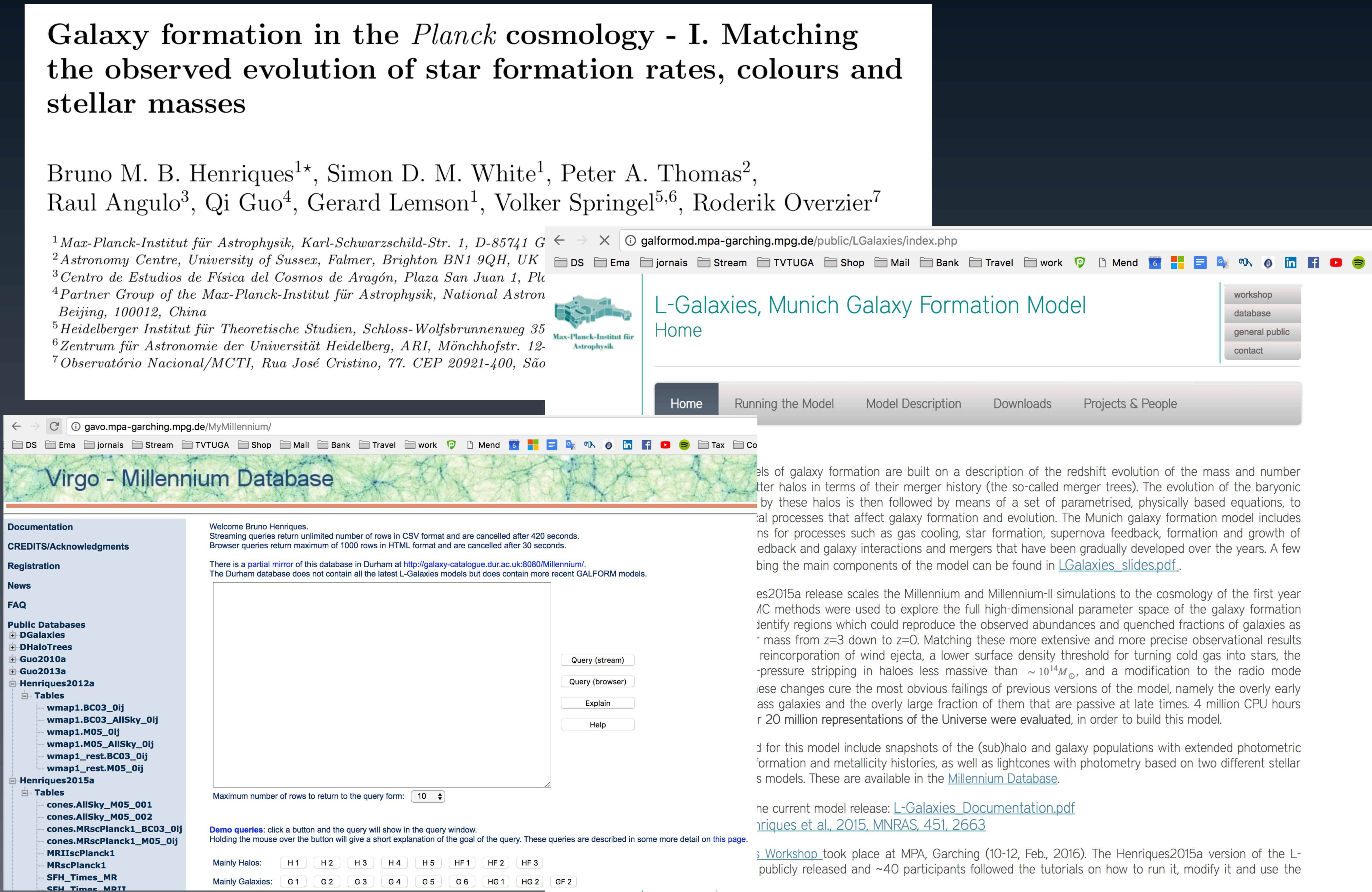
Modelling the impact of environment on galaxy properties

Bruno Henriques (Zwicky Fellow, ETH Zurich)

Simon White, Peter Thomas, Simon Lilly
Raul Angulo, Qi Guo, Gerard Lemson, Volker Springel

Henriques2015 model



Galaxy formation in the *Planck* cosmology - I. Matching the observed evolution of star formation rates, colours and stellar masses

Bruno M. B. Henriques[1*], Simon D. M. White[1], Peter A. Thomas[2], Raul Angulo[3], Qi Guo[4], Gerard Lemson[1], Volker Springel[5,6], Roderik Overzier[7]

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[2] *Astronomy Centre, University of Sussex, Falmer, Brighton BN1 9QH, UK*
[3] *Centro de Estudios de Física del Cosmos de Aragón, Plaza San Juan 1, Pla*
[4] *Partner Group of the Max-Planck-Institut für Astrophysik, National Astron Beijing, 100012, China*
[5] *Heidelberger Institut für Theoretische Studien, Schloss-Wolfsbrunnenweg 35*
[6] *Zentrum für Astronomie der Universität Heidelberg, ARI, Mönchhofstr. 12-*
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galformod.mpa-garching.mpg.de/public/LGalaxies/index.php

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…els of galaxy formation are built on a description of the redshift evolution of the mass and number …tter halos in terms of their merger history (the so-called merger trees). The evolution of the baryonic … by these halos is then followed by means of a set of parametrised, physically based equations, to …al processes that affect galaxy formation and evolution. The Munich galaxy formation model includes …ns for processes such as gas cooling, star formation, supernova feedback, formation and growth of …edback and galaxy interactions and mergers that have been gradually developed over the years. A few …bing the main components of the model can be found in LGalaxies_slides.pdf .

…es2015a release scales the Millennium and Millennium-II simulations to the cosmology of the first year …MC methods were used to explore the full high-dimensional parameter space of the galaxy formation …dentify regions which could reproduce the observed abundances and quenched fractions of galaxies as … mass from z=3 down to z=0. Matching these more extensive and more precise observational results … reincorporation of wind ejecta, a lower surface density threshold for turning cold gas into stars, the …-pressure stripping in haloes less massive than $\sim 10^{14} M_\odot$, and a modification to the radio mode …ese changes cure the most obvious failings of previous versions of the model, namely the overly early …ass galaxies and the overly large fraction of them that are passive at late times. 4 million CPU hours …r 20 million representations of the Universe were evaluated, in order to build this model.

…d for this model include snapshots of the (sub)halo and galaxy populations with extended photometric …ormation and metallicity histories, as well as lightcones with photometry based on two different stellar …s models. These are available in the Millennium Database.

…e current model release: L-Galaxies_Documentation.pdf
…riques et al., 2015, MNRAS, 451, 2663

…s Workshop took place at MPA, Garching (10-12, Feb., 2016). The Henriques2015a version of the L-… publicly released and ~40 participants followed the tutorials on how to run it, modify it and use the

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Virgo - Millennium Database

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- Guo2013a
- Henriques2012a
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    - wmap1.BC03_0ij
    - wmap1.BC03_AllSky_0ij
    - wmap1.M05_0ij
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- Henriques2015a
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    - cones.MRscPlanck1_M05_0ij
    - MRIIscPlanck1
    - MRscPlanck1
    - SFH_Times_MR
    - SFH_Times_MRII

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.

There is a partial mirror of this database in Durham at http://galaxy-catalogue.dur.ac.uk:8080/Millennium/.
The Durham database does not contain all the latest L-Galaxies models but does contain more recent GALFORM models.

Query (stream)
Query (browser)
Explain
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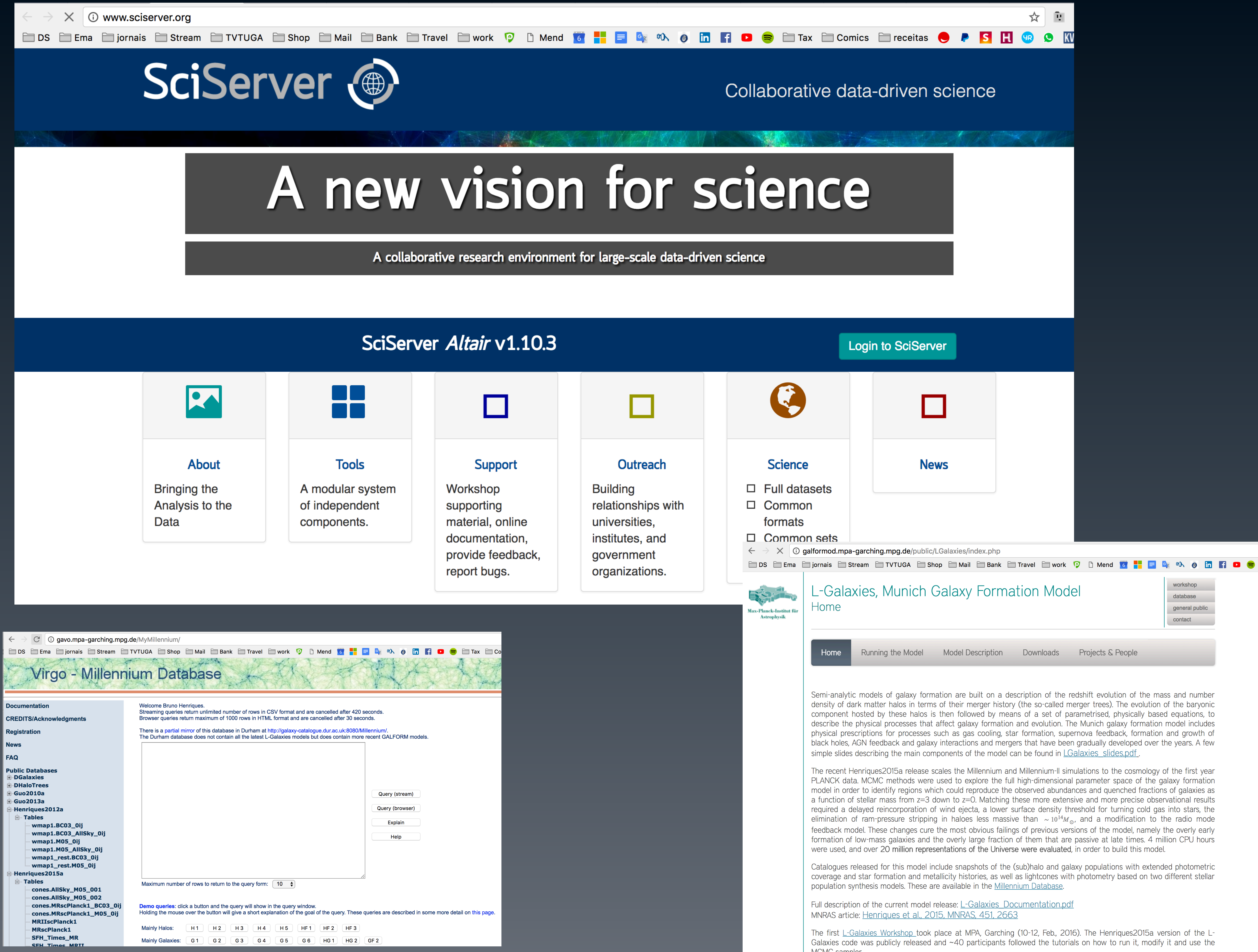
Maximum number of rows to return to the query form: 10

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 detail on this page.

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



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Tables
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Henriques2015a
Tables
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cones.MRscPlanck1_M05_0ij
MRIIscPlanck1
MRscPlanck1
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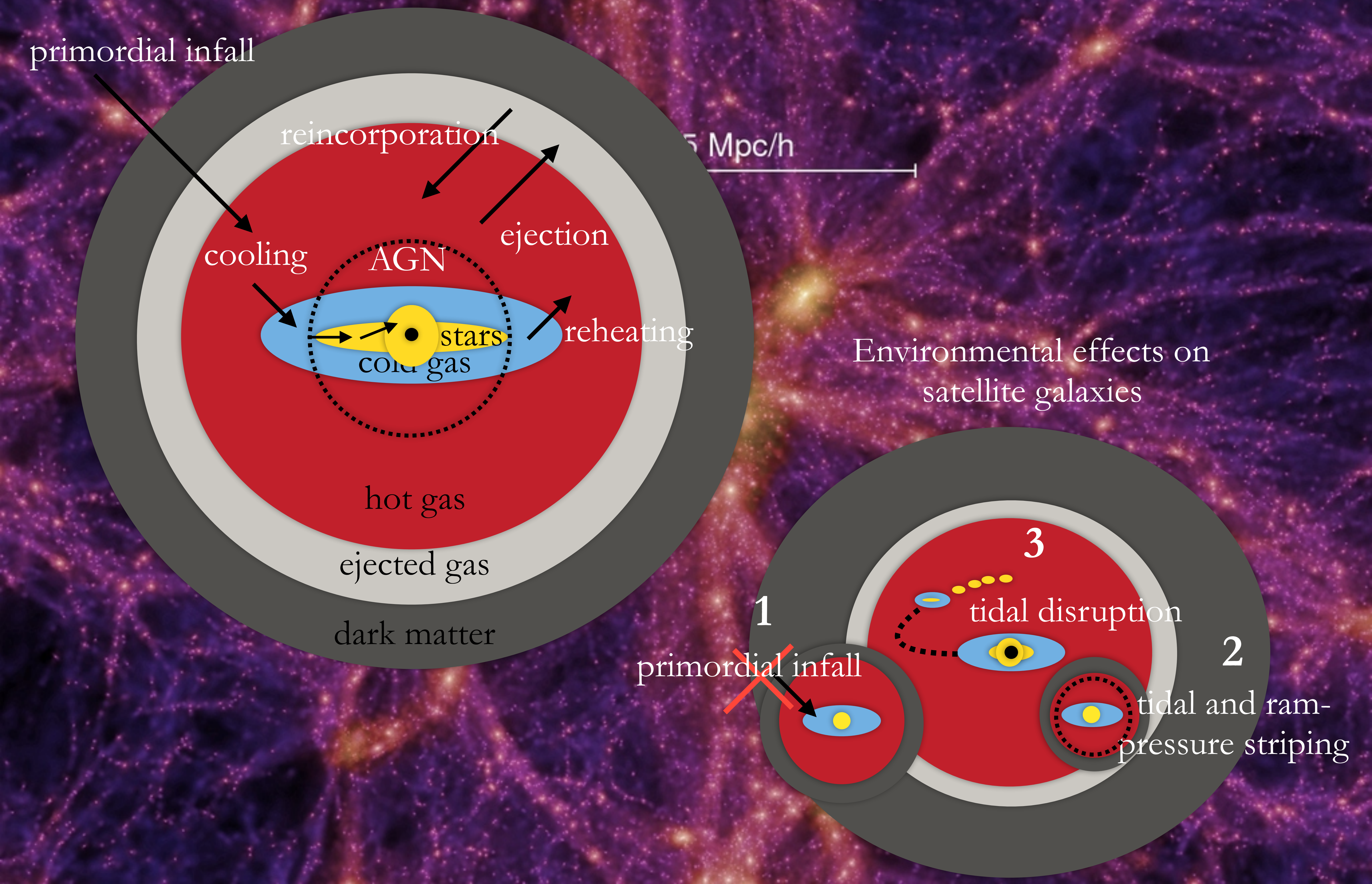
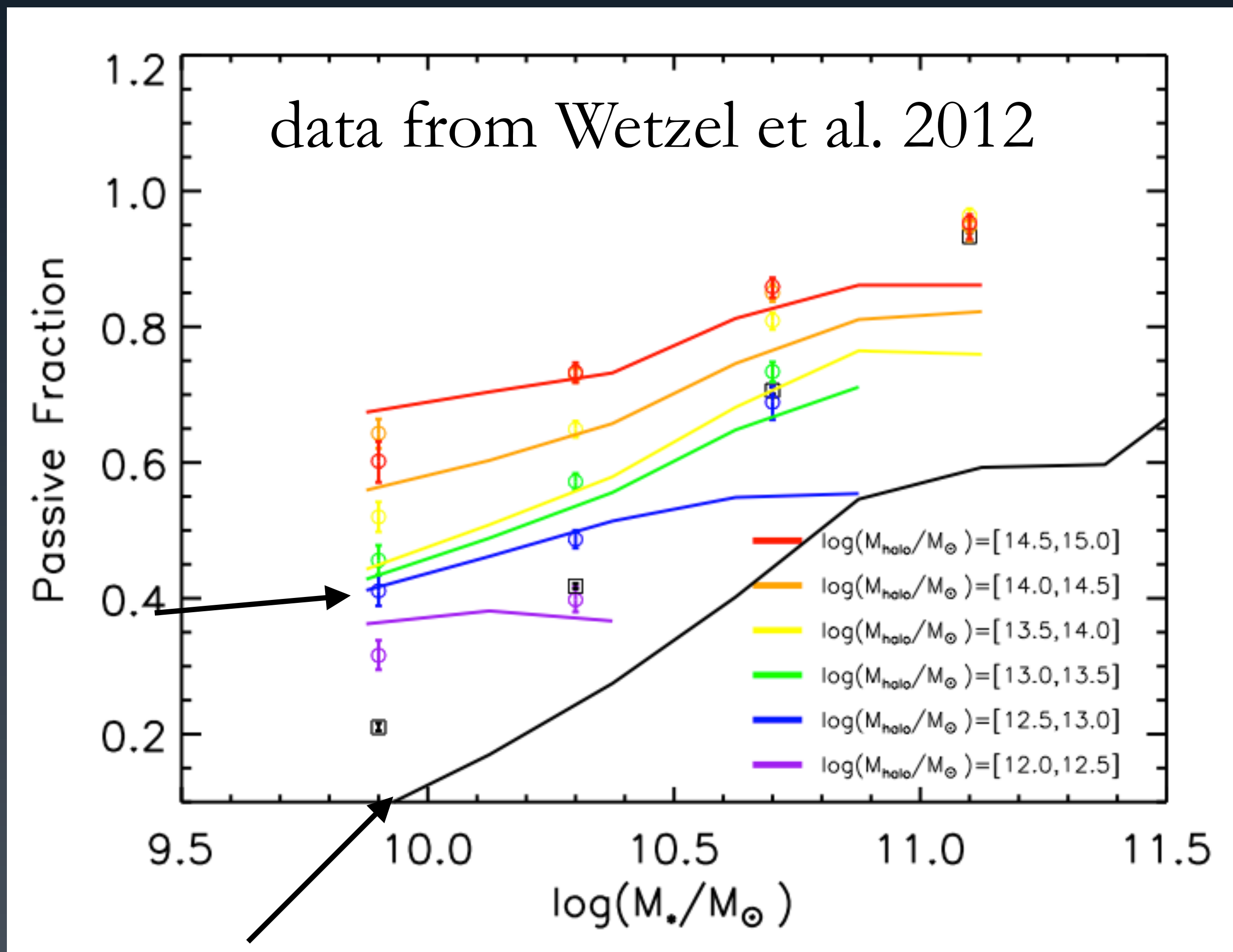
Semi-analytic models of galaxy formation are built on a description of the redshift evolution of the mass and number density of dark matter halos in terms of their merger history (the so-called merger trees). The evolution of the baryonic component hosted by these halos is then followed by means of a set of parametrised, physically based equations, to describe the physical processes that affect galaxy formation and evolution. The Munich galaxy formation model includes physical prescriptions for processes such as gas cooling, star formation, supernova feedback, formation and growth of black holes, AGN feedback and galaxy interactions and mergers that have been gradually developed over the years. A few simple slides describing the main components of the model can be found in LGalaxies_slides.pdf .
The recent Henriques2015a release scales the Millennium and Millennium-II simulations to the cosmology of the first year PLANCK data. 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 the observed abundances and quenched fractions of galaxies as a function of stellar mass from z=3 down to z=0. Matching these more extensive and more precise observational results required a delayed reincorporation of wind ejecta, a lower surface density threshold for turning cold gas into stars, the elimination of ram-pressure stripping in haloes less massive than $\sim 10^{14} M_\odot$, and a modification to the radio mode feedback model. These changes cure the most obvious failings of previous versions of the model, namely the overly early formation of low-mass galaxies and the overly large fraction of them that are passive at late times. 4 million CPU hours were used, and over 20 million representations of the Universe were evaluated, in order to build this model.
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. These are available in the Millennium Database.
Full description of the current model release: L-Galaxies_Documentation.pdf
MNRAS article: Henriques et al., 2015, MNRAS, 451, 2663
The first L-Galaxies Workshop took place at MPA, Garching (10-12, Feb., 2016). The Henriques2015a version of the L-Galaxies code was publicly released and ~40 participants followed the tutorials on how to run it, modify it and use the MCMC sampler.

Galaxy Formation model



AGN and Environment Quenching

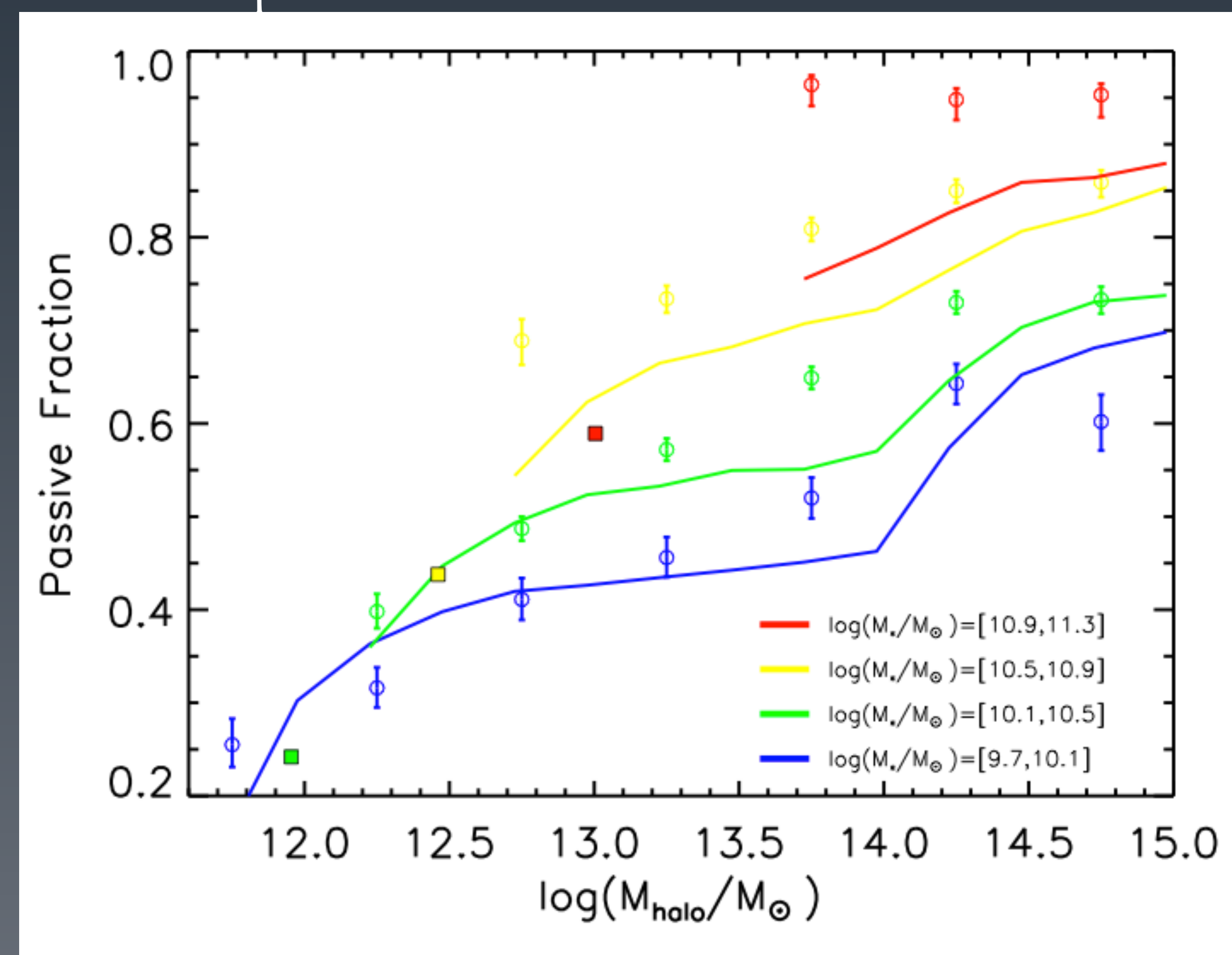
passive fraction vs stellar mass



higher quenched fractions for higher higher stellar masses and denser environments

- massive galaxies quenched due to AGN
- most low mass galaxies are star-forming centrals
- 40% of low mass galaxies are satellites of which ~50% are quenched (20% quenched low mass)

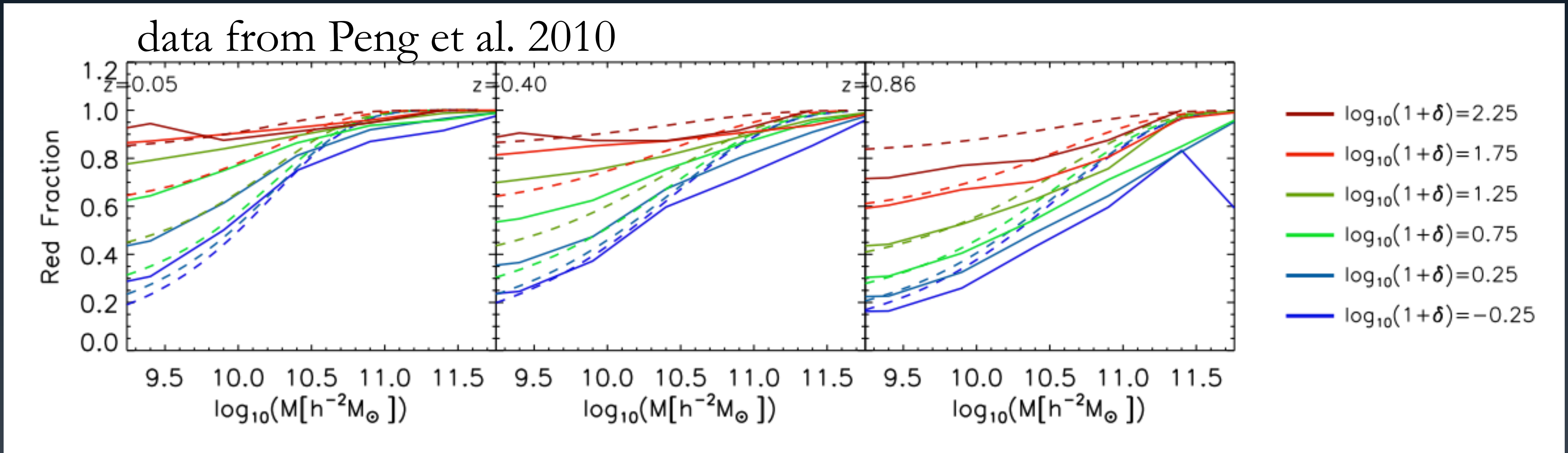
passive fraction vs halo mass



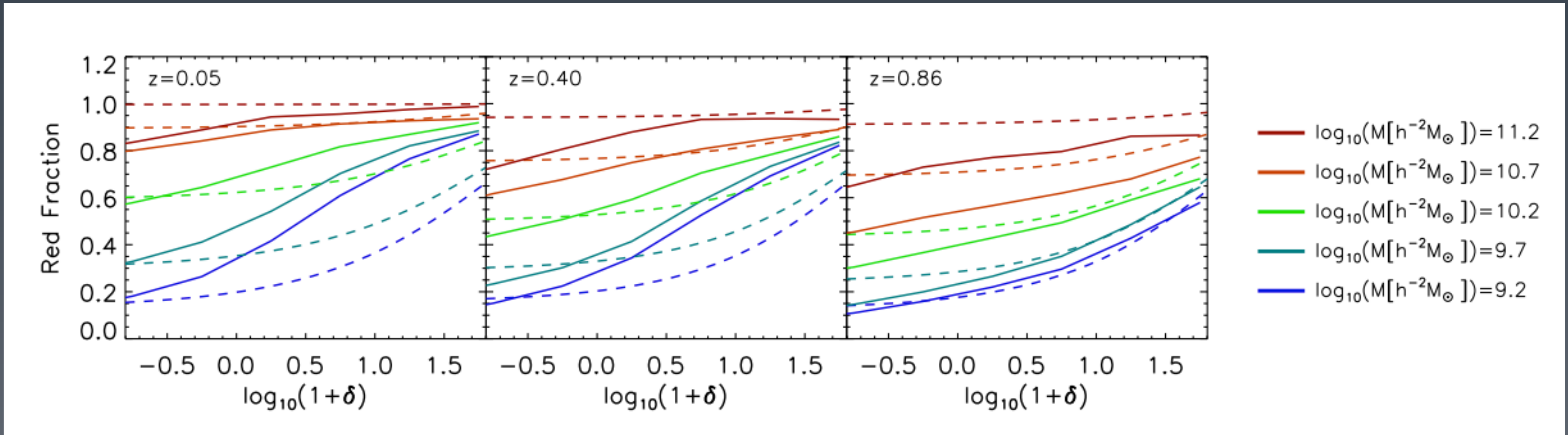
Galaxy Formation in the Planck Cosmology IV; Henriques, White, Thomas, et al.; 2016, MNRAS

AGN and Environment Quenching

passive fraction vs stellar mass

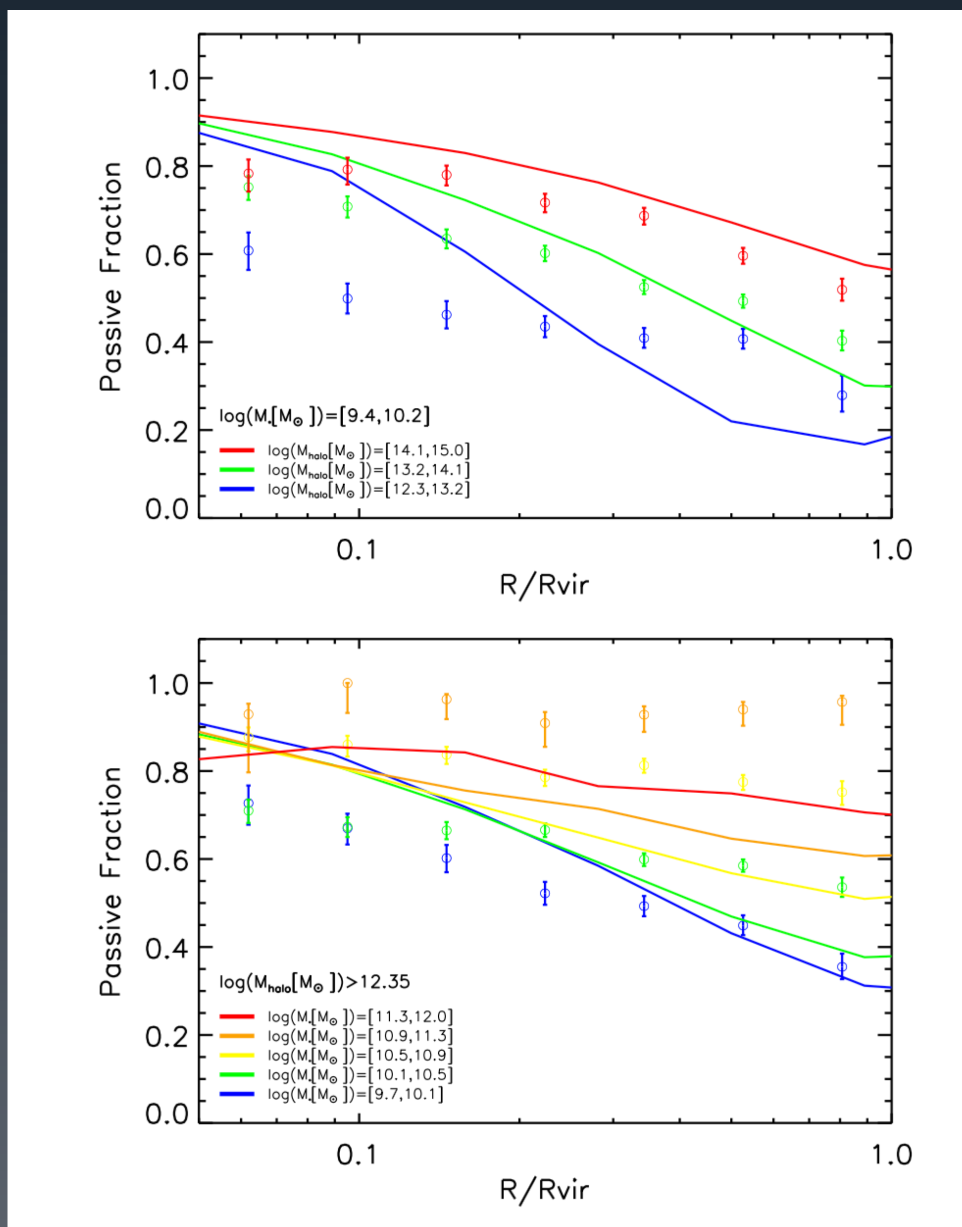


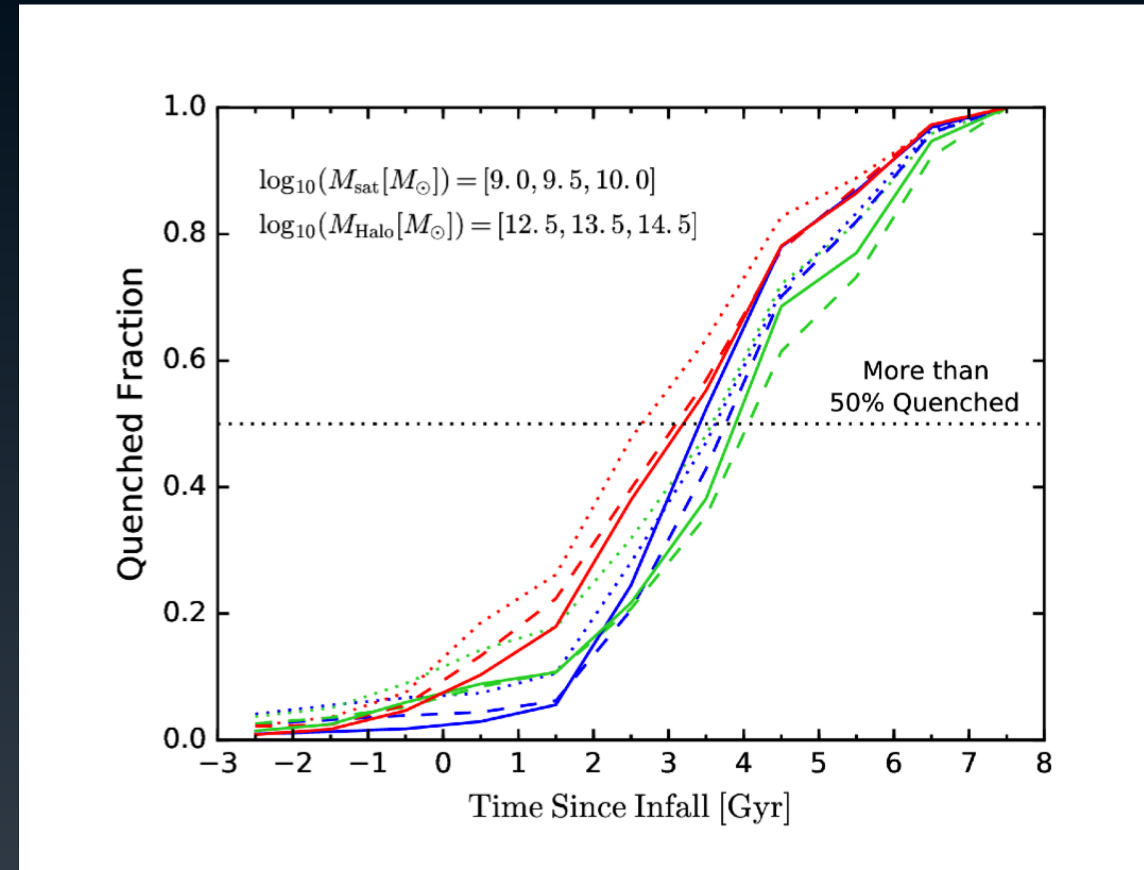
passive fraction vs local density



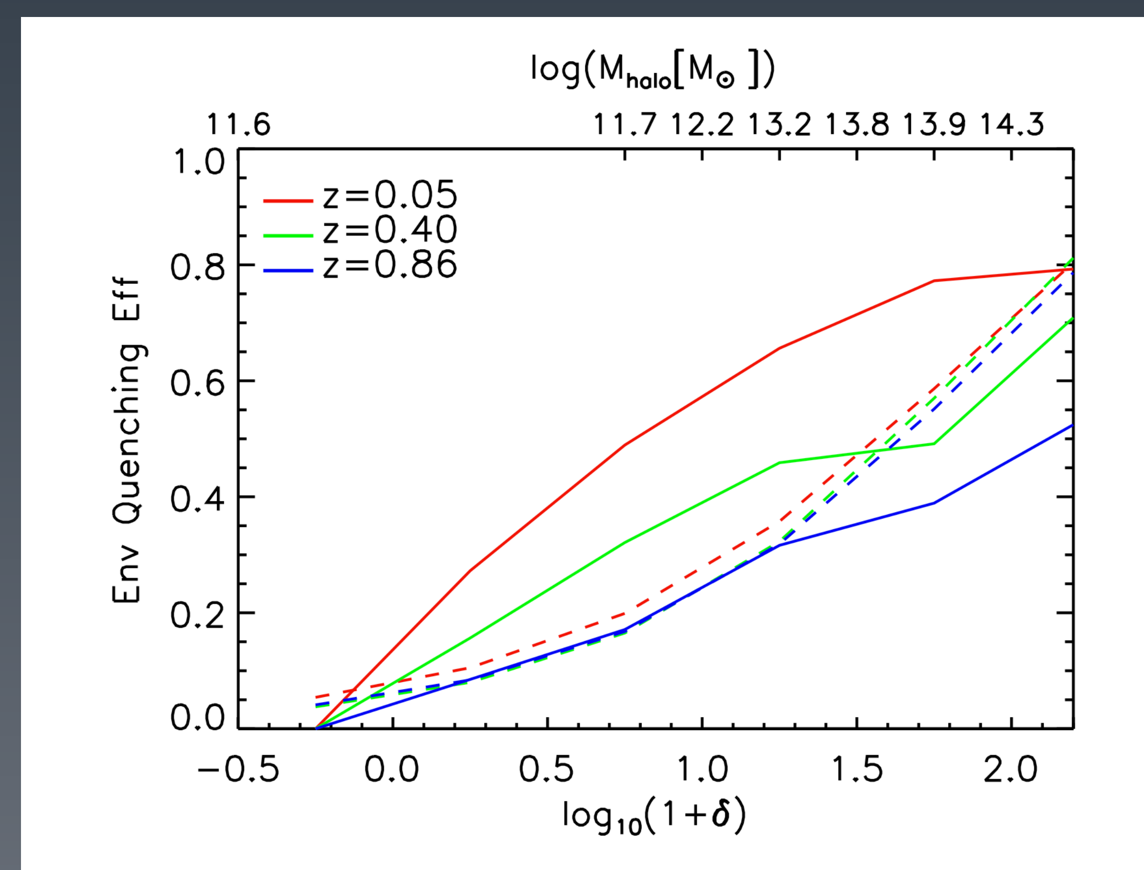
Galaxy Formation in the Planck Cosmology IV; Henriques, White, Thomas, et al.; 2016; MNRAS

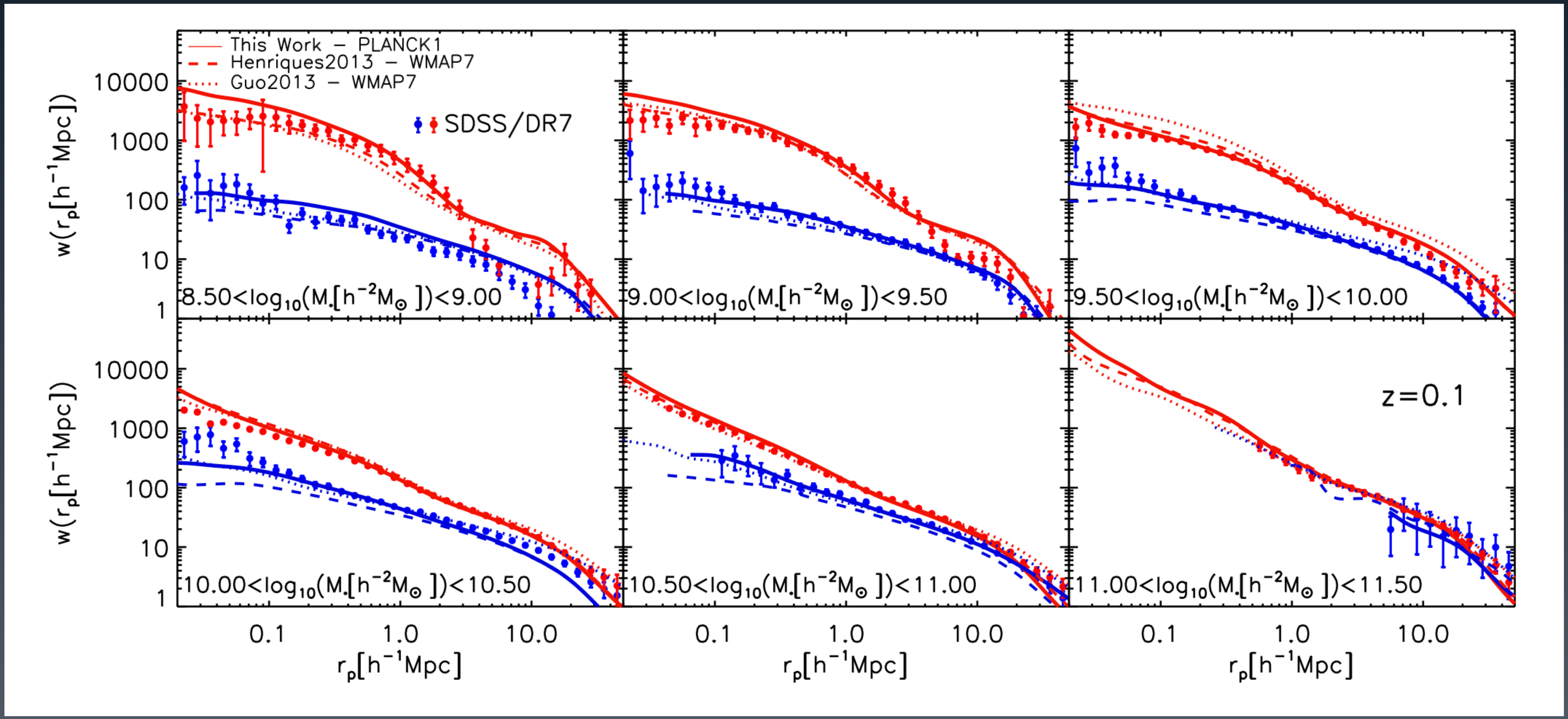
quenched fraction as a function of distance from group center





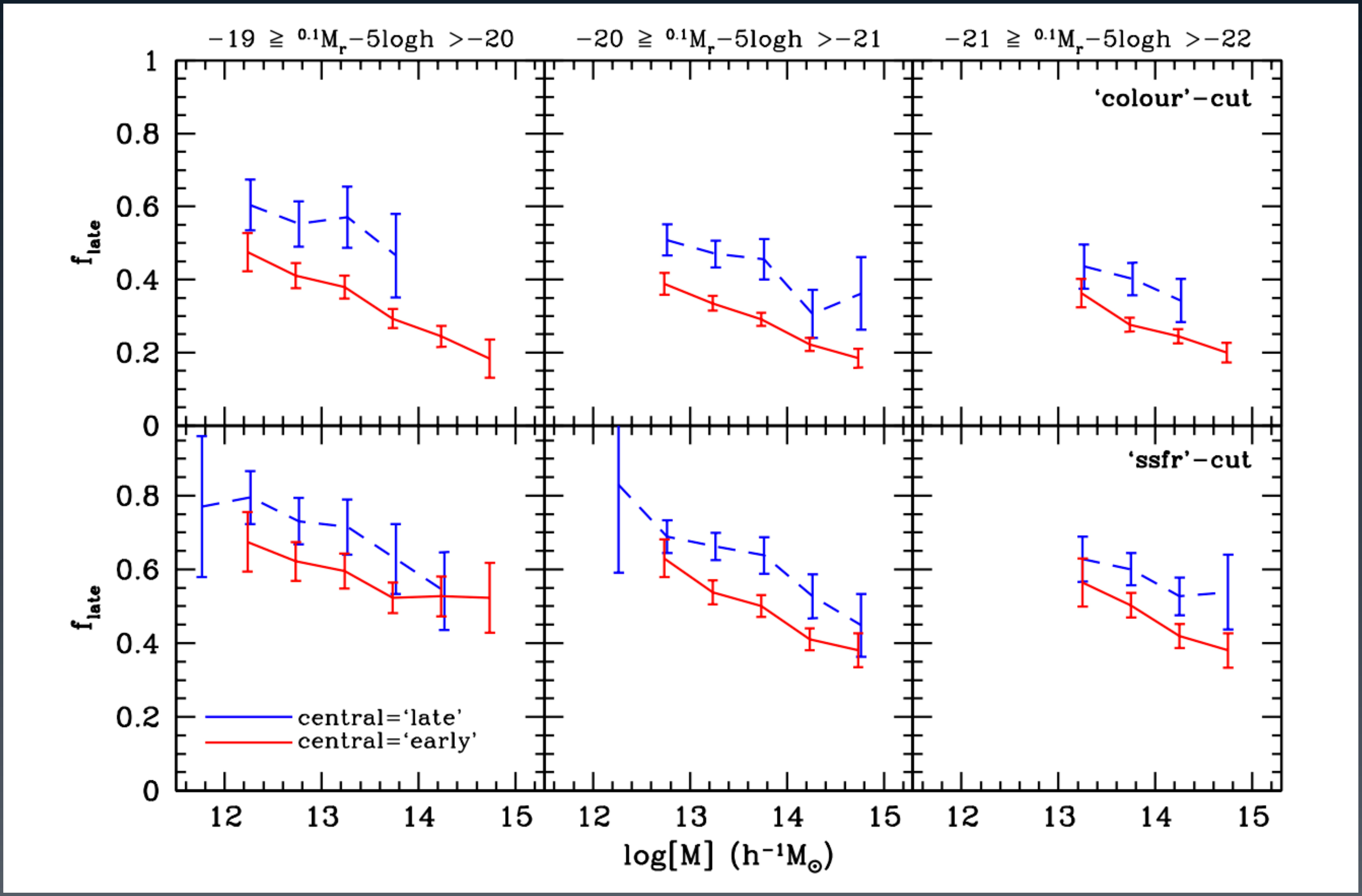
quenching times

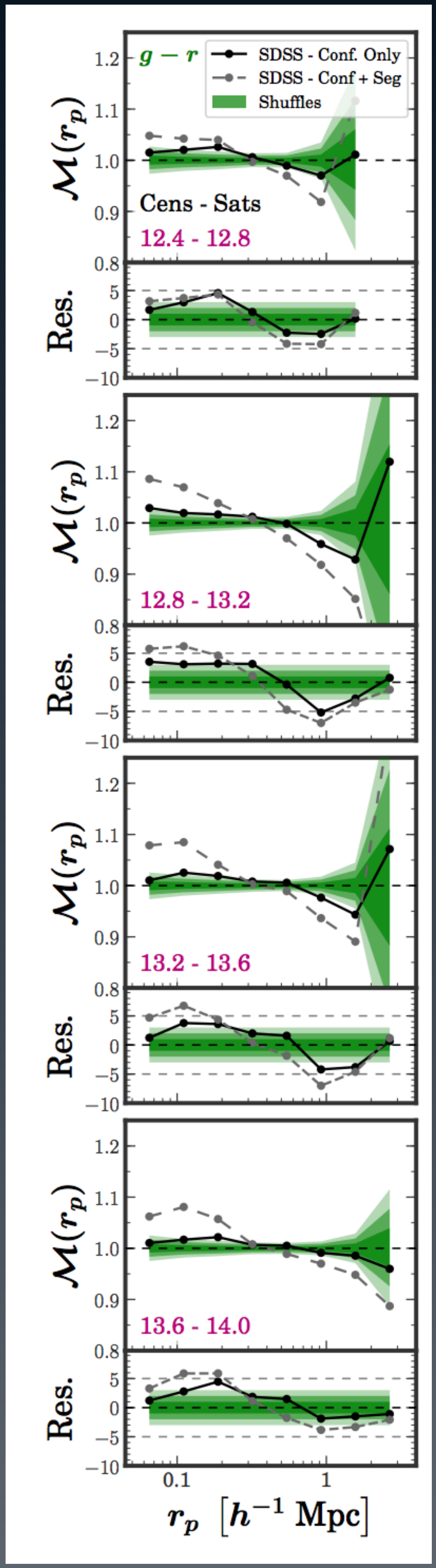




Galaxy Formation in the Planck Cosmology IV;
Henriques, White, Thomas, et al.; 2016; MNRAS

Conformity

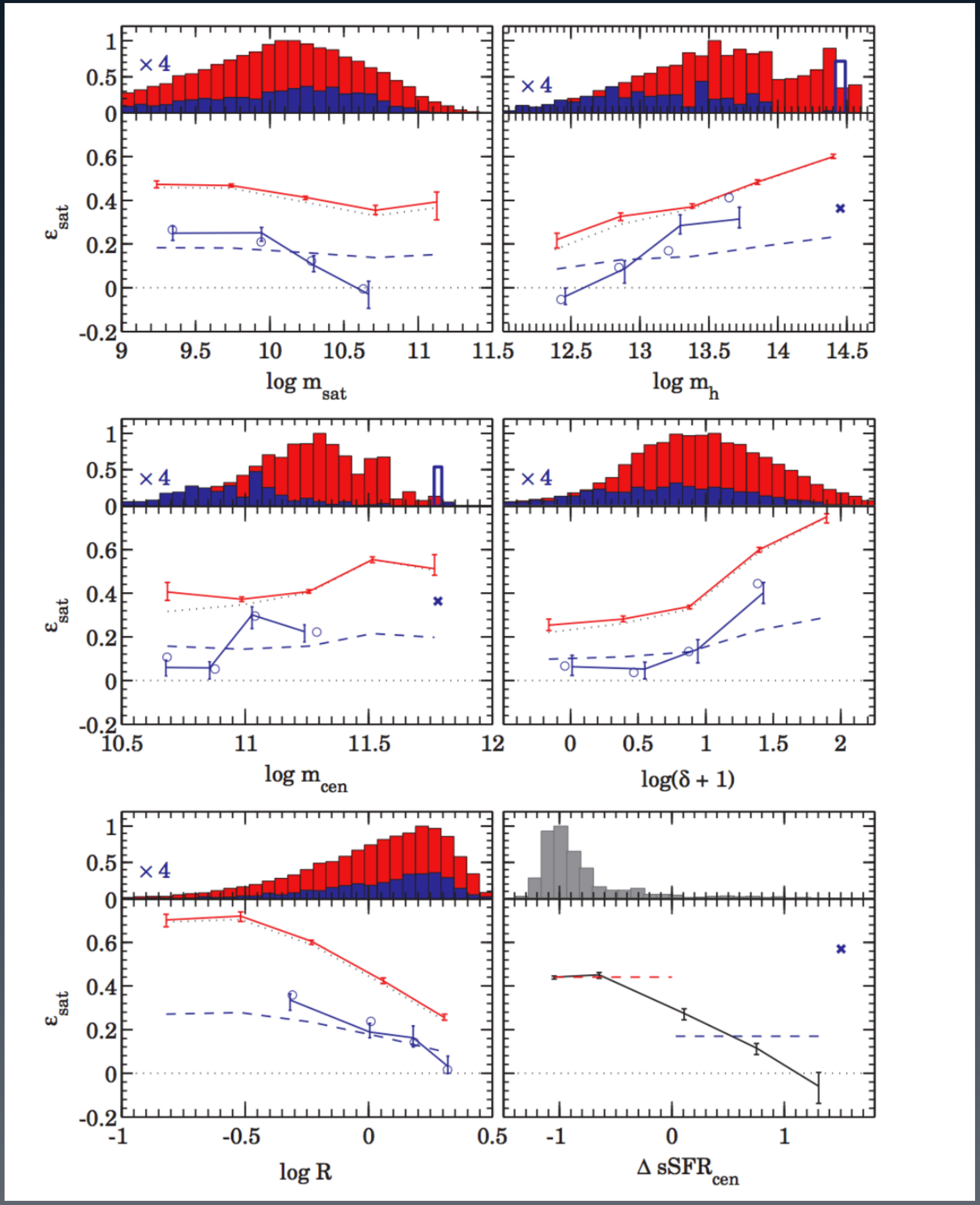




Weinmann et al. 2006

Calderon et al. 2017

Conformity



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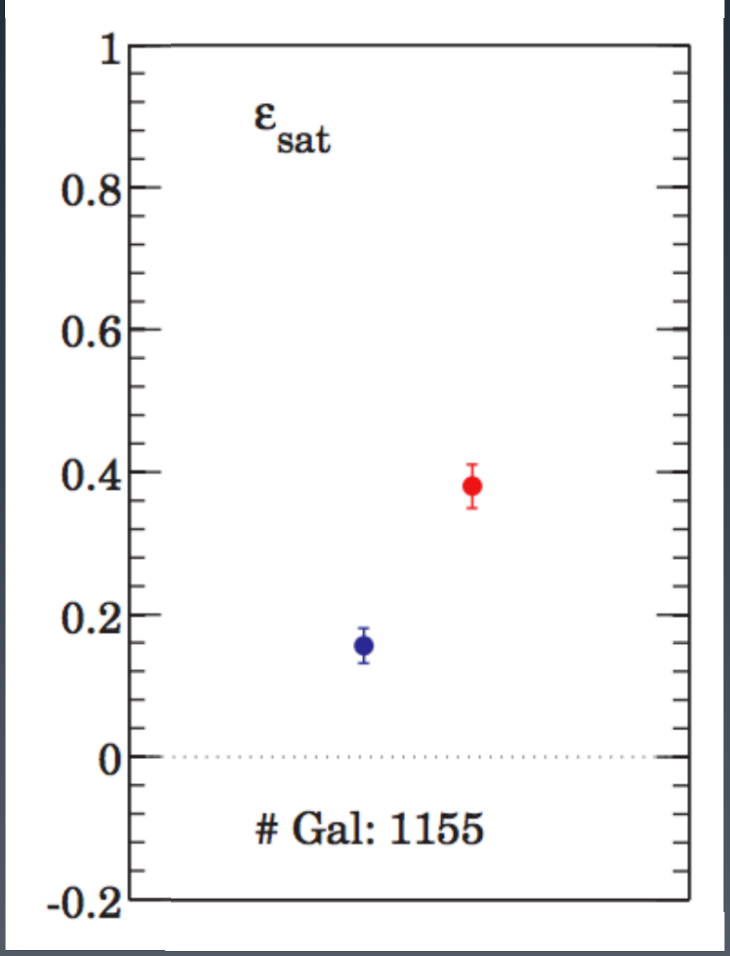
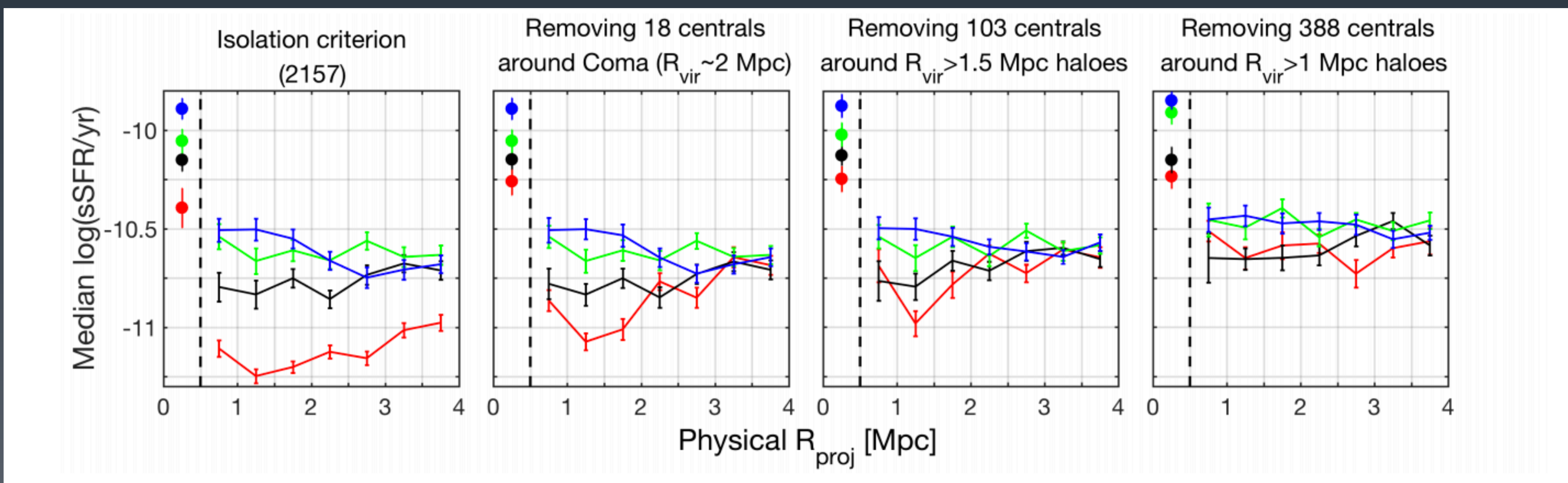


Knobel, Lilly, et al. 2015

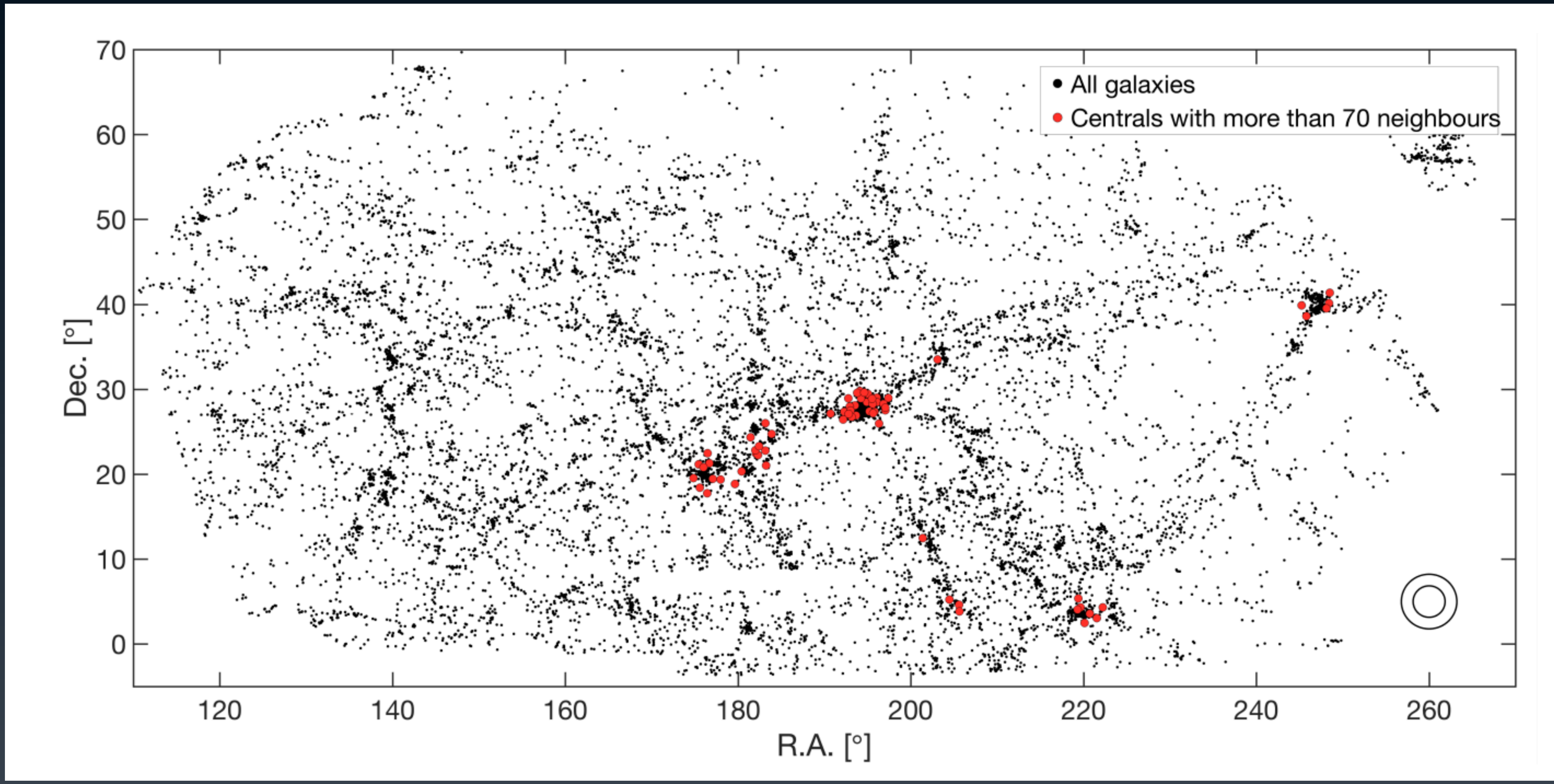
On the evidence for large-scale galactic conformity in the local Universe

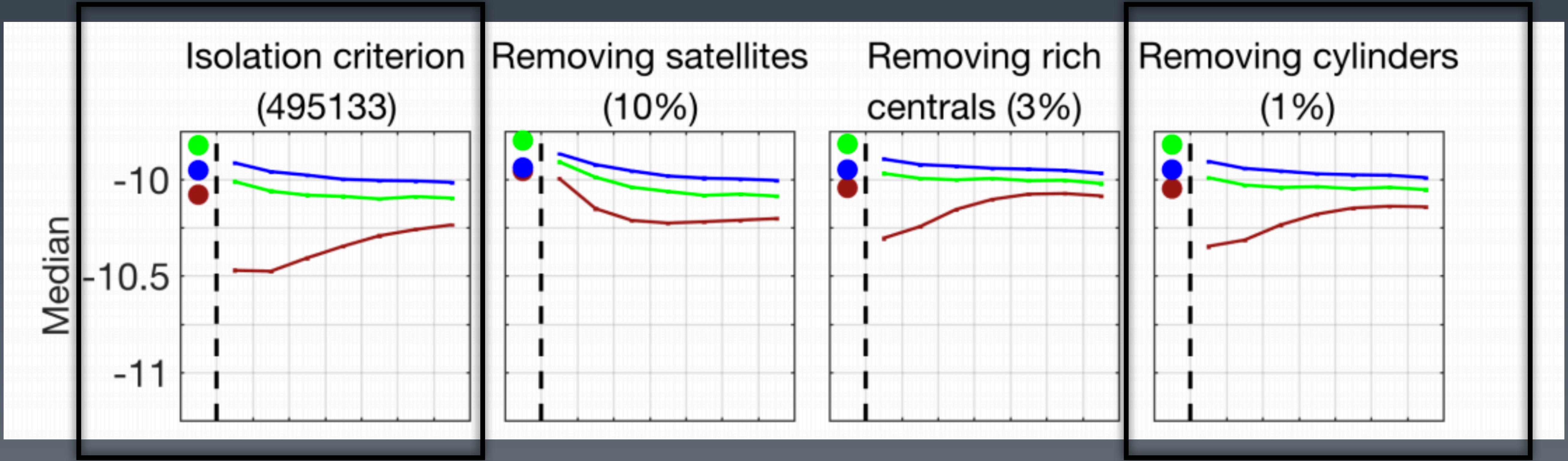
Larry P. T. Sin[1*], Simon J. Lilly[1], Bruno M. B. Henriques[1]

[1] *Institute for Astronomy, Department of Physics, ETH Zürich, CH-8093 Zürich, Switzerland*



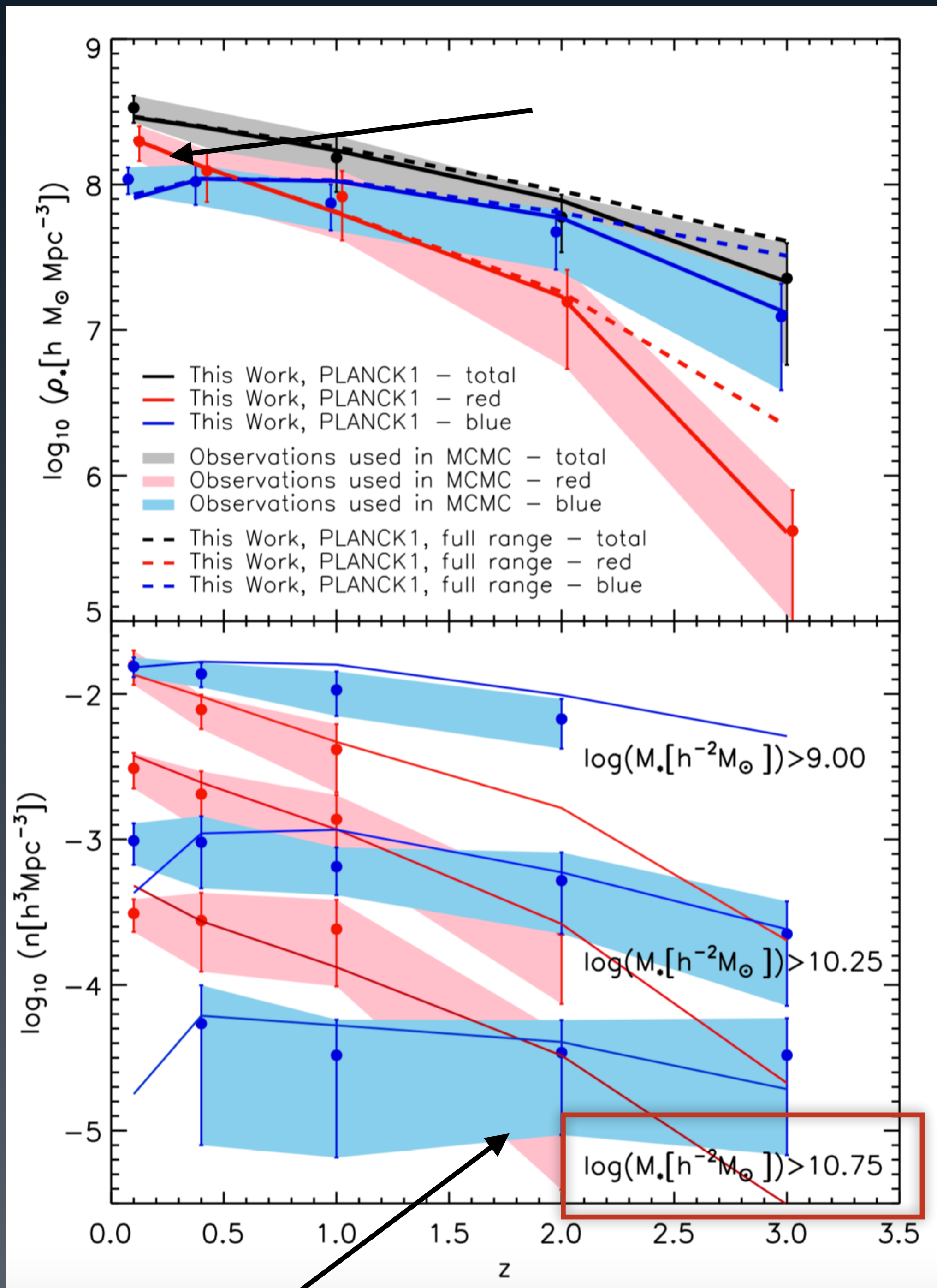
SDSS - DR7





L-Galaxies, Henriques2015

Properties of Massive Galaxies



More than 50% of the stellar mass density at z=0 is in quenched galaxies

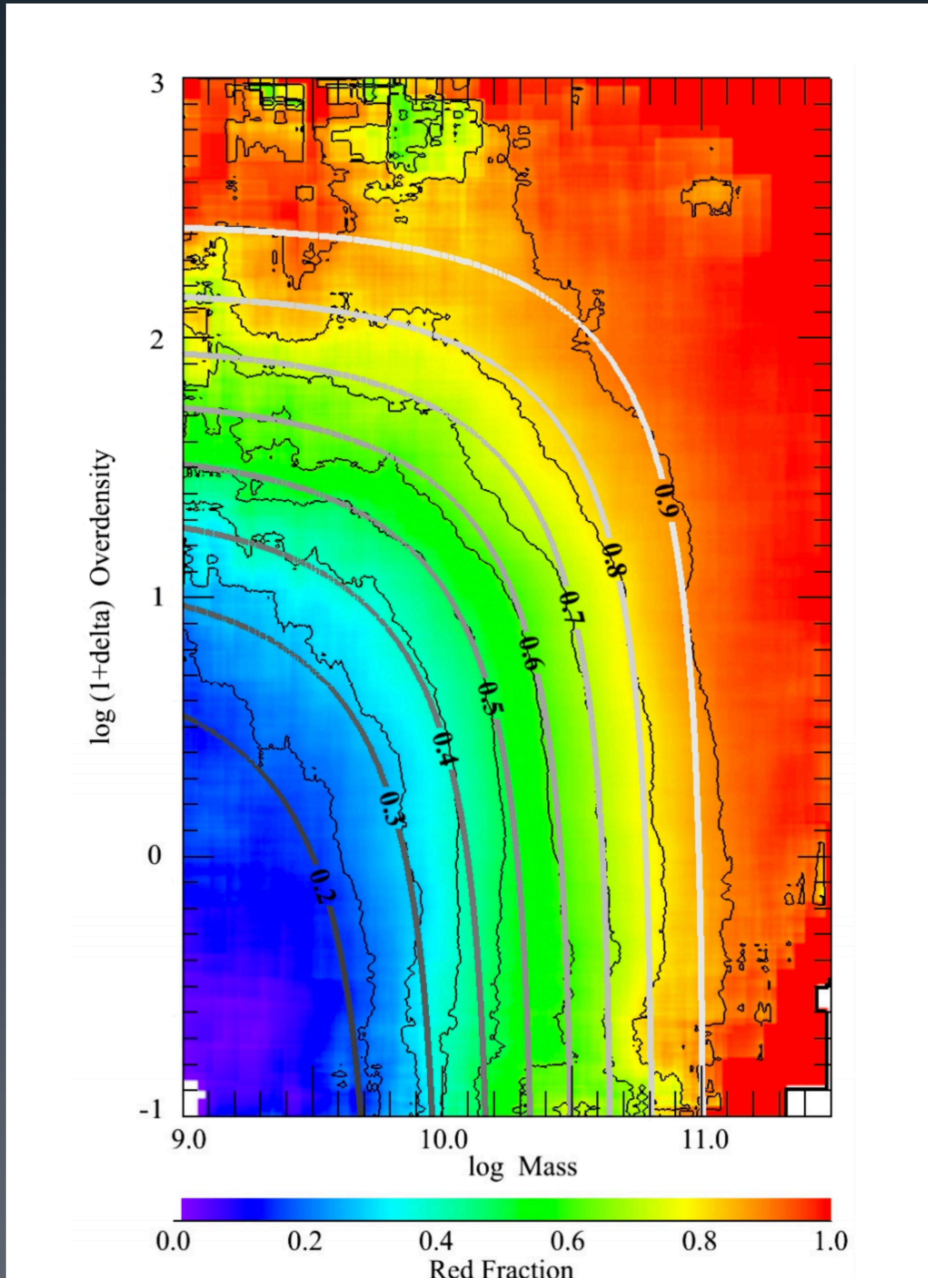
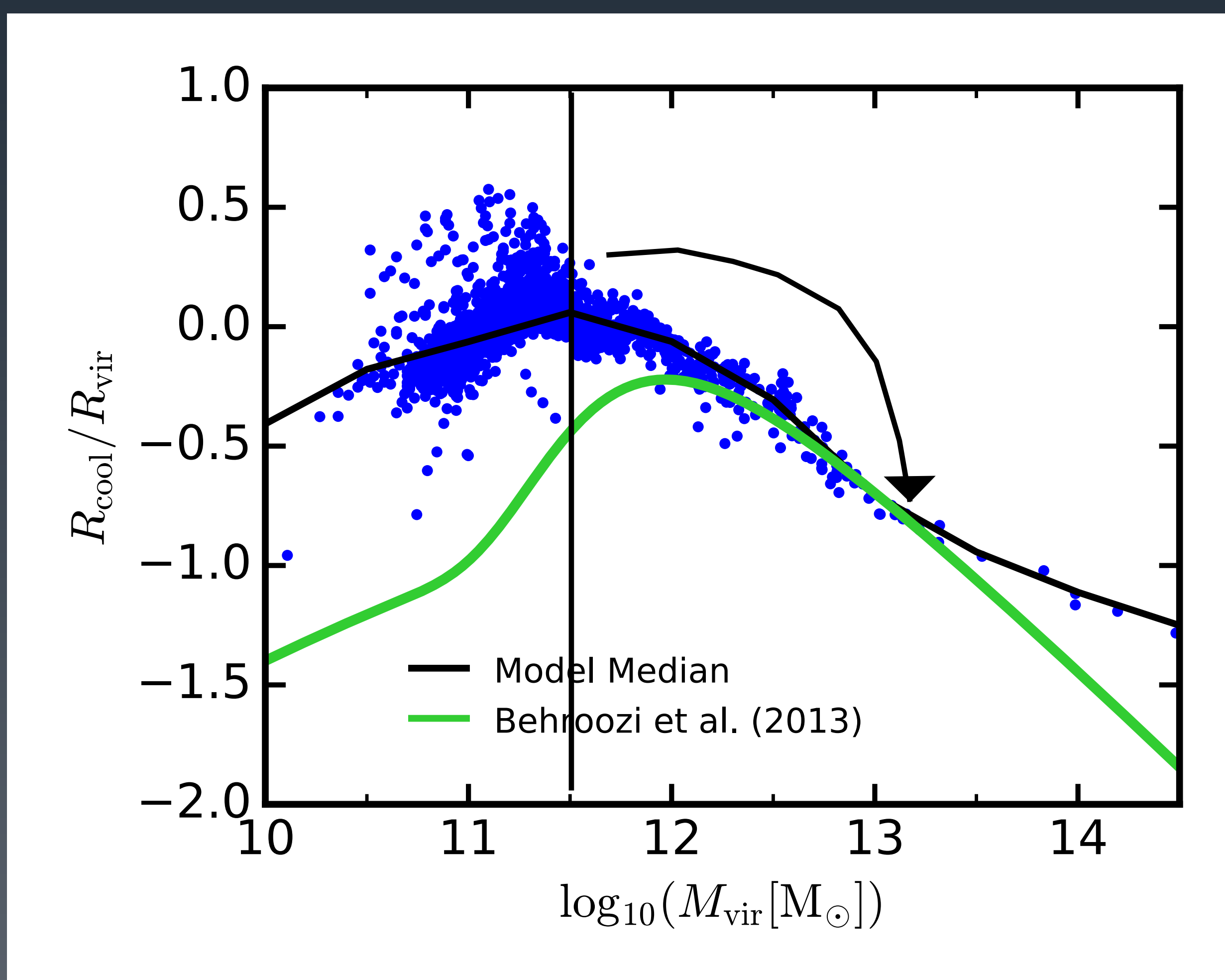


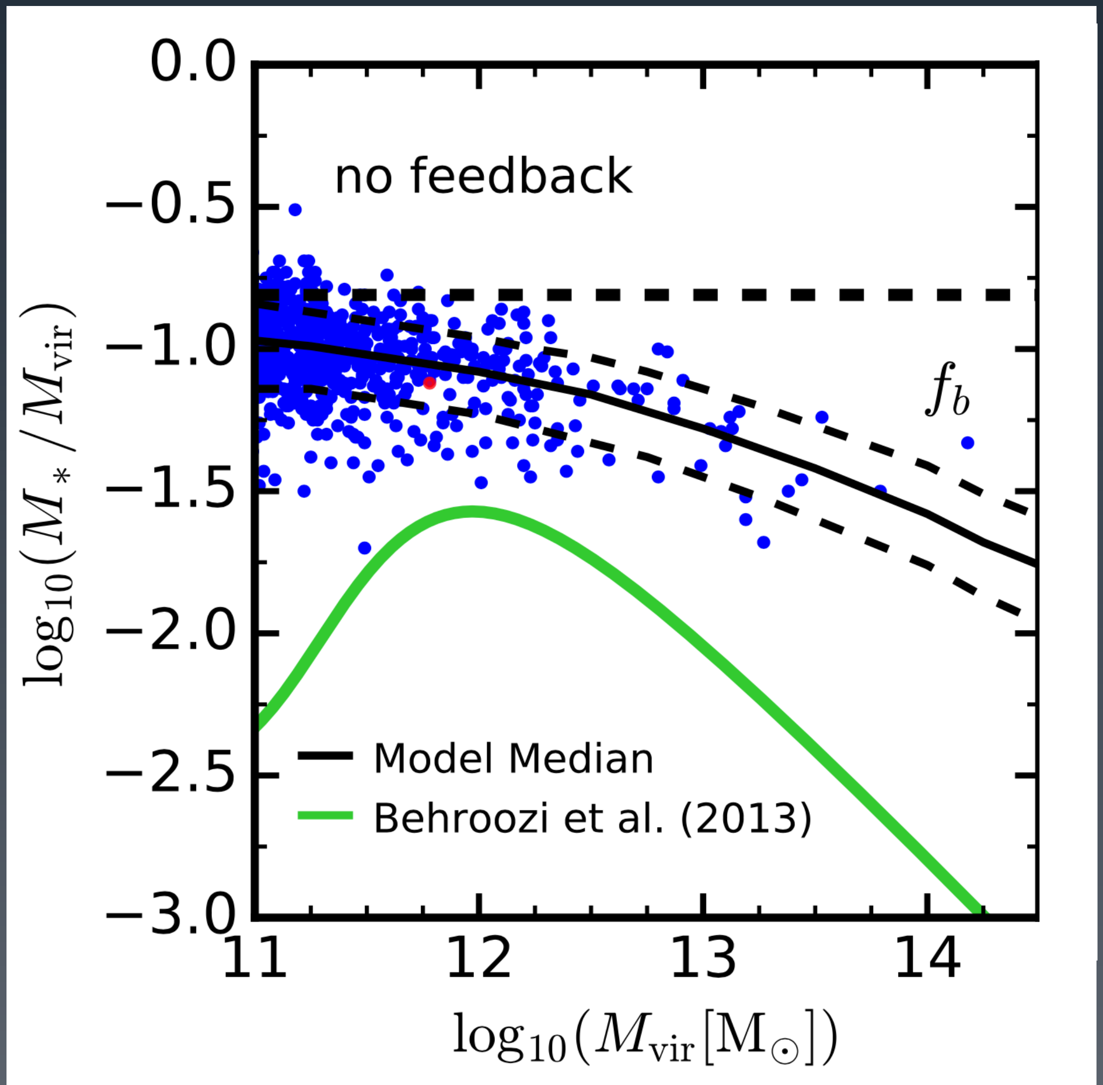
Fig 6: The red fraction in SDSS as functions of stellar mass and environment.

at z=2, 50% of the massive galaxies are already quenched

Shock Heating (longer cooling times >$10^{11.5}M_\odot$)

Although it seems that inefficient cooling could be enough, there is much more mass to cool at high masses due to the efficient cooling in lower masses

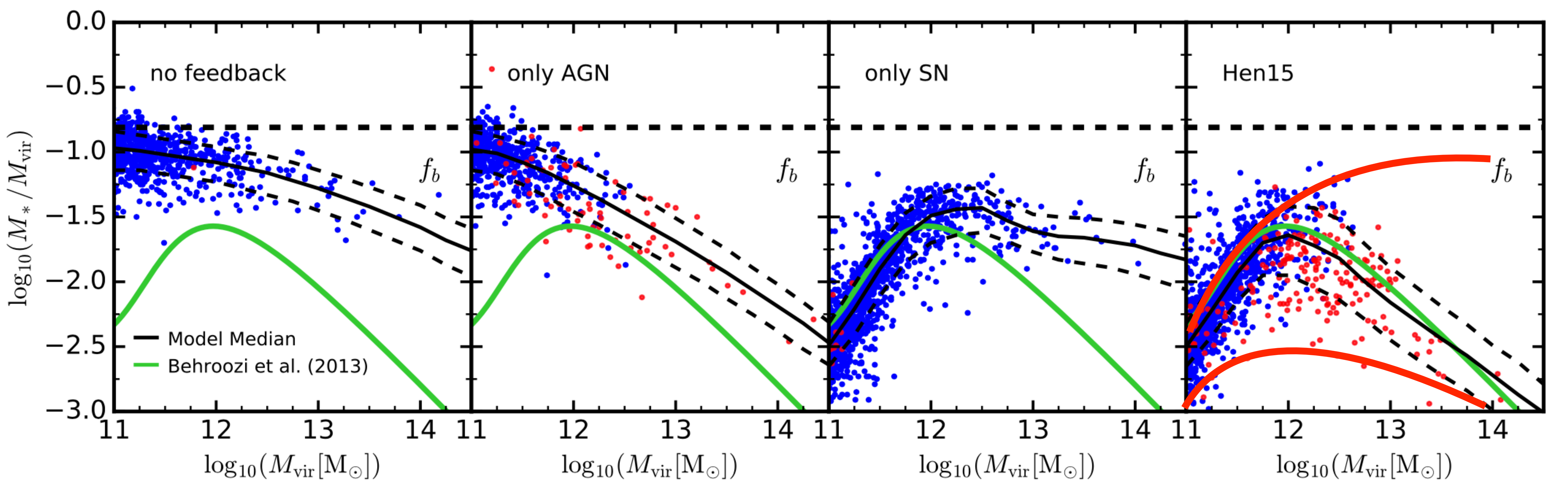




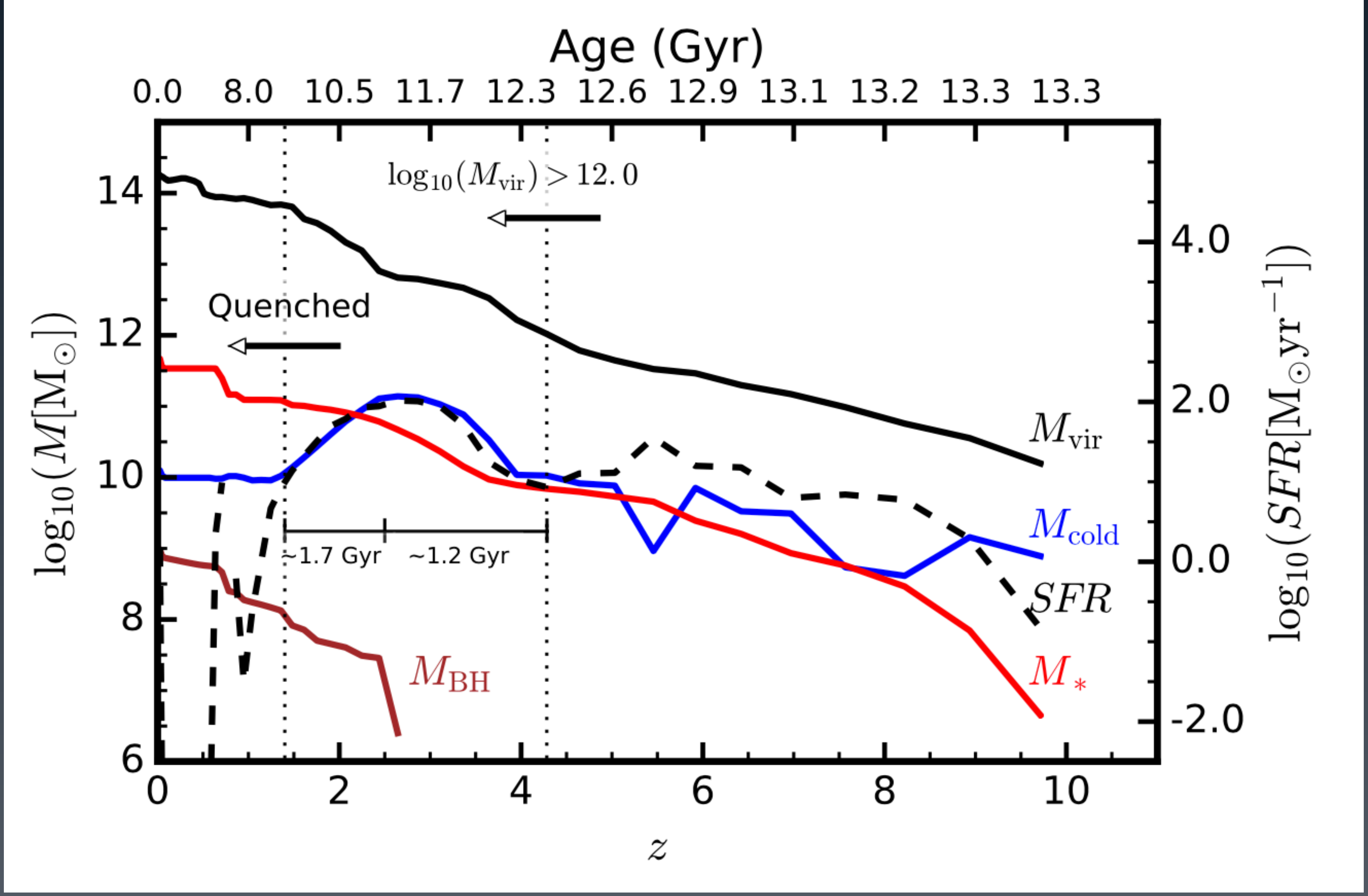
Supernovae are in control: the origin of the mass scales for maximal star formation efficiency and quenching in galaxies.

Bruno M. B. Henriques[1*], Simon D. M. White[2], Simon Lilly[1], Eric Bell[3], Asa Bluck[1], Bryan Terrazas[3]

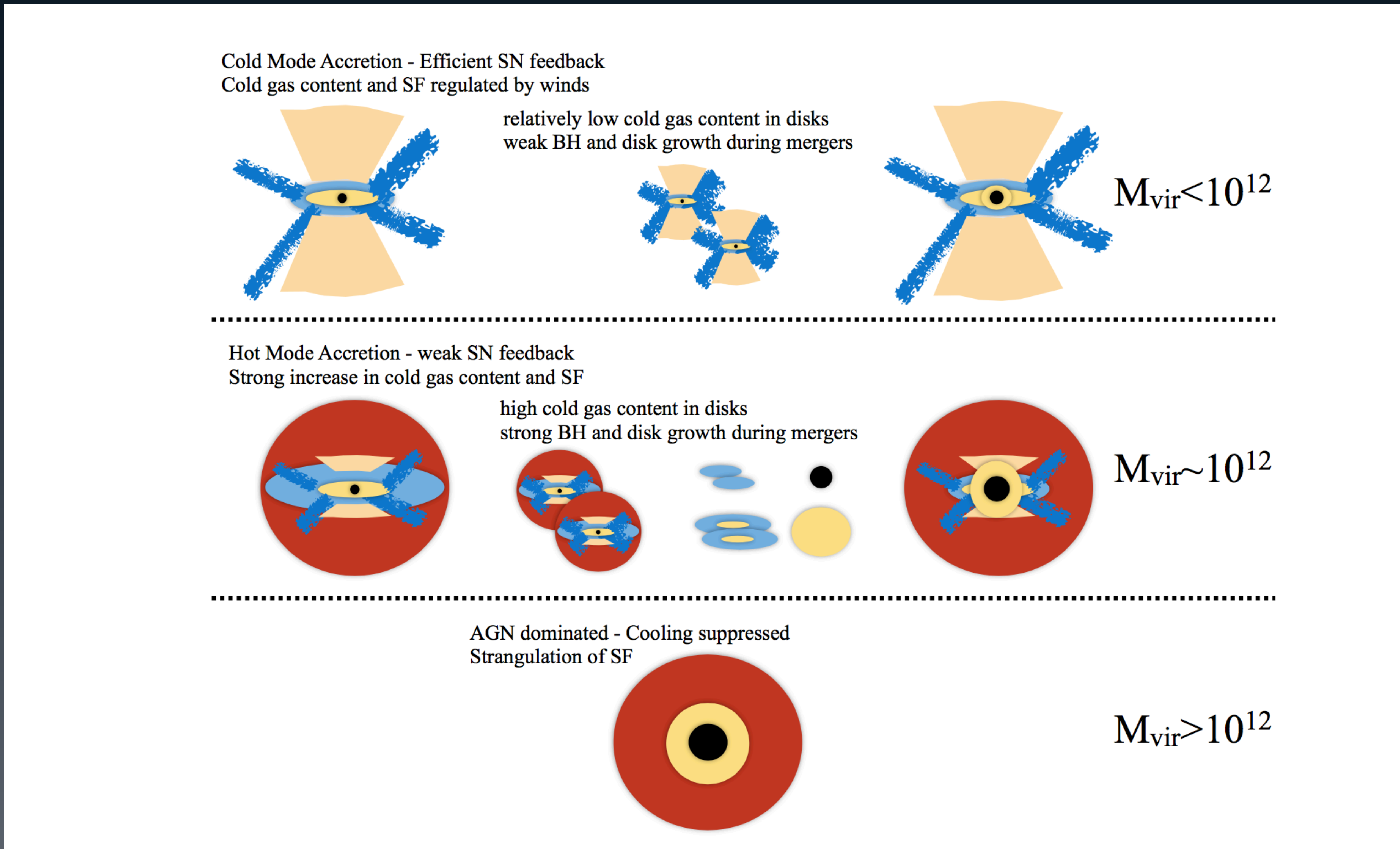
[1] *Institute for Astronomy, ETH Zurich, CH-8093 Zurich, Switzerland*
[2] *Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Str. 1, D-85741 Garching b. München, Germany*
[3] *Department of Astronomy, University of Michigan, Ann Arbor, MI 48109, USA*



Halos create a mass scale at which SN ejection becomes inefficient. This is followed by a period of strong SF and BH growth and quenching shortly after.



also seen in Dubois et al. 2015 (Horizon-AGN)
and Bower et al. 2017 (EAGLE)


Cold Mode Accretion - Efficient SN feedback
Cold gas content and SF regulated by winds
relatively low cold gas content in disks
weak BH and disk growth during mergers
$M_{vir}<10^{12}$
Hot Mode Accretion - weak SN feedback
Strong increase in cold gas content and SF
high cold gas content in disks
strong BH and disk growth during mergers
$M_{vir}\sim10^{12}$
AGN dominated - Cooling suppressed
Strangulation of SF
$M_{vir}>10^{12}$