

The origin of Ultra Diffuse Galaxies

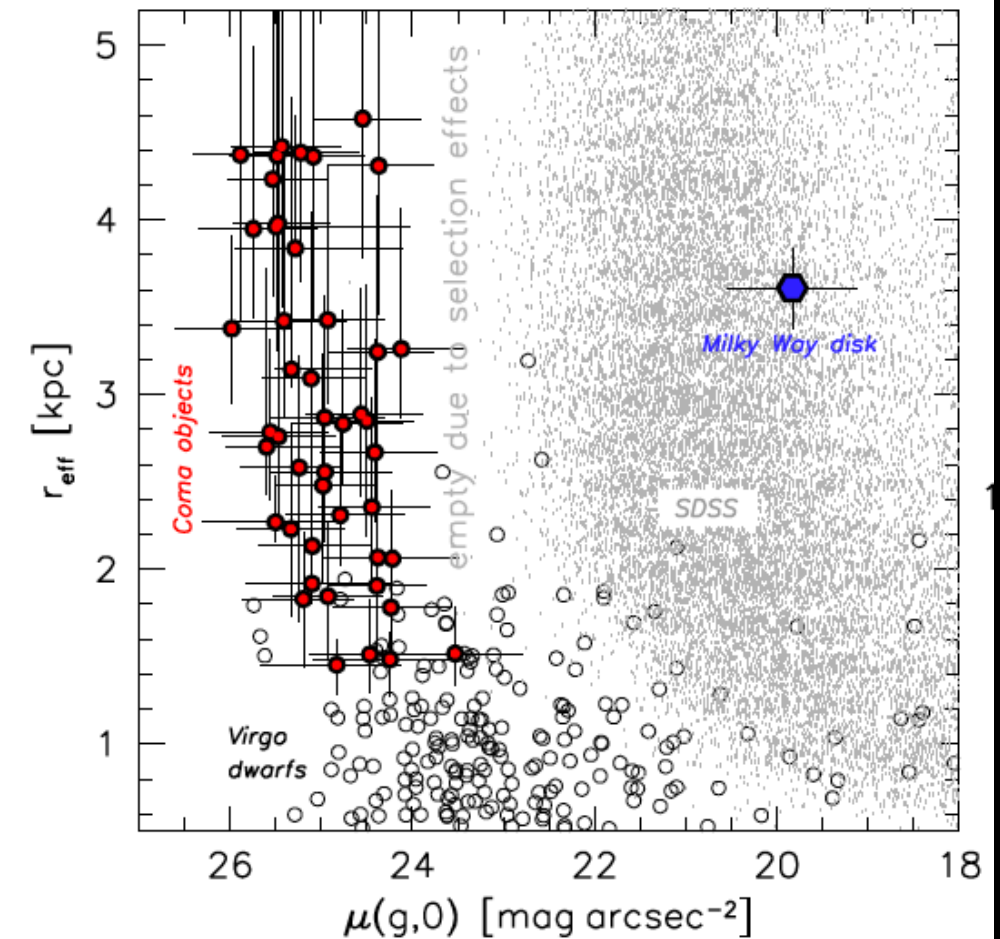
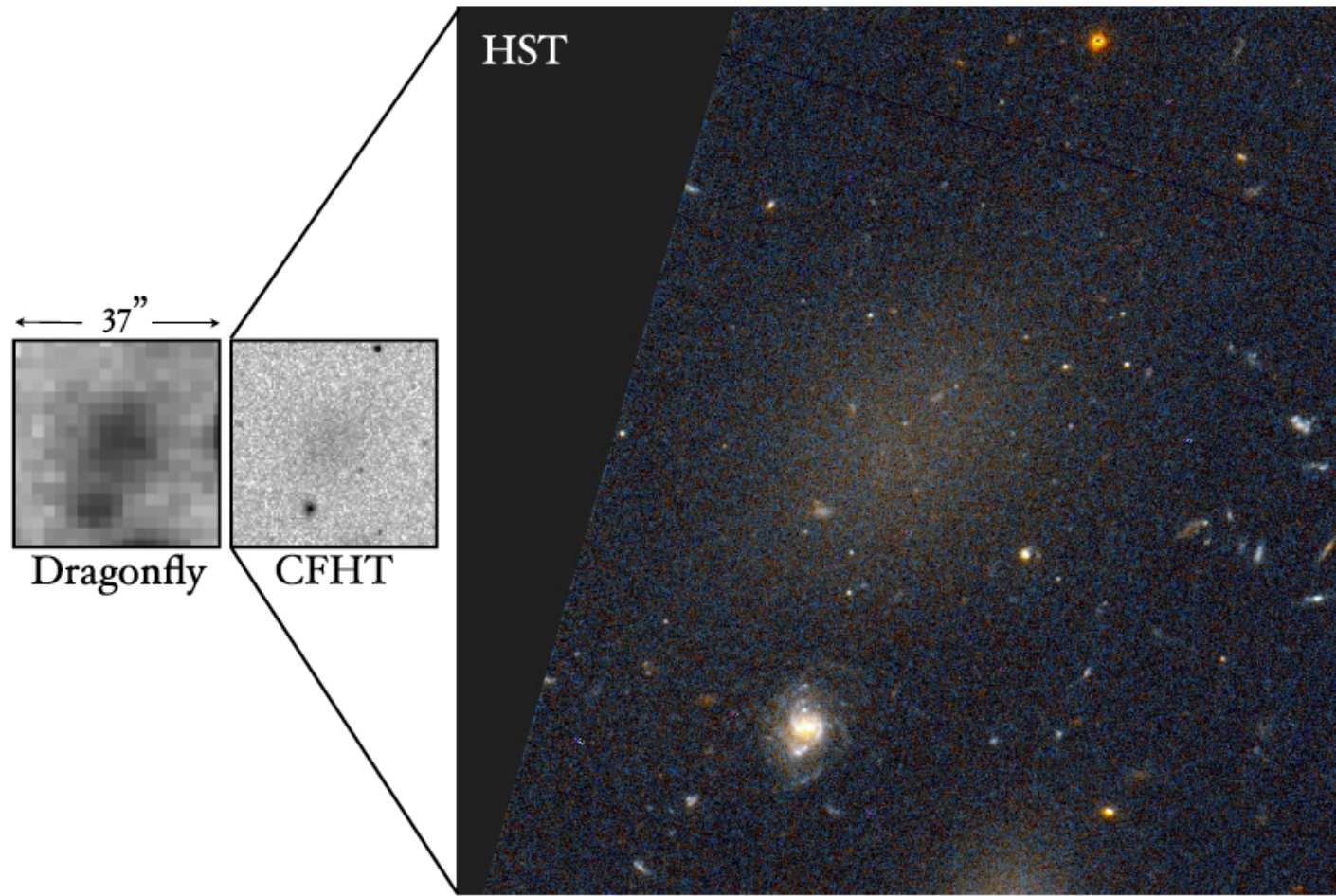
How do they form? Can feedback help?

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Shea Garrison-Kimmel (Caltech), the FIRE collaboration**

Ultra diffuse galaxies

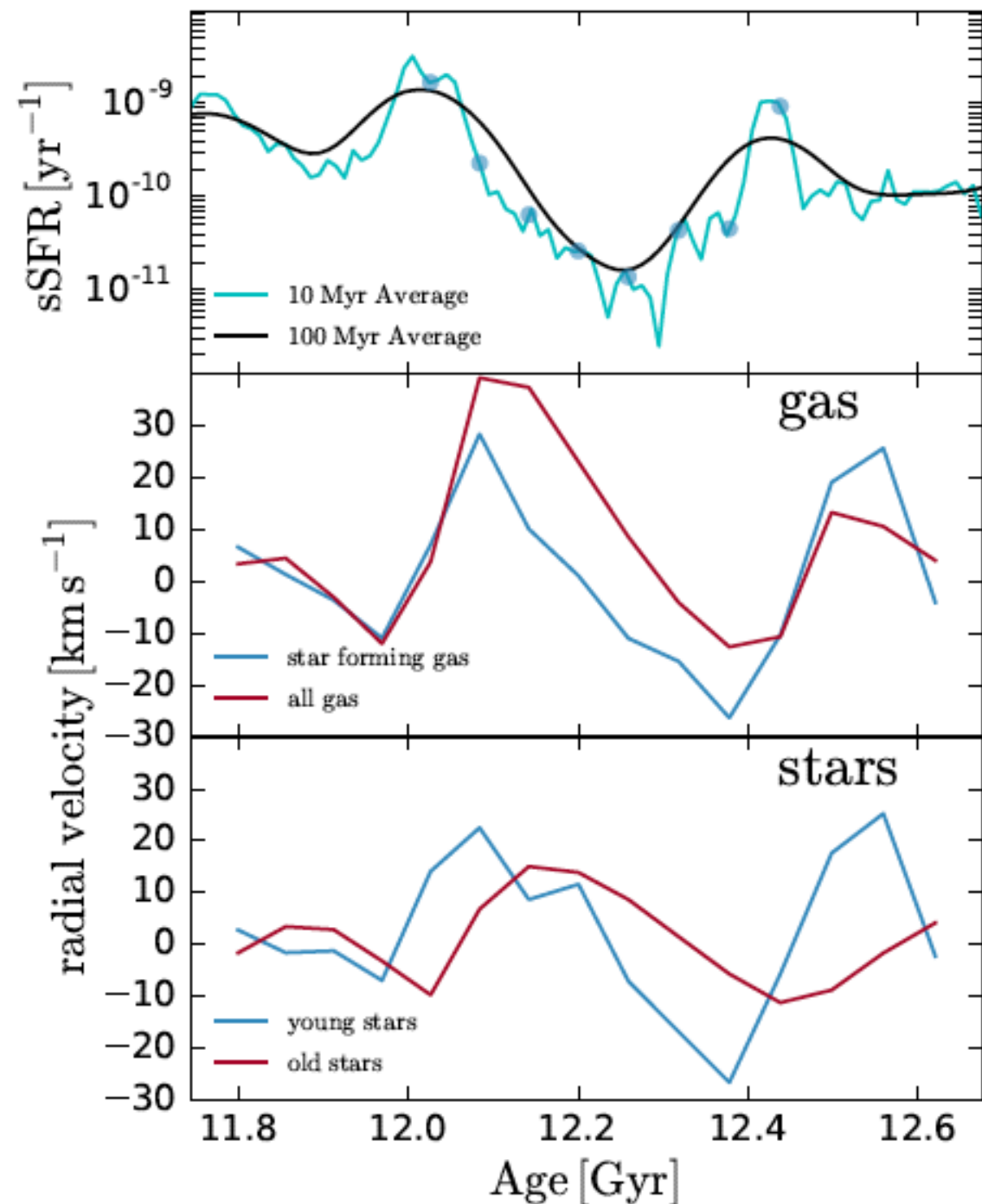
(van Dokkum+2015)



Strange properties:

- Size $\sim$ MW; $\mu \sim$ dwarfs $\rightarrow$ extremely diffuse
- Red $\rightarrow$ old stars or high metallicity
- axis ratio ~ 0.8 $\rightarrow$ spherical

Galaxy expansion in FIRE simulation



- ***Stellar*** distributions are expanded by stellar feedback
- Stars inherit the motions of the gas

A 'red' UDG recipe

Ingredients

- Fully cosmological zoom-in simulations of isolated halos
- halos at $z=0$: $M_{\text{vir}} \sim 5 \times 10^{10} - 5 \times 10^{11} M_{\text{sun}}$

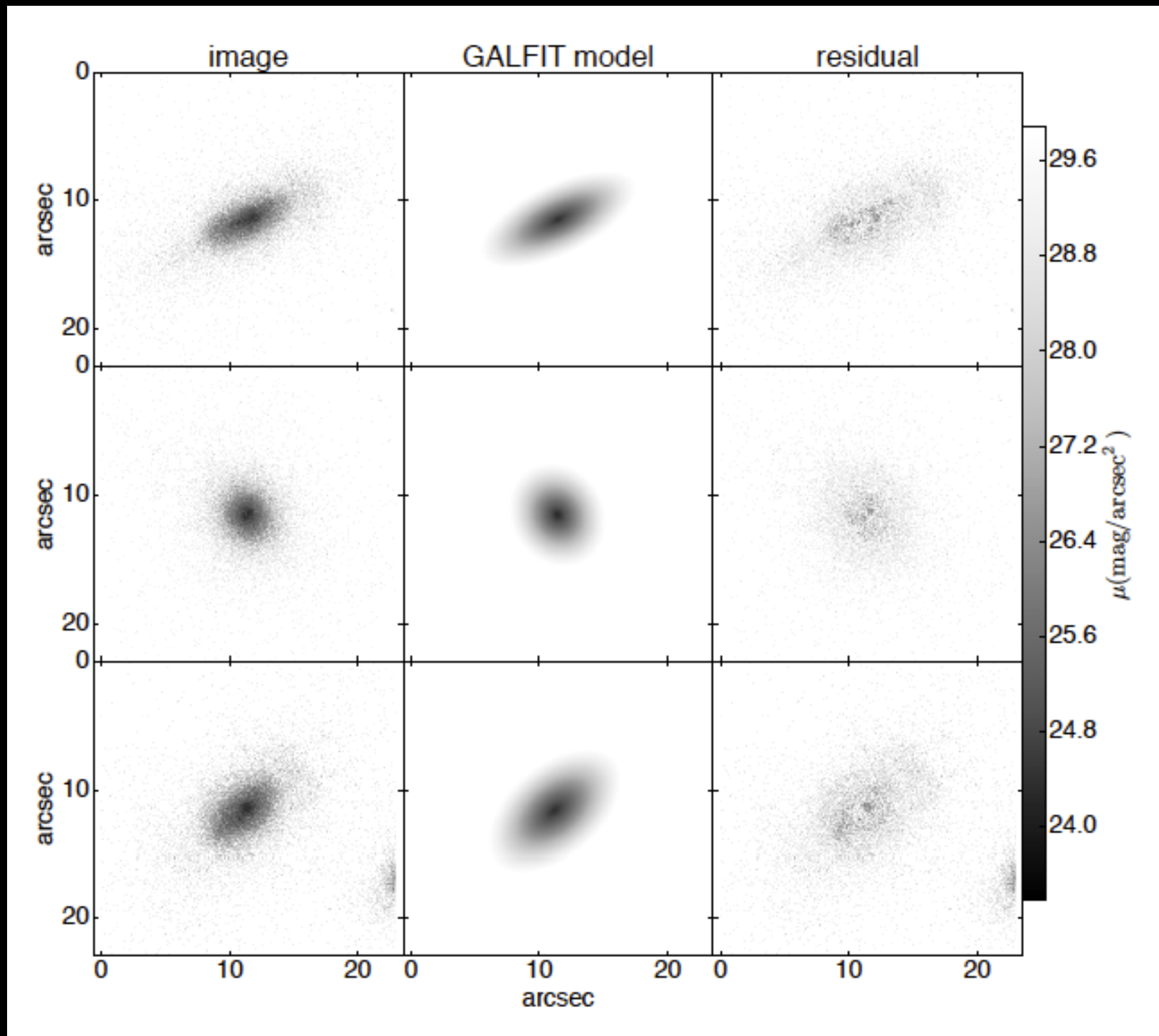
Directions:

1. puff up the galaxies with FIRE feedback
2. quench them* at cosmic time t_q
3. passively evolve their stars to $z \sim 0$ according to a stellar population synthesis model (FSPS)

*dynamical effects of gas removal ignored

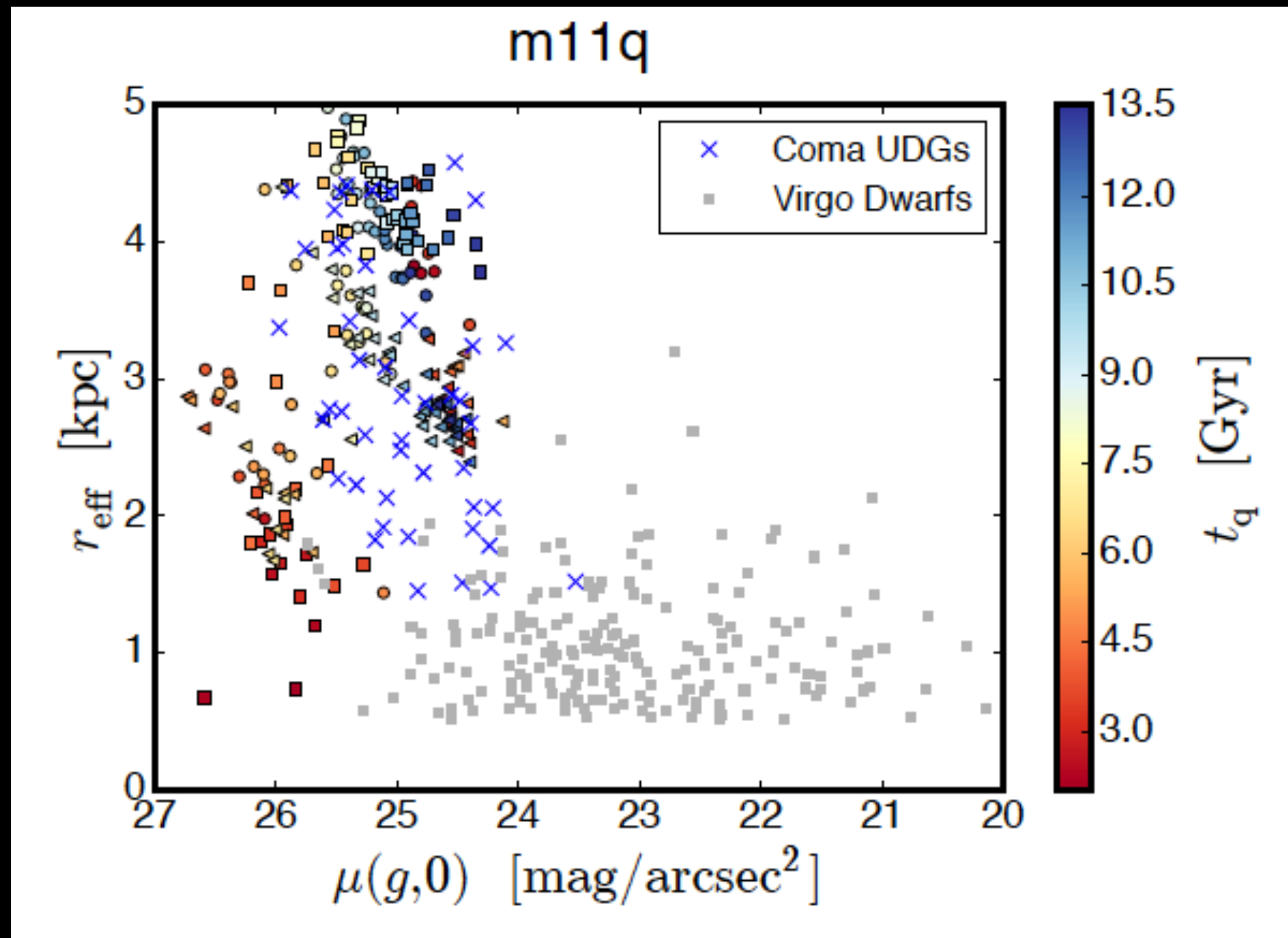
we ran extra galaxies
with **FIRE-2**
to fill up the range

Simulated UDGs in GALFIT



- generate galaxy images (without dust attenuation)
- fit with GALFIT

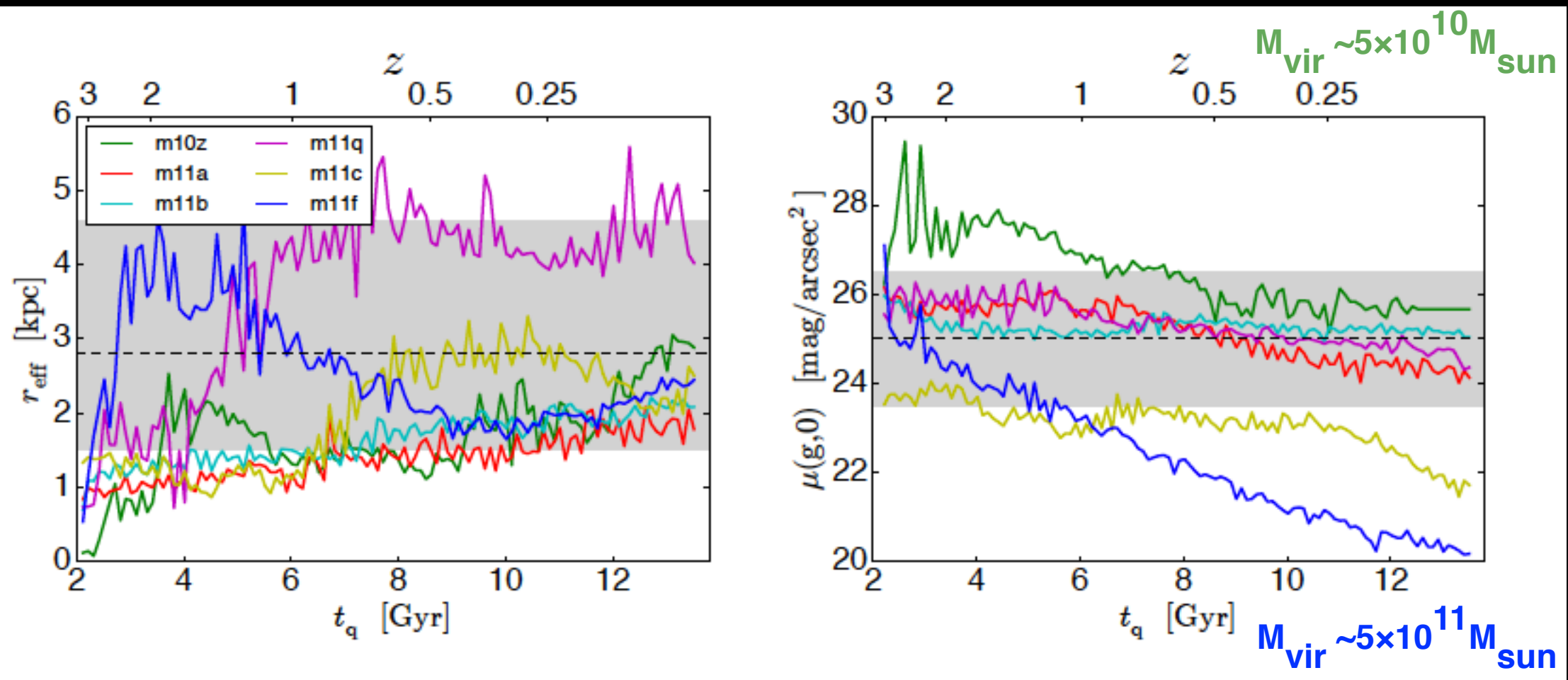
r_{eff} vs surface brightness



$$M_* \sim 10^7 - 5 \times 10^8 M_{\text{sun}}$$

- Our galaxies match the properties of observed UDGs at some quenching times!

UDGs in progress



1. Feedback $\rightarrow$ expand galaxies $\rightarrow$ diffuse profile
2. dwarf mass galaxies $\rightarrow$ UDGs
3. higher mass galaxies $\rightarrow$ early quench $\rightarrow$ UDGs

Failed dwarf or L^* galaxies?

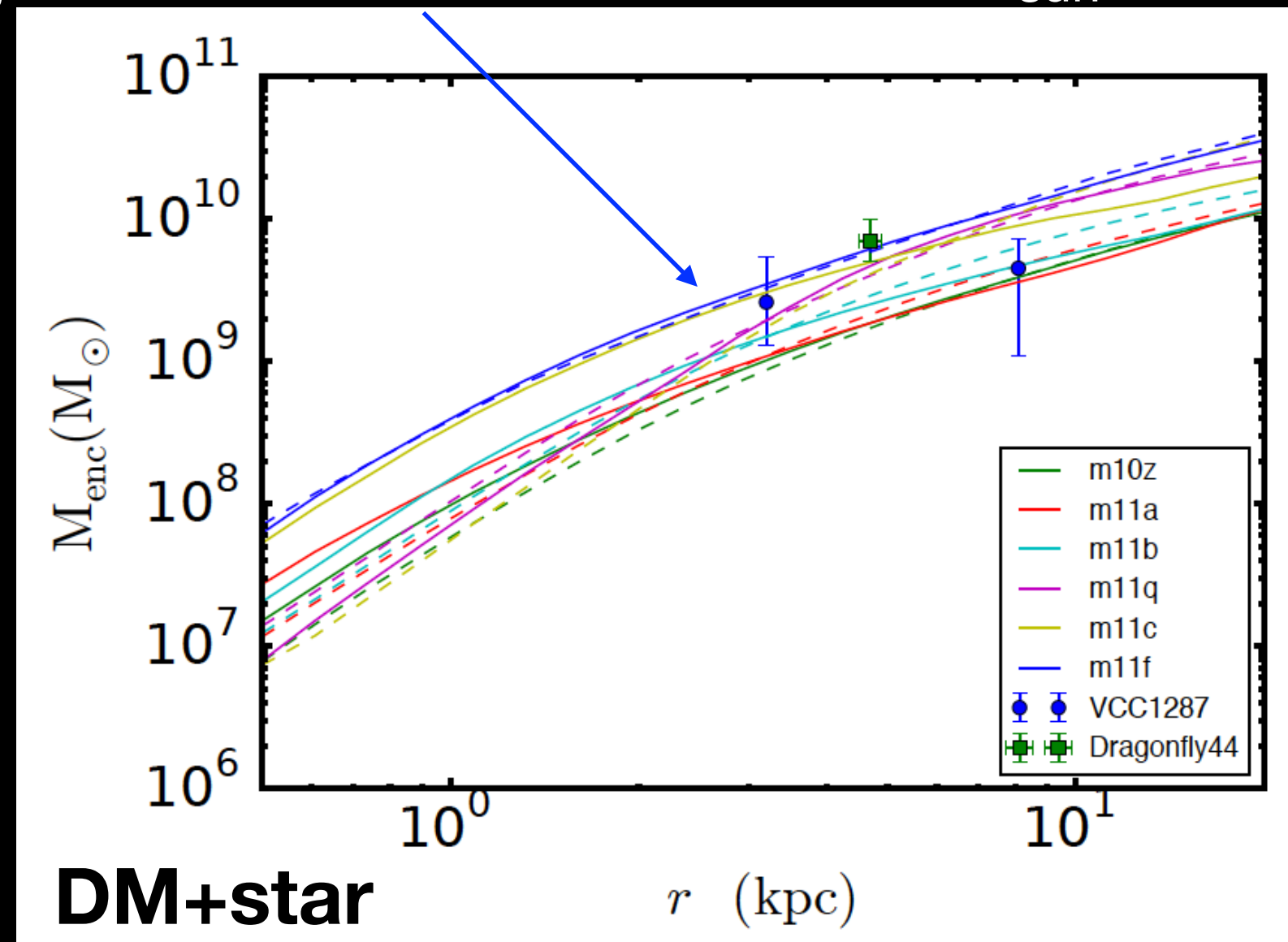
failed L^* (at $z=0$ $M_h \sim 5 \times 10^{11} M_{\text{sun}}$
at quenching $M_h \sim 10^{11} M_{\text{sun}}$)

- if growth continued, UDGs would be

1. dwarf mass
(Bealsey+2016)

2. $\sim L^*$ mass
(von Dokkum+2016)

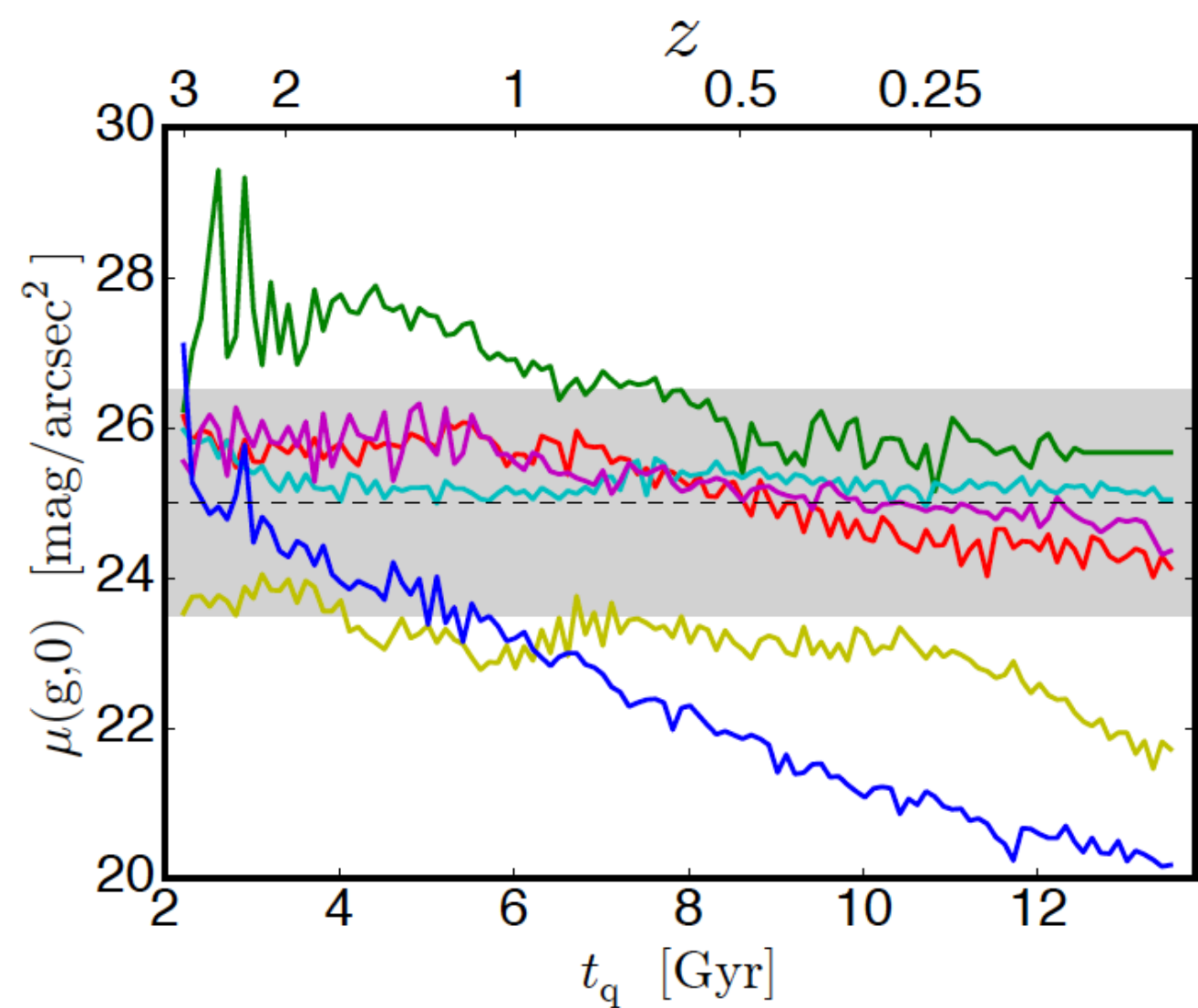
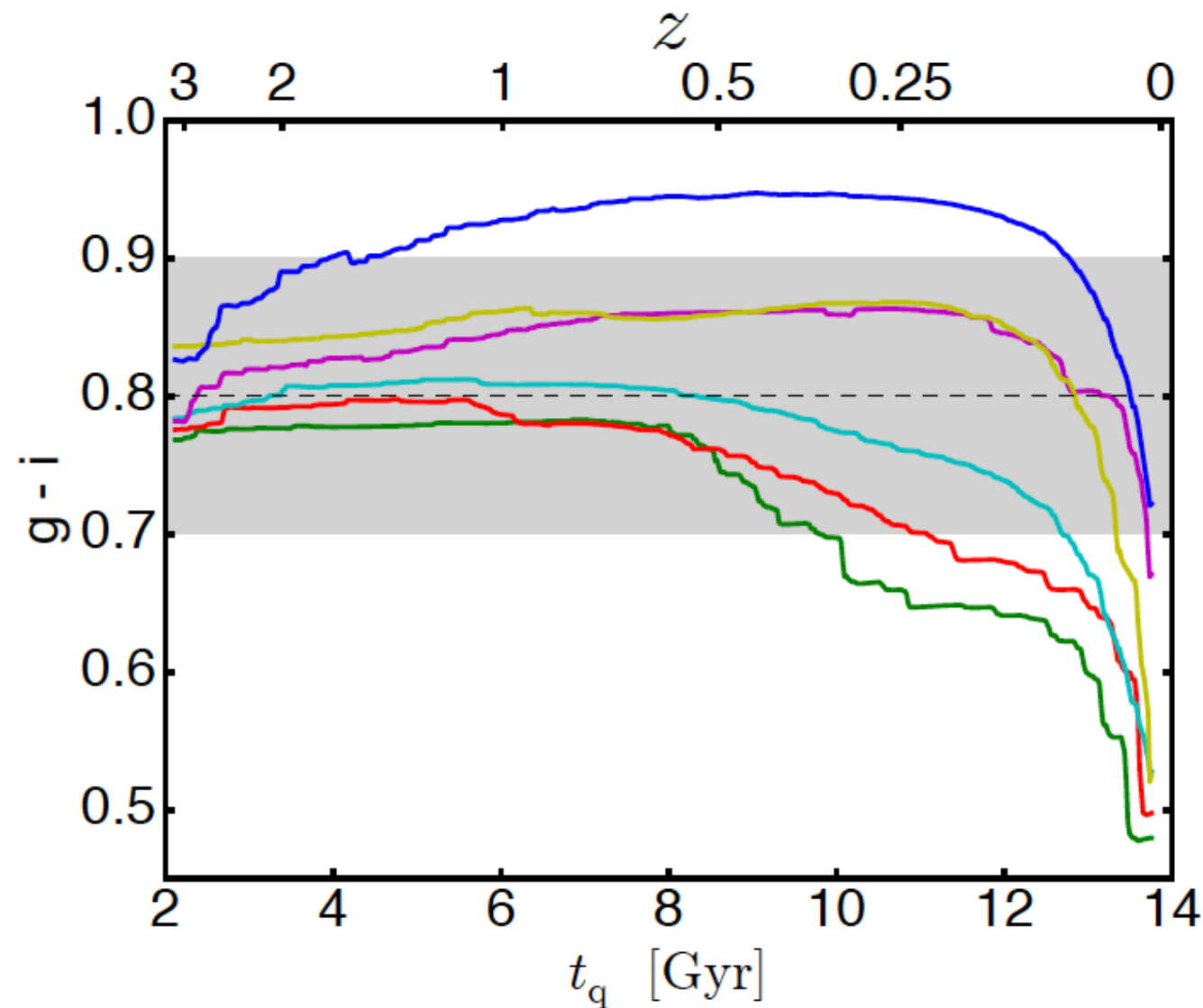
- Key evidence :
enclosed masses!



Chan+ in prep

Blue UDGs in field?

RED



BLUE

Summary

- UDGs are quenched galaxies, expanded by stellar feedback
- Some of UDGs are 'failed' dwarfs
- more massive ones could be 'failed' L^* galaxies, quenched at $z > 2$
- we predict plenty of 'blue' UDGs in the field
- Chan+ in prep (final draft state, to submit)