SDSSとDEEP2で見た星形成銀河のアウトフロー

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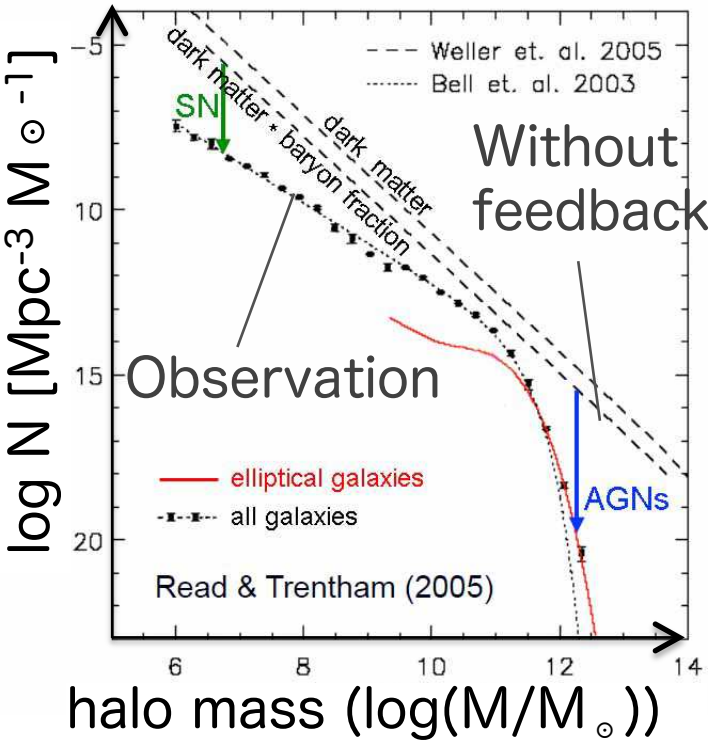
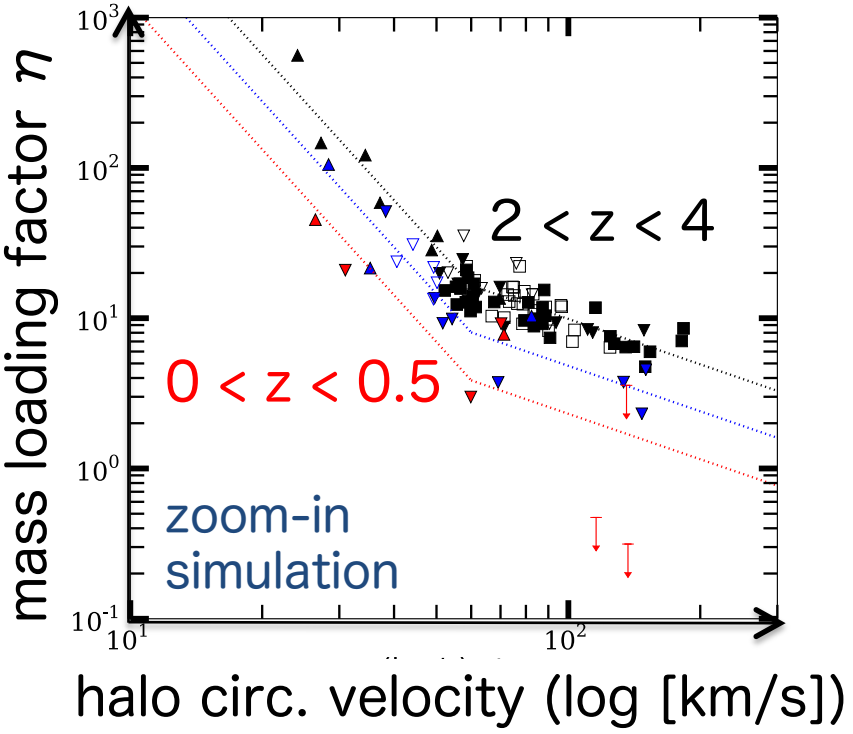
Introduction

Feedback: Key mechanism to galactic evolution.

Outflows: One of main sources of feedback



Kormendy & Ho 2013



Muratov+2015

Introduction

Feedback: Key mechanism to galactic evolution.

Outflows: One of main sources of feedback

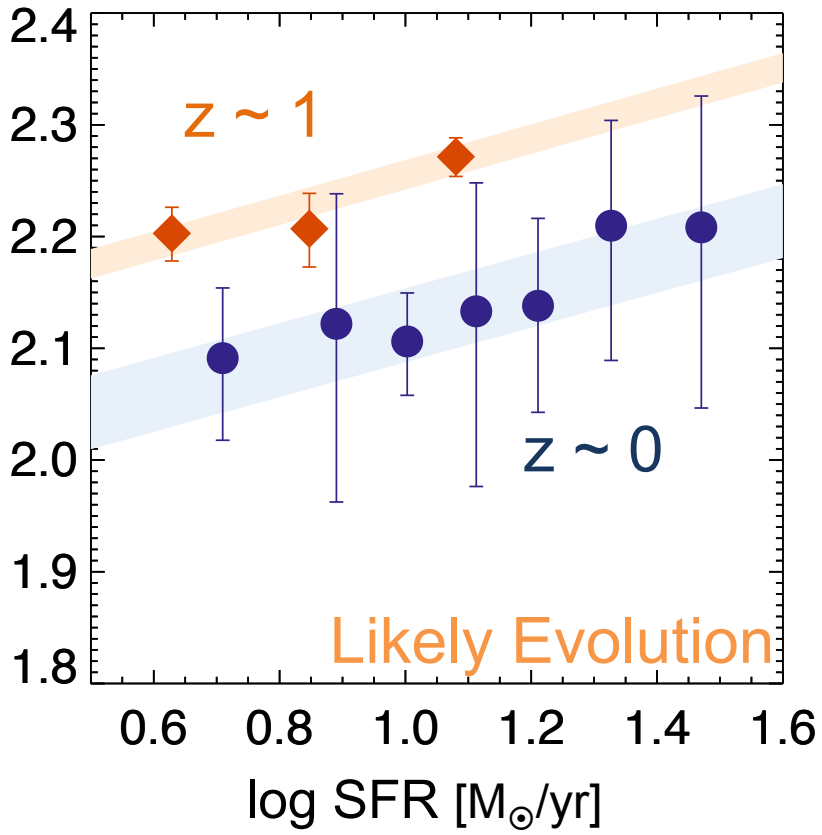
PURPOSE:

Confirm redshift evolution of Outflow

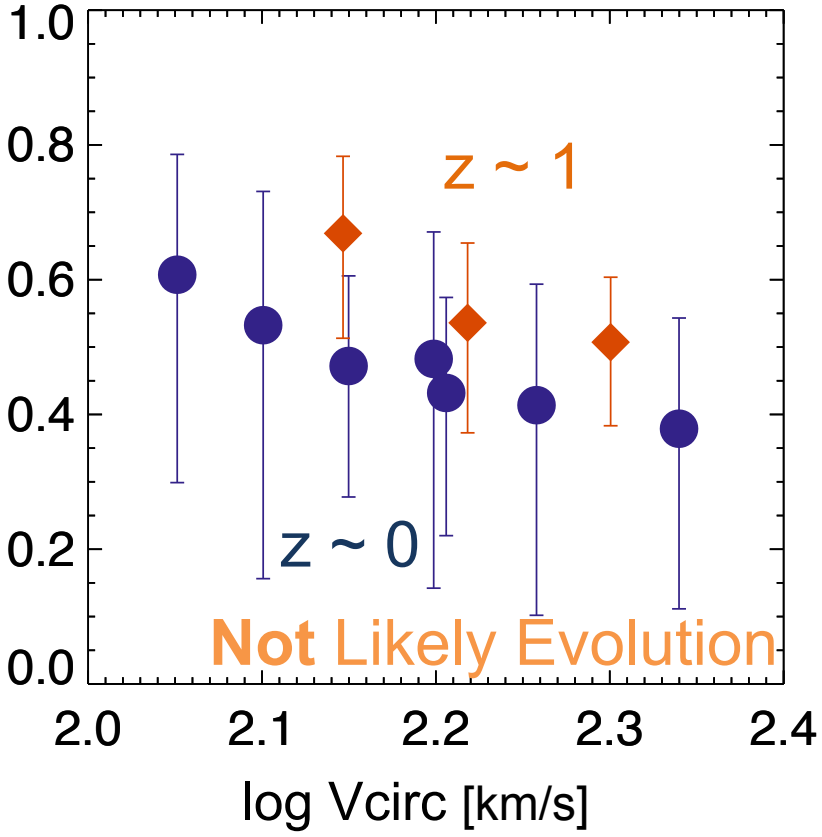
between at z ~ 0 and at z ~ 1

Result

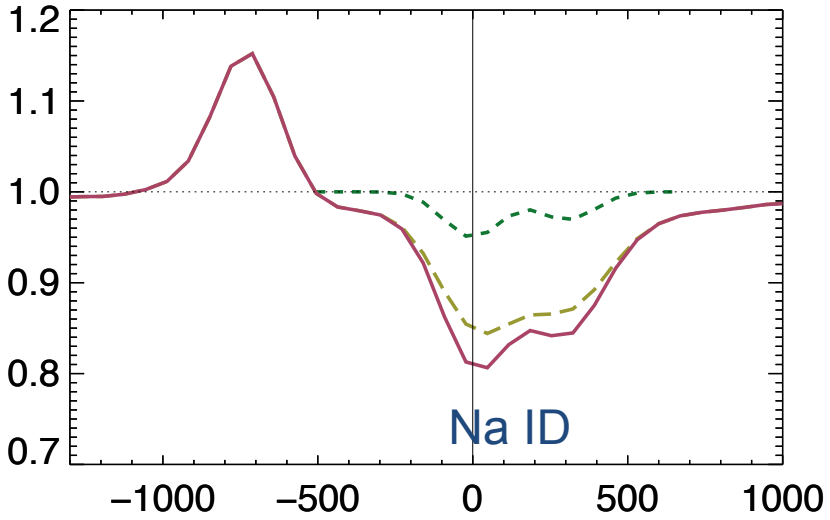
Outflow Velocity

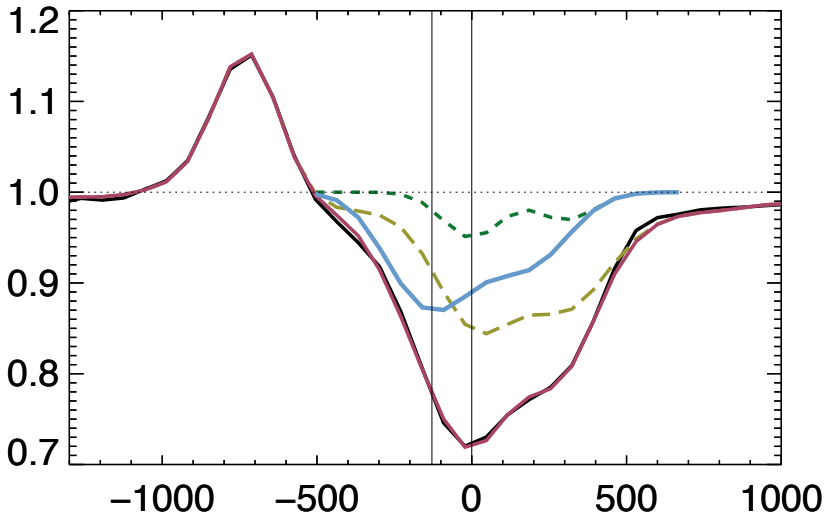


Mass Loading Factor



Method


1.2
1.1
1.0
0.9
0.8
0.7
Na ID
−1000
−500
0
500
1000


1.2
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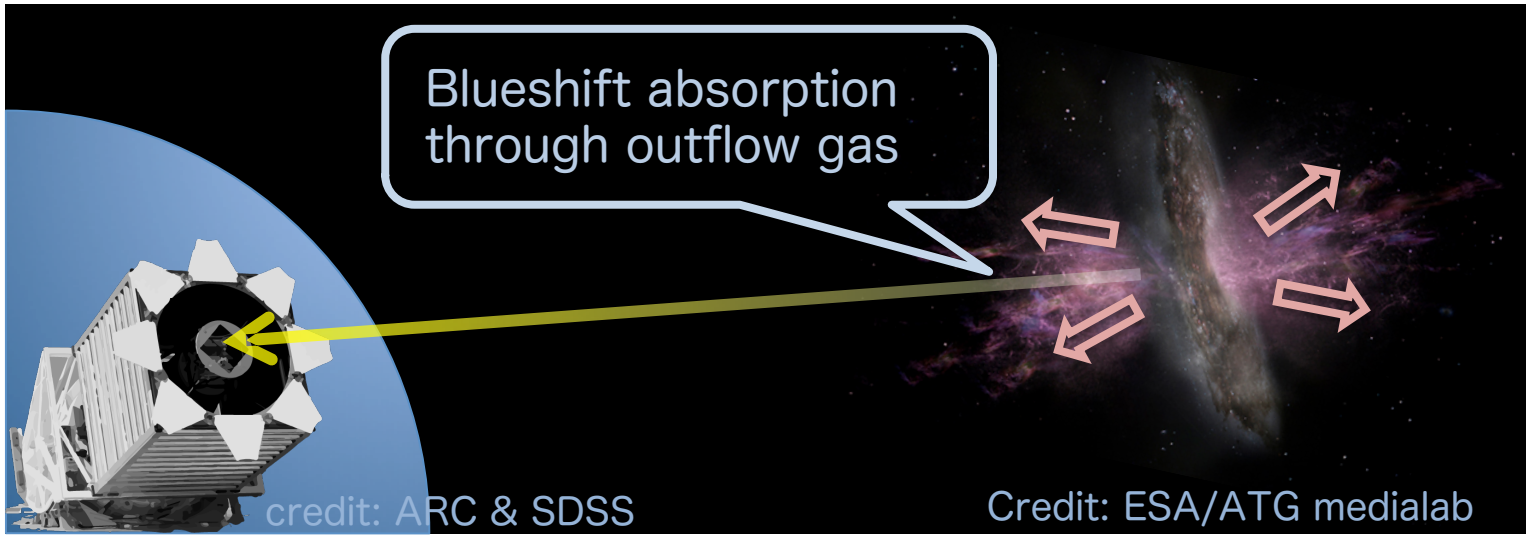
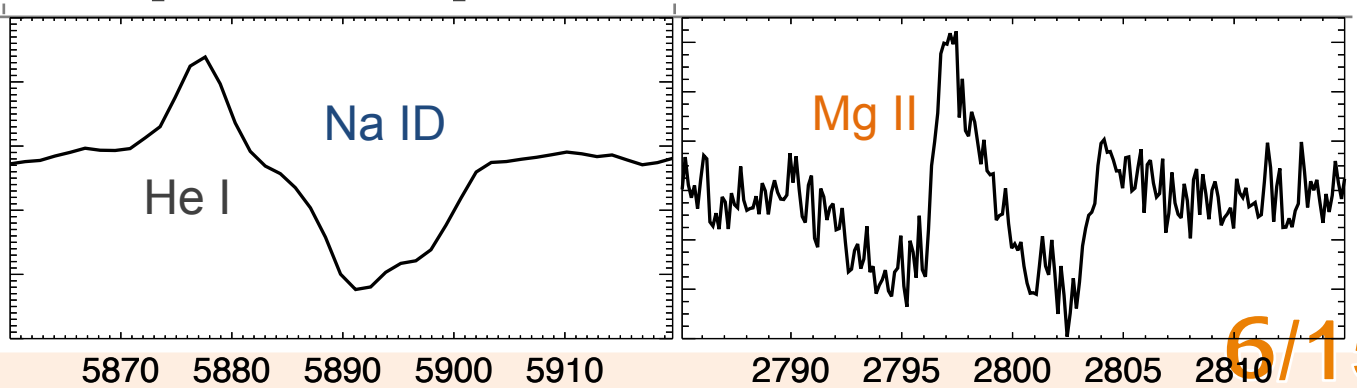

Blueshift absorption
through outflow gas
credit: ARC & SDSS
Credit: ESA/ATG medialab

Data

Data	SDSS DR7	DEEP2
Redshift	0.05 < z < 0.18 (z ~ 0)	1.2 < z < 1.4 (z ~ 1)
Metal Line	Na ID λλ 5891.58, 5897.56	Mg II λλ 2796.35, 2803.53
Selection	Star-forming Galaxy $\log(\Sigma_{\rm SFR}) > -0.5$	non-AGN
Total N	2679	1404
Stacked N	150 [S/N = 300]	500



Absorption Line Model

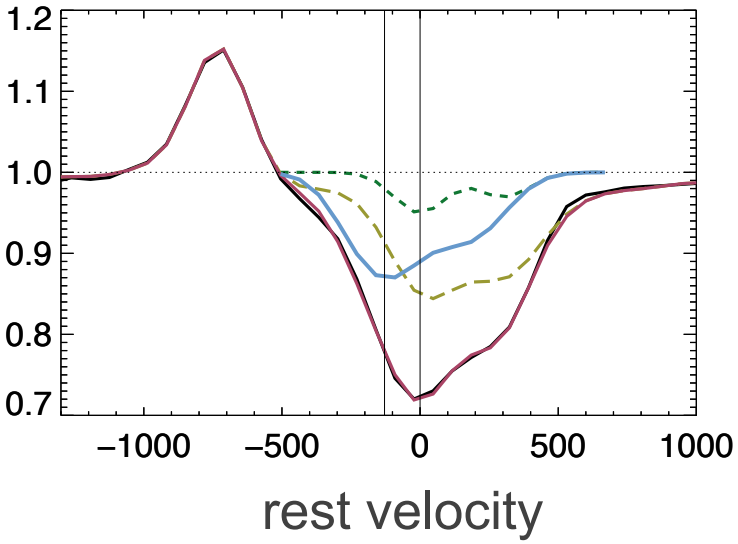
$$\tau(\lambda) = \tau_0 \exp\left(-\frac{(\lambda-\lambda_0)^2}{(\lambda_0 b/c)^2}\right)$$

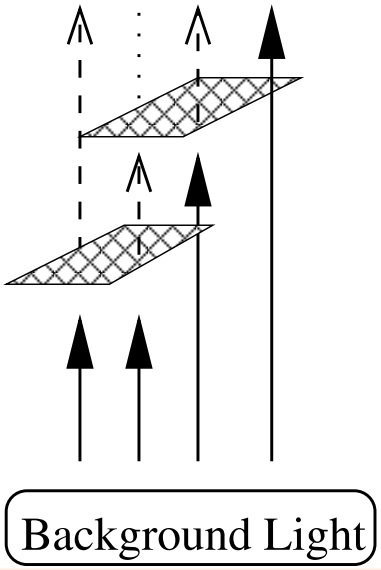
Outflow: $I_{\rm wind} = I_0(1 - C_f + C_f e^{-\tau_{\rm B} - \tau_{\rm R}})$

Systemic: SDSS (same as above), DEEP2 (emission)

Continuum: single stellar population synthesis model

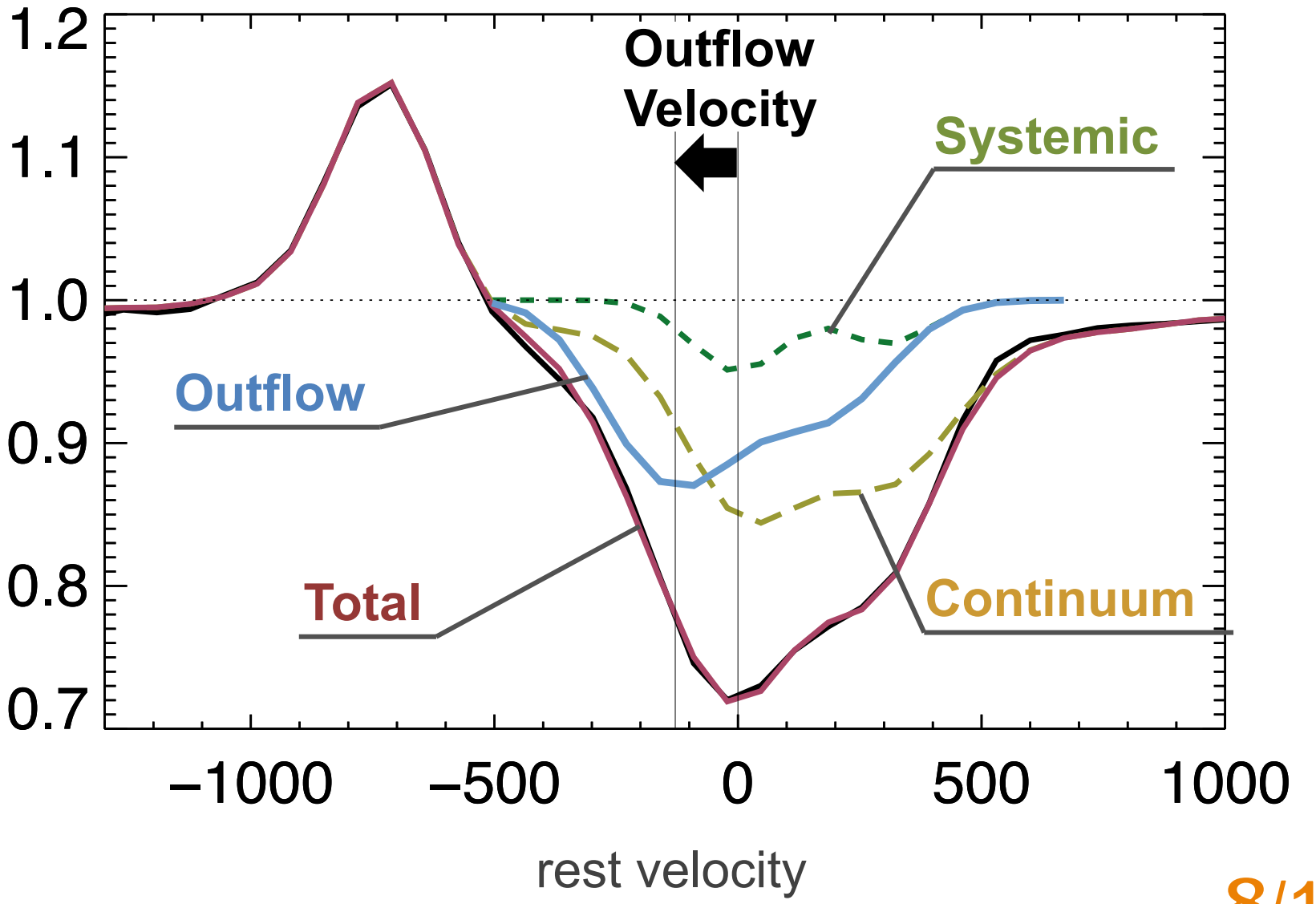
Total: $I_{\rm gal} = I_{\rm wind} I_{\rm sys} I_{\rm cont}$; $I_{\rm gal} = I_{\rm wind}(I_{\rm sys} + I_{\rm cont})$





Rupke, Veilleux, & Sanders 2005

Absorption Line Model



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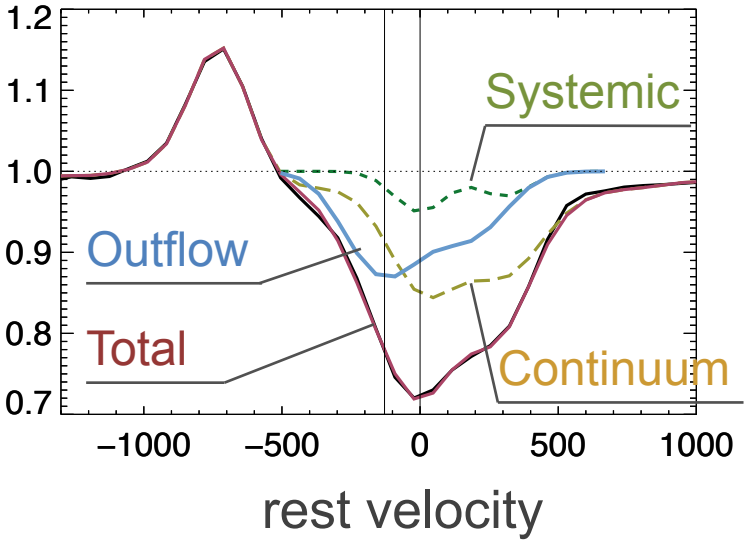


Fitting parameters of outflow

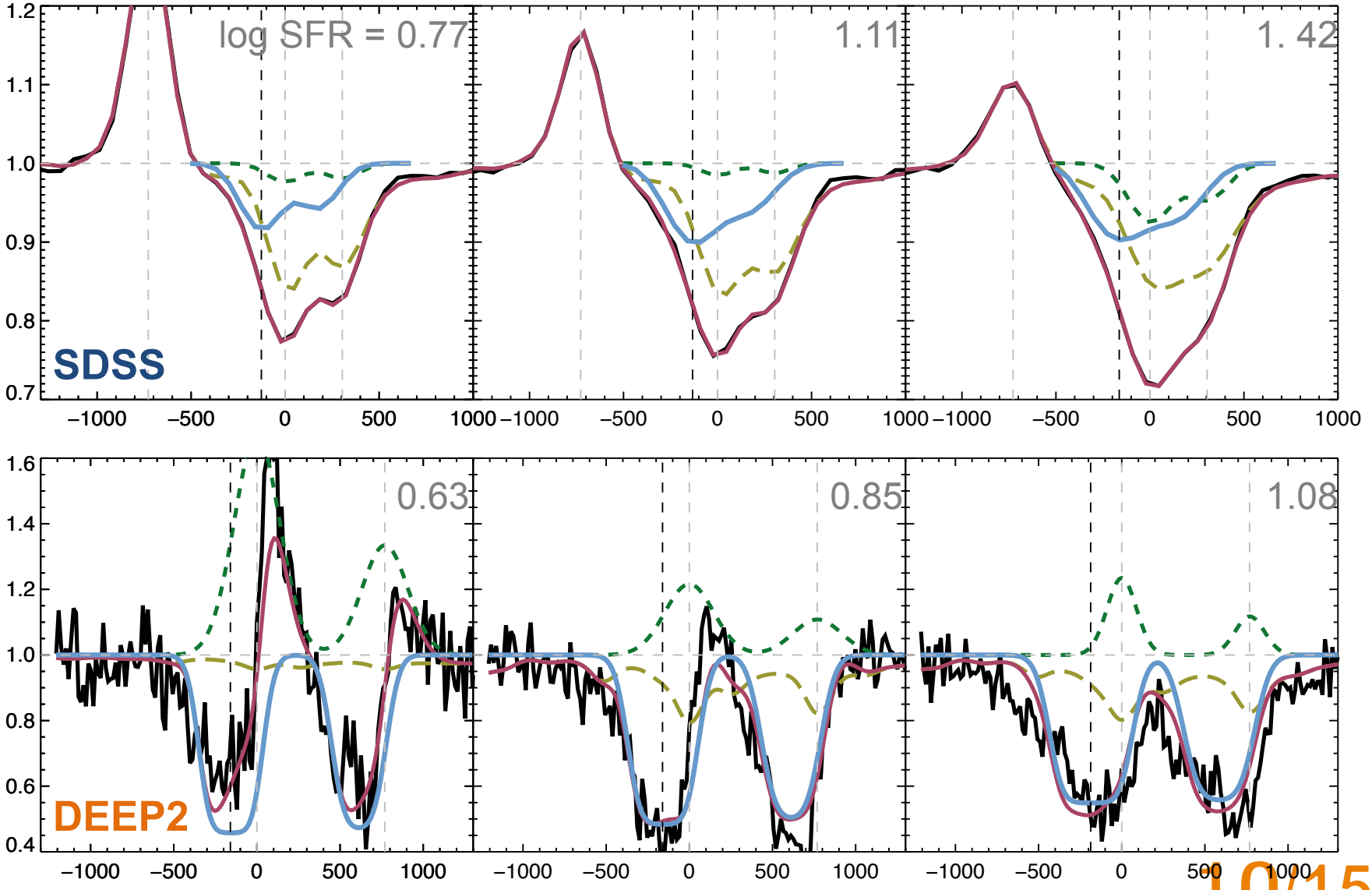
C_f : covering factor

τ_0 : optical depth

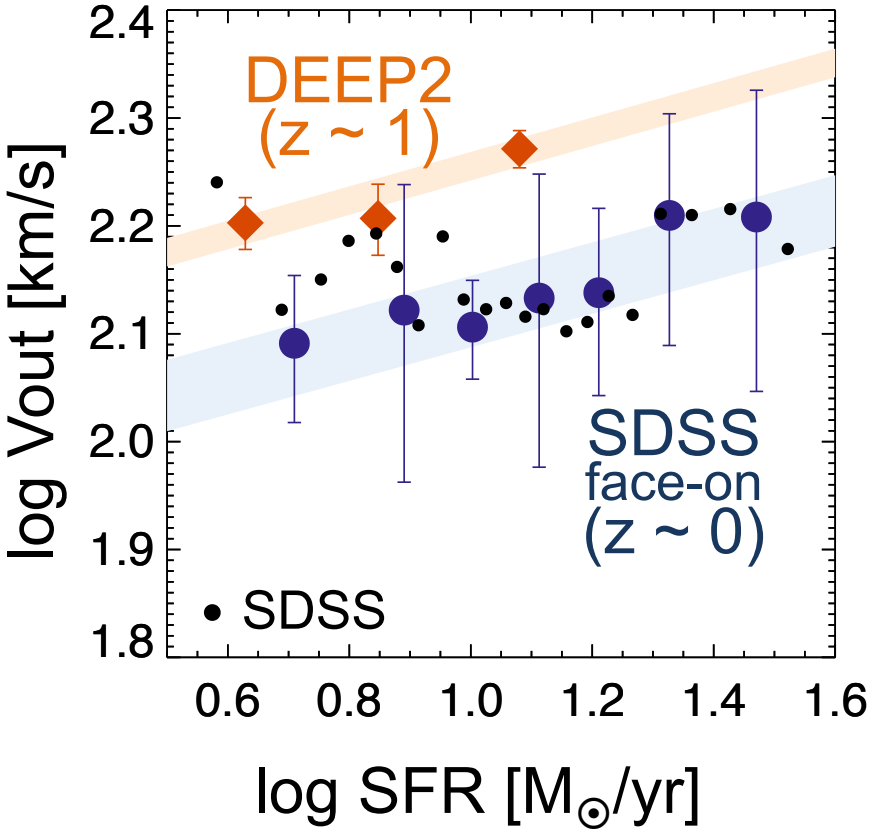
b : Doppler width

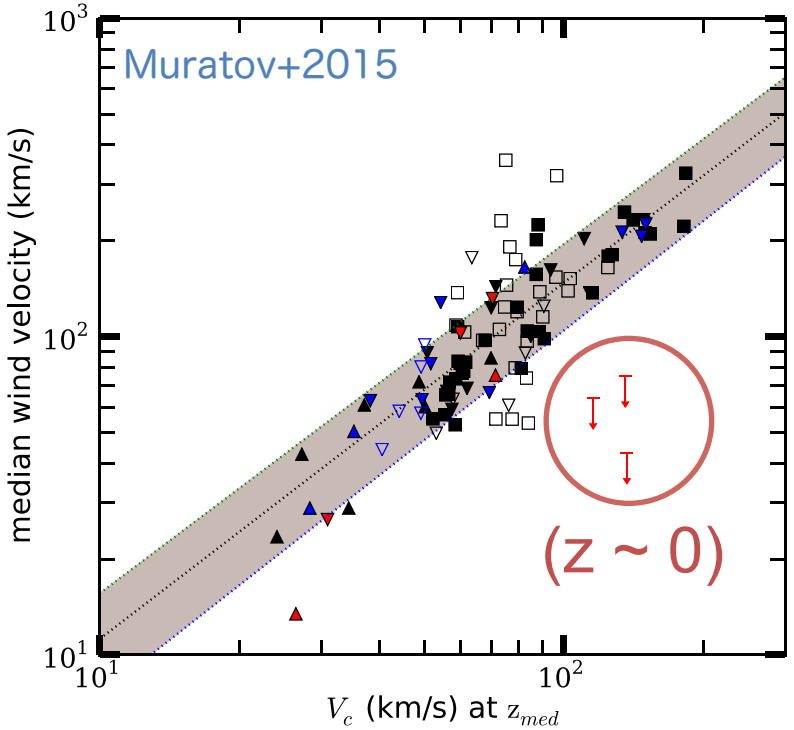
$\lambda_0 \left(v_{\rm wind} = \frac{\lambda_0 - \lambda_{\rm sys}}{\lambda_{\rm sys}}\right)$

Best Fit



Outflow Velocity





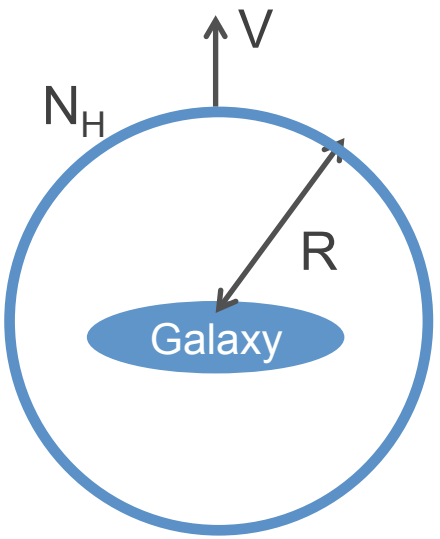
Vout (**z~1**) **faster** than Vout (**z~0**) at 4σ significance

Due to difference of SF mode?

Calculation — mass

Column Density of X (Na I, Mg II)

$$N_{\rm X} \geq \frac{\tau_0 b}{1.497 \times 10^{-15} \lambda_{sys} f}$$



Column Density of Hydrogen

$$N_{\rm H} = N_{\rm X} \times \chi^{-1} \times 10^{-d_{\rm X} + \log({\rm X/H})_\odot}$$

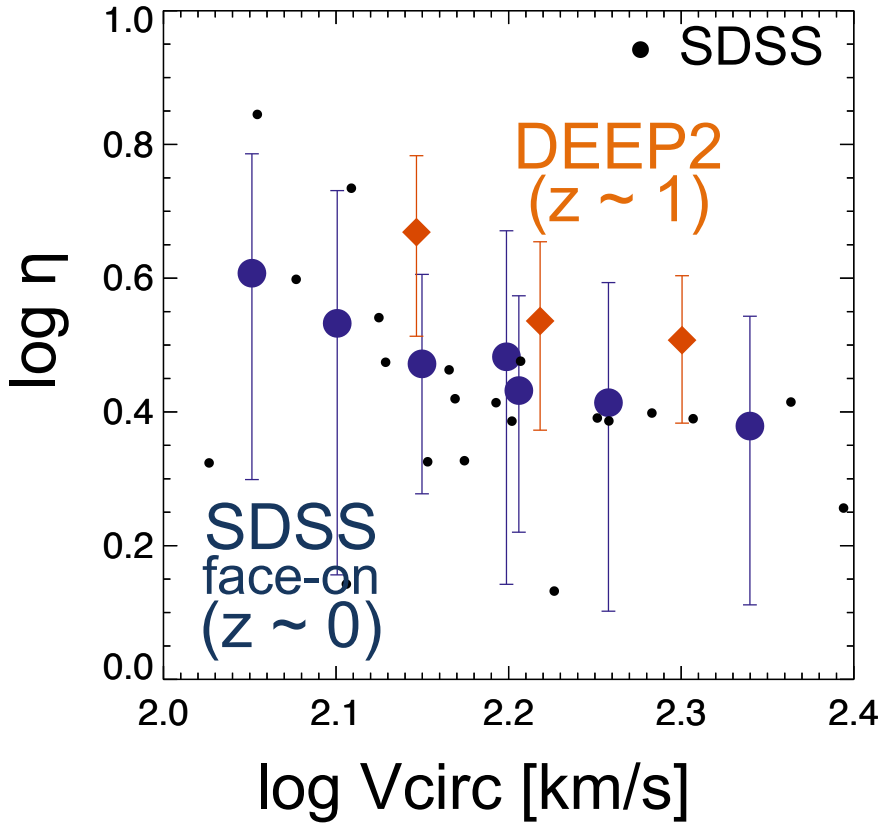
Outflow Rate

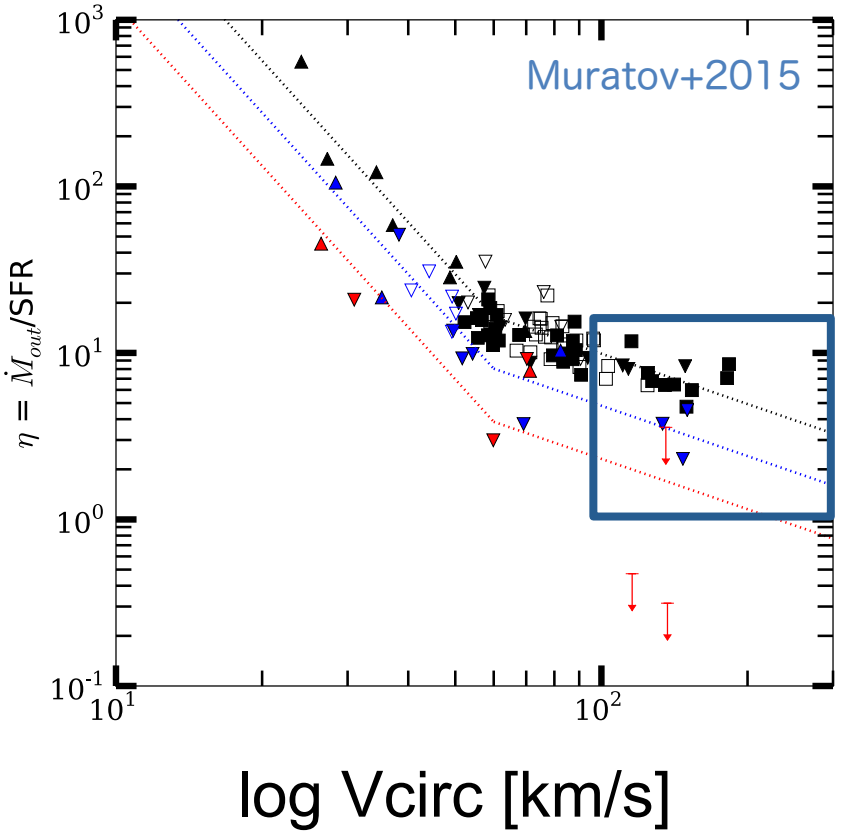
$$\dot{M}_{\rm out} \simeq 22 \times C_f \ M_\odot {\rm yr}^{-1} \frac{N_{\rm H}}{10^{20}\ {\rm cm}^{-2}} \frac{R}{5\ {\rm kpc}} \frac{v}{300\ {\rm km/s}}$$

Mass Loading Factor

$$\eta = \dot{M}_{\rm out}/SFR$$

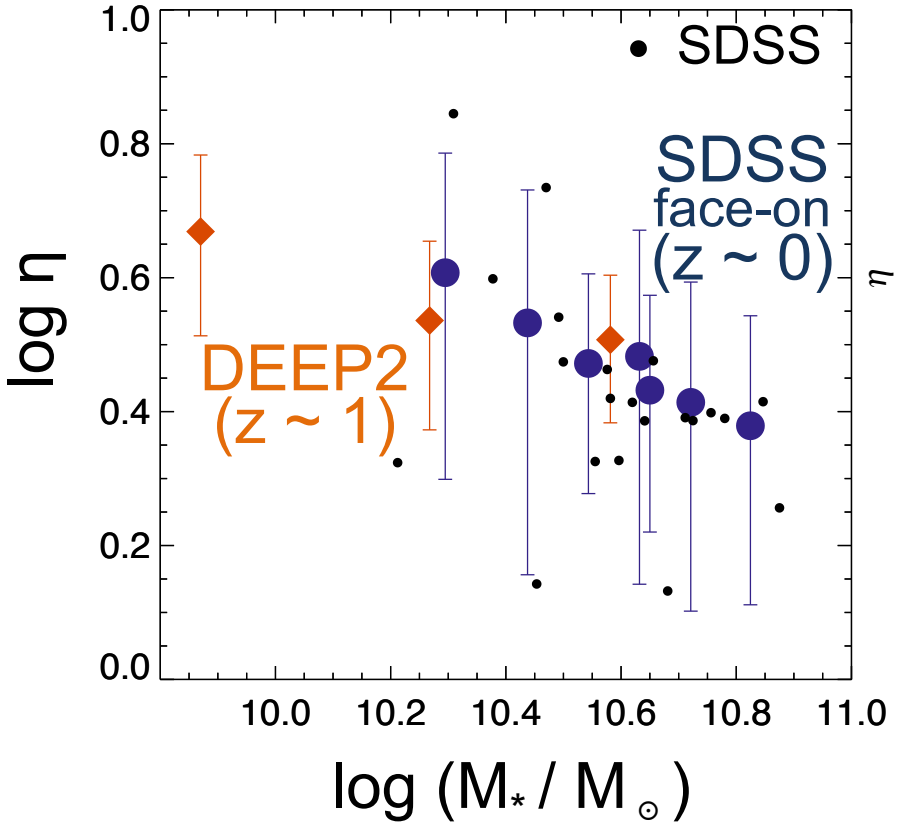
Mass Loading Factor

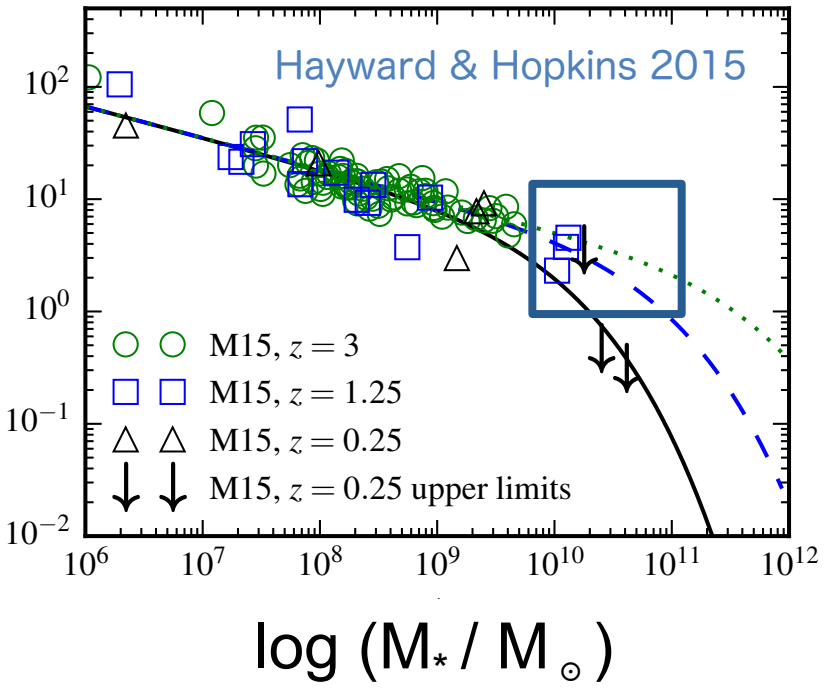




Halo circular velocity: Berhoozi+2013, Mo & White 2002

Mass Loading Factor





Theoretical models, “η goes down due to lack of gas”

No such a steep slope

Summary

PURPOSE: Confirm redshift evolution of Outflow

DATA: SDSS (z~0; NaID) & DEEP2 (z~1; MgII)

METHOD: Decompose absorption line into 3 components

Calculate Outflow Rate & Velocity

RESULT: Outflow Velocity ⟶ **Likely Evolution**

Mass Loading Factor ⟶ **Not likely Evolution**

NOTE: Different metal absorptions at each z