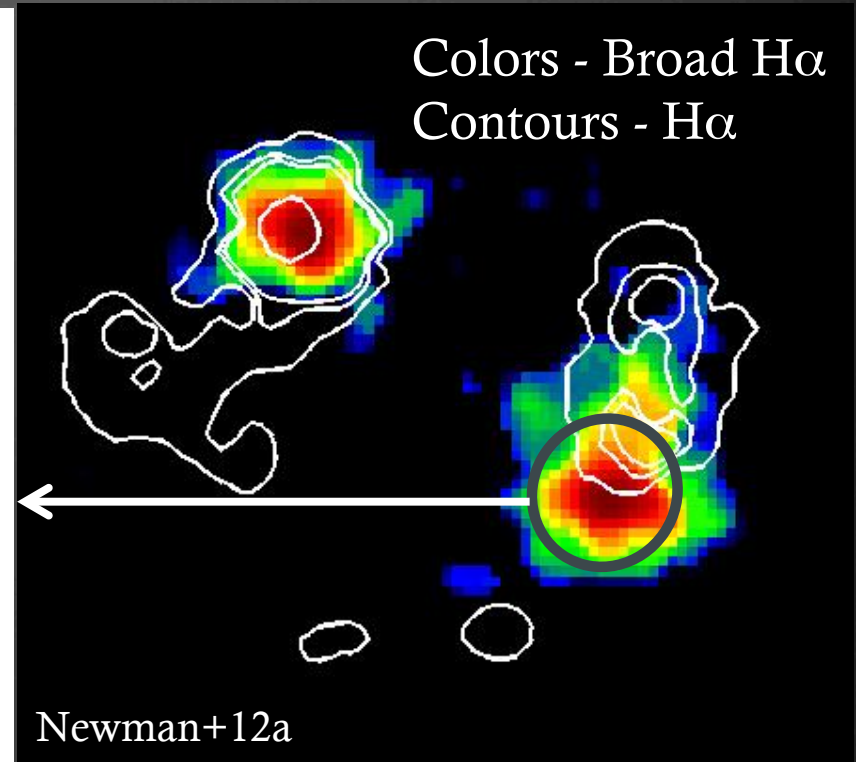
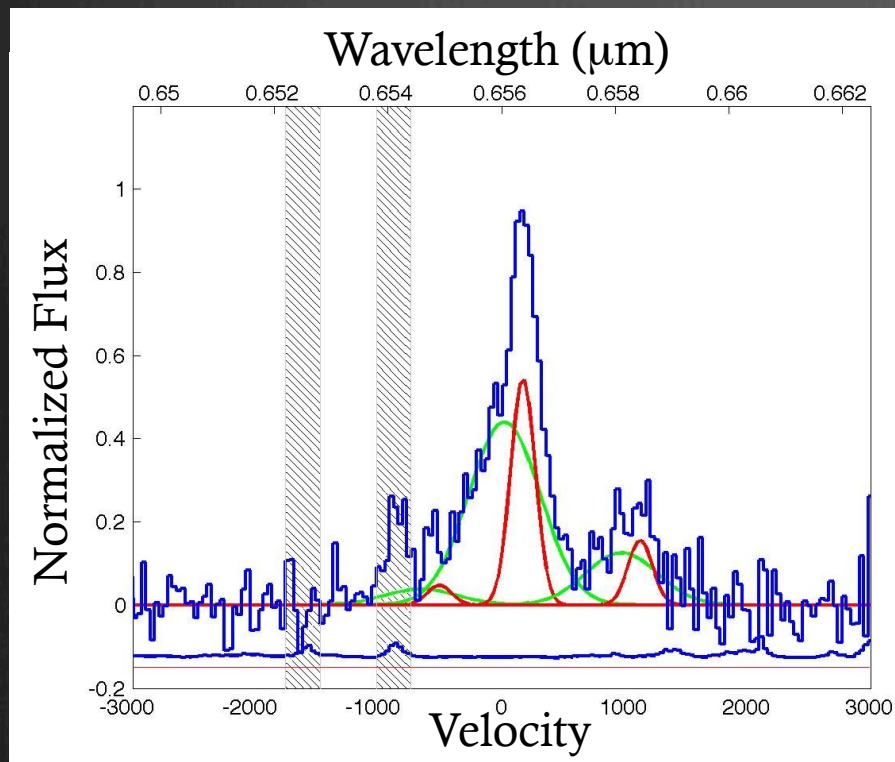


Outflows from $z \sim 2$ SFGs



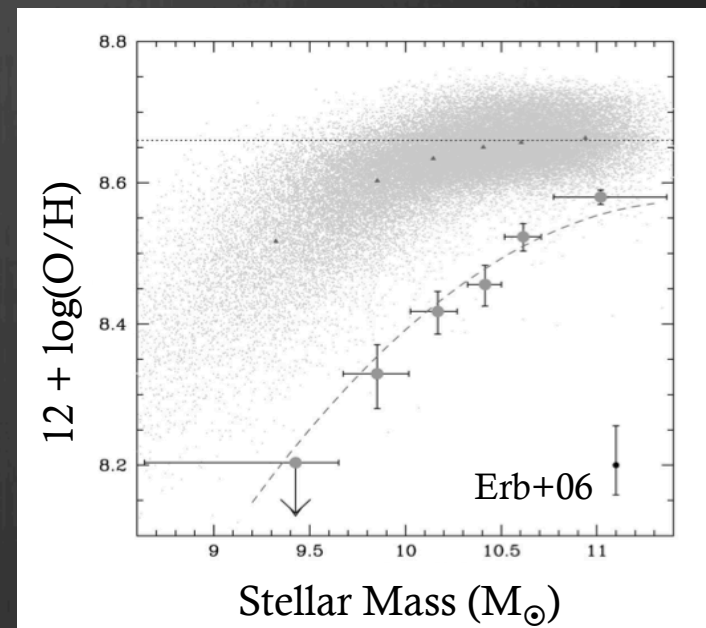
Sarah Newman (UCB), Reinhard Genzel (MPE/UCB)

Natascha Förster-Schreiber (MPE), Linda Tacconi (MPE), Chiara Mancini (Padova), Alvio Renzini (Padova), Kristen Shapiro Griffin (Northrup-Grunman) and the SINS/ZC-SINF team

see arxiv: 1207.5897

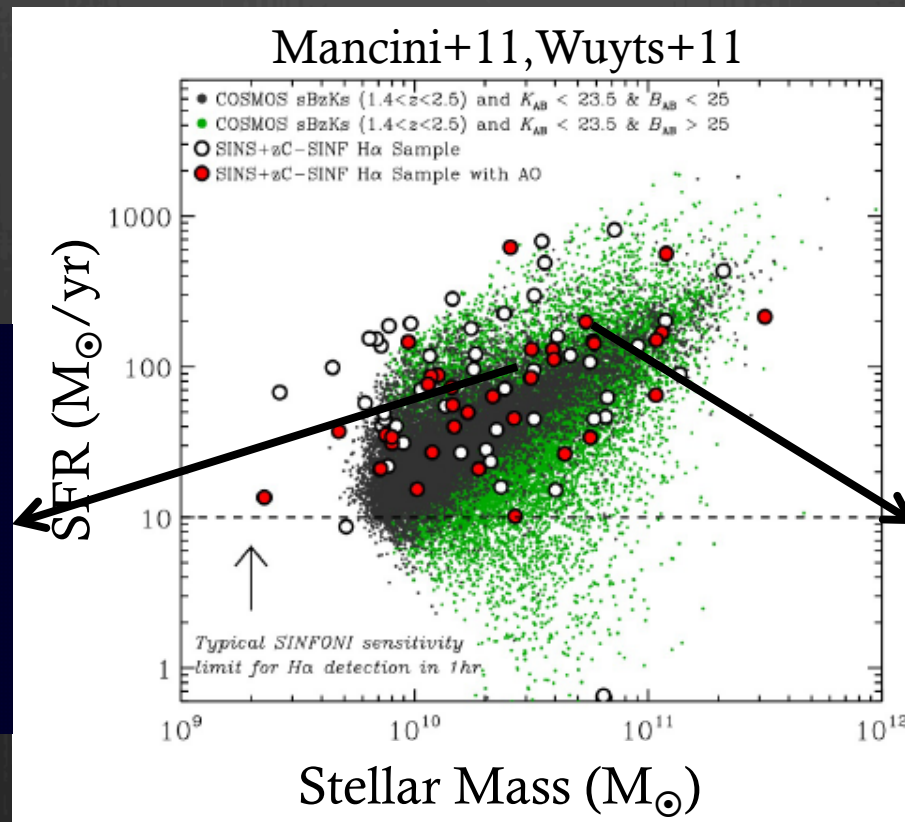
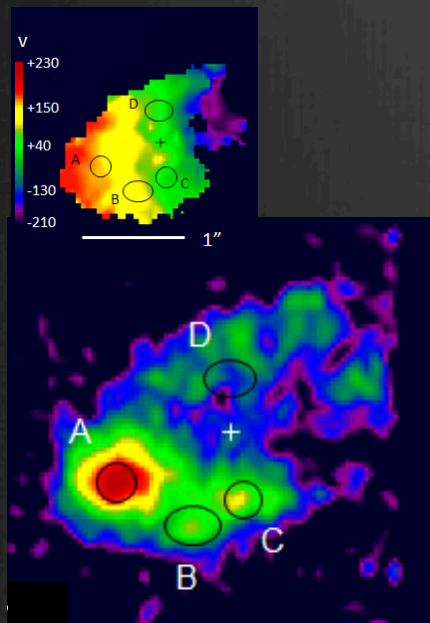
What drives high-z galactic winds?

- Outflows ubiquitous at $z \sim 2$: Do they vary with galaxy properties?
- Are they more prominent in the inner/outer regions of the galaxy?
- Where does most of the mass come from?

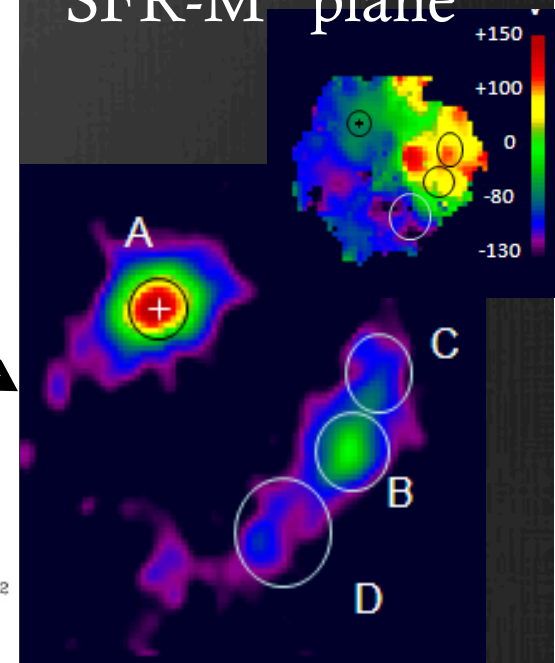


30 $z \sim 2$ SFGs from SINS/zC-SINF surveys

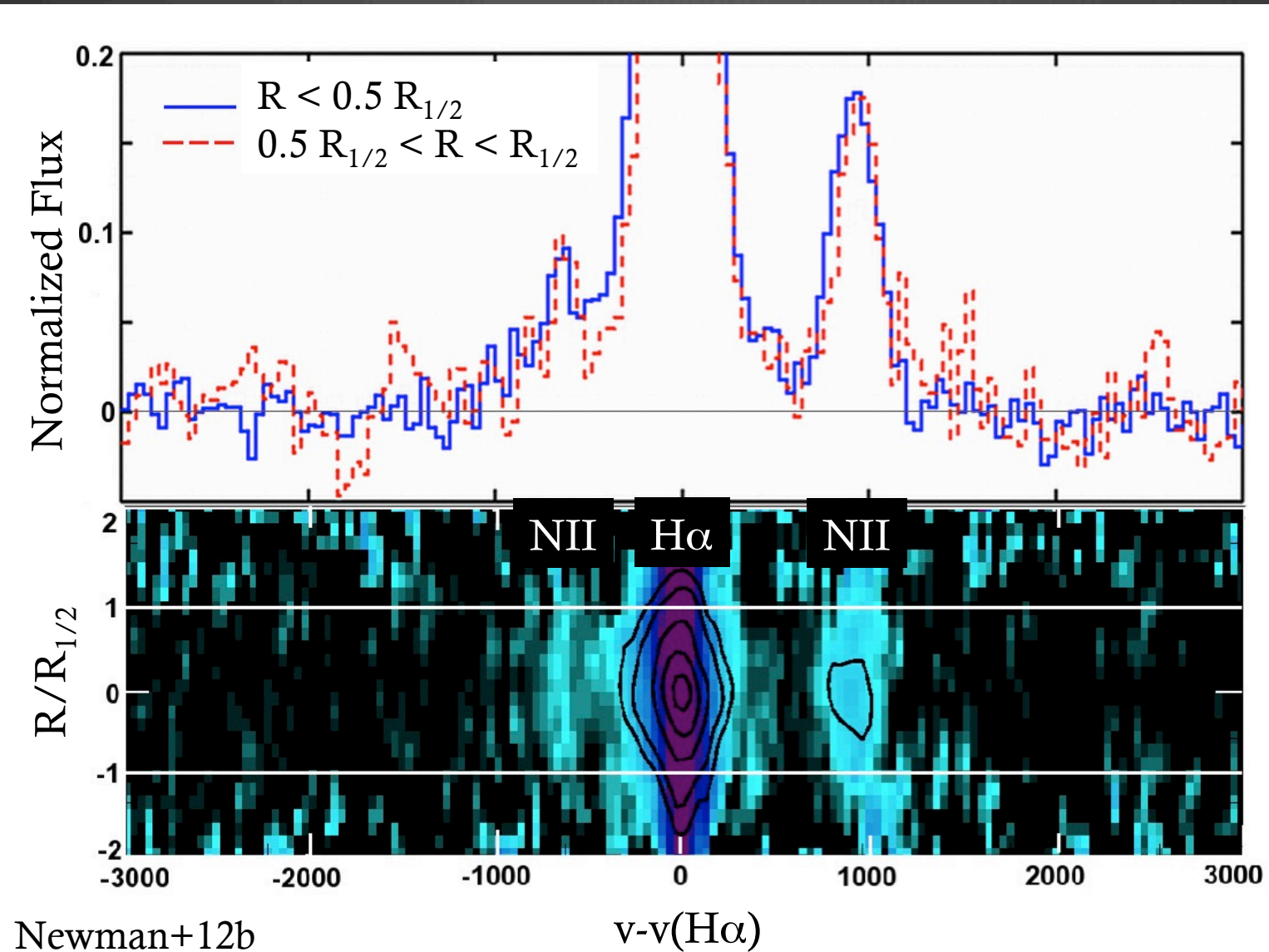
- SINFONI IFU spectrometer on VLT at Paranal
 - AO (LGS/NGS) and seeing modes, FWHM $\sim 0.2''$ and $0.5''$
 - $0.05''$ pixels (with AO) and 50 km/s spectral res



Covers most of
SFR- M^* plane



Outflows are spatially extended

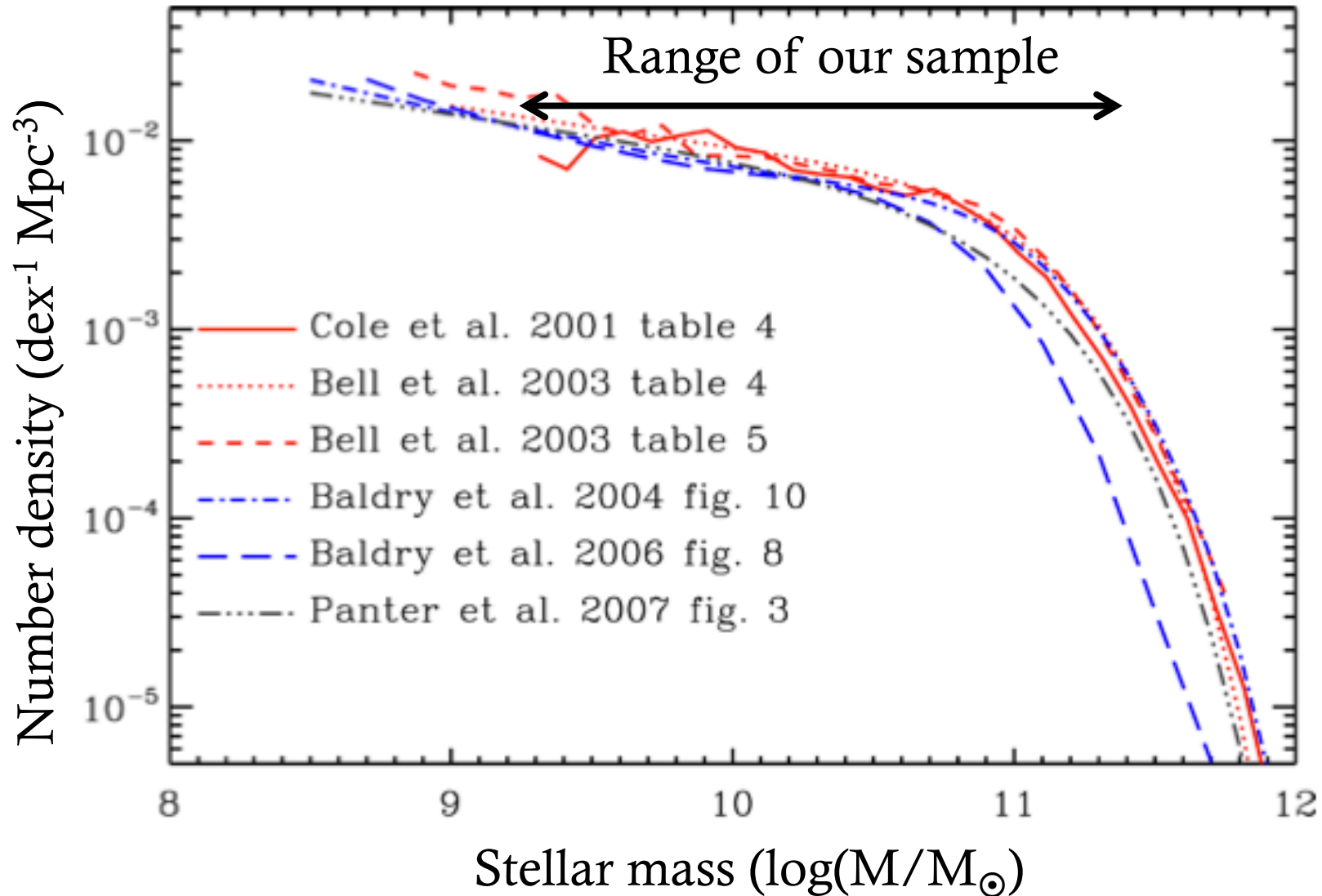


Outflow strength correlated with Σ_{SFR} , SFR, M_* , $R_{1/2}$, inclination

Property	$F_{\text{broad}}/F_{\text{narrow}}$		Significance of difference	Dividing value
	High bin	Low bin		
SFR	0.65 ± 0.074	0.47 ± 0.042	2σ	$100 M_{\odot}/\text{yr}$
M_*	0.63 ± 0.056	0.41 ± 0.042	4σ	$10^{10} M_{\odot}$
Σ_{SFR}	0.77 ± 0.027	0.16 ± 0.030	20σ	$1 M_{\odot}/\text{yr}/\text{kpc}^2$
$R_{1/2}$	0.50 ± 0.054	0.76 ± 0.082	3σ	3 kpc
inclination	0.47 ± 0.055	0.77 ± 0.091	3σ	$50-55^{\circ}$

Σ_{SFR} threshold for outflows

Baldry+07



Wind break-out governed by pressure balance

- $P_{\text{weight}} = P_{\text{feedback}}$

$$\Sigma_{\text{SFR,crit}} = \pi G f_g \Sigma_d^2 / 2(P/m_*)$$

$$\sim 1 M_{\odot}/\text{yr}/\text{kpc}^2 \text{ at } z \sim 2 (f_g = 0.5)$$

$$\sim 0.1 M_{\odot}/\text{yr}/\text{kpc}^2 \text{ at } z \sim 0 (f_g = 0.07)$$

- $\dot{M}_{\text{out}} \sim F_{\text{br}} \times v_{\text{out}}/R_{\text{out}}$ and $\text{SFR} \sim F_{\text{na}} \Rightarrow \eta \sim F_{\text{br}}/F_{\text{na}} v_{\text{out}}/R_{\text{out}}$

- From obs, $F_{\text{br}}/F_{\text{na}} \sim M_*^0 \Rightarrow \eta \sim M_*^0 v_{\text{out}}$

since $v_{\text{out}} \sim \text{SFR}^{0.3}$ and $\text{SFR} \sim M_*^{0.7}$

$$\Rightarrow \eta \sim M_*^{0.2} \quad \text{and} \quad \dot{M}_{\text{out}} \sim M_*^{0.9}$$

Summary

- In $z \sim 2$ SFGs, outflows are important on all spatial scales
- Strength of winds ($F_{\text{broad}}/F_{\text{narrow}}$) scales with Σ_{SFR} , M_* , SFR and inclination
- Above Σ_{SFR} threshold ($1 M_{\odot}/\text{yr}/\text{kpc}^2$), $F_{\text{broad}}/F_{\text{narrow}}$ constant with M_*
- High M_* galaxies responsible for most of outflowing mass:

$$M_{\text{out}} \sim M_*^{0.9}$$

