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The University of Manchester

Sunyaev Zel'dovich Clusters in Millennium Gas Simulations

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[Kay et al. 2012, MNRAS, 422, 1999]

Millennium Gas Simulations

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- Strengths
  - Large cluster samples (>10^3 objects)
  - Large volume (mass range)
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- Strengths
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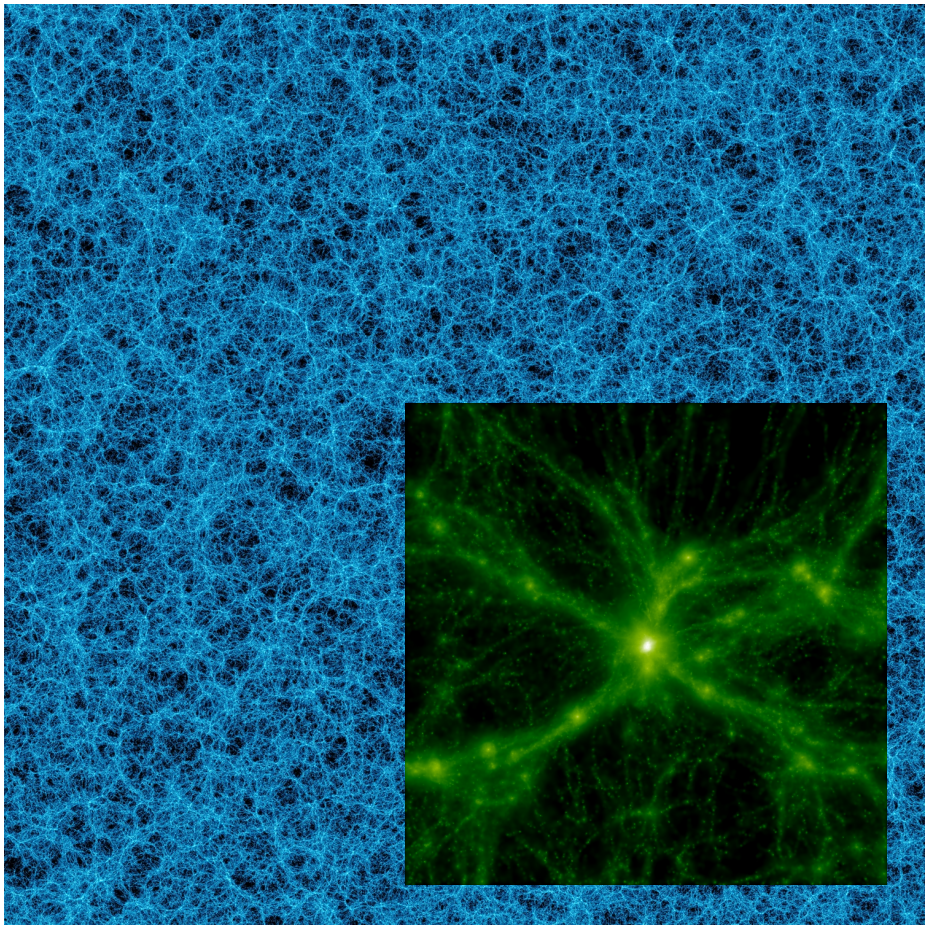
- Weaknesses
  - Modest resolution (<10^5 particles/cluster)
  - Older cosmological model (*WMAP* 1)
  - Cooling ineffective/absent

Millennium Gas Simulations



Millennium Simulation:

- Tracks CDM only (+SA galaxies)
- N=2160^3 particles
- L=500 h^{-1}Mpc (comoving)
- *WMAP*1 cosmology (σ_8=0.9)

Old Millennium Gas Simulations:

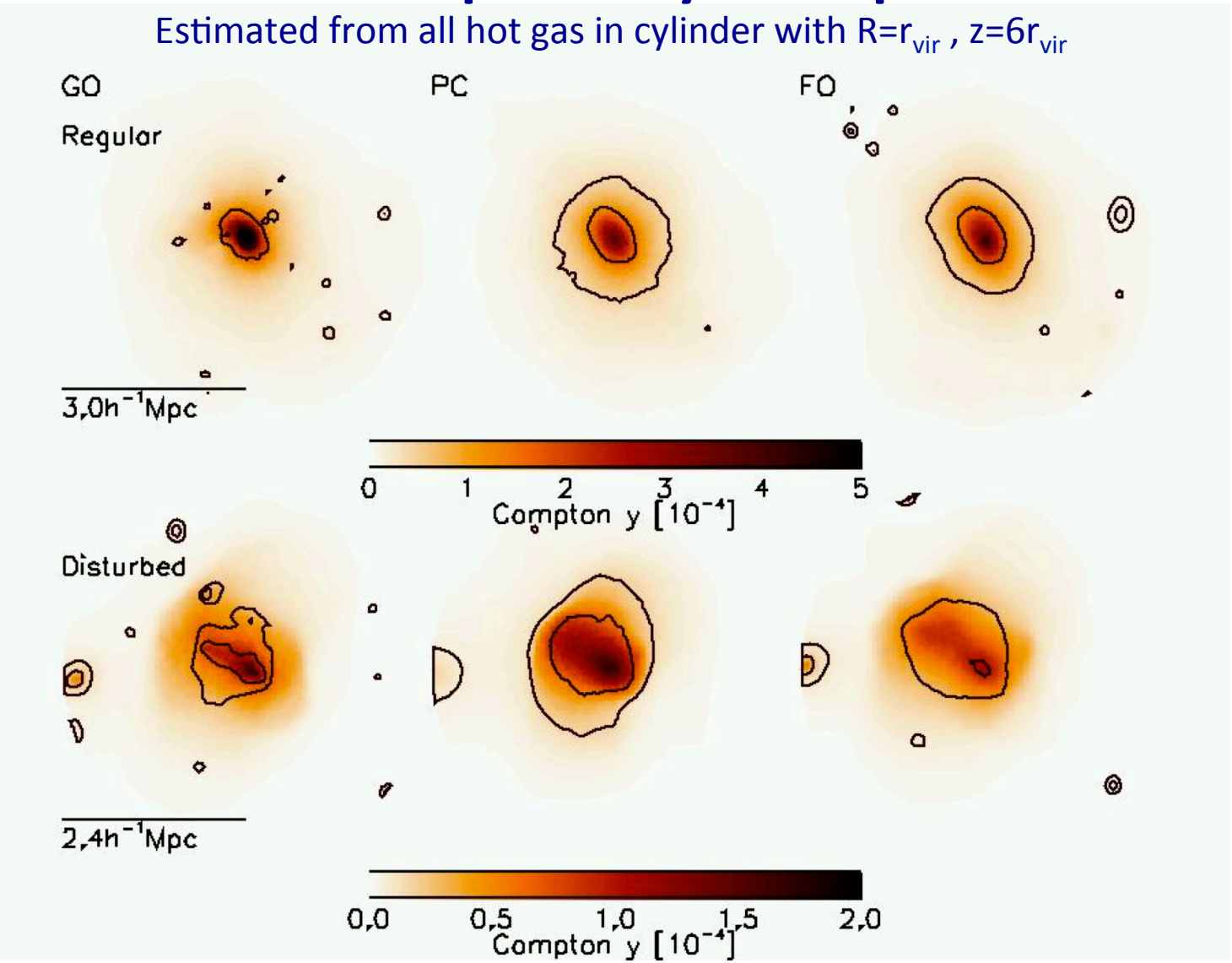
- Same large-scale structure as MS
- Same cosmology as MS
- Fewer (10^9) particles than MS
- GO (non-radiative), PC (pre-heating +cooling), FO (SA feedback) models

New Millennium Gas Simulation:

- Uses *WMAP*7 cosmology (σ_8=0.8)
- New SA model (Guo+11)
- New feedback model (Short+12)
- 1e10 DM, 5e9 gas particles

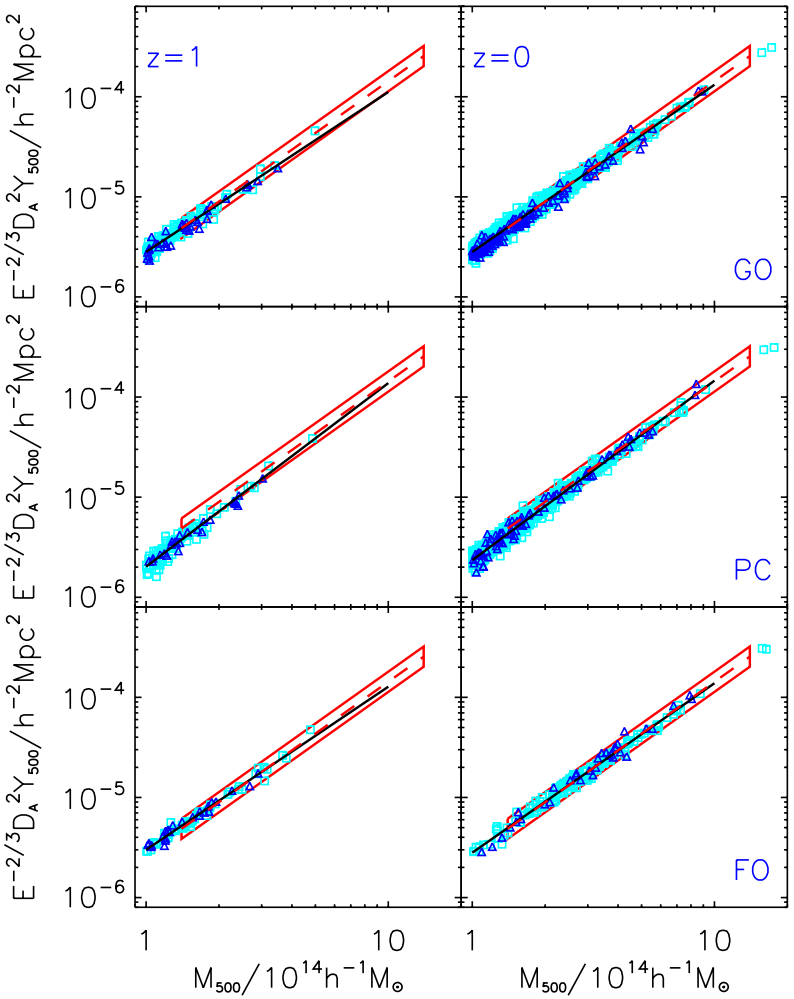
Compton y Maps

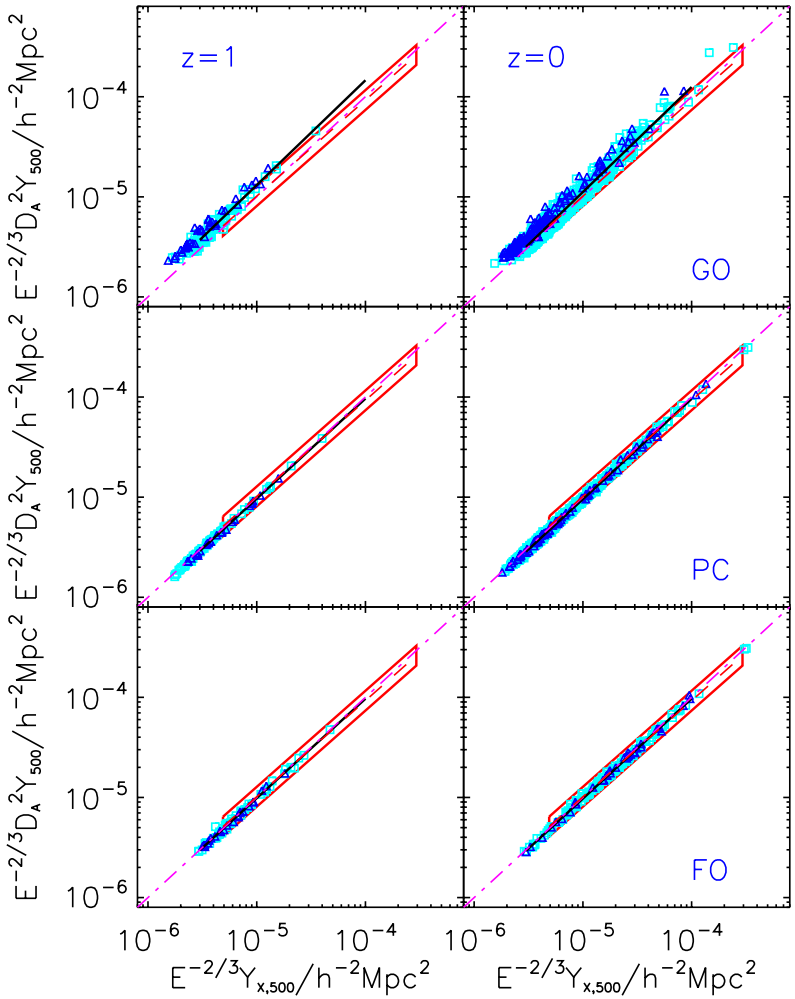
Estimated from all hot gas in cylinder with $R=r_{vir}$, $z=6r_{vir}$



SZ Y_{500}-M_{500} relation

Evolution with redshift and comparison with Planck-XMM data





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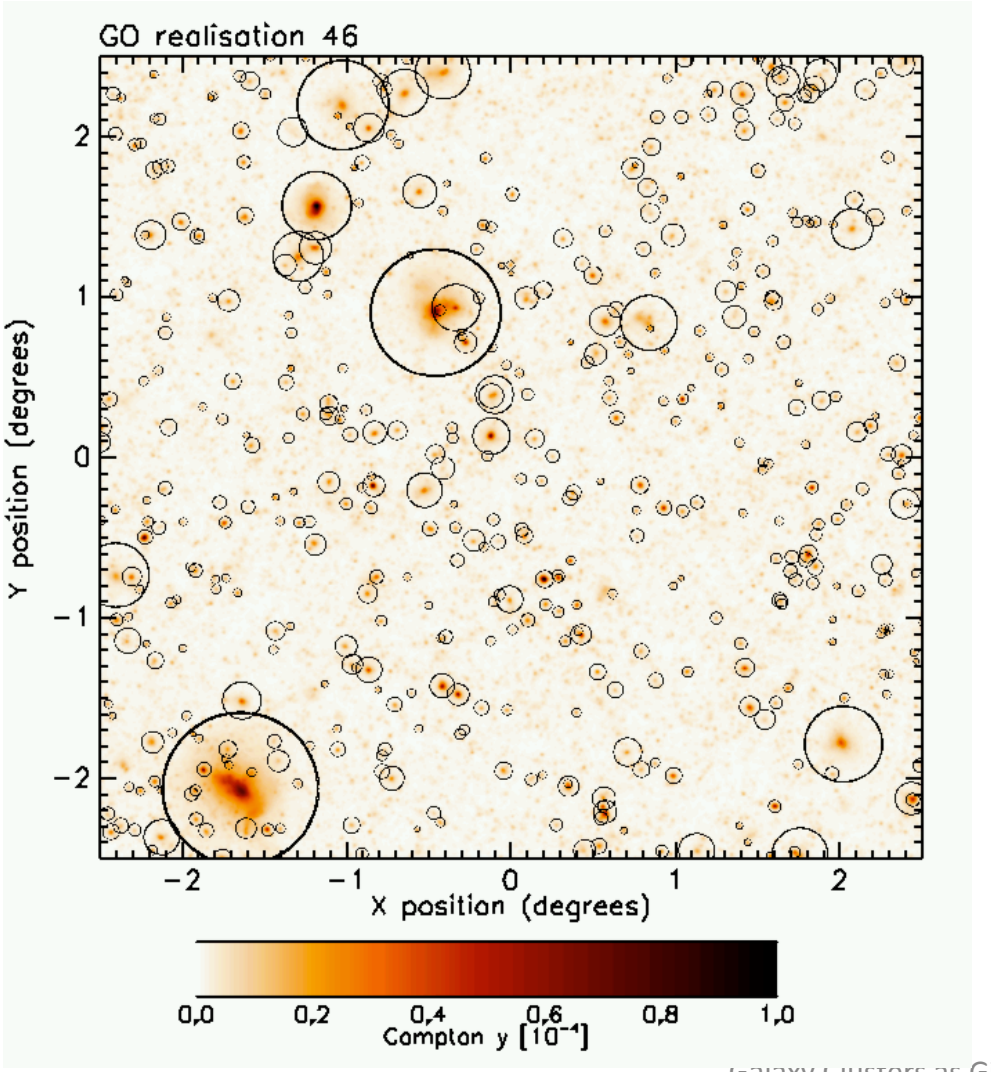
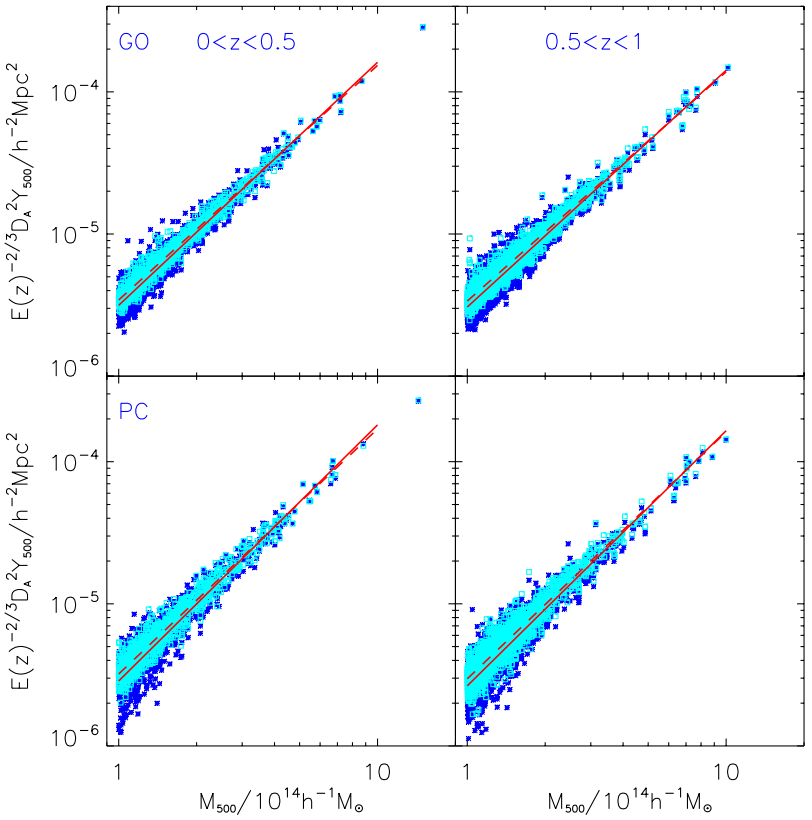
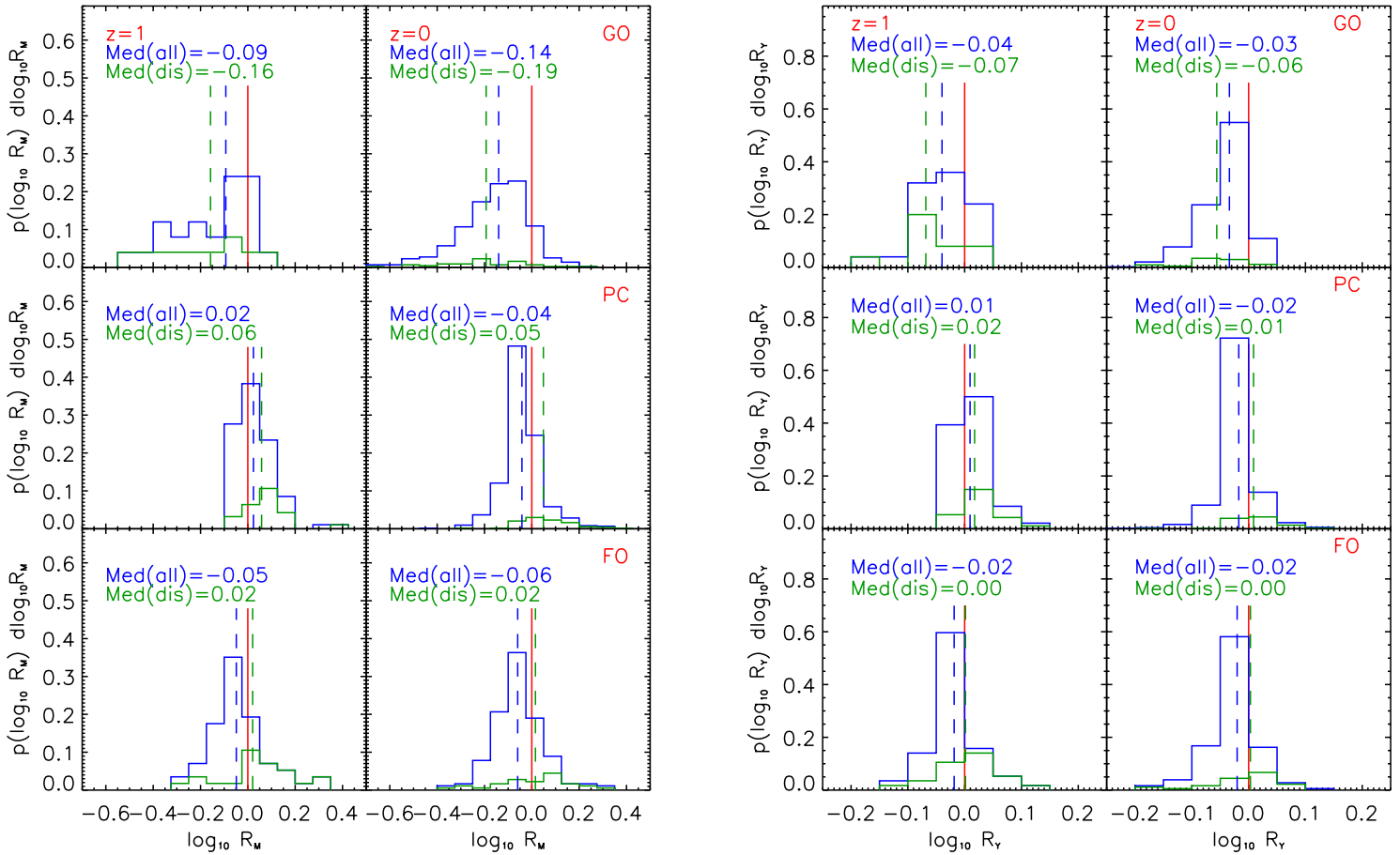


Projected large-scale structure



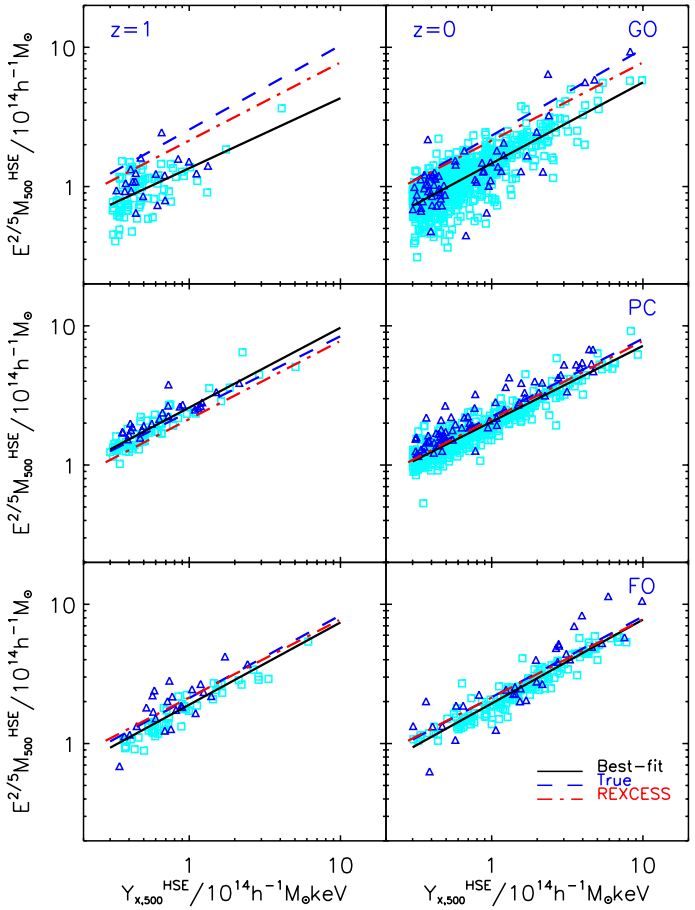
SZ Y_{500}-M_{500} relation

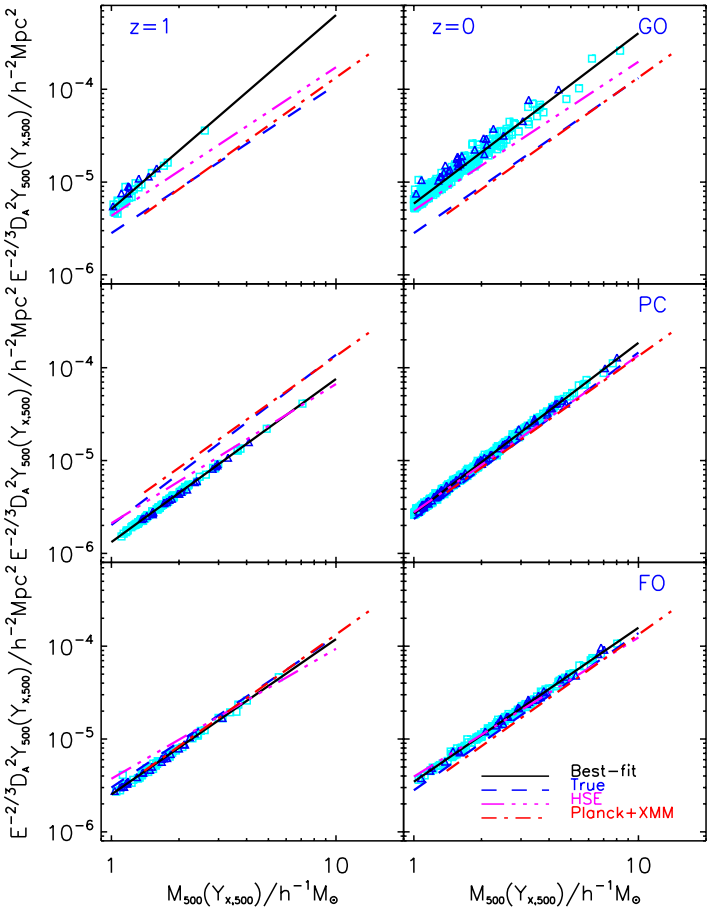
Hydrostatic bias: effect on M_{500} and Y_{500}



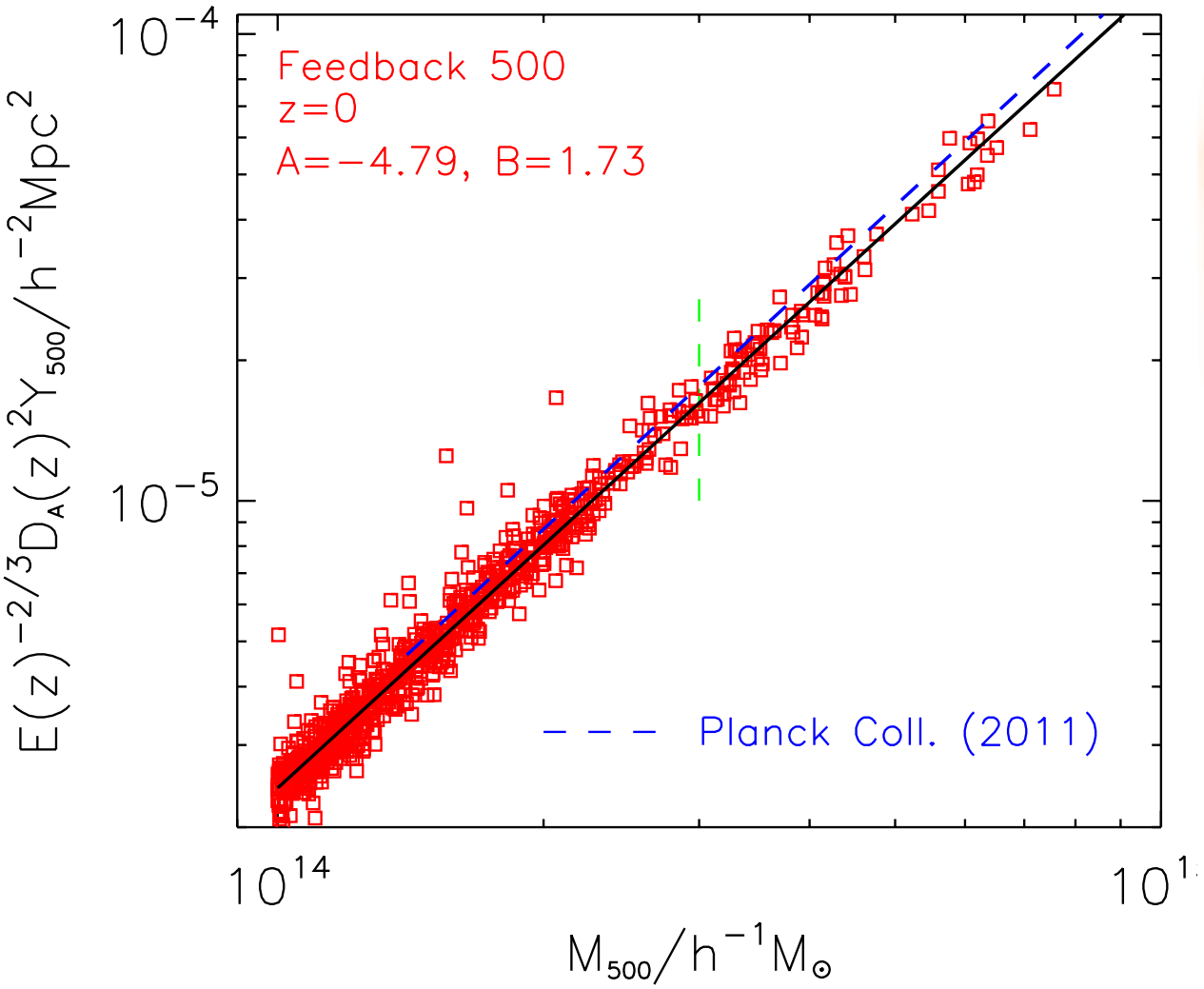
SZ Y_{500}-M_{500} relation

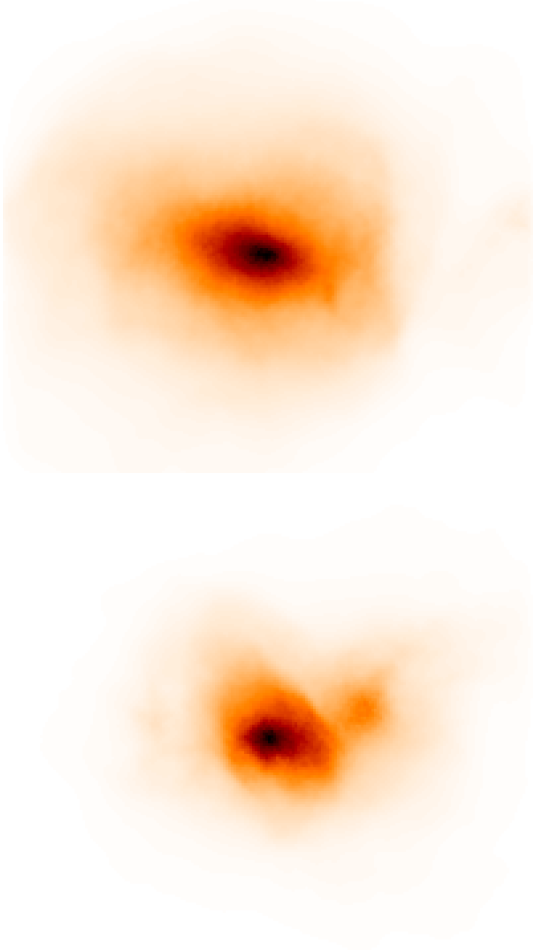
Hydrostatic bias: use of Y_X as a mass proxy





New Millennium Gas run





Summary

- Spherical Y_{500}-M_{500} relation
  - Insensitive to gas heating mechanism (*without* cooling)
  - Redshift evolution is close to self-similar
  - Intrinsic scatter very small
  - Mean relation in good agreement with *Planck+XMM* data

- Projection effects (lightcones with mean background subtracted)
  - Recover mean (cylindrical) relation
  - Projection increases scatter (more so in preheating case)

- Hydrostatic mass bias
  - Small (10-15%) in simulations with pre-heating/feedback
  - Estimated M-Y_X relation in good agreement with observations
  - Very small scatter in Y-$M(Y_X)$ relation due to $Y \sim Y_X$