Merger-driven star formation activity in Cl J1449+0856 at z=1.99 as seen by ALMA and VLA

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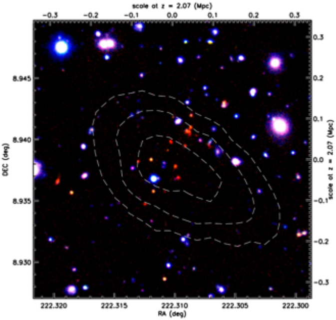
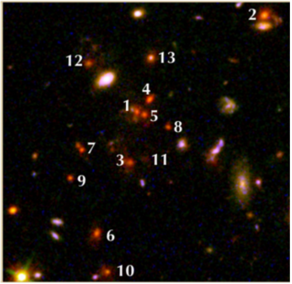
Journées National PNCG, Lyon 2017

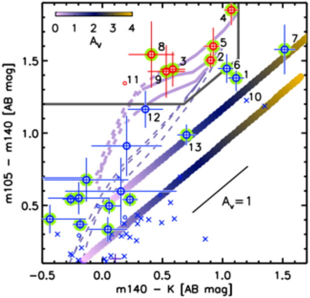
An old cluster in a young Universe

CL J1449+0856



R. Gobat et al. 2011





V. Strazzullo et al. 2016

X-ray detected cluster at z=1.99! Spectroscopically confirmed.

Observations: ALMA and JVLA

Tracing cold molecular gas through ^{12}CO

^{12}CO as a tracer for cold H_2 gas. $$M_{H_2} = \alpha_{CO} L_{CO}$$

ALMA:

- **Continuum** at 850μm, 2mm, 3mm: dust
- CO rotational transitions J=4-3, J=3-2: excited, dense gas

JVLA:

- Continuum at 7mm
- CO rotational transition J=1-0: total molecular gas reservoir

Detect cold gas at different densities, different modes of star-formation: MS or SB?

Continuum detections of star-forming galaxies

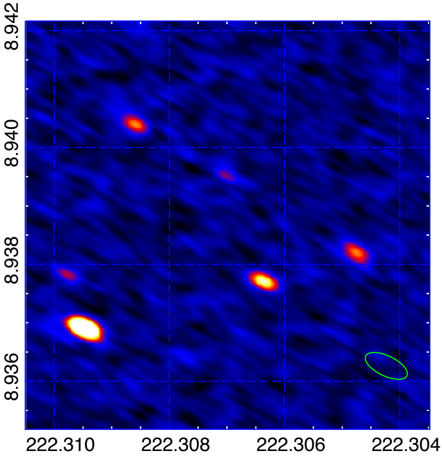


Figure: 850μm continuum

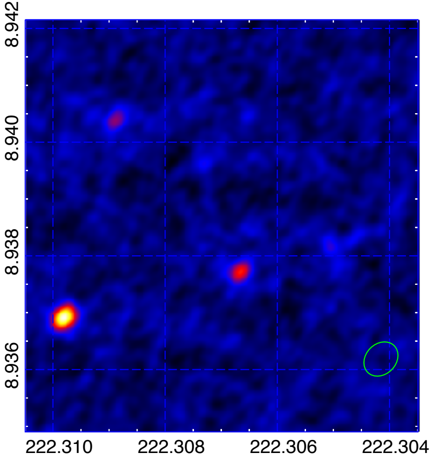
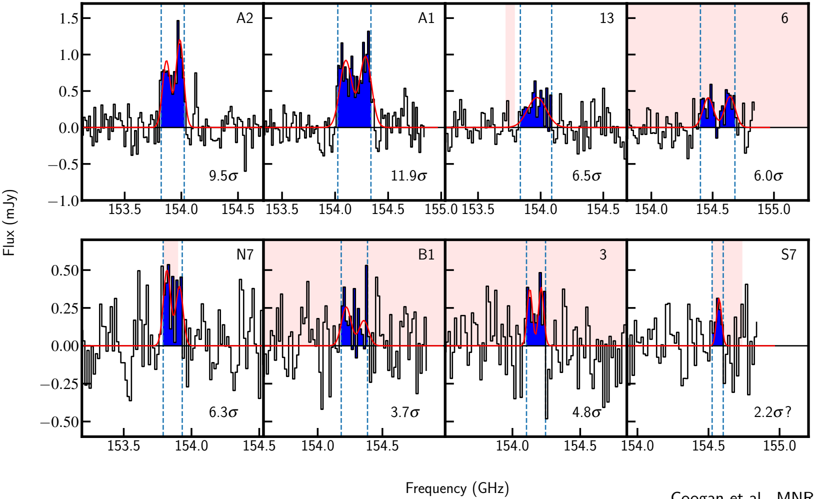


Figure: 2mm continuum

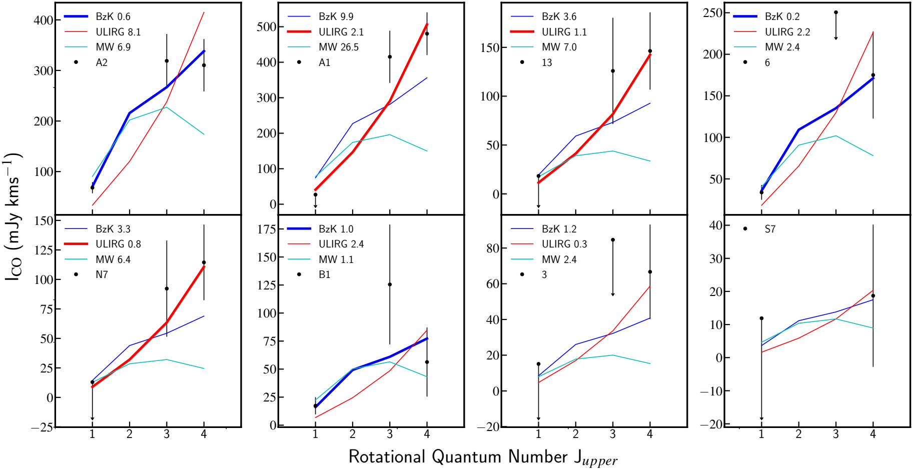
Molecular gas detections through CO J=4-3



Coogan et al., MNRAS submitted

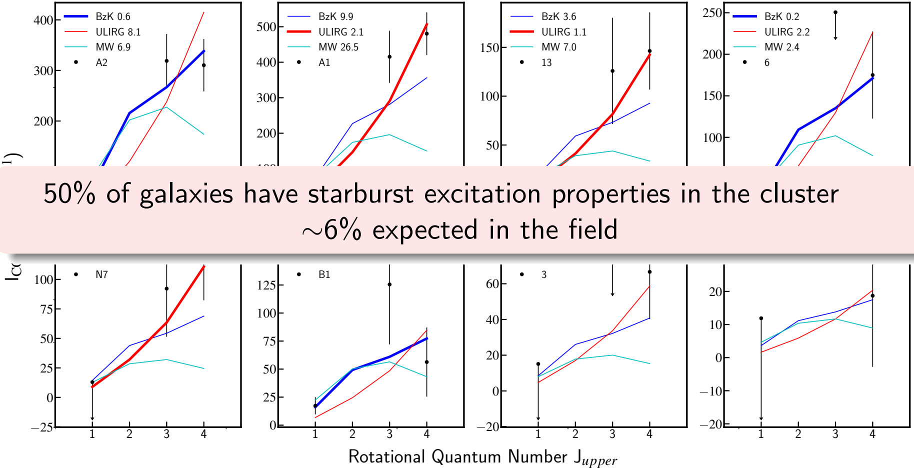
Secure detections of excited, dense molecular gas in cluster galaxies

CO Spectral Line Energy Distributions



Coogan et al., submitted

CO Spectral Line Energy Distributions

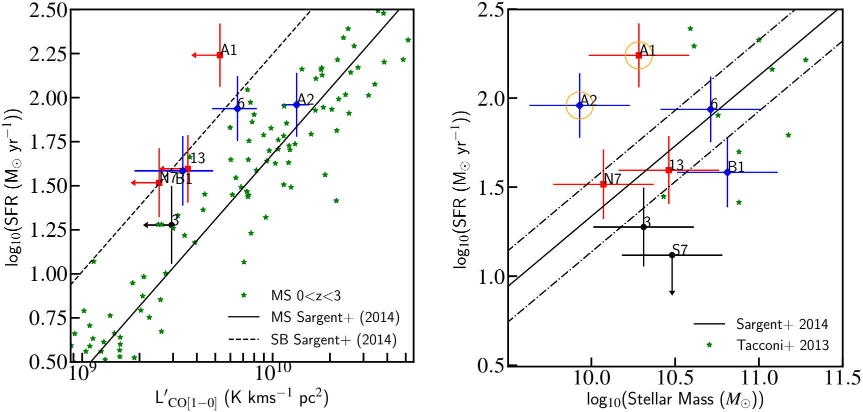


50% of galaxies have starburst excitation properties in the cluster
~6% expected in the field

Coogan et al., submitted

Star Formation Efficiency

SFR-$L'_{CO[10]}$ relation, sSFR



Strazzullo et al., submitted, Coogan et al., submitted

Star Formation Efficiency

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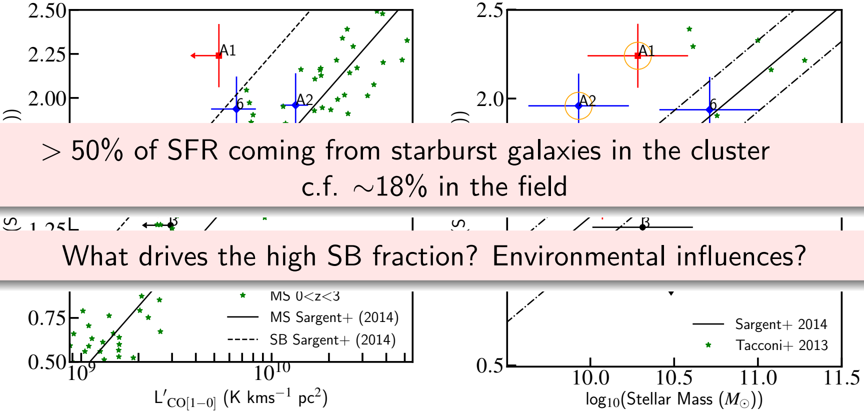
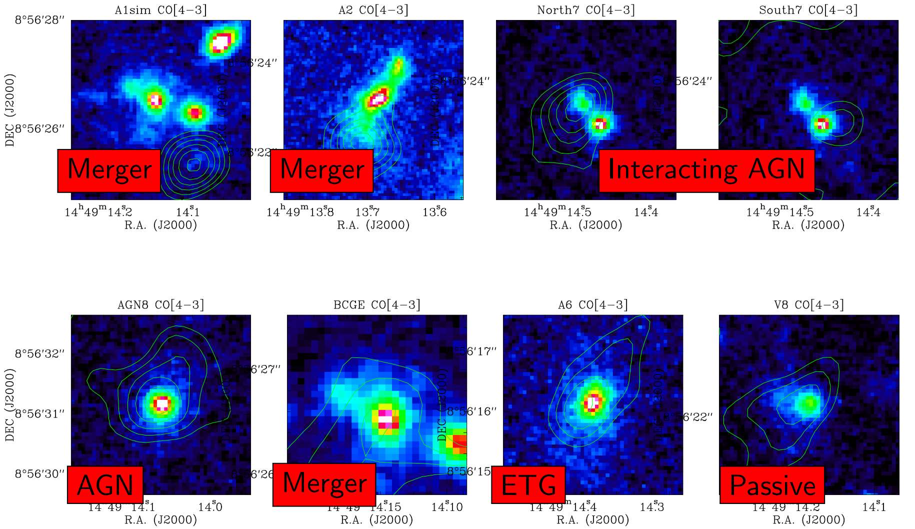


$>$ 50% of SFR coming from starburst galaxies in the cluster
c.f. $\sim$18% in the field

What drives the high SB fraction? Environmental influences?

Strazzullo et al., submitted, Coogan et al., submitted

What drives the high SB fraction?



Coogan et al., submitted

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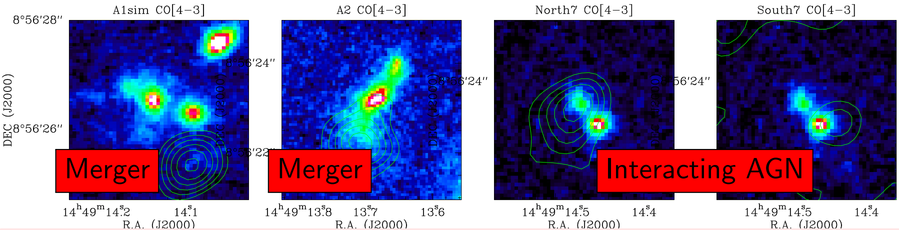
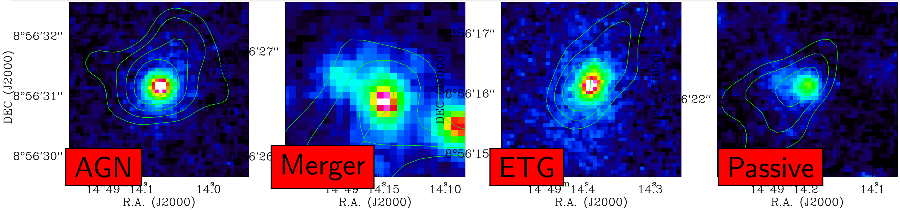


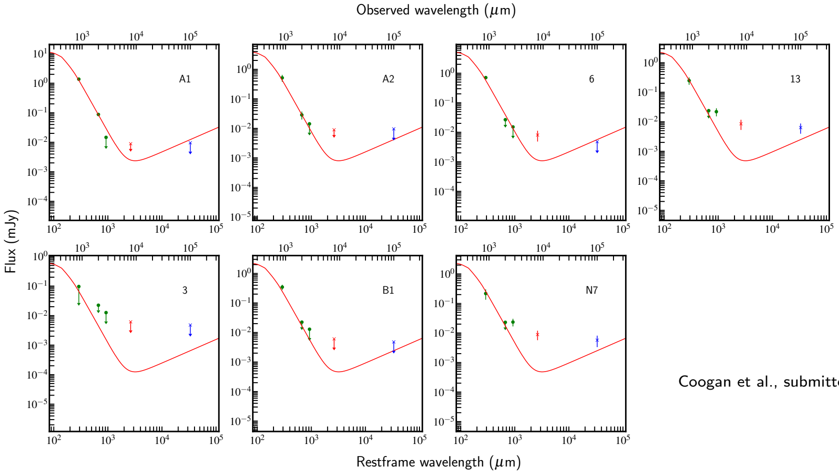
High fraction of mergers and interactions driving the high starburst fraction



Coogan et al., submitted

Dust Masses and H_2 masses

- $L'_{CO(10)}$ and M_d consistent, α_{CO} and G/D from FMR

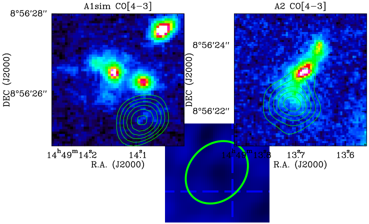


Coogan et al., submitted

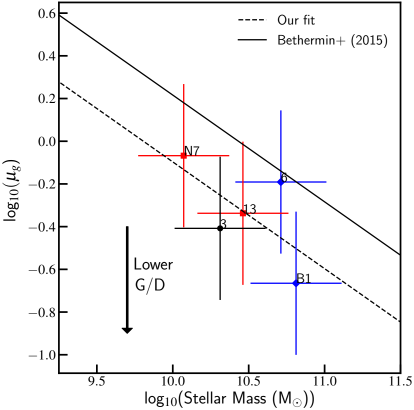
Dust Masses and H_2 masses

Gas fractions and depletion timescales

ID	μ_g	$\log\tau_{dep}$ (yrs)
A1	$1.00^{*+1.66}_{-0.62}$	7.97±0.35
A2	$1.00^{*+1.66}_{-0.62}$	7.98±0.35
A6	$0.64^{+0.75}_{-0.35}$	8.58±0.24
13	$0.46^{+0.54}_{-0.25}$	8.53±0.24
3	$0.39^{+0.46}_{-0.21}$	8.63±0.27
1	$0.22^{+0.25}_{-0.12}$	8.56±0.25
N7	$0.86^{+1.00}_{-0.46}$	8.49±0.25

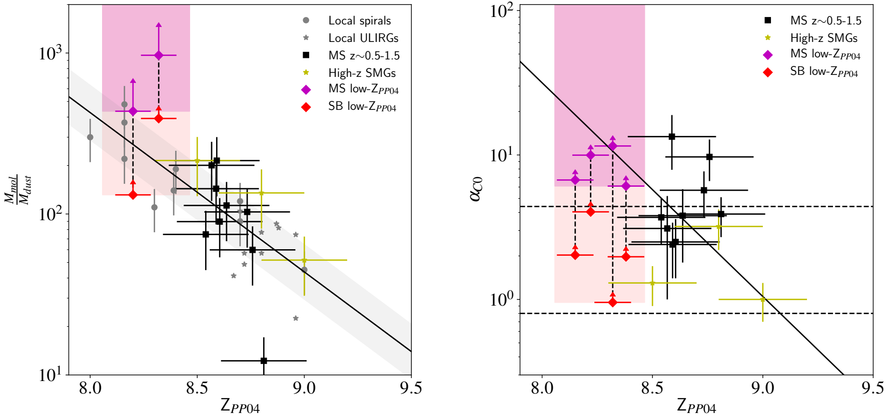


Coogan et al., MNRAS submitted



Low-metallicity Galaxies

Preliminary Work

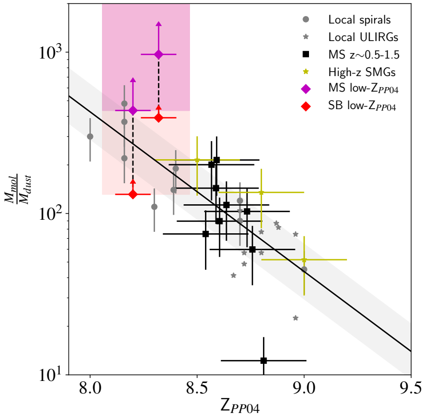


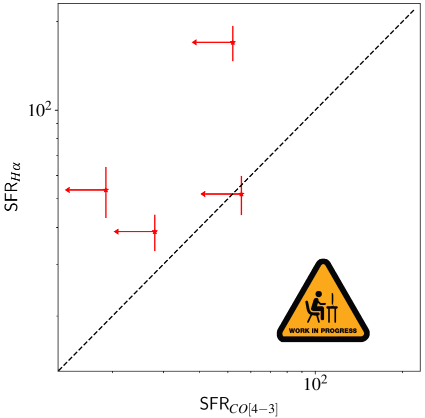
Magdis et al., 2012, Valentino et al. 2015, Coogan et al., in prep.

Direct observations of dust and gas in low-Z galaxies at z=2

Effect of low-Z on high-J CO transitions - different SFR tracers

Low-metallicity Galaxies
Preliminary Work





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Direct observations of dust and gas in low-Z galaxies at z=2

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Summary

- A transitioning cluster provides insight into environmental influence on the gas content of galaxies
- High fraction of starburst-like excited galaxies
- High fraction of mergers and interactions
- Outlook
  - Resolved gas observations
  - Gas and dust content of passive galaxies
  - Low-metallicity galaxies at high z