ALMA observations of [CII] line and dust emission in primeval galaxies

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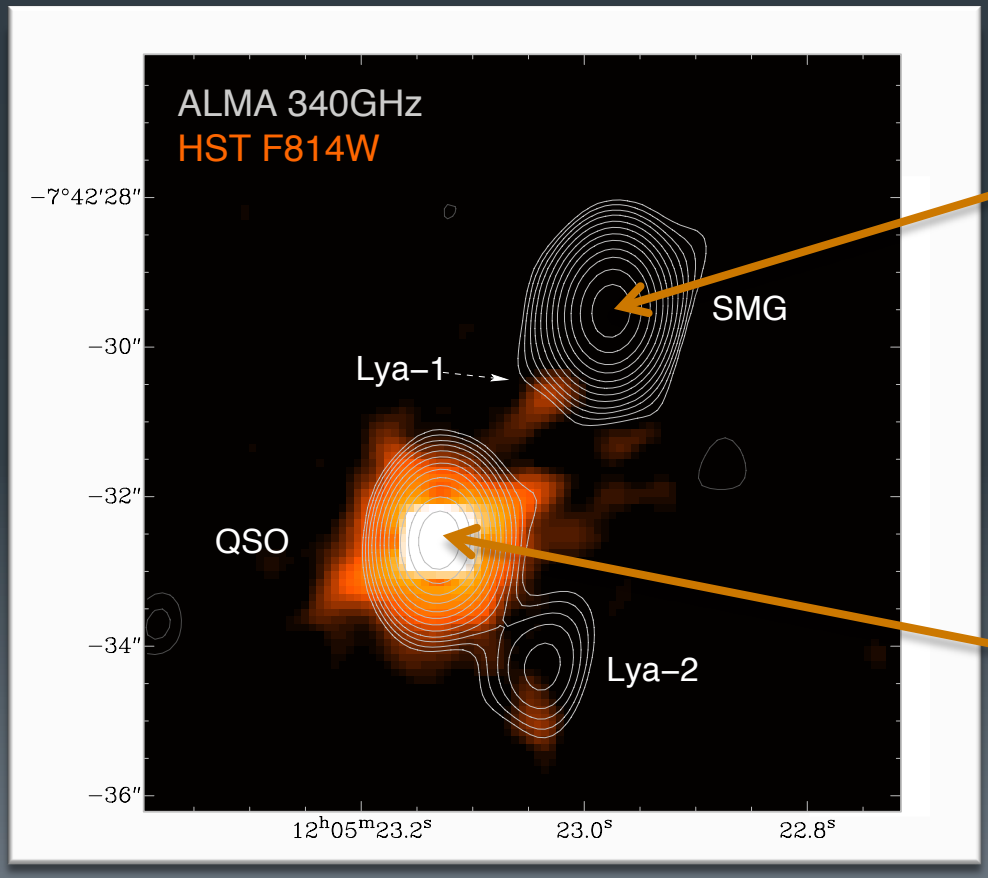
BR1202 – 0725 (z ~ 4.7)

First ALMA detection of [CII]158μm at high-z (Wagg+12 & Carilli+13)

- 18 antennae with a maximum baseline of ~ 280 m
- Total exposure time ~25 min
- 4 papers on this data (Wagg+13,Carilli+13,Carniani+13,Williams+14)



Optically obscured SMG

QSO

Hu et al. 1996, Carilli et al. 2013

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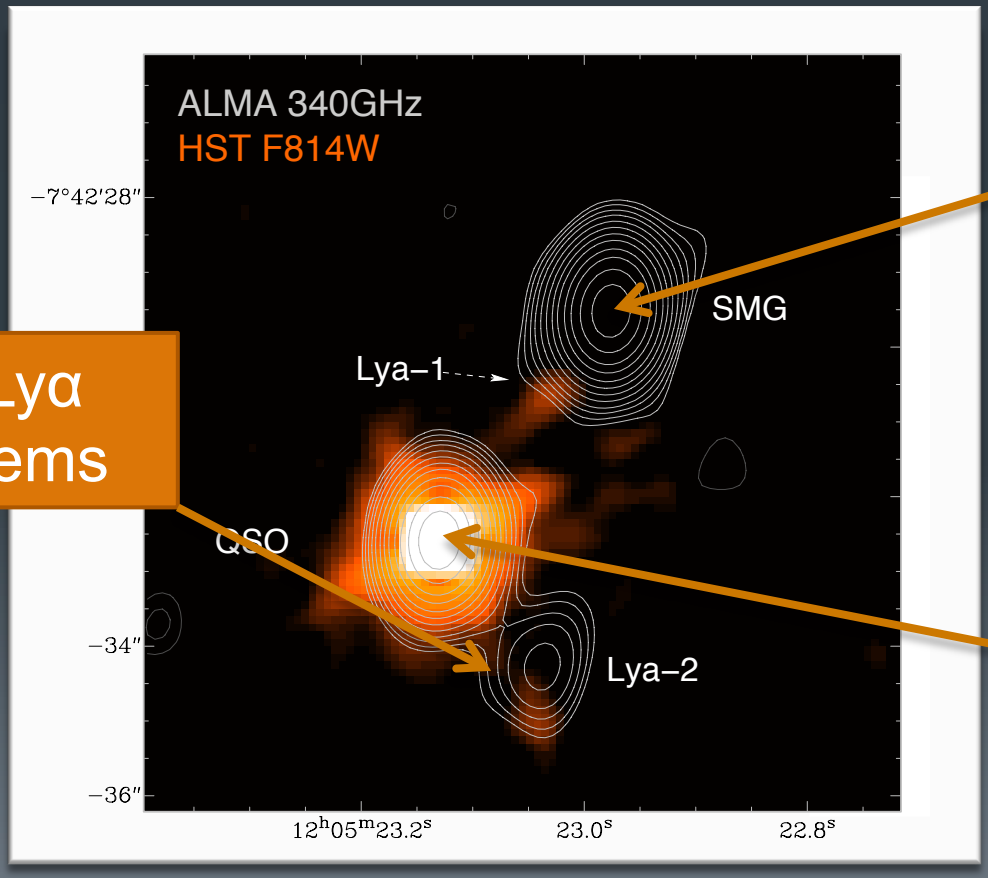


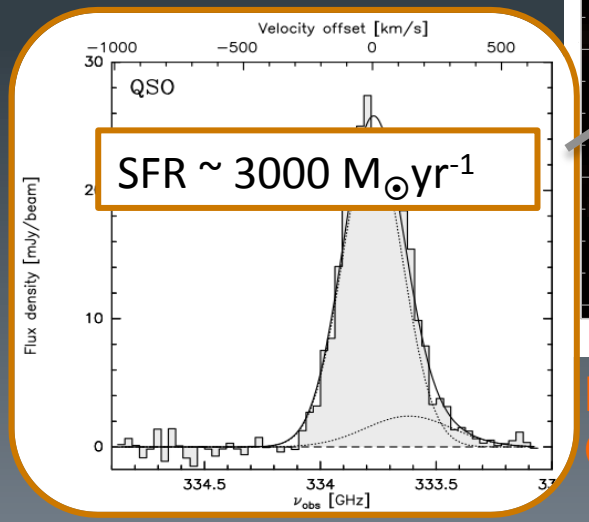
detection of Lyα emitting systems

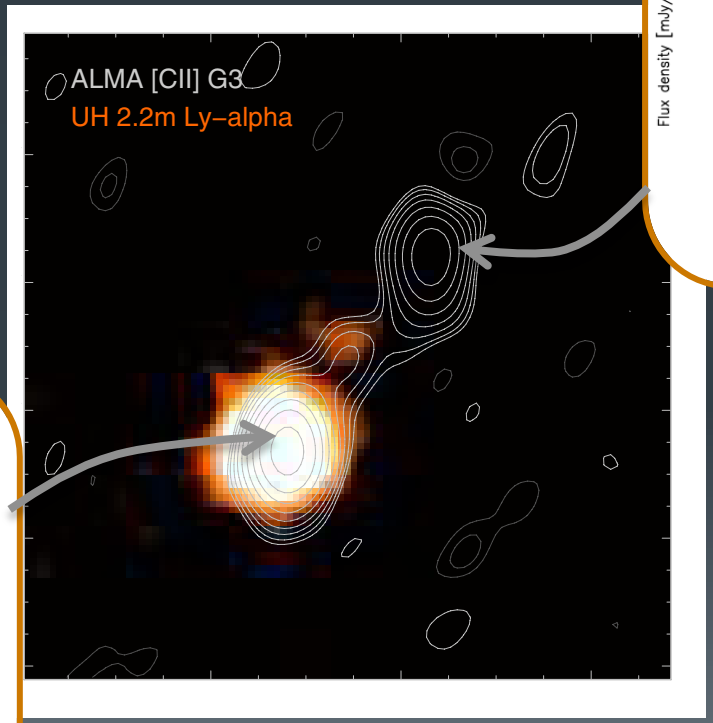
Optically obscured SMG

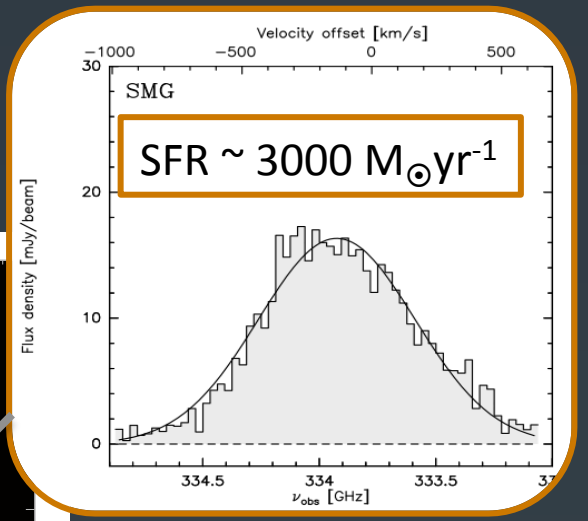
QSO

Hu et al. 1996, Carilli et al. 2013

BR1202 – 0725 [CII] emission



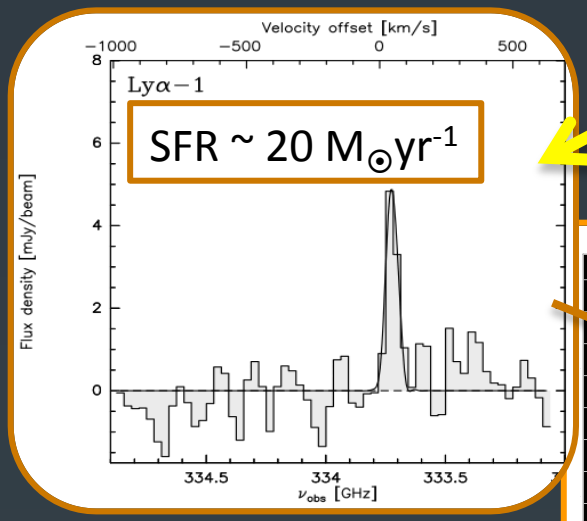


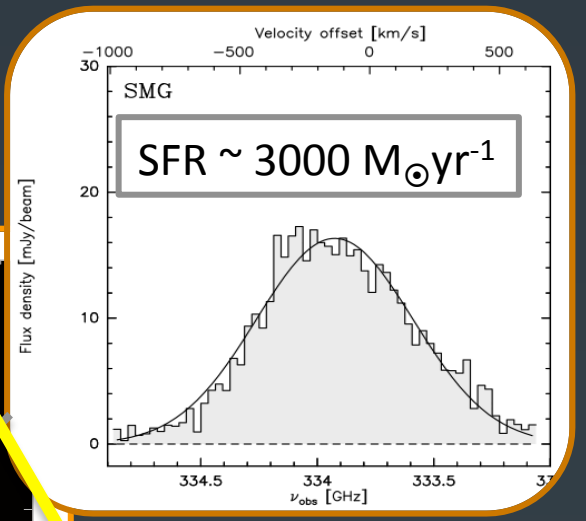


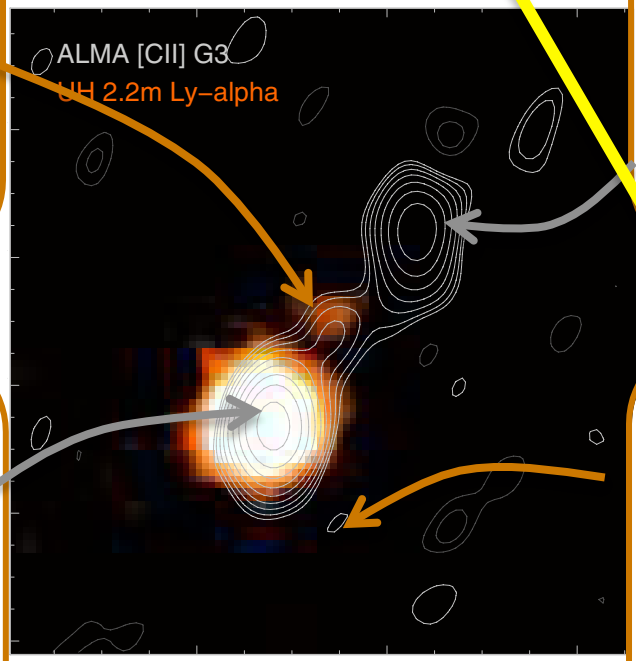
Hu et al. 1996
Carilli et al. 2013

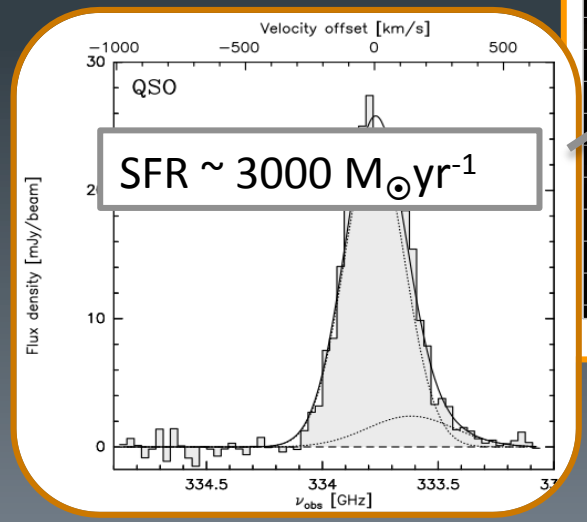
BR1202 – 0725 [CII] emission

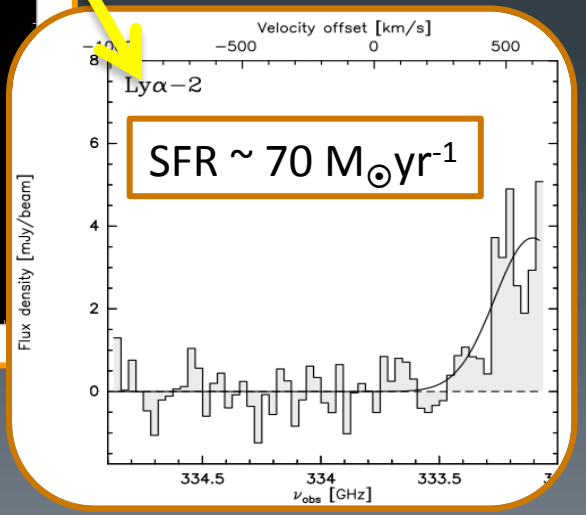
Star forming systems more representative of the bulk of the population







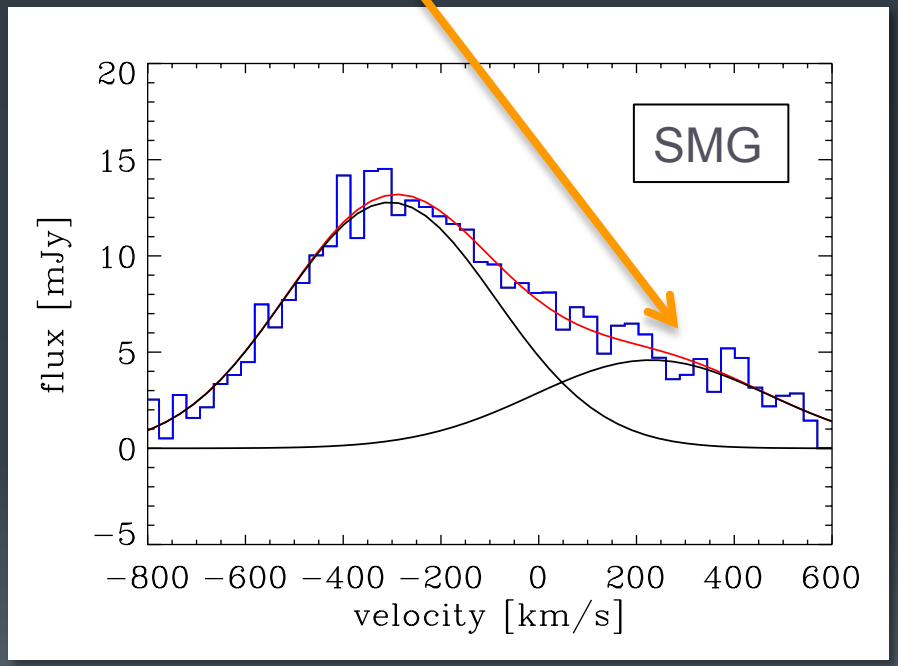


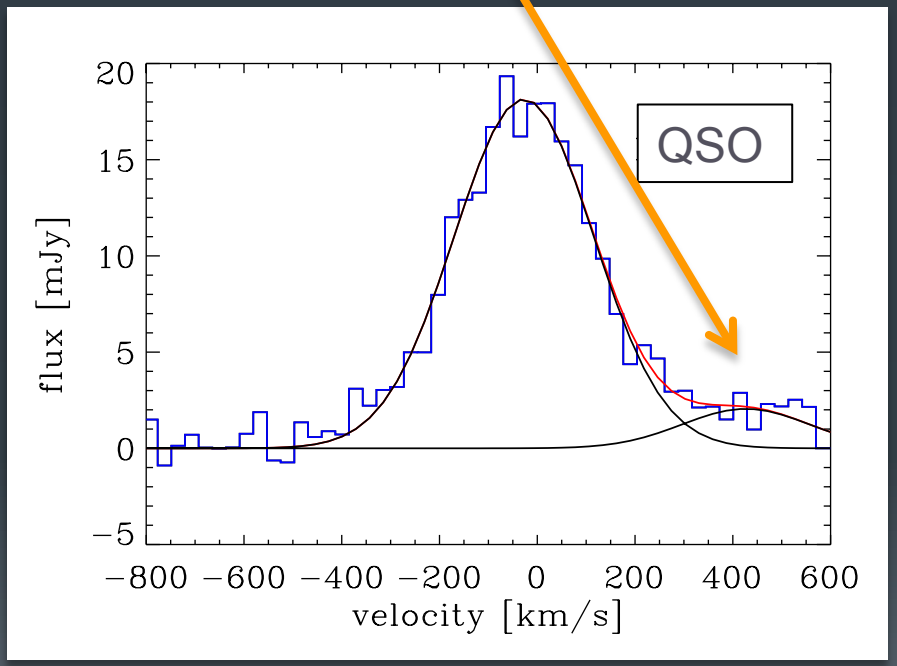


Hu et al. 1996
Carilli et al. 2013

BR1202 – 0725 [CII] emission

The asymmetry of the [CII] line emission suggests the presence of a companion

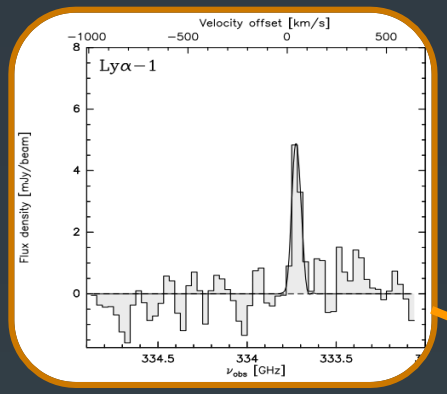


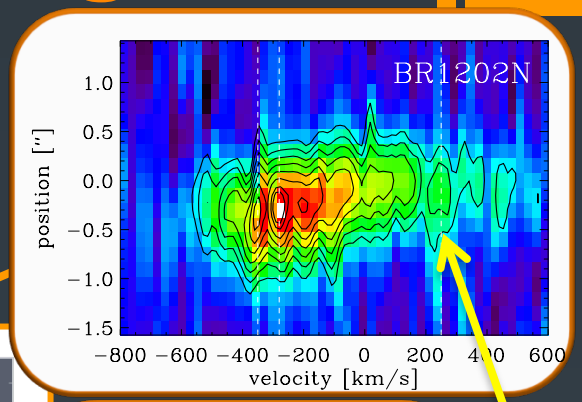


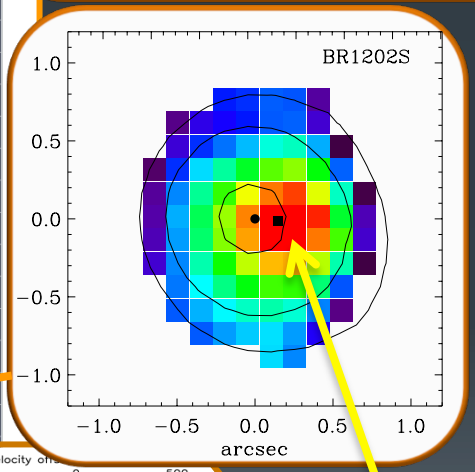
Carniani et al. 2013

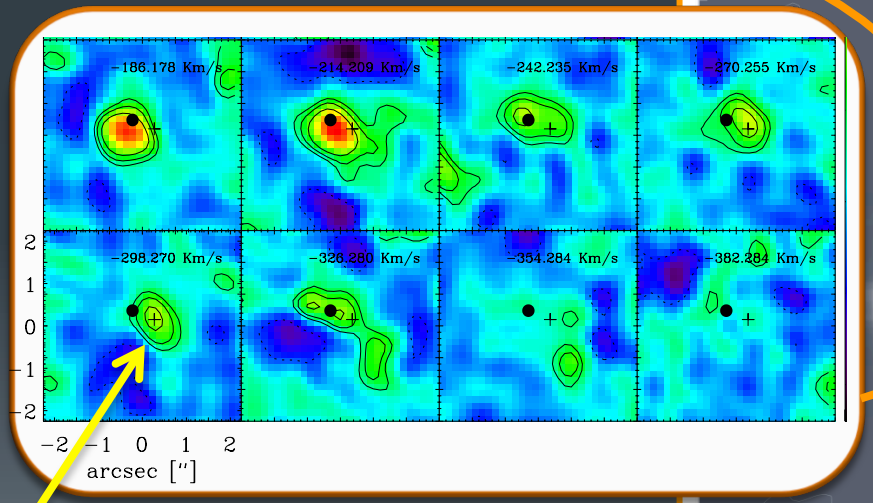
Major and Minor Merging ??

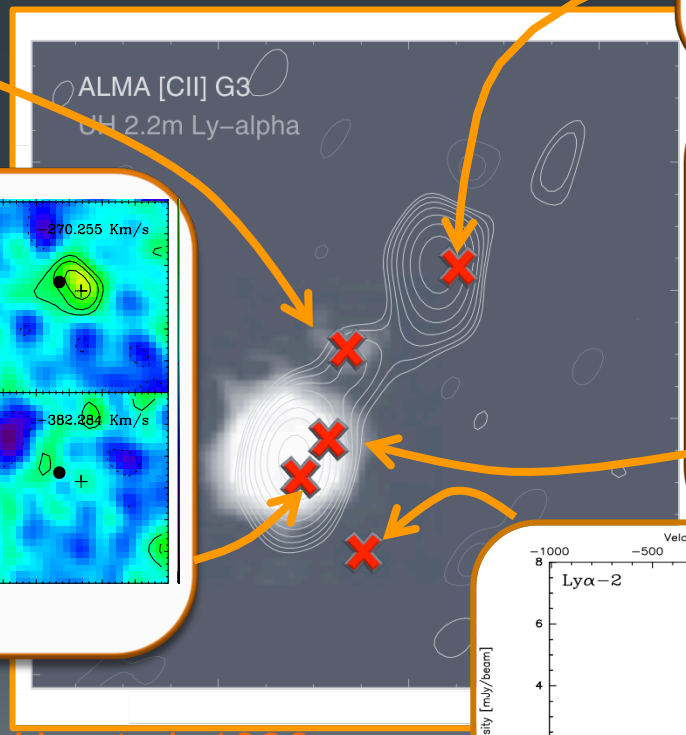
QSO & SMG
+
5 faint [CII] sources

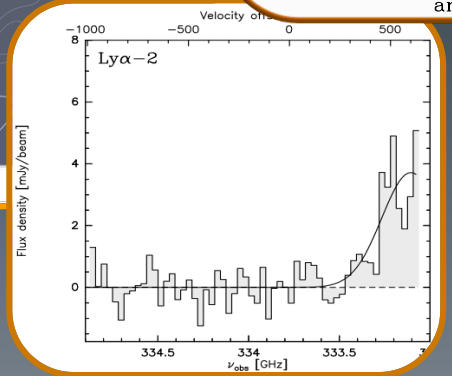










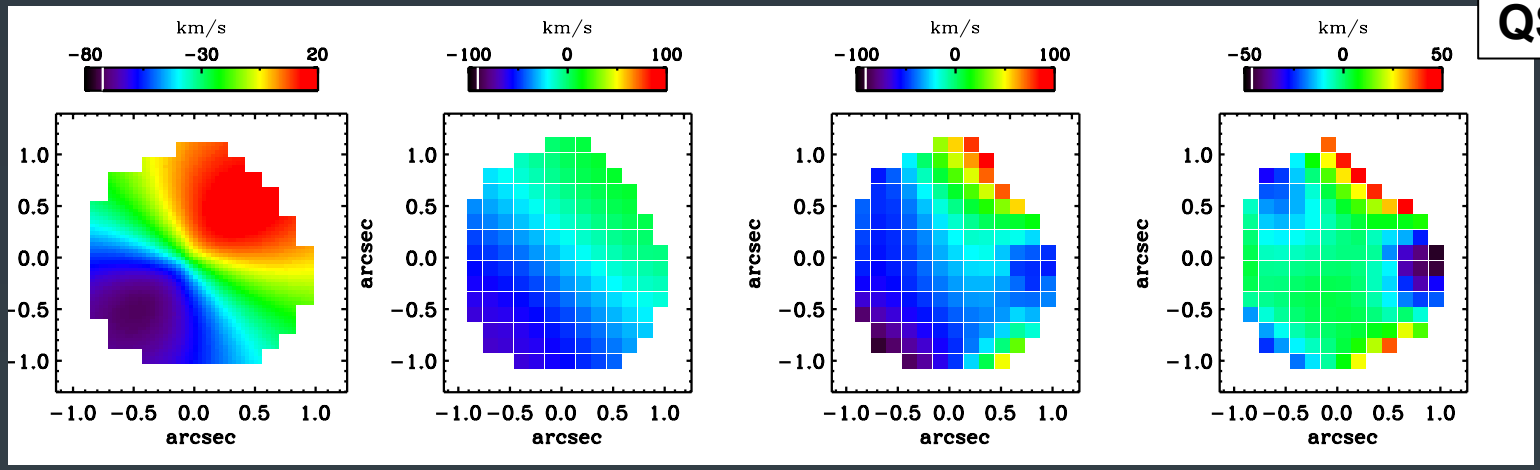


Carniani et al. 2013

Hu et al. 1996
Carilli et al. 2013

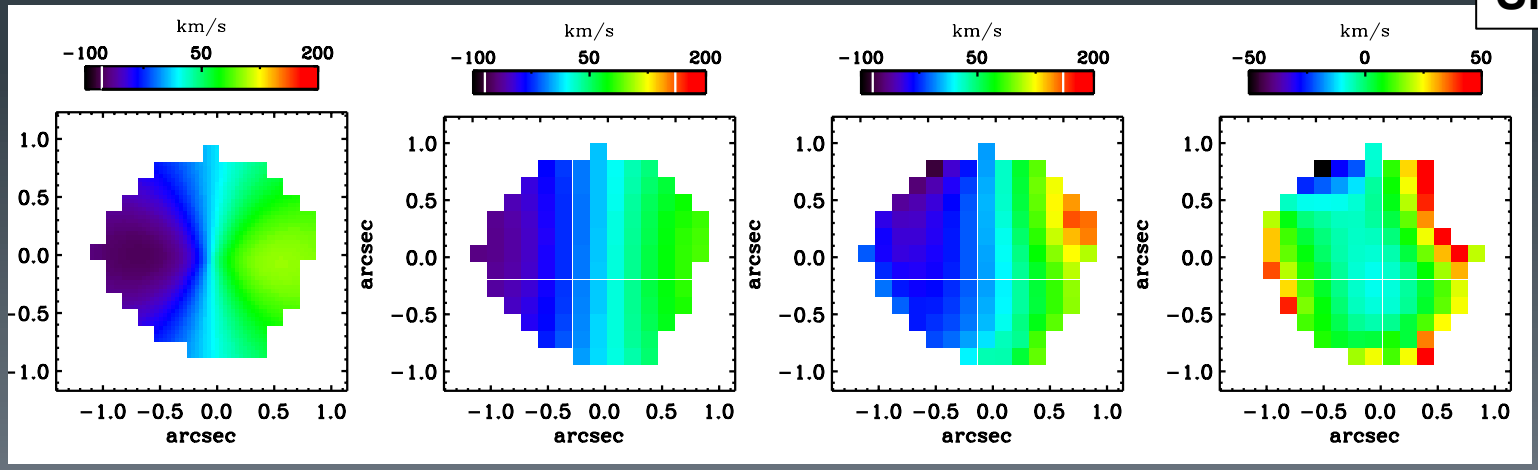
Kinematic Analysis of [CII]

Carniani et al. 2013



M_{dyn}~10^{10} $M_\odot$

inc ~ 15°



M_{dyn} ~ 10^{10} $M_\odot$

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Kinematic Analysis of [CII]

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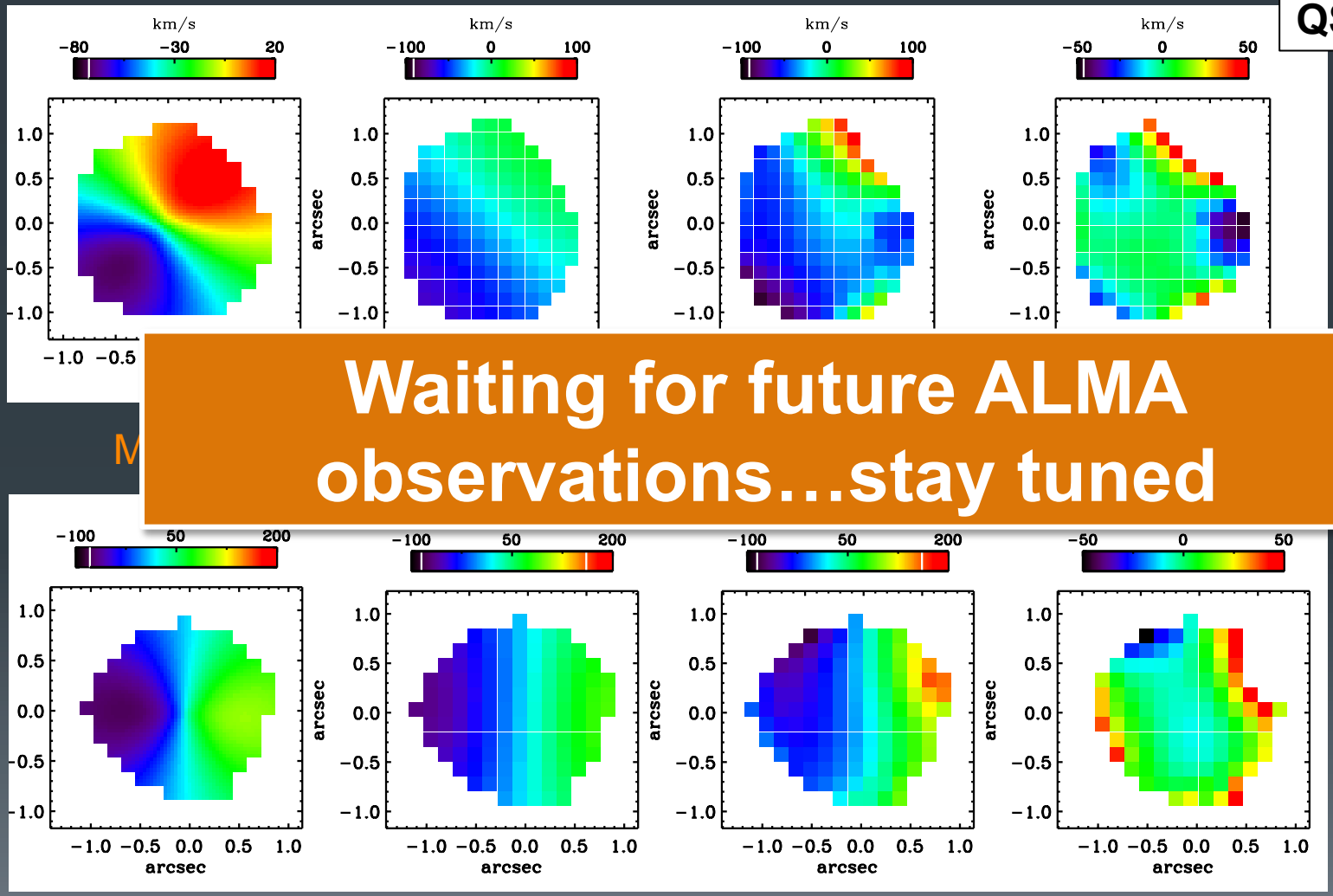

M_{dyn}~10^{10} $M_\odot$

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Waiting for future ALMA observations…stay tuned

M_{dyn} ~ 10^{10} $M_\odot$

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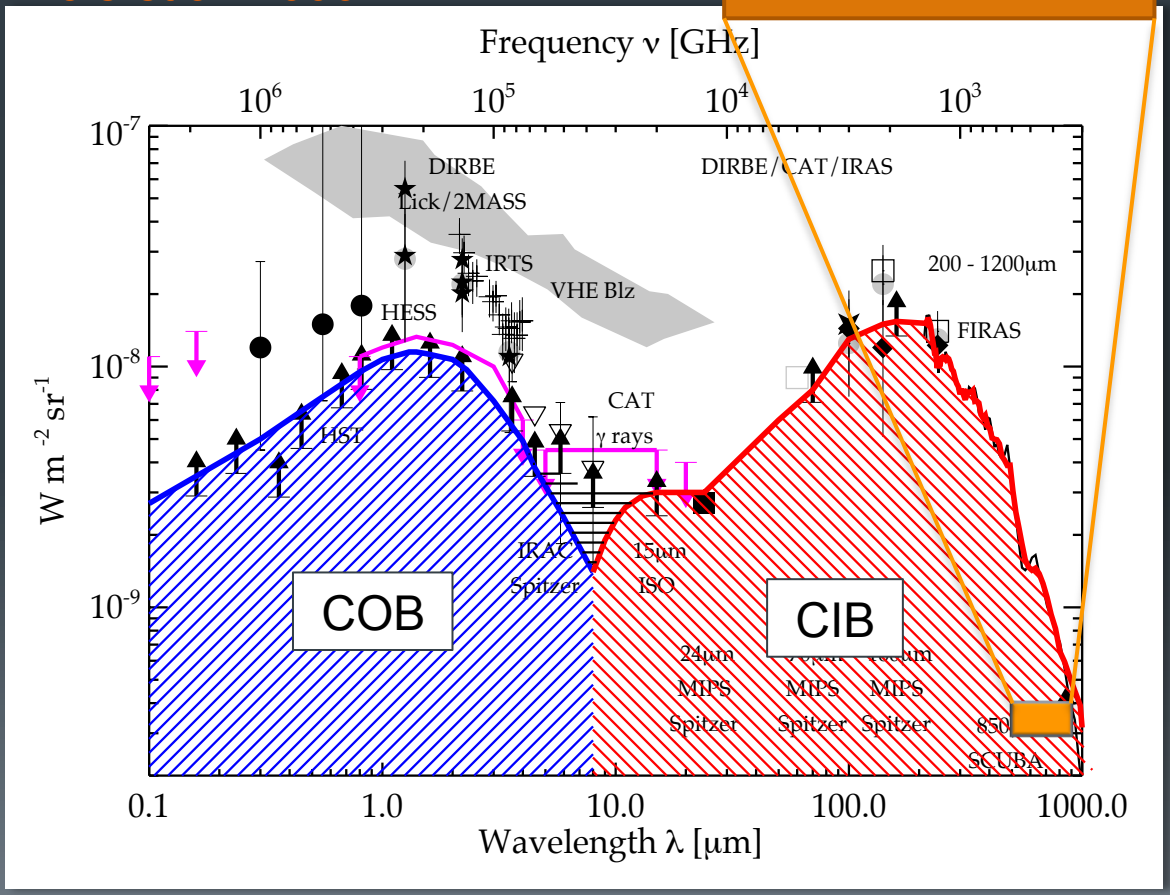
Cosmic Infrared Background

The CIB is due to UV light absorbed by dust and re-radiated in the infrared wavelength range

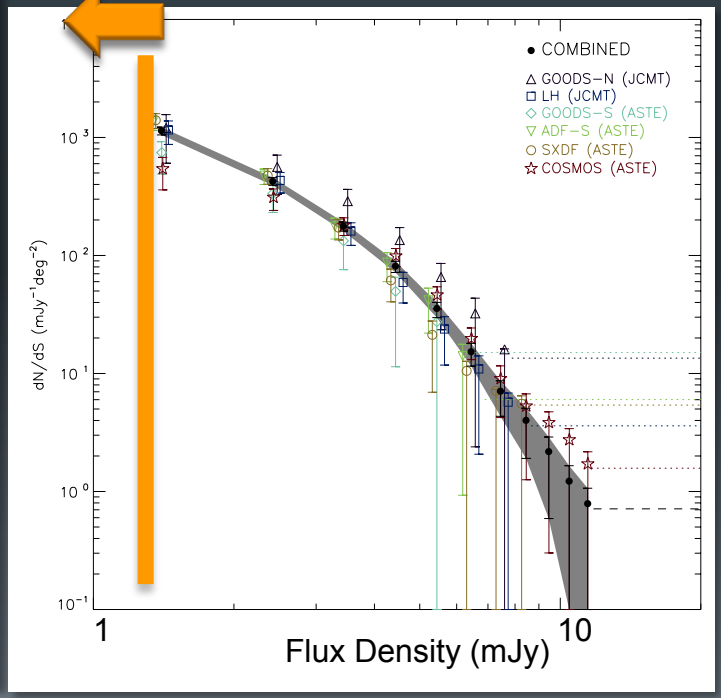
Dole et al. 2006

~ 7% is resolved



ALMA

Scott et al. 2012



Source Extraction

Carniani et al. (in prep.)

Data:

ALMA band 6 & 7 cycle 0 & 1

18 continuum maps

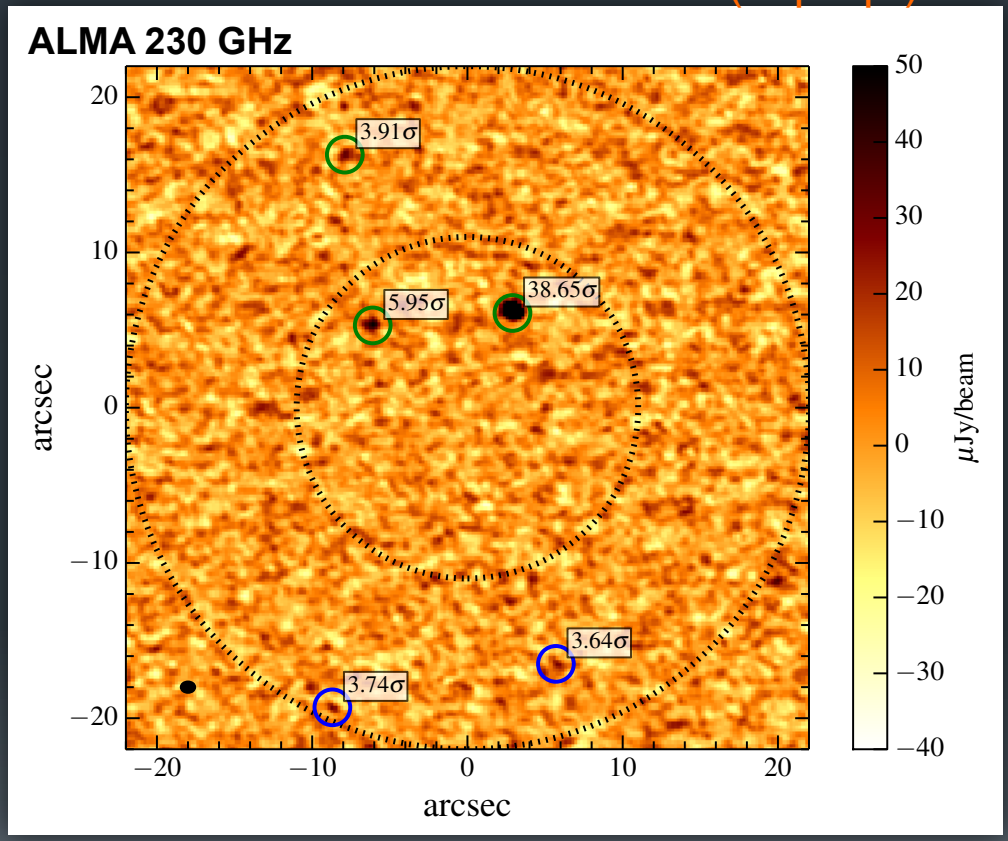
σ = 7.8-52.1 μJy/beam

Area:

2 primary beams (r ~ 22")

Source extraction requirements:

1. **S/N > 3.5**
2. **size source ≈ ALMA beam**



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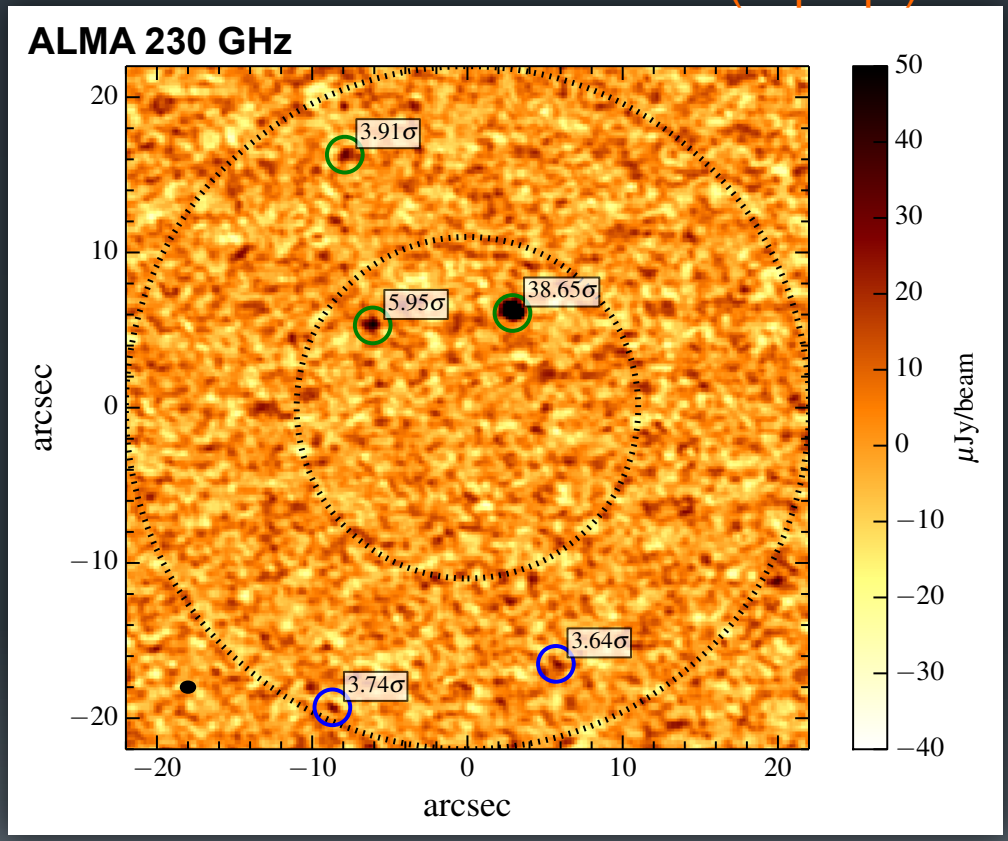


50 sources with flux densities down to 60 μJy

24 at 1.1 mm

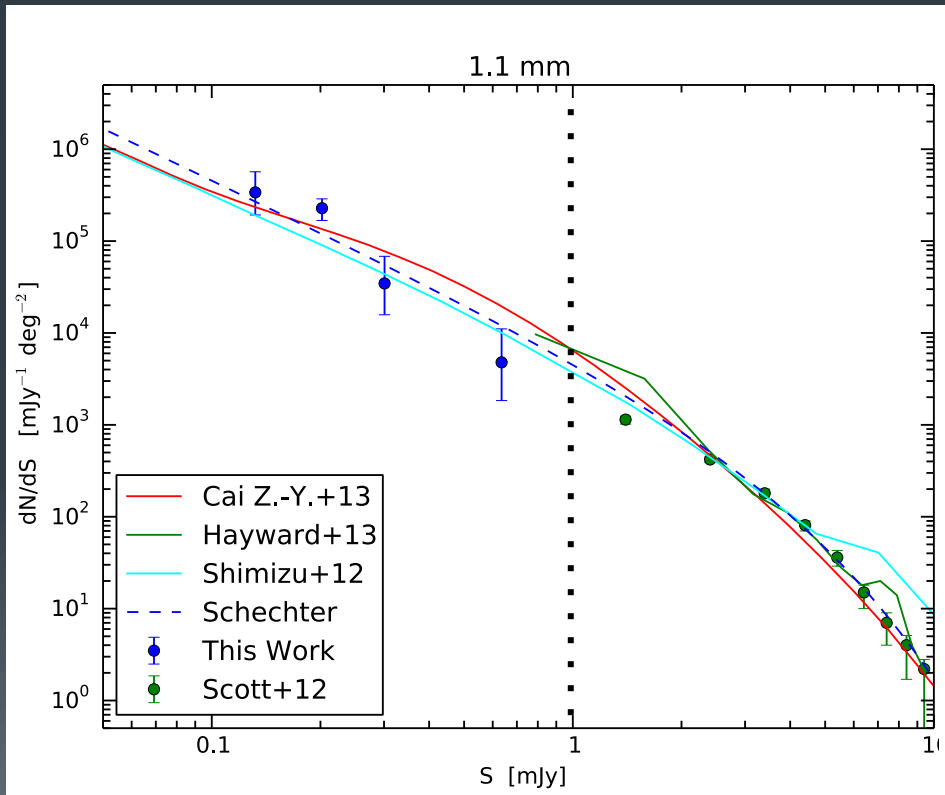
26 at 1.3 mm

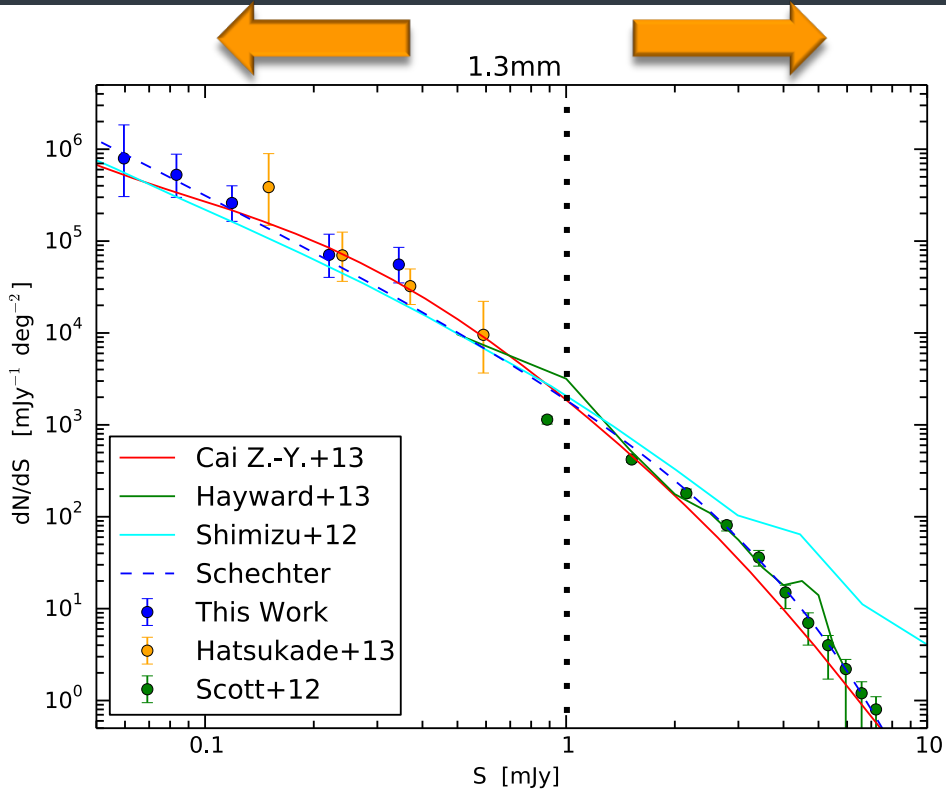
Number Counts

The differential number counts increase with decreasing flux density down to 0.1 mJy at 1.1 mm and to 0.06 mJy at 1.3 mm

Faint sources

Bright sources

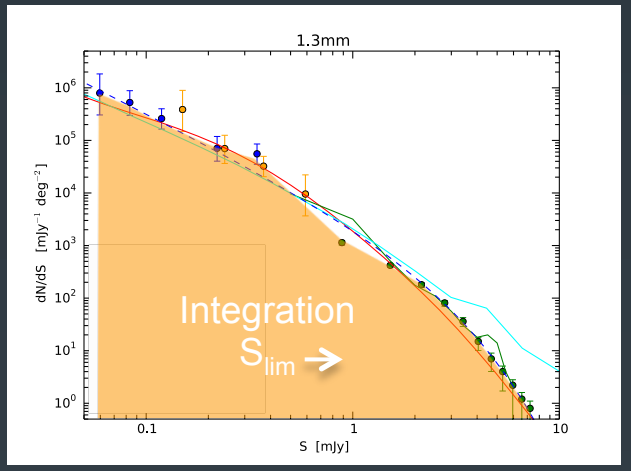




Carniani et al. (in prep)

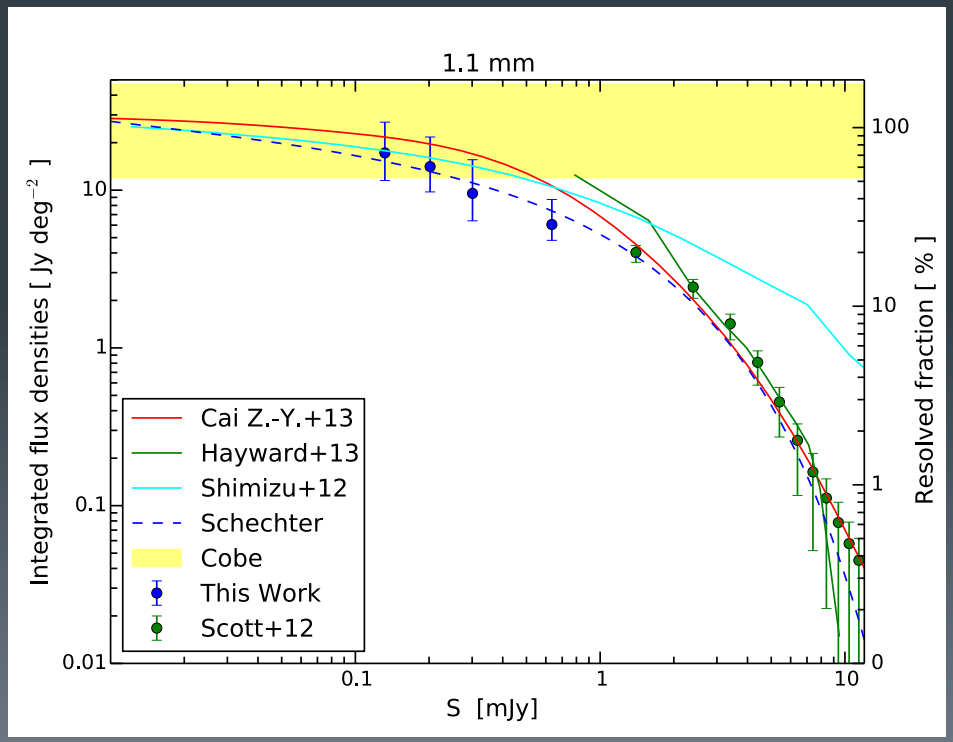
Resolving the CIB

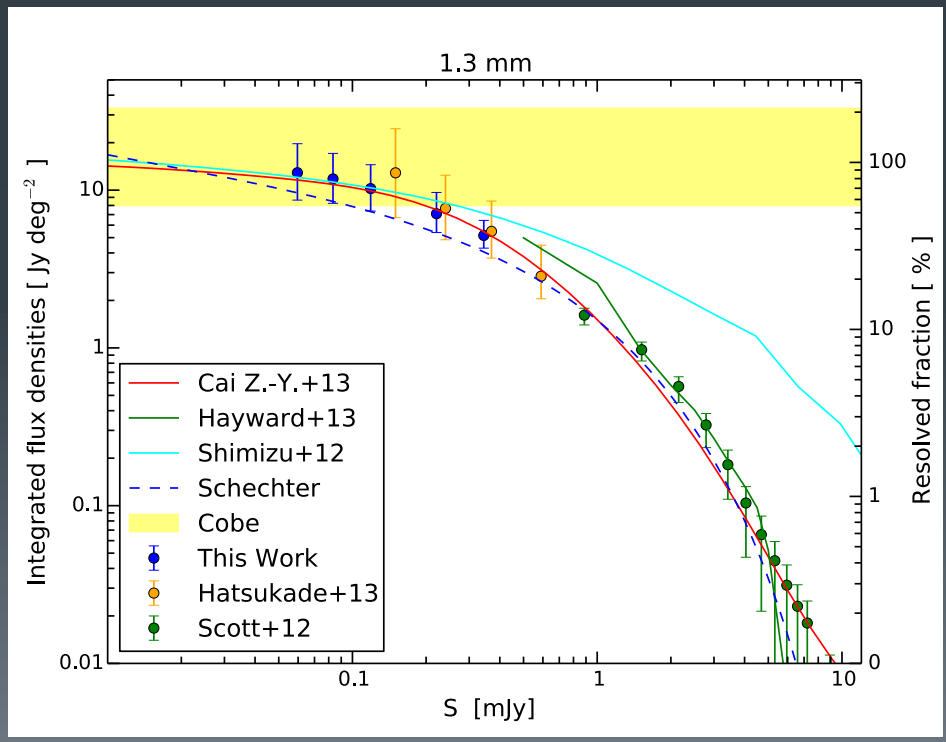
Integrated flux densitiy $\int_{S_{lim}}^{\infty} \frac{dn}{dS} S dS$



- Contribution from faint sources is larger than the one from bright (> 1mJy) objects

Carniani et al. (in prep)

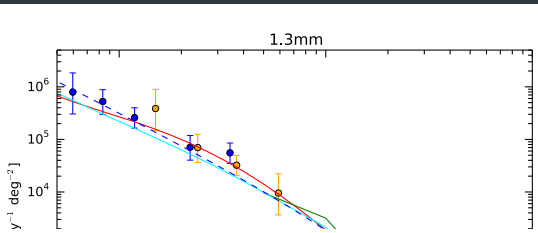


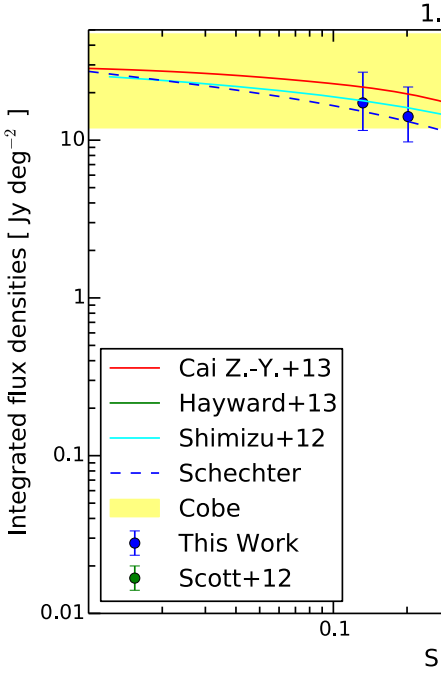


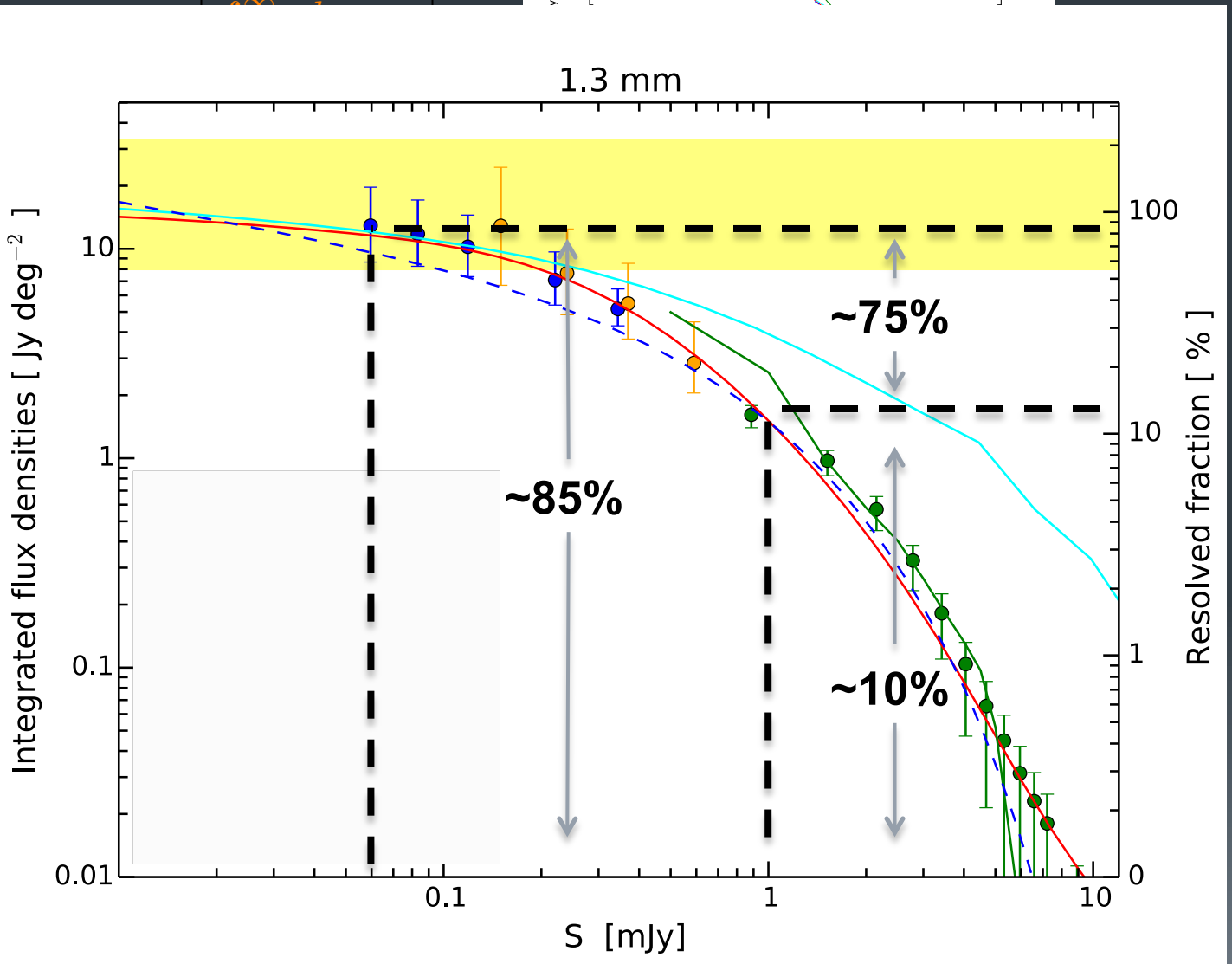
Resolving the CIB

Integrated flu

- Contribution fr
than the one fr







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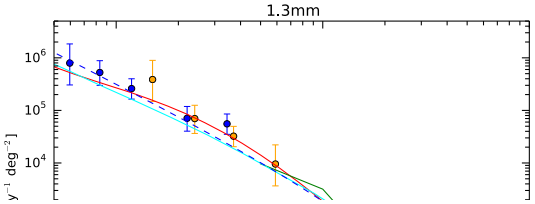
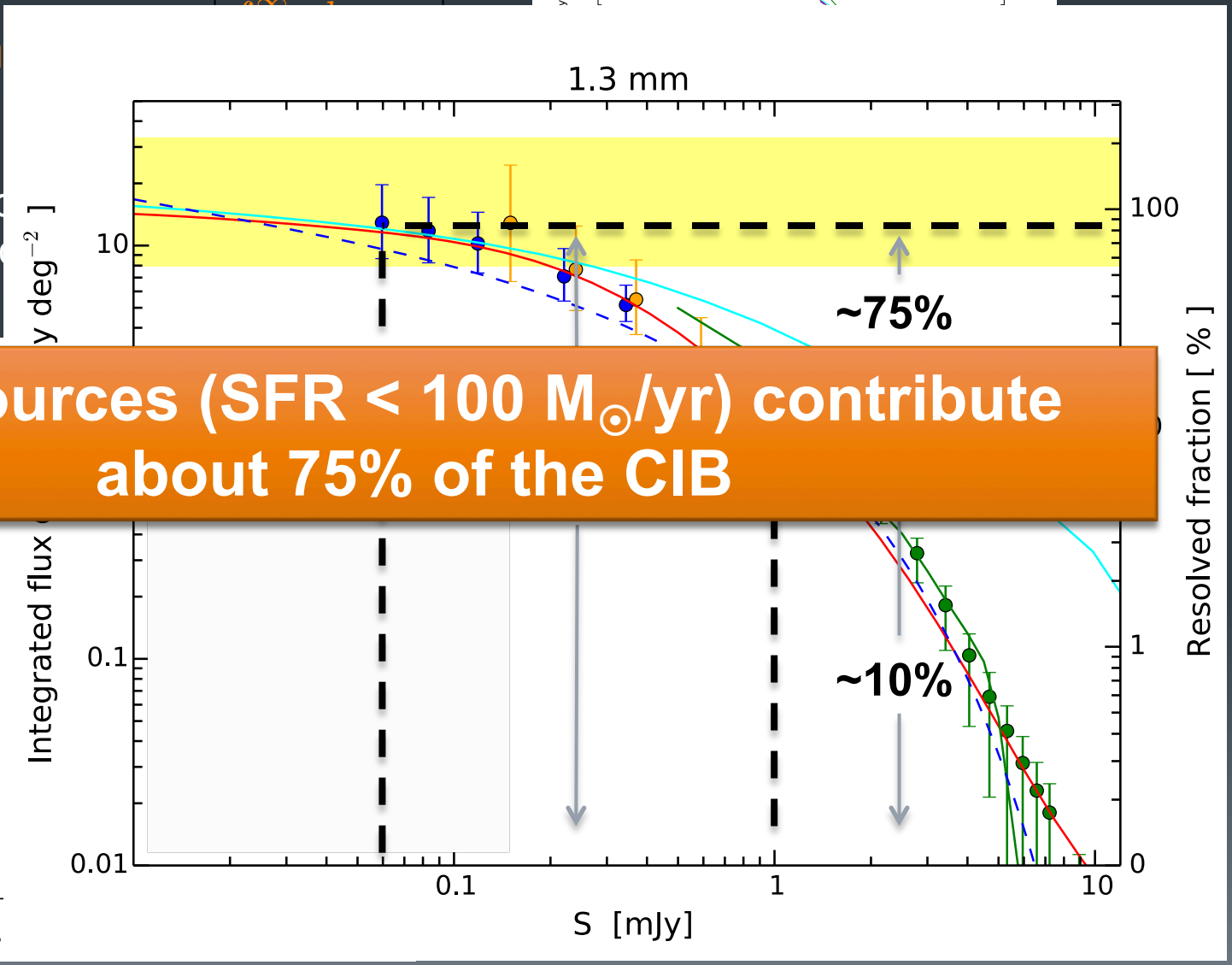
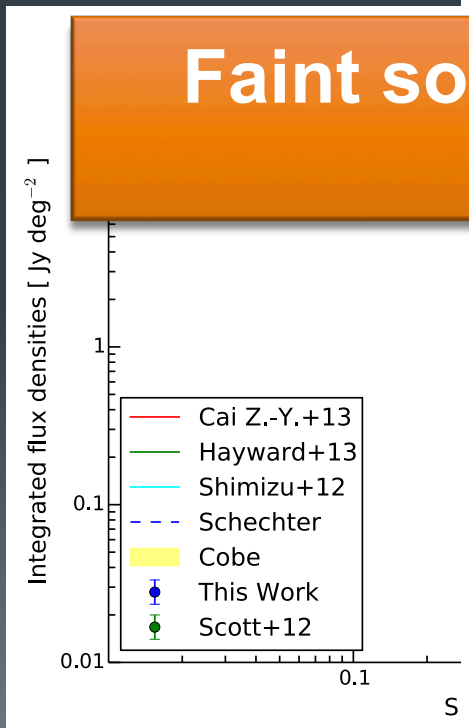
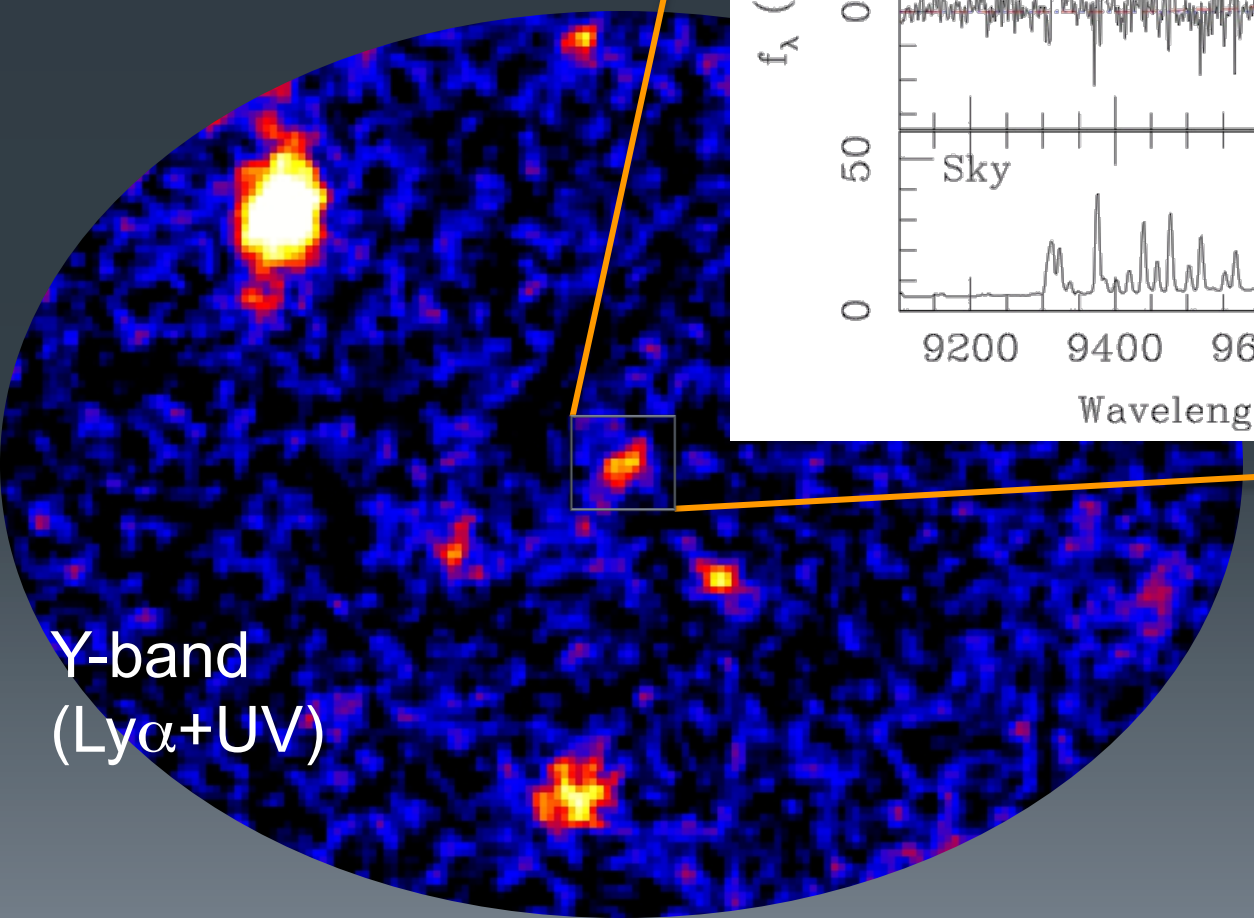


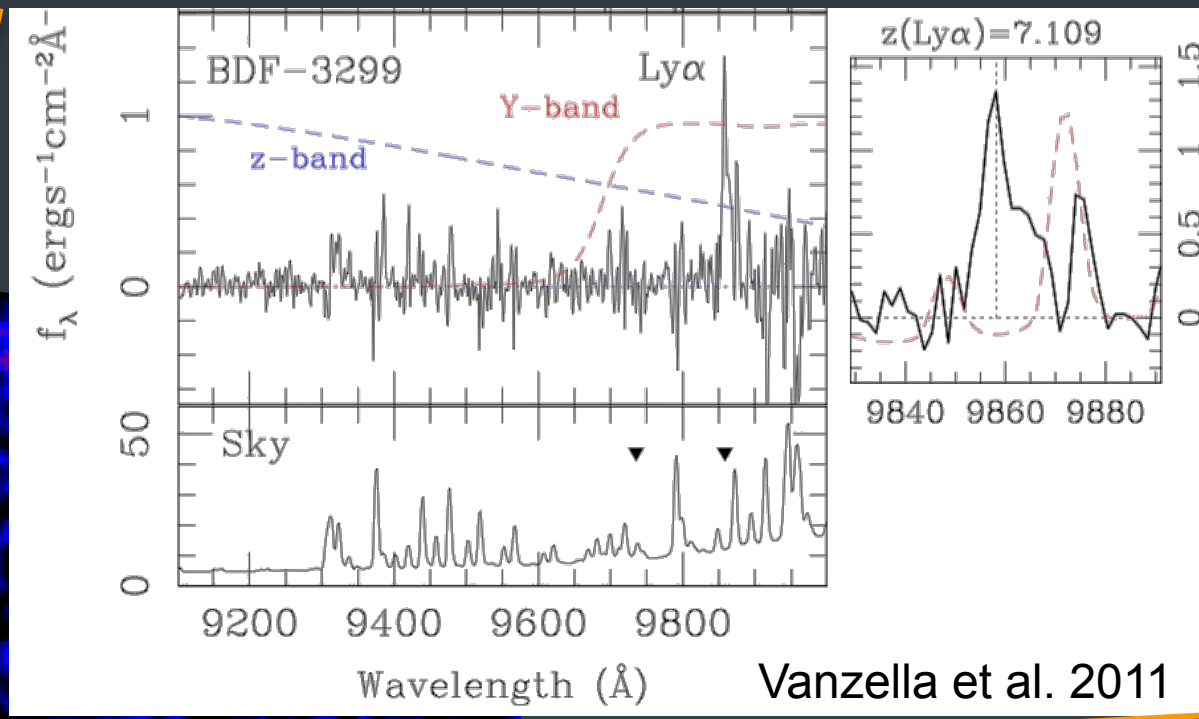


Faint sources (SFR < 100 $M_\odot$/yr) contribute about 75% of the CIB



Star Forming Galaxy at z~7.1



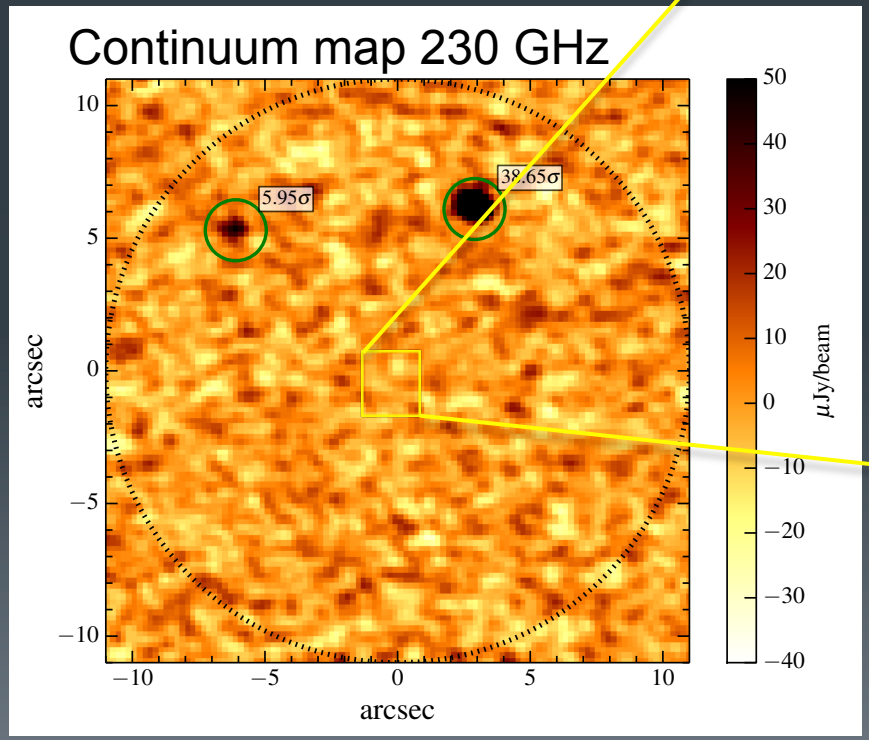


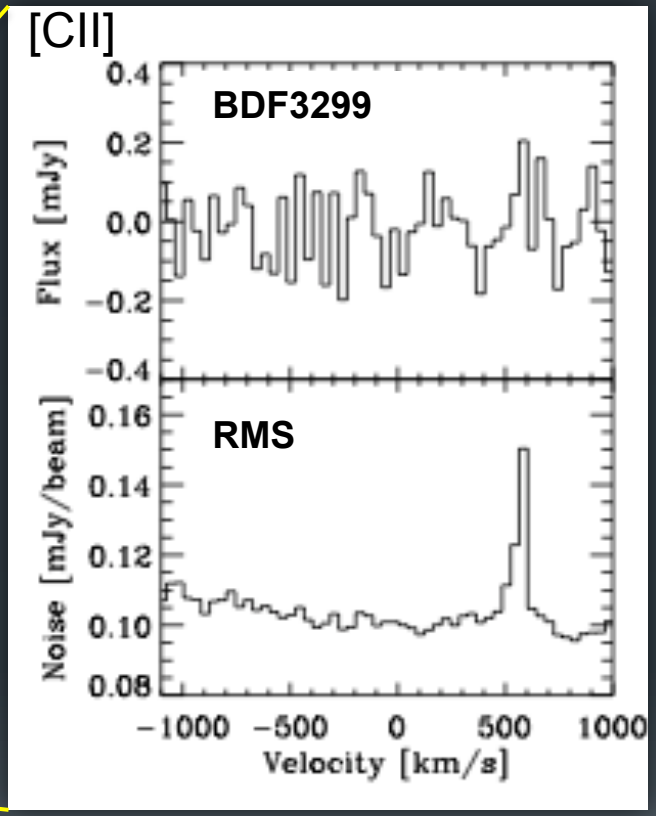
Vanzella et al. 2011

SFR ~ 6 $M_\odot$/yr
(representative
of the galaxy pop.
at high-*z*)

Star Forming Galaxy at z~7.1

- **No [CII] detection at the location of UV+Lyα emission**



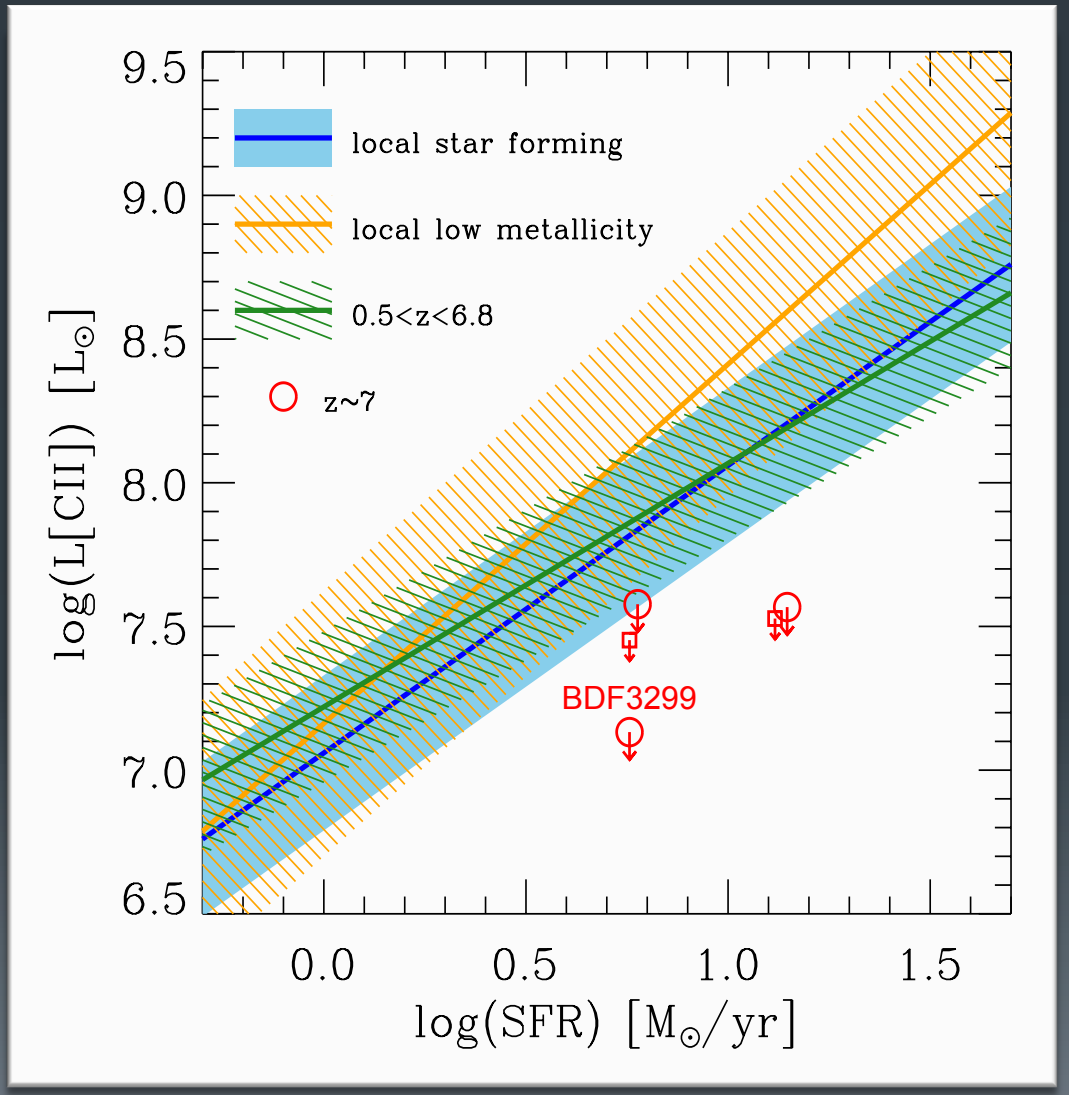


Maiolino et al. (in prep)

Star Forming Galaxy at z~7.1

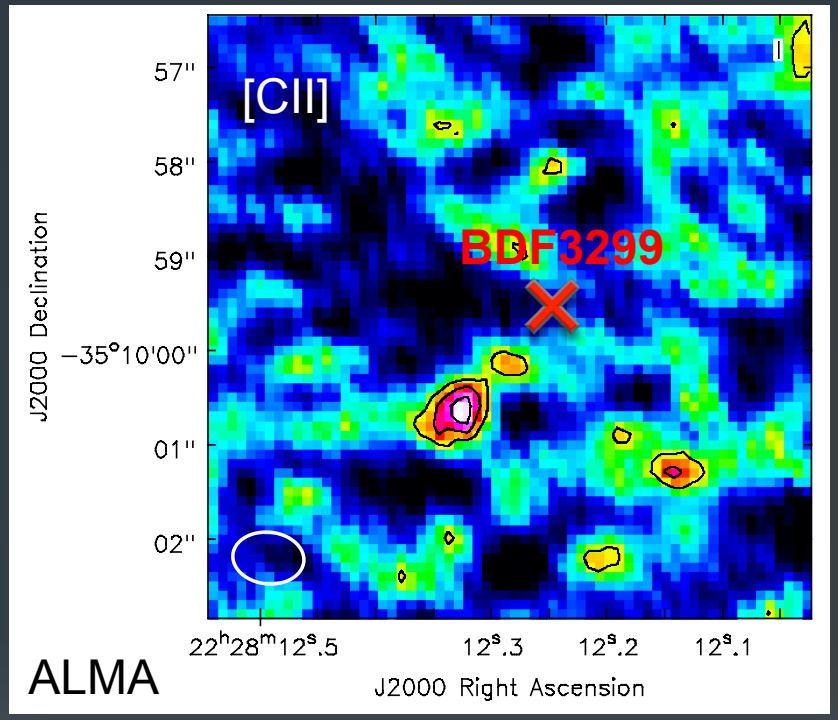
- No [CII] detection at the location of UV+Lyα emission

- **Inconsistent with local galaxies, even low metallicity ones, and inconsistent with other detections at lower and intermediate *z***
  (see L. Pentericci's talk)



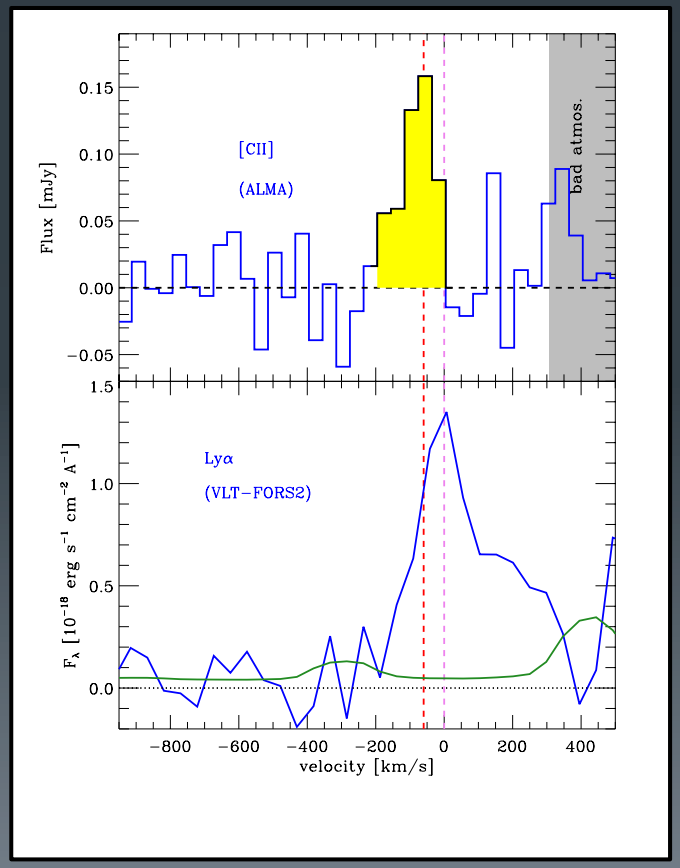
Maiolino et al. (in prep)

[CII] Detection at $z \sim 7.1$



v = -60 km/s (i.e. consistent with Lyα redshift especially if considering its IGM absorption)

FWHM = 100 km/s

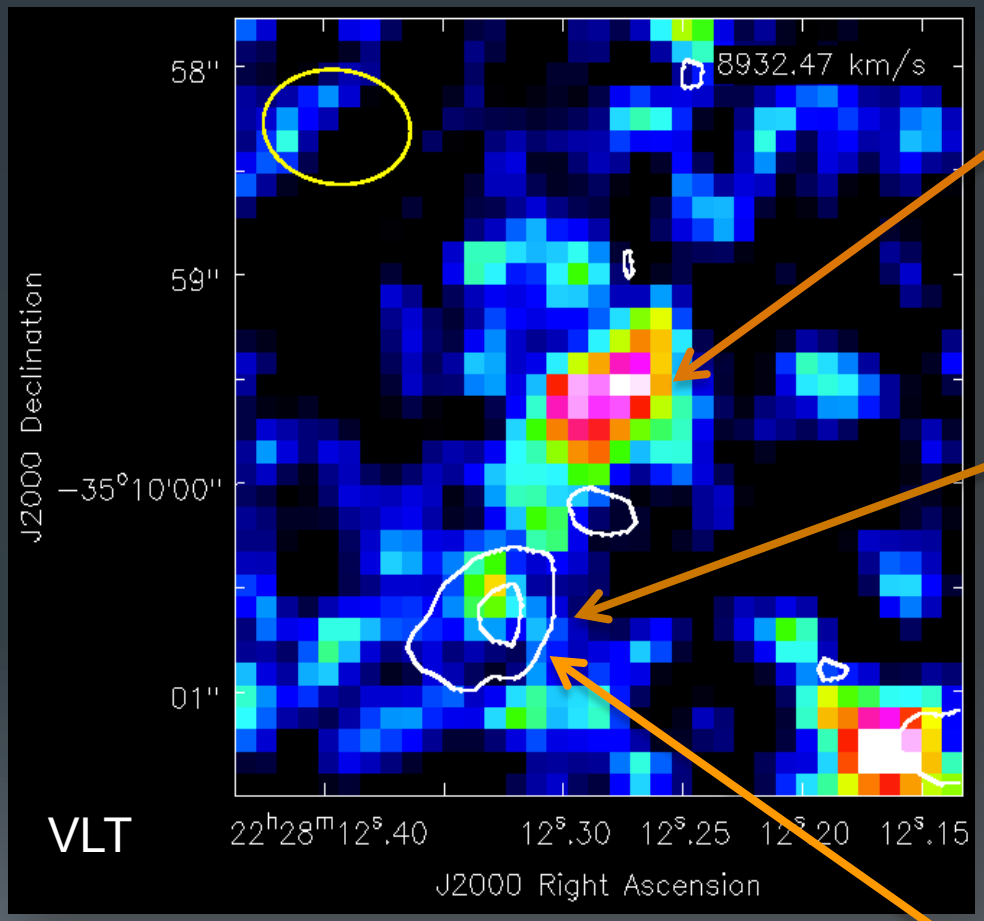


Peak emission only at 4.7σ

but integrated emission at 6.7σ

Maiolino et al. (in prep)

[CII] Detection at $z \sim 7.1$??

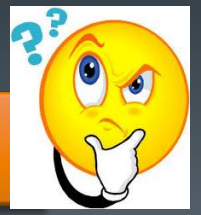


Maiolino et al. (in prep.)

BDF3299:
Y_{105}-band: UV & Lyα

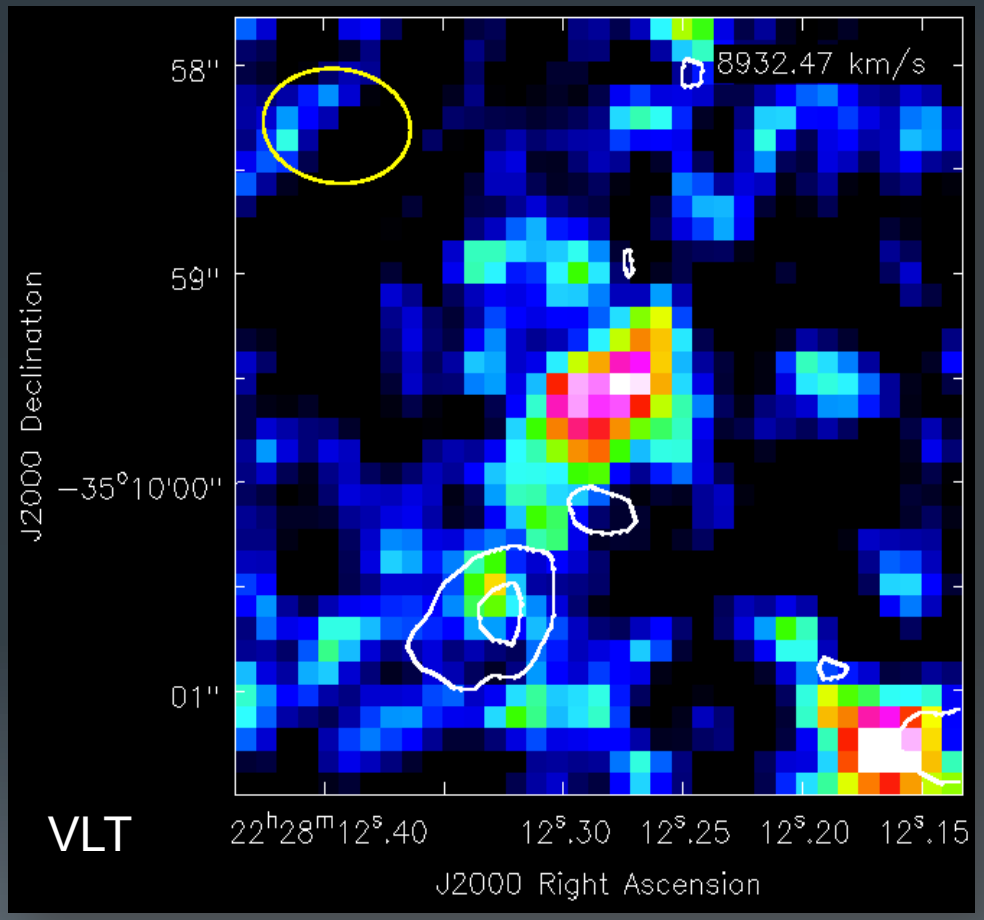
Detected in recent deep HST observations in Y_{105} and I_{814} band

$z \sim 7.1$?



[CII]

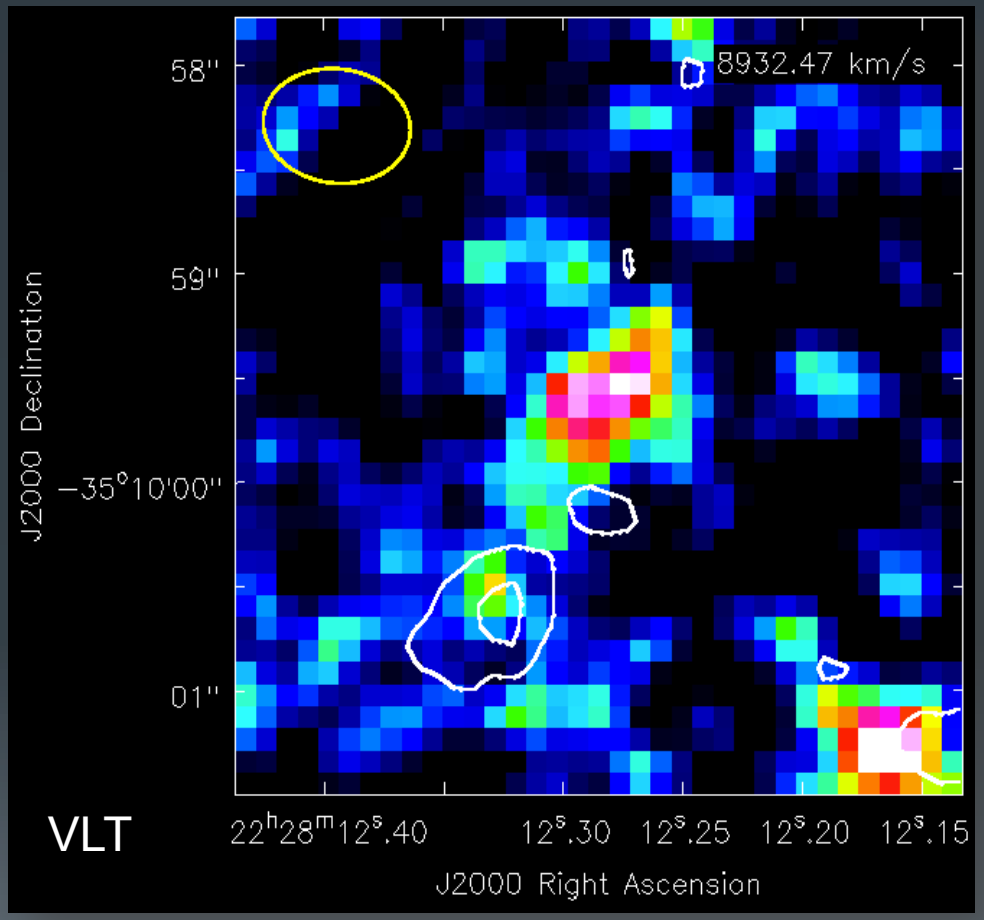
[CII] Detection at *z* ~ 7.1 ??



- **CO line emission at low-*z***
  - ➡ probability ~ 0.01%
- **Y source + [CII] source**
  - ➡ probability ~ 0.5%
- **Y source + [CII] cloud**

Maiolino et al. (in prep.)

[CII] Detection at z ~ 7.1 ??



Maiolino et al. (in prep.)

- **CO line emission at low-z**
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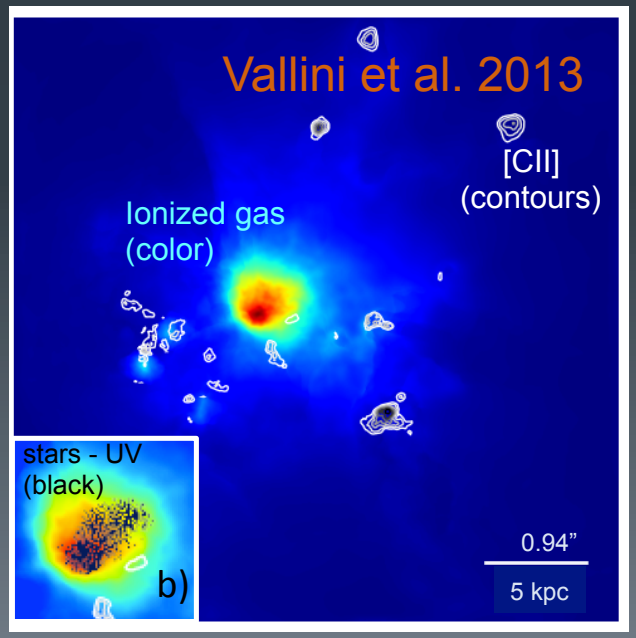
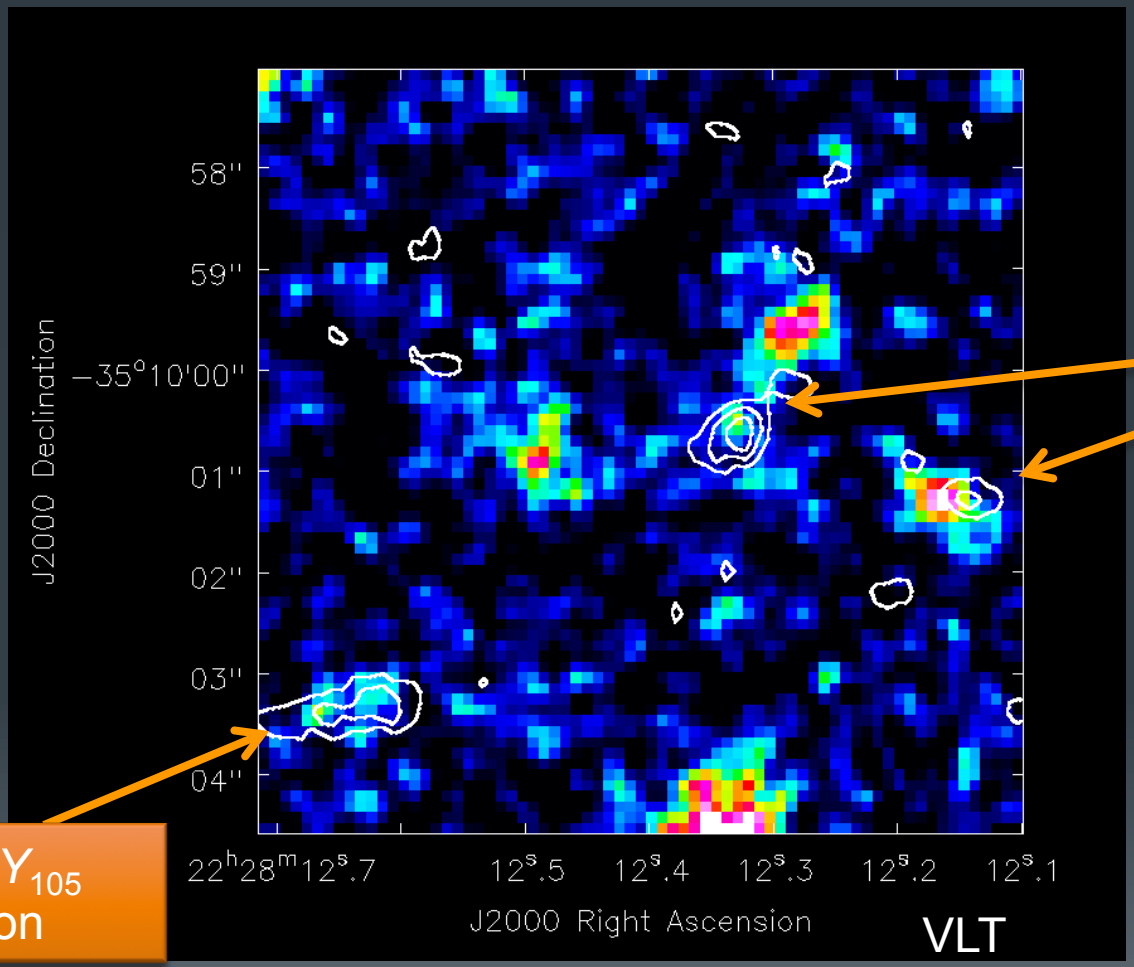


[CII] Detection at $z \sim 7.1$??



[CII] & Y_{105} detections

[CII] & Y_{105} detection

Maiolino et al. (in prep.)

Conclusions

BR 1202-0725 system :

- First [CII] detections of faint galaxies at $z \sim 4.7$
- Strongly star-forming rotating disks in a complex merging system

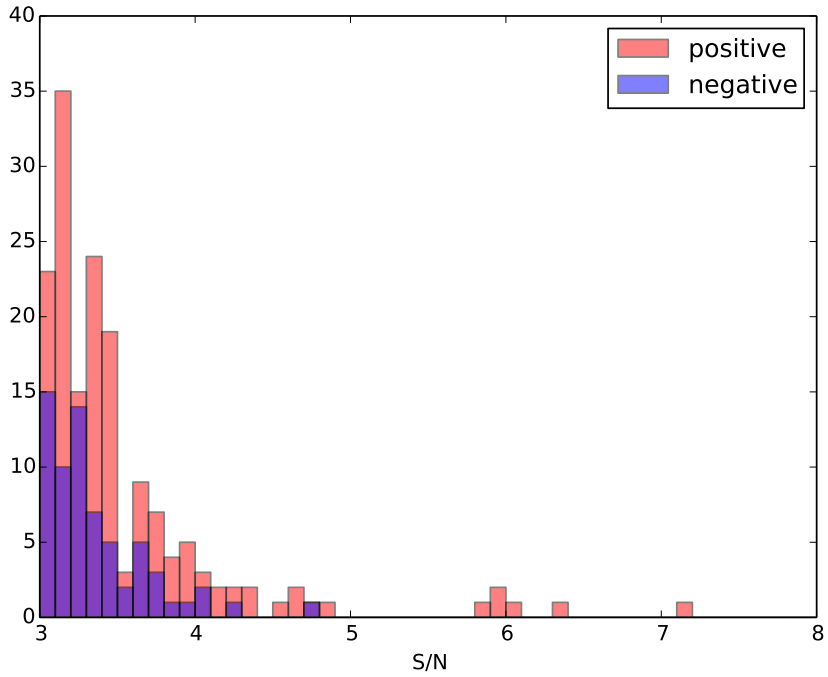
CIB observed with ALMA :

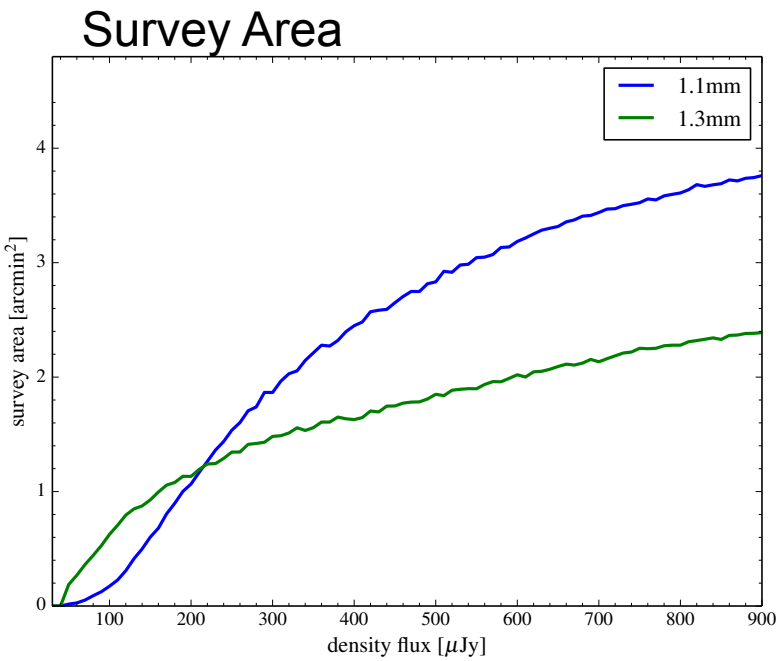
- 50 sources detected at 1.1 and 1.3 mm
- ~75% of the CIB is due to sources with $25 < SFR < 100\ M_{\odot}/yr$

Primeval galaxy probed by ALMA :

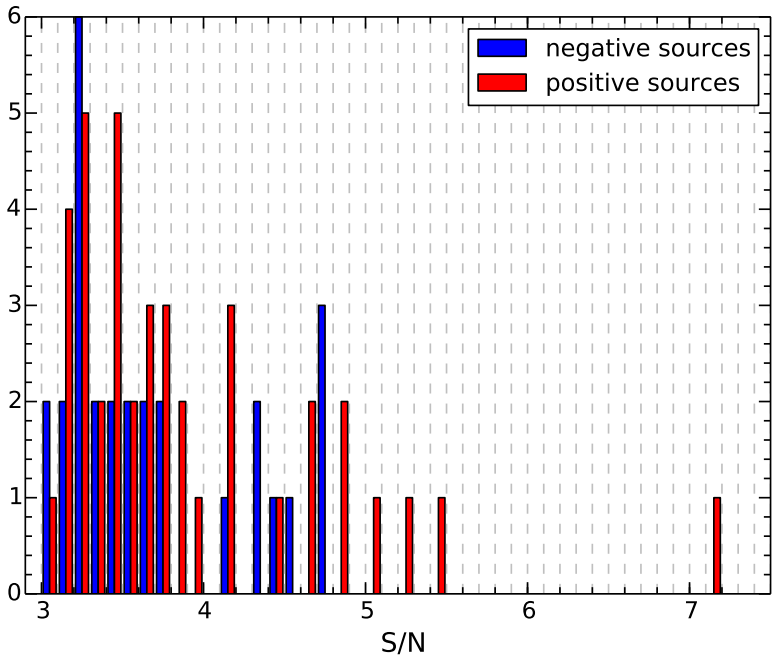
- Faint detection at $z \sim 7.1$

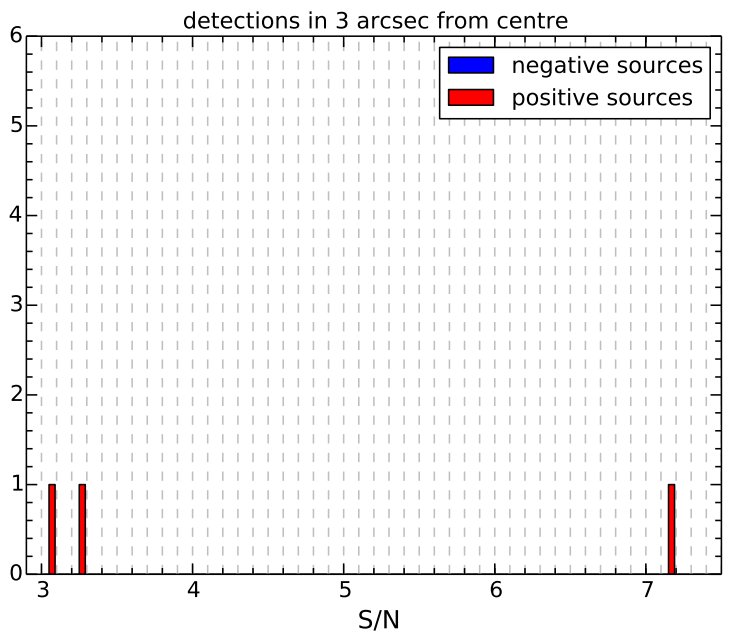
Source Extraction



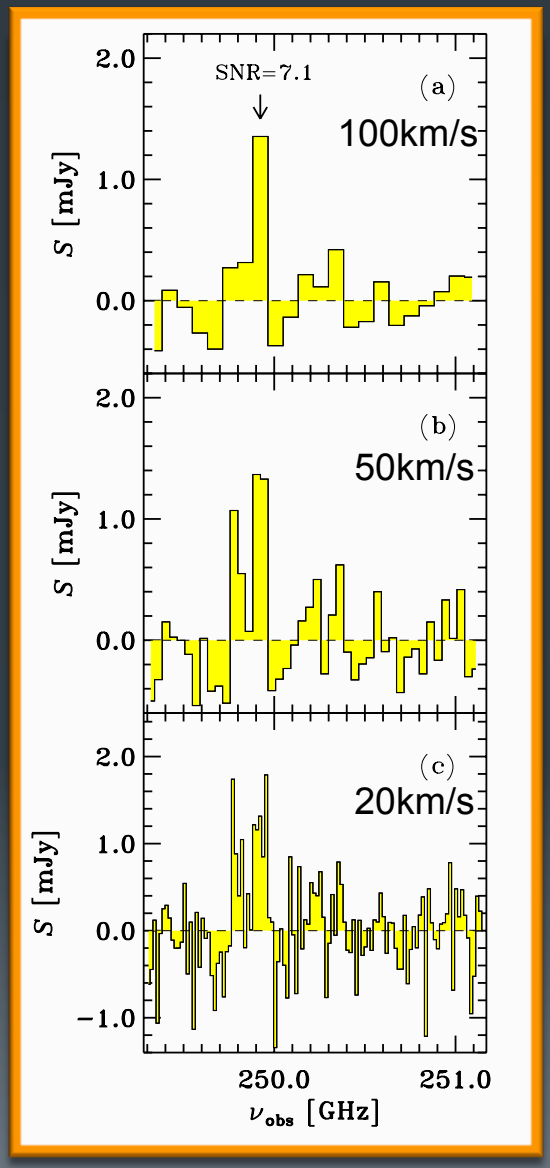


Source Extraction [CII]





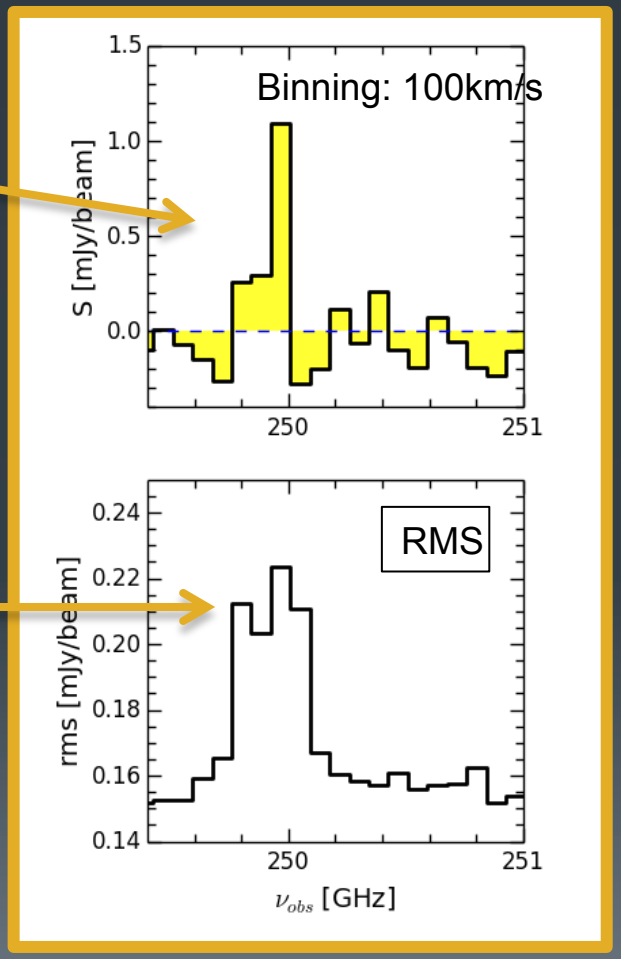
Ono et al 2014 Detection



Ono et al. 2014

- In ALMA, the noise is not spectrally uniform!

Re-reduced data and see detection

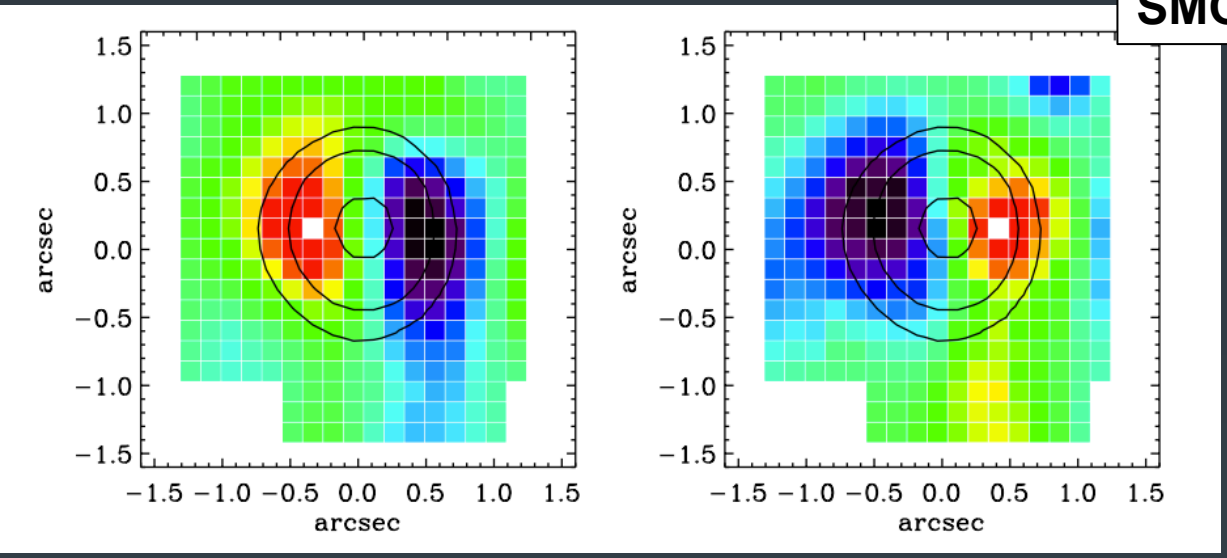


However it is in a bad atmospheric region

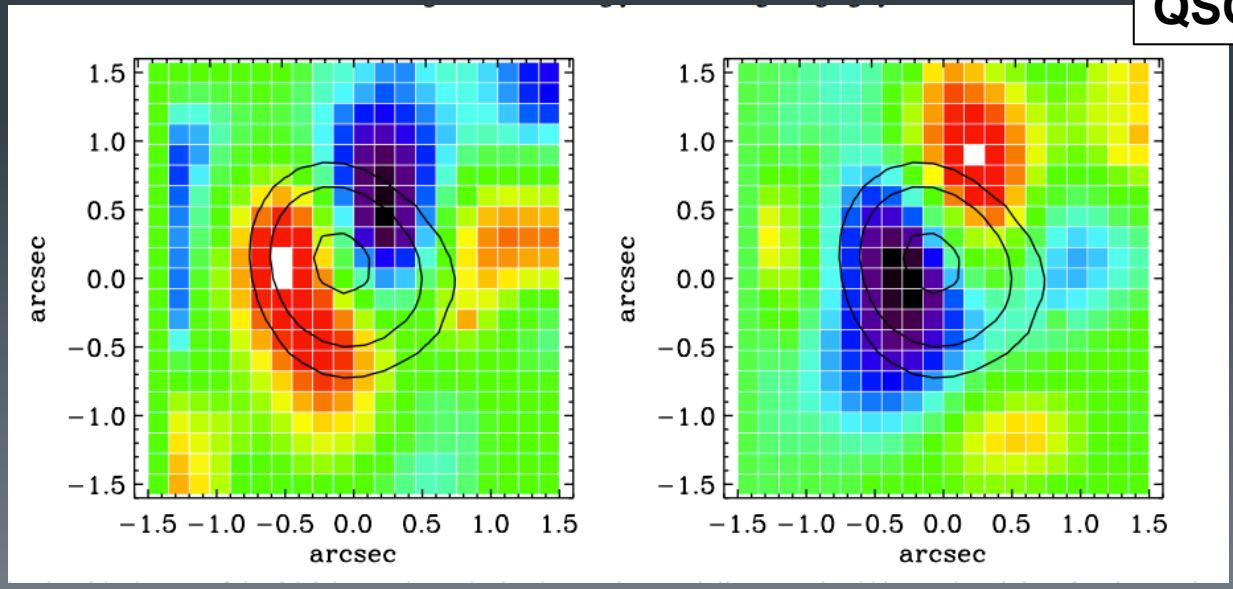
-> noise is higher

-> S/N lower

SMG


1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
arcsec
−1.5 −1.0 −0.5 0.0 0.5 1.0 1.5
arcsec

QSO


1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
arcsec
−1.5 −1.0 −0.5 0.0 0.5 1.0 1.5
arcsec