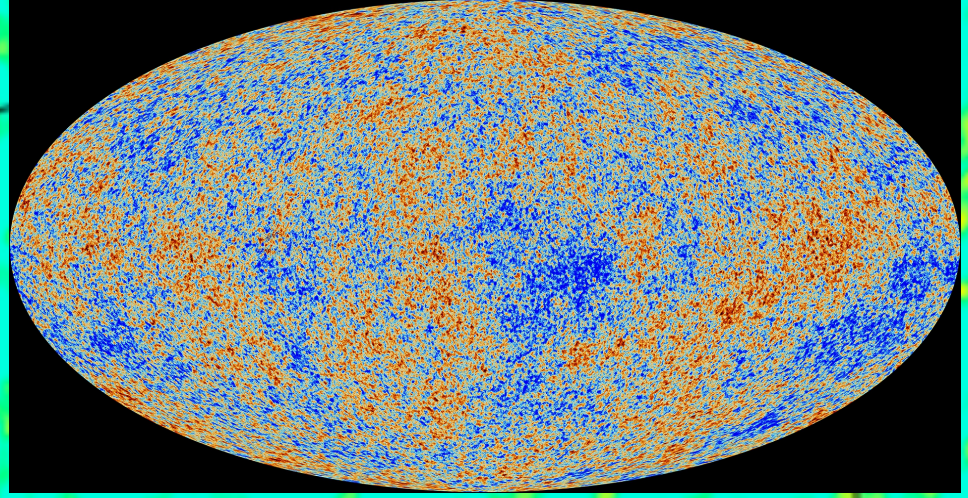


Hawaii, IAU
August 2015

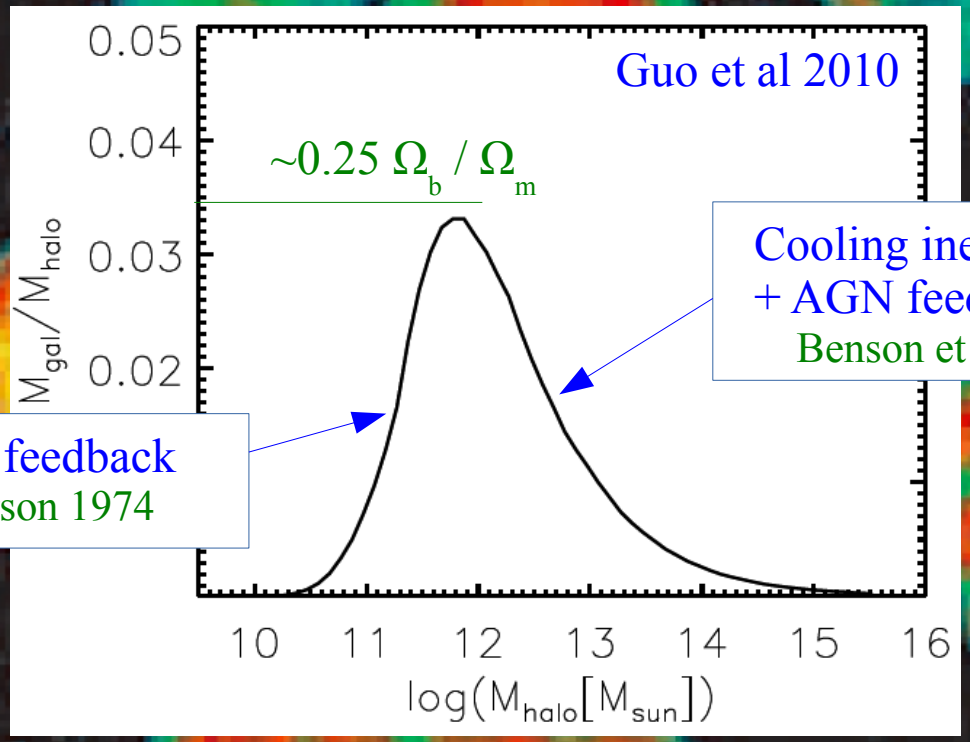
The gas content of dark halos

Simon White
Max Planck Institute for Astrophysics

Central galaxies contain <25% of the expected baryons within halos

In rich clusters most of the expected baryons are in the IGM, but in lower mass halos most are “missing”

Blown out? How far? What state are they in? How to see them?

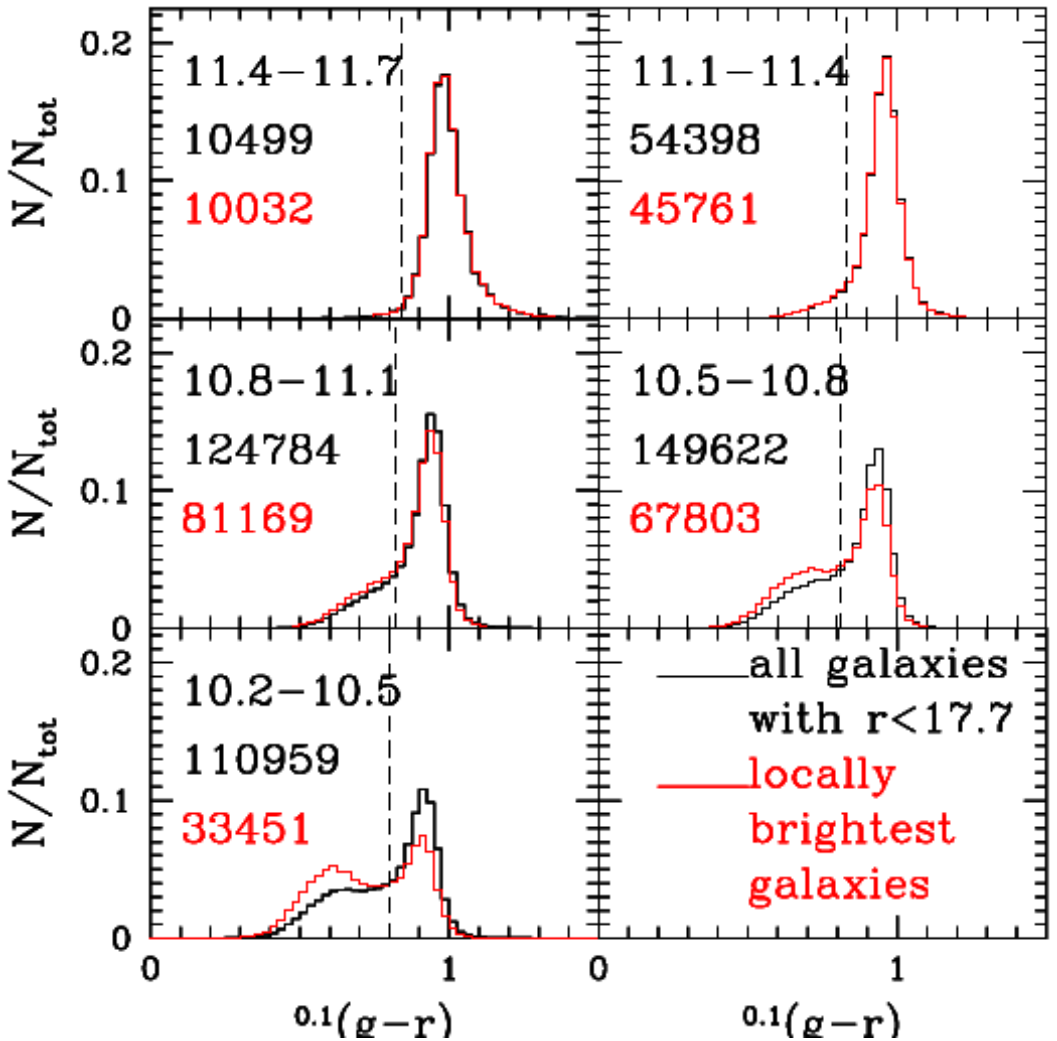


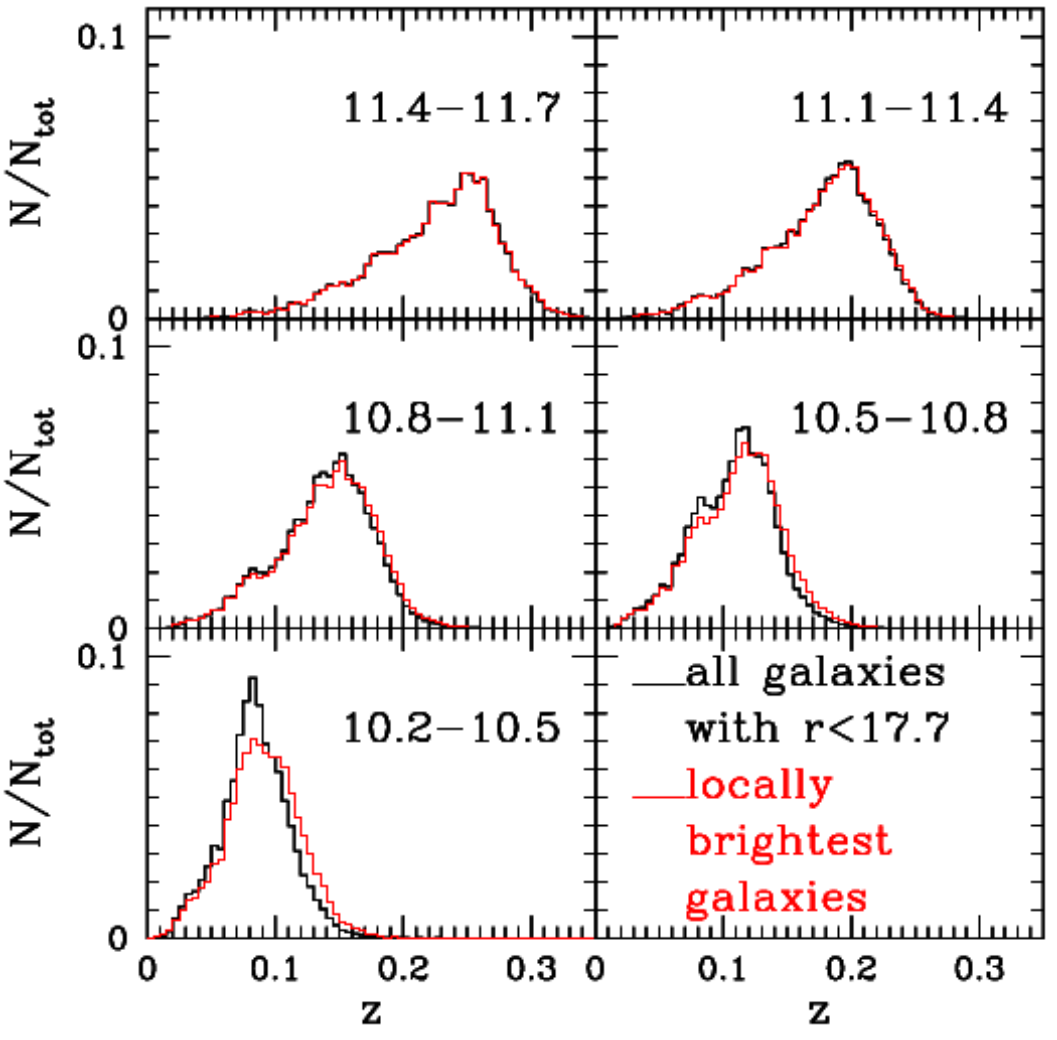
Locally brightest galaxies as halo proxies

SDSS/DR7: $r < 17.7$, $z > 0.03$

Brighter than all neighbours with $r_p < 1.0$ Mpc, $\Delta z < 1{,}000$ km/s

Planck Collaboration 2013





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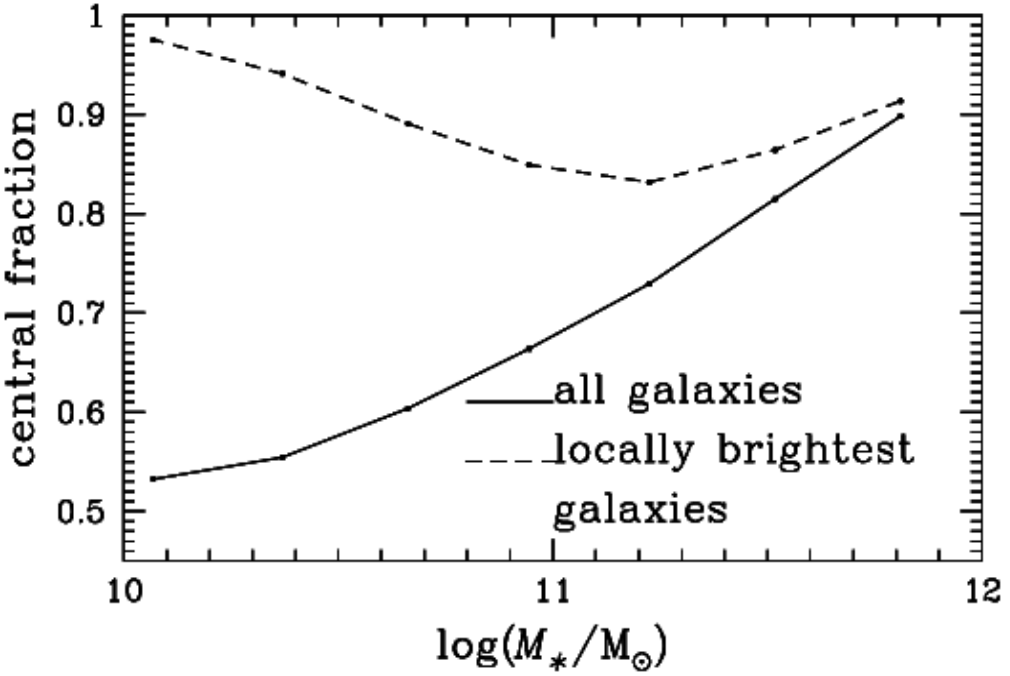
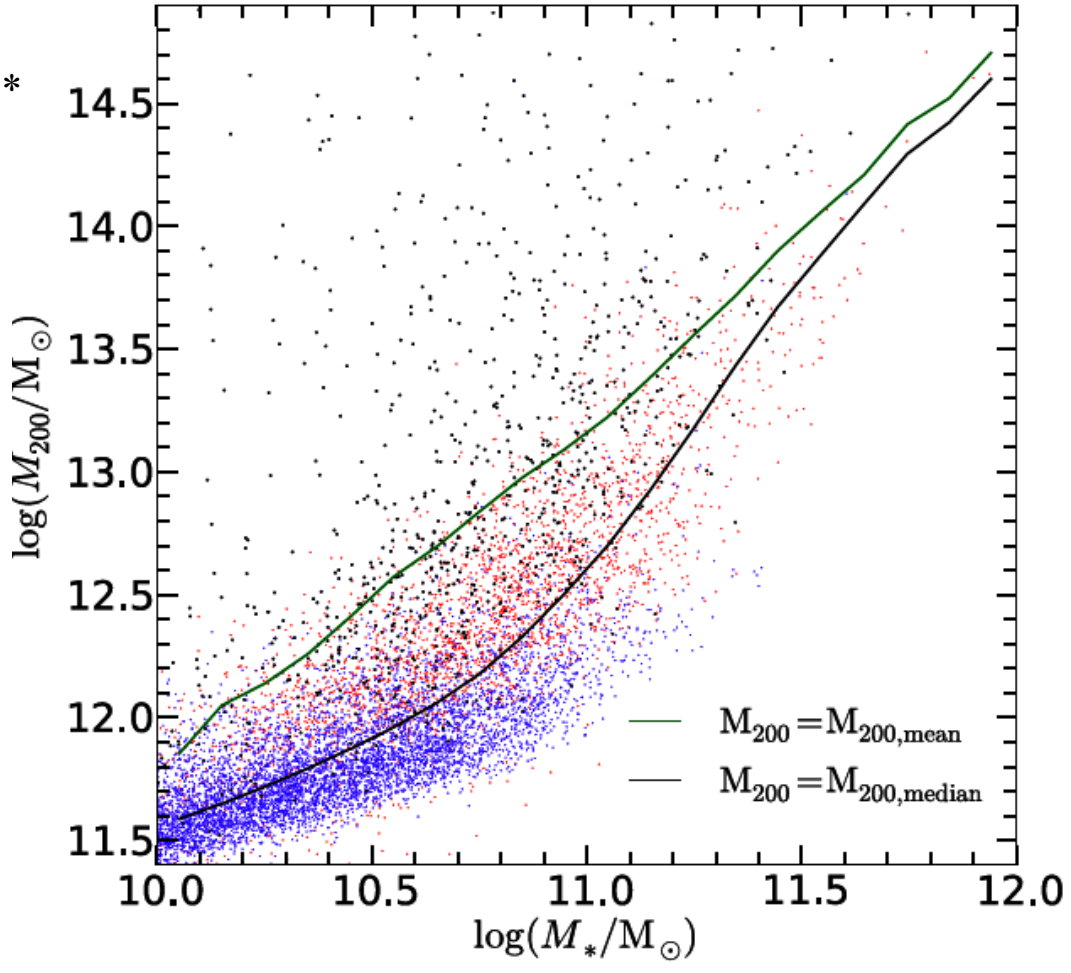
Mock light-cone: Guo et al (2013) simulation in the WMAP7 cosmology

>83% of LBGs are halo centrals

Large spread in M_{200} at given M_*

Planck Collaboration 2013





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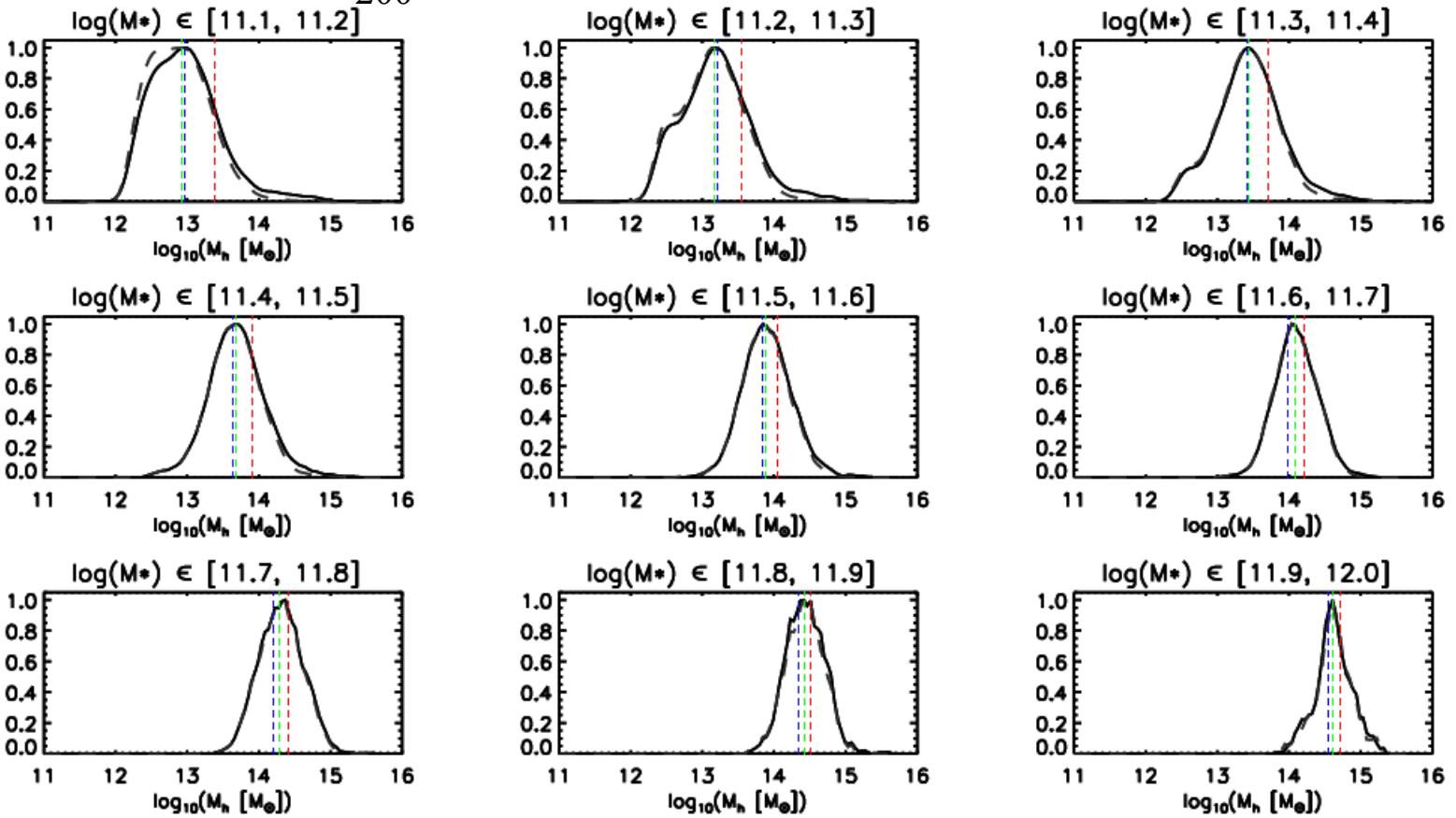
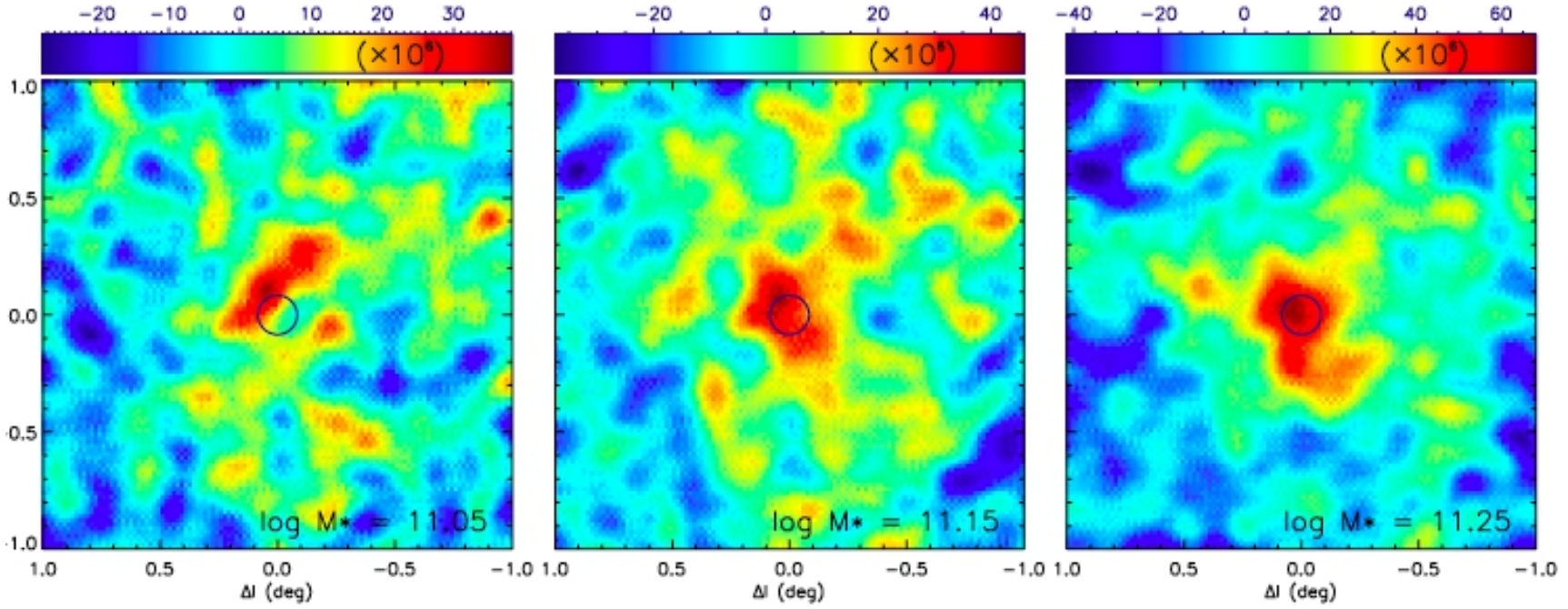
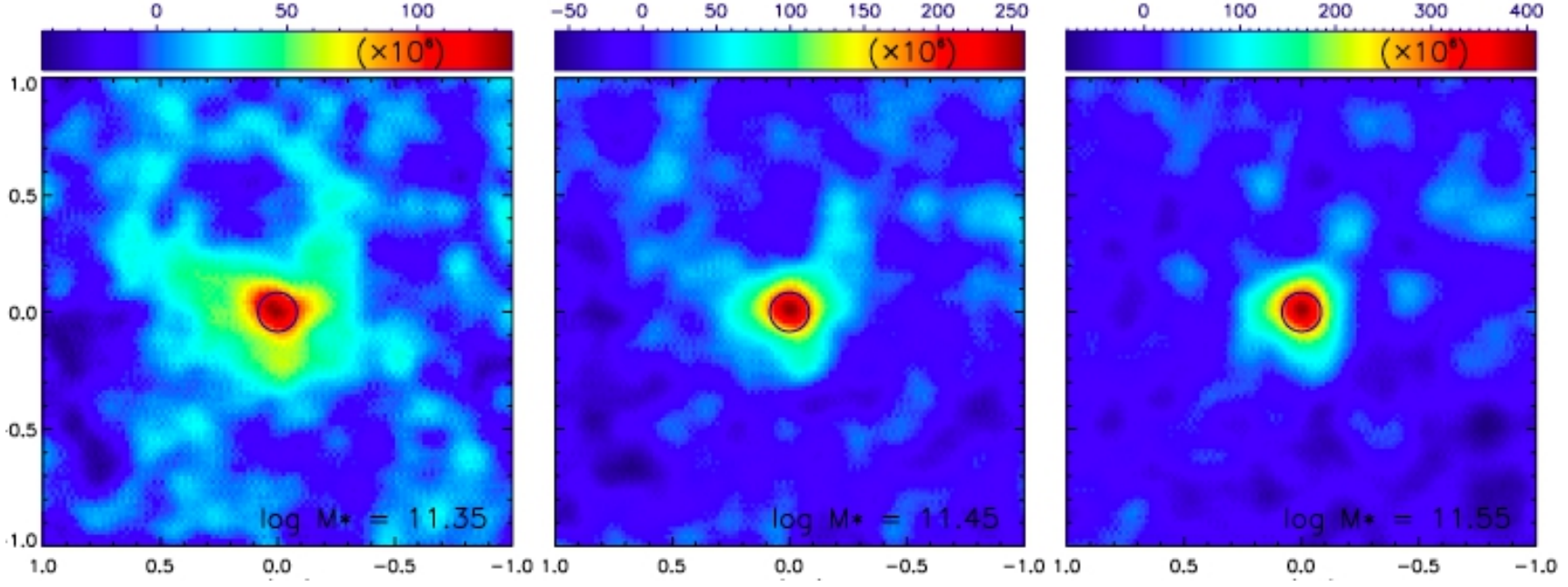


Stacked images of the Planck SZ signal from LBGs

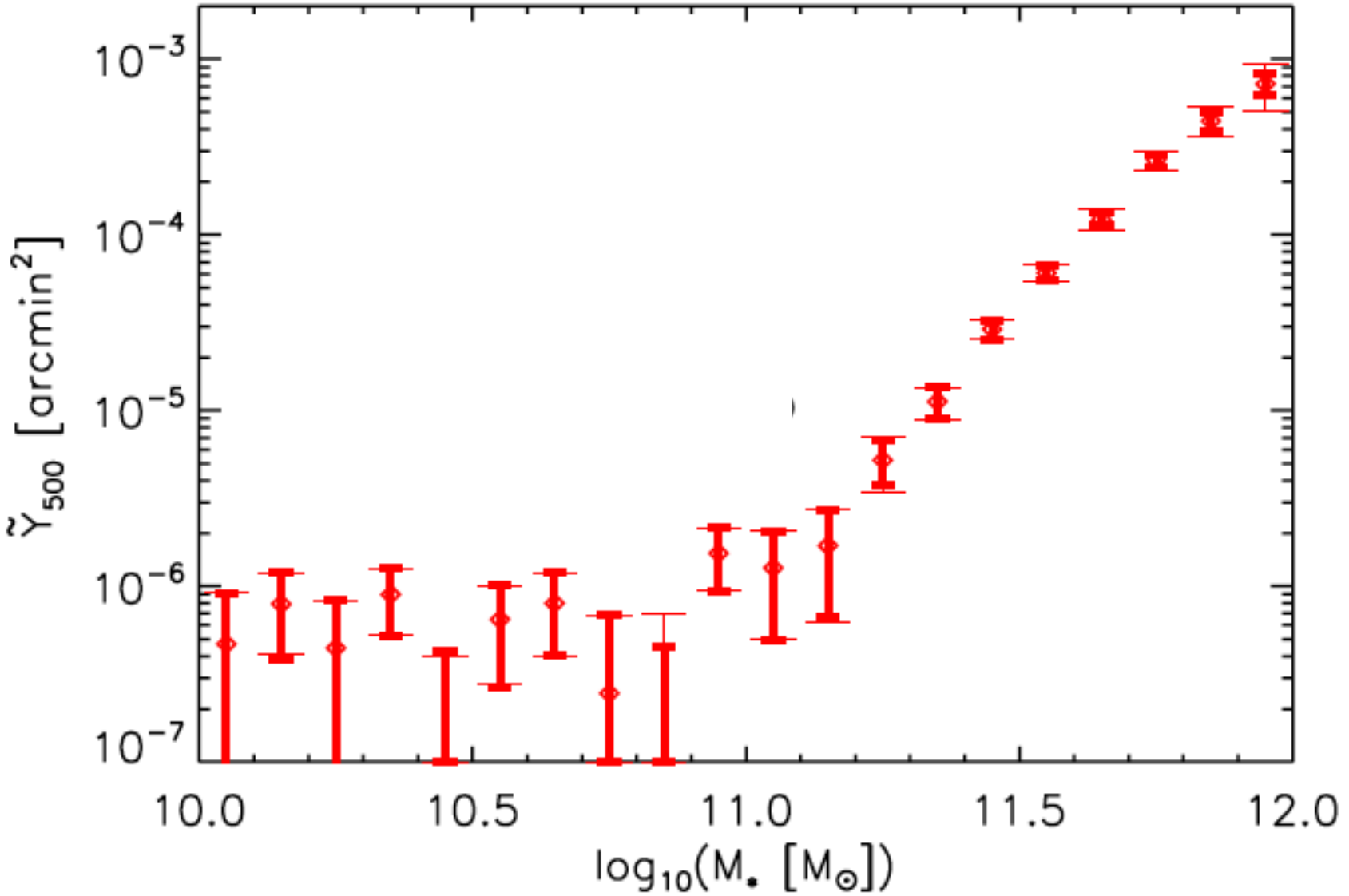


Planck Collaboration 2013



Stacked Planck SZ signal from LBGs

Planck Collaboration 2013



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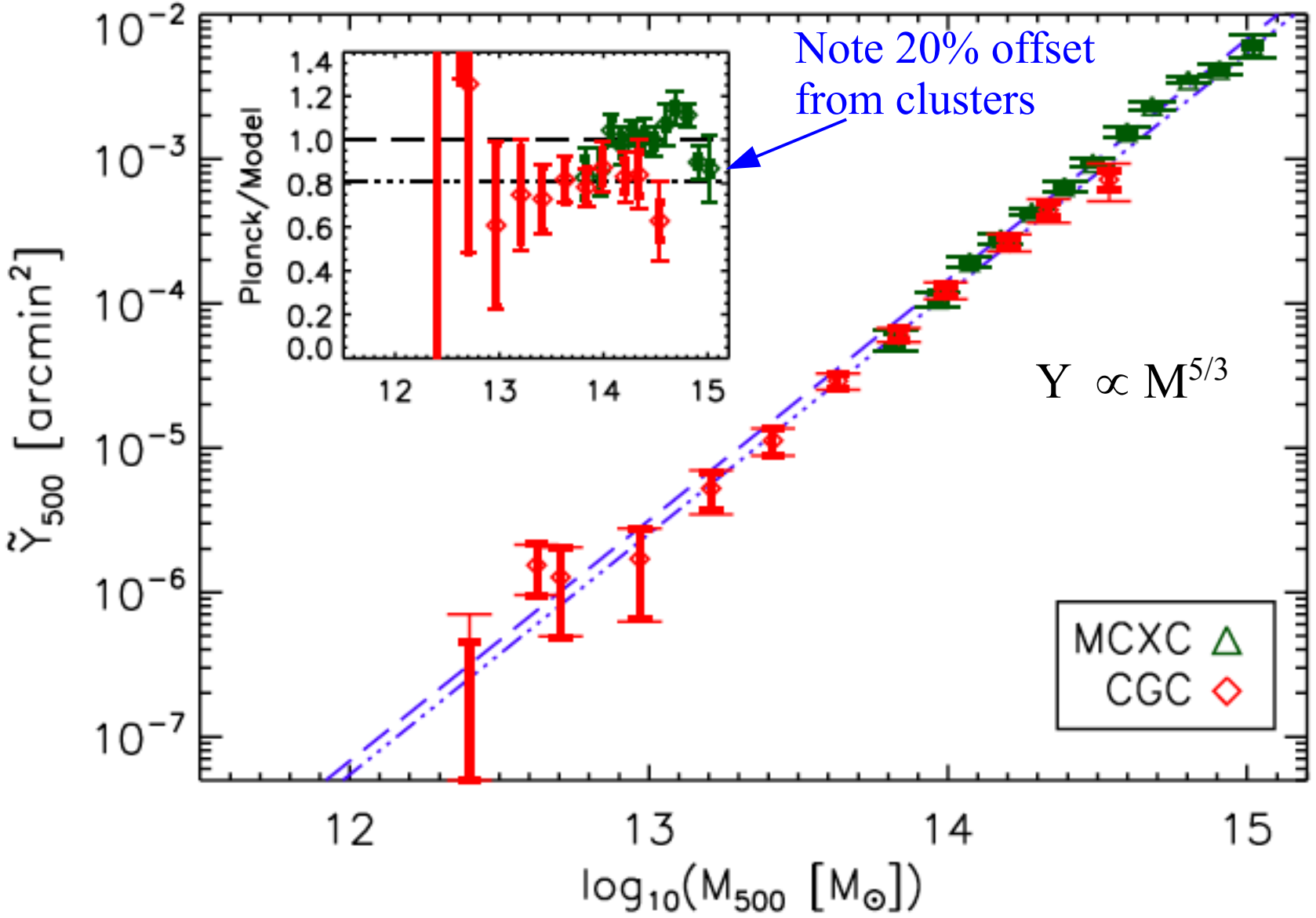

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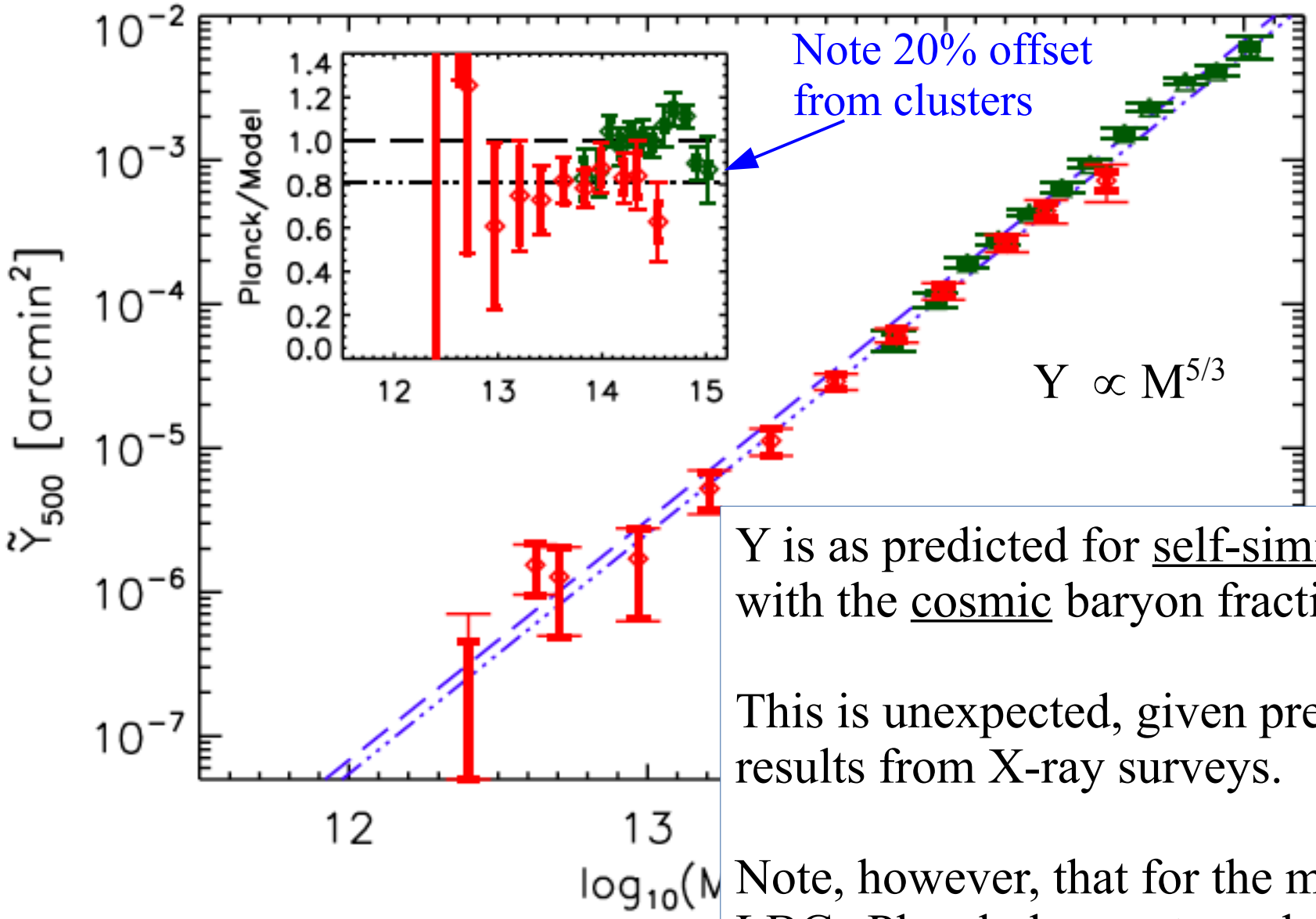


Y is as predicted for <u>self-similar</u> halos with the <u>cosmic</u> baryon fraction

This is unexpected, given previous results from X-ray surveys.

Note, however, that for the majority of LBGs Planck does <u>not</u> resolve R_{500}

Stacked Rosat X-ray signal from LBGs

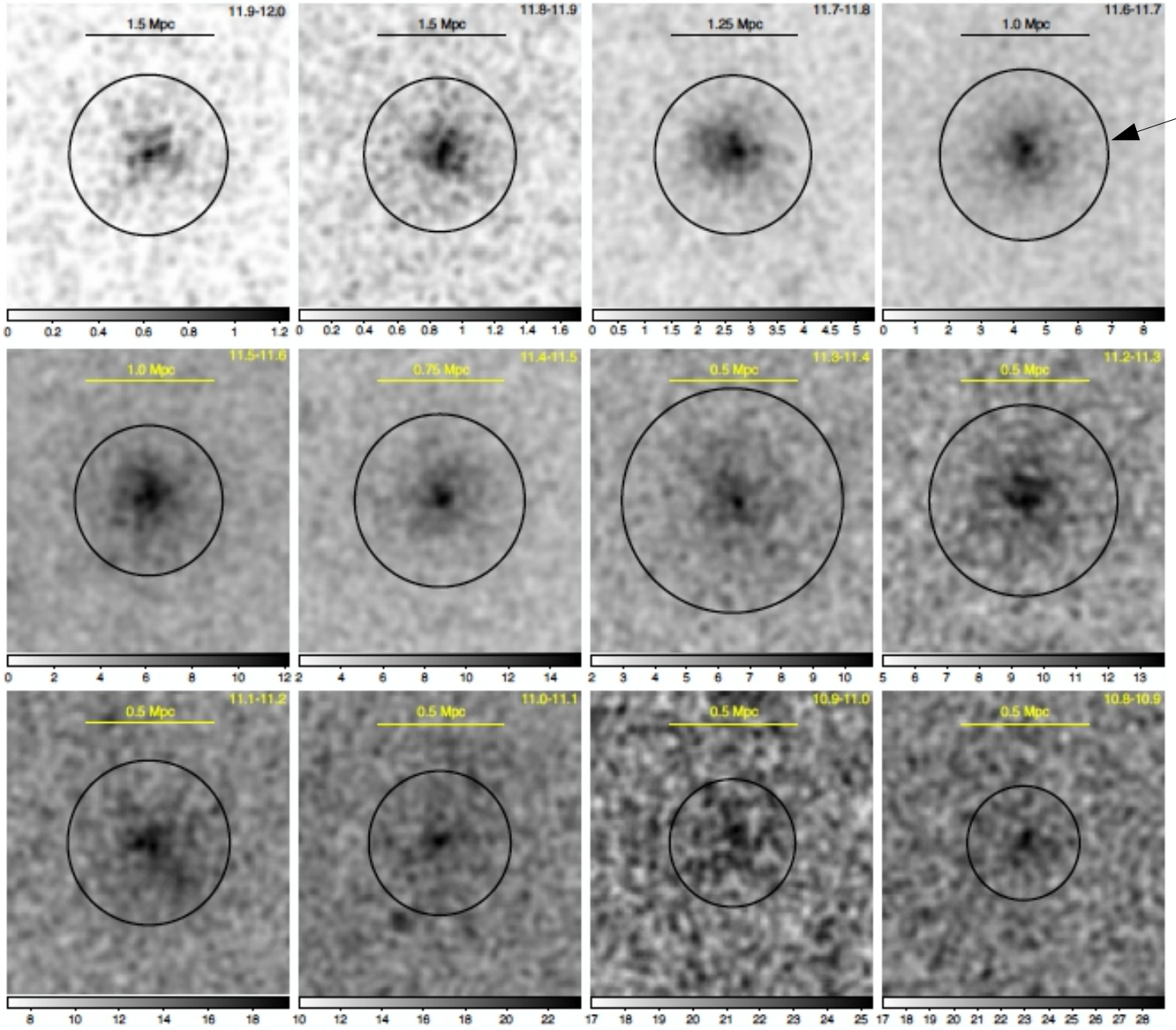
log M_*

Anderson et al 2015

11.9 – 12.0

11.5 – 11.6

11.1 – 11.2

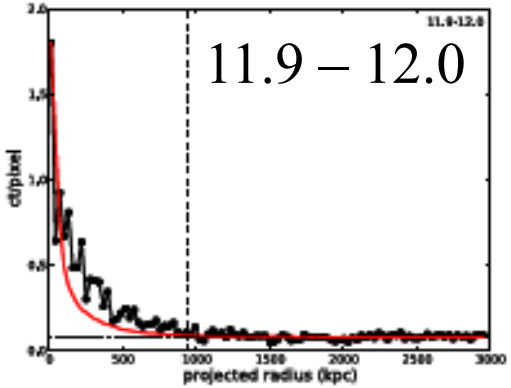


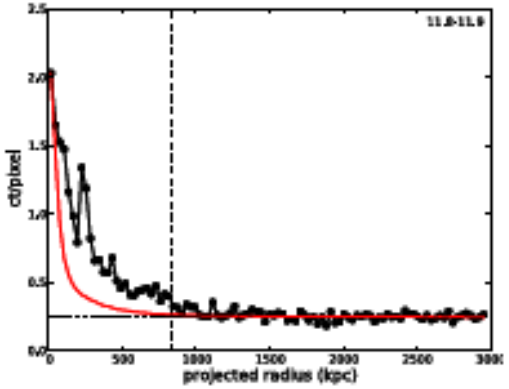
R_{500}

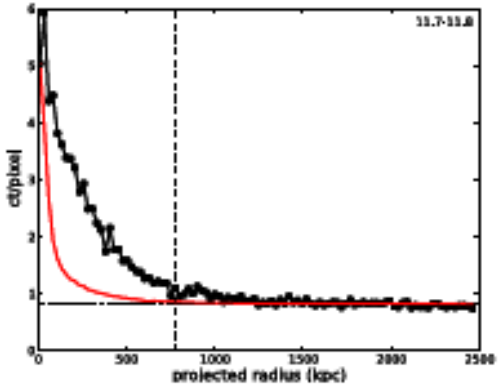
Stacked Rosat X-ray signal from LBGs

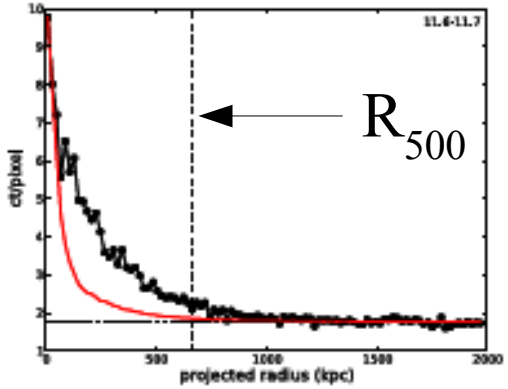
log M_*

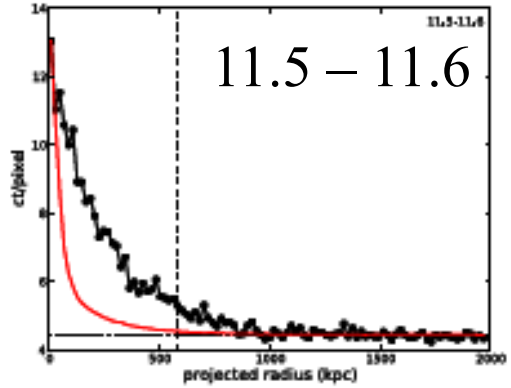
Anderson et al 2015

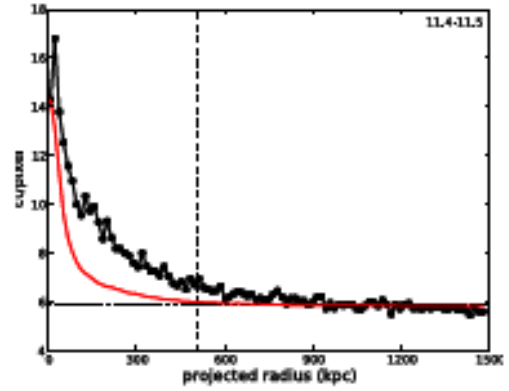


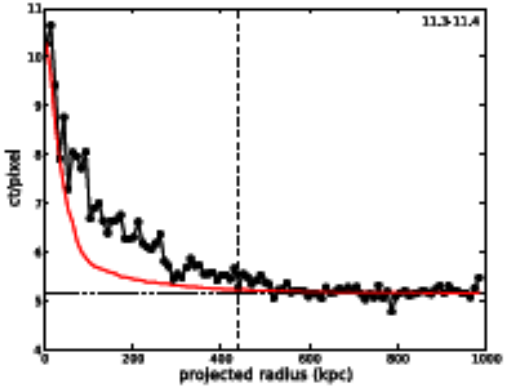


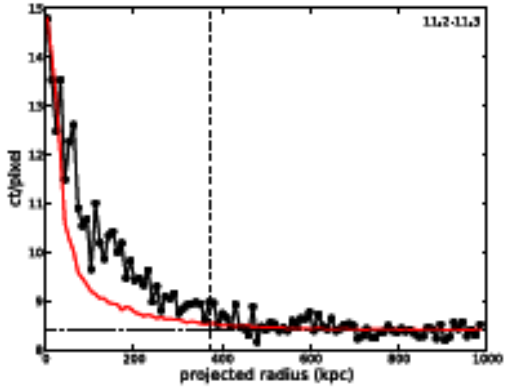


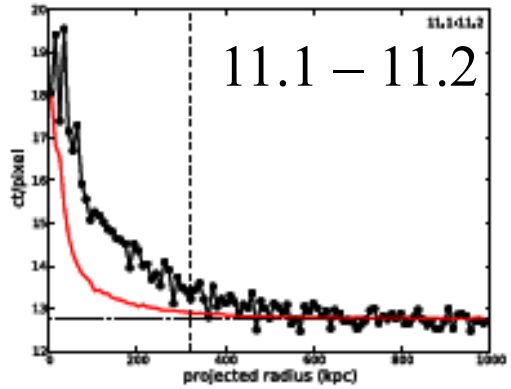


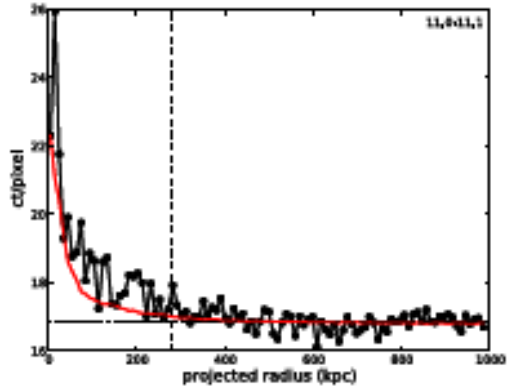


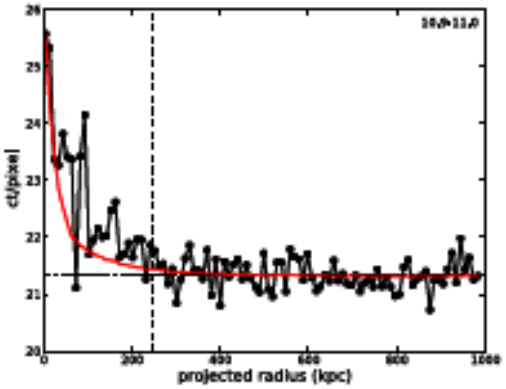


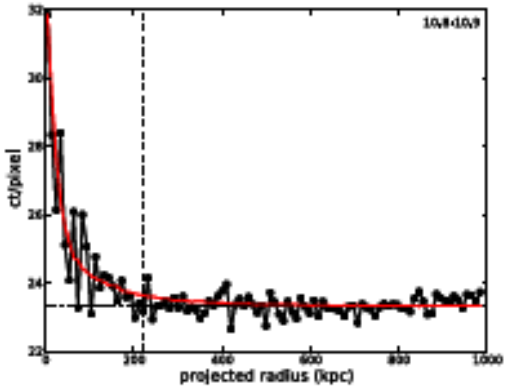






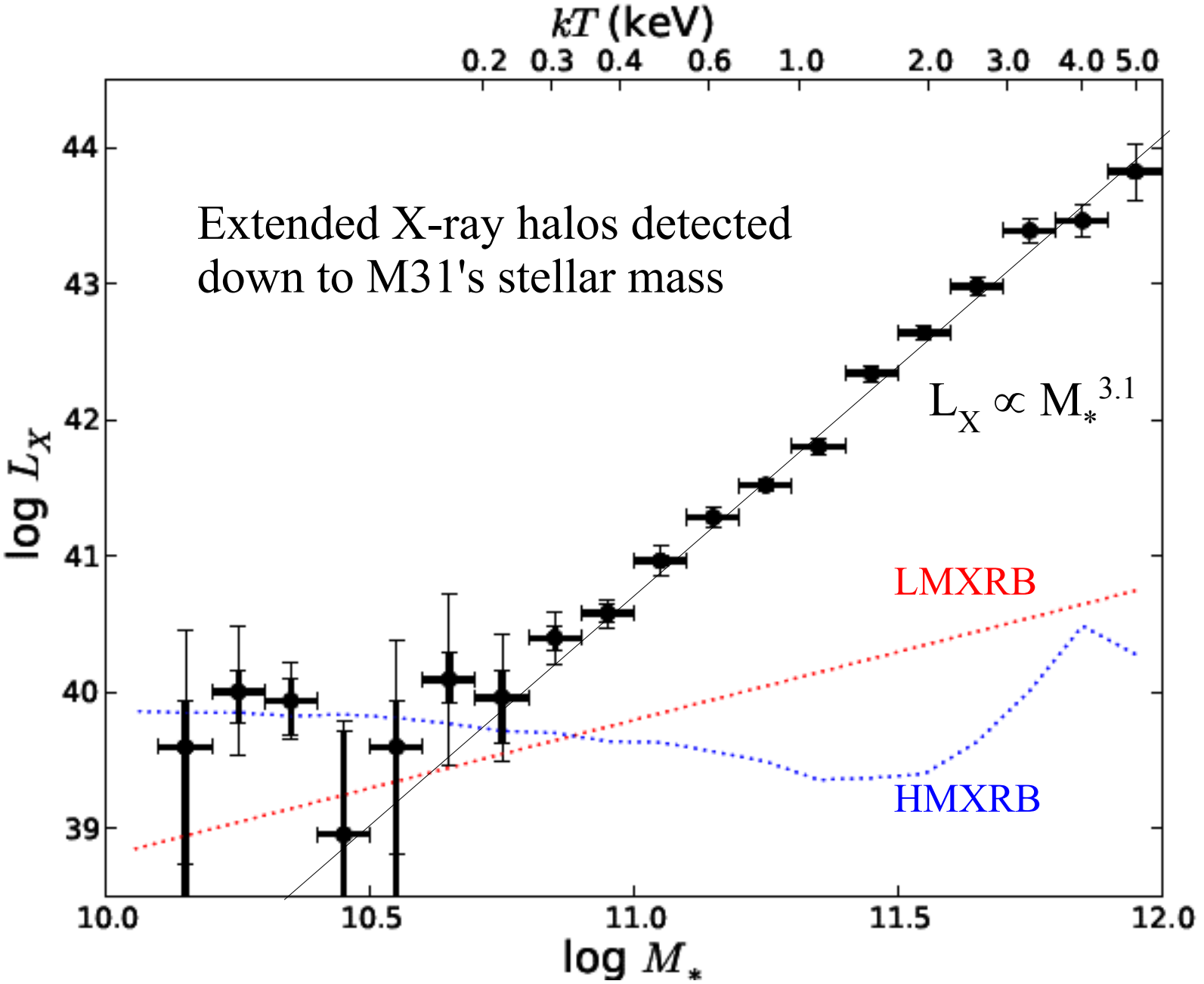






Stacked Rosat X-ray signal from LBGs

Anderson et al 2015



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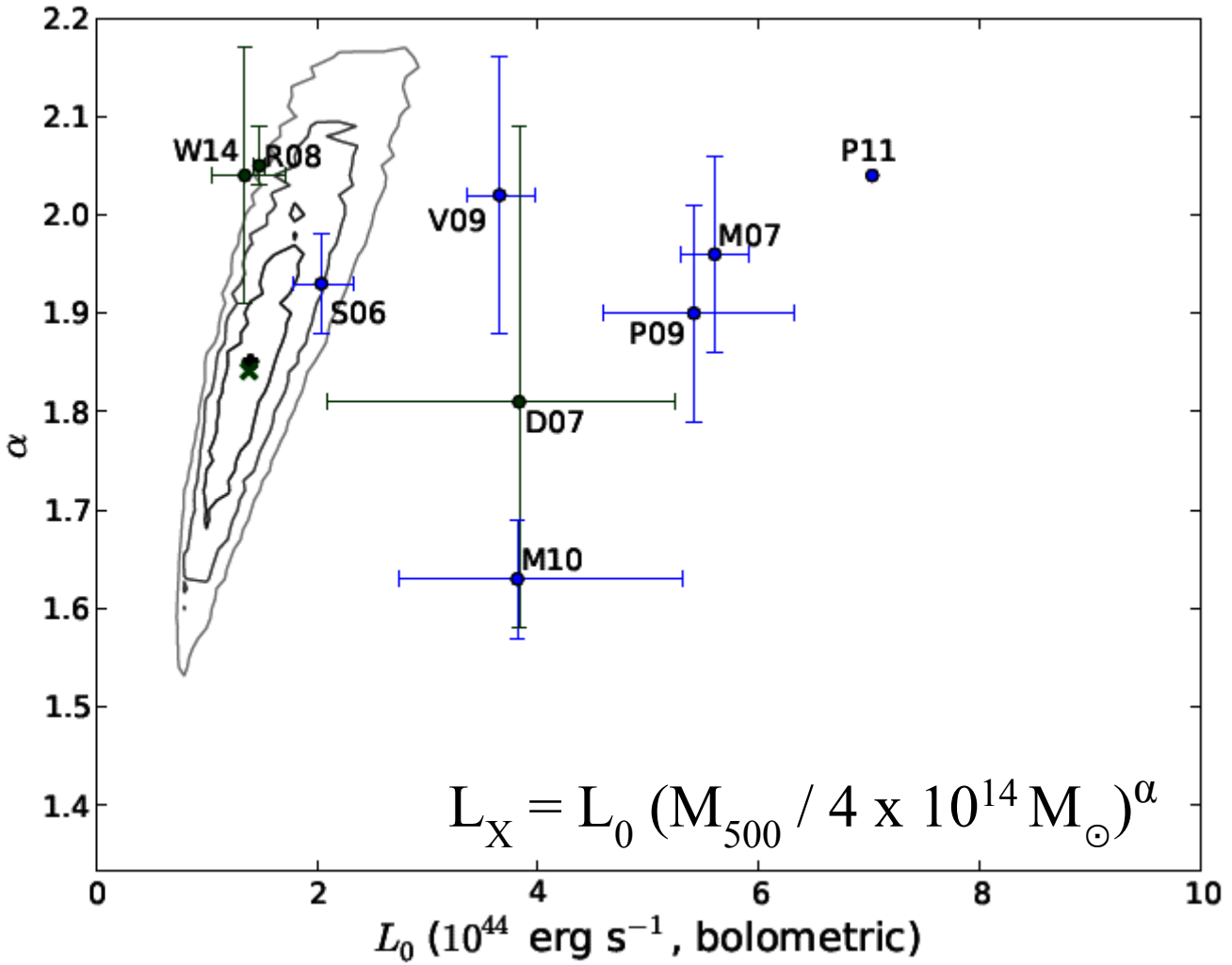

Anderson et al 2015

$\alpha = 4/3$ is expected for self-similar halos with constant baryon fraction

X-ray luminosity grows much faster with mass than this

Forward modelling using the Guo13 mock LBG catalogue gives 1, 2 and 3σ ranges for the parameters of the $L_X - M_{500}$ relation

→ rough agreement with results for optically selected clusters

<u>disagreement</u> in normalisation with results for X-ray selected clusters

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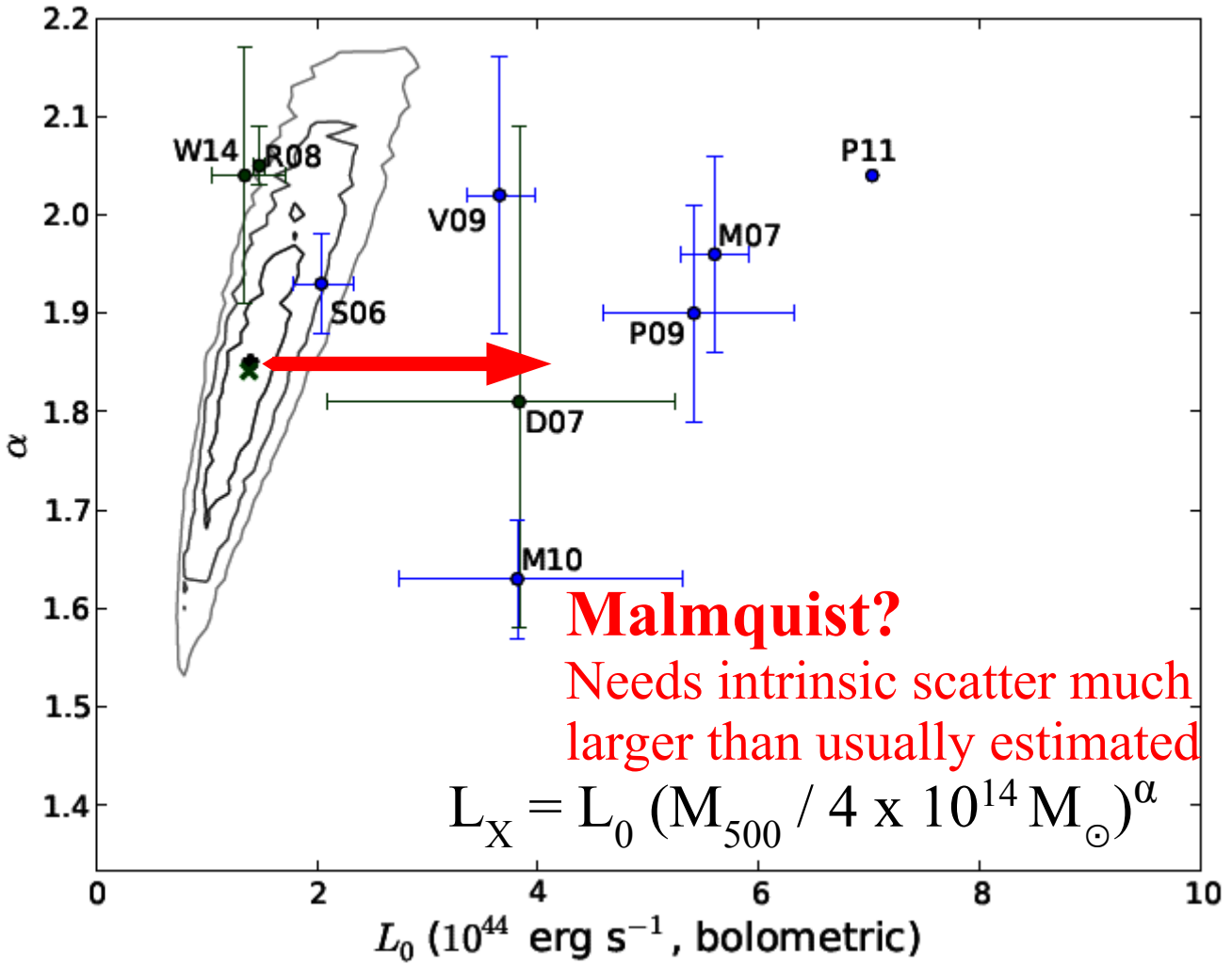

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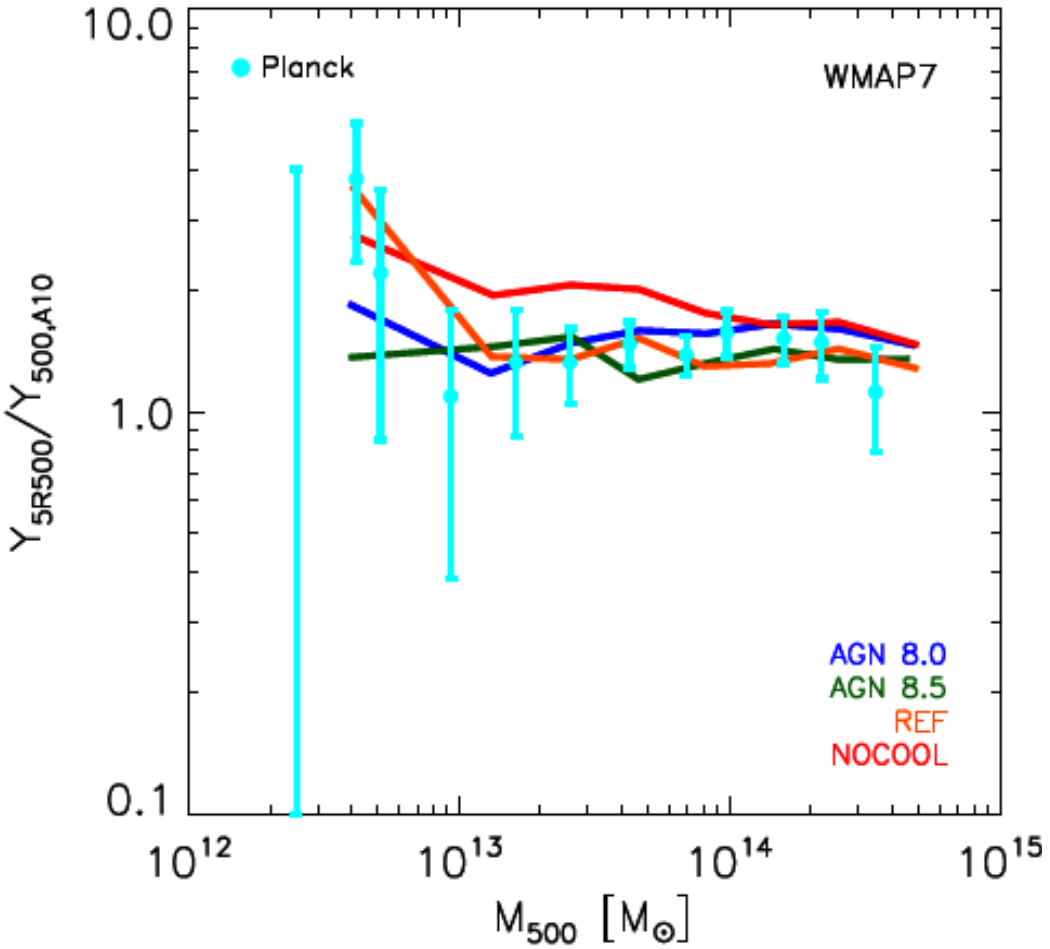
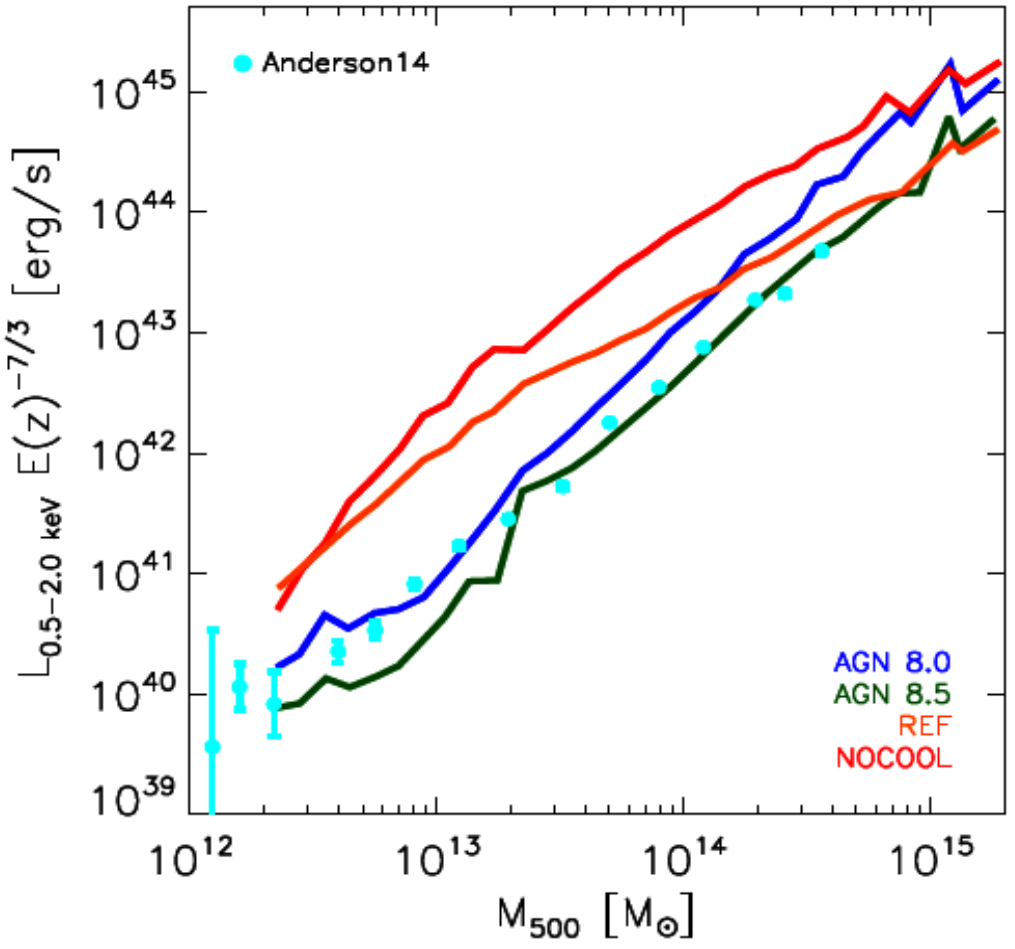
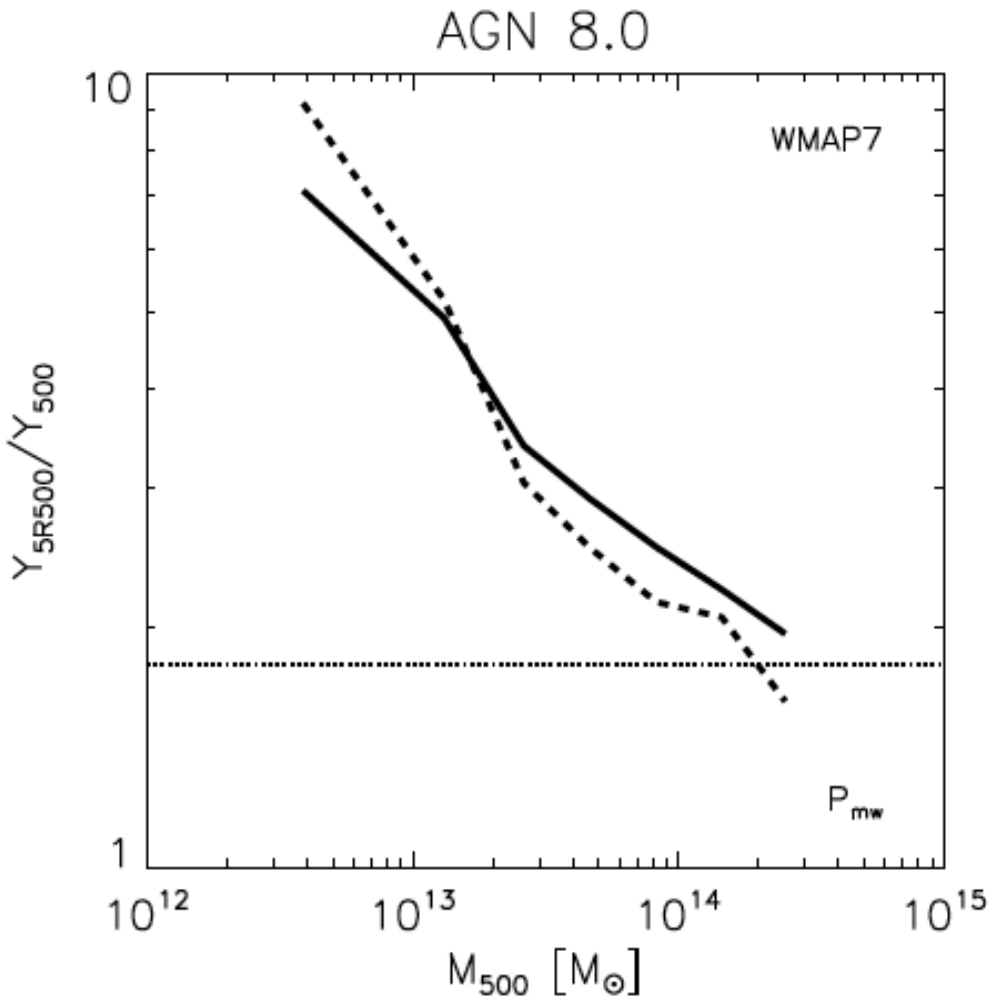
Le Brun, McCarthy & Melin 2015





With AGN feedback, the cosmo-OWLS simulations come close to reproducing *both* the nearly self-similar behaviour of the Planck SZ measurements and the non-self-similar behaviour of the ROSAT stacks

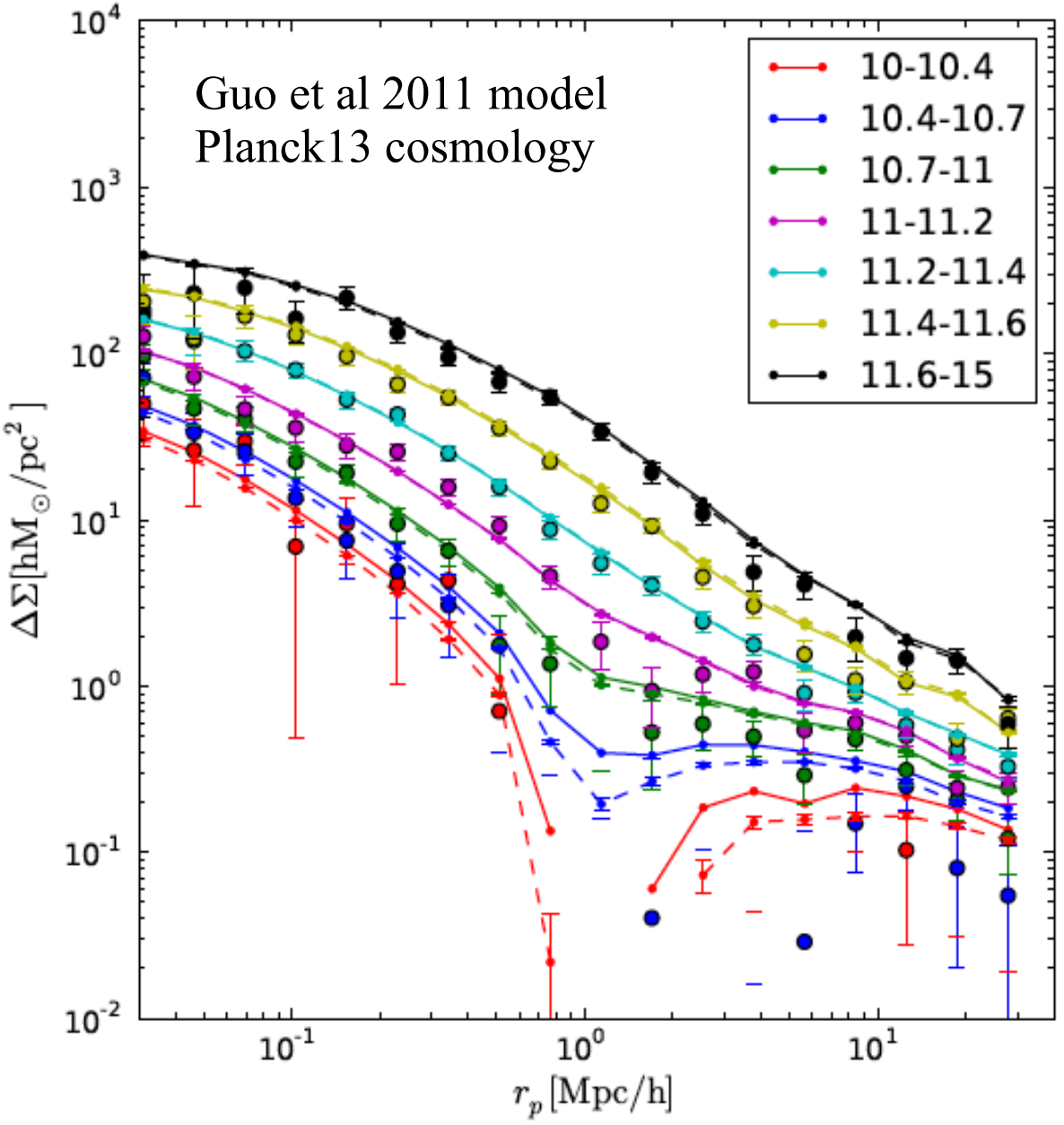
Le Brun, McCarthy & Melin 2015



With AGN feedback, the cosmo-OWLS simulations come close to reproducing *both* the nearly self-similar behaviour of the Planck SZ measurements and the non-self-similar behaviour of the ROSAT stacks

They predict the Y signal to be much less concentrated in low-mass halos

Stacked weak lensing signal from LBGs



Wang, Mandelbaum et al (2015)

Points are results for SDSS/DR7

Lines are results for locally brightest galaxies simulated in a *Planck* cosmology and with stellar mass function agreeing closely with SDSS

This externally calibrates the halo masses in the SZ and X-ray scaling relations over the mass range

$10^{13}\,M_\odot < M_{halo} < 10^{14.5}\,M_\odot$

Conclusions for Locally Brightest Galaxies in SDSS/DR7

- Planck detects SZ signal for LBG stacks with $\log M_* > 11.0$

  ROSAT detects X-ray halos for stacks with $\log M_* > 10.8$

  Both signals vary approximately as powers of M_* with no break

- Calibrating to halo mass with a simulation which matches the SDSS stellar mass function in a WMAP7 cosmology

  → $Y - M_{halo}$ as expected for self-similarity at the cosmic baryon fraction

  $L_X - M_{halo}$ substantially steeper than the self-similar prediction

- These can be reconciled if halo baryons are more extended in lower mass halos but still hot. This is consistent with AGN feedback simulations.

  → Planck has found the "missing" baryons from lower mass halos

- Lensing signal of LBG stacks is as predicted by a simulation matching SDSS stellar mass function and clustering in the Planck cosmology

  → No obvious "cluster abundance problem" ?