MACS0416_Y1

dust and carbon in the EoR

NECO 猫

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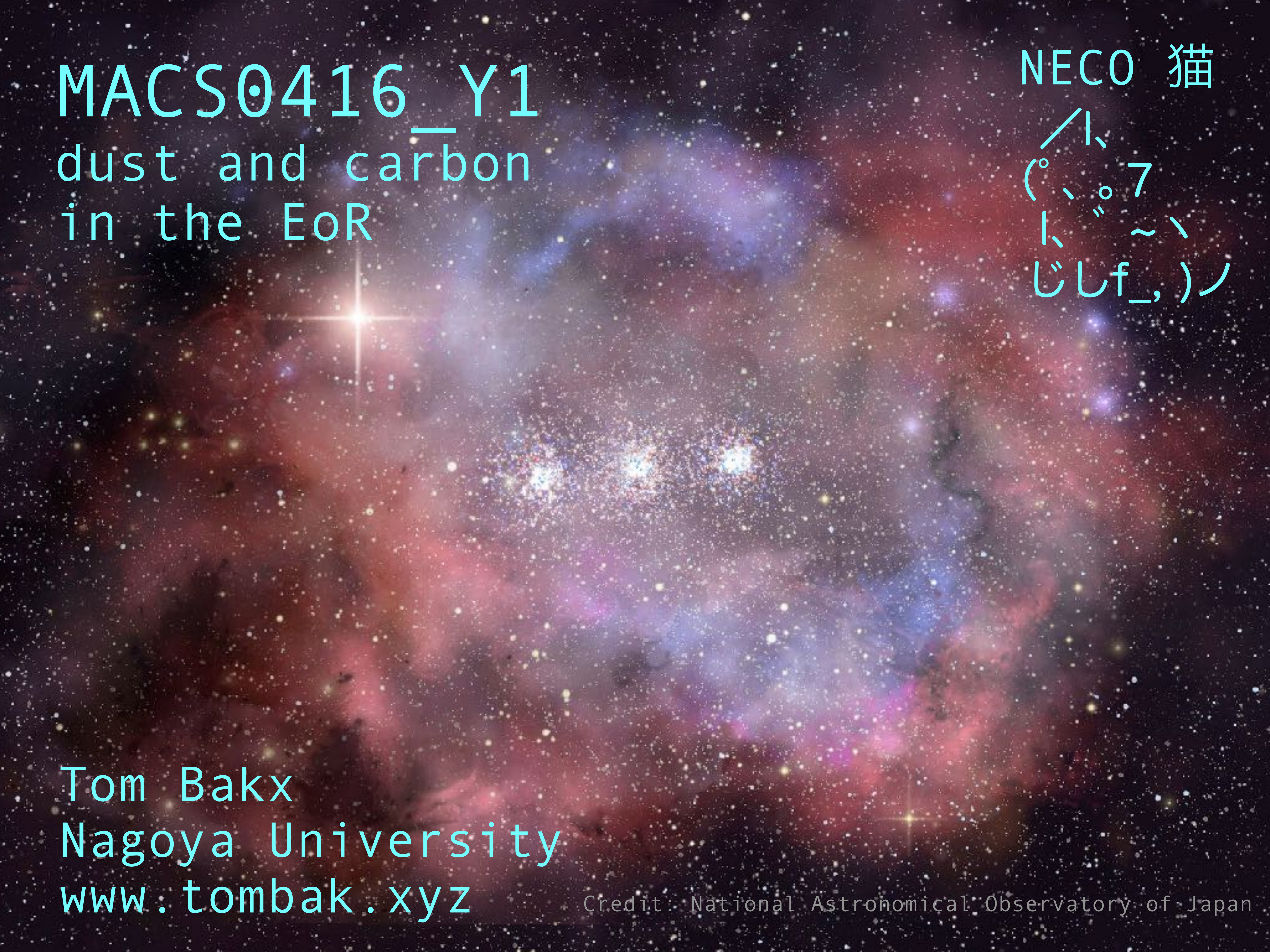
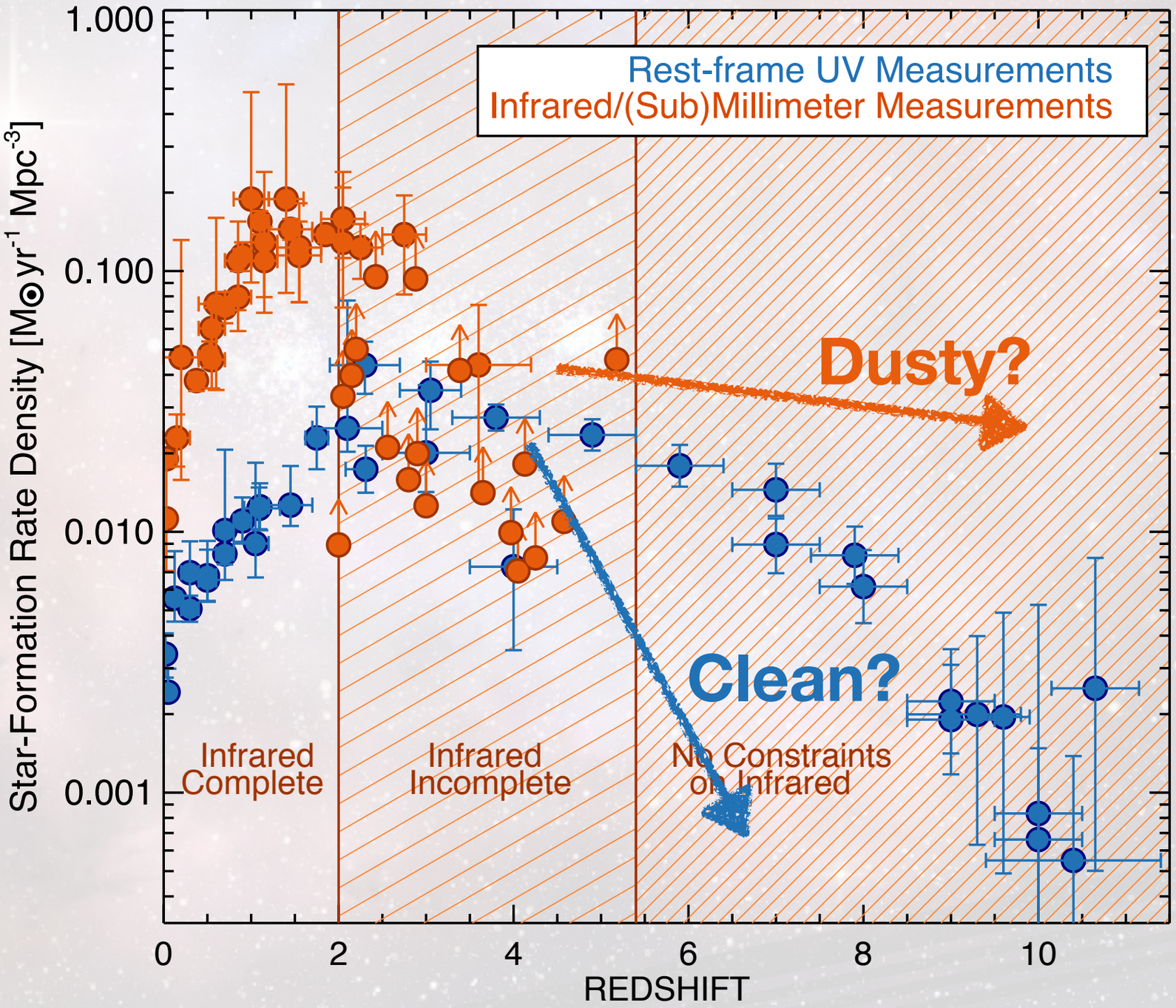
Tom Bakx
Nagoya University
www.tombak.xyz



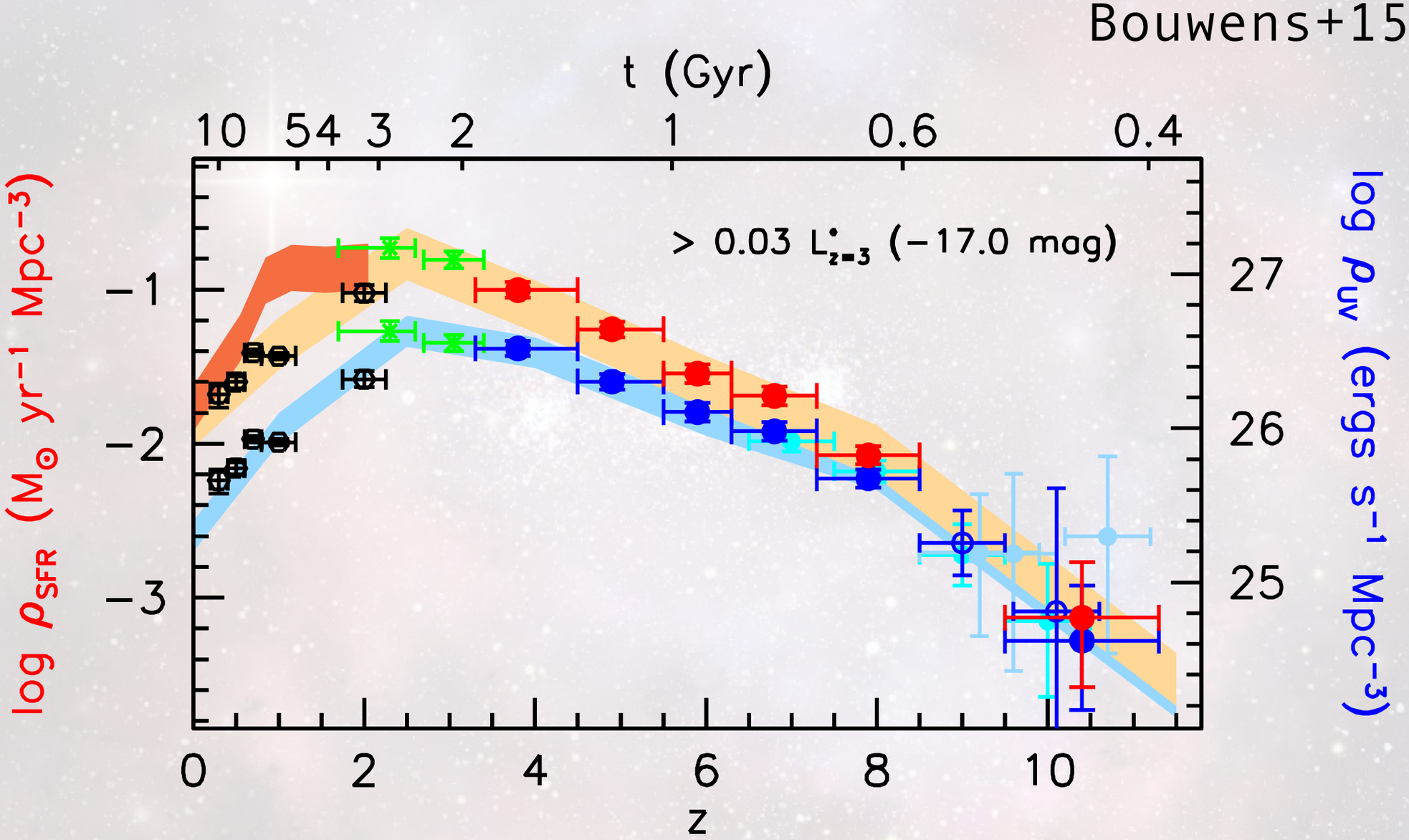
Credit: National Astronomical Observatory of Japan

How dusty is the high-redshift Universe?

Casey+18

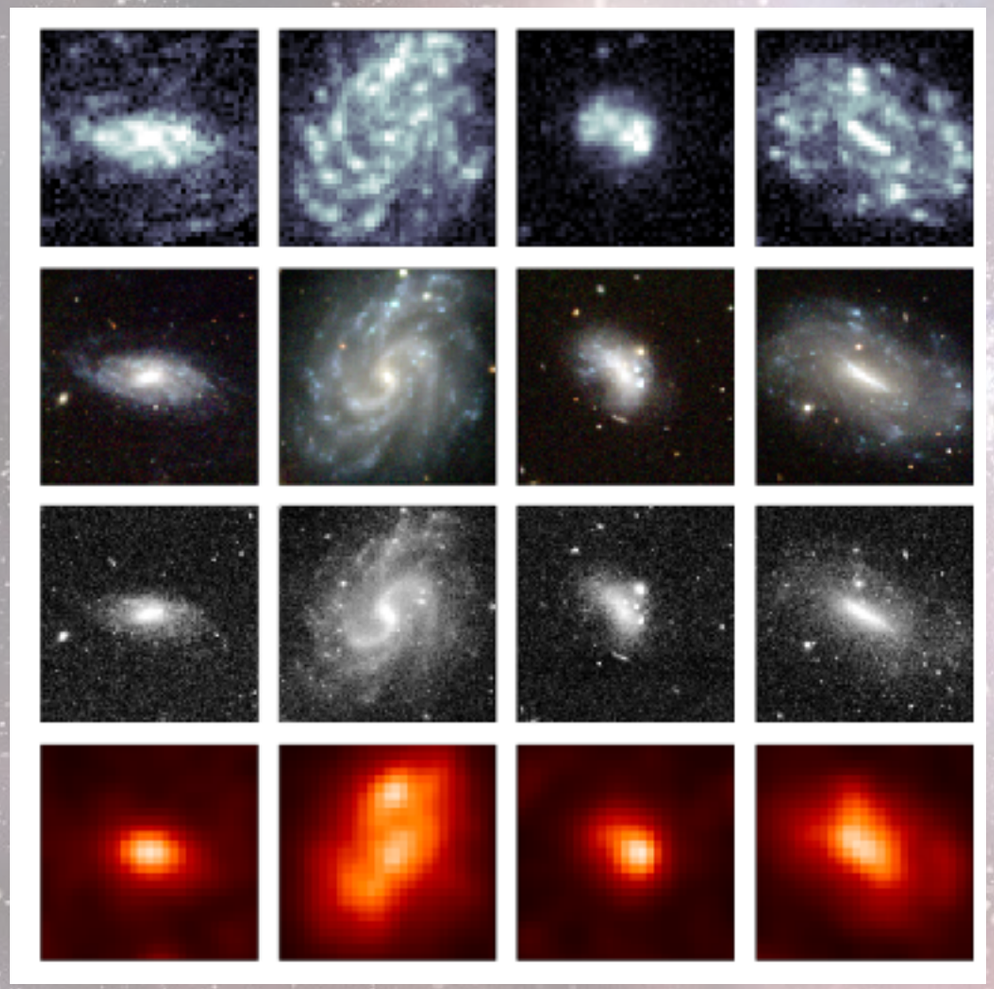


UV slopes suggest the high-z Universe is not very dusty

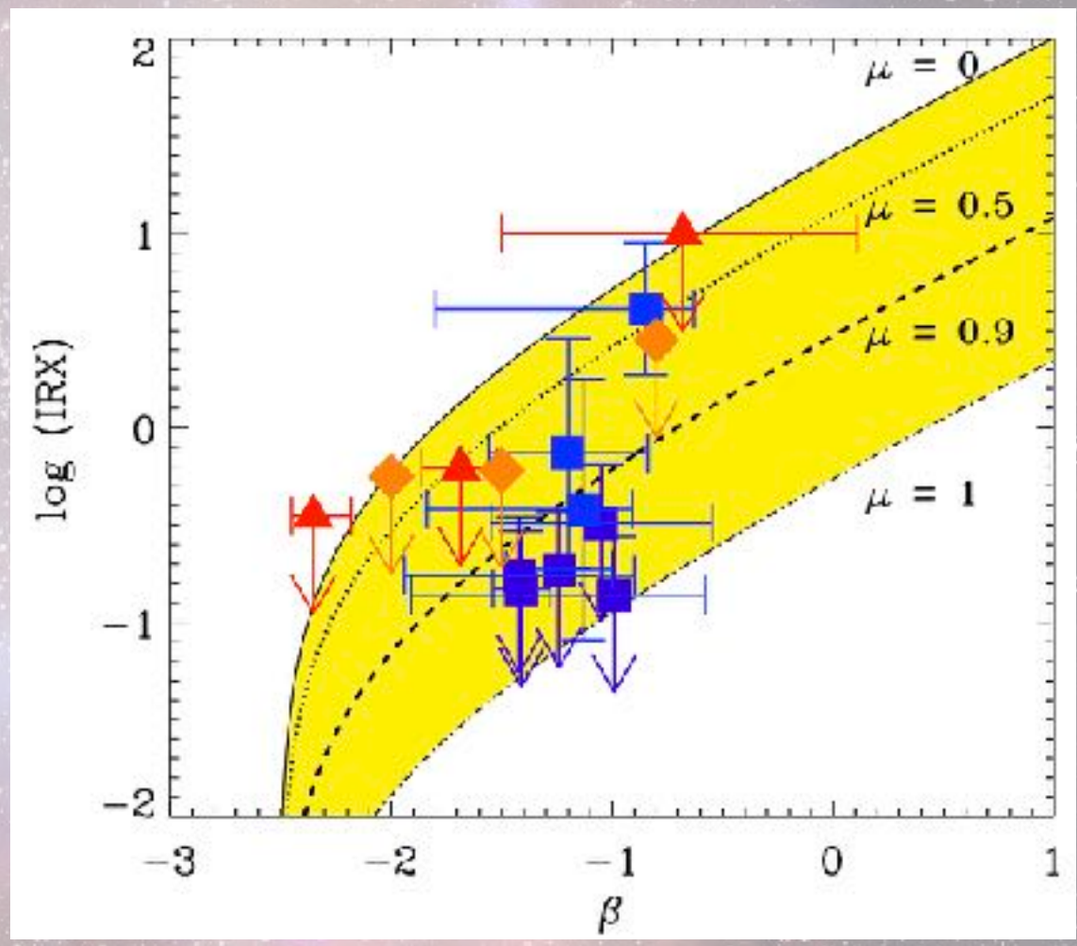


But can we trust UV corrections?

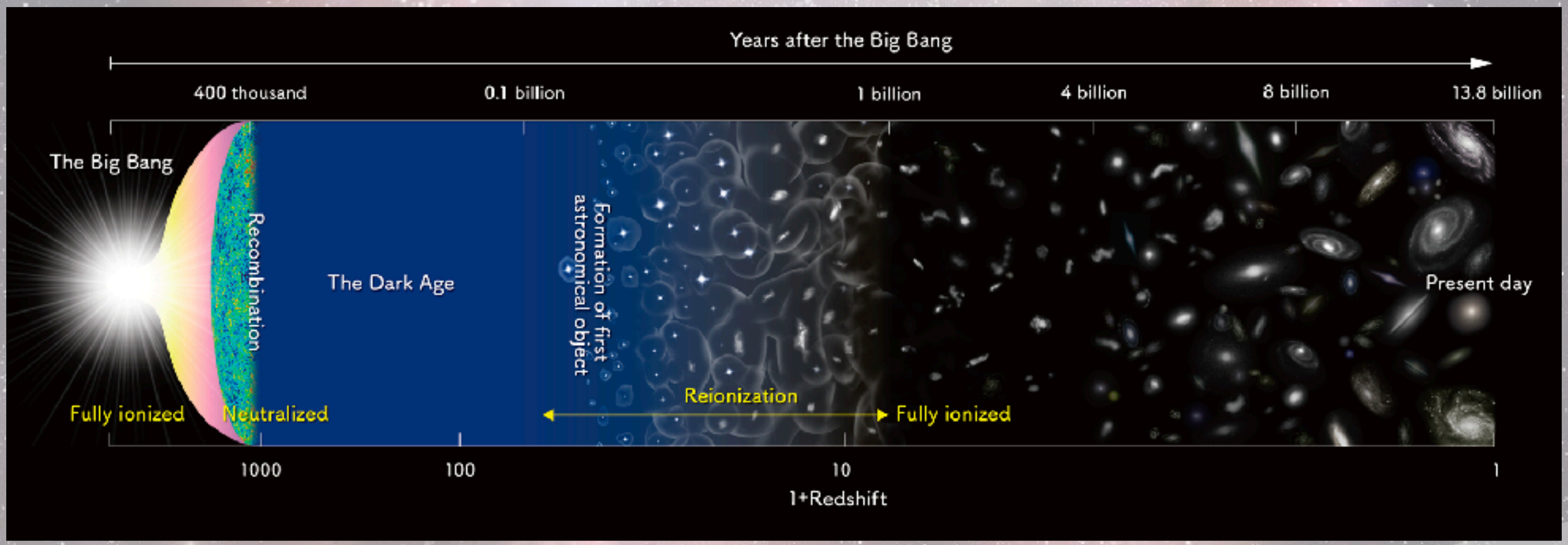
Blue And Dusty Gas-Rich Sources (BADGRS; Clark+15, Dunne+19)



Discrepant UV slopes for sub-mm brightness (Ferrara+17)



Revealing what is obscured by dust …

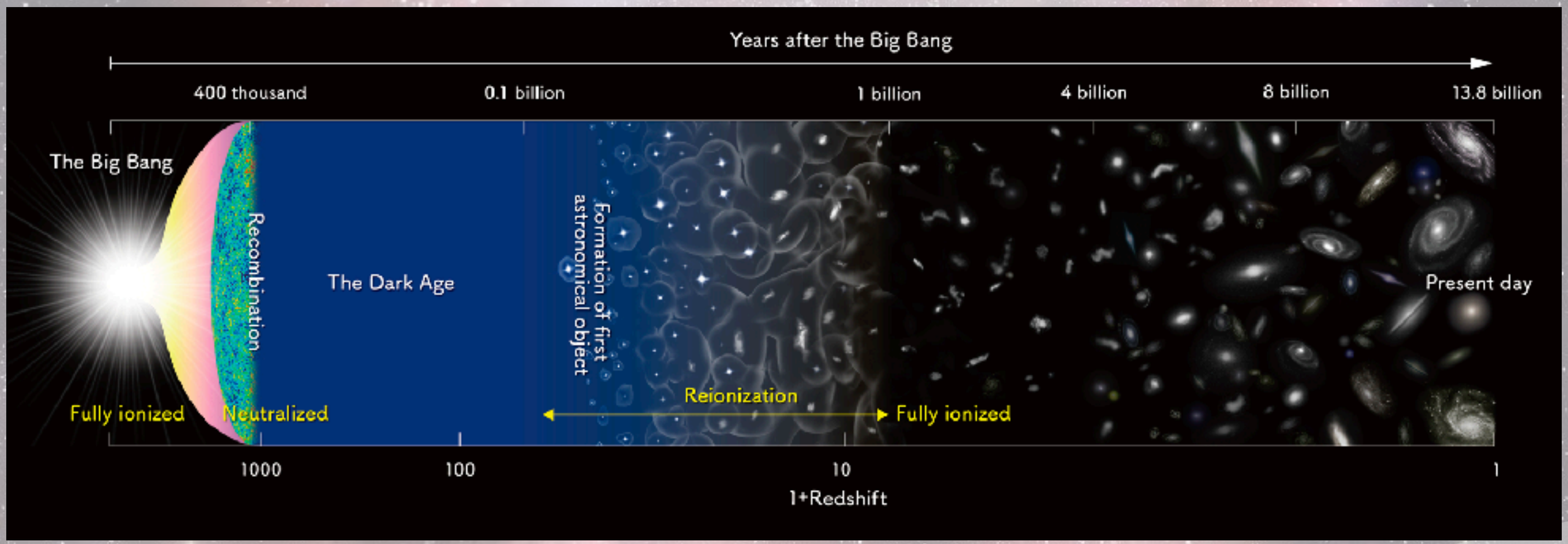


Revealing what is obscured by dust …

18 May 2020	COX, Pierre		IRAM/NOEMA Large Program z-GAL

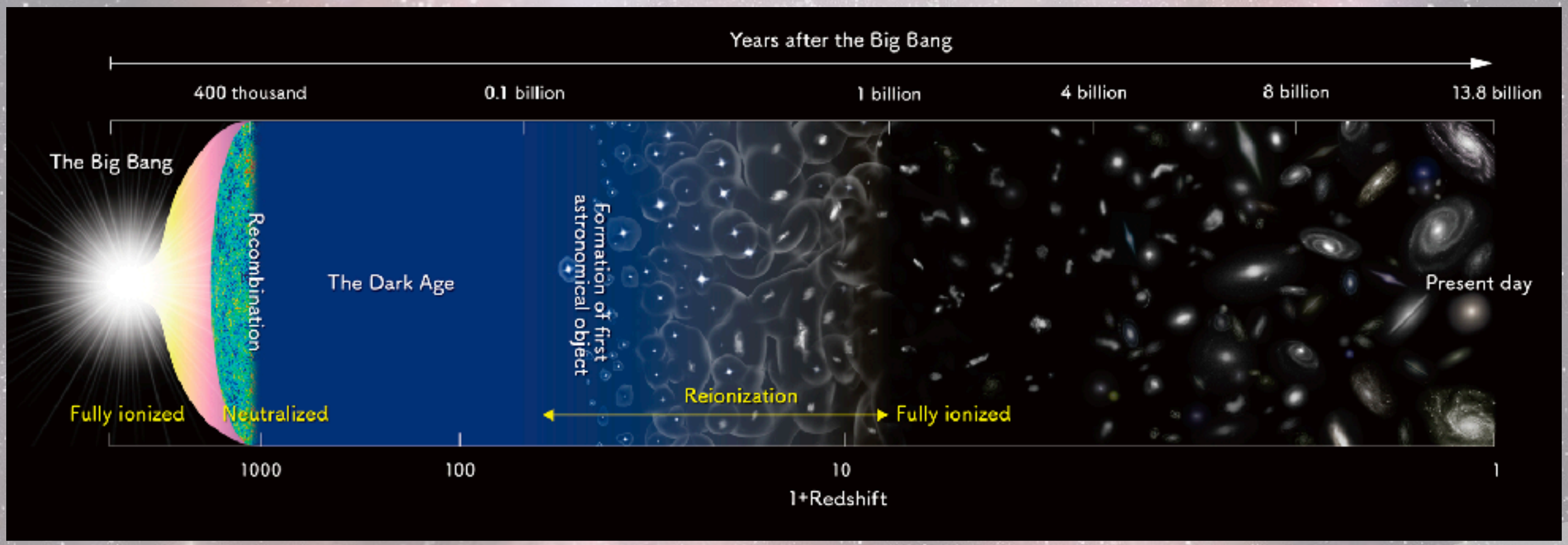
Herschel Bright Sources

z-GAL



Revealing what is obscured by dust …

LBGs

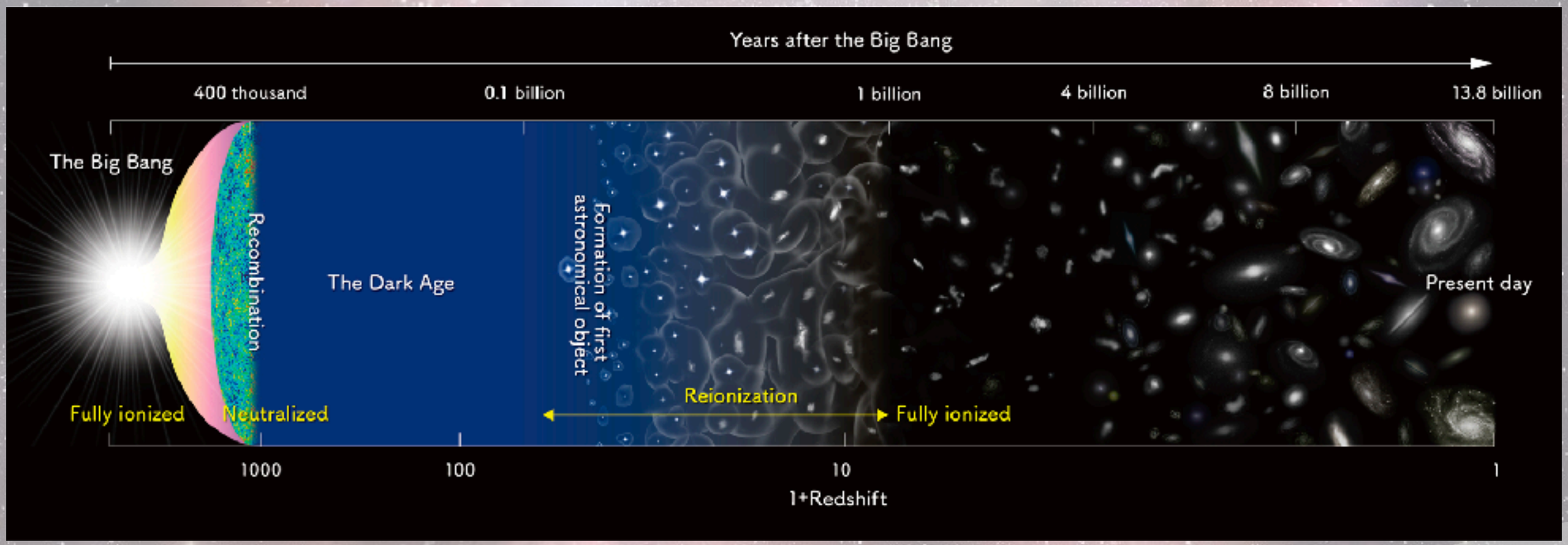


… where models and observations meet

LBGs

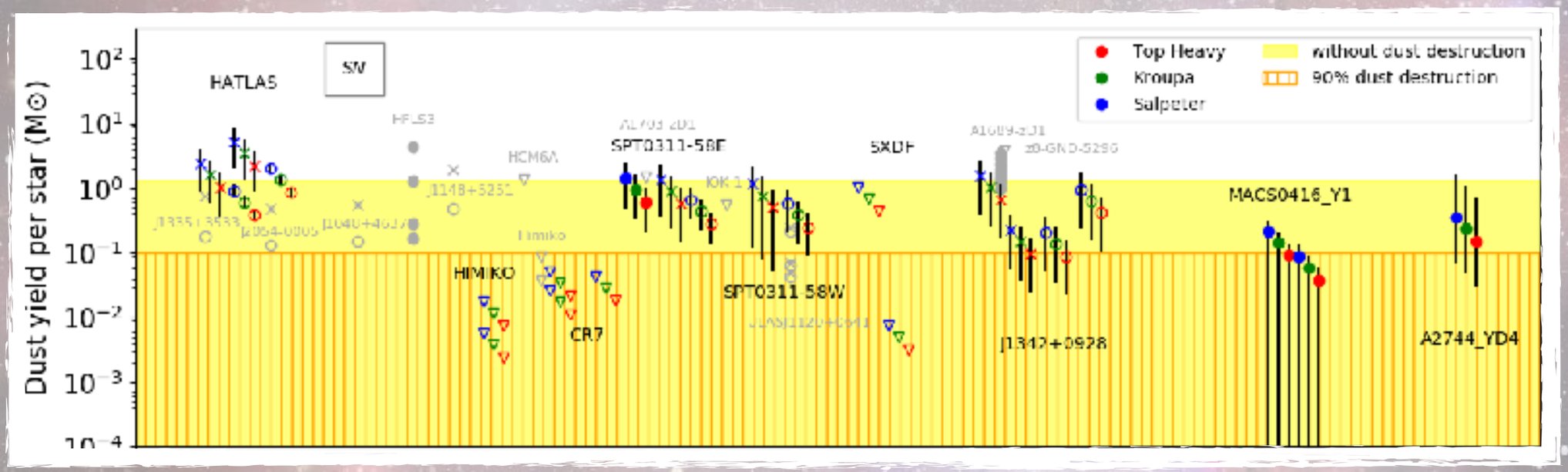
Models

Observations

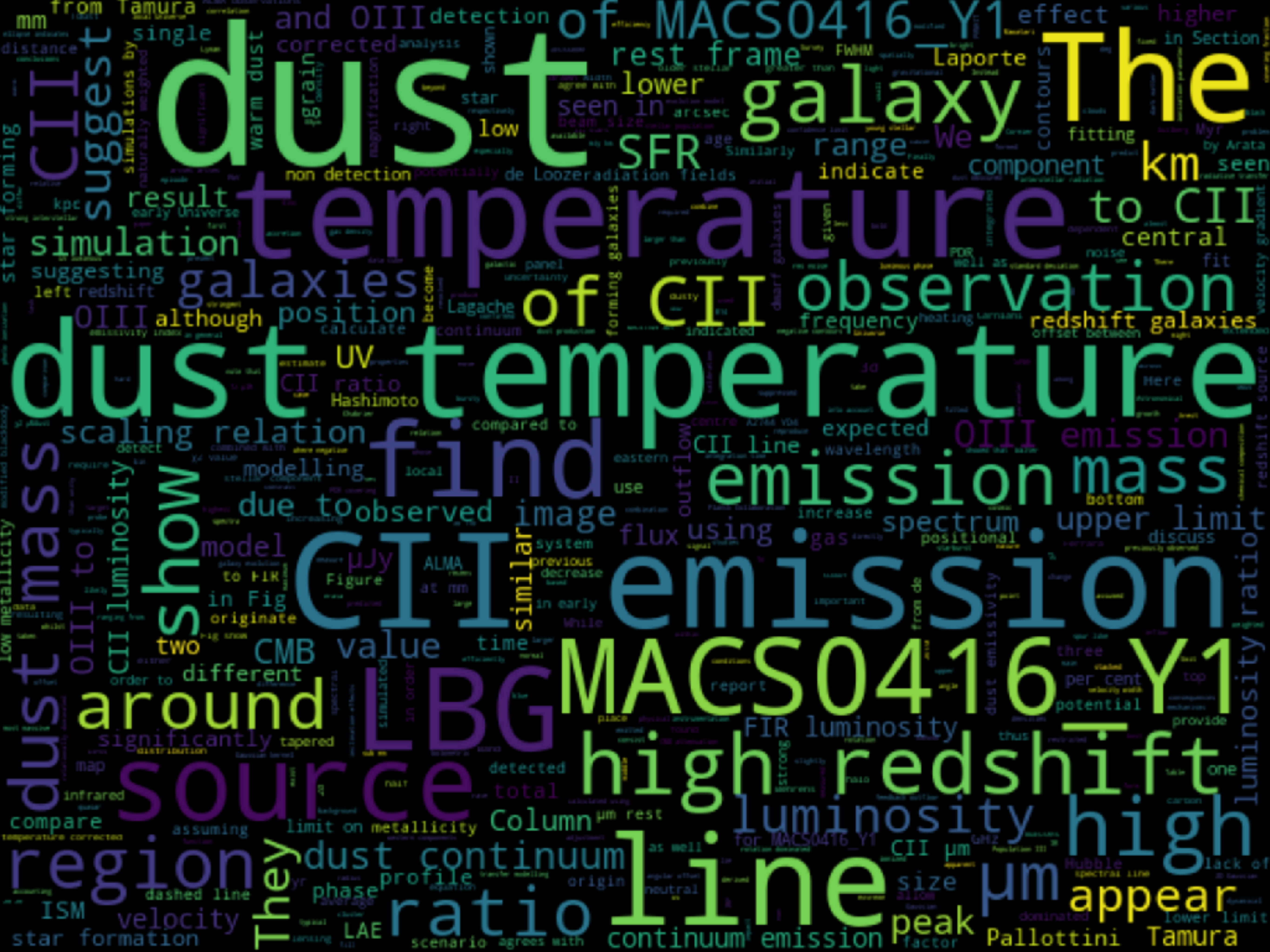


SNe don’t produce enough dust!

Leśniewska+19



Redshift



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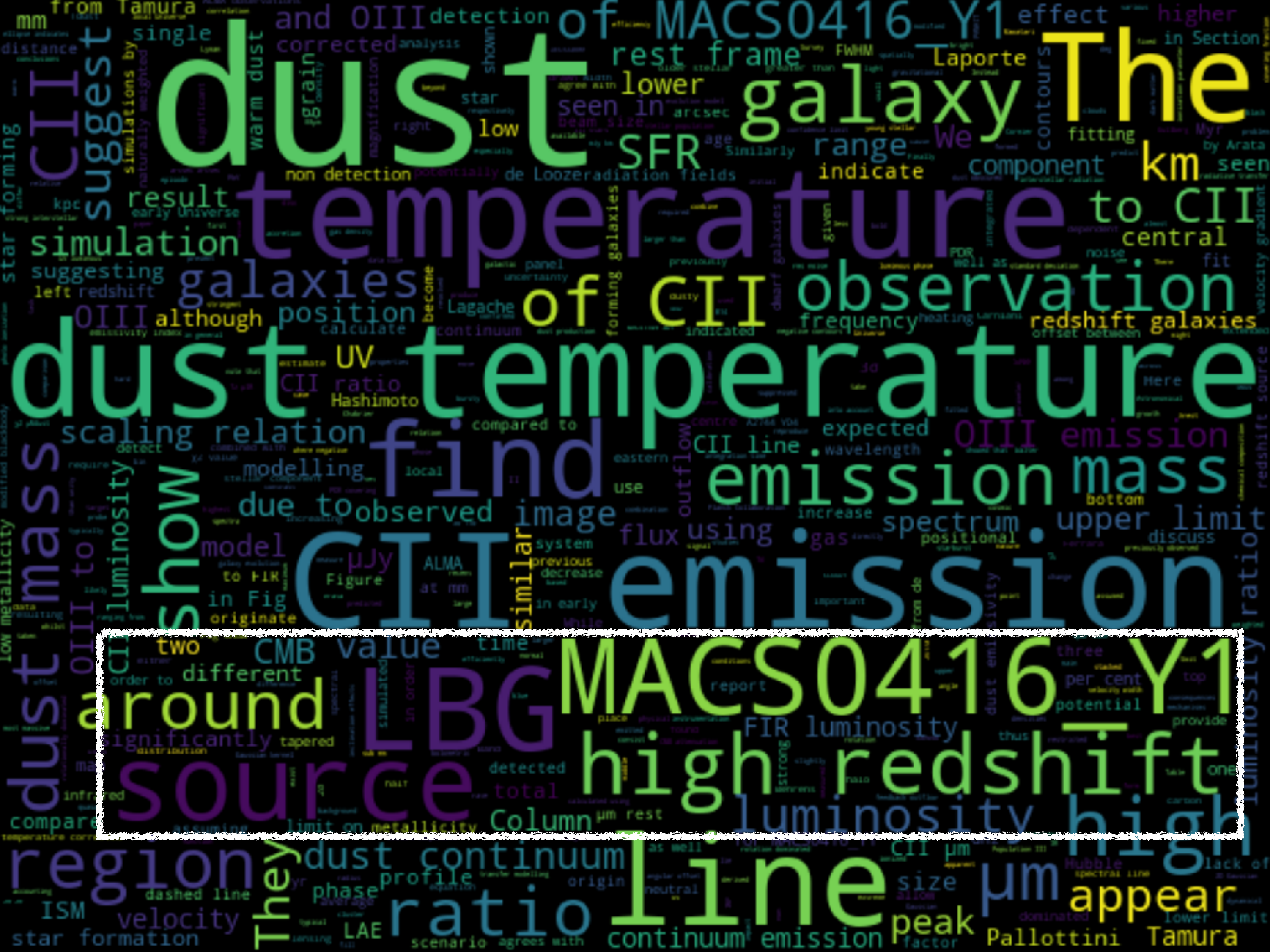

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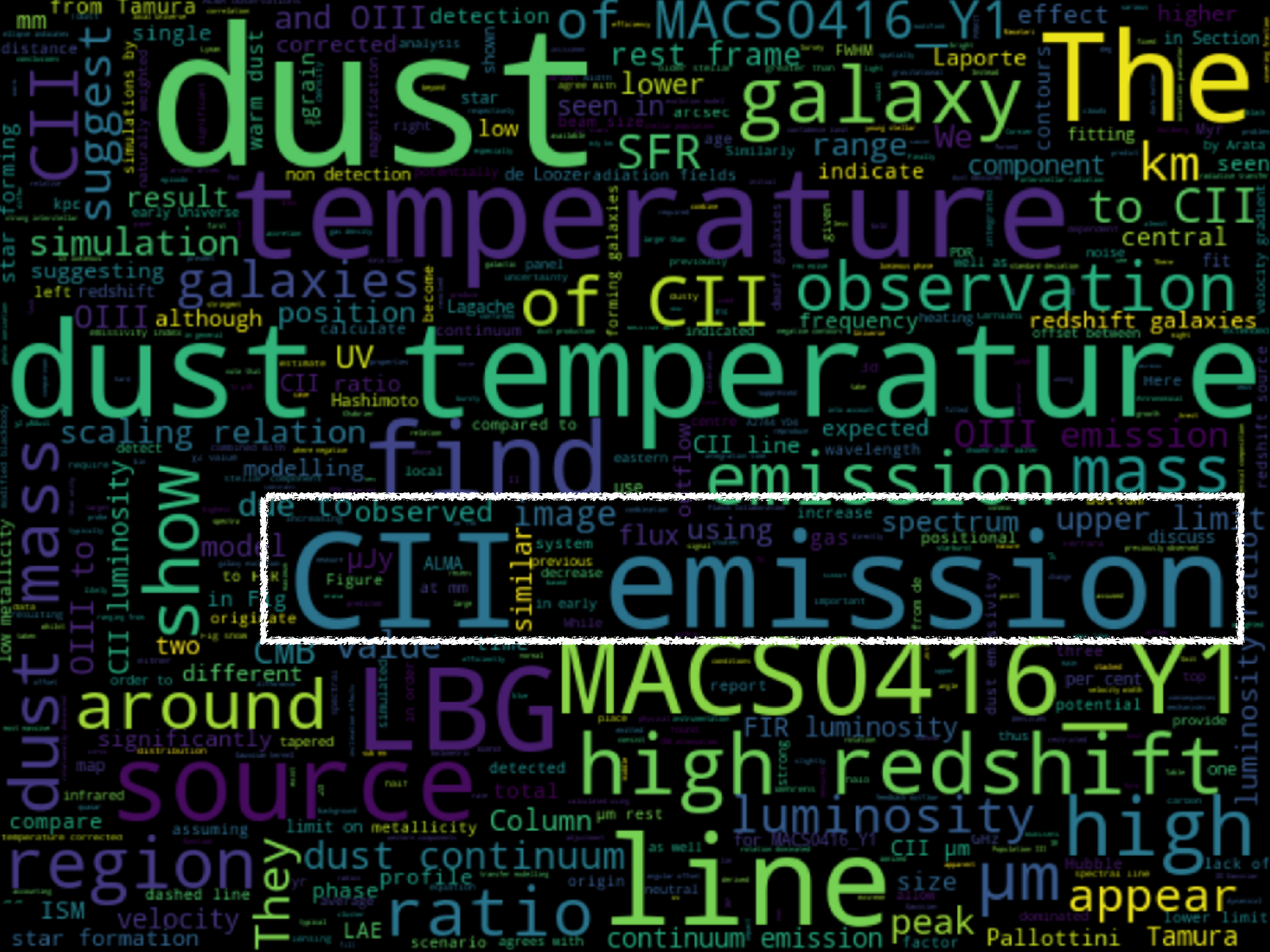
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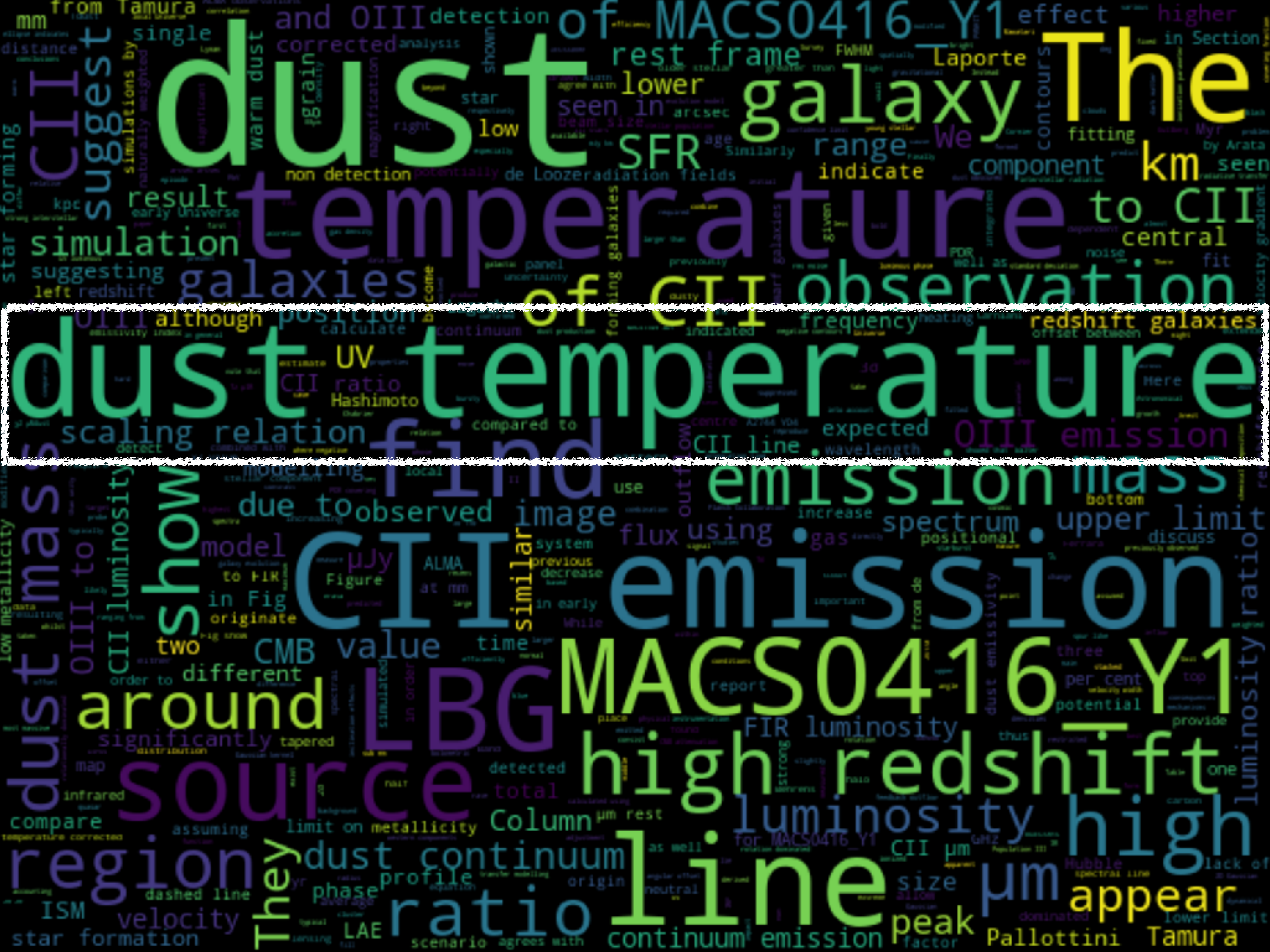
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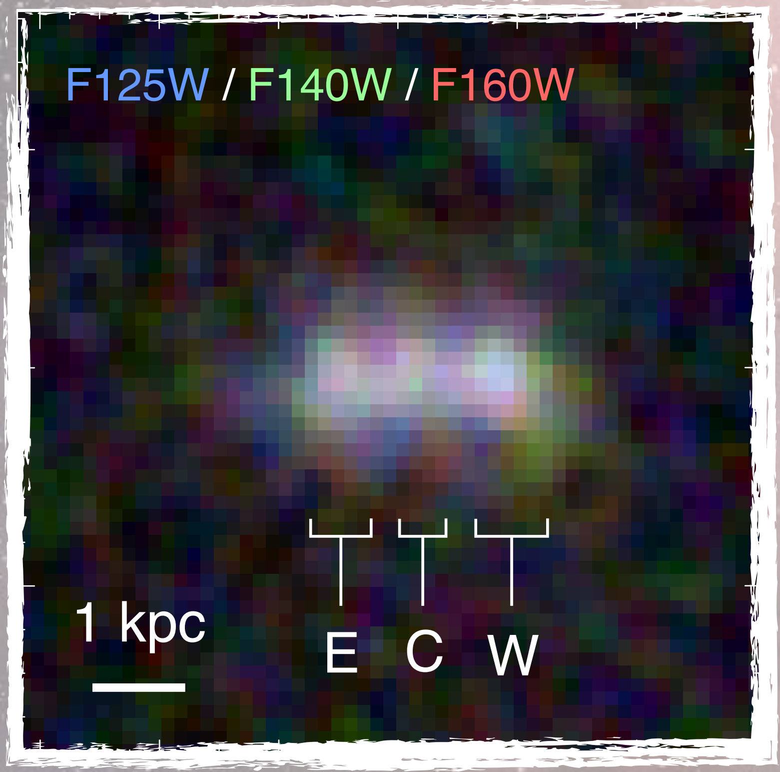
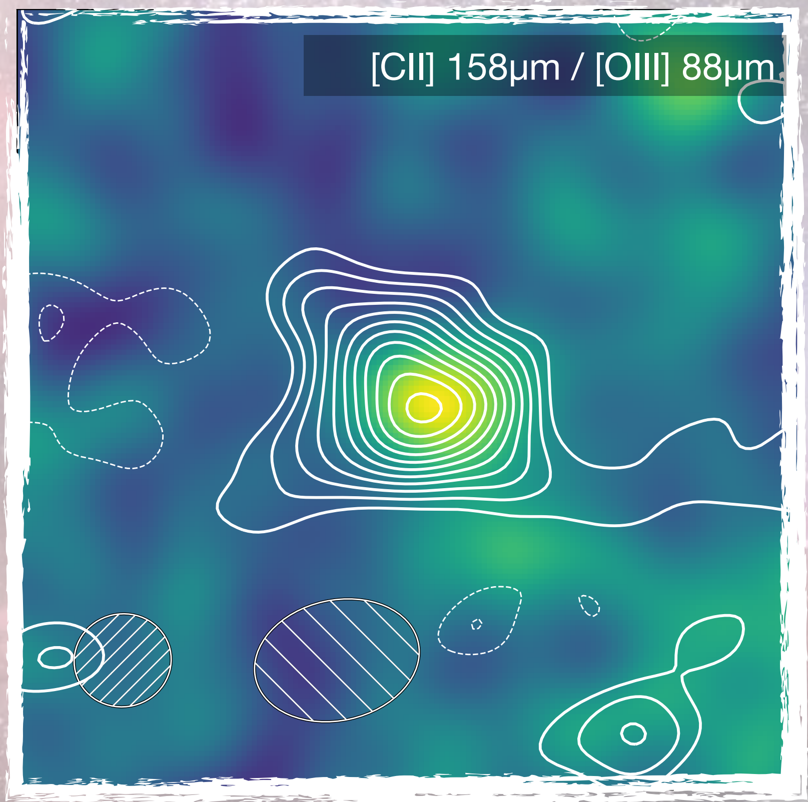
MACS0416_Y1

dust and carbon at z = 8.3

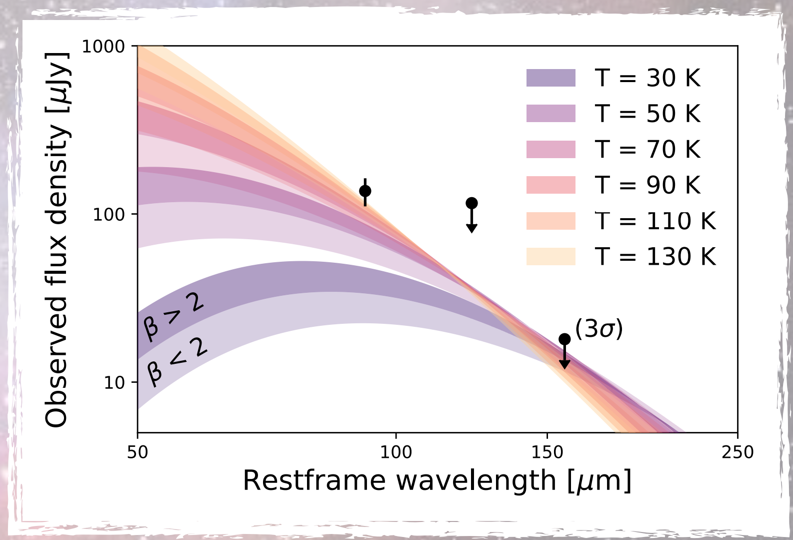
The source …



… the lines …

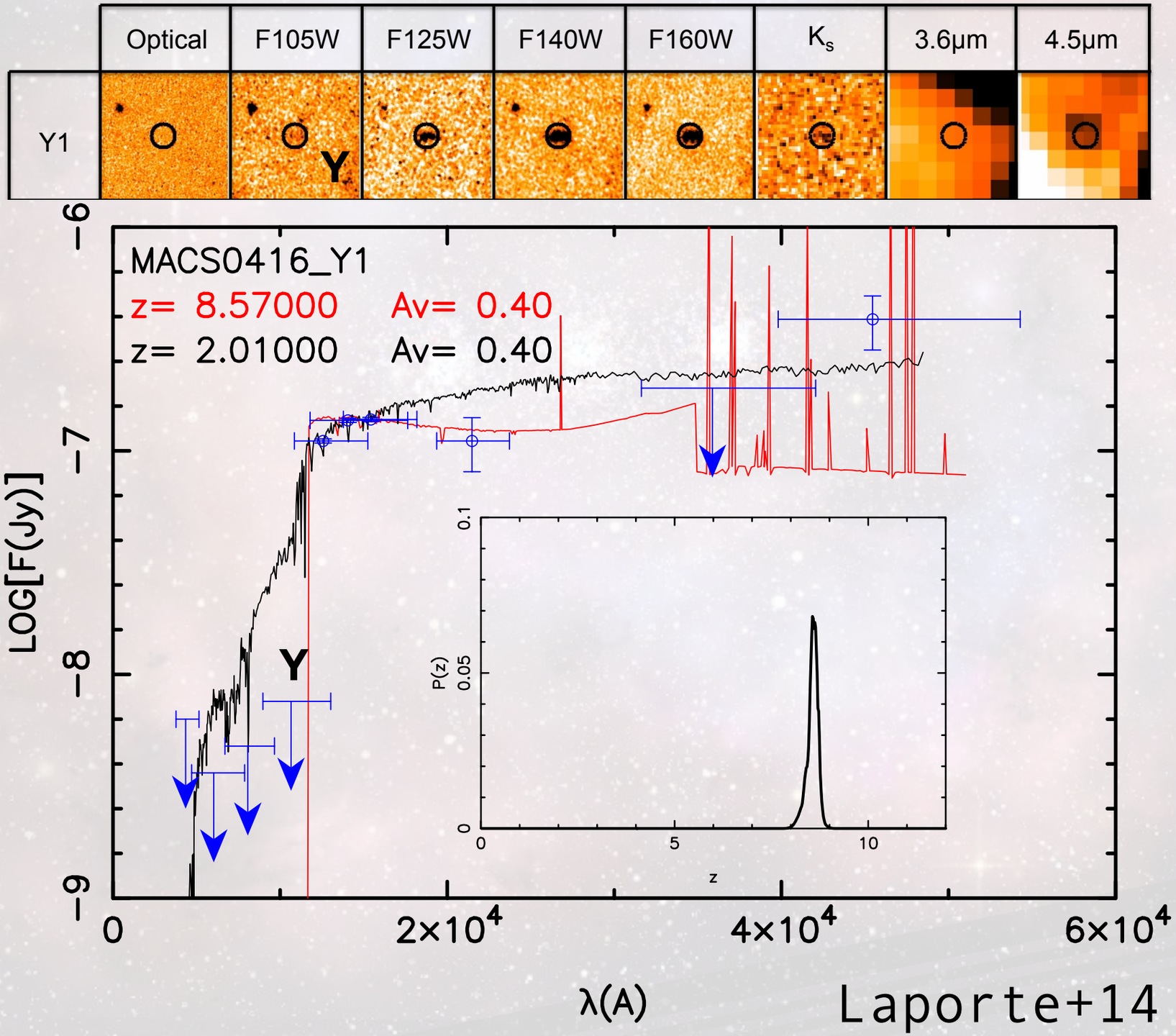


… and the spectrum!



Bakx+2020:
2001.02812

Y-band drop-out LBG found behind the Hubble Frontier Field



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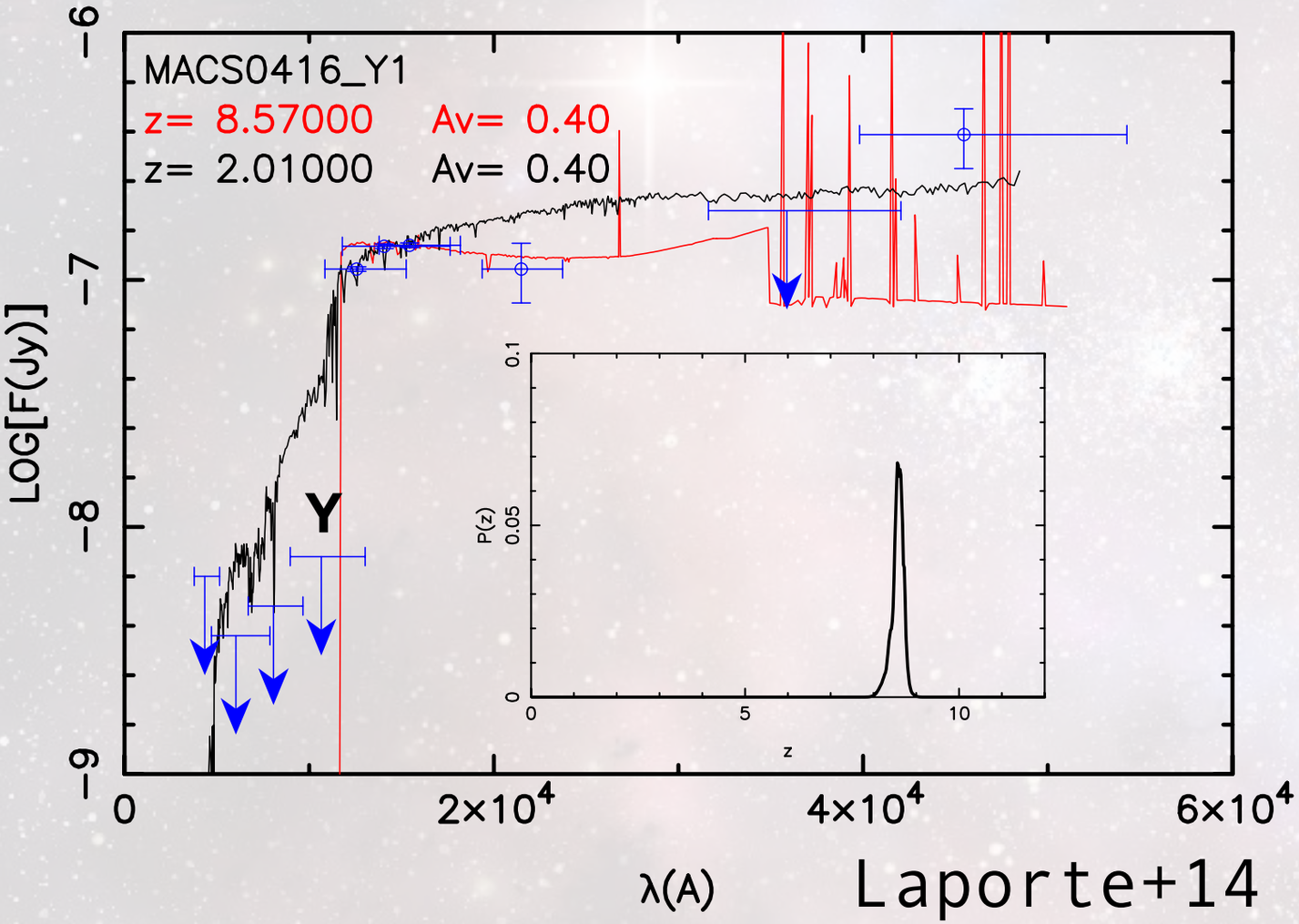
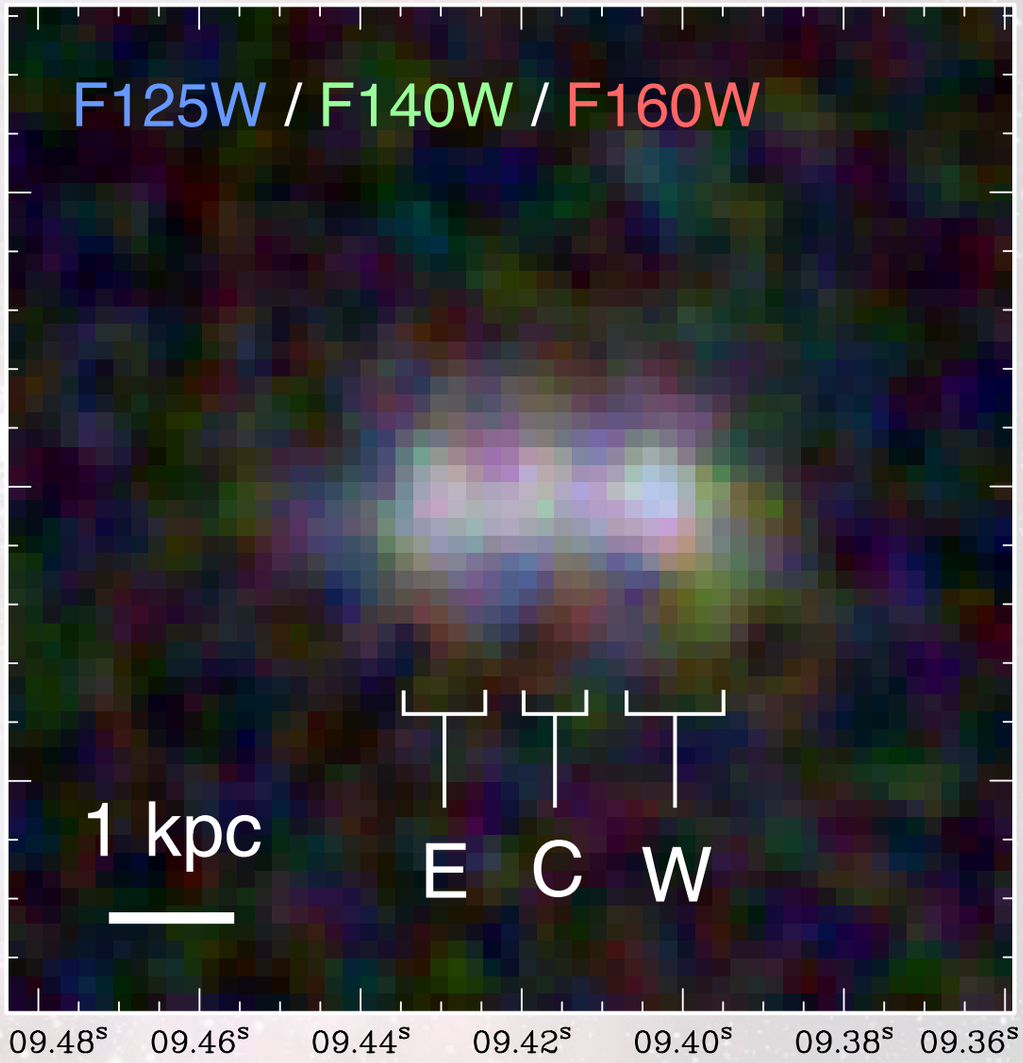
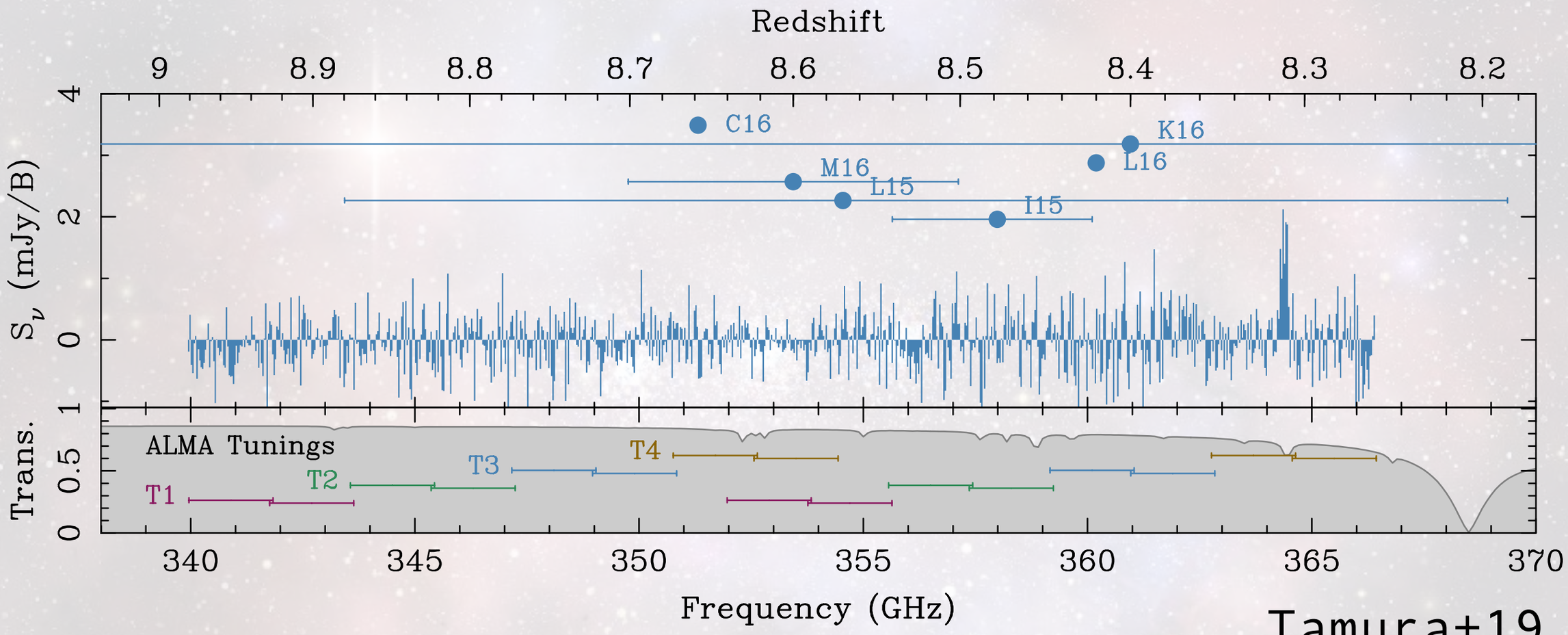


Laporte+14

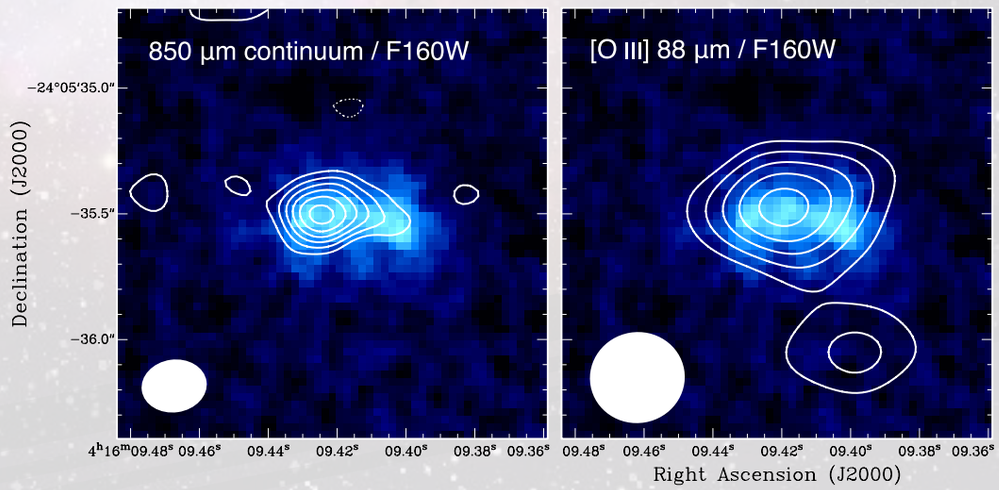


Tamura+19

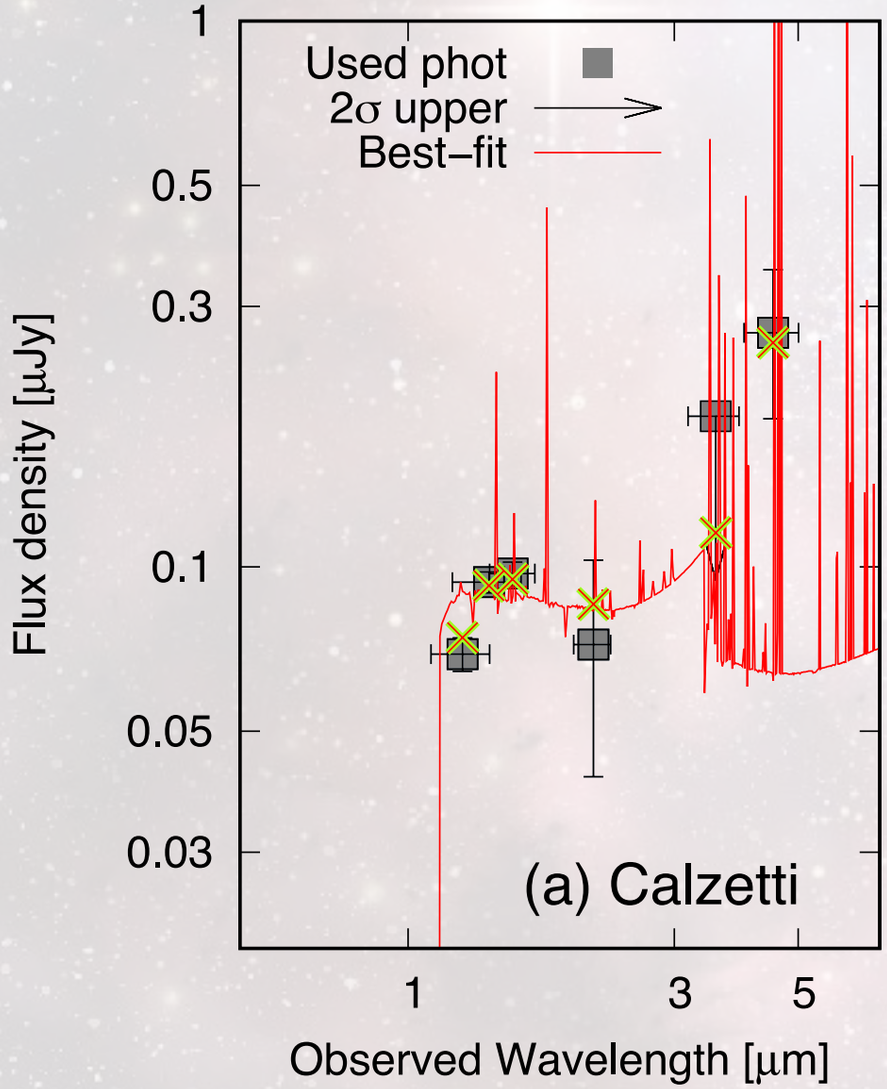
ALMA redshift sweep found [OIII]88um confirming z = 8.31

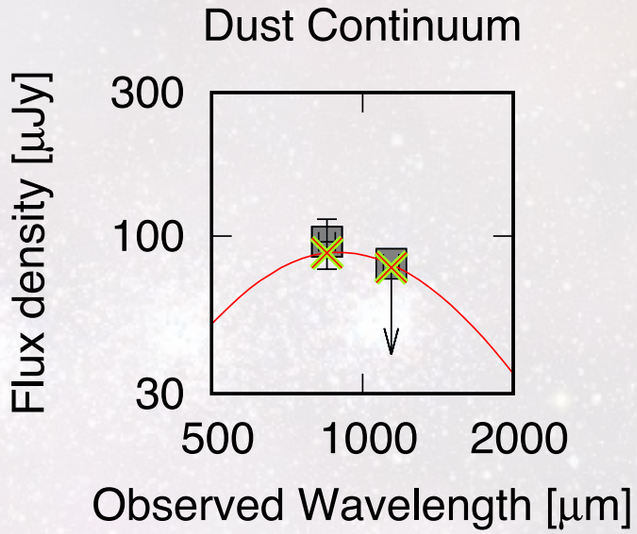


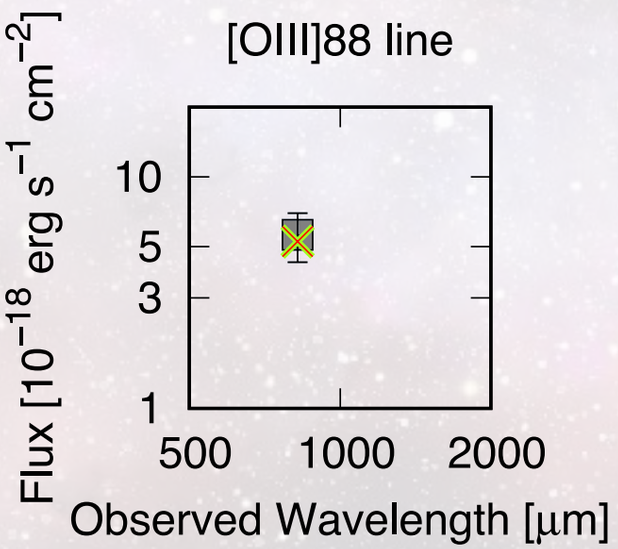
Tamura+19



UV-to-FIR suggests a young stellar population

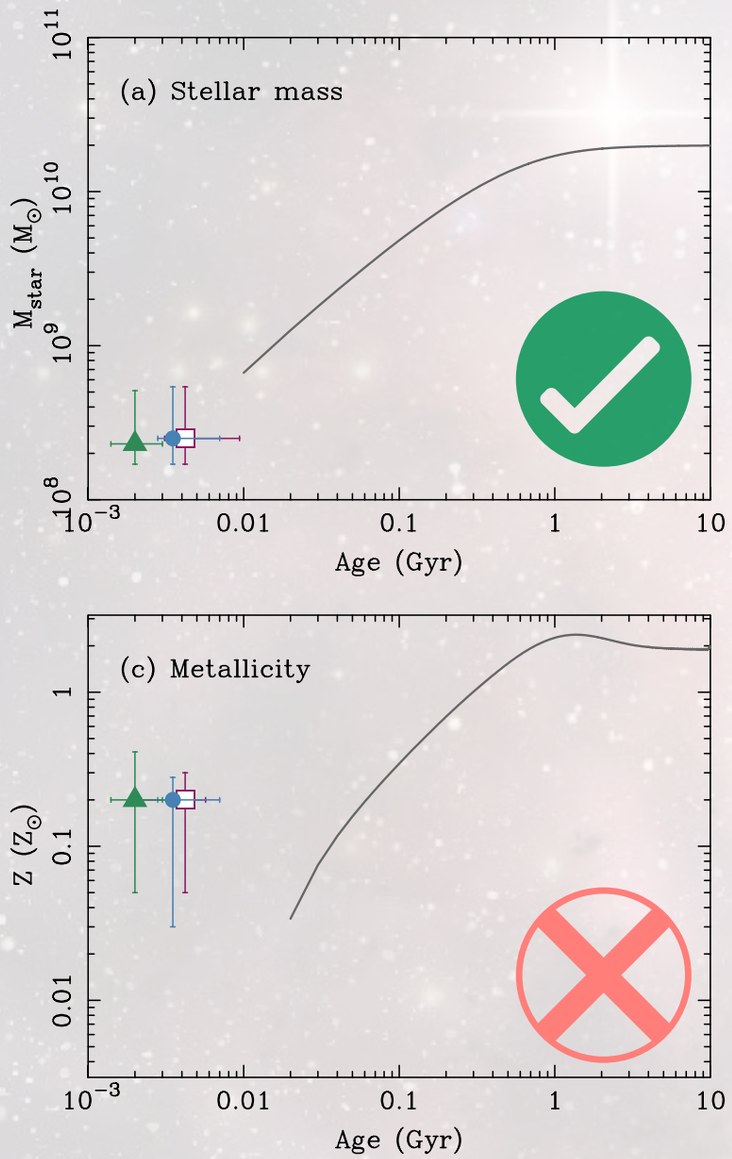


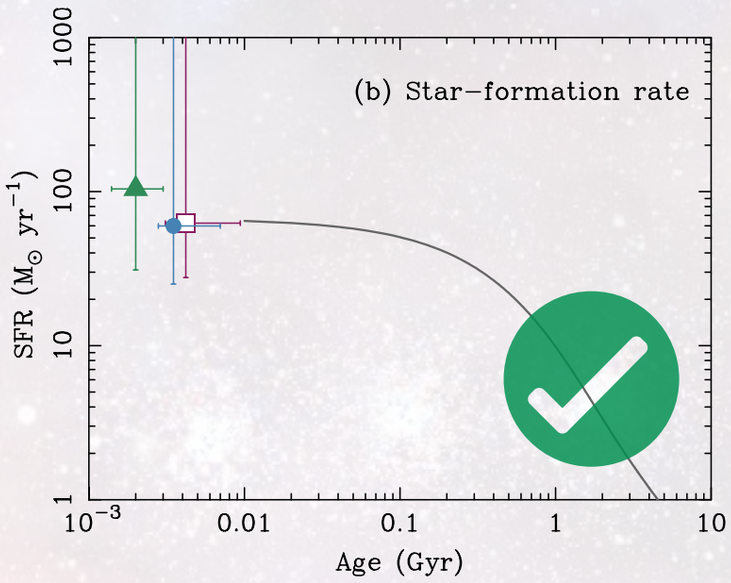


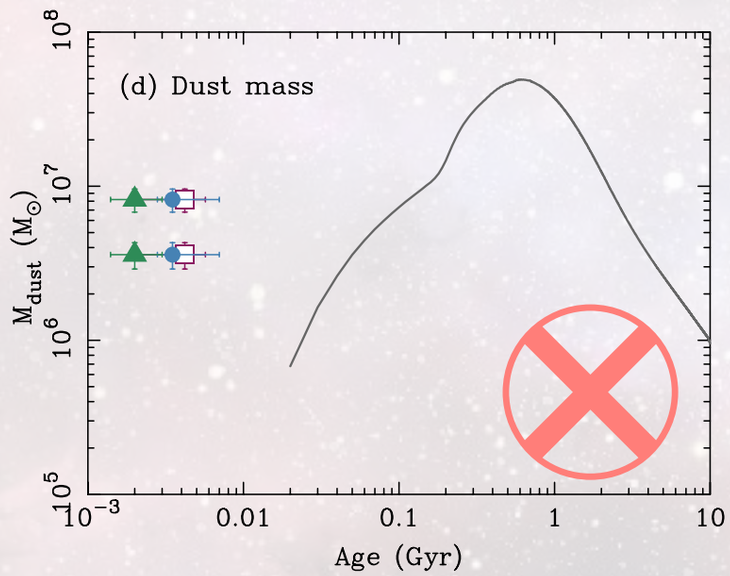


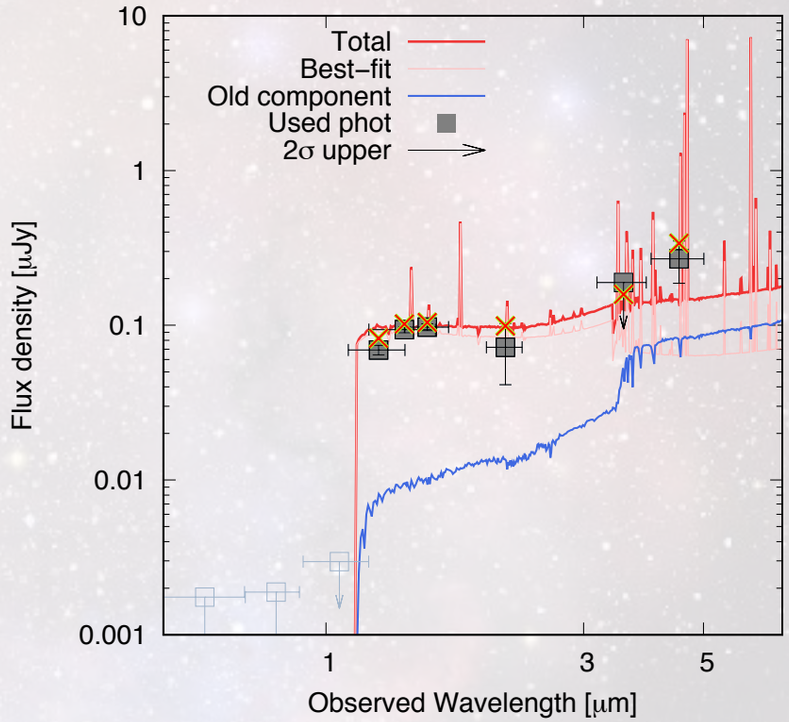
t_{age}	.=	3.5 Myr
Z	.=	$0.2^{0.16}_{-0.18}\,Z_\odot$
M_{star}	.=	$2.4 \times 10^8\,M_\odot$
SFR	.=	$57\,M_\odot$ / yr

Dust mass evolution model suggests older stellar component at z = 15







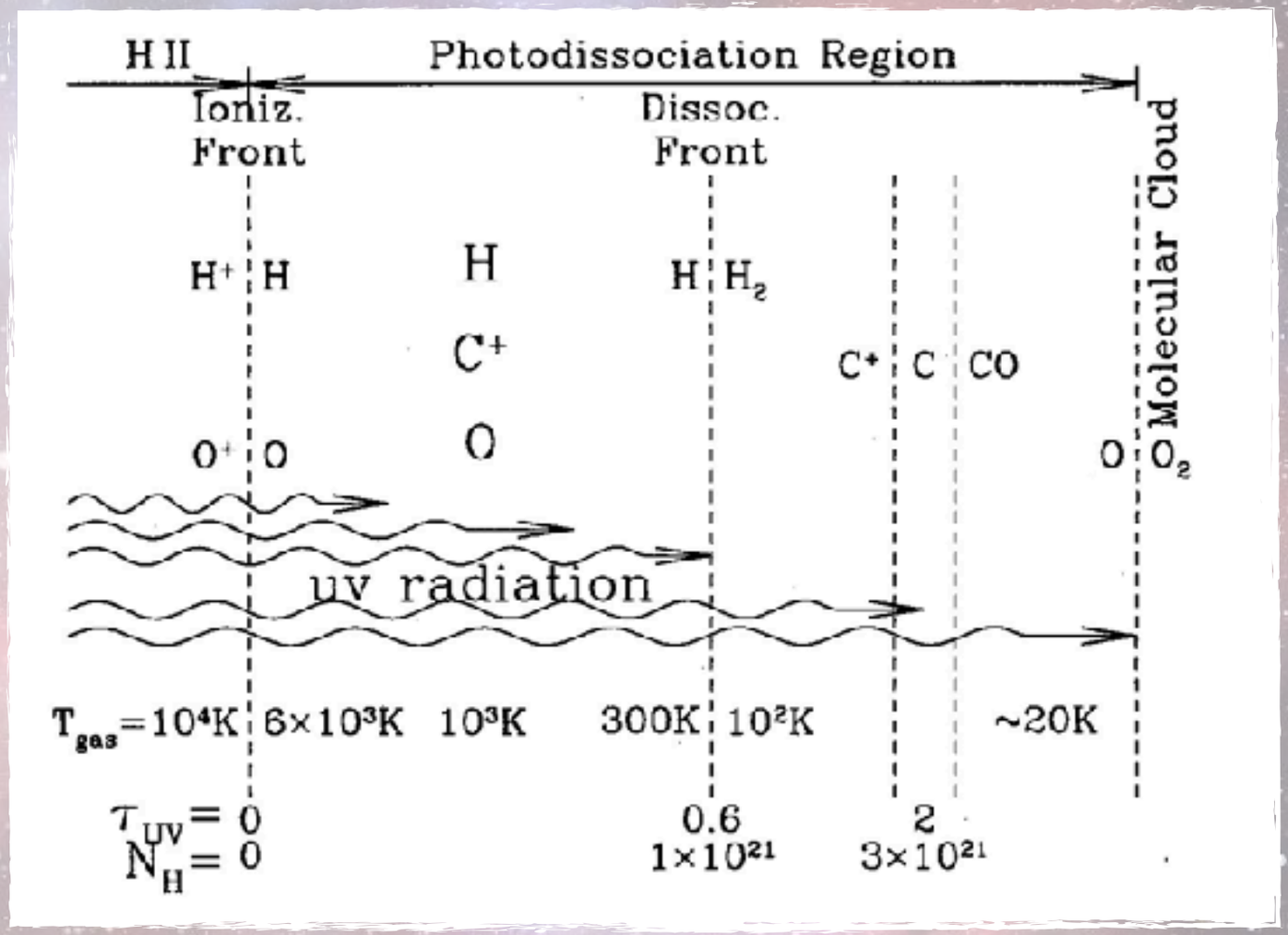


Asano+13, Tamura+19

See also:
Roberts-Borsani+20
Sommovigo+20
Nishida+in prep.

Theoretical intermission

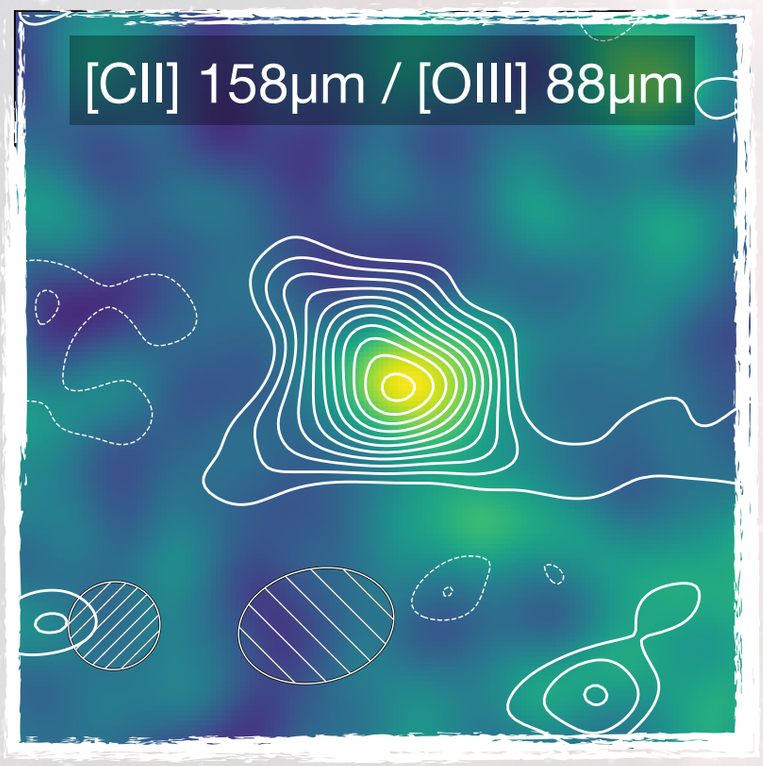
Photo-dissociation regions



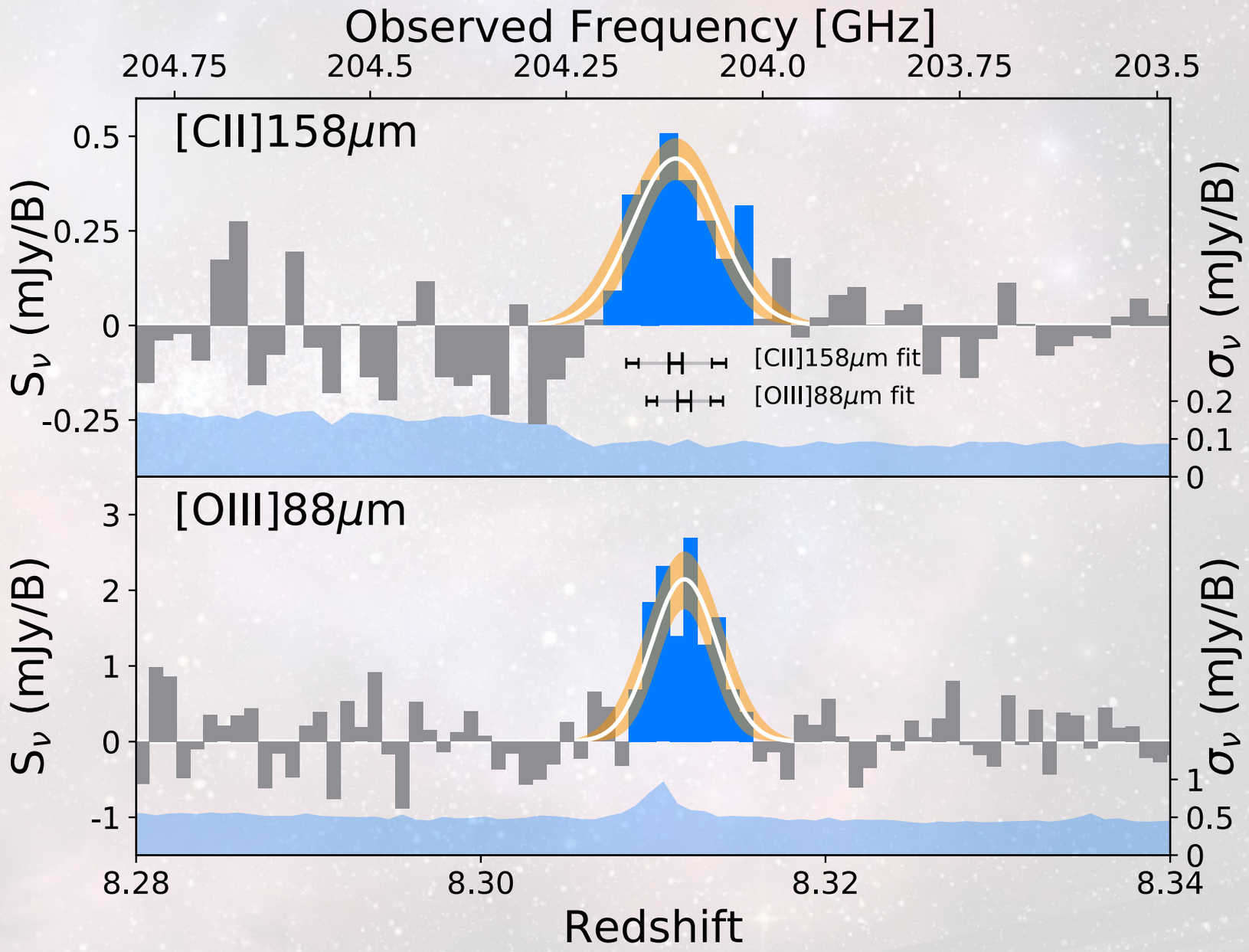
O & B stars

[OIII] [CII]

No obvious offset between [CII] and [OIII]

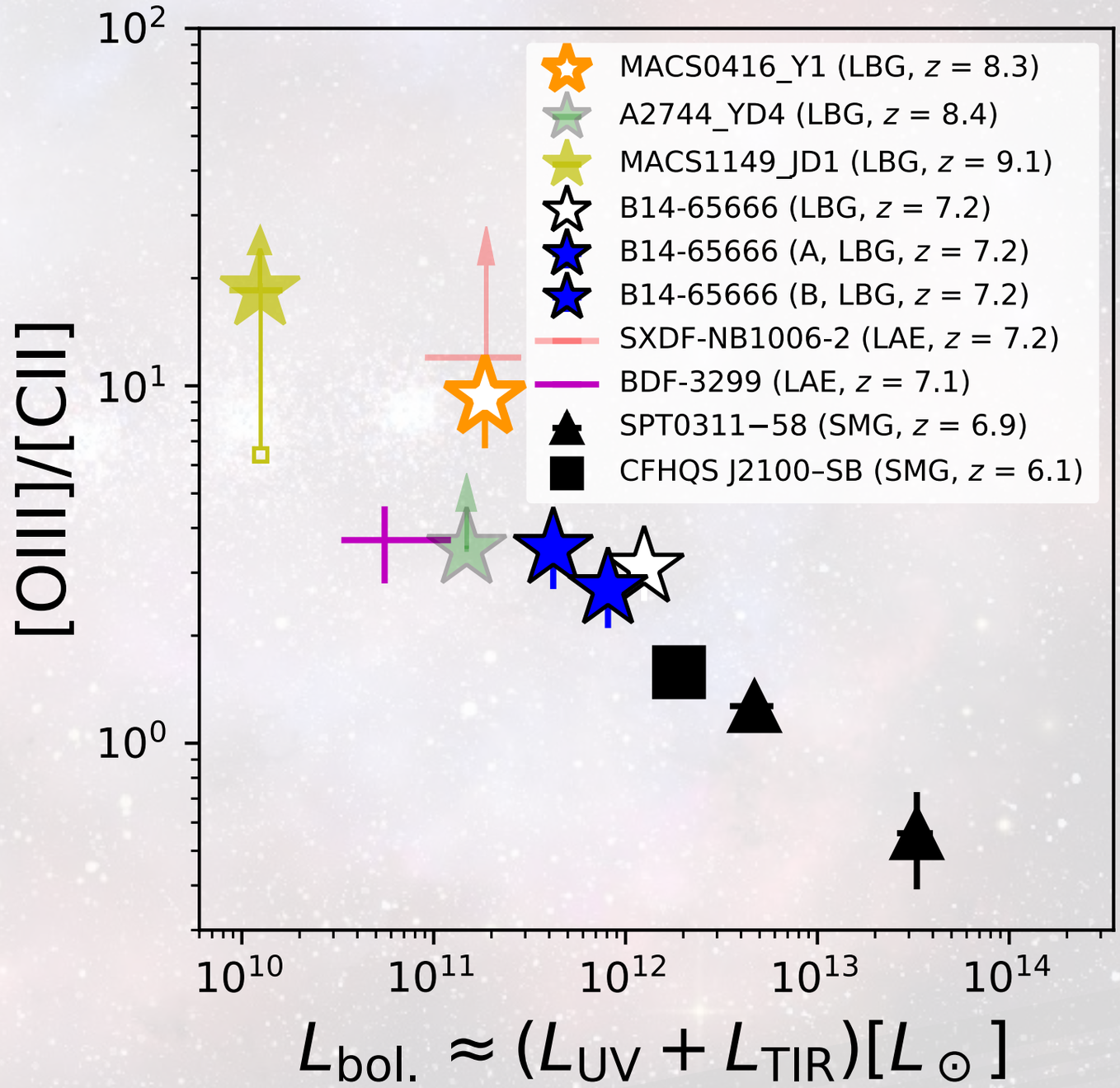


Bakx+2020

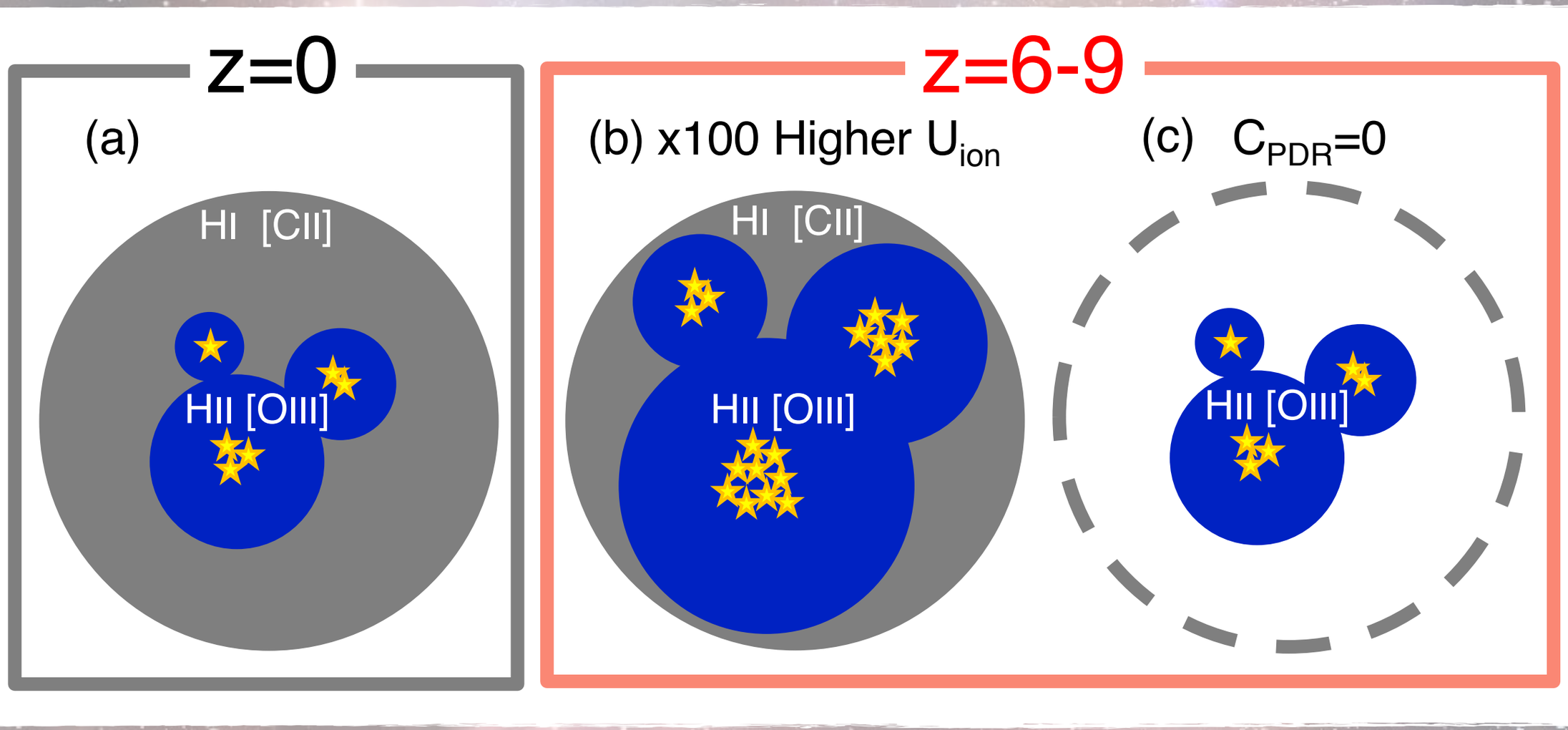


Unlike observations (e.g. Carniani+18)
Unlike models (e.g. Arata+20, Pallottini+19)

High [OIII]/[CII] ratio suggests strong radiation fields

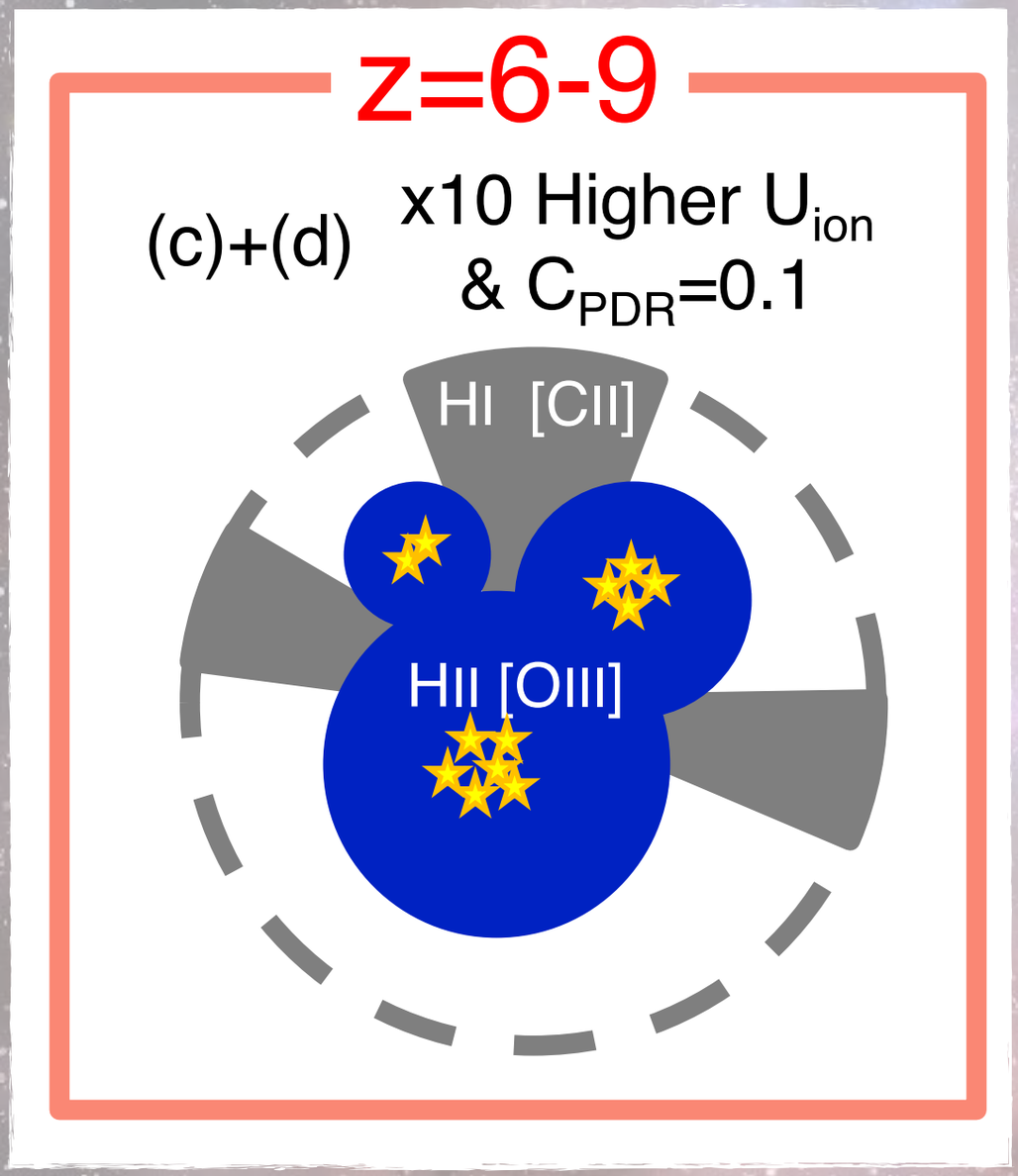


High [OIII]/[CII] due to Ionization parameter Covering fraction



Harikane+20

High [OIII]/[CII] due to a combination:



Harikane+20

Or…

Higher density

Lower C/O ratio

CMB attenuation effect

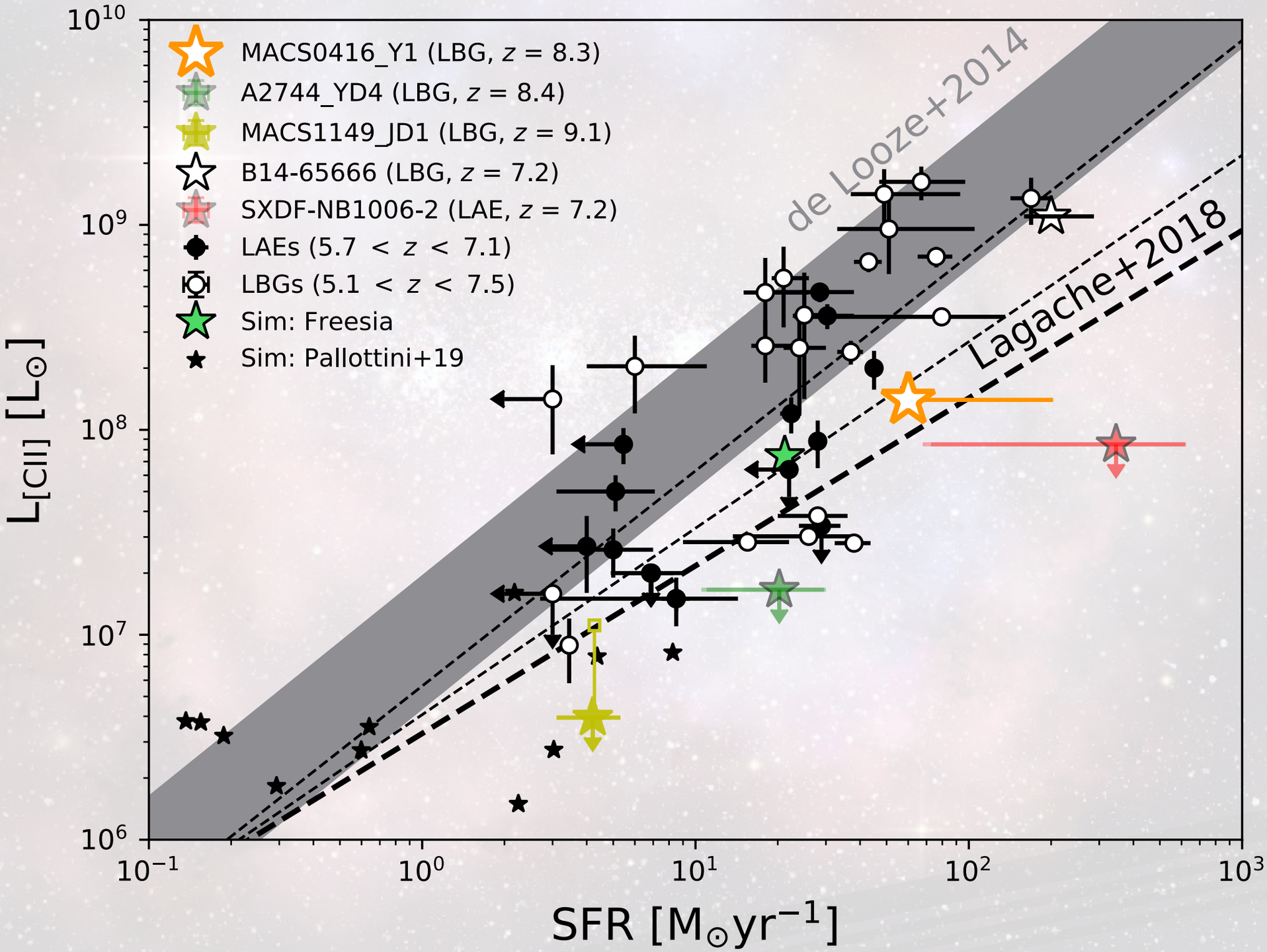
But not…

Lower metallicity

Spatially-extended [CII]

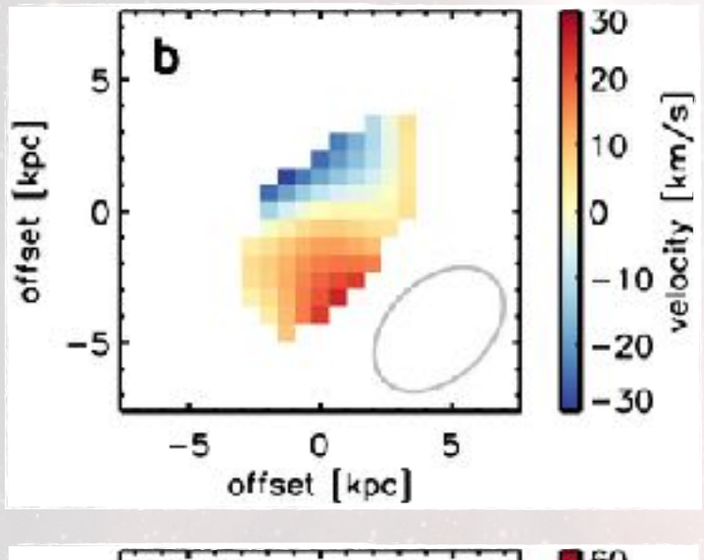
See also Hagimoto+in prep, Carniani+20, Arata+20

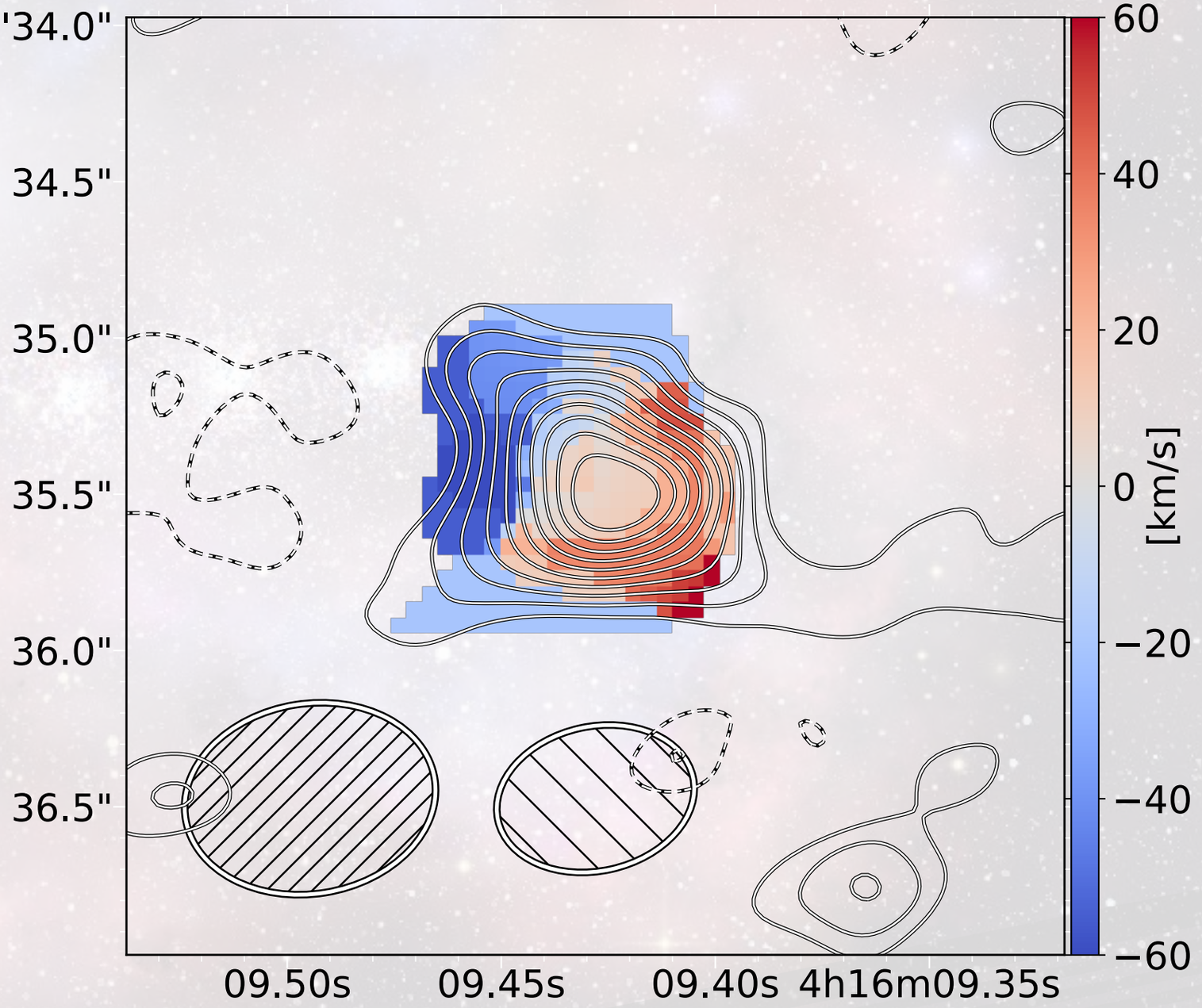
Is there a [CII] deficit at high redshift?



Are we witnessing rotation at z = 8.31?

Smit+18

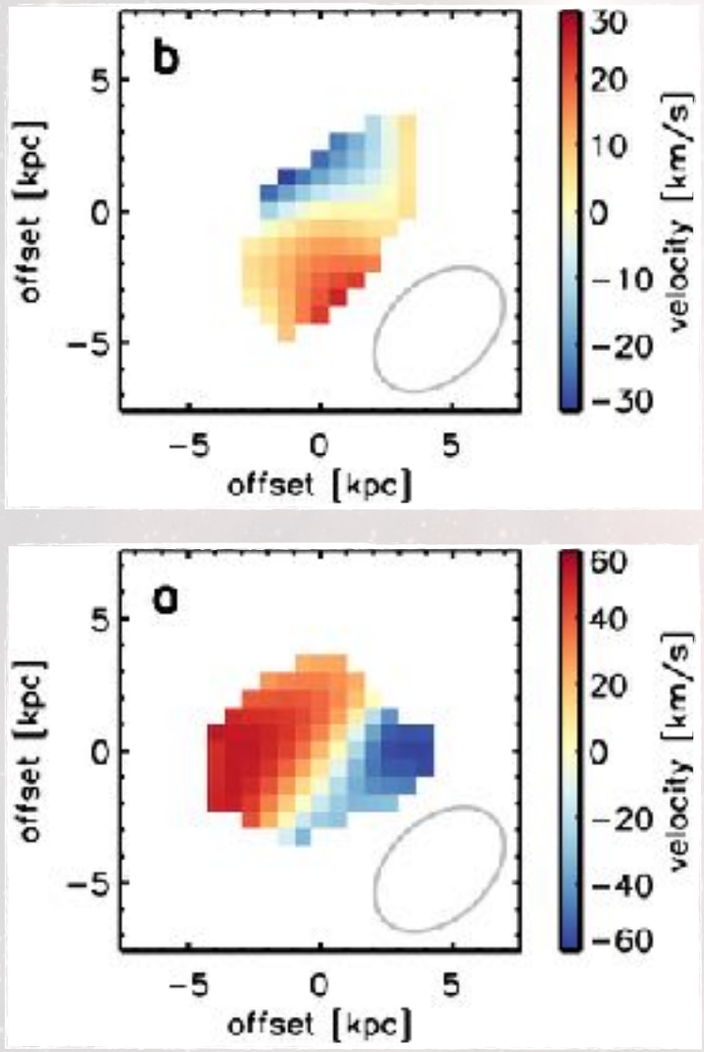




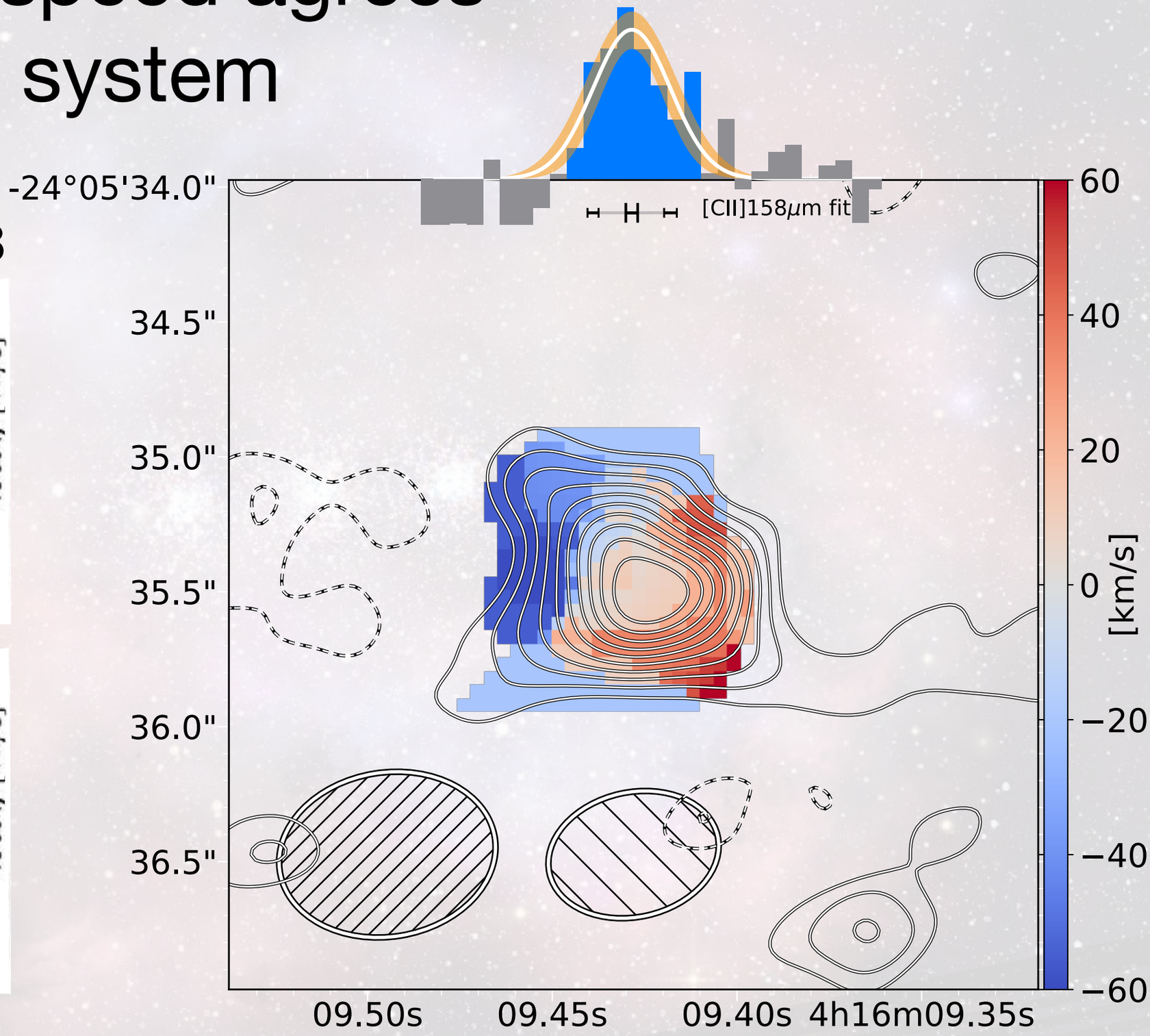
See also:
Jones+20

The rotation speed agrees with a stable system

Smit+18

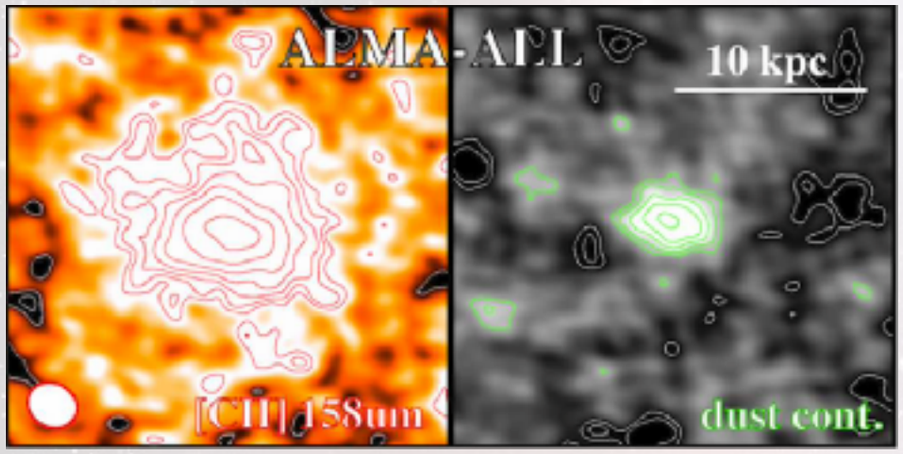


See also:
Jones+20

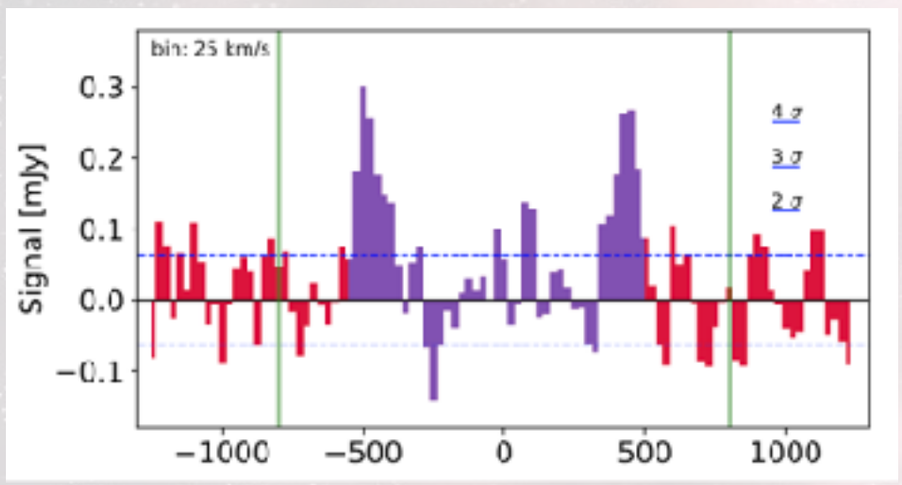


Galaxy mass agrees with UV-FIR

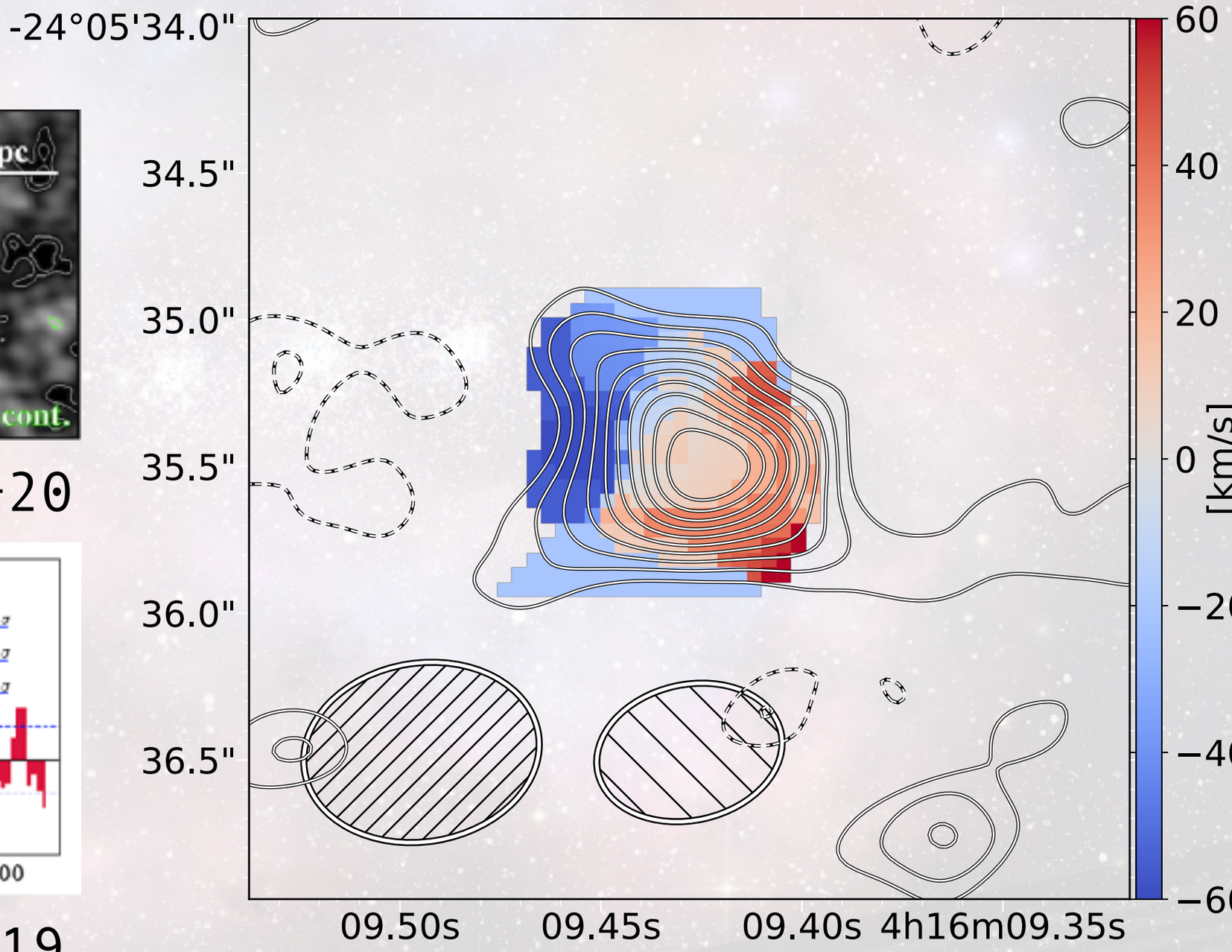
Or is gas outflowing at z = 8.31?



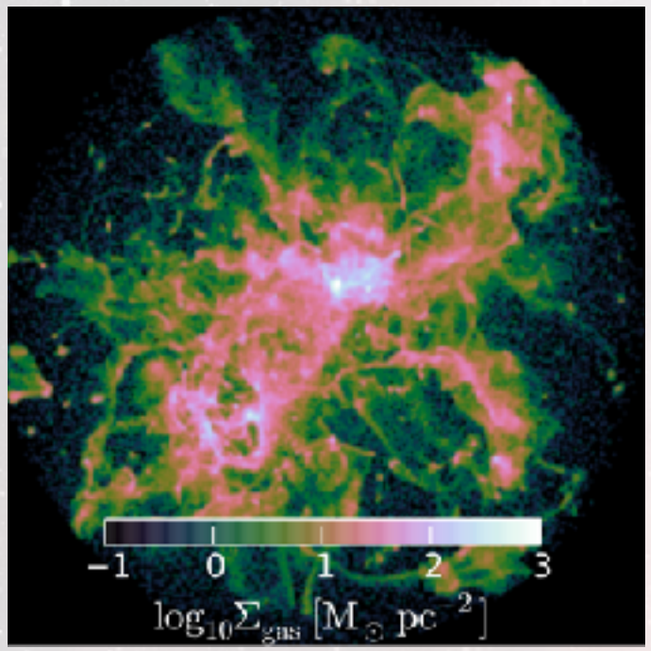
Fujimoto+19,+20



Ginolfi+19

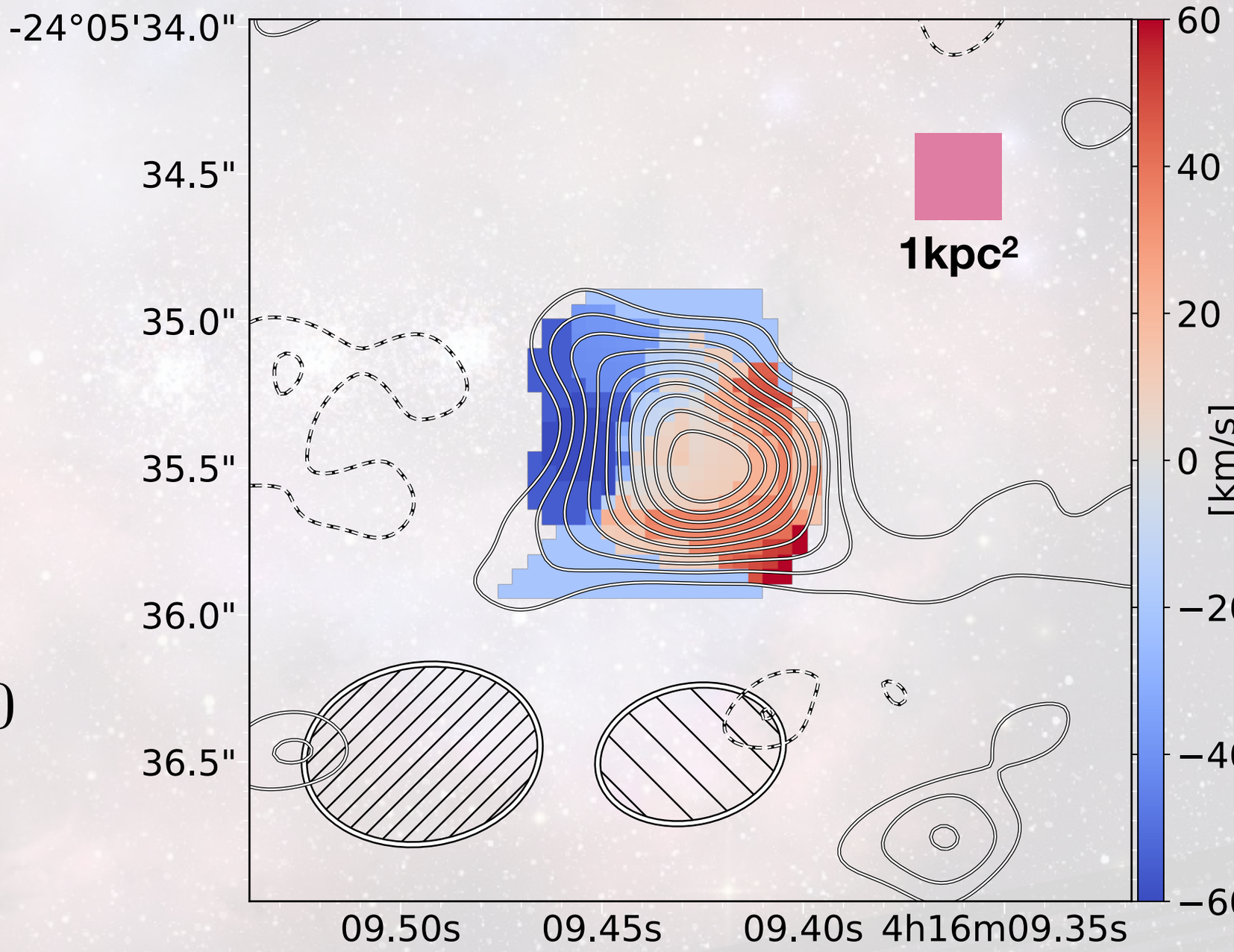


Perhaps the shallow dark matter halo cannot keep the gas together



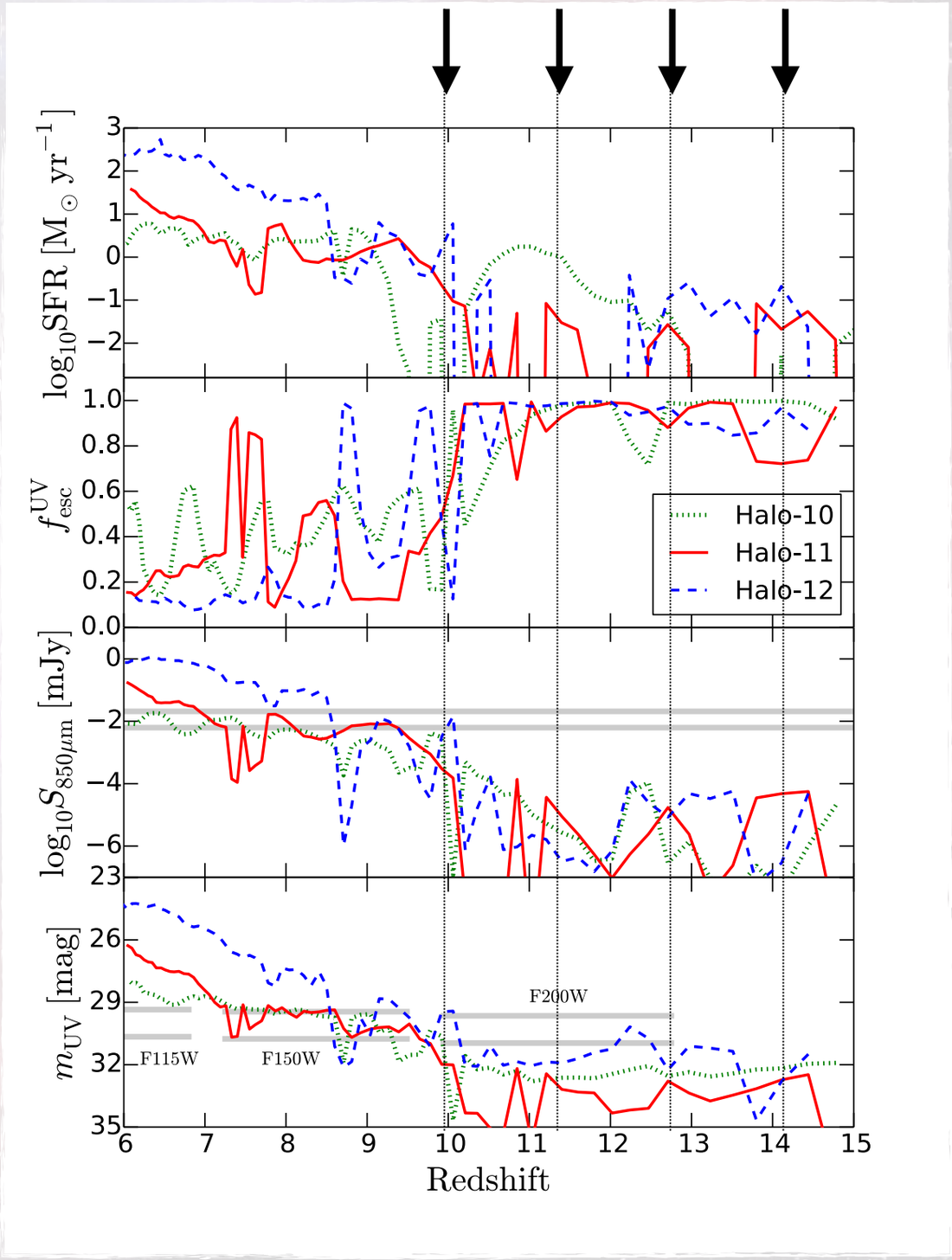
Arata+19

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



See also:
Katz+in prep, Burgarella+20,

Cycling between two galactic phases

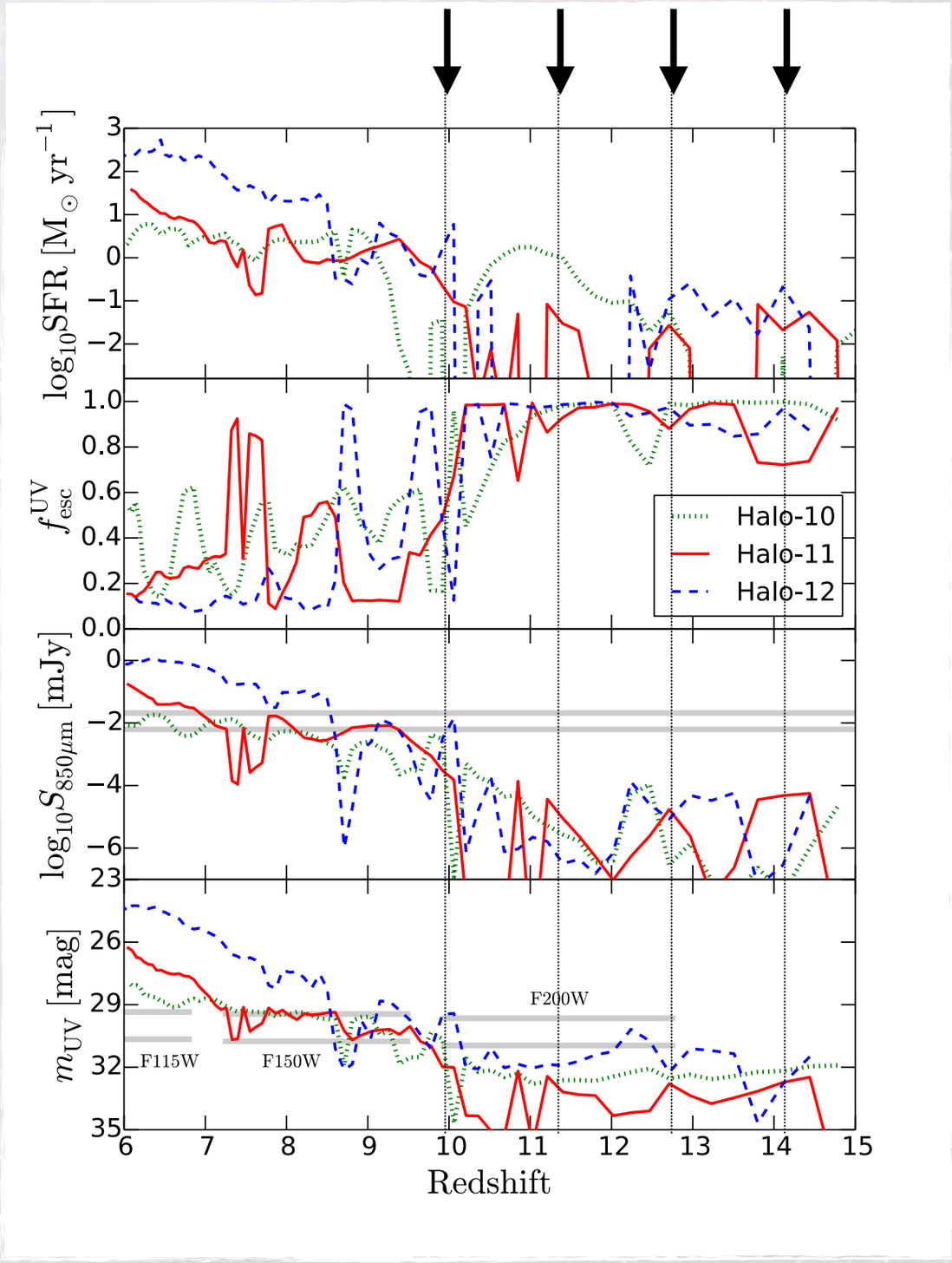


Arata+19,+20
Katz+in prep

Cycling between two galactic phases

Submm bright:

Dust clouds obscure UV
Increased star-formation
Inflowing gas



Arata+19,+20
Katz+in prep

Cycling between two galactic phases

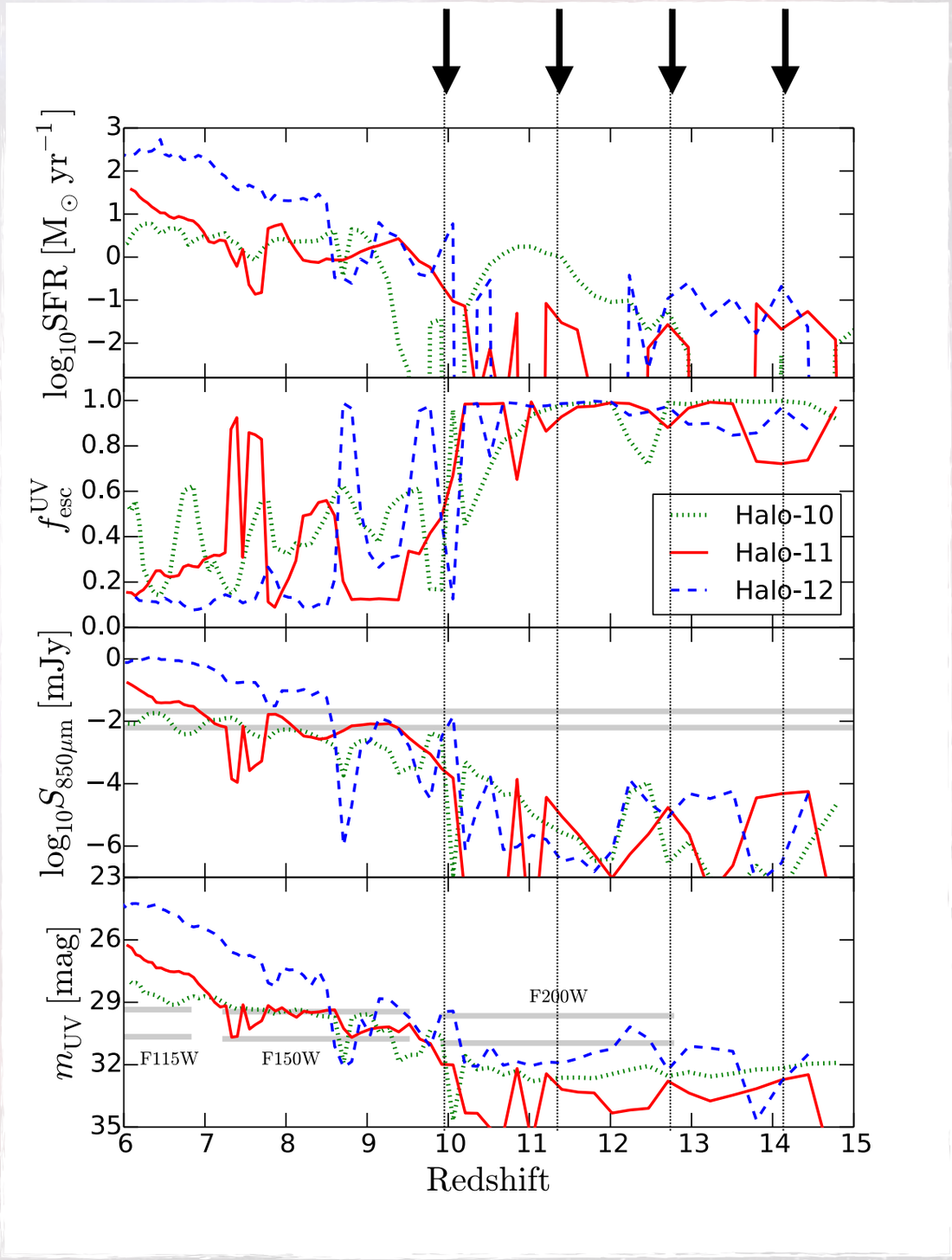
Submm bright:

Dust clouds obscure UV
Increased star-formation
Inflowing gas

UV bright:

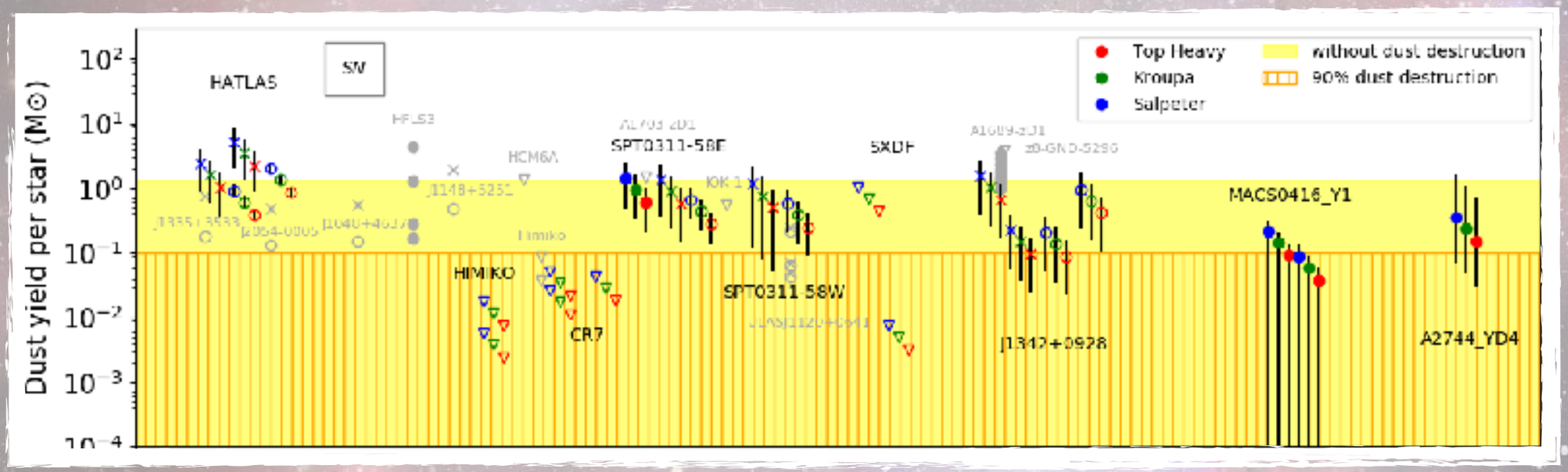
Star-formation feedback
UV-unobscured
Remaining dust is hot

Arata+19,+20
Katz+in prep



SNe don’t produce enough dust!

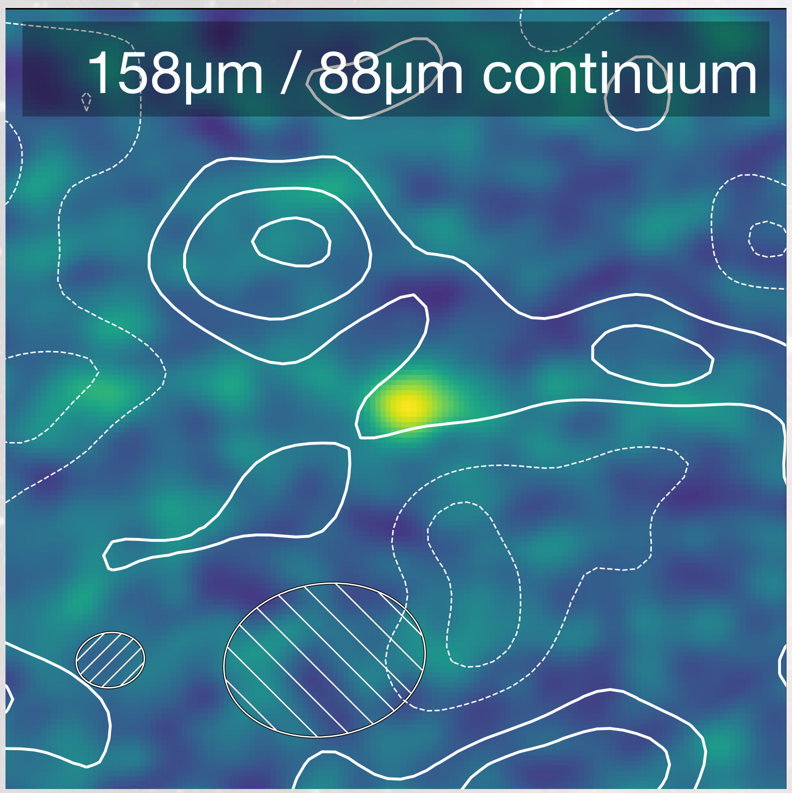
Leśniewska+19

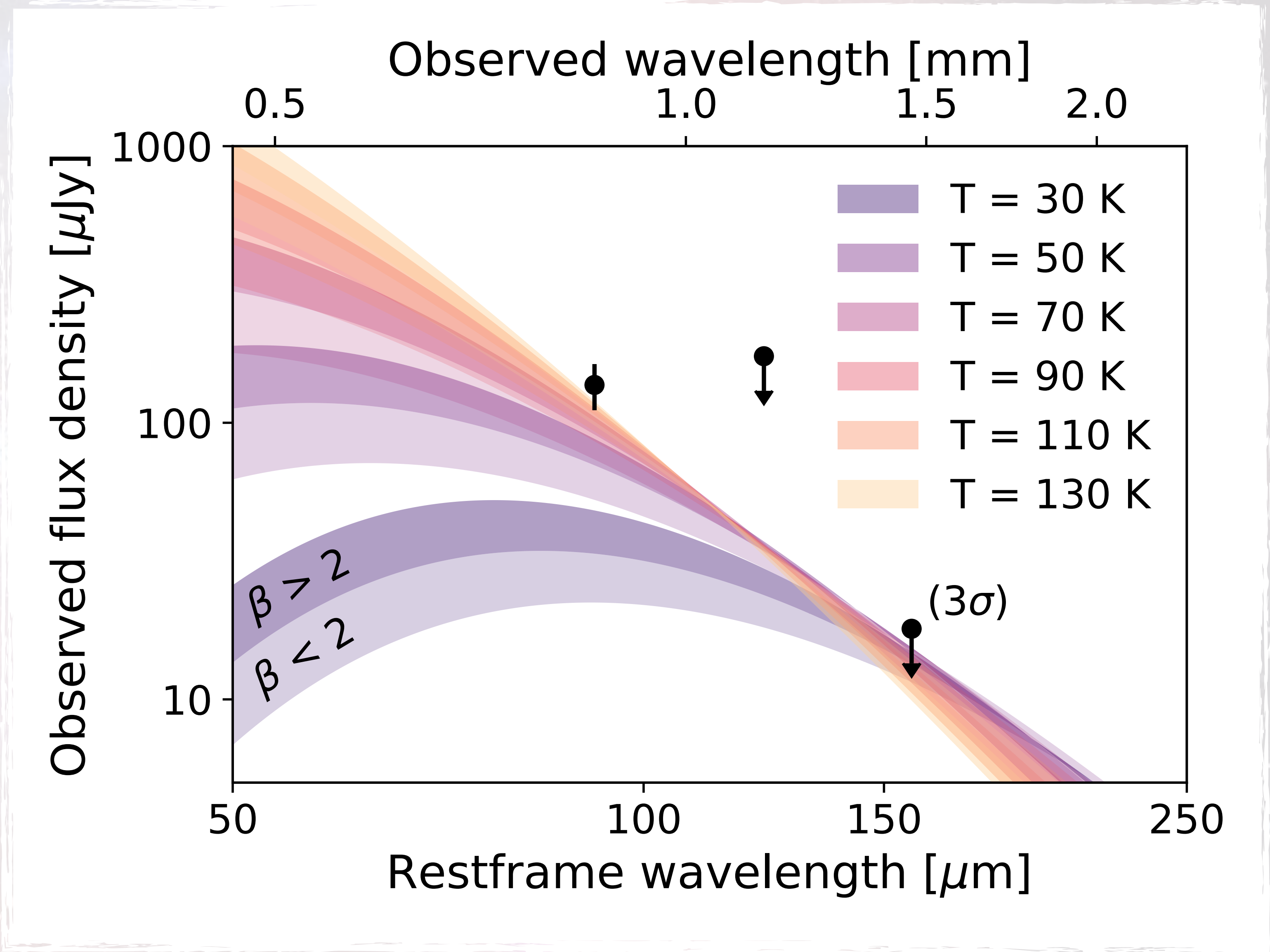


Redshift

MACS0416_Y1

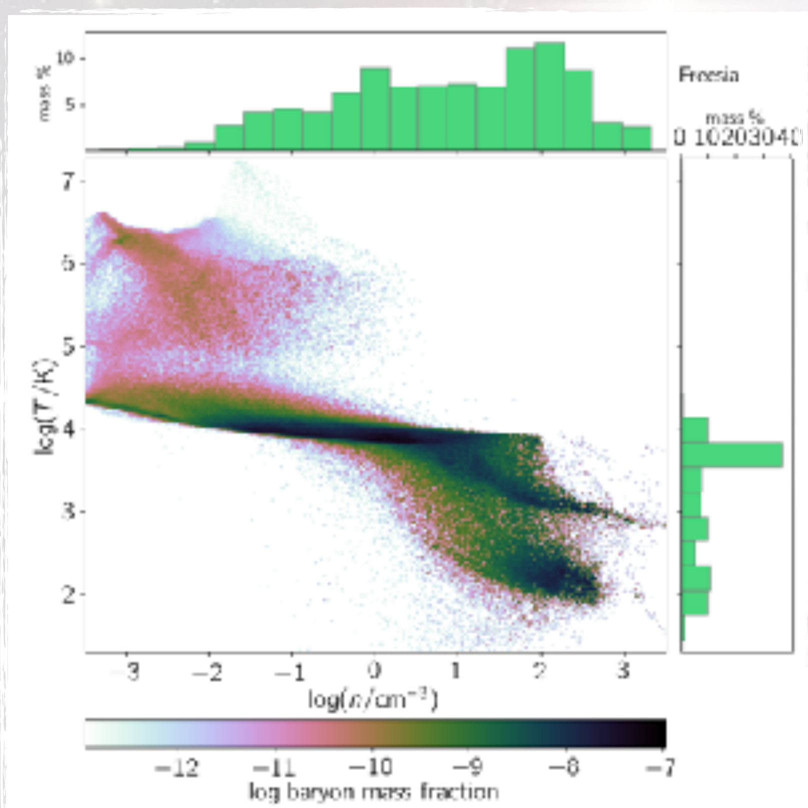
No detection at 158µm ∴ high dust temperatures

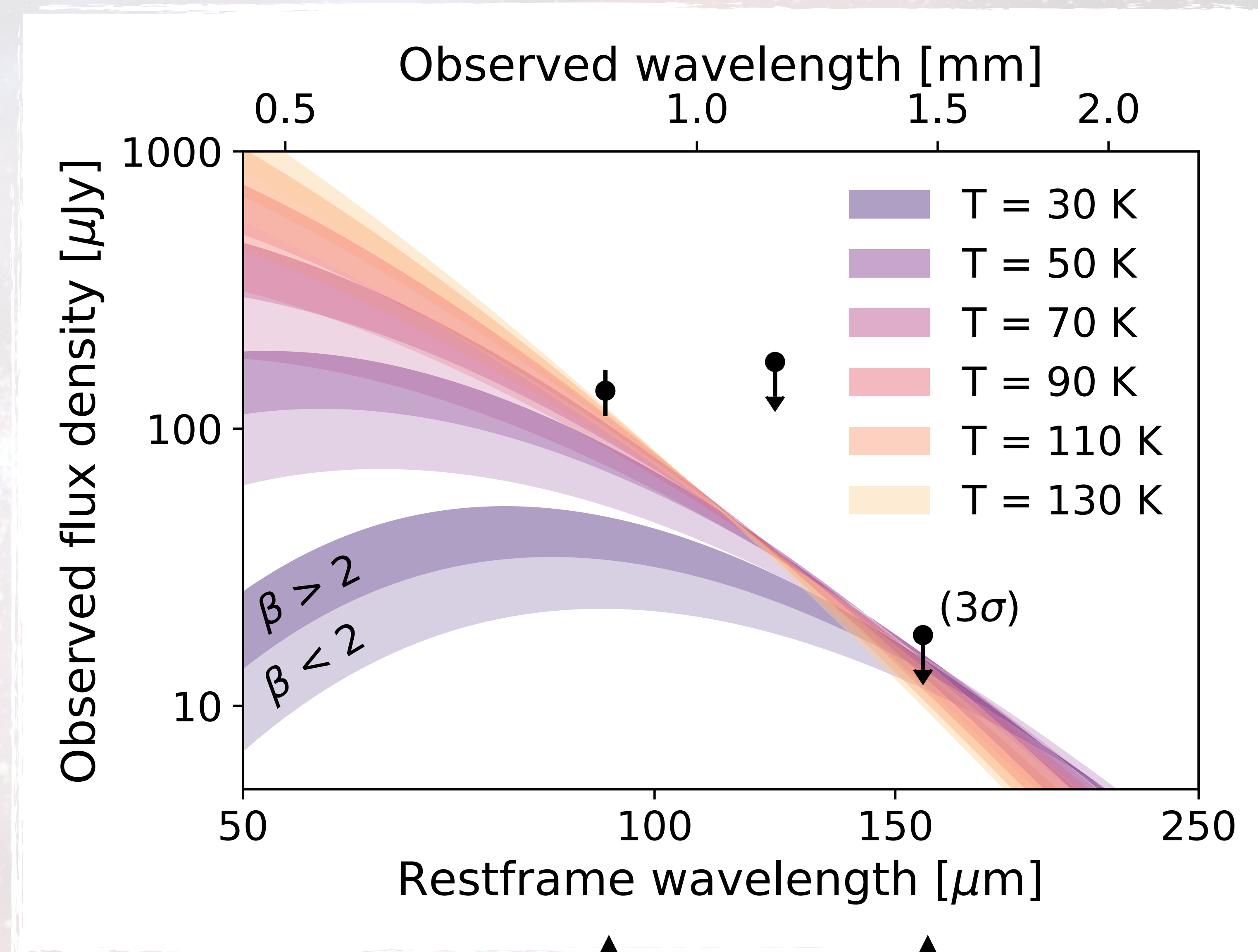




MACS0416_Y1

High dust temperatures ∴ lower dust masses



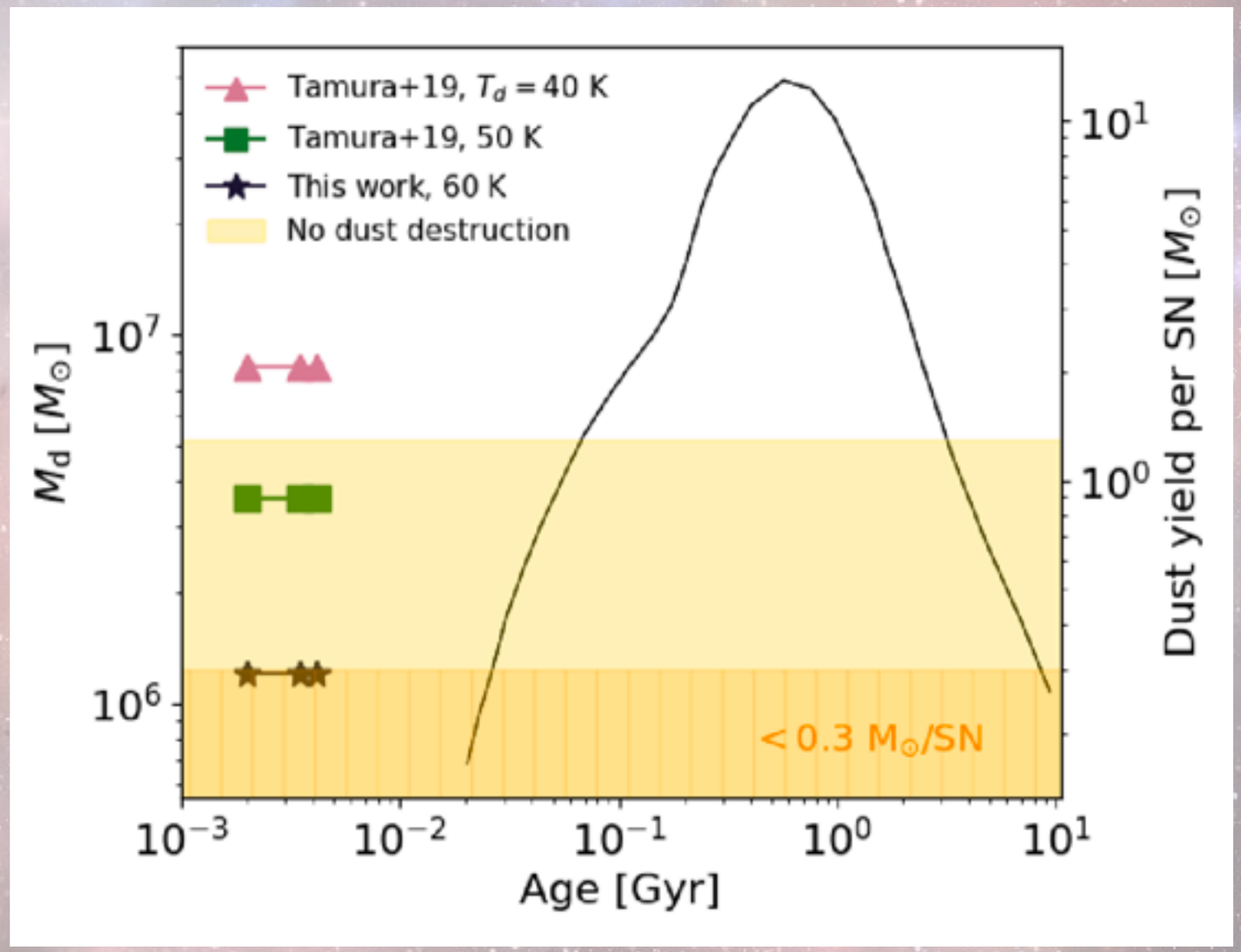


Pallottini+19

See also:
Arata+2019, Sommovigo+20

[OIII] **[CII]**

Recent dust production models reduce the age of the stellar population

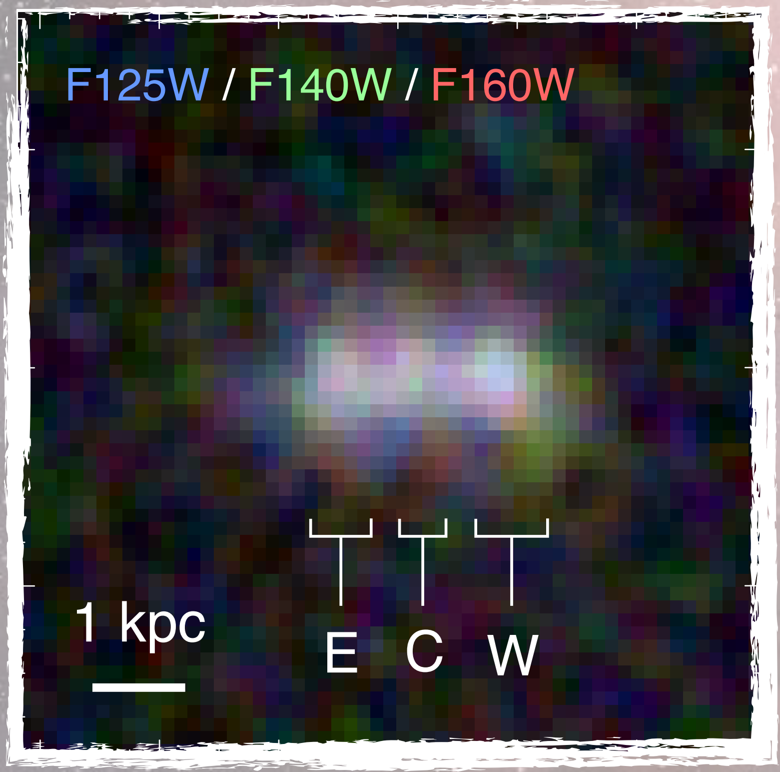


Sommovigo+20

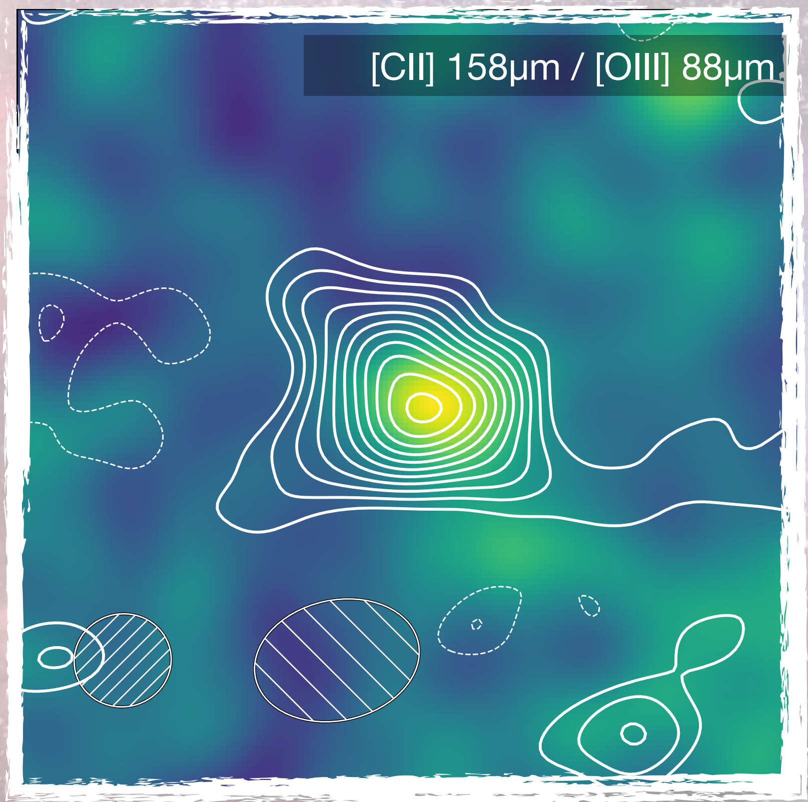
MACS0416_Y1

dust and carbon at z = 8.3

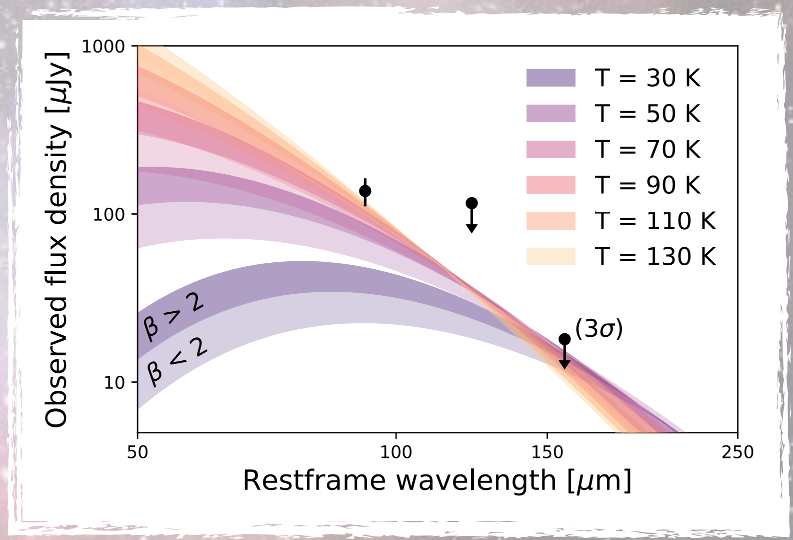
The source …



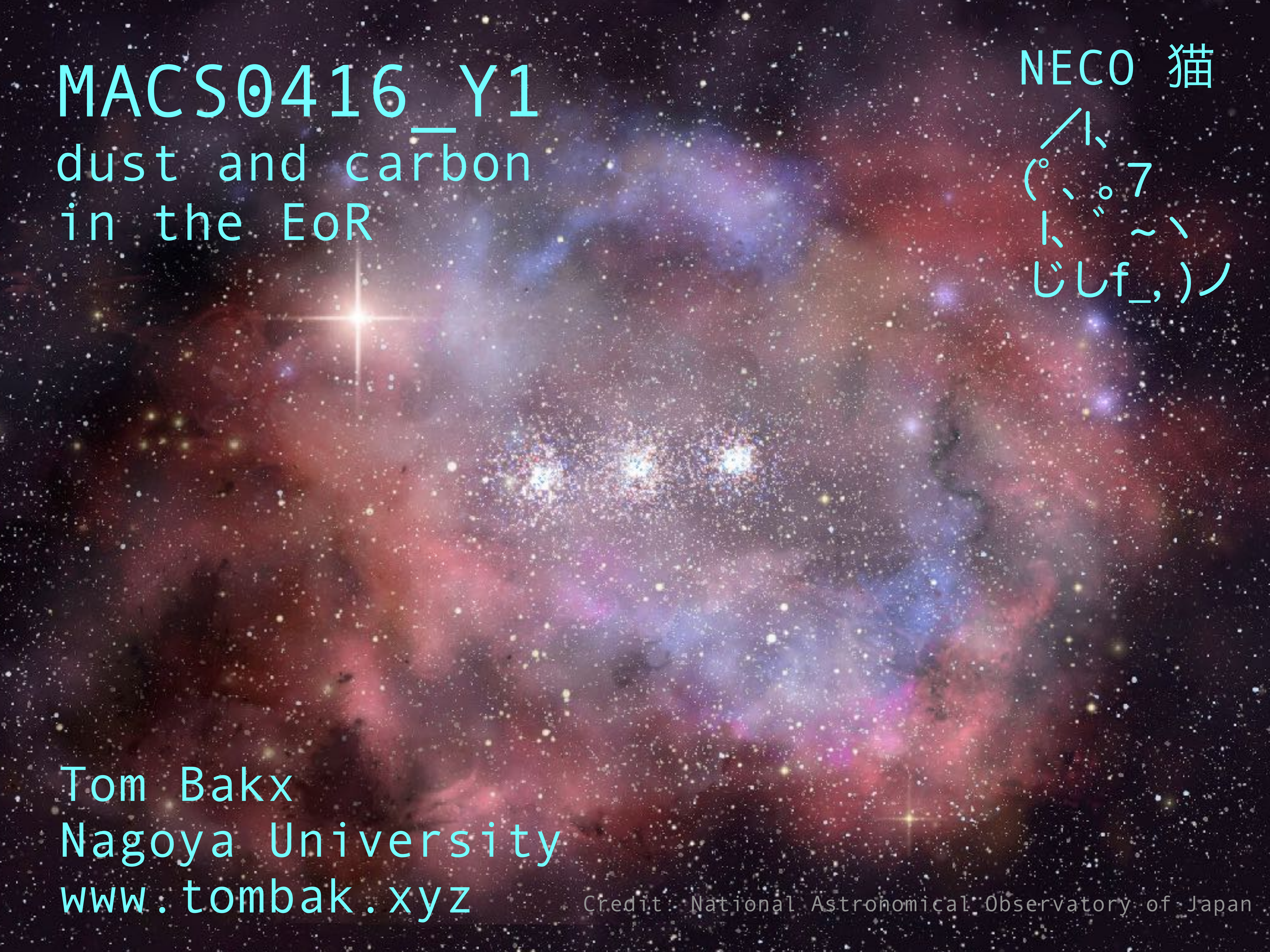
… the lines …



… and the spectrum!



Bakx+2020: 2001.02812



MACS0416_Y1

dust and carbon in the EoR

NECO 猫

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Tom Bakx
Nagoya University
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Credit: National Astronomical Observatory of Japan