Comparatively Inefficient Star Formation in Simulated Dwarf Galaxies: *Divergent evolution*

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Evolution

- *Q: How do dwarf galaxies evolve in contrast to spiral galaxies?*

Evolution

- *Q: How do galaxies of different masses evolve?*
- Simulated "similar" galaxies, a dwarf and a low-mass spiral
  - Same initial conditions
  - Scaled down spatially by a factor of **2**
  - Scaled down in mass by a factor of **8**
  - Resulting in the same density

Gasoline (Wadsley, et al., 2003)

- SPH code with
  - Cosmic UV background radiation
  - H & He ionization
  - **Metal line cooling** (Shen+ 2010)
  - Metal diffusion
  - **Star formation**
  - **Supernovae feedback (blastwave)** (Stinson+ 2006)
  - **Molecular Hydrogen** (Christensen+ *submitted*)

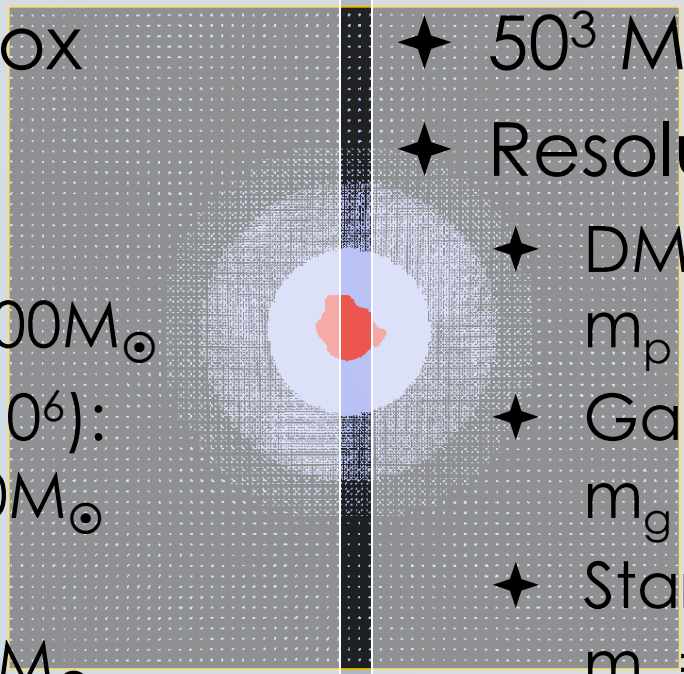
- Which reproduces
  - **Damped Lyman-α systems** (Pontzen et al., 2008, 2010)
  - **Mass-metallicity relation** (Brooks et al., 2007)
  - Broken exponential disks in spirals (Roskar et al., 2008)
  - Tully-Fisher relation (Governato et al., 2007)
  - **Realistic rotation curves in dwarfs** (Governato et al., 2010)
  - Reduced bulge mass in spiral galaxies (Guedes et al., 2011)
  - Change the angular momentum distribution (Brook et al., 2011, Pontzen et al., 2011)
  - …

Implementing Molecular Hydrogen

- H_2 abundances per particle
  - Integrated through simulation (Gnedin et al., 2009)
  - Based on local formation and destruction rates
  - Non-equilibrium
- Shielding of H_2 and HI
- Lyman-Werner Radiation
- Other gas-phase physics: H_2 cooling, collisional dissociation, formation via H^-
- H_2-based star formation

Initial Conditions

- Dwarf Galaxy
- 25^3 Mpc^3 Box
- Resolution
  - DM (10^7): $m_p = 16{,}000 M_\odot$
  - Gas (6×10^6): $m_g = 3300 M_\odot$
  - Star: $m_s = 1000 M_\odot$
  - Spatial Resolution: ~60 pc in disk



- Spiral Galaxy
- 50^3 Mpc^3 Box
- Resolution
  - DM (10^7): $m_p = 128{,}000 M_\odot$
  - Gas (6×10^6): $m_g = 25{,}000 M_\odot$
  - Star: $m_s = 8000 M_\odot$
  - Spatial Resolution: ~100 pc in disk

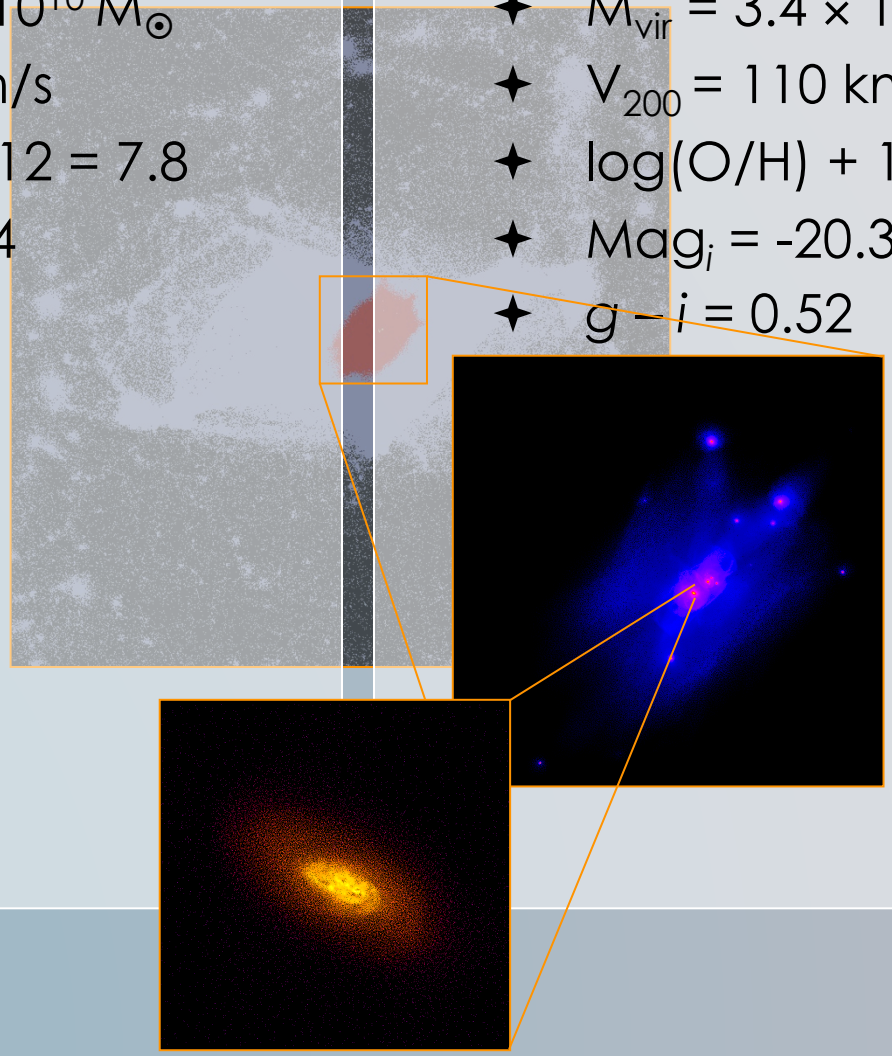
Final State at z = 0

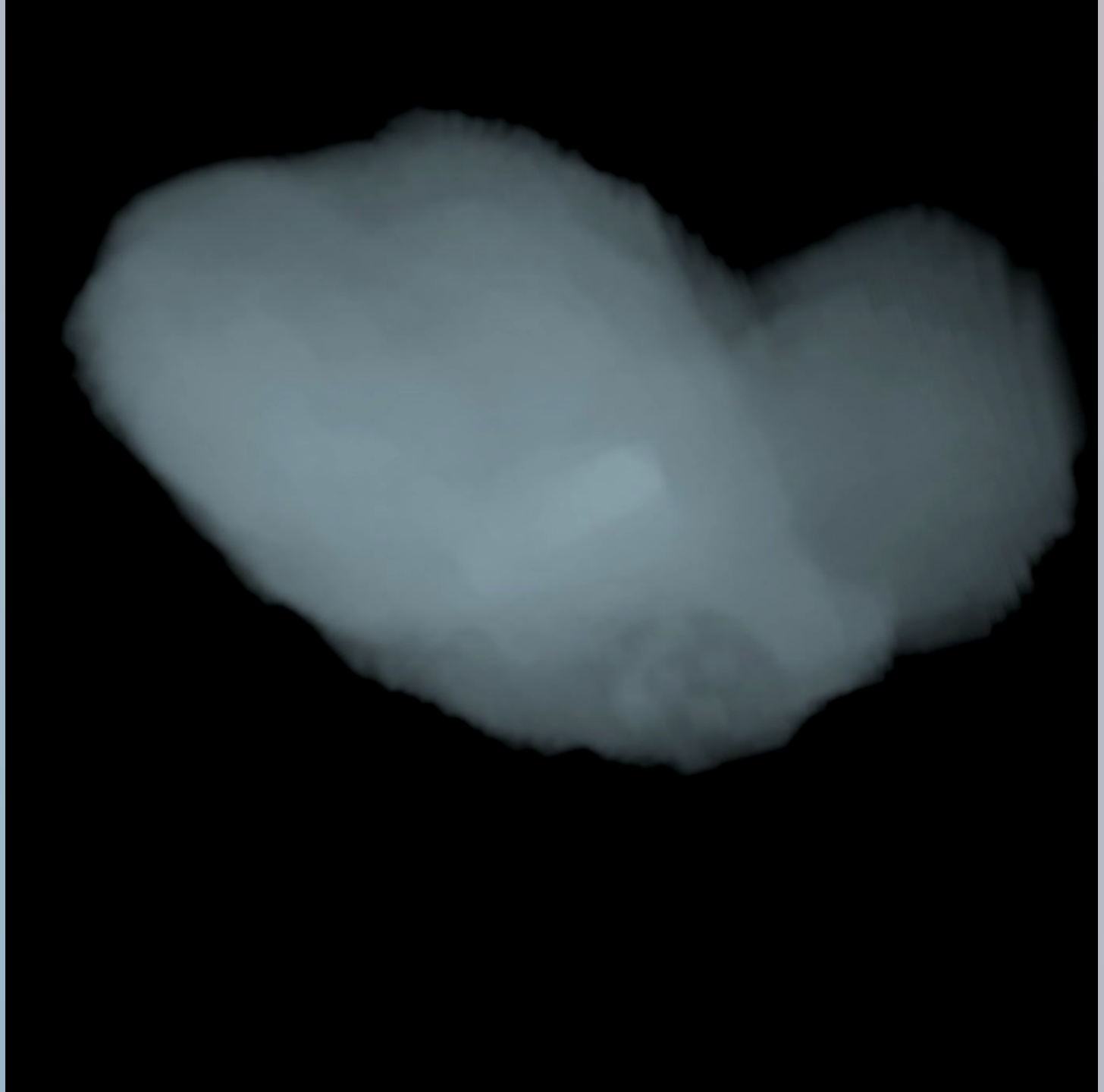
Dwarf Galaxy

- $M_{vir} = 3.8 \times 10^{10}\ M_{\odot}$
- $V_{200} = 60$ km/s
- log(O/H) + 12 = 7.8
- $Mag_i = -16.4$
- $g - i = 0.42$

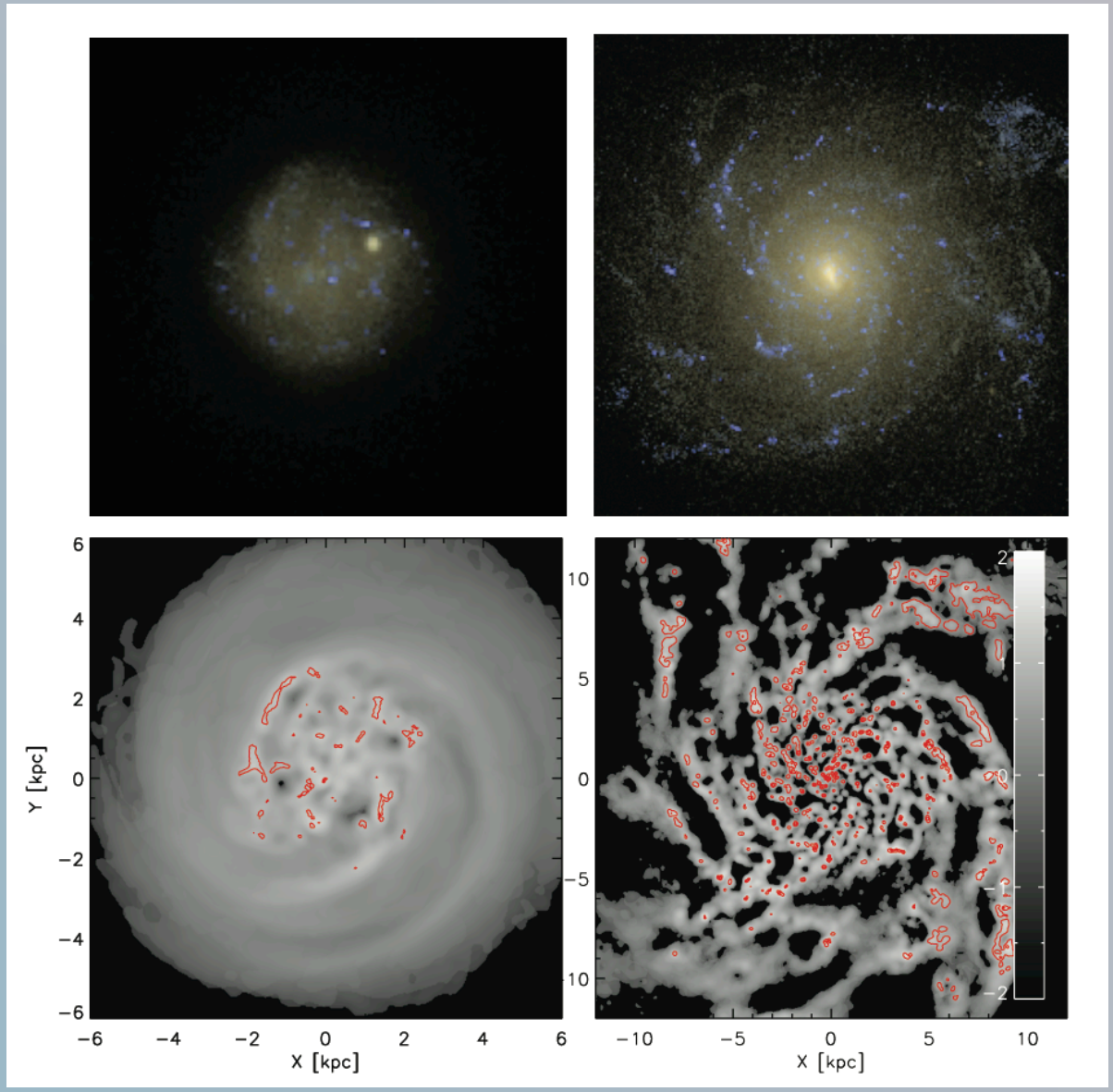
Spiral Galaxy

- $M_{vir} = 3.4 \times 10^{11}\ M_{\odot}$
- $V_{200} = 110$ km/s
- log(O/H) + 12 = 8.5
- $Mag_i = -20.3$
- $g - i = 0.52$



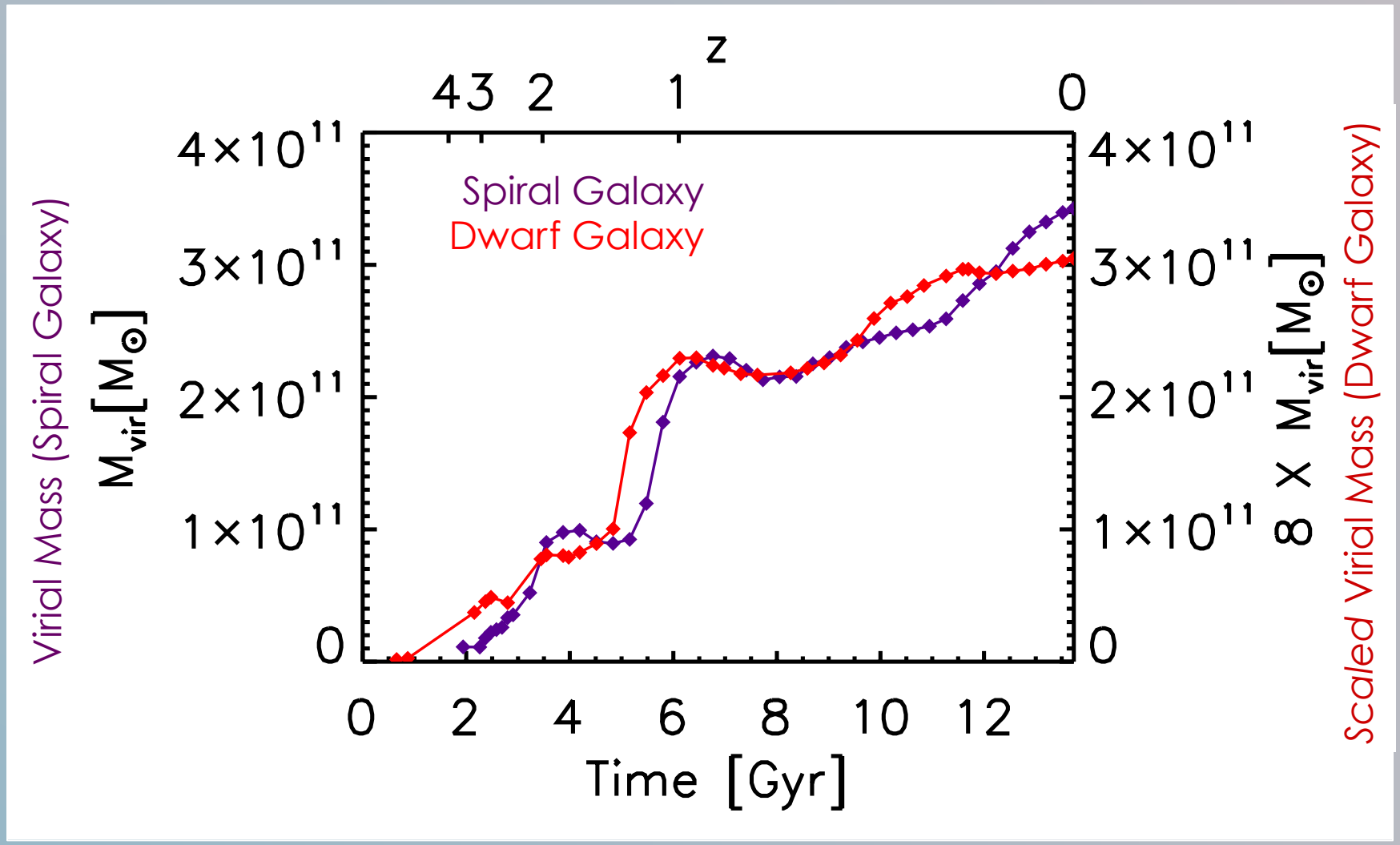


Mock-Observations at z=0

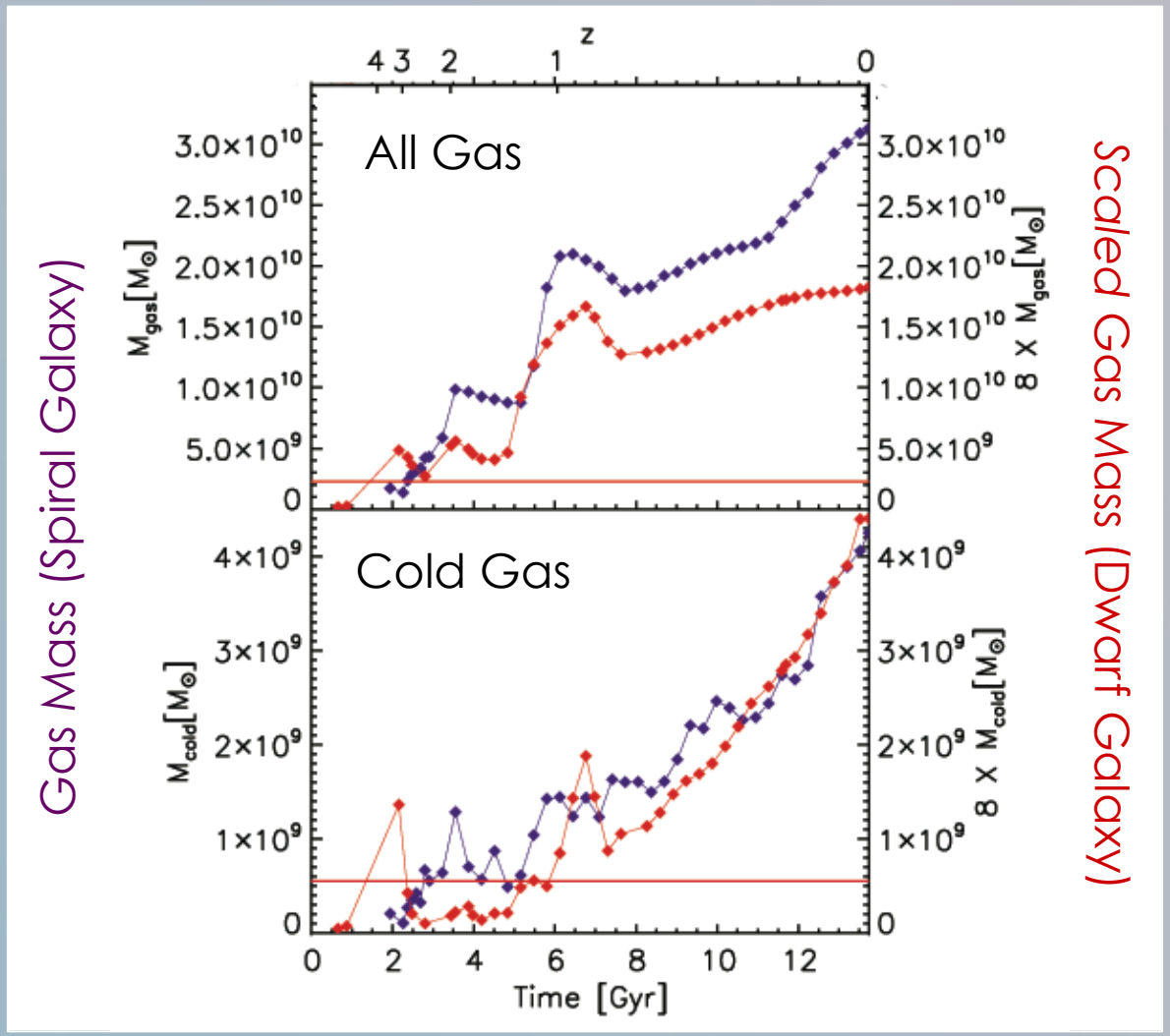


Images from SUNRISE (Jonsson '06)

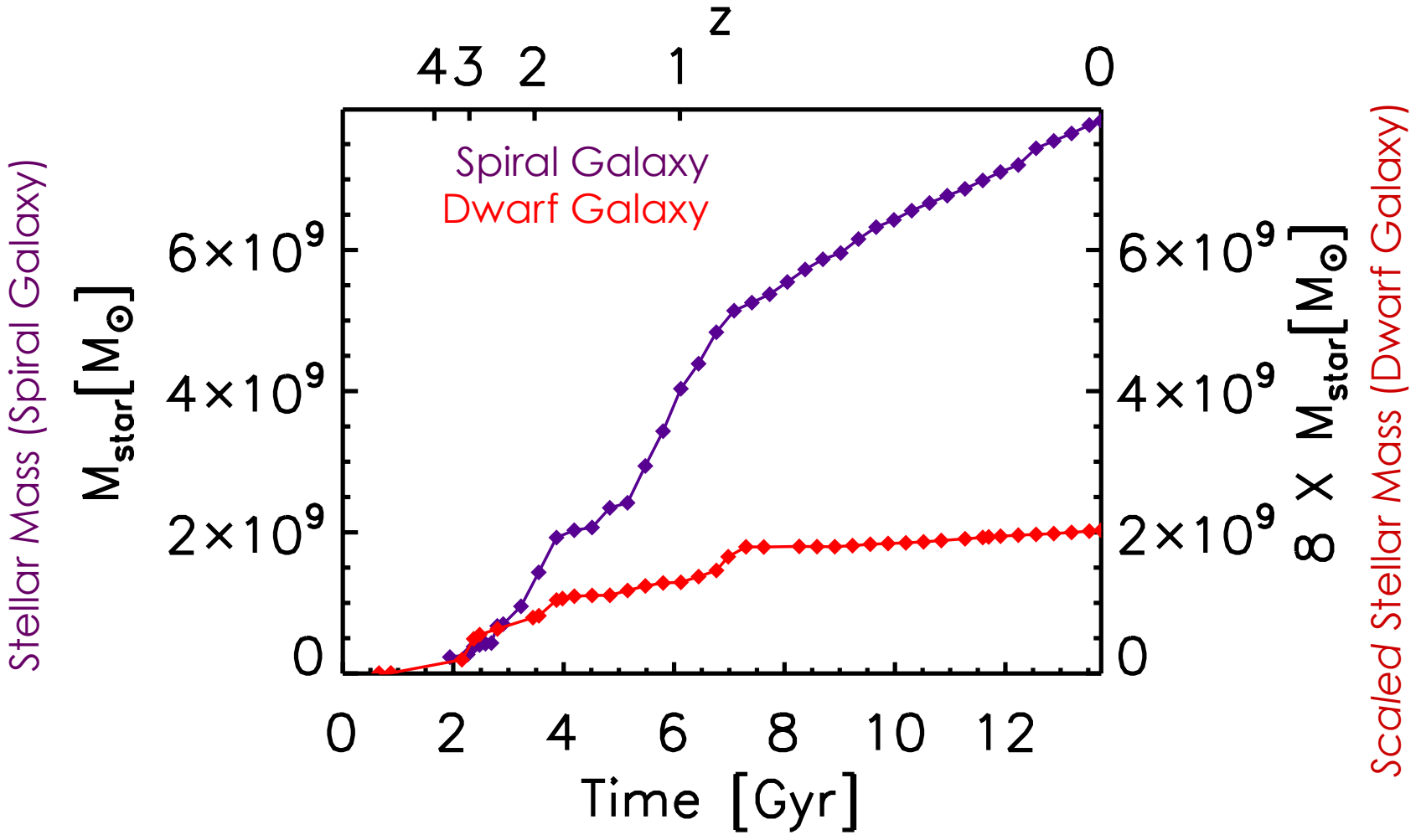
Evolution of Total Mass



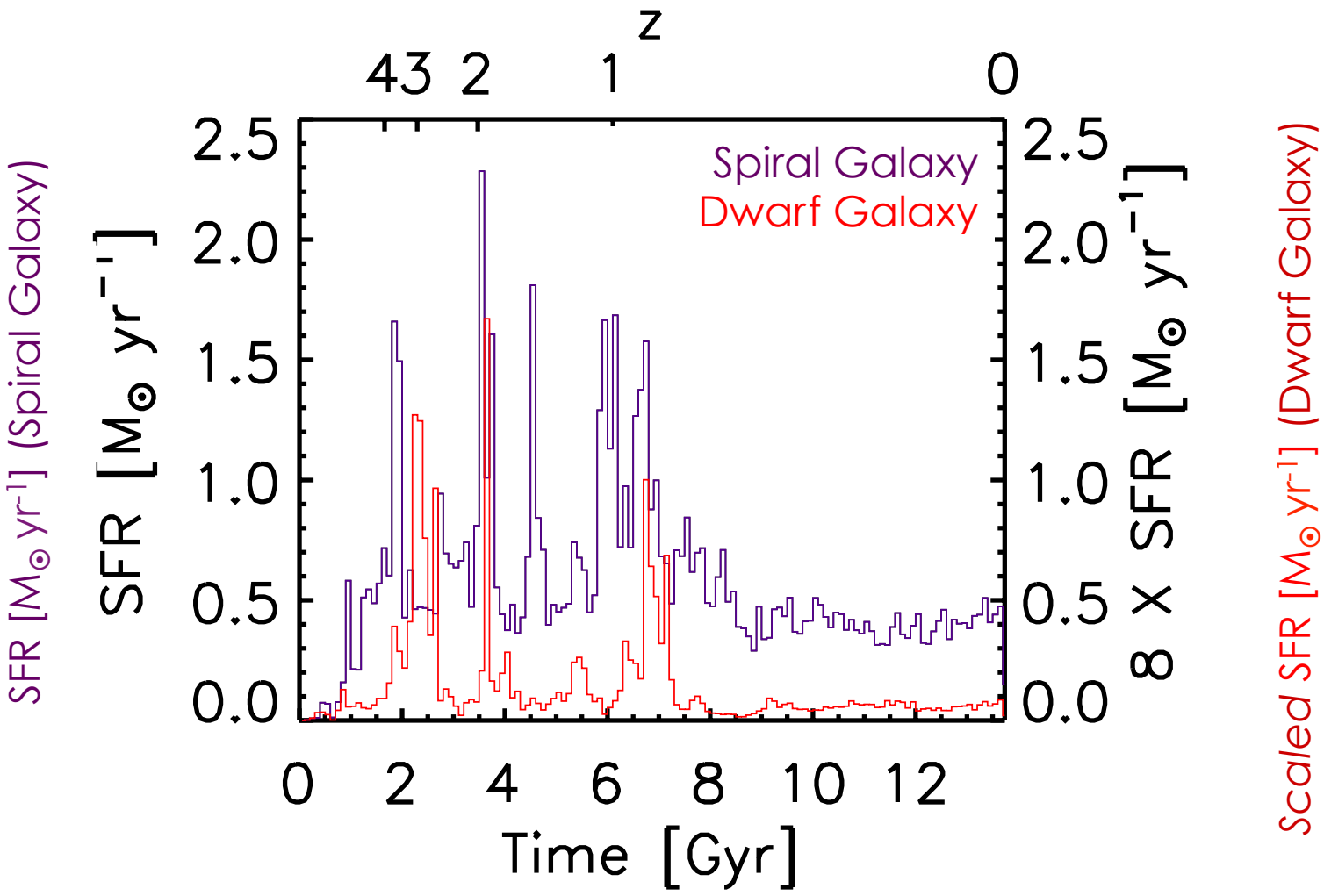
Evolution of Gas Mass



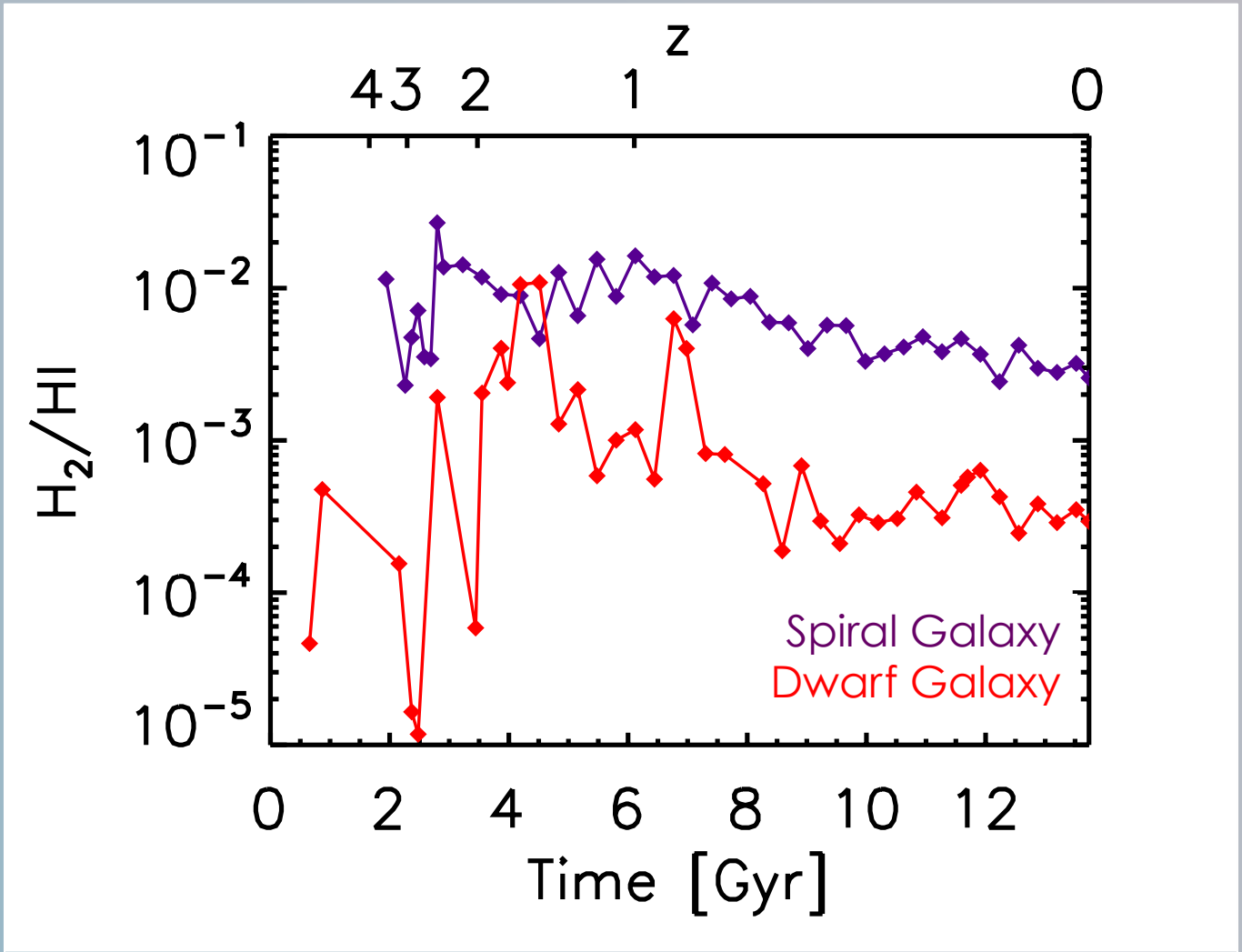
Evolution of Stellar Mass



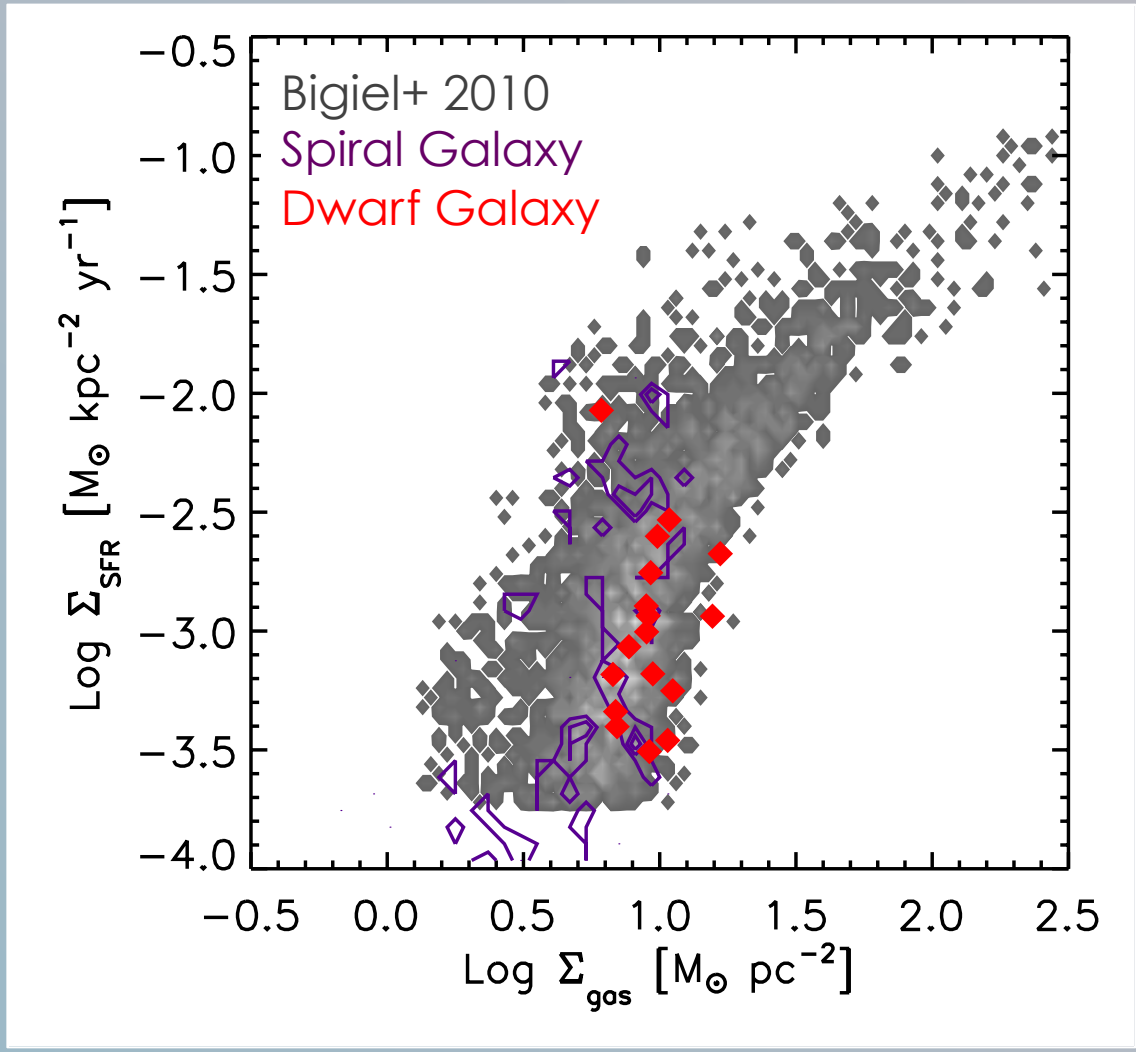
Star Formation Histories



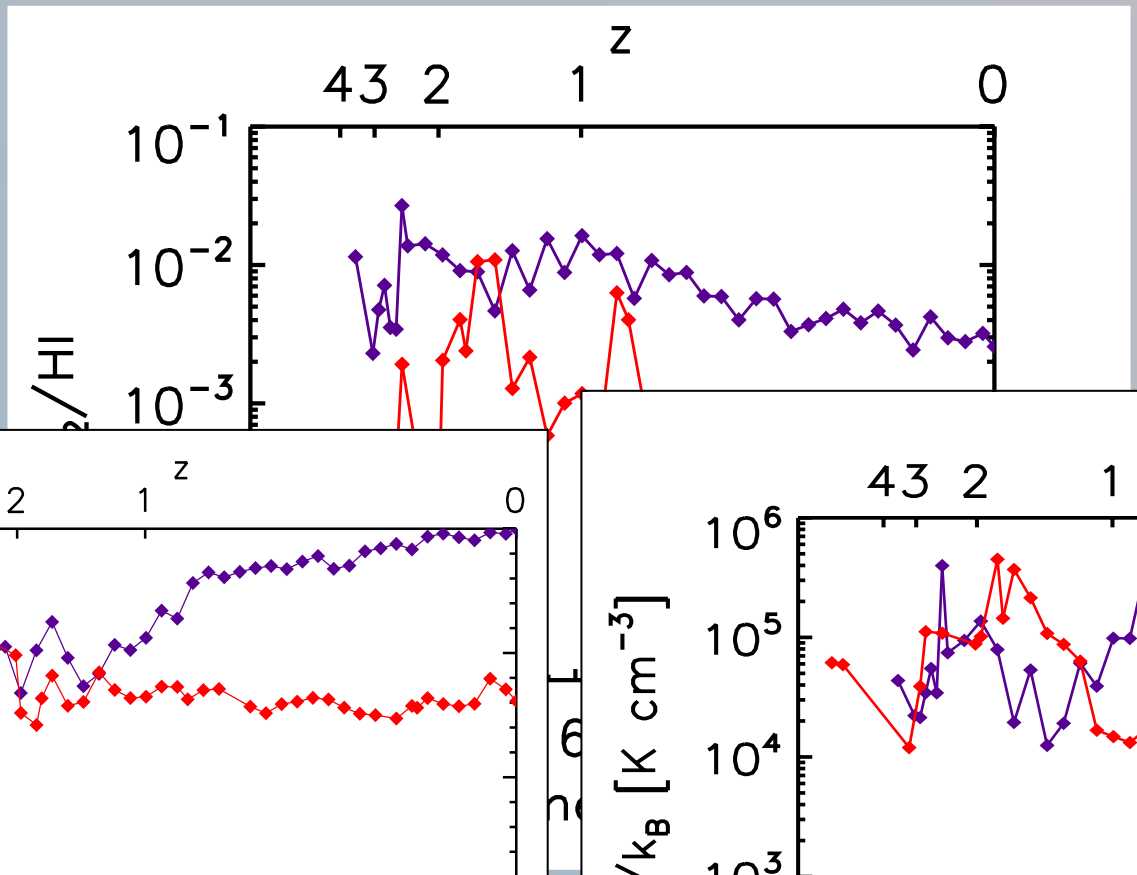
Molecular Hydrogen Over Time

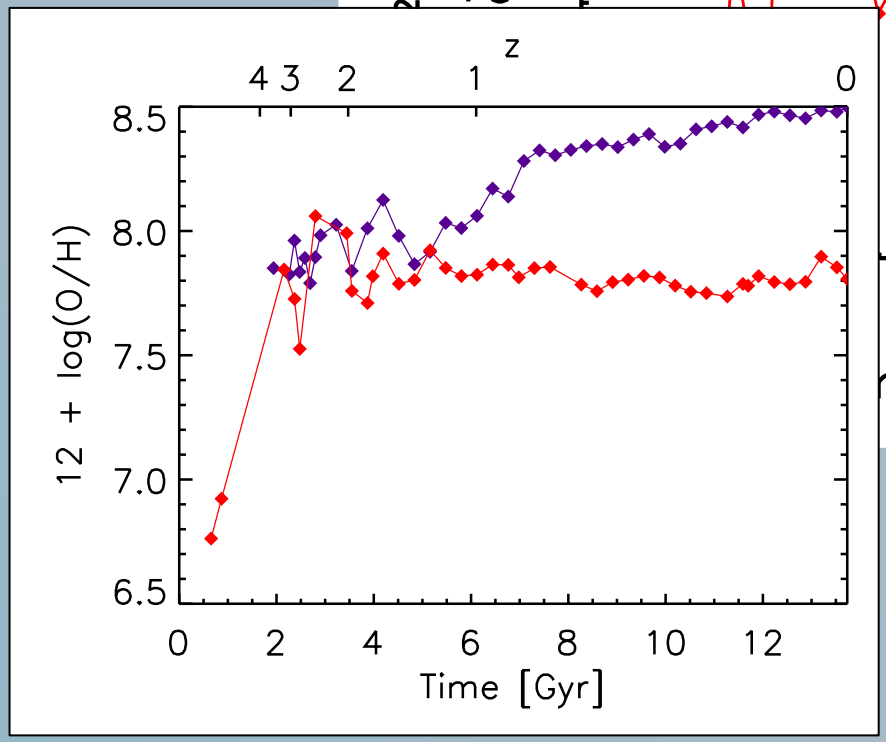


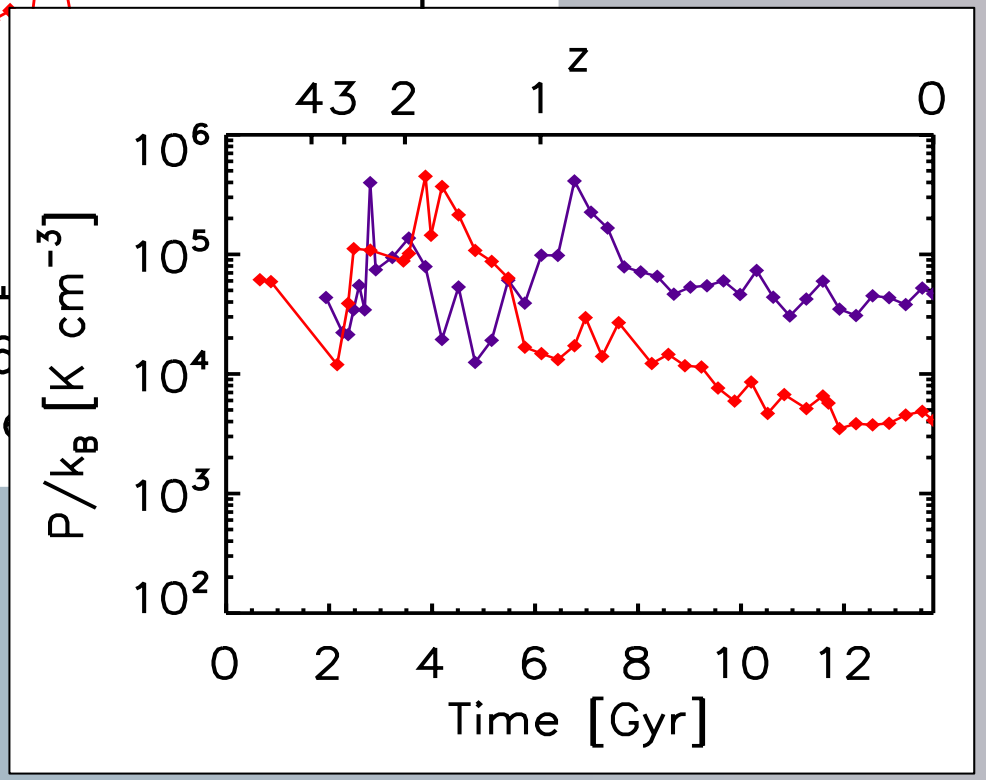
Kennicutt–Schmidt Relation



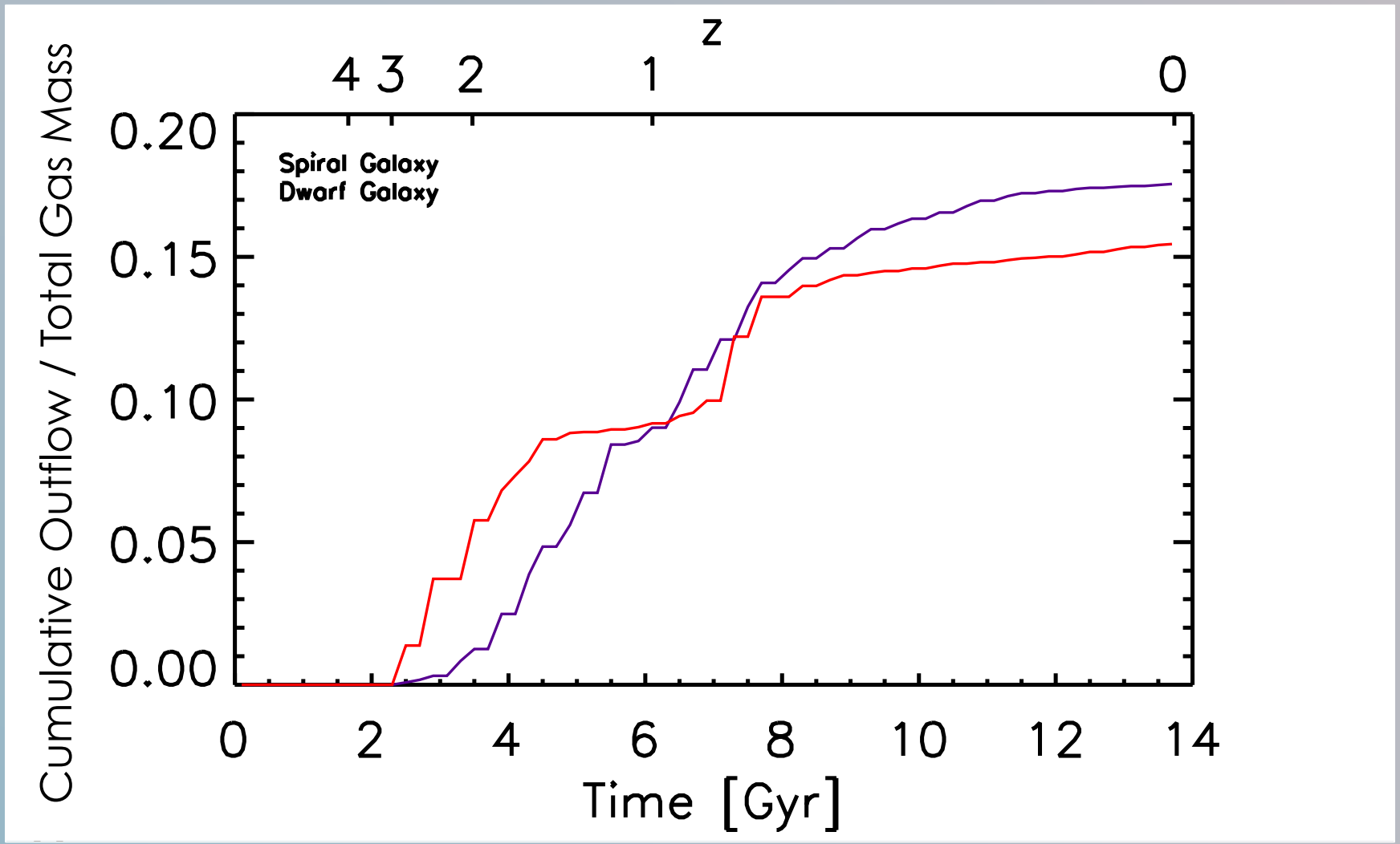
Molecular Hydrogen Over Time







Outflowing Gas



Evolution

- *Q: How do galaxies of different masses evolve?*
- Simulated "similar" galaxies
- We demonstrate how lower pressure and metallicity result in smaller H_2 abundances in the dwarf galaxy and lower stellar fractions
- In the future:
  - Higher time resolution high-z runs
  - Quantify H_2-pressure-Z-SF connection and compare to theory