MACS0416_Y1

dust and carbon at z = 8.3

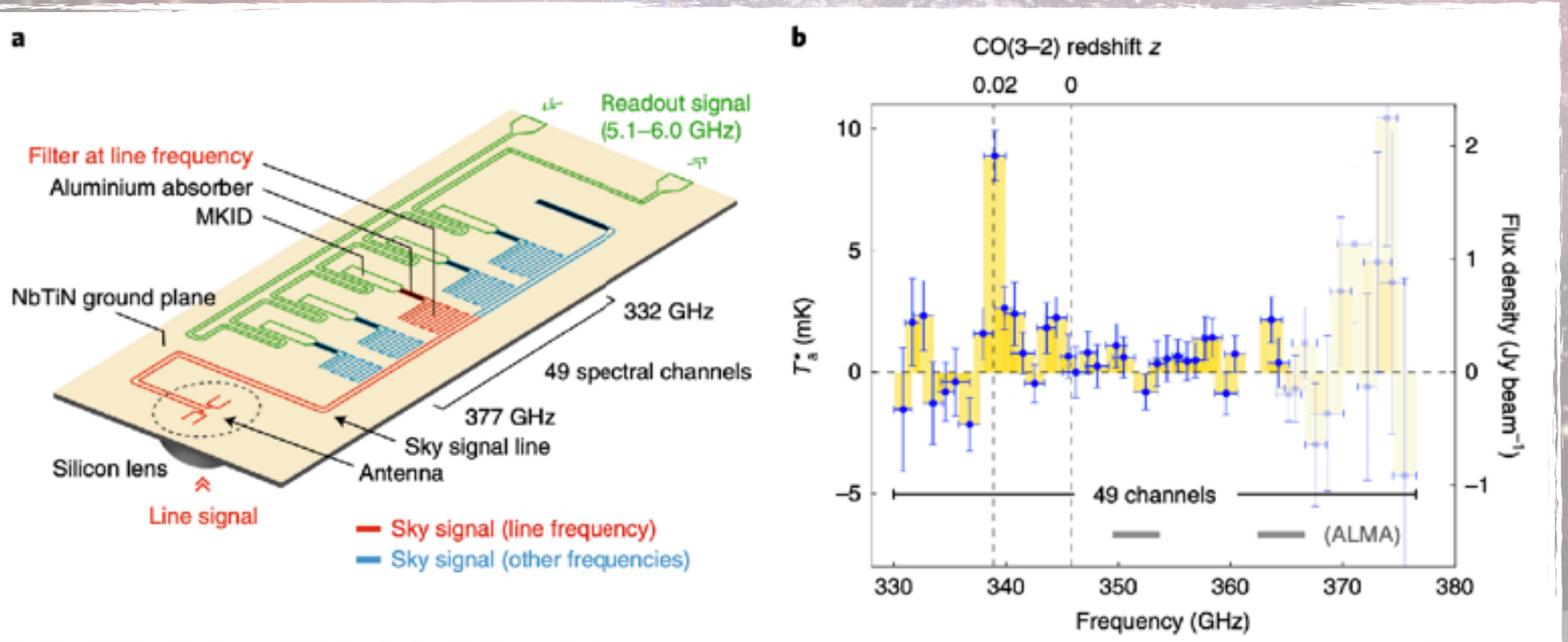
Tom Bakx

Credit: National Astronomical Observatory of Japan

Hi! I’m Tom!

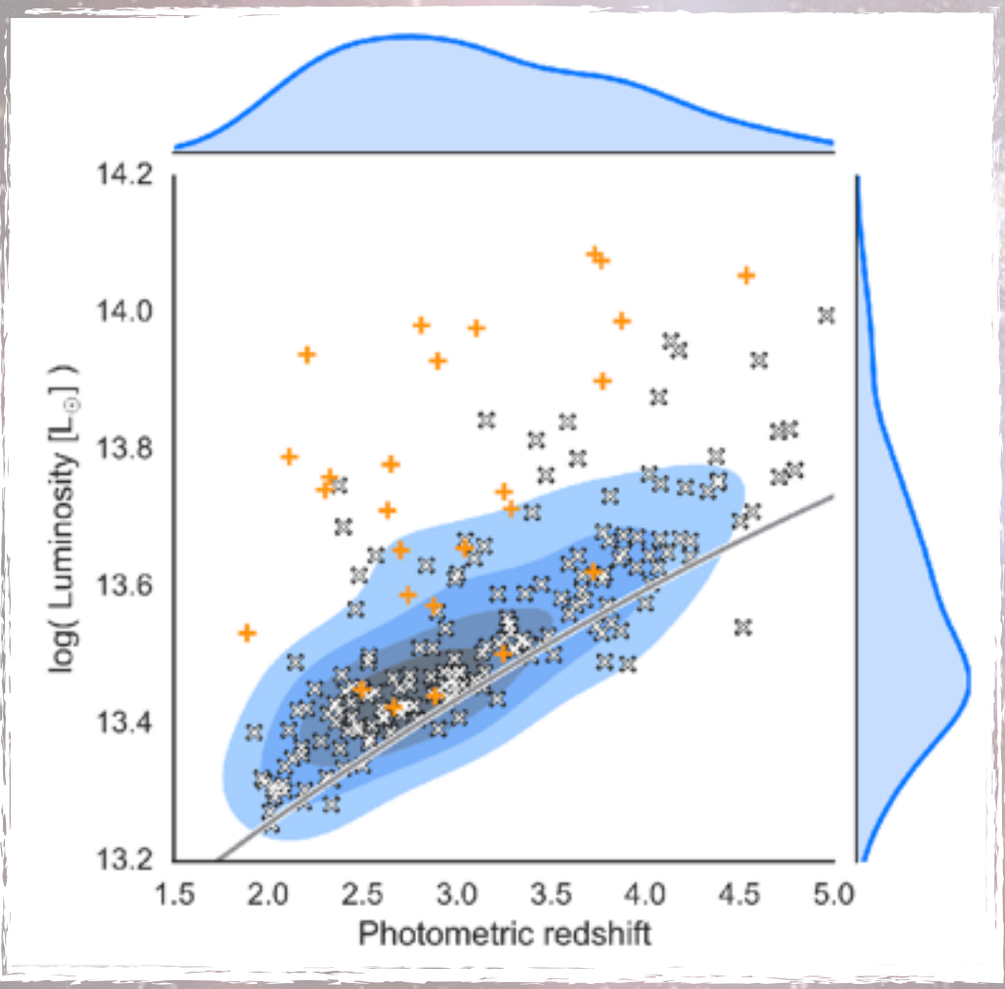
DESHIMA


DESHIMA


a
Readout signal
(5.1–6.0 GHz)
Filter at line frequency
Aluminium absorber
MKID
NbTiN ground plane
332 GHz
49 spectral channels
377 GHz
Sky signal line
Antenna
Silicon lens
Line signal
Sky signal (line frequency)
Sky signal (other frequencies)
b
CO(3–2) redshift z
0.02
0
10
5
0
–5
T_a^* (mK)
2
1
0
–1
Flux density (Jy beam^{-1})
49 channels
(ALMA)
330
340
350
360
370
380
Frequency (GHz)

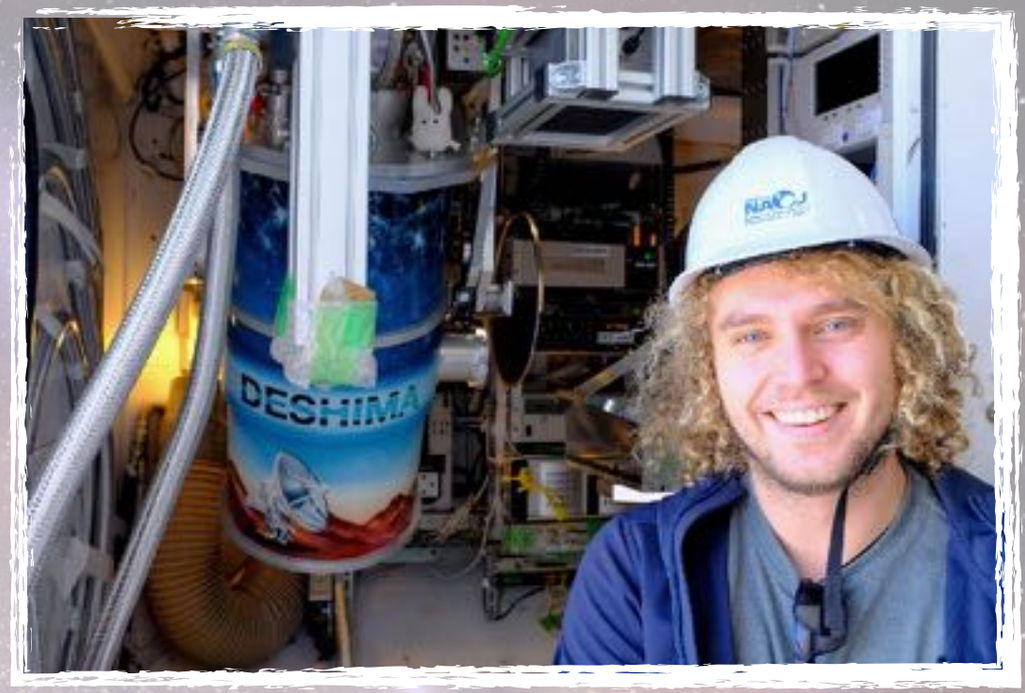
Dutch

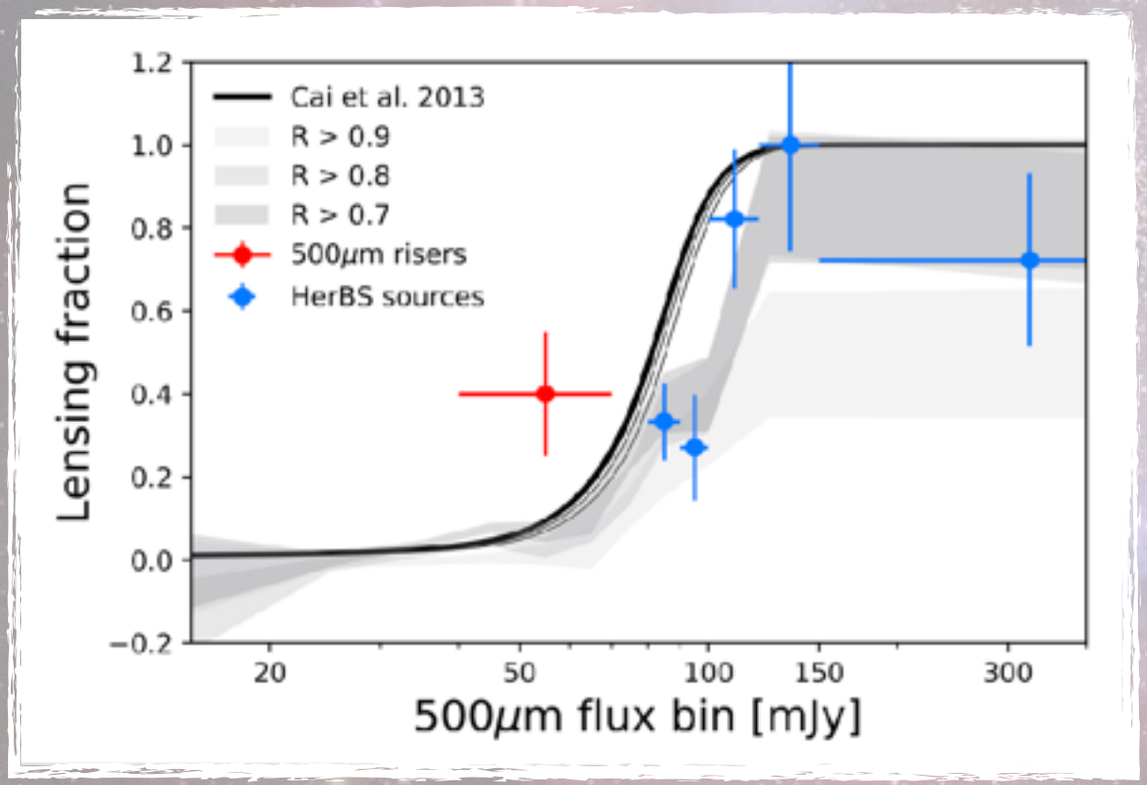
HerBS



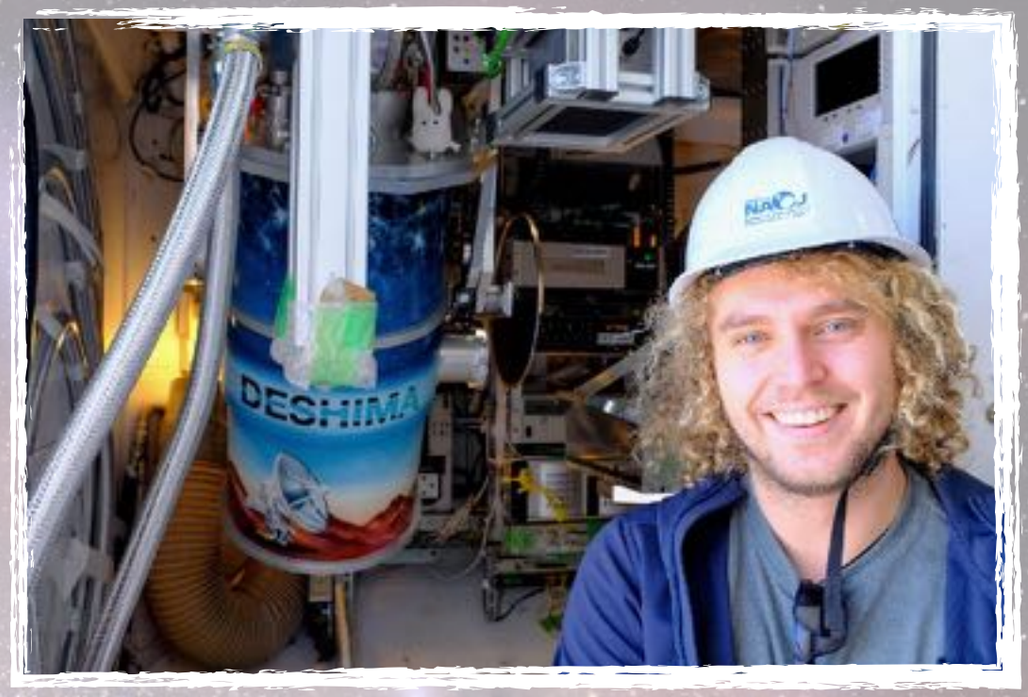
300 SMGs @ z > 2
90% Redshift complete
@ 2021

FaintLens


DESHIMA


Cai et al. 2013
R > 0.9
R > 0.8
R > 0.7
500μm risers
HerBS sources
Lensing fraction
500μm flux bin [mJy]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
20
50
100
150
300

Wales



日本の食べ物

Carbon

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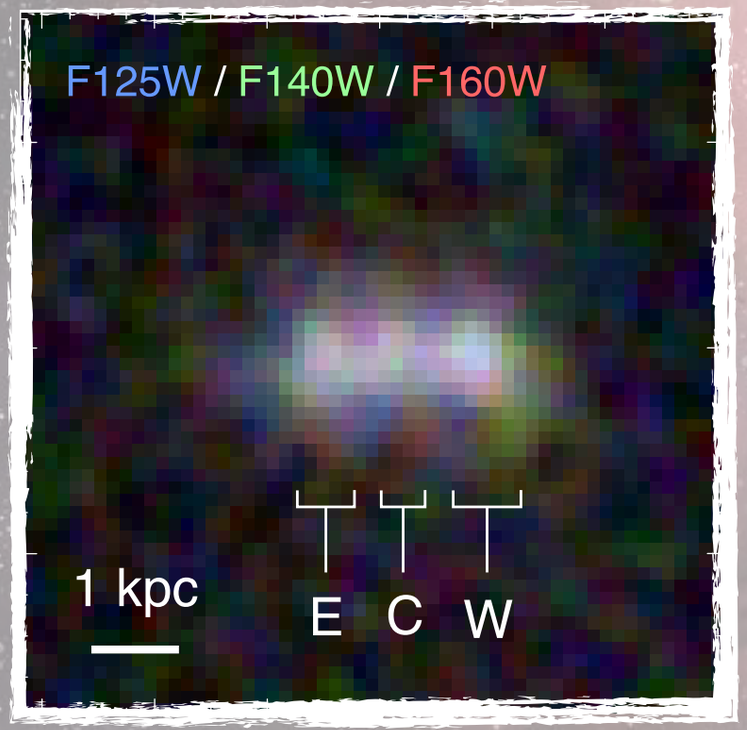
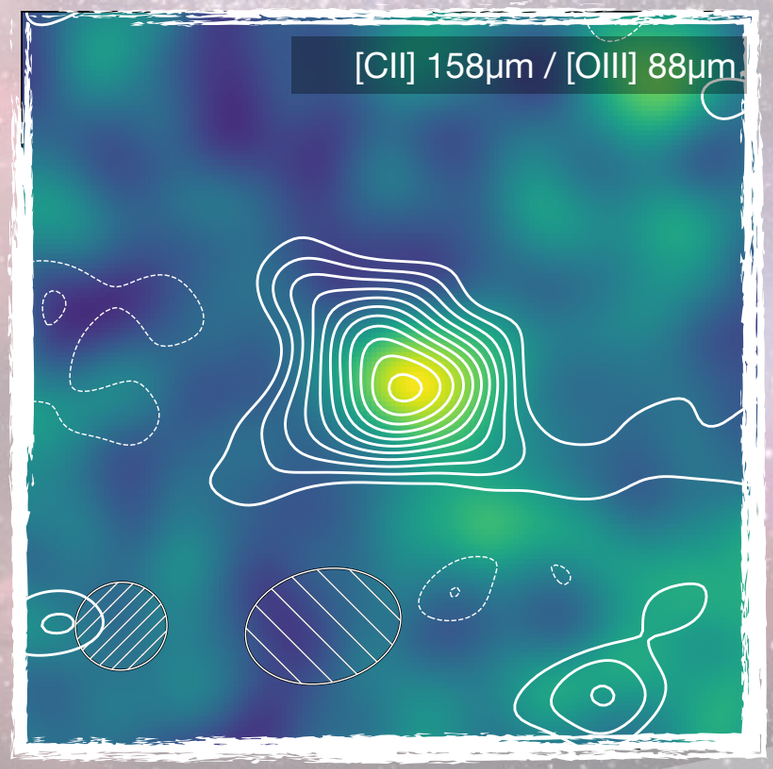
dust and carbon at z = 8.3

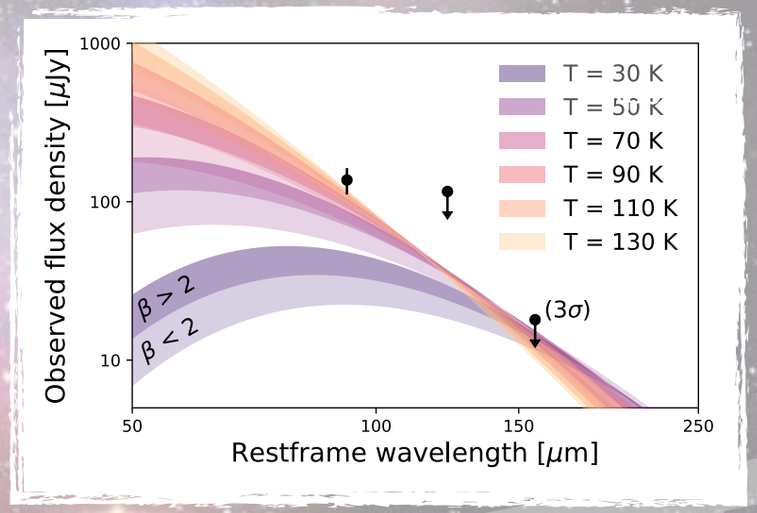
The source …



… the lines …

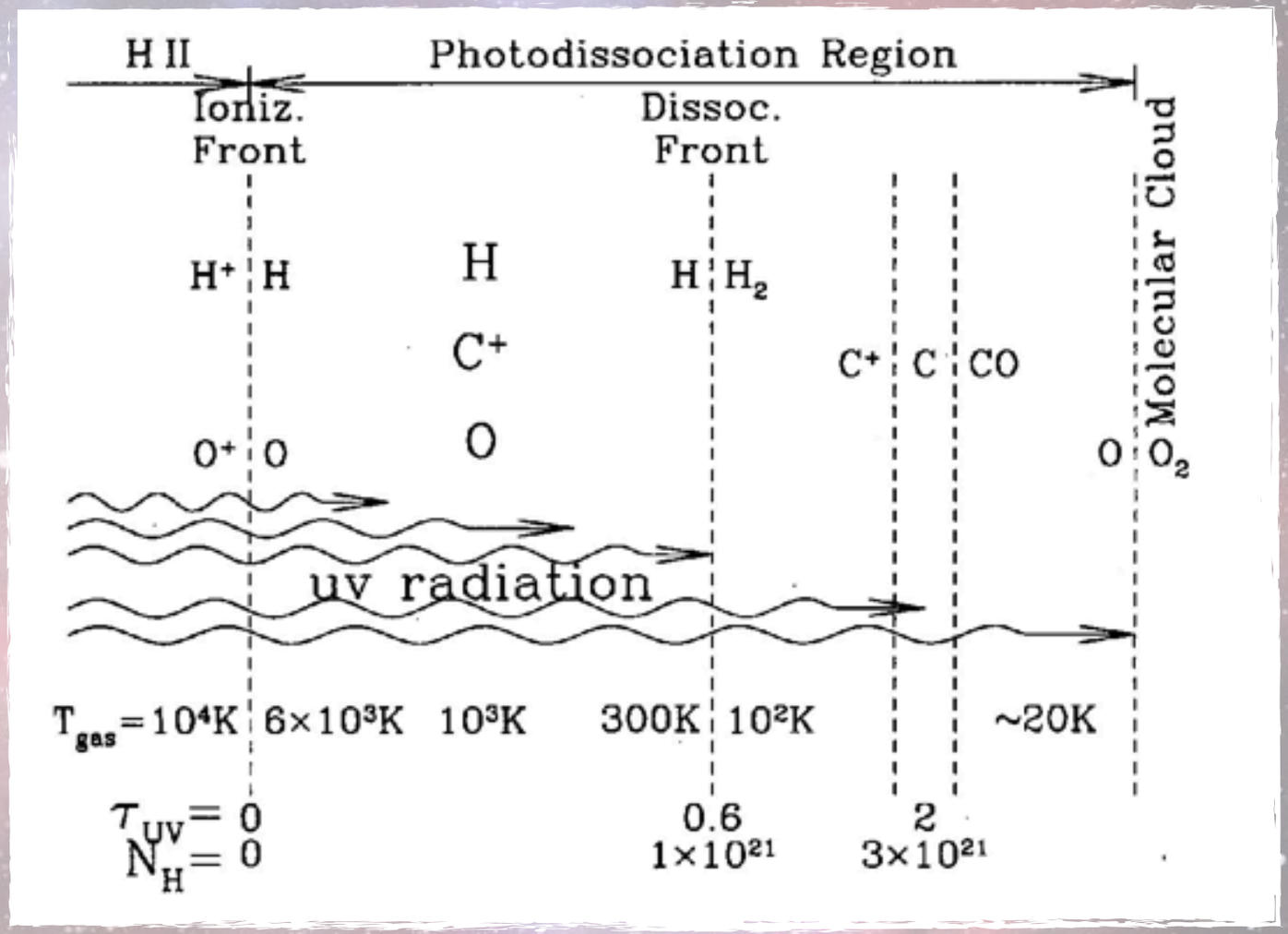


… and the spectrum!



Theoretical intermission

Photo-dissociation regions



O & B stars

[OIII]

[CII]

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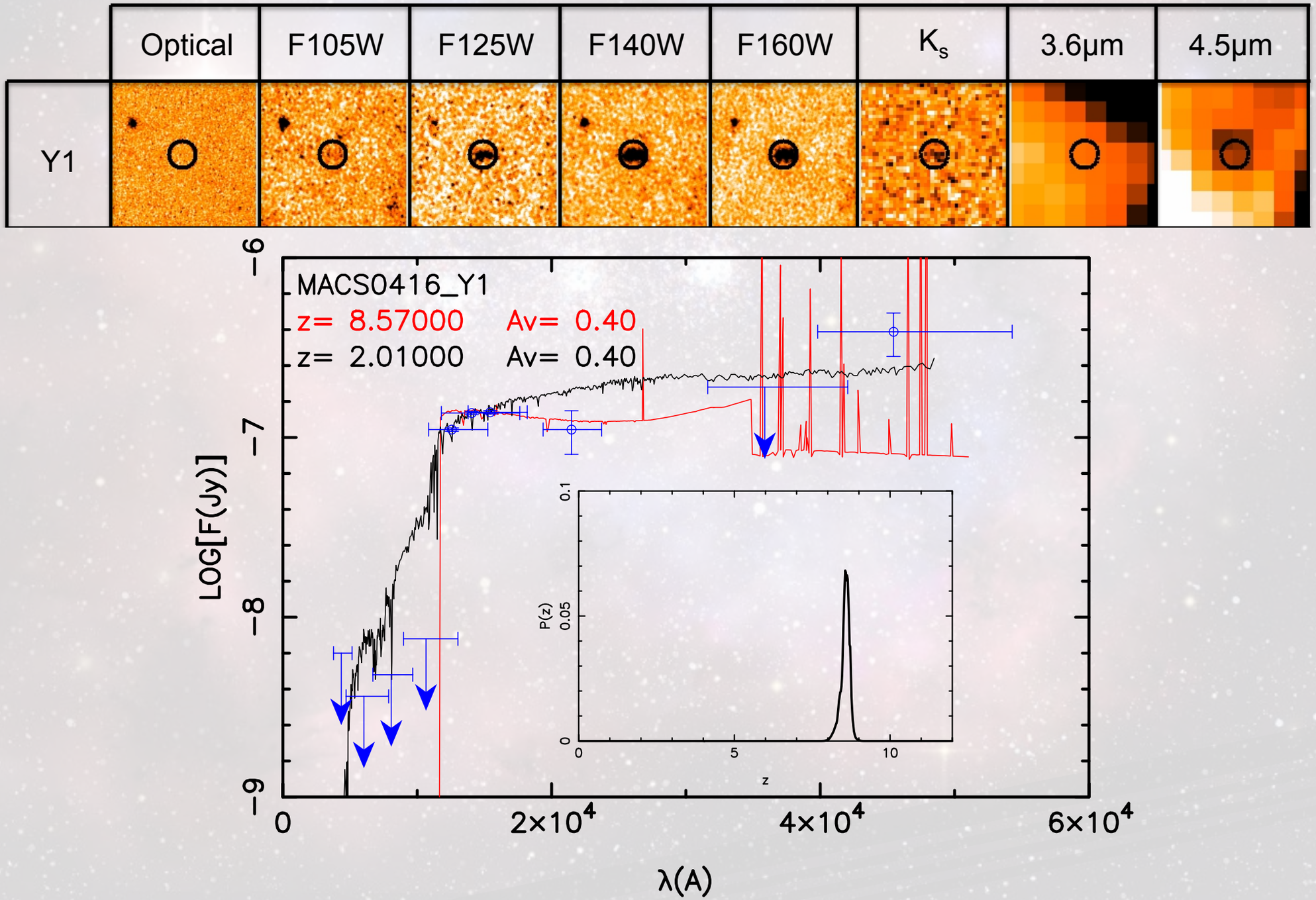
Y-band dropout from the HFF

Laporte et al. 2014



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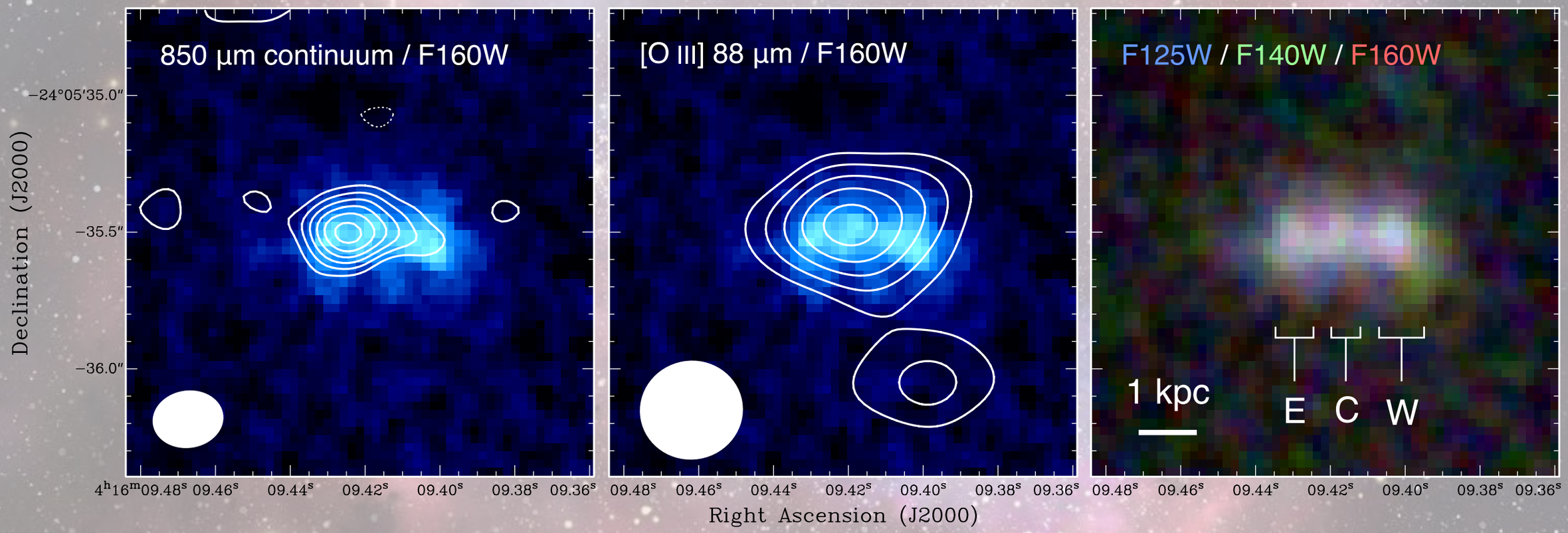
Hubble Frontier Fields LBG



Tamura et al. 2019

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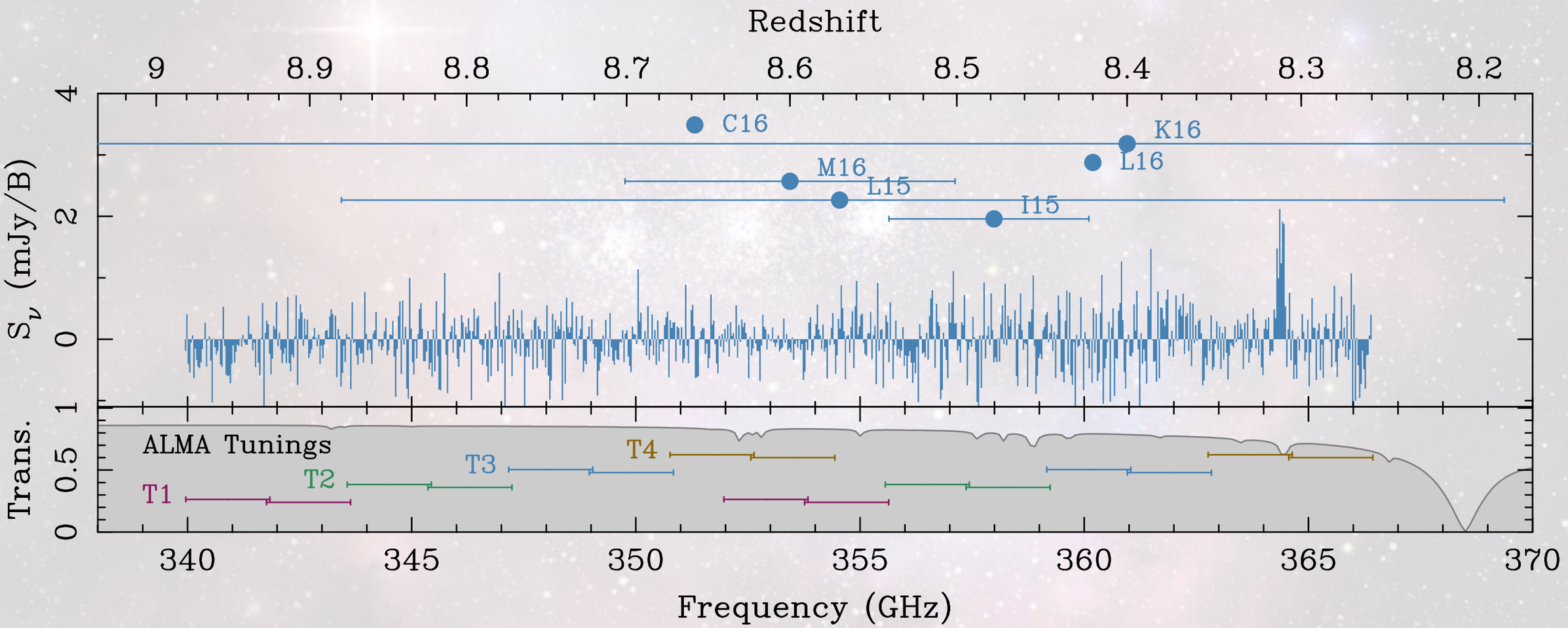
[OIII] 88μm at z = 8.31



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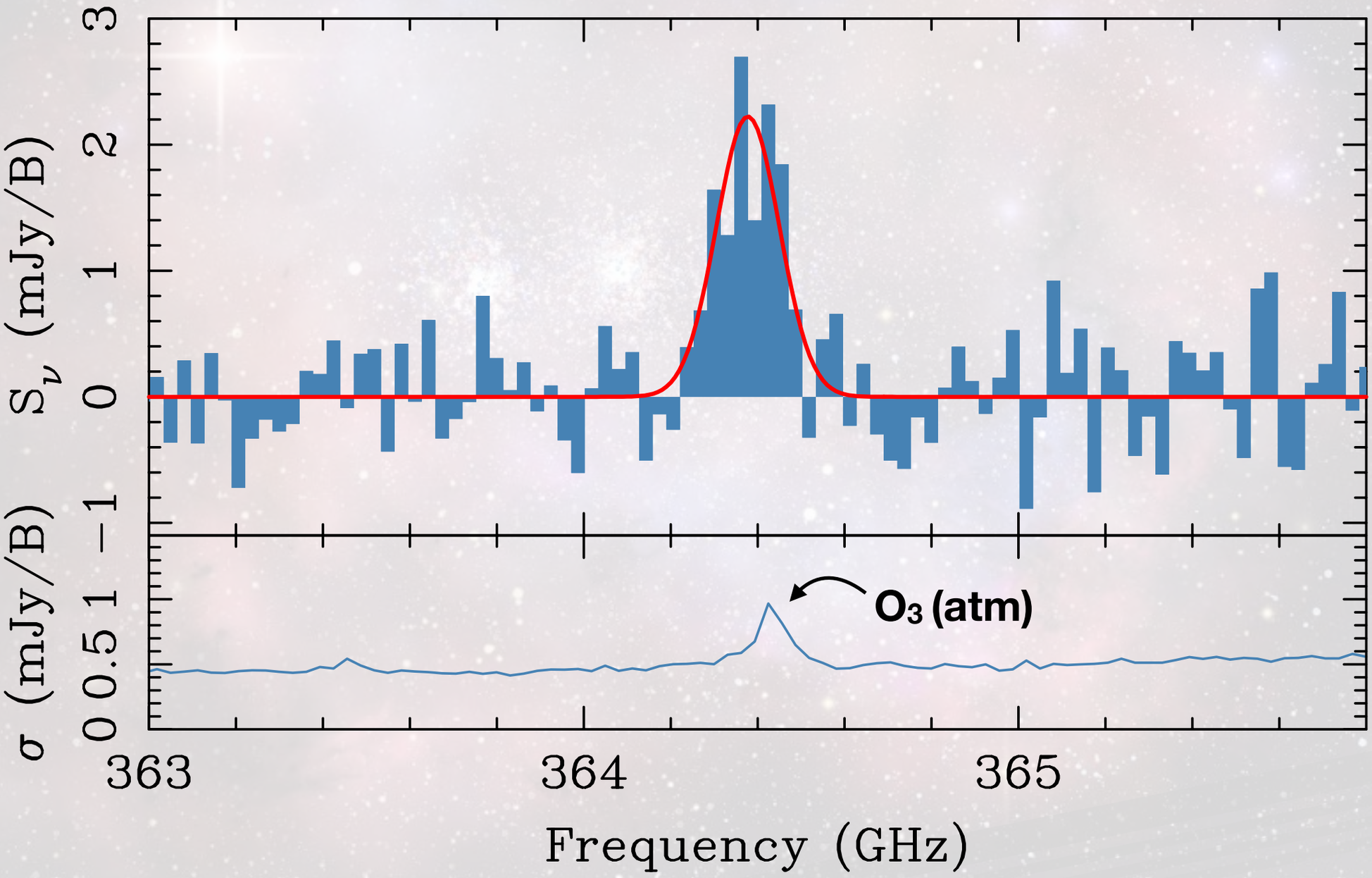
[OIII] 88μm at z = 8.31

dv	.=	141 ± 21 km/s
$L_{[OIII]}$	.=	(1.2±0.3) × 10^9 $L_\odot$
z	.=	8.3118 ± 0.0003
$S_{88\mu m}$	.=	137 ± 26 μJy
L_{FIR}	.=	(1.7±0.3) × 10^{11} $L_\odot$



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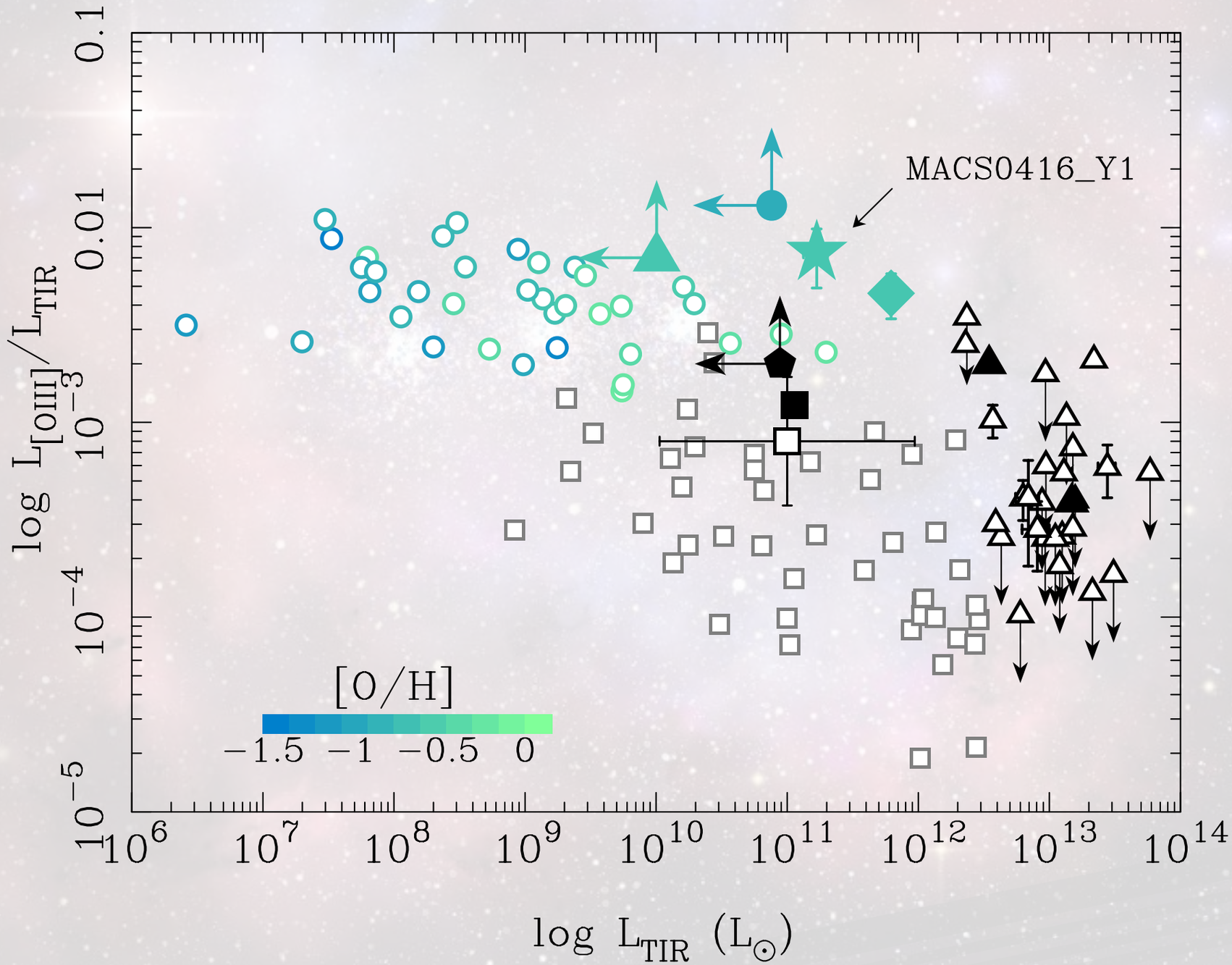
[OIII] 88μm deficit at high-z



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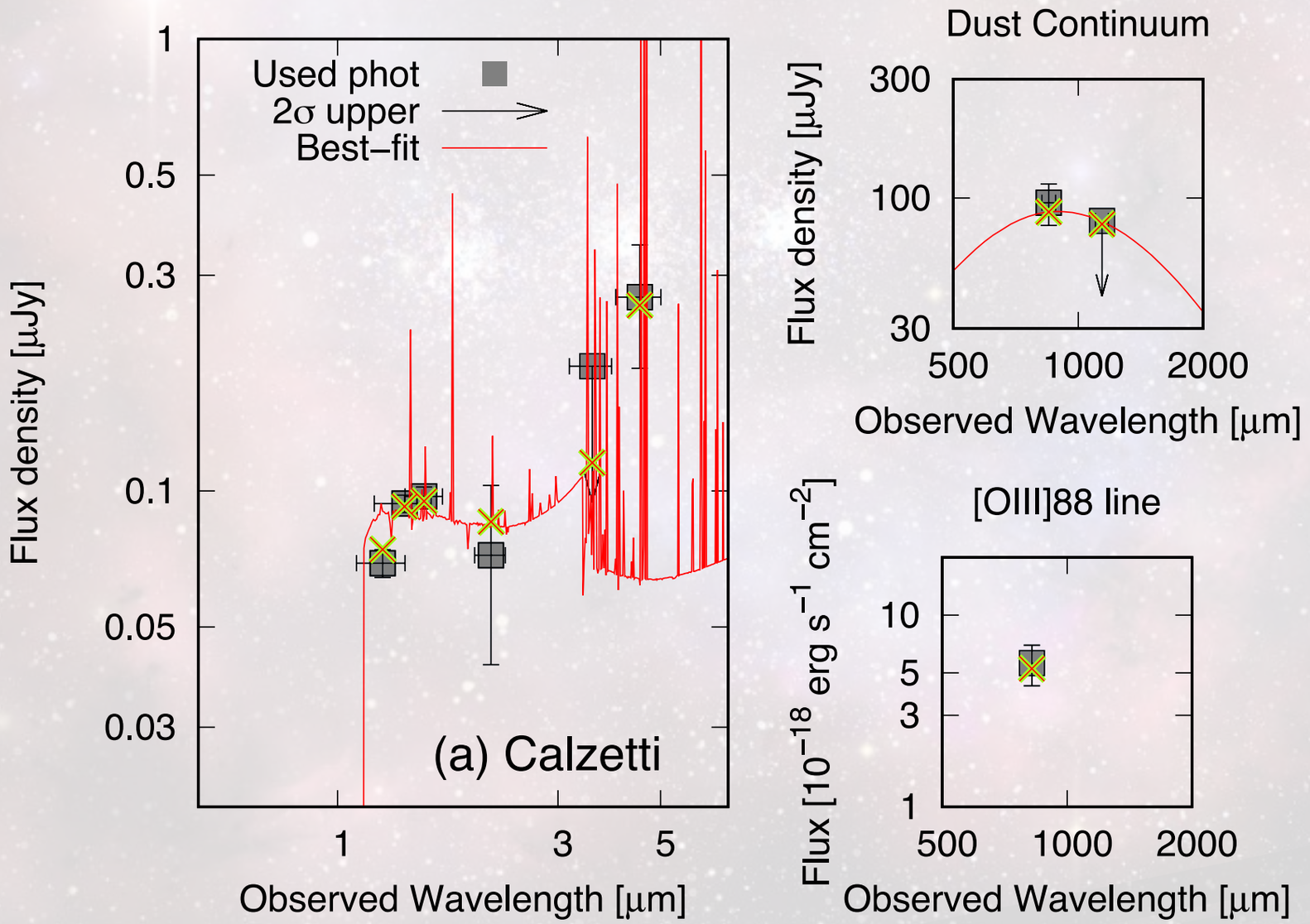
Starburst at z = 8.3

t_{age}	.=	3.5 Myr
Z	.=	$0.2^{0.16}_{-0.18}\,Z_{\odot}$
M_{star}	.=	$2.4 \times 10^{8}\,M_{\odot}$
SFR	.=	$57\,M_{\odot}$ / yr



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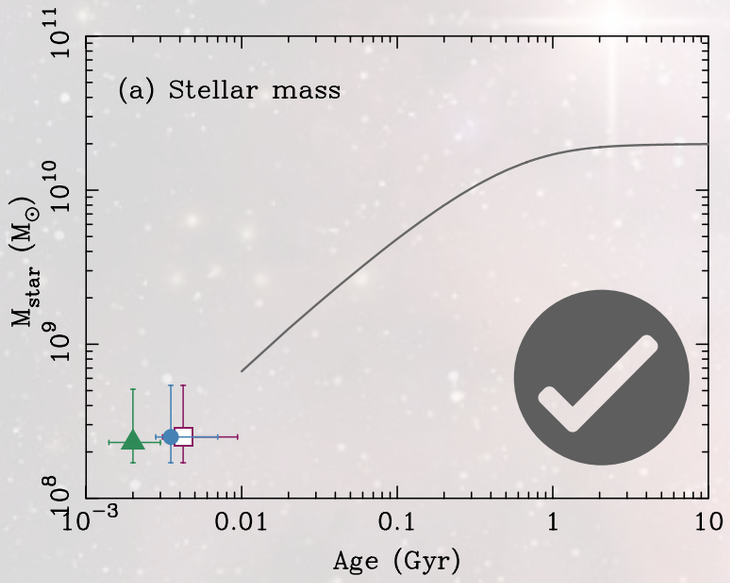
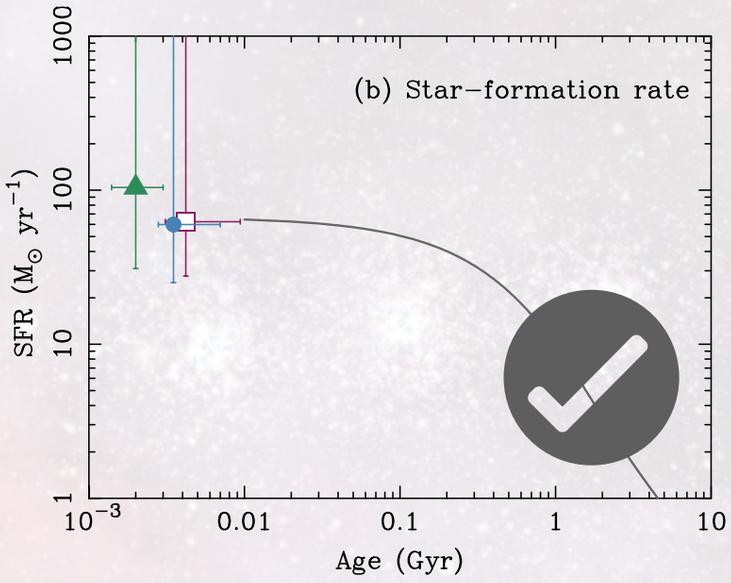
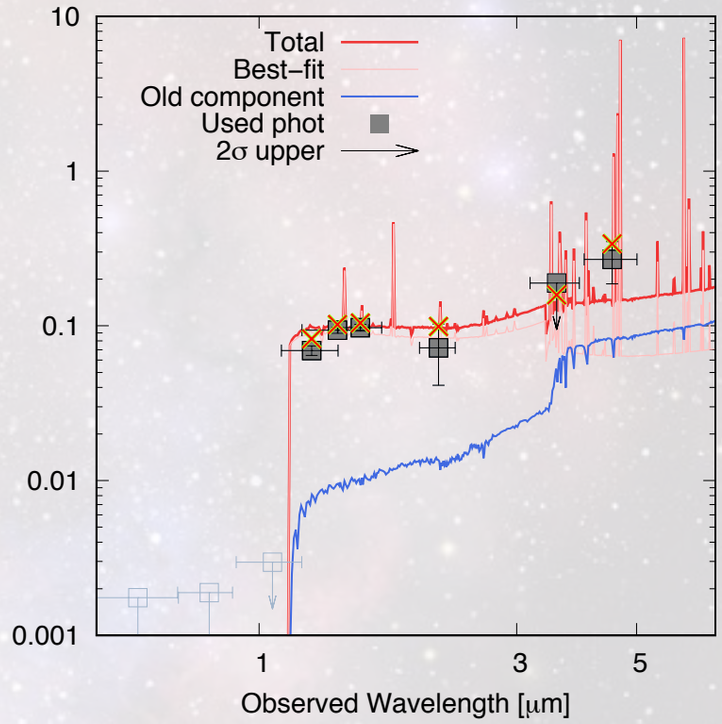
Stellar component at z = 15

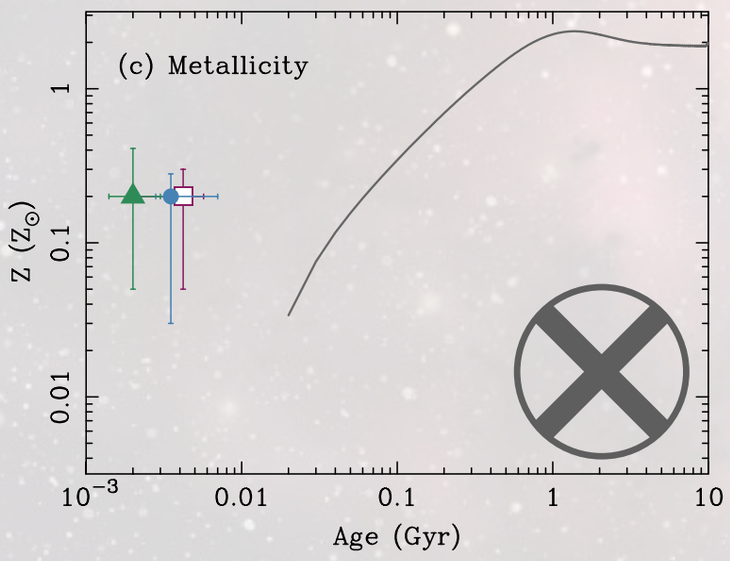
M_{dust} .= $4 \times 10^6\ M_\odot$

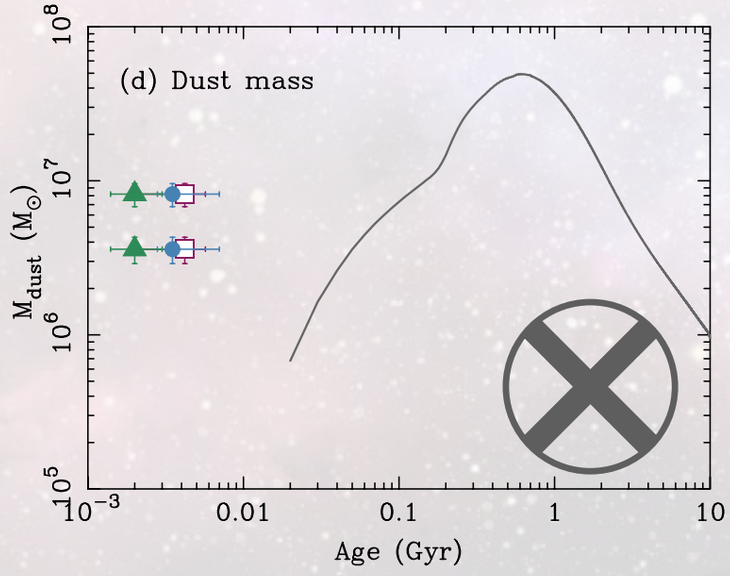
t_{age} .= 0.3 Gyr











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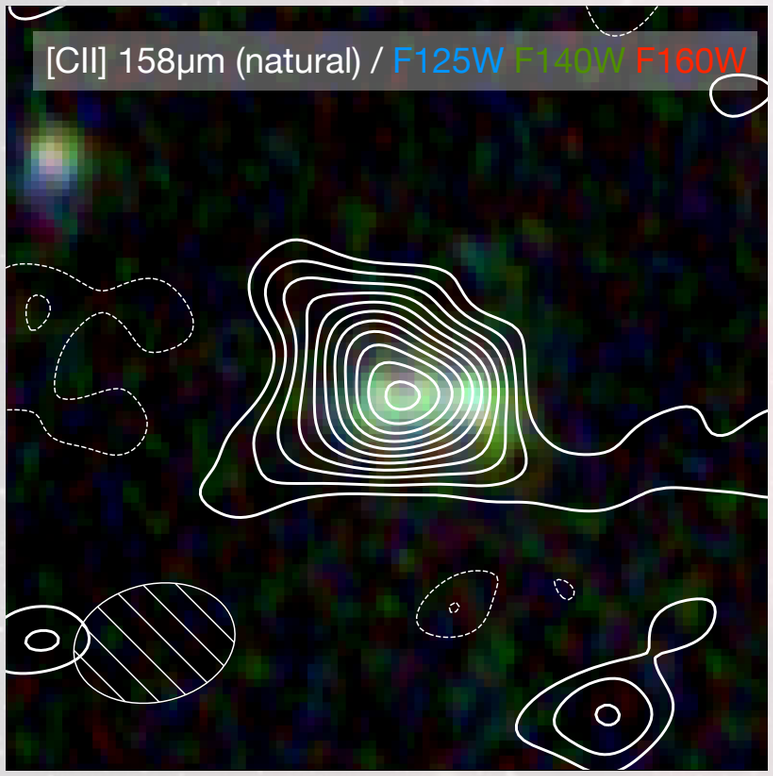
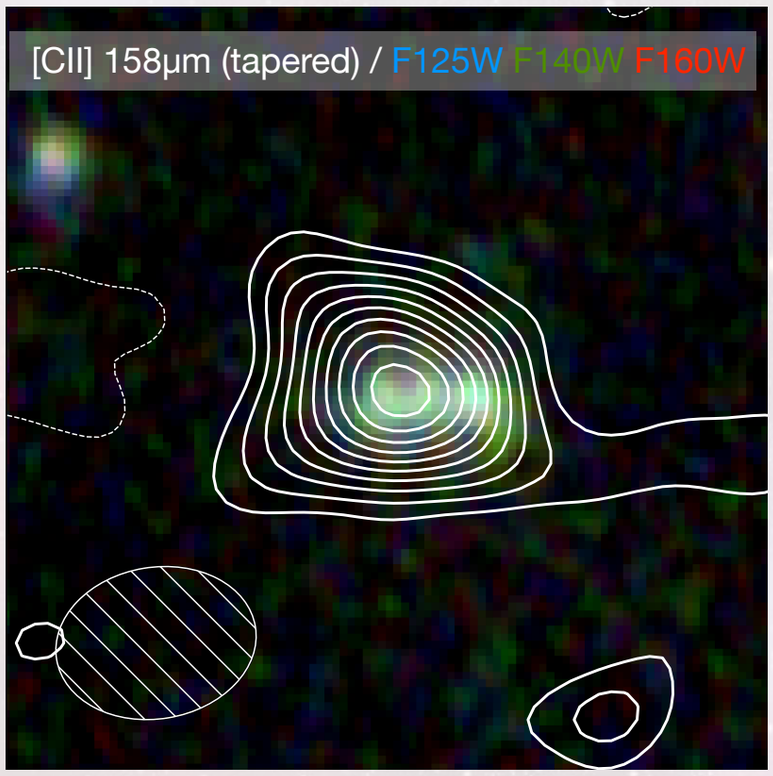
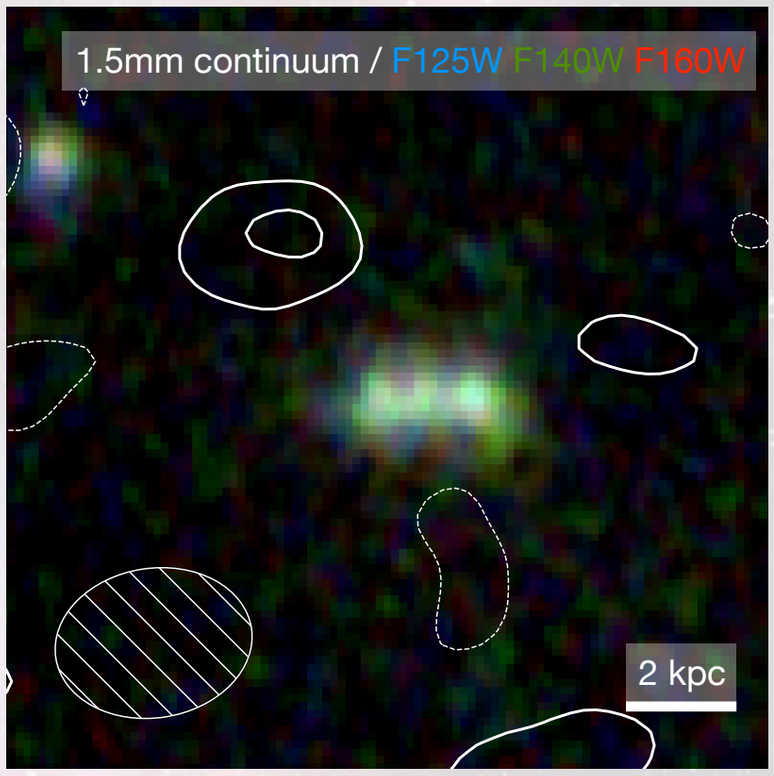
Detection of [CII] at z = 8.31

dv	.=	191 ± 29 km/s
$L_{[CII]}$	.=	(1.4±0.2) × 10^8 $L_\odot$
z	.=	8.31132 ± 0.00037
$S_{158\mu m}$	.=	< 18 μJy (3σ)

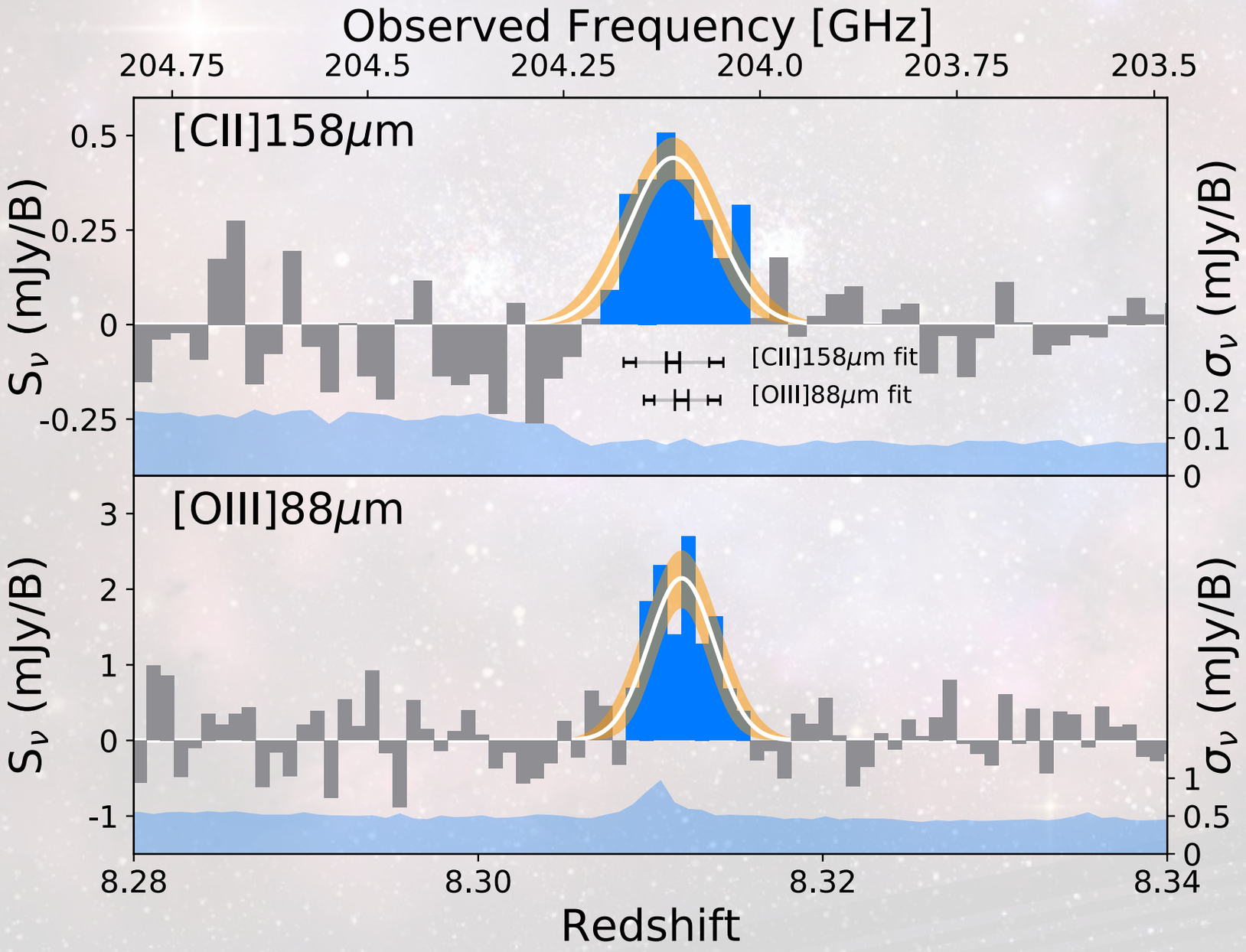






MACS0416_Y1

Detection of [CII] at z = 8.31



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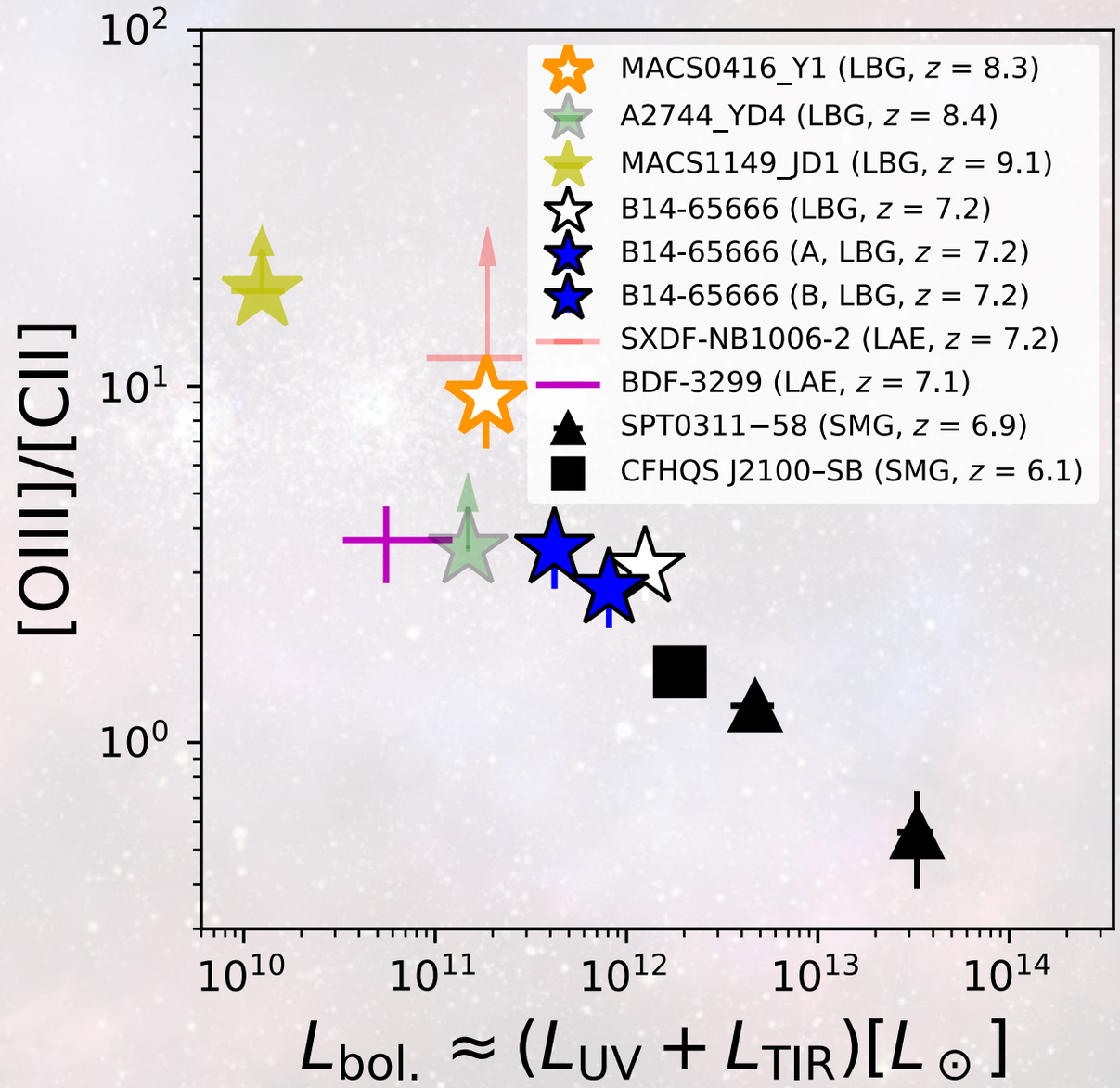
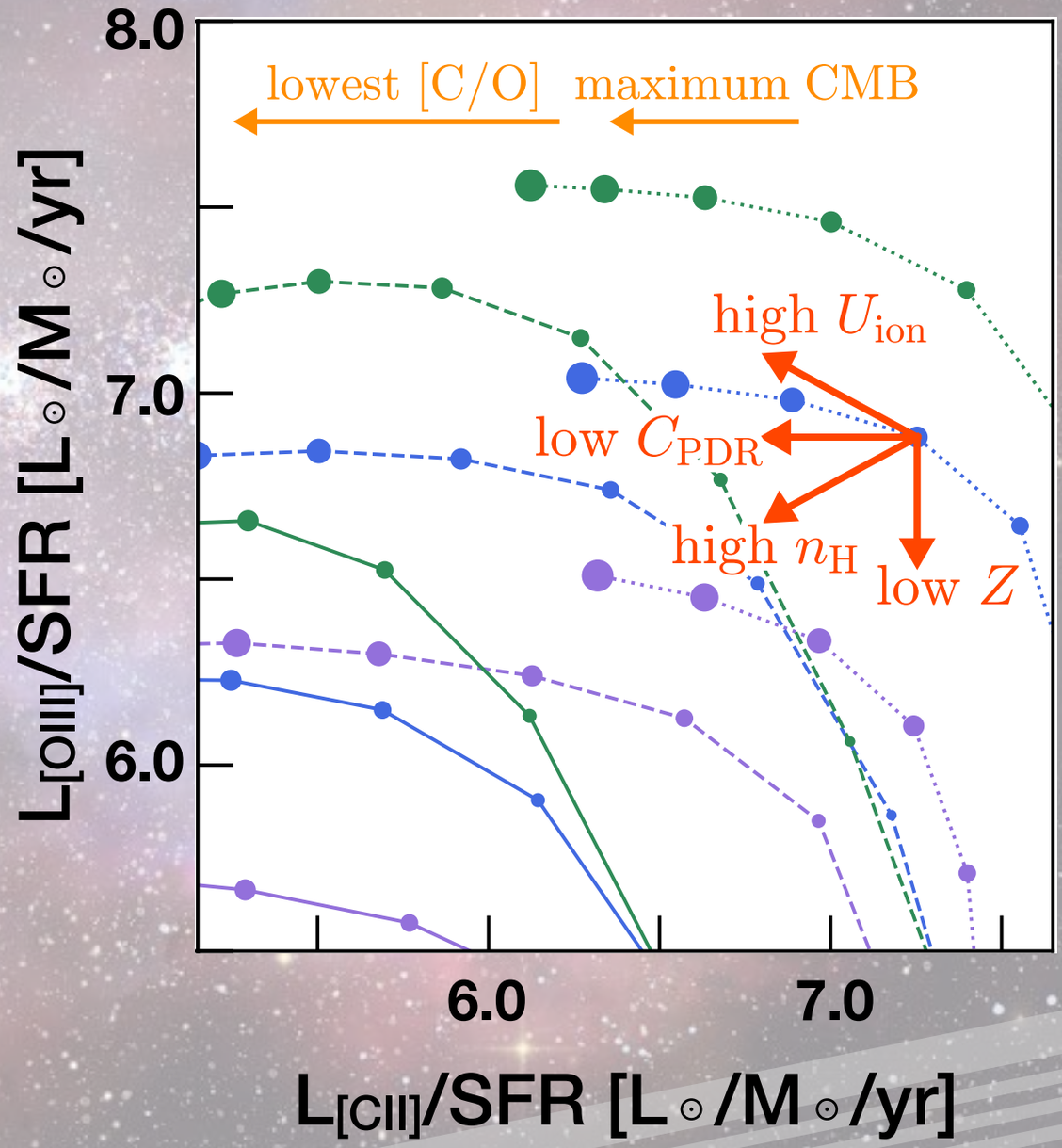
High [OIII]/[CII] ratio



MACS0416_Y1

CLOUDY modeling by Harikane+2019

- **Higher ionization parameter**
- **Lower gas metallicity**
- **Higher density**
- **Lower C/O ratio**
- **Lower covering fraction**
- **CMB attenuation effect**
- **Spatially-extended [CII]**
- **Inclination effect**



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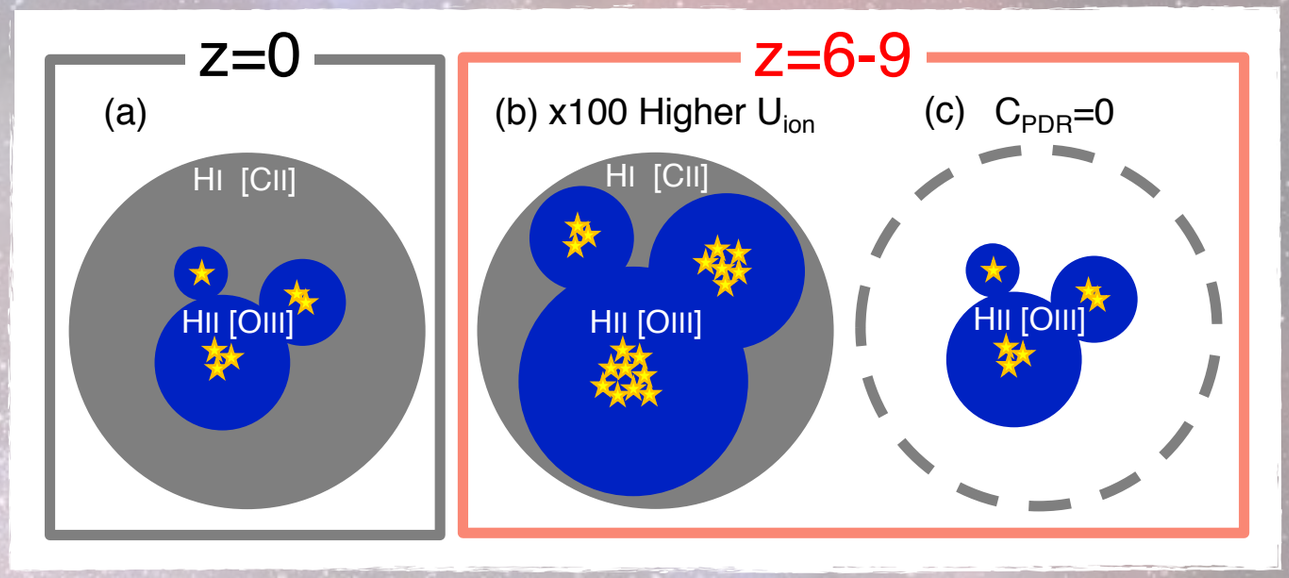

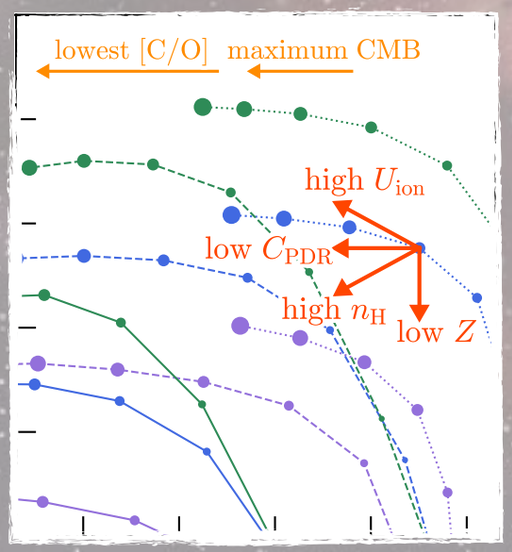

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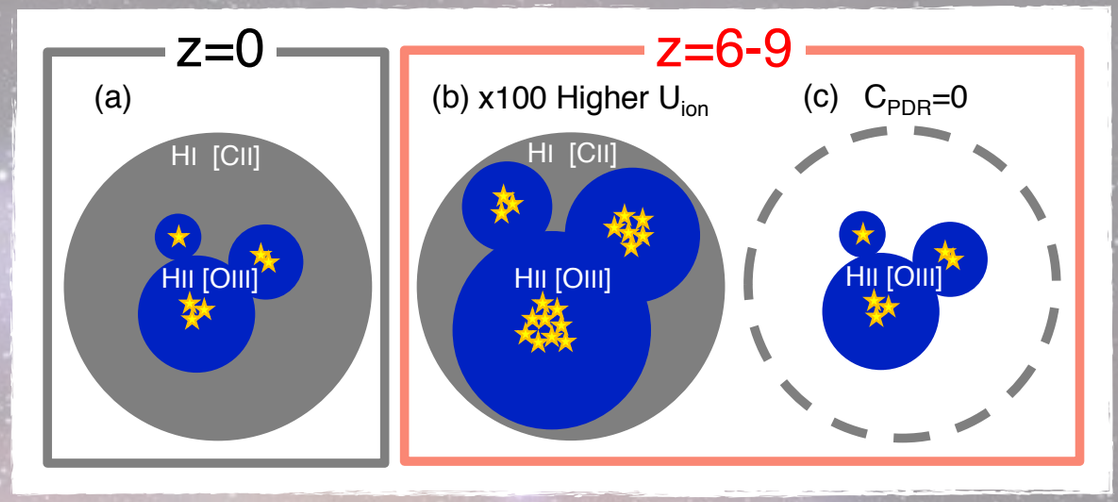
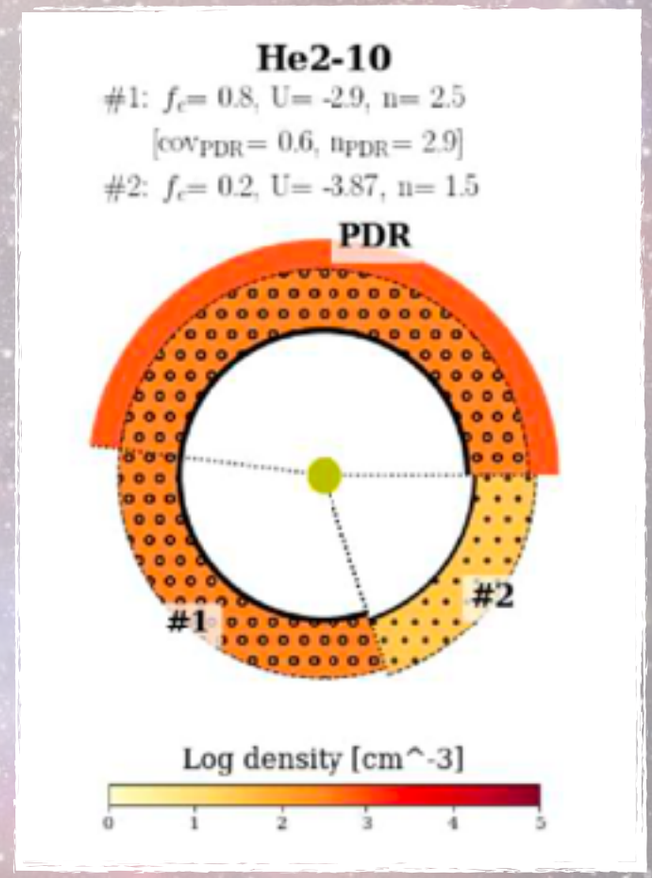
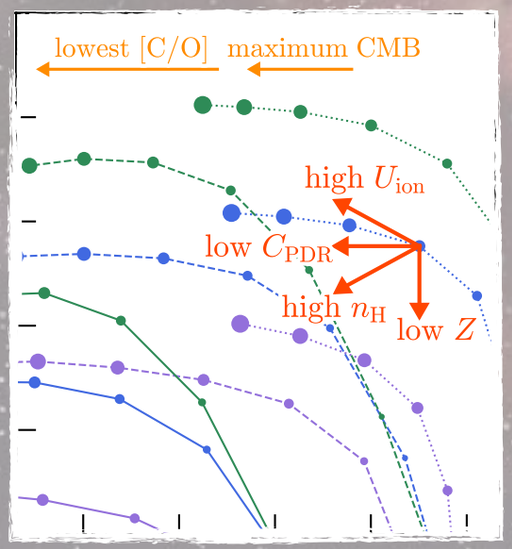
Dwarf Galaxies also have low CF

- Higher ionization parameter
- Lower gas metallicity
- Higher density
- Lower C/O ratio
- **Lower covering fraction**
- CMB attenuation effect
- Spatially-extended [CII]
- Inclination effect





Cormier et al. 2019



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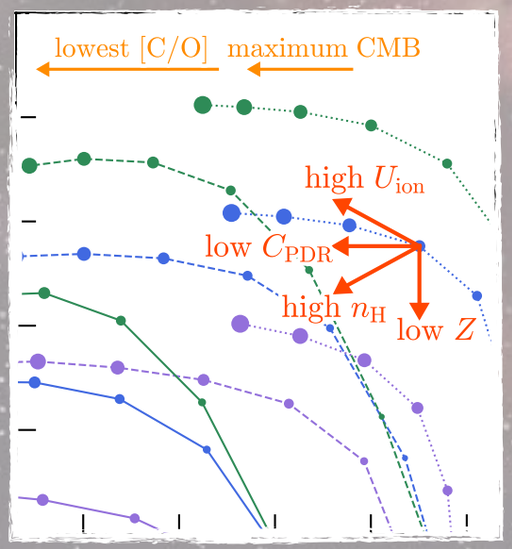
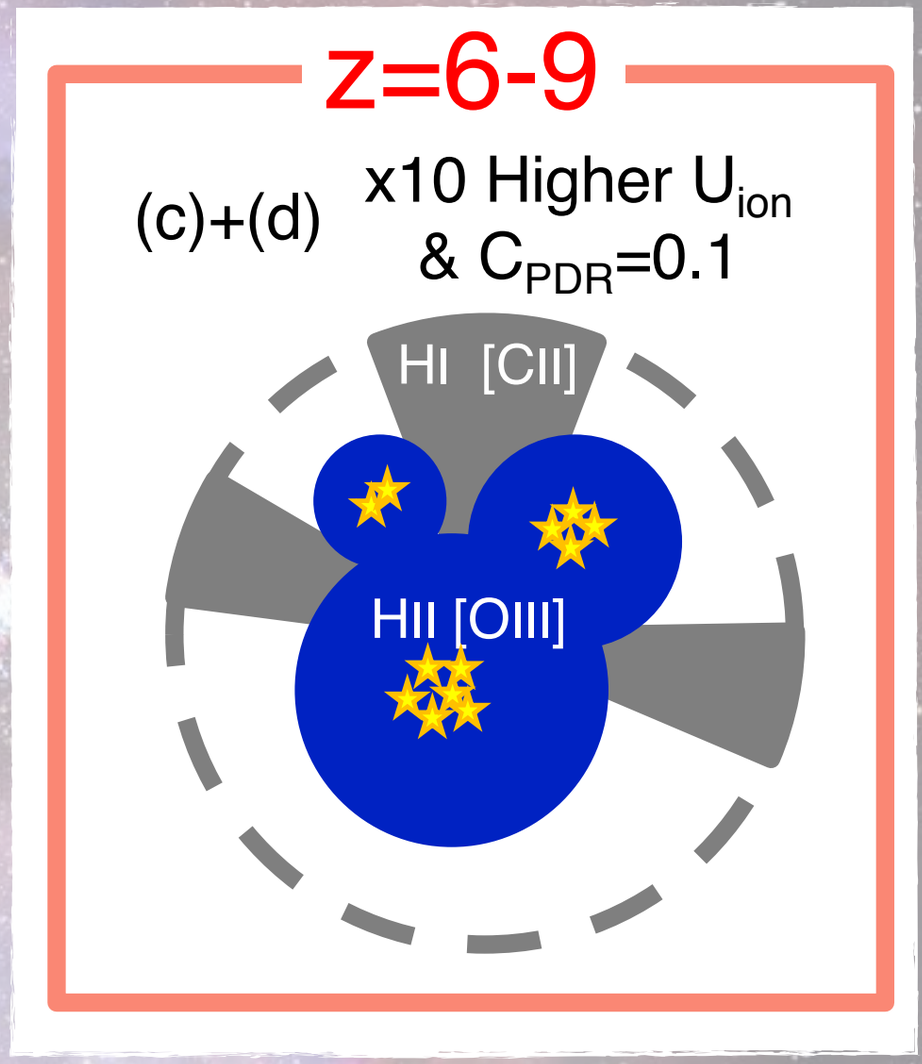
Or a combination of things?

- **Higher ionization parameter**
- **Lower gas metallicity**
- **Higher density**
- **Lower C/O ratio**
- **Lower covering fraction**
- **CMB attenuation effect**
- **Spatially-extended [CII]**
- **Inclination effect**





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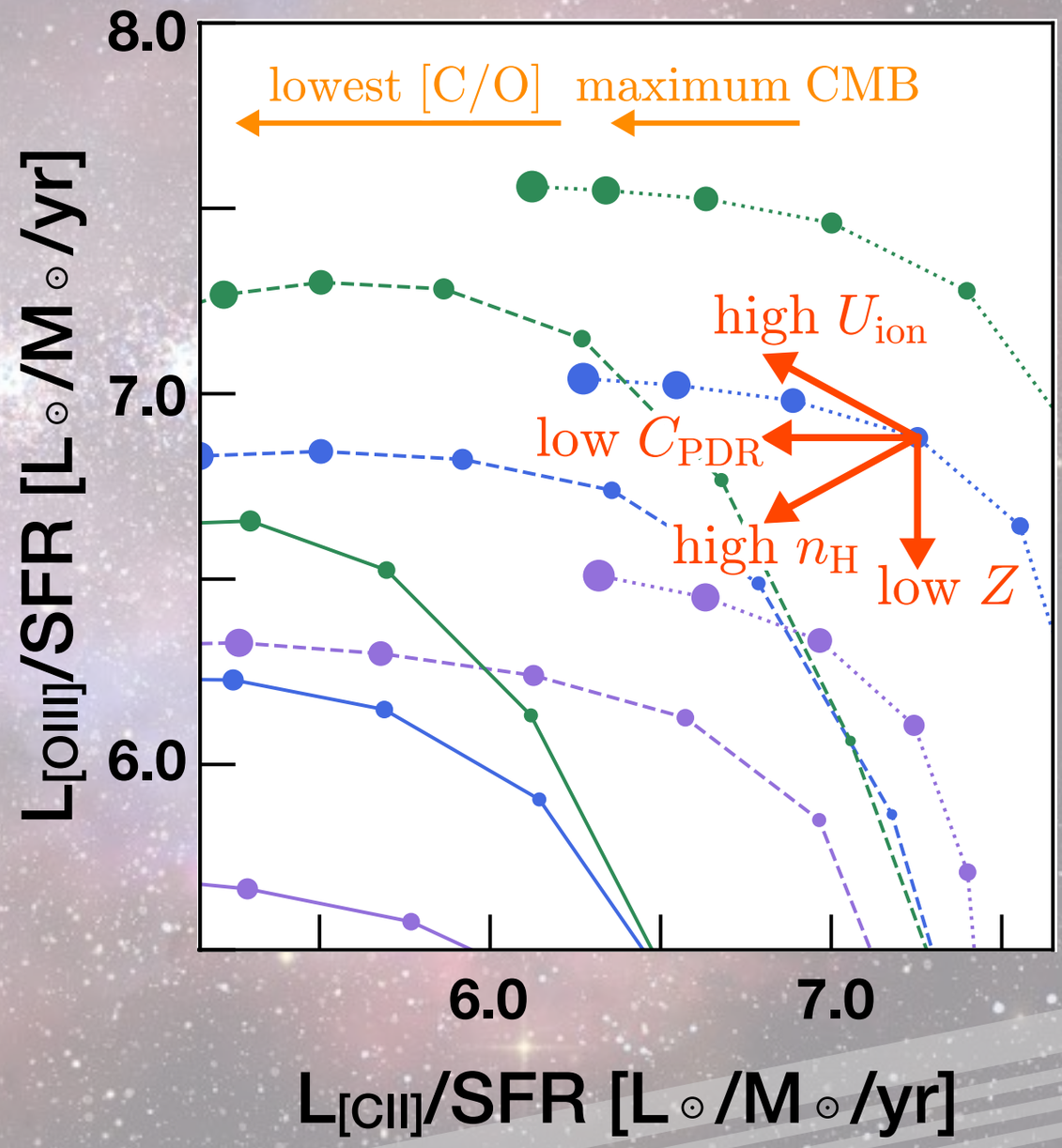
Even including these…

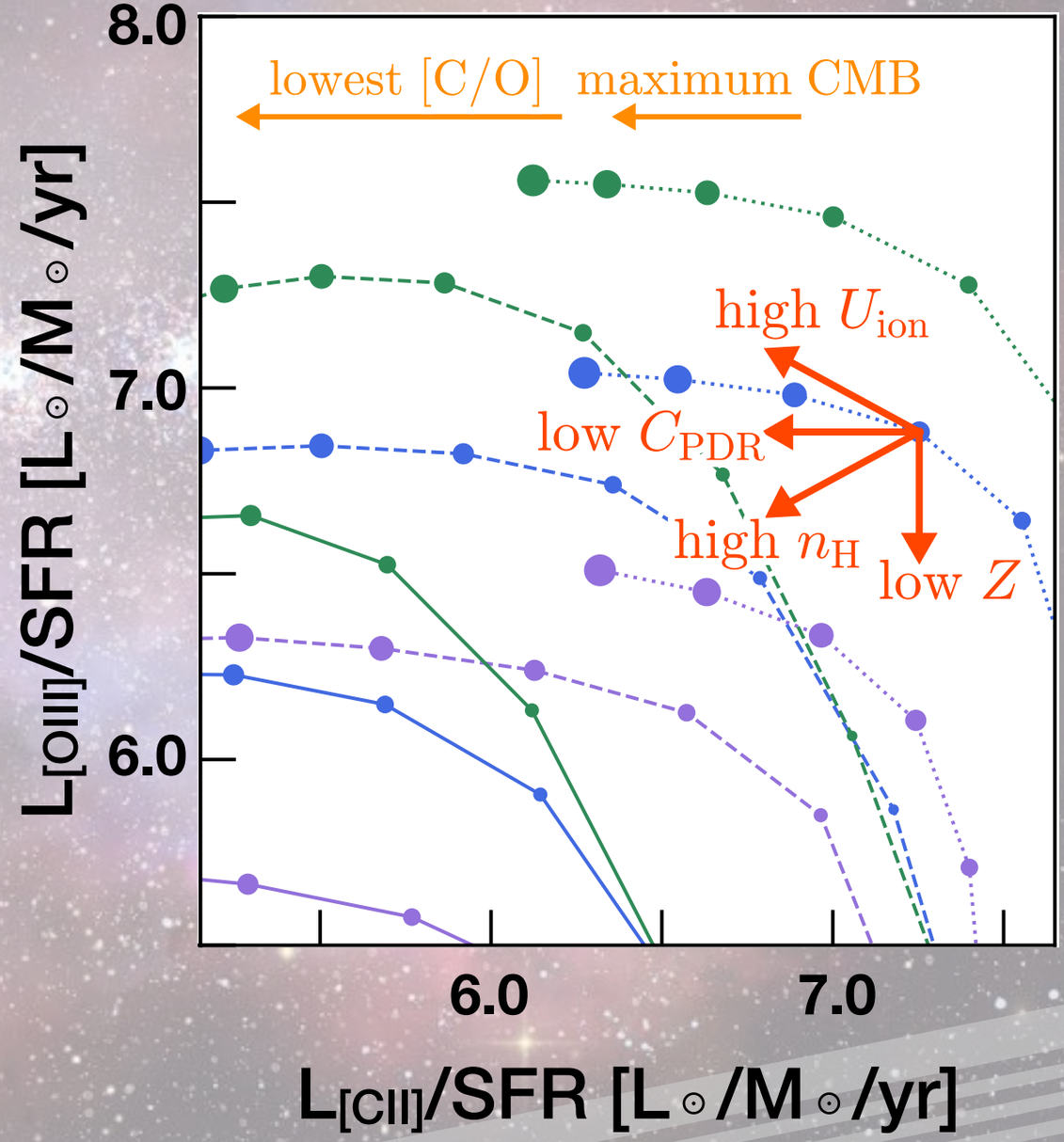
- Higher ionization parameter
- Lower gas metallicity
- **Higher density**
- **Lower C/O ratio**
- Lower covering fraction
- **CMB attenuation effect**
- Spatially-extended [CII]
- Inclination effect



MACS0416_Y1

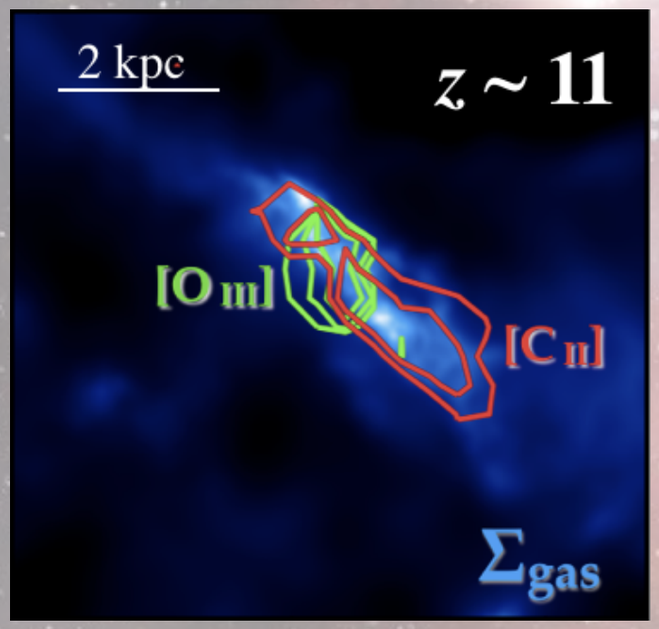
Though CLOUDY rejects…

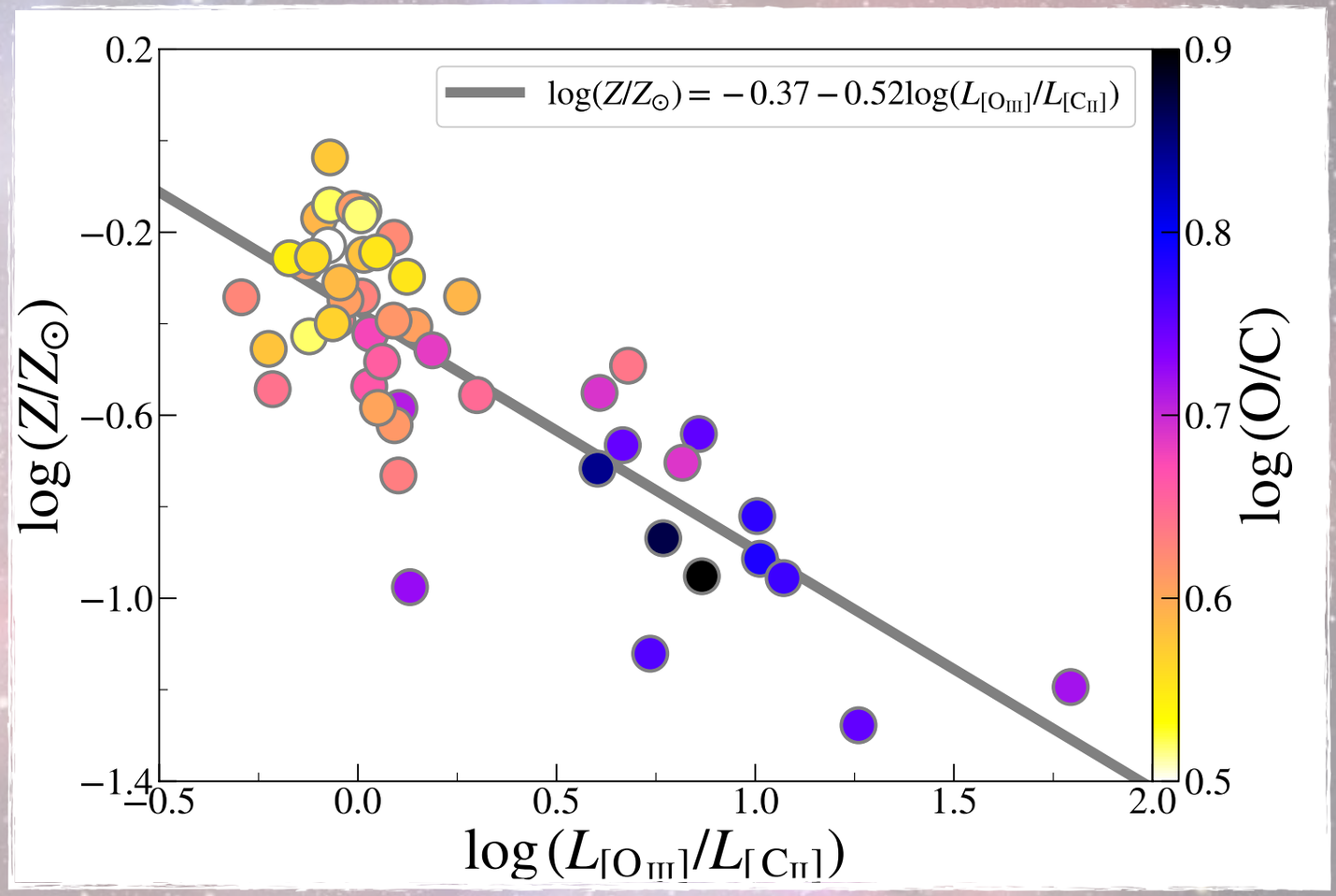
- Higher ionization parameter
- **Lower gas metallicity**
- Higher density
- Lower C/O ratio
- Lower covering fraction
- CMB attenuation effect
- **Spatially-extended [CII]**
- **Inclination effect**



MACS0416_Y1

Most full scale simulations still disagree, but…





Arata et al. 2020

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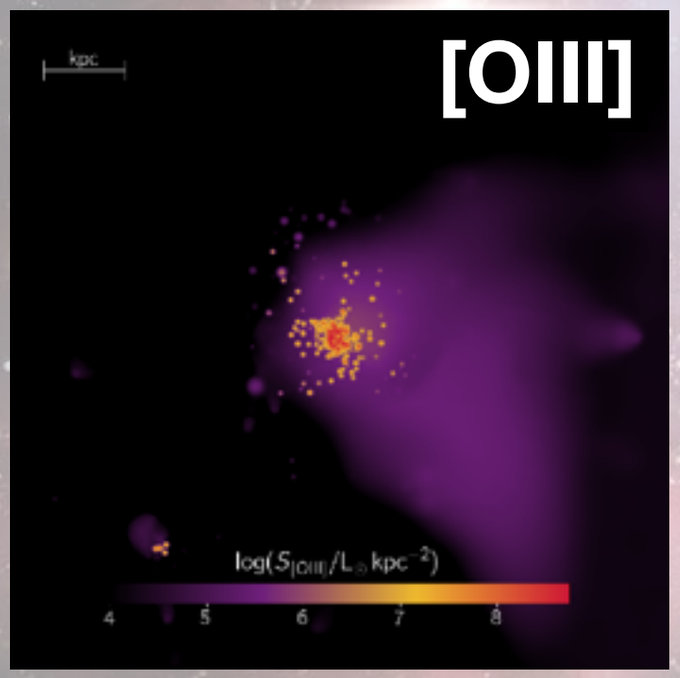
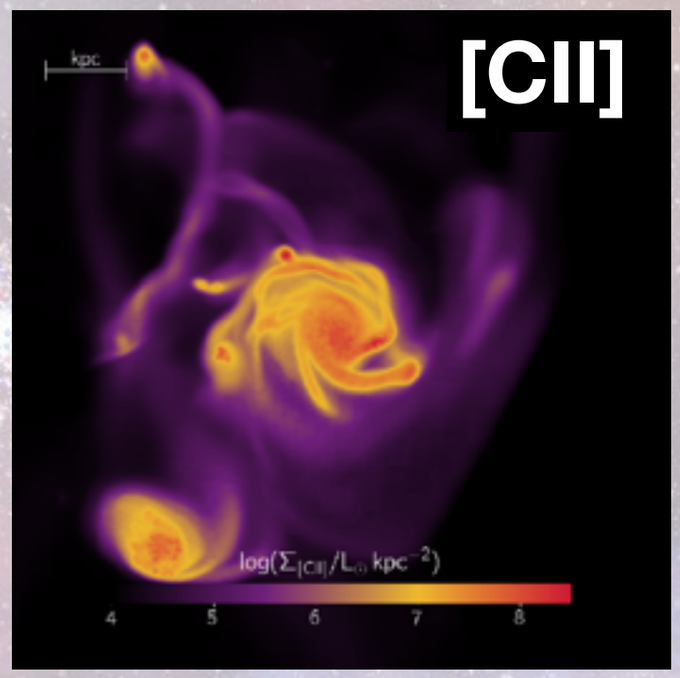
Full scale simulations still disagree





Pallottini et al. 2019

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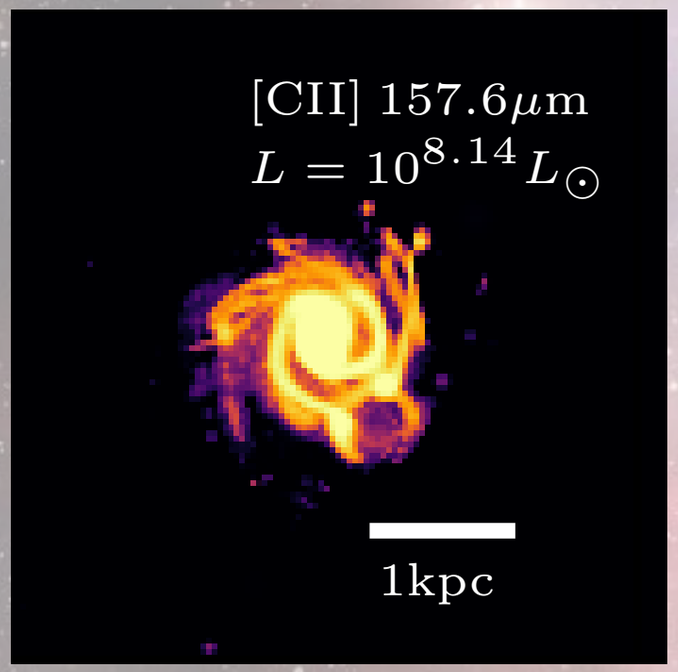
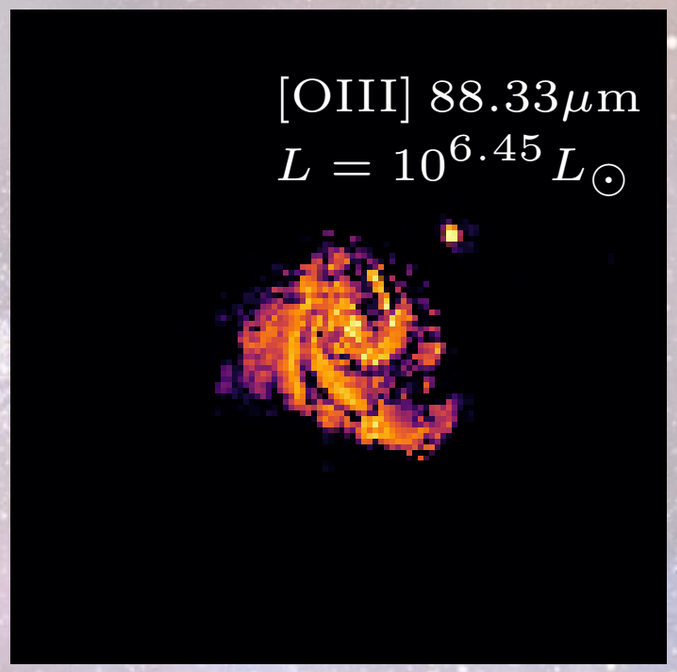
Full scale simulations still disagree





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Katz et al. 2019

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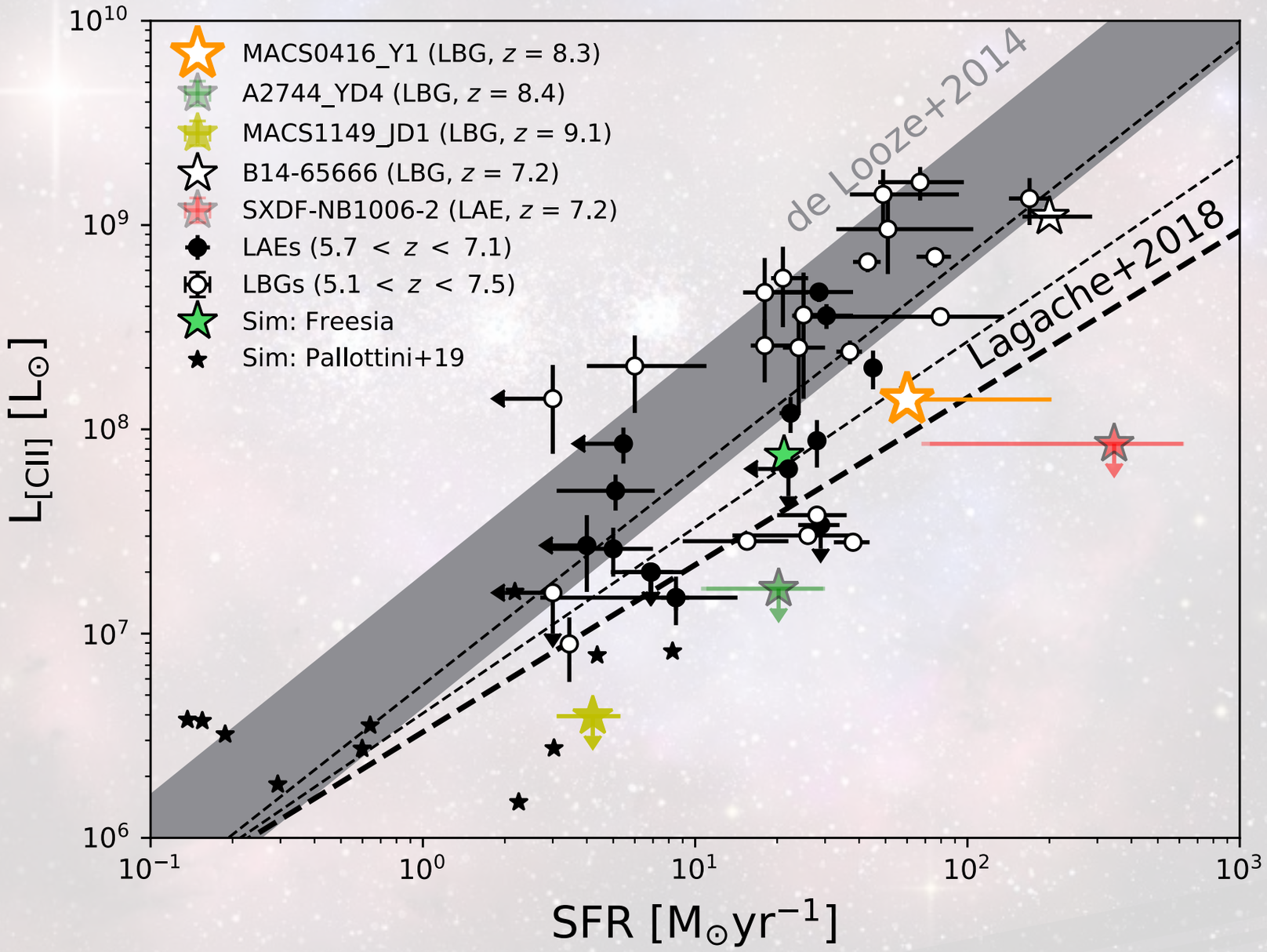
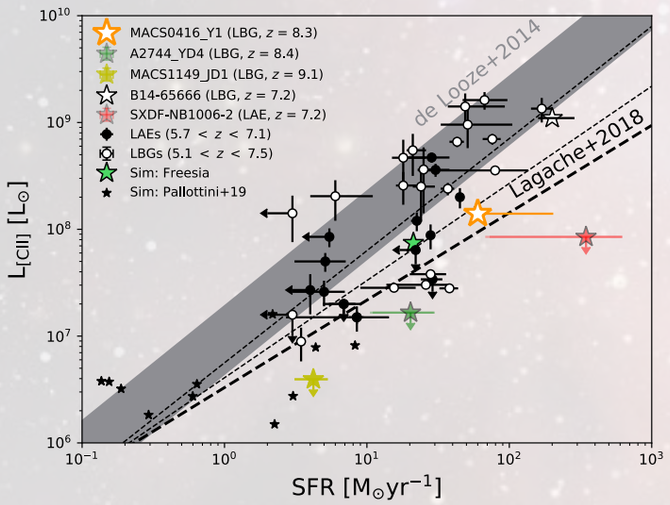
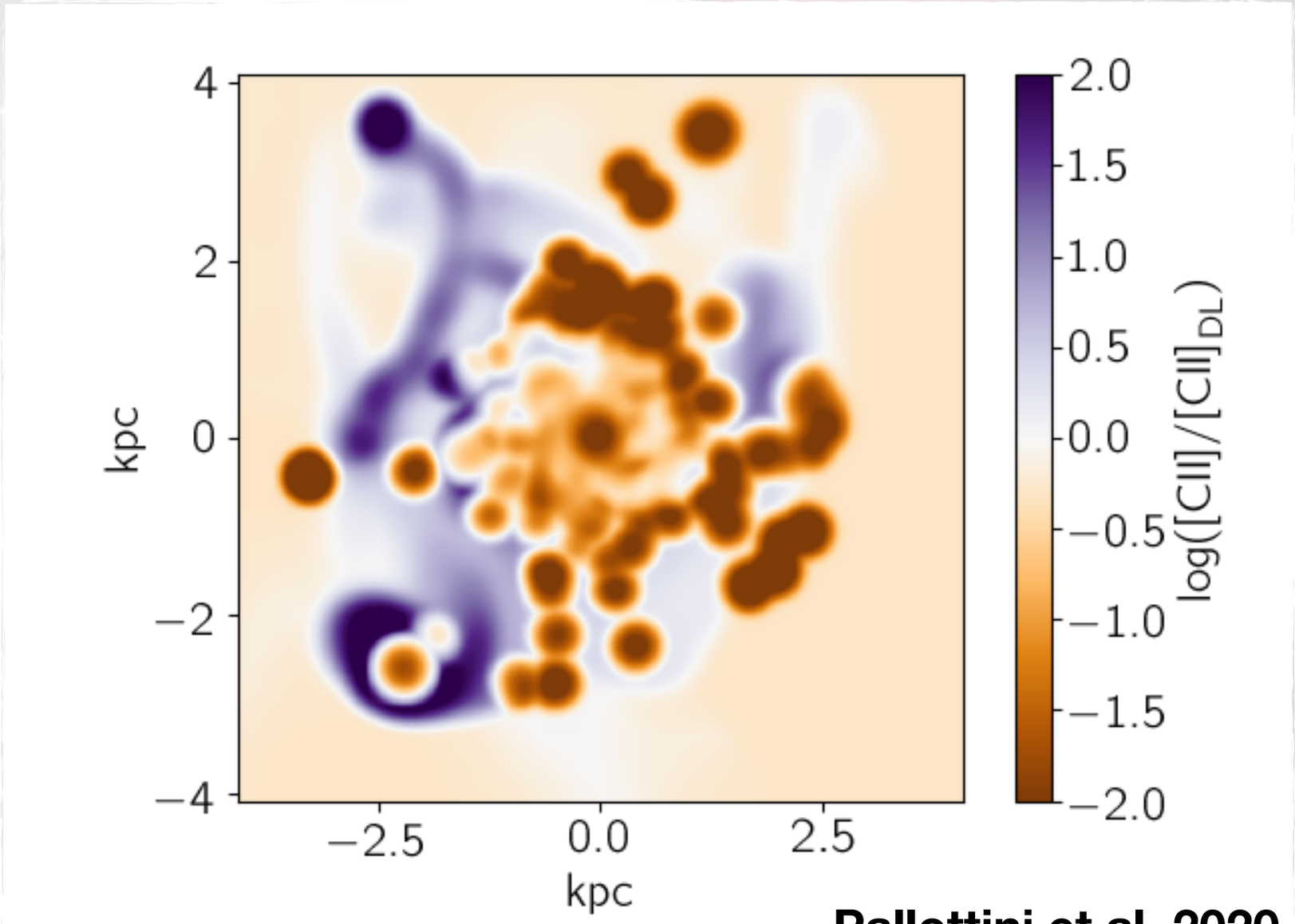
[CII] deficit at high redshift



MACS0416_Y1

[CII] deficit at high redshift





Pallottini et al. 2020

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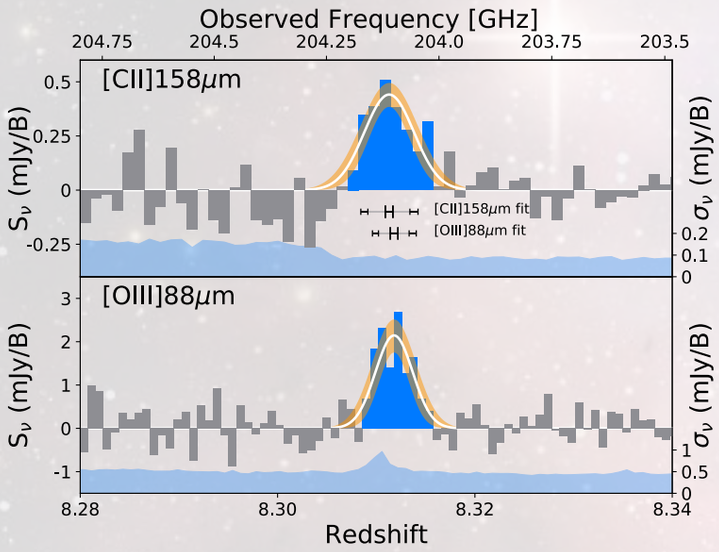
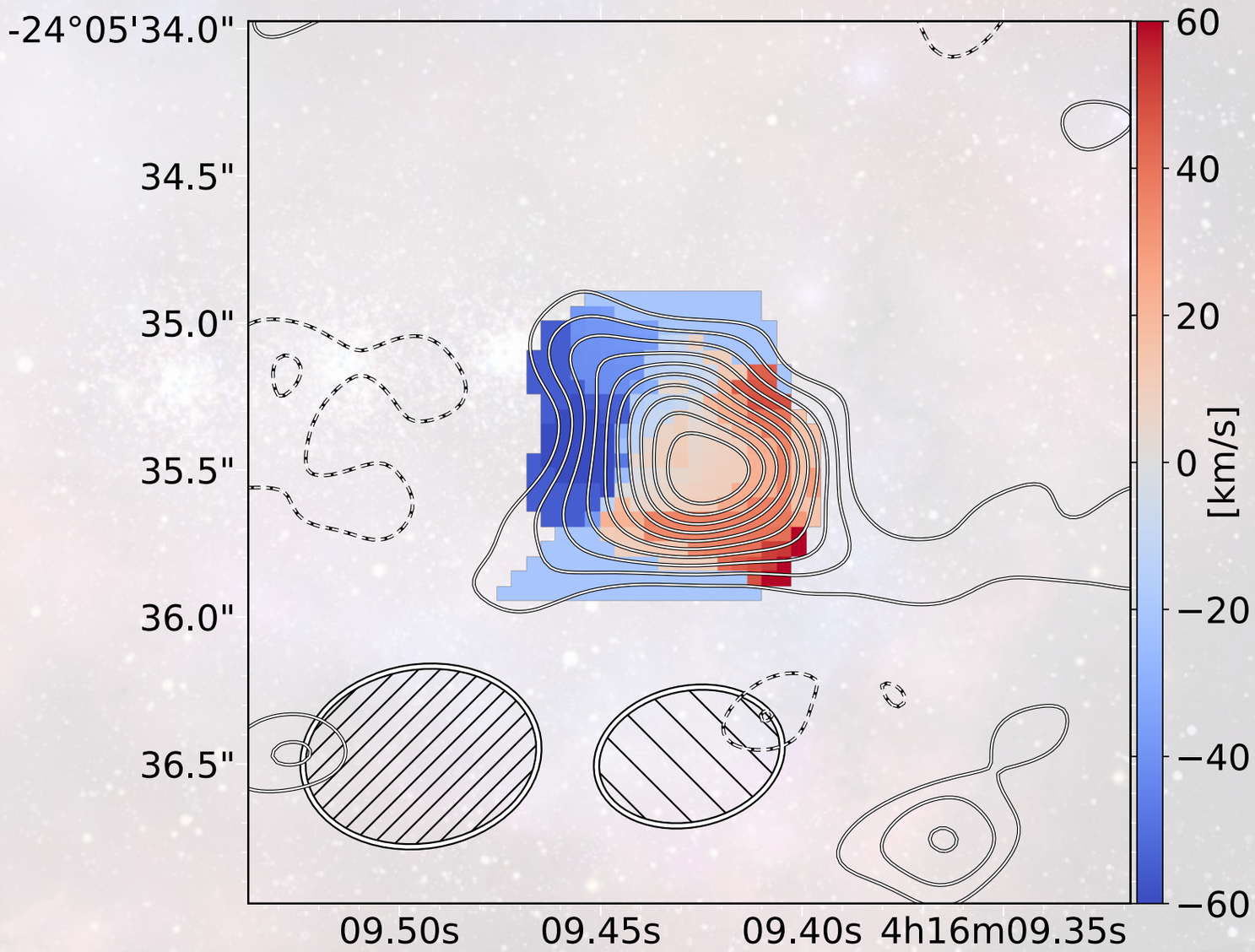
Rotation at z = 8.31?

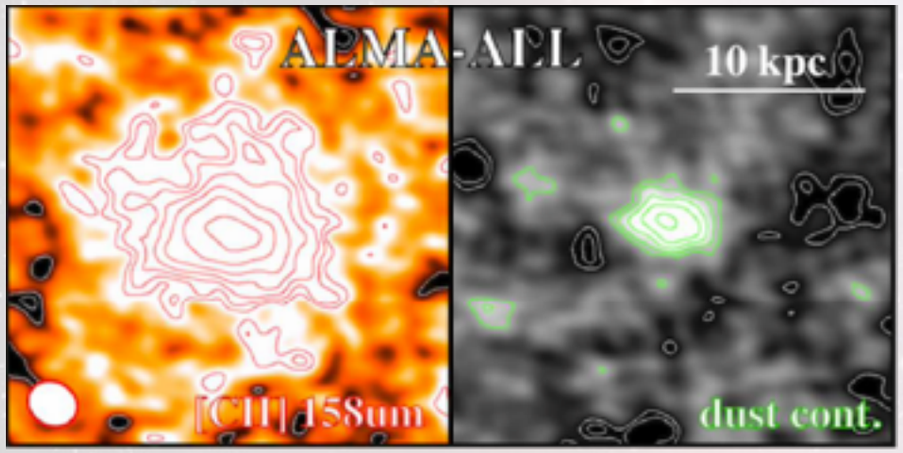


$$\mathrm{dv}/2\sigma > 0.4$$

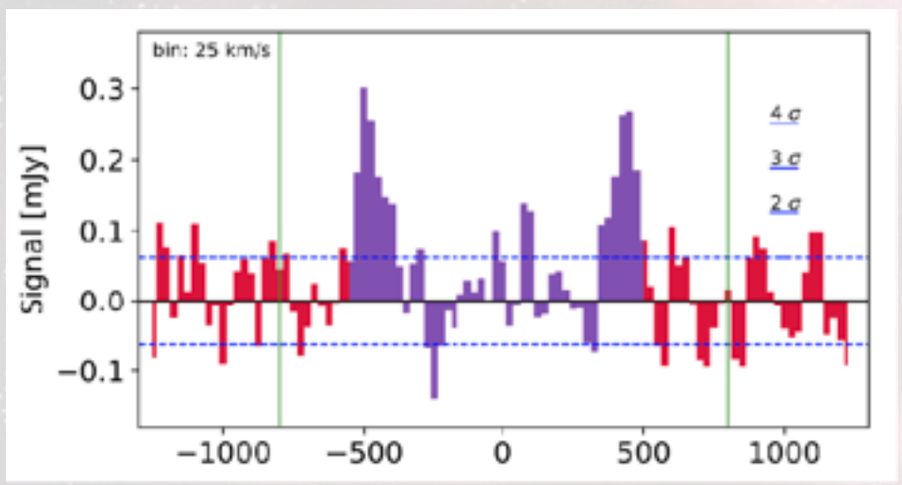


MACS0416_Y1

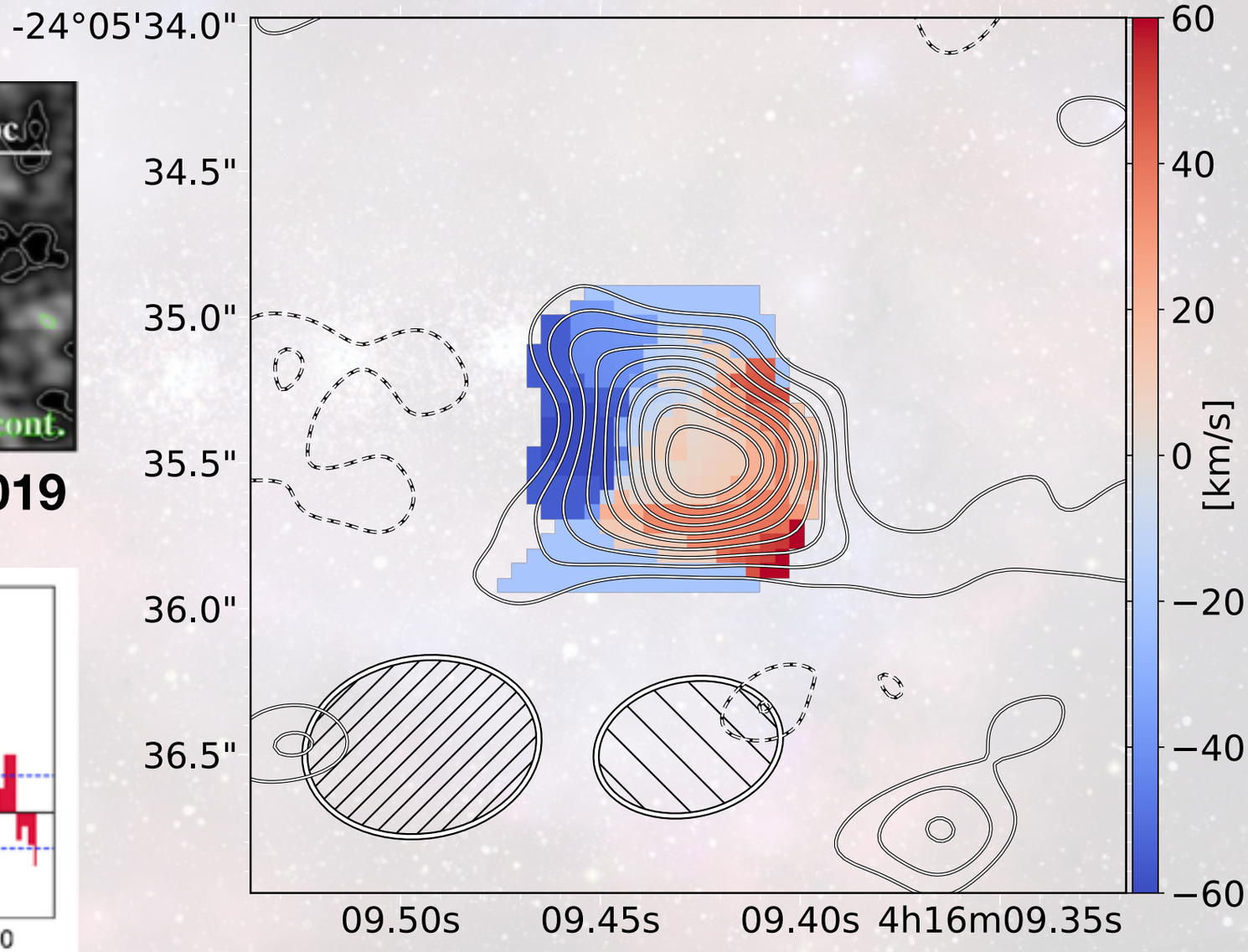
Or an outflow?



Fujimoto et al. 2019

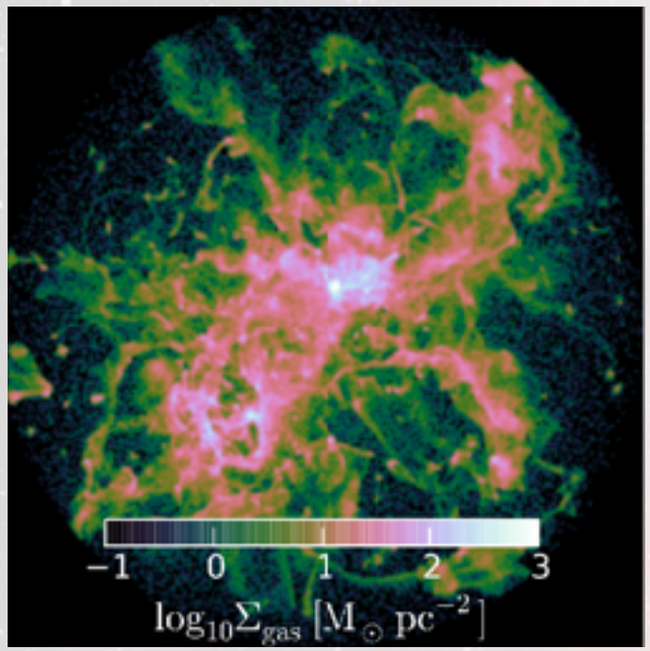


Ginolfi et al. 2019



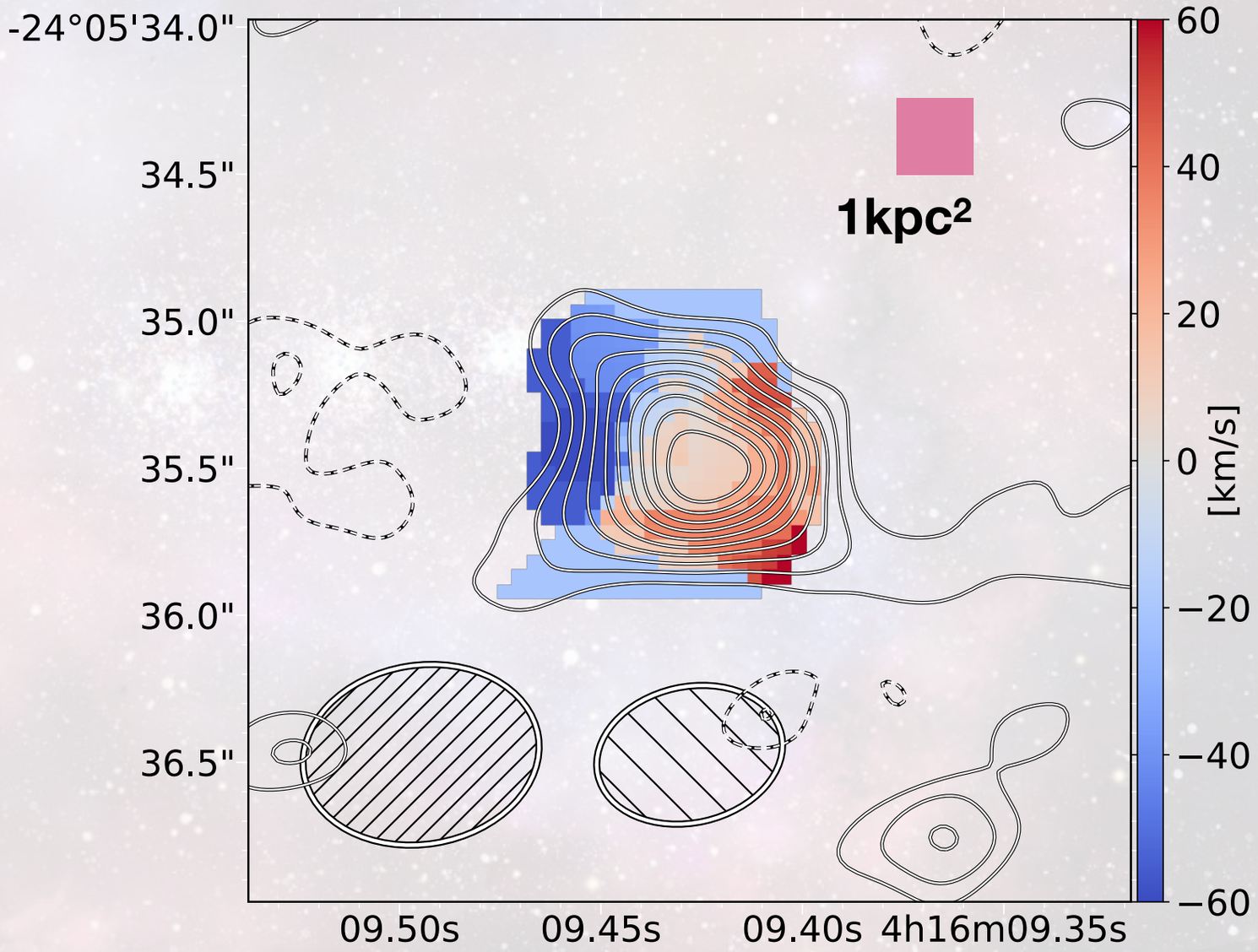
MACS0416_Y1

Or an outflow?



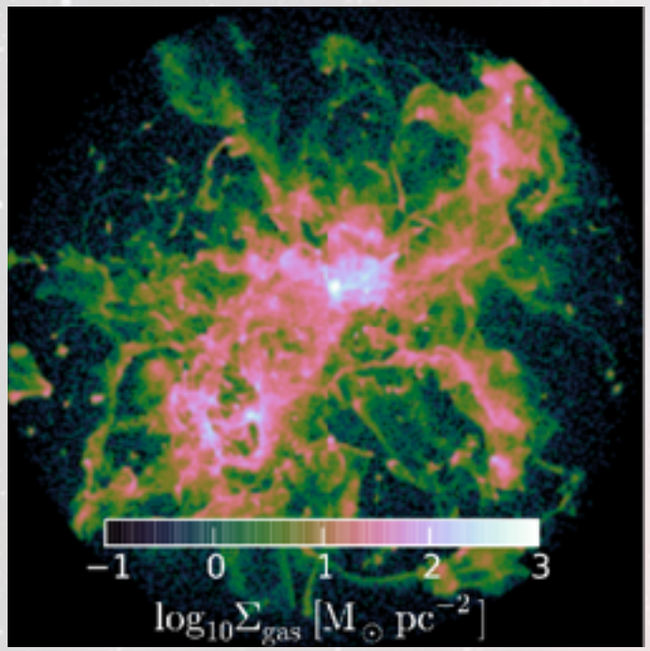
Arata et al. 2019

$$\frac{\dot{\rm M}}{\rm SFR} \sim 0.1 - 100$$



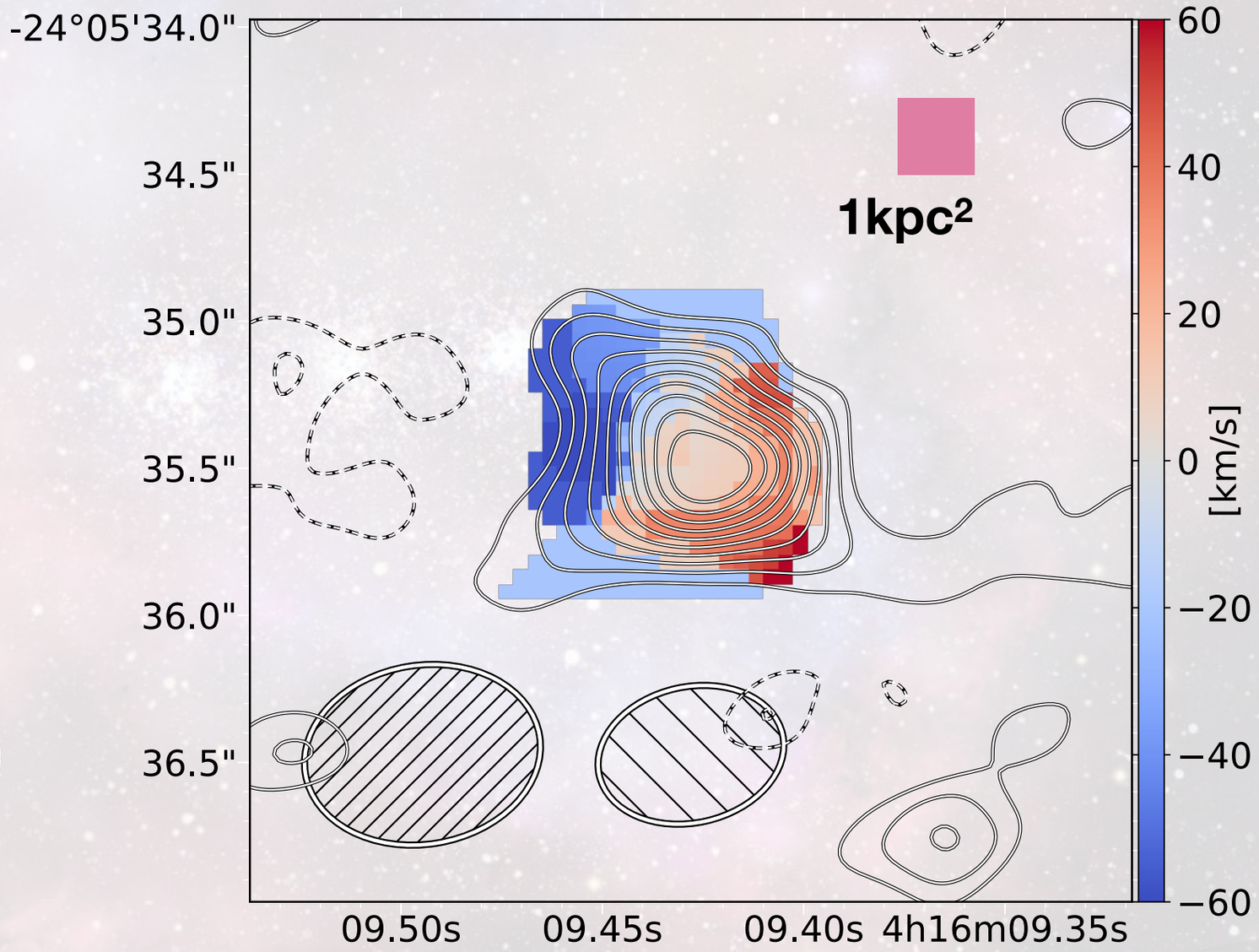
MACS0416_Y1

Same goes for an inflow…



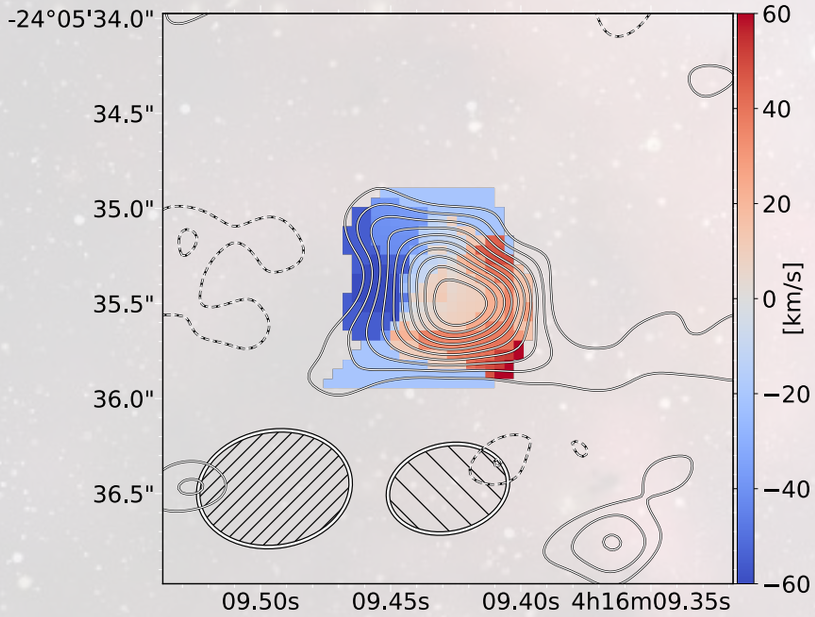
Arata et al. 2019

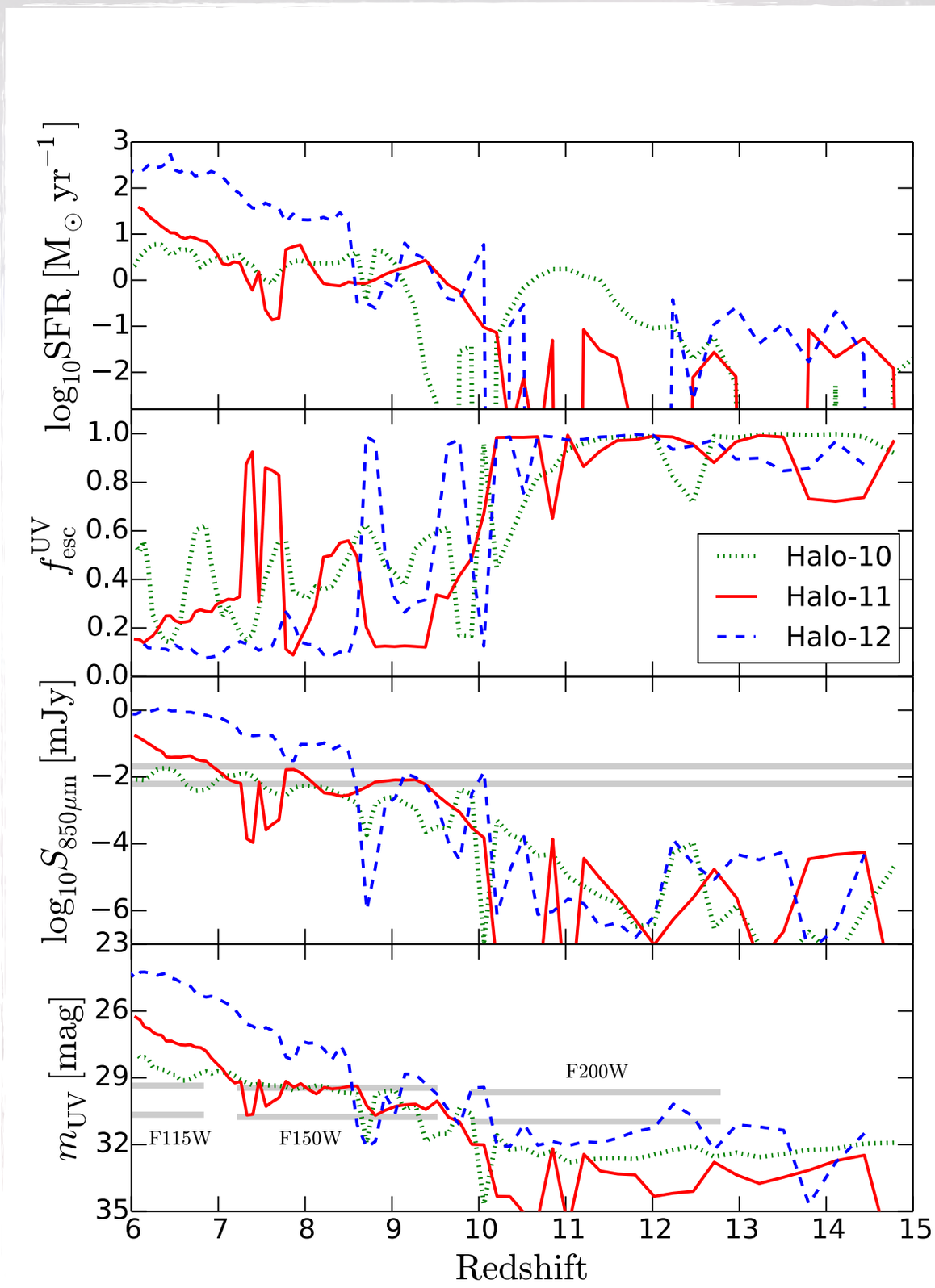
$$\frac{\dot{\rm M}}{\rm SFR} \sim 0.1 - 100$$



MACS0416_Y1

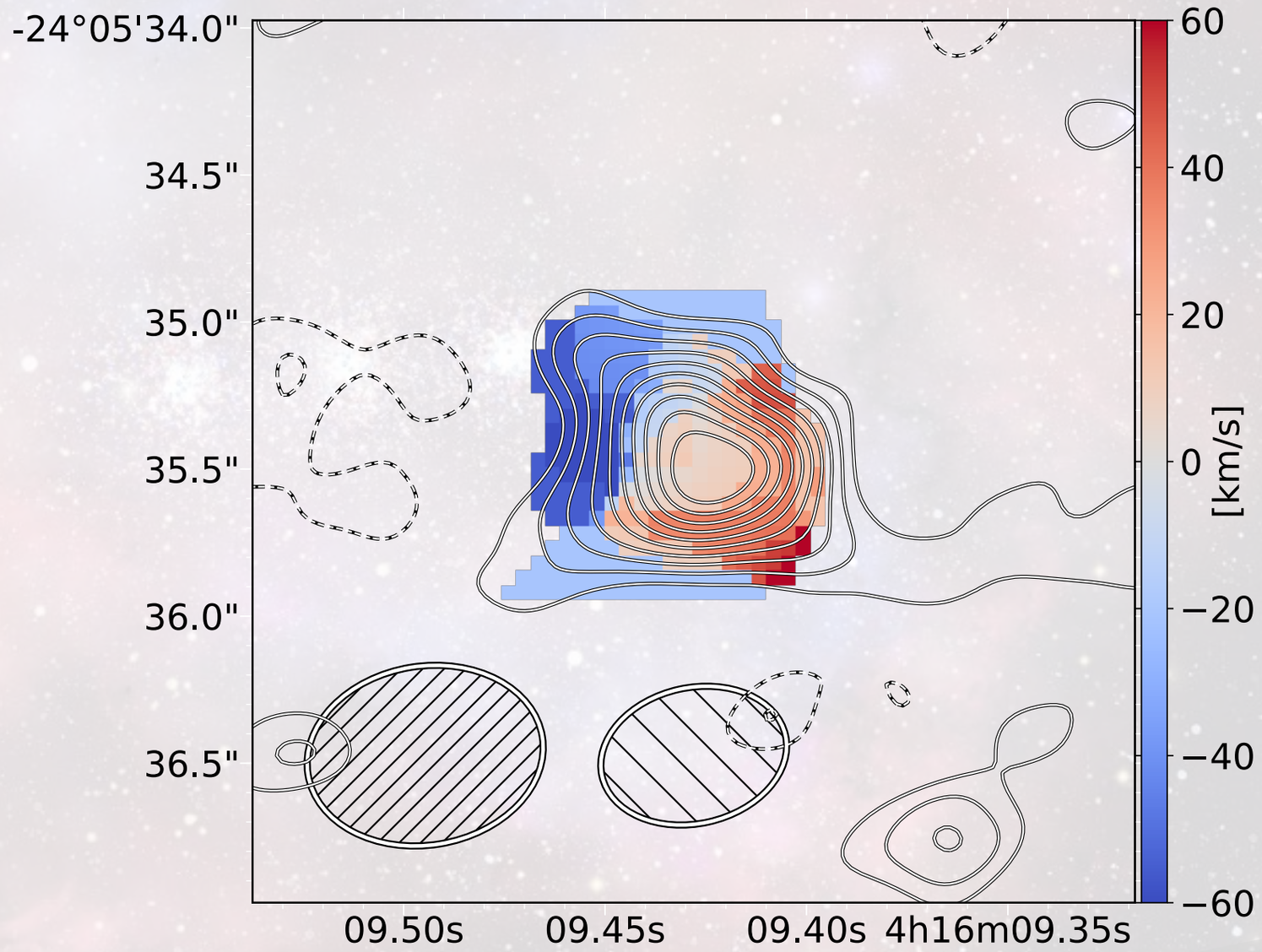
Same goes for an inflow…





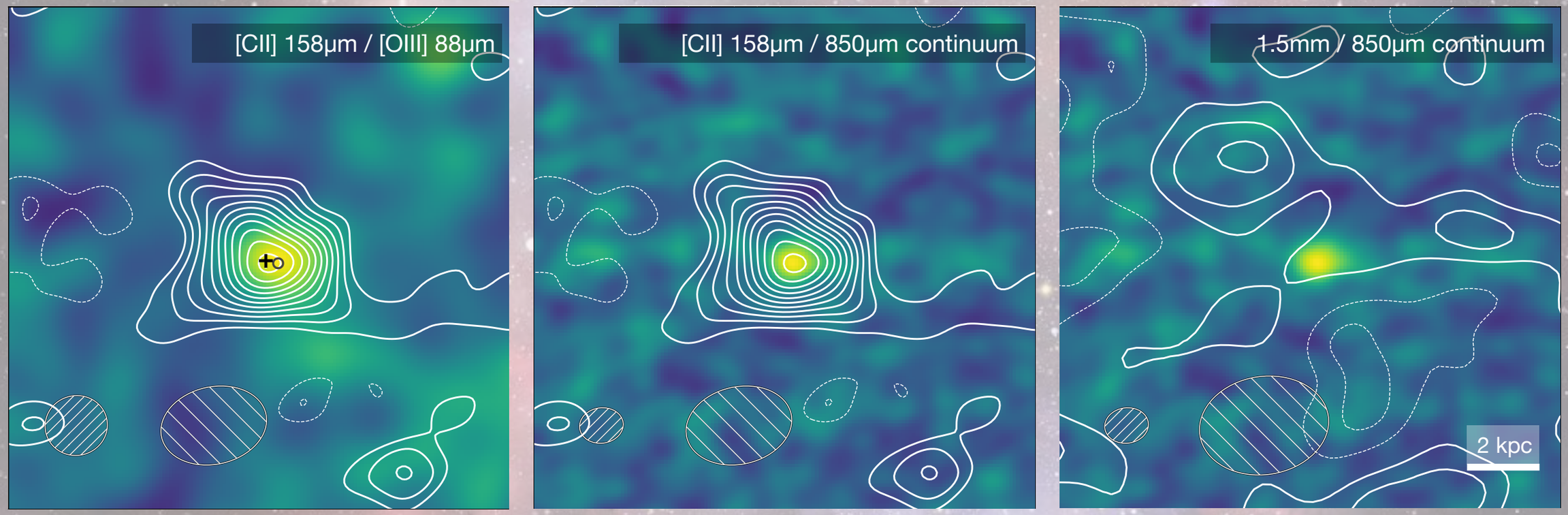
MACS0416_Y1

Or a merger?!



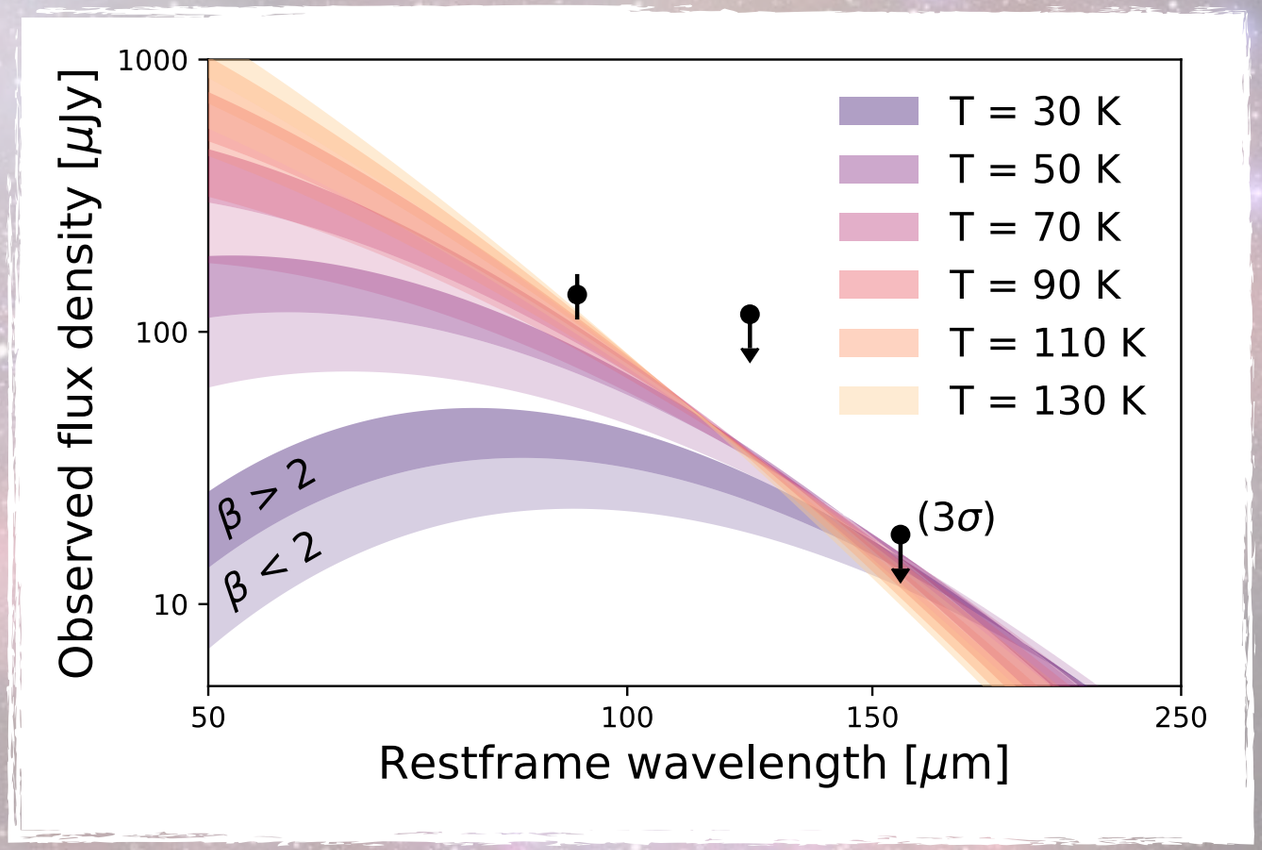
MACS0416_Y1

Though no dust detection...



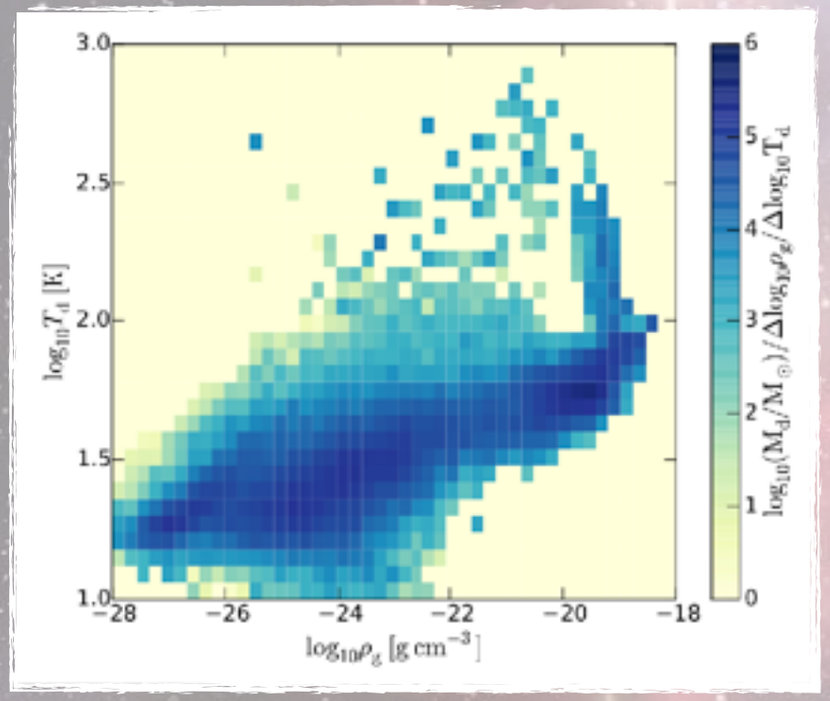
MACS0416_Y1

T > 80 K, or beta > 2 at z = 8

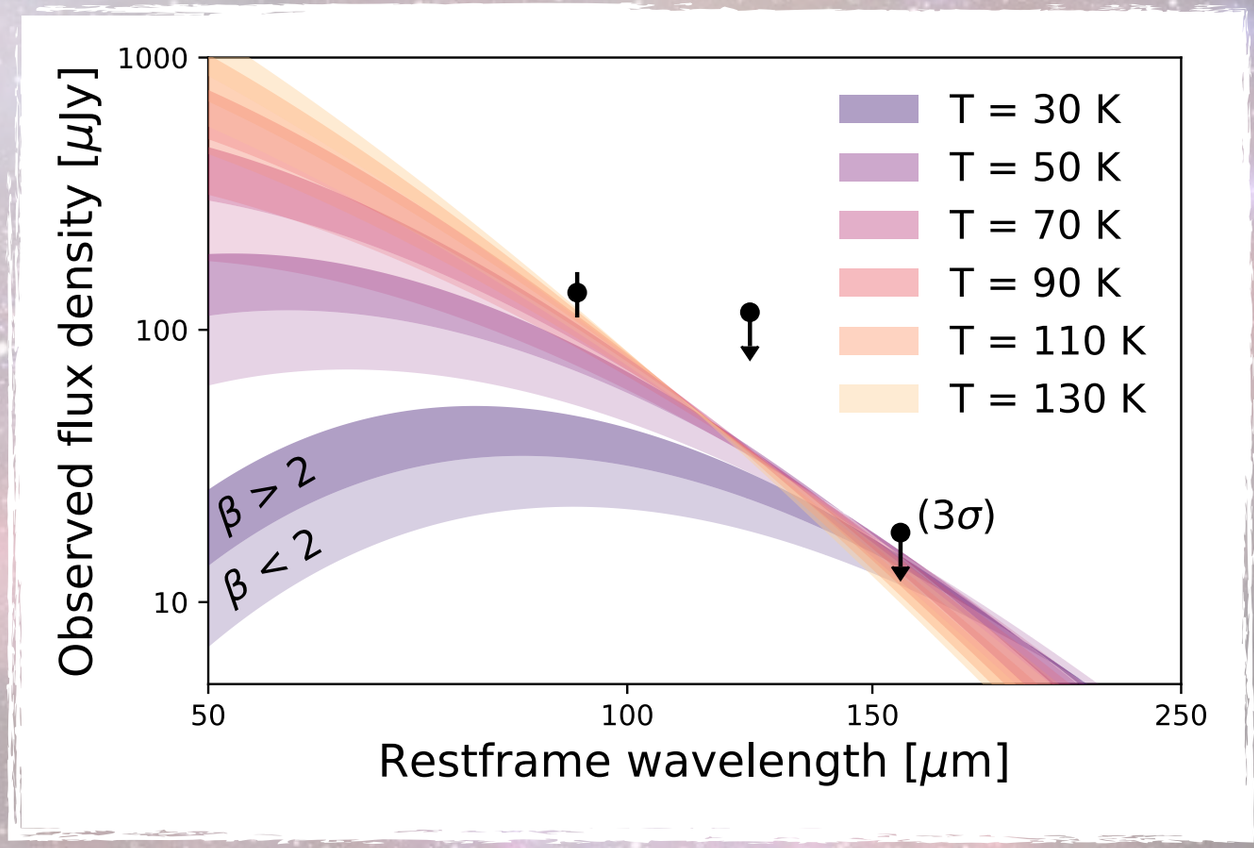


MACS0416_Y1

T > 80 K, or beta > 2 at z = 8

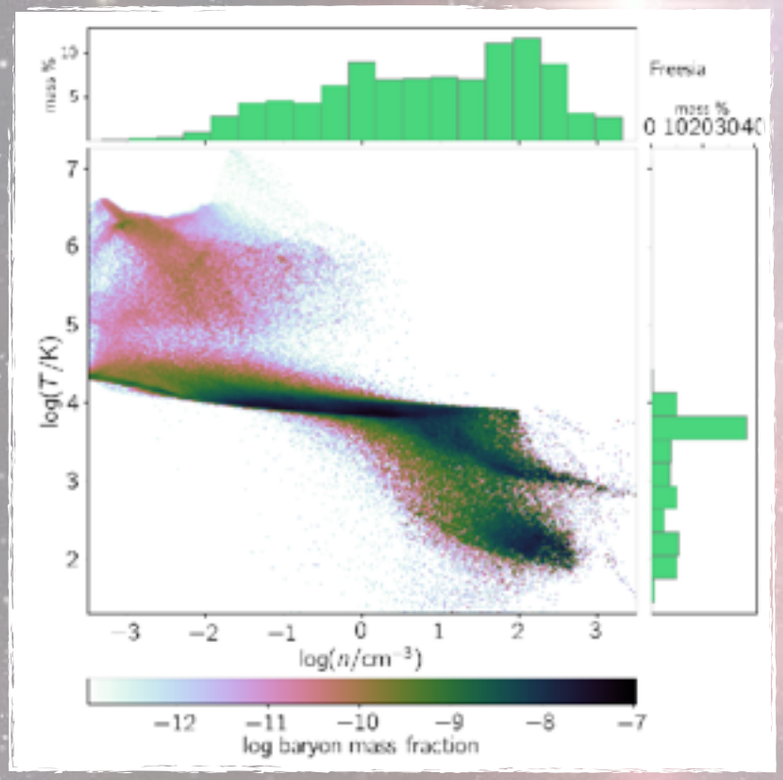


Arata et al. 2019

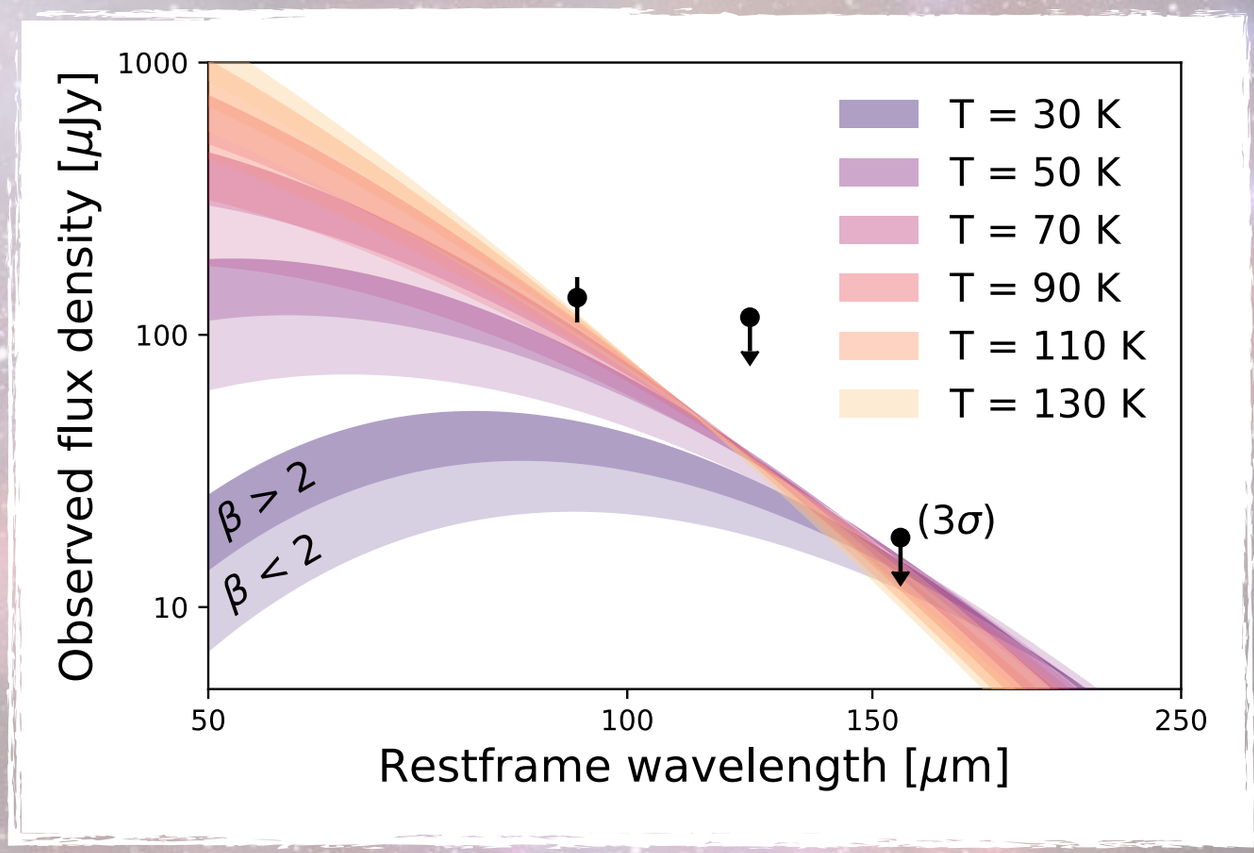


MACS0416_Y1

T > 80 K, or beta > 2 at z = 8



Pallottini et al. 2019



MACS0416_Y1

T > 80 K, or beta > 2 at z = 8

Table 1: The fitting parameters of the tested single-temperature spectrum fits

	$\beta = 1.5$				$\beta = 2.0$		
$T_{z=0}$ (K)	μIR Lum. (10^{11} $L_\odot$)	χ^2 -	μM_{dust} (10^6 $M_\odot$)	$T_{z=0}$ (K)	μIR Lum. (10^{11} $L_\odot$)	χ^2 -	μM_{dust} (10^6 $M_\odot$)
30	0.31	18.9	11	-	0.49	15.8	5.1
50	1.34	10.3	3.0	-	2.21	6.79	1.2
70	4.53	6.15	1.6	-	8.11	3.40	0.6
90	12.2	4.15	1.1	-	23.8	2.00	0.4
110	28.5	3.07	0.8	-	59.8	1.30	0.3
130	59.2	2.42	0.7	-	133.4	0.90	0.2
121	46.0	2.7 (**90%**)	0.74	80	15.9	2.7 (**90%**)	0.5

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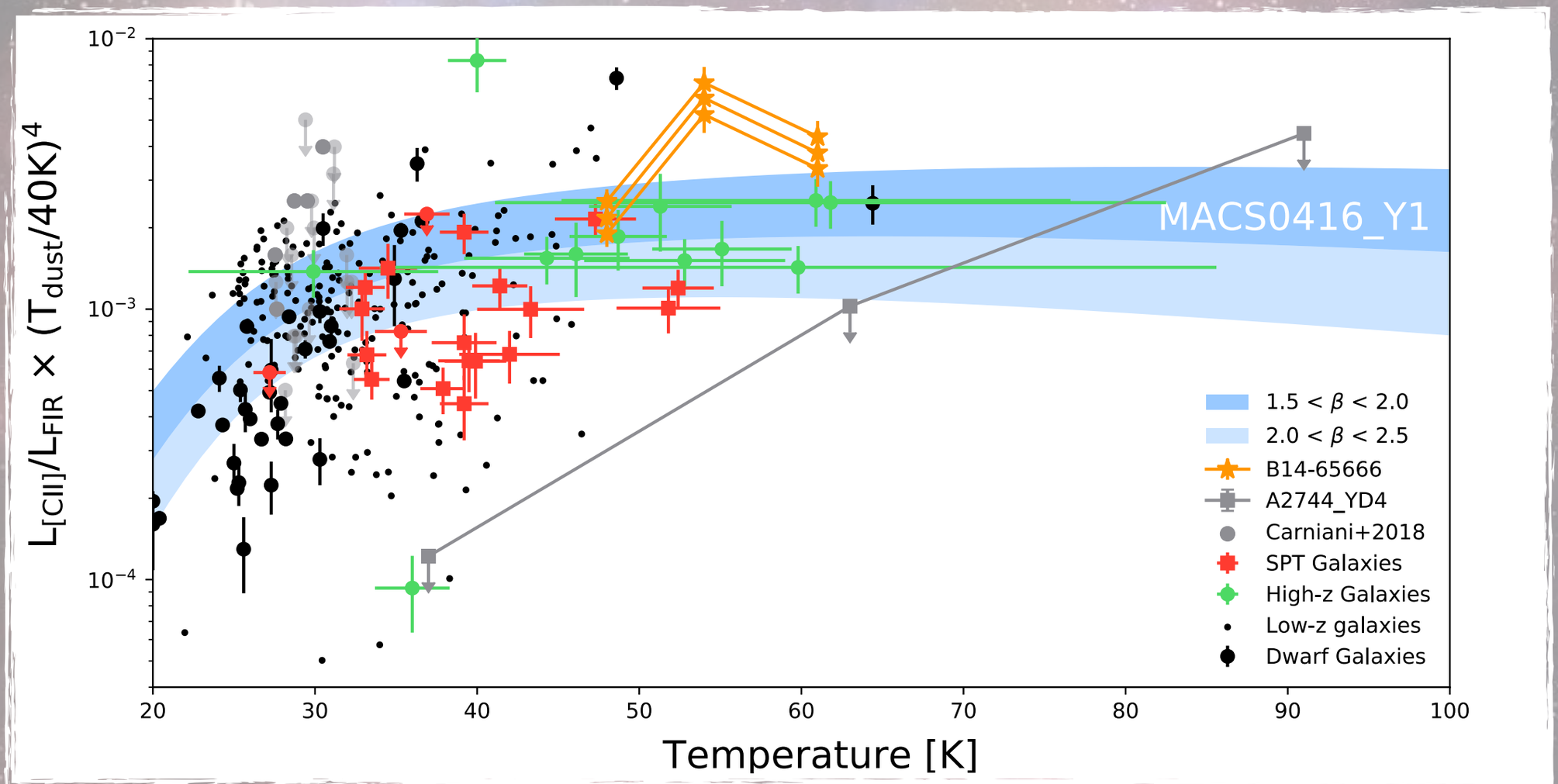
Typical [CII] / FIR values



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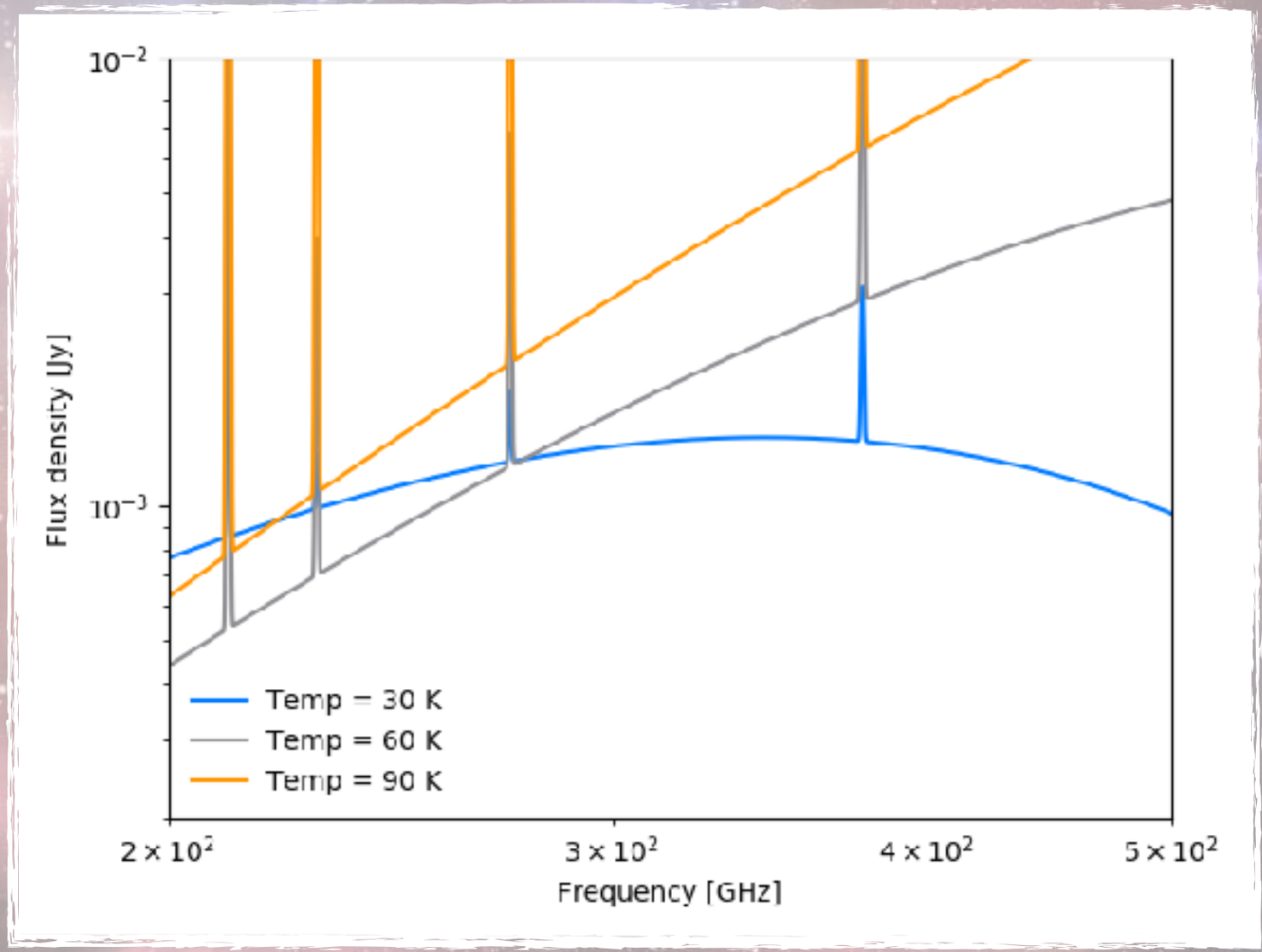
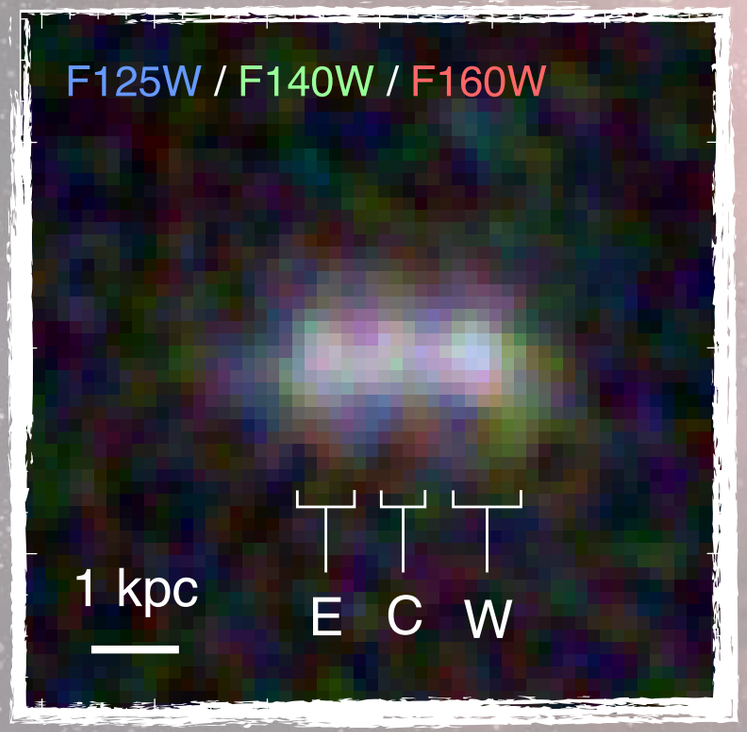
[OIII] and [CII] freq. cause biases



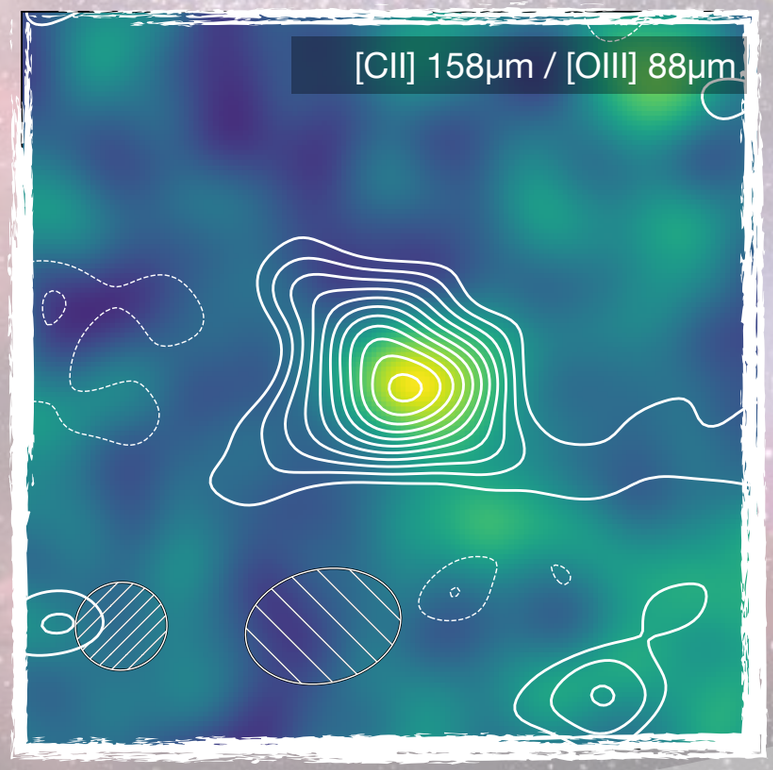
MACS0416_Y1

dust and carbon at z = 8.3

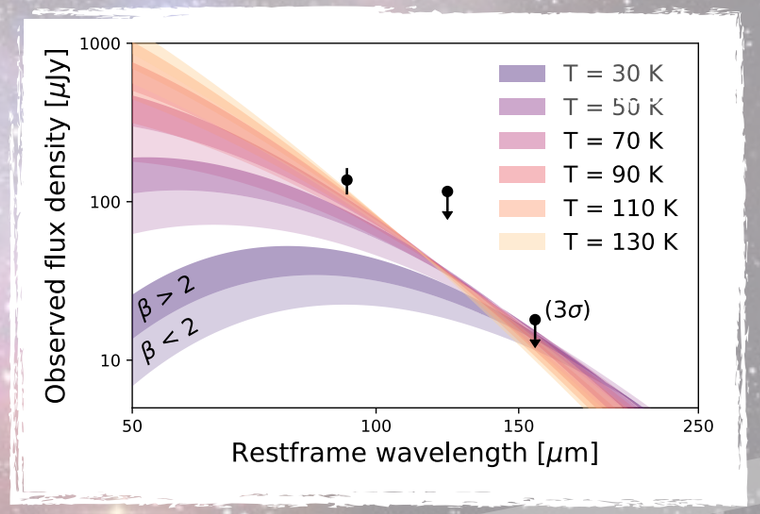
The source …



… the lines …



… and the spectrum!



MACS0416_Y1

dust and carbon at z = 8.3

Tom Bakx

Credit: National Astronomical Observatory of Japan

MACS0416_Y1

dust and carbon at z = 8.3

Tom Bakx

Credit: National Astronomical Observatory of Japan