Gas & Stellar Properties of Galaxies in Cosmological Hydro Simulations

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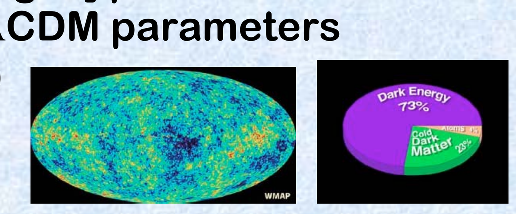
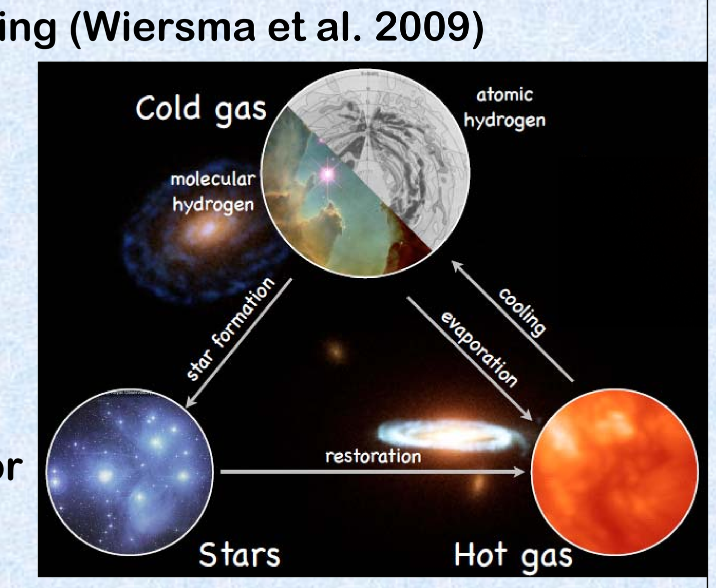
Numerical Methodology

- 3D code Gadget-3 : Tree-PM (gravity) + SPH (Springel 2005)
- Cosmological volume evolved using [DM + gas] particles
  - Start with gaussian $\Delta\rho$ at CMB epoch, ΛCDM parameters
  - Box $(25/h\ \mathrm{Mpc})^3$, from z = 99, up to z = 0

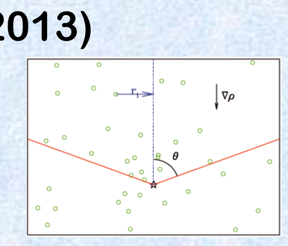


➢ Baryonic sub-resolution physics :

- Metal-line cooling, radiative heating (Wiersma et al. 2009)
- Star formation in multiphase ISM
  $\rho > \rho_{SF,th} = (0.01 - 0.13)\ \mathrm{cm}^{-3}$

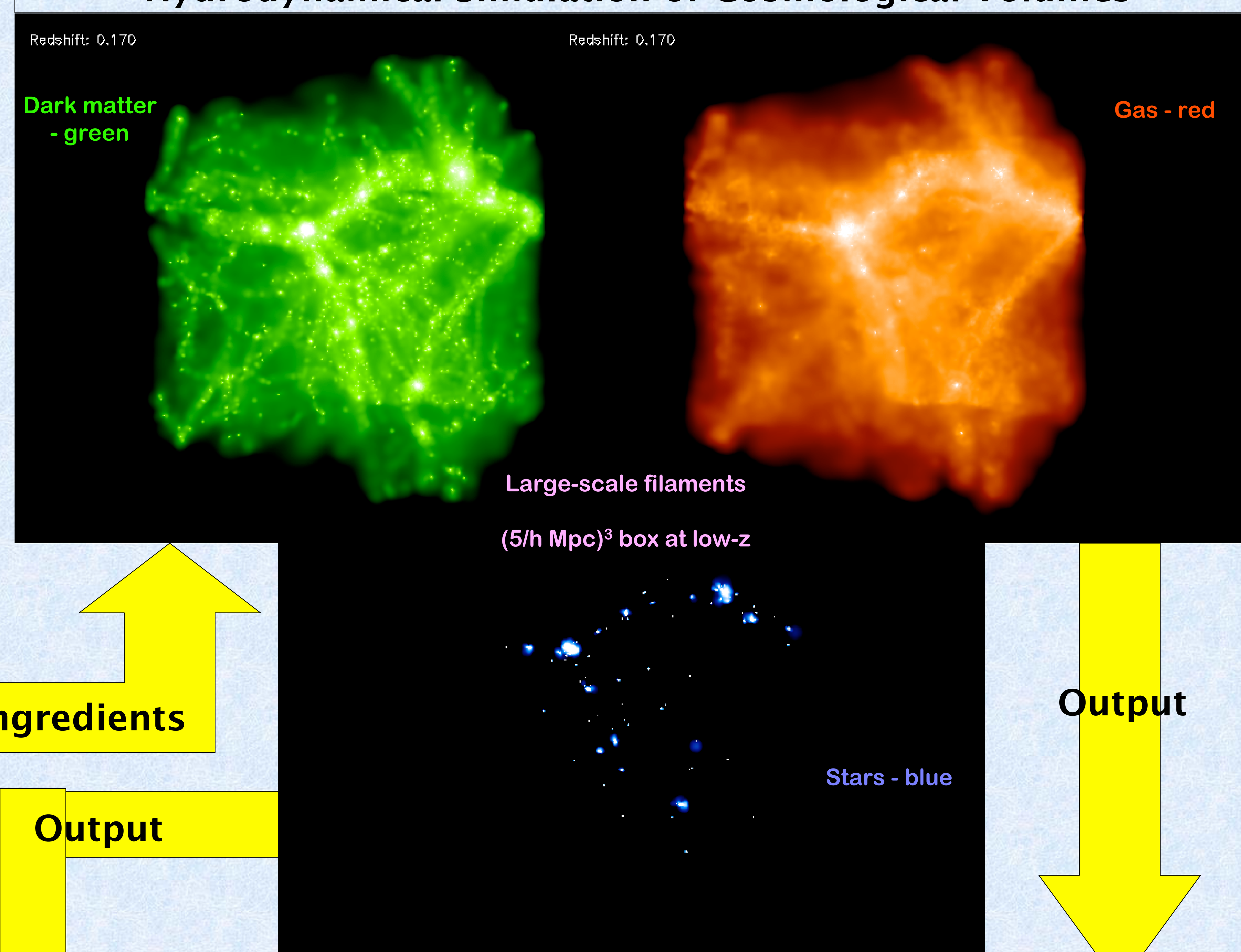


- Effective model
  - Springel & Hernquist (2003)
- MUPPI
  - MUlti-Phase Particle Integrator
  - Monaco (2004)
  - Murante et al. (2010)
  - ODEs numerically integrated within SPH timestep
- Chemical enrichment, metals: C, Ca, O, N, Ne, Mg, S, Si, Fe
  - Tornatore et al. (2007)
- Kinetic feedback from SNe-driven galactic outflows
  - Energy-driven constant-velocity wind
  - Radially varying wind (Barai et al. 2013)



- MUPPI : Distribution of thermal & kinetic energy using local properties, efficiency fraction, probability

Hydrodynamical Simulation of Cosmological Volumes

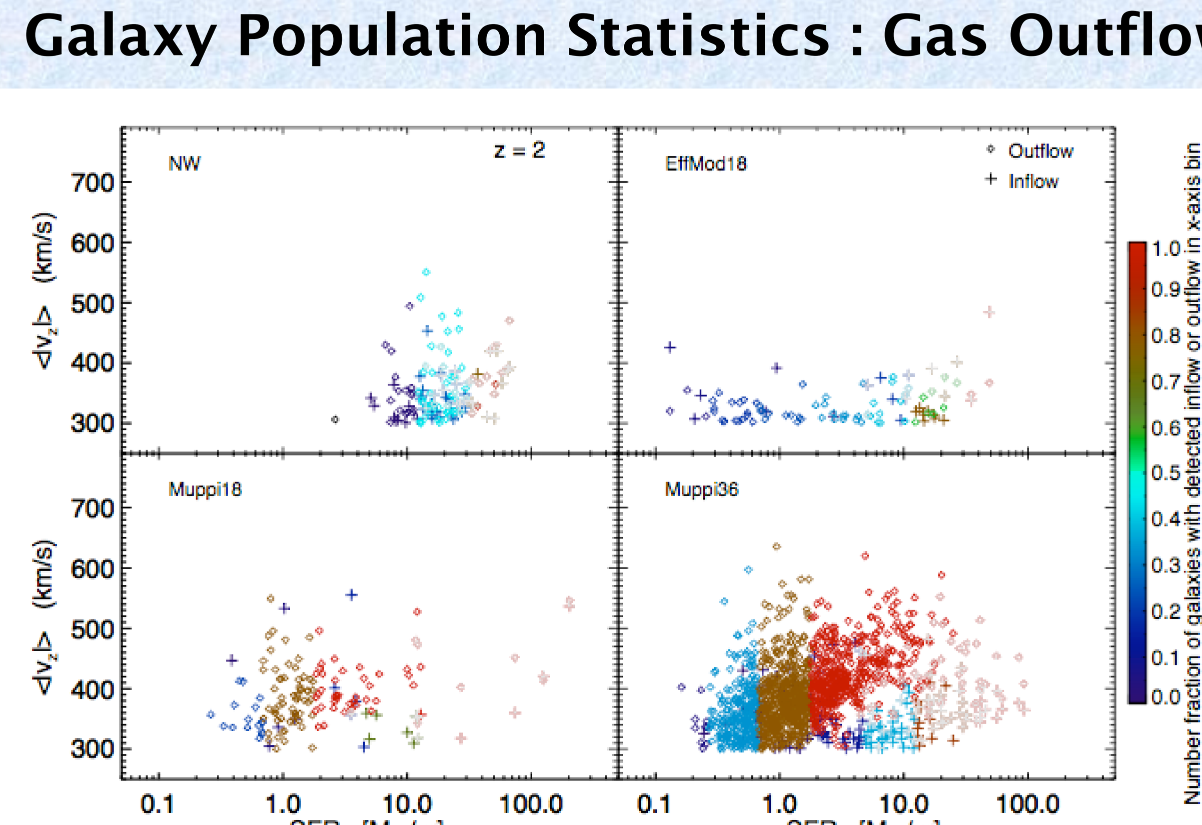


Ingredients

Output

Output

Galaxy Population Statistics : Gas Outflow Correlations



Outflow velocity vs. galaxy SFR at z=2.

MUPPI model exhibits a positive correlation
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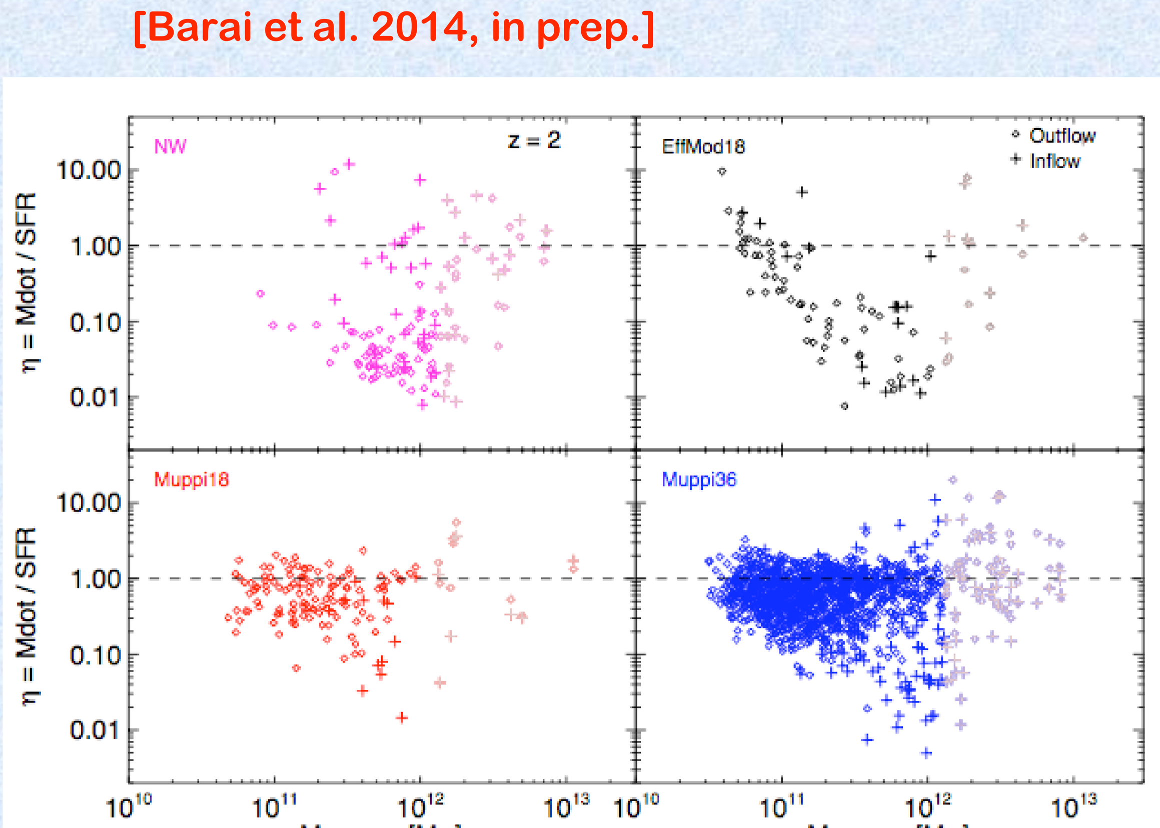
as seen in observations (e.g. Martin 2005, Banerji et al. 2011, Bordoloi et al. 2013).

[Barai et al. 2014, in prep.]

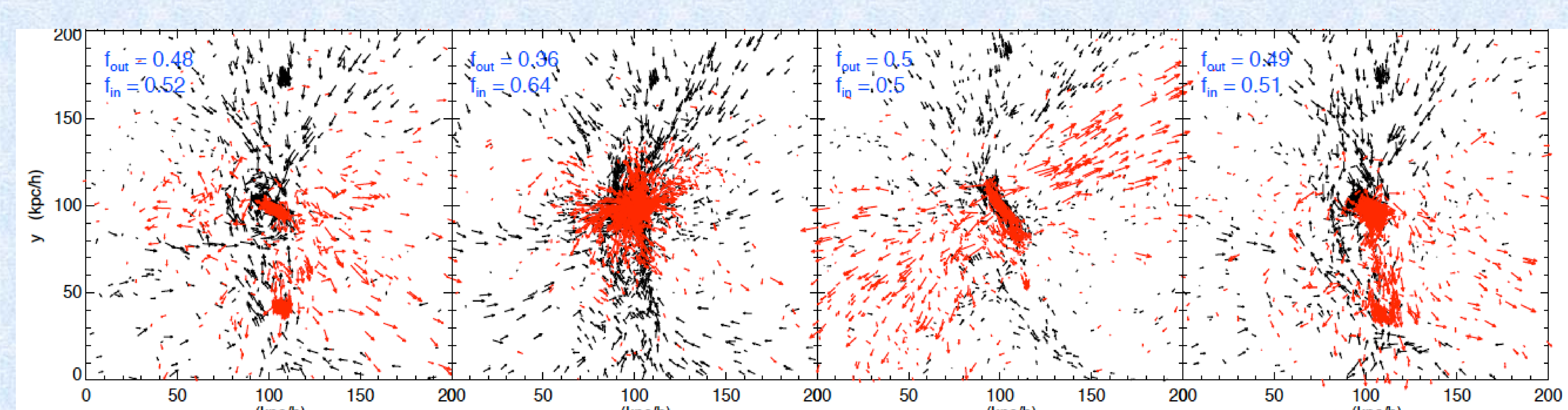
Outflow mass loading factor (η = mass outflow rate / SFR) vs. halo mass at z=2.

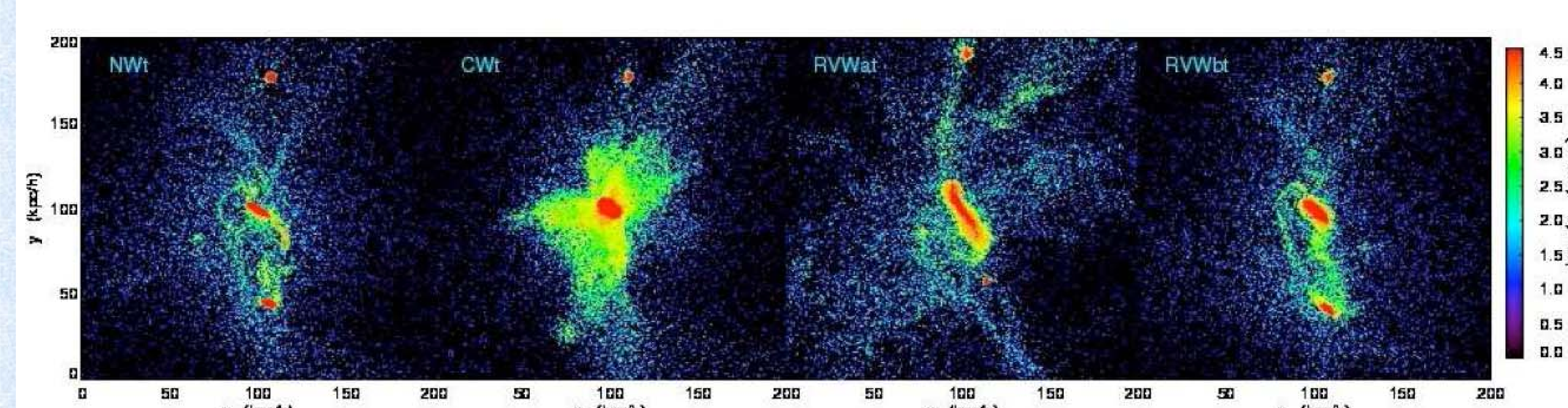
MUPPI model displays a constant-η scattered within values of [0.2 - 2]

η range consistent with observations (eg. Pettini et al. 2002, Bradshaw et al. 2013).

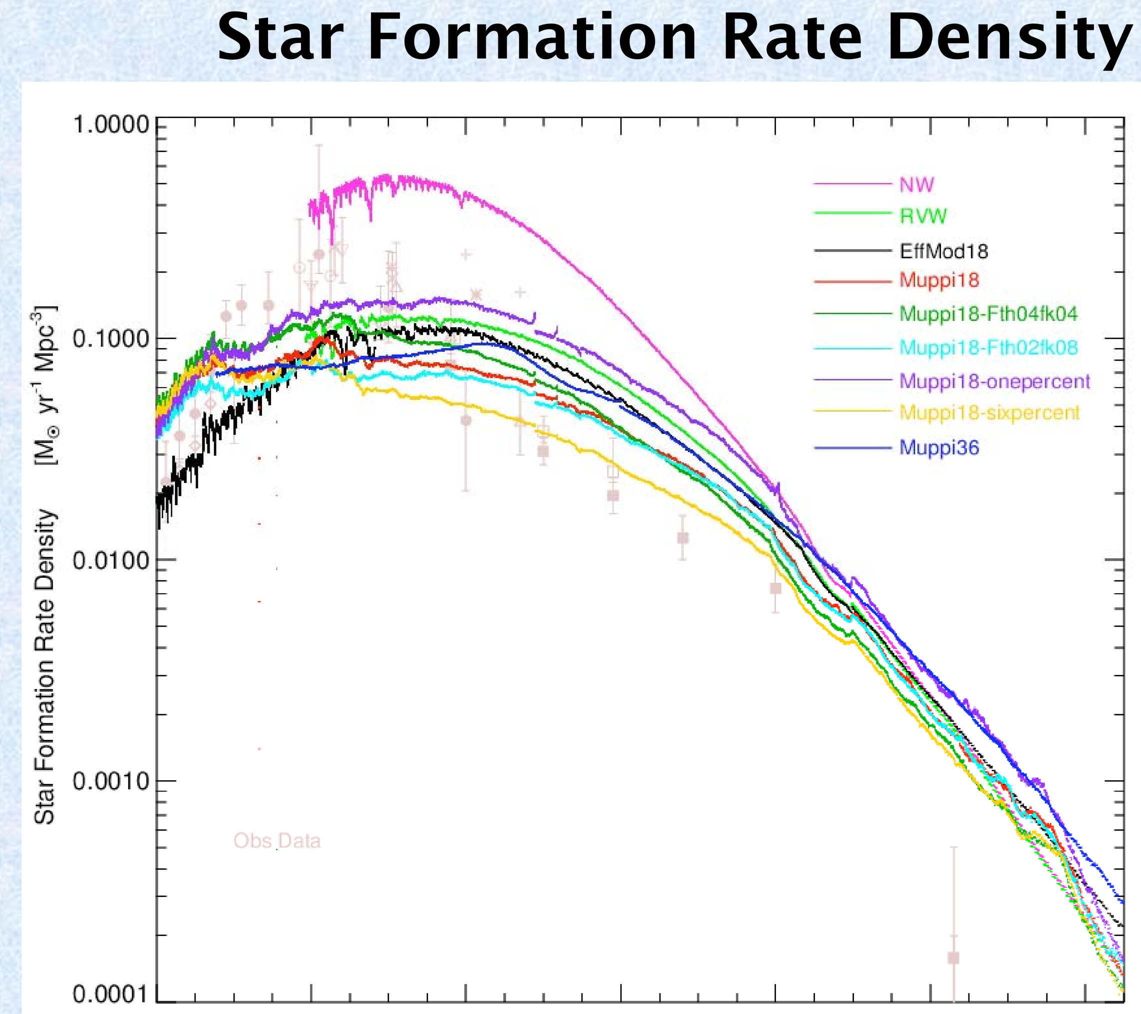


Single Galaxy : Morphology





Star Formation Rate Density (SFRD) Evolution



SFRD in whole simulation volume as a function of redshift.
The respective SF/SNe feedback models labeled by the colors.

The grey symbols and error bars denote observational data from different studies.

Kinetic SNe feedback (in the form of galactic wind) has significant impact on SFRD, reducing SFR several times depending on the feedback efficiency parameters.

References

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