Searching for star-forming early-type galaxies: the role of the environment

Laurie Riguccini

Valongo Observatory/ Federal University of Rio de Janeiro (UFRJ), Brazil

Astronomia a meio dia, IAG, SP

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Collaborators

Paulo Lopes (Valongo, Brazil)
Douglas Brambila (Valongo, Brazil)
Alexandre Amblard (NASA Ames/ BAER Institute)
Pasquale Temi (NASA Ames/ BAER Institute)
Michael Fanelli (NASA Ames/ BAER Institute)

+ LASEX team @ Valongo

Spiral galaxies

Spiral Galaxy NGC 4622

Hubble Heritage

NASA and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope WFPC2 • STScI-PRC02-03

Elliptical

Spiral Galaxy NGC 4622

Hubble Heritage

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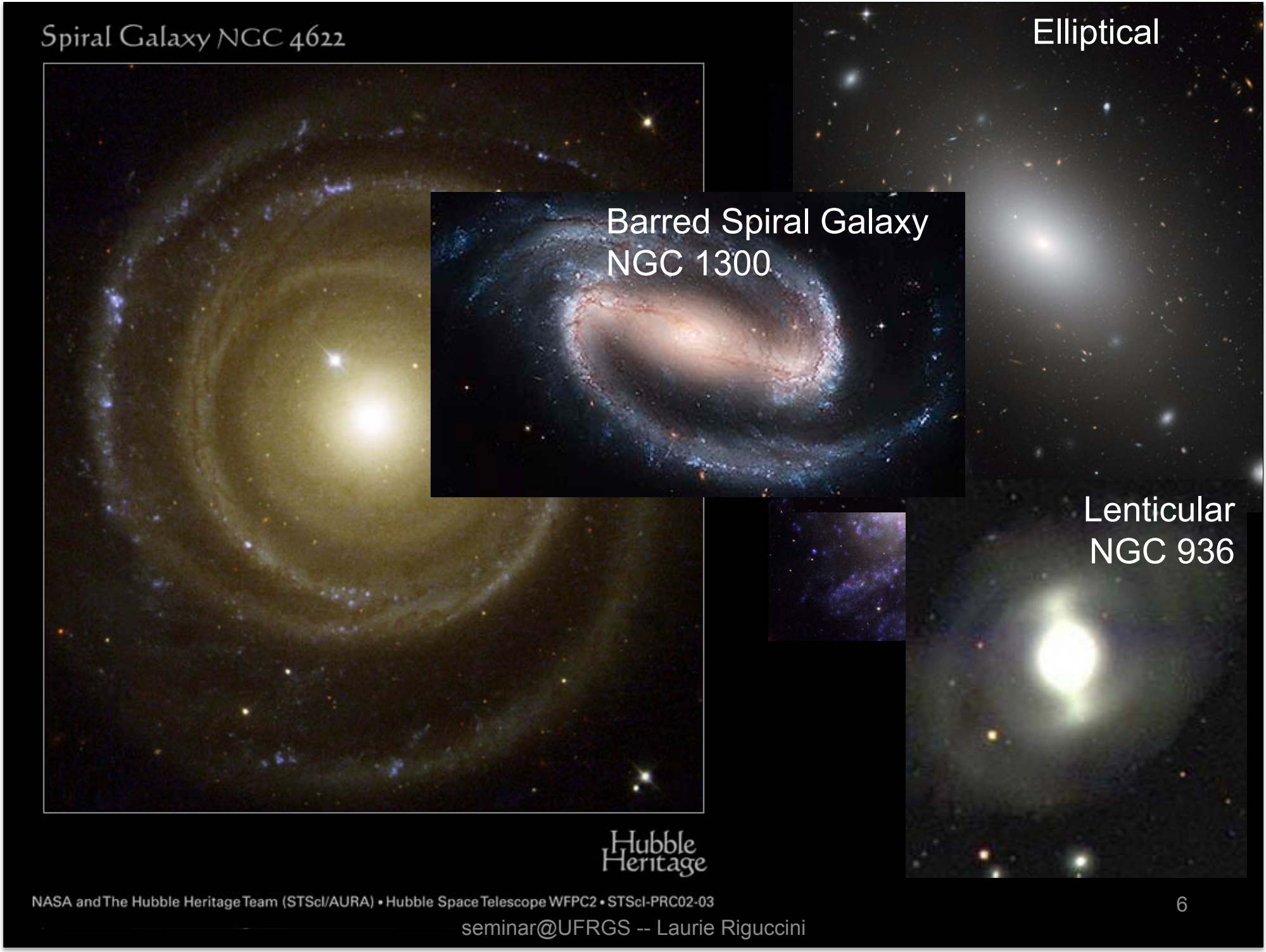
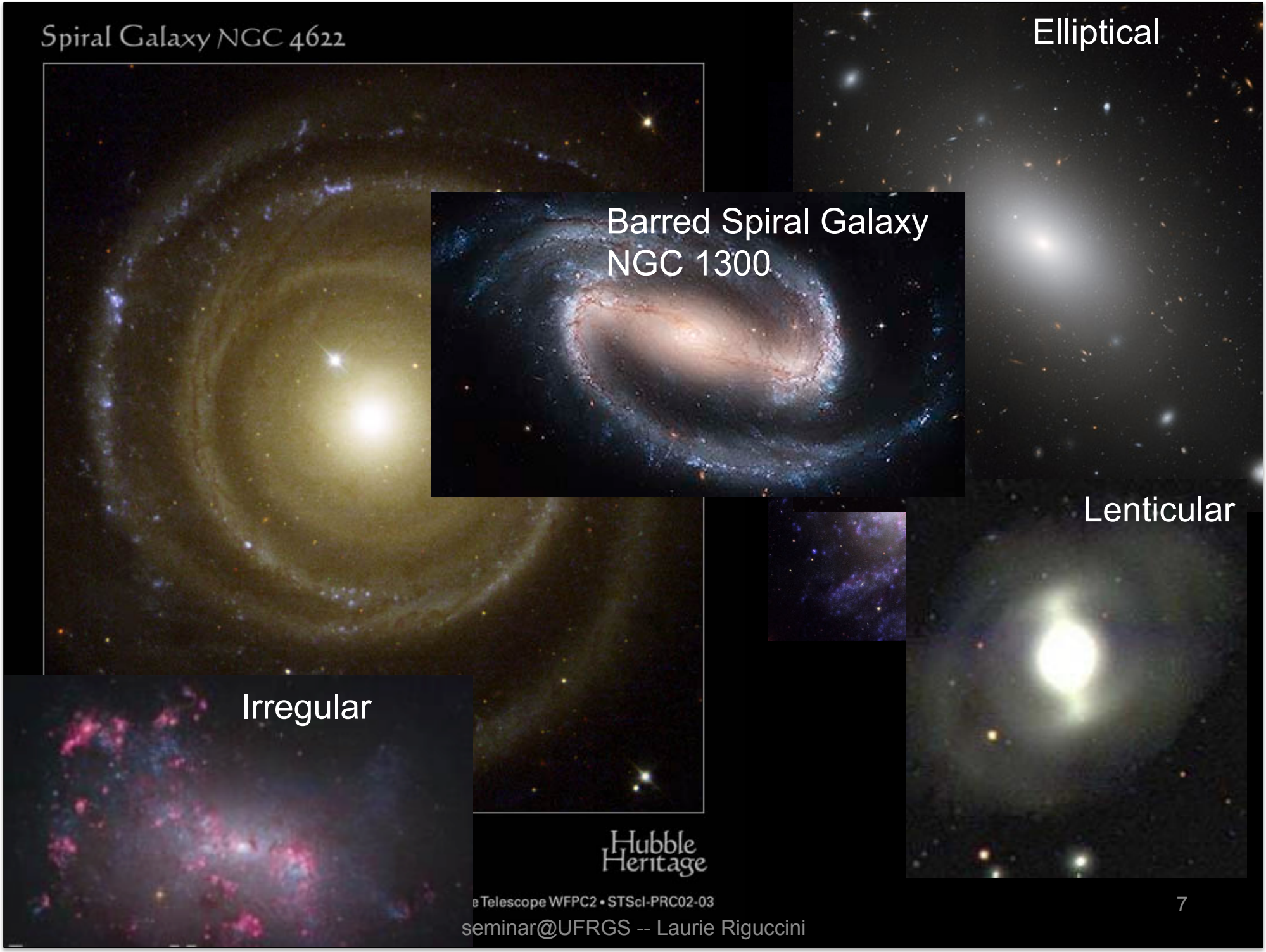
Elliptical

Lenticular
NGC 936


Spiral Galaxy NGC 4622
Elliptical
Barred Spiral Galaxy
NGC 1300
Lenticular
NGC 936
Hubble Heritage
NASA and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope WFPC2 • STScI-PRC02-03


Spiral Galaxy NGC 4622
Elliptical
Barred Spiral Galaxy
NGC 1300
Lenticular
Irregular
Hubble
Heritage
e Telescope WFPC2 • STScI-PRC02-03

Spiral Galaxy NGC 4622

Hubble Heritage

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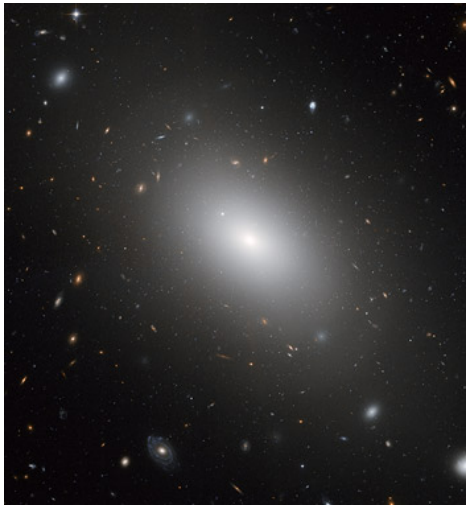
Elliptical

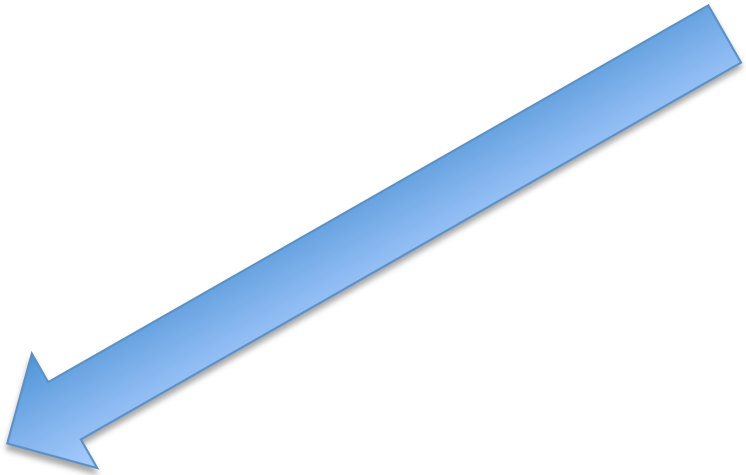
Lenticular
NGC 936

The Hubble Tuning Fork Diagram

Galaxy Morphological Classification

All images taken with the Faulkes Telescopes





Spiral Galaxy NGC 4622

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Elliptical

Lenticular
NGC 936

Spiral Galaxy NGC 4622

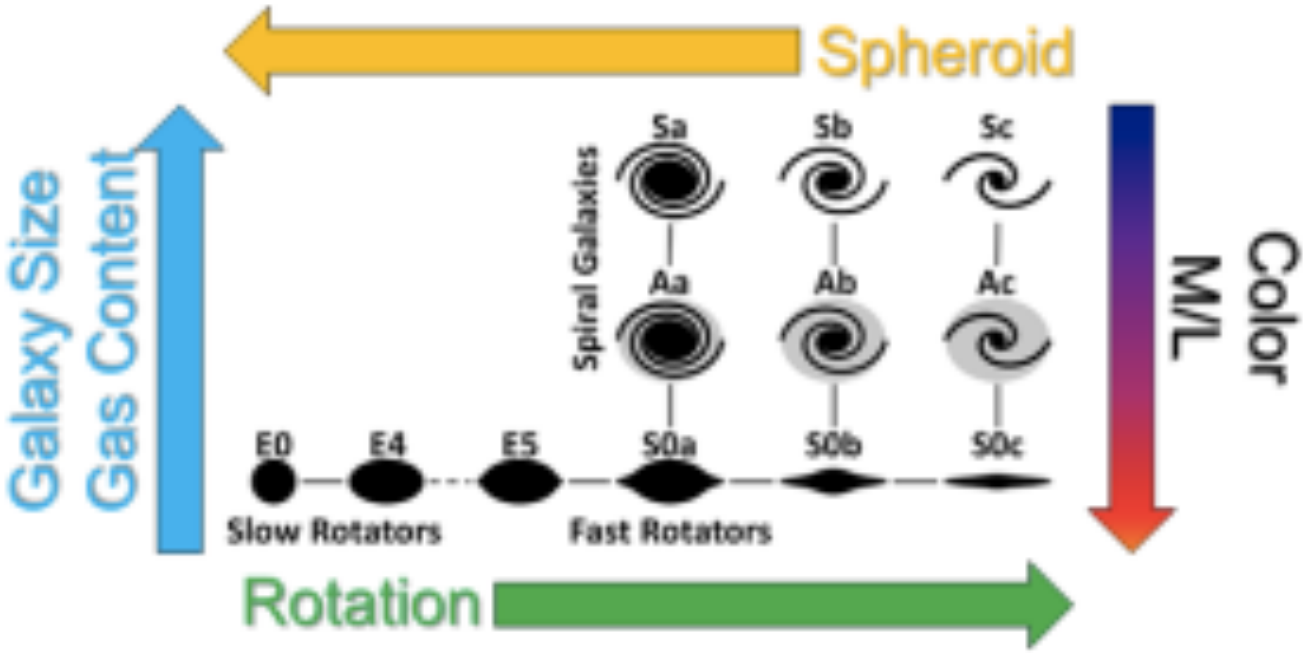
Elliptical

✓ Amount of dust and gas
✓ Age of stellar population
✓ Galaxy Size
✓ Stellar Mass
✓ Star formation Rate
…

Lenticular
NGC 936

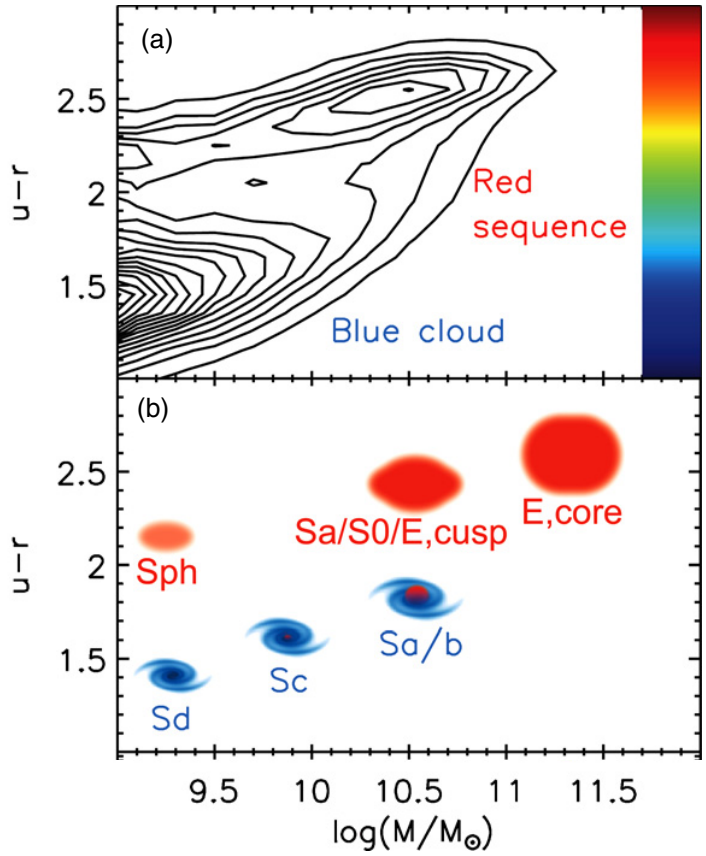
Hubble Heritage

NASA and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope WFPC2 • STScI-PRC02-03



The ATLAS^{3D} comb (2011)

Color bimodality



Elliptical galaxies:
redder and
more massive

Kormendy & Bender (2012)

Spiral Galaxy NGC 4622

Elliptical

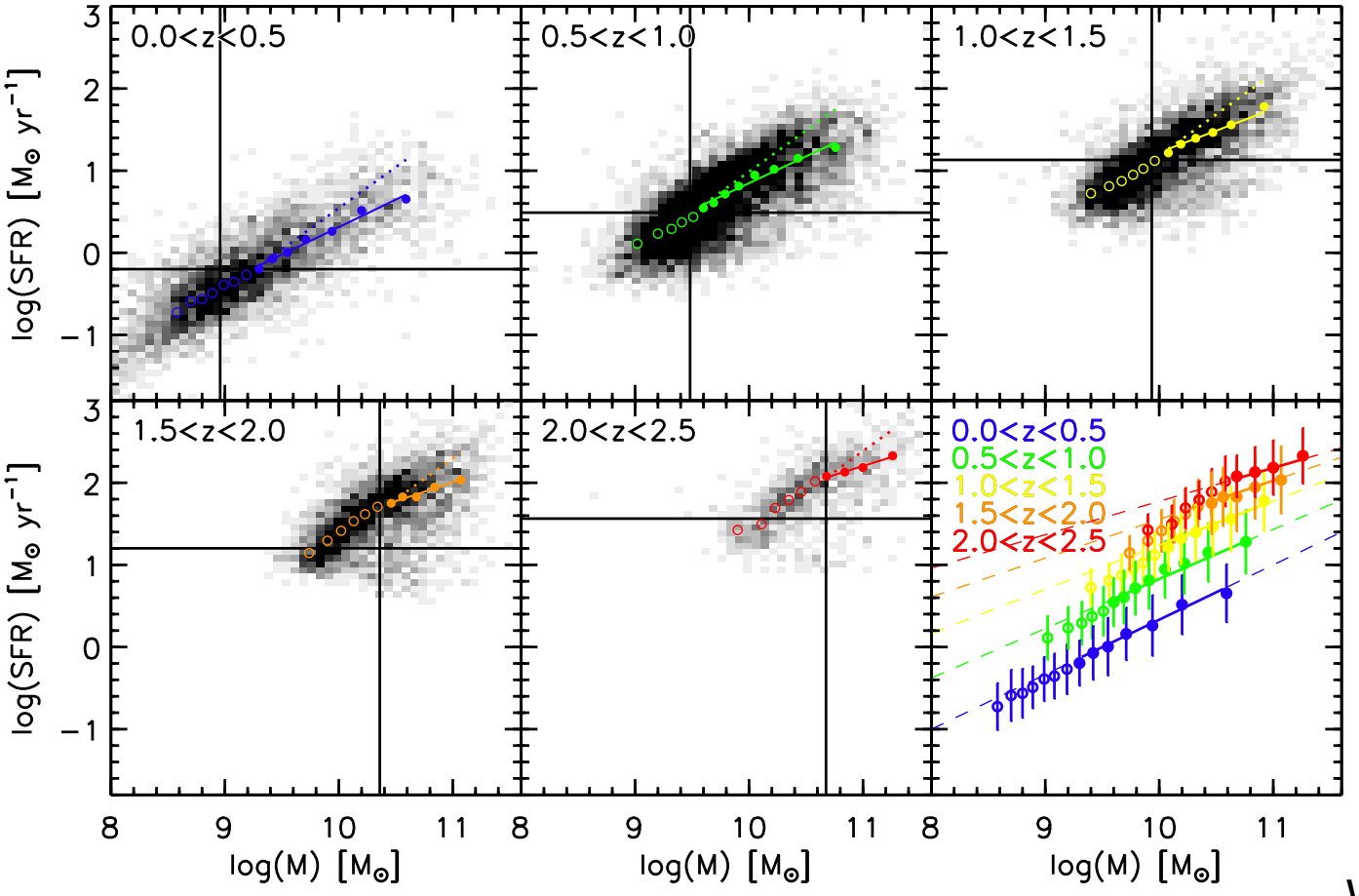
✓ Amount of dust and gas
✓ Age of stellar population
✓ Galaxy Size
✓ Stellar Mass
✓ Star formation Rate
…

Lenticular
NGC 936

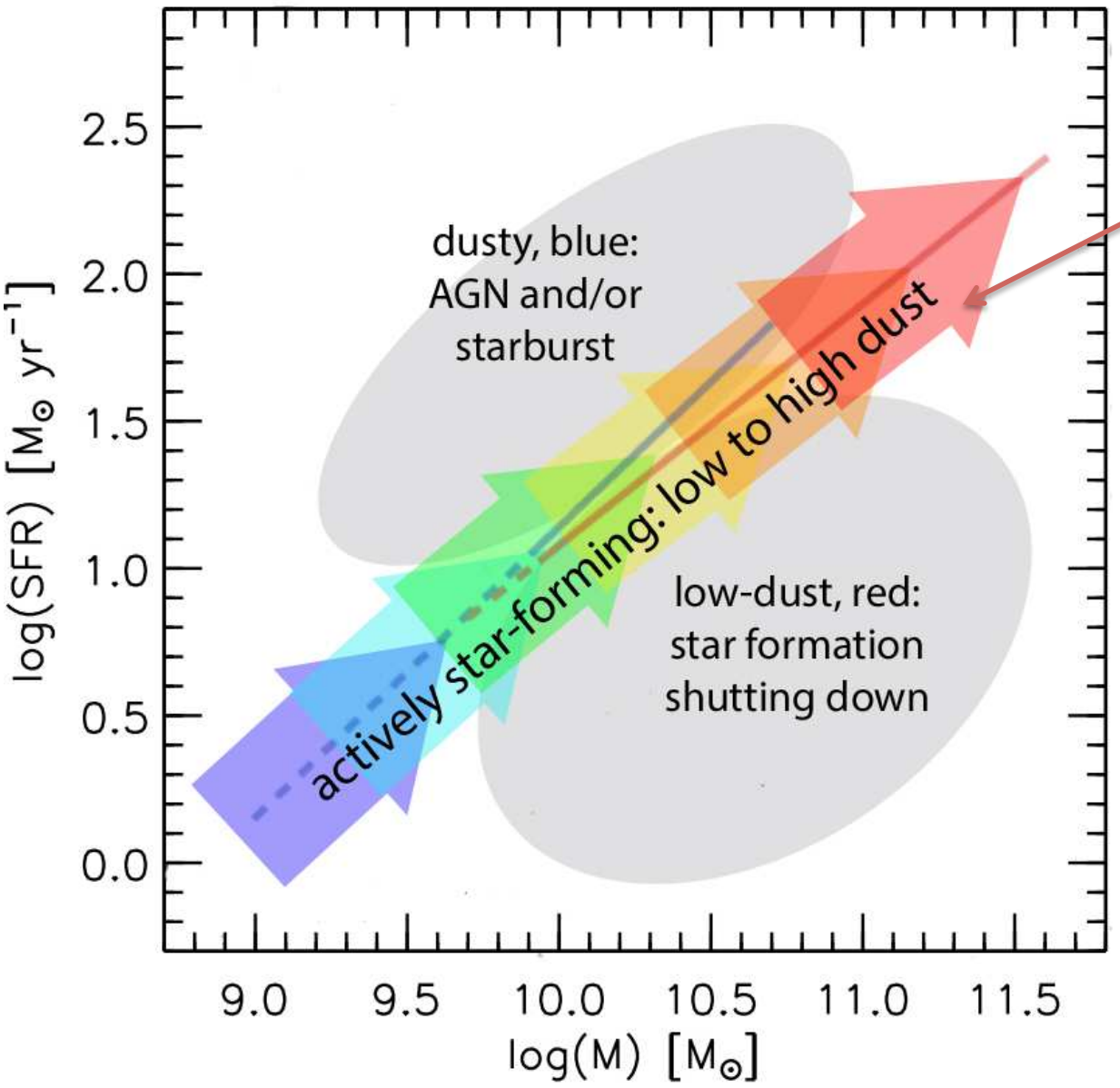
Hubble Heritage

NASA and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope WFPC2 • STScI-PRC02-03

The Main Sequence of star-forming galaxies

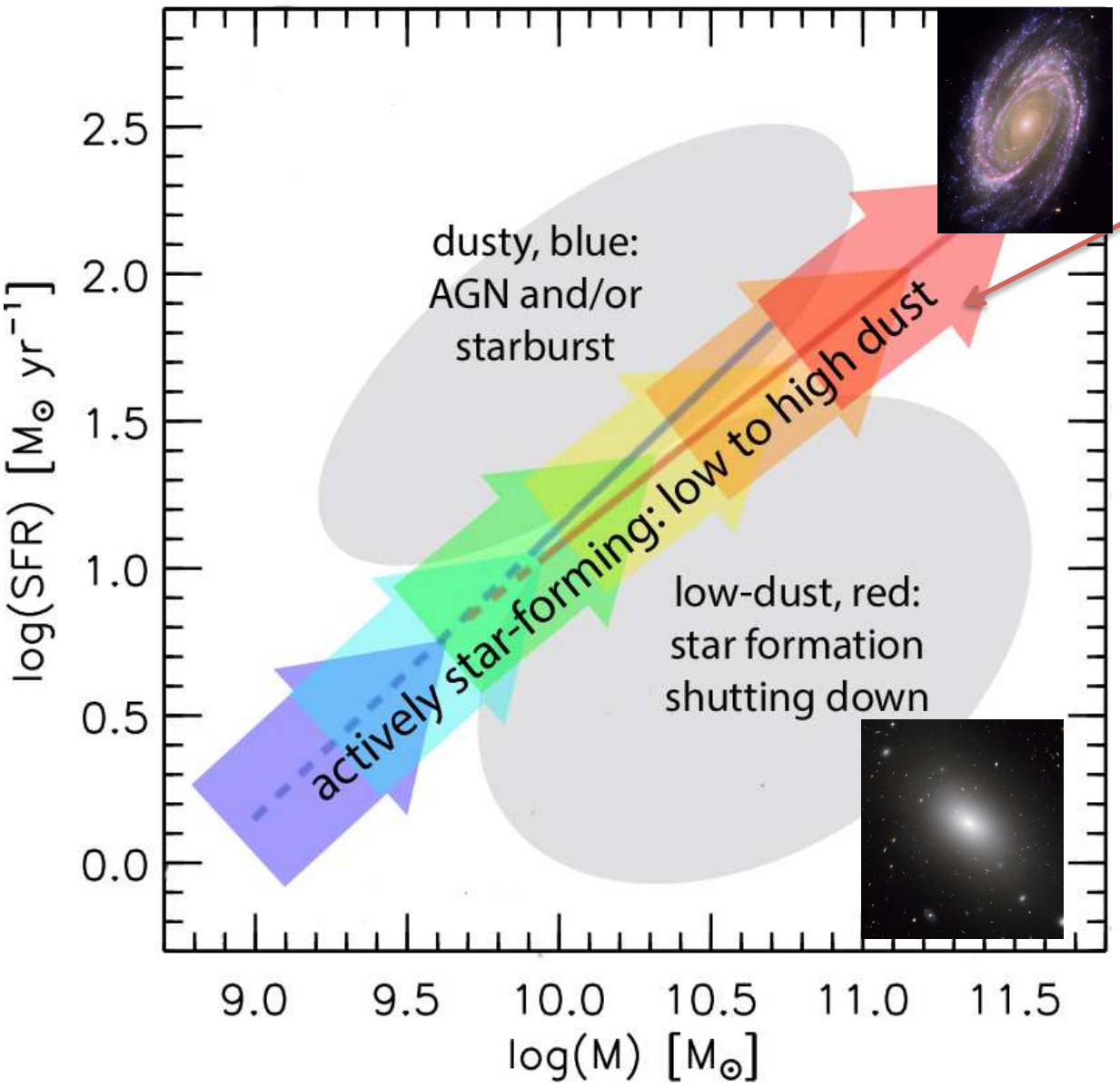


Whitaker+15



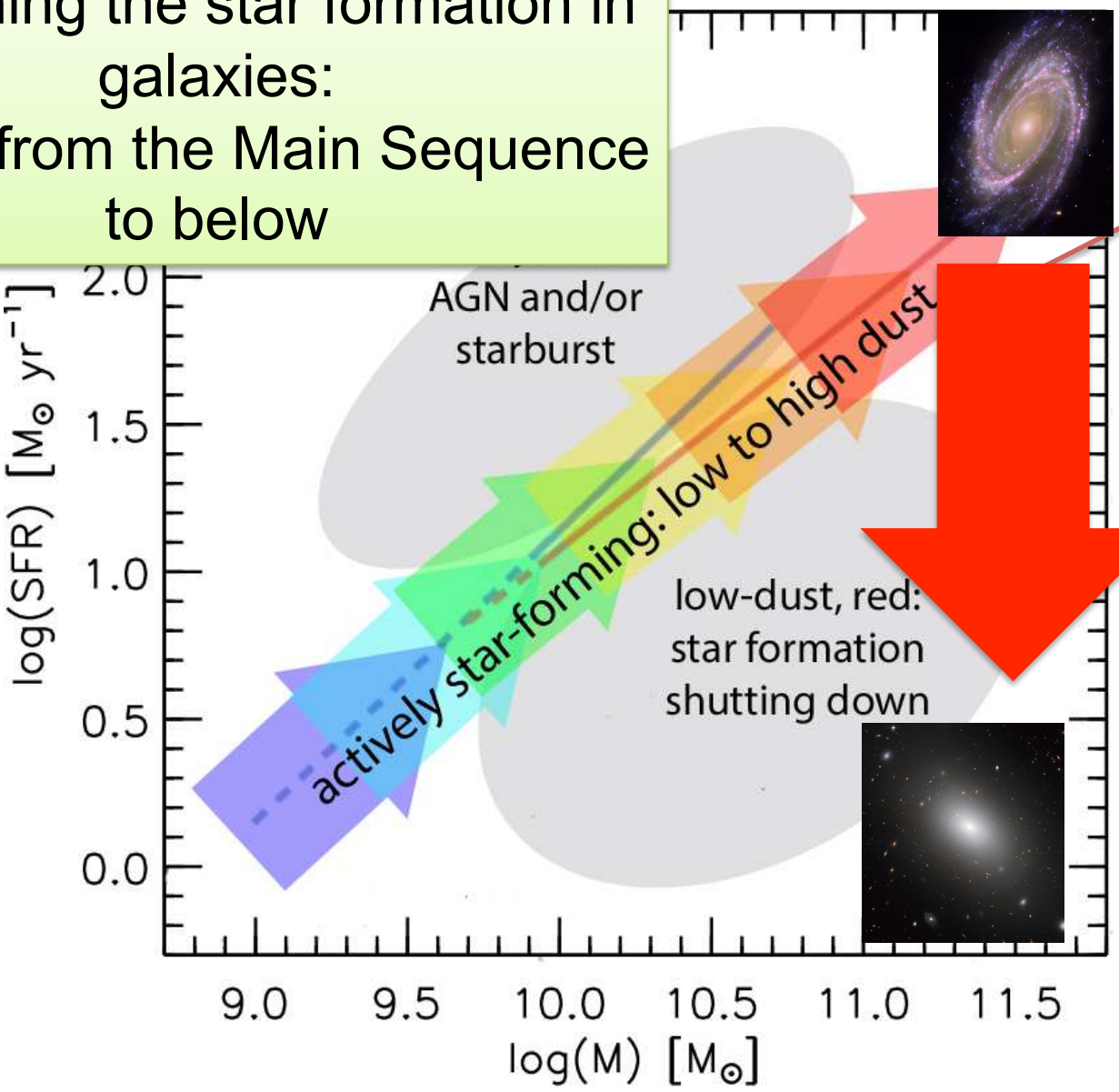
Main Sequence

Whitaker+15


Main Sequence
dusty, blue: AGN and/or starburst
actively star-forming: low to high dust
low-dust, red: star formation shutting down
log(SFR) [M⊙ yr⁻¹]
log(M) [M⊙]
2.5
2.0
1.5
1.0
0.5
0.0
9.0
9.5
10.0
10.5
11.0
11.5

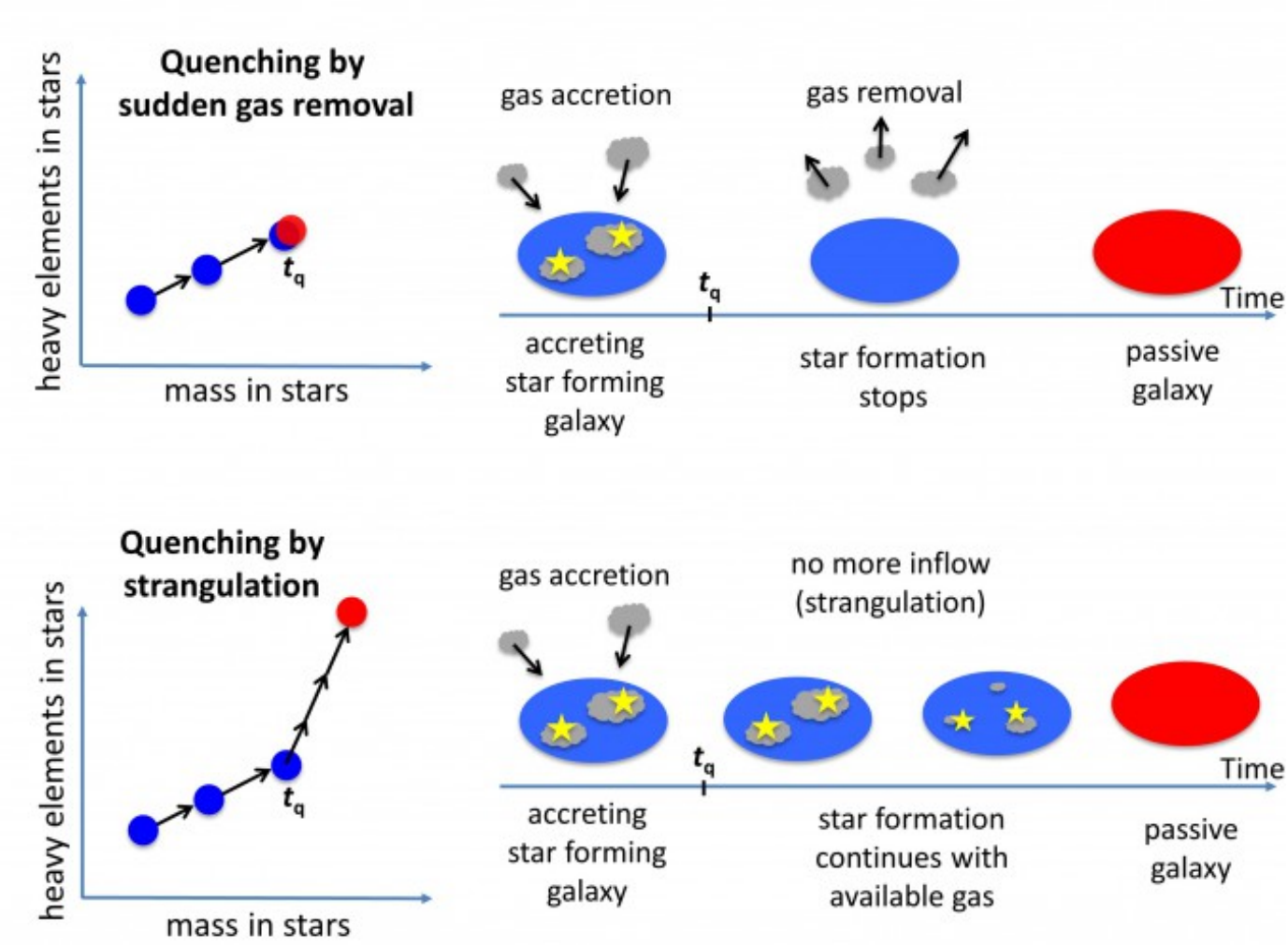
Whitaker+15

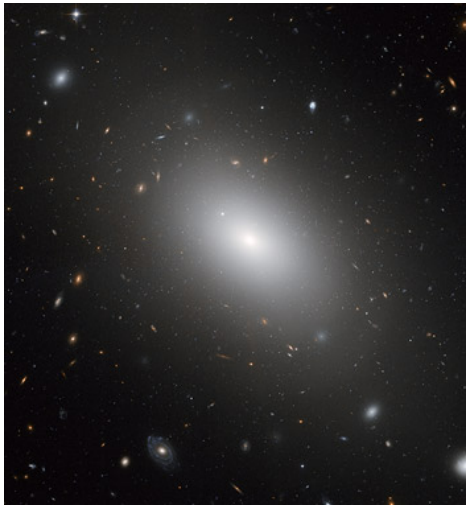
Quenching the star formation in galaxies: Moving from the Main Sequence to below

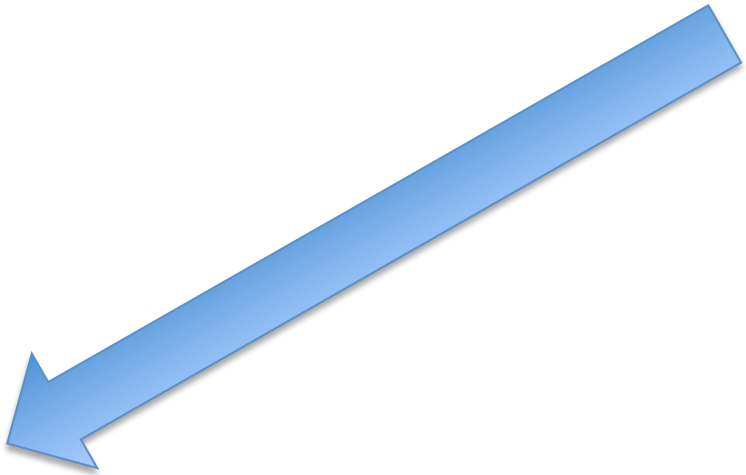


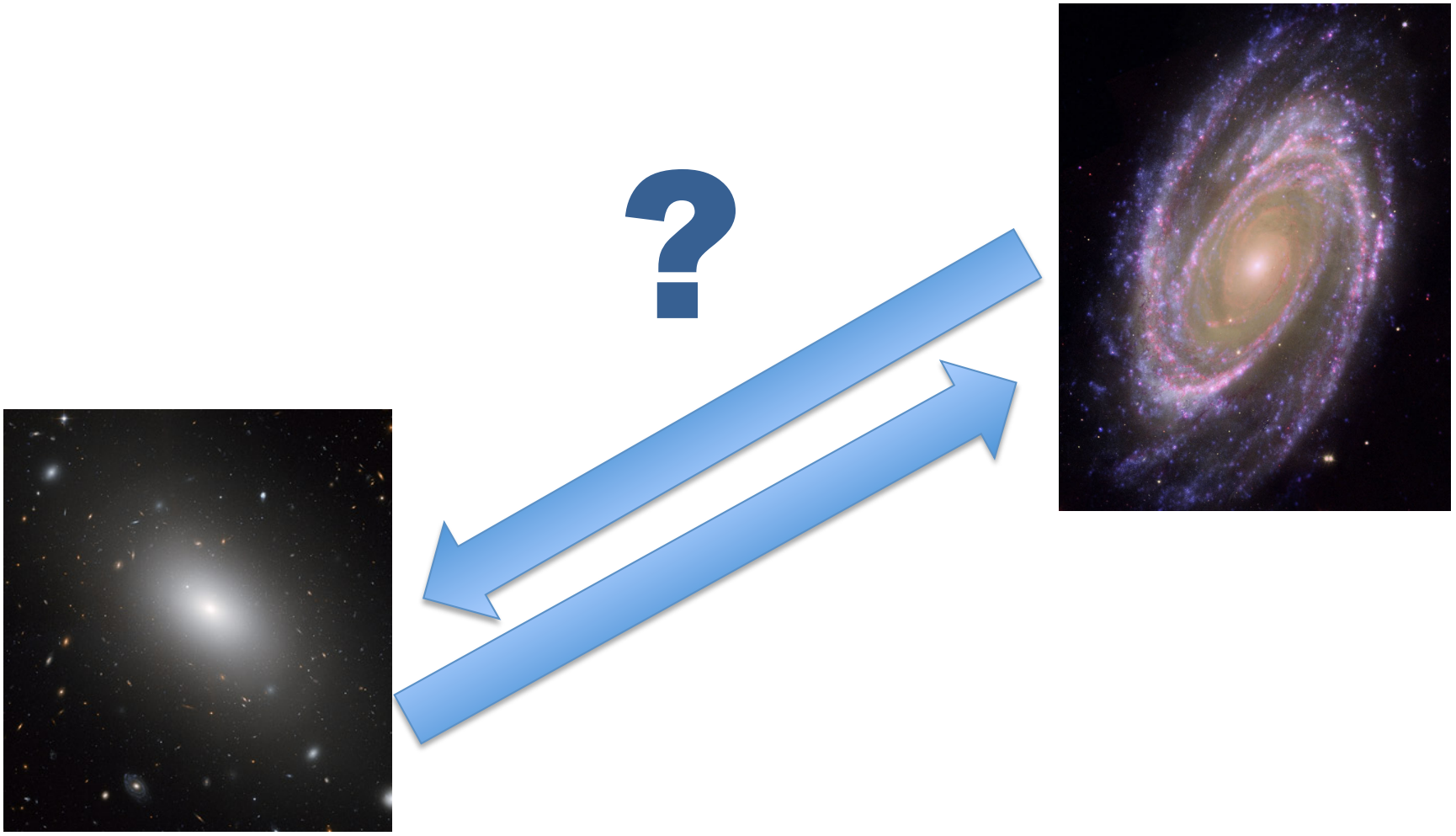
Whitaker+15

Two different star formation quenching scenarios

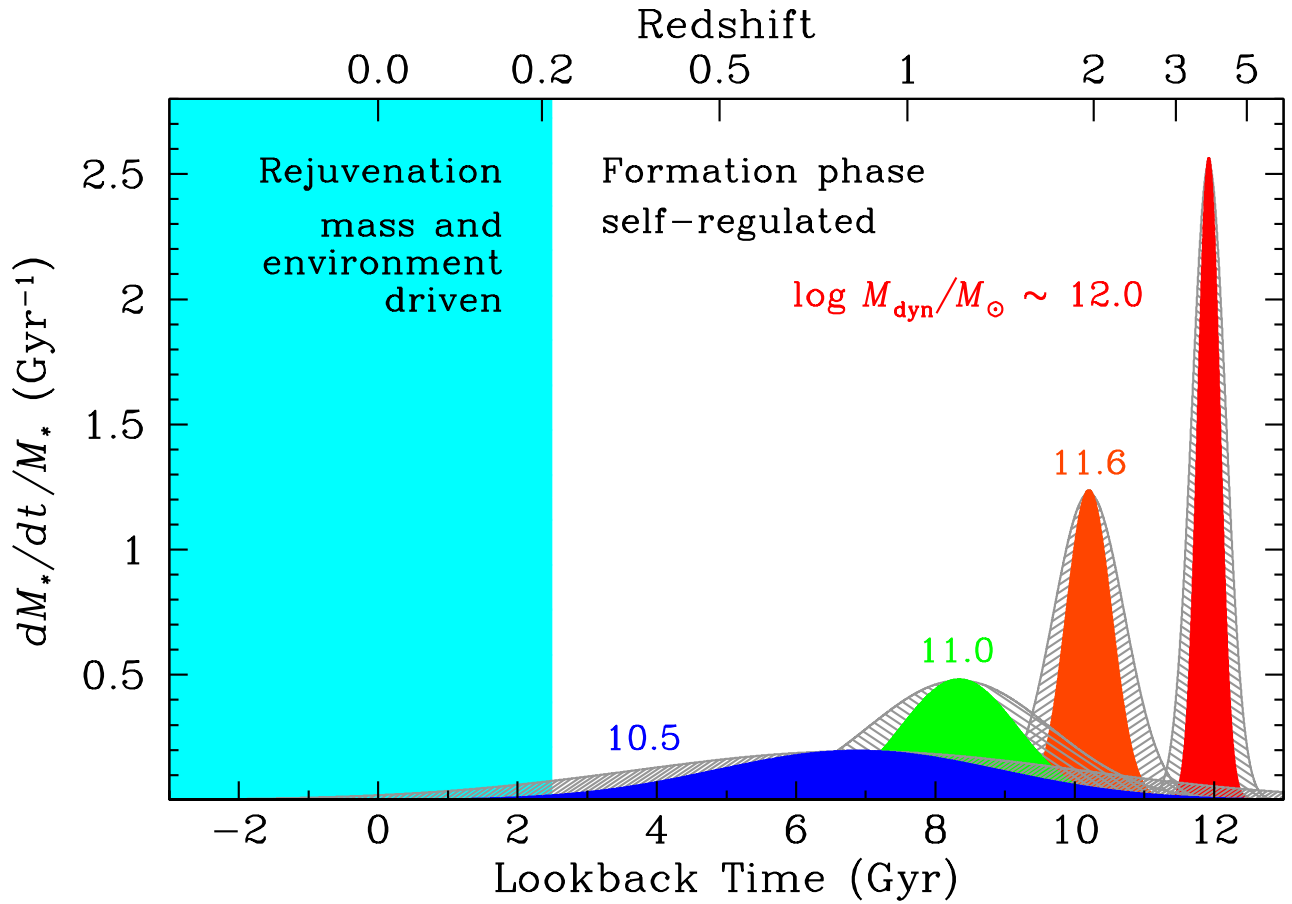




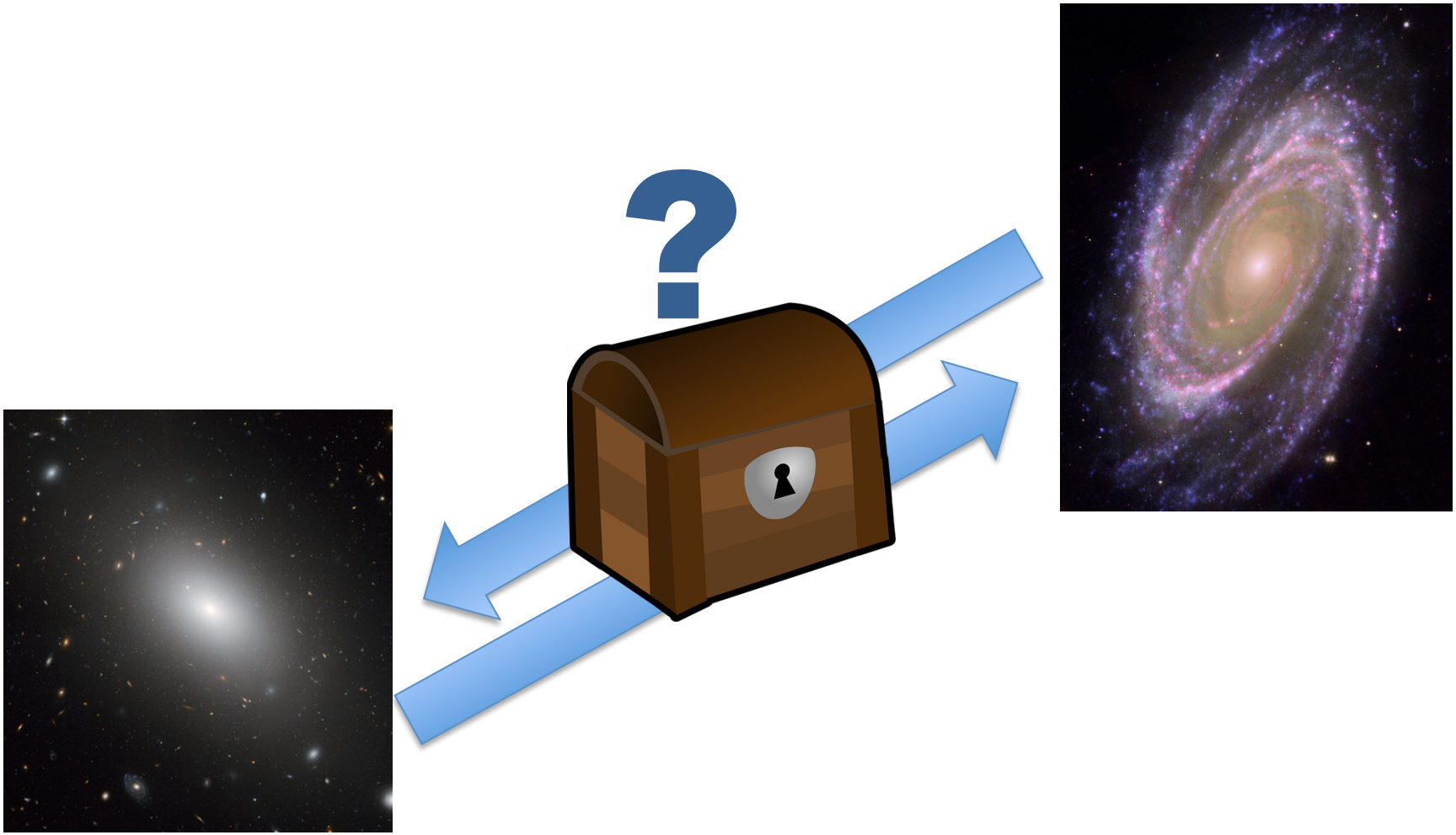




Rejuvenated galaxies?

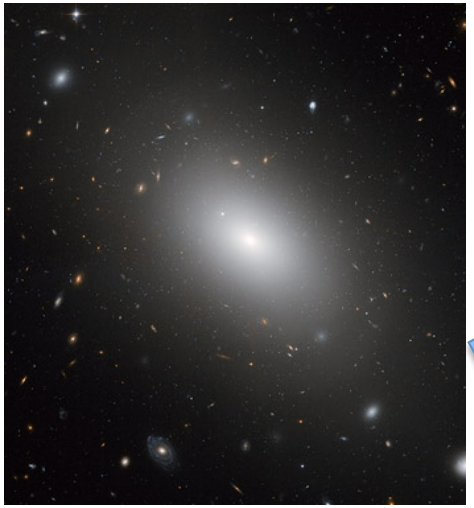


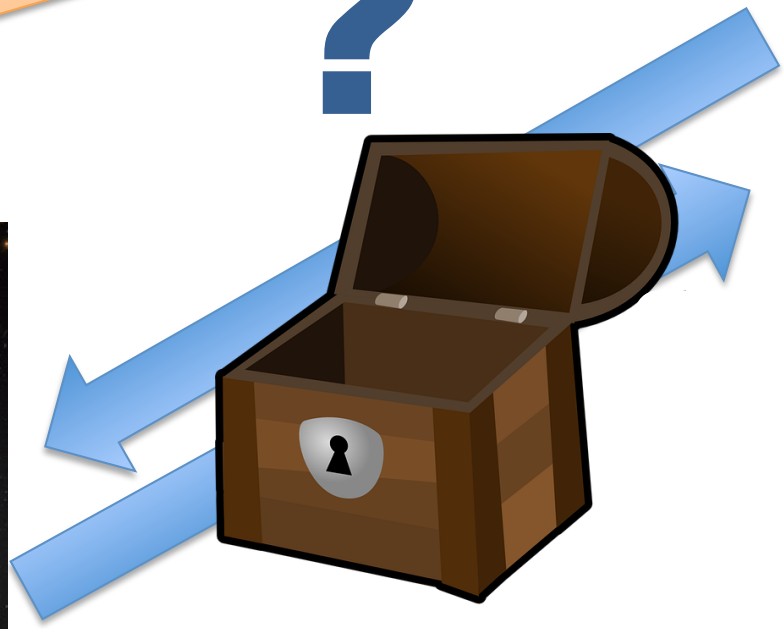
Thomas+09



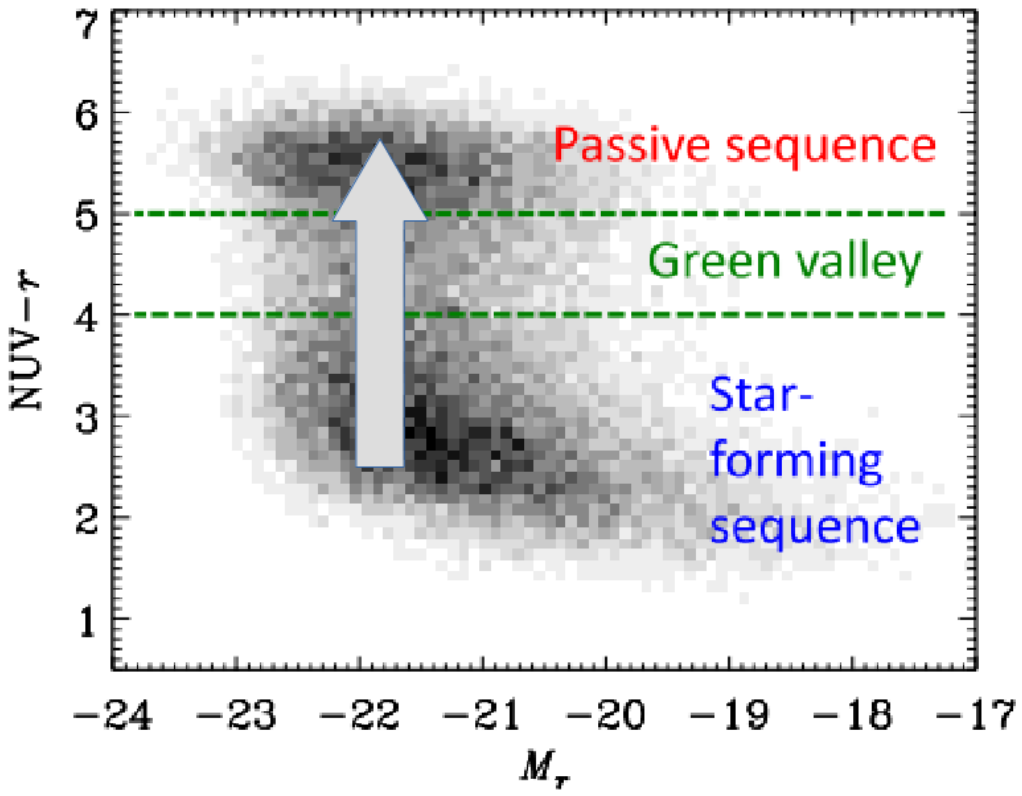
Galaxies in transitions

?



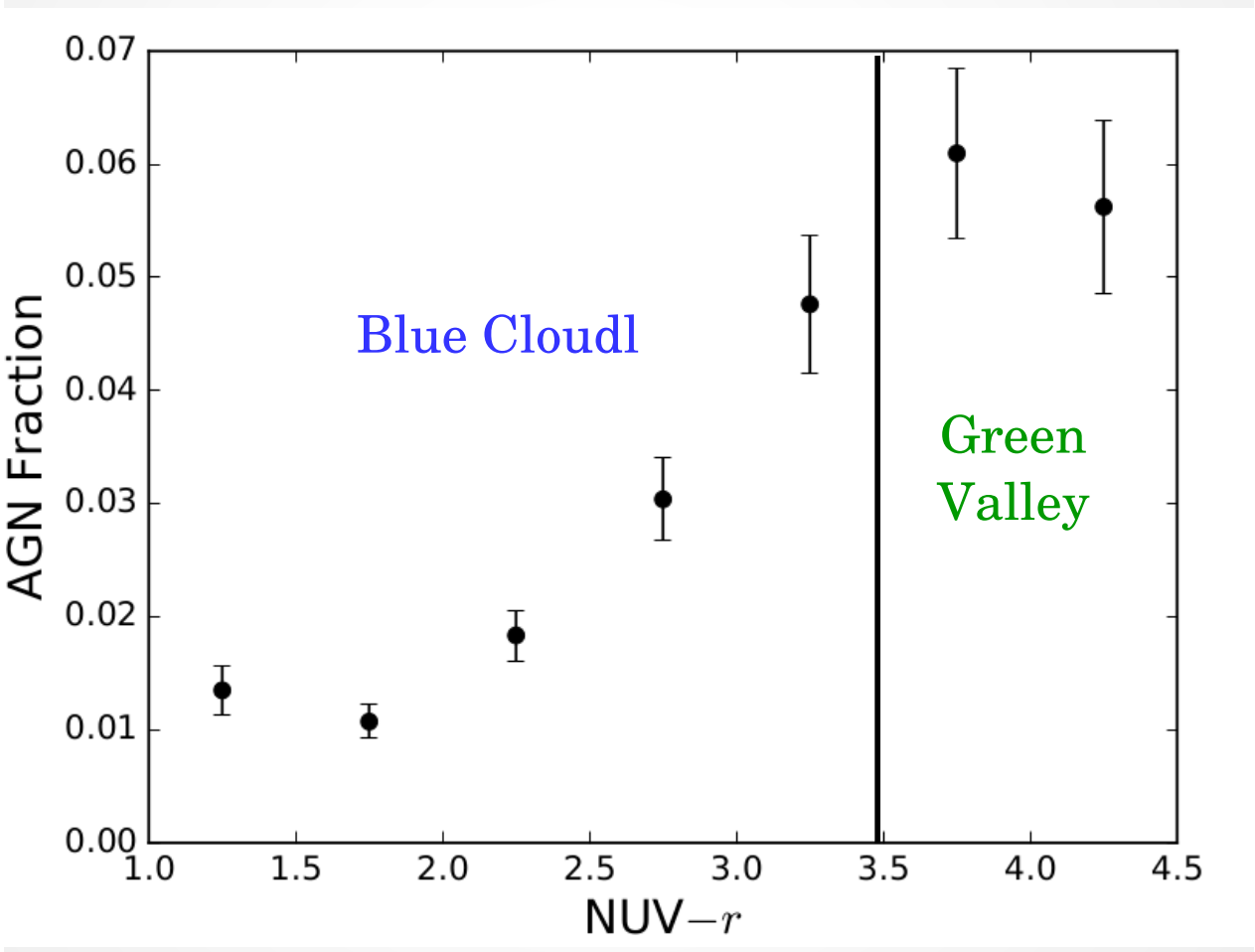


Bimodality in galaxies distribution



Salim+07

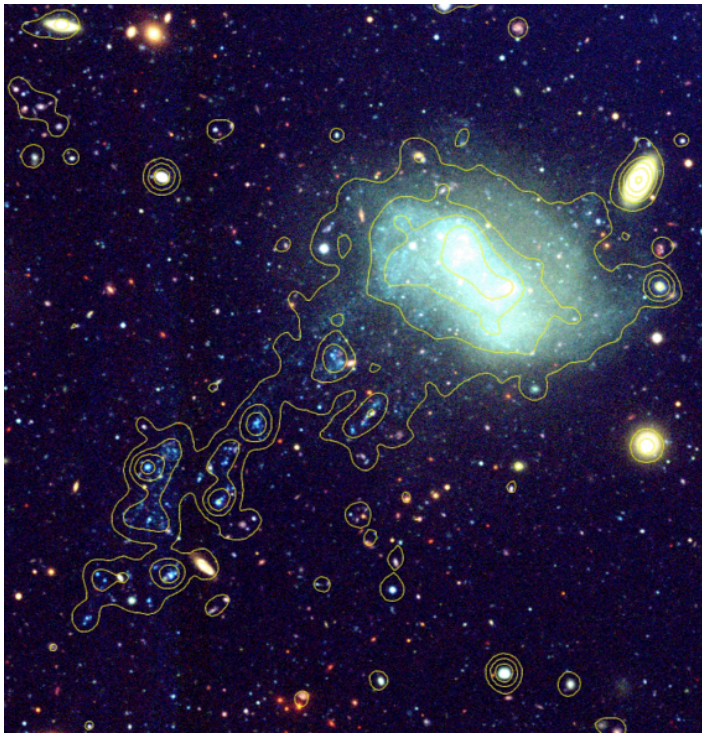
AGN feedback in the Green Valley



Nogueira-Cavalcante, Riguccini et al., in prep

Galaxies in Transition

Jellyfishes galaxies

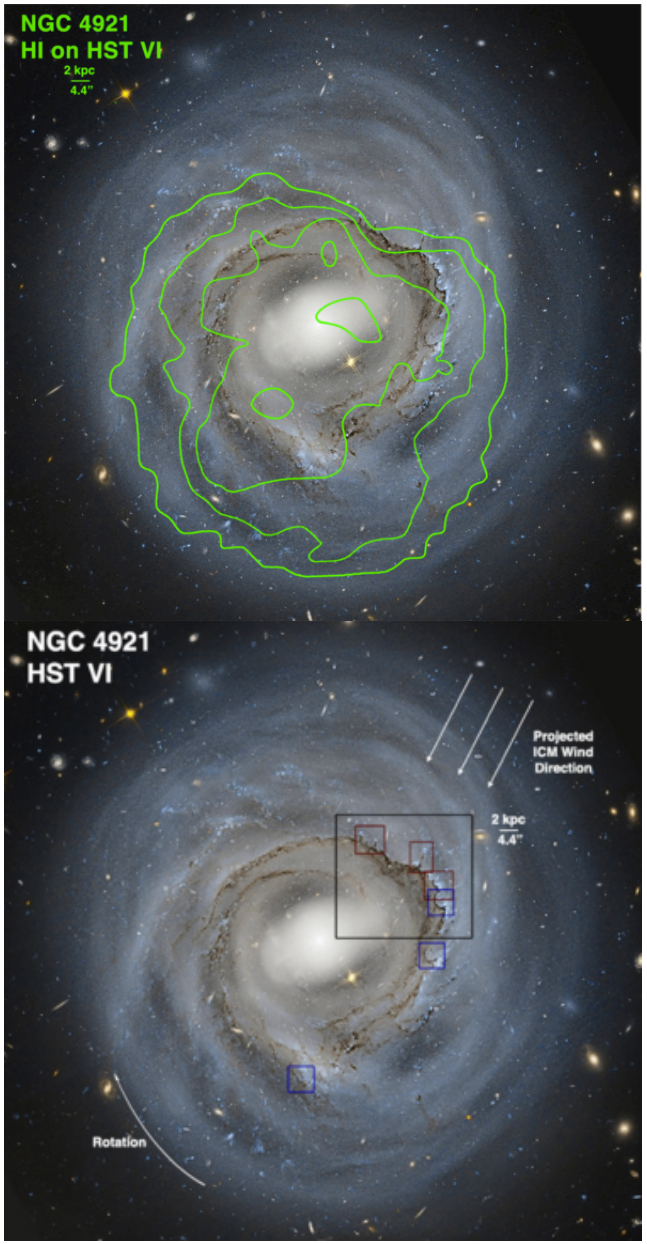


VCC1217 in the Virgo cluster, Fumagalli+11

Check also Ebeling+14, Poggianti+15, etc.

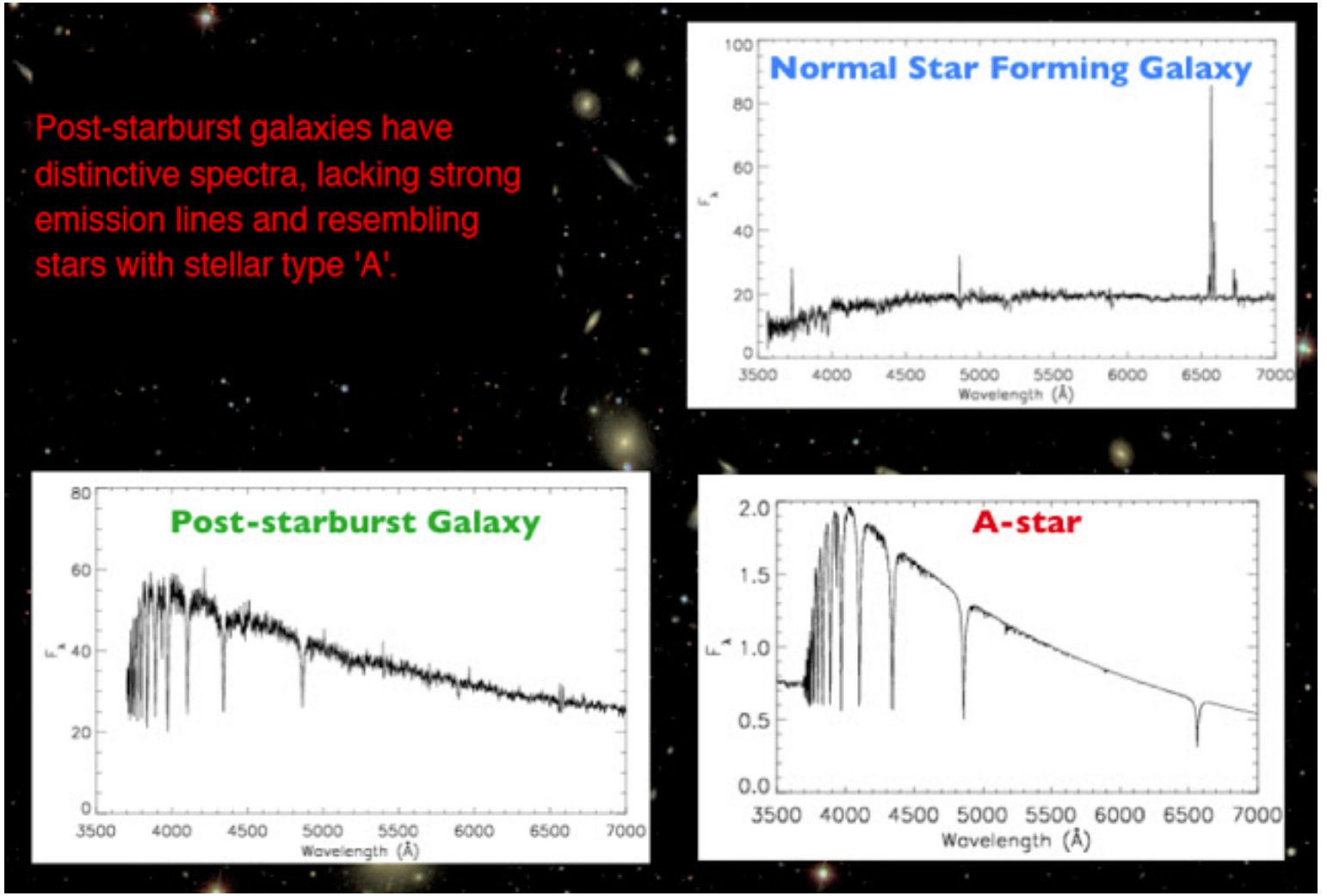
Ram-pressure stripped galaxies

In the Coma cluster, Kenney+15

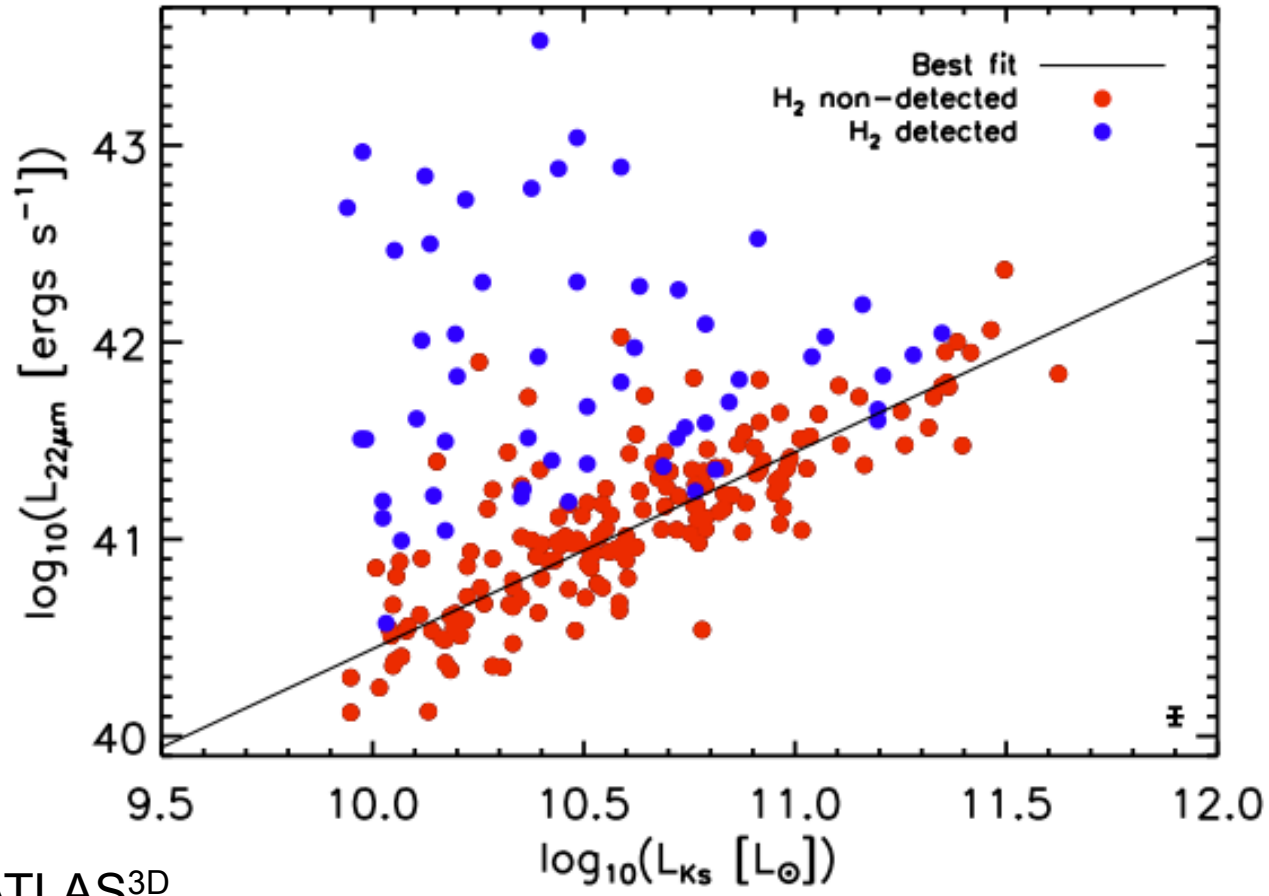


Galaxies in Transition

E+A galaxies

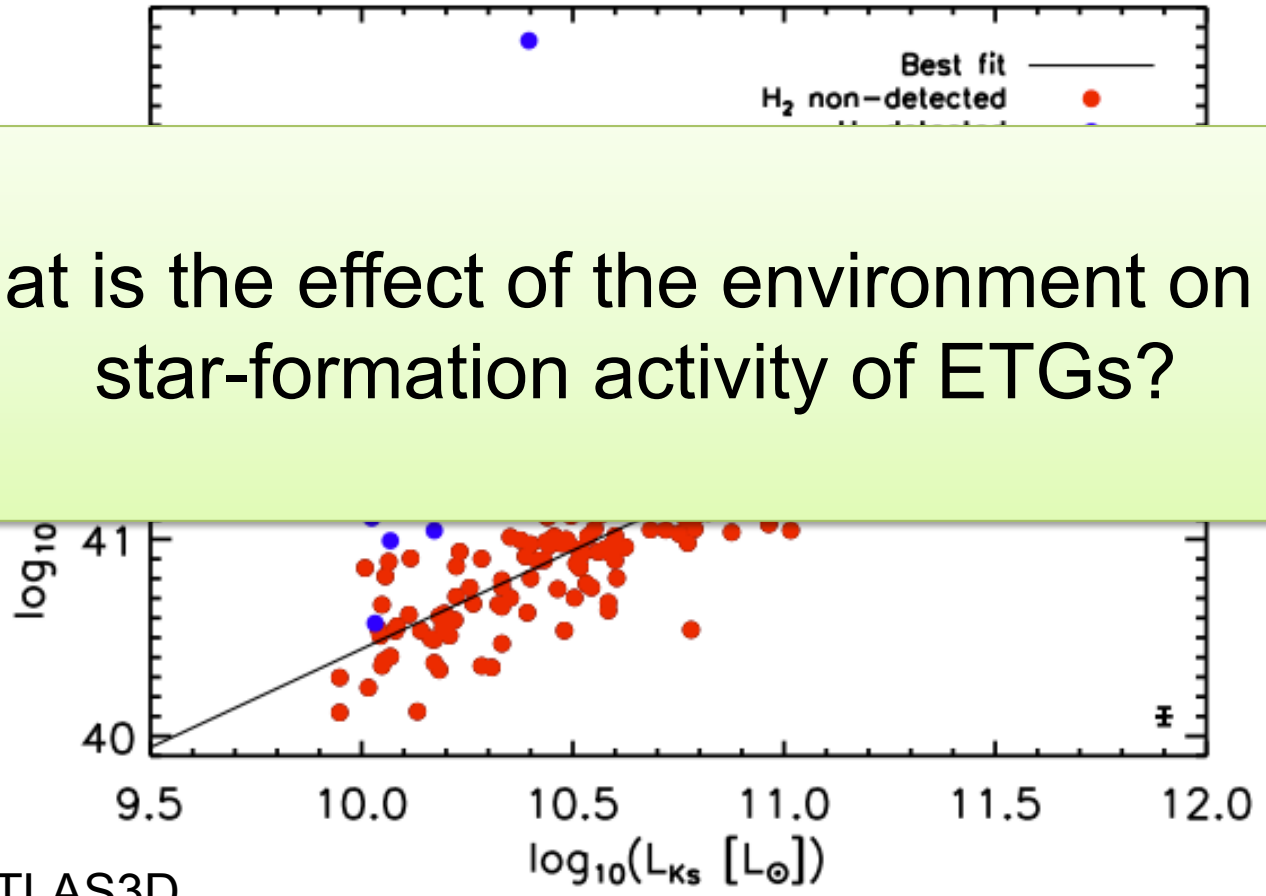


Star-formation activity in Early-type galaxies (ETGs)



Davis+12, ATLAS^{3D} collaboration

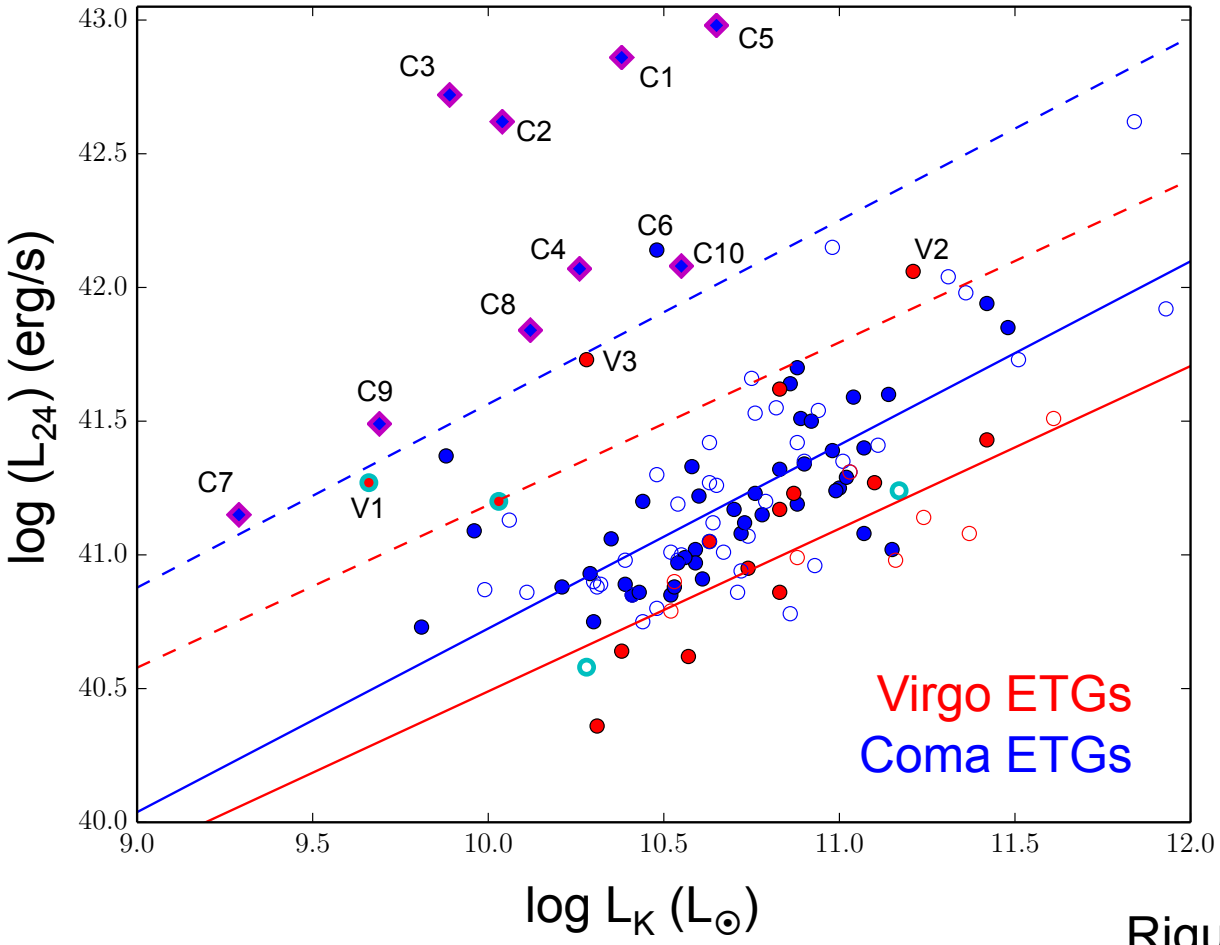
Star-formation activity in Early-type galaxies (ETGs)



What is the effect of the environment on the star-formation activity of ETGs?

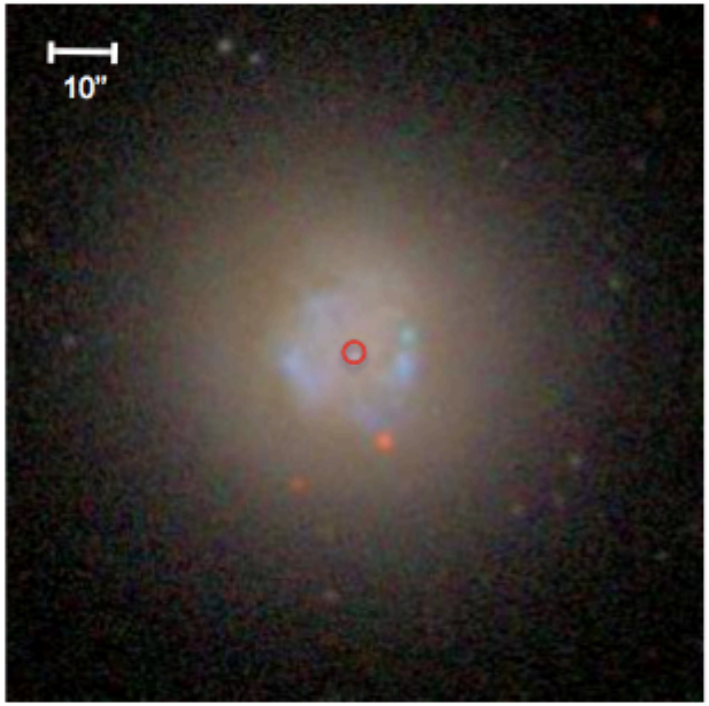
Davis+12, ATLAS3D collaboration

Mid-IR Enhanced Galaxies (MIEGs)



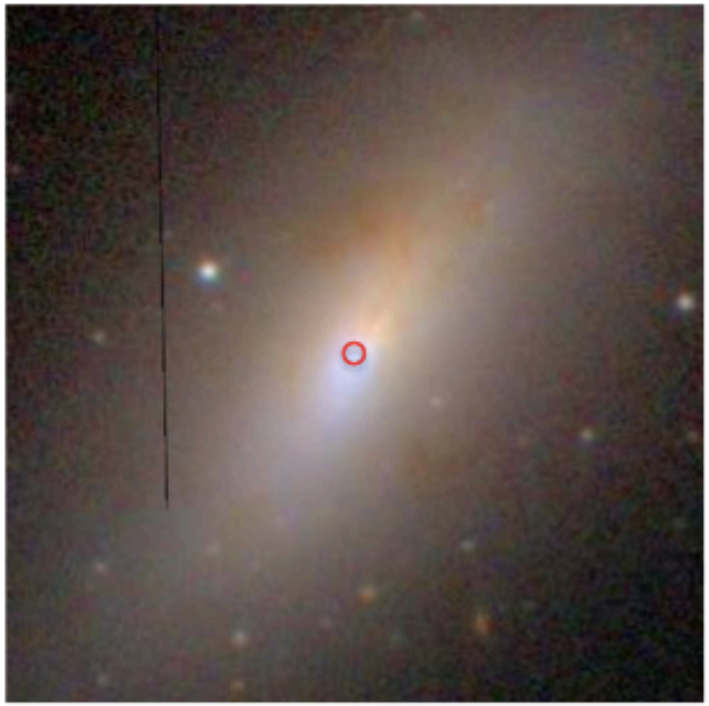
Riguccini+15b (ApJ)

Virgo MIEGs

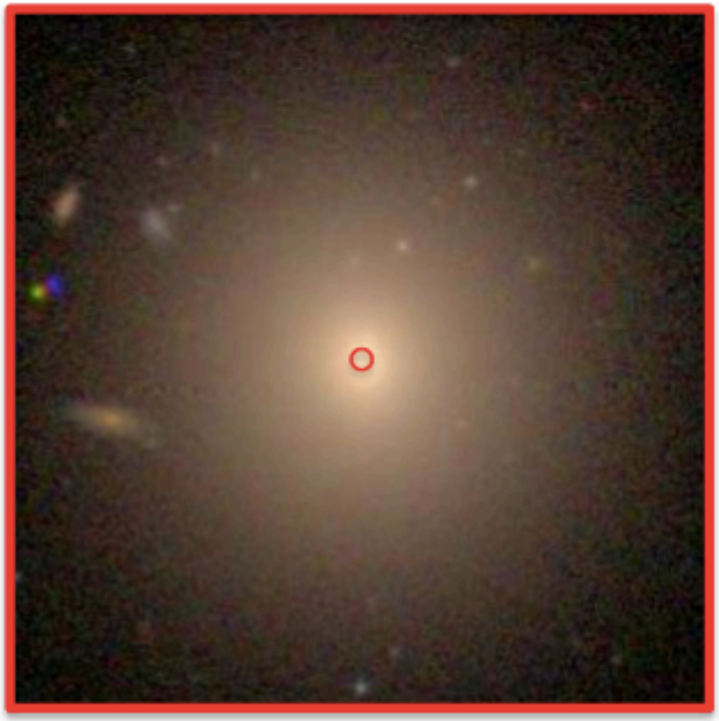


NGC 4344

NGC 4526

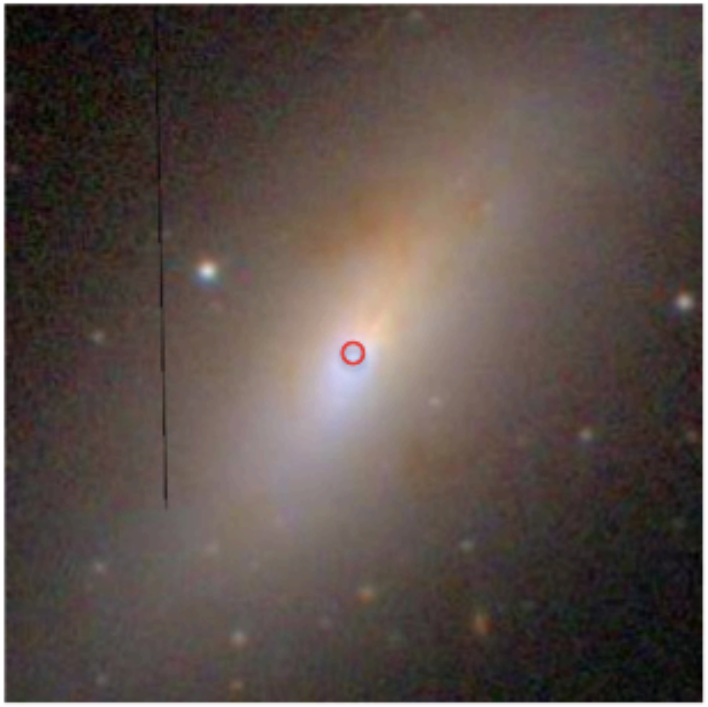


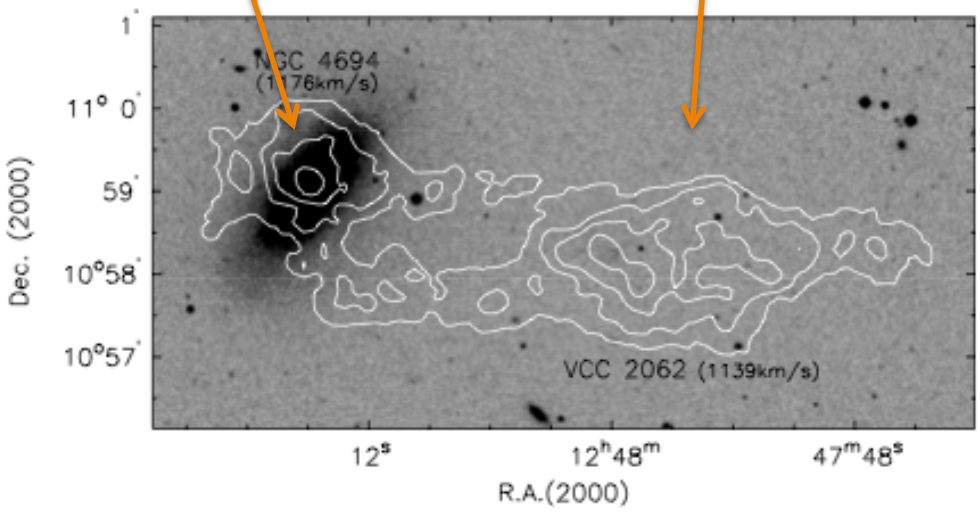
NGC 4694



Typical ETG in Virgo (as a reference)

NGC 4694

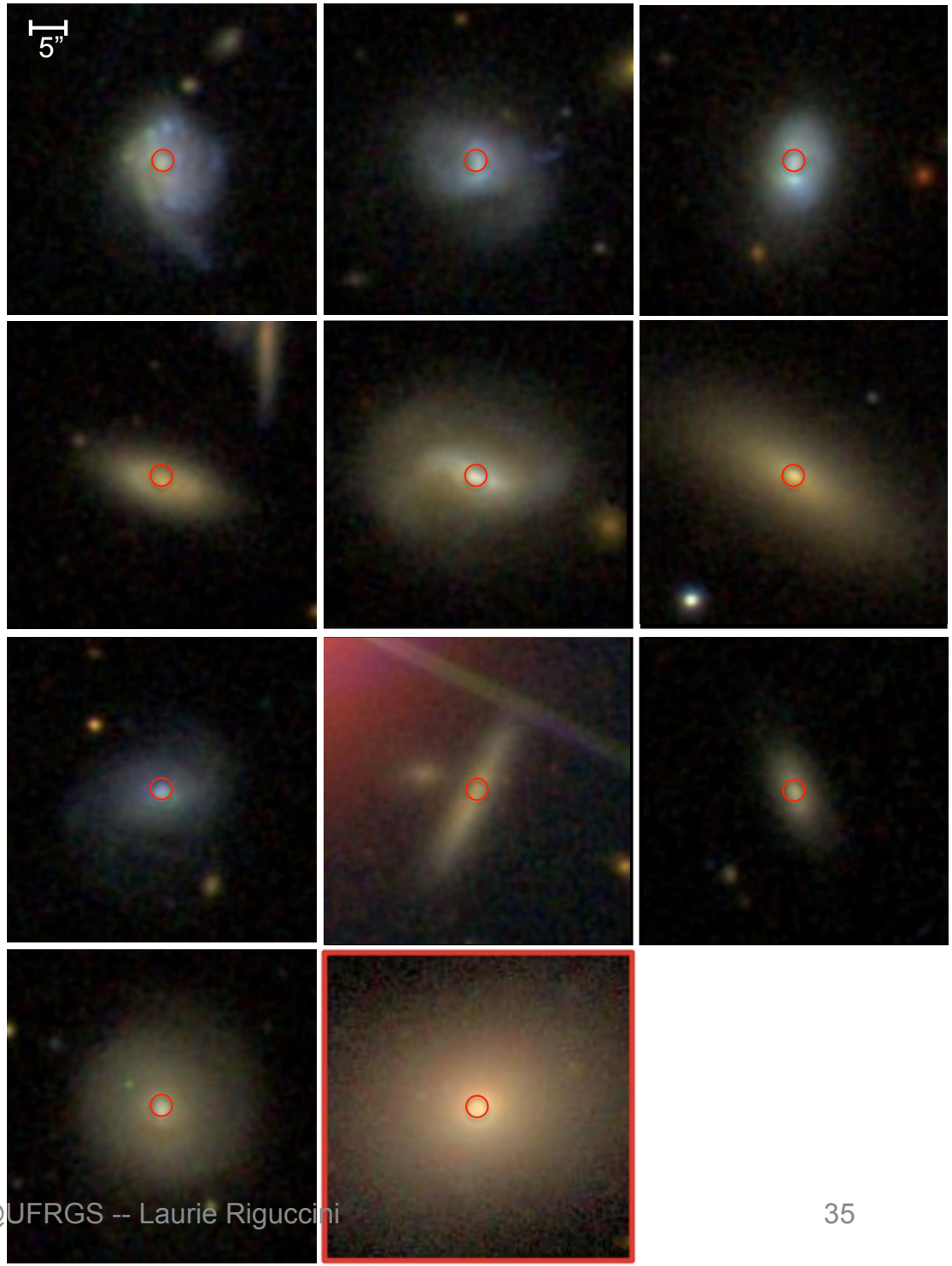




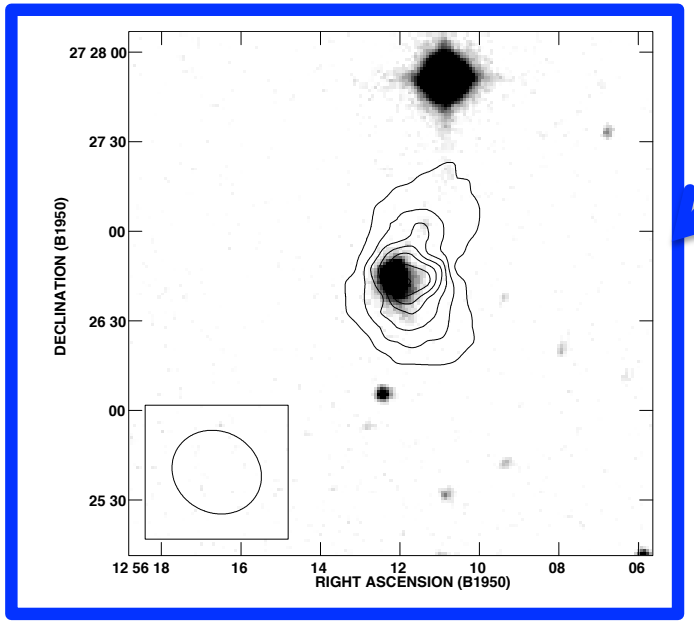
HI distribution of NGC 4694 region from Chung+09

Coma MIEGs

Riguccini+15b



HI detections



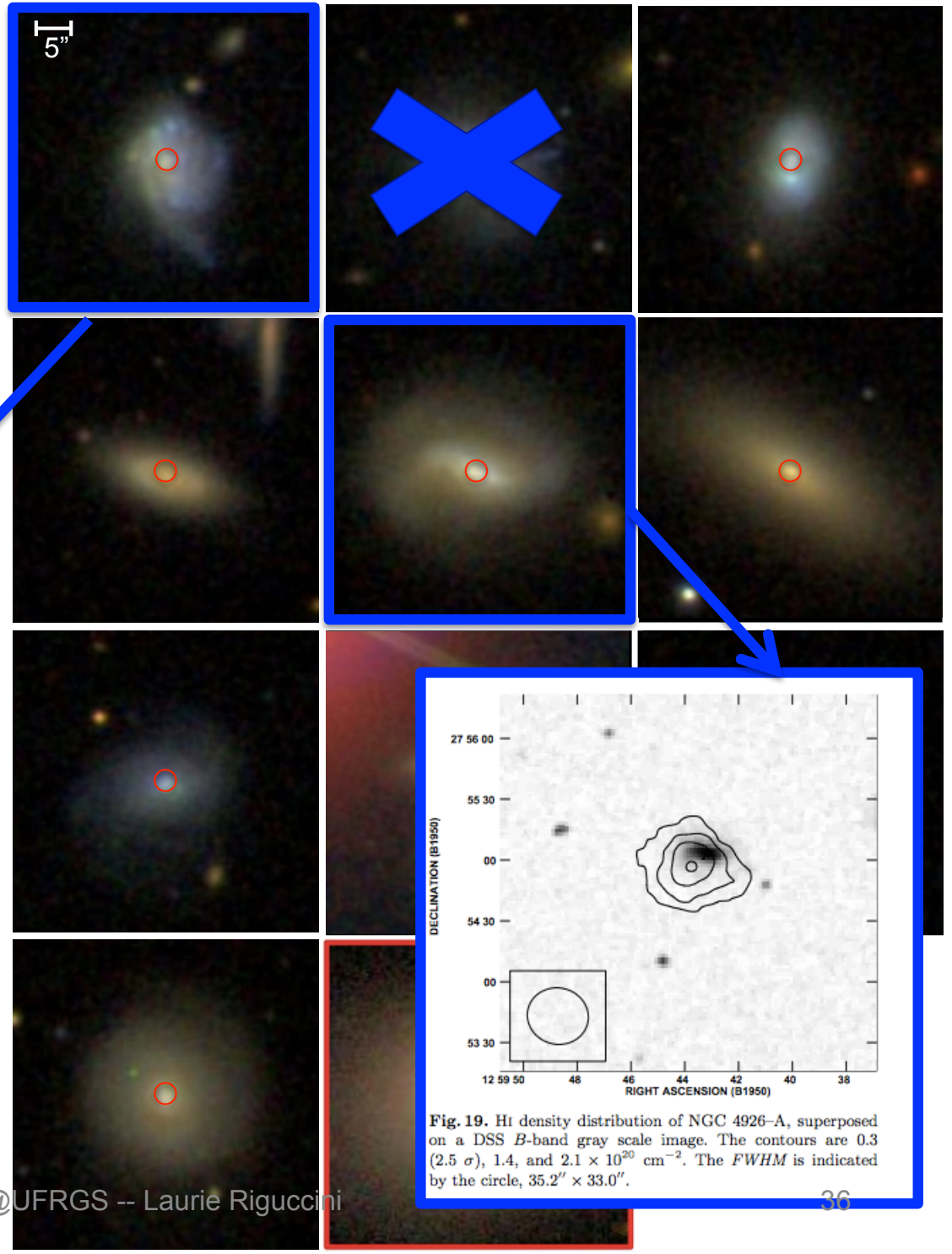


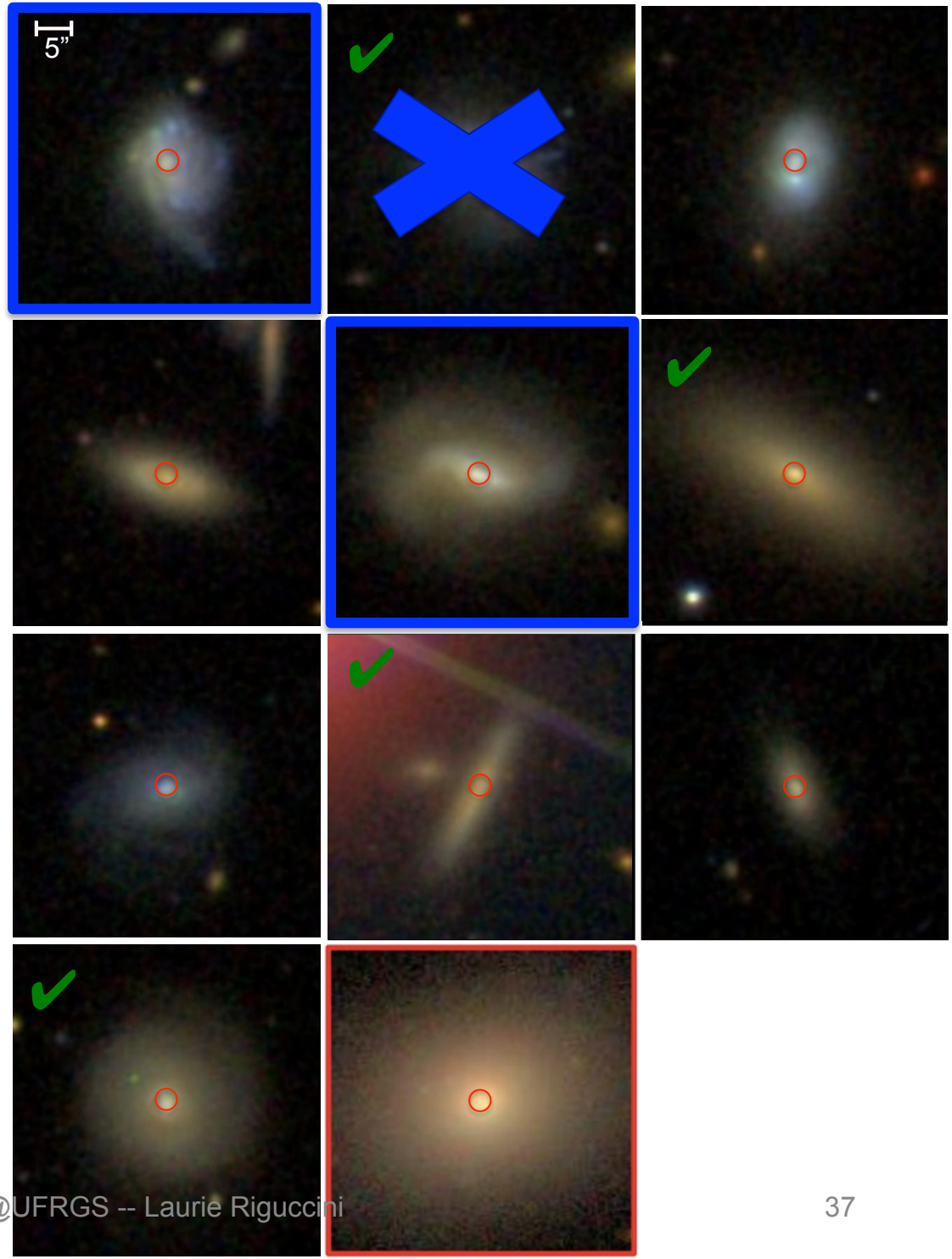
Fig. 19. HI density distribution of NGC 4926–A, superposed on a DSS *B*-band gray scale image. The contours are 0.3 (2.5 σ), 1.4, and 2.1 $\times$ 10^{20} cm^{-2}. The *FWHM* is indicated by the circle, 35.2″ $\times$ 33.0″.

Bravo-Alfaro+01

HI detections

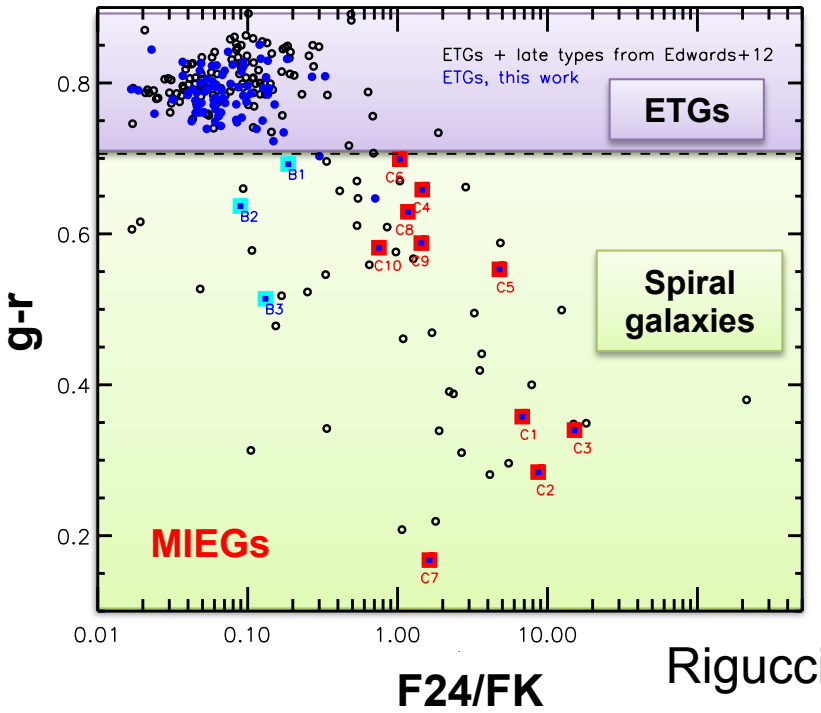
GMRT observations carried out last July-August

Data reduction on the way…

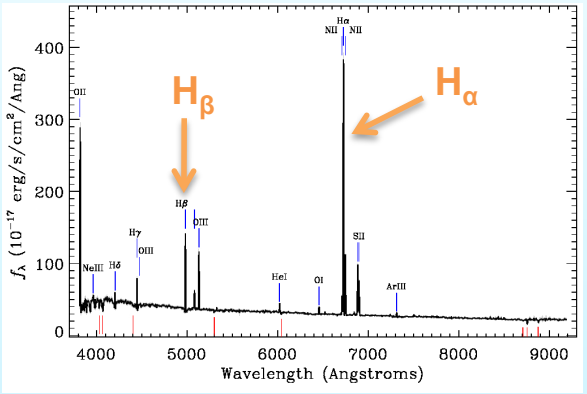


Bravo-Alfaro+01

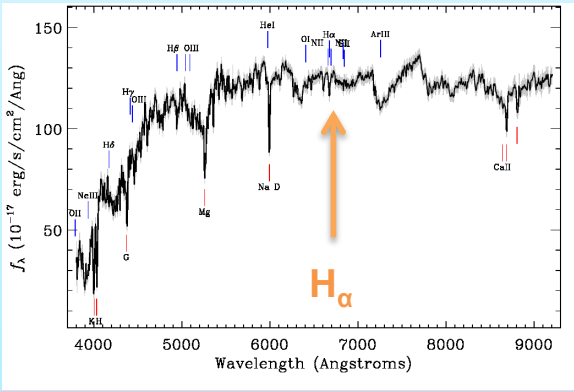
Nature of the MIEGs



Riguccini+15



Typical spectra of a MIEG; numerous emission lines

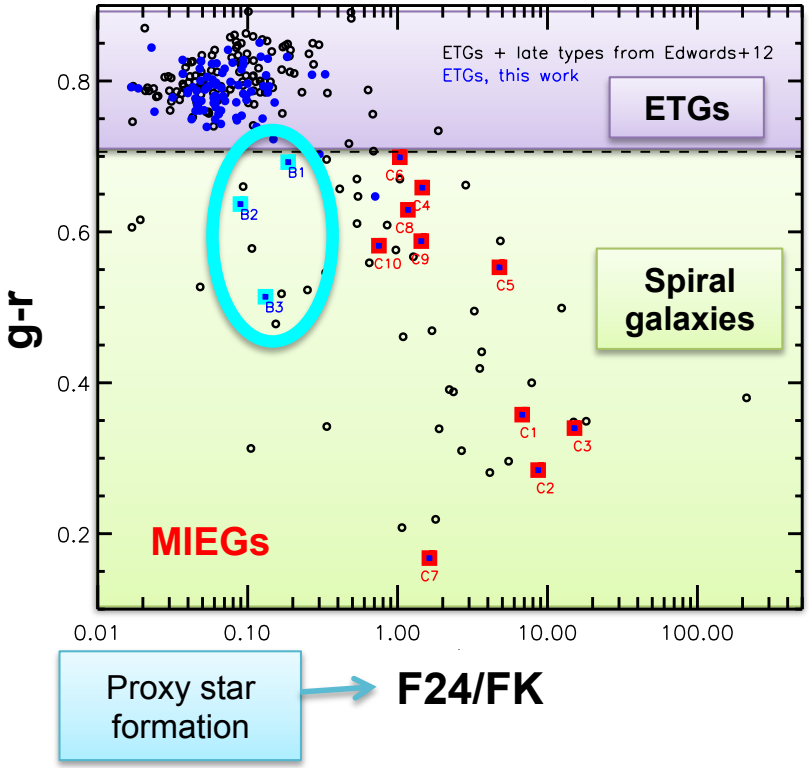


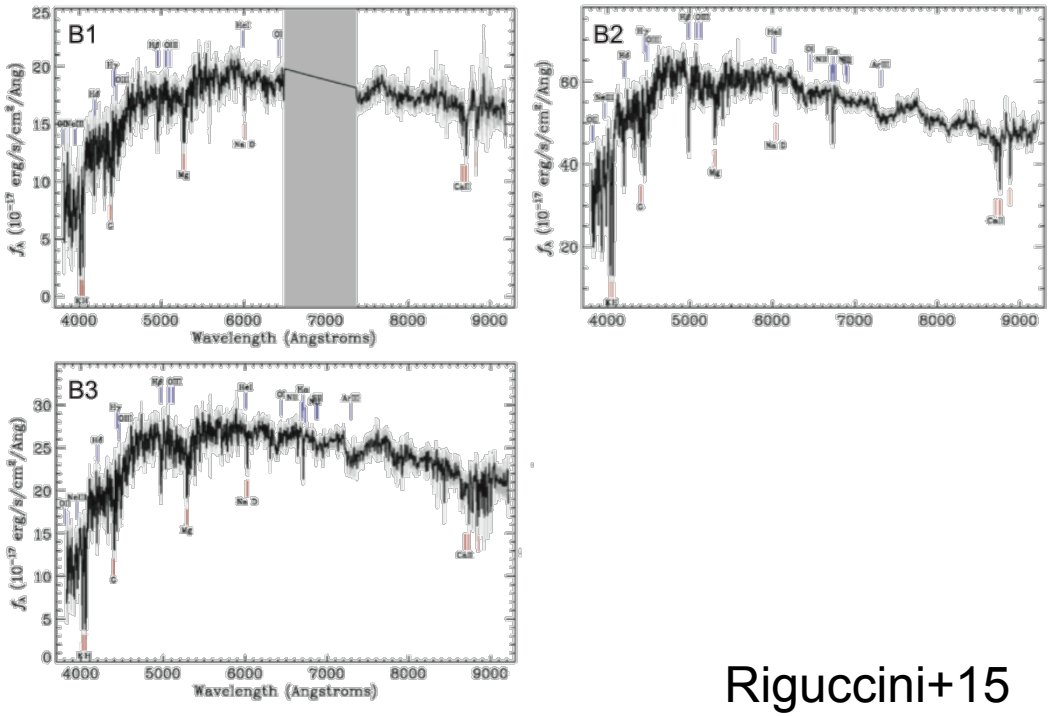
Typical spectra of an ETG (non MIEG), no emission lines, few absorption lines

MIEGs:

- star formation as high as in late-types
- optical colors much bluer than normal galaxies
- H_α emission line : confirmed star formation activity

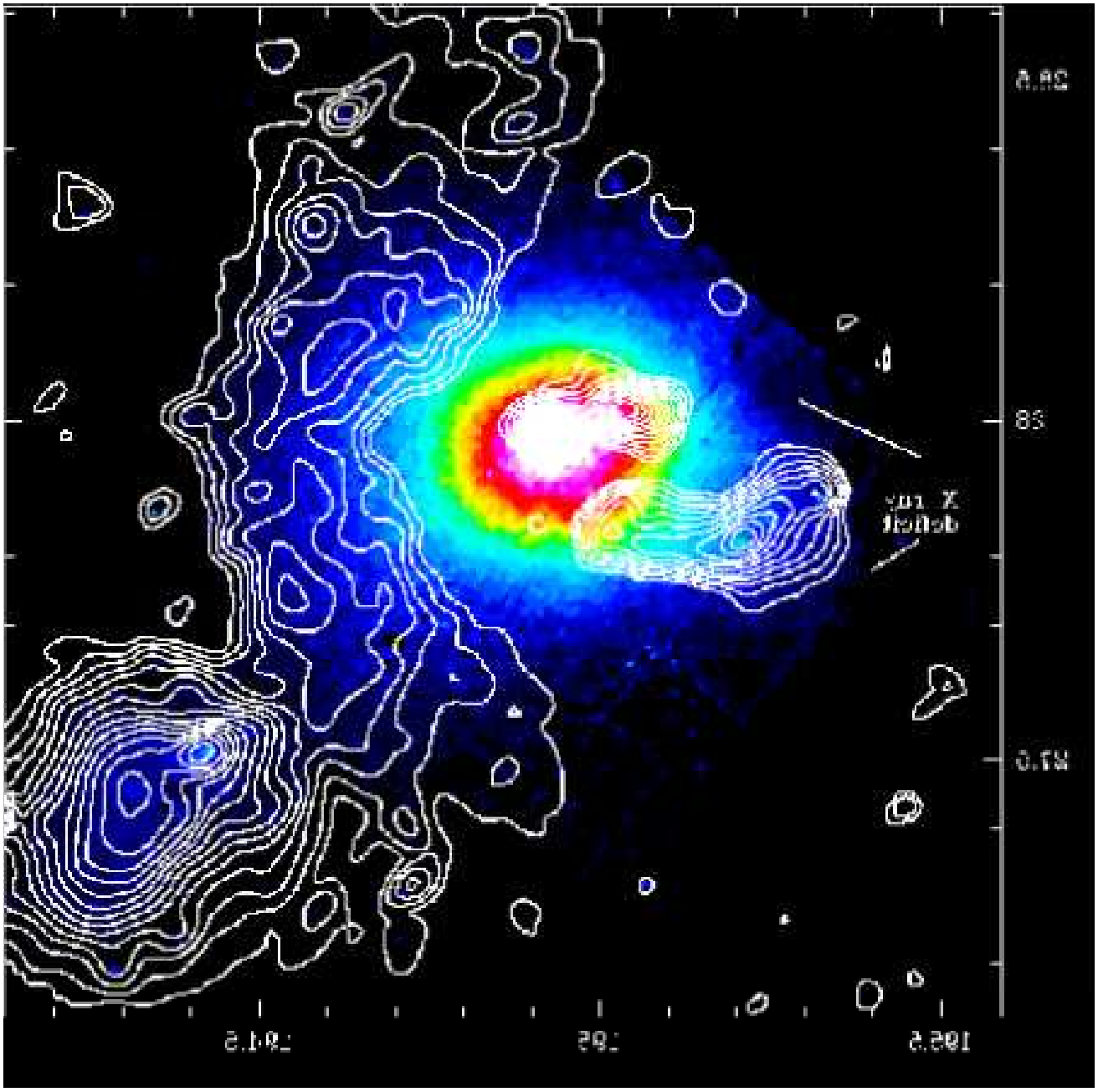
Blue ETGs in Coma





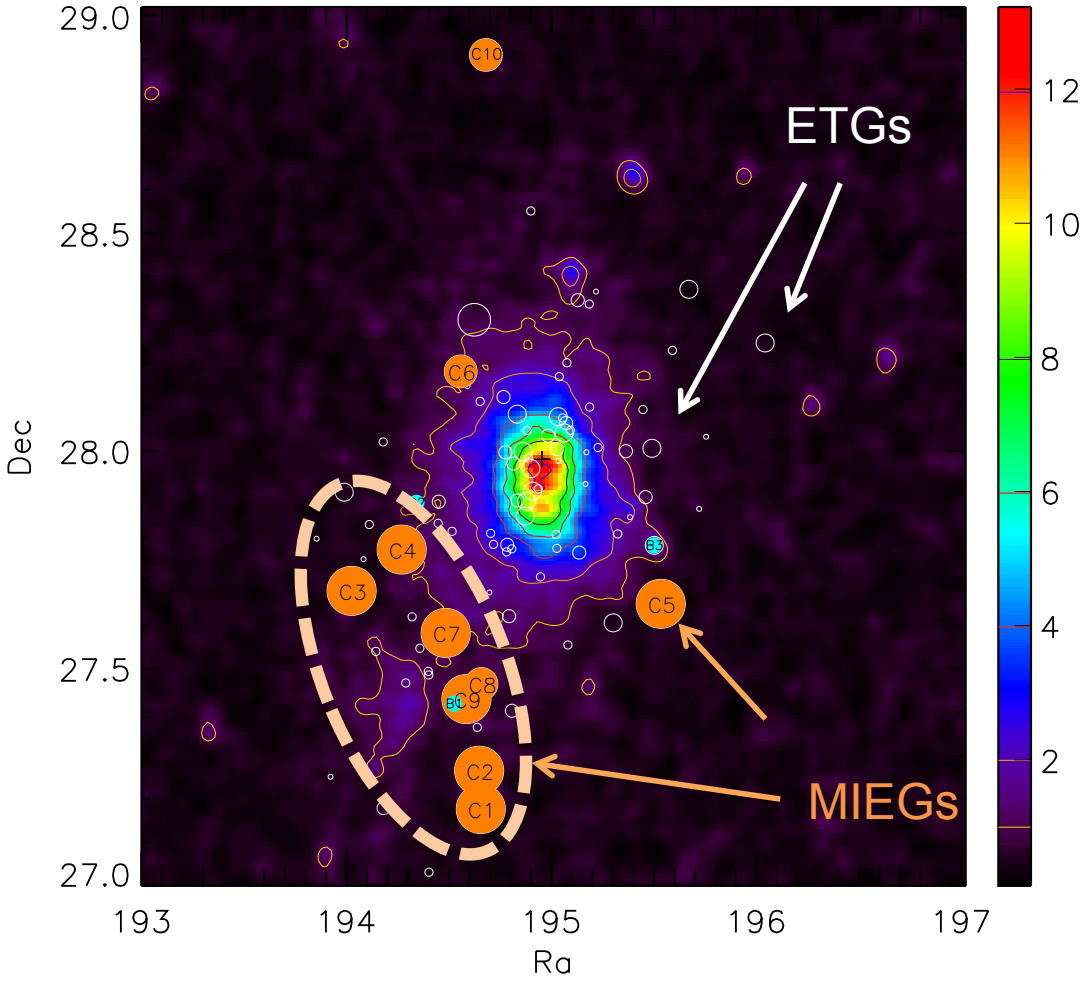
Riguccini+15

3 optically blue galaxies with F24/FK ratio similar to the bulk of ETGs in Coma



Neumann+03

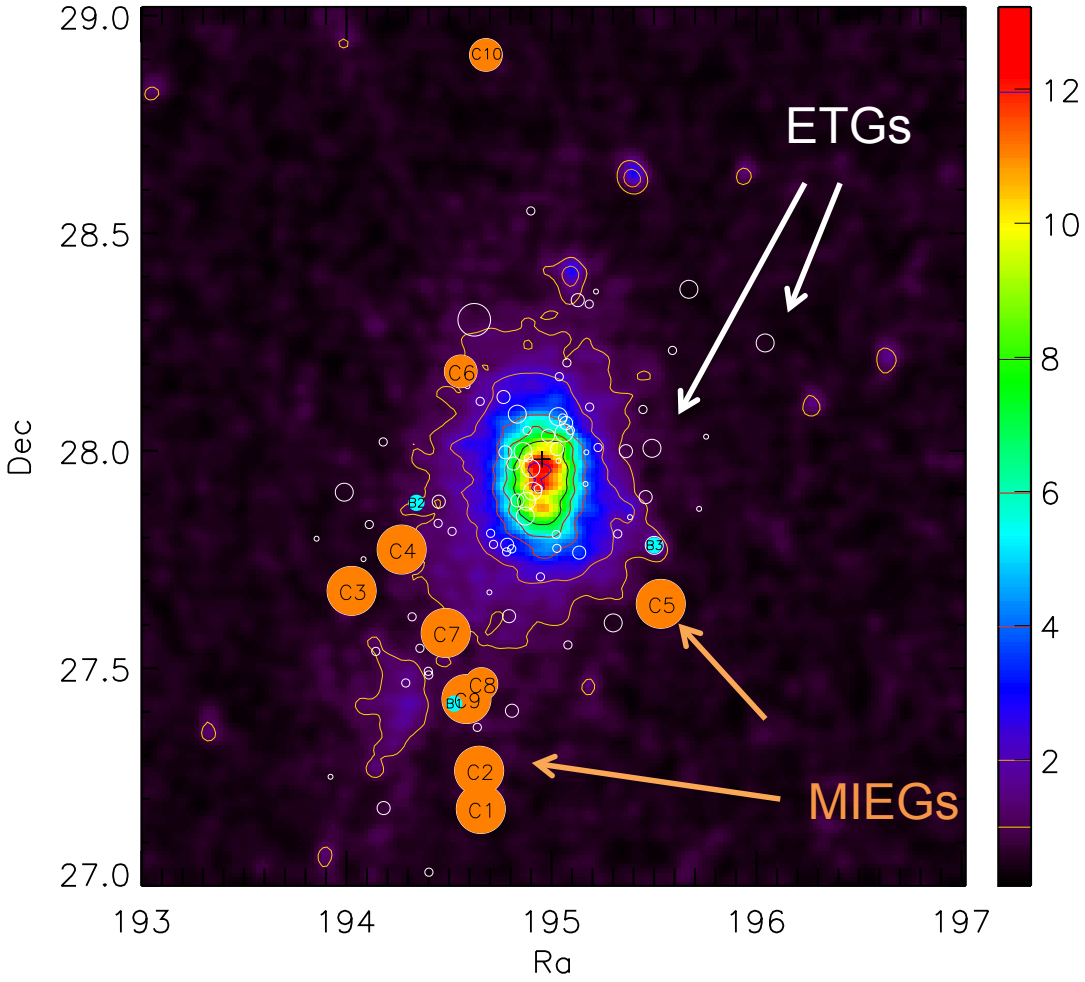
Distribution of the MIEGs among the Coma cluster



Background image: ROSAT X-ray image

Riguccini+15

Distribution of the MIEGs among the Coma cluster



Galaxies at different stages of their evolutionary history :

- MIEGs = ETGs with signs of strong star formation (hypothesis of cluster merging triggering the star formation)

- « Blue sources » = ETGs with blue optical colors but no remaining of current star formation (post-MIEG candidates where the recent star formation would have been quenched due to ram pressure stripping)

Background image: ROSAT X-ray image

Riguccini+15

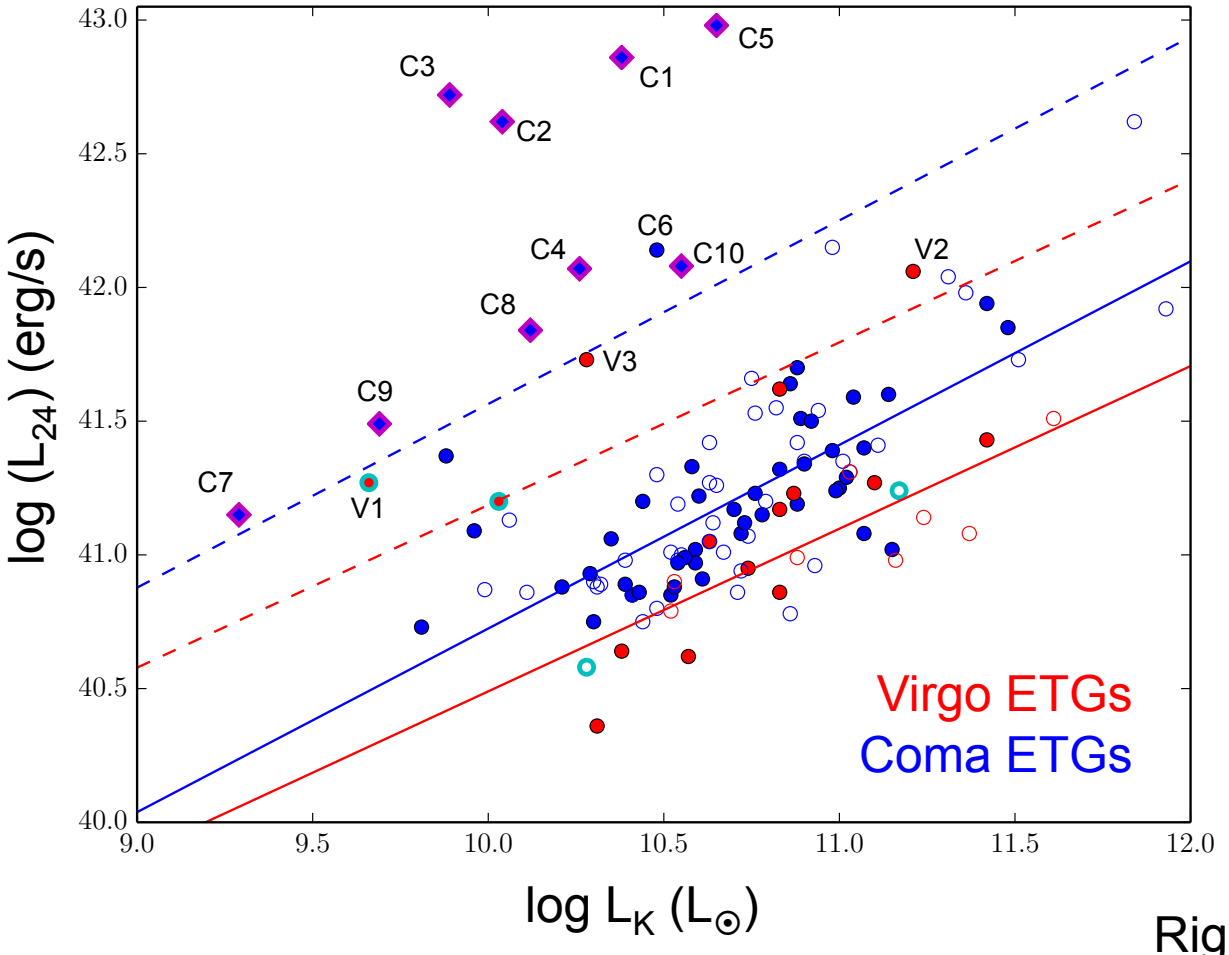
Search for MIEGs-type sources in other clusters

- Work lead by **Douglas Brambila** (Valongo)

- Need to adapt the MIEGs criterium from Riguccini+15 to a all sky survey
- Need to revise the way to select ETGs

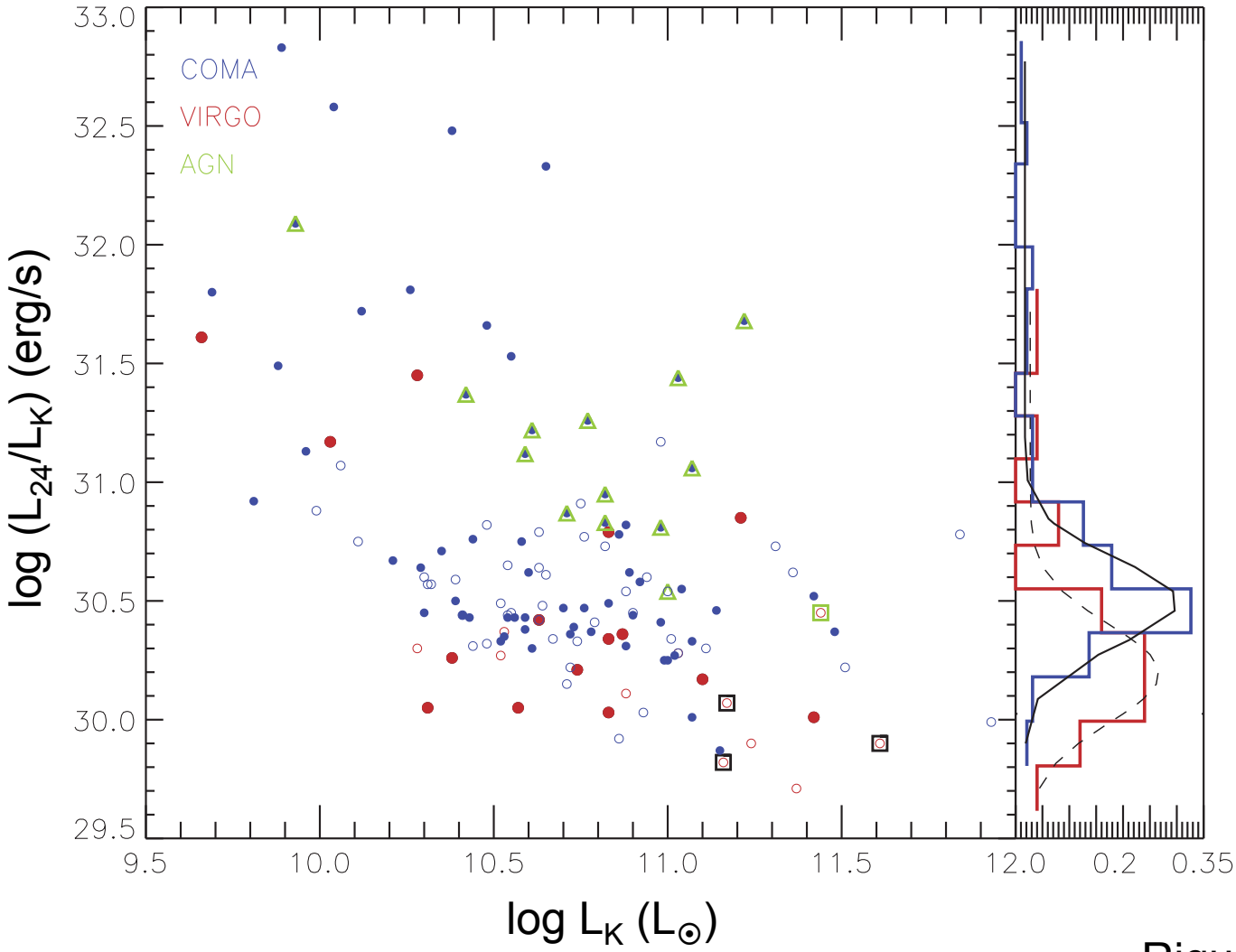
- Solutions:
  - WISE all-sky survey: $L_{22}/L_{3.4}$ instead of L_{24}/L_K
  - Morphological parameters: frac-dev> 0.8 and concentration > 2.6

Mid-IR Enhanced Galaxies (MIEGs)



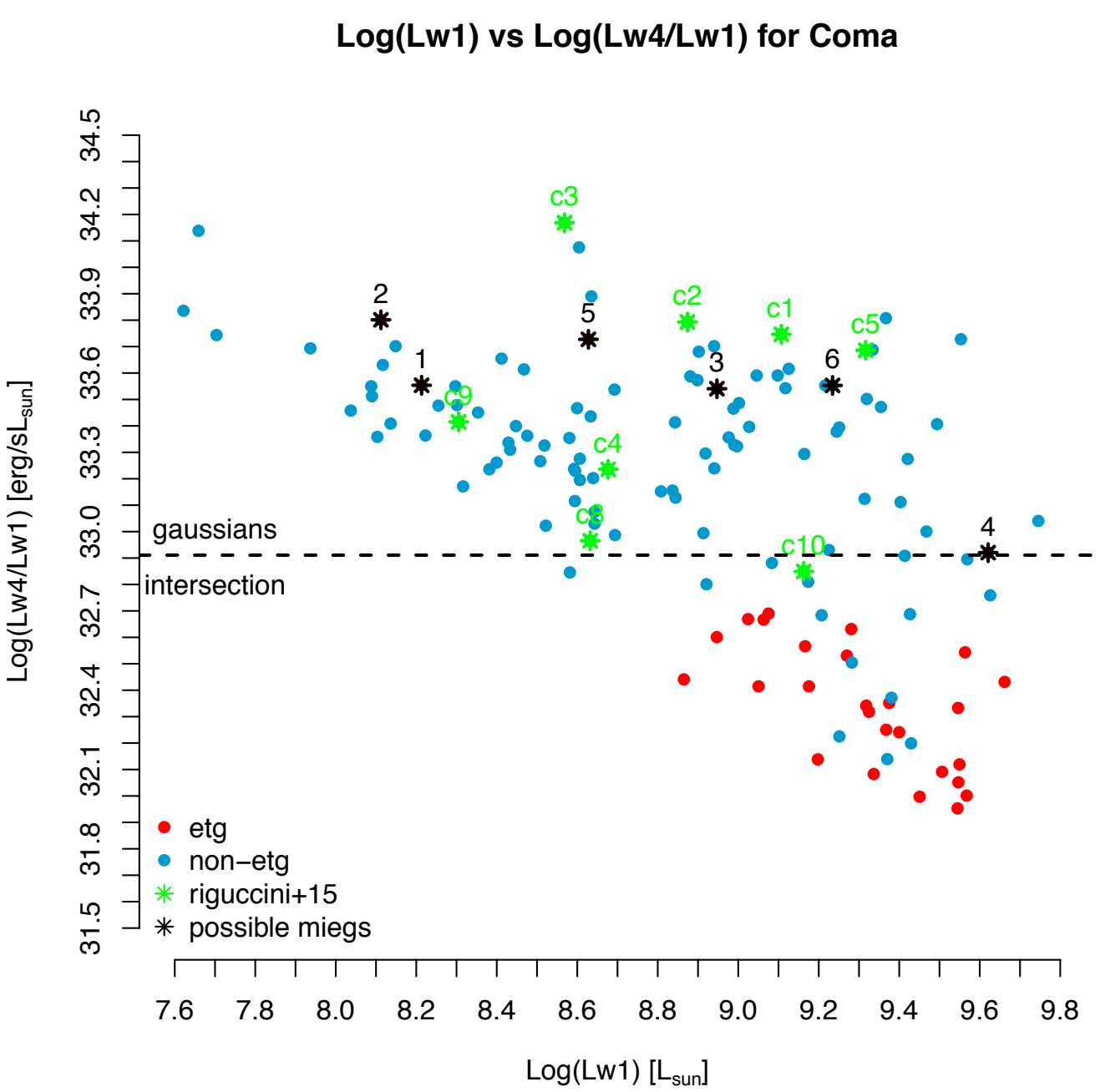
Riguccini+15 (ApJ)

Mid-IR Enhanced Galaxies (MIEGs)



Virgo ETGs
Coma ETGs

Riguccini+15 (ApJ)

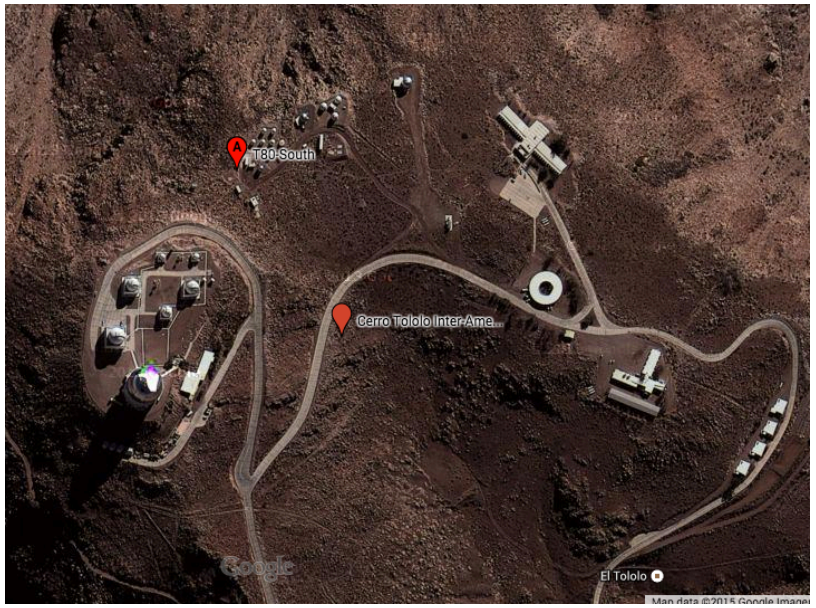


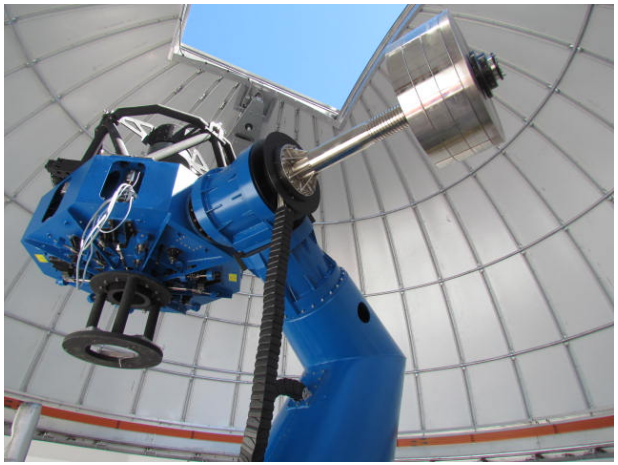
Check of the new method on the Coma cluster:

- The already known MIEGs from Riguccini+15 are not selected as ETG by the new ETG selection but they lie in the « non-ETG » part of the diagram
- 6 new MIEG-type source have been found

S-PLUS survey

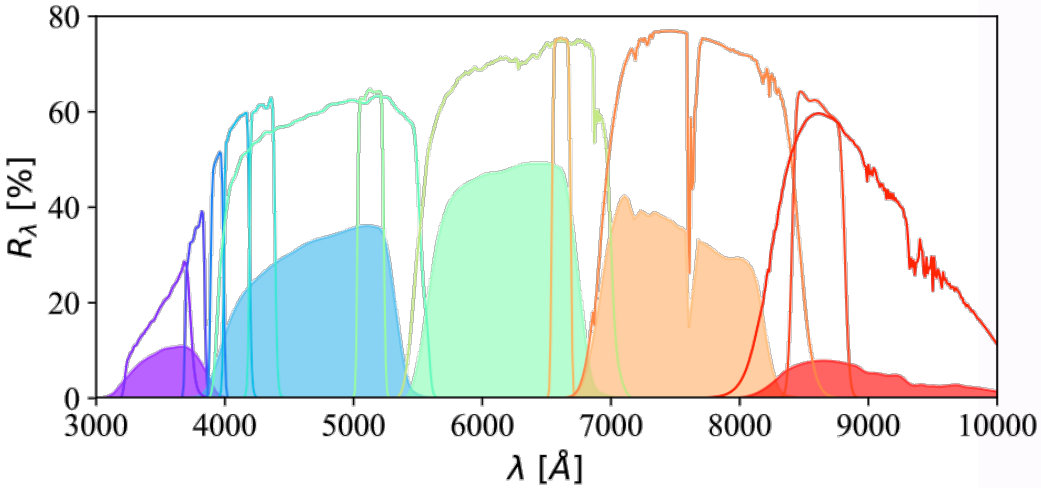
astronomical facility in Chile (Cerro Pachón), dedicated to mapping the observable Universe in 7 narrow-band filters and 5 broad-band (Sloan-like, ugriz) filters in the optical region





Covering 8,500 sq degrees with the T-80 South Telescope (0.826-meter)

S-PLUS survey: filters

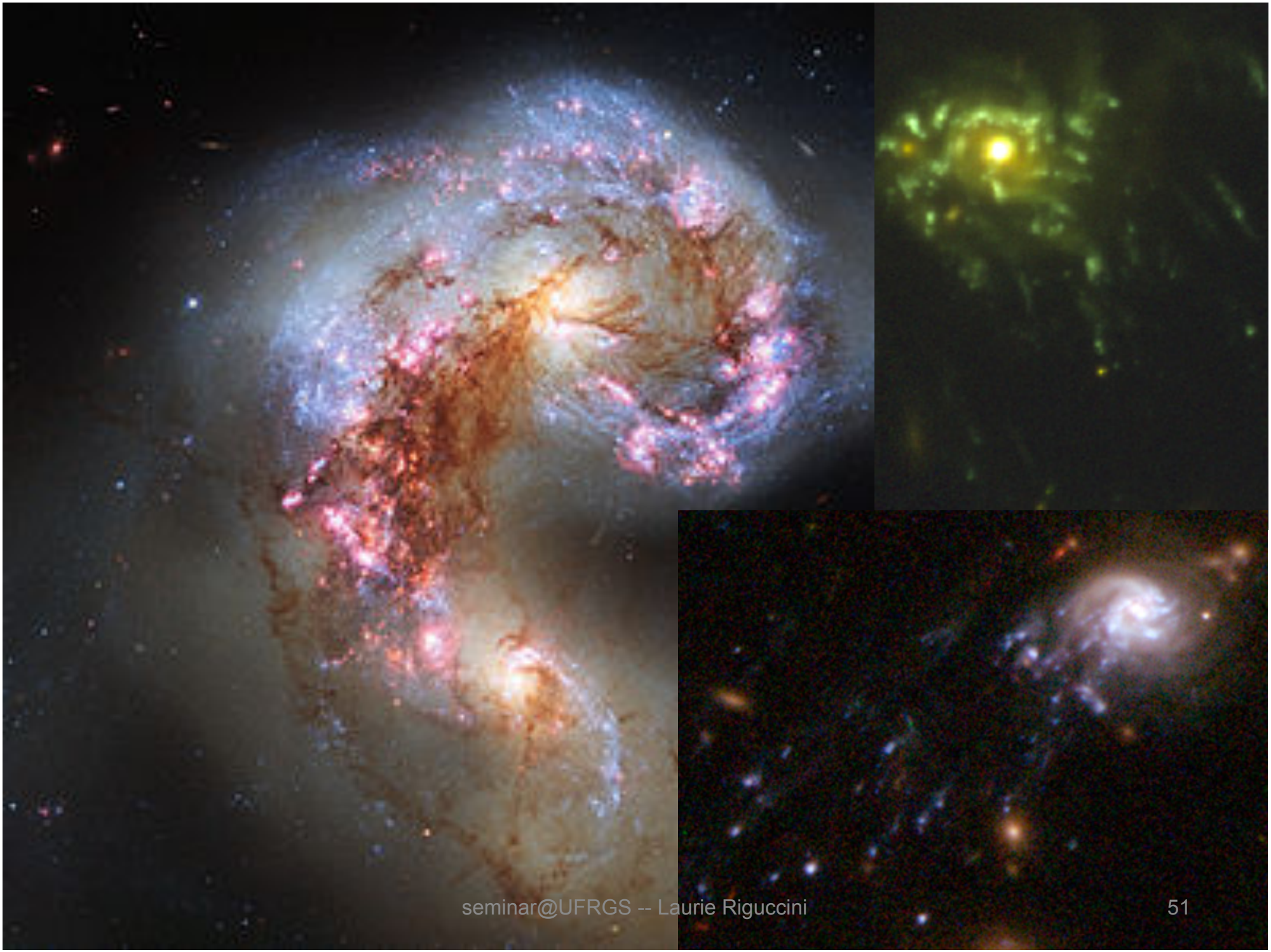


Filter#	Name	Central wavelength [nm]	FWHM [nm]	Wavelength interval [nm]	Comments
JPLUS-01	u_J	348.5	50.8		In common with J-PAS
JPLUS-02	F378	378.5	16.8		[OII]; in common with J-PAS
JPLUS-03	F395	395.0	10.0		Ca H+K
JPLUS-04	F410	410.0	20.0		Hδ
JPLUS-05	F430	430.0	20.0		G-band
JPLUS-06	g′	480.3	140.0		SDSS
JPLUS-07	F515	515.0	20.0		Mgb Triplet
JPLUS-08	r′	625.4	138.8		SDSS
JPLUS-09	F660	660.0	13.8		Hα; in common with J-PAS
JPLUS-10	i′	766.8	153.5		SDSS
JPLUS-11	F861	861.0	40.0		Ca Triplet
JPLUS-12	z′	911.4	140.9		SDSS

Conclusions

- We isolate extreme lenticulars (MIEGs) in the Coma sample and the Virgo sample: **sample of transition galaxies**
- Coma MIEGs show peculiar properties, different than the rest of the ETGs sample:
  - Located in the SW part of the cluster (infalling substructure): enhanced star formation
  - Typical spectra with emission lines (and bluer g-r colors)
  - Interesting objects with peculiar morphology (disturbed): new class of transition objects?
- **Analogy:** These blue sources would be the analogs of the post-starburst candidates in a evolutionary path for ETGs where MIEGs would be the analog of starburst galaxies.
- Interest in expanding the search for MIEGs to other clusters: we want large numbers of galaxies in transition
- great candidates for an S-PLUS project!!


OBRIGADA!



Star formation quenching as a function of morphology in the Green Valley

Nogueira-Cavalcante et al., submitted