The birth of the giants: gas & dust in QSO host galaxies at z~6

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MPIA, Heidelberg

Fabian Walter, Bram Venemans, Emanuele Paolo Farina, Eduardo Banados, Chiara Mazzucchelli, Xiaohui Fan, Frank Bertoldi, Chris Carilli, Dominik Riechers, Hans-Walter Rix, Michael Strauss, Ran Wang, Yujin Yang

Yet again… z>6 QSOs!

z>6
t < 1 Gyr

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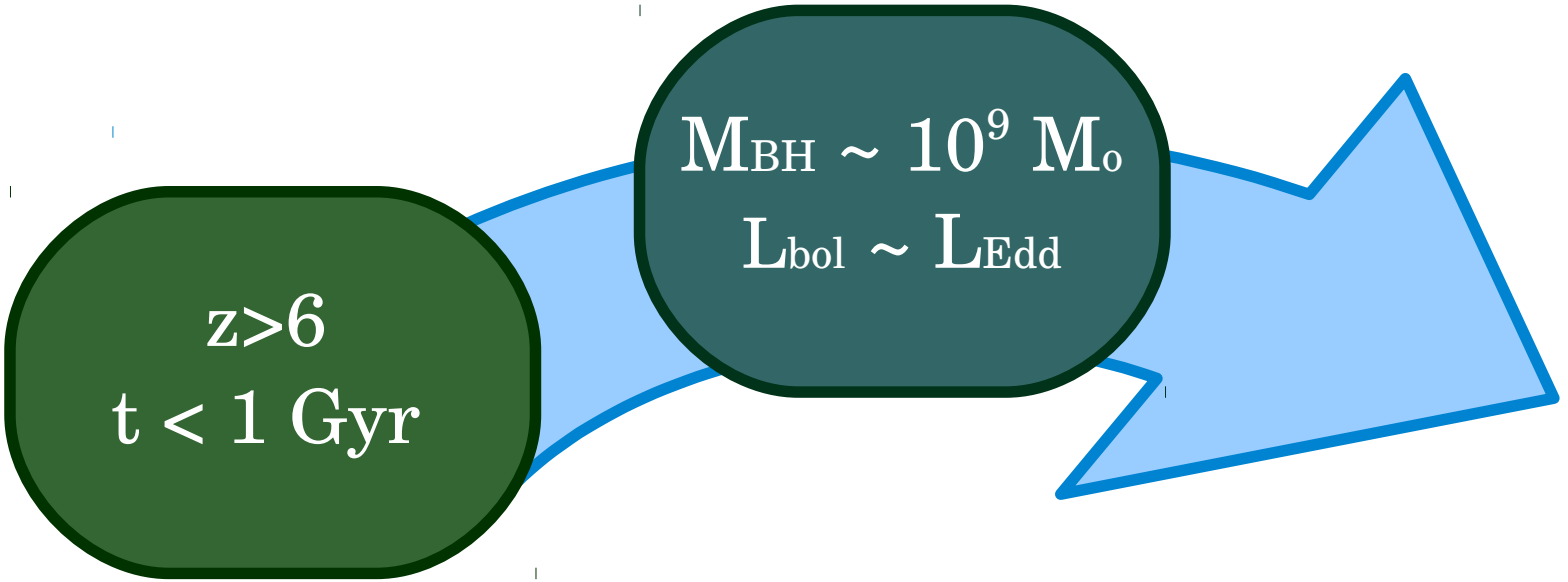

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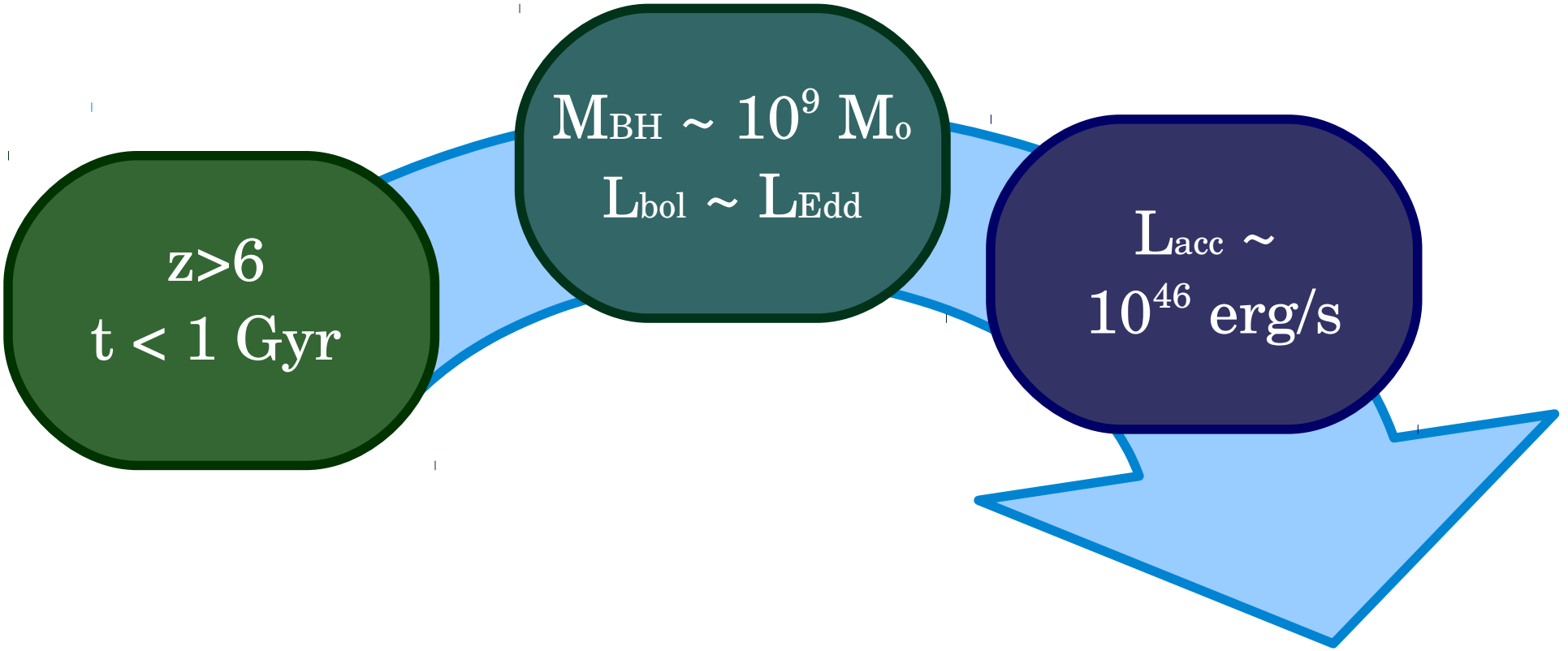

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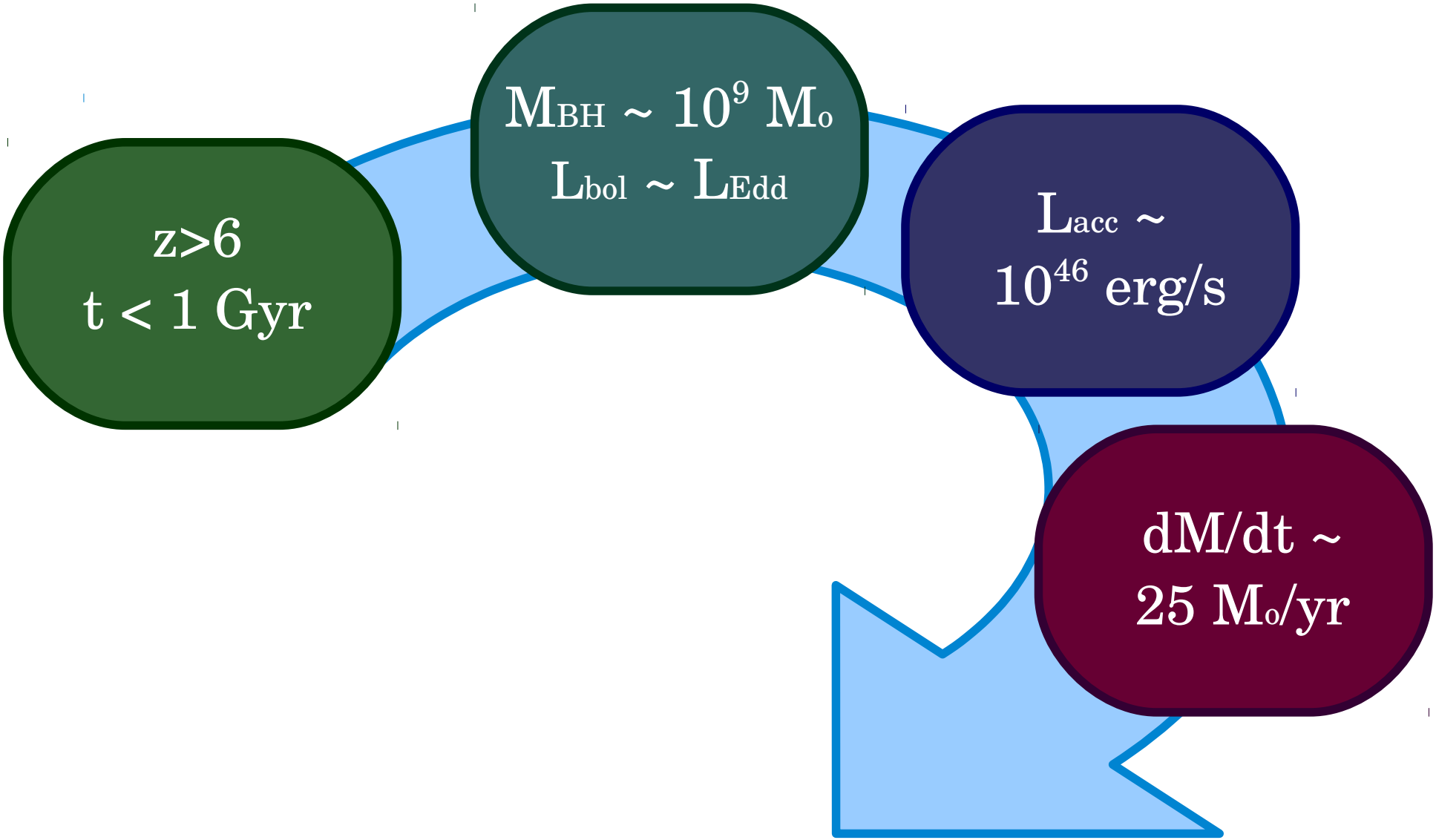

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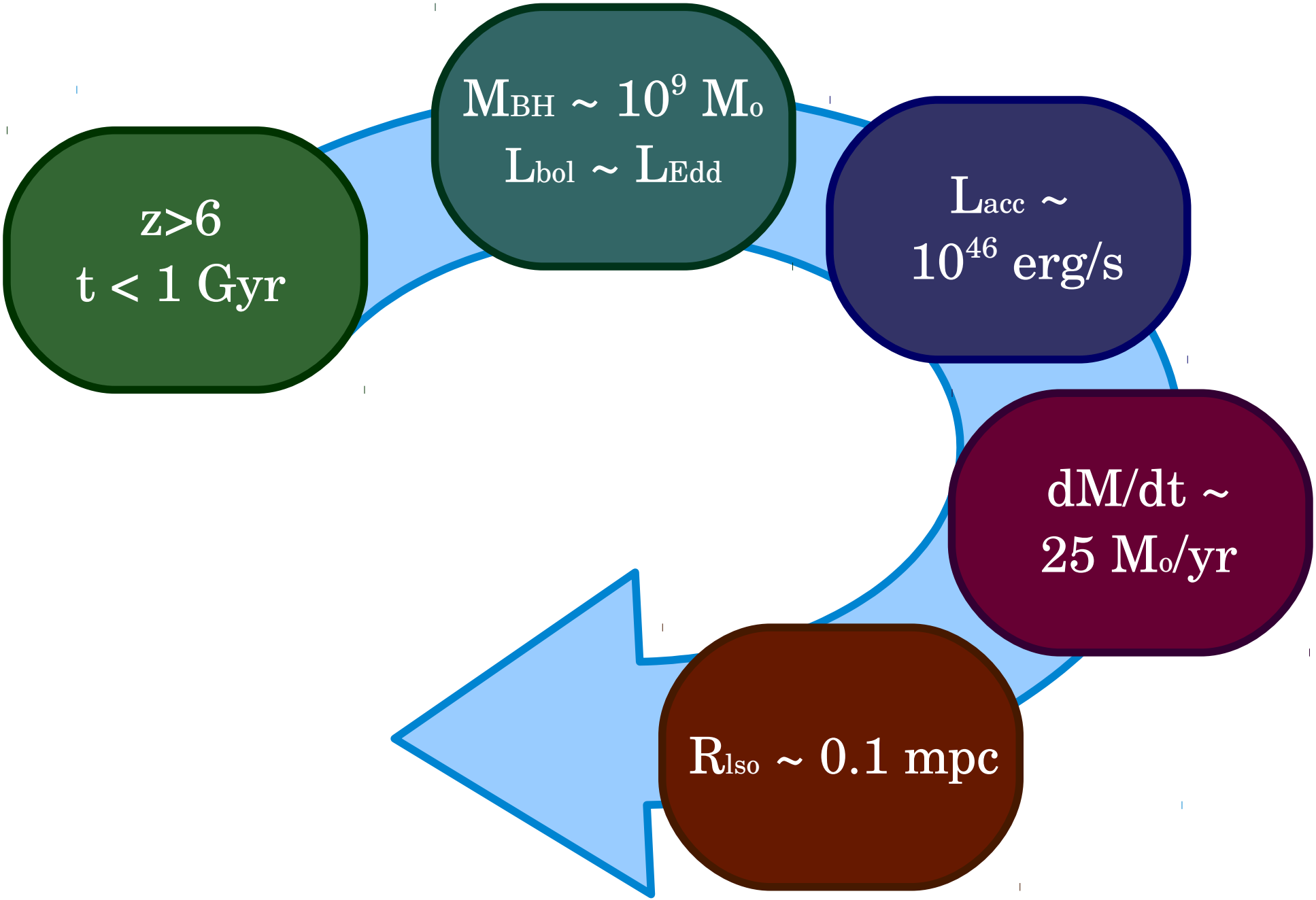

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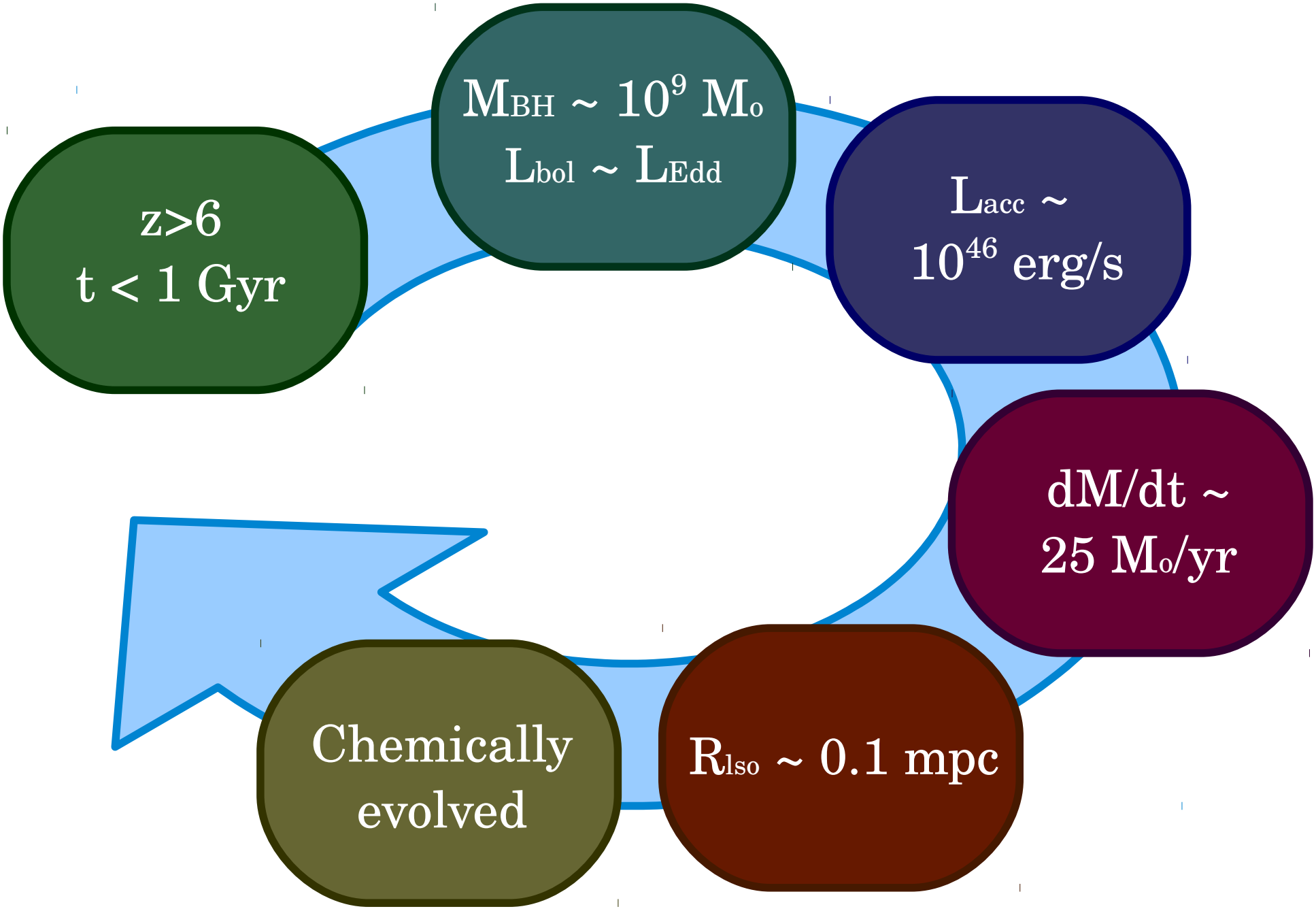
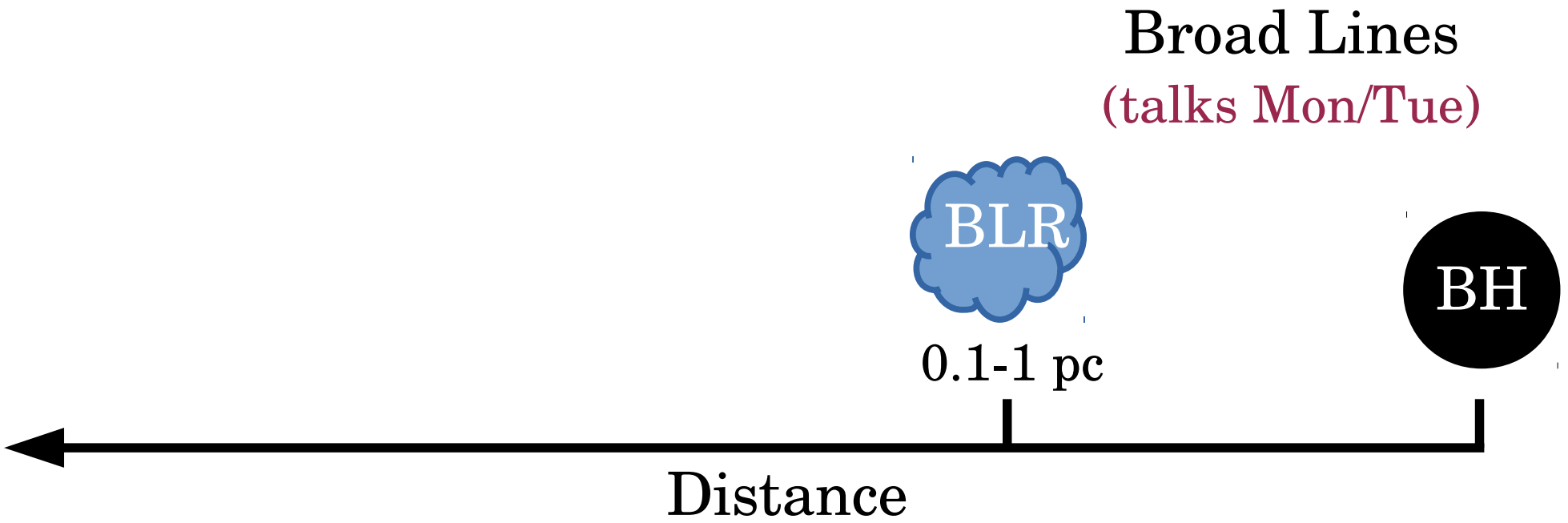


The gas cycle



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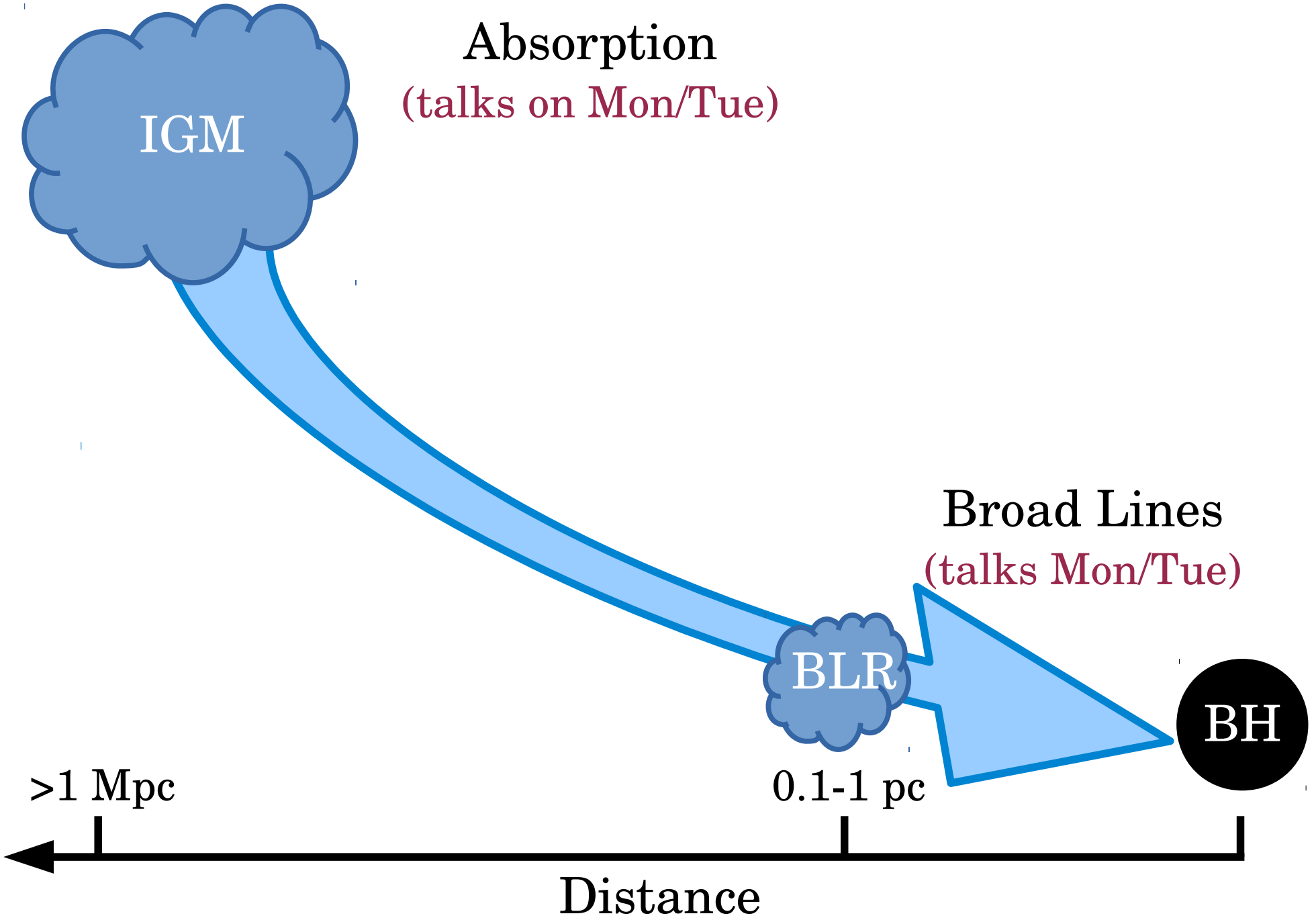

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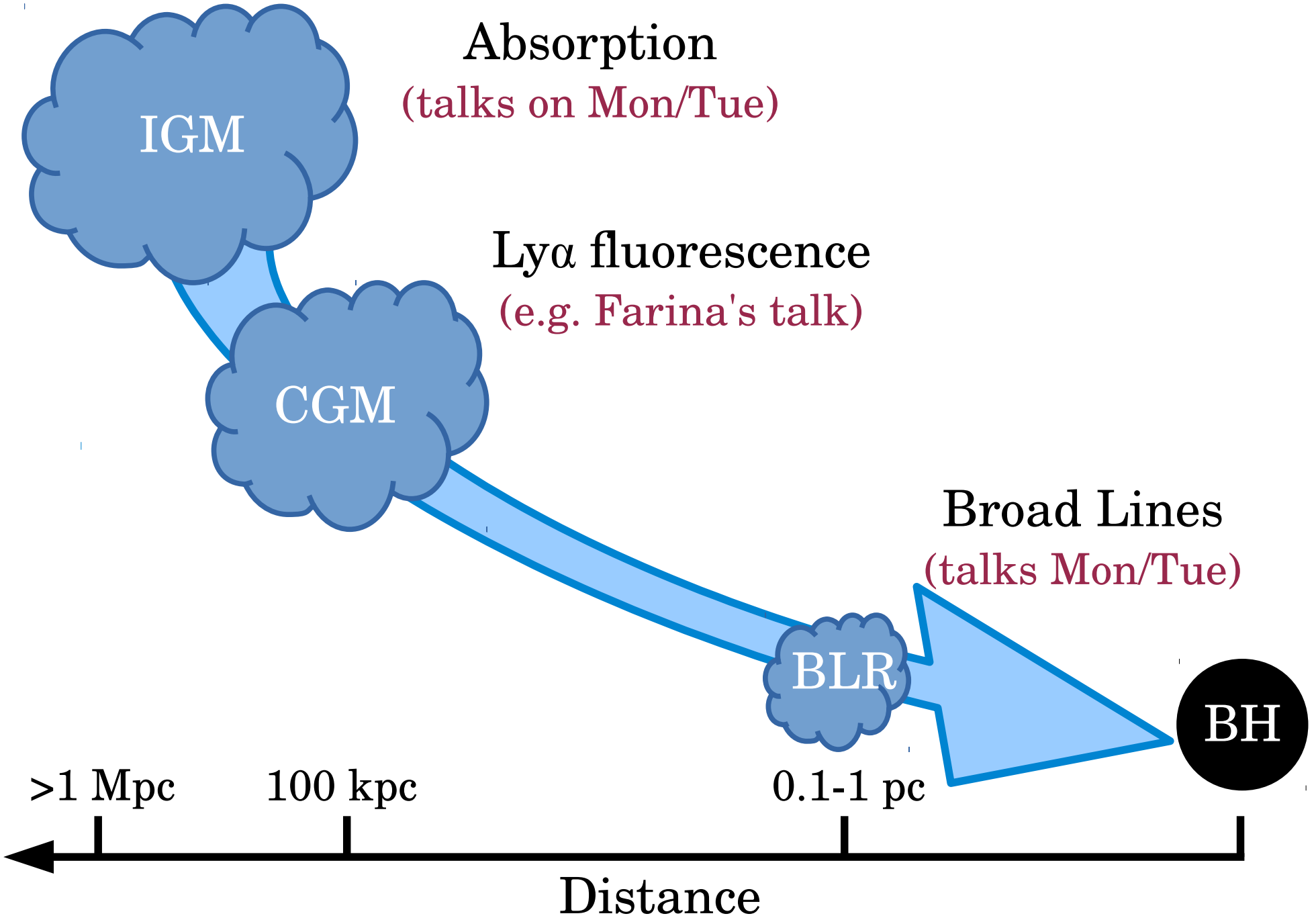

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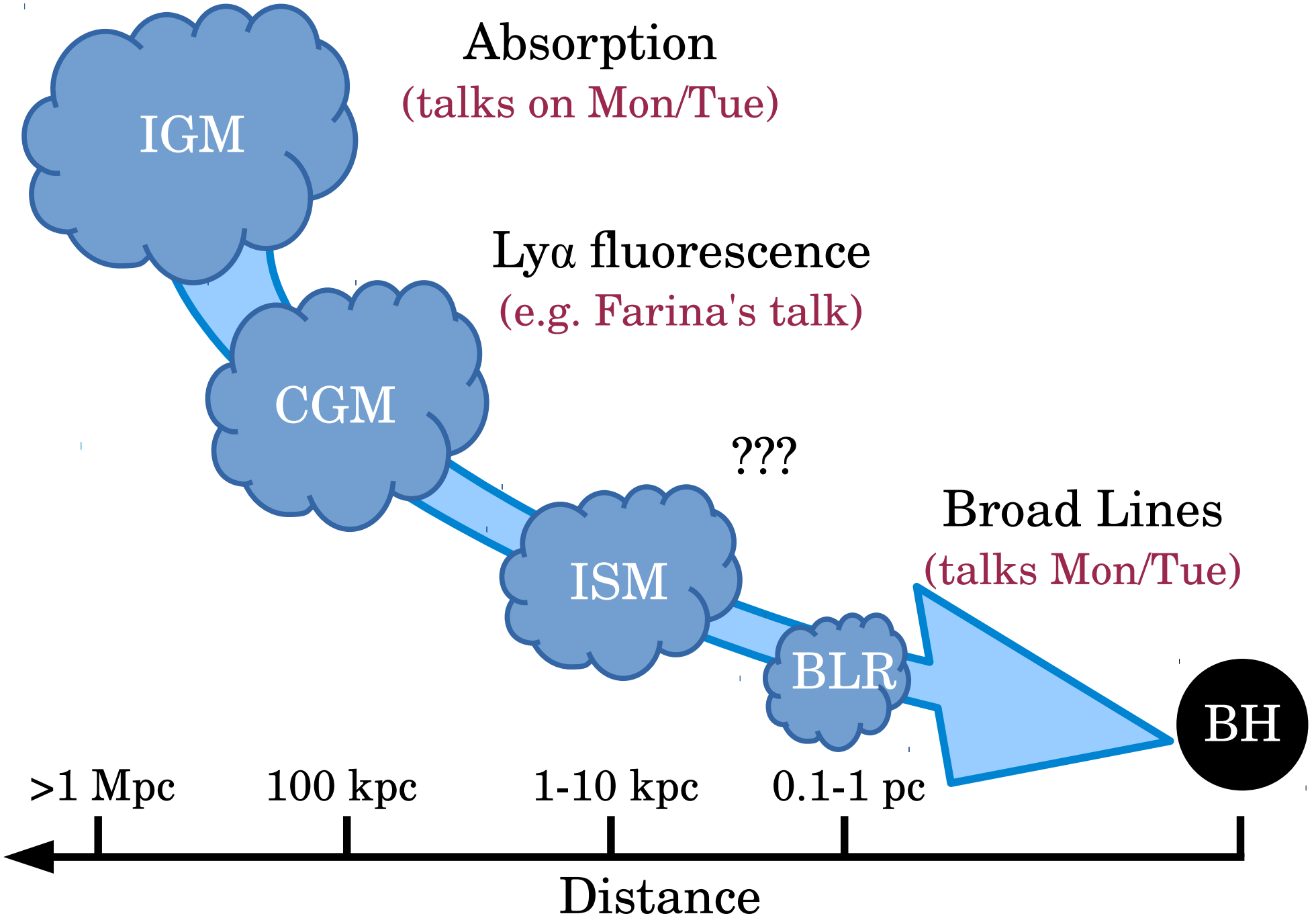
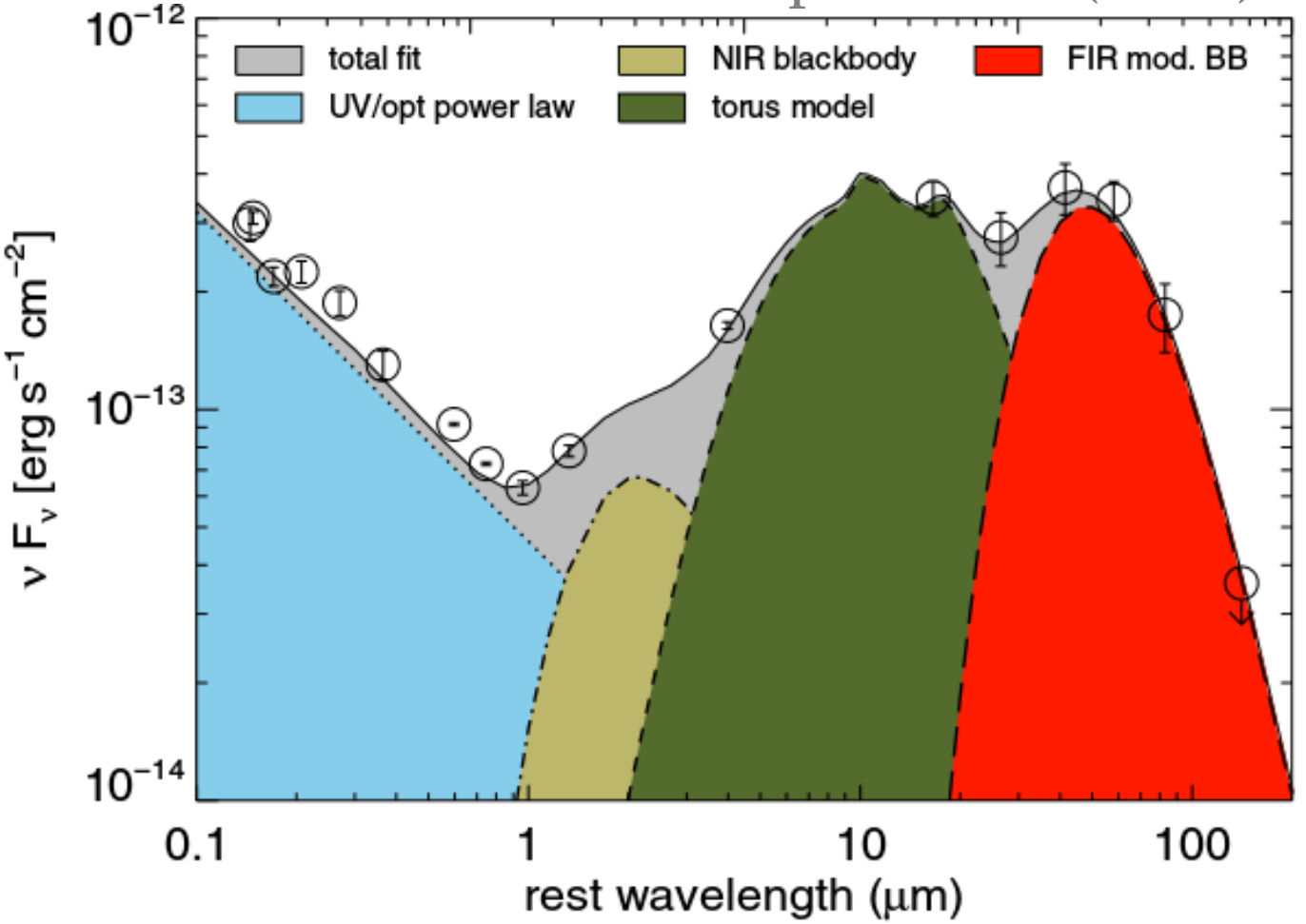


Exposing the build-up of the host galaxies

Leipski et al. (2014)



Exposing the build-up of the host galaxies

The nucleus outshines starlight from the host galaxies (>3 dex)

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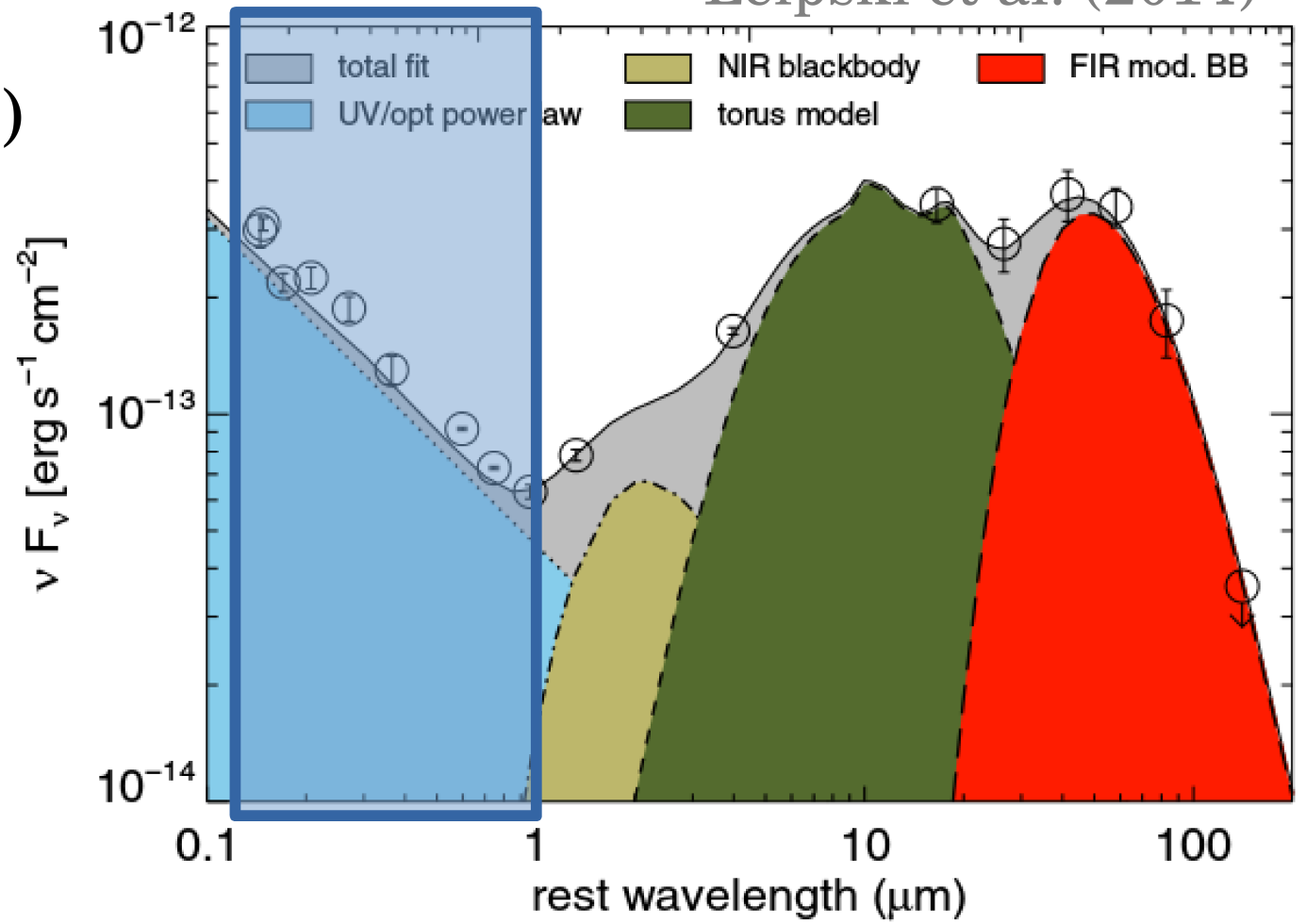

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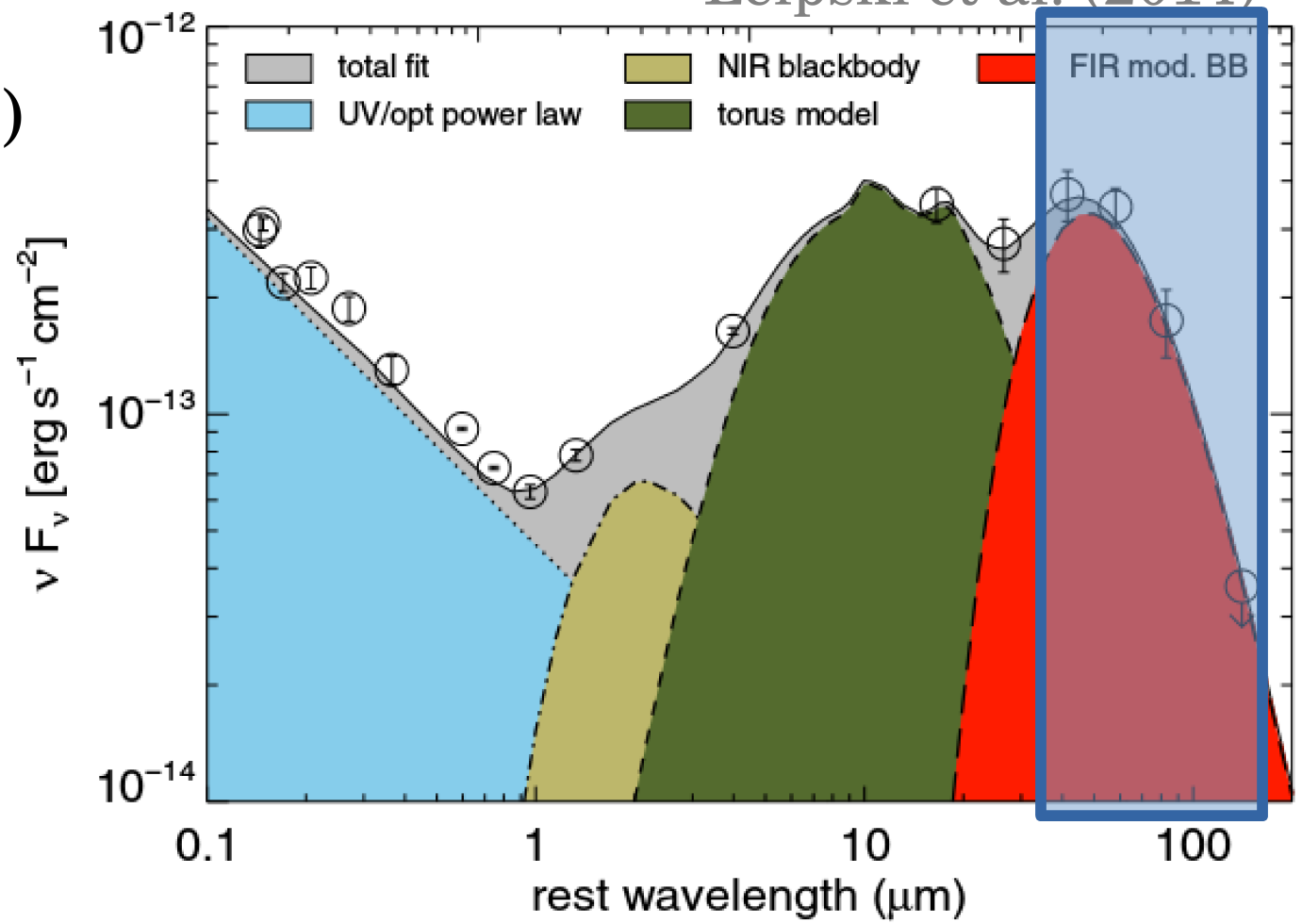
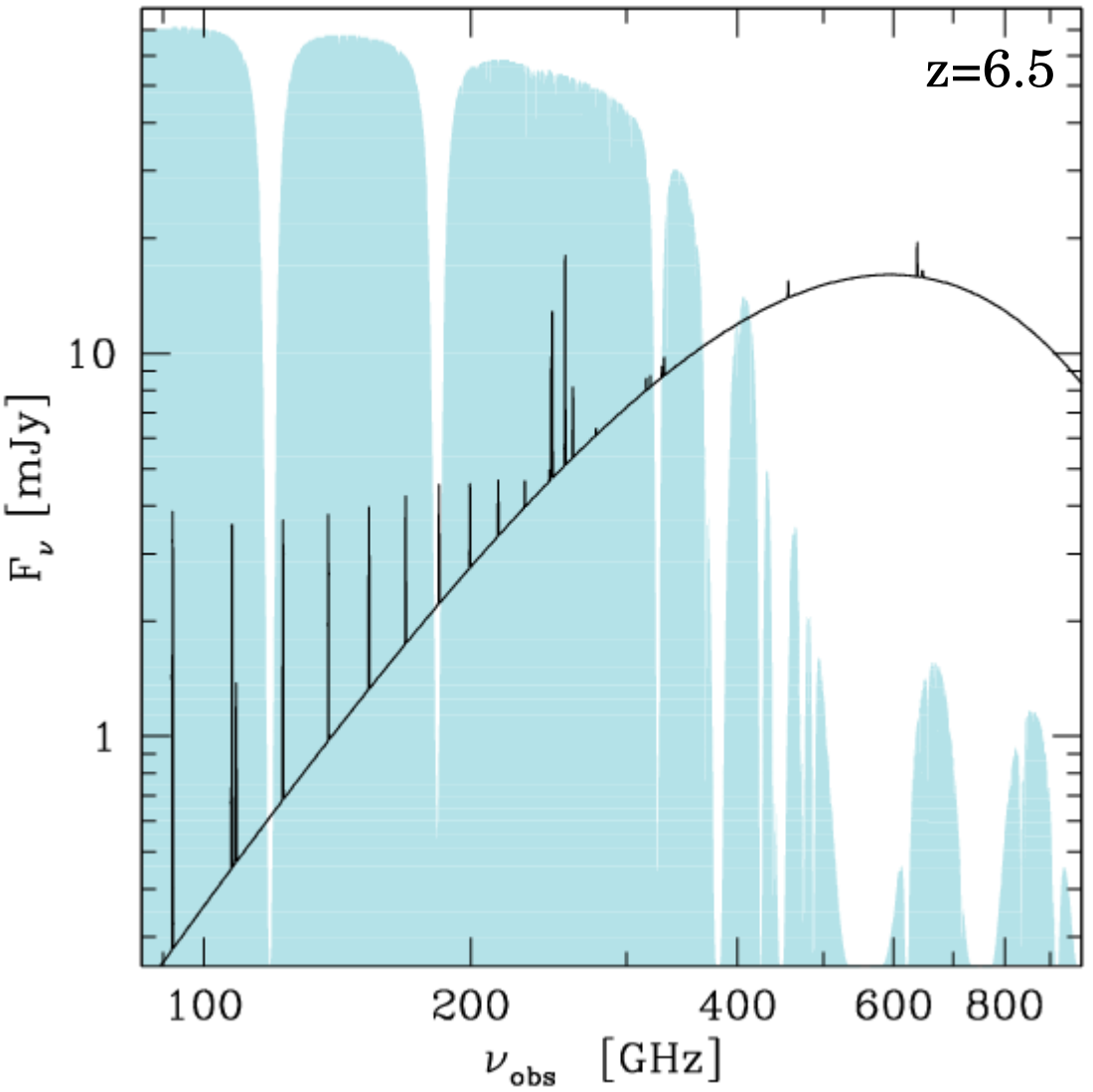


Exposing the build-up of the host galaxies

FIR (= obs [sub-]mm)
is the way to go



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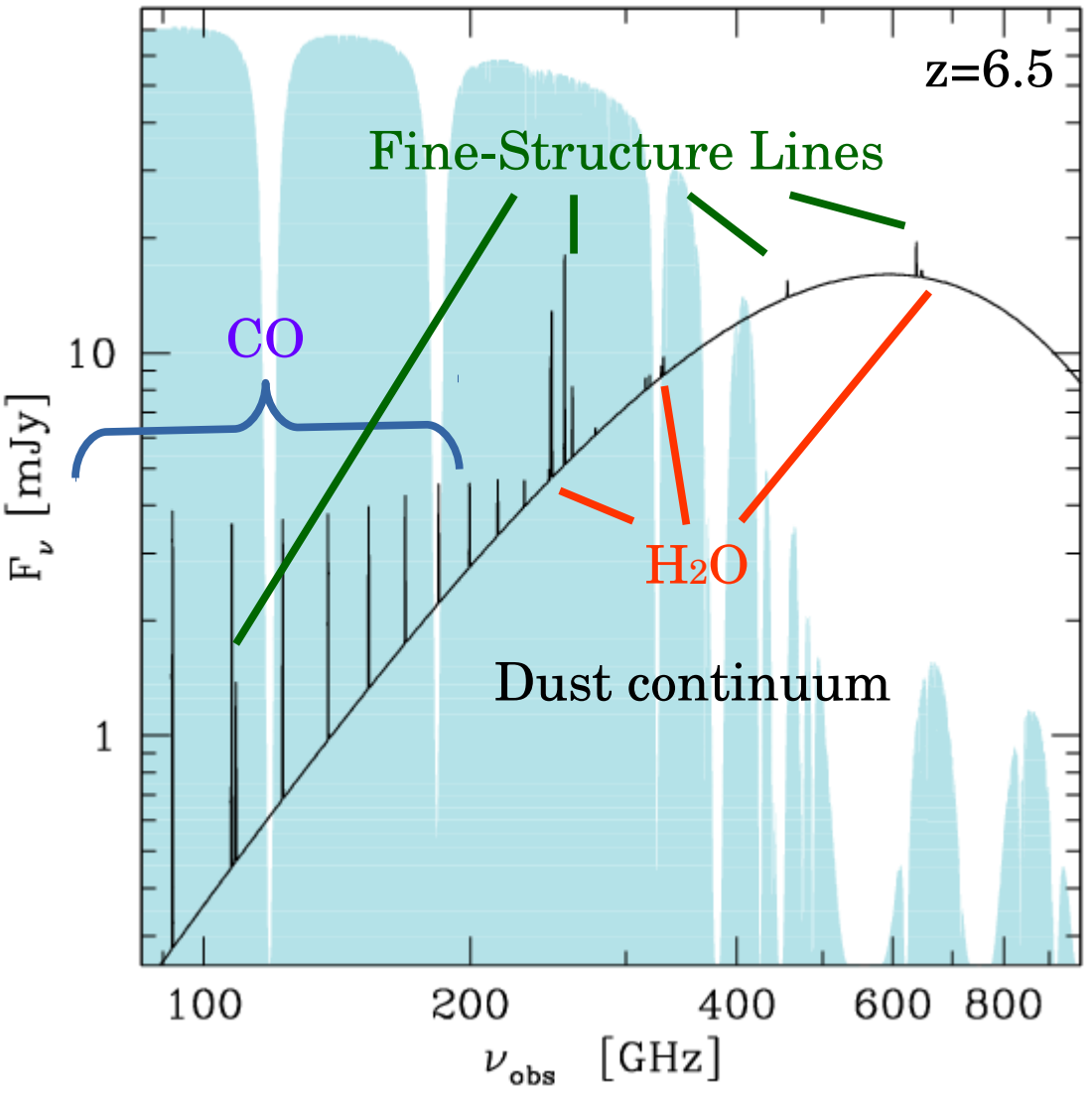
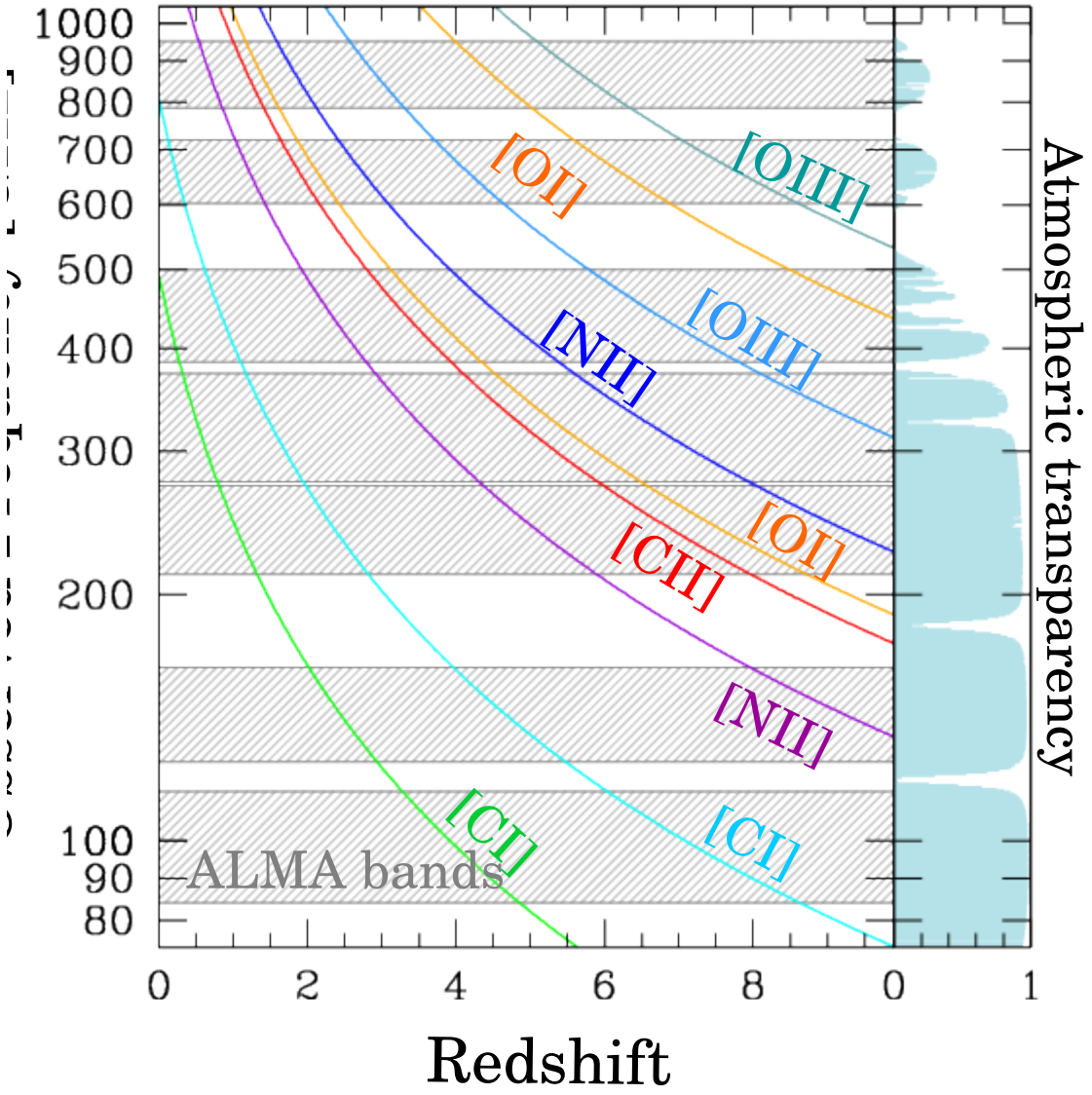


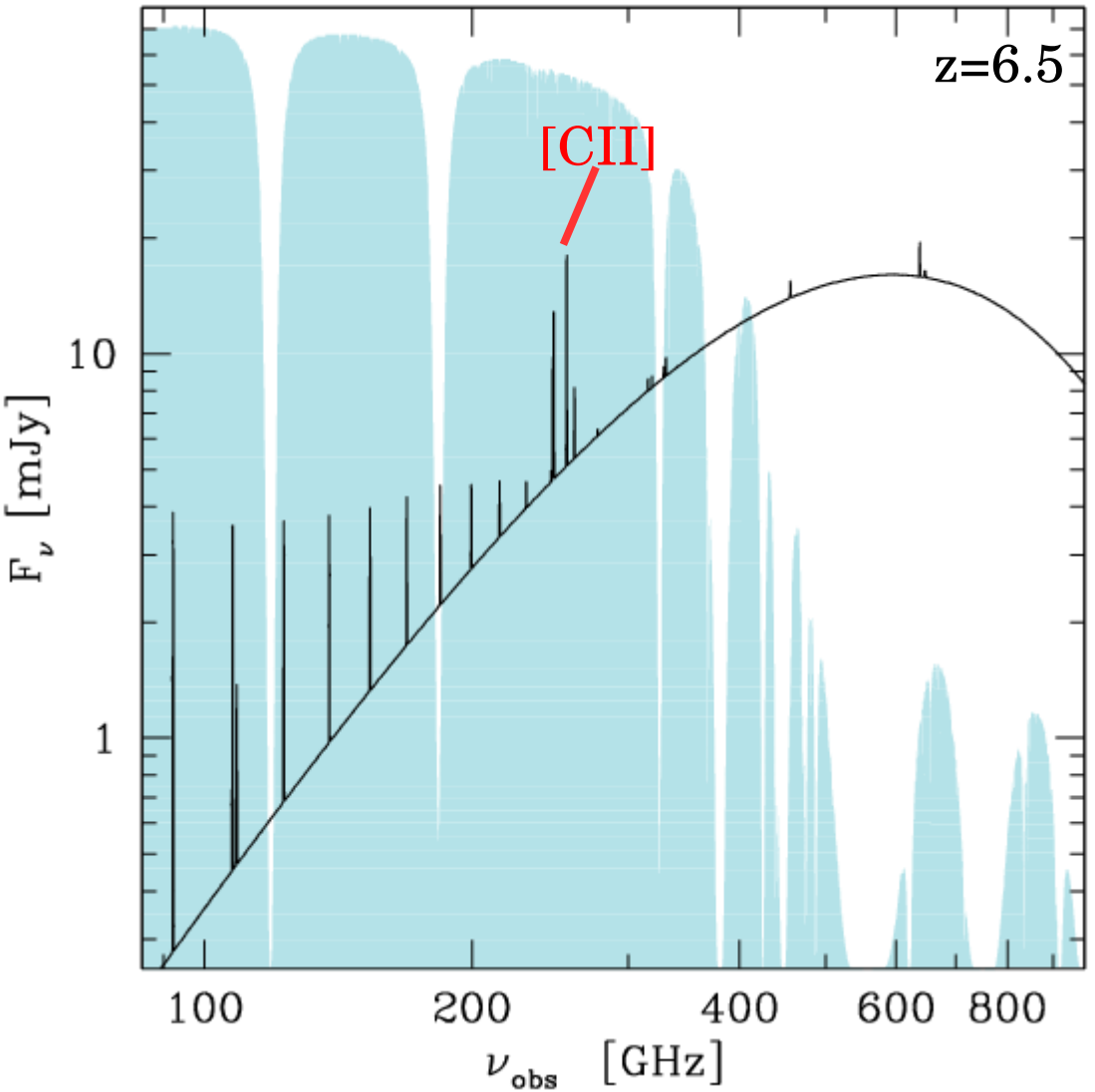
Exposing the build-up of the host galaxies

Fine-Structure Lines:
- main coolant
of the cold ISM
- accessible at
[sub-]mm
wavelengths



Exposing the build-up of the host galaxies

[CII] 158 μm:
carries ~0.3% of the
ENTIRE luminosity
of the galaxy



Exposing the build-up of the host galaxies

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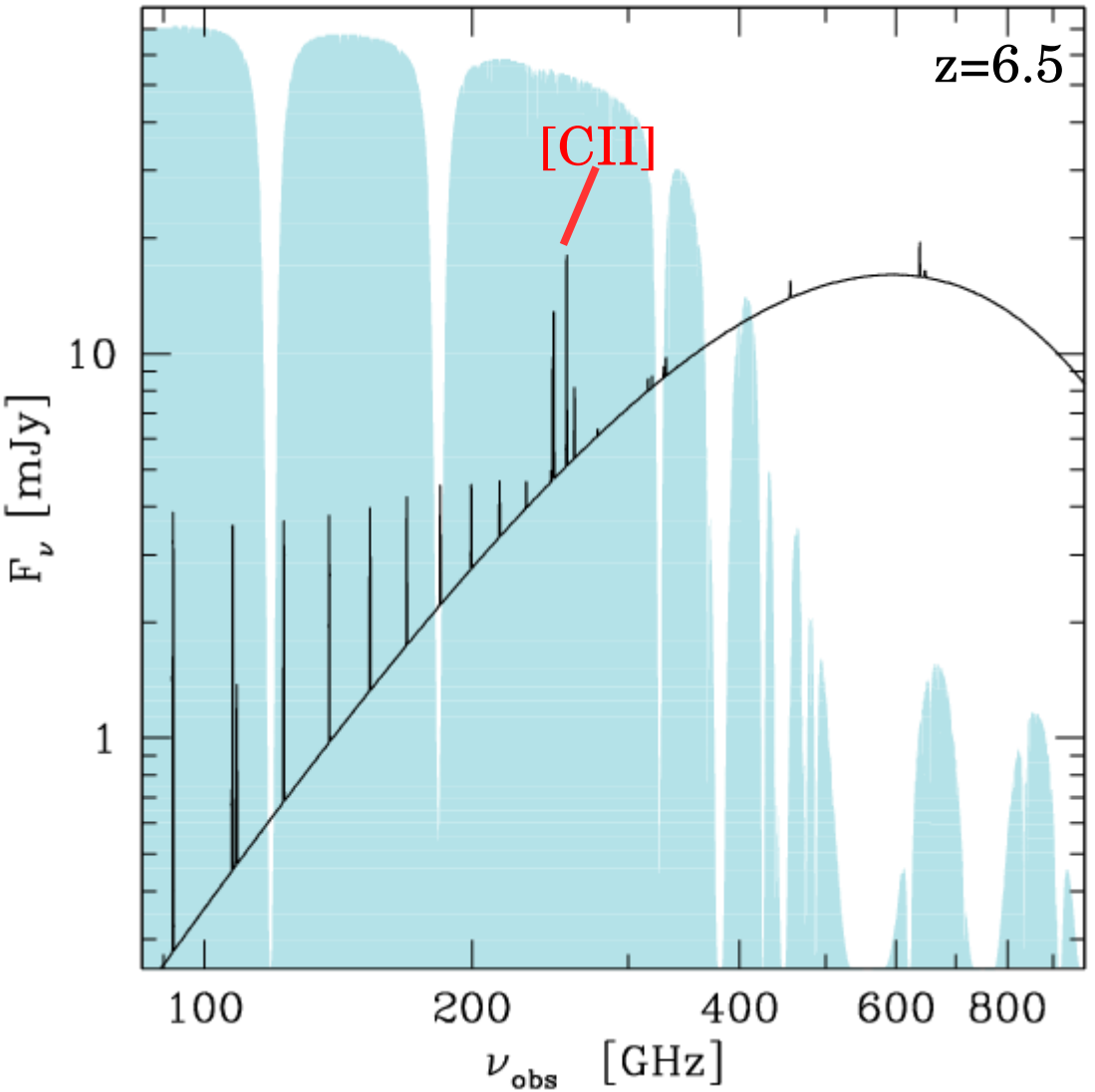
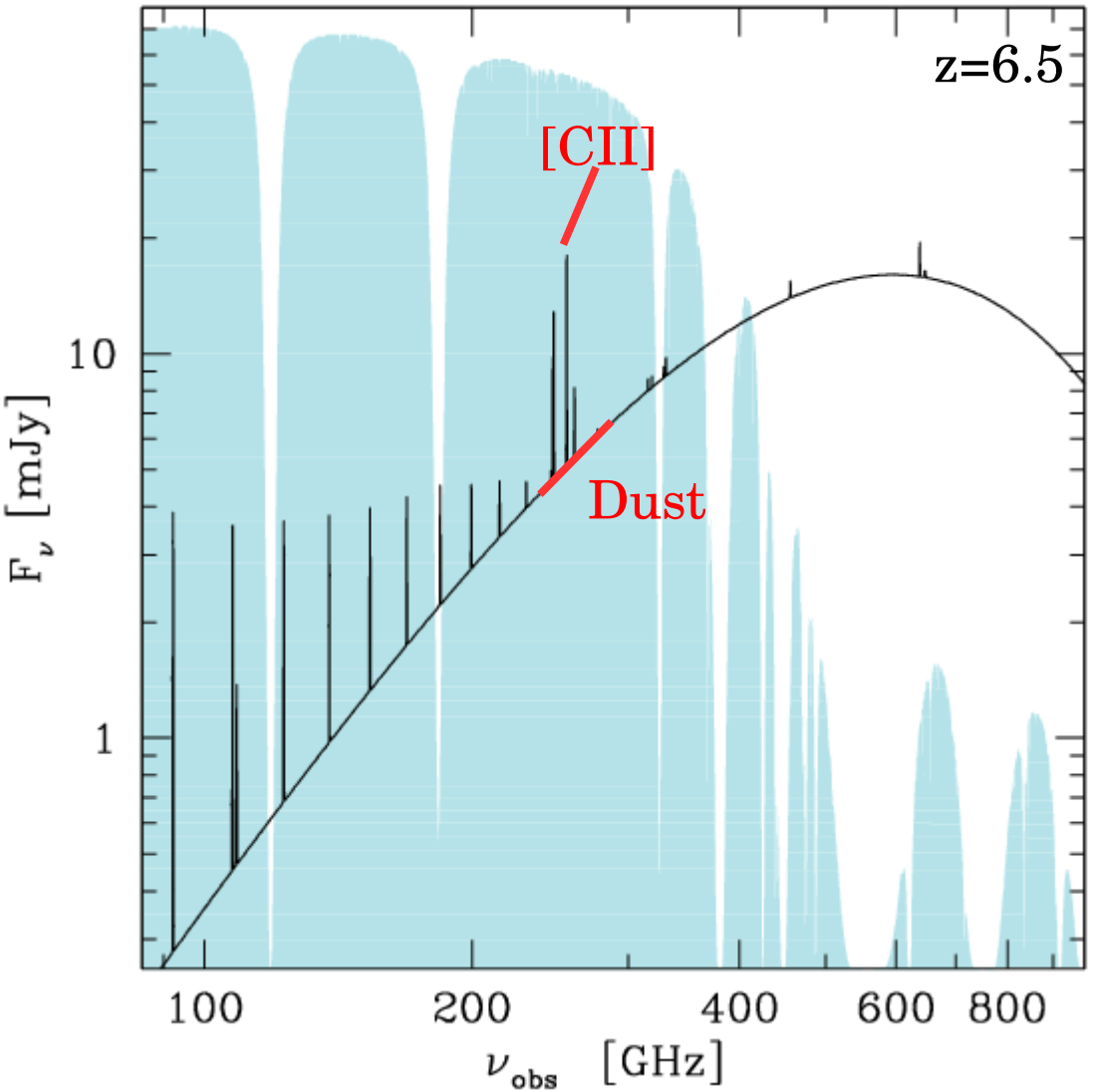
Ideal for redshift /
dynamical
measurements at
high-z



Exposing the build-up of the host galaxies

[CII] obs give dust RJ continuum for free!



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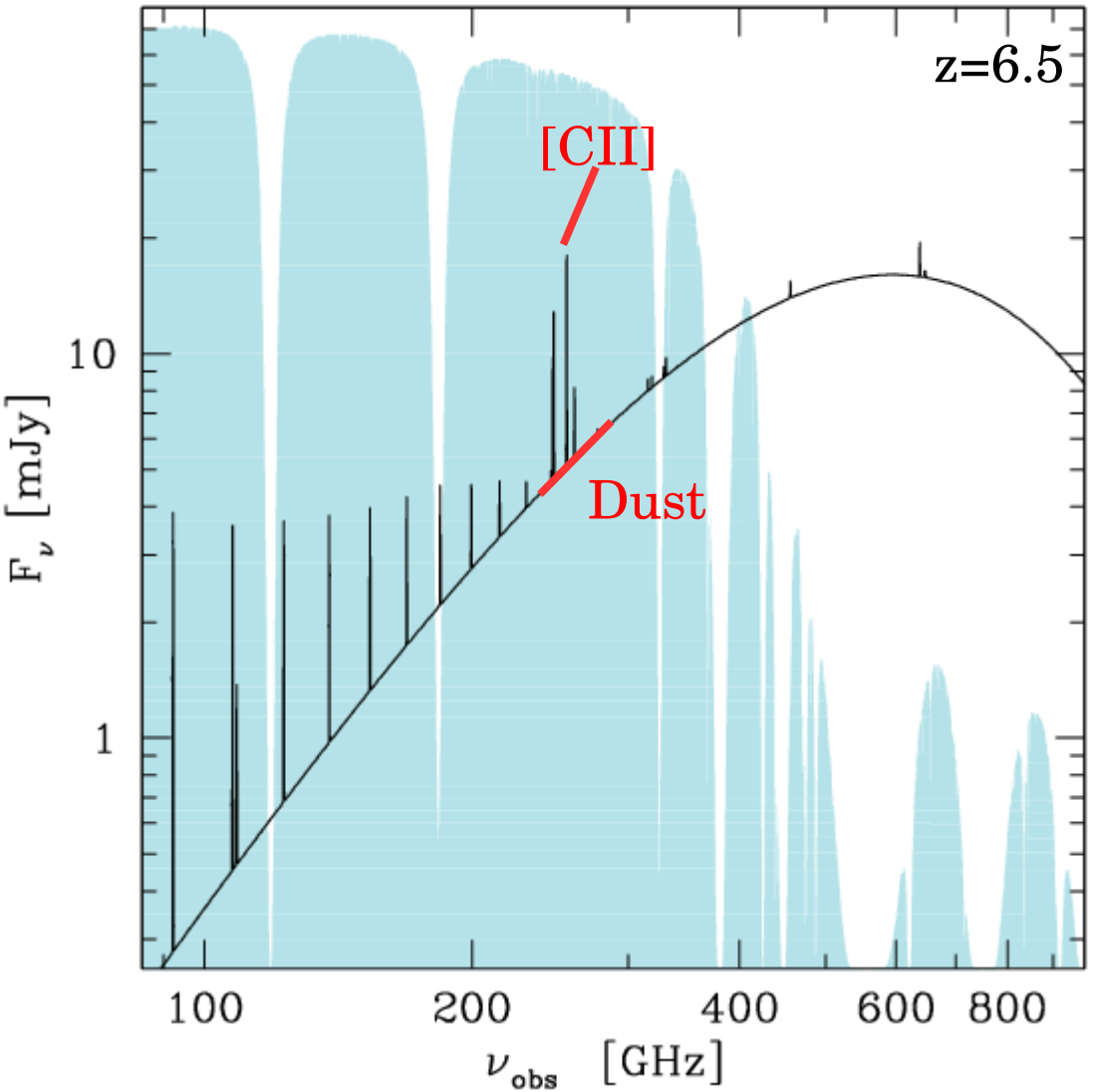
RJ ~ M_{dust}



Exposing the build-up of the host galaxies

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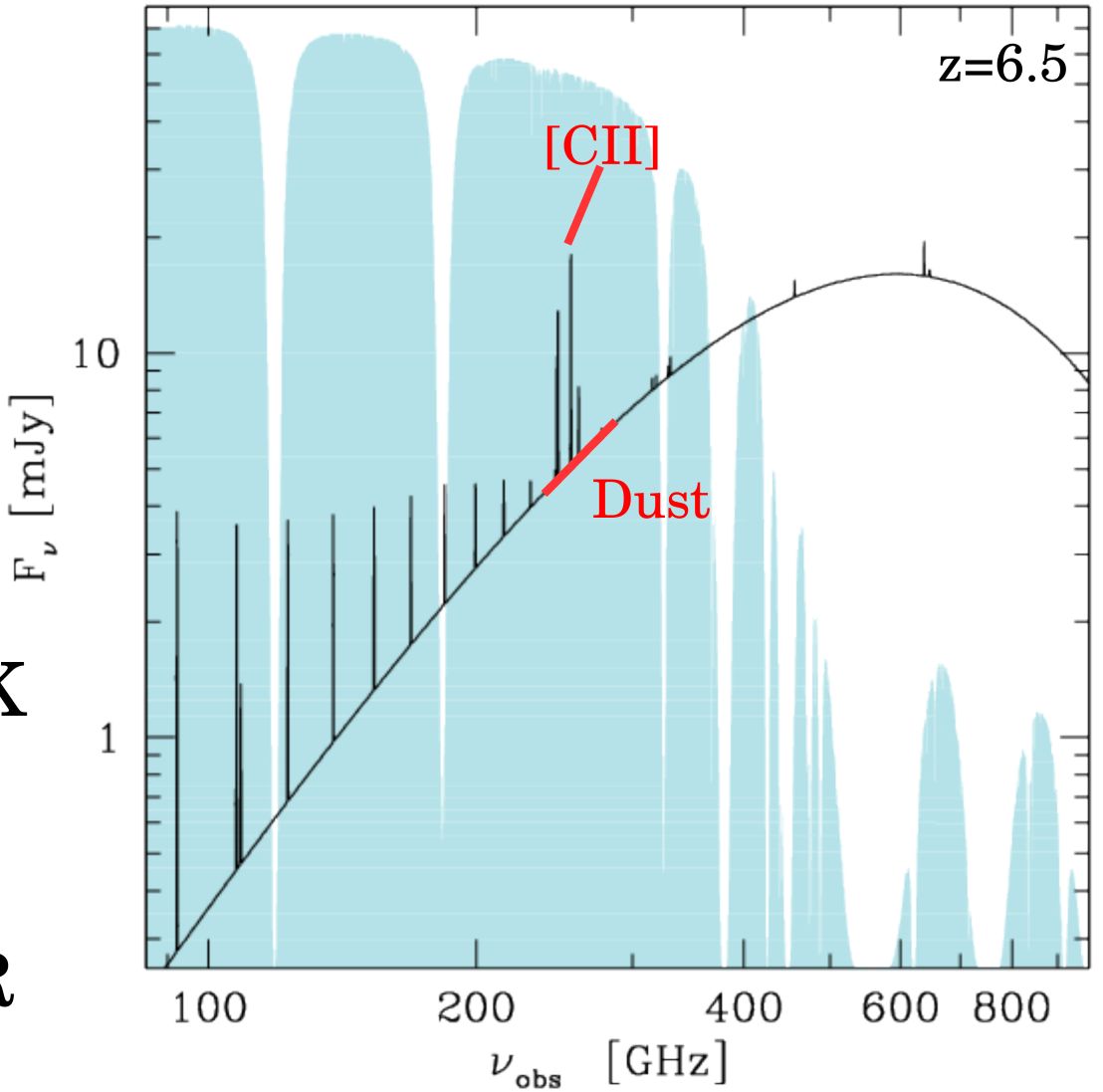
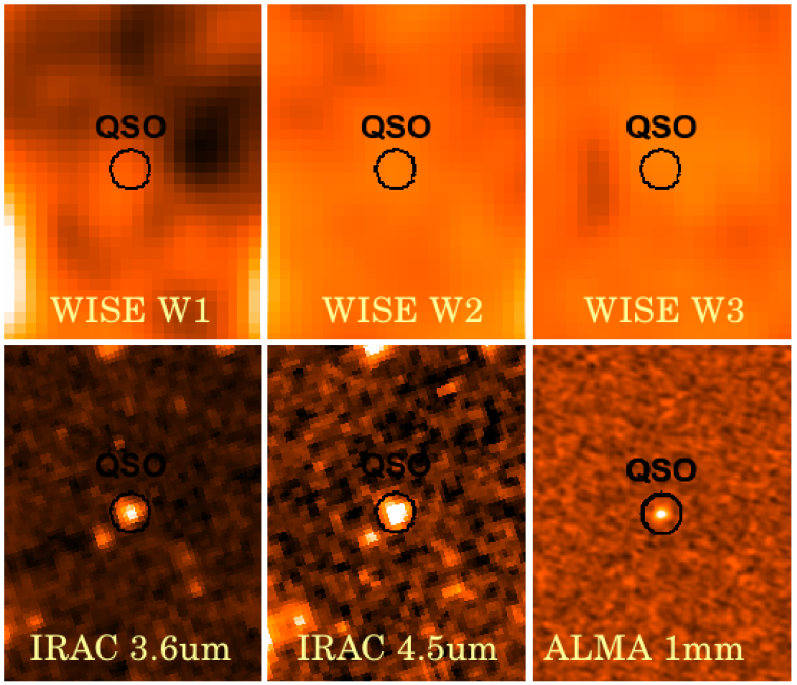
If we assume T_{dust}~47 K (Beelen+06, Leipski+14):

F_ν(dust) => L_{IR} => SFR

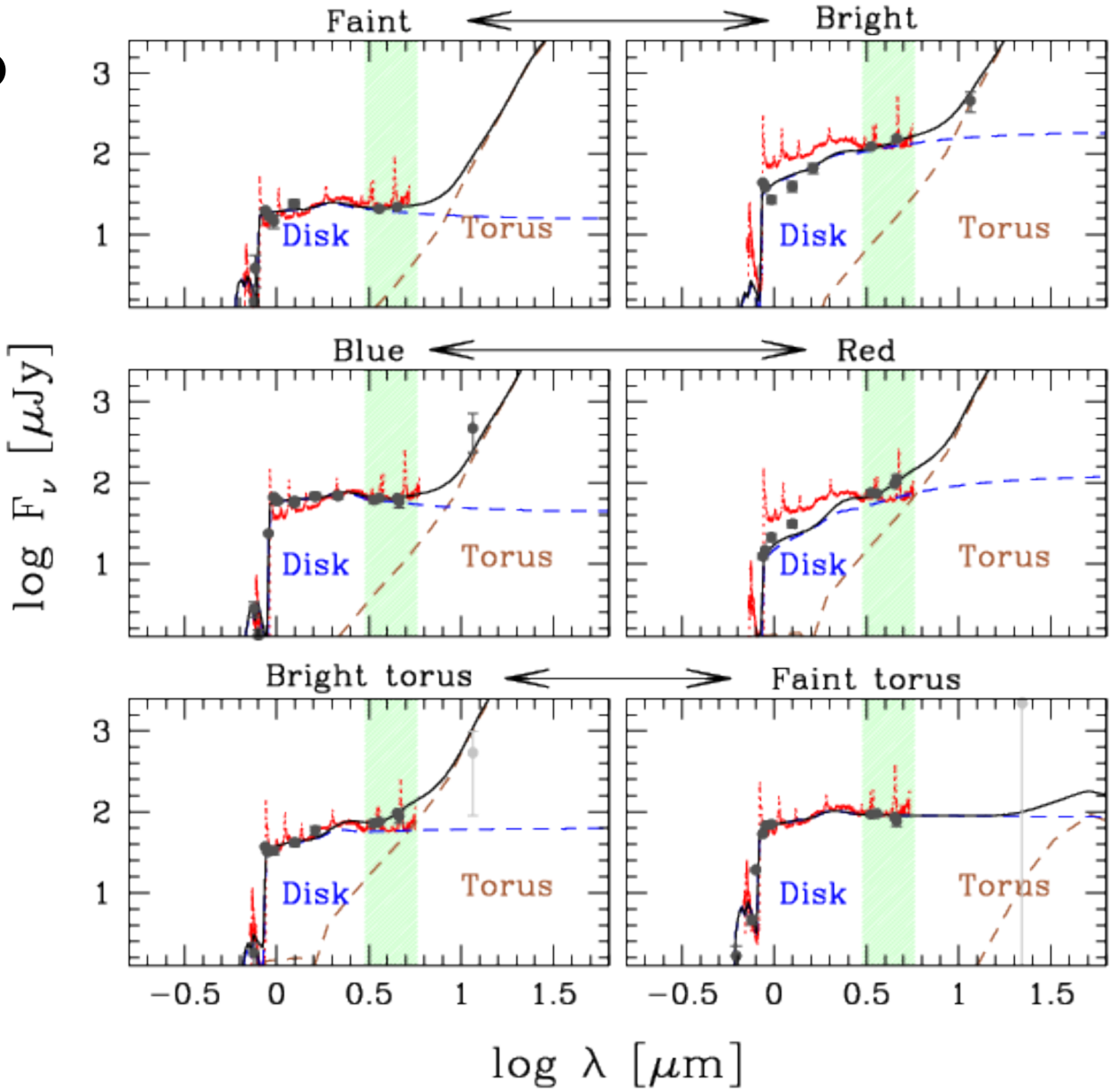


Exposing the build-up of the host galaxies

Dust constraints also from Opt/NIR/MIR SED fits

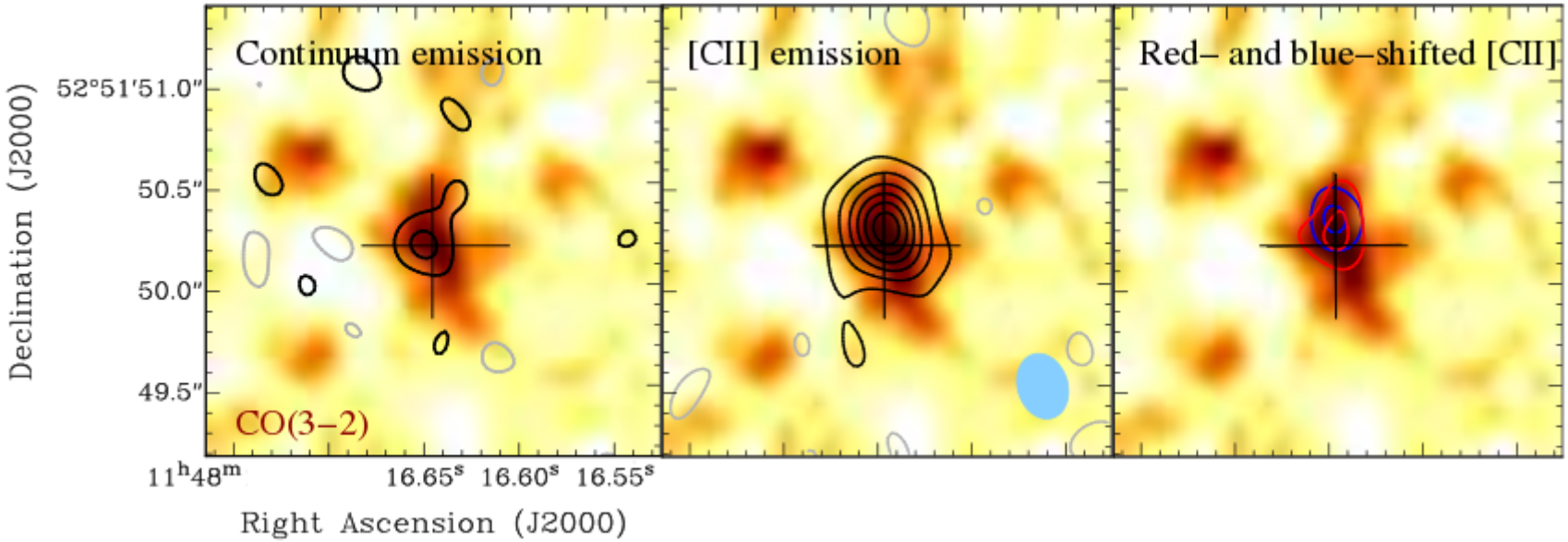


Decarli et al. (in prep)



[CII] in high-z QSOs

Walter et al. (2009)



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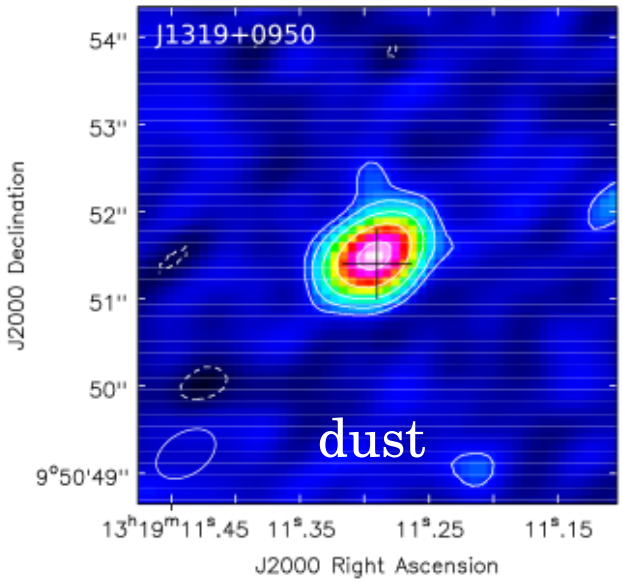
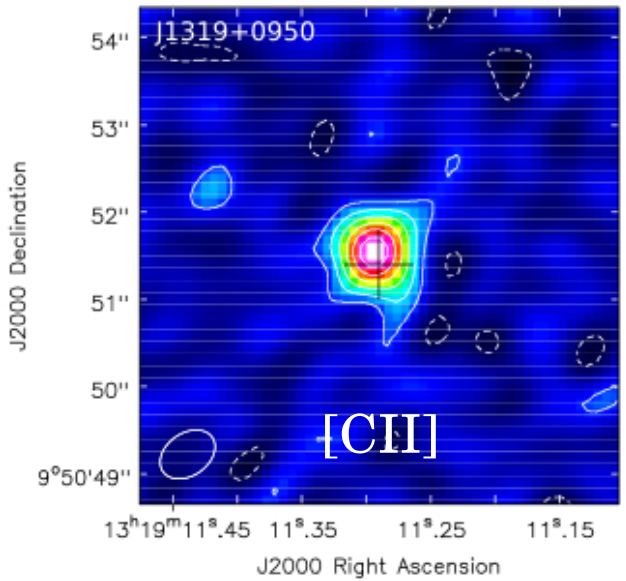
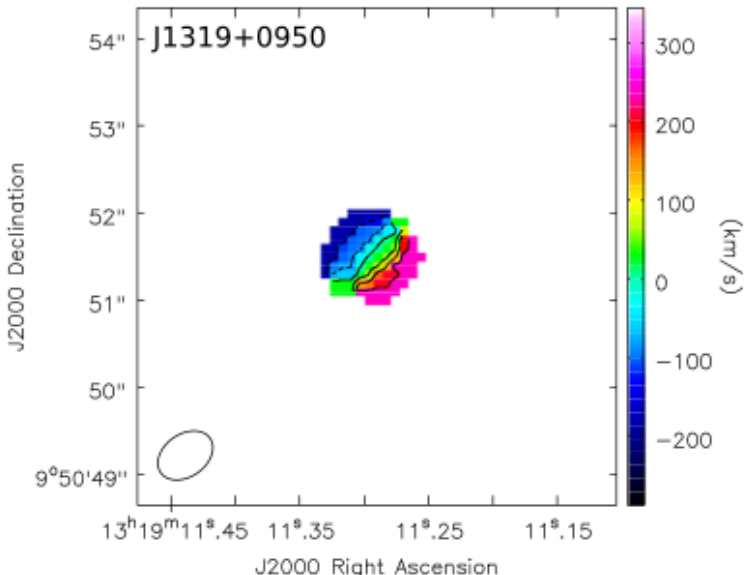
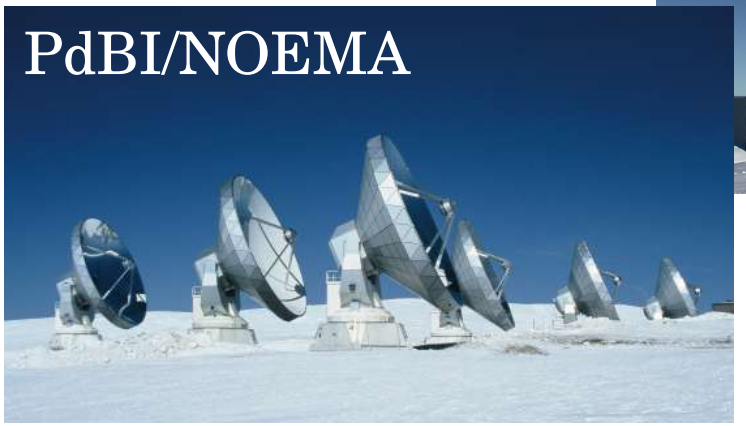






[CII] in high-z QSOs

Maiolino+05, Walter+09 (1)
Venemans+12 (1)
Willott+13 (2)
Banados+15 (1)
Decarli+ in prep (2)



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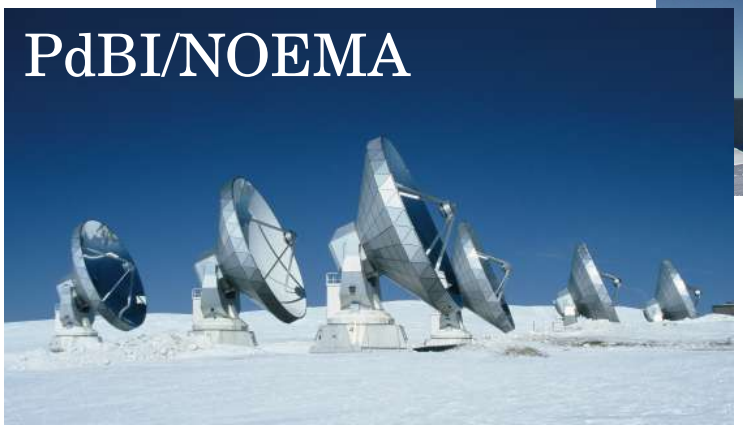

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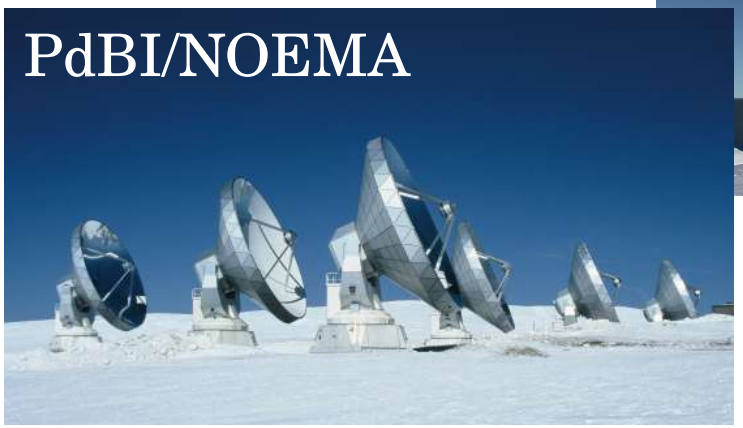

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[CII] survey in z>6 QSOs (35)

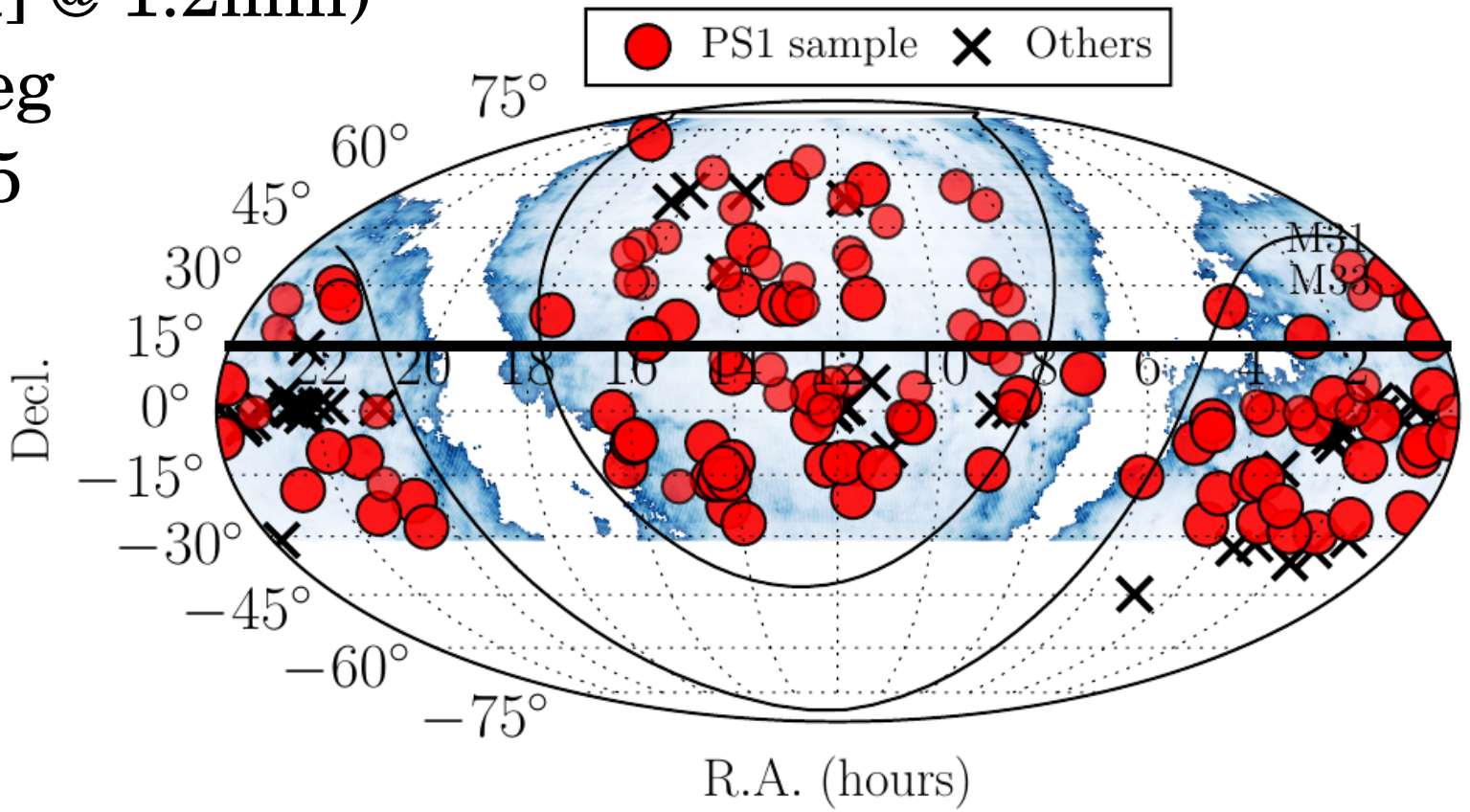
Survey design

z>5.94 ([CII] @ 1.2mm)

Dec < +15 deg

M_{1450} < -25.25

PI: Walter



Banados et al. (subm)

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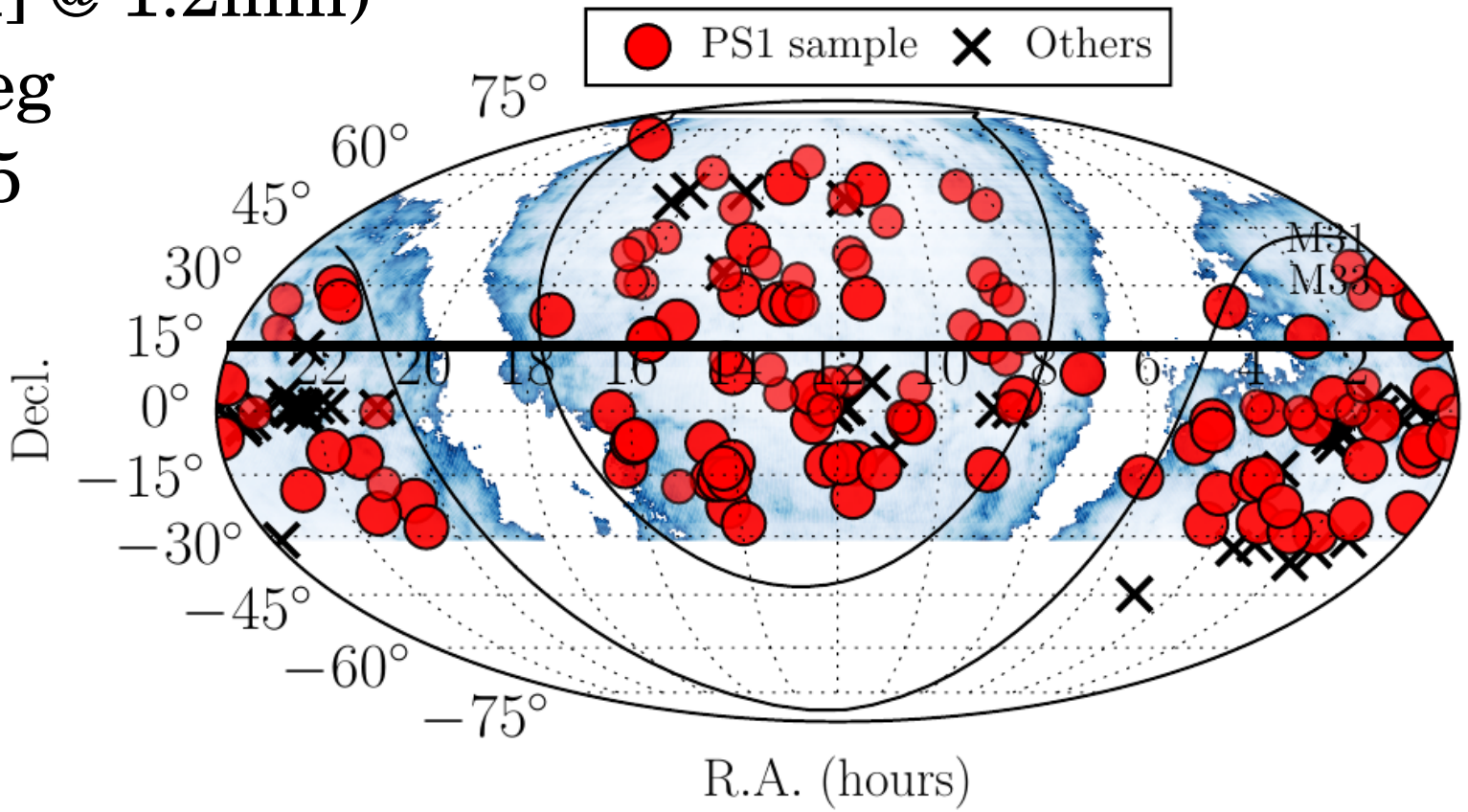

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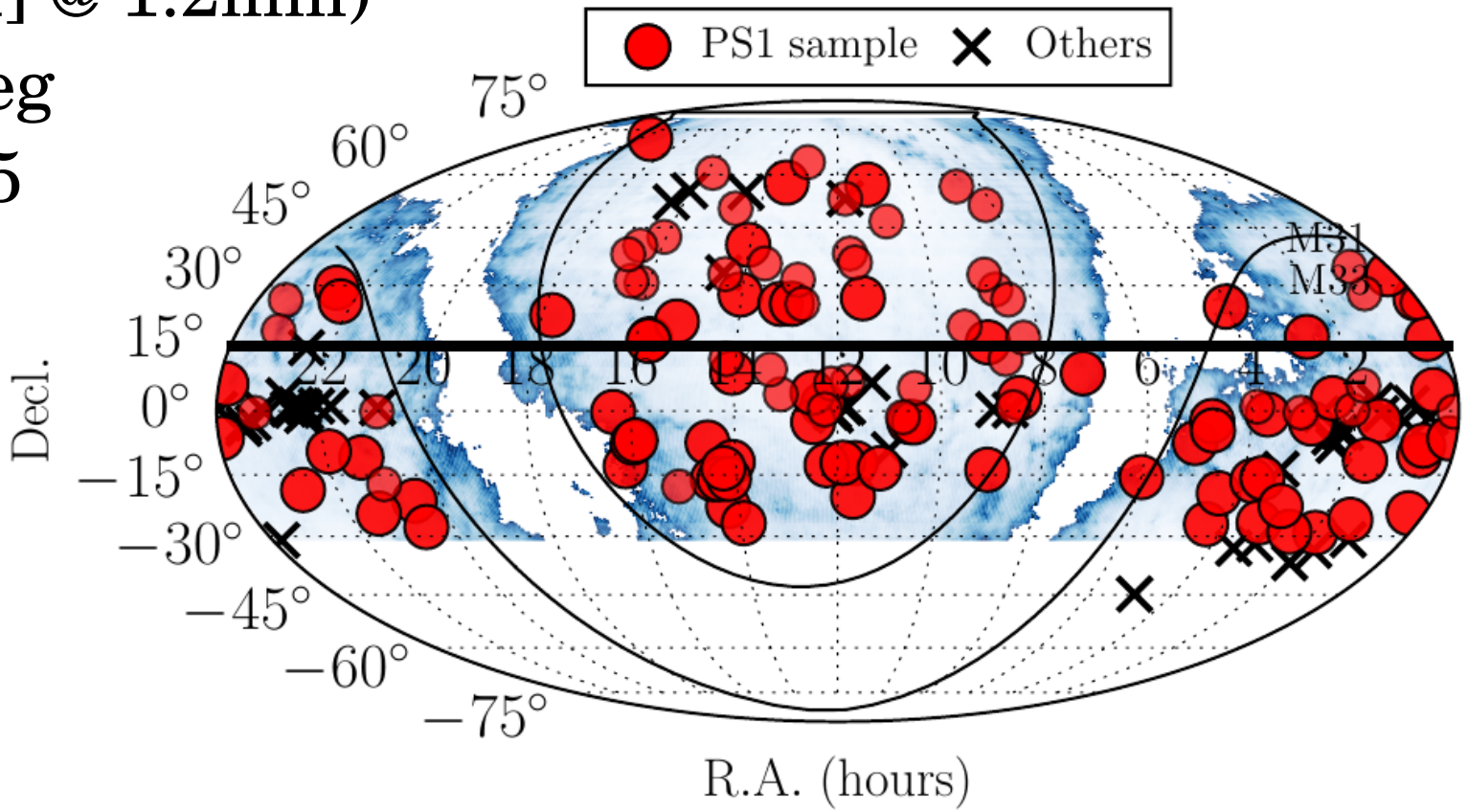


Banados et al. (subm)

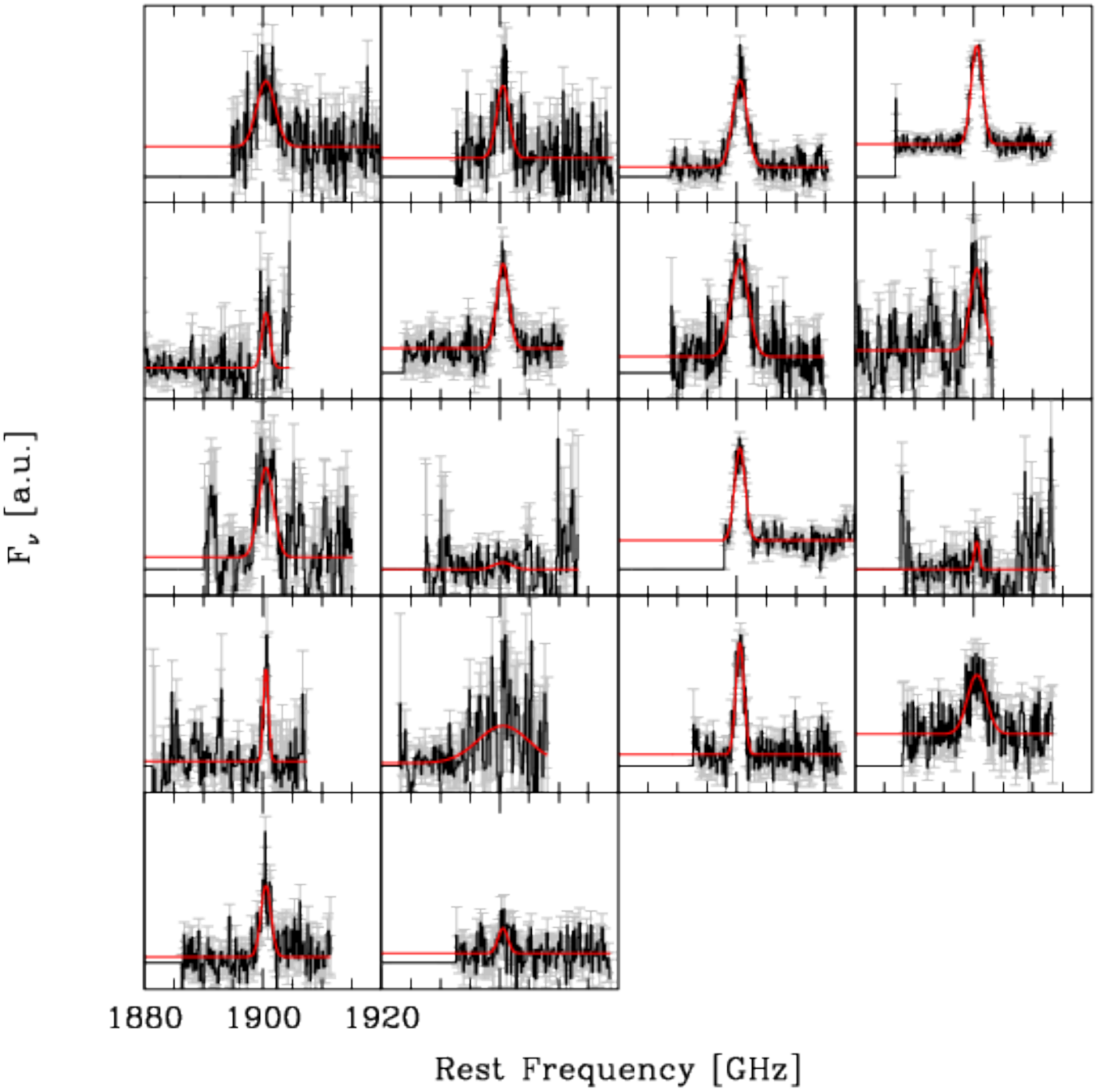
8 min on source

18 (+2) delivered so far

[CII] survey in z>6 QSOs

15 clear [CII] detections (83%)

16 (89%) detected in the continuum (at various significance)



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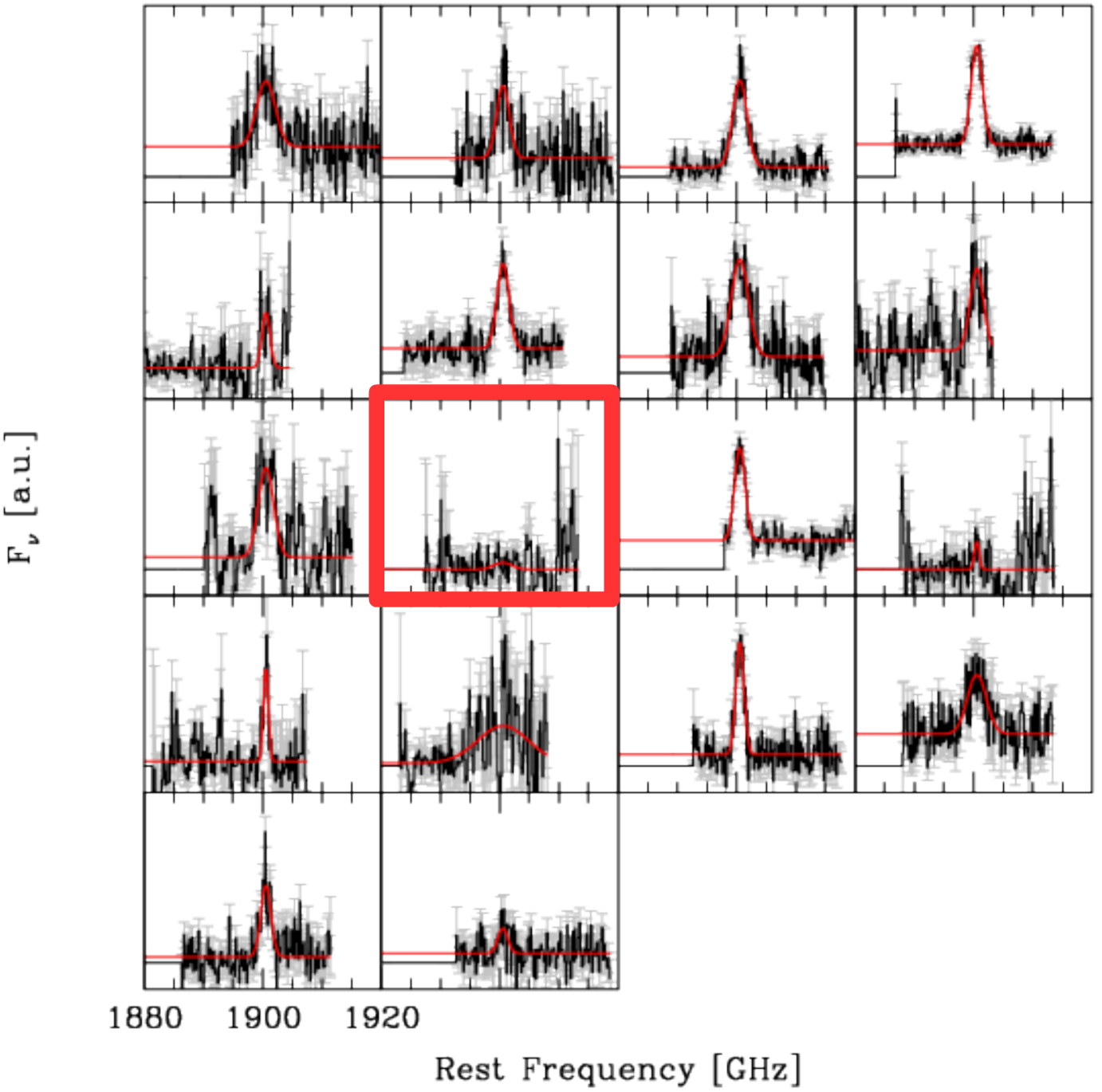
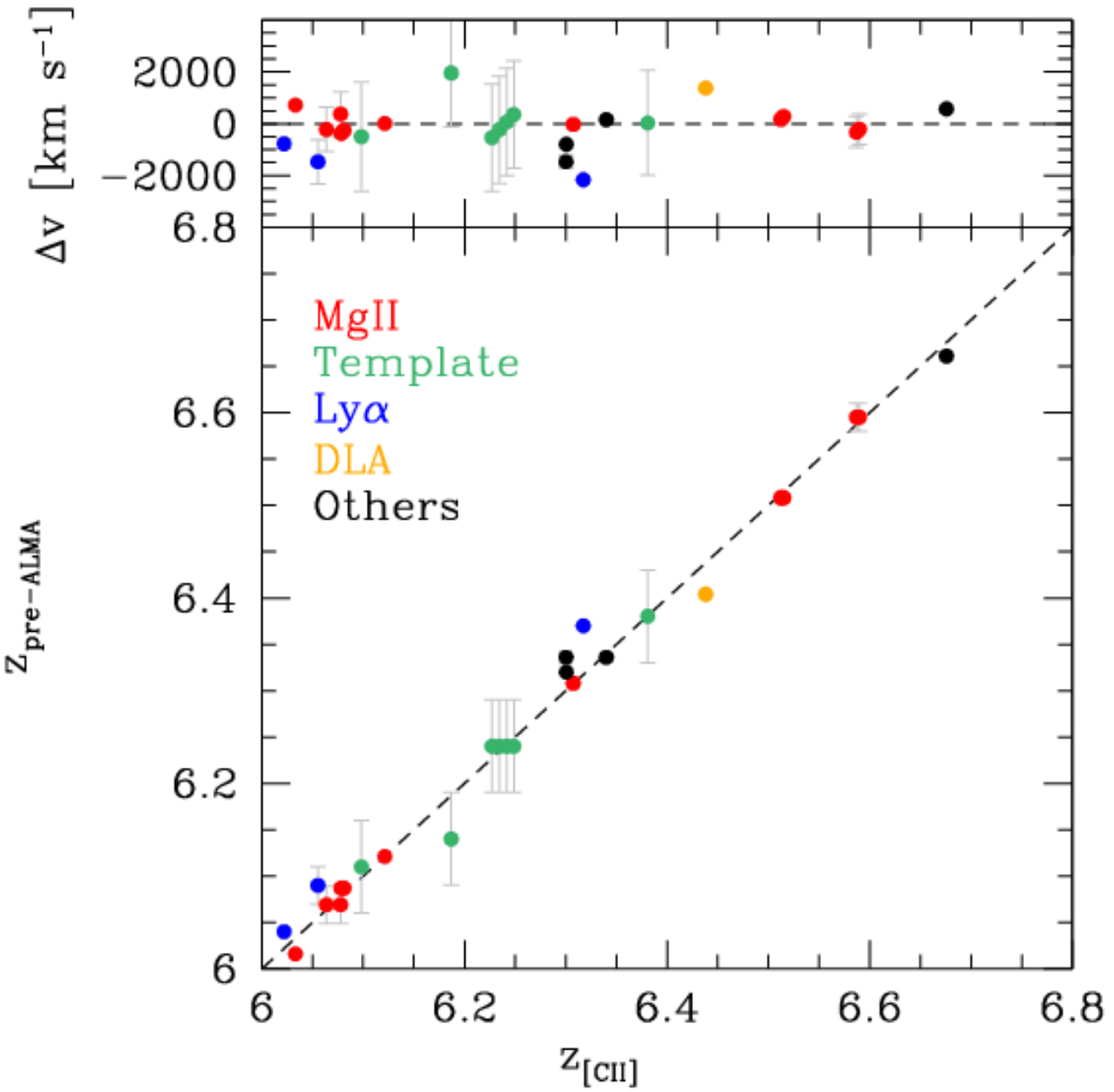
Laura's favorite J1030+0524 is NOT detected!



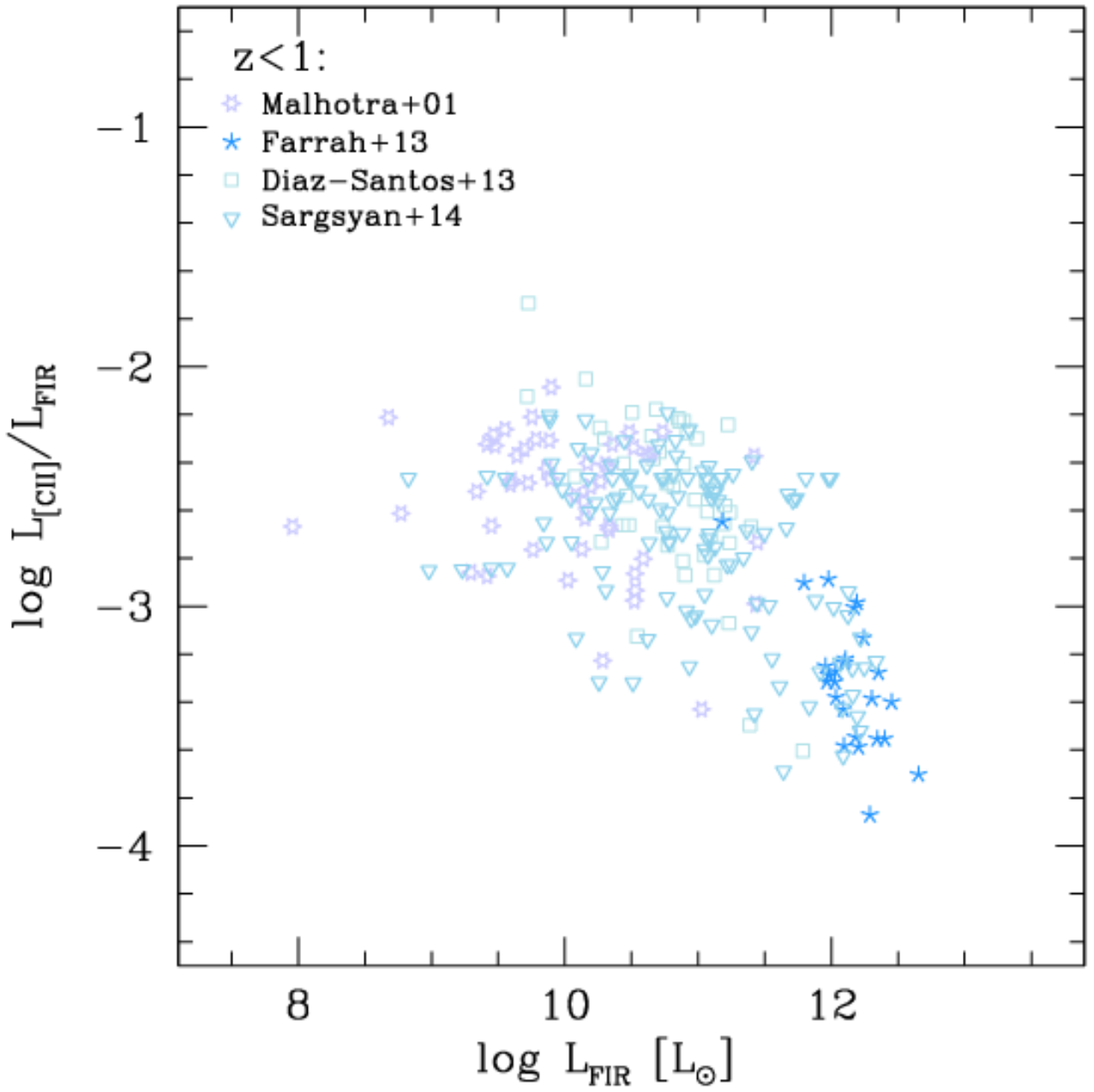
[CII] survey in z>6 QSOs

MgII-based redshifts:
$|\Delta v| < 500$ km/s

Lya-based redshifts:
off by ~1000 km/s



[CII] contribution to ISM cooling



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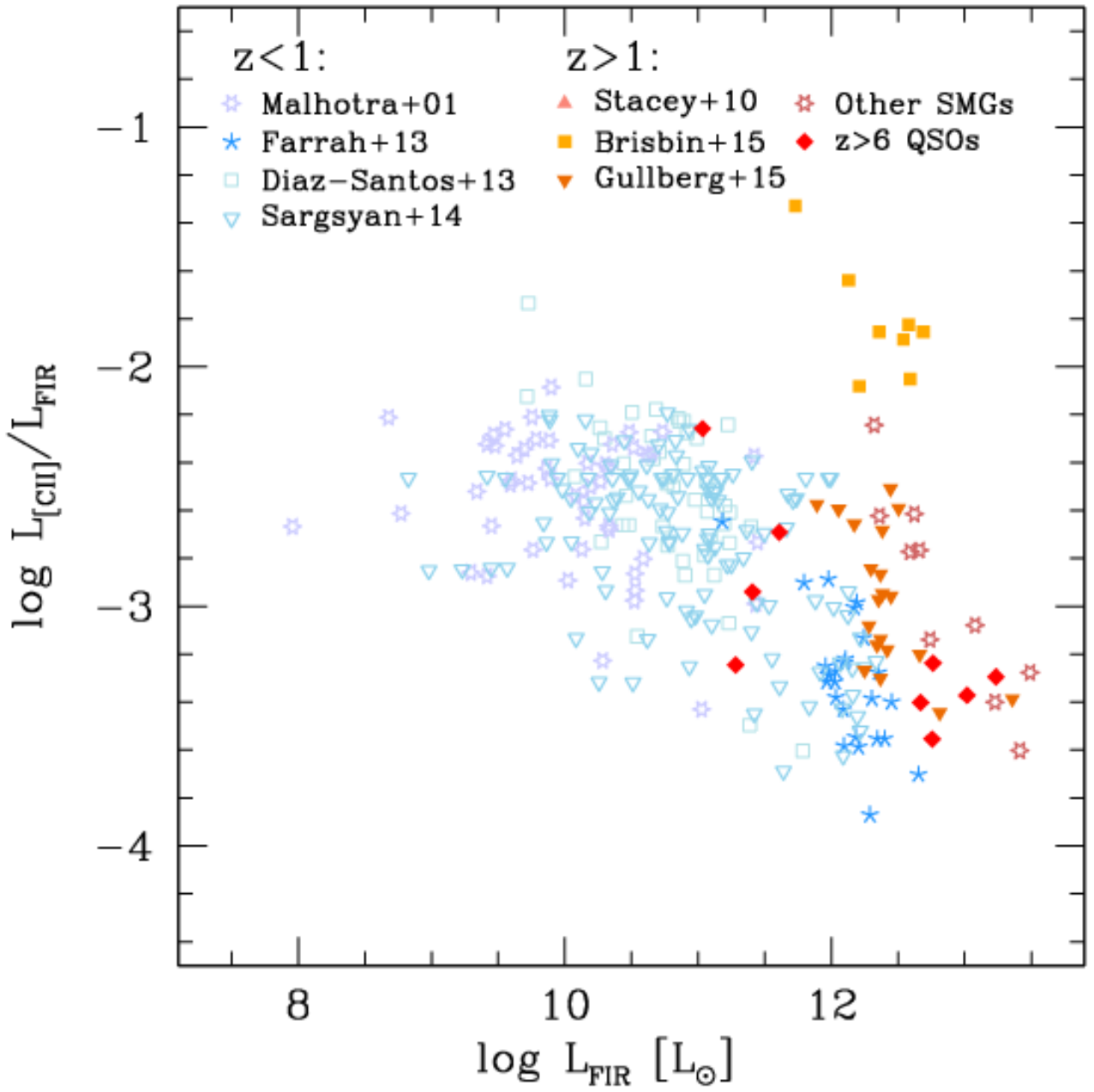

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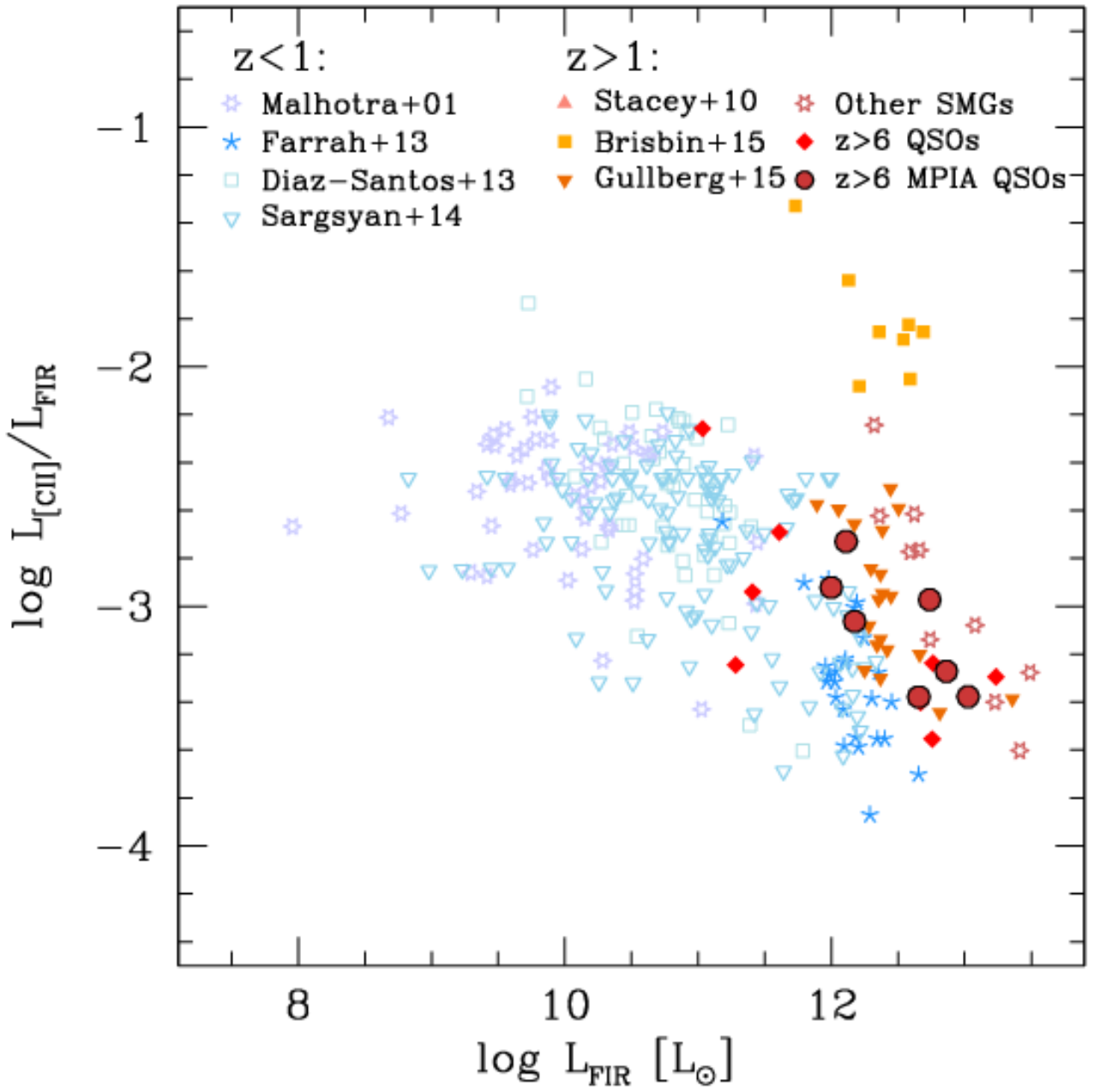

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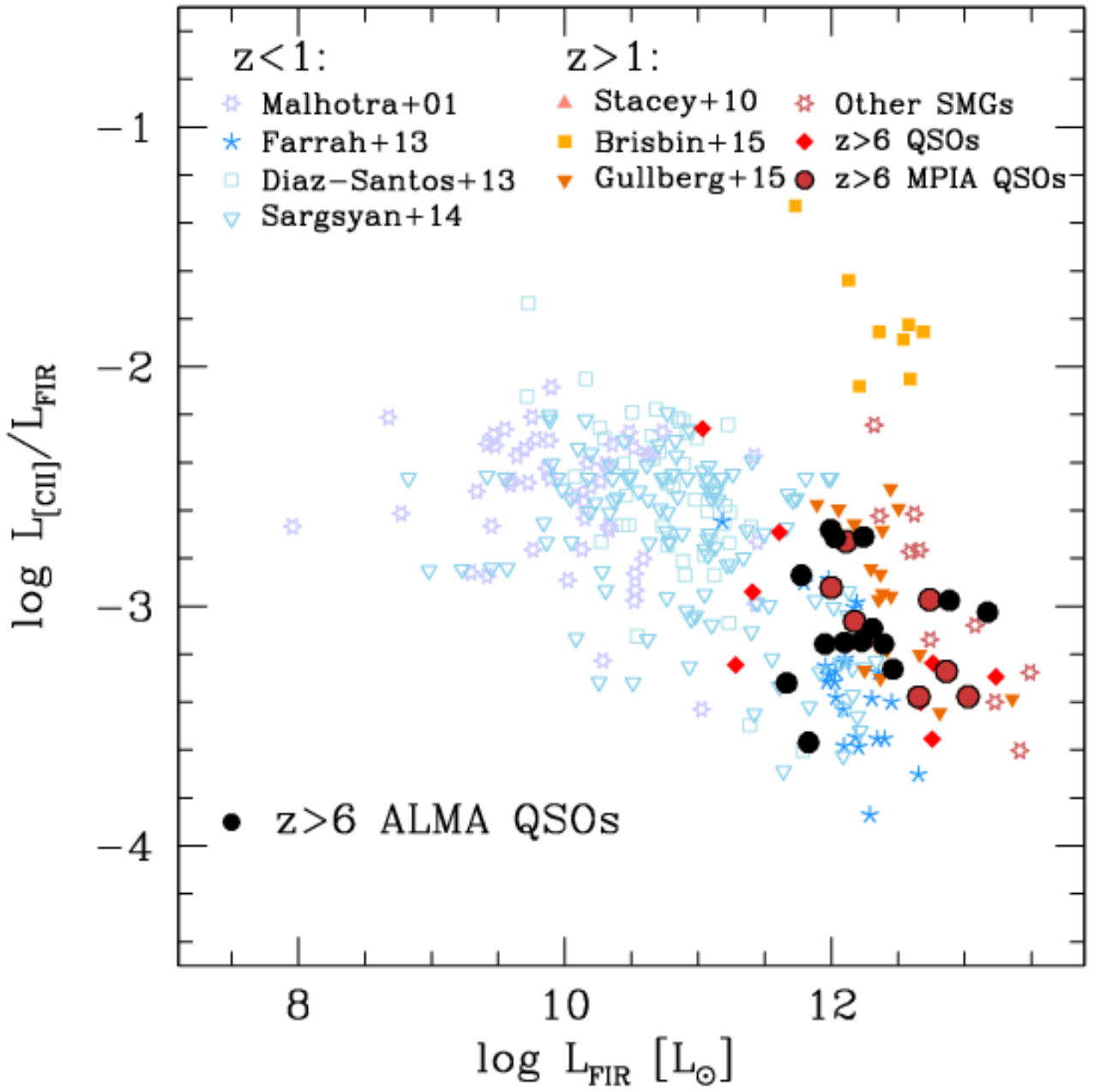


Unveiling ISM physics with [CII]

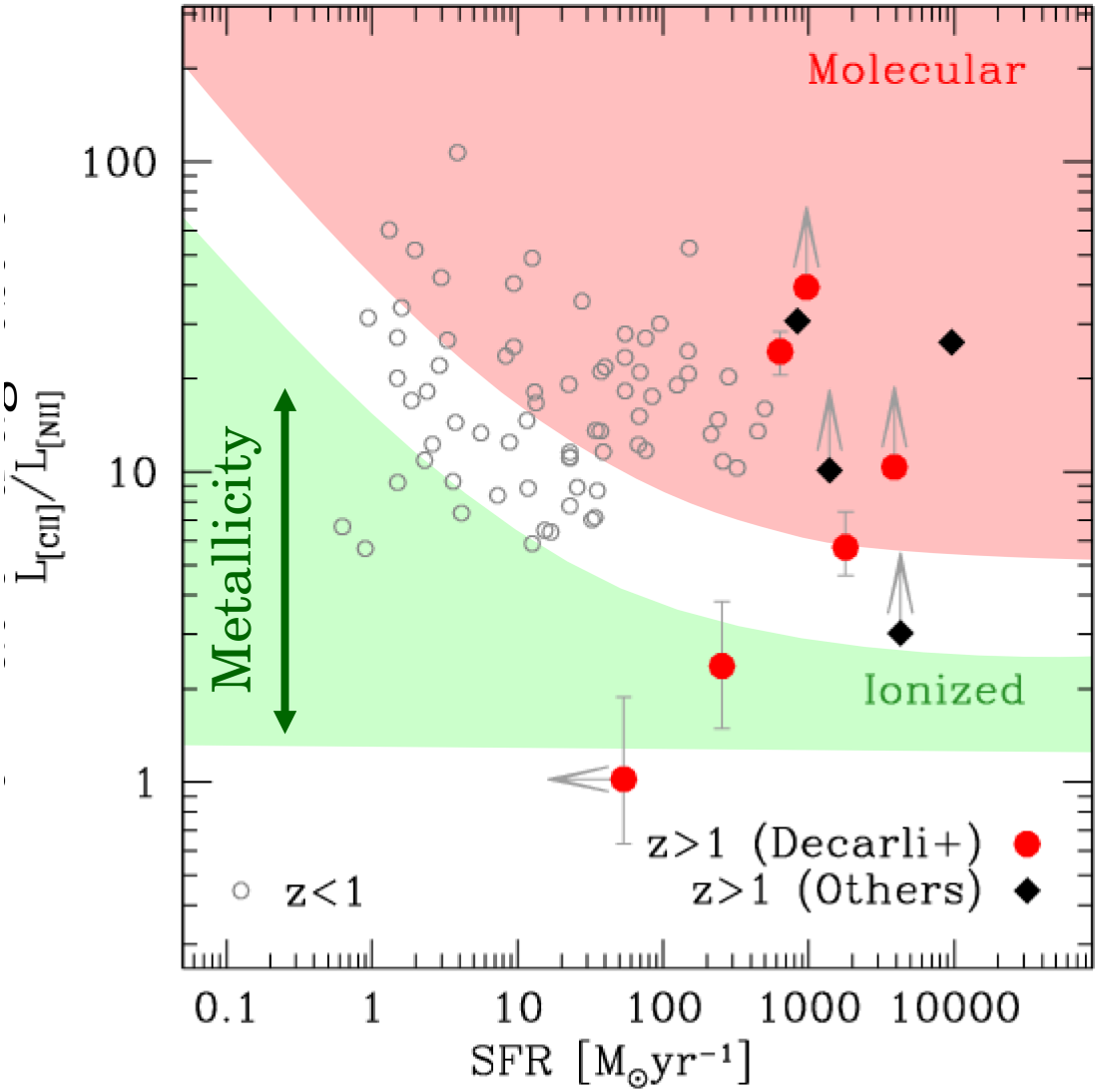
In ionized gas:
[CII] ~ Z
[NII] ~ Z^2
[CII]/[NII] ~ 1/Z
(0th order, it's actually
more complicated...)

Unveiling ISM physics with [CII]

In ionized gas:
[CII] ~ Z
[NII] ~ Z^2
[CII]/[NII] ~ 1/Z
(0th order, it's actually more complicated...)

Also,
[NII] = only ionized gas
[CII] = ionized+neutral phase

Decarli et al. (2014b)



Star formation rate

[CII]-emitting companions!

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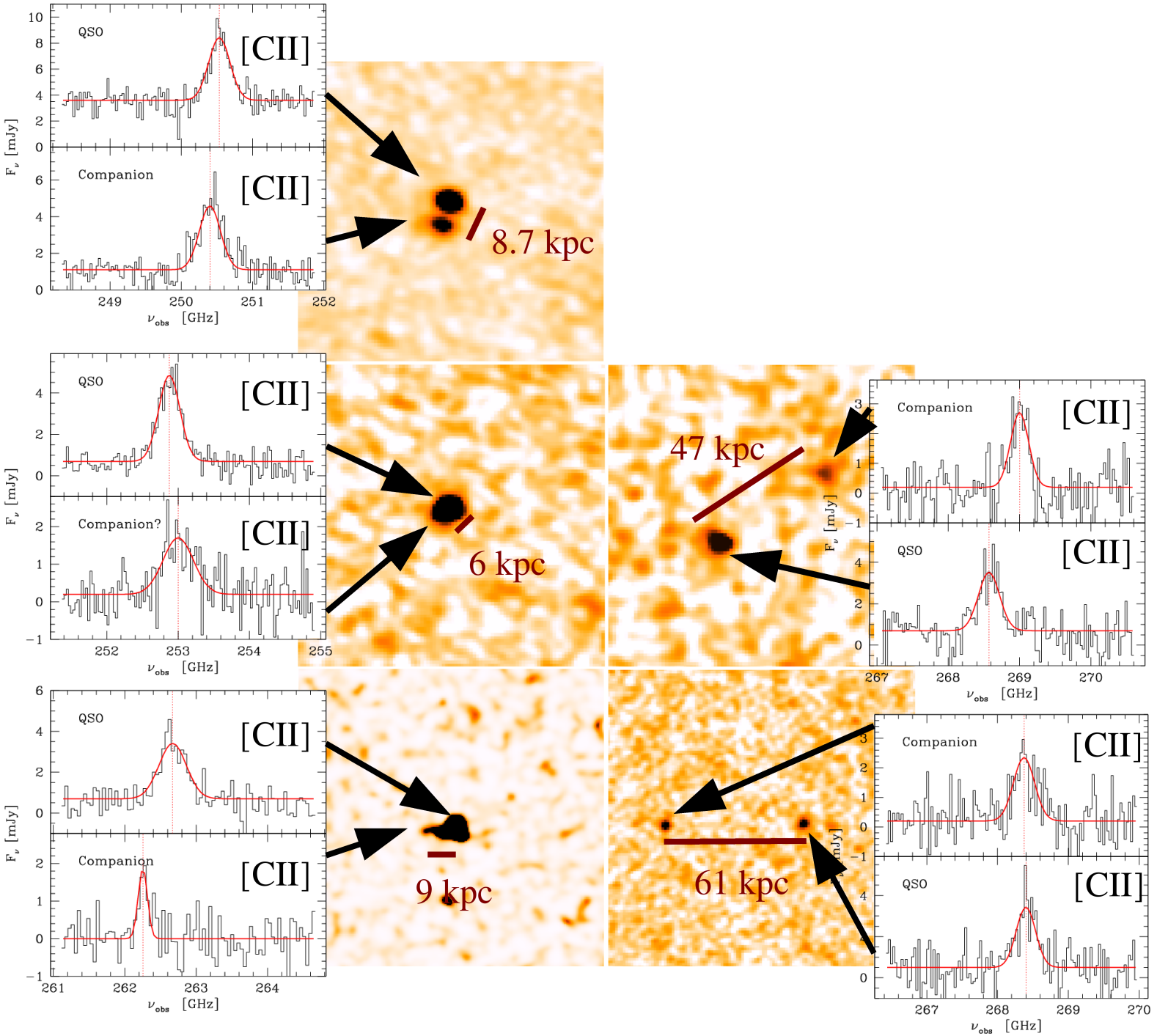

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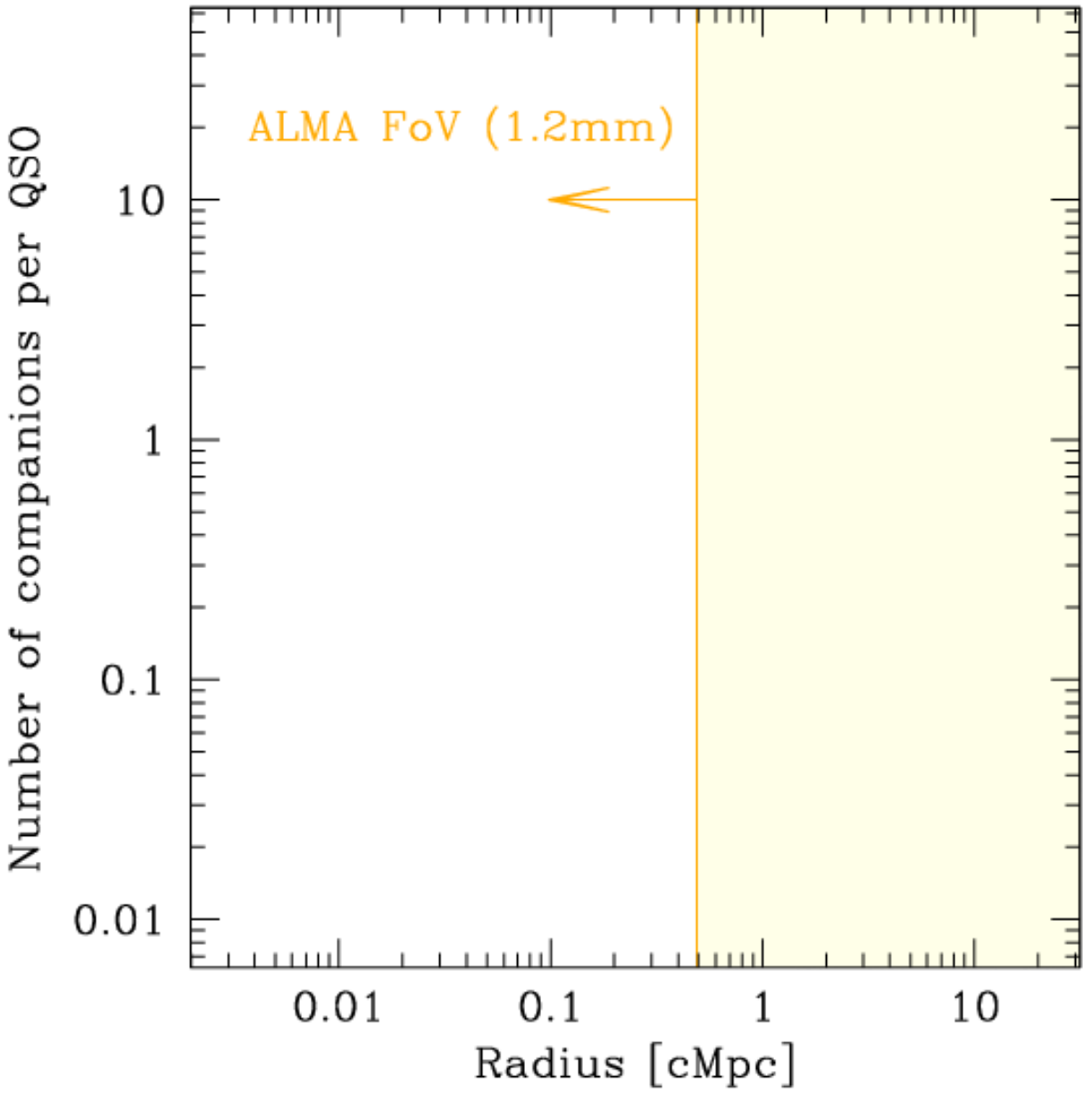

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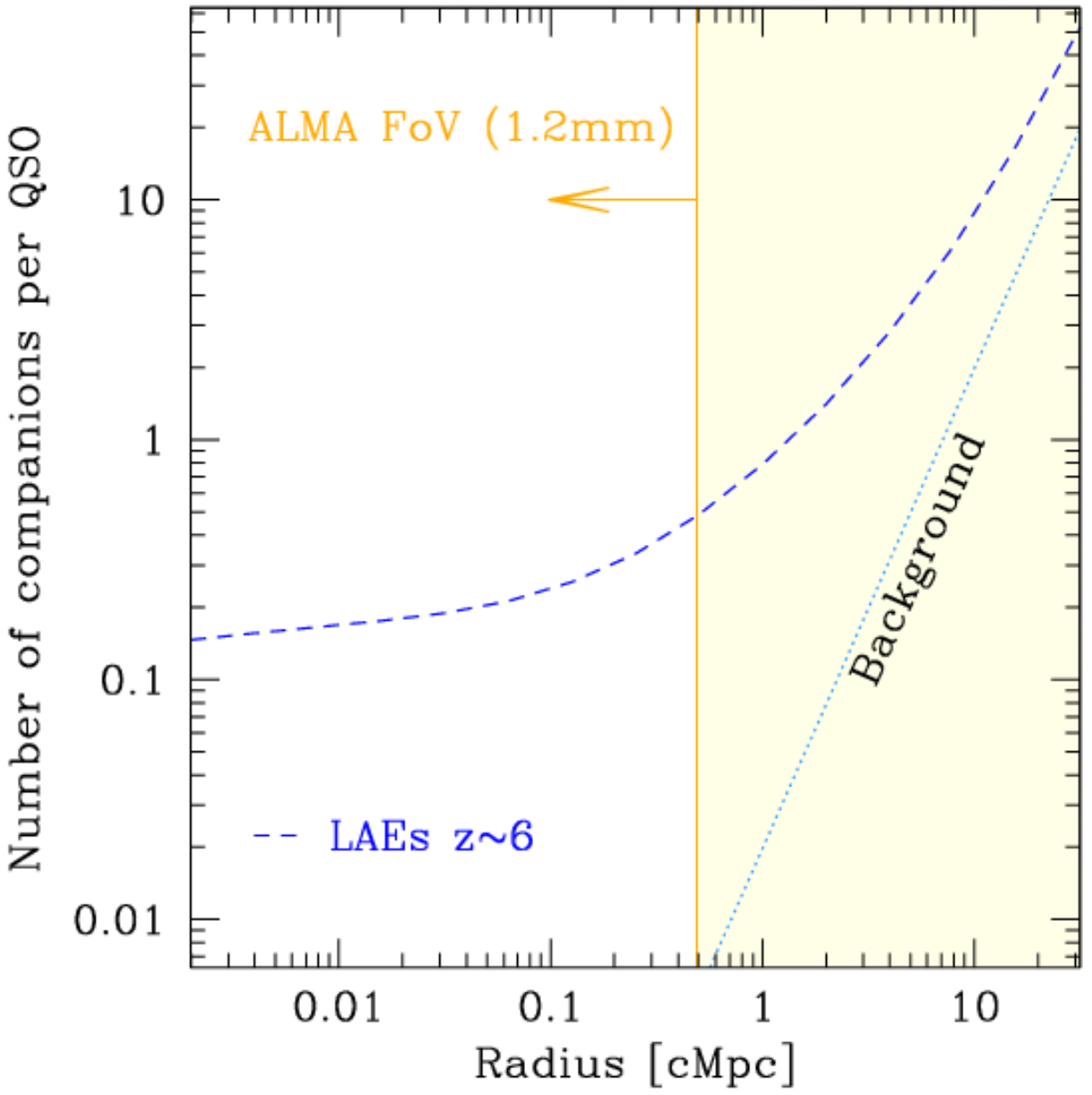

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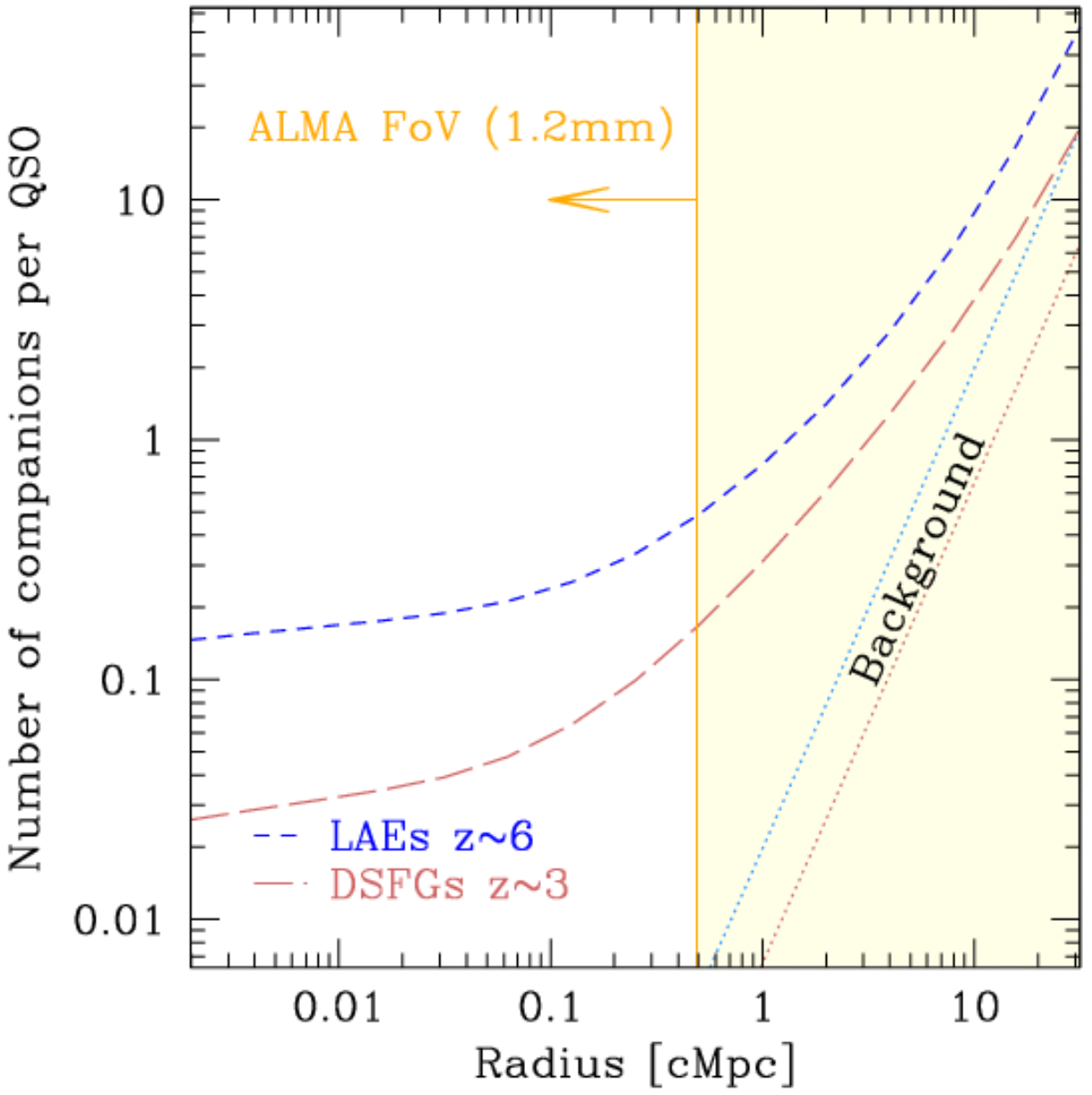

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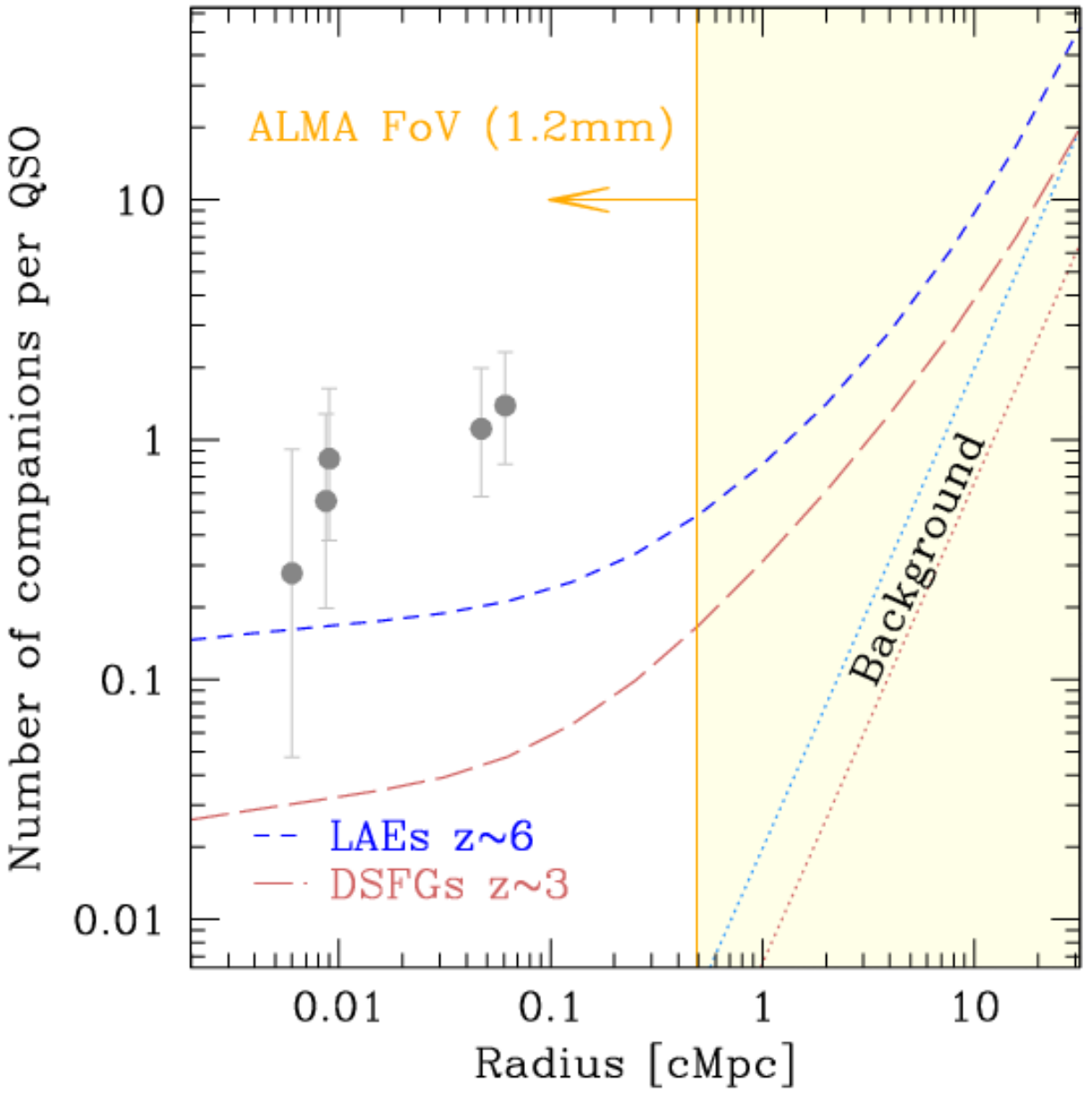
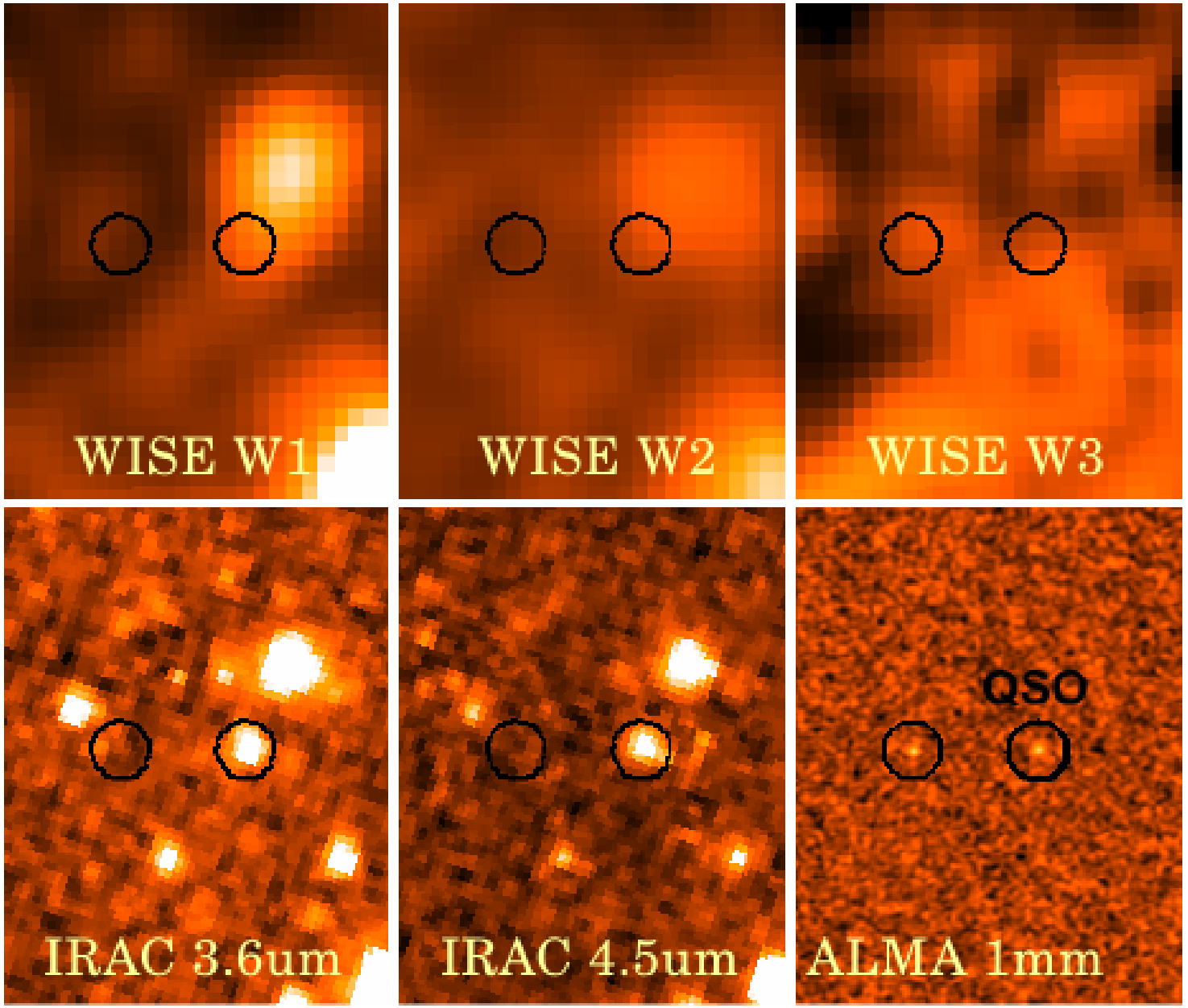


What kind of galaxies are they?



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Spitzer/IRAC non-detections: $M_{star} < (1\text{-}7)e10\ M_{sun}$

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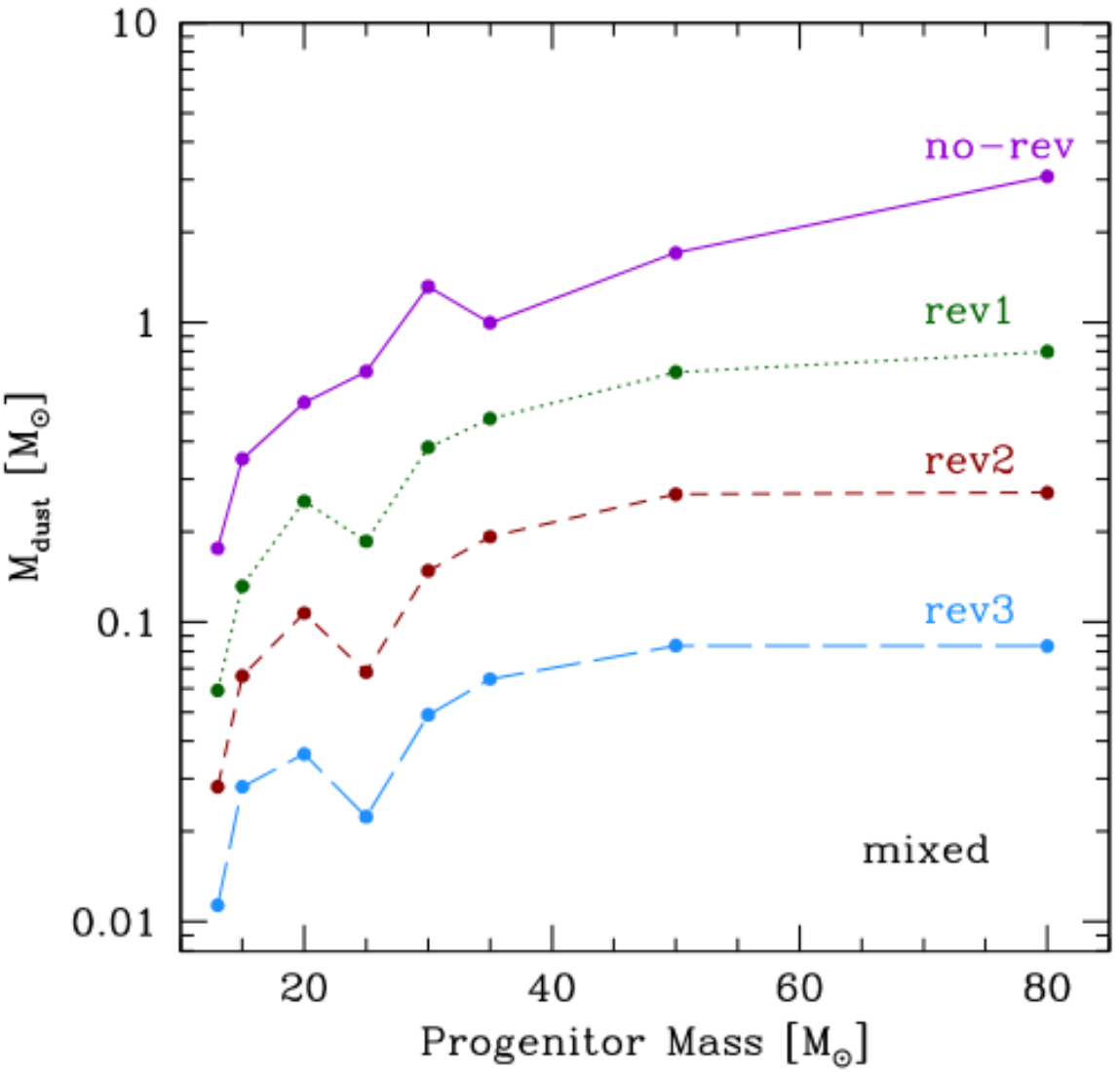

Dust RJ detections:

$M_{dust} \sim (1\text{-}8)e7\ M_{sun}$

But:

dust yield $y < 1/20$ of progenitor mass

$\Rightarrow M_{star} > (2\text{-}16)e9\ M_{sun}$

Marassi et al. (2015)

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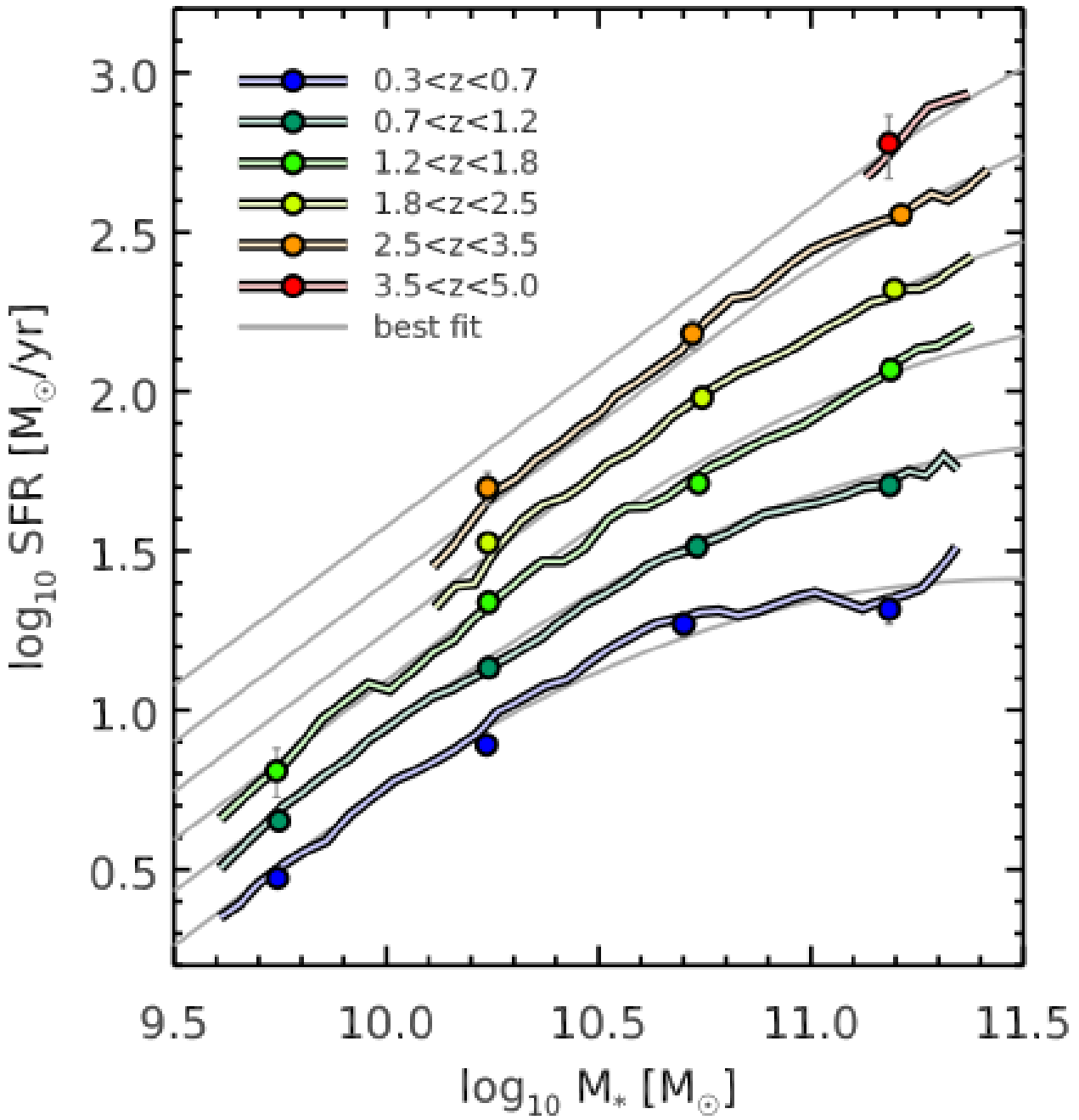

Schreiber et al. (2015)

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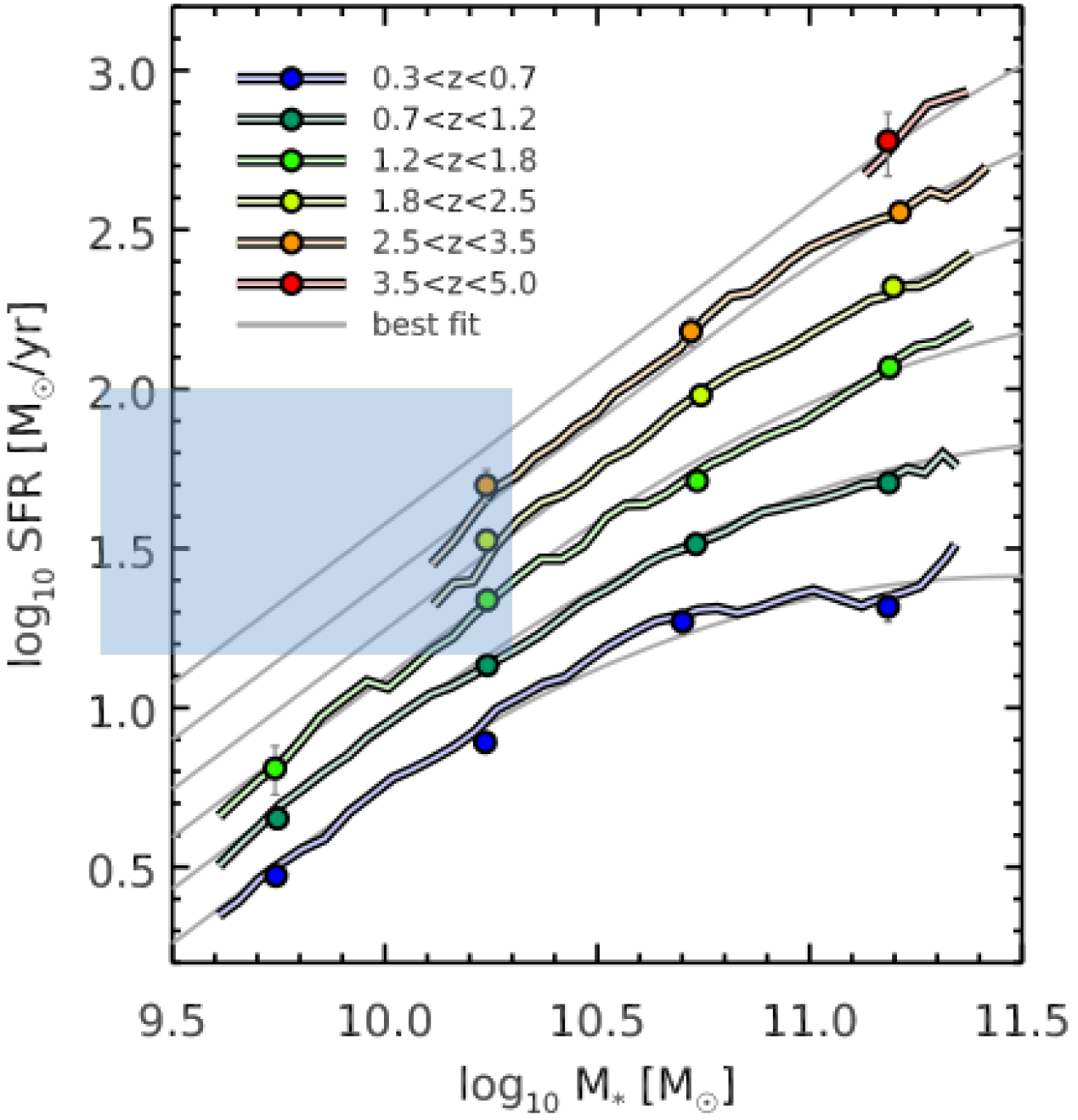
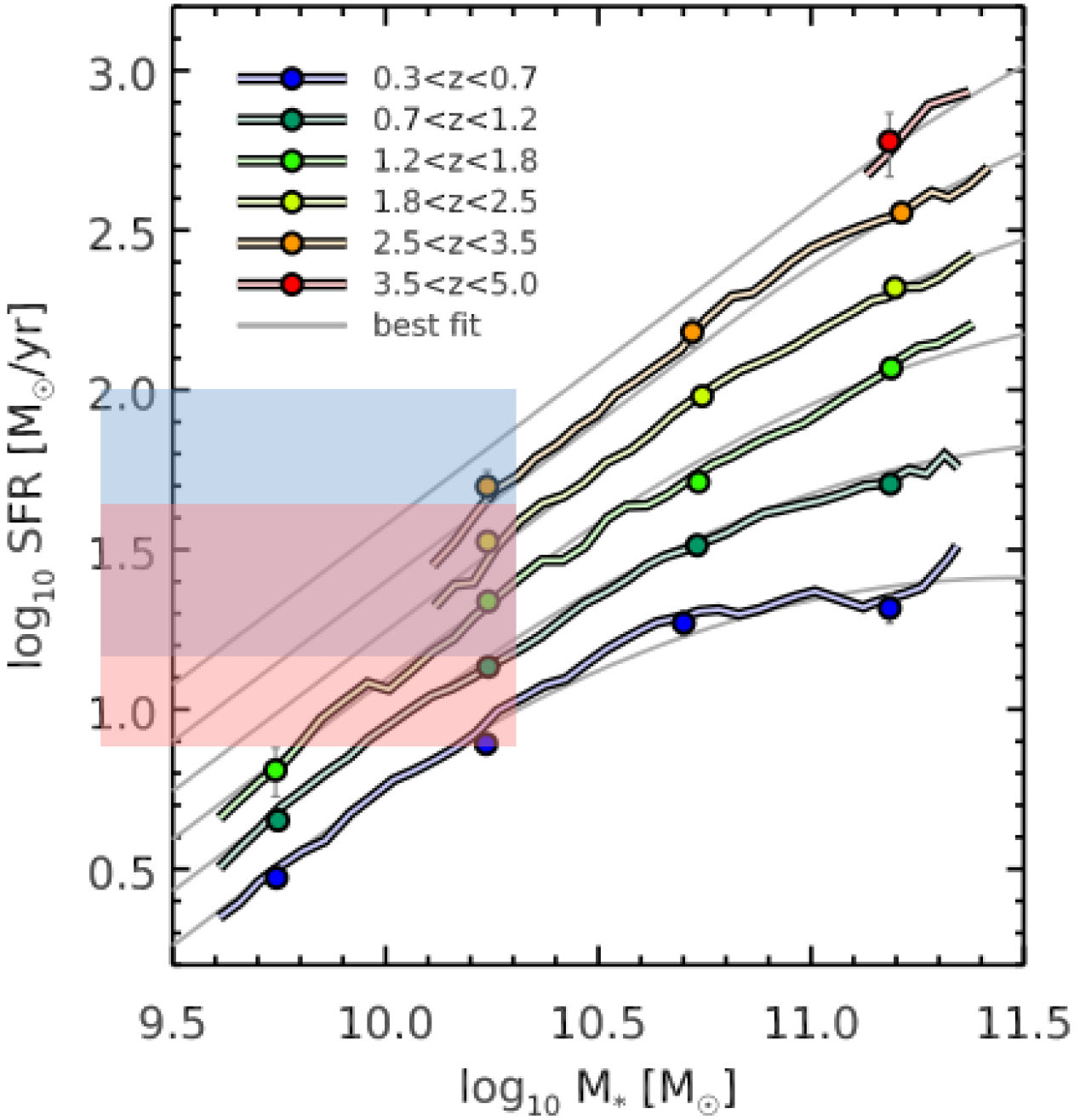


If $T_{dust} \sim 47$ K,

SFR = 15-120 M_{sun}/yr

Schreiber et al. (2015)

What kind of galaxies are they?

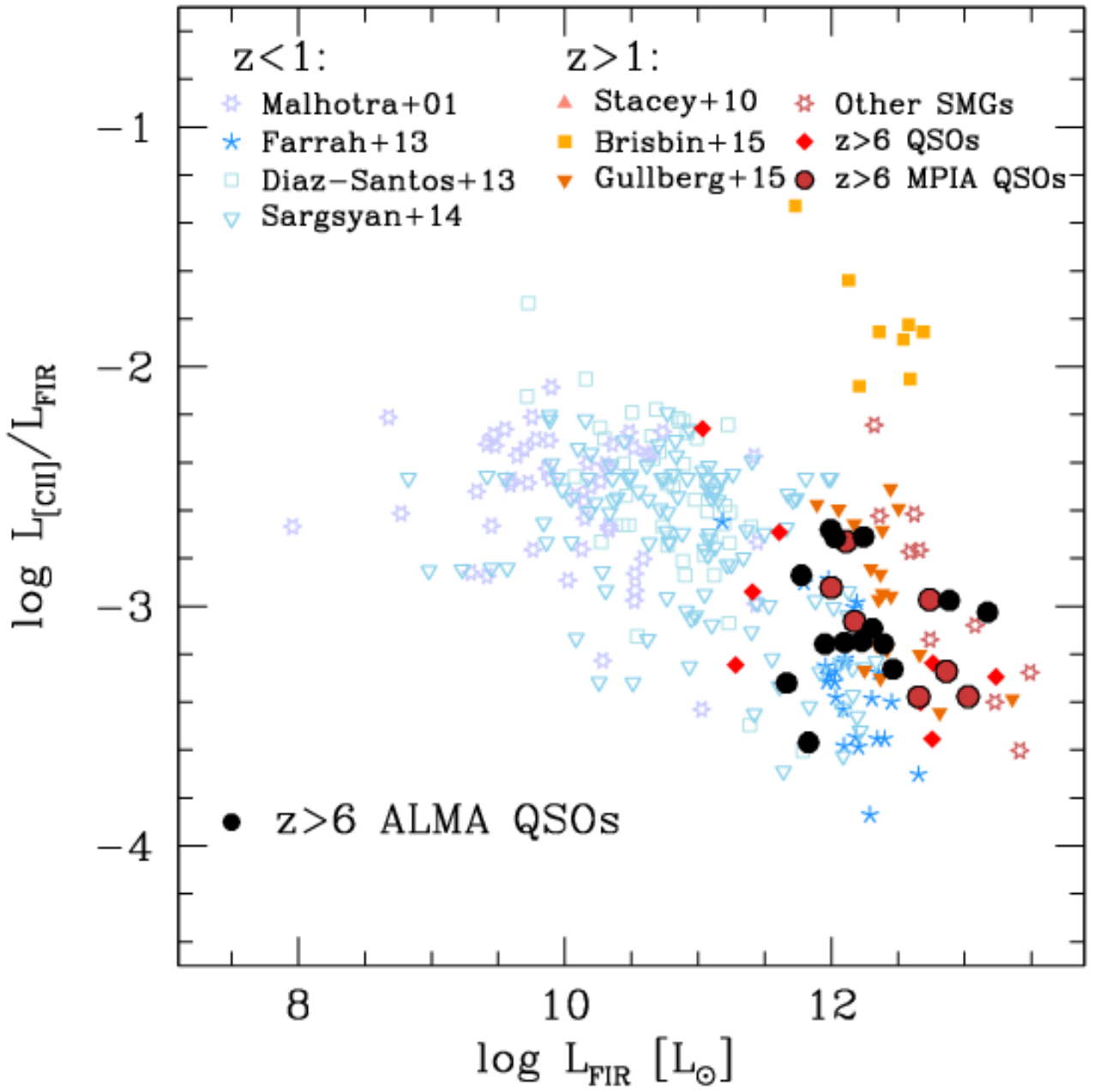


If T_{dust} ~ 47 K,
SFR = 15-120 M_{sun}/yr

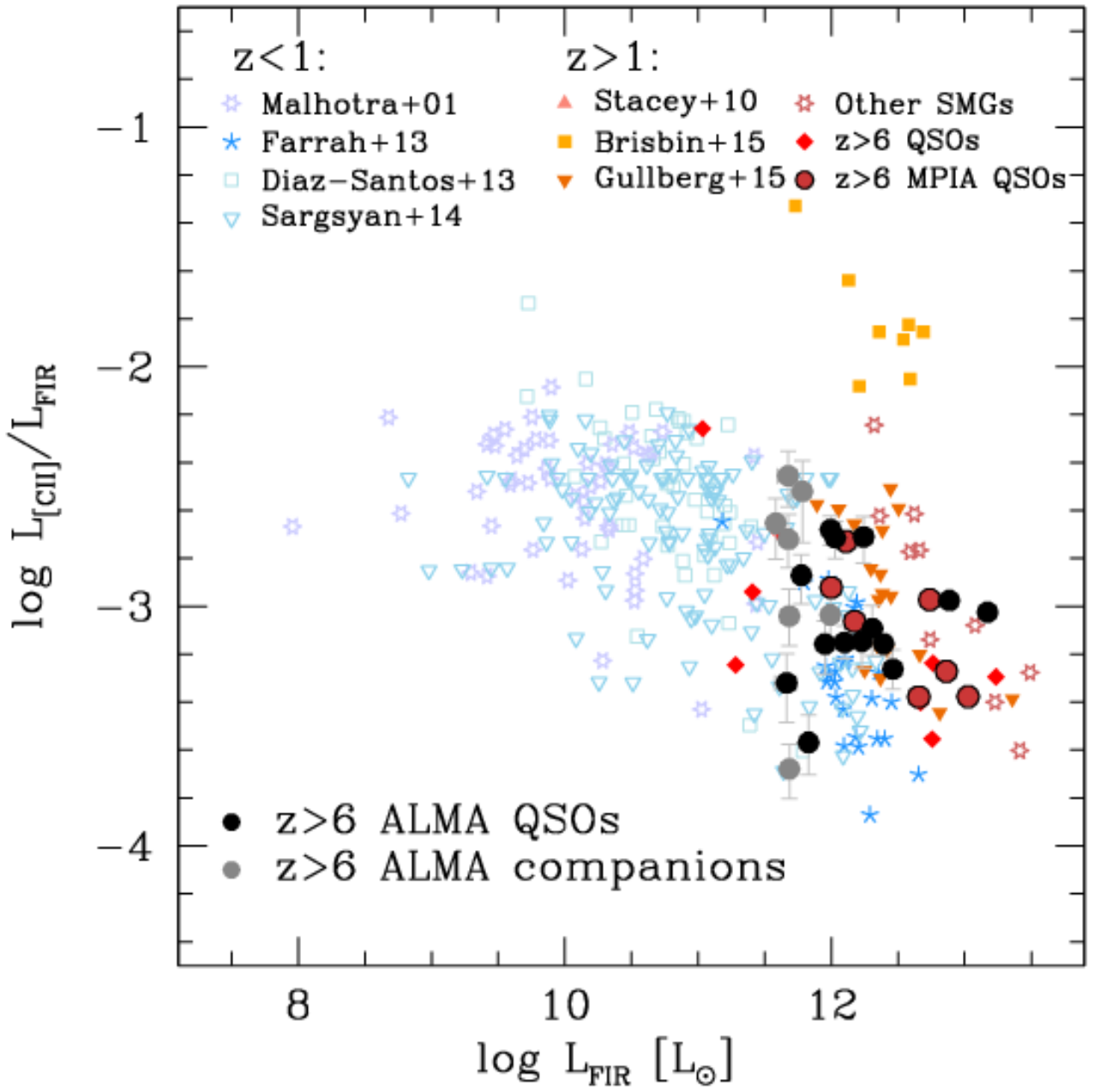
If T_{dust} ~ 25 K,
SFR = 5-40 M_{sun}/yr

Schreiber et al. (2015)

[CII] contribution to ISM cooling



[CII] contribution to ISM cooling



Summary

First systematic survey of [CII] & dust in a statistical sample of z>6 QSOs

>80% [CII] detection rate,
~90% continuum detection rate

~1/3 of the QSOs show a dusty companion galaxy!