Max-Planck-Institut
für Astrophysik

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Galaxy Formation in the Planck Cosmology I

Matching the observed evolution of star-formation rates, colours and stellar masses

Bruno Henriques, Simon White, Peter Thomas, Raul Angulo, Qi Guo, Gerard Lemson, Volker Springel, Roderik Overzier, MNRAS, 2014, submitted

Galaxy Formation in the Planck Cosmology II - AGN and environmental quenching; B. Henriques, S. White, P. Thomas, et al.; MNRAS; 2015; in prep

Galaxy Formation in the Planck Cosmology III - Star formation histories and post-processing magnitude reconstruction, S. Shamshiri, P. Thomas, B. Henriques, et al.; MNRAS; 2015; submitted

Galaxy Formation in the Planck Cosmology VI- The high-redshift Universe; S. Clay, P. Thomas, S. Wilkins, B. Henriques; MNRAS; 2015; submitted

Millennium Simulations

gavo.mpa-garching.mpg.de/MyMillennium/

Apps | jornais | movies list | TV TUGA | series/movies | papers | Mp3 | Keep!

Virgo - Millennium Database

Documentation

CREDITS/Acknowledgments

Registration

News

FAQ

Public Databases

- DGalaxies
- DHaloTrees
- Guo2010a
- Guo2013a
- Henriques2012a
- Henriques2014a
  - Tables
    - cones.MRscPlanck1_BC03_0ij
    - cones.MRscPlanck1_M05_0ij
    - MRIIscPlanck1
    - MRscPlanck1
- MField
- MillenniumII
- millimil
- miniMilII
- MMSnapshots
- MPAGalaxies
- MPAHaloTrees
- MPAMocks
- Snapshots

Private (MyDB) Databases

Welcome Bruno Henriques.
Streaming queries return unlimited number of rows in CSV format and are cancelled after 420 seconds.
Browser queries return maximum of 1000 rows in HTML format and are cancelled after 30 seconds.
For long duration batch queries, or file uploads into your MyDB, use the MyMillenniumTAP service in the Galformod Dashboa

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galformod.mpa-garching.mpg.de/public/henriques2014a/

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Galformod project

Henriques2014a: Model

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These webpages contain documentation for the Henriques 2014 release of the Munich model of galaxy formation. This scales the Millennium and Millennium-II simulations to the cosmology of the first PLANCK data release. MCMC methods were used to explore the full high-dimensional parameter space of the galaxy formation model in order to identify regions which could reproduce observed abundances and quenched fractions as a function of stellar mass from z=3 down to z=0. More than 4 million CPU hours were used and over 20 million models of galaxy formation in a region representative of the entire Universe evaluated.

Matching these calibrating datasets required the treatment of several astrophysical processes to be changed with respect to earlier models. Low-mass galaxies now form later than massive systems and almost all of them continue to form stars actively at z=0. Catalogues released for this model include snapshots of the (sub)halo and galaxy populations with extended photometric coverage and star formation and metallicity histories, as well as lightcones with photometry based on two different stellar population synthesis models.

MNRAS article: Henriques et al. 2014a

Download links for theoretical properties (SMFs, red fractions, color histograms, SSFR histograms, age histograms, etc) and combined observational data plotted in the paper: figures & data.
Description of the physics included in the model: description.

Millennium Database with full catalogs available for download: Millennium Database.
Henriques2014 database description: Henriques2014 table.

Millennium

Volume = 500 $h^{-1}Mpc^3$

MillenniumII

Volume = 100 $h^{-1}Mpc^3$

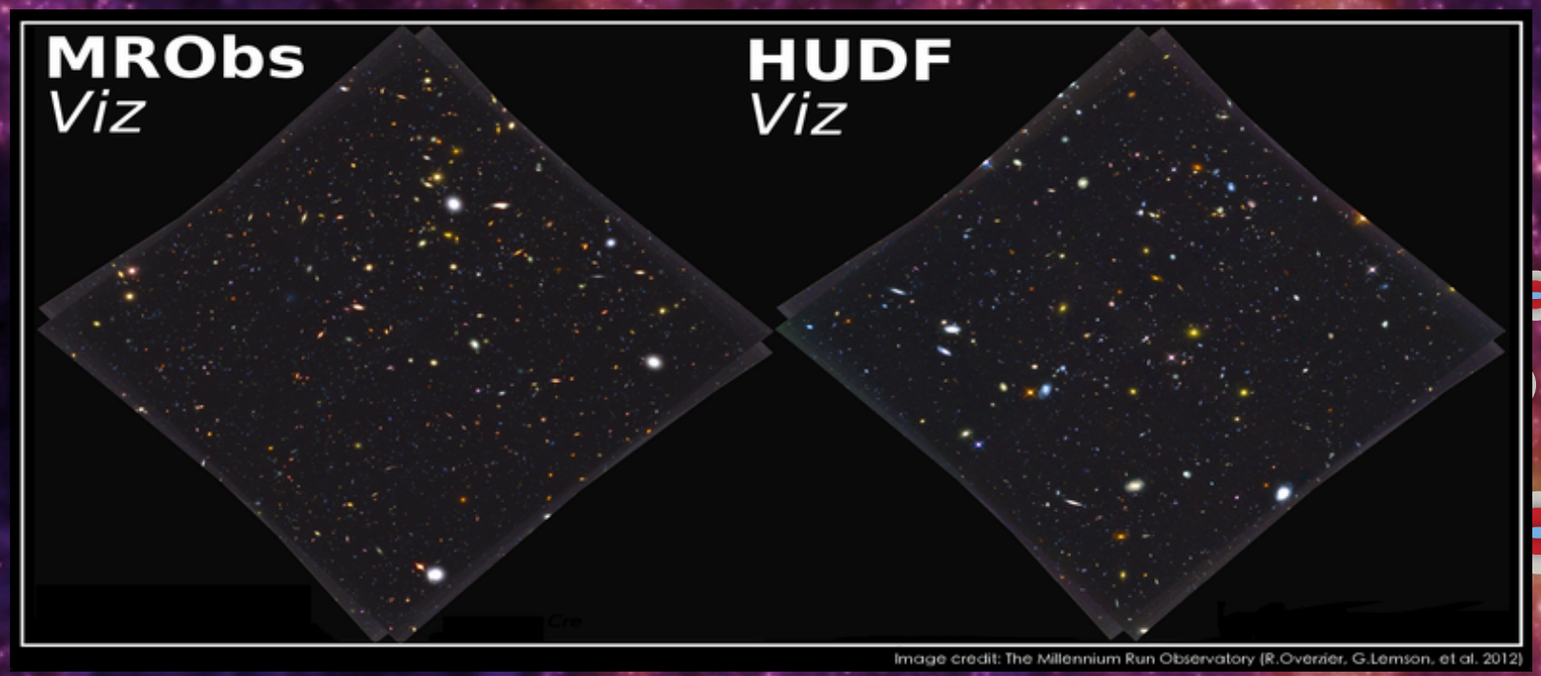
Springel et al. 2005

Boylan-Kolchin et al. 2009

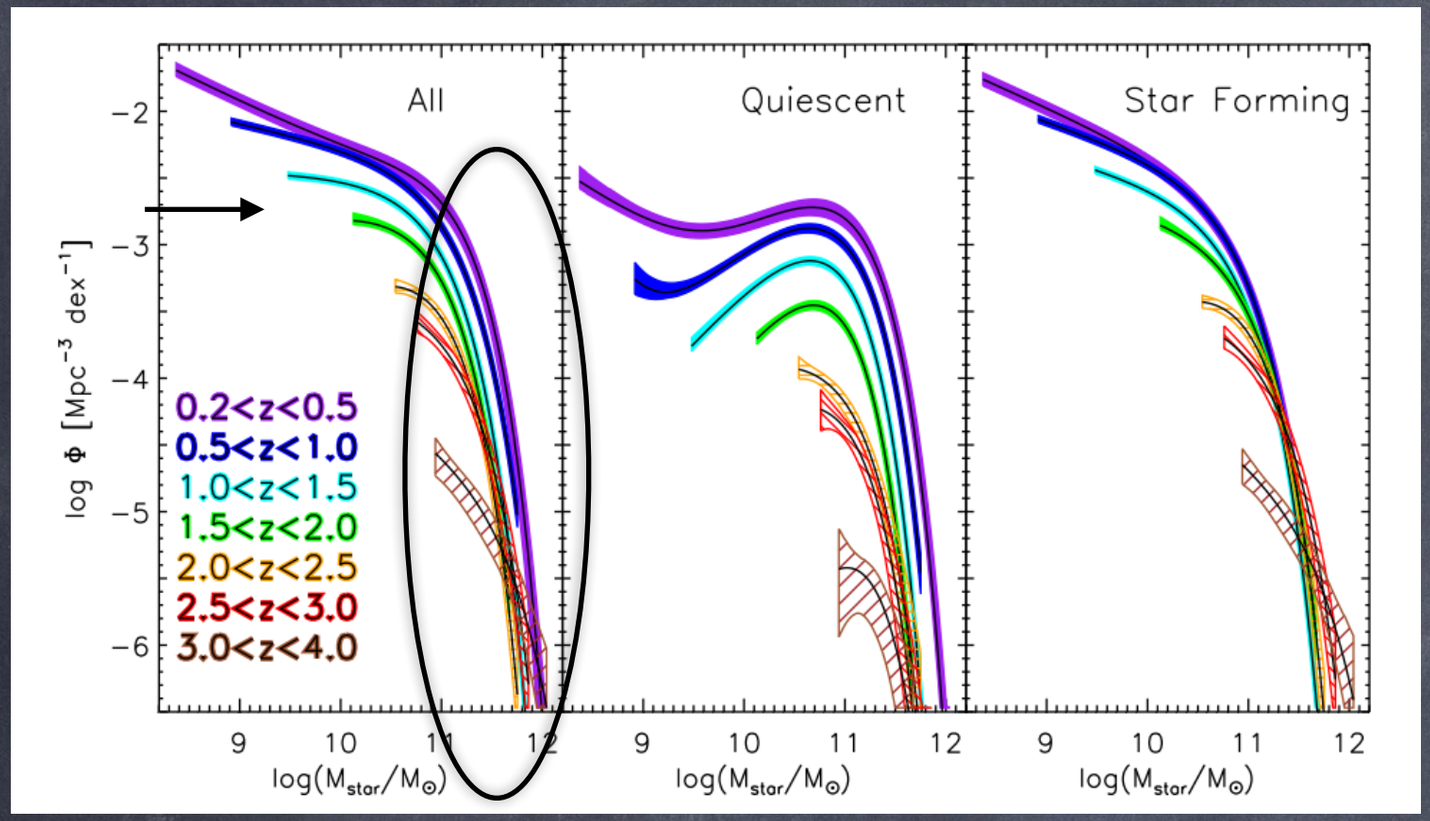
31.25 Mpc/h

R_{200}

f_b of baryons



Mass assembly and Age Downsizing

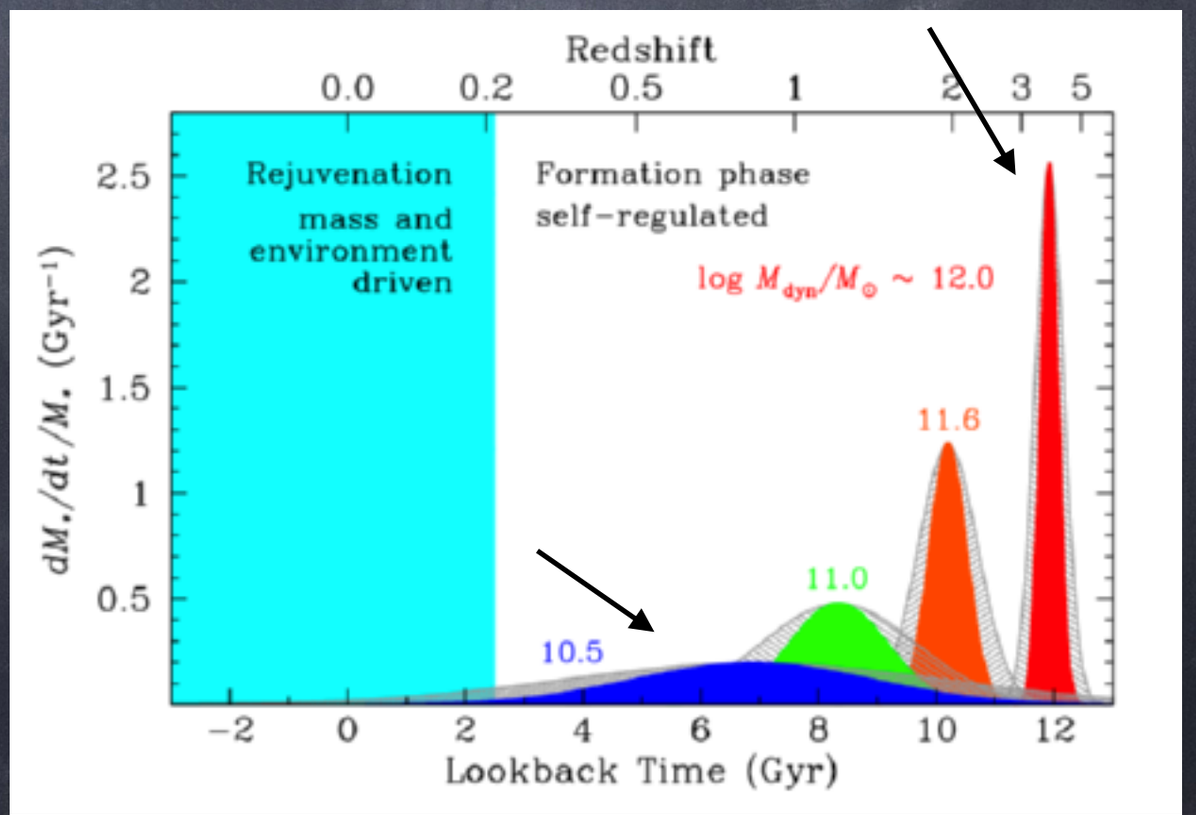


Muzzin et al. 2013 / Ilbert et al. 2013

massive galaxies form most of their stars at early times while low mass galaxies retain star formation until z=0

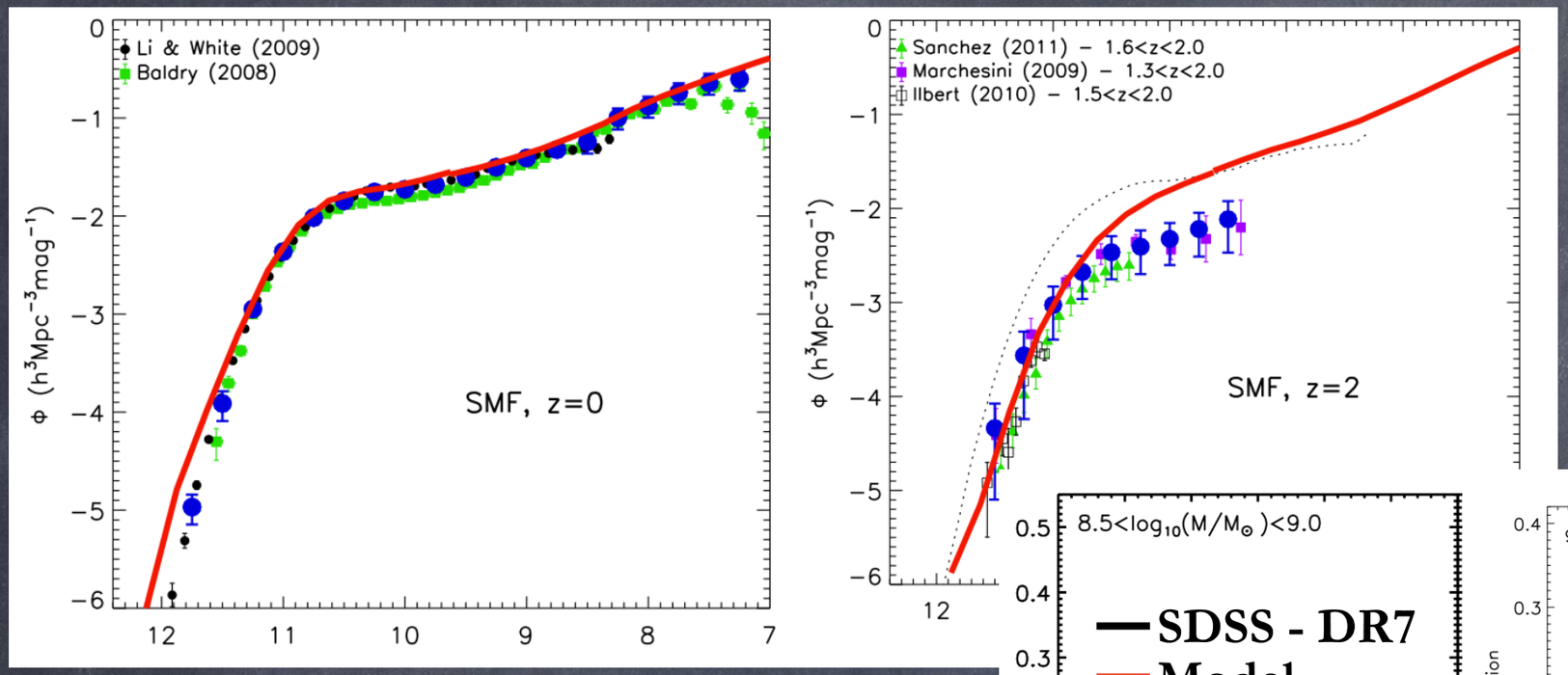
massive galaxies assemble most of their mass at early times

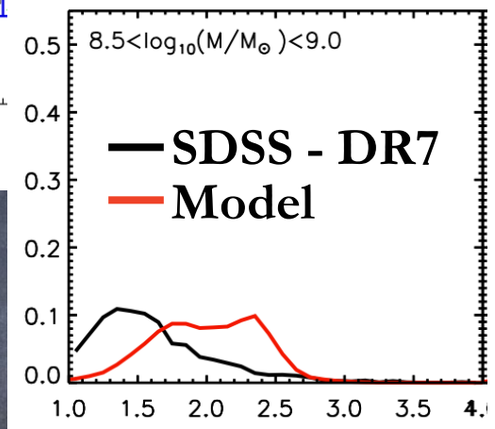
Thomas et al. 2005

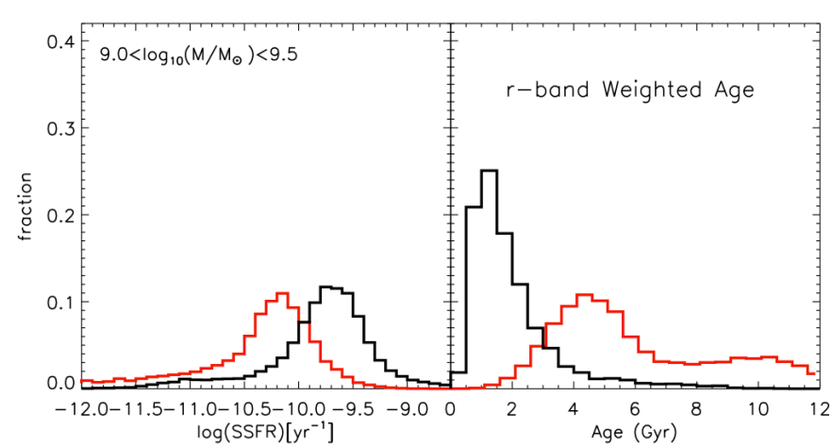


Guo2010/2013 model

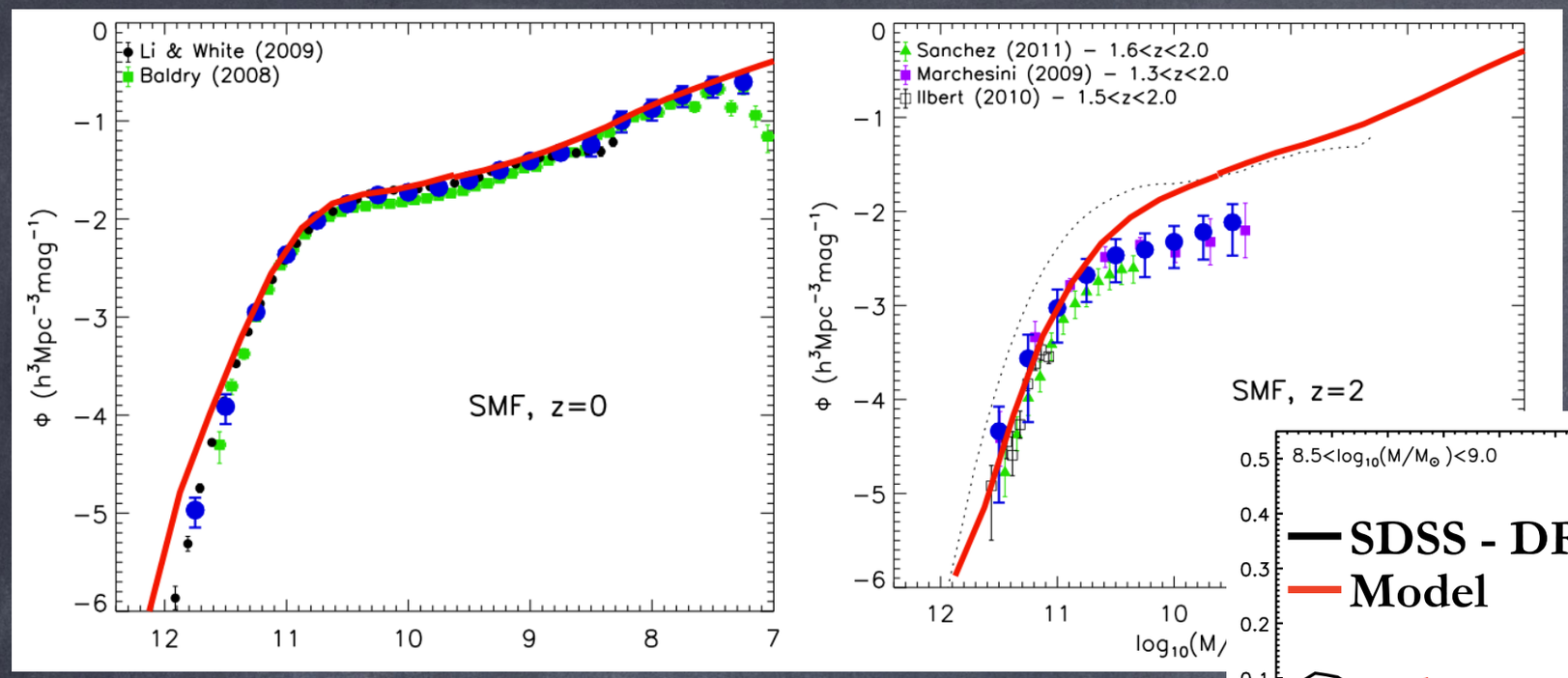
Excessive number of low mass galaxies forming at high-z

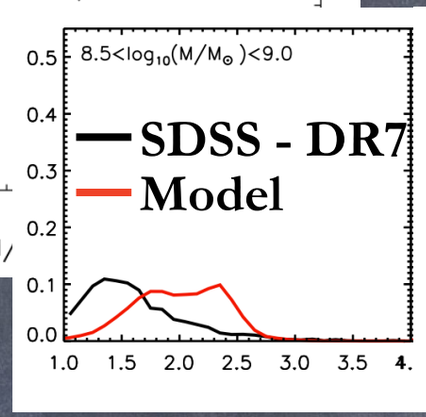


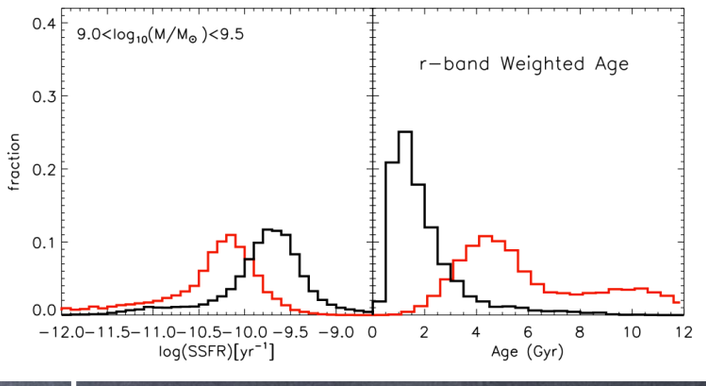




Excessive number of low mass galaxies forming at high-z







models fail to match observations because the parameters were not properly adjusted?

models fail to match observations because physics are wrong?

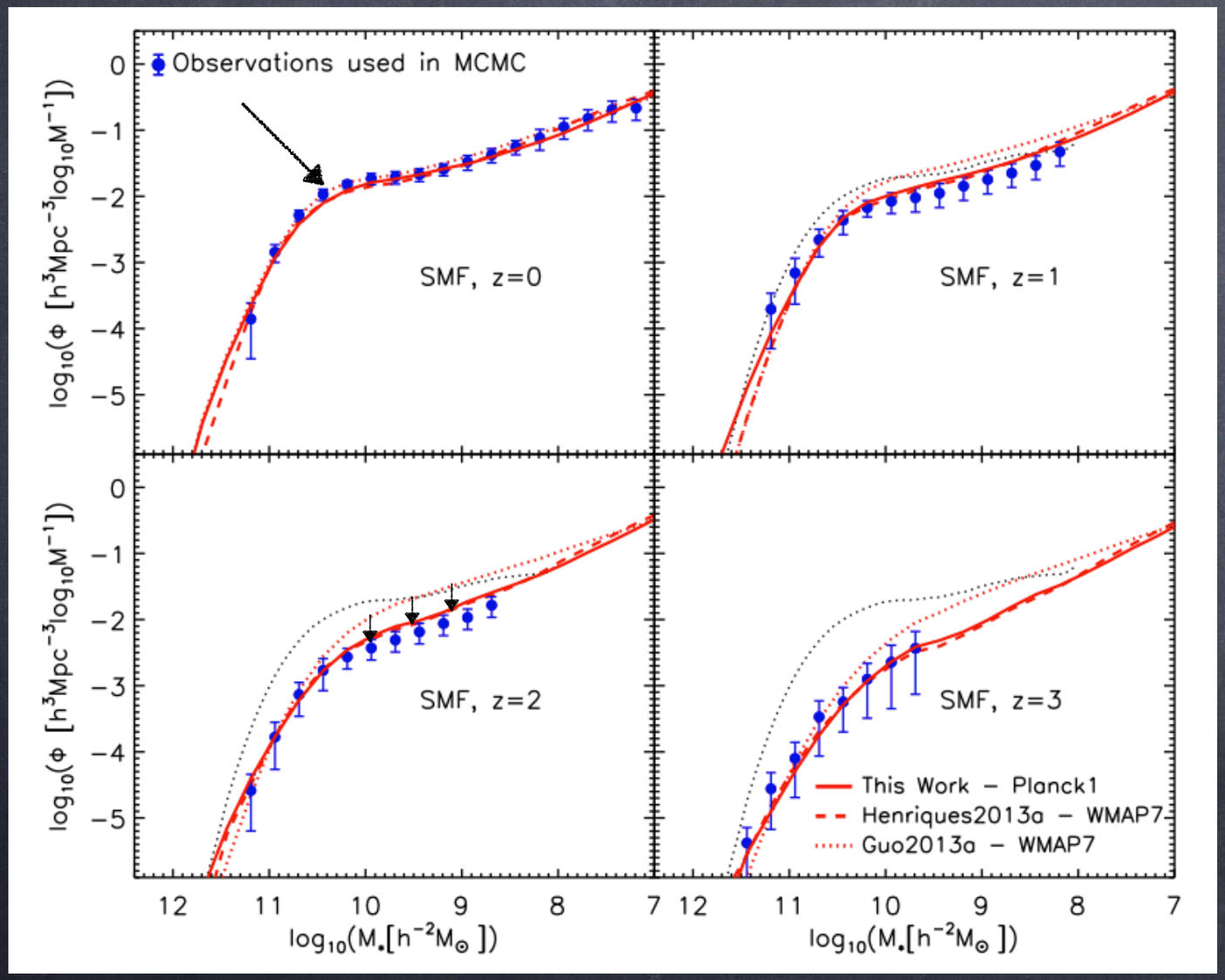
Full sampling of the parameter space (e.g. MCMC)

Henriques, Thomas et al. (2009), Henriques & Thomas (2010), Henriques et al. (2013), Henriques et al. (2014)

1 - Changes in the SN feedback

1 - longer reincorporation time-scales for gas ejected by SN in low mass galaxies

lower number density at early times, stronger build up at later times



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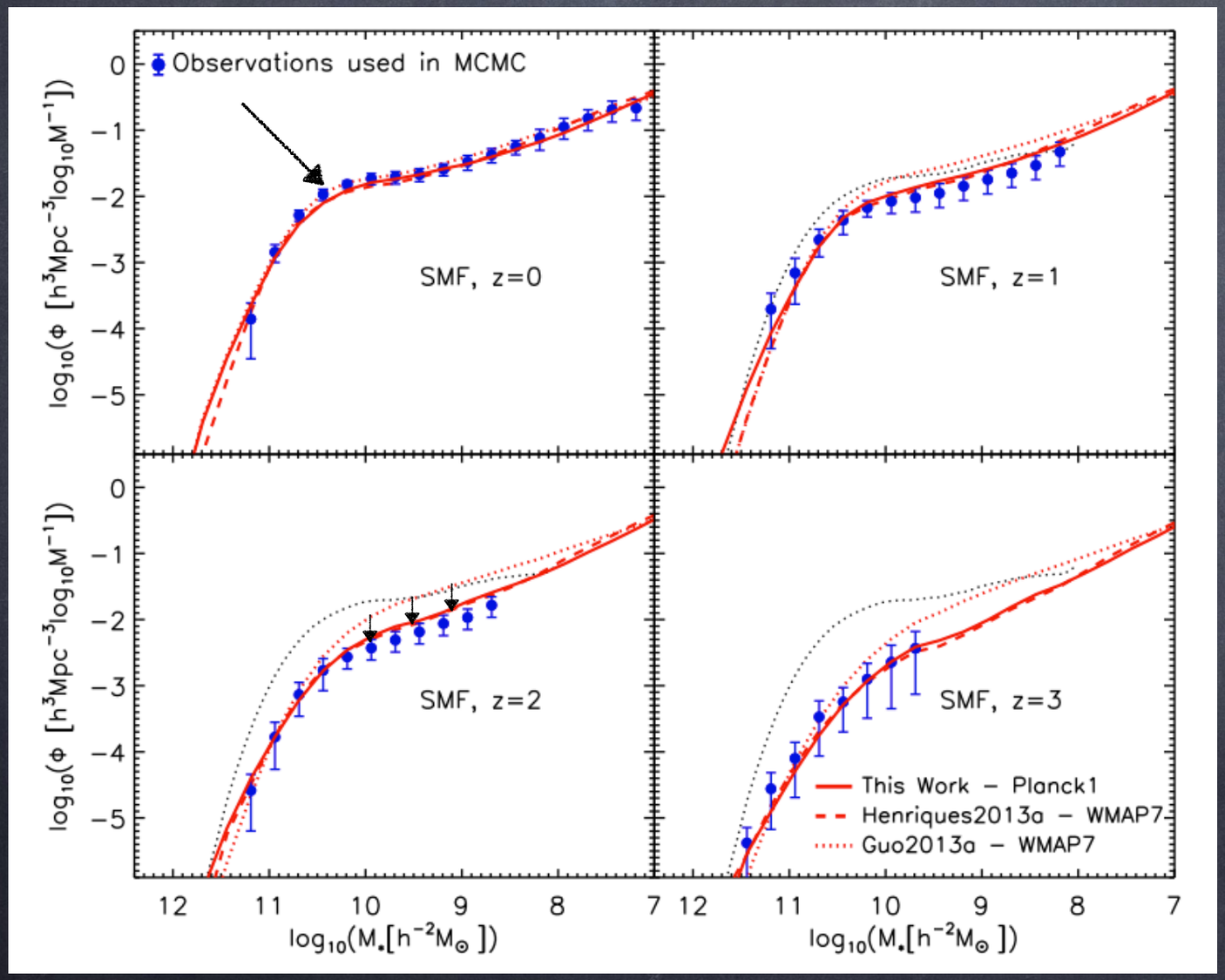


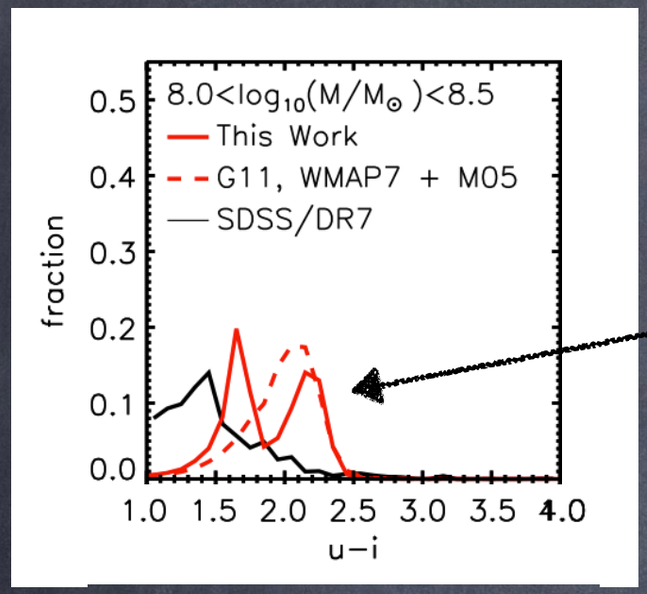
$$t_{\rm reinc} = -\gamma' \frac{10^{10}\,{\rm M}_\odot}{M_{\rm vir}},$$

Henriques et al. 2013

scaling in agreement with Oppenheimer & Dave 2008

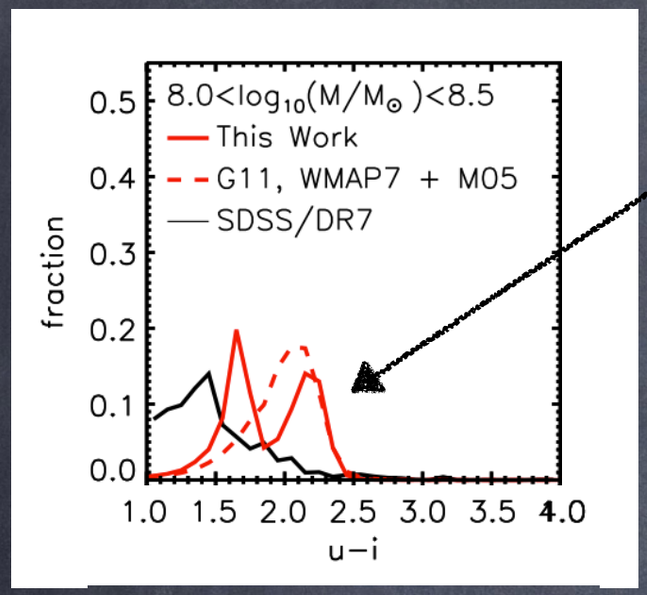
hydro should correctly follow the gas flows

2 & 3 - Changes in the SF threshold and in the ram-pressure stripping



despite the later build up a population of low mass red satellites remained at z=0

2 & 3 - Changes in the SF threshold and in the ram-pressure stripping



despite the later build up a population of low mass red satellites remained at z=0

2 - lower the cold gas surface density threshold for star-formation

$$\dot{m}_\star = \alpha_{\rm SF} \frac{(m_{\rm cold} - m_{\rm crit})}{t_{\rm dyn,disk}},$$

3 - ram-pressure only in clusters ($M_{vir}>10^{14}$)

Galaxy Formation in the Planck Cosmology I;
Henriques, White, Thomas, et al.; 2014; MNRAS

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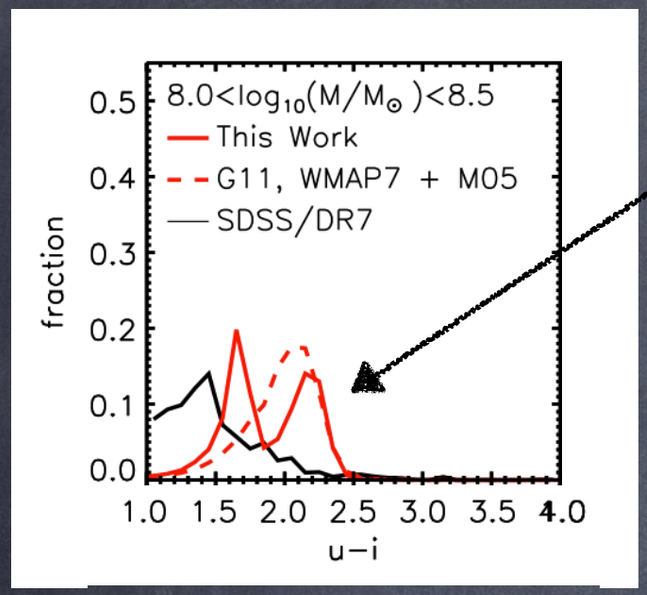

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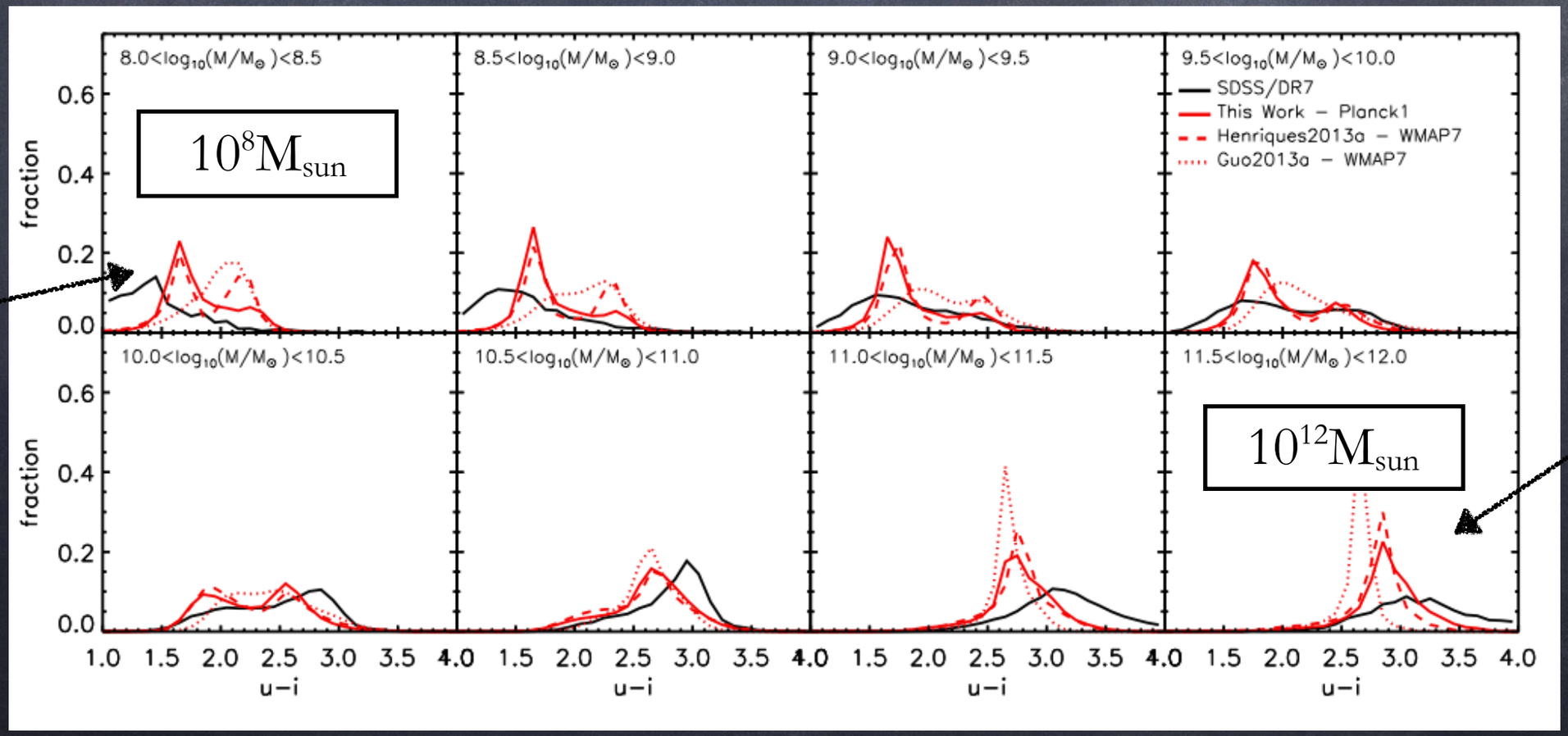
low mass galaxies are blue



massive galaxies are red

1 - longer reincorporation time-scales for gas ejected by SN in low mass galaxies

to ensure that low mass galaxies build up predominately at later times

1 - longer reincorporation time-scales for gas ejected by SN in low mass galaxies

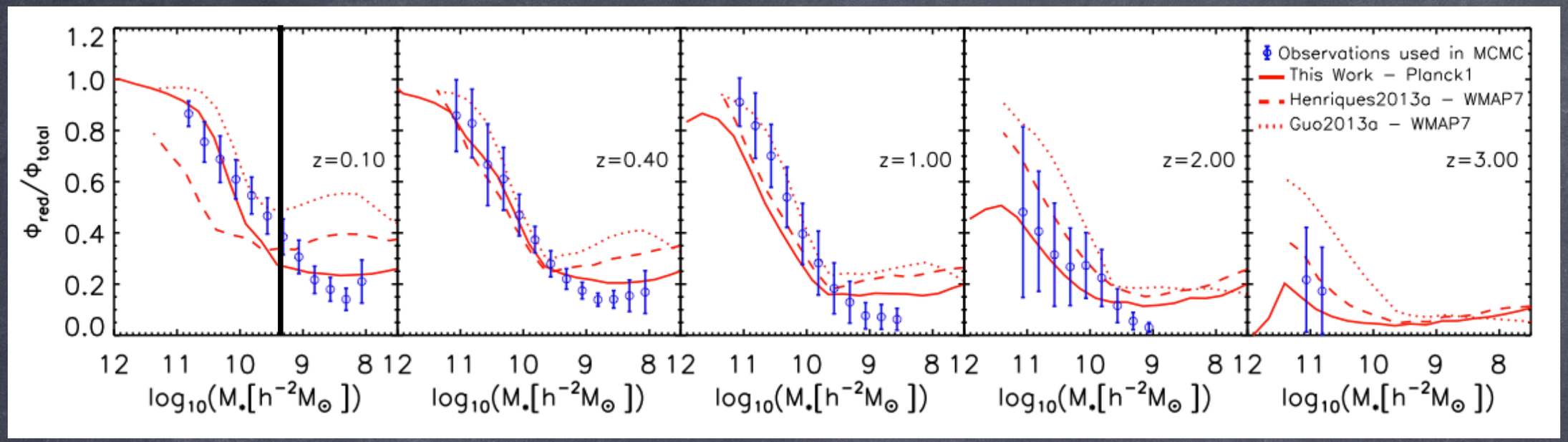
to ensure that low mass galaxies build up predominately at later times

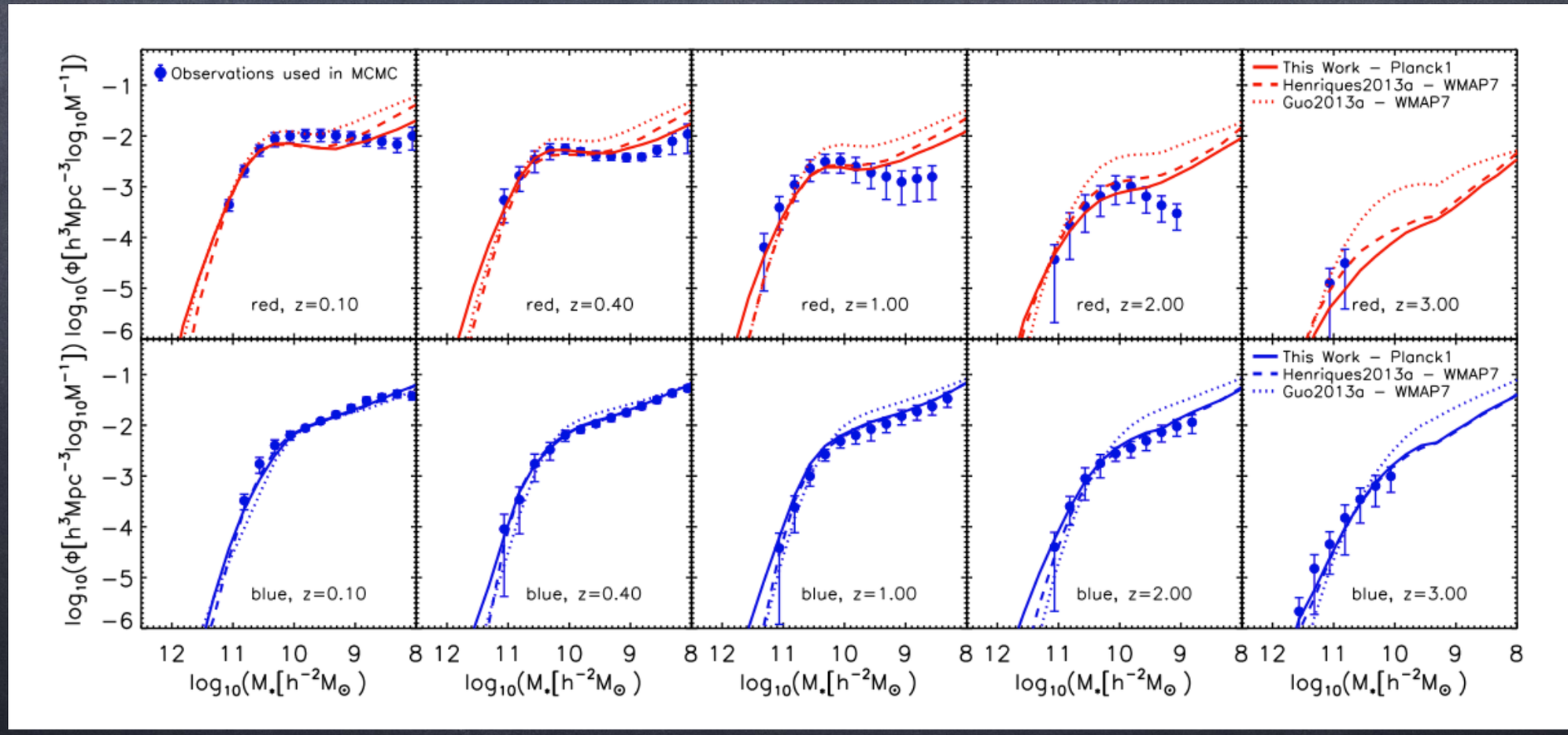
2 - lower the cold gas surface density threshold for star-formation

3 - ram-pressure only in clusters ($M_{vir}>10^{14}$)

to ensure that most low mass galaxies, even satellites, form stars until $z=0$

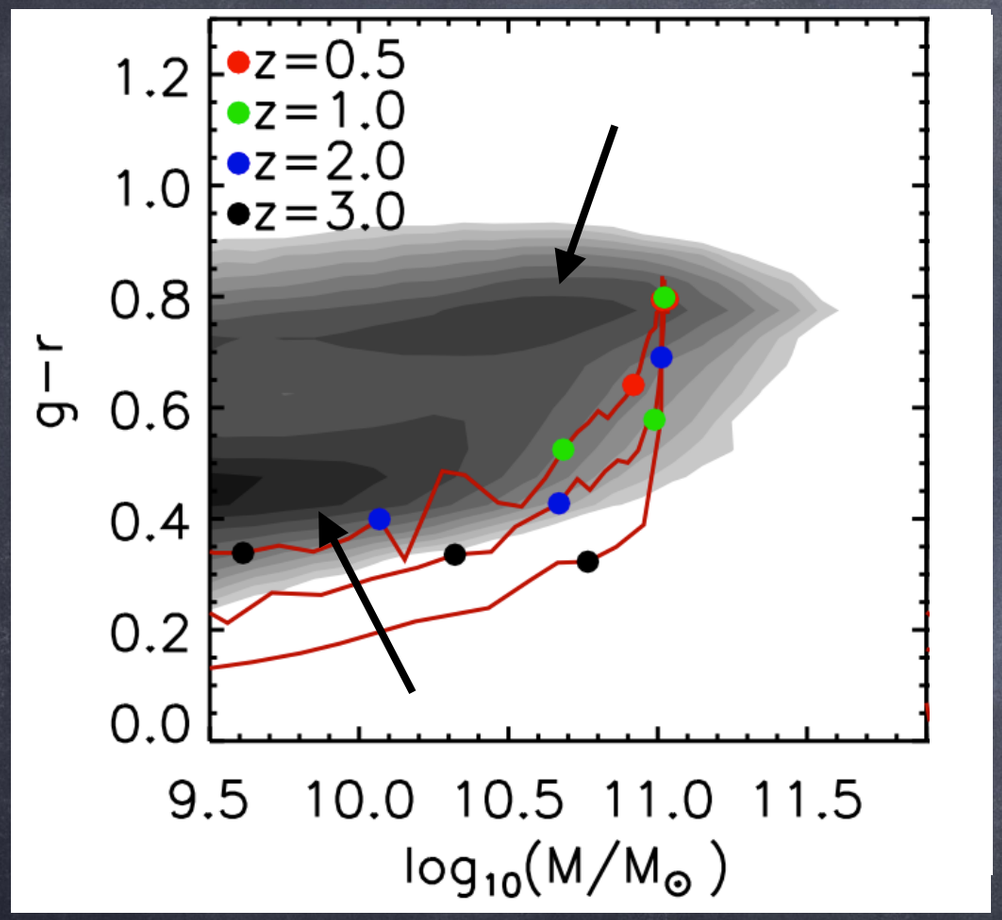
Galaxy Colours



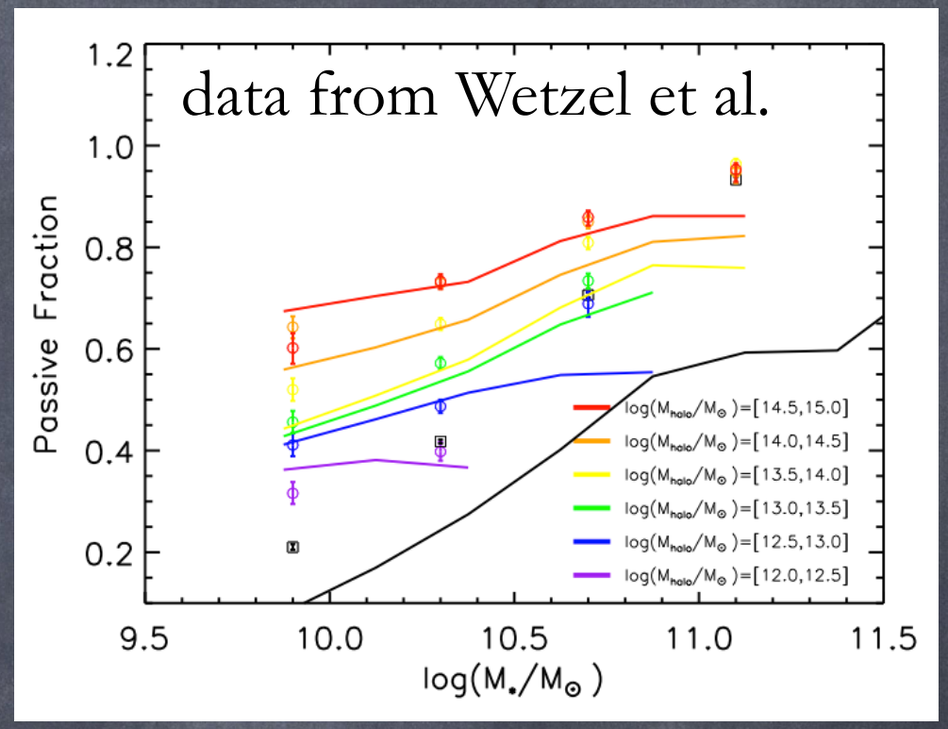


AGN and Environment Quenching

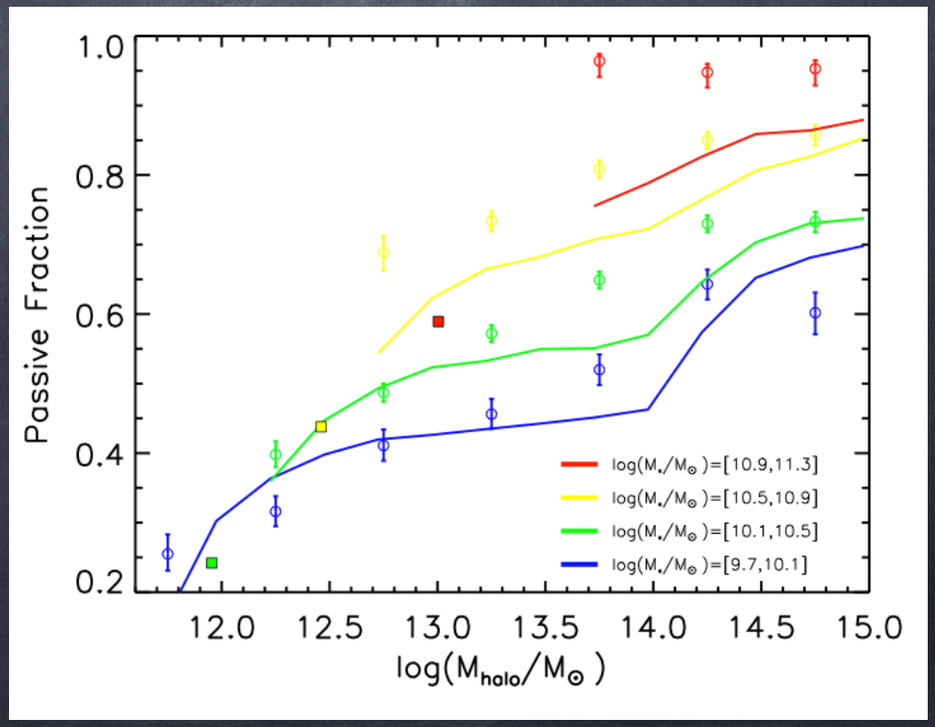
colour - stellar mass relation



passive fraction vs stellar mass

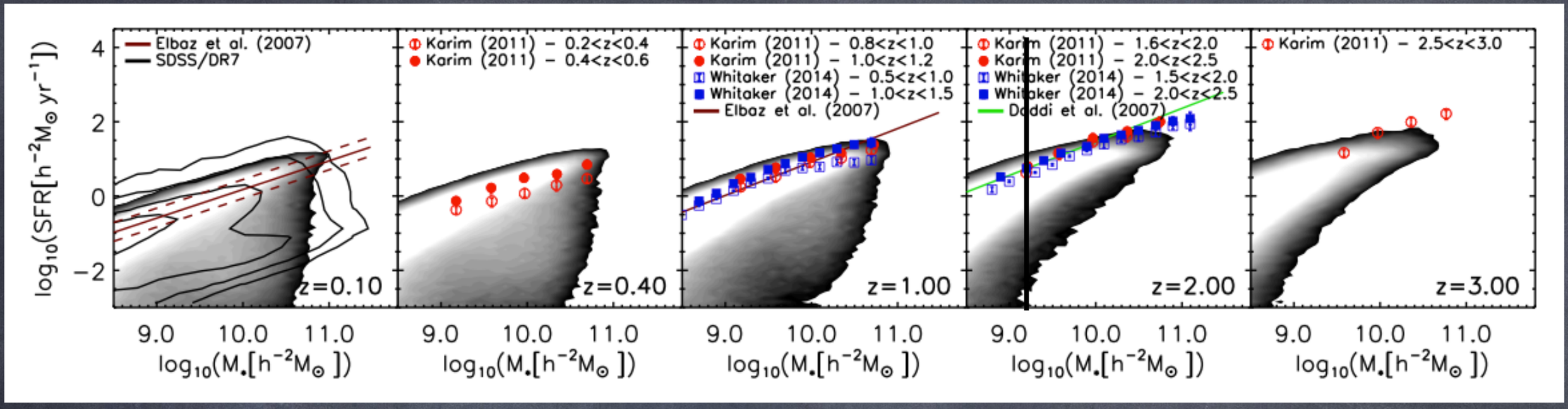


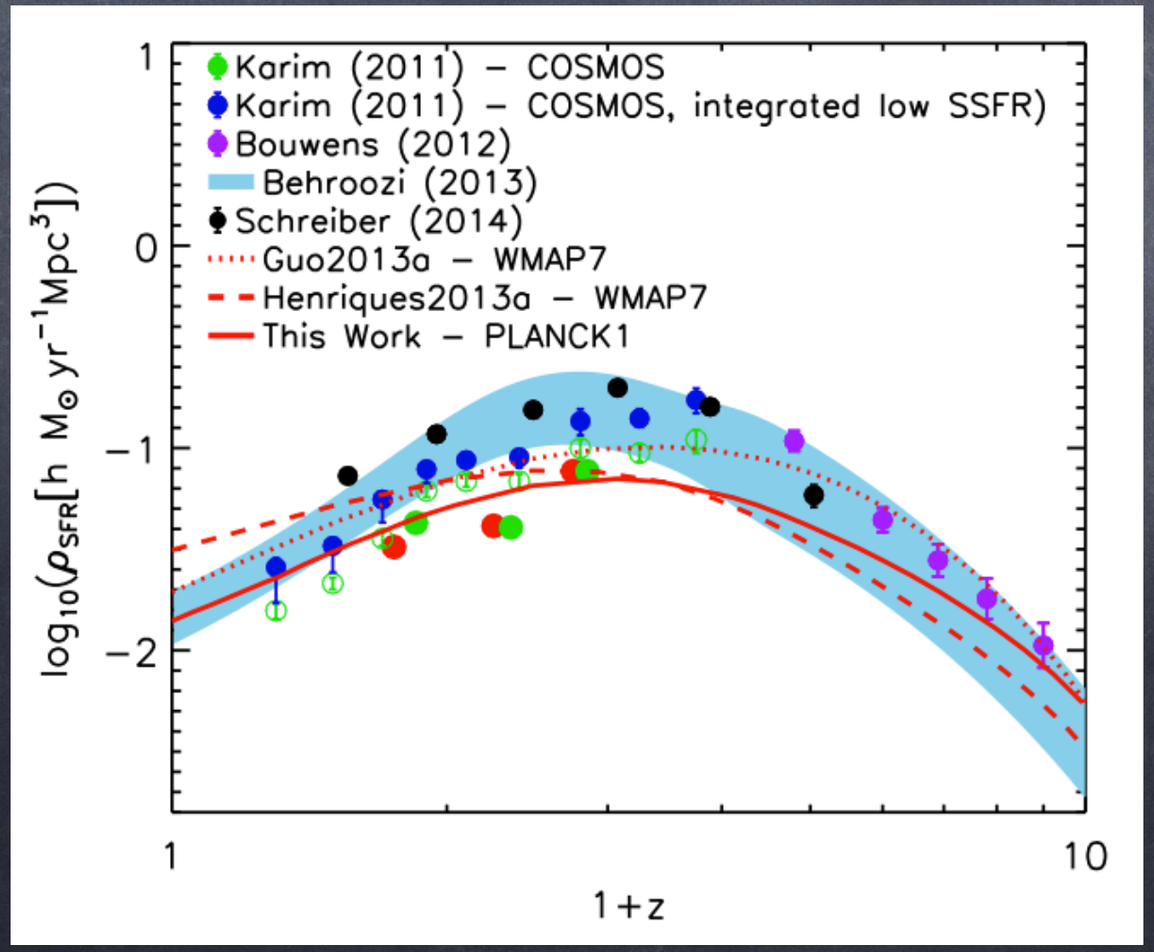
passive fraction vs halo mass



Galaxy Formation in the Planck Cosmology II; Henriques, White, Thomas, et al.; 2015; in prep

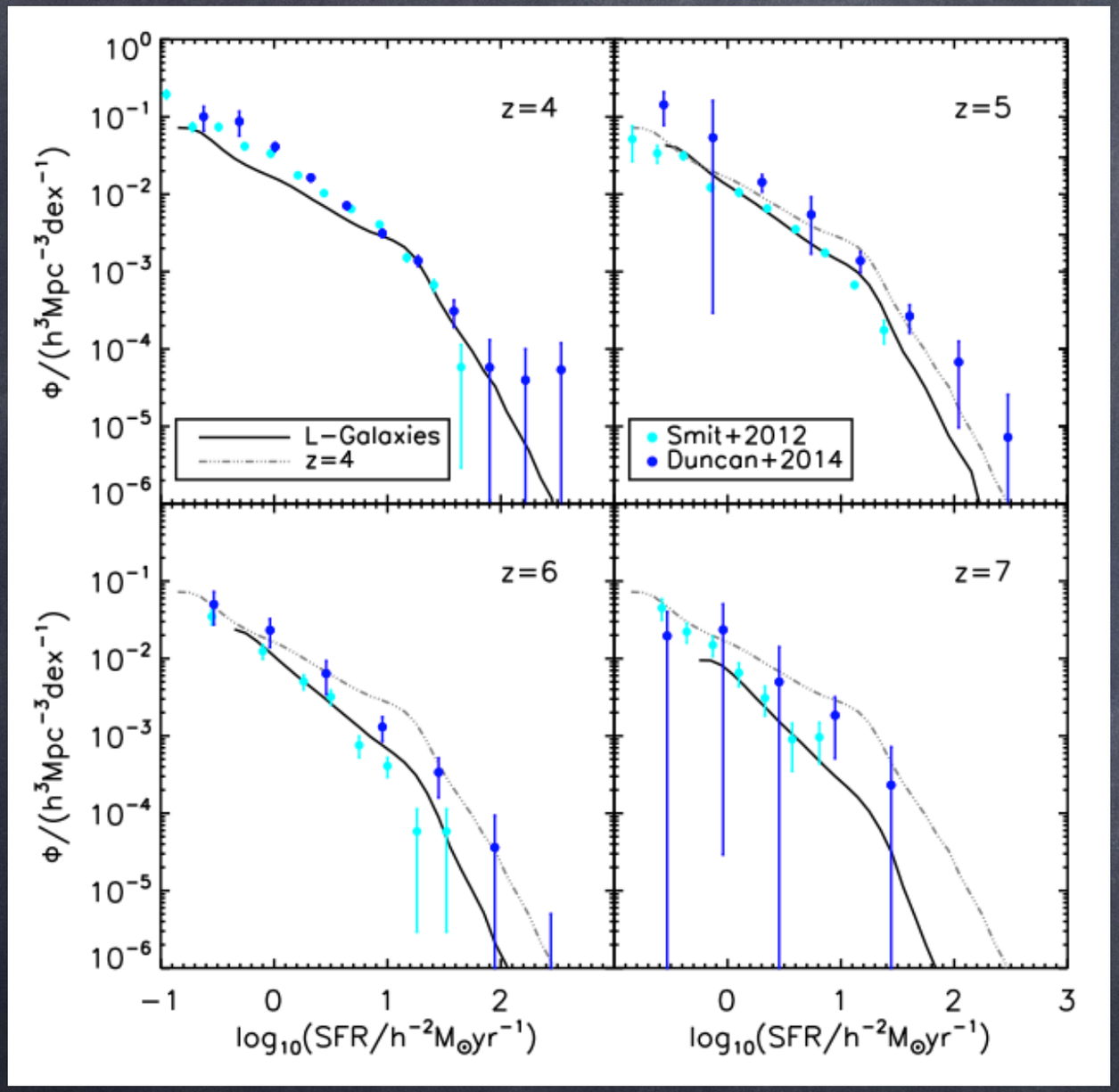
Star Formation Rates



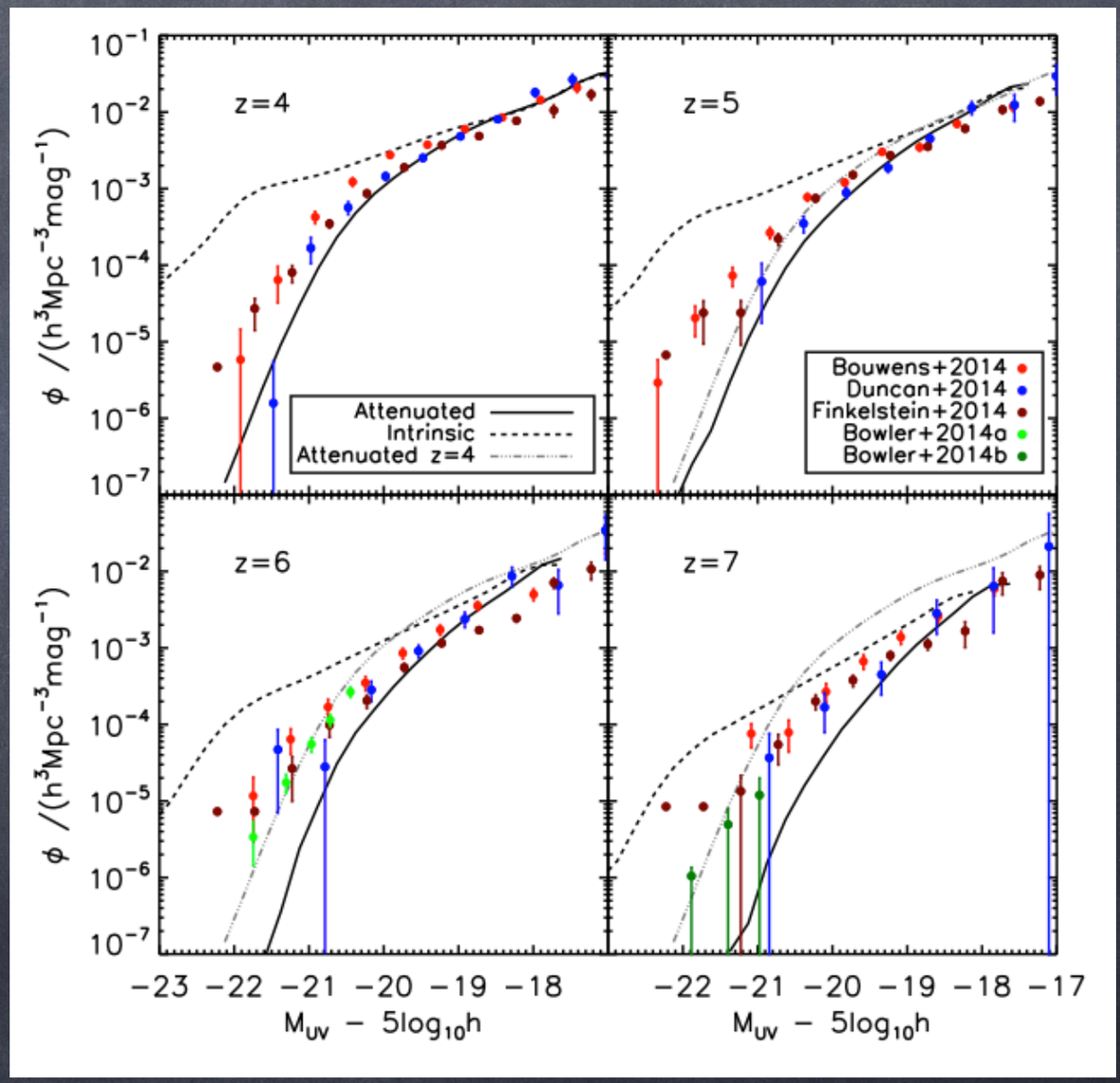


High-redshift

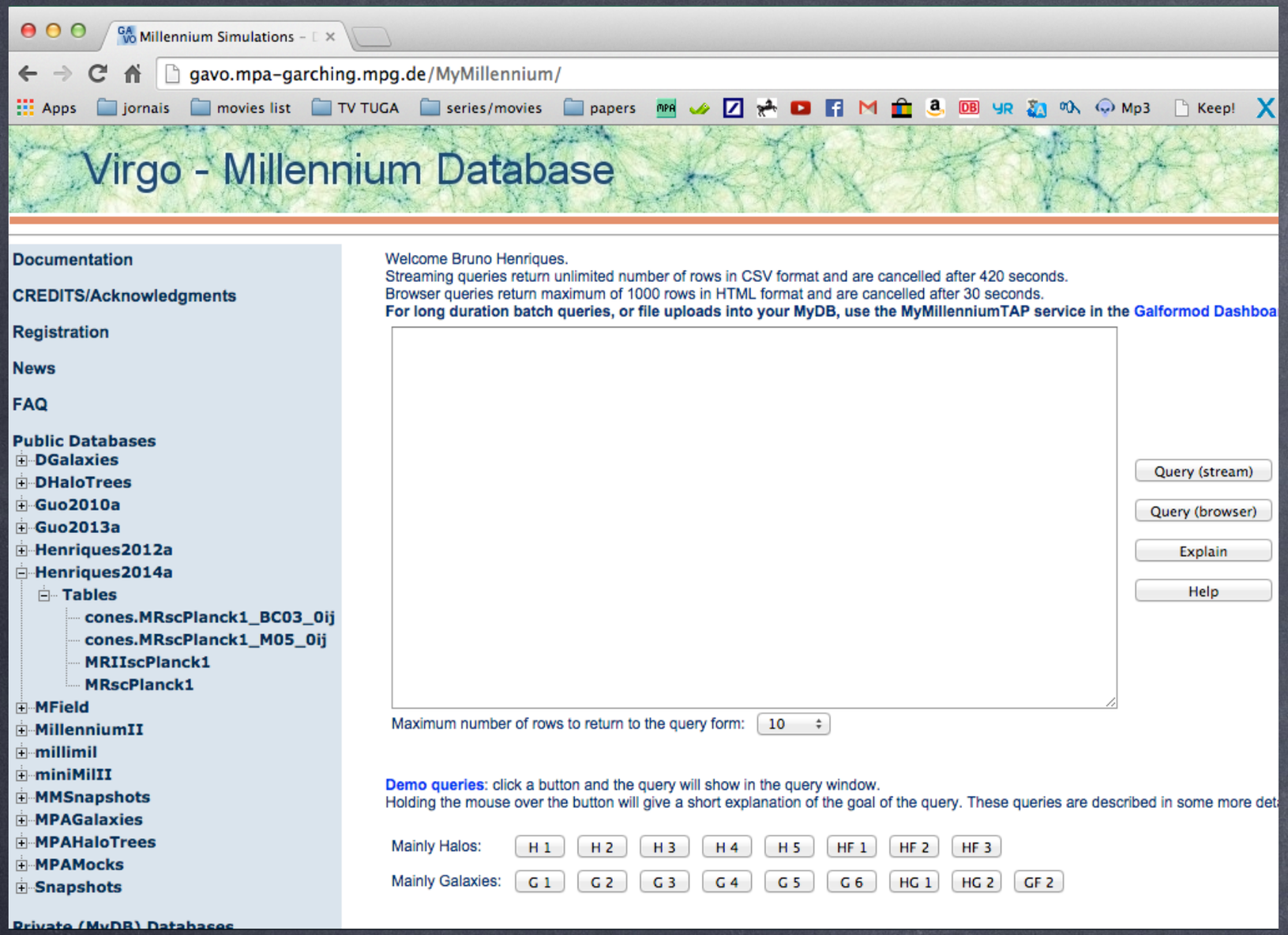
SFRF



UV-LF



Galaxy Formation in the Planck Cosmology VI;
Clay, Thomas, Wilkins, Henriques, et al.; 2015, MNRAS, sub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Private (MyDB) Databases
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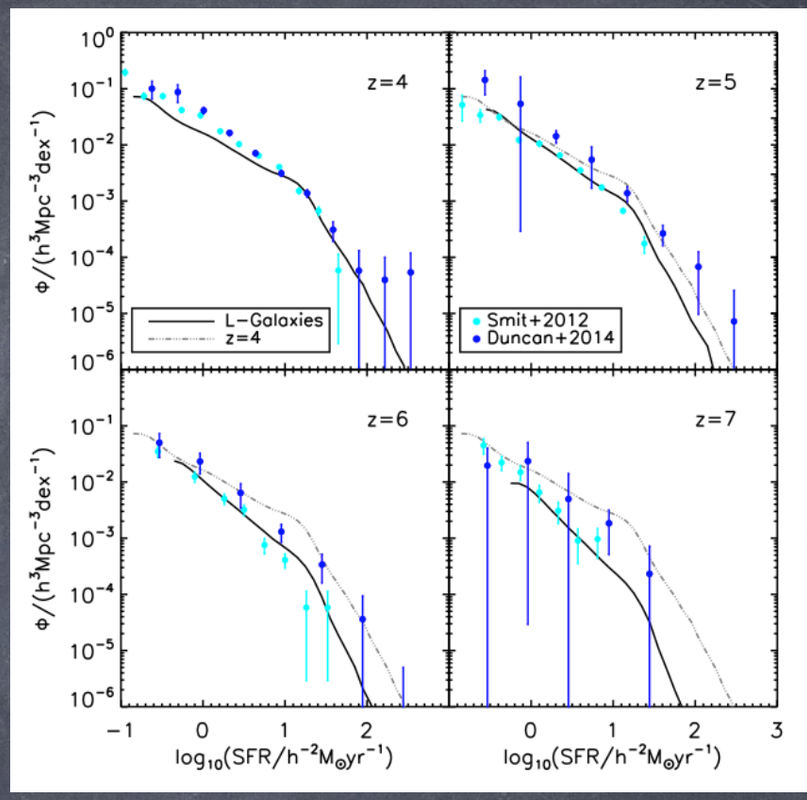
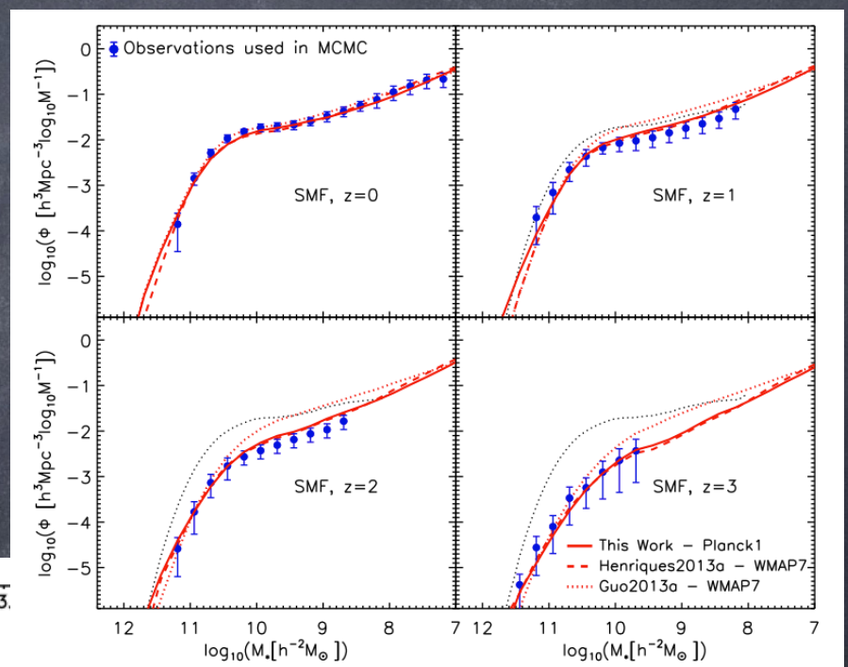
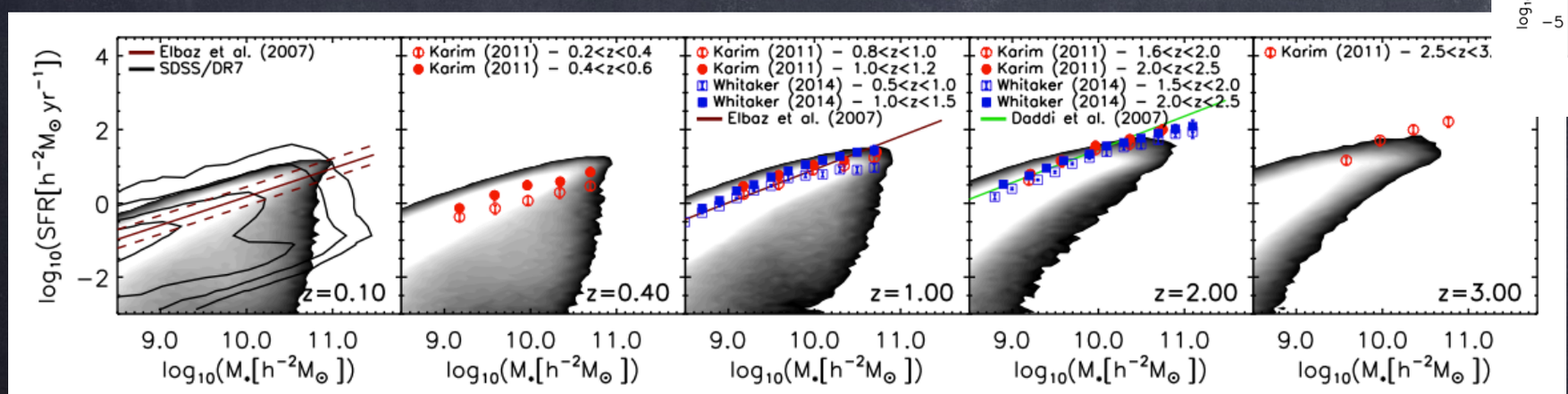
Query (stream)
Query (browser)
Explain
Help
Maximum number of rows to return to the query form:
10
Demo queries: click a button and the query will show in the query window.
Holding the mouse over the button will give a short explanation of the goal of the query. These queries are described in some more det
Mainly Halos:
H 1
H 2
H 3
H 4
H 5
HF 1
HF 2
HF 3
Mainly Galaxies:
G 1
G 2
G 3
G 4
G 5
G 6
HG 1
HG 2
GF 2

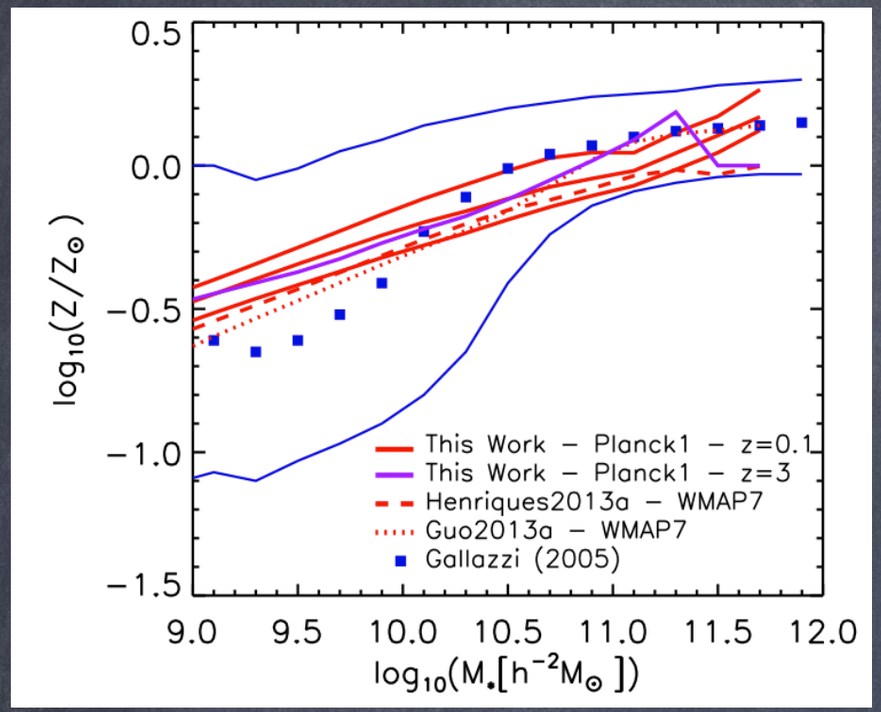

z=4
z=5
z=6
z=7
L−Galaxies
z=4
Smit+2012
Duncan+2014
$\Phi/(h^3Mpc^{-3}dex^{-1})$
$\log_{10}(SFR/h^{-2}M_\odot yr^{-1})$


Observations used in MCMC
SMF, z=0
SMF, z=1
SMF, z=2
SMF, z=3
This Work − Planck1
Henriques2013a − WMAP7
Guo2013a − WMAP7
$\log_{10}(\Phi\ [h^3Mpc^{-3}\log_{10}M^{-1}])$
$\log_{10}(M_*[h^{-2}M_\odot])$

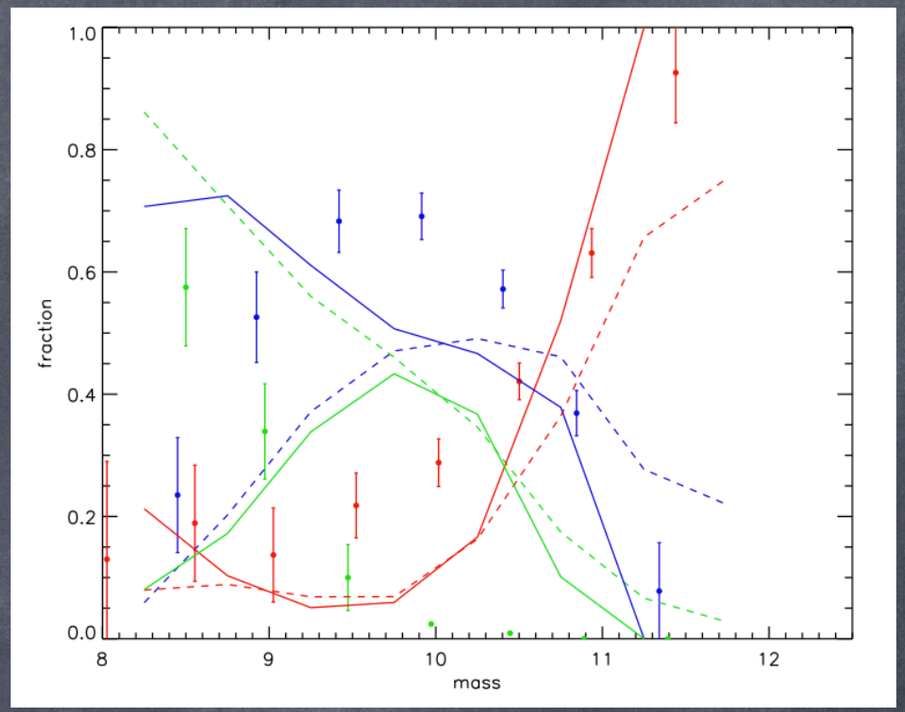

Elbaz et al. (2007)
SDSS/DR7
Karim (2011) − 0.2<z<0.4
Karim (2011) − 0.4<z<0.6
Karim (2011) − 0.8<z<1.0
Karim (2011) − 1.0<z<1.2
Whitaker (2014) − 0.5<z<1.0
Whitaker (2014) − 1.0<z<1.5
Elbaz et al. (2007)
Karim (2011) − 1.6<z<2.0
Karim (2011) − 2.0<z<2.5
Whitaker (2014) − 1.5<z<2.0
Whitaker (2014) − 2.0<z<2.5
Daddi et al. (2007)
Karim (2011) − 2.5<z<3.
z=0.10
z=0.40
z=1.00
z=2.00
z=3.00
$\log_{10}(SFR[h^{-2}M_\odot\ yr^{-1}])$
$\log_{10}(M_*[h^{-2}M_\odot])$

Additional Predictions

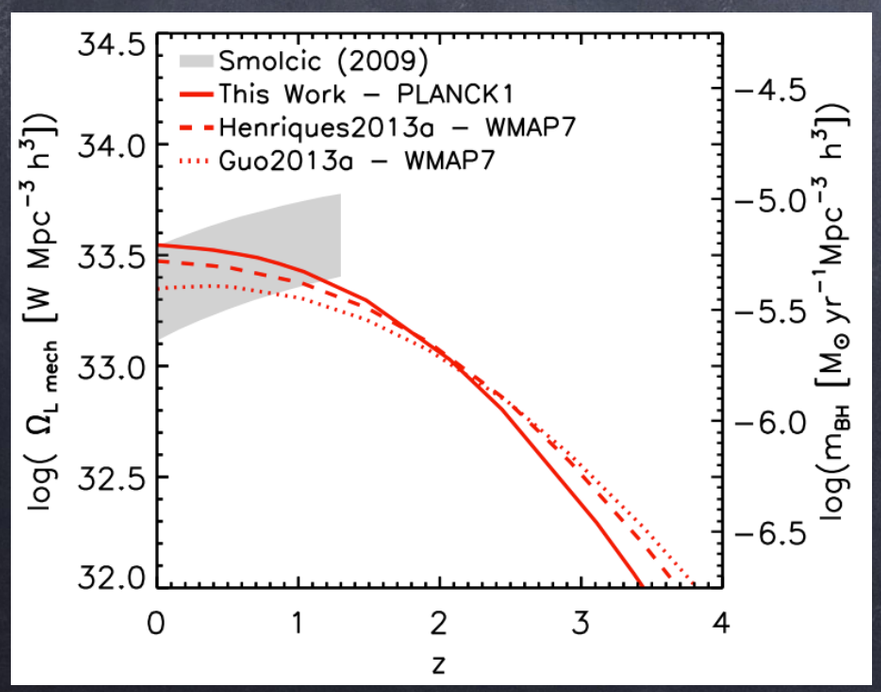
mass-metallicity relation



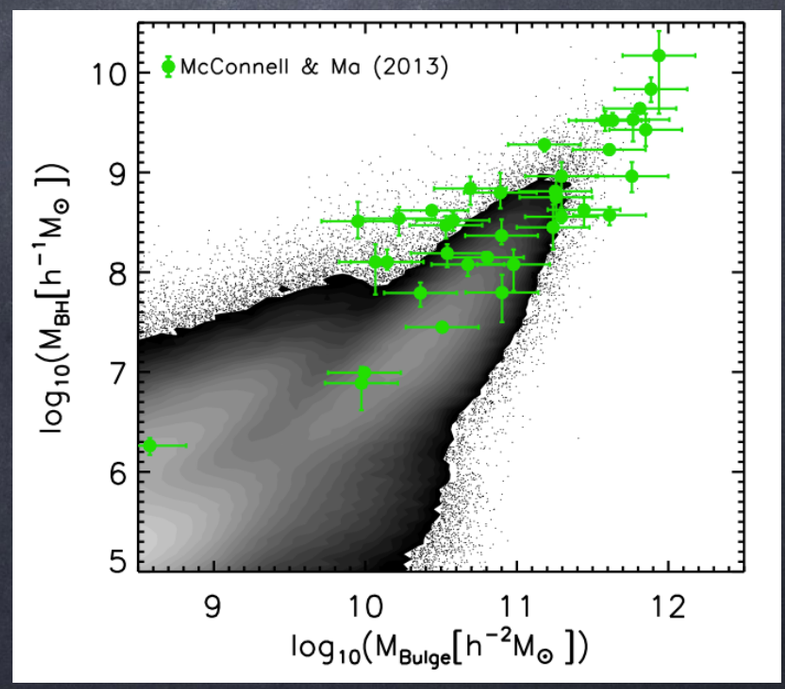
mass-morphology relation



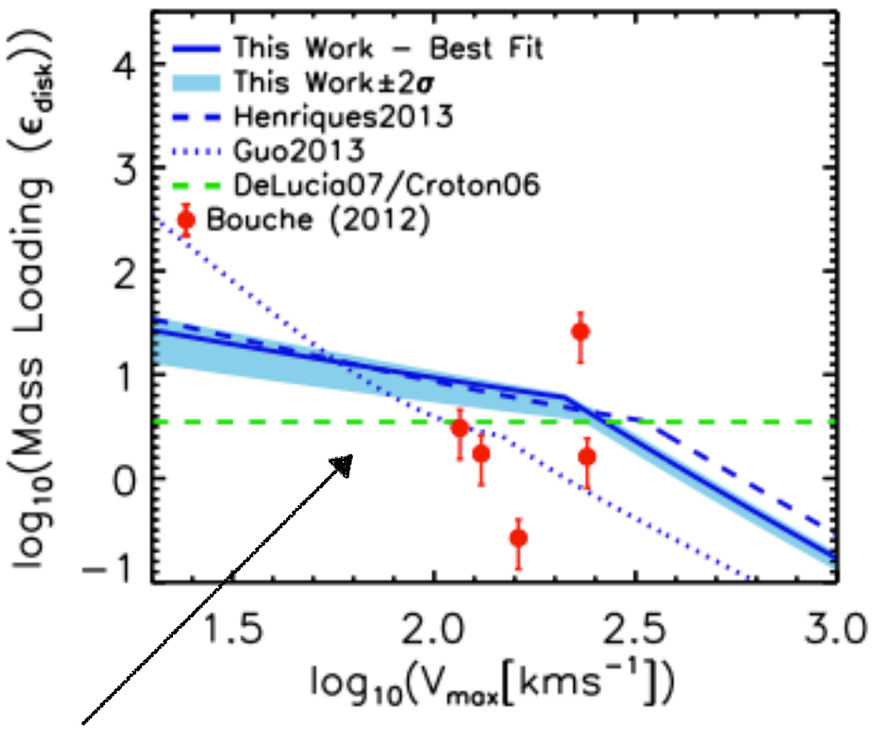
radio mode accretion vs redshift

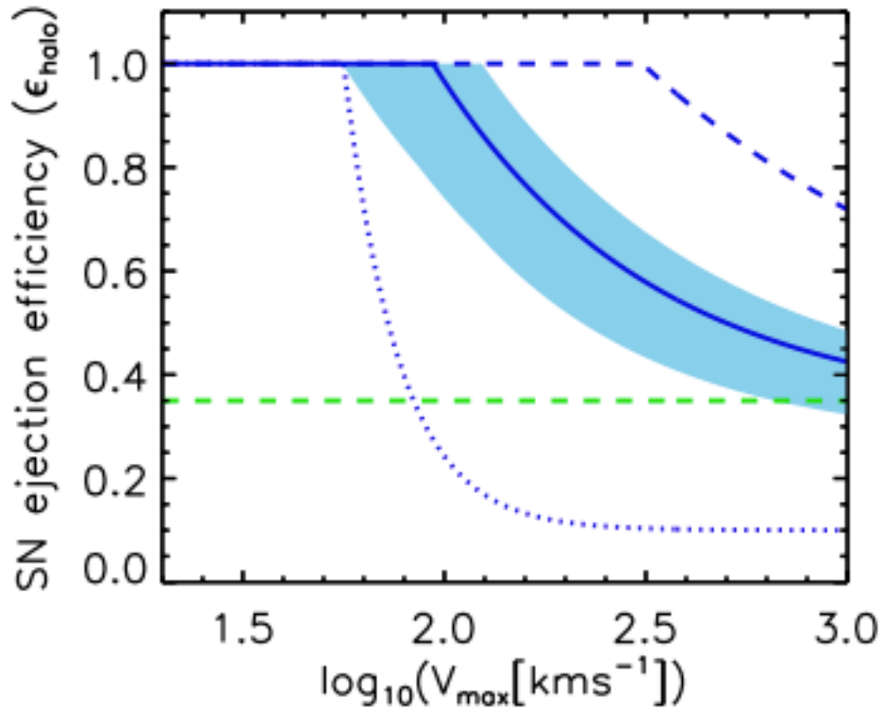


black hole-bulge mass relation



SN feedback





similar reheating and ejection between models