THE PROGENITORS OF MASSIVE GALAXIES:

INSIDE-OUT GROWTH AT 0<z<2

AND

IDENTIFICATION OF THEIR STAR FORMING ANCESTORS AT z~3

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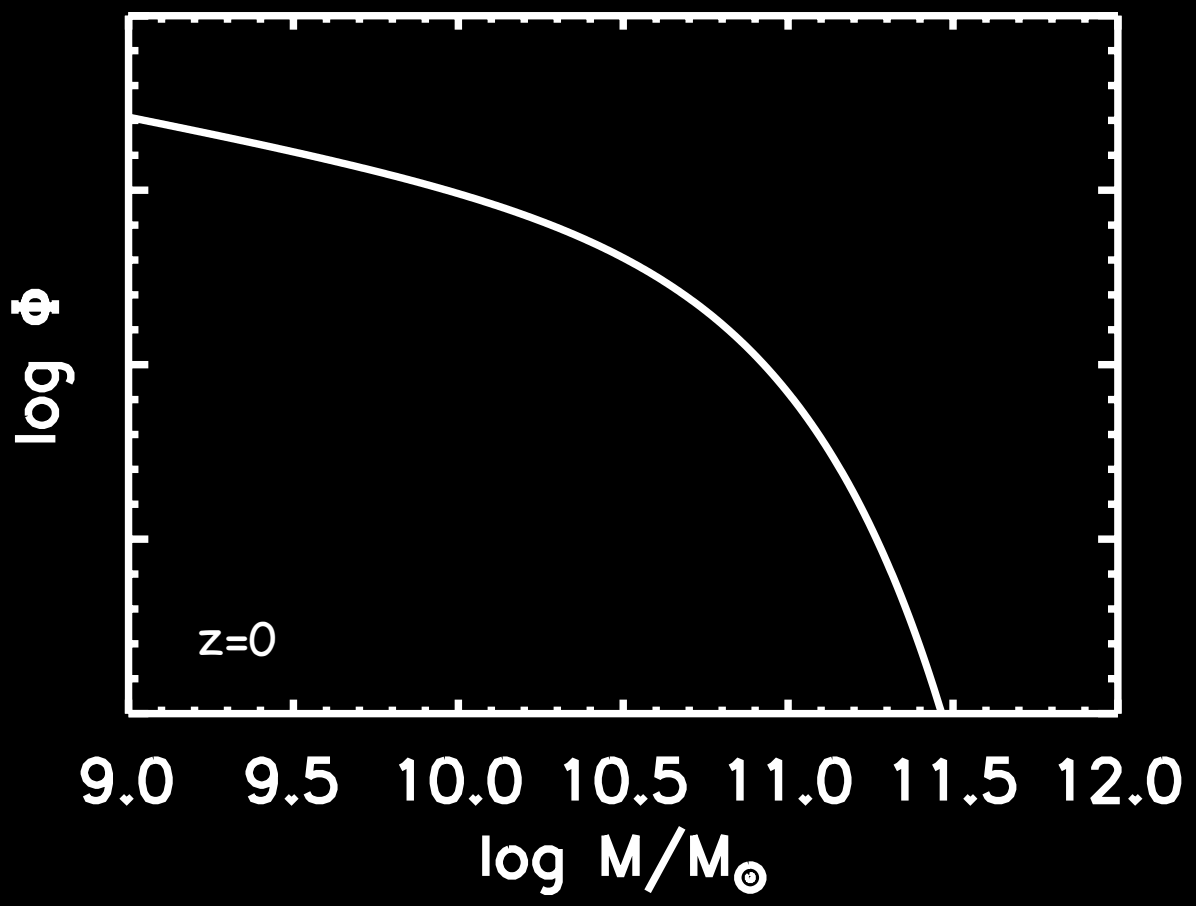
Galactic Girths, IPMU

February 5, 2015

How did the Most Massive Galaxies Assemble?



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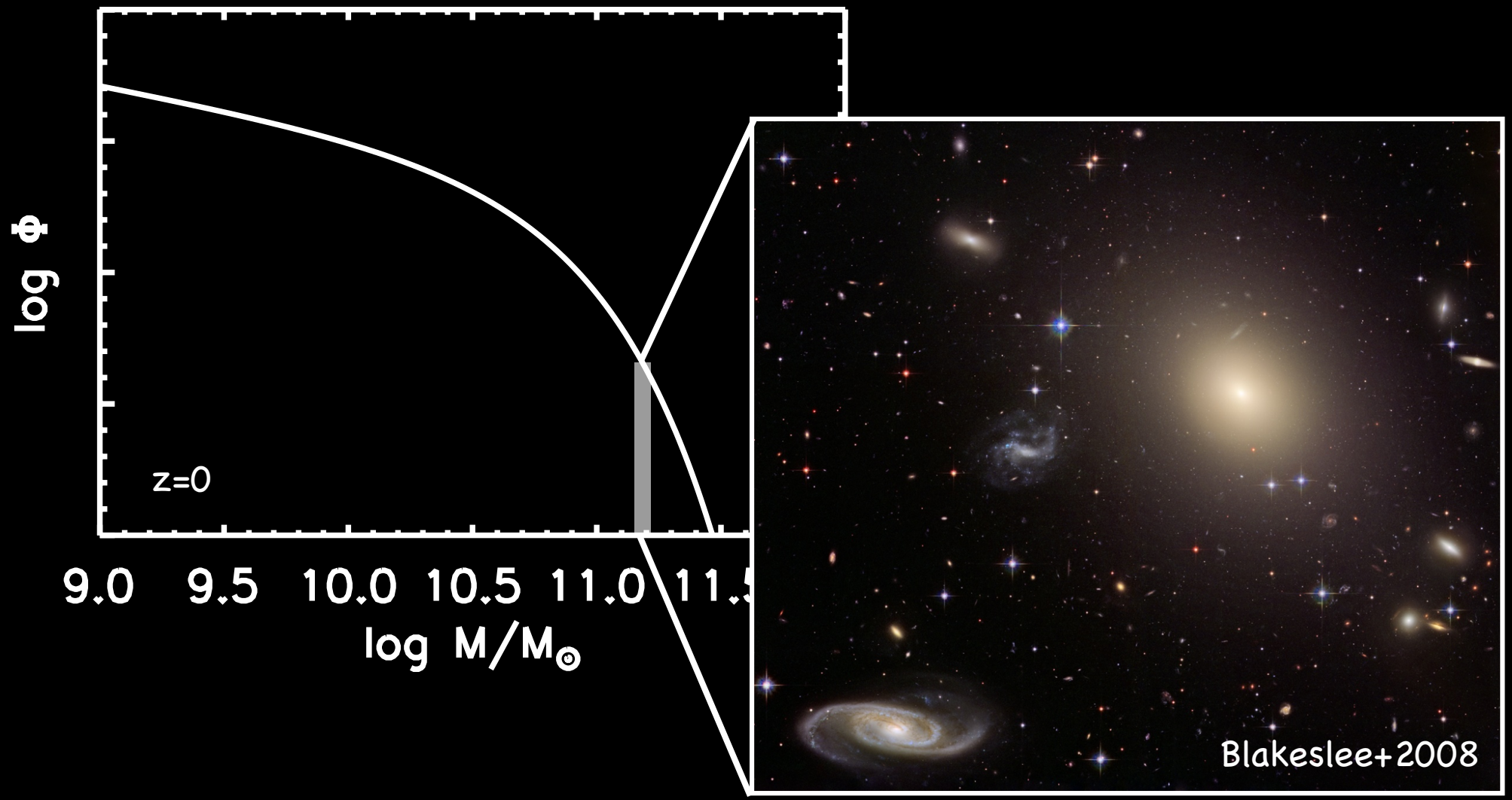
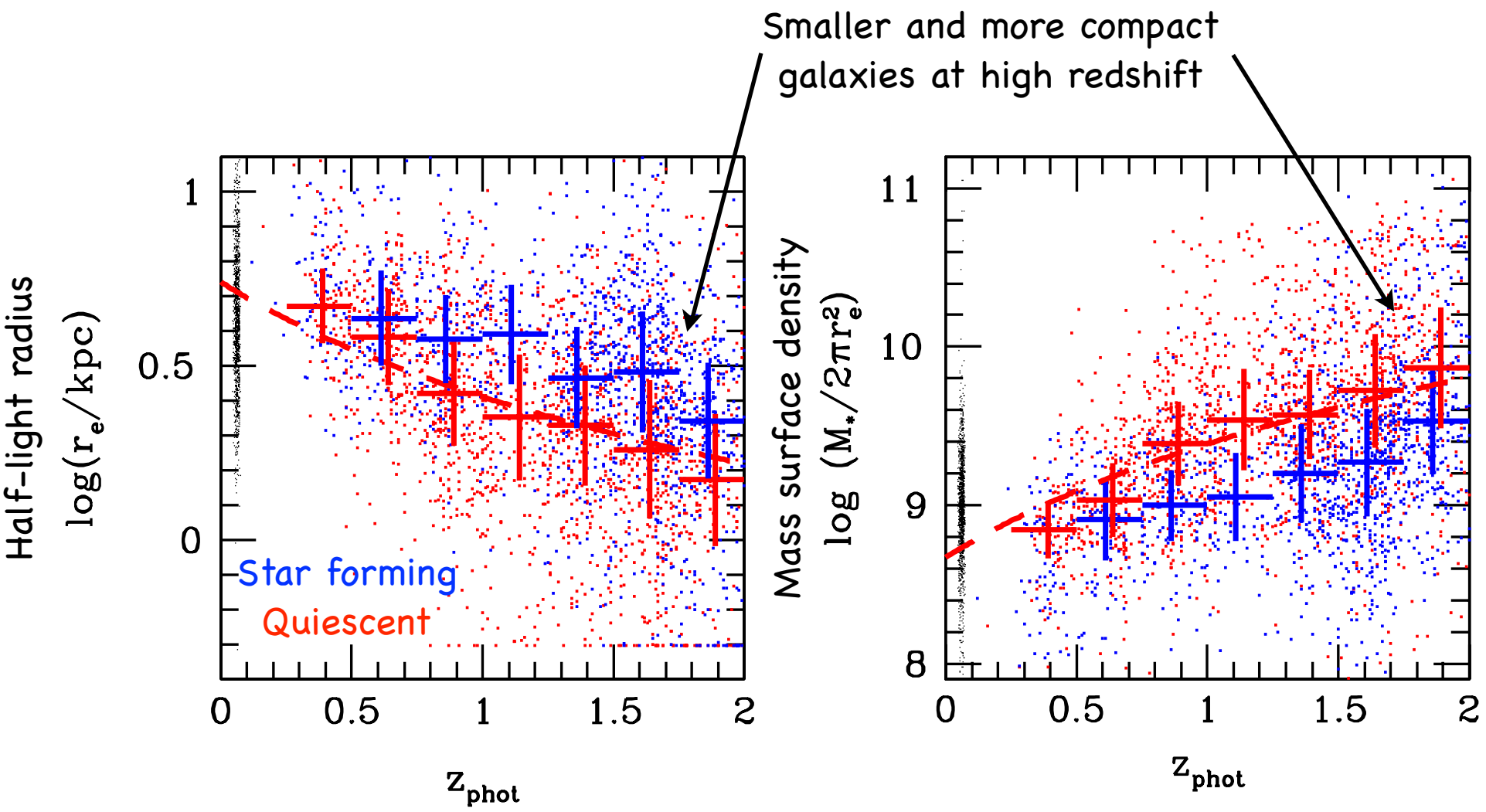


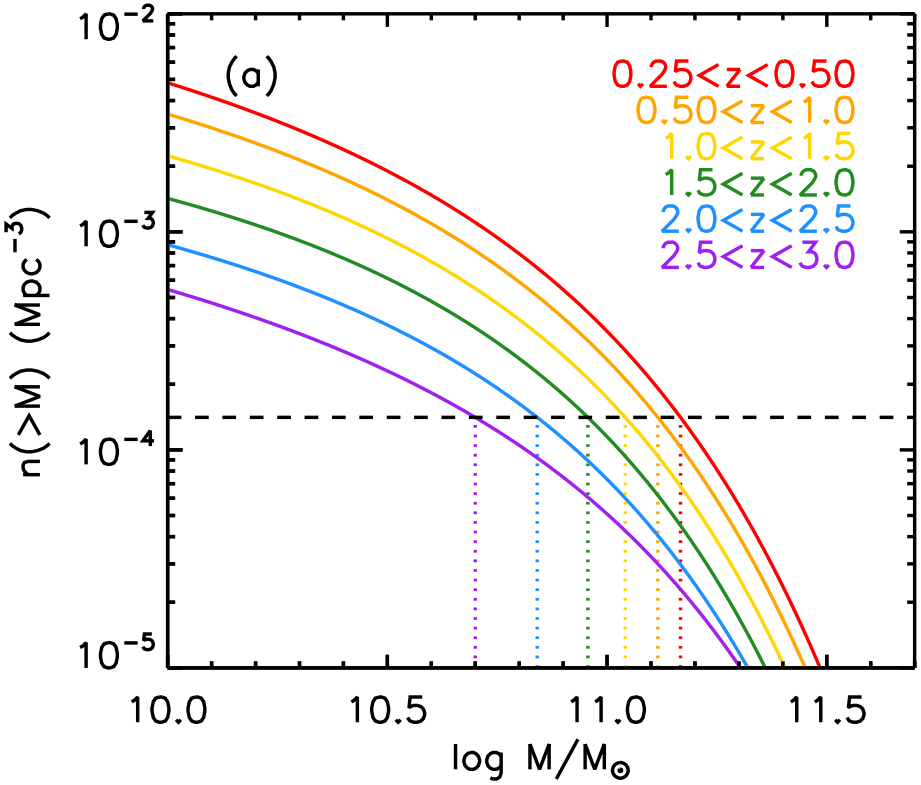
Size Evolution for Mass-Selected Samples



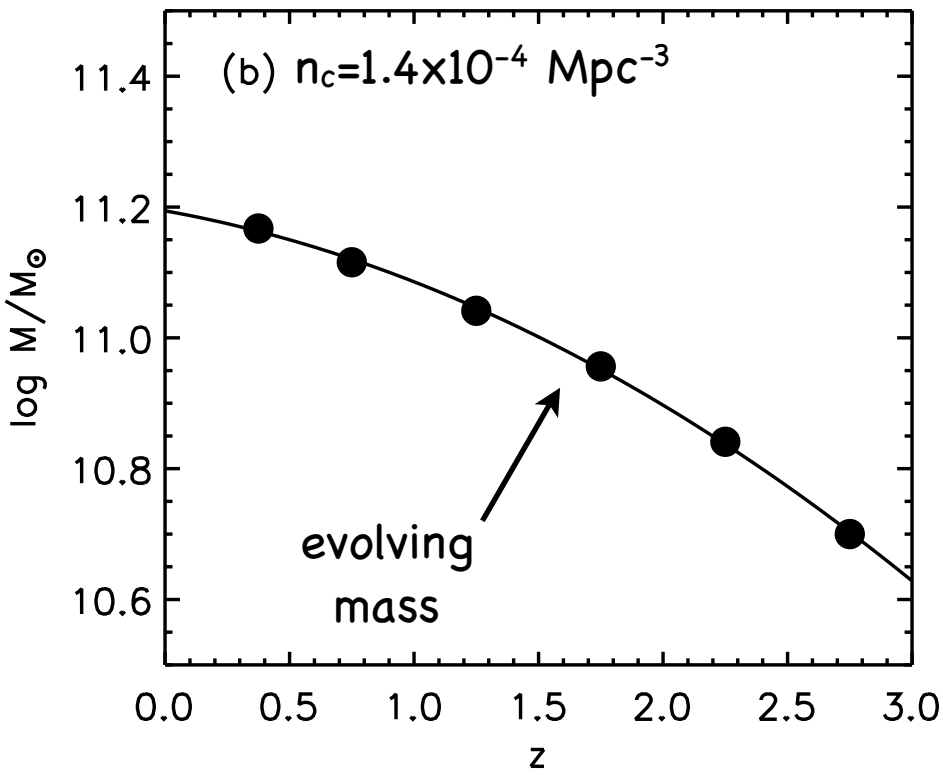
Mass-selection: $M > 10^{10.8}\ M_\odot$

Williams+2010

Connecting progenitors and descendants: selecting galaxies at a constant cumulative number density

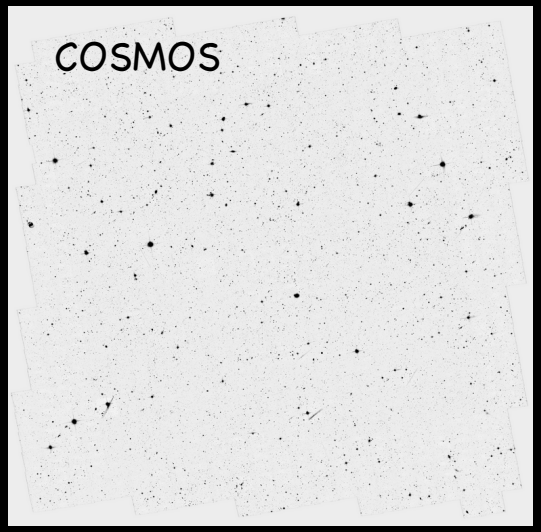


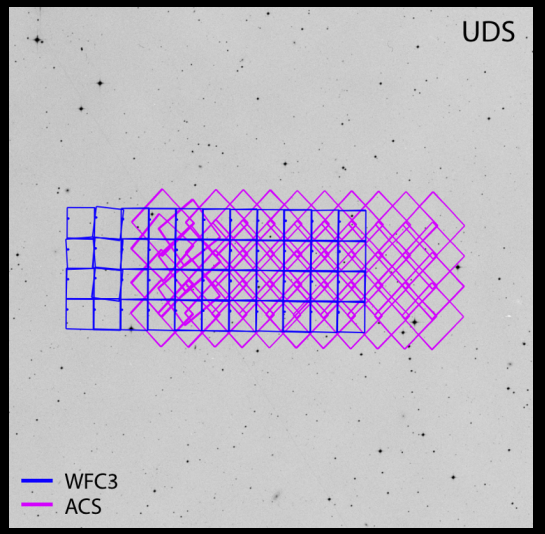
Stellar mass functions from Marchesini+2009

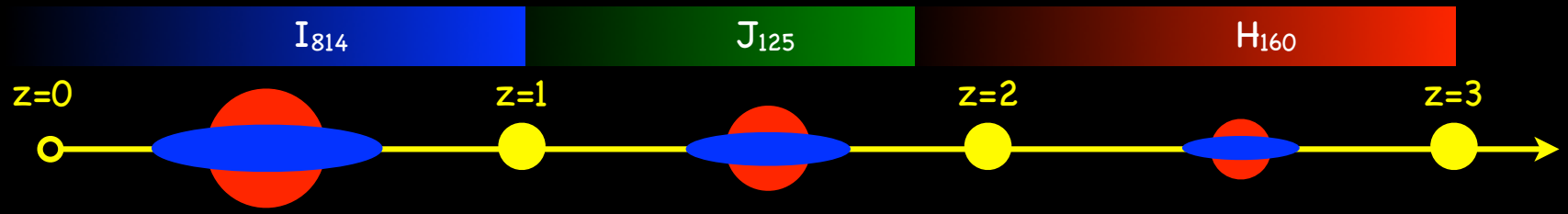


Patel+2013

Data and Analysis







COSMOS (0.25<z<1):

- Wide-area ACS I_{814} (Koekemoer +2007, Scoville+2007)
- Ks-selected UVISTA catalog (29 bands) (Muzzin+2013b)
- Wide area: needed to sample massive galaxies

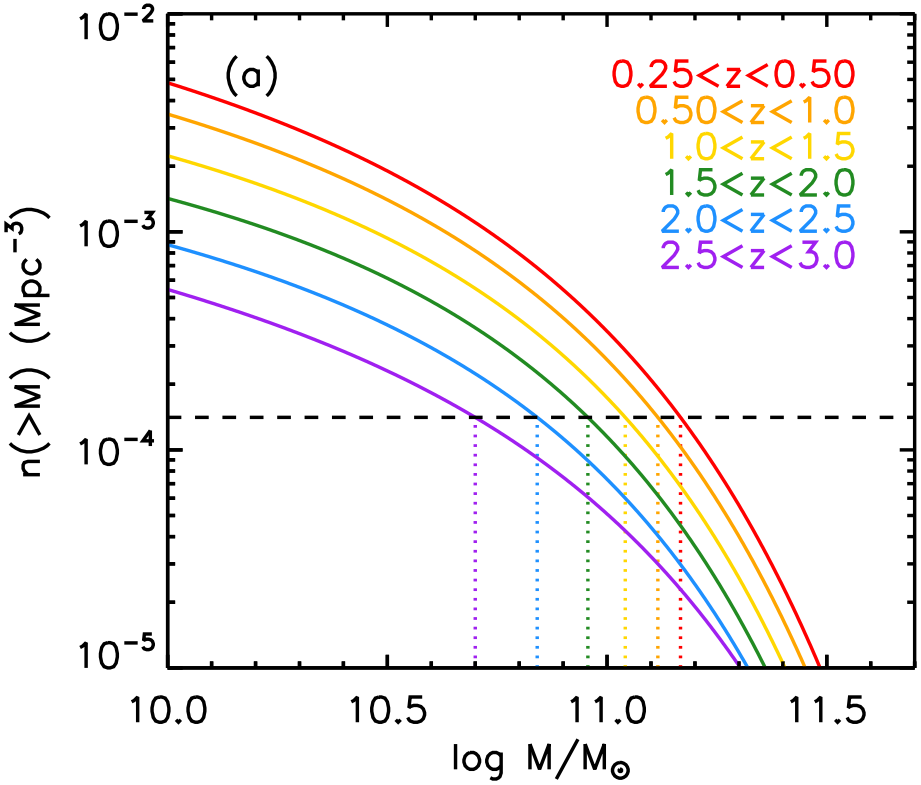
UDS (1<z<3):

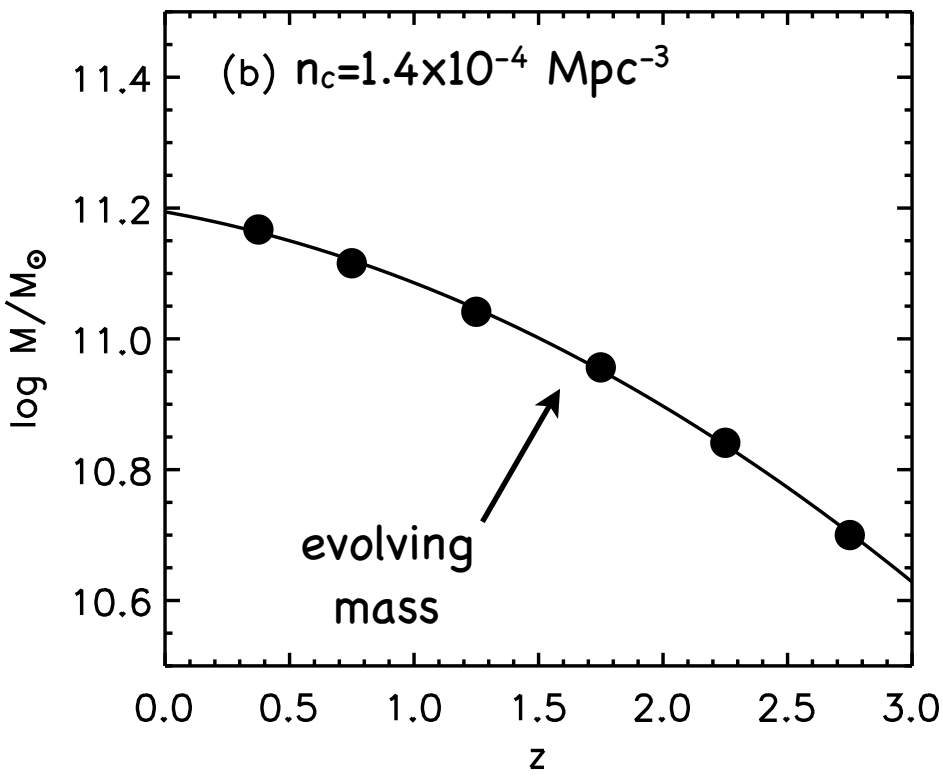
- CANDELS J_{125}, H_{160} (Koekemoer +2011, Grogin+2011)
- K-selected catalog from R. Williams+, in prep (DR8)
- Deep near-IR: crucial to reach low mass limits at high redshift

Uniform Analysis:

- Photo-z's w/EAZY
- Stellar masses w/FAST
- Structural parameters w/ GALFIT (Peng+2002)

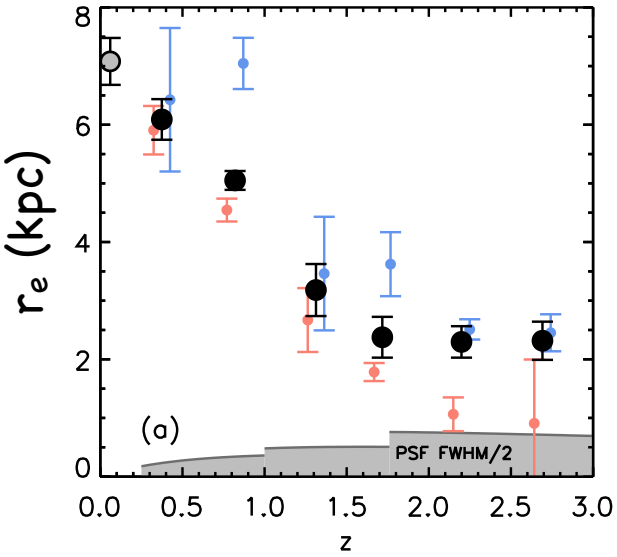
Connecting progenitors and descendants: selecting galaxies at a constant cumulative number density

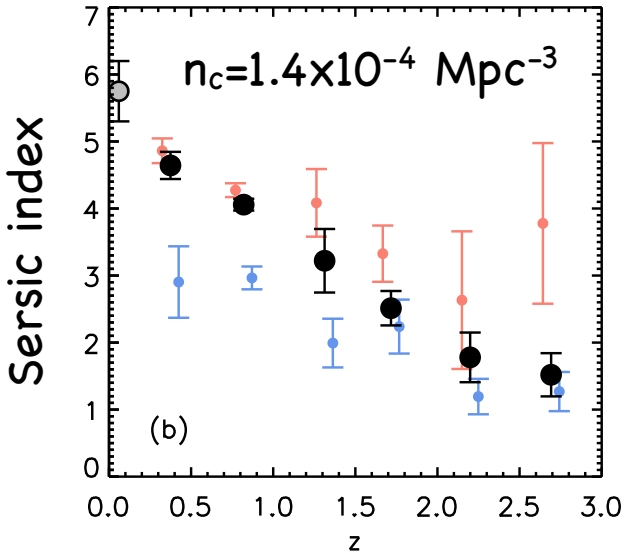


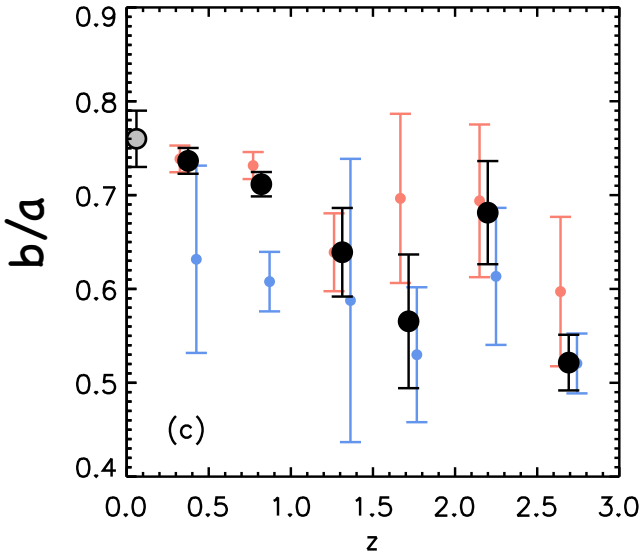


Patel+2013

Structural Evolution at Constant Number Density







Patel+2013

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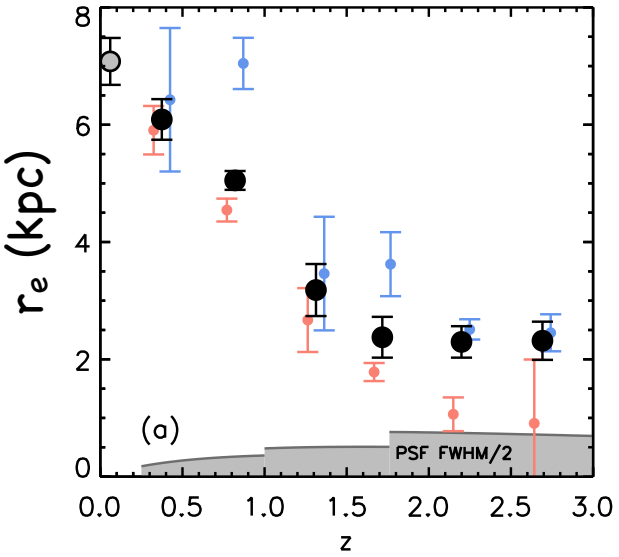
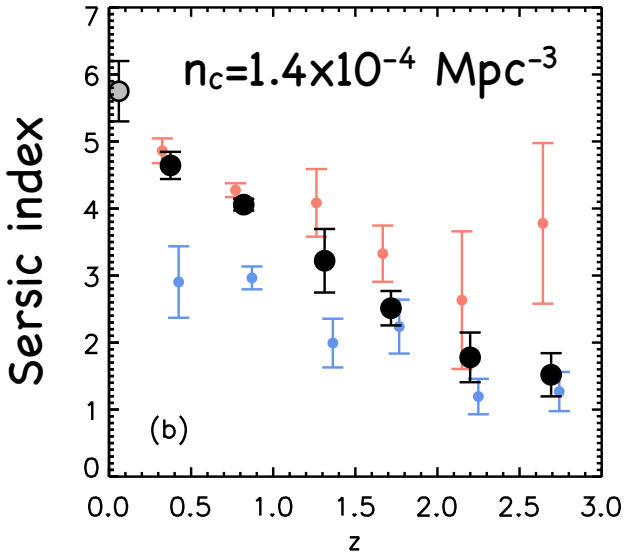
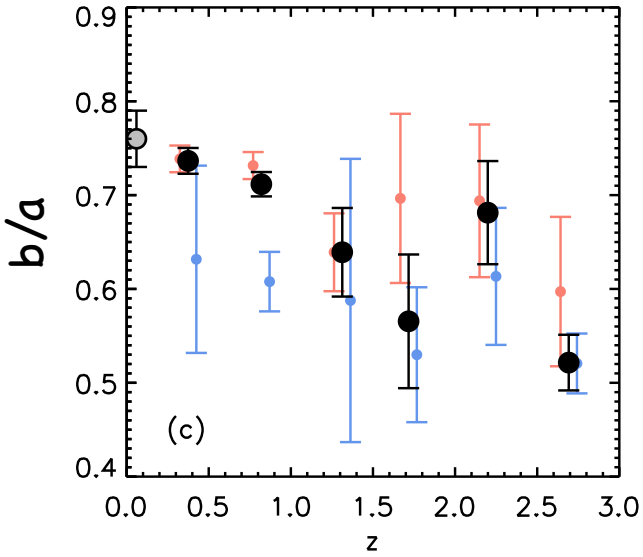
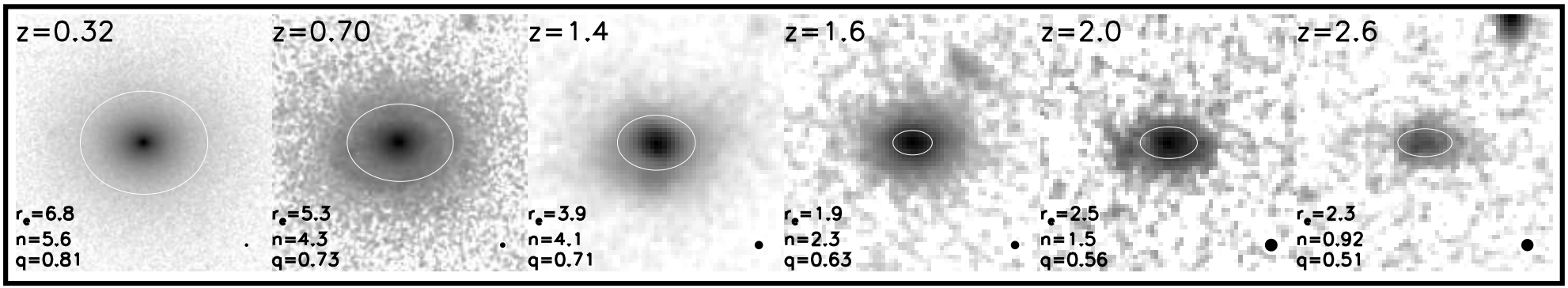






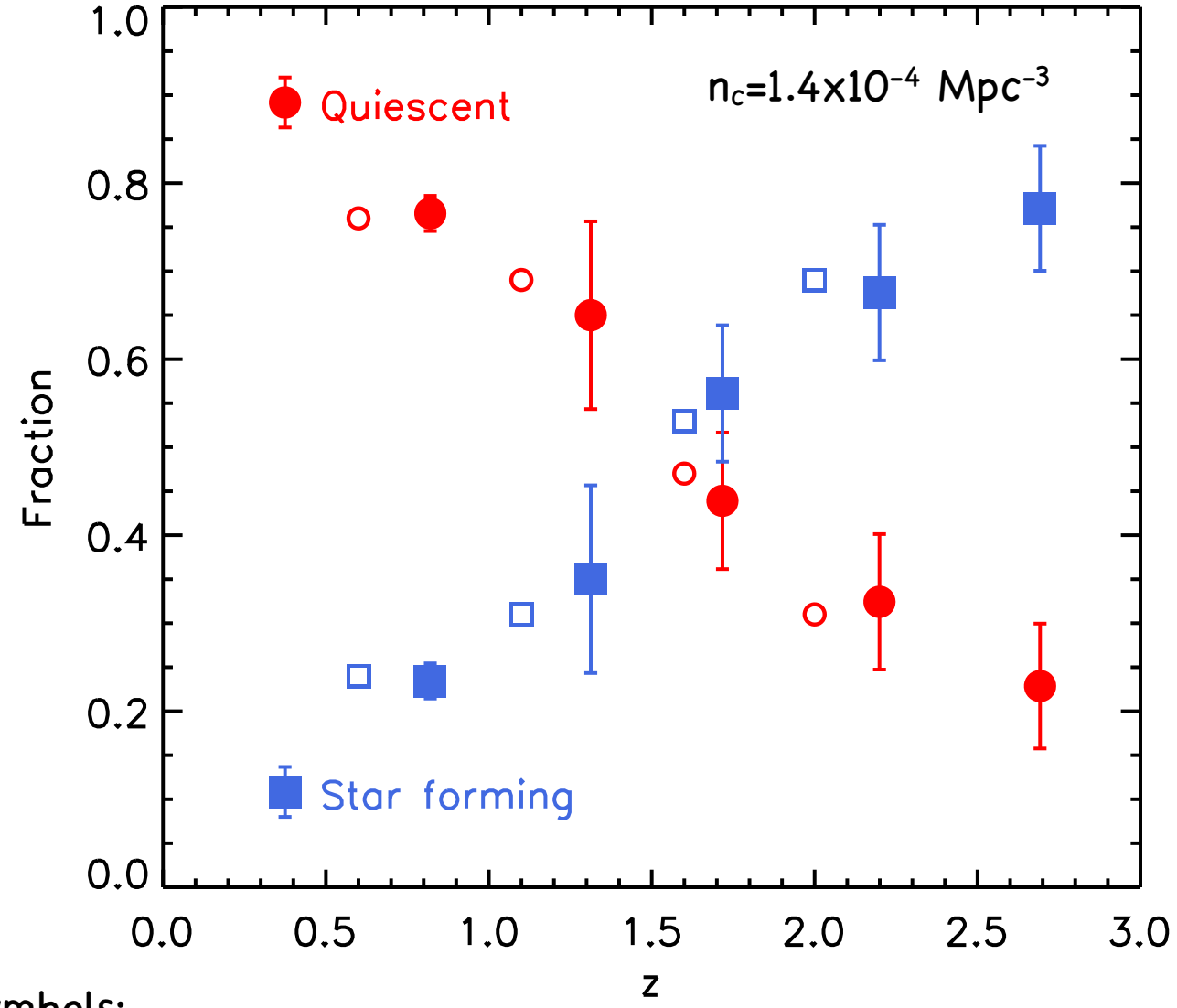


I_{814} J_{125} H_{160}

Example progenitors

Patel+2013

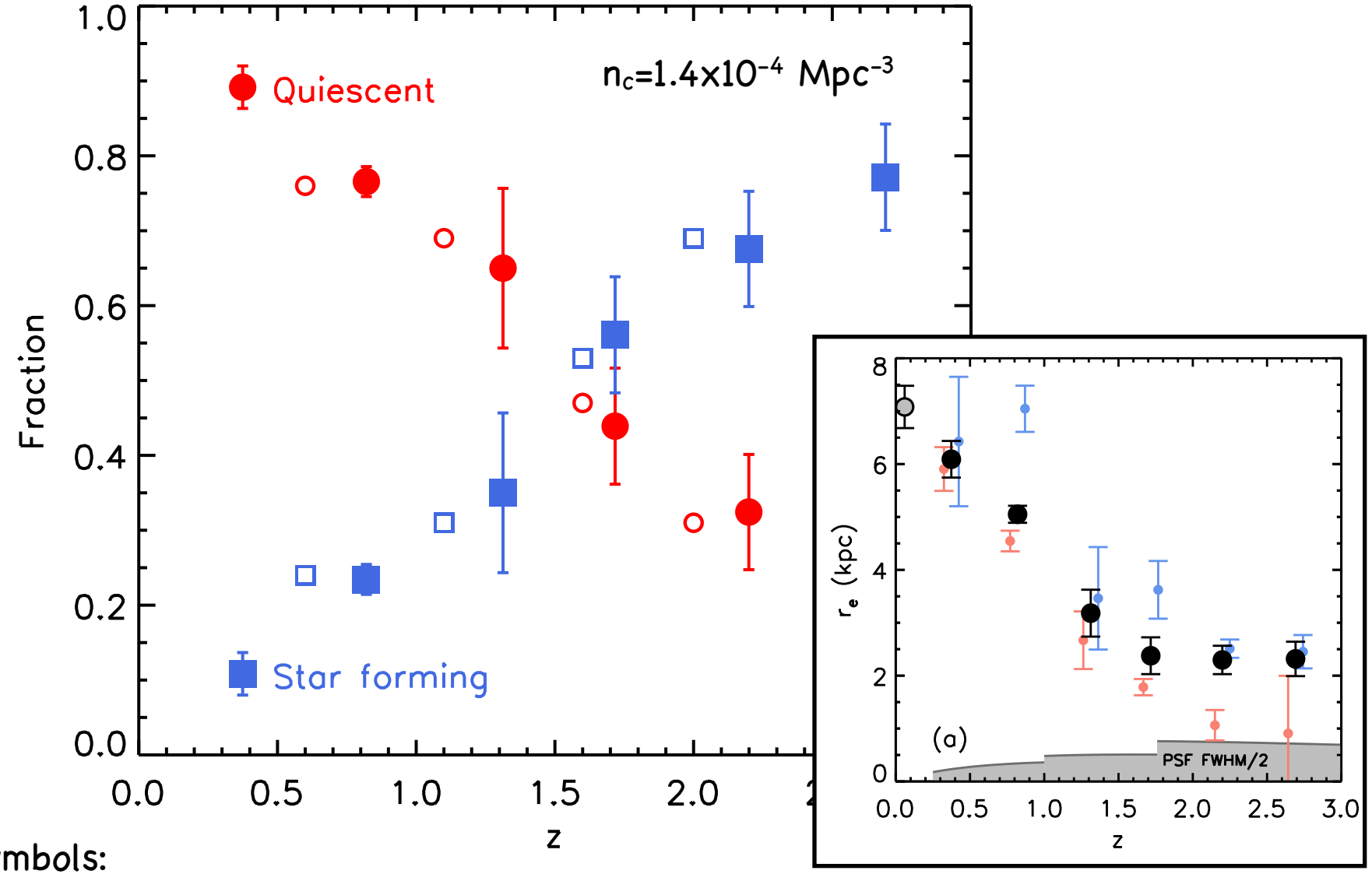
Progenitors at z=3 are Star Forming



open symbols:
Brammer+2011

Patel+2013

Star Forming Disks Give Way to Compact Quiescent Galaxies over 1.5<z<3



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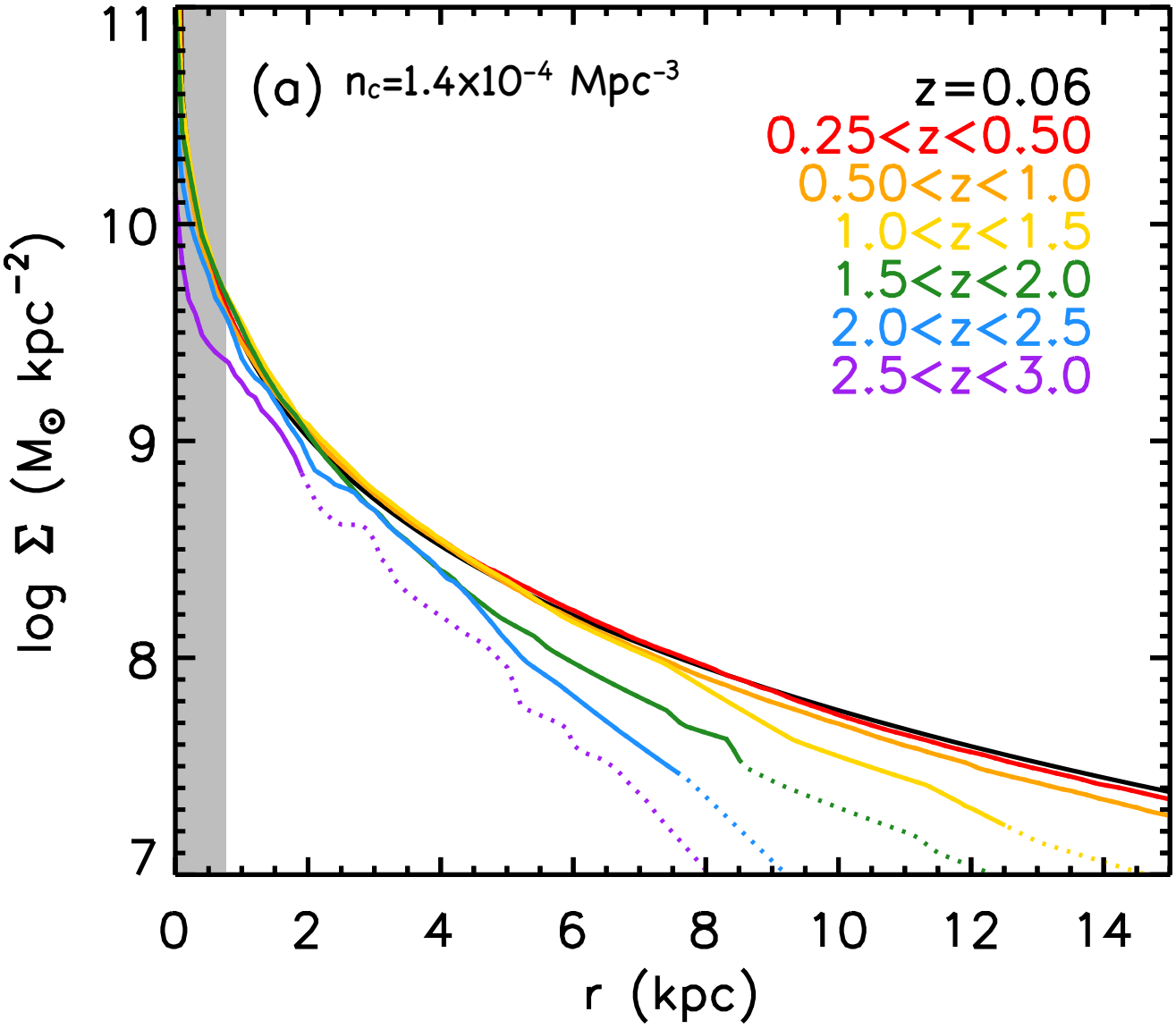
Mass profiles of galaxies selected at a constant number density

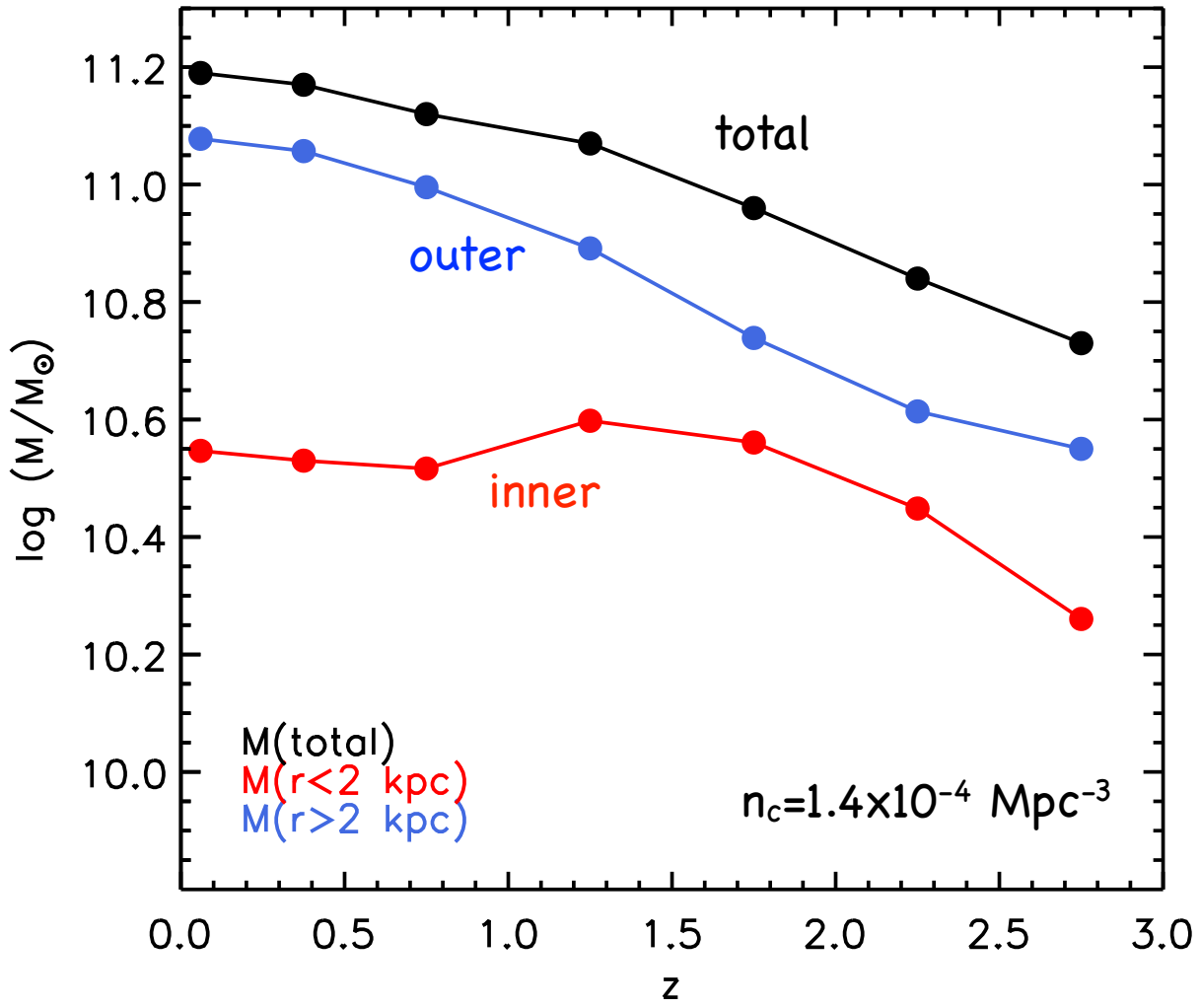


0.25 < z < 1
COSMOS
(ACS I_{814})

1 < z < 3
UDS
(WFC3 J_{125}, H_{160})

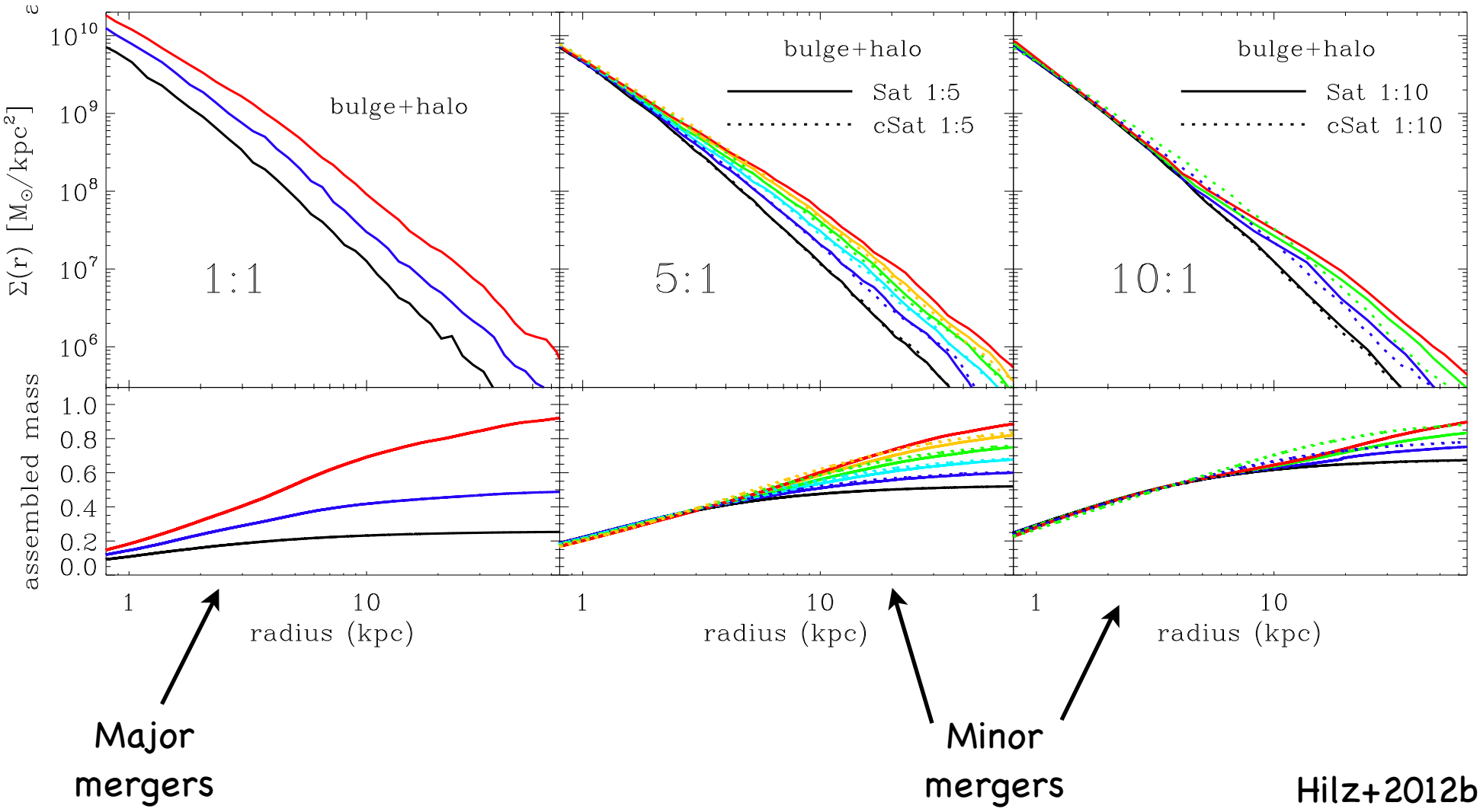
Patel+2013

Inside-Out Mass Growth at z<2



Patel+2013

Simulations: dry minor mergers can grow galaxies inside-out



Hilz+2012b

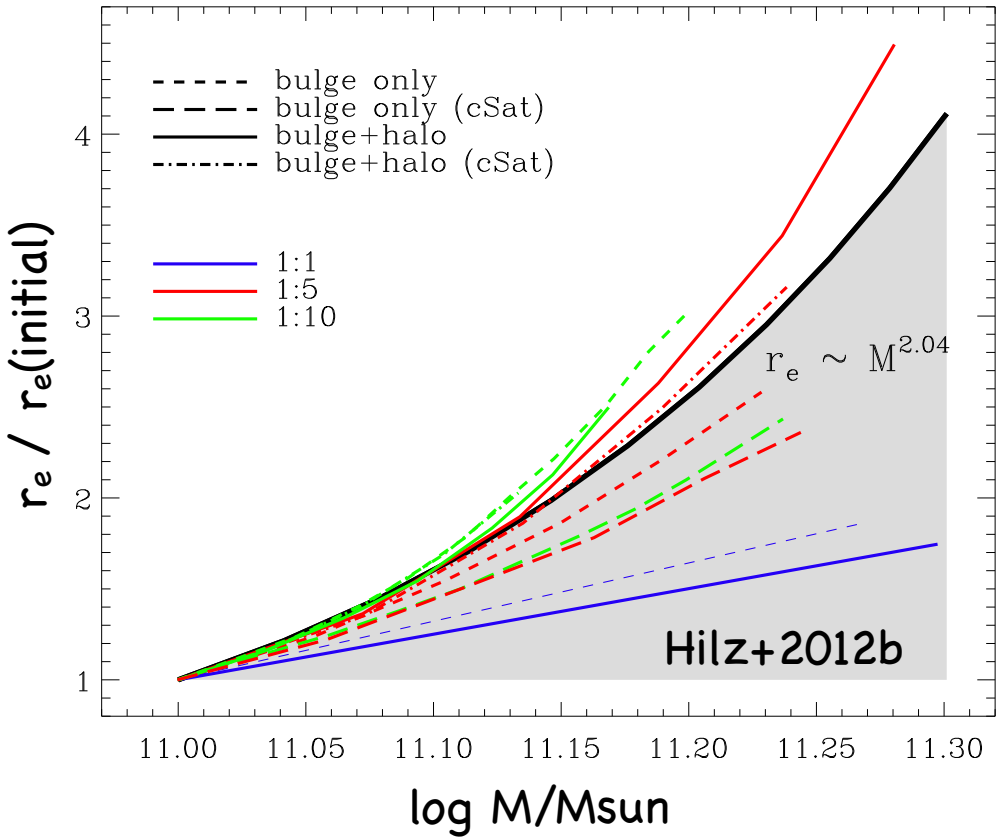
Size-Mass Growth: $r_e \propto M^2$

Our observations:

Combine mass growth with size growth at z<2:

$$r_e \propto M^{2.0\pm0.3}$$

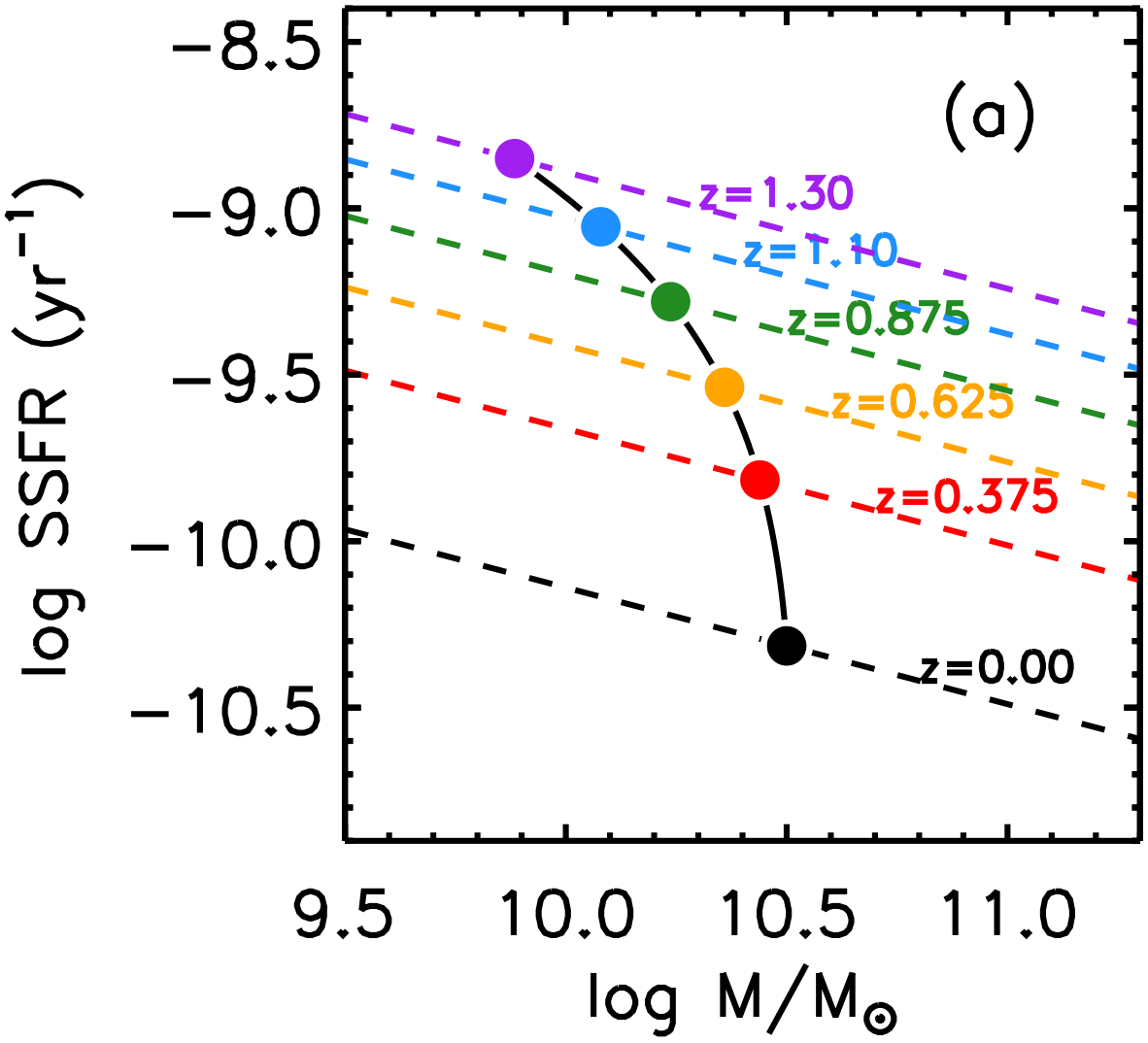
Simulations:



see also, Bezanson+2009,
van Dokkum+2010

How does QG formation/ mass assembly compare to that of lower mass, SFGs?

Stellar mass growth history from an evolving star forming sequence

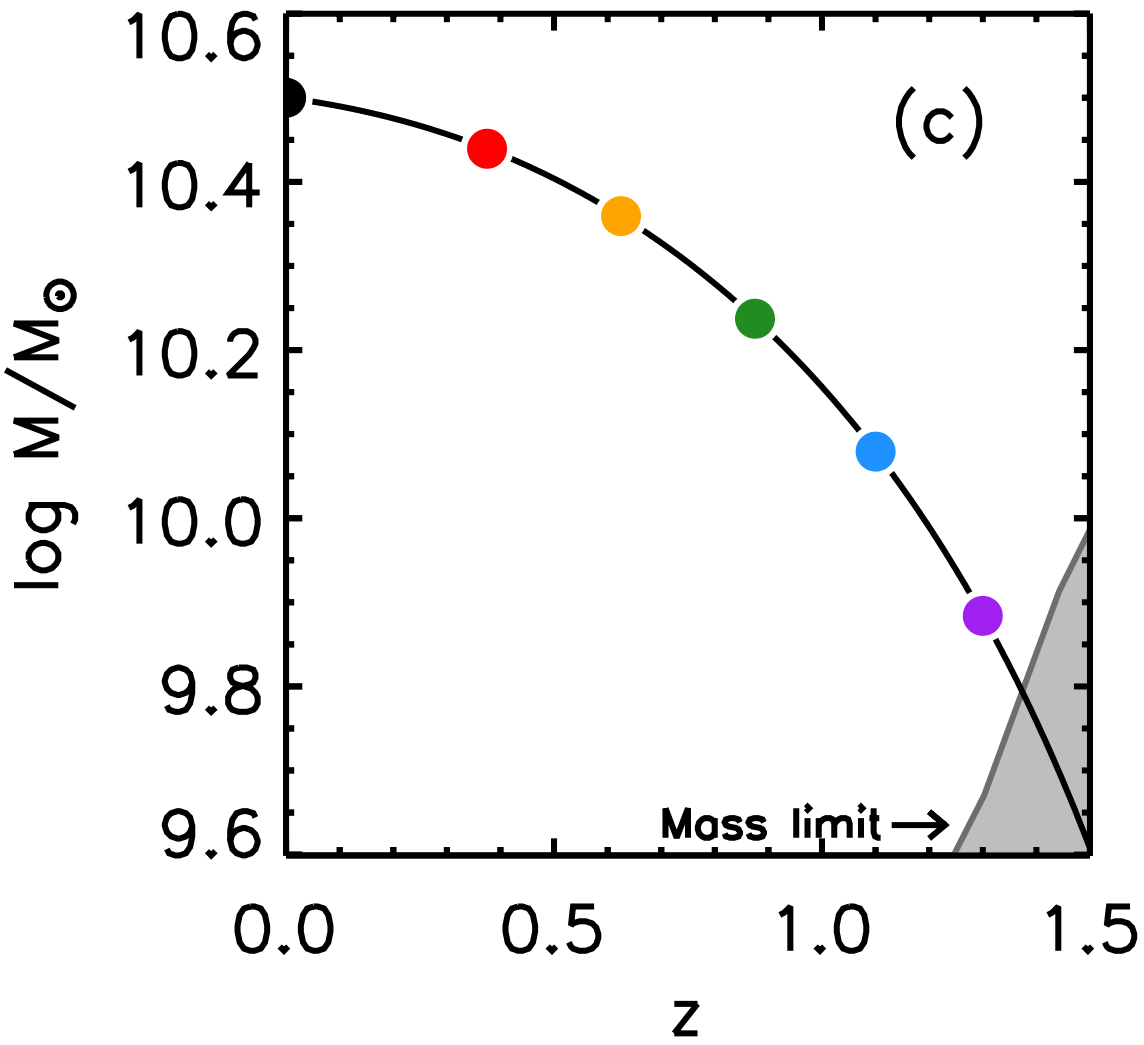


SSFR ∝ $M^{-0.35}(1+z)^{3.45}$
(Karim+2011)

Mass growth computed by
Leitner 2012

Patel+2013b

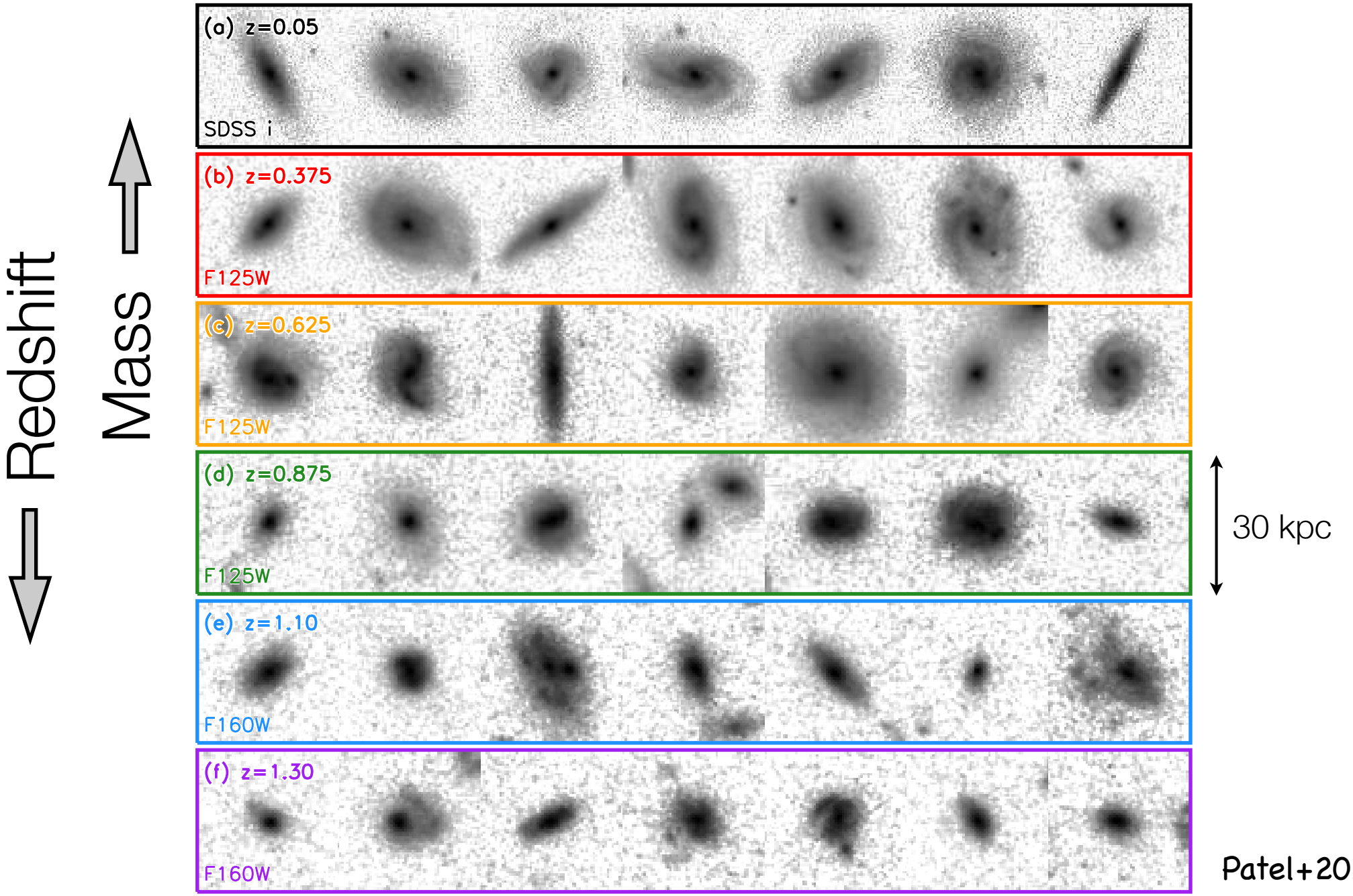
Stellar mass growth for a SFG with final mass $M=3x10^{10}\ M_{\odot}$



- Late mass assembly: since z=1, mass roughly doubles

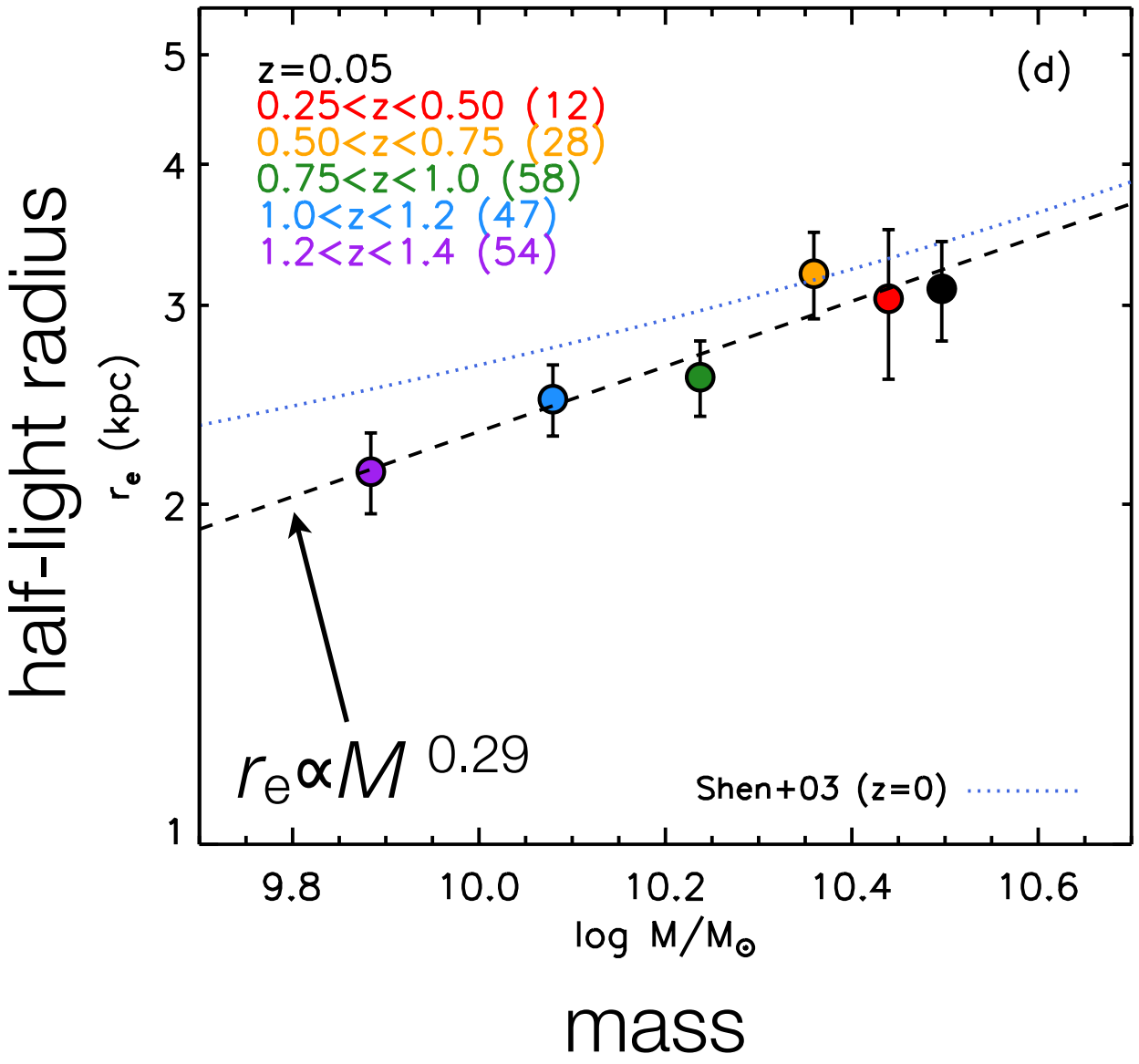
Patel+2013b

Example progenitors in 3D-HST



Patel+2013b

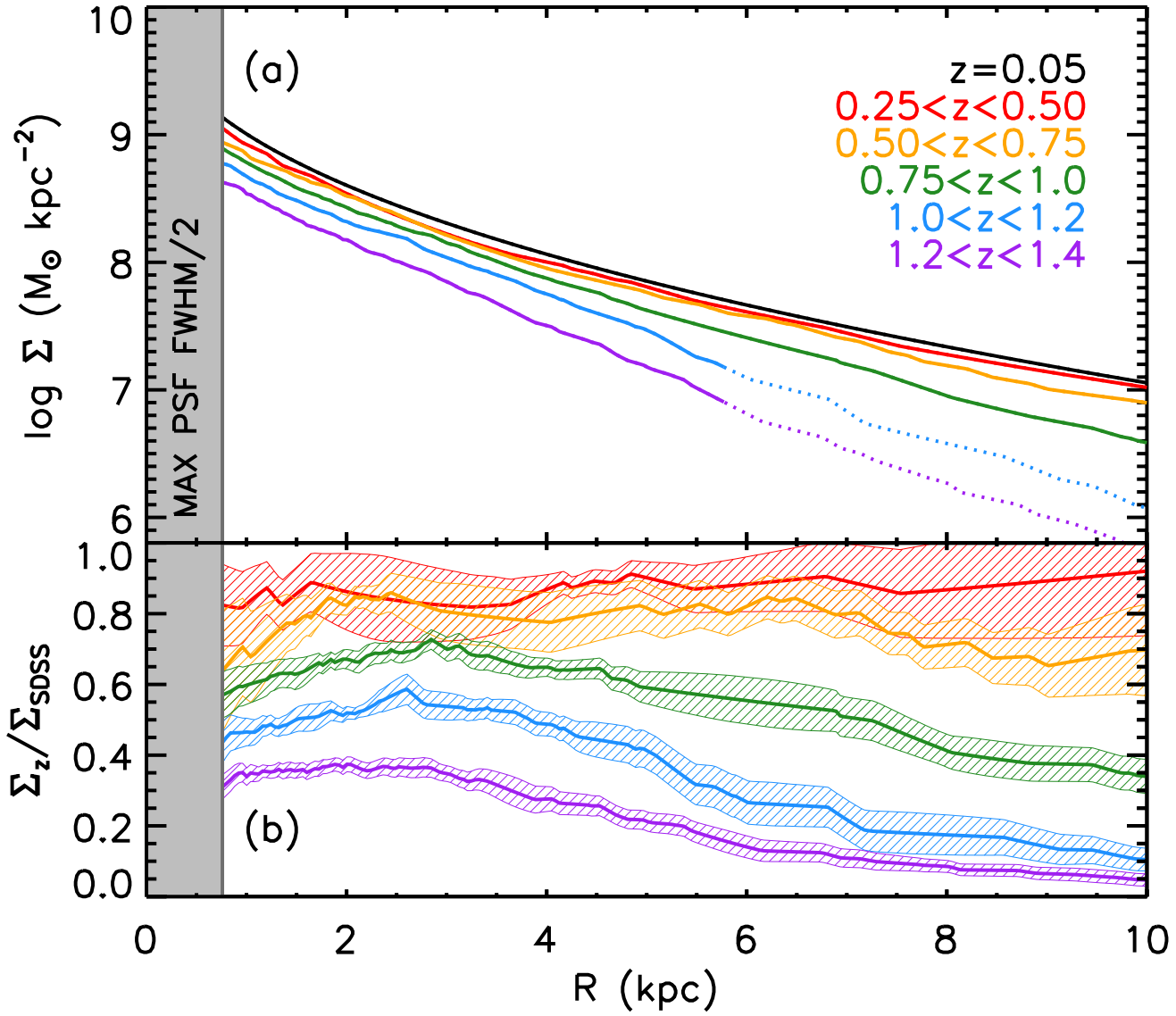
Evolution in the size-mass plane for SFGs



- SFGs: $r_e \propto M^{0.29}$
- Quiescent galaxies: $r_e \propto M^2$ (e.g., Bezanson+2009, van Dokkum +2010, Patel+2013)

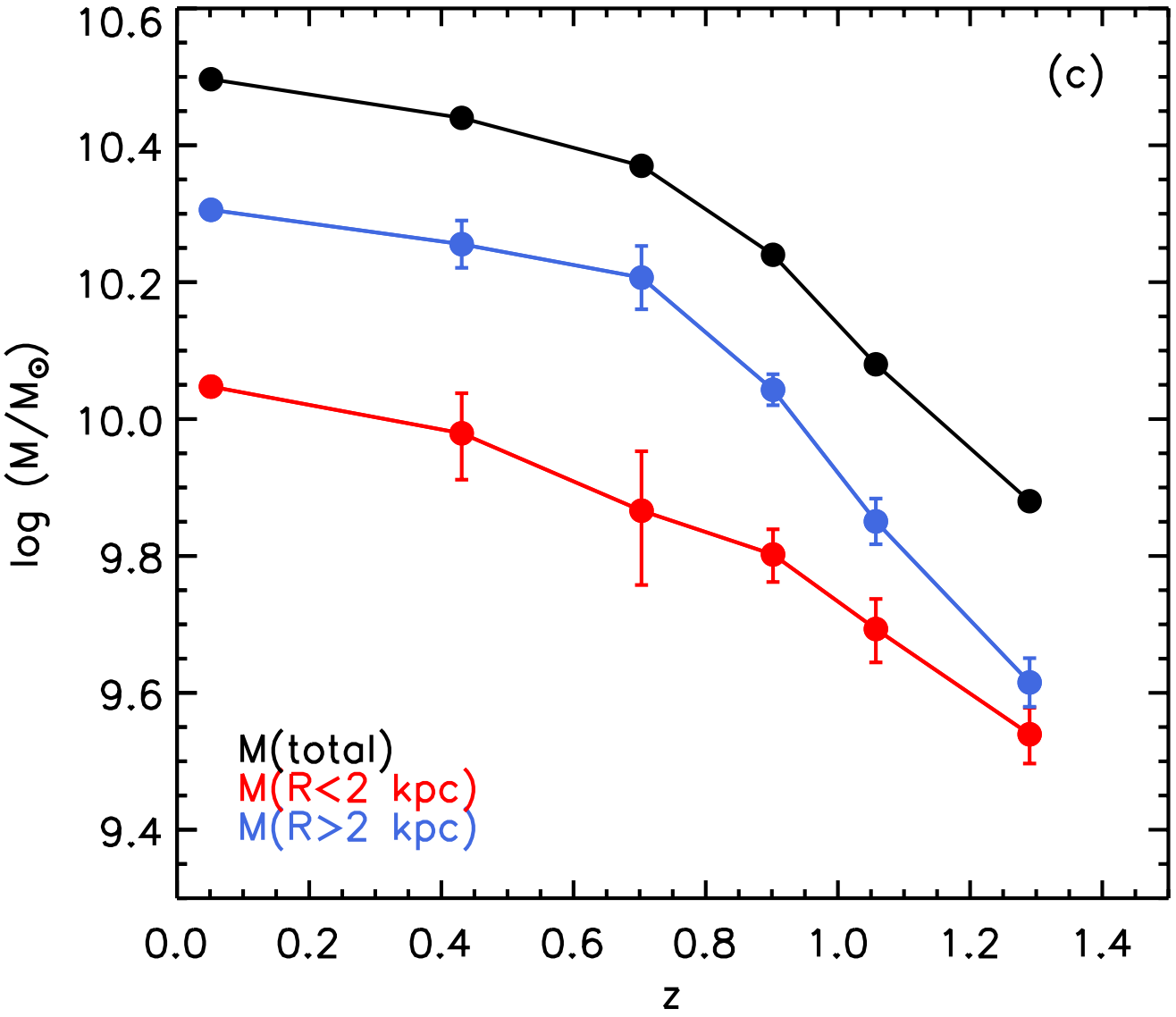
Patel+2013b

Mass surface density profiles: continual stellar mass growth at all radii



Patel+2013b

Relative mass growth in the central/outer regions



- Most new stellar mass forms in outer regions → increasing r_e toward low redshift
- Central regions grow more gradually

Patel+2013b

Summary

- We have traced the progenitors of massive ($M \approx 10^{11}\ M_\odot$) elliptical galaxies to $z \approx 3$
  - At $z \approx 3$: 3x less massive, compact, star forming, likely disks
  - These disappear and give way to compact QGs over $1.5 < z < 3$
  - Below $z < 2$: sizes grow with mass as $r_e \propto M^2$
- Size evolution of massive galaxies proceeds via inside-out mass growth at $z < 2$
  - Core mostly formed by $z \approx 2$, new mass added at larger radii
  - Formation channel different from lower mass SFGs ($10^{10.5}\ M_\odot$), which grow in size with $r_e \propto M^{0.3}$, and continually add mass in both the central and outer regions
- Questions
  - Fixed mass vs. evolving mass-selected samples?
  - Diversity in galaxy SFHs: impact on tracing median/mean properties - realistic?