Extreme excitation in the lensed object G12v2.30

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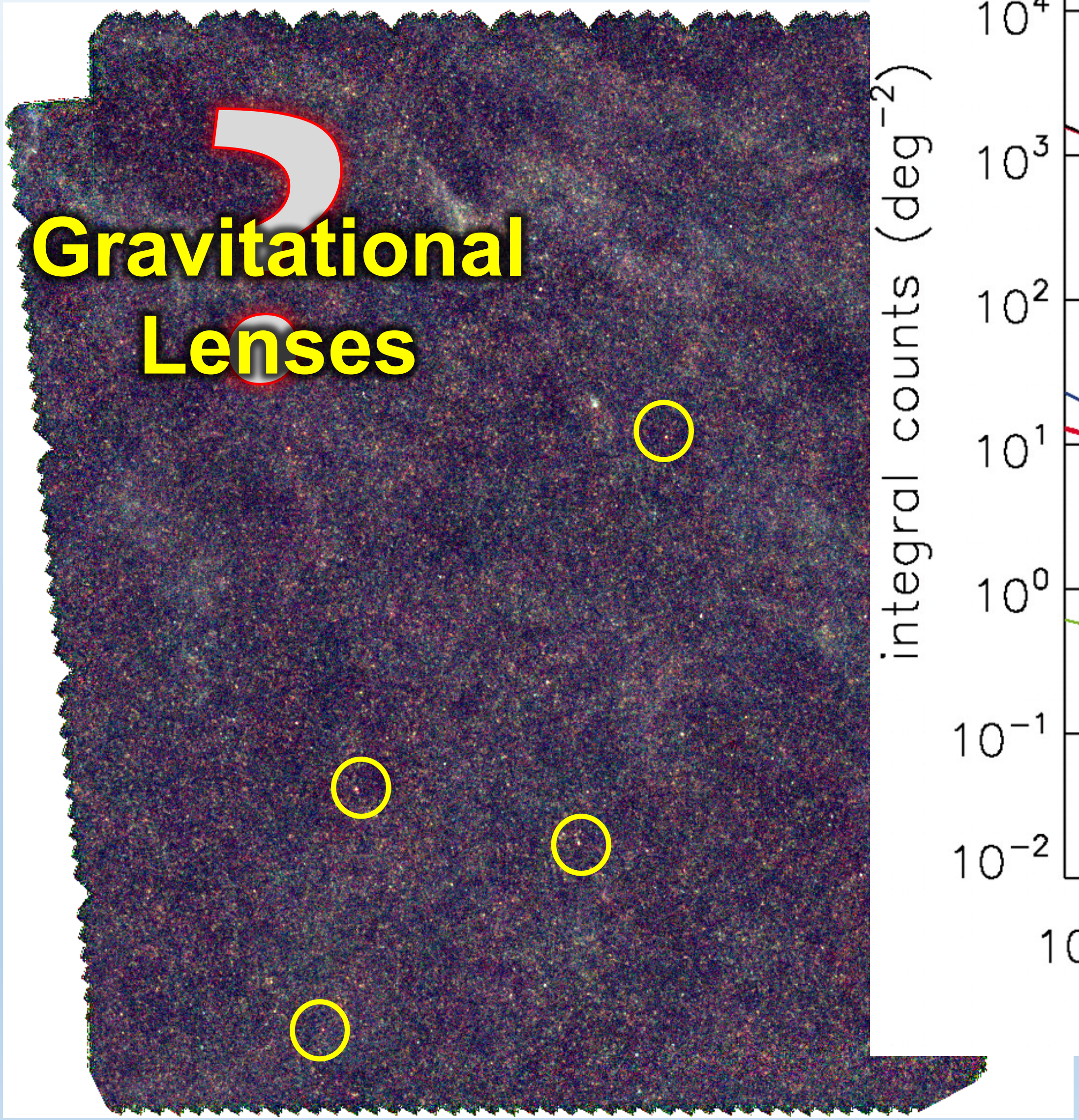
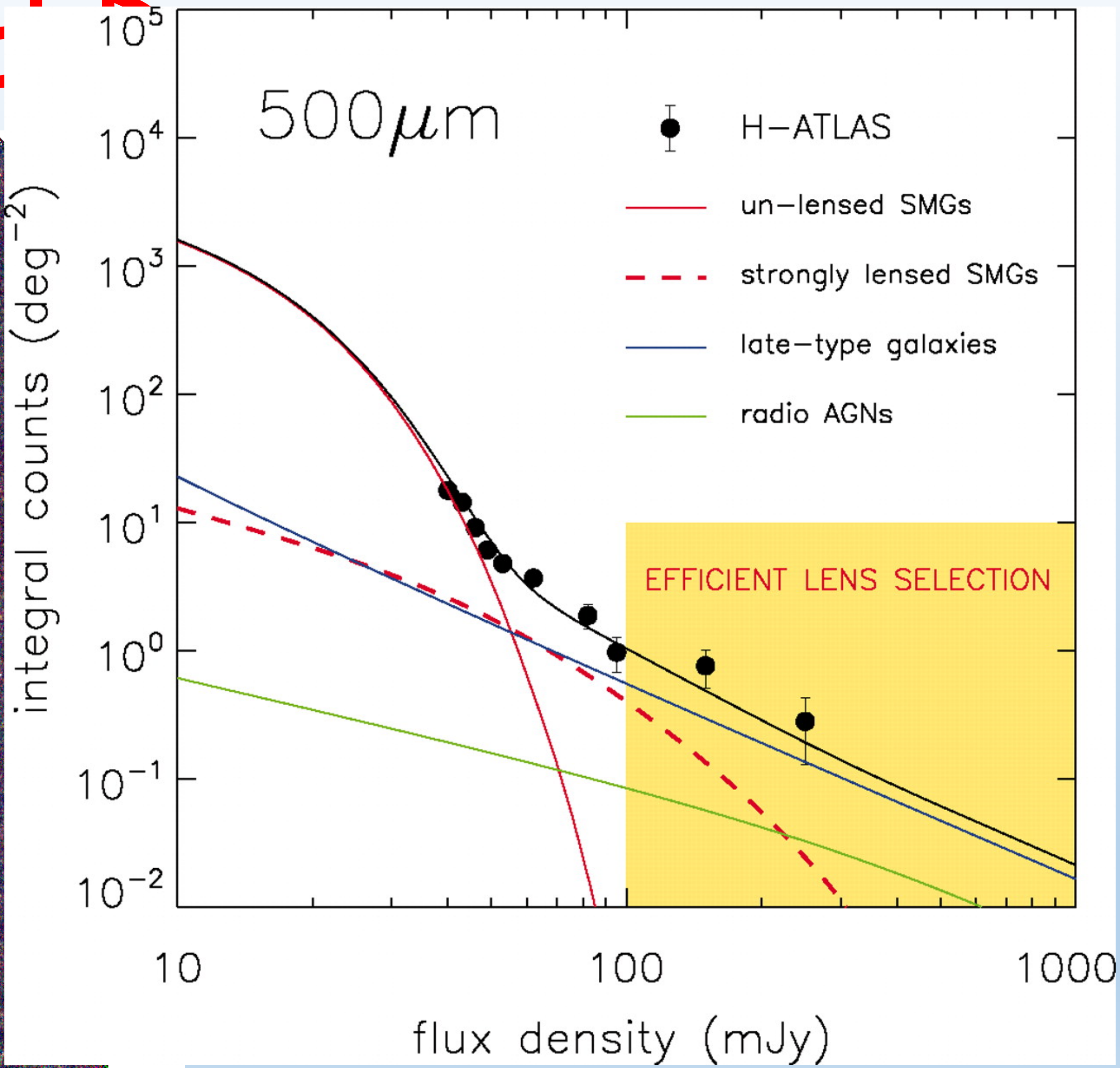
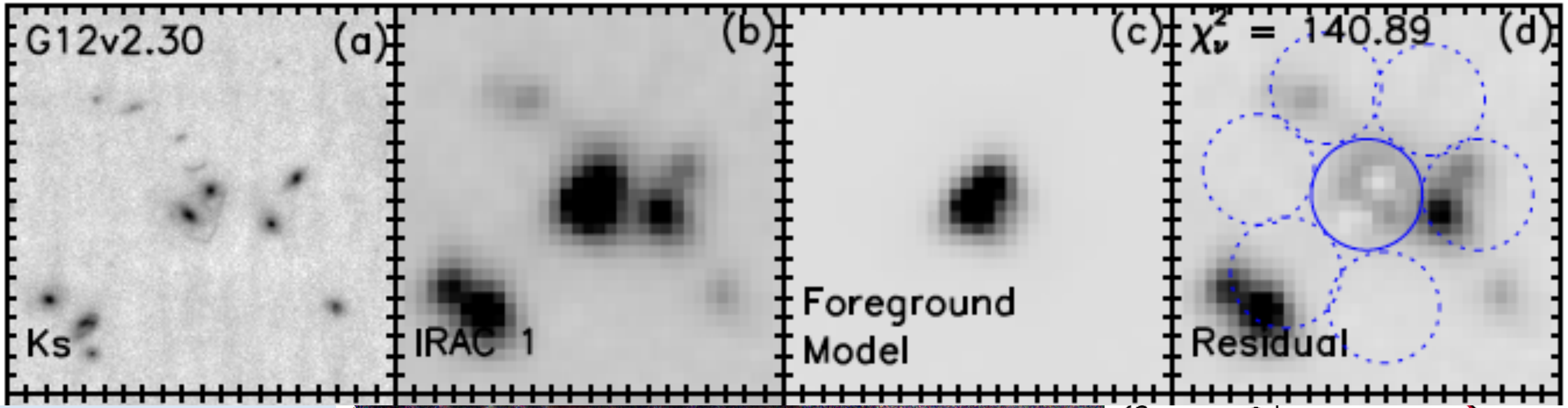
Zhi-Yu Zhang, Padelis Papadopoulos, Chentao Yang, Simona Vegetti

HATLAS SDP FIELD



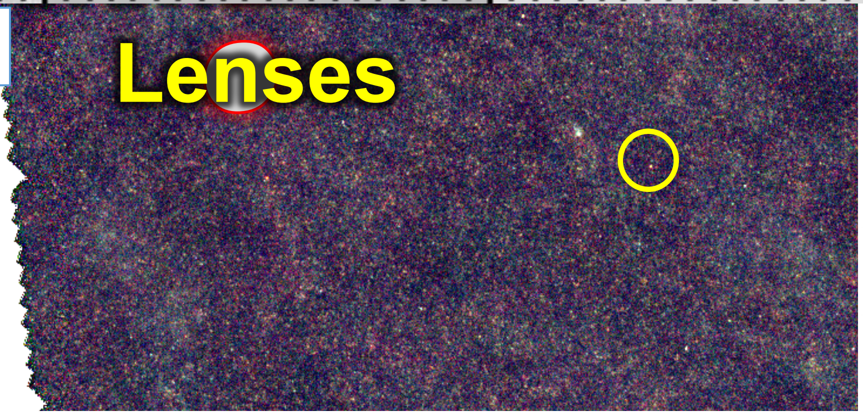


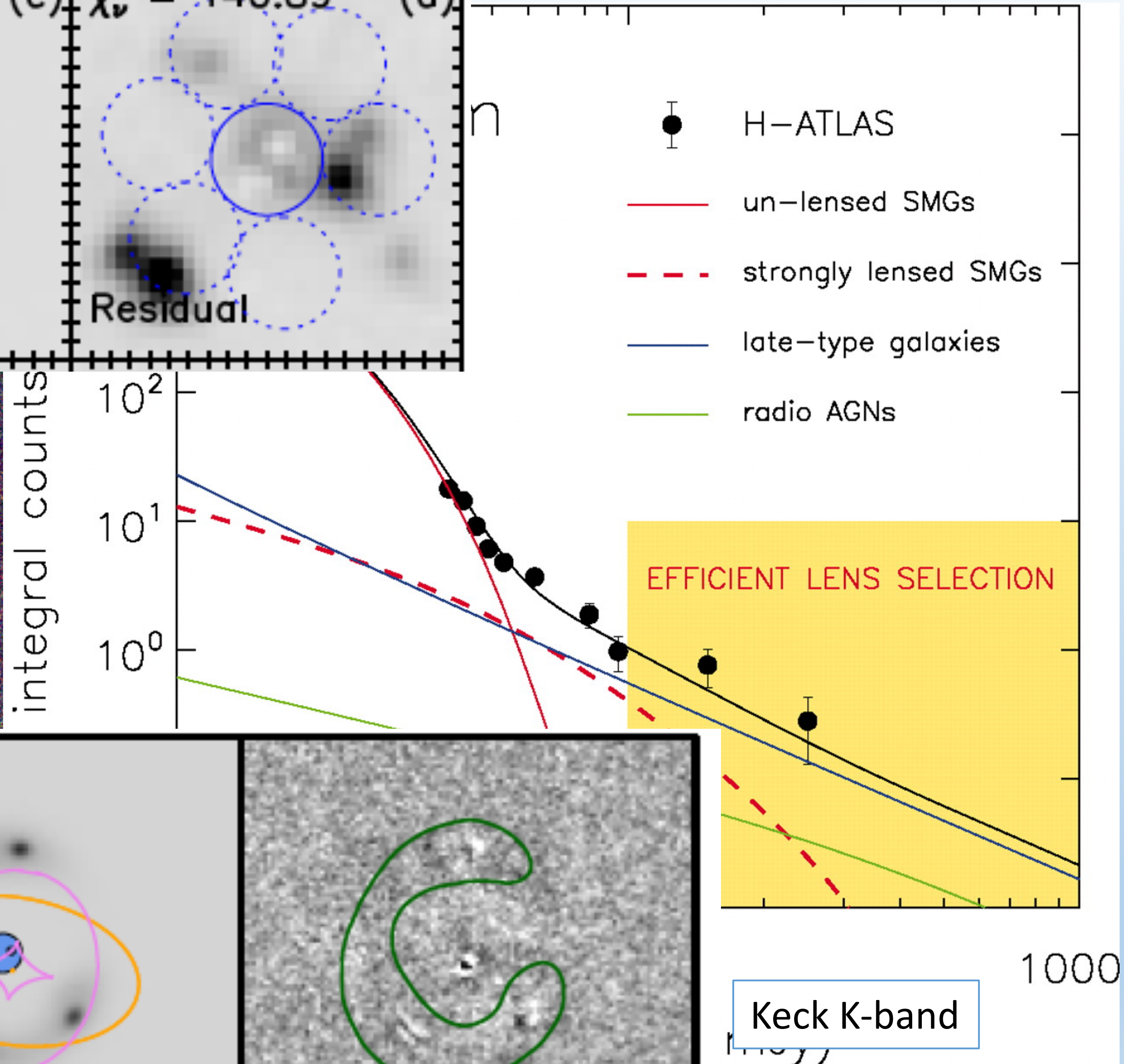
Negrello et al., 2007, 2010

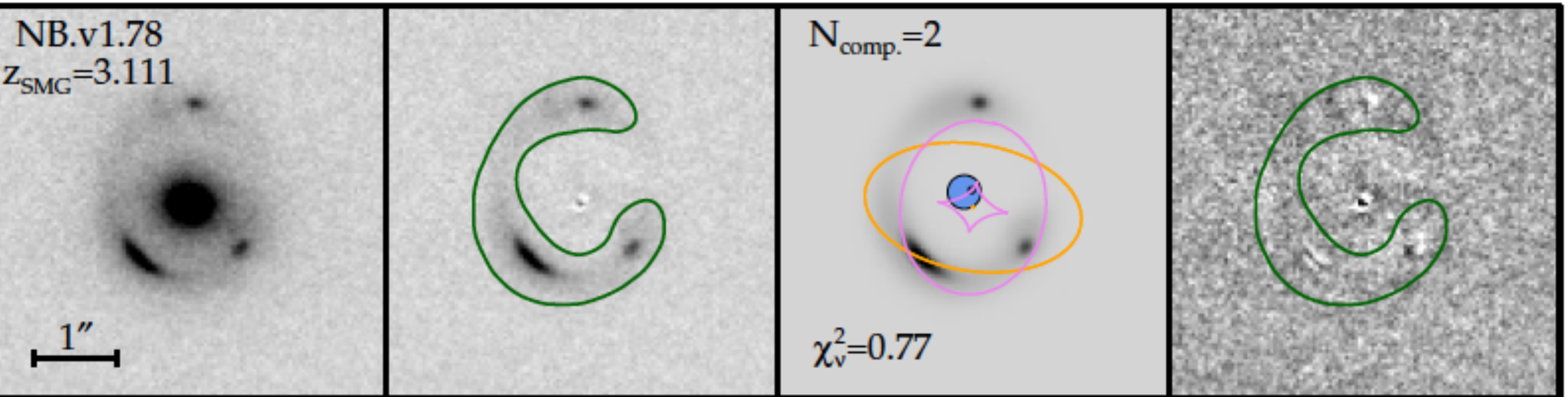


Keck K-band + IRAC

Ma+,2015



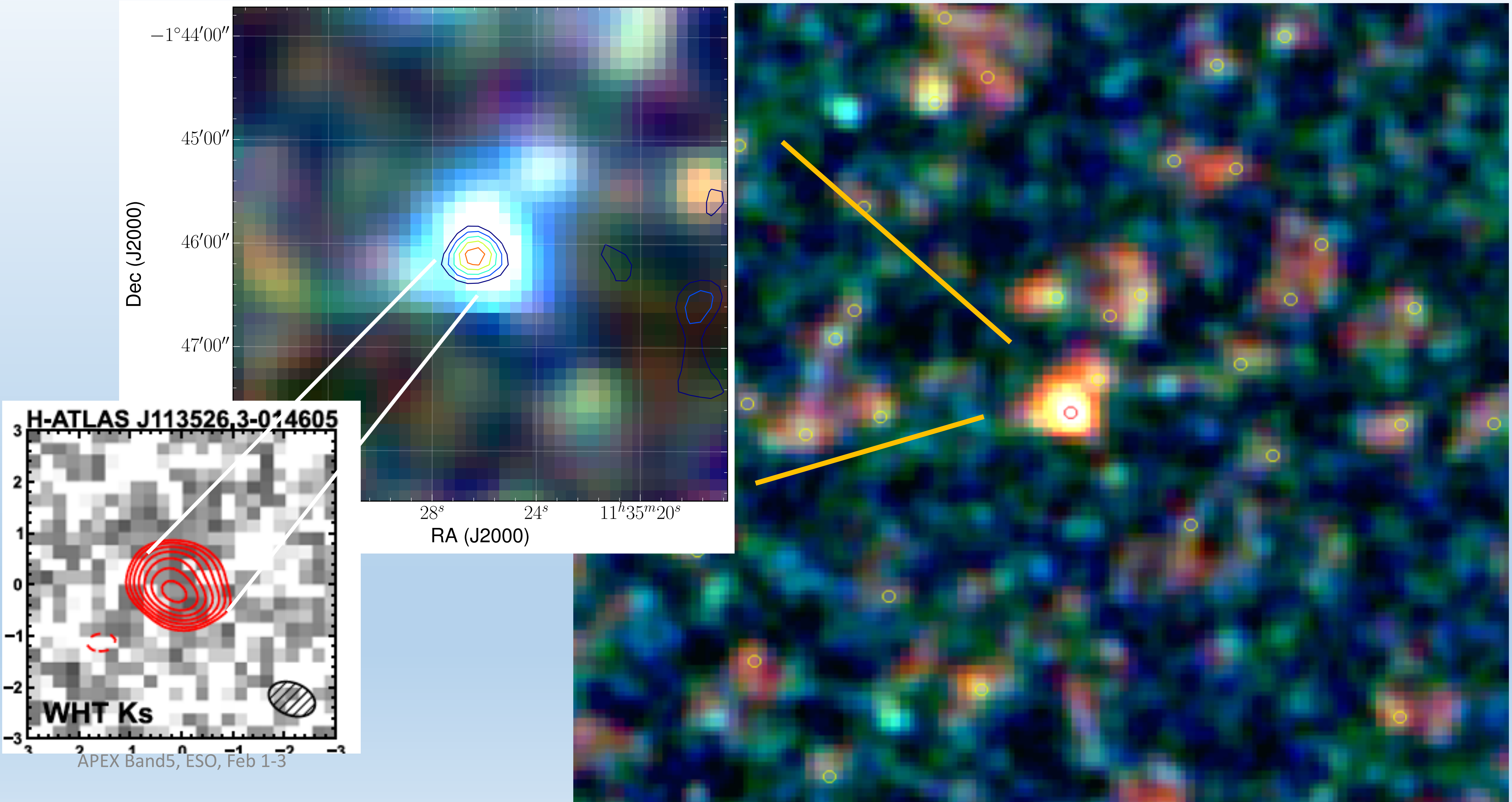




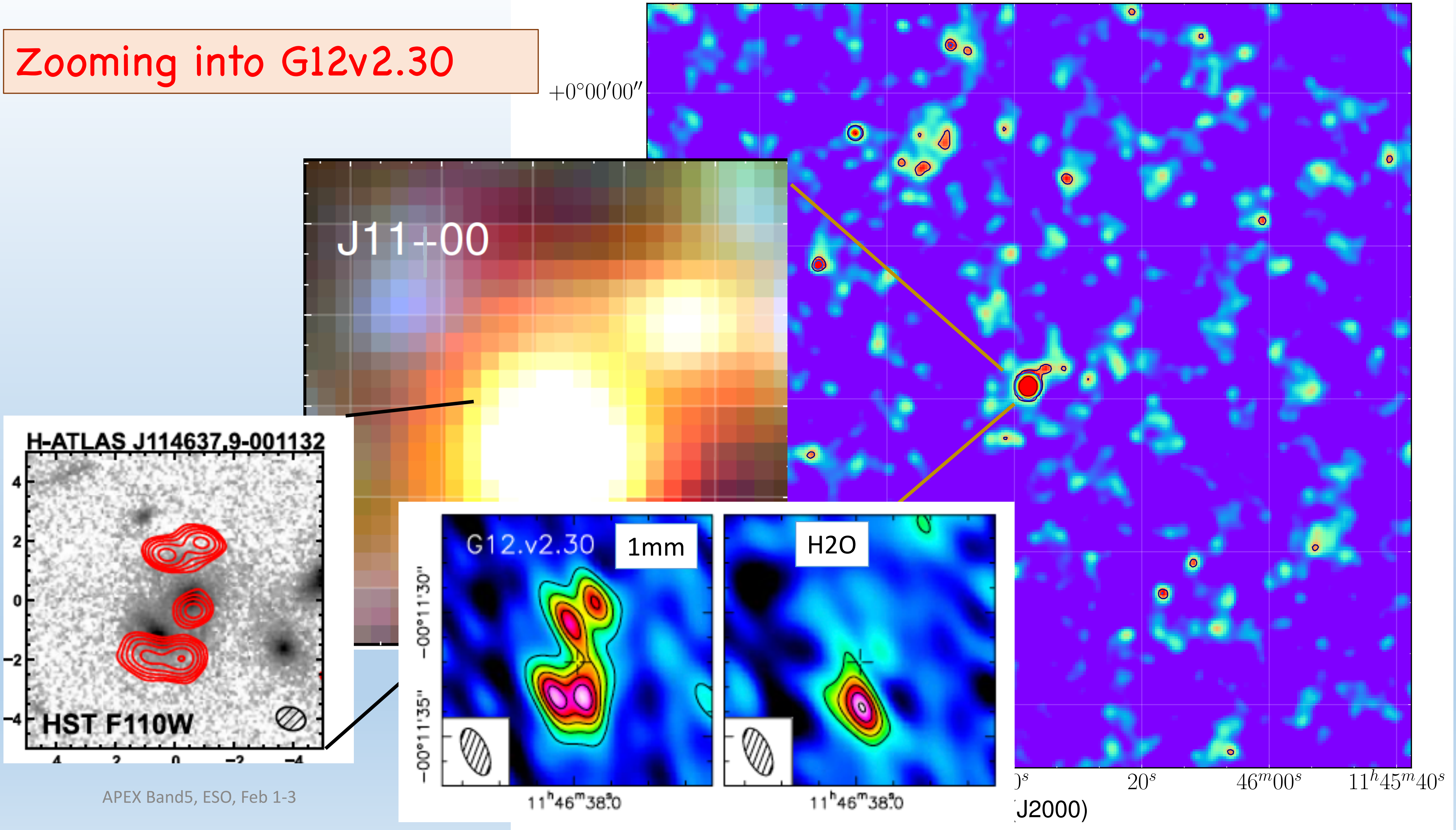
Keck K-band

Canalog+, 2015

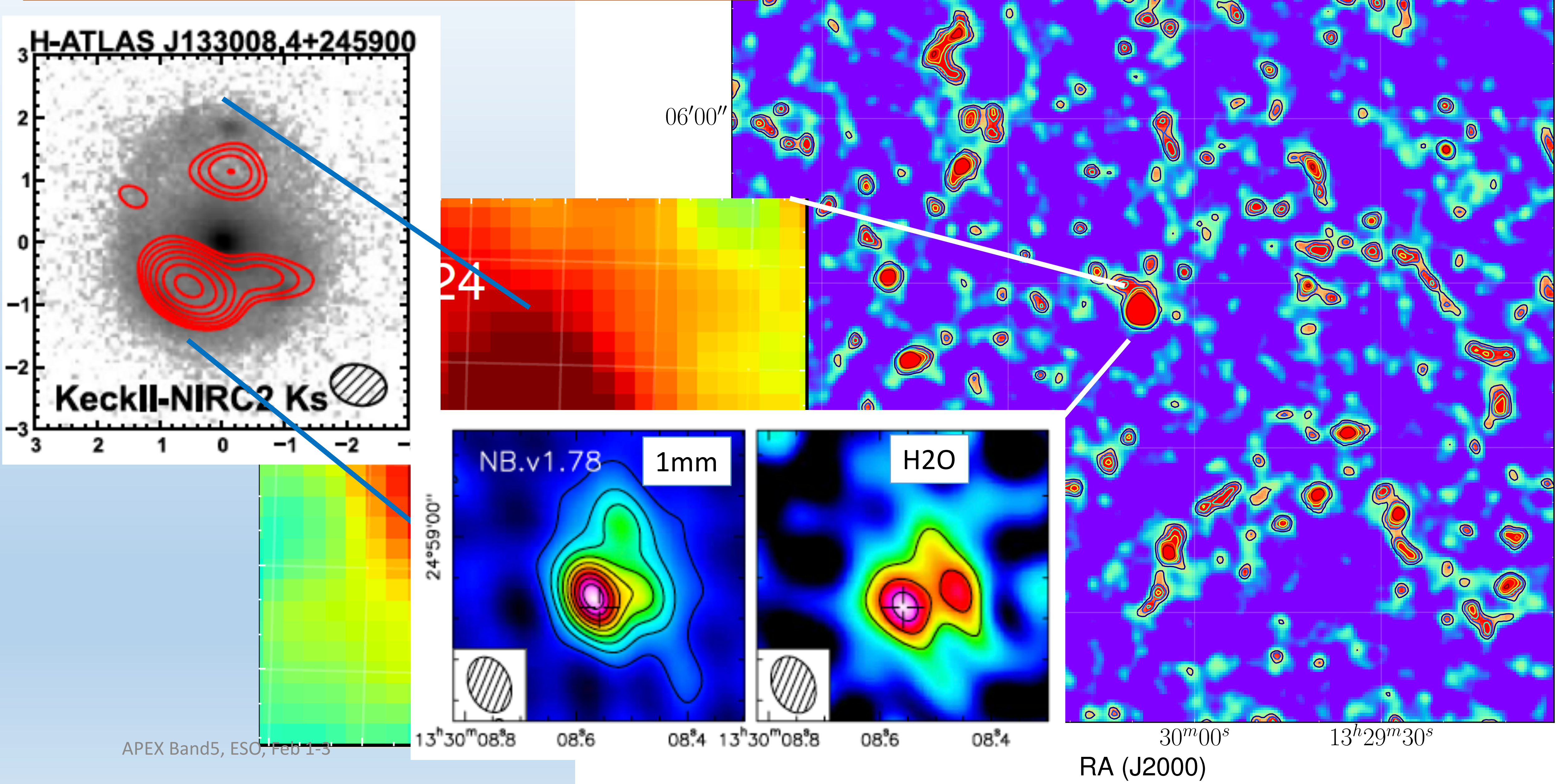
A zoomed view on G12v2.43



Zooming into G12v2.30



Zooming into NBv1.78



The SEPIA 5 observations restframe frequencies 809.3 and 806.65 GHz

Why atomic carbon?

- 3P fine structure [CI] lines
  - @ 492.2 and 809.3 GHz
  - n_c ~ 500 and 10^3 cm^{-3}
  - Optical thin

- well mixed with all the CO-rich H_2 → a good H_2 bulk mass tracer (Papadopoulos et al. 2004)
- positive K correction at high z's over the low-J CO lines
- Trace the CO invisible H_2 gas where Cosmic Rays from SN destroy CO and leave behind C (Bisbas et al. 2015)
- less affected by the CMB effect

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  - @ 492.2 an
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- well mixed w … cer
  (Papadopoulos et
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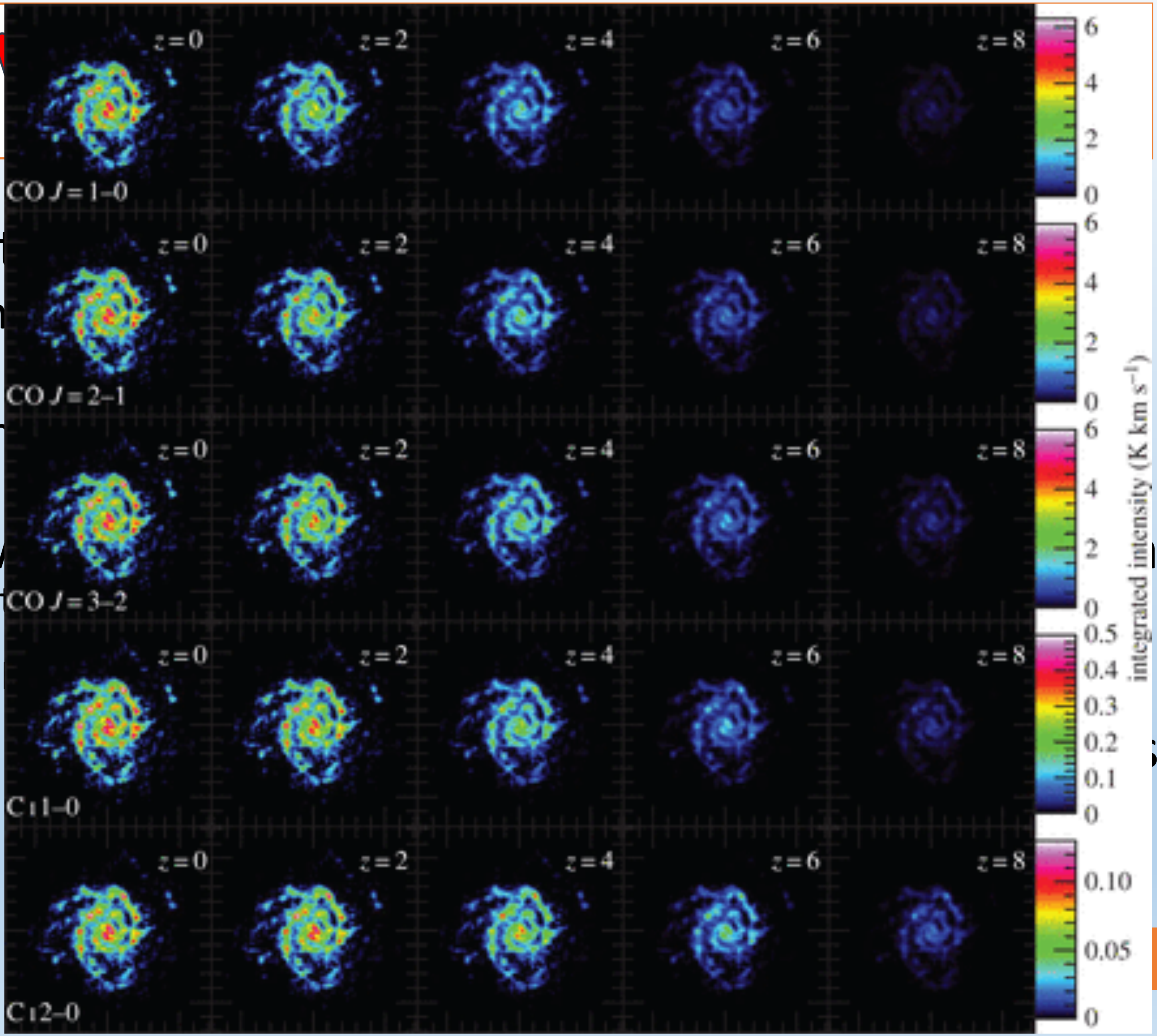
  and leave be
- less affected

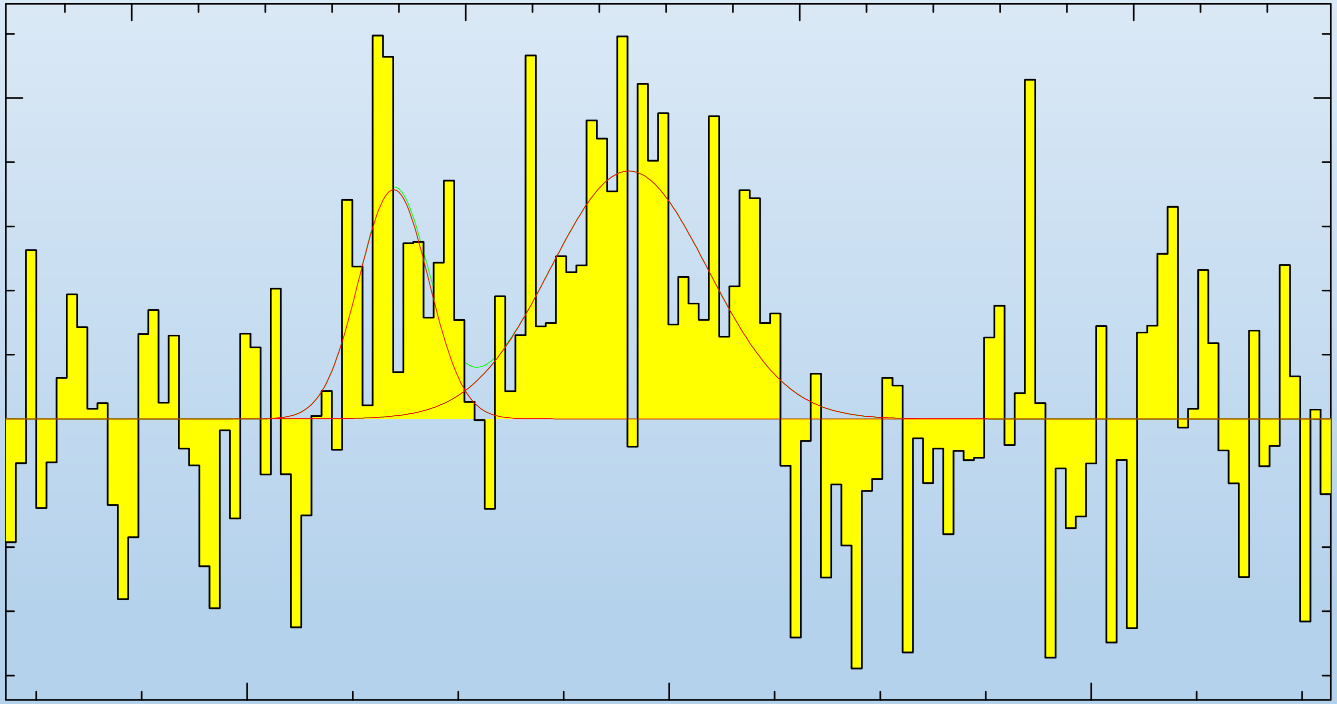


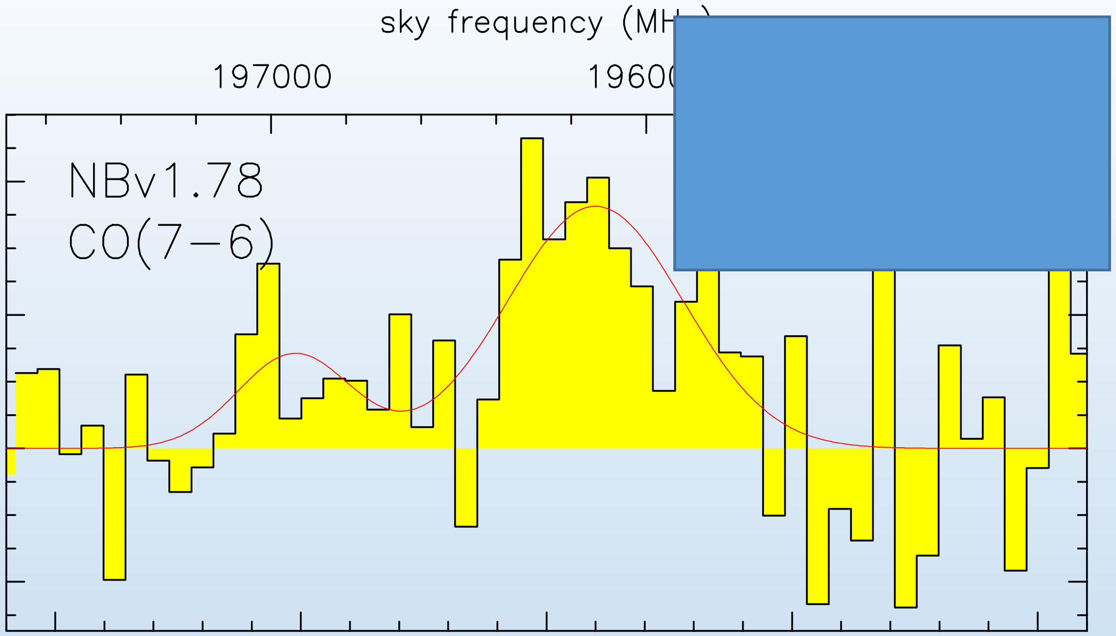
Zhang et al., 2016

Why high-J CO lines?

- ISM energy supply : few CO lines (high-J CO lines as CO 7-6, and low-J ones like CO 1-0, 2-1)
- Comparison CO J=7-6 luminosity vs CO 1=1-0 or vs CI(1-0) CI(2-1)
  - insights on whether FUV-photons from SF regions power the molecular gas
  - whether other, more powerful and global heating mechanisms of H_2 are needed (Cosmic rays and/or strong turbulence).
- CO(7-6)/CI(2-1) ratio → Mdense,warm(H_2)/M_total(H_2) tracer
- Caveats: CI 2-1 (or CI 1-0) to be calibrated as H_2 global mass tracers

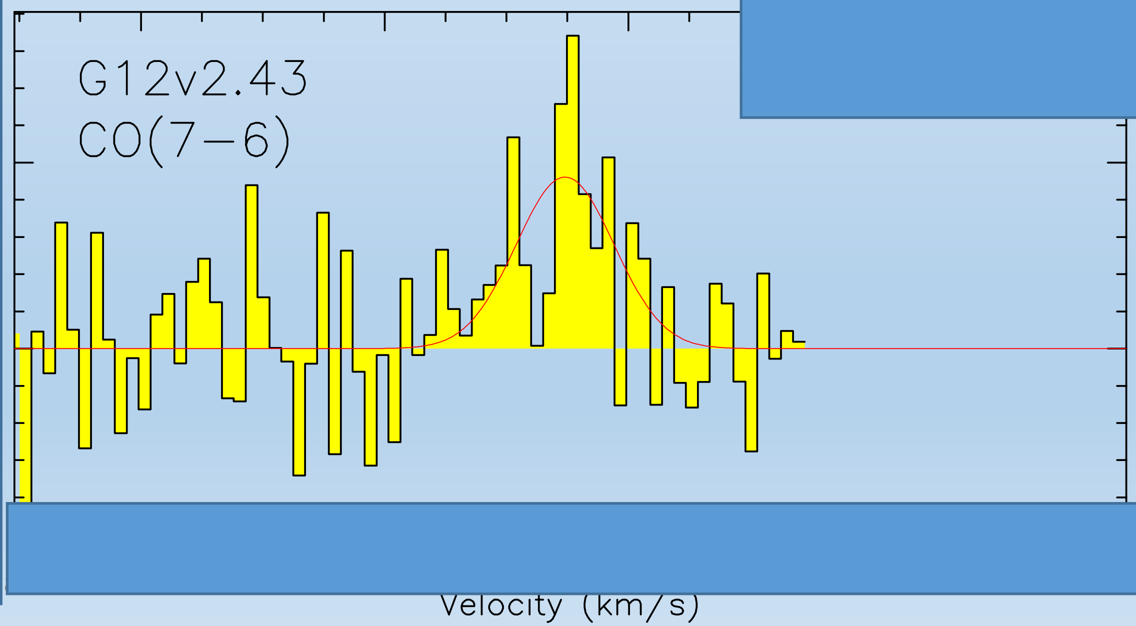
G12v2.30
H-ATLAS J114637.9−001132
z= 3.2592



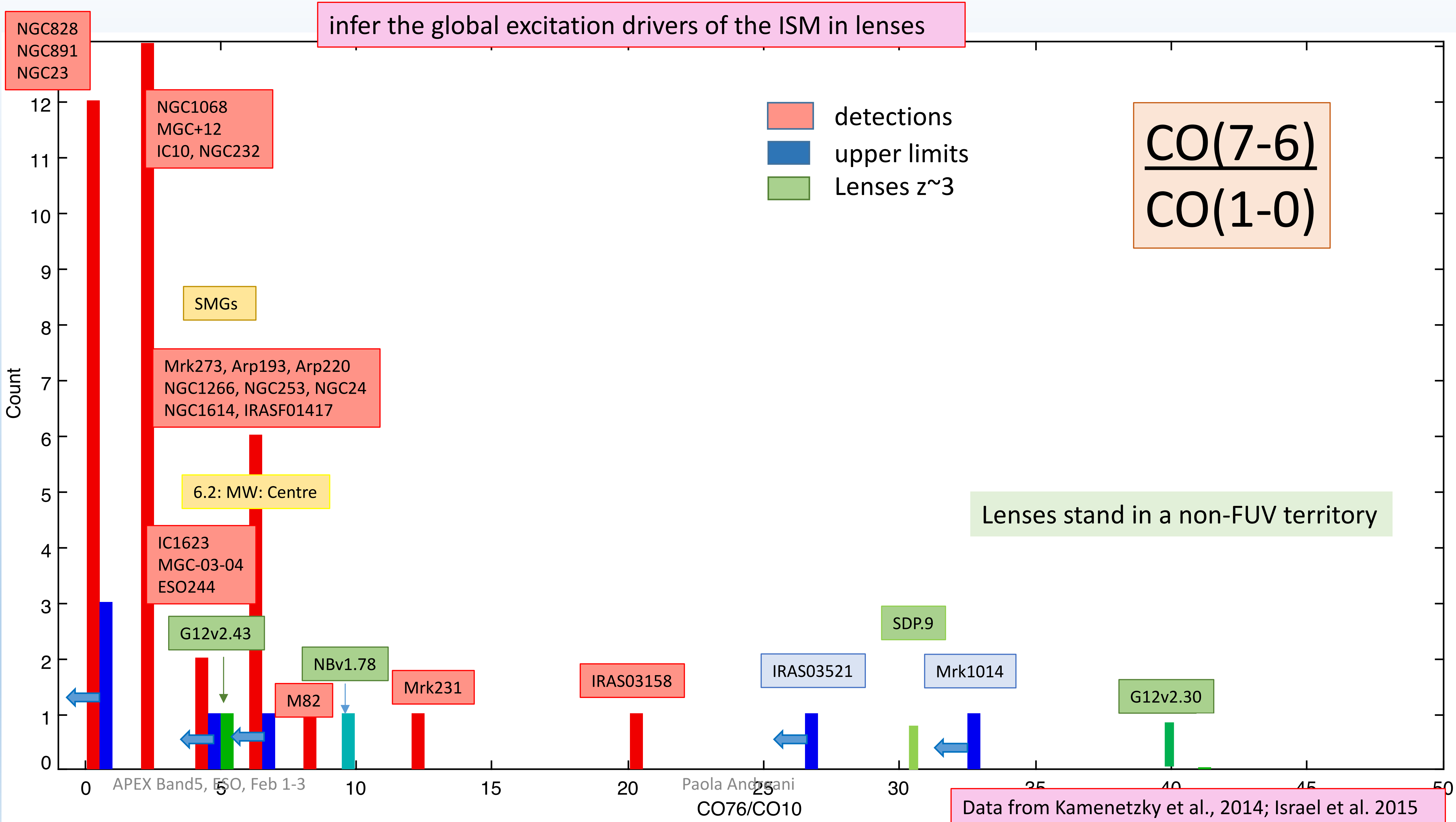


NBv1.78
H-ATLAS J133008.4+245900
z=3.1112

G12v2.43
(H-ATLAS J113526.3-014605
Z=3.1276)



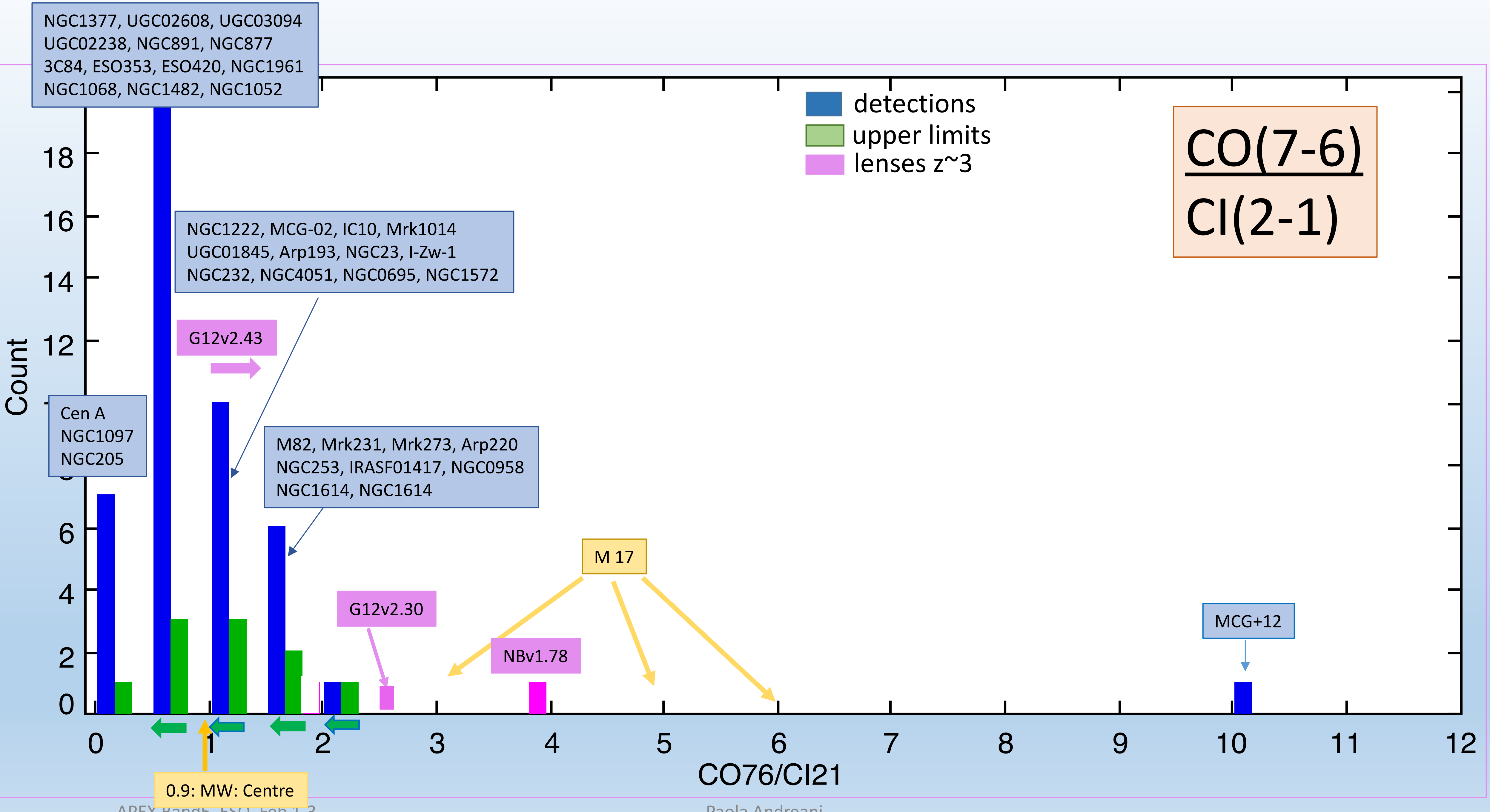
infer the global excitation drivers of the ISM in lenses



APEX Band5, ESO, Feb 1-3

Paola Andreani

Data from Kamenetzky et al., 2014; Israel et al. 2015

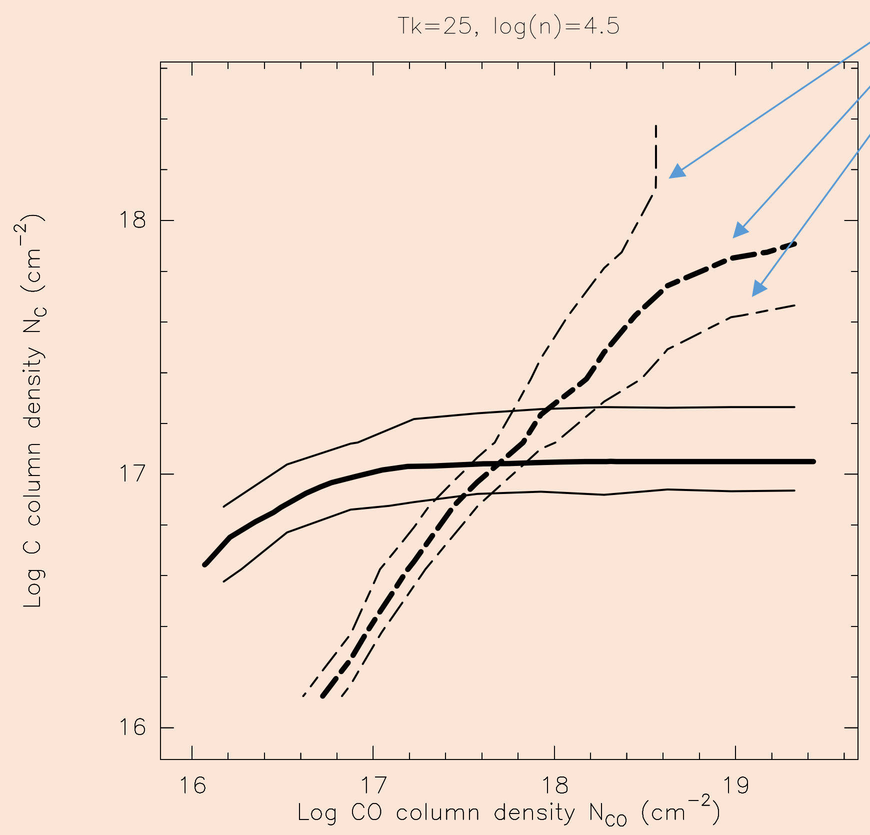


NGC1377, UGC02608, UGC03094
UGC02238, NGC891, NGC877
3C84, ESO353, ESO420, NGC1961
NGC1068, NGC1482, NGC1052
detections
upper limits
lenses z~3
CO(7-6)
CI(2-1)
NGC1222, MCG-02, IC10, Mrk1014
UGC01845, Arp193, NGC23, I-Zw-1
NGC232, NGC4051, NGC0695, NGC1572
G12v2.43
Count
Cen A
NGC1097
NGC205
M82, Mrk231, Mrk273, Arp220
NGC253, IRASF01417, NGC0958
NGC1614, NGC1614
M 17
G12v2.30
NBv1.78
MCG+12
18
16
14
12
6
4
2
0
0
1
2
3
4
5
6
7
8
9
10
11
12
CO76/CI21
0.9: MW: Centre

LVG models

Atomic C column density

Constant flux ratio CO(7-6)/CI(2-1)



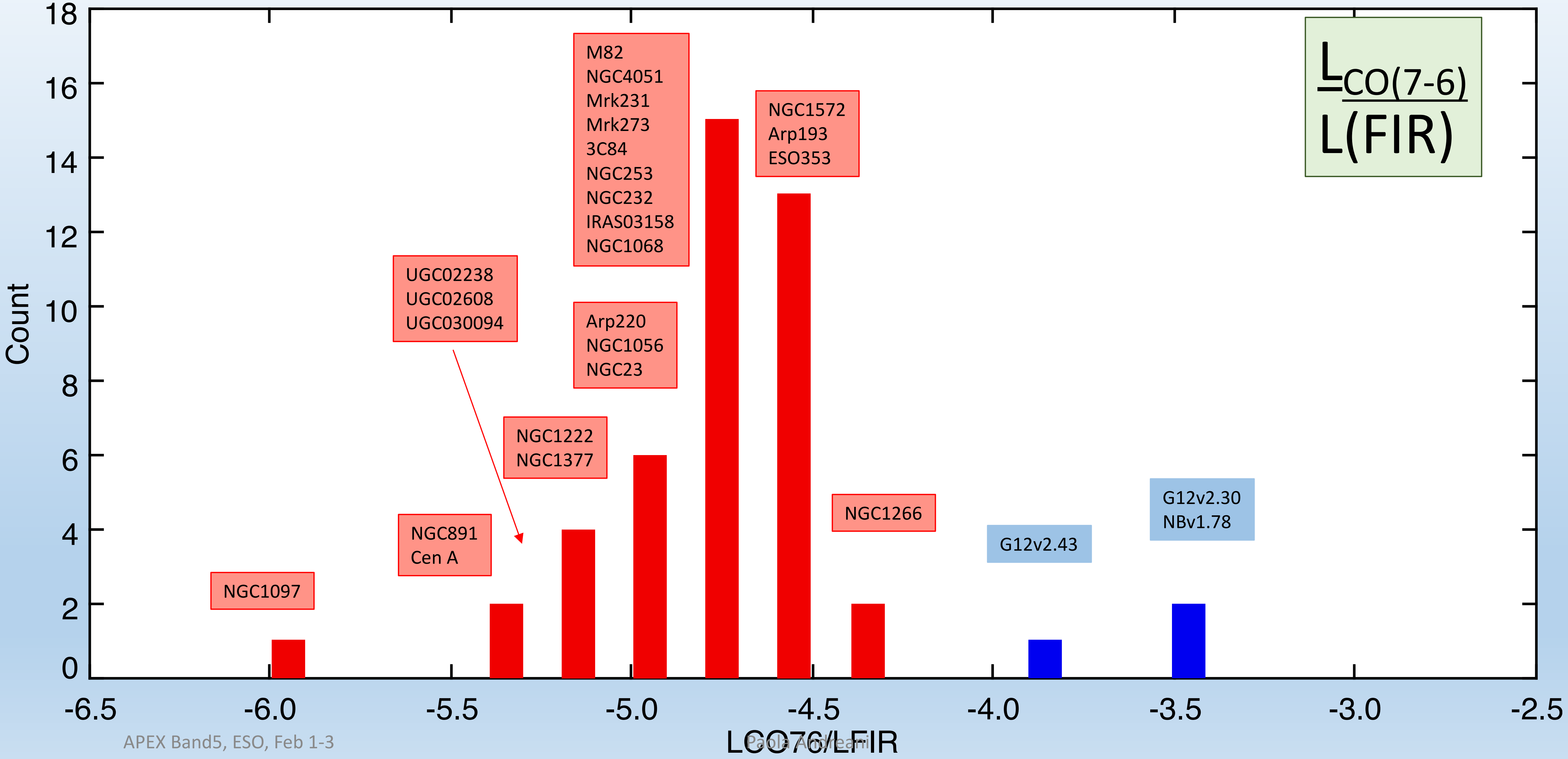
T_k = 25 K
$\log(n_c)$ = 4.5 cm^{-3}

CO column density

[CI] emission arises from a dense and warm gas, ~10-20% of the C in gas phase

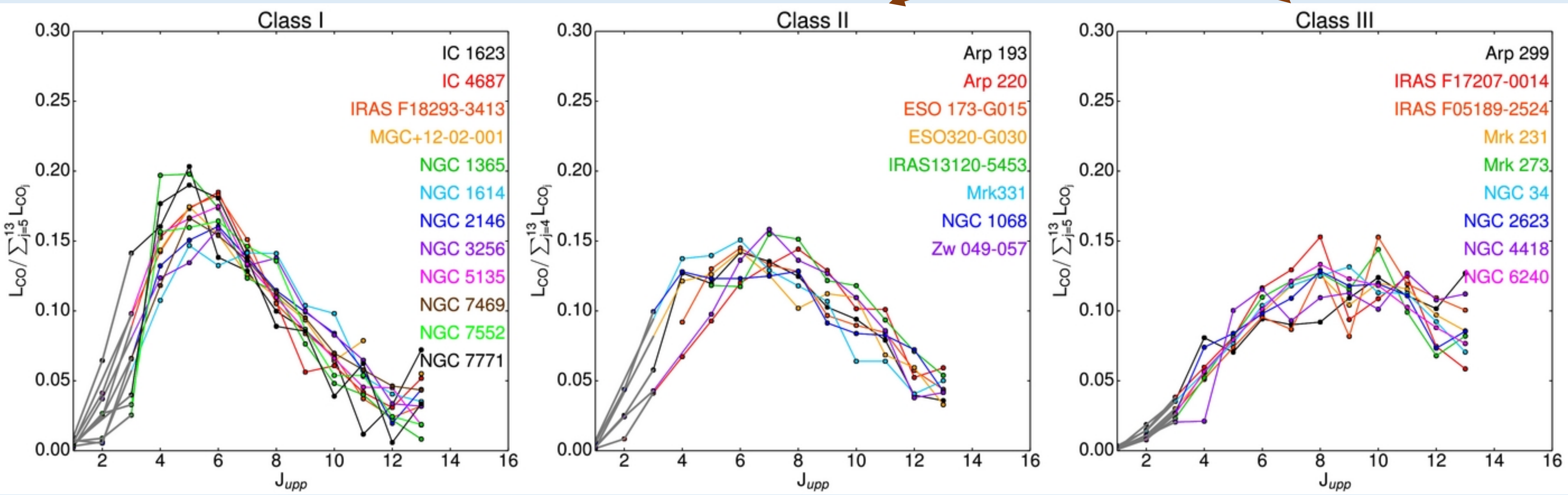
Israel+, 2015

L CO(7-6) ($L_\odot$) / L (FIR) ($L_\odot$)



A single component theoretical PDR model cannot match these flat SLED shapes

Additional heating mechanism necessary to explain the observed molecular emission



Rosenberg et al., 2015

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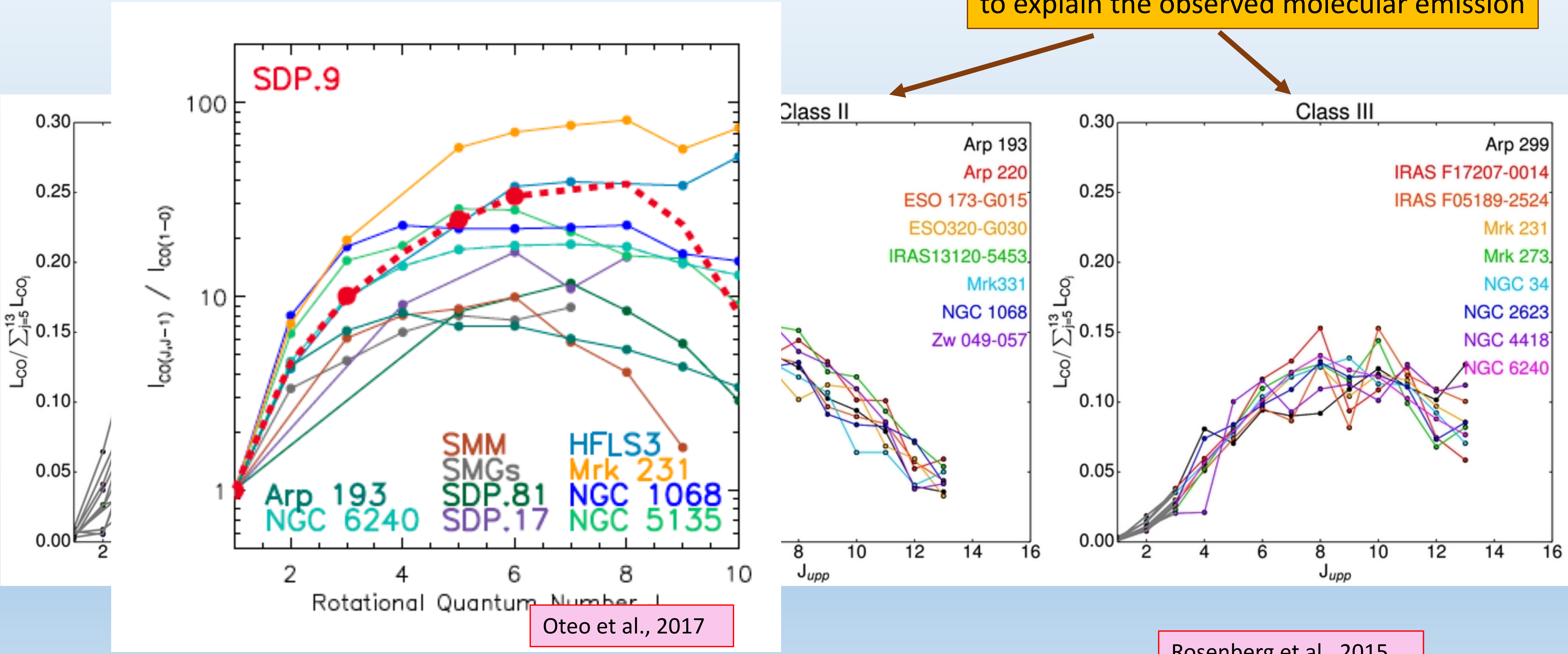

Oteo et al., 2017

Rosenberg et al., 2015

Conclusions

- 3 lensed z~3 galaxies observed and detected with APEX/SEPIA 5
  - CO(7-6) has been detected in all 3 objects
  - CI[2-1] in 2 out of 3
- The analysis of the ratios CO(7-6)/CI[2-1], CO(7-6)/CO(1-0) and CO(7-6)/L(FIR) shows:
  - These 3 objects locate far away from FUV dominated excitation and other excitation mechanism need to be acting.
  - Differential lensing magnification needs to be investigated if the distribution of the warm and cold dust is different
- Consequences
  - If strong turbulence and/or high CR energy densities responsible for the large amounts of very warm and dense gas initial conditions of SF may change.
  - the wide range of average ISM conditions will strongly impact the so-called Xco factor and the determination of the amount of molecular gas