Title: Sharpening the Precision of SZ Studies

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Abstract:

Sharpening the Precision of SZ Studies

Gil Holder

McGill

25 years cifar
Canadian Institute for Advanced Research

Sharpening the Precision of SZ Studies

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Outline

- Understanding the impact of scatter in relation between Y and M
- Source masking in power spectrum studies
- Pink elephants and cosmological parameters

Work done by Laurie Shaw

Cartoon Cosmology: Counting Galaxy Clusters

$$\frac{d^2N}{dz\,d\ln S} = \int \frac{dP(\ln S \mid \ln M, z)}{d\ln S}\,\frac{dn}{d\ln M}\,d\ln M\,\frac{dV}{dz}$$

Observed distribution as function of flux and redshift

PHYSICS!!!!

Mapping between cluster observable and theory mass (e.g., Gaussian+)

Mass function

Volume element

Understanding scatter

$$\frac{dN}{d\ln S_{obs}} = \int \frac{dN}{d\ln S_{true}} P(\ln S_{obs}|\ln S_{true})$$

Define G(x) : Gaussian exp(-x^2/2) $\quad x \equiv \frac{\ln S_{obs} - \ln S_{true}}{\sigma}$

Use Edgeworth expansion:

$$P(\ln S_{obs}|\ln S_{true}) \sim G(x) - \frac{\gamma\sigma^3}{6}\frac{d^3G}{dx^3} + \frac{\kappa\sigma^4}{24}\frac{d^4G}{dx^4} + \frac{\gamma^2\sigma^6}{72}\frac{d^6G}{dx^6} +$$

skewness kurtosis

Understanding scatter

$$\frac{dN}{d\ln S_{obs}} = \int \frac{dN}{d\ln S_{true}} P(\ln S_{obs} | \ln S_{true})$$

Assume power-law counts $dN/dlnS \propto S^{-\alpha}$

$$\frac{dN}{d\ln S_{obs}} = \left(\frac{dN}{d\ln S}\right)_{\circ} e^{\alpha^2\sigma^2/2}\left[1 - \frac{\alpha^3\sigma^3}{6}\gamma + \frac{\alpha^4\sigma^4}{24}\kappa + \frac{\alpha^6\sigma^6}{72}\gamma^2 + ...\right]$$

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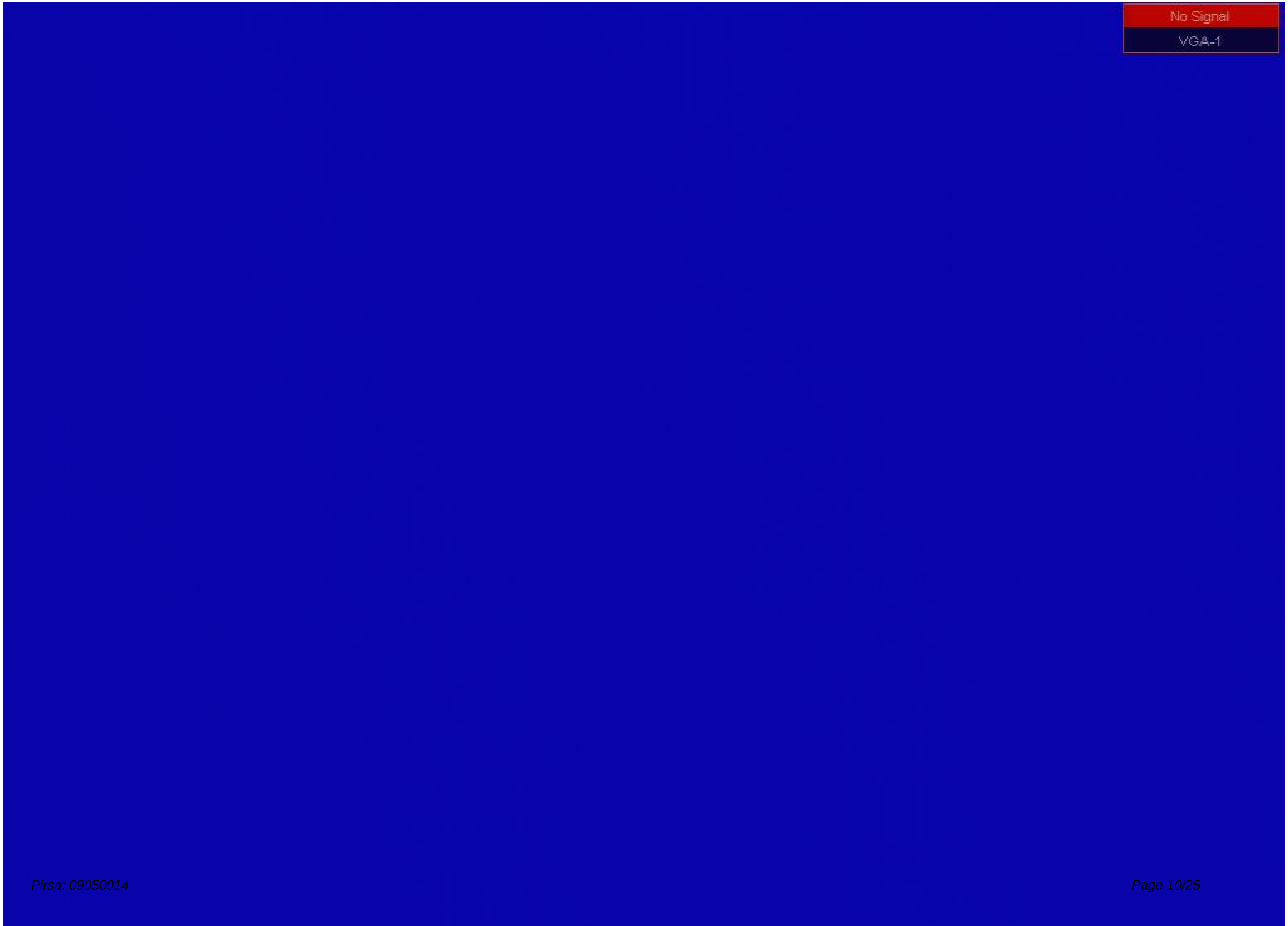
No Signal
VGA-1

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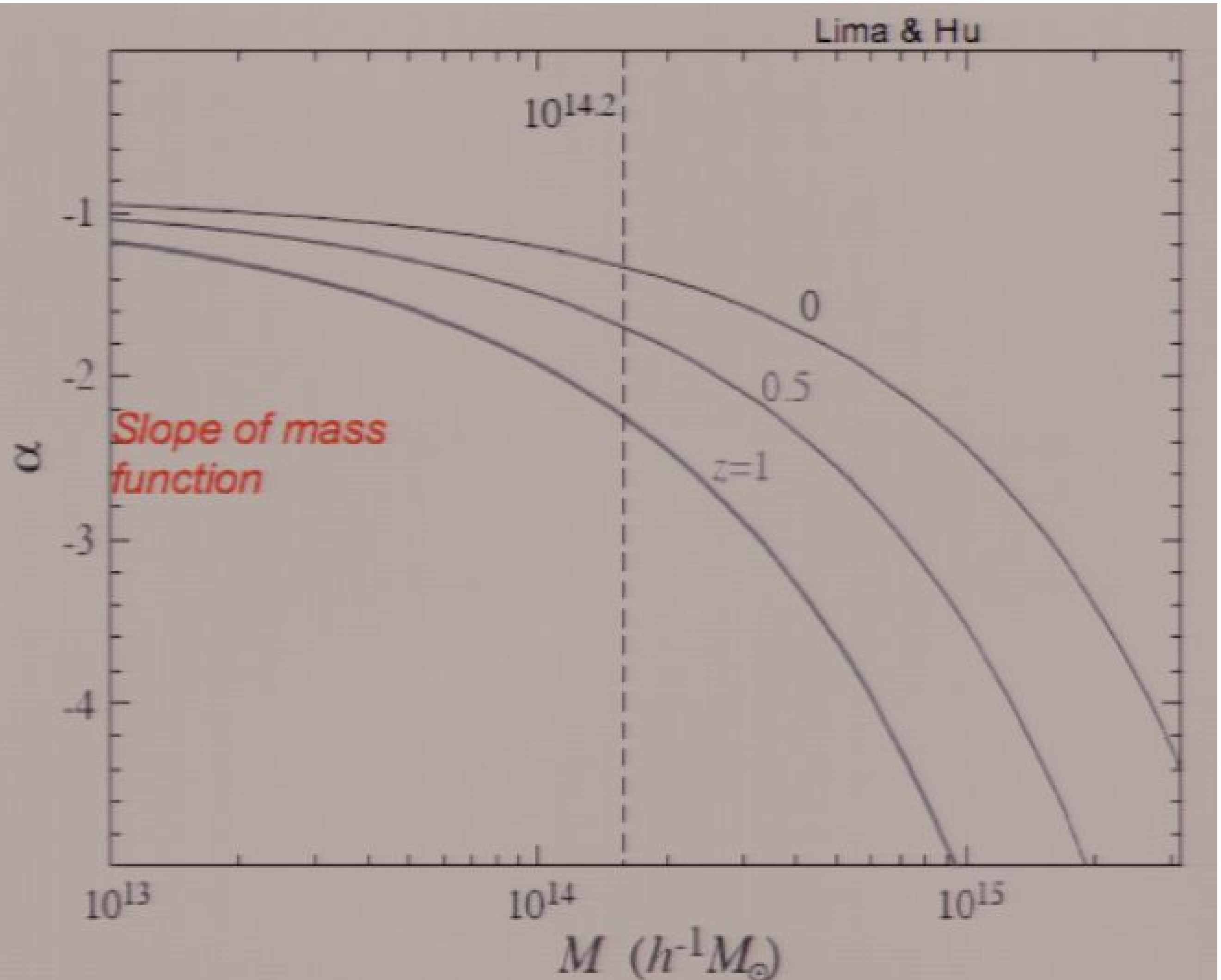
The Importance of being precise



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Calculating the SZ Power Spectrum

Power spectrum

$$C_\ell = \int dz \frac{dV}{dz} \int d\ln M \frac{dn(M,z)}{d\ln M} \tilde{y}(M,z,\ell)^2$$

1 halo part of trispectrum

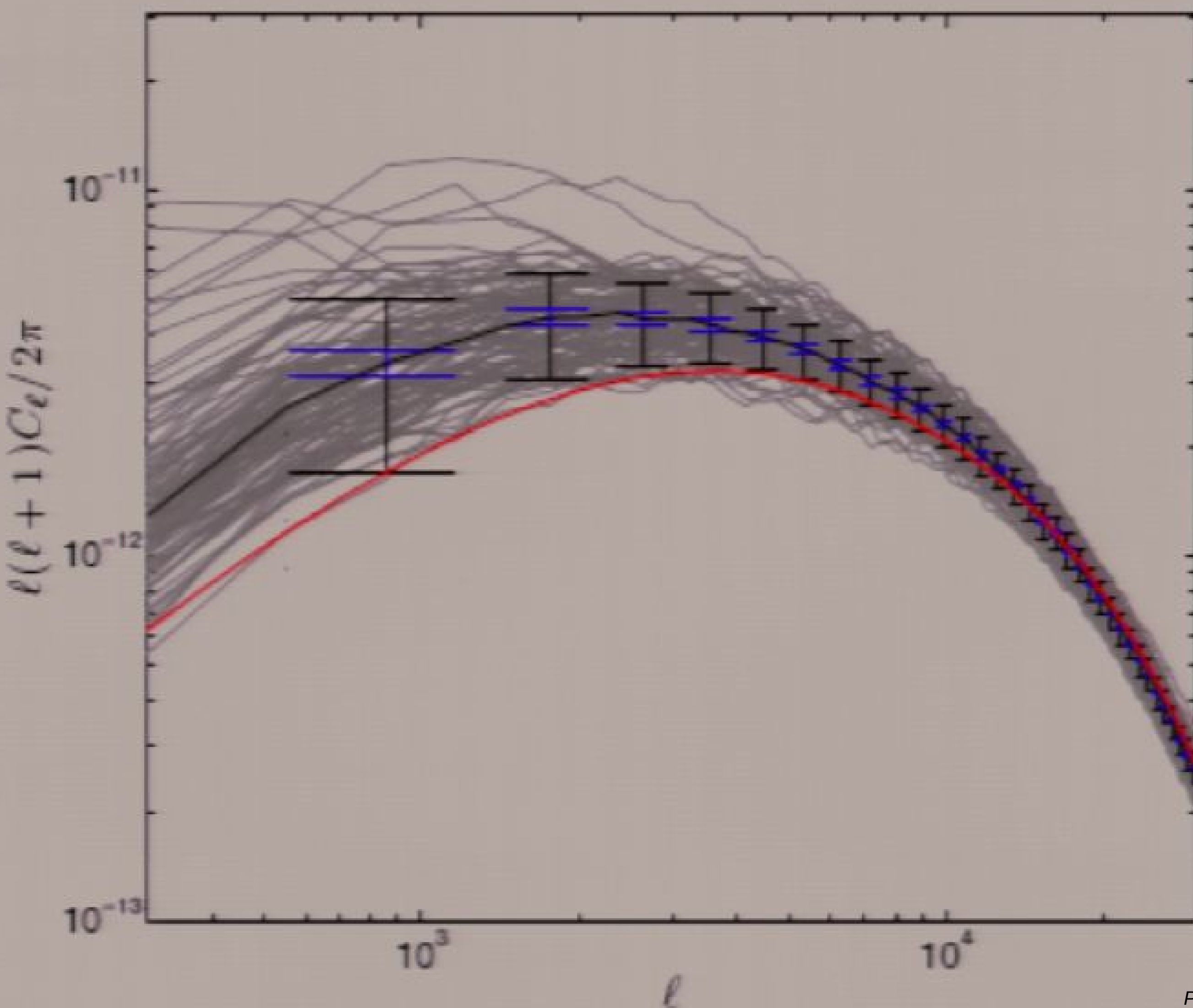
$$T_{\ell\ell} = \int dz \frac{dV}{dz} \int d\ln M \frac{dn}{d\ln M} \tilde{y}(M,z,\ell)^4$$

$$\sigma^2(C_\ell) = f_{sky}^{-1}\left[\frac{2C_\ell^2}{(2\ell+1)\Delta\ell} + \frac{T_{\ell\ell}}{4\pi}\right]$$

Komatsu & Seljak

Variance in the SZ Power

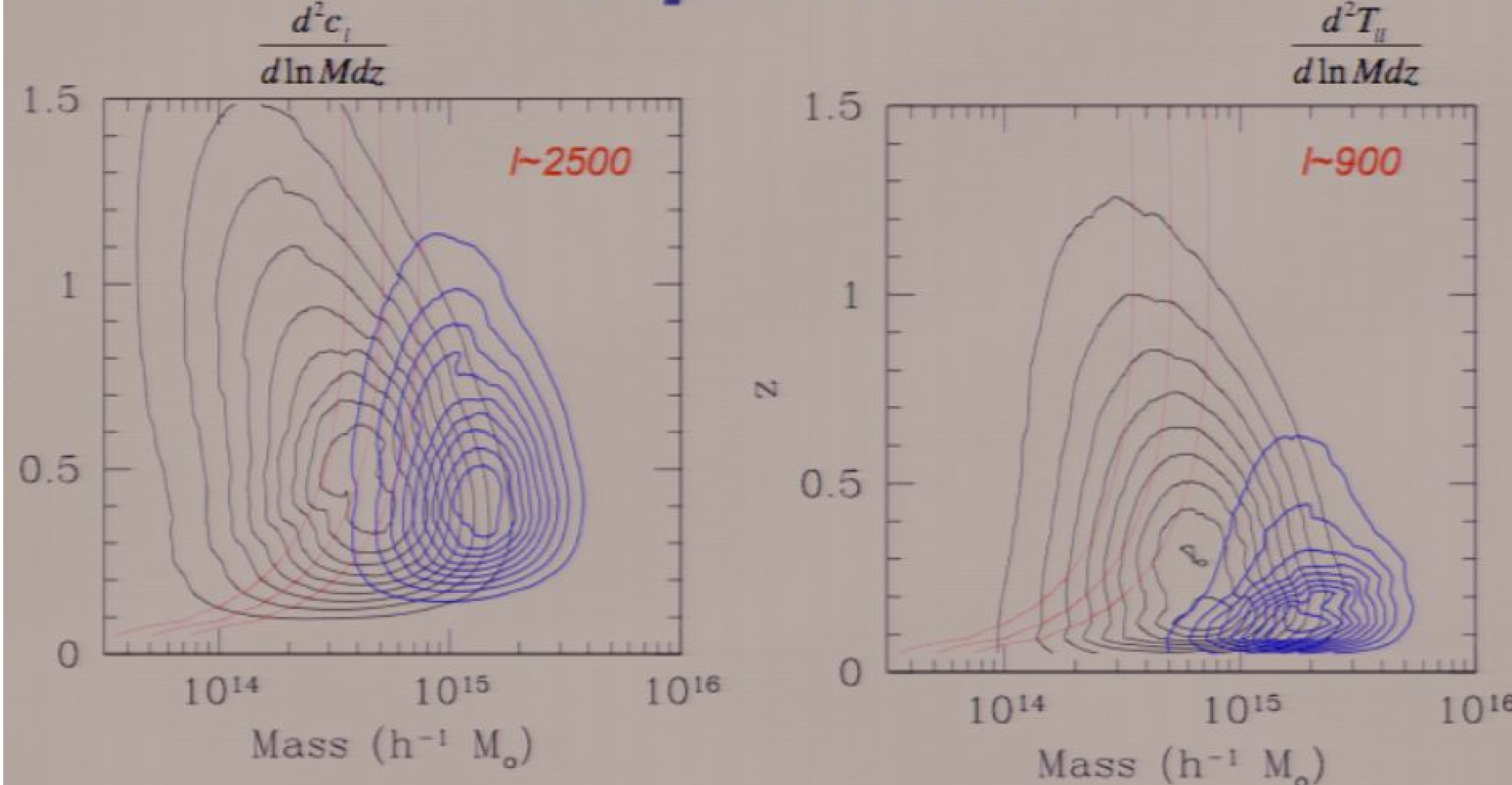
Power spectra for 96 maps, each 5x5deg based on Bode/Ostriker clusters



Scatter much larger than sample variance

Blue: sample variance

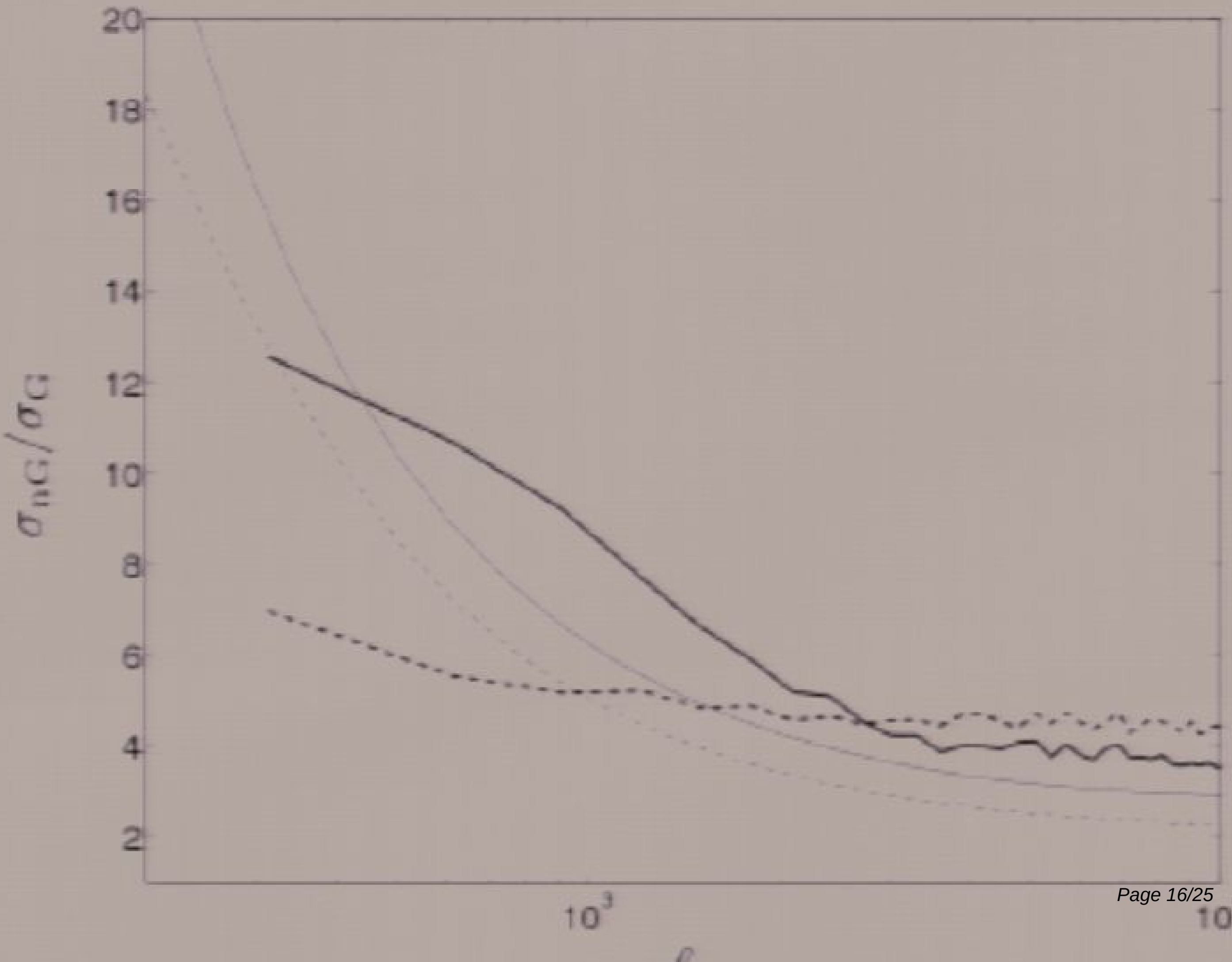
Contributions to Power and Trispectrum



Comparison with Gaussian expectations

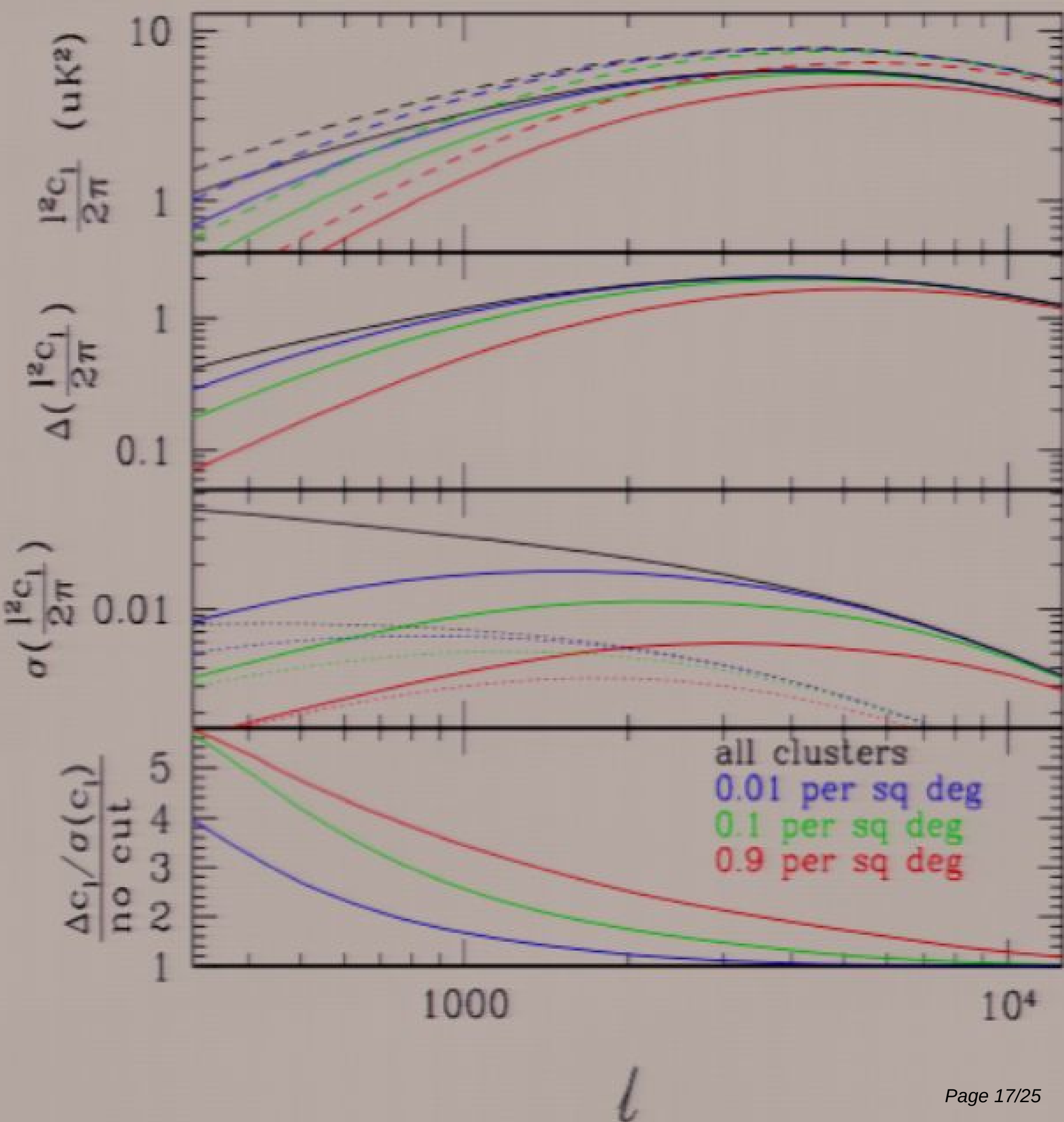
Reasonable, but not perfect match with simple model

(but, good agreement for Poisson-distributed beta model profiles; not shown)



Advantage of Masking Bright Sources

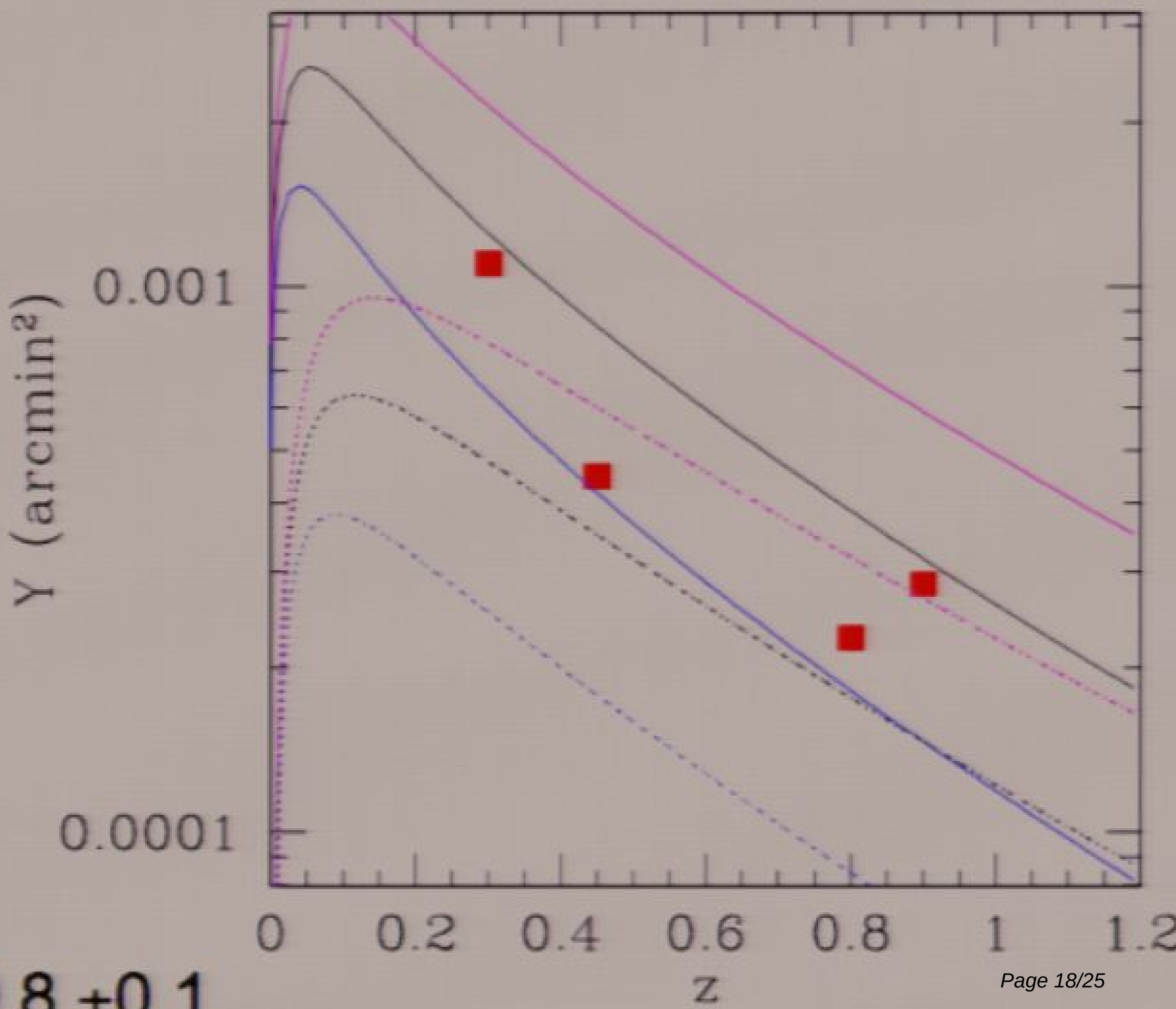
- Shot noise in massive objects add much more noise than signal!



Pink & Grey Elephants

- σ_8=0.9,0.8,0.7 (purple, black, blue)
- Solid: 0.5 clusters per 40 sq deg for dz=dlogY=0.2
- Dotted: 2 clusters per sq deg
- Red squares: the four public SPT clusters
- Too many high flux clusters for σ_8=0.7
- Where are all the massive clusters for σ_8=0.9?

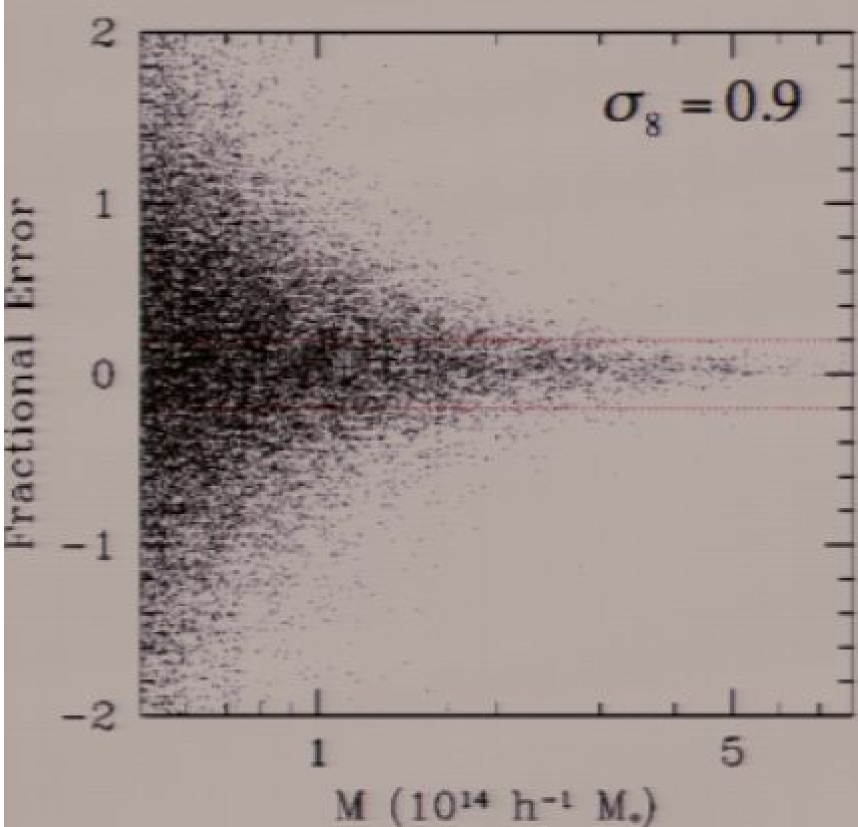
Contours of differential number density

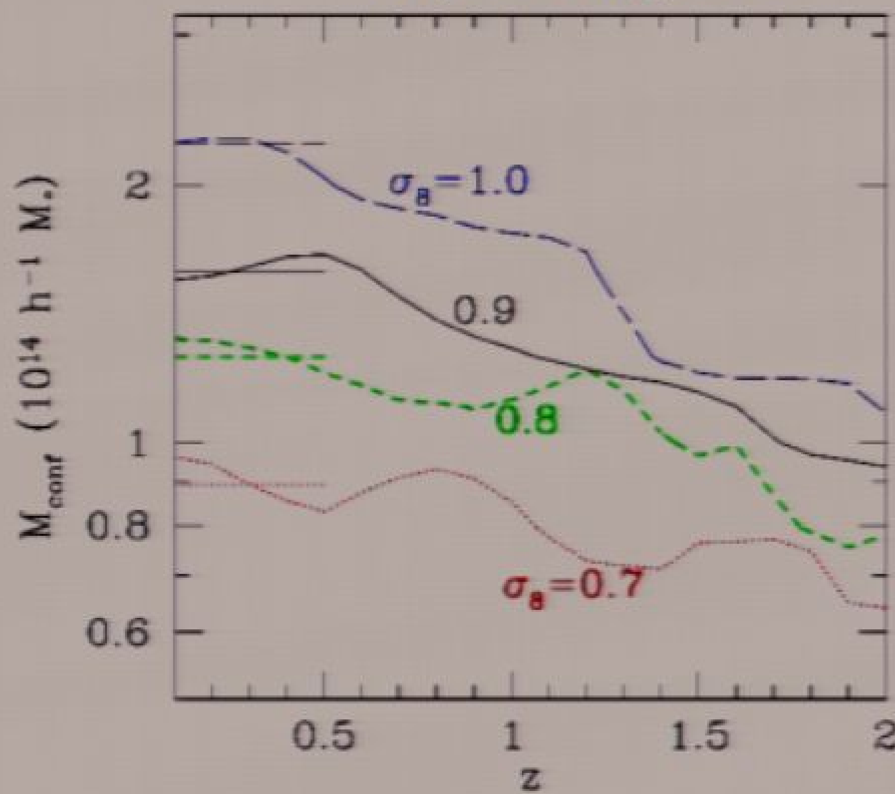


/ith only 40 sq deg: σ_8~0.8 ±0.1

SZ Confusion

GH, McCarthy, Babul





(input-measured)/input for simulated filtered SZ maps

Mass at which rms error is 20%

Assuming single frequency

Summary

- Large scatter in cluster surveys is bad for two reasons
  - Increases number counts dramatically
  - Amplifies importance of tails of distribution
- Masking of galaxy clusters improves precision of power spectrum estimates
  - Rare objects have a lot of shot noise and not much extra information for the power spectrum
- SZ cosmology nearly here
  - Can nearly do interesting cosmology with only 4 clusters! *[although I wouldn't recommend it…]*

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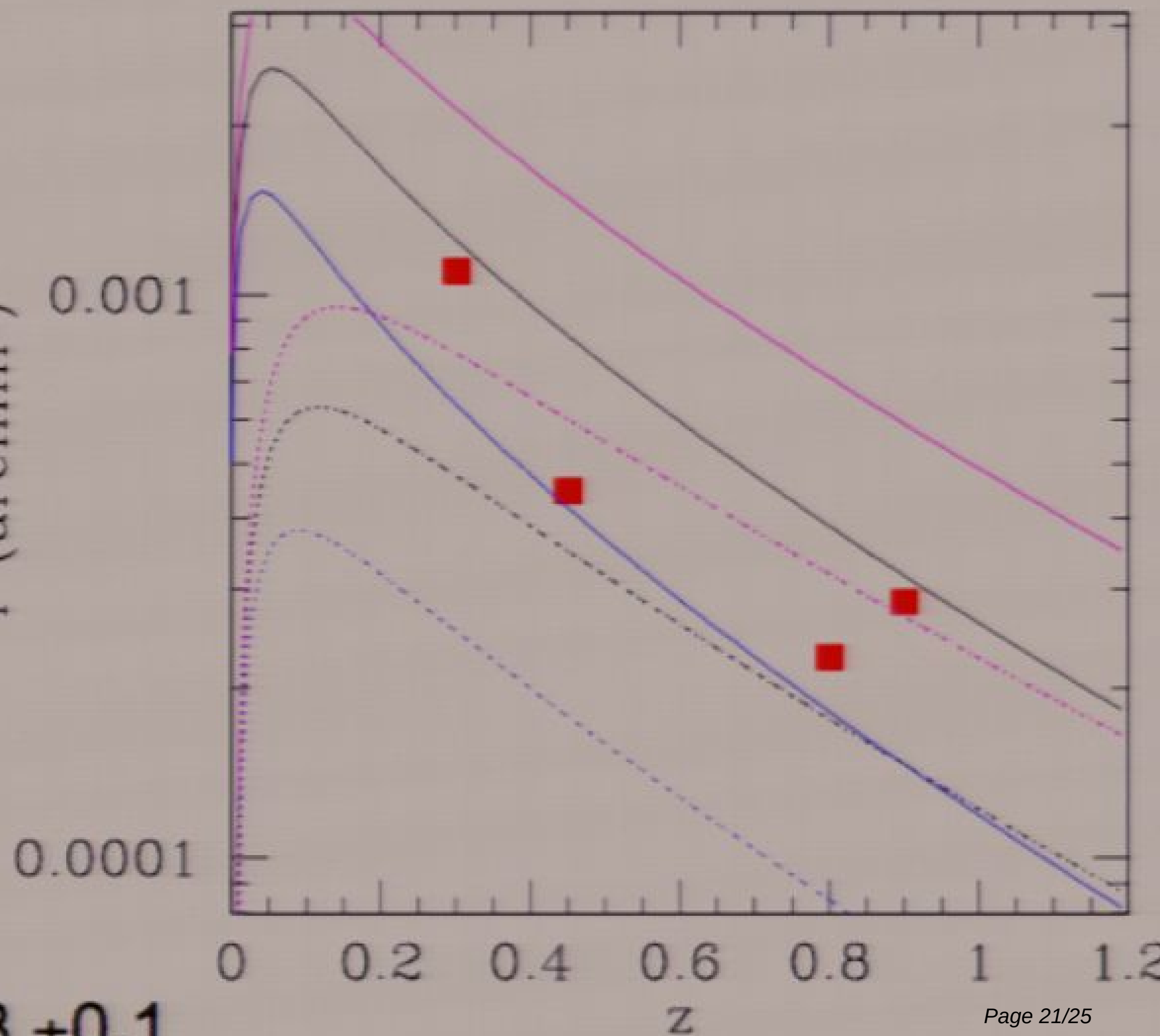

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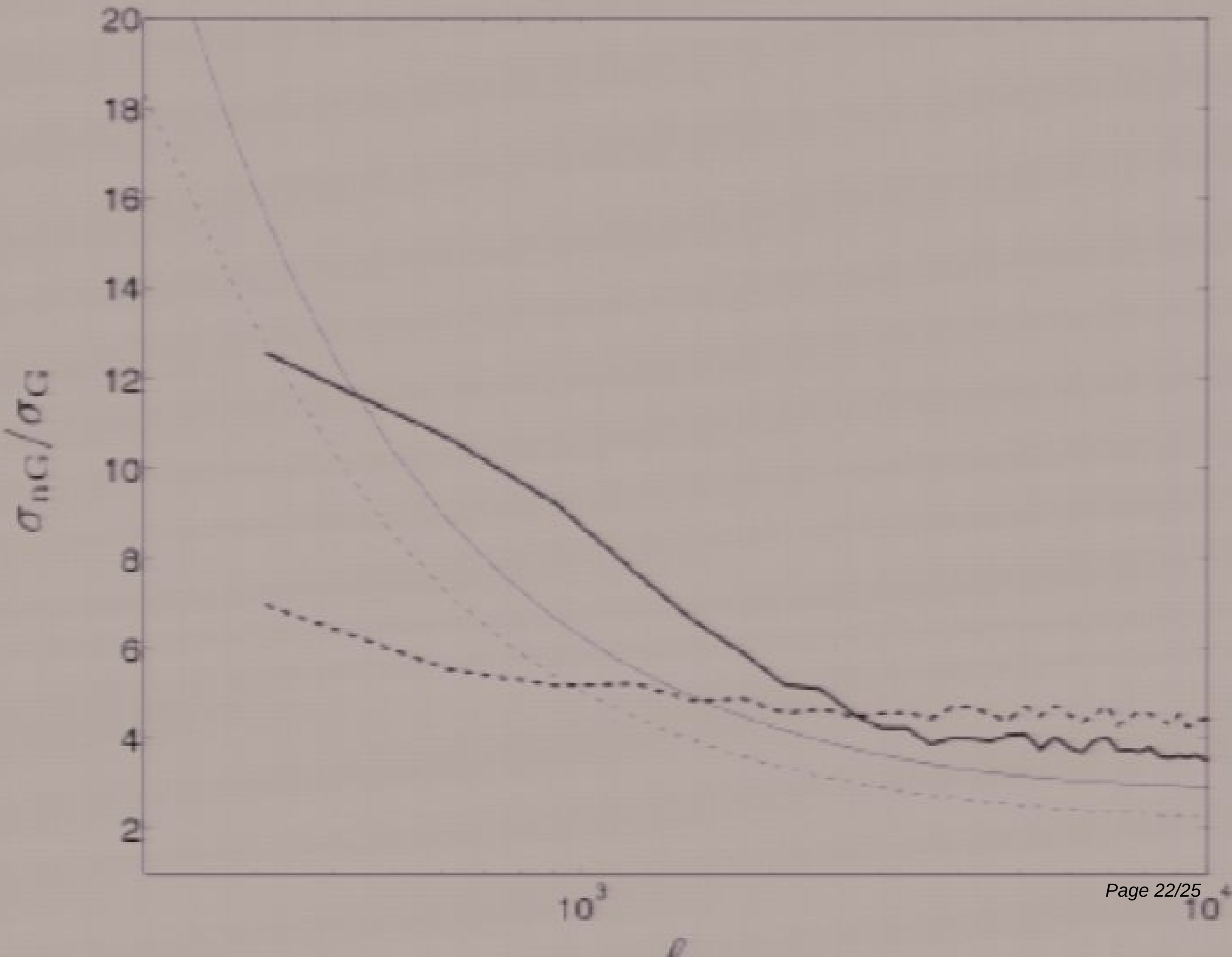

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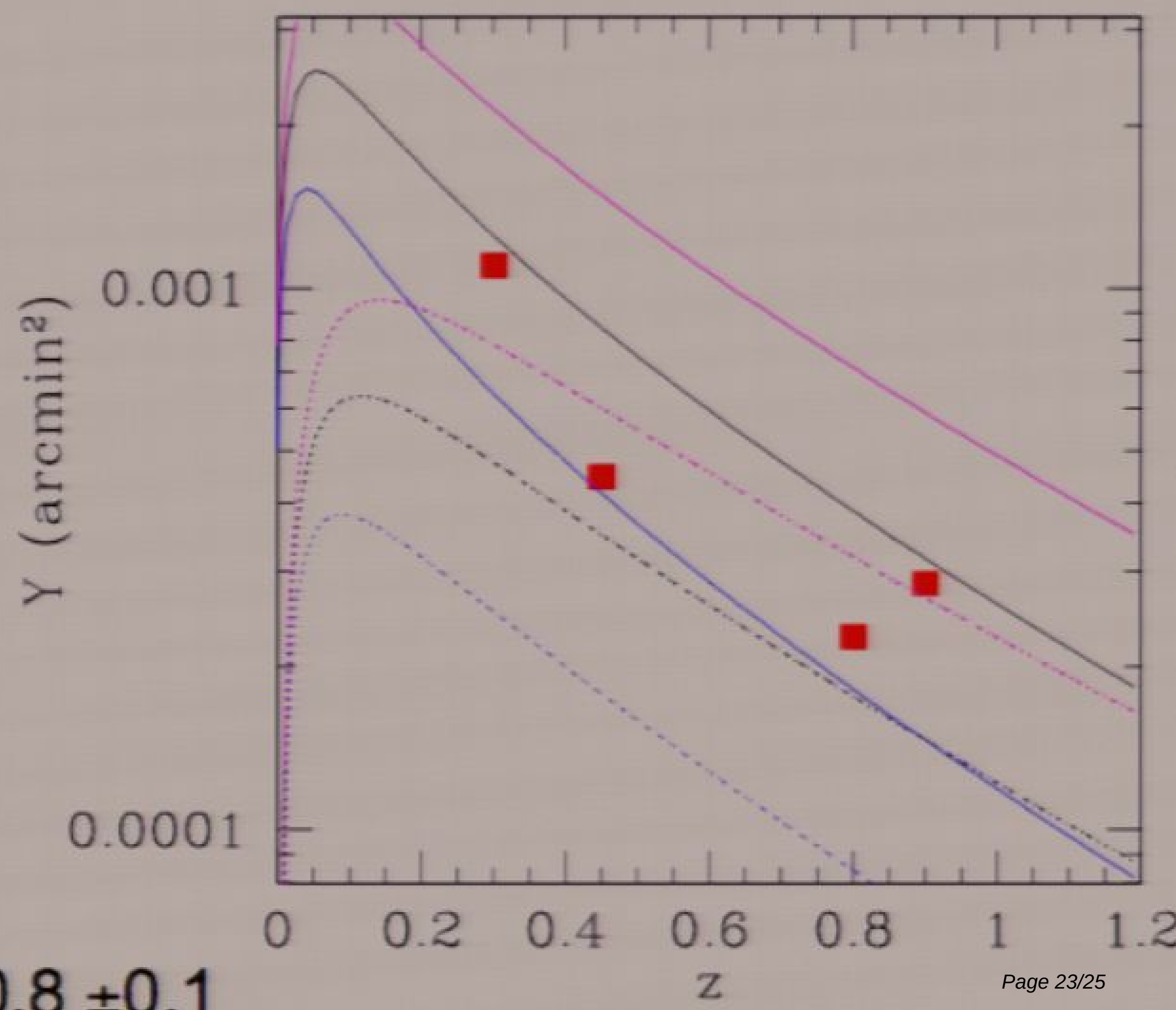

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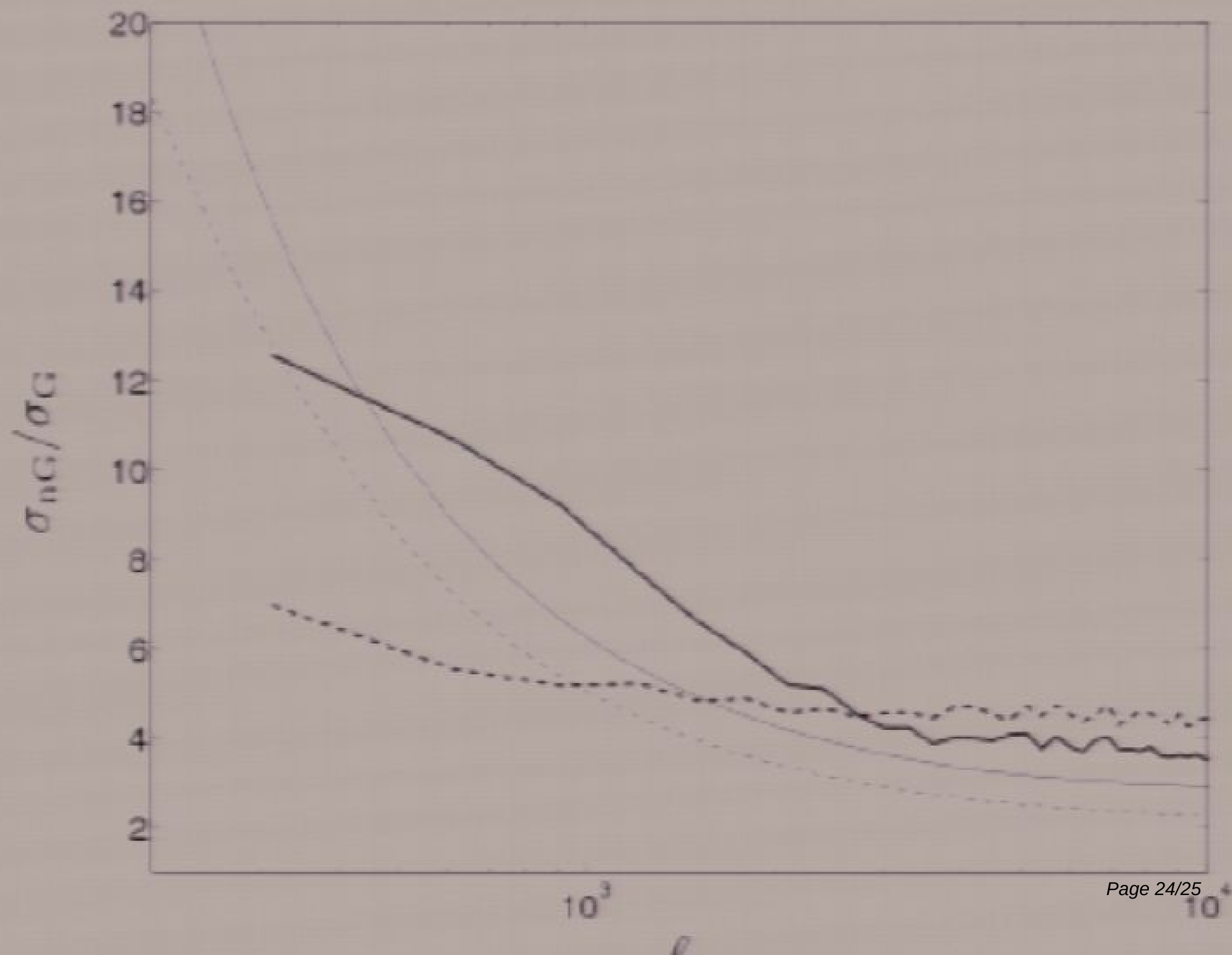

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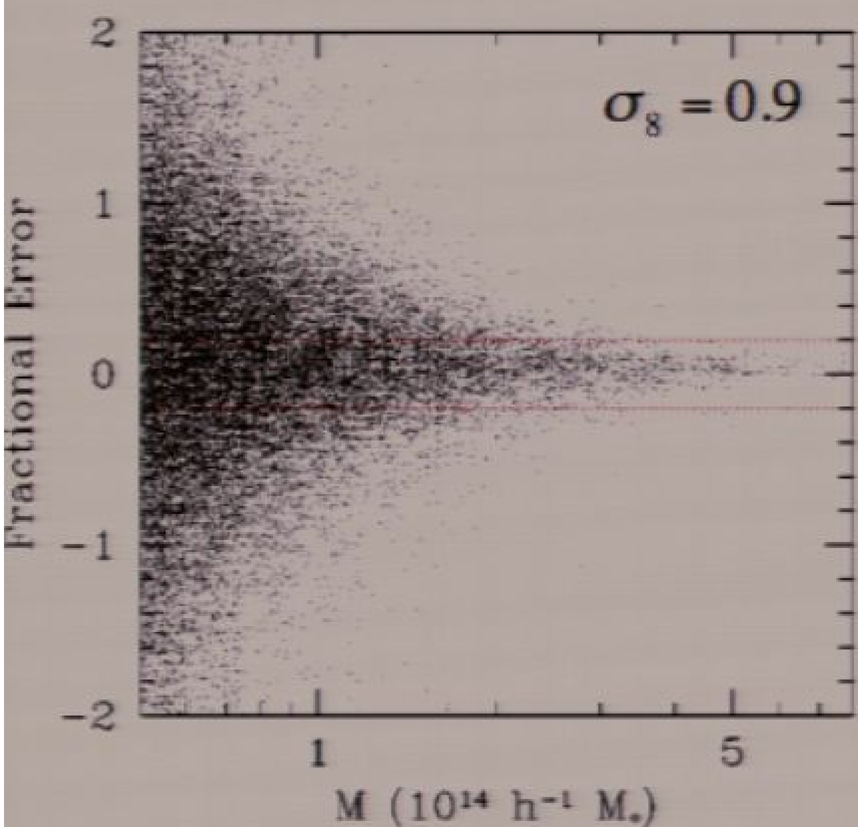

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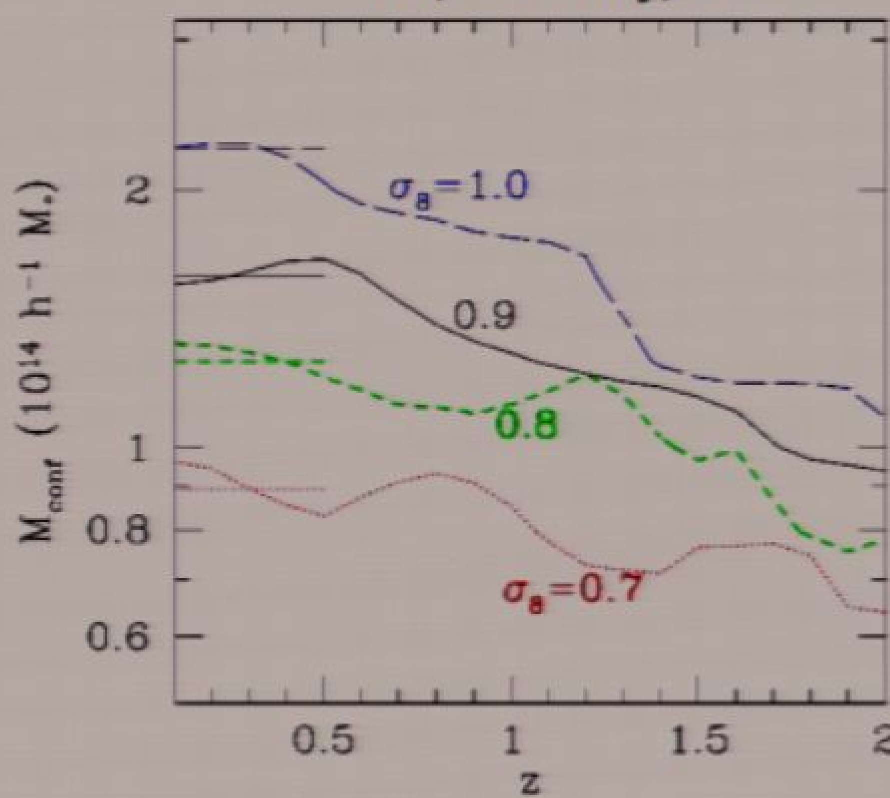

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