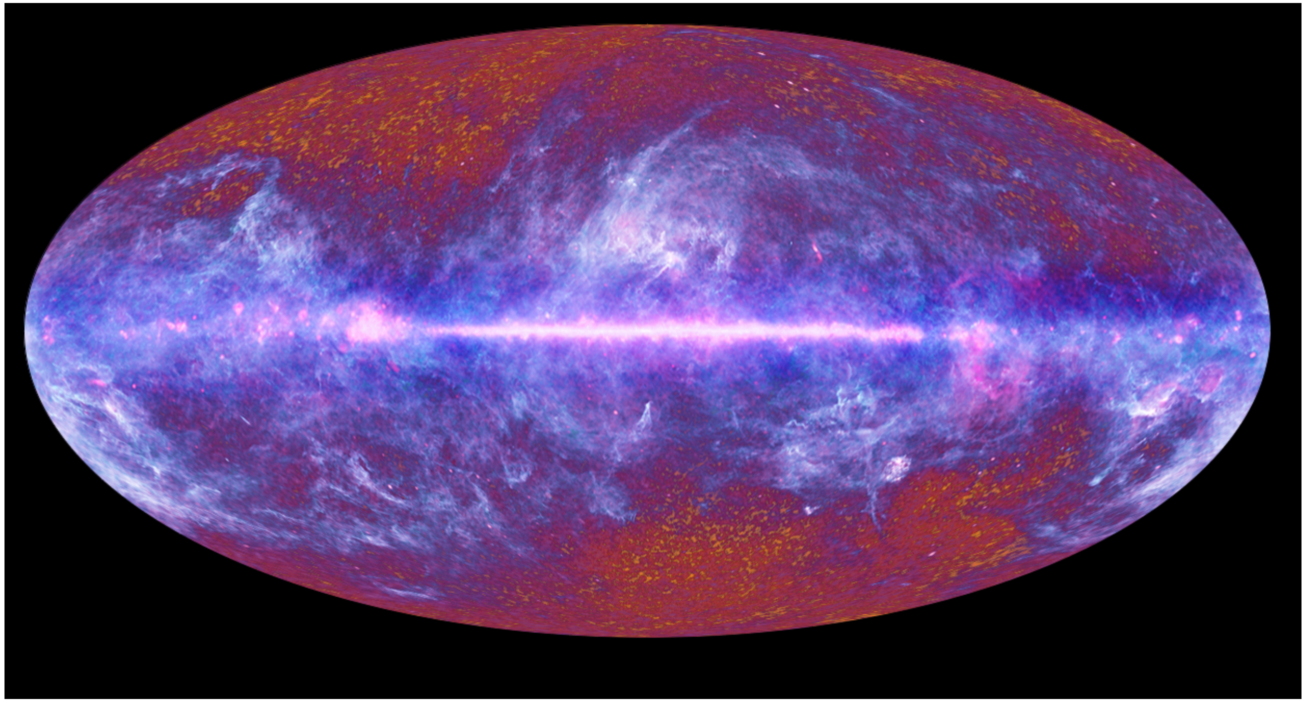
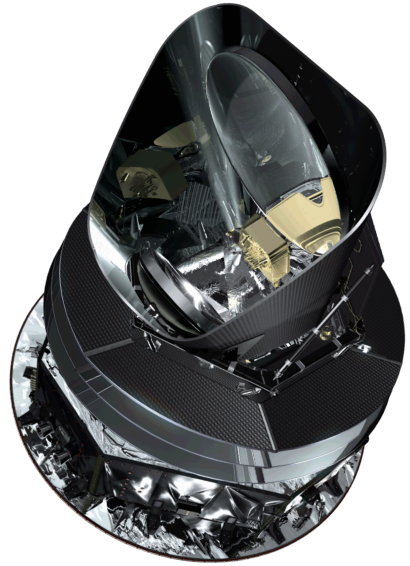




Planck Intermediate Results:
The gas content of Dark matter haloes
(the Sunyaev-Zeldovich stellar mass relation for central galaxies)

Planck Collaboration,
presented by José Alberto Rubiño-Martín (IAC)

"Astrophysics from the radio to the sub-millimetre". Bologna, February 13-17, 2012.

The scientific results in these papers are a product of the Planck Collaboration, including individuals from more than 50 scientific institutes in Europe, the USA and Canada

Planck is a project of the European Space Agency -- ESA -- with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.

Outline of the talk

I. Motivation of the work

II. Methodology. The "Central" Galaxy sample (CGC)

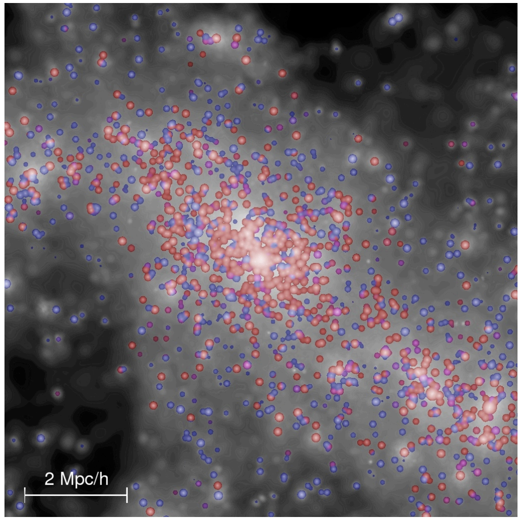
III. PLANCK SZ signal as a function of stellar mass

IV. Consistency tests

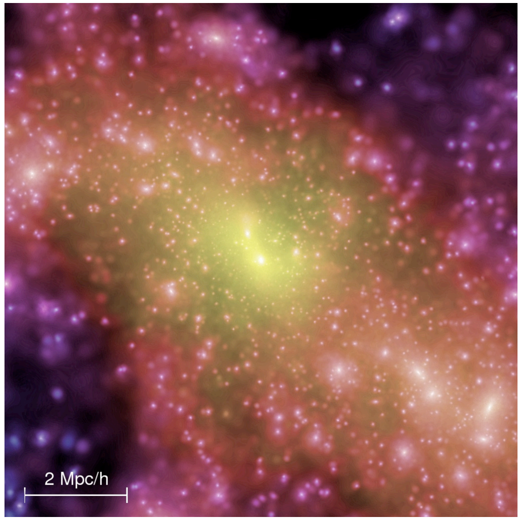
V. Discussion and implications for the missing baryons problem.

I. The gas content of dark matter haloes

- Key ingredient for understanding galaxy formation.
  - Relationship between gas, stellar and dark matter properties of haloes. Feedback/cooling?
  - Where are the missing baryons?



- PLANCK approach to the problem:
  - Statistical study based on external catalogues tracing DM haloes.
  - Sky coverage of PLANCK is an asset here.



➔“central” galaxies from SDSS-DR7 to trace haloes;

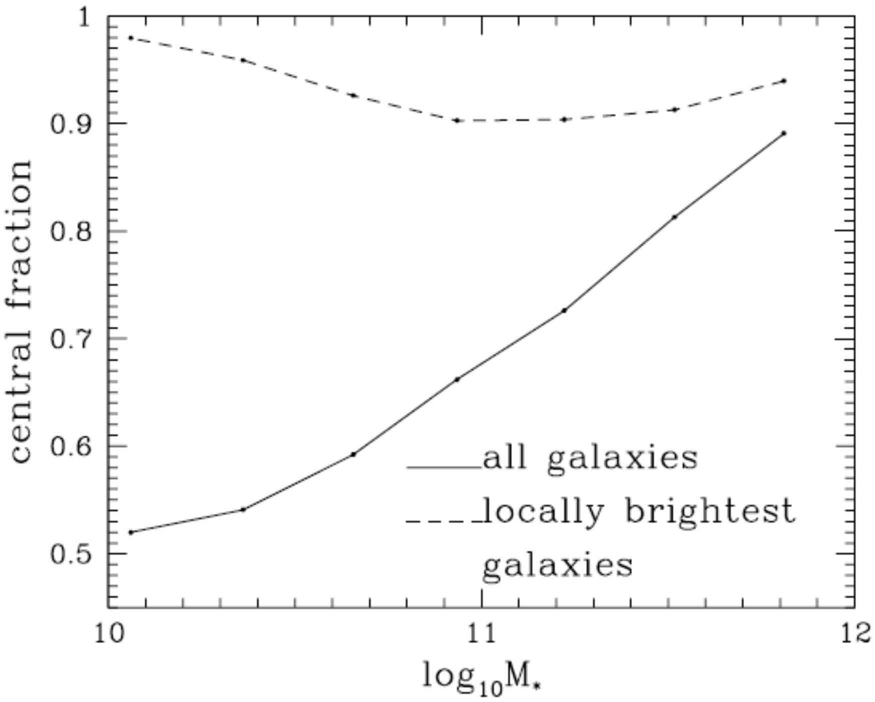
➔ galaxy models to establish the $M_\star$-M_h relation.

II. A "central" galaxy catalogue

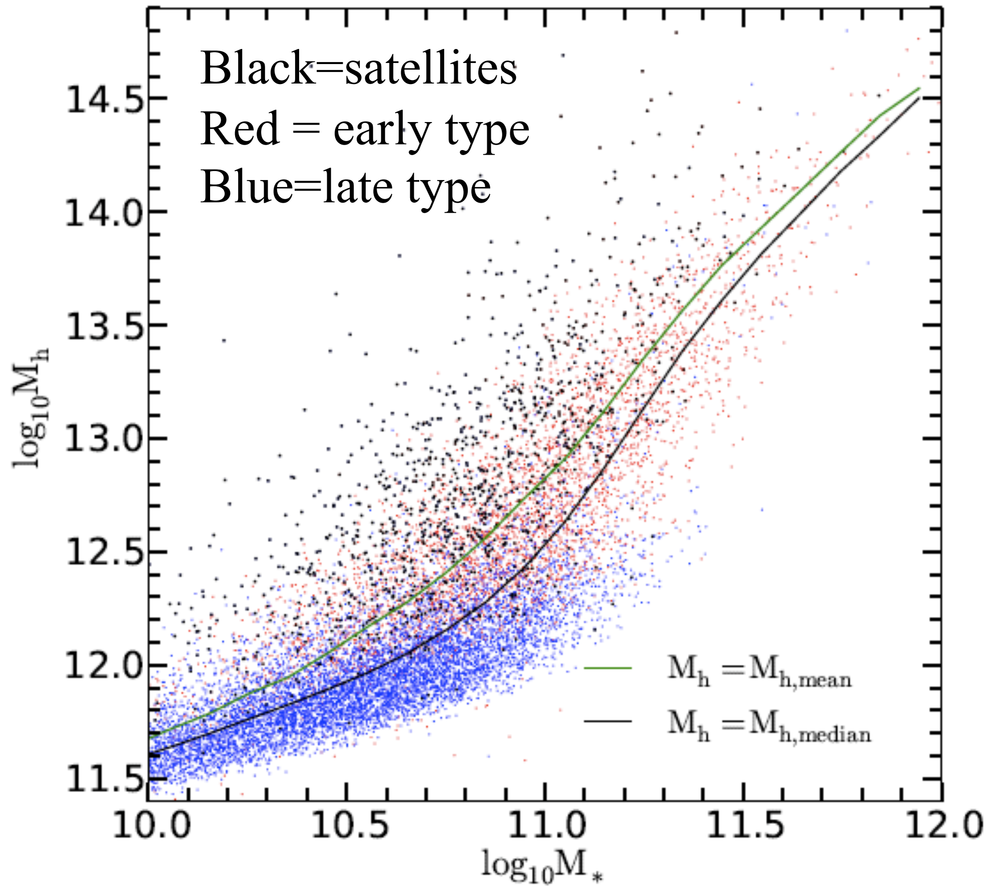
- "Central" galaxies selected here as a "locally brightest" galaxy catalogue.
- **Parent population**: galaxies with $r<17.7$ from the spectroscopic catalogue based on NYU VAGC (SDSS DR7).
- **Isolation criteria**: no galaxy of equal or brighter magnitude at
  - $r_p<1$ Mpc
  - $dz<1000$ km/s
- Additional "cleaning" from the photometric catalogue yields a final sample of 262,673 galaxies

- We use semianalytic galaxy formation simulation (Guo et al. 2011 based on a re-scaling of the Millenium simulation to the WMAP7 cosmology) to calibrate the purity and $M_\star$-M_h (stellar-to-halo mass) relation (hereafter SHM).
- Consistency tests done for other isolation criteria.

Purity and SHM relation



Mocks indicate >90% purity

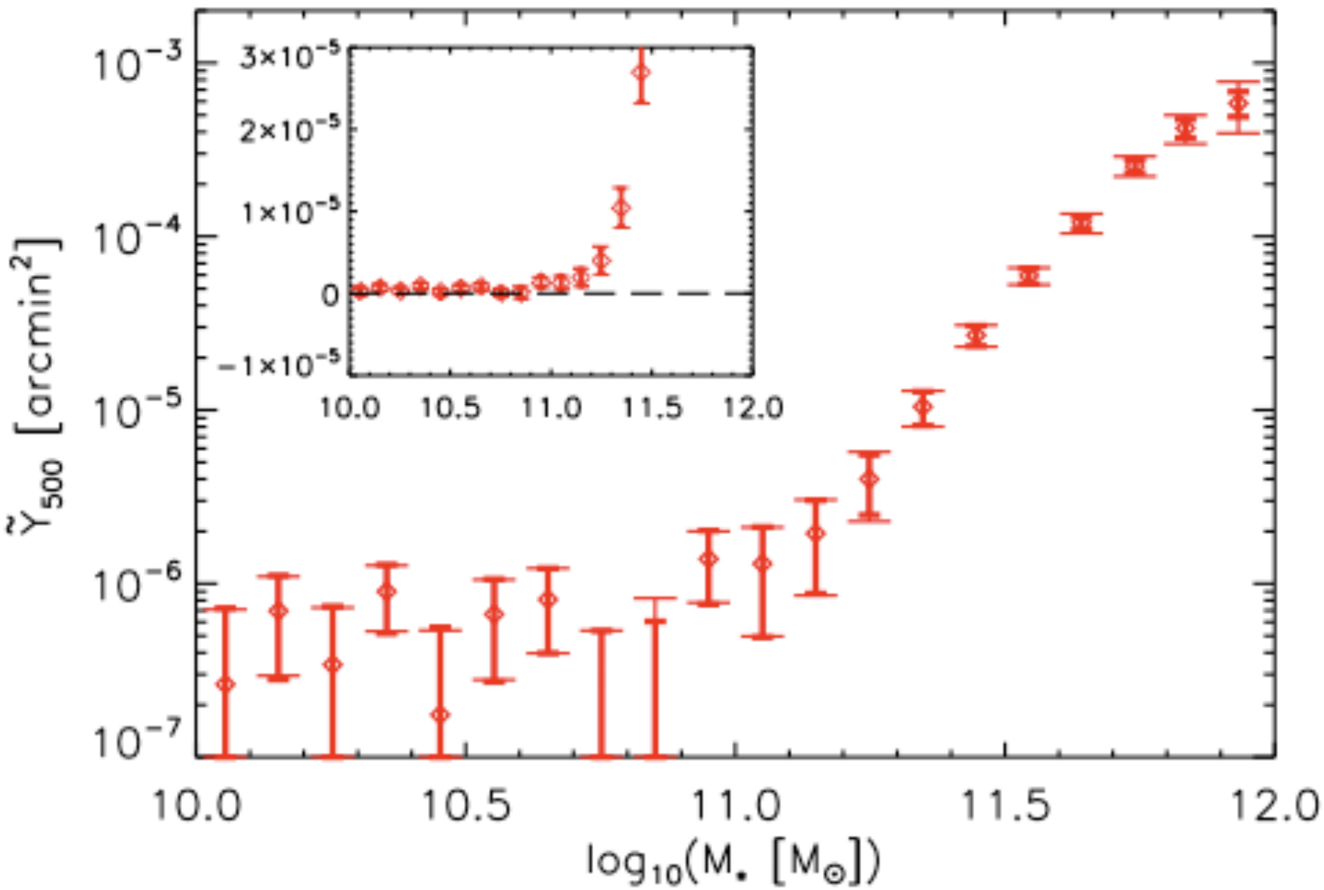


SZ signal extraction

- Reference method: matched multi-frequency filter (MMF; Herranz et al. 2002; Melin et al. 2006), to obtain Ysz (e.g. Planck Collaboration X,XI,XII 2011).
  - Filter size adapted to each object using M_h.
  - Adopt the Universal pressure profile (Arnaud et al. 2010)
  - Use re-scaled value $\tilde{Y}_{500} = Y_{500} E^{-2/3}(z)(D_A(z)/500\,Mpc)^2$

- Two additional photometry methods also considered for consistency/robustness tests
  - Aperture photometry.
  - Gaussian (beam) fitting.

III. Main result (preliminar)

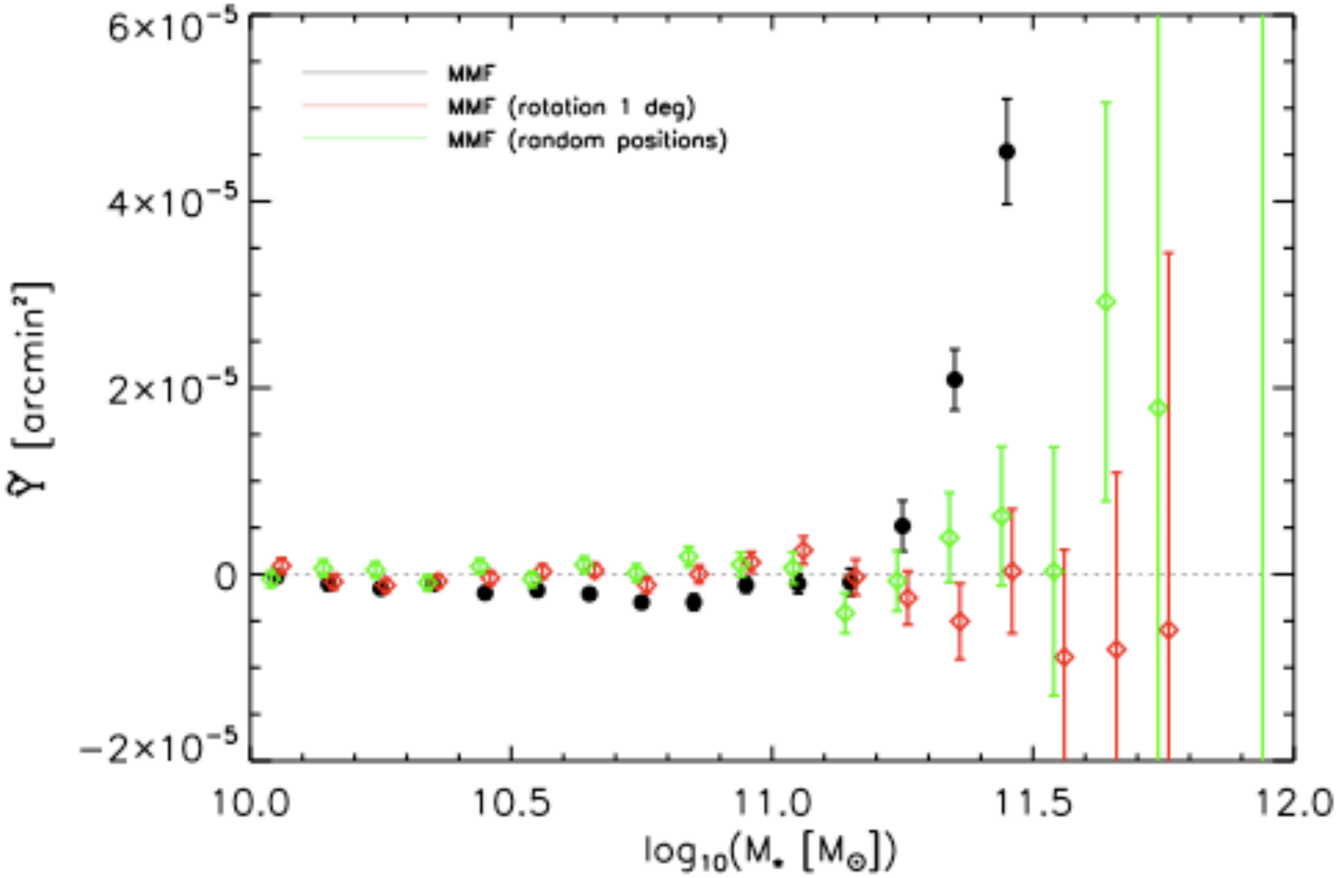


Clear relation between the SZ signal and stellar mass down to 10^{11} $M_\odot$, which corresponds to a halo masses of $\sim10^{13}M_\odot$

IV. Consistency checks

- Null tests
- Photometry comparison
- Foreground (dust) contamination

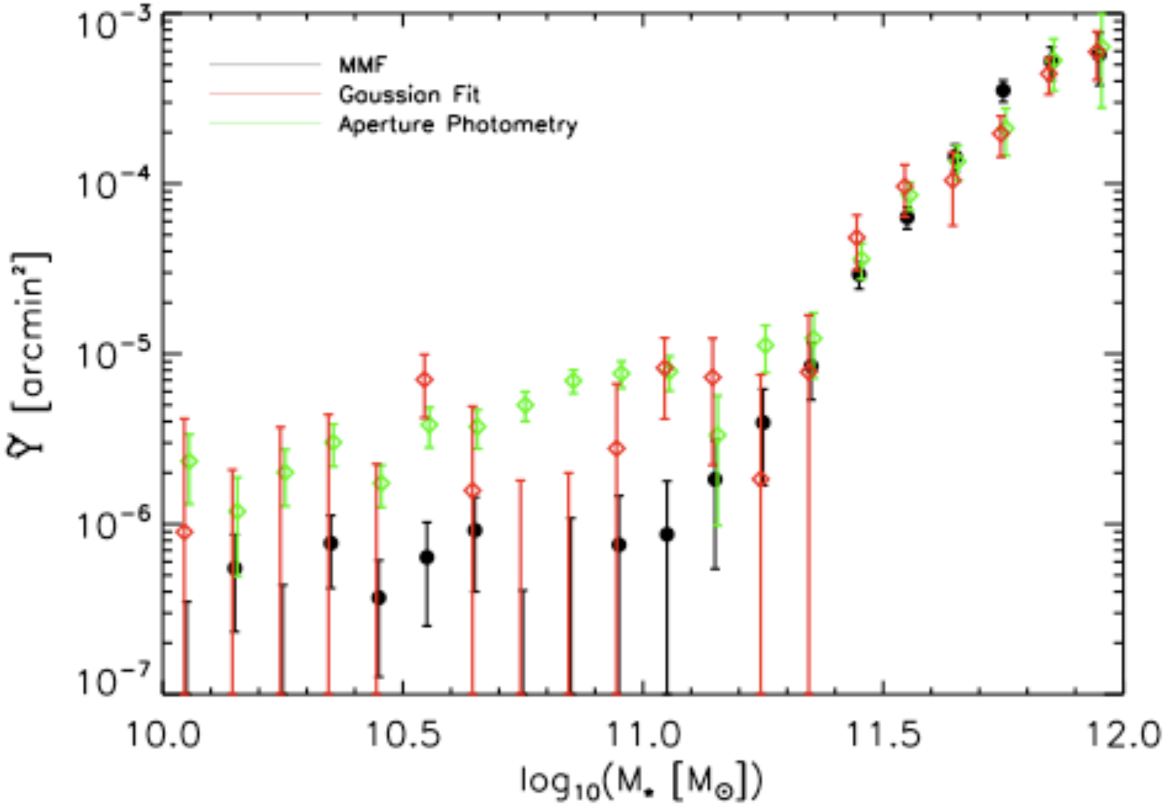
IV. Consistency checks (I)



○ Two type of tests: random positions and rotations.

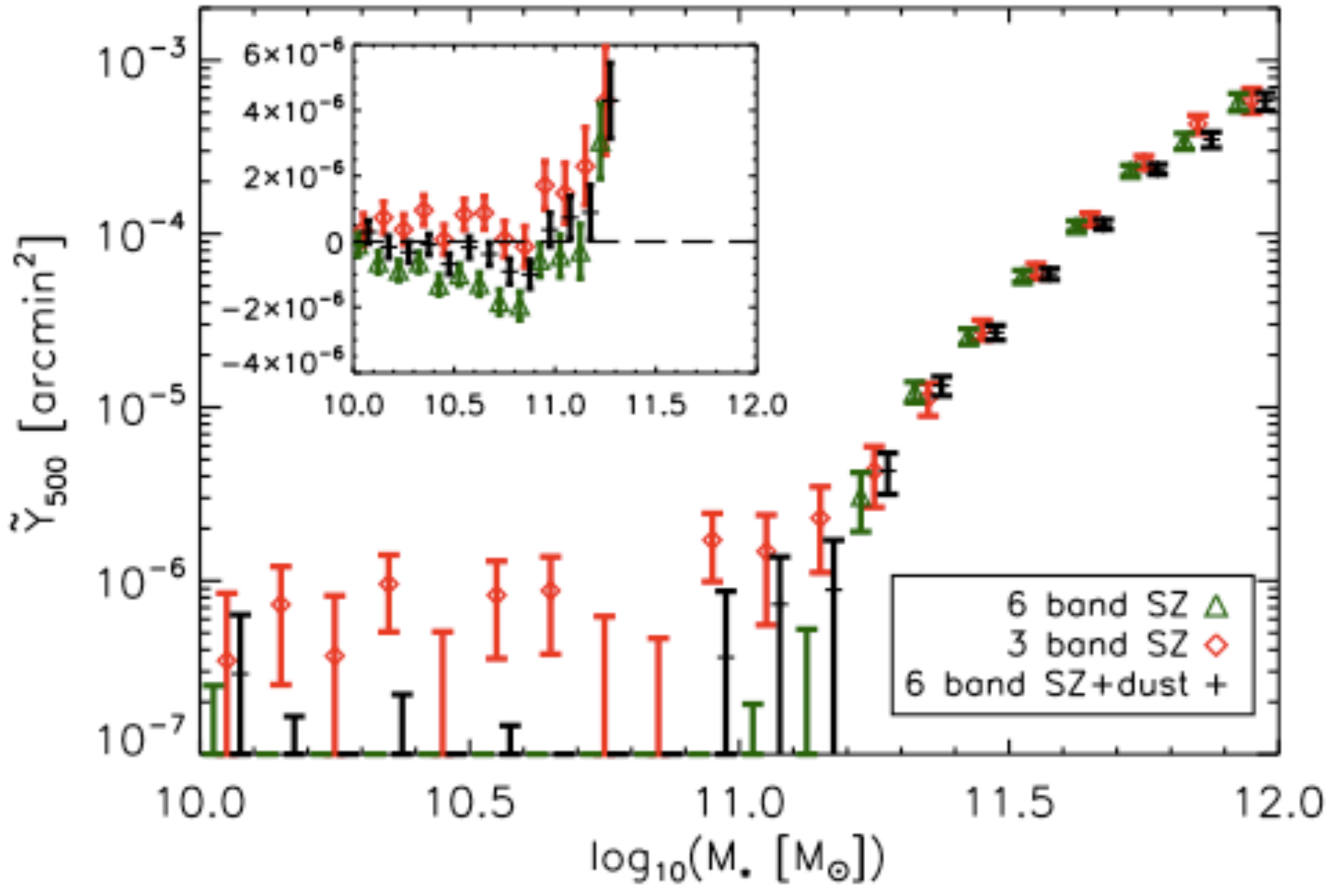
○ Last stable bin is at log(M*)~11.25.

IV. Consistency checks (II)



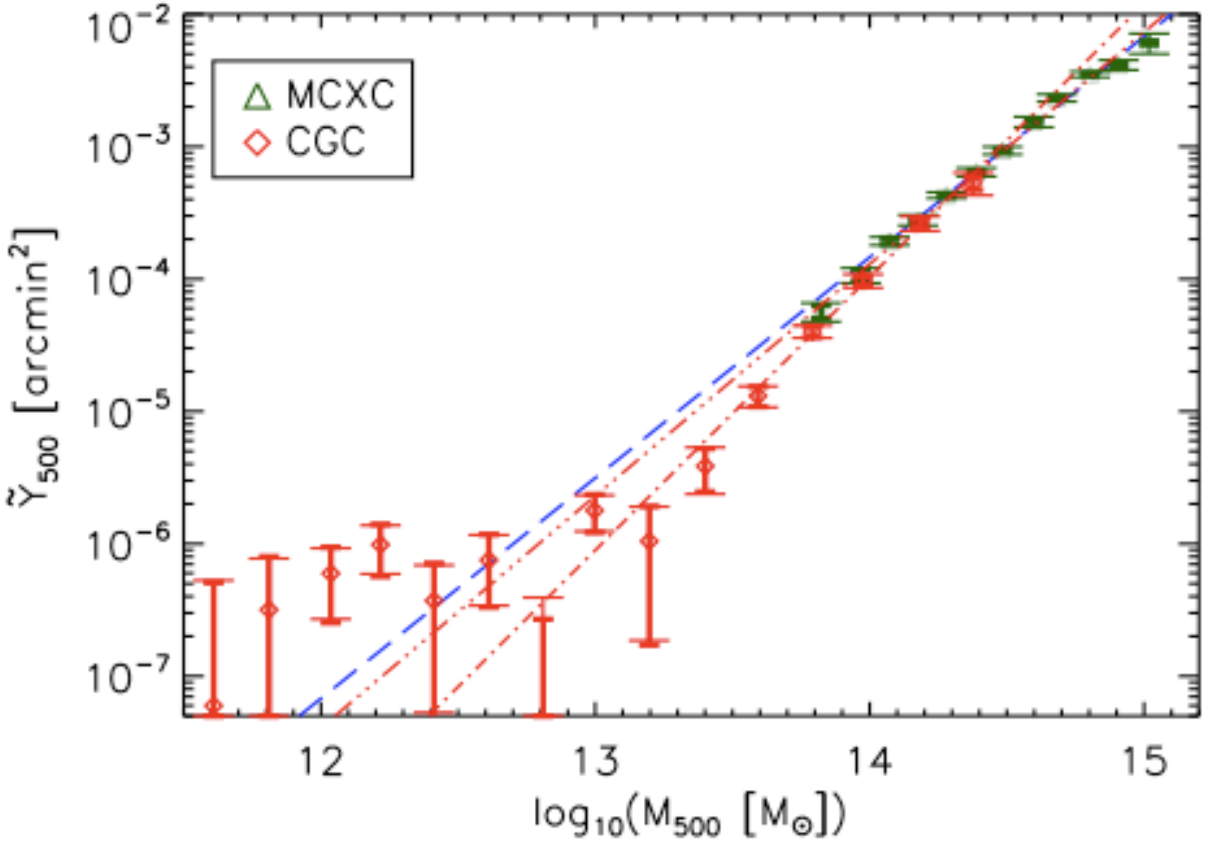
- Three photometry methods: MMF, Aperture photometry and Gaussian fitting.
- Consistency for log(M*)>11.25, despite the different assumptions on source profile.
- Different sensitivity to dust contamination seen for stellar masses below log(M*)=11.25

IV. Consistency checks (III)



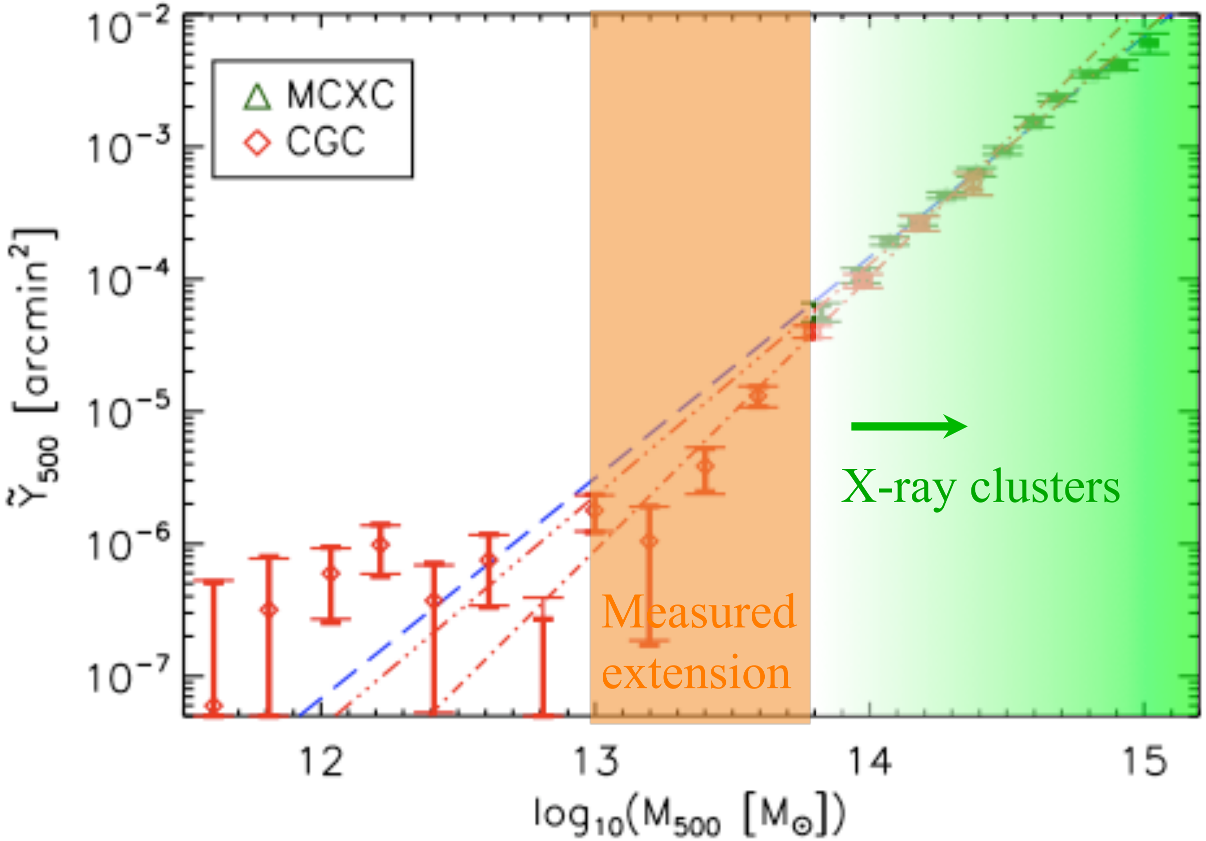
- Dust effects are clearly present, notably at high frequency
- Three filters applied. Final results presented for the 3-band MMF.

V. Discussion and Implications



The observed cluster relation based on X-ray sample (MCXC sample, Planck Collaboration X, 2011) matches our observations.
The new result extends the relation down to $\sim 10^{13} M_\odot$

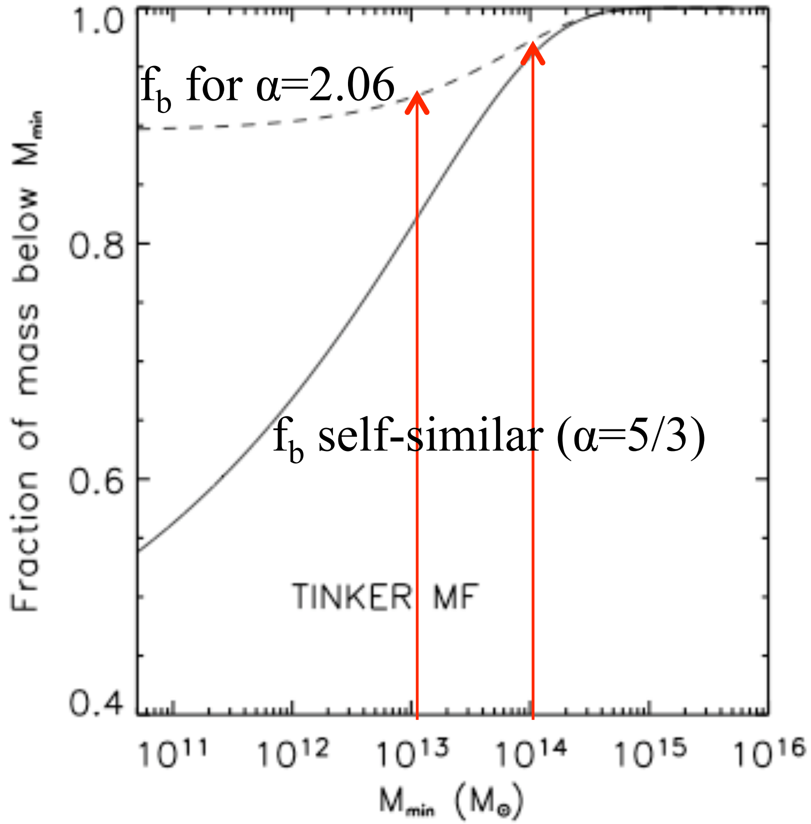
V. Discussion and Implications



Power law fits give the following exponents:

- MCXC+CGC : 1.752 ±0.010 (stat) ±0.030 (bootstrap) (2.8 sigmas from self-similar)
- CGC only : 2.064 ±0.063 (stat) ±0.089 (bootstrap) (4.5-sigmas from self-similar)

Missing baryons



$$f_{b,haloes} = f_{cosmo}\left(\frac{M_{200}}{10^{15} M_{sun}}\right)^{\beta}$$

$$\beta = \alpha - \frac{5}{3}$$

- Mass fraction estimate: f_b(haloes) (Tinker et al. 2008) + f_b(stars) (Leauthaud et al. 2011).
- Detection of *new baryons: **roughly 1.4 (0.7) times*** **the amount of formerly detected baryons in characterized** higher mass halos for α=5/3 (2.06), respectively.

Conclusions

- First measurement of SZ signal to stellar mass scaling relation.
- Unique Planck capability (full coverage of SDSS area)
- Determination of SZ signal down to ~$10^{13}M_{\odot}$ – smallest systems to date
- Evidence of a steepening in the scaling with mass. However, the fit to a single power-law including X-ray clusters marginally agrees with self-similarity.
- Implication for "missing baryon problem": almost double the amount of the formerly known baryons.

- Paper to be submitted soon to the journal.