Global star formation and gas scaling relations

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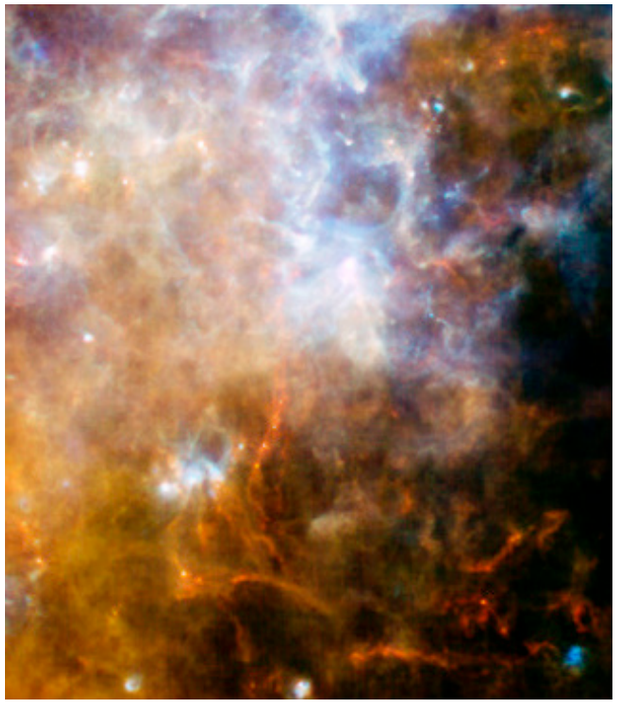
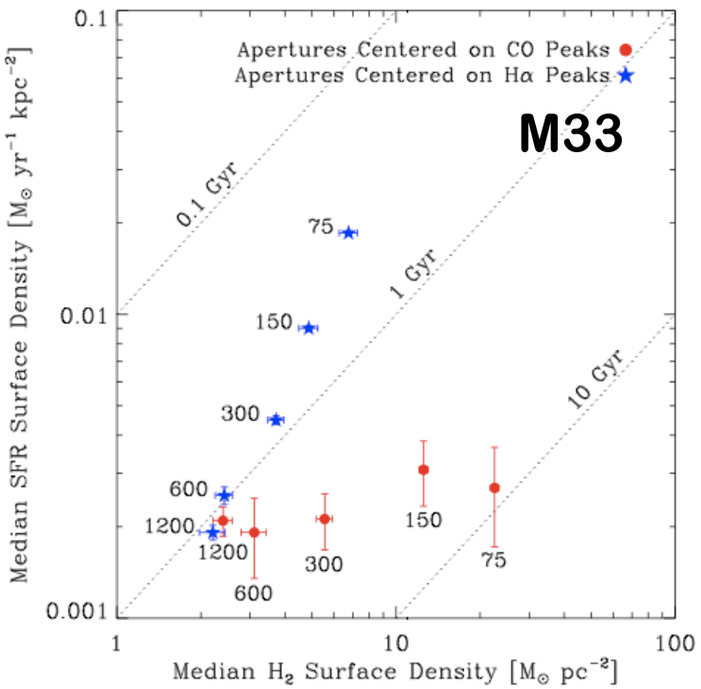
MPA/MPE

Kloster Seeon - 15 June 2011

the star formation relation on various scales

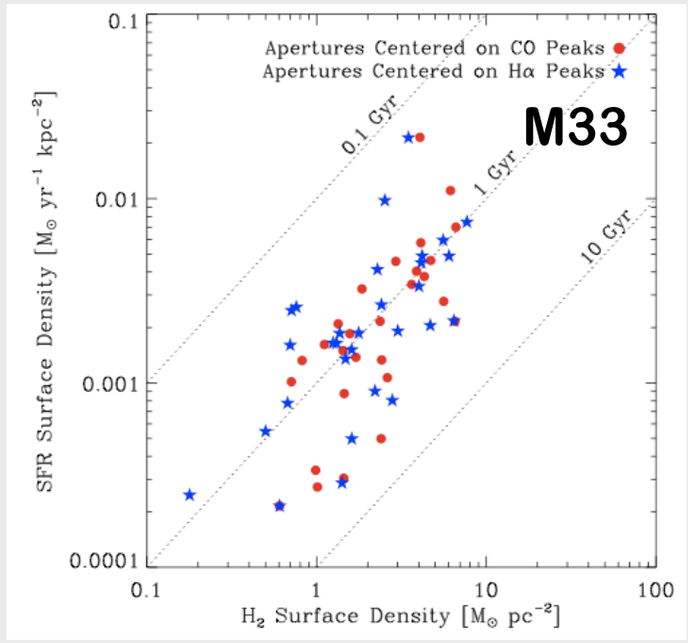
<500pc scales

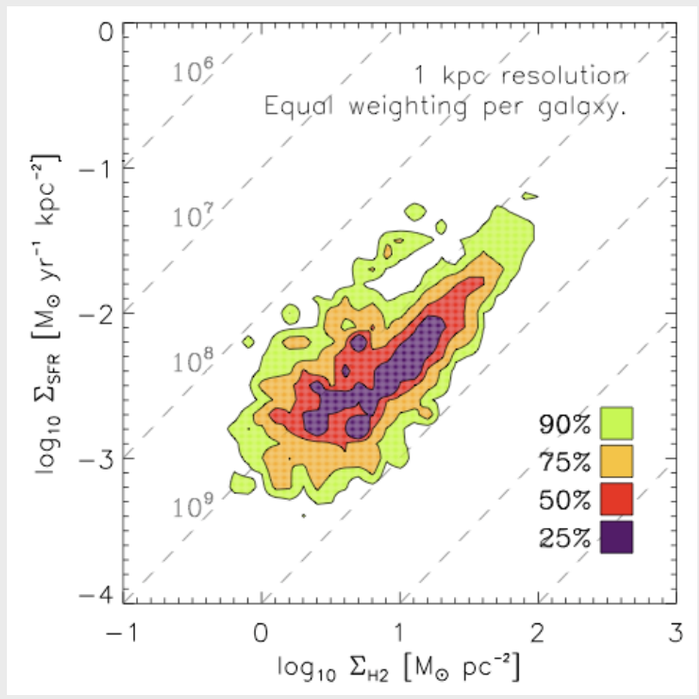




Schruba et al. (2010)

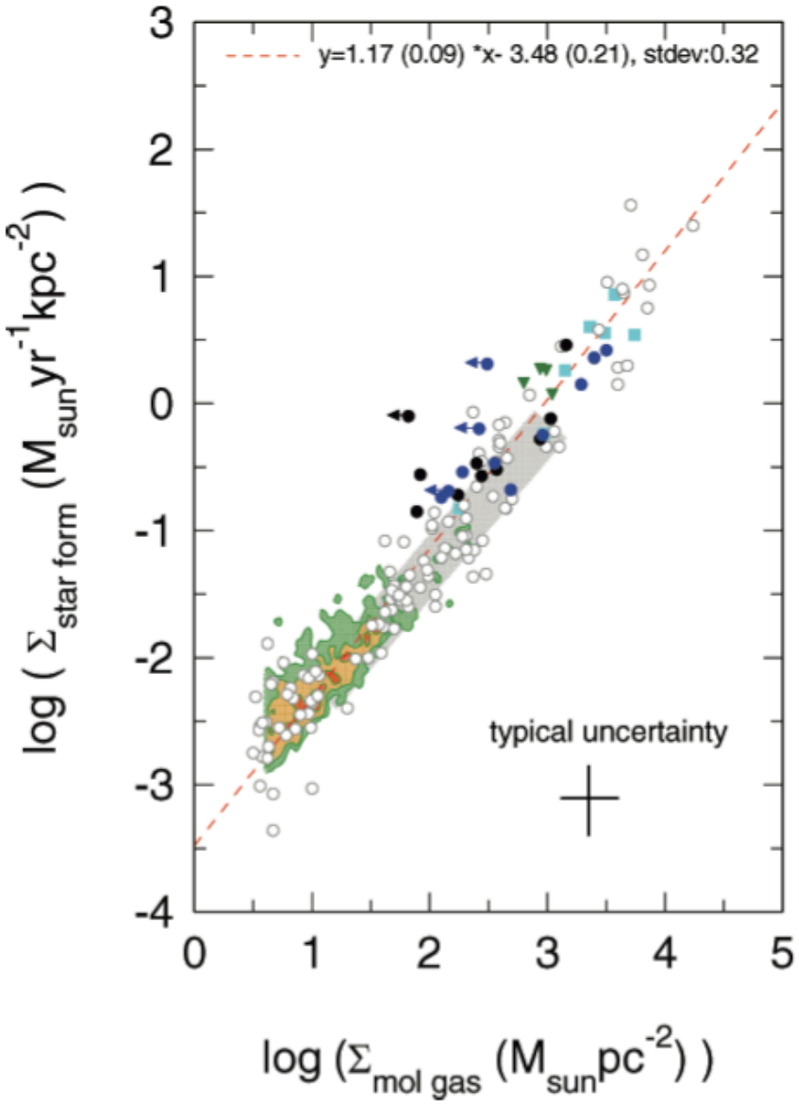
~kpc scales





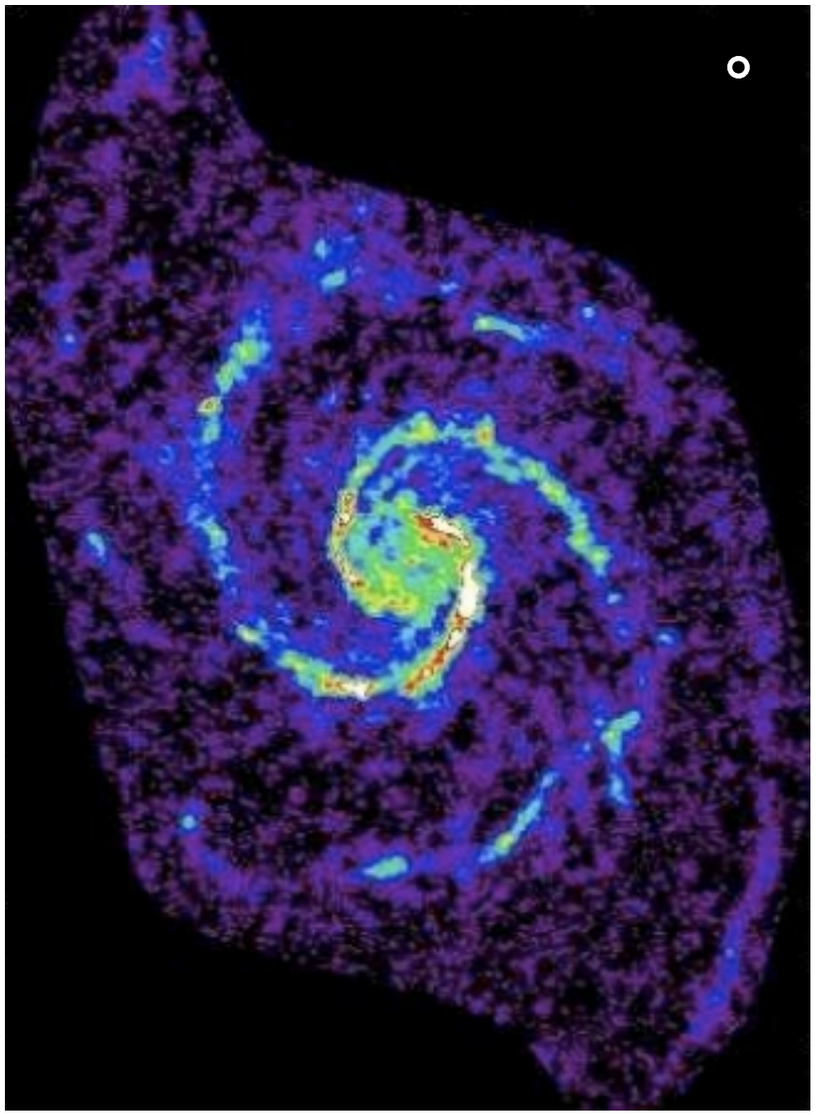
Bigiel et al. (2011)

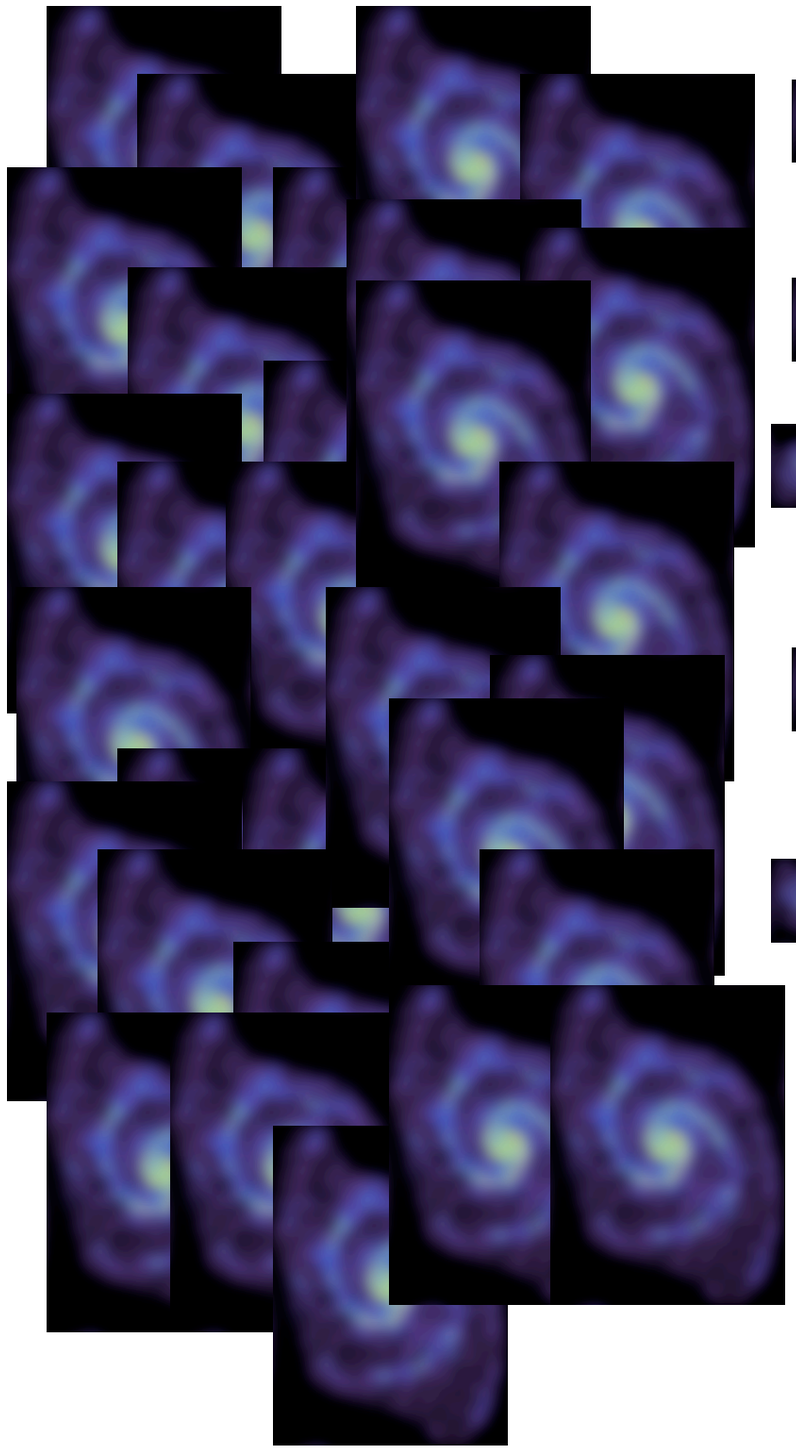
global scales

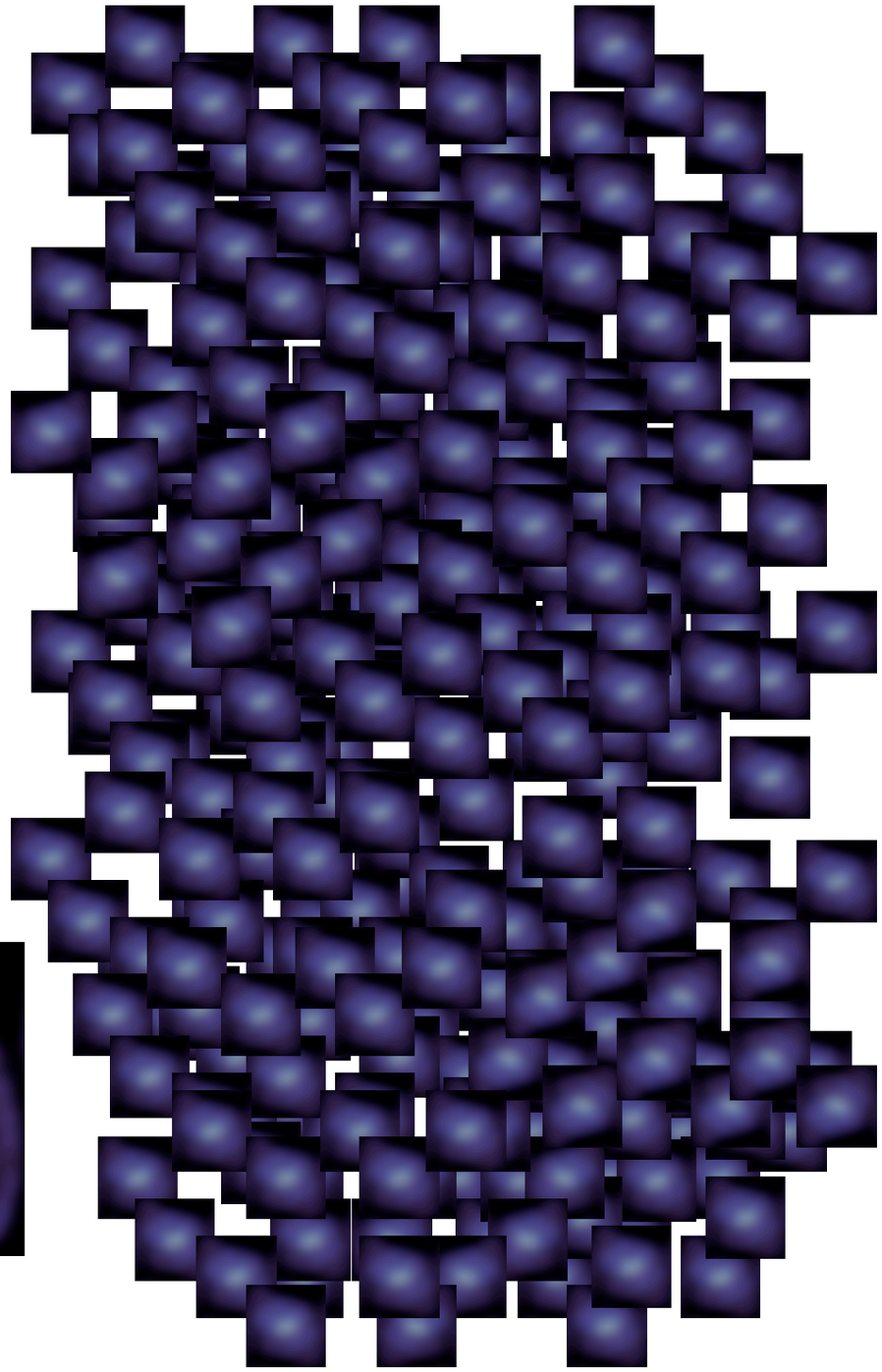


Genzel et al. (2010)

the star formation relation on various scales







the “GALEX-Arecibo-SDSS Survey” (GASS)

Goal: Provide the first statistical sample of massive galaxies with homogeneously measured stellar and gas masses, to study their link with star formation and other global physical properties.

Project: 1000 galaxies with atomic gas measurements (Arecibo) et 350 with molecular gas (IRAM 30m).

P.I.s: G. Kauffmann, D. Schiminovich, C. Kramer (B. Catinella & A. Saintonge)

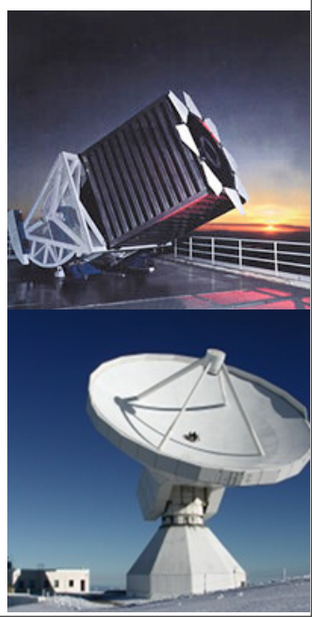
COLD GASS

CO LEGACY DATABASE FOR GASS

AN IRAM LARGE PROGRAM

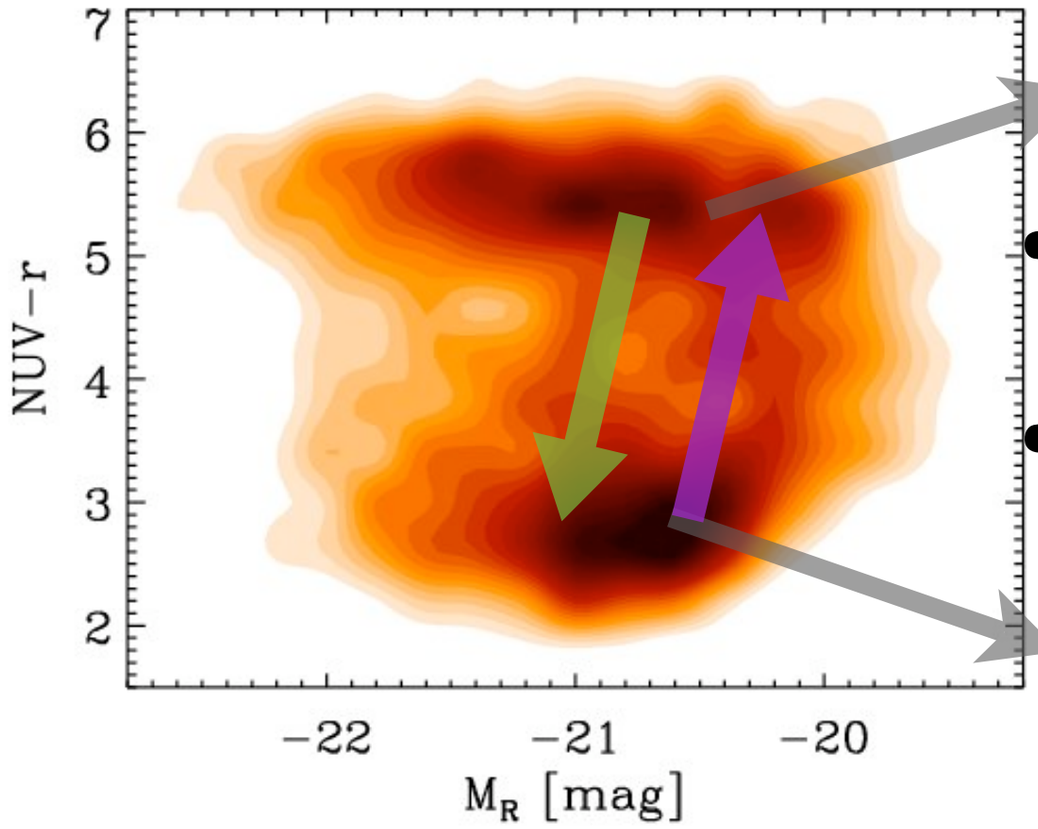
iram

Institut de Radioastronomie Millimétrique



GASS sample

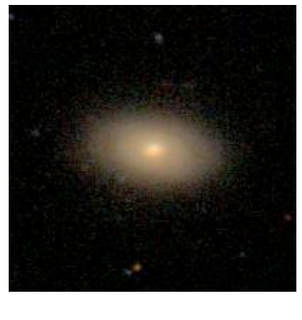
the sample is selected purely on mass ($M_* > 10^{10}\ M_\odot$) and volume (100<D<200 Mpc)

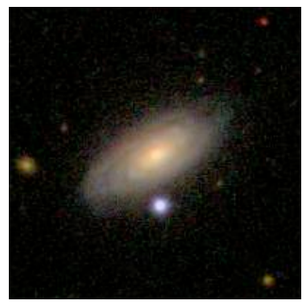


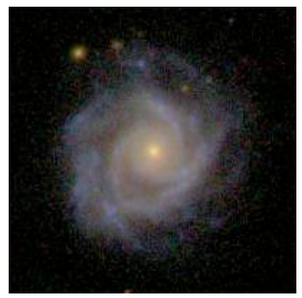
red sequence

transition

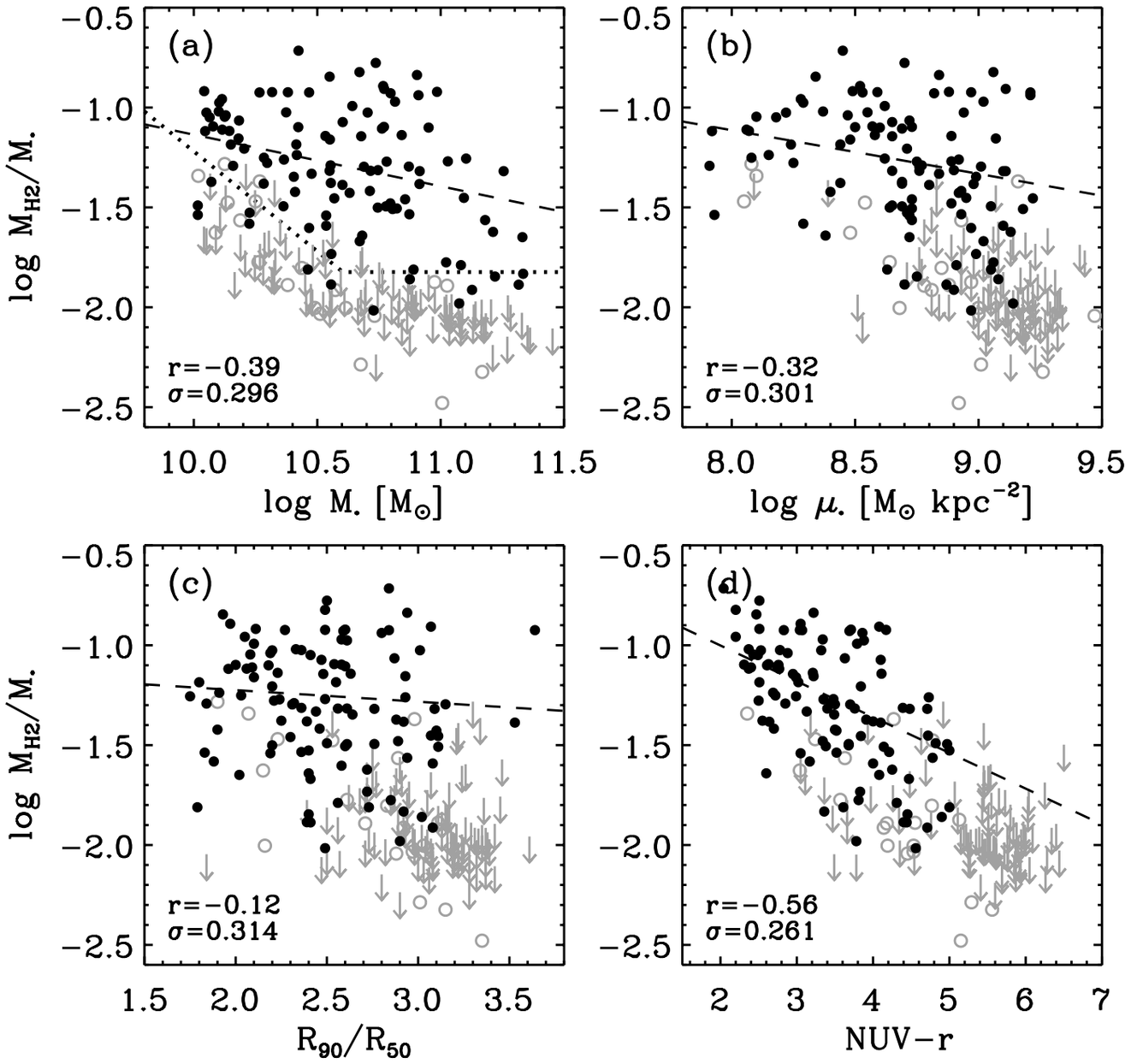
blue cloud

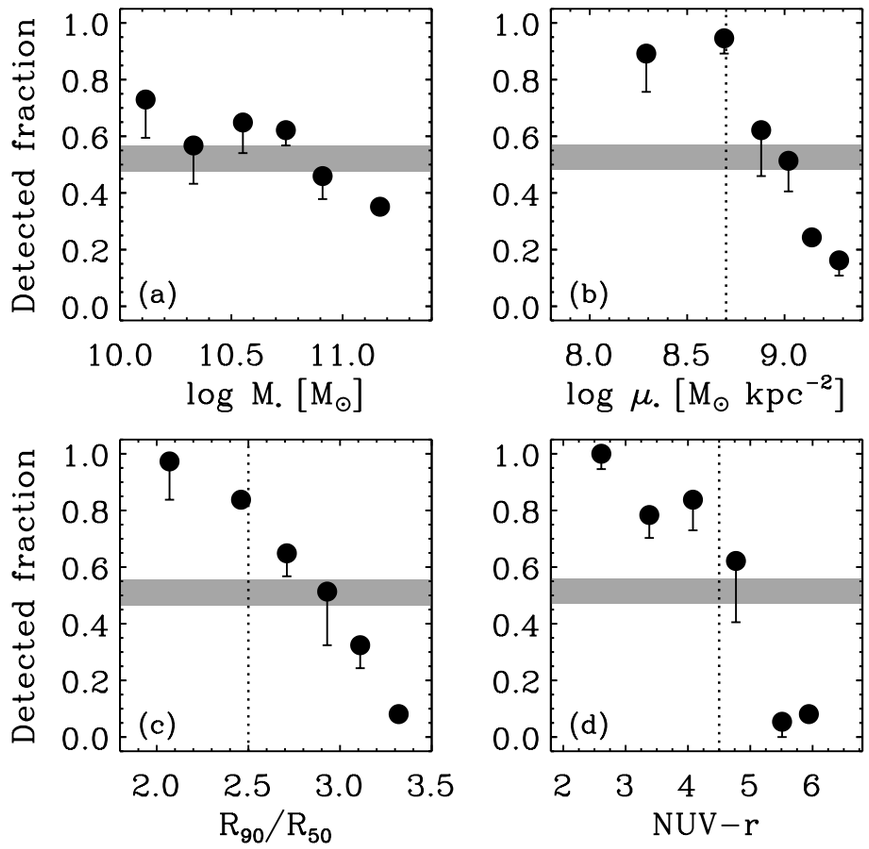






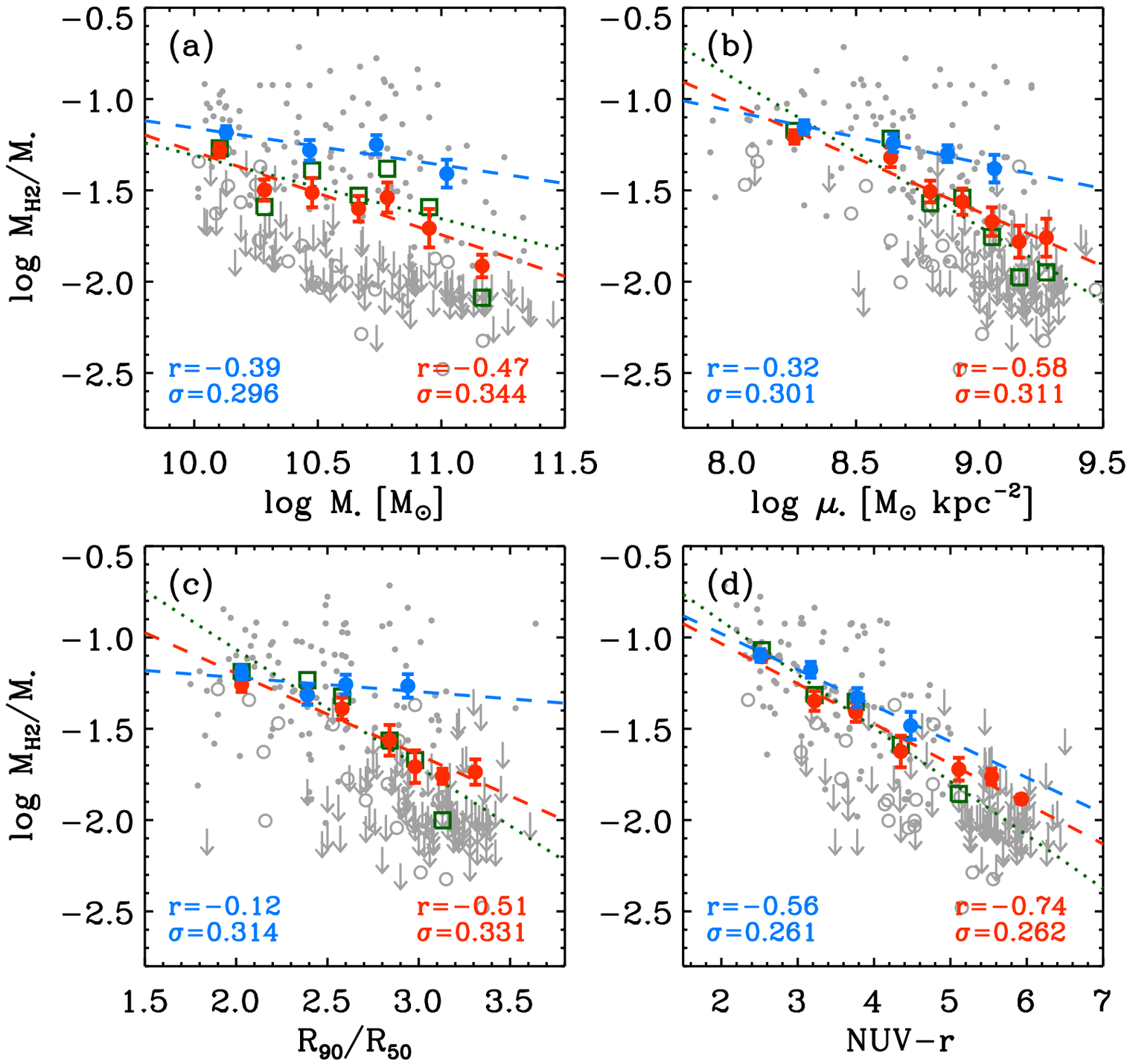
molecular gas and physical properties





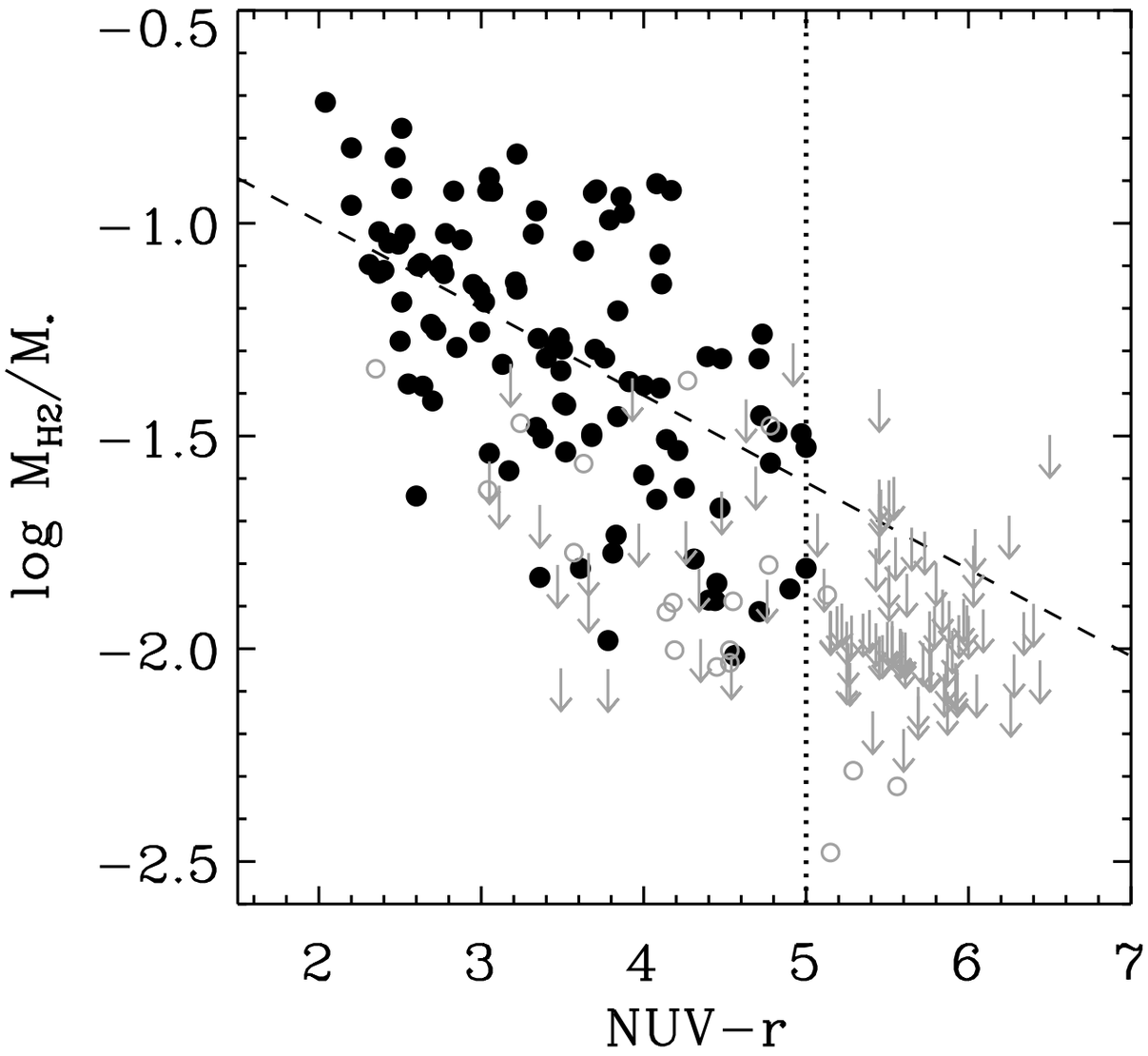
Saintonge et al. (2011a)

molecular gas and physical properties



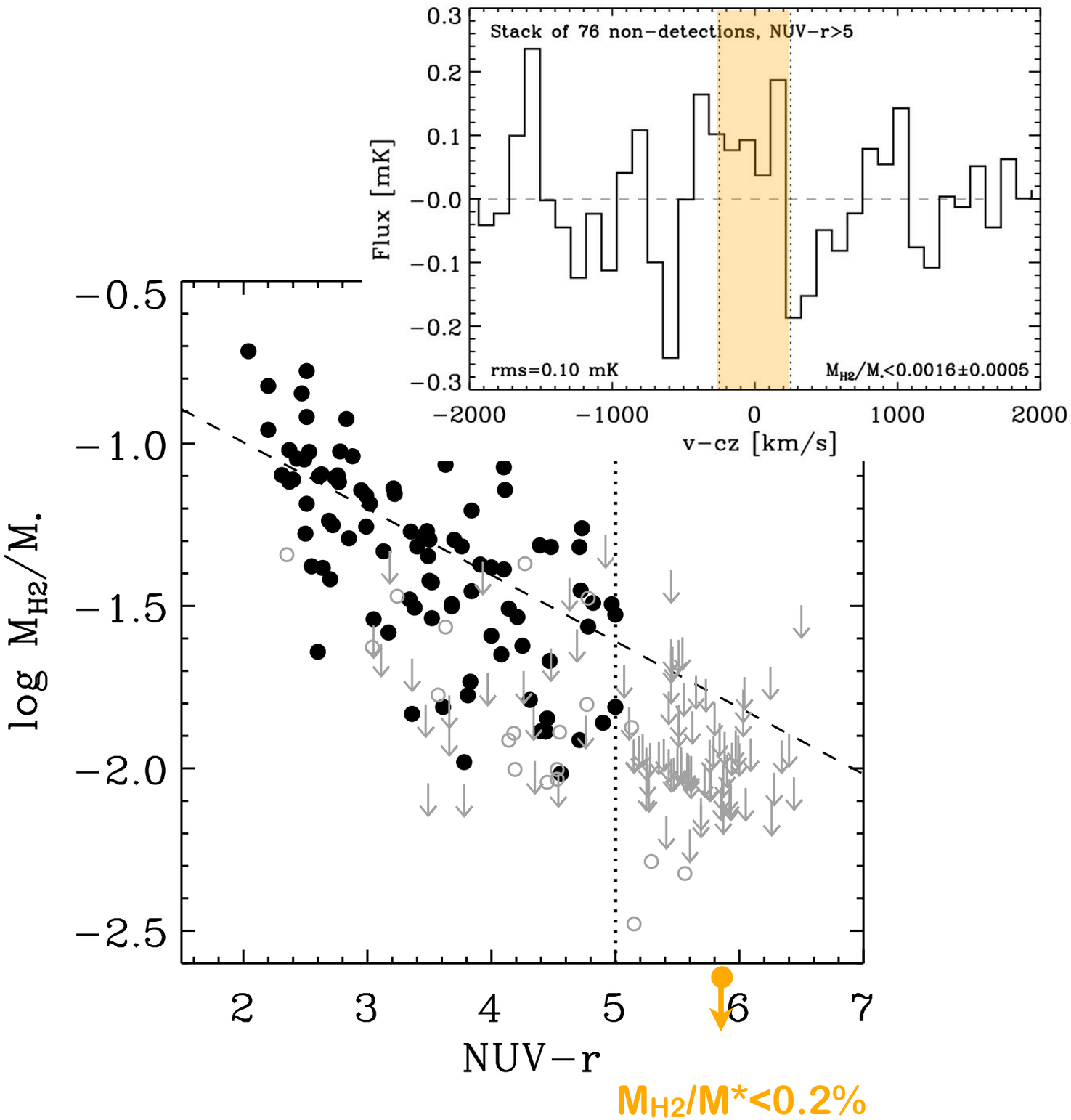
Saintonge et al. (2011a)

molecular gas in early-type galaxies



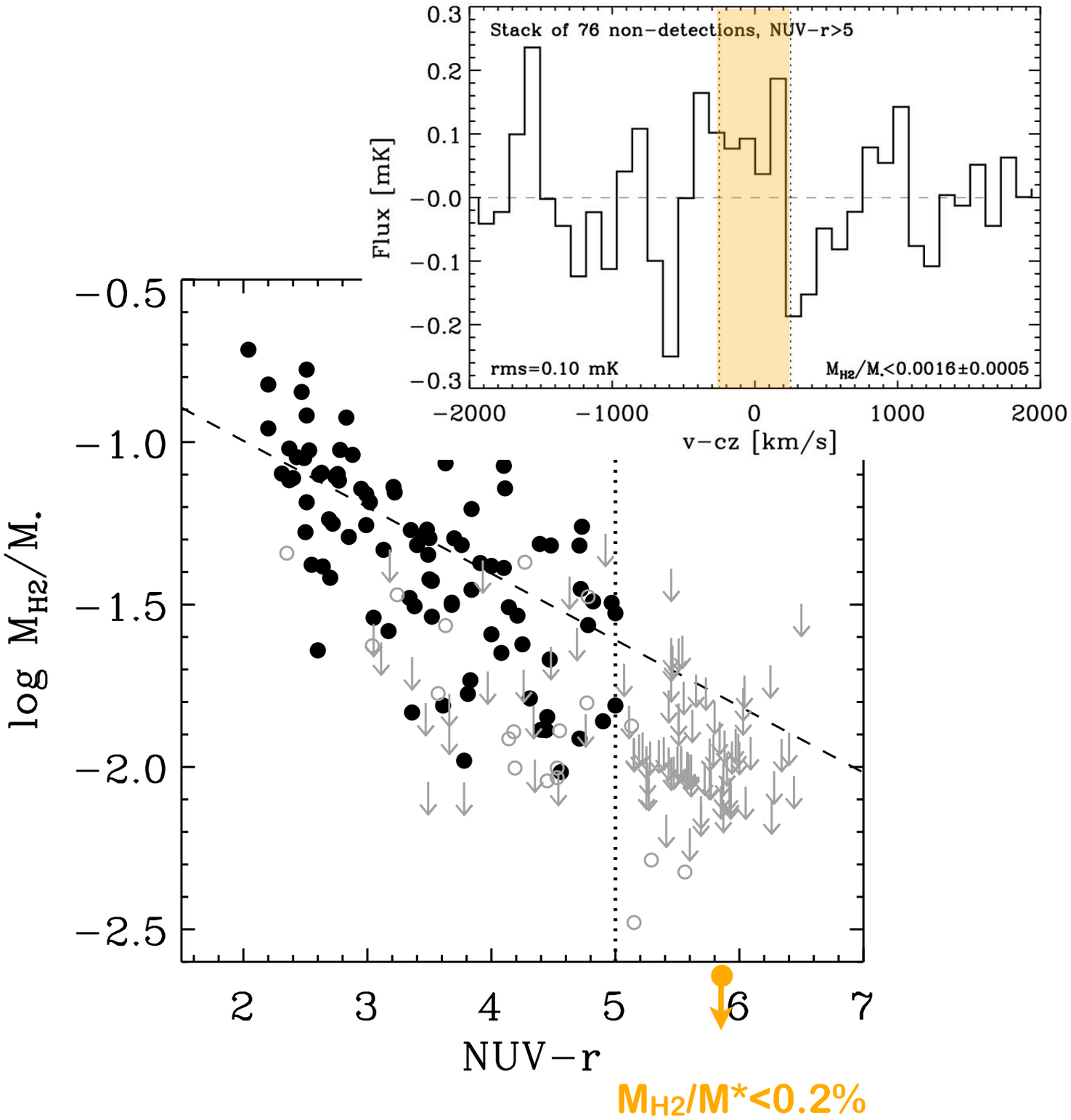
Saintonge et al. (2011a)

molecular gas in early-type galaxies



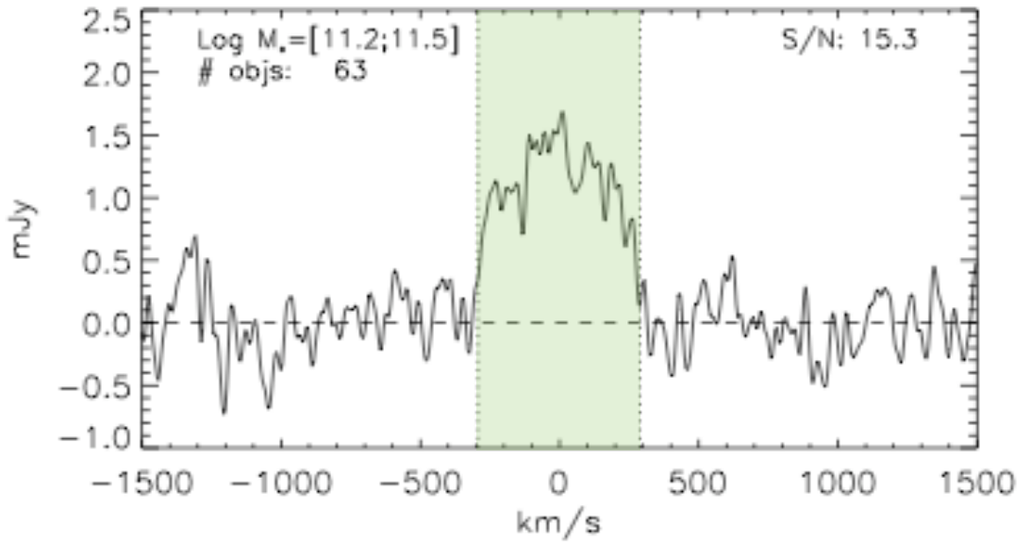
Saintonge et al. (2011a)

molecular gas in early-type galaxies

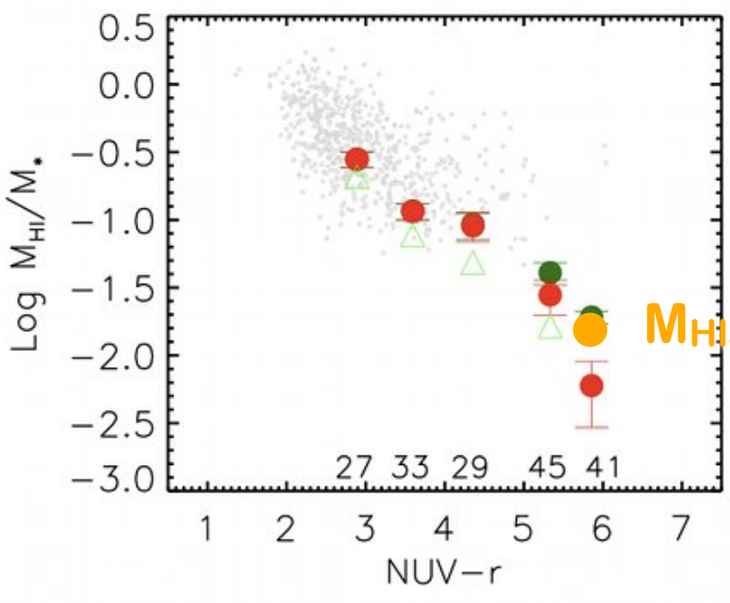


$M_{H2}/M^*<0.2\%$

Saintonge et al. (2011a)



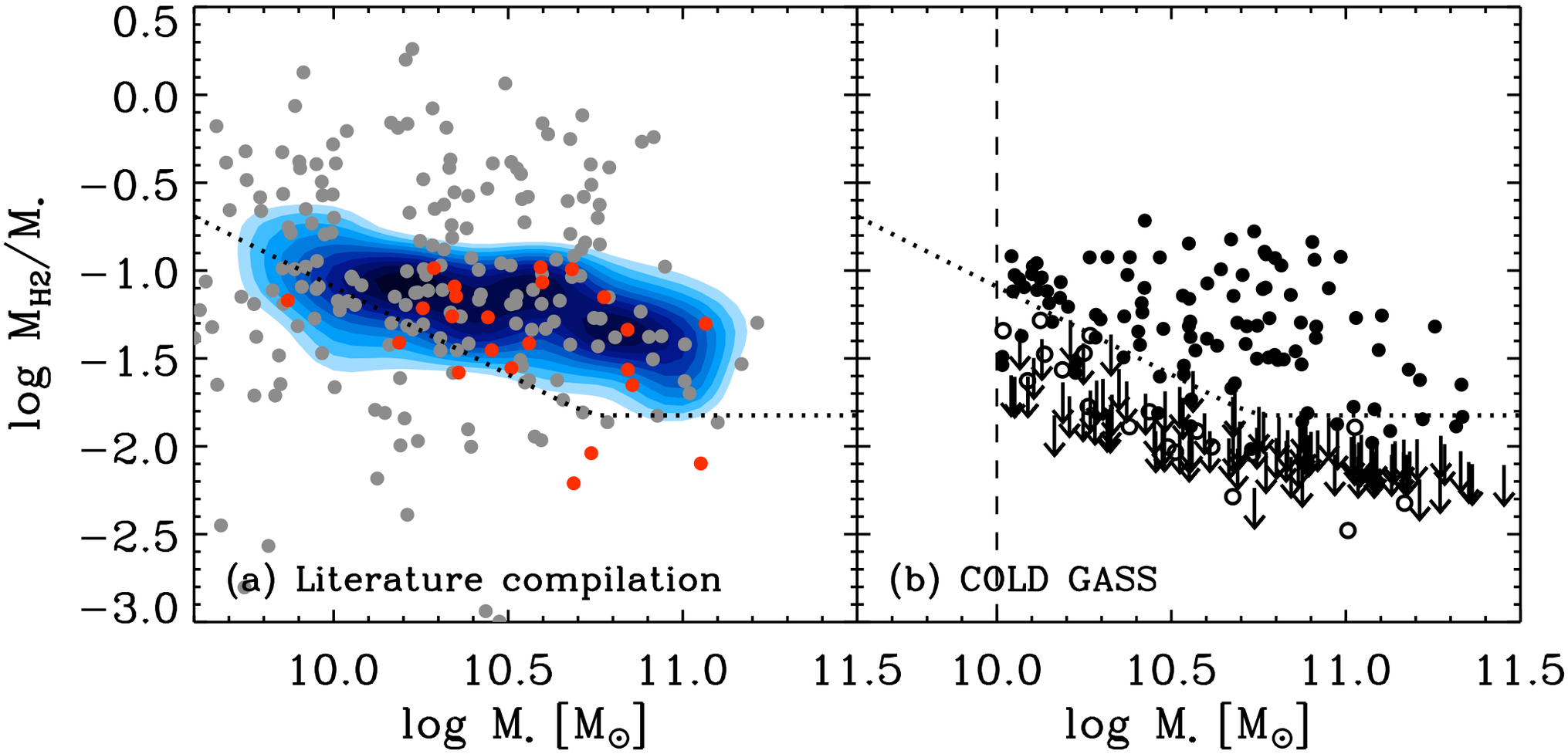
Fabello et al. (2010)



$M_{HI}/M^*=2\%$

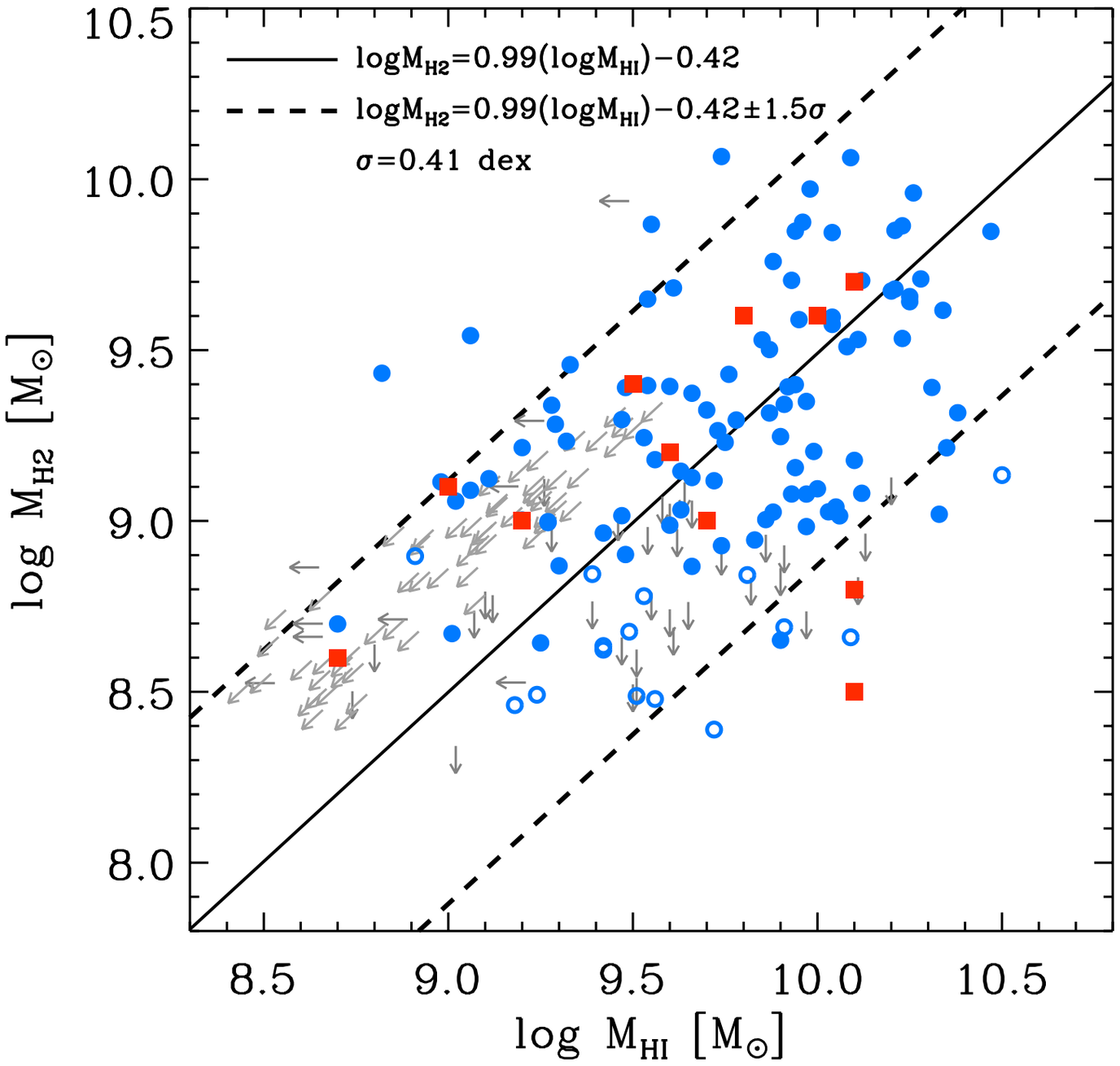
Catinella et al. (2010)

COLD GASS vs previous surveys



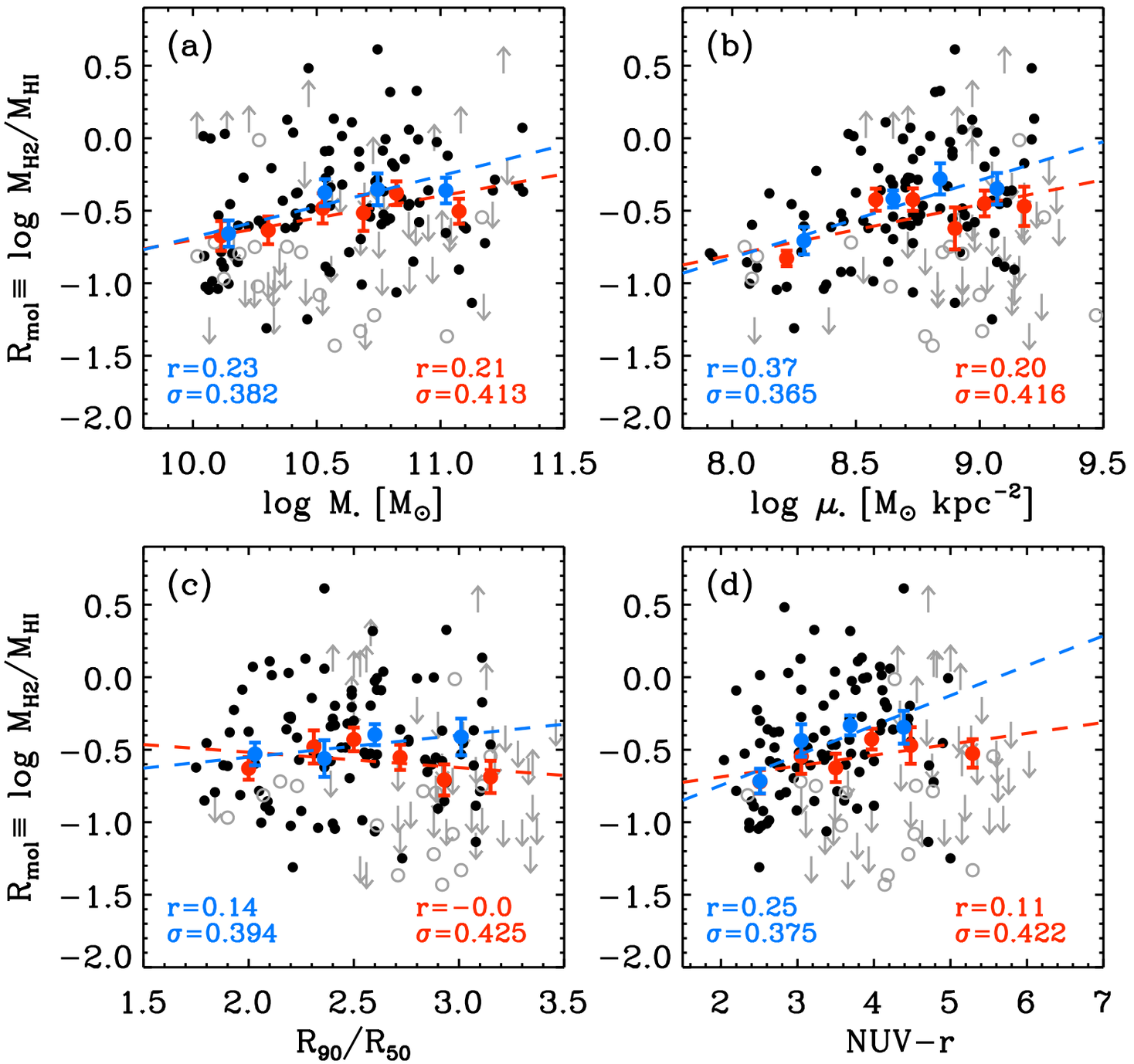
Saintonge et al. (2011a)

the balance of atomic and molecular gas



Saintonge et al. (2011a)

the balance of atomic and molecular gas



Saintonge et al. (2011a)

quantifying the gas contents of massive galaxies

$\langle M_{H2}/M^* \rangle$ = 6%
independently of
M*, μ*, C
$M_{H2}/M^* = f(NUV-r)$

$\langle M_{H2}/M^* \rangle$ < 0.2%
$\langle M_{HI}/M^* \rangle$ = 2%

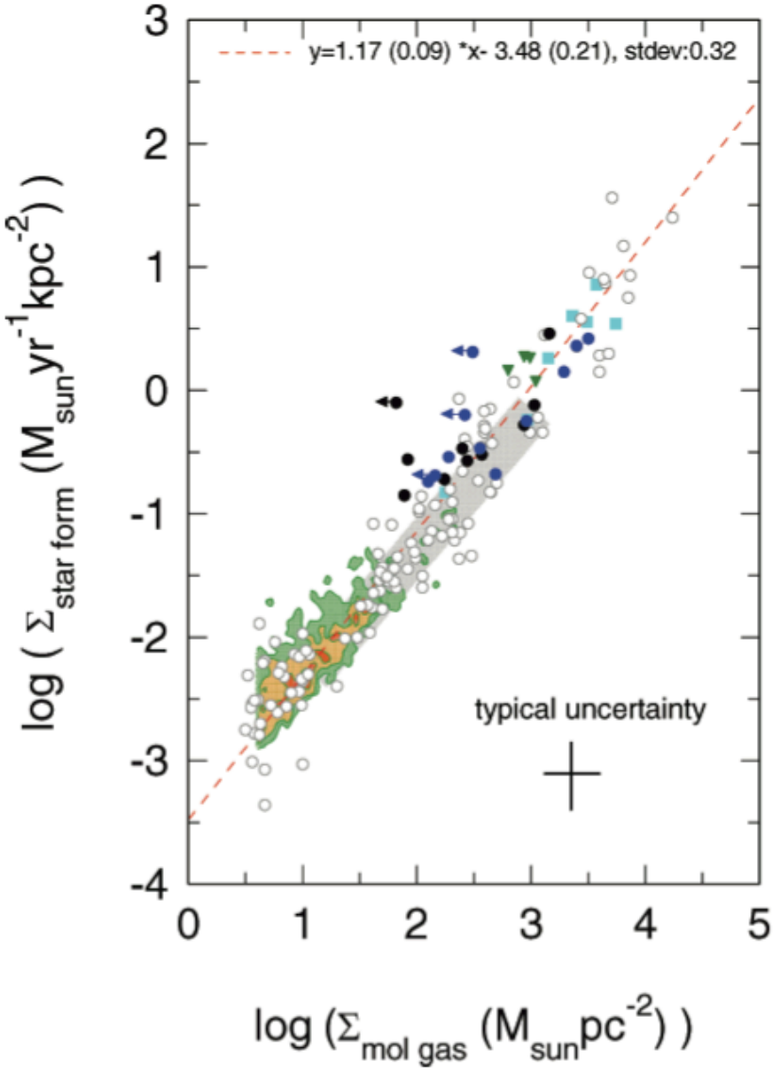
$\langle M_{H2}/M_{HI} \rangle$ = 30%
$M_{HI}/M^* = f(\mu^*, NUV-r)$

$\langle M_{H2}/M_{HI} \rangle$ < 10%

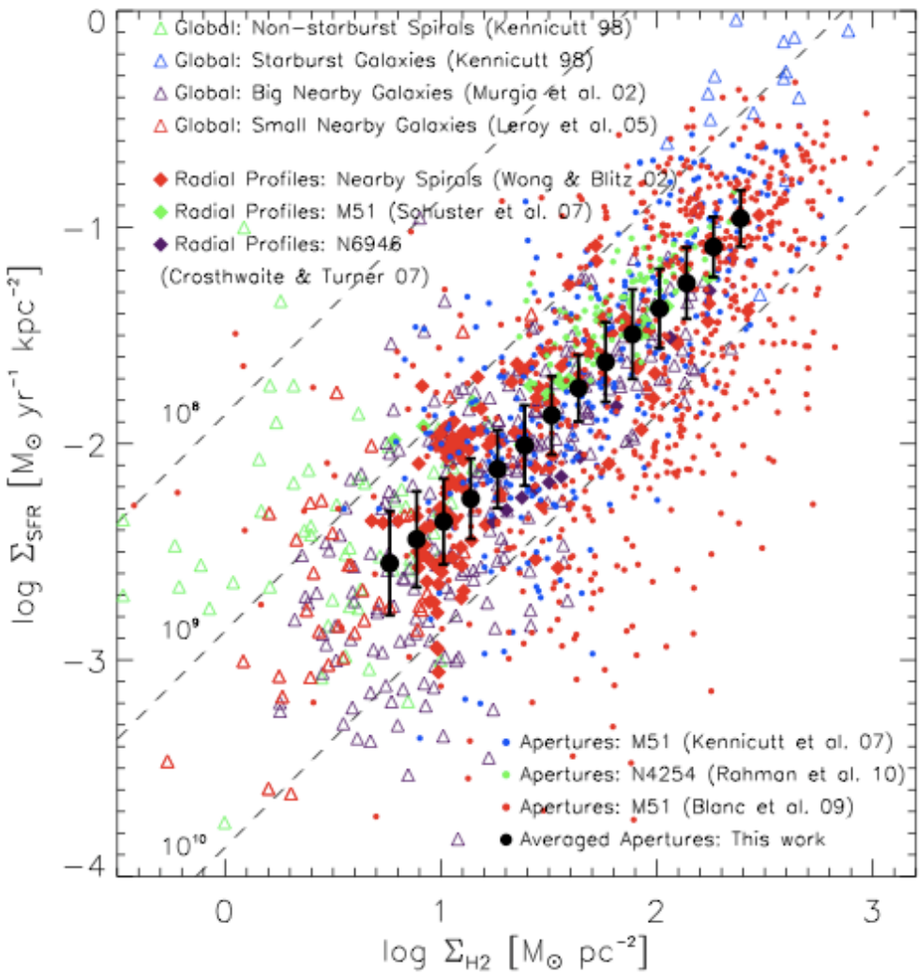
- constraints for simulations
- comparison point for observations of special populations, high redshift samples...

the balance between gas and star formation

Genzel et al. (2010)



Bigiel et al. (2011)

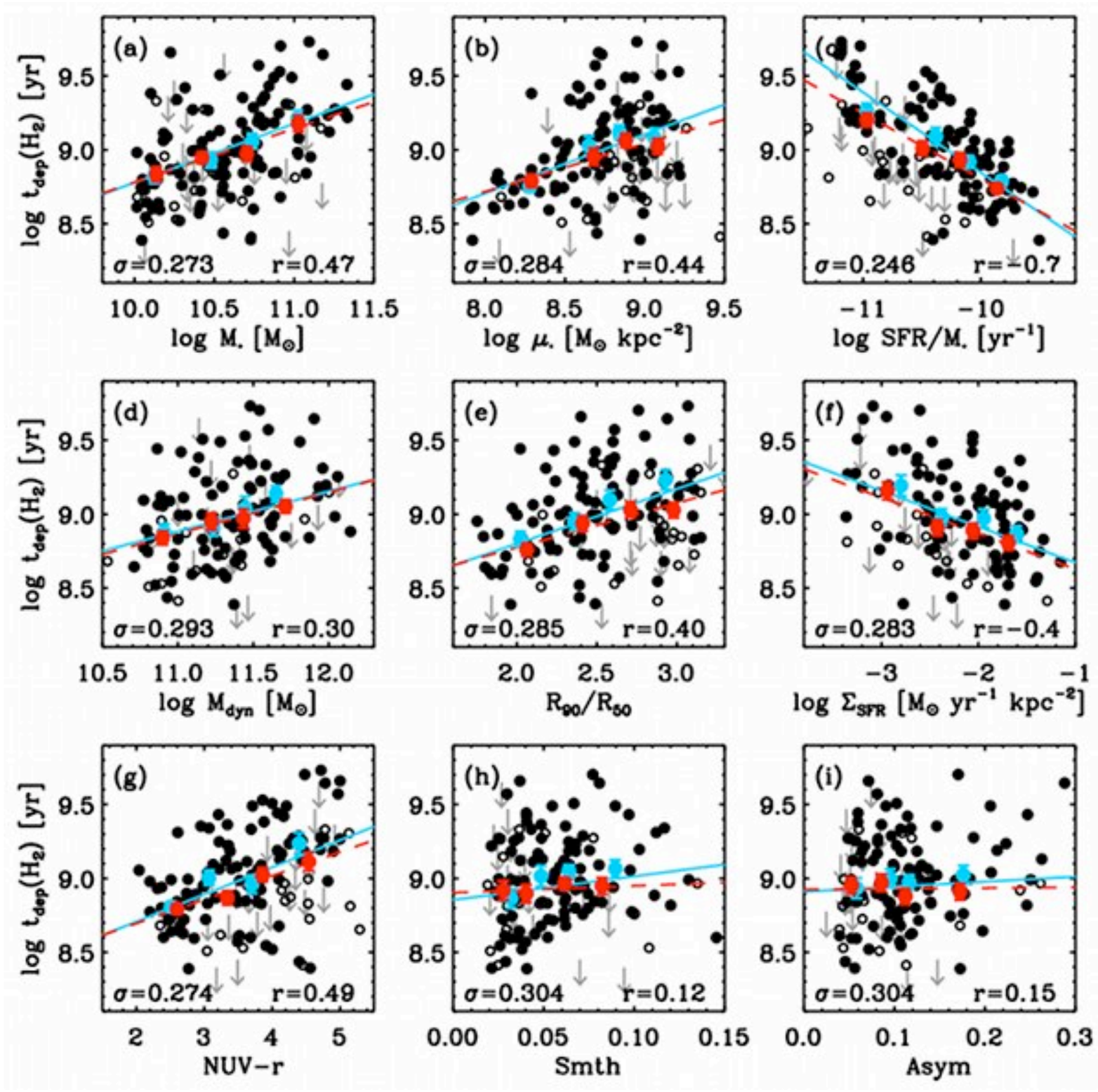


$t_{dep}(H_2) = M_{H2}/SFR$

↓

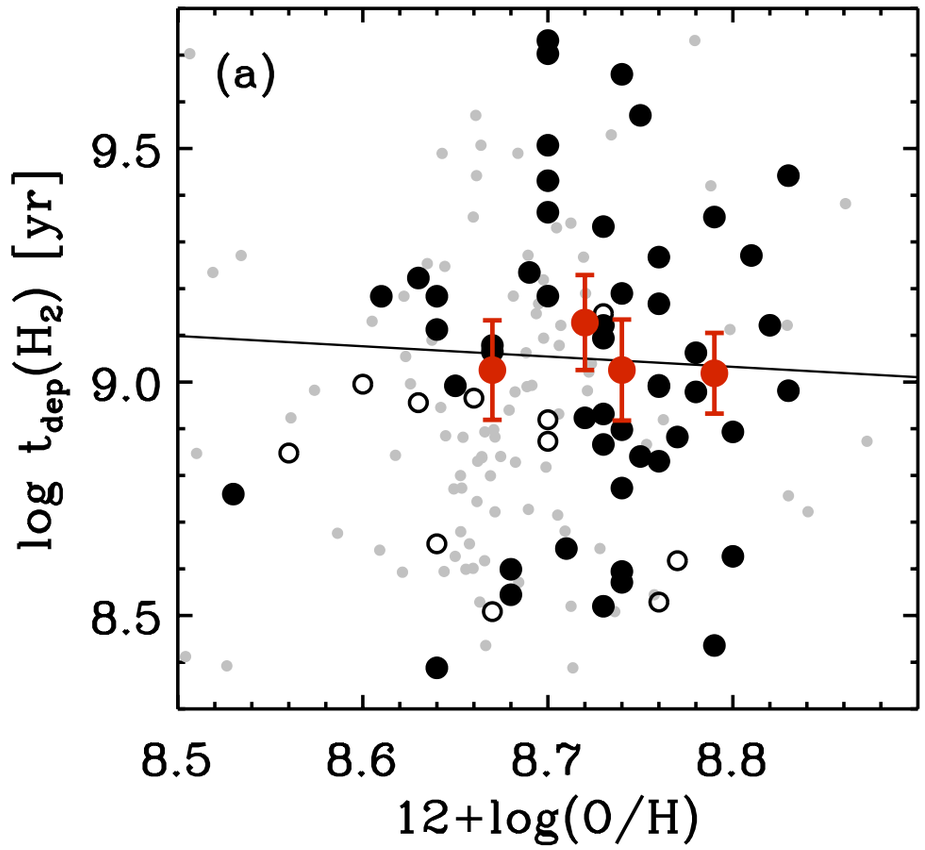
period of time over which star formation can be sustained at the current rate, assuming the system is closed

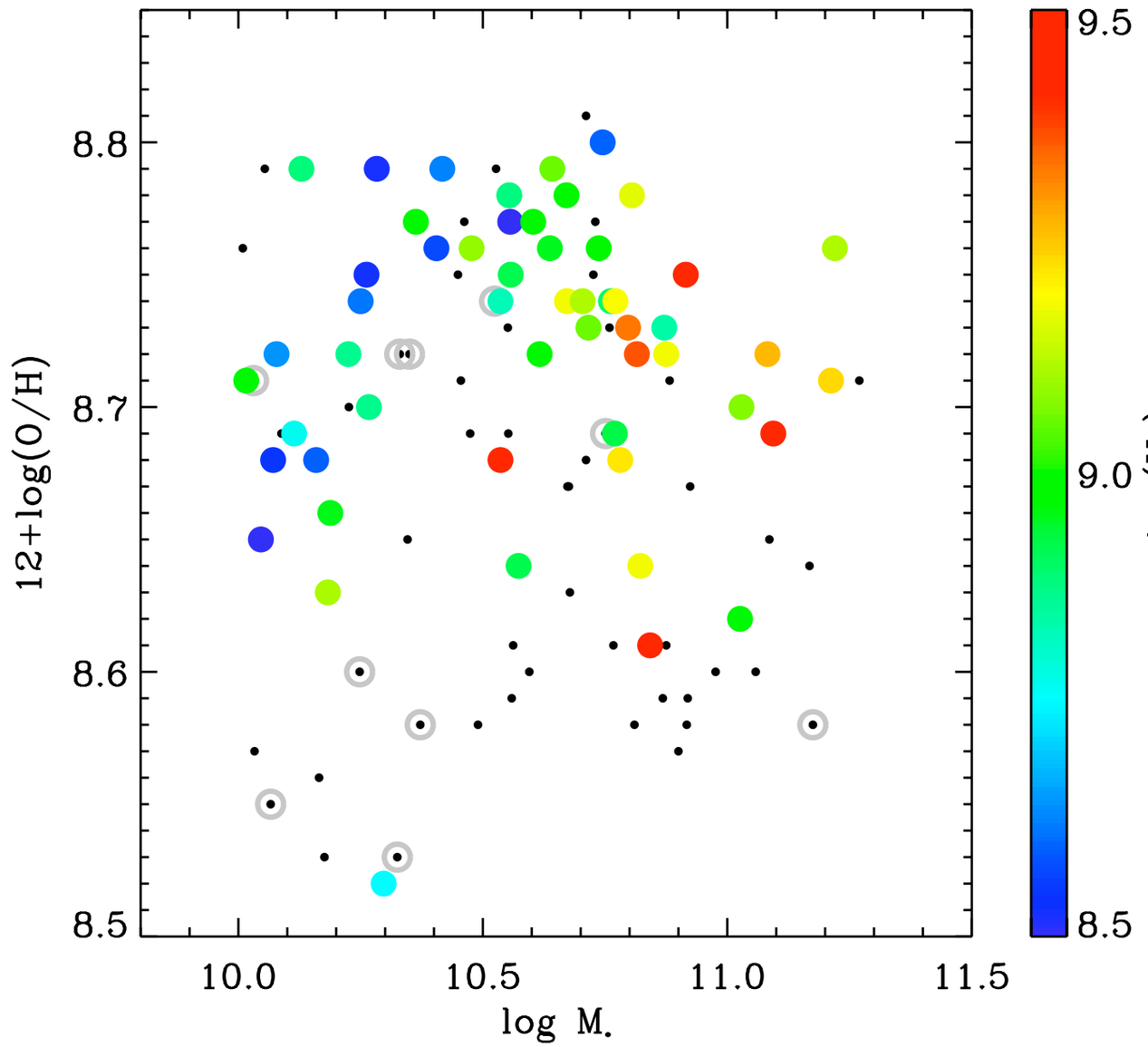
molecular gas depletion time



Saintonge et al. (2011b)

a metallicity effect on X_{CO}?





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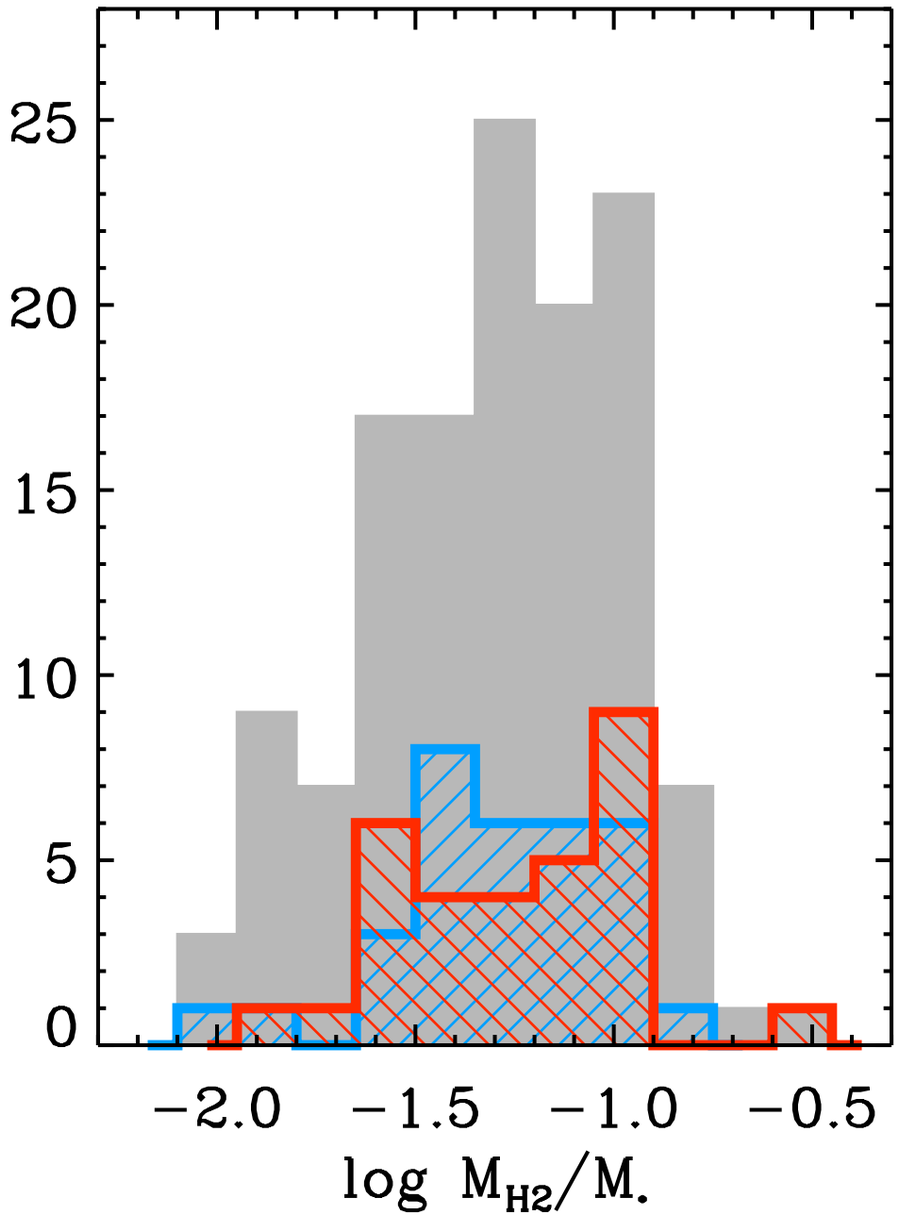
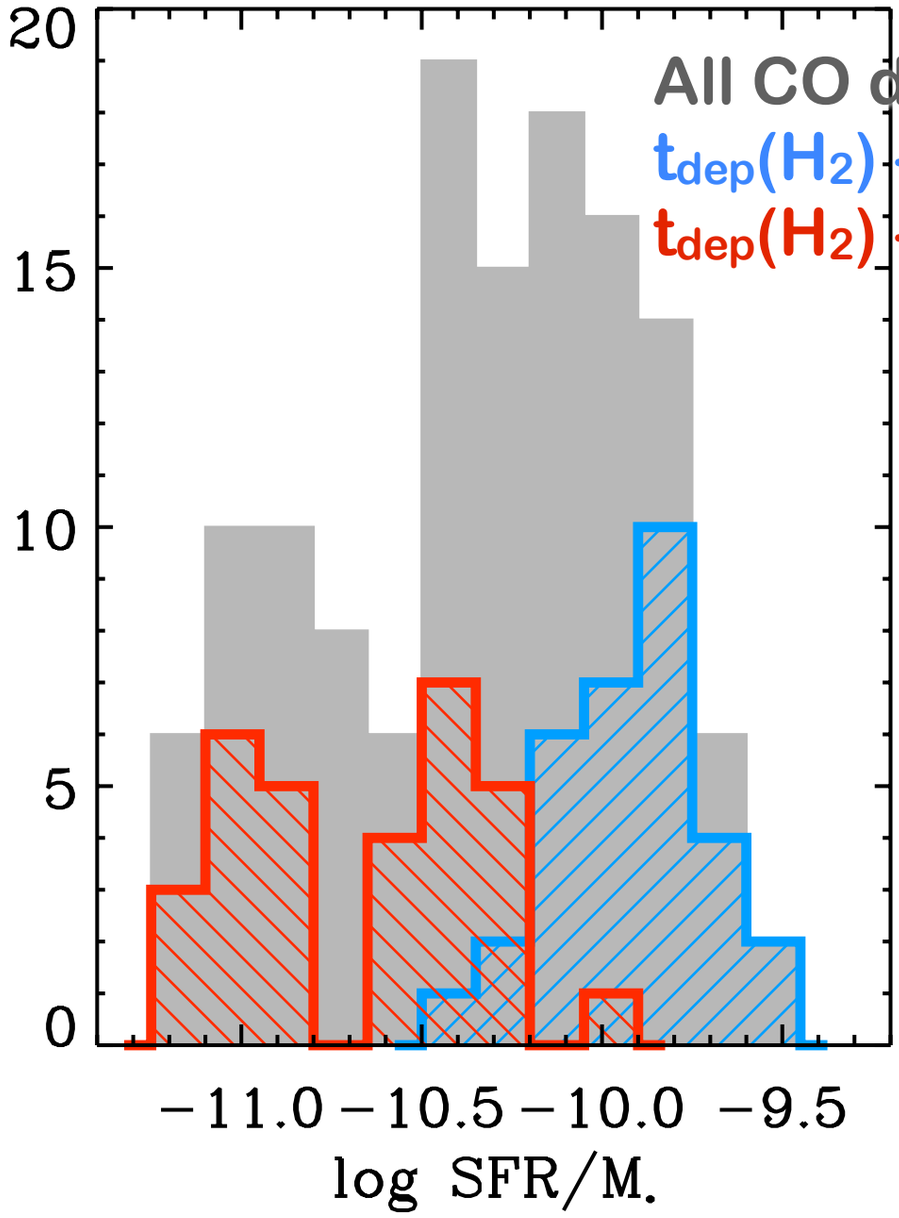




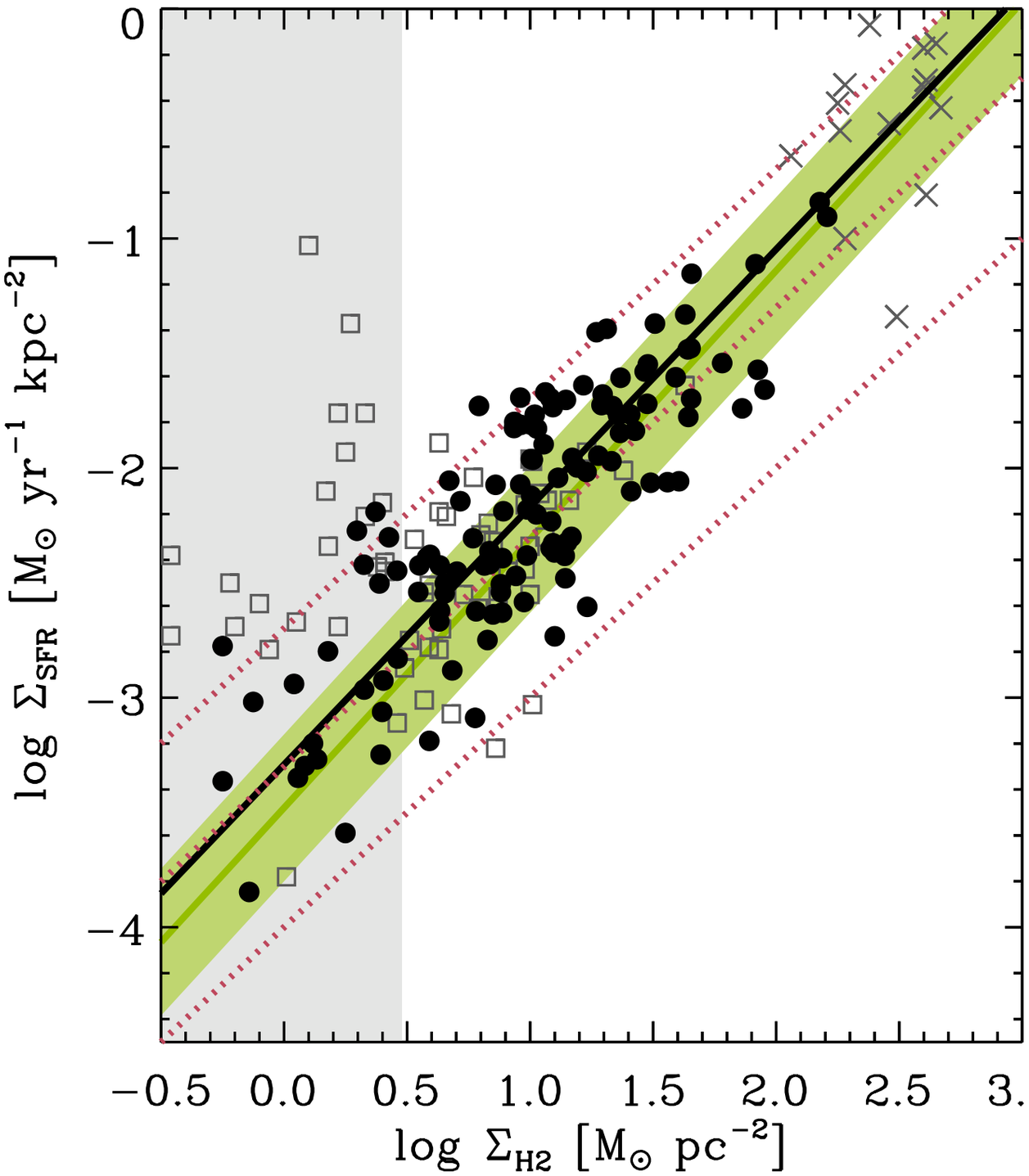
All CO detections

$t_{dep}(H_2)$ - lower quartile

$t_{dep}(H_2)$ - upper quartile

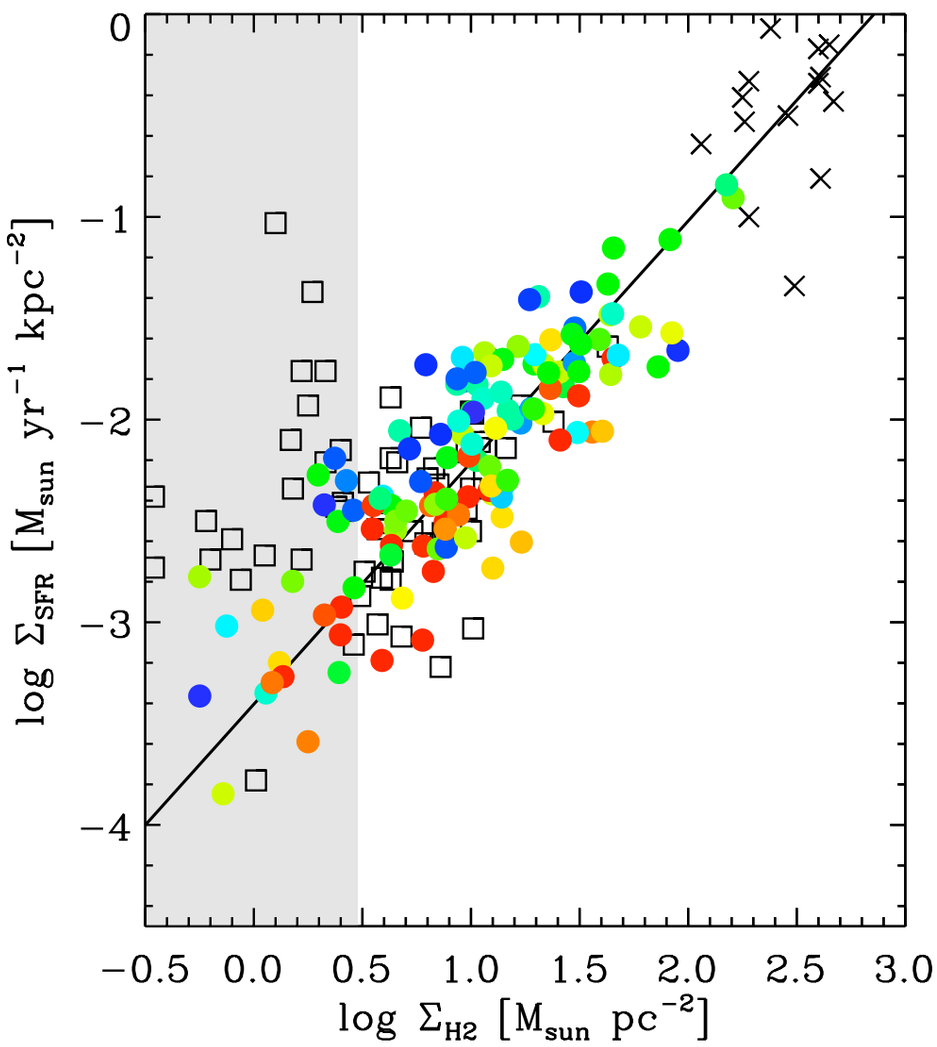
No evidence for metallicity effects on X_{CO}

the global star formation law

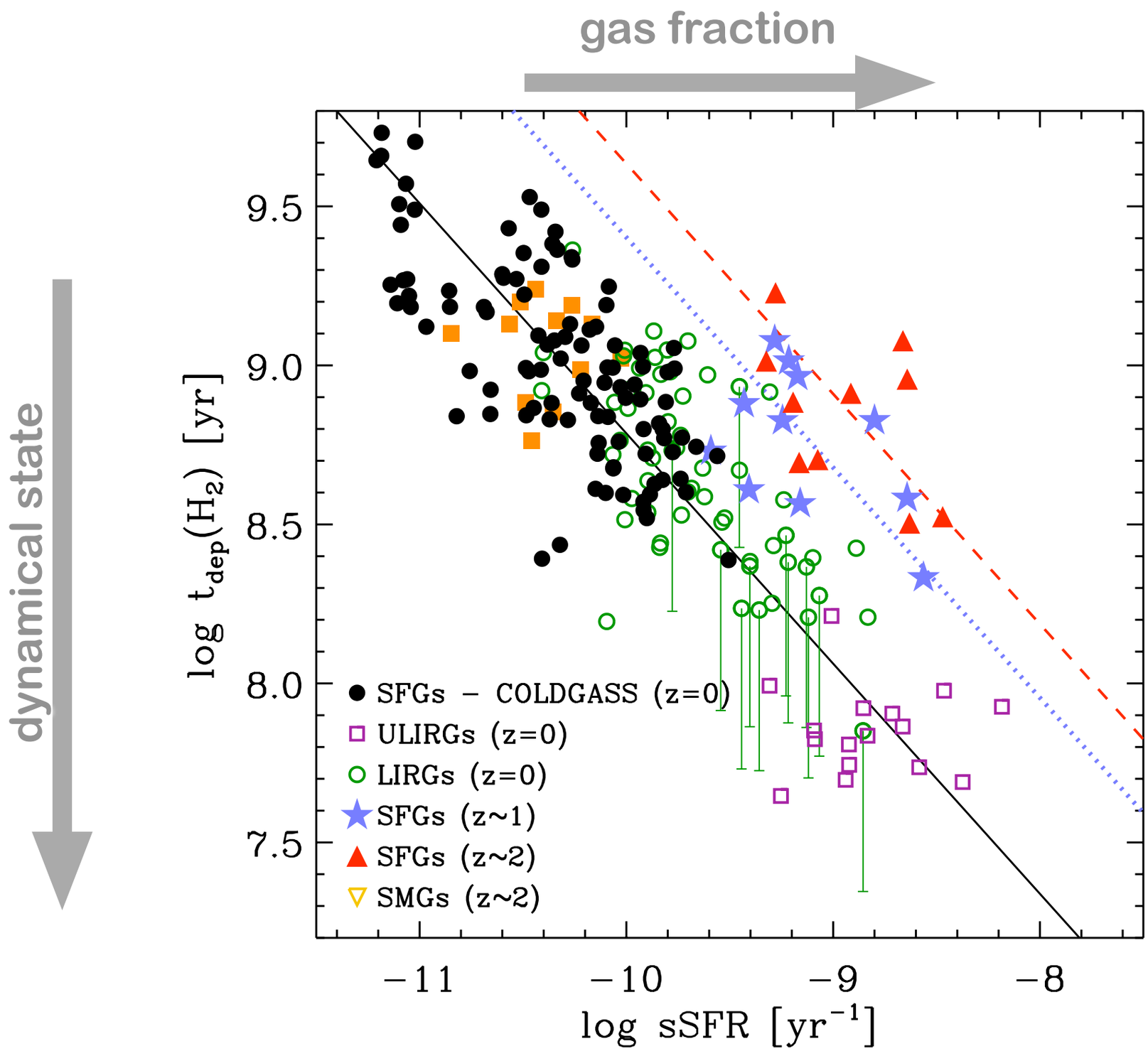


Genzel et al. (2010):
y=1.17x-3.48
standard deviation: 0.32

COLD GASS:
y=1.20x-3.42,
standard deviation: 0.32

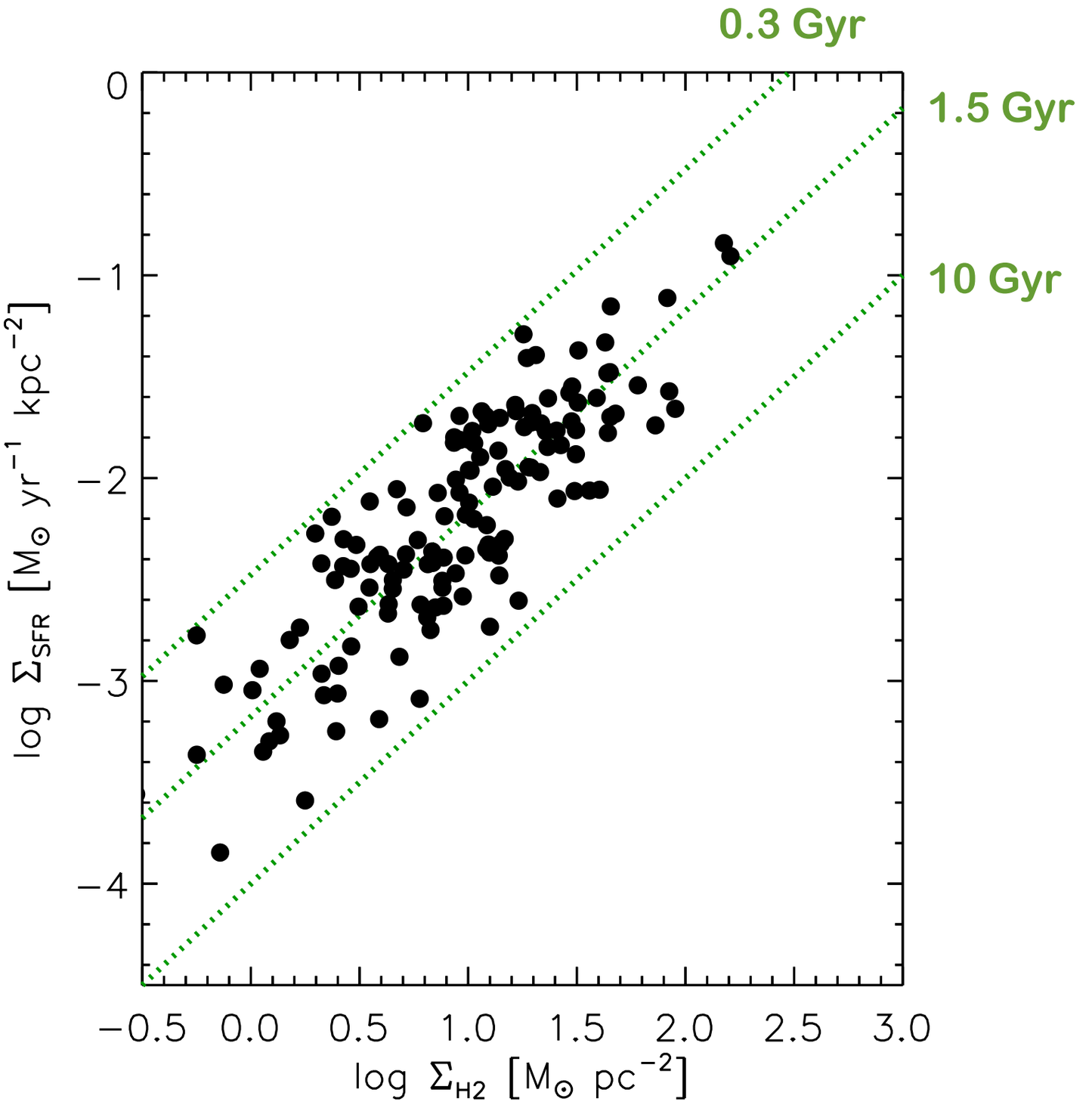


linking the various galaxy populations



data from: Leroy et al. (2009), Howell et al. (2010), da Cunha et al. (2010), Genzel et al. (2010), Hainline et al. (2010), Saintonge et al. (2011b)

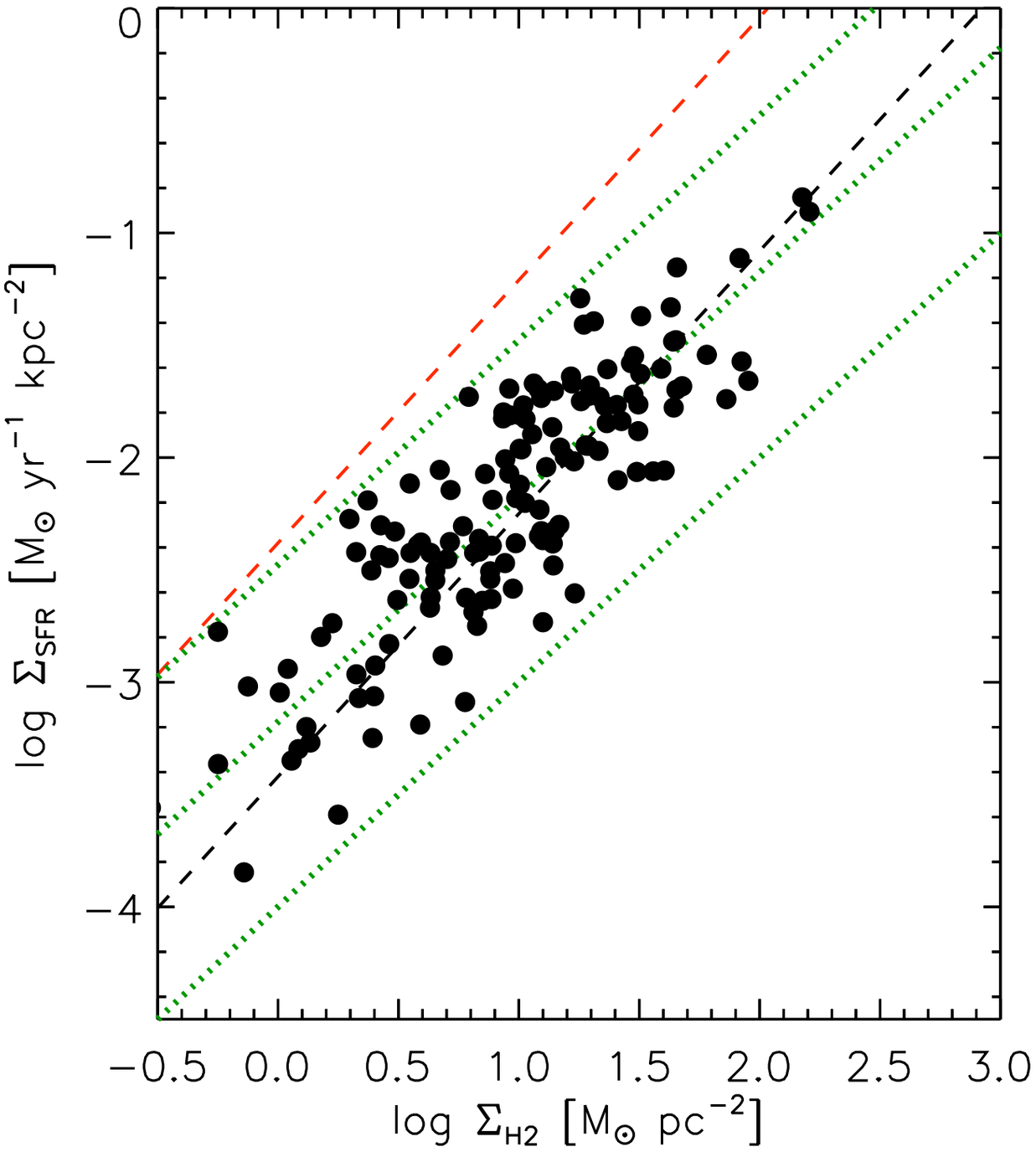
explaining the depletion time variations



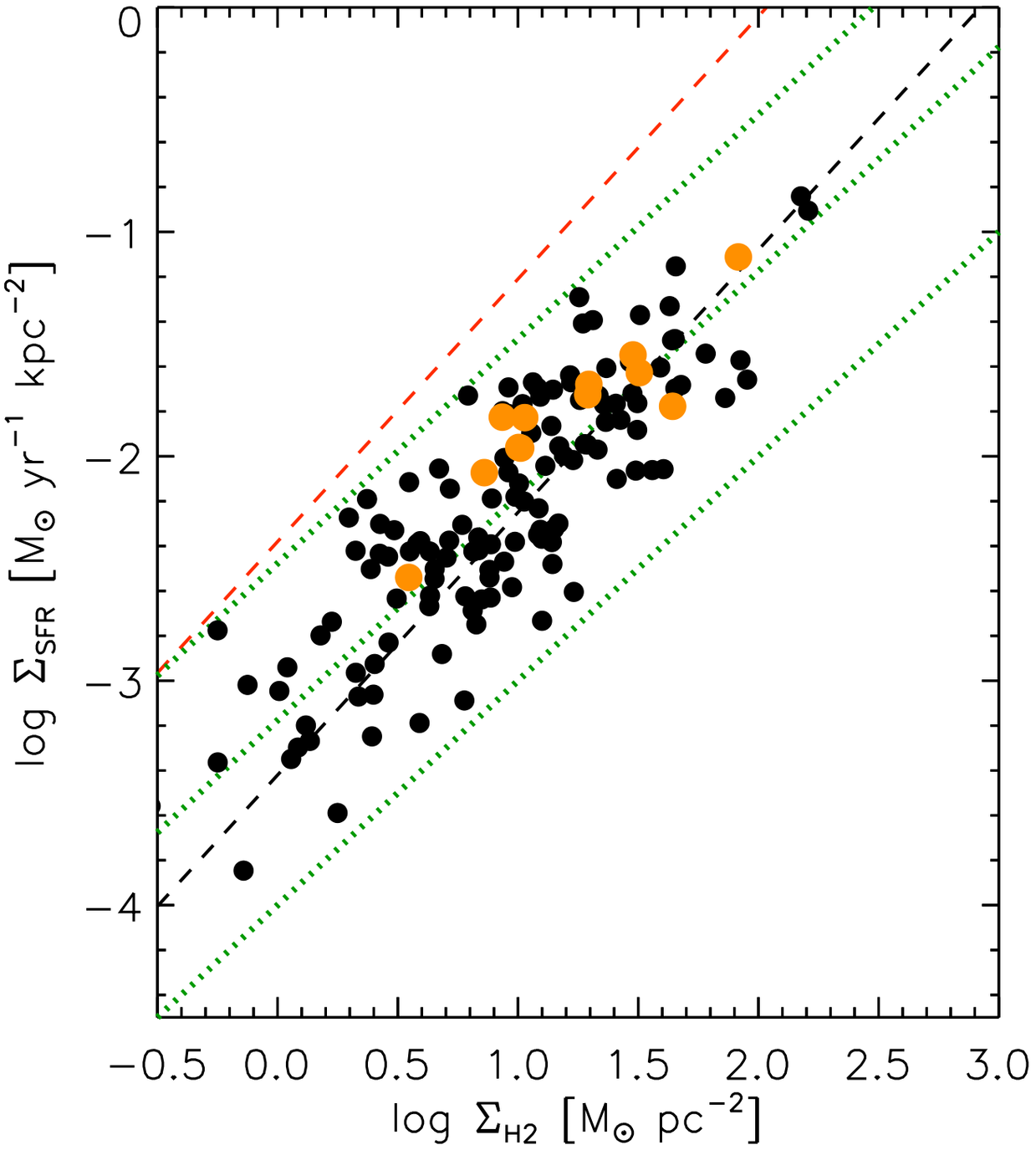
explaining the depletion time variations

merging galaxies

normal starforming galaxies

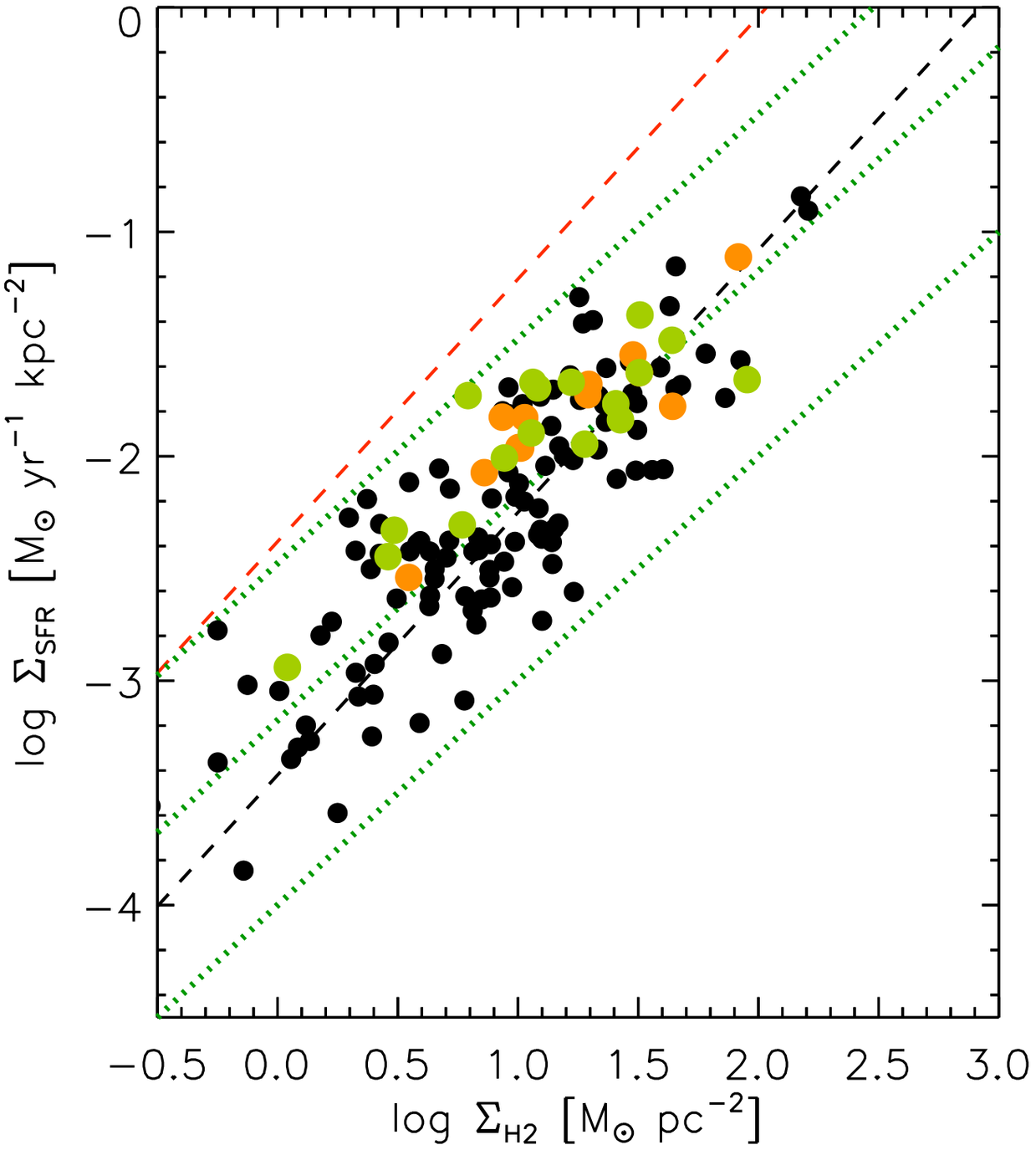


explaining the depletion time variations



strong bars

explaining the depletion time variations



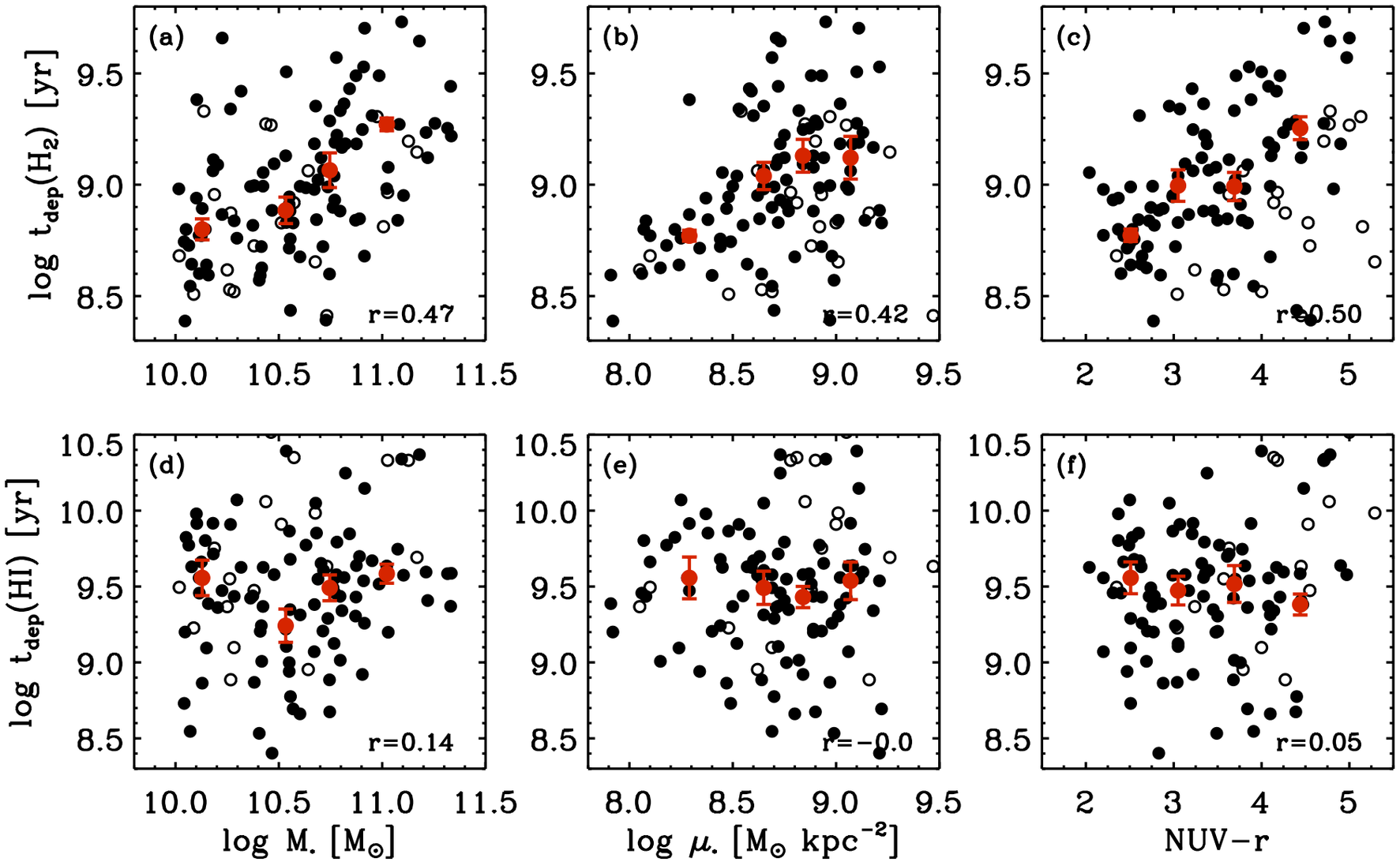
strong bars

asymmetric galaxies

summary

- COLD GASS offers a complete view of the balance between HI, H2 and stars in massive galaxies
- H2 gas fractions and their trends are quantified. Strongest dependence is on star formation indicators.
- There are sharp thresholds in galaxy properties, above which any cold gas is found in the atomic phase.
- The molecular depletion timescale is not universal: varies from ~500Myr to 3Gyr in the mass range of 10^{10} to $10^{11.5}$ Msun.
- The tdep-sSFR relation extends smoothly from the normal COLD GASS galaxies to nearby LIRGs and ULIRGs
- Normal galaxies at z=1,2 are displaced from this plane, having longer depletion times at fixes sSFR, owing to their large gas fractions.

atomic and molecular depletion times

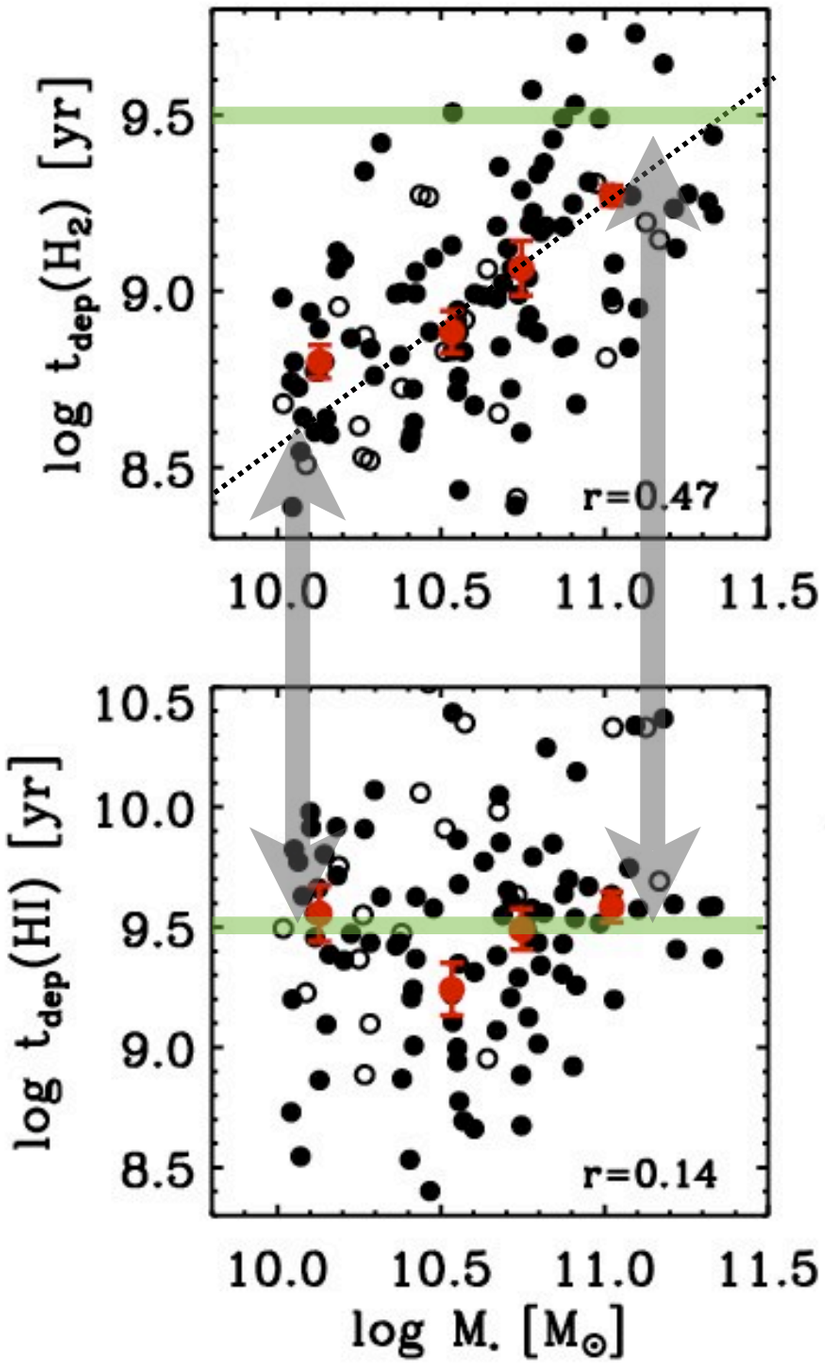


Saintonge et al. (2011b)

fuelling star formation

moderate mass galaxies:

$t_{dep}(H_2) \ll t_{dep}(HI)$



very massive galaxies:

$t_{dep}(H_2) \approx t_{dep}(HI)$

a larger fraction of the atomic gas reservoir does not "participate" in the star formation process

Saintonge et al. (2011b)