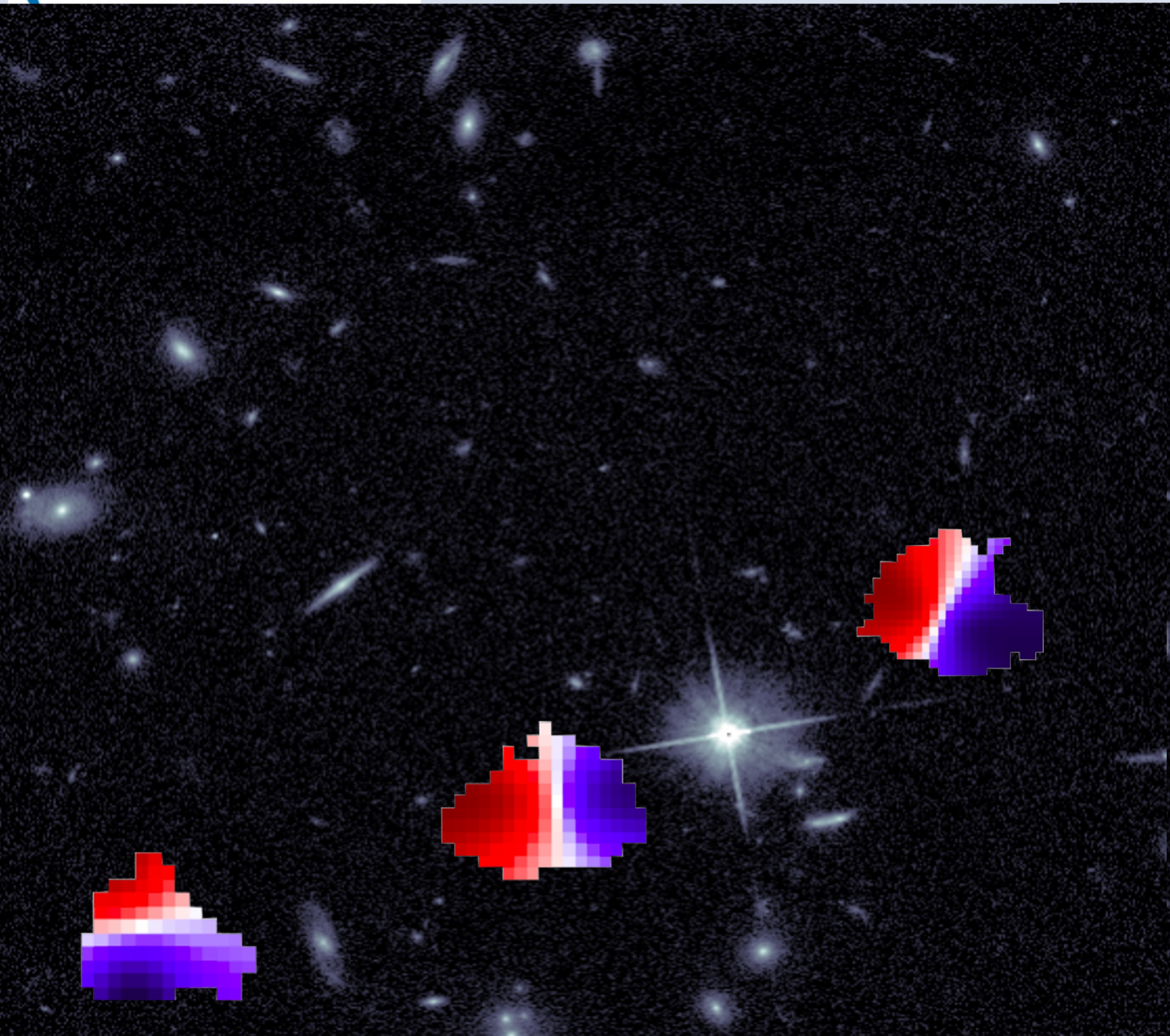
First Morpho-kinematic analysis of galaxies in dense environments in the MAGIC Survey



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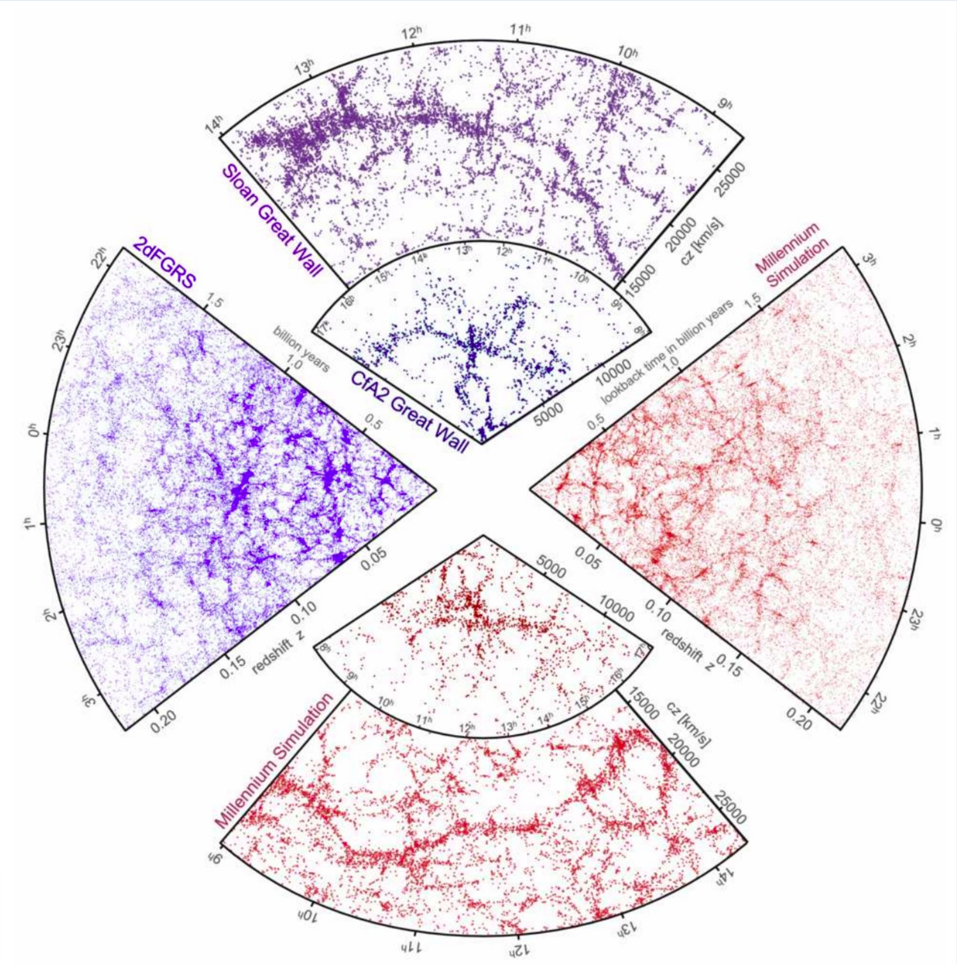
Benoît Epinat (LAM/CFH), Thierry Contini (IRAP), Wilfried Mercier (IRAP), Philippe Amram (LAM)

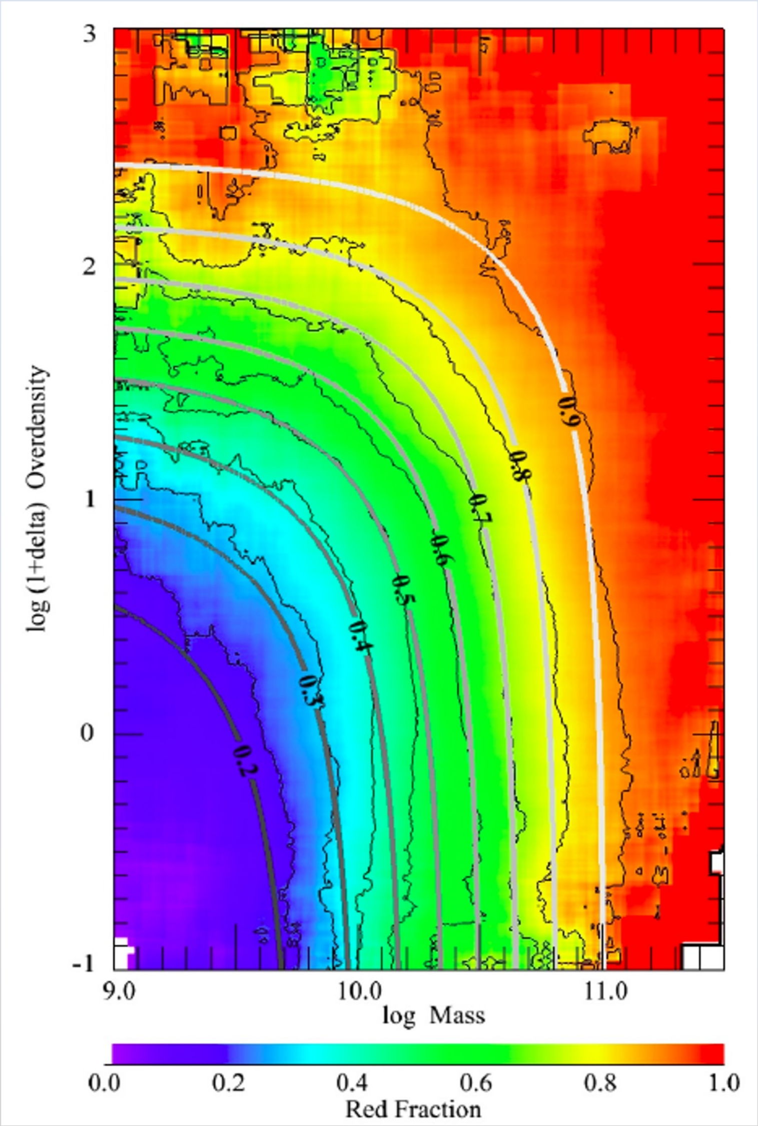
From Galaxies to Cosmology, Marseille. July 2022

Morphological evolution and Mass assembly processes



- Mass assembly mechanisms
- Star formation quenching processes
- Red sequence build-up

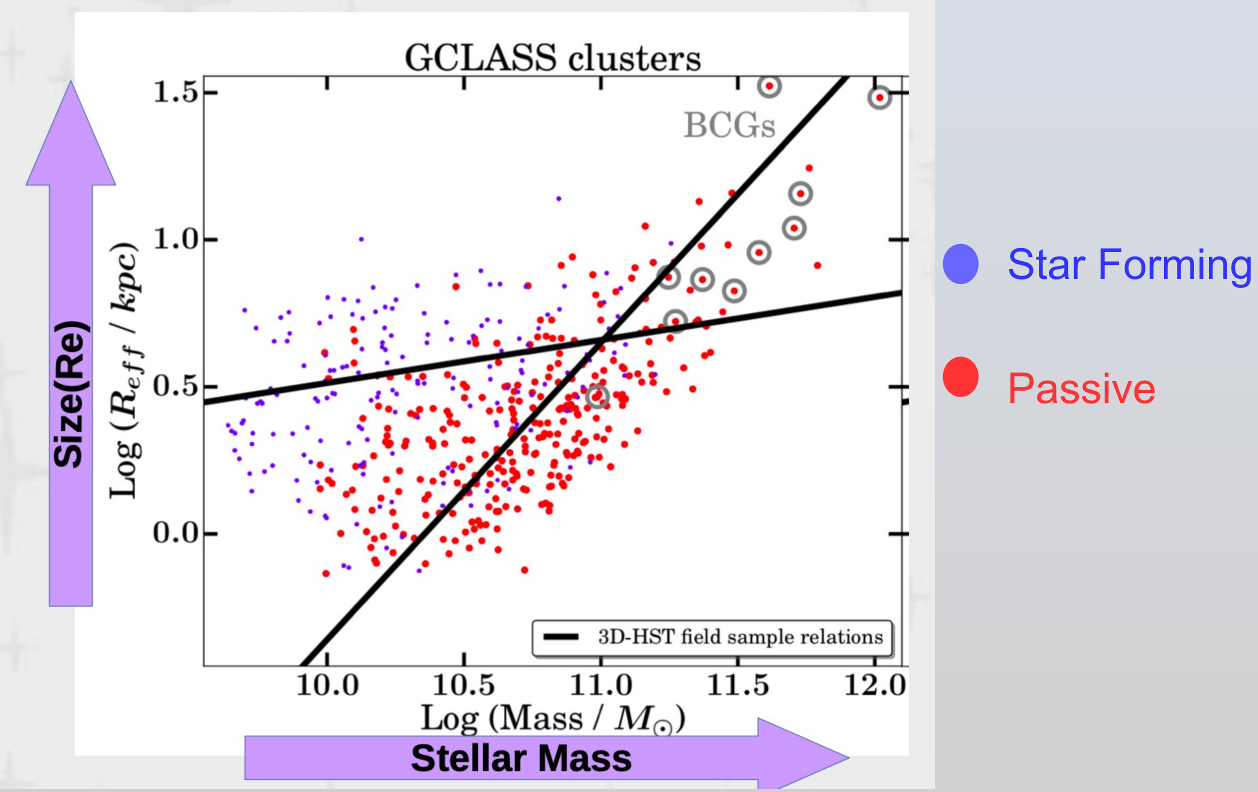
What is the impact of large-scale environment?



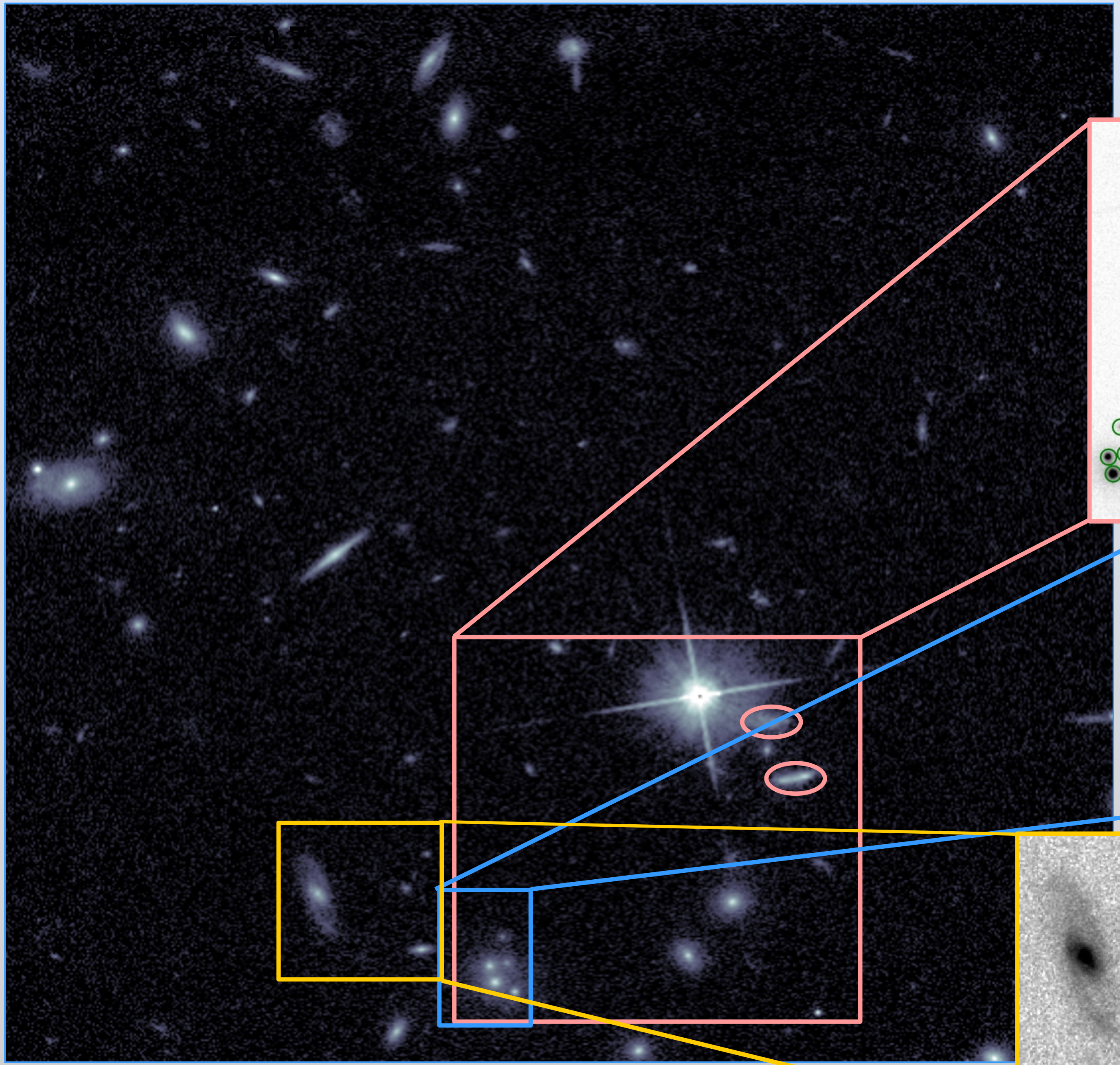
Red Fraction SDSS (Peng et al. 2010)

Quenching of SF earlier in structures than galaxies in field.
Peng et al. 2010 → Larger fractions of passive galaxies in dense environments

Contraction of the stellar distribution in dense environments
Matharu et al. 2019 → Cluster galaxies are smaller

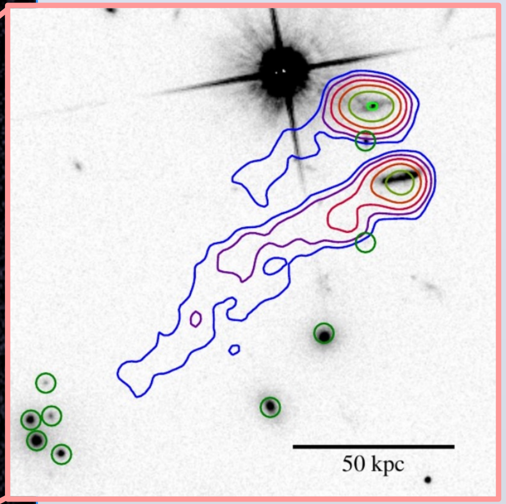


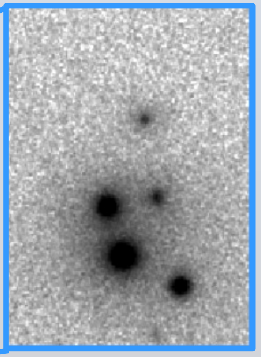
Galaxy Evolution in Dense environments



Ram pressure stripping

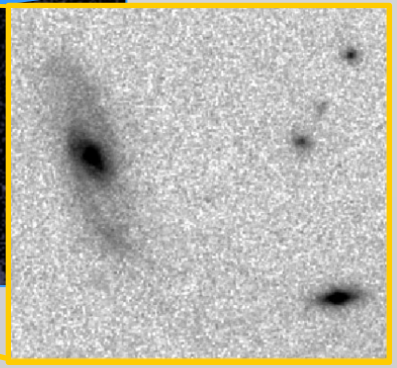
Boselli et al. 2019





Interactions / Mergers

Schmidt et al. 2019

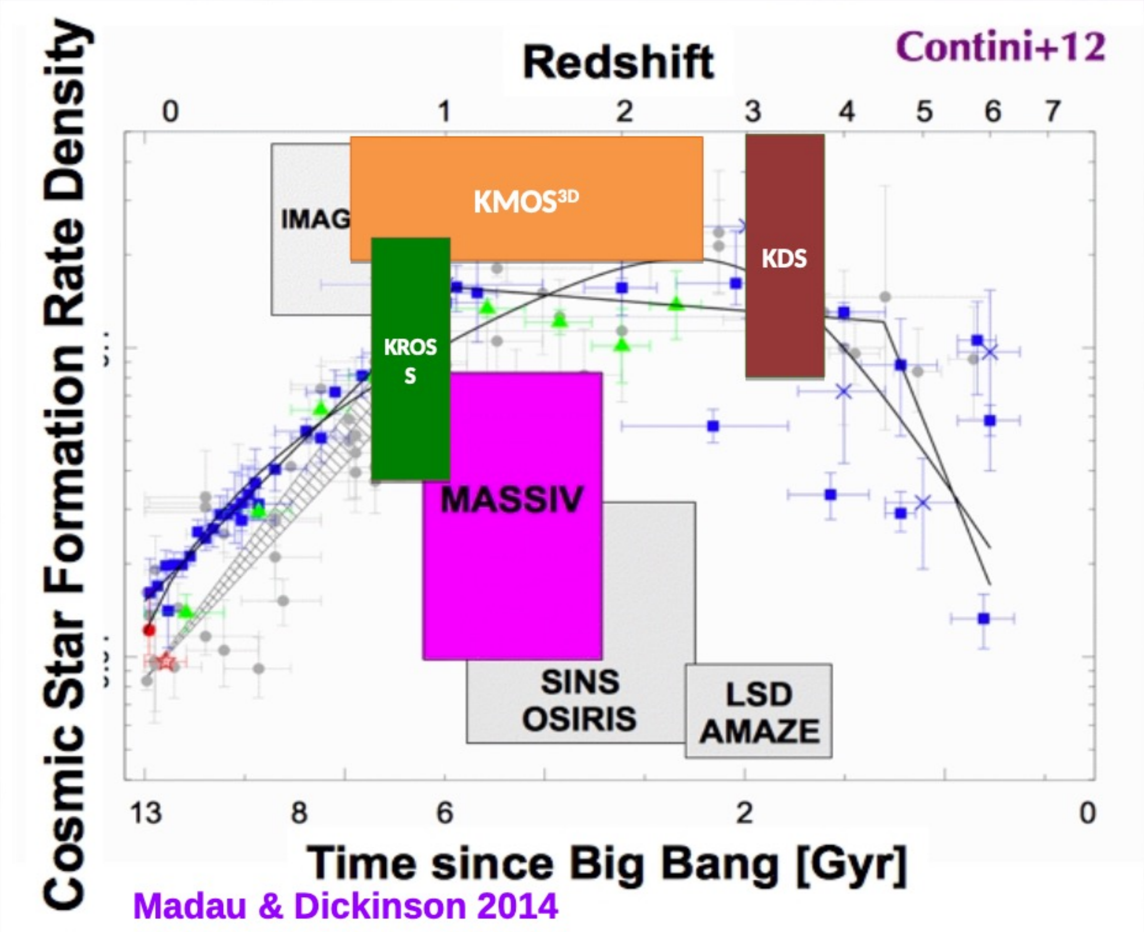


Interactions / fly-by

Gas loss / Quenching mechanisms:

- **Ram pressure stripping → gal-cluster**
- **Gravitational int.:**
  - **galaxy-cluster:** *Harassment*
  - **gal- gal:** *Tidal int.,* ***merger*** **fly-by**
- **Starvation**→ Stopped gas accretion

Previous IFU Surveys



Survey	N gal.	z	log(M_*) $M_\odot$	log(SFR) $M_\odot$ yr^{-1}	Operating band
MASSIV	84	0.9 – 1.8	9 –10	0.7 – 2.6	J, H SINFONI
KMOS 3D	739	0.6 – 2.7	9 – 11.4	-0.7 – 2.5	YJ, H, K KMOS
KROSS	795	0.6 – 1	10.0 ± 0.1	5 ± 1	J KMOS
IMAGES	68	0.4 – 0.75	10.2 – 11.1	2	Optical–NIR FLAMES GIRAFFE
SINS	80	1.3 – 2.6	10 –11.1	1.14 – 2.9	J,H,K SINFONI

- Mainly focused in massive SF galaxies (>10^{10} M_{sun})
- Studies independent from the environment

Scientific Goals

- What are the drivers of galaxy evolution and morphology transformation?
- Has environment a fundamental role in the Quenching of Cosmic SFR?
- When Quenching mechanisms get efficient? → How they act on M_{bar} distribution and their fraction inside DMH?

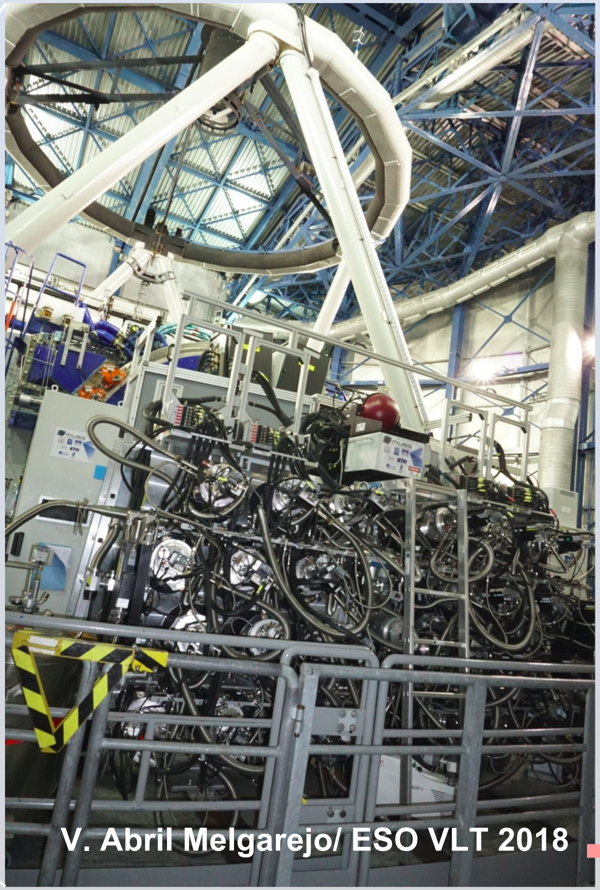
→Previously in literature: Spectroscopic surveys + HR Im

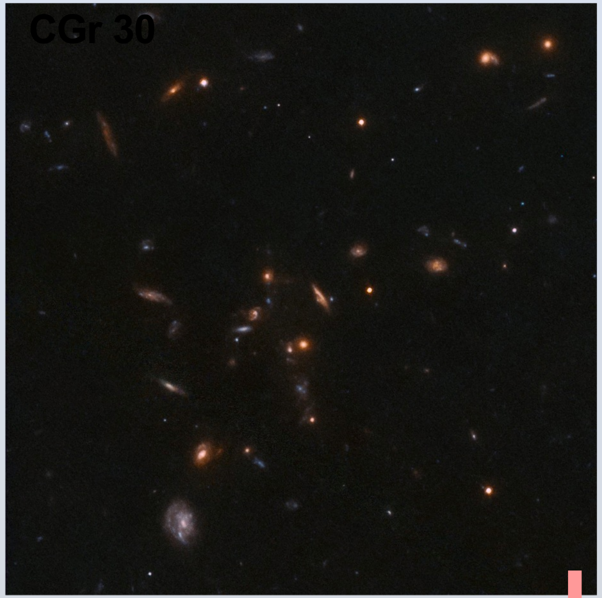
Explore the parameter space and gain statistics

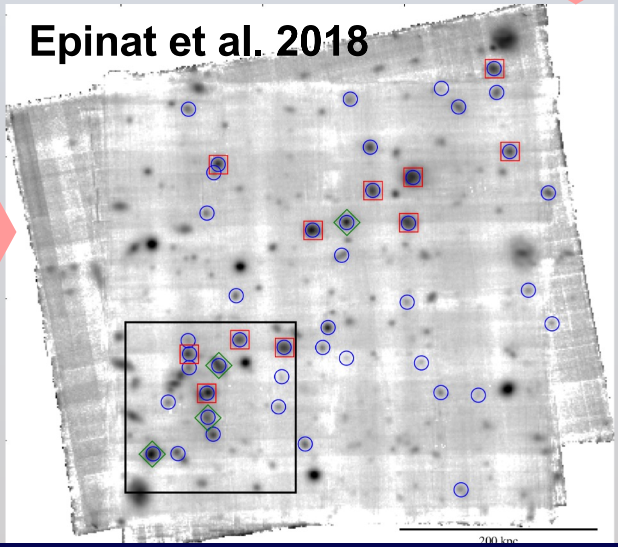
Morpho-kinematic approach

Statistics from MUSE (IFS)+HST

3D Spectroscopy → MUSE, Multi Unit Spectroscopic Explorer

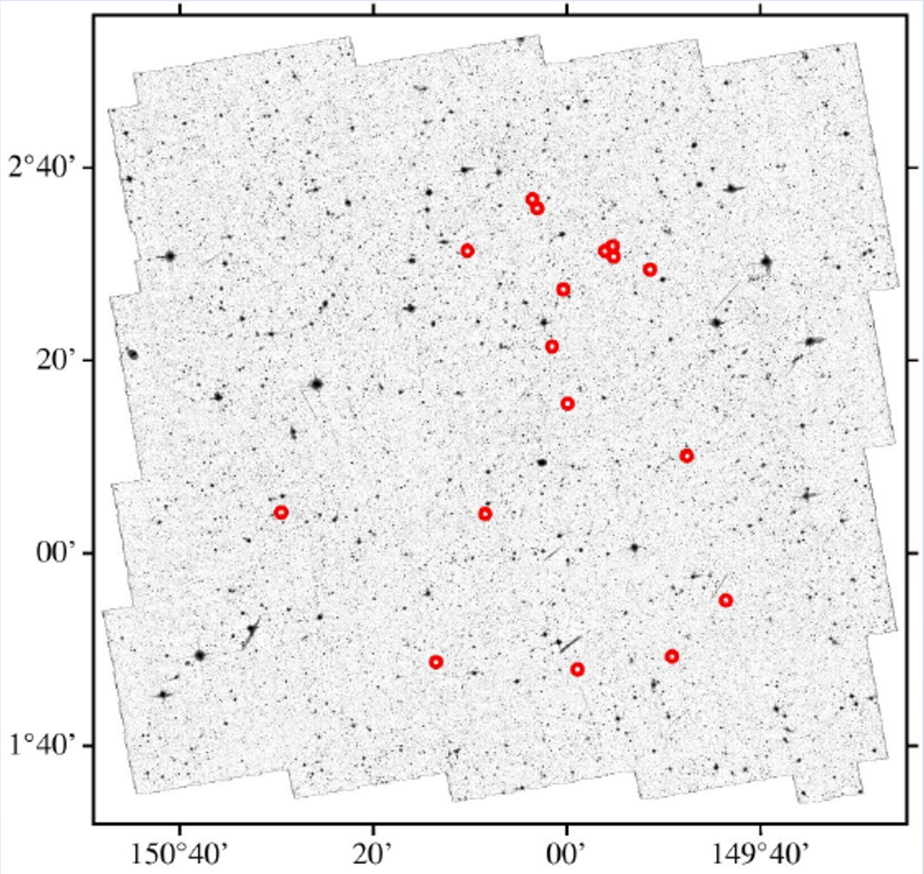




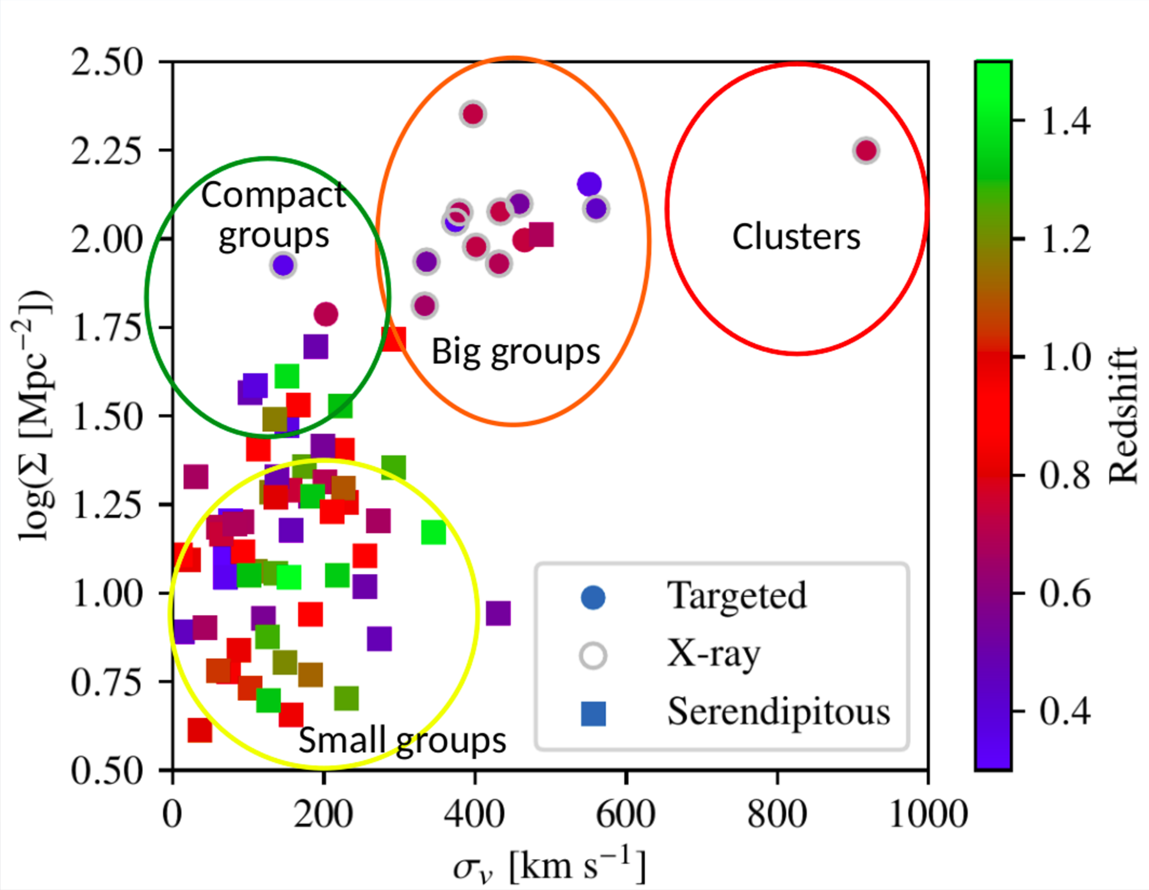


Field of View → **1 arcmin^2 at z ~ 0.7 → 500 kpc**
Wavelength range → 4800 – 9300 A
Spatial Sampling → 0.2''/spaxel
Spectral Resolution → 1770 – 3590
With AO and without AO observations

The MUSE gAlaxy Groups In Cosmos (MAGIC). Epinat et al. in prep



Selection Criteria for Groups → FoF algorithm
Maximum linking length **ΔL= 450 kpc**
Maximum velocity separation **ΔV= 500 km s^{-1}**
Small groups from **3-5** members
Targeted groups → At least **10** members



Part of MUSE-GTO program to investigate the role of environment in galaxy evolution over the past 8 Gyrs (PI: T. Contini)

- 70 hours observing campaign
- 18 selected fields
- 16 massive groups at 0.25<z<0.85
- From gal. Group catalogs in **COSMOS** (Knobel et al. 2009, 2012) and in the **VIMOS VLT Deep Suvrvey** (VVDS, Cucciati et al. 2010)

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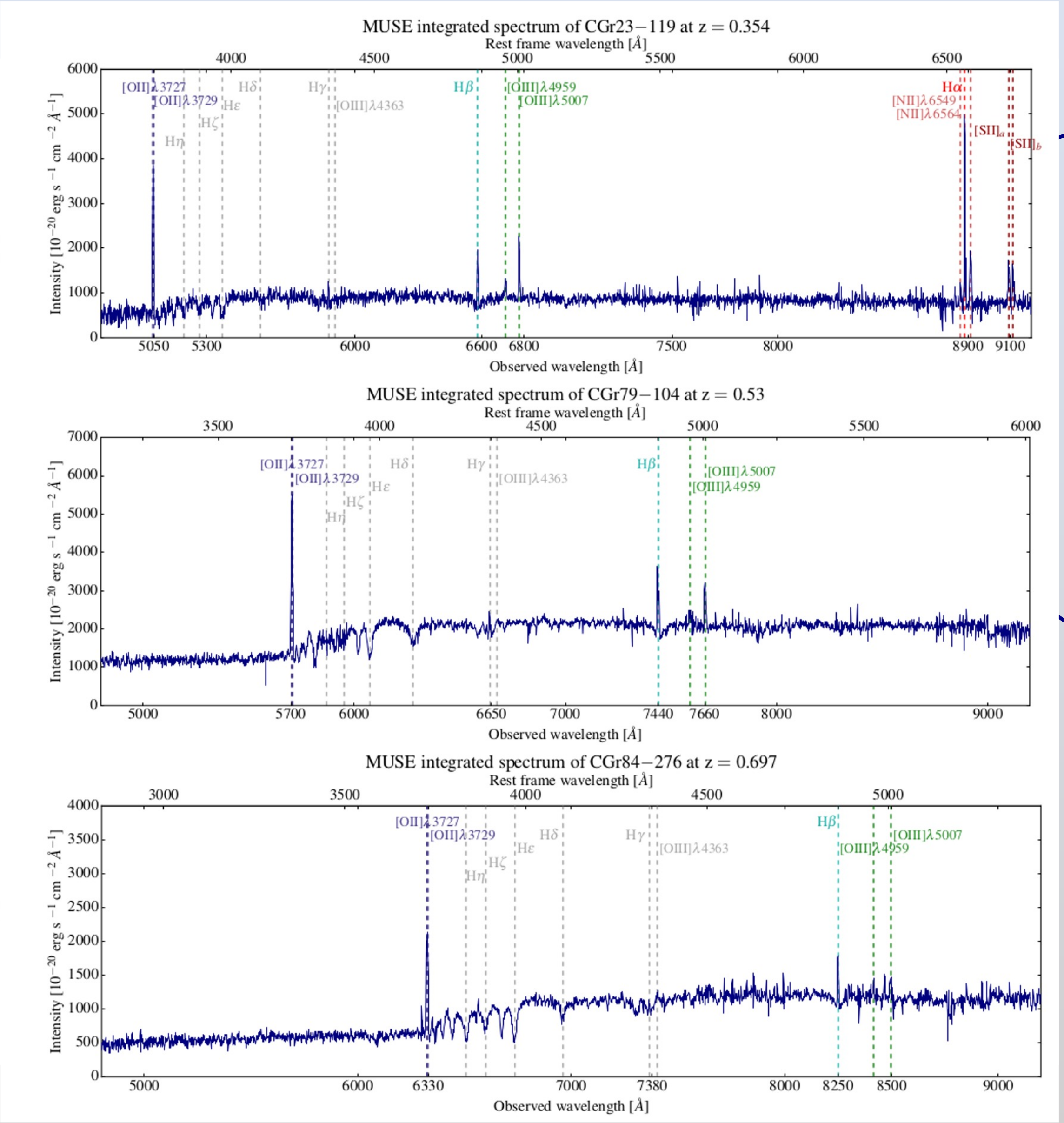
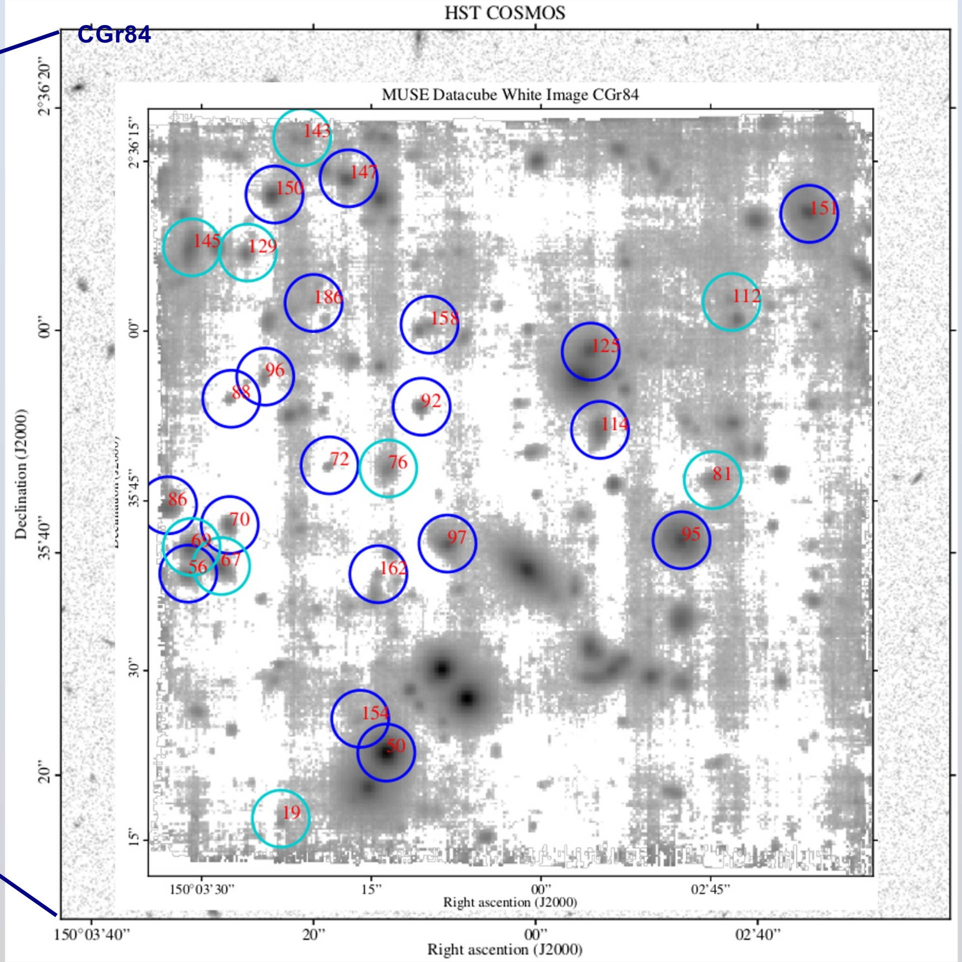




Extended MUSE FoV covers structures and multiple objects at different z (**~200 up to I_{AB}=29.5**)

Accurate spectral redshift determination (Inami et al. 2017)

The Tully-Fisher Relation

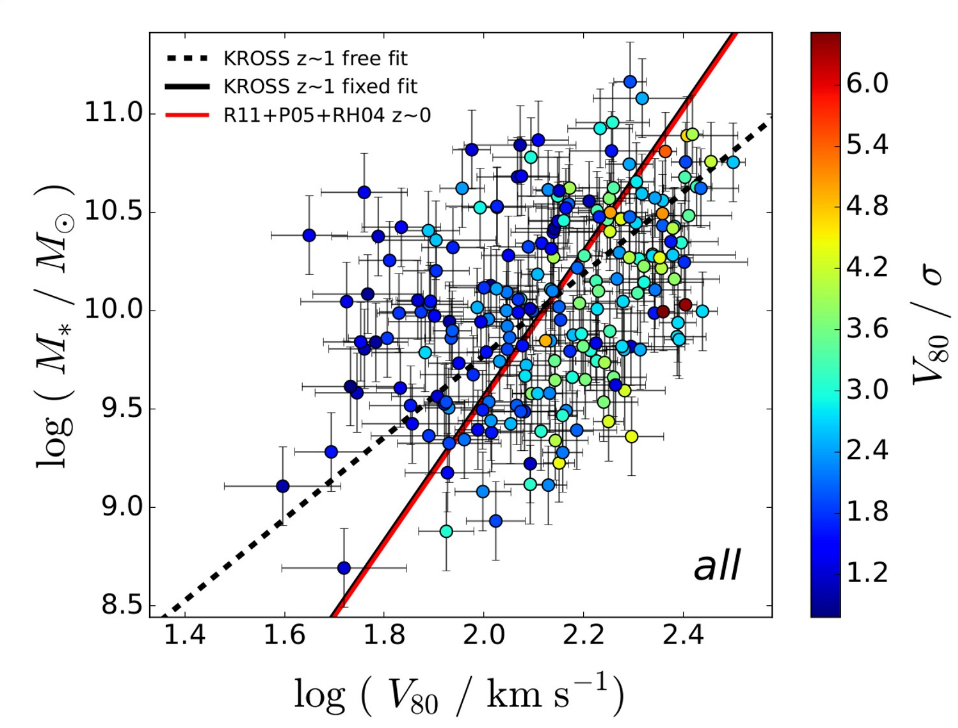
→The TFR → tight scaling relation: **Luminosity vs. V_{rot}** (Tully & Fisher 1977)

- **Important to study structure and evolution of disk-like galaxies**
  TFR links M_{dyn} to M_{star} / M_{bar}

→Several studies on TFR evol. with IFS data

- **IMAGES** (Puech et al. 2008, 2010) at z~0.6, **SINS** (Cresci et al. 2009) at z~2, **MASSIV** (Vergani et al. 2012) at z~1.2
- **KMOS3D** (Ubler+17)
- **KROSS** (Tiley +16,19)

→Debate on evol. of the TFR zero point remains open BUT
→ Comparisons affected by: measurement bias and different datasets, kinematic extraction and selection.
→ Selection using dynamical support V/σ
→ No conclusion on environment



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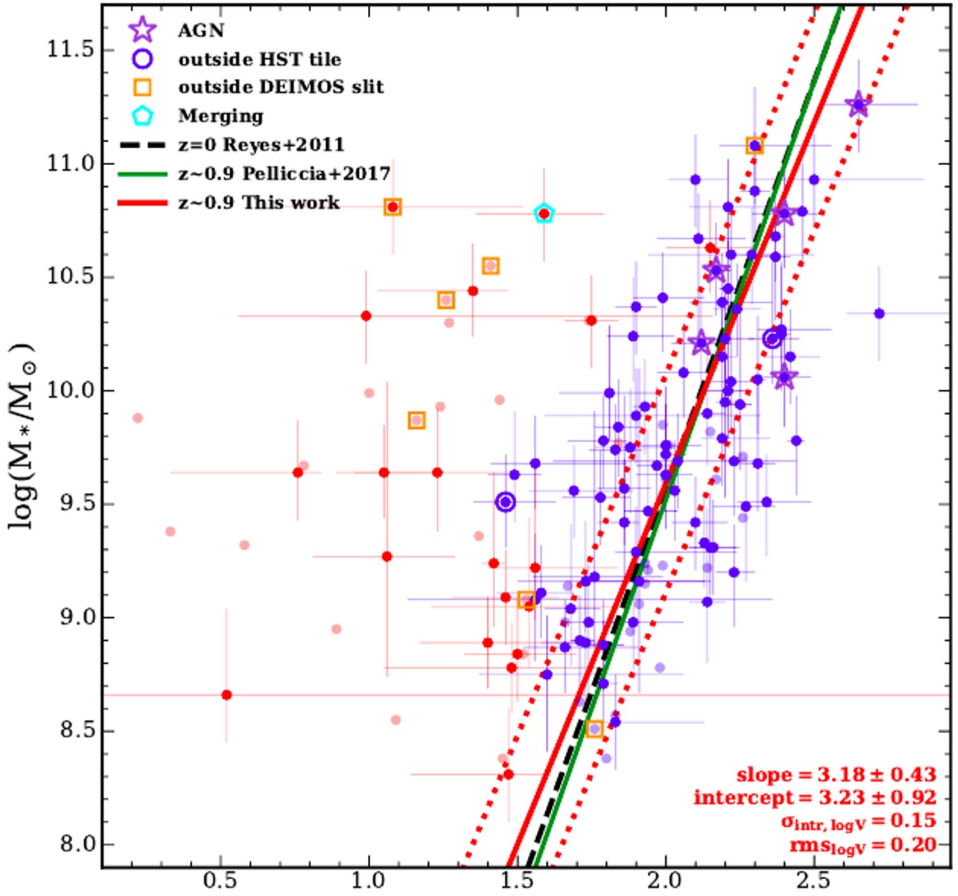


Pelliccia et al. 2019

Environmental study on the evolution of the TFR
➔**ORELSE** (Pelliccia et al. 2019) → long-slit study on clusters

➔94 SF galaxies in in clusters at z~0.9 compared to field galaxies in the HR COSMOS survey (Pellicia et al. 2017)
→ No evidence for evolution of the TFR

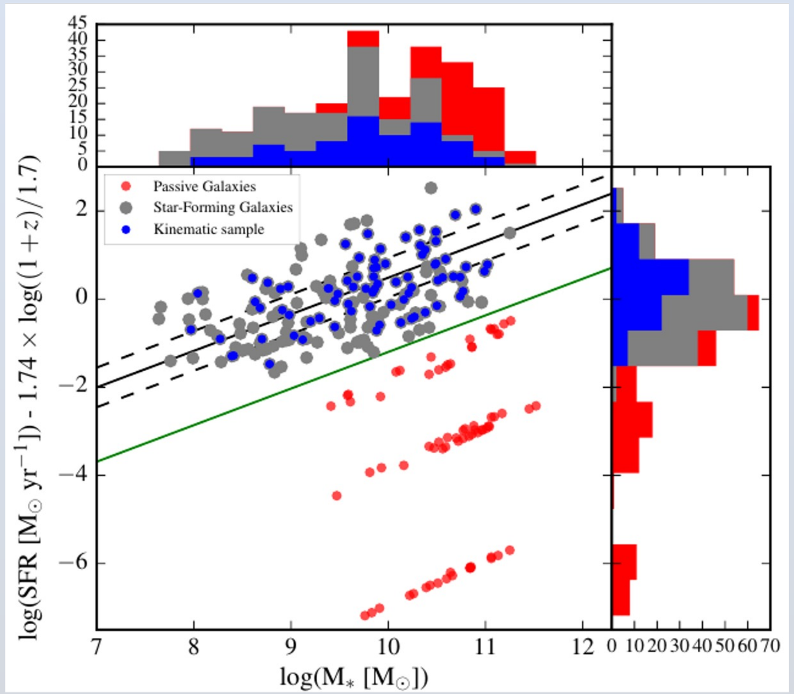
Morpho-kinematics analysis

Abril-Melgarejo et al. 2021

MAGIC Survey observations

➔Good seeing / AO
➔8 dense groups, Virial masses of 10^{13} – 10^{14} Msun → Denser by at least x 25
➔ ~300 galaxies in groups – 178 in the MS

ID COSMOS Group	Seeing "	Number of galaxies (all/MS)	M_{vir} 10^{13} $M_{\odot}$
CGr28	0.654	10/9	7.1
CGr30	0.700	44/33	6.5
CGr32	0.596-0.624-0.722	106/50	81.4
CGr34	0.664	20/17	10.4
CGr79	0.658	19/15	11.2
CGr84	0.620-0.578	31/21	8.2
CGr84b	0.620-0.578	35/25	8.8
CGr114	0.740	12/8	3.5
Median	**0.656**		**8.5**
Total		**277/178**	

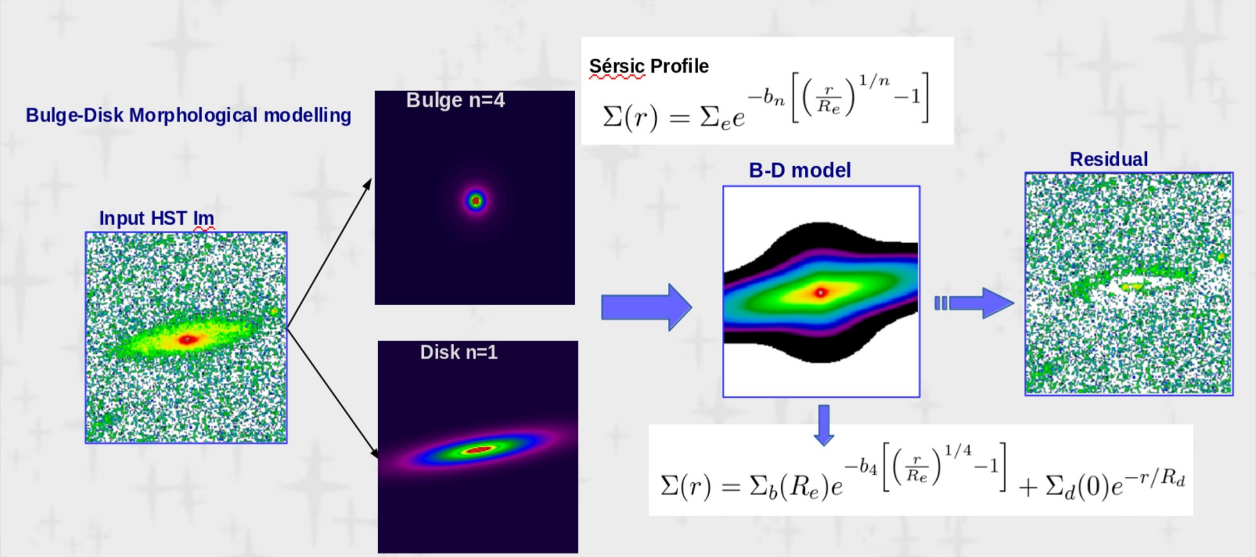


➔**Morphology on high resolution F814W ACS/HST images:**

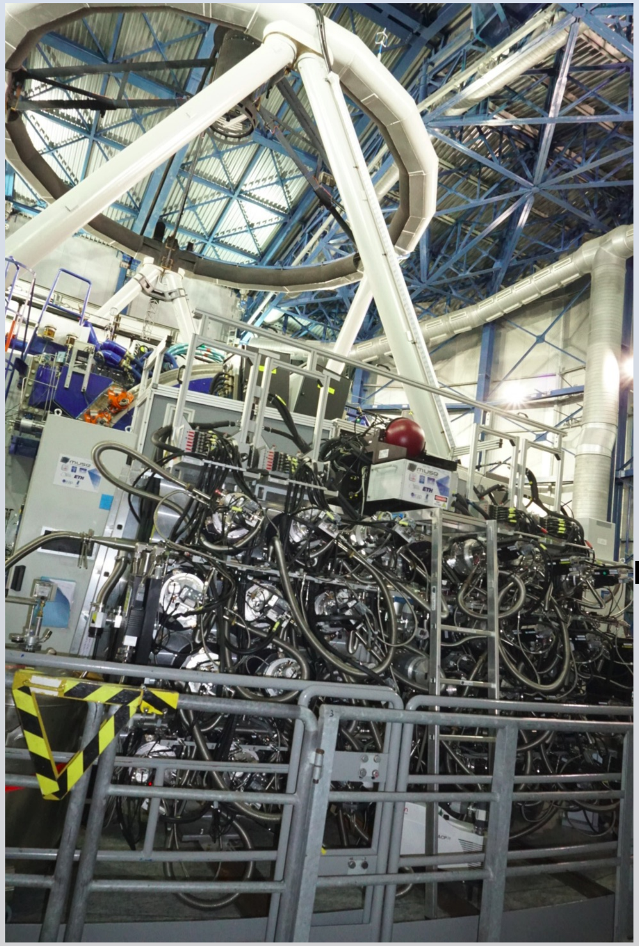
- Bulge /disk decomposition with GALFIT
- Size of disk

•Projection parameters of disk (for kinematics)

- Centre
- Disk inclination
- Position Angle of major axis

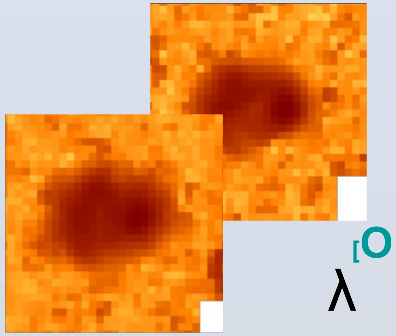


Extraction of kinematic maps



Reduction

δ



[OIII]- Hβ

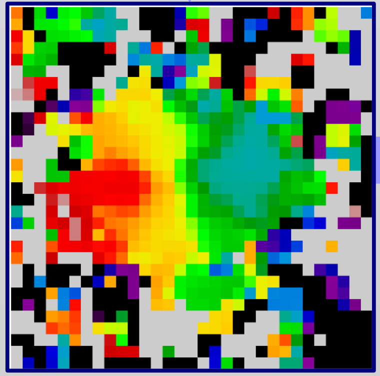
λ

[OII]

α

CAMEL

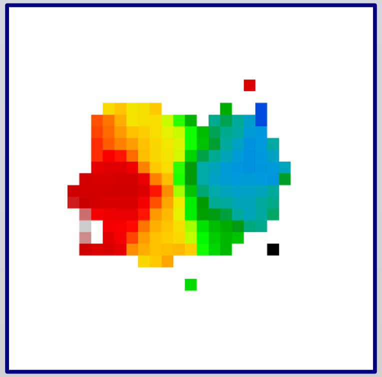
Extracted Objects in 14 FoV:



Automatic cleaning

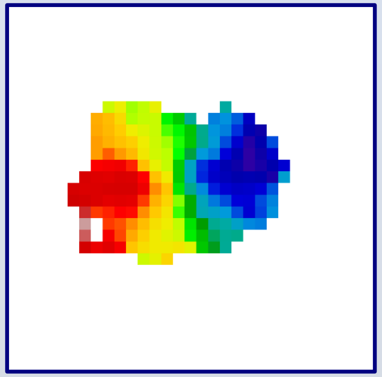
$S/N_{\lambda} \geq 5$

$FWHM_{\lambda} \geq LSF(z)$



CGr28-85

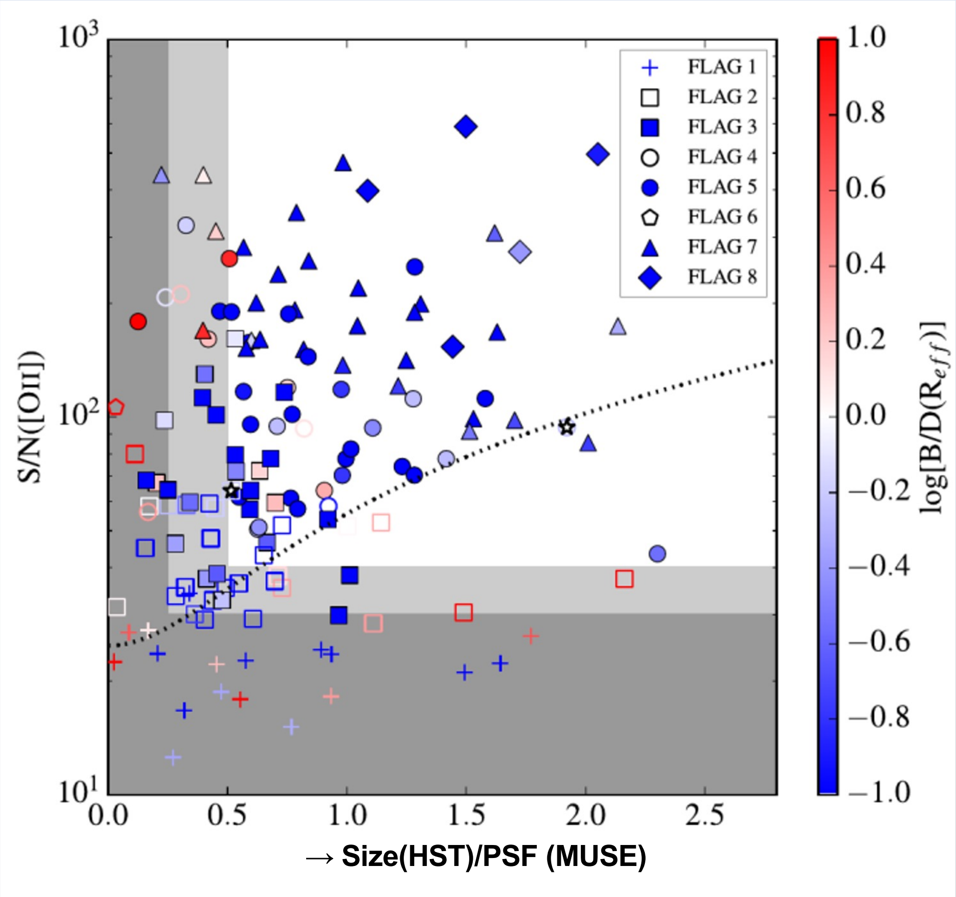
Manual cleaning



https://gitlab.lam.fr/bepinat/CAMEL/tree/master

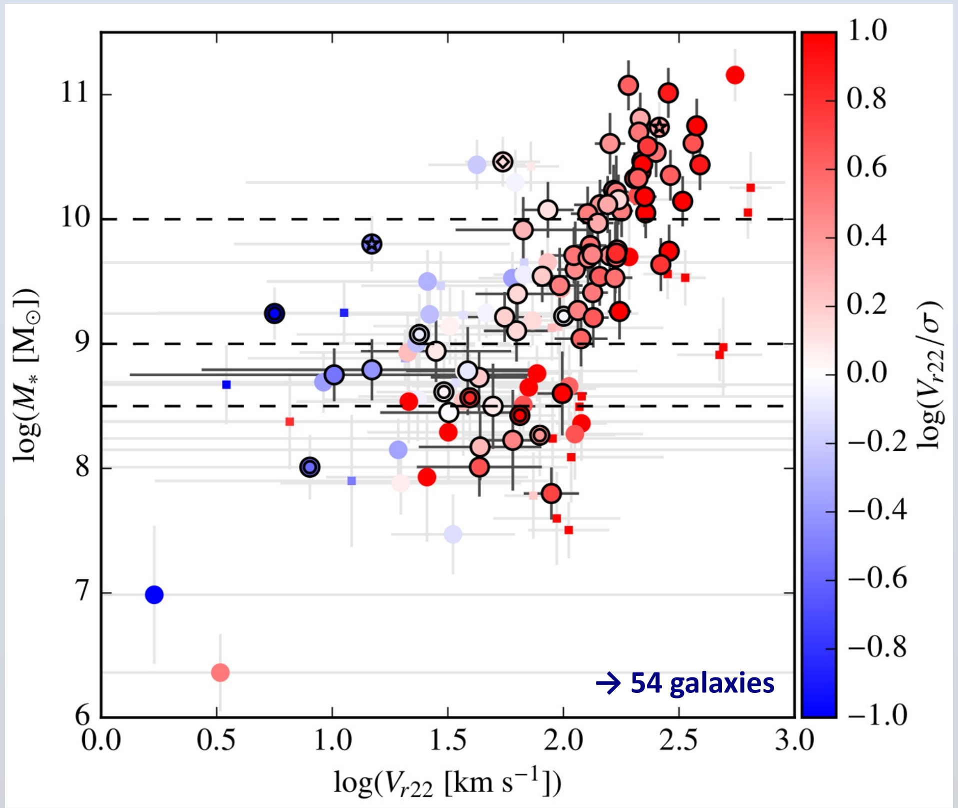
kinematic Sample Selection

Abril-Melgarejo et al. 2021



- On the main sequence of star-forming galaxies
- Need to be resolved → **Re/FWHM≥ 0.5**
- Need sufficient SNR over the disk → **SNR>40**

→ 77 galaxies in the group kinematic sample (0.5 < z < 0.8)

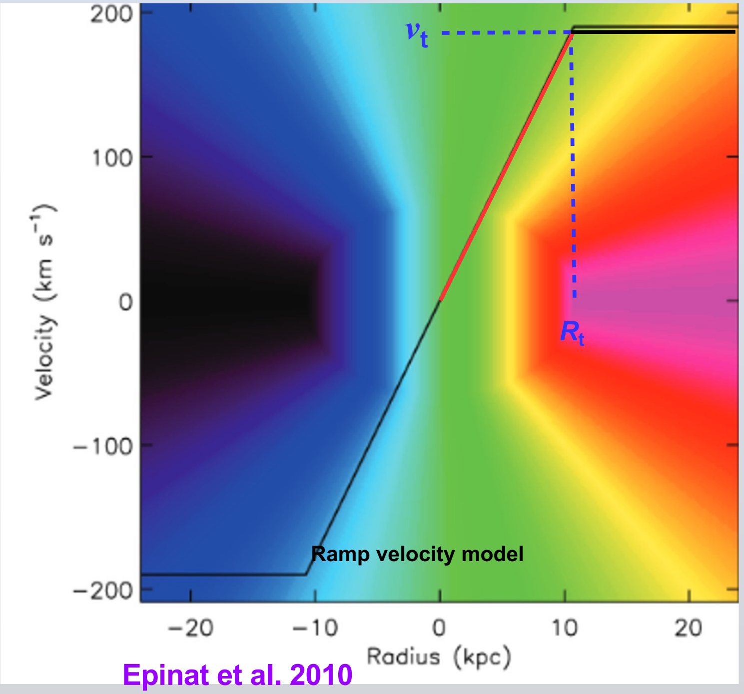


Selection:

- Most of dispersion dominated system are removed
- Size effect: for galaxies not resolved: σ = rotation?

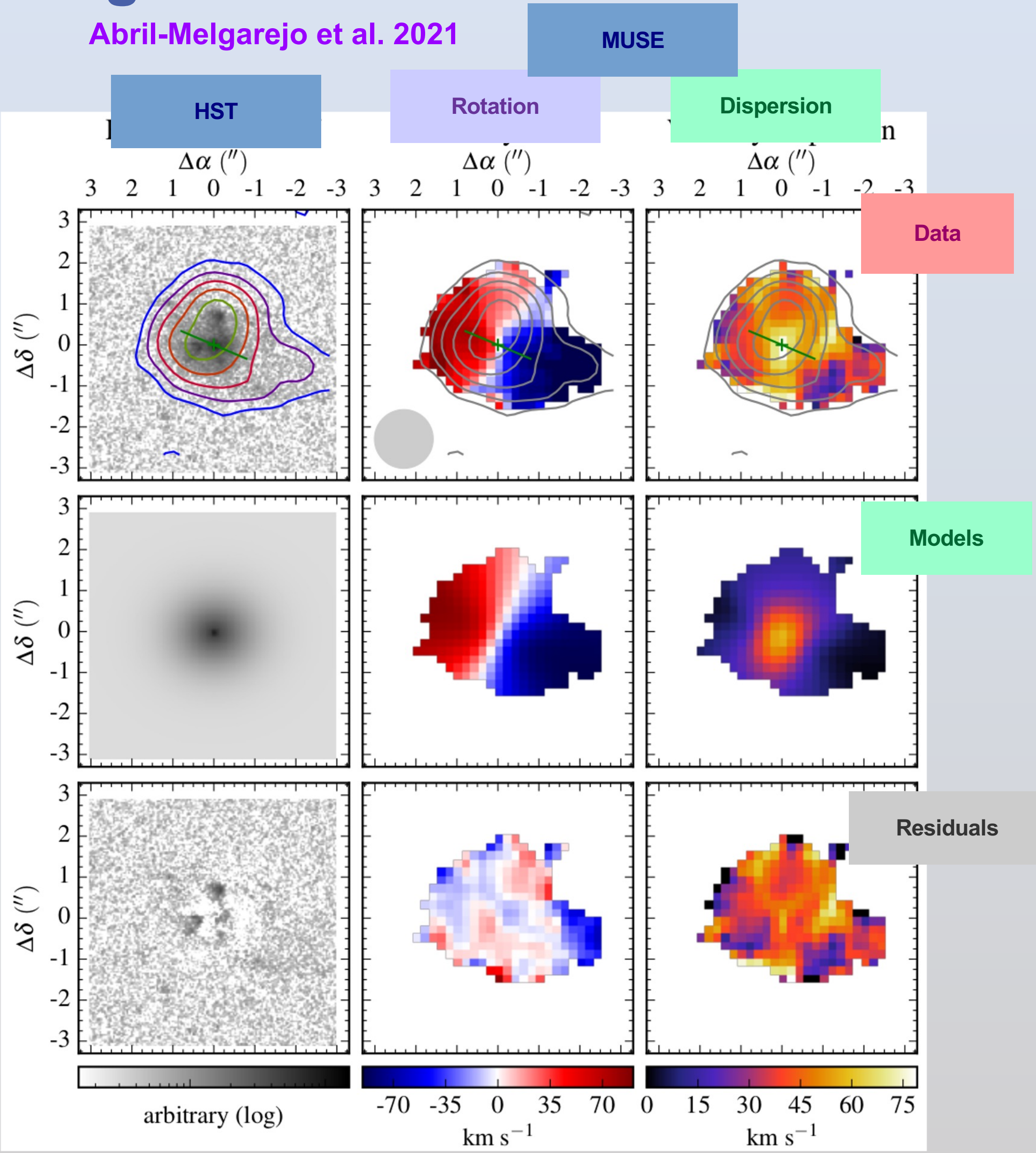
kinematic Modeling

Flat rotating disk assumption (Freeman disk)
➔Input fixed parameters: **[x_0, y_0 , i]** **From Morphology**
➔Free parameters: R_t, v_t , z_s, **PA**



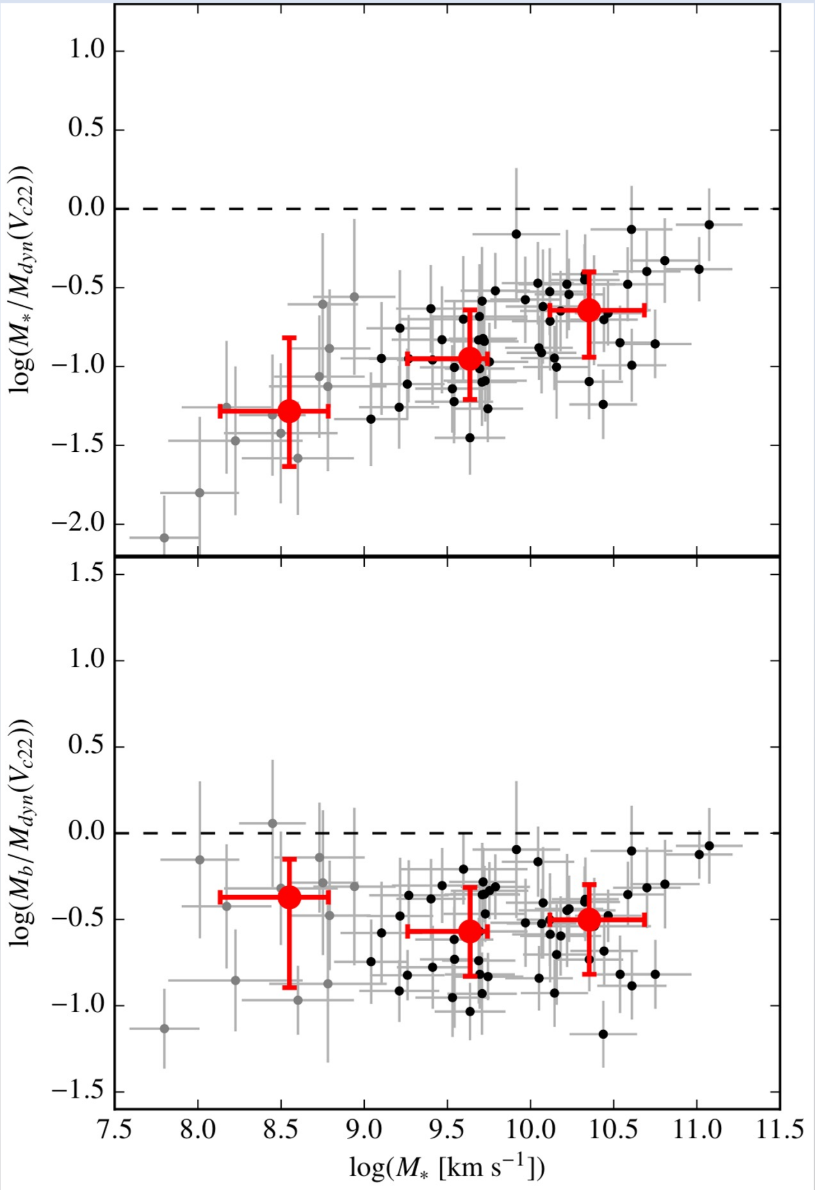
Epinat et al. 2010

Abril-Melgarejo et al. 2021



[OII] kinematic analysis
2D Maps extraction (CAMEL)
2D Rotating disk kinematics models (Epinat et al. 2010)
➔Including Beam smearing
➔→ V_{max}, σ_{gas}, dynamical masses, PA_K

Stellar and Baryon Mass Fractions



Abril-Melgarejo et al. 2021

Mass gas estimates

- Kennicutt-Schmidt law using [OII] flux
- Hypothesis: constant SFR surface density within R22

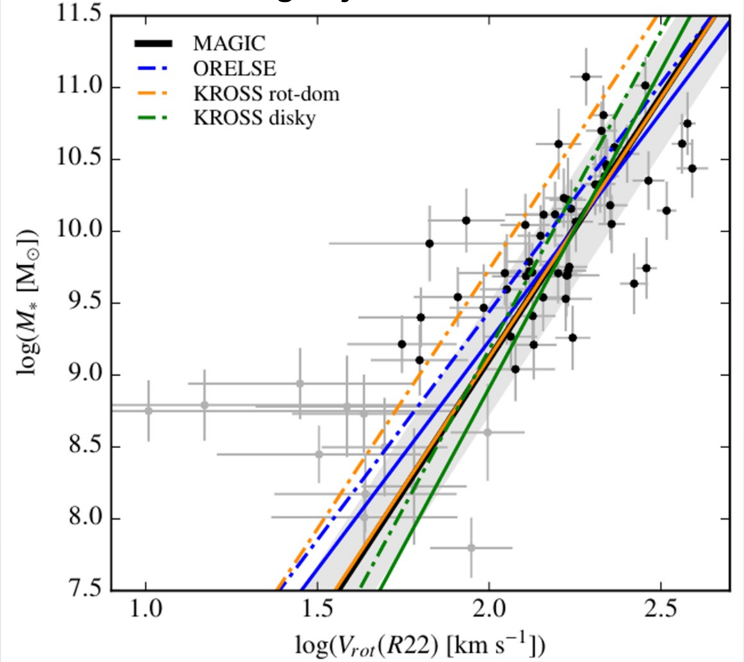
$$M_g = (4.756 \pm 1.944) \times 10^{-23} \times (\pi R22^2)^{2/7} (4\pi D_L^2 F_{[OII]})^{5/7}$$

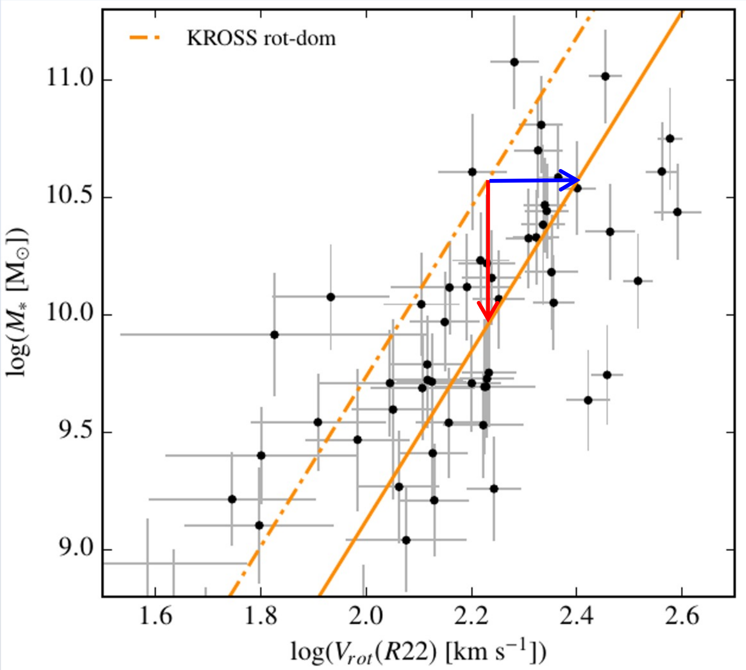
Stellar and baryonic mass fraction:

- M_* / M_{dyn}
- M_{bar} / M_{dyn}
- < 50%
- Stellar fraction increases with mass
- Less clear for baryons

Main Results on the TFR with MAGIC sample

Abril-Melgarejo et al. 2021





Contraction $\Delta(\log V) \sim 0.04$ dex

- V traces mass within R_{22}: $M_{\rm dyn}(r) = \frac{rV(r)^2}{G}$
- Contraction of distribution by ~0.05 dex:

$$\Delta(\log V) = -0.5\Delta(\log R_{22}) \sim 0.025 \text{ dex}$$

→ Explains part of the offset

Total offset in the TFR could be due to a combination of both effects

Offset of the zero-point of the various TFR compared to various samples at z~0.9:

- 3D samples: **KMOS3D** & **KROSS** (mainly field galaxies)
- 2D sample: **ORELSE** (mainly cluster galaxies)

Typical offset of ~ 0.3 dex

Quenching $\Delta(\log M_*) \sim 0.2$ dex

- V traces DMH mass

→ Less stars/baryons at a given DMH mass

- Decrease of SF by ~0.3 dex (*Tomczak et al. 2019*)

→ Quenching timescale

$$\Delta T = \frac{\Delta(\log M_*)}{\alpha \times \Delta(\log \mathrm{SFR})} = 1 - 3 \text{ Gyr}$$

Conclusions

Analysis on the intermediate redshift sample on dense groups

- Original sample selection → no need for a posteriori selection
- Impact of selection and methodology on TFR

→**Clear offset of zero point**, even with ORELSE (cluster galaxies)

1. Quenching of SF
   - Linked to quenching mechanisms?

   → E.g. starvation, gravitational interactions, mergers, ram pressure stripping
2. Contraction of baryons

→**Need for a proper comparison sample**

Same data quality and ancillary data (Mass, SFRs, etc.), same sample selection and similar kinematics extraction

→ Stay tuned for Wilfried Mercier's talk on more details and results with the MAGIC Survey.