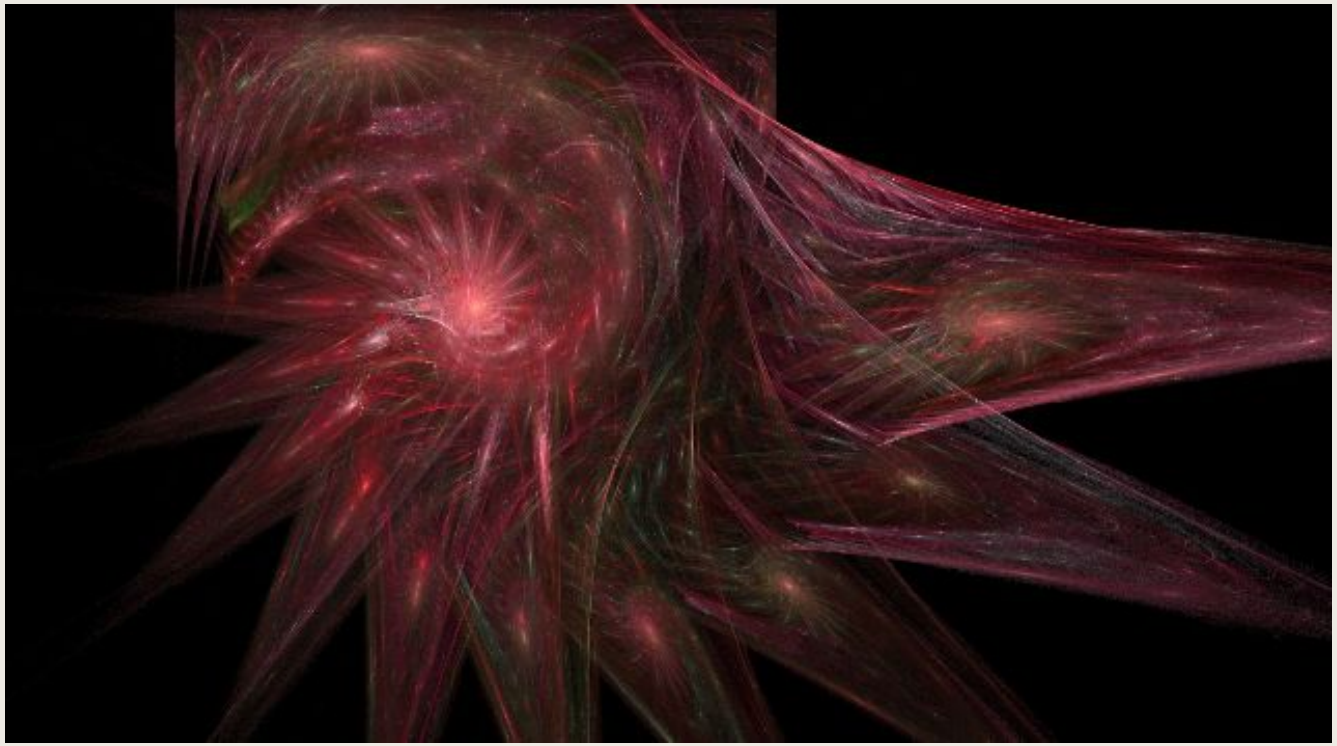
EVOLUTION OF BRIGHTEST CLUSTER GALAXIES IN A HIERARCHICAL UNIVERSE



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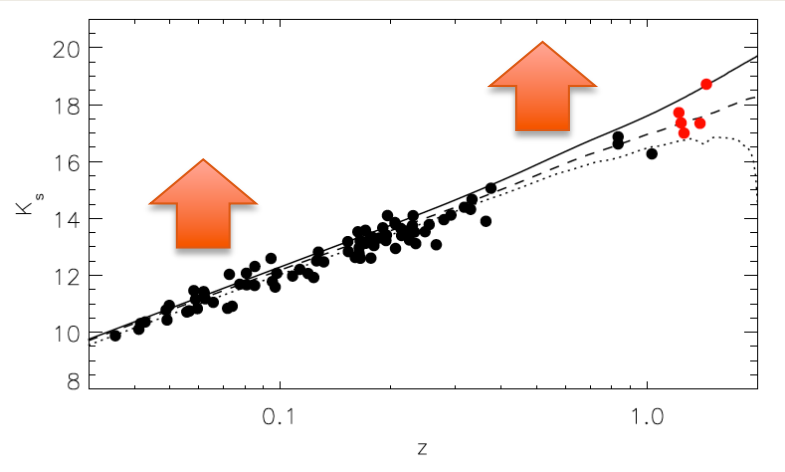
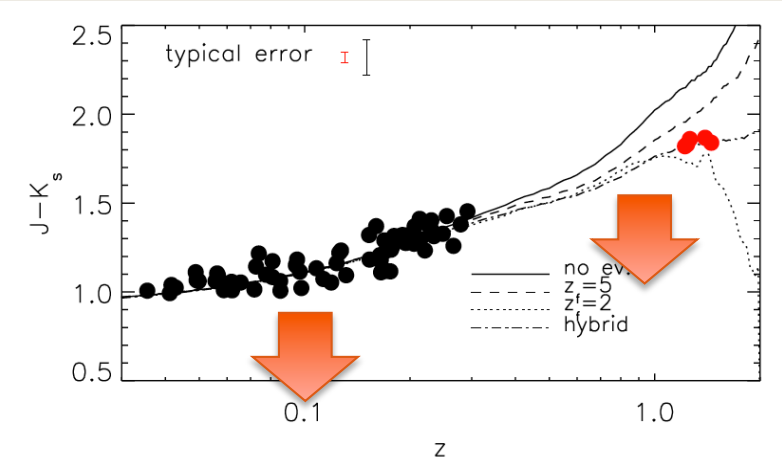
in collaboration with
Max Bernyk, Darren Croton, Claudia Maraston, Daniel Thomas

CT et al. 2012 ApJ..759..43

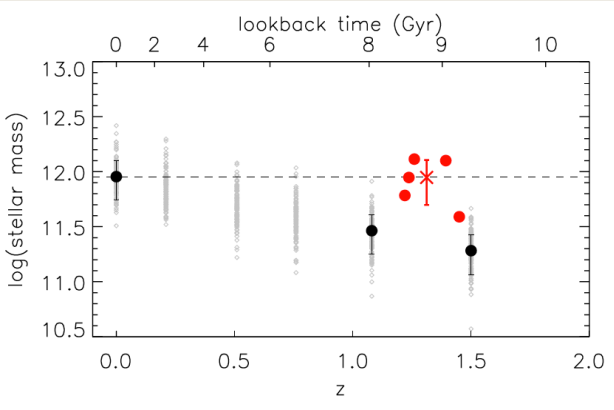
BIG RED GALAXIES IN A YOUNG UNIVERSE





Collins et al. 2009

BCGs are very luminous in K,and very red



With BC03 modeling, they are also estimated to be the most massive galaxies we observe. They evolve in luminosity and colour like single stellar population models, with epoch of formation z~3-5: passive evolution

Hierarchical semi-analytic models produce slower and more prolonged evolution, and lower masses at high redshift, OR: less luminous, bluer galaxies

IS THIS PROBLEM REAL?

Is there really something fundamentally wrong with the hierarchical clustering idea?

Galaxy formation models

MASS
SFR, age, Z → LIGHT

Observations

LIGHT → MASS
SFR, age, Z

Synthetic spectra associated to stellar mass at each timestep (intrinsic SFH)

SED fitting with template synthetic spectra + template SFH

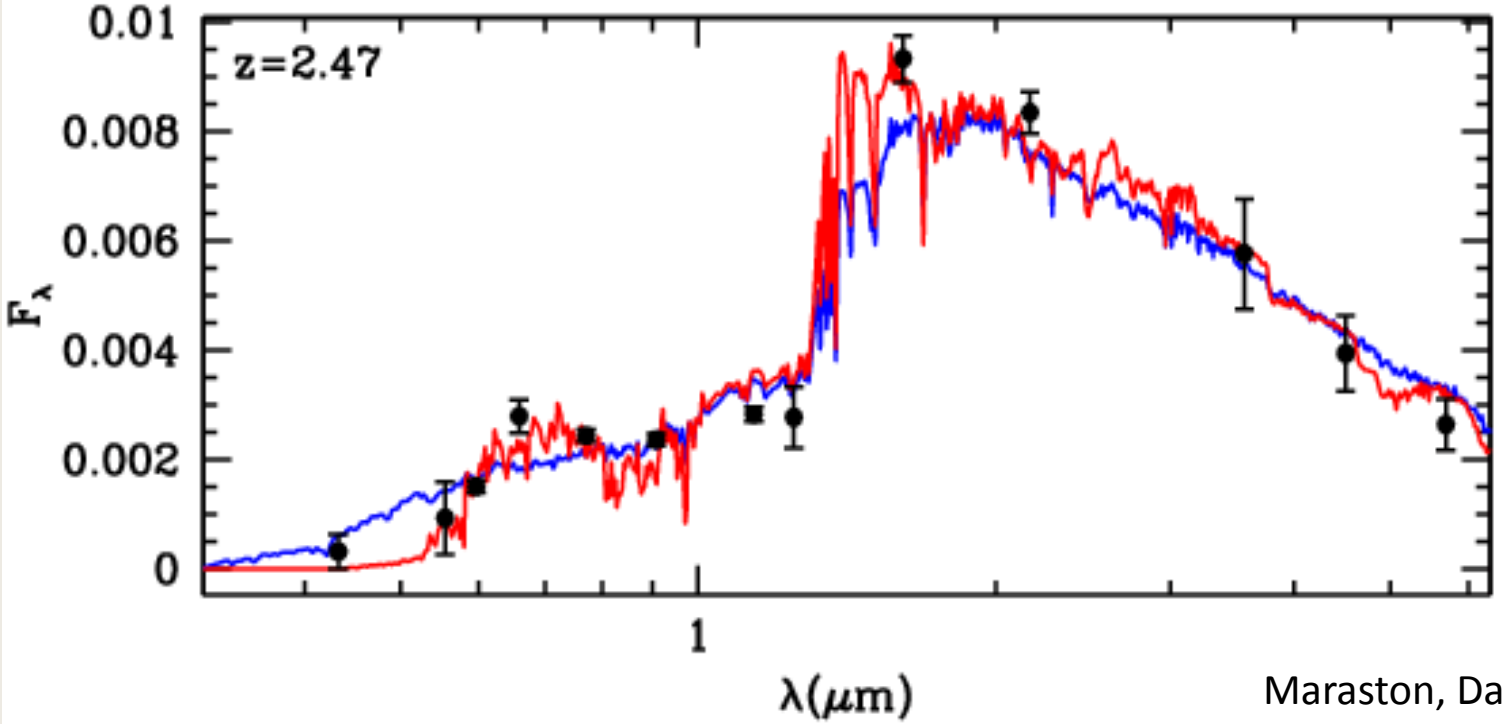
\+ K-corr + E-corr

“OBSERVED” PARAMETERS

t=0.4 Gyr; SFH: SSP; Z=2 $Z_\odot$; E(B−V)=0. (Maraston05)

t=2.6 Gyr; SFH: $e^{-t/1\ Gyr}$; $Z=Z_\odot/2.5$; Calzetti's law E(B−V)=0.3 (BC03)

↳ Older then the Universe!

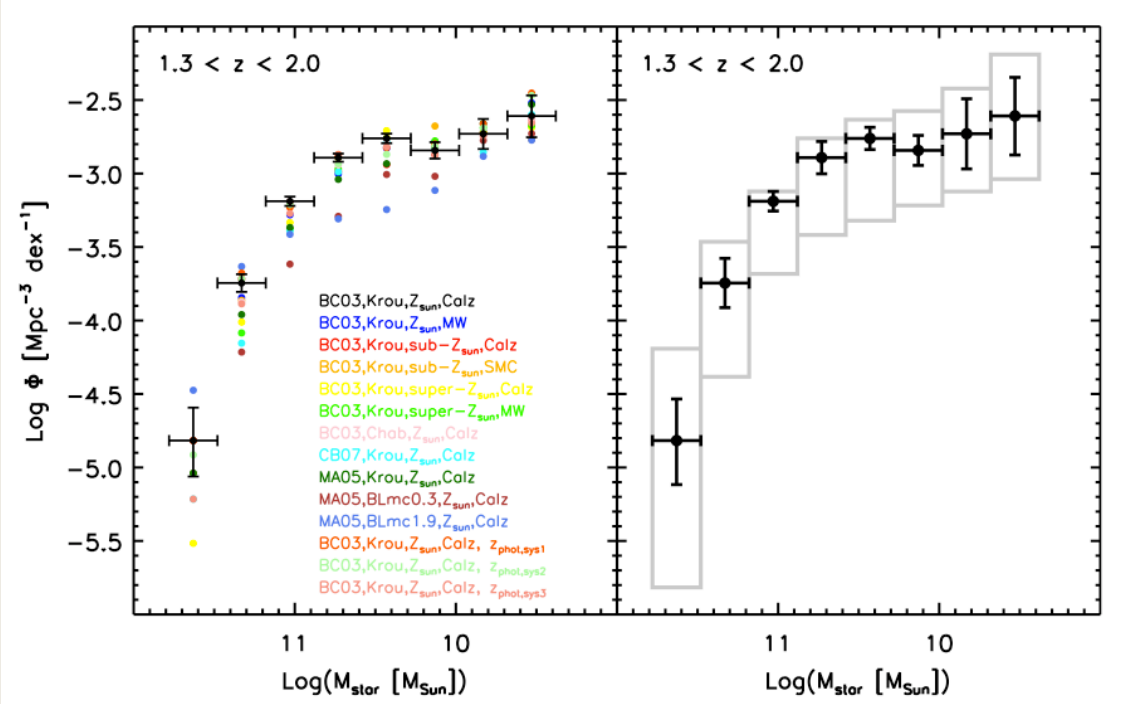


Maraston, Daddi, Renzini, et al. 2006

Different evolutionary population synthesis mostly agree at low z

Until recently, other discrepancies with data made this effect negligible

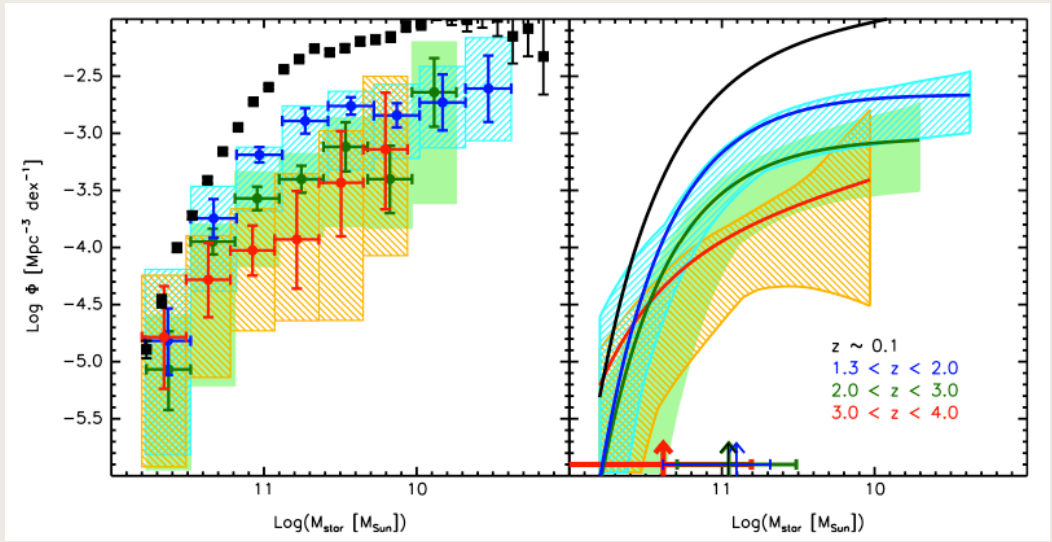
DERIVED STELLAR MASS FUNCTION



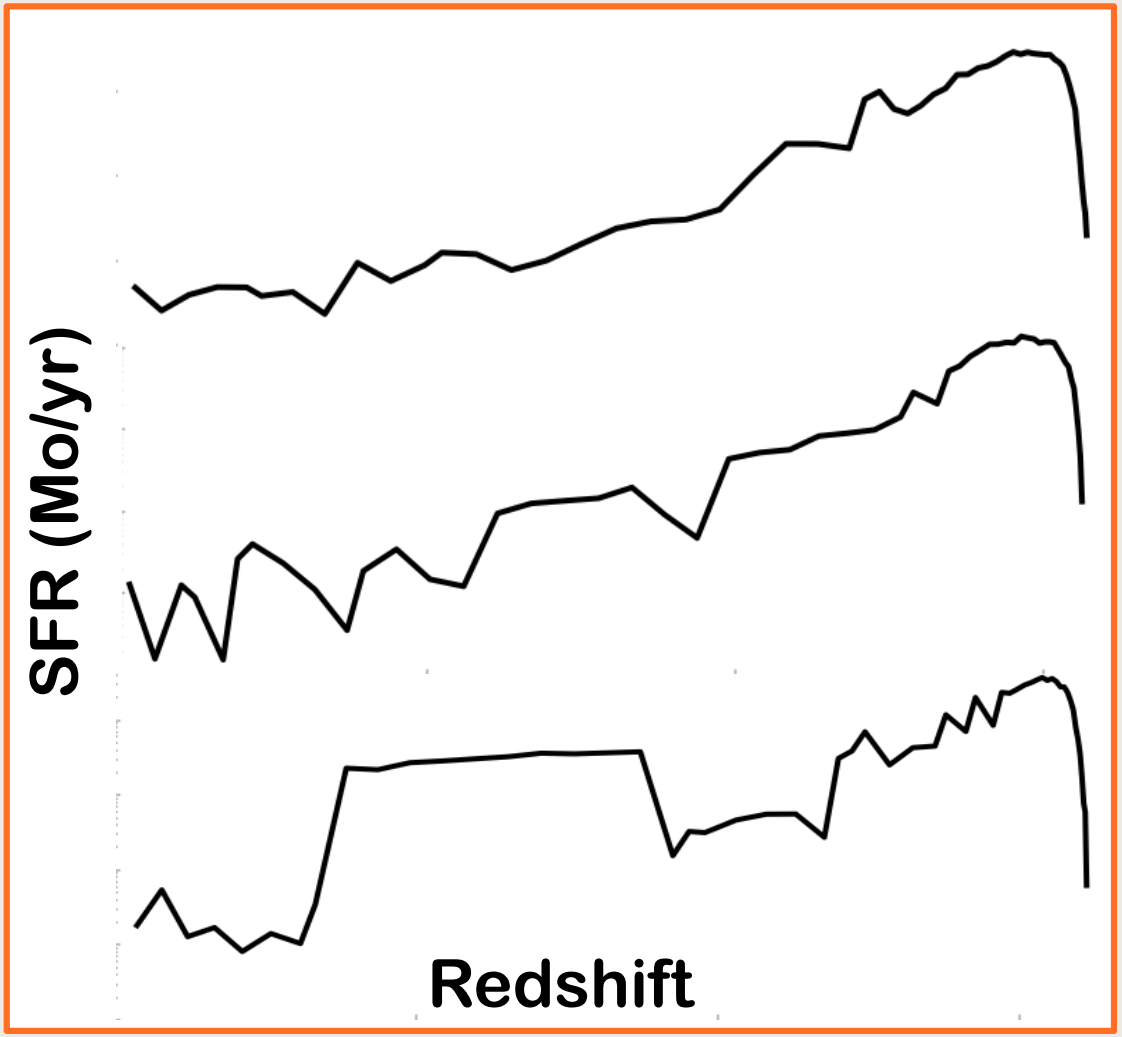
Optical to mid-infrared data

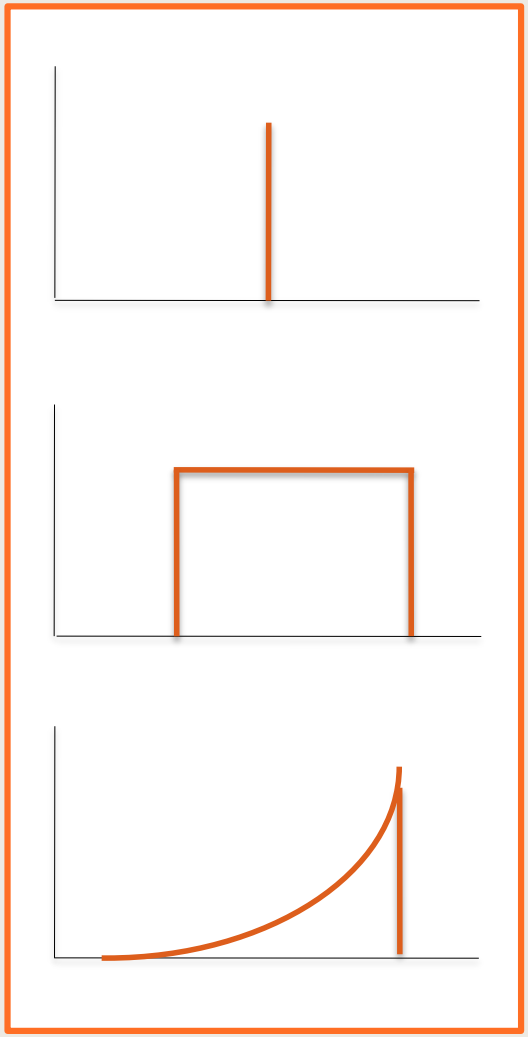
Goods – Giavalisco et al. 2004
Musyc – Gawiser et al. 2006

Marchesini et al. 2009



STAR FORMATION HISTORIES





MODELING BCGs

STAR-FORMATION HISTORIES
with a non-uniform time grid, in lookback time at every output redshift (every galaxy has the same age-grid), matching the age resolution of the SSP model (to capture younger stellar generations)

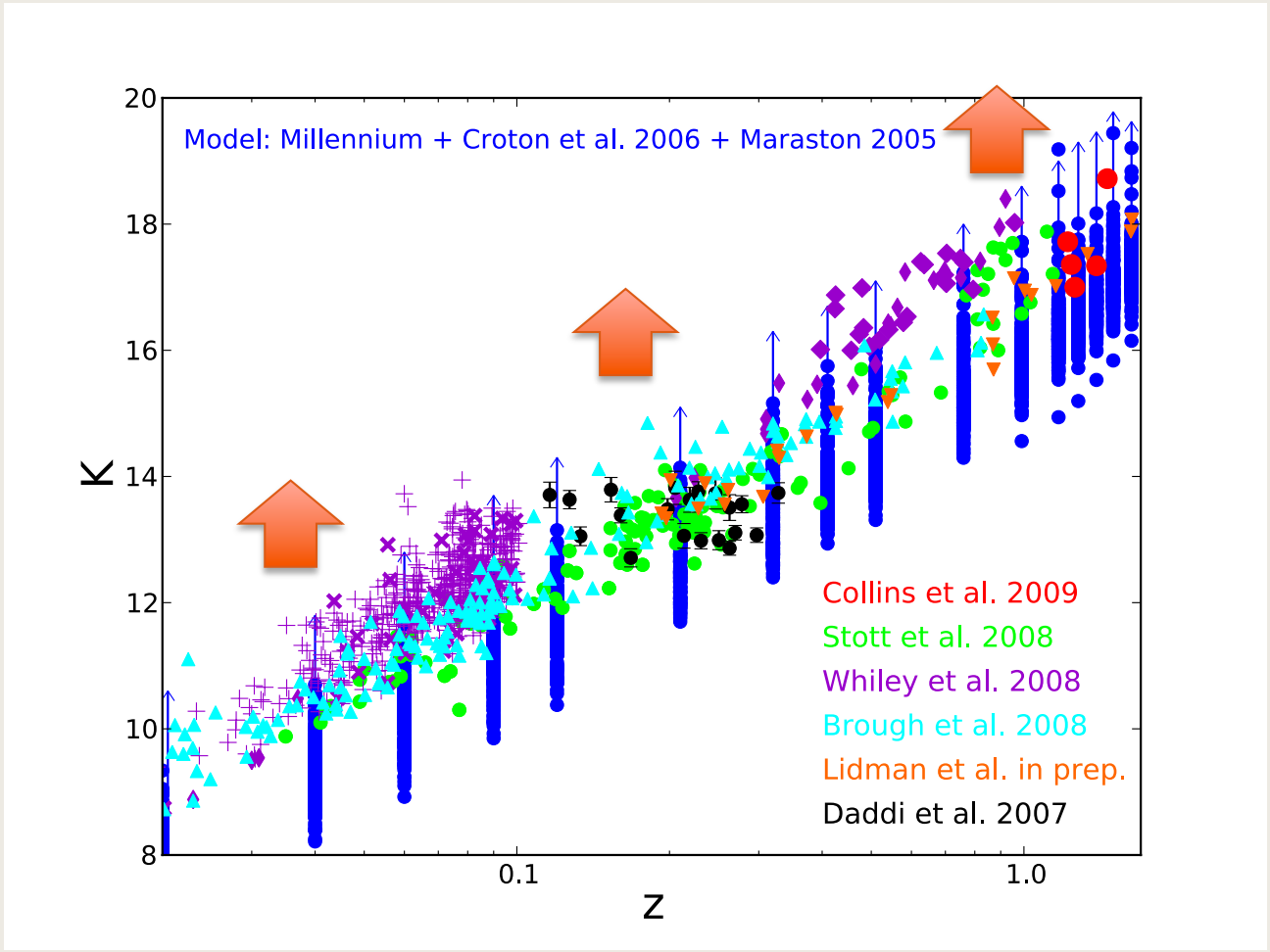
STELLAR POPULATION MODEL
M05; see Tonini et al. 2009, 2010
with new dust model (E(B-V) proportional to SFR, calibrated with observations). No re-calibration of the semi-analytic model, no new physics!

OUTPUT
galaxy spectra: mock galaxy catalogues with apparent magnitudes taylored on each survey's specifications (filters, errors, cuts…)

Theoretical Astrophysical Observatory (TAO)
http://tao.it.swin.edu.au/

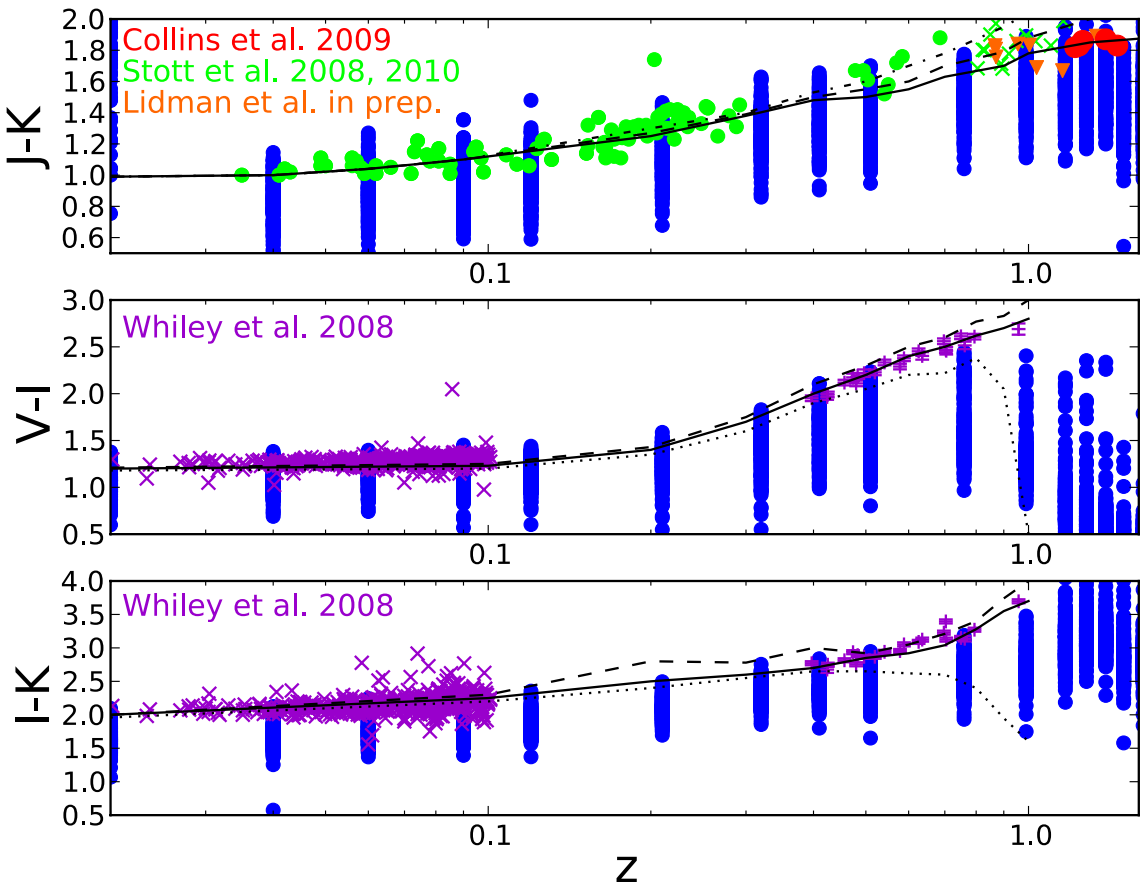
Bernik, Tonini, Croton et al. in prep.
Croton et al. 2006, Croton et al. in prep.

LUMINOSITY EVOLUTION



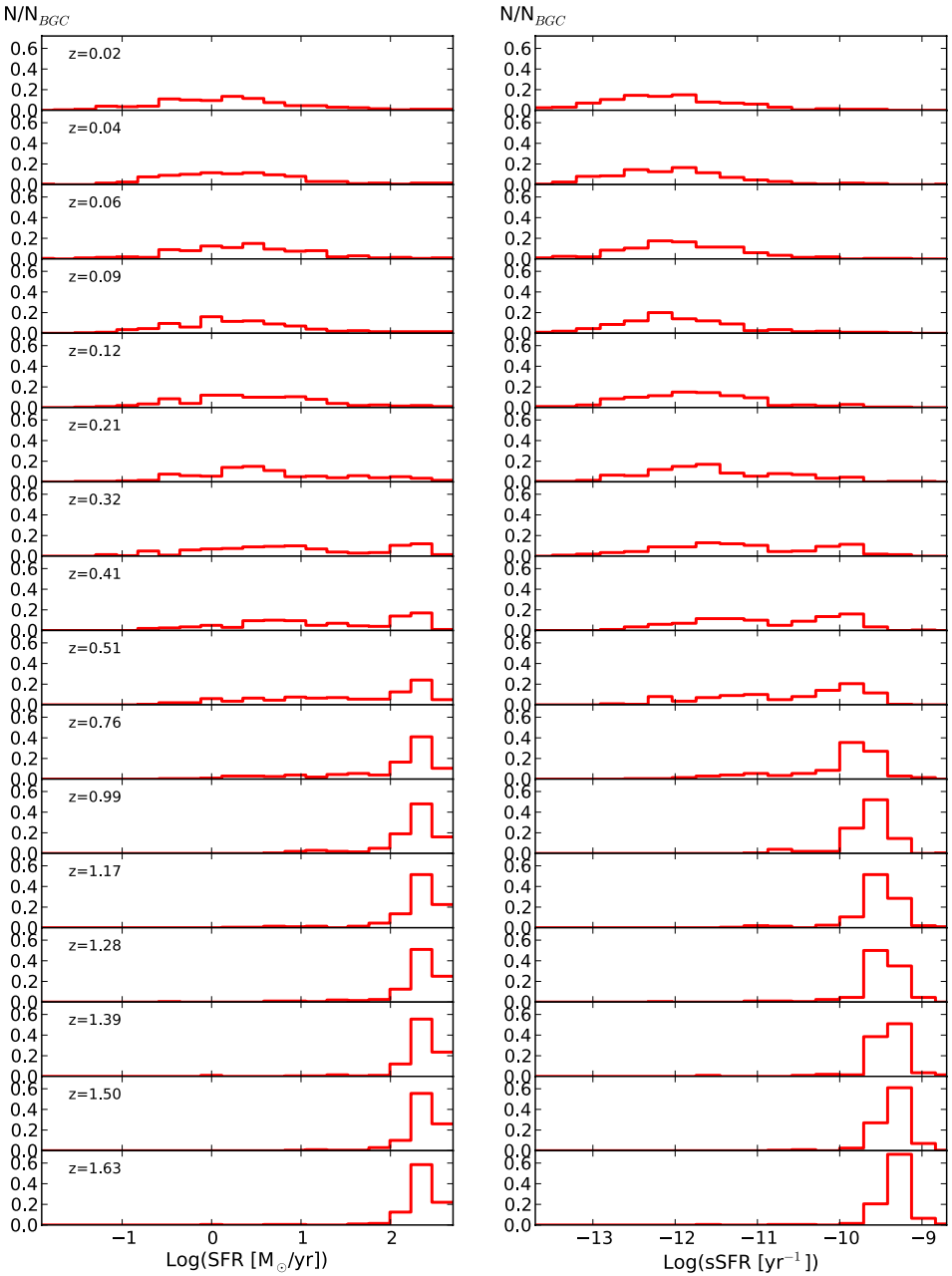
Model BCGs are luminous enough! In fact, a little too much …. so the hierarchical build-up of structures can assemble enough mass to reproduce the luminosity evolution of BCGs

COLOUR EVOLUTION

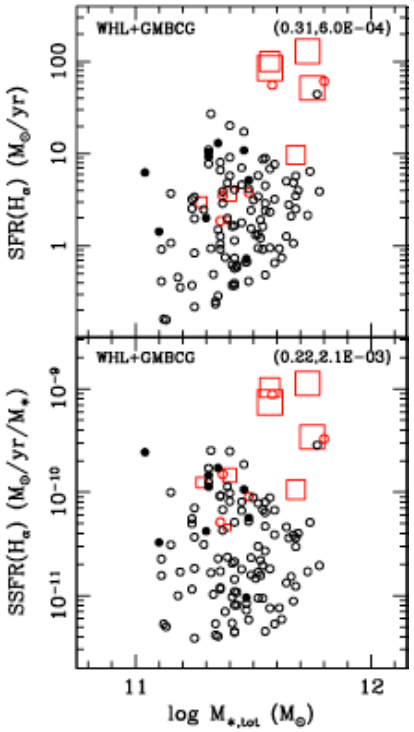


Model BCGs match the observed colours. Their colour evolution is indistinguishable from that of single stellar populations of age > 10 Gyr…

STAR FORMATION RATE

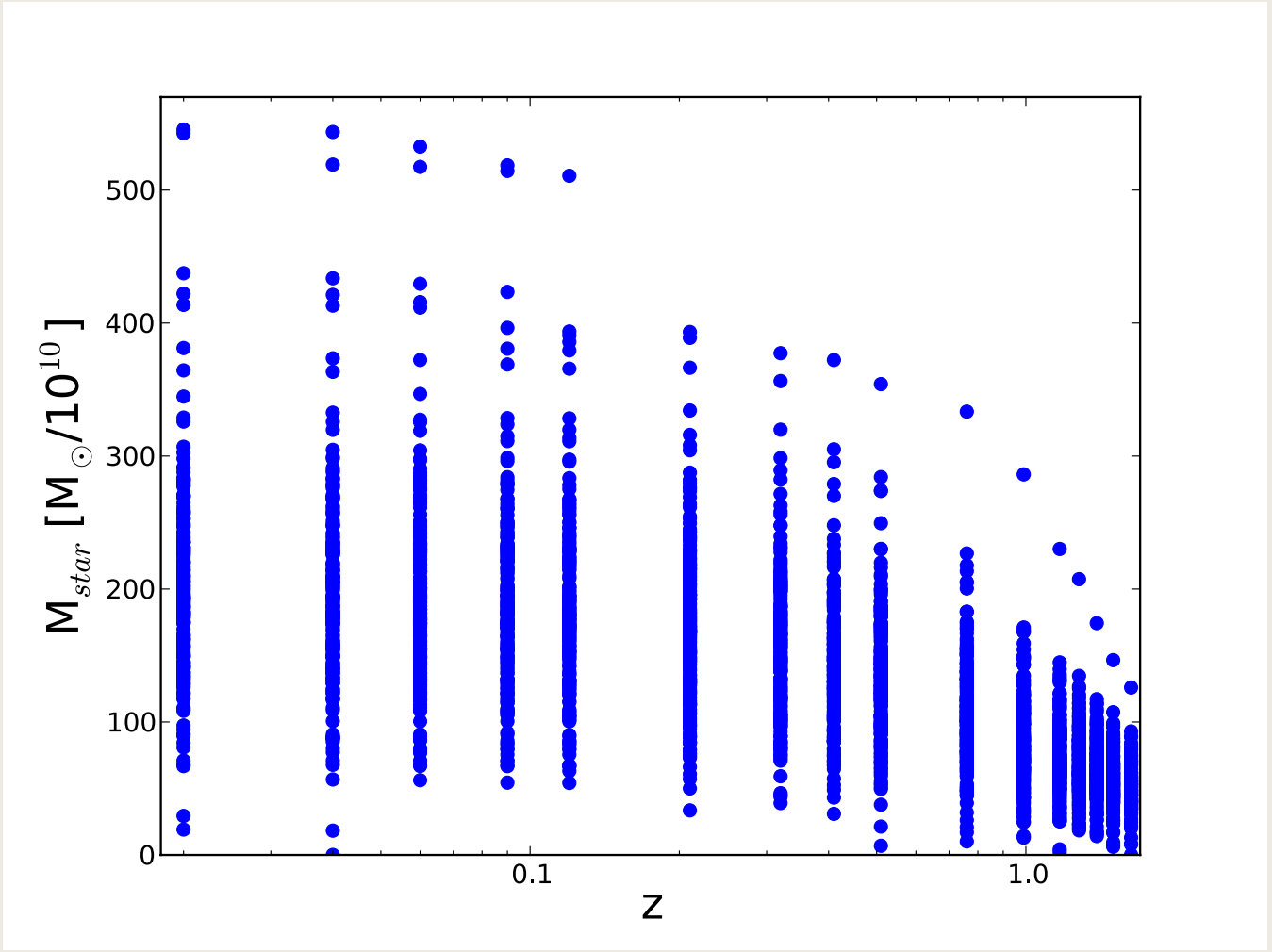


Total **Specific**



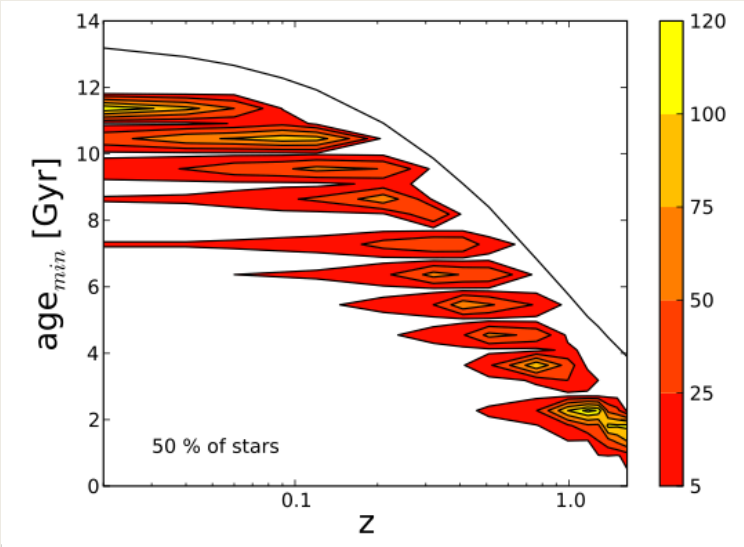
Liu et al. 2012

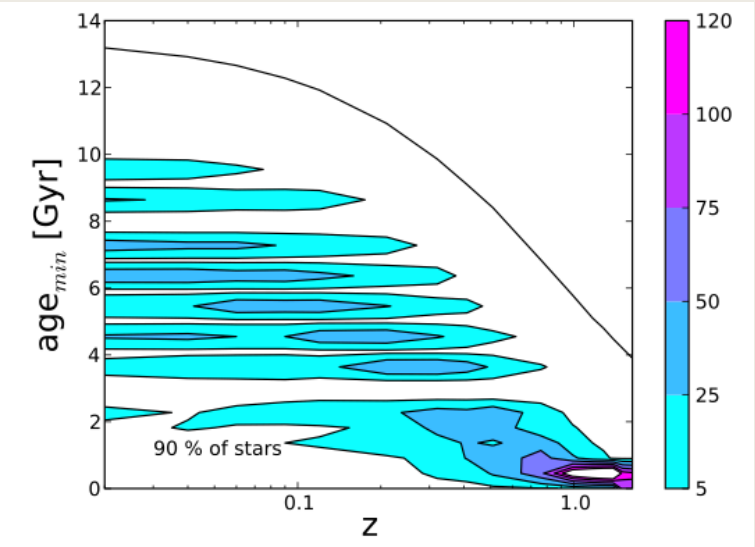
MASS EVOLUTION



Model BCGs grow a significant amount of mass down to z=1, mostly due to mergers (and some star formation). They are not single stellar populations. (see Lidman et al. 2012)

PASSIVE EVOLUTION IN THE HIERARCHICAL SENSE





Age of a galaxy: minimum age of certain fraction of its stars

1: model BCGs are old at z=0
2: BCGs age a lot since z=1, but so does the Universe, with the same speed
3: the SFRs are not large enough to offset this behaviour

The ageing of the BCG is dominated by its stellar populations getting older, regardless of where they formed and when they were accreted: ageing of the merger tree

CONCLUSIONS - part I

The model reproduces reasonably well the K-band luminosity evolution and the colour evolution of BCGs up to z~1.6

The hierarchical mass assembly is fast enough to reproduce the K-band observations: model BCGs have enough mass

The K-band luminosity and colour evolution produced with the hierarchical star formation history of the SAM + M05 SP models is indistinguishable from that of a single stellar population + BC03

The physical properties of the galaxy and their evolution are completely different in the two scenarios. There is a degeneracy in the star-formation history – SP model combination, that is not broken by current observations. The evolution history of BCGs is currently inaccessible

Hierarchical model BCGs are “active” galaxies. However SFRs and assembly histories are such that the evolution is dominated by the ageing of the stars in the merger tree. We define such behaviour as passive evolution in the hierarchical sense.

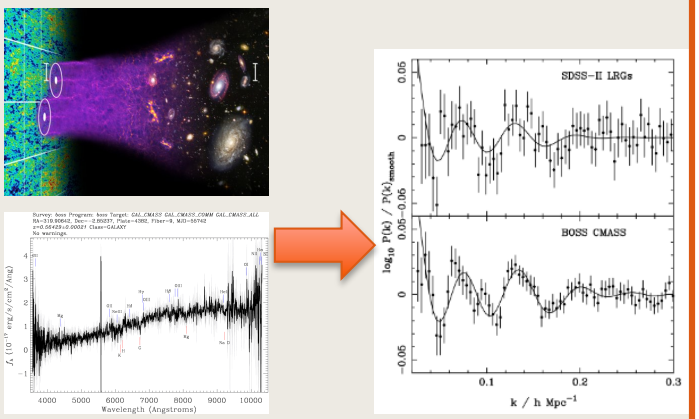
THE FUTURE

TAO spectroscopy

mock galaxy catalogues with spectra: flexibility to be taylored to particular instruments and surveys

passive evolution and Dark Energy surveys

BOSS (SDSS-III) mock catalogues in search of passive evolution constrain the photometry of the passive population for selection criteria → large-scale structure growth with minimum biases



AGN feedback models

the high-mass end of the stellar mass function is obtained with ad-hoc parameters → → →
physically motivated model for the cooling-heating cycle, to be 'constrained' by the star formation history