

Compact dwarf galaxies

Testing the continuity hypothesis with high-mass early-type galaxies

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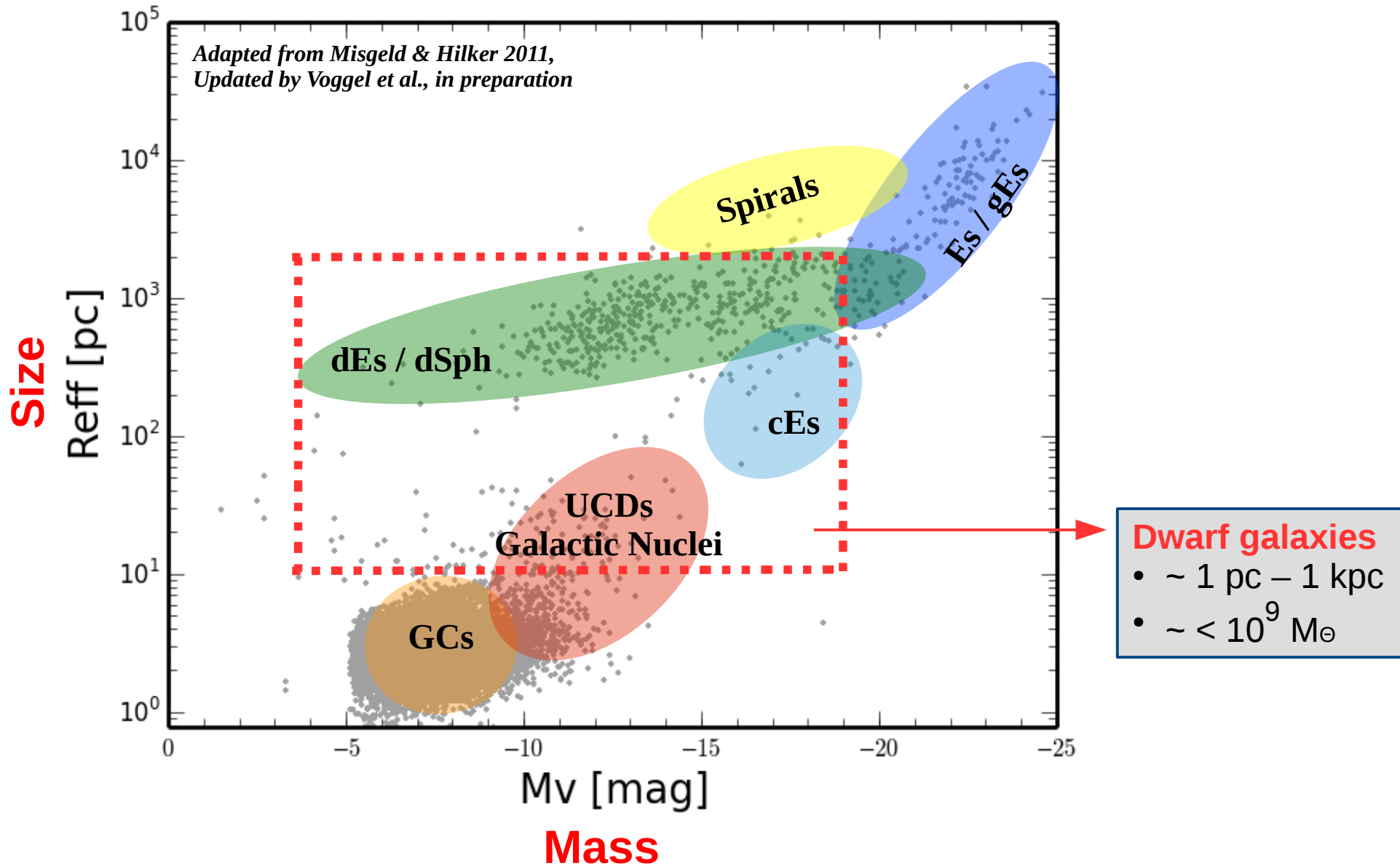
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Patrick Côté (Herzberg Institute of Astrophysics)
+ NGVS team & MUSE team





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“Mass – size” plane of galaxies

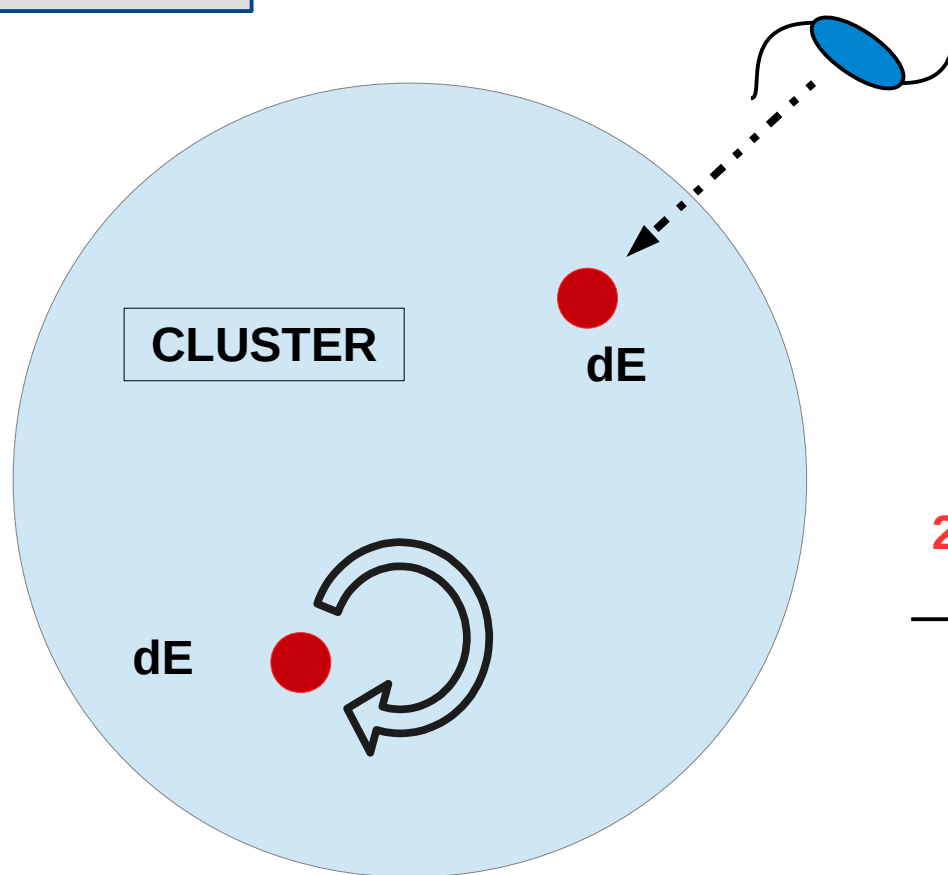


Dwarf early-types (dEs) in clusters

Formation – Evolution scenarios

1. Born as dE inside

- Long time in the cluster
- Pure spheroids
- Old stars, no gas



2. Morphological transformation

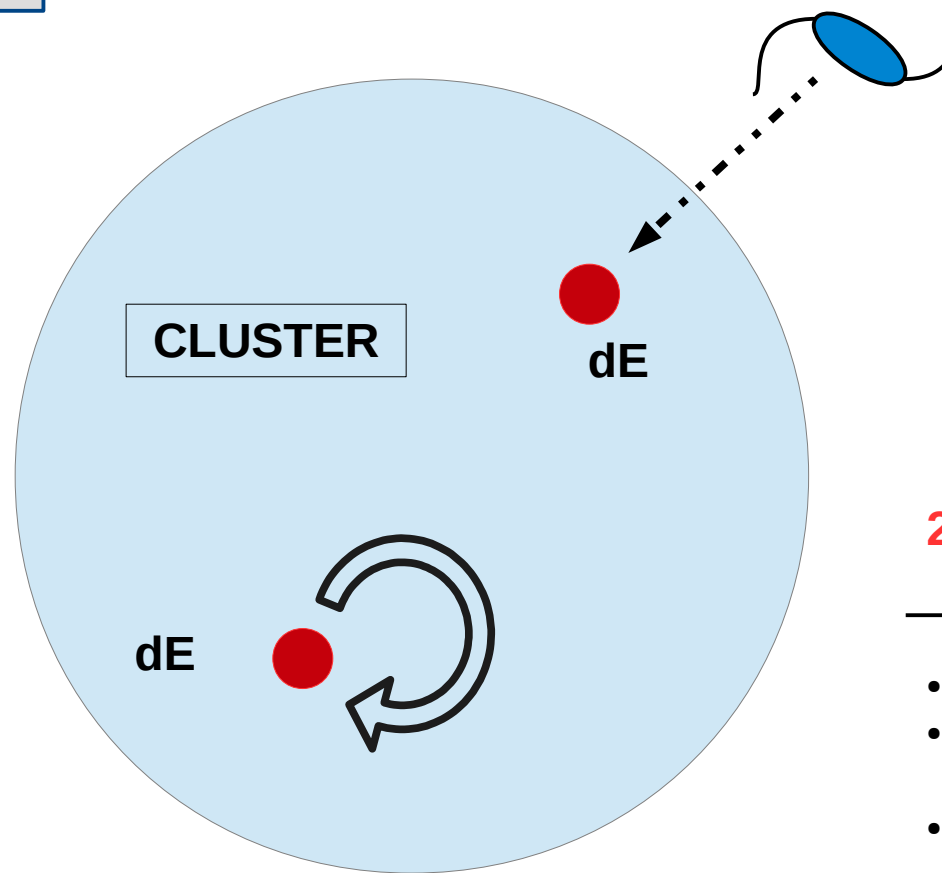
- Less time in the cluster
- Substructures
- Younger stars

Dwarf early-types (dEs) in clusters

Physical processes

1. Born as dE inside

- Stripping
- Harassment

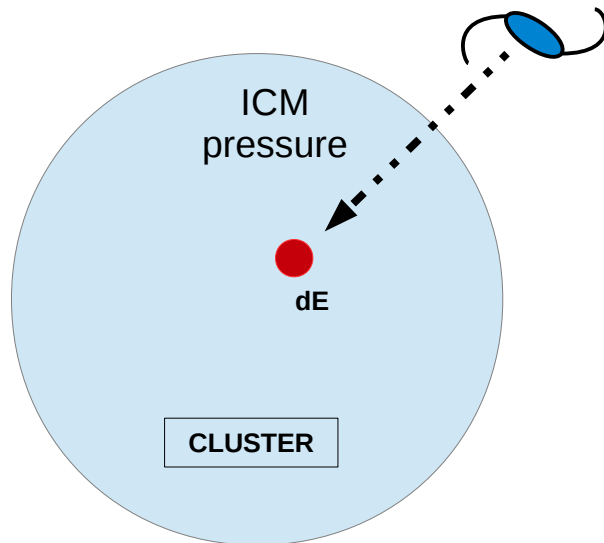


2. Morphological transformation

- Merging
- Gas accretion
- Ram pressure stripping
- Stripping
- Harassment

Dwarf early-types (dEs) in clusters

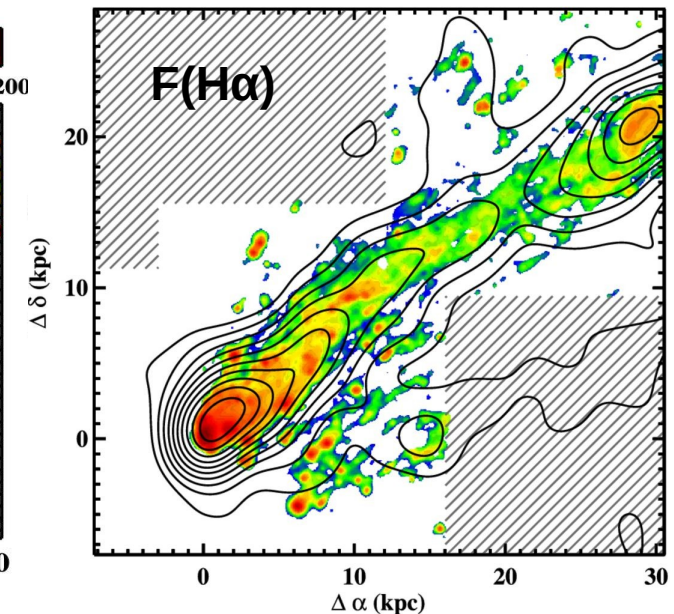
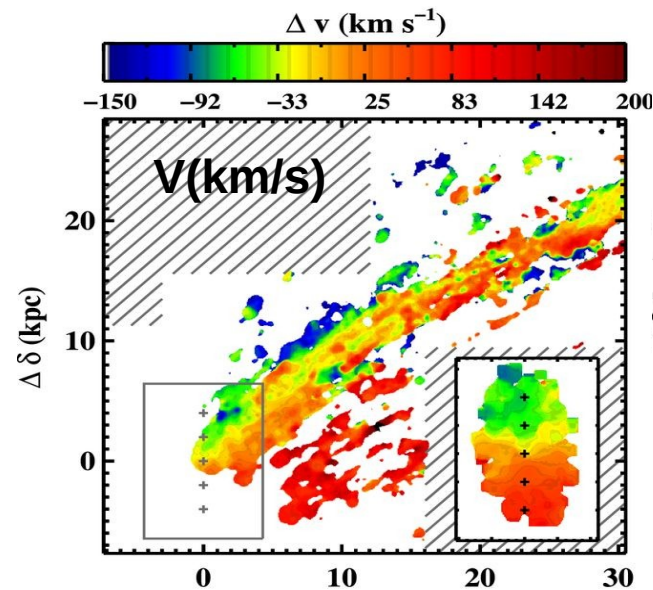
Ram Pressure Stripping



- Gas removed
- Kinematics (AM) conserved
- Central Star formation enhanced

ESO137-001, Norma cluster

Image credit: NASA / ESA / CXC.



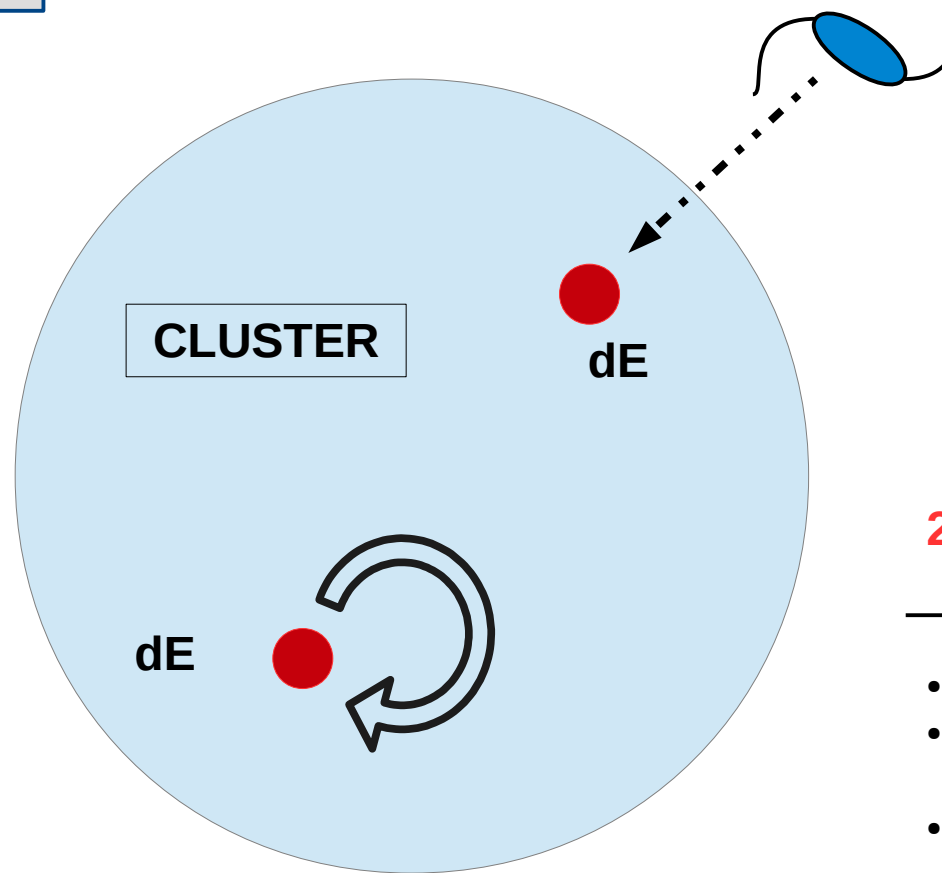
Fumagalli et al. (2014)

Dwarf early-types (dEs) in clusters

Physical processes

1. Born as dE inside

- Stripping
- Harassment

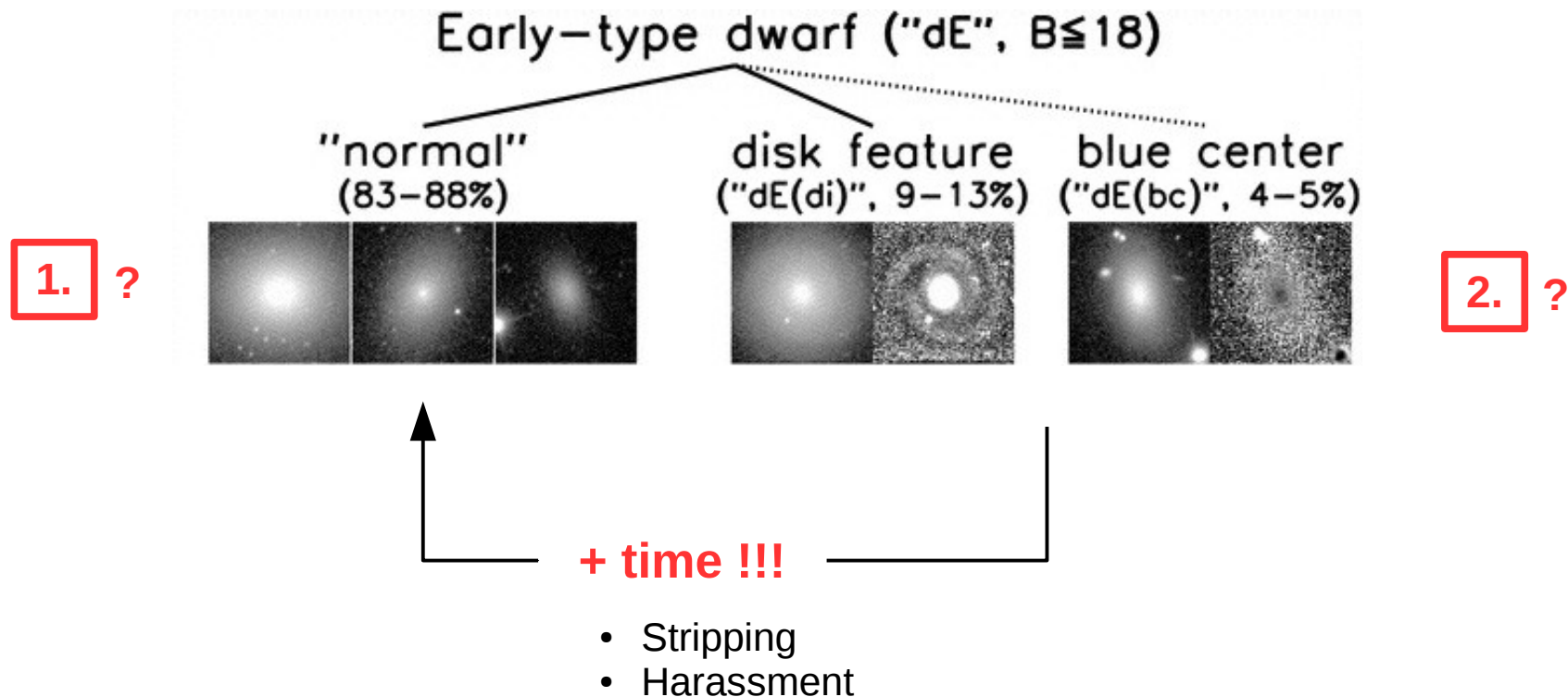


2. Morphological transformation

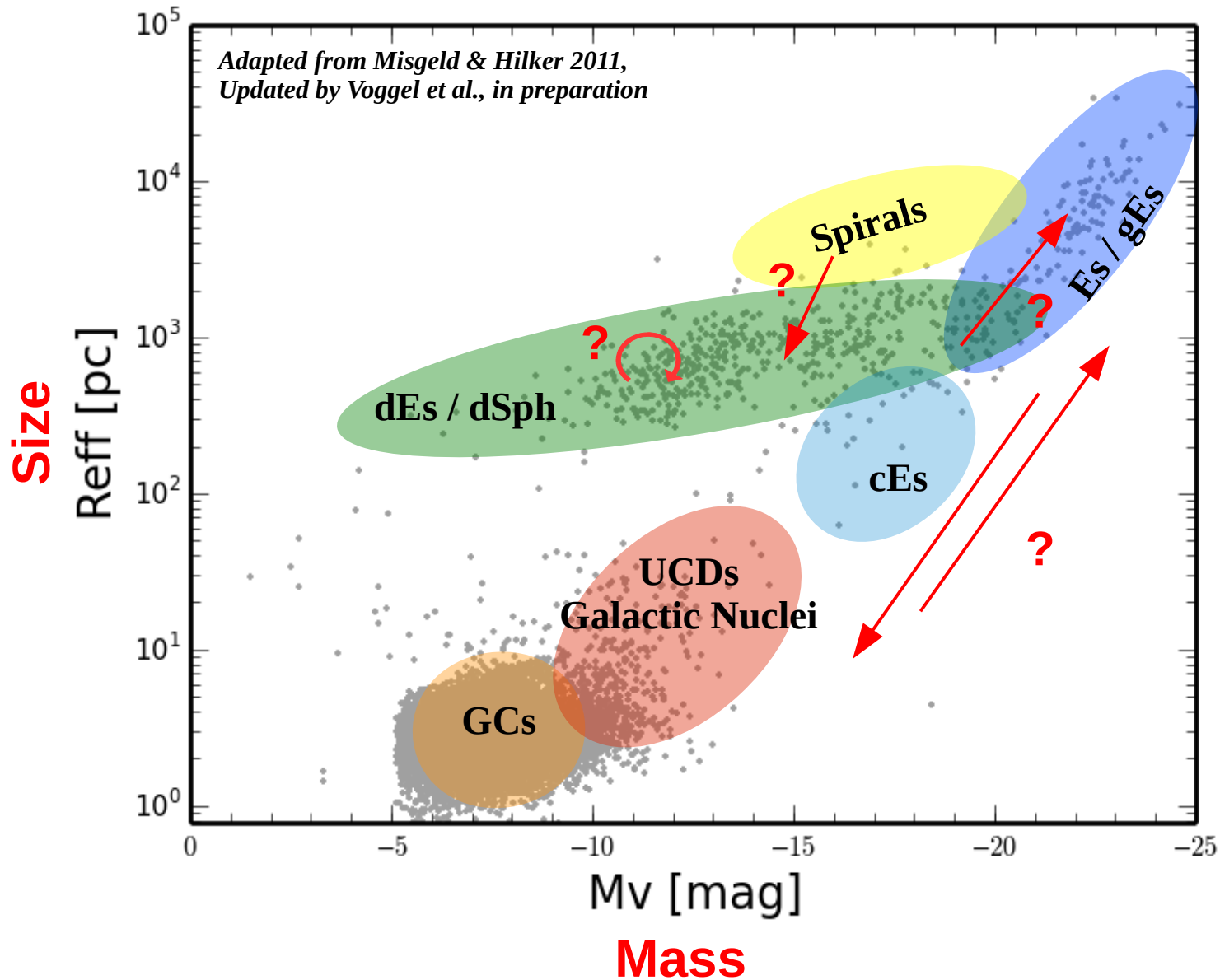
- Merging
- Gas accretion
- Ram pressure stripping
- Stripping
- Harassment

Dwarf early-types (dEs) in clusters

- *Lisker et al. (2007)*
413 dE galaxies (~50% of the Virgo dE population)



“Mass – size” plane of galaxies



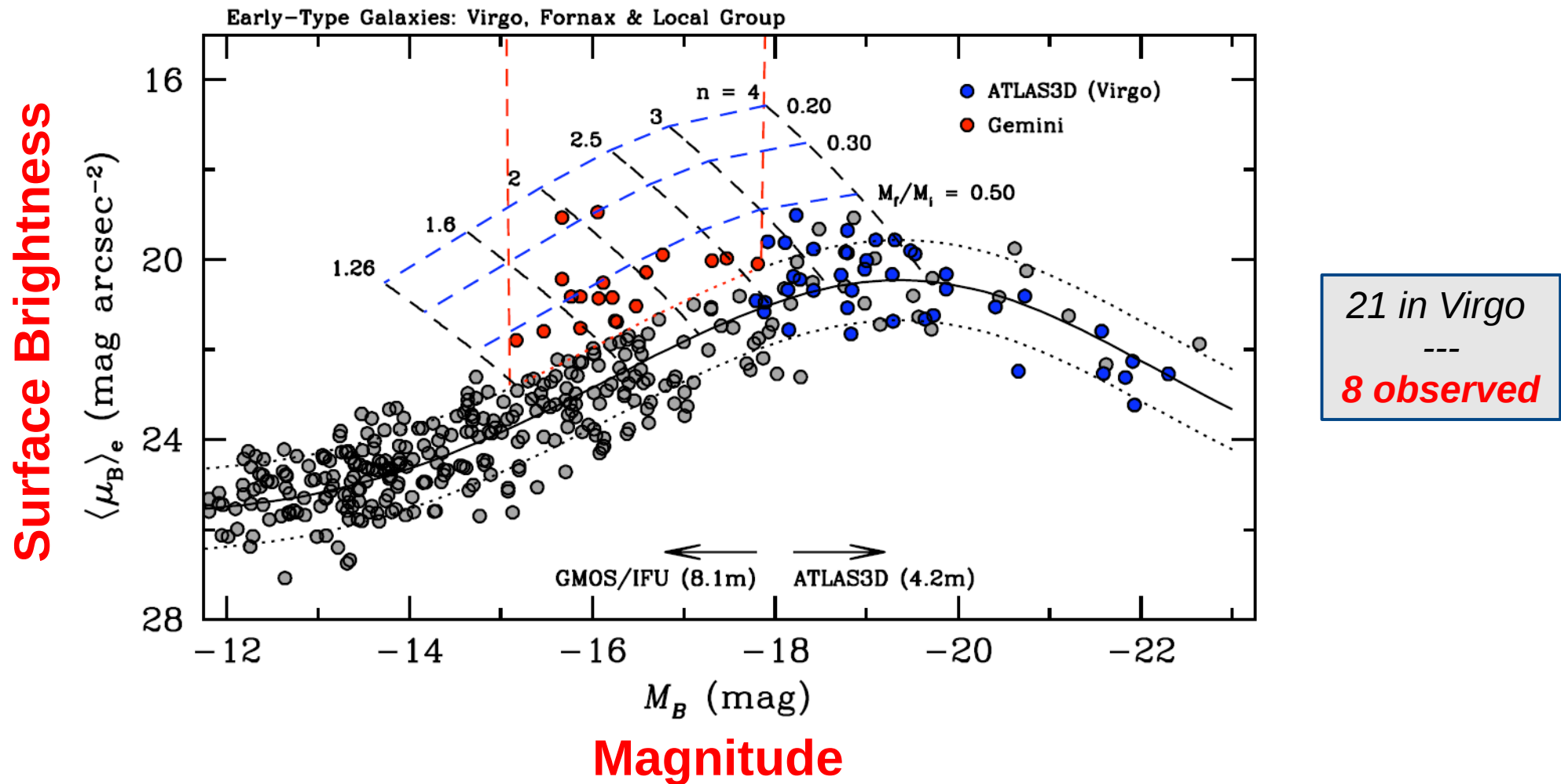
Processes

- **Transformed**
 - Merging
 - Gas accretion
 - Ram pressure
 - Stripping
 - Harassment
- **Born as dE**
 - Secular evolution
 - Cluster influence

+ time !!!

NGVS / GMOS-IFU program

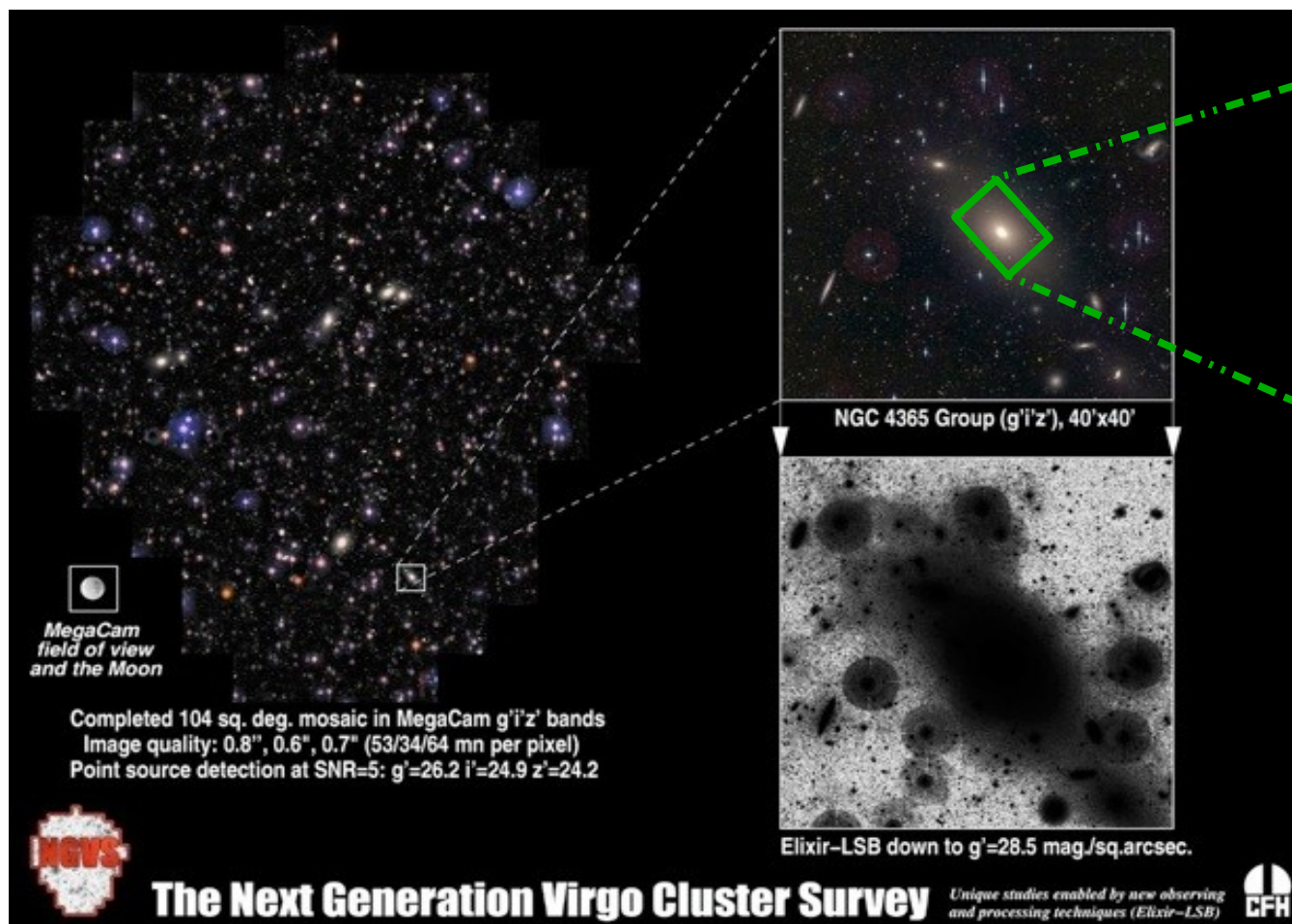
- “Compact, low-mass” ETGs



NGVS / GMOS-IFU program

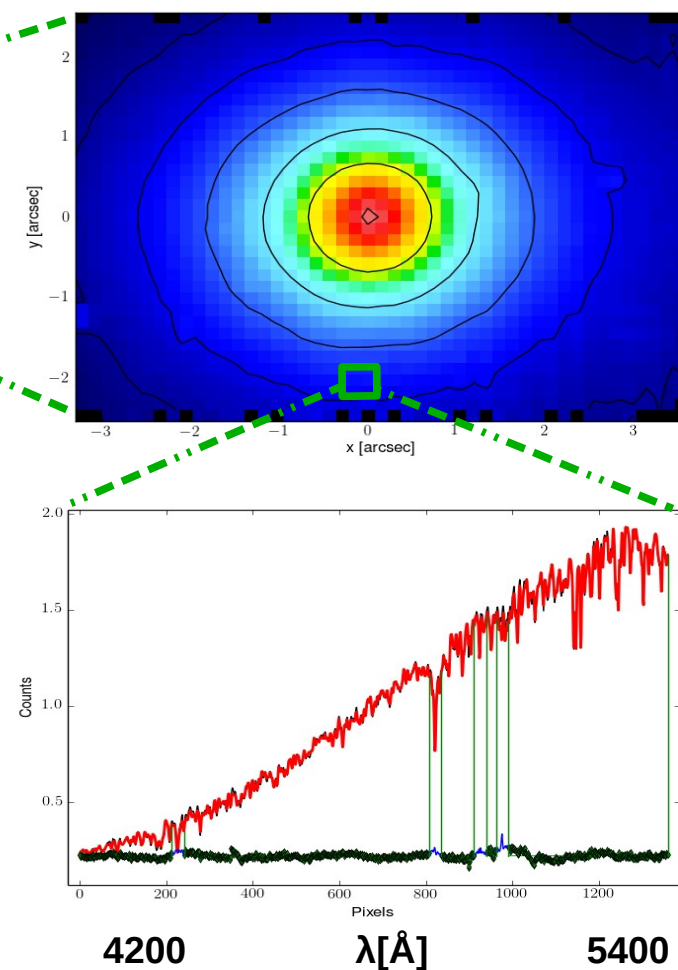
NGVS – *Ferrarese et al. (2012)*

- *Megacam* on CFHT
- 104 sq. deg.

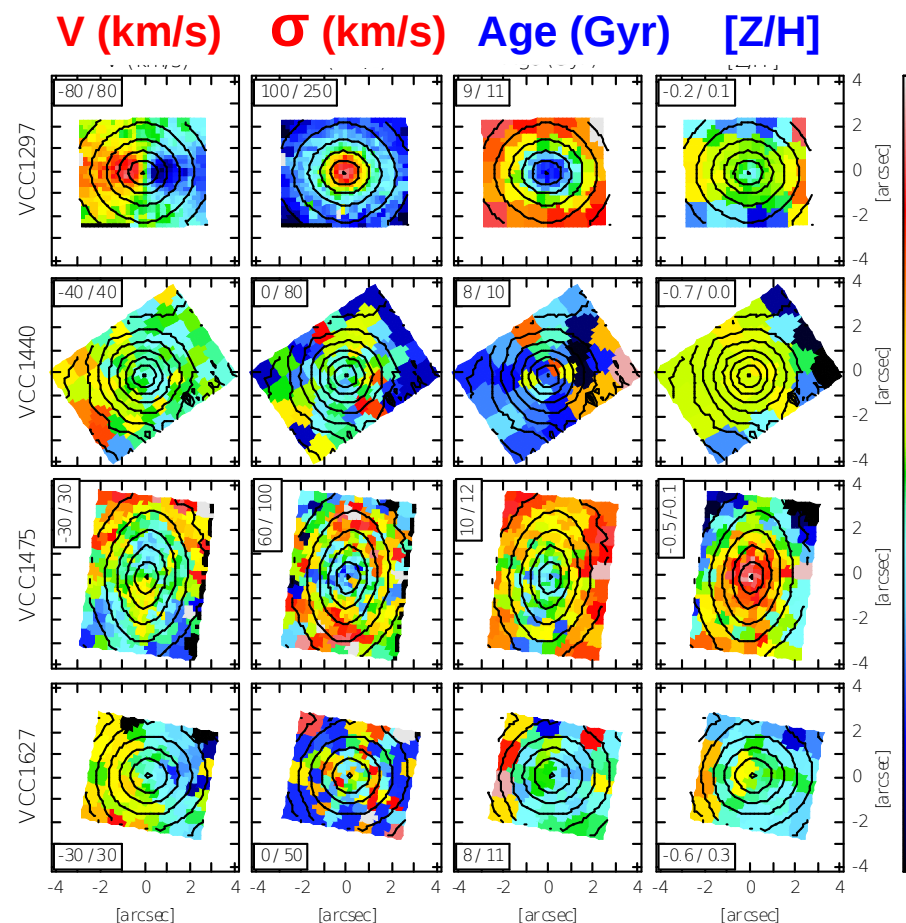
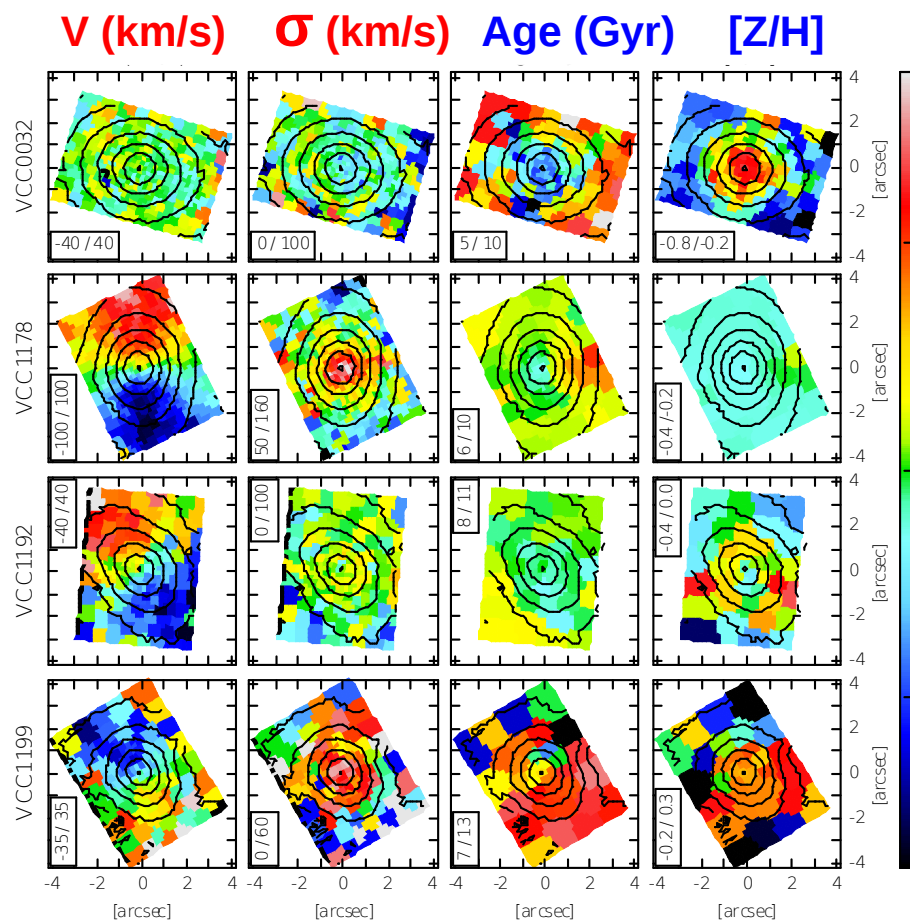


GMOS-IFU

FOV $\sim 5'' \times 7''$



Compact dEs: kinematics & stellar population



Guérou et al. (2015)
2015ApJ...804...70G

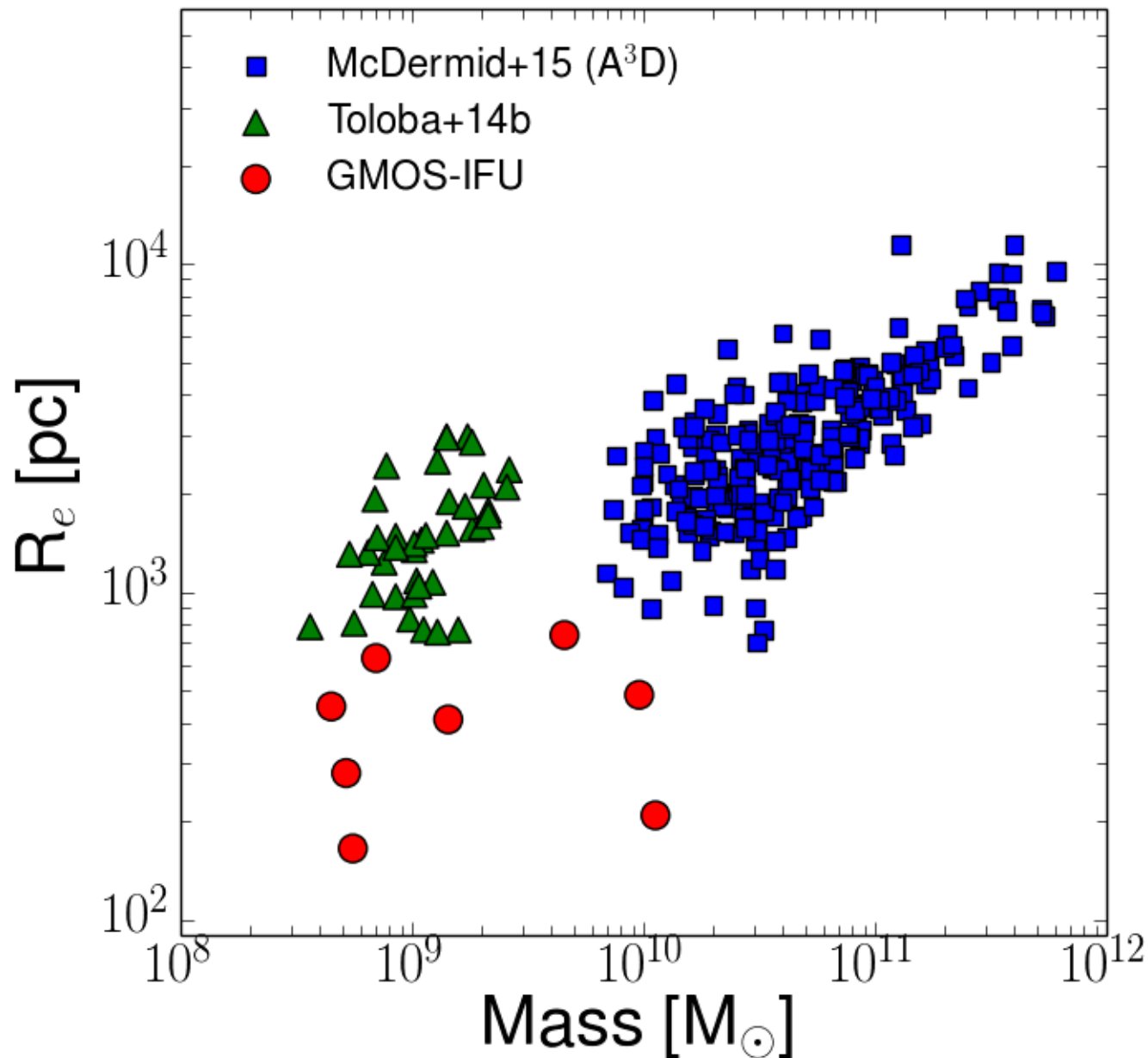
- Kinematics**

V : 30 – 40 km/s
 σ : 20 – 60 km/s

- Stellar population**

Age : 6 – 11.5 Gyr
[Z/H] : -0.8 – 0.2 dex

Low-mass, compact galaxies in the “Mass-size” plane

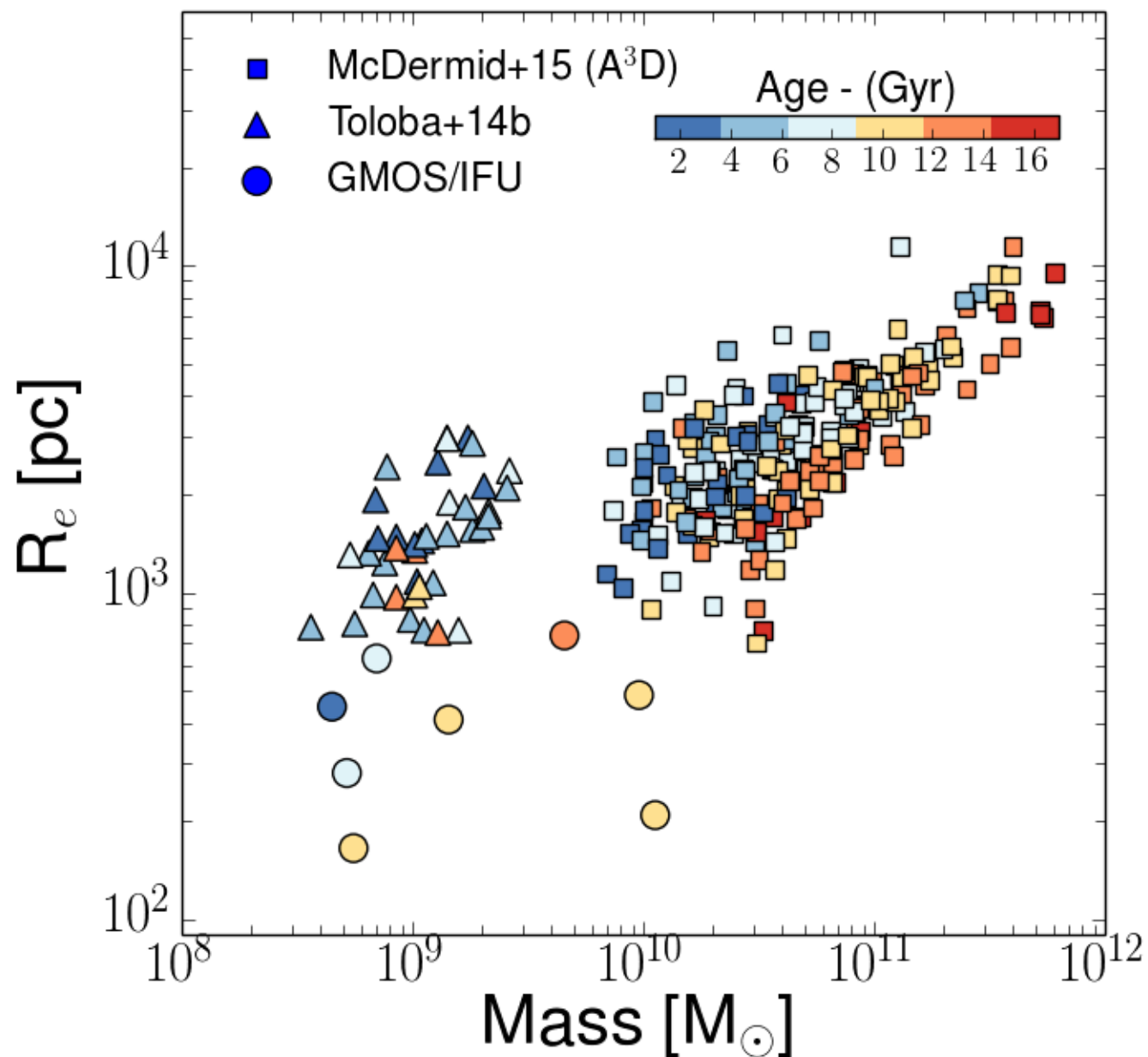


260 “massive” ETGs
(A3D, $M_k < -21.5$)

39 “low-mass” ETGs
(SMAKCED survey)

**8 “low-mass,
COMPACT”** ETGs
(GMOS-IFU program)

NGVS / GMOS-IFU program : results



AGE

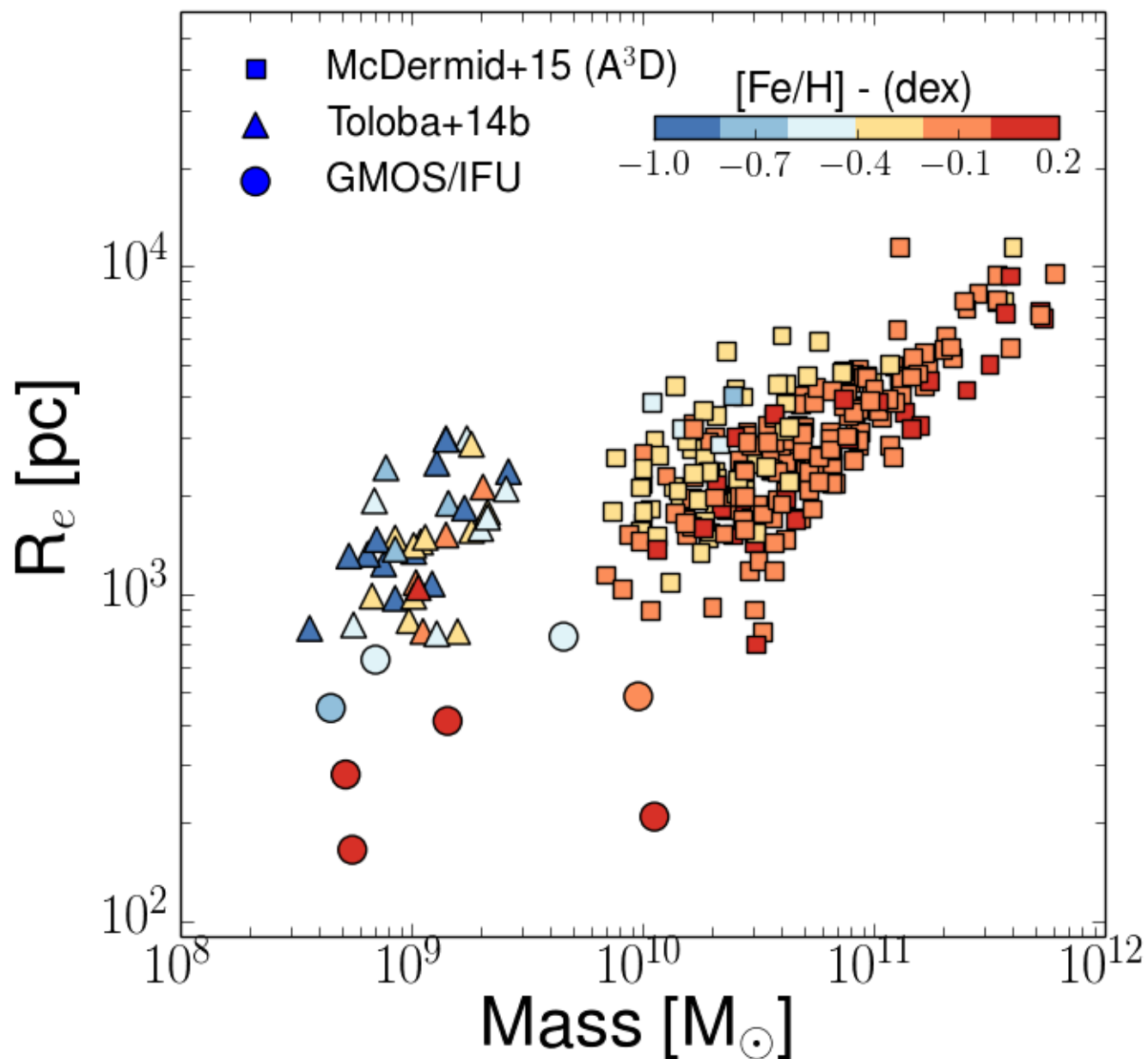
*Single Stellar Population
within R_e*

COMPACT = OLDER

**CONTINUITY
MASSIVE & LOW-MASS**

Guérou et al. (2015)

NGVS / GMOS-IFU program : results



[Z/H]

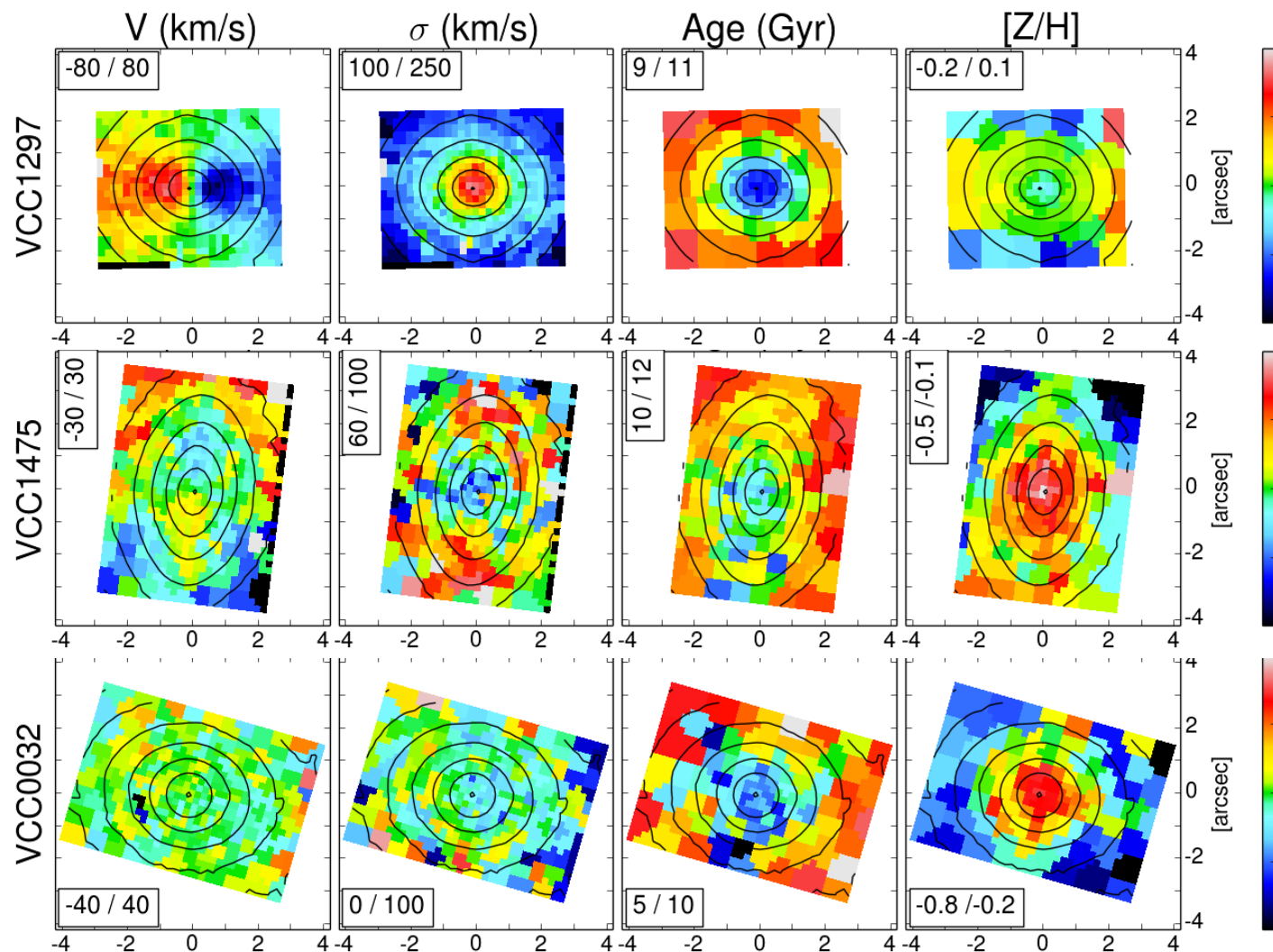
*Single Stellar Population
within R_e*

**COMPACT
MORE METAL-RICH

CONTINUITY
MASSIVE & LOW-MASS**

Guérou et al. (2015)

Younger & more [Z/H] rich cores



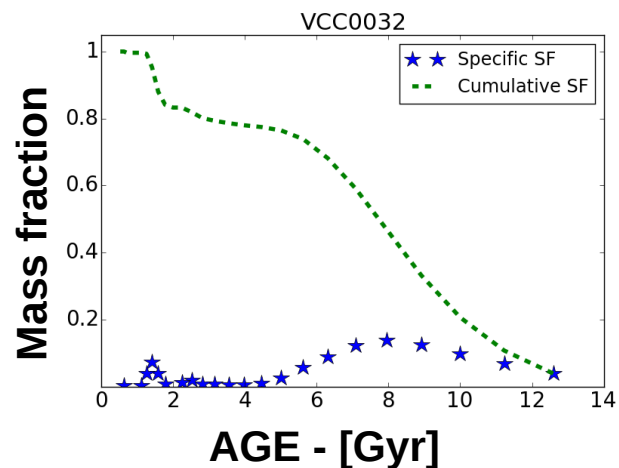
**Star Formation
episode
at the center**

Scenarios:

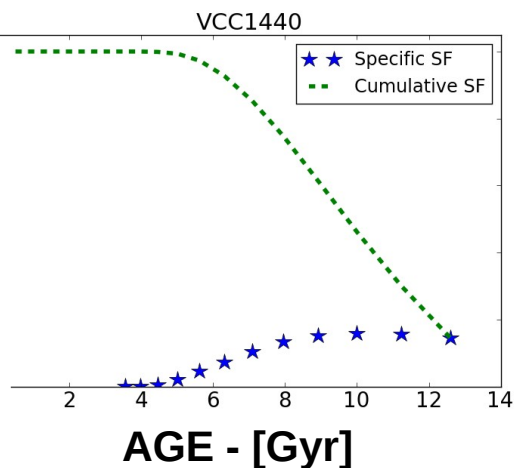
- Secular processes
- External processes:
 - Gas accretion
 - Grav. Interaction
 - Ram pressure

Star Formation Histories of dEs

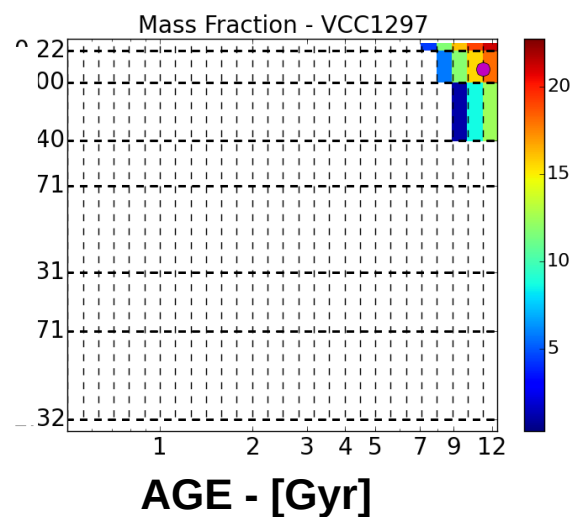
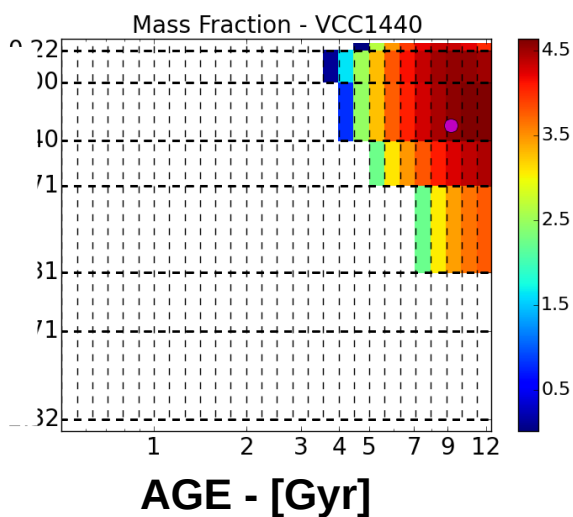
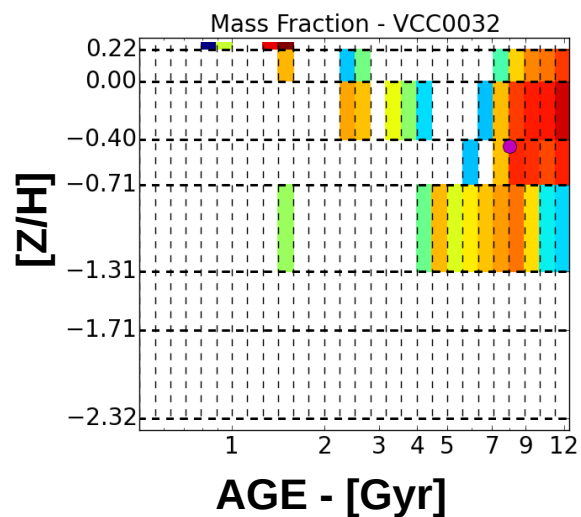
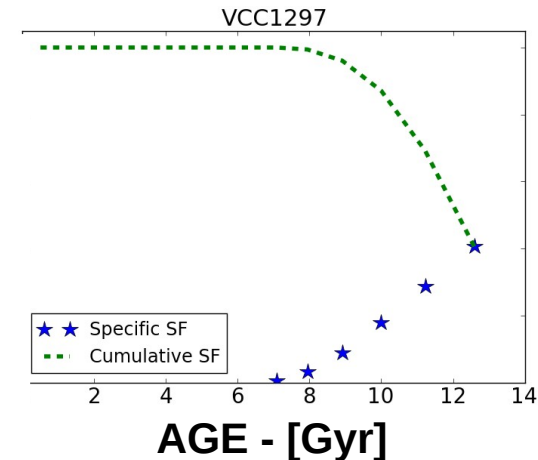
“Complex” (1/8)



“Extended” (2/8)

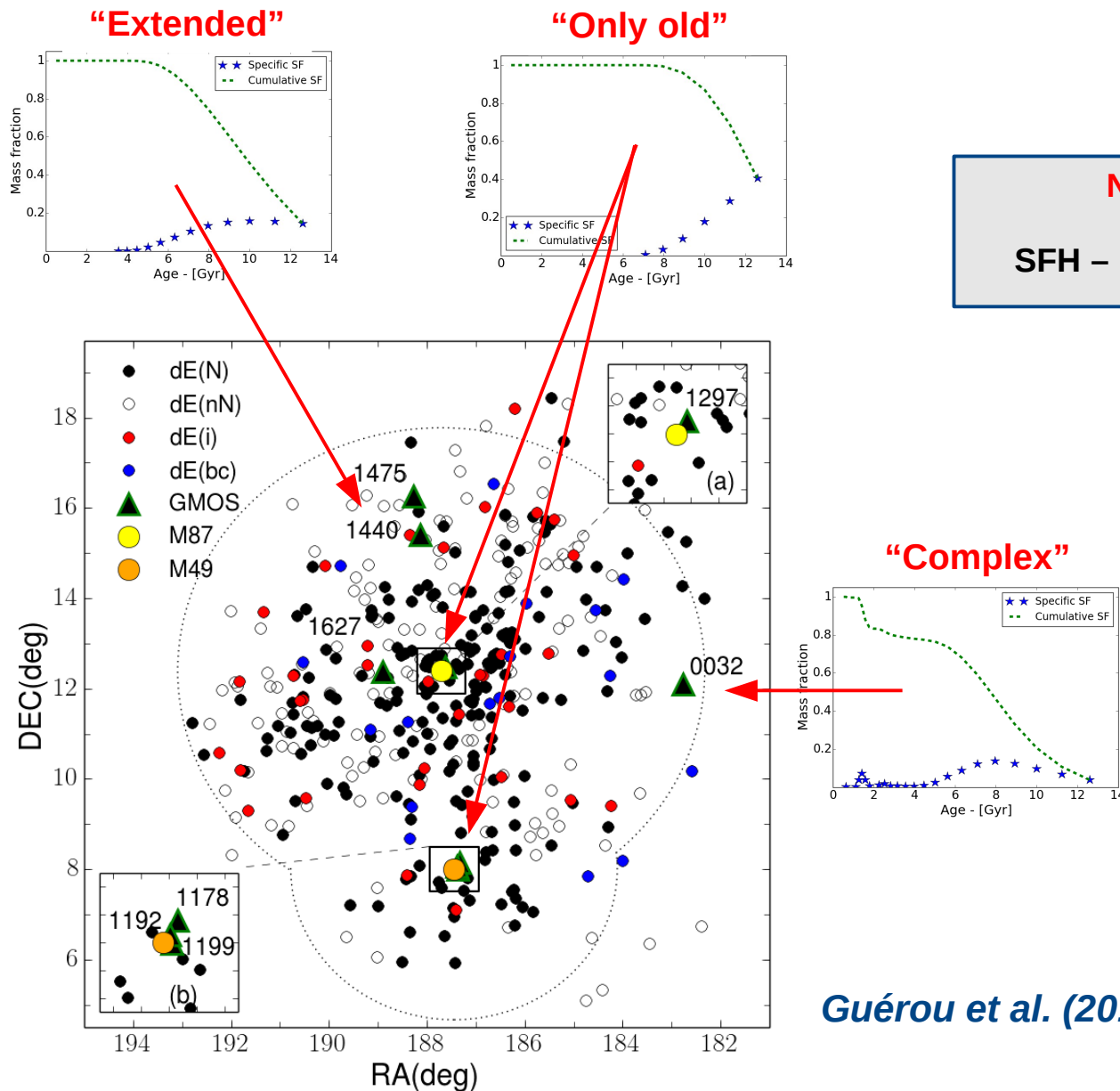


“Only old” (5/8)



Various formation / evolution scenarios

Probing the environment with NGVS



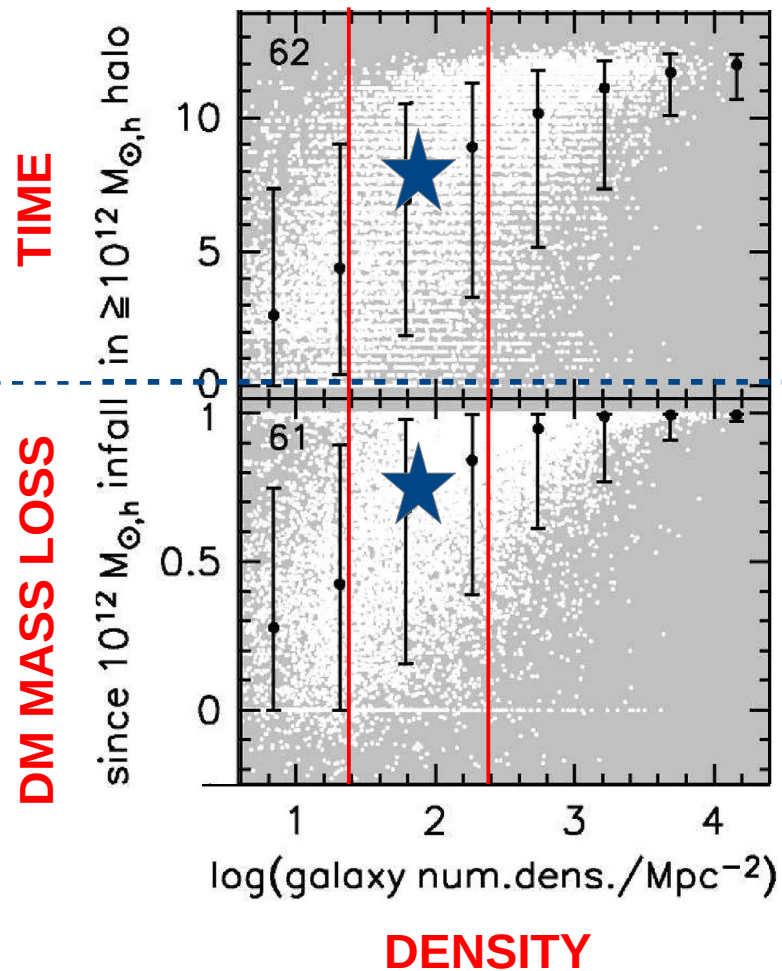
No general trend

SFH – location in the cluster

Guérou et al. (2015)

Cluster environment from simulations

(Adapted from *Lisker et al., 2013*)



⇒ ~ **7 Gyr** spent in $M > 10^{12} M_{\odot}$

Compact galaxies ~ 9 Gyr old

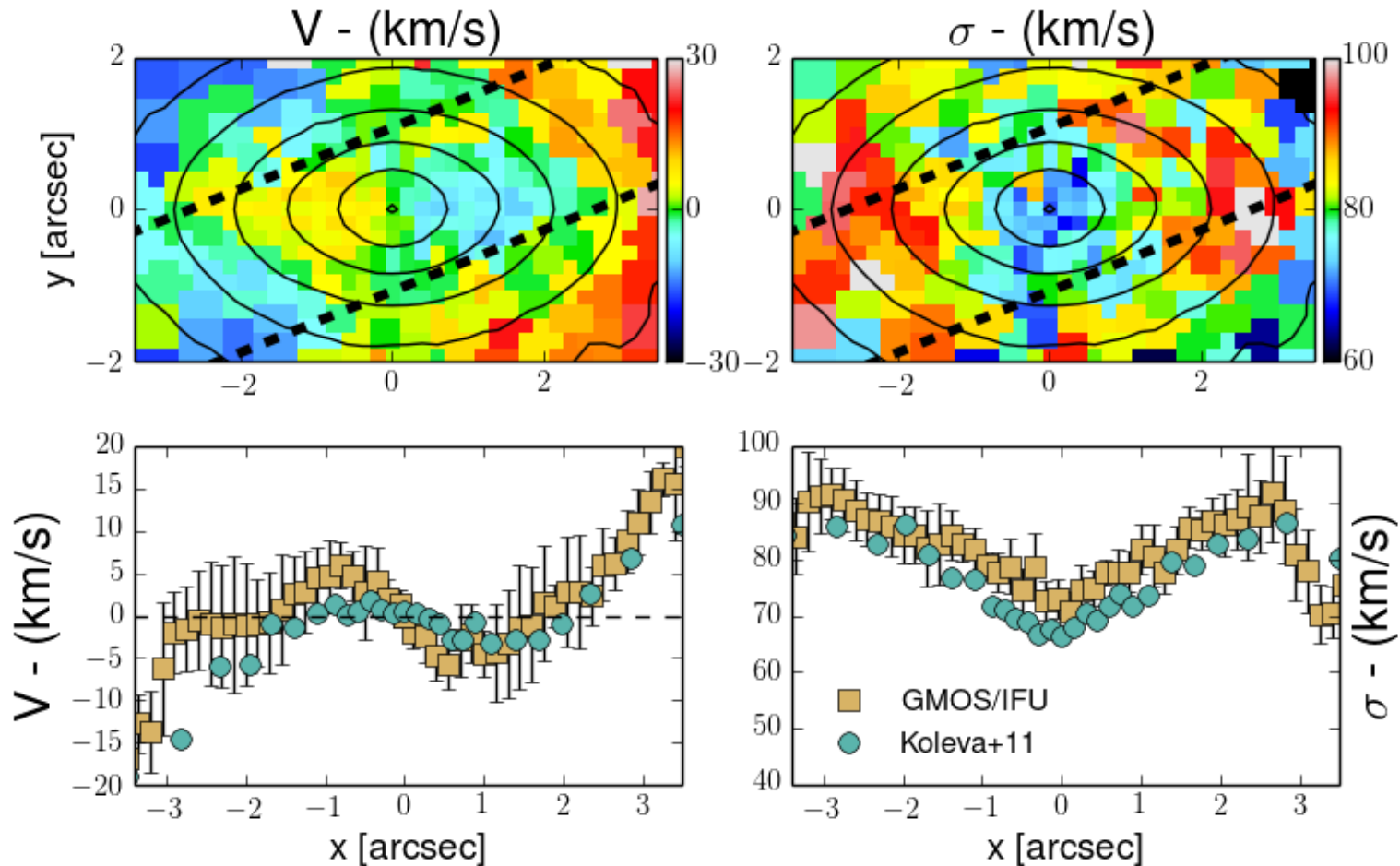
Most of their life in dense environment

⇒ ~ **80%** of DM mass loss

Strong environmental influence
(companions, pair, cluster)

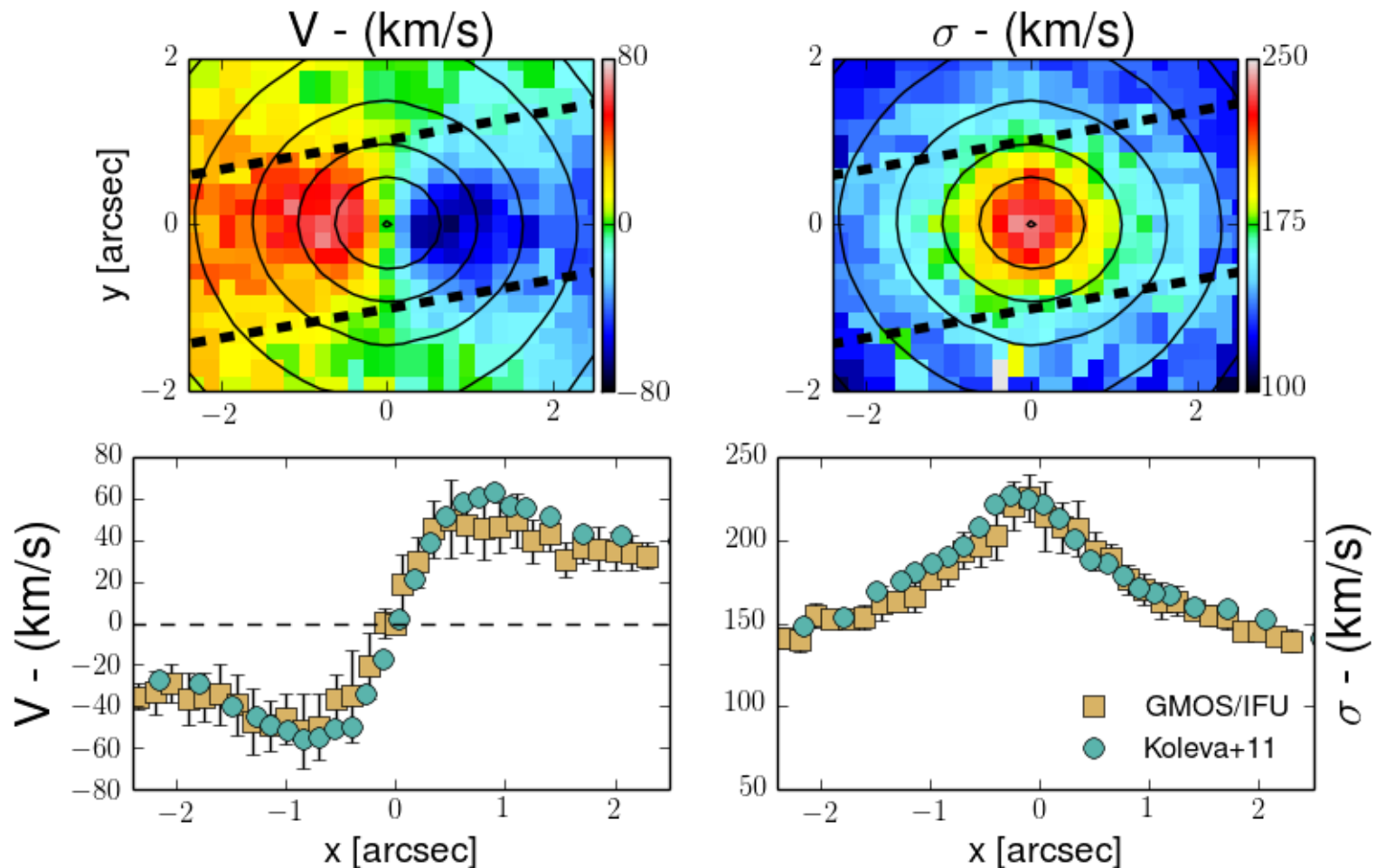
Large scatter
Various evolution path

VCC 1475: a Kinematically decoupled core (KDC)



- **2 – σ galaxy** (Krajnović, 2011)
- A few other found in dEs/dSph (Toloba, 2014 (a,b) ; Geha, 2005)

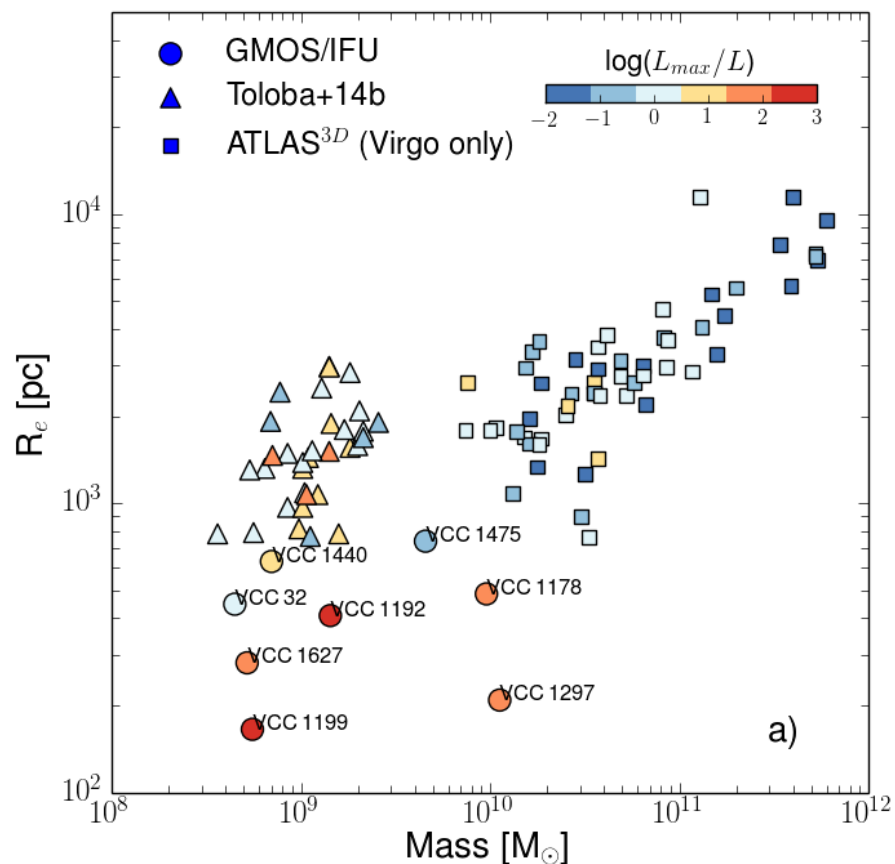
VCC1297 (NGC4486b): a central BH ... ?



- **Central BH** of $\sim 10^8 M_{\odot}$ (Kormendy & Bender, 1997)
- 5% of its dynamical mass ($\sim 1.1 \times 10^{10} M_{\odot}$)

Probing the environment with NGVS

Guérou et al. (2015)



COMPACT DWARFS

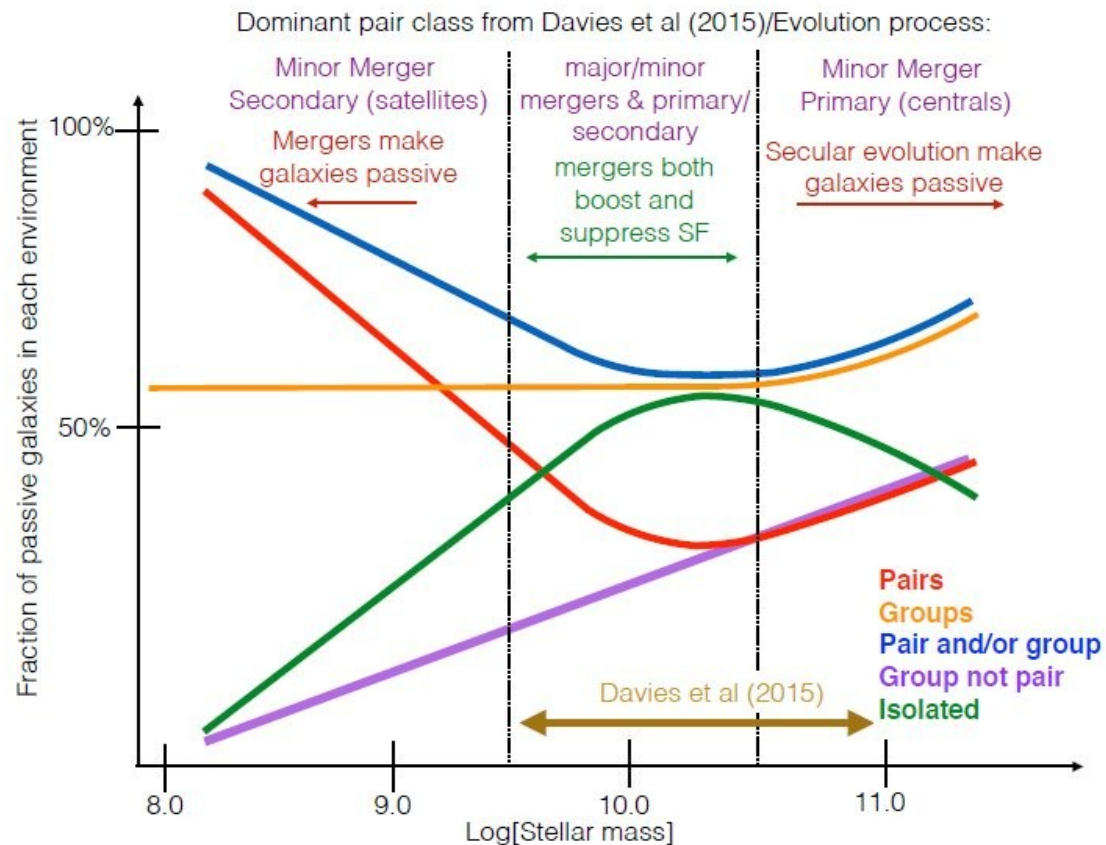
**HAVE MORE MASSIVE
COMPANIONS**

Using densities information
from NGVS data
[Ferrarese, L. et al. 2012]

**OLDER
MORE [Z/H] rich**

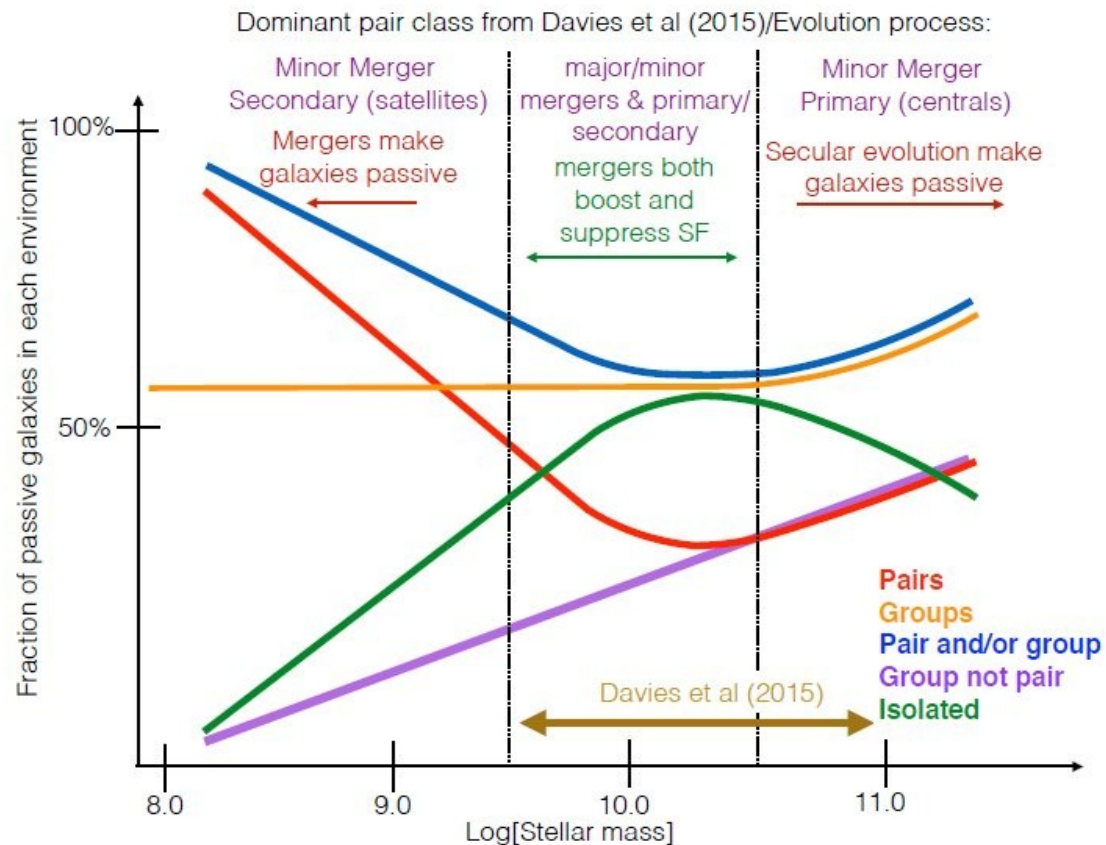
Quenching in low-mass galaxies

- **Davies et al. (2015)**
GAMA survey (300.000 galaxies, $r < 19.8$ mag)



Quenching in low-mass galaxies

- **Davies et al. (2015)**
GAMA survey (300.000 galaxies, $r < 19.8$ mag)



Most low-mass galaxies are in pairs/groups & are passive

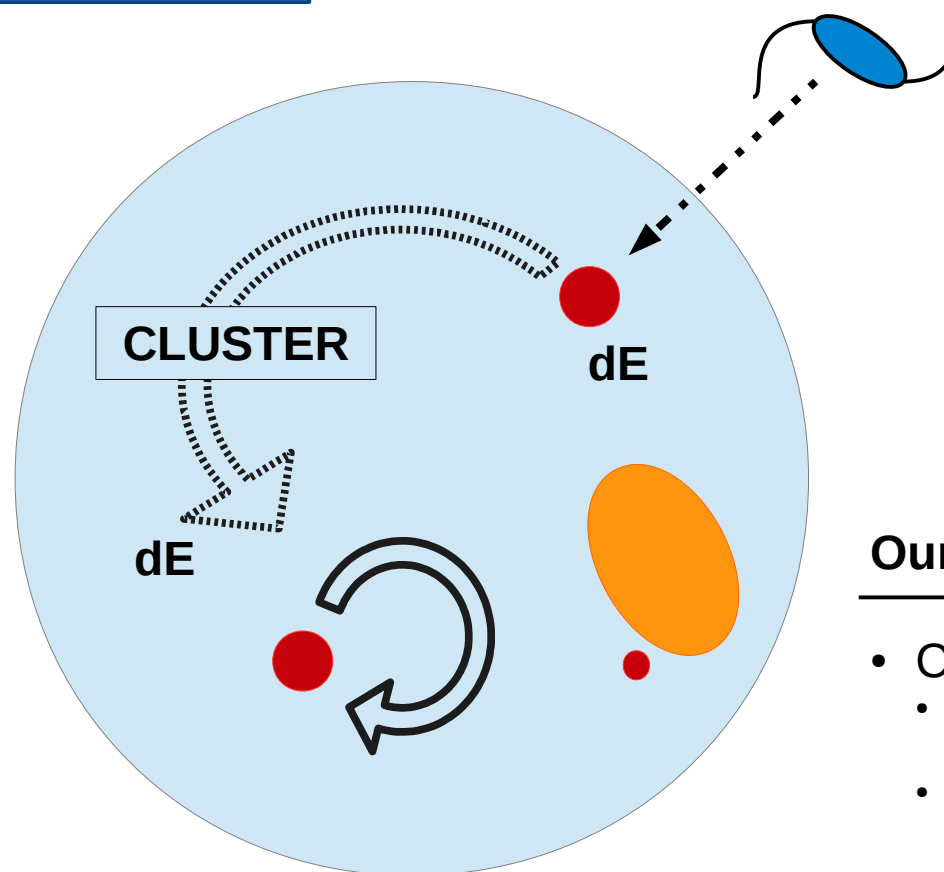
**Massive companion stops star formation
In dwarf galaxies**

NGVS / GMOS-IFU program : conclusions

Formation – Evolution scenarios

1. Born as dE inside

2. Morphological transformation

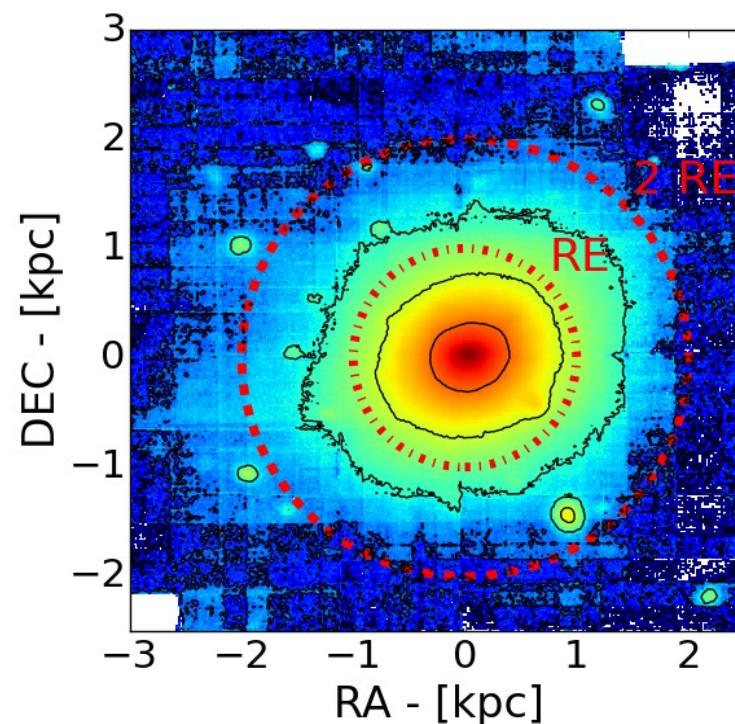


Our research:

- Consistent with **1. + 2.**
 - Continuity in integrated properties
 - Diversity in detailed properties
- Strong influence of **most massive members** to create **compact dEs**

MUSE GTO Programs

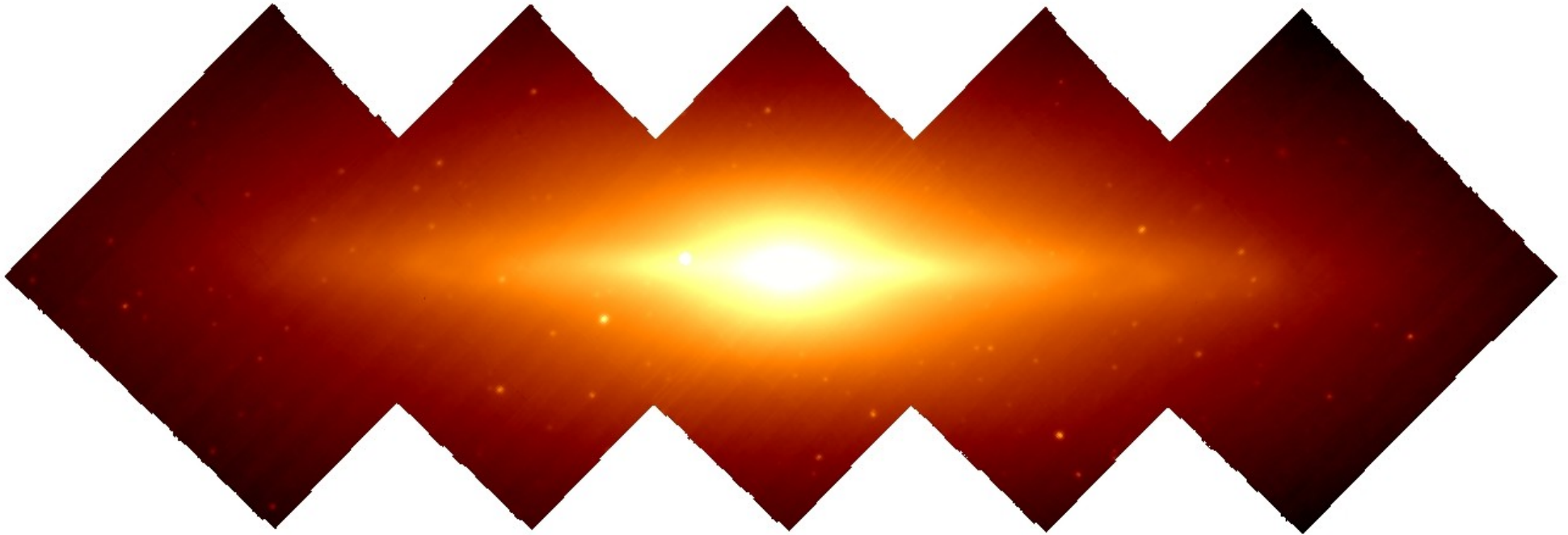
- Local dwarfs
 - Are dwarf galaxies dark matter dominated ?
 - Observations:
 - 3 targets
 - Up to 2 Re
 - One target started - (80% completed, ~2h)



Preliminary MUSE white light image
(~40 minutes)

New projects

MUSE commissioning: *NGC3115*



250" / ~ 12kpc / ~3.5 Re

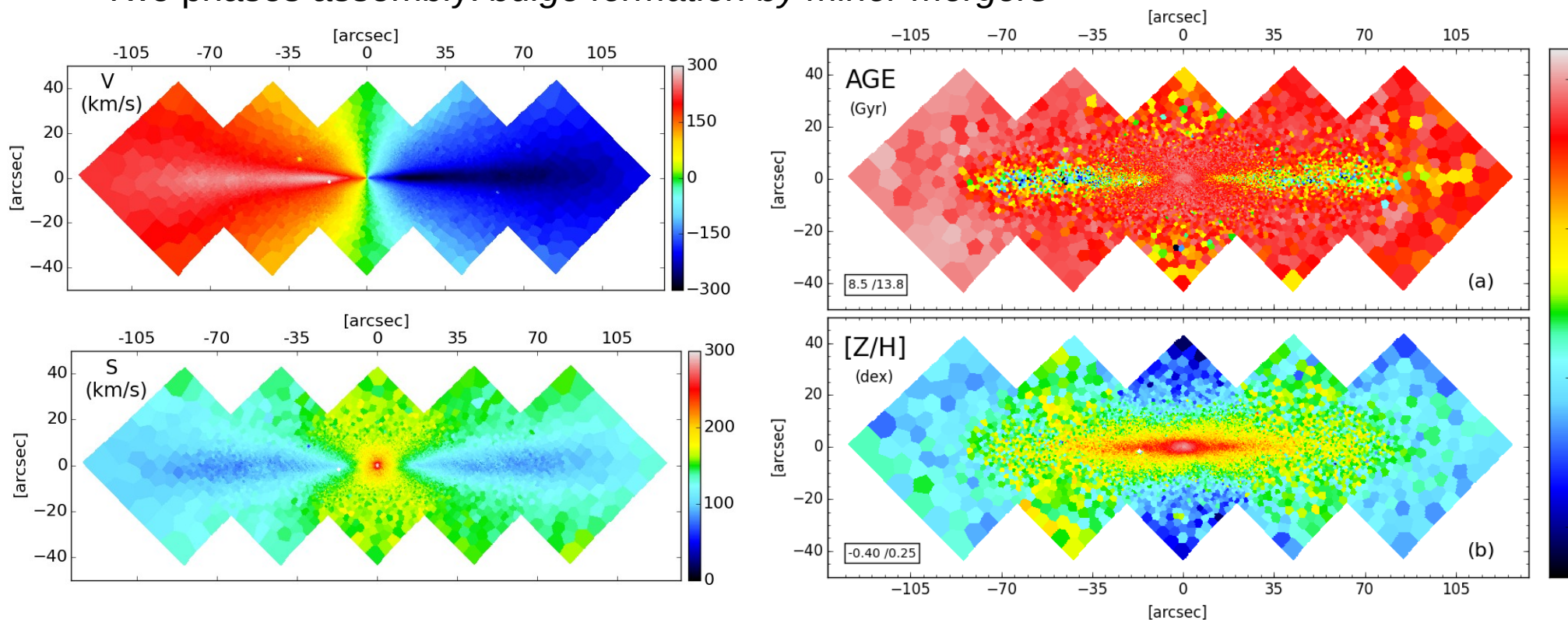
5 x 10 min exposures !

350.000 spectra ...

New projects

MUSE commissioning: *NGC3115*

- Two phases assembly: *bulge formation by minor-mergers*



Guérou et al. (in prep.)

**THANKS FOR
YOUR ATTENTION!**

DUSE

