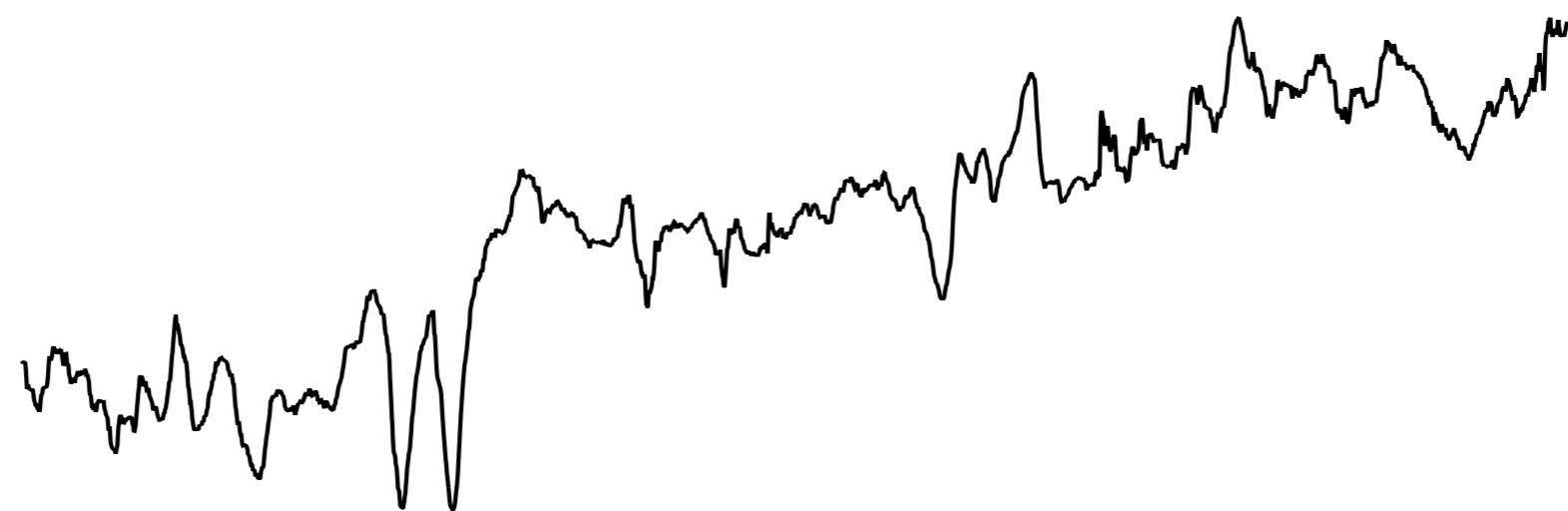


The Star-Formation Histories of Massive Quiescent Galaxies at $z \sim 2$



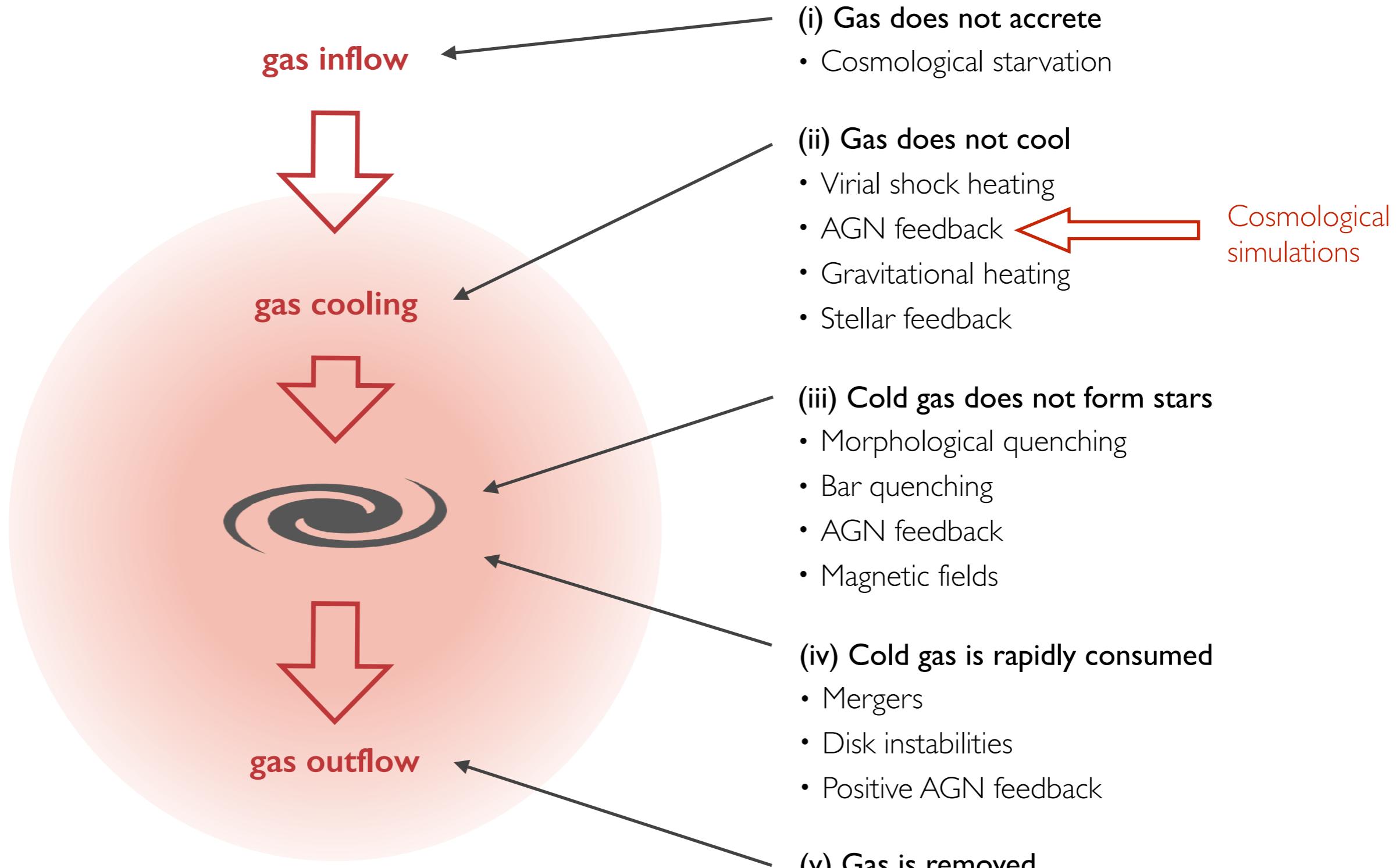
Sirio Belli

Clay Fellow

Center for Astrophysics | Harvard & Smithsonian

with Drew Newman (Carnegie) and Richard Ellis (UCL)

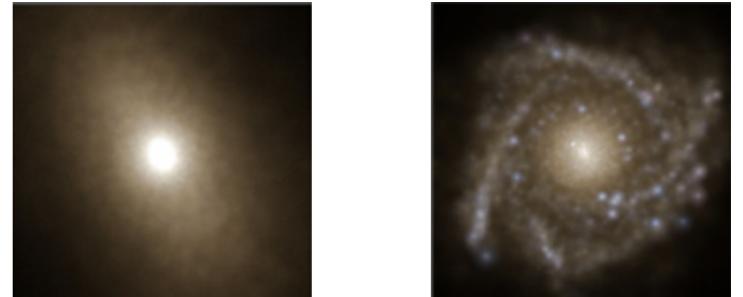
What causes quenching in massive galaxies?



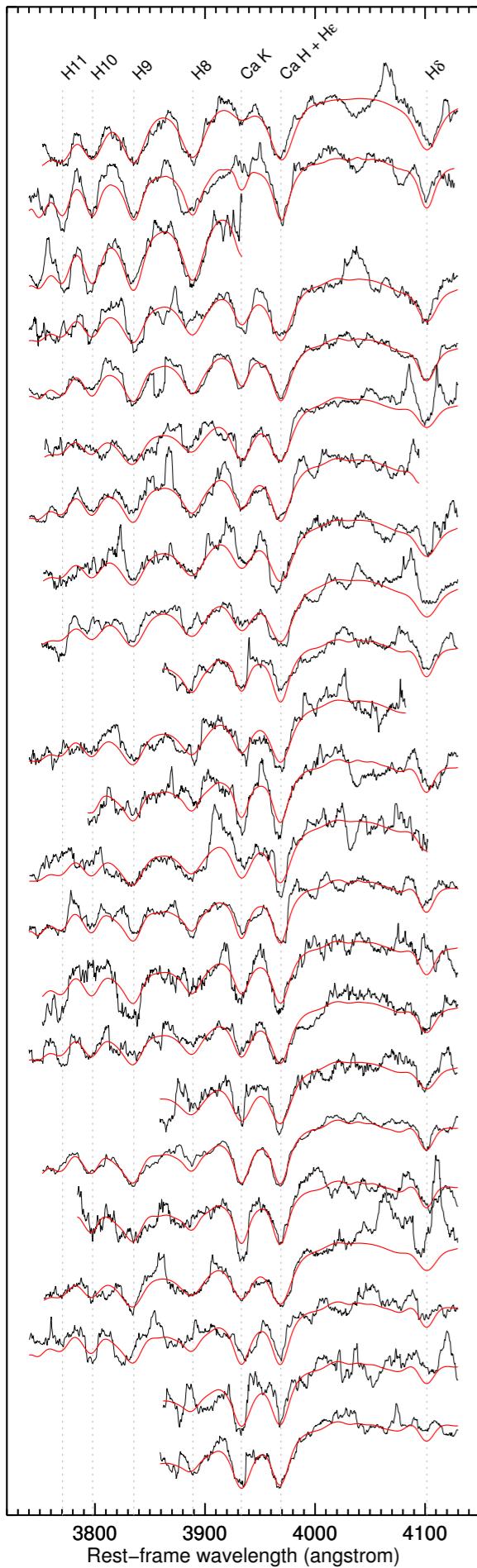
Cosmological Simulations



Simulated galaxies are qualitatively in agreement with observations



Unfortunately, there is **no observational evidence** for a causal link between AGN feedback and galaxy quenching
(see, e.g., review by Harrison 2017)

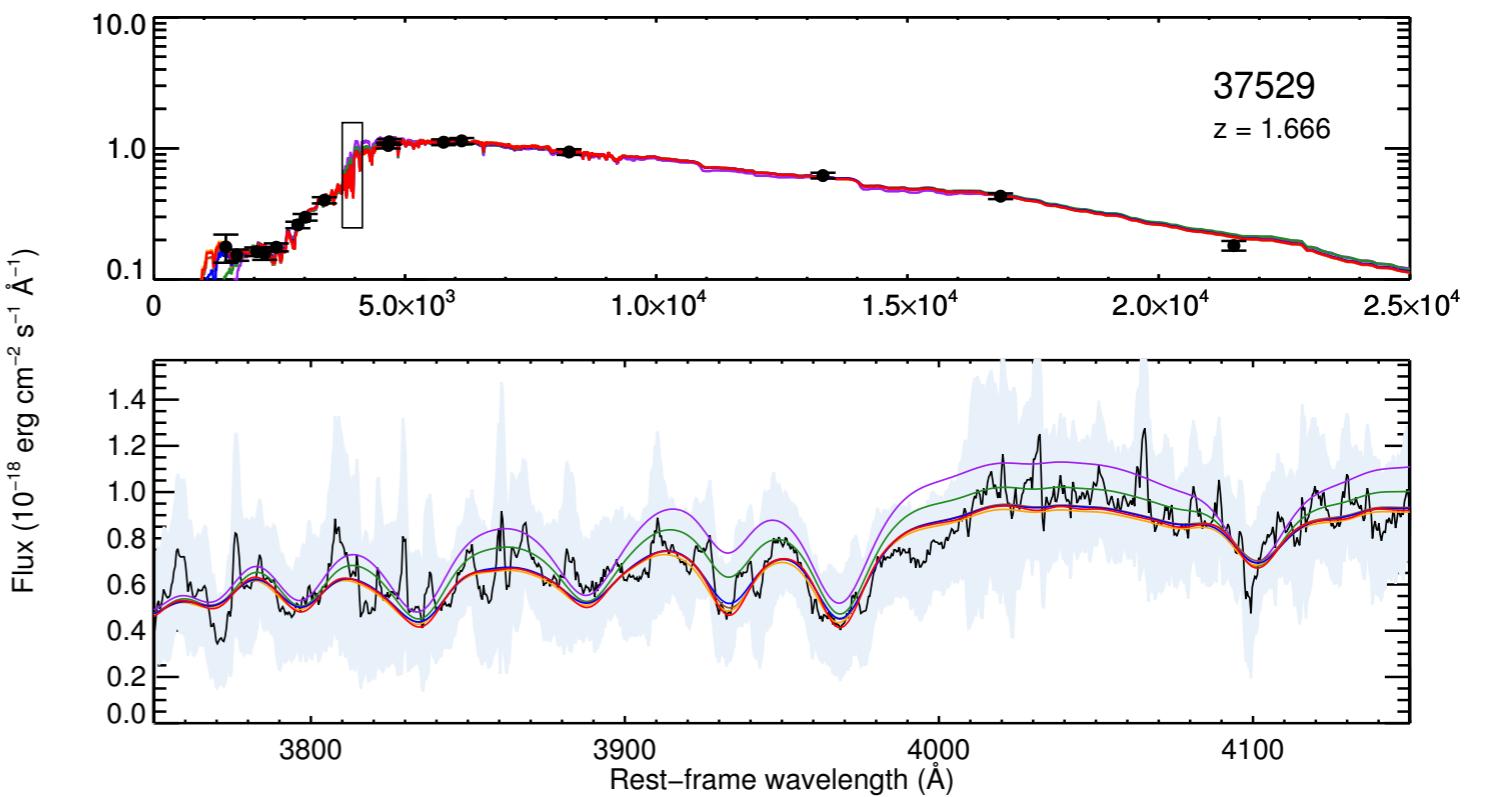


The Keck Sample of Quiescent Galaxies



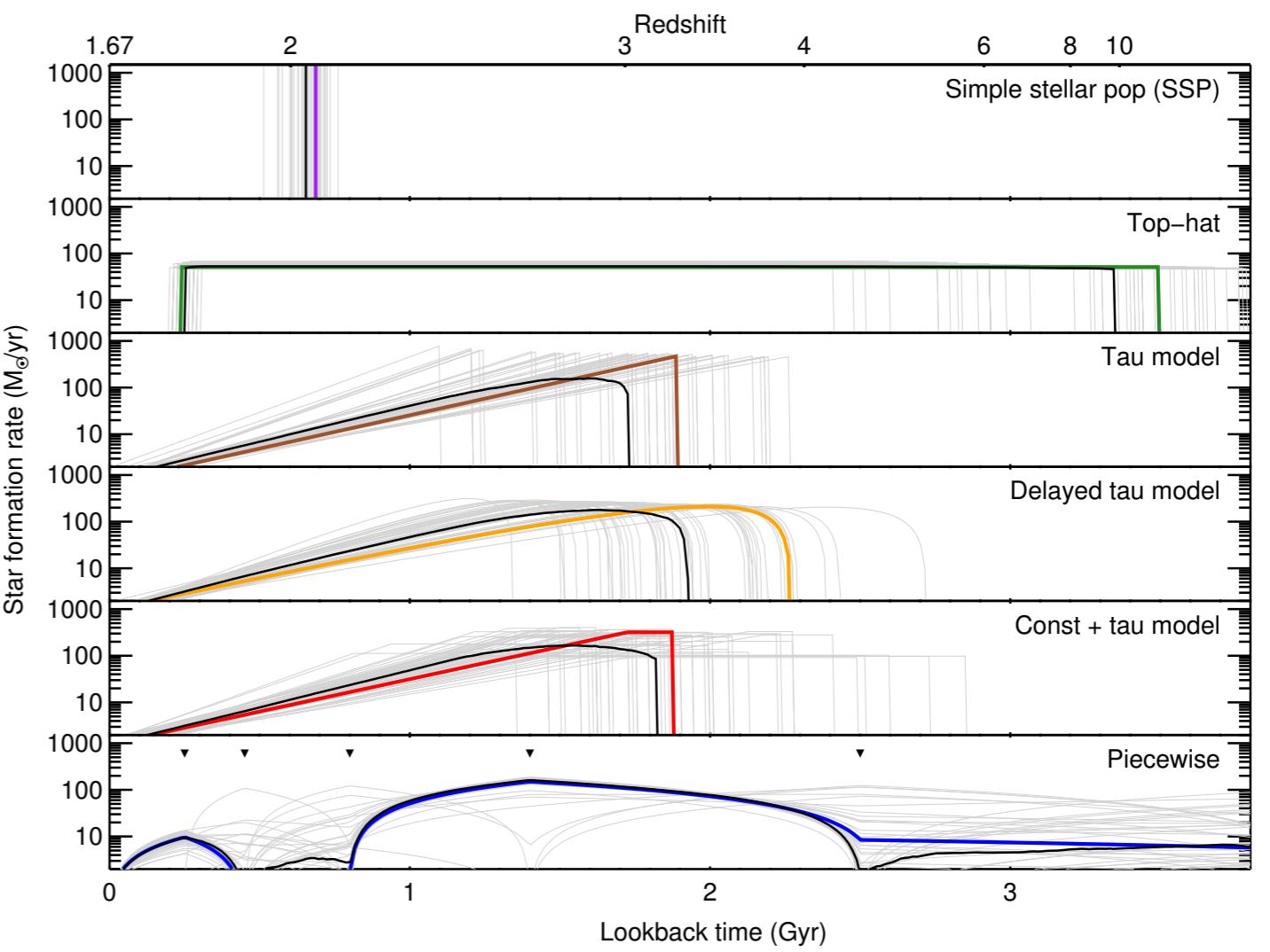
- 80 quiescent galaxies at $1 < z < 2.5$
- Deep Keck (LRIS and MOSFIRE) spectra
- Covering rest-frame optical region
- Targets in CANDELS fields
- Reduced spectra now publicly available at the Keck Observatory Archive
- Newman et al. (2010), Belli, Newman & Ellis (2014a, 2014b, 2015, 2017, 2019)

Fitting simultaneously
Keck spectra and photometry
using *pyspecfit* (Newman et al. 2014)

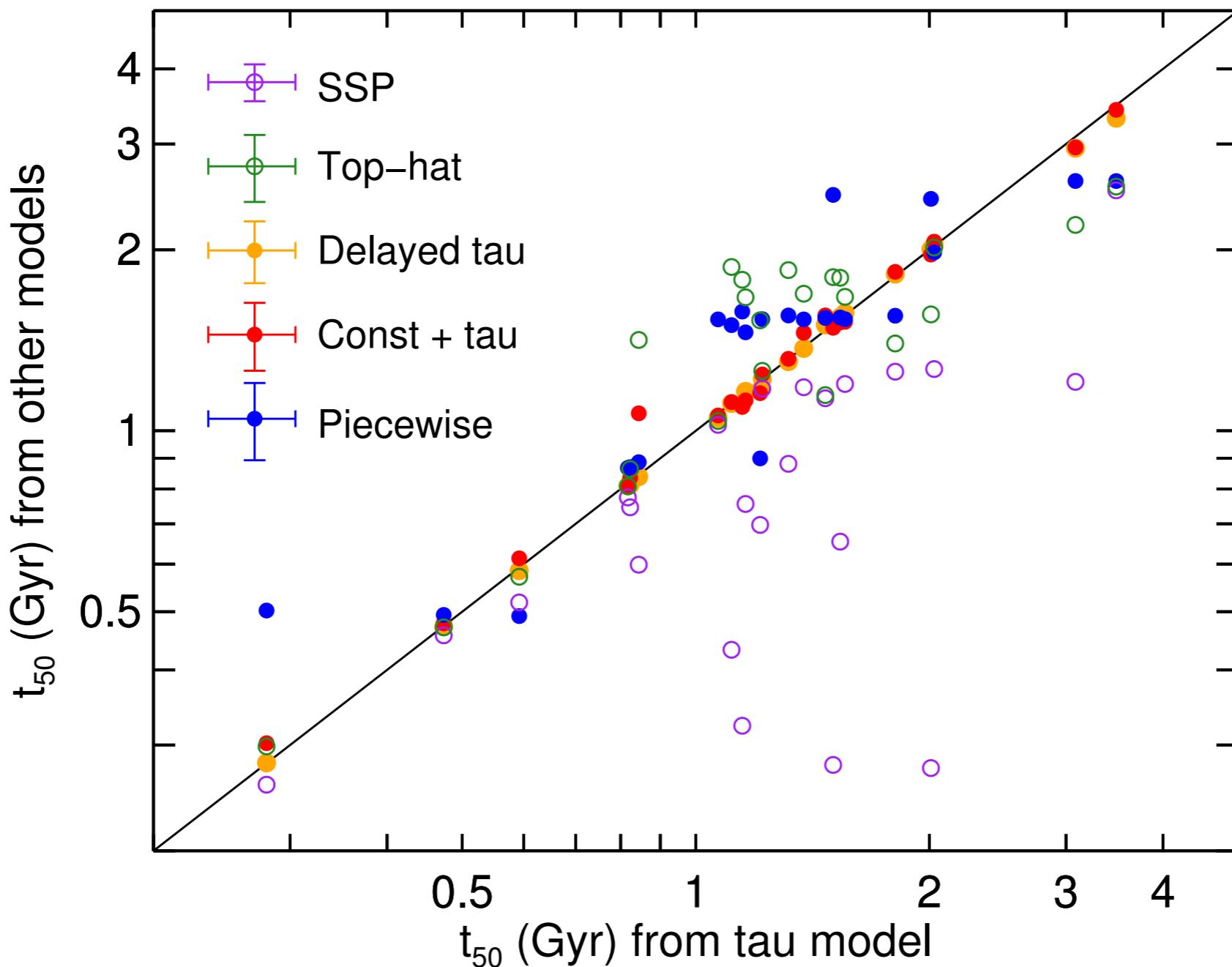


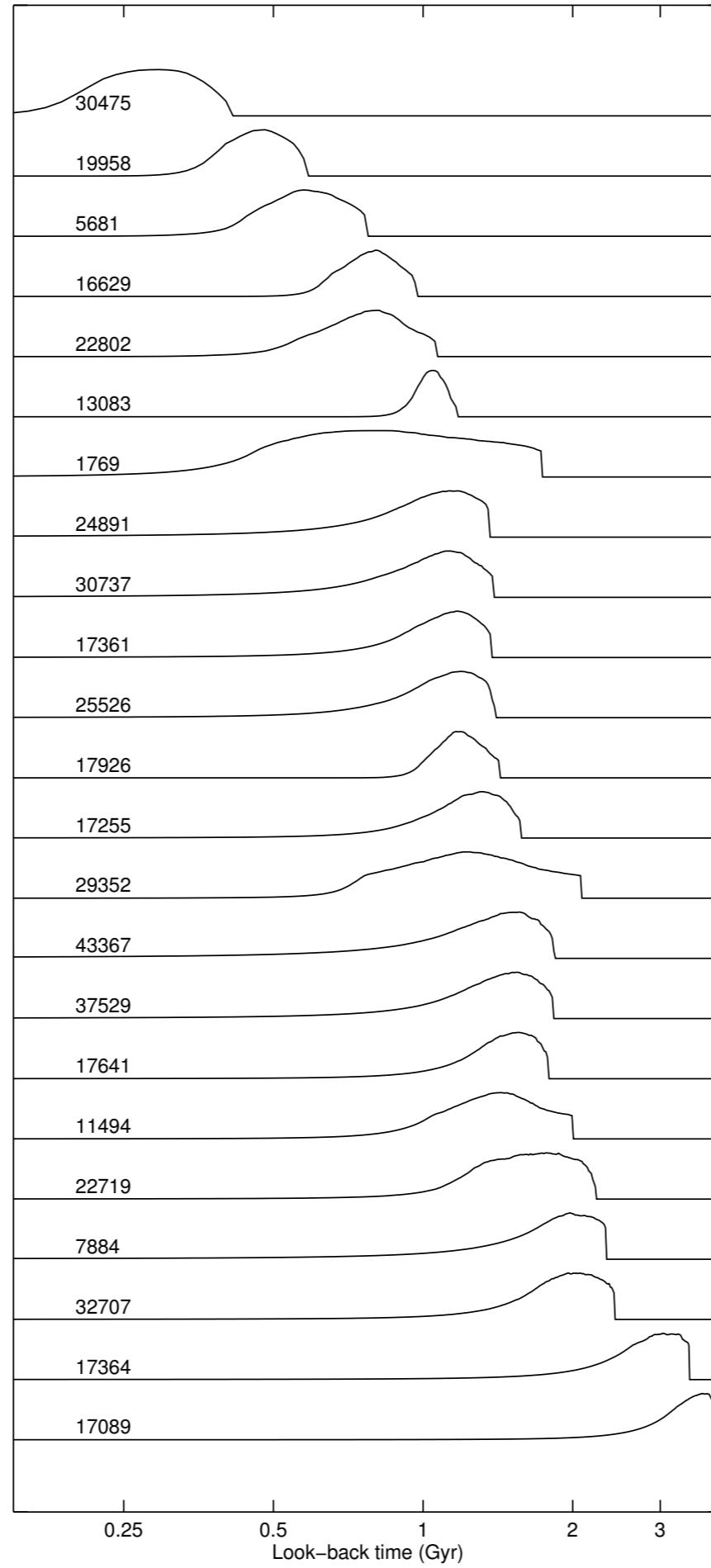
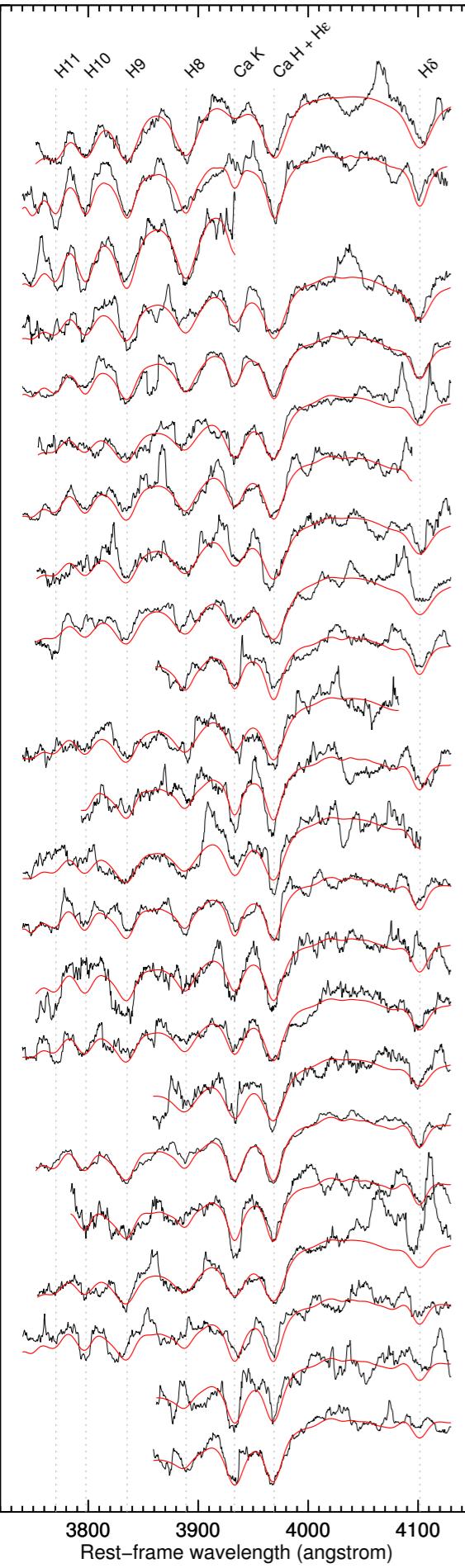
Assumptions

- Bruzual and Charlot (2003) templates
- Chabrier (2003) IMF
- Six different models for the star formation history



Median stellar ages are robust except for SSP



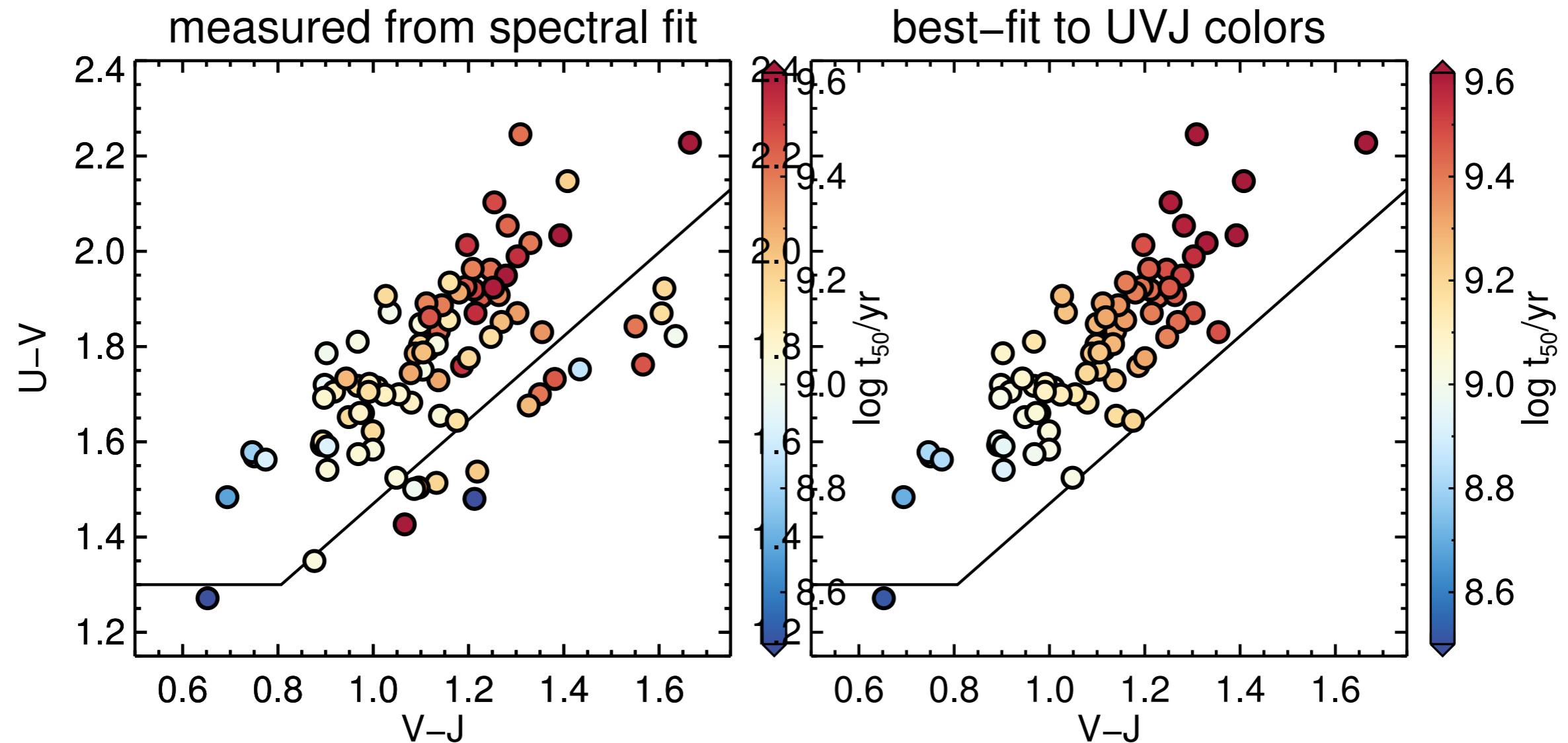


“A-type galaxies”
age < 1 Gyr
 (post-starburst, recently
 quenched, rapidly quenched)

Intermediate galaxies
age ~1-2 Gyr

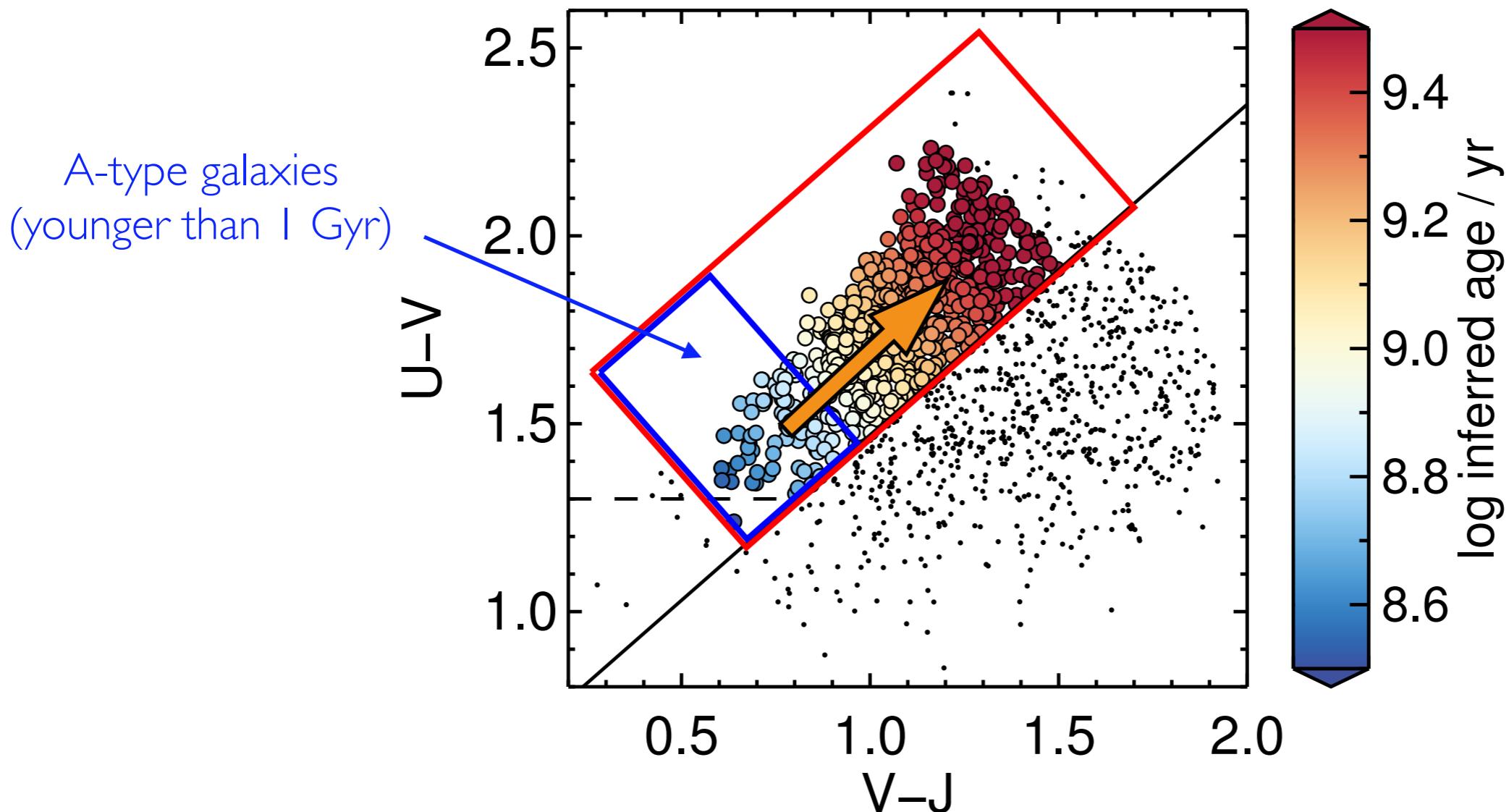
Relatively old galaxies
age ~ 2-4 Gyr

Tight relation between median stellar age and rest-frame UVJ colors

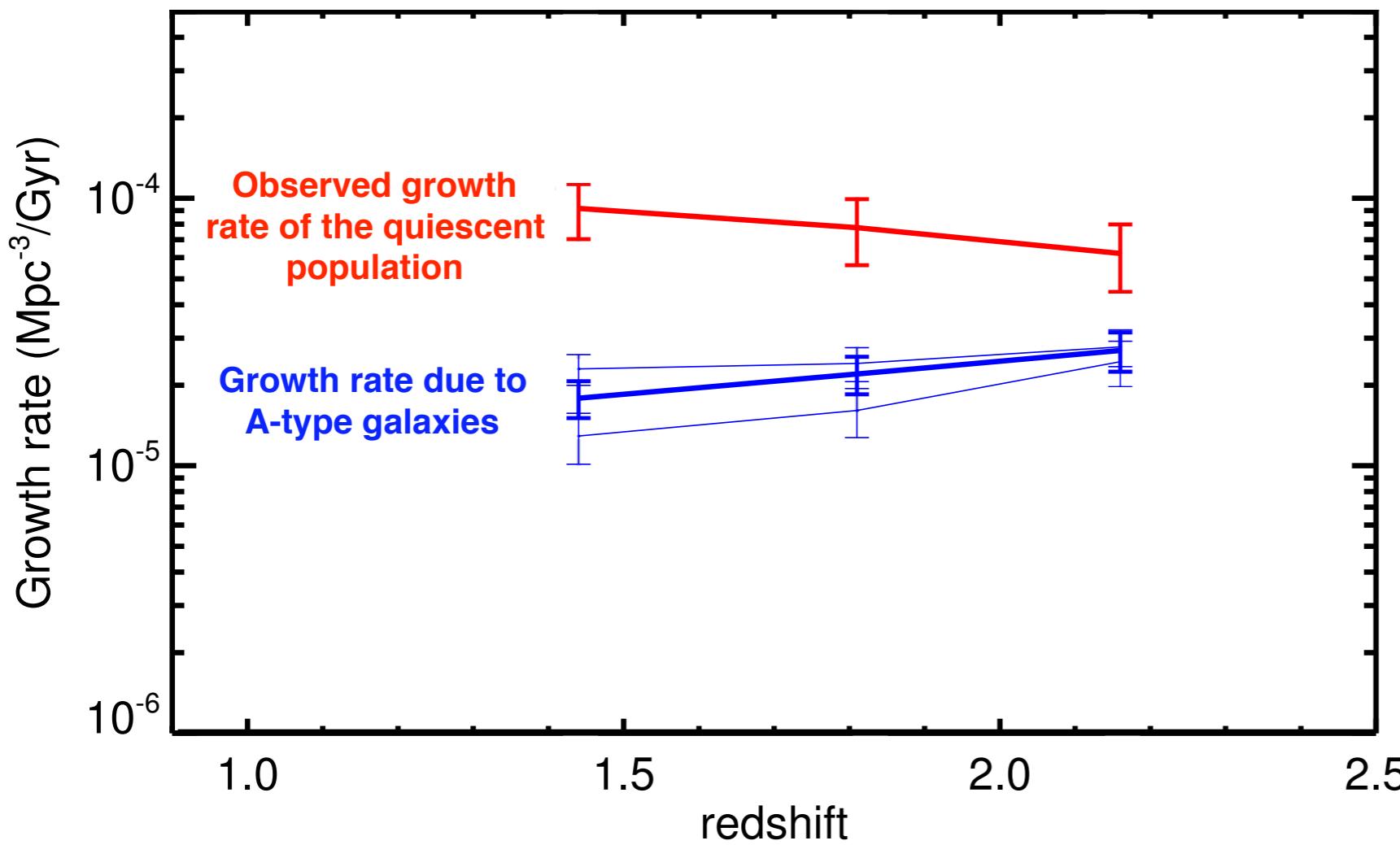
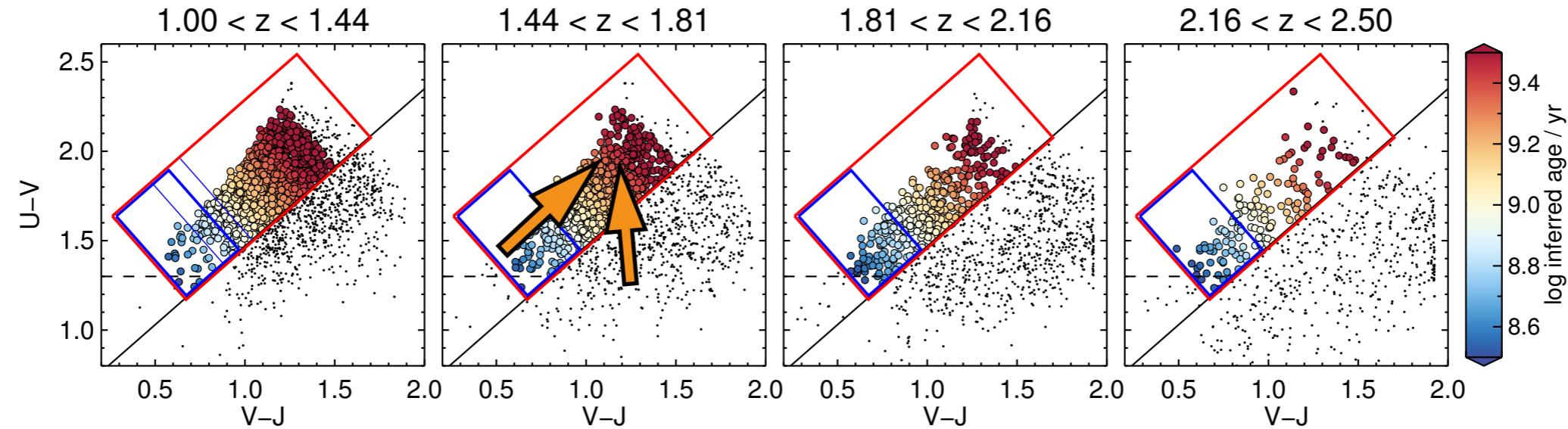


$$\log t_{50}/\text{yr} = 7.03 + 0.84 (V - J) + 0.74 (U - V)$$

Apply age - color relation to the galaxy population
from the UltraVISTA survey (Muzzin et al. 2013)

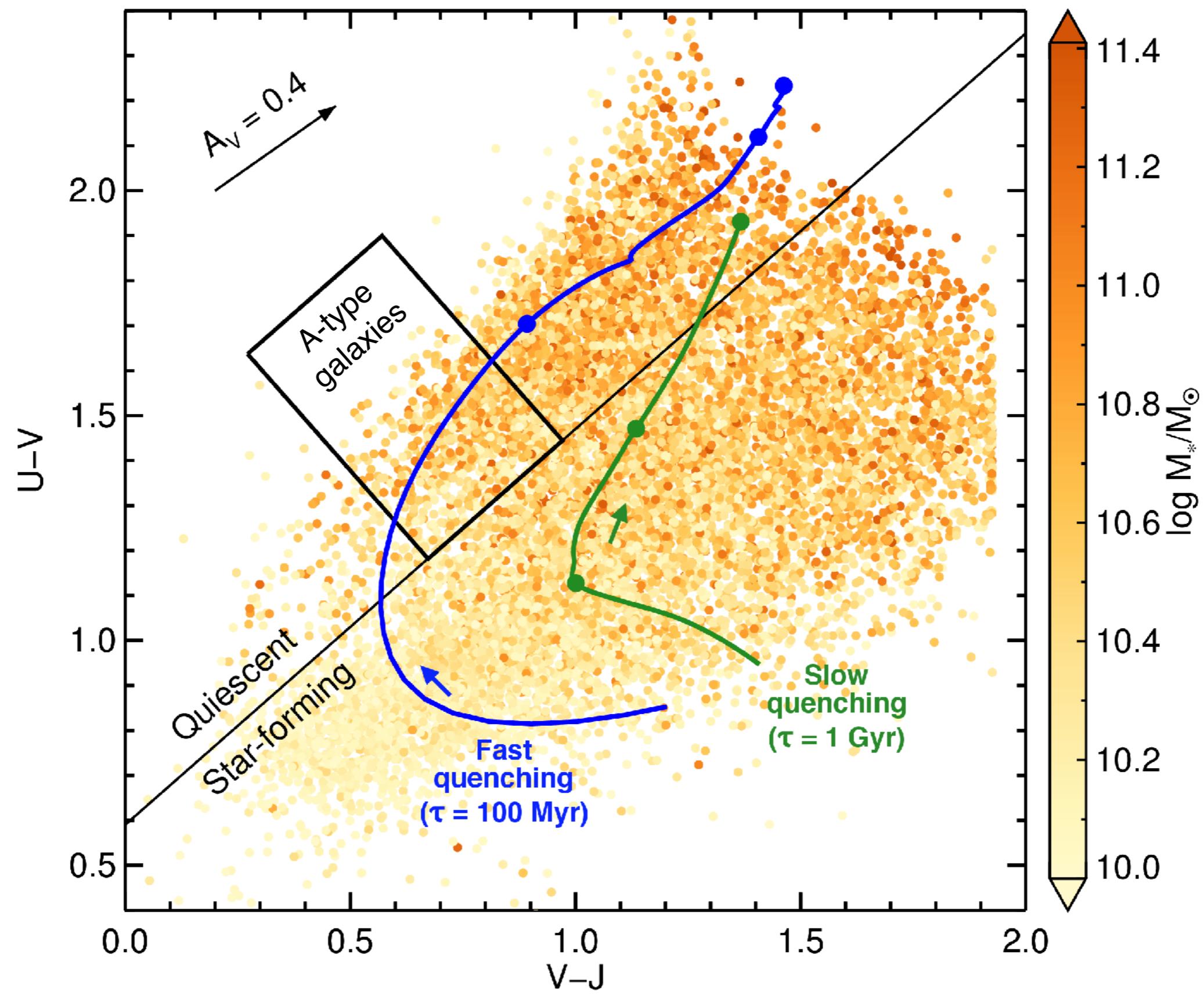


Do all galaxies evolve **along** the red sequence, from blue (young) to red (old)?



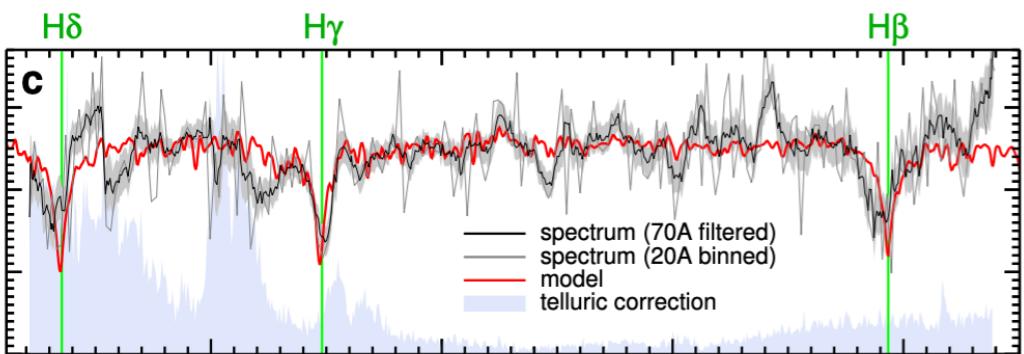
The A-type population
cannot explain the
growth of the quiescent
population

Not all quiescent galaxies
were A-type galaxies!

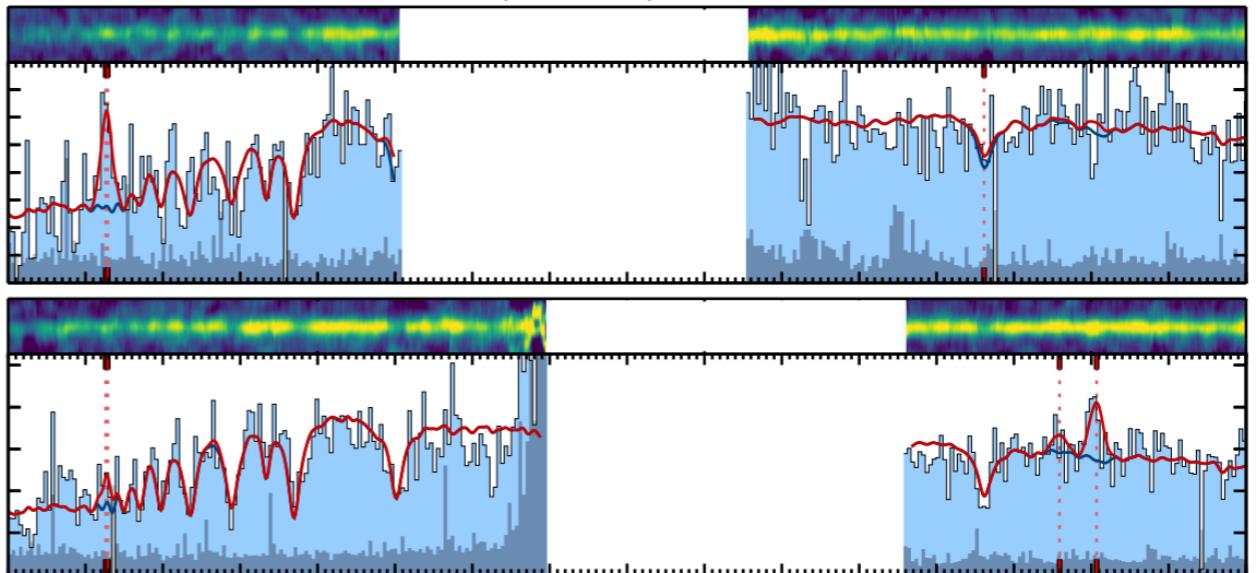


At $z > 3$, all quiescent galaxies must be A-type

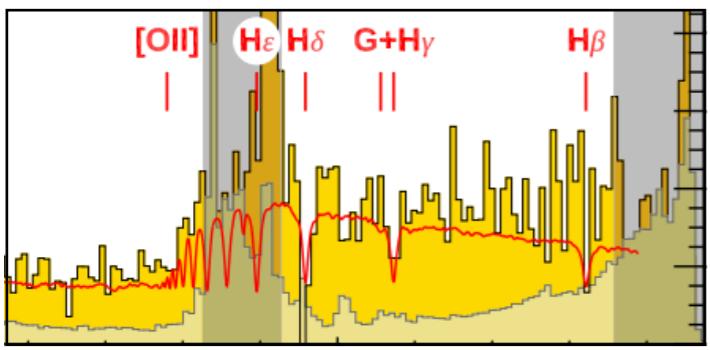
Glazebrook et al. (2017)



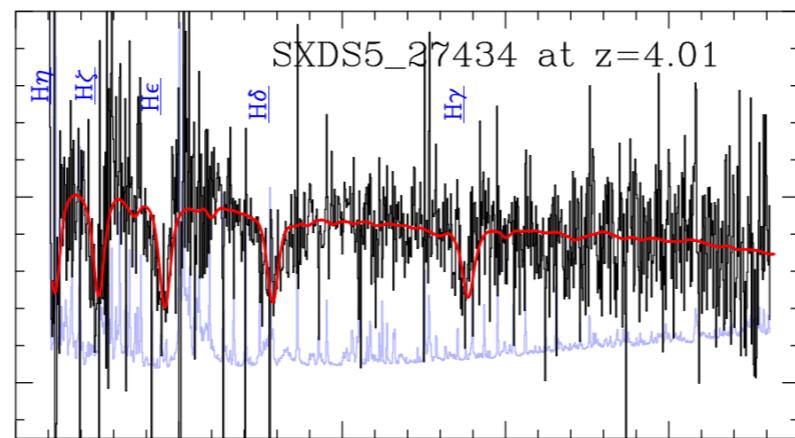
Schreiber et al. (2018)



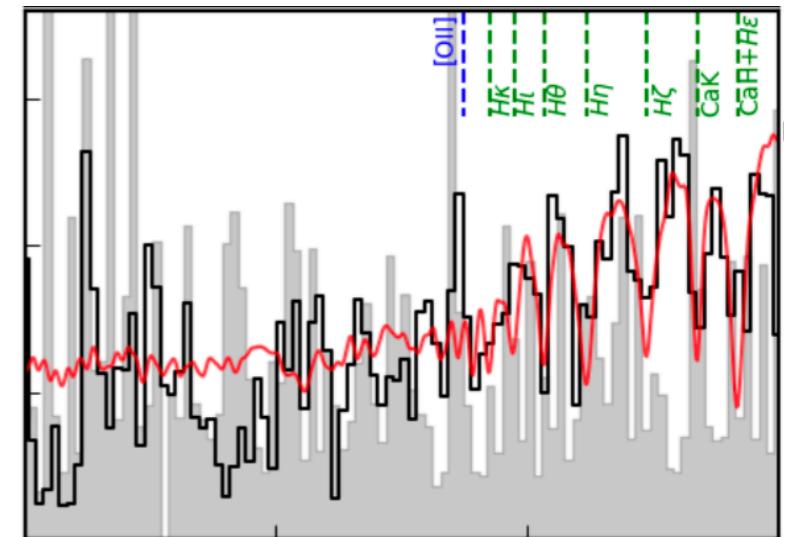
Valentino et al. (2019)



Tanaka et al. (2019)

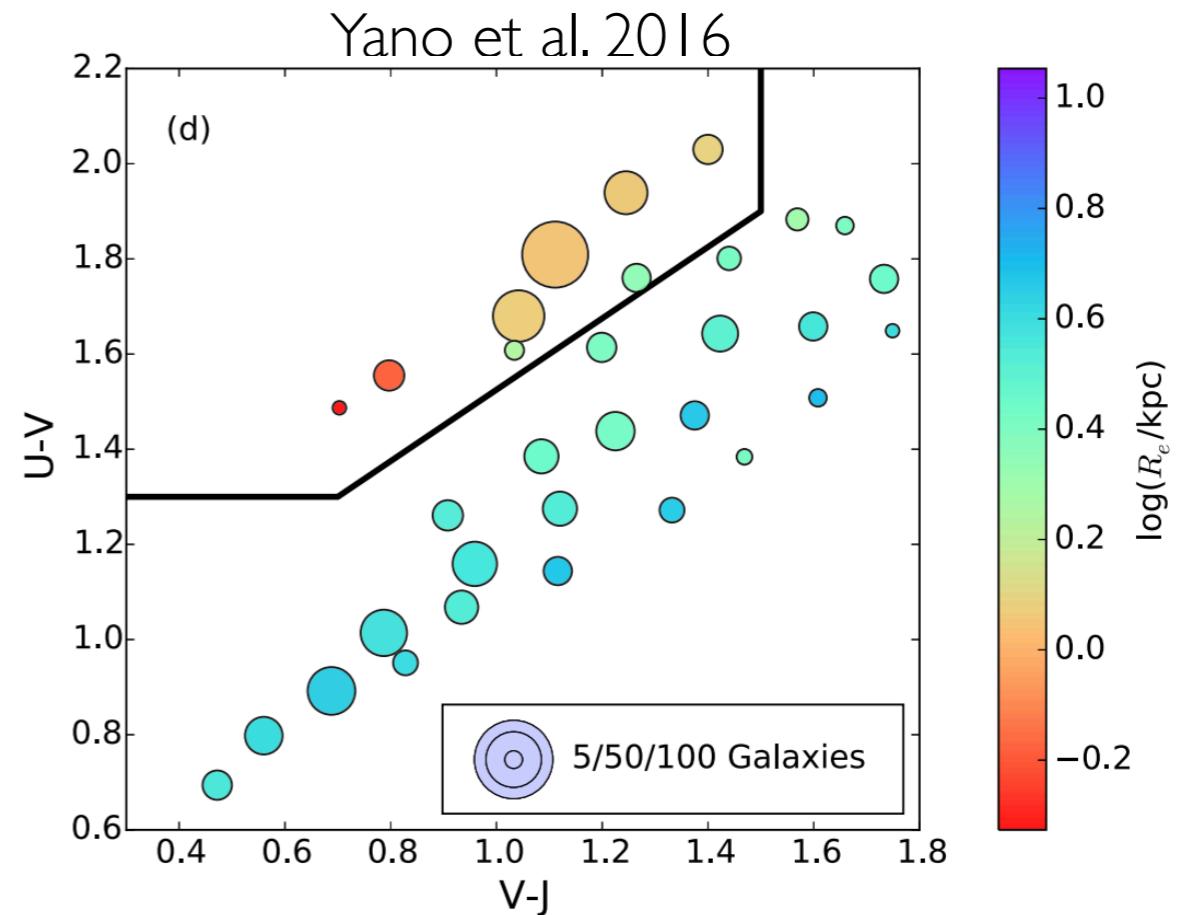


Forrest et al. (2019)

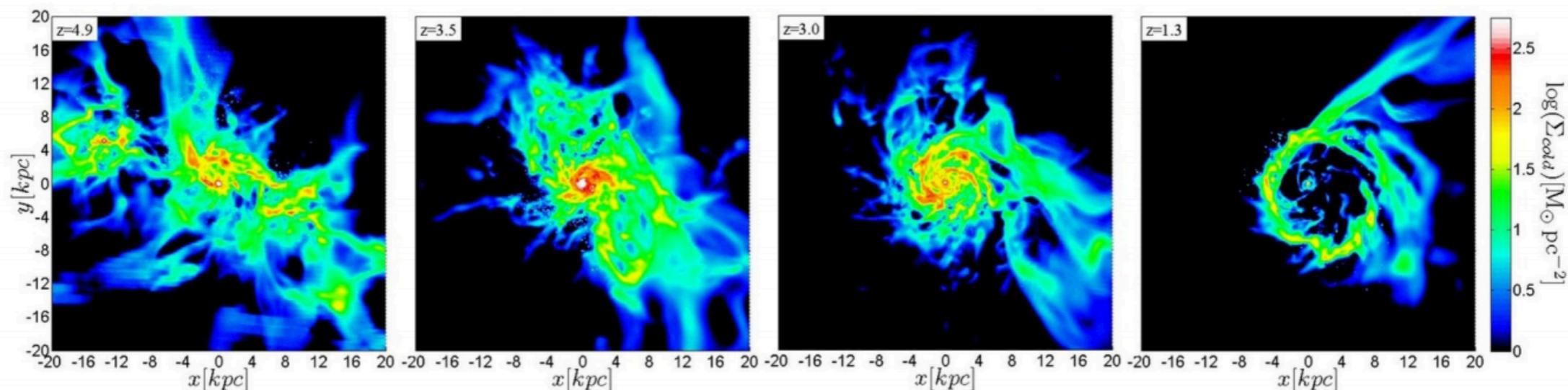


A-type galaxies are more **compact** than all other types of galaxies

(Whitaker et al. 2012, Yano et al. 2016, Wild et al. 2016, Almaini et al. 2017, **Wu et al. 2018**)



Compatible with the *compaction* scenario, perhaps triggered by gas-rich mergers or counter-rotating streams (Dekel & Burkert 2014, Zolotov et al. 2015)



What causes quenching in massive galaxies?

