Mass assembly of galaxies: Smooth accretion versus mergers

L'Huillier, Combes, & Semelin, A&A, 2012, 544, A68

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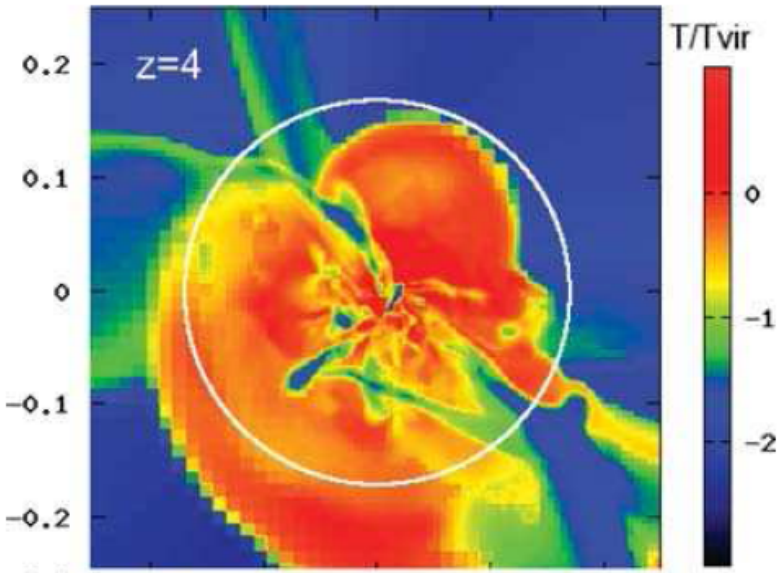
Galaxy Formation

Galaxy Formation

- Two modes of galaxy growth:
  - Mergers of galaxies (hierarchical model),
  - Accretion of gas from the intergalactic medium.
- Kereš et al (2005): two modes of accretion
  - Hot, isotropic, spherical at low z for massive galaxies (in groups and clusters)
  - Cold mode along filaments at all z for small galaxies, and only at high z for massive systems



Lengths in h^{-1} Mpc
(Birnboim & Dekel 2006)

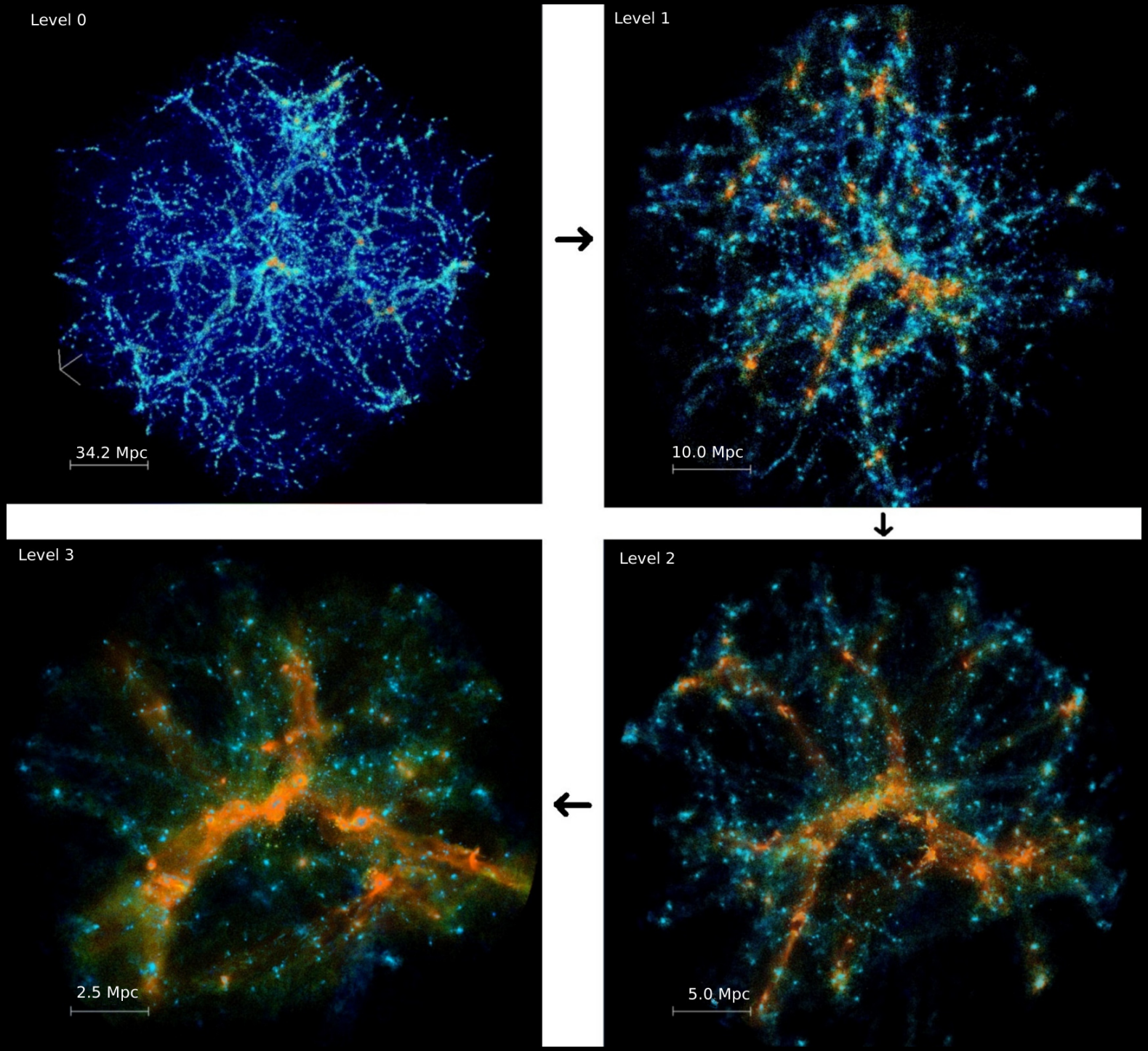
Galaxy Mass Assembly: Merger vs Smooth Accretion

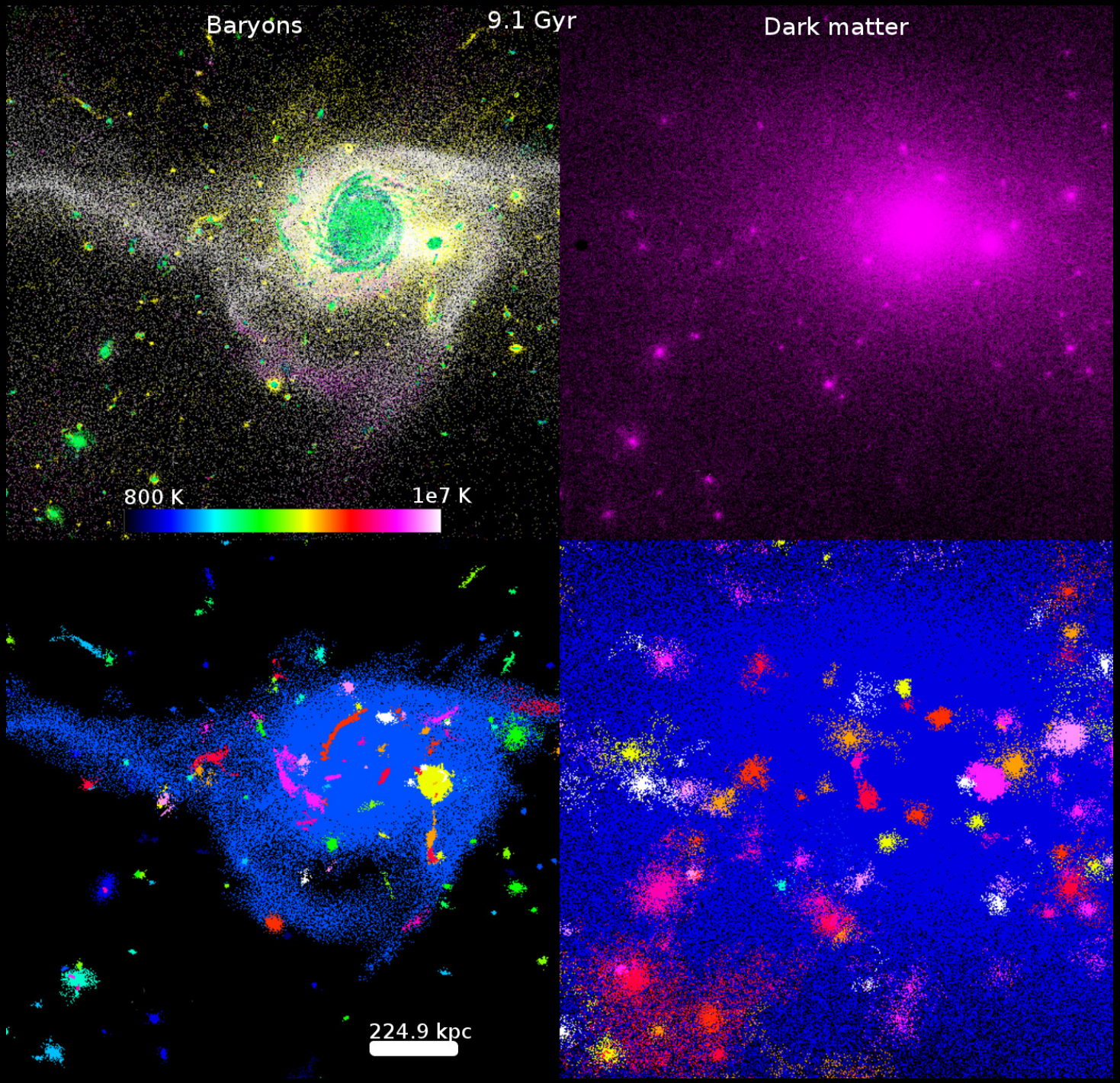
with Françoise Combes and Benoît Sémelin, A&A, 2012, 544, A68

- Baryonic mass assemby: quantify the mass assembled by mergers and accretion
  - Large dynamical range ($\simeq 100h^{-1}\mathrm{Mpc}$ to $\lesssim 1h^{-1}\mathrm{kpc}$): need for zoom simulations
  - Detection of structures at each timestep (AdaptaHOP, Aubert et al 2004)
  - Time tracking: build *merger trees* (Tweed et al 2009)
- Downsizing: massive galaxies have older stars (e.g. Cowie et al 1996). Is it inconsistent with the hierarchical structure formation model?
  - Simulations allow to study the star formation history

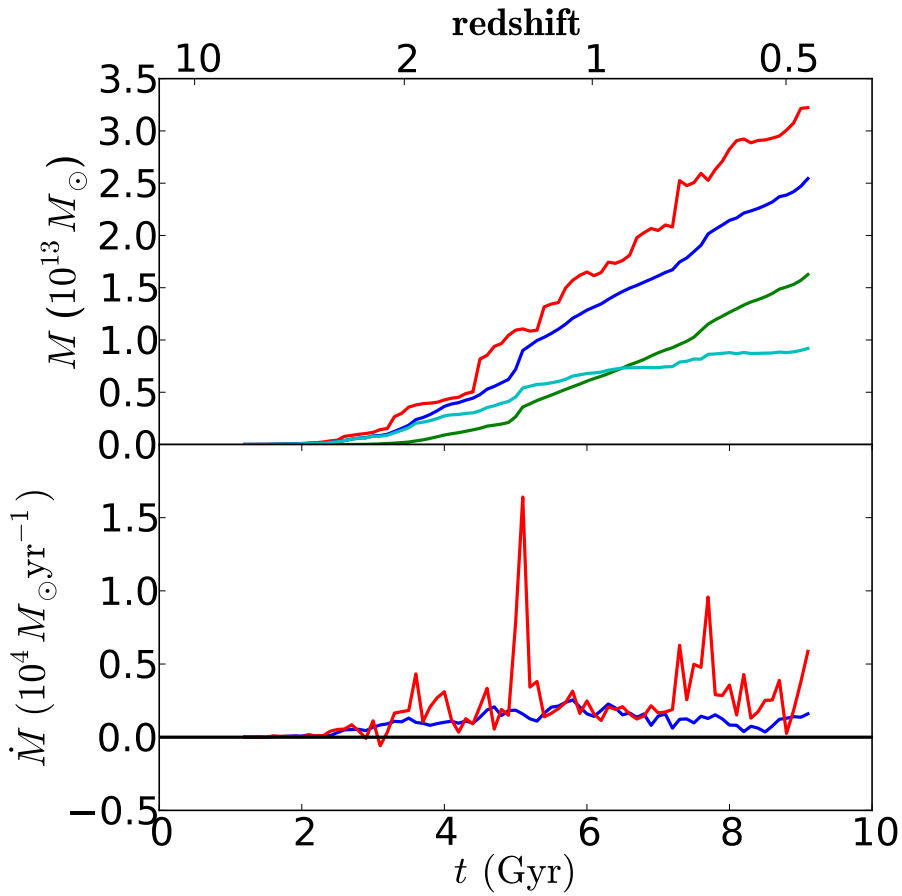
Simulations

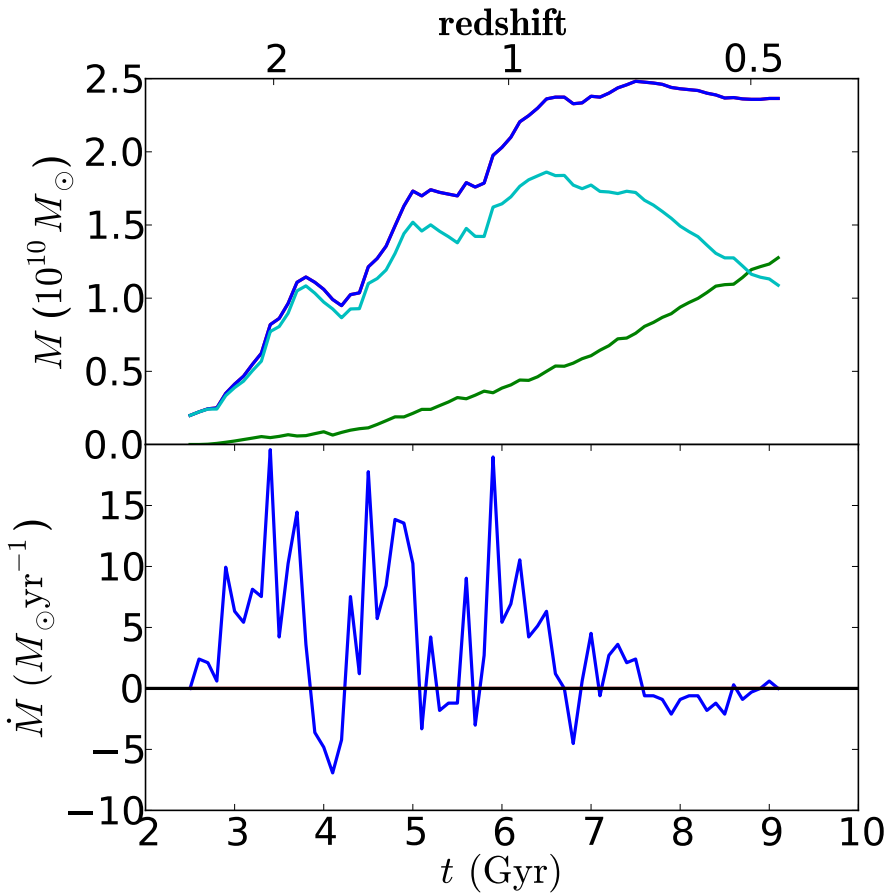
- Simulations: TreeSPH multi-zoom code (Semelin & Combes 2002; 2005)
  - Low resolution cosmological simulation ($N_p = 128^3$, $L_0 = 137\,\mathrm{Mpc}$)
  - Resimulation: length resolution $\times 2$, mass resolution $\times 8$
  - 4 zoom levels, centered on a dense environment ($\simeq 15 \times \bar{\rho}$ at $z = 0.46$.)
  - At the 4^{th} level: $L_3 = 8.56\,\mathrm{Mpc}$, $m_{\mathrm{DM}} = 1.4 \times 10^8\,\mathrm{M}_\odot$; $m_{\mathrm{b}} = 3 \times 10^7\,\mathrm{M}_\odot$ (equivalent to 1024^3 particles).
  - In each level: DM, stars and gas particles
  - WMAP3 cosmology
  - Baryonic physics: Star formation, SN feedback, no AGN feedback


Level 0
34.2 Mpc
Level 1
10.0 Mpc
Level 2
5.0 Mpc
Level 3
2.5 Mpc


Baryons
9.1 Gyr
Dark matter
800 K
1e7 K
224.9 kpc

Mass history of individual galaxies

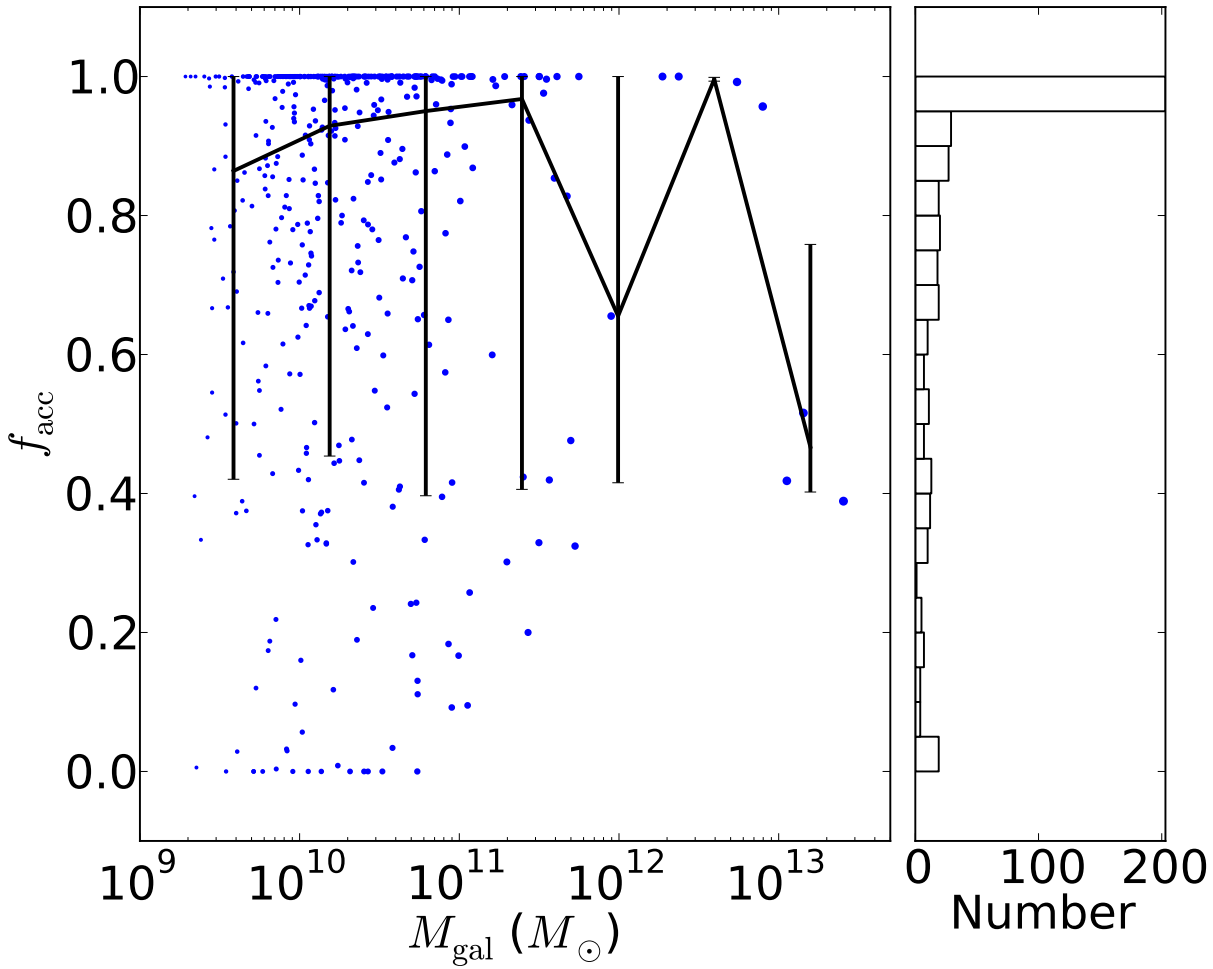




Top: Galaxy + Satellites; Galaxy; Stars; Gas

Bottom: Merger; Accretion

Mergers vs Accretion Fractions

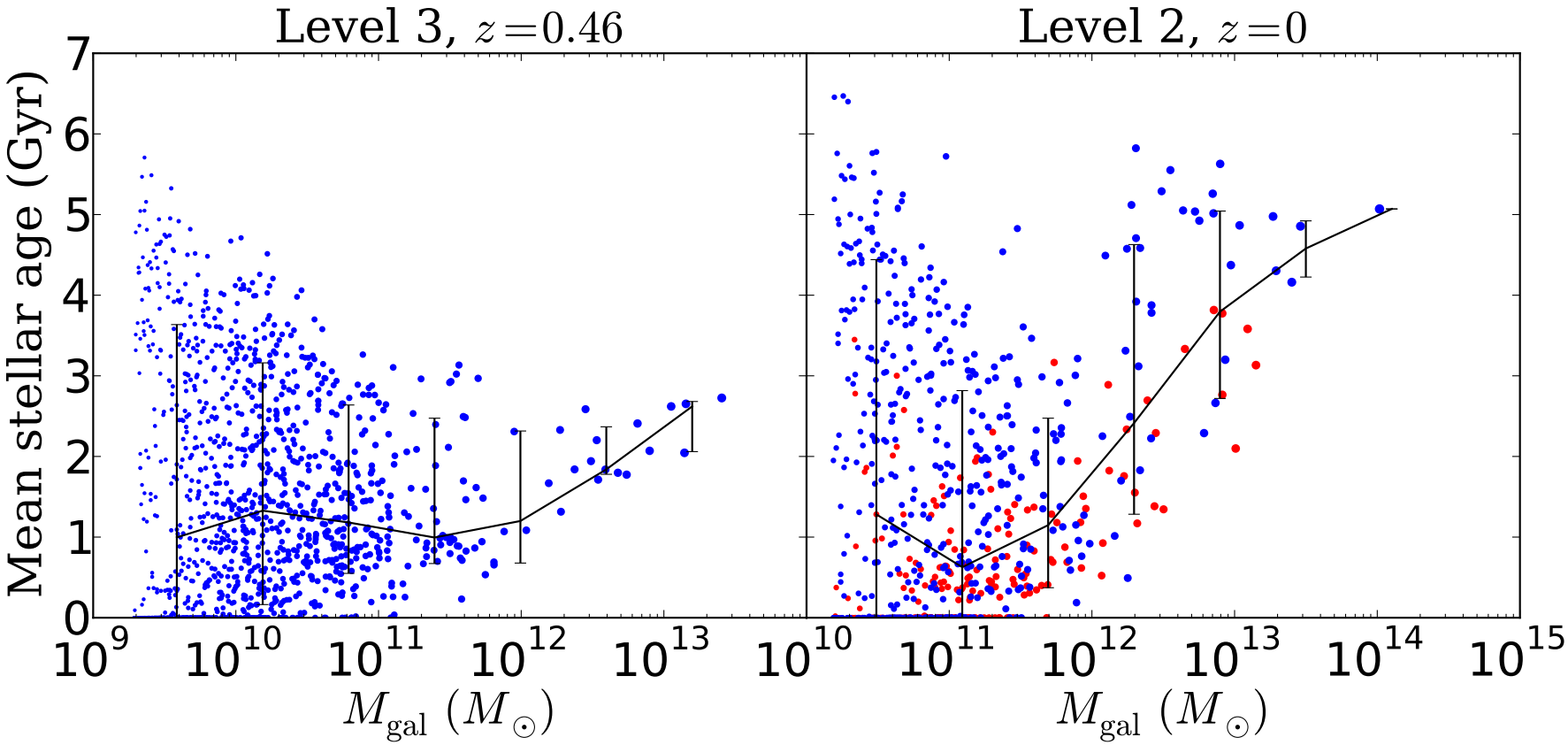


$$f_{\rm acc} = \frac{\text{accretion}}{\text{accretion} + \text{merger}}$$

530 galaxies followed from 7.0 to $9.1\,\mathrm{Gyr}$

median accretion fraction: 92%

Downsizing



Red: Galaxies of level 2 outside from level-3 box

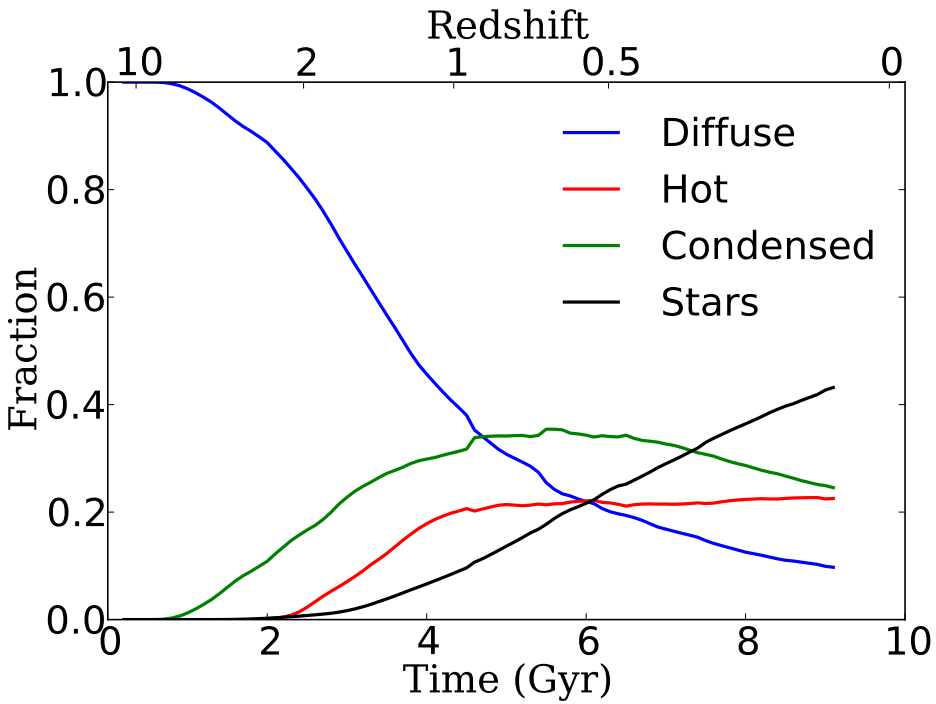
Massive galaxies formed their stars early

Low-mass galaxies form stars at all epoch

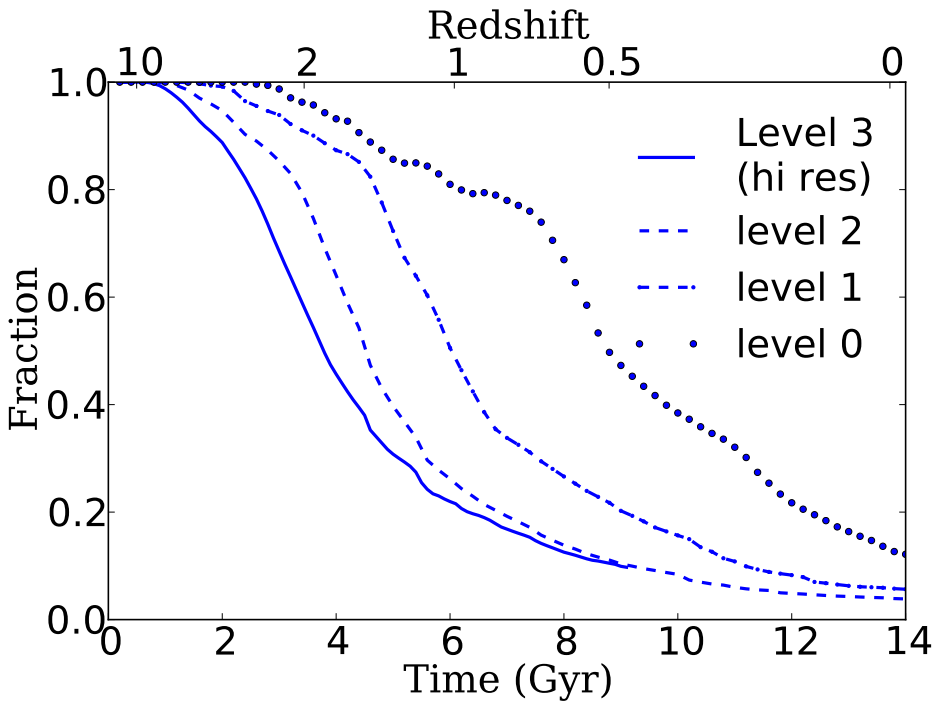
Baryon phases

Evolution of the baryon phases within the level-3 box

Evolution



Effects of resolution



Condensed: $\rho/\bar{\rho}_{\mathrm{b}} > 1000$, $T < 10^5\,\mathrm{K}$

Diffuse: $\rho/\bar{\rho}_{\mathrm{b}} < 1000$, $T < 10^5\,\mathrm{K}$

Hot: $T > 10^5\,\mathrm{K}$

Convergence between levels 2–3

Project: simulating the Sloan Great Wall

with Juhan Kim & Changbom Park

- Constrained hydrodynamical simulations using Gadget-3 (Springel 2005)
- Aim to reach percent level accuracy
- Right now: Study of the initial conditions
  - Starting redshift?
  - Glass or grid configuration?
  - 1^{st} or 2^{nd} order of perturbation theory?
  - Comparison Gadget-3 & GOTPM

Conclusion & Perspectives

Conclusions

- Galaxy formation: importance of gas accretion
  - Agreement with previous work (e.g. Kereš et al 2005;2009, Van der Voort et al 2011)
  - Consequences on morphology
- Downsizing observed in simulations

Perspectives

- Comparison with the *N*-body only simulation: work in progress
  - Backreaction of baryons & gas dynamics
  - Mass function, triaxiality & concentration of the haloes, ...
- Exploring the role of SN & AGN feedback
  - AGN feedback needed to obtain realistic masses (overcooling)
  - Baryonic physics can change the accretion fraction (outflows)
  - Need to study deeper the effect of feedback