

Leading the Next Generation of Studies of Coma Cluster Galaxies with LOFAR

Alessandro Ignesti

[Astronomical Institute of the Czech Academy of Science]

On behalf of the **ALMAJELLY** and **CLIFS** collaborations

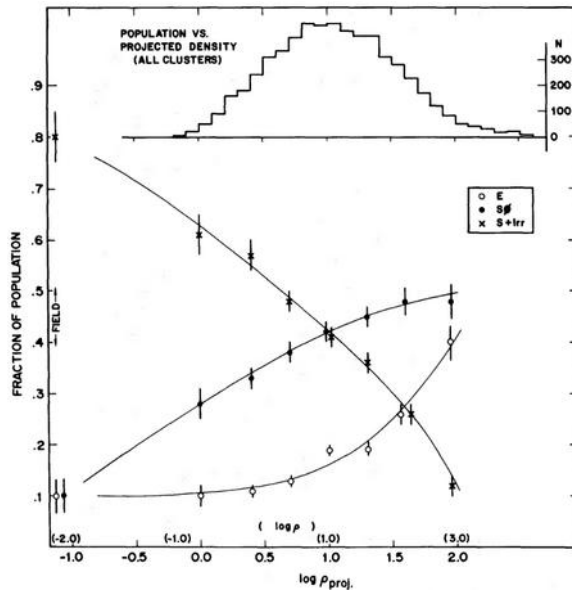


Astronomical Institute
of the Czech Academy of Sciences

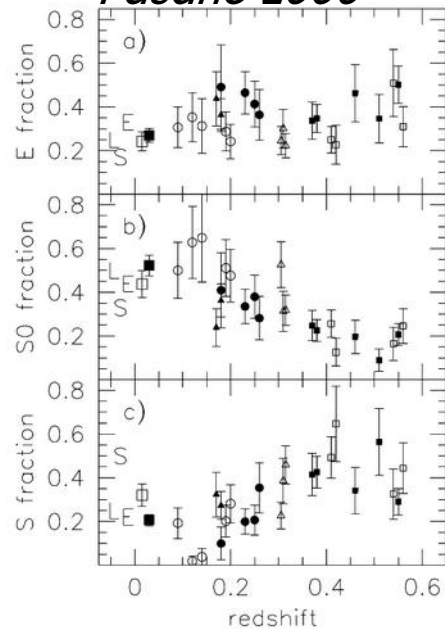


Ram pressure stripping

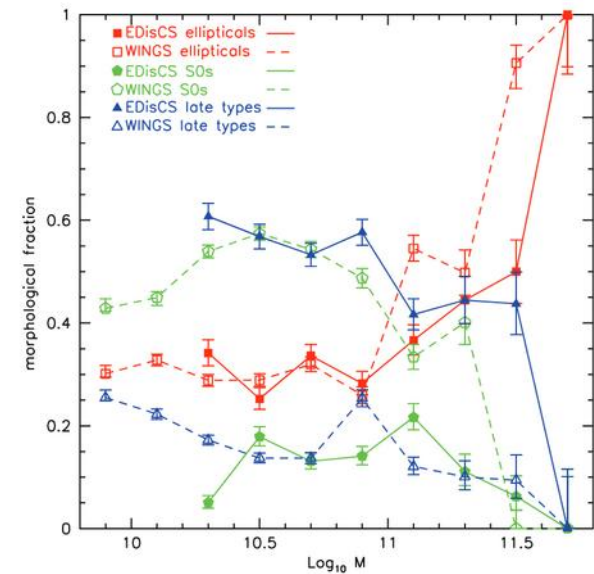
Dressler 1980



Fasano 2000



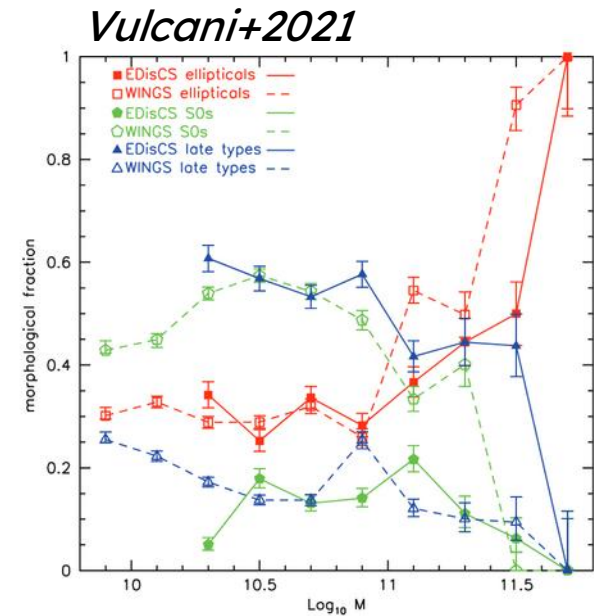
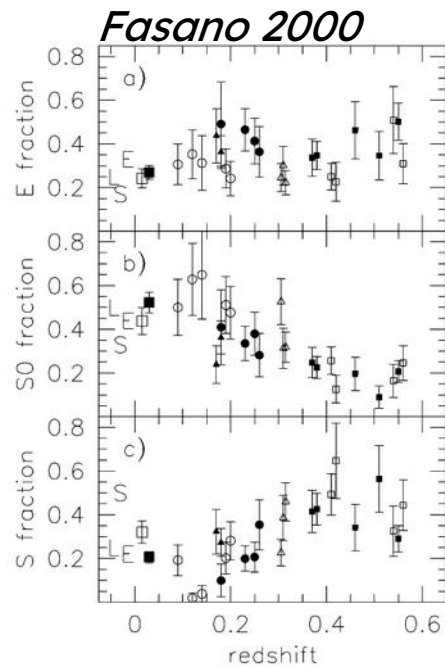
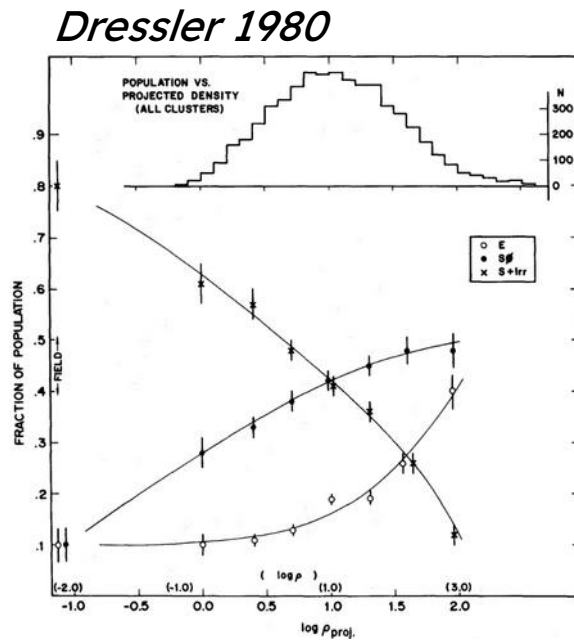
Vulcani+2021



Galaxy clusters are accelerator of galaxy evolution

....but how?

Ram pressure stripping



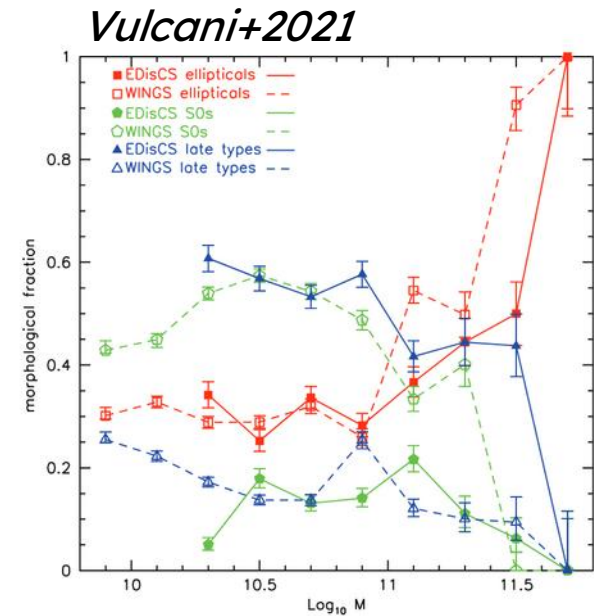
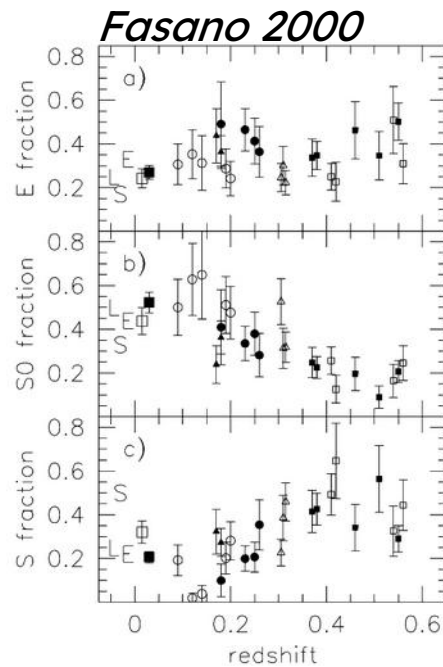
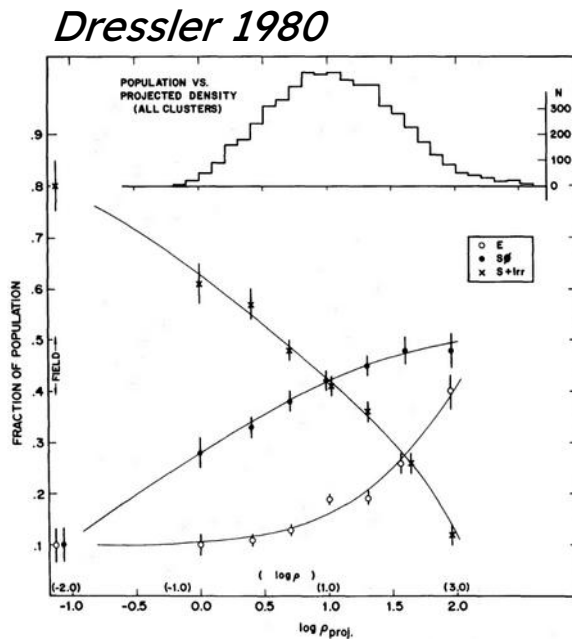
Galaxy clusters are accelerator of galaxy evolution

....but how?

Ram pressure: *pressure exerted on a body moving through a fluid medium*



Ram pressure stripping



Galaxy clusters are accelerator of galaxy evolution

....but how?

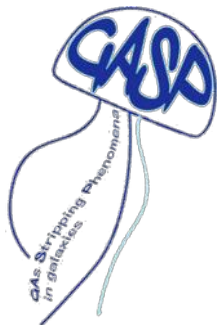
Ram pressure: *pressure exerted on a body moving through a fluid medium*

ICM Ram pressure = (ICM density) x (Galaxy velocity)² [Gunn&Gott 1972]

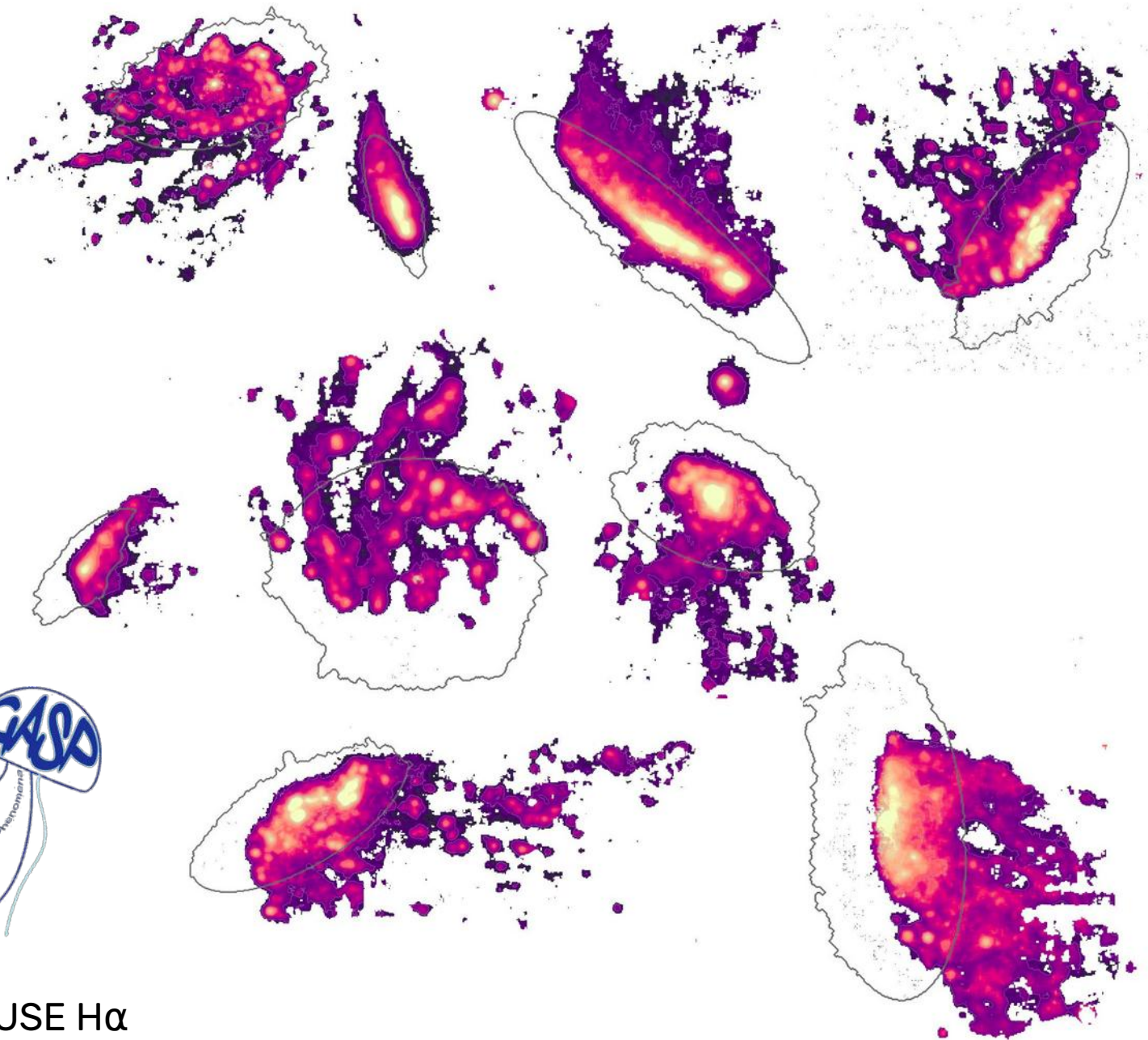


For reference: van Gorkom 2003, Boselli & Gavazzi 2006, Poggianti+2016, Boselli+2021

Jellyfish galaxies



MUSE H α

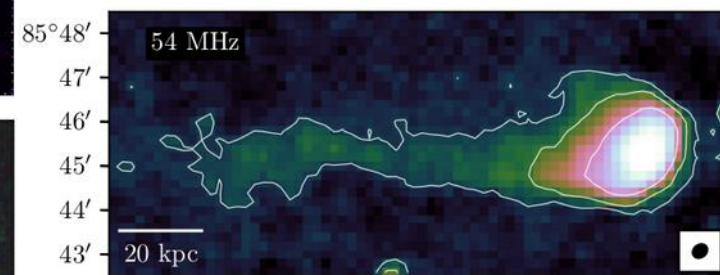
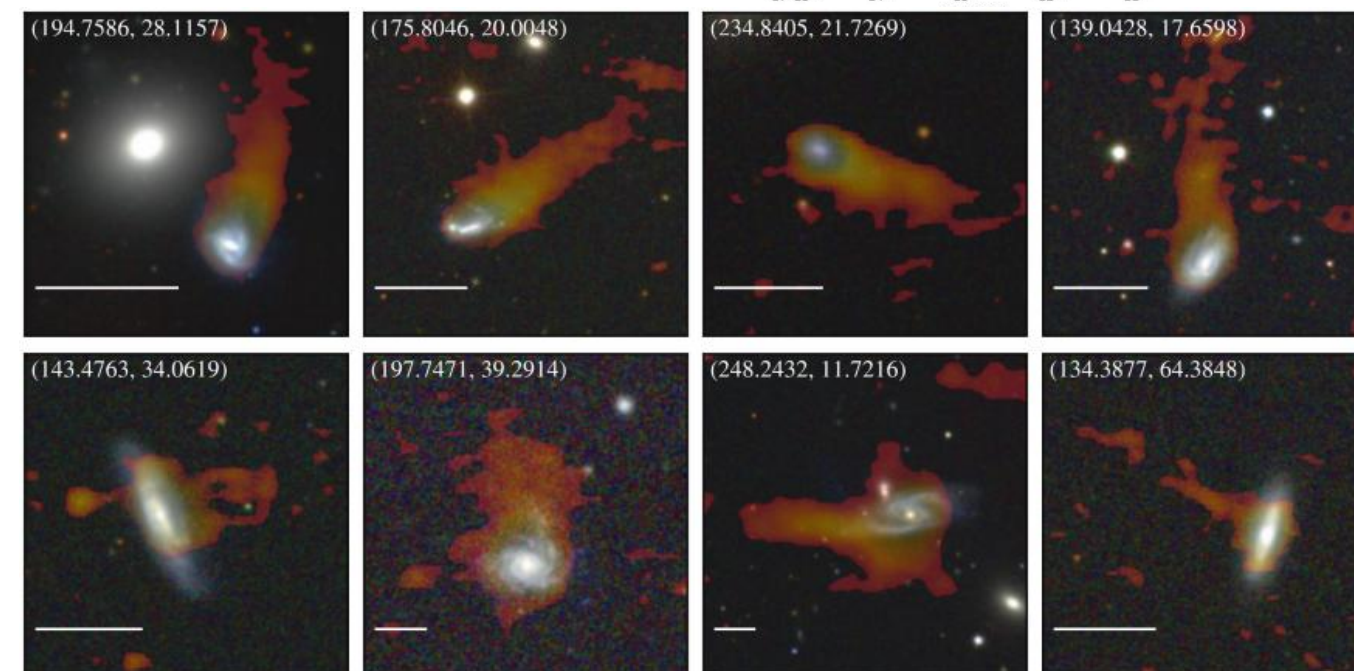
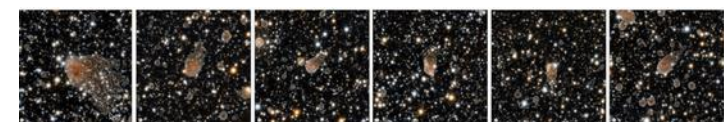
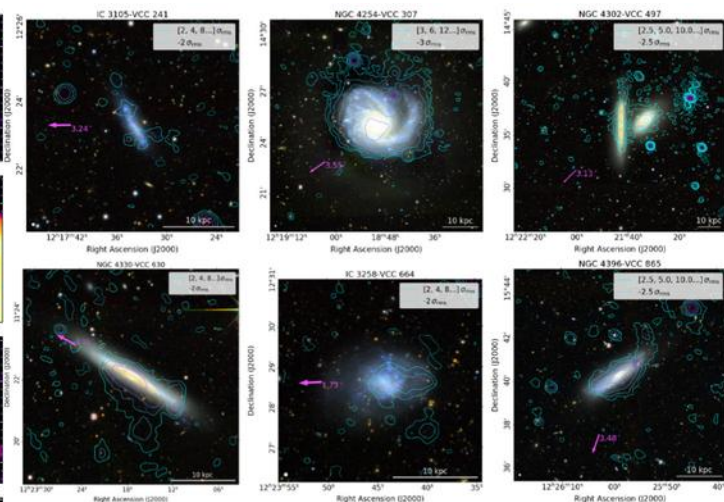
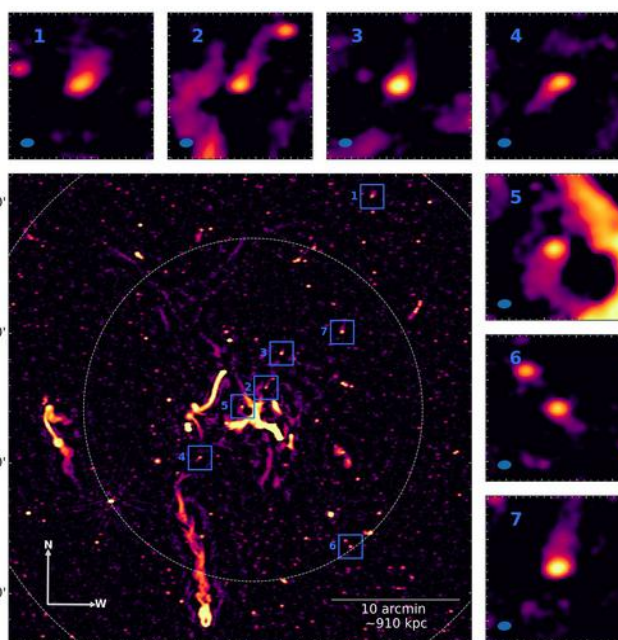
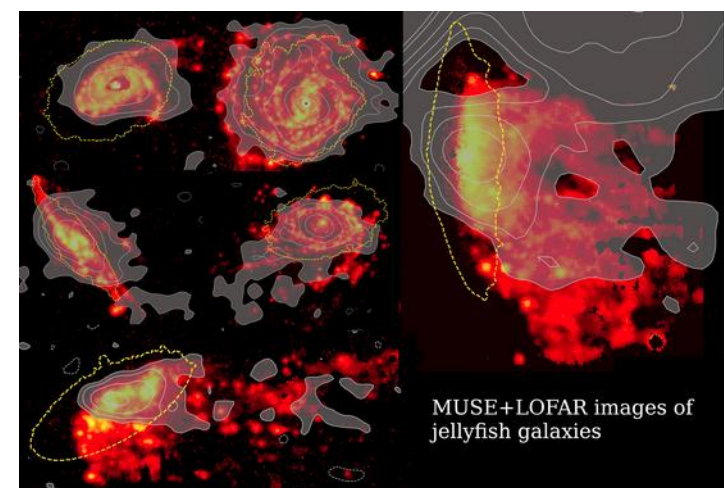


With JF galaxies we can study:

- **Galaxy evolution in environment**
- **ISM physics under extreme conditions**
- **ICM microphysics**

Jellyfish galaxies in the radio sky

1st detection Gavazzi 1987 → ~200 (2025) → ~400-500 LoTSS DR3 (Roberts, in prep)



Some references:

- Ignesti+2022, 2023
- Roberts+2021a,c, 2023
- Edler+2023
- Hu+2023
- Muller+2021
- Botteon+2025
- MeerKAT Cluster survey

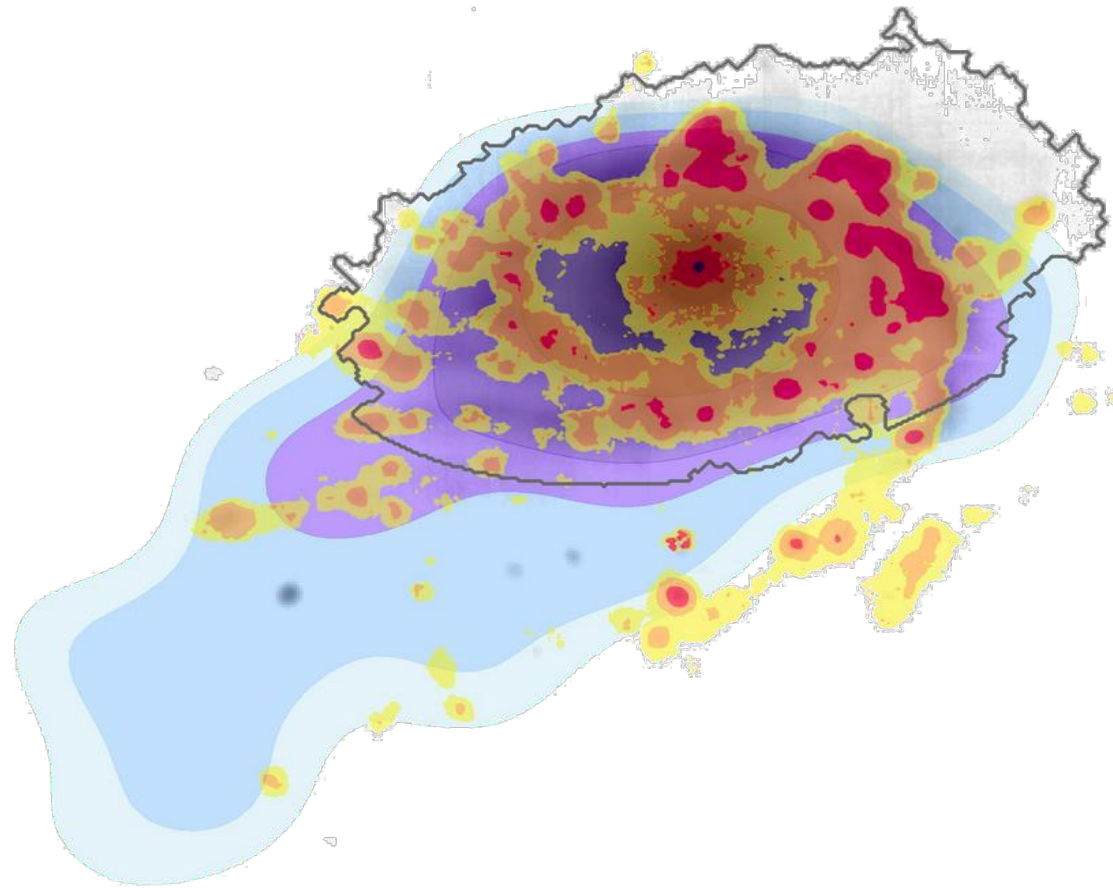
Jellyfish galaxies in the radio sky

JW39 [Ignesti+2022]

MUSE+LOFAR $H\alpha$

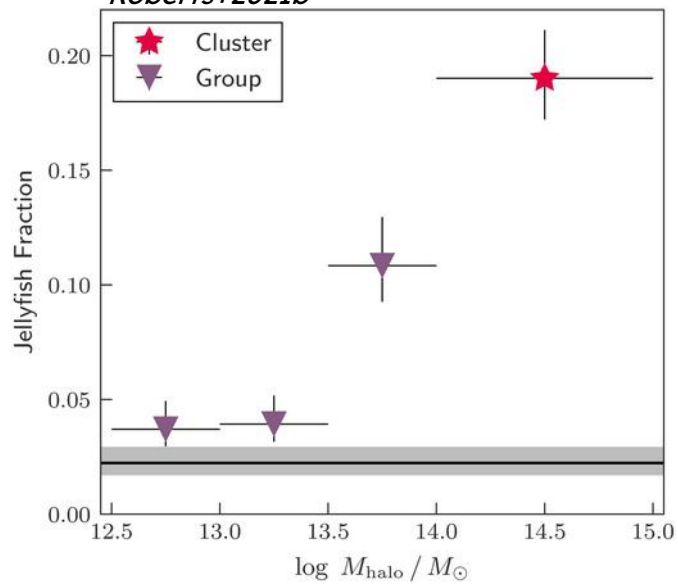
Radio continuum @144 MHz

Stellar continuum



Groups vs Clusters

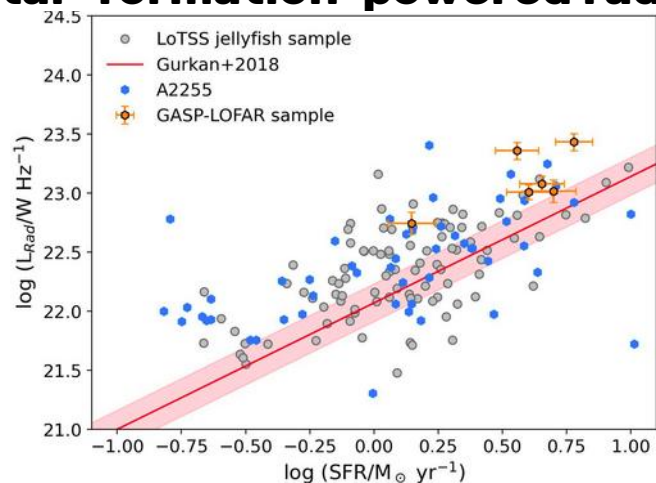
Roberts+2021b



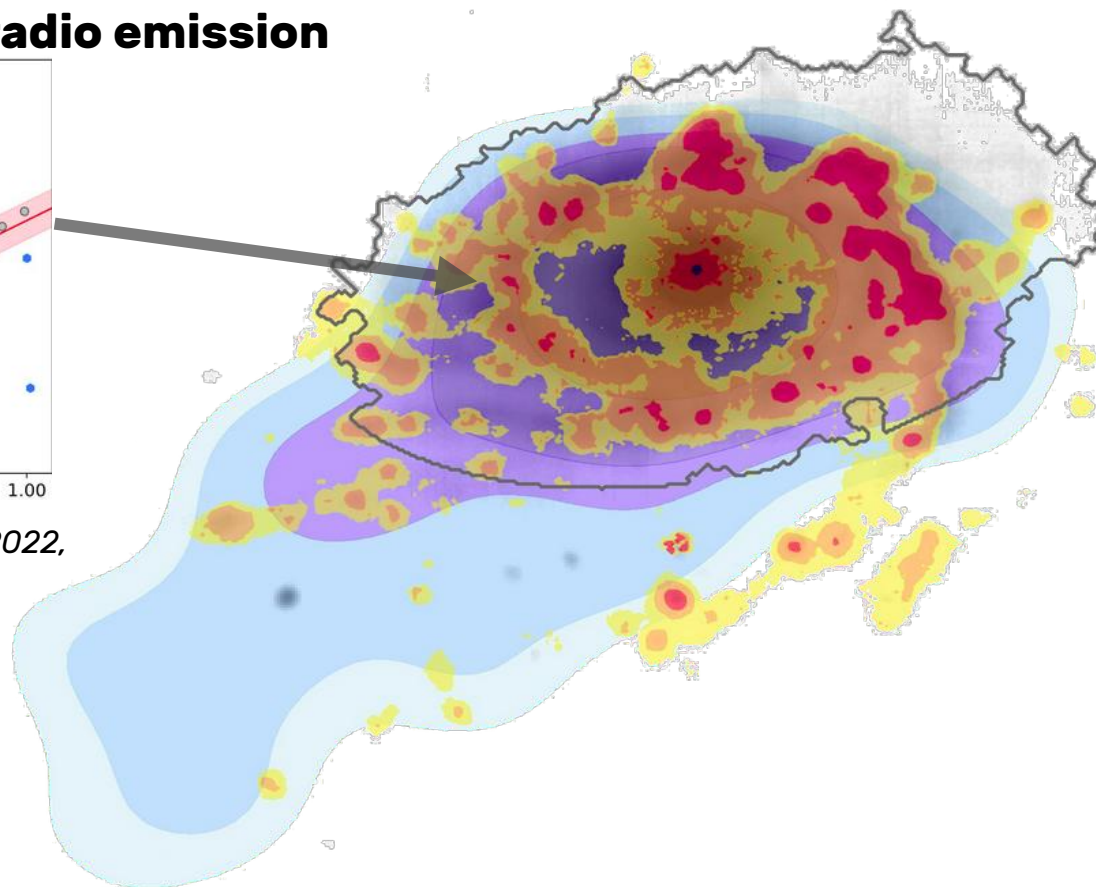
Jellyfish galaxies in the radio sky

JW39 [Ignesti+2022]
MUSE+LOFAR $H\alpha$
Radio continuum @144 MHz
Stellar continuum

Star-formation-powered radio emission

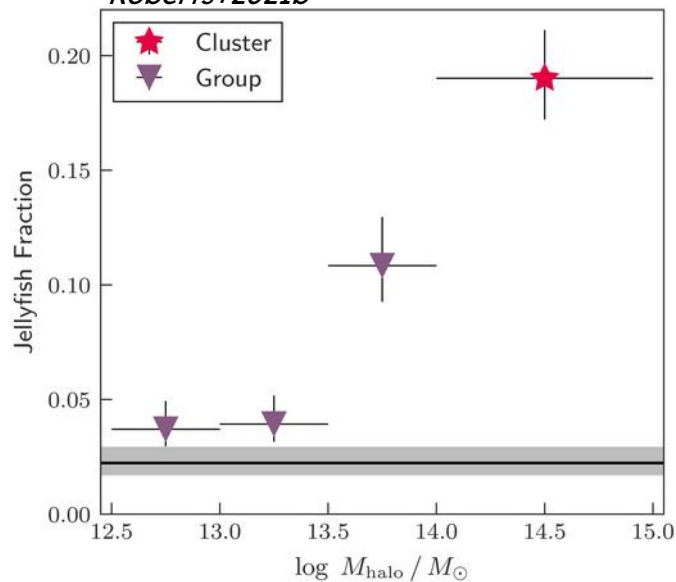


[Chen+2020, Roberts+2021, Ignesti+2022, Edler+2023]



Groups vs Clusters

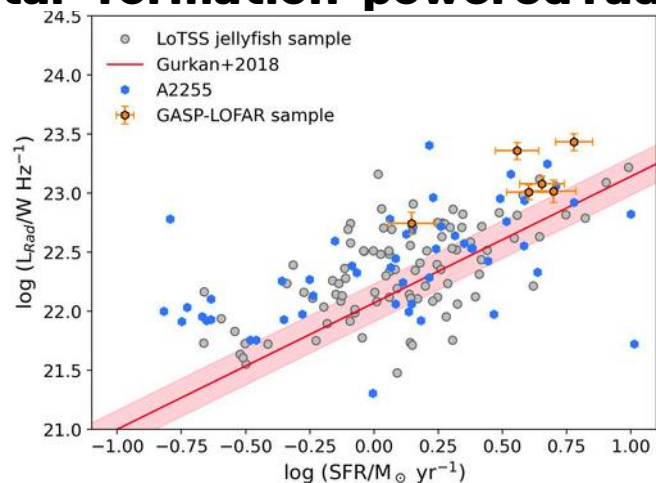
Roberts+2021b



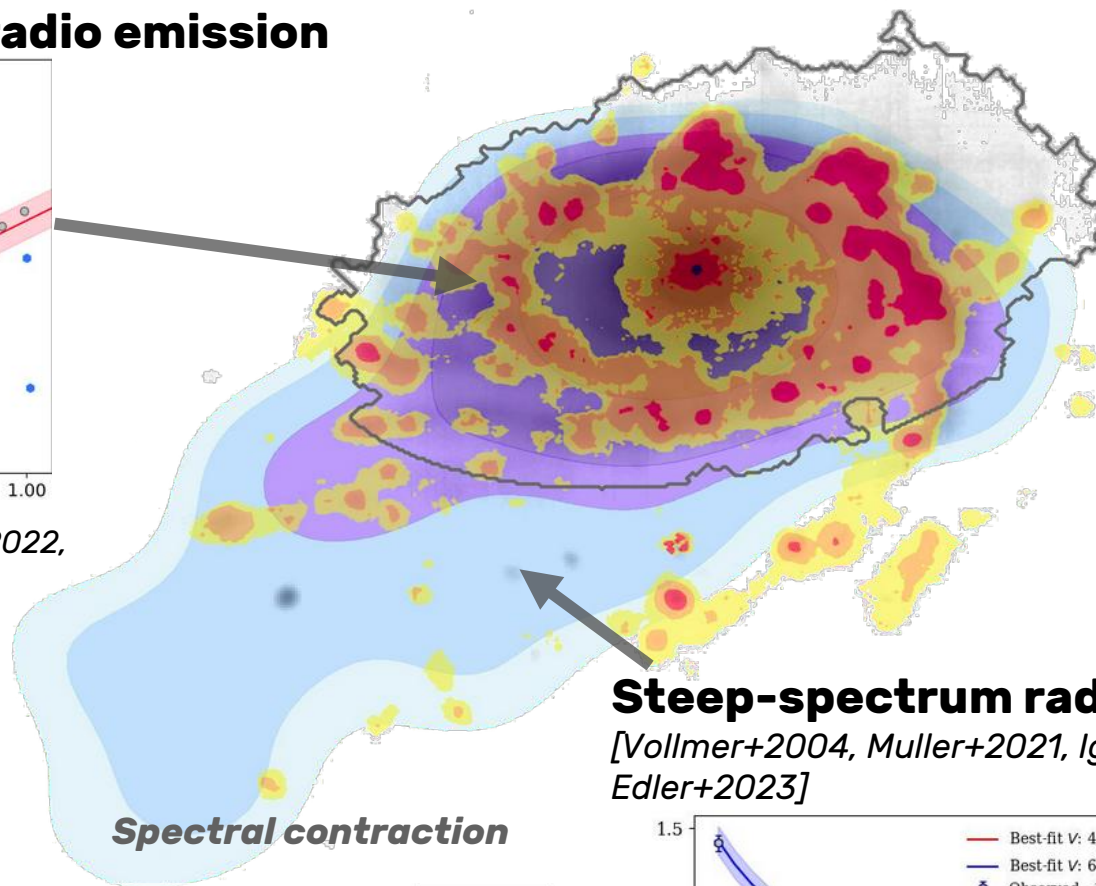
Jellyfish galaxies in the radio sky

JW39 [Ignesti+2022]
 MUSE+LOFAR **H α**
 Radio continuum @144 MHz
 Stellar continuum

Star-formation-powered radio emission



[Chen+2020, Roberts+2021, Ignesti+2022, Edler+2023]

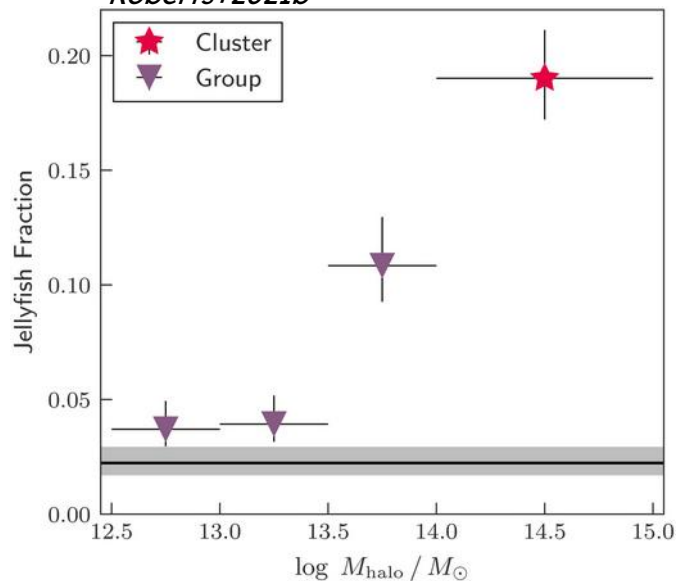


Spectral contraction

$$L_{\text{tail}} \propto \sqrt{\frac{1}{\nu_{\text{obs}}}}$$

Groups vs Clusters

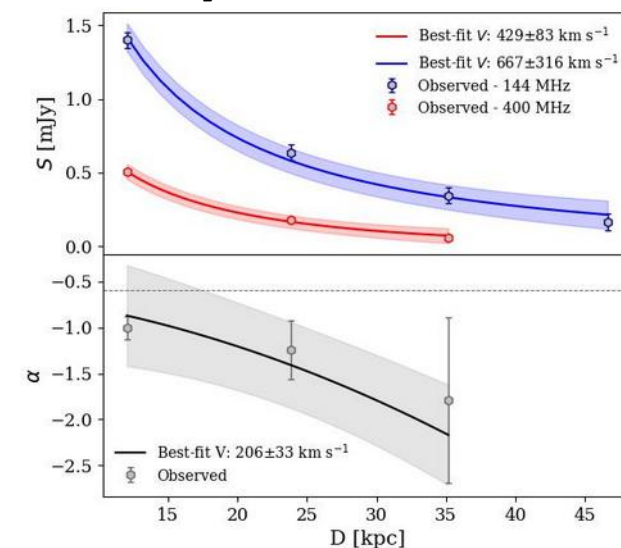
Roberts+2021b



RPS outflow velocity constrained by RC gradients
 $V \sim 500 \text{ km/s}$
 [Ignesti+2023, Roberts+2024]

Steep-spectrum radio tail

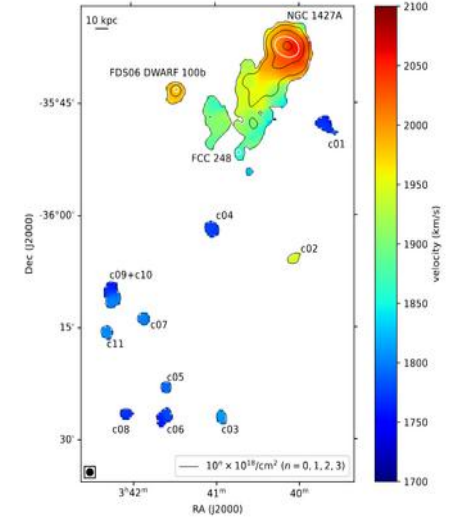
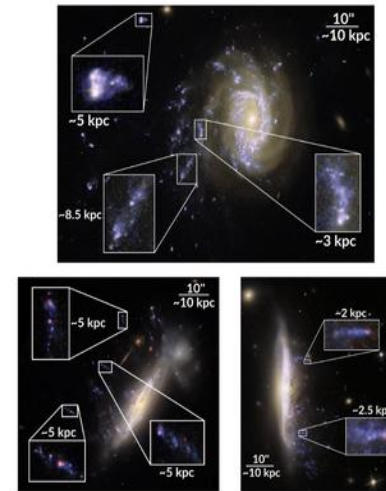
[Vollmer+2004, Muller+2021, Ignesti+2022, Edler+2023]



Some currently open questions



The RPS sequence: we are missing the early stages because optical observations are biased toward late stages.



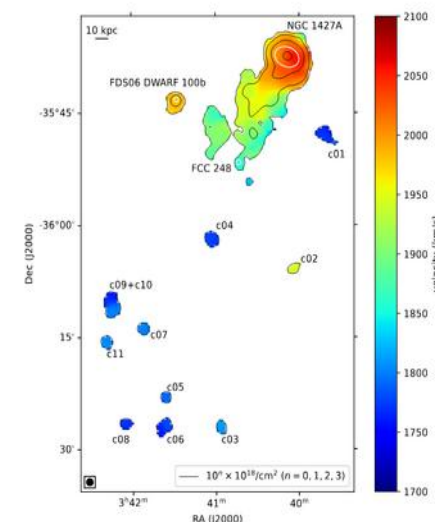
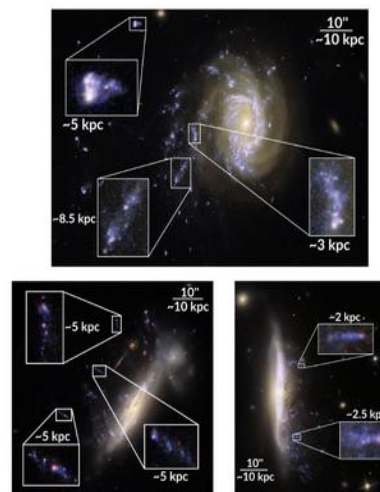
Giunchi+2023, Serra+2024

The fate of the stripped material: why in some galaxies it evaporates and in others it form stars?

Some currently open questions



The RPS sequence: we are missing the early stages because optical observations are biased toward late stages.



Giunchi+2023, Serra+2024

The fate of the stripped material: why in some galaxies it evaporates and in others it form stars?

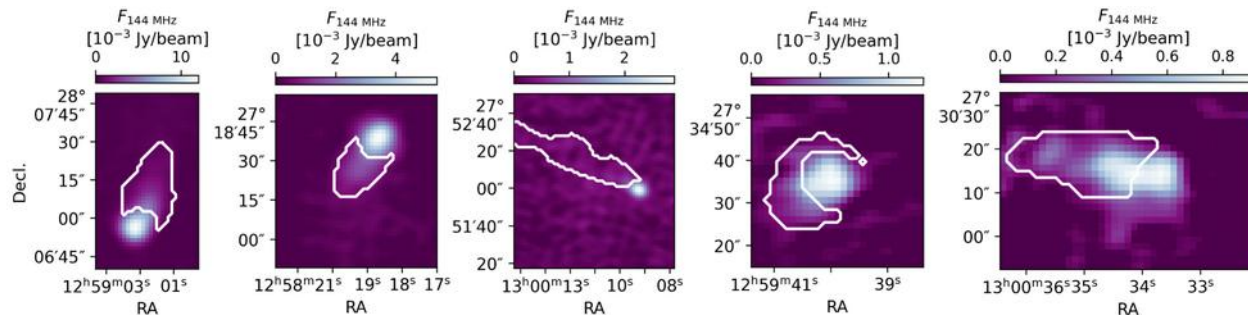
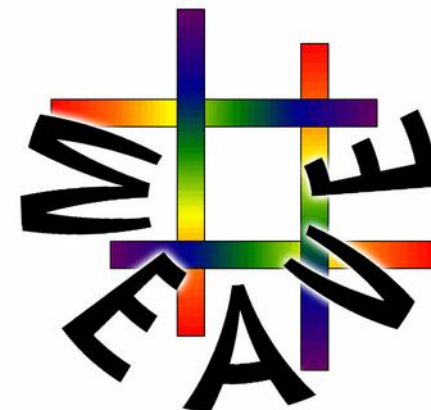
- **How to advance this field:** look at the **radio continuum**. LoTSS has revealed that at 144 MHz radio tails are already present in galaxies without optical tails, and radio+optical studies have shown that magnetic fields are crucial in preserving the stripped material (Ignesti+2026)
- **Where to look:** the **Coma cluster**. Near, Massive, plethora of data

CLIFS: Coma Legacy Integral Field Survey

PI I. D. Roberts

Four pillars:

- 1) Existing MaNGA IFU spectroscopy (94 galaxies),
- 2) CLIFS-RP sub-sample [LIFU]: Coma galaxies with ram pressure stripped tails detected by LOFAR (30 galaxies from Roberts+24),
- 3) CLIFS low-mass ($10^9 < M_{\text{star}} < 10^{10} M_{\text{sun}}$), non-tailed sample (102 galaxies with WEAVE multi-object),
- 4) CLIFS High-mass [LIFU]: non-tailed sample (25 galaxies, CLIFS-High-M)

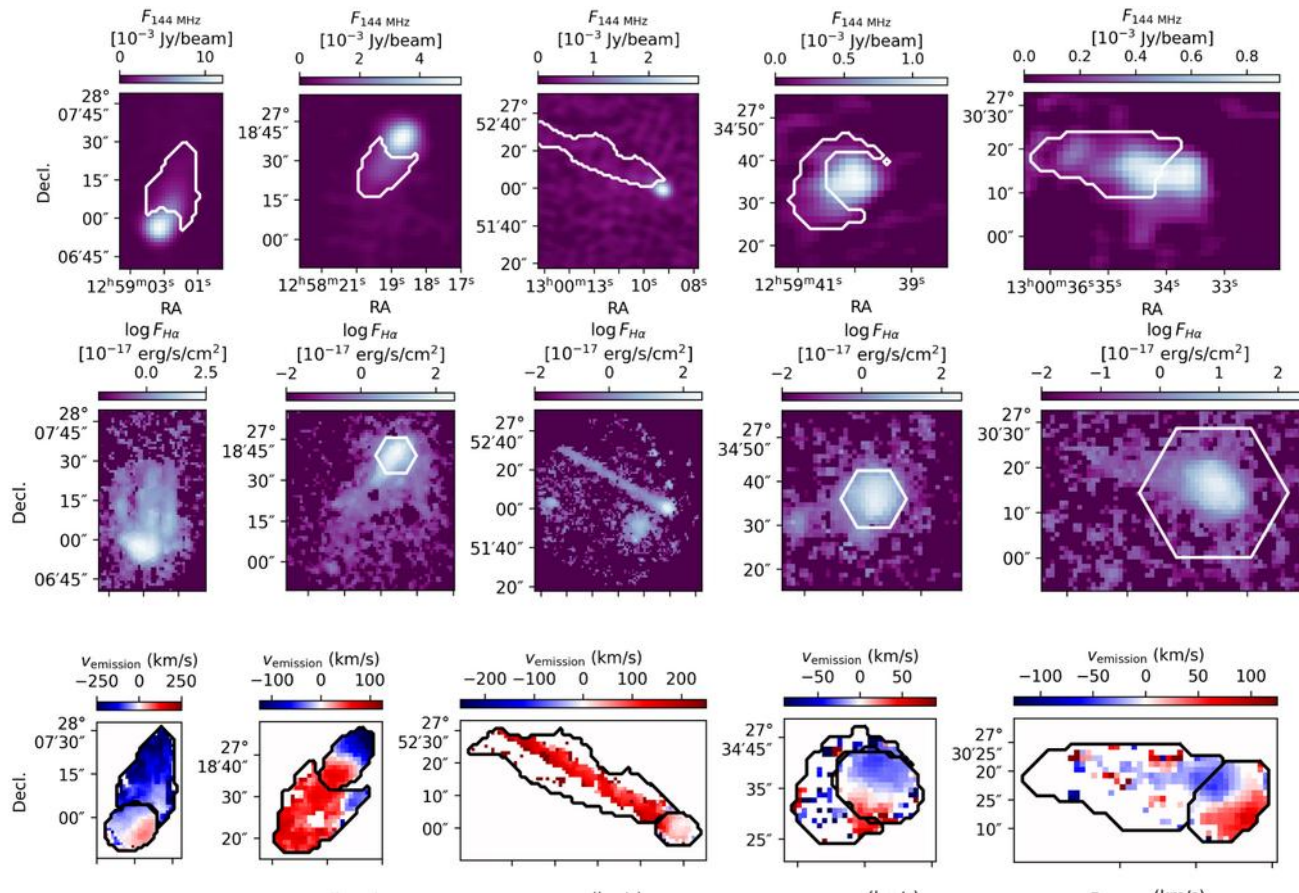
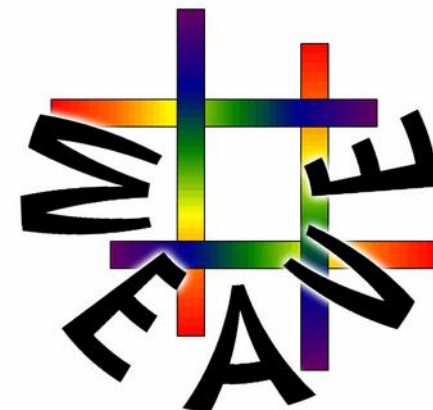


CLIFS: Coma Legacy Integral Field Survey

PI I. D. Roberts

Four pillars:

- 1) Existing MaNGA IFU spectroscopy (94 galaxies),
- 2) CLIFS-RP sub-sample [LIFU]: Coma galaxies with ram pressure stripped tails detected by LOFAR (30 galaxies from Roberts+24),
- 3) CLIFS low-mass ($10^9 < M_{\text{star}} < 10^{10} M_{\text{sun}}$), non-tailed sample (102 galaxies with WEAVE multi-object),
- 4) CLIFS High-mass [LIFU]: non-tailed sample (25 galaxies, CLIFS-High-M)



→ Which ISM phase
“contains” the radio
emission?

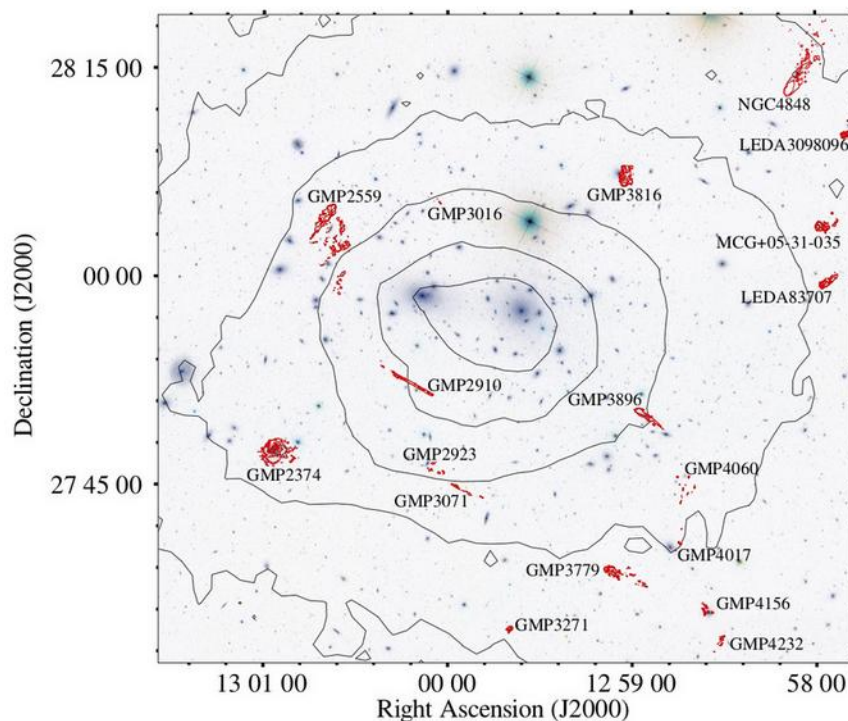
→ Which is the ISM
stripping sequence?

Foster+2026

The LOFAR-ALMA project

ALMAJELLY survey (PI Jachym)

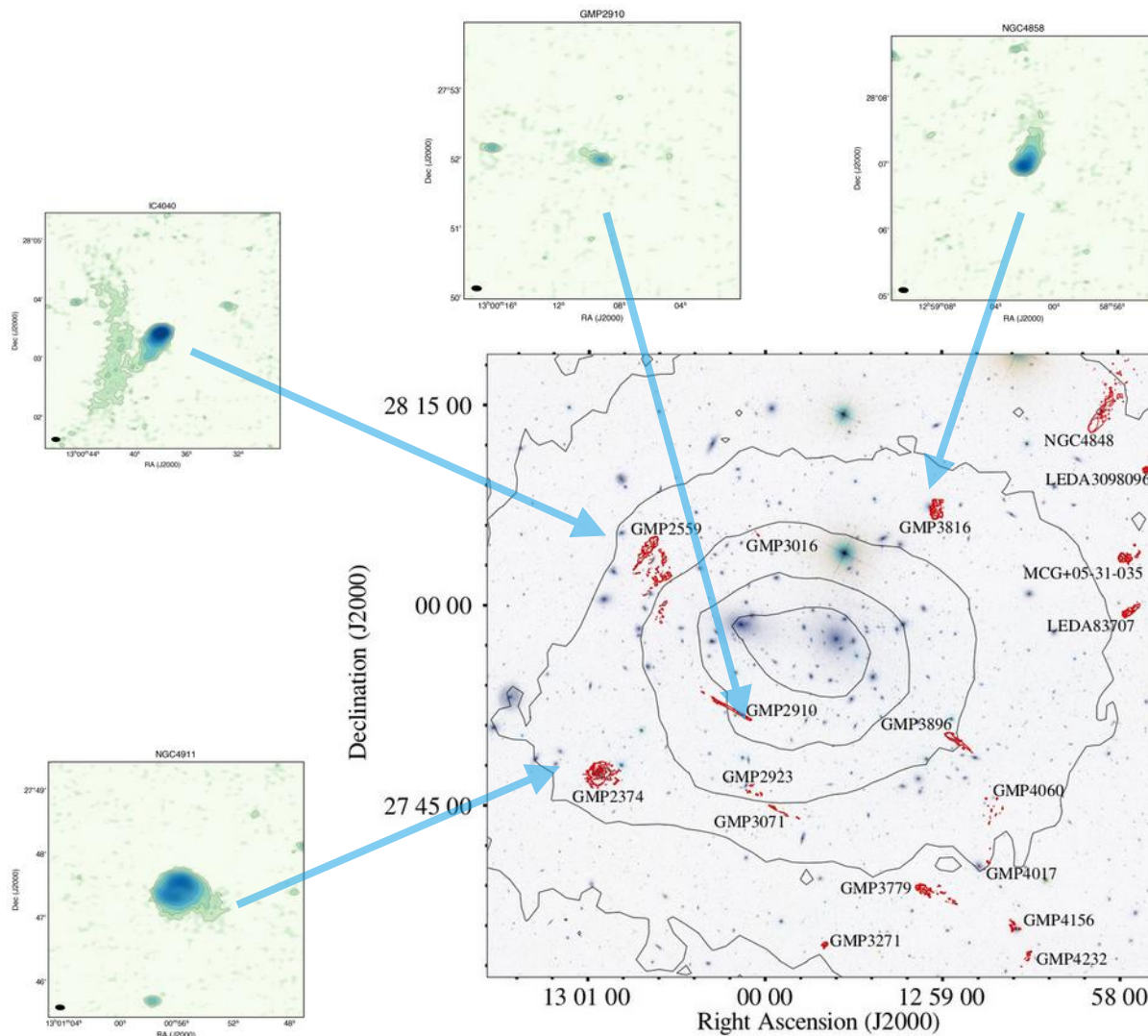
- ALMA 7+12m band 6 observations of 18 galaxies in the Coma cluster → **0.3 kpc** physical resolution
- **GOAL:** determine how the molecular gas content evolve during the ICM ram pressure and characterize the stripped material properties
- **Ancillary data:** MUSE, HST, APEX, MeerKAT (HI and Continuum), Chandra, LOFAR (LoTSS), VLA → **International collaboration**



The LOFAR-ALMA project

ALMAJELLY survey (PI Jachym)

- ALMA 7+12m band 6 observations of 18 galaxies in the Coma cluster → **0.3 kpc** physical resolution
- **GOAL:** determine how the molecular gas content evolve during the ICM ram pressure and characterize the stripped material properties
- **Ancillary data:** MUSE, HST, APEX, MeerKAT (HI and Continuum), Chandra, LOFAR (LoTSS), VLA → **International collaboration**



Only 7/18 are currently detected by LOFAR: intrinsic low luminosity or “hidden” in the radio halo?

Deep HBA observations of the Coma cluster field

(LC15_20, PI Bonafede)

- 1) Achieve higher sensitivity, remove the halo and search for the emission beneath it
→ Do the radio emission coexist with molecular gas?
- 2) Use international stations to achieve ~1 arcsec resolution
→ Disk radio morphology? Filaments?

Summary and conclusions

- Jellyfish galaxies are excellent laboratories to study baryon physics, or how the ISM evolves under extreme conditions
- Radio continuum observations are now focusing on their complex magnetic fields
- LOFAR has been revolutionary by detecting a large number of jellyfish galaxies in the northern sky → **LoTSS DR3 will further increase the statistic!**
- Now LOFAR will lead the next-generation studies in the Coma cluster
 - **CLIFS:** Investigate optical properties in the first radio-selected sample
 - Coma Ultra deep: use deeper data to search for the faintest sources + obtain the first high-resolution image of **ALMAJELLY** galaxies

Stay tuned for the upcoming results!

Contacts:

alessandro.ignesti@asu.cas.cz
More at <https://aignesti.github.io/>

We acknowledge support from the institutional project RVO:67985815 and the project 25-19512L of the Czech Science Foundation.

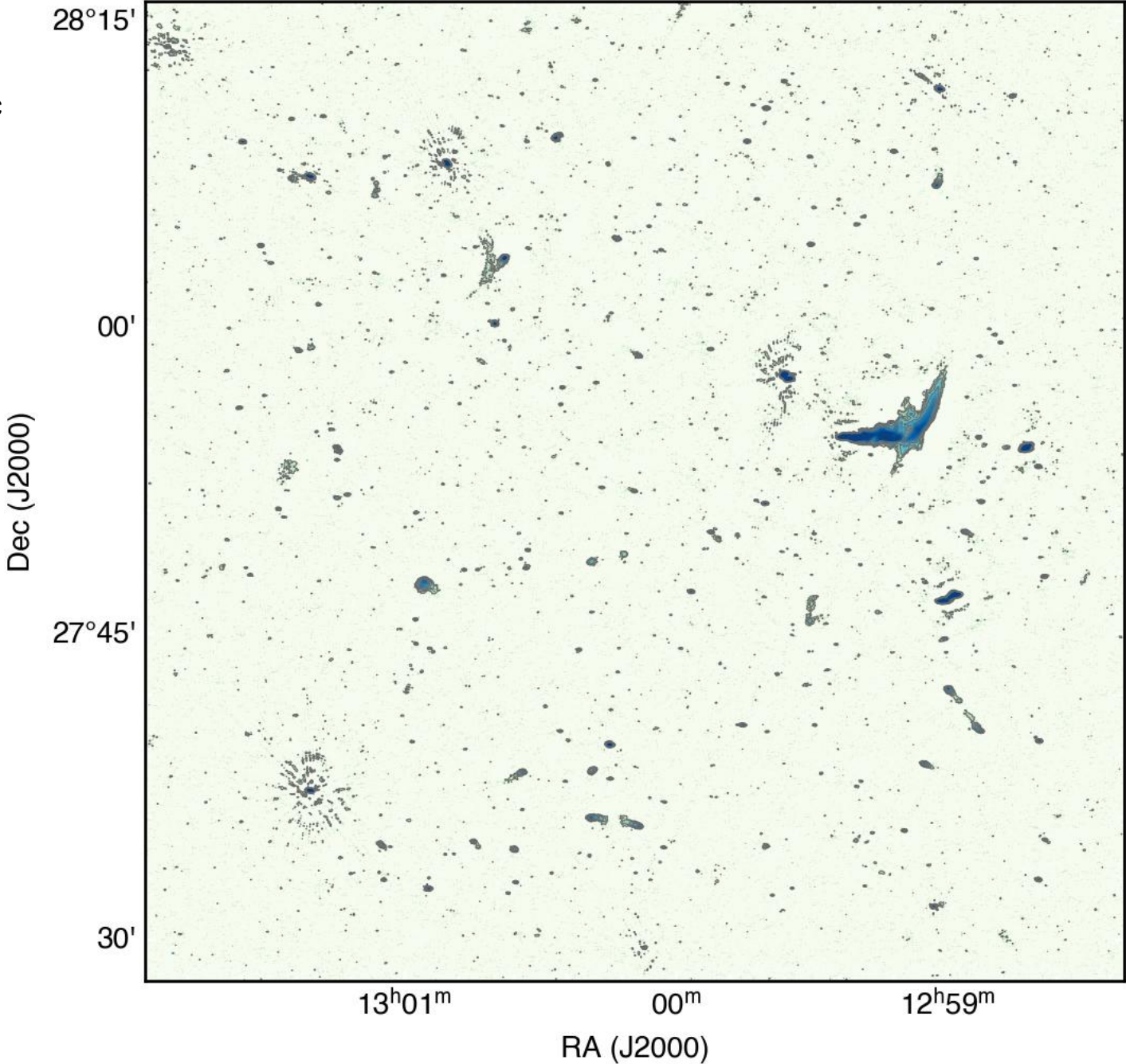
EXTRA

Preliminary work:

Extracted LoTSS image
Imaging with
lower UV-thresh of ~100 kpc
+ tapering

Beam: 16.6x12.3 arcsec²

RMS: 139 μ Jy/beam



LBA view – Courtesy of Chiara Stuardi

