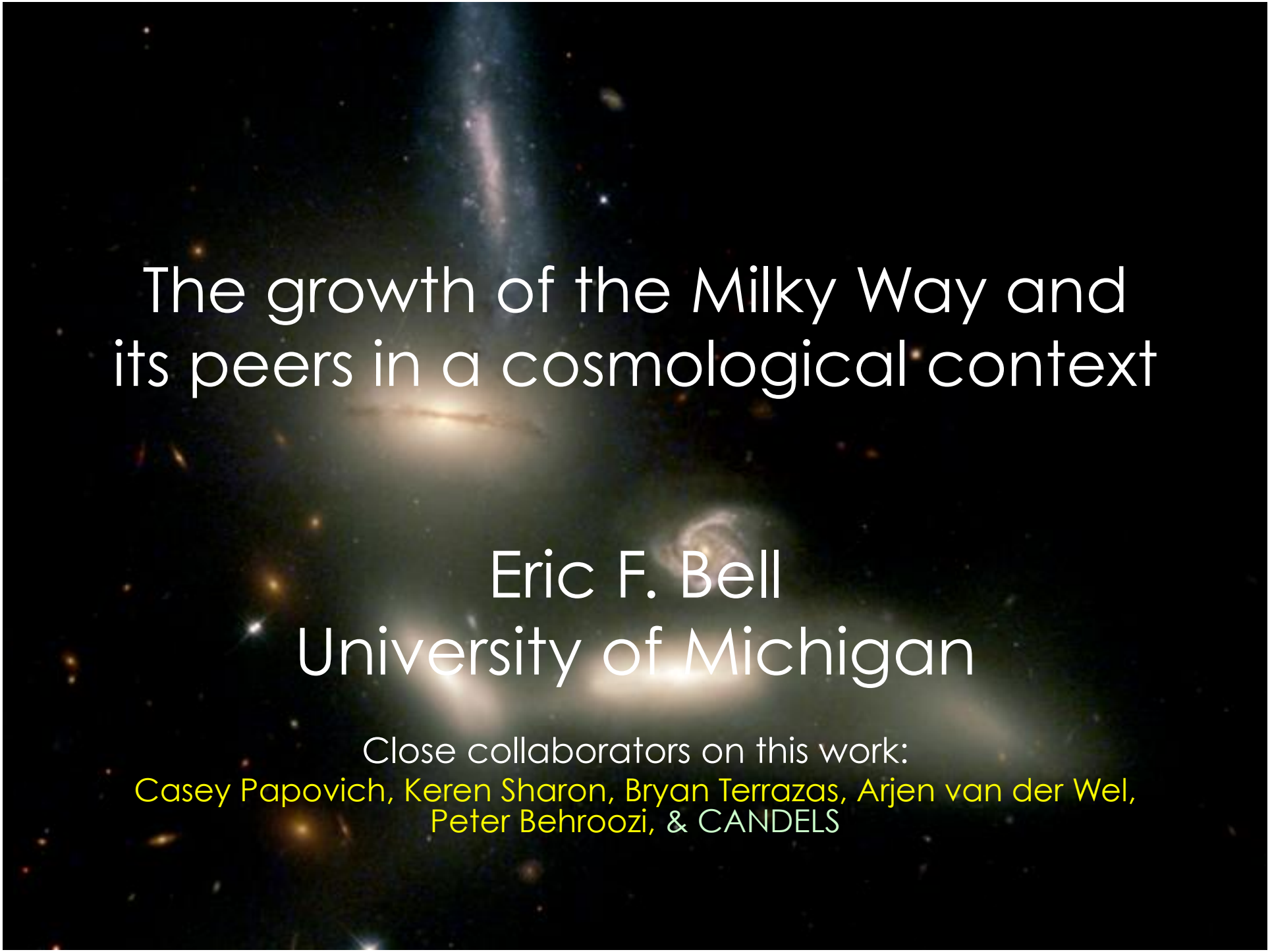


The growth of the Milky Way and its peers in a cosmological context

Eric F. Bell
University of Michigan

Close collaborators on this work:
Casey Papovich, Keren Sharon, Bryan Terrazas, Arjen van der Wel, Peter Behroozi, & CANDELS

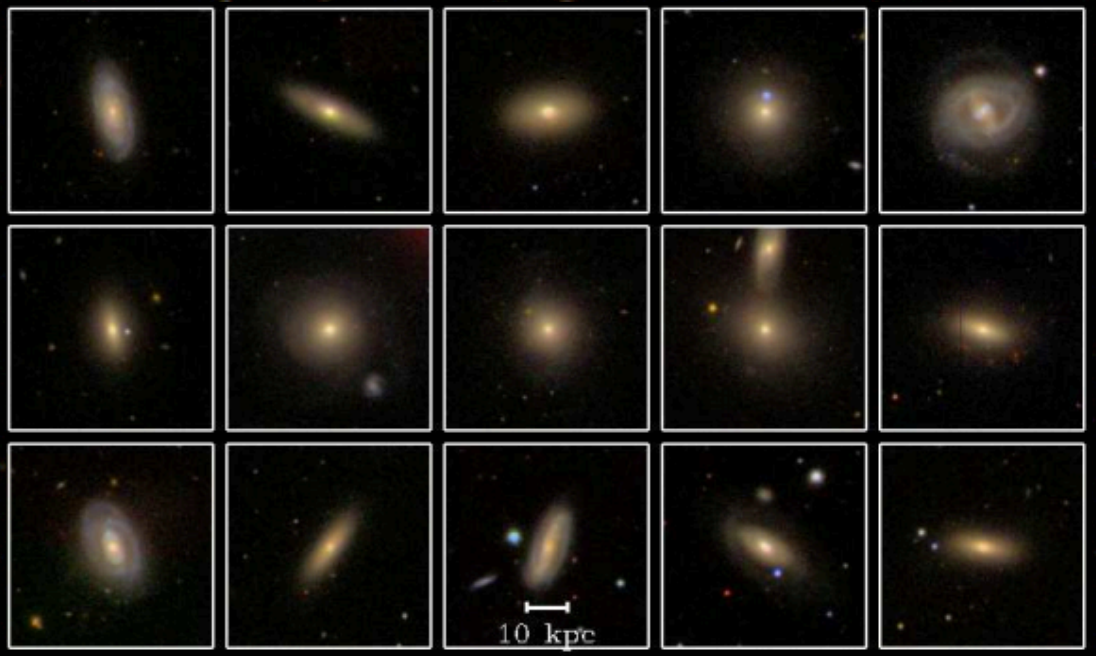
What are Milky Way mass galaxies & why do I care?

Peak conversion efficiency of gas to stars

Maximally diverse population (half quiescent, half star forming, full range of disk/spheroid ratios

We live in one and close to a number of others (M31, M81, NGC 253, NGC 891, etc.)

- chance to link resolved stellar populations & kinematics → do inferences from look-back studies mesh with what we infer locally?



Papovich et al. 2014

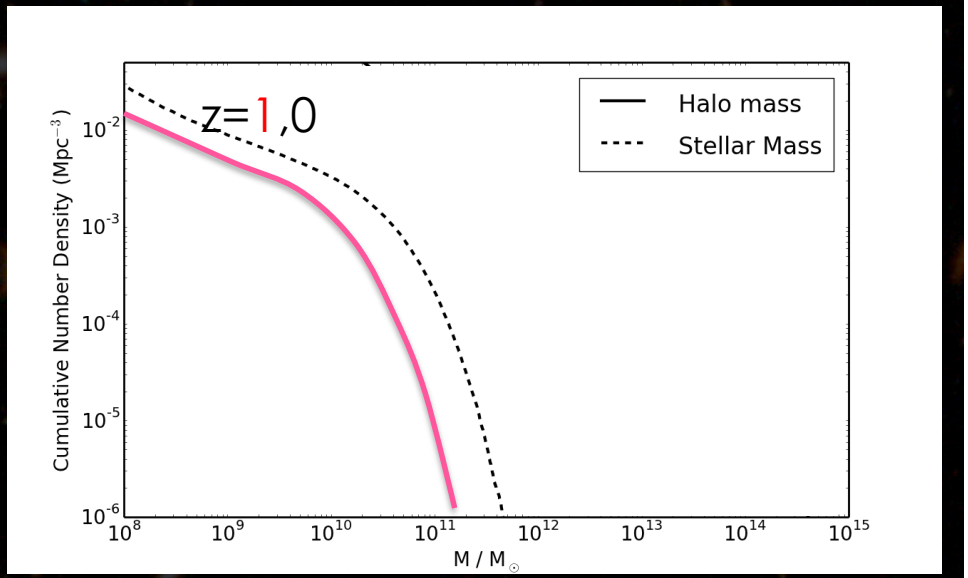

UDF
8/14/14
Eric Bell

- What can we learn about how Milky Way mass galaxies grow?
  - Look-back surveys
  - Cosmological models / simulations

Lotz et al. 2011
Hydro+rad trans.

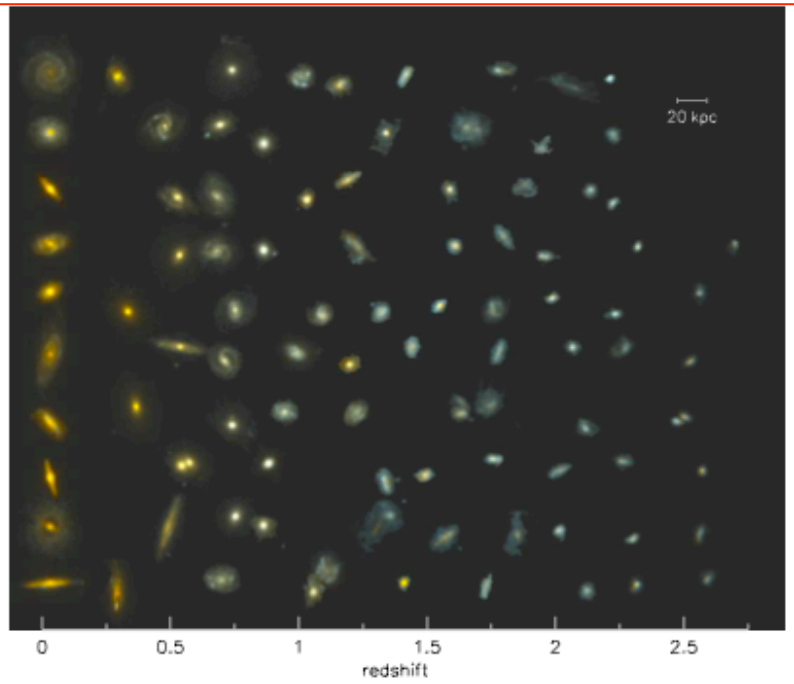
The growth history of Milky Way mass galaxies since z~2?

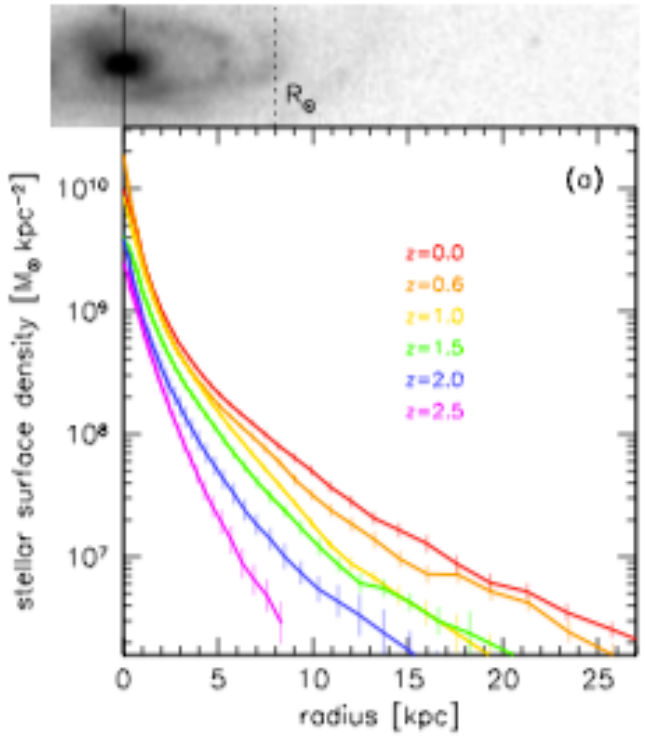
- Method – connect MW mass galaxies today with plausible progenitors
  - Basic assumption – connect galaxies via (cumulative) number densities
    - Simple version – rank order of galaxies in stellar mass same at all times
      - » Once a runt, always a runt ☹
      - » Papovich, van Dokkum (tested c.f. merger trees)

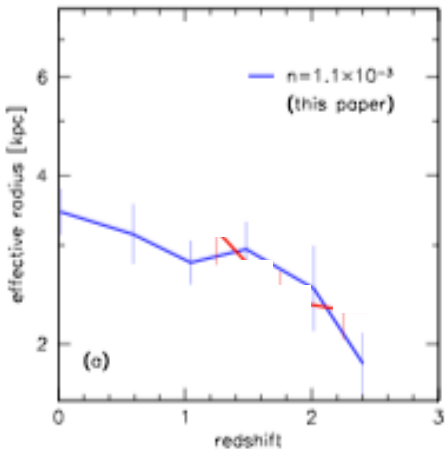


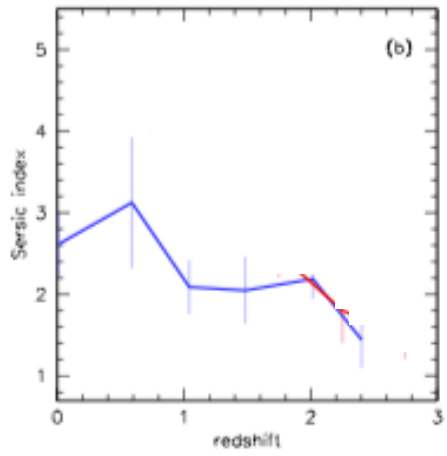
Growth of ~MW mass peers at constant number density – van Dokkum + 2013

Mass growth takes place at all radii
Bulges built up at same time as disks
Transition to more bulge-dominated at later times









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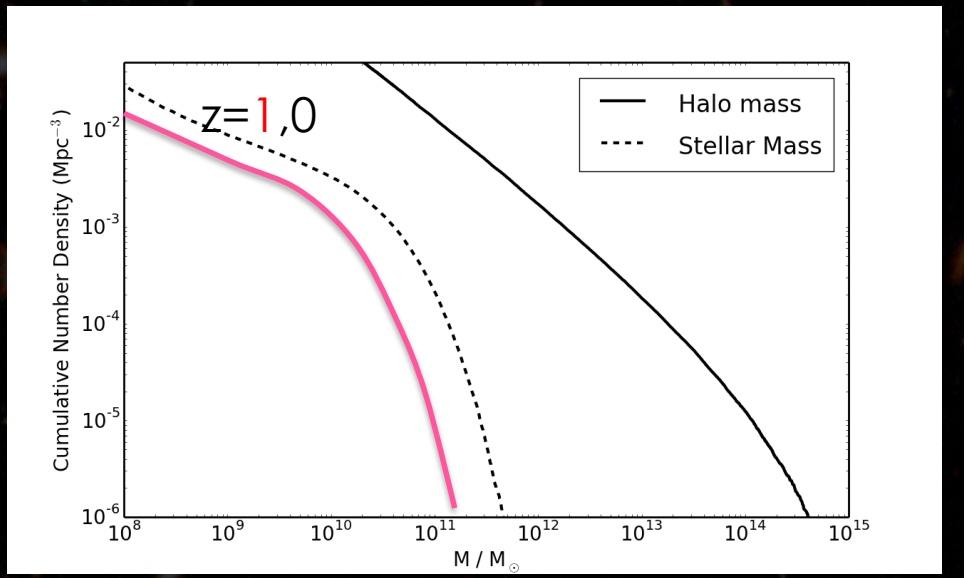
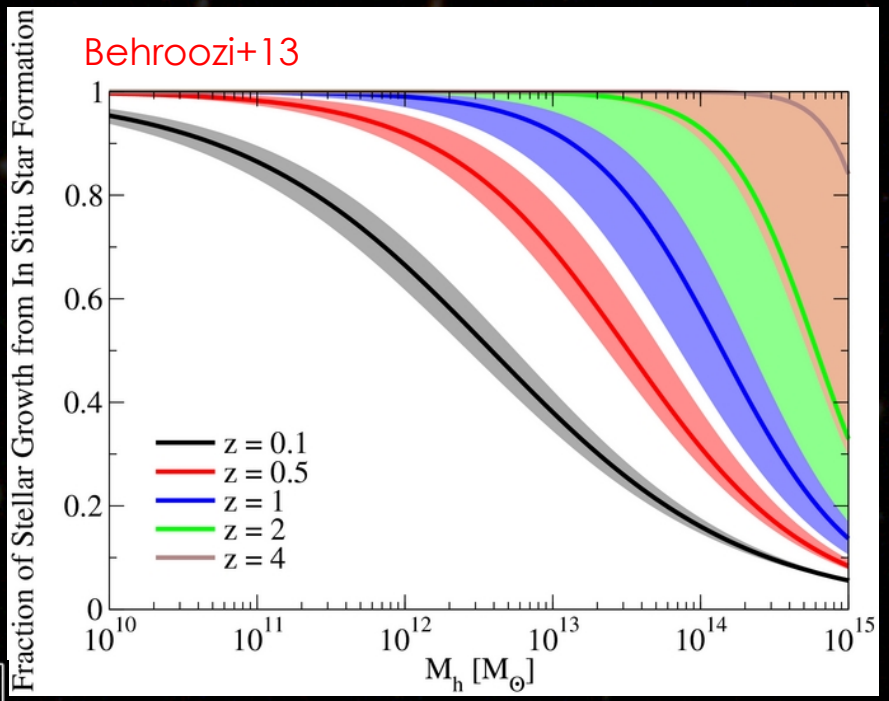
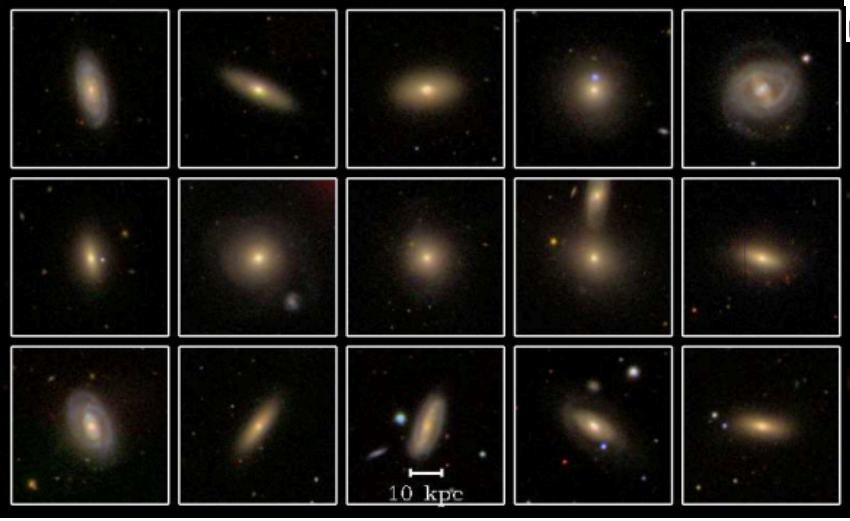
  - Basic assumption – connect galaxies via (cumulative) number densities
    - Simple version – rank order of galaxies in stellar mass same at all times
      - » Once a runt, always a runt ☹
      - » Papovich, van Dokkum (tested c.f. merger trees)
    - Complicated version – fit average mass growth history + scatter to fit stellar mass functions
      - » best guess of growth histories including realistic merger histories
      - » Behroozi, Moster
      - » Leja et al. (with Guo et al. semi-analytic models)



What does ‘halo occupation’ say about MW-mass galaxy growth histories?

- Only a fraction of ~MW-like galaxies major merged
- Minor mergers & accretions much more frequent
- Scatter in growth histories significant





Papovich et al. 2014

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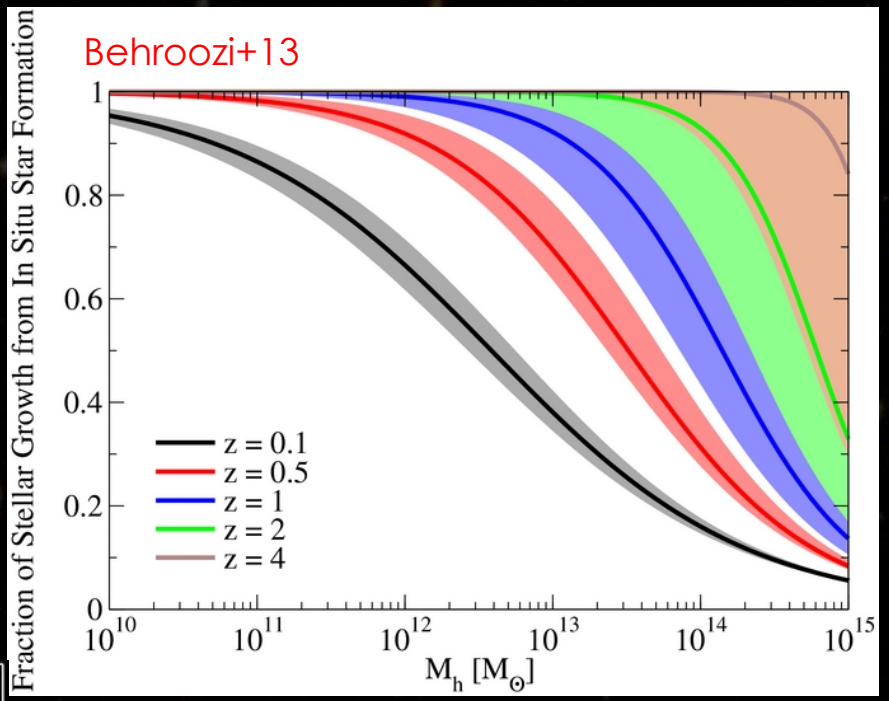

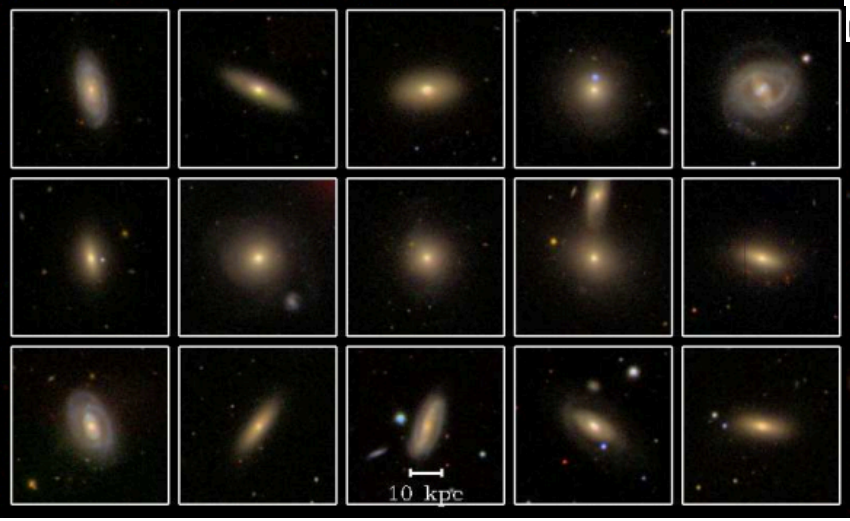

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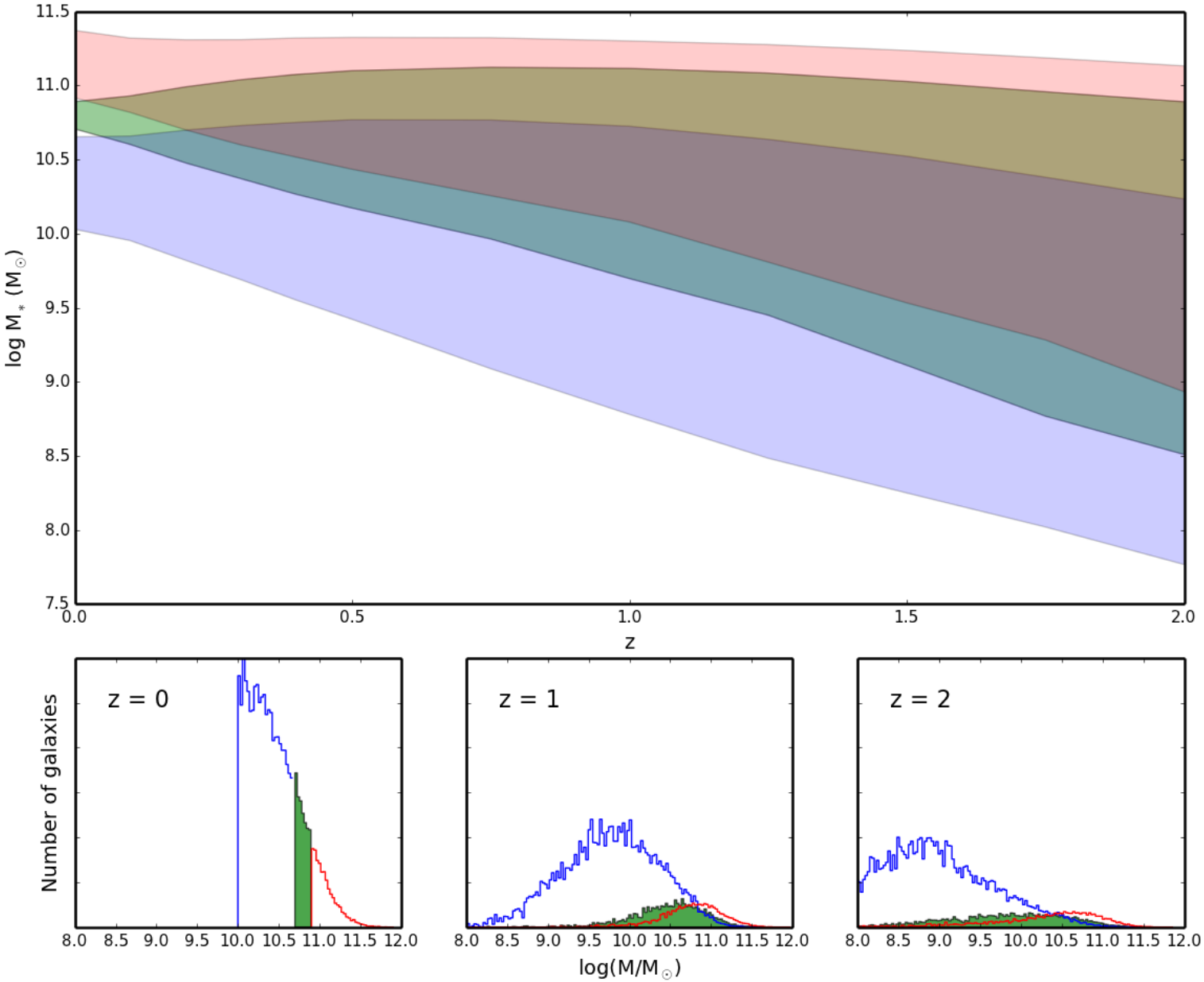
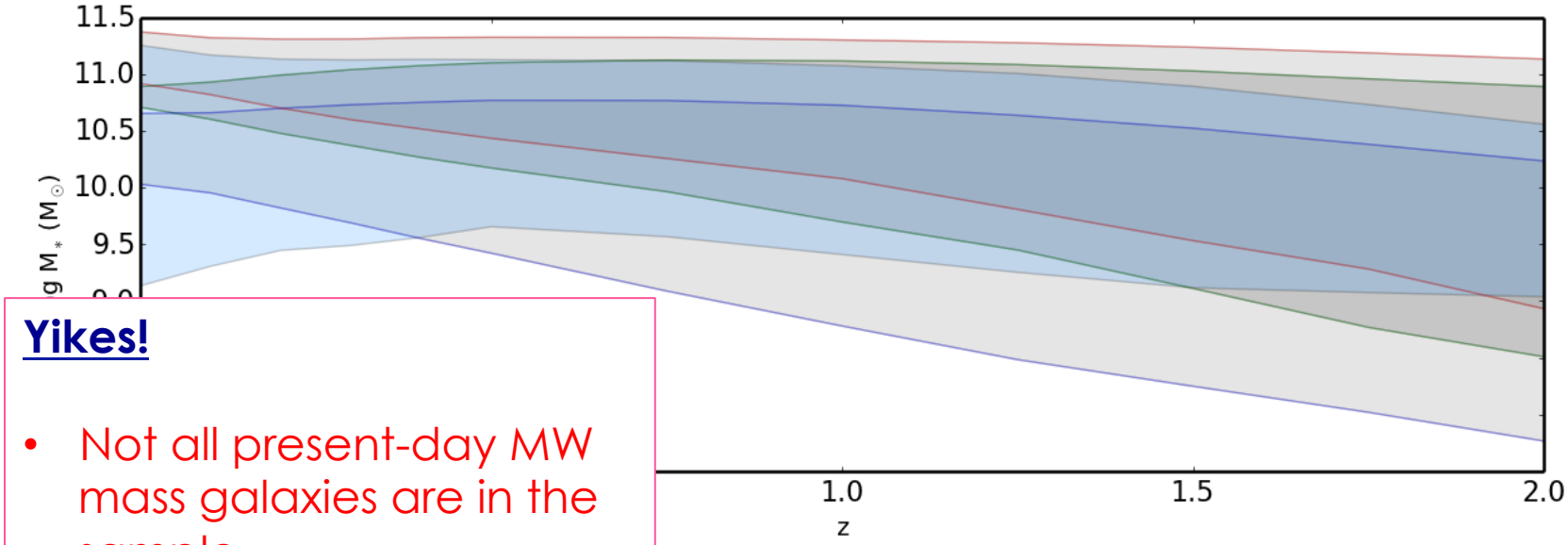
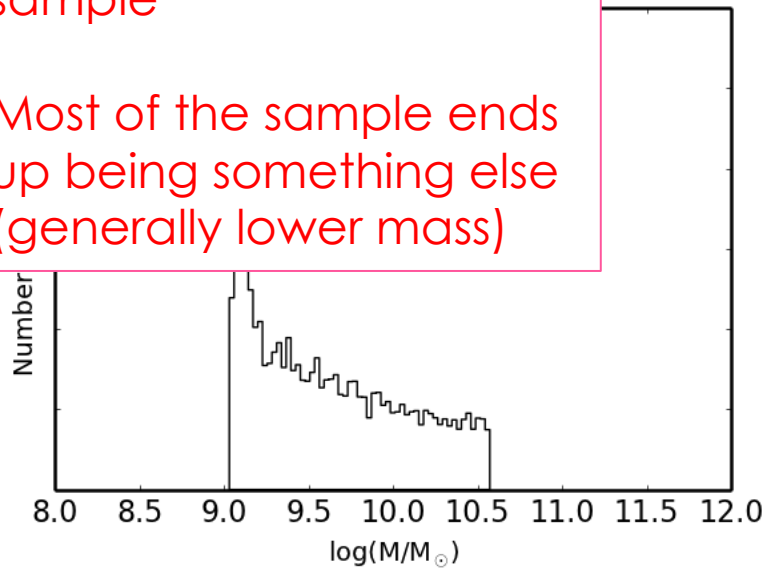
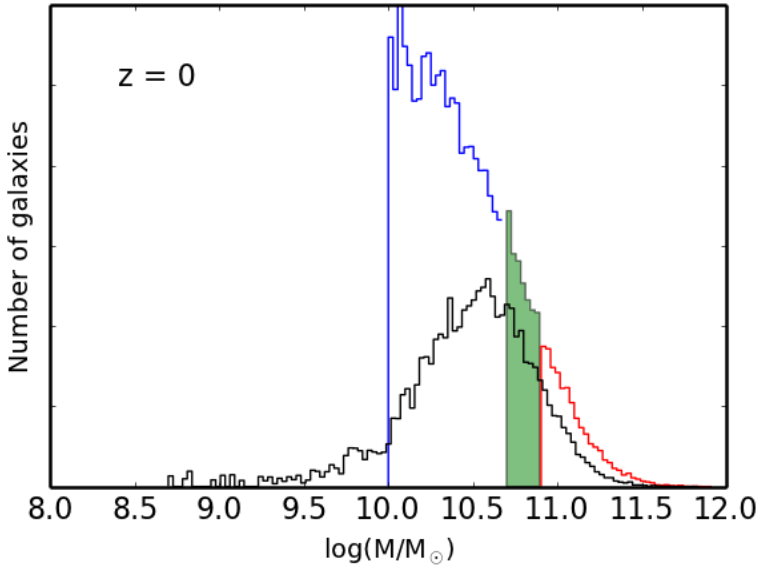

log M* (M⊙)
z
z = 0
z = 1
z = 2
Number of galaxies
log(M/M⊙)



Yikes!

- Not all present-day MW mass galaxies are in the sample
- Most of the sample ends up being something else (generally lower mass)

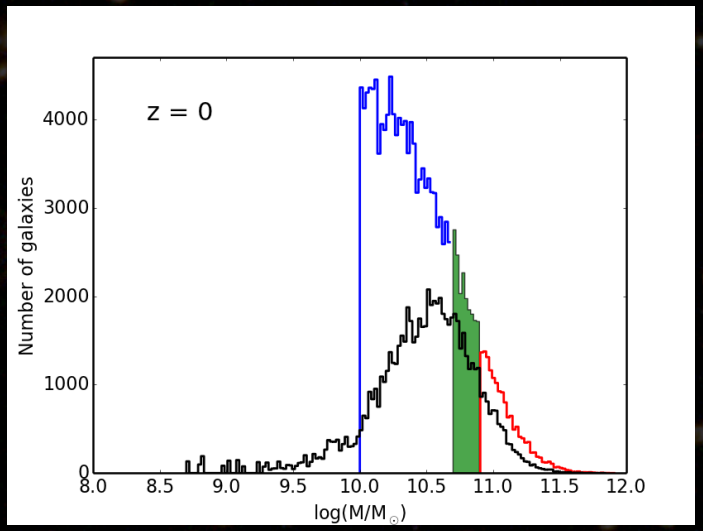




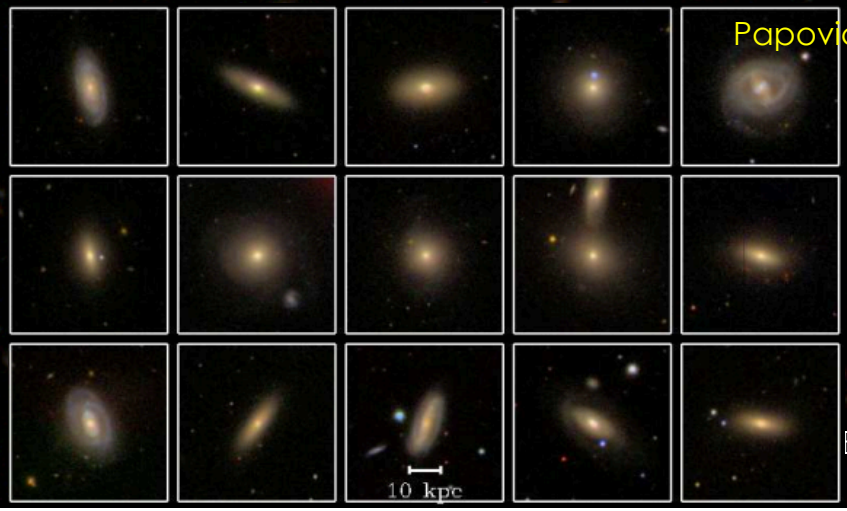
What does ‘halo occupation’ say about MW-mass galaxy growth histories?

- Few majors, Minor mergers & accretions much more frequent
- Scatter in growth histories significant
  - Any progenitor selection is incomplete & contaminated
  - Contamination dominant
  - Mostly galaxies with low present-day masses

Bell, Sharon, Terrazas +14



Papovich et al. 2014



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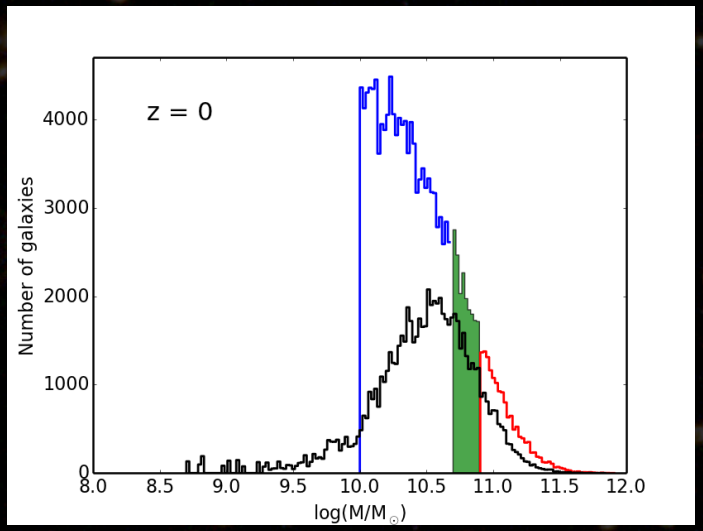
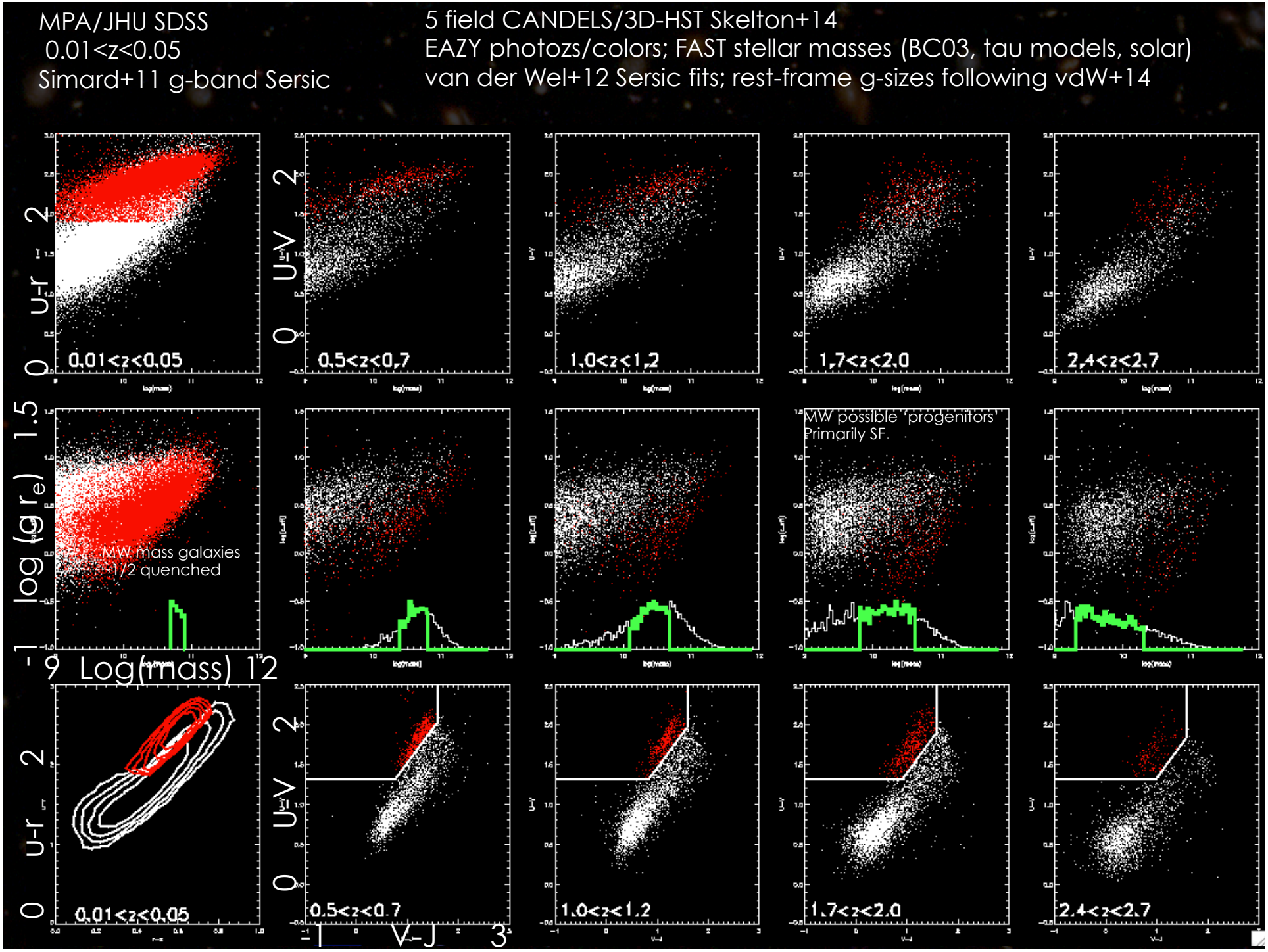


Papovich et al. 2014

In order to proceed, must assume galaxies at a given mass at z~(2→0.5) do not know how they are going to grow
i..e., non-progenitors at z~(2→0.5) are same as progenitors at z~(2→0.5), and differ only later

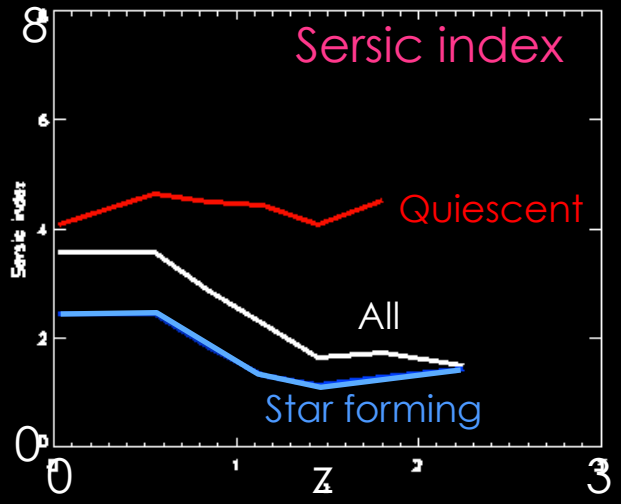

MPA/JHU SDSS
0.01<z<0.05
Simard+11 g-band Sersic
5 field CANDELS/3D-HST Skelton+14
EAZY photozs/colors; FAST stellar masses (BC03, tau models, solar)
van der Wel+12 Sersic fits; rest-frame g-sizes following vdW+14
U-r
U-V
log (g r_e)
0.01<z<0.05
0.5<z<0.7
1.0<z<1.2
1.7<z<2.0
2.4<z<2.7
MW mass galaxies
~1/2 quenched
MW possible "progenitors"
Primarily SF.
Log(mass)
V-J

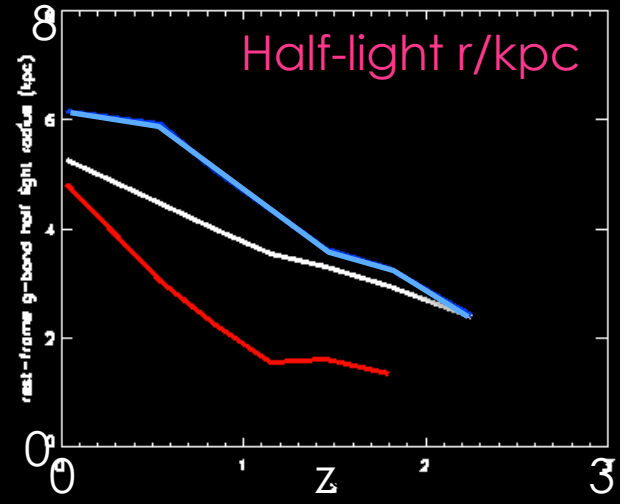
Exploring the structural evolution of Milky Way progenitors

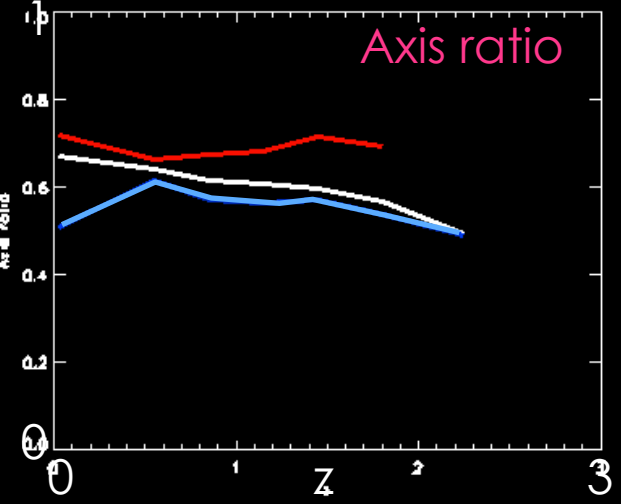
Eric Bell, Keren Sharon, Bryan Terrazas, et al., in prep.

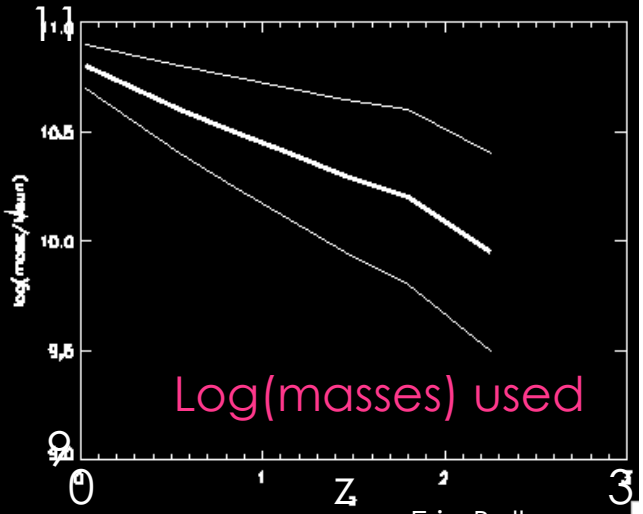
- Approximately reproduce previous results overall population growth (van Dokkum et al. 2013)
  - Half-light radius doubles
  - Sersic index n~1.5→3.5
  - inference of bulge growth at late time

- Color split decisive
- Star formers – little change in n, 2.5x growth in r_e
  - Inside-out growth of disks
  - Similar qualitatively to Patel et al. (2013; they used lower mass disks ~ 3e10)
- Quiescent – r_e changes by x3-4; n~4
  - Population grows constantly by quenching
  - Growth of individual members + addition of new galaxies









How do ~Milky Way mass galaxies grow?

- Model and observational exploration of plausible MW progenitor growth
  - Milky Way mass galaxies very diverse today → half are quiescent
    - Models with physically-motivated scatter imply 'progenitors' incomplete and contaminated
    - SF progenitors appear to grow inside-out with ~exponential profile (x2.5 half-light radius growth since z~2)
    - Much of 'bulge' growth is from emergence of quiescent population