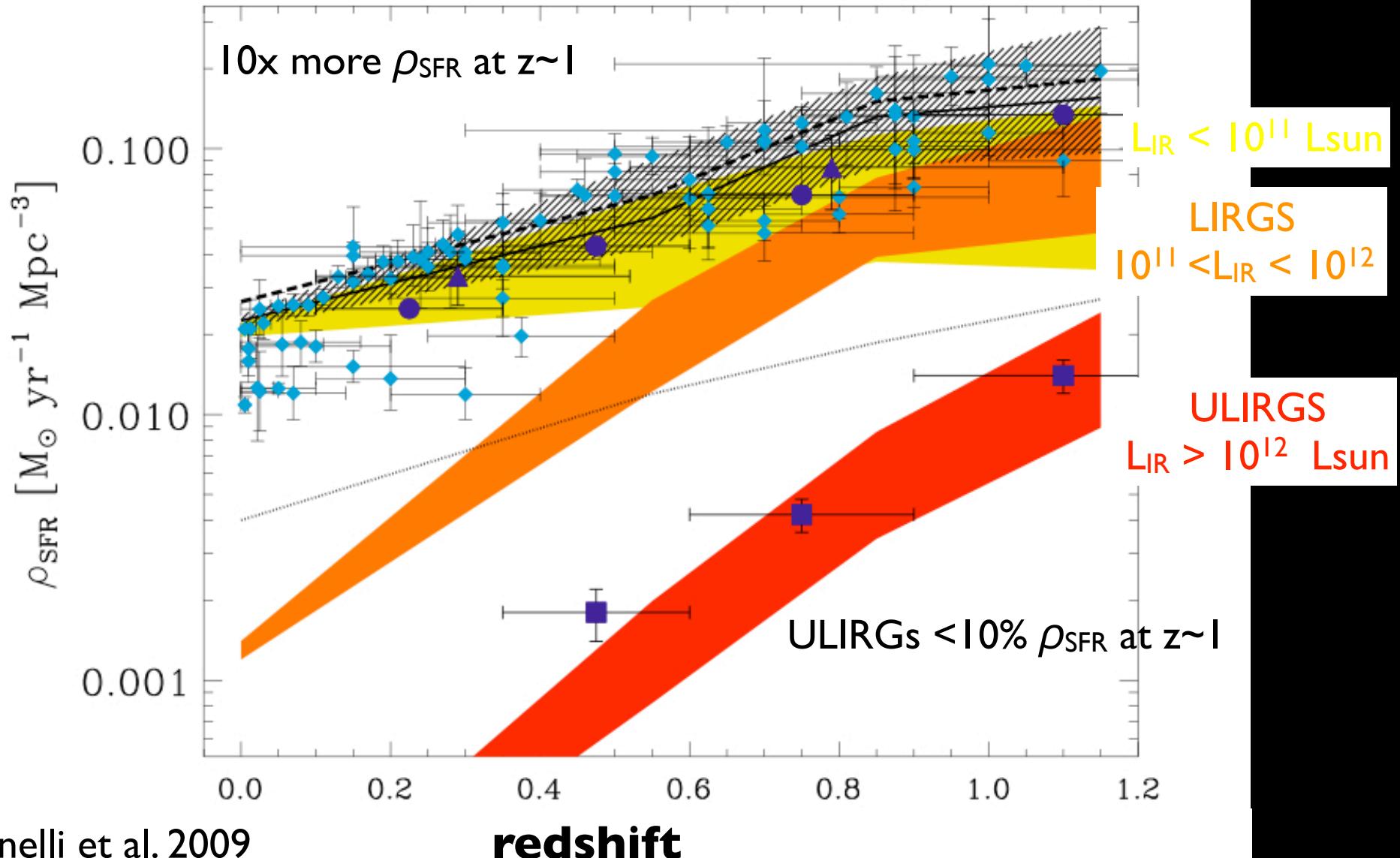




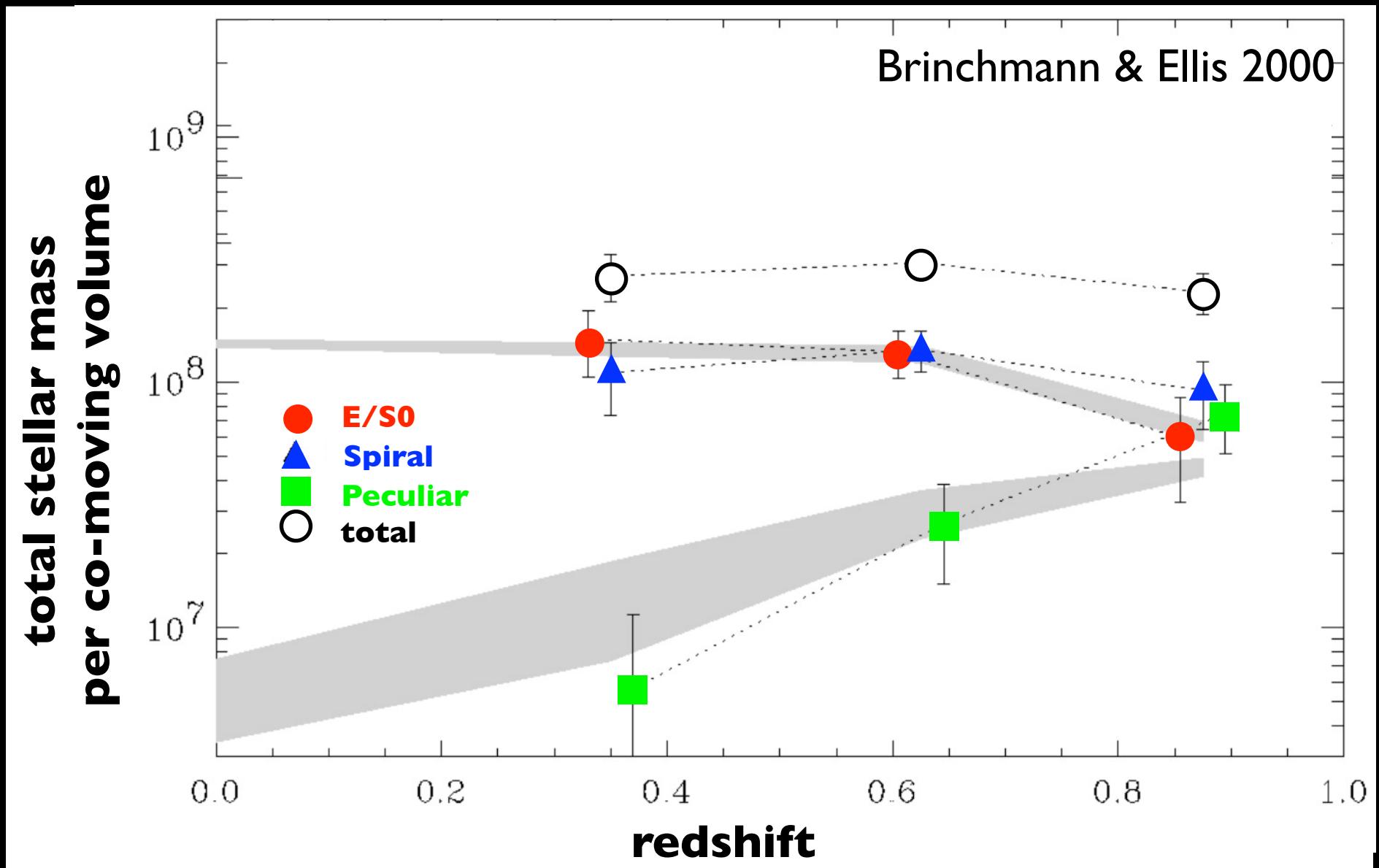
Star-Formation at $z < 1$: Mergers v. Gas Accretion

Jennifer Lotz
Goldberg Fellow - NOAO

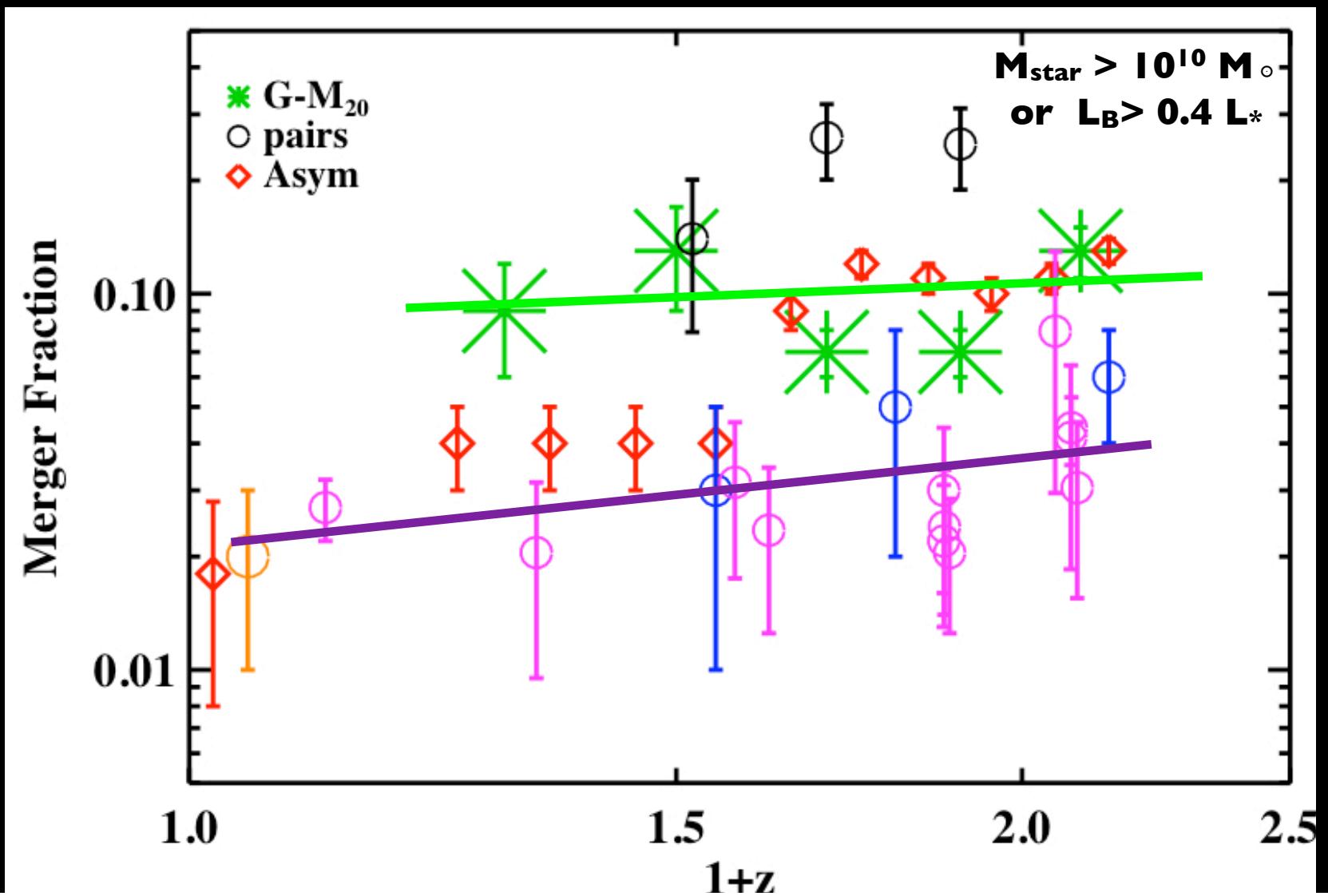
Strong Evolution in SFR density $0 < z < 1$



More Galaxy Mergers/Peculiars at $z \sim 1$?

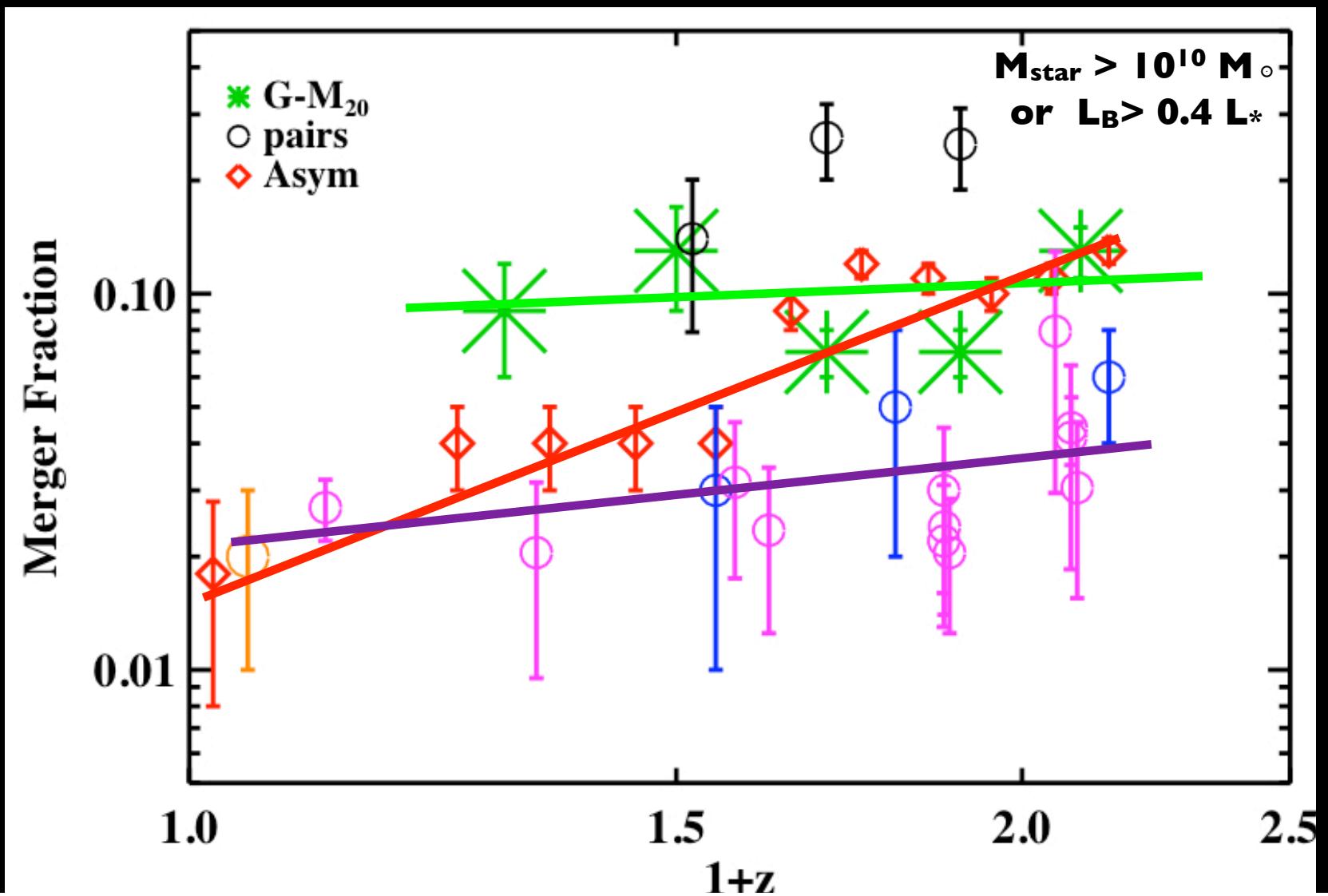


Galaxy Merger Fractions disagree!



Lotz et al. 2008a, Lin et al. 2008, Conselice et al. 2009, Bundy et al. 2009, Darg et al. 2009,
de Ravel et al. 2009;
also Kartaltepe et al. 2007, Jogee et al. 2009, Shi et al. 2009, Bridge et al. 2010

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How to Calculate the Galaxy Merger Rate

We observe Φ'_{merg} merger events at particular stages (depending on method)

$$\Phi'_{\text{merg}} = \Phi_{\text{merg}} T'_{\text{merg}} / T_{\text{merg}}$$

where T'_{merg} is the observability timescale

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$$\Rightarrow \Gamma_{\text{merg}} = \Phi'_{\text{merg}} / T'_{\text{merg}}$$

Φ', T' depend on the method used to identify mergers

Merger Timescales - Gas Fraction

camera 2

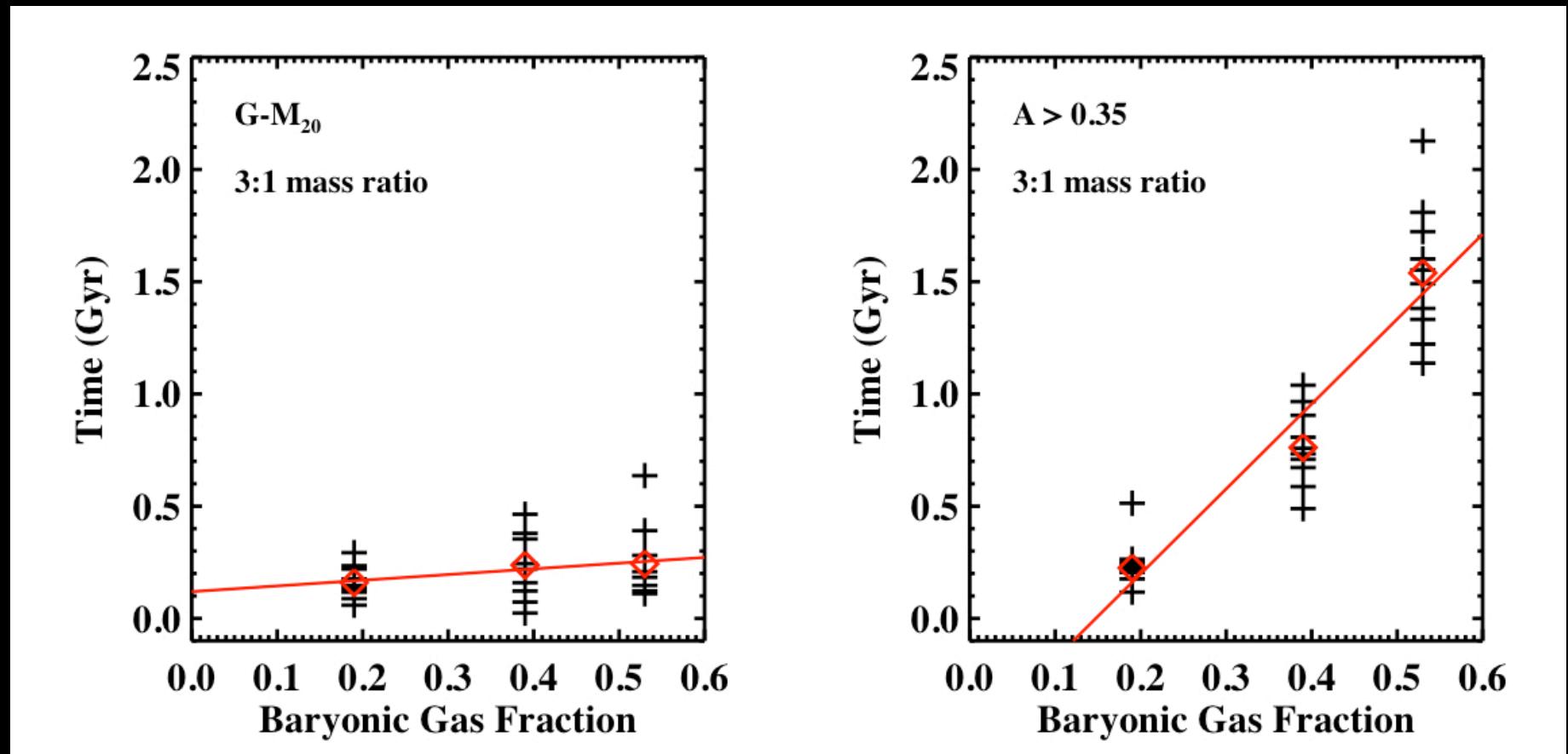
20% gas fraction

camera 4

40% gas fraction

asymmetry (+ visual classification) timescales
depend on gas fraction

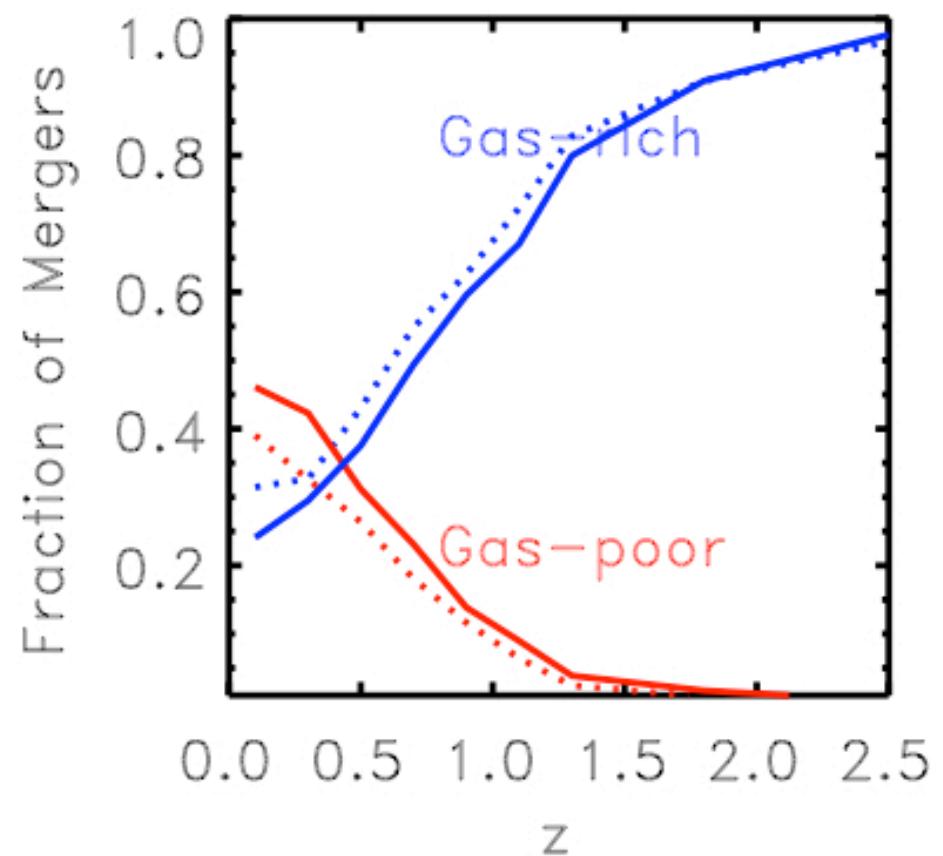
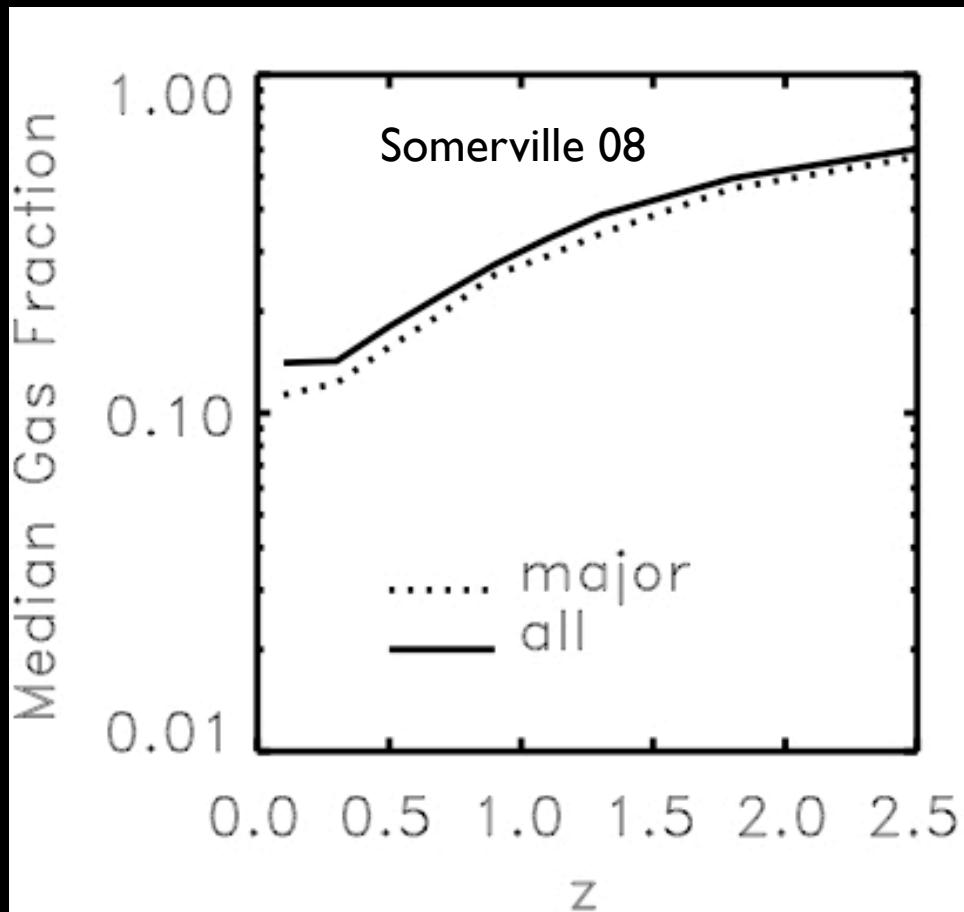
Merger Timescales - Gas Fraction



Asymmetry timescales depend on gas fraction

Lotz, Jonsson, Cox, & Primack, 2010b, arXiv:0912.1593

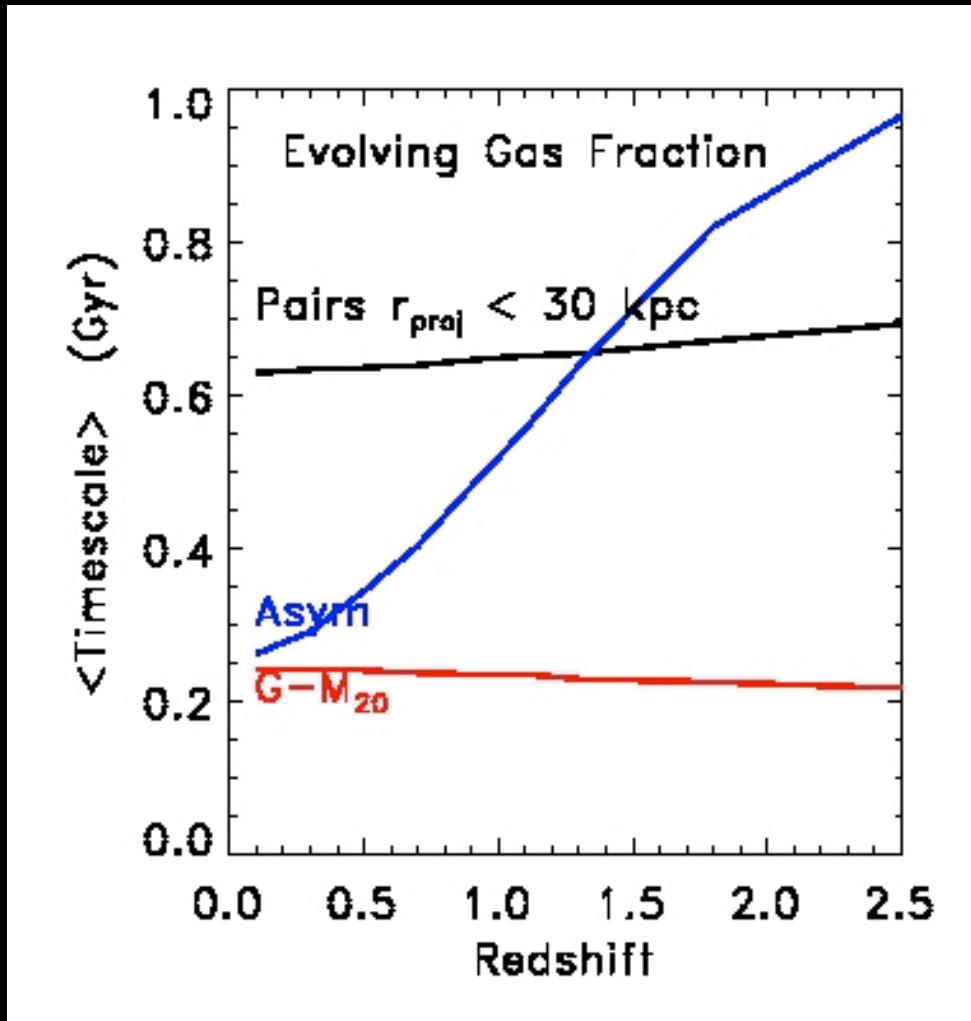
Gas Fraction should evolve with redshift



consistent with recent CO observations
Daddi et al. 2009, Tacconi et al. 2010

Cosmological Weighting

Timescale v. z

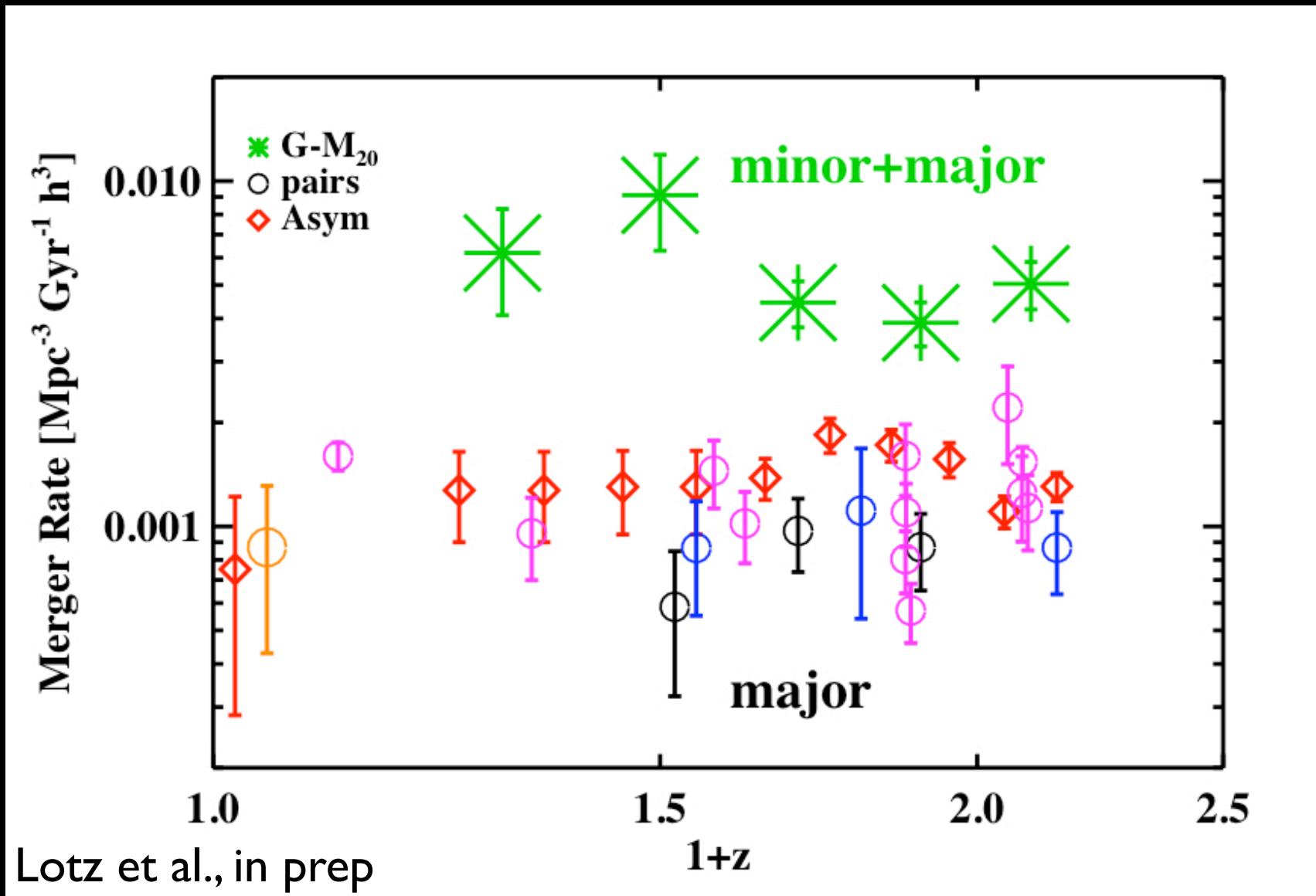


$T(\text{pair})$, $T(G\text{-M}_{20})$
independent of f_{gas}

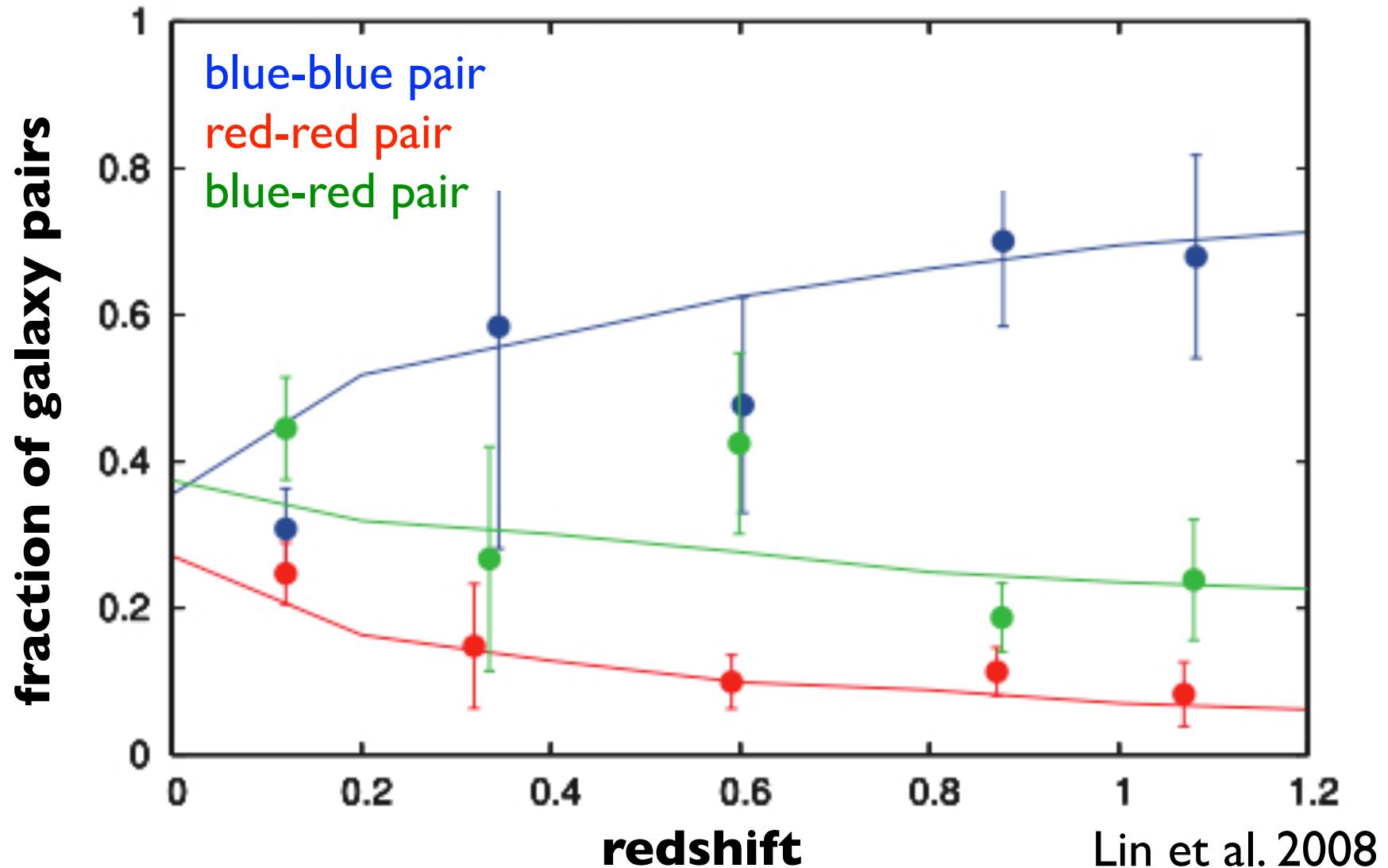
$$T(\text{Asym}) \sim f_{\text{gas}}(z)$$

Lotz et al., 2010 in prep

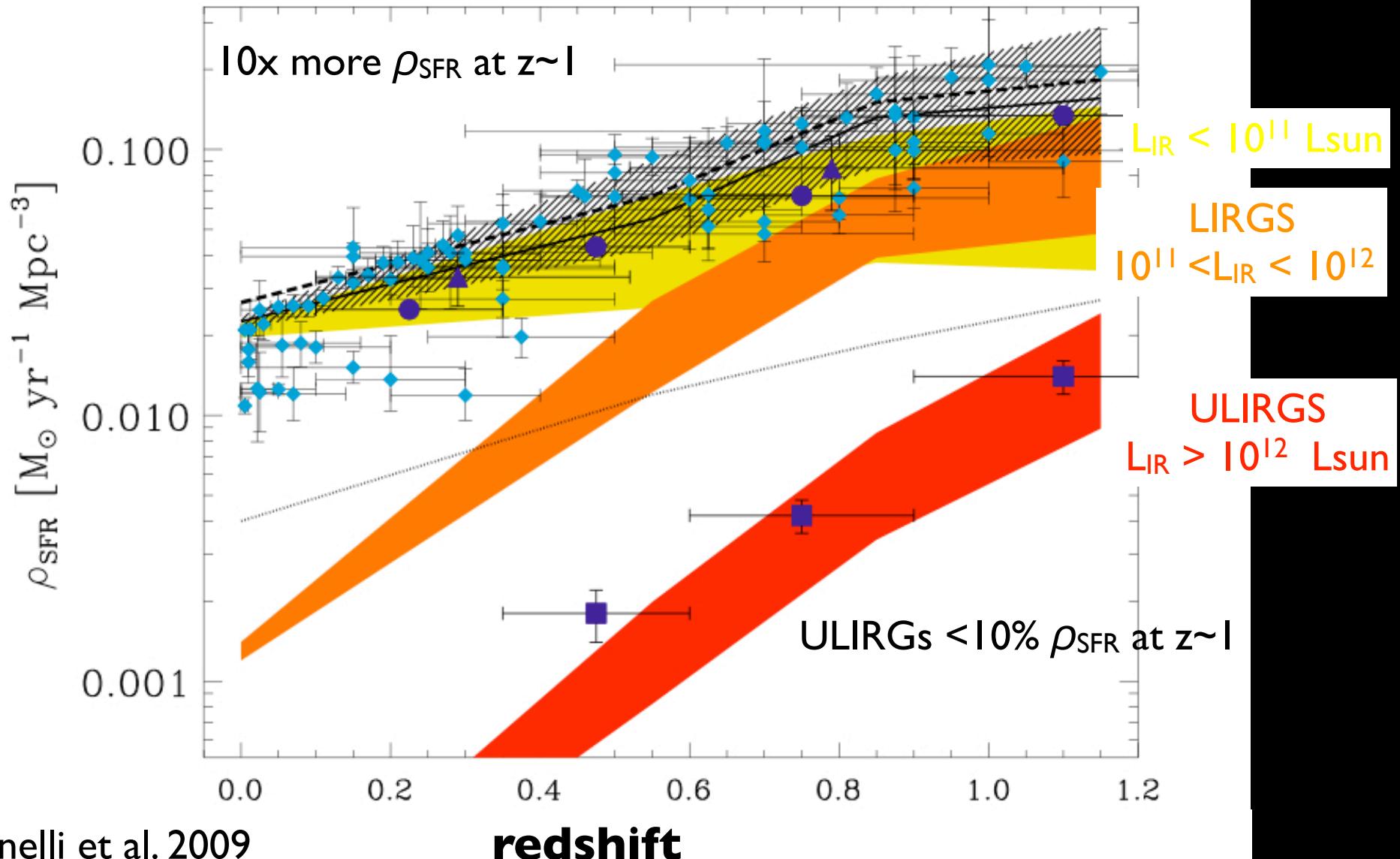
Galaxy Merger Rate at $z < 1$



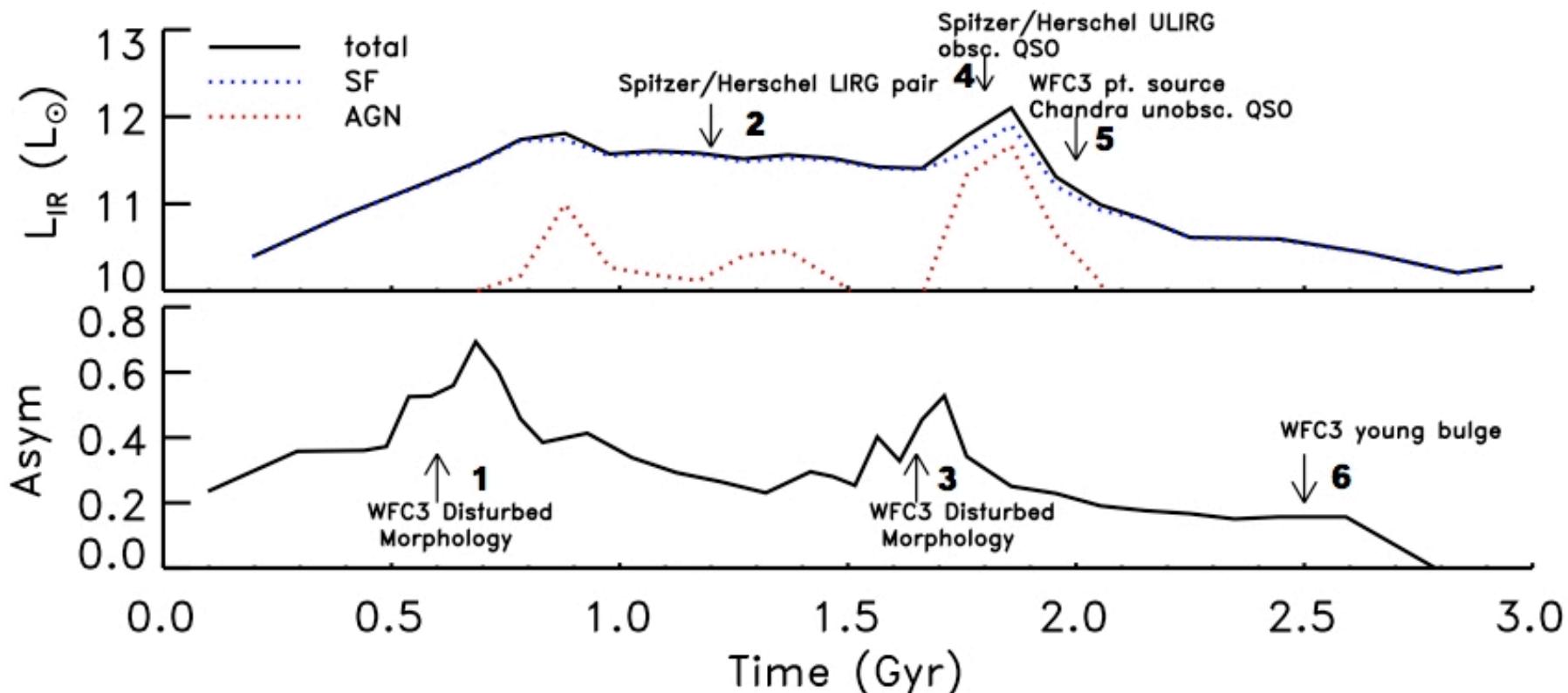
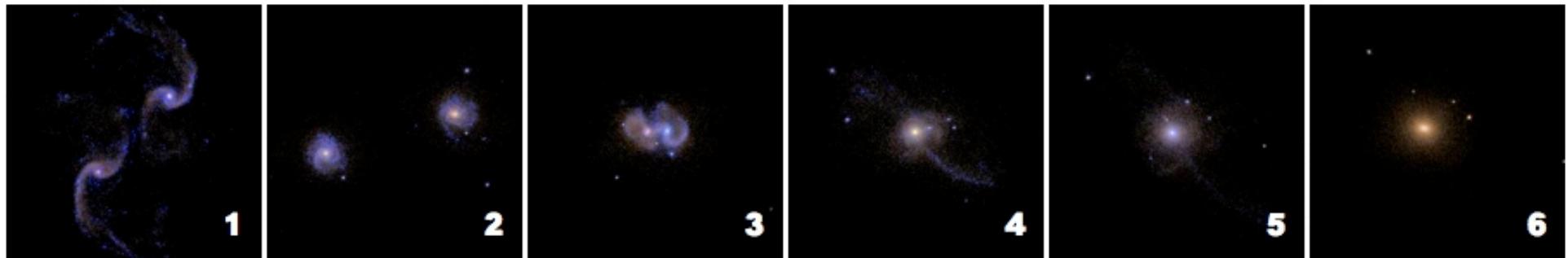
More Gas-Rich Galaxy Mergers at $z \sim 1$



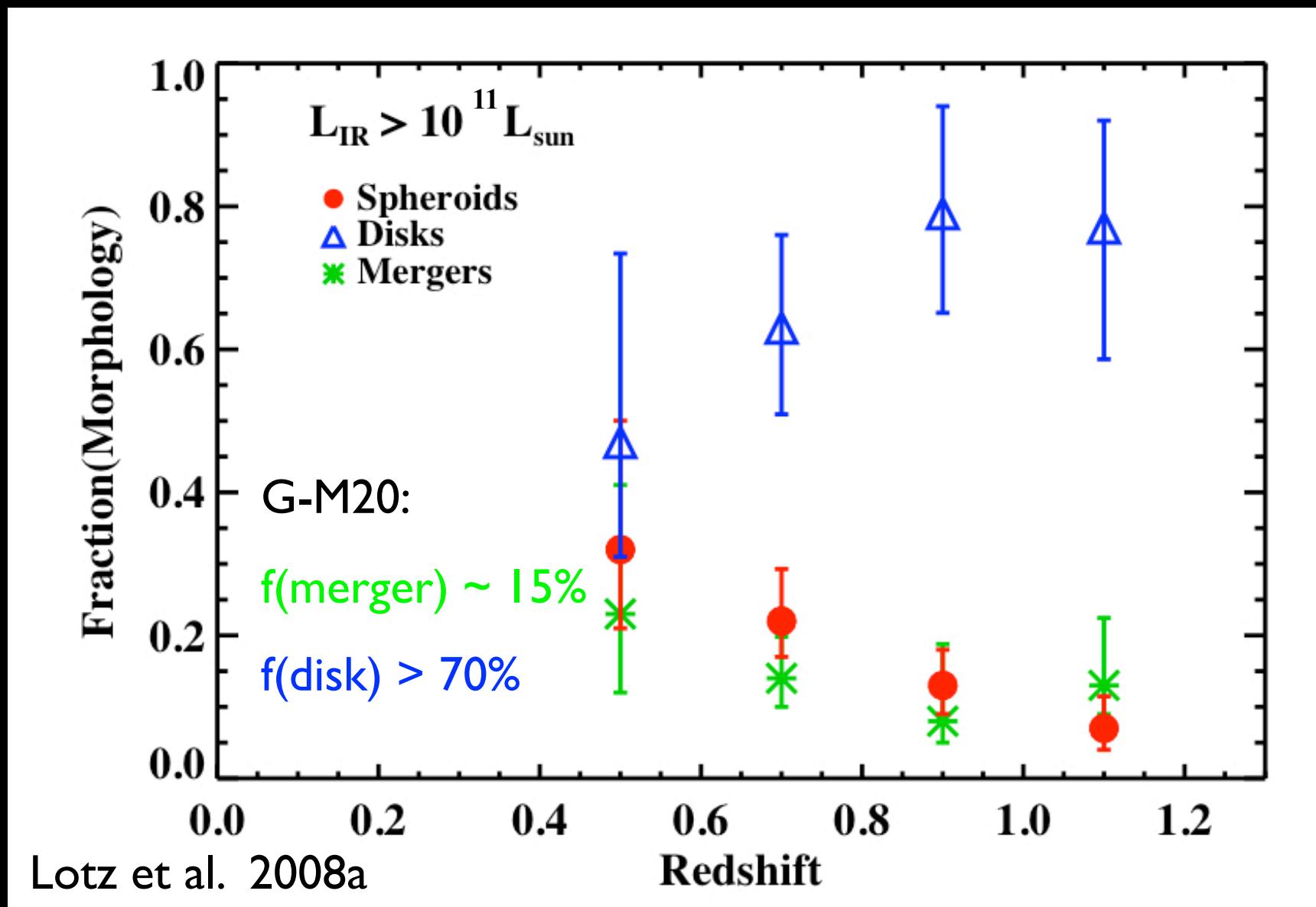
LIRGs dominate ρ_{SFR} at $z \sim 1$



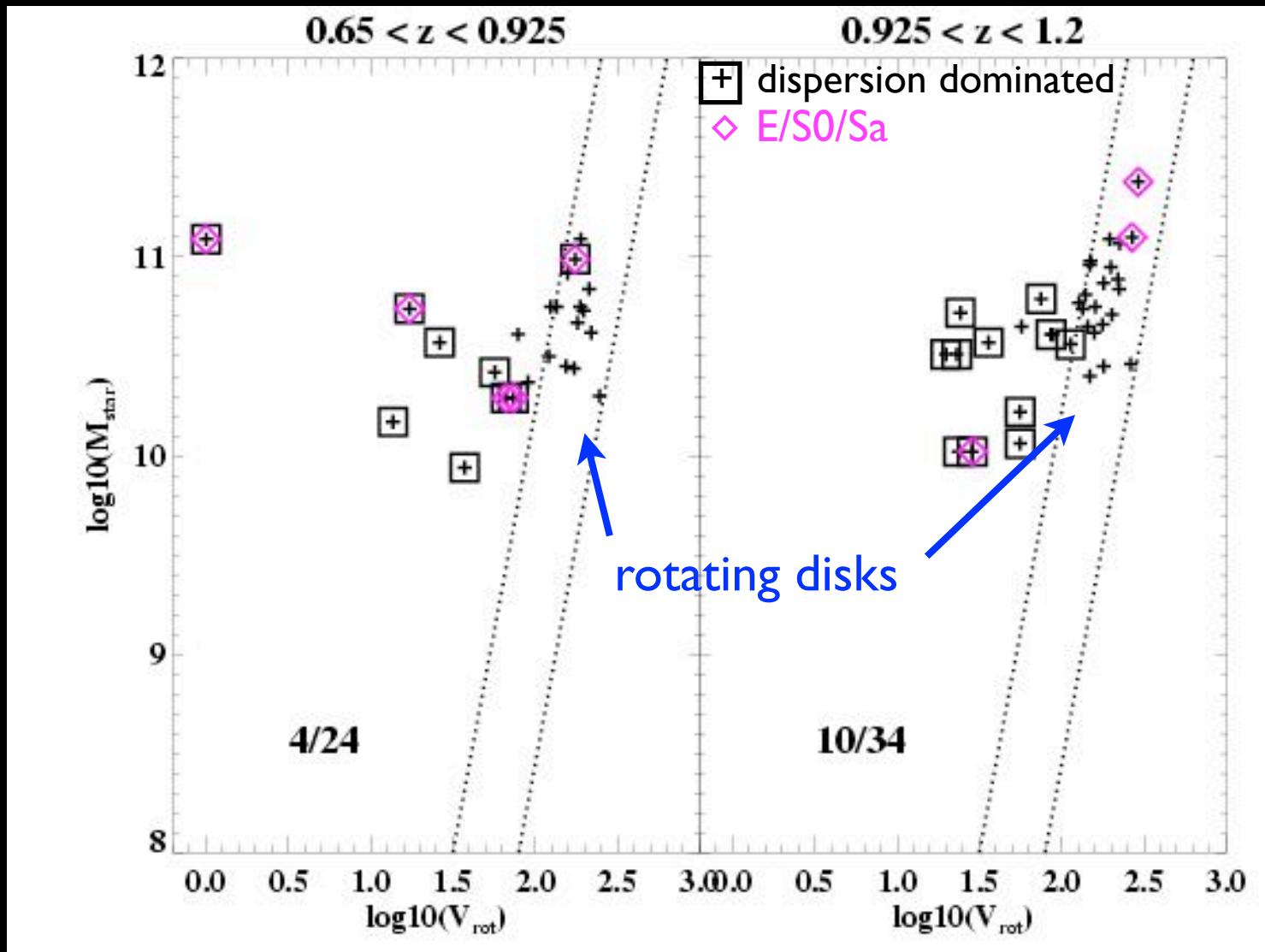
$z \sim 1$ LIRGs = Gas-Rich Mergers ?



$z \sim 1$ LIRGs = Gas-Rich Mergers ?



$z \sim 1$ LIRGs = Mergers ?



only 15-30% of LIRGs are not bulge-dominated and not on Tully-Fisher reln

\Rightarrow

$\sim 70\%$ LIRGs normal galaxies?

$z \sim 1$ LIRGs = Gas-Rich Mergers ?

Visual Classification of LIRGs

Table 1. Percentage of COSMOS 70 μm Sources Classified as Mergers as a Function of Redshift and Luminosity

Redshift	N ^a	9.0 – 10.0 ^b	10.0 – 10.5	10.5 – 11.0	11.0 – 11.5	11.5 – 12.0	12.0 – 12.5	12.5 – 13.0	> 13
0.0 – 0.5	752	5	4	8	14	21	0	...	...
0.5 – 1.0	478	...	...	...	26	45	45	88	...
1.0 – 1.5	171	...	...	...	...	51	39	37	...
1.5 – 2.0	73	...	...	...	...	...	28	31	33
2.0 – 3.0	28	...	...	...	...	...	25	22	27

^aThe total number of sources in each redshift bin

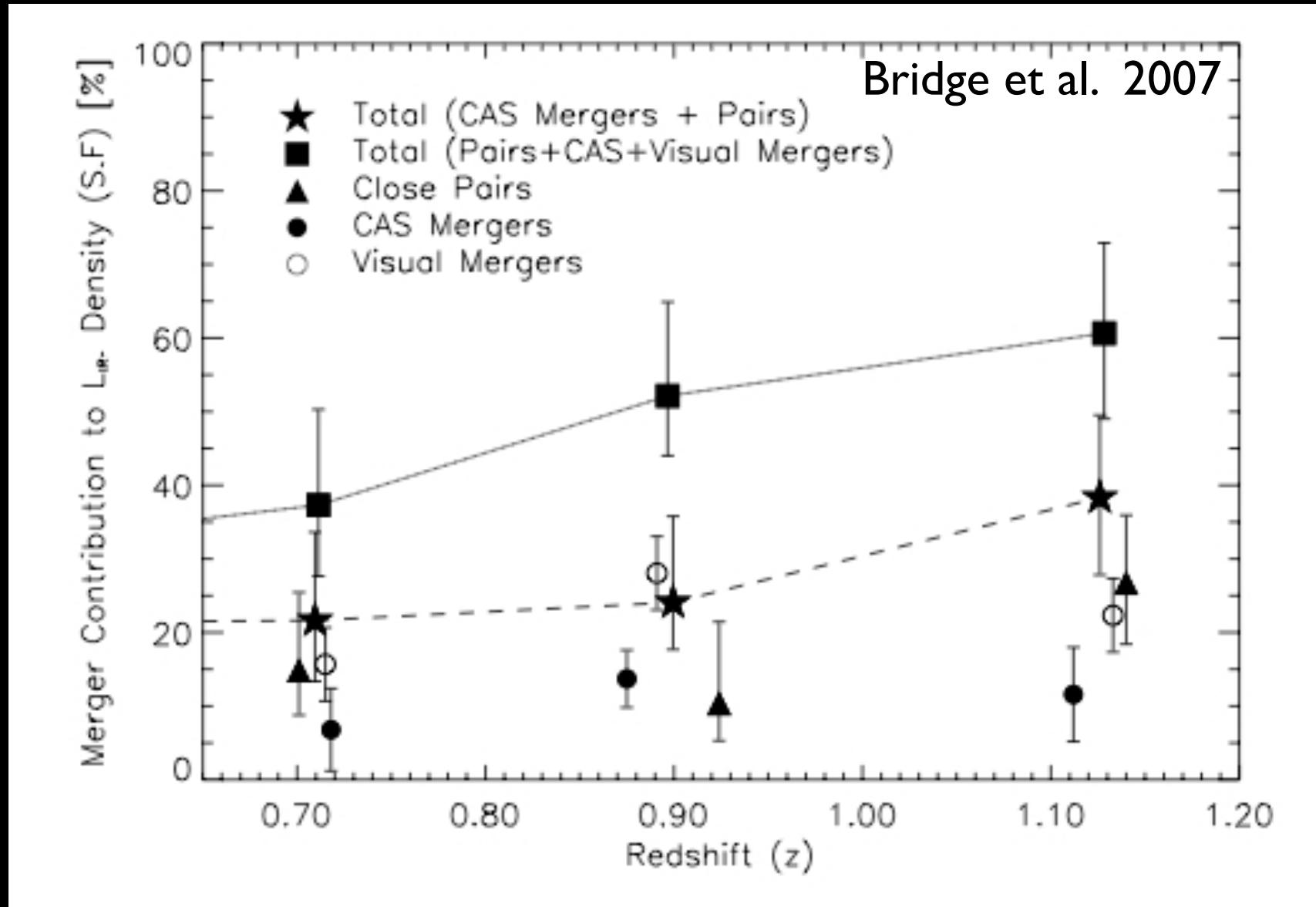
^bTotal infrared luminosity ($\log(L_{\text{IR}})$) bins

Kartaltepe et al. 2010

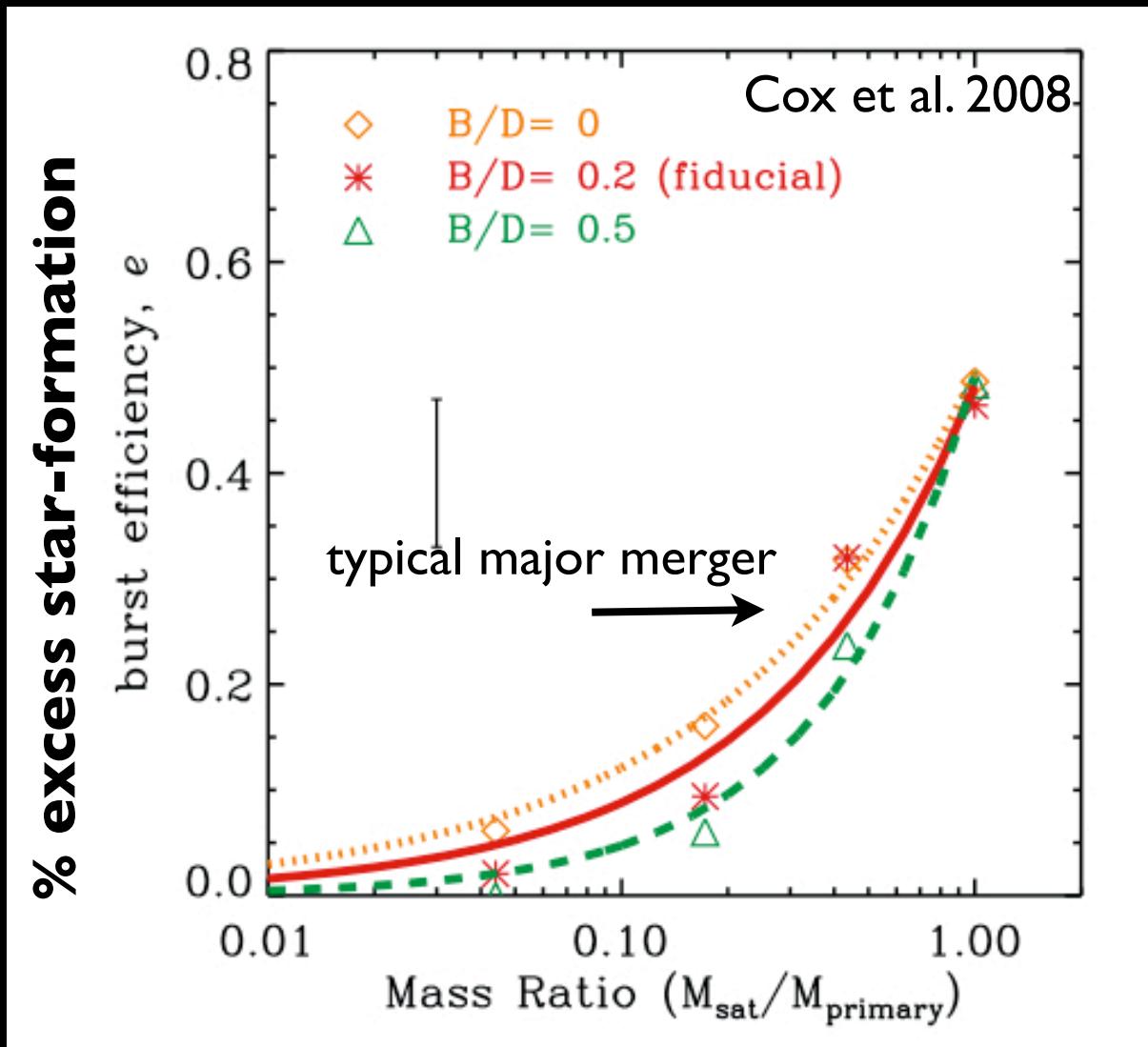
LIRGS: 26-45% mergers

ULIRGS : 45-88% mergers

$z \sim 1$ Star-Formation is Merger-Driven?



Efficiency of Merger-Driven Starburst



entropy conservation,
lower burst eff than
Mihos & Hernquist 1996

no AGN feedback; higher
gas fraction mergers have
lower burst eff.

How Much $z \sim 1$ SF is Merger-Driven?

ULIRGs:

$$<100\% f_{\text{merg}} \times 10\% \rho_{\text{SFR}} \times 30\% e_{\text{burst}} = 3\%$$

LIRGs:

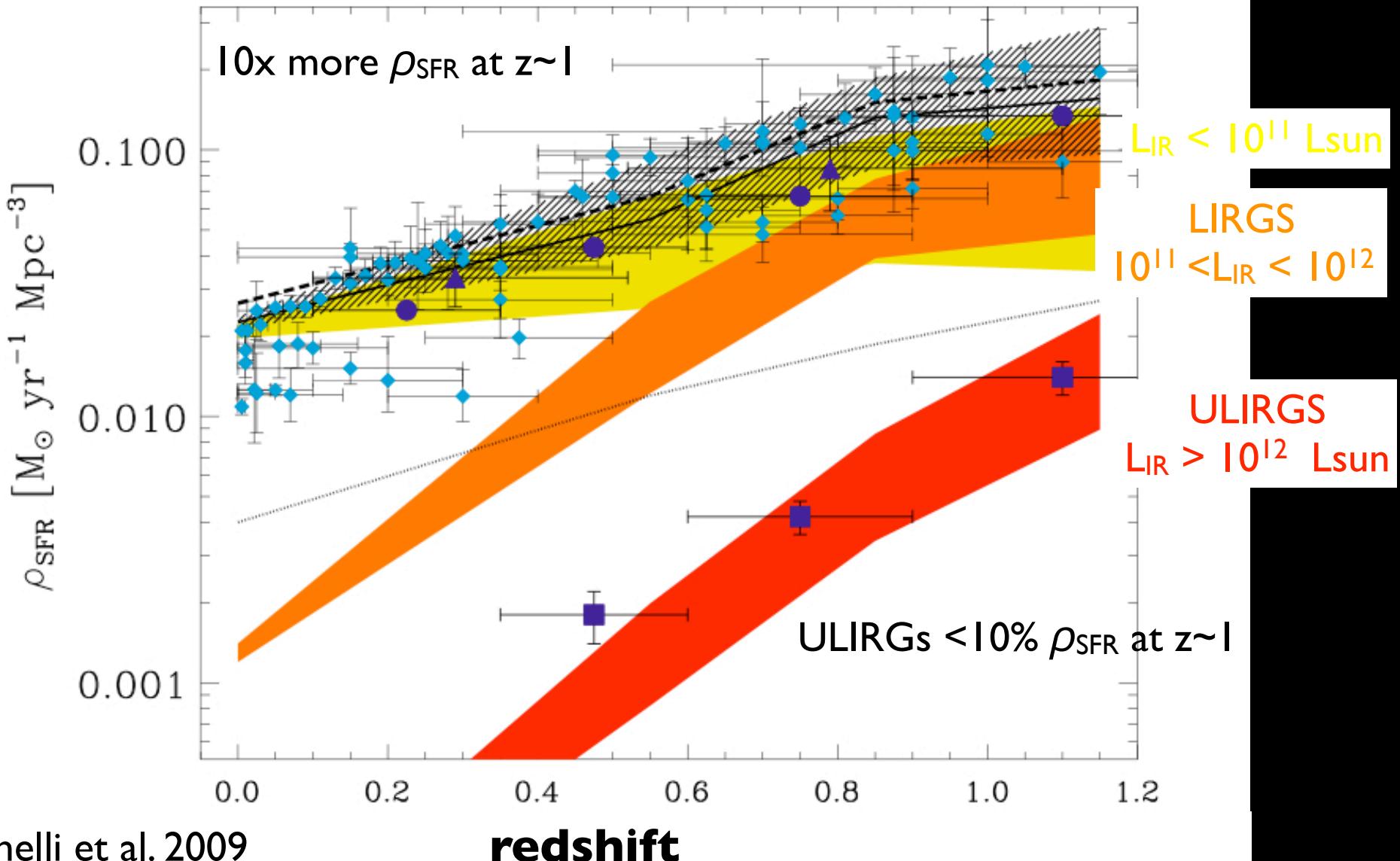
$$<50\% f_{\text{merg}} \times 50\% \rho_{\text{SFR}} \times 30\% e_{\text{burst}} = 7.5\%$$

other galaxies:

$$<10\% f_{\text{merg}} \times 50\% \rho_{\text{SFR}} \times 30\% e_{\text{burst}} = 1.5\%$$

$\Rightarrow < 12\% \text{ total } \rho_{\text{SFR}} \text{ at } z \sim 1 \text{ is ‘merger-driven’}$

Gas-Rich Mergers not driving SF evoln!



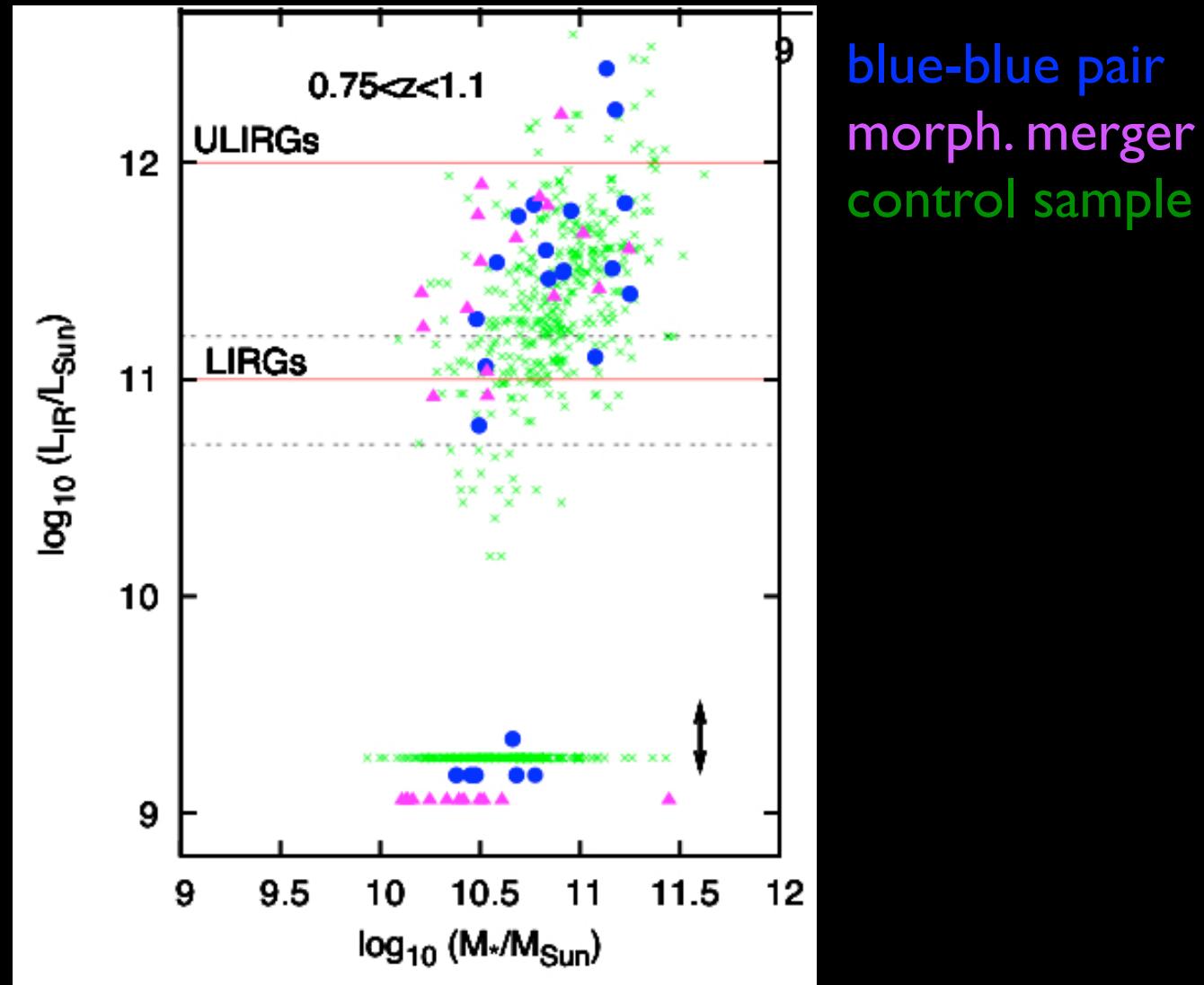
Galaxy Merger Rate evolves weakly at $z < 1$
but Gas-Rich Galaxy Mergers evolve strongly

30-50% of LIRGs at $z \sim 1$ are mergers
50-100% ULIRGs at $z \sim 1$ are mergers

but $< 12\%$ ρ_{SFR} at $z \sim 1$ is ‘merger-driven’
because burst efficiency $\sim 30\%$
and ULIRGs are $\sim 10\%$ ρ_{SFR}

increased gas fraction/accretion driving SF evolution?

Star-formation Rate v. Stellar Mass



Lin et al. 2007