Cold-Mode Accretion: The Cause of the Fundamental Mass Metallicity Relation at z=2

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ZFIRE

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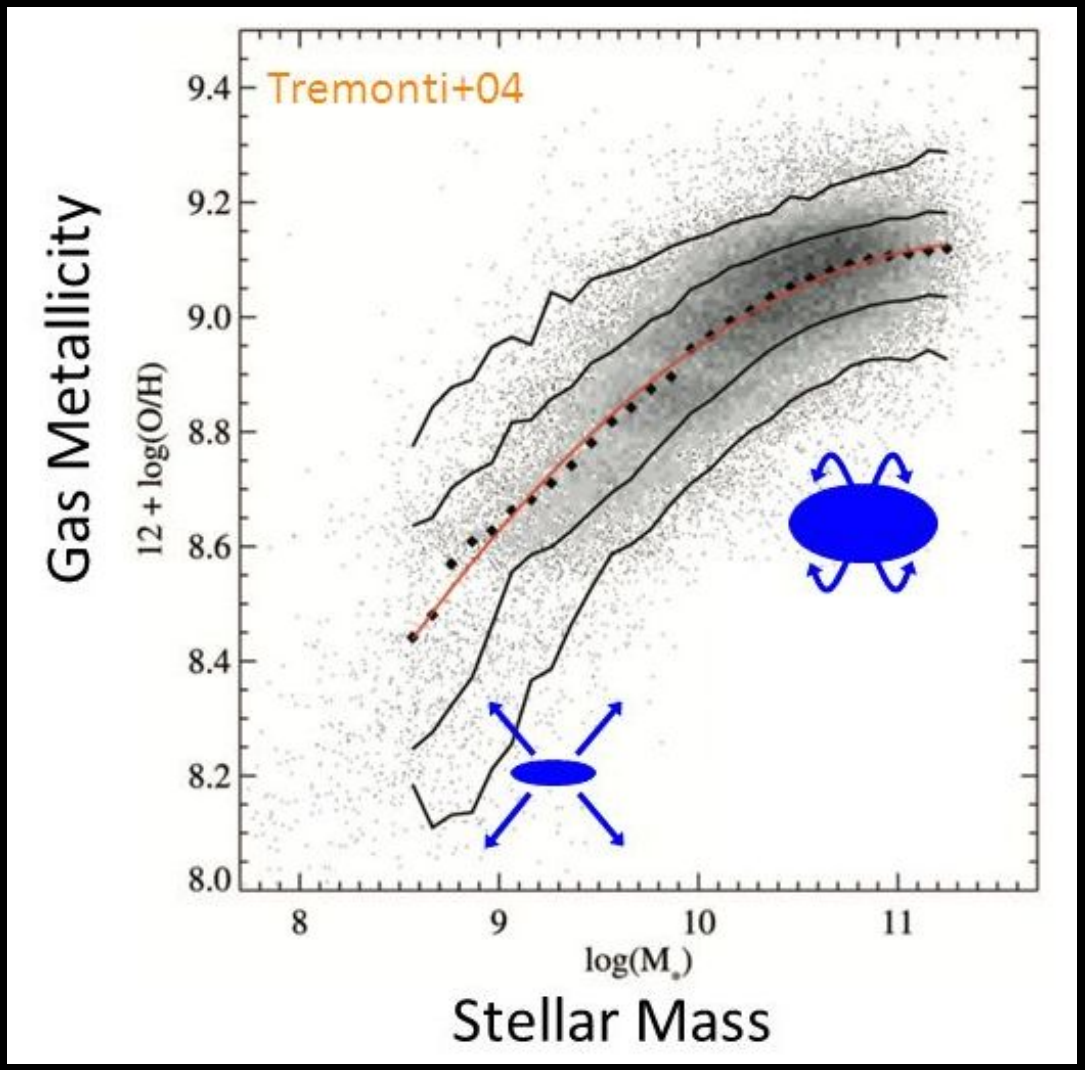
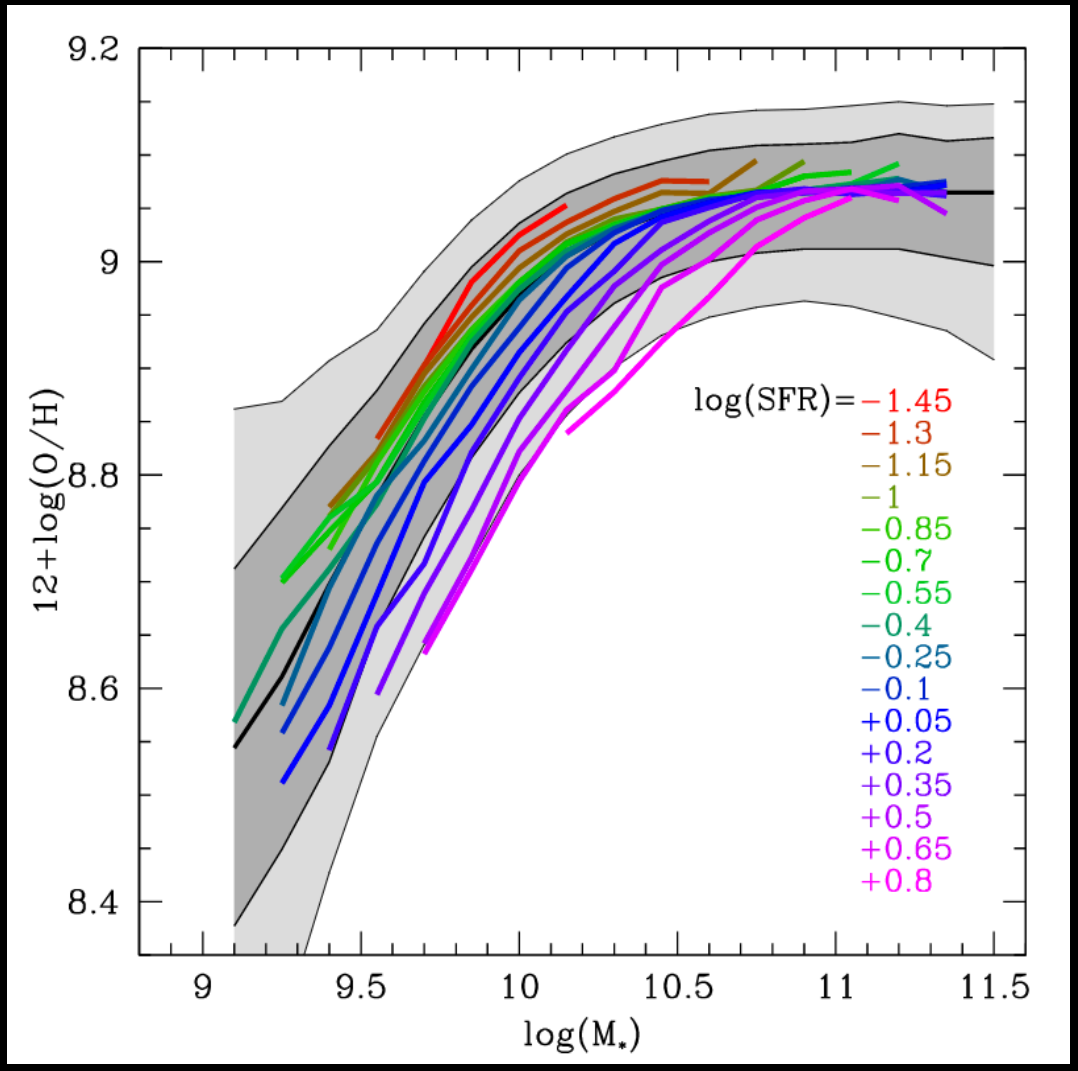
Empirical Relation - Mass-Metallicity



Empirical Relation – Fundamental Mass-Metallicity

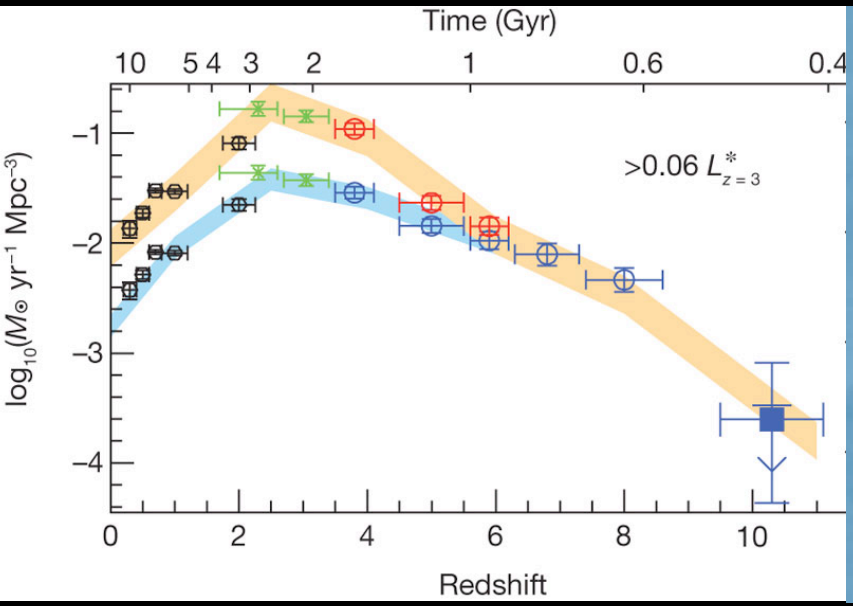


Mannucci et al. 2010 (see Ellison+08, Lara-López+10; Yates+12, Zahid+13)

interplay of pristine gas accretion (dominating at high z)
+
Enriched outflows (dominating at low z)

Can we test the accretion scenario at high z?

Importance of the Circumgalactic Medium

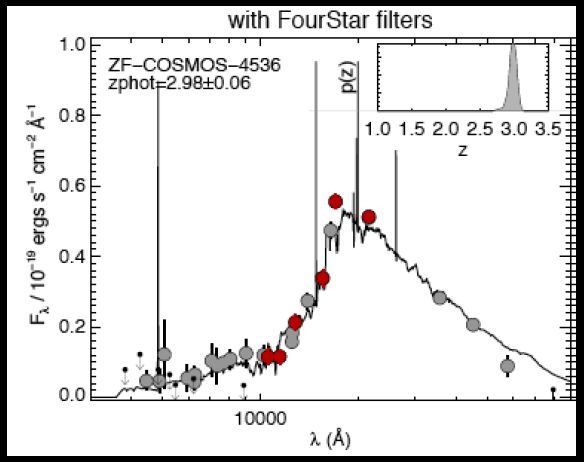


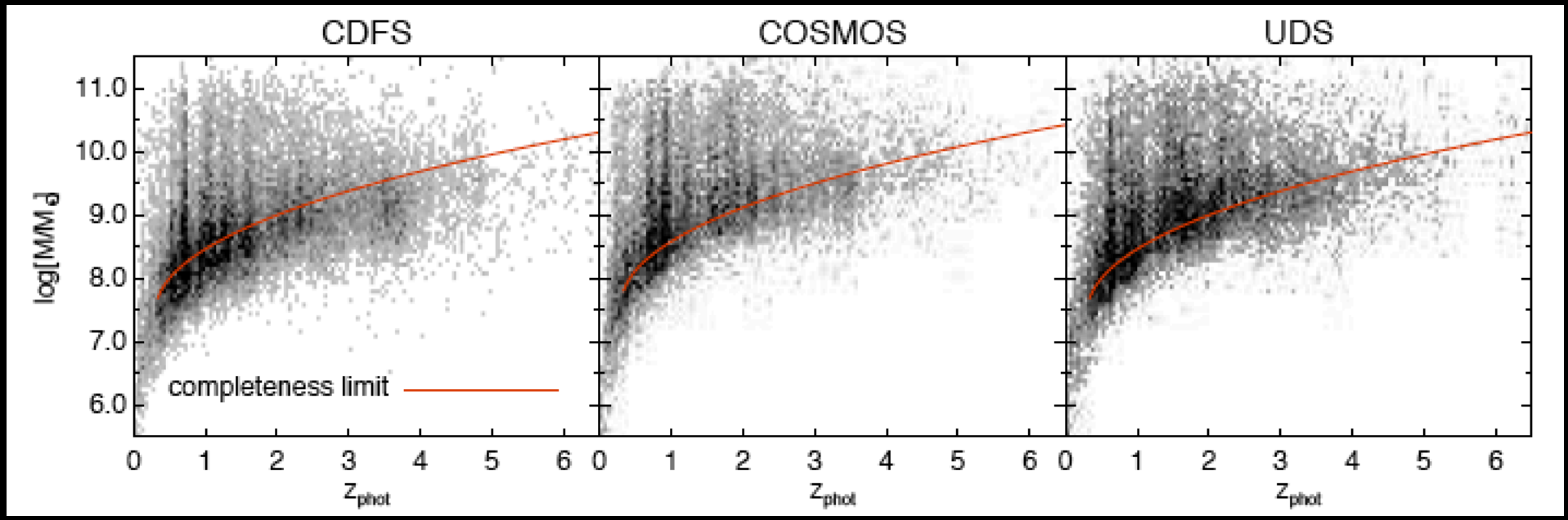
Bouwens et al. 2011

Gas accretion is critical to understanding how galaxy properties evolve.

Acquiring a Sample of z~2 Galaxies

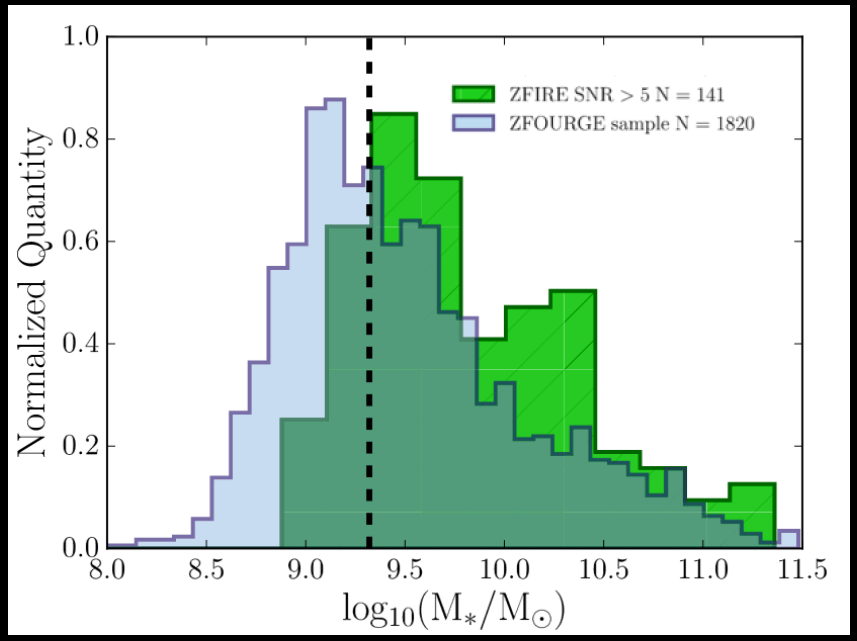
http://zfourge.tamu.edu/DR2016/data.html





ZFIRE: Spectroscopic Survey from ZFOURGE at z~2

http://zfire.swinburne.edu.au/data.html



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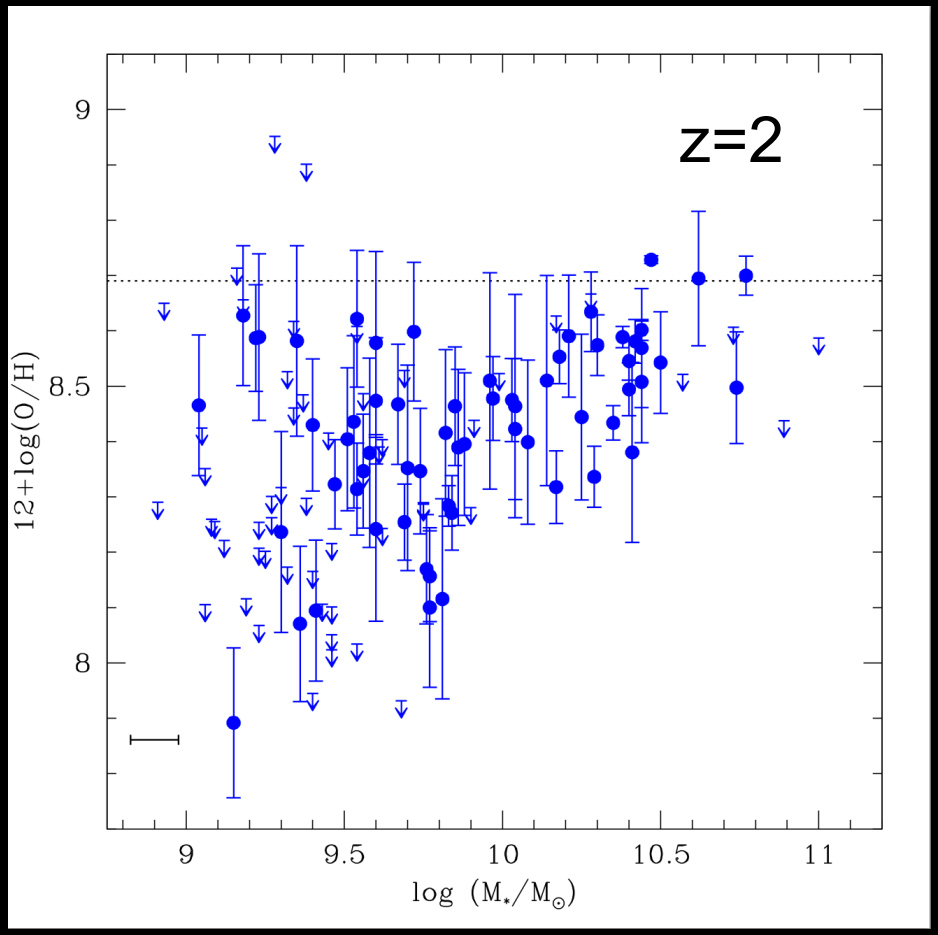
Mass-Metallicity Relation at z=2

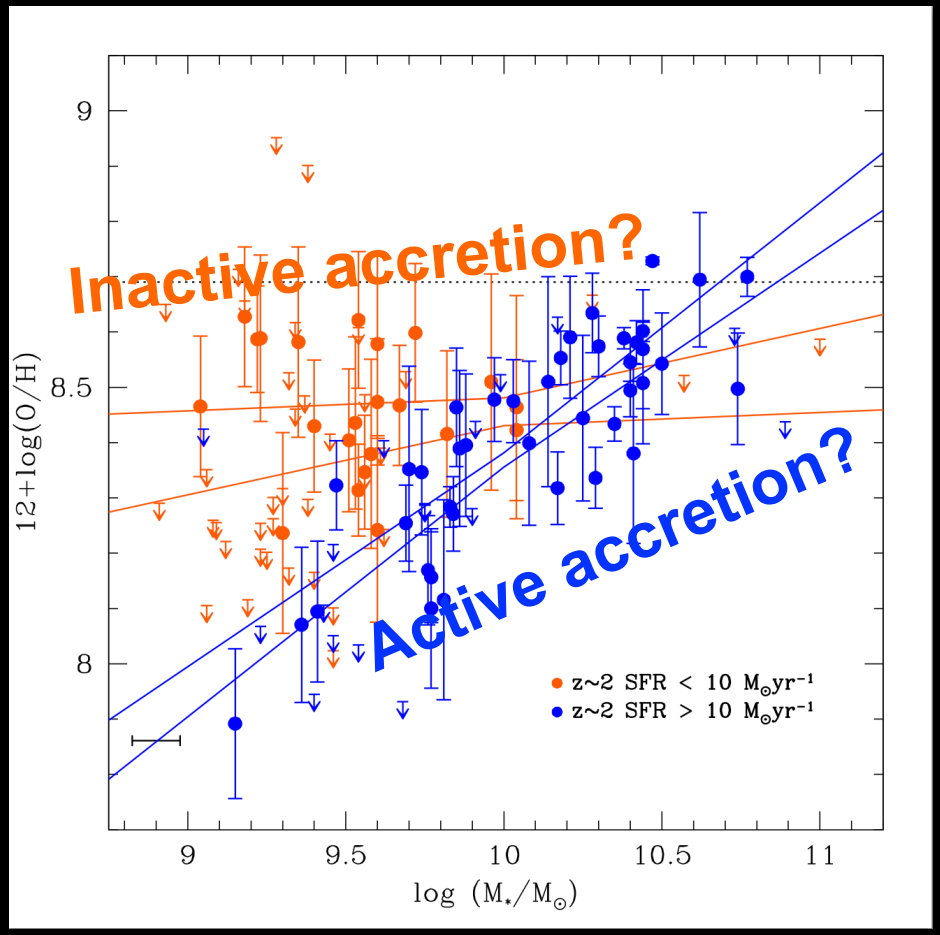


Kacprzak et al. 2015,2016

Why is there so much scatter at high redshift?

- **Star-formation rates?**
- **CGM accretion phases?**

Fundamental Mass-Metallicity Relation at z=2



Kacprzak et al. 2015,2016

Splitting the population into two SFR bins:

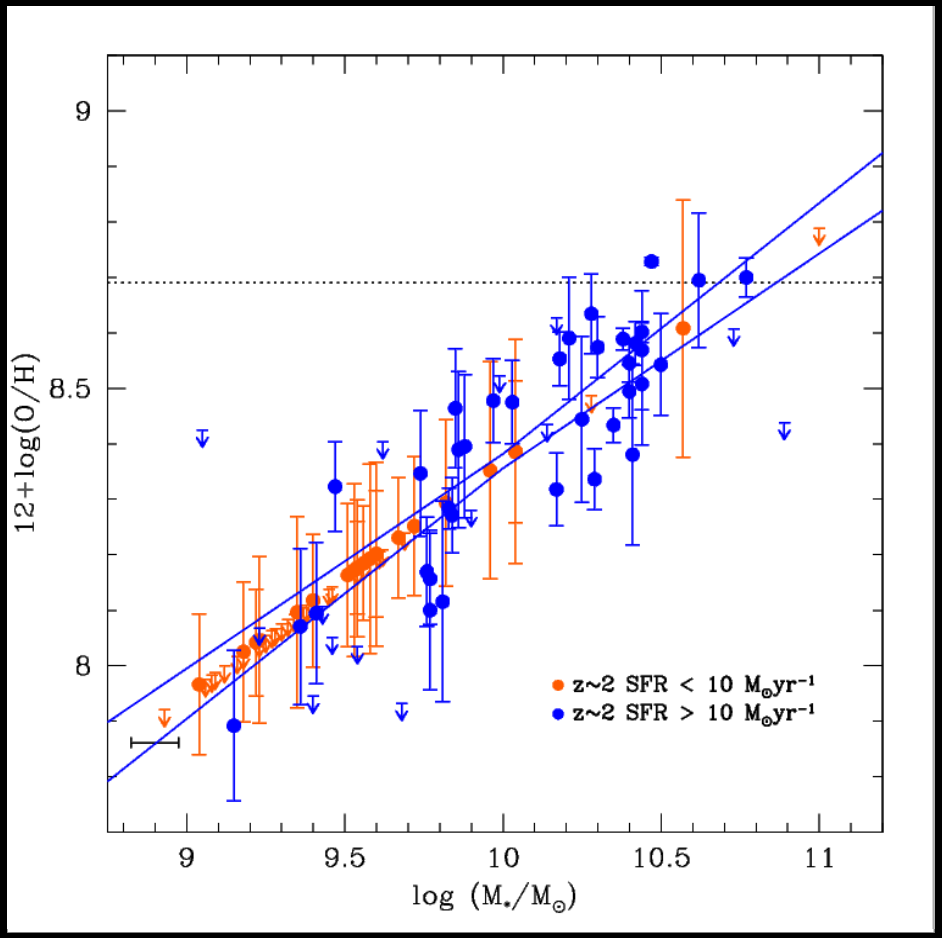
- Two different slopes for high and low SFRs

- Low SFRs have higher metallicity

- High SFRs have lower metallicity

What does this mean?

Fundamental Mass-Metallicity Relation at z=2

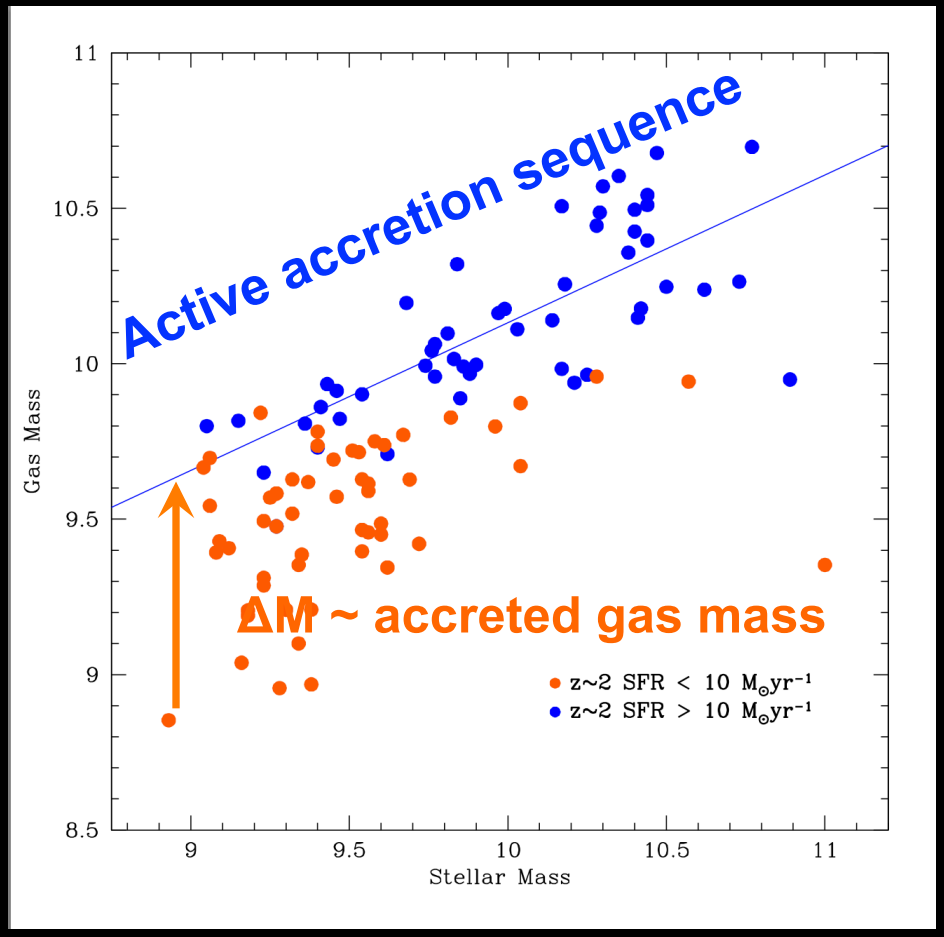


Is it possible that if all galaxies were actively accreting, they would form a defined main sequence?

Metal poor cosmic (cold-mode) accretion could resolve this.

Need to know:
-how much gas is accreted?
-how much metals are accreted?

Estimated Total Gas Mass at z=2



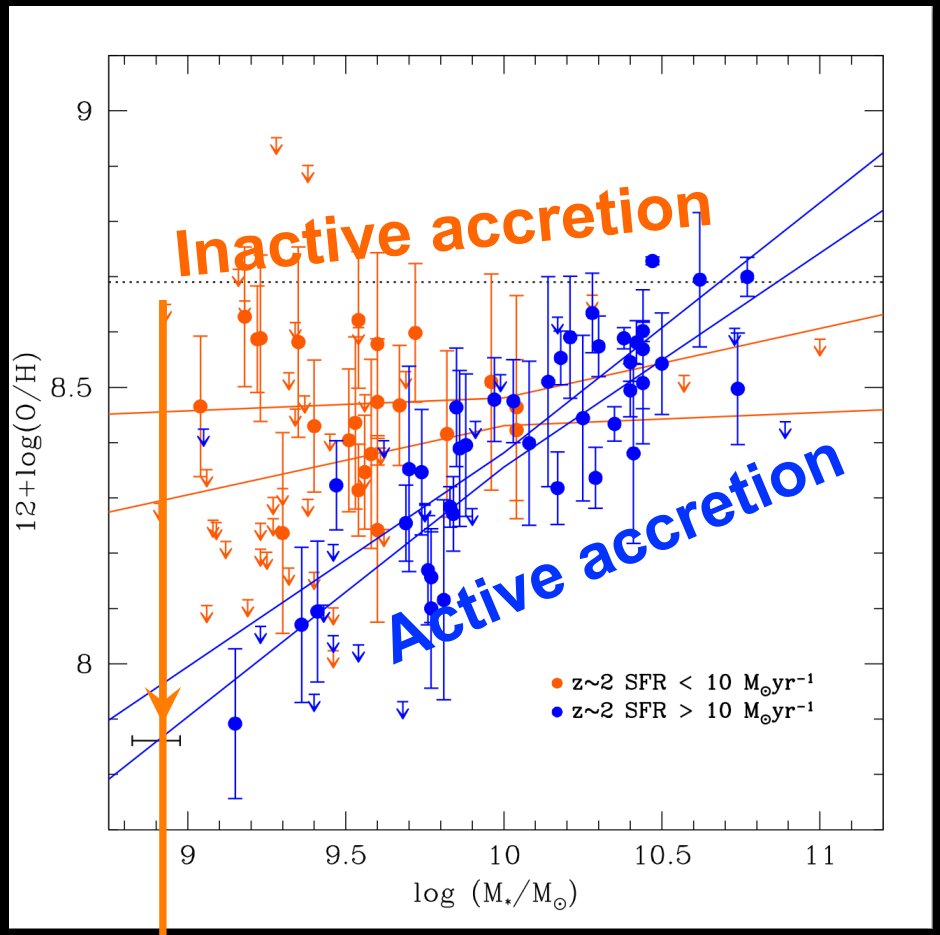
Gas mass via inverse Kennicutt-Schmidt law:

$$\frac{M_{\rm gas}}{6.8\times10^8\ M_\odot} = \left(\frac{\Psi}{1\ M_\odot\ {\rm yr}^{-1}}\right)^{5/7} \left(\frac{r_{\rm eff}}{1\ {\rm kpc}}\right)^{4/7},$$

Papovich et al. 2015

Offset from accretion sequence provides the accretion gas mass required

Estimated Accretion Metallicity

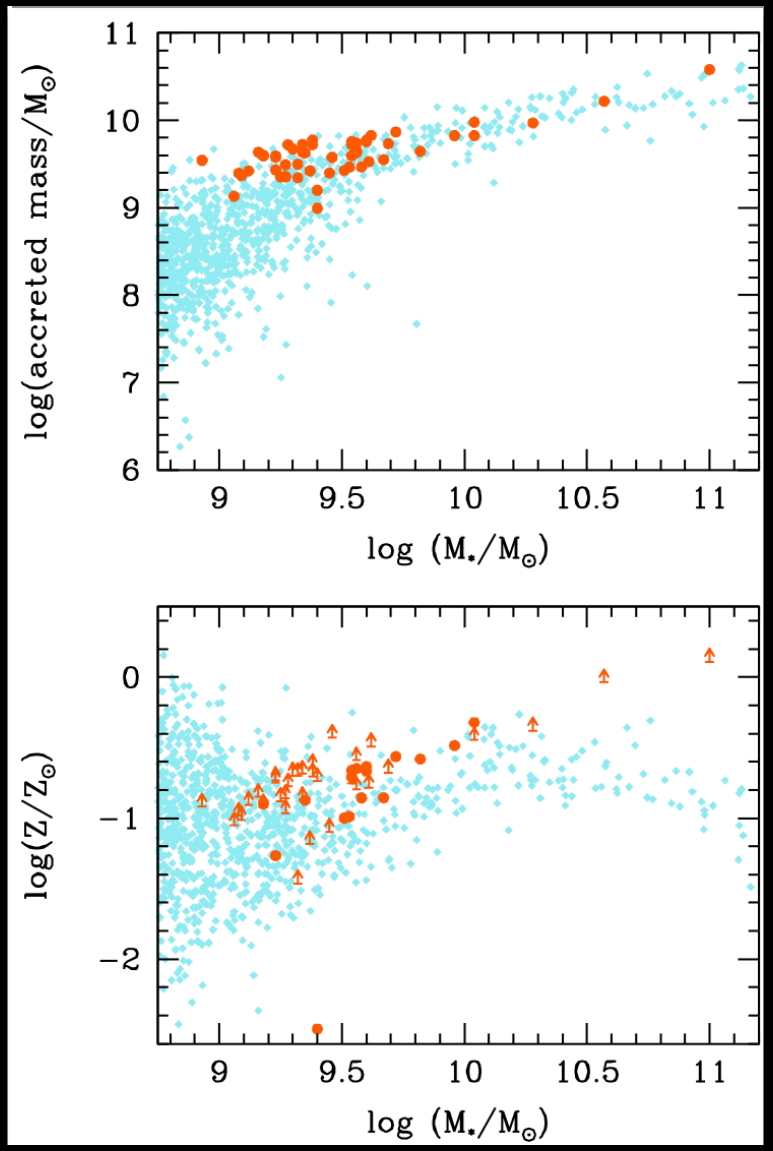


ΔM ~ accreted gas mass ✔

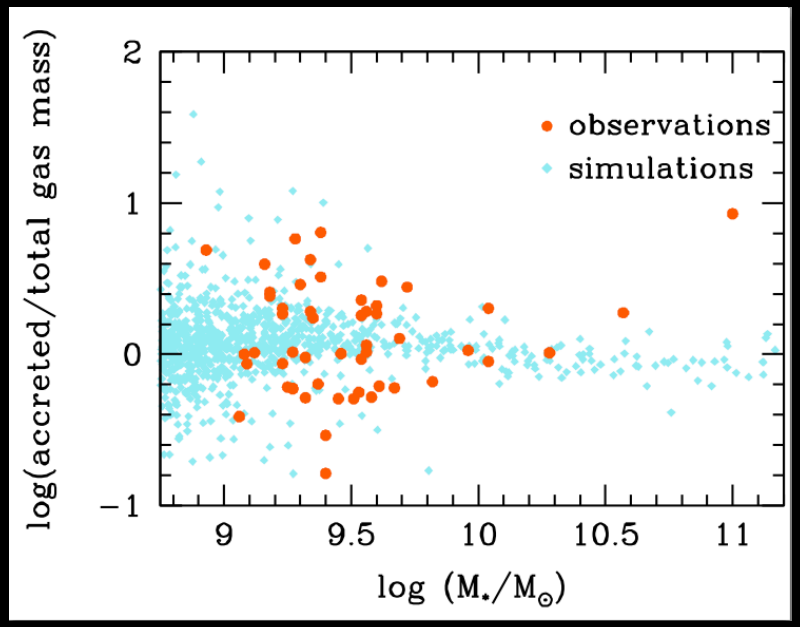
What's the accreted metallicity ~ΔZ?

ΔZ ~ accreted metallicity ✔

Gas Accretion and Mass-Metallicity Relation at z=2



Kacprzak et al. 2016



Using basic assumptions, observations and cosmological simulations agree!

Is suggestive that scatter in this fundamental relation is driven by accretion.

Conclusions

- Fundamental Mass Metallicity relation at z~2
- Using basic assumptions, CGM accretion can explain the scatter in the MMR
- Consistent with Simulations
- Caveats
  - gas conditions are different at high z and also likely can contribute to scatter but it is still unclear by how much.