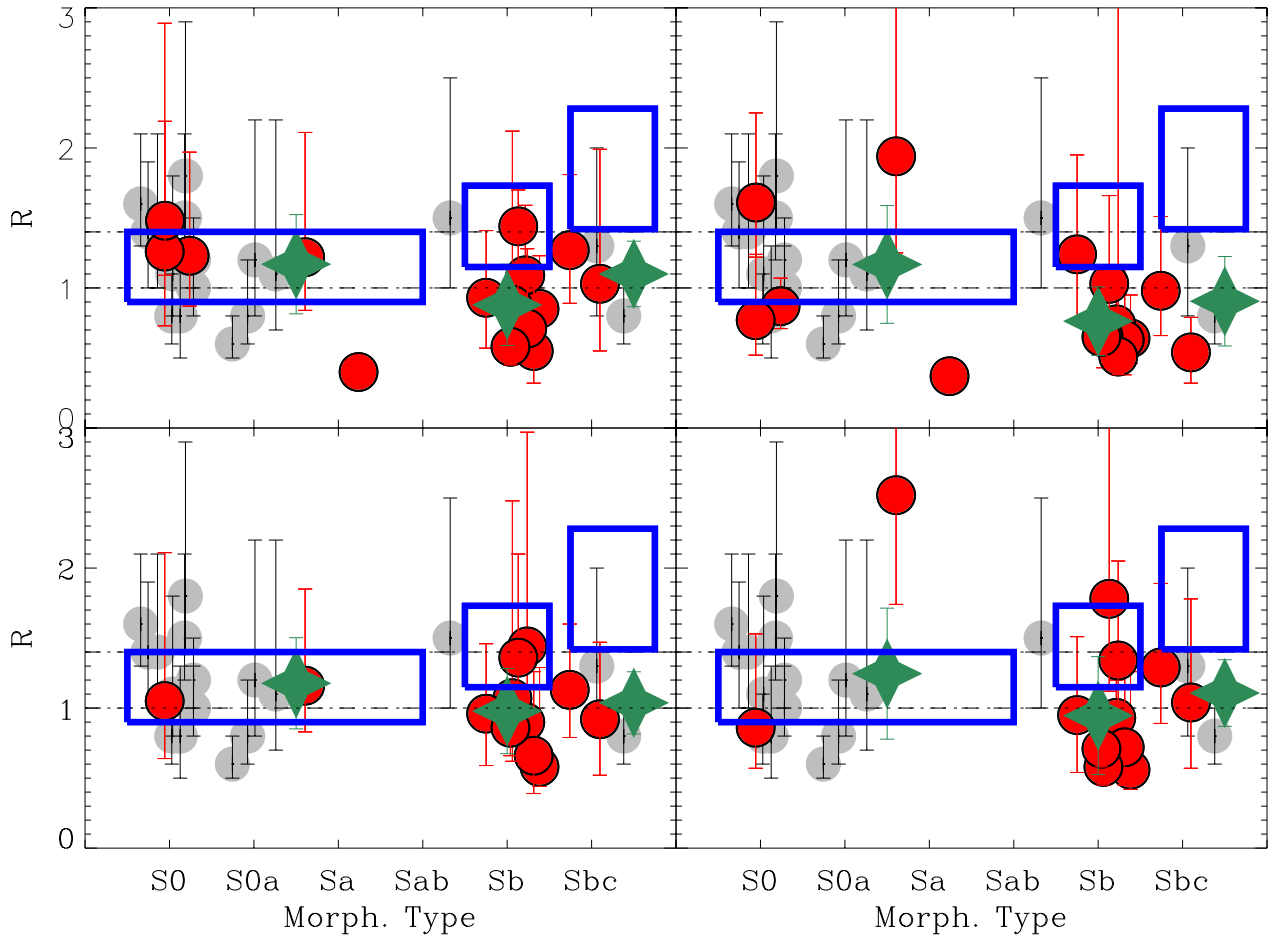


- Observational parameters of bars
  - **Bar pattern speed:** is the rotational velocity of the bar. Determines the co-rotation radius (R_{CR})
  - Orbital theory → $R_{CR}/R_{bar} > 1.0$
  - Slow bars: $R_{CR}/R_{bar} > 1.4$→central regions dominated by non-barionic matter
  - Fast bars: $R_{CR}/R_{bar} < 1.4$→ barion dominates matter

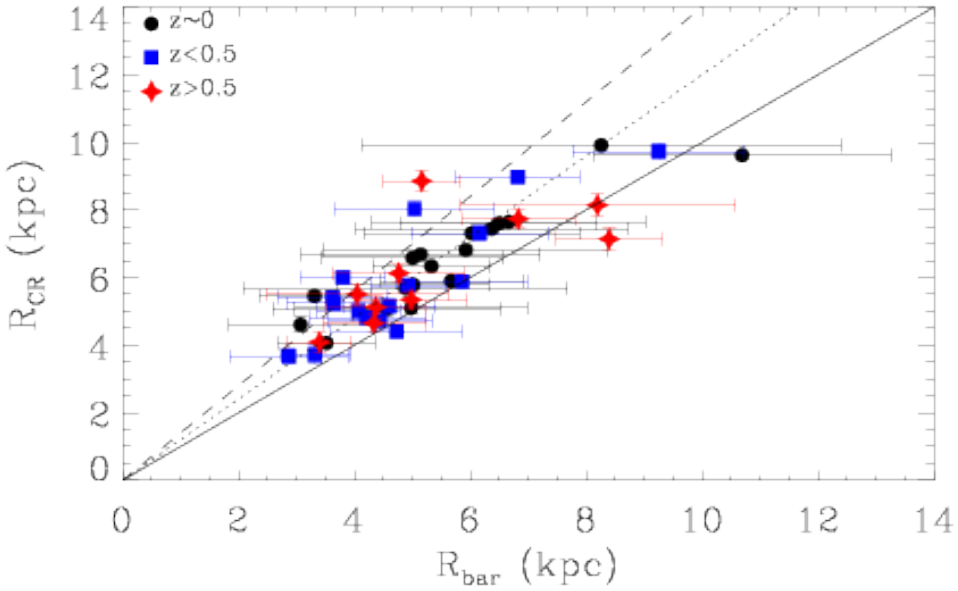
Bar parameters

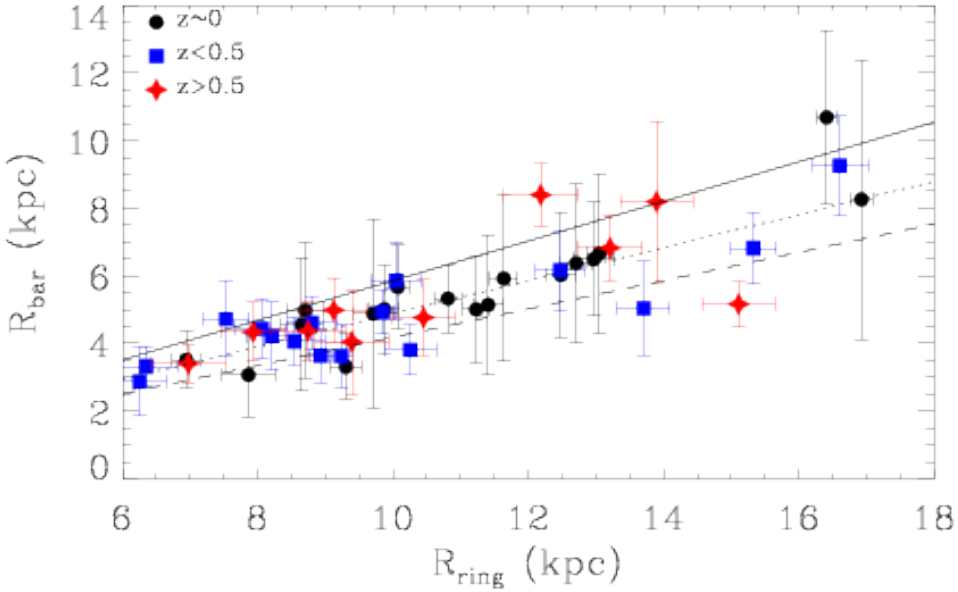


Kent87; Merrifield+95; Gerssen+99; Debattista+02; Aguerri+03; Corsini+03,07; Treuthardt+07



Aguerri et al. 2014, in preparation





Pérez, Aguerri, Méndez-Abreu 2012

Fraction of local bars

- In the optical the fraction bars are located in about 40-50% of disks (see e.g. Marinova & Jogee07; Barazza+08; Aguerri+09)
- This fraction is larger in the Near-Ir: about 60-70% of disks host bars (see e.g. Knapen+00; Eskridge+00; Menendez-Delmestre +07;
- What is driven the bar formation?
  - Internal processes: Mass, instabilities in cold discs, Hubble type, … (e.g. Miller+70; Holh+71; Ostriker & Peebles 73; Sellwood 80,81; Combes & Sanders 81; Athanassoula & Sellwood 86; Athanassoula & Misiriotis 02; Martinez-Valpuesta +04; Dubinski+09; Aguerri+09; Buta+10)
  - External processes: interactions, harassment, minor mergers,… (e.g. Byrd+86; Noguchi 87, 88,90; Gerin+90; Athanassoula+90; Elmegreen+90; Salo+91; Miwa & Noguchi 98; Berentzen+04; Curir+06)

The role of environment in bar formation

Environment does affect bars

- Thompson 1981, ApJ, 244, 43
- Elmegreen et al. 1990, ApJ, 364, 415
- Andersen 1996, AJ, 111, 1805
- Eskridge et al. 2000, AJ, 119, 536
- Van den Bergh 2002, AJ, 124, 782
- Barazza et al. 2009, A&A, 497, 713
- Barway et al. 2011, MNRAS, 410, 18
- Skibba et al. 2012, MNRAS, 423, 1485

Environment does not affect bars

- Aguerri et al. 2009, A&A, 495, 491
- Li et al., 2009, MNRAS, 397, 726
- Marinova et al. 2009, ApJ, 698, 1693
- Méndez-Abreu et al. 2010, ApJ, 711, 61
- Cameron et al. 2010, MNRAS, 409, 346
- Martínez & Muriel, 2011, MNRAS, 418, 148
- Giordano et al. 2011, ArXiv:1111.1532
- Lee et al. 2012, ApJ, 745, 125
- Marinova et al. 2012, ApJ, 746, 136

FIELD1	FIELD2	VIRGO	COMA
Aguerri et al. (2009)	Sánchez-Janssen et al. (2010)	Zarattini et al. (in prep.)	Méndez-Abreu et al. (2010)
SDSS volume-limited	SDSS volume-limited	SDSS within R_{vir}	SDSS Coma Treasury Survey
$R_{bar} > 1300$ pc	$R_{bar} > 150$ pc	$R_{bar} > 150$ pc	$R_{bar} > 150$ pc
2389 (1604 disks)	352 (336 disks)	588 (228 disks)	169 (44 disks)
$-24 < M_r < -20$	$-21 < M_r < -13$	$-22 < M_r < -13$	$-23 < M_r < -14$

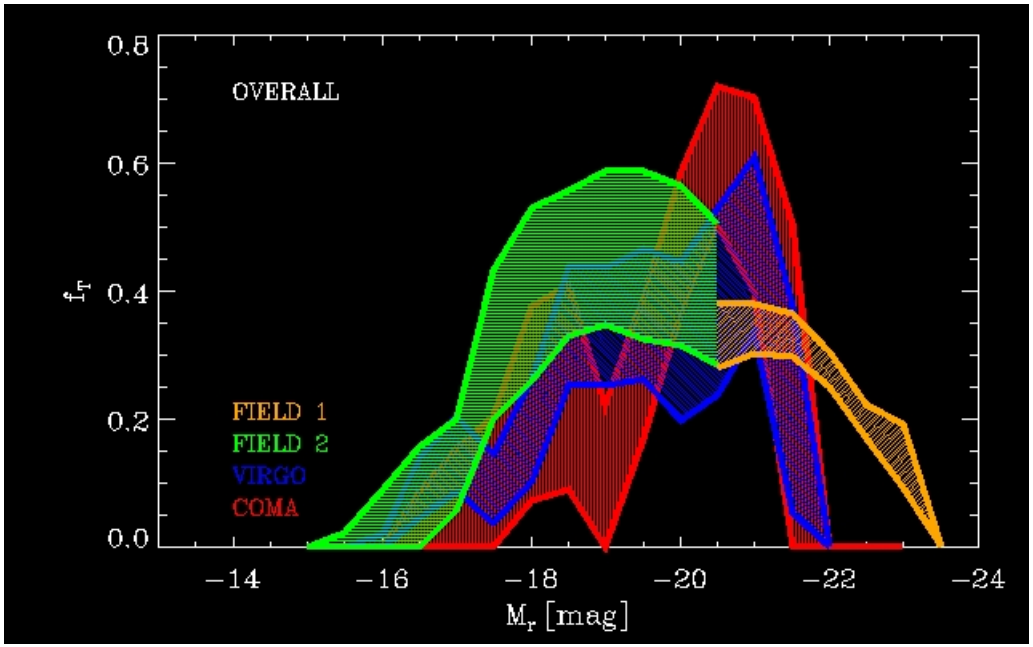
Methodology

Bars: Independent visual inspection of galaxy images

Strong (= secure) bar
Weak (= doubtful) bar
No bar

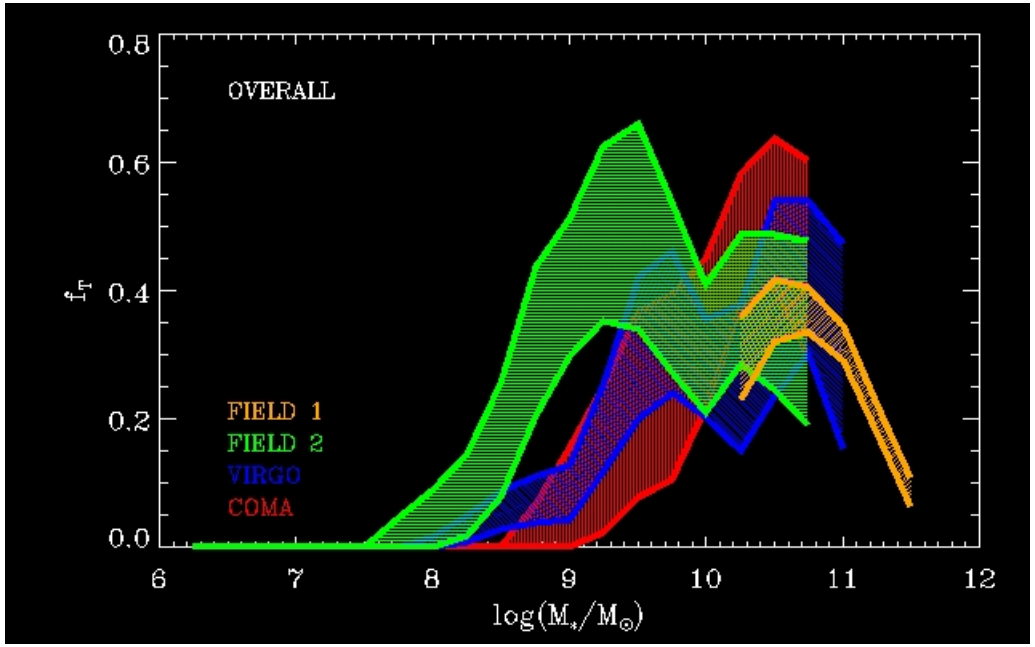
Bar fraction as a function of luminosity (or mass) and environment

Overall bar fraction: bars/galaxies
Ordinary bar fraction: bars/disks



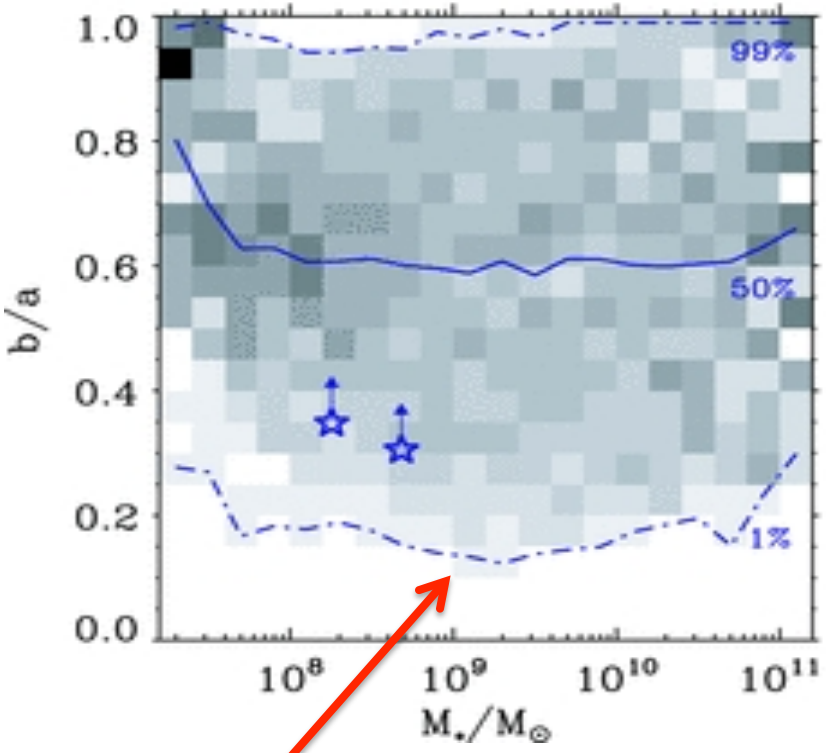
The bar fraction is not constant
With luminosity or mass

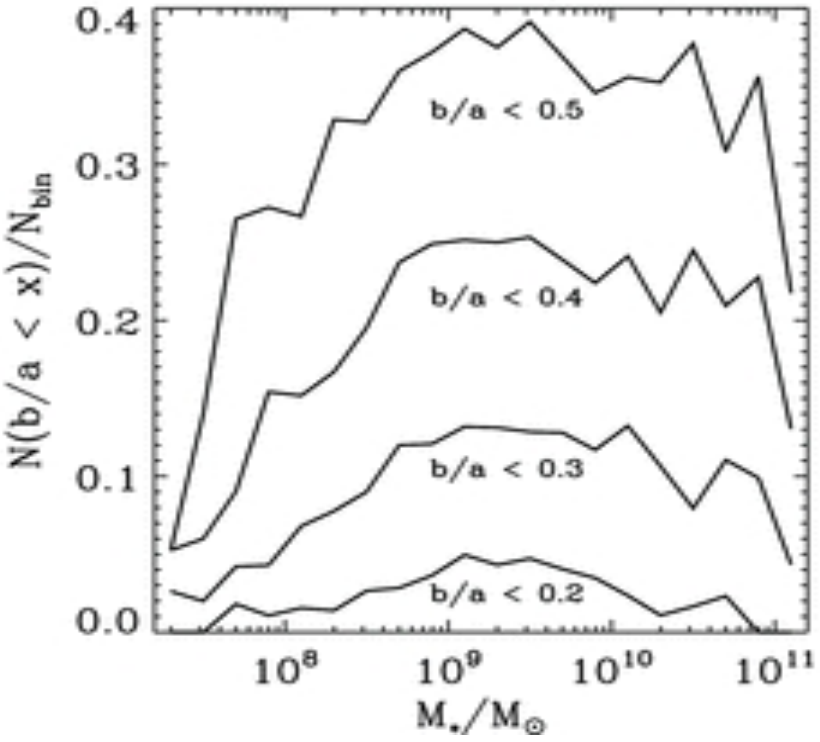
No bars are present in very
Luminous (massive) or low
Luminous (massive) systems



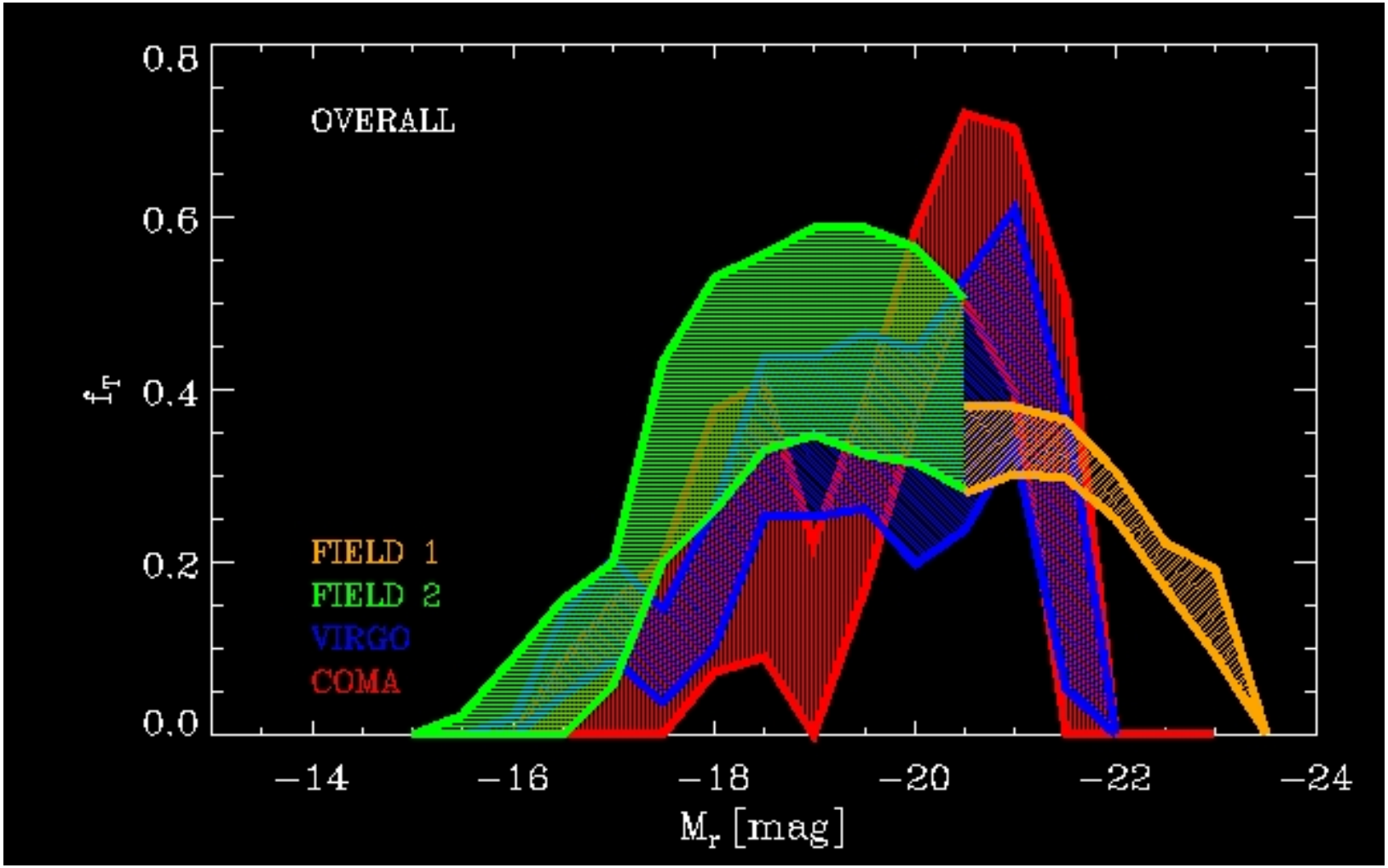
No thin discs!!!!

Mendez-Abreu, Sánchez-Janssen, Aguerri (2010, 2012)

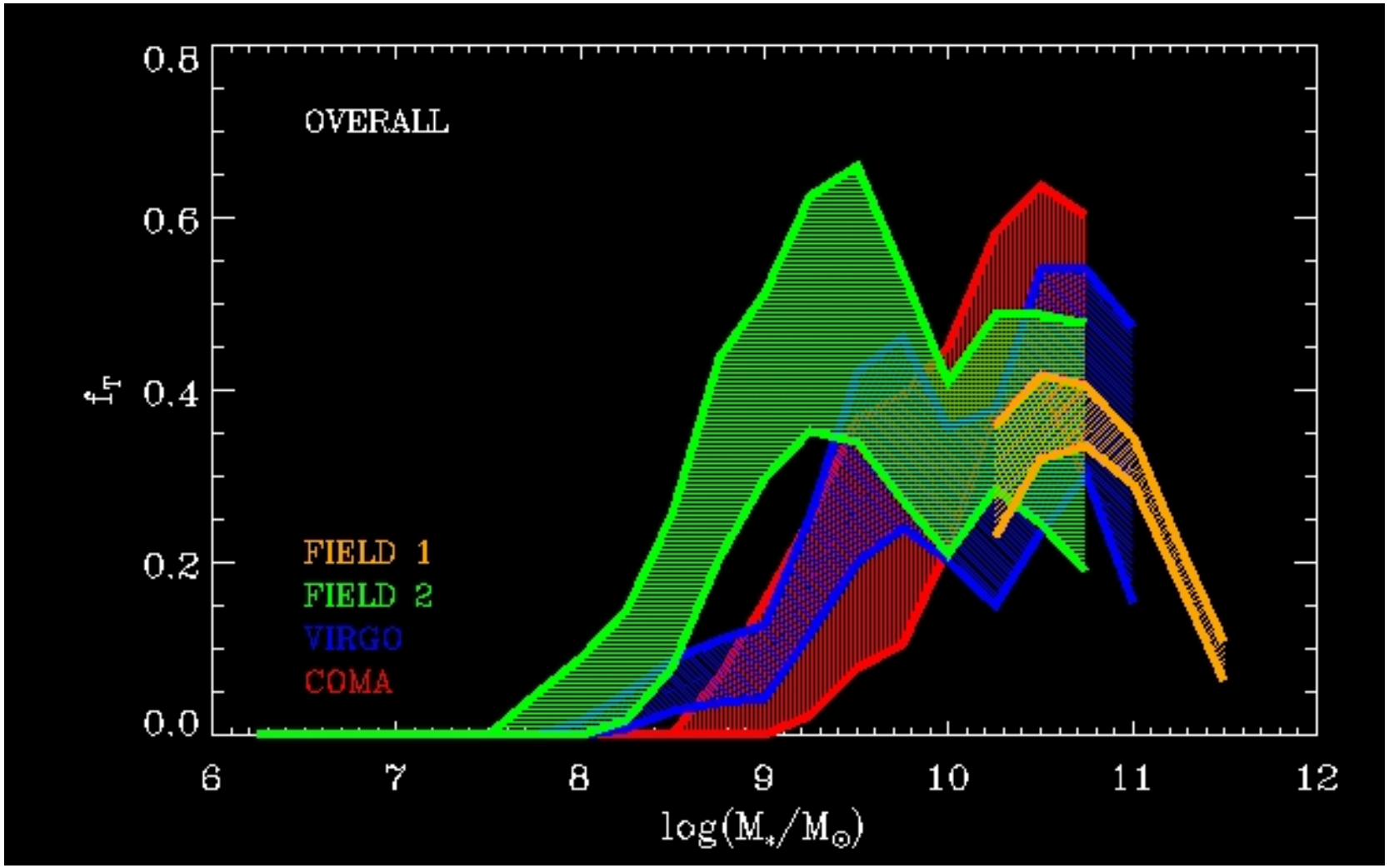




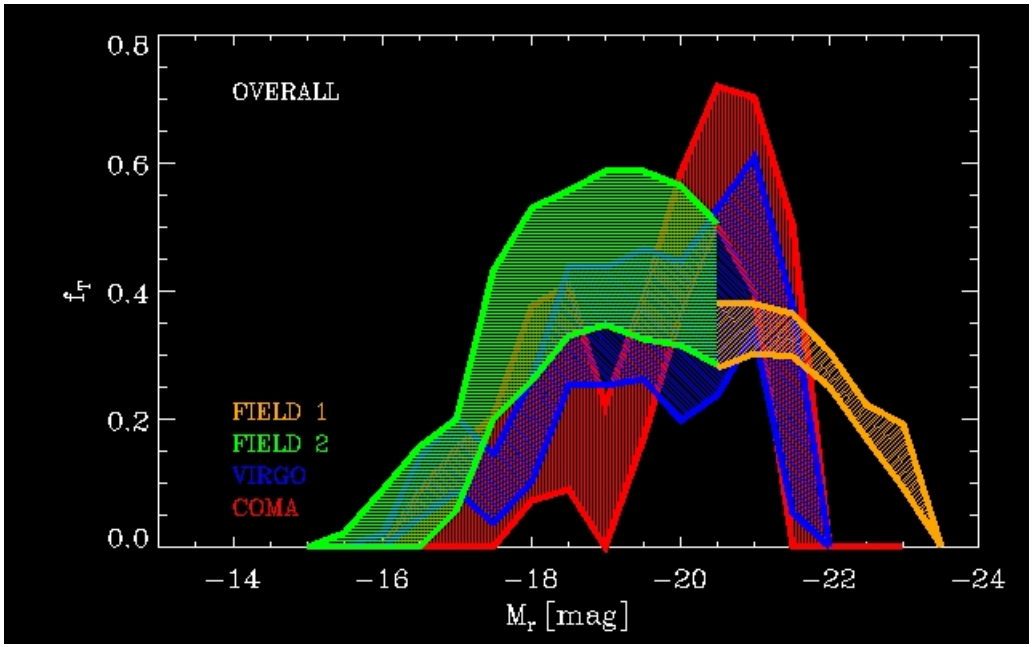
Sánchez-Janssen, Méndez-Abreu, Aguerri (2010)



FIELD	-19.07±0.72		FIELD	-19.45±0.12
PeakVIRGO	-20.41±0.81	**Mean**	VIRGO	-19.50±0.18
COMA	-20.64±0.45		COMA	-19.85±0.25

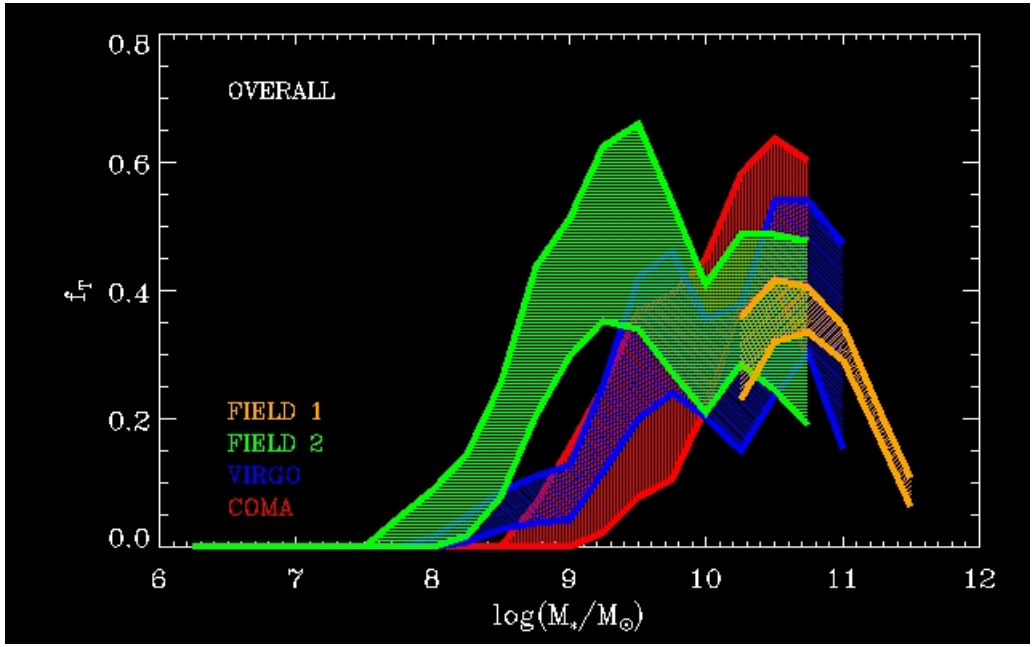


	FIELD	9.49±0.36		FIELD	9.61±0.06
Peak	VIRGO	10.34±0.44	**Mean**	VIRGO	9.94±0.07
	COMA	10.45±0.24		COMA	10.13±0.09



The bar fraction is affected by the environment in two ways:

Environment destroys thin discs in low-mass systems



In contrast, galaxy interactions produce more bars in the bright galaxies but not destroy the discs

Mendez-Abreu, Sánchez-Janssen, Aguerri (2010, 2012)

Summary

- The bar fraction strongly depends on the luminosity (mass) of the galaxies
- The bar fraction is drops for very luminous (massive) or very faint systems
- This trend is due to the absent of thin discs in the two extreme mass regimes.
- The bar fraction also depends on the environment. Thus, strong environment heat dwarf galaxies and produce the destruction of thin discs in them. In addition, the interactions in high density environments produce bars in bright galaxies.