Star Formation, Metallicity and Stellar Mass

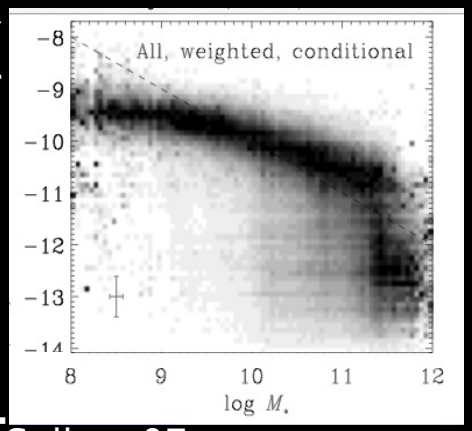
scaling relationships for galaxies provide (blunt) tools for understanding star formation and galaxy evolution

what are the physical processes that set the relations?
what are the (smaller scale) physical processes that are irrelevant?

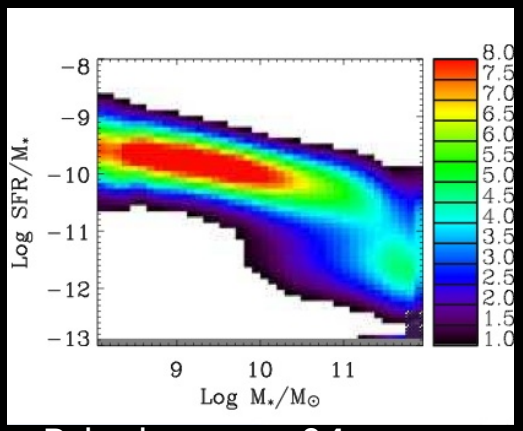
alternately,
what are the model ingredients that the relations constrain/do not constrain.

The Local Star Formation "Sequence"

"Specific SFR" SFR/M*

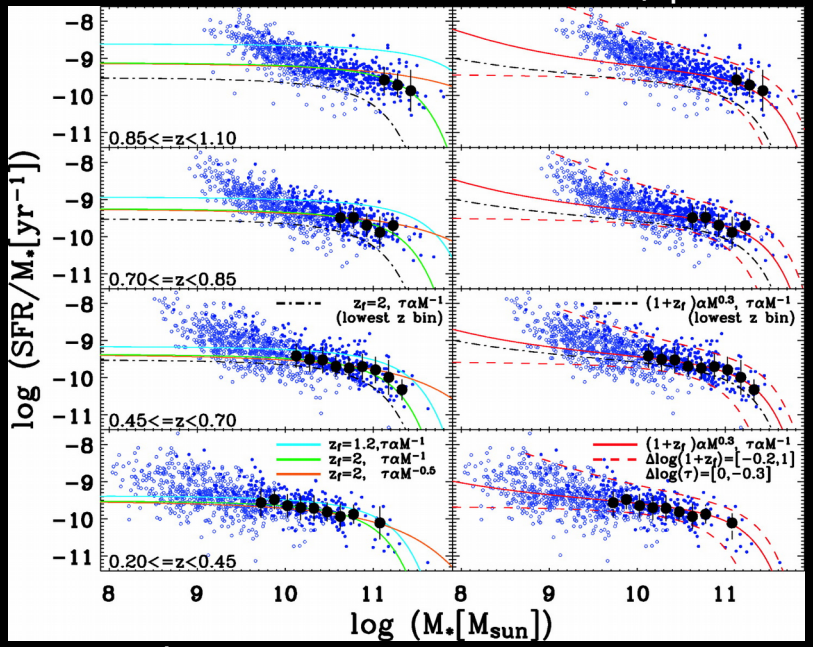


Salim+07
GALEX + SDSS



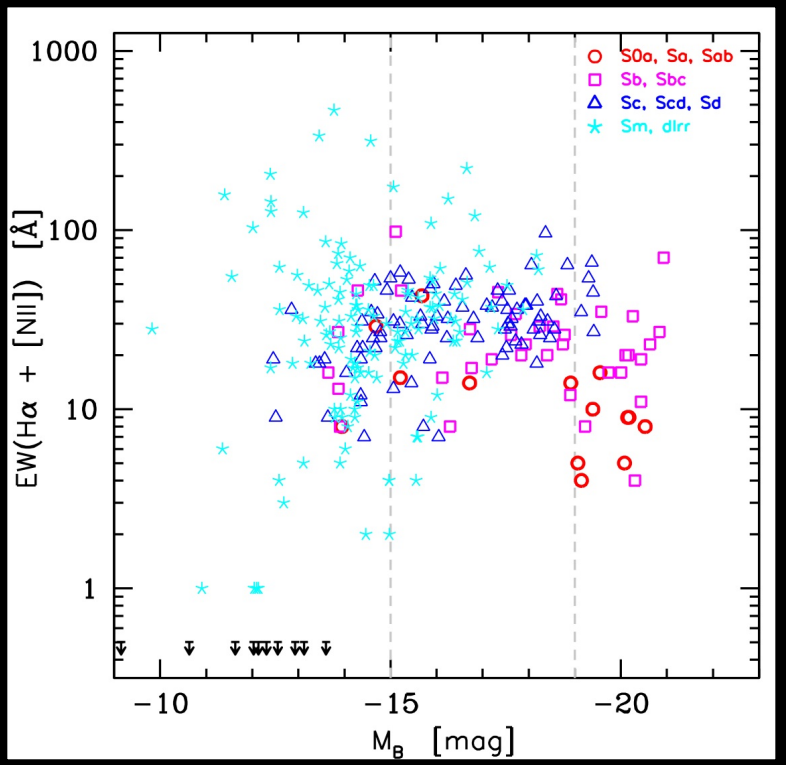
Brinchmann+04
SDSS Hα (spectroscopy)

"Specific SFR" SFR/M*



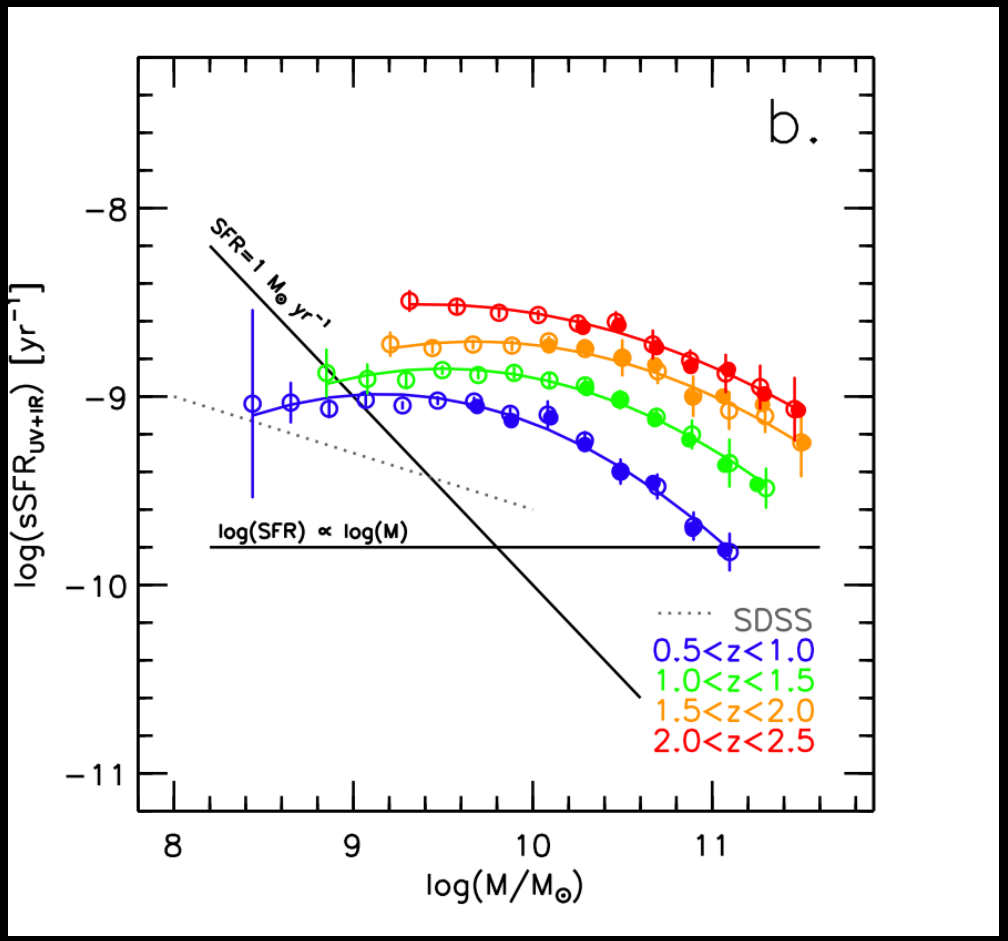
Noeske+07
AEGIS (DEEP2, optical spectra, 24 micron)

a galaxy SED...



J.C. Lee et al. 2007, 2009b
11 Mpc Hα imaging

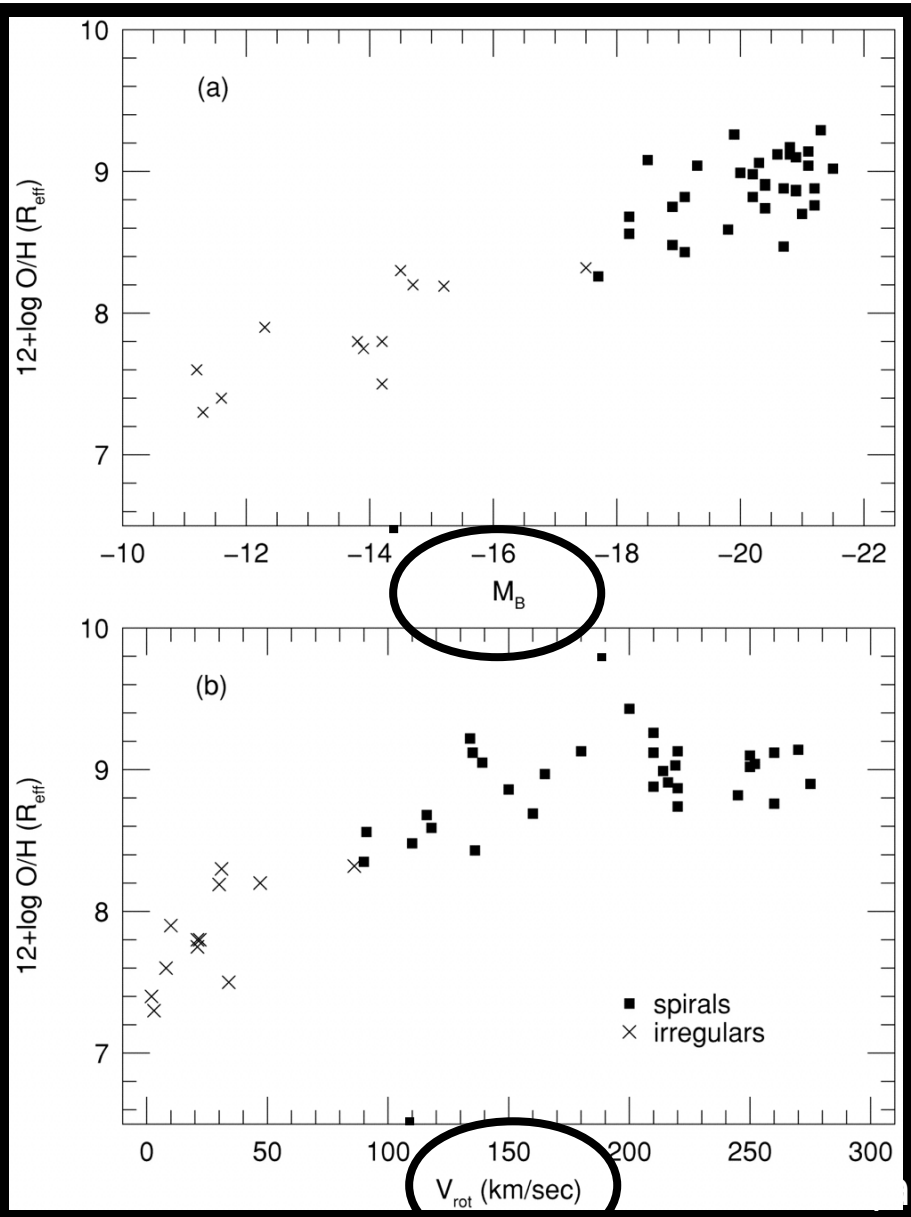
Evolution in the Star Formation Sequence



a galaxy SED...

Whitaker et al. (2014)

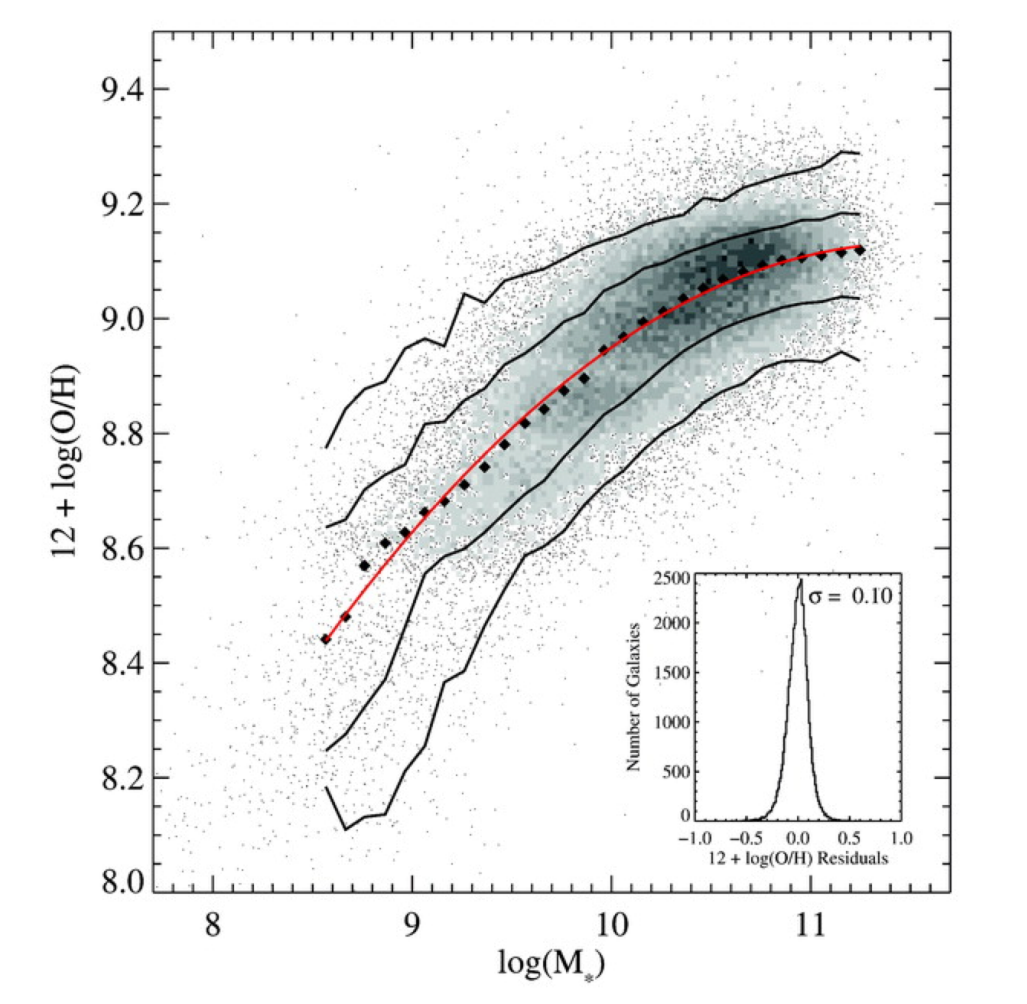
The Local Stellar Mass – Gas Metallicity Relation



a galaxy SED...

Garnett et al. 2002
(also Lequeux et al. 1979)

The Local Stellar Mass – Gas Metallicity Relation

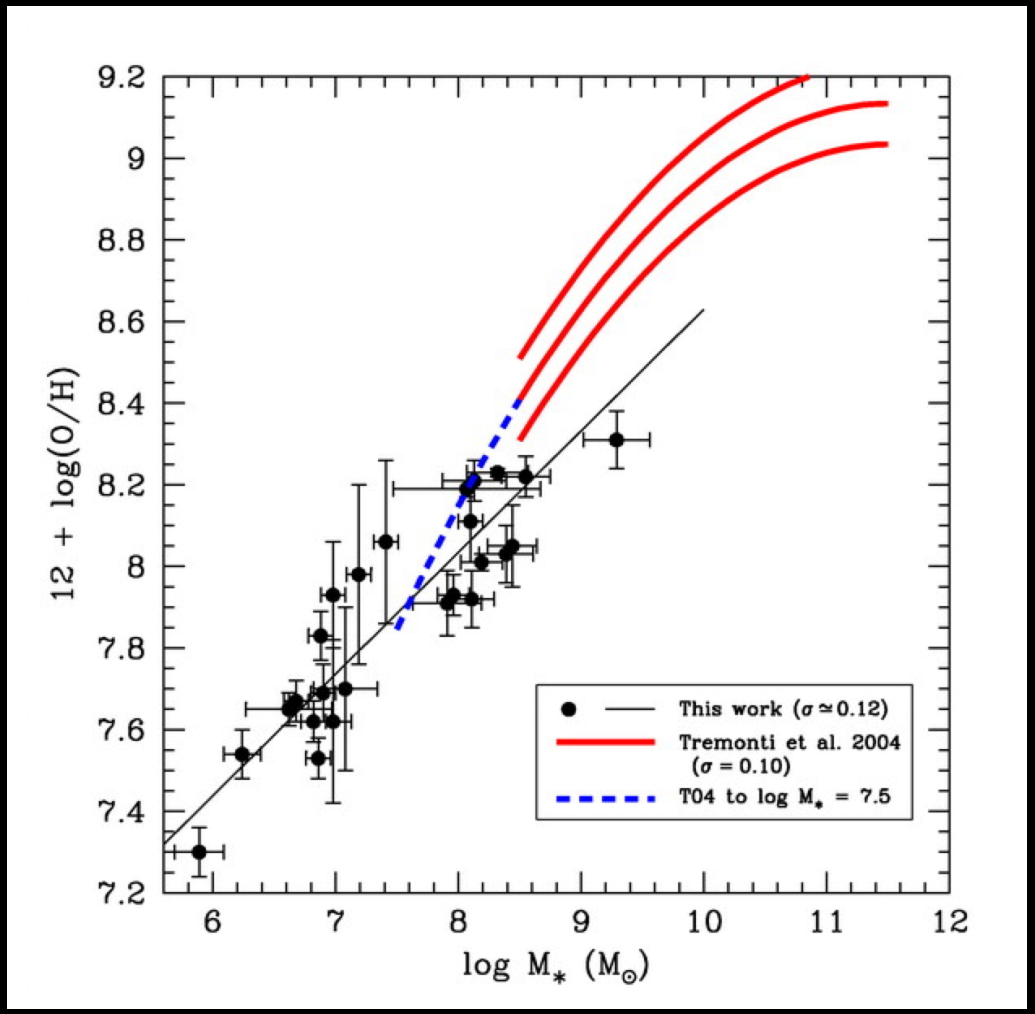


a galaxy SED...

Increase statistics and use stellar masses from SED fitting.

Tremonti et al. 2004
~50,000 SDSS galaxies

The Local Stellar Mass – Gas Metallicity Relation

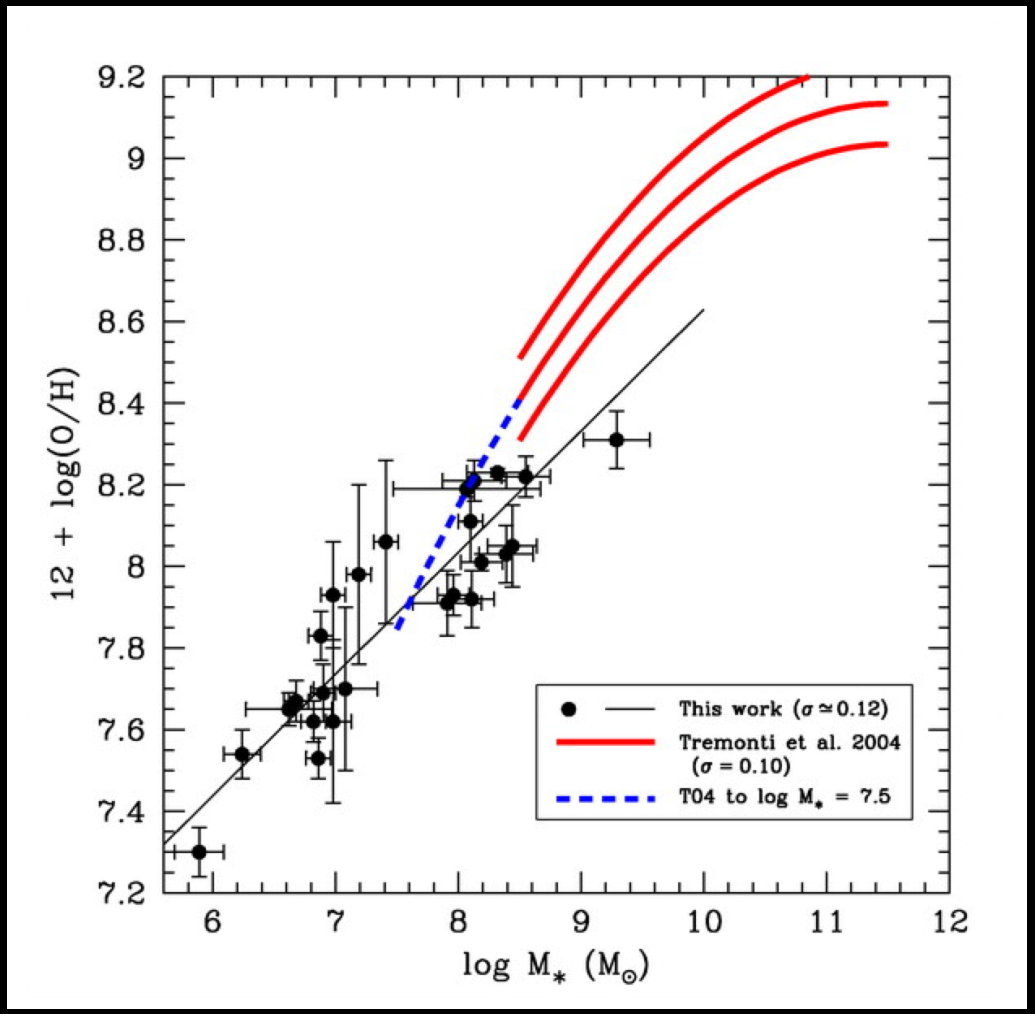


a galaxy SED...

Extension to lower masses.

H. Lee et al. 2006
+
Tremonti et al. 2004

The Local Stellar Mass – Gas Metallicity Relation



a galaxy SED...

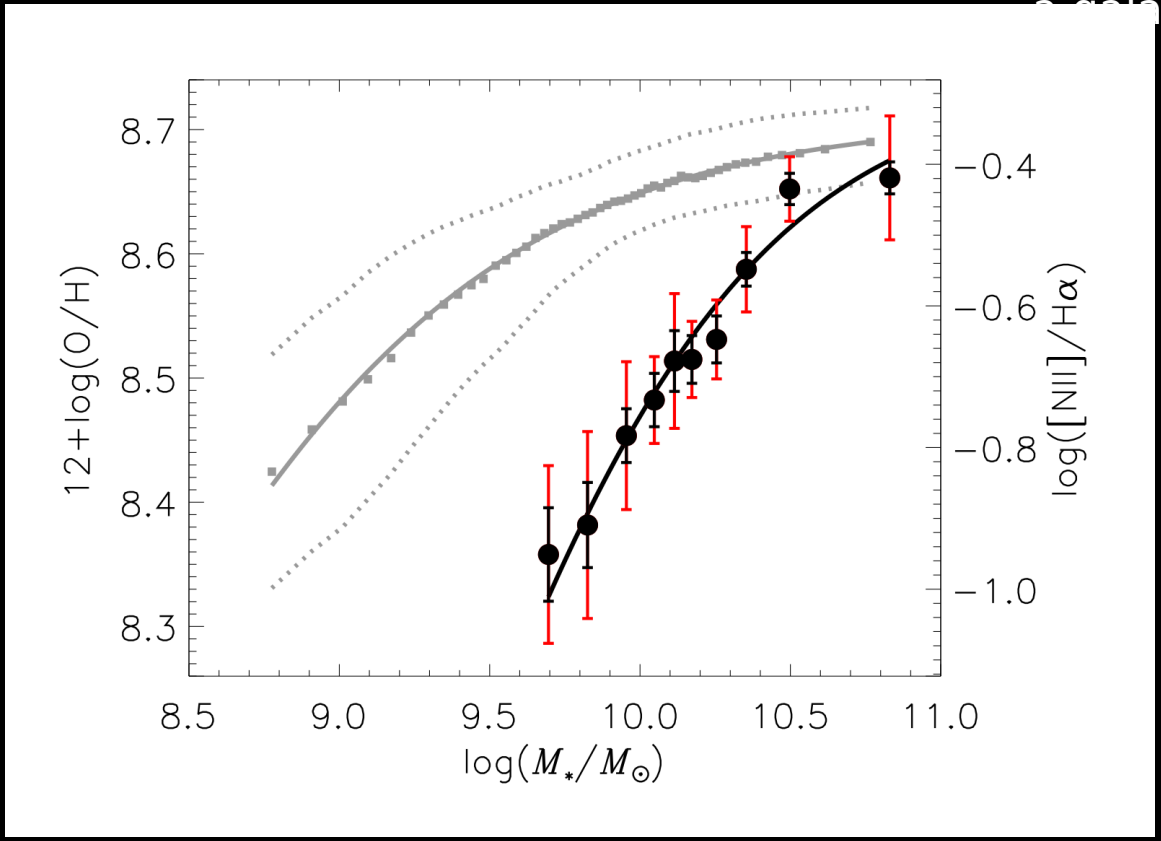
Extension to lower masses.

Messiness with metallicity indicators as with SFR indicators
-> maybe later

H. Lee et al. 2006
+
Tremonti et al. 2004

Evolution of the Stellar Mass – Gas Metallicity Relation

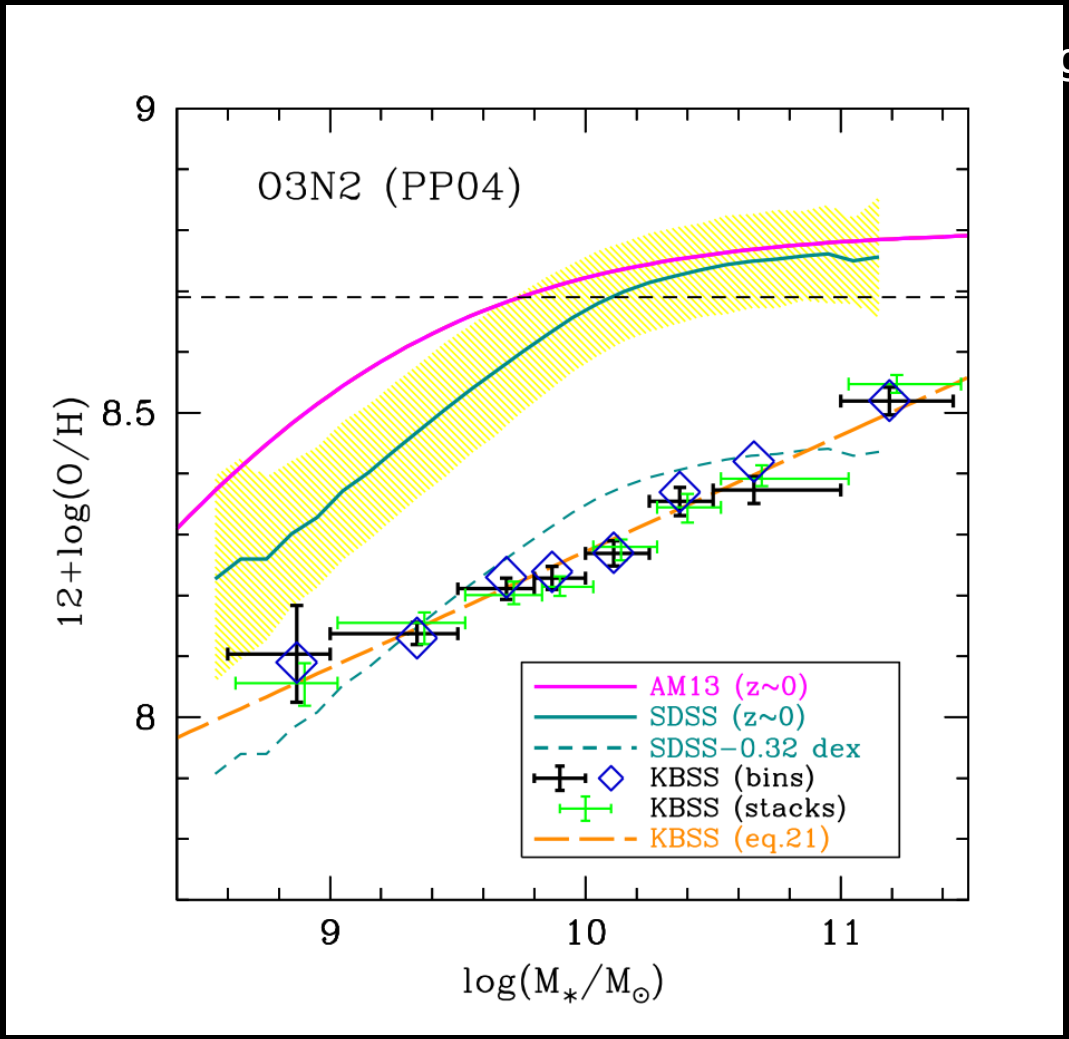
a galaxy SED...



Zahid et al. 2014; z=1.6

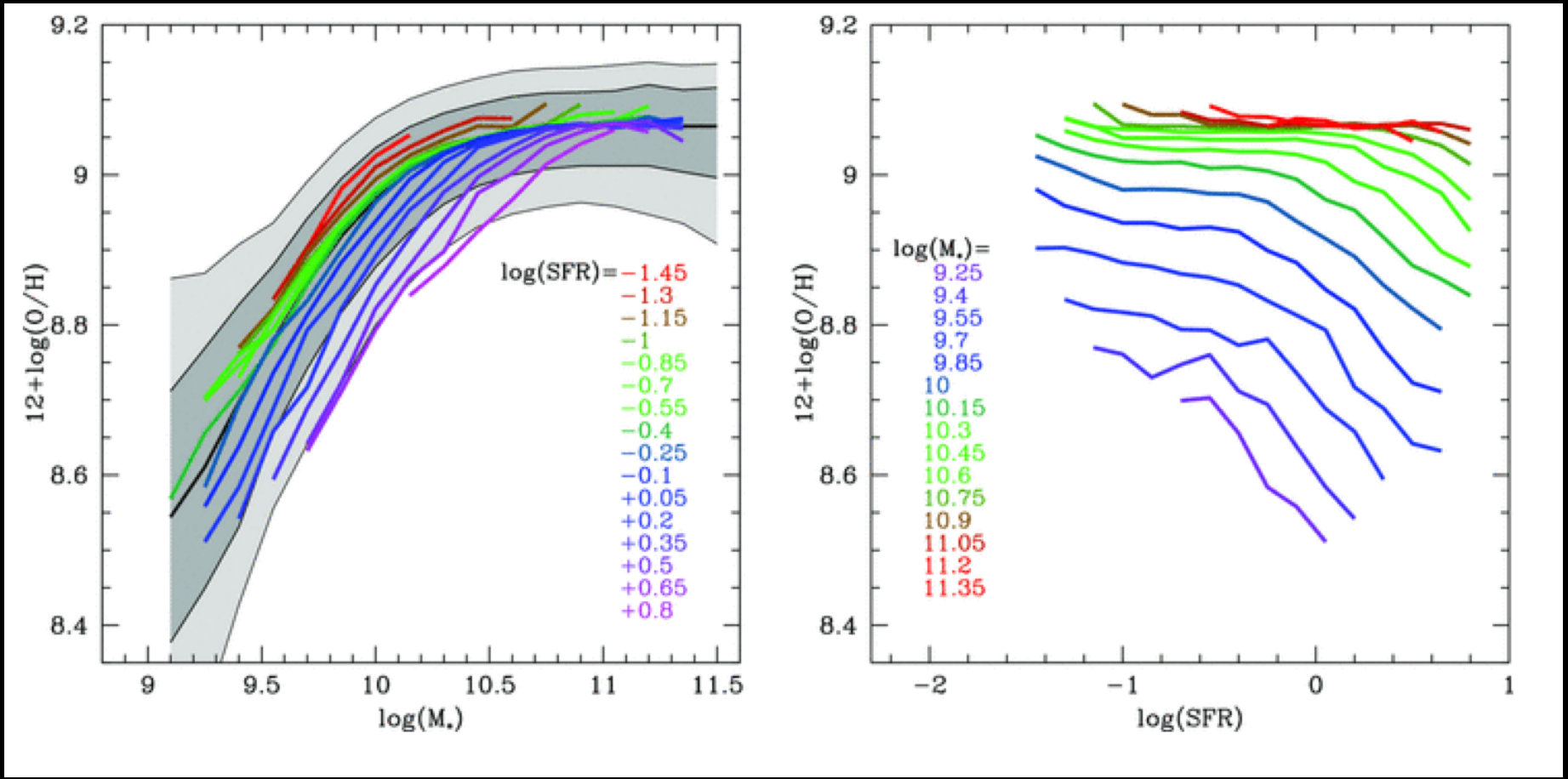
Evolution of the Stellar Mass – Gas Metallicity Relation

galaxy SED...



Steidel et al. 2014; z~2.3

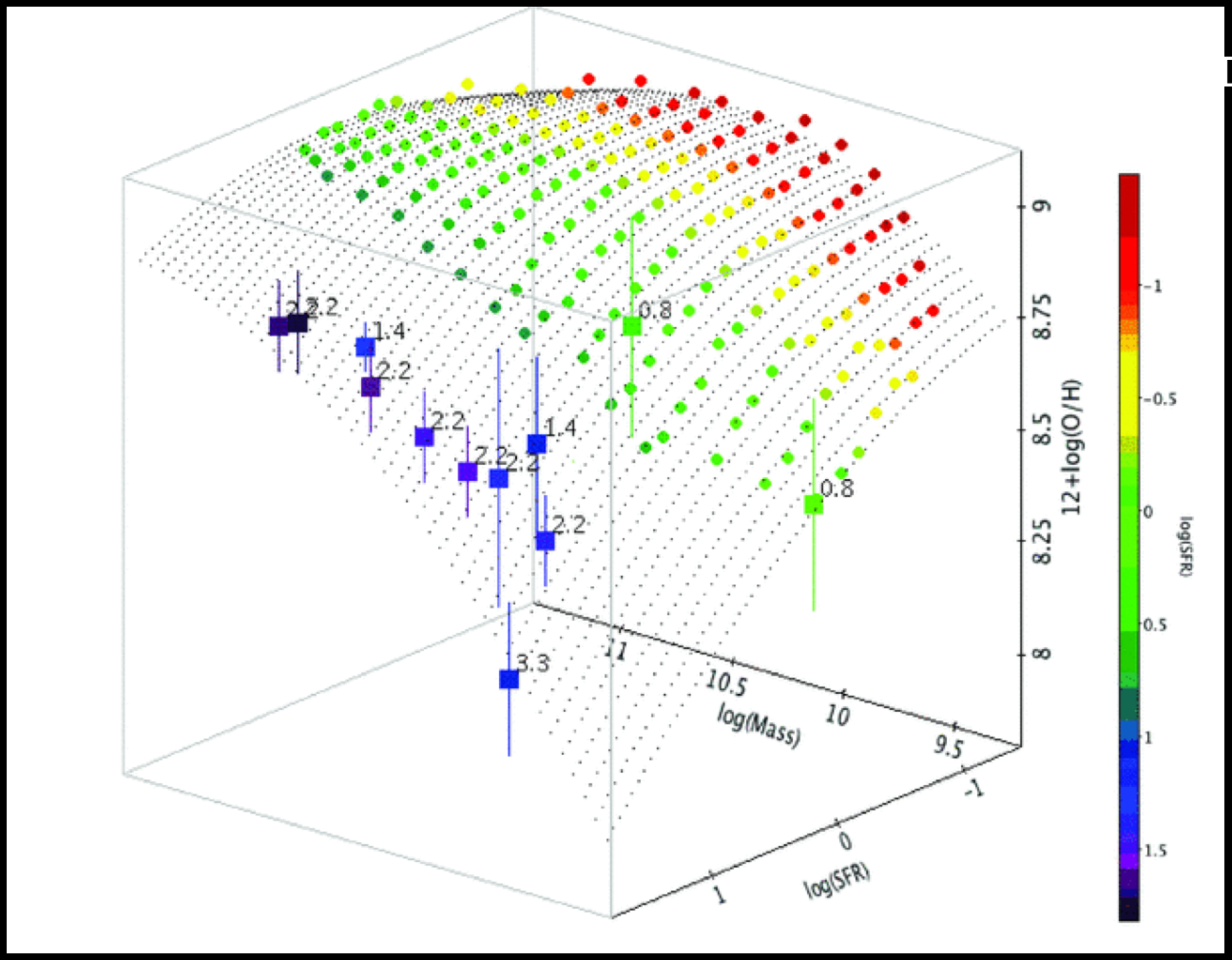
Is there a secondary dependence on SFR?



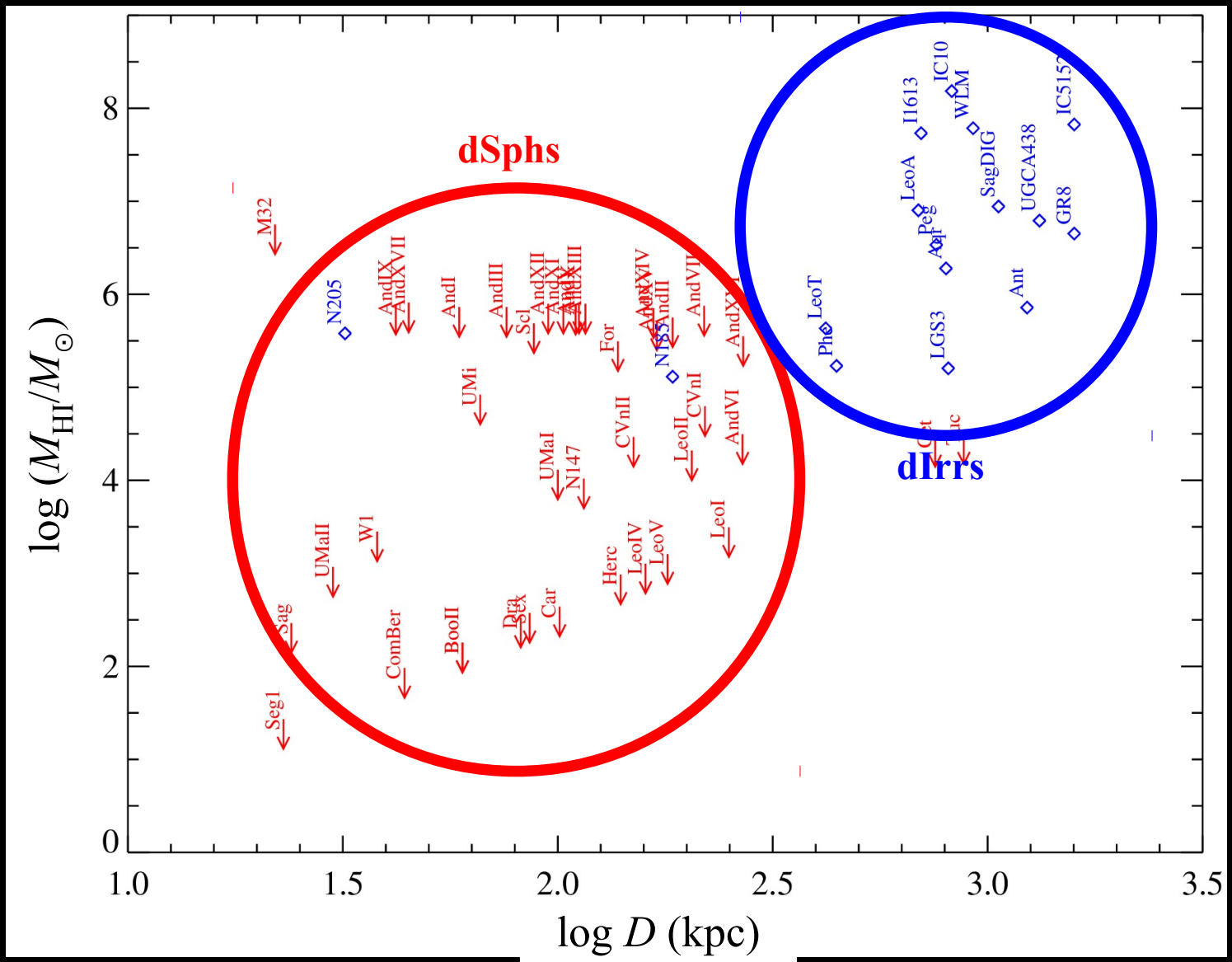
Mannucci et al. 2010; SDSS

Is M-Z-SFR relation "fundamental" invariant with redshift?

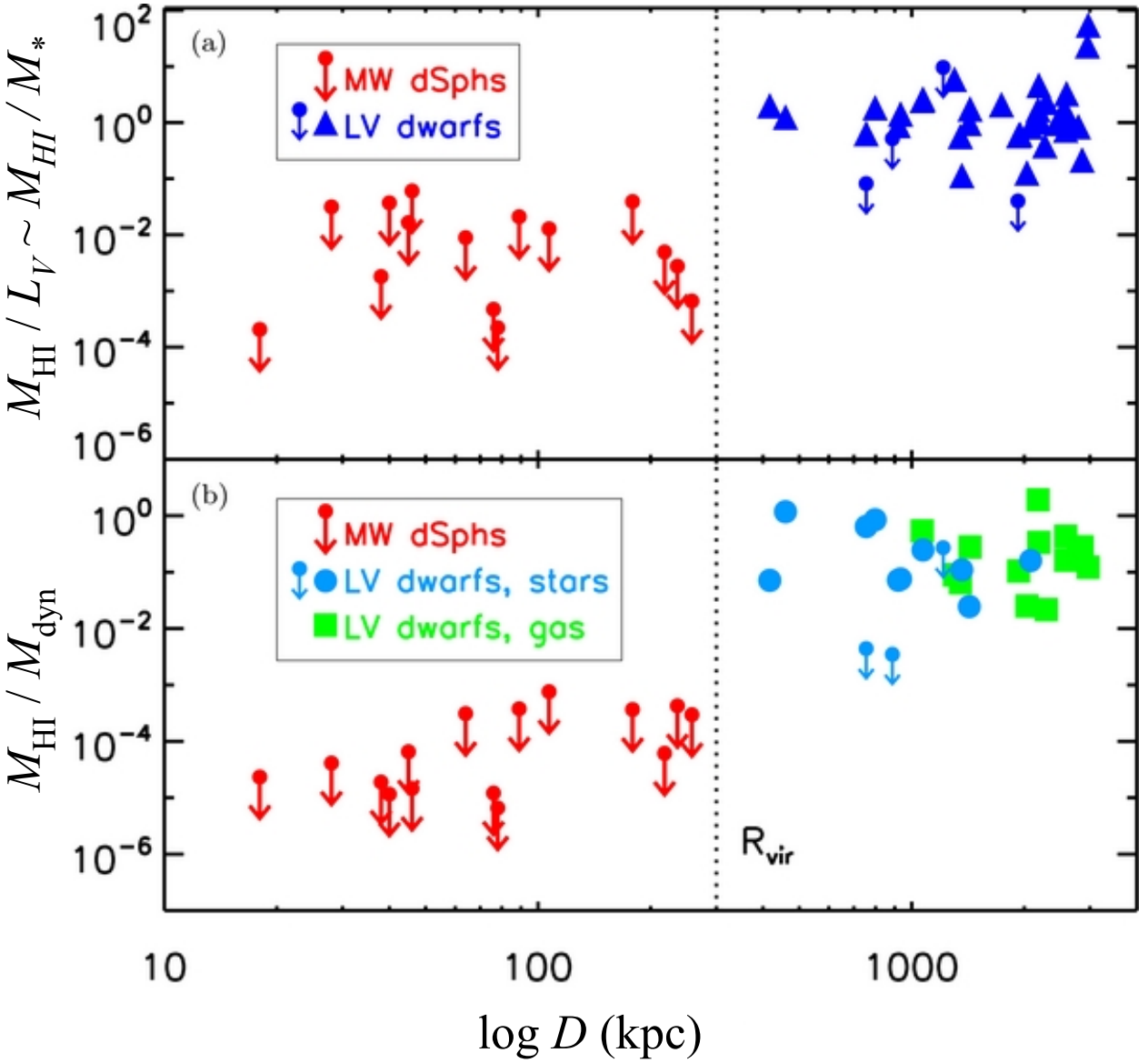
D...



Mannucci et al. 2010; SDSS

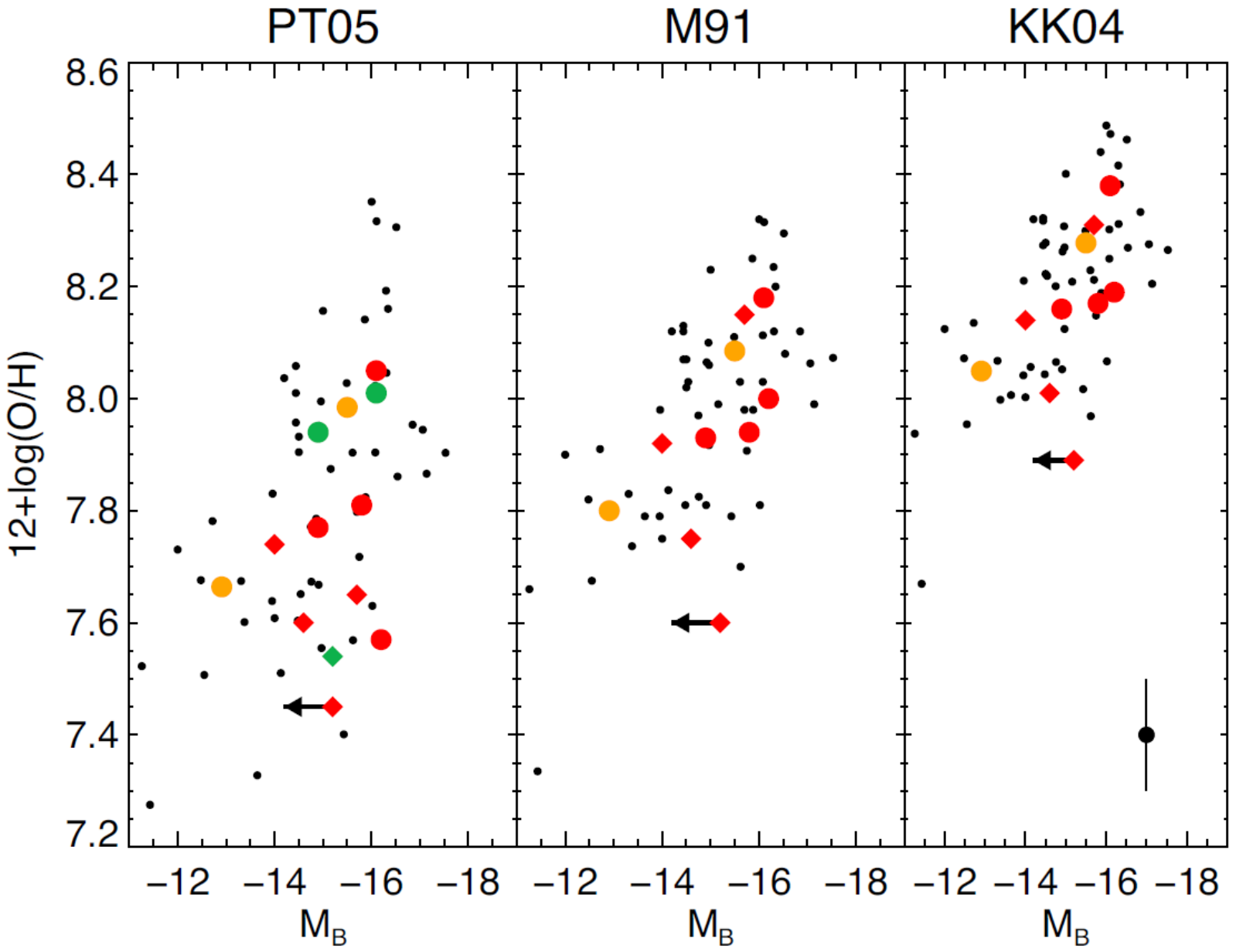

dSphs
dIrrs
log ($M_{HI}/M_{\odot}$)
log D (kpc)
0
2
4
6
8
1.0
1.5
2.0
2.5
3.0
3.5
M32
N205
AndIX
AndXVII
AndI
AndIII
Scl
AndXII
AndXI
AndXIII
For
AndXIV
AndII
AndVII
AndX
N185
UMi
CVnI
CVnII
LeoII
AndVI
UMaI
N147
LeoI
UMaII
W1
Herc
LeoIV
LeoV
Sag
Dra
Sex
Car
ComBer
BooII
Seg1
IC10
I1613
WLM
LeoA
SagDIG
IC5152
Peg
UGCA438
GR8
Ant
LeoT
Phe
LGS3

Environment: Distance from host



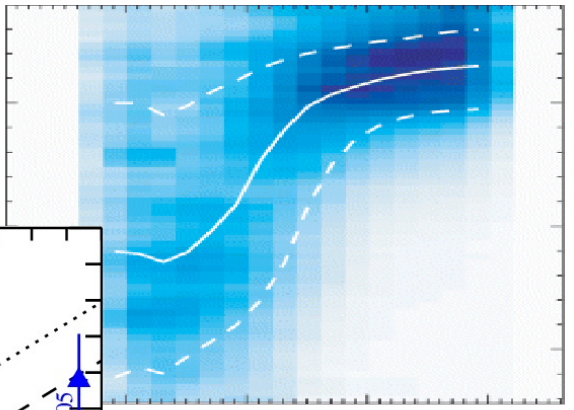
Spekkens et al., 2014, ApJ, 795, 1

Mass-gas metallicity in voids

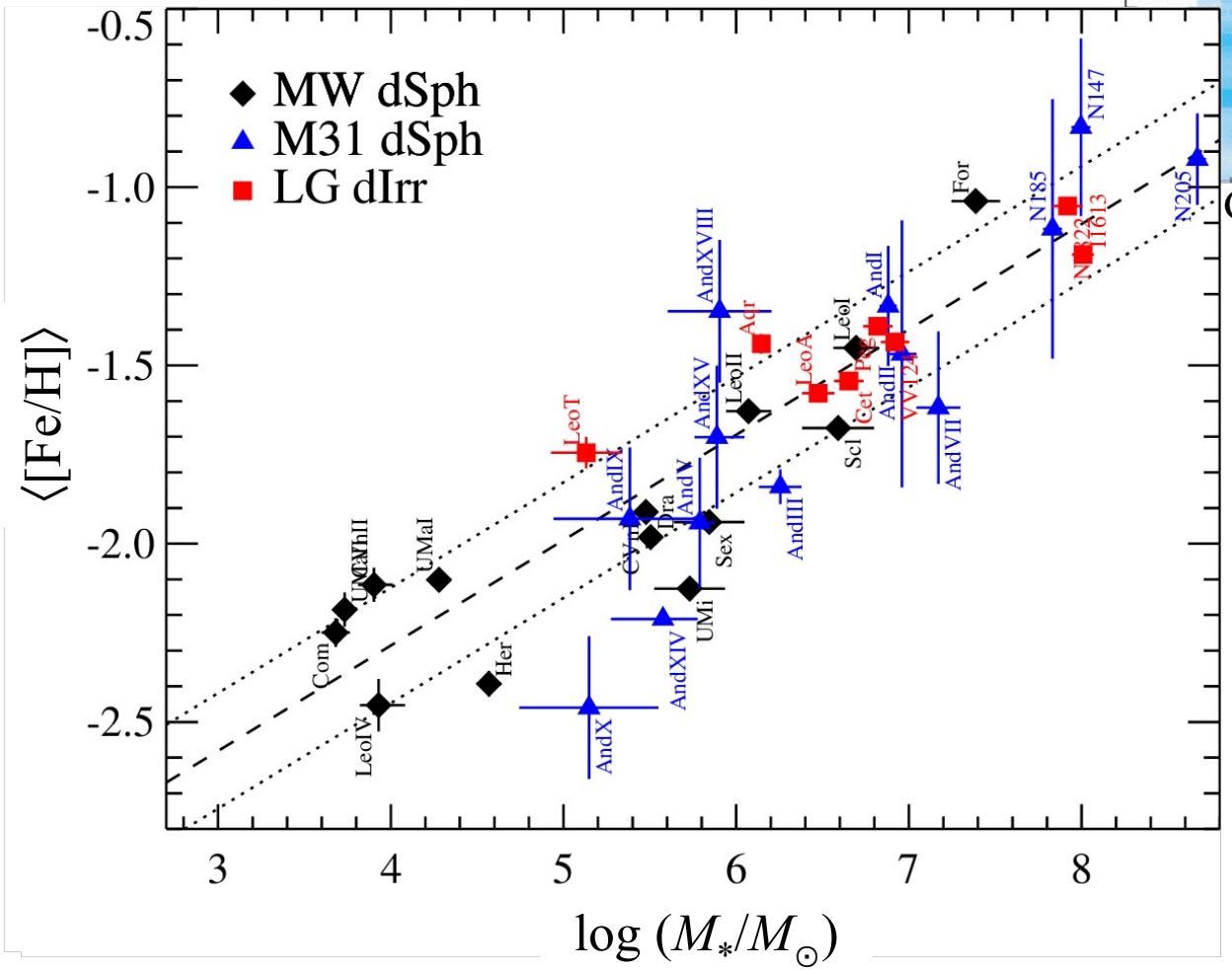


Kreckel et al. 2014, ApJL, submitted, arXiv:1410.5821

Mass-stellar metallicity in Local Group

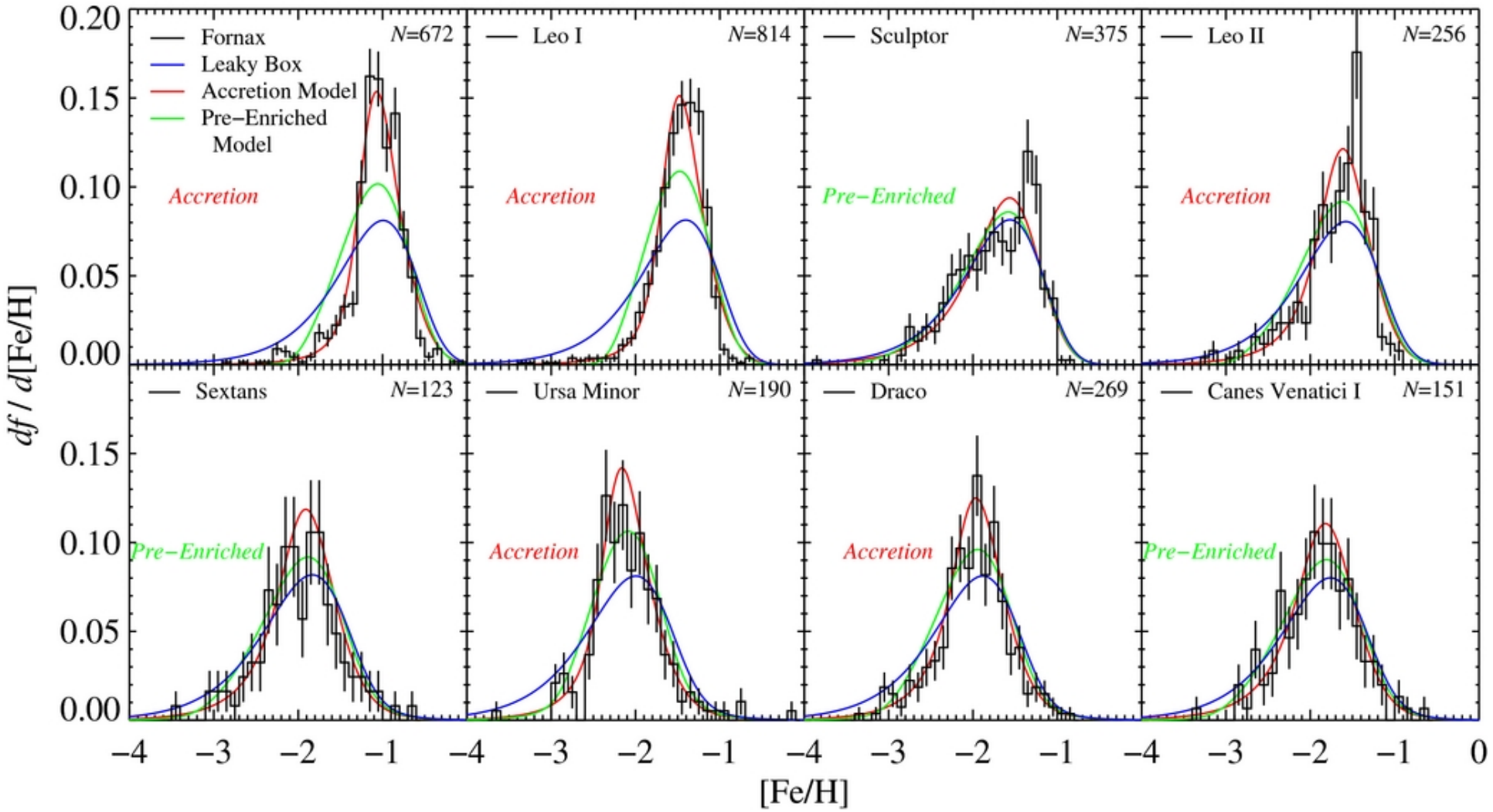


Gallazzi et al. 2005, MNRAS, 362, 41



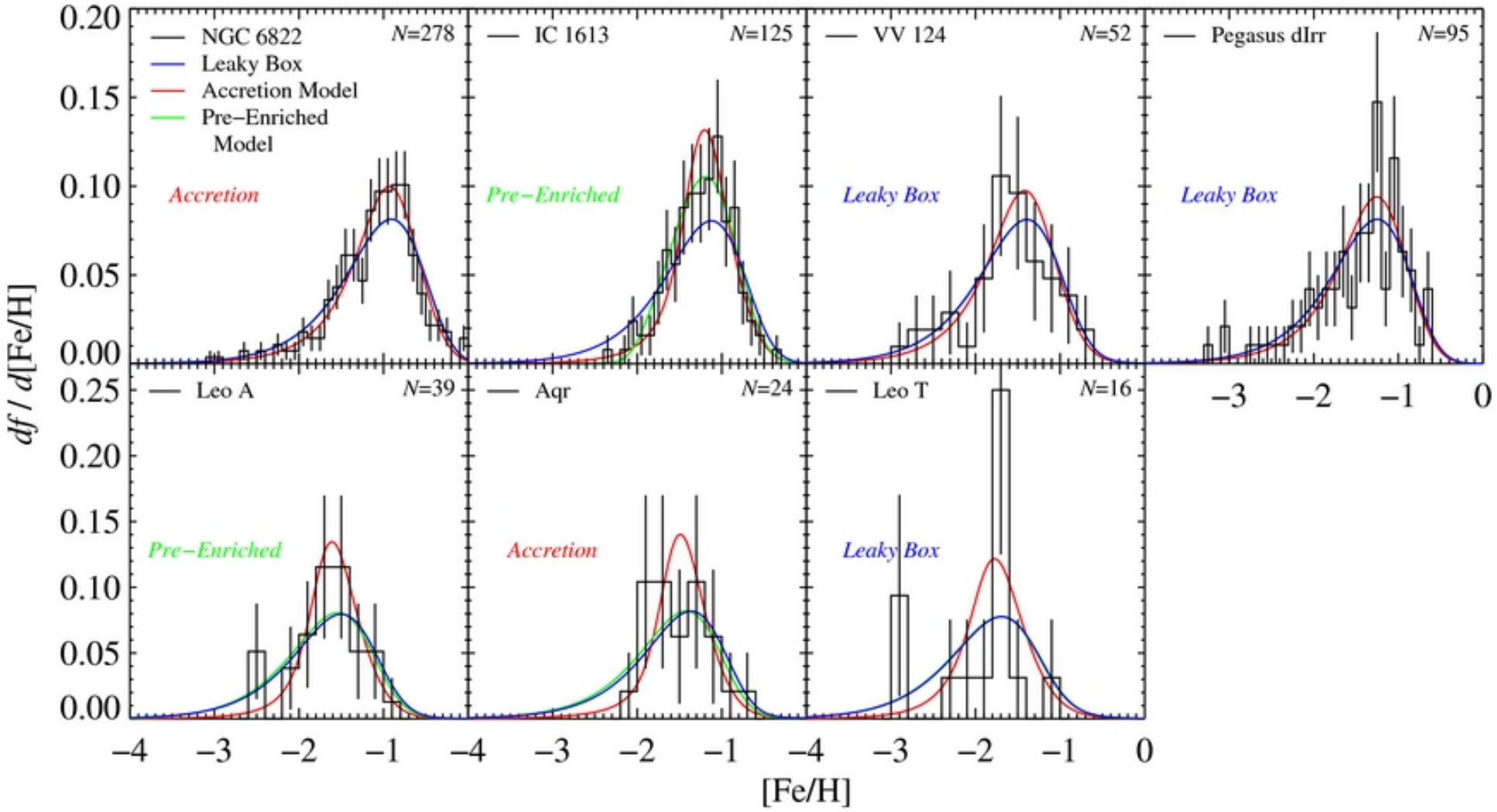
Kirby et al. 2013b, ApJ, 779, 102

Diversity of stellar metallicity distributions



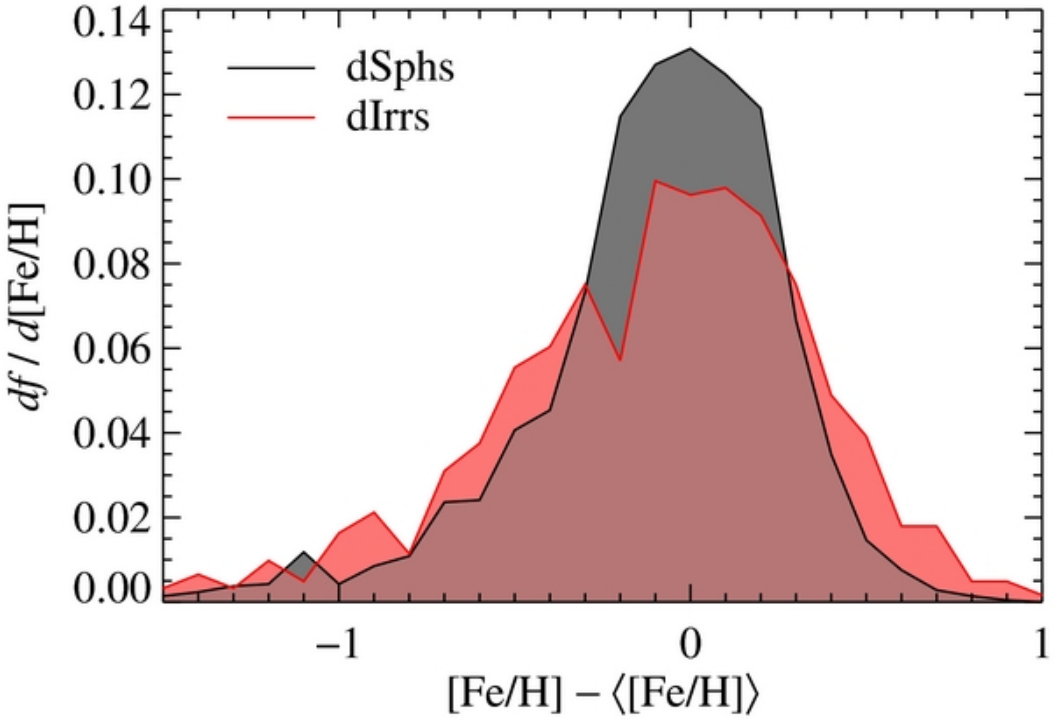
Kirby et al. 2013b, ApJ, 779, 102

Diversity of stellar metallicity distributions



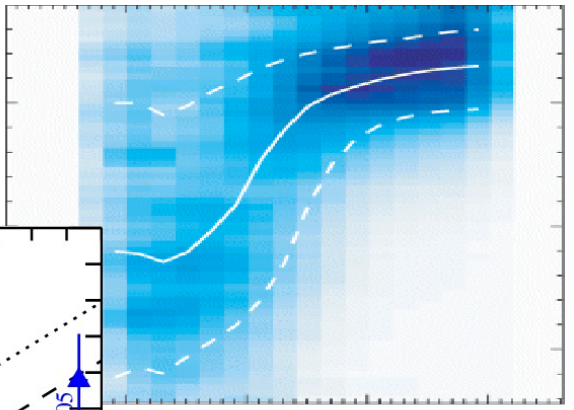
Kirby et al. 2013b, ApJ, 779, 102

Diversity of stellar metallicity distributions

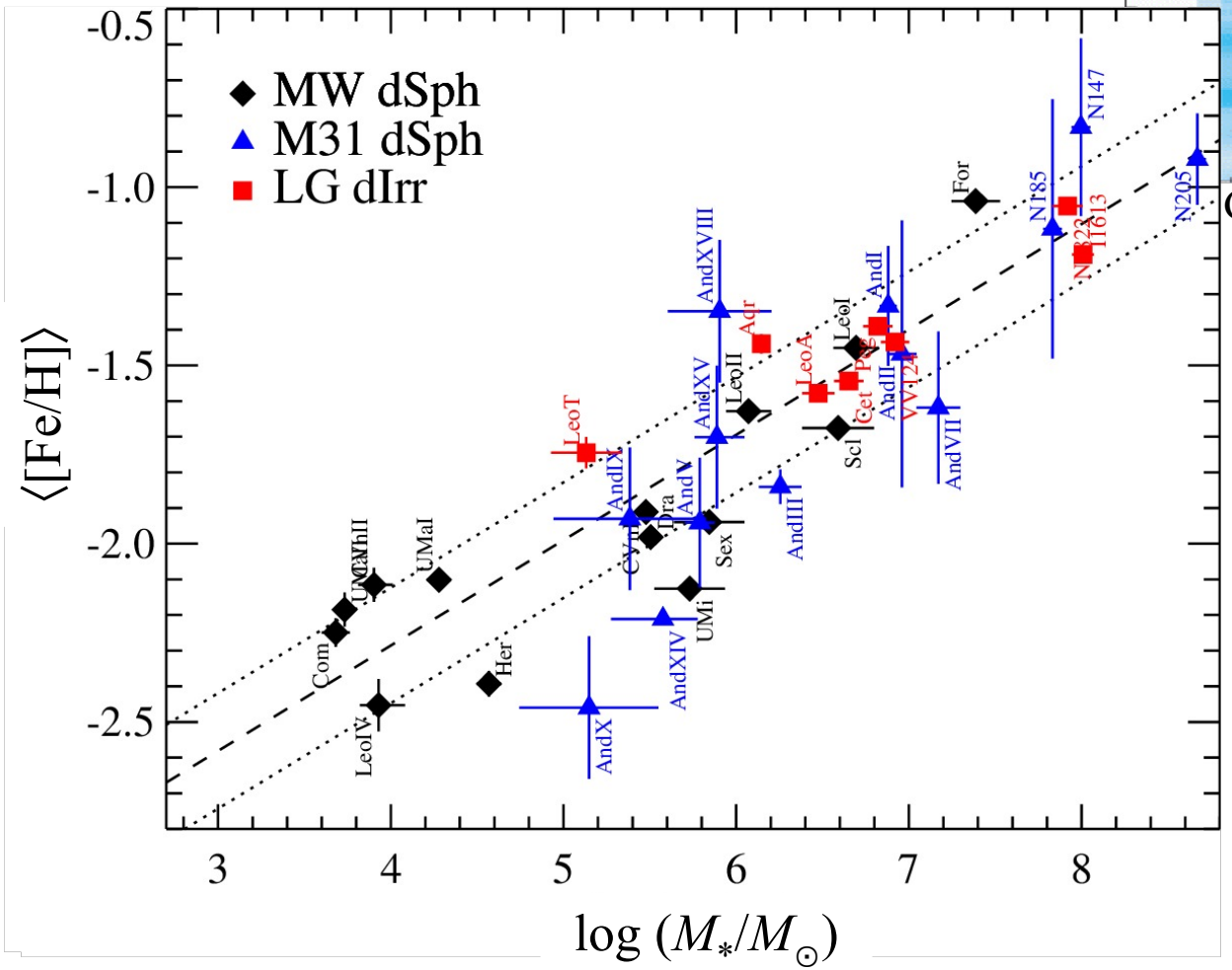


Kirby et al. 2013b, ApJ, 779, 102

Mass-stellar metallicity in Local Group

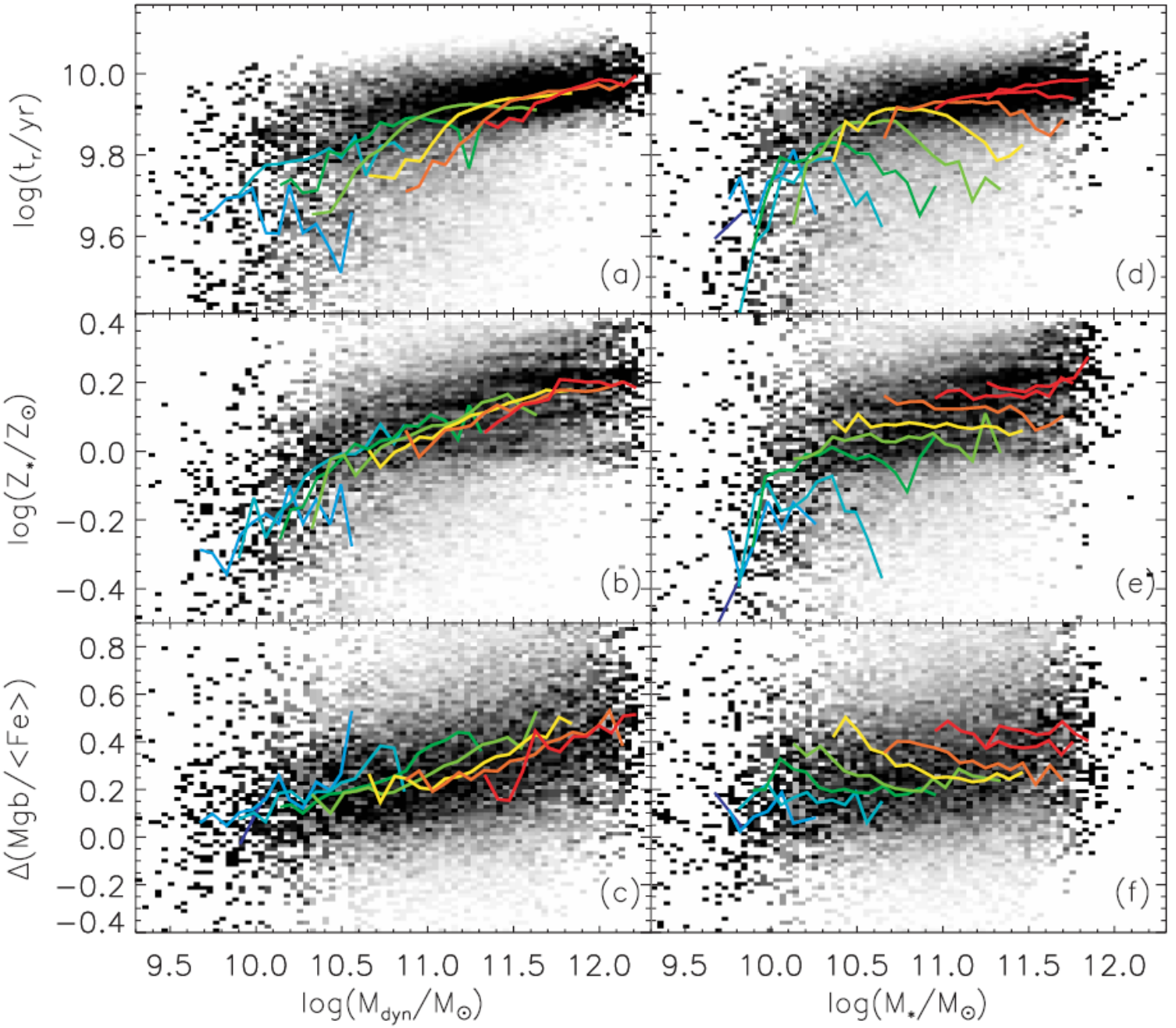


Gallazzi et al. 2005, MNRAS, 362, 41



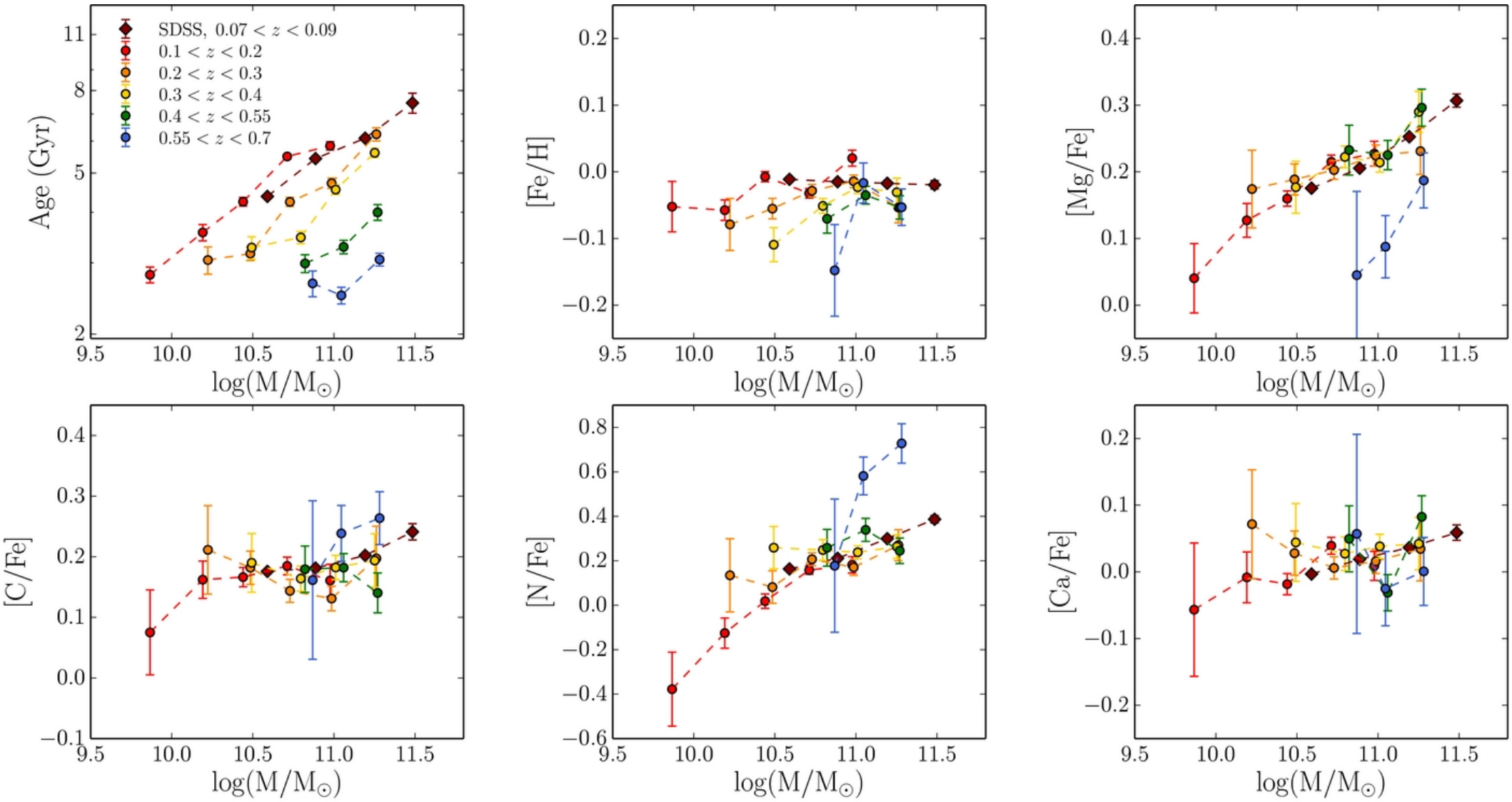
Kirby et al. 2013b, ApJ, 779, 102

Mass-stellar metallicity in SDSS



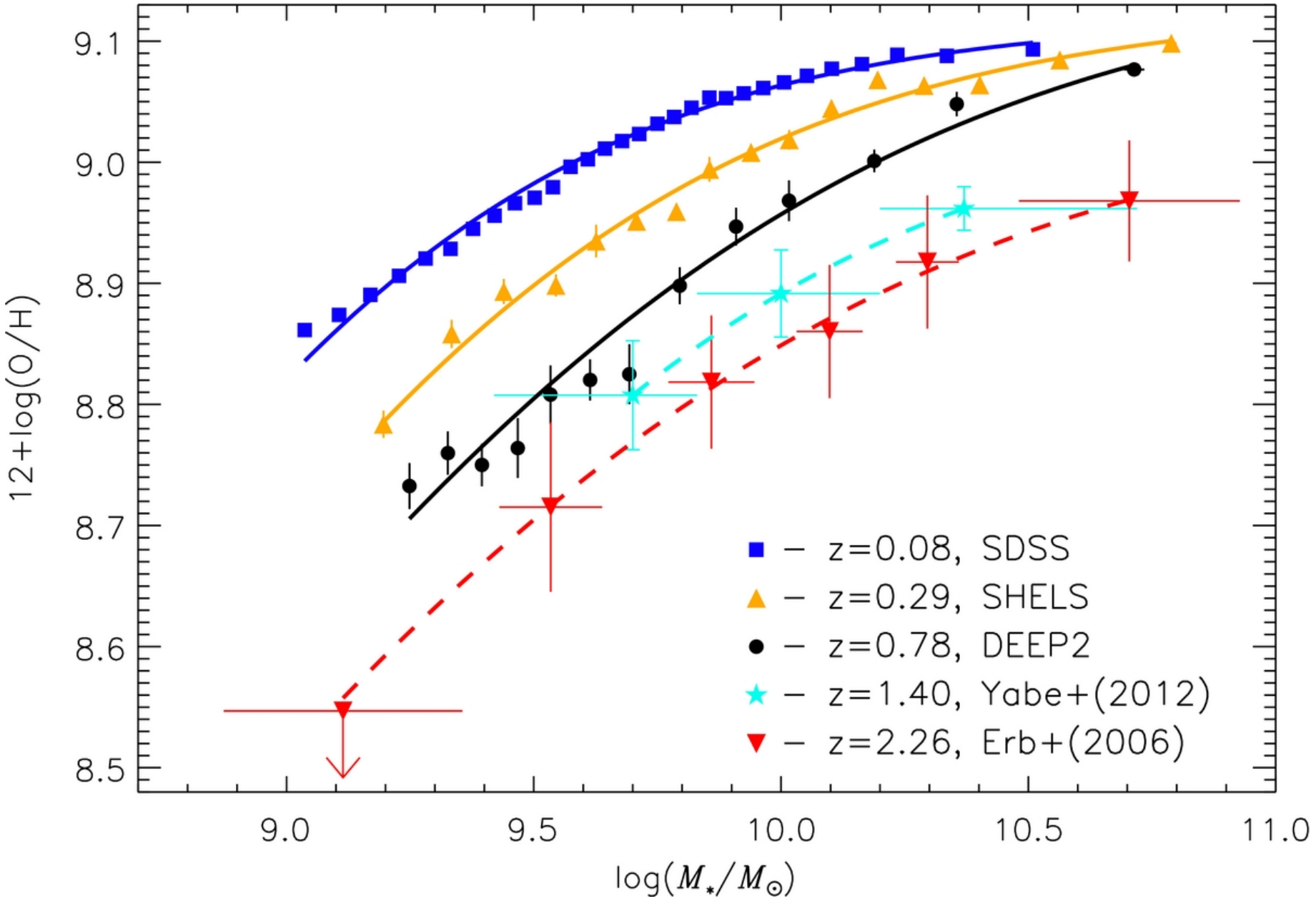
Gallazzi et al. 2006, MNRAS, 370, 1106

Mass-stellar metallicity at $0 < z < 0.7$



Jieun Choi et al. 2014, ApJ, 795, 95

Mass-gas metallicity at $0 < z < 2.3$



Zahid et al. 2013, ApJ, 771, L19 and references therein

Questions

What affects the chemical enrichment of gas on galaxy scales?

- chemical “feedback” from star formation
- Gas removal
- feedback propelled winds
- ram pressure stripping
- Gas accretion
- inflow from IGM
- accretion of previously expelled gas
- accretion from gas-rich mergers

What causes the stellar mass-metallicity relations?
Do we expect the stellar mass- gas metallicity to evolve with time?
Should we expect SFR to be a second parameter?
Should the M-Z-SFR relation be invariant with time?