Title: Primordial non-gaussianity and DM small scale structure

Date: Jun 08, 2008 03:15 PM

URL: http://pirsa.org/08060021

Abstract:

what is the worst possible thing I could do?

primodial non-gaussianity

sexy

interesting

primodial non-gaussianity

sexy

primodial non-gaussianity

interesting

sexy	interesting
primodial non-gaussianity	

sexy	interesting
primodial non-gaussianity Neal Dalal	

sexy	interesting
primodial non-gaussianity	
Neal Dalal	
Licia Verde	
Niayesh Afshordi	

sexy	interesting
primodial non-gaussianity	small scale CDM structure
Neal Dalal	
Licia Verde	
Niayesh Afshordi	

Constraints on Primordial non-Gaussianity

Constraints on Primordial non-Gaussianity from Small-scale CDM Structure

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Rolling Stone, July 2008 (cover story)

Why is non-Gaussianity interesting in general?

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Inflation, or something like it, is necessary

* some source of primordial fluctuations
* acausal perturbations
* roughly Gaussian statistics

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Any information we can get about inflation is very important;

but we are really limited to statistics of primordial fluctuations

This sort of information can select between whole classes of models, e.g. $n \neq 1$ or non-Gaussianity rule out simplest single-field pictures.

(So much more important than, e.g. Ω_m or similar "nuisance" parameters)

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$$\Phi(\mathbf{x})|_{\rm super} = \Phi_{pG}(\mathbf{x}) - f_{NL}\left[\Phi_{pG}^2(\mathbf{x}) - \langle\Phi_{pG}^2(\mathbf{x})\rangle\right]$$

$f_{NL} = 10^5 \Leftrightarrow$ order unity effects , single-field slow-roll predicts $|f_{NL}| \sim 0.1$

Why is it interesting right now:
A recent history of non-Gaussianity

2007 Yadav & Wandelt:

analyse CMB (WMAP 3-year release)

claim 2.9 σ detection of non-Gaussianity:

$$\boxed{f_{NL} = 87 \pm 30}$$

2008 Komatsu et al.

re-analyse more CMB (WMAP 5-year release)

evidence goes down to 1.7 σ

$$\boxed{f_{NL} = 51 \pm 30}$$

2008 Kendrick Smith

re-re-analyses WMAP 5-year release

evidence now less than ~1σ

?? $f_{NL} = 20 \pm 30$??

(note this has not appeared in print yet)

Scale-dependent non-gaussianity!

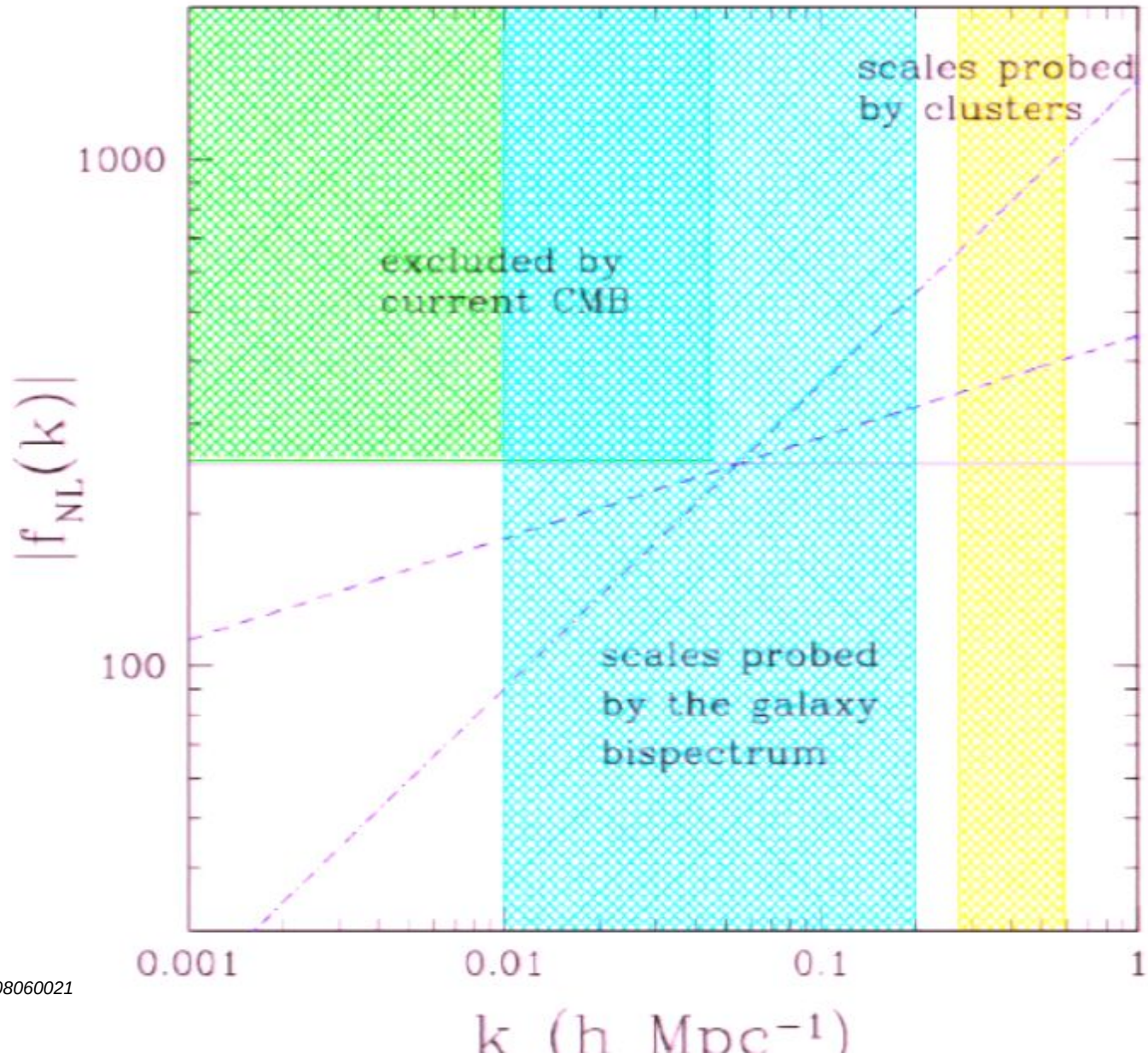
LoVerde, Miller, Shandera & Verde
(JCAP 04,14, 2008 / astro-ph/0711.4126)

why not $f_{NL} = f(k)$?

e.g. $d\ln f_{NL}/d\ln k = -2\kappa$ where $\kappa = -0.1$ to -0.3

Scale-dependent non-Gaussianity:

LoVerde, Miller, Shandera & Verde astro-ph/0711.4126



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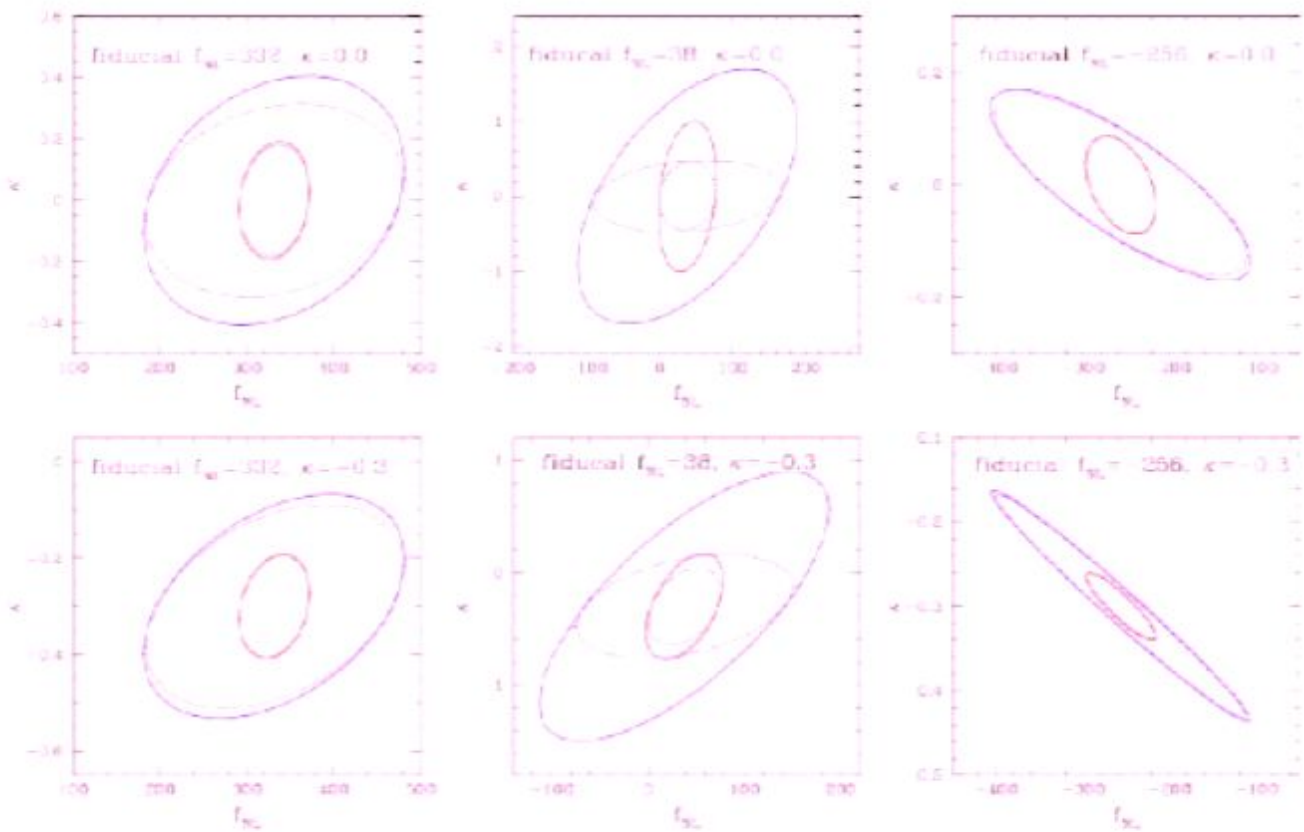

Figure 6: The joint constraints on $f_{NL}^{eq}(k_{CMB})$ and the running of the non-Gaussianity κ for a full-sky cluster survey marginalized over Ω_m, h, σ_8 and M_{lim}. Shown are 1-σ contours for WMAP (blue outer curves) and Planck (red inner curves) priors. Note that the plot range varies from panel to panel. Recall, $f_{NL}^{eq} \propto k^{-2\kappa}$ so the degeneracy line changes when the sign of f_{NL}^{eq} is changed. The fact that κ is a slow roll parameter restricts its value to $\kappa << 1$, the dotted lines show the constraints if a Gaussian prior of ± 0.5 is put on κ to enforce this.

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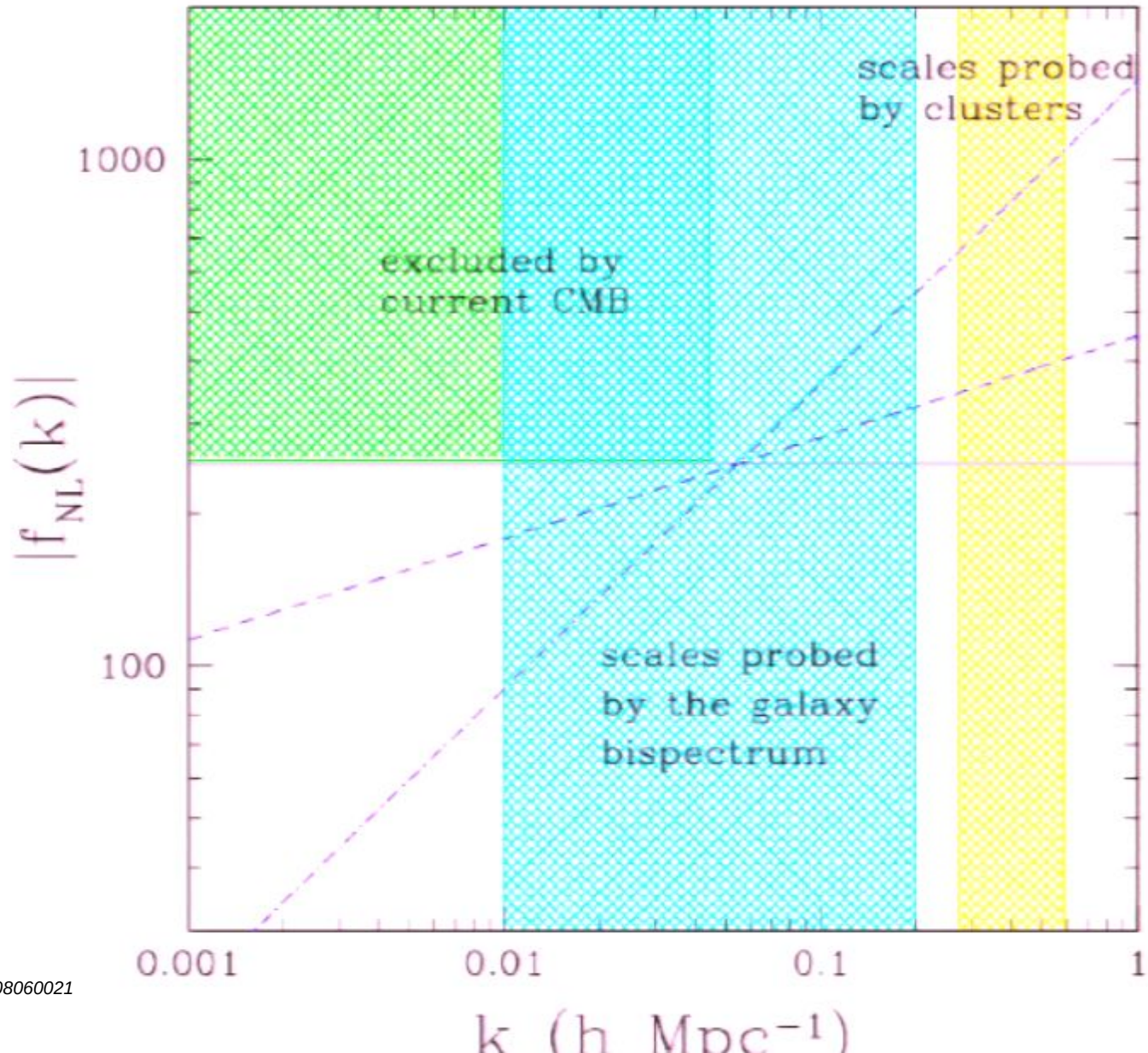

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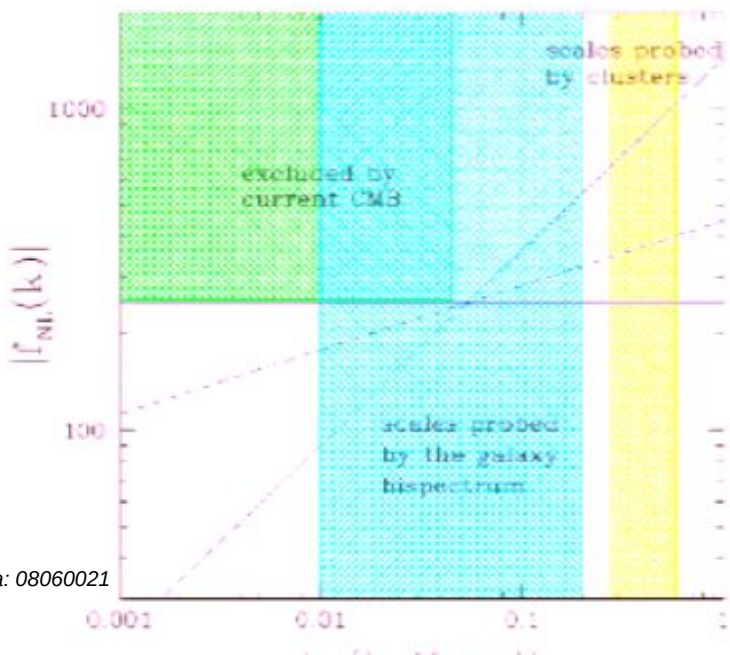

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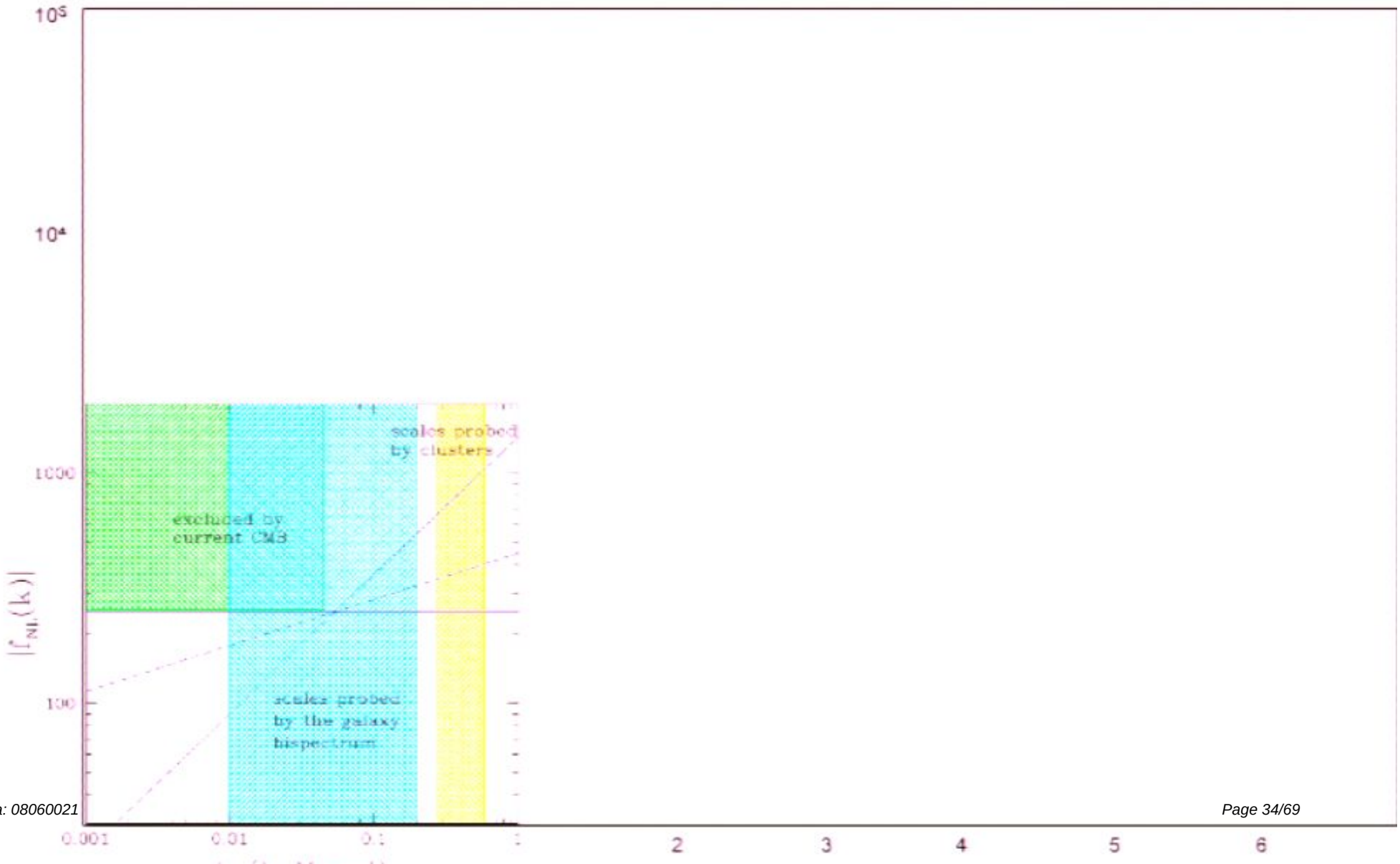

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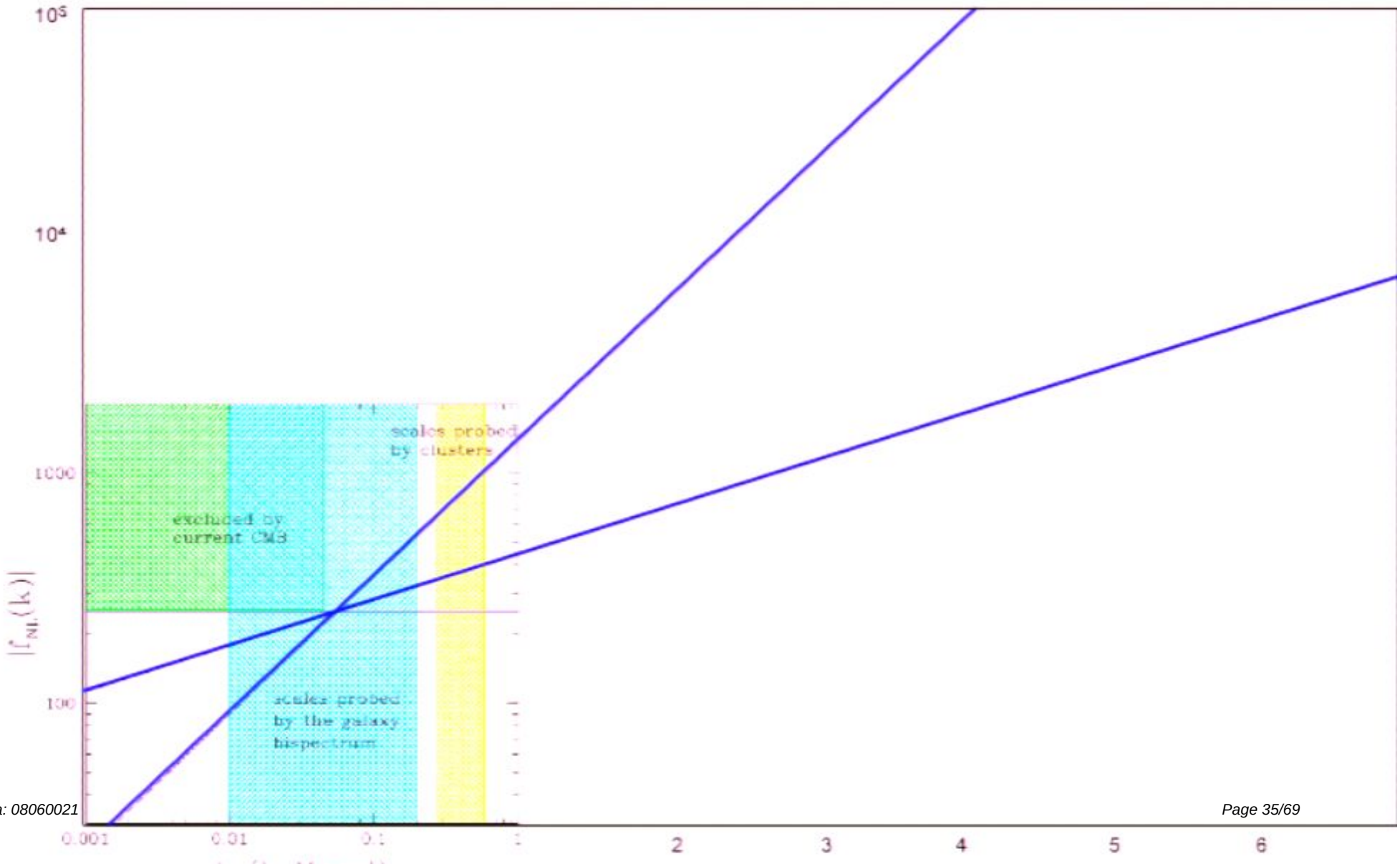

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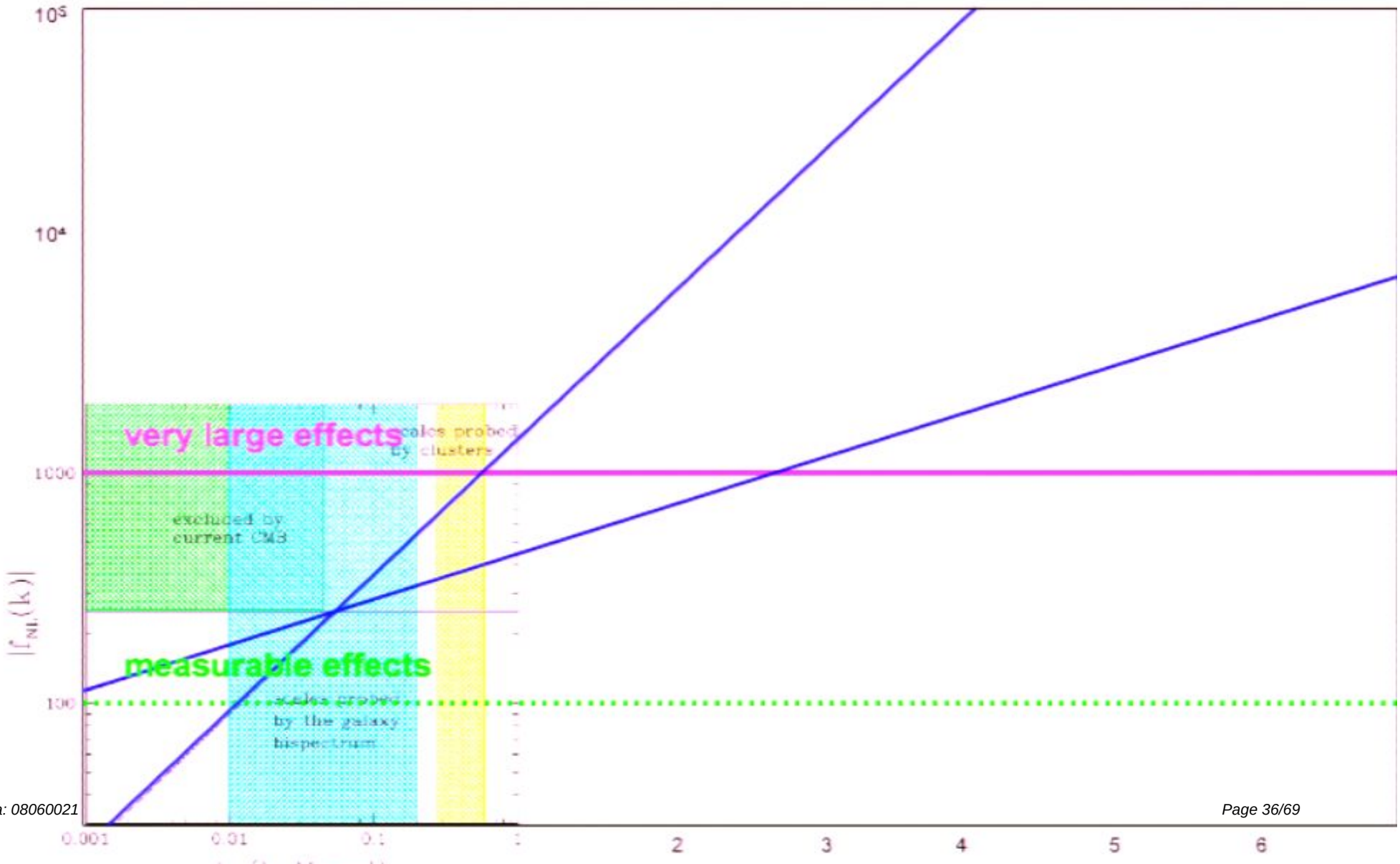

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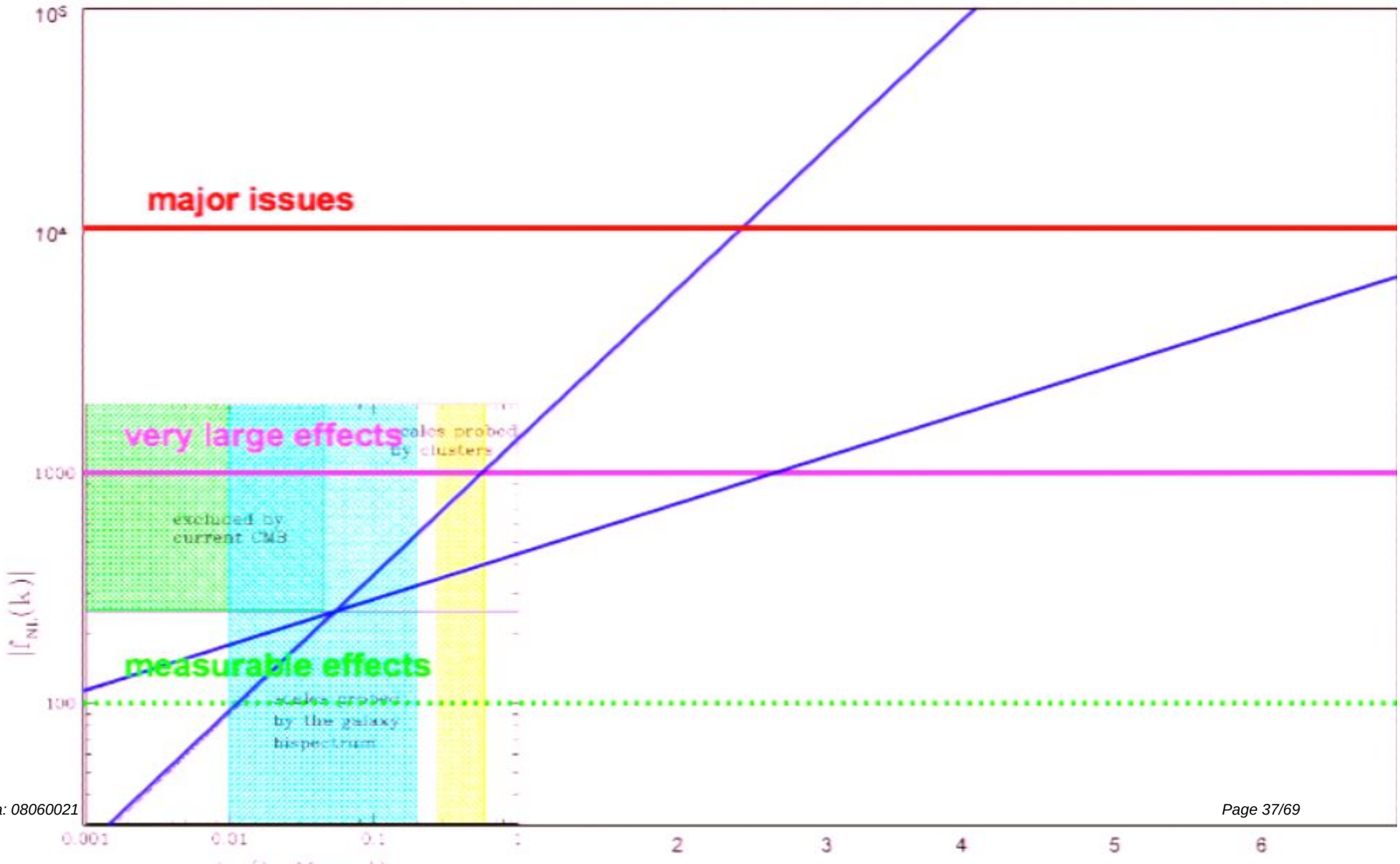

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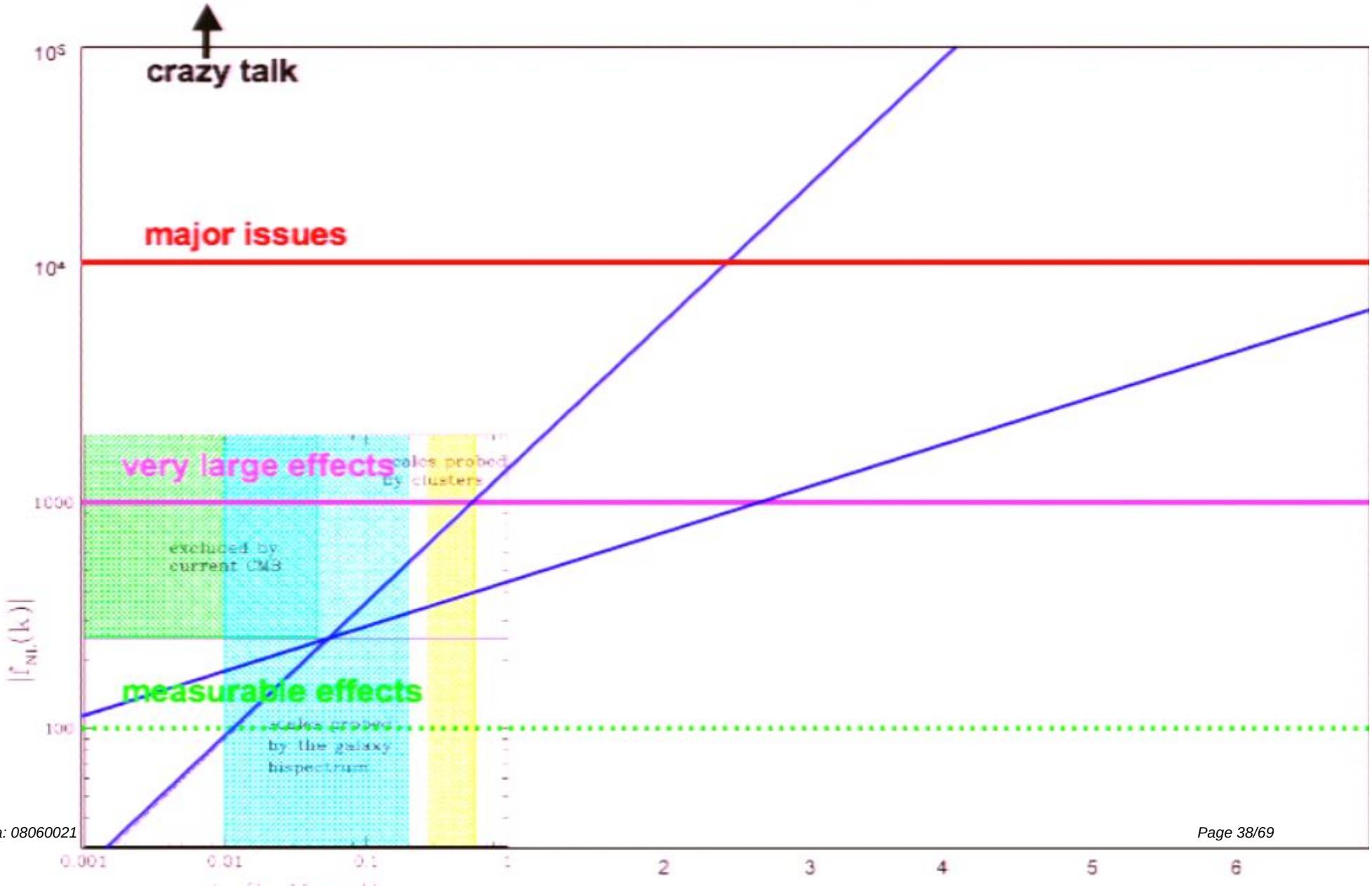

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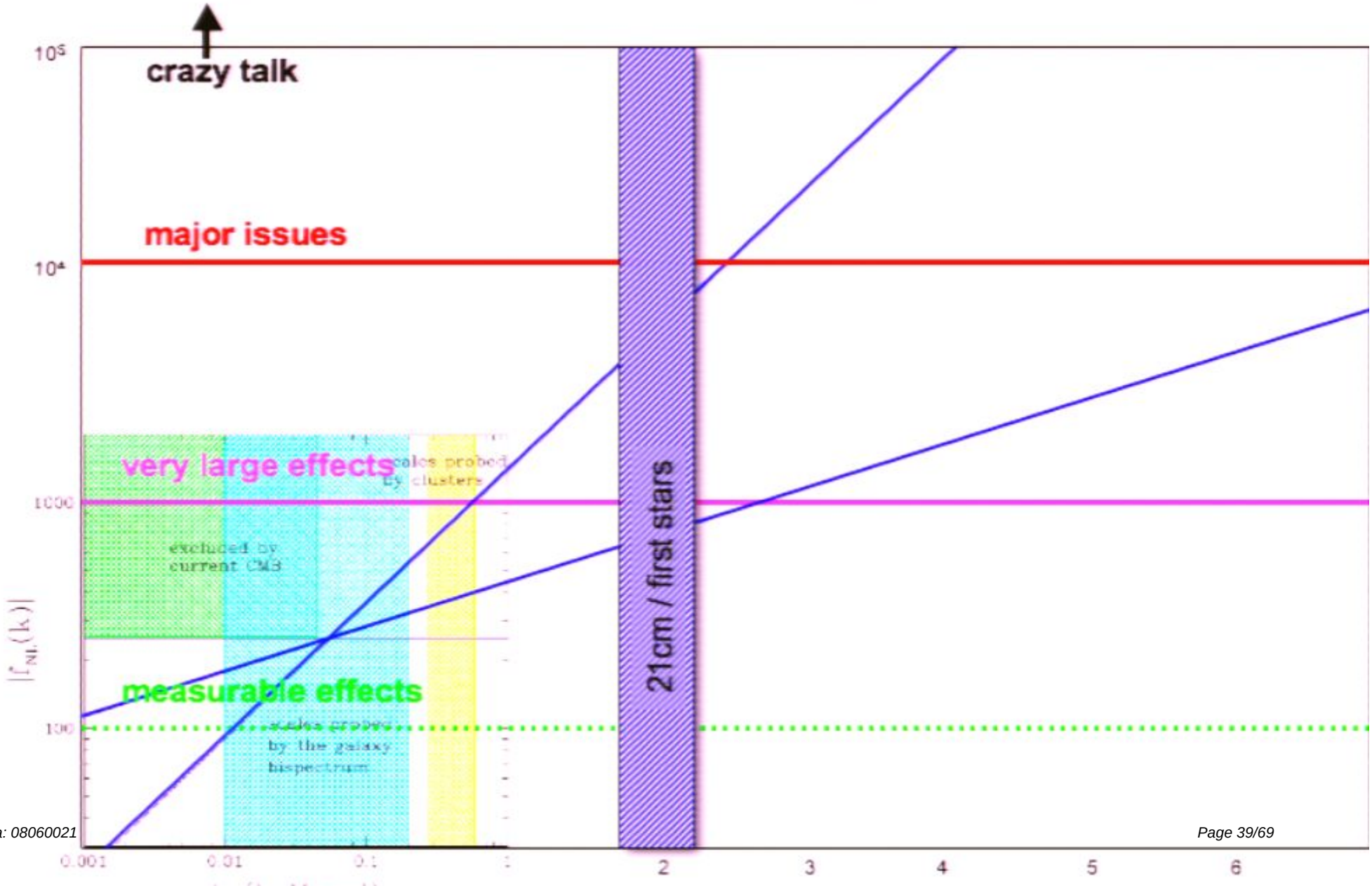

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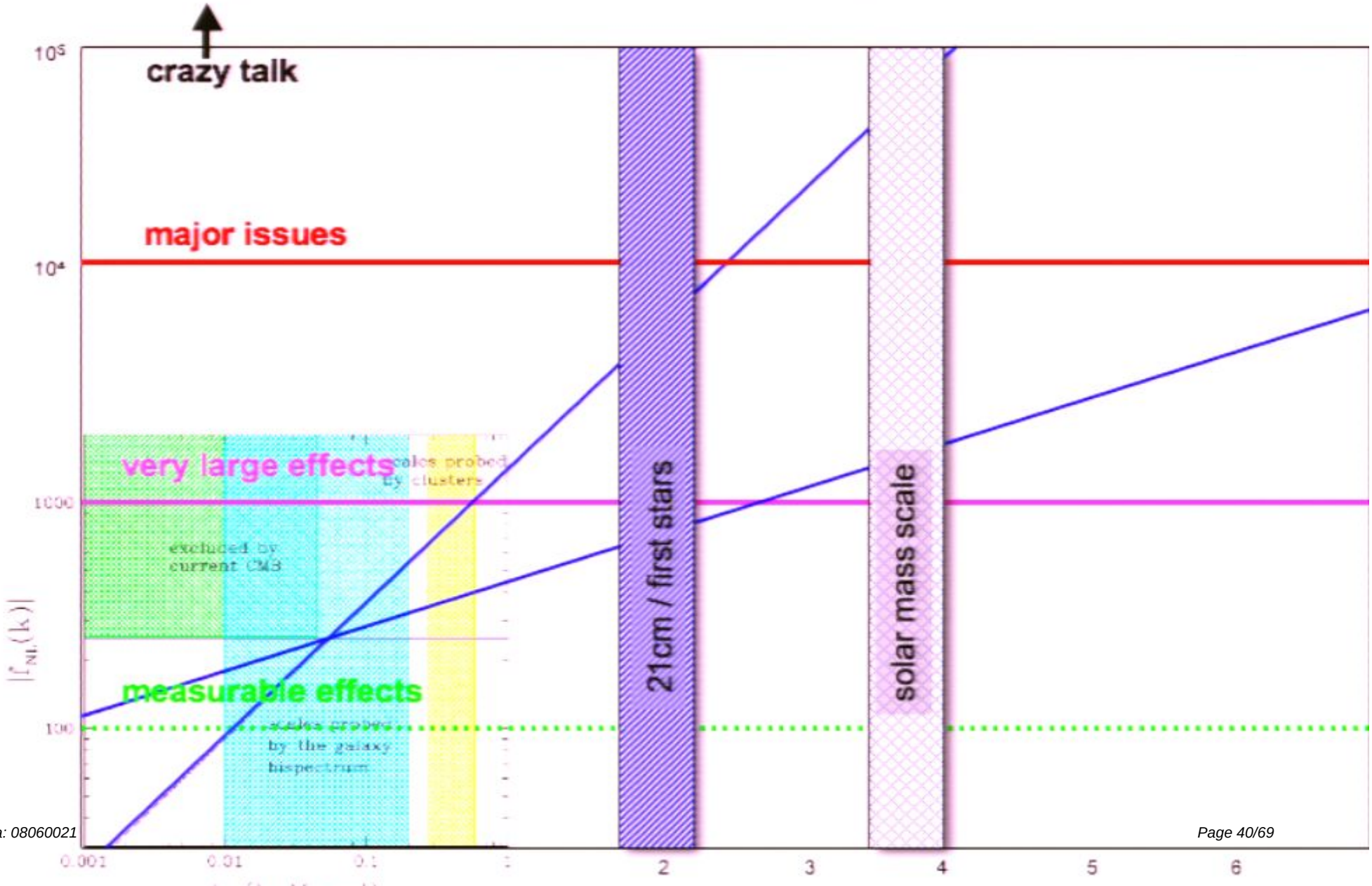

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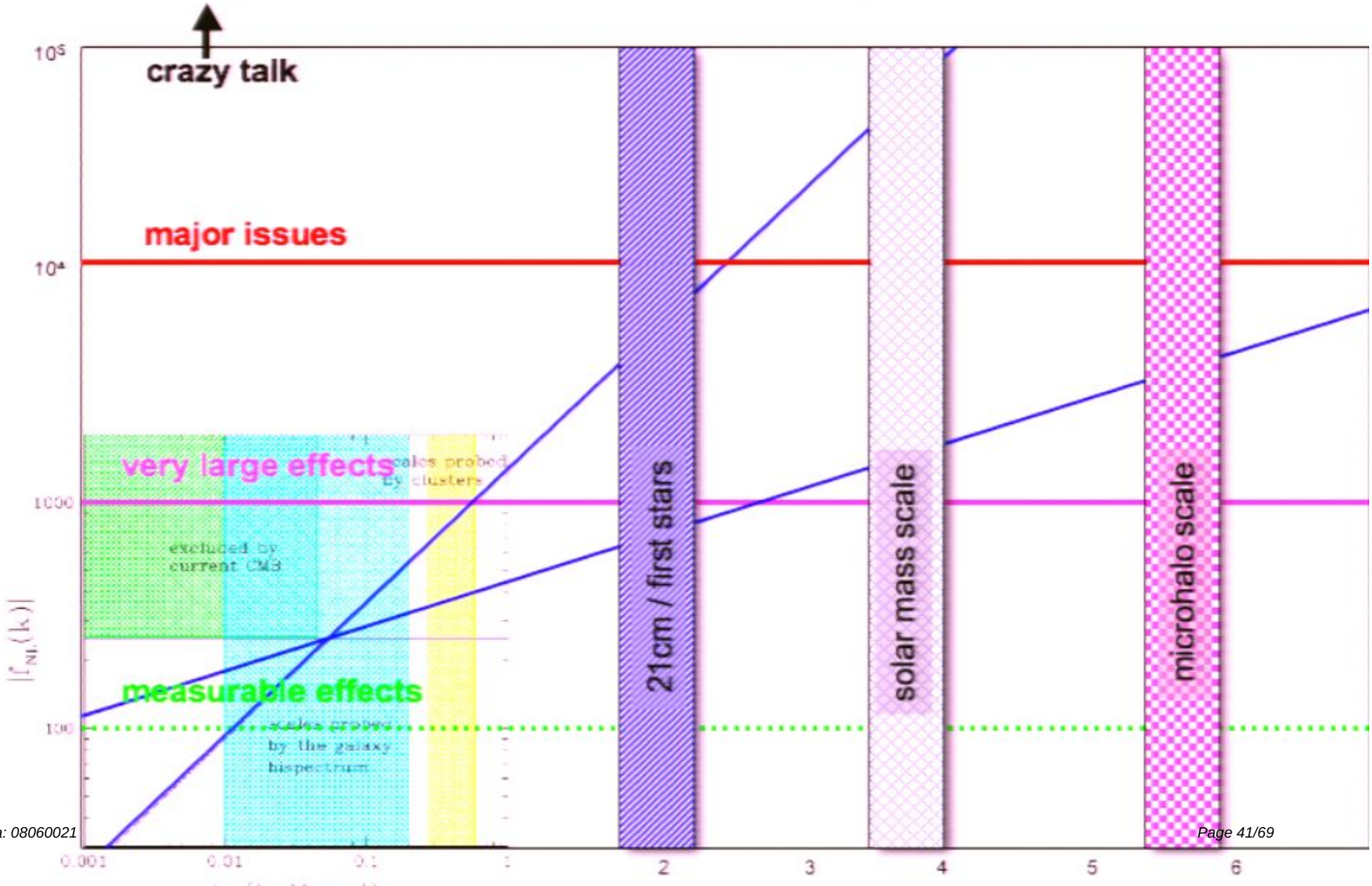

EPS for small f_{NL}

Afshordi & Tolley 2008:

start by determining fluctuations from potential

$$\delta_{m,\mathbf{k}} \equiv -\frac{k^2\Phi_{\mathbf{k}}}{4\pi G a^2 \rho_m} = -A^{-1}(k;t)\Phi_{\mathbf{k}},$$

where

$$A(k;t) = \frac{3}{2}\Omega_m H_0^2 a(t)^{-1} k^{-2}.$$

$$\Phi(\mathbf{x})|_{\text{super}} = \Phi_{pG}(\mathbf{x}) - f_{NL}\left[\Phi_{pG}^2(\mathbf{x}) - \langle\Phi_{pG}^2(\mathbf{x})\rangle\right]$$

$$\delta_m(\mathbf{x};t,M) \simeq \delta_{mG}(\mathbf{x};t,M) - f_{NL}\left\{2\Phi_{pG}(\mathbf{x};M)\delta_{mG}(\mathbf{x};t,M) + \frac{\epsilon(M)}{ag}\left[\delta_{mG}(\mathbf{x};t,M)\right]^2\right\}$$

Ellispoidal collapse condition:

$$\delta_m > \delta_{ec} \Rightarrow \delta_{mG} - 2f_{NL}\delta_{ec}\Phi_{pG} \gtrsim \delta_{ec} + \frac{\epsilon f_{NL}}{ag}\delta_{ec}^2.$$

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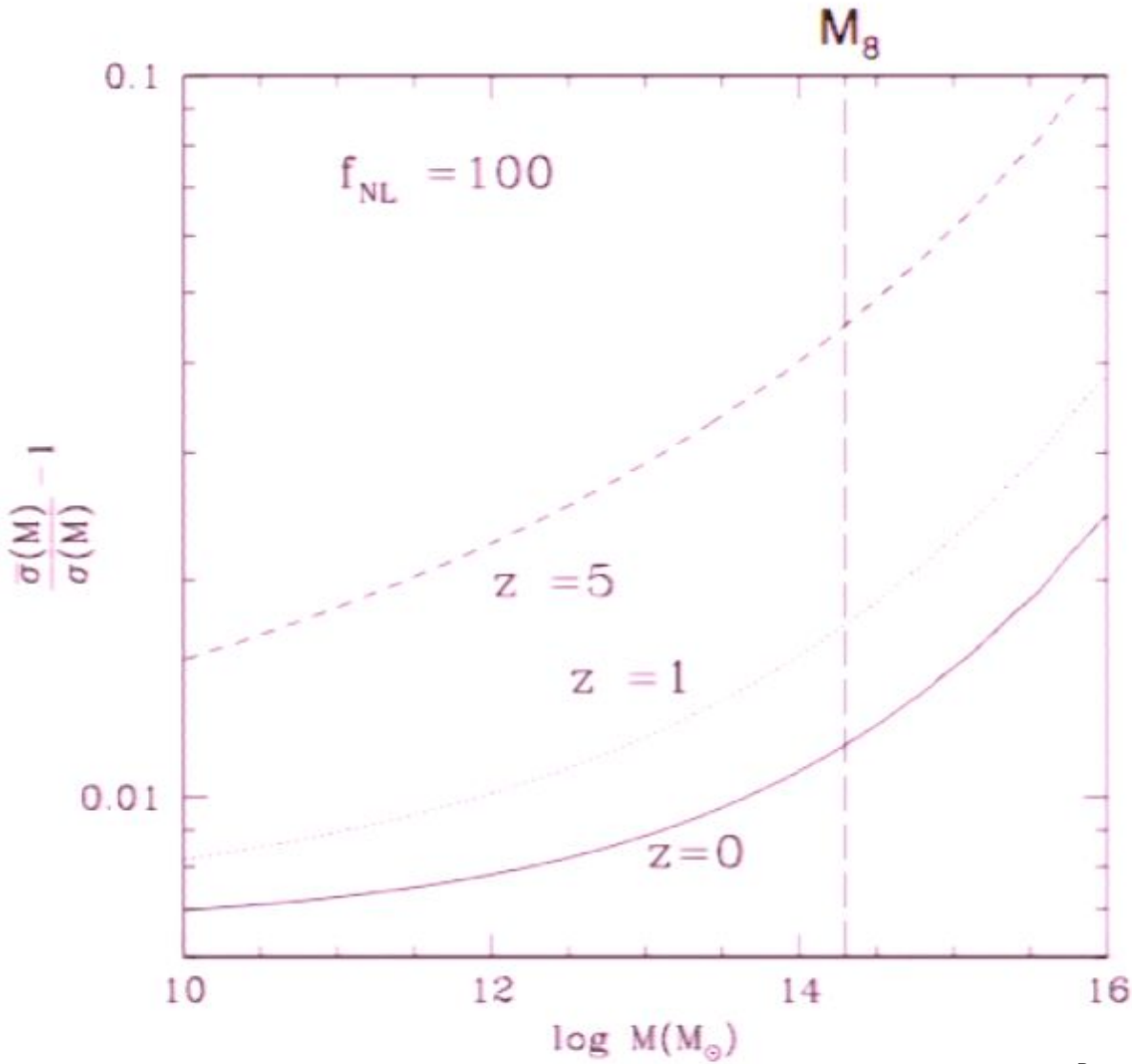
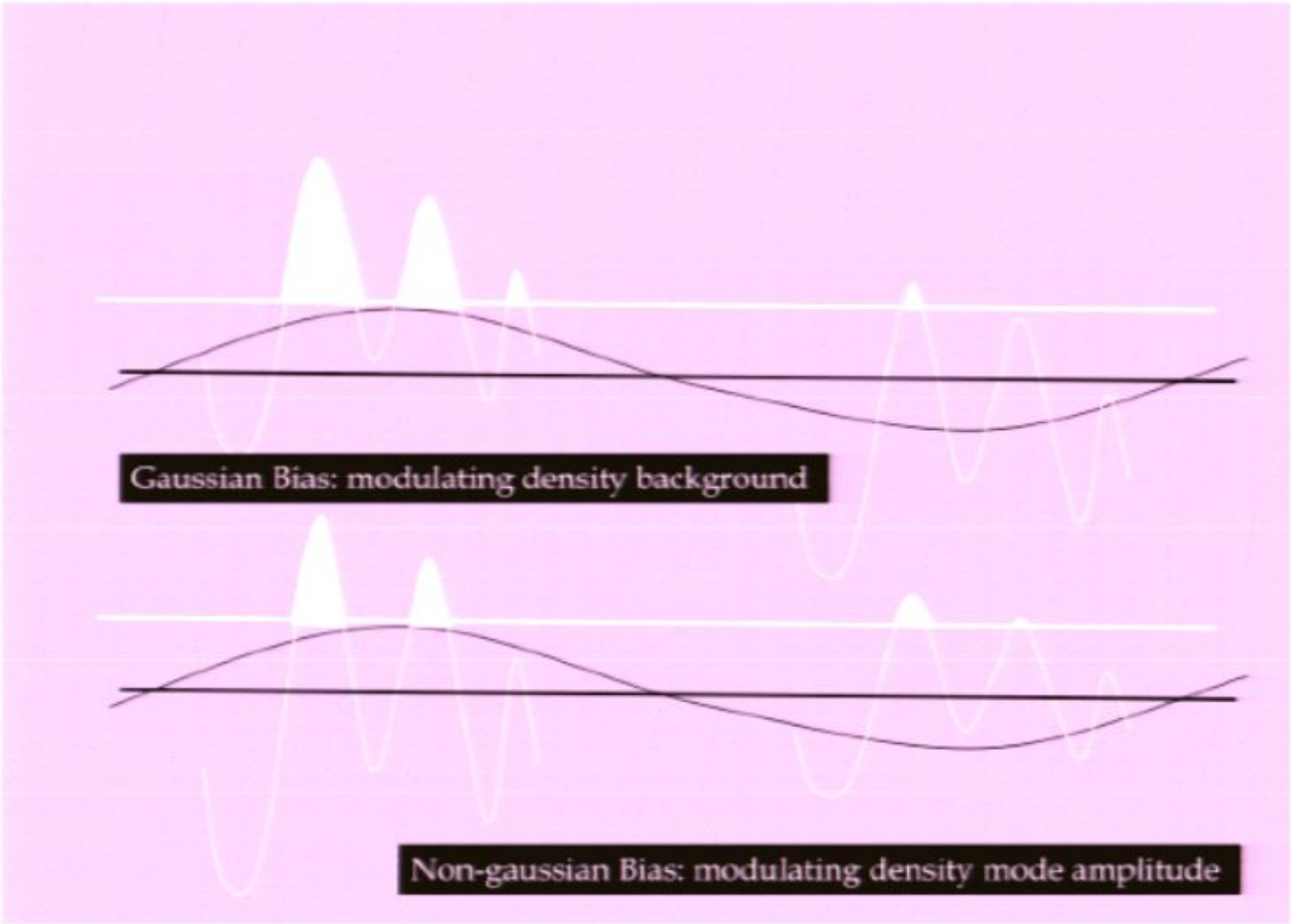
Resulting change in effective sigma

e.g. for f_{NL} = 100



Afshordi & Tolley 2008

Resulting change in clustering

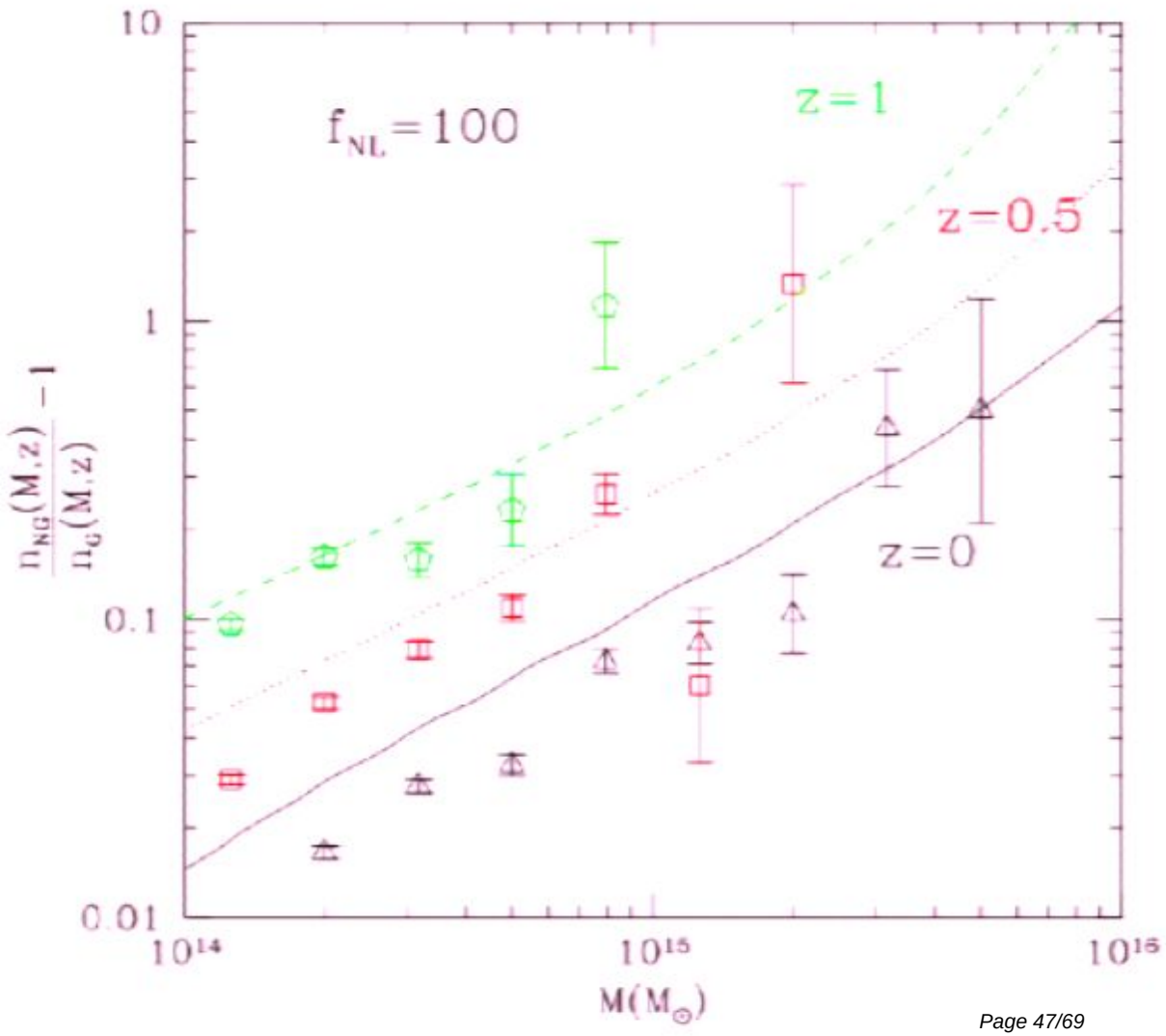


Afshordi & Tolley 2008 - see also work by Dalal et al.

Cluster abundance

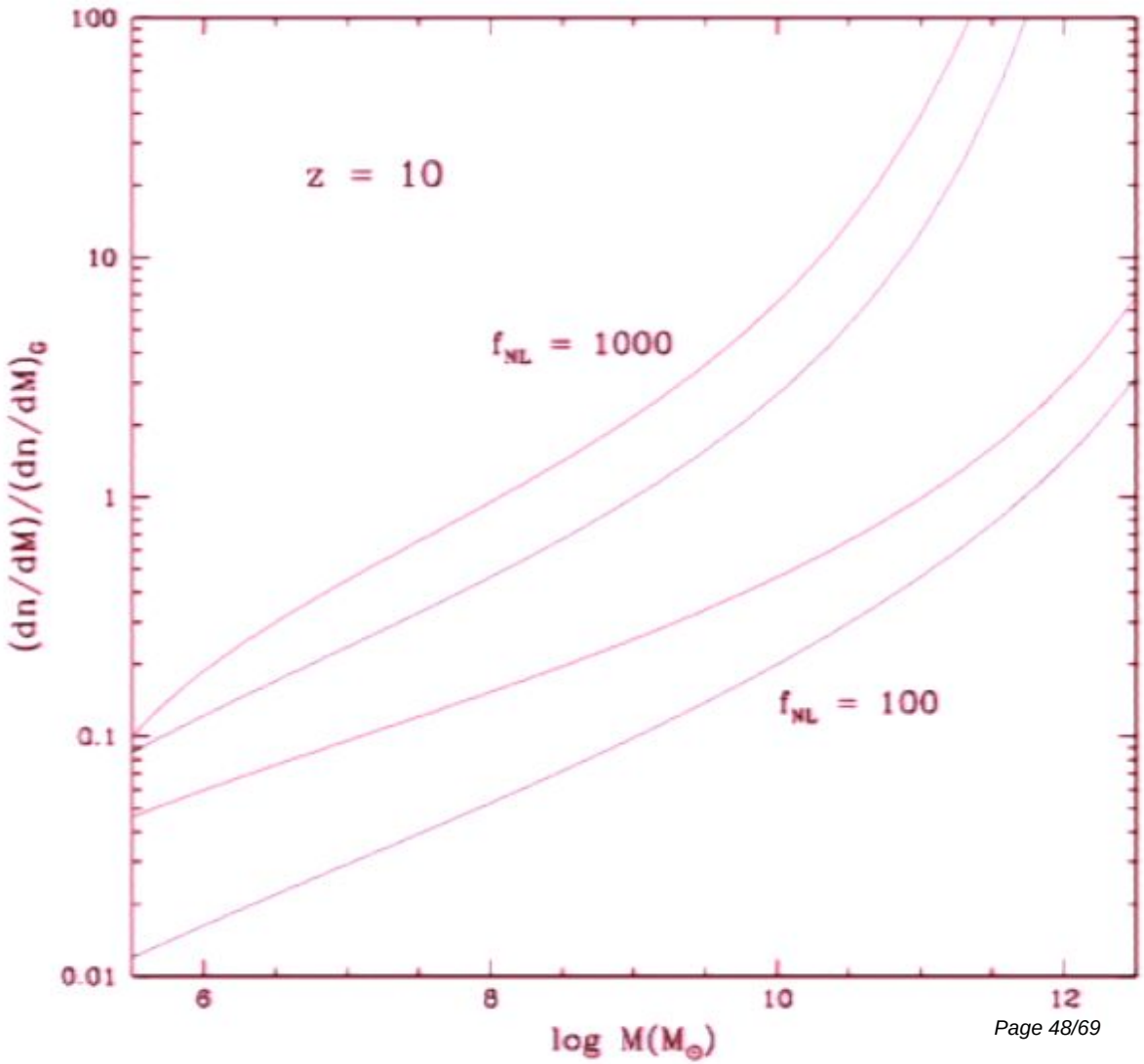
* Can get large relative changes, because of sensitivity to high peaks

* But these objects are rare



Afshordi & Tolley 2008 - points from Dalal et al. 2008

Halo abundances



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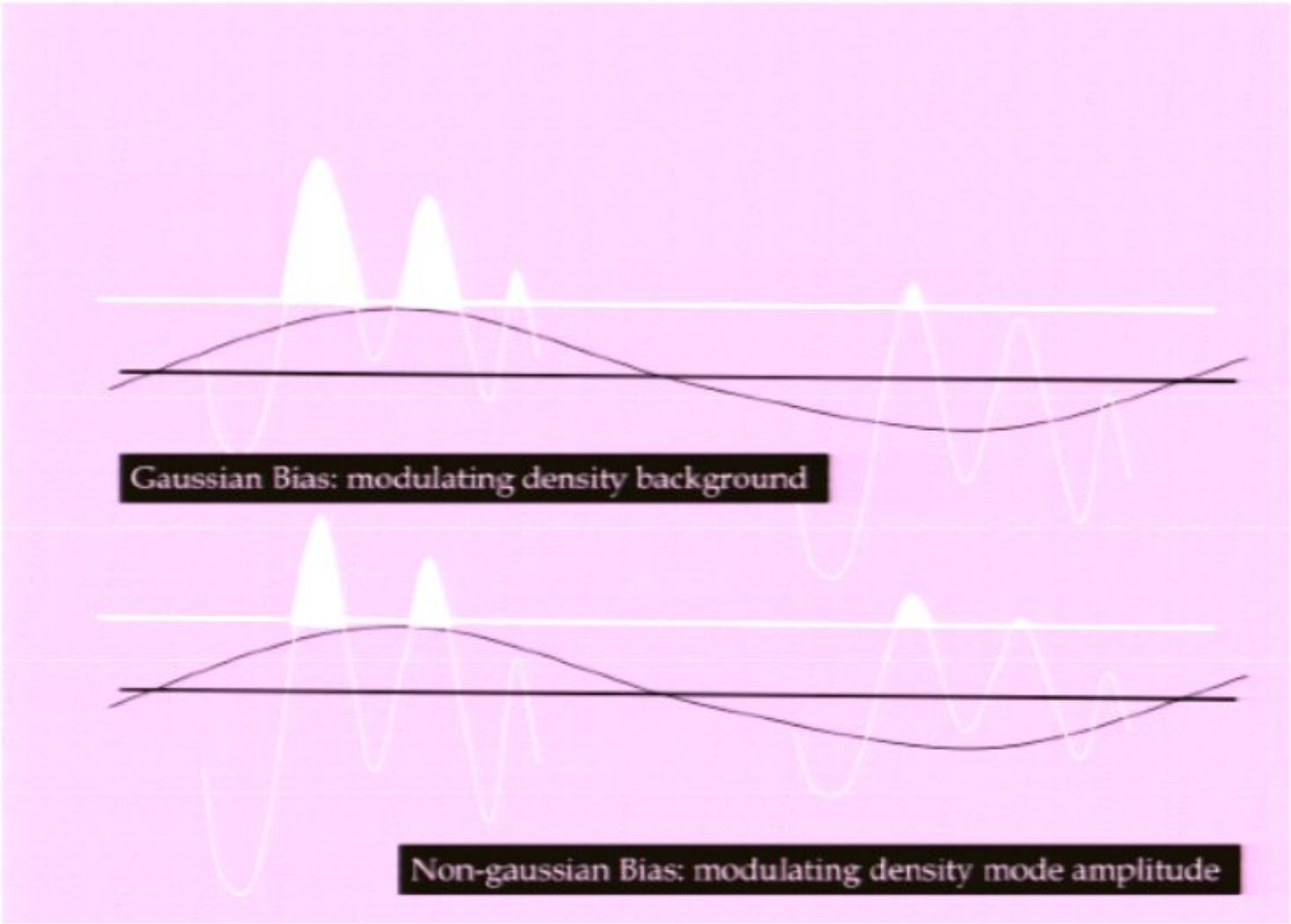

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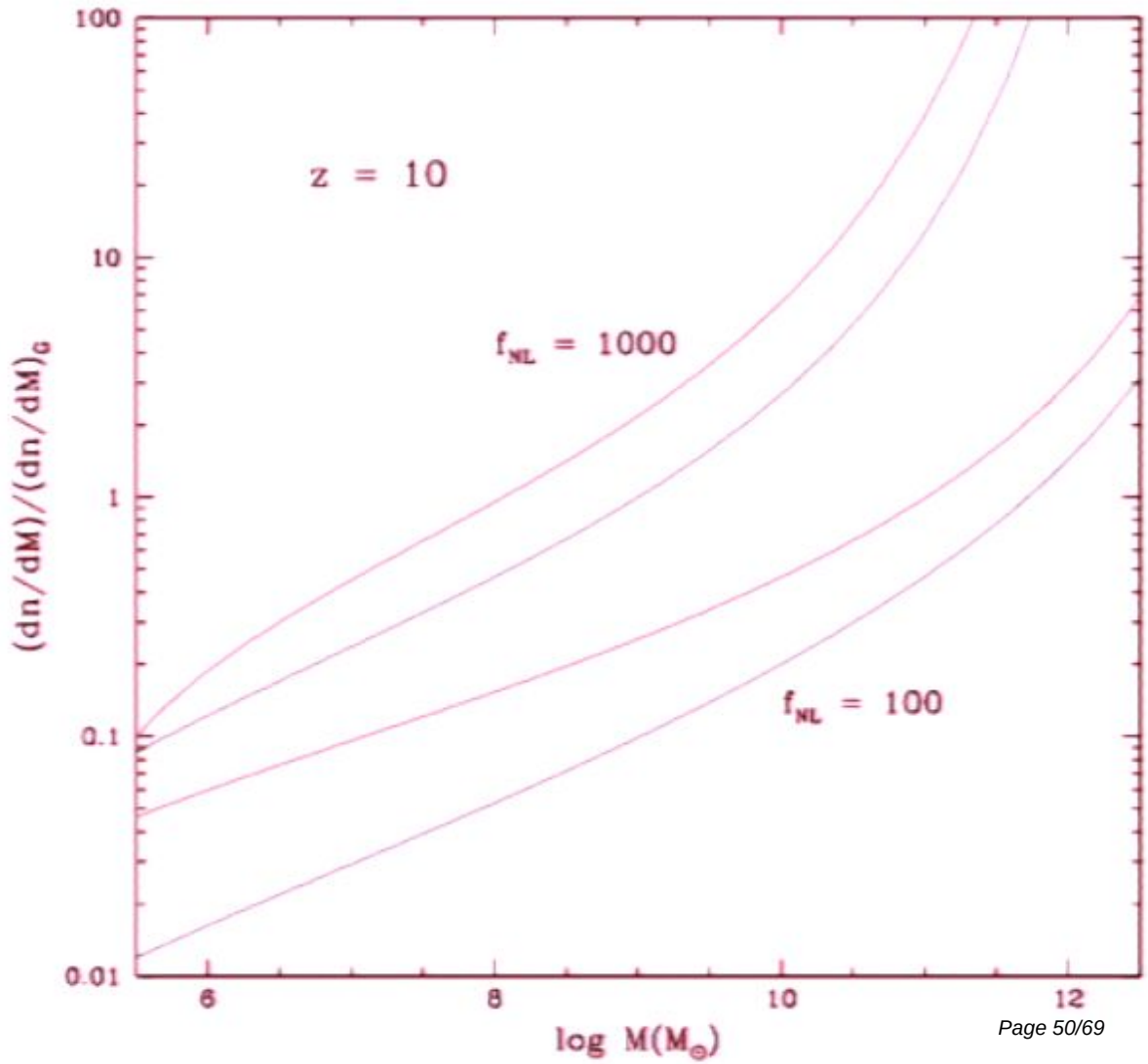
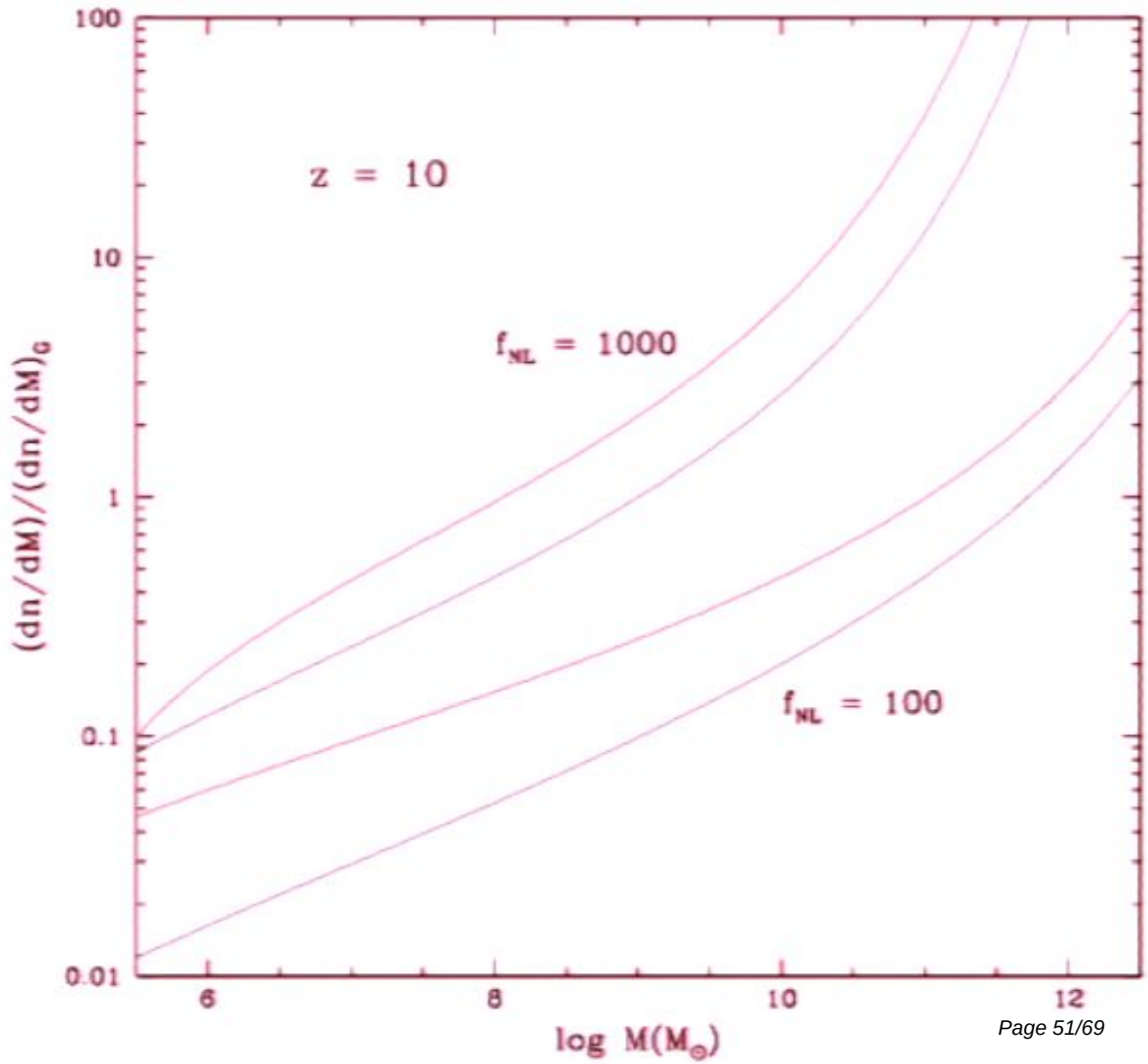


Halo abundances

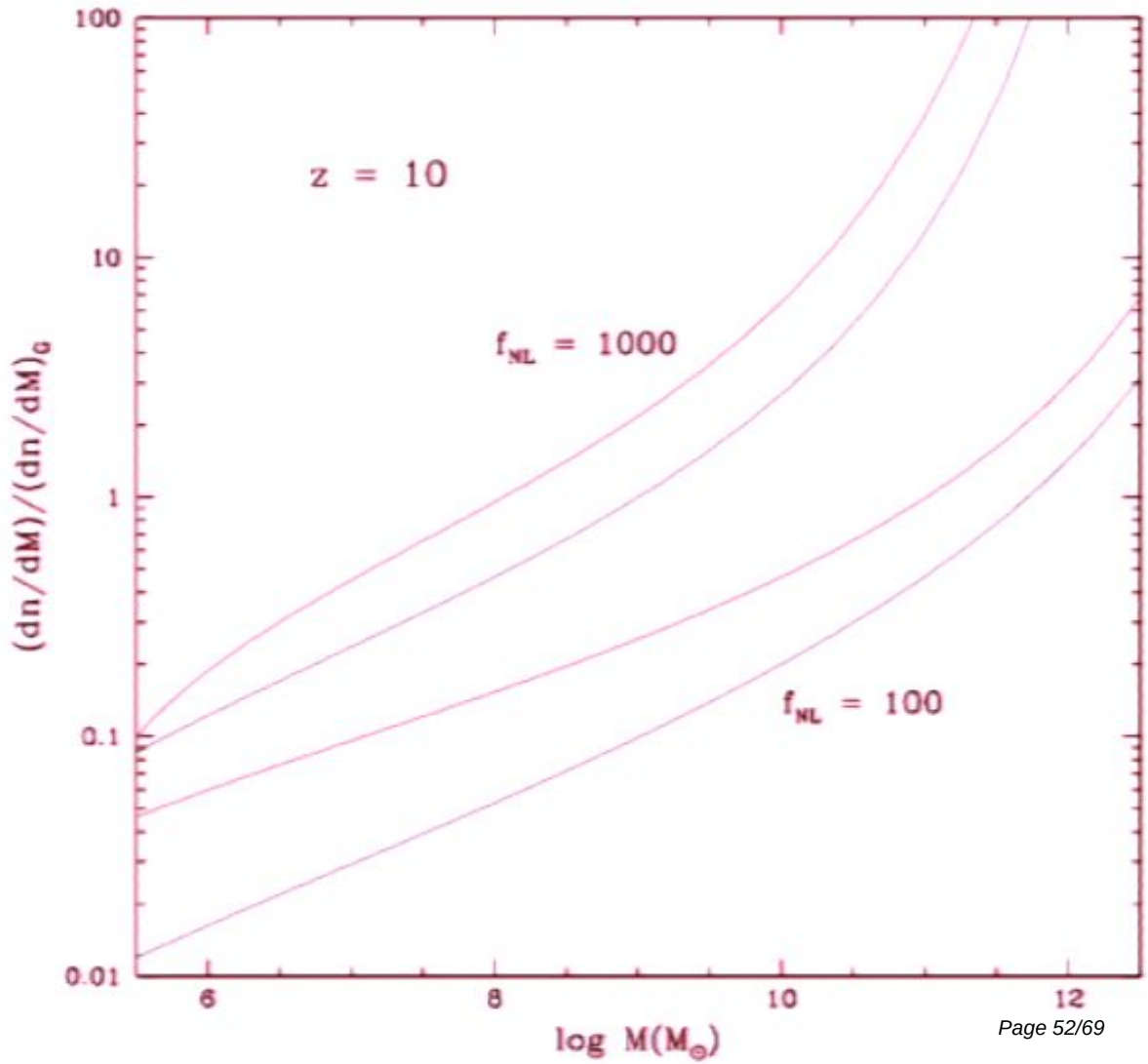
* Where are rare peaks important?



Halo abundances

* Where are rare peaks important?

e.g. high-z galaxies



Halo abundances

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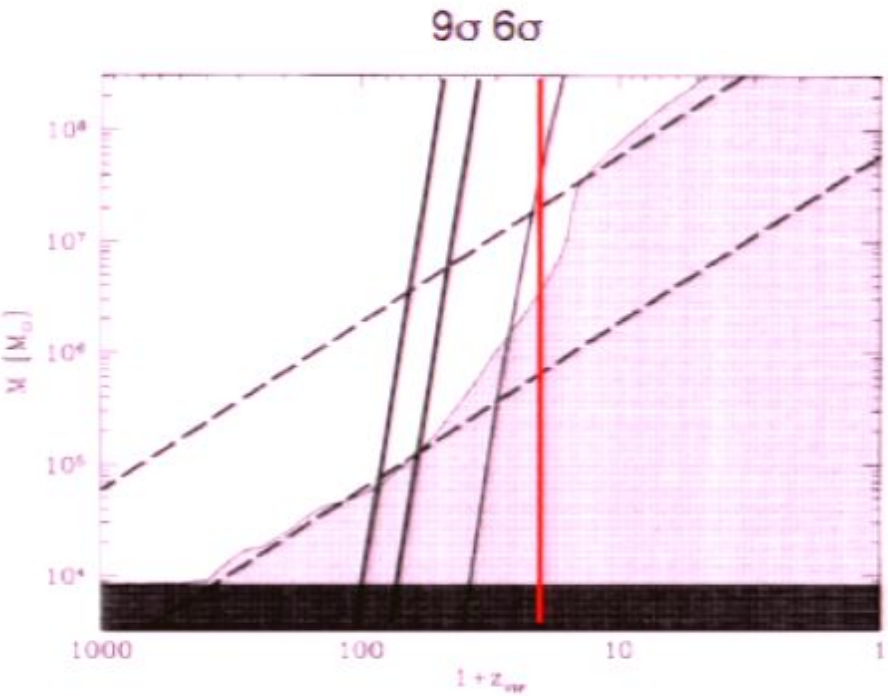
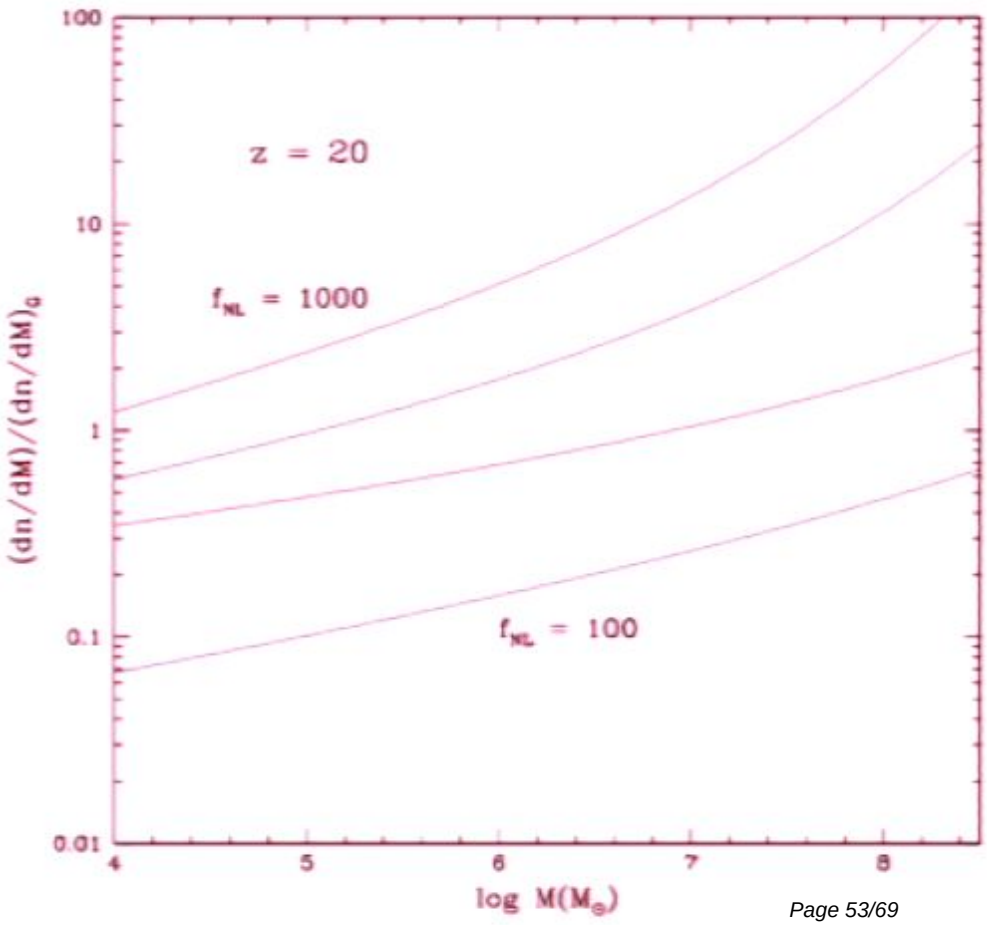
first stars



Tegmark et al. 2007



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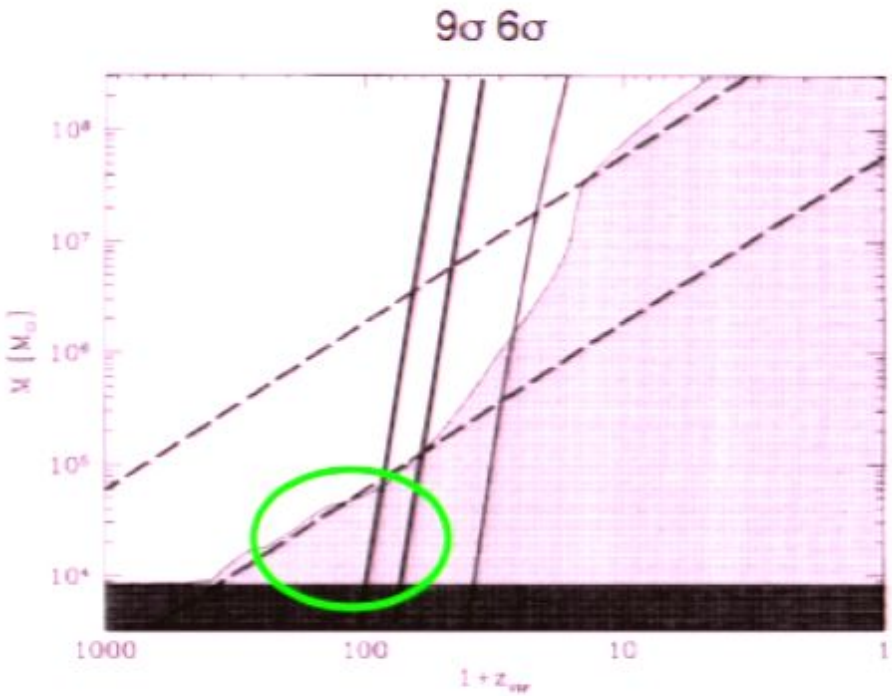

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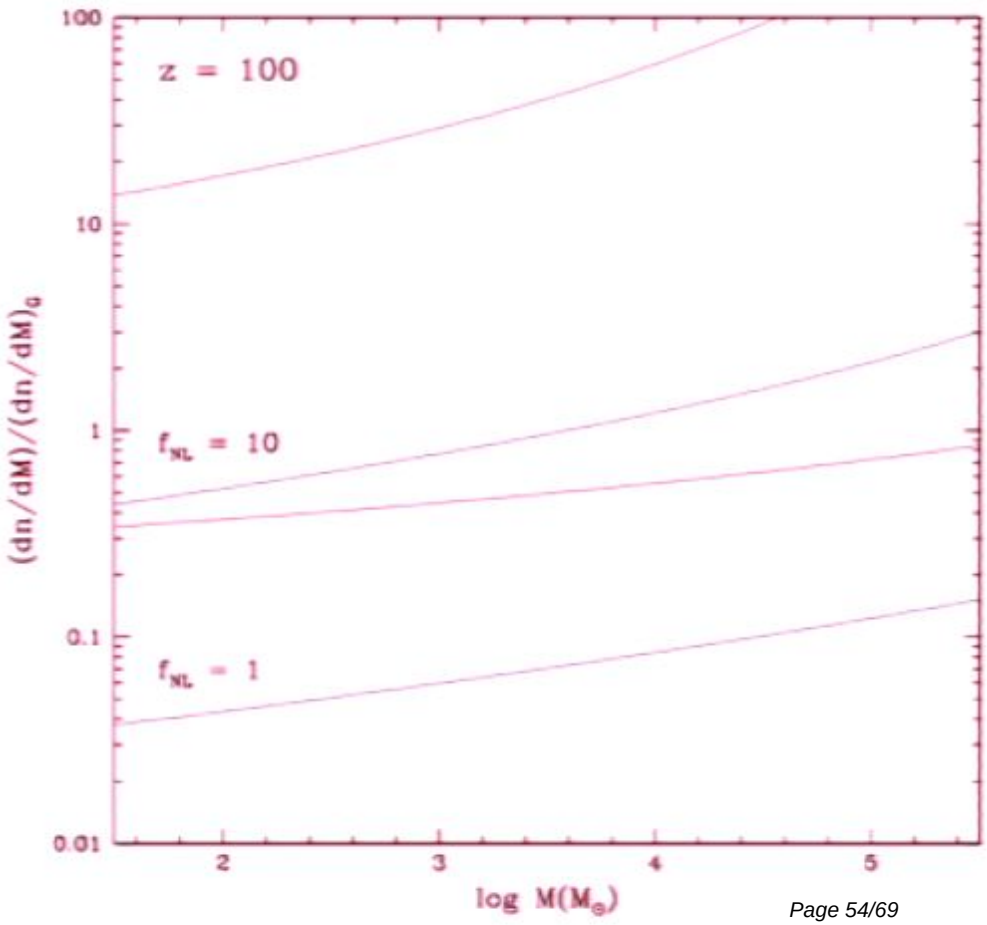

Halo abundances

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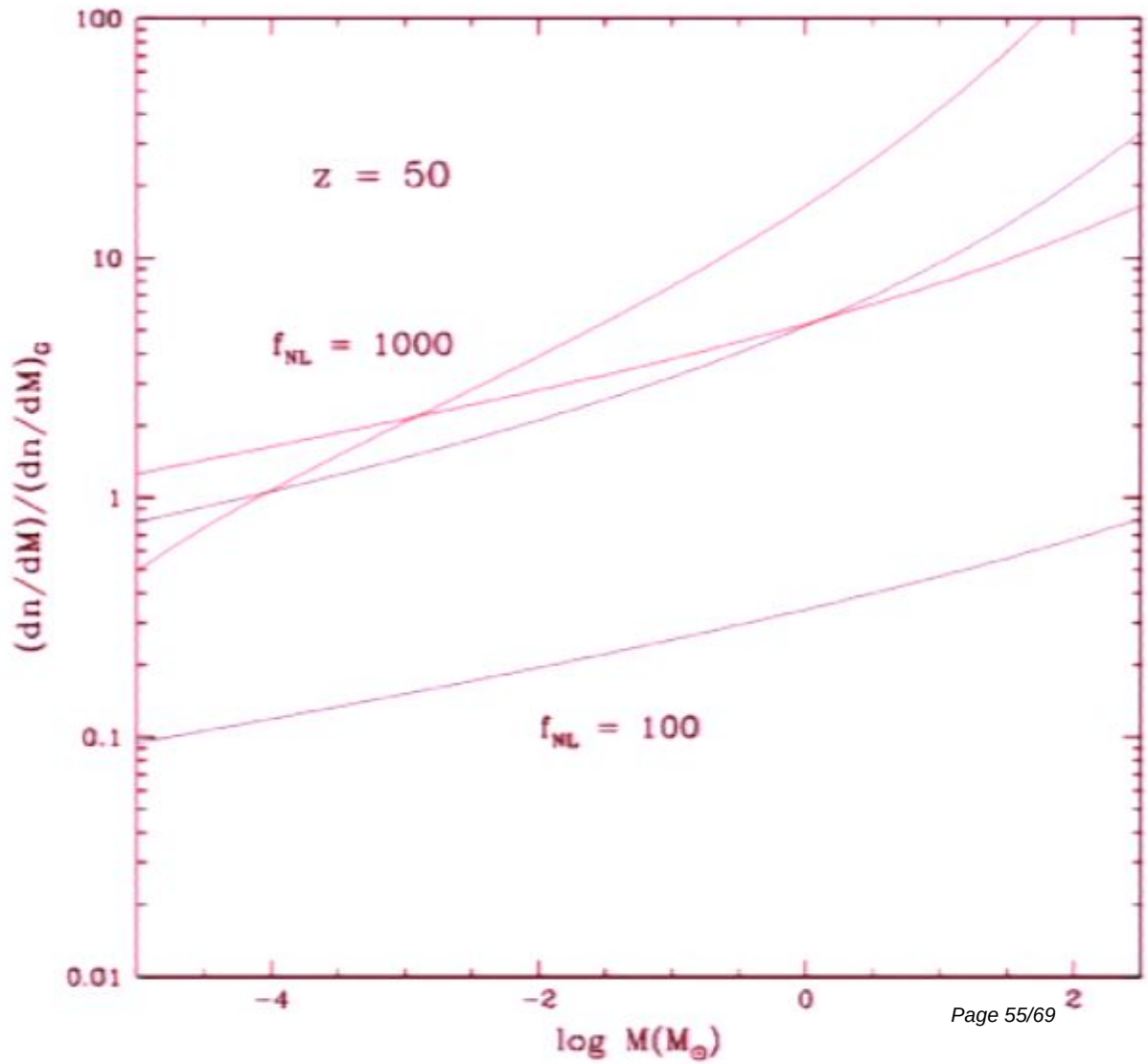
dark matter microhalos?



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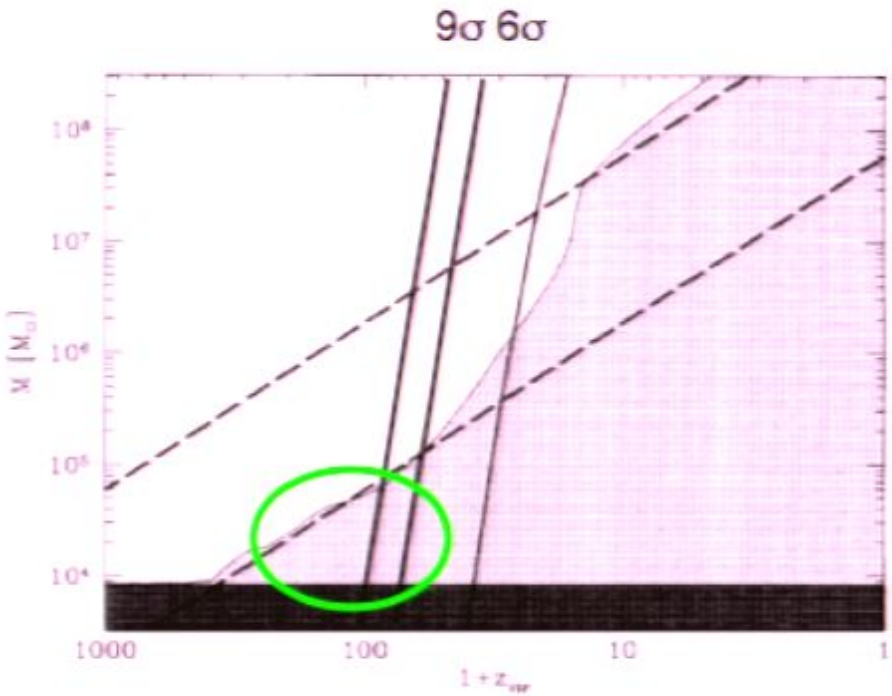

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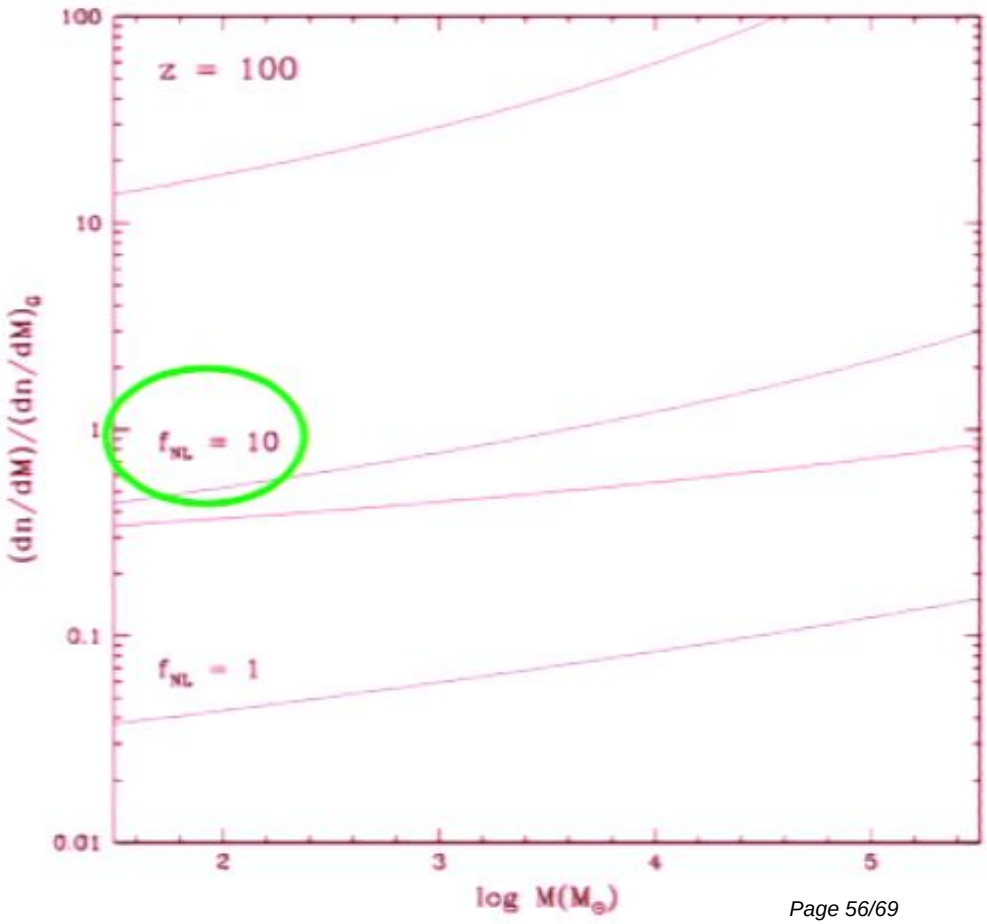

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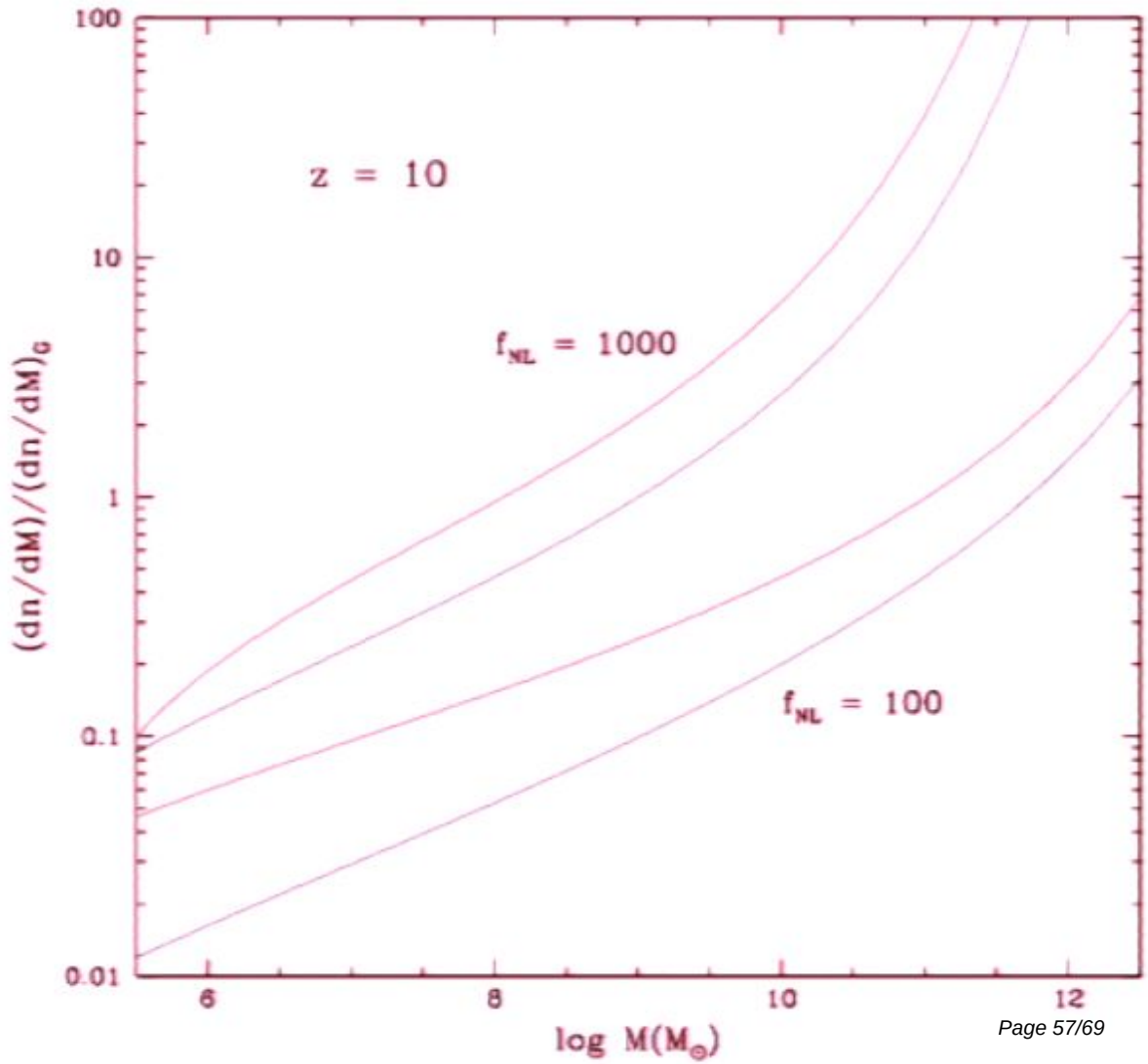

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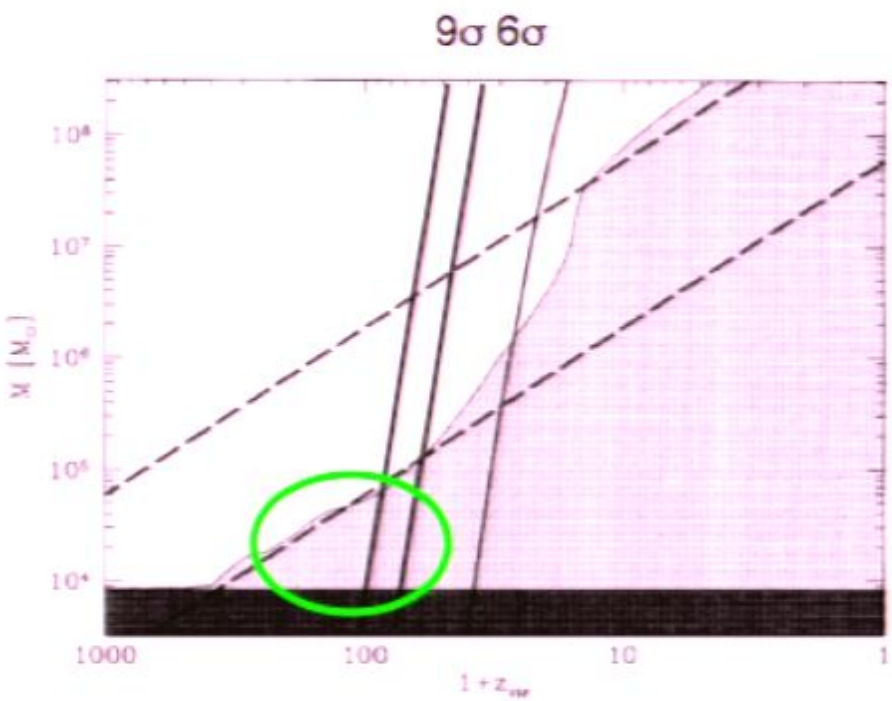

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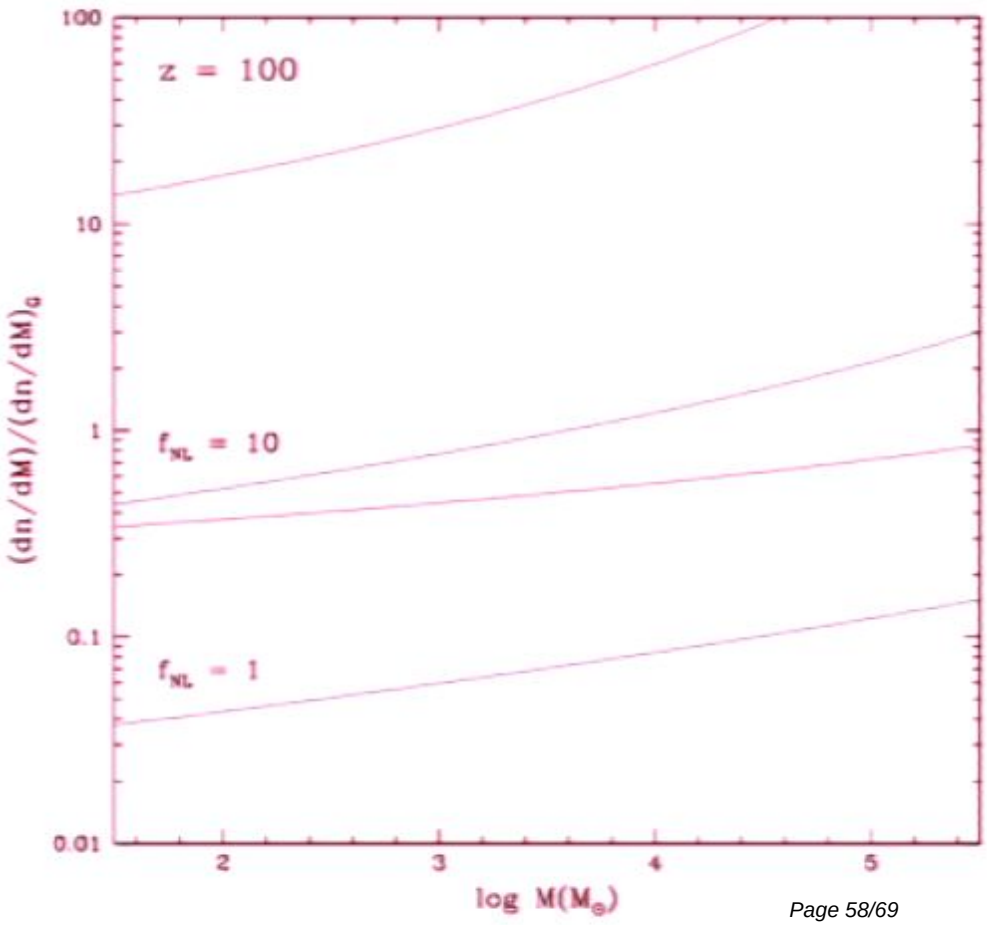
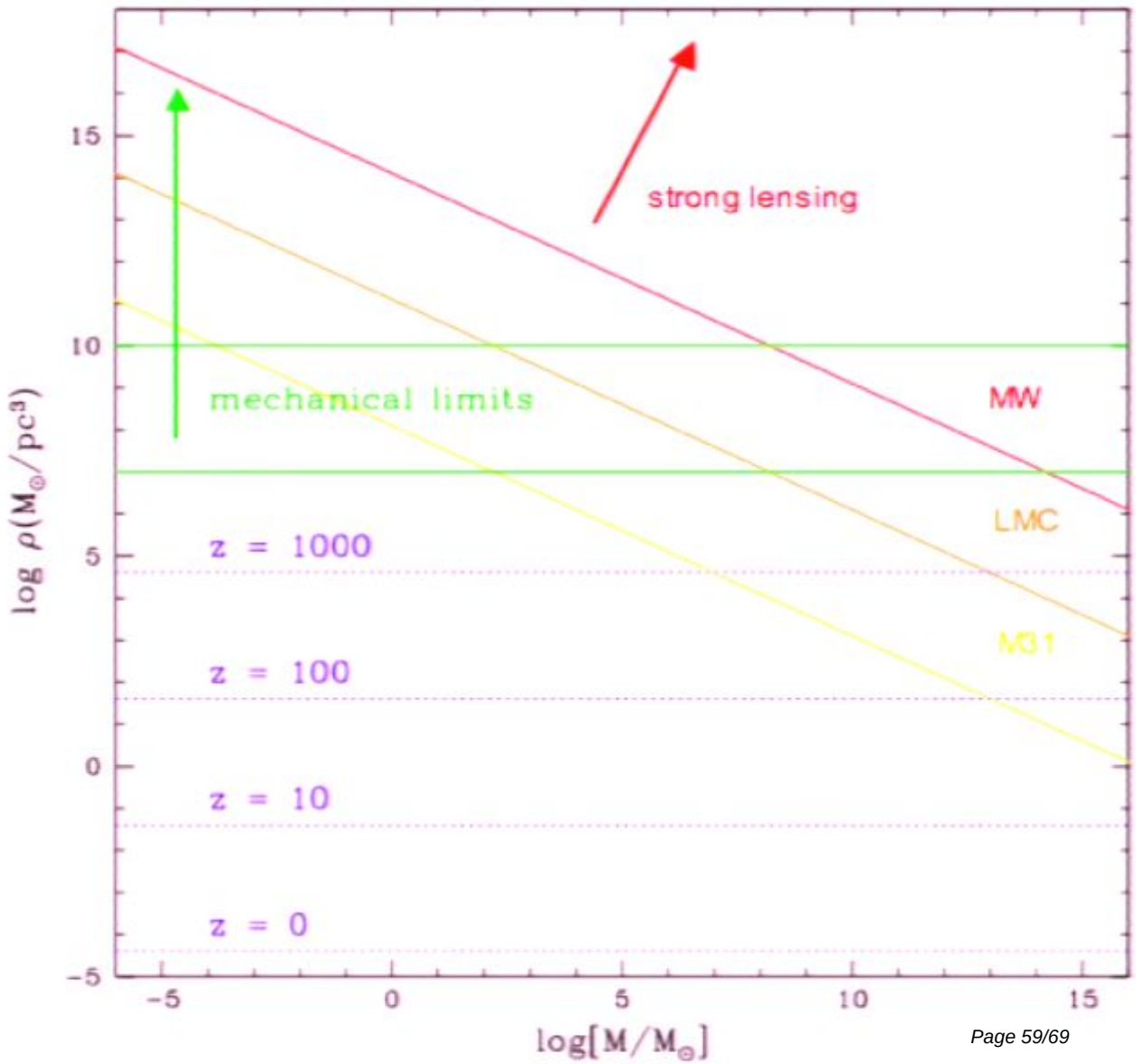


Halo abundances

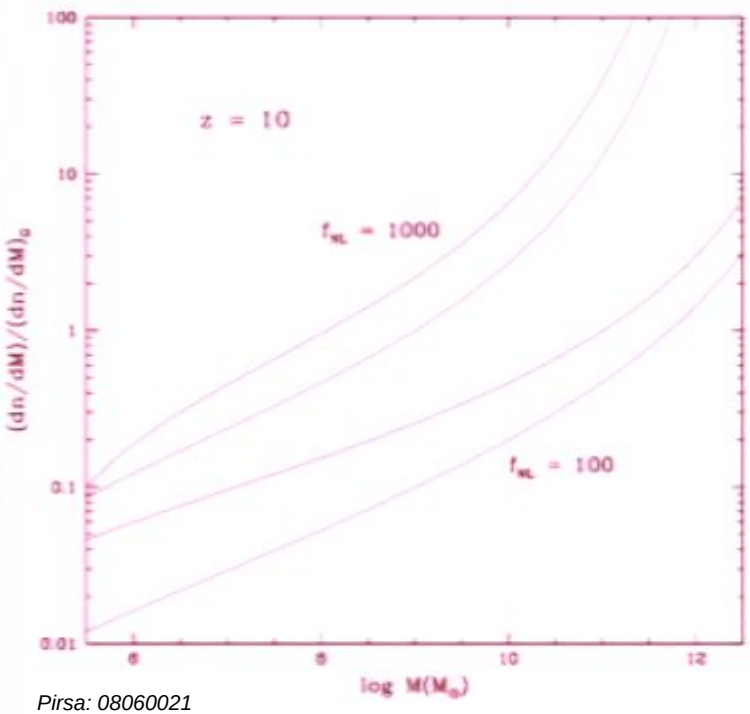
Unfortunately, no interesting lensing or mechanical constraints on the microscale…



N.B.: Clustering: the degeneracy-breaker

* How do we tell f_{NL} from changes in n_s or similar?

Number



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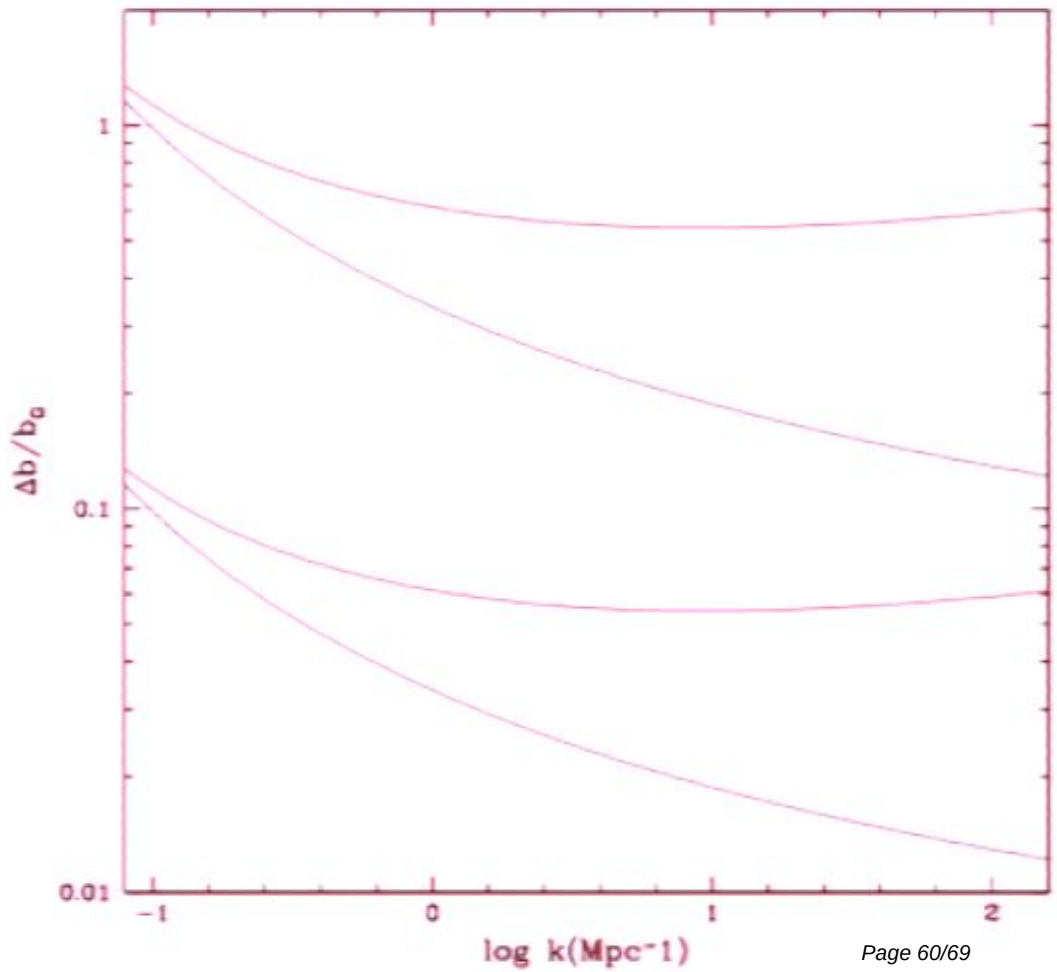

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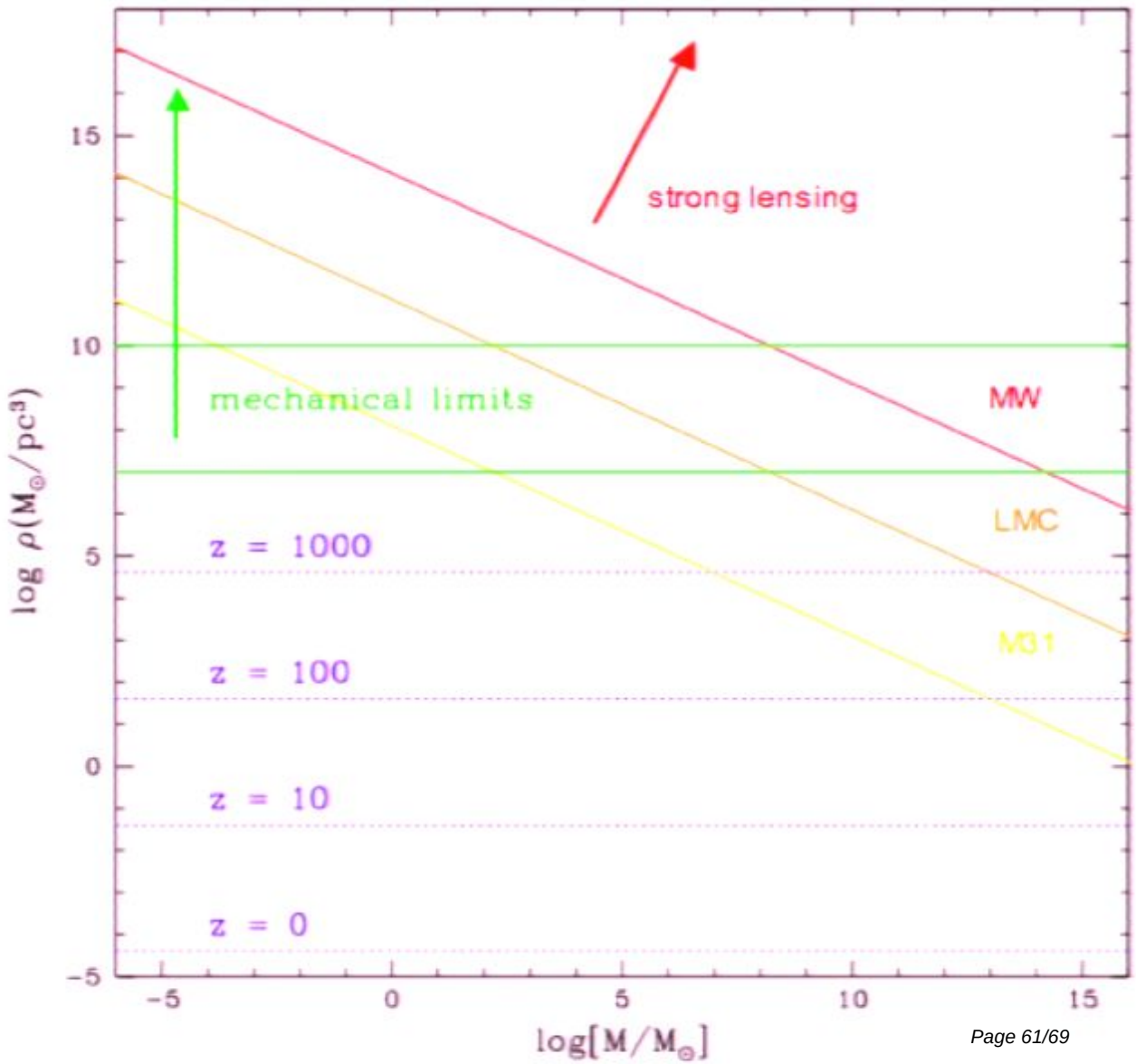

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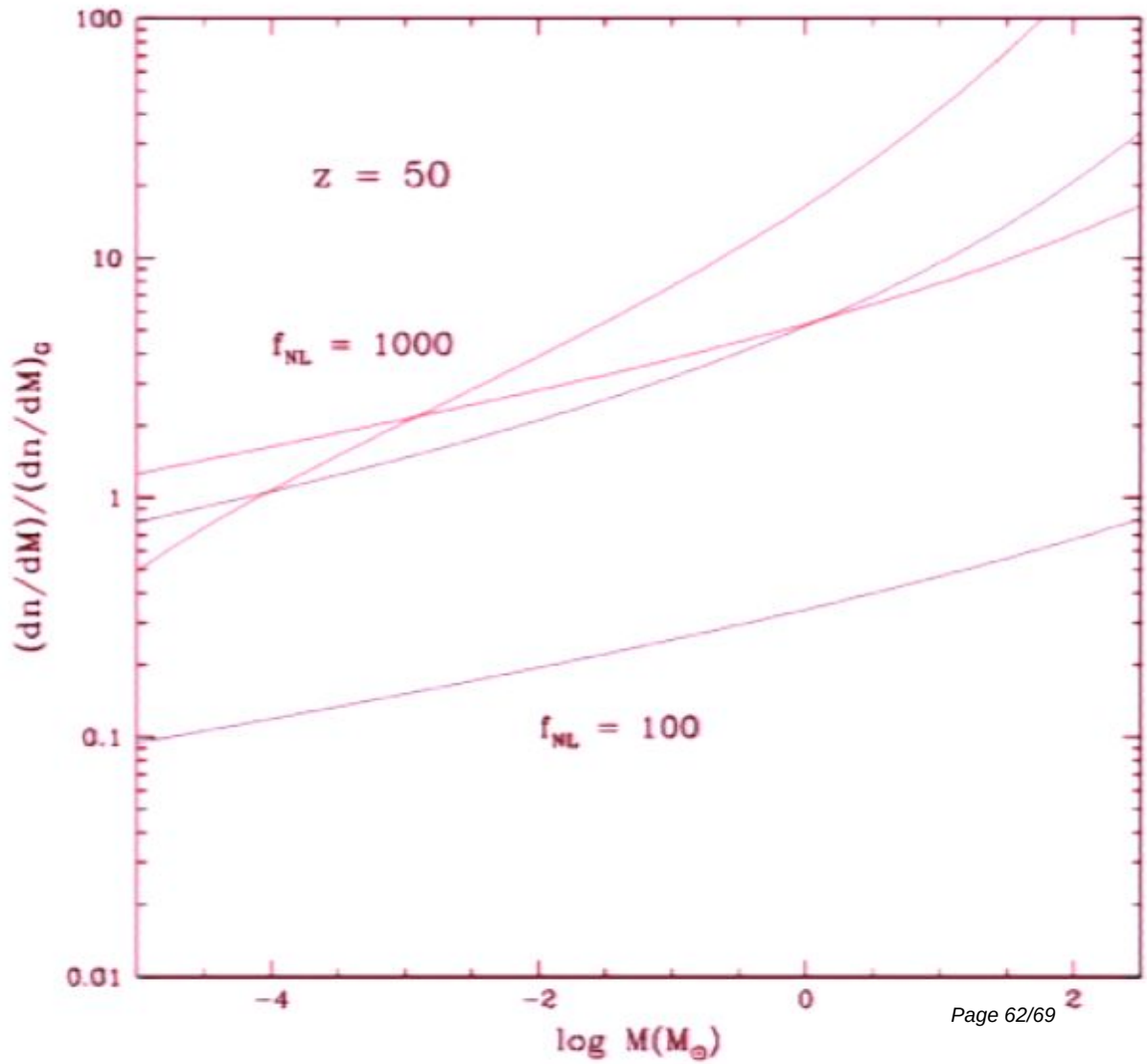
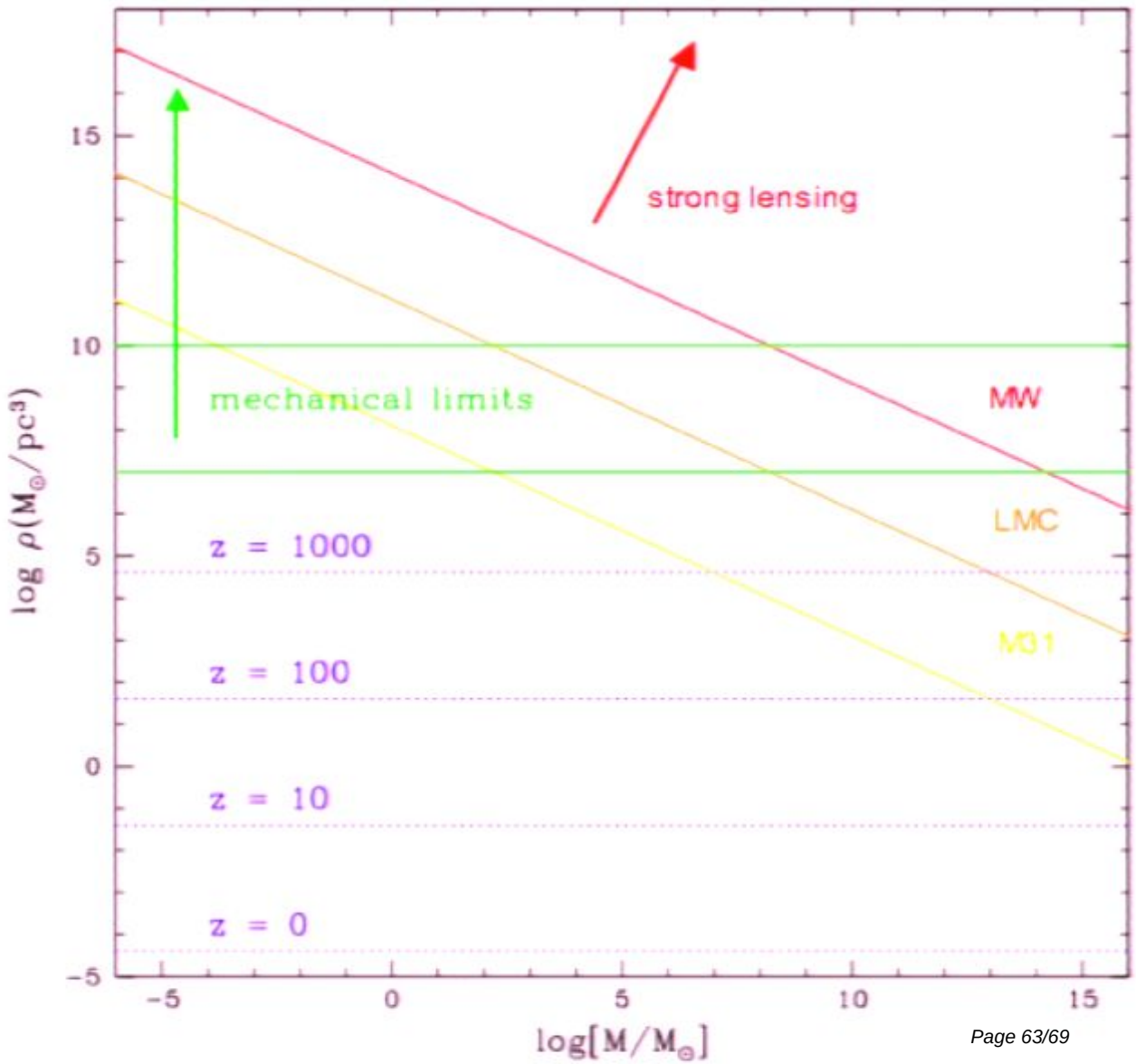
dark matter microhalos?



Halo abundances

Unfortunately, no interesting lensing or mechanical constraints on the microscale…



Summary

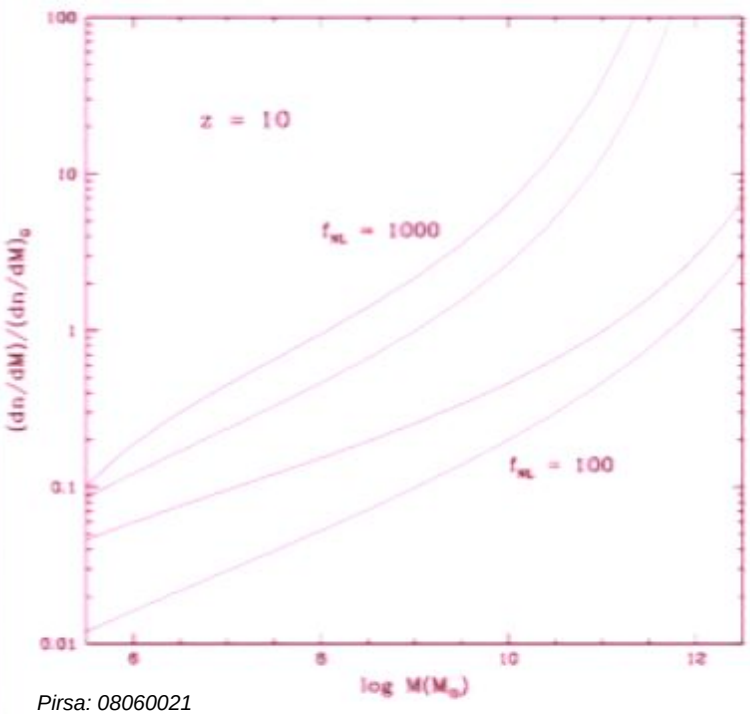
- Non-zero f_{NL} is definitely worth checking for.
- While slightly baroque, scale-dependent f_{NL} has been suggested.
- Lots of interesting effects/constraints on small scales.
- Yet another reason to nail down the calculations on these scales.

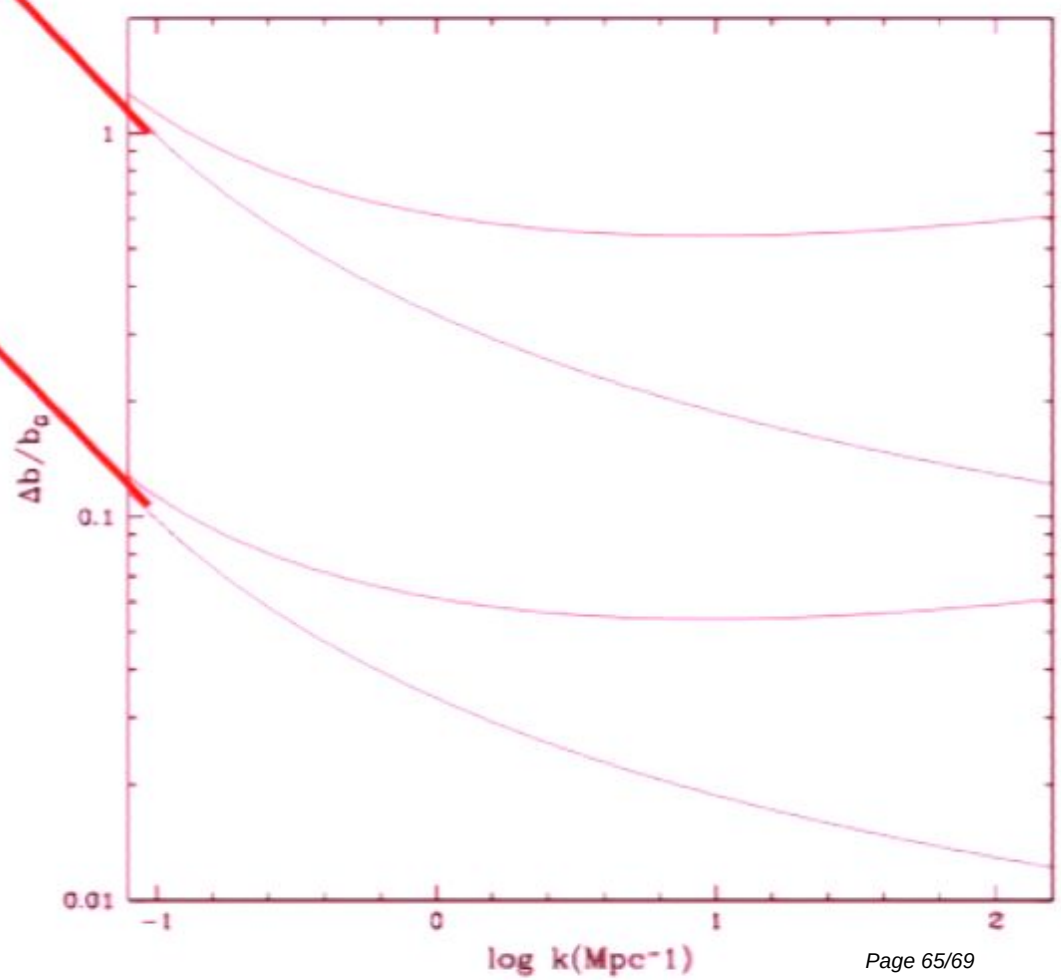
N.B.: Clustering: the degeneracy-breaker

* How do we tell f_{NL} from changes in n_s or similar?

Clustering

Number





Summary

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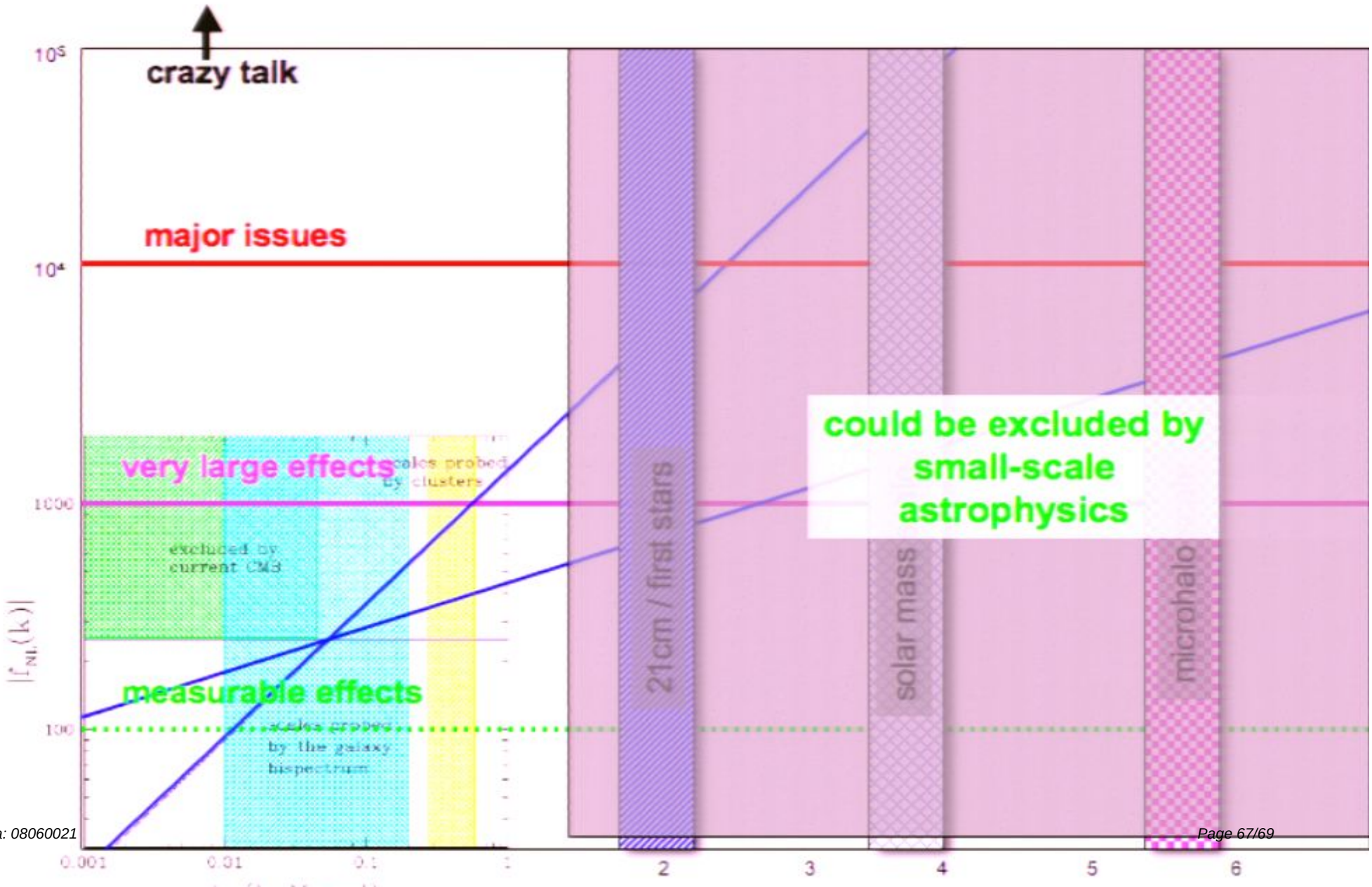
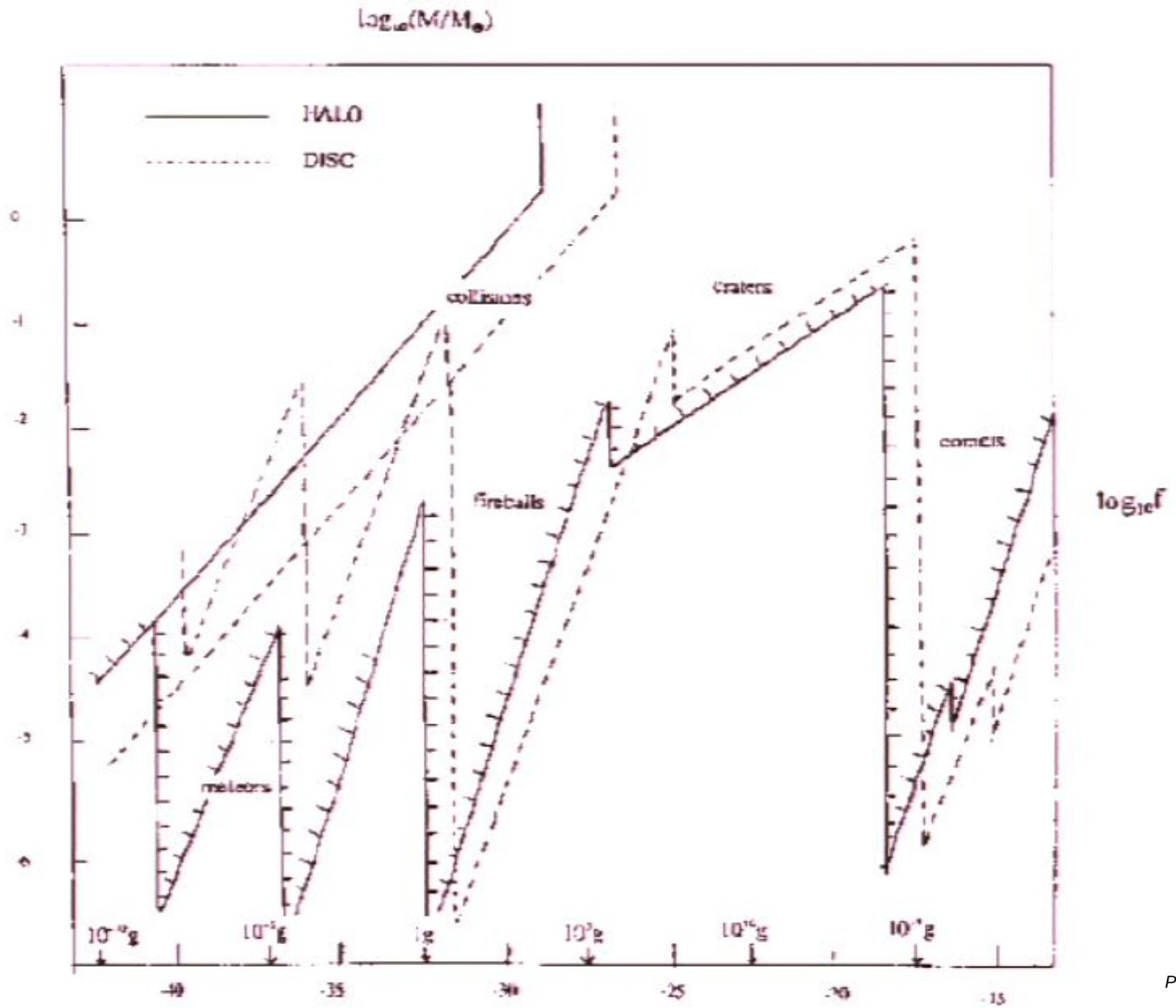
Scale-dependent non-Gaussianity



Carr & Sakellariadou 1999



Discussion

- What have we done?
  - what can we agree on, what scales/techniques are understood, what progress have we made in the past 5 years?

  e.g. microhalo abundance, dwarf velocity dispersions, first stars

- What should we be doing?
  - predictions for GLAST? The first stars? Local dwarfs?
  - What is our role?

- How should we be doing it?
  - many complex modelling efforts by individuals; is there call for more collective work on methods, e.g. code comparisons etc.?

- What data will be available in the short term? What effect will it have?
  - will GLAST really produce a detection? if so, when? what about LHC?

- What comes after that experimentally?
  - is there any way forward if GLAST fails? if it succeeds?