

Cold gas in the Hydra Cluster

2nd Sweden SKA days Gothenburg 2024

Clara Cabanillas de la Casa
Instituto de Astrofísica de Andalucía (IAA-CSIC)

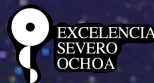
Supervised by:

Kelley Hess

(Chalmers University of Technology)

Lourdes Verdes-Montenegro (IAA-CSIC)

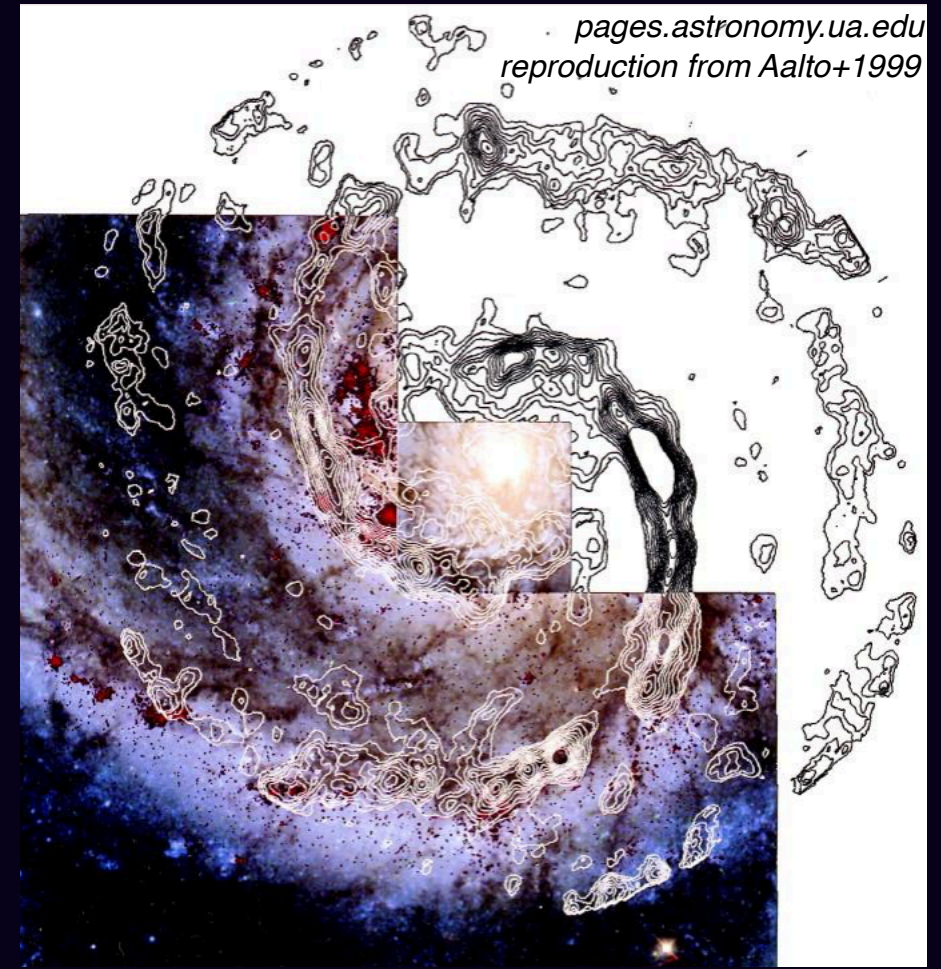
Grant TED2021-130231B-I00 funded by:



EUROPEAN ARC
ALMA Regional Centre || Nordic

Context: tracers of environmental interactions

Gas is the best tracer of environmental interactions.



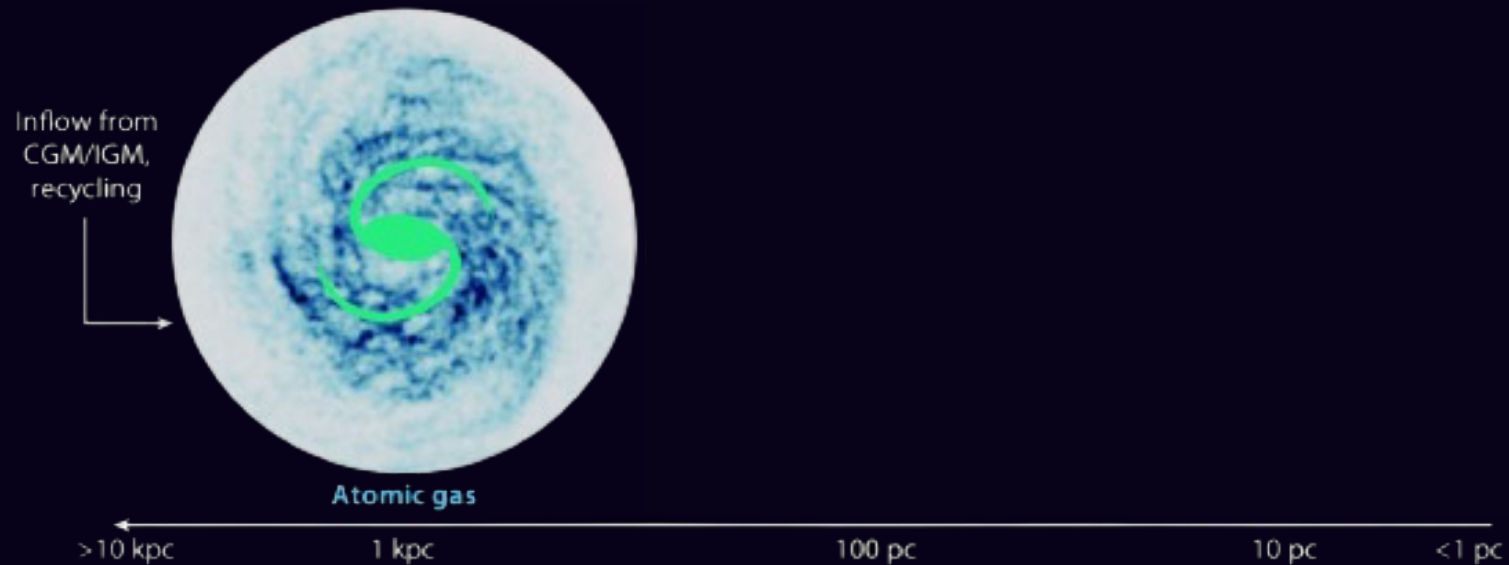
Context: tracers of environmental interactions

Atomic gas - HI

Reservoir for future SF

Extended in disks

Loosely bound

Saintonge+2022

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Atomic gas - HI

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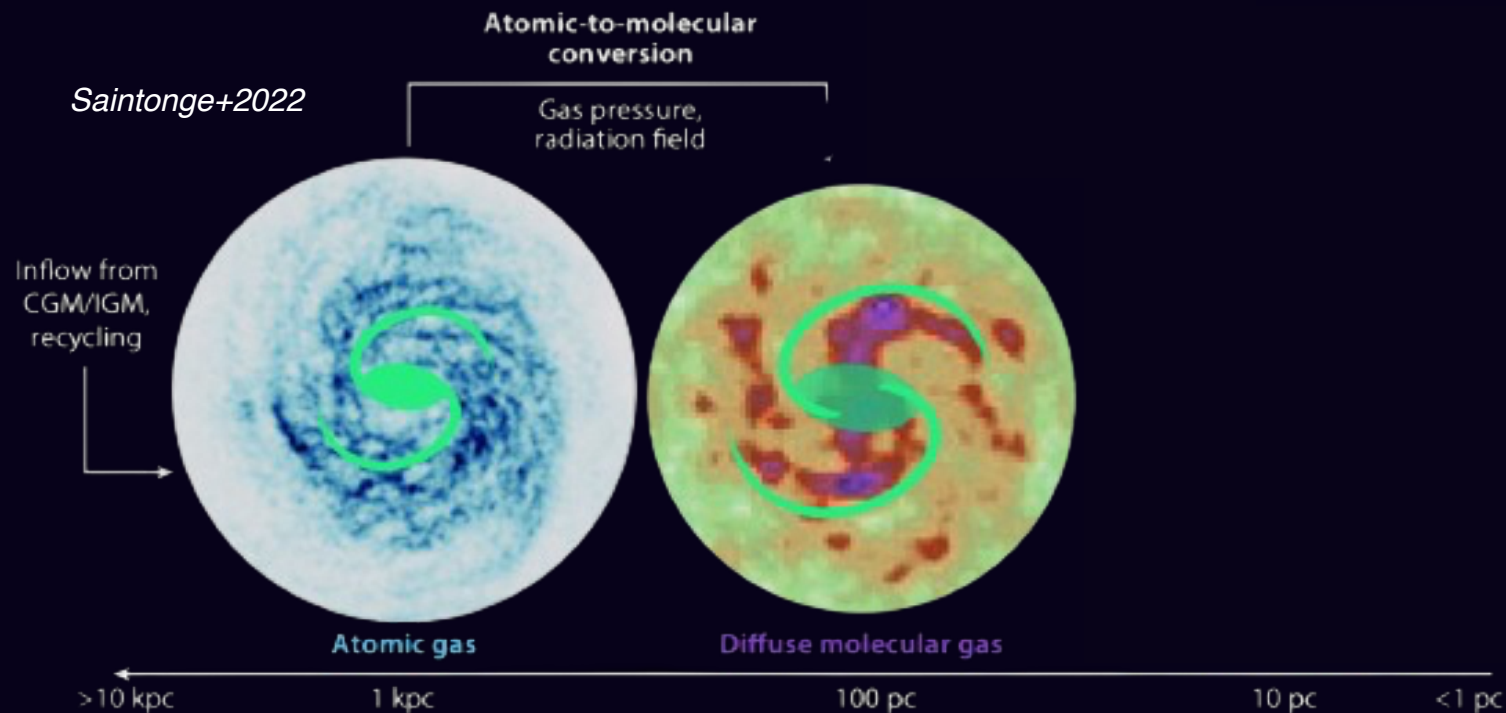
Loosely bound

Molecular gas - H₂

Direct fuel for SF

Compact

Less exposed



Context: tracers of environmental interactions

Atomic gas - HI

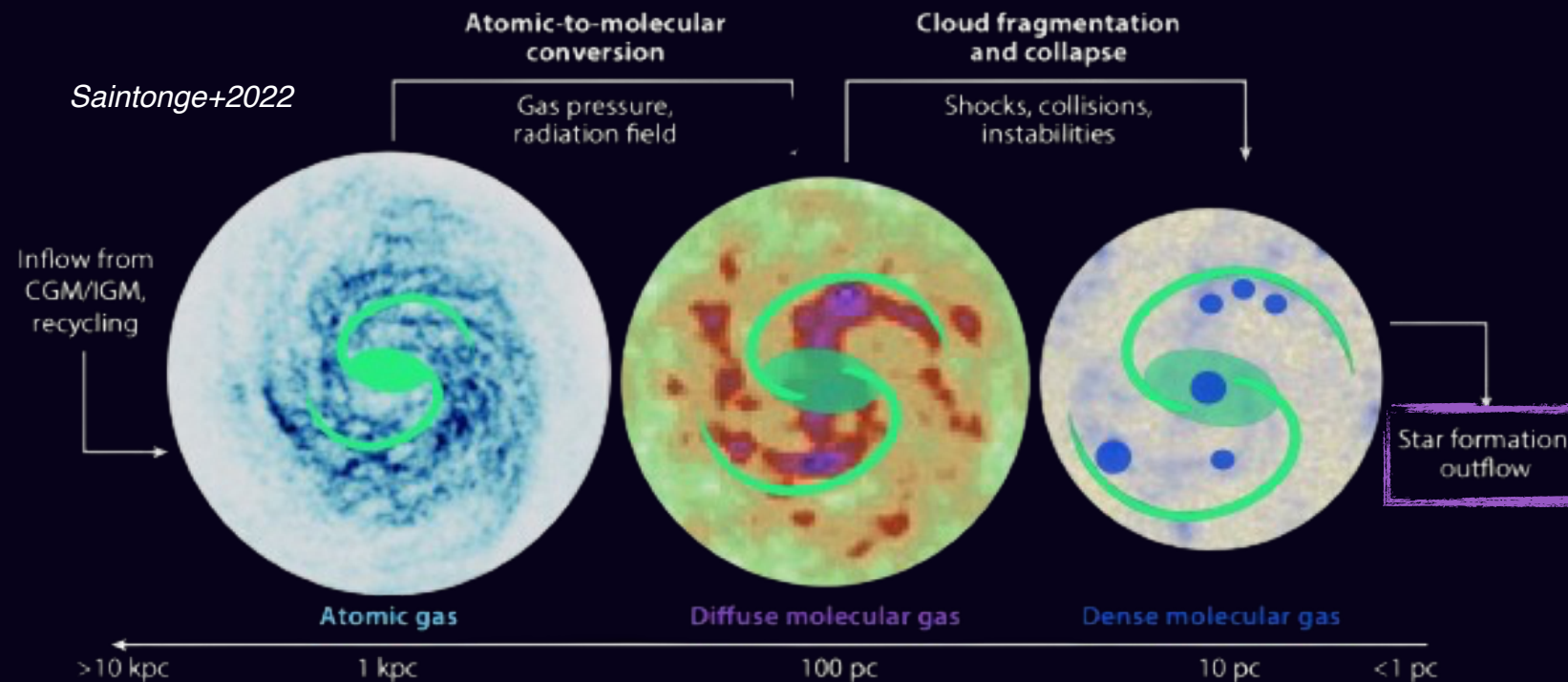
Reservoir for future SF
Extended in disks
Loosely bound

Molecular gas - H₂

Direct fuel for SF
Compact
Less exposed

Ionized gas - H α

“Smoking gun” for SF
Localised on SF regions
Hot component



Context: lessons from the different gas phases

Simultaneous impact of environment on HI and H₂

Cold gas asymmetries

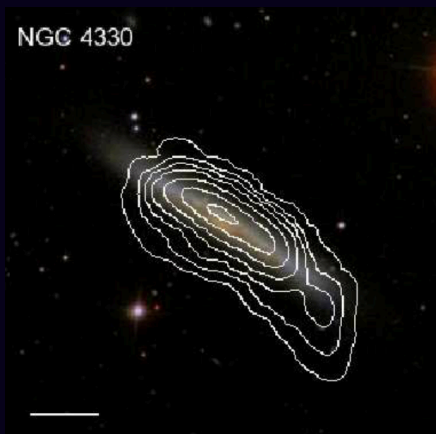
Roberts et al., 2023:

Evidence for enhanced H₂ content on the leading halves of HI-tailed galaxies

Brown et al., 2023

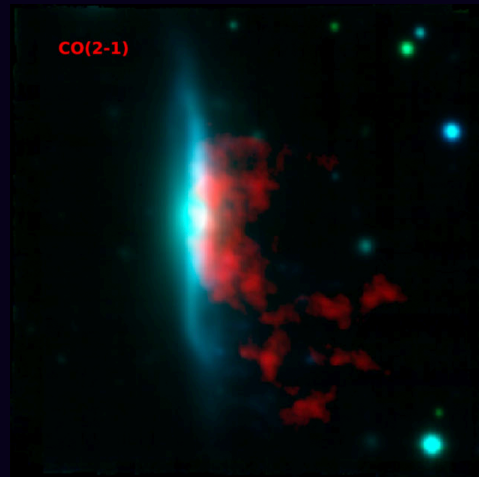
Ram pressure stripping first triggers SF through gas compression, then removes H₂ and quenches the system

Neutral gas: white contours



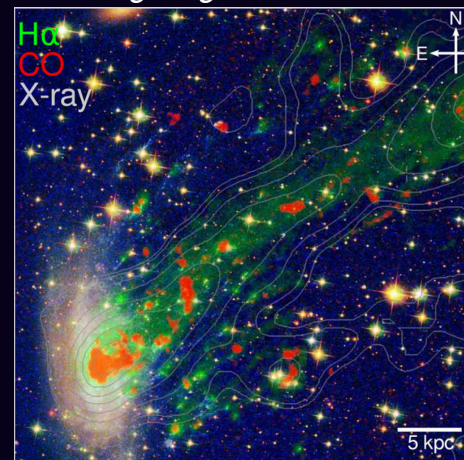
Wong+2014

Molecular gas: red



Moretti+2020a

Ionized gas: green



Jáchym+2019

Context: lessons from the different gas phases

Simultaneous impact of environment on HI and H2

HI is much more affected by the cluster environment than H2

Cold gas asymmetries

Relative impact of environment

Roberts et al., 2023:

Brown et al., 2023

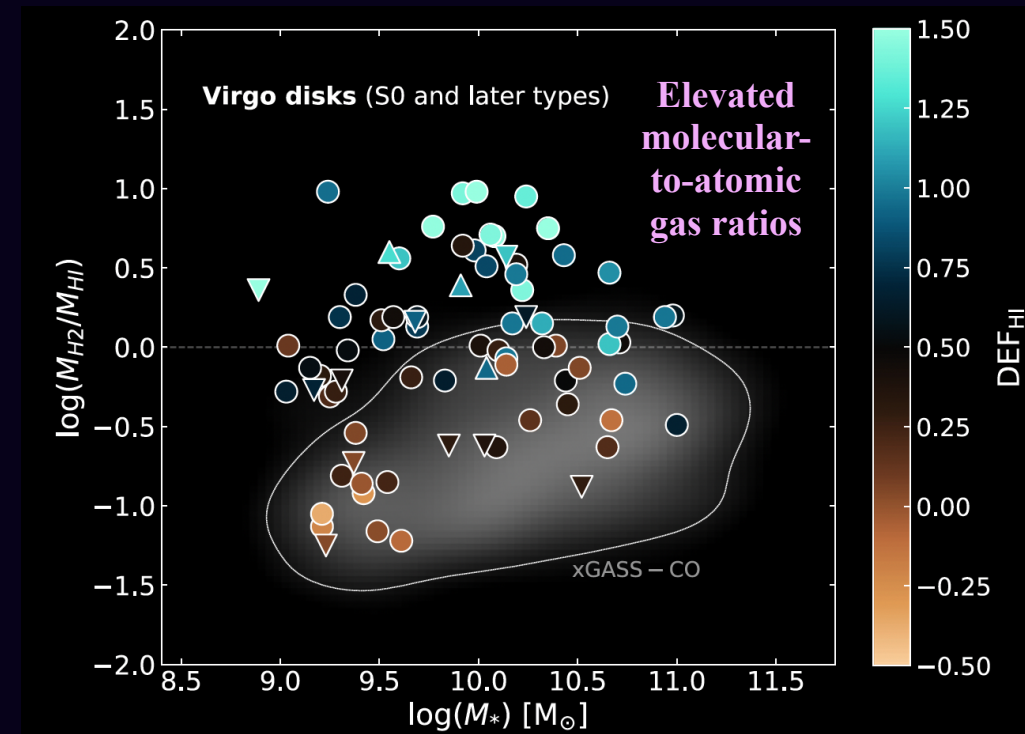
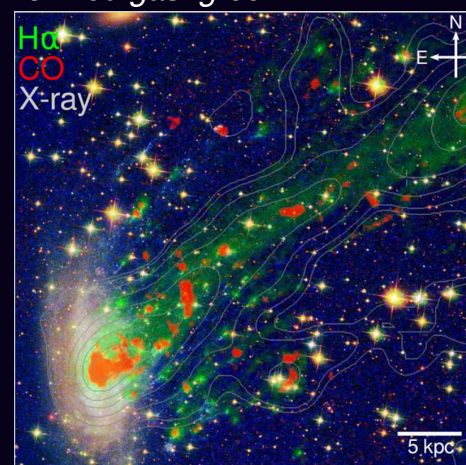
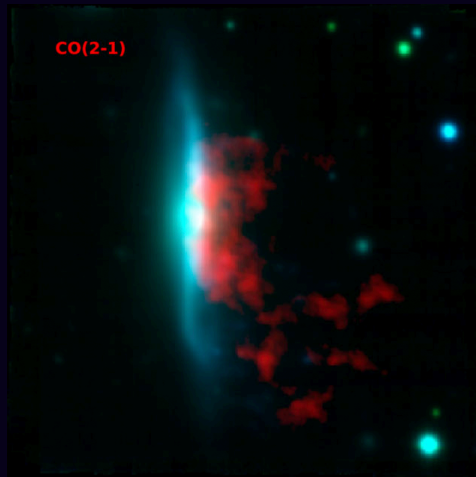
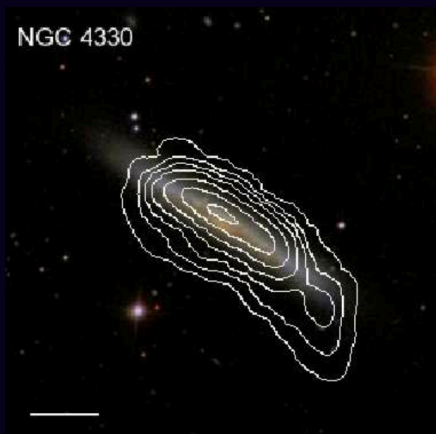
Evidence for enhanced H2 content on the leading halves of HI-tailed galaxies

Ram pressure stripping first triggers SF through gas compression, then removes H2 and quenches the system

Neutral gas: white contours

Molecular gas: red

Ionized gas: green



Cortese+2021

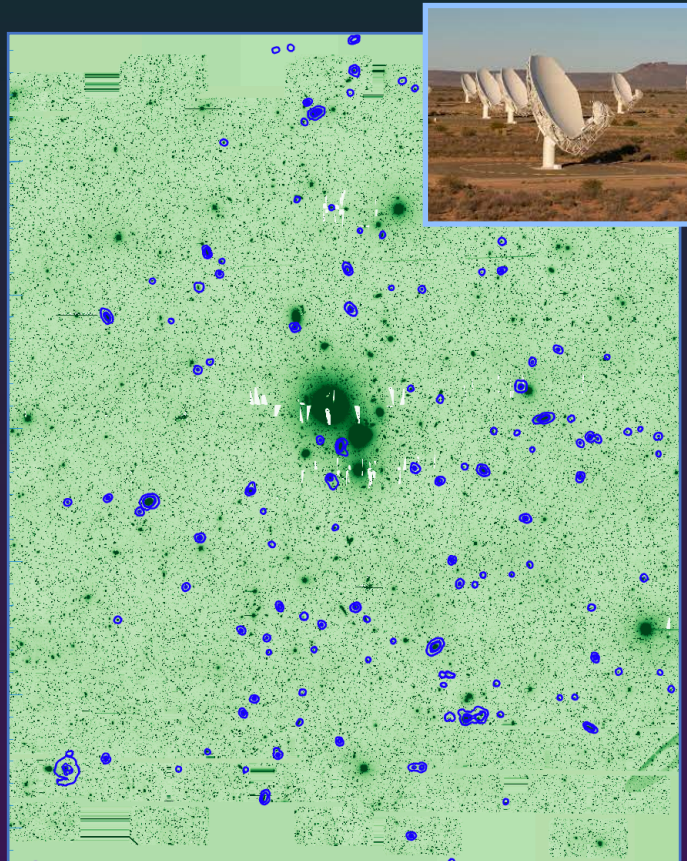
Wong+2014

Moretti+2020a

Jáchym+2019

The Hydra cluster project: environmental impact on galaxy evolution

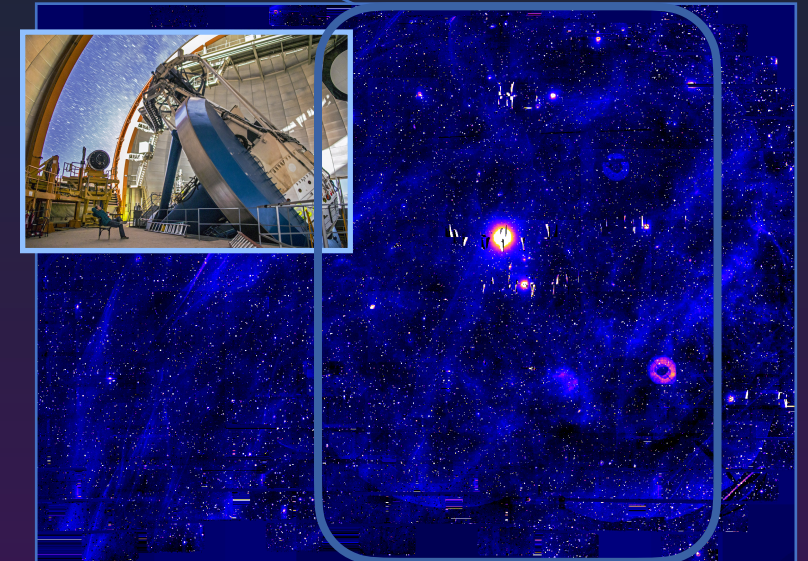
MeerKAT HI



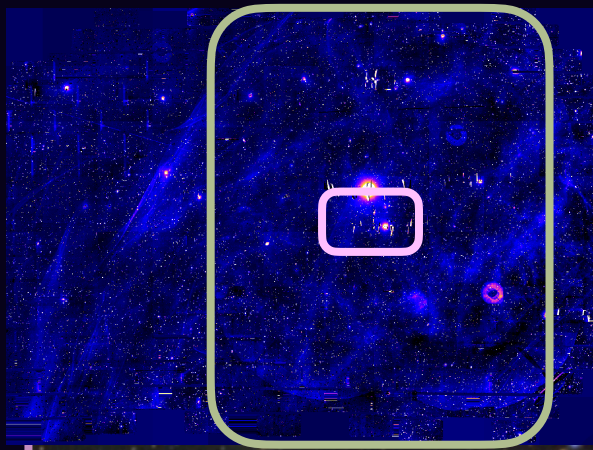
ALMA CO(1-0)



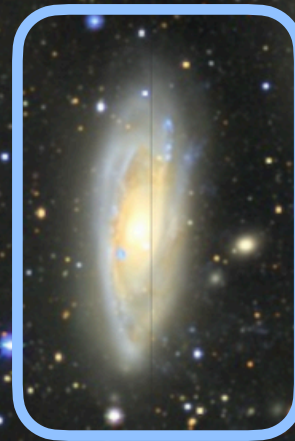
DECam optical broad (ugriz) and narrowband(Ha) imaging



Example: multi-wavelength analysis of NGC 3312



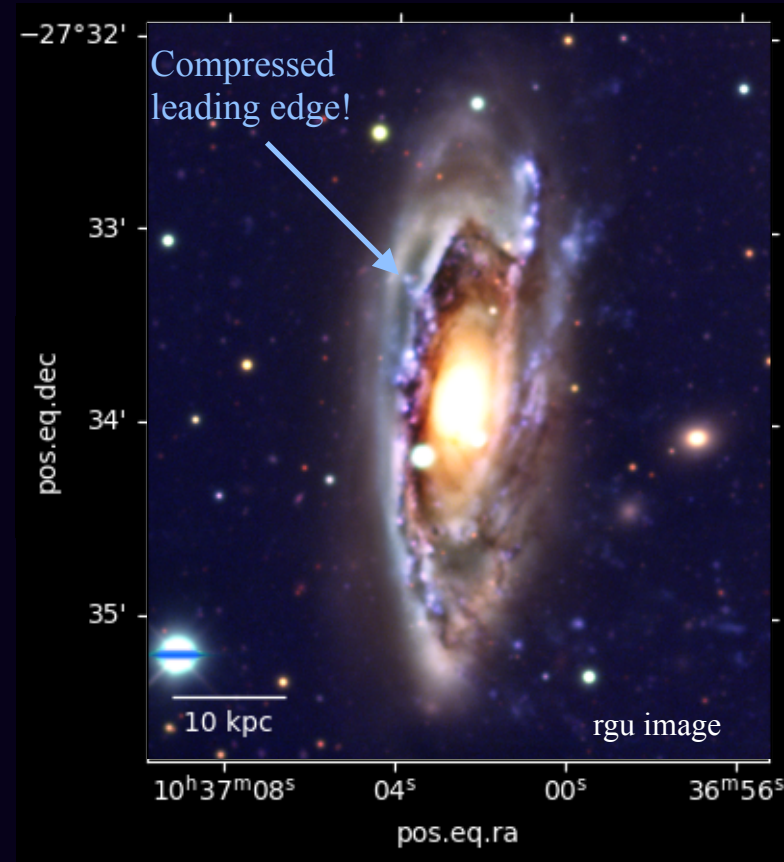
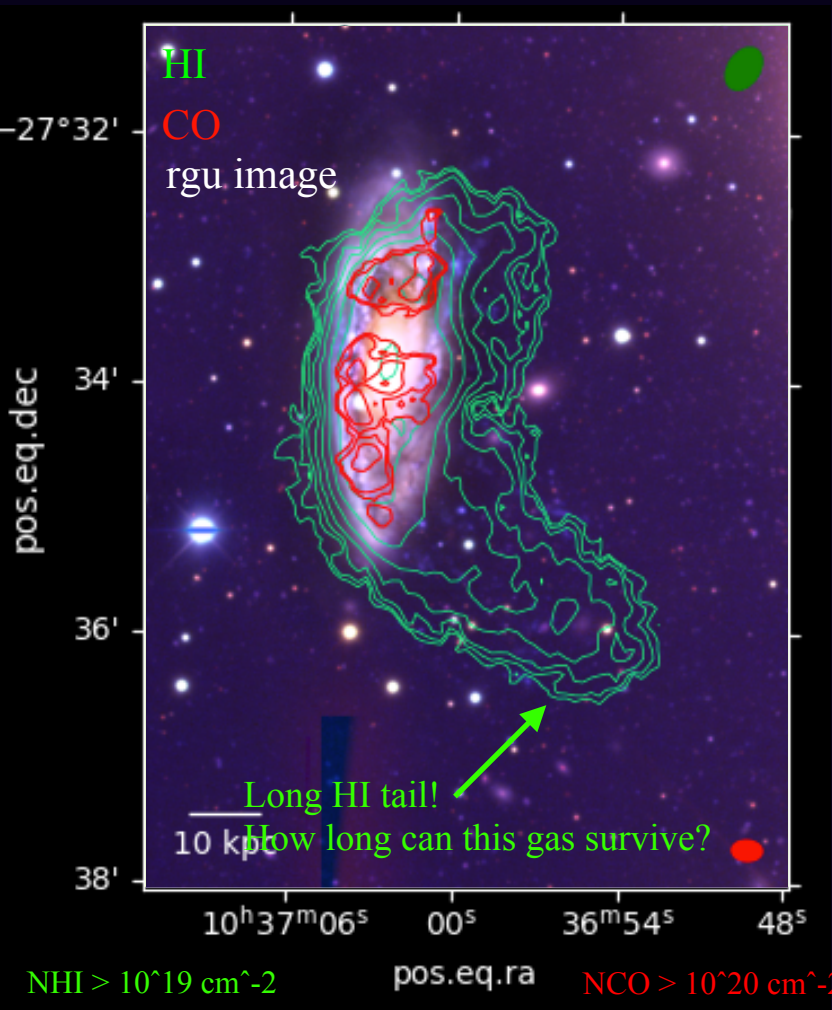
Cluster centre



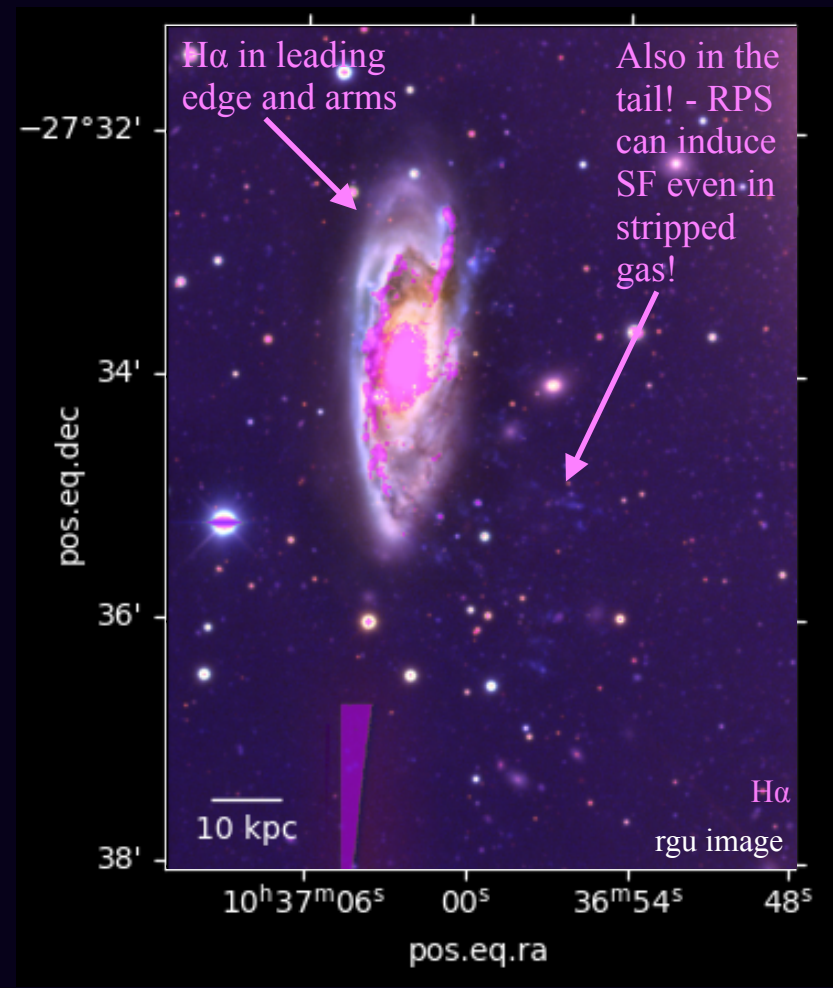
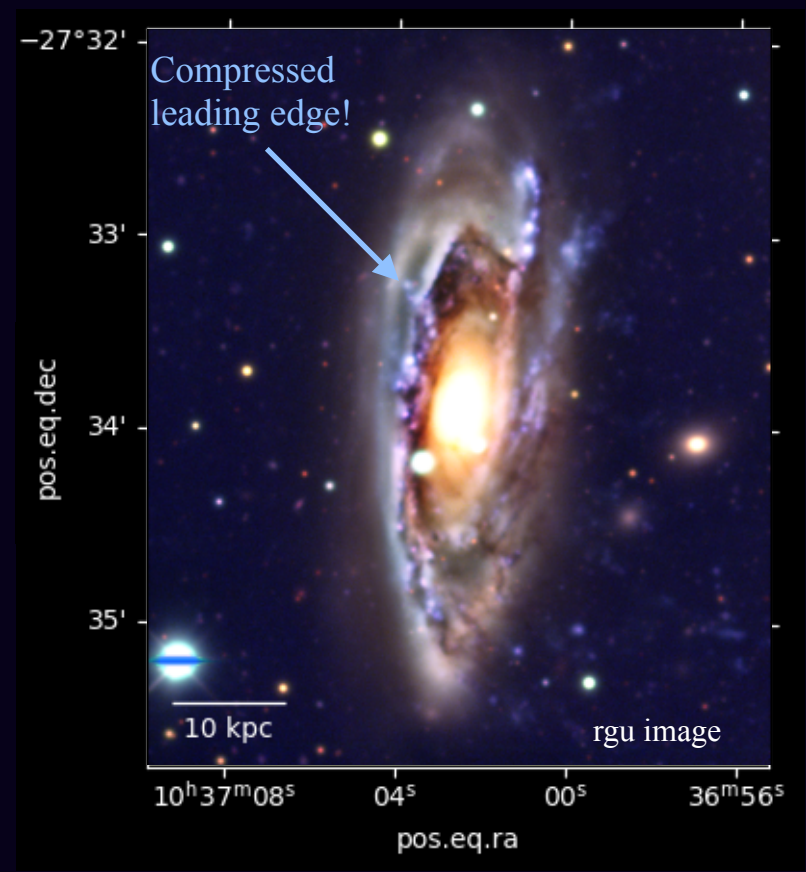
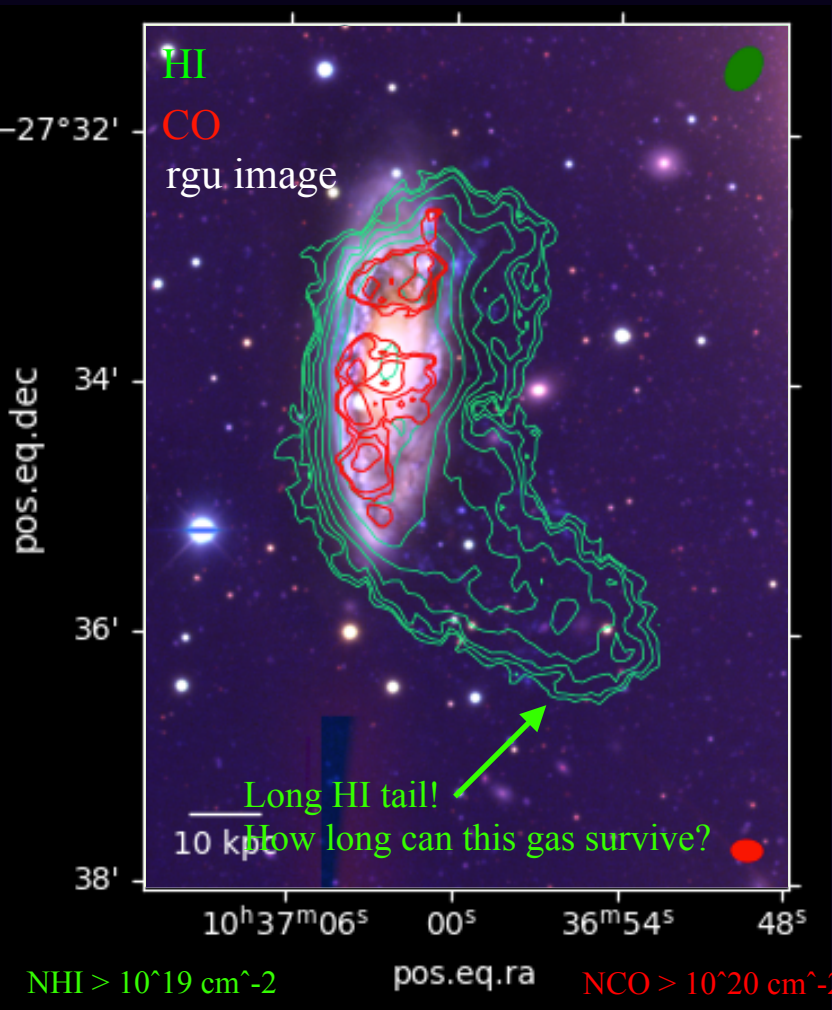
NGC 3312

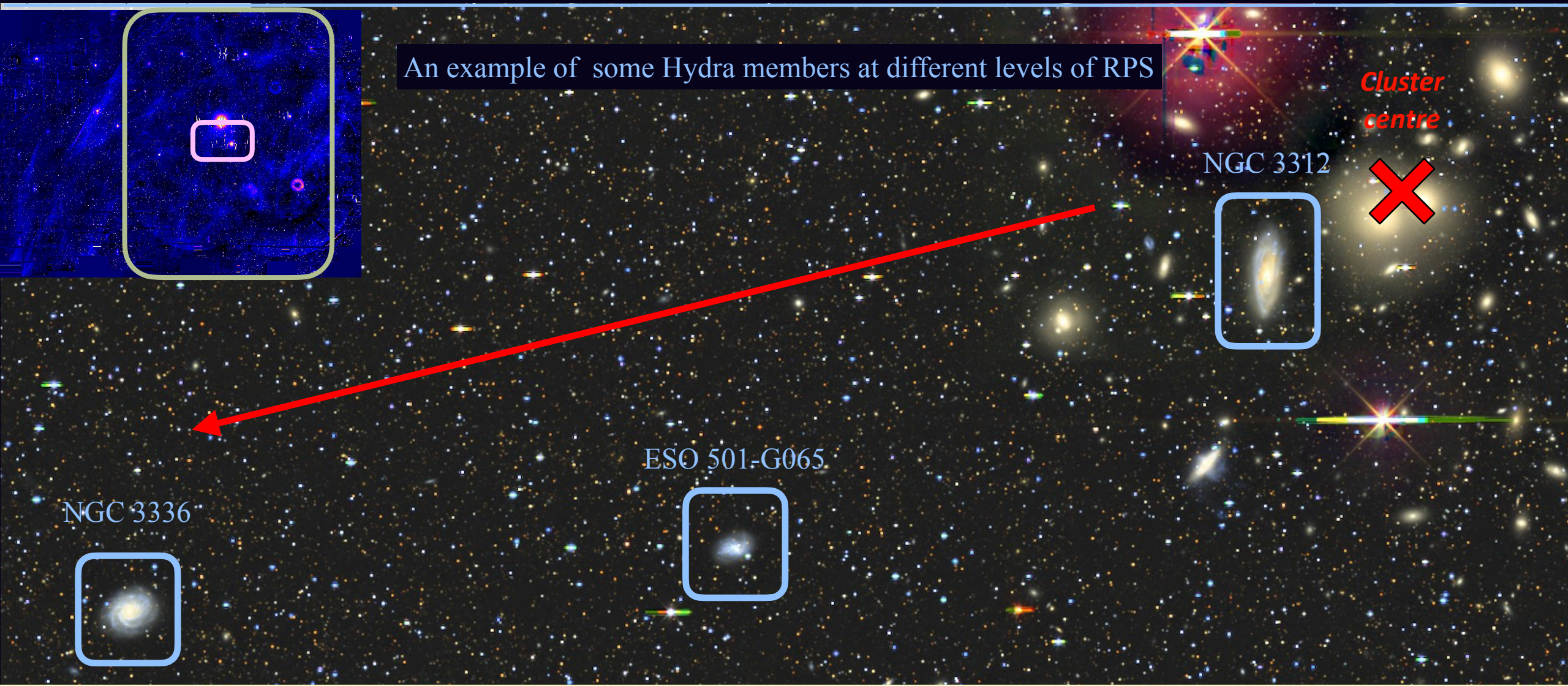
Member of foreground group
recently fallen into the cluster
Hess+2022

Example: multi-wavelength analysis of NGC 3312



Example: multi-wavelength analysis of NGC 3312





An example of some Hydra members at different levels of RPS

Cluster centre

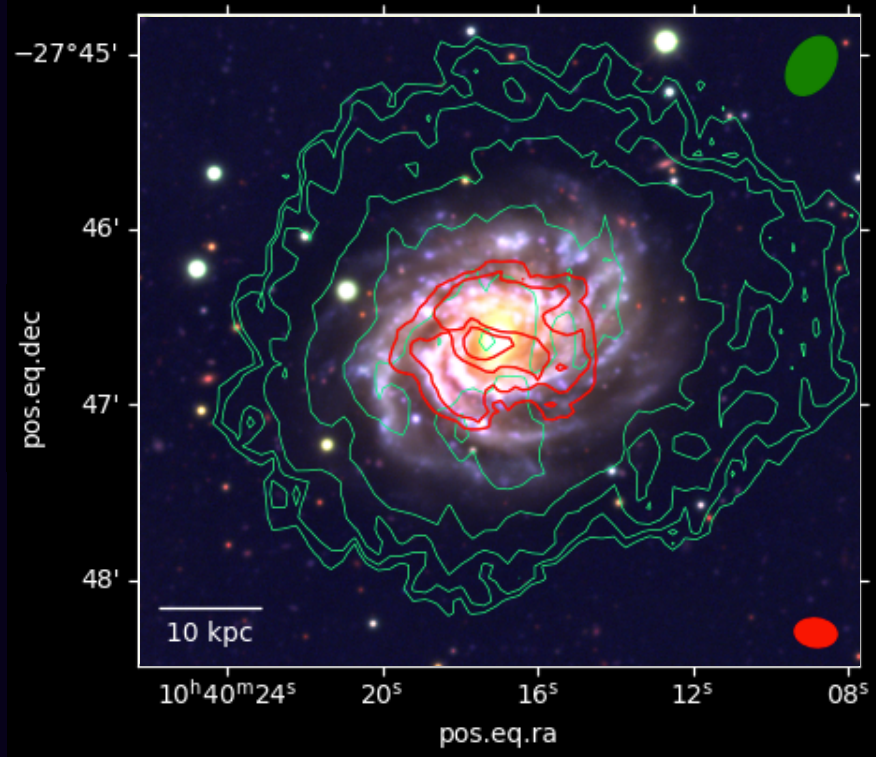
NGC 3312

ESO 501-G065

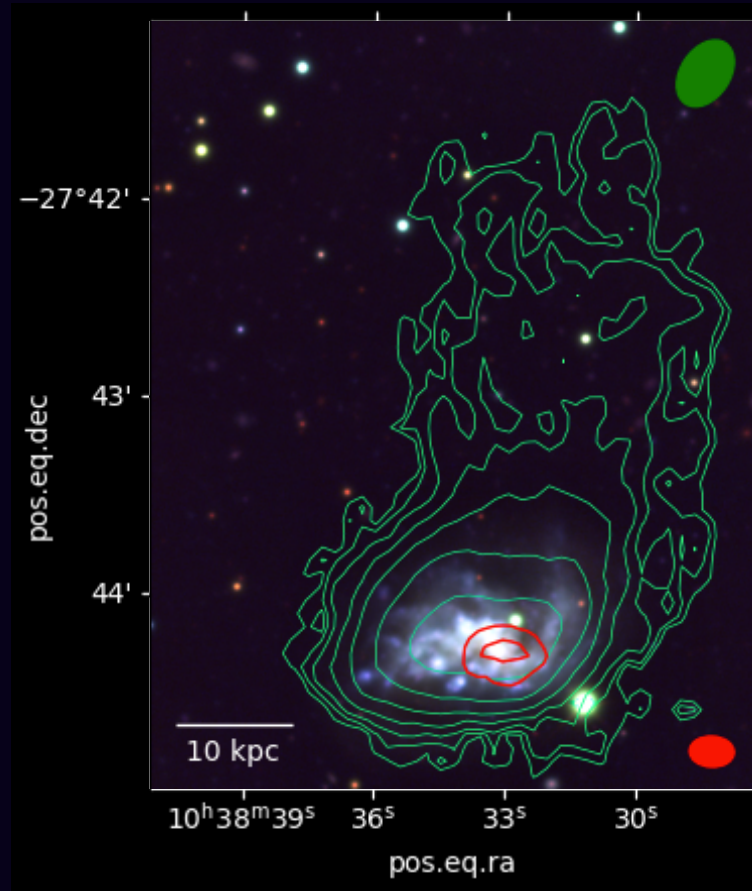
NGC 3336

Different levels of environmental interaction (or RPS at least)

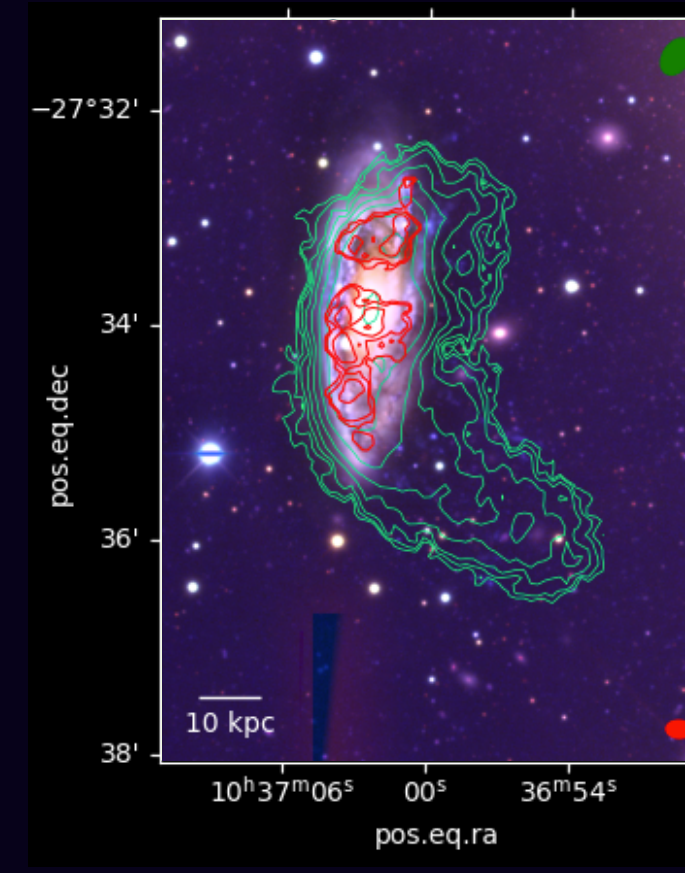
NGC 3336



ESO 501-G065

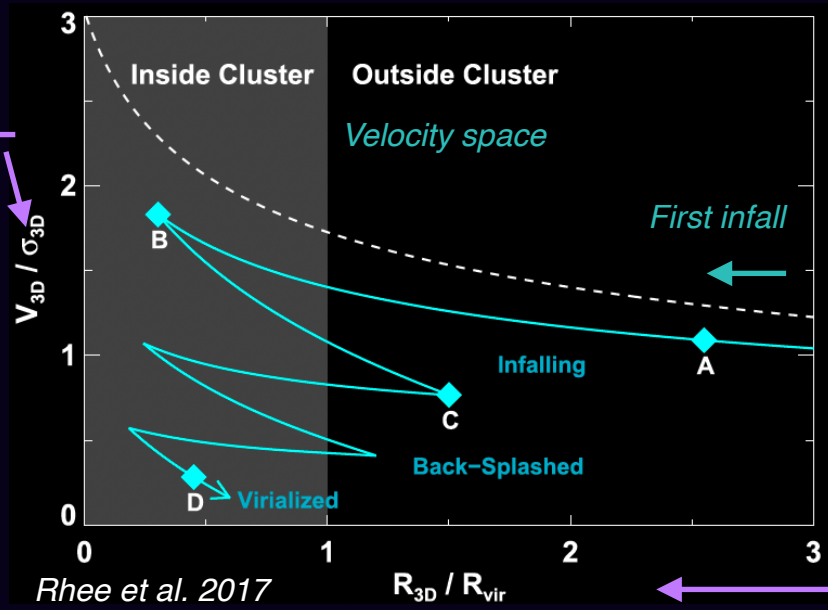


NGC 3312



Velocity of the galaxy

Velocity dispersion of cluster

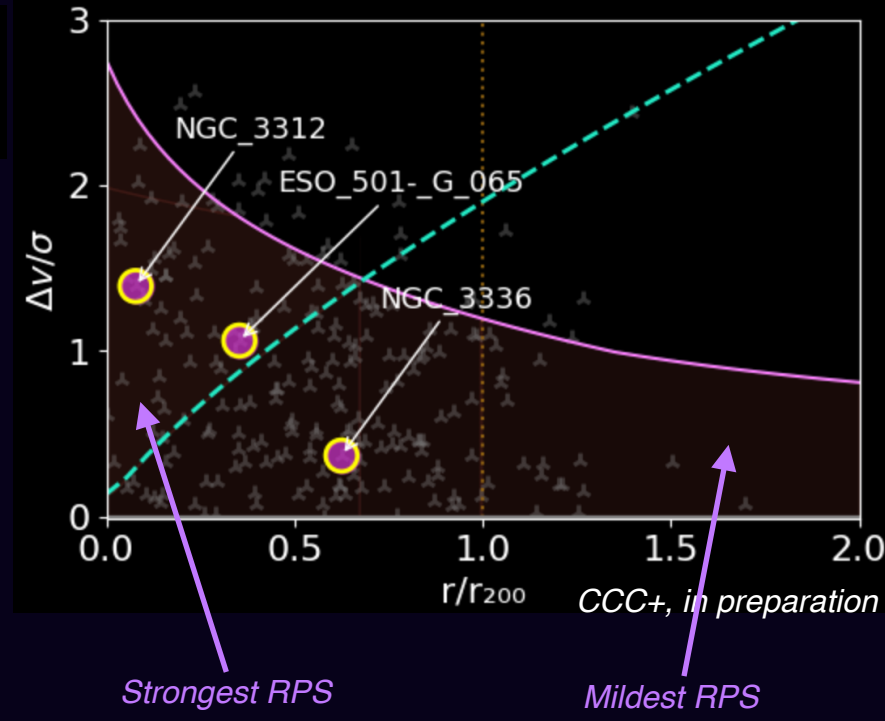
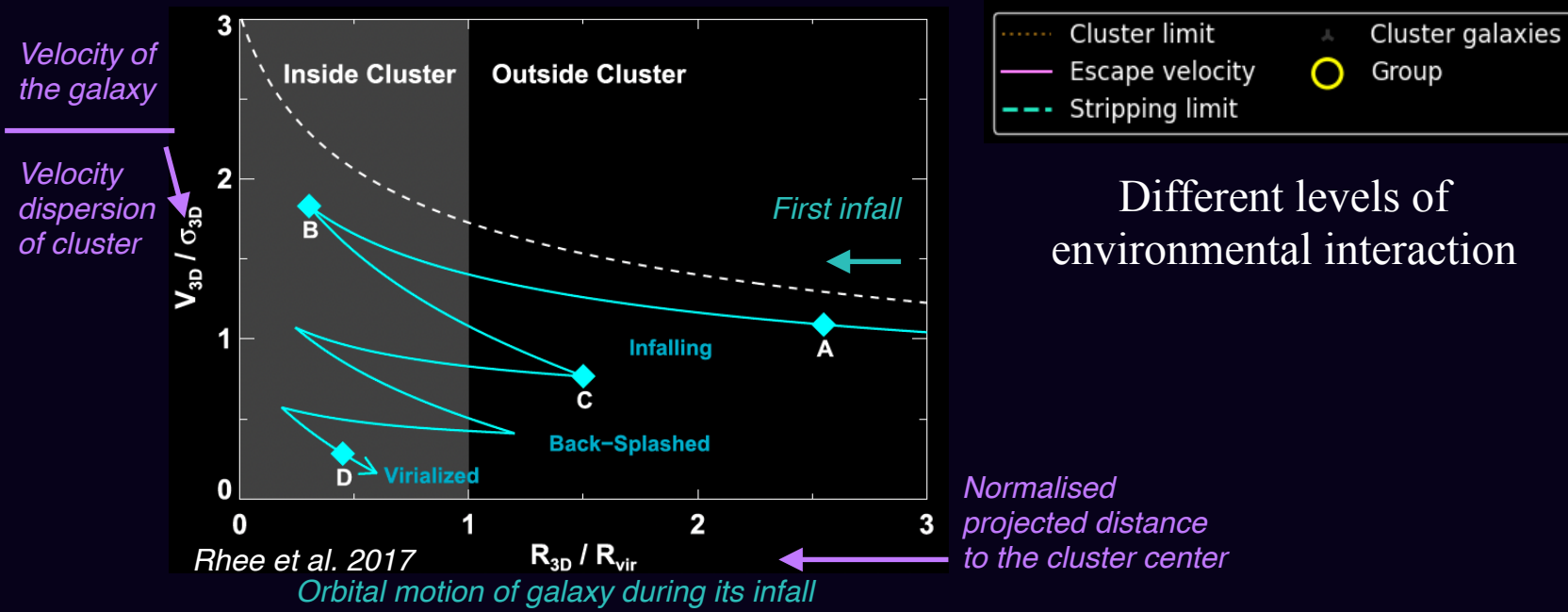


Different levels of environmental interaction

Normalised projected distance to the cluster center

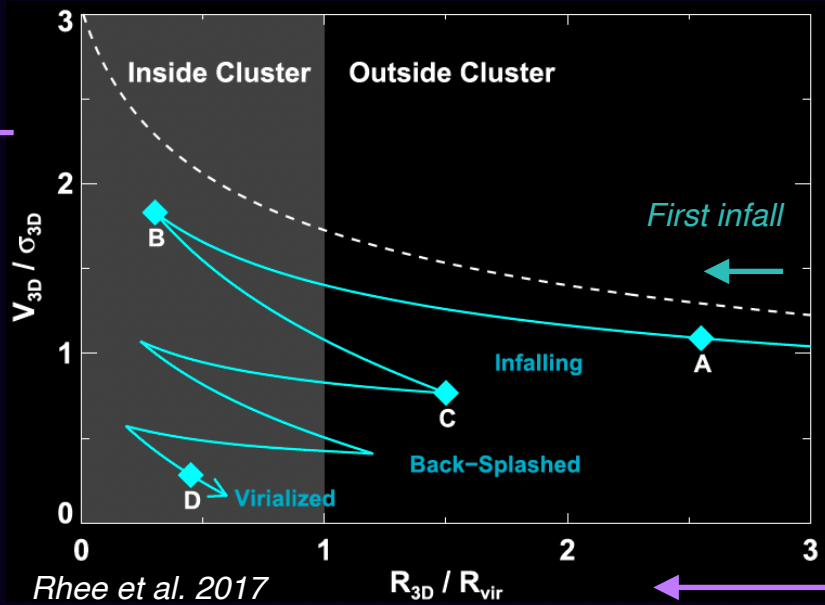
Orbital motion of galaxy during its infall

Rhee et al. 2017



Velocity of the galaxy

Velocity dispersion of cluster



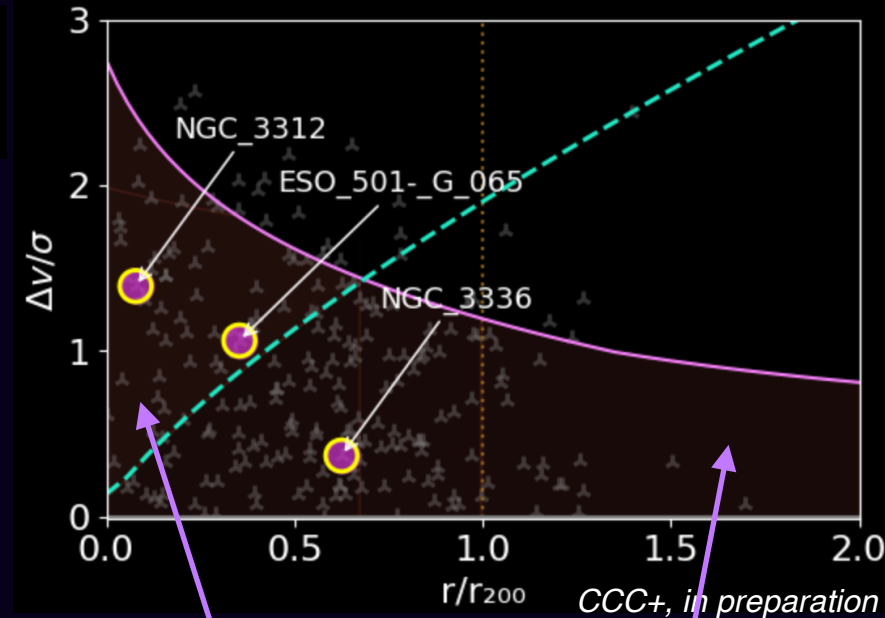
Rhee et al. 2017

Orbital motion of galaxy during its infall

Normalised projected distance to the cluster center

Different levels of environmental interaction

- Cluster limit
- Escape velocity
- Stripping limit
- Cluster galaxies
- Group

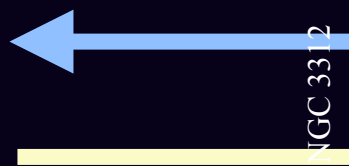


Strongest RPS

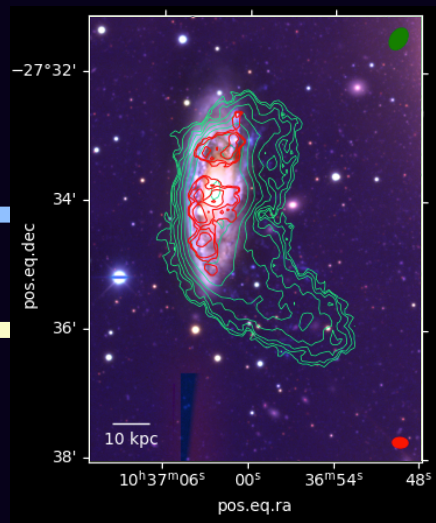
Mildest RPS

CCC+, in preparation

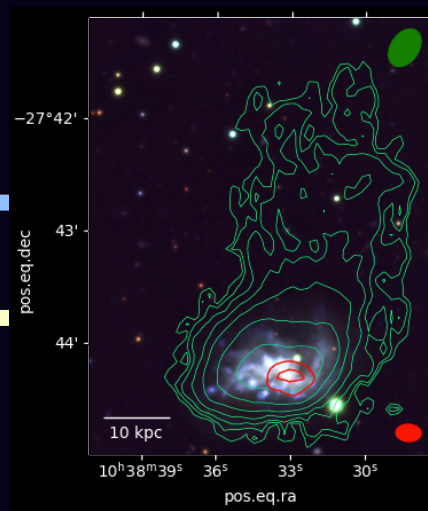
RPS



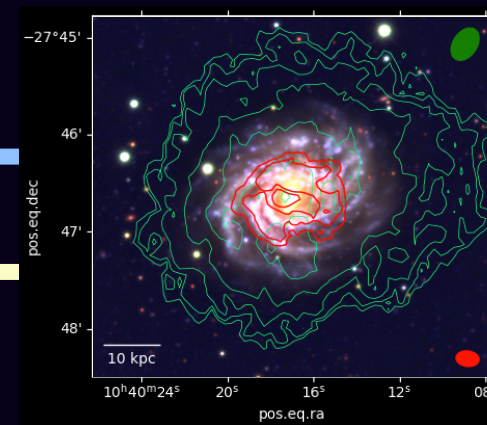
NGC 3312



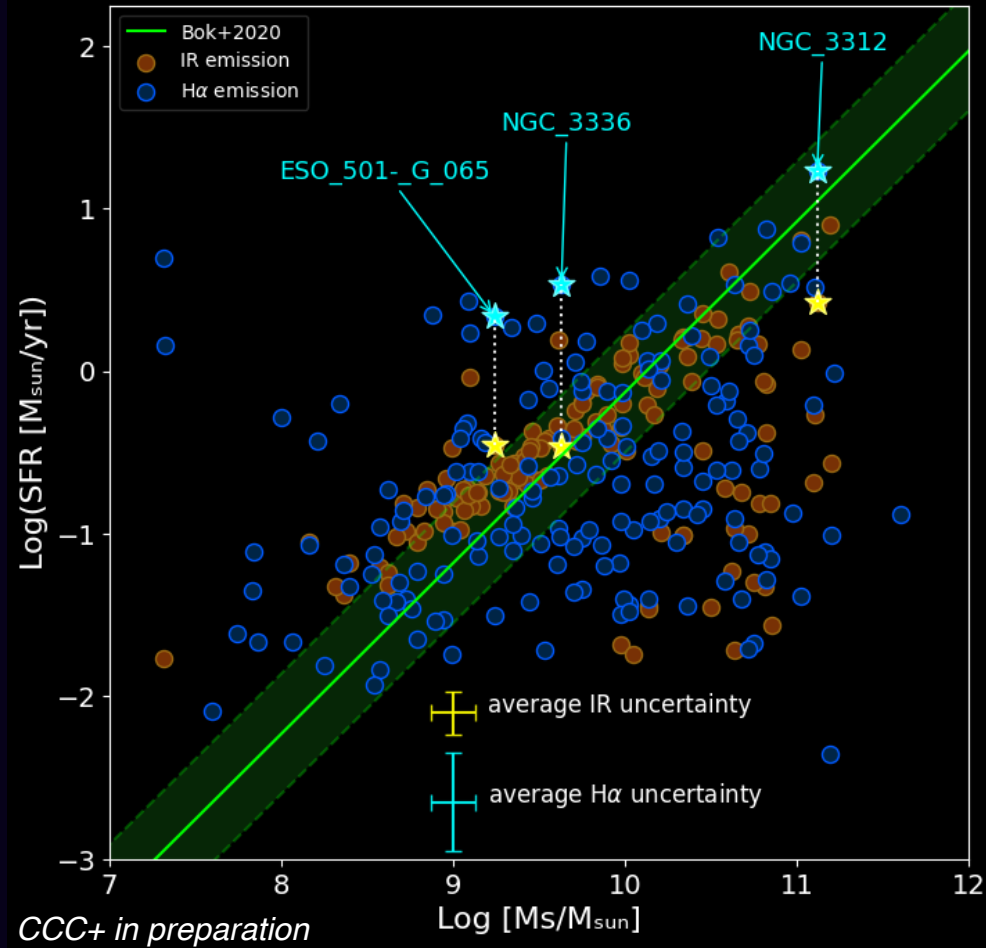
ESO 501-G065



NGC 3336



Distance to centre

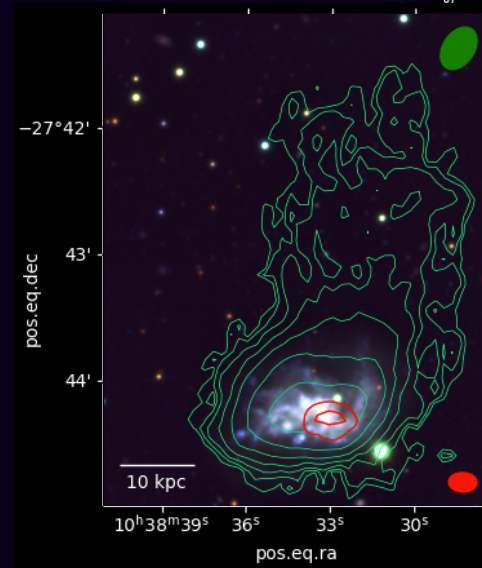


Green: Main Sequence of star formation - expected SFR for isolated galaxies with different stellar mass content

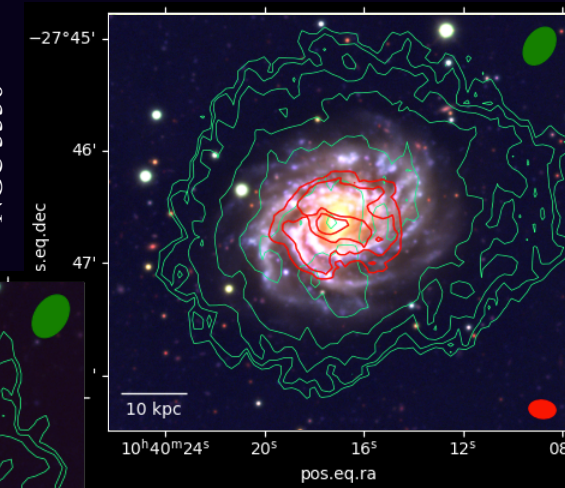
Blue: Recent SF ($\sim 10^7$ yr - H α)

Orange: Less recent SF ($\sim 10^9$ yr - WISE IR)

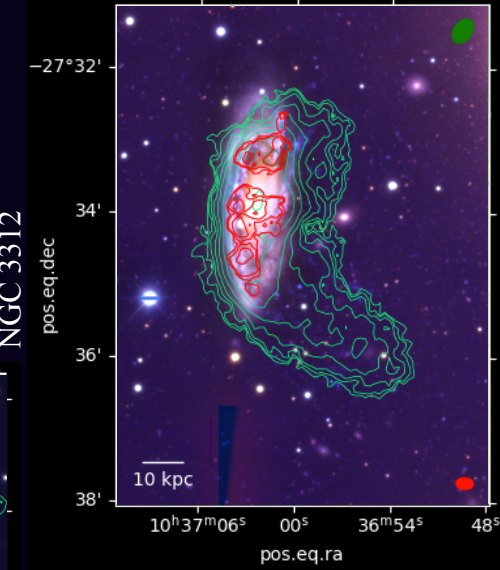
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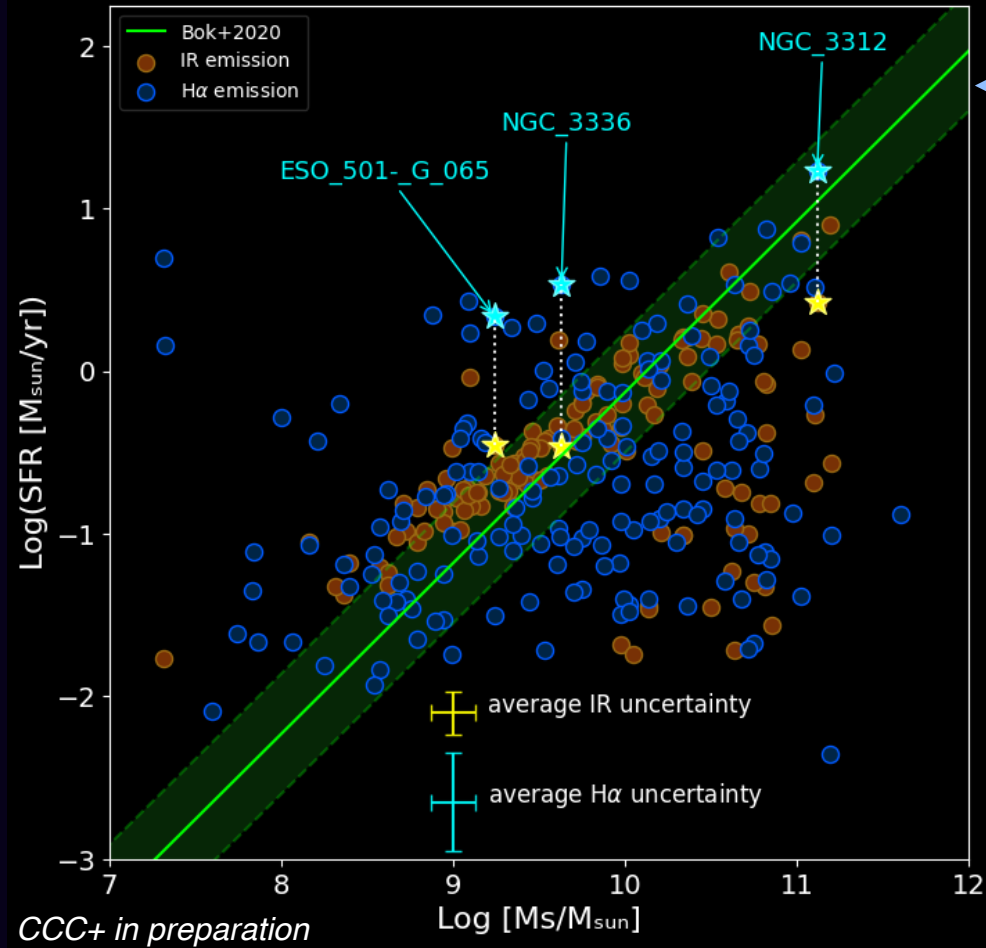


NGC 3336



NGC 3312





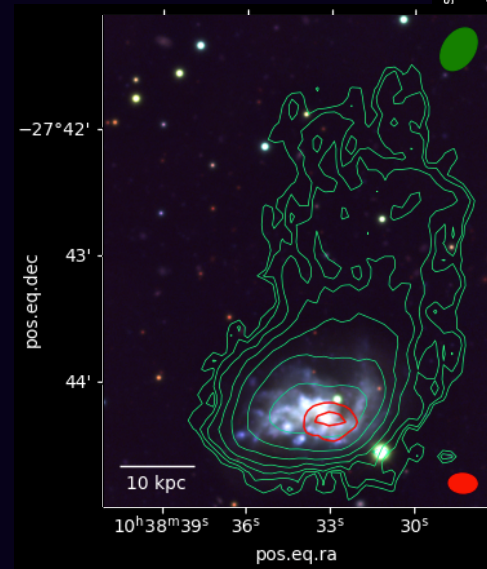
Recent burst in SF!

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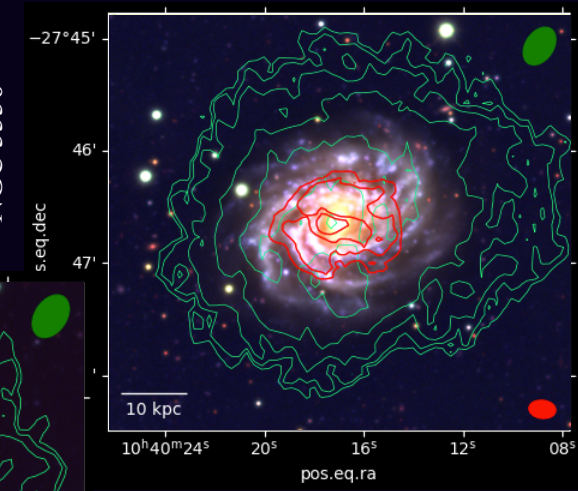
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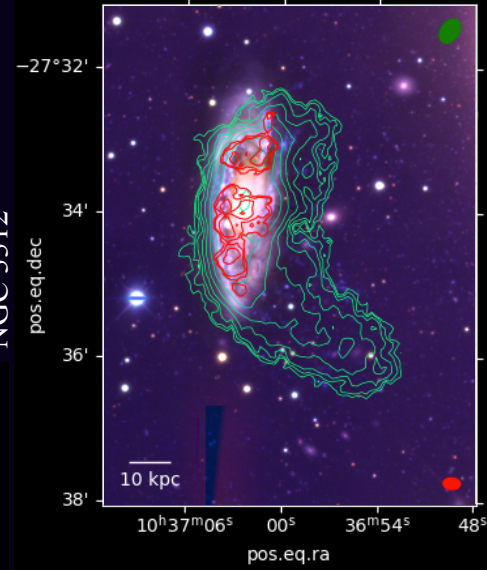
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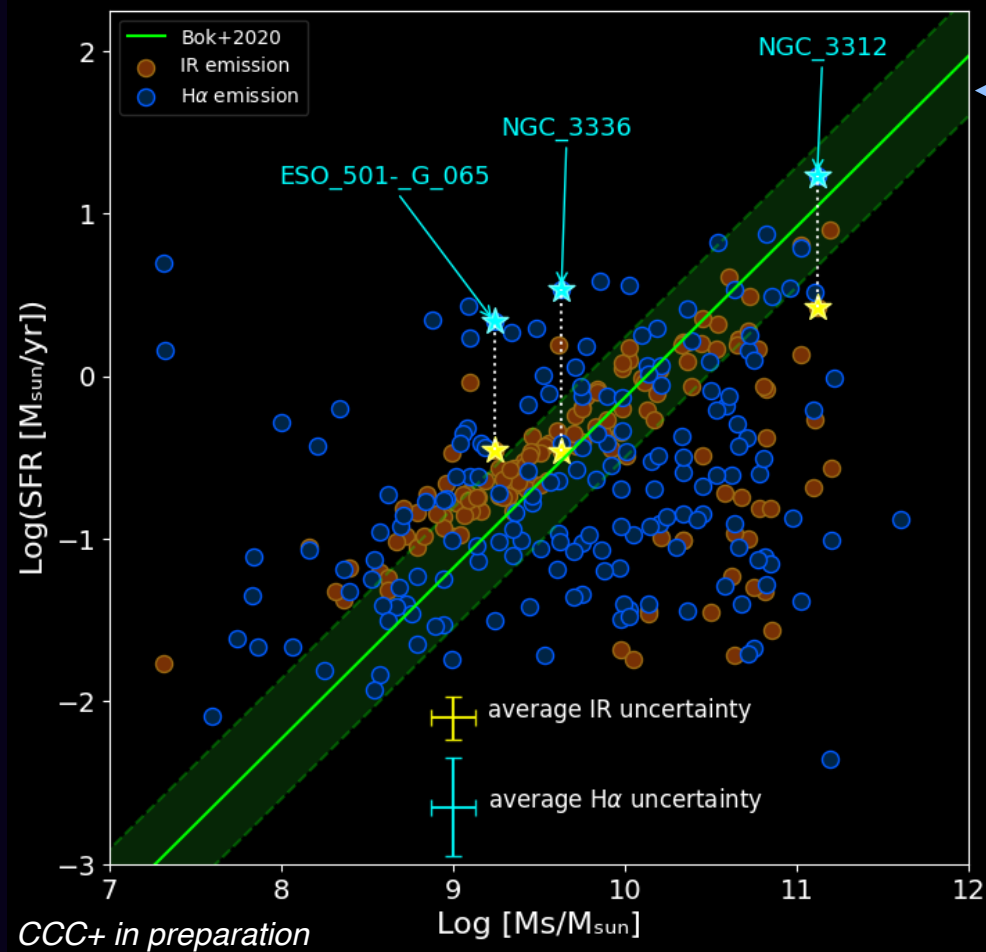


NGC 3336



NGC 3312



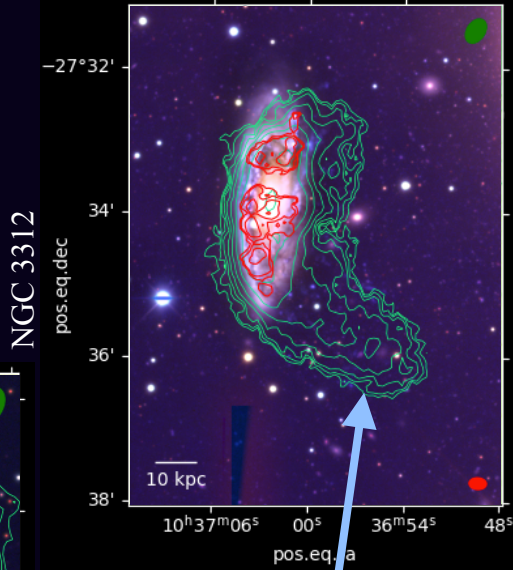
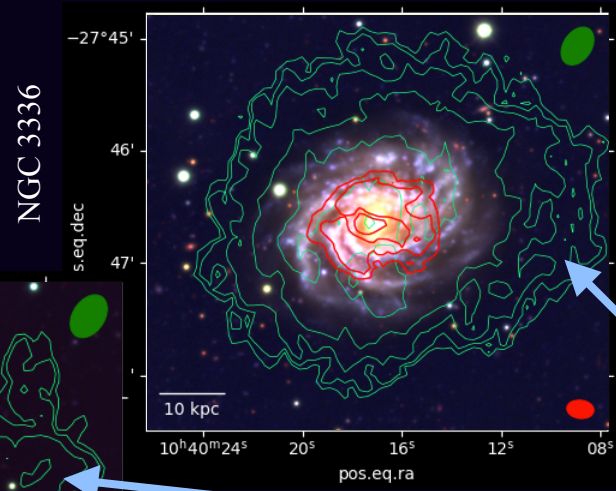
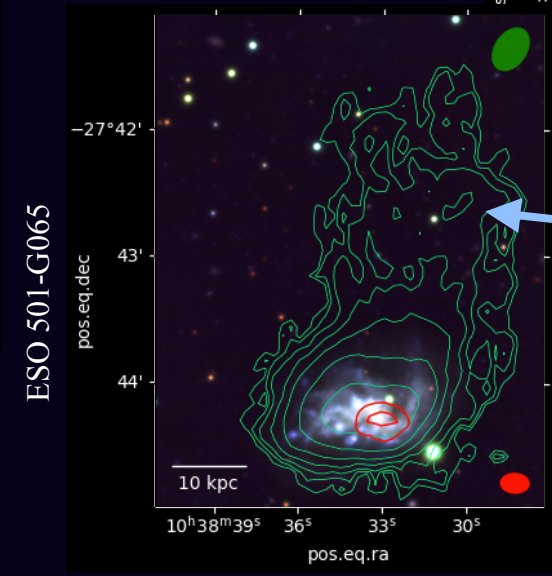


Recent burst in SF!

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SF triggered by environment?

Summary and conclusions

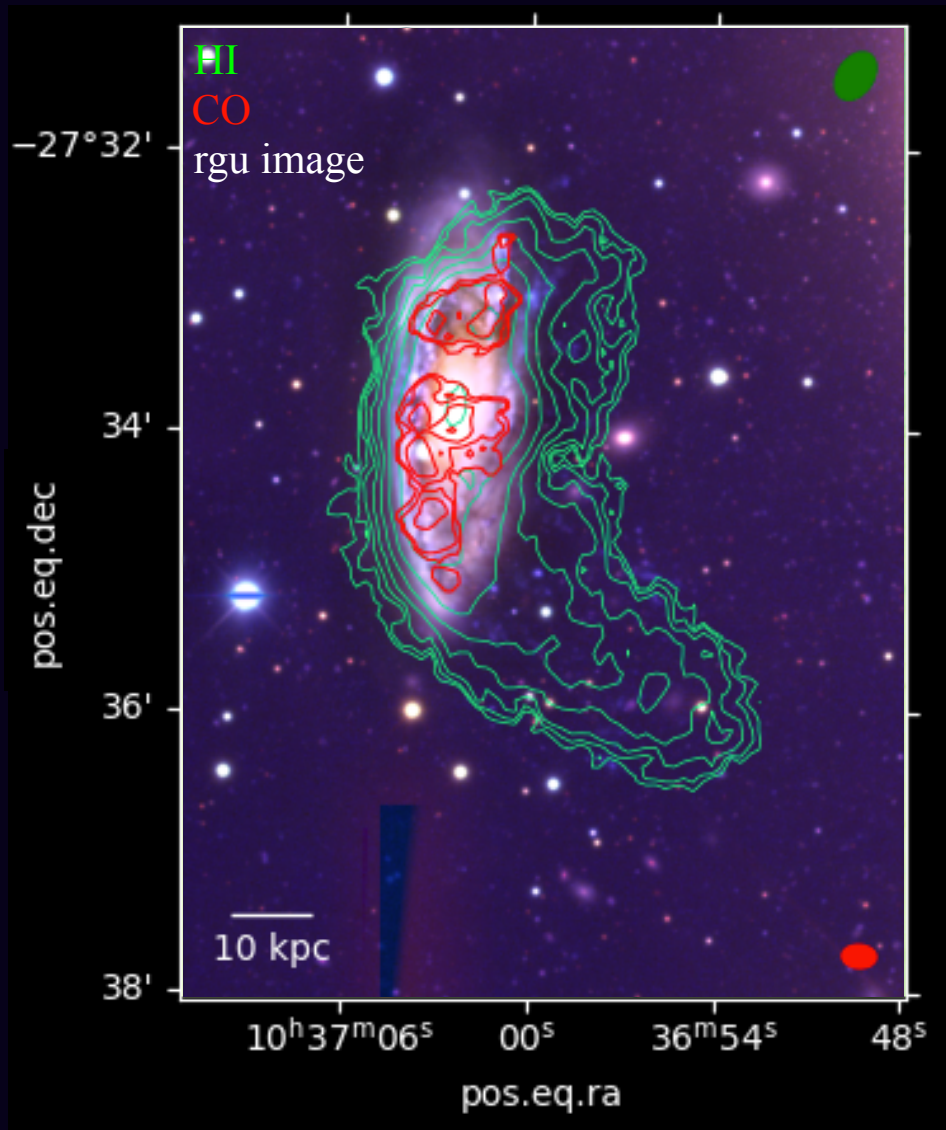
Picture of galaxy evolution limited by reachable resolution and studies focused on unique wavelength

Hydra's project: example of the potential of multiwavelength analysis combining observations from state-of-the-art facilities

The future looks even brighter:
SKA will push the boundaries even further

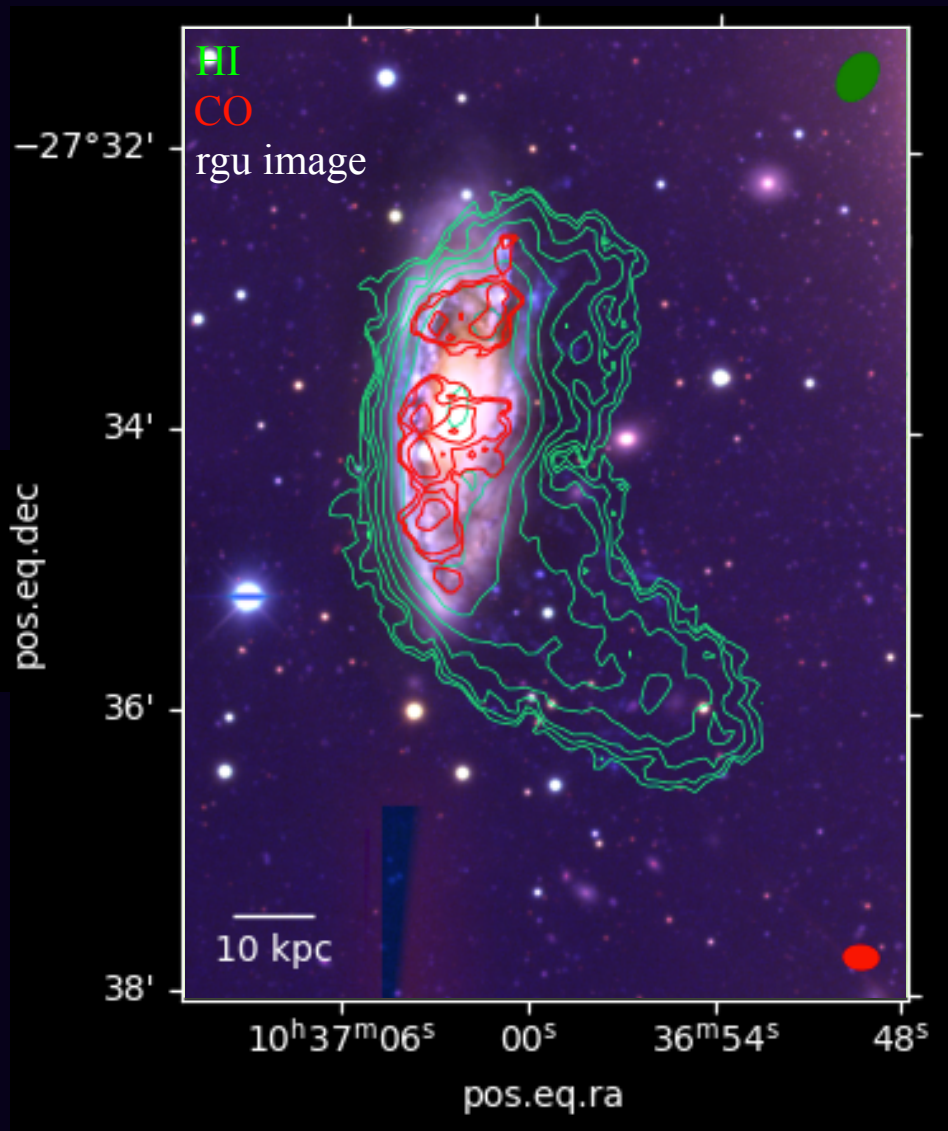
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Collaboration with future facilities: ALMA+, AtLAST,...



ANY QUESTIONS?

clarac@iaa.es



Summary and conclusions

Our picture of galaxy evolution is limited by our ability to trace multiple gas phases with optimal depth and resolution for uniform samples of galaxies across the whole parameter space

Hydra's multiwavelength effort to characterise galaxy evolution and the influence of environment is an example of the many exciting studies that combine the potential of state-of-the-art facilities, and how they can impact our knowledge of galaxy evolution and large scale structure assembly of the Universe

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+

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EXTRA MATERIAL

<https://indico.chalmers.se/event/47/registrations/7/?token=f80e900e-8347-4a44-bedc-42efbe6ed323>

15 min + 5QQ