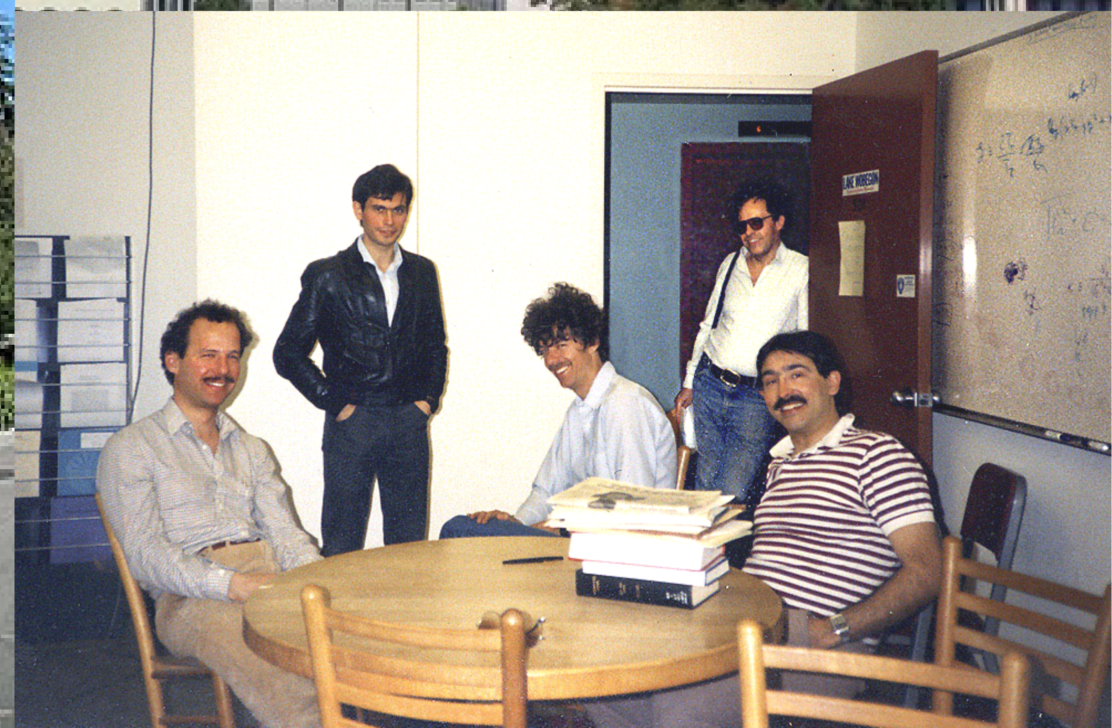


How galaxies acquire their neutrino haloes

Bond, J. R.; Szalay, A. S.; White, S. D. M.

AA(Stanford University, Stanford, CA), AB(California, University, Berkeley, CA), AC(California, University, Berkeley, CA)

Nature, vol. 301, Feb. 17, 1983, p. 584, 585. (Nature Homepage)

Abstract

One-dimensional simulations of the nonlinear growth of structure in a universe dominated by a population of nonrelativistic collisionless particles such as massive neutrinos show that a subpopulation of slowly moving particles exists within the "pancakes" that form. These particles can cluster in a low velocity condensate around any seed perturbation which may be present. The schematic calculation of this aggregation presented here suggests that the properties of neutrino clusters depend only weakly on seed mass but substantially on seed separation. Their mass and velocity dispersion may be quite comparable with the values inferred for the haloes of "dark" matter surrounding real galaxies.

COBE background radiation anisotropies and large-scale structure in the universe

Efstathiou, G.; Bond, J. R.; White, S. D. M.

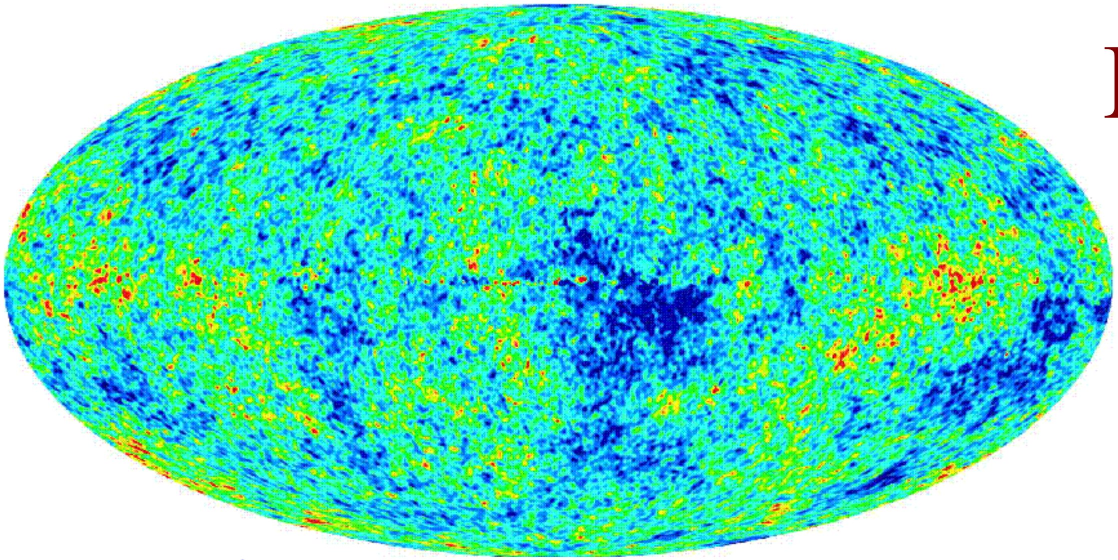
AA(Oxford, University, United Kingdom), AB(Toronto, University, Canada), AC(Cambridge University Institute of Astronomy, United Kingdom)

Royal Astronomical Society, Monthly Notices (ISSN 0035-8711), vol. 258, no. 1, Sept. 1, 1992, p. 1P-6P. Research supported by SERC. (MNRAS

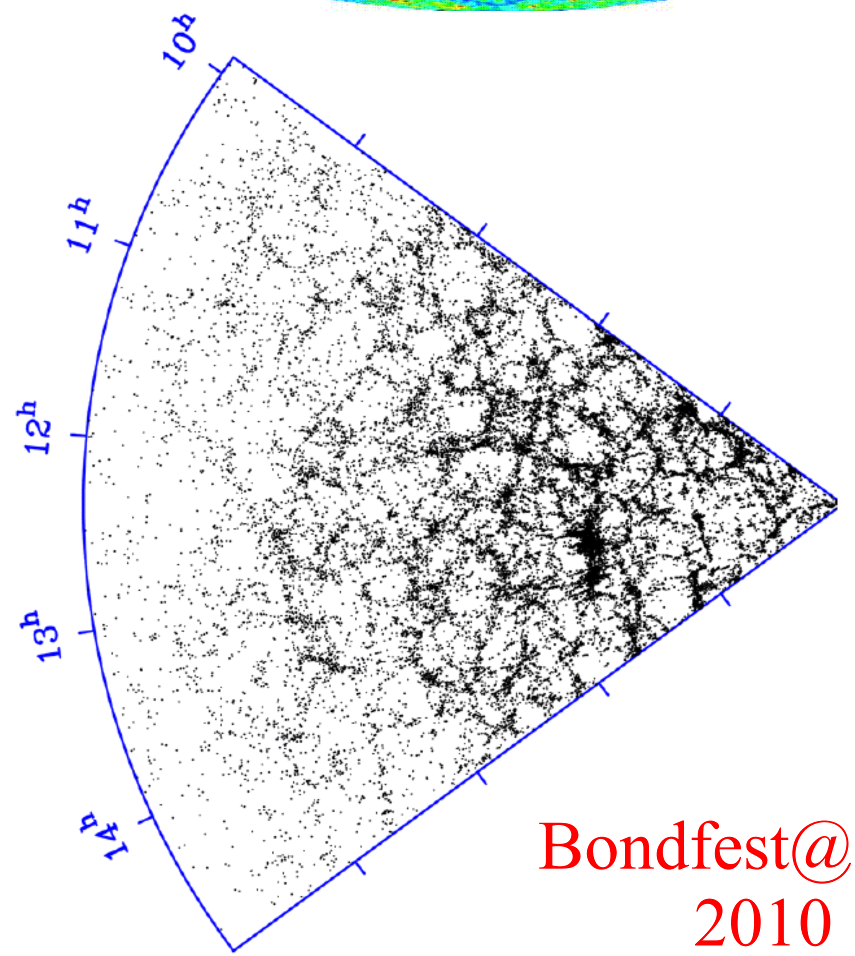
Abstract

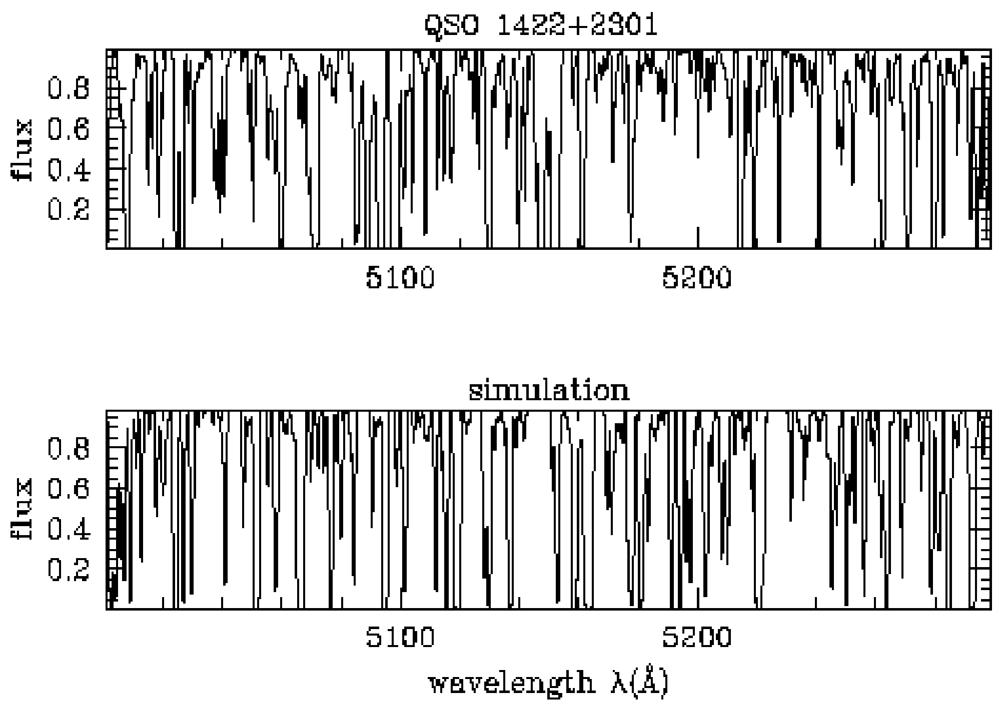
We discuss the constraints imposed on theoretical models by the COBE measurements of the microwave background anisotropies by observations of galaxy clustering, and by the observed streaming motions of galaxies. When normalized to match the COBE results, models with Omega = 1 and with more large-scale power than the standard cold dark matter (CDM) model predict lower streaming motions than are observed, but agree well with the dynamics of clustering on smaller scales. Unbiased Omega = 1 CDM models fit the COBE data and the streaming motions, but are less easily reconciled with galaxy clustering data on either small or large scales. Spatially flat CDM models with Omega of about 0.2 and a cosmological constant require the mass to be substantially more clustered than the galaxies in order to be consistent with COBE and with observed streaming motions. They are then in conflict, however, with dynamical measurements on smaller scales.

Modelling the galaxy population



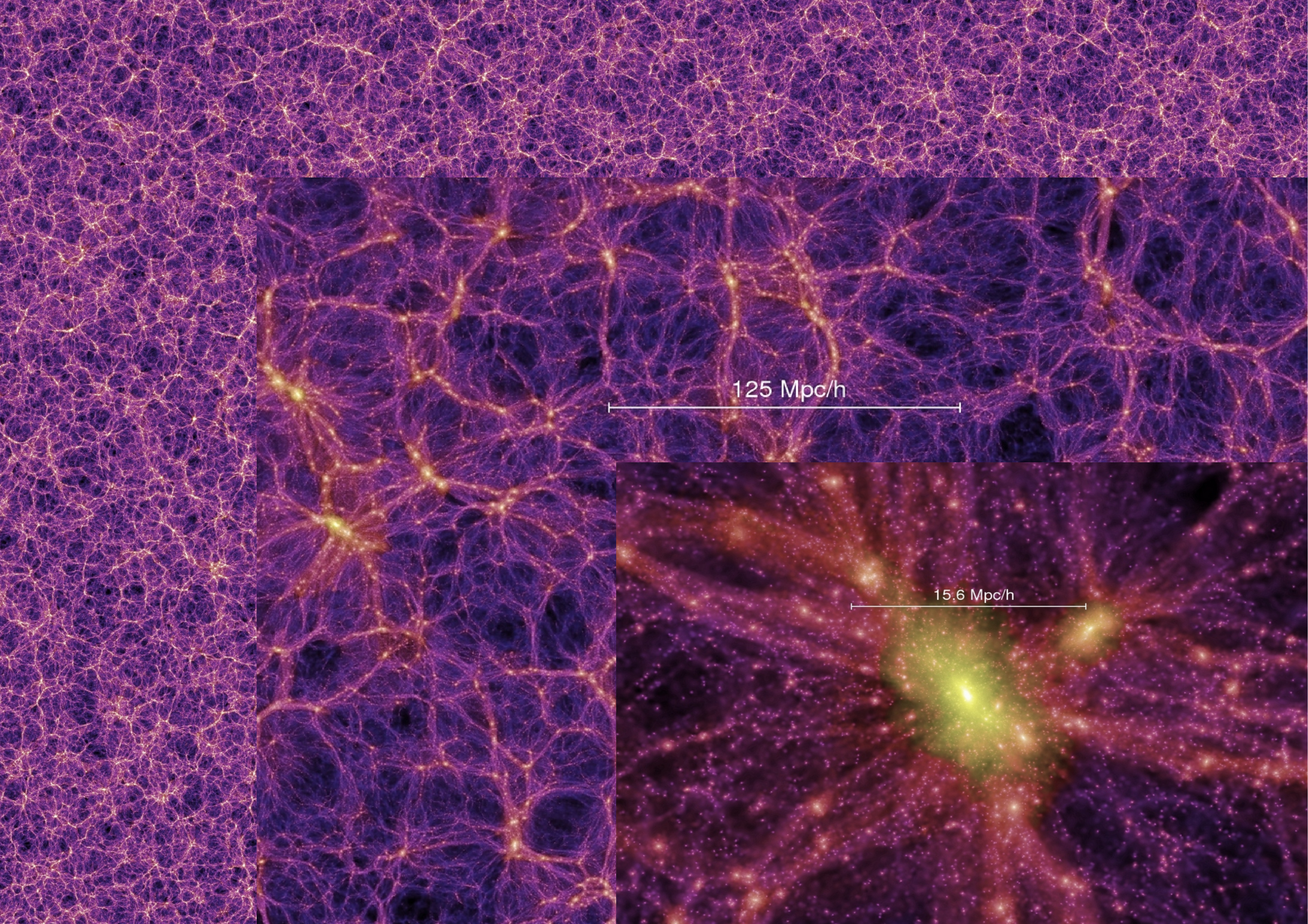
Simon White
Max Planck Institut für Astrophysik

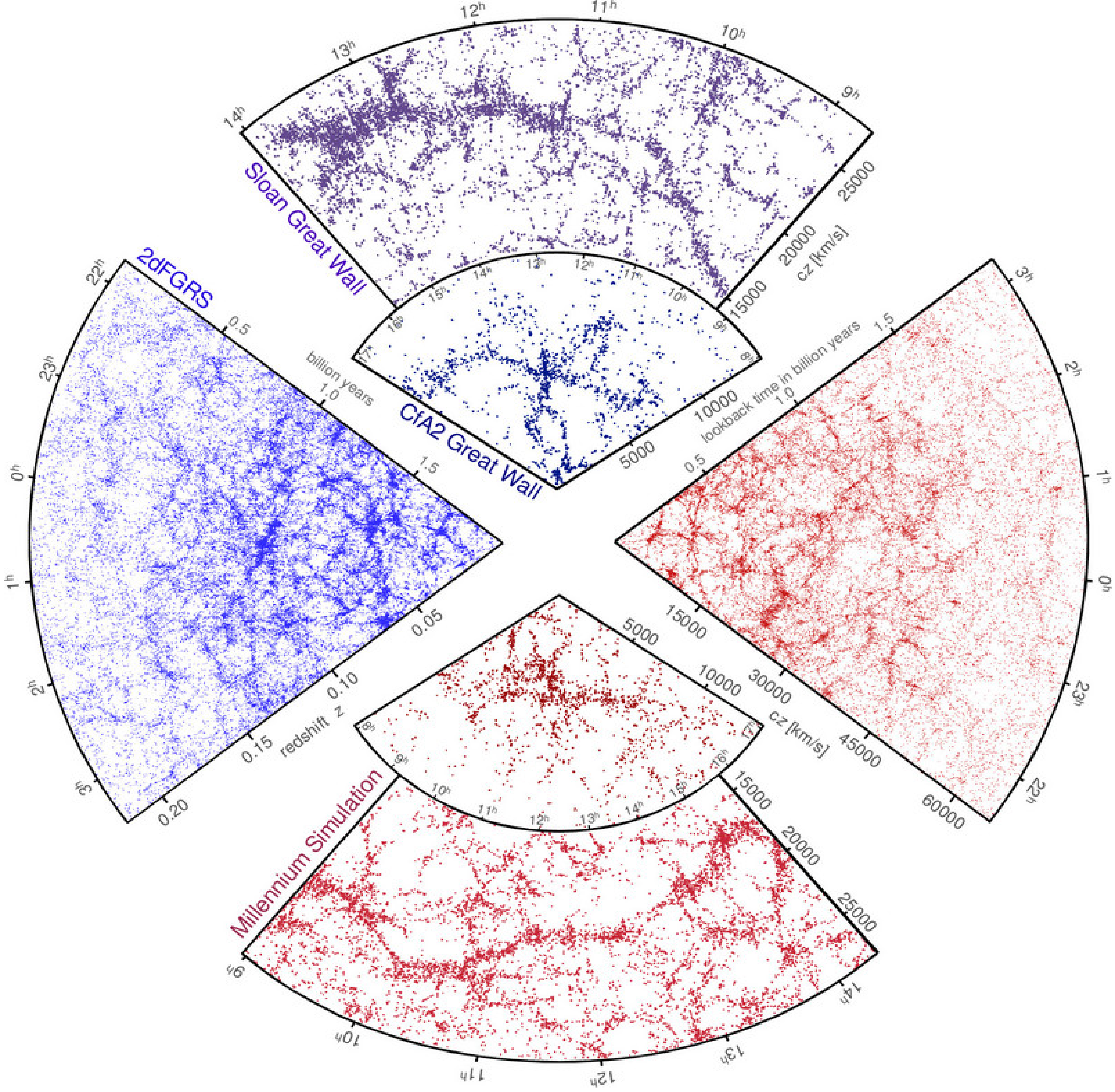




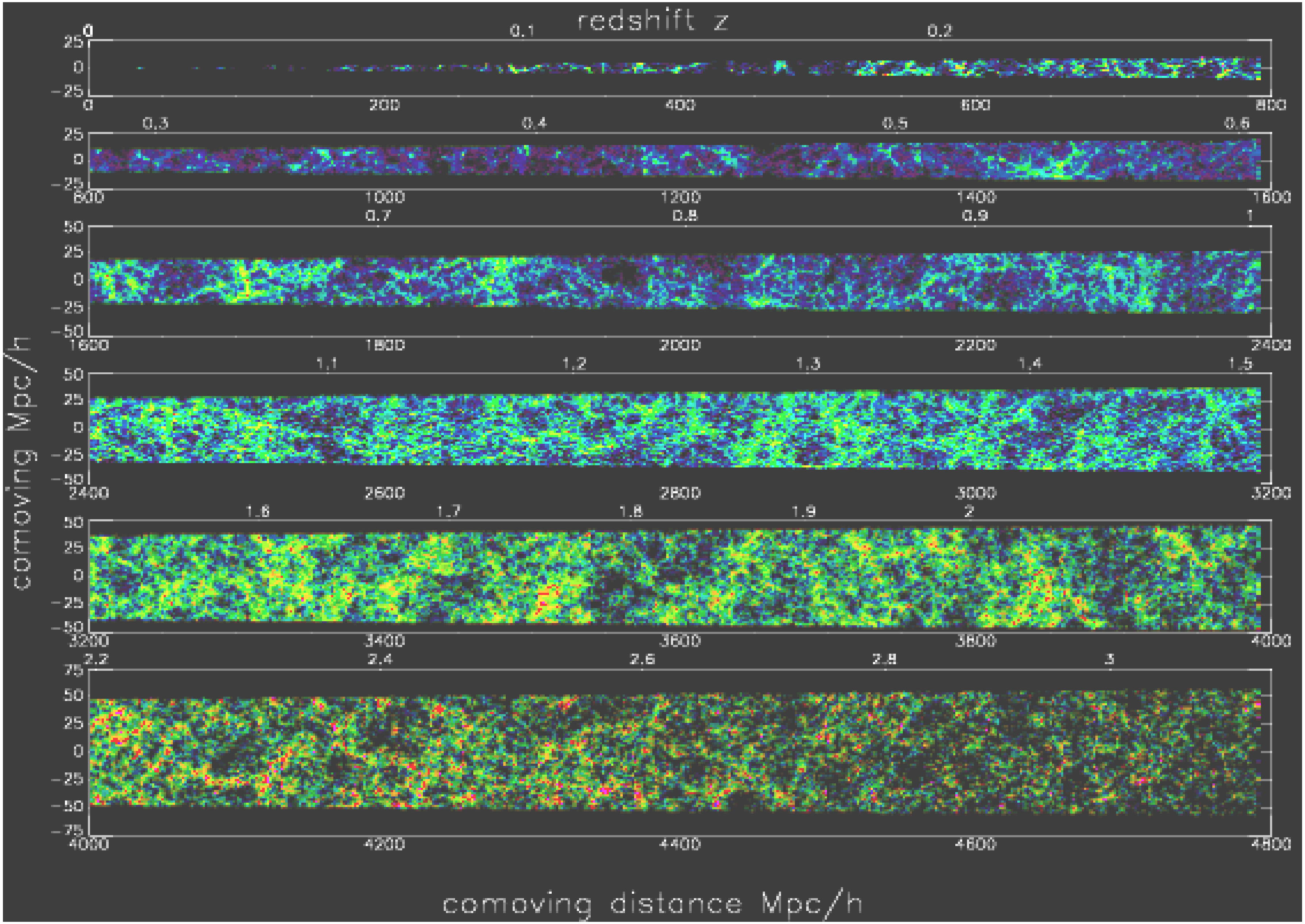
Bondfest@CITA
2010

The Millennium Simulation (2005)





Sloan Great Wall
2dFGRS
CfA2 Great Wall
Millennium Simulation
cz [km/s]
lookback time in billion years
billion years
redshift z

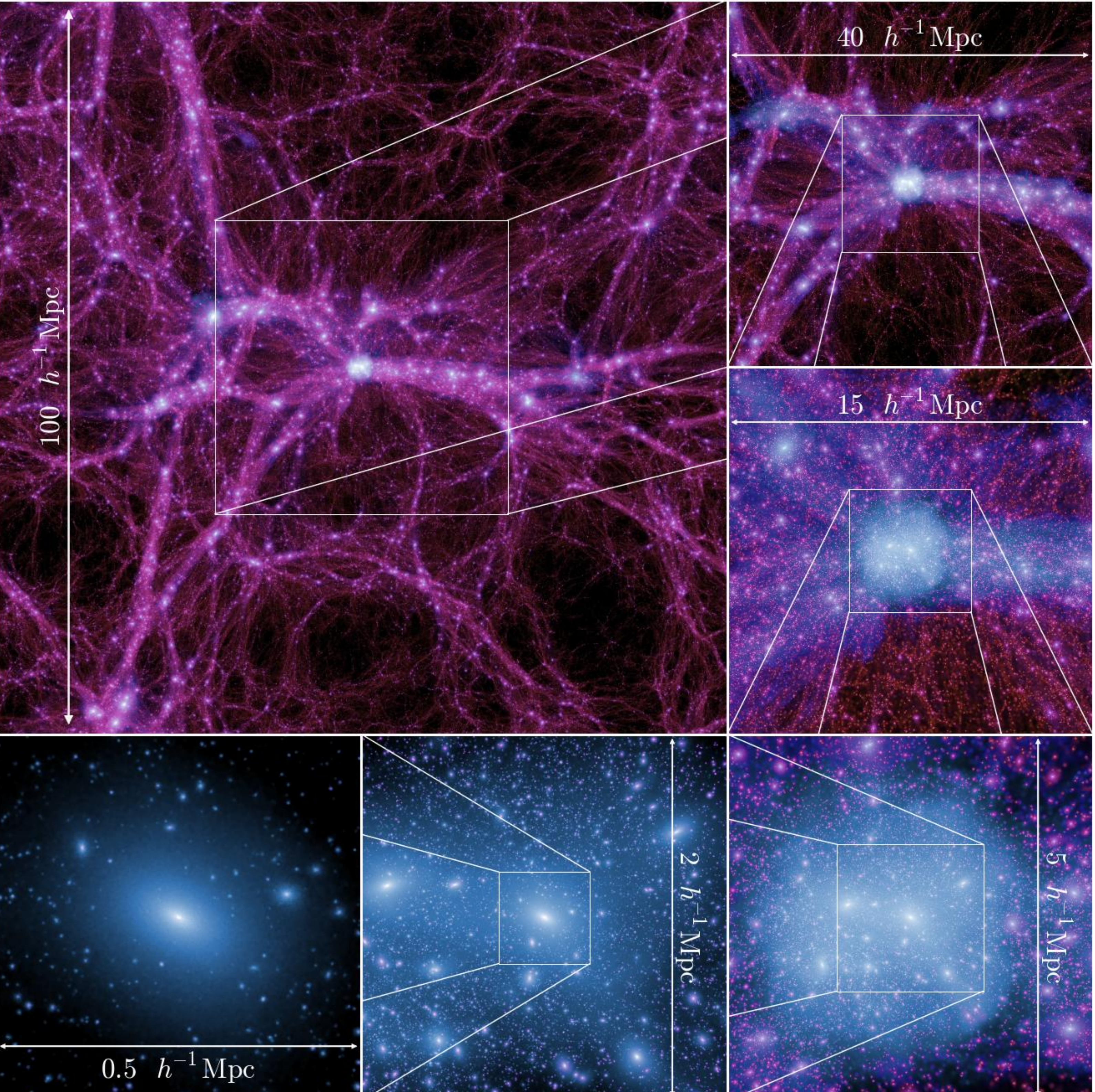


307 papers making direct use of data from the MS (14-05-2010)
Most by authors unassociated with the consortium
Most based on the galaxy catalogues, particularly mock surveys

Limitations of the Millennium Simulation

- Limited volume – too small for BAO work, precision cosmology
- Limited resolution – too poor to model formation of dwarfs
- No convergence tests – are galaxy results numerically converged?
- Only one (“wrong”) cosmology
- Users unable to test dependences on parameters/assumptions

Millennium-II (2008)



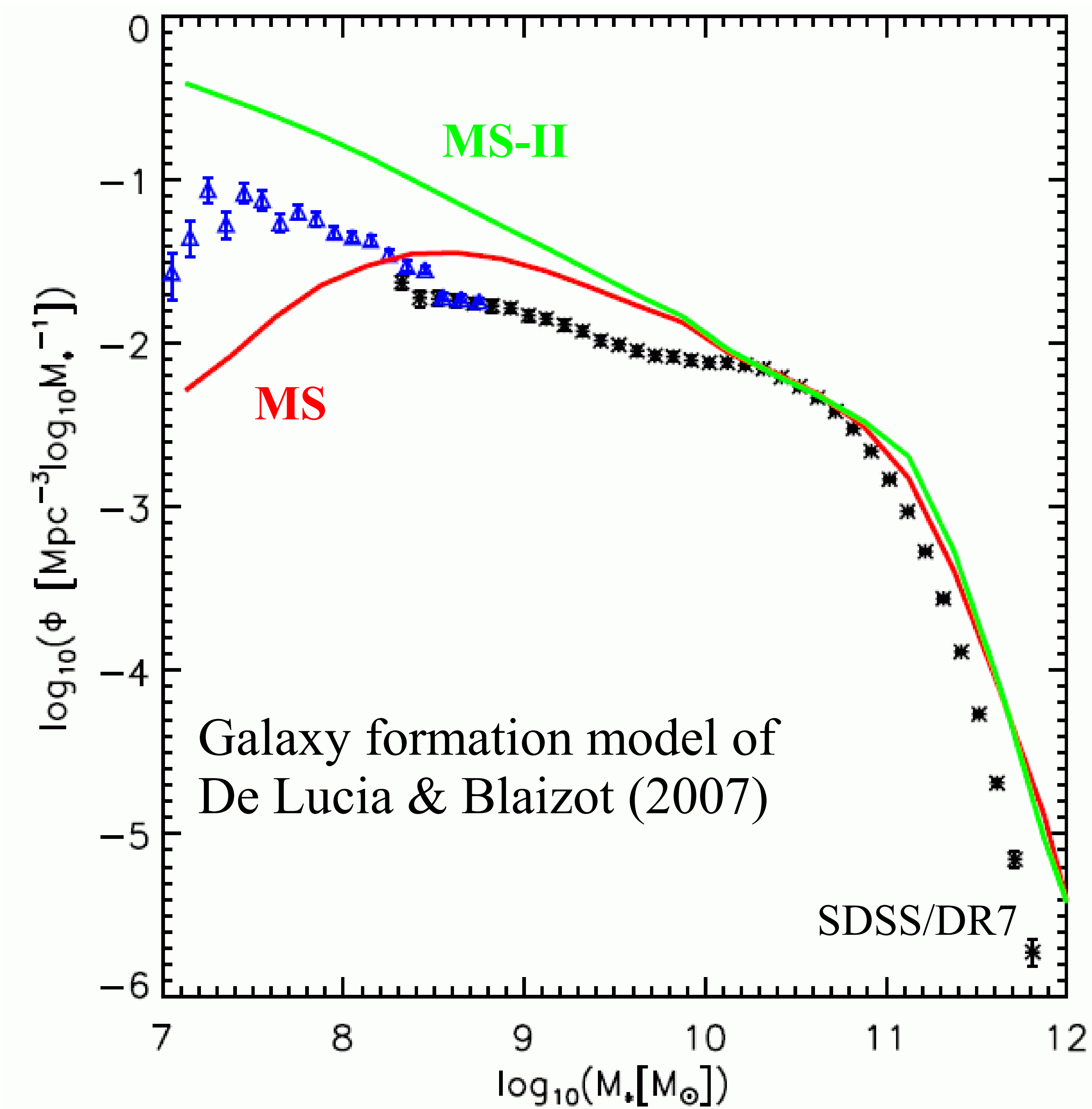
Same cosmology

Same N

1/5 linear size

Same outputs/
post-processing

Resolution tests of MS results and extension to smaller scales



Galaxy formation modelling on the MS is affected by resolution for log $M_* < 9.5$

The current standard models do not fit recent "precision" data

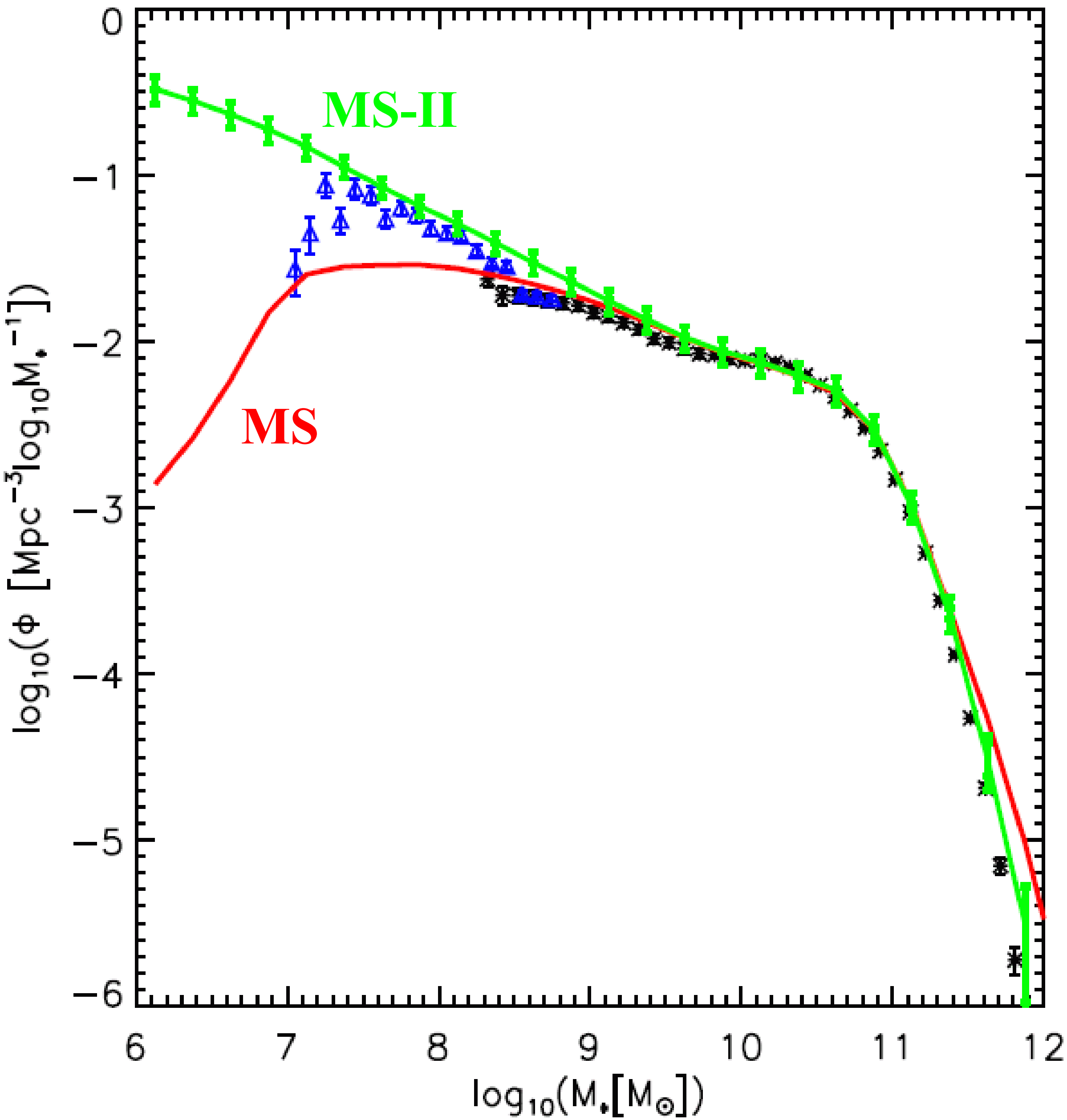
New galaxy formation models based on MS+MS-II

Qi Guo et al 2010

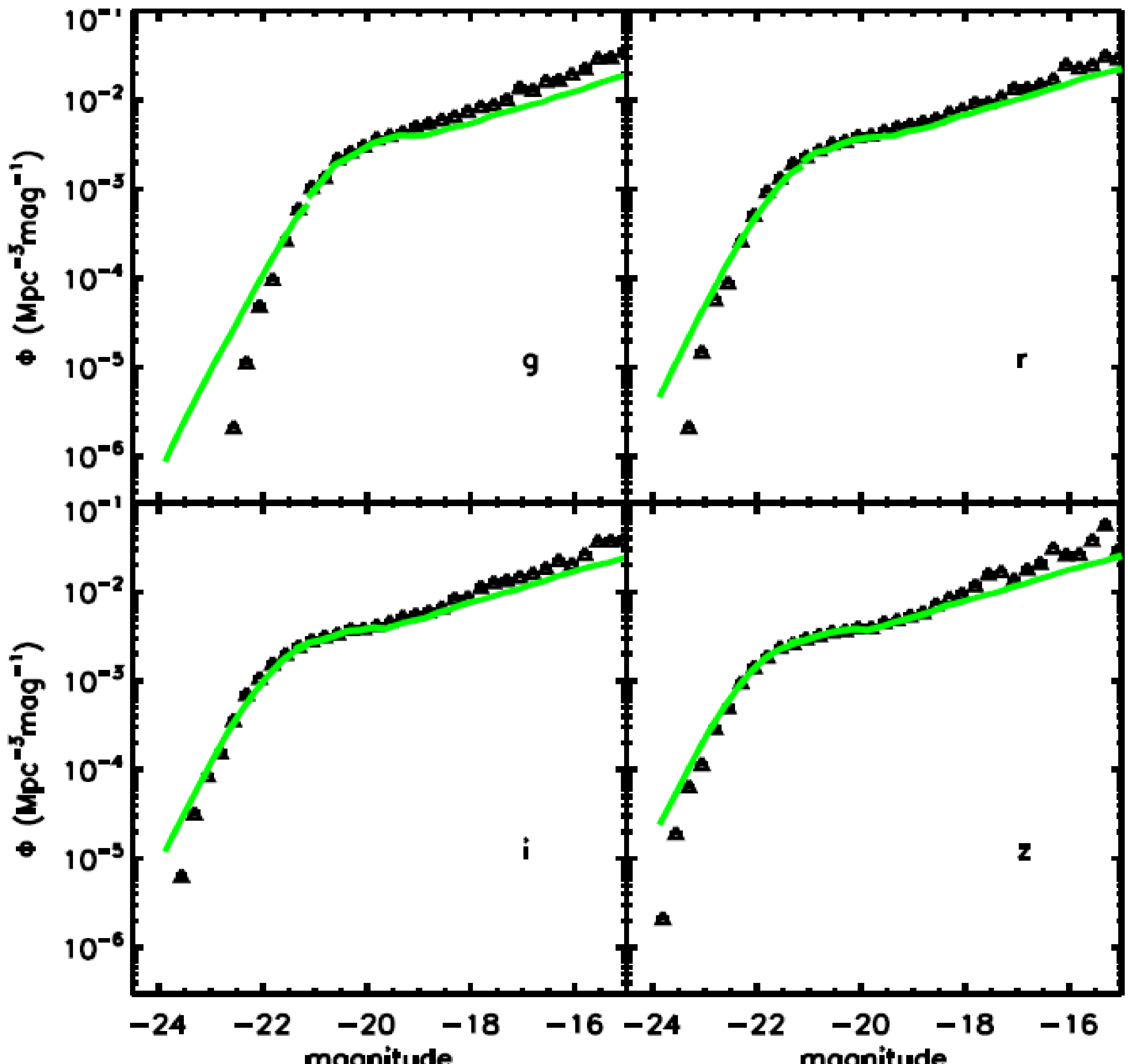
- Implement modelling simultaneously on MS and MS-II
- Test convergence of galaxy properties near resolution limit of MS
- Extend to properties of dwarf galaxies
- Improve/extend treatments of “troublesome” astrophysics
- Adjust parameters to fit new, more precise data
- Test against clustering and redshift evolution

Things that work well

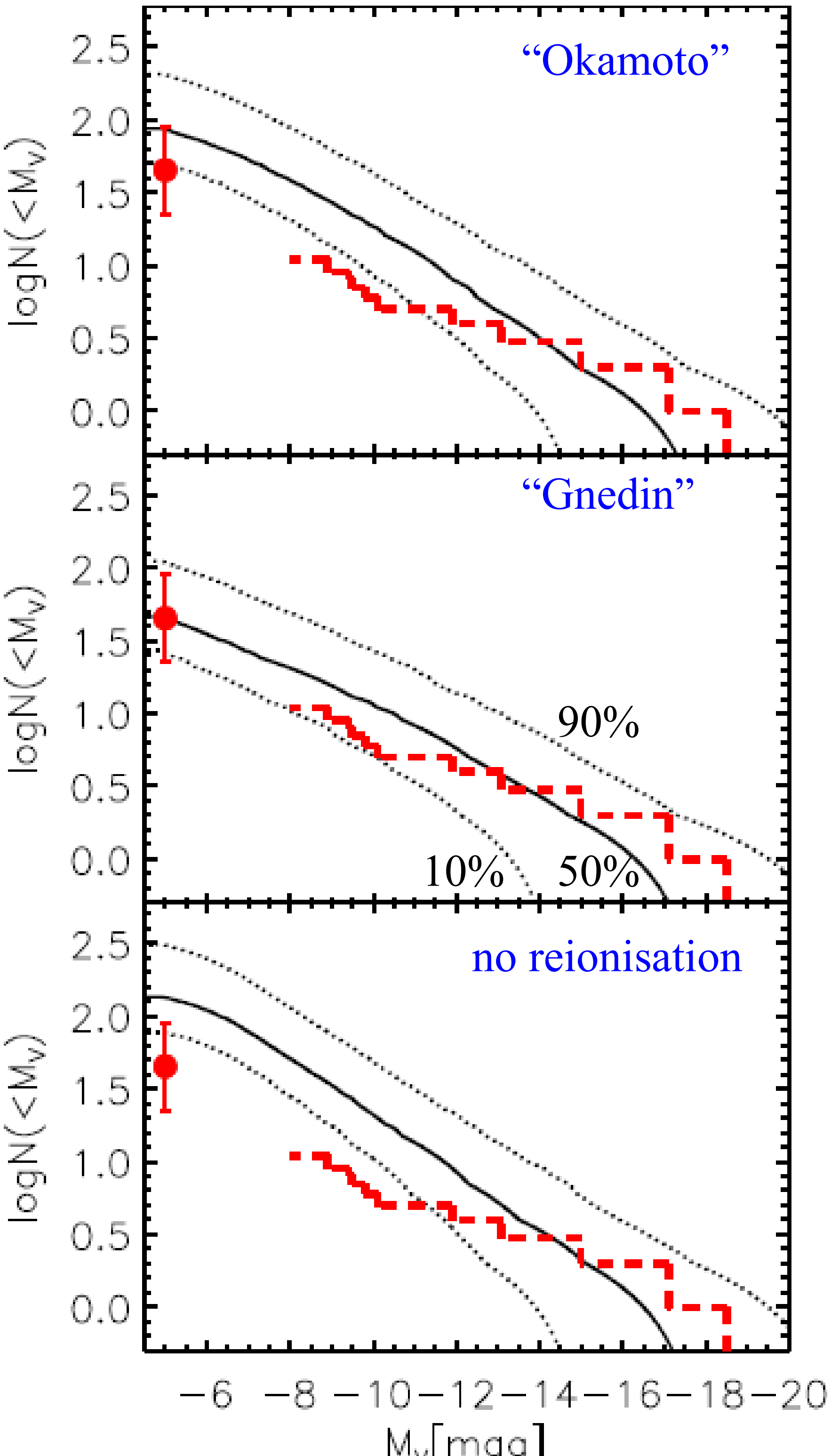
The stellar mass function of galaxies



Luminosity functions of galaxies

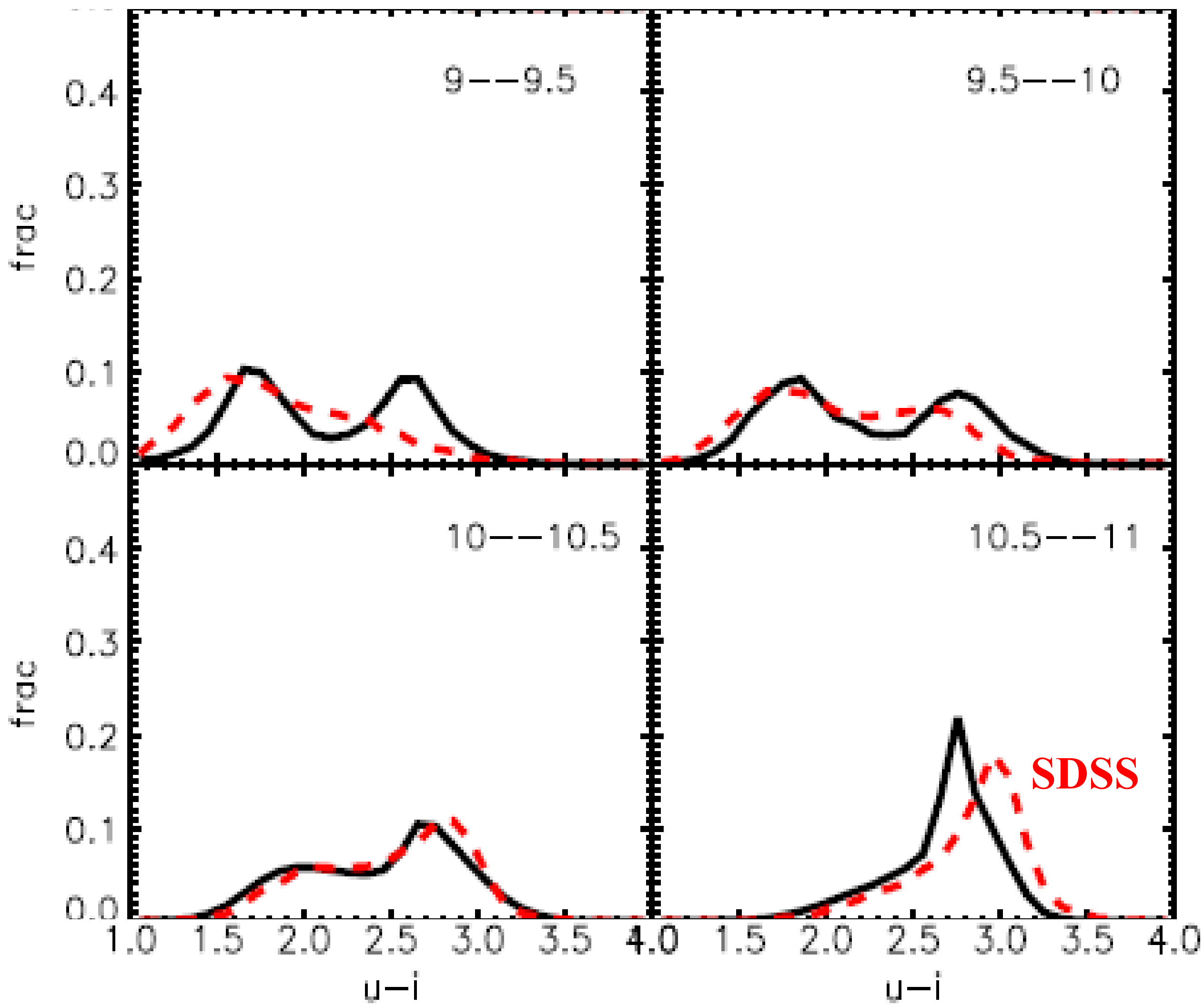


Luminosity function of Milky Way satellites

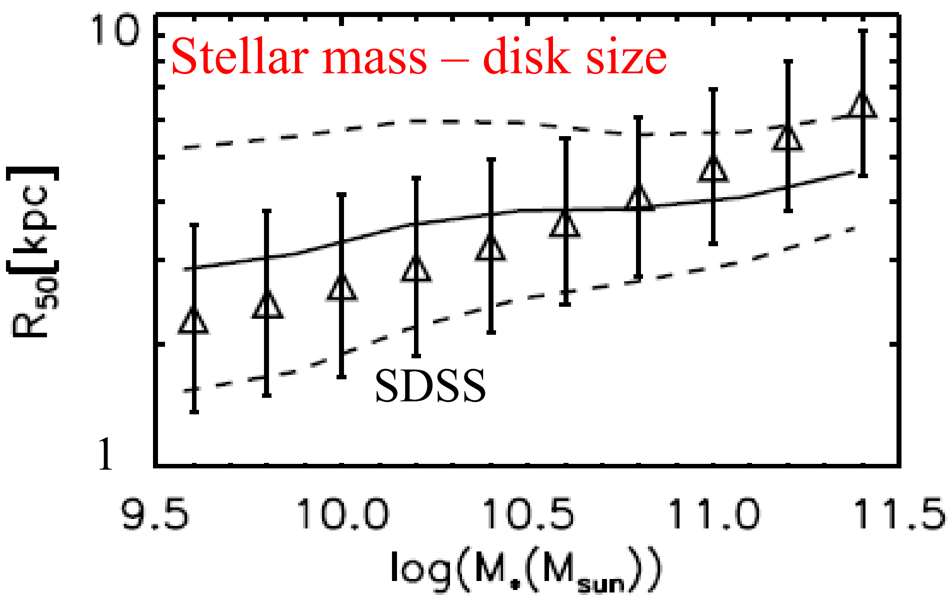


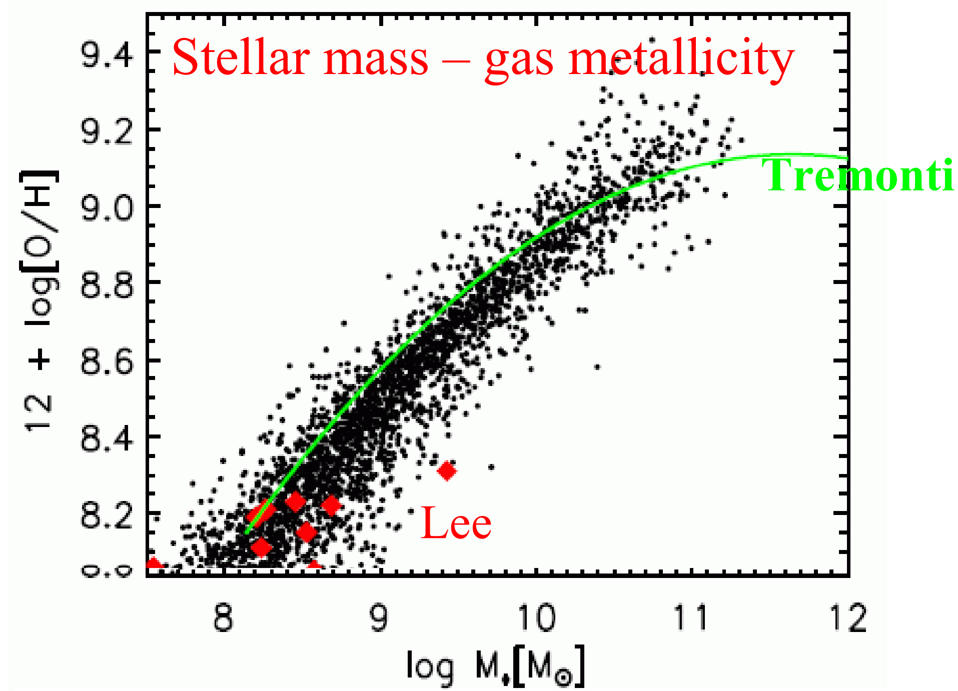
Luminosity functions of satellites around 1500 "Milky Ways" i.e. isolated disk galaxies with log $M_* = 10.8$

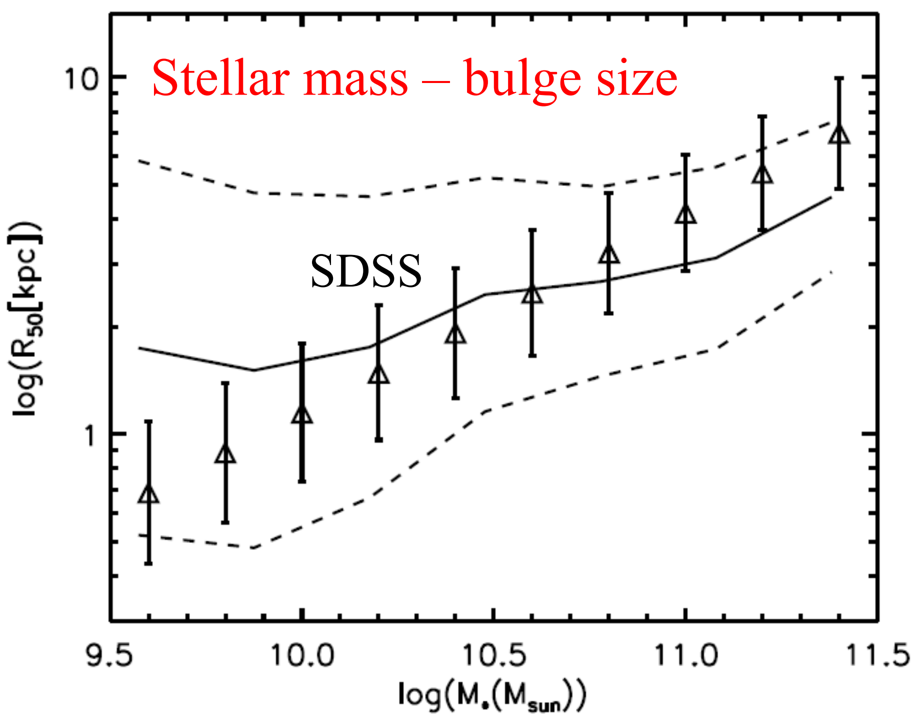
Galaxy colour distributions

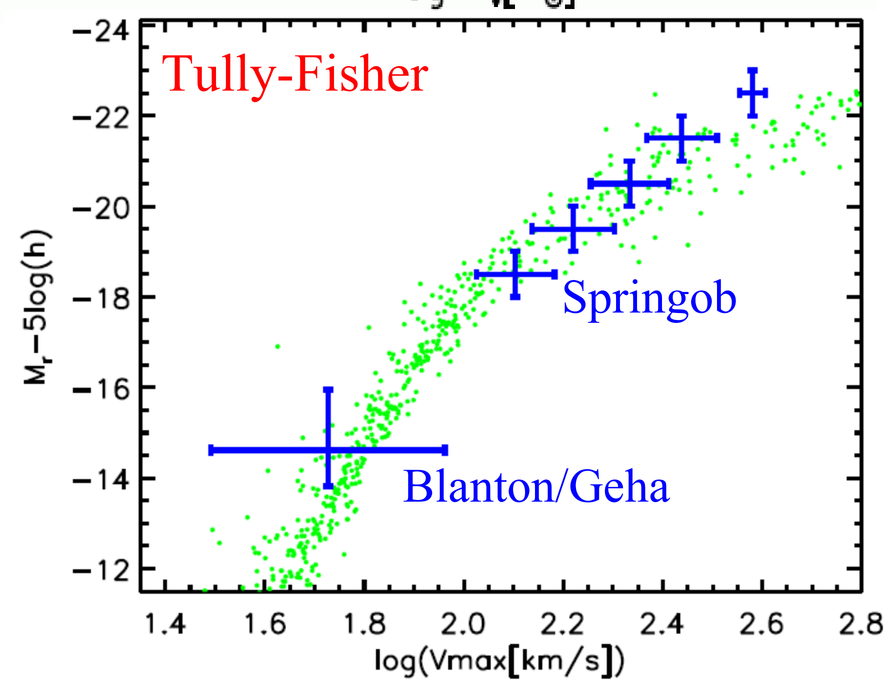


Scaling relations

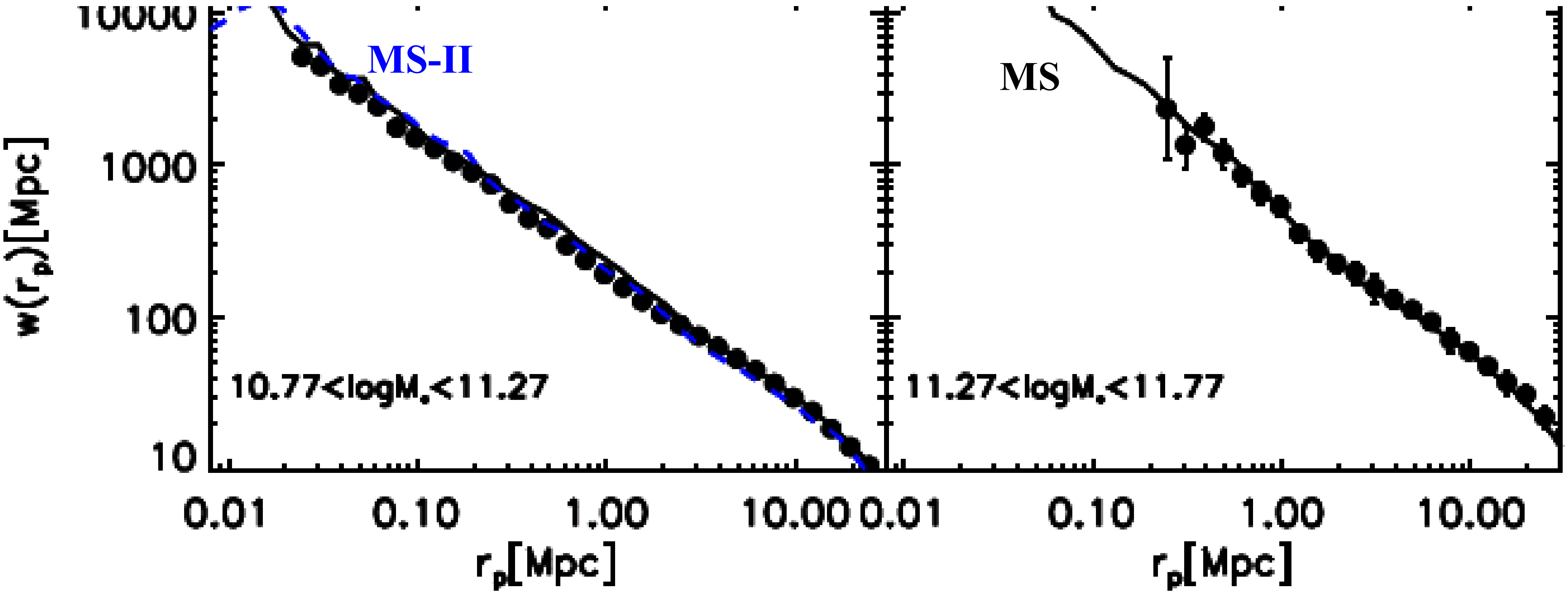






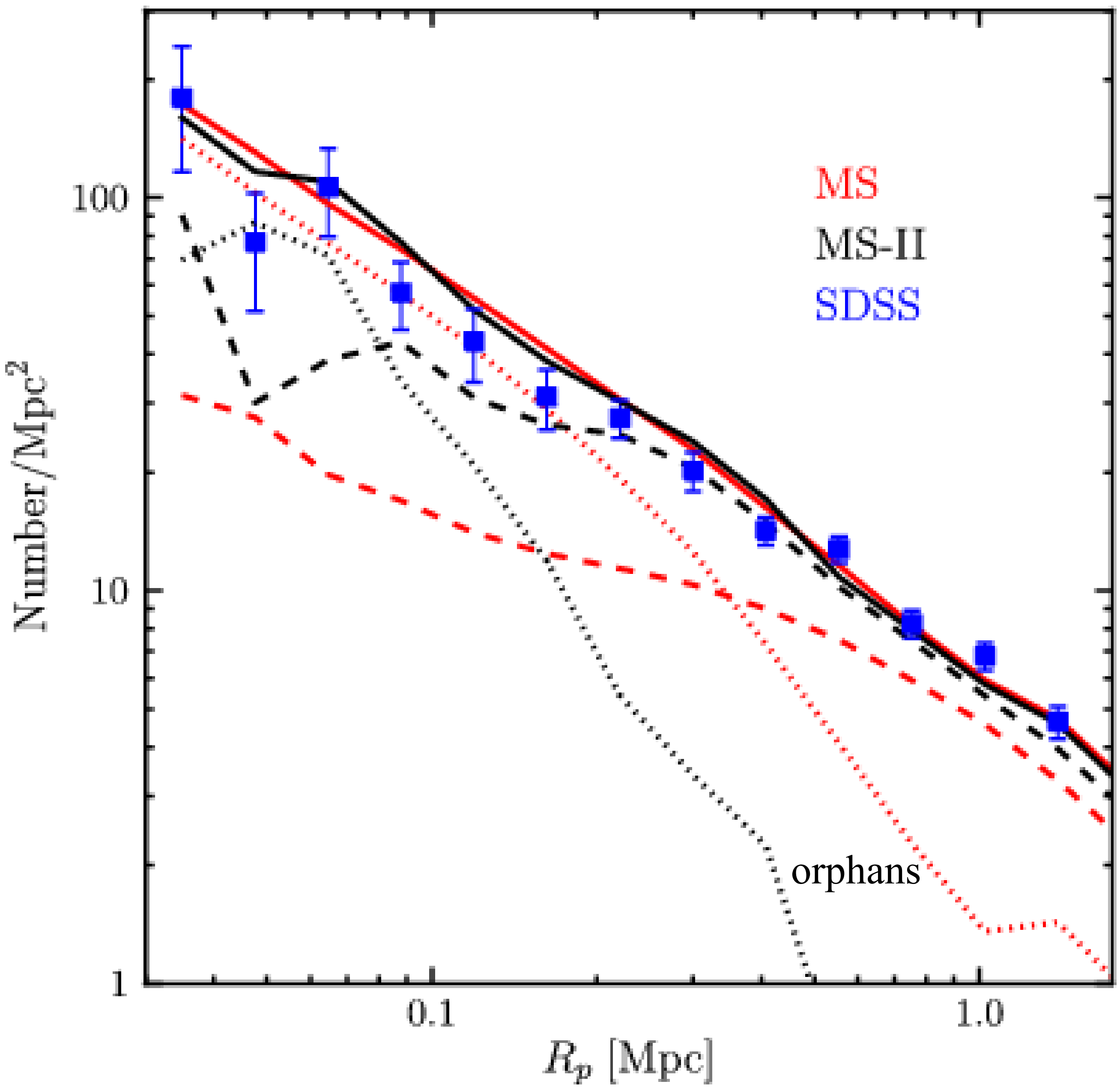


Clustering of massive galaxies



Data from SDSS/DR7

Projected galaxy number density profiles of clusters



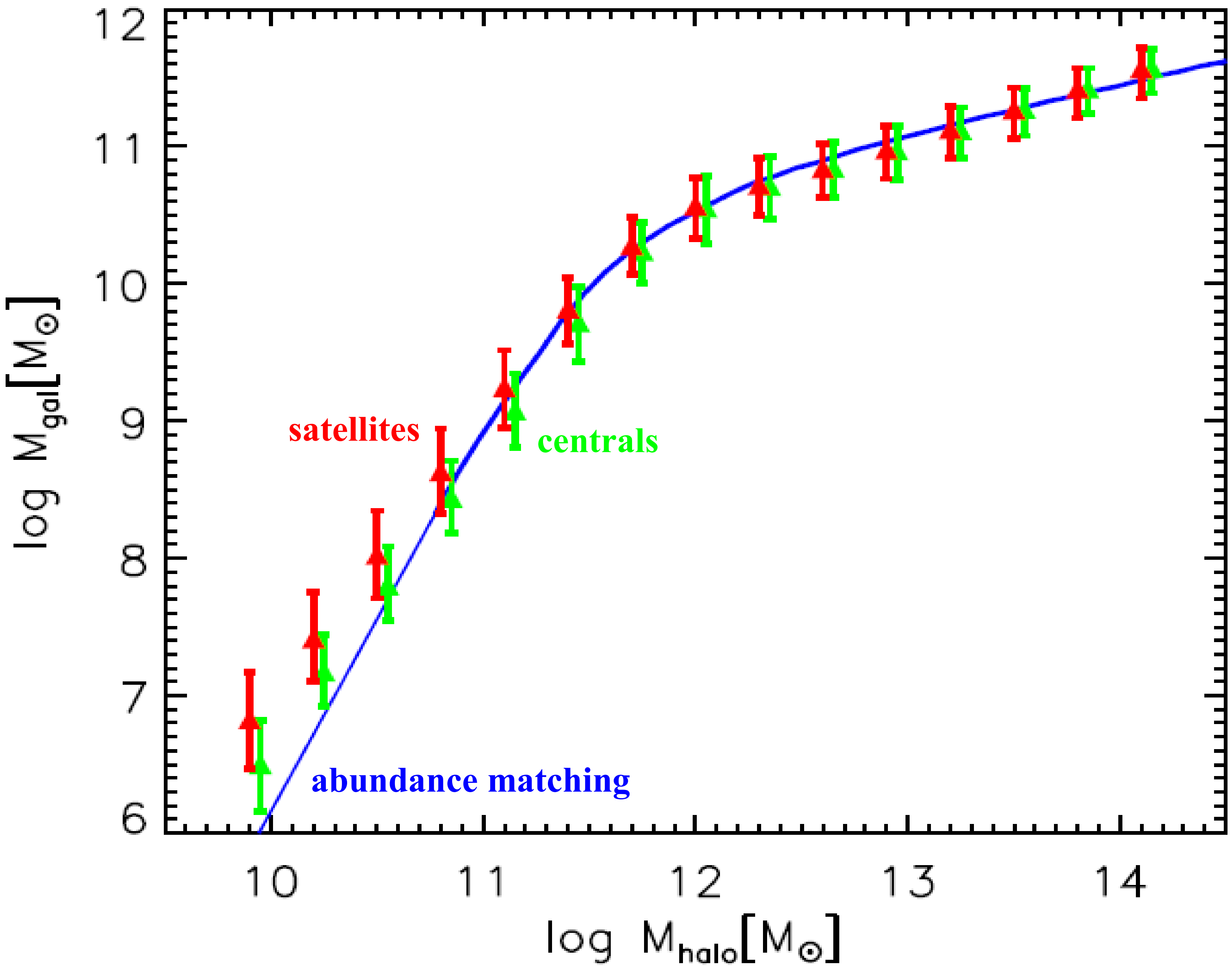
log $M_{gal} > 10.0$

$14.0 < \log M_{clus} < 14.3$

Note: good agreement of MS with MS-II is *only* when orphans are included

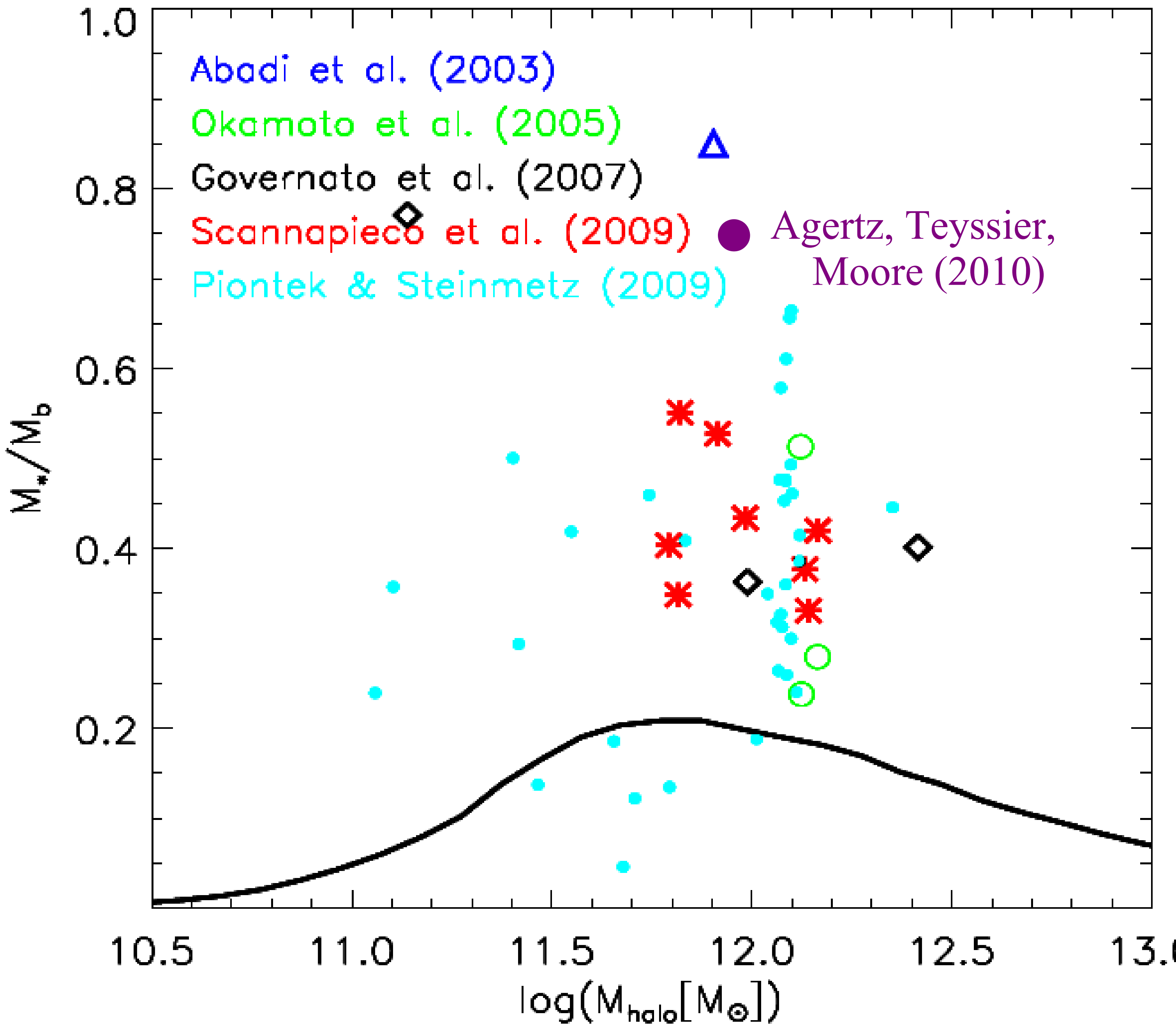
Orphan treatment is physically consistent and needed to fit SDSS

Galaxy stellar mass versus maximum past halo mass



“Successful” simulations fail to match this

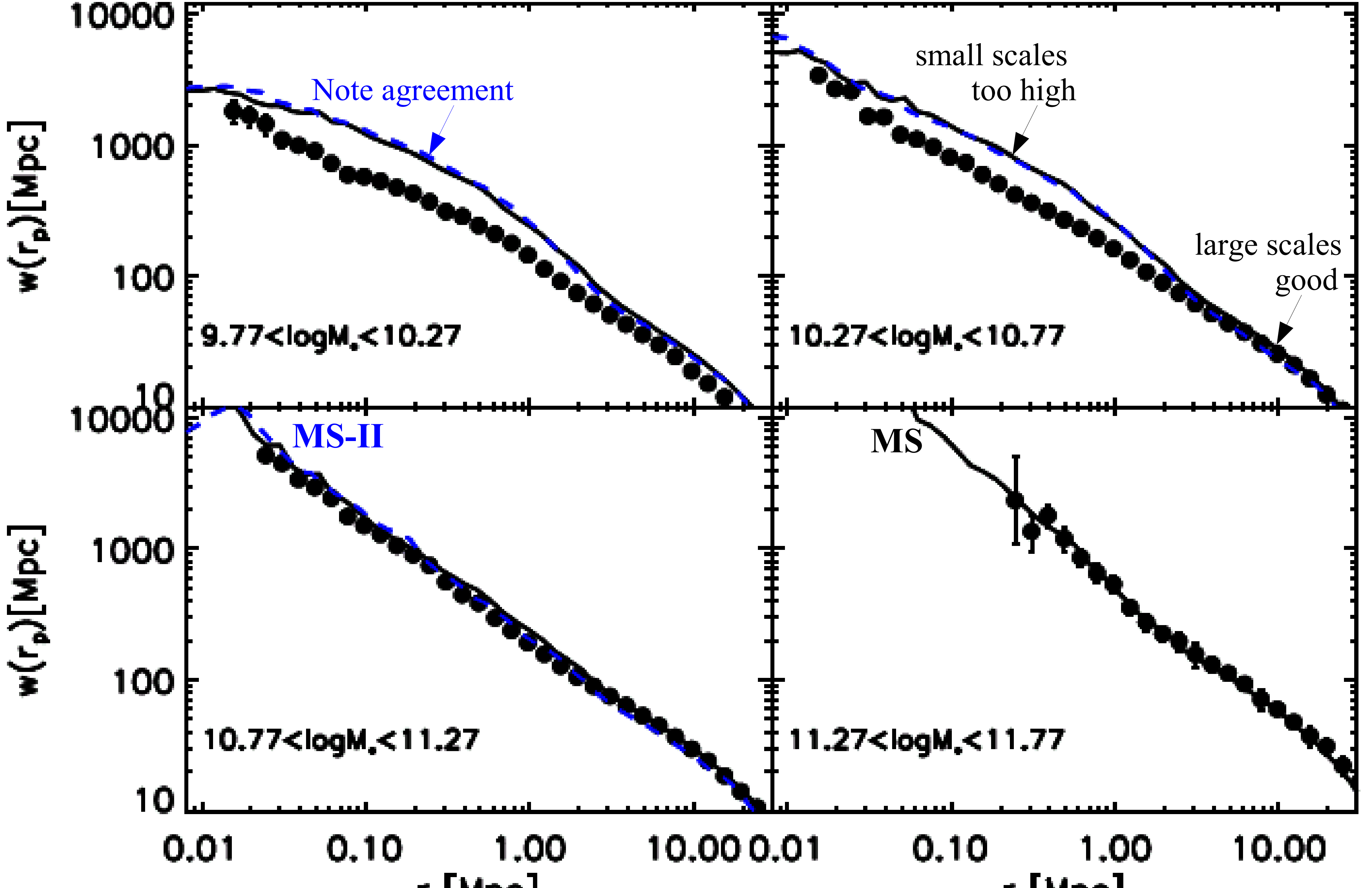
Guo et al 2010



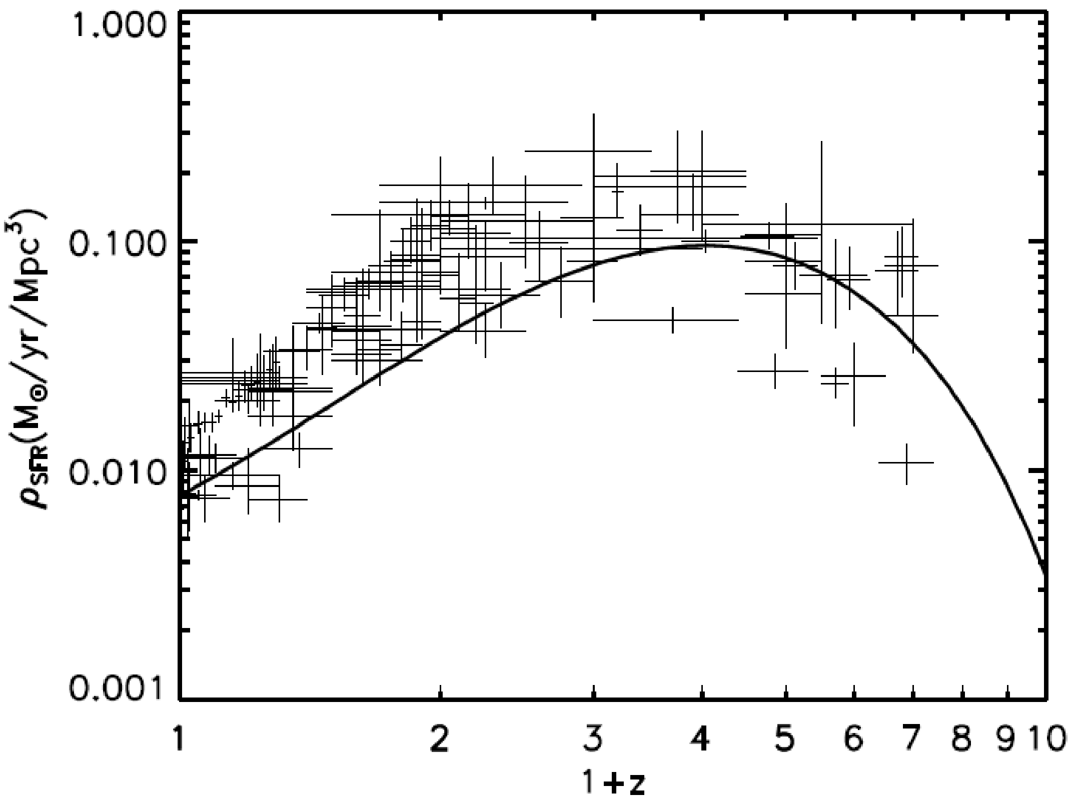
Things that work less well

Clustering of less massive galaxies

--- $\sigma_8 = 0.9$ is too high ---

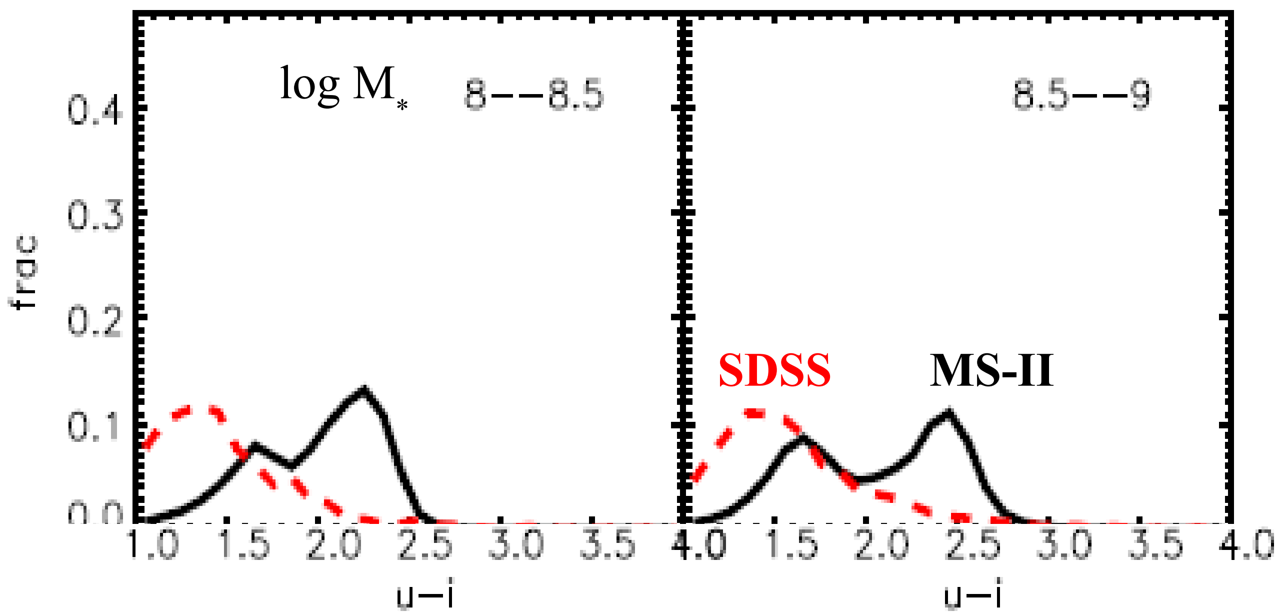


The cosmic star formation density history



--- observed SFR are inconsistent with observed stellar masses ---
--- star formation peaks too early in the model ---

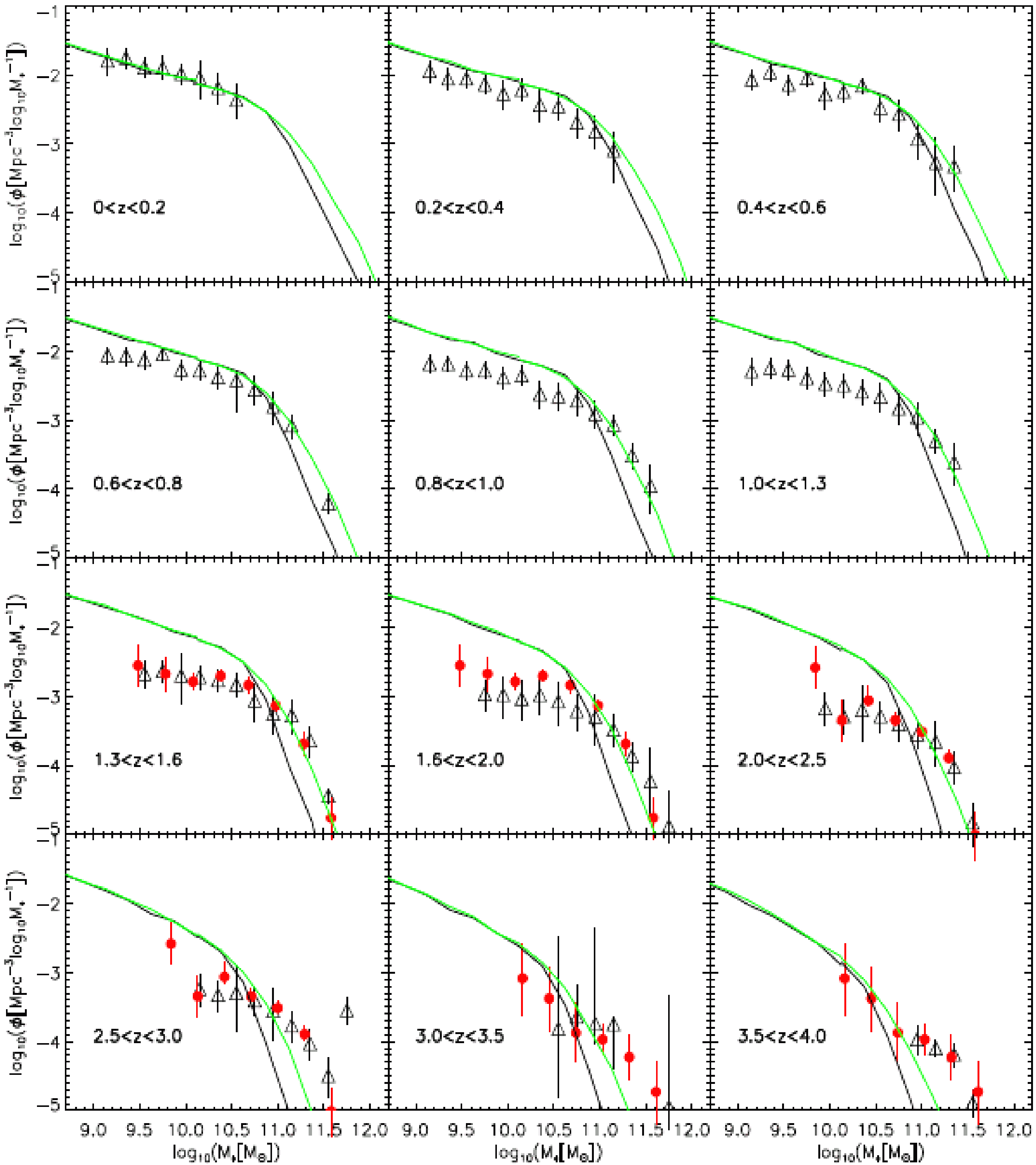
Colours of dwarf galaxies



Too many passive low mass galaxies in the MS-II

--- formation is too fast/too early ---

Evolution of stellar mass function



Lower mass galaxies
$\log M_* < 10.5$
form <u>too early</u>

Conclusions

"Precision" modelling of the formation and evolution of the galaxy population is now possible

Viable models should address abundances *and* scaling relations *and* clustering *and* evolution

The Millennium Simulation amplitude $\sigma_8 = 0.9$ is too high

In current models star formation occurs *too early* in low-mass systems

→ Need a better understanding of star formation and a lower fluctuation amplitude