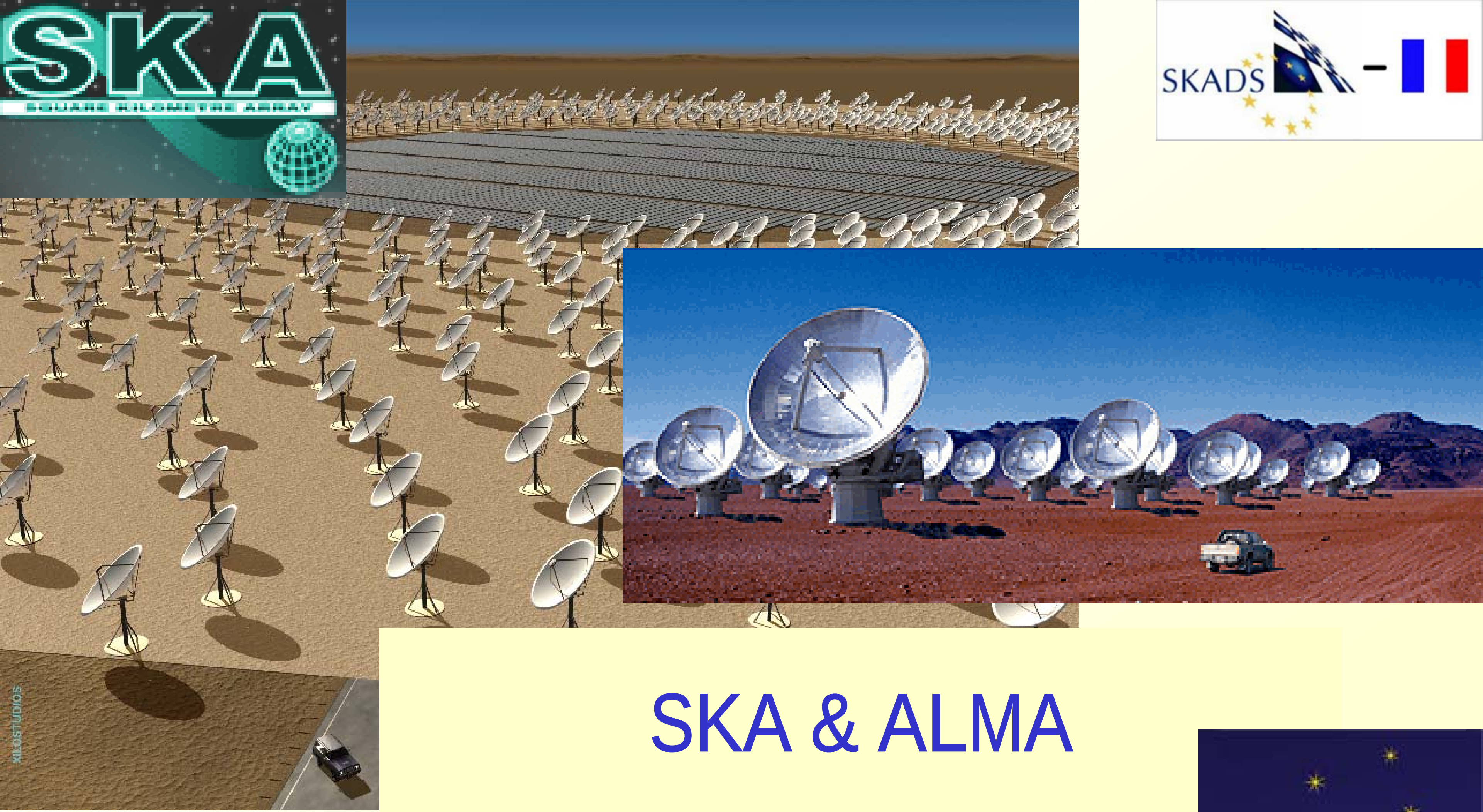
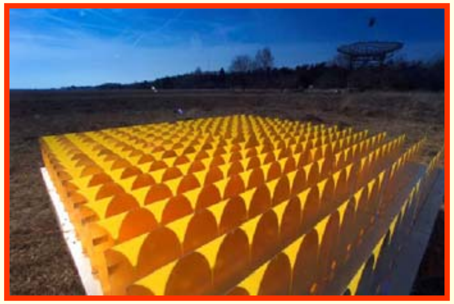


SKA & ALMA



Françoise Combes

Observatoire de Paris

16 Juin 2009

Capacities of ALMA

➔50 x 12m, bases from 200m to 14km, 3mm to 0.3mm
(factor ~6 in surface with respect to IRAM-PdB)
➔4 frequency bands at the beginning
84-116 GHz, 211-275 GHz, 275-370 GHz, 602-720 GHz
Large bandwidth of 8GHz/polar

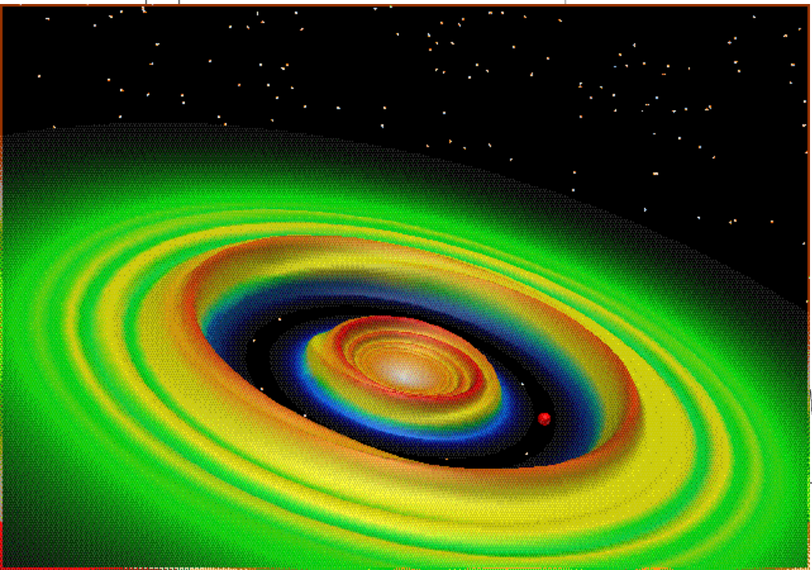
Spatial resolution, up to 10mas,
Spectral resolution up to $R=10^8$
Dynamical range from 128x128 to 8192x8192 pixels

Small field of view: from 1arcmin (3mm) to 6 arsec (0.3mm)
Possibility of mosaics

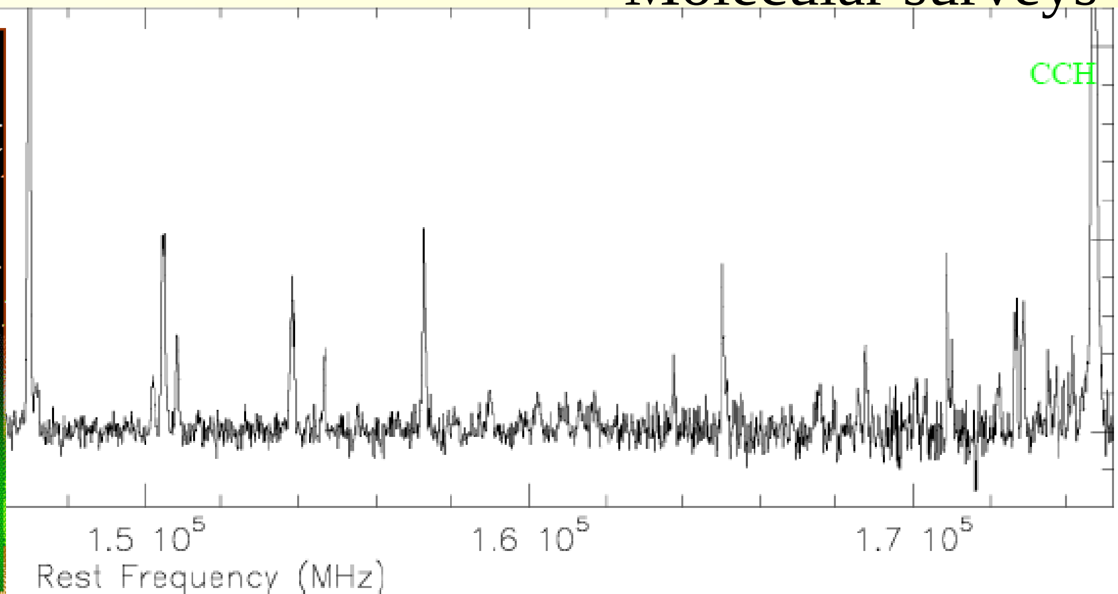
Early Science? Debated **In 2012-3:** Full Operation

Synergy on the 5 Key Projects

- **KP-1 Cradle of life**
  (search for Earth-like planets, astrochemistry/biology)
- **KP-2 Strong-field tests of gravity**
  (using pulsars and black holes, pulsar timing array)
- **KP-3 Origin and evolution of cosmic magnetism**
  (Faraday rotation, Zeeman effect)



Molecular surveys



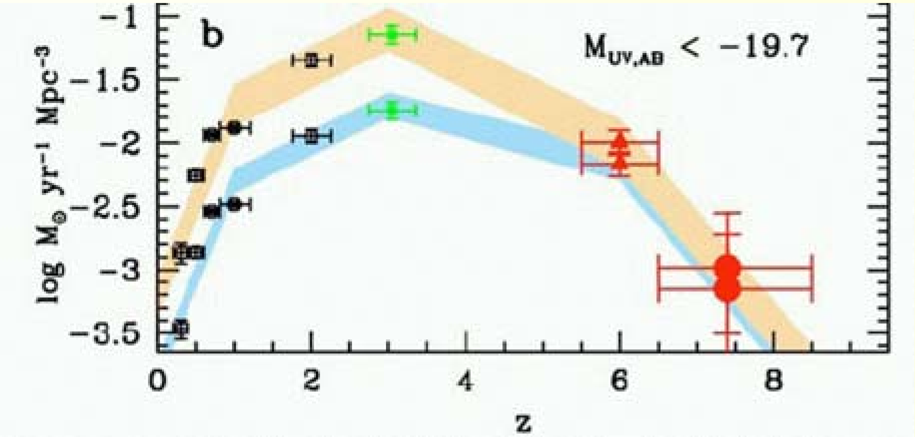
Synergy on the 5 Key Projects

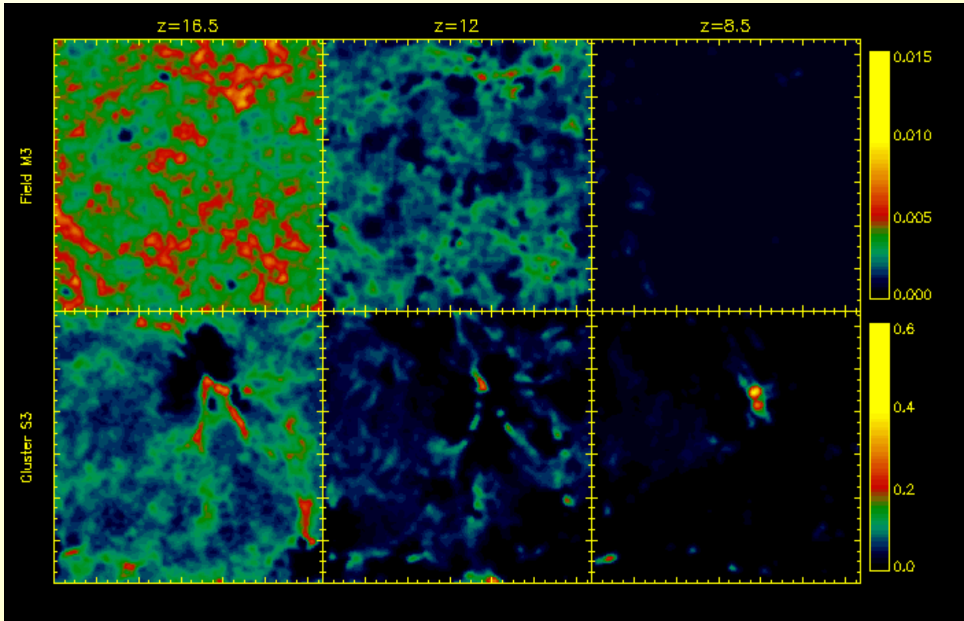
➔KP-4 Galaxy evolution and cosmology
(surveys in HI at z up to 2, CO and continuum)

➔KP-5 Probing the dark ages (Epoch of Reionisation)
(HI in emission/absorption, CO, continuum)

reionization

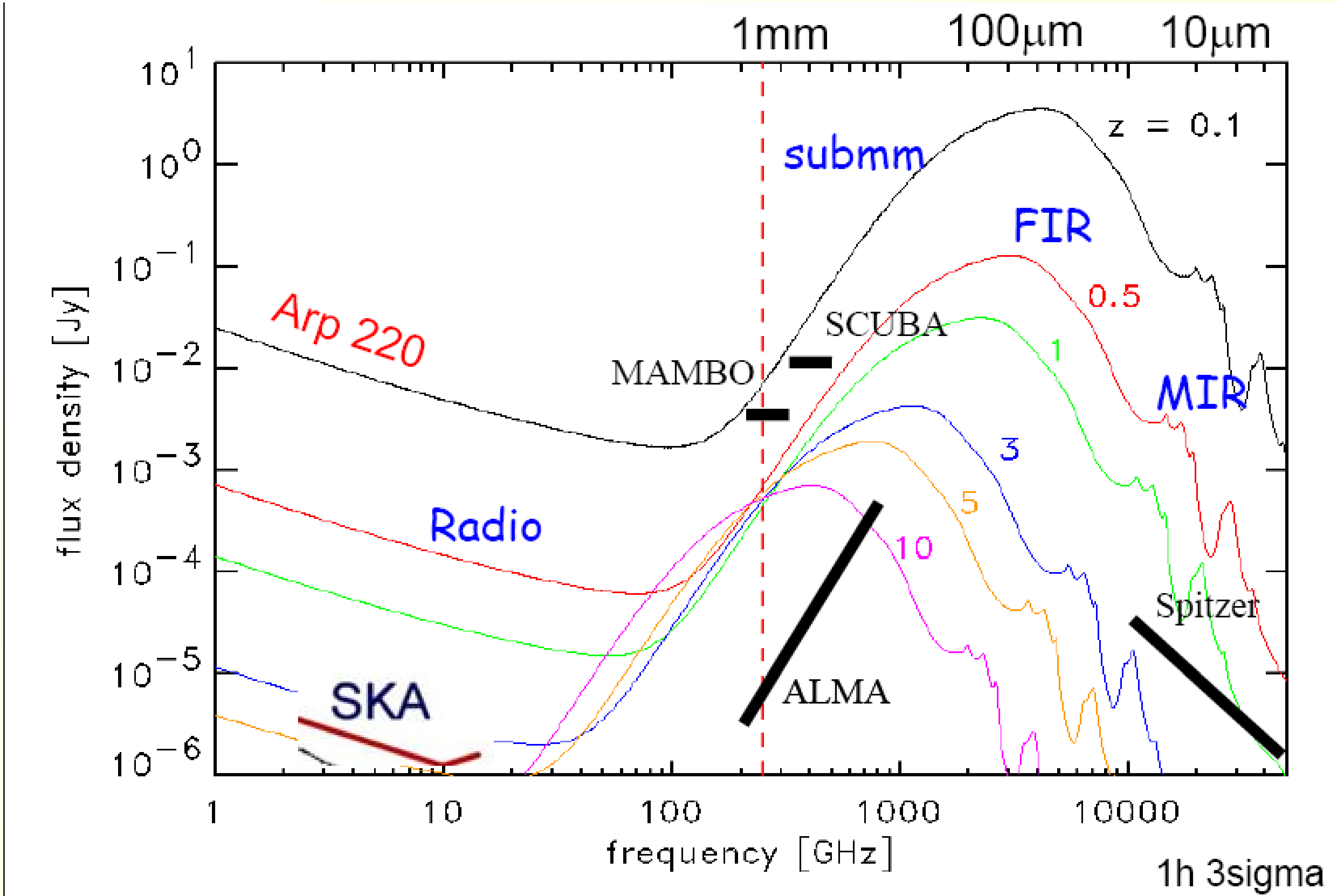
Galaxies at high z, SFH





Main privilege of the mm/submm domain

Negative K-correction: example of Arp 220



Detecting galaxies at high redshift with ALMA // SKA

➔For high z galaxies, go to low frequencies
z=6 CO(7-6) at 3mm

➔At 3mm (115GHz), field of 1 arcmin x 1 arcmin
Most frequently 300x 300 = 90 000 pixels/spectra

Bandwidth 2x 8GHz ~ 16%, or ~50 000km/s
Possibility to have several lines from the Rotational ladder of CO, or other molecules..

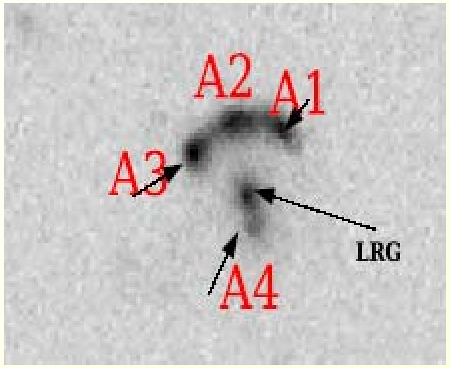
@z =6, the spacing between CO lines is of 16 GHz.
With 2 tunings, one obtains a « redshift-machine »

Star formation rate in LBGs

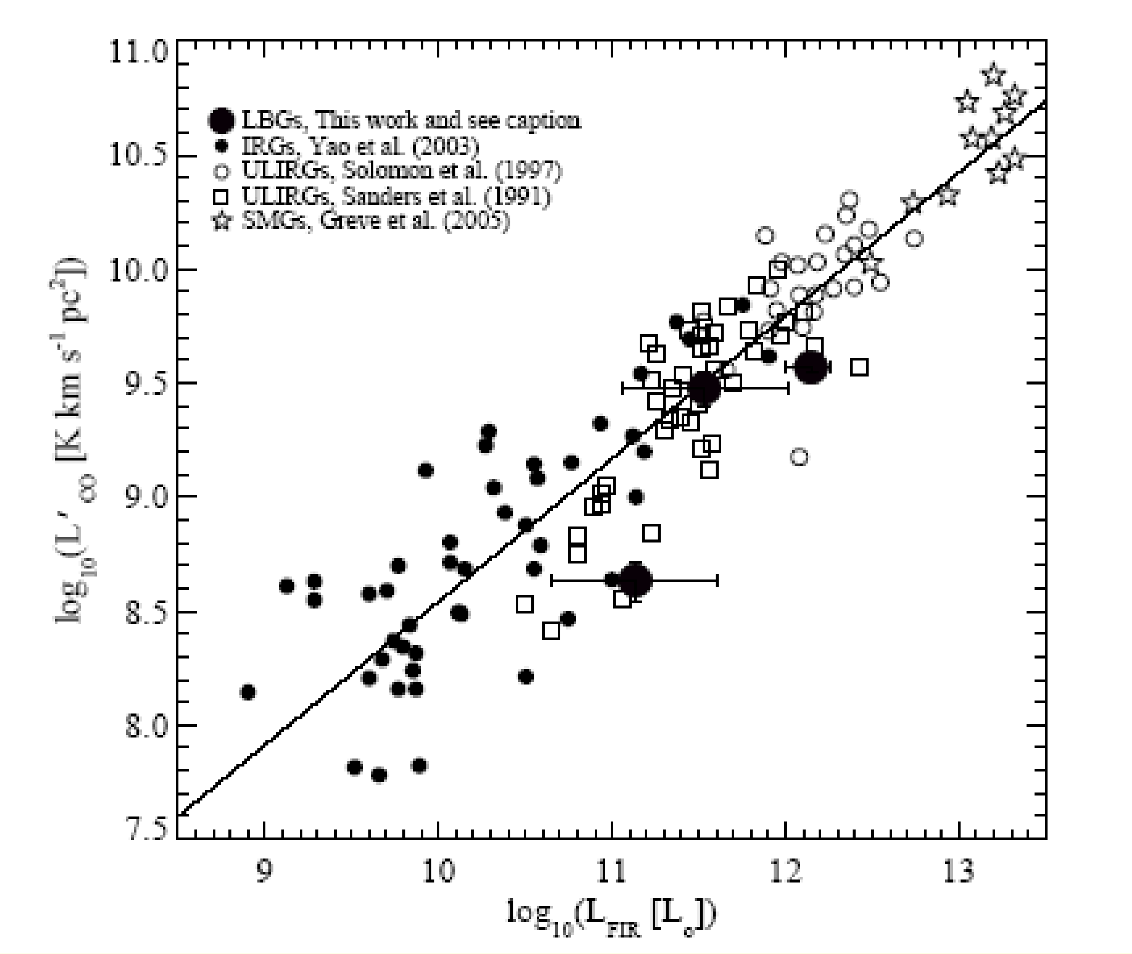
SFE ~140 Mo/Lo

LCO & gas mass
7 times higher than cB58

z=2.73

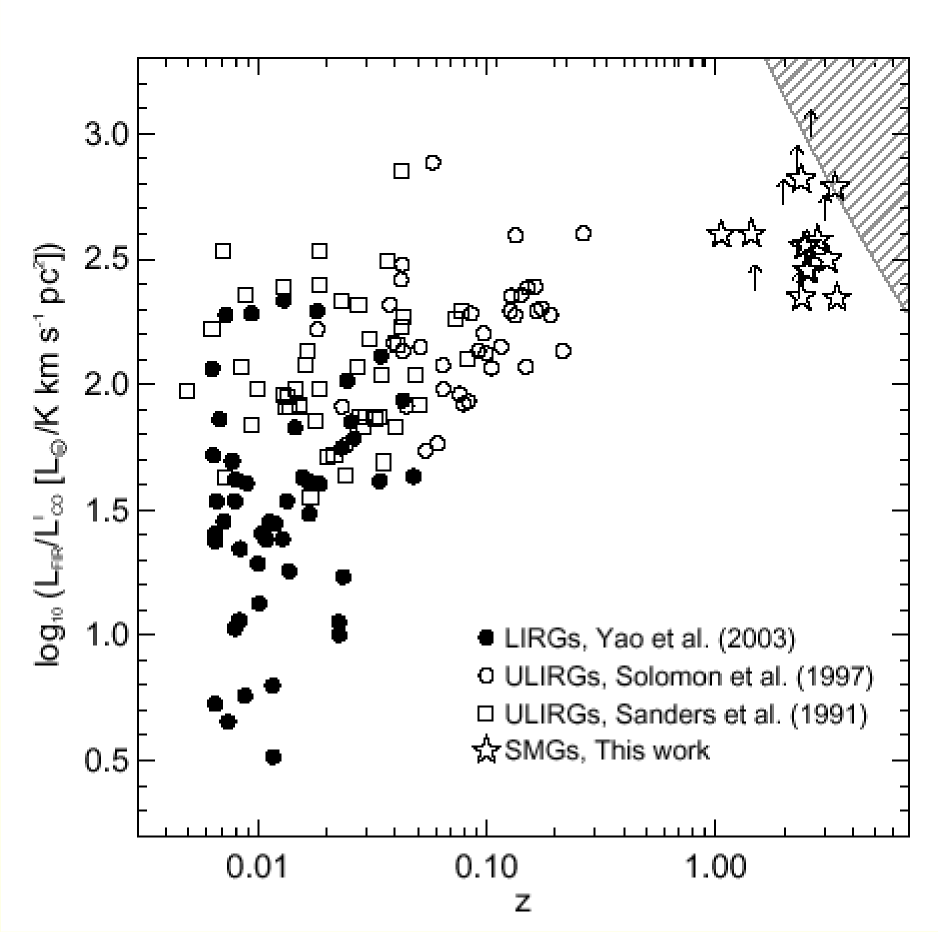


8 o'clock arc
Allam et al 2007



SMGs: Submillimeter Galaxies
Star formation efficiency L_{IR}/L'_{CO} vs z

Greve et al 2005



6 SMGs not detected in CO

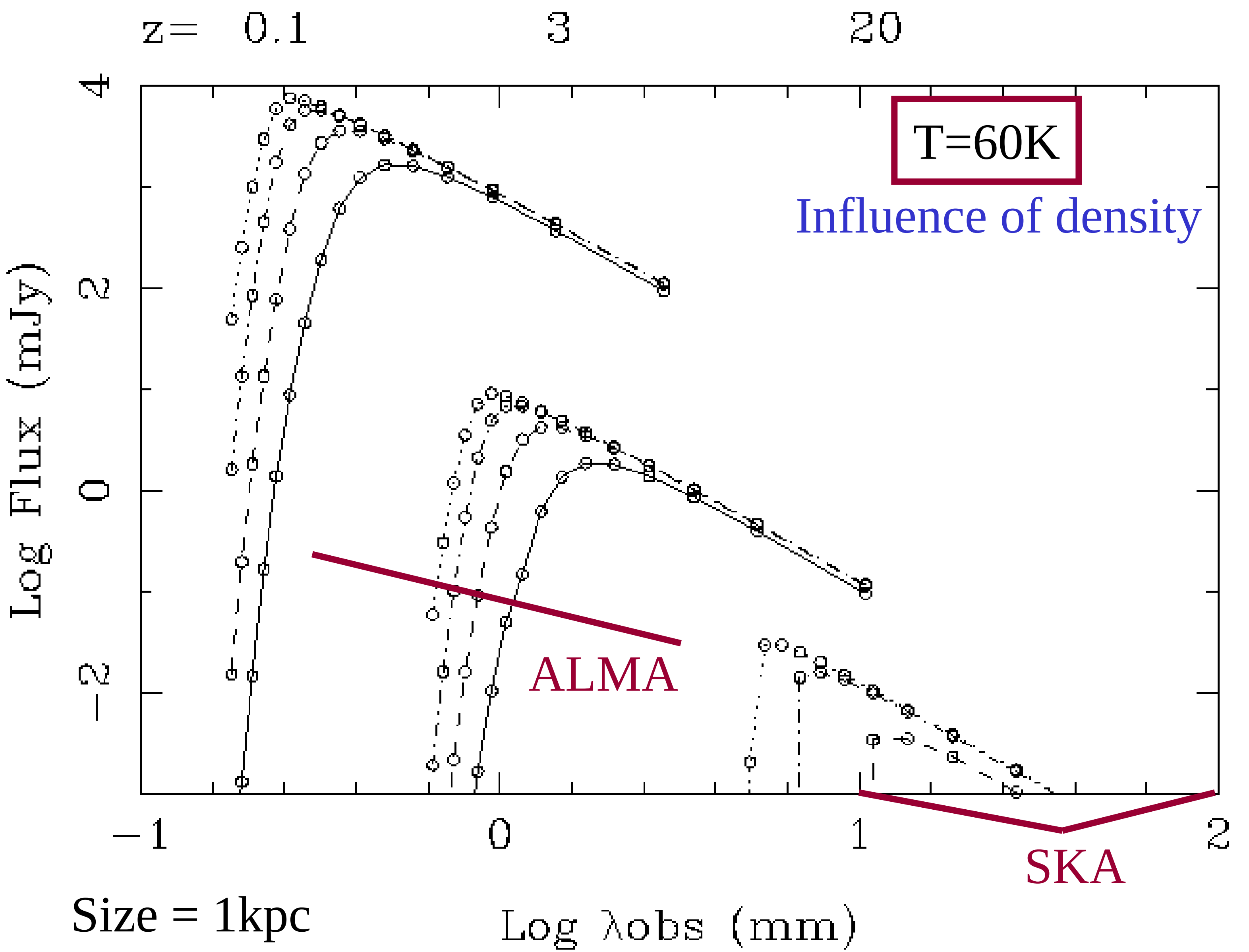
40- 200 Myr SB phase
SFR ~700 Mo/yr
More efficient than ULIRGs

Mergers without bulges?

Total masses ~0.6 M_*

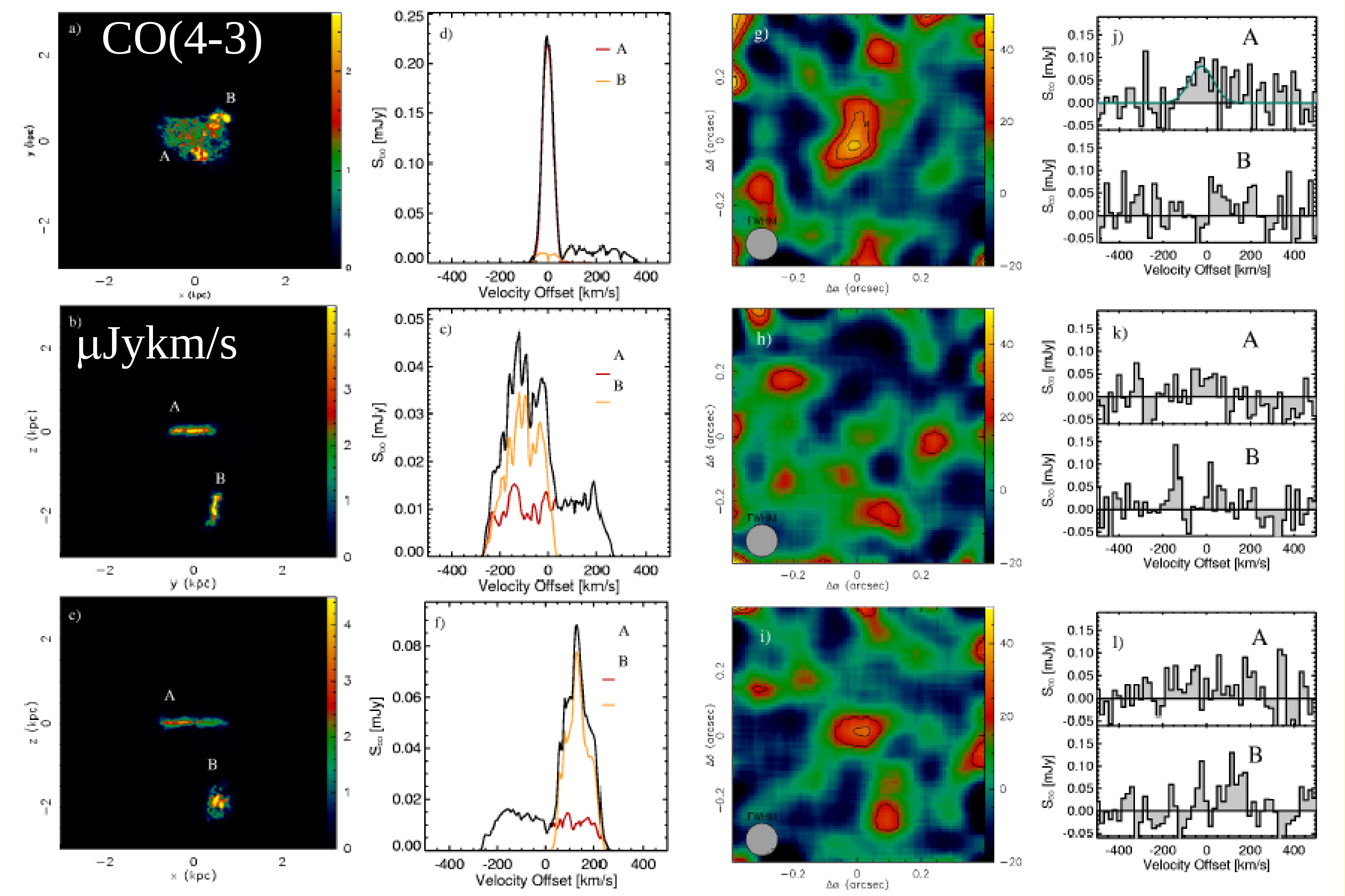
Z=3 ULIRGs easy to detect with ALMA

$M(H_2) = 6\ 10^{10} Mo$, $N(H_2) = 3.5\ 10^{24}\ cm^{-2}$, $CO/H_2 \sim 10^{-4}$



Size = 1kpc

Predictions for LBG at z~3: ALMA 24h, 0.1"

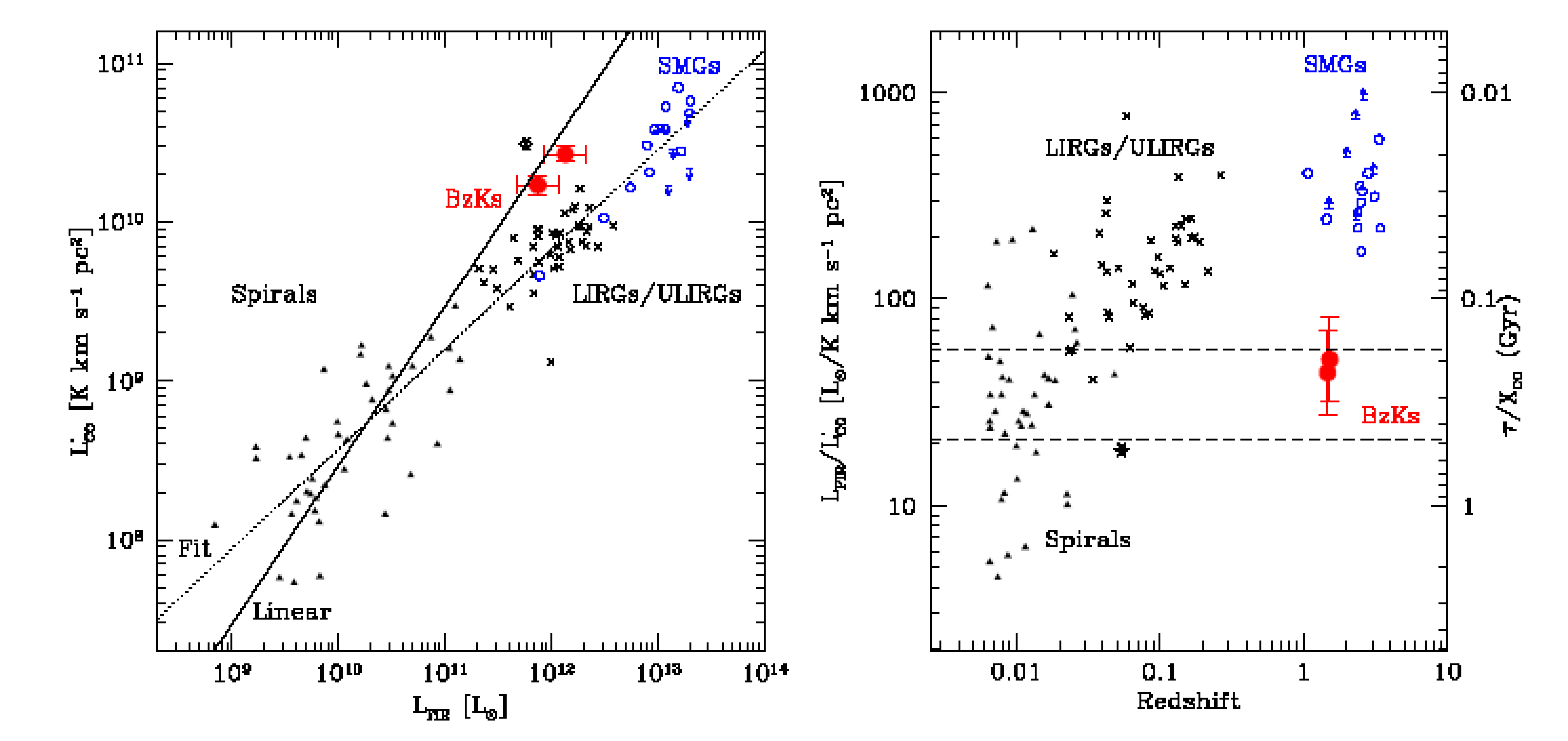


Greve & Sommer-Larsen 2008 rms=10 μJy/beam (2-3 σ)

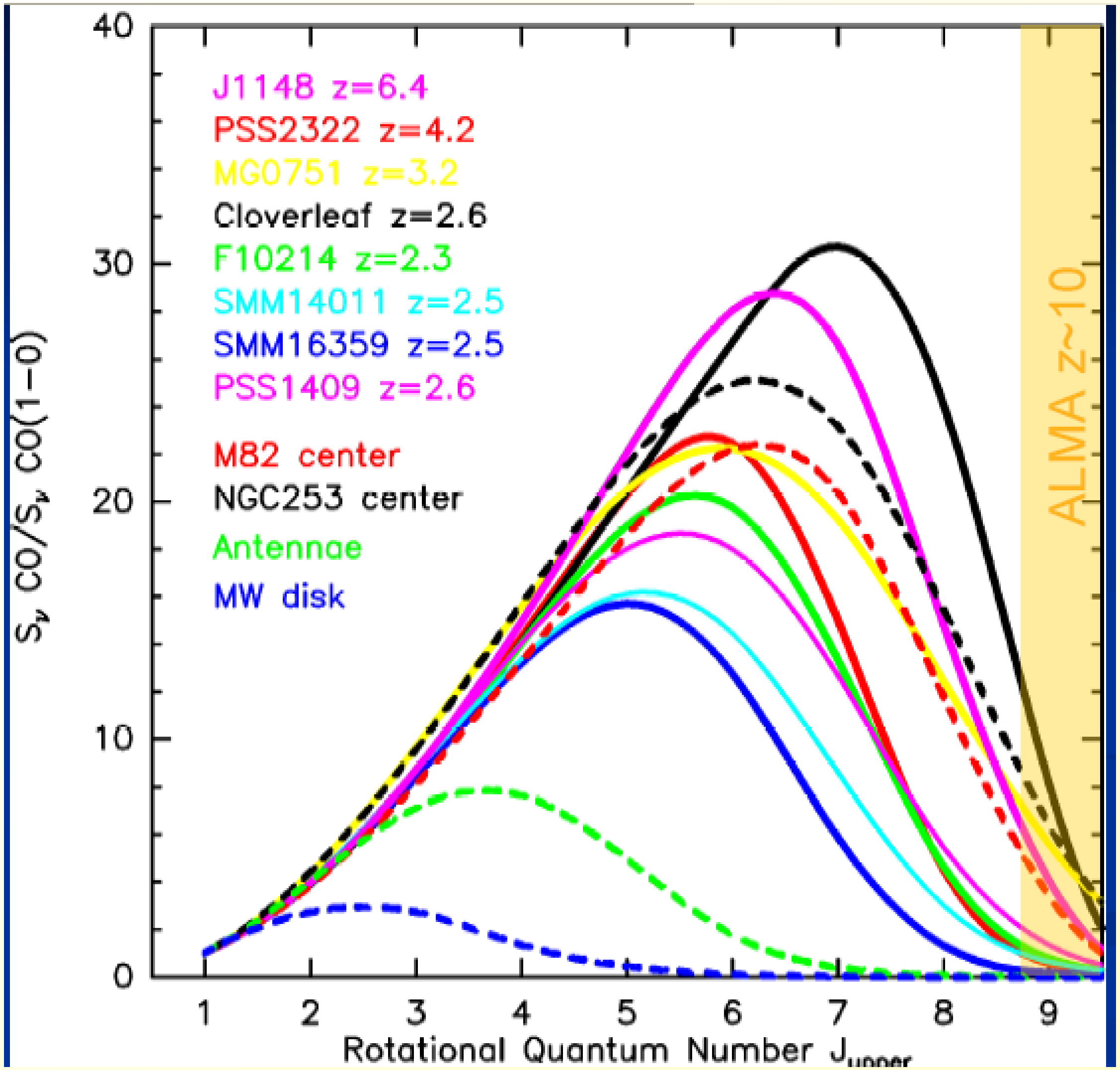
Low efficiency of star formation

In BzK galaxies, much more CO emission detected than expected
Massive galaxies, CO sizes 10kpc? L(FIR) ~10^{12} Lo
Normal SFR, M(H2) ~ 2 10^{10} Mo τ ~2 Gyr
➔ Much larger population of gas rich galaxies at high z

Daddi et al 2008

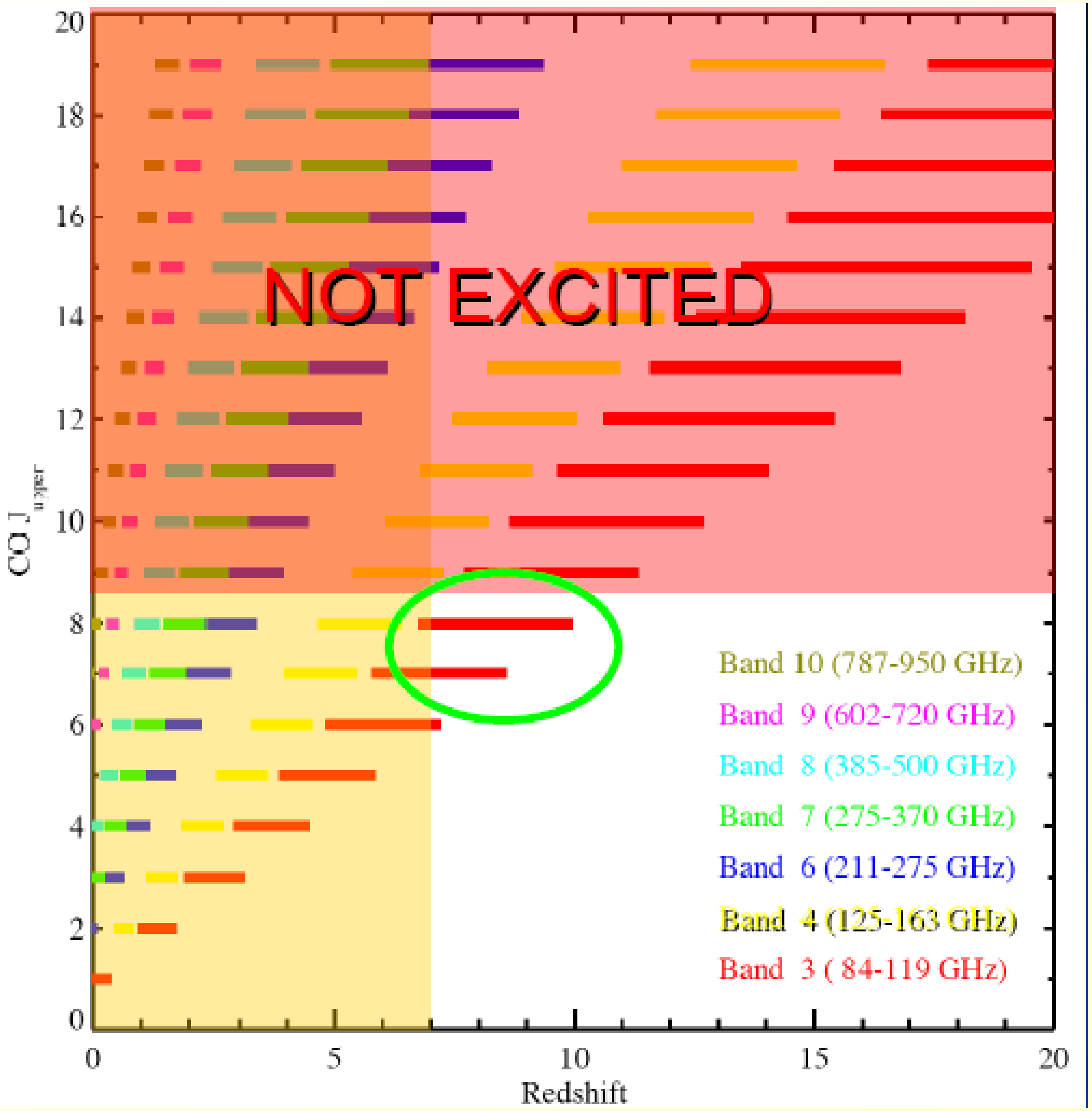


Excitation in high-z starbursts



Weiss et al 2007

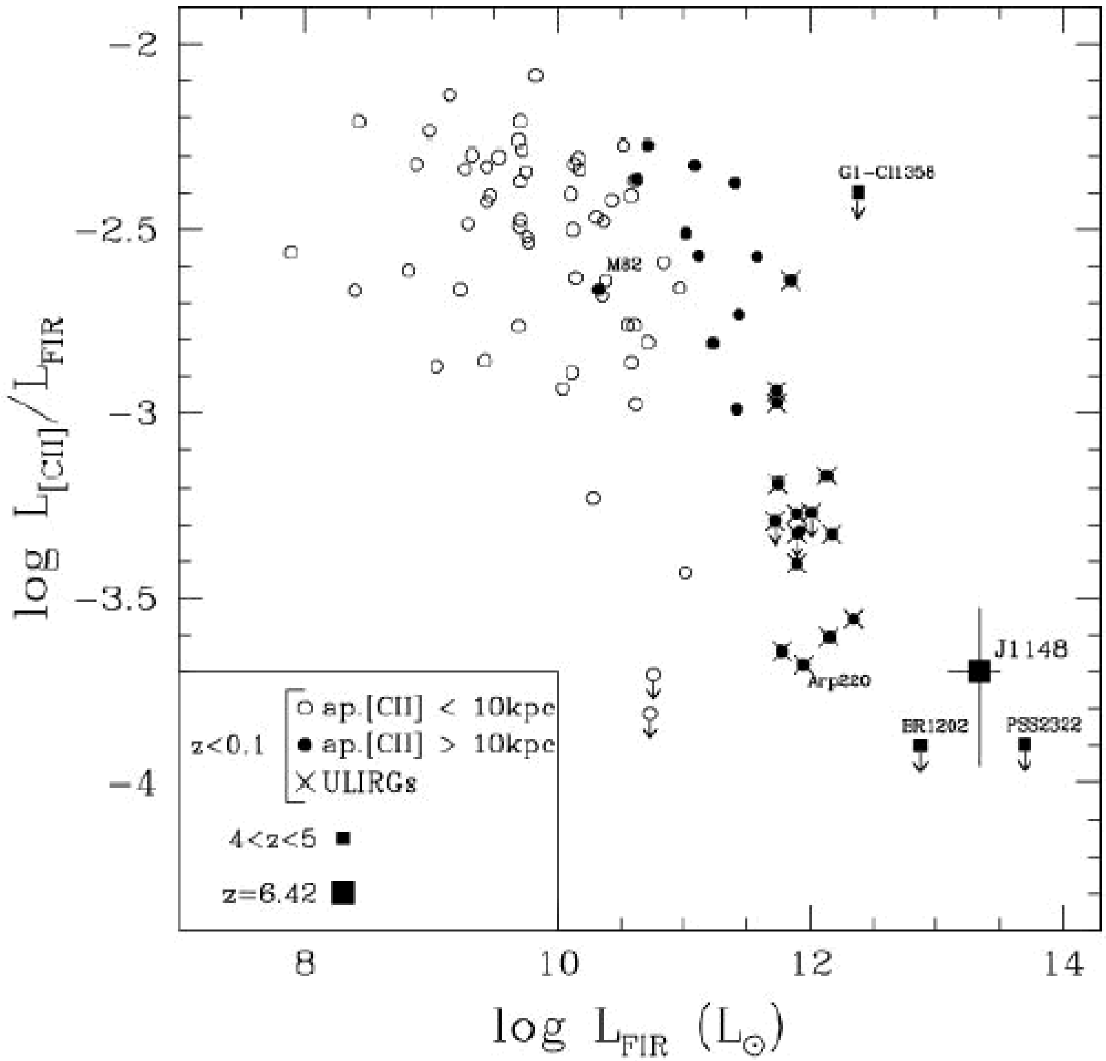
z> 7 sources: ALMA CO discovery space

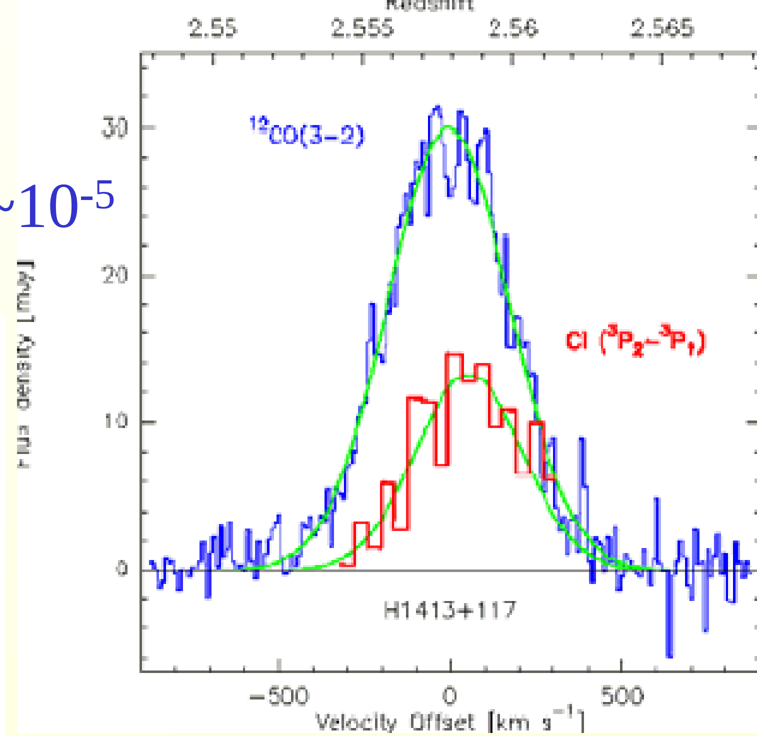


Walter & Carilli 2007

Other lines CII 158m, CI, NII…

CI/H_2 ~10^{-5}





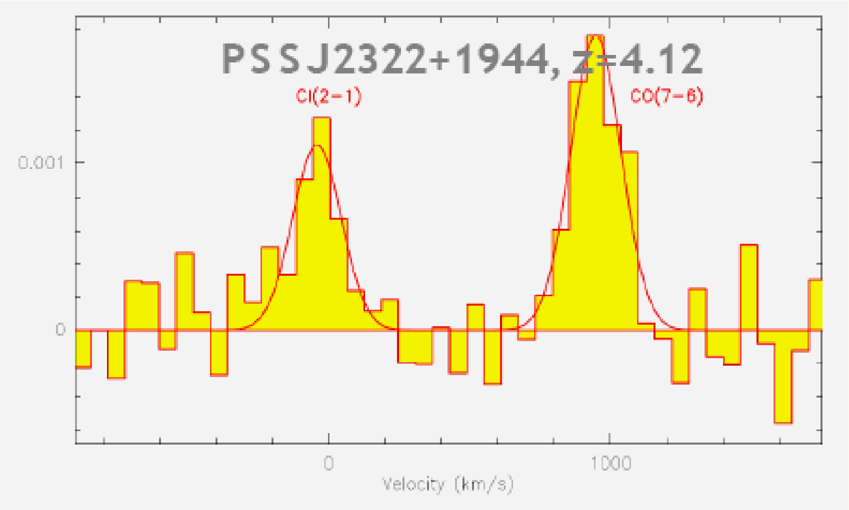
Cloverleaf

CII/LFIR ~0.06%,
10 times less than locally

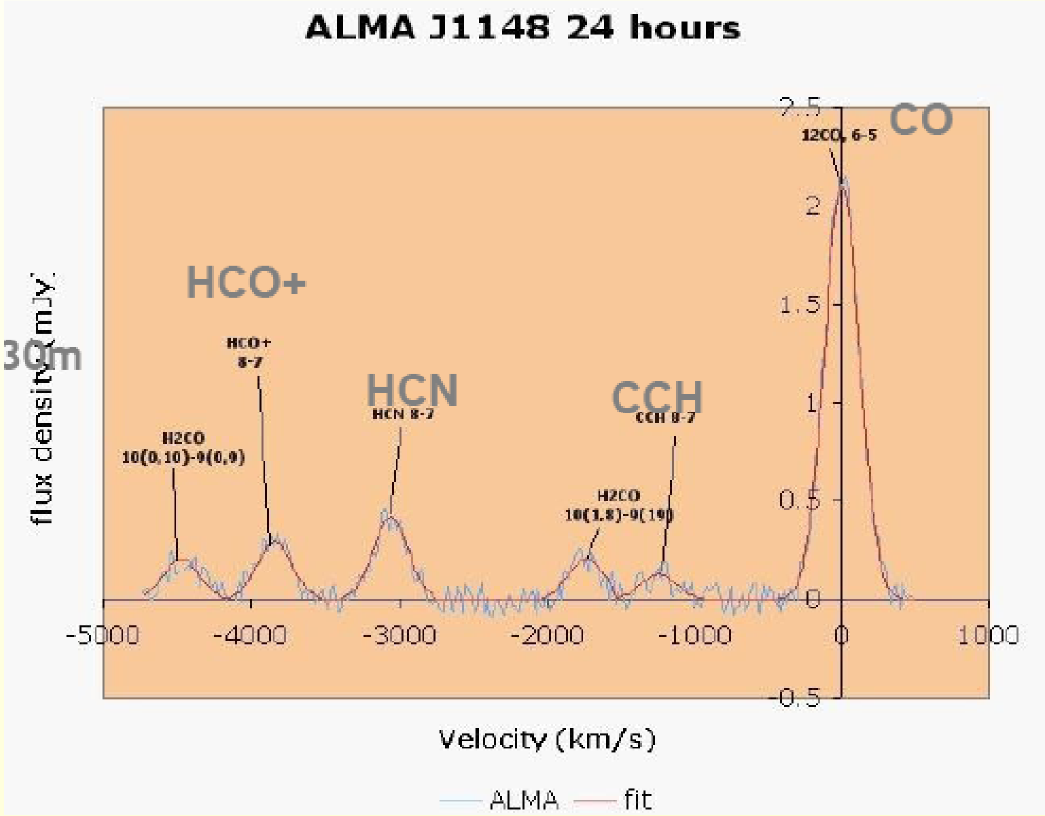
CII detected in
J1148 QSO at IRAM

Molecular surveys

TODAY



TOMOROW



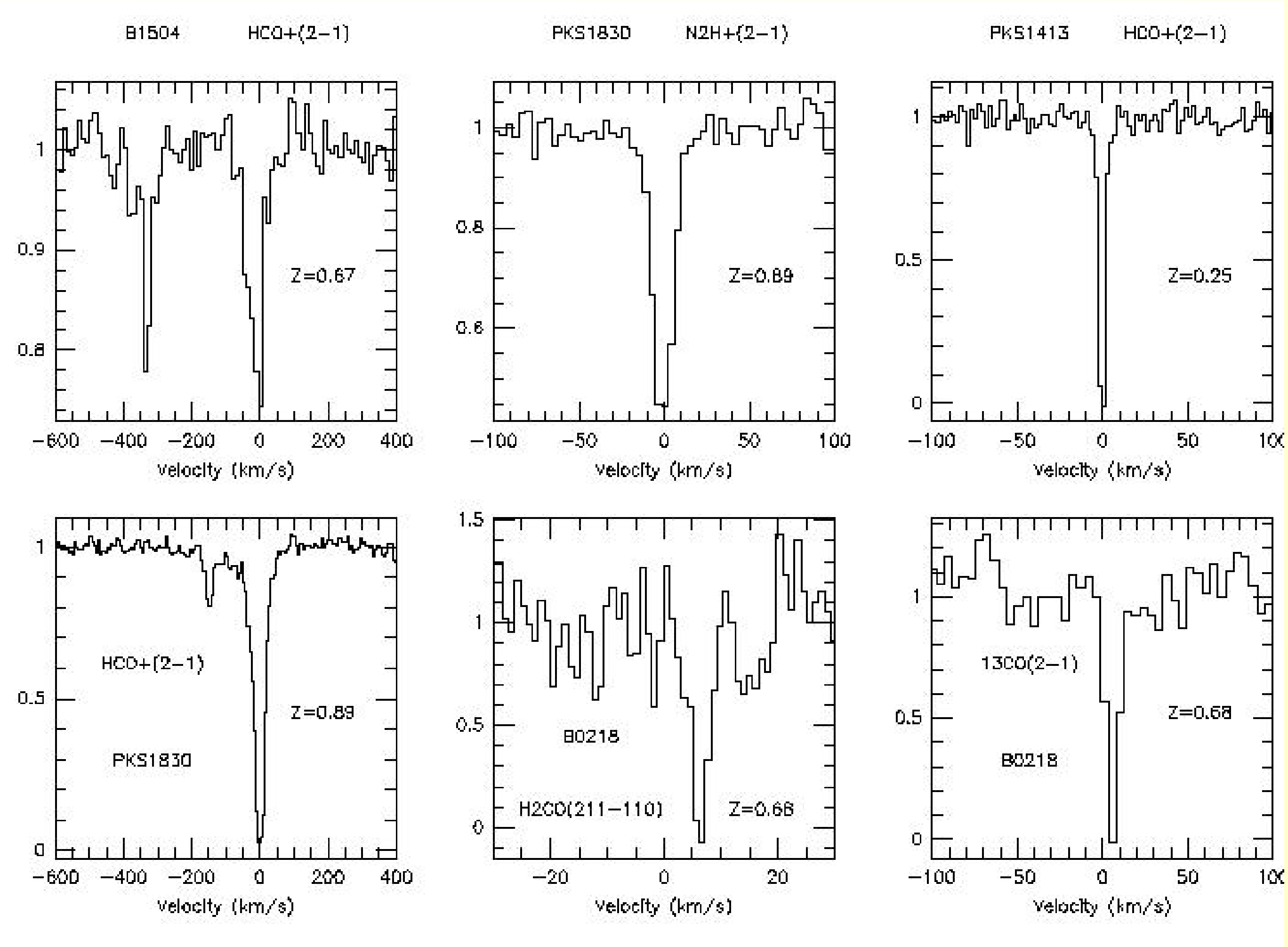
ALMA prediction

Molecular Absorptions (mm & cm)

Up to now, only 5 systems: PKS1413, B3 1504 (self-abs)
B0218, PKS1830, PMN J0134 (OH): gravit lenses
+ local: CenA, 3C293 (0.045), 4C 31.04 (0.06)

Chemistry @highz
Variations of cst

~ 30-100 times more sources with ALMA?



Combes & Wiklind 1998

Conclusions

- ALMA deep field in continuum: N(S), SFR (z) and SFH

- the CO lines will be intensively observed at high z with ALMA
➔ efficiency of star formation (z), and the kinematics, Mdyn

➔If CO not excited, either CII, or go to GBT, EVLA and SKA precursors to detect the low-J CO lines