mm Universe
Grenoble
26-30 June 2023

“Metal enrichment in the CGM around high-z merging galaxies”

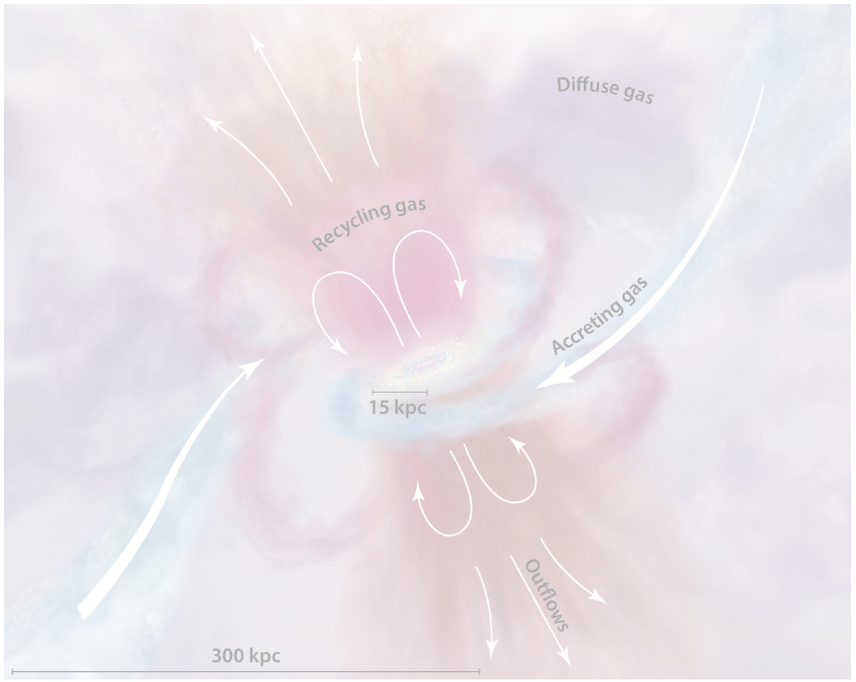
(Di Cesare et al., in prep)

Claudia Di Cesare

in collaboration with :

**Michele Ginolfi (UniFi, Italy); Luca Graziani (Sapienza, Italy);
Raffaella Schneider (Sapienza, Italy);
Michael Romano (NCBJ,Poland)**

[CII] 158 μm rest-frame

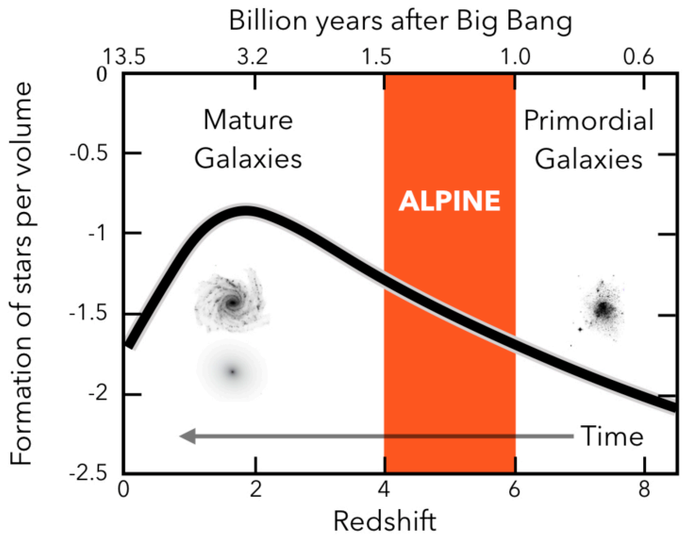


Tumlinson+2017

"Metal enrichment in the CGM around high-z merging galaxies"

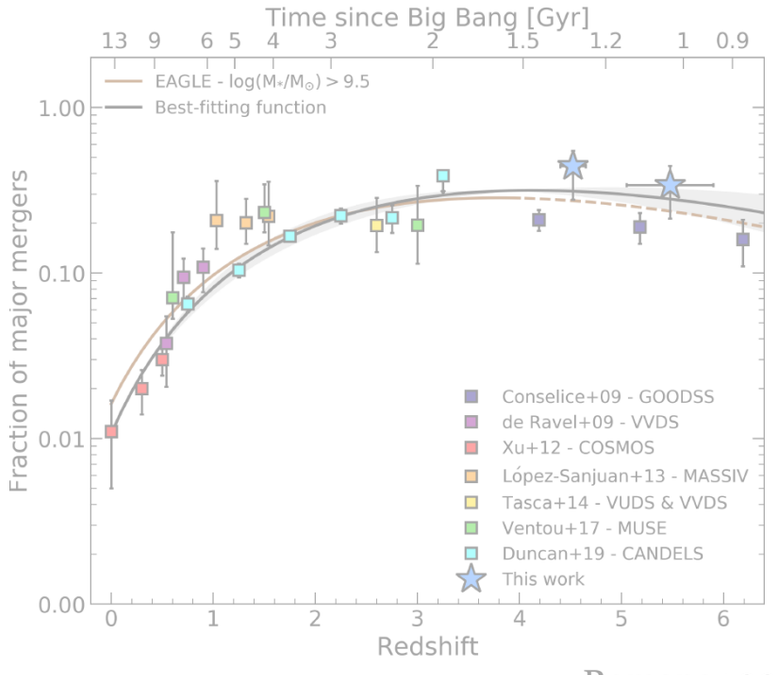
4 < z < 6

post Epoch of Reionization



credits : ALPINE collab.

fraction interacting systems
increase from the Local to high-z Universe



Romano+2021

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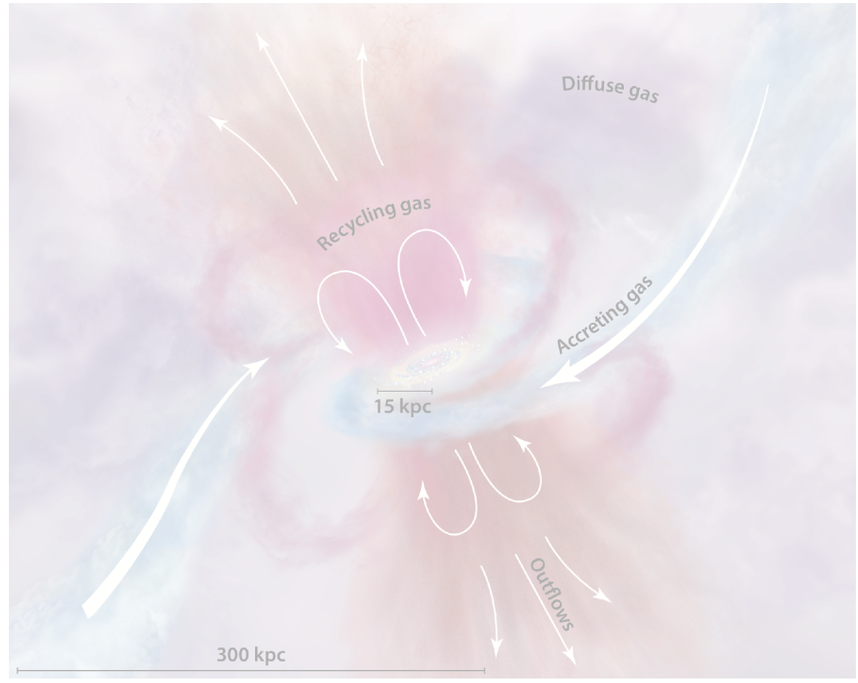

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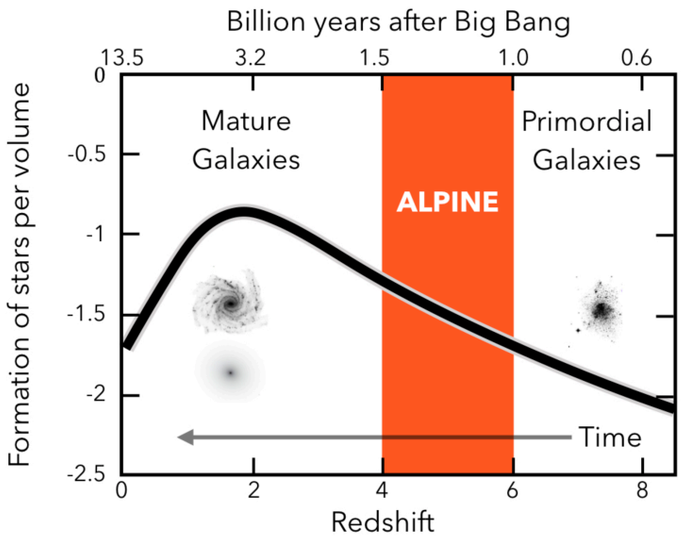

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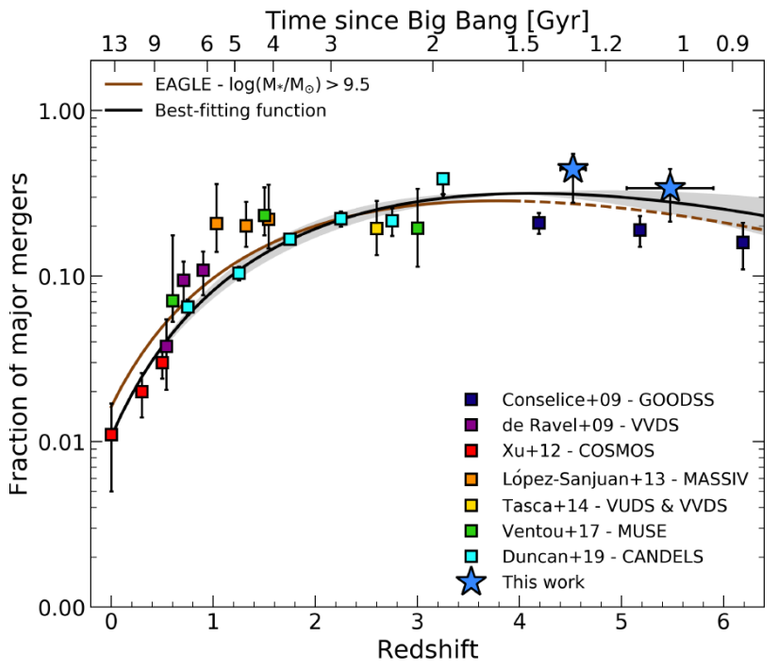

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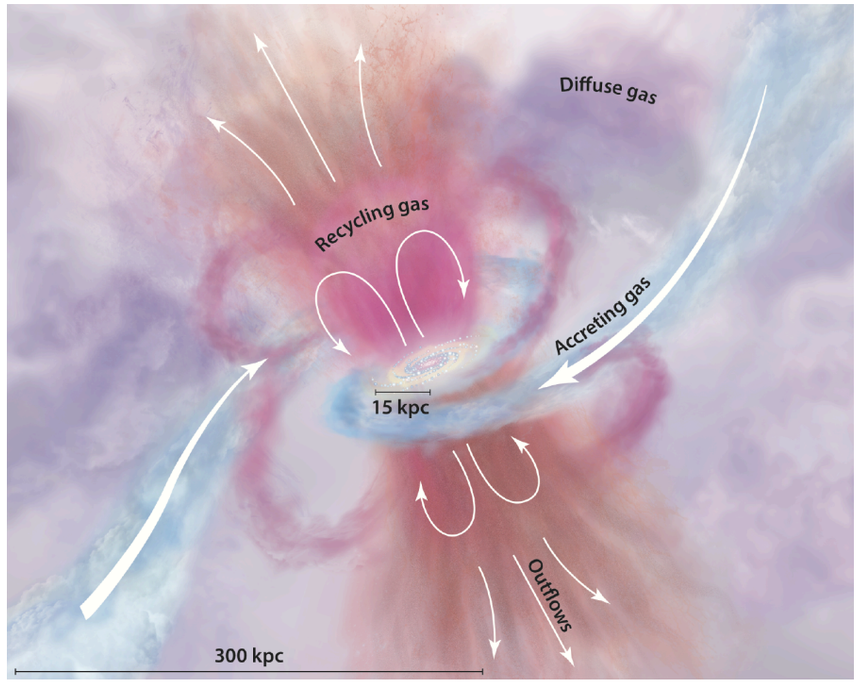

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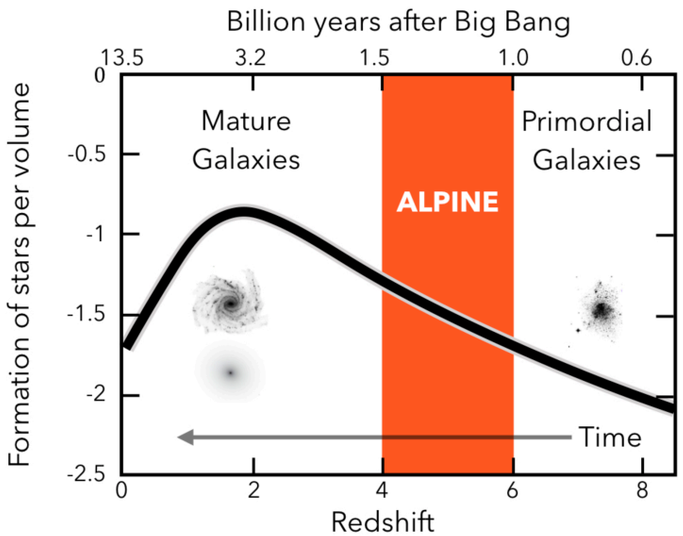

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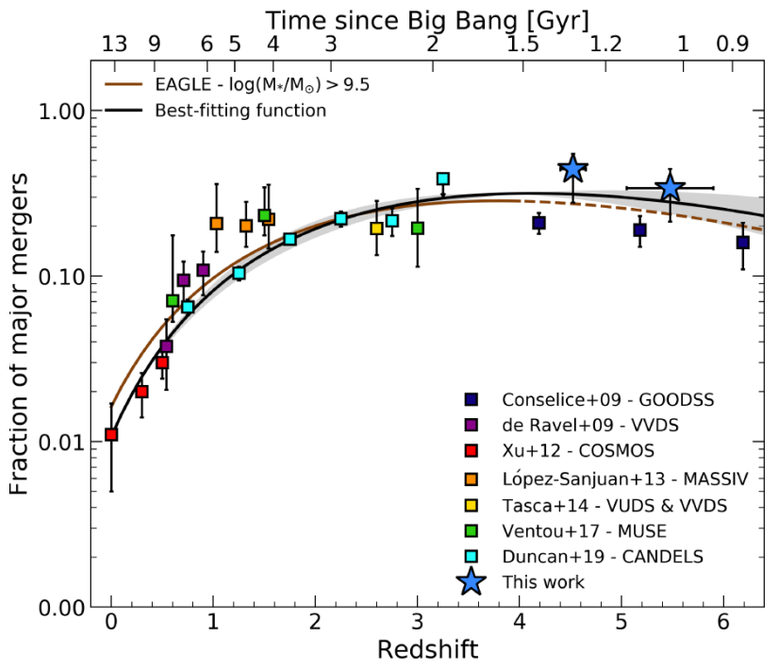

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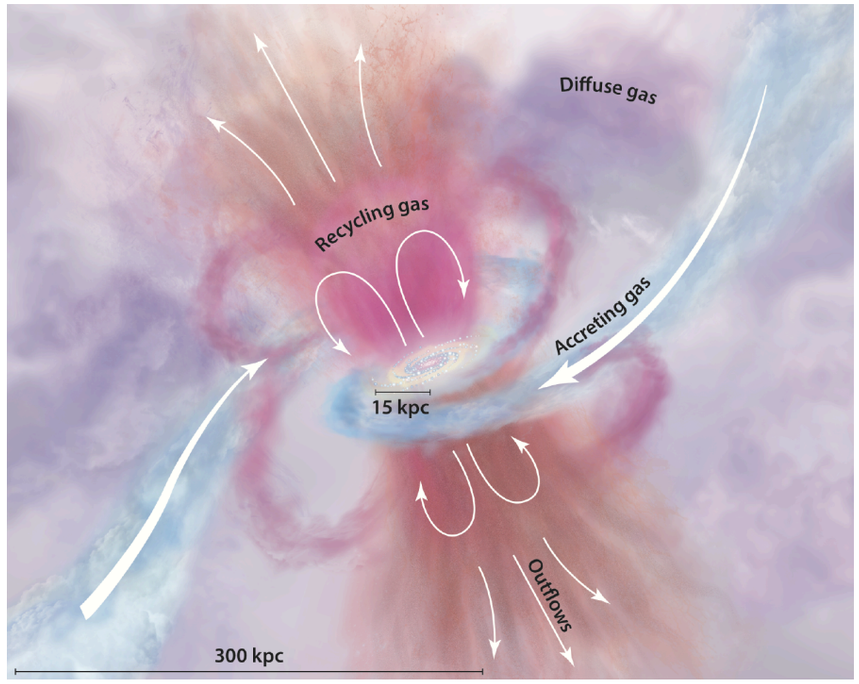

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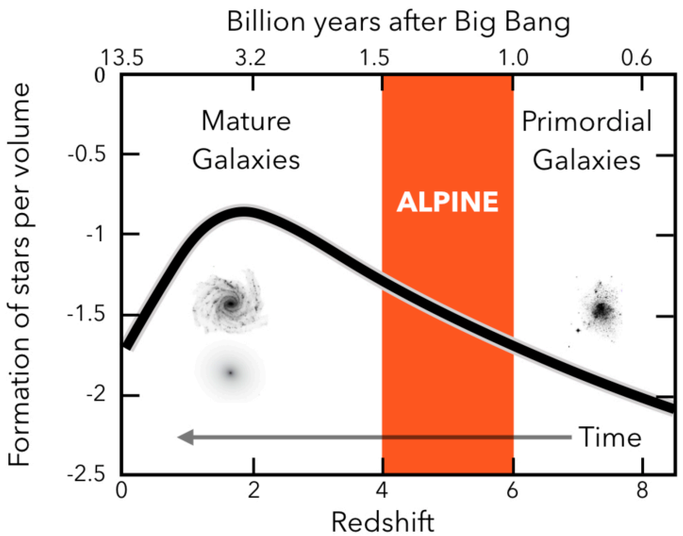

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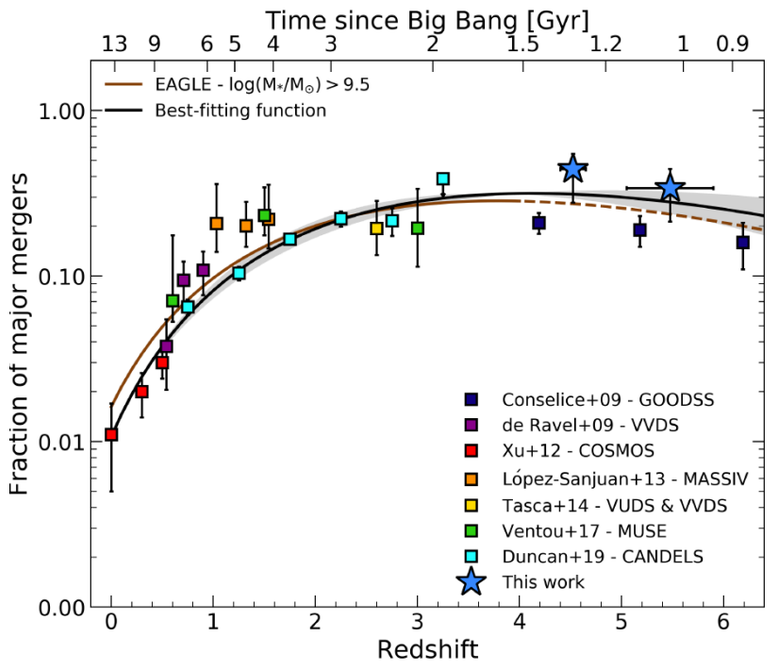


Romano+2021

MAIN MOTIVATIONS :

* What merging systems tell us about the metal enrichment of their CGM ?

* Where does diffuse [CII] emission come from ?

observations :
ALMA survey

cosmological simulations :
dustyGadget

OBSERVATIONS

ALMA Large Program to INvestigate C+ at Early times (ALPINE)

(Le Fèvre+2020, Faisst+2020, Béthermin+2020)

A2C2S | ALMA ALPINE [CII] Survey

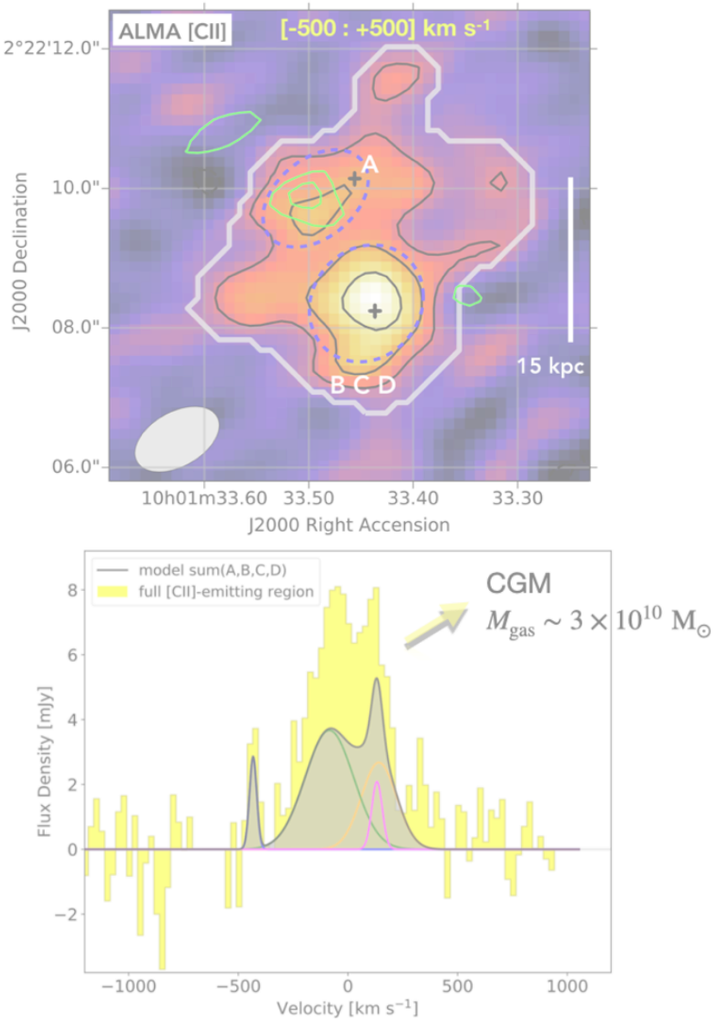
118 main sequence galaxies at $4.4 \leq z \leq 5.9$
with dust continuuum (23) and [CII] measurements (75)

Ginolfi+2020b :

major merging system at z ~ 4.57
[CII] emission from CGM up to ~30 kpc — 50% of total flux *between* the galaxies

Romano+2021 :

morpho-kinematic information from [CII] emission
fraction of major merger systems in the ALPINE survey
~40% systems in ALPINE are mergers



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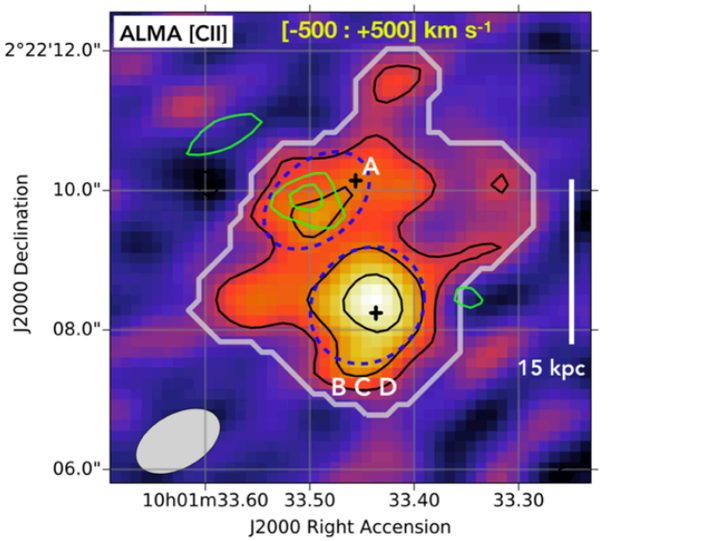

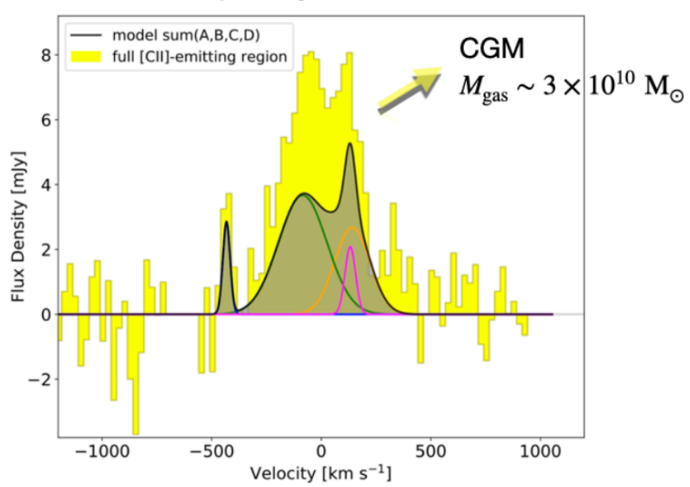

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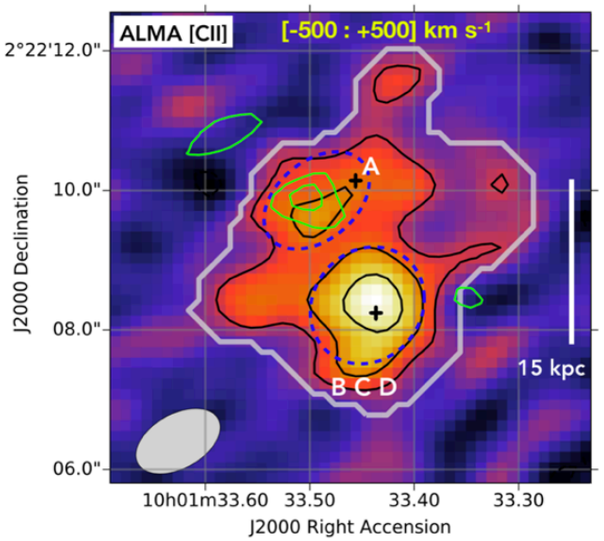
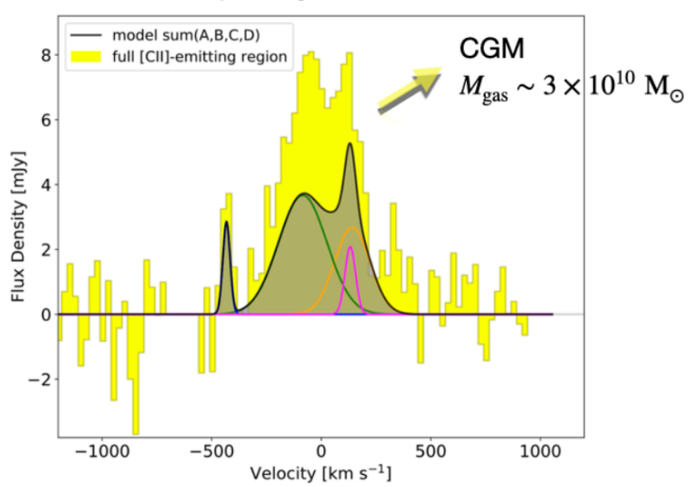




Ginolfi+2020b

1. candidates selection

(Romano+2021)

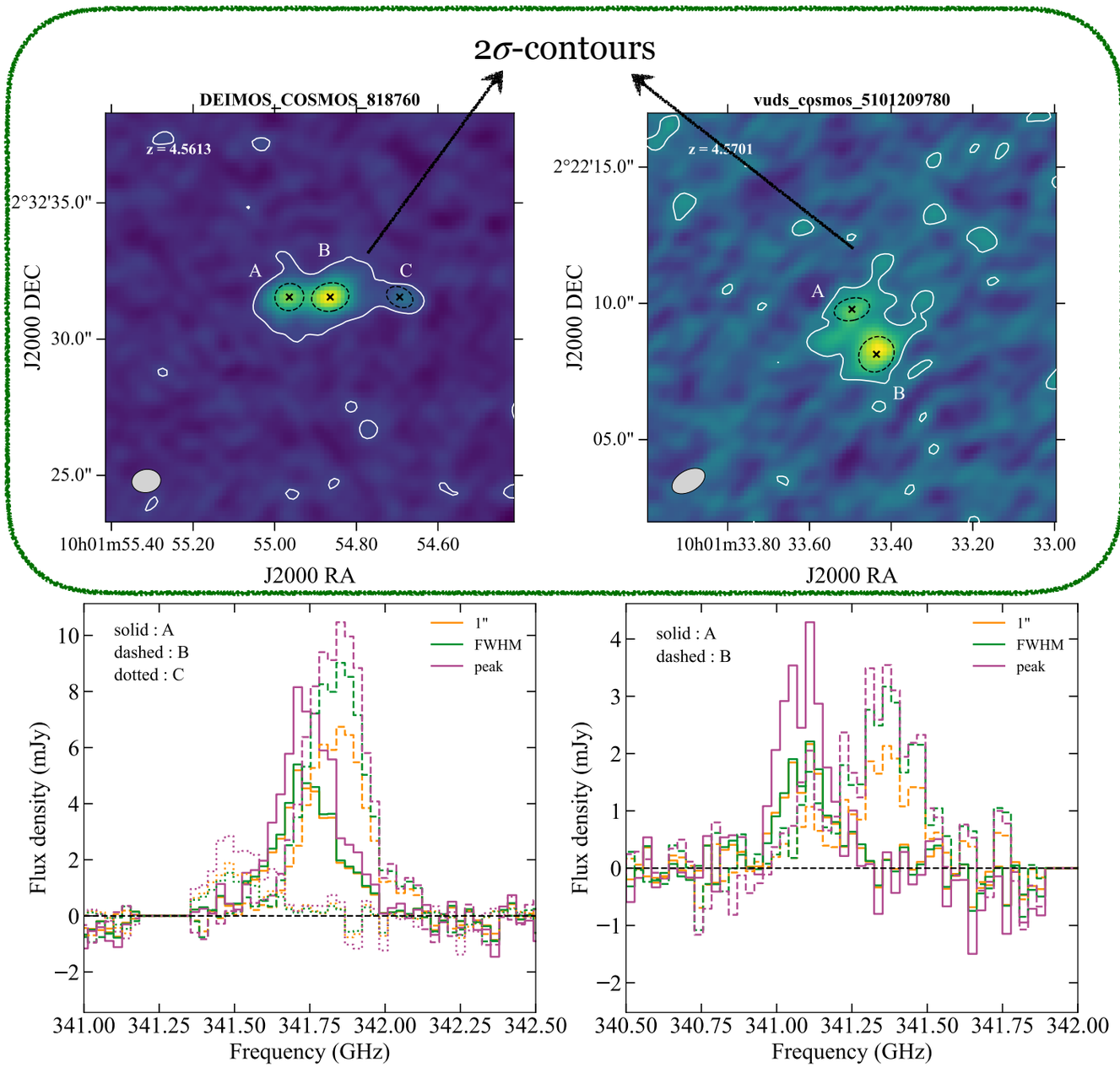
Source	z_1	z_2	Δv [km s^{-1}]	r_p [kpc]	$\mu_{[CII]}$	μ_K
(1)	(2)	(3)	(4)	(5)	(6)	(7)
CG_38	5.5731	5.5698	152.3	2.7	1.8	–
DC_308643	4.5238	4.5221	92.3	3.0	1.2	–
DC_372292	5.1345	5.1374	144.0	1.8	2.7	2.9
DC_378903	5.4311	5.4293	94.5	0.9	1.9	–
DC_417567	5.6676	5.6700	106.7	5.3	2.1	–
DC_422677	4.4361	4.4378	92.8	0.0	1.4	–
DC_434239	4.4914	4.4876	206.1	5.5	6.9	–
DC_493583	4.5122	4.5141	103.4	1.0	4.7	–
DC_519281	5.5731	5.5765	158.0	0.9	4.5	–
DC_536534	5.6834	5.6886	234.6	4.4	2.7	–
DC_665509	4.5244	4.5261	95.9	1.0	2.0	–
DC_680104	4.5288	4.5308	106.4	0.0	1.0	–
DC_773957	5.6802	5.6770	141.2	3.0	1.6	5.6
DC_814483	4.5823	4.5796	145.5	7.9	2.4	–
DC_818760	4.5626	4.5609	92.3	9.9	1.3	2.6
DC_834764	4.5076	4.5055	119.0	1.0	1.7	–
DC_842313	4.5547	4.5406	751.5	11.6	32.9	1.5
DC_859732	4.5353	4.5315	205.2	4.9	3.9	–
DC_873321	5.1545	5.1544	4.5	6.5	1.2	3.1
vc_5100541407	4.5628	4.5628	1.9	13.8	1.6	1.4
vc_5100822662	4.5210	4.5205	22.3	10.9	1.6	1.7
vc_5101209780	4.5724	4.5684	217.3	10.8	4.1	2.5
vc_5180966608	4.5294	4.5293	8.9	7.2	3.0	3.7

$r_p > 4\ kpc$

$1 < \mu_K < 4$

2. ALMA data reduction and analysis

2.1 total moment zero maps



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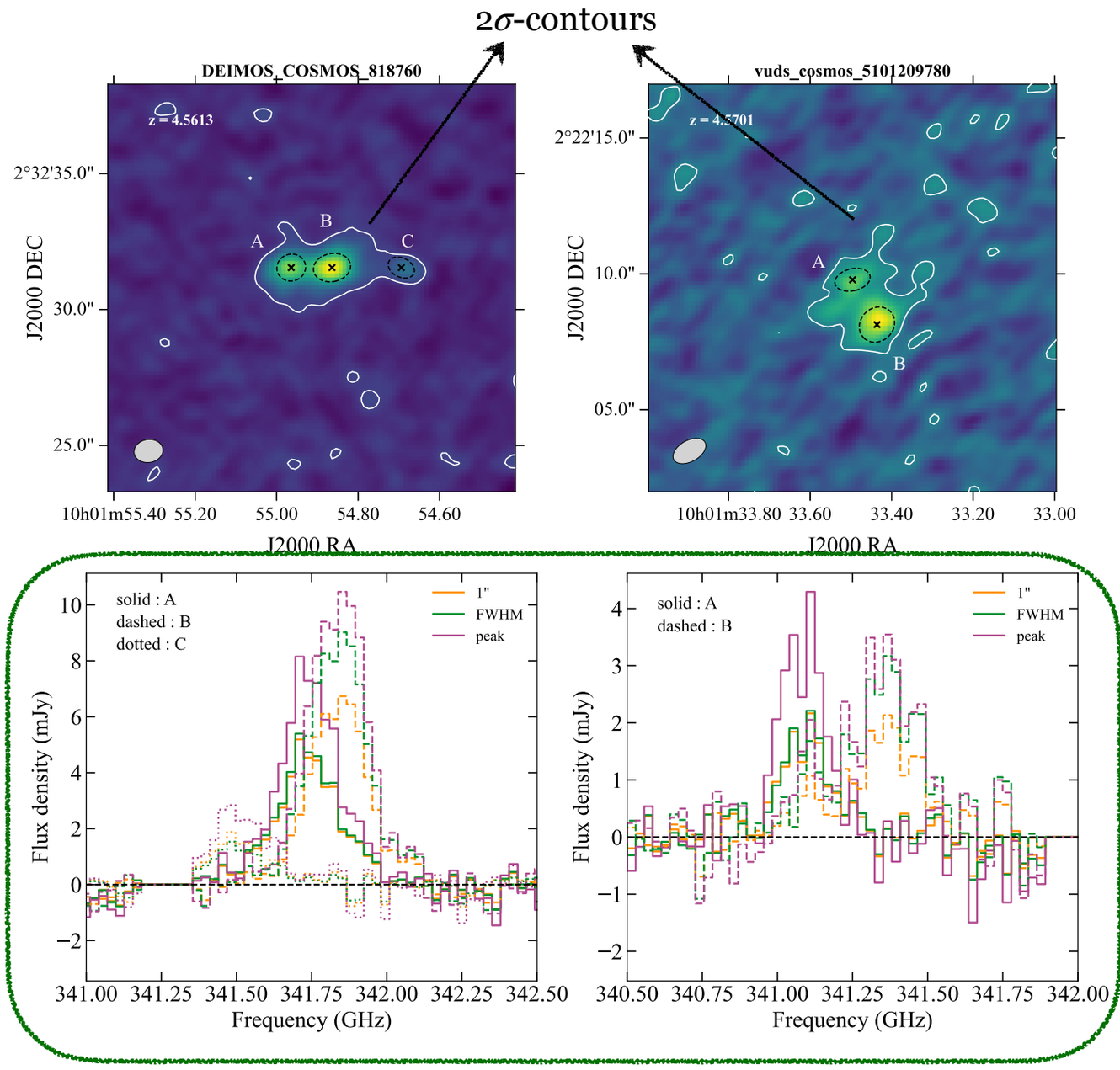
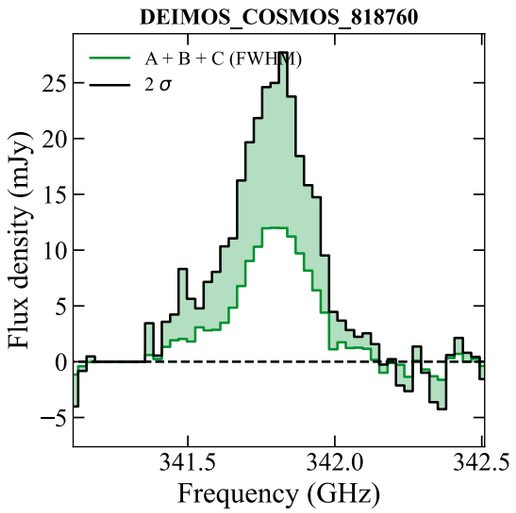
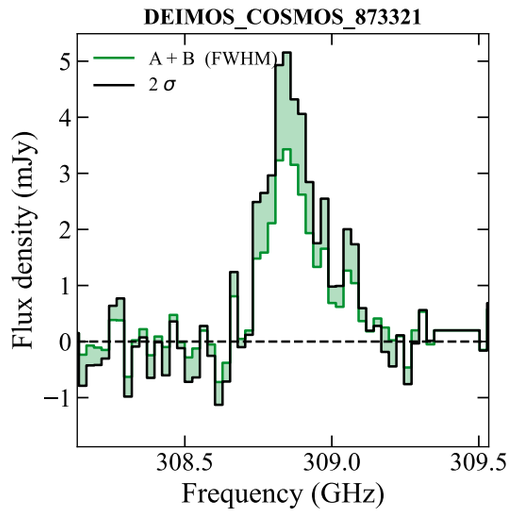
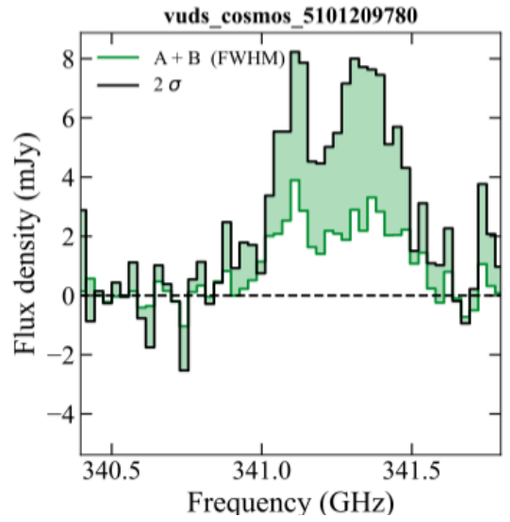


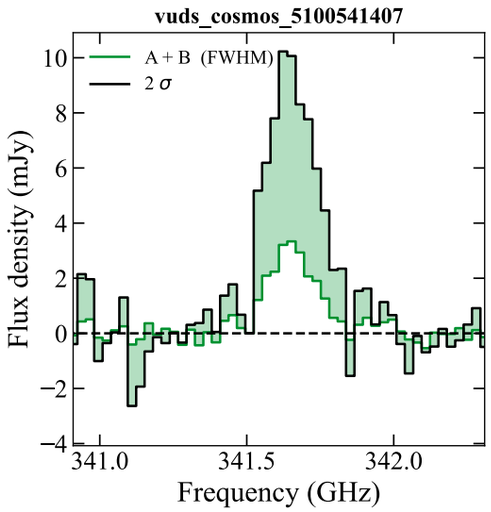
2.2 [CII] emission for each merging component from different apertures

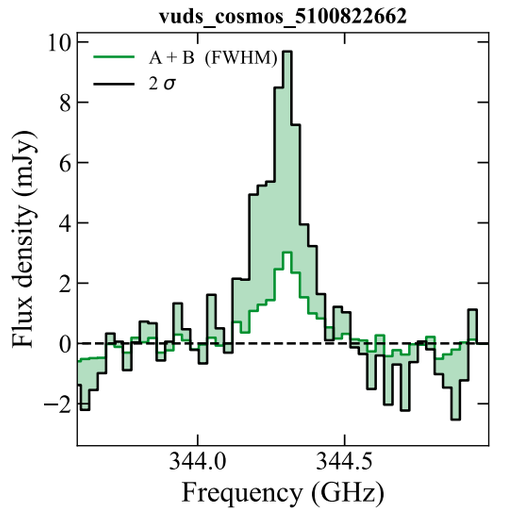
sum of components emission from optimal apertures

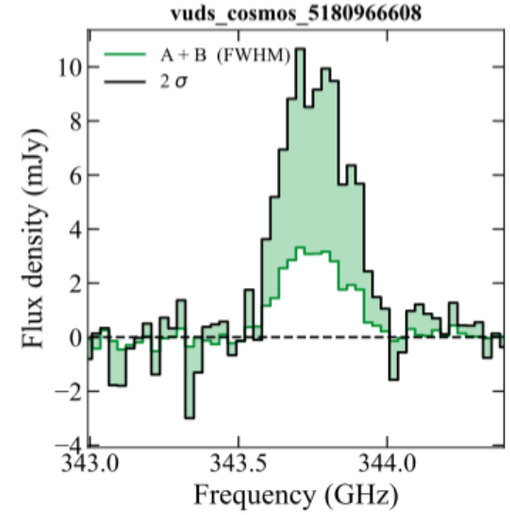








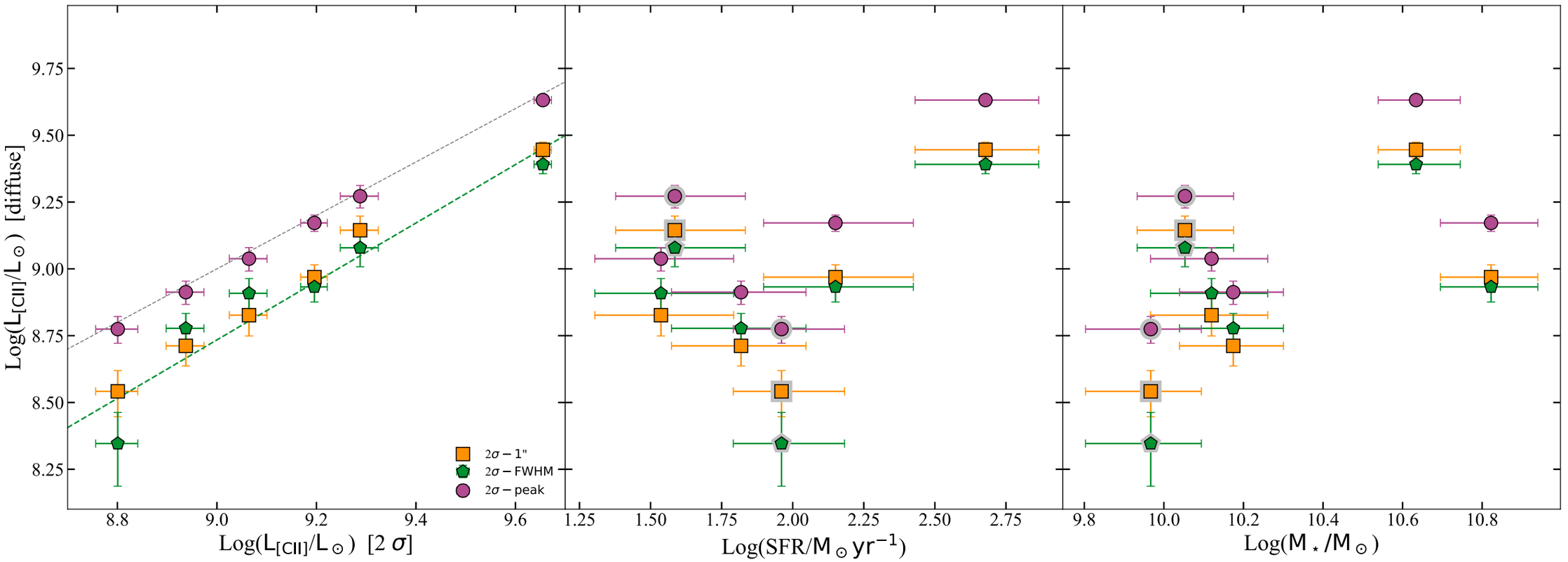




qualitatively : [CII] emission coming from the diffuse medium

more *quantitative* analysis

[CII] emission from the diffuse medium



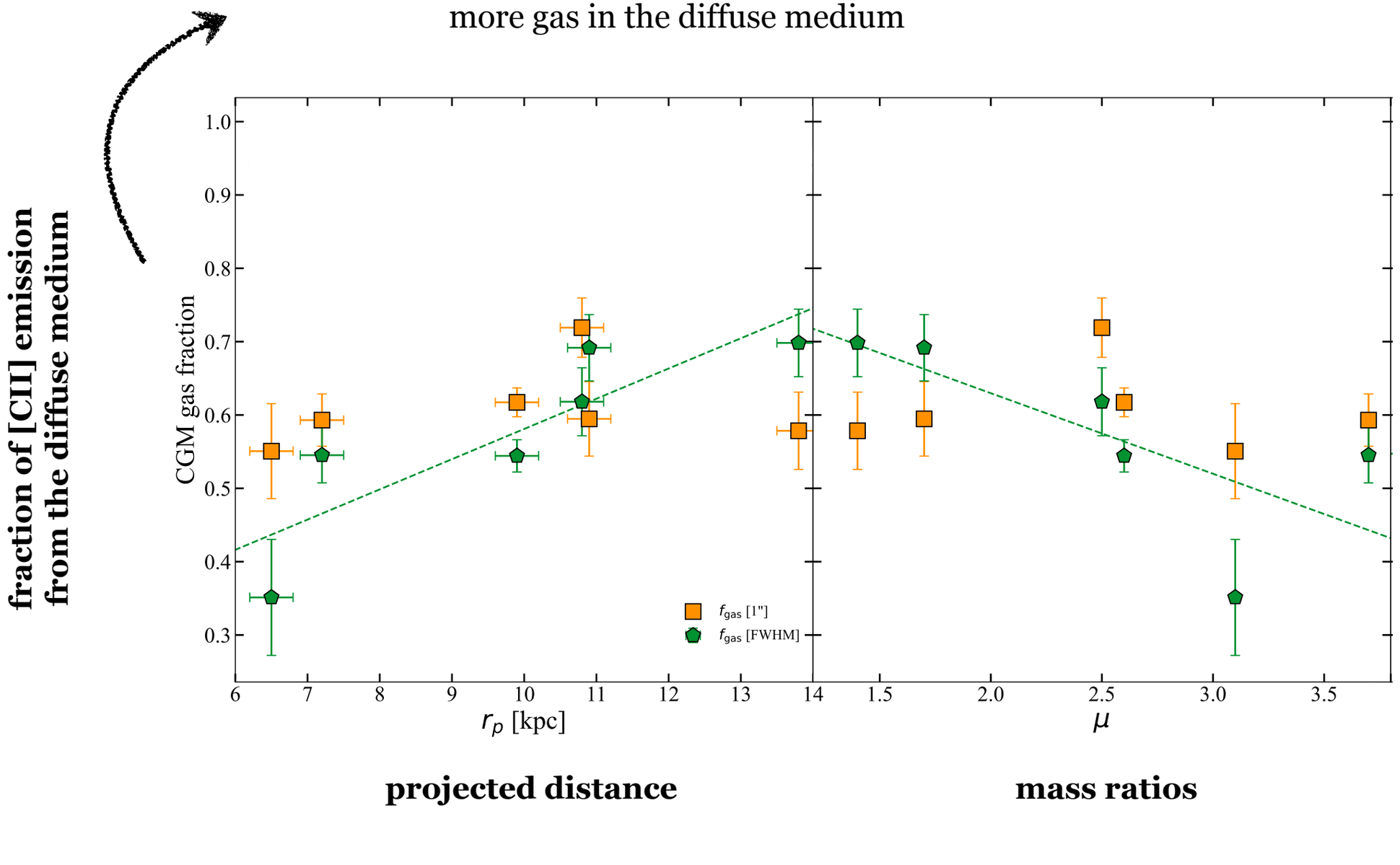
outflows ?

satellites ?
dynamical interaction ?

more *quantitative* analysis

i) 35%-70% emission coming from the diffuse medium

ii) the higher the distance the higher the CGM gas fraction :
more gas in the diffuse medium



iii) lower μ (major merger) results in a more efficient stripping
leading to a more polluted CGM

why do we want to compare these observations with simulations ?

1. time evolution of the merging systems

2. CGM emitting? or satellites galaxies we can't observe (resolution)?

SIMULATIONS

dustyGadget (Graziani+2020)

[extension of Gadget-2 Springel+2005]

WHAT DOES dustyGadget DO?

i) SPH hydrodynamical simulations with PopIII/PopII stellar populations
ii) chemical evolution of the gas [Tornatore+2007]
iii) dust production and evolution in the ISM (cold and hot phases)

the code follows the spreading of **grains and atomic metals** through galactic winds at the scales of CGM and IGM

ΛCDM cosmology (Planck 2015)
box size : 50 cMpc/h

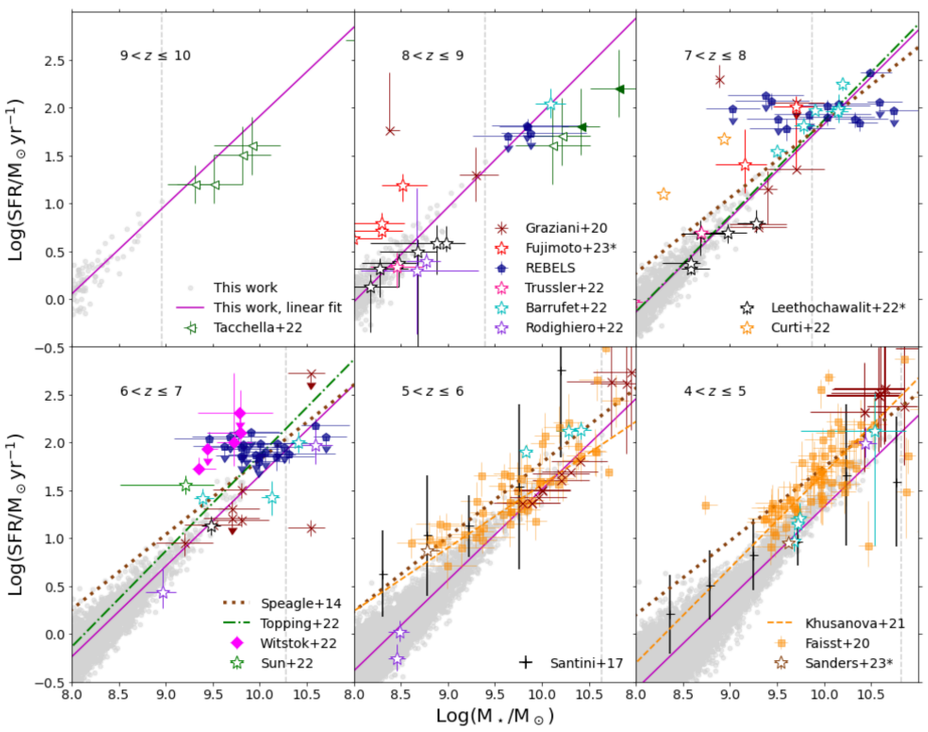
$m_{DM} = 3.53 \times 10^7\ M_\odot/h$
$m_b = 5.56 \times 10^6\ M_\odot/h$

N. of cubes : 8

statistical study on high-z galaxies

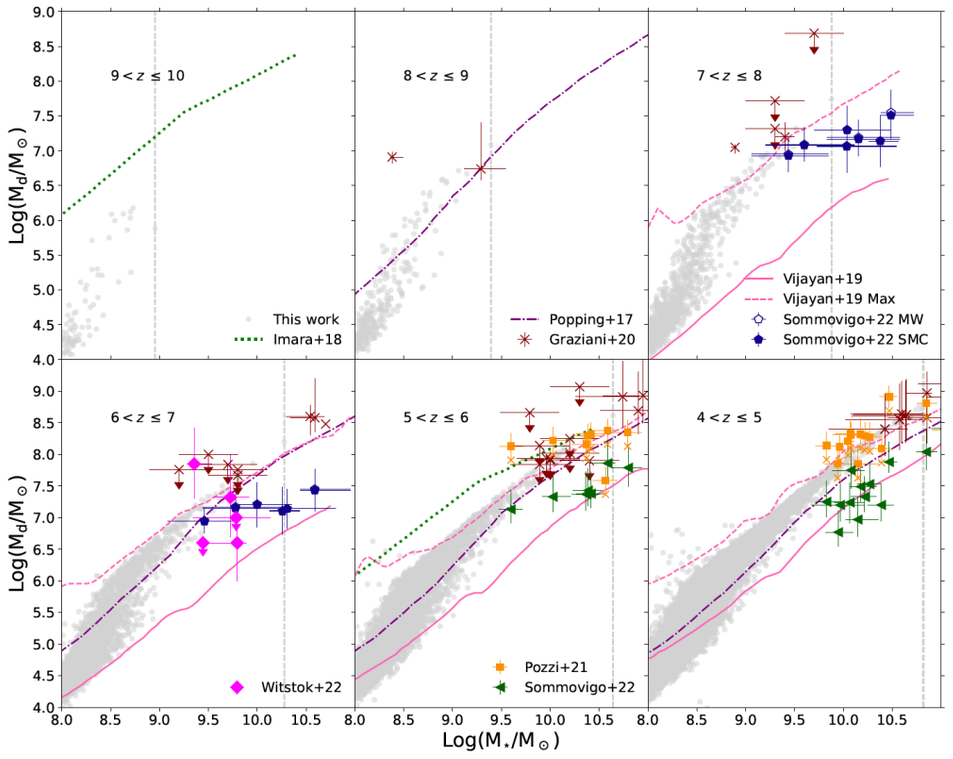
(Di Cesare+2023)

MAIN SEQUENCE OF GALAXY FORMATION



dustyGadget predictions are in **global agreement** with high redshift available data

DUST MASS STELLAR MASS RELATION

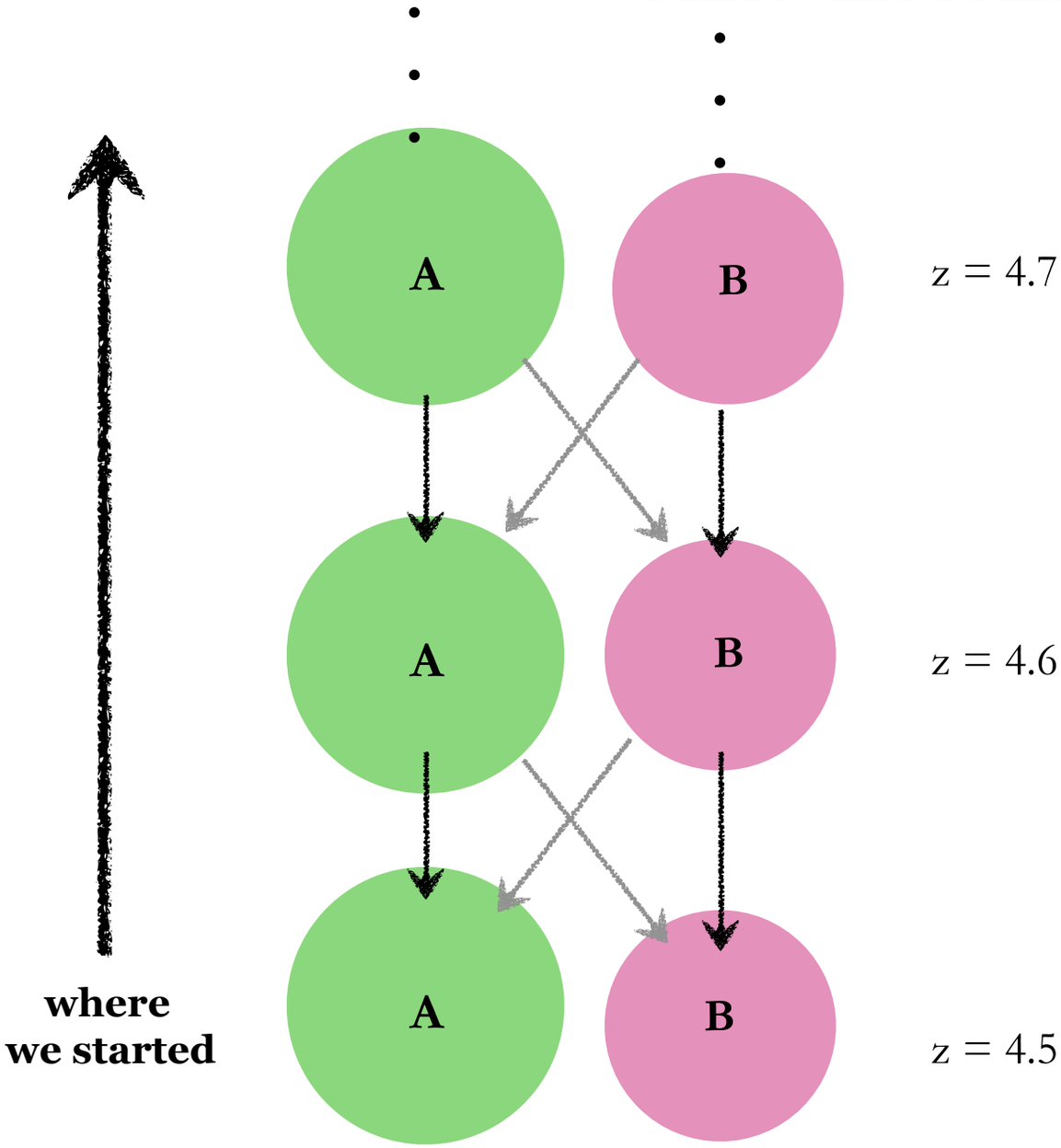


now! **looking for MAJOR MERGING SYSTEMS in dustyGadget**

1. observed redshift range
2. cut on the stellar masses ($\mathrm{Log}(M_\star/M_\odot) \geq 10$)
3. mass ratios comparable with observations

sample of 10 galaxies at z~4.5

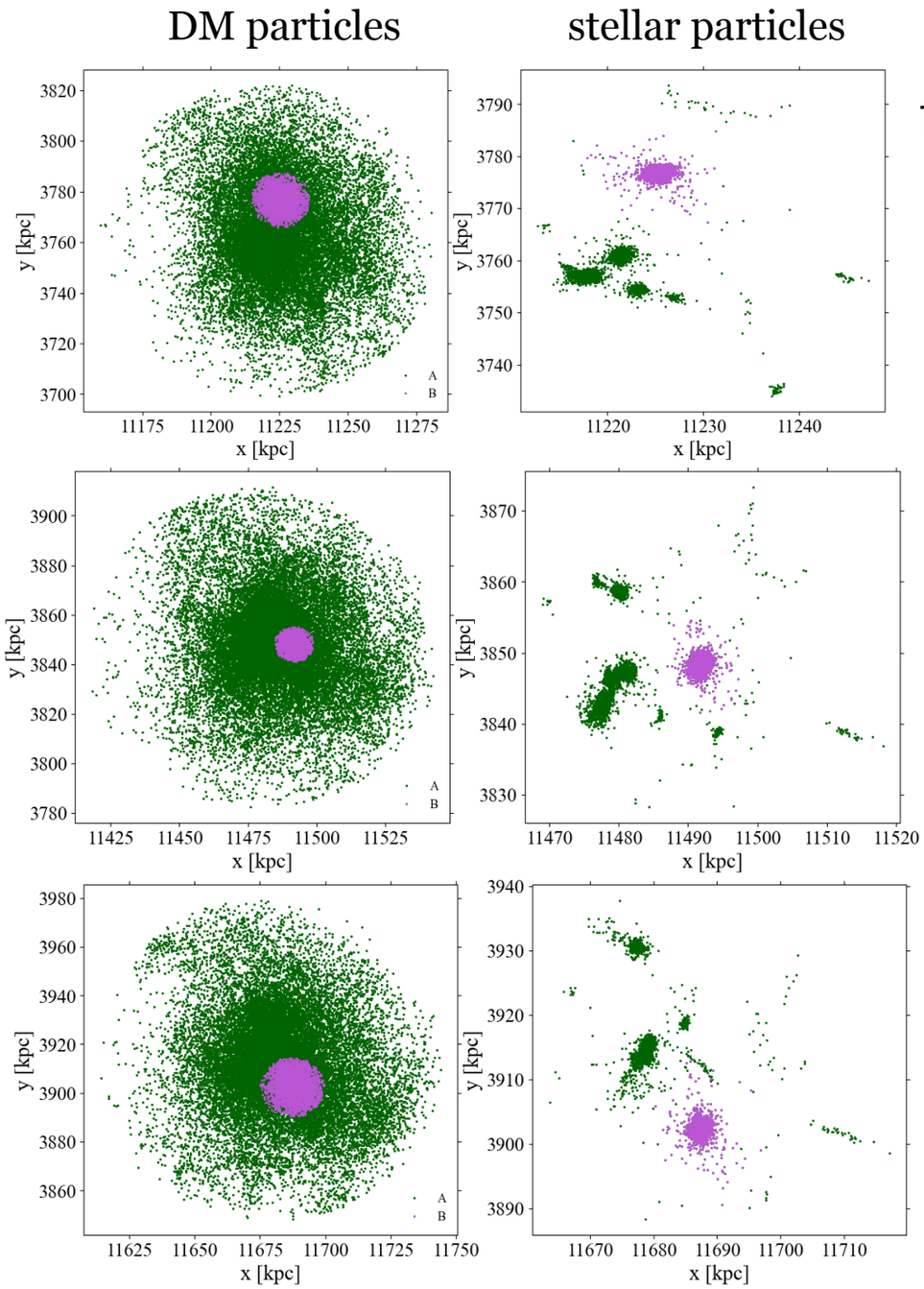
MERGER TREE RECONSTRUCTION



z = 4.7

z = 4.6

z = 4.5

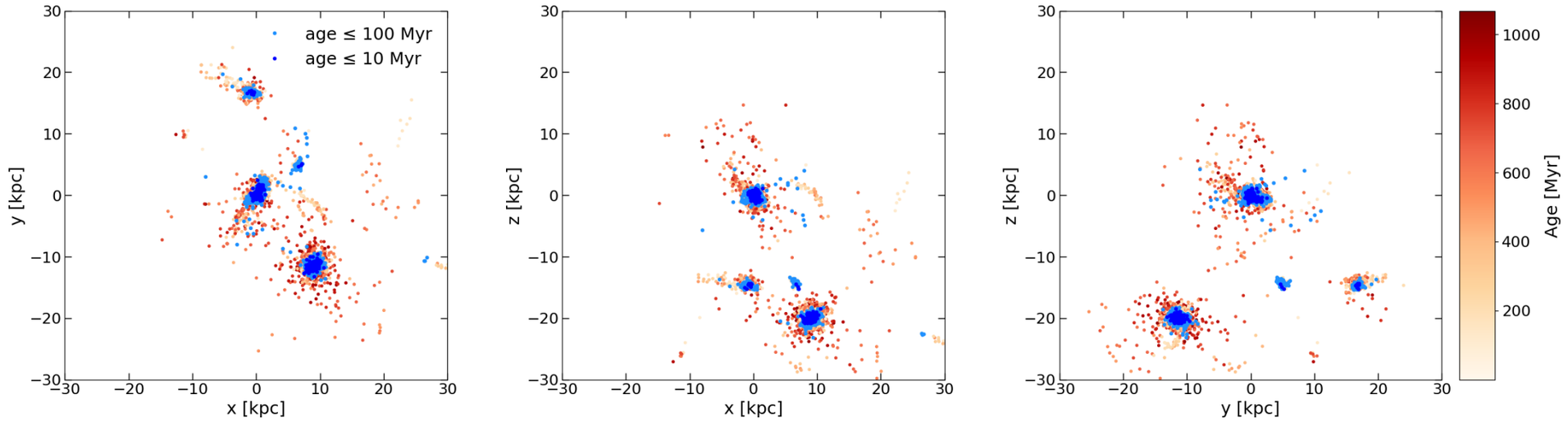


i) merger happens before in DM than baryonic matter

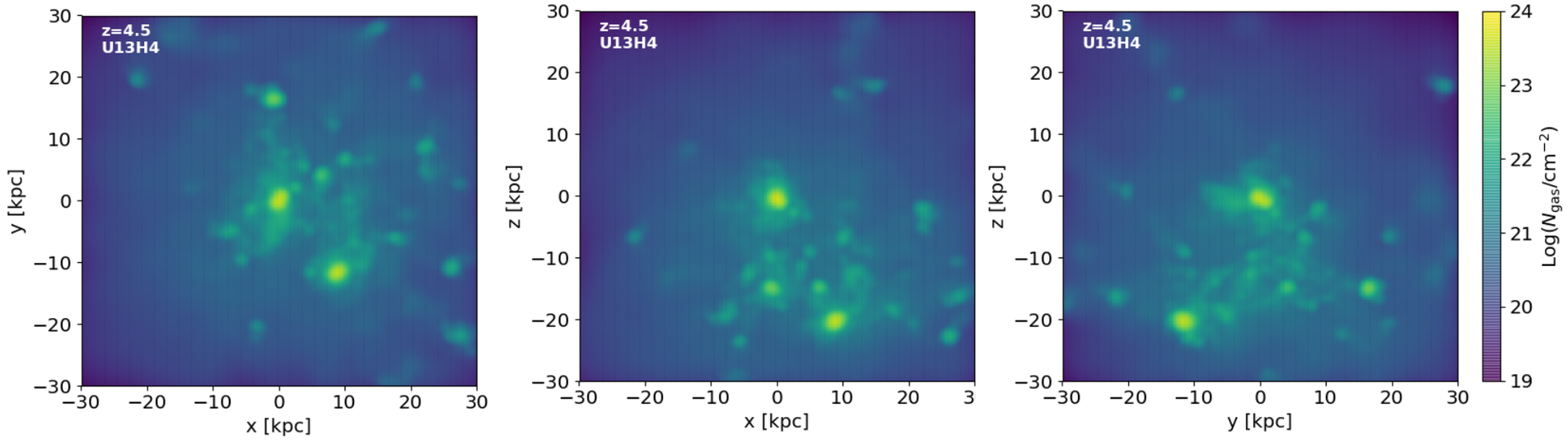
ii) satellites in baryonic matter

z = 4.5

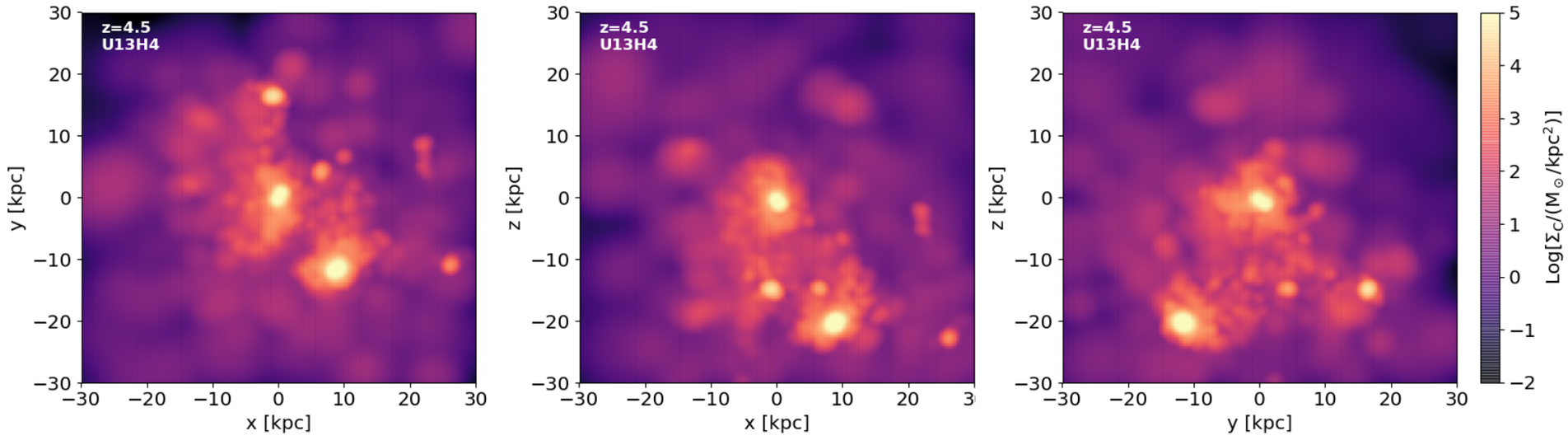
stellar particles



gas column density



C surface density



PRELIMINARY

preliminary CONCLUSIONS :

- diffuse [CII] emission from a sample of 6 interacting galaxies
- 35%-70% emission is coming from the medium *between* the galaxies
- tentative trends between the diffuse emission, physical properties ($L_{[CII]}$; $M_\star$; SFR) and the relative properties (r_p ; μ) of analysed systems
- merger tree reconstructions with dustyGadget
- predictions from simulations to interpret the observations

Thanks for your attention!

email:
claudia.dicesare@uniroma1.it