A&A, in press, astro-ph/1410.4875

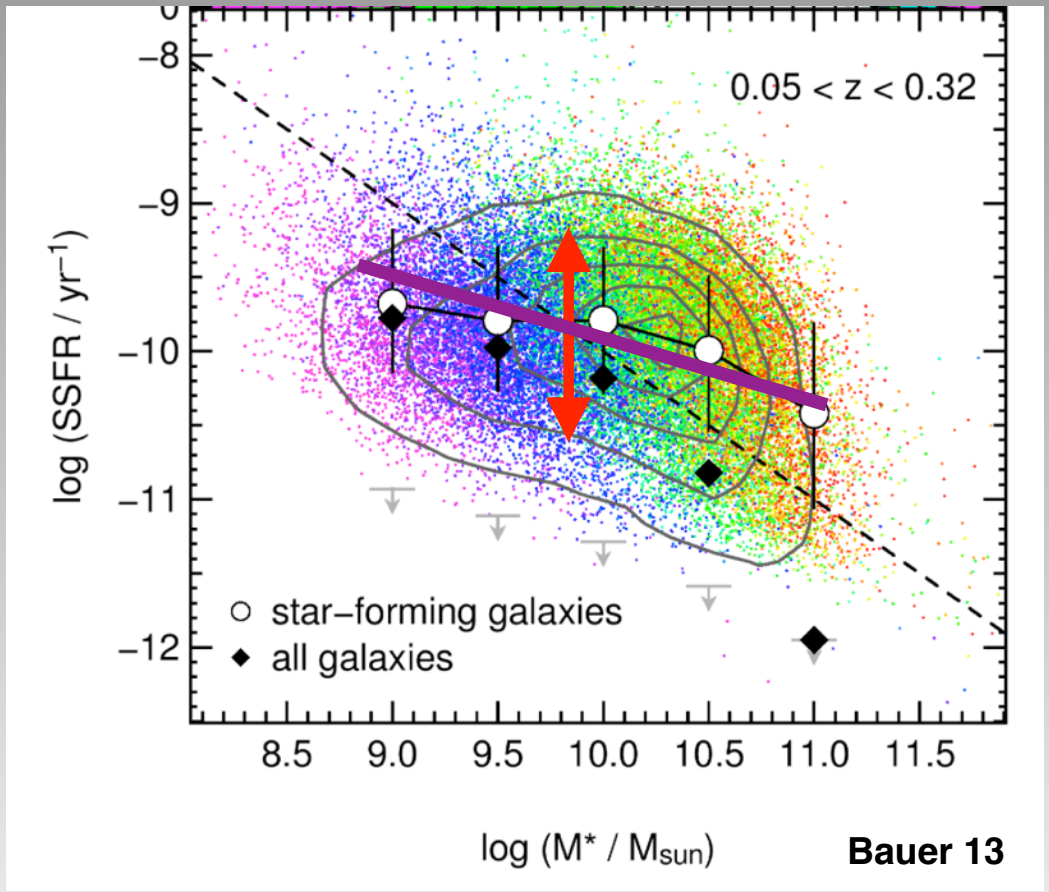
Dissecting the mass-SFR plane in COSMOS and GOODS at z<1.4

Ilbert Olivier

Arnouts S., Le Floc'h E. and the COSMOS team

LAM
LABORATOIRE D'ASTROPHYSIQUE
DE MARSEILLE

Characterize the star-forming main sequence



scatter

- stochasticity of the SFH
- diversity of SFH
- mergers

slope SFR $\propto M_{\star}^{\beta}$

- activity driven by $M_{\star}$?

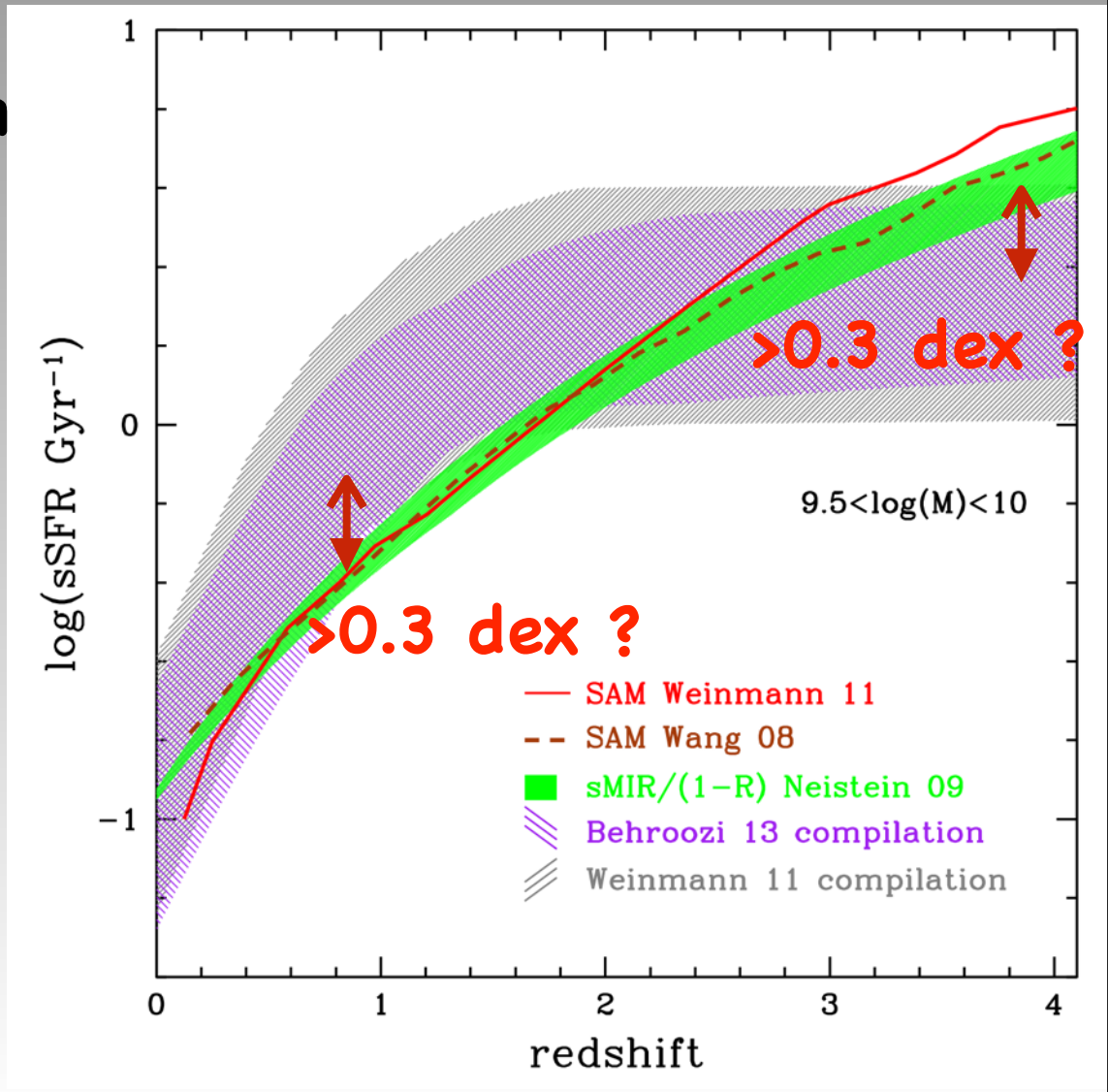
➢ large dispersion between publications (Speagle 14)

Evolution of the sSFR and link with the cosmological accretion rate

There is a tension between the observed and predicted sSFR

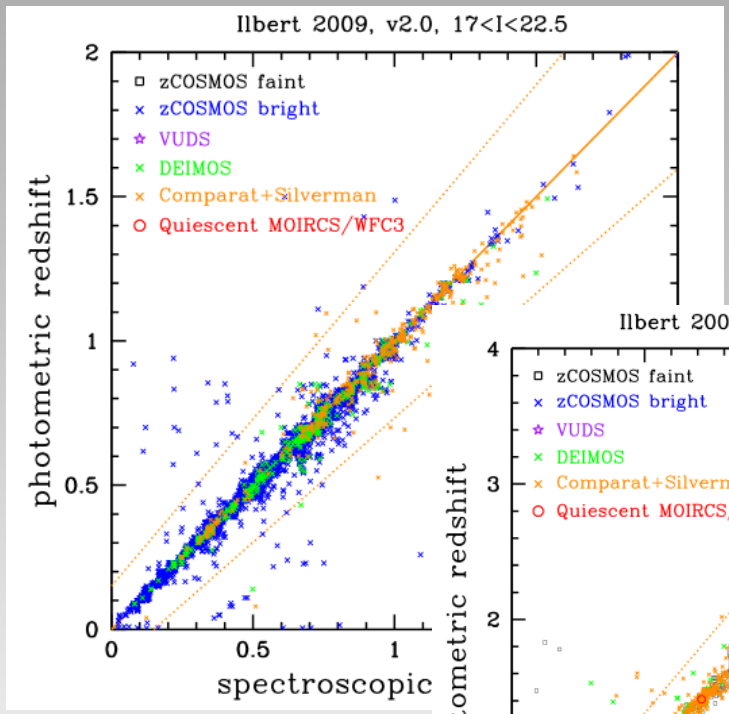
Even at z<1.5

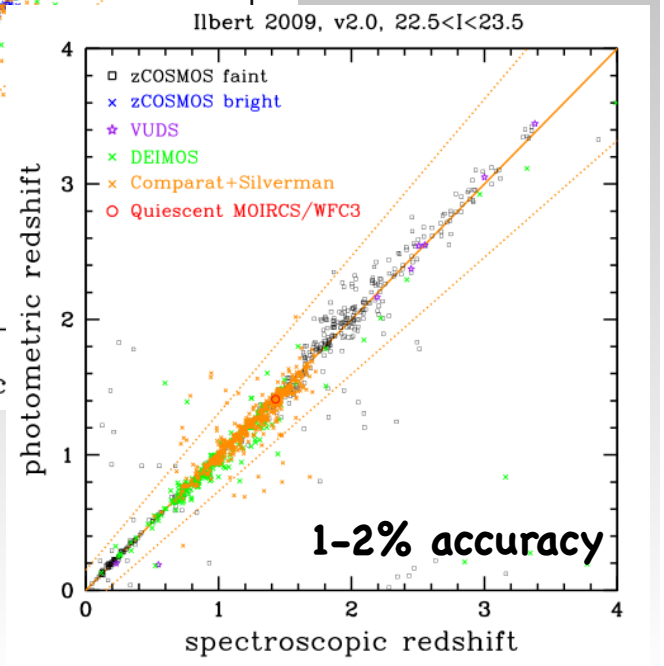
Missing physical processes or selection effects in the data ?

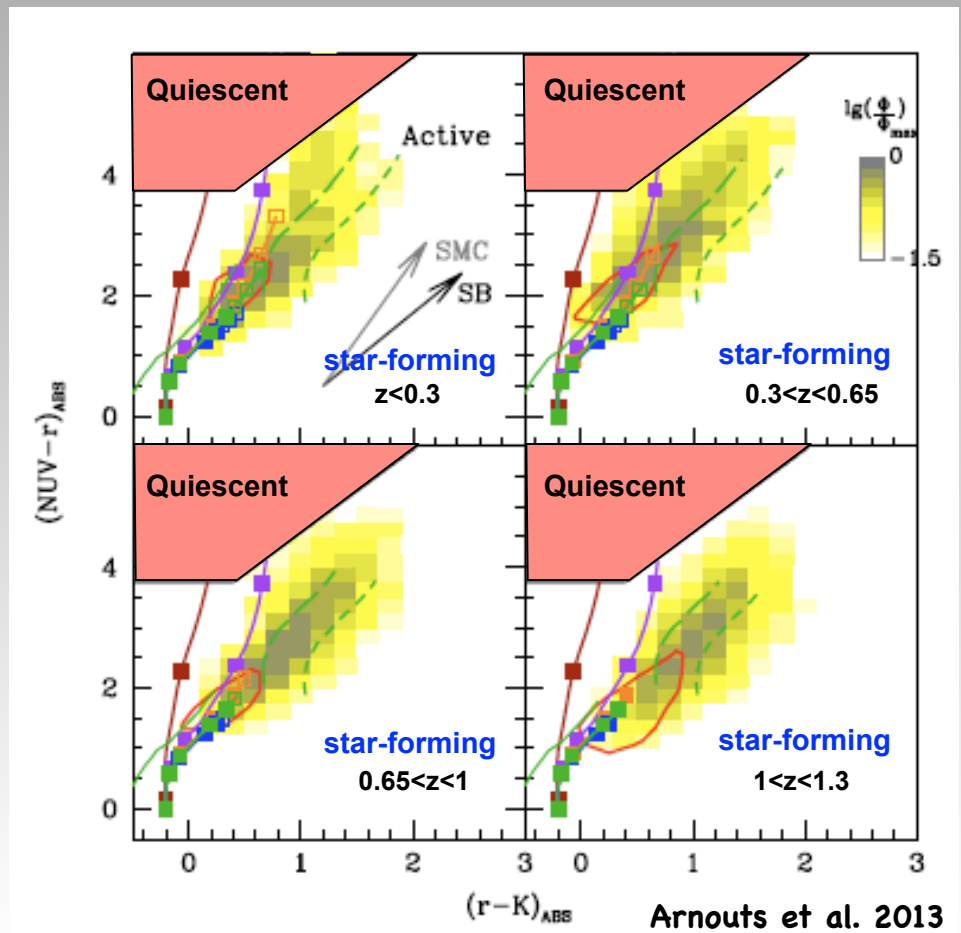


The MIPS selected samples

- COSMOS at F_{24}>80μm and GOODS at F_{24}>20μm
- A single SFR tracer ➢ UV+IR (MIPS+Herschel)
- Select star-forming galaxies with NUV-R versus R-K







Arnouts et al. 2013

mass-sSFR relation in the MIPS 24μm sample

GOODS 160 arcmin^2

K<24.3 F24>20μJy

COSMOS 1.5deg^2

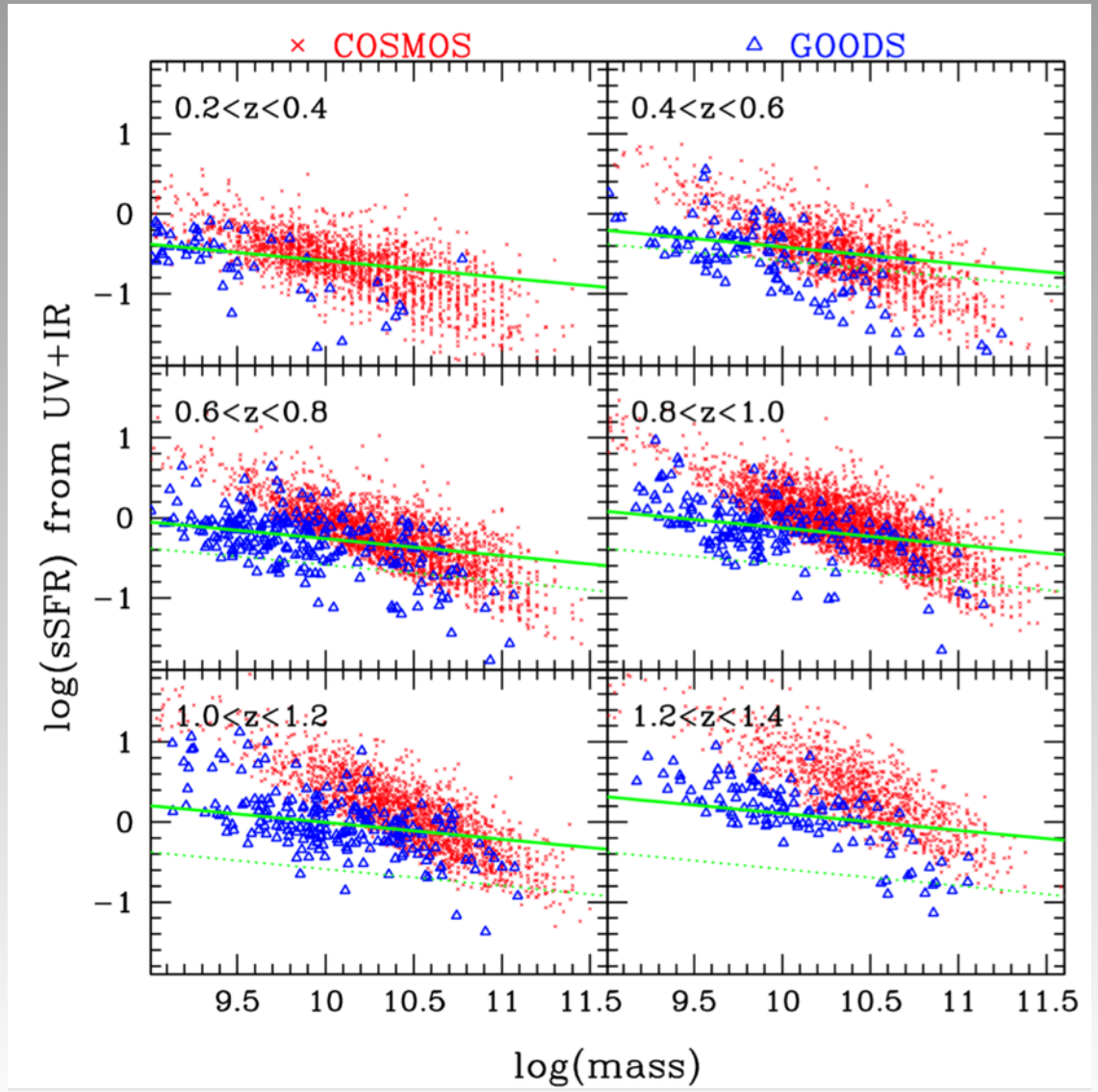
K<24.0 F24>80μJy

The two surveys

do not follow the same

mass-sSFR relation

in a scatter plot



mass-sSFR relation in a semi-analytical model

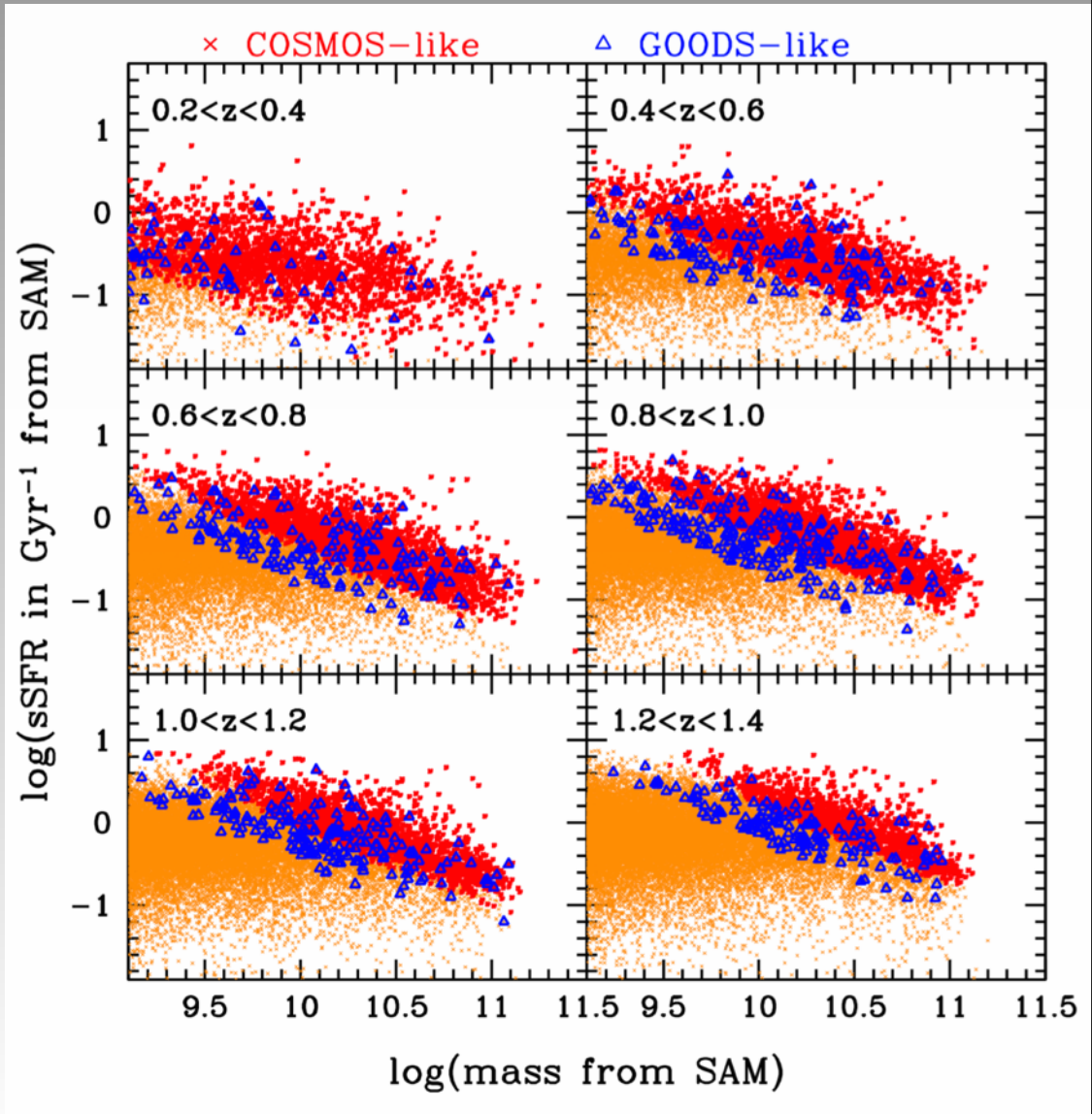
GOODS-like 160 arcmin^2

K<24.3 F24>20μJy

COSMOS-like 1.5deg^2

K<24.0 F24>80μJy

same cut applied to the SAM (Millenium, Wang 08)



mass-sSFR relation in a semi-analytical model

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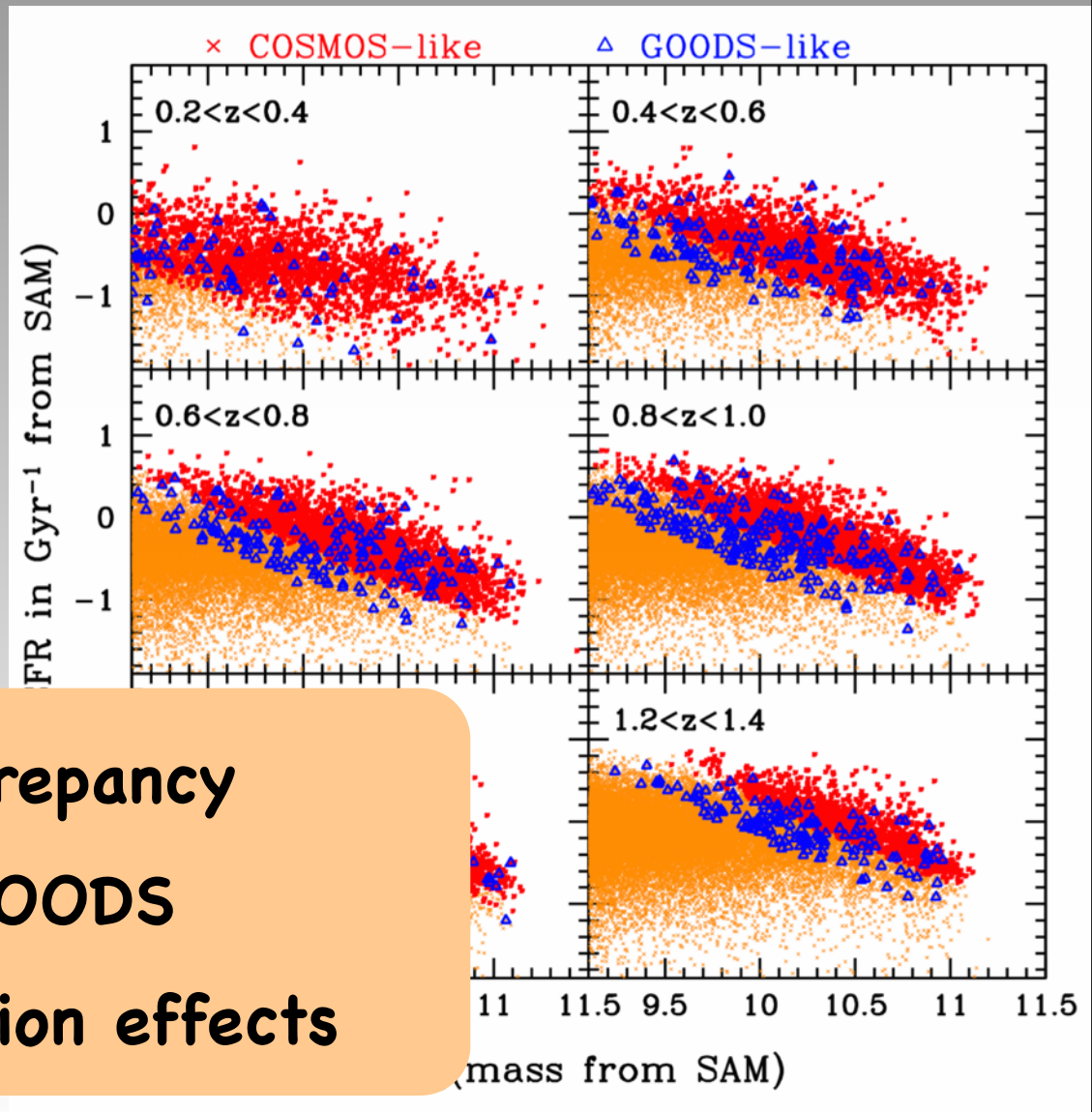


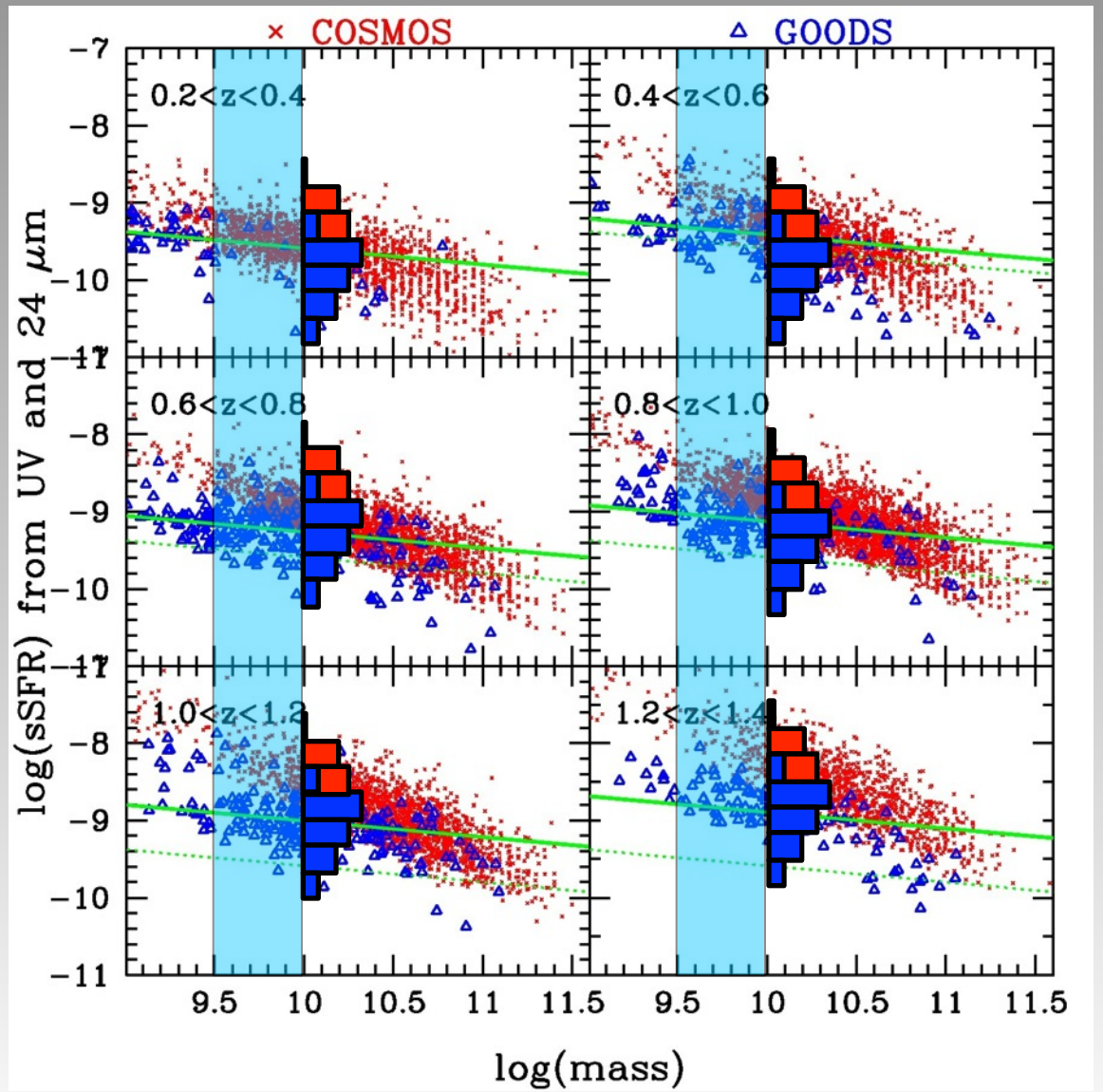
reproduce the same discrepancy between COSMOS and GOODS

➢ be careful with selection effects

Dissecting the mass-SFR relation

In a given stellar mass bin ➢ Compute the sSFR function N/Mpc^3/dex

Done in 4 mass bins



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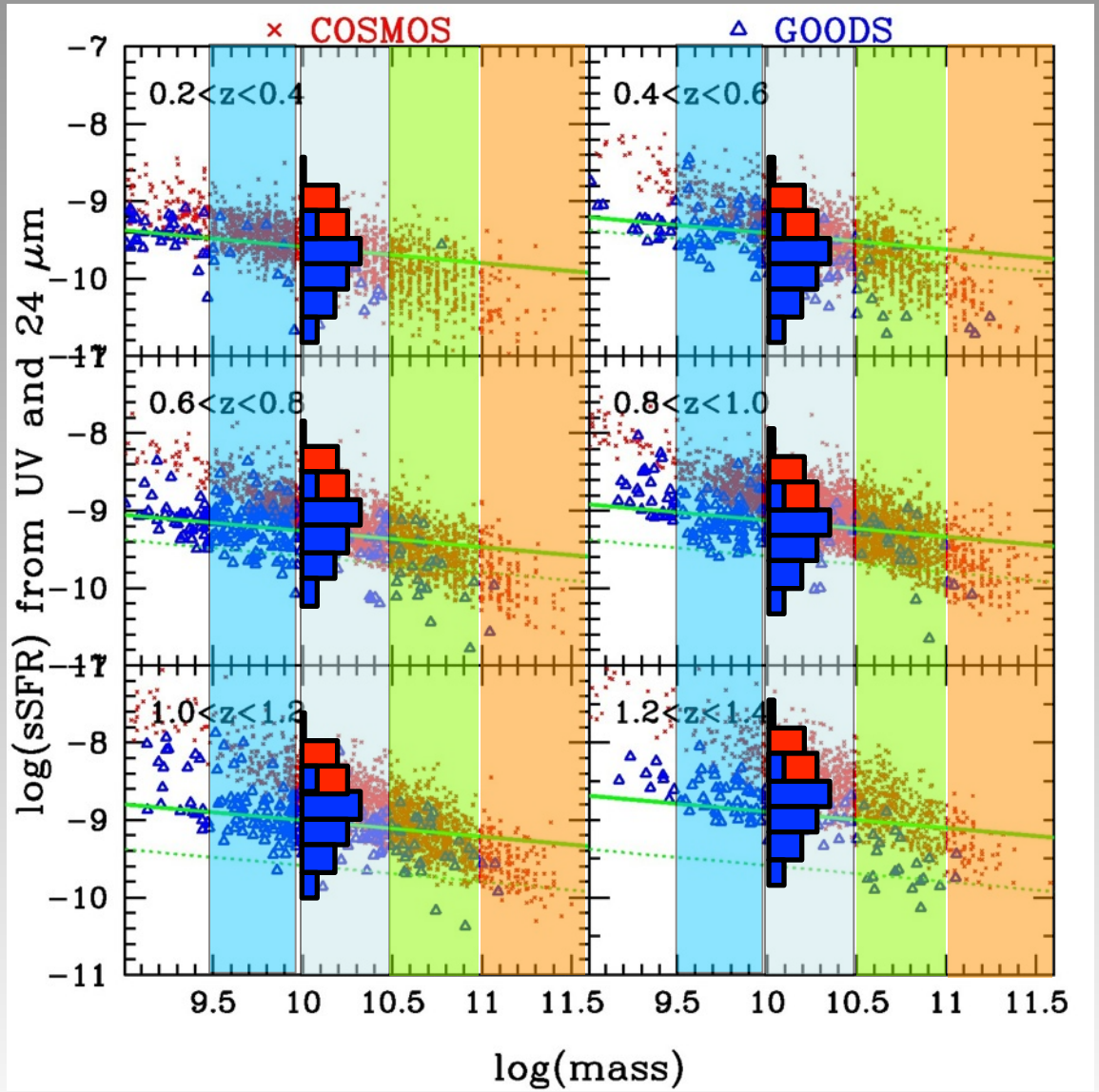
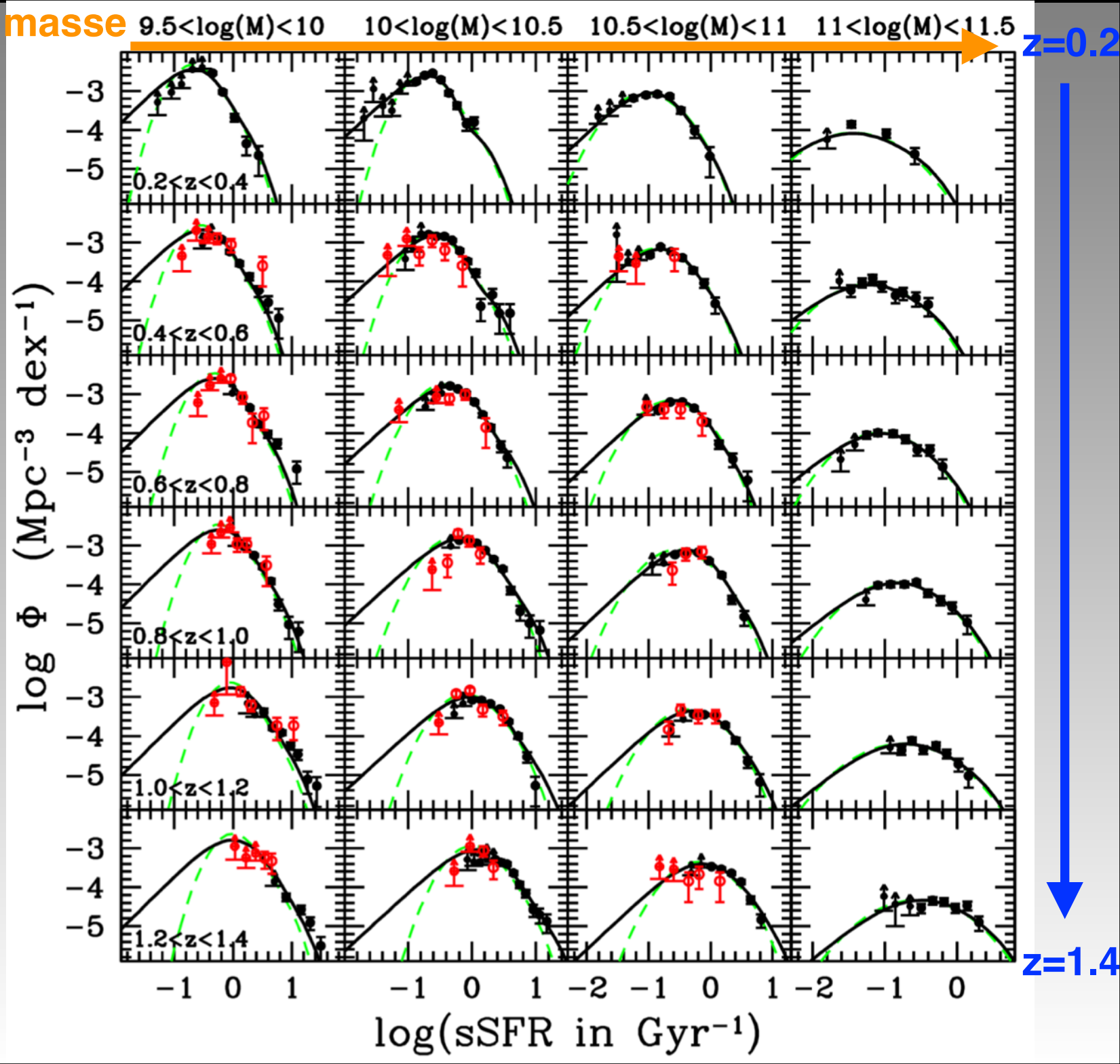


24μm samples

COSMOS

GOODS

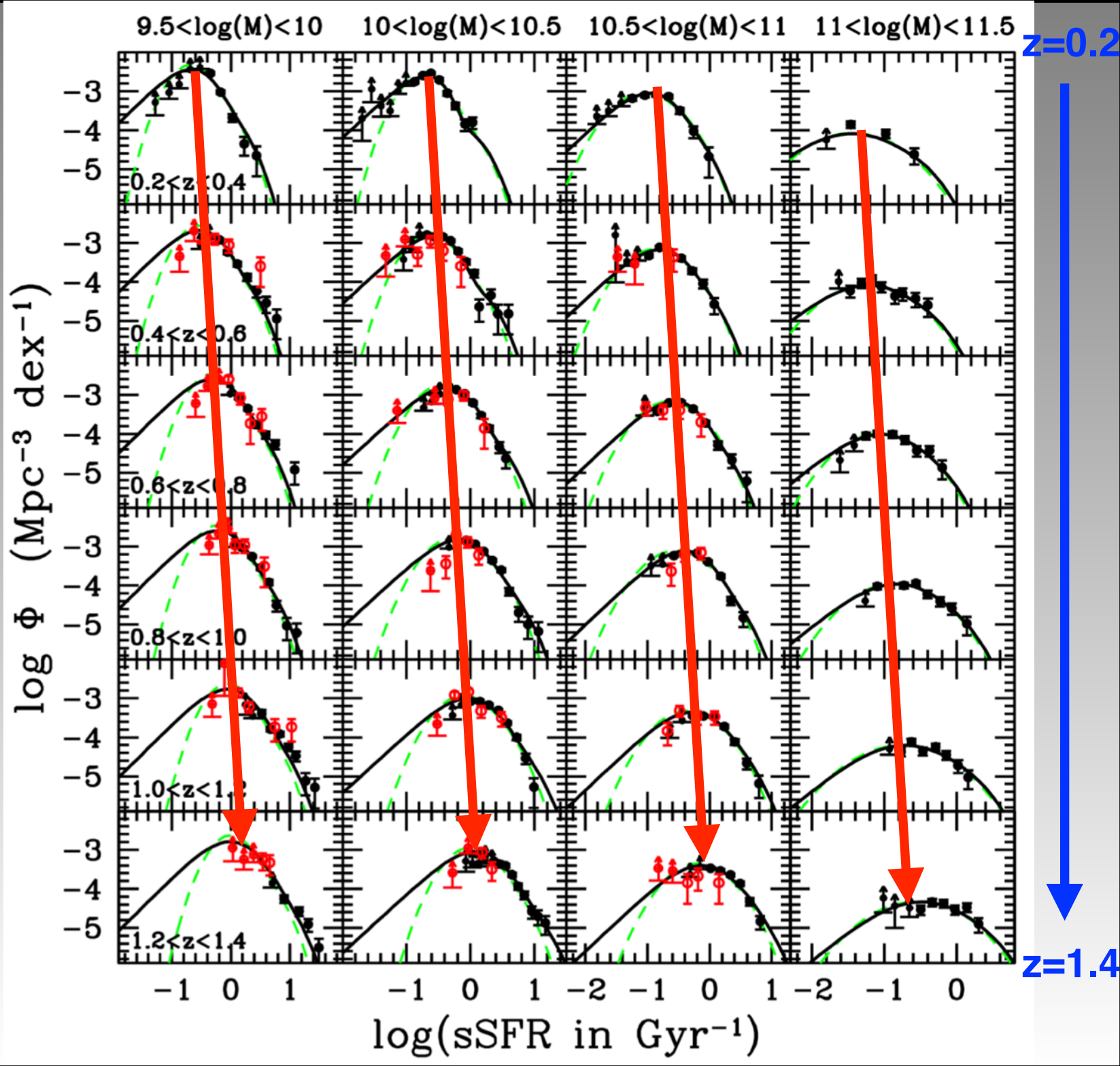


24μm samples

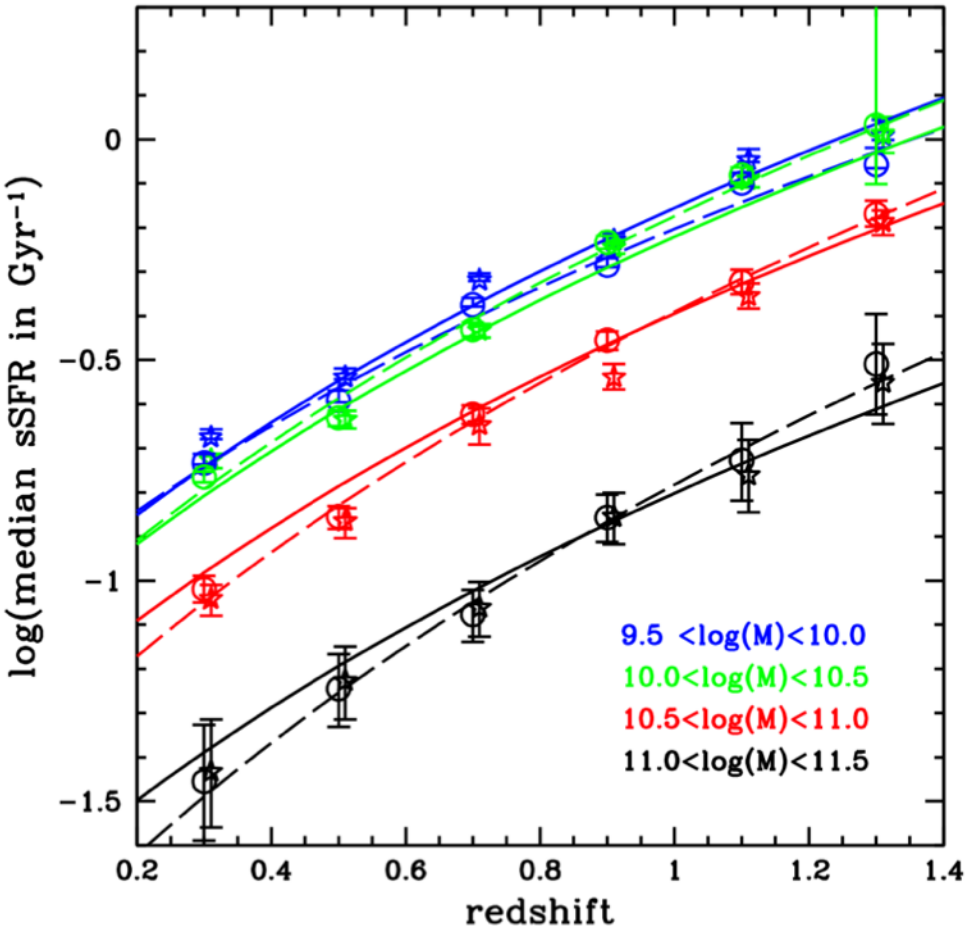
COSMOS

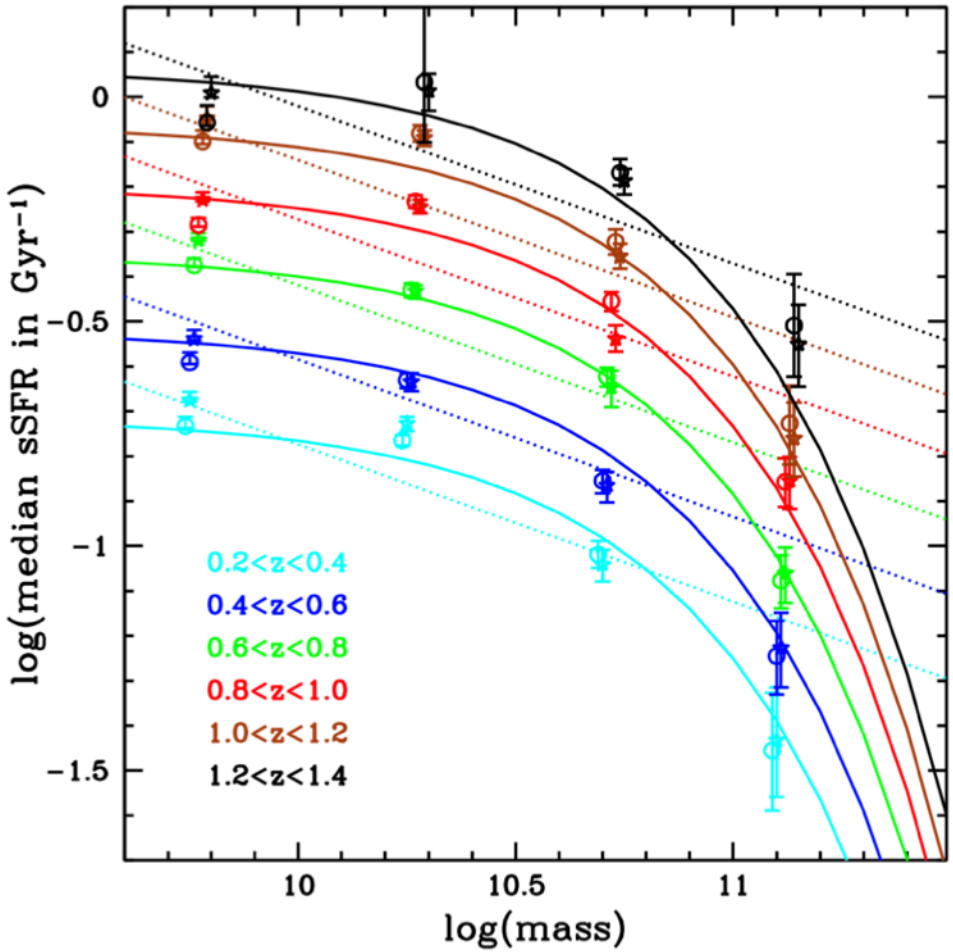
GOODS

Median sSFR directly from the best-fit functions



Evolution with redshift and mass

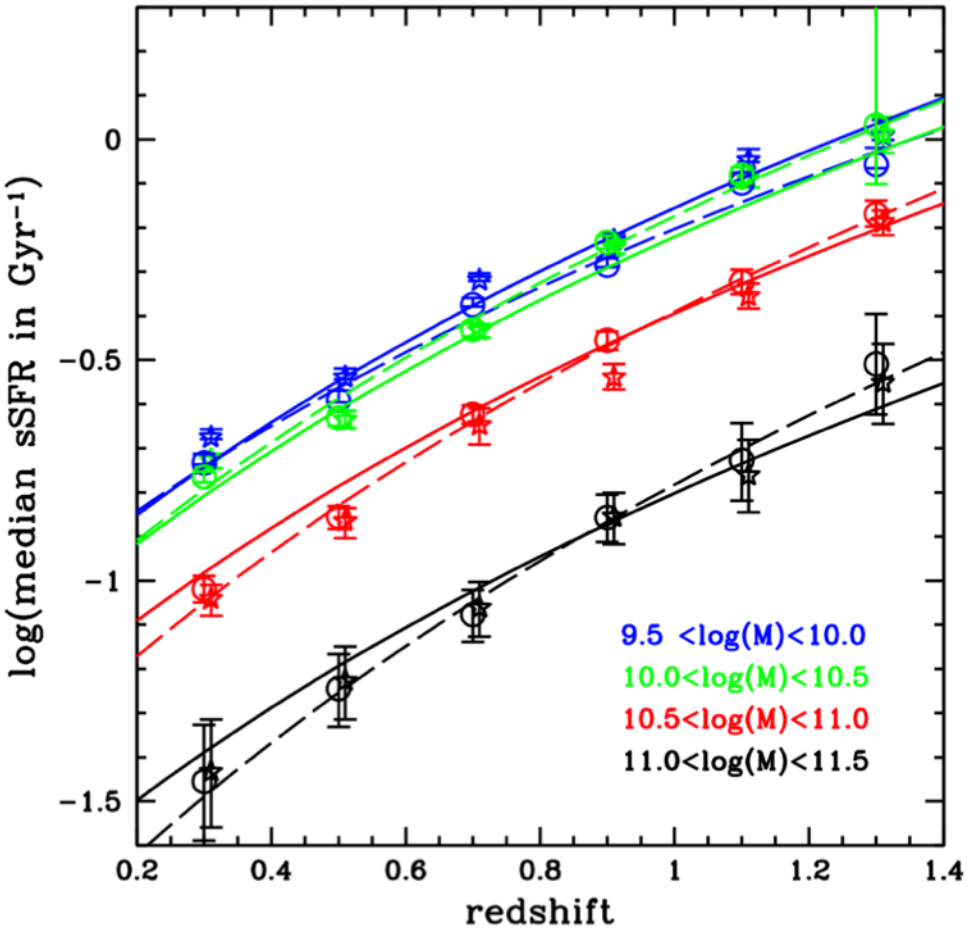


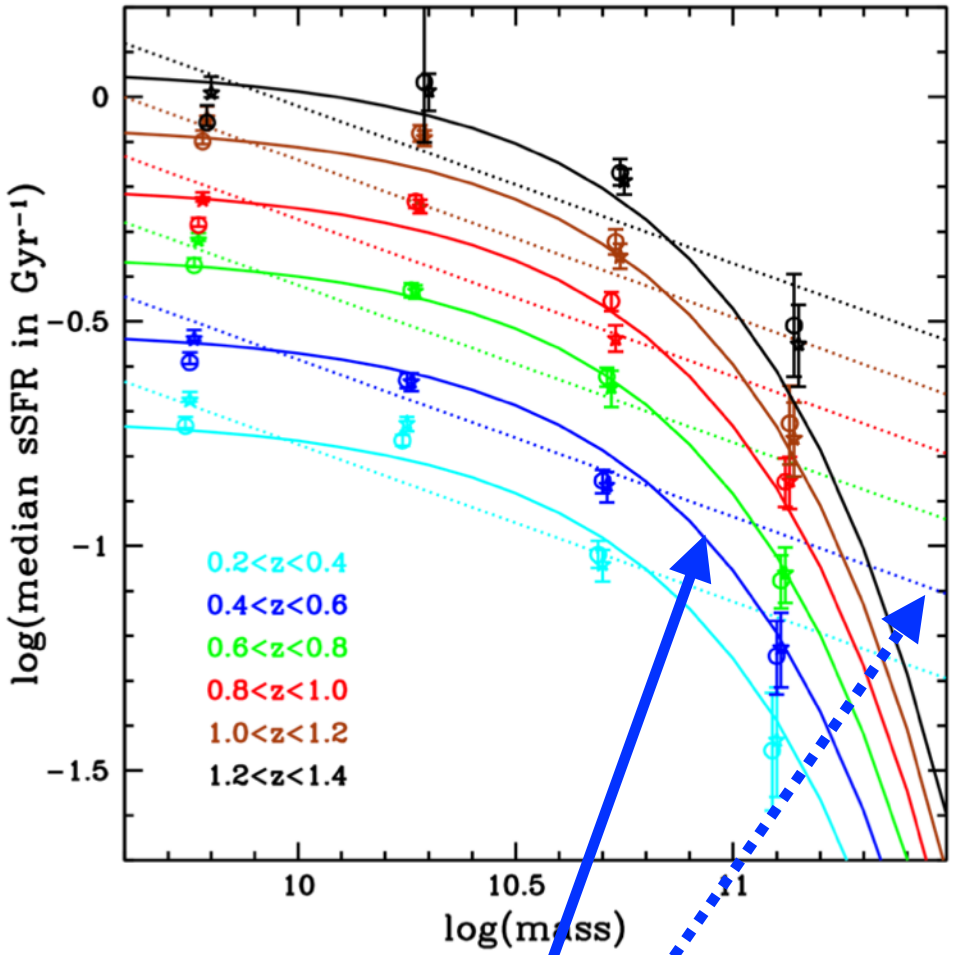


$$log(s\mathcal{SFR}) = a + \beta \times \frac{\mathcal{M}_\star}{10^{10.5}\mathcal{M}_\odot} + b \times log_{10}(1+z)$$

solid lines

Evolution with redshift and mass





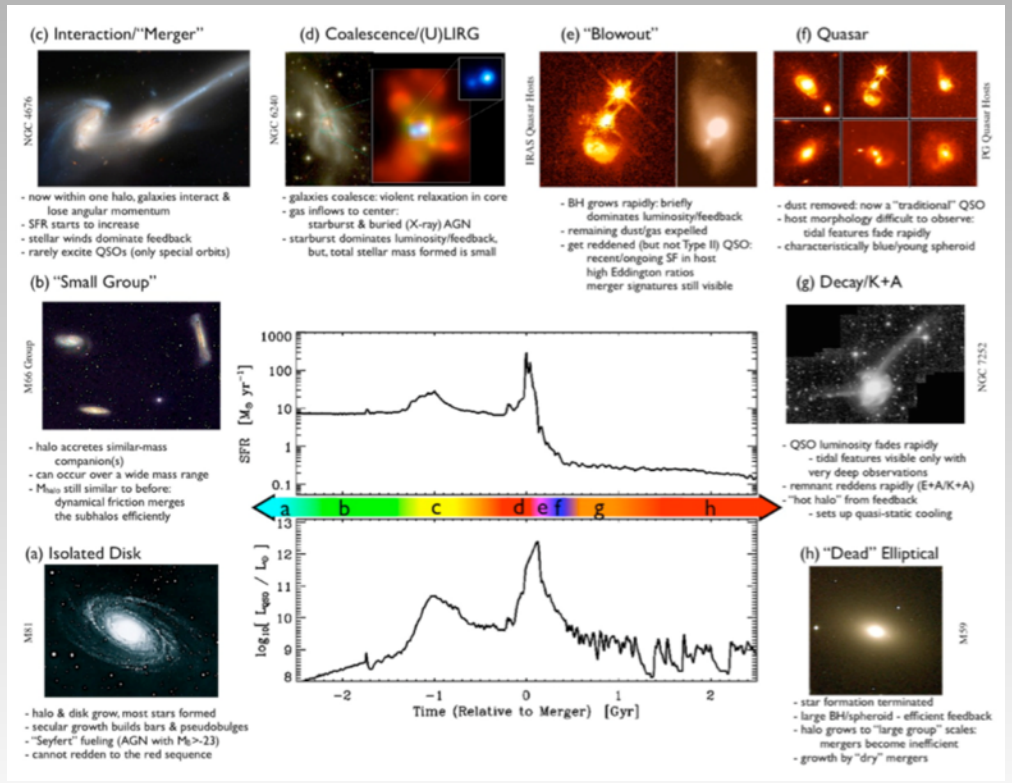
$$log(s\mathcal{SFR}) = a + \beta \times \frac{\mathcal{M}_\star}{10^{10.5}\mathcal{M}_\odot} + b \times log_{10}(1+z)$$

different parametrization with $M_\star$ than usual (in log $M_\star$)

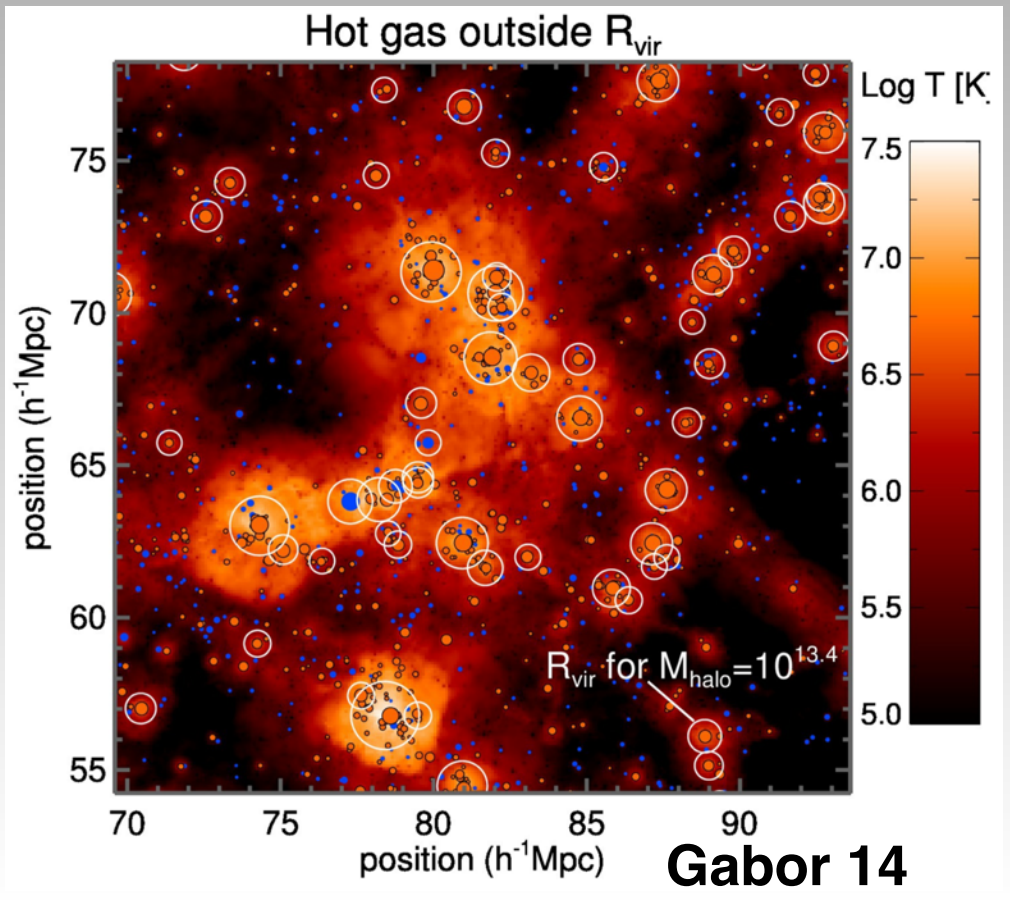
gradual sSFR declines with $M_{\star}$

Rapid cessation of the star formation activity for massive galaxies: e.g. AGN feedback, hot halo mode

Quenching in <1Gyr → too fast to see a gradual bending



Hopkins 07



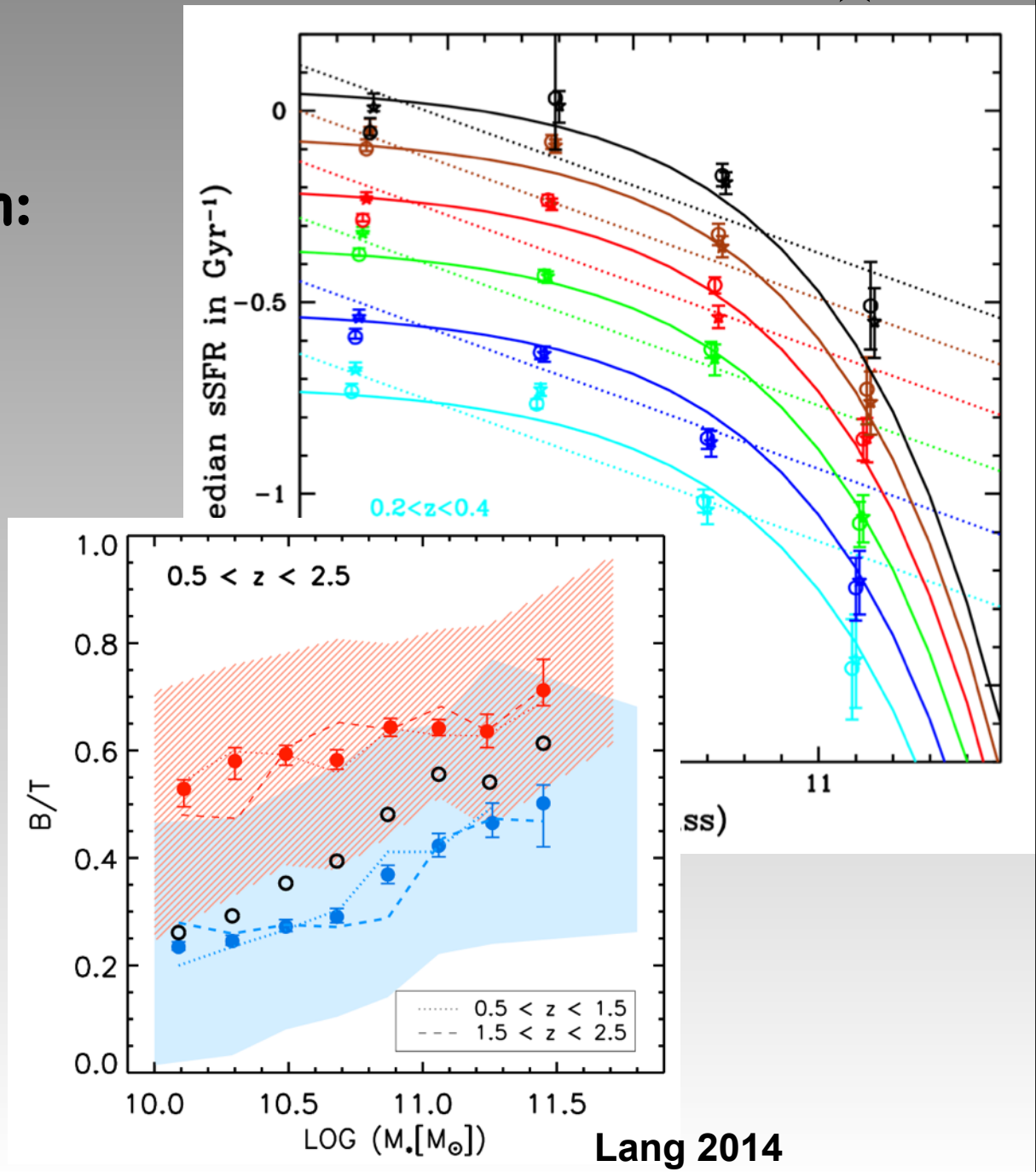
Gabor 14

gradual sSFR declines with $M_\star$

Long timescale variation: few Gyr

Possible link with an increasing bulge contribution with mass

➢ secular process ?



Lang 2014

broadening of the sSFR function with $M_{\star}$

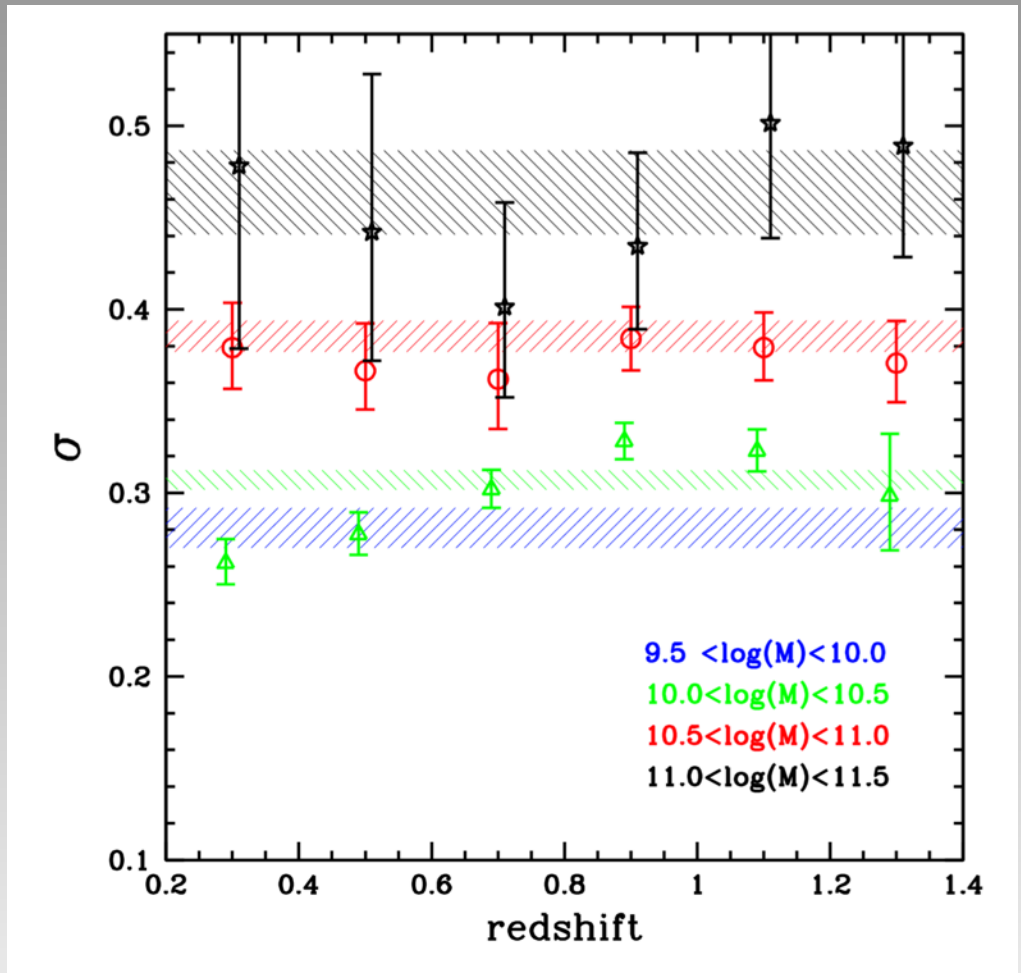
scatter of the main sequence increases with $M_{\star}$

stochasticity of the SFH decreases with masses

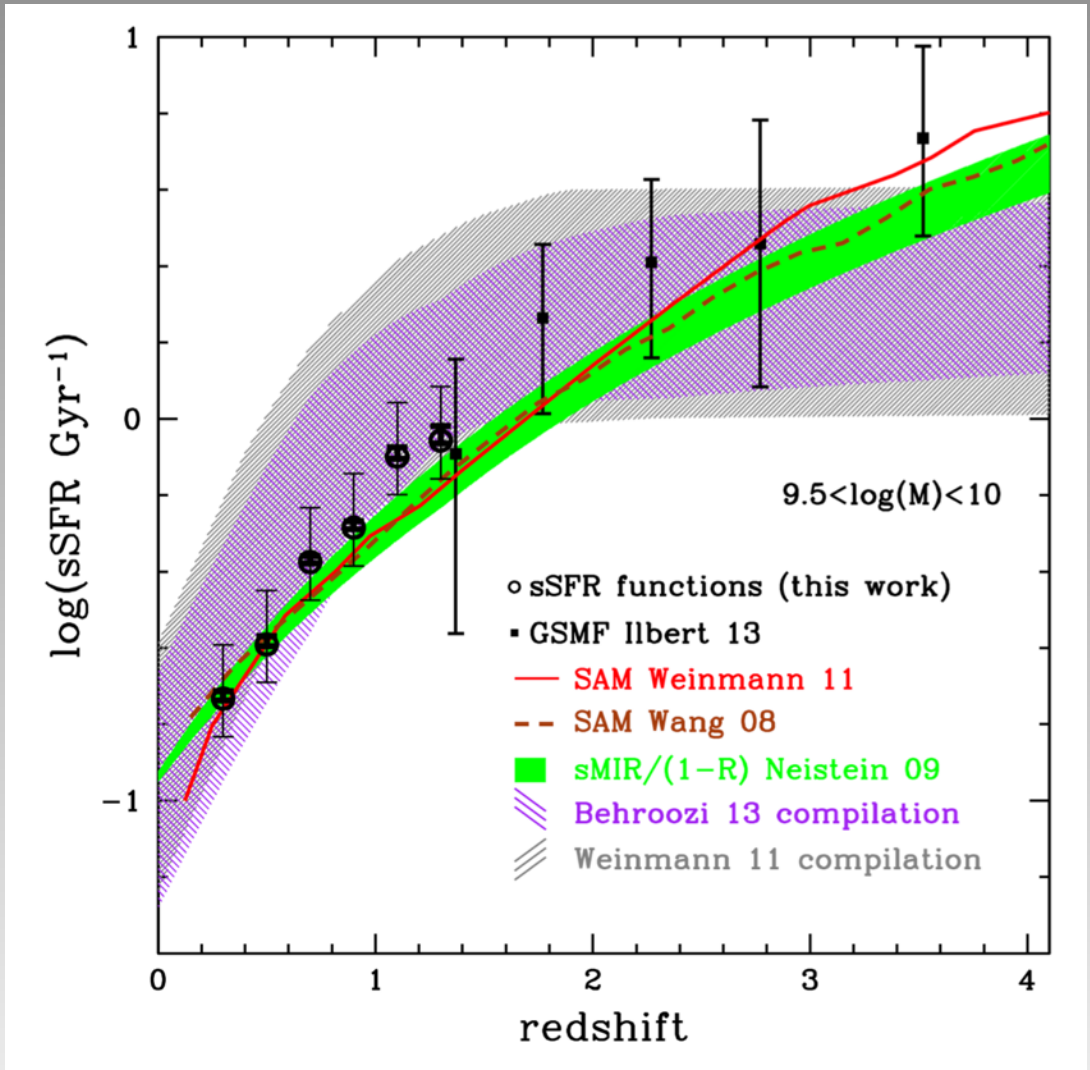
➢ not the explanation

tentative interpretation

➢ increasing diversity of the SFH toward high masses



Evolution of the sSFR with redshift

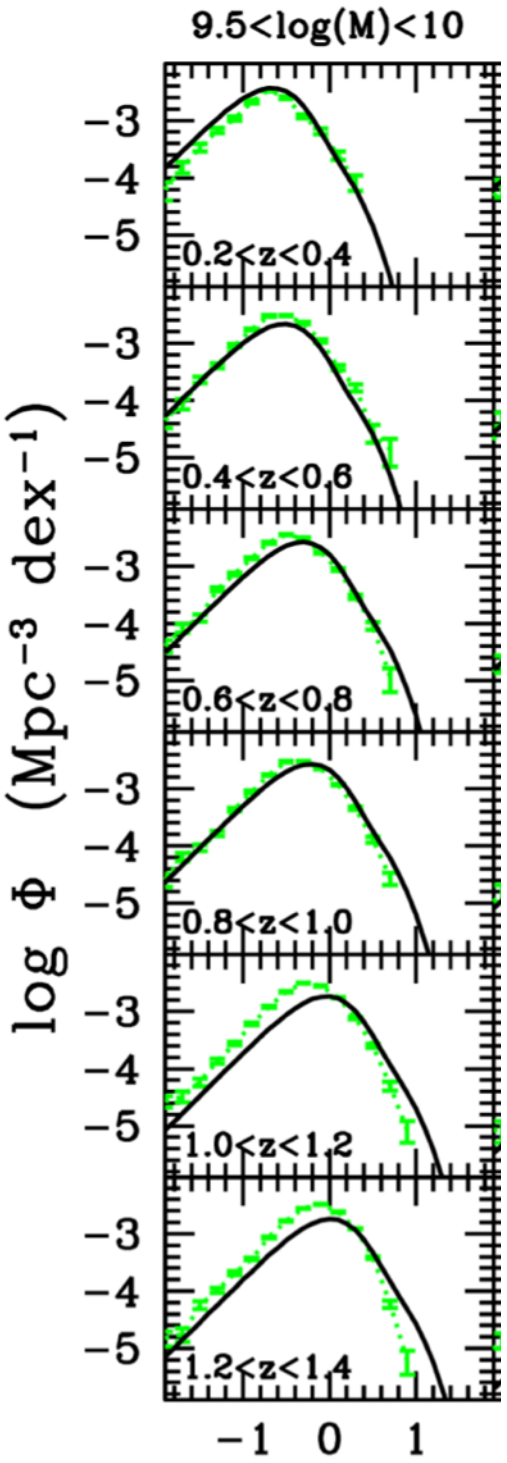


Less tension with SAM predictions at z<1.5, for the low mass galaxy sample 9.5<log(M)<10

Semi Analytical Model

Wang 08

Our data in black



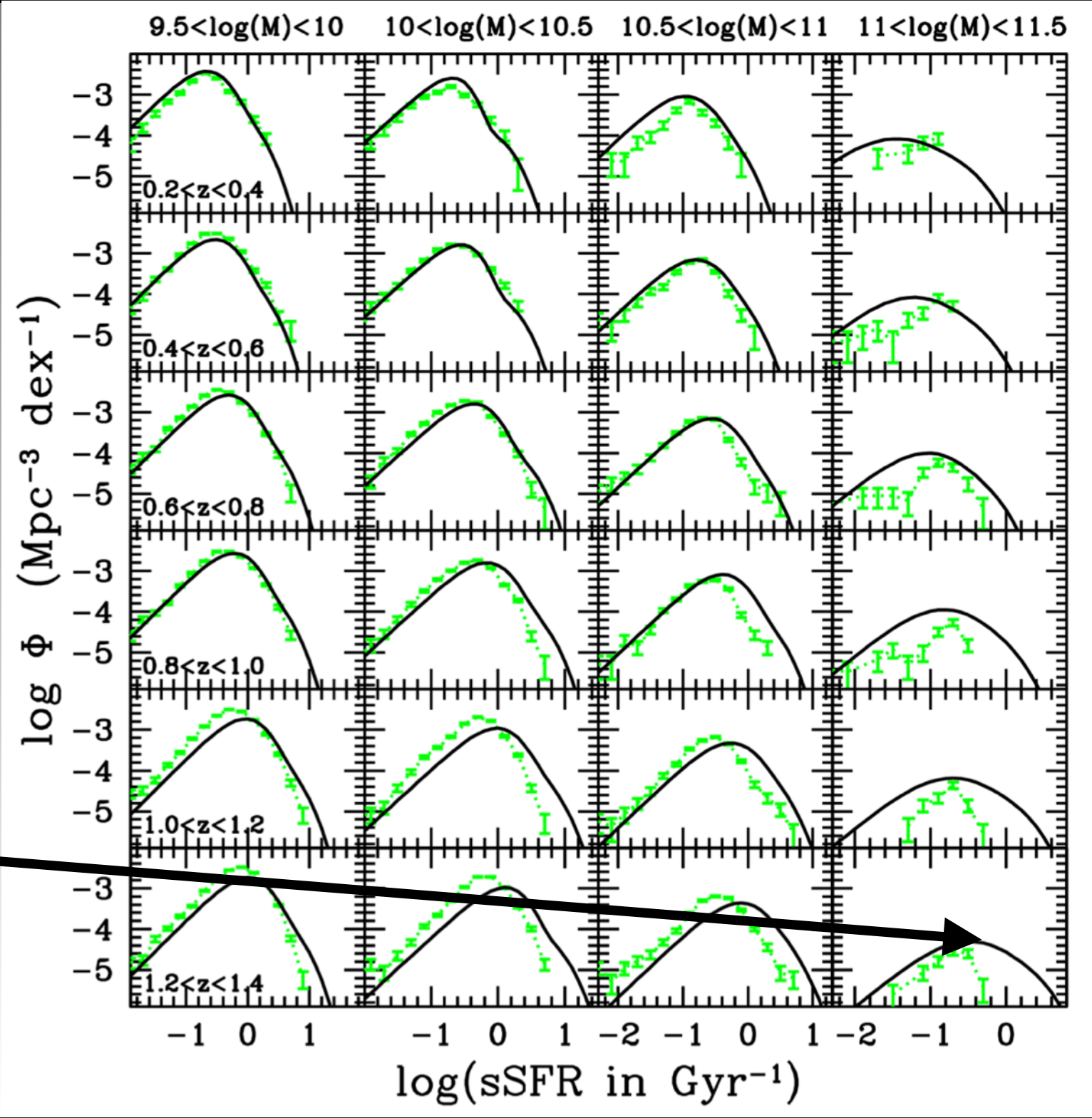
log(sSFR in Gyr^{-1})

Semi Analytical Model

Wang 08

Our data in black

agreement breaks down for the massive galaxies



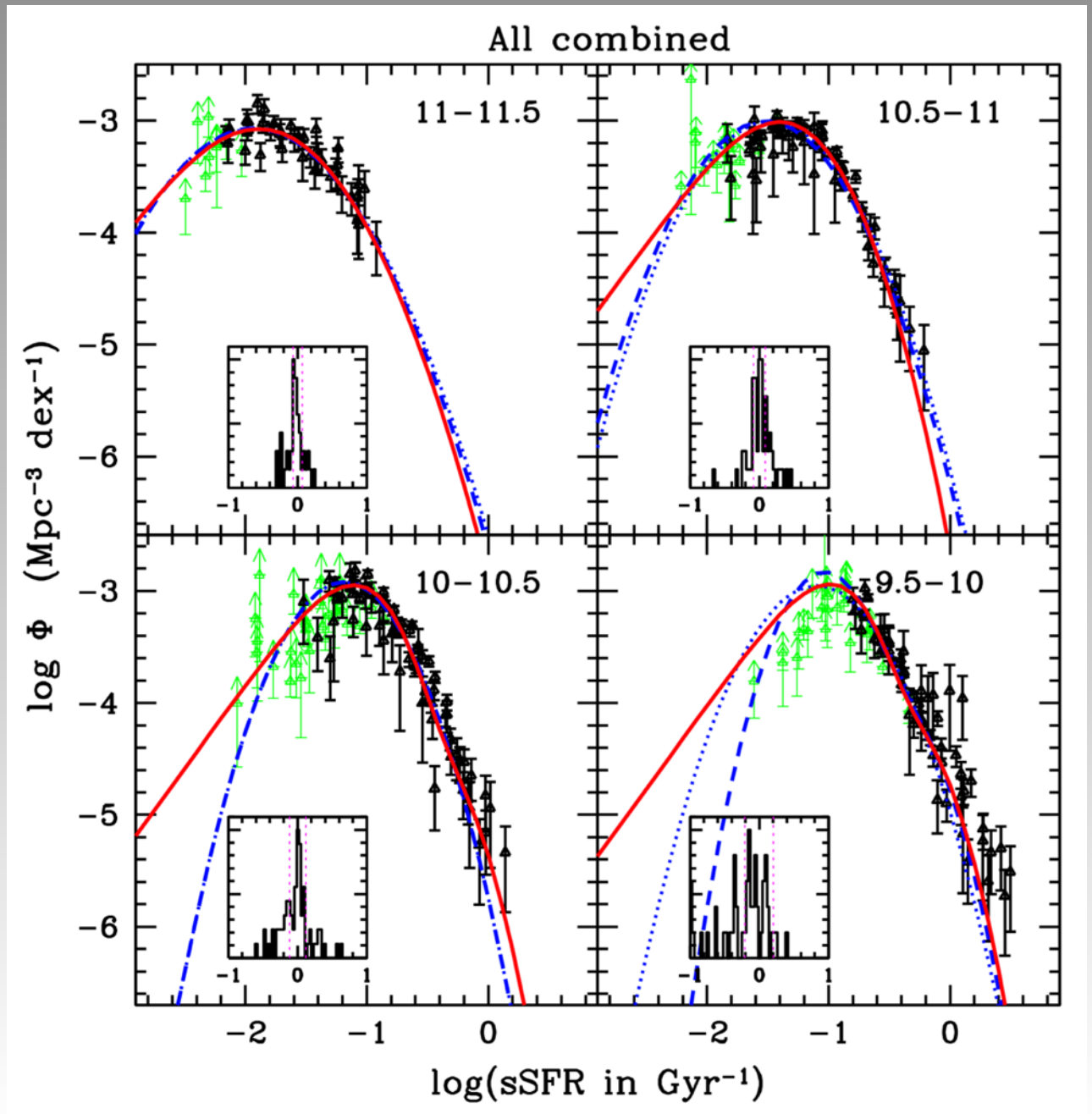
shape of the sSFR function

Bring everything at z=0 correcting for the evolution of the sSFR

The shape of the sSFR function

1) does not change with redshift

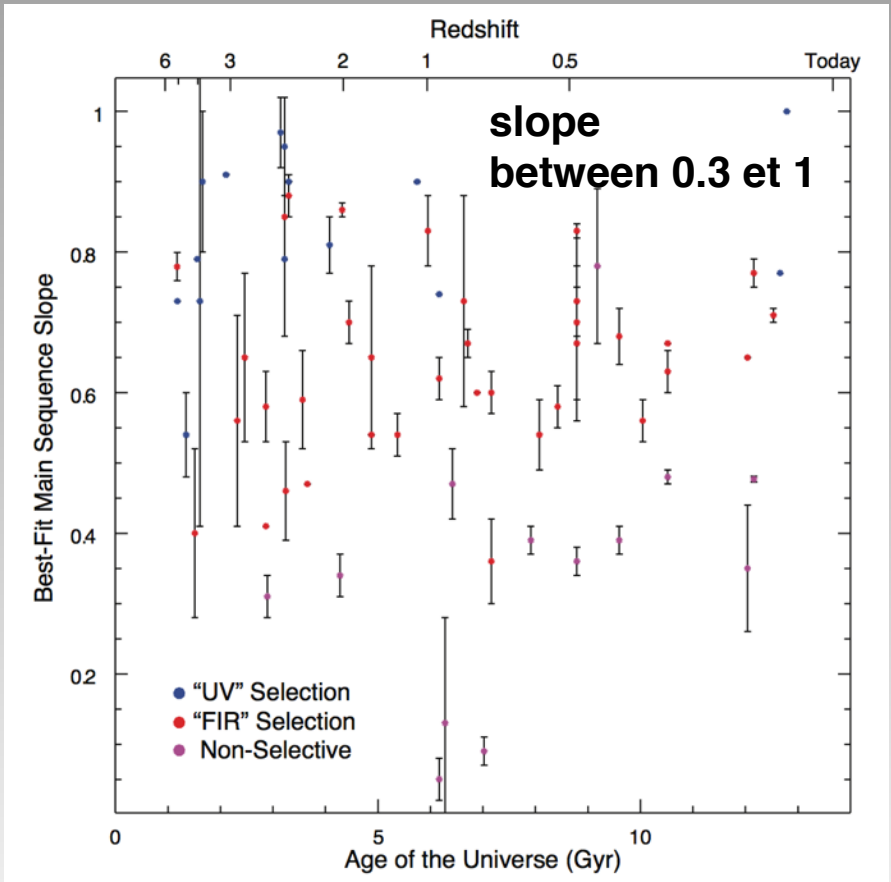
2) changes with mass



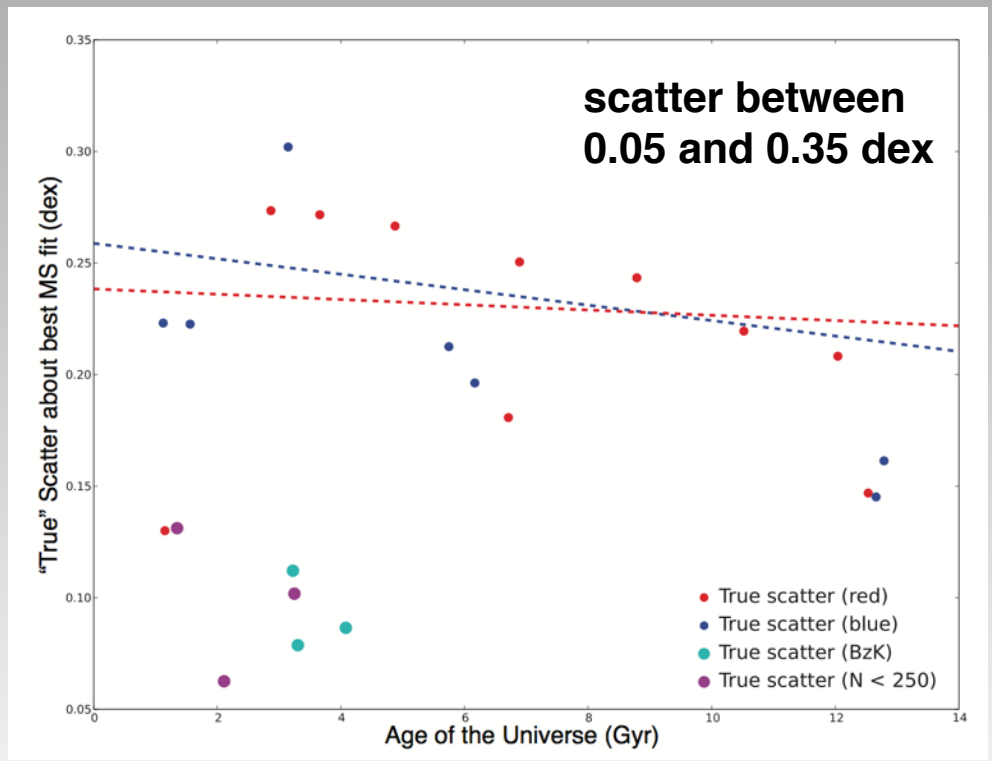
conclusions

- when studying the mass-SFR relation, be careful to selection effects
- shape of the sSFR function does not evolve at z<1.4 and depends on the mass ➢ broadening with mass
- evolution of the sSFR with redshift follows the cosmological accretion for the galaxies at $M<10^{10}M_{\odot}$ but differ at higher masses
- log(sSFR) decreases as $-0.18M_{\star}$, long timescale effects (>1Gyr) probably associated with the presence of the bulge

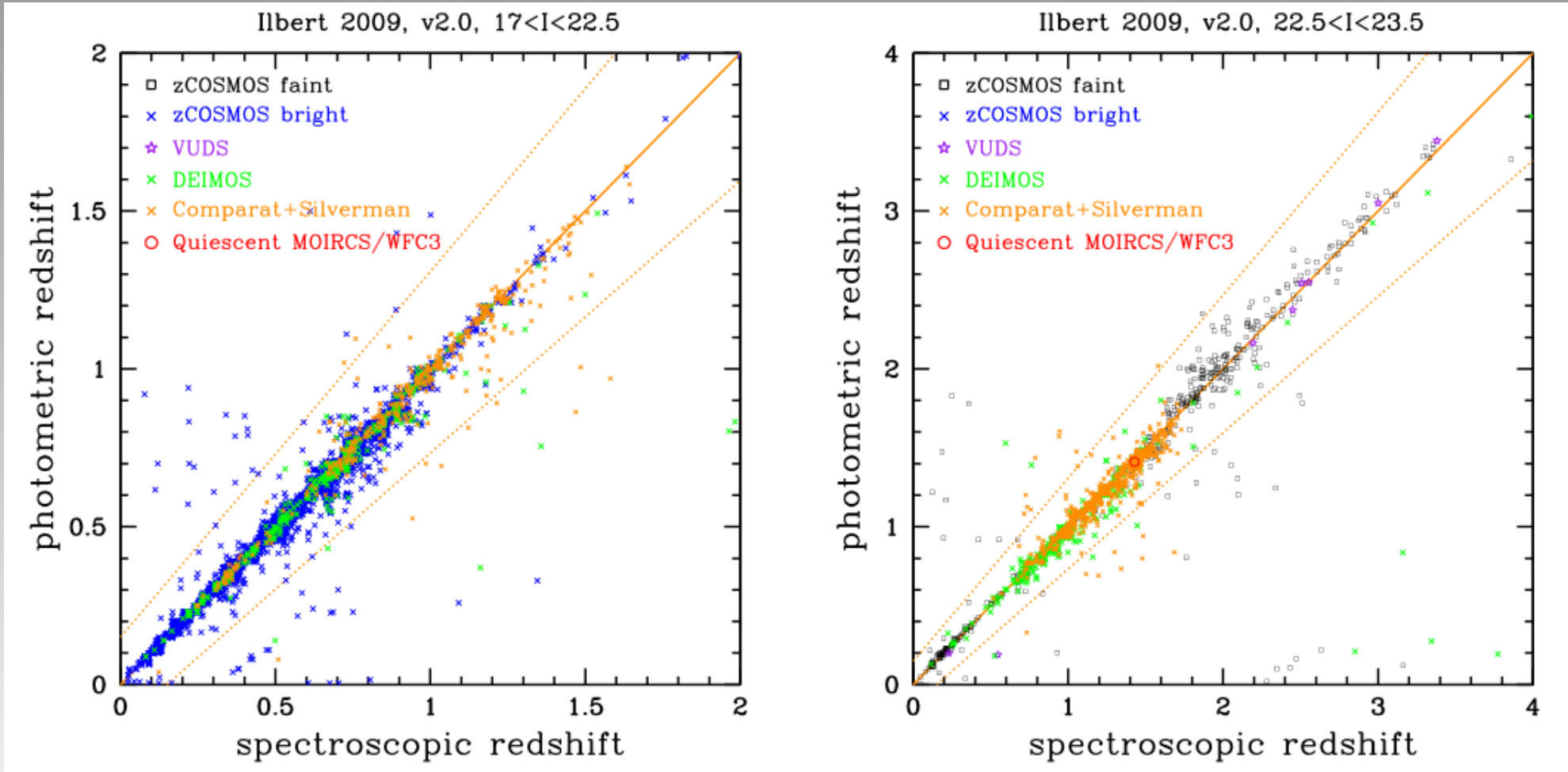
Characterize the star-forming main sequence



Speagle 2014 compilation



Analysis based on photo-z

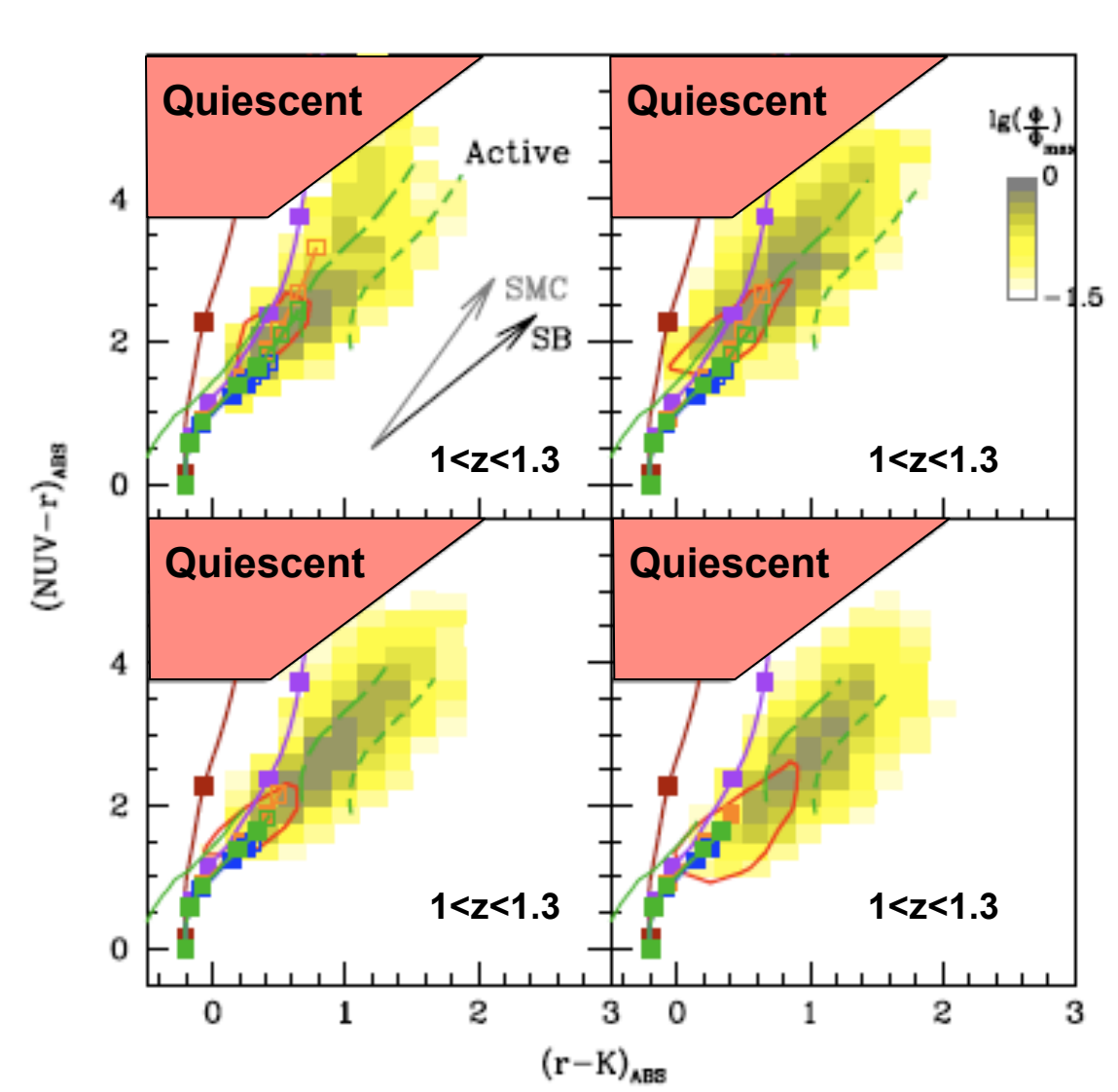


1-2% accurate and well tested photo-z at z<1.5

Select the star-forming population

Extinction is moving galaxies along a diagonal axis

Star forming galaxies with extinction fall in a different locus than galaxies with a quenched SFR



Arnouts et al. 2013 with COSMOS MIPS

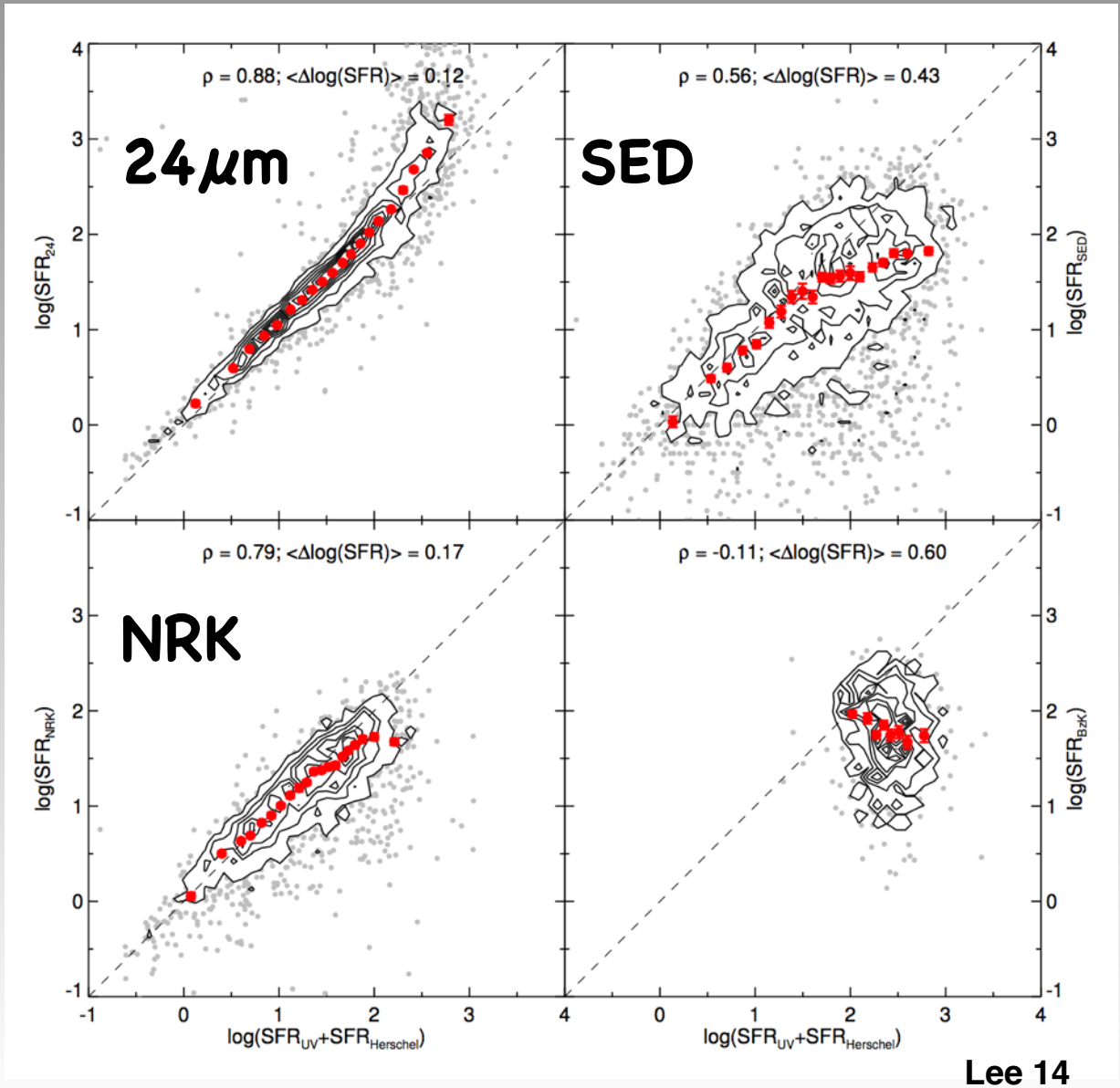
see also Williams 09 for U-V-J

Characterize the SFR

Use the 24μm as main SFR tracer

- reach low SFR
- robust at z<1.5
- does not require uncertain dust modeling

Stick with one SFR tracer



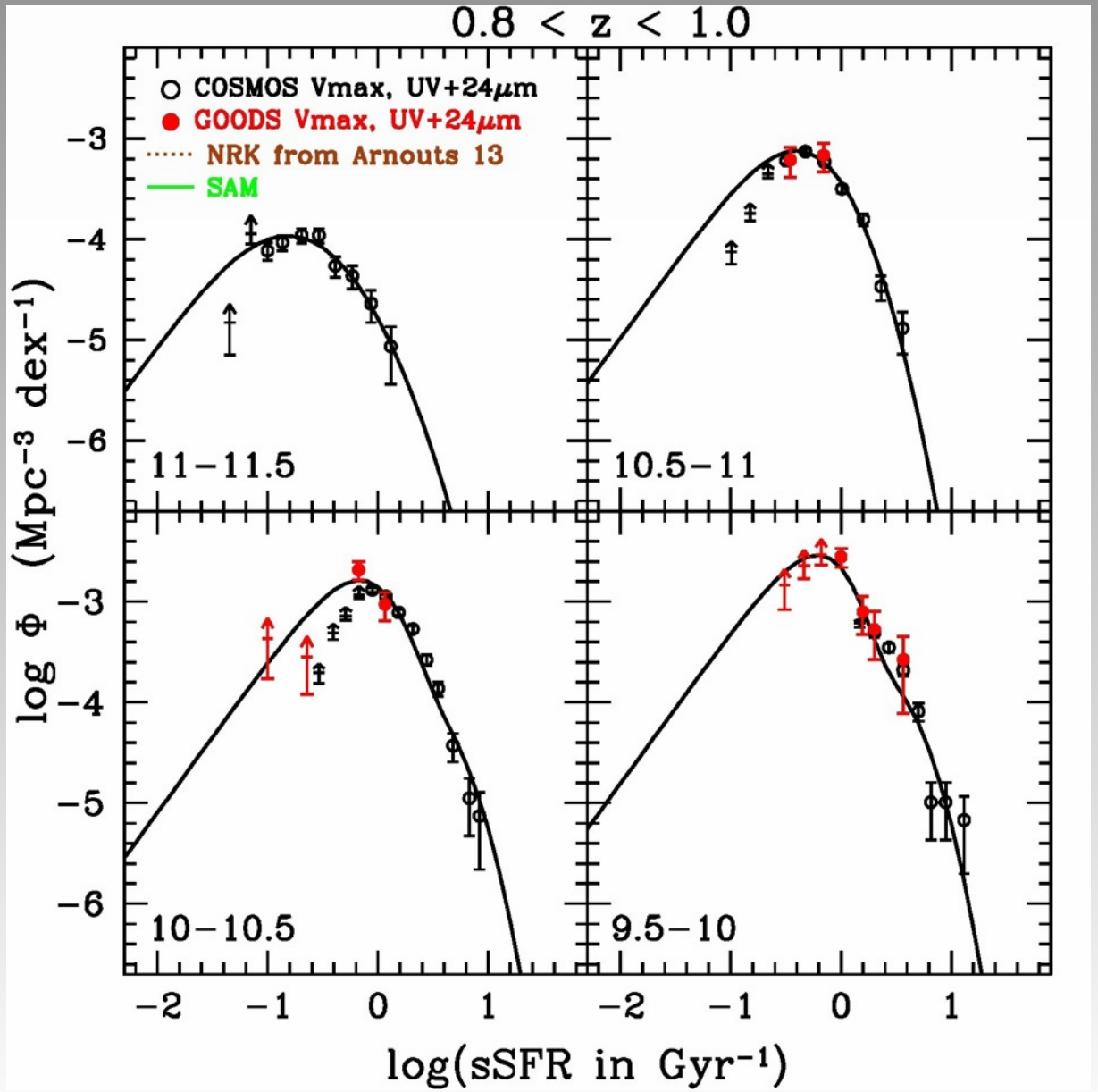
sSFR function per stellar mass bin

COSMOS and GOODS complementary

Fit with a double-exponential

$$\Phi(sSFR) = \Phi^* \left(\frac{sSFR}{sSFR^*}\right)^{1-\alpha} exp\left[-\frac{1}{2\sigma^2} log_{10}^2(1+\frac{sSFR}{sSFR^*})\right]$$

+ starburst component



SFR function

SFR function in each mass bin

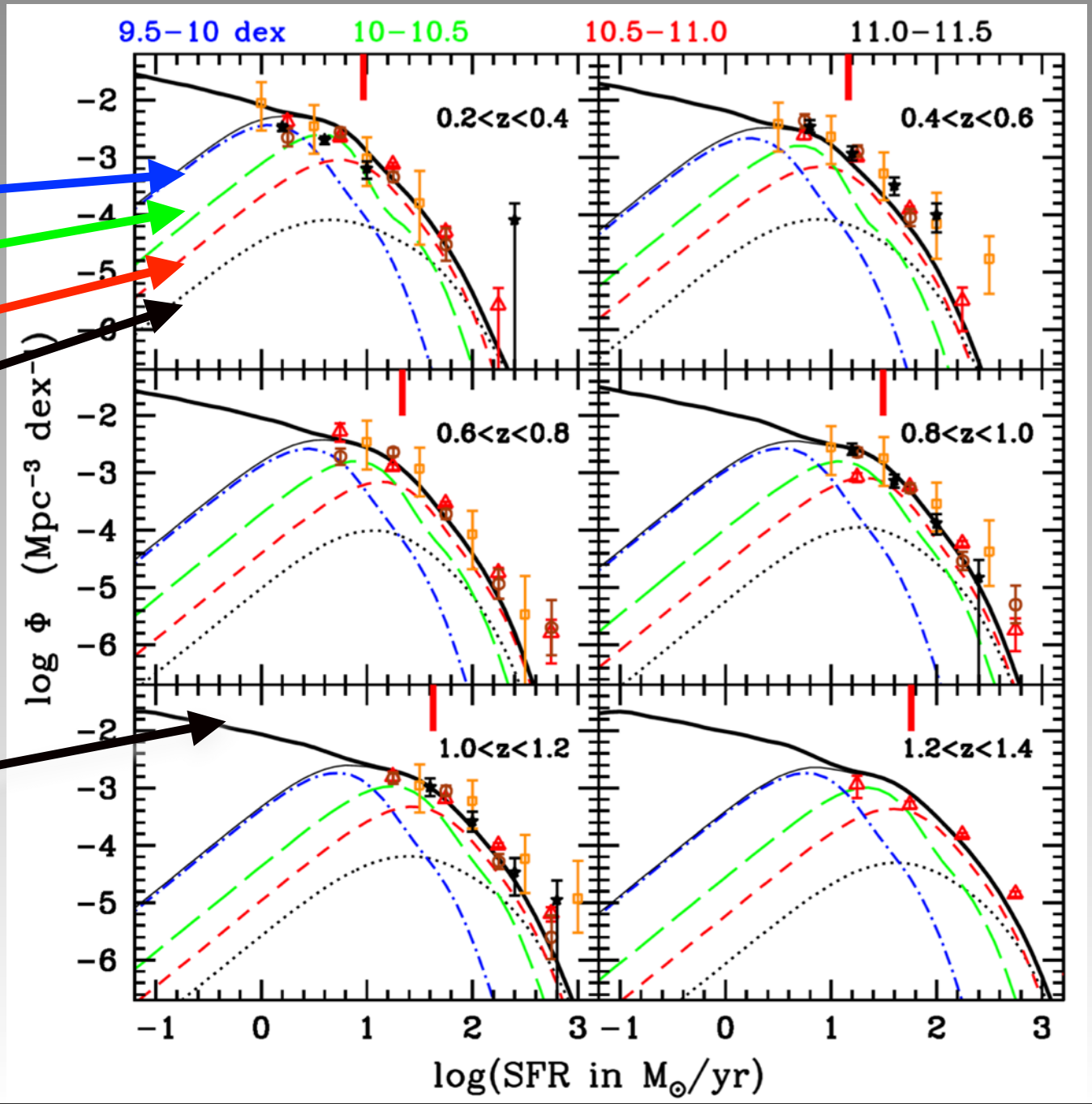
9.5<log(M)<10

10<log(M)<10.5

10.5<log(M)<11

11<log(M)<11.5

sum of each SFR function + extrapolation at low SFR using the GSMF

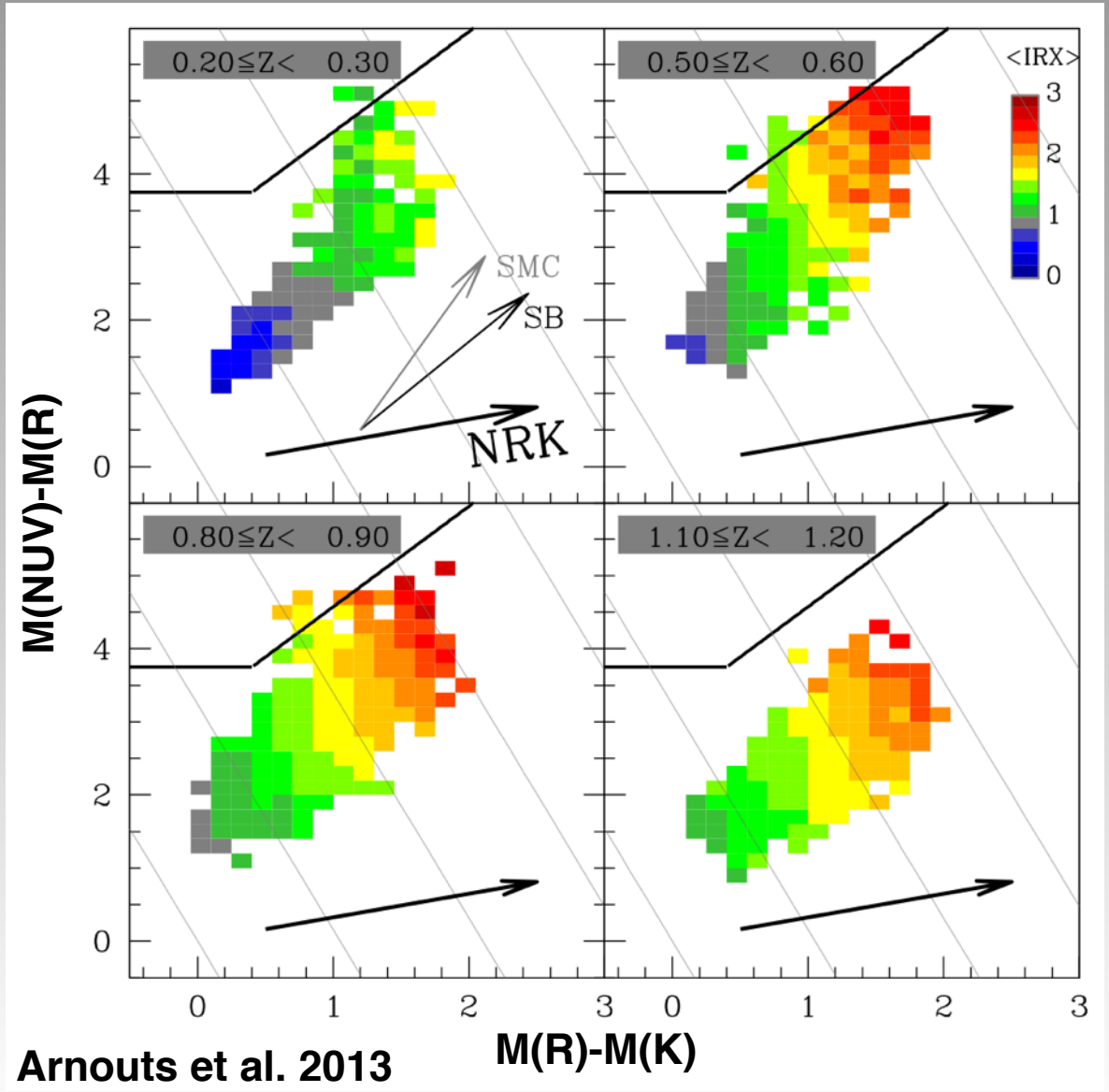


NRK to estimate the SFR

An alternative method to derive the SFR from optical

➢SFR estimate based only on

M(NUV), M(R), M(K)

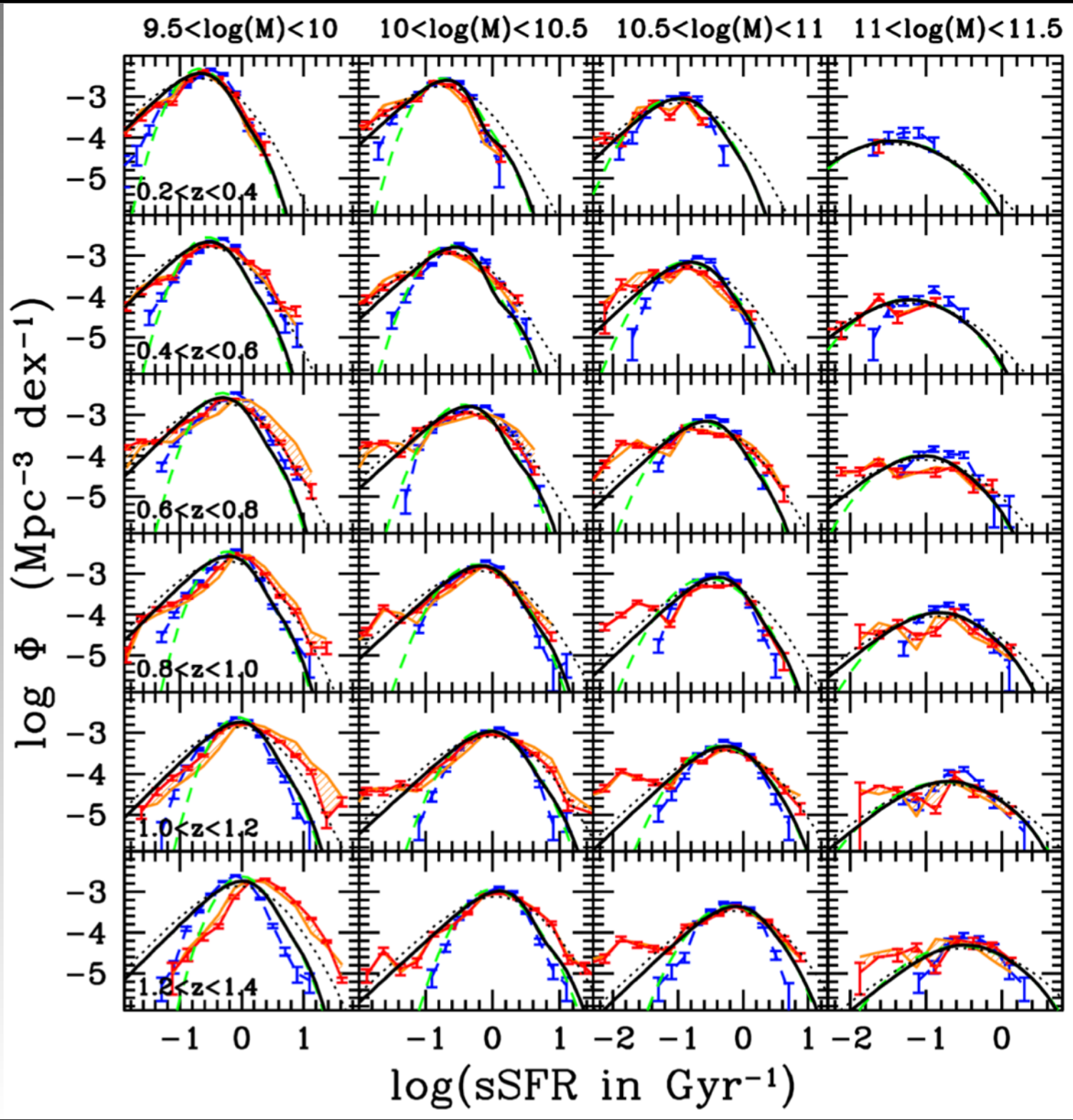


Arnouts et al. 2013

optical SFR tracers

NRK

SED

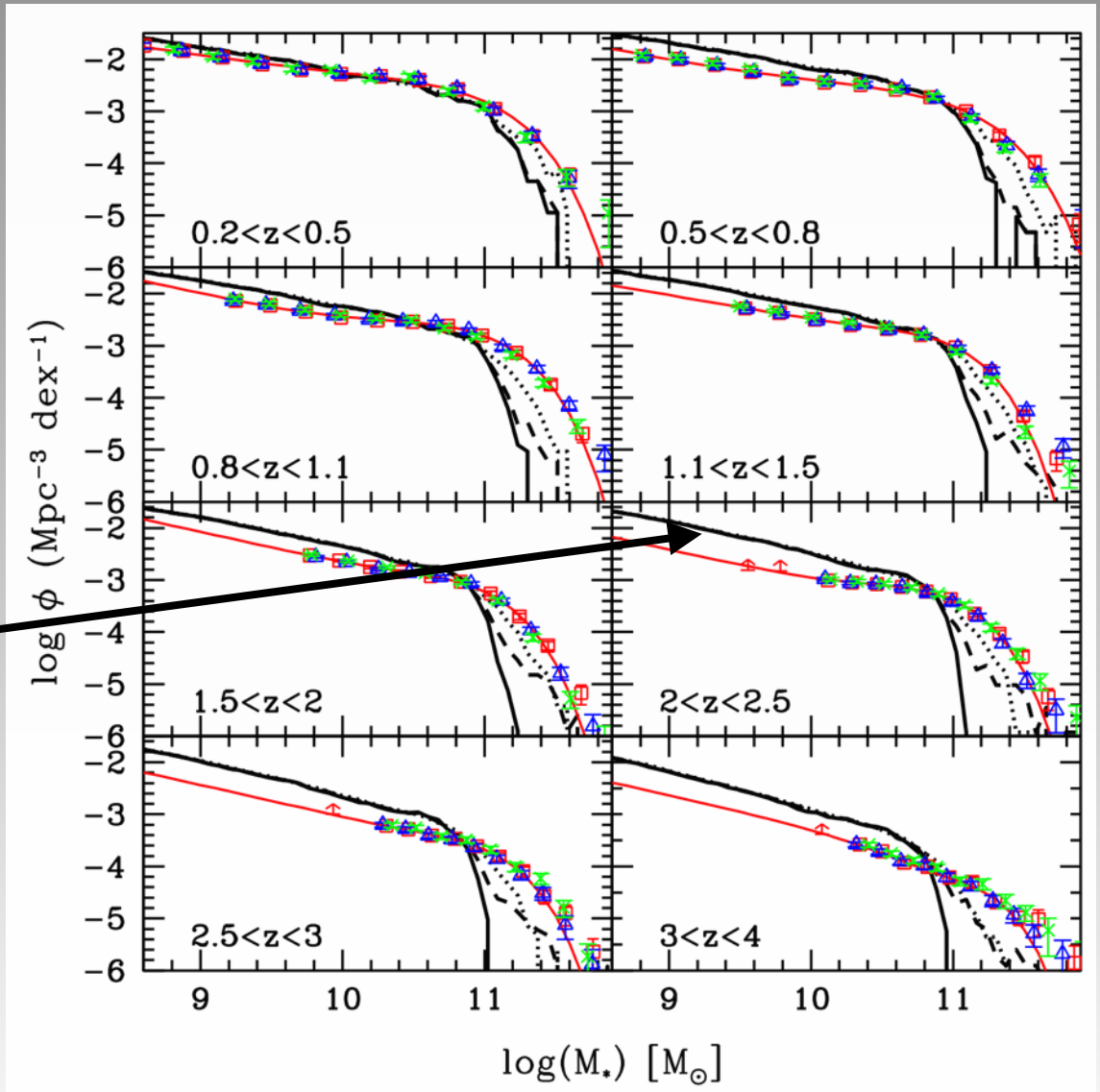


comparison with semi-analytical models

SAM from

Wang et al. 2008

mock catalogue created for COSMOS over 1.4x1.4 deg^2

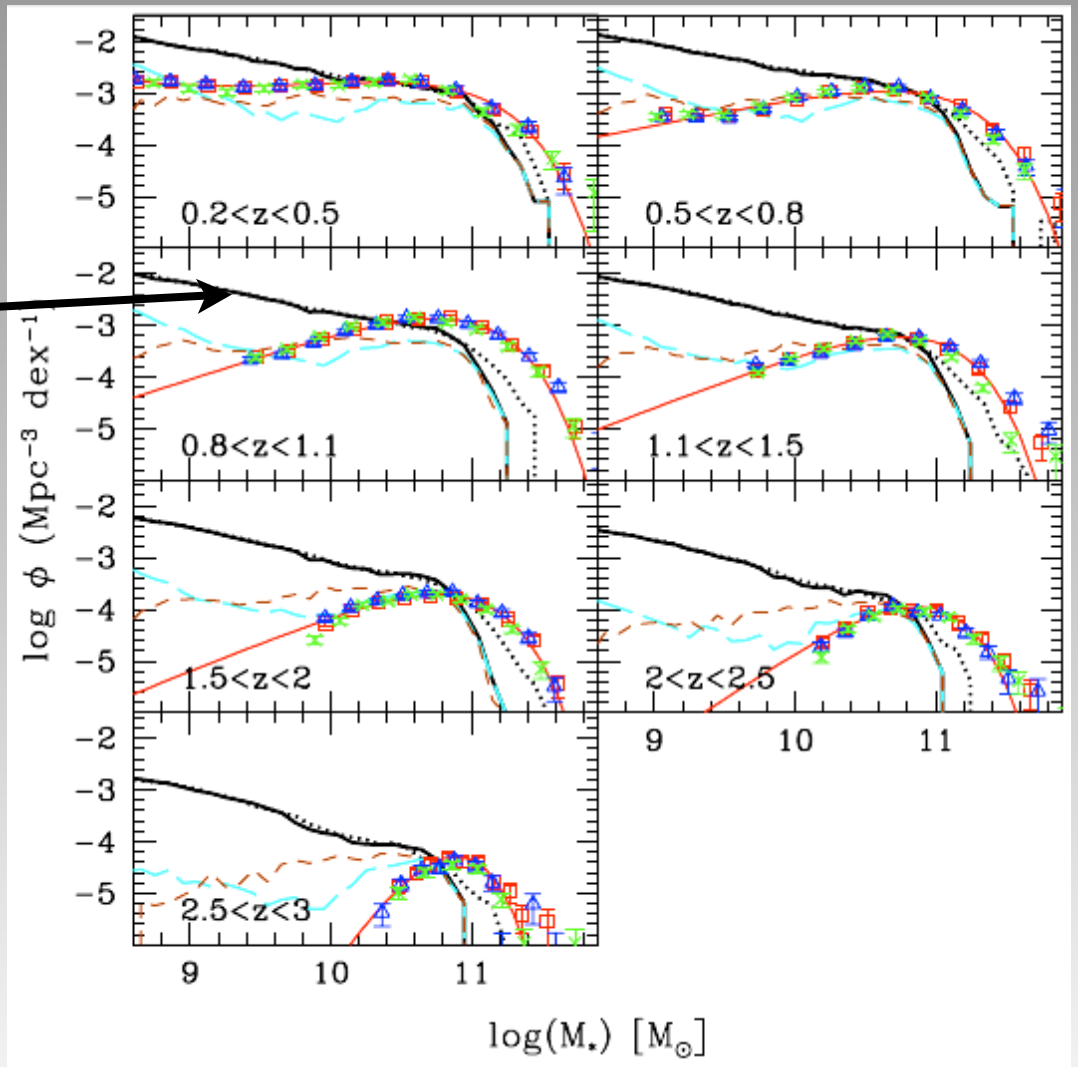


comparison with semi-analytical models for quiescent galaxies

x10-100 too many low mass quiescent galaxies in the model

seems improved now

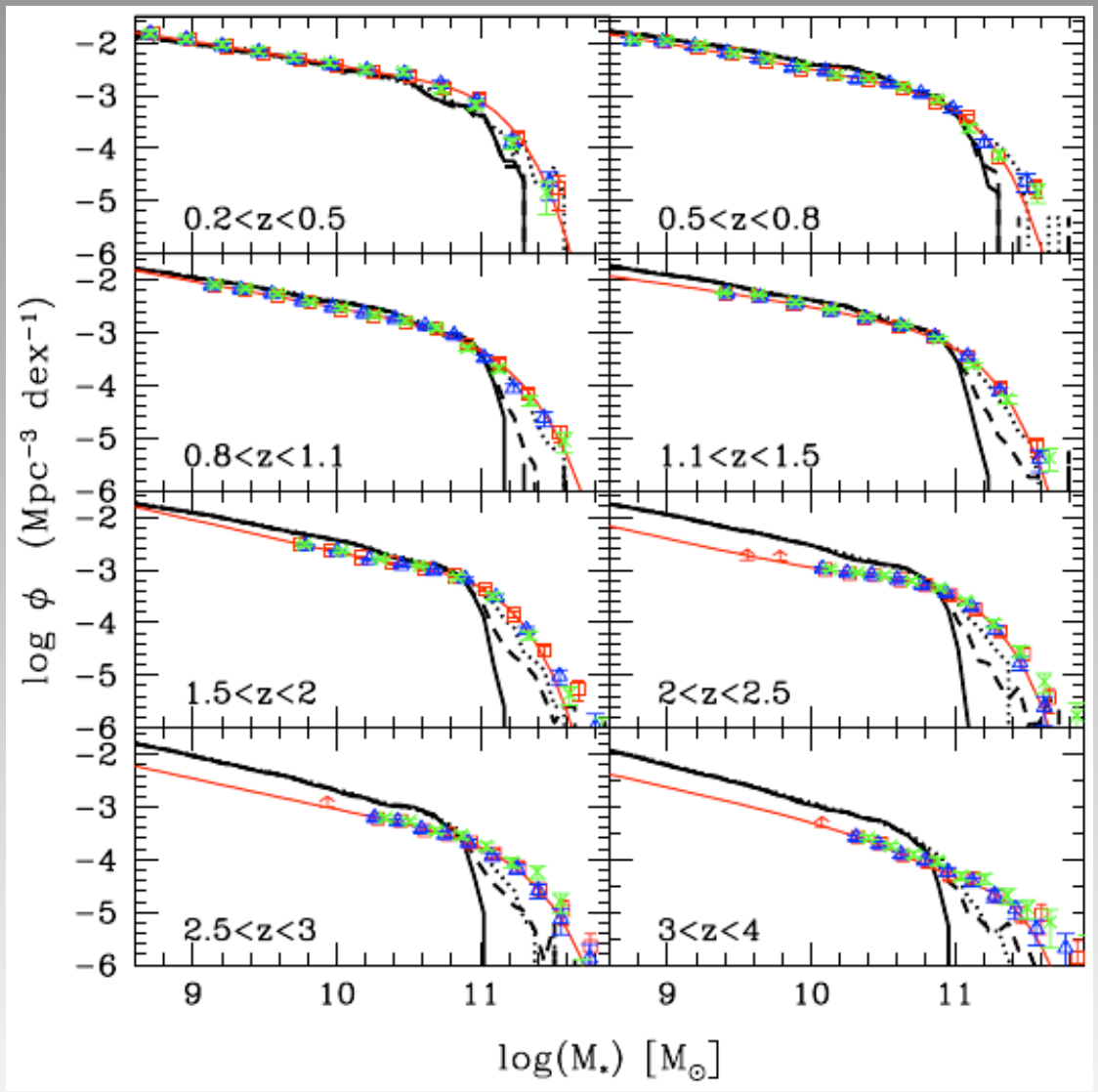
➢ talk of Bruno



comparison with semi-analytical models for star-forming galaxies

Right slope

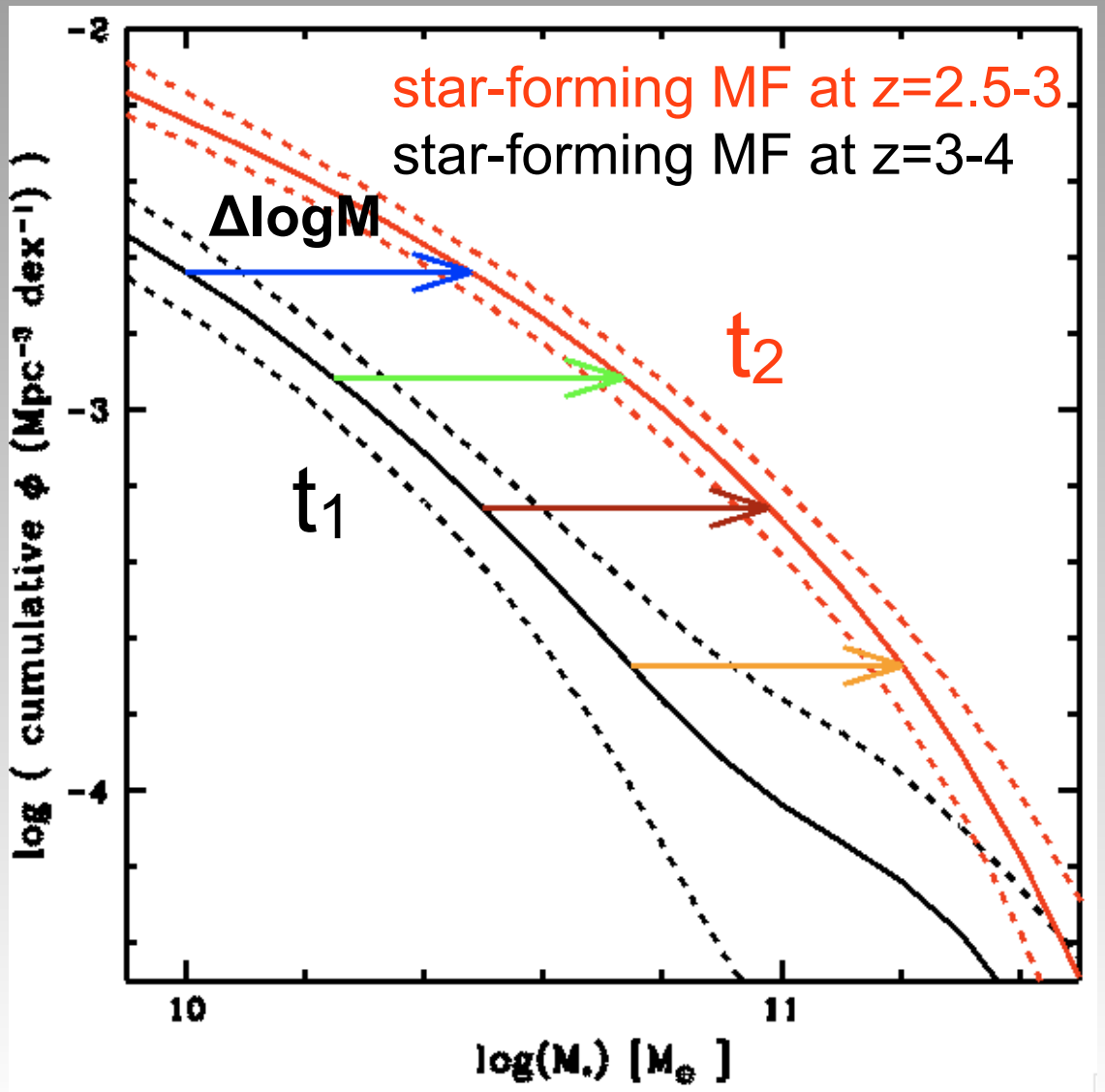
➢ seems to work for log(M)<10.5 star-forming



Infer the specific SFR from the star-forming MF evolution

Evolution of the star-forming MF

$\Delta \log M \propto \log(1+sSFR*\delta t)$

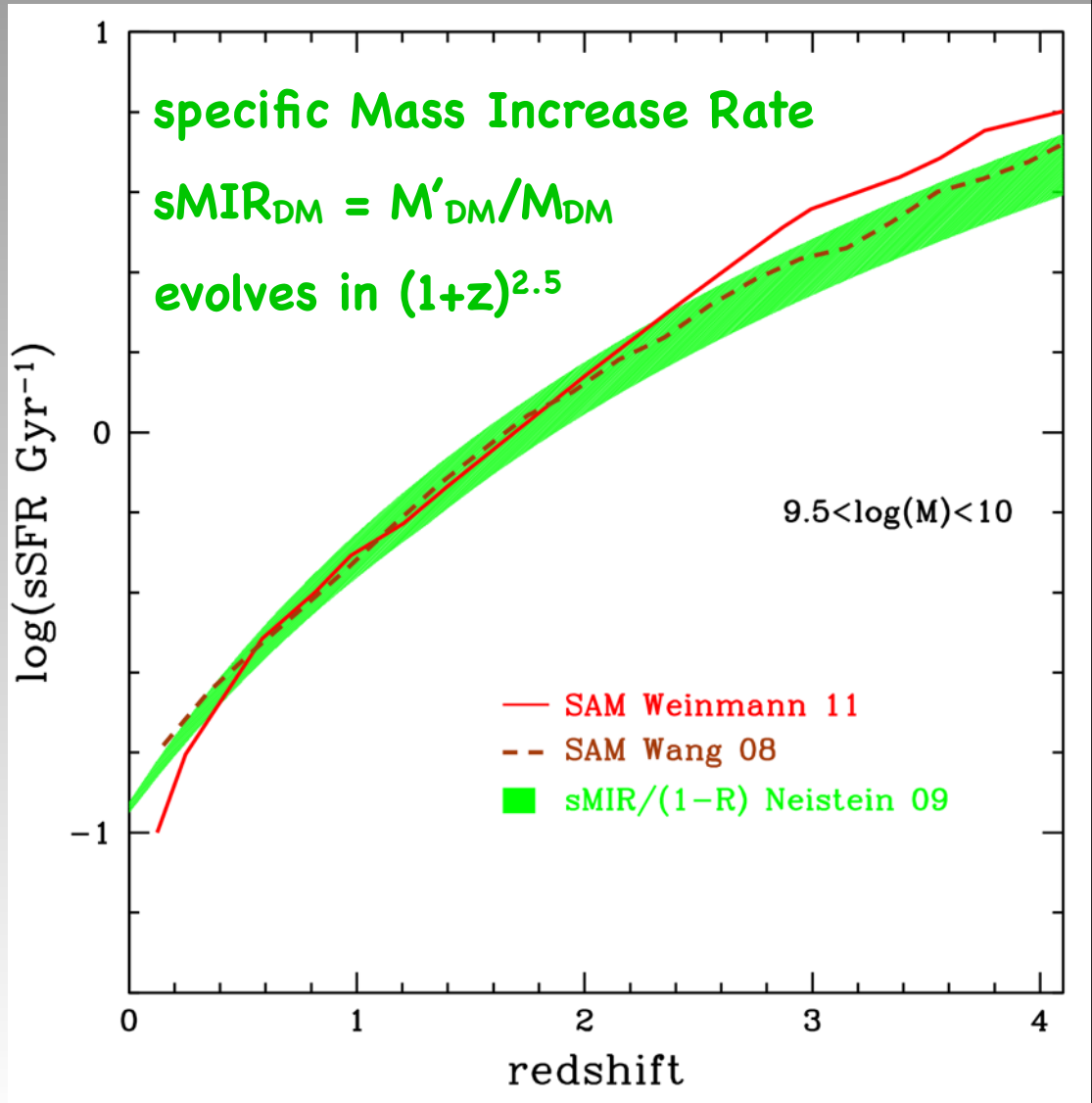


Evolution of the sSFR and link with the cosmological accretion rate

If a constant fraction of baryons converted in old ☆

$M'_{DM}/M_{DM} \propto M'_b/M_b \propto SFR/M_\star$

sSFR follows the $sMIR_{DM}$ in most models despite the complexity of the involved processes



Evolution of the sSFR z<1.5

Tension increases with mass

Flat evolution in the model, not seen in data for the most massive galaxies

➢ complexity of the SFHs and quenching processes increases with mass