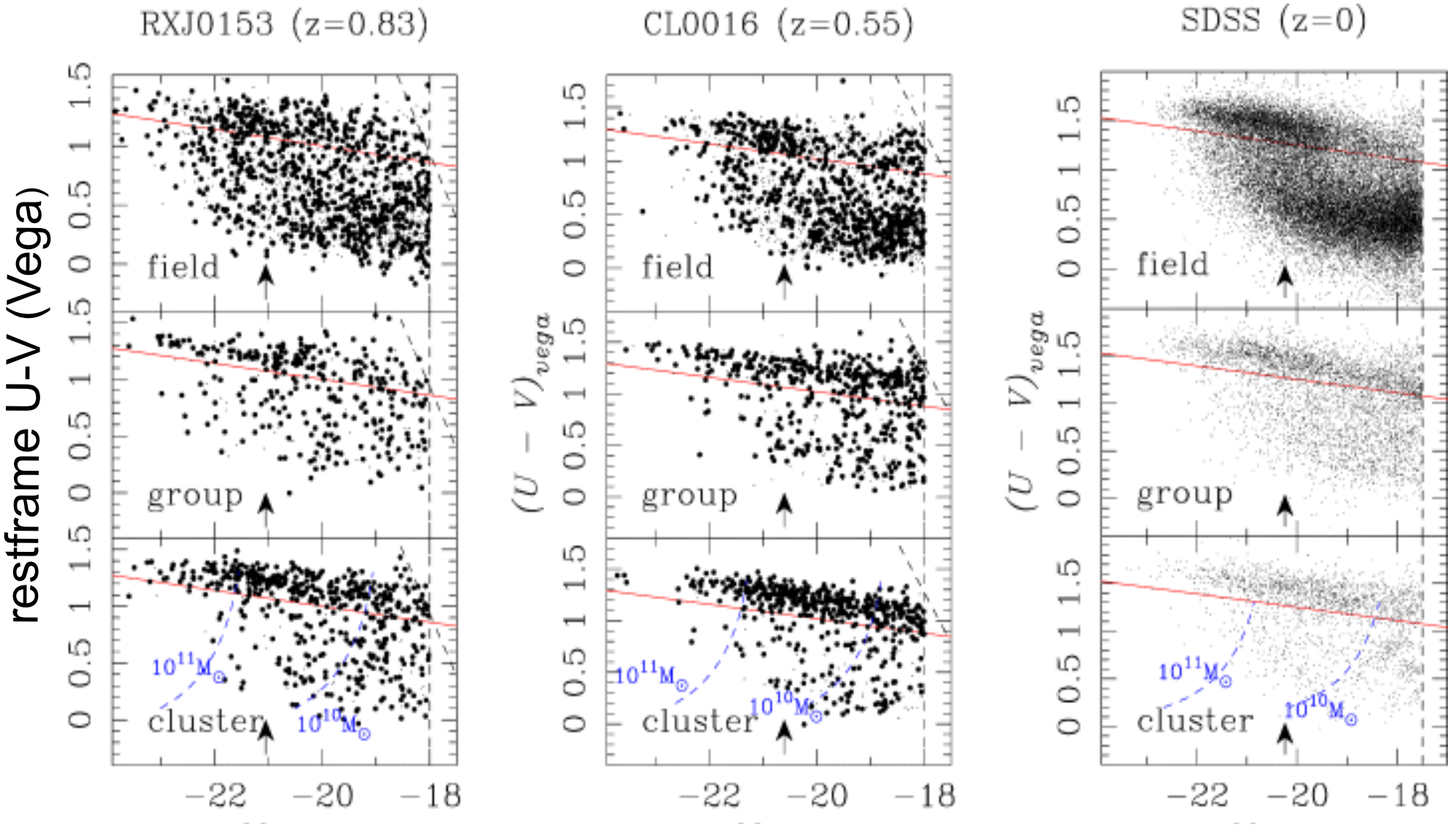
The massive red sequence of cluster galaxies at redshift 1.4

Veronica Strazzullo
NRAO

Piero Rosati, Maurilio Pannella, Chris Lidman, Chris Mullis,
Ricardo Demarco, Raphael Gobat, Mario Nonino

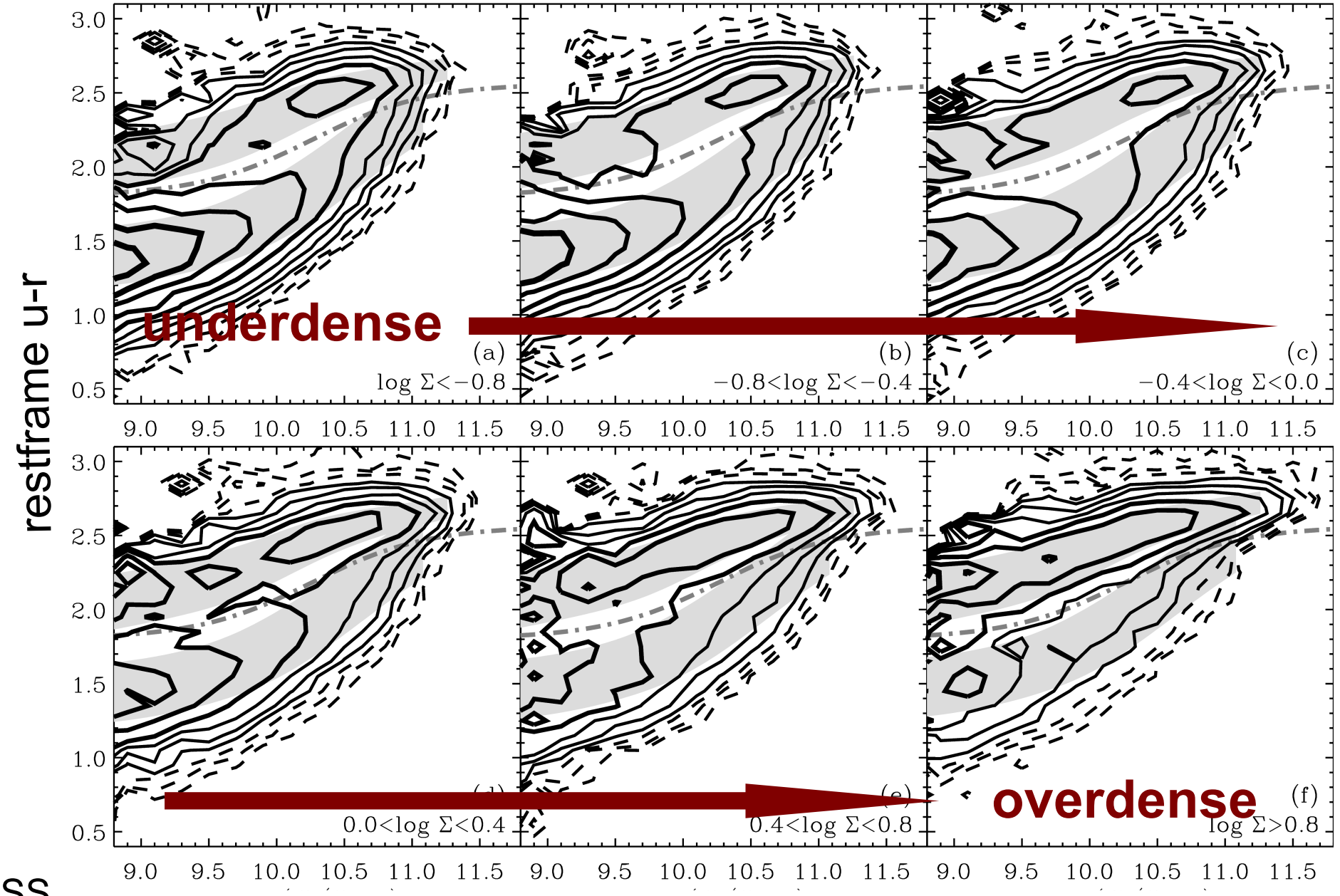
The 25th New Mexico Symposium

The red sequence



Tanaka et al. 2005

The red sequence (color-mass)



SDSS
Baldry et al. 2006

Environments at high redshifts

The need for high redshift

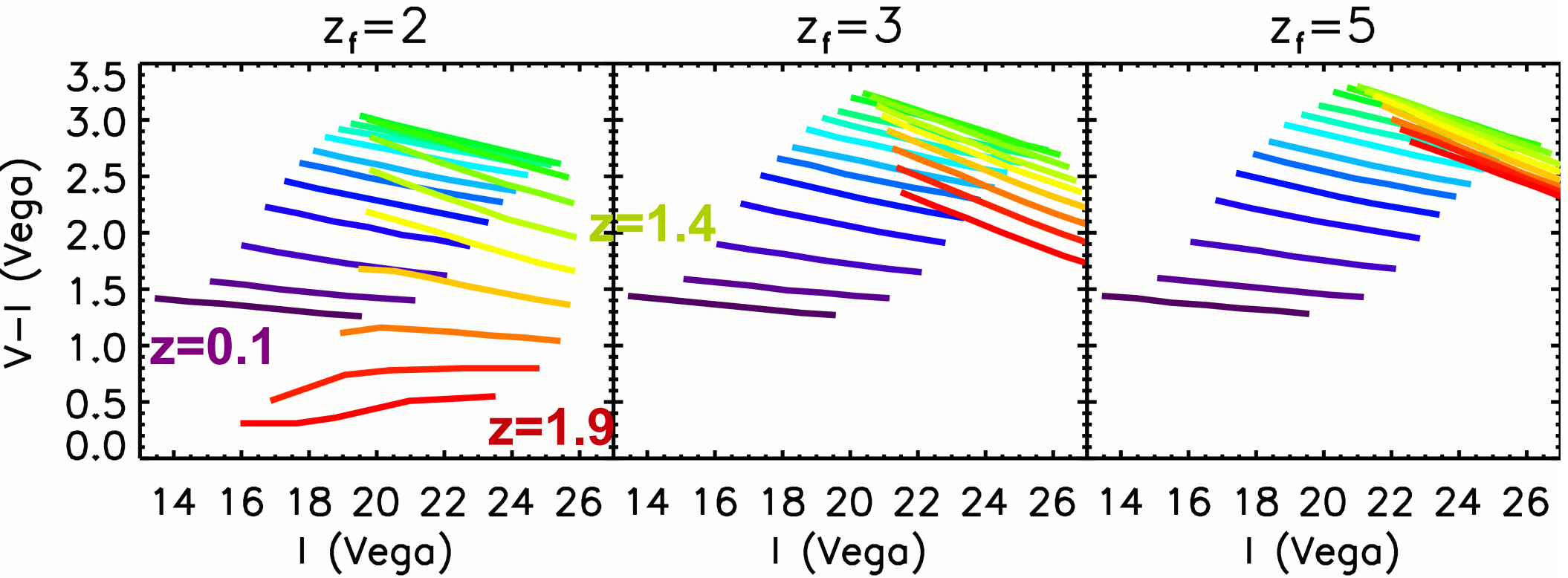
➔ Deep surveys probe environments only up to group densities. To probe the highest density environments need to find (elsewhere) and follow up massive clusters.

➔ “Time machine” vs “fossil record” approach: probe both star formation ***and*** mass assembly history.

➔ The closer the observations to the formation epoch, the tighter the constraints we get.

Clusters red sequence(s)

model redshift evolution of the red sequence
(**apparent** magnitudes and colors)
(Kodama & Arimoto 1997 models)



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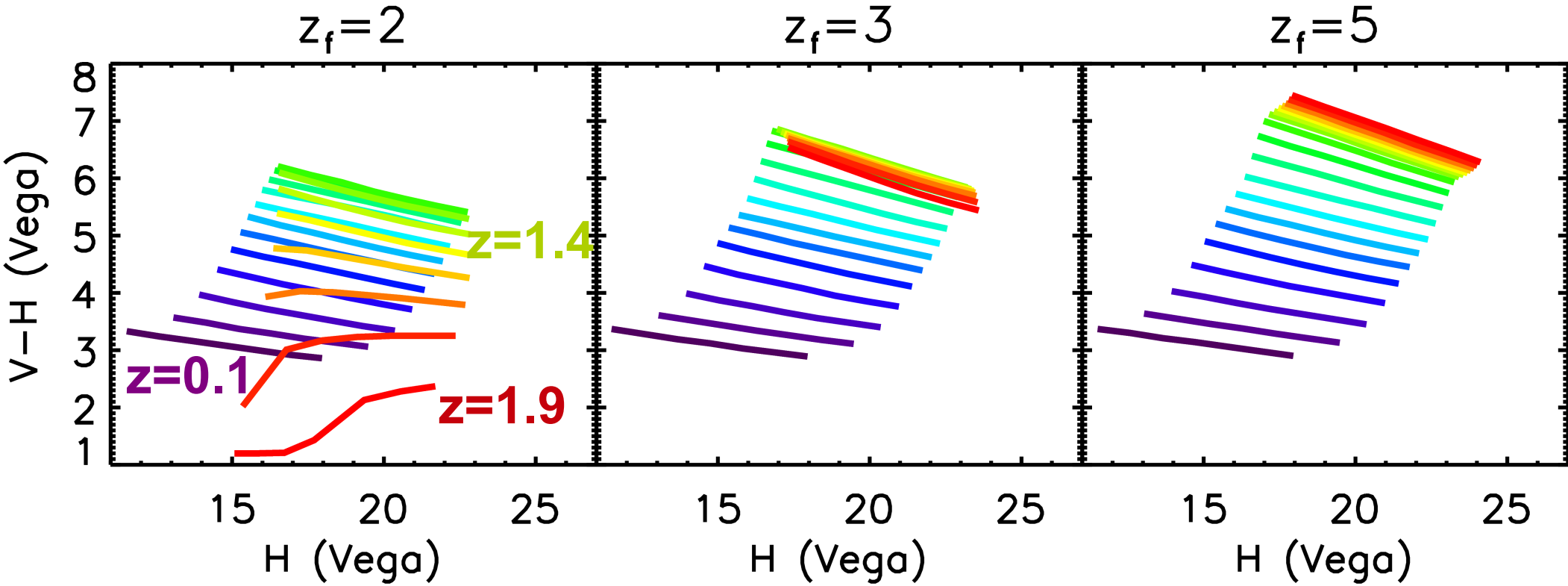
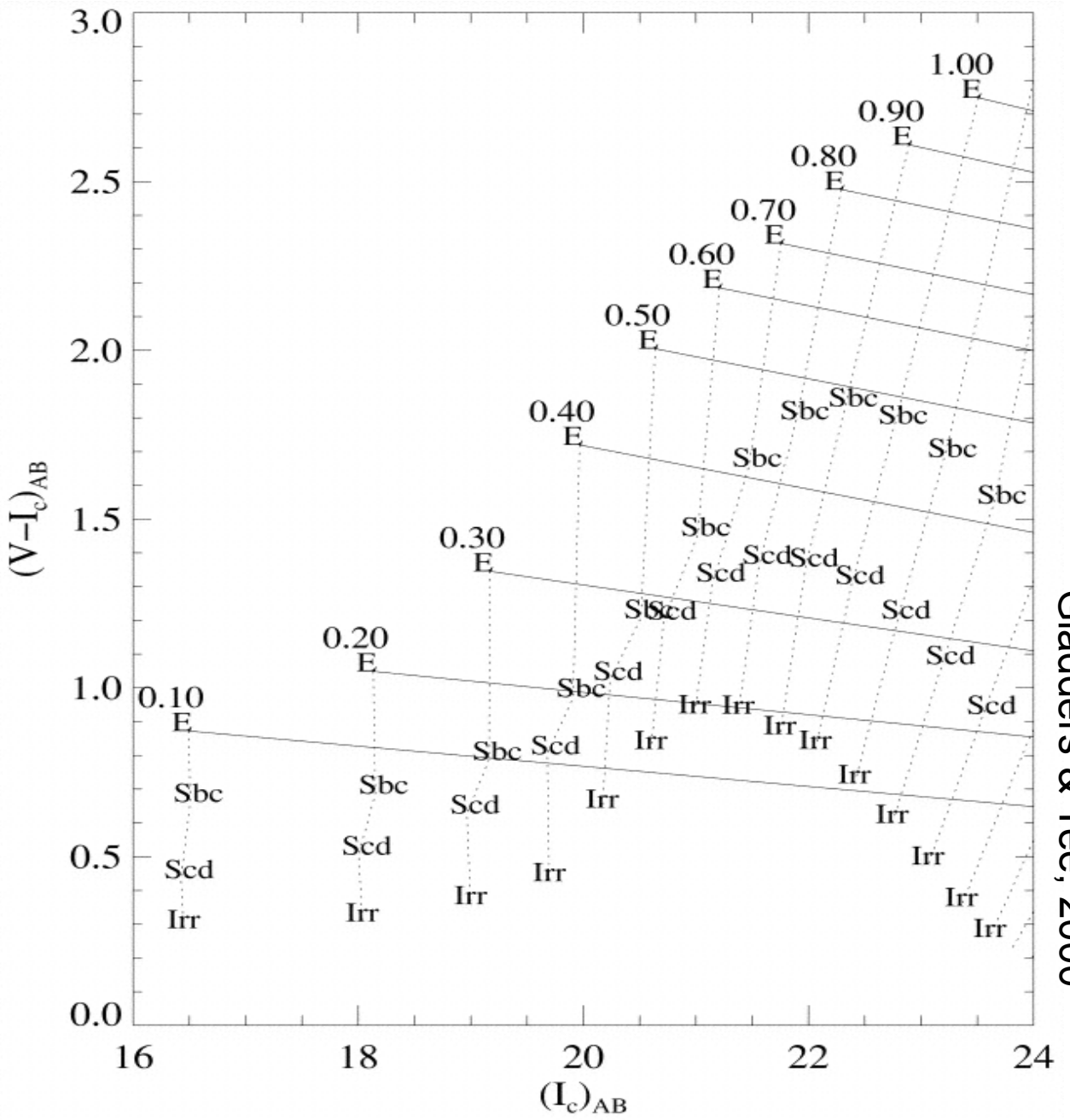


Clusters red sequence(s)

The red sequence of galaxy clusters may be observed as a conspicuous feature in color-magnitude diagrams at all redshifts

Apparent magnitudes and colors.
Red sequence evolution as predicted by Kodama & Arimoto 1997



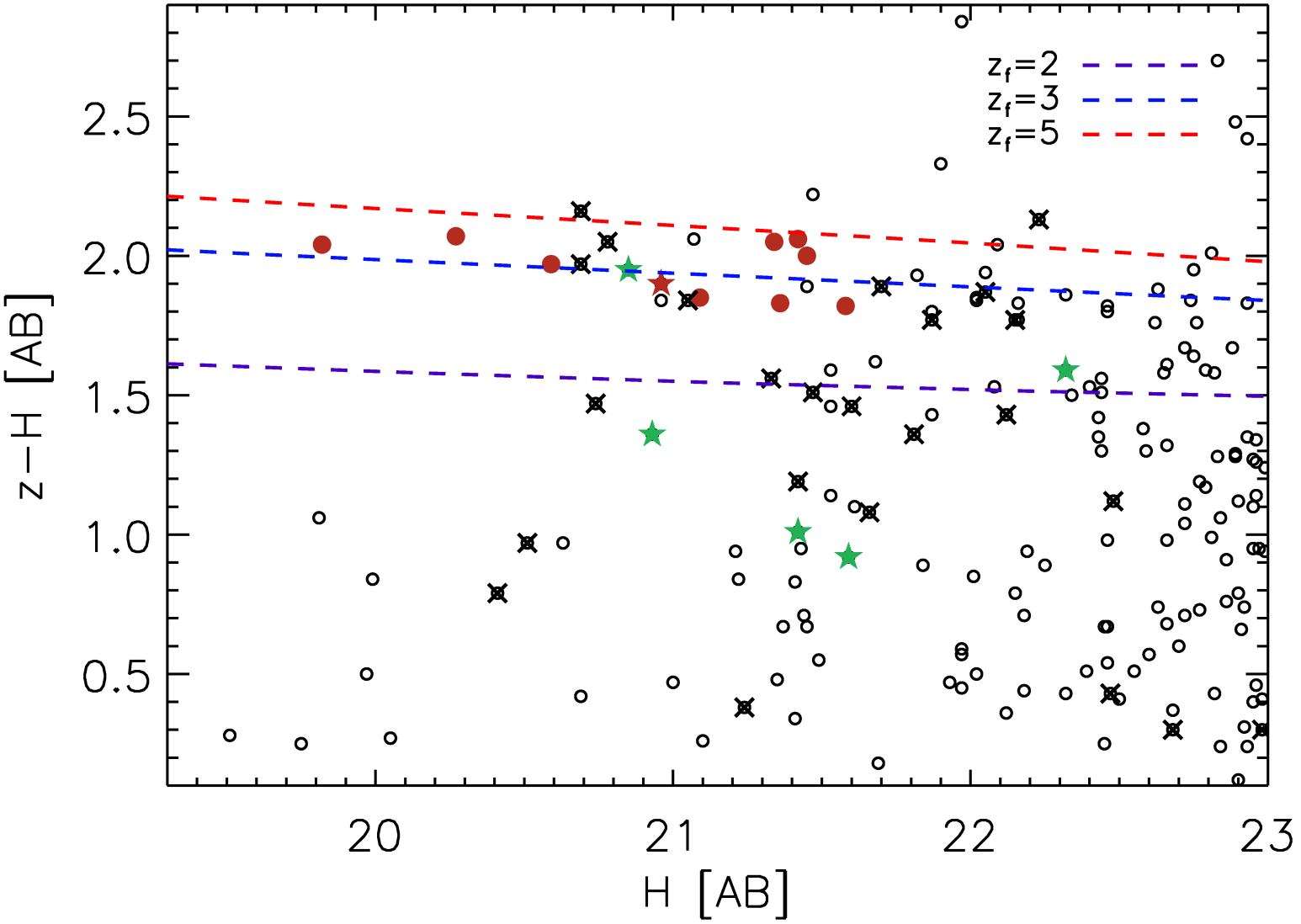
XMMU J2235-2557

- X-ray luminous massive cluster at z=1.39 (Mullis et al. 2005)
- The most massive cluster known at z>1
  ($L_{X,bol<1Mpc}$~10^{45} erg/s, M_{200}~6 $10^{14}M_{sun}$, $M_{proj<1Mpc}$~$10^{15}M_{sun}$)
- Multi-wavelength coverage (X U R i z J H Ks 3.5μm 4.6μm)
  from Chandra, VLT, HST, Spitzer
- Extensive spectroscopy secured 30 cluster members
- A well evolved structure at 1/3 of the Universe age

Lidman et al. 2008, Jee et al. 2009, Rosati et al. 2009, Strazzullo et al. in prep.

The red sequence at z~1.4

The color-magnitude diagram in the core of XMMU J2235



The red sequence at z~1.4

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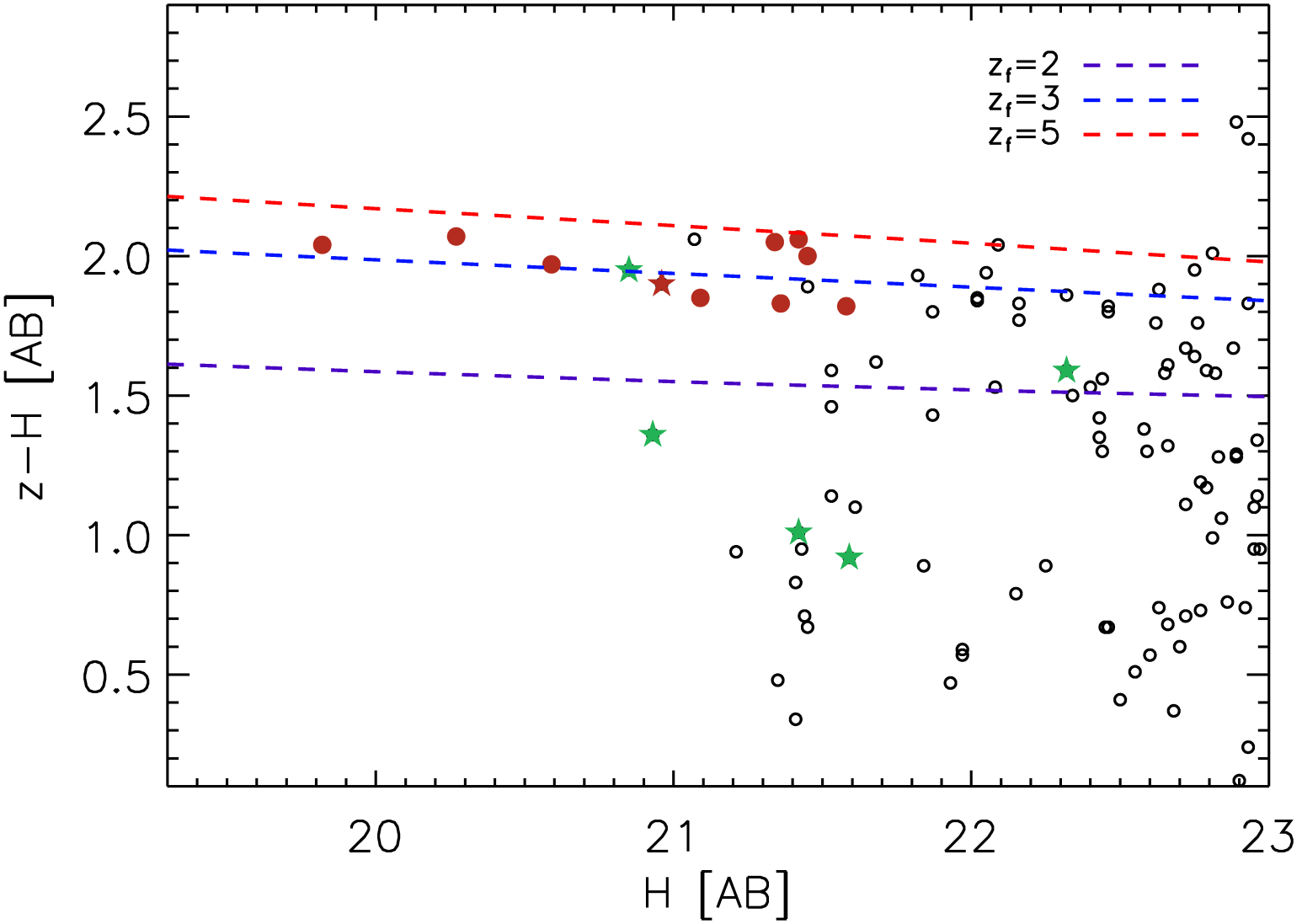
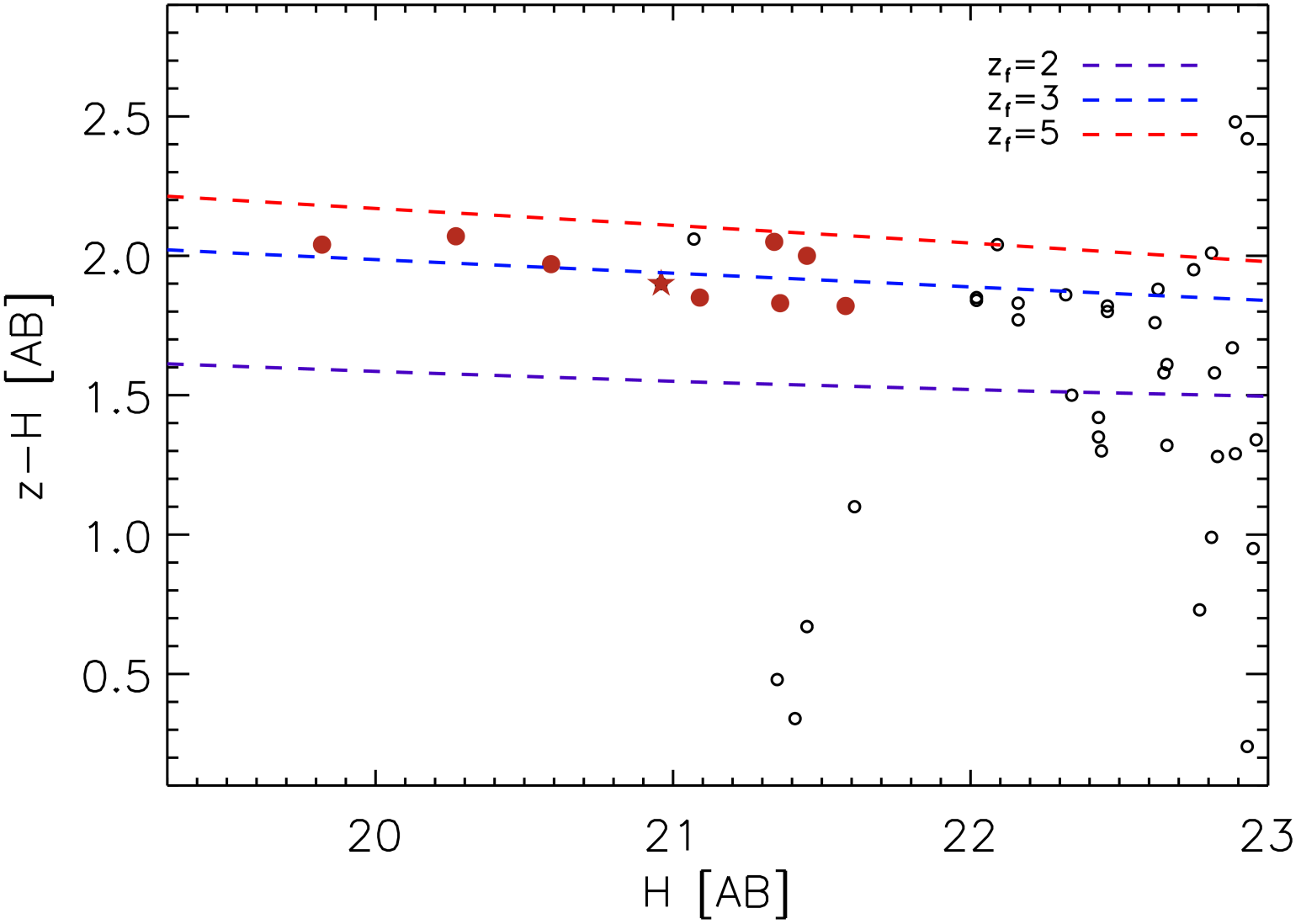


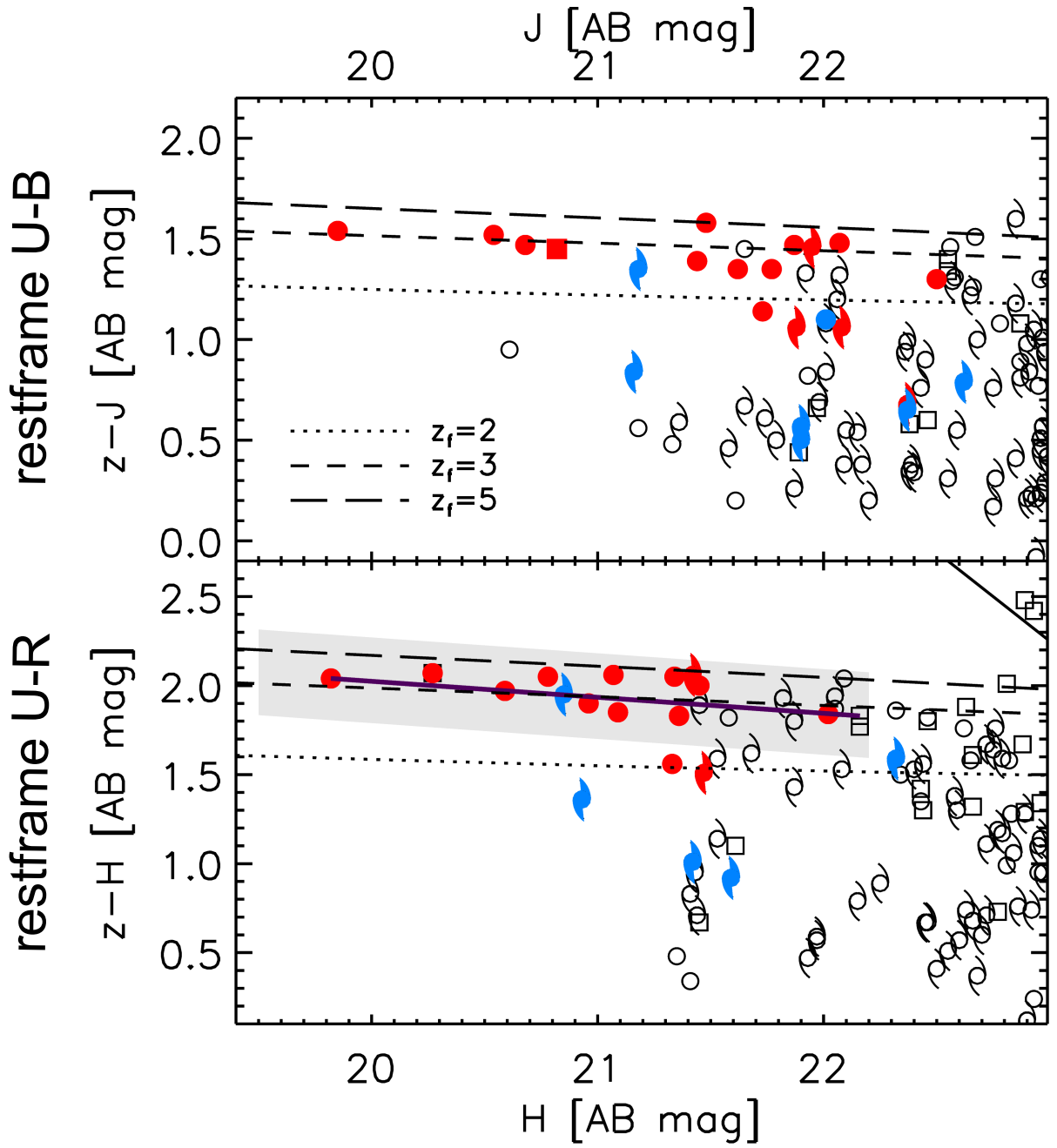
obvious interlopers removed (spec. and photo-z)

The red sequence at z~1.4



obvious interlopers (spec. and photo-z) and disk galaxies removed

The red sequence at z~1.4

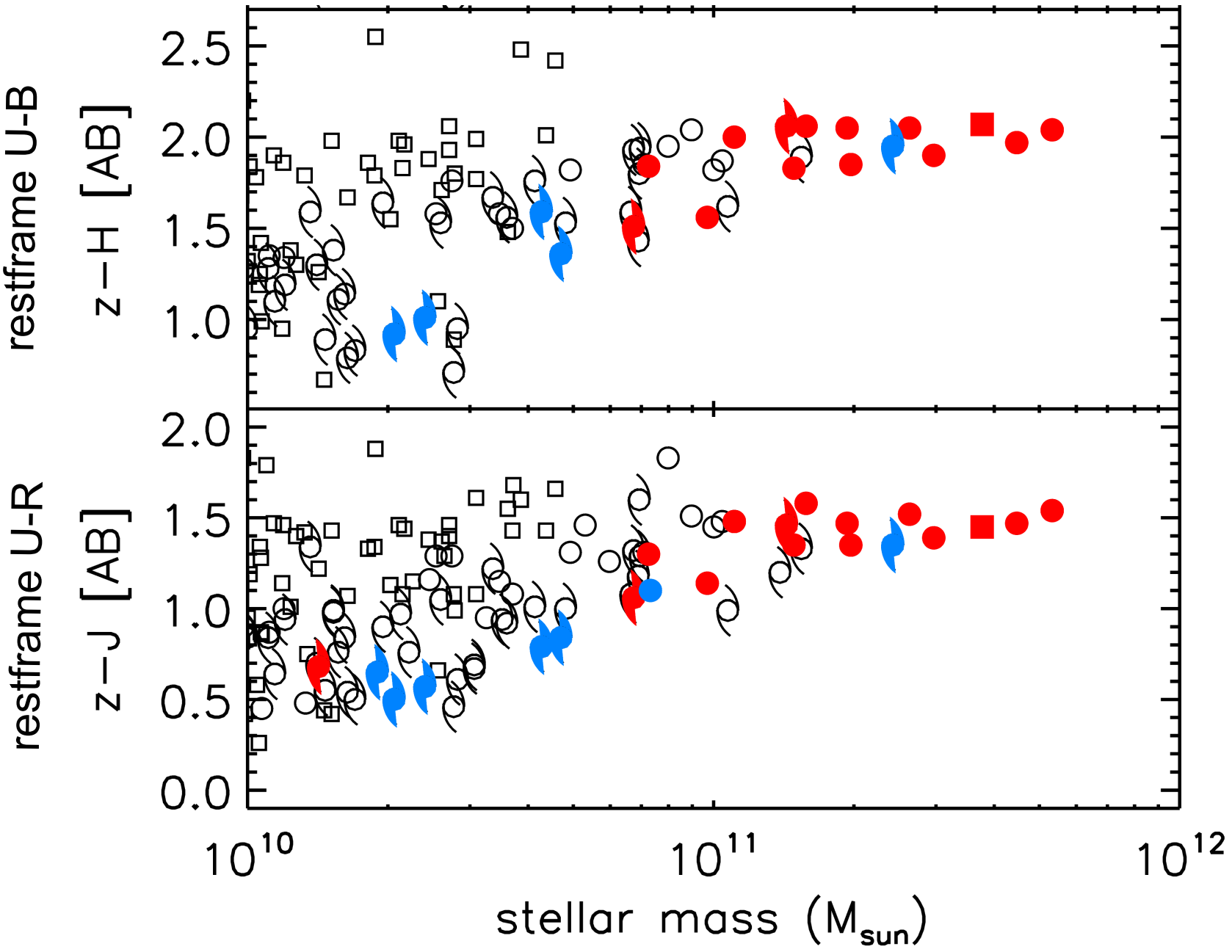


A clear, tight red sequence is already in place, dominated by massive early types

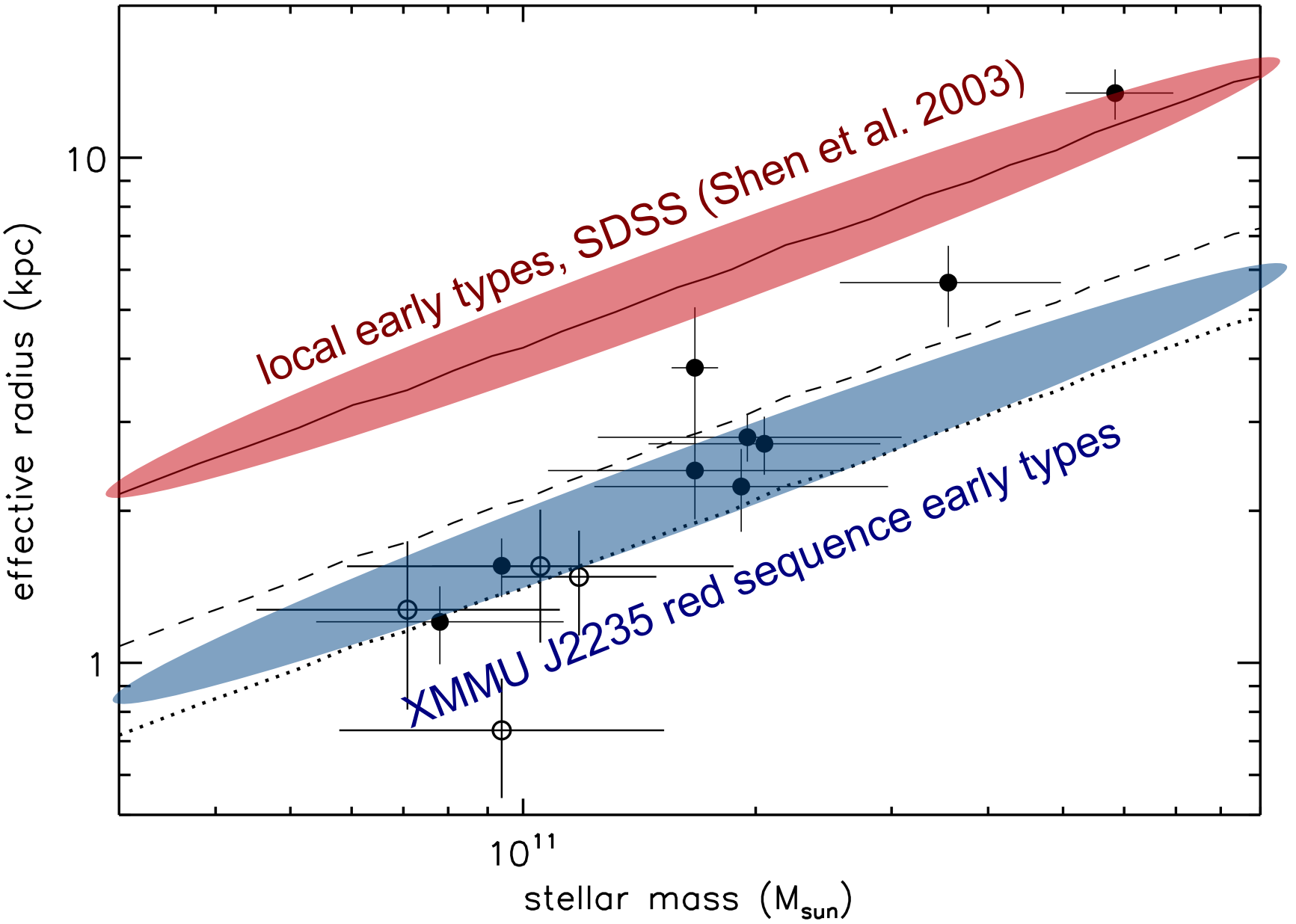
The bulk of the stellar populations formed at z~3

Bright galaxy populations in cluster core dominated by massive early types, hosting ~passively evolving stellar populations

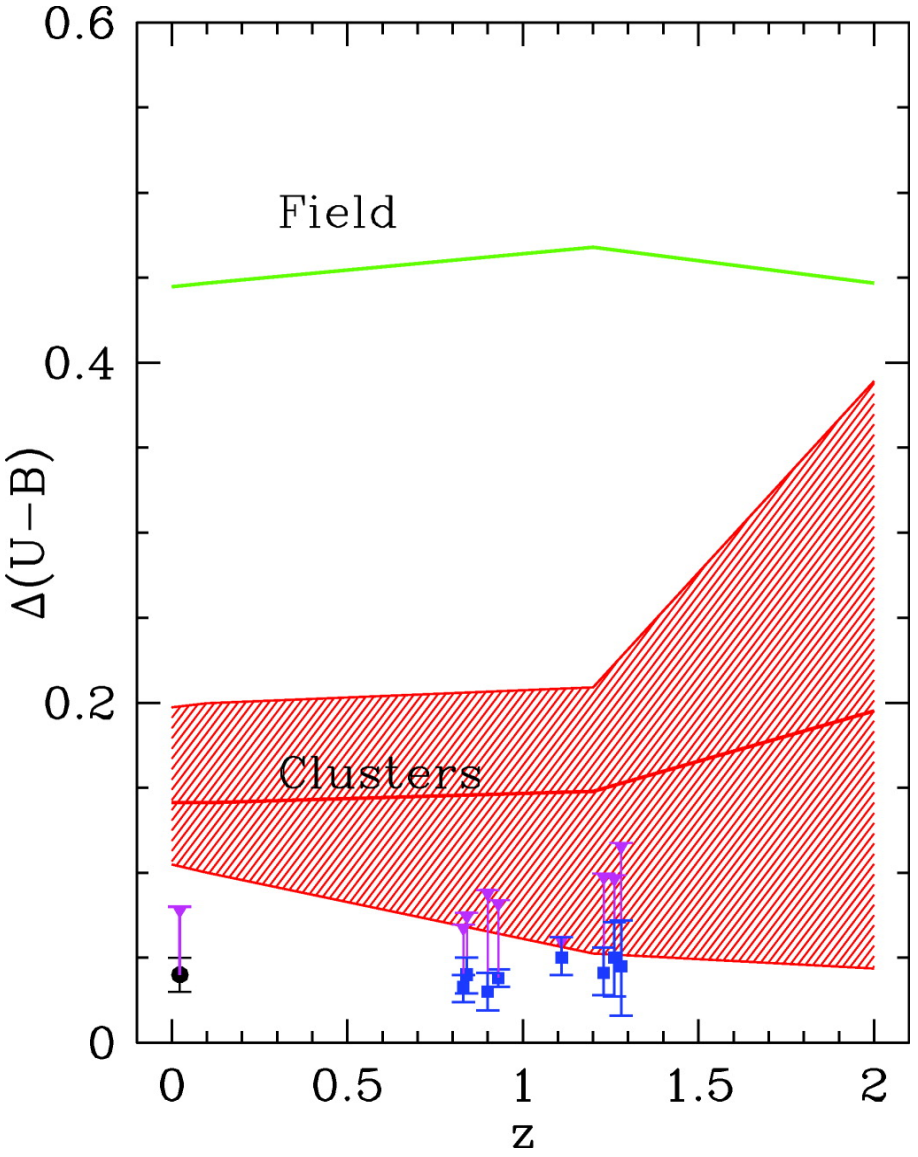
The red sequence at z~1.4



The mass-size relation at z~1.4

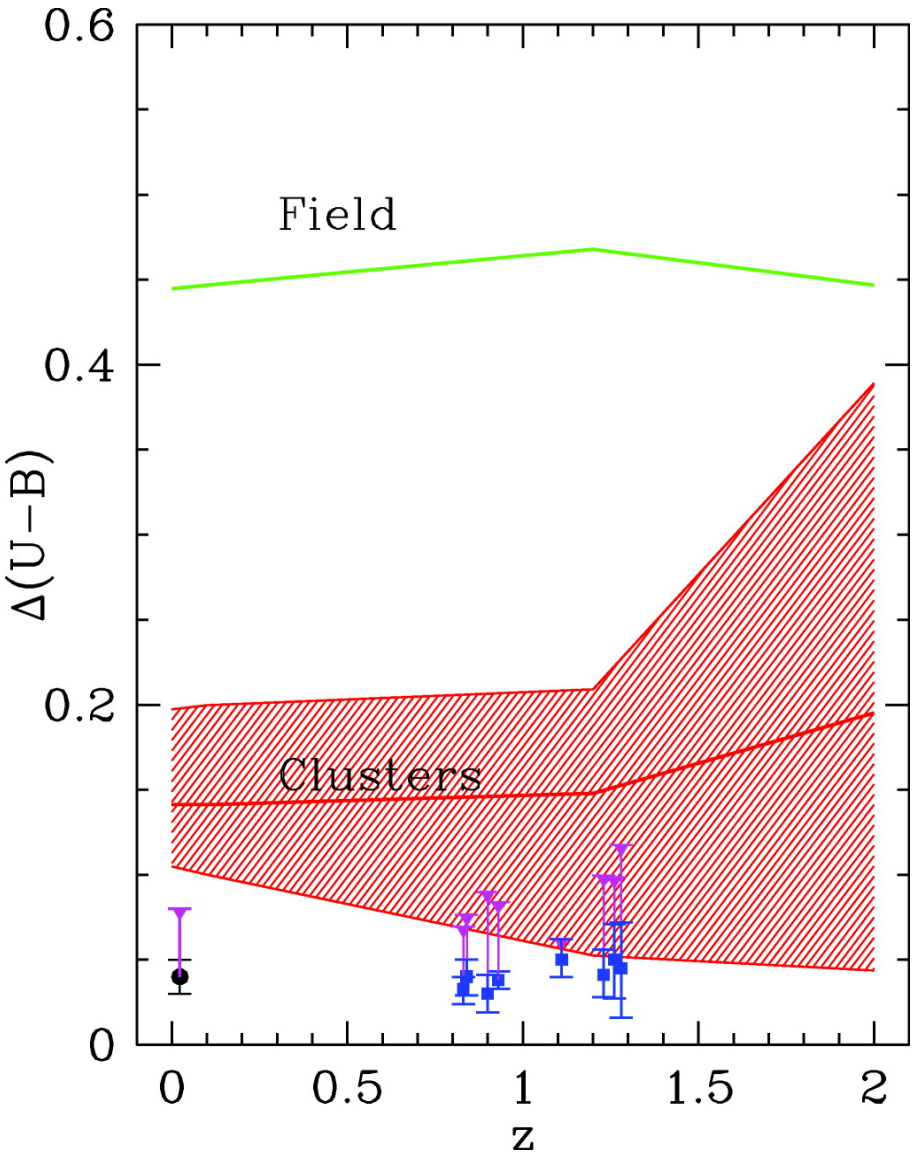


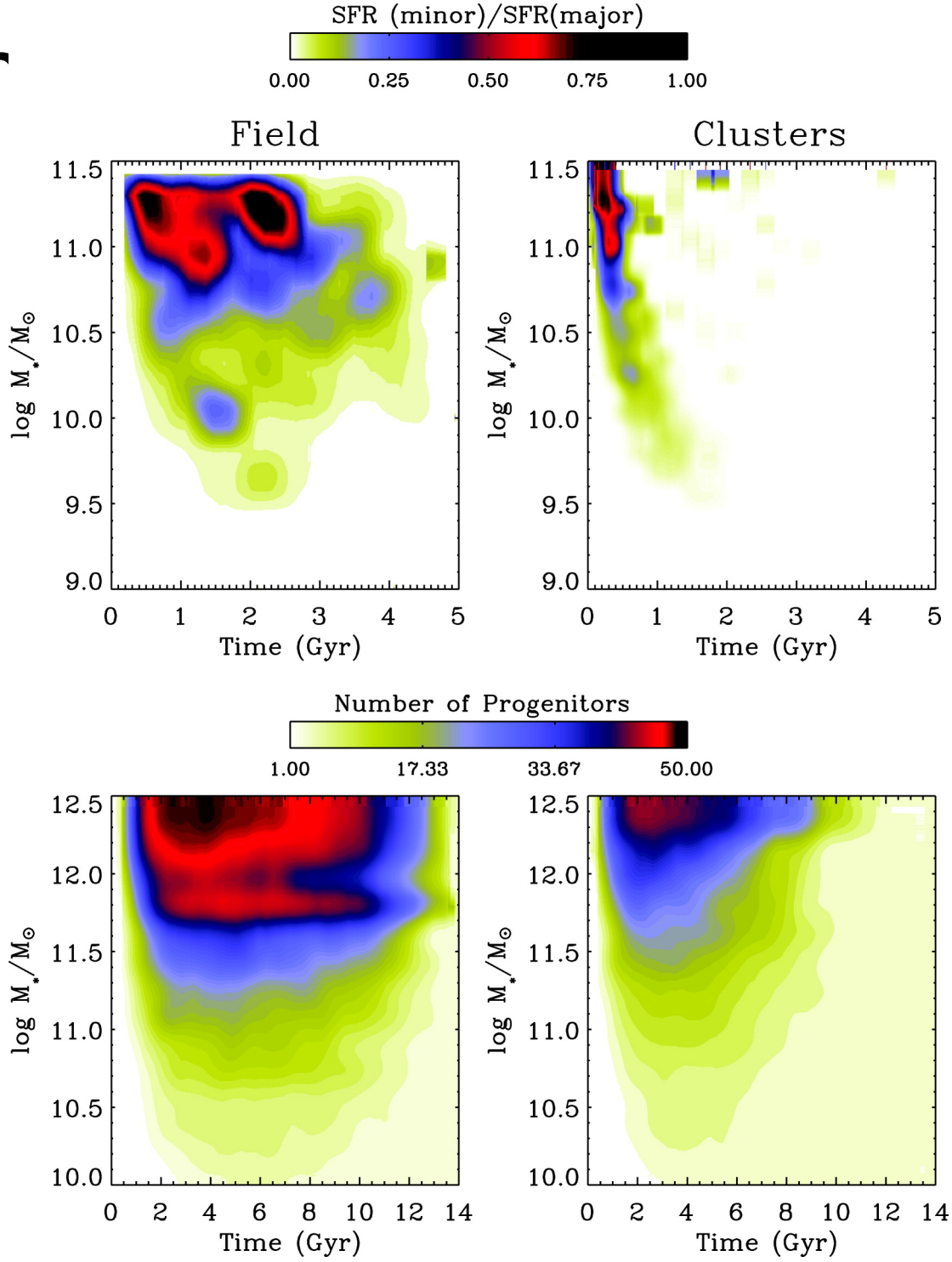
Models: semi-analytical predictions



Menci et al. 2008

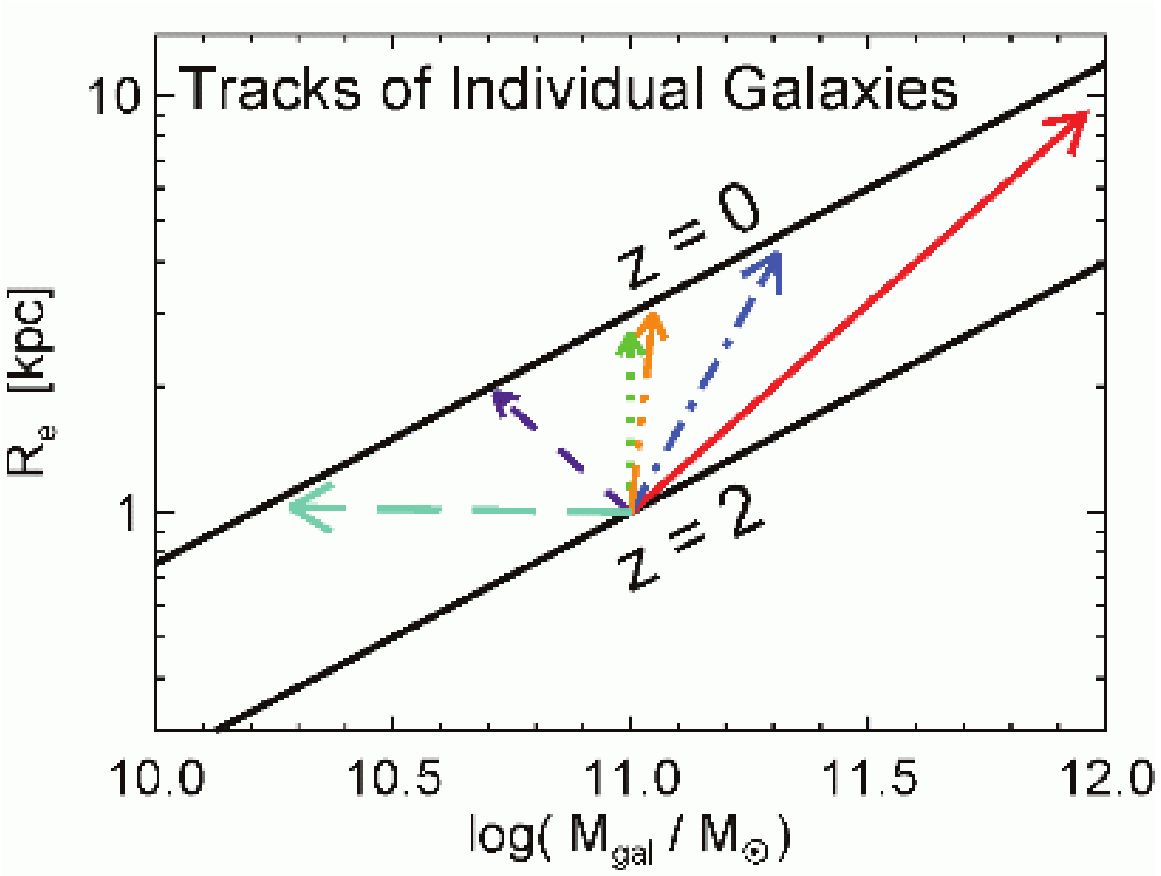
Models: semi-ar





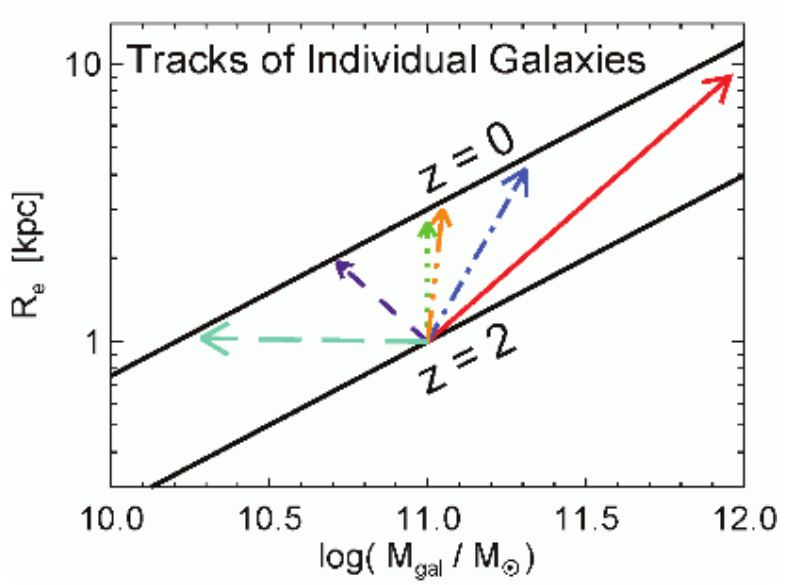
Menci et al. 2008

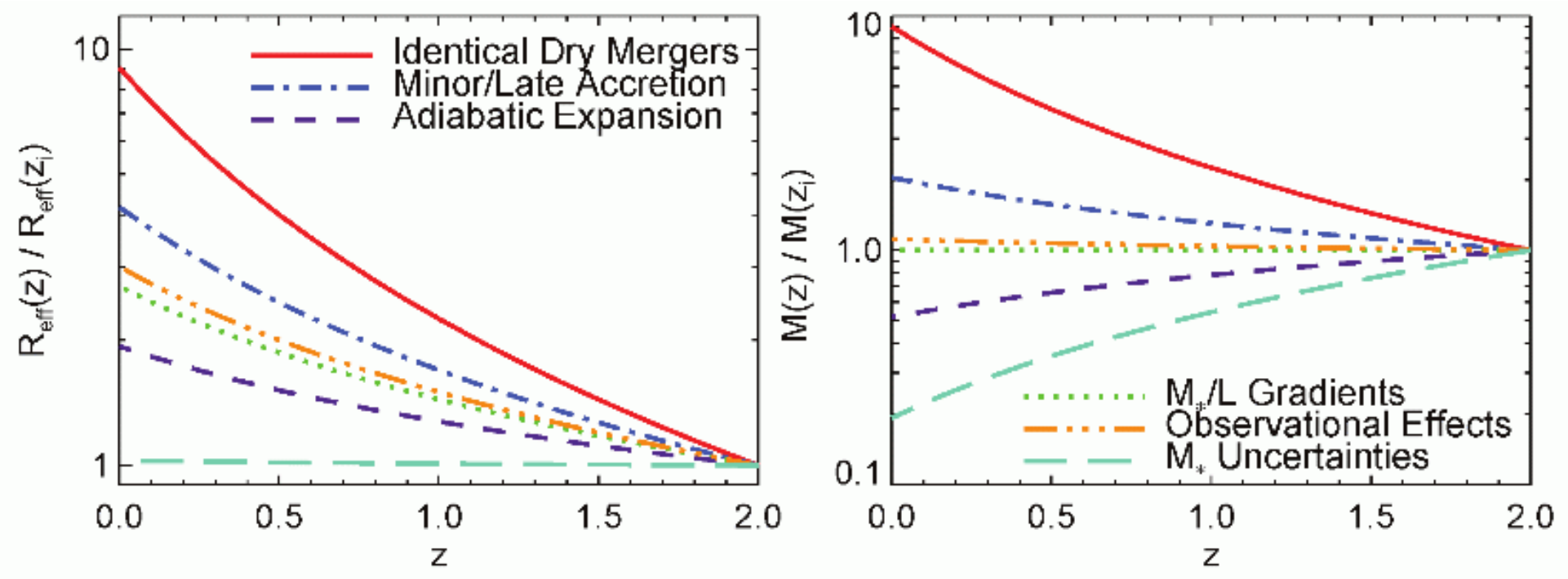
Models: hydrodynamic simulations



Hopkins et al. 2010

Models: hydrodynamic simulations





Hopkins et al. 2010

Outlook

- A tight red sequence of massive early types is already in place at 1/3 of the Universe present age

- Stellar populations formed at high redshift

- Stellar masses >$10^{11}M_{sun}$ already assembled in single galaxies

- Evolved morphology, but smaller sizes (more compact than local)

➔ redshift ~1.5 already too late for big action in the most massive structures (go to z>2 protoclusters)

➔ explore gas content, fraction and evolution

➔ not just red sequence galaxies - probe the starforming populations