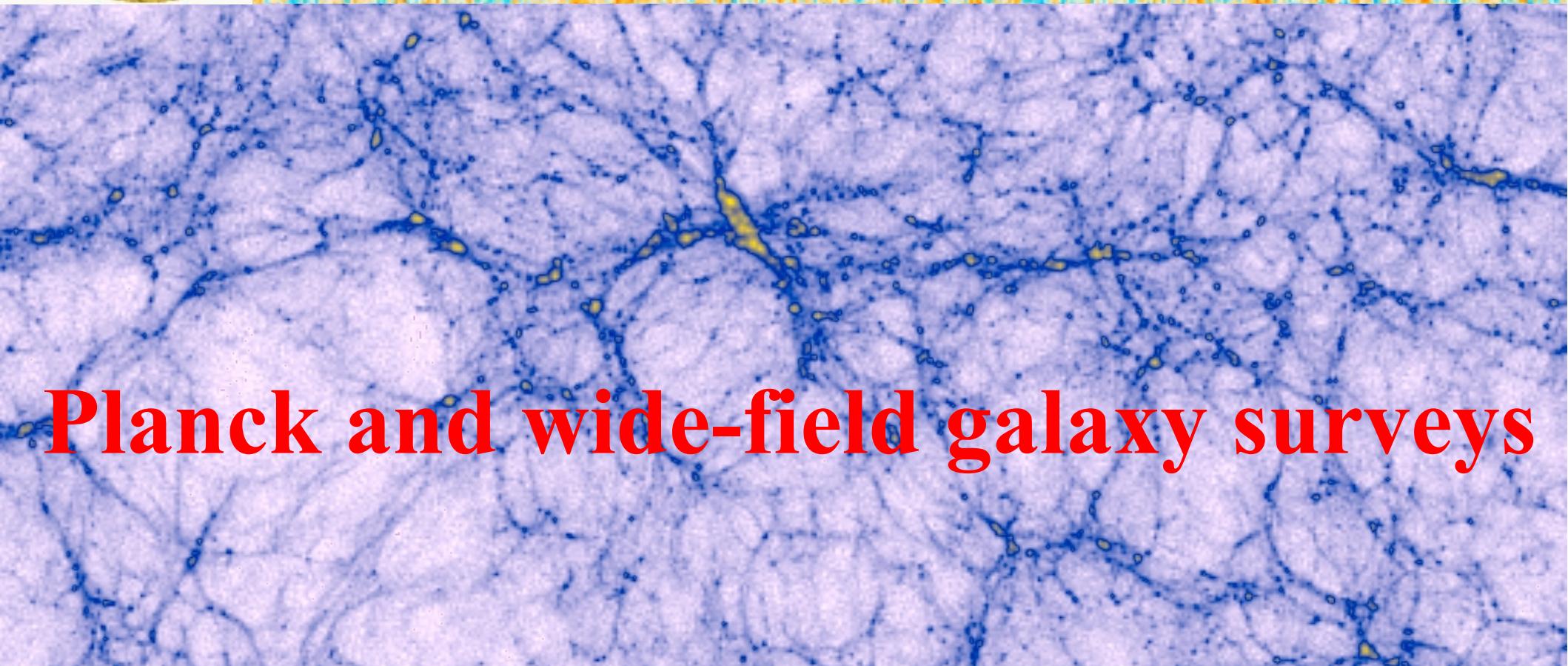




*ESLAB – Planck Symposium
April 2013*



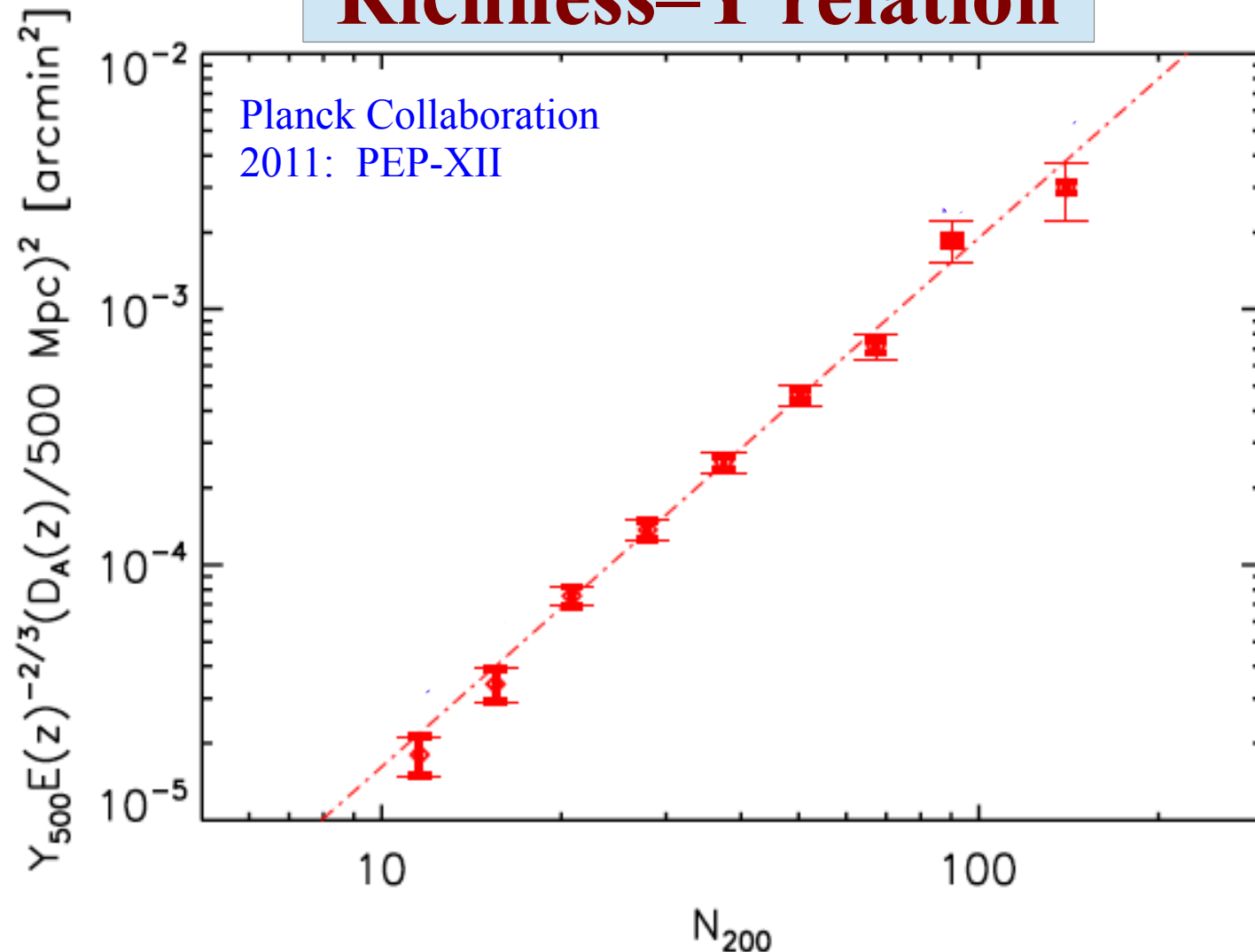
Planck and wide-field galaxy surveys



*Simon White
Max Planck Institute for Astrophysics
on behalf of the Planck Collaboration*

- Combination of Planck maps with wide-angle optical surveys allows high S/N detection of mean stacked signals due to
 - total mass (through lensing)
 - total hot gas content (through the SZ effect)
 - dust emission (through high frequency channels)
 - radio emission (through low-frequency channels)
- Here I will concentrate on results from stacking of SZ signals around objects defined from the Sloan Digital Sky Survey
 - cluster scaling relations for optically selected clusters
 - halo baryon content of dark halos down to galaxy scales

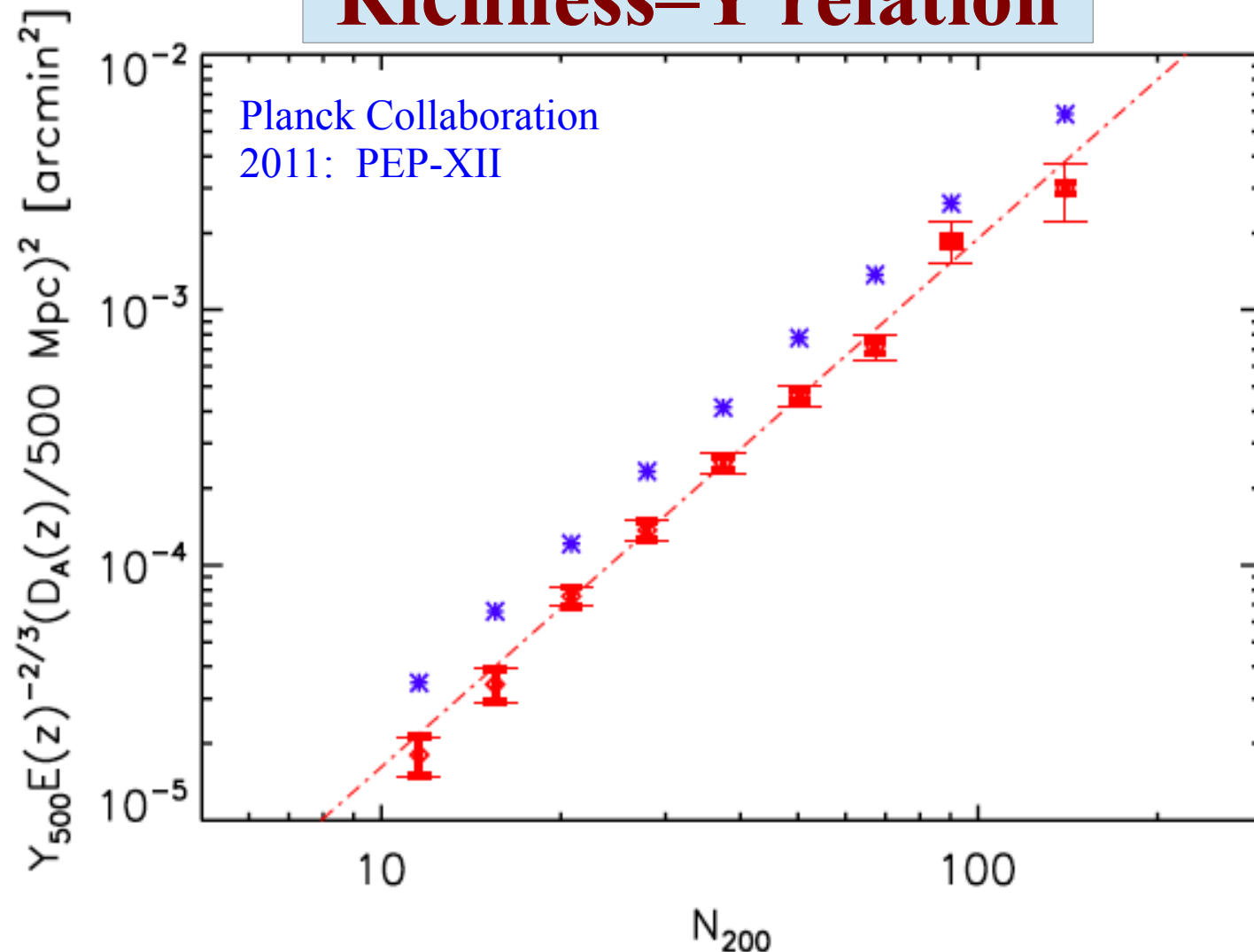
Richness–Y relation



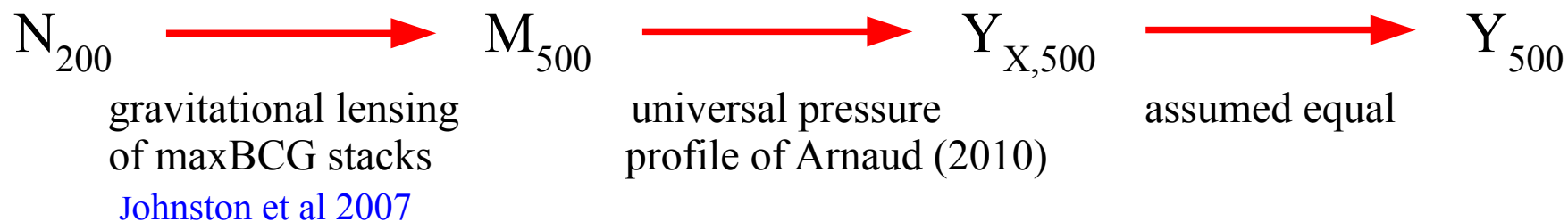
The MaxBCG catalogue, based on SDSS/DR5 contains $\sim 14,000$ galaxy clusters with richness $N_{200} > 10$ over 7,500 squ.deg.

Stacking Planck SZ measurements based on a multi-frequency matched filter detects the mean $Y_{500} - N_{200}$ relation at high significance.

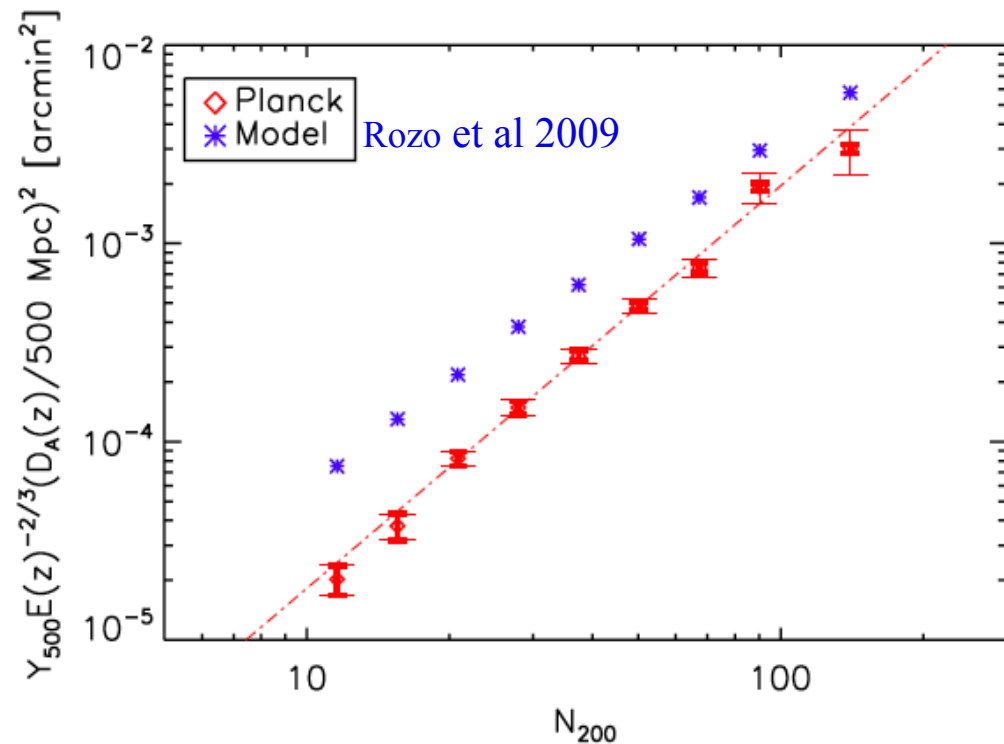
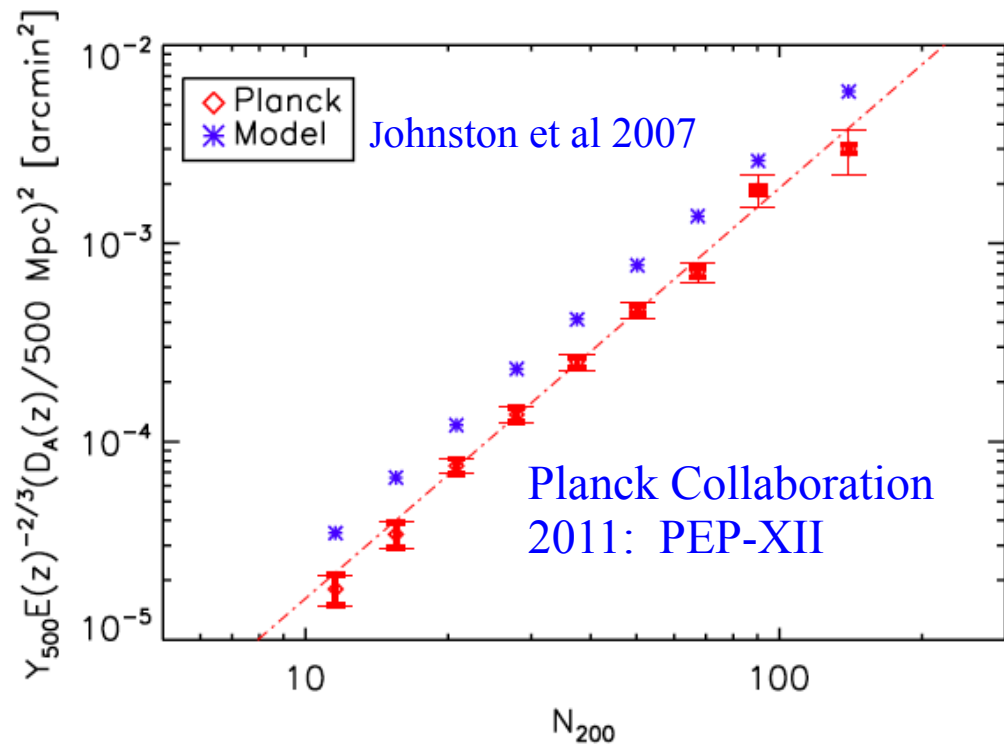
Richness–Y relation



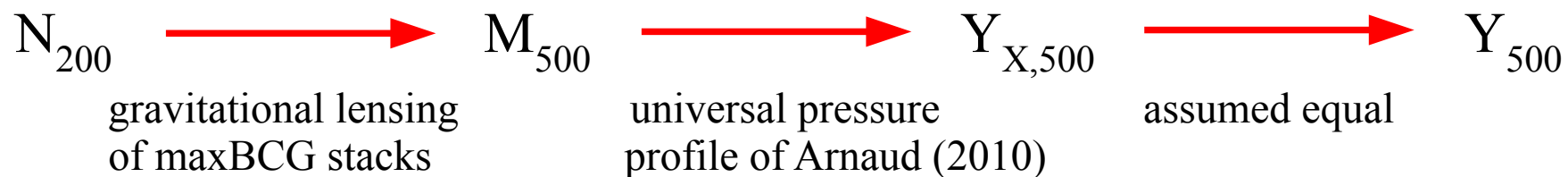
The result disagrees with the prediction from



Richness–Y relation



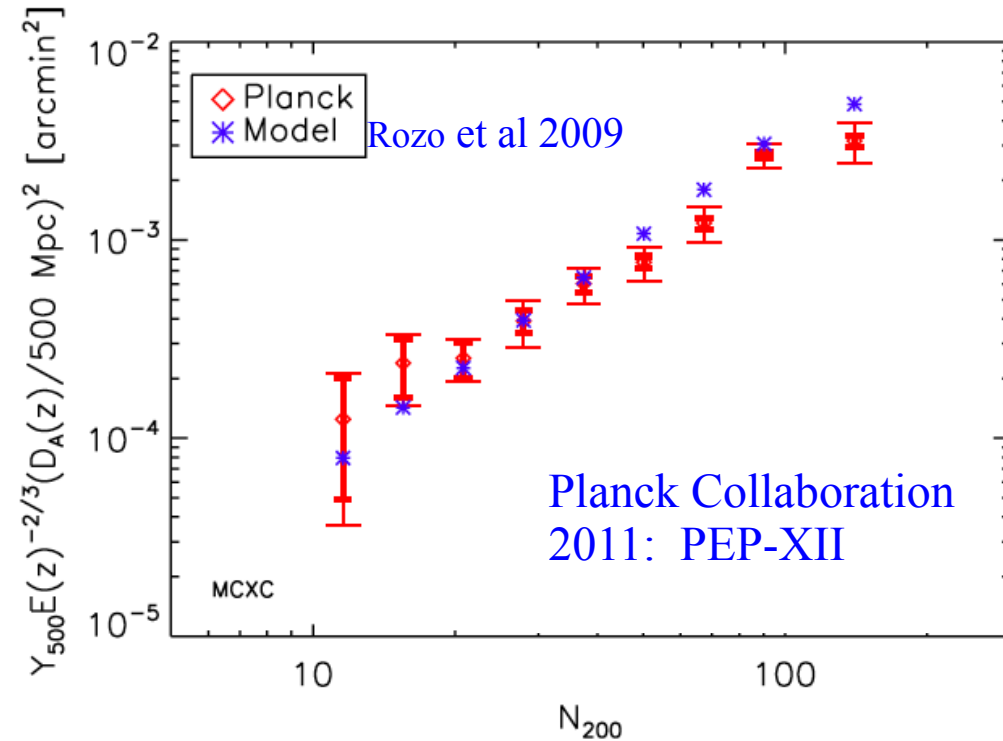
The result disagrees with the prediction from



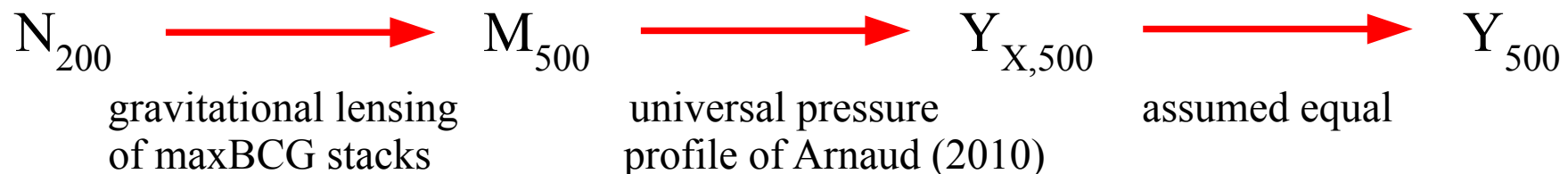
Richness–Y relation

Yet when sample is restricted to clusters which also appear in an X-ray selected sample, the discrepancy disappears

Malmquist bias transferred from the X-ray to the SZ!

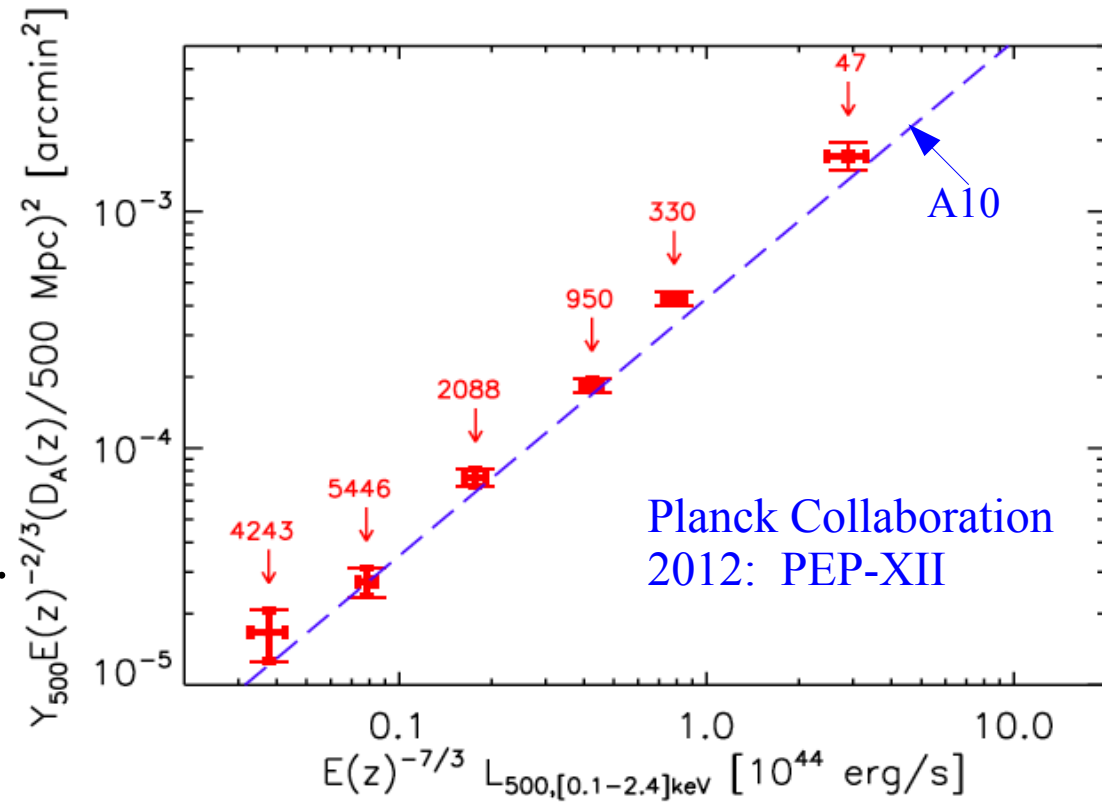


The result now agrees with the prediction from



Y – L_X relation

Yet for stacks of given N_{200} in the full maxBCG sample, mean $L_{X,500}$ is related to mean Y_{500} as predicted by the Arnaud (2010) “universal” profile derived from X-ray clusters.



The Y – L relation is the same for X-ray-selected and non-X-ray-selected cluster samples

Thus the Malmquist bias in X-ray-selected samples shifts Y and L along the mean relation

Problems with scaling relations?

Cluster selection by optical, X-ray and SZ methods leads to samples with systematically different properties.

X-ray selection picks clusters which are systematically more regular and centrally concentrated than SZ selection which in turn picks clusters which are more regular than optical selection

These differences can shift scaling relations between observables, and between observables and a fiducial cluster mass, by amounts which are significant compared to cosmology dependences.

Such shifts are likely to be redshift-dependent and must be understood before cluster abundances can be used for cosmology

 **Sample selection and calibration are critical.**
Scatter and evolution must be fully characterised

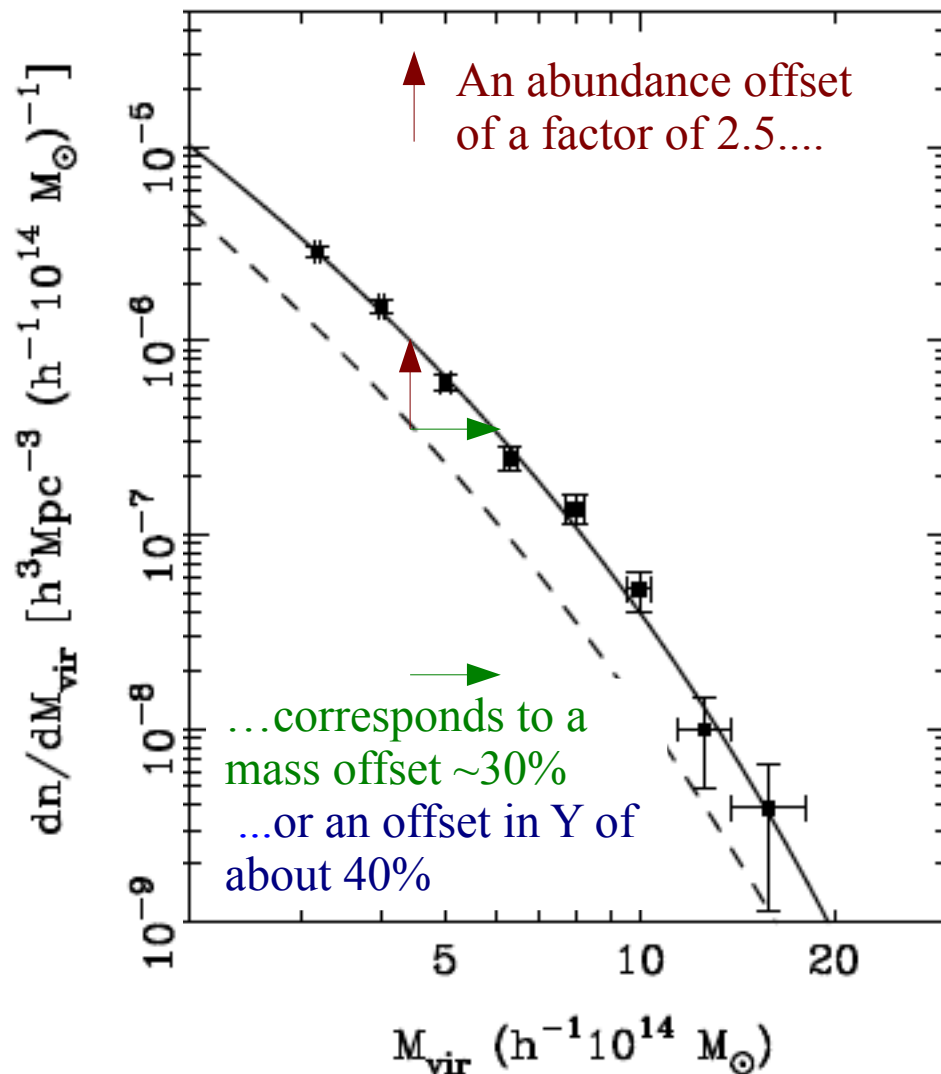
Problems with scaling relations?

Cluster selection
samples with:

X-ray selection
regular and central
picks clusters

These differ
and between clusters
which are significant

Such shifts are
understood better



leads to

usually more
clusters in which in turn
selection

in observables,
shifts, by amounts
independences.

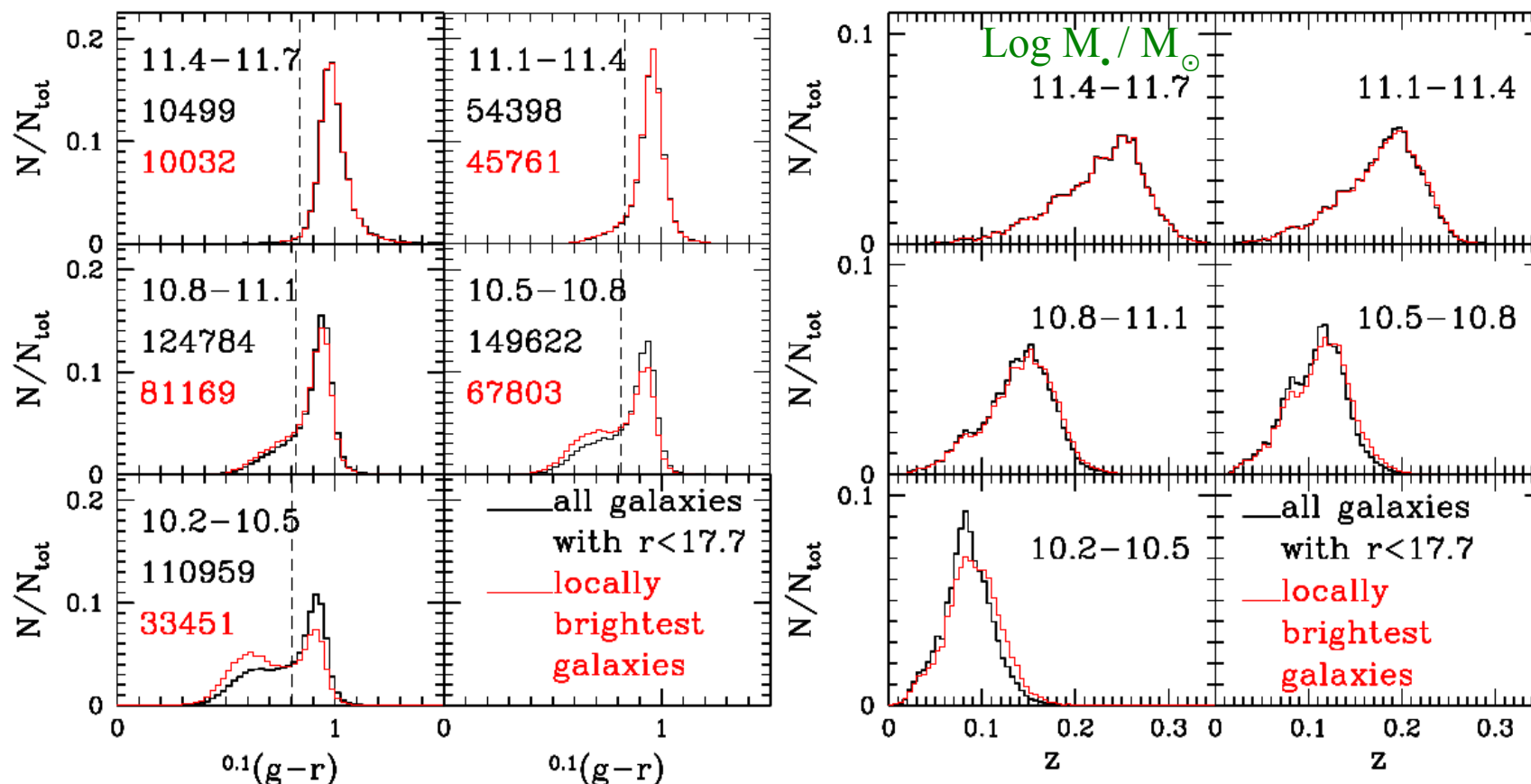
must be
correct for cosmology

Sample selection and calibration are critical.

Scatter and evolution must be fully characterised

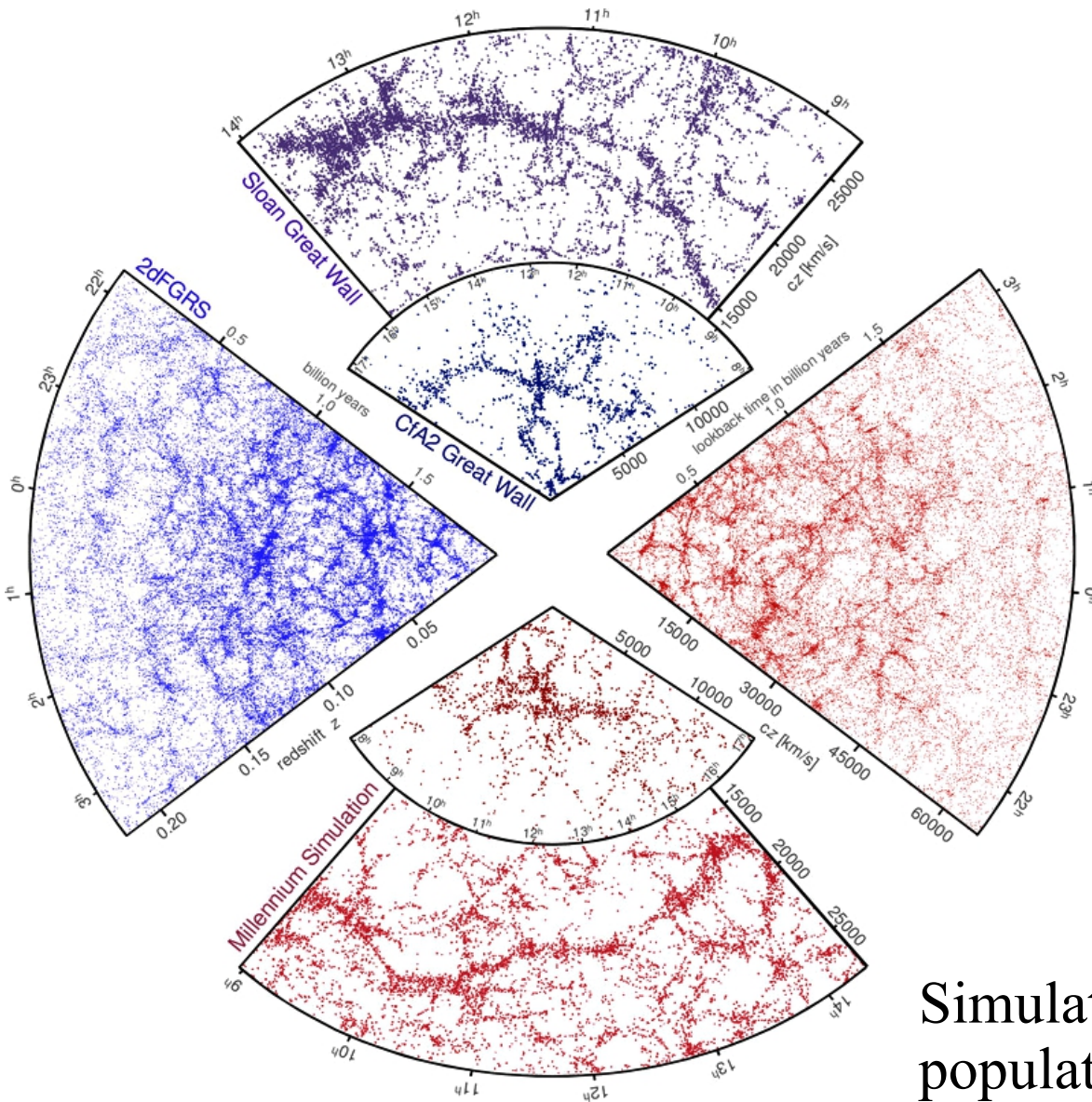
A complete sample of locally brightest galaxies

Planck Collaboration 2013: PIP-XI

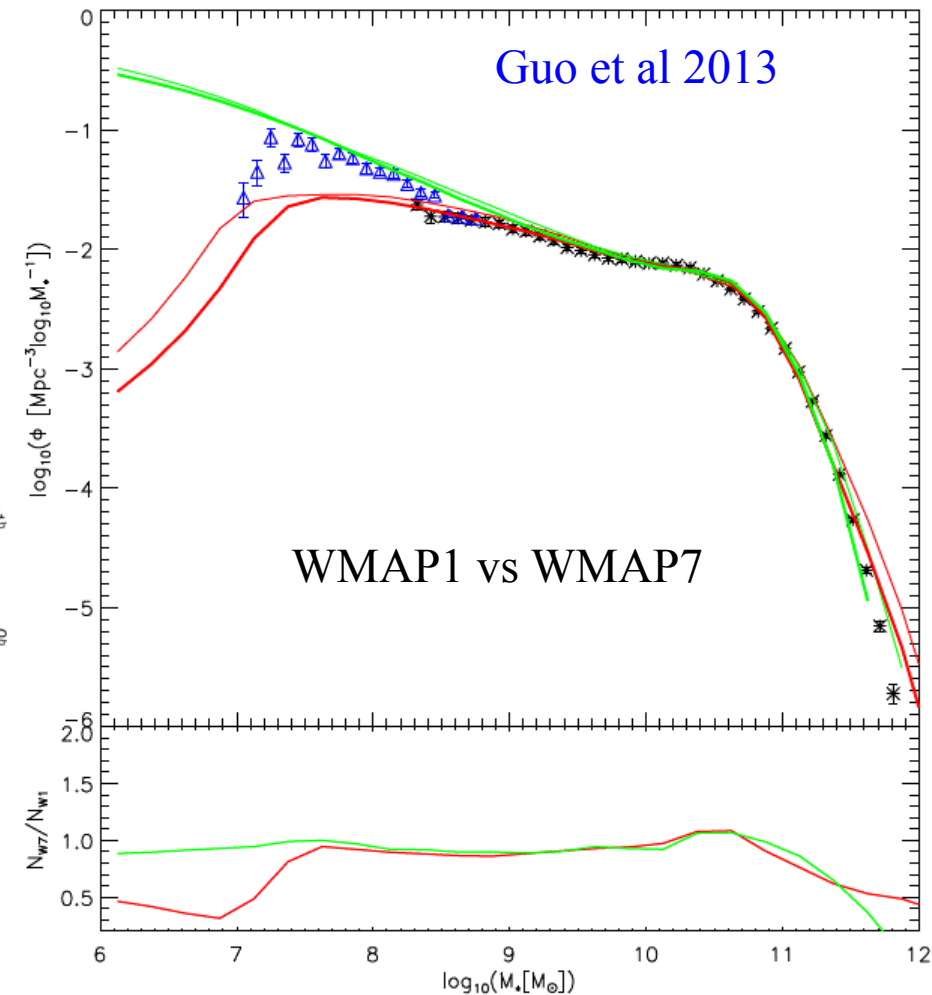


All SDSS/DR7 galaxies in the main spectroscopic sample with:
 $r < 17.7$ (extinction-corrected Petrosian mag.), $z > 0.03$, and
no brighter companion with $\Delta r_p < 1$ Mpc, $|c\Delta z| < 1000$ km/s in
either the spectroscopic or photometric catalogues

Galaxy population simulations as calibrators



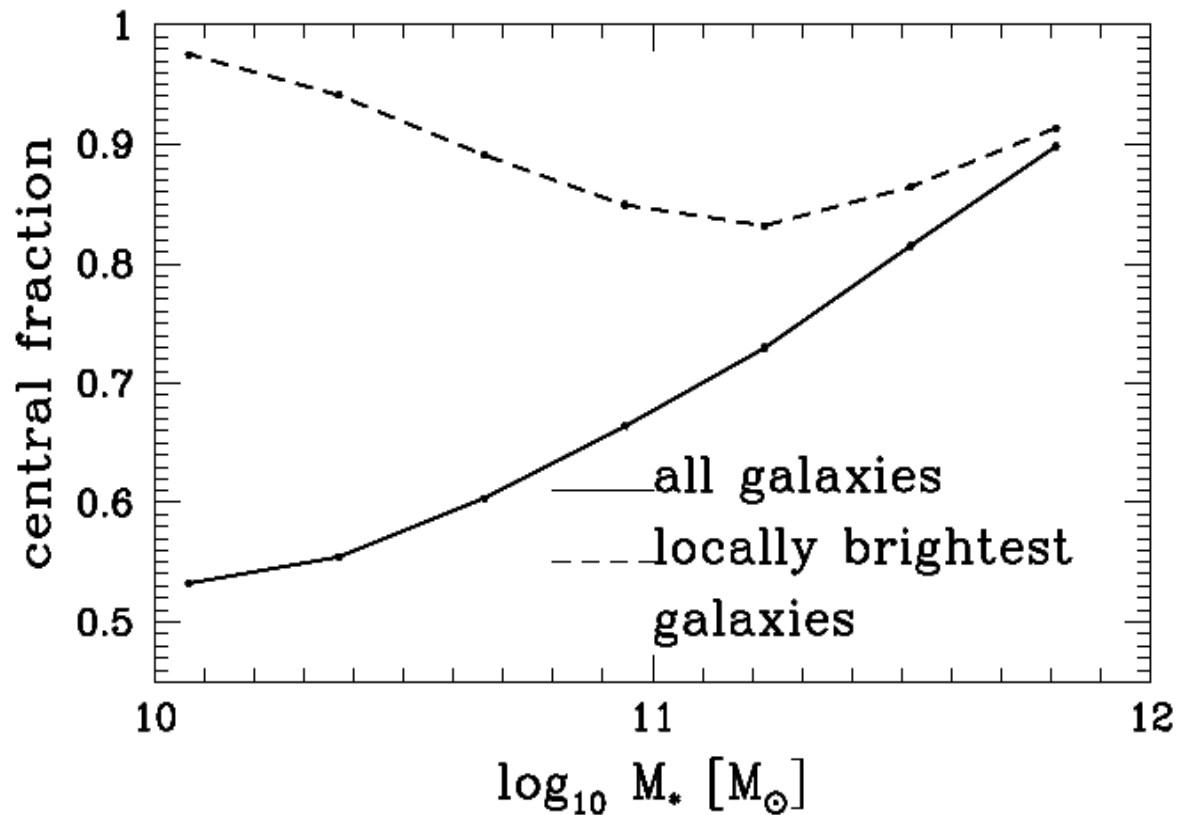
Springel et al 2006



Simulations of the formation of the galaxy population can reproduce the abundance and clustering of galaxies in any viable Λ CDM cosmology (here WMAP7)

LBG's are predominantly halo central galaxies

Planck Collaboration 2013: PIP-XI



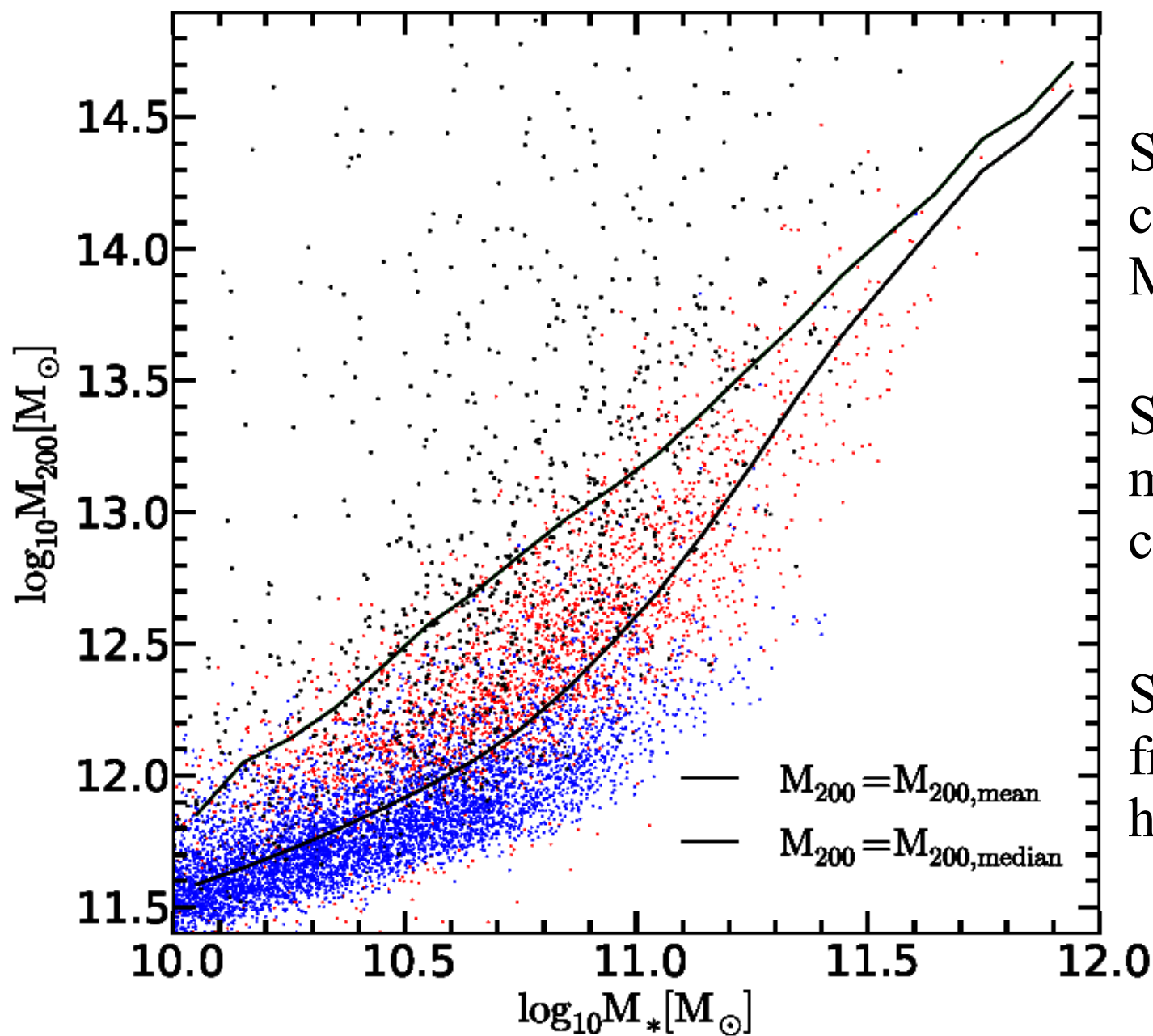
LBG's selected according to the observational criteria in a mock catalogue constructed from the Guo et al (2012) model of galaxy formation in the Millennium Simul'n (scaled to WMAP7)

At least 83% of LBGs are the central galaxies of their dark haloes

2/3 of the rest are brighter than the central galaxy of their halo

LBG stellar mass is related to halo mass

Planck Collaboration 2013: PIP-XI



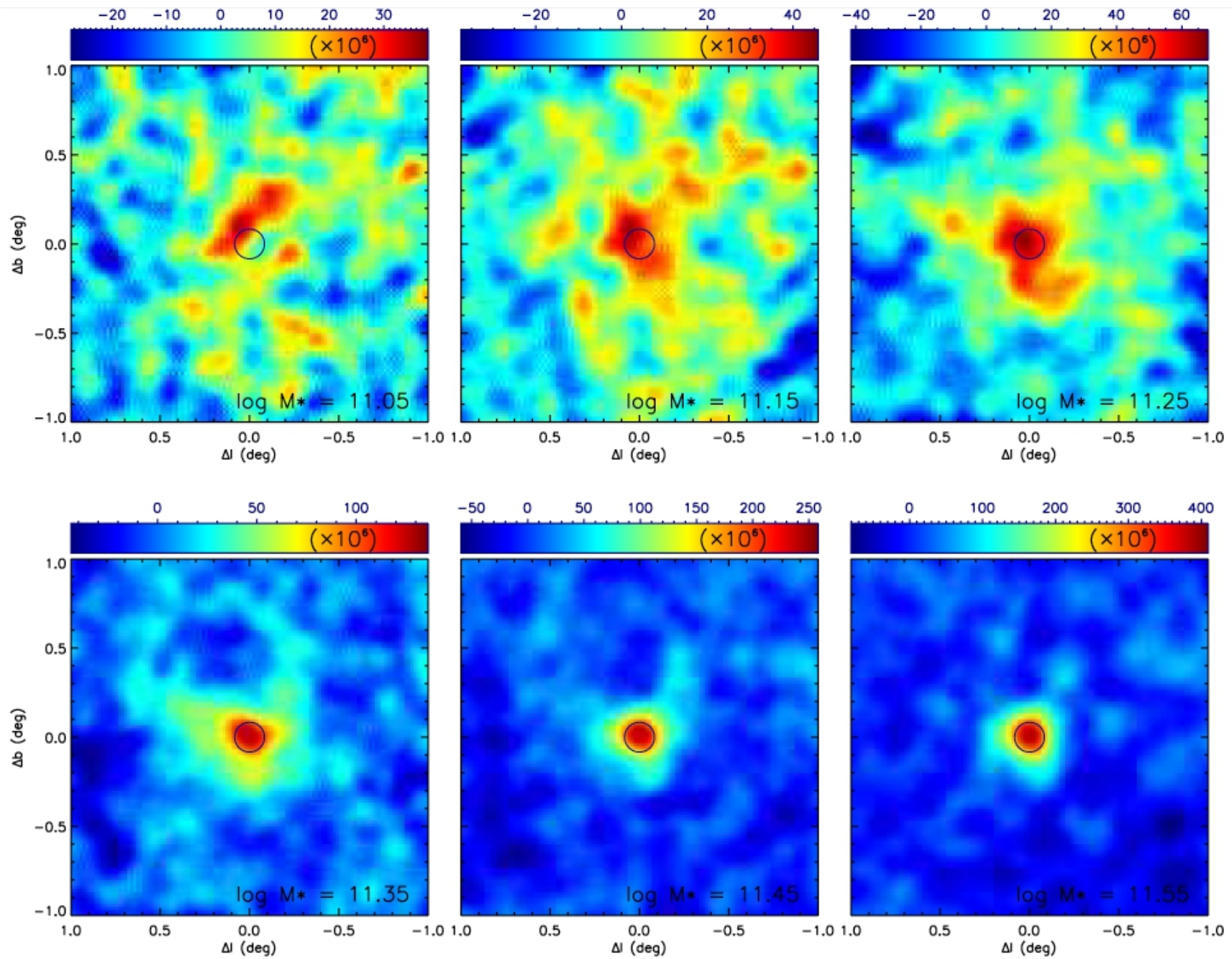
Star-forming and passive centrals lie on different M_* -- M_h relations

Satellites tend to have more massive halos than centrals of the same M_*

Satellites are also offset from the centres of their halos

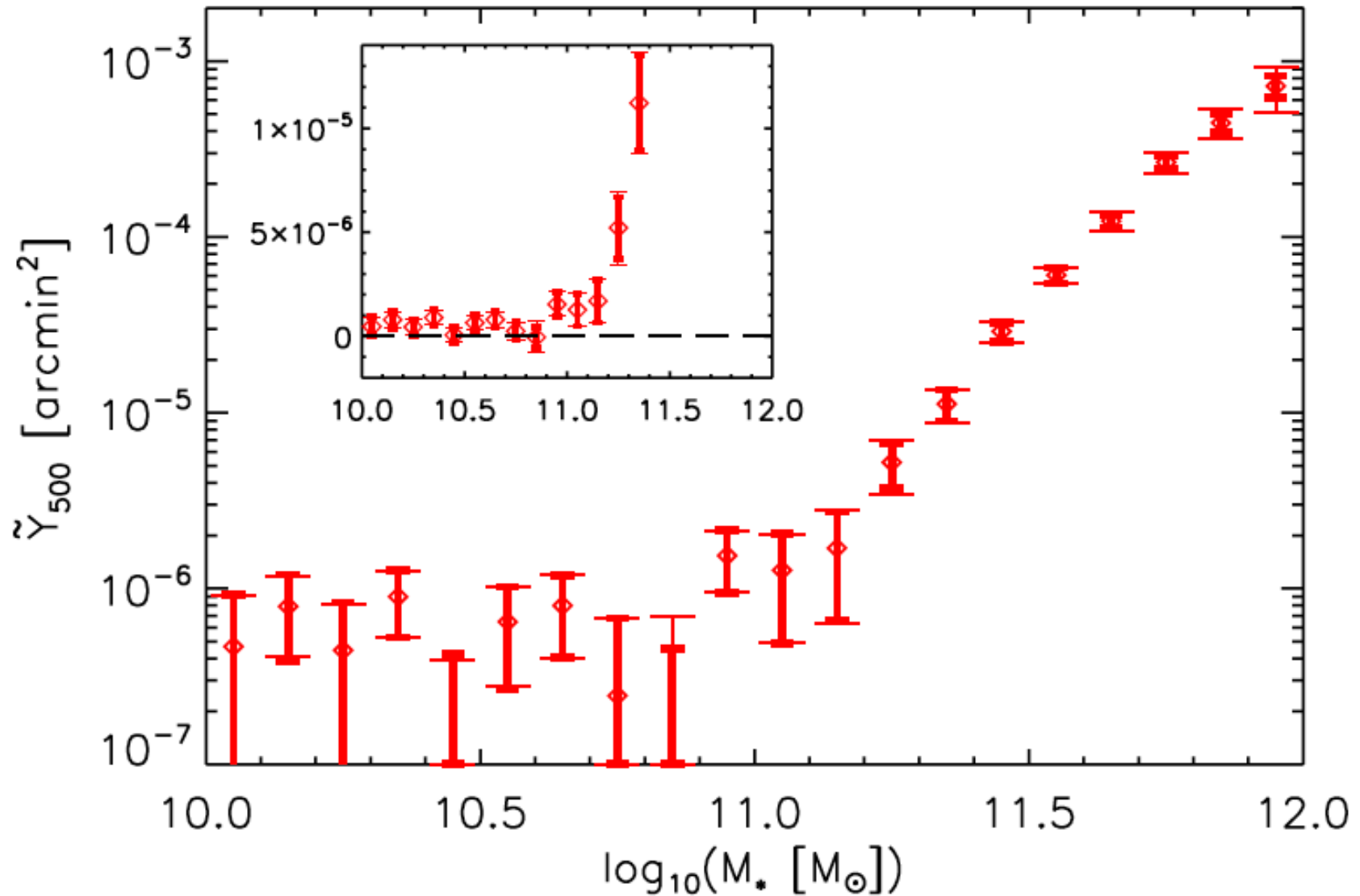
Stacked Planck y-maps for LBGs

Planck Collaboration 2013: PIP-XI



Mean Y_{500} as a function of M_* for LBGs

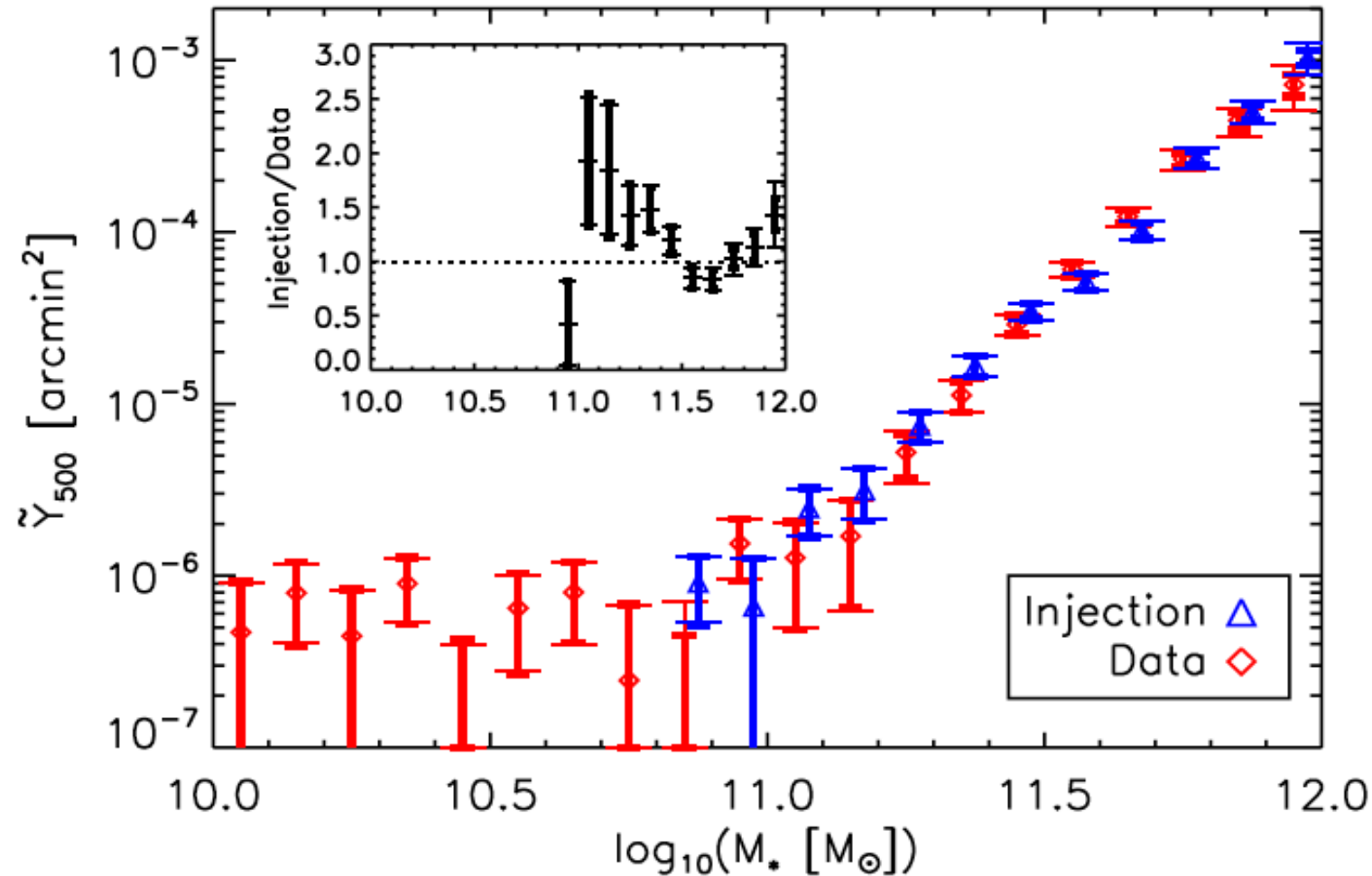
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Signal is detected down to $\log M_* / M_\odot \sim 11.0$

Mean $Y-M_*$ expected for self-similar $Y-M_h$

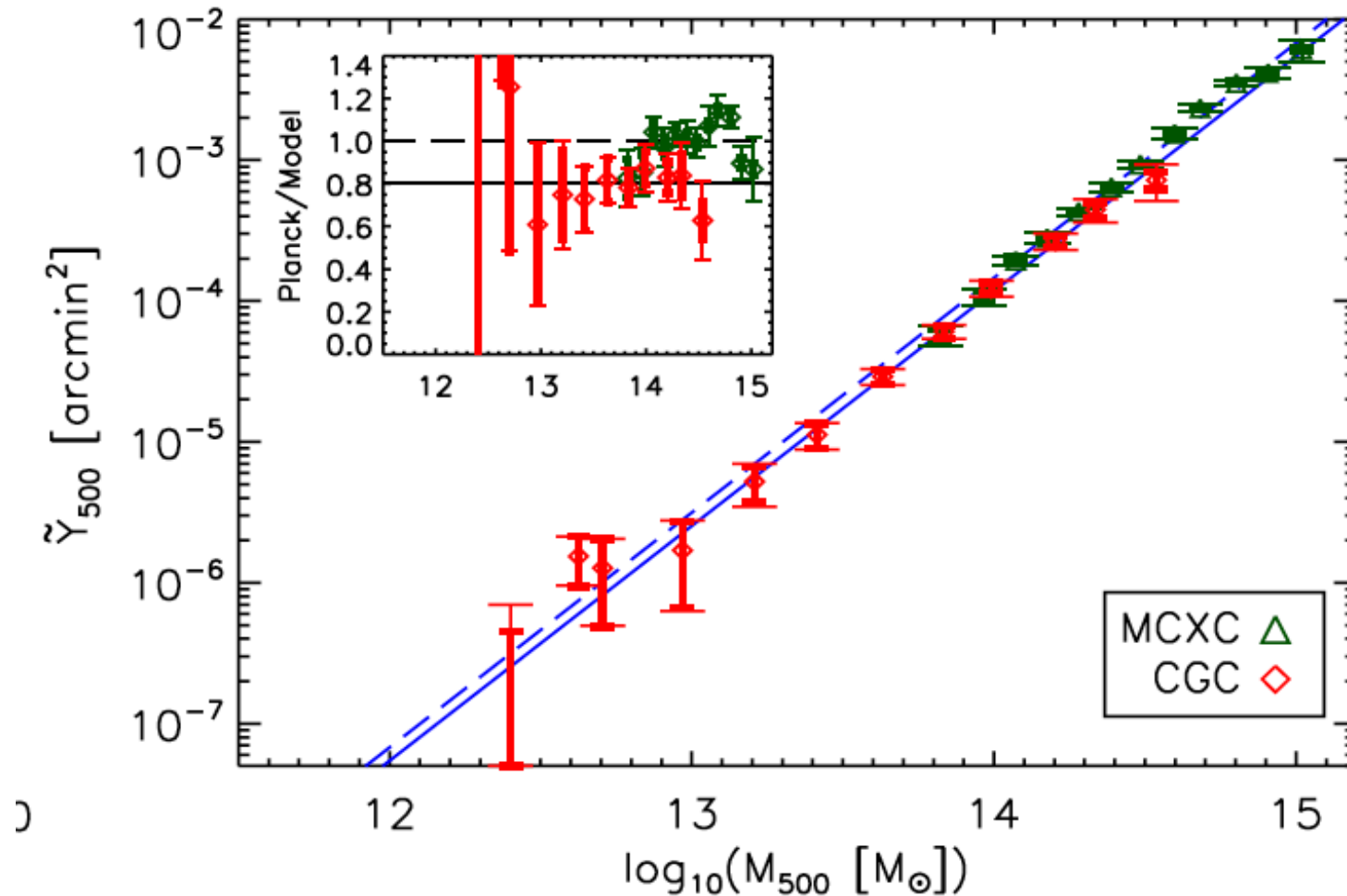
Planck Collaboration 2013: PIP-XI



To each real LBG assign a random mock LBG of the same M_*
Use offset and M_h of mock LBG with $Y = A M_h^\beta + A_{10}$ profile
“Detect” using same filter as for observations, stack and compare
Fit for A and β $\longrightarrow$ cosmic baryon fraction + self-similar β !

Inferred $Y-M_h$ compared to X-ray cluster result

Planck Collaboration 2013: PIP-XI



LBG and MCXC results consistent to 20% – Malmquist bias in MCXC?
Scaling continues down to $\log M_h / M_{\odot} \sim 12.5$ with no break.
Planck has seen about 25% of all cosmic baryons in this SZ signal!

Conclusions

Cluster scaling relations and their evolution are the critical factor in using cluster abundances for cosmology

- Scatter in mass proxies can interact with sample selection to produce seriously biased results. The multi-dimensional scatter in the observables–mass relation must be fully modelled

Adopting a cosmology allows cluster physics to be studied

- By stacking LBGs, Planck detects Y down to $M_h \sim 10^{12.5} M_\odot$ with no break in the self-similar $Y - M_h$ scaling relation
- SZ-detected hot gas in halos accounts for $\sim 25\%$ of all baryons
- Future work should measure evolution in the $Y - M_h$ relation