

# Inflows and outflows in high-redshift simulated galaxies



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# Inflows and outflows

- Determine
  - star formation
  - chemical evolution

# This talk

- Gas flows around star-forming galaxies at  $z \sim 2$  in a cosmological simulation.

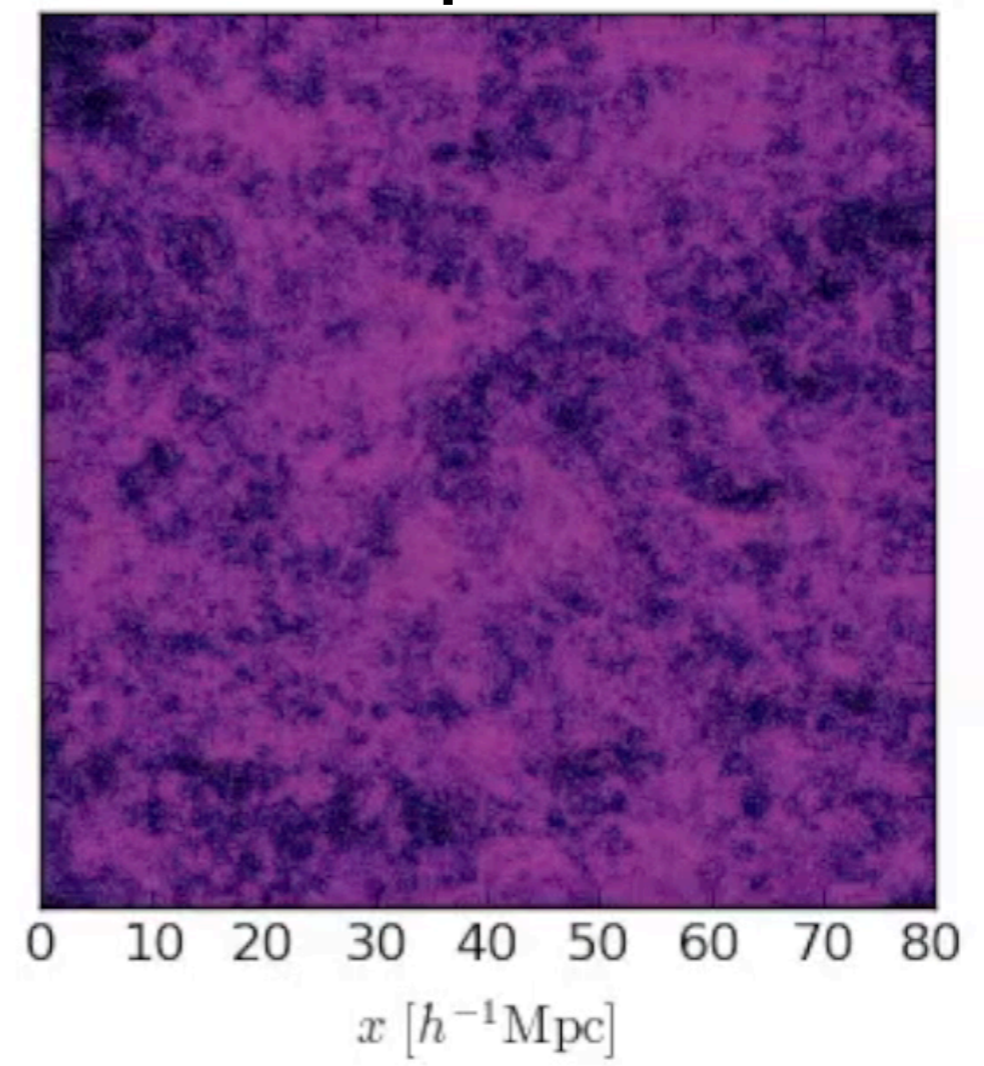
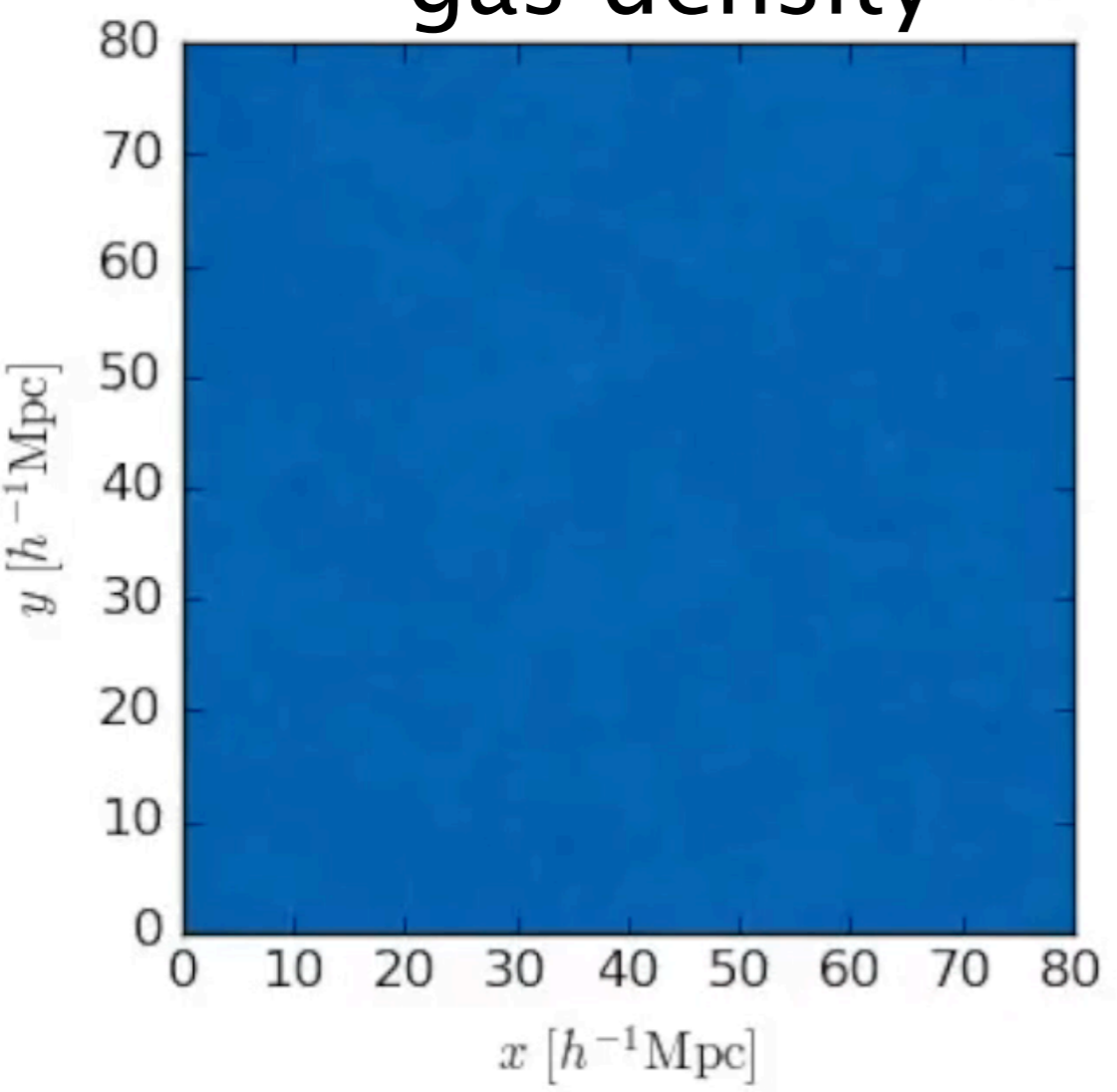
# Simulation

- High resolution version of cosmological simulations by Okamoto, Shimizu, Yoshida (2014: OSY14)
- OSY14 Reproduced many observed properties of galaxies from  $z = 4$  to 0.

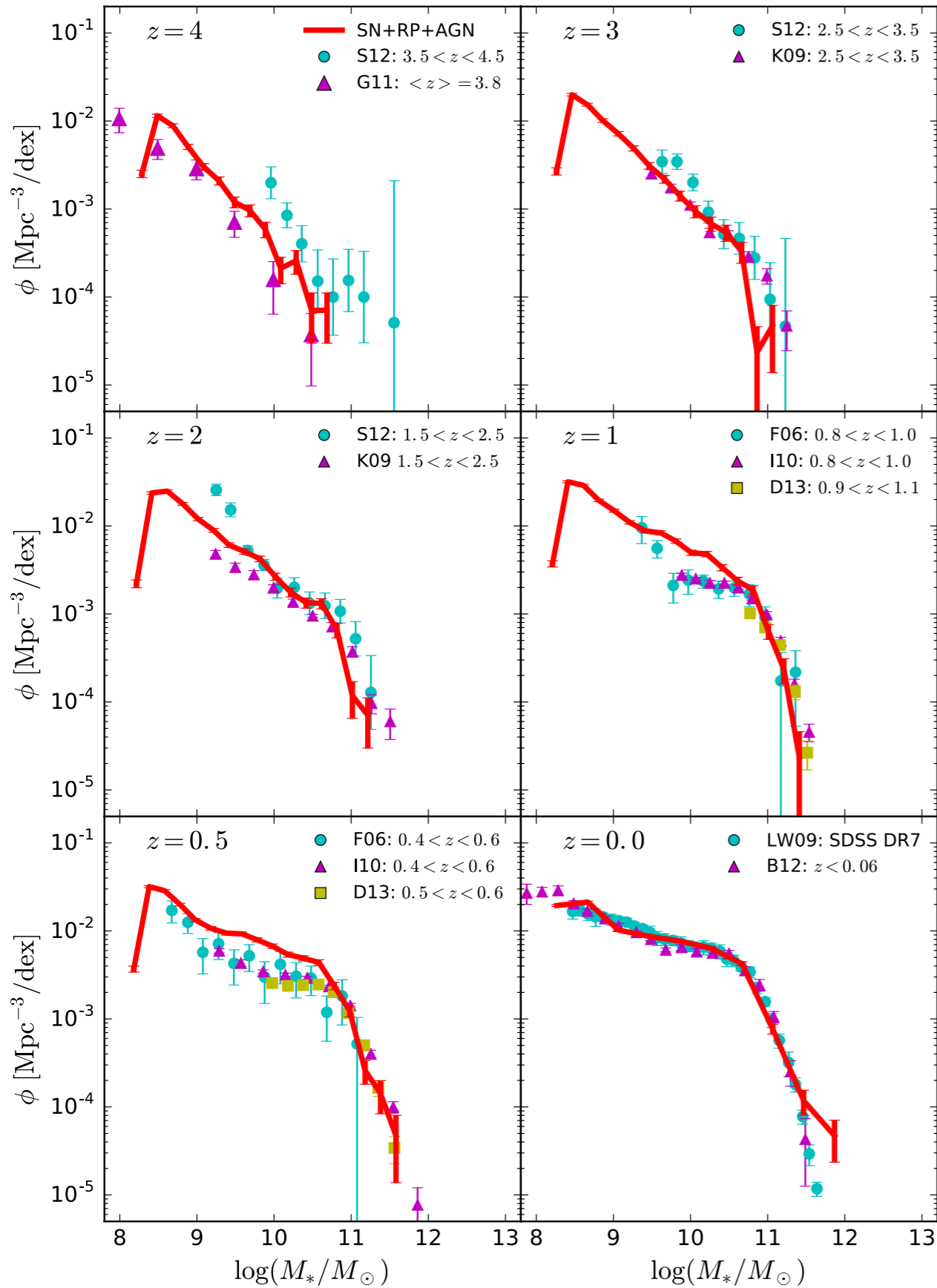




gas density  $z = 22.011$  temperature



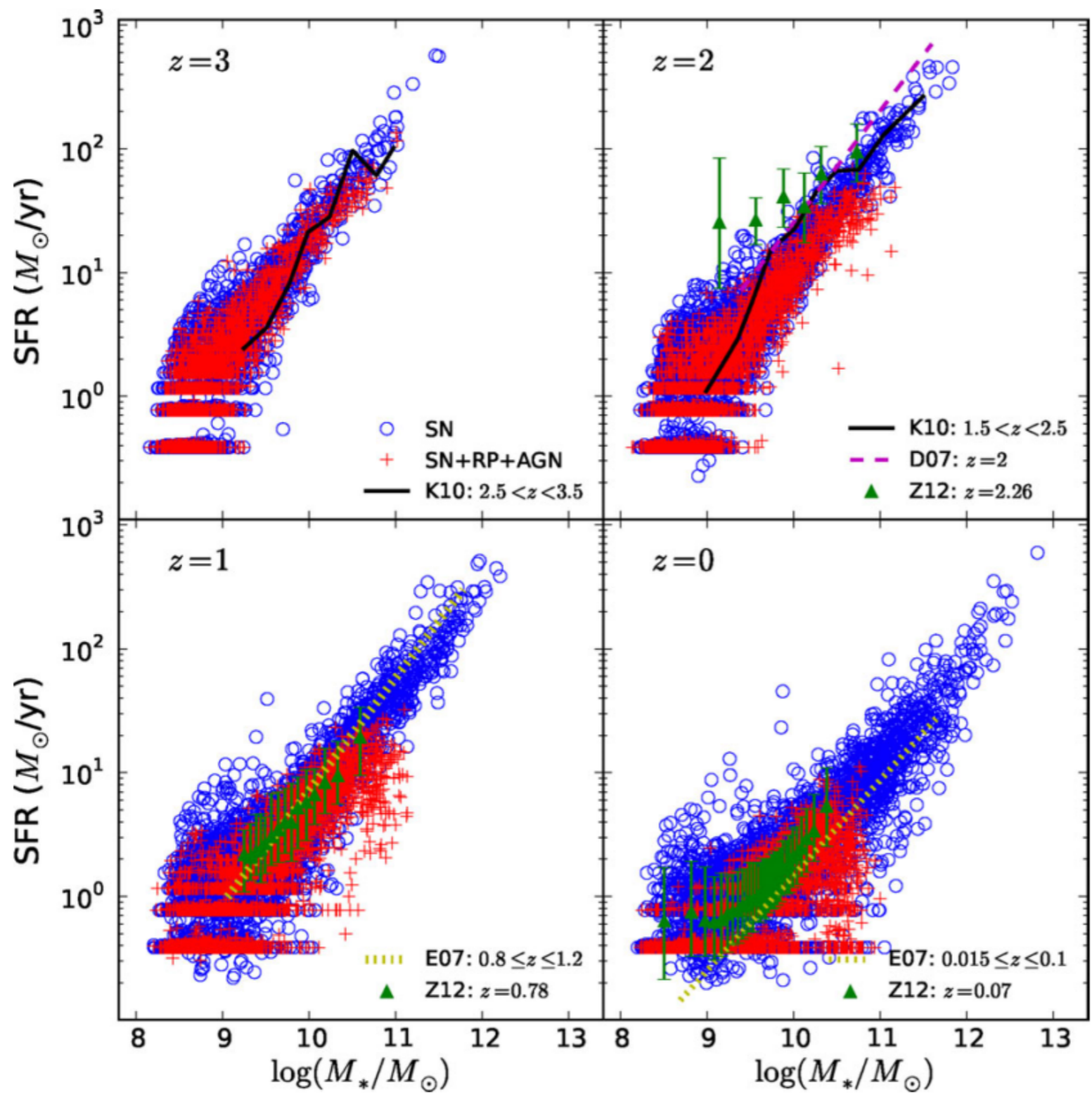
# Okamoto+'14



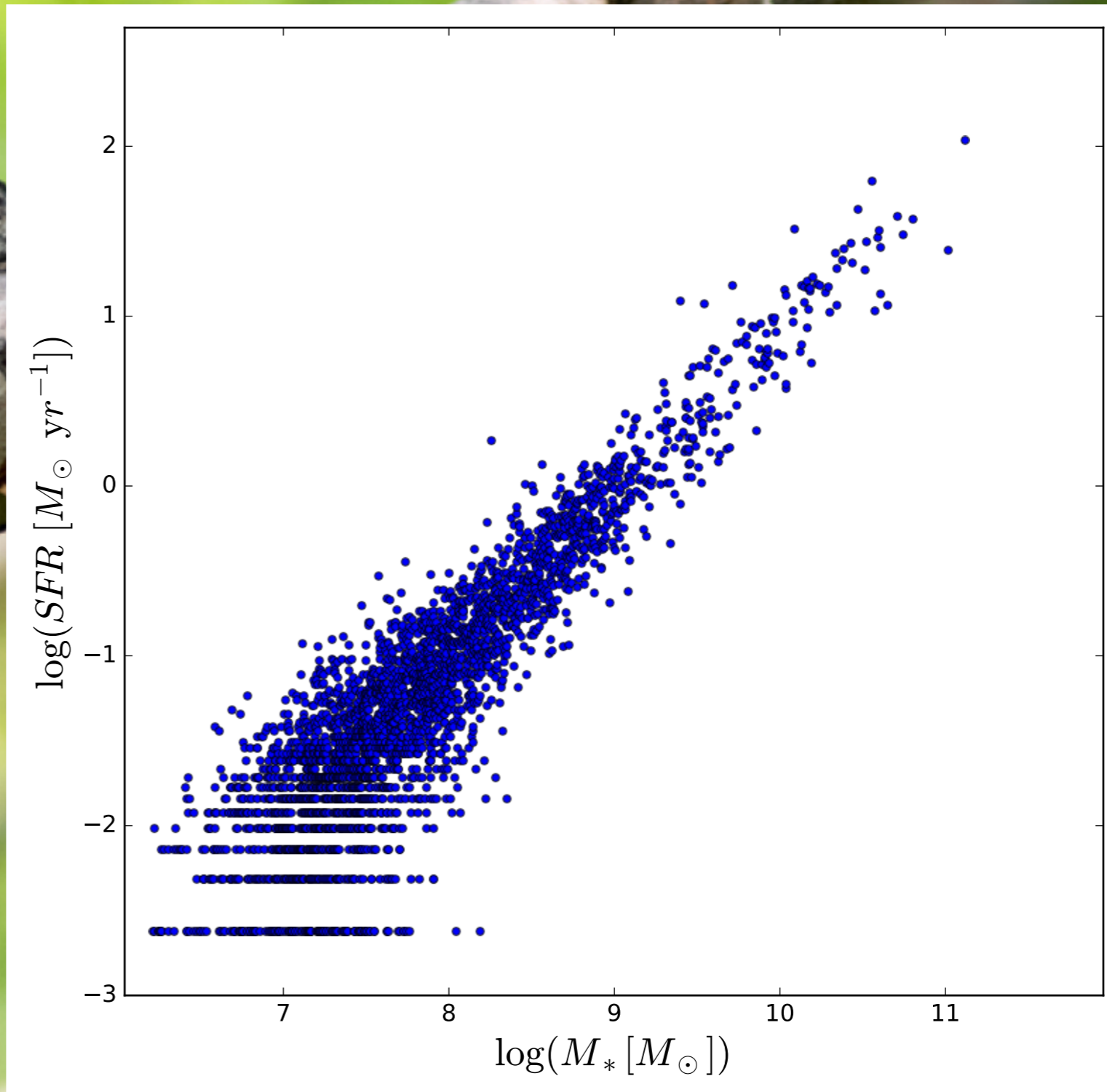
# Stellar mass functions



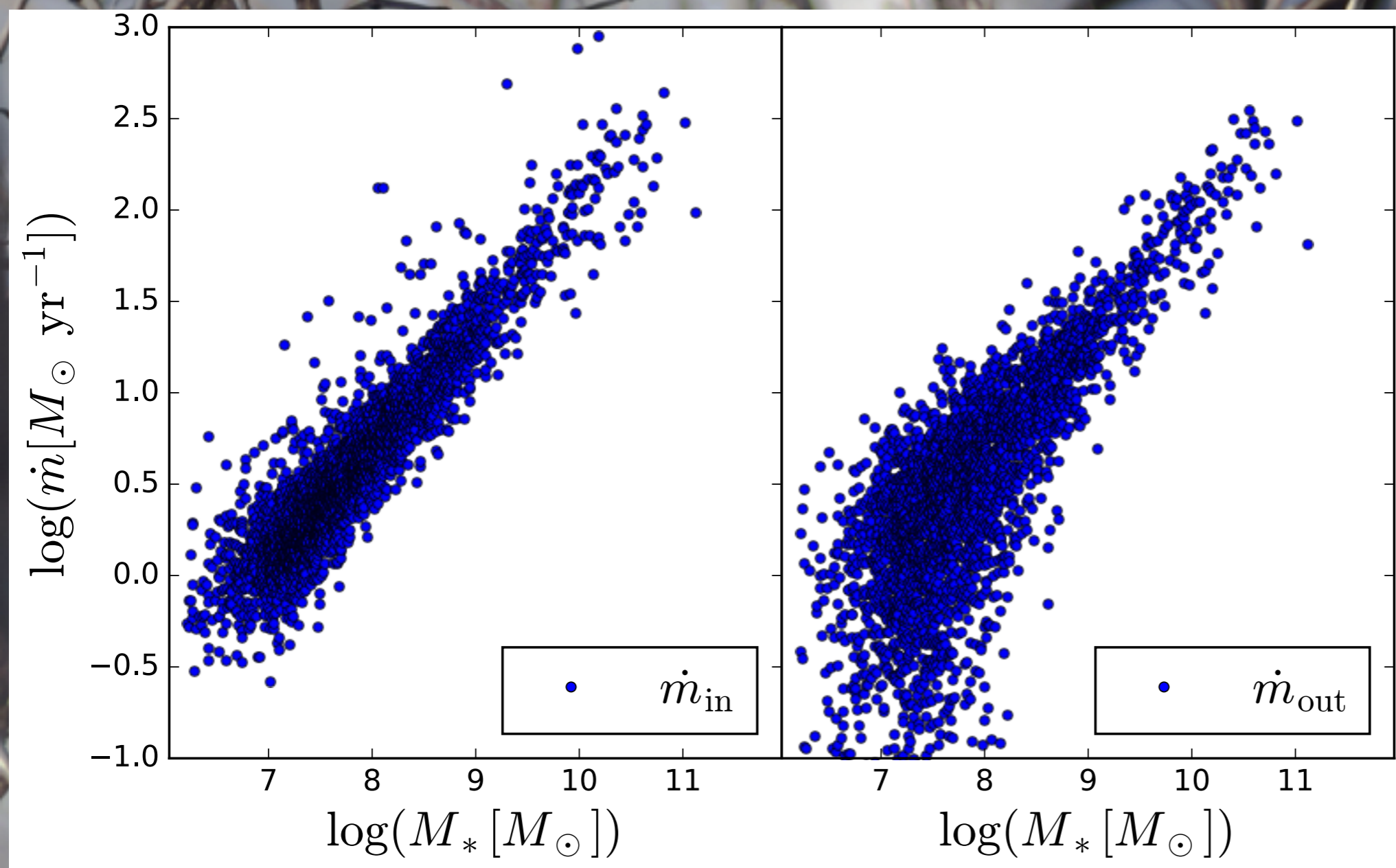
# SFR v.s. $M_\star$ ★



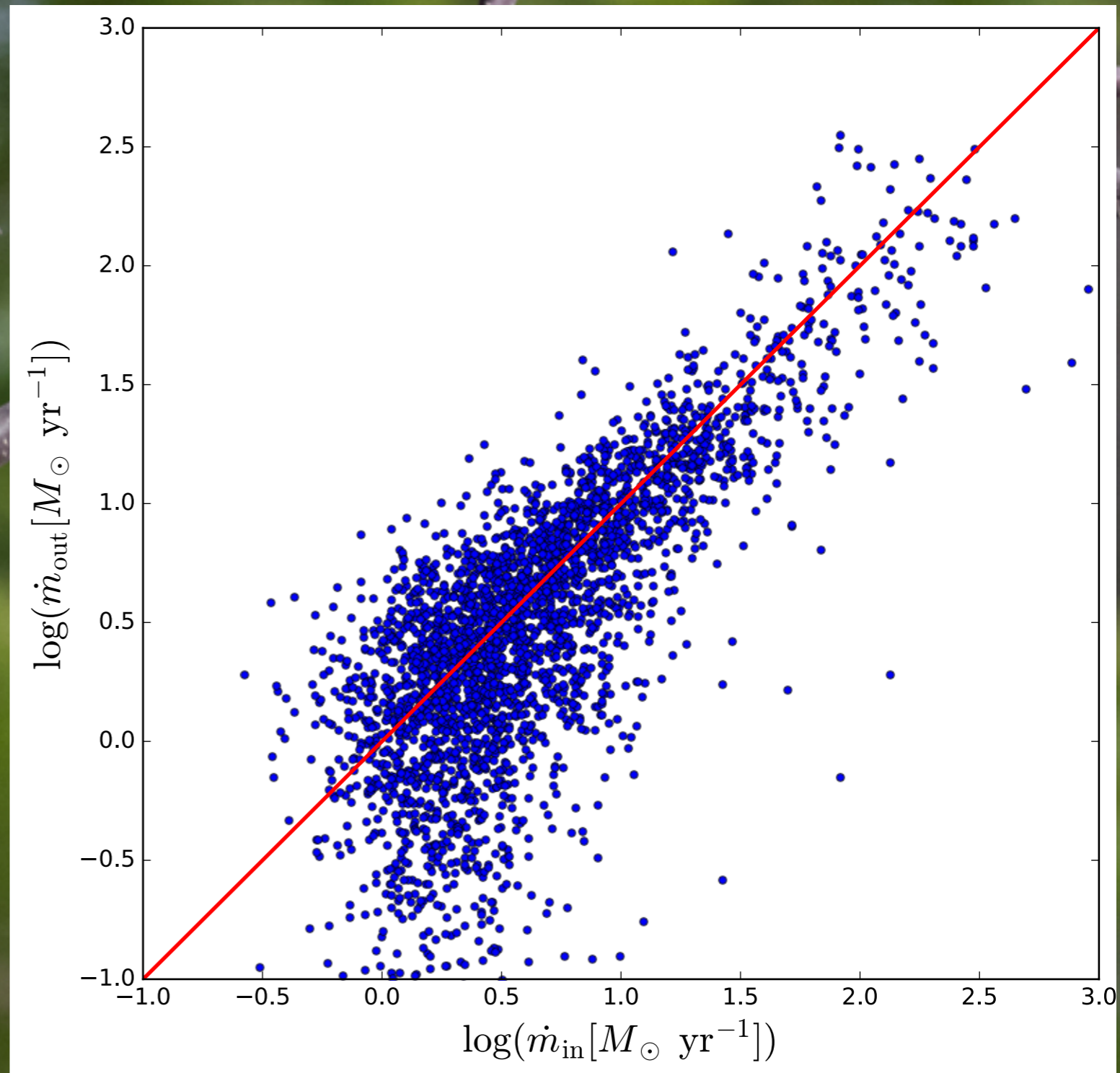
# Star-forming galaxies at $z = 2$



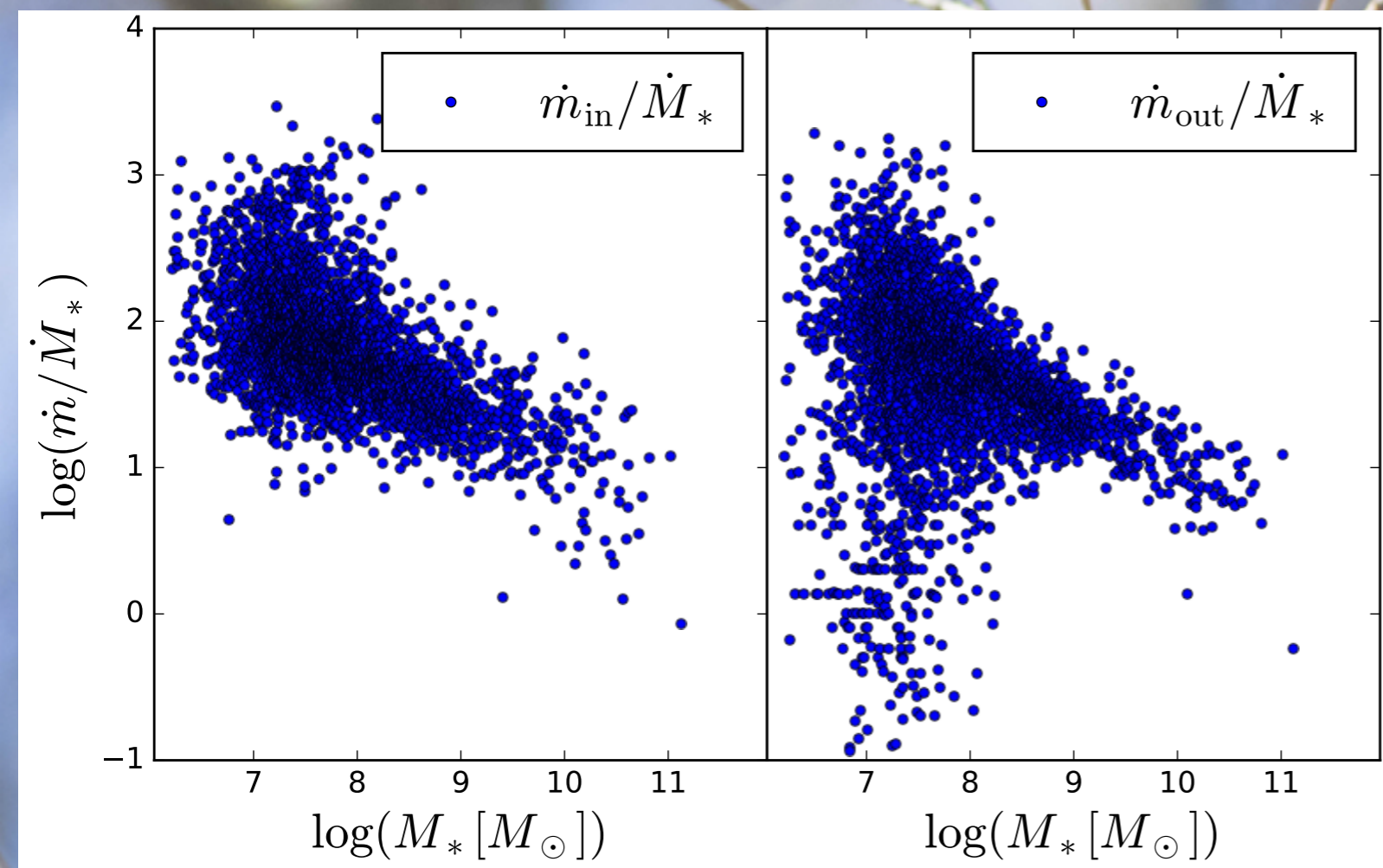
# Inflow and outflow rates at $R_{\text{vir}}/4$



# Inflow v.s. outflow

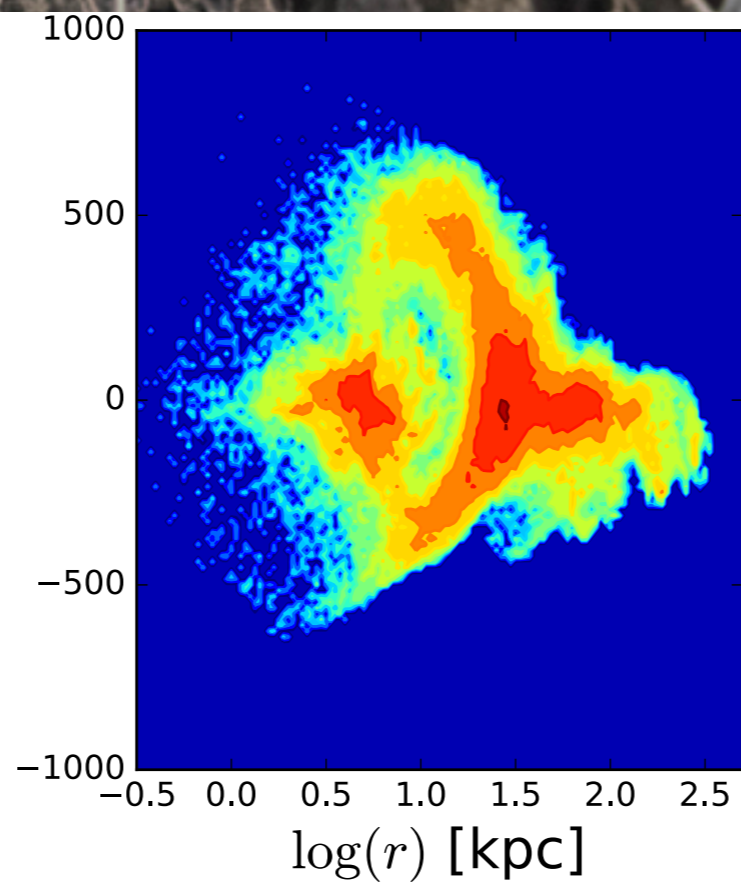
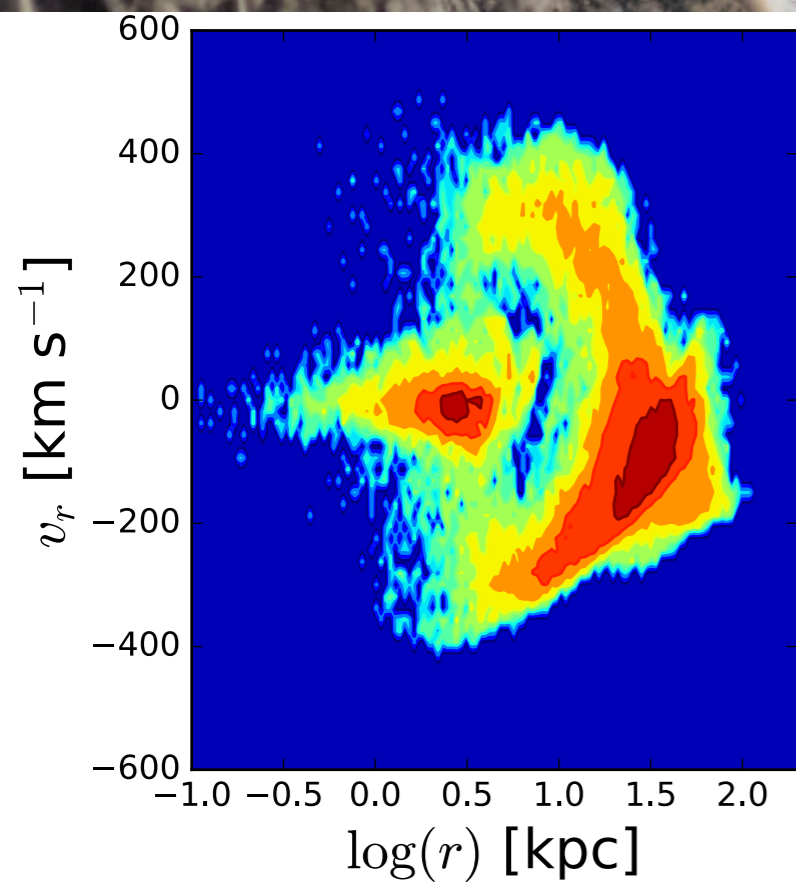


# Star formation efficiency and mass-loading



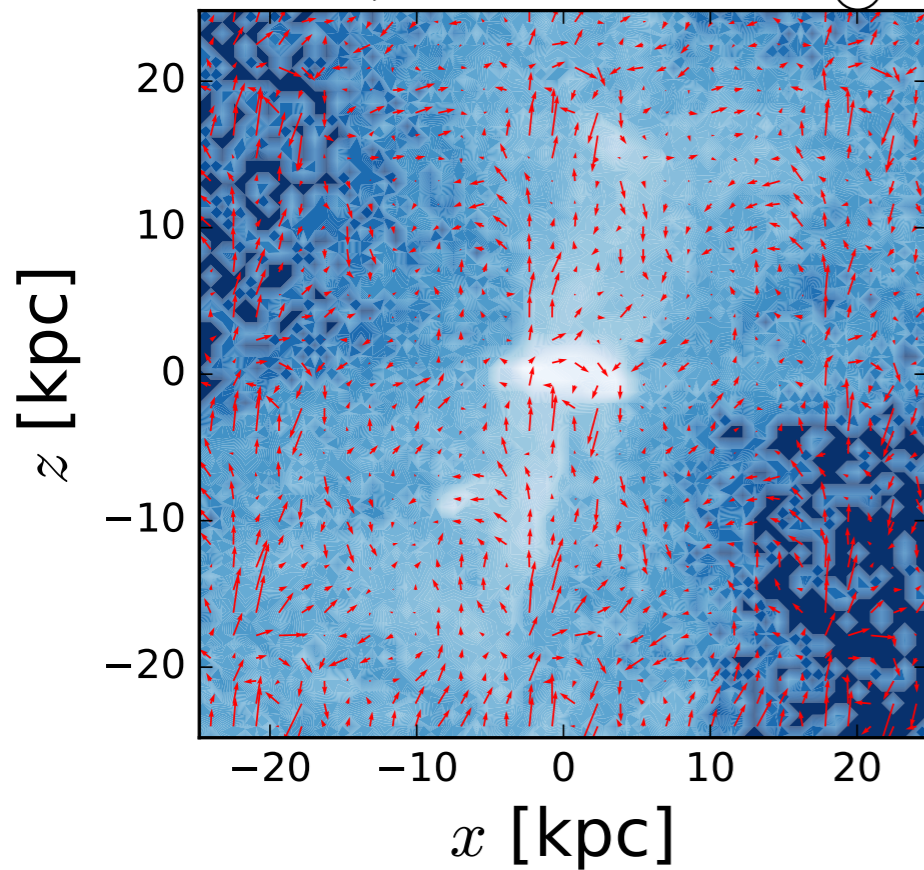
# Radial velocities in individual galaxies

$$M_* = 10^{10} M_\odot \quad M_* = 5 \times 10^{10} M_\odot$$

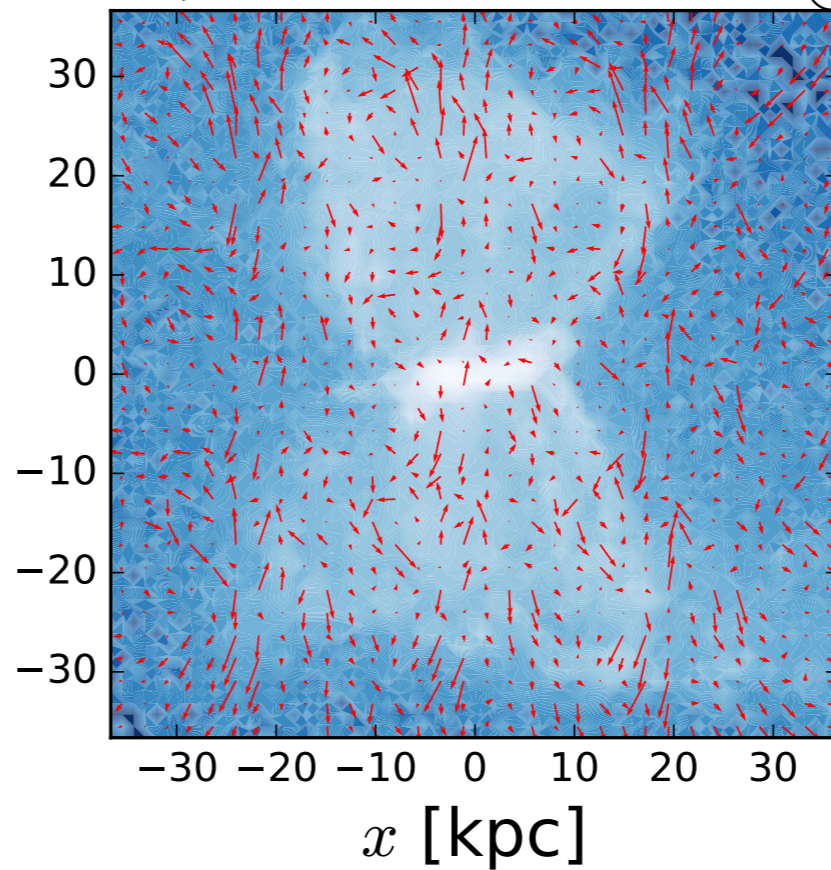


# Velocity maps

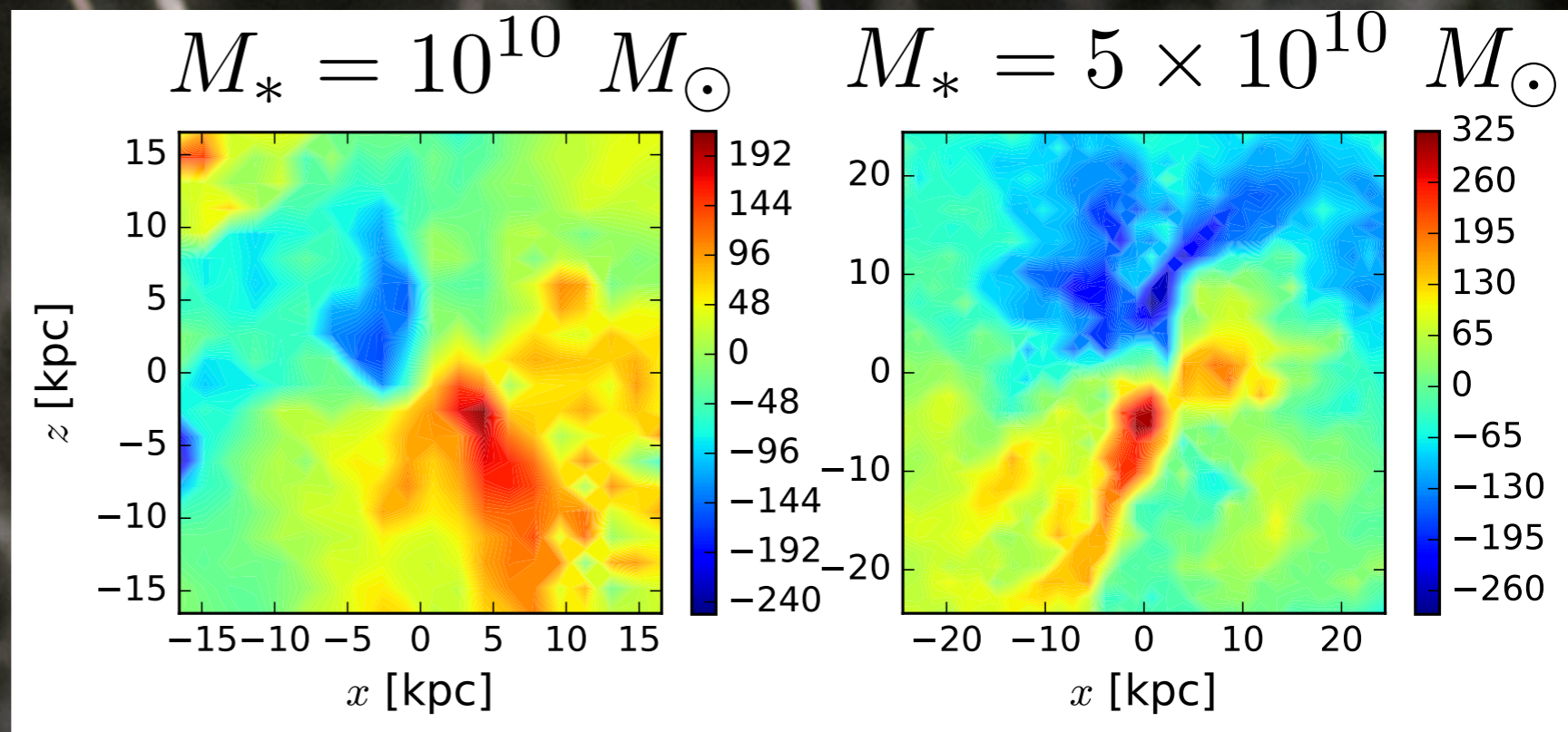
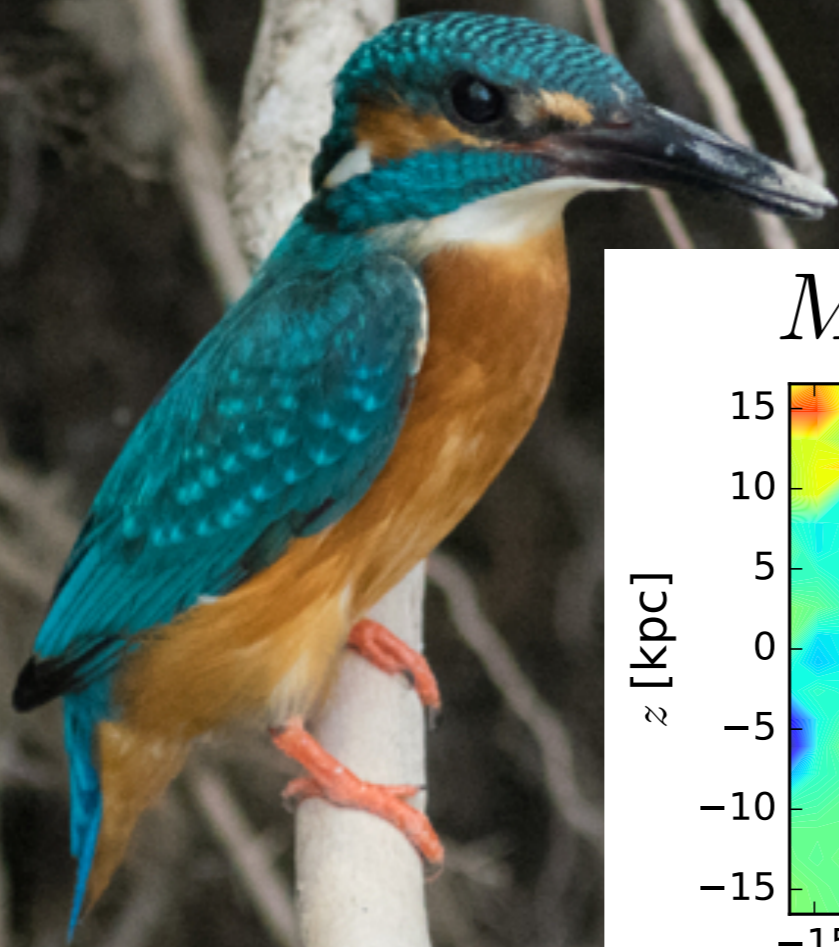
$$M_* = 10^{10} M_\odot$$



$$M_* = 5 \times 10^{10} M_\odot$$



# LOS velocity maps



# Answers to the questions

- A1 (key science)
  - Galaxy evolution at  $z = 1 \sim 3$
- A2 (Priority)
  - WFC
- A3 (GLAO+MOIRCS)
  - SFR & metallicity gradients in high- $z$  gals?
- A4 (Survey design)
  - (A) or (B)



# Questions to observers

- What type of simulations do you want?
  - Large box, relatively low resolution
  - Zoomed, high-resolution, a handful of galaxies
  - Milky Way-like
  - High- $\sigma$  regions
  - First galaxies & reionization
  - Quiet galaxies, do planets.



# Summary

- Inflows and outflows always coexist
- $\dot{m}_{\text{in}} \sim \dot{m}_{\text{out}}$
- Not easy to observationally constrain them