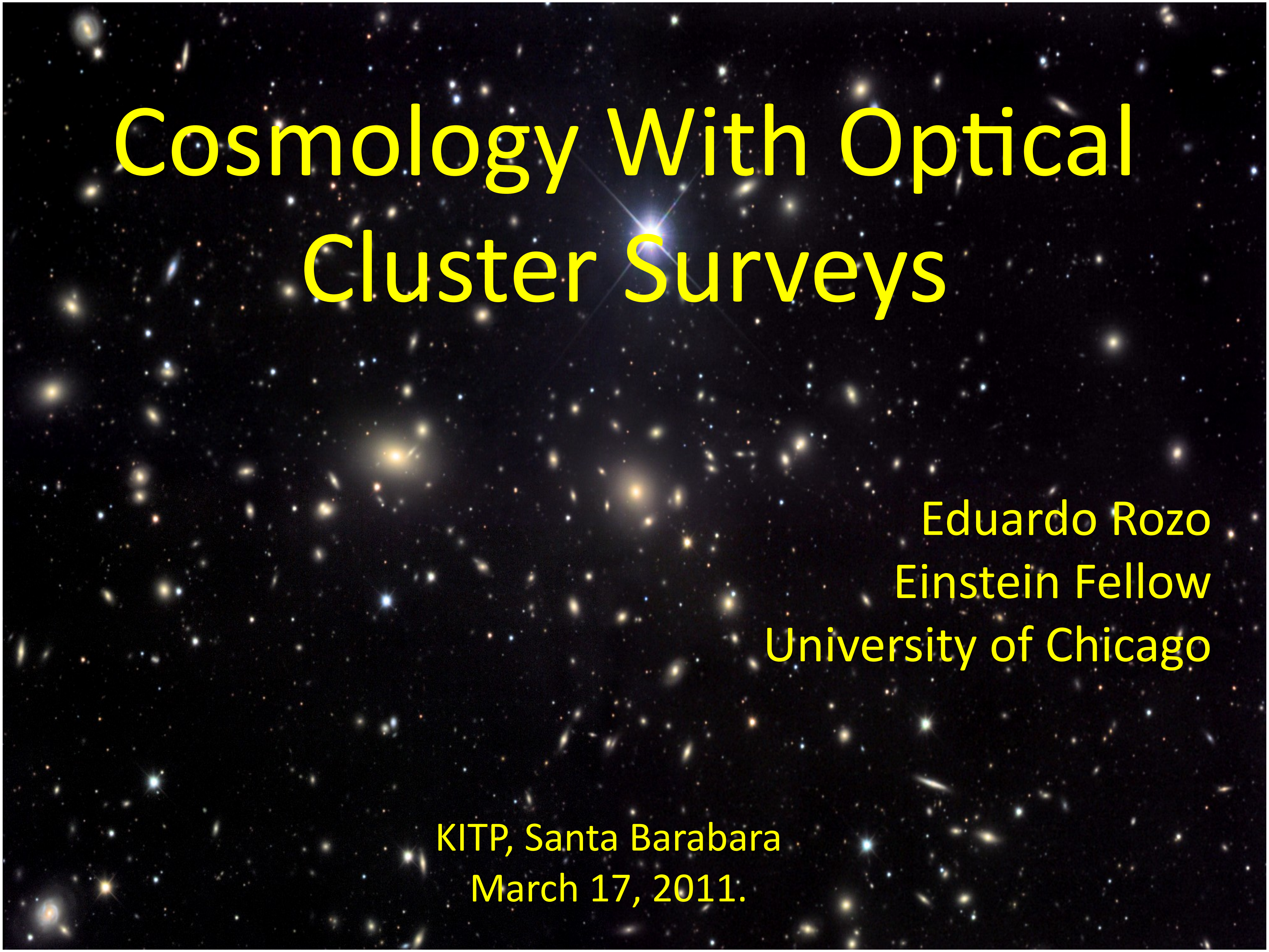

Cosmology With Optical Cluster Surveys

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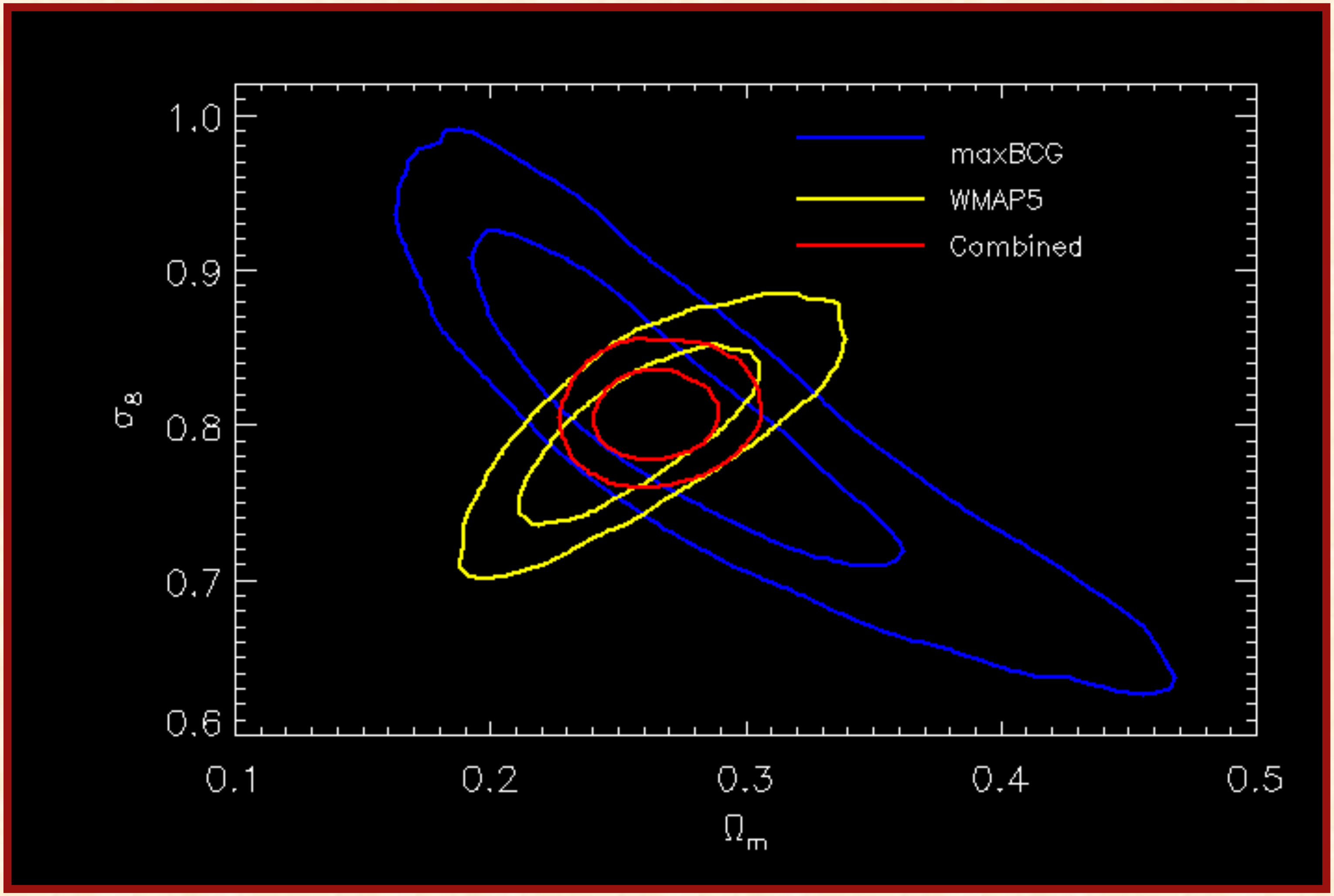
Einstein Fellow
University of Chicago

KITP, Santa Barabara
March 17, 2011.

Where We Are Today



Joint constraints: σ_8 = 0.807±0.020 Ω_M = 0.265±0.016

Constraints Are Systematics Dominated

Limited by calibration of the observable—mass relation.

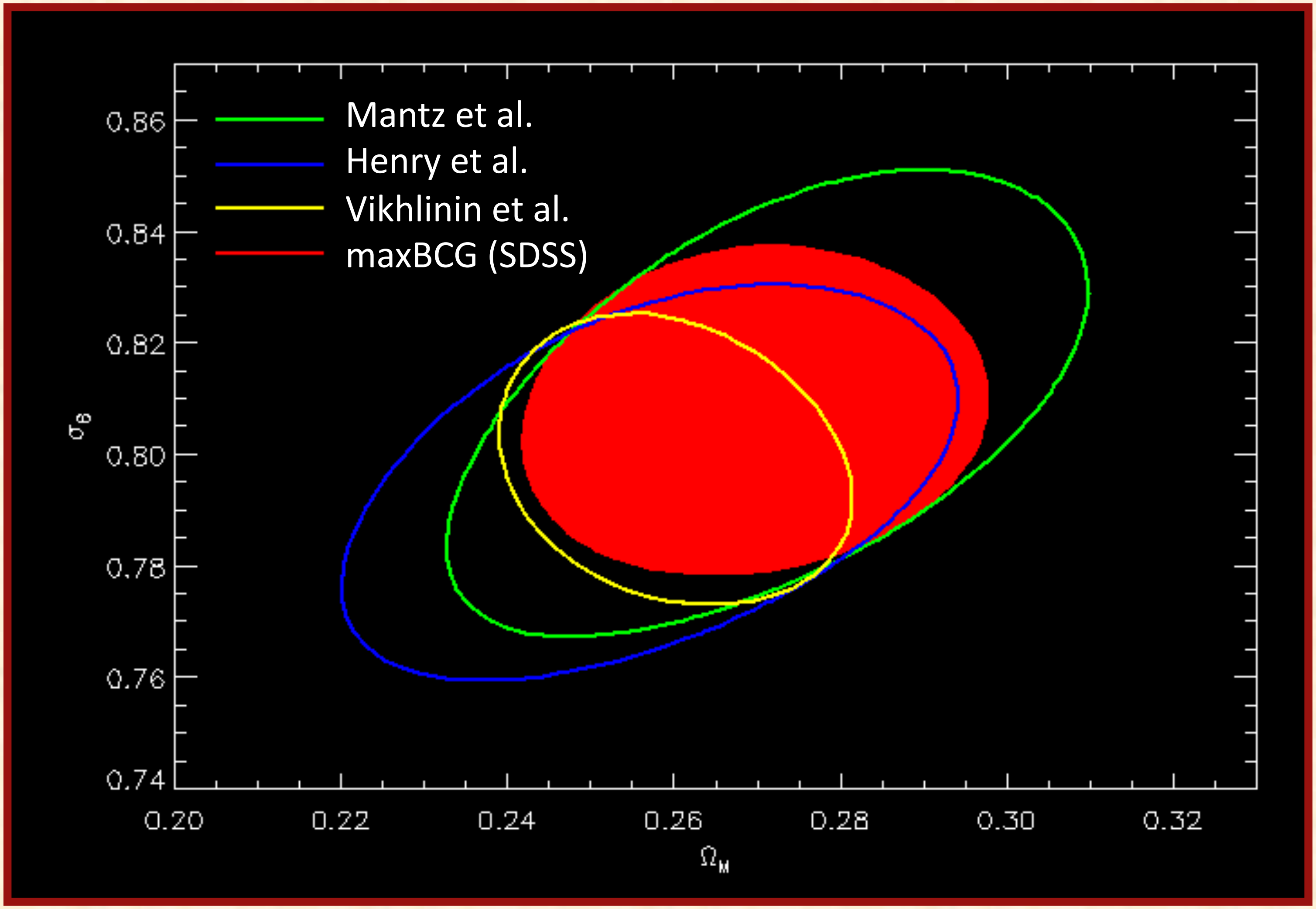
Not unique to optical***: all cluster cosmology analysis are limited by uncertainties in the mass calibration***.

Optical: use stacked weak lensing calibration.

- Photo-z errors on lensing sources.
- Cluster miscentering.

Uncertainties in selection function are *not* significant.

Comparison to X-rays



Excellent agreement, comparable errors.

Interpreting the Agreement

X-rays: 50 clusters ➔ $\Delta\sigma_8$ = ±1.5% (stat) ± 3% (sys)

SDSS: 10,000+ clusters ➔ $\Delta\sigma_8$ = ±3.3% (stat+sys ≈ sys)

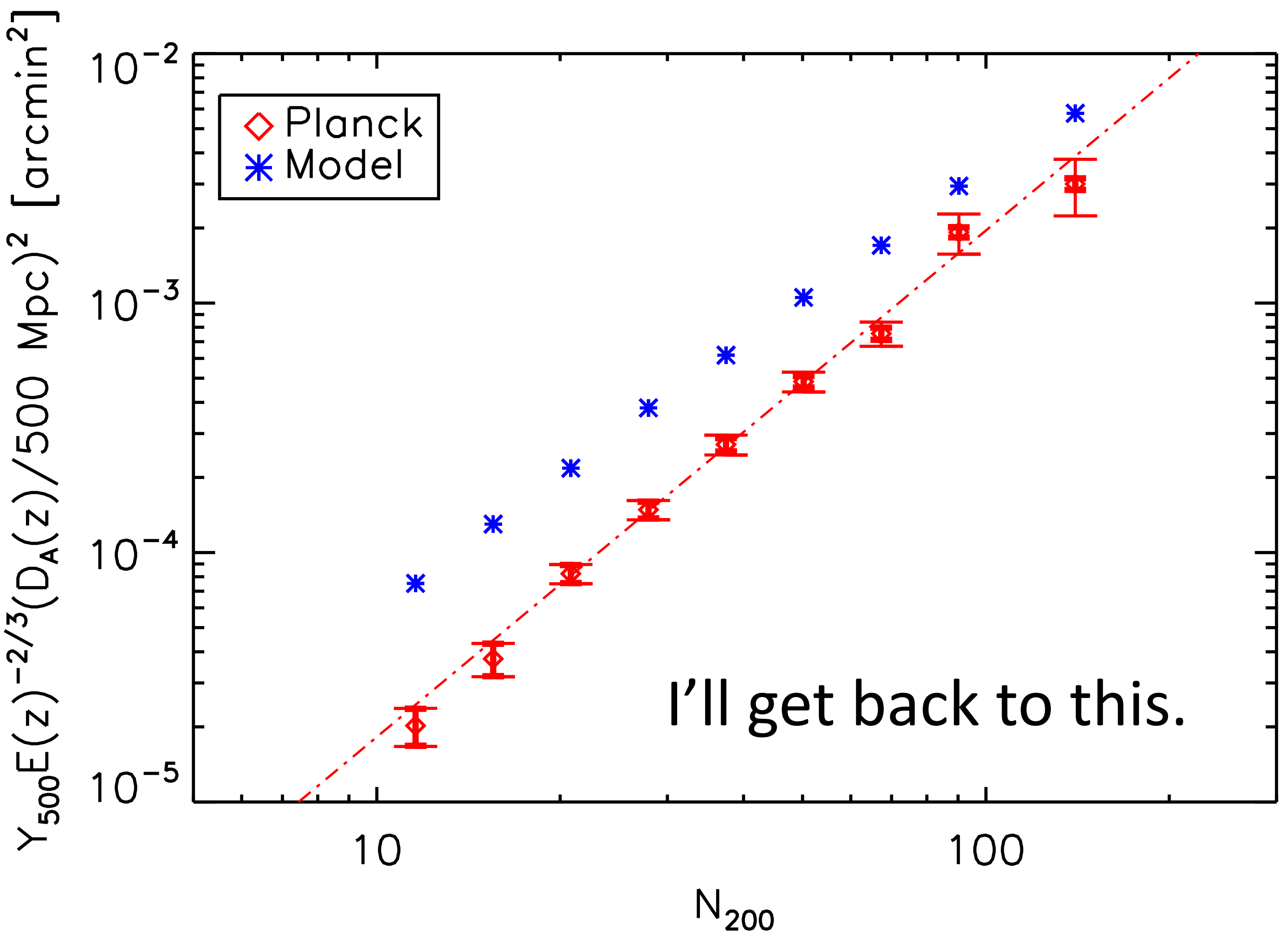
The number of clusters is beside the point.

What matters is mass calibration/systematics.

Cluster cosmology is a hard sell, and these results are a strong selling point.

Agreement is an explicit demonstration that the dominant systematics are being properly accounted for.

Oh, Really?



$Y_{500}E(z)^{-2/3}(D_A(z)/500\ \mathrm{Mpc})^2$ [arcmin^2]
10^{-2}
10^{-3}
10^{-4}
10^{-5}
Planck
Model
I'll get back to this.
10
100
N_{200}

What is the Future for Optical?

Several large photometric surveys coming online:

e.g. DES, LSST, PanSTARRS, HSC.

Statistical precision of these data sets is unrivalled.

Can achieve 3% level mass calibration via cluster stacking.

We need to *demonstrate* that
we can beat down systematics.

The DES Blind Cosmology Challenge

1. Start with a dark matter simulation.
2. Populate with galaxies.
3. Ray trace through entire survey volume (Becker).
4. Lens all galaxies.
5. Run cluster finders.
6. Do weak lensing mass calibration.
7. Recover input cosmology

Explicit test of systematics in a controlled environment.

The DES Cluster Comparison Project

First step towards the blind cosmology challenge.

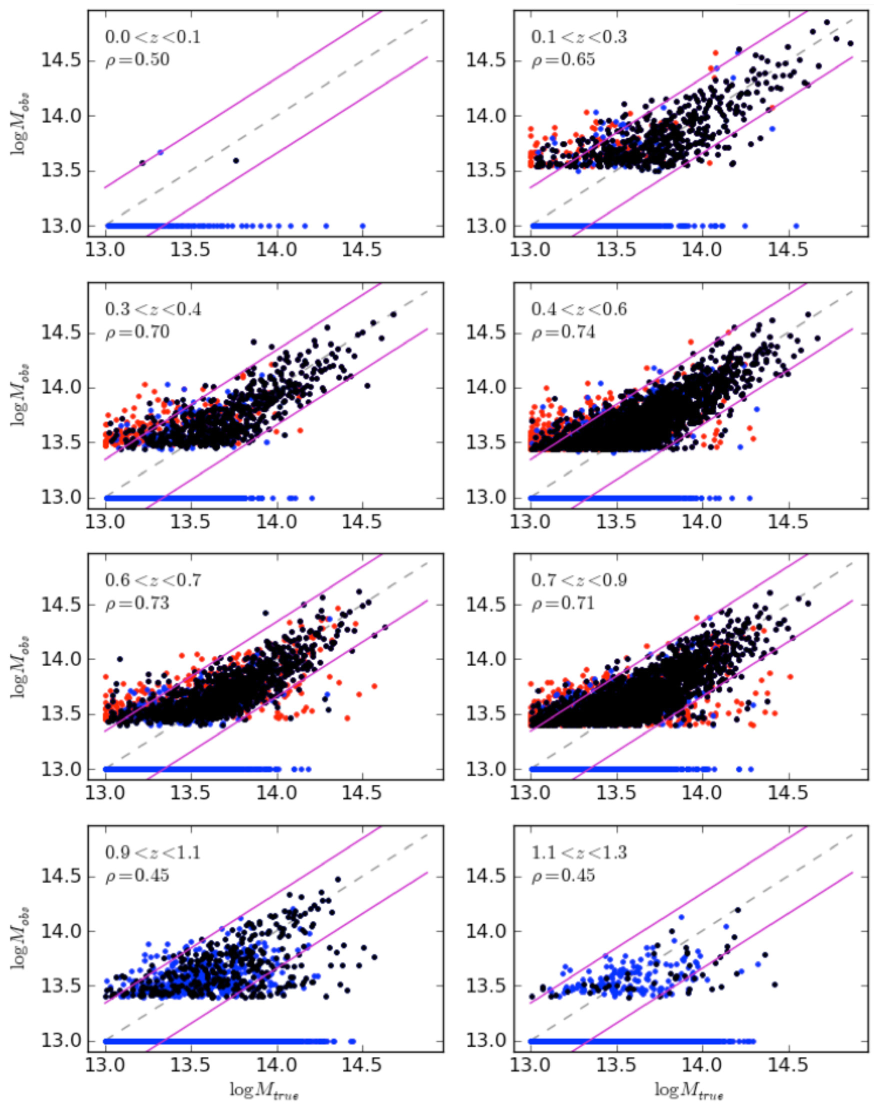
Run a variety of cluster finders in simulated catalogs to evaluate their performance.

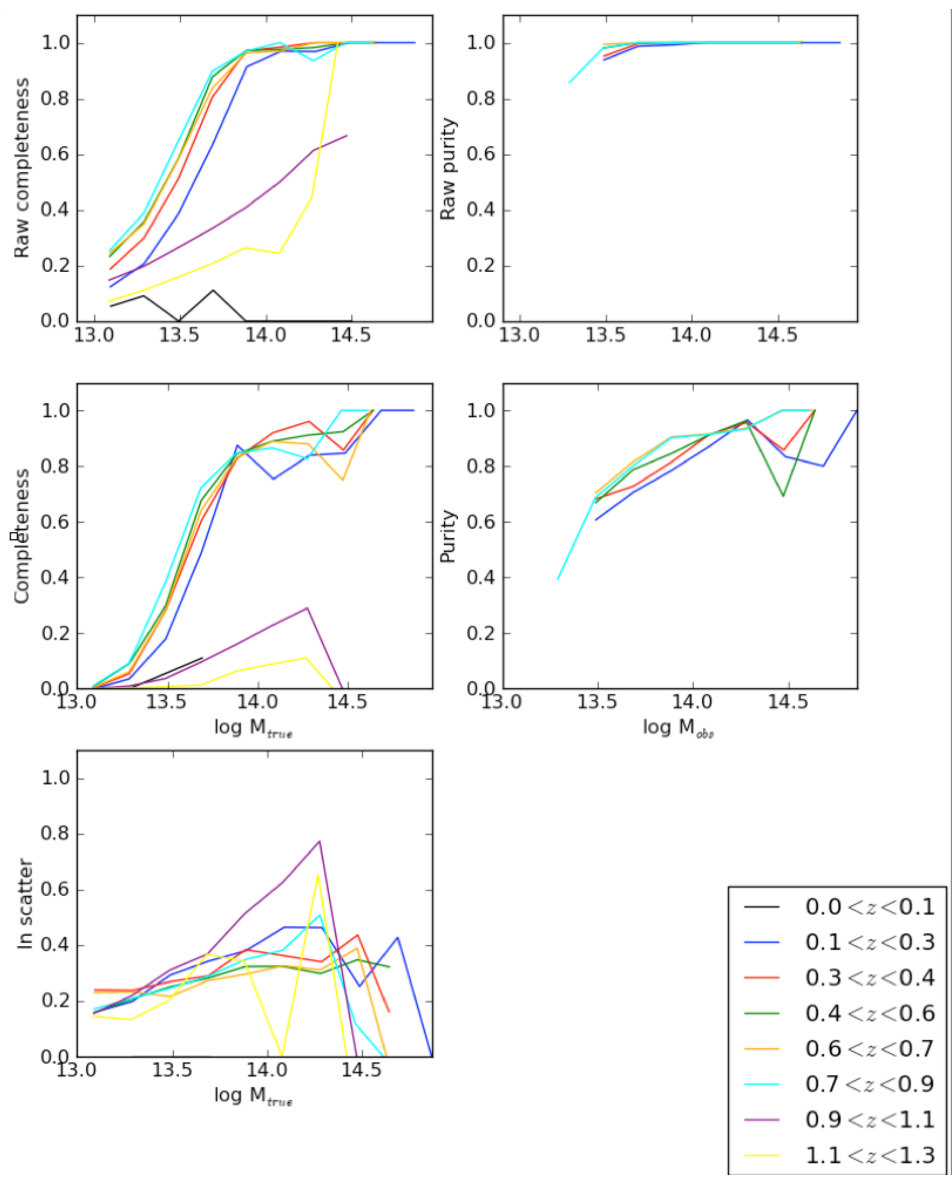
Characterize and improve cluster selection function.

Simulations will be open to the community later this year.

Entire pipeline is automated.

Sample Output





Other Places with Room for Improvement

The scatter in mass at fixed richness is large.

e.g. $\sigma_{\ln M|N} = 0.45 \pm 0.1$ for maxBCG.

Can we do better?

A New Richness Estimator: λ

Probabilistic framework: we don't specify member galaxies, we quote membership probabilities.

Easy to code/implement.

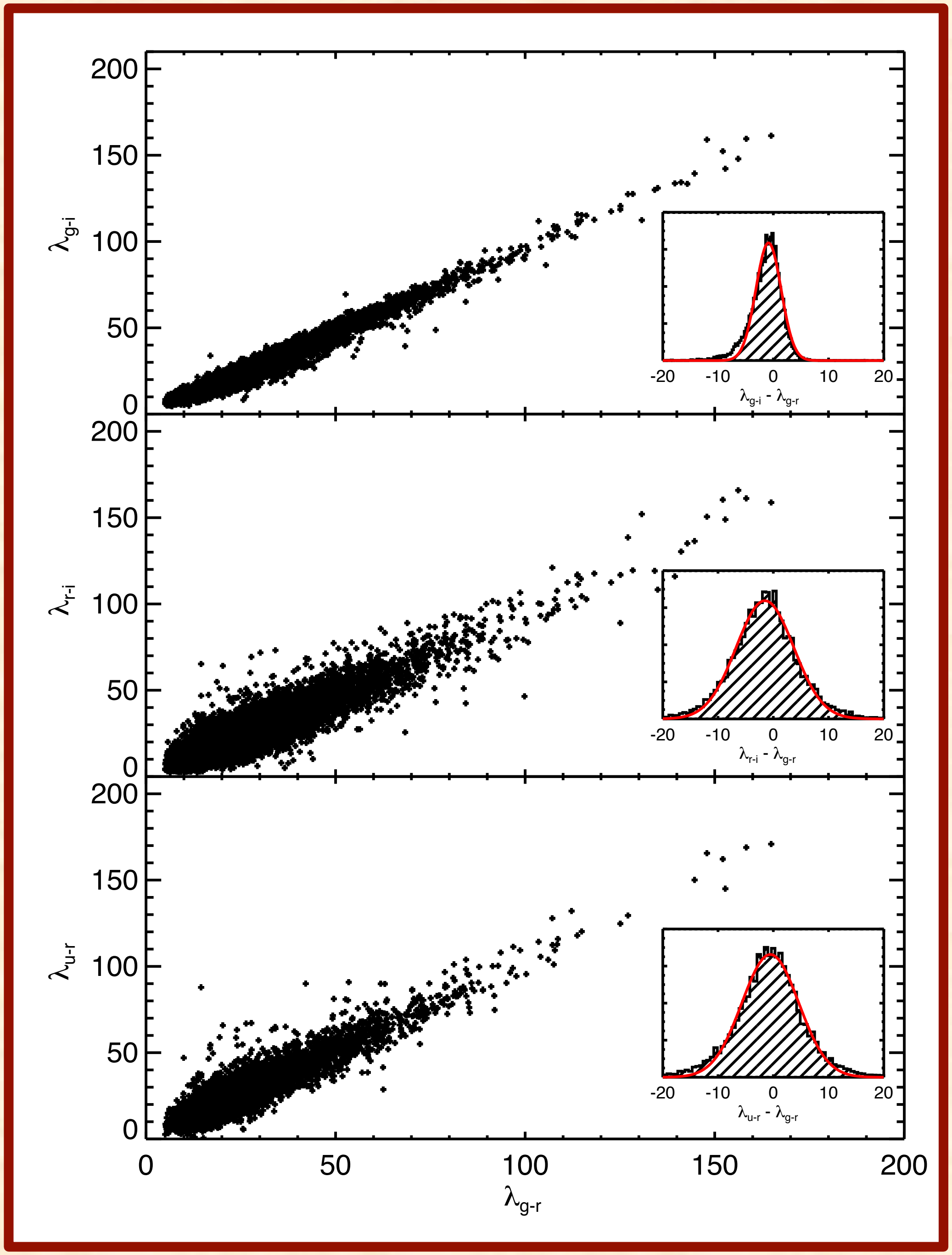
Extremely robust.

Recovered richness is robust to the choice of optical filters, so long as they cover the 4000A break.

We will be releasing code with the papers.

Rozo et al. 2009, **Rozo et al. 2011**, **Rykoff et al. 2011.**

Richness λ is Independent of Which Filters Are Used for Color Selection



x-axis: (g-r) Richness

y-axis: (g-i) Richness

(r-i) Richness

(u-r) Ricness

A New Richness Estimator: λ

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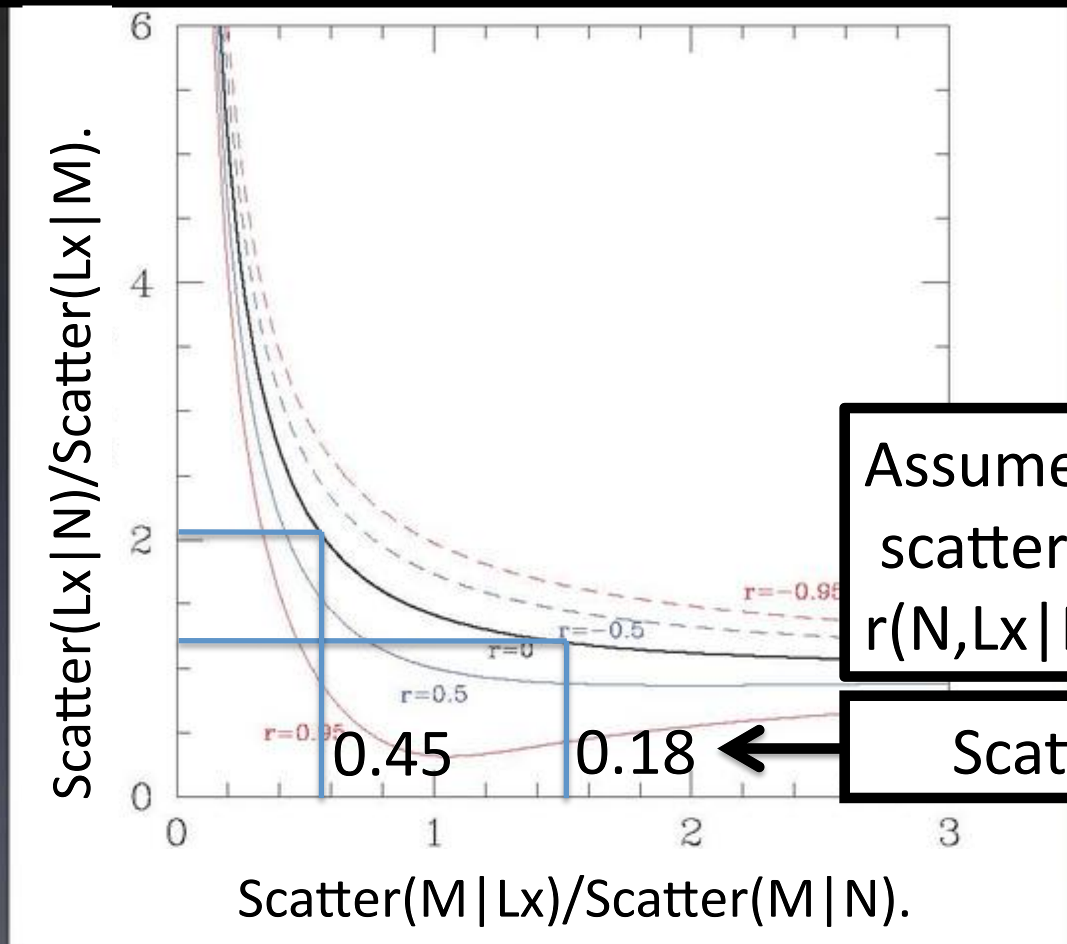
Scatter in ln(Lx) is dramatically reduced: 62% vs. 83%.

Rozo et al. 2009, Rozo et al. 2011, **Rykoff et al. 2011.**

scatter in second property for one-property selection

Plot shamelessly stolen from Gus's talk:
convert scatter in Lx|N into scatter in M|N.

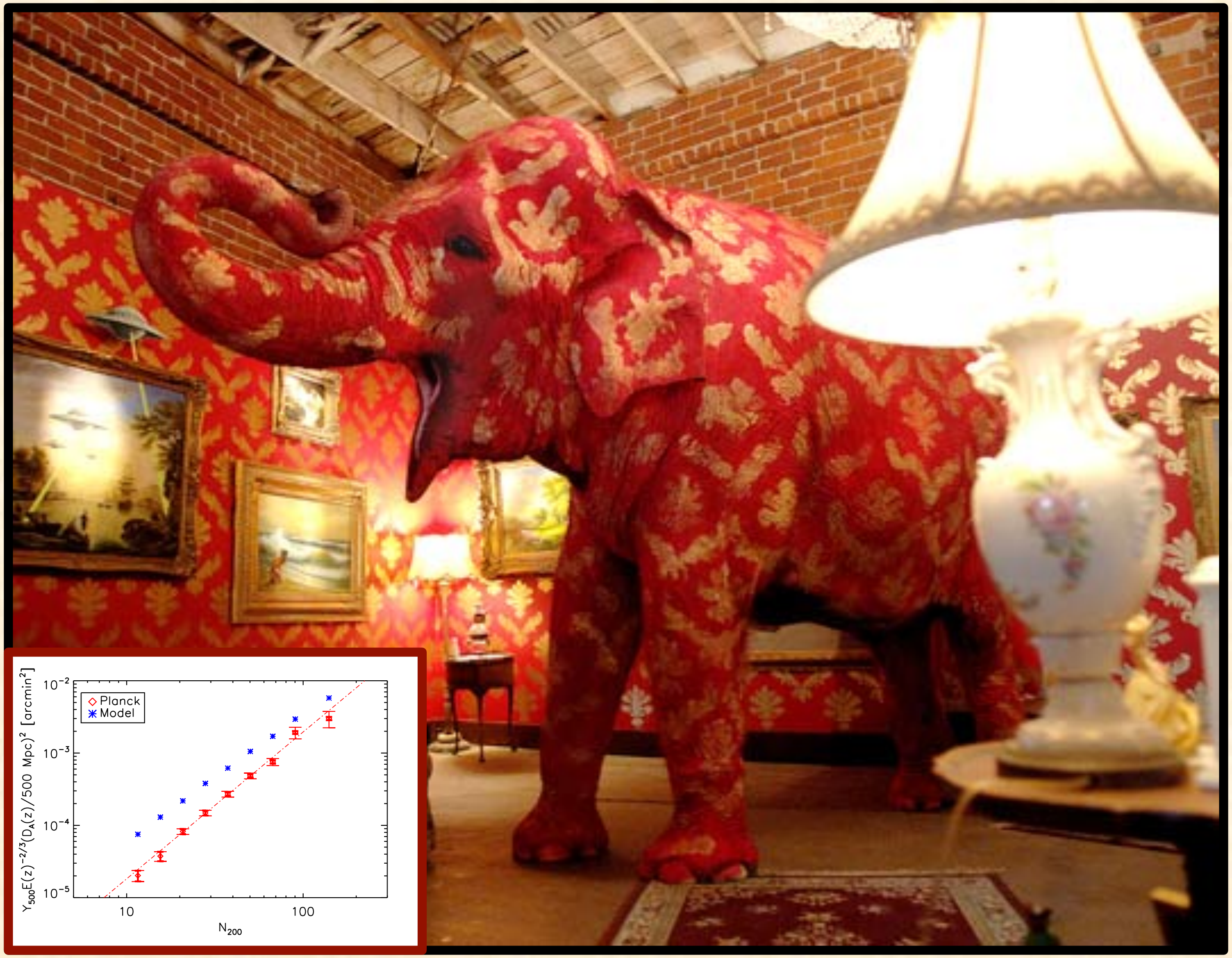


Assumes:
scatter(Lx|M)=0.4
r(N,Lx|M)=0

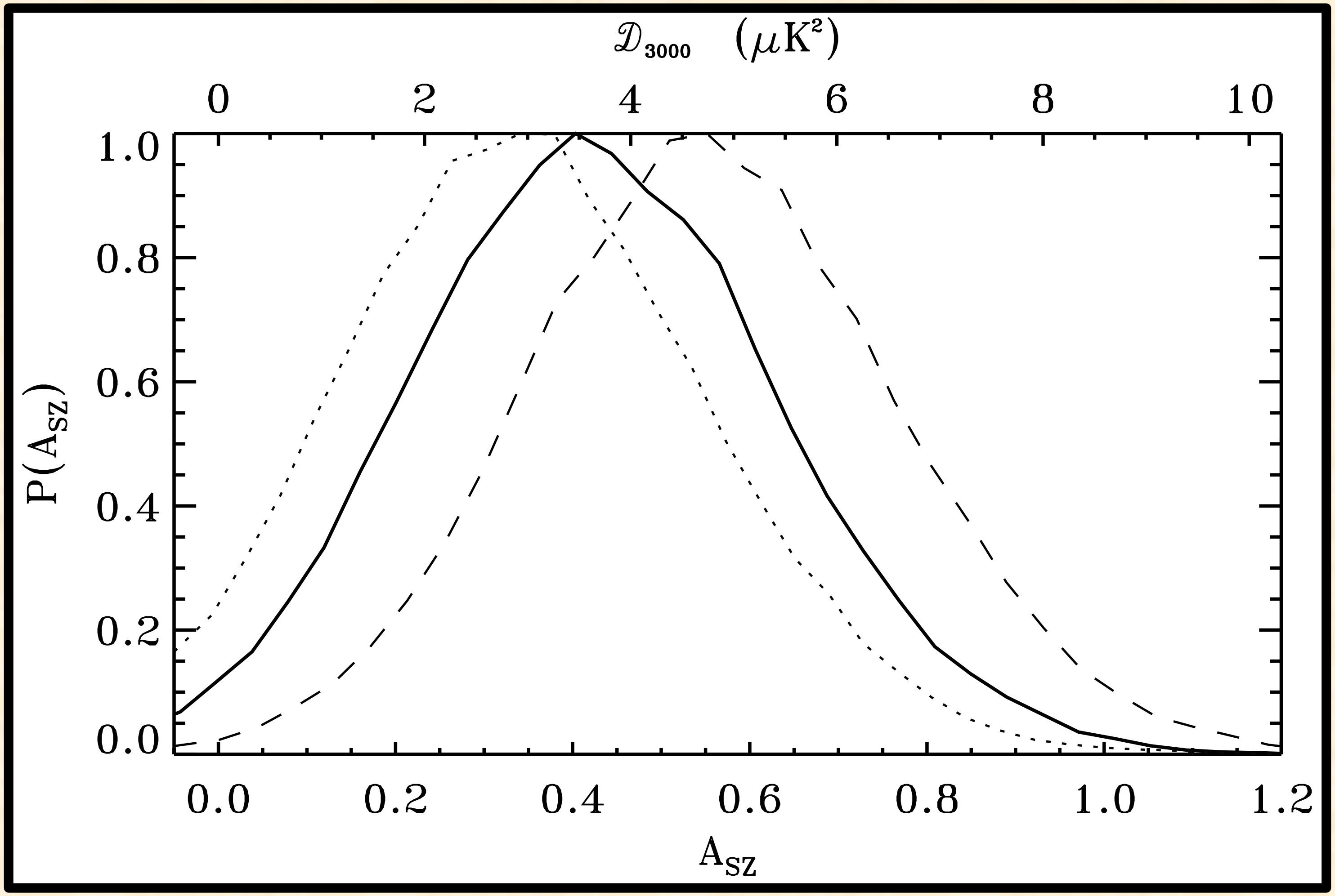
Scatter(M|N).

Scatter of ~20% consistent with preliminary analysis from SZA follow-up. (Chris Greer)

Elephant? What Elephant?



Not the First Time We Get an SZ Surprise of This Type



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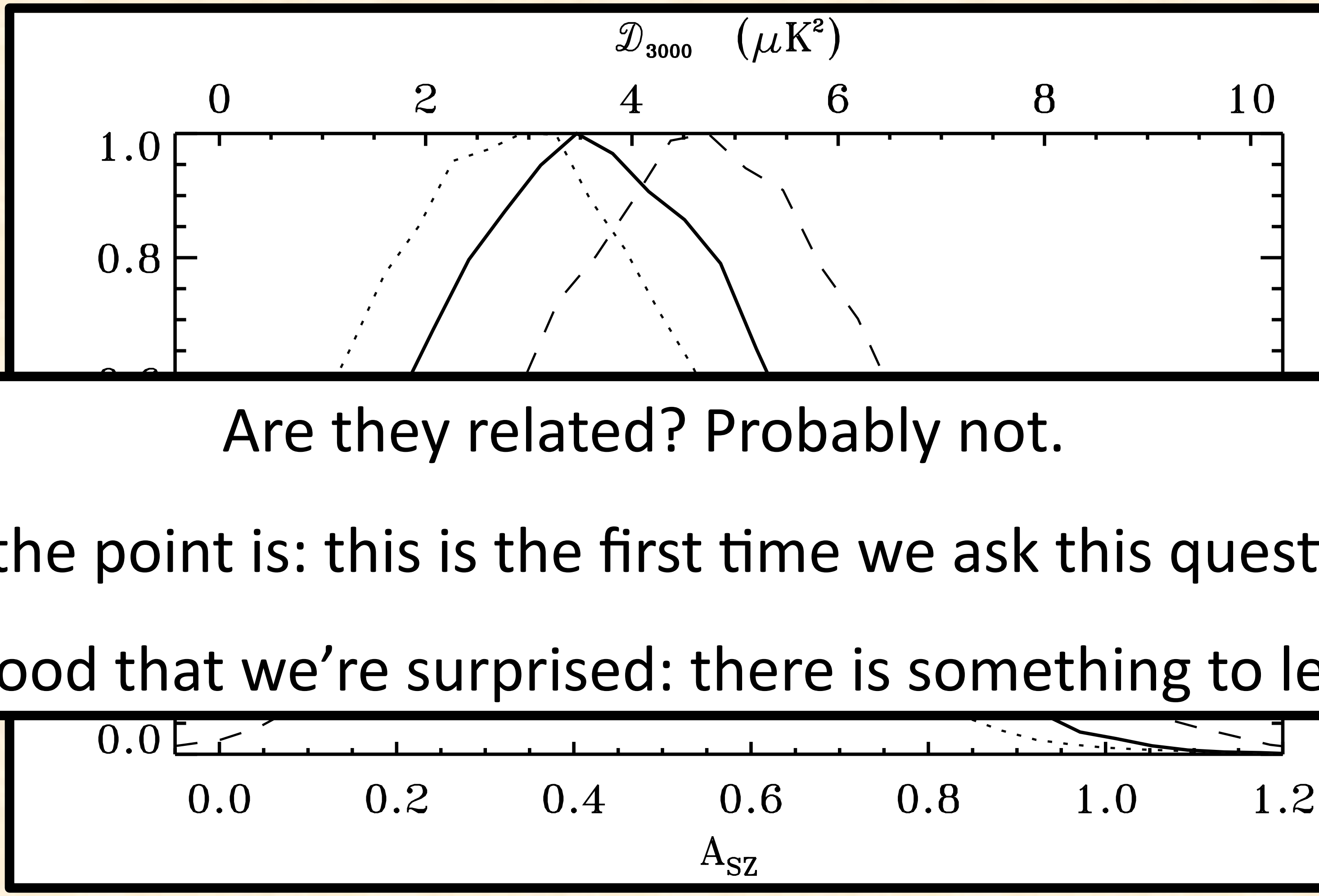


Are they related? Probably not.

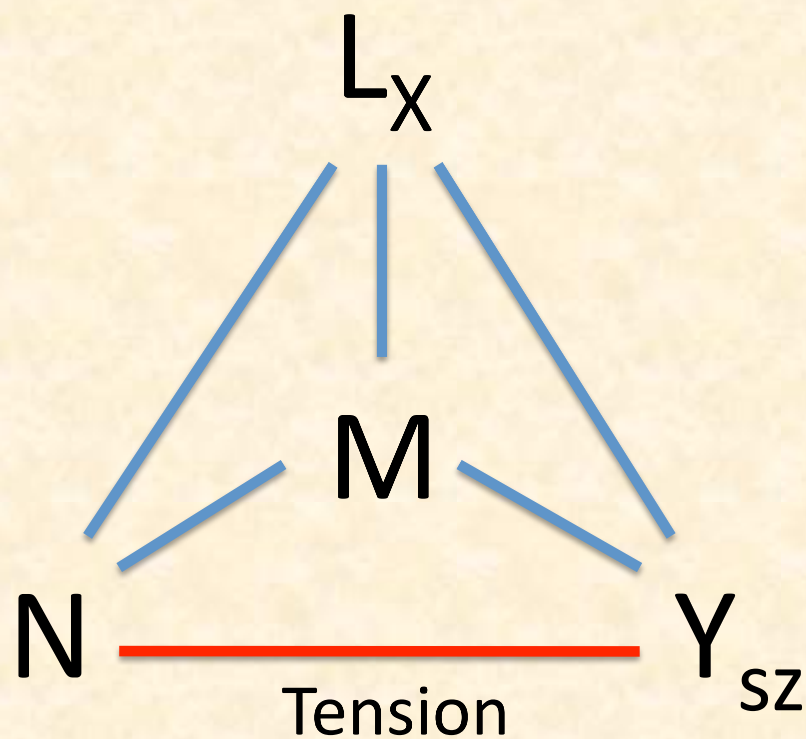
But, the point is: this is the first time we ask this question!

It's good that we're surprised: there is something to learn.

Lueker et al. 2010

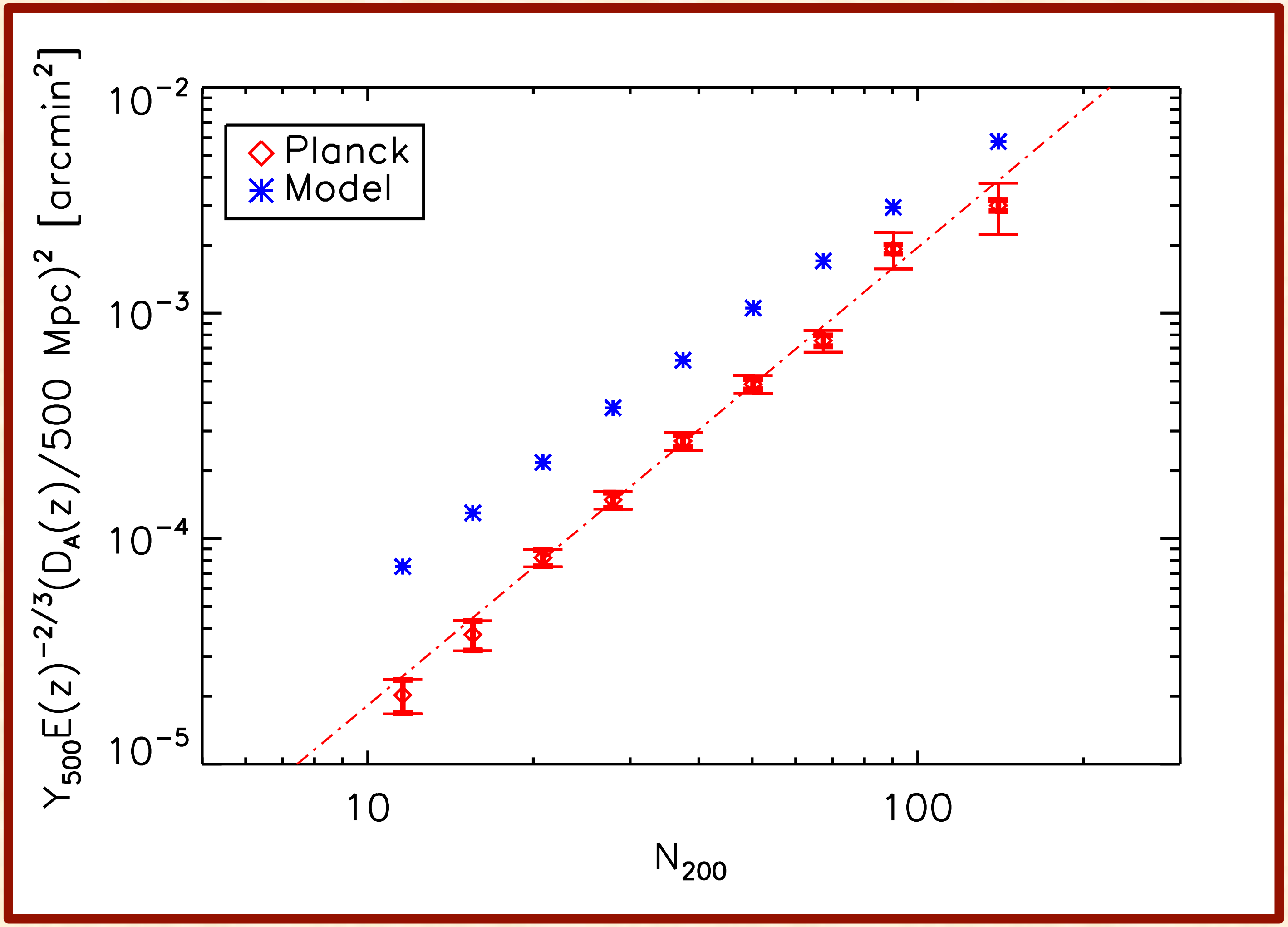
My own take on this problem:

Is it the maxBCG Masses ?

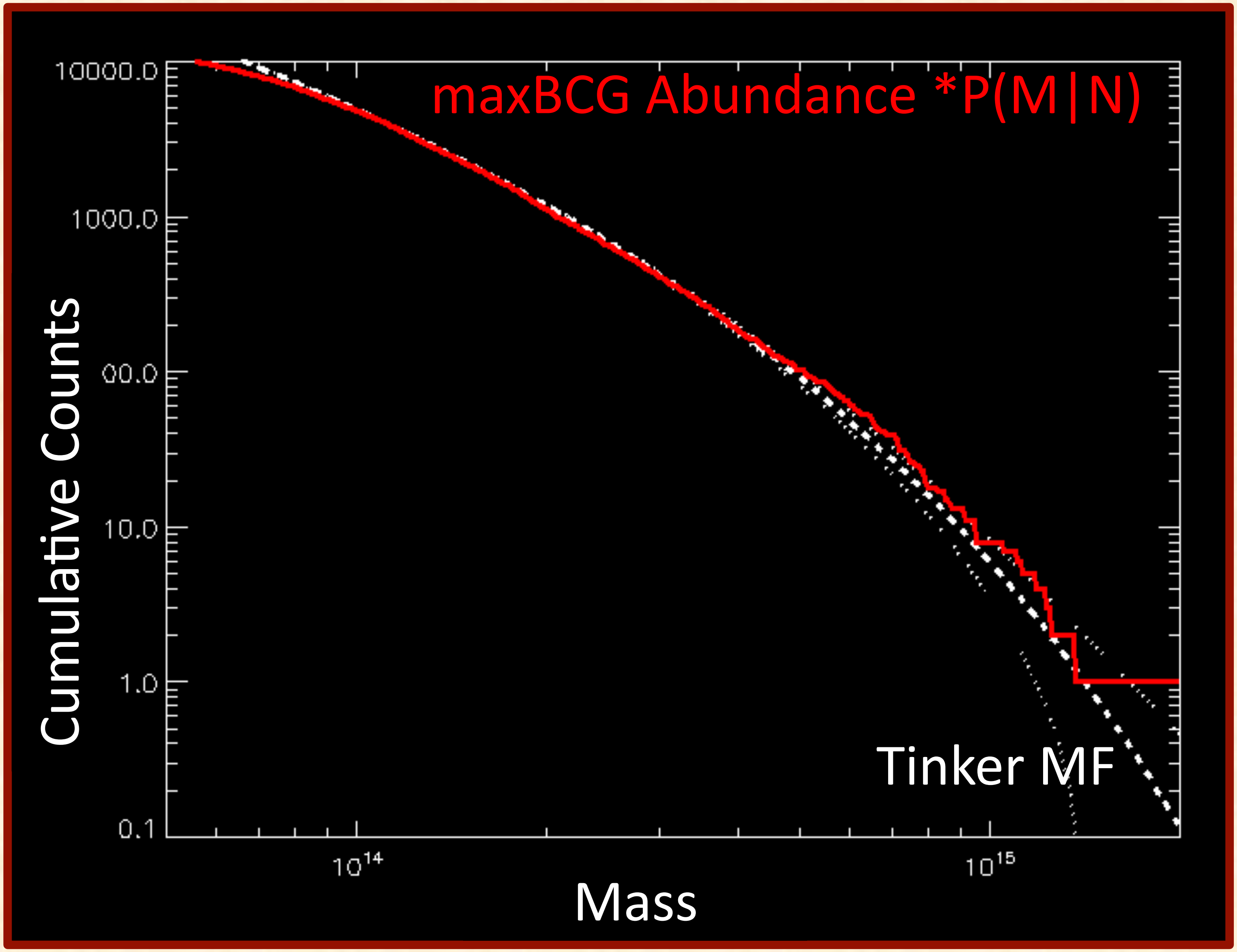


Shamelessly stealing Jim's triangle.

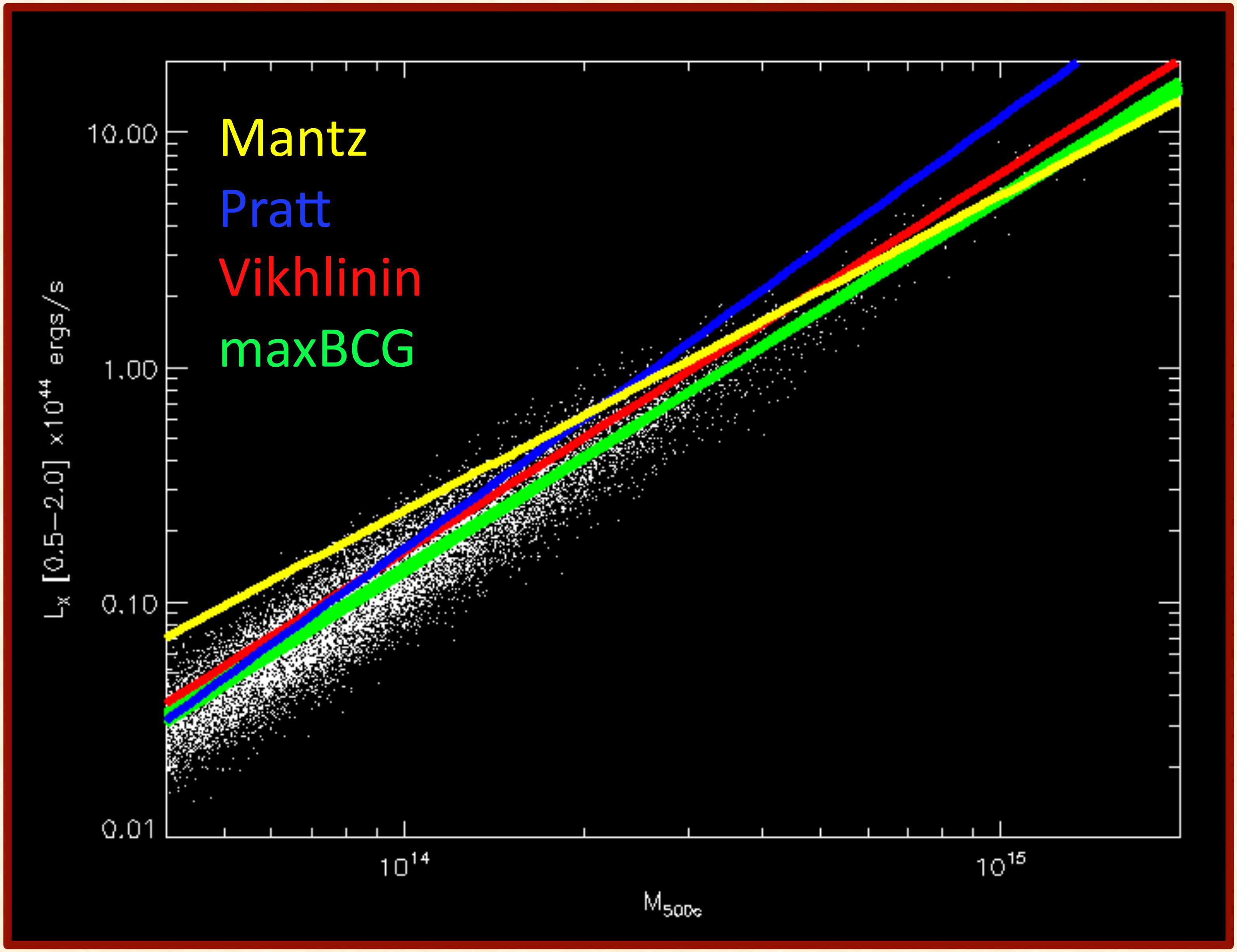
The Same Masses that Produce This Plot…



Produce This Plot…

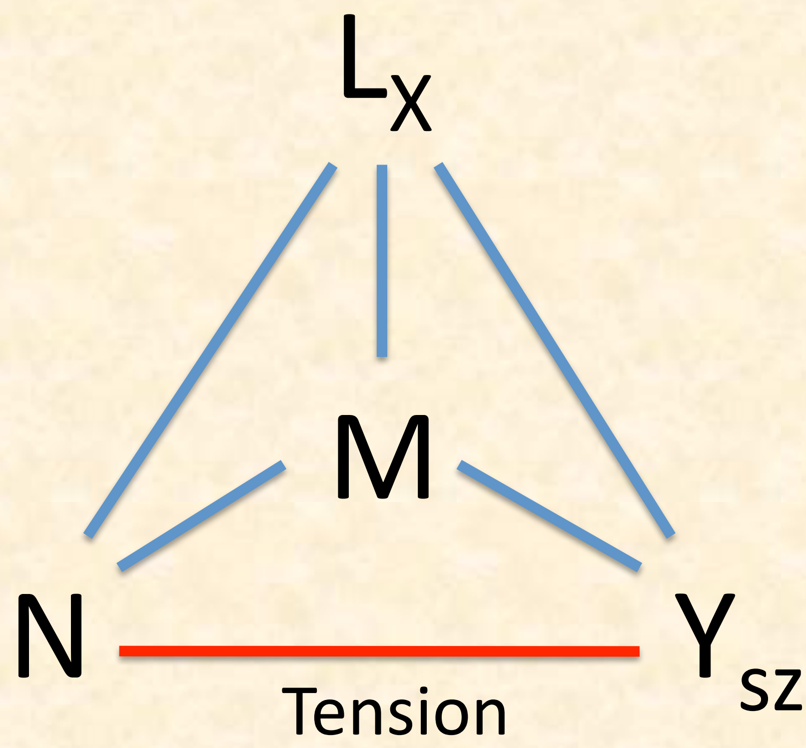


And This Plot

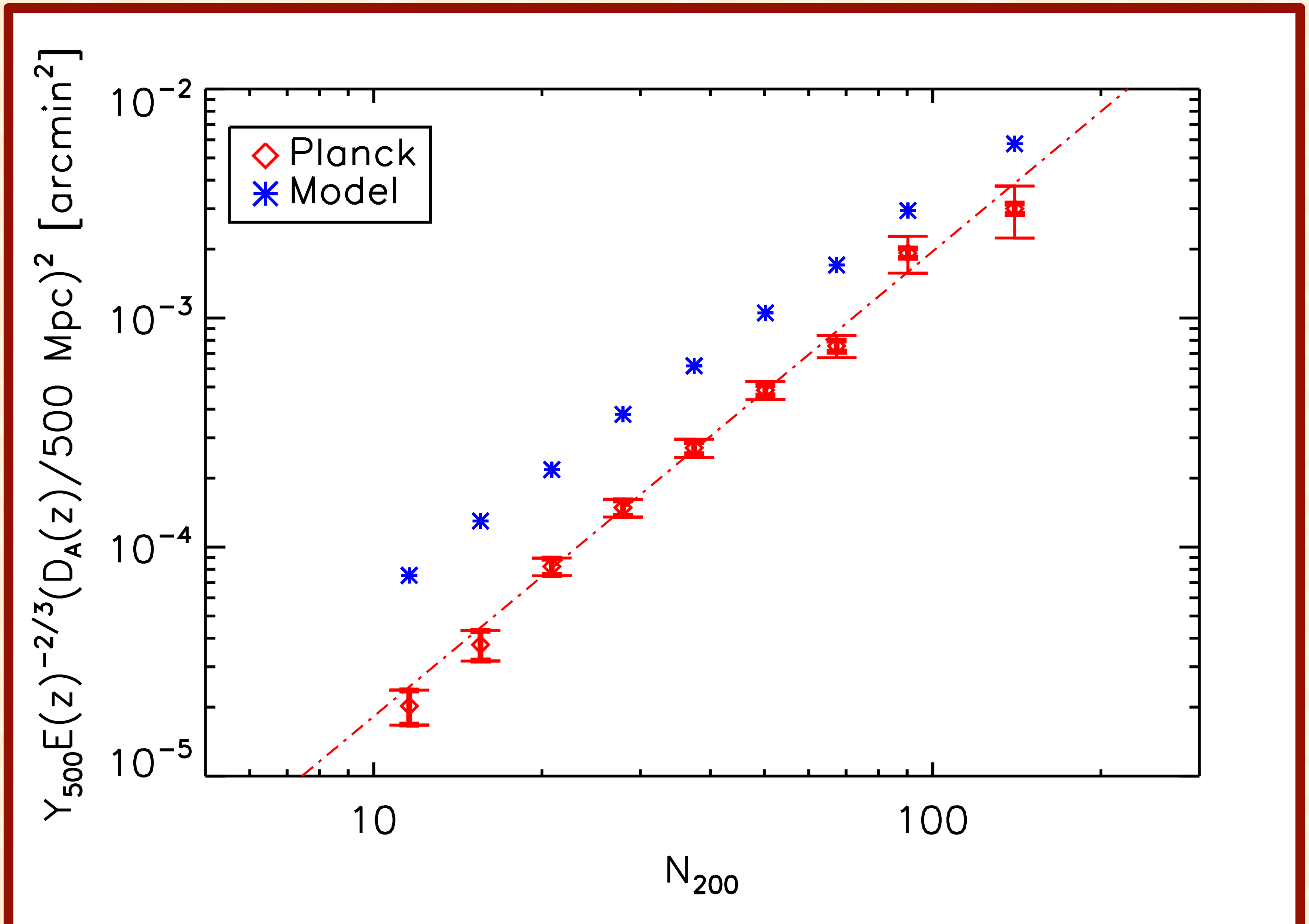


My own take on this problem:

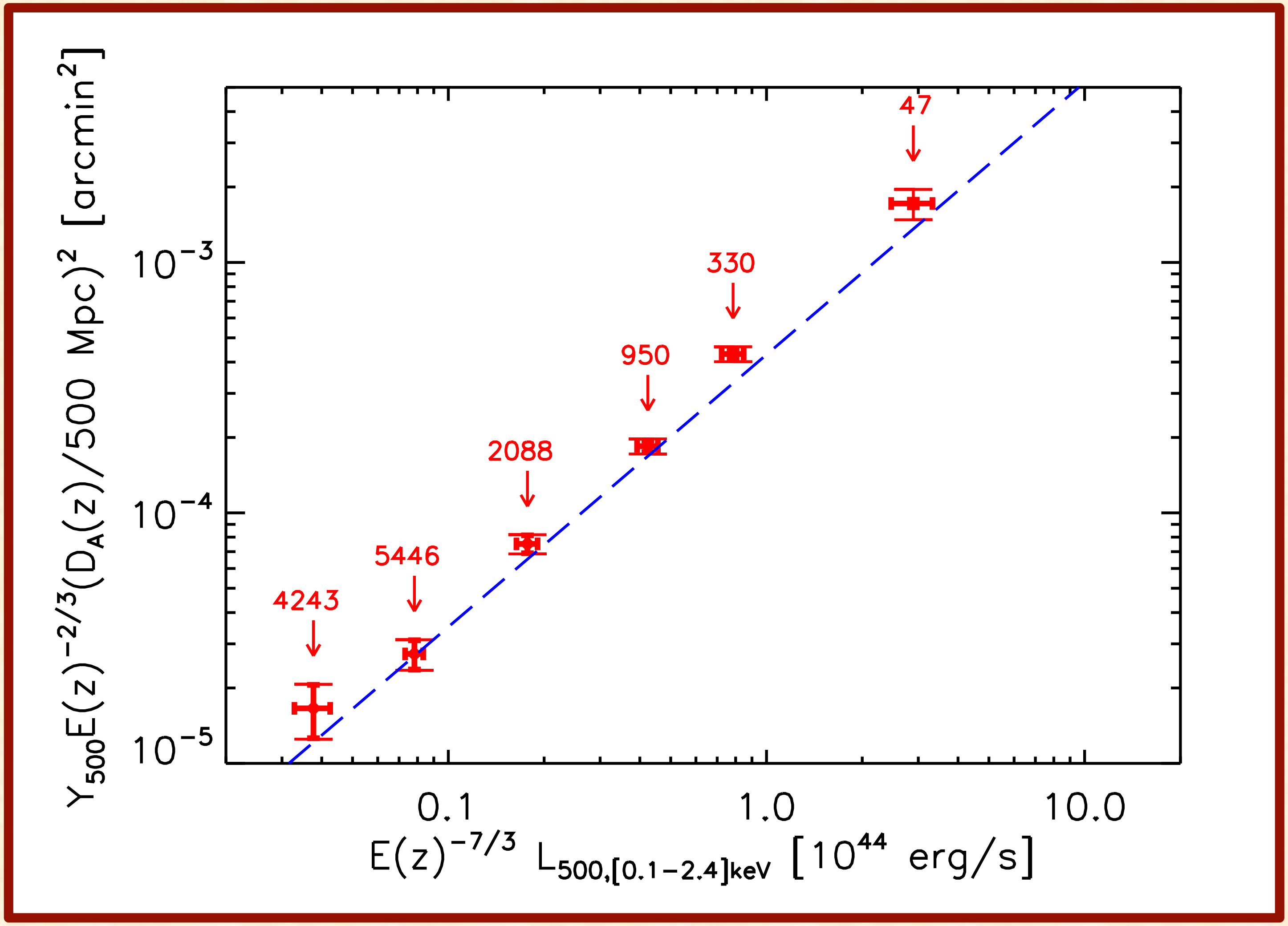
Is it Y_{SZ}?



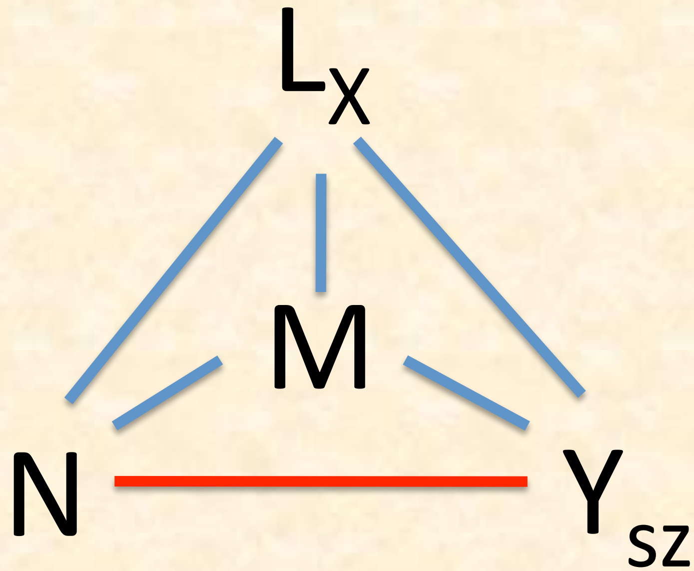
The Same Y_{sz} Values that Produce This Plot...



Produce This Plot…

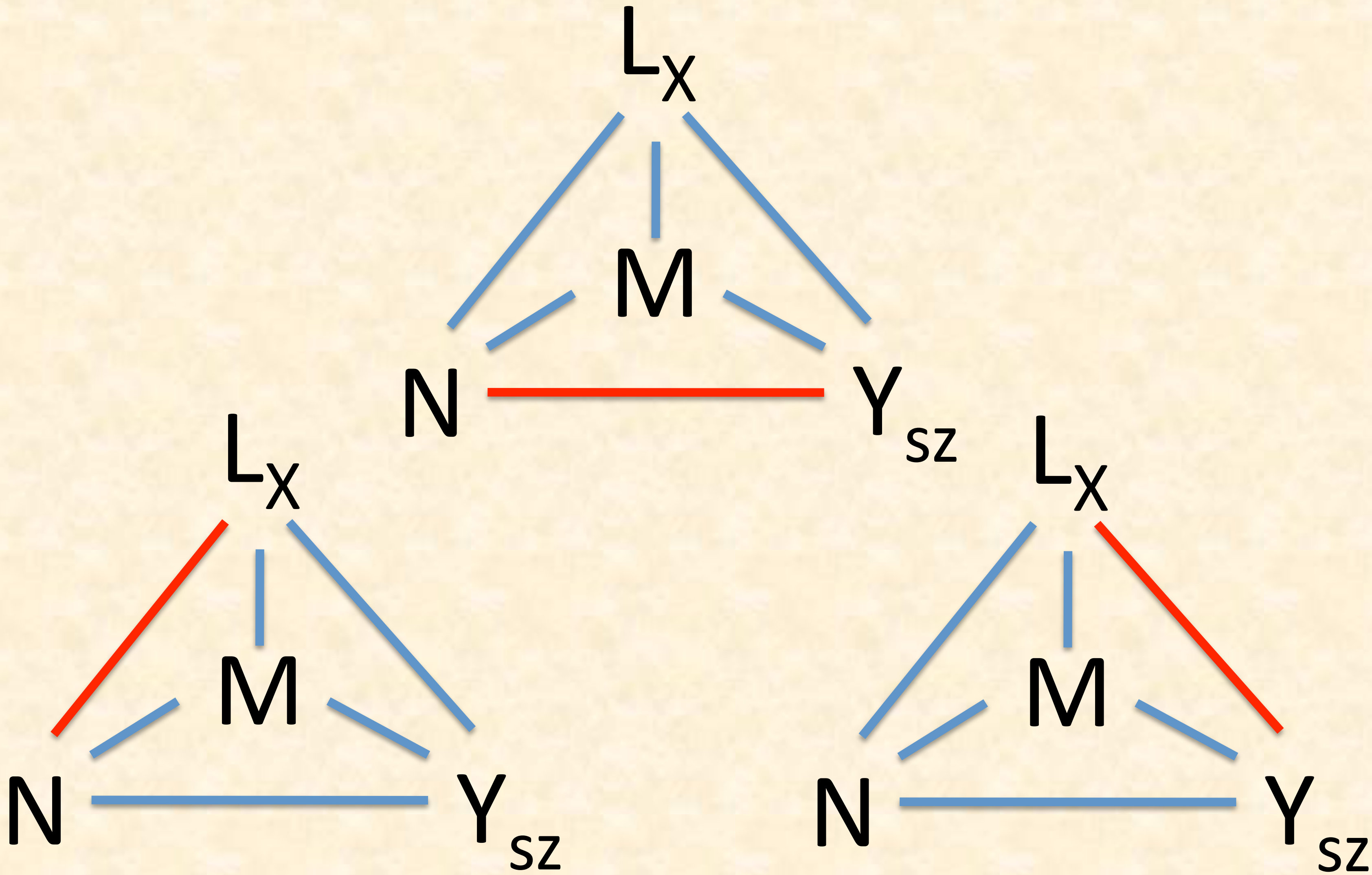


Something Has to Give

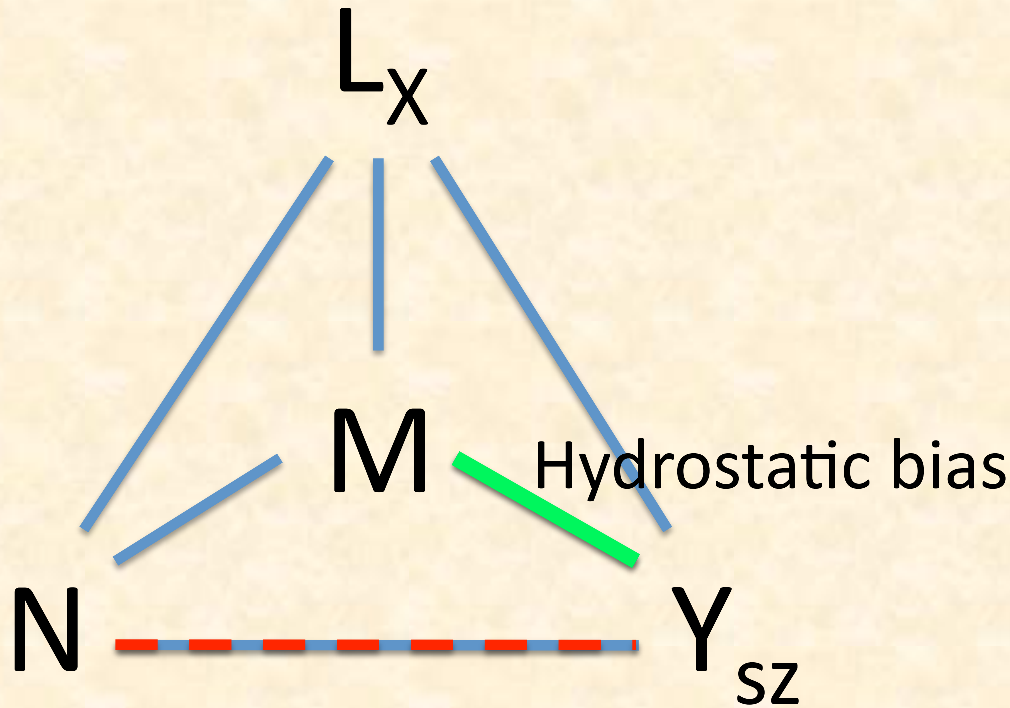


Fixing one thing will break another!

Something Has to Give



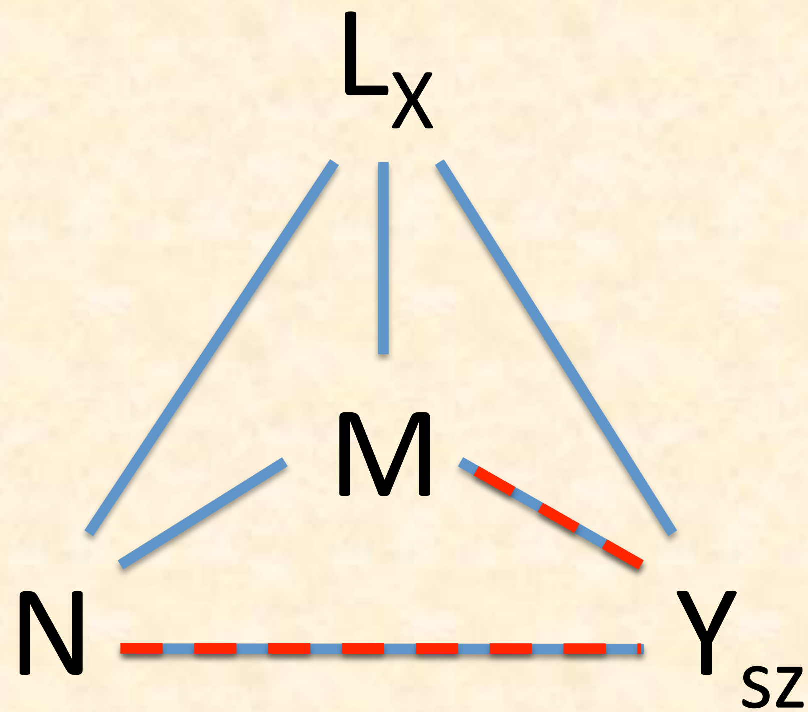
Hydrostatic Bias



Hydrostatic bias alleviates *some* of the tension.

See Jim Bartlett's talk.

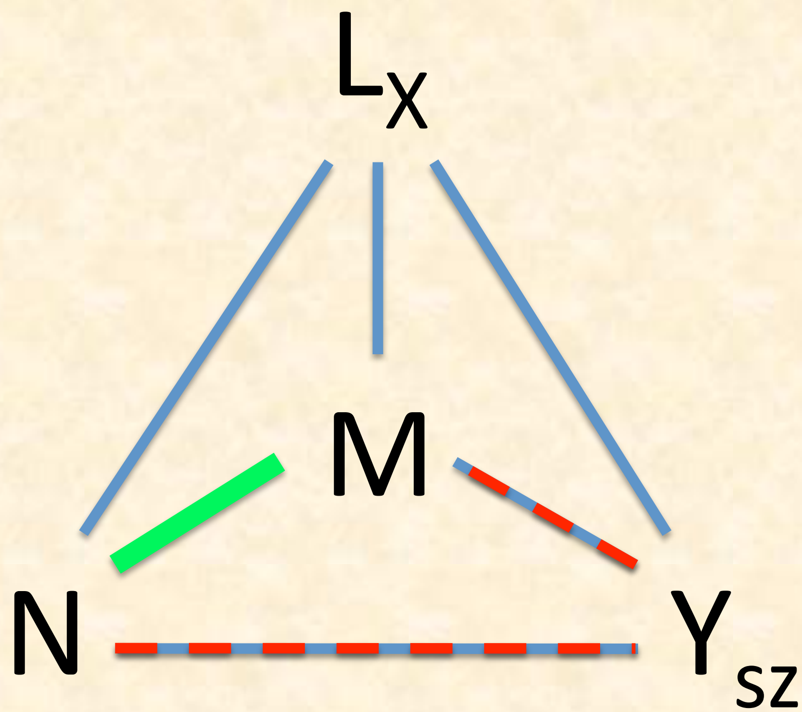
What About Non-Gaussian Scatter/Projections?



Unlikely: why is Y_{SZ} – N affected but not L_X - N?

There remains more to be understood.

Our Weakest Point is Probably the Photoz's for Weak Lensing



Could be a way out, but has implications for Lx-M.

Summary

Optical clusters are a competitive cosmological probe.

We are making dramatic improvements in our ability to estimate mass from optical data.

Mass calibration remains the most difficult problem for cluster cosmology by far.

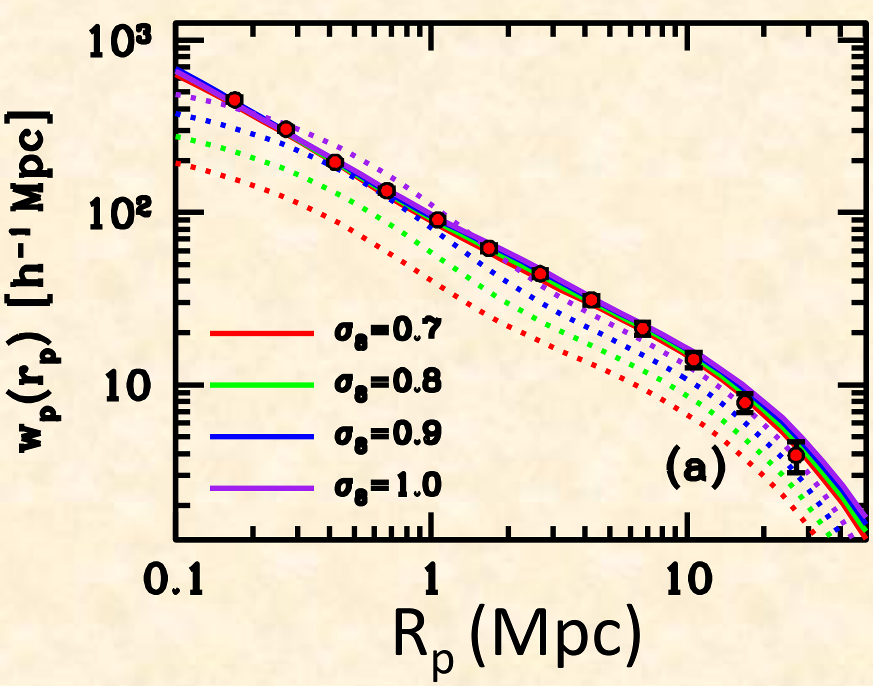
Demonstrating that we can control systematics will require an extensive simulations program.

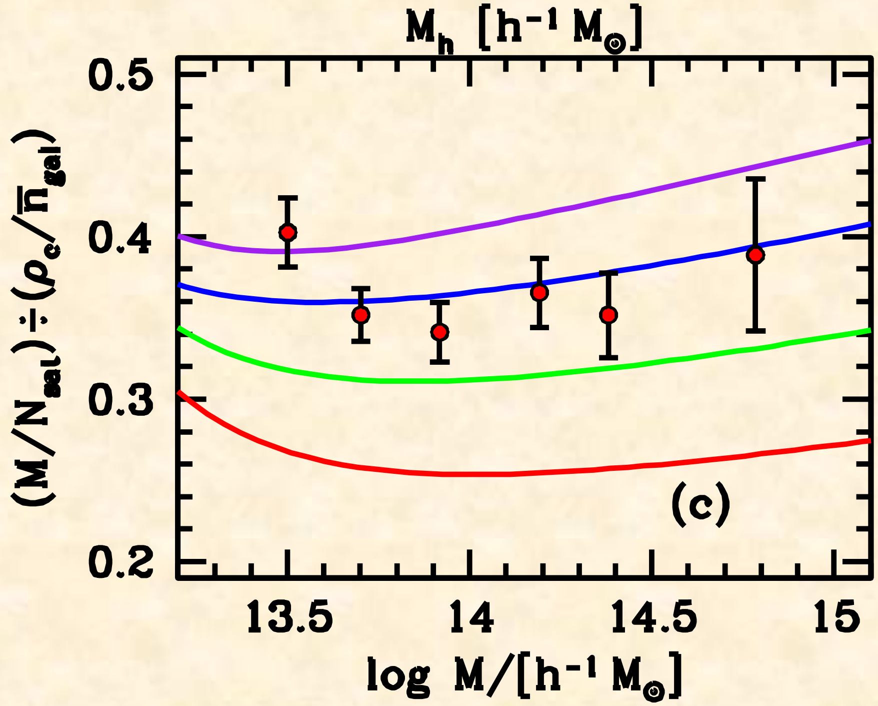
Planck/maxBCG comparison is the first of its kind, and a surprise means we have something to learn.

Mass connects all observables: if one piece doesn't fit, it affects the other pieces as well, *and that's a good thing.*

There's More to Cluster Cosmology than Just Counting

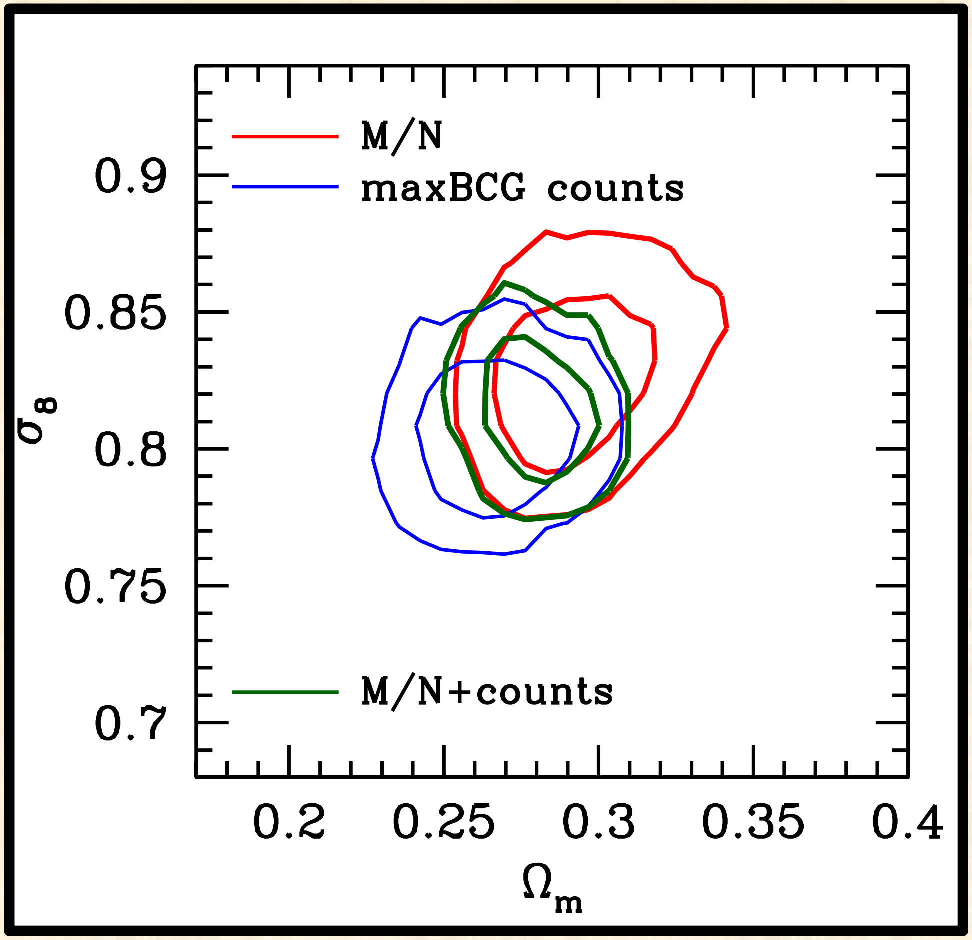
Cosmology From Galaxy Correlations and Clusters





Tinker et al, in preparation.

Cosmology From w_p and Clusters



$\sigma_8 = 0.850 \pm 0.060$

no WMAP

$\sigma_8 = 0.826 \pm 0.020$

w/ WMAP

Cosmological constraints have *independent systematics* relative to maxBCG counts analysis.