MPAC

Ringberg Castle
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Cluster scaling relations: the SZ-signal – Halo mass relation

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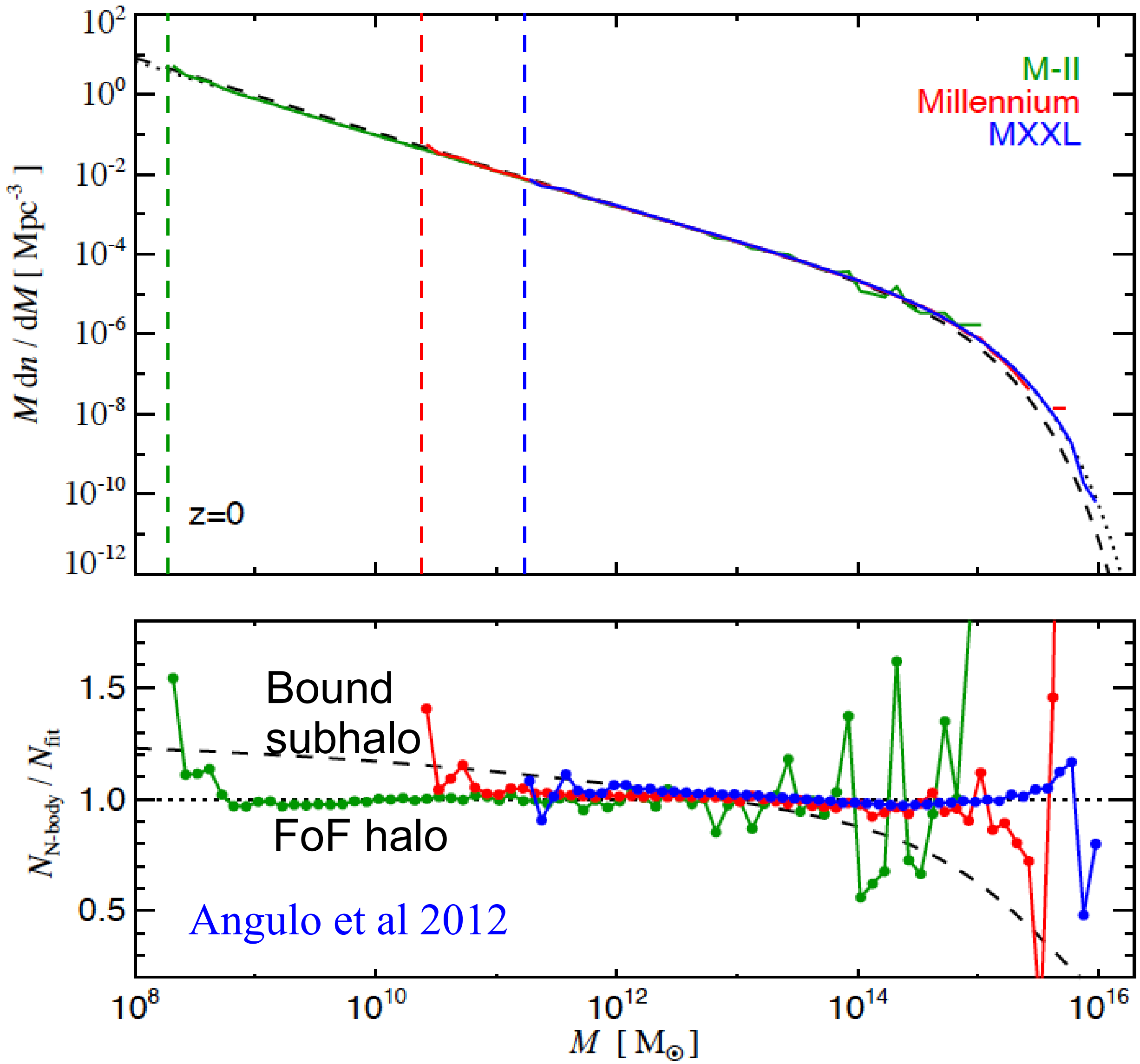
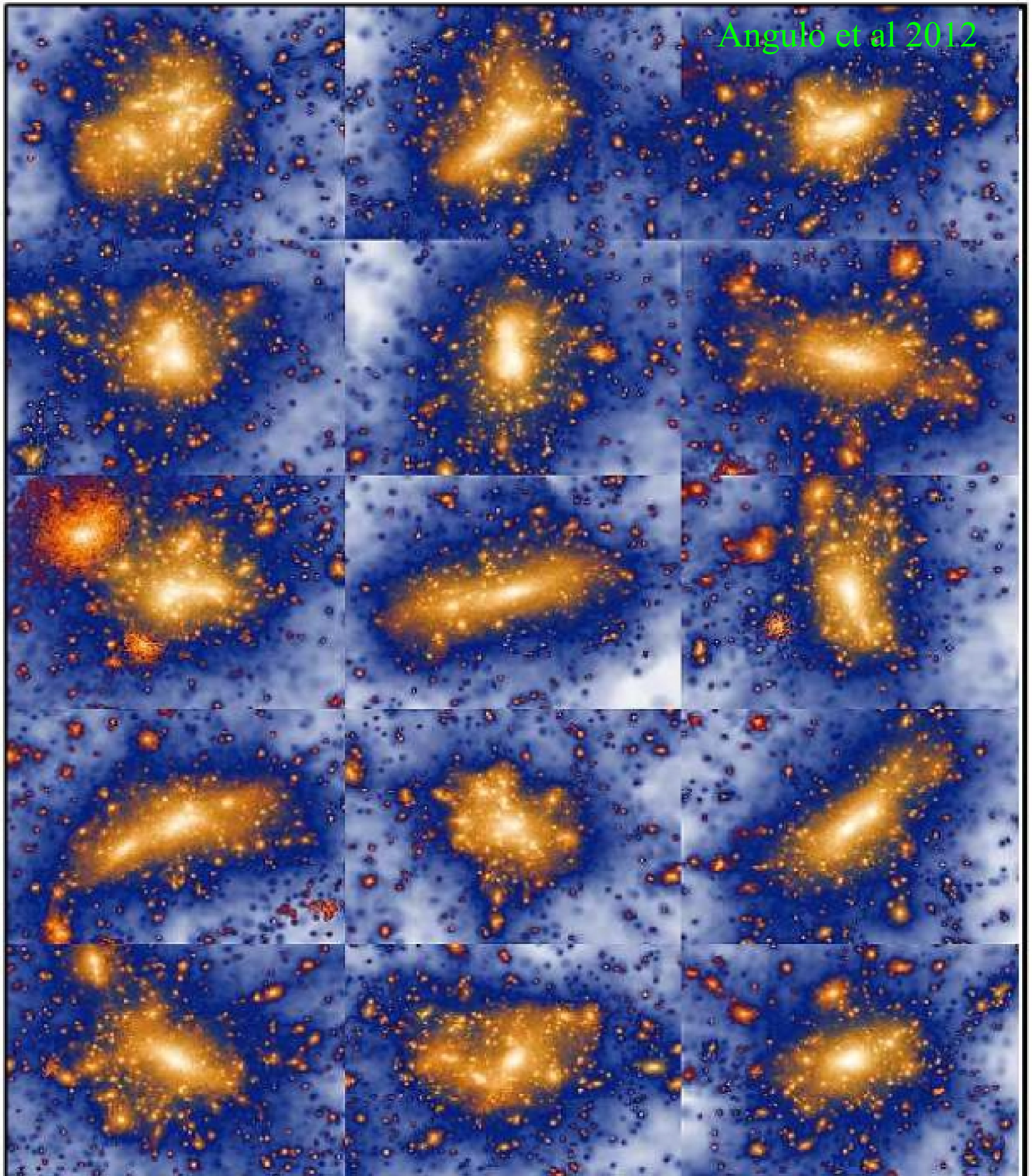
Cluster abundances as a cosmological probe



Halo abundances are very well estimated as a function of mass and cosmological parameters from N-body simulations.

Current accuracies are of order a few percent

Abundance depends on mass definition in a given simulation by much larger factors

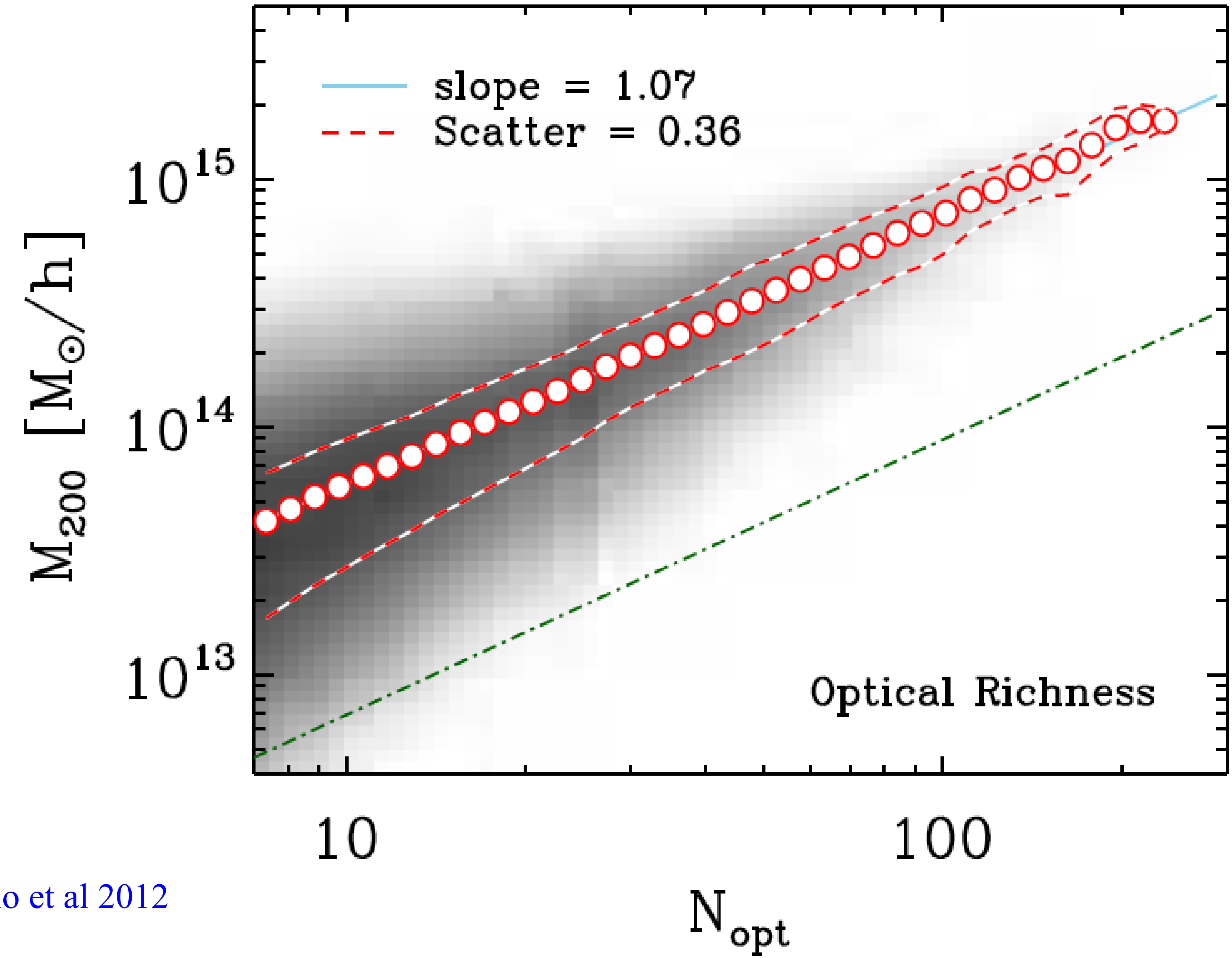


Scatter

Relations between mass measures show scatter because of:
(i) internal structure
(ii) orientation
(iii) environment
(iv) line-of-sight proj'ns

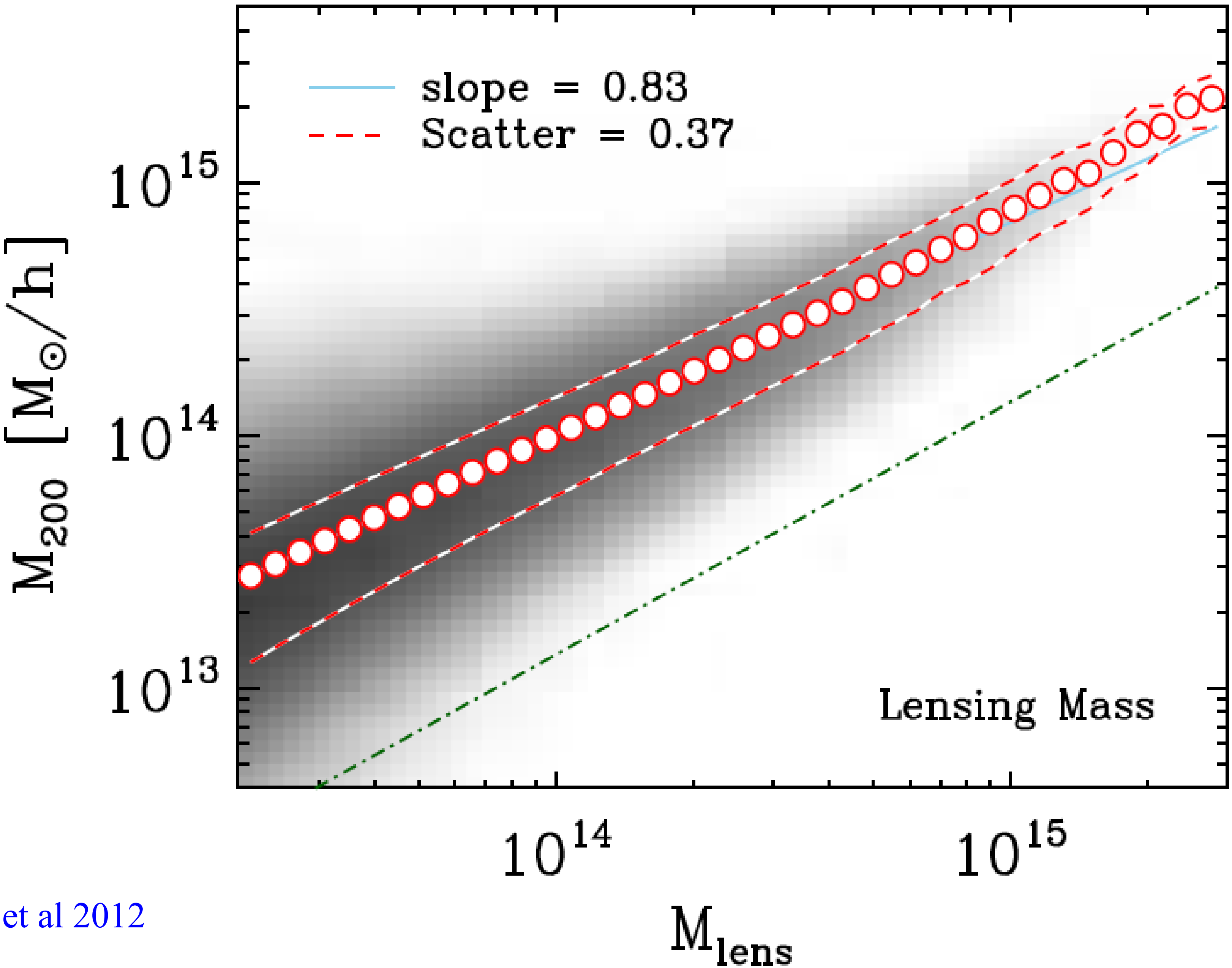
Relations to observable mass proxies show <u>additional</u> scatter because of:
(v) extra astrophysics
(vi) observational error

Scatter between mass and proxy in the MXXL



Angulo et al 2012

Scatter between mass and proxy in the MXXL



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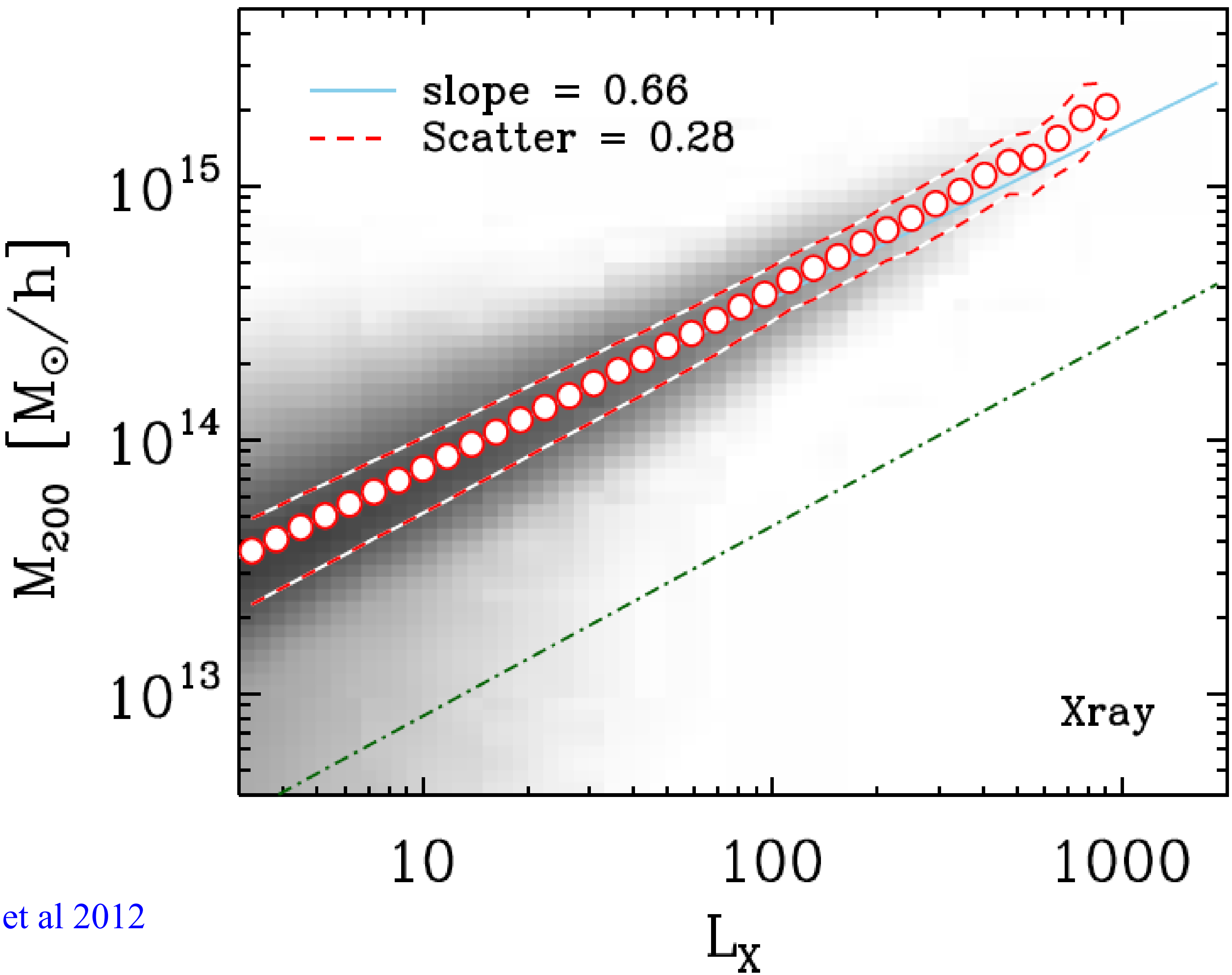

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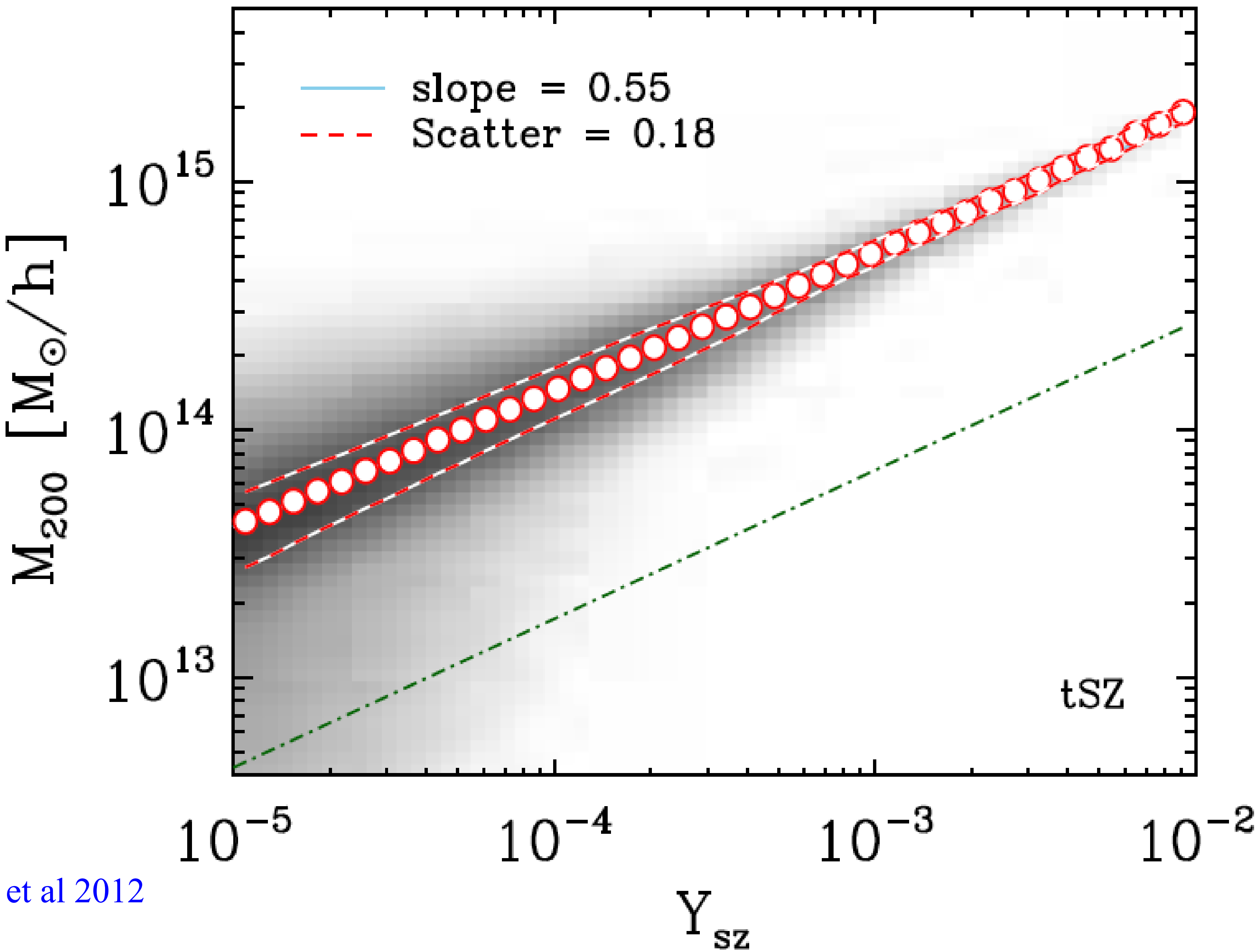

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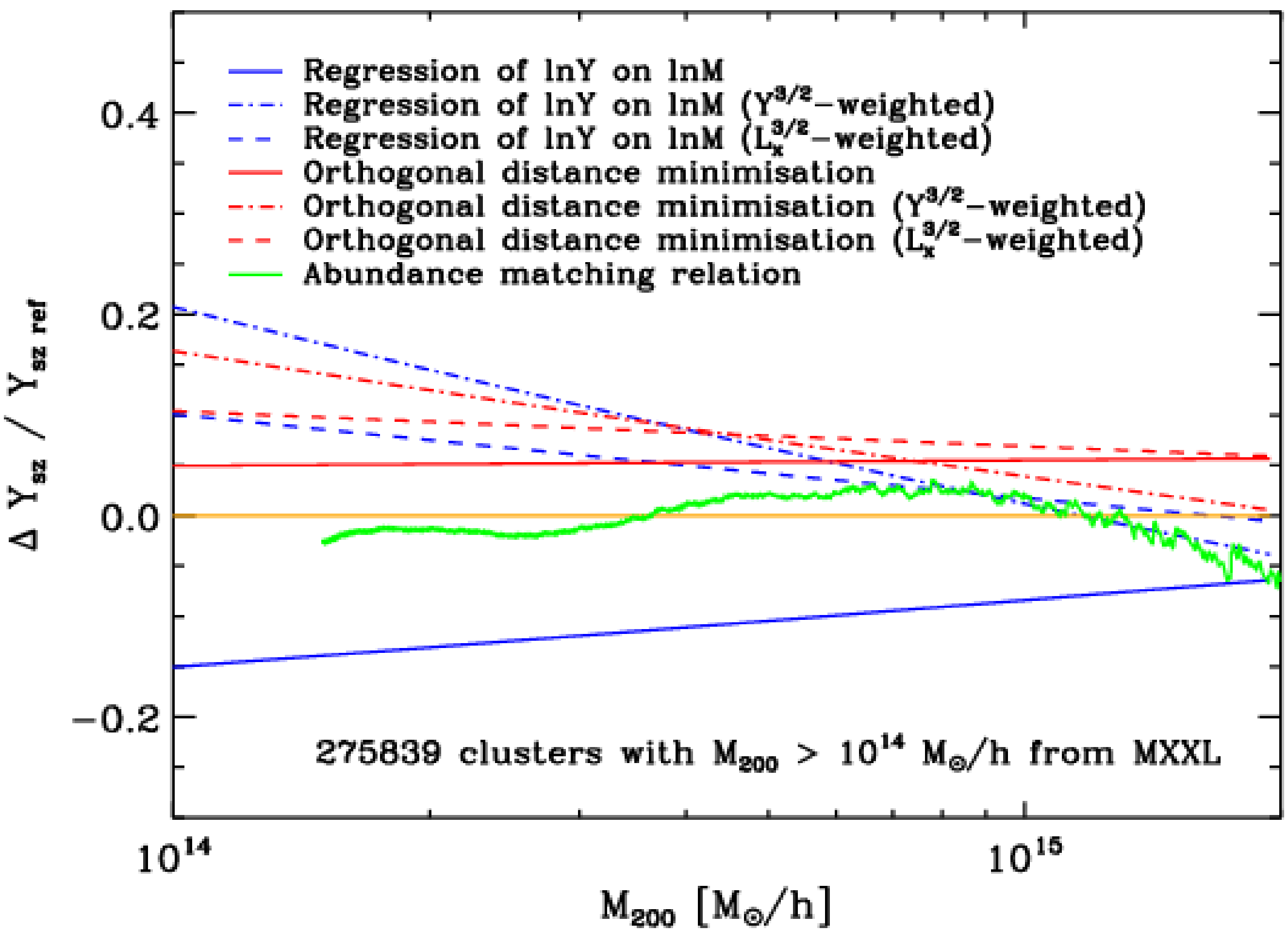
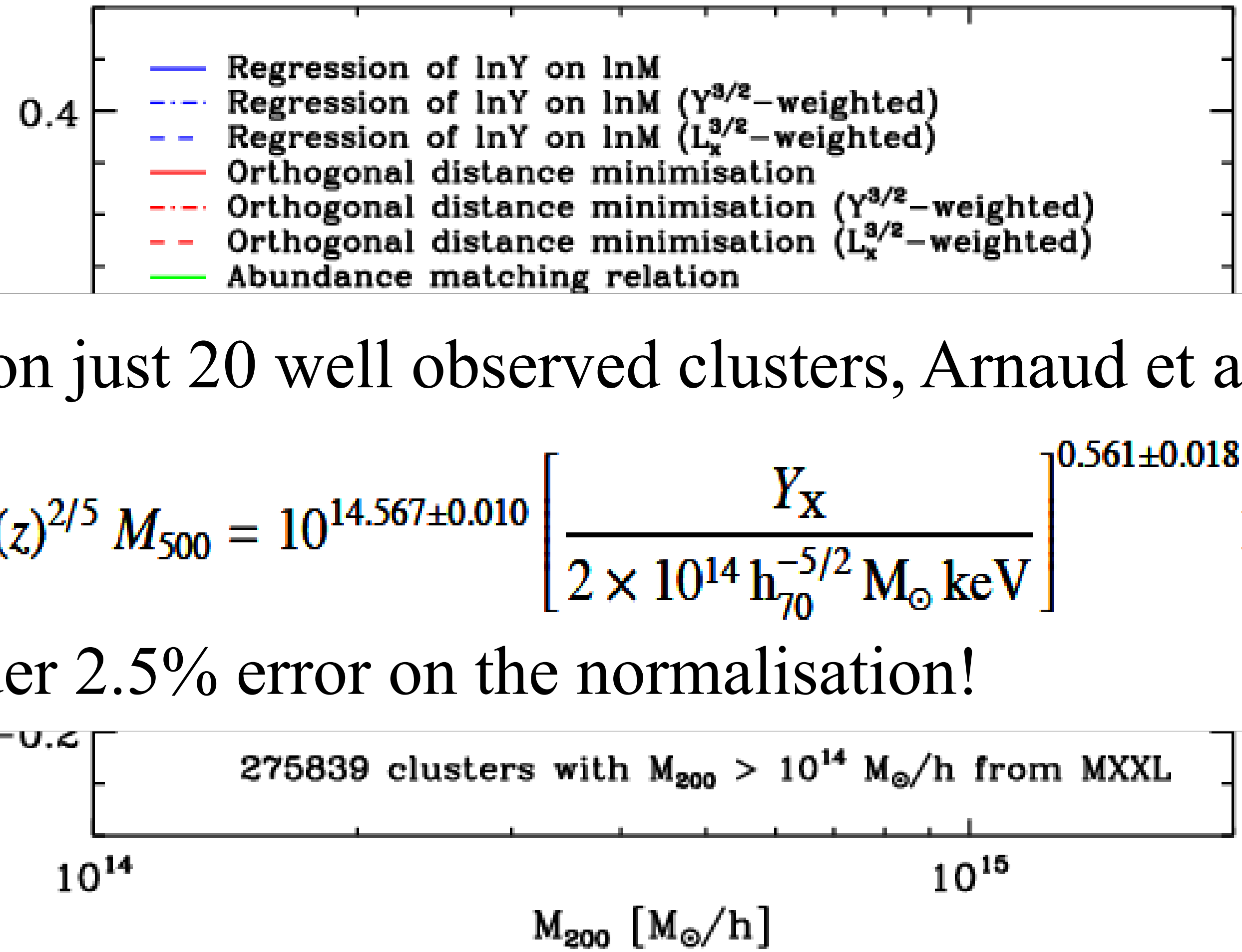


~ 20% scatter in Y_X--M according to sample selection and fit type

Astrophysical and observational sources of scatter not included

Scatter between mass and proxy in the MXXL



Based on just 20 well observed clusters, Arnaud et al (2010) give

$$h(z)^{2/5} M_{500} = 10^{14.567\pm0.010} \left[\frac{Y_X}{2\times10^{14}\,\mathrm{h}_{70}^{-5/2}\,\mathrm{M}_\odot\,\mathrm{keV}} \right]^{0.561\pm0.018} \mathrm{h}_{70}^{-1}\,\mathrm{M}_\odot$$

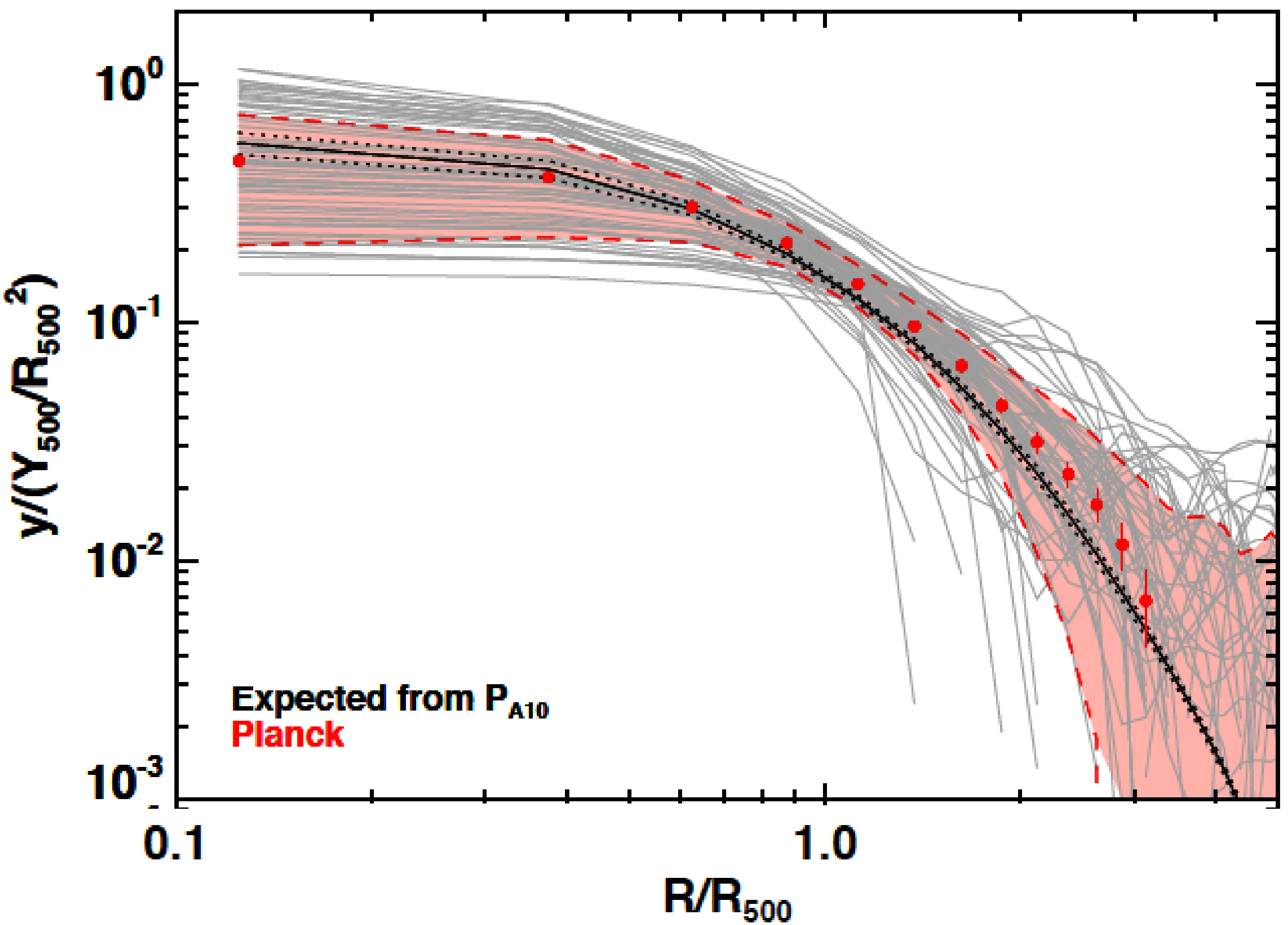
i.e. under 2.5% error on the normalisation!

~ 20% scatter in Y_X--M according to sample selection and fit type

Astrophysical and observational sources of scatter not included

Scatter in y-profiles for 62 Planck clusters

Planck Collaboration 2012 PIP-V



Scatter among the y-profiles is big, reflecting differing internal structure

Beyond R_{500} the mean pressure lies above the universal profile of A10

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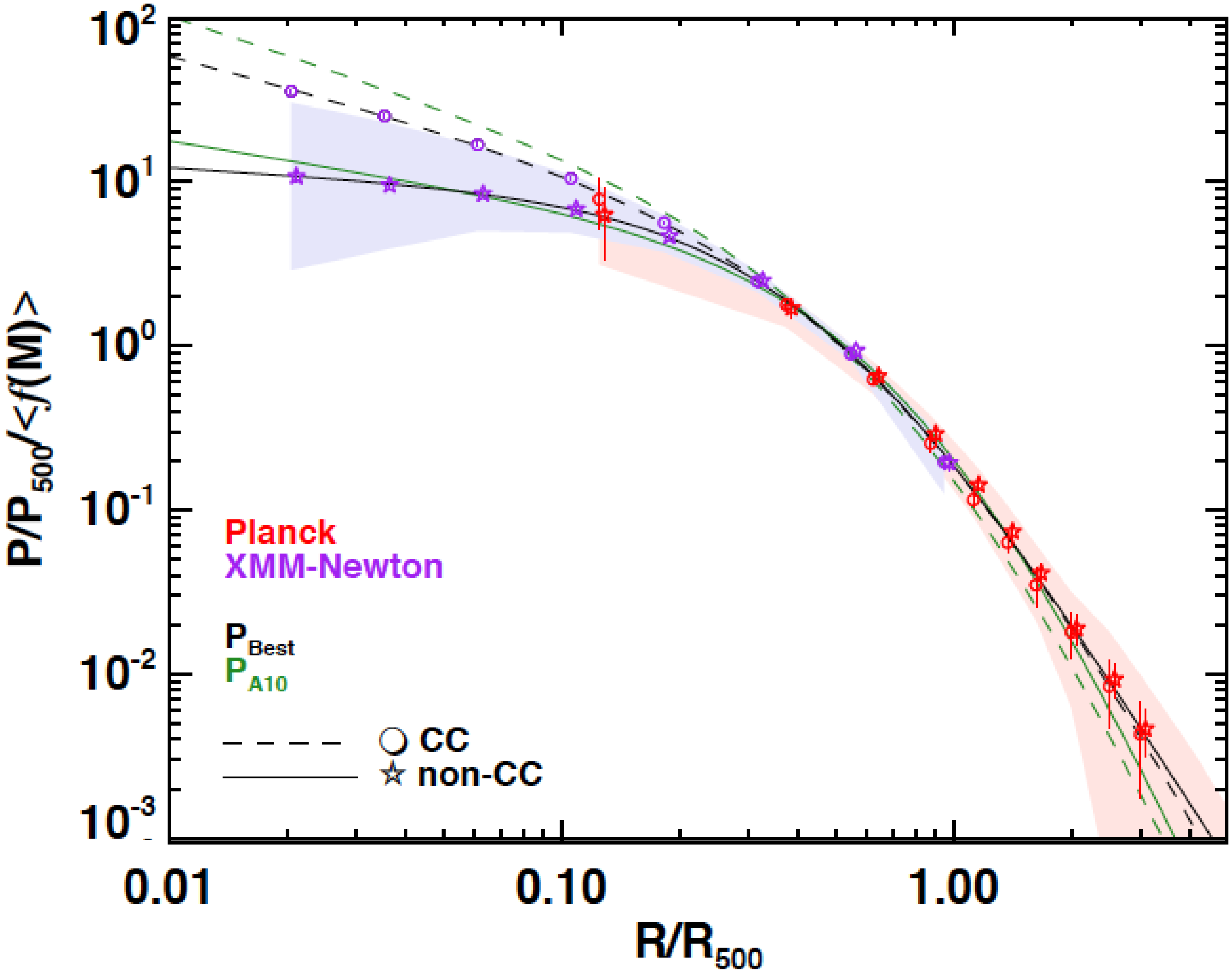

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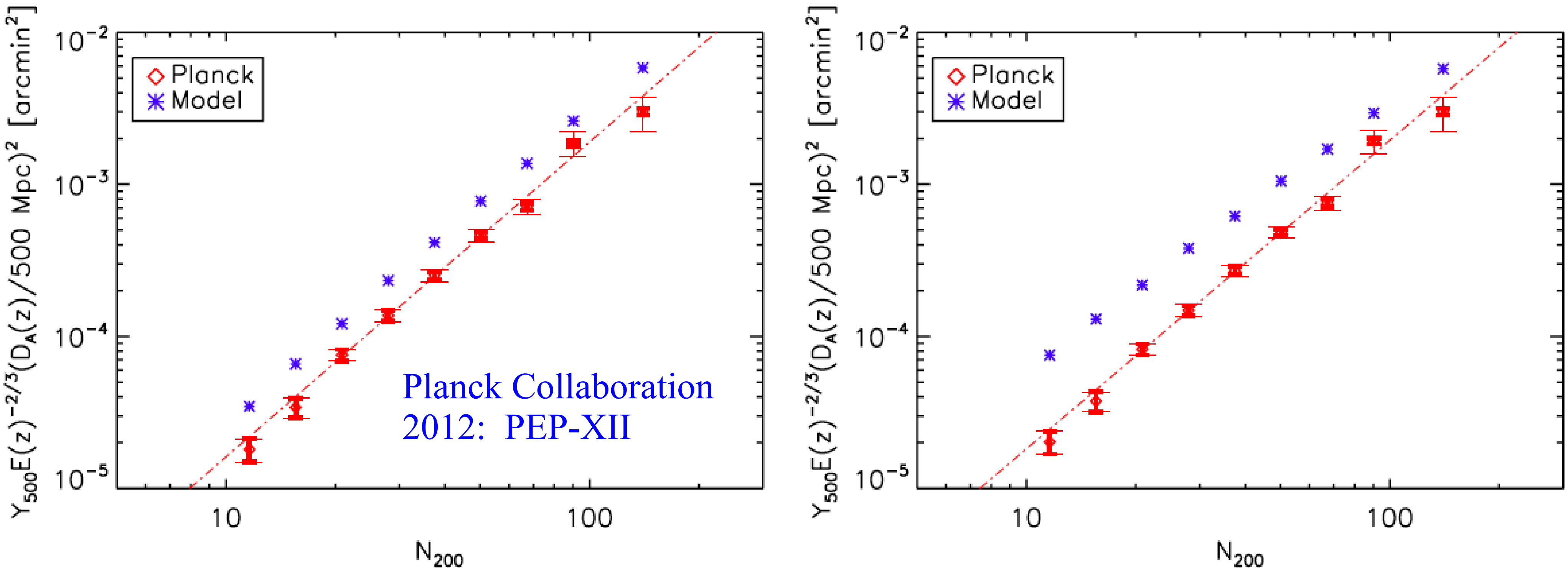
Beyond R_{500} the mean pressure lies above the universal profile of A10

“Excess” does not correlate with inner structure

Problems with scaling relations?



Stacked Y for large numbers of maxBCG clusters do not agree with the prediction from

N_{200} → M_{500} → $Y_{X,500}$ → Y_{500}

gravitational lensing of maxBCG stacks

universal pressure profile of A10

assumed equal

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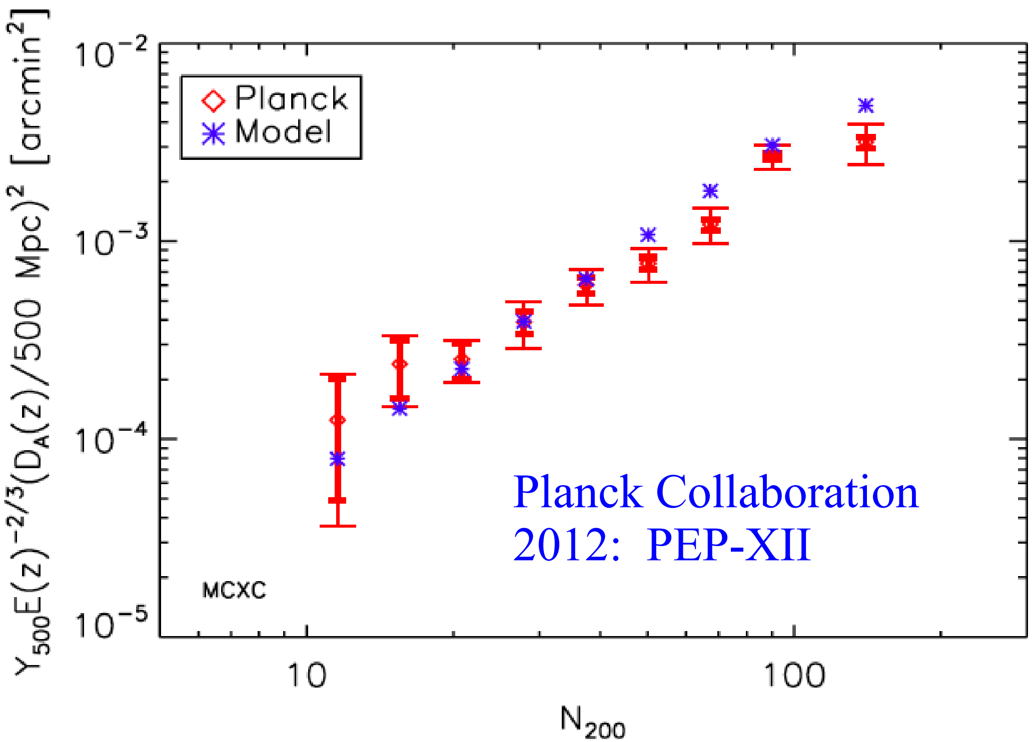

Yet when sample is restricted to clusters which also appear in an X-ray selected sample, the discrepancy disappears

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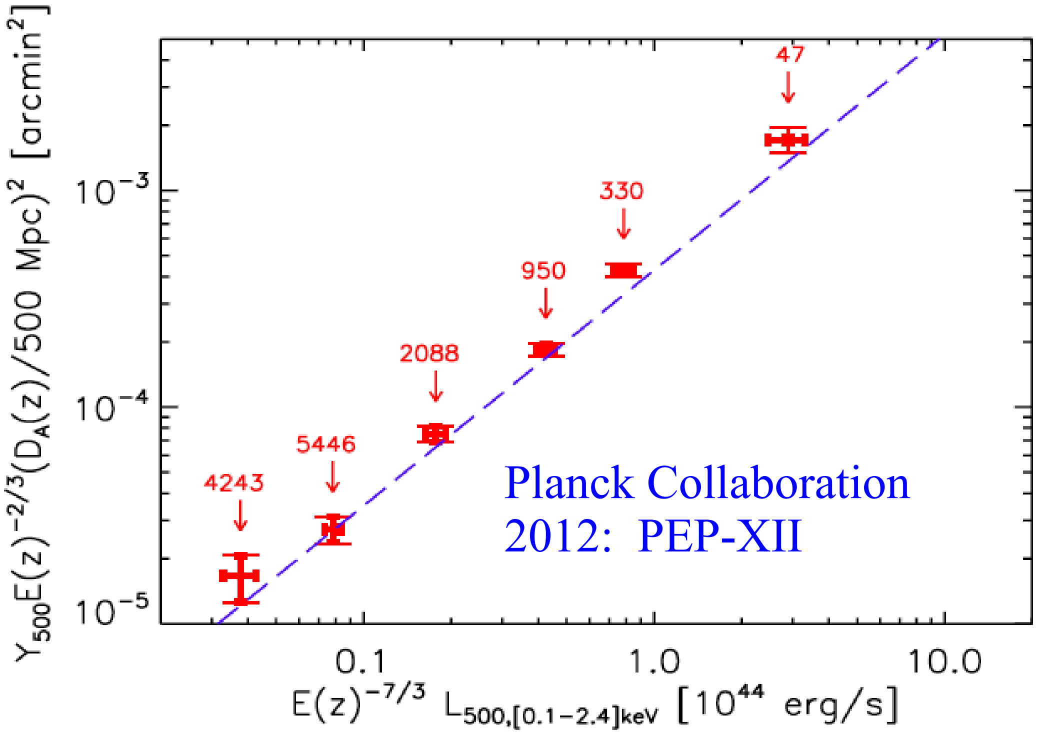

...and mean stacked $L_{X,500}$ is related to mean stacked Y_{500} as predicted by A10 for the <u>full</u> maxBCG sample.

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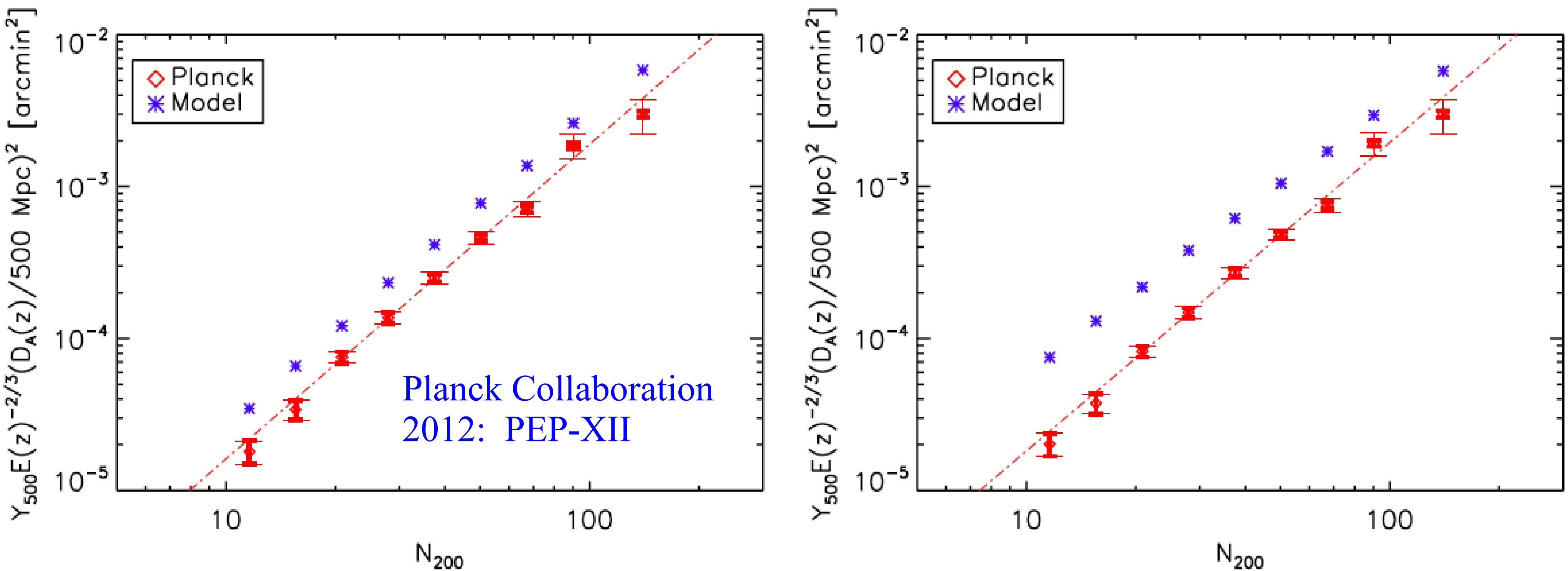

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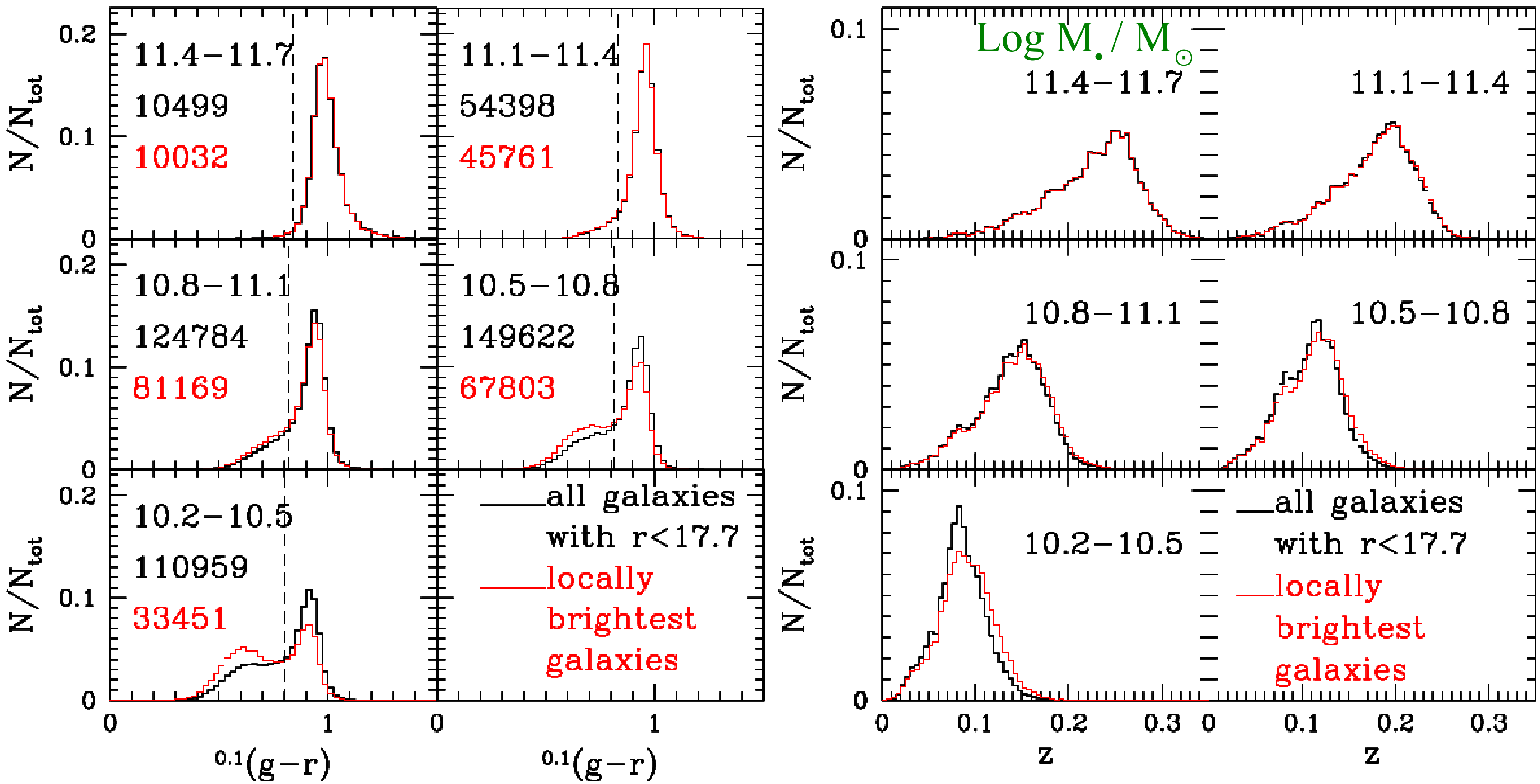
Problem of sample selection, calibration and scatter?

A complete sample of locally brightest galaxies

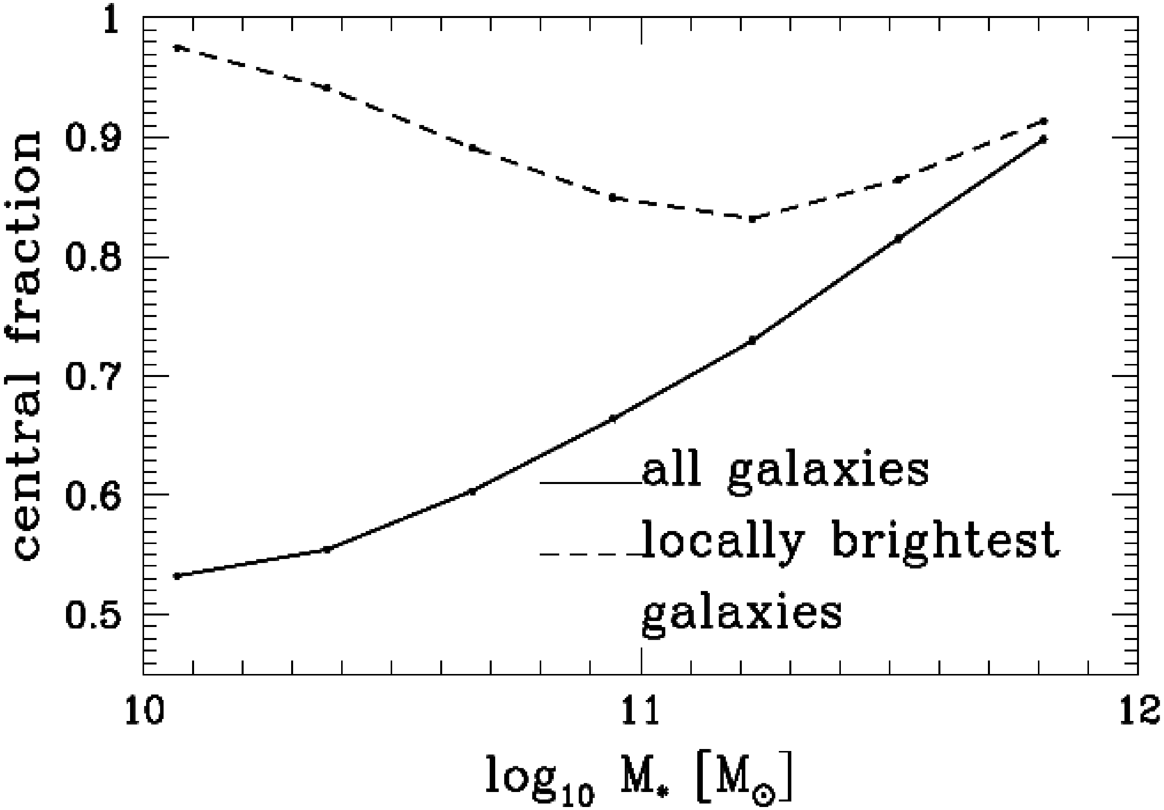
Planck Collaboration 2012: PIP-XI



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

LBG's are predominantly halo central galaxies

Planck Collaboration 2012: PIP-XI



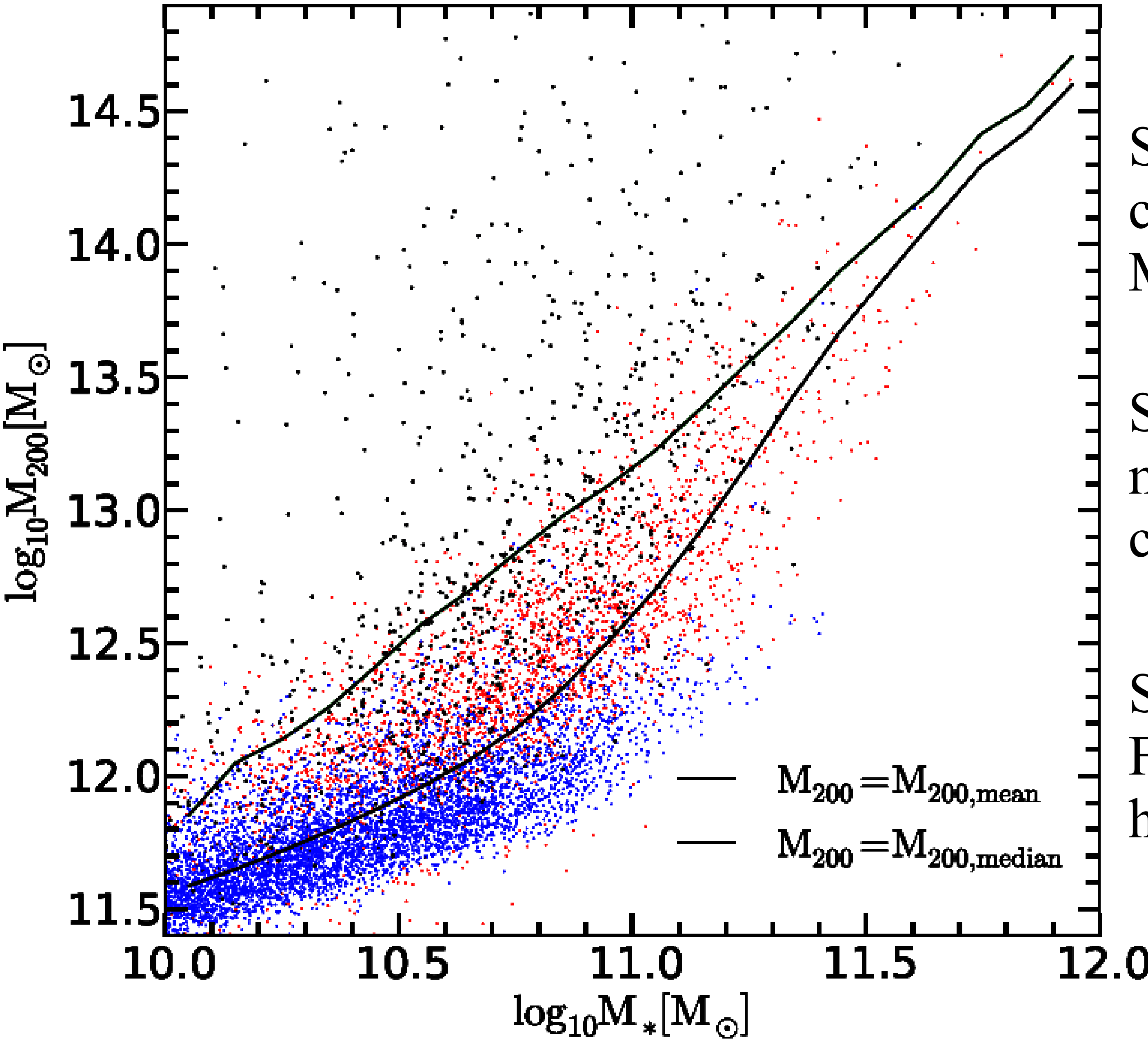
LBG's selected according to the observational criteria in a mock catalogue constructed from the Guo et al (2012) model of galaxy formation in the Millennium Simul'n (scaled to WMAP7)

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

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

LBG stellar mass is related to halo mass

Planck Collaboration 2012: PIP-XI



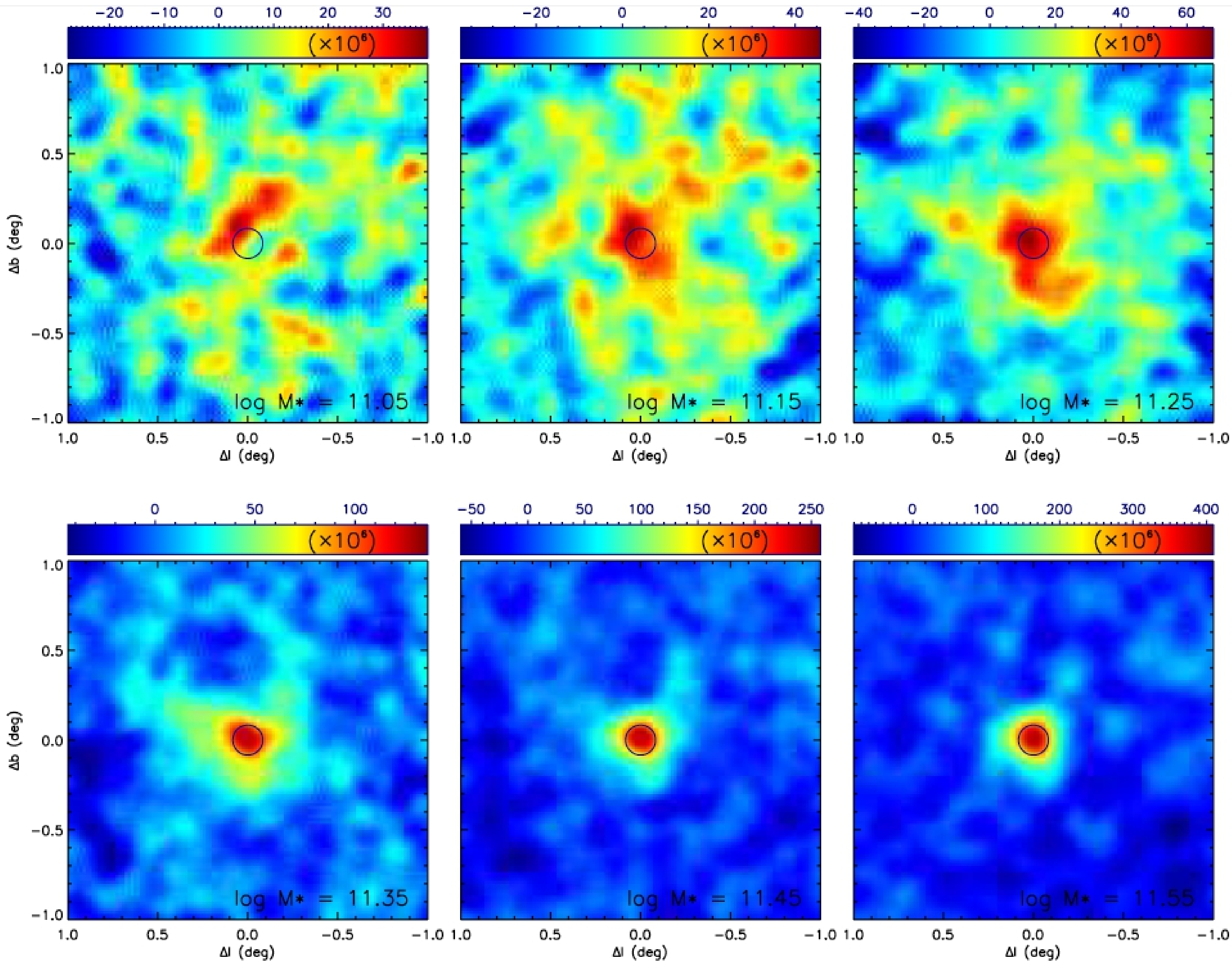
Star-forming and passive centrals lie on different M_* --M_h relations

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

Satellites are also offset From the centres of their halos

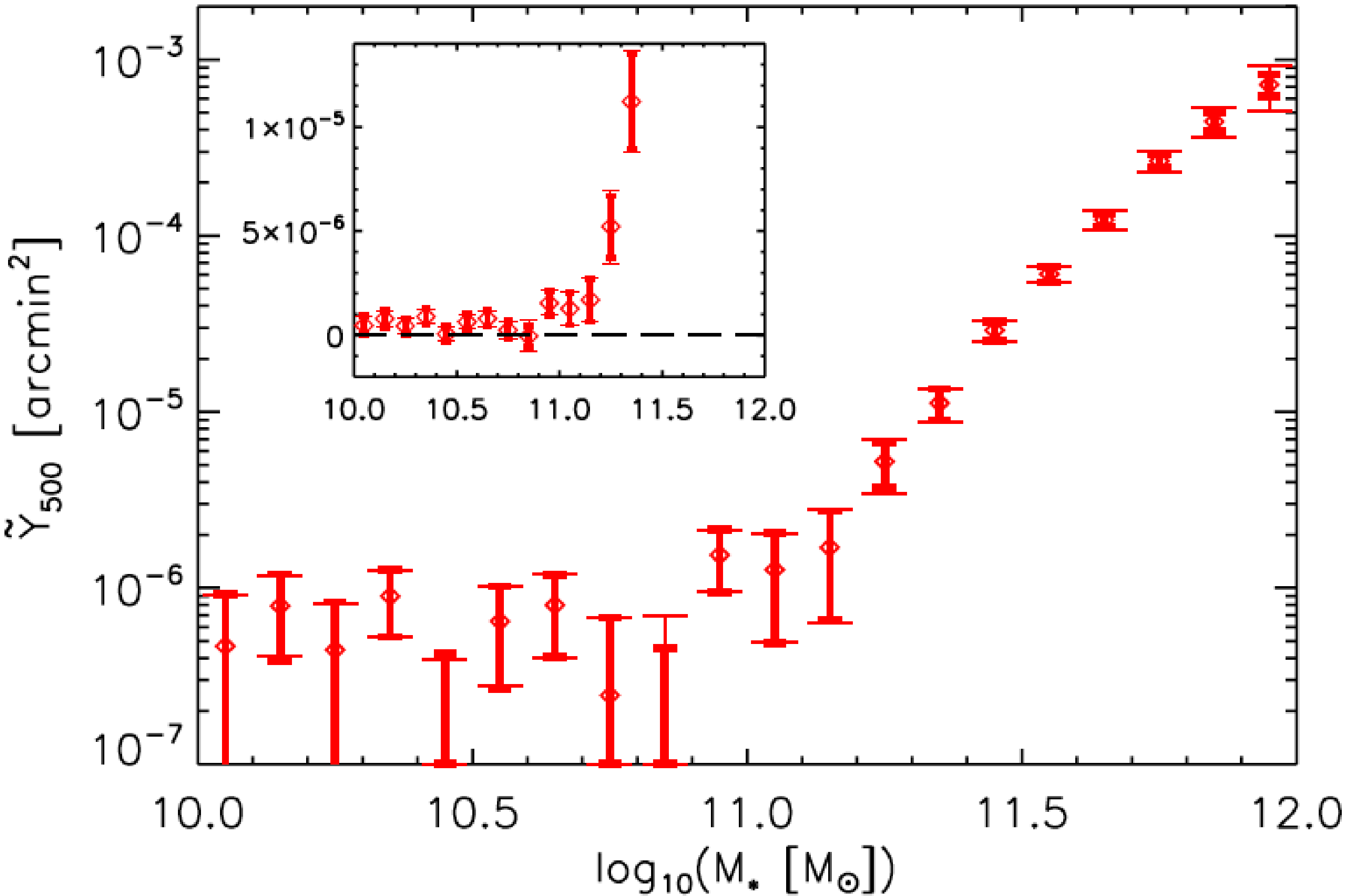
Stacked Planck y-maps for LBGs

Planck Collaboration 2012: PIP-XI



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

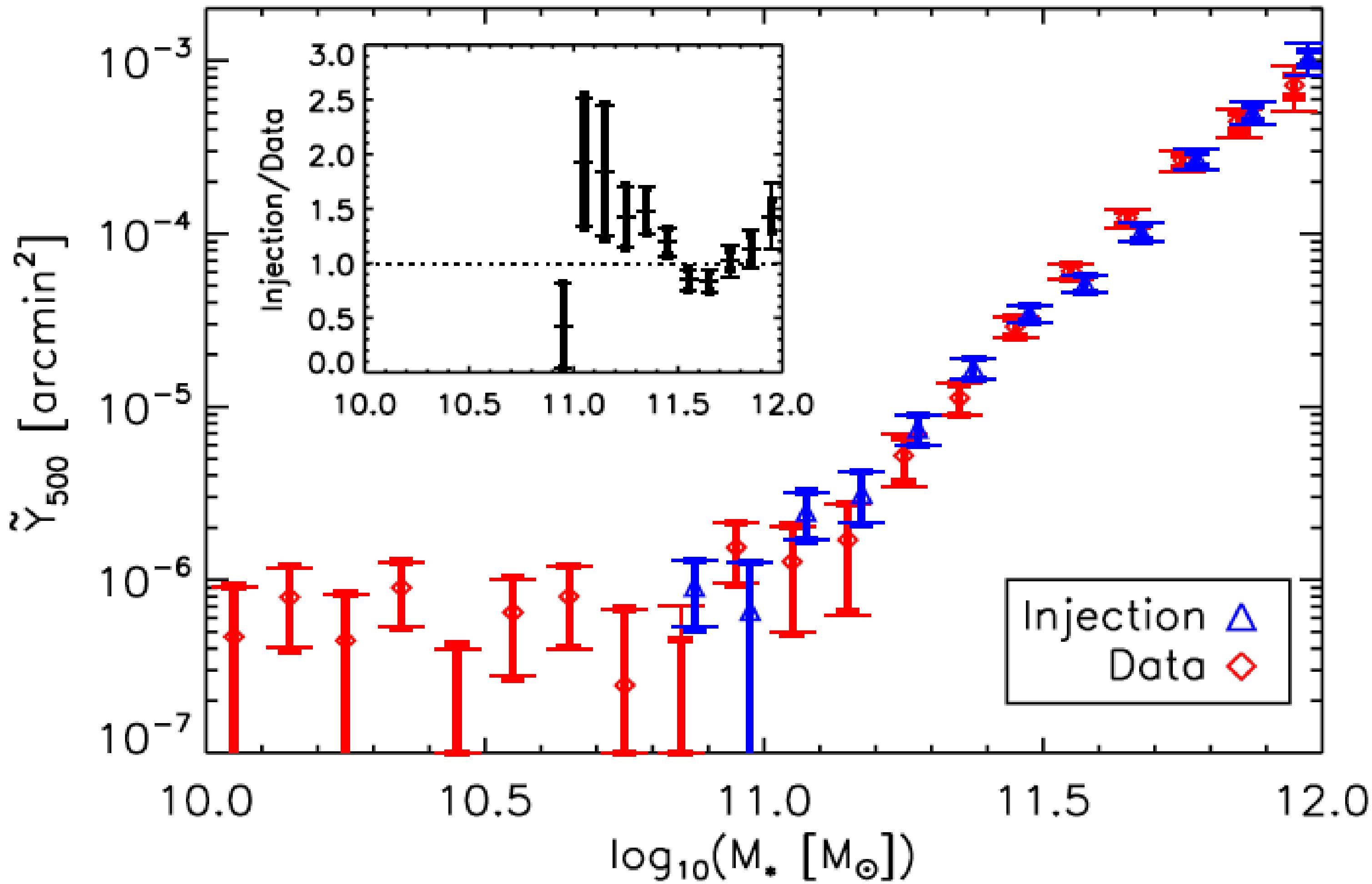
Planck Collaboration 2012: PIP-XI



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

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

Planck Collaboration 2012: PIP-XI



To each real LBG assign a random mock LBG of the same M_*

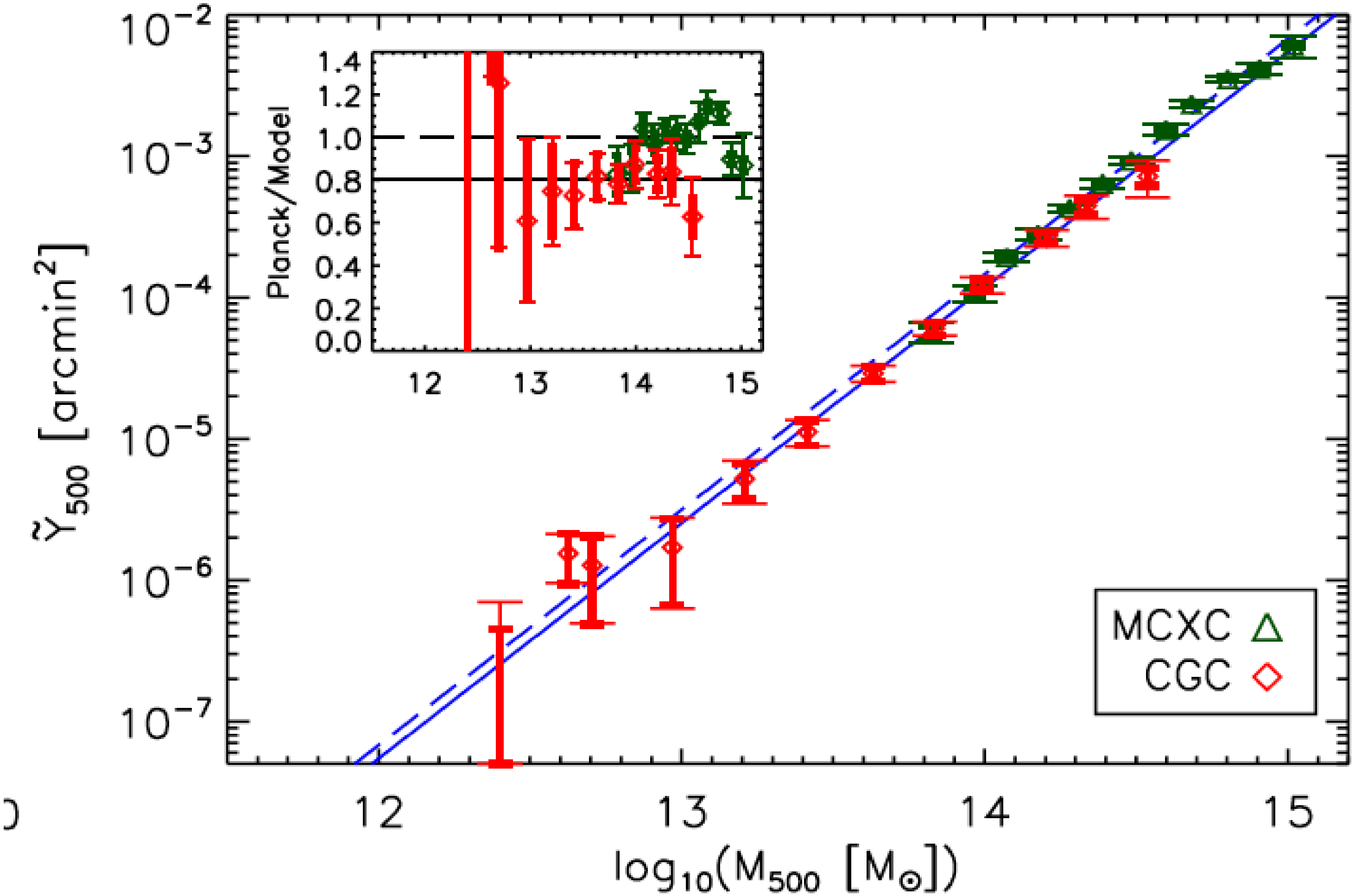
Use offset and M_h of mock LBG with $Y = A\, M_h^{\beta}$ + A10 profile

"Detect" using same filter as for observations, stack and compare

Fit for A and β ⟶ cosmic baryon fraction + self-similar β !

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

Planck Collaboration 2012: PIP-XI



LBG and MCXC results consistent to 20% – Malmquist bias in MCXC?
Scaling continues down to log M_h / $M_\odot$ ~ 12.5 <u>with no break</u>.
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
- The currently quoted uncertainties on scaling relations often appear to be underestimated
- Scatter in mass proxies can interact with sample selection to produced biased results. Scatter between all observables and the mass must be fully modelled
- Adopting a cosmology allows cluster physics to be studied
- By stacking LBGs, Planck detects Y down to $M_h \sim 10^{12.5}\ M_\odot$
- SZ-detected hot gas in halos accounts for ~25% of all baryons