A survey of molecular gas in HI-Absorption-Selected Systems

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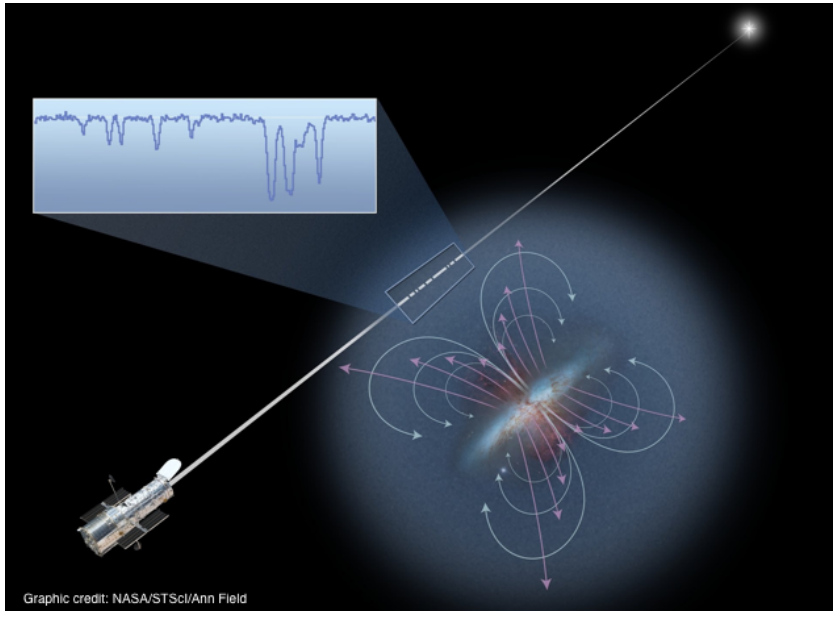
Short Introduction

Absorption-selected systems

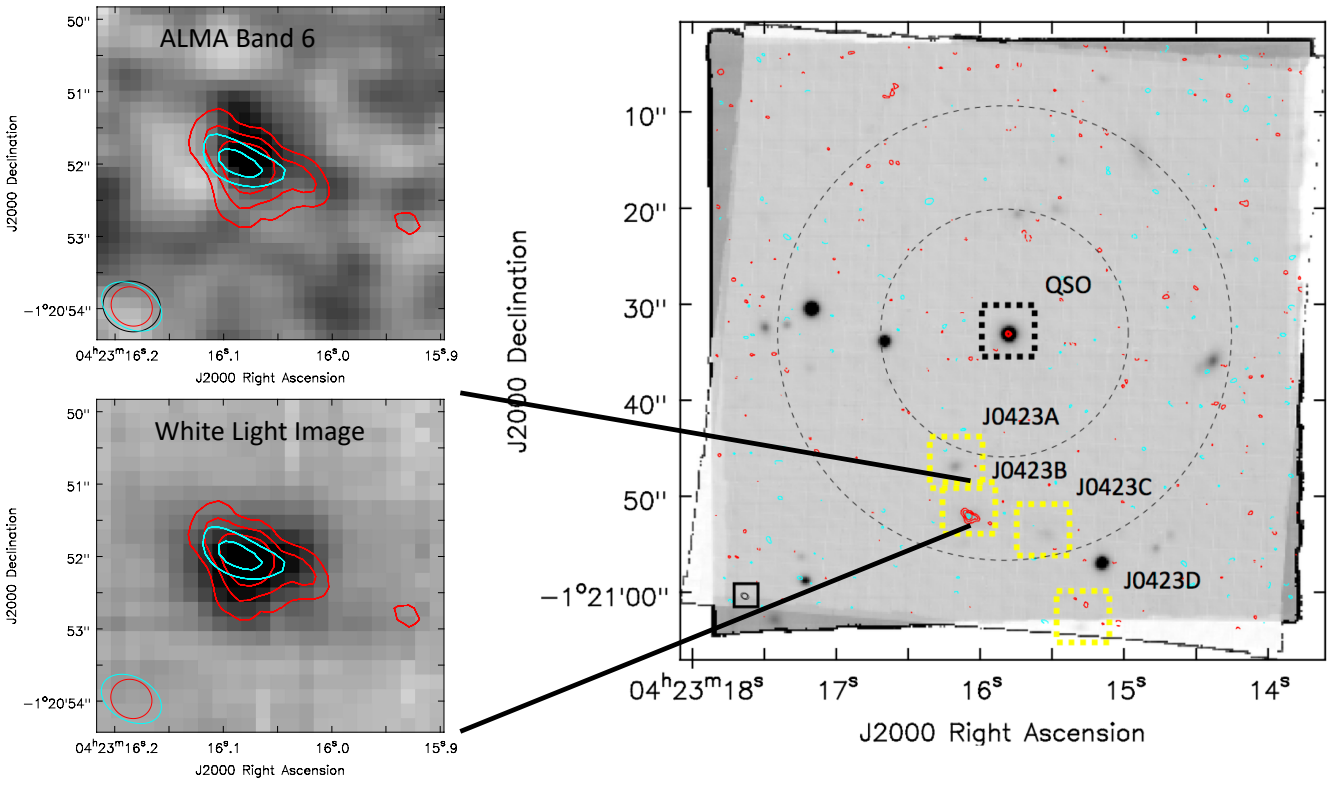
Our Tools and Aims

- Use intervening absorbers to study the CGM.
- Study the multiphase ISM and CGM of the connected galaxies (neutral, ionized and **molecular** gas)
- Understand the flow of bayons into and out of galaxies



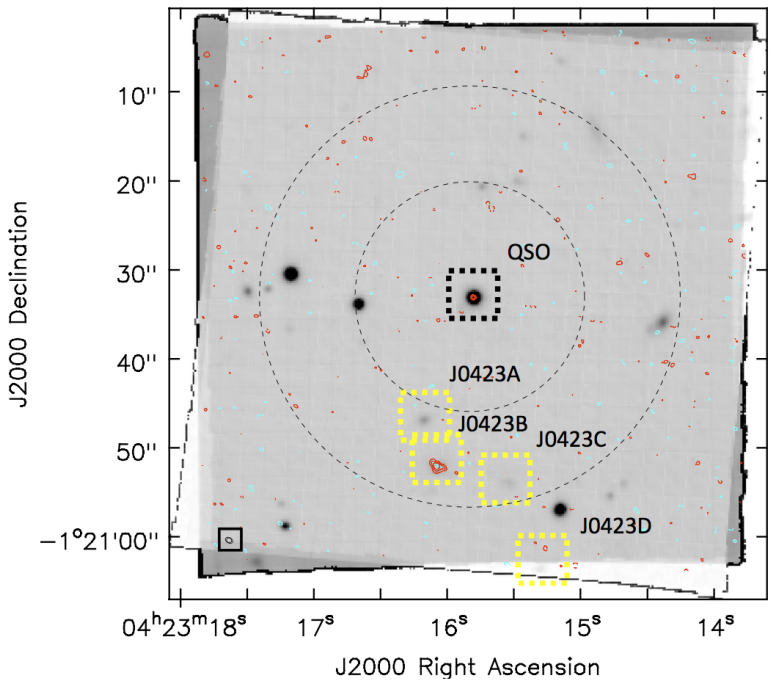
The Power of ALMA and MUSE

Census of the cold gas phase



HI absorber towards J0423−0120 at $z = 0.633$

MUSE DDT observations reveal galaxy group



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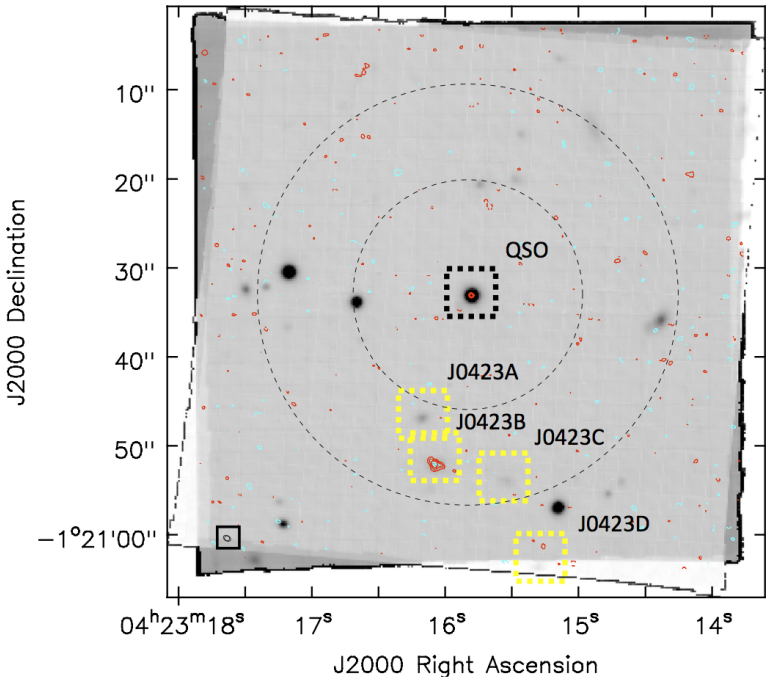

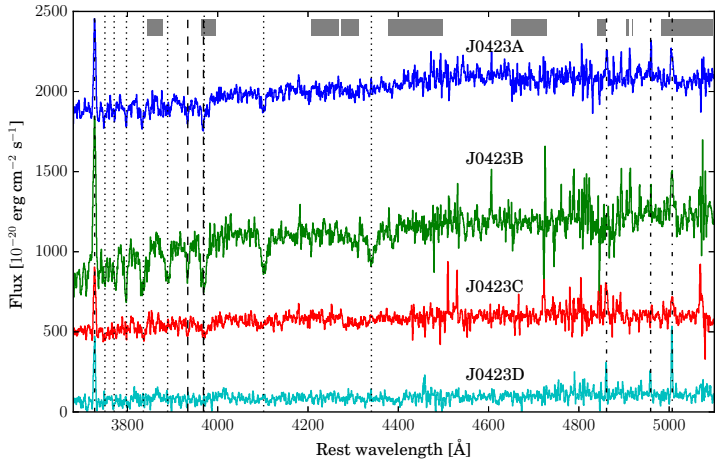

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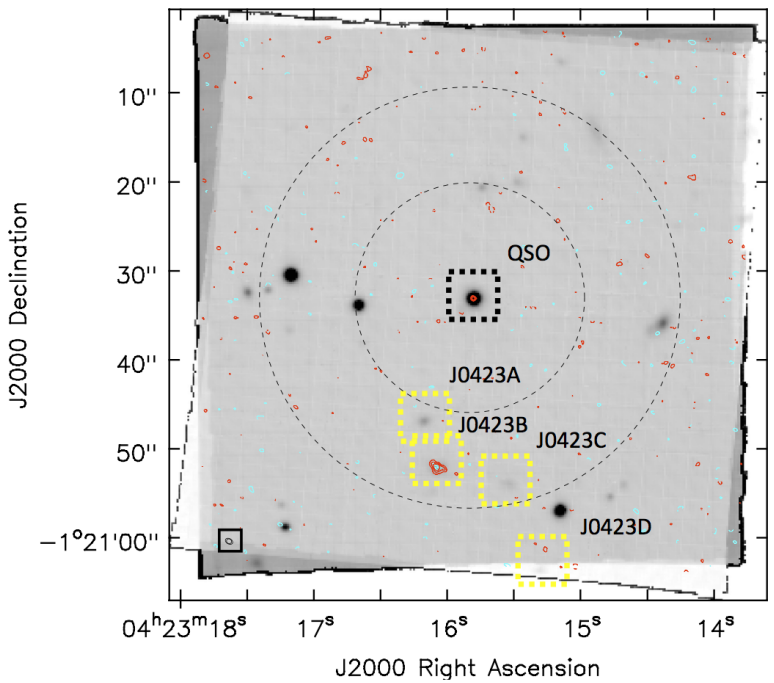
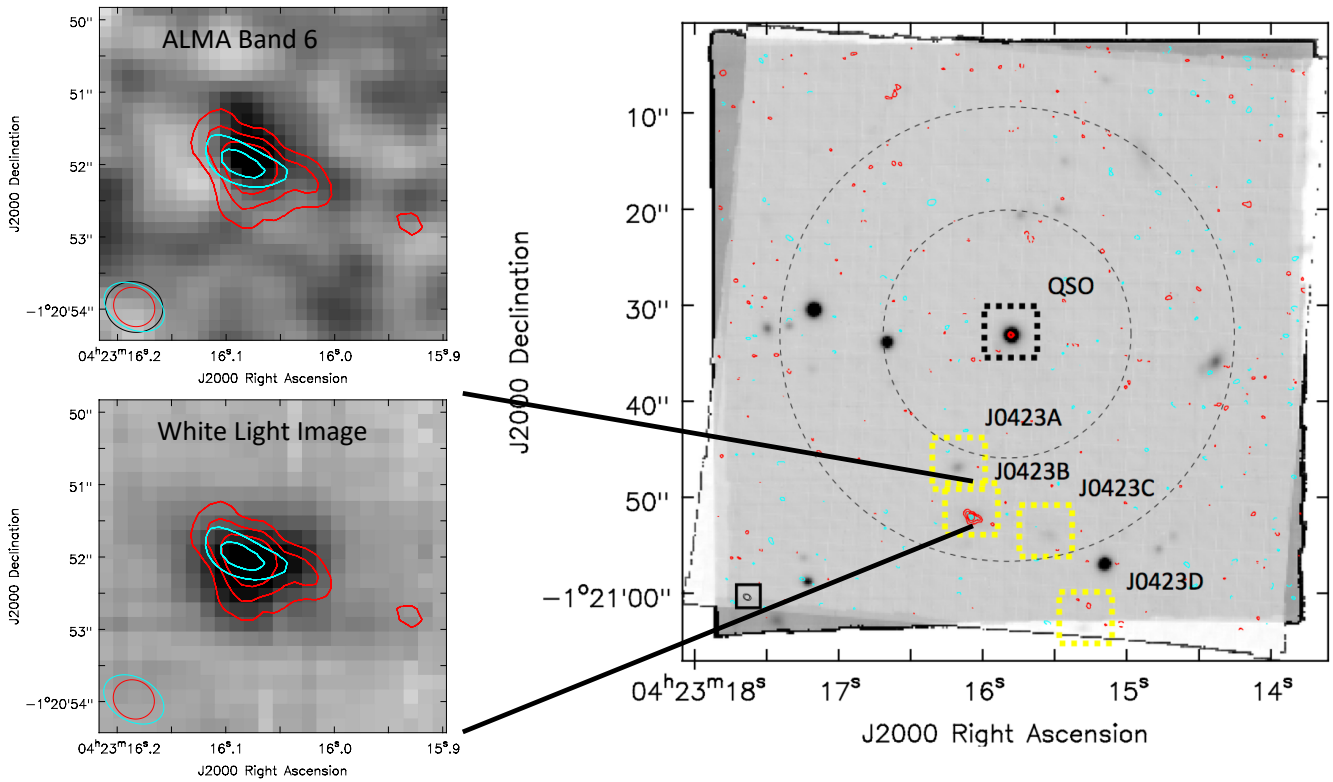


- Identify 4 galaxies at the absorber redshift
- Super solar metallicity

Name	$M_\star$ [$M_\odot$]	SFR [$M_\odot$/yr]
A, C, D	$\sim 10^{10.3}$	$3 - 7.5$
B	$\sim 10^{11.2}$	~ 50

HI absorber towards J0423−0120 at $z = 0.633$

ALMA observations indicate large molecular gas reservoirs



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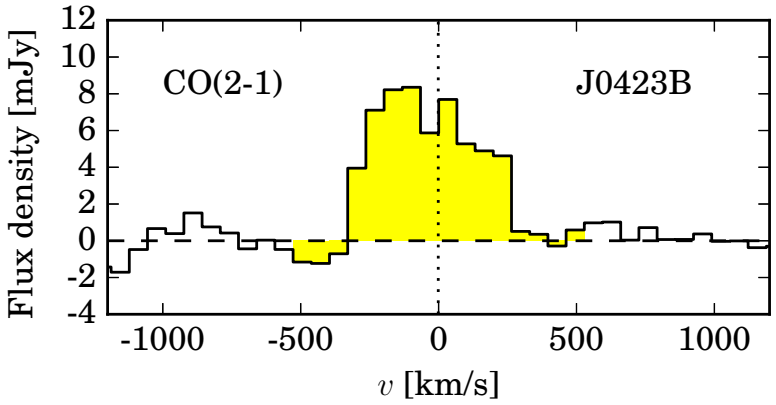
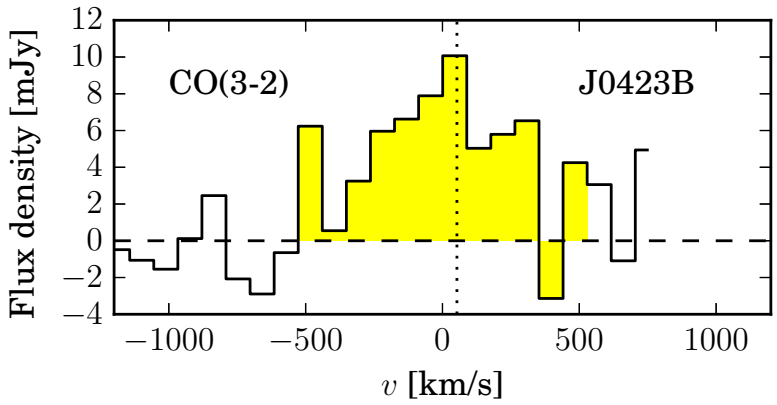


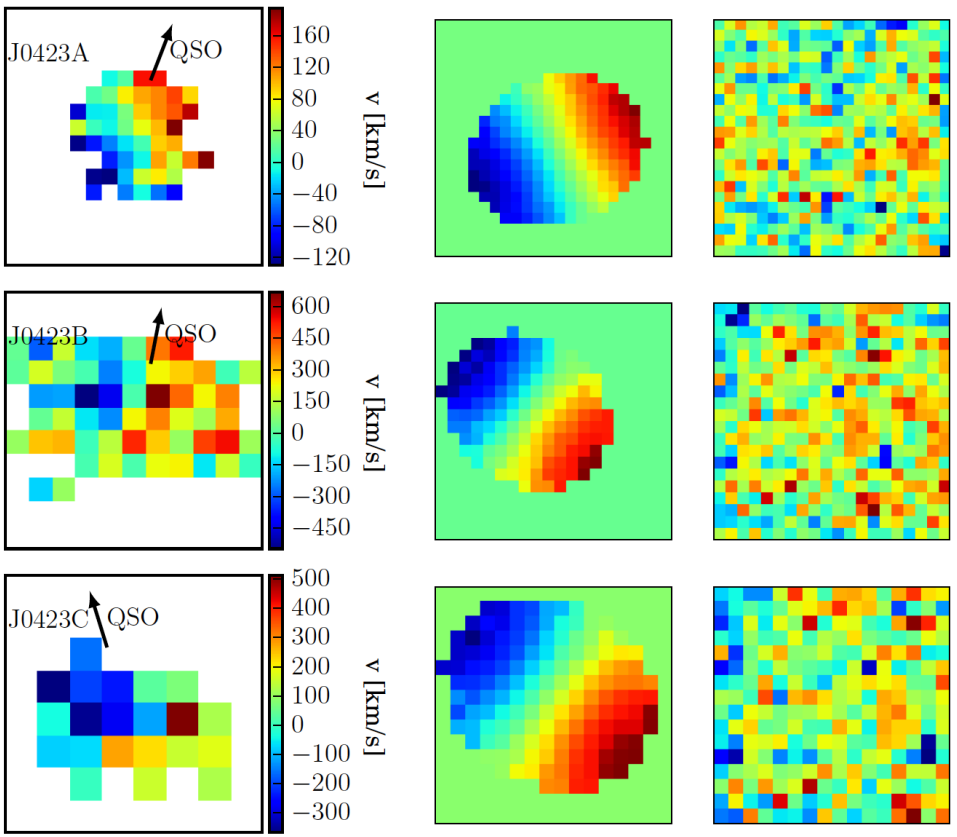


- Line width: FWHM ~ 600 km/s
- Emission line ratio suggest LIRG-type ISM conditions.
- Molecular gas mass: $M_{H2} = 1.3 \times 10^{10}\ M_{\odot}$

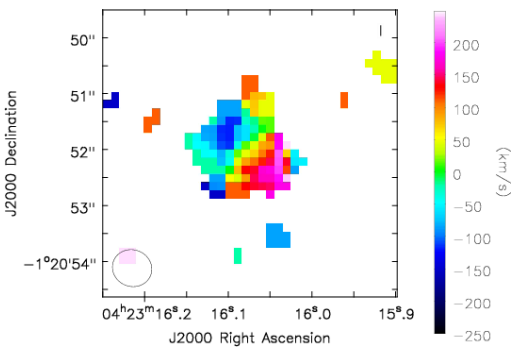
HI absorber towards J0423−0120 at $z = 0.633$

Comparable kinematics in ionized and molecular gas

Ionized Gas



Molecular Gas



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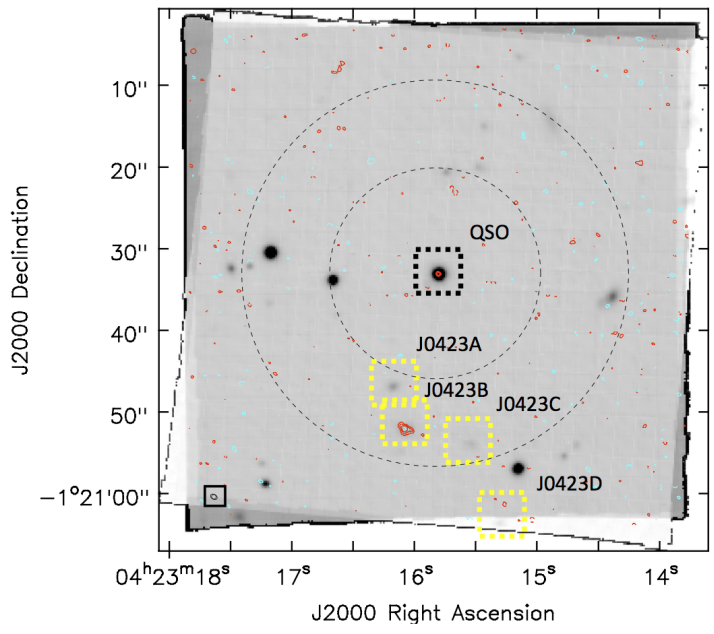
Outflow or intra-group gas detected in absorption



- Are we missing another galaxy?
  - b >100 kpc
  - Limiting SFR: 0.2 $M_\odot$/yr (field), 0.3 $M_\odot$/yr (QSO)

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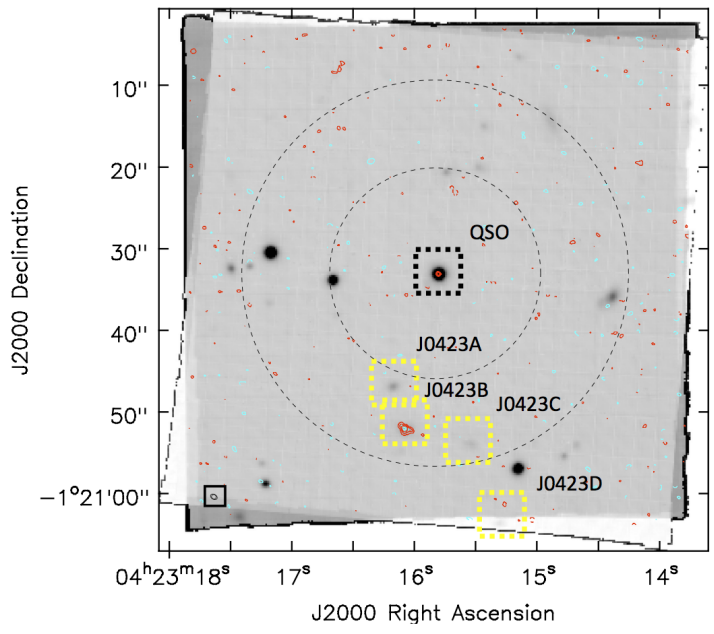
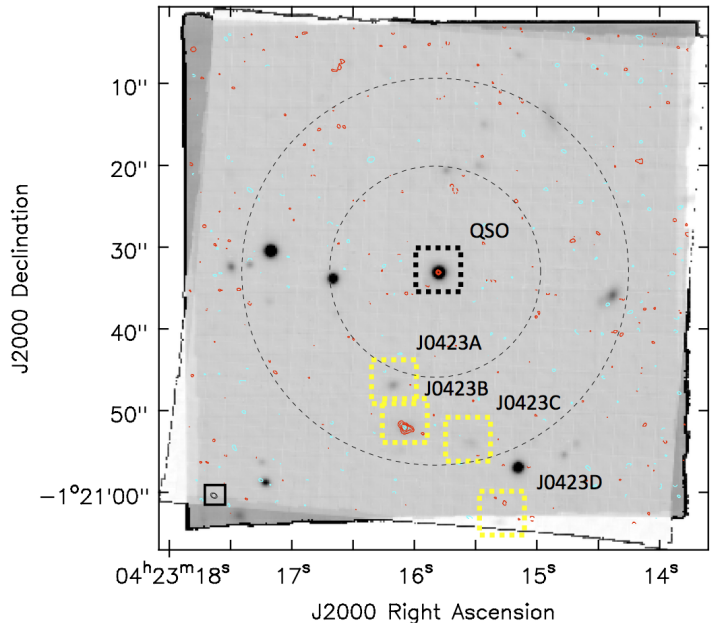


HI absorber towards J0423−0120 at $z = 0.633$

- Are we missing another galaxy?
- Could it be outflow from J0423B?
  - Aligned with the minor axis
  - If $v_{\rm out} =$ **300km/s** $\Delta t \sim$ **440 Myr**

Outflow or intra-group gas detected in absorption

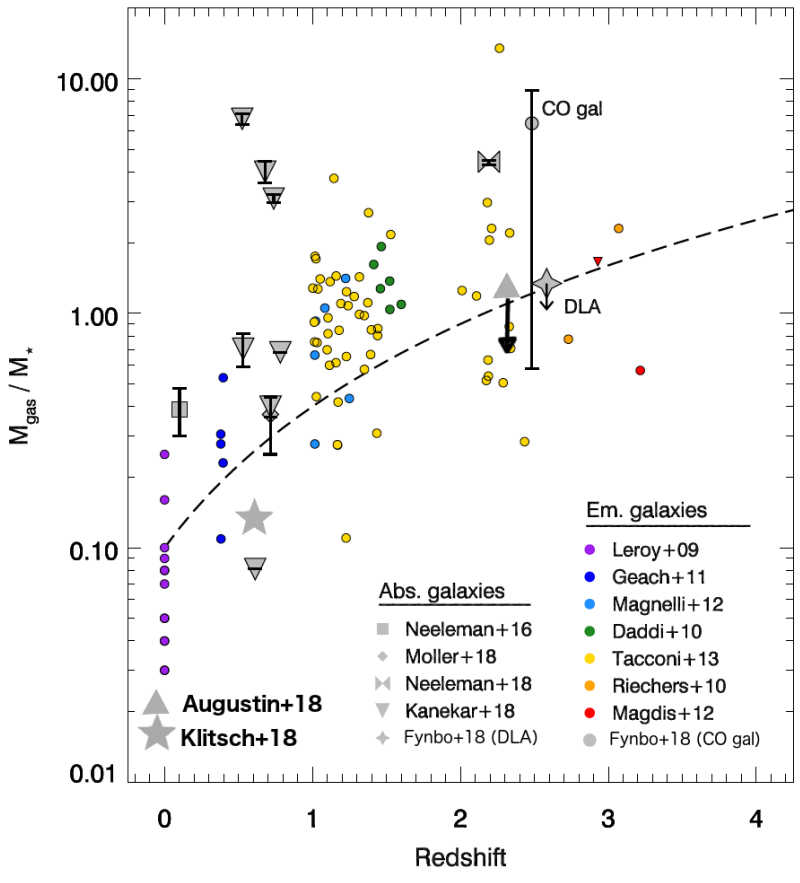


HI absorber towards J0423−0120 at $z = 0.633$

- Are we missing another galaxy?
- Could it be outflow from J0423B?
- Is it intra-group gas?
  - 130 kpc is within the quoted range of the CGM extent in groups
  - intra-group gas in literature: Whiting et al. 2006, Péroux et al. 2017, Bielby et al. 2017 and others

Molecular Gas

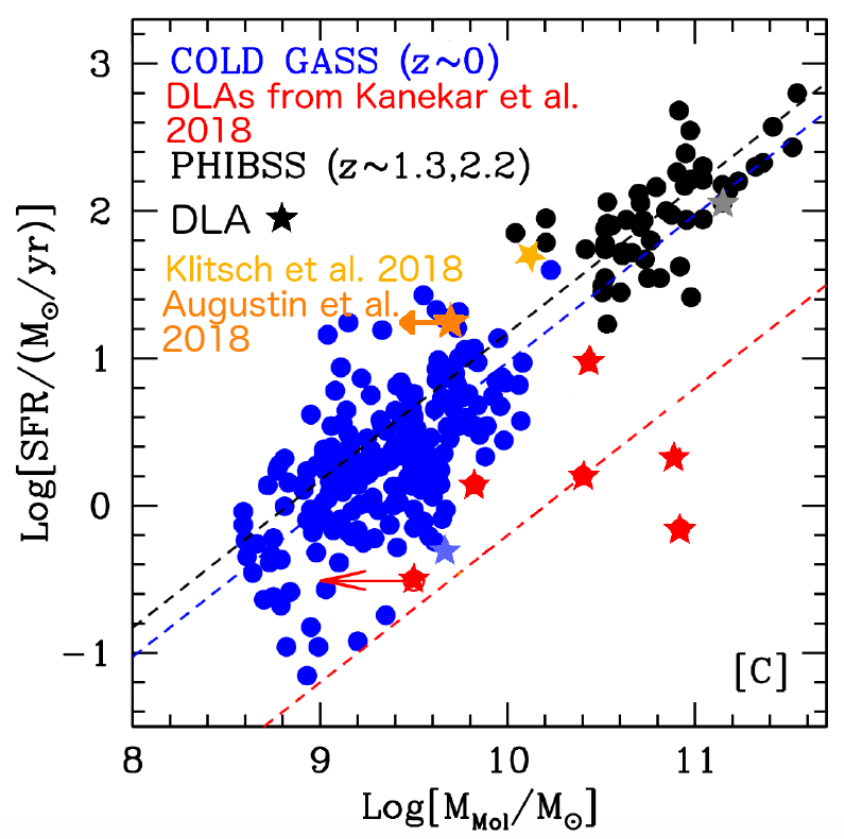
Gas mass / stellar mass vs. redshift



adapted from Fynbo et al. (2018)

- Molecular gas fraction is decreasing with redshift
- Absorption-selected galaxies follow the same trend as emission selected galaxies
- Most studies use Milky Way type conversion factor and line ratios

SFR vs. molecular gas mass correlation



adapted from Kanekar et al. (2018)

- 9 molecular gas measurements for DLAs (+2 upper limits)
- High molecular gas masses and low SFE?
- Most studies use Milky Way type conversion factor and line ratios

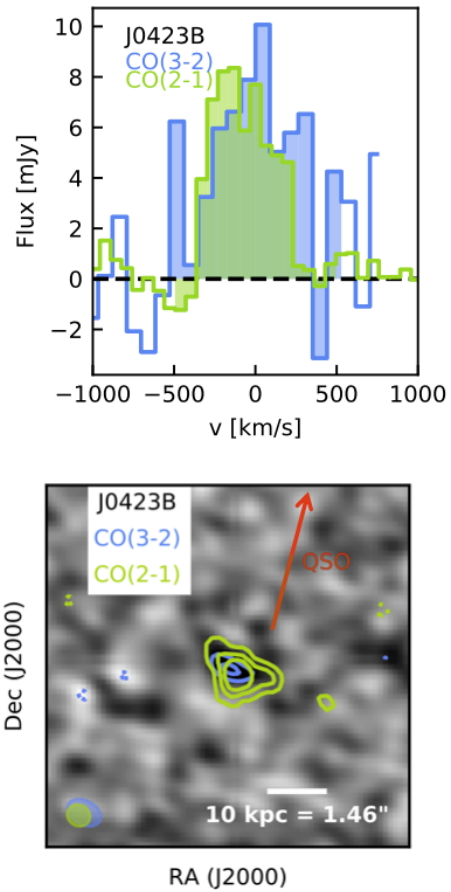
Our Survey

ALMACAL

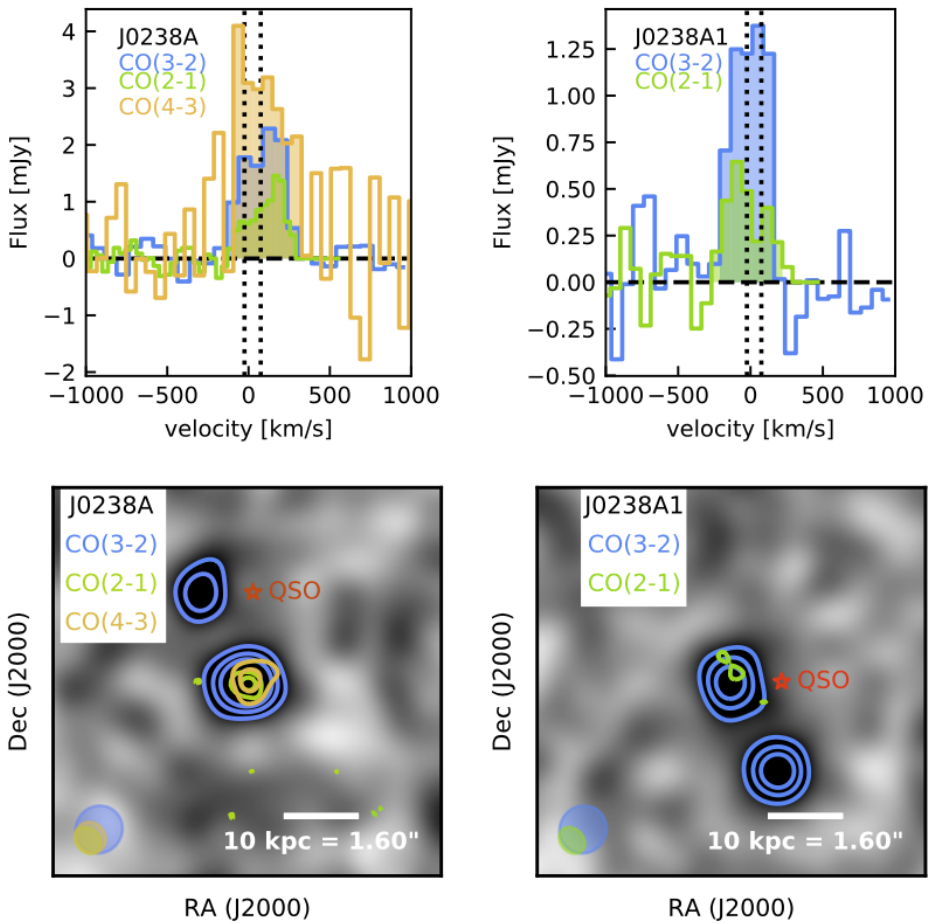
- Unique (sub)mm archival survey carried out by utilizing ALMA calibrator observations.
- Up until today ~ 750 quasar fields observed.
- Frequency setup depends on the science observations.
- Cross match with known absorbers to search for CO emission from connected galaxies.

CO line detections from absorption-selected galaxies

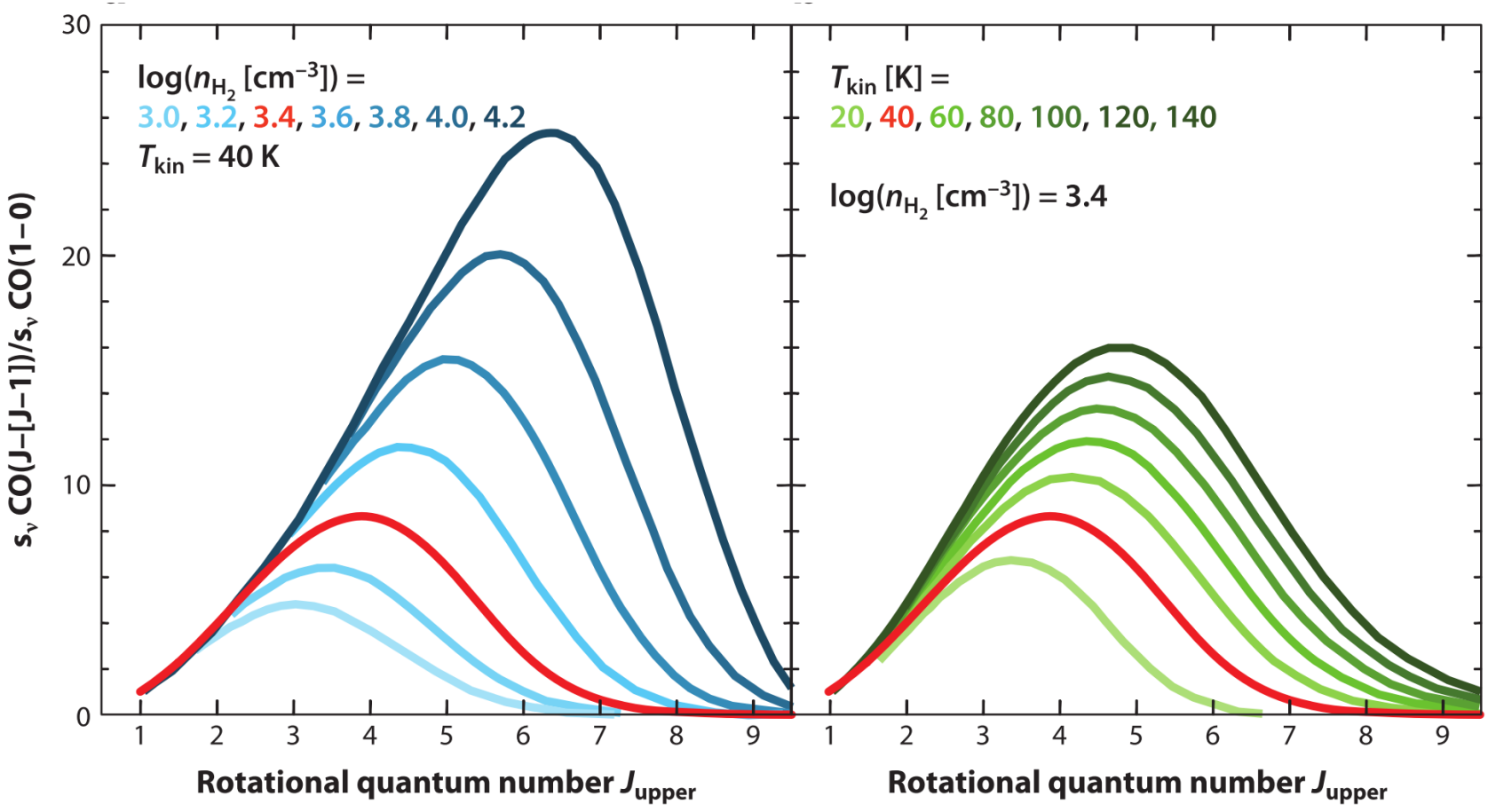
J0423-0120
(z_{abs} = 0.633)



J0238+1636
(z_{abs} = 0.524)

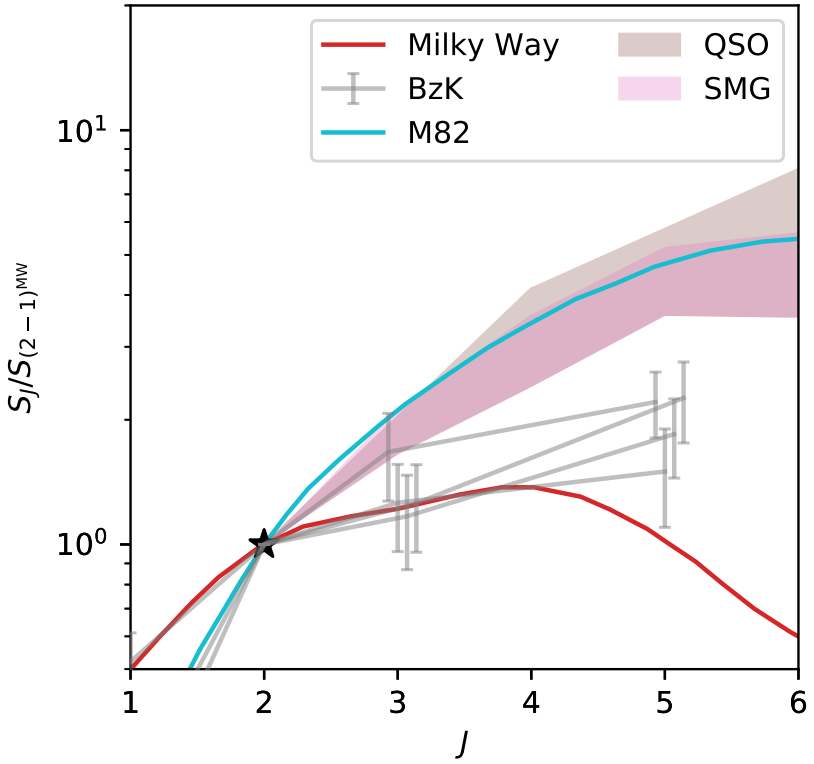


Measuring molecular gas temperature and density

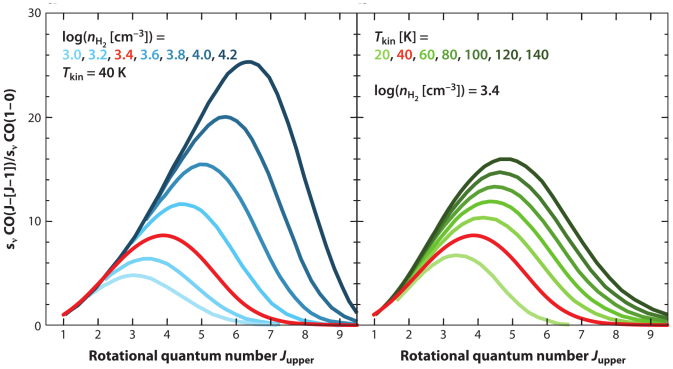


Carilli & Water (2013)

Molecular gas conditions in different galaxies

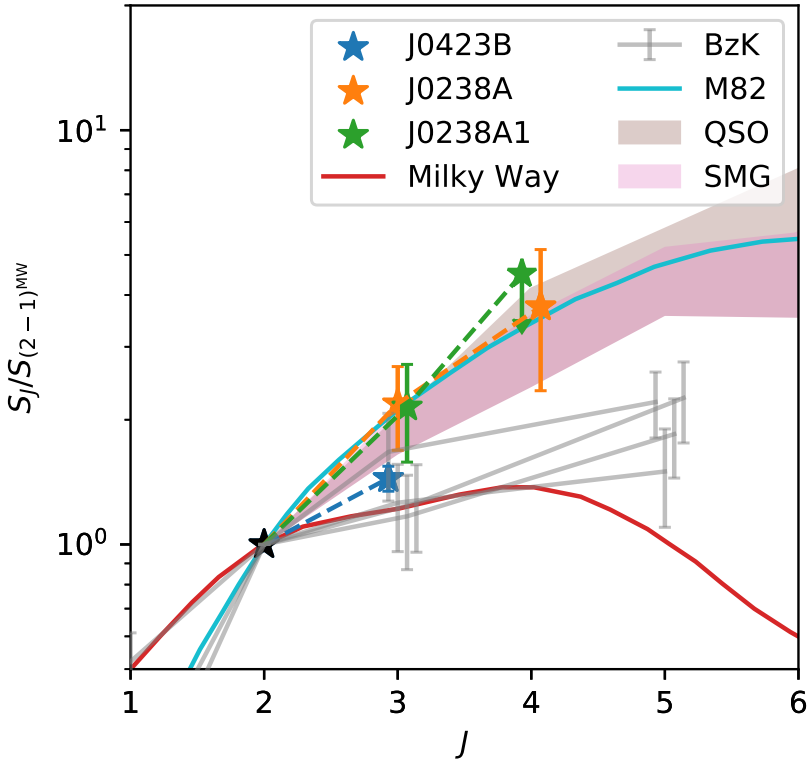


Measuring the molecular gas temperature and density:



Carilli & Water (2013)

ISM conditions differ from Milky Way



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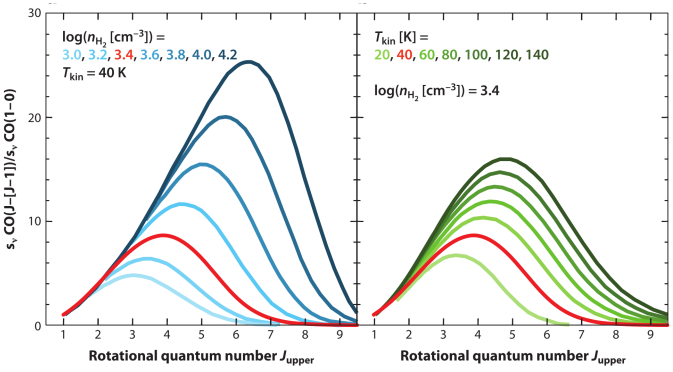

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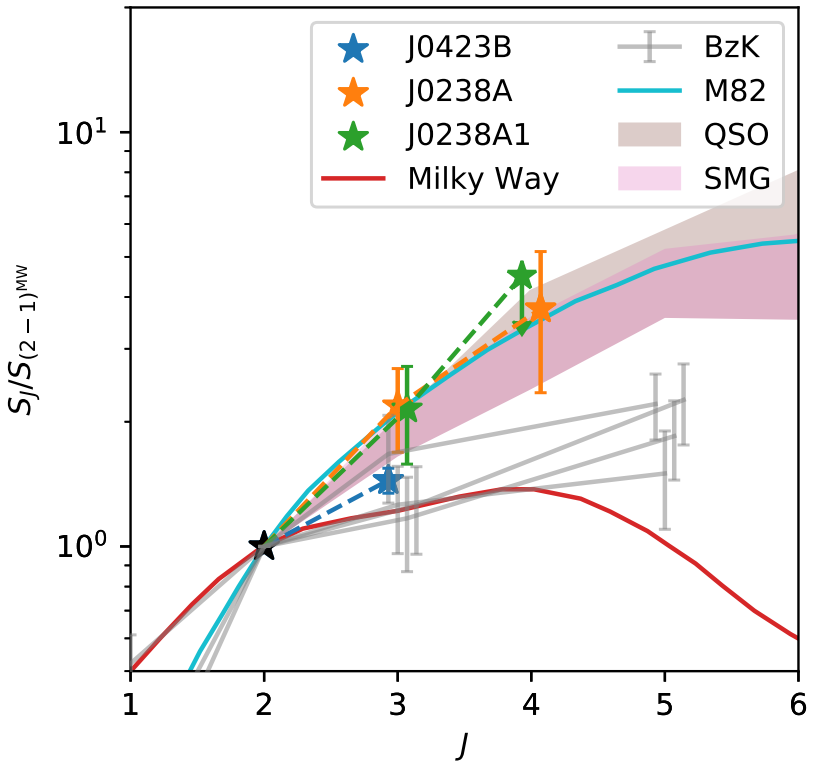
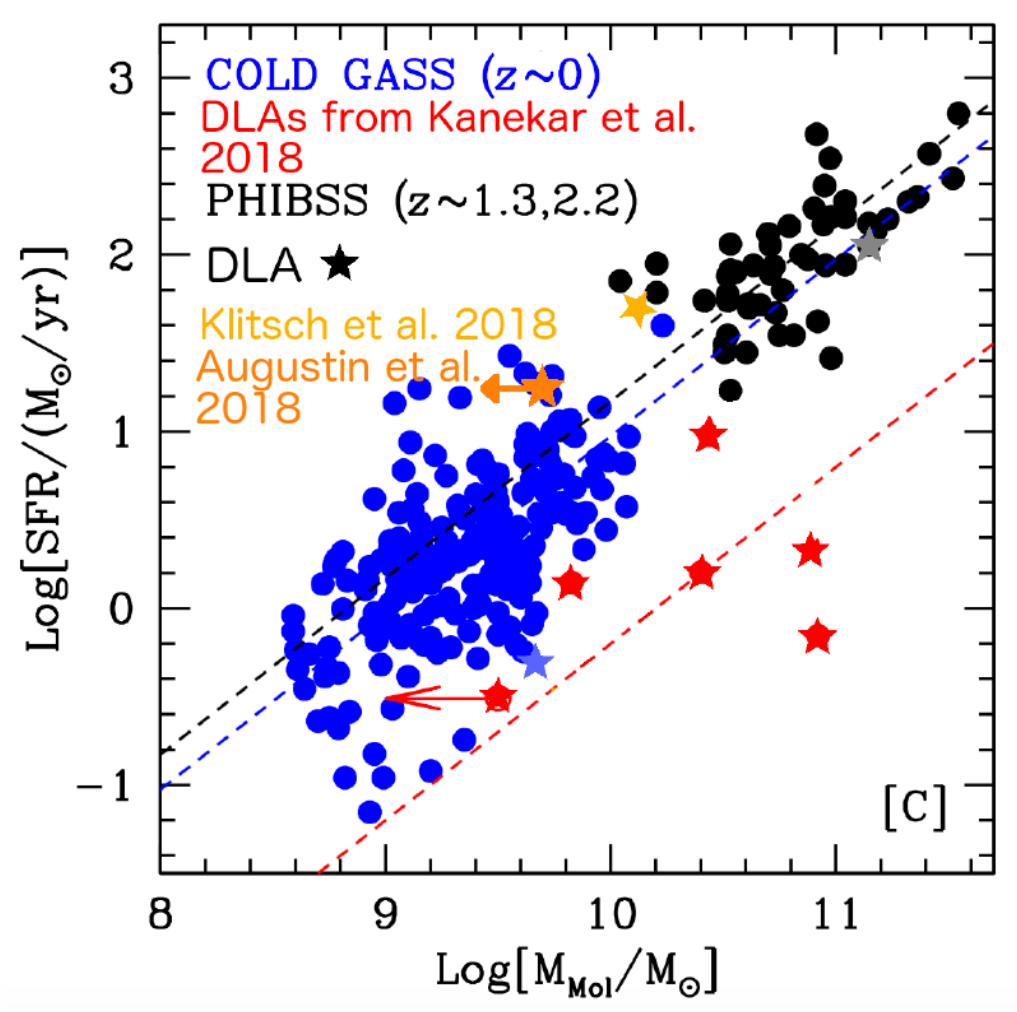


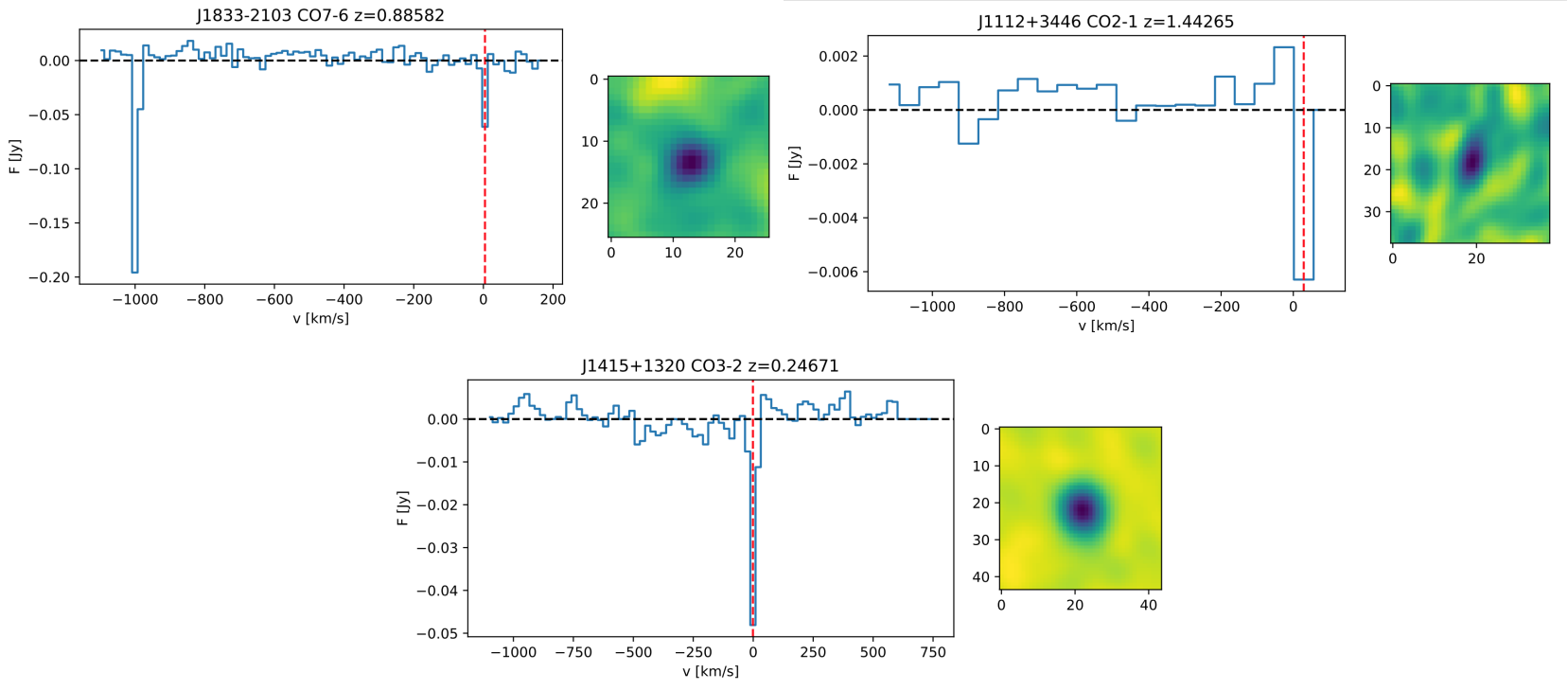
- CO SLEDs deviate from MW
- Galactic conversion factors not applicable?
- Galactic line ratios not applicable?
- High masses in the literature overestimated?

Molecular gas masses overestimated?



Future Work

Future work - CO mass function from absorption lines



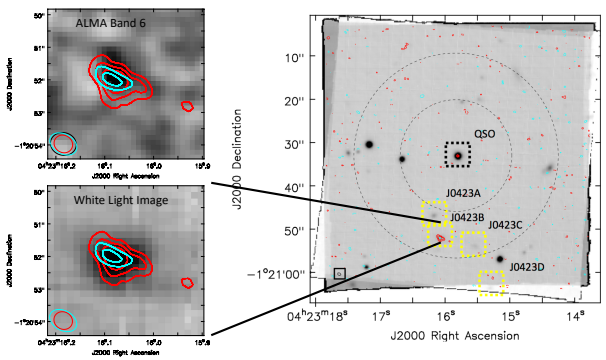
Detected 3 candidate absorbers in low resolution data

-> high resolution study started

Summary

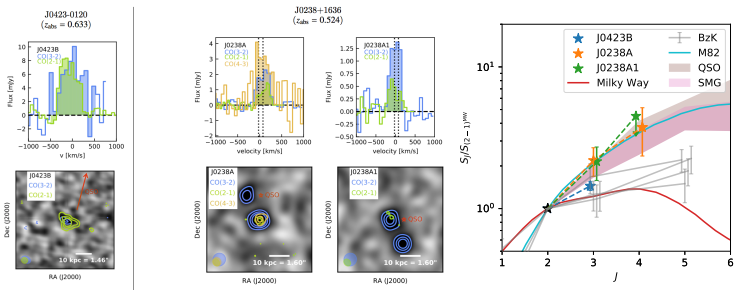
Summary

Detection of an outflow or intra-group gas:



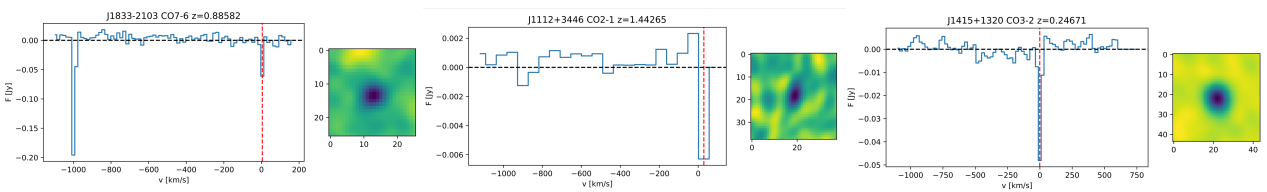
Check out Klitsch et al. (2018) [https://doi.org/10.1093/mnras/stx3184]

ISM conditions in absorption-selected galaxies differ from Milky Way:



Look forward to Klitsch et al. subm.

Future - CO mass function from absorption lines:



Stay tuned!