STAR FORMATION IN COMPACT GROUPS

THEODOROS BITSAKIS
Instituto de Radioastronomía y Astrofísica, UNAM

P. Appleton (Caltech), K. Alatalo (Carnegie Obs.), V. Charmandaris (Univ. of Crete), P. Guillard (IAP), D. Dultzin (UNAM), T. Diaz-Santos (Diego Portales), L. Ciesla (CEA/Saclay), E. Le Floc'h (CEA/Saclay)

image credit: I. Konstantopoulos (AAO)

THE PHYSICS OF GROUPS AND GALAXY PROPERTIES THEREIN MEETING, PARIS DEC. 2016

Field galaxy
NGC2442

- high densities
- low σ

Compact group
Seyferts Sextet

- low densities
- low σ

Interacting pair
Arp271

- pre-processing in groups (Cortese+06)

- high densities
- high σ

Galaxy cluster
Abell 1689

Hickson compact groups

- at least 3 galaxies within 3mags from the brightest one
- no additional galaxies within 3 times the angular size of the group
- group surface brightness <26mag/arsec^2

Field galaxy
NGC2442

- low densities
- low σ

Interacting pair
Arp271

- high densities
- low σ

Compact group
Seyferts Sextet

groups (Cortese+06)

- high densities
- high σ

Galaxy cluster
Abell 1689

Basic properties

- 31% E's and 43% S's
- 43% display **bridges, tails** and other tidal distortions (Mendes de Oliveira et al. 1994)
- Hot **X-ray intragroup gas** in 75% of them (Ponman et al. 1996)
  - **Ram pressure** inefficient (Rasmussen et al. 2008)
- 45% host **LLAGN** (with typical $L_{H\alpha}<10^{40}$ erg/sec)

Do compact groups display the SF and colours that are expected given their unusually high densities?

But what do we expect?

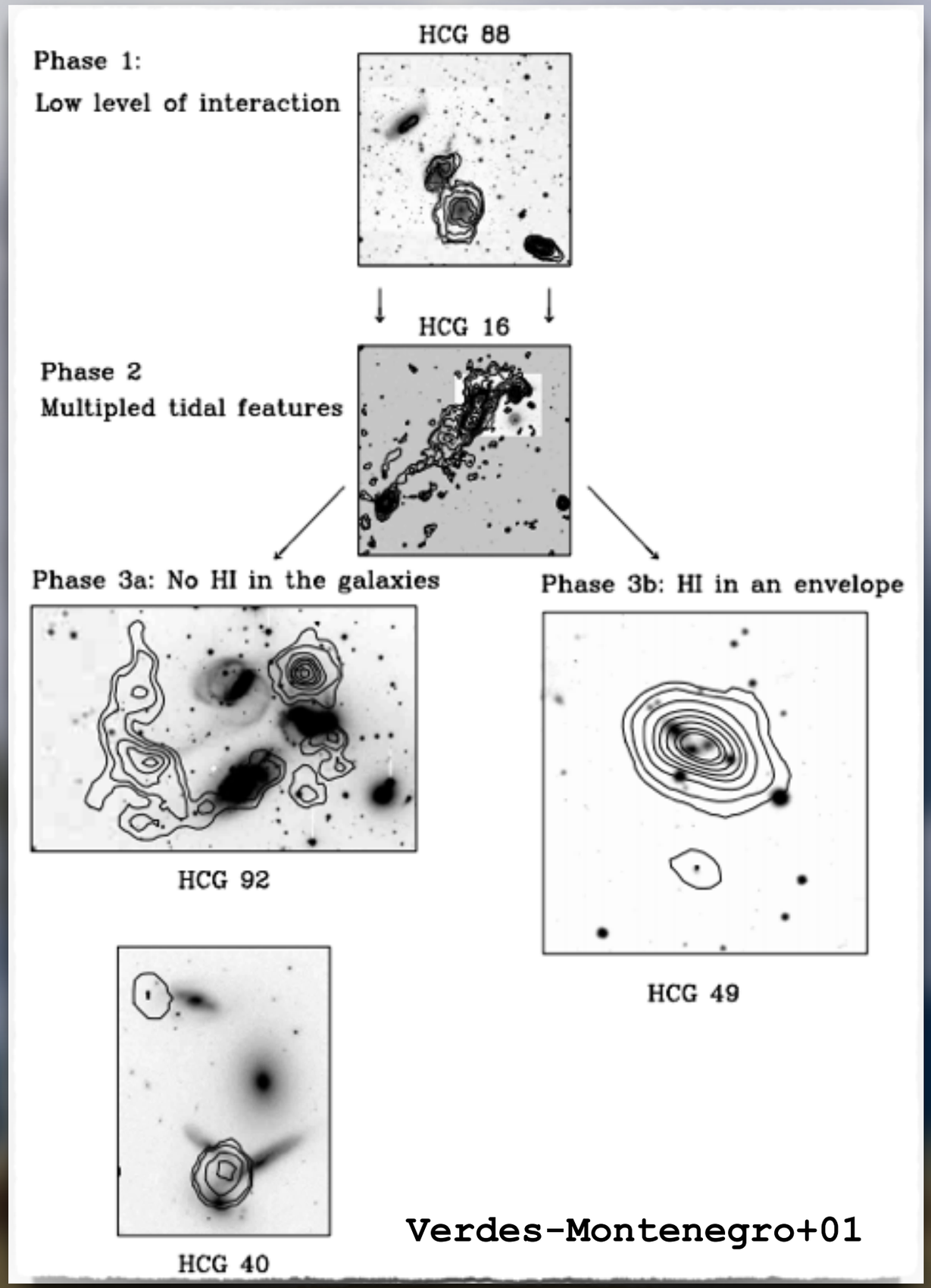
SF enhancement & bluer colours

- Nuclear Hα enhancement (e.g. Keel+85)
- IR enhancement (e.g. Lonsdale+84, Joseph & Wright 85)
- Starburst increase with interactions (20-30% , Sanders & Mirambel 96)
- Interactions drive gas inwards (e.g. Mihos +93)

SF reduction & red colours

- Lower HI content in clusters than in field (Davis & Lewis 73)
- Ram pressure stripping (Gunn&Gott72)
- Strangulation (e.g. Larson+80)
- warm molecular gas due to collisional shocks (e.g. Guillard+12)

What do we really observe in compact groups?



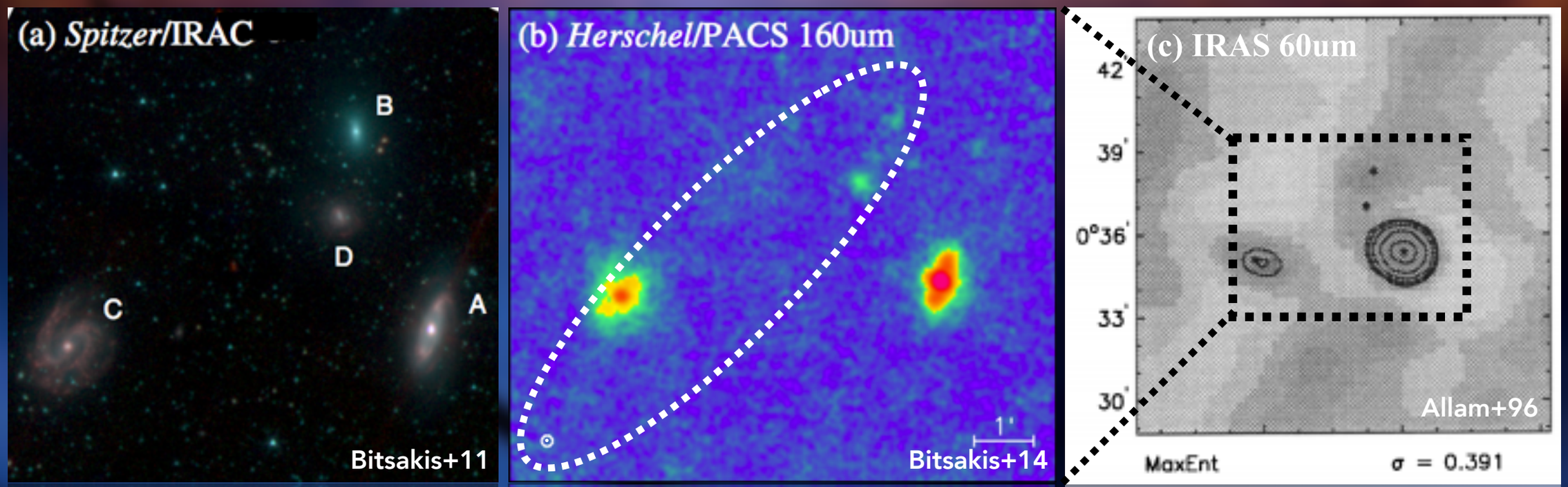
- HI fraction **half** from that of loose groups (Williams & Rood 87)
- **Interactions remove gas** from CG spirals (Menon+95)
- **24% of expected HI** in HCG galaxies and 40% in groups (Verdes-Montenegro+01) - Borthakur +10 enhanced the diffuse HI IGM fraction to ~50%
- Lisenfeld+14 found HCG galaxies with **reduced H_2 content**

Gas stripping must play a crucial role in the evolution of star formation!

First infrared observations

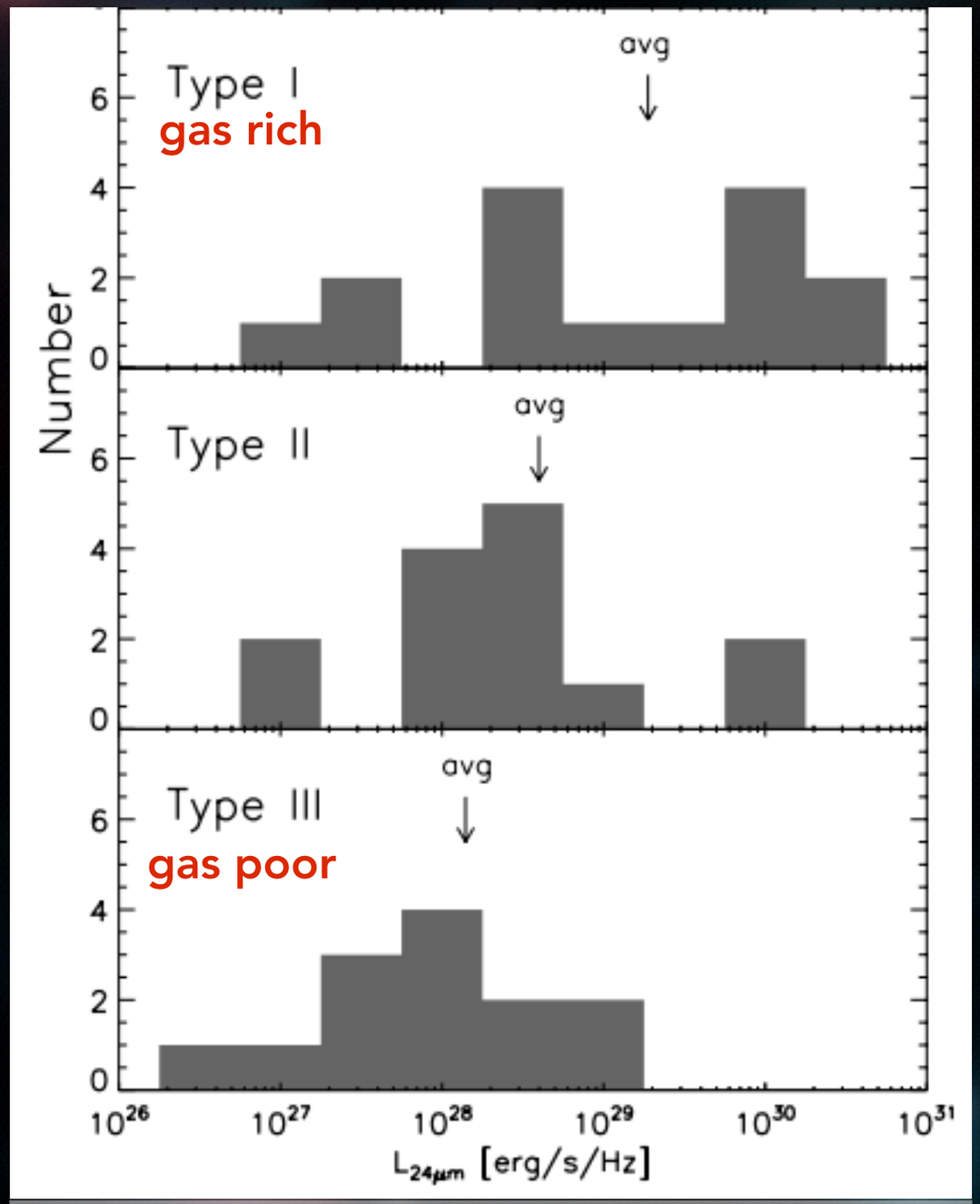
- Hickson+89 using IRAS data suggested enhanced IR luminosities
- However, Sulentic & De Mello 93 showed that these were overestimated due to the limited resolution of IRAS
- Allam+96 presented first complete catalog of IR properties of HCGs

HCG07



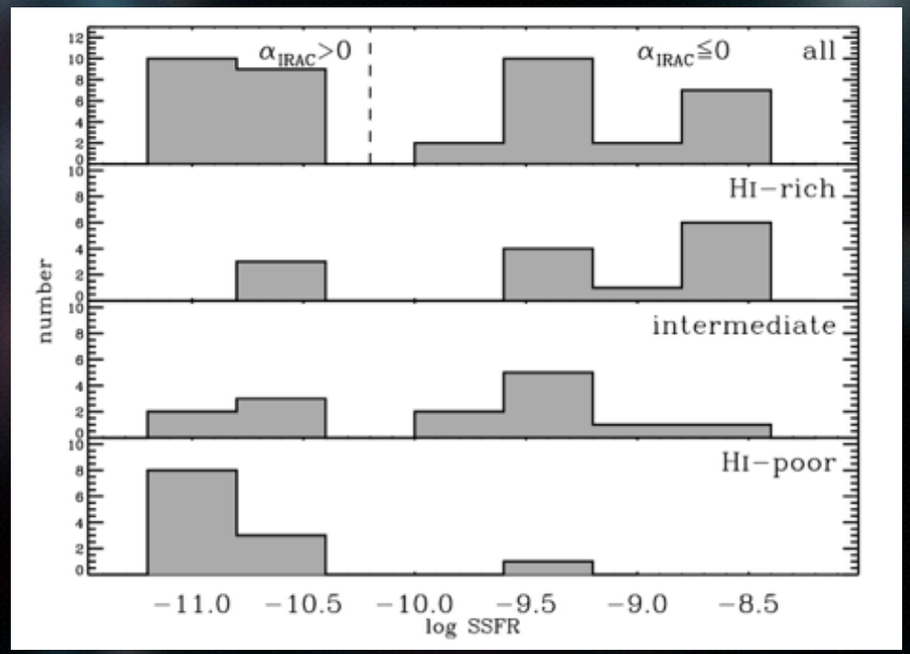
The advent of a new era

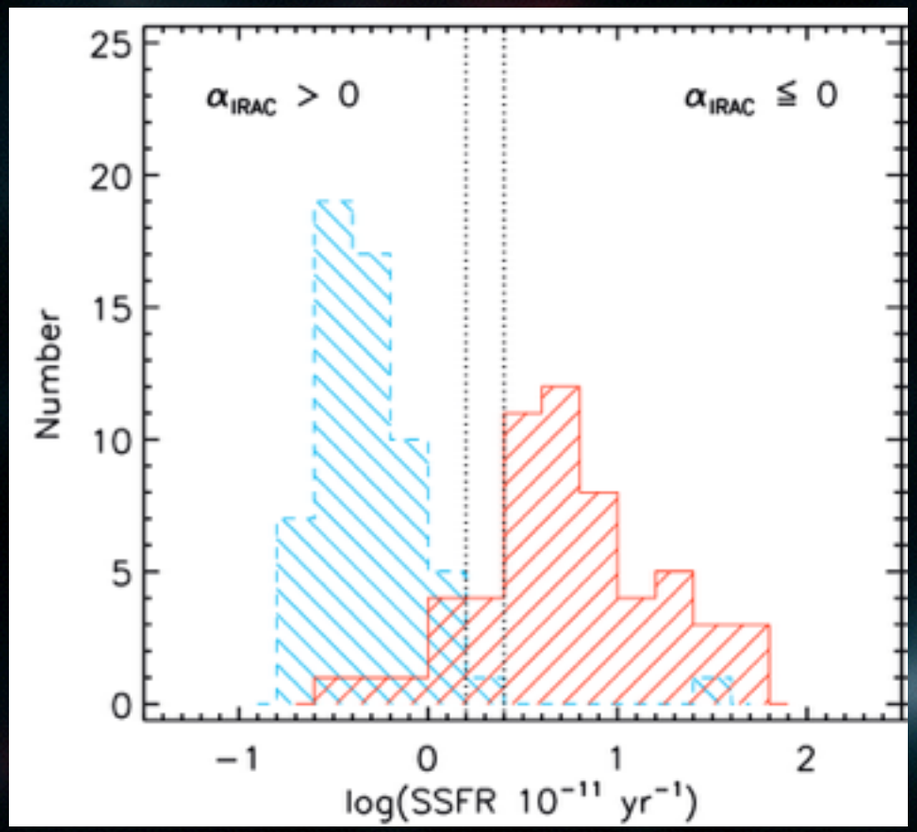
- Johnson+07 examined for first time the IR luminosities of individual galaxies



The advent of a new era

- Johnson+07 examined for first time the IR luminosities of individual galaxies
- Tzanavaris+10 used UV+IR data to derive the SFRs of 11 HCGs (expanded by Lenkic+16)



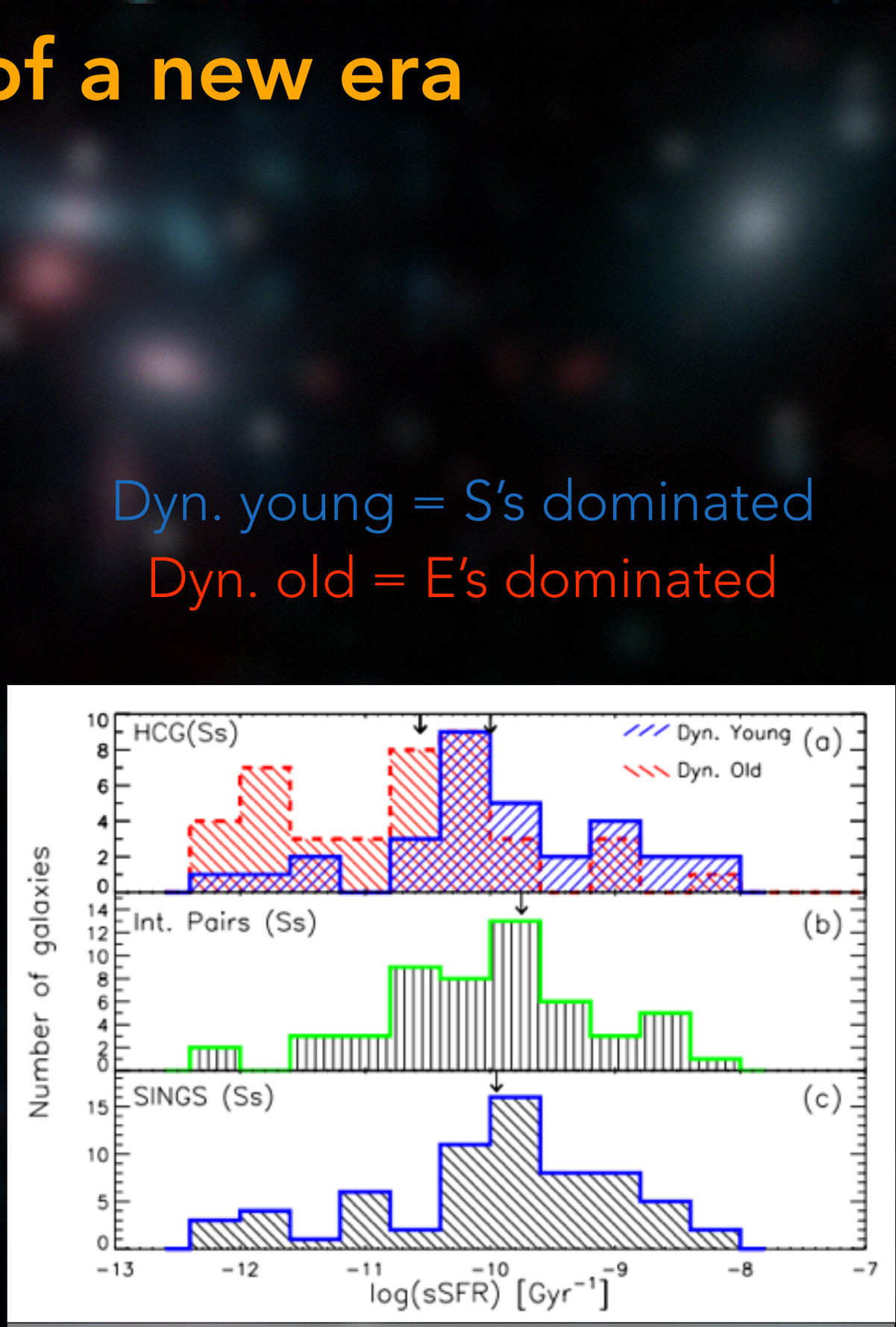


The advent of a new era

- Johnson+07 examined for first time the IR luminosities of individual galaxies
- Tzanavaris+10 used UV+IR data to derive the SFRs of 11 HCGs (expanded by Lenkic+16)
- Bitsakis+10,11 introduced a new dynamical classification and concluded that LTGs in Dyn. Old groups (gas poor) display reduced SF activity

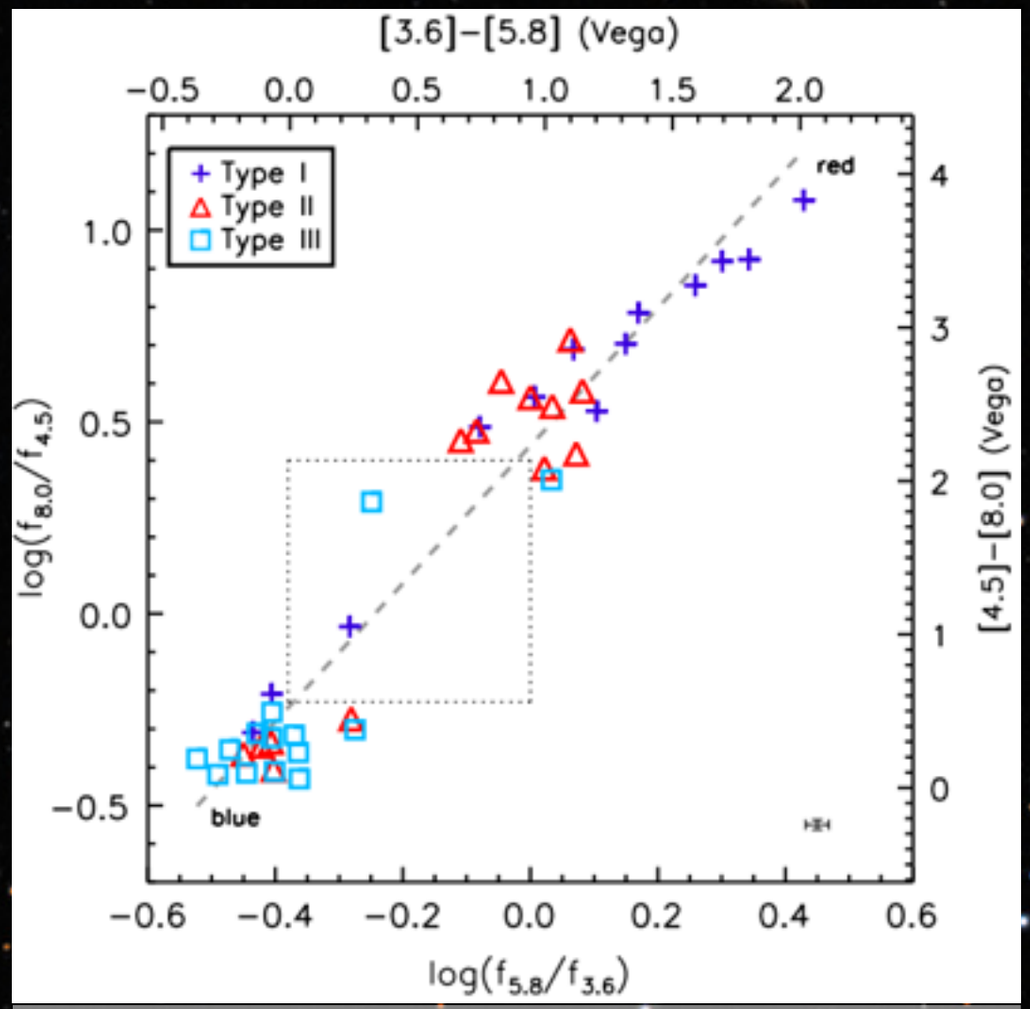
Dyn. young = S's dominated

Dyn. old = E's dominated



The galaxy colours

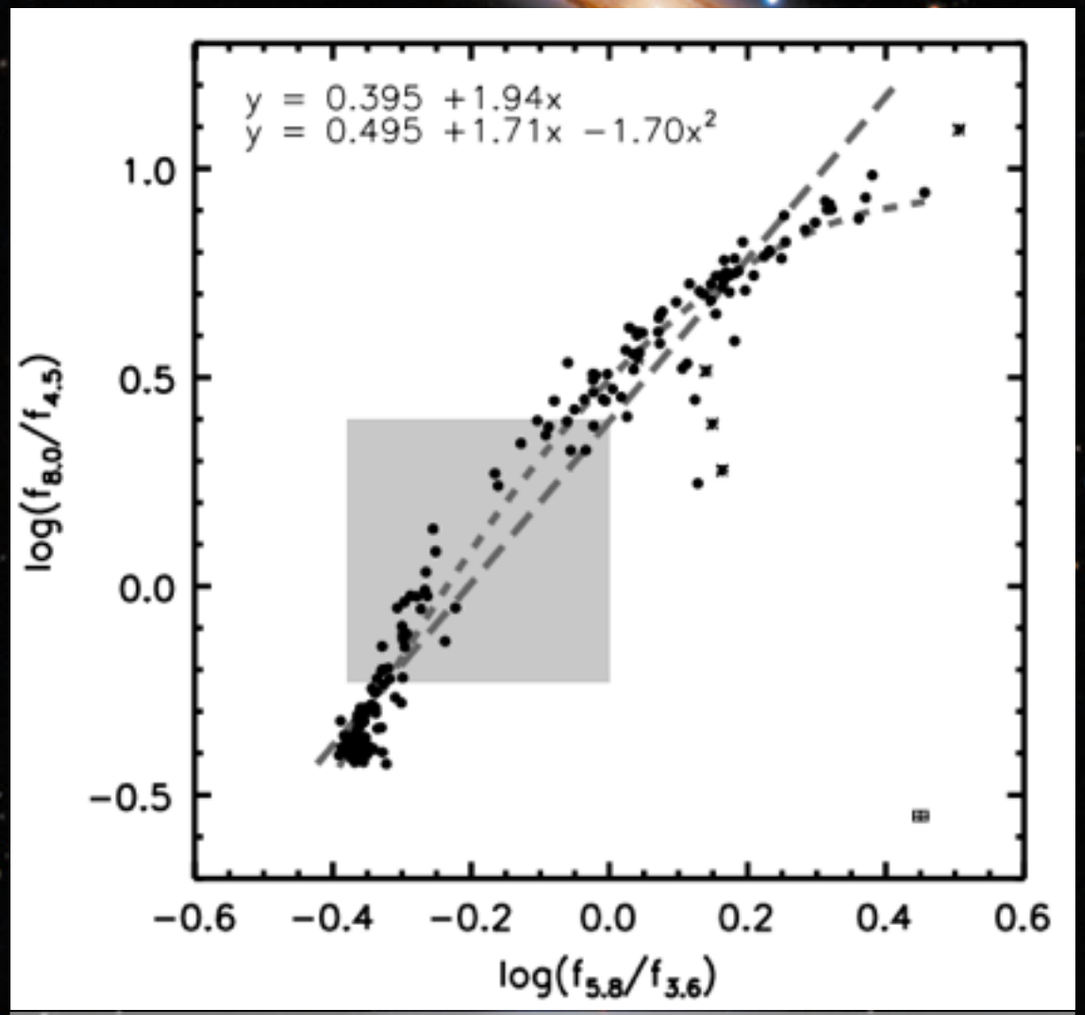
- Johnson+07 spotted a gap in the mid-IR colours and concluded accelerated evolution



The galaxy colours

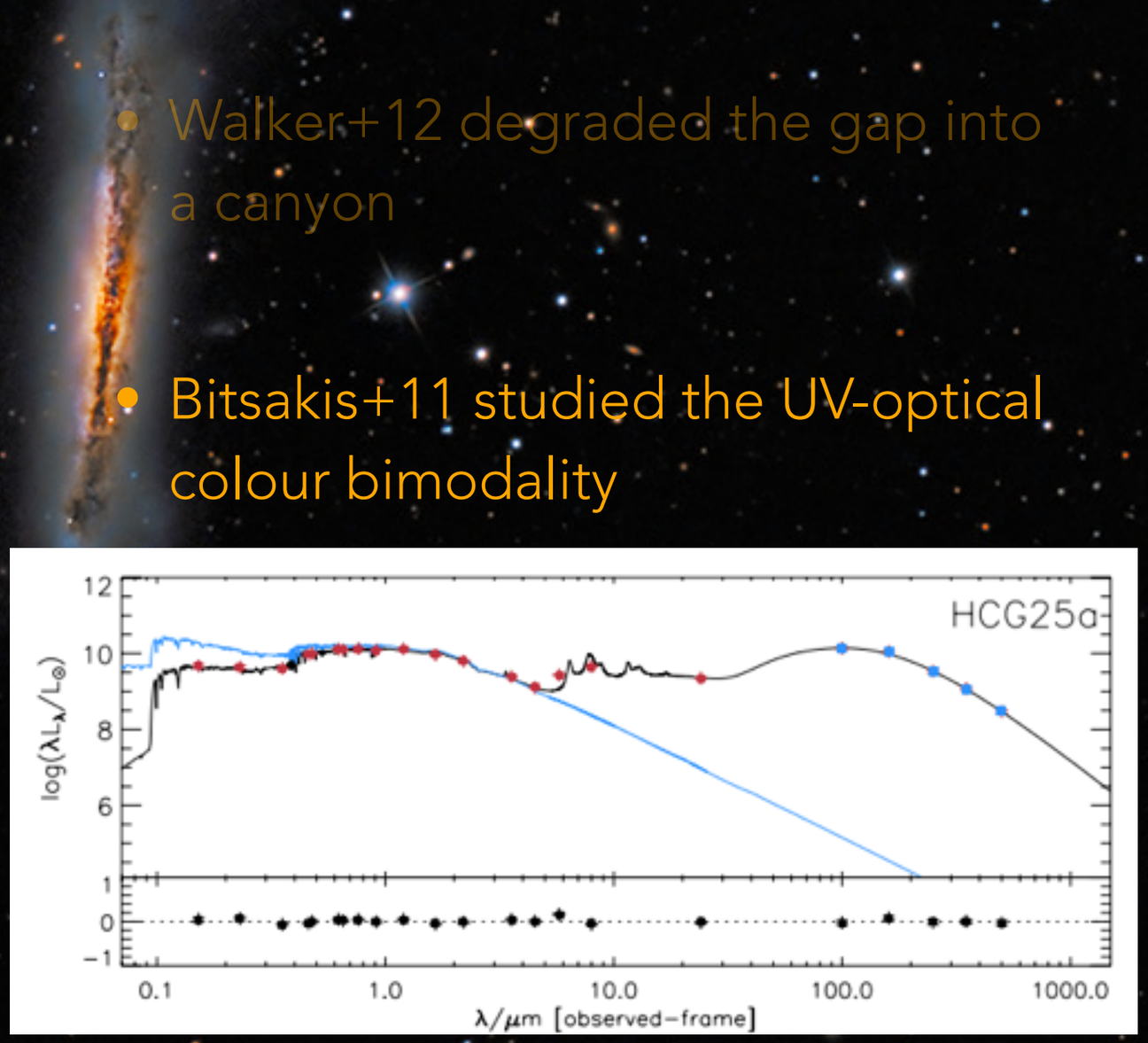
- Johnson+07 spotted a gap in the mid-IR colours and concluded accelerated evolution

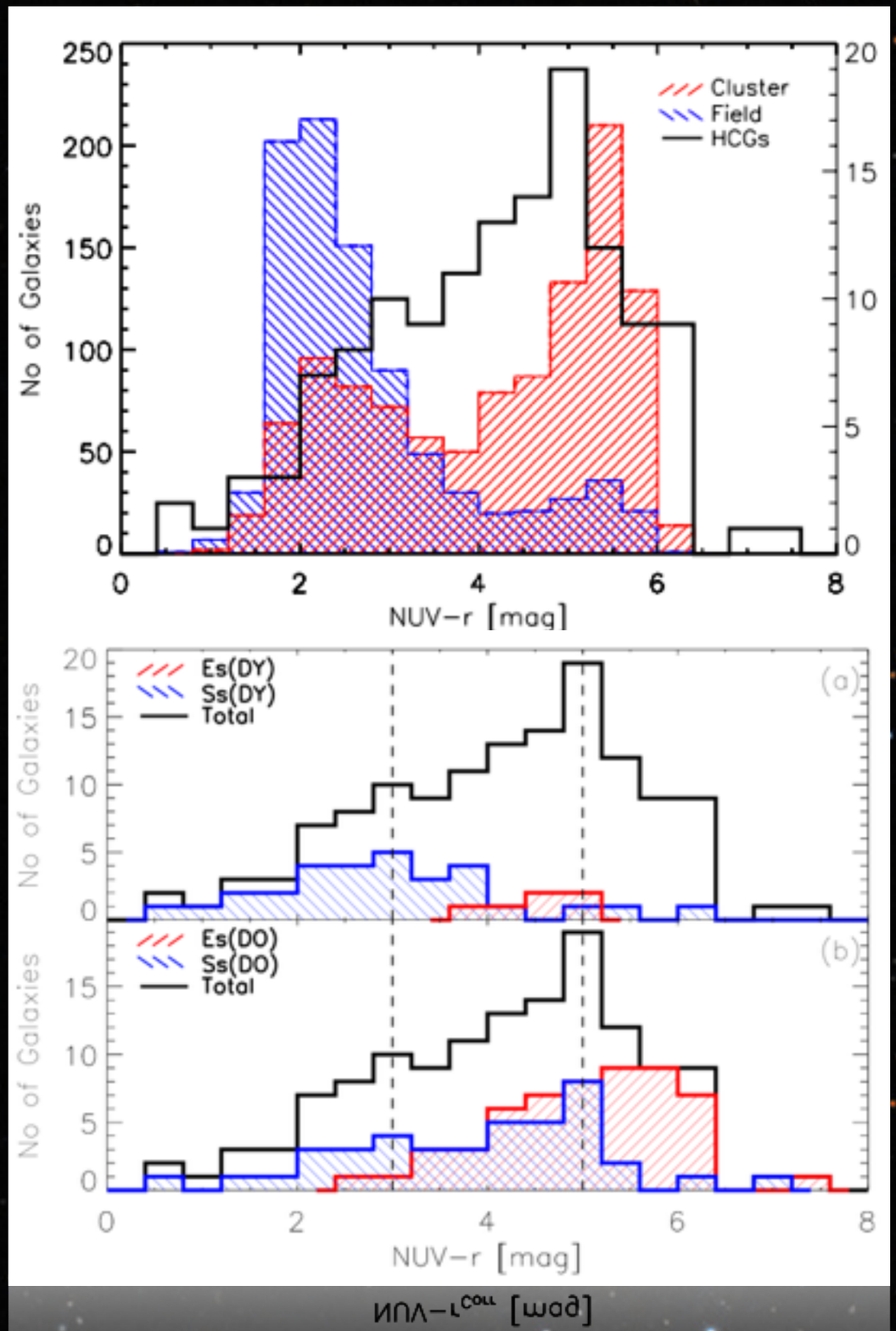
- Walker+12 degraded the gap into a canyon



The galaxy colours

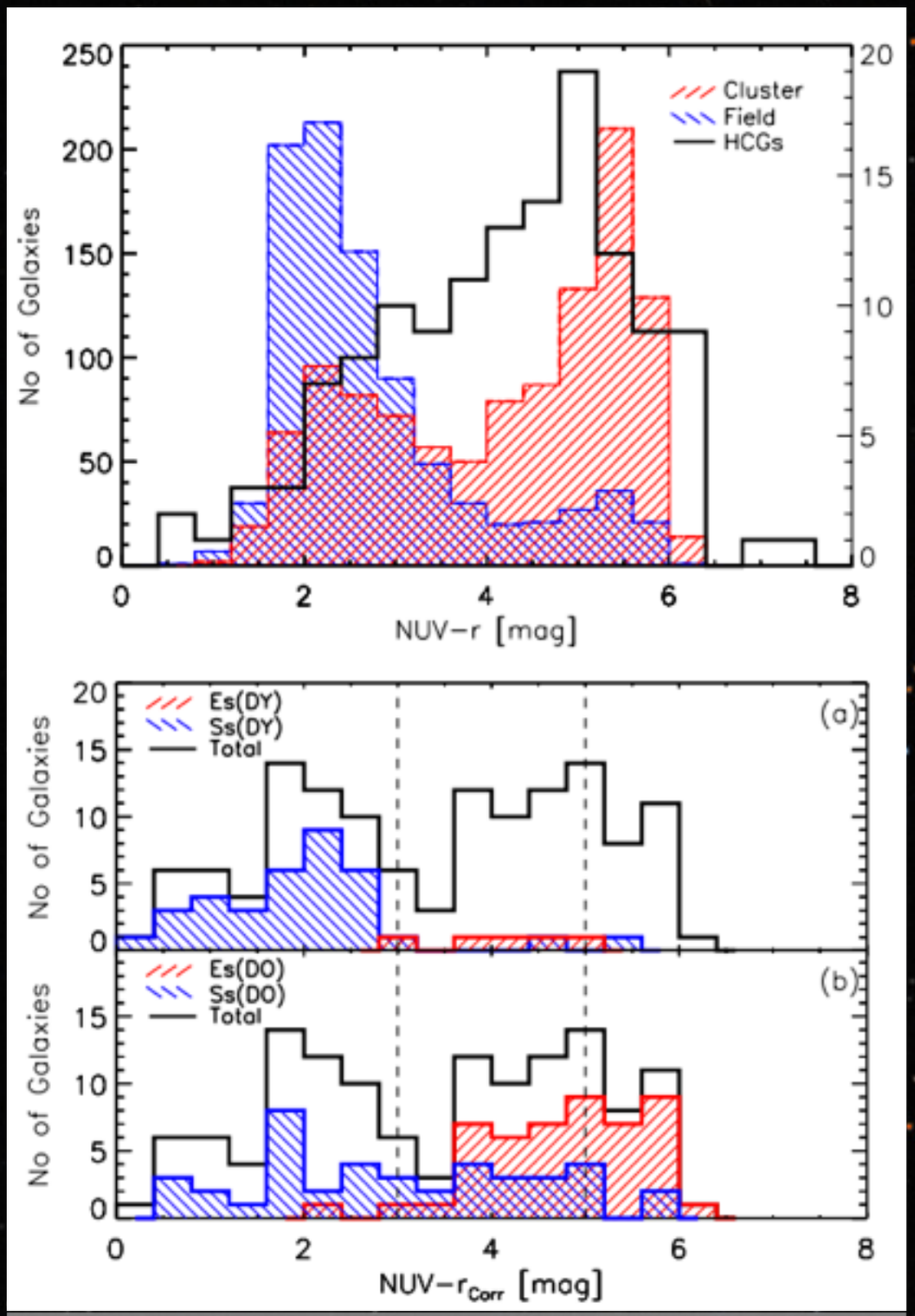
- Johnson+07 spotted a gap in the mid-IR colours and concluded accelerated evolution
- Walker+12 degraded the gap into a canyon
- Bitsakis+11 studied the UV-optical colour bimodality

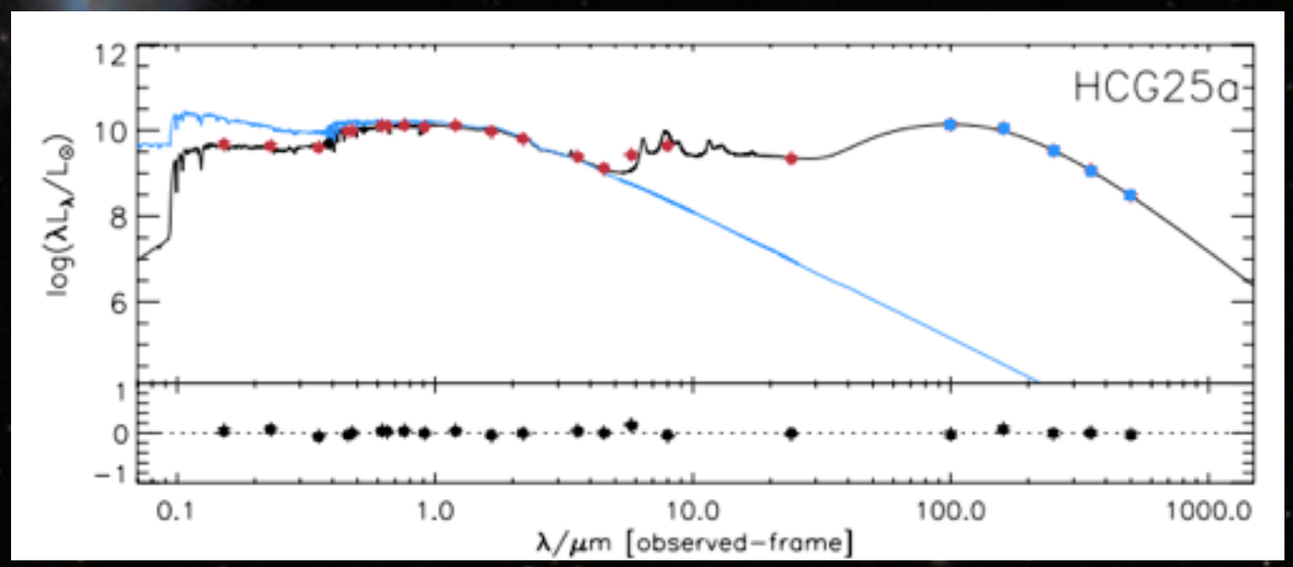




The galaxy colours

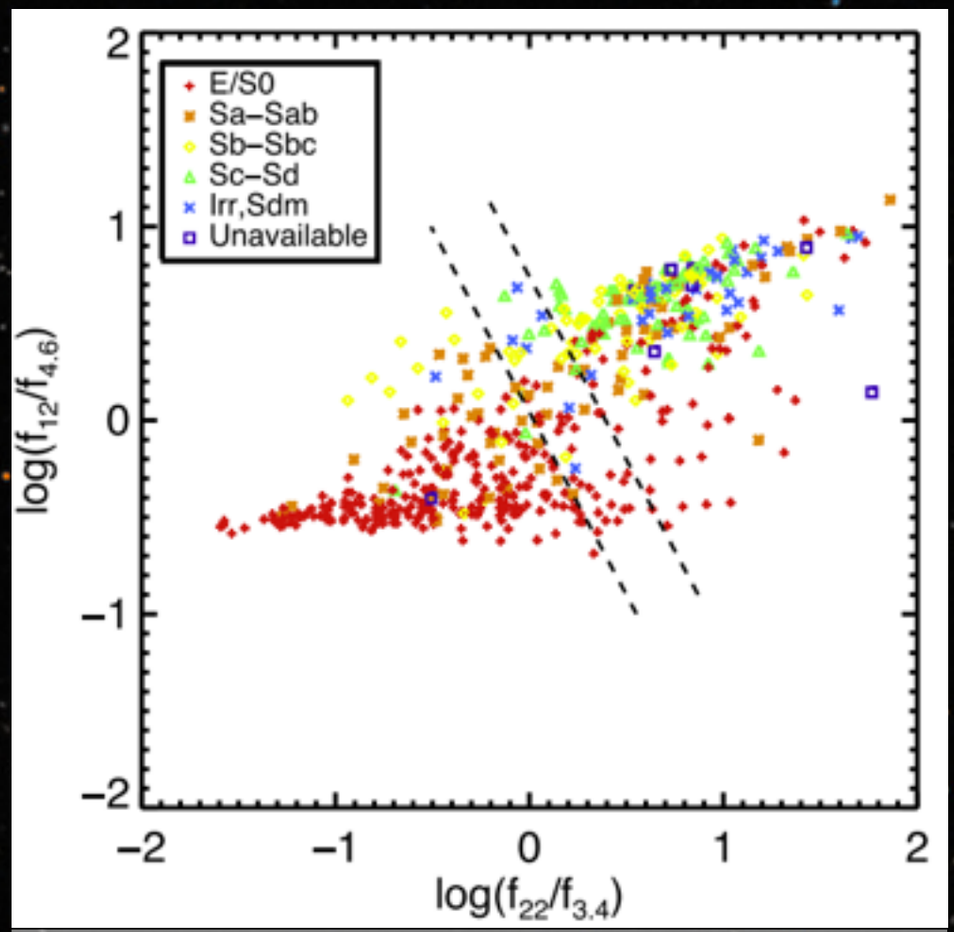
- Johnson+07 spotted a gap in the mid-IR colours and concluded accelerated evolution
- Walker+12 degraded the gap into a canyon
- Bitsakis+11 studied the UV-optical colour bimodality





The galaxy colours

- Johnson+07 spotted a gap in the mid-IR colours and concluded accelerated evolution
- Walker+12 degraded the gap into a canyon
- Bitsakis+11 studied the UV-optical colour bimodality
- Zucker+16 studied WISE colours of 163 HCG galaxies and confirmed many LTGs in the quiescent sequence

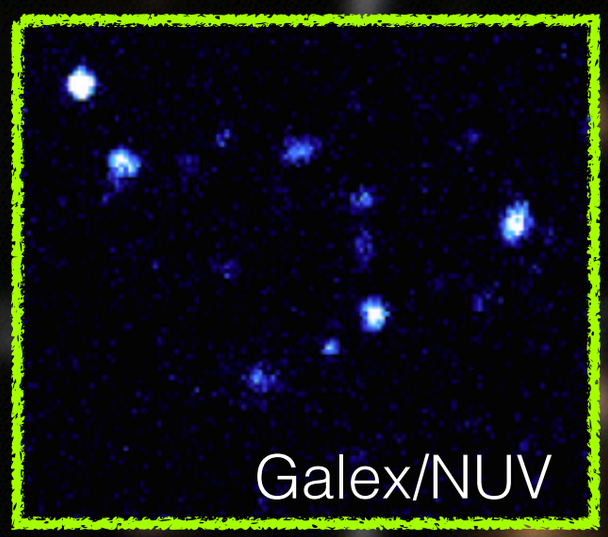


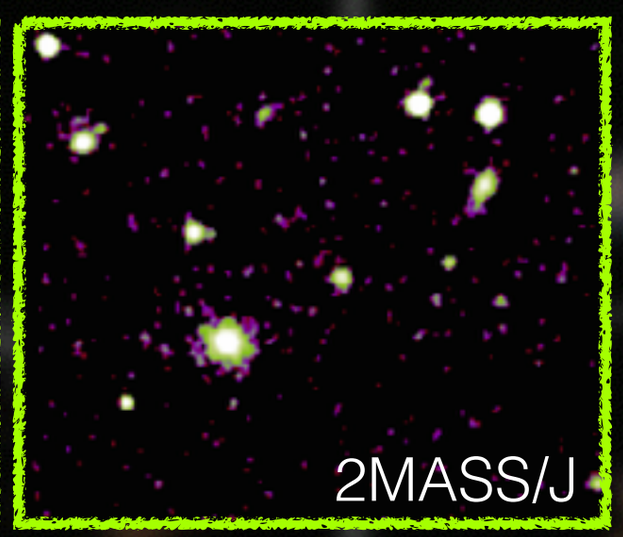
Studying the evolution over the past 3 Gyr

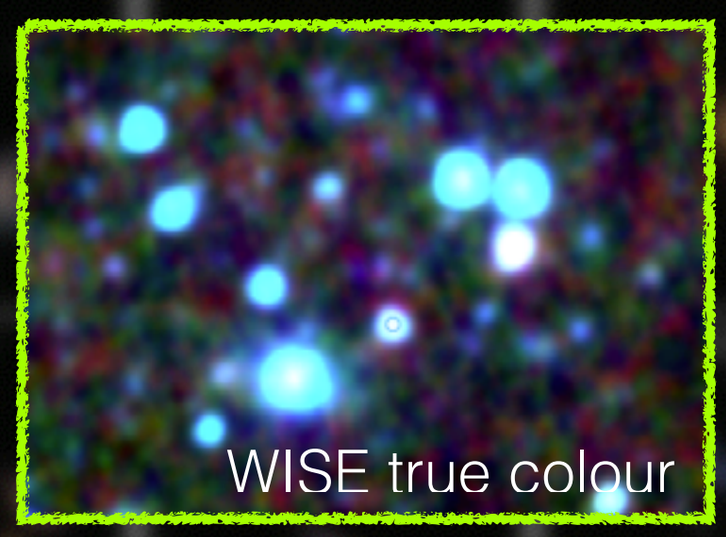
- We compile a new CG sample based on McConnachie+08,09 with available UV-to-IR colours for **1,770 CGs** (~**7,500** galaxies) => largest multiwavelength CG sample to-date

- Morphological classifications based on **radial profile fits** (Simard+11)

- z=0.01-0.23 (**looking-back time ~3Gyr**) [HCGs @ z~0.03]

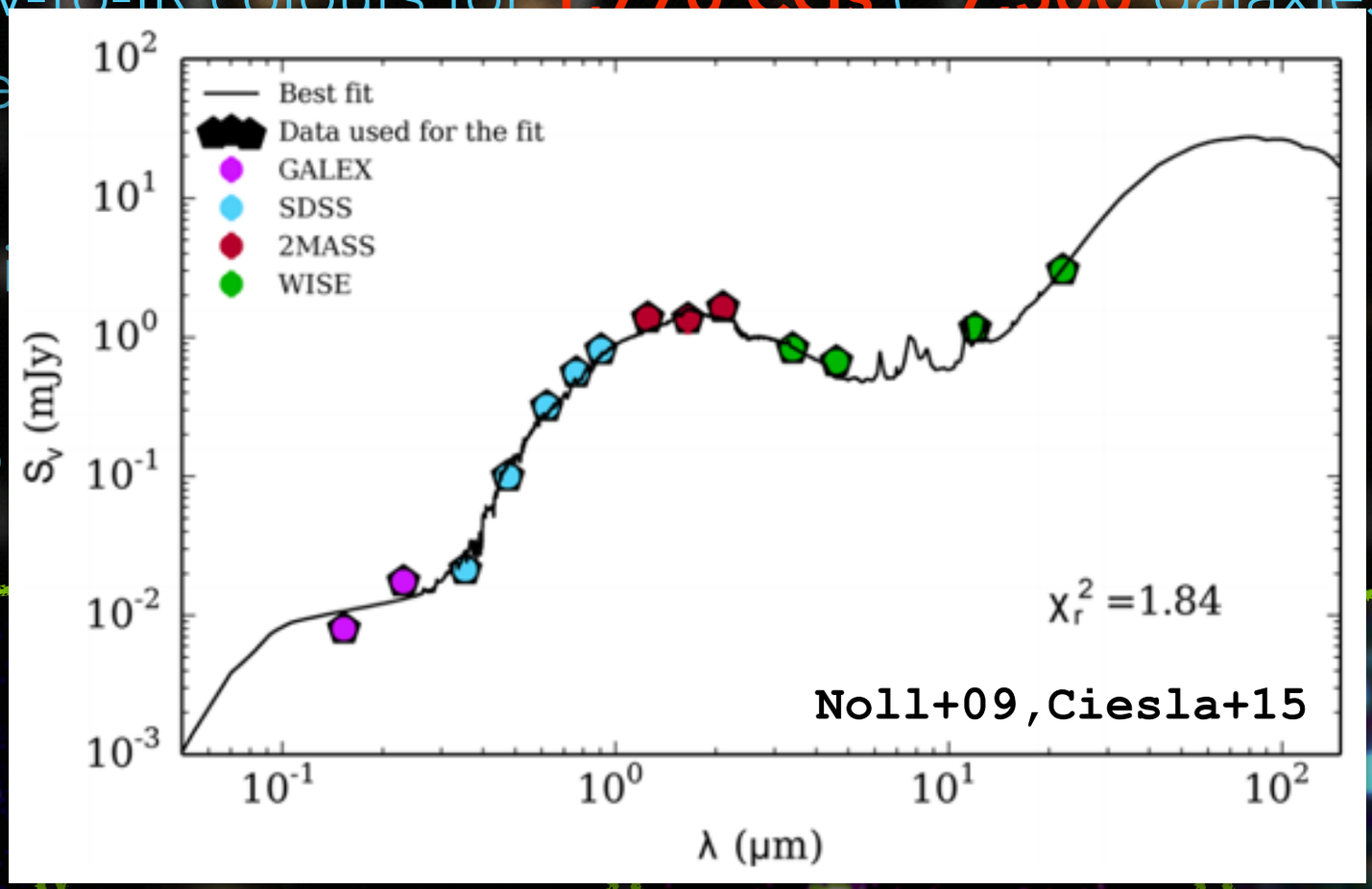


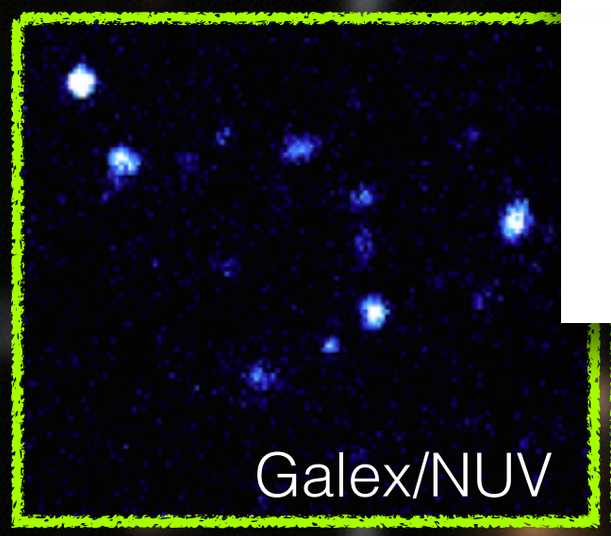




Studying the evolution over the past 3 Gyr

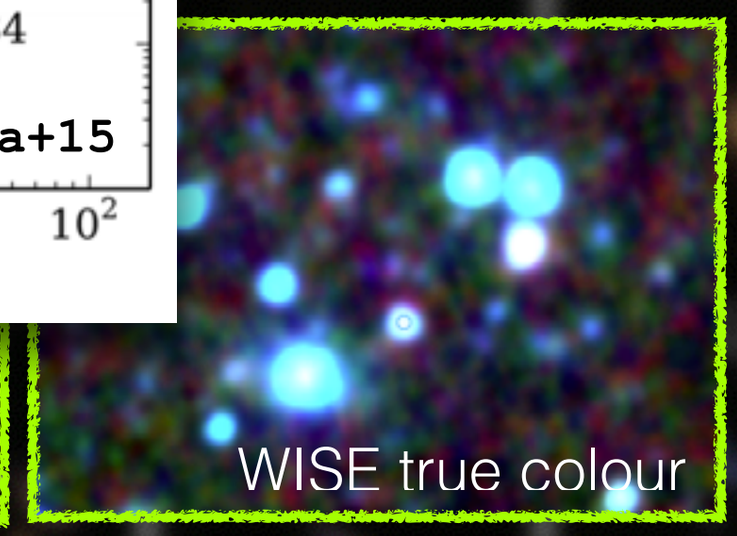
- We compile a new CG sample based on McConnachie+08,09 with available UV-to-IR colours for **1,770 CGs** (~**7,500** galaxies) => largest multiwavele
- Morphologi (Simard+11)
- z=0.01-0.23



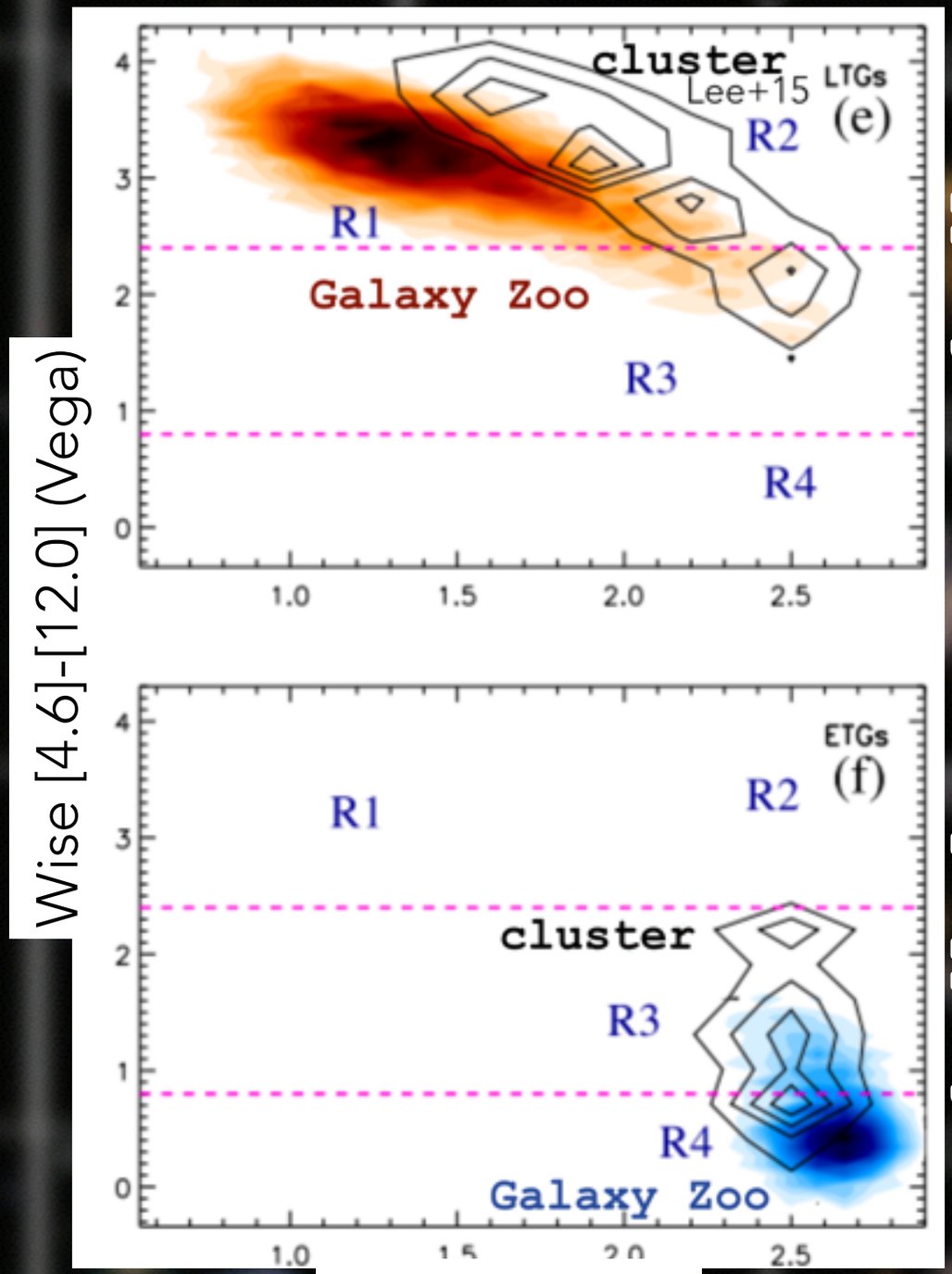

Galex/NUV

SDSS true colour

2MASS/J


WISE true colour

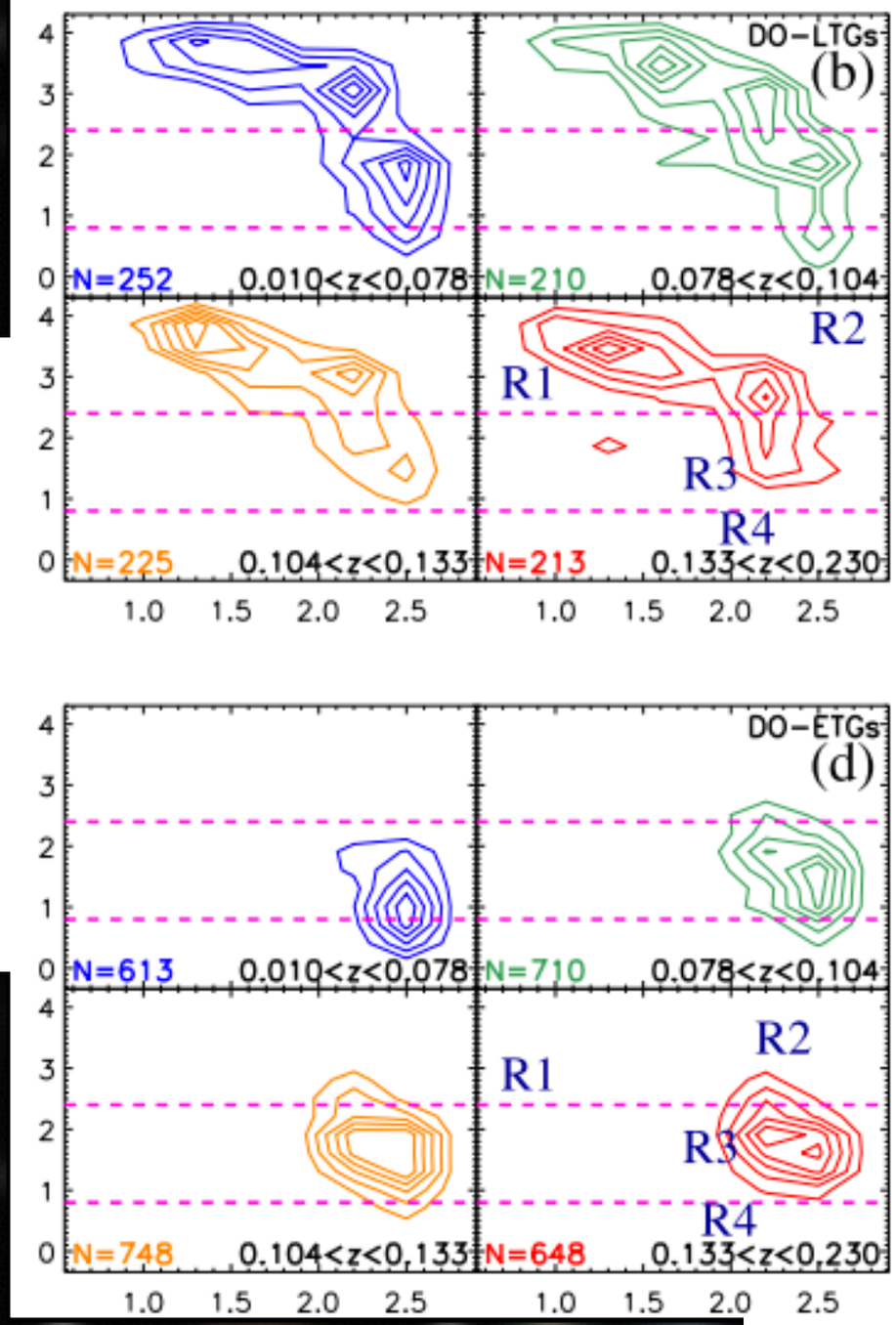
The evolution of colours

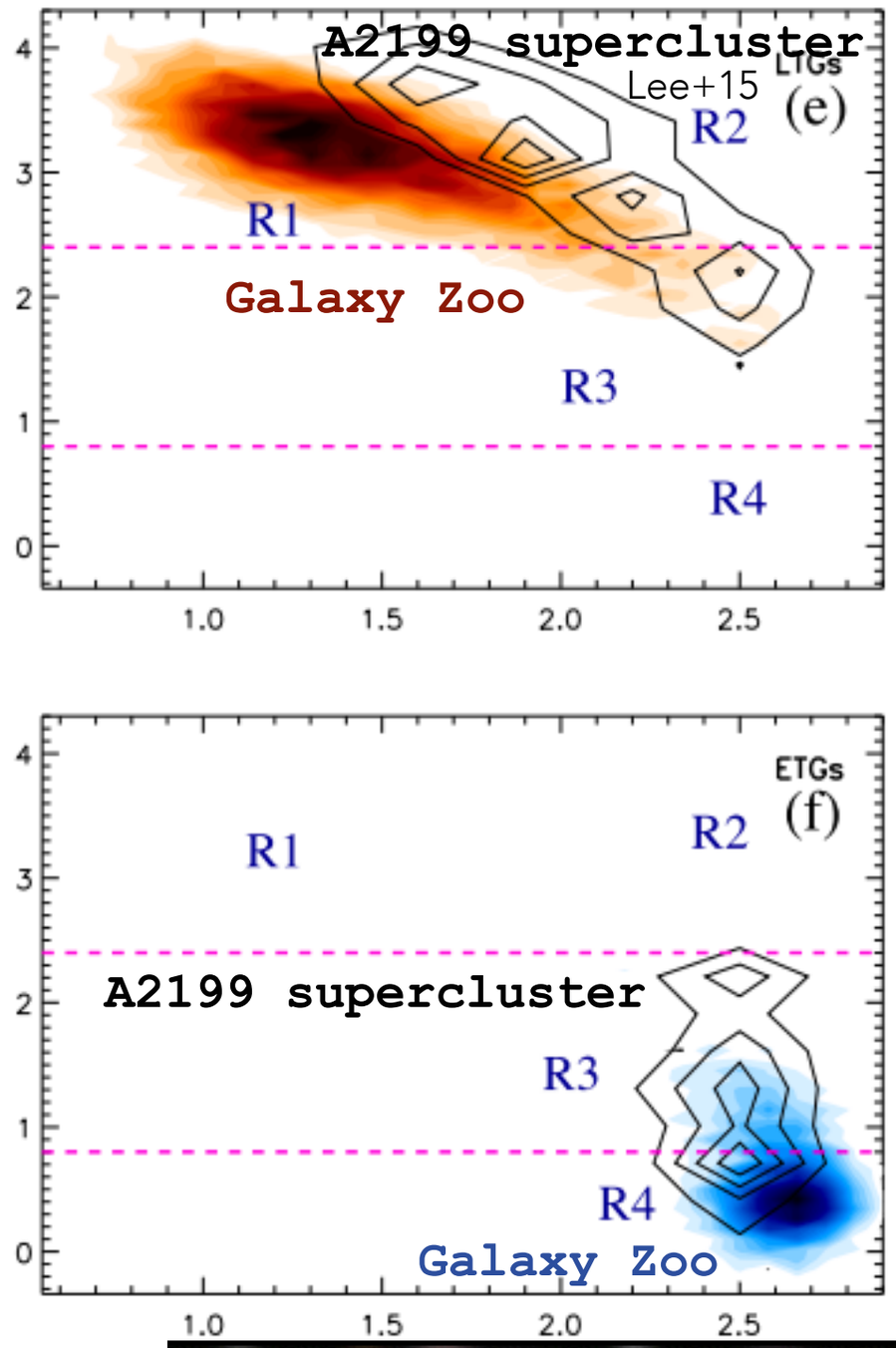


The evolution of colours

Dynamically old groups

Bitsakis+15, 16

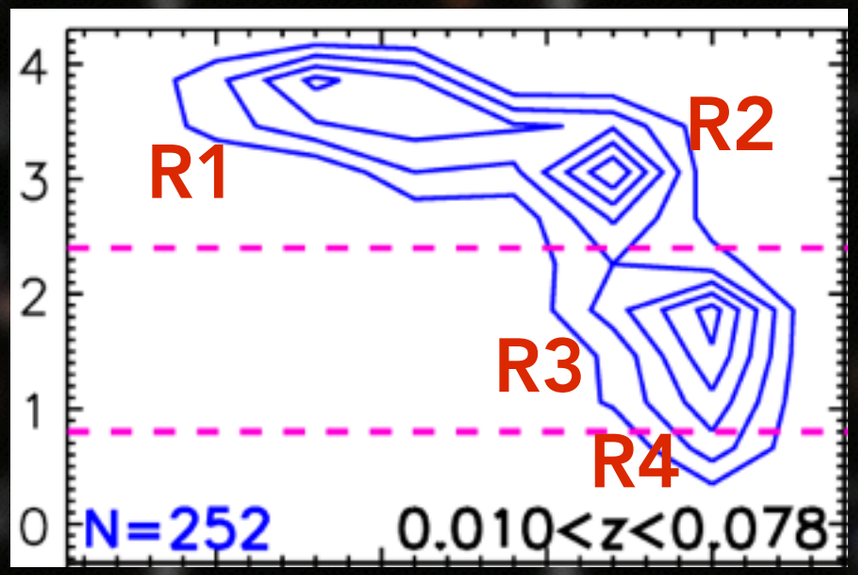




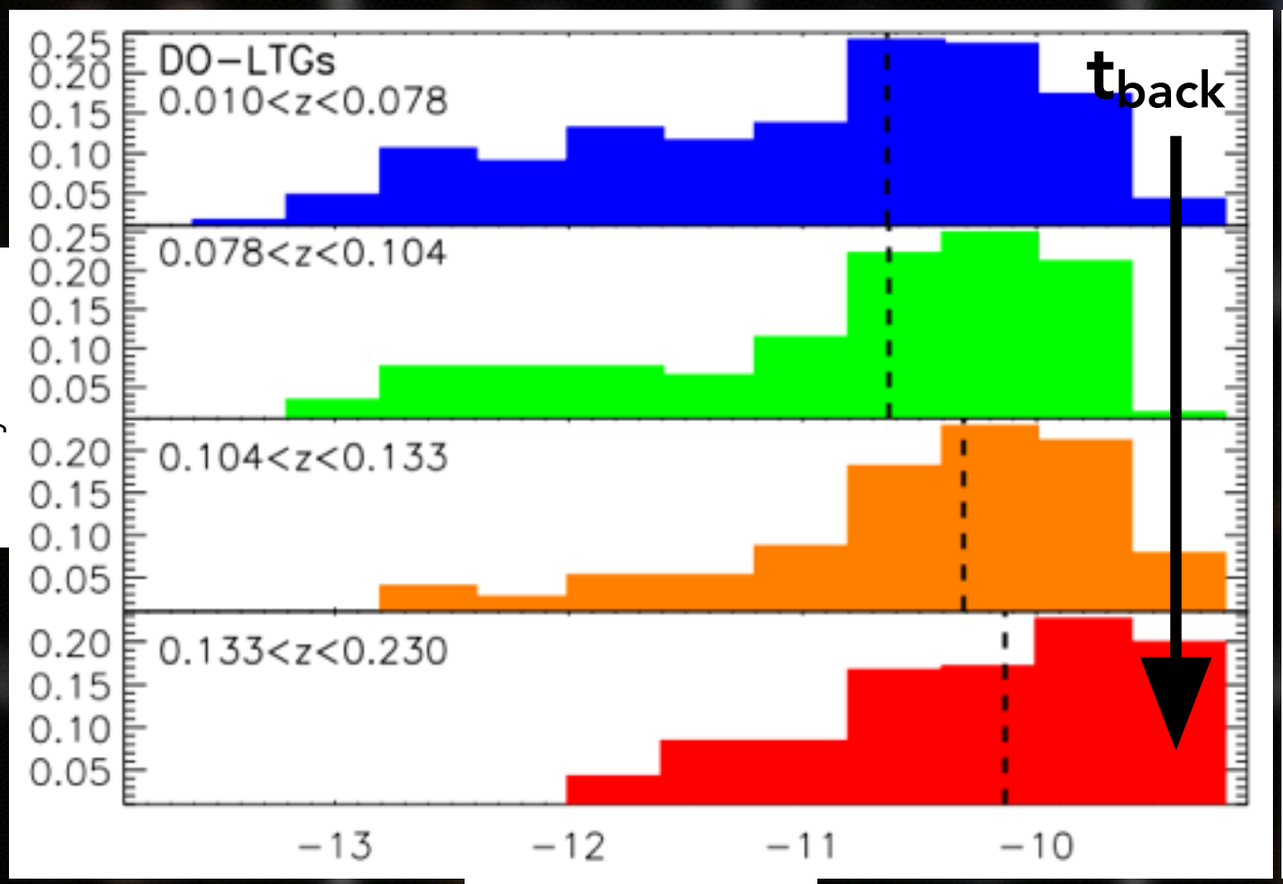
Late-type galaxies

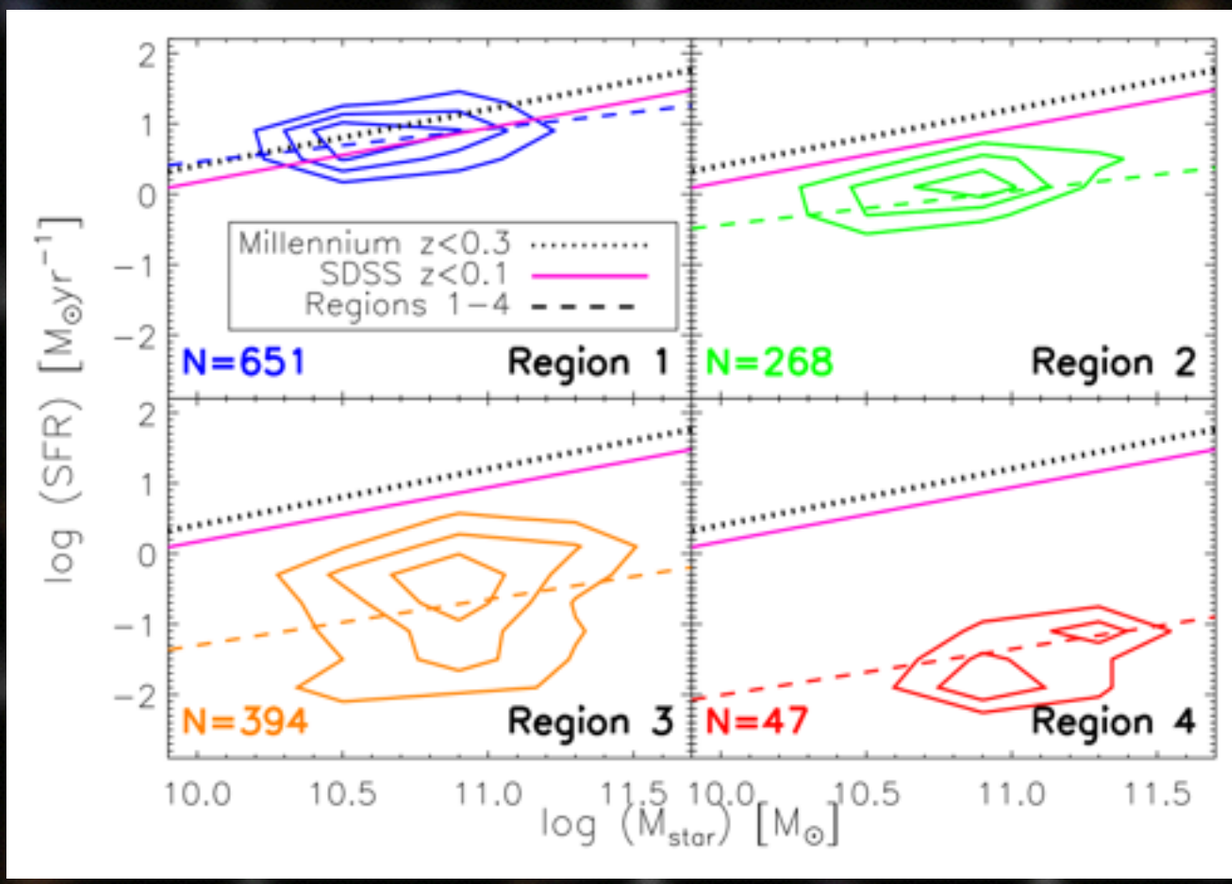
Early-type galaxies

The evolution of star formation



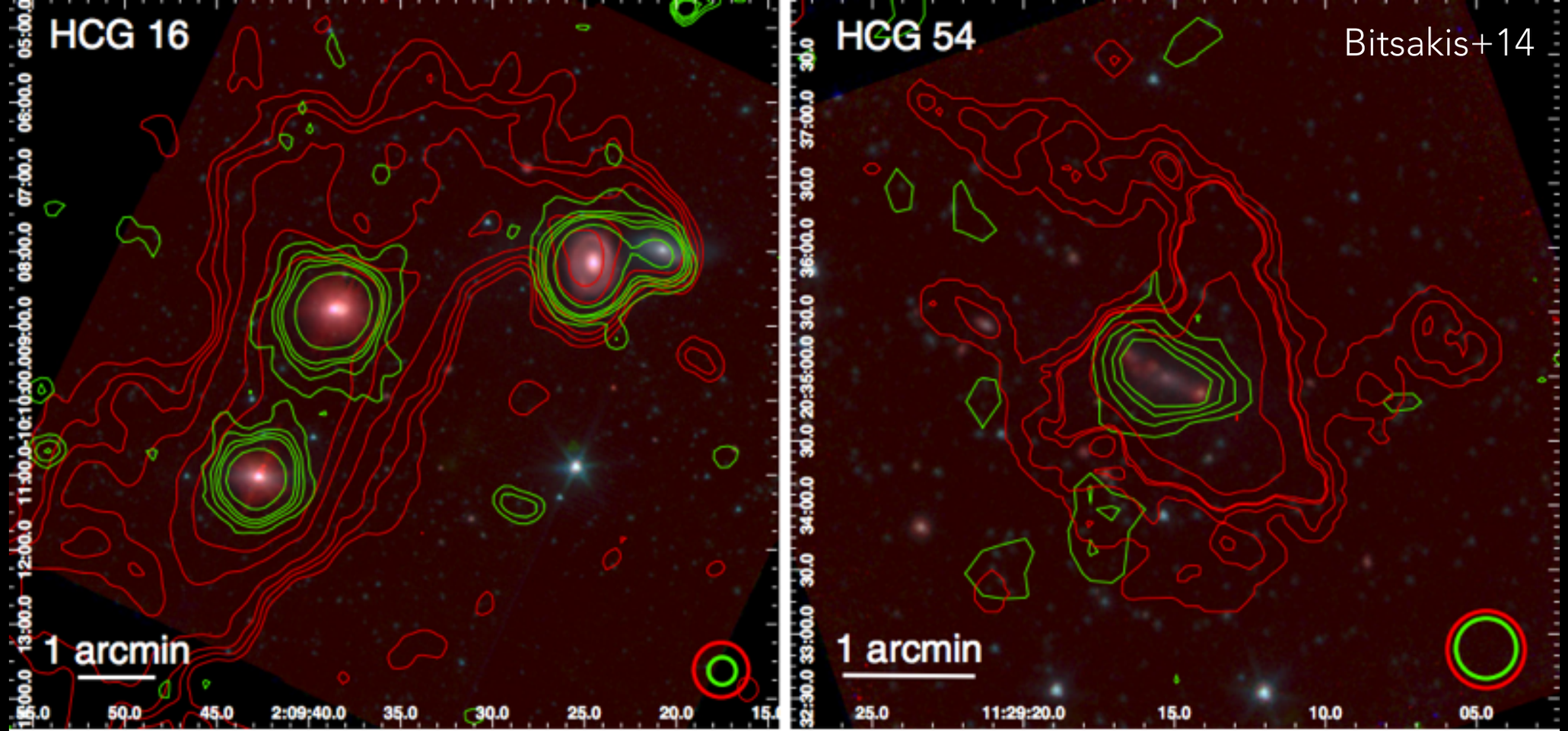
- R1 - star forming region
- R2 - “the elbow”
- R3 - Infrared Transition Zone (Alatalo+14)
- R4 - quiescent sequence





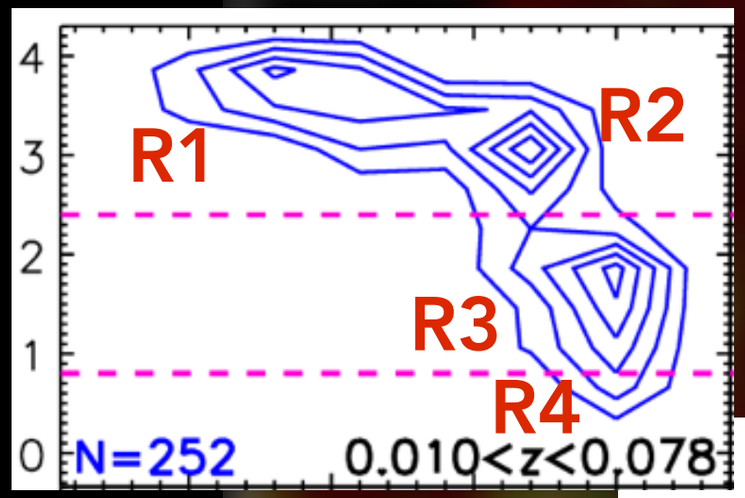
Bitsakis+15, 16

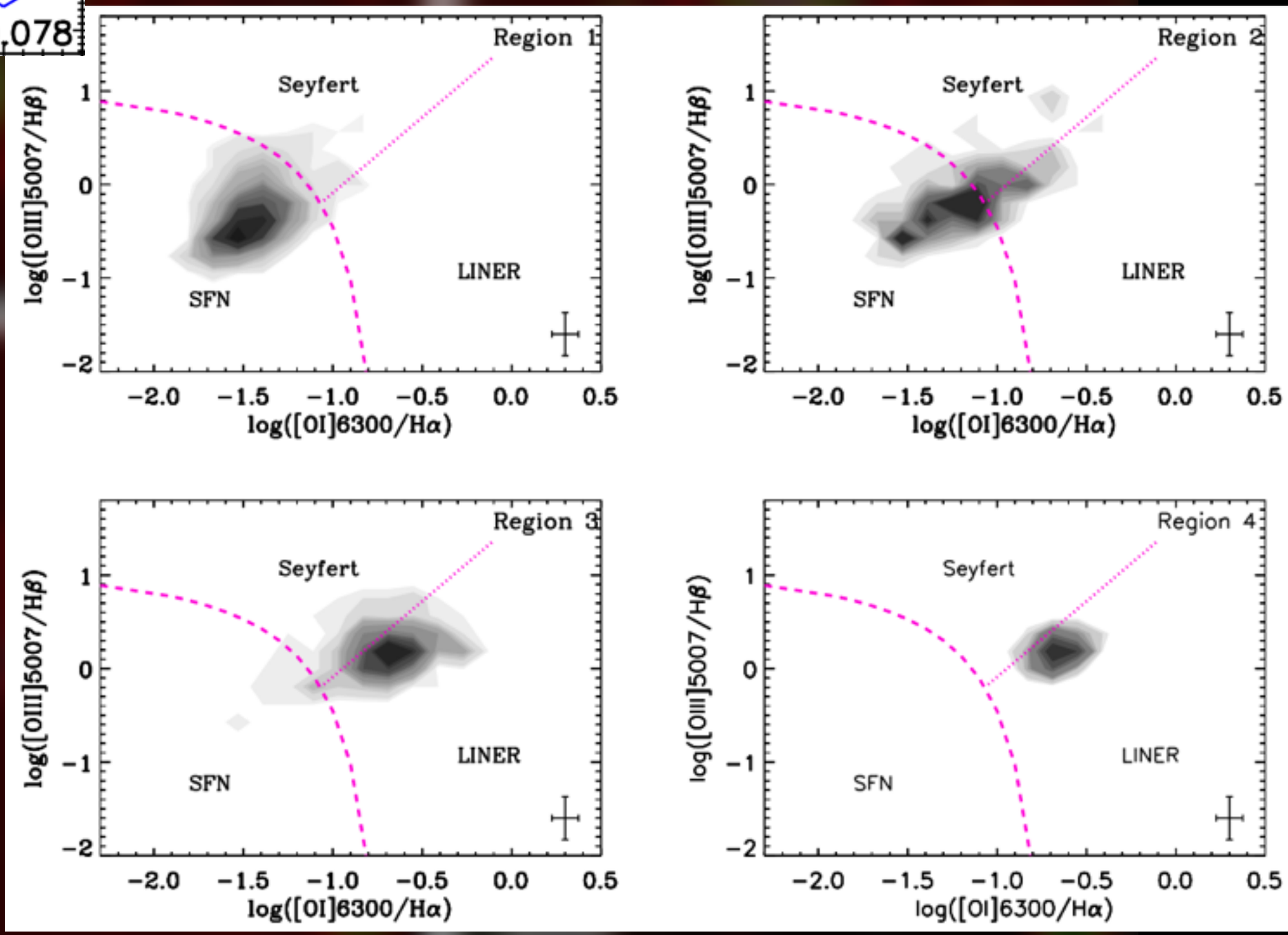
Which are the driving forces of this evolution?


HCG 16
1 arcmin
HCG 54
Bitsakis+14
1 arcmin
HCG 79
Dust (Bitsakis+14)
1 arcmin
HCG 92
HI (Verdes-Montenegro+01)
1 arcmin

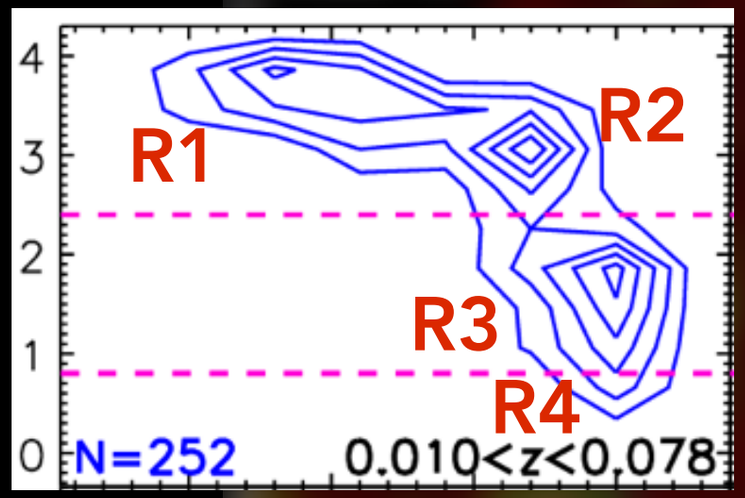
S DEC. 2016

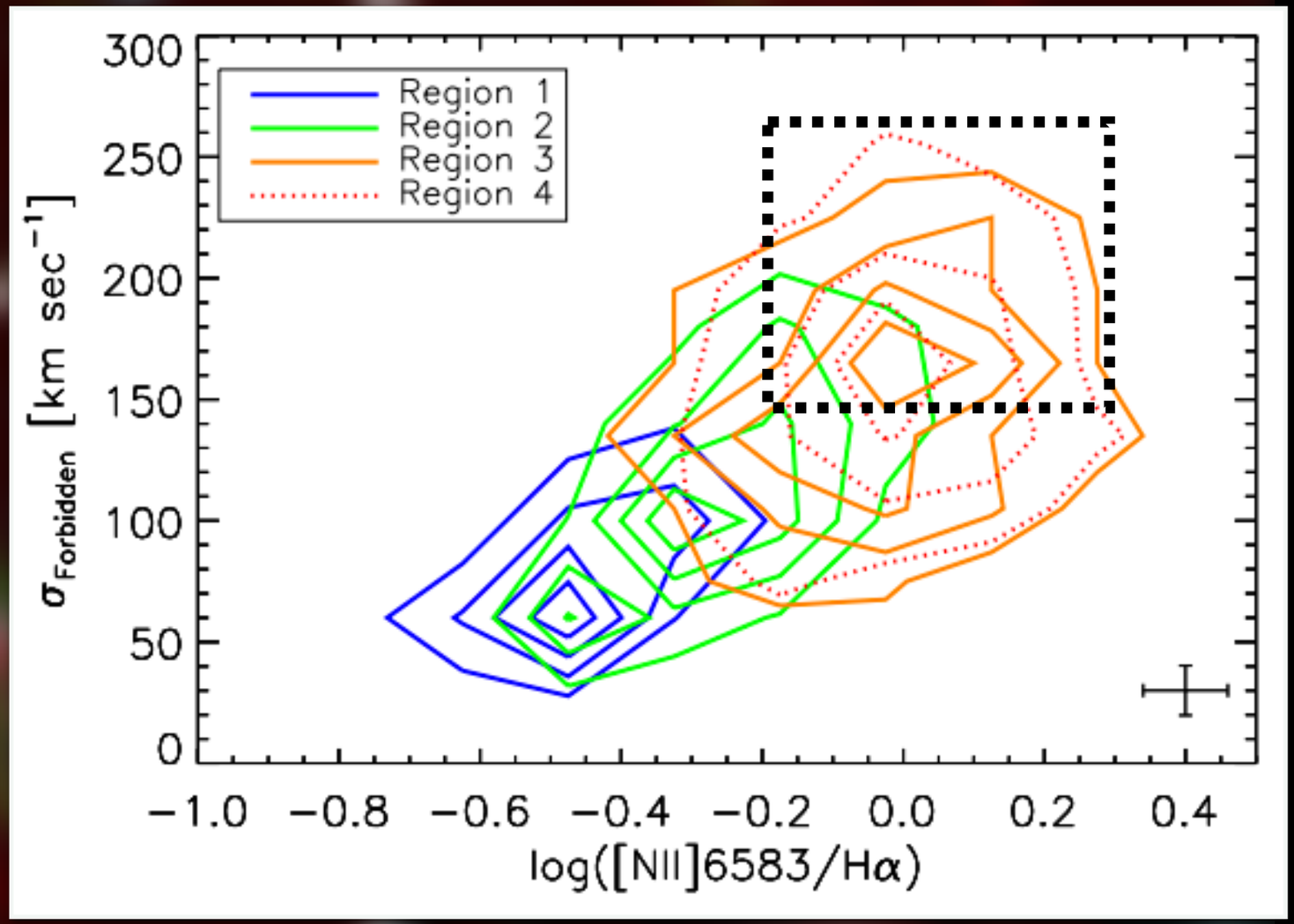
However, our data also suggest…



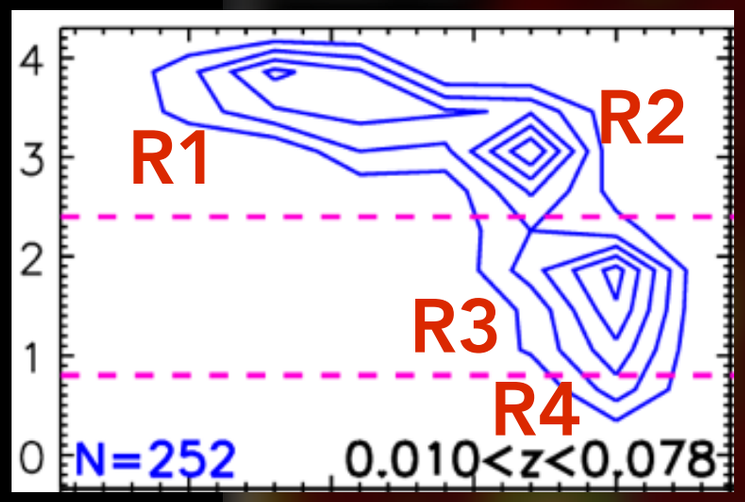


However, our data also suggest…





However, our data also suggest…



Future goals:
Use the unique capabilities of JWST and IFU spectroscopy to study the special properties of these galaxies

Region	SSFR$\times 10^{-11}$ [yr^{-1}]	σ_{median} [km sec^{-1}]	EW(NaD) Å
Region 1	12.21±0.08	75.6±2.5	1.91±0.06
Region 2	2.07±0.01	111.4±7.3	2.90±0.19
Region 3	0.24±0.01	152.7±8.6	3.34±0.19
Region 4	0.07±0.01	159.6±11.0	3.50±0.23

shocks and turbulence could bust up the σ_{gas} with result to further suppress SF (e.g. Guillard+12, Appleton+13, Alatalo+14,15, Cluver+13, Lisenfeld +14)

Do compact groups display the SF and colours that are expected given their unusually high densities?

Compact group environment influences uniquely the evolution of star formation in its members.

Multiple interactions have as a result to reduce the SF, by reducing the gas content (tidal stripping), but also suppress it by introducing turbulence/shocks that make the remaining gas inefficient to form stars

(see more in the presentations of K. Alatalo, P. Appleton, P. Guillard, U. Lisenfeld)