Molecular Gas in Star Forming Galaxies at z=1-3

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&
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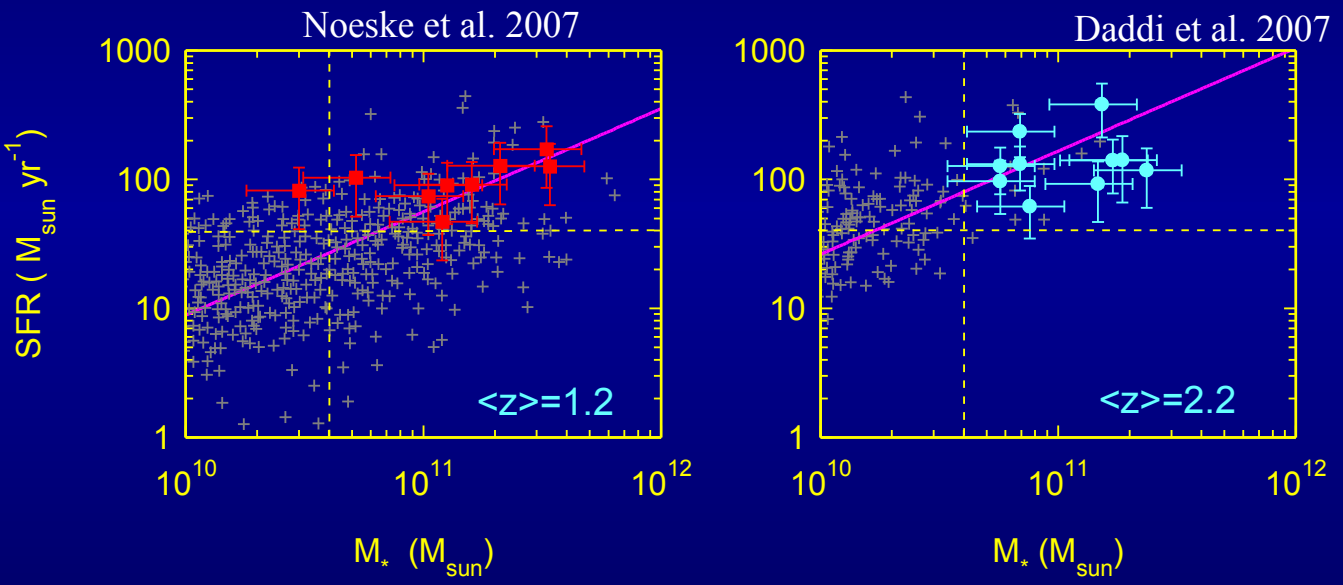
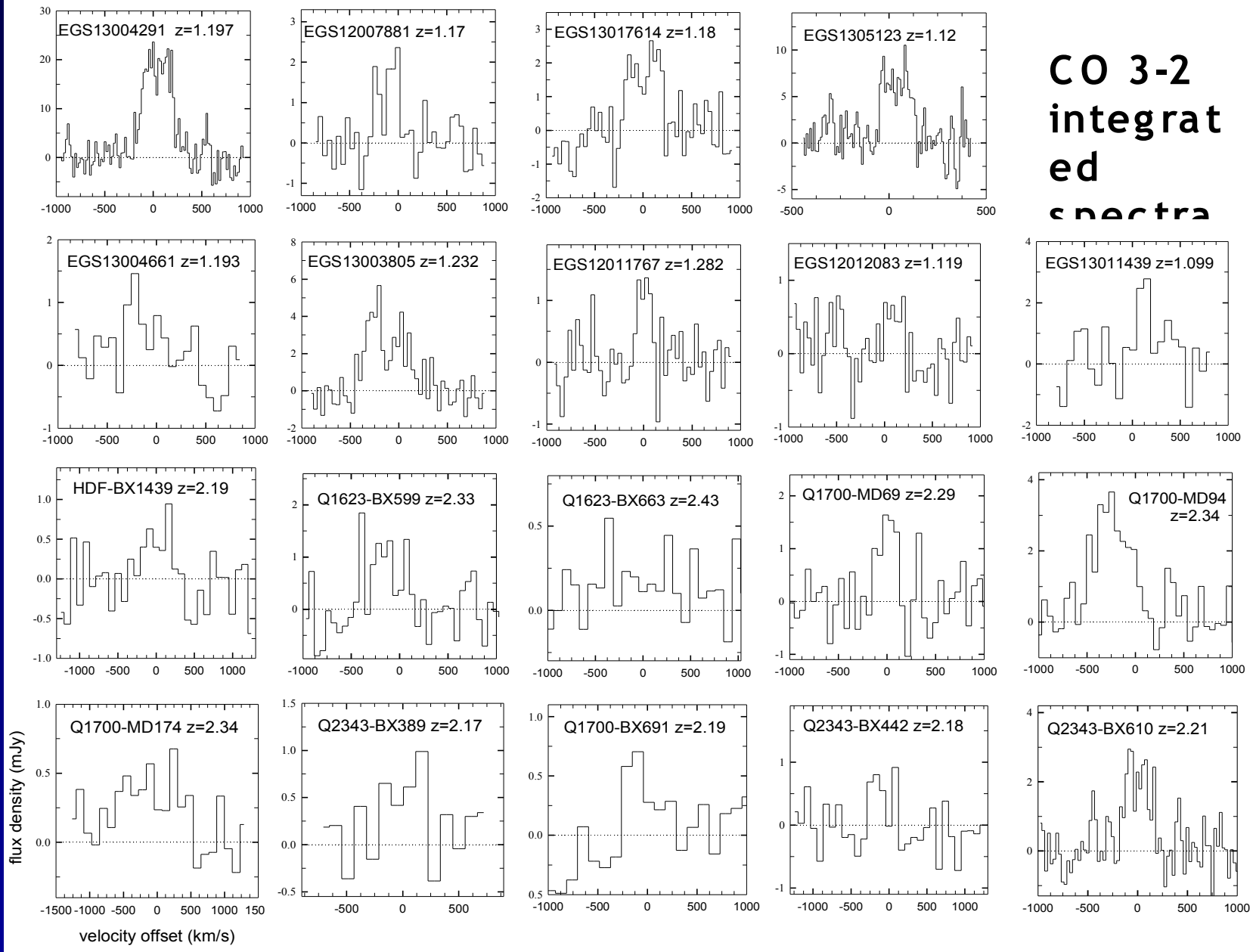
Santa Cruz Galaxy Evolution Workshop
August 19, 2010

A Survey of CO (3-2) Line Emission in Massive z~1.2 and 2.2 Star Forming Galaxies

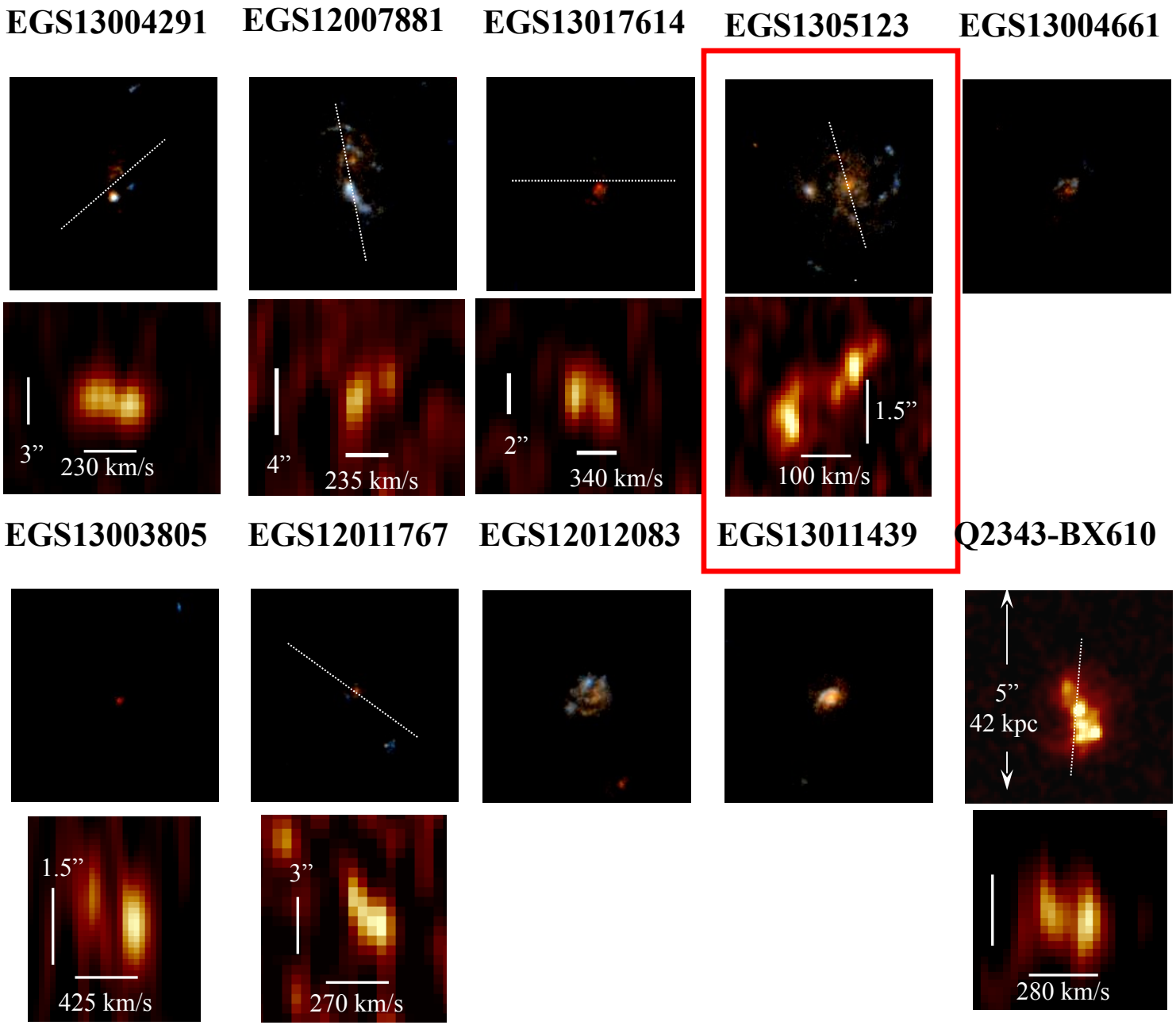


15-20 z~1-1.5 and z~2-2.5 SFGs
$M_*=10^{10.7\text{-}11.2}\ M_\odot$
SFR = 40-200 $M_\odot$/yr

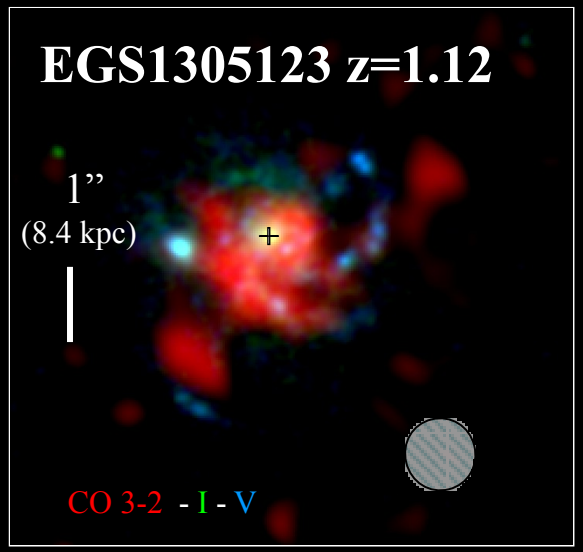
Tacconi et al. 2010,
Genzel et al. 2010,
IRAM LP Team, in prep

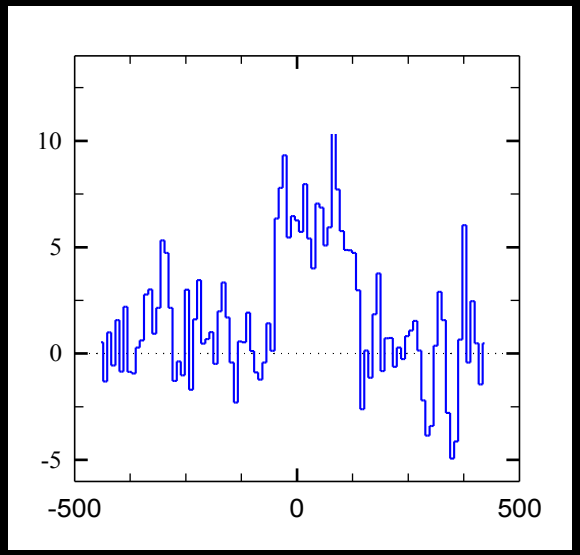


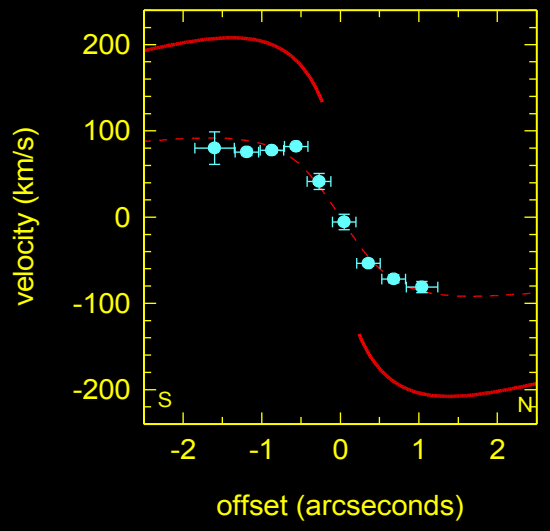
CO 3-2 integrated spectra

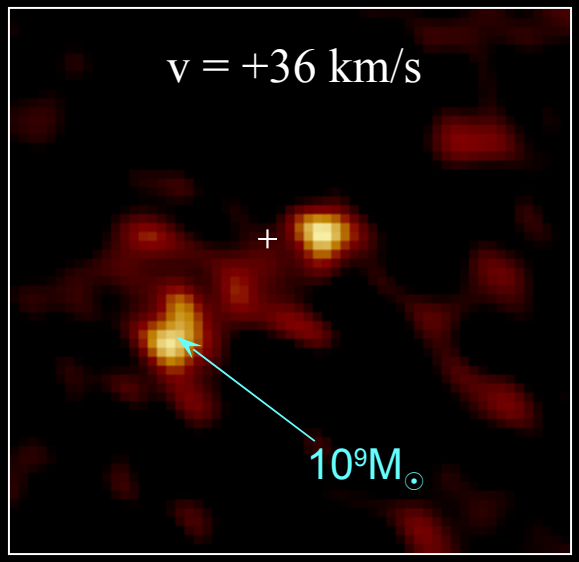

EGS13004291
EGS12007881
EGS13017614
EGS1305123
EGS13004661
3”
230 km/s
4”
235 km/s
2”
340 km/s
1.5”
100 km/s
EGS13003805
EGS12011767
EGS12012083
EGS13011439
Q2343-BX610
5”
42 kpc
1.5”
425 km/s
3”
270 km/s
280 km/s

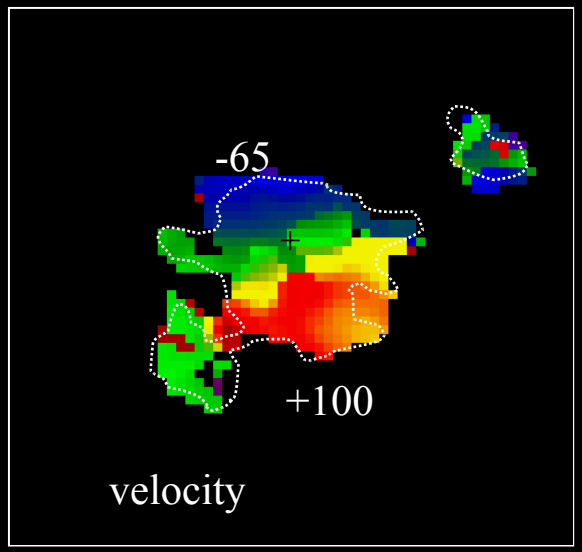
First z~1.2 CO Rotation Curve

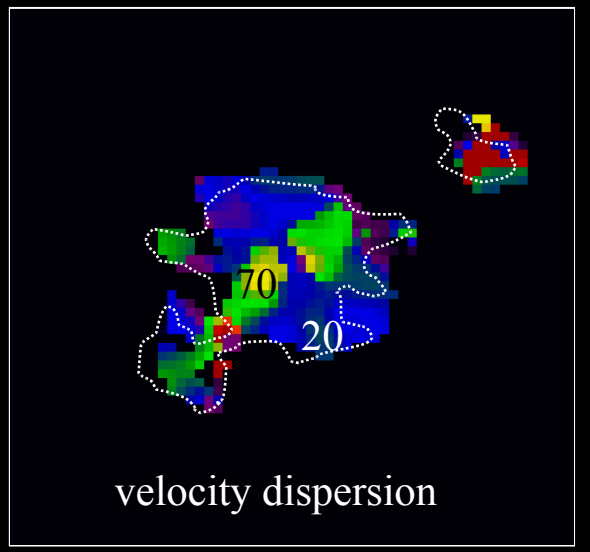










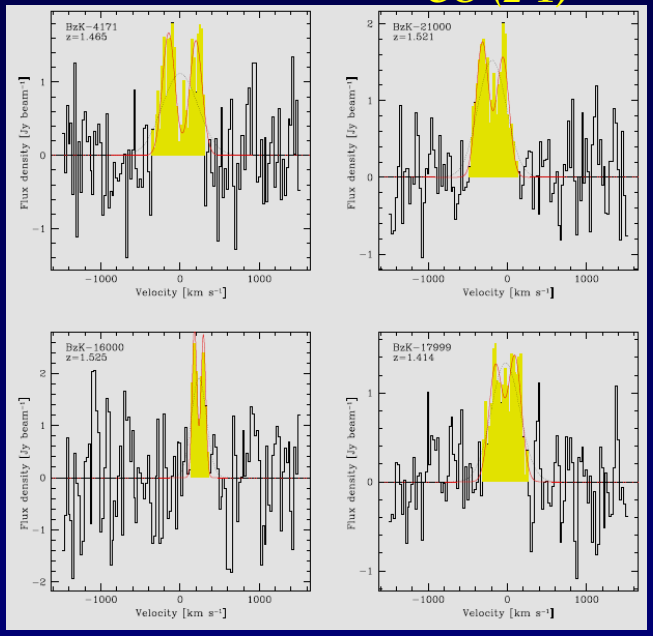


M_{gas} ~1.3x10^{11} $M_\odot$; , M_*~ 3x10^{11} $M_\odot$,, f_{gas} ~0.3,
v_{rot}/σ = 8±2

Tacconi et al. 2010

CO in z=1.5 BzK Galaxies in GOODS-N

CO (2-1)



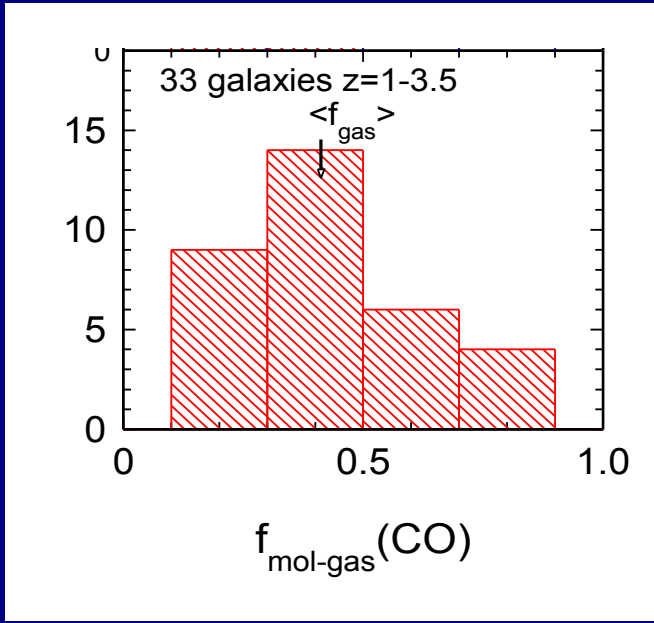
- *6 massive BzK galaxies*
- *Clumpy, unstable disks*
- *Spatially resolved emission in 4*
- *CO sizes (FWHM) 6-11 kpc*
- M_{gas} = 0.4-1.2x10^{10} $M_{\odot}$

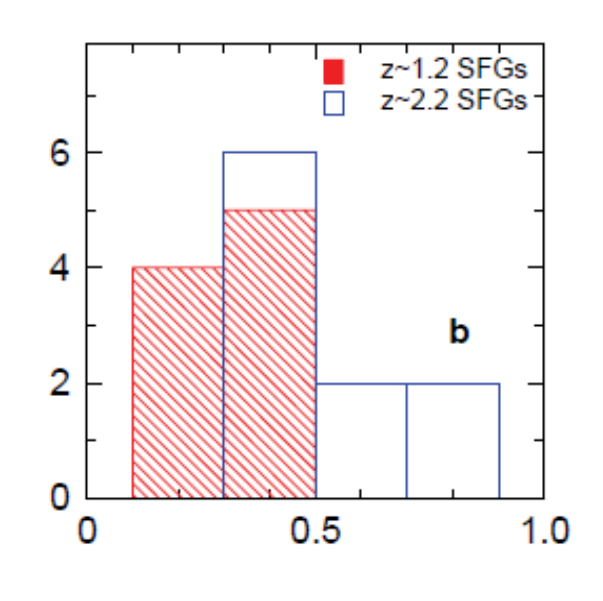
Daddi et al. 2008, 2010a, b
Dannerbauer et al. 2009

A First Census of Cold Gas Fractions in z~1-3 Star Forming Galaxies

Tacconi et al. 2010

$$M_{mol-gas} = (1 + f_{He})\alpha_{CO}(Z, \Sigma....)R_{32}L_{CO3-2}$$

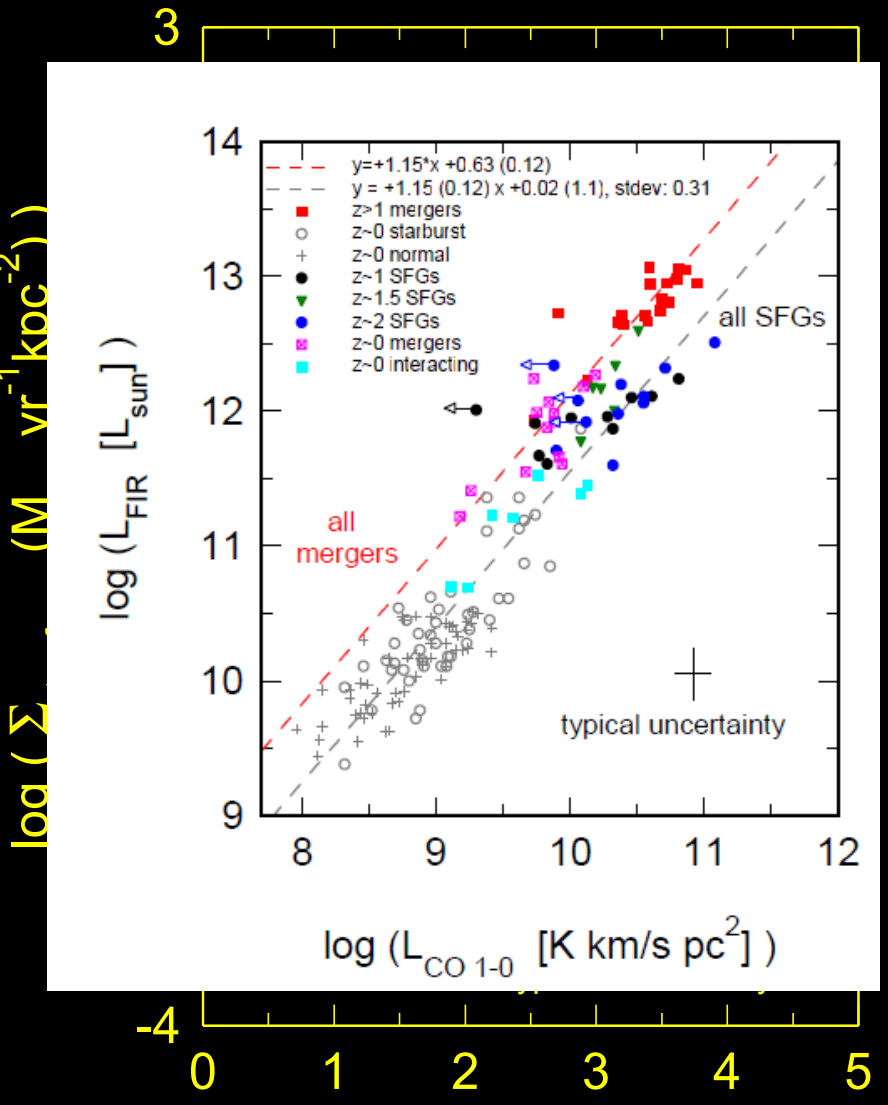


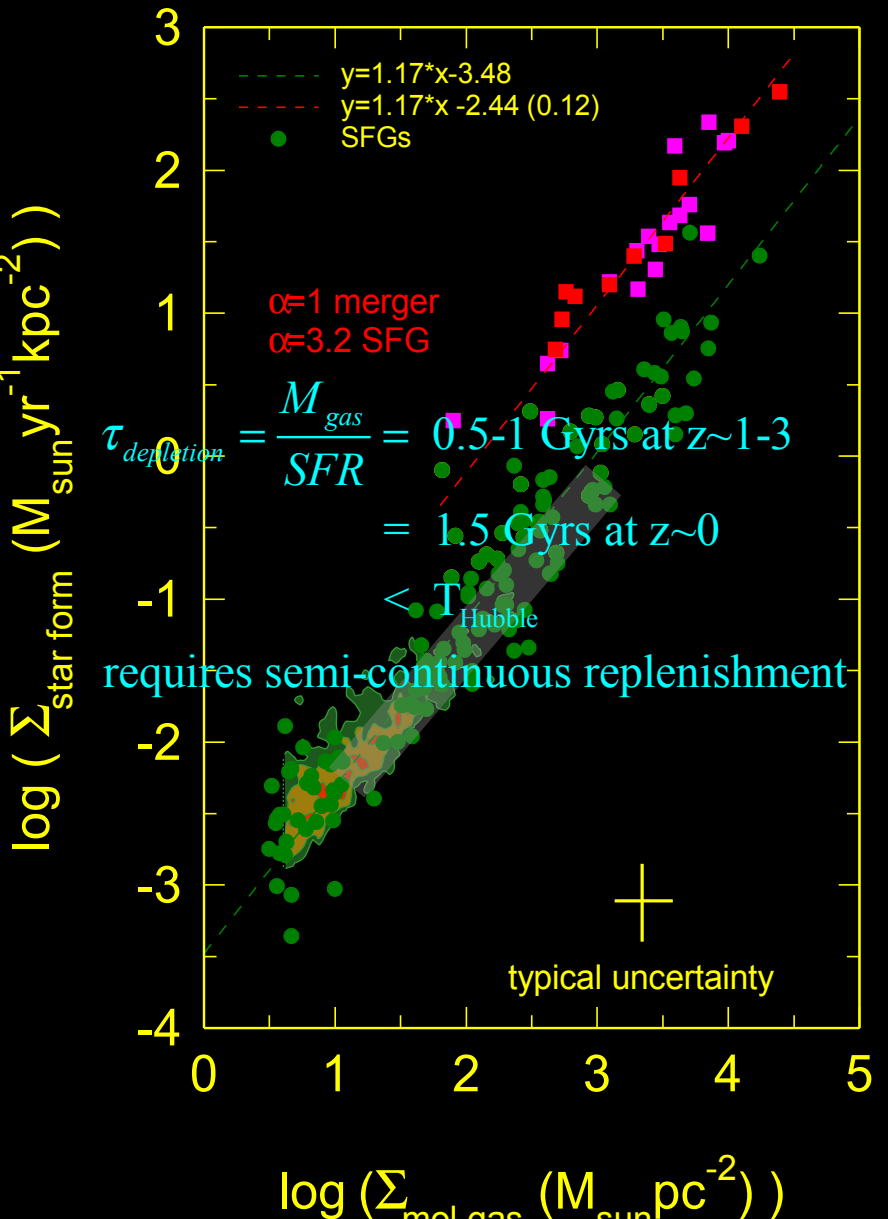


$F_{mol\text{-}gas} = M_{gas}/(M_{gas}+M_*)$

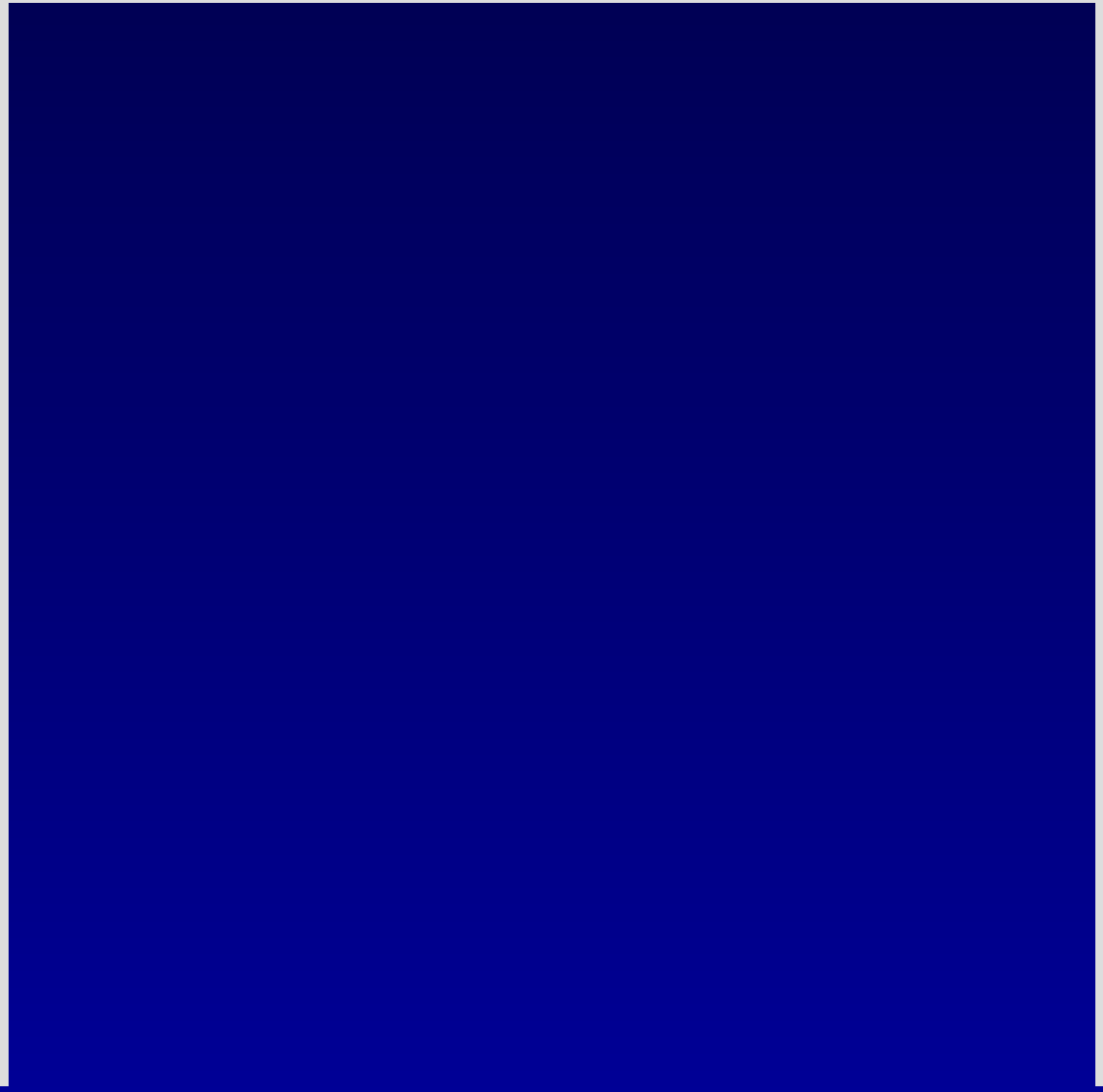
Gas-Star Formation Relation

Genzel et al. 2010
Also Daddi et al. 2010





‘Elmegreen-Silk’ Star Formation Relation Accounting for Global Galaxy Dynamical

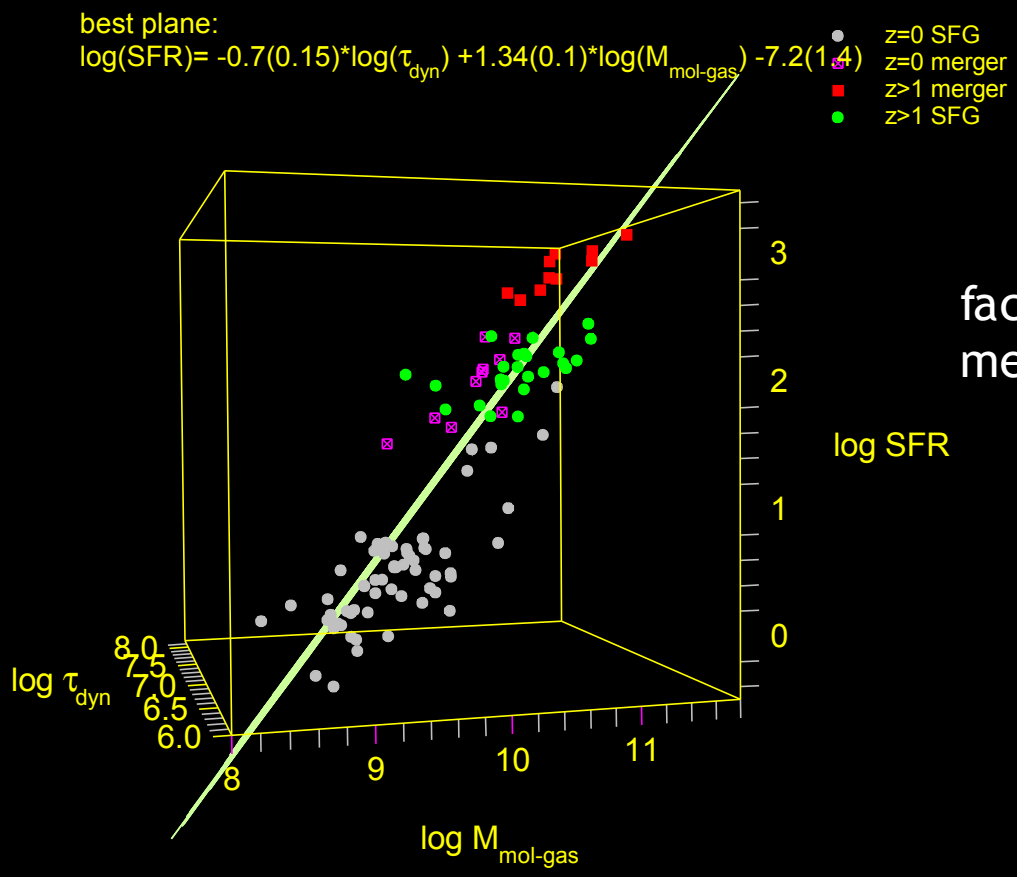


SF relation likely driven by global dynamical processes

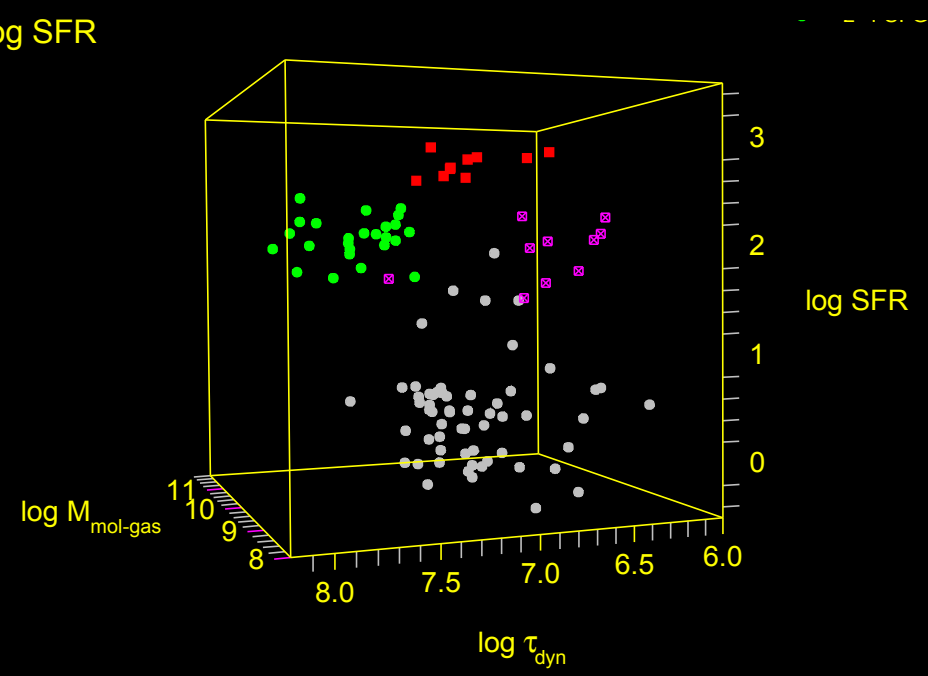
enzel et al 2010

Fundamental Plane of Star Formation

Genzel et al. 2010



face on view: large difference between mergers and SFGs at z~0 and z>1



edge on view: stdev ~0.39 dex
little difference between mergers and SFGs at all z

Summary

- Star forming galaxies from z=1-3 are gas-rich with
$\langle f_{gas} \rangle$ ~ 0.4-0.5 (still limited statistics); slight decreasing trend with from z=2 to z=1.

- Evidence for molecular gas in rotating disks in some z~1 "normal" SF galaxies, probably also at z~2.

- The molecular gas-star formation relation does not depend much on redshift. Low- and high-z SFG galaxy populations follow a relation with slope 1.1 to 1.2, over three orders of magnitude in gas mass or surface density.

- SF-molecular gas relation likely driven by global