Title: Constraints on scale dependent non-Gaussianity

Date: Oct 30, 2007 02:00 PM

URL: http://pirsa.org/07100004

Abstract: The detection of primordial non-Gaussianity could provide a powerful means to rule out various inflationary scenarios. Although scale-invariant non-Gaussianity is currently best constrained by the Cosmic Microwave Background, single-field inflation models with changing sound speed can have strongly scale dependent non-Gaussianity. I will discuss the theoretical motivation for such models and present work on the likely ability of current and future large scale structure measurements to constrain them.

SCALE-DEPENDENT NON-GAUSSIANITY

Sarah Shandera
Columbia University

Based on work with Marilena LoVerde, Amber Miller, Licia Verde (arXiv:0711:xxxx)

PI, Oct. 30, 2007

Is there a useful discriminating feature of inflation models?

- or -

Can string theory suggest cosmologically interesting ideas?

- or -

Could there be a *distinctive* signature of string theory in inflation?

GOALS:

I. Why non-Gaussianity?

II. Why scale-dependence? (DBI, general sound speed)

III. Observations: Galaxy Clusters

IV. Observations: Dark matter (galaxy) Bispectrum

PI, Oct. 30, 2007

I. WHY (AND WHAT) NON-GAUSSIANITY

USUAL INFLATIONARY OBSERVABLES

- COBE normalization
- Spectral index + running
- Tensor/scalar ratio
- Tensor index (+ running)

$\rightarrow V(\phi)$ + derivatives

(at some scale k_0)

"RECONSTRUCTING" THE POTENTIAL DOES NOT GIVE A UNIQUE ANSWER (EASTHER, KINNEY, PEIRIS E.G.)

THE 3-POINT FUNCTION: MORE INFORMATION

- A simple ansatz (local model):

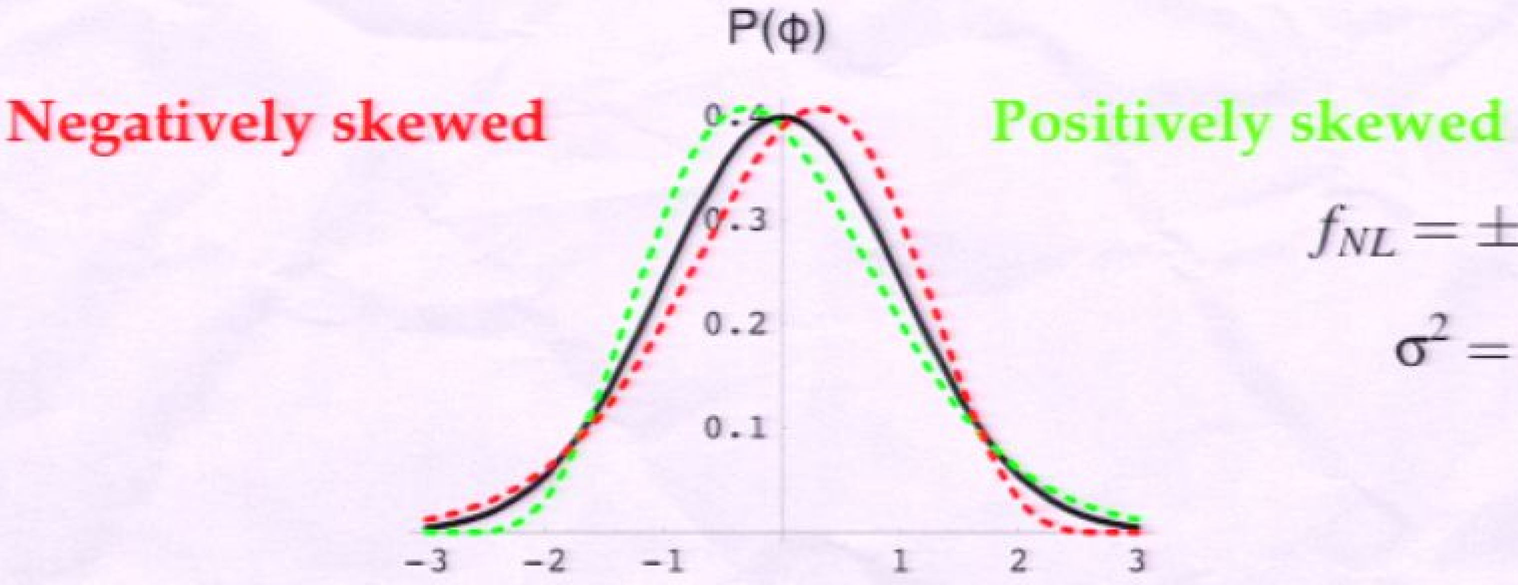
$$\boxed{\zeta(x) = \zeta_g(x) + f_{NL}\left[\zeta_g^2(x) - \langle\zeta_g^2(x)\rangle\right]}$$

- Then in Fourier space:

$$\begin{aligned}\langle\zeta_{NG}(k_1)\zeta_{NG}(k_2)\rangle &= \langle\zeta_G(k_1)\zeta_G(k_2)\rangle + O(f_{NL}^2)\\ &\approx (2\pi)^3\delta(k_1+k_2)\frac{2\pi^2\mathcal{P}^{\zeta_G}(k)}{k^3}\end{aligned}$$

$$\begin{aligned}\langle\zeta_{NG}(k_1)\zeta_{NG}(k_2)\zeta_{NG}(k_3)\rangle = f_{NL}\frac{(2\pi)^7}{2}\delta^3(k_1+k_2+k_3)\left(\frac{\mathcal{P}^{\zeta_G}(k_1)\mathcal{P}^{\zeta_G}(k_2)}{k_1^3k_2^3}+\text{perm.}\right)\\ +O(f_{NL}^3)\end{aligned}$$

PHYSICALLY (LOCAL MODEL)...



$f_{NL} = \pm 0.1$

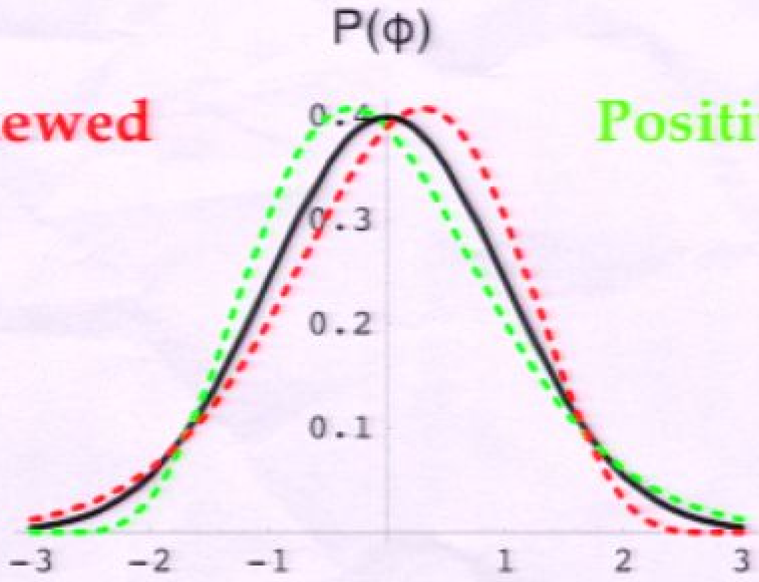
$\sigma^2 = 1$

$k^2\zeta = 4\pi G a^2 \delta\rho.$

$+f_{NL}$=more clusters

PI, Oct. 30, 2007

PHYSICALLY (LOCAL MODEL)...



Negatively skewed

Positively skewed

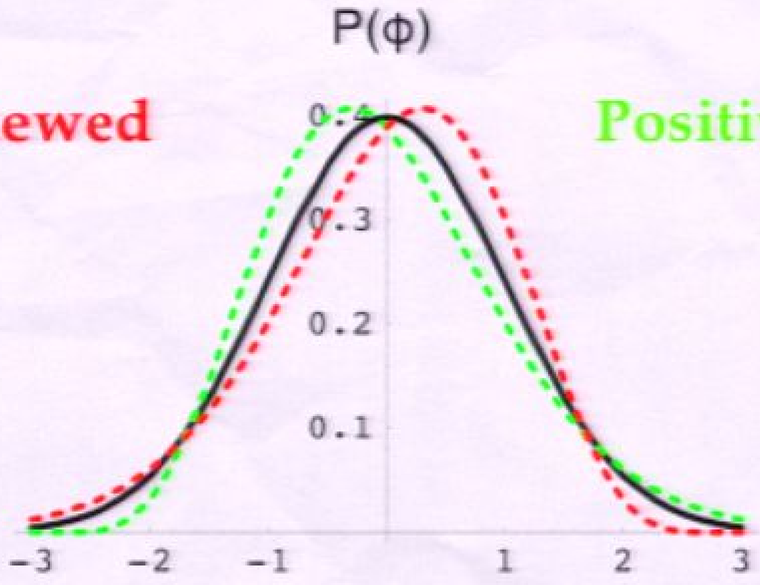
$$f_{NL} = \pm 0.1$$

$$\sigma^2 = 1$$

$$k^2\zeta = 4\pi G a^2 \delta\rho.$$

+f_{NL}=more clusters

PHYSICALLY (LOCAL MODEL)...



Negatively skewed

Positively skewed

$$f_{NL} = \pm 0.1$$

$$\sigma^2 = 1$$

$$k^2\zeta = 4\pi G a^2 \delta\rho.$$

$+f_{NL}$=more clusters

PI, Oct. 30, 2007

MORE GENERALLY...

- For a fundamental inflaton, we know its interactions

$$S = \frac{1}{2}\int d^4x\sqrt{-g}\,[M_p^2 R - 2P(X,\phi)]$$

$$X = -\frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi$$

$$3M_p^2H^2 = E$$

$$E = 2XP_{,X} - P$$

$$c_s^2 = \frac{P_{,X}}{E_{,X}} = \frac{P_{,X}}{P_{,X} + 2XP_{,XX}}$$

(Armendariz-Picon, Damour, Garriga, Mukhanov)

THE 3-POINT FUNCTION: MORE INFORMATION

- A simple ansatz (local model):

$$\zeta(x) = \zeta_g(x) + f_{NL}\left[\zeta_g^2(x) - \langle\zeta_g^2(x)\rangle\right]$$

- Then in Fourier space:

$$\begin{aligned}\langle\zeta_{NG}(k_1)\zeta_{NG}(k_2)\rangle &= \langle\zeta_G(k_1)\zeta_G(k_2)\rangle + O(f_{NL}^2)\\ &\approx (2\pi)^3\delta(k_1+k_2)\frac{2\pi^2\mathcal{P}^{\zeta_G}(k)}{k^3}\end{aligned}$$

$$\begin{aligned}\langle\zeta_{NG}(k_1)\zeta_{NG}(k_2)\zeta_{NG}(k_3)\rangle = f_{NL}\frac{(2\pi)^7}{2}\delta^3(k_1+k_2+k_3)\left(\frac{\mathcal{P}^{\zeta_G}(k_1)\mathcal{P}^{\zeta_G}(k_2)}{k_1^3k_2^3}+\text{perm.}\right)\\ +O(f_{NL}^3)\end{aligned}$$

PI, Oct. 30, 2007

MORE GENERALLY...

- For a fundamental inflaton, we know its interactions

$$S = \frac{1}{2}\int d^4x\sqrt{-g}\,[M_p^2 R - 2P(X,\phi)]$$

$$X = -\frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi$$

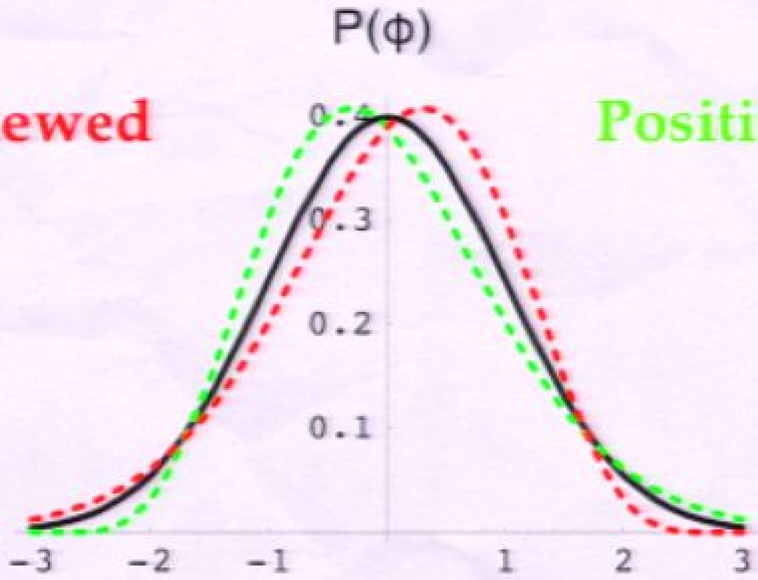
$$3M_p^2 H^2 = E$$

$$E = 2XP_{,X} - P$$

$$c_s^2 = \frac{P_{,X}}{E_{,X}} = \frac{P_{,X}}{P_{,X} + 2XP_{,XX}}$$

(ARMENDARIZ-PICON, DAMOUR, GARRIGA, MUKHANOV)

PHYSICALLY (LOCAL MODEL)...



Negatively skewed

Positively skewed

$$f_{NL} = \pm 0.1$$

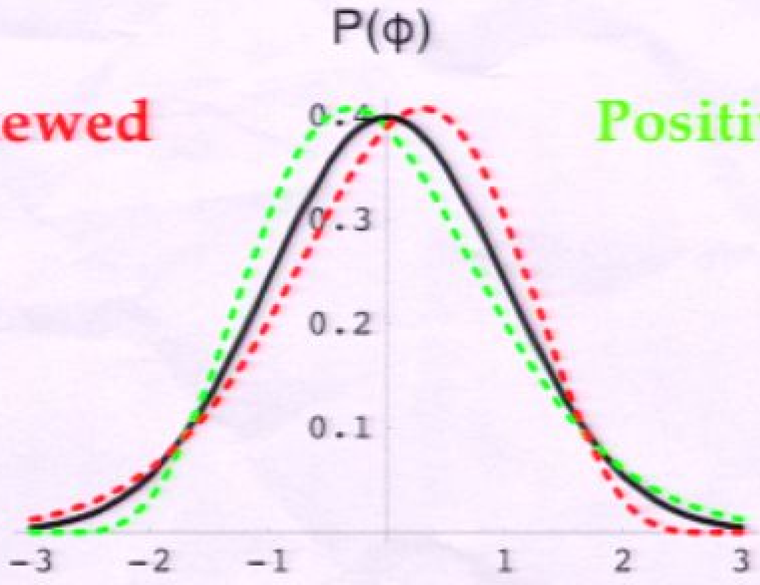
$$\sigma^2 = 1$$

$$k^2\zeta = 4\pi G a^2 \delta\rho.$$

$+f_{NL}$=more clusters

PHYSICALLY (LOCAL MODEL)...

Negatively skewed



Positively skewed

$f_{NL} = \pm 0.1$

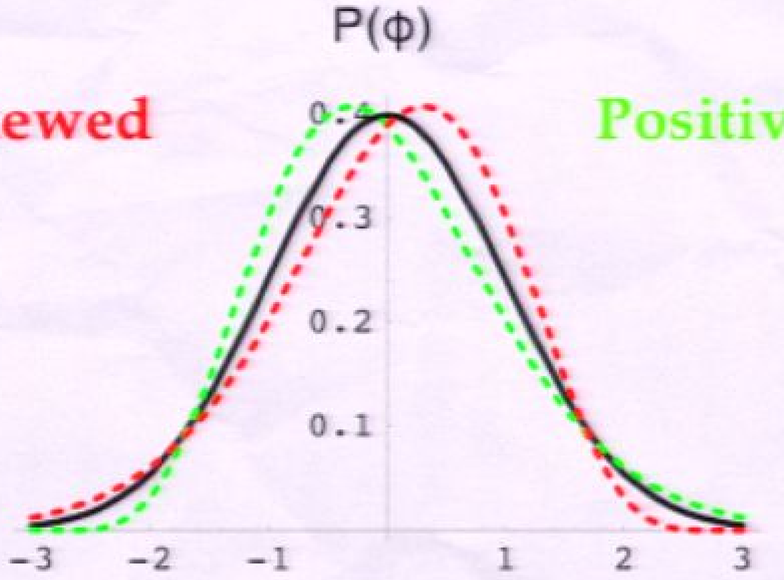
$\sigma^2 = 1$

$$k^2\zeta = 4\pi G a^2 \delta\rho.$$

$+f_{NL}$=more clusters

PI, Oct. 30, 2007

PHYSICALLY (LOCAL MODEL)...



Negatively skewed

Positively skewed

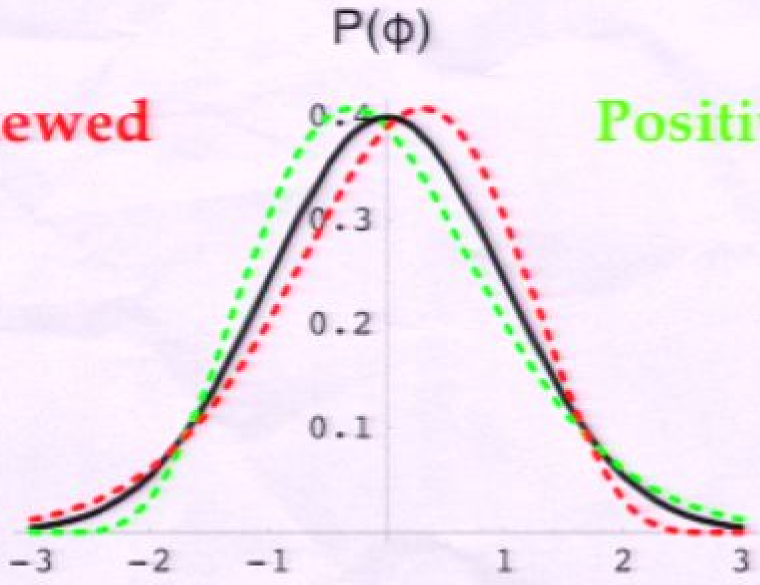
$f_{NL} = \pm 0.1$

$\sigma^2 = 1$

$k^2\zeta = 4\pi G a^2 \delta\rho.$

+f_{NL}=more clusters

PHYSICALLY (LOCAL MODEL)...



Negatively skewed

Positively skewed

$f_{NL} = \pm 0.1$

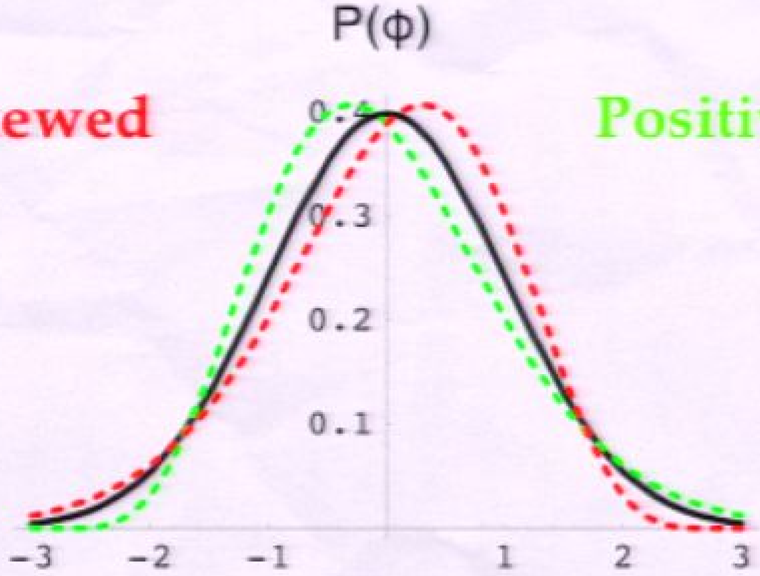
$\sigma^2 = 1$

$k^2 \zeta = 4\pi G a^2 \delta\rho.$

+f_{NL}=more clusters

PI, Oct. 30, 2007

PHYSICALLY (LOCAL MODEL)...



Negatively skewed

Positively skewed

$f_{NL} = \pm 0.1$

$\sigma^2 = 1$

$$k^2\zeta = 4\pi G a^2 \delta\rho.$$

+f_{NL}=more clusters

PI, Oct. 30, 2007

MORE GENERALLY...

- For a fundamental inflaton, we know its interactions

$$S = \frac{1}{2}\int d^4x\sqrt{-g}\,[M_p^2 R - 2P(X,\phi)]$$

$$X = -\frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi$$

$$3M_p^2H^2 = E$$

$$E = 2XP_{,X} - P$$

$$c_s^2 = \frac{P_{,X}}{E_{,X}} = \frac{P_{,X}}{P_{,X} + 2XP_{,XX}}$$

(ARMENDARIZ-PICON, DAMOUR, GARRIGA, MUKHANOV)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

Current CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}(\boxed{\mathcal{A}_\lambda}+\mathcal{A}_c+\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s})}$$

$$\boxed{K = k_1+k_2+k_3}$$

~ 0 for DBI

lower order

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1 = k_2 = k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\underbrace{\mathcal{A}_\lambda}_{\sim 0 \text{ for DBI}}+\mathcal{A}_c+\underbrace{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s}_{\text{lower order}})}$$

$$\boxed{K = k_1+k_2+k_3}$$

$$\boxed{\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)}$$

(Chen, Huang, Kachru, Shiu)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$

(Creminelli et al.)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_{\lambda}+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_{\epsilon}+\mathcal{A}_{\eta}+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

Current CMB bound: $f_{NL}^{eff}(k_1 = k_2 = k_3)$

$$-256 < f_{NL}^{eq} < 332$$

(CREMINELLI ET AL.)

MORE GENERALLY...

- For a fundamental inflaton, we know its interactions

$$\boxed{\begin{gathered} S=\frac{1}{2}\int d^4x\sqrt{-g}\,[M_p^2R-2P(X,\phi)] \\ X=-\frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi \end{gathered}}$$

$$\boxed{\begin{gathered} 3M_p^2H^2=E \\ E=2XP_{,X}-P \end{gathered}} \qquad \boxed{c_s^2=\frac{P_{,X}}{E_{,X}}=\frac{P_{,X}}{P_{,X}+2XP_{,XX}}}$$

(ARMENDARIZ-PICON, DAMOUR, GARRIGA, MUKHANOV)

MORE GENERALLY...

- For a fundamental inflaton, we know its interactions

$$S=\frac{1}{2}\int d^4x\sqrt{-g}\,[M_p^2R-2P(X,\phi)]$$

$$X=-\frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi$$

$$3M_p^2H^2=E$$

$$E=2XP_{,X}-P$$

$$c_s^2=\frac{P_{,X}}{E_{,X}}=\frac{P_{,X}}{P_{,X}+2XP_{,XX}}$$

(ARMENDARIZ-PICON, DAMOUR, GARRIGA, MUKHANOV)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_{\lambda}+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_{\epsilon}+\mathcal{A}_{\eta}+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(Chen, Huang, Kachru, Shiu)

urrent CMB bound: $f_{NL}^{eff}(k_1 = k_2 = k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (Creminelli et al.)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1 = k_2 = k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_\upsilon+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$-256 < f_{NL}^{eq} < 332$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$

(CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$-256 < f_{NL}^{eq} < 332$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$

(CREMINELLI ET AL.)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_\alpha+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1 = k_2 = k_3)$

$-256 < f_{NL}^{eq} < 332$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)}$$

$$\boxed{K = k_1+k_2+k_3}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1 = k_2 = k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\boxed{\mathcal{A}_\lambda}+\mathcal{A}_c+\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s})$$

$K = k_1 + k_2 + k_3$

~ 0 for DBI

lower order

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1 = k_2 = k_3)$

$-256 < f_{NL}^{eq} < 332$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\boxed{\mathcal{A}_\lambda}+\boxed{\mathcal{A}_c}+\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s})$$

$$\boxed{K = k_1+k_2+k_3}$$

~ 0 for DBI

lower order

$$\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$-256 < f_{NL}^{eq} < 332$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}\left(\underbrace{\boxed{\mathcal{A}_\lambda}}_{\sim 0\text{ for DBI}}+\boxed{\mathcal{A}_c}+\underbrace{\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s}}_{\text{lower order}}\right)$$

$$\boxed{K = k_1+k_2+k_3}$$

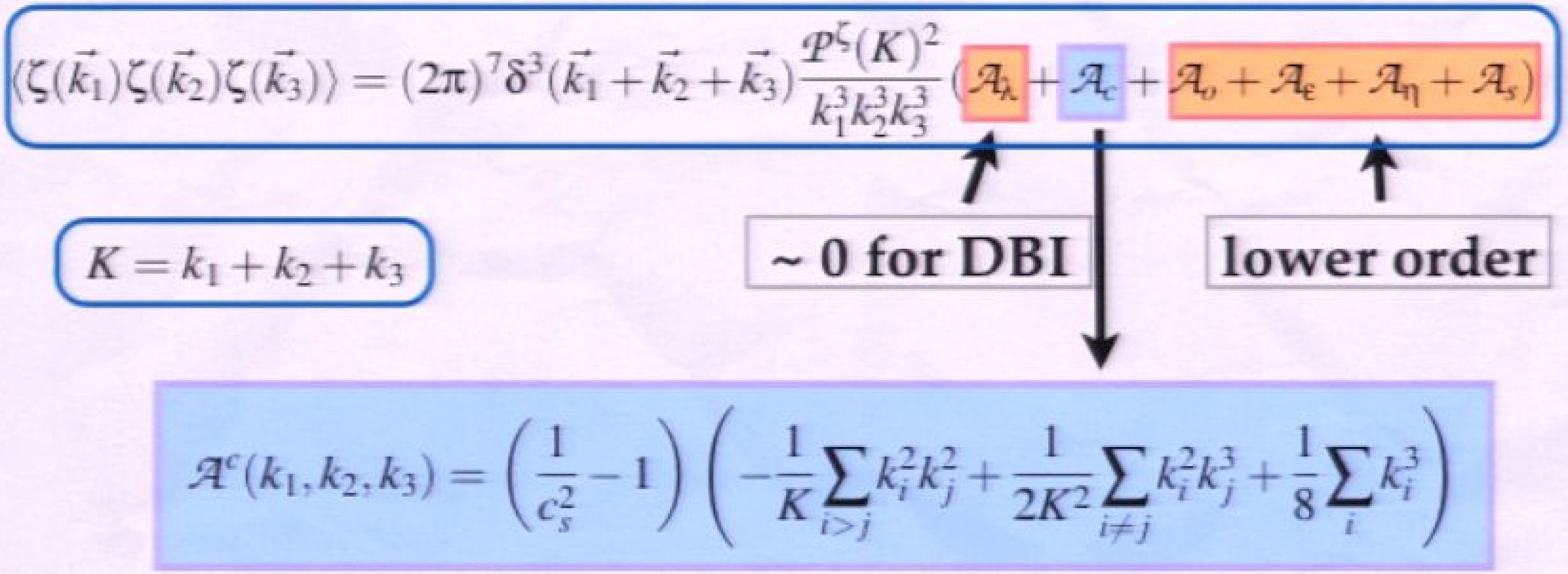
$$\boxed{\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)}$$

(Chen, Huang, Kachru, Shiu)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$-256 < f_{NL}^{eq} < 332$ (Creminelli et al.)

GENERAL SOUND SPEED



$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}\left(\boxed{\mathcal{A}_\lambda}+\boxed{\mathcal{A}_c}+\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s}\right)$$

$$\boxed{K = k_1+k_2+k_3}$$

~ 0 for DBI

lower order

$$\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}\left(\boxed{\mathcal{A}_\lambda}+\boxed{\mathcal{A}_c}+\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s}\right)$$

$$K = k_1+k_2+k_3$$

~ 0 for DBI

lower order

$$\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)$$

$$K = k_1+k_2+k_3$$

~ 0 for DBI

lower order

$$\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}\left(\boxed{\mathcal{A}_\lambda}+\boxed{\mathcal{A}_c}+\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s}\right)$$

$$K = k_1+k_2+k_3$$

~ 0 for DBI

lower order

$$\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\underbrace{\boxed{\mathcal{A}_\lambda}}_{\sim 0 \text{ for DBI}}+\boxed{\mathcal{A}_c}+\underbrace{\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s}}_{\text{lower order}})$$

$$\boxed{K = k_1+k_2+k_3}$$

~ 0 for DBI

lower order

$$\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)$$

(Chen, Huang, Kachru, Shiu)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (Creminelli et al.)

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}\Big(\underbrace{\boxed{\mathcal{A}_\lambda}}_{\sim 0 \text{ for DBI}}+\boxed{\mathcal{A}_c}+\underbrace{\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s}}_{\text{lower order}}\Big)$$

$$K = k_1 + k_2 + k_3$$

$$\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)$$

(Chen, Huang, Kachru, Shiu)

Current CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (Creminelli et al.)

GENERAL SOUND SPEED

$$\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^\zeta(K)^2}{k_1^3k_2^3k_3^3}(\mathcal{A}_\lambda+\mathcal{A}_c+\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s)$$

$K = k_1 + k_2 + k_3$

~ 0 for DBI

lower order

$$\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

PI, Oct. 30, 2007

GENERAL SOUND SPEED

$$\boxed{\langle\zeta(\vec{k}_1)\zeta(\vec{k}_2)\zeta(\vec{k}_3)\rangle = (2\pi)^7\delta^3(\vec{k}_1+\vec{k}_2+\vec{k}_3)\frac{\mathcal{P}^{\zeta}(K)^2}{k_1^3k_2^3k_3^3}\Big(\underbrace{\boxed{\mathcal{A}_\lambda}}_{\sim 0 \text{ for DBI}}+\boxed{\mathcal{A}_c}+\underbrace{\boxed{\mathcal{A}_o+\mathcal{A}_\epsilon+\mathcal{A}_\eta+\mathcal{A}_s}}_{\text{lower order}}\Big)}$$

$$\boxed{K = k_1+k_2+k_3}$$

$$\boxed{\mathcal{A}^c(k_1,k_2,k_3) = \left(\frac{1}{c_s^2}-1\right)\left(-\frac{1}{K}\sum_{i>j}k_i^2k_j^2+\frac{1}{2K^2}\sum_{i\neq j}k_i^2k_j^3+\frac{1}{8}\sum_i k_i^3\right)}$$

(CHEN, HUANG, KACHRU, SHIU)

urrent CMB bound: $f_{NL}^{eff}(k_1=k_2=k_3)$

$$-256 < f_{NL}^{eq} < 332$$ (CREMINELLI ET AL.)

HOW NON-GAUSSIAN?

(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
(Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
(Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

PI, Oct. 30, 2007

HOW NON-GAUSSIAN?

(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
  (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
  (Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

HOW NON-GAUSSIAN?
(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$ (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound) (Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

PI, Oct. 30, 2007

HOW NON-GAUSSIAN?
(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
  (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
  (Silverstein, Tong)

  ✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

HOW NON-GAUSSIAN?
(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
  (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
  (Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

PI, Oct. 30, 2007

HOW NON-GAUSSIAN?
(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
  (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
  (Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

HOW NON-GAUSSIAN?
(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
  (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
  (Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

PI, Oct. 30, 2007

HOW NON-GAUSSIAN?

(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$ (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound) (Silverstein, Tong)

* Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

PI, Oct. 30, 2007

HOW NON-GAUSSIAN?

(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
  (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
  (Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

PI, Oct. 30, 2007

HOW NON-GAUSSIAN?

(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
(Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
(Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

HOW NON-GAUSSIAN?
(SMOOTH MODELS)

- Slow-roll (squeezed limit): $f_{NL} \sim -(n_s - 1)$ (Maldacena)
- EFT suggests adding higher derivative terms gives $f_{NL} \sim 1$
  (Creminelli; 'equilateral model')
- DBI: Observationally limited (saturates CMB bound)
  (Silverstein, Tong)

✱ Surprisingly large: the square root sums an infinite number of powers of the derivative; similar effect found in tachyon actions (Barnaby, Cline)

II. WHY SCALE-DEPENDENCE?

II. WHY SCALE-DEPENDENCE?

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

PI, Oct. 30, 2007

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

PI, Oct. 30, 2007

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

WHY NOT?

- No reason for NG to be scale-independent (even slow-roll case)
- The well-motivated case with large NG ***is*** scale-dependent
- If NG is scale-dependent: interesting correlations with other scale-dependent quantities (tensor/scalar ratio), many observational tests are possible.

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

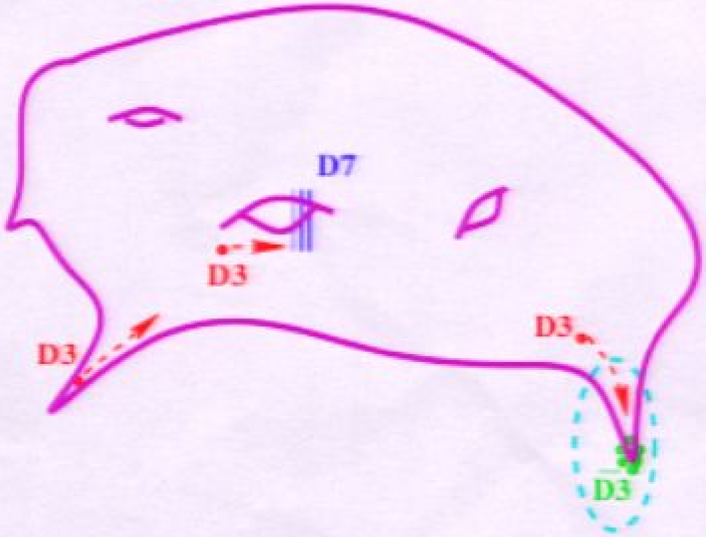
$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T}+V(\phi)-T\right]$$

$$T = T_3 h^{-1}(\phi)$$

$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$



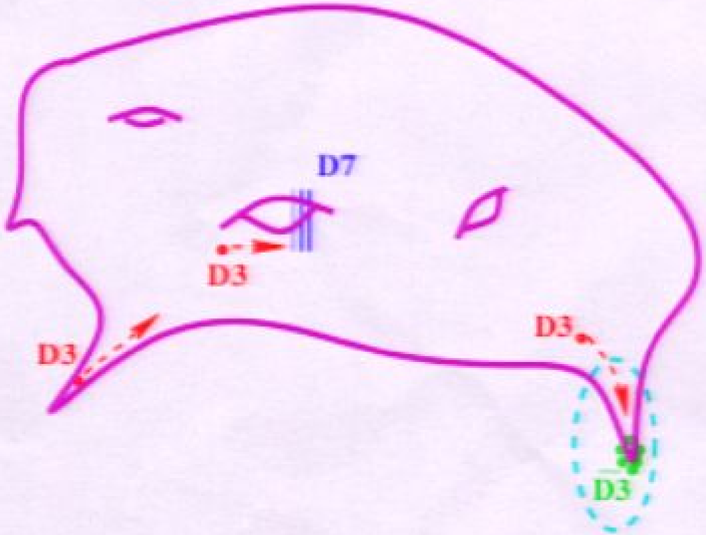
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\epsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

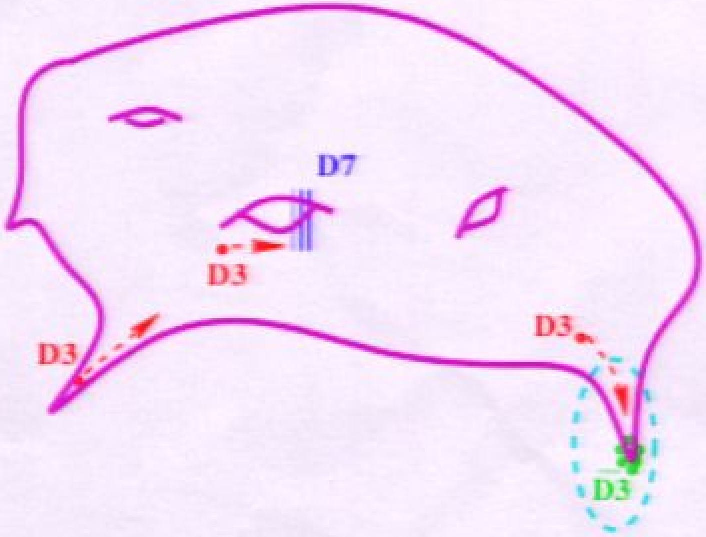
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

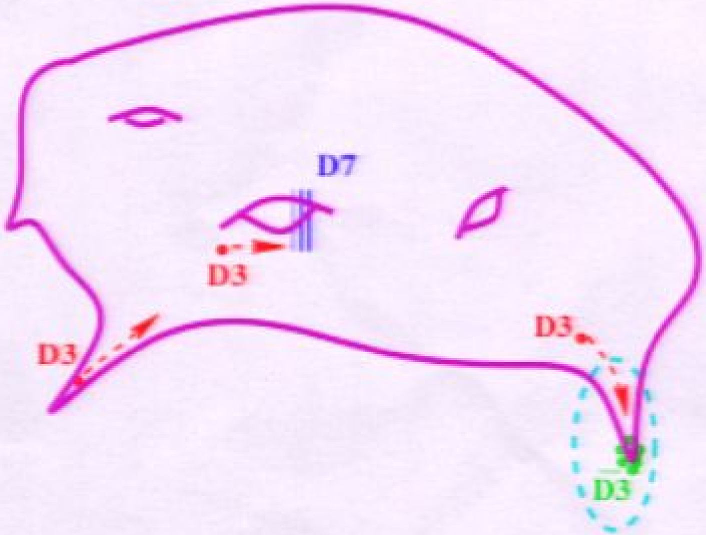
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

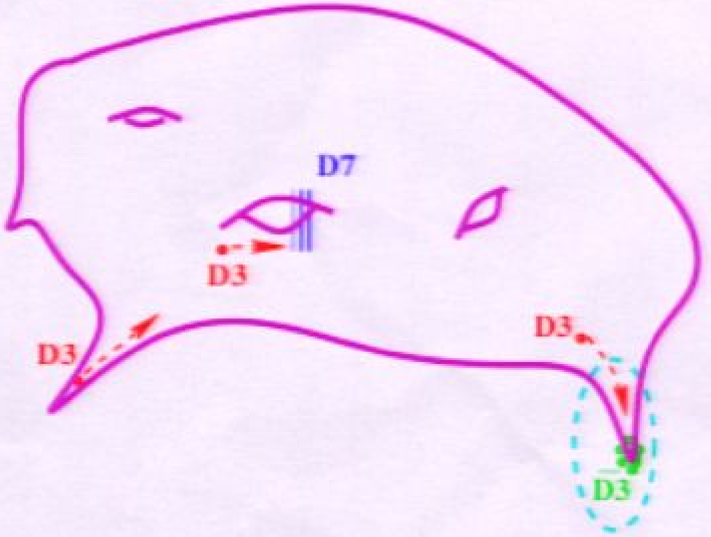
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

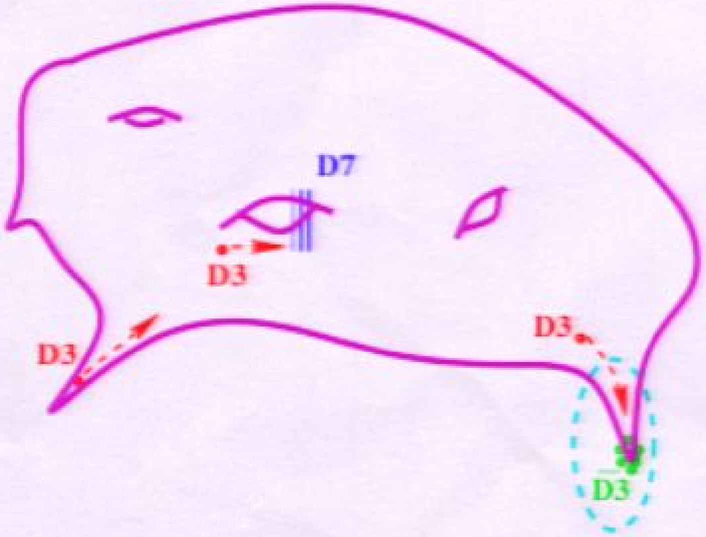
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

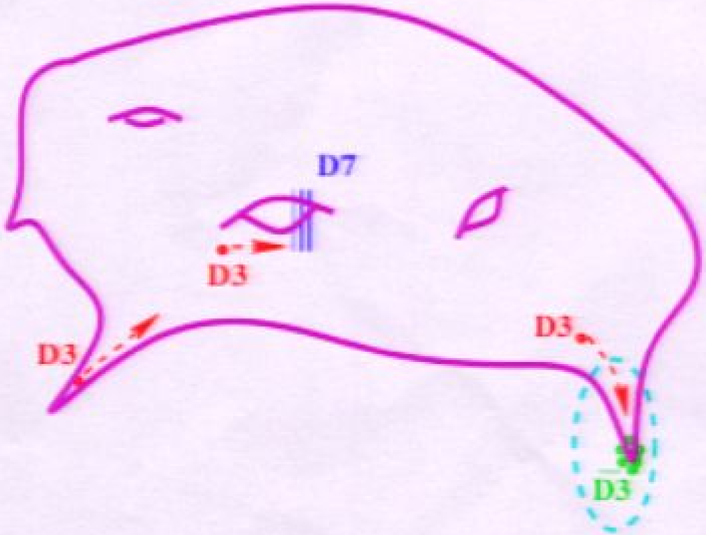
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

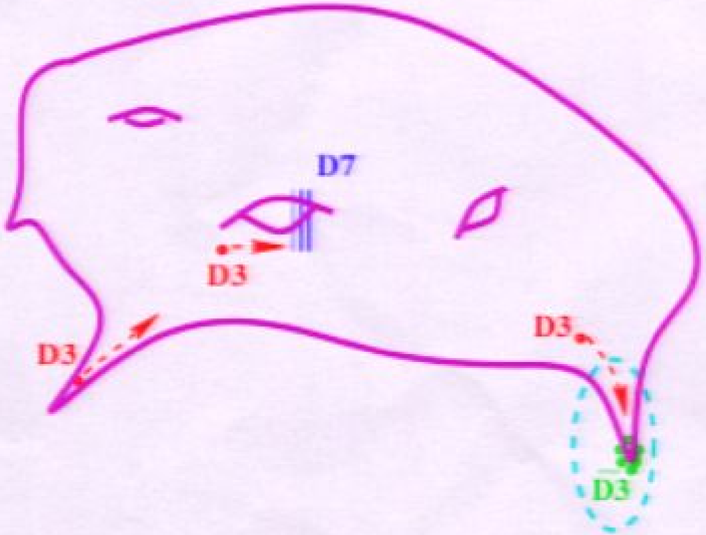
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

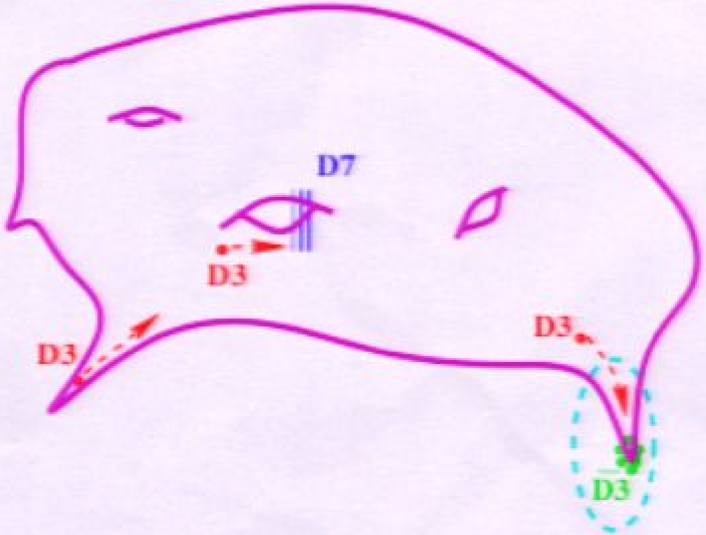
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

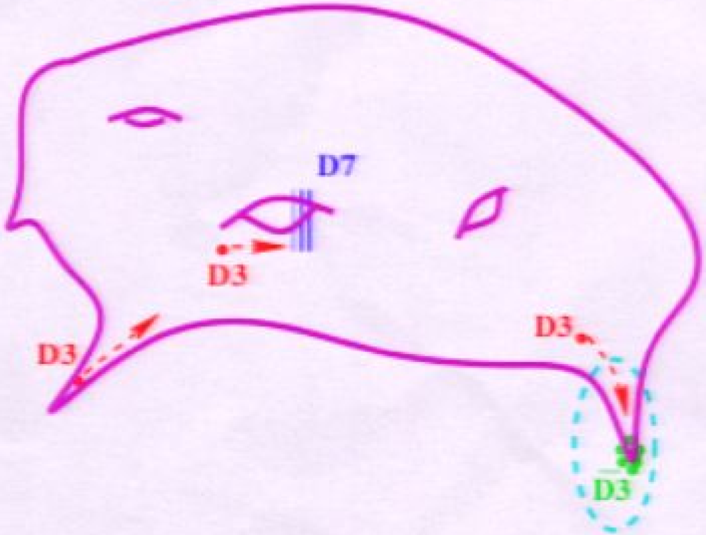
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

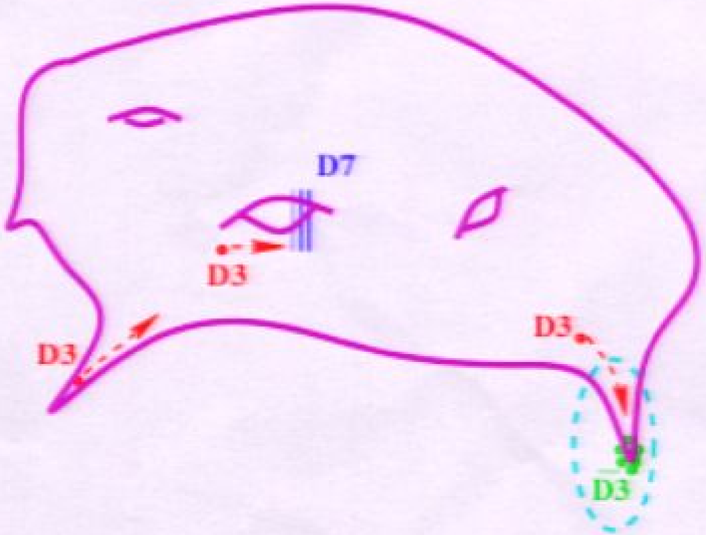
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T}+V(\phi)-T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

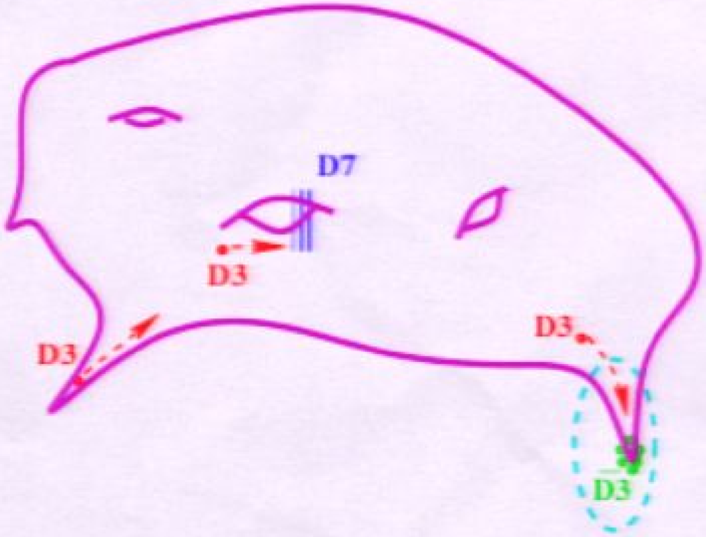
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

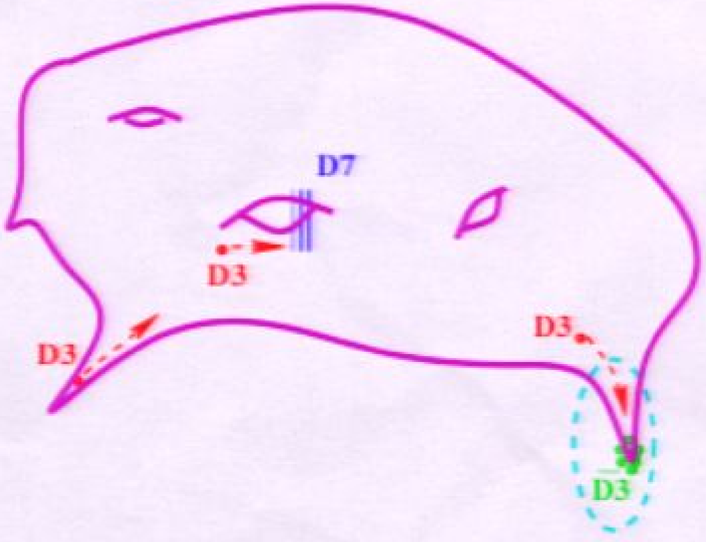
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

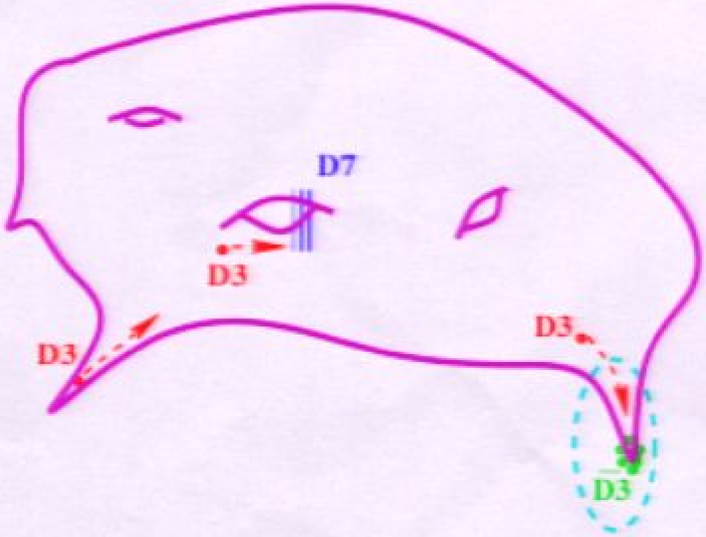
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

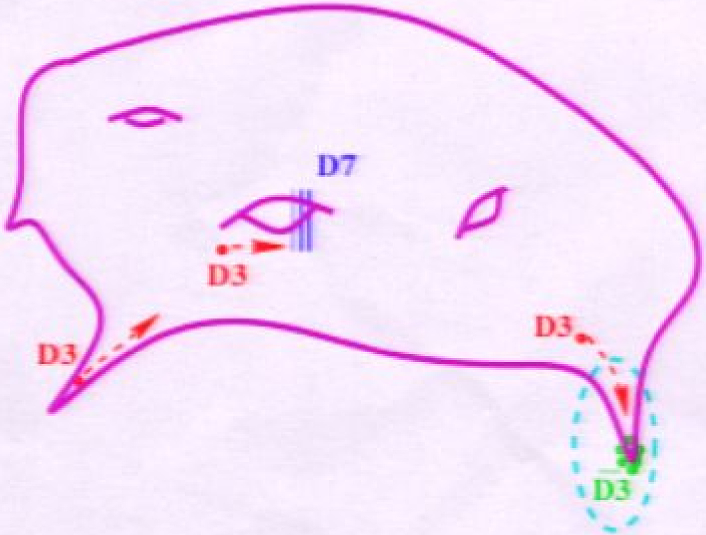
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

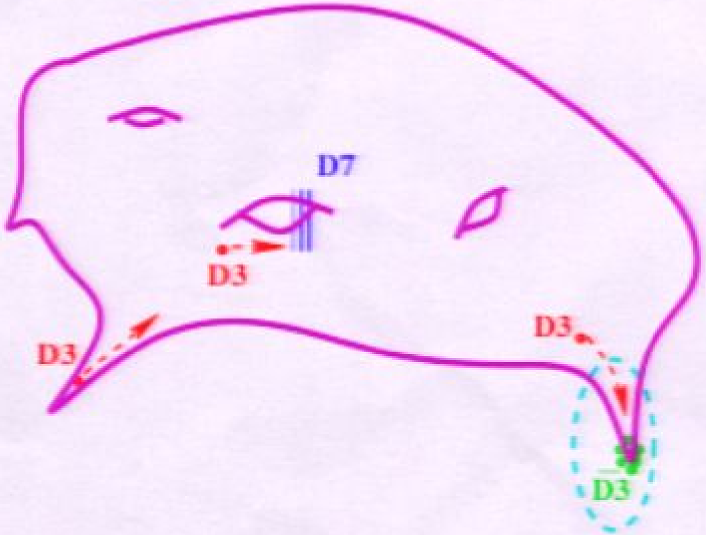
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

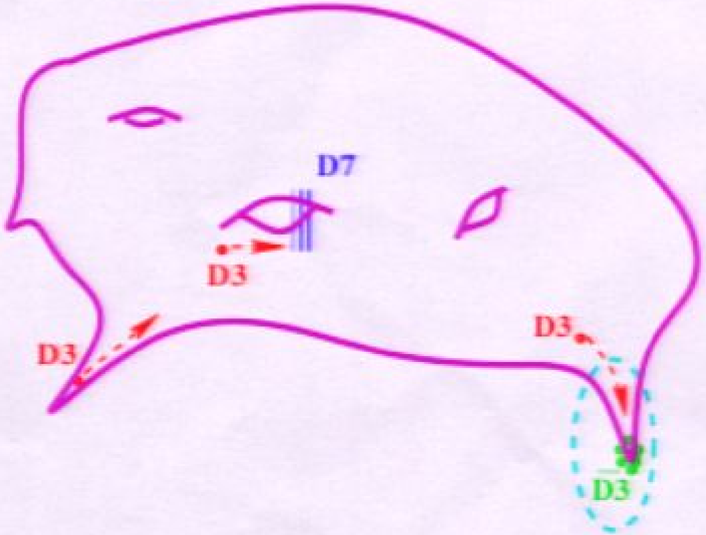
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

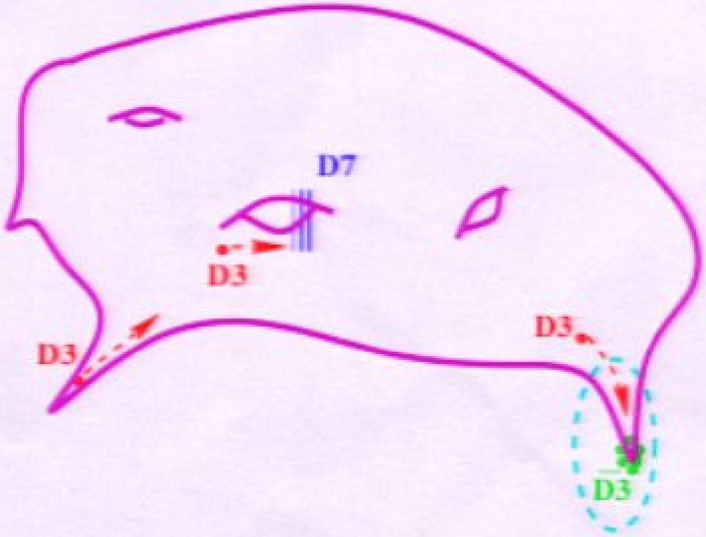
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

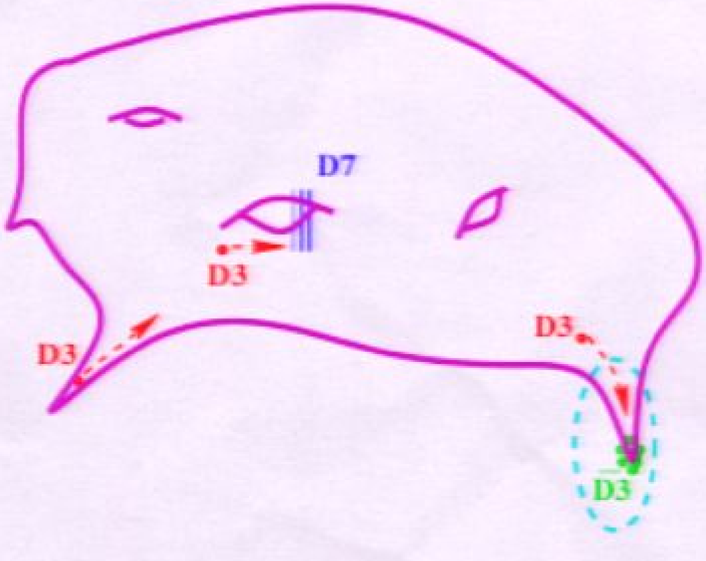
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

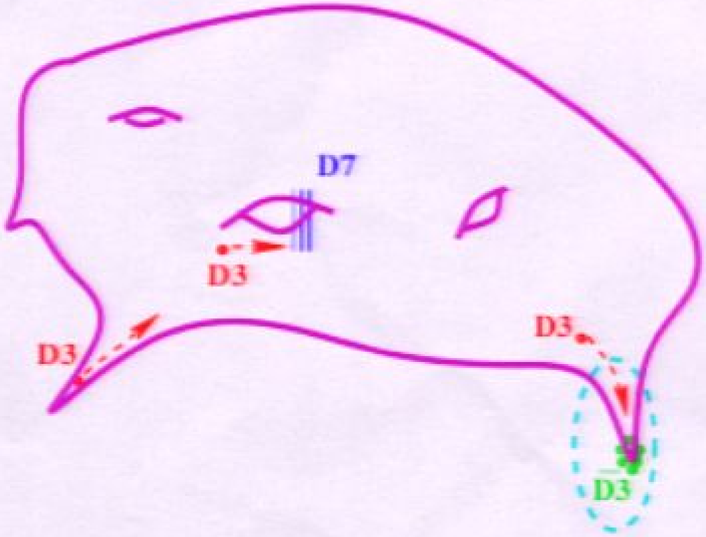
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

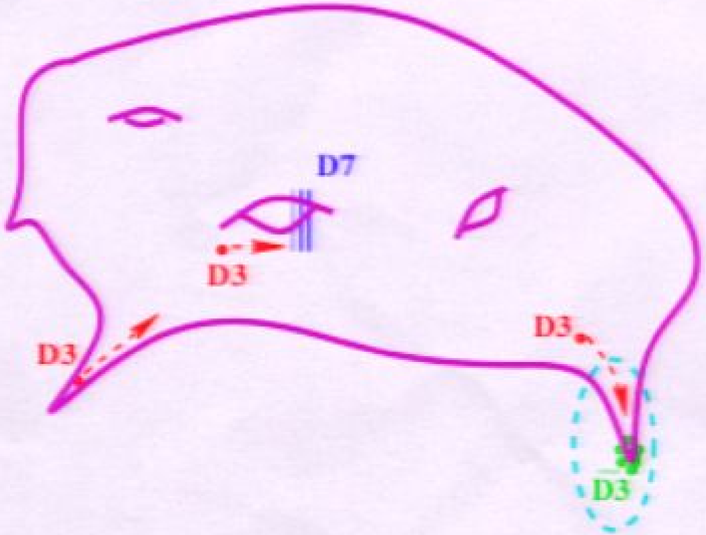
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1 - \dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1 - \dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

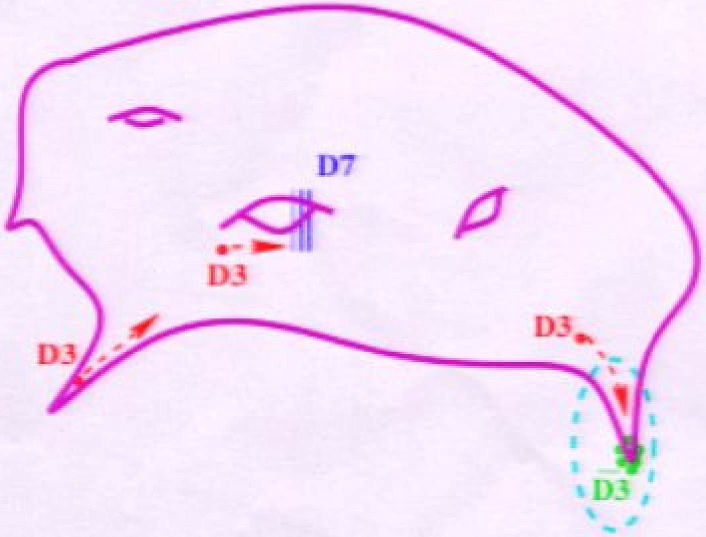
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

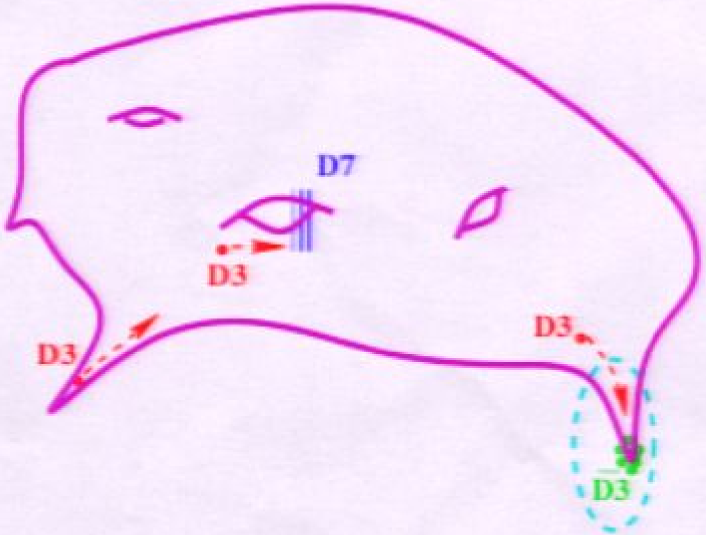
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

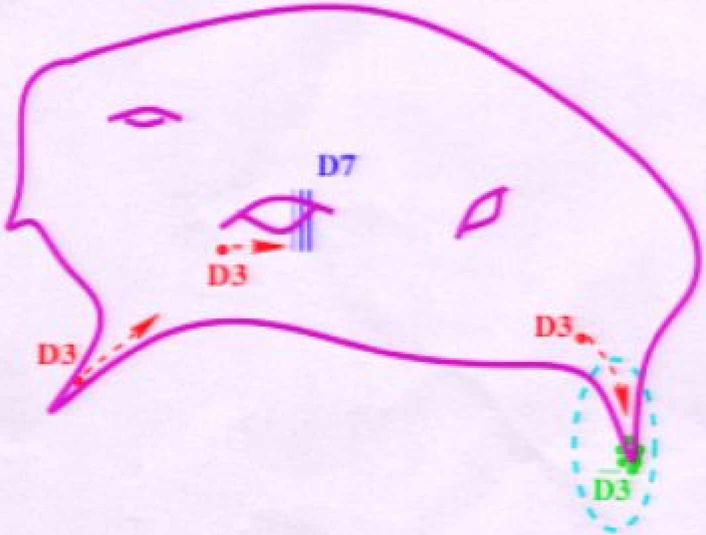
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

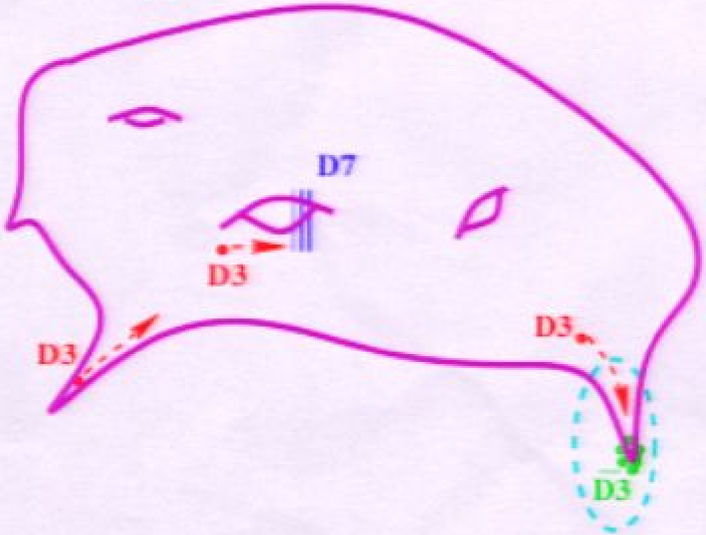
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

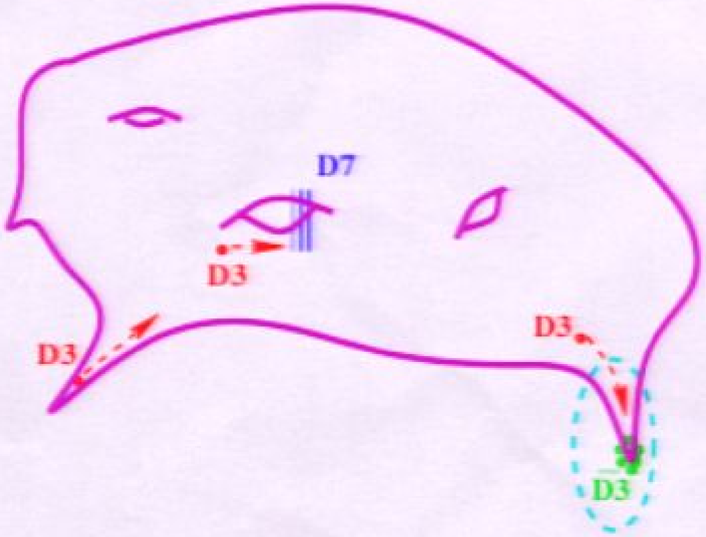
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\epsilon}{\gamma}$$

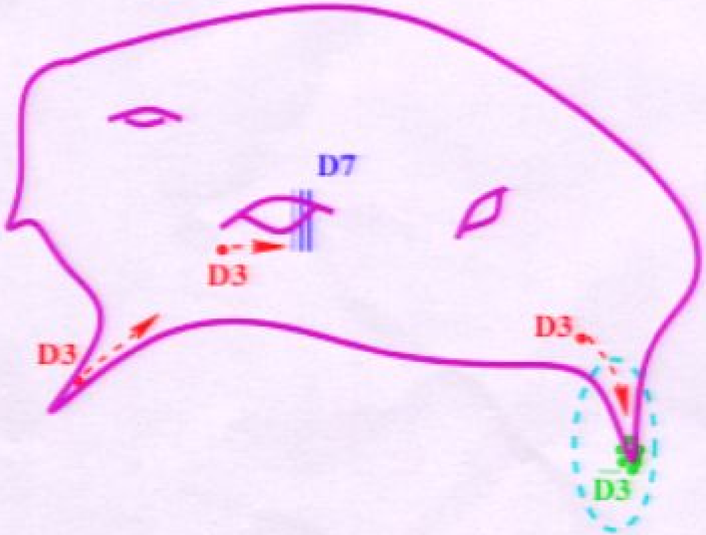
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

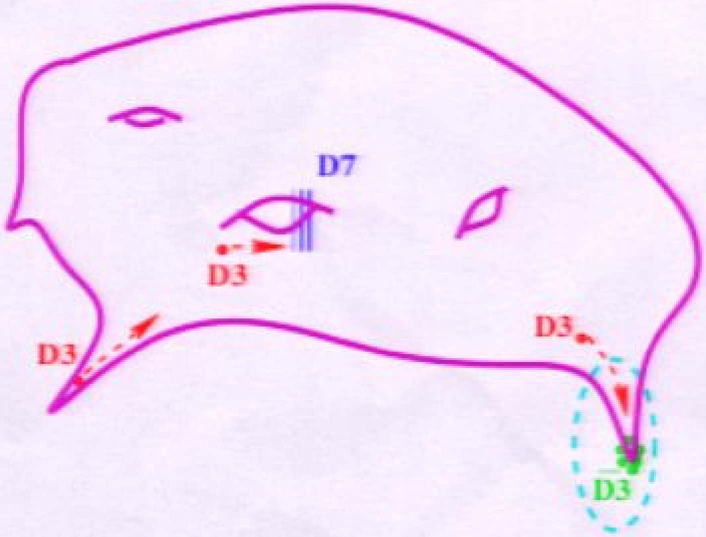
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T}+V(\phi)-T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

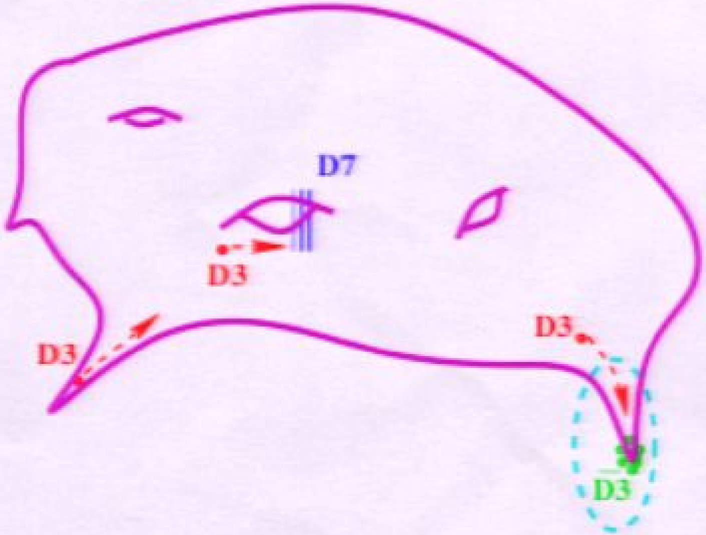
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

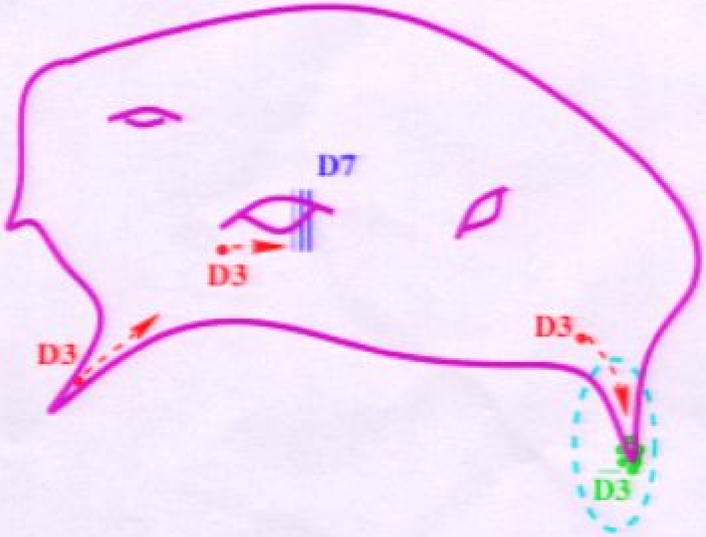
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\epsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

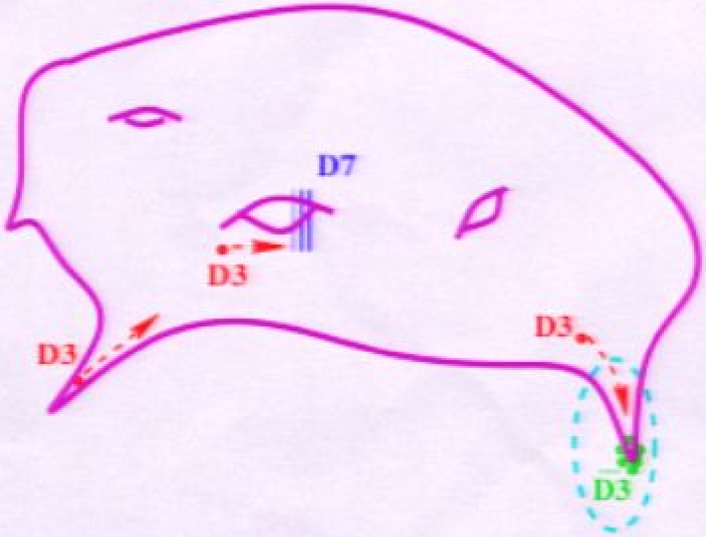
PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T\right]$$

$$T = T_3 h^{-1}(\phi)$$

$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$



$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

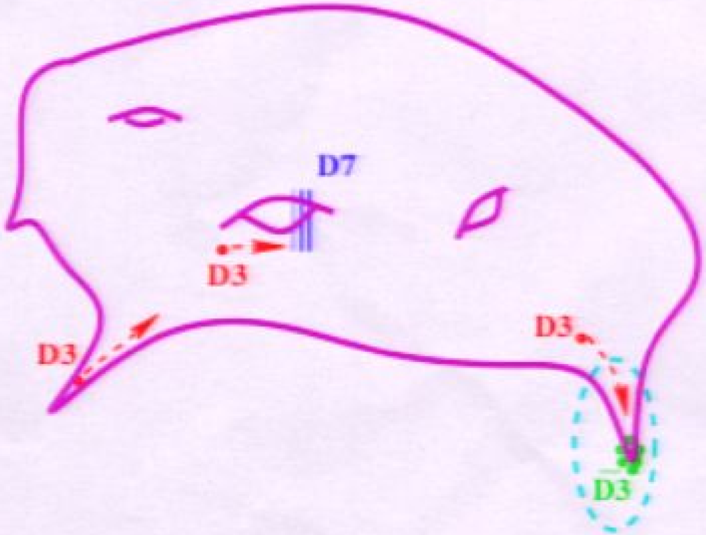
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

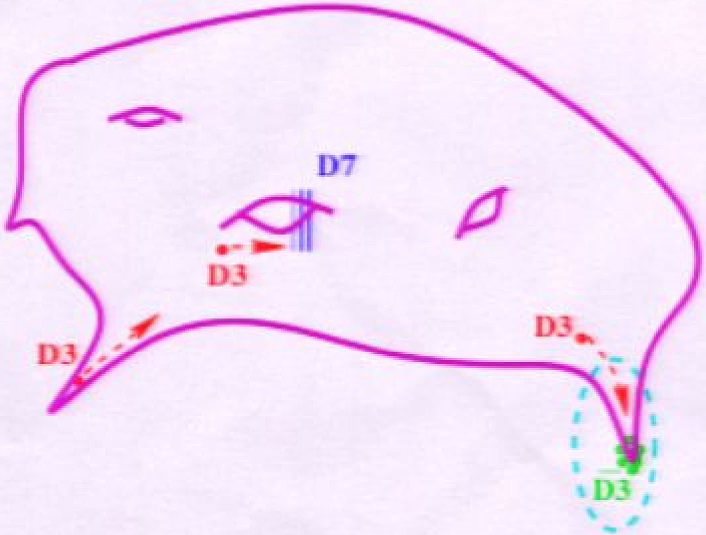
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

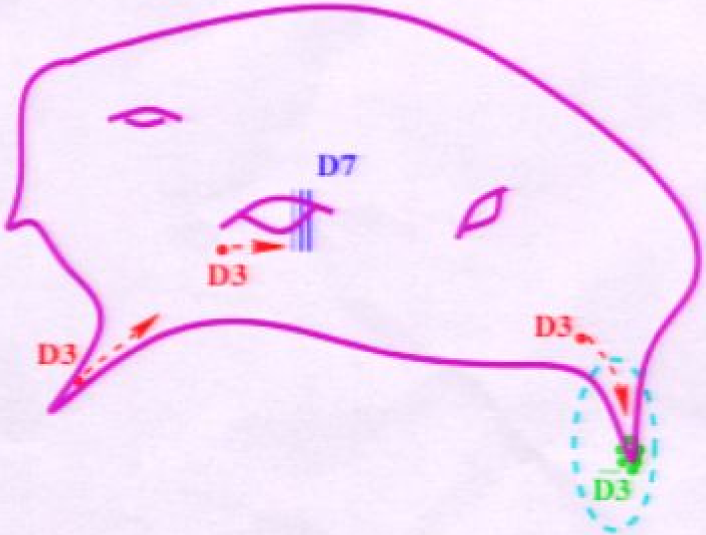
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

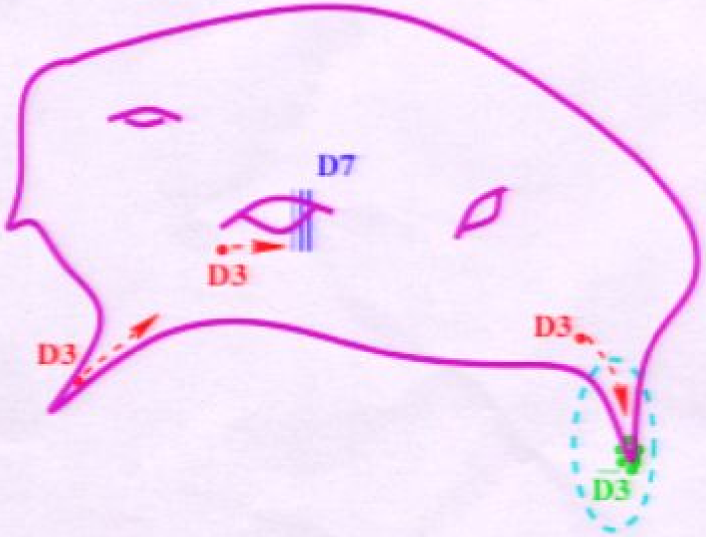
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T}+V(\phi)-T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

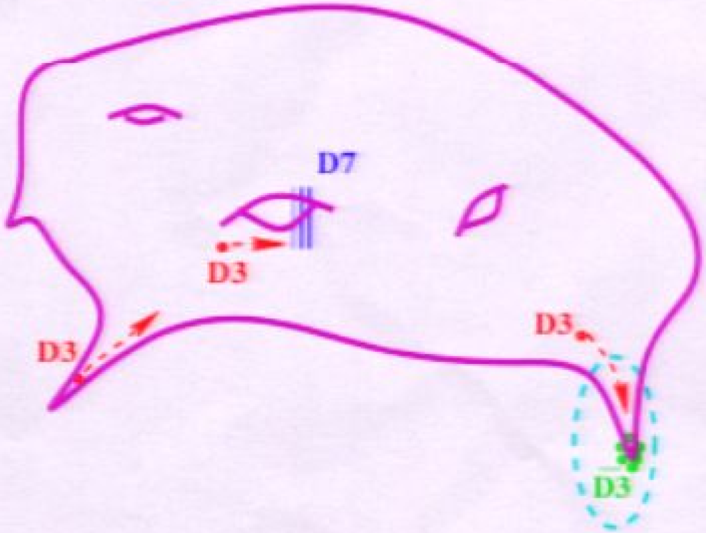
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t)\left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T\right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

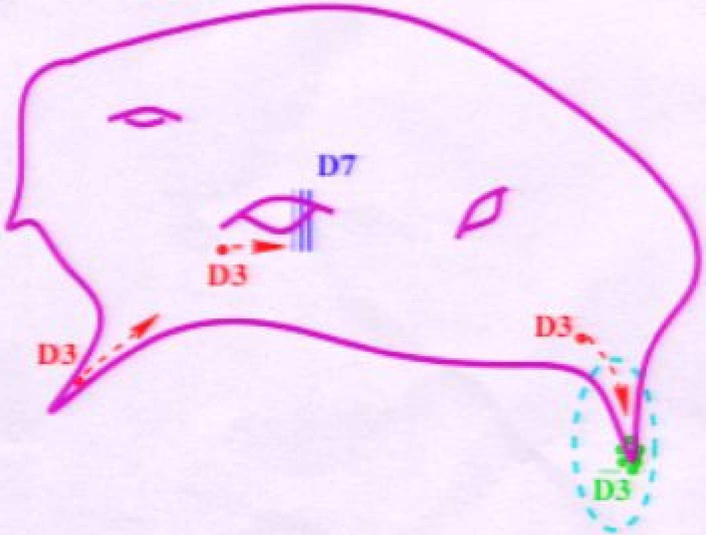
$$f_{NL} \approx (0.32)\gamma^2$$

Silverstein, Tong; Alishahiha

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$S = -\int d^4x\, a^3(t) \left[T\sqrt{1 - \dot{\phi}^2/T} + V(\phi) - T \right]$$

$$T = T_3 h^{-1}(\phi)$$



$$\gamma(\phi) = \frac{1}{\sqrt{1 - \dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}$$

$$r = \frac{16\varepsilon}{\gamma}$$

$$f_{NL} \approx (0.32)\gamma^2$$

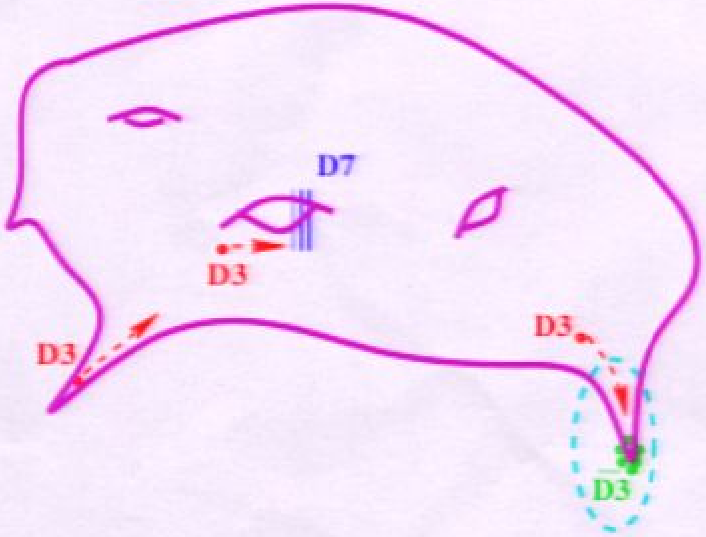
Silverstein, Tong; Alishahiha

PI, Oct. 30, 2007

EXAMPLE: (DBI) BRANE INFLATION (DBI=DIRAC-BORN-INFELD)

$$\boxed{S = -\int d^4x\, a^3(t) \left[T\sqrt{1-\dot{\phi}^2/T} + V(\phi) - T\right]}$$

$$\boxed{T = T_3 h^{-1}(\phi)}$$



$$\boxed{\gamma(\phi) = \frac{1}{\sqrt{1-\dot{\phi}^2 T^{-1}}} = \frac{1}{c_s}}$$

$$\boxed{r = \frac{16\varepsilon}{\gamma}}$$

$$\boxed{f_{NL} \approx (0.32)\gamma^2}$$

Silverstein, Tong; Alishahiha

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\epsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

PI, Oct. 30, 2007

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

PI, Oct. 30, 2007

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

PI, Oct. 30, 2007

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

PI, Oct. 30, 2007

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

PI, Oct. 30, 2007

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

PI, Oct. 30, 2007

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

PI, Oct. 30, 2007

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

PI, Oct. 30, 2007

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

PI, Oct. 30, 2007

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\epsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

PI, Oct. 30, 2007

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

PI, Oct. 30, 2007

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

FRAMEWORK FOR CALCULATING OBSERVABLES

- modified HSR parameters

$$\varepsilon_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'(\phi)}{H(\phi)}\right)^2$$

$$\eta_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H''(\phi)}{H(\phi)}\right)$$

$$\kappa_D \equiv \frac{2M_p^2}{\gamma}\left(\frac{H'}{H}\frac{\gamma'}{\gamma}\right)$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot} \left(\frac{k}{k_{pivot}} \right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108} 3^{2(n_s-1)} \left(\frac{1}{c_s^2} - 1 \right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq} \left(\frac{k}{k_{pivot}} \right)^{-2\kappa}$$

PI, Oct. 30, 2007

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f^c_{NL} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f^{eq}_{NL}(k) = f^{eq}_{NL,\,pivot}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

PI, Oct. 30, 2007

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

ADDING SCALE-DEPENDENCE

For DBI: $c_s(k) = c_s^{pivot}\left(\frac{k}{k_{pivot}}\right)^{\kappa}$

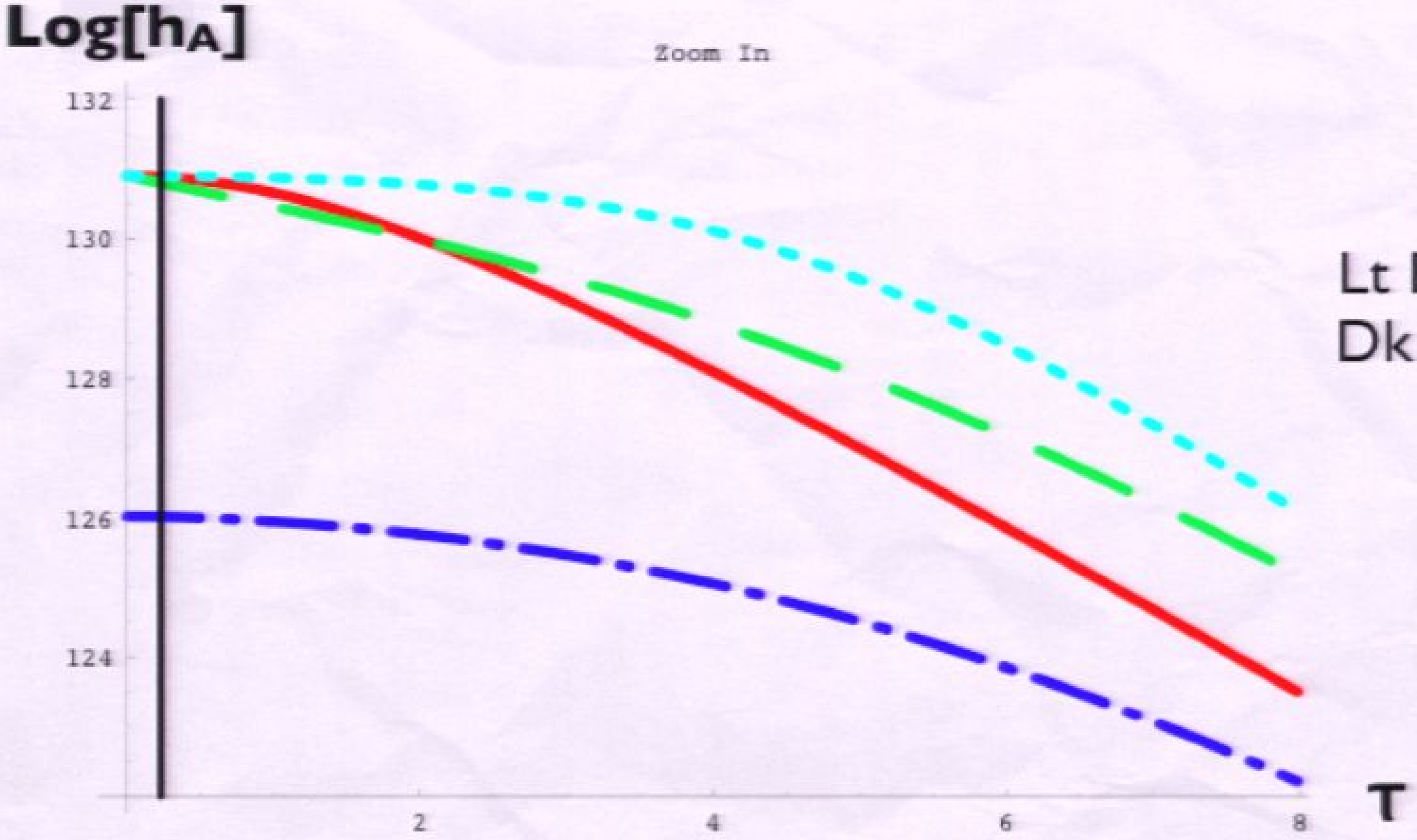
- Defining an effective f_{NL} from the equilateral limit:

$$f_{NL}^{c} = -\frac{35}{108}3^{2(n_s-1)}\left(\frac{1}{c_s^2}-1\right)$$

- We can use the DBI case to suggest an ansatz, with κ a free parameter

$$f_{NL}^{eq}(k) = f_{NL,\,pivot}^{eq}\left(\frac{k}{k_{pivot}}\right)^{-2\kappa}$$

CHANGE IN SOUND SPEED TRACKS GEOMETRY

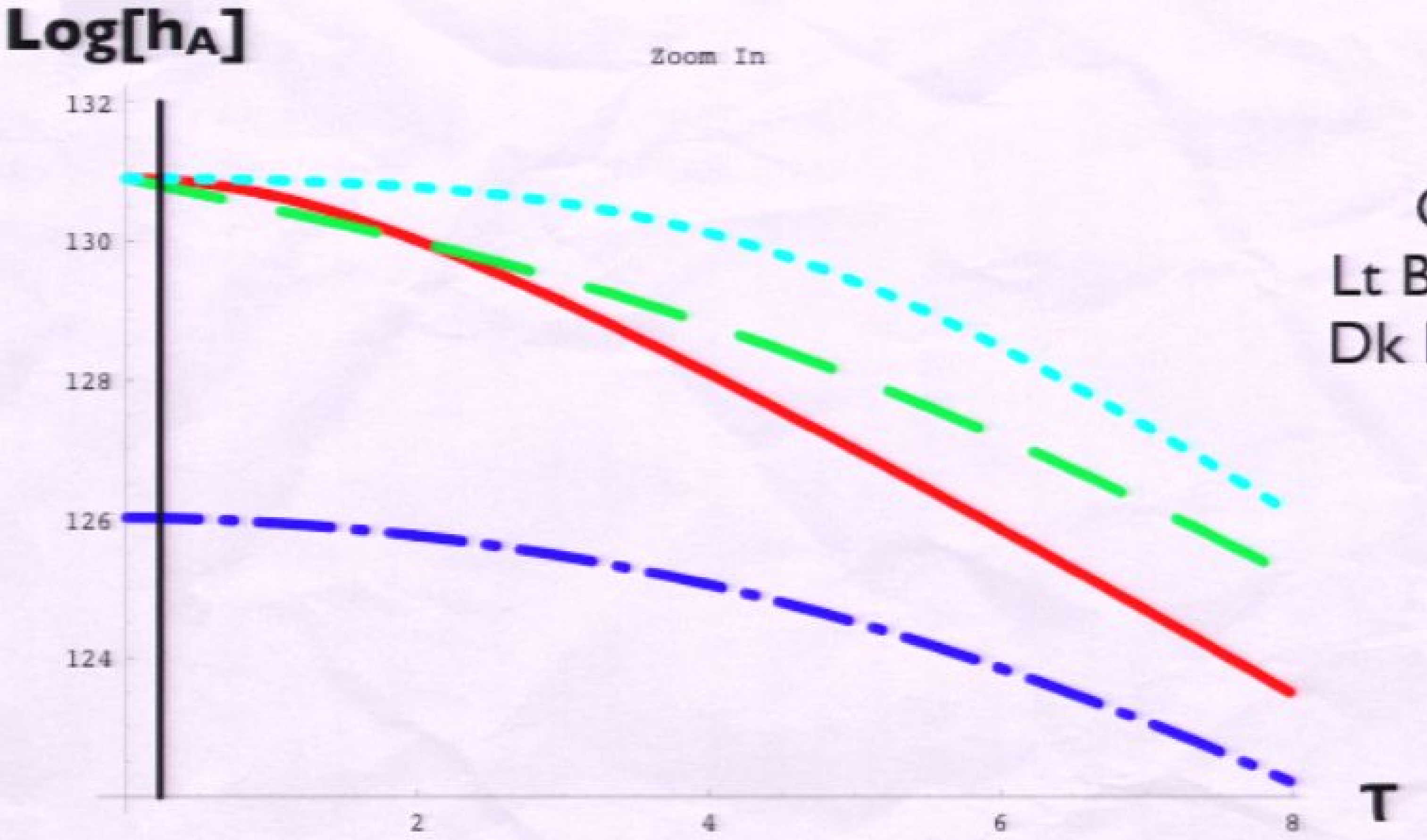


Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

N=10^6
M=800

PI, Oct. 30, 2007

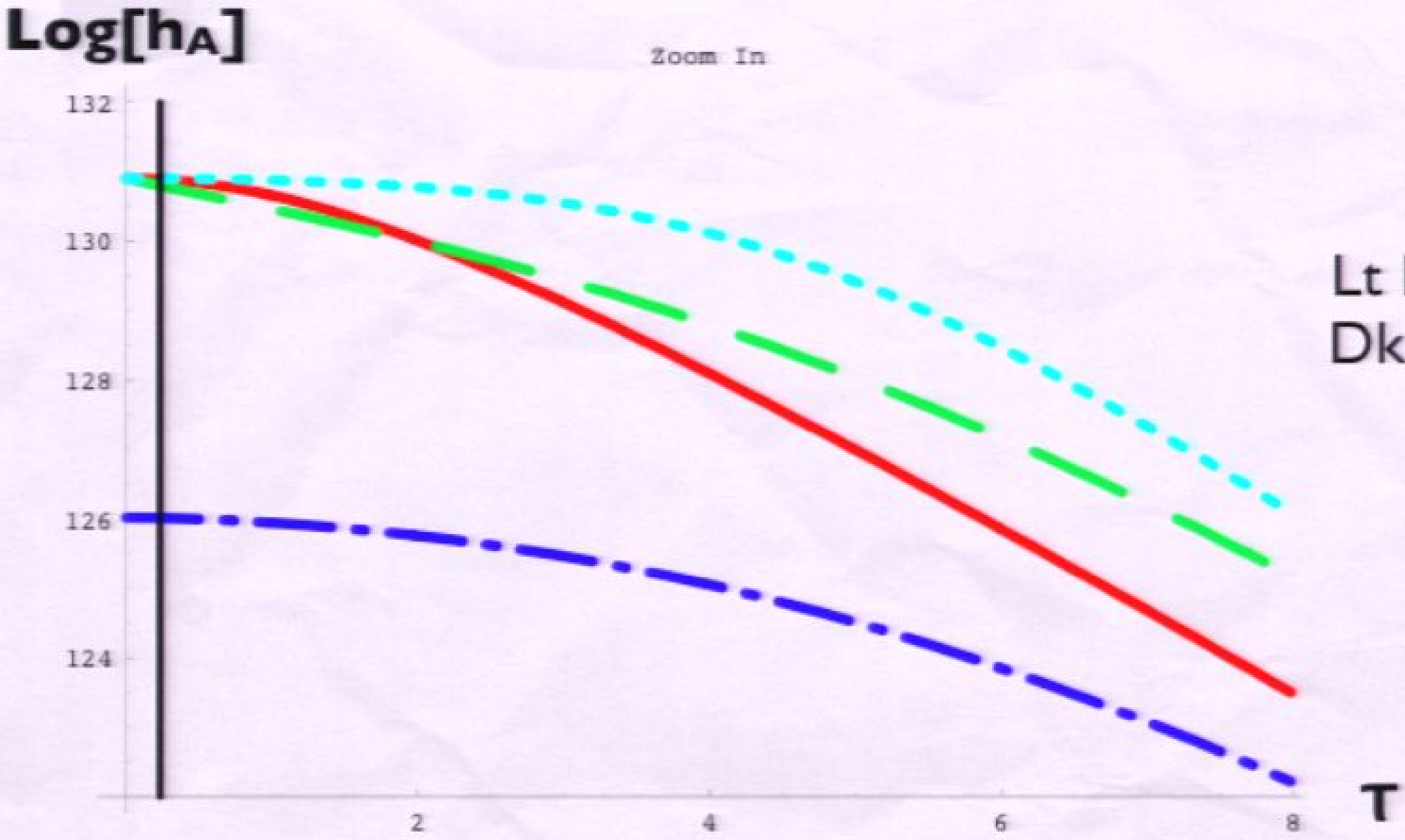
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

CHANGE IN SOUND SPEED TRACKS GEOMETRY

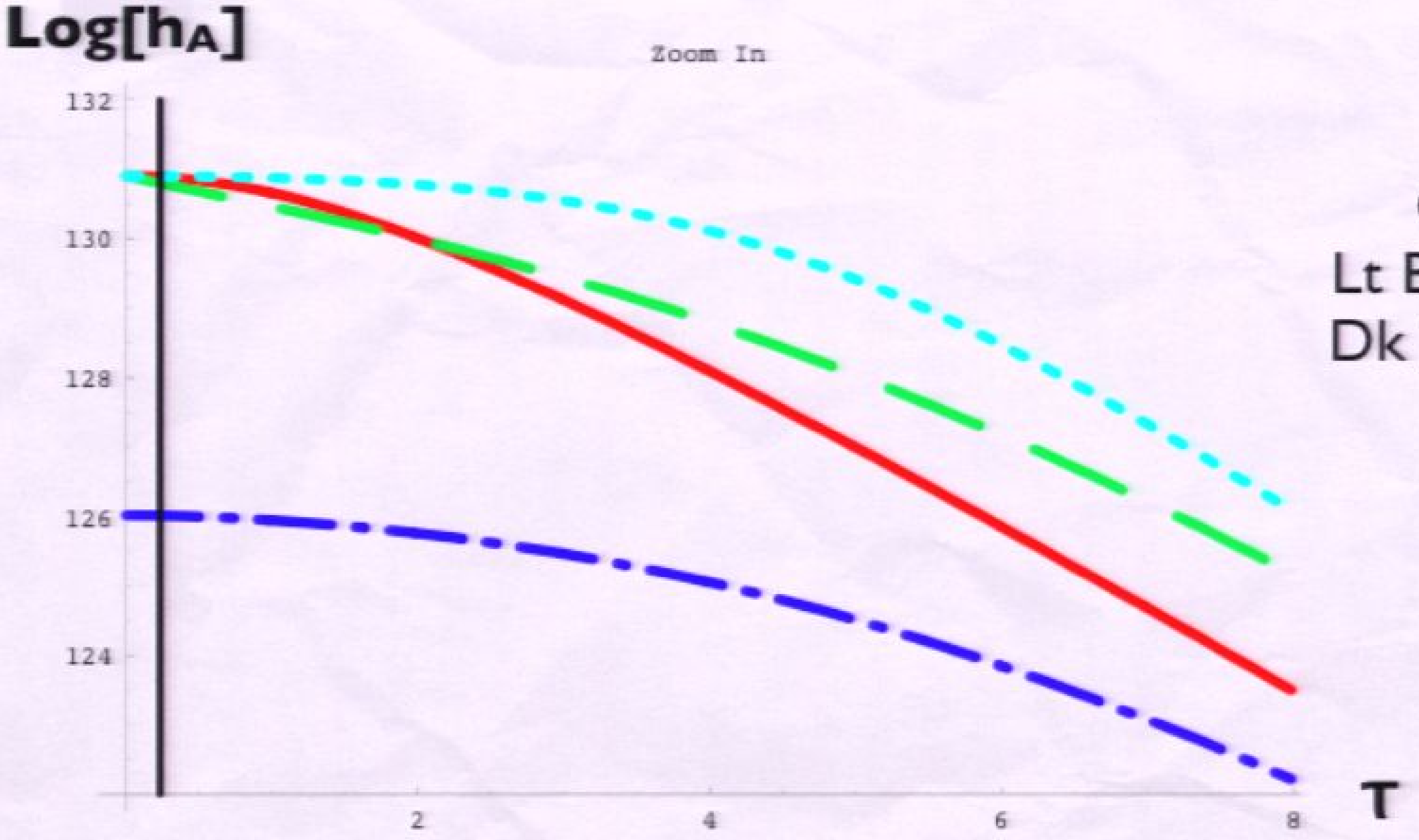


Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

PI, Oct. 30, 2007

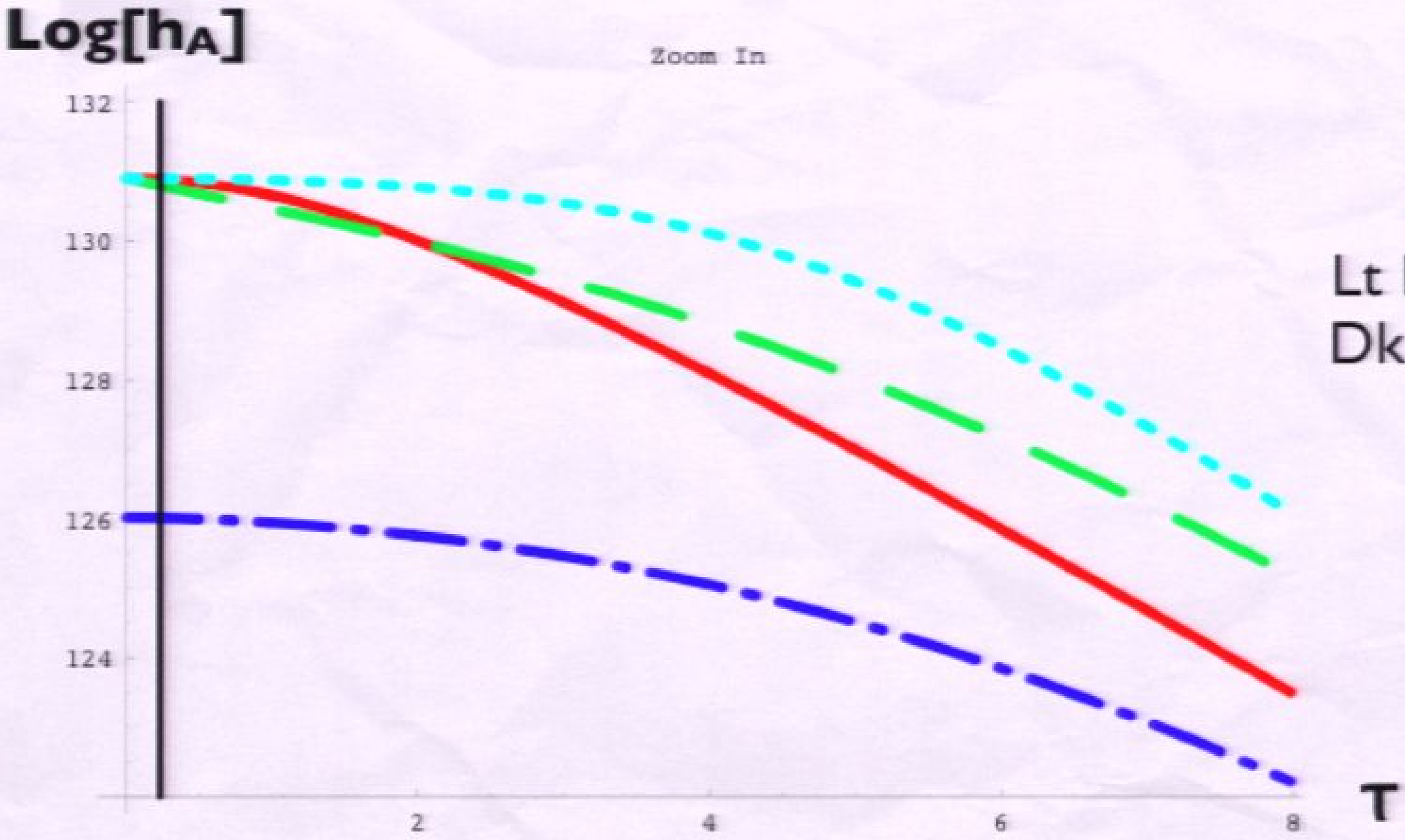
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

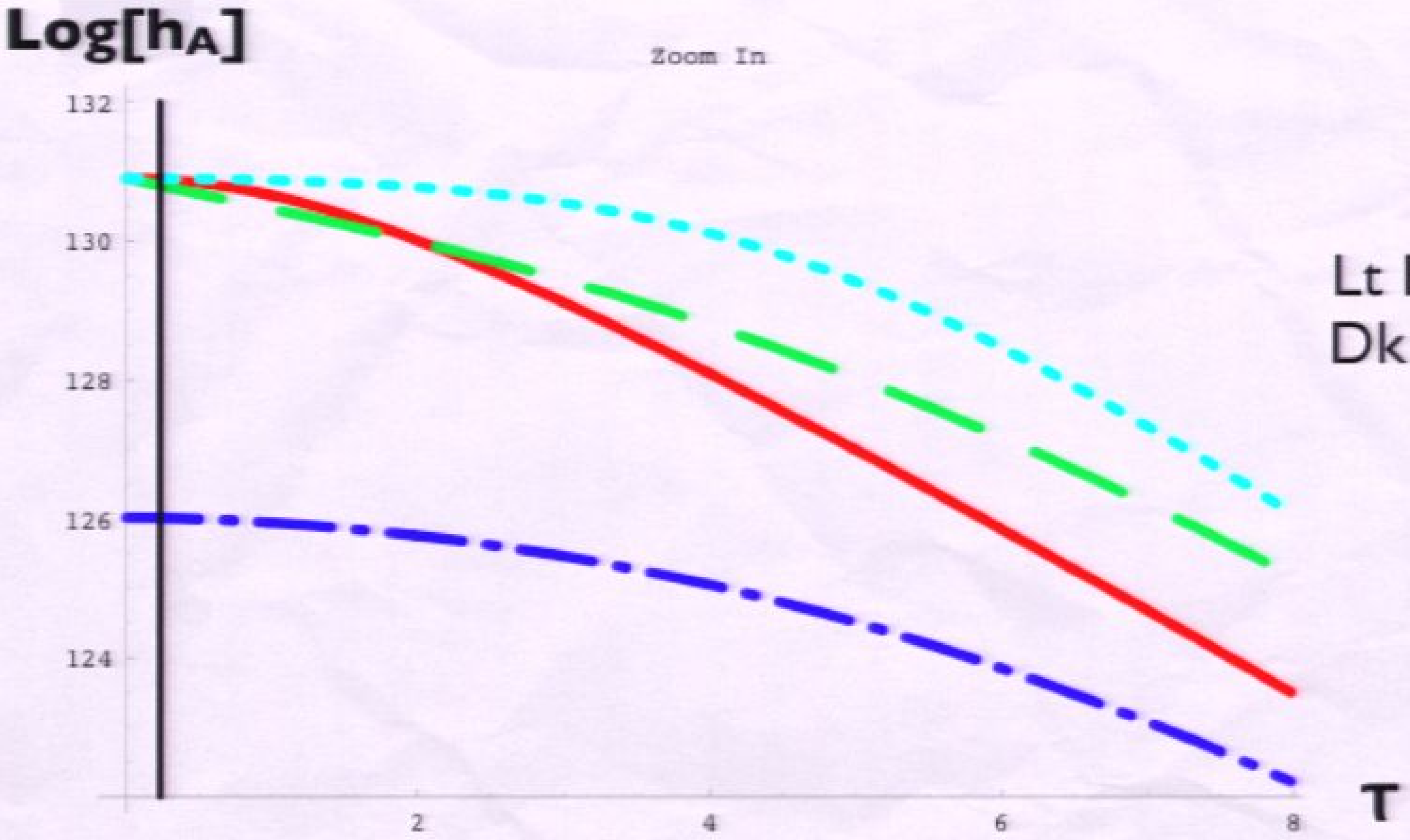
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

CHANGE IN SOUND SPEED TRACKS GEOMETRY

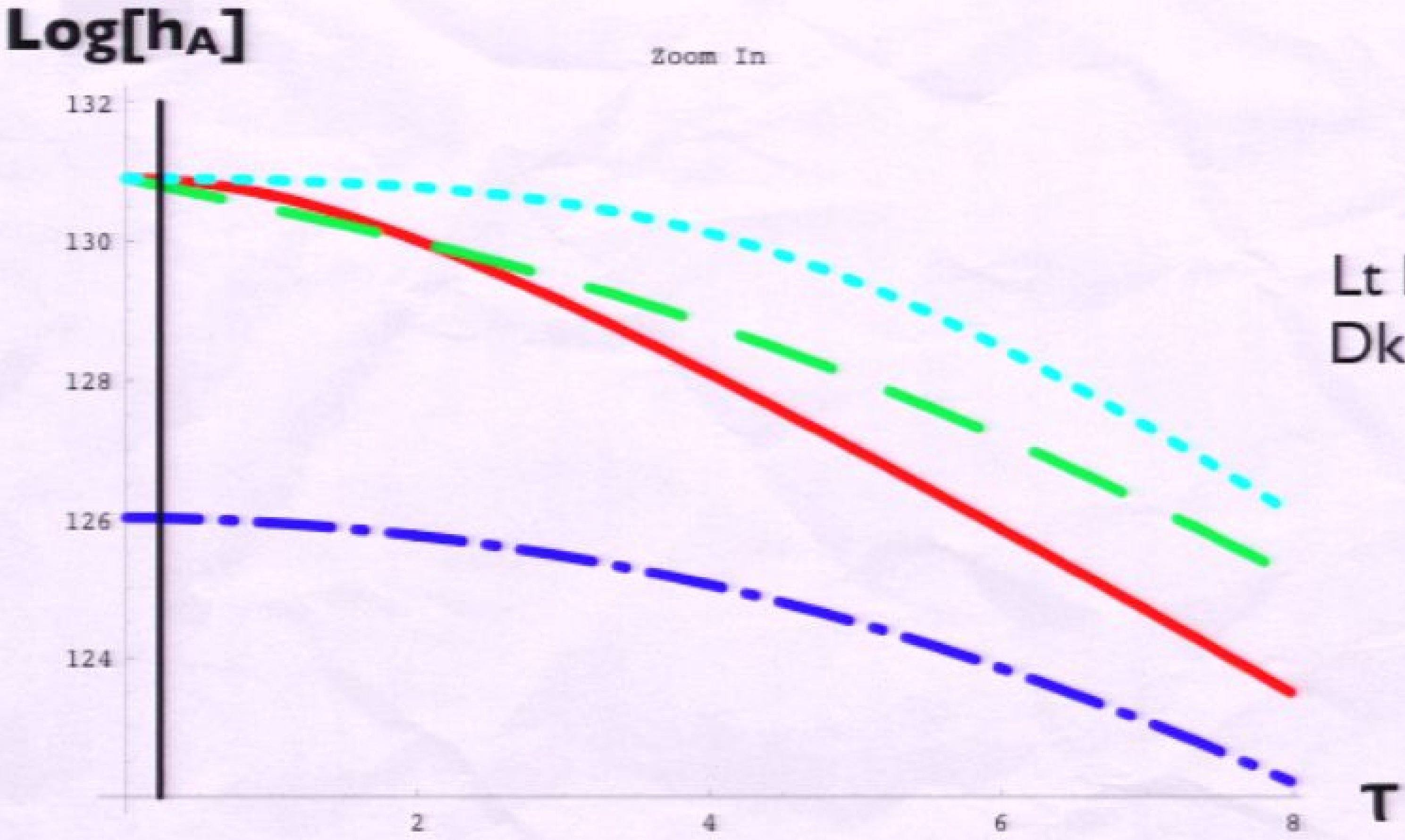


Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

N=10^6
M=800

PI, Oct. 30, 2007

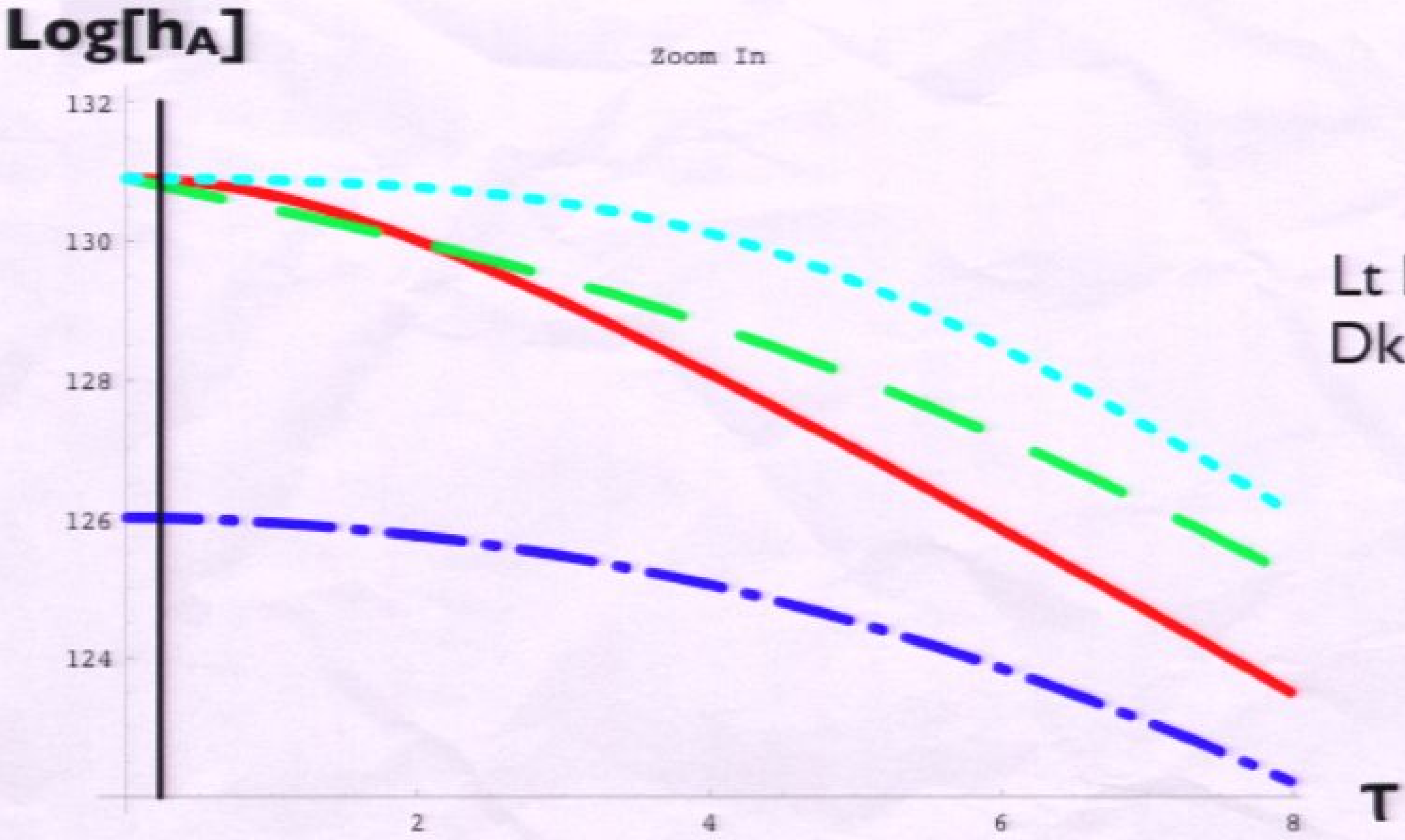
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
M=800

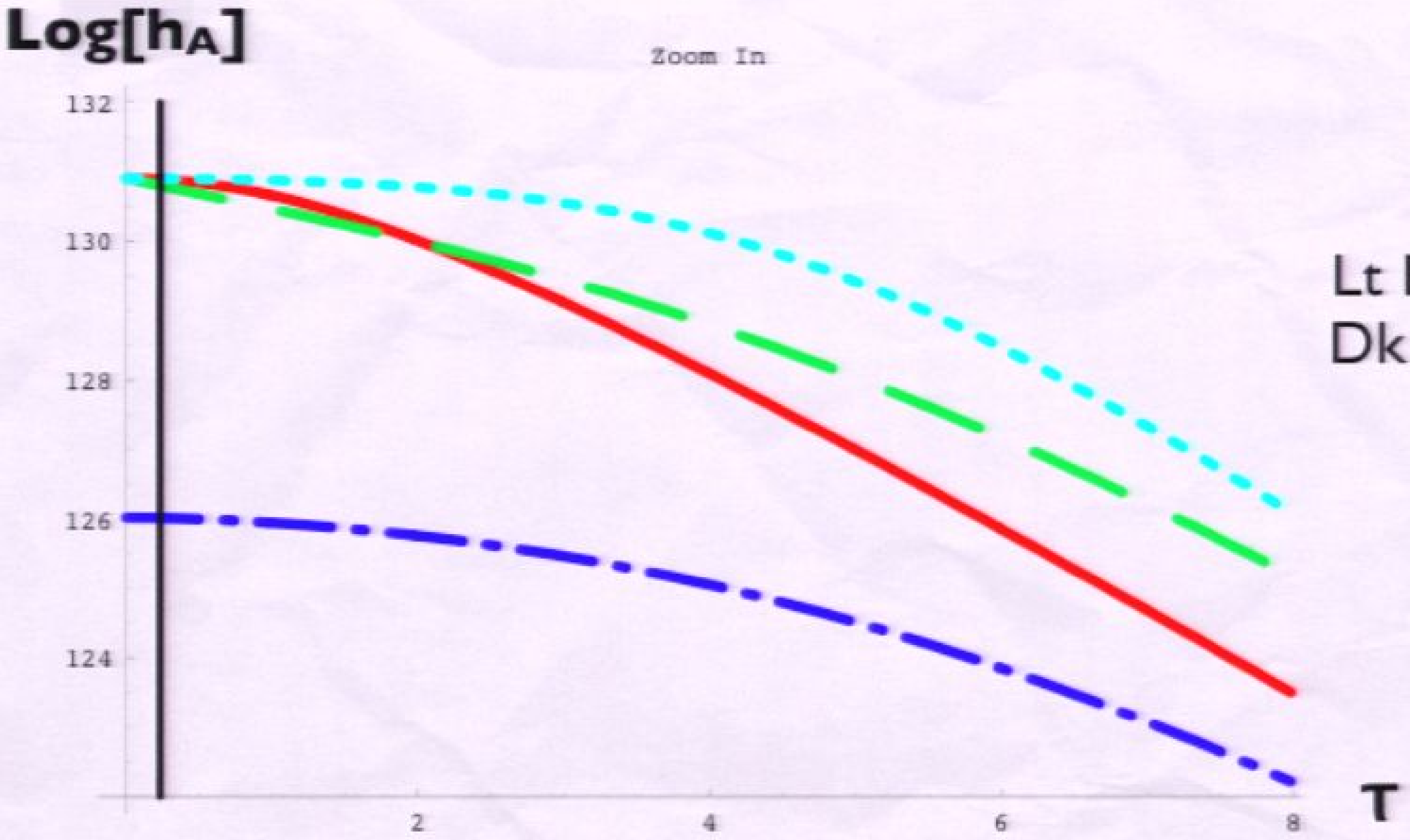
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

CHANGE IN SOUND SPEED TRACKS GEOMETRY

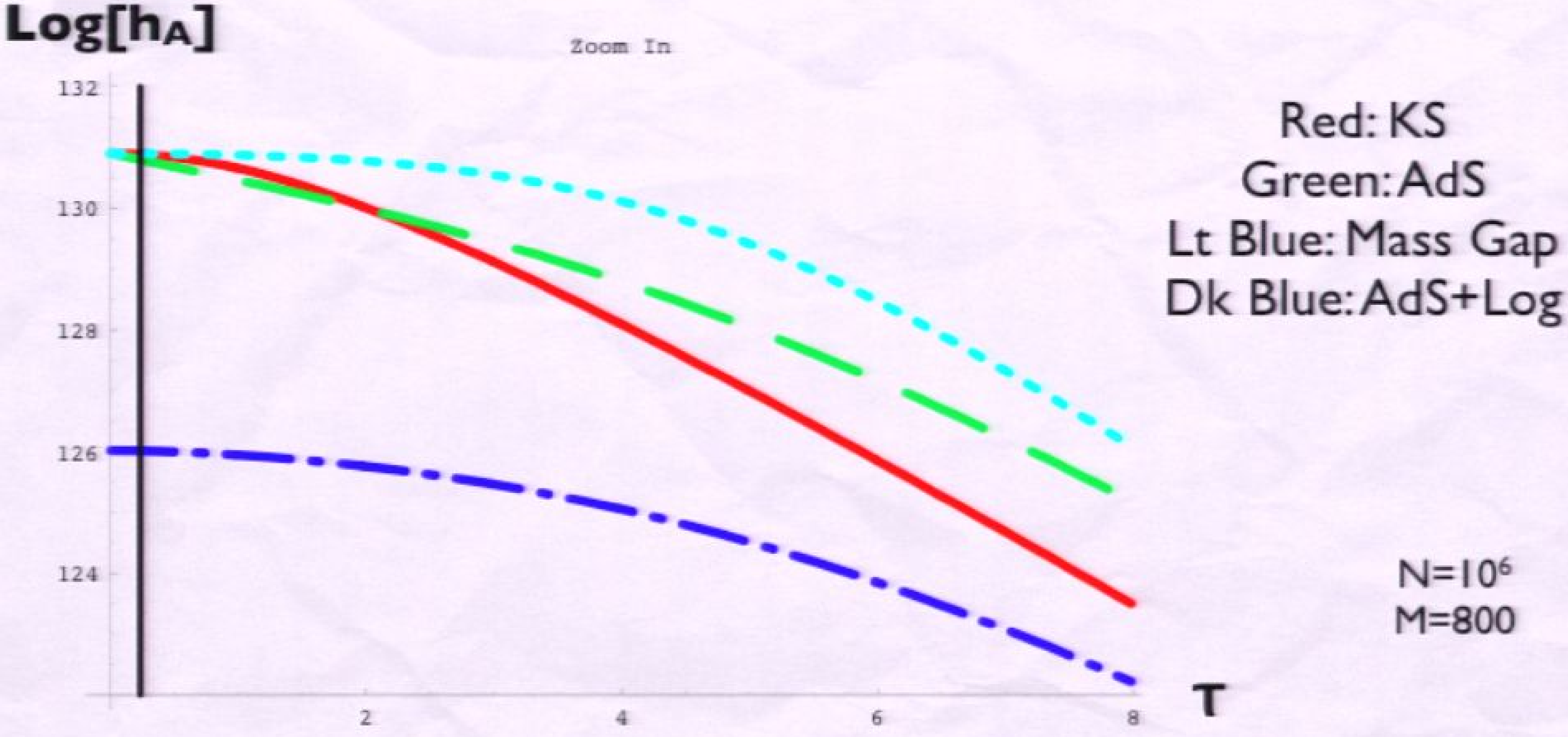


Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

PI, Oct. 30, 2007

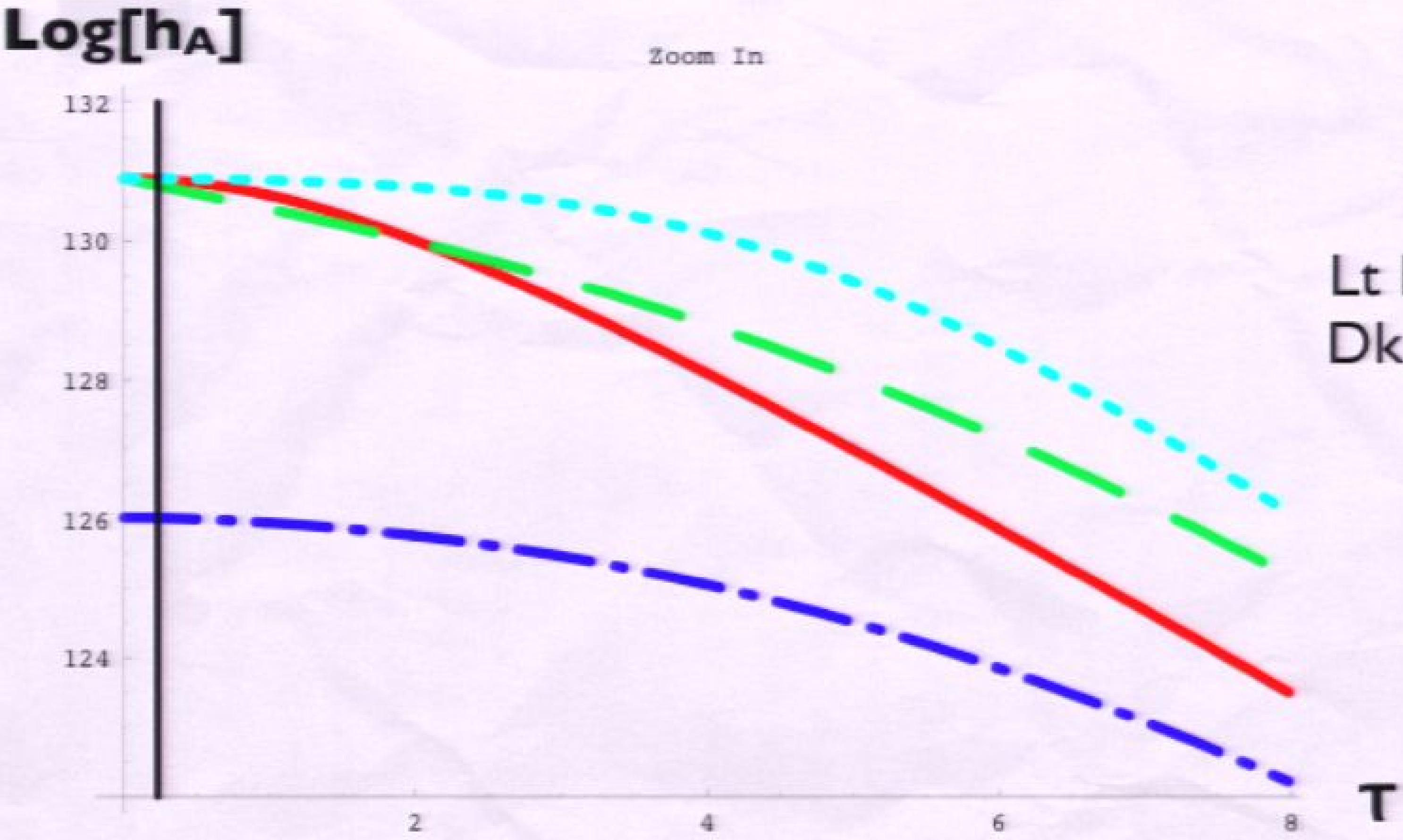
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
M=800

CHANGE IN SOUND SPEED TRACKS GEOMETRY

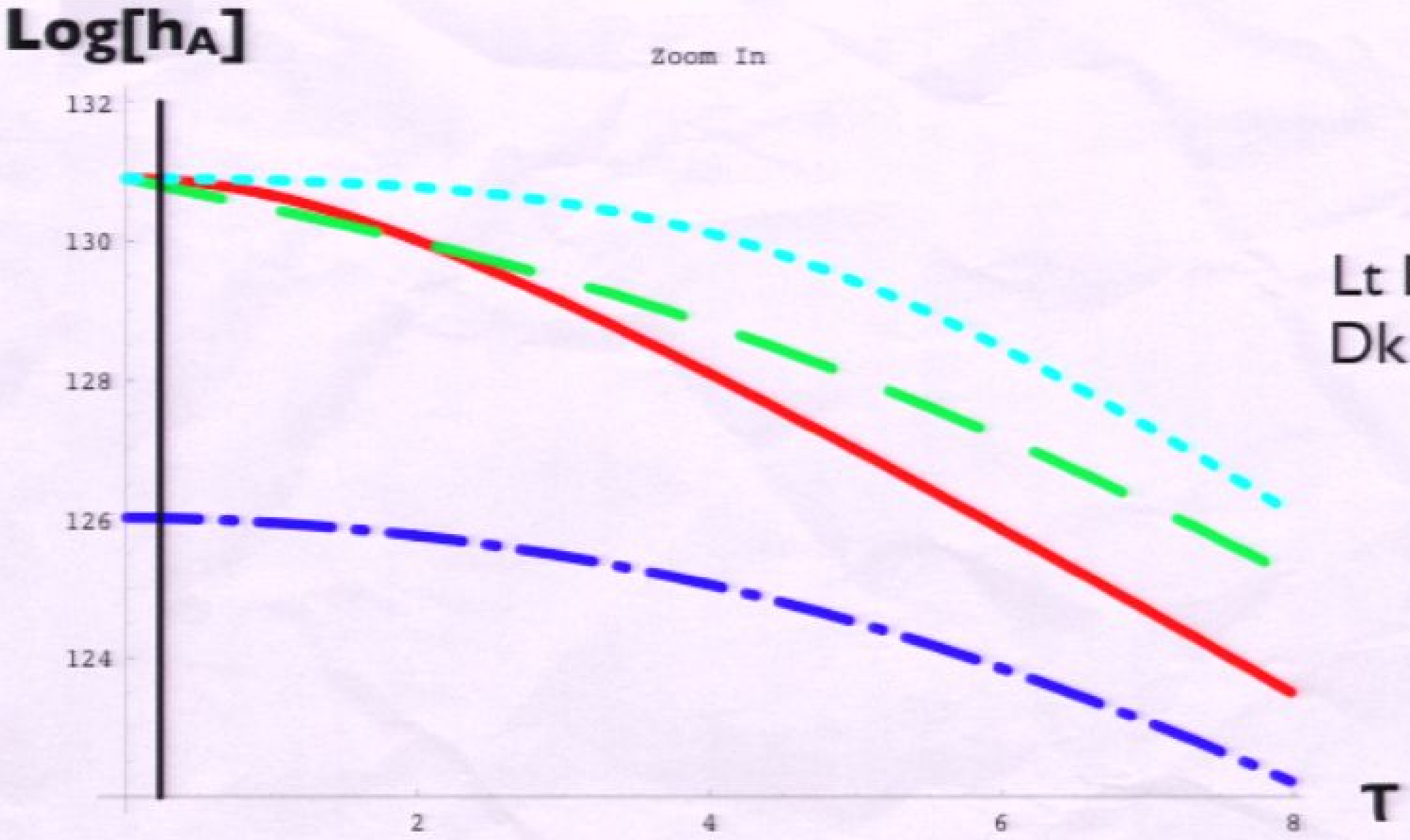


Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

PI, Oct. 30, 2007

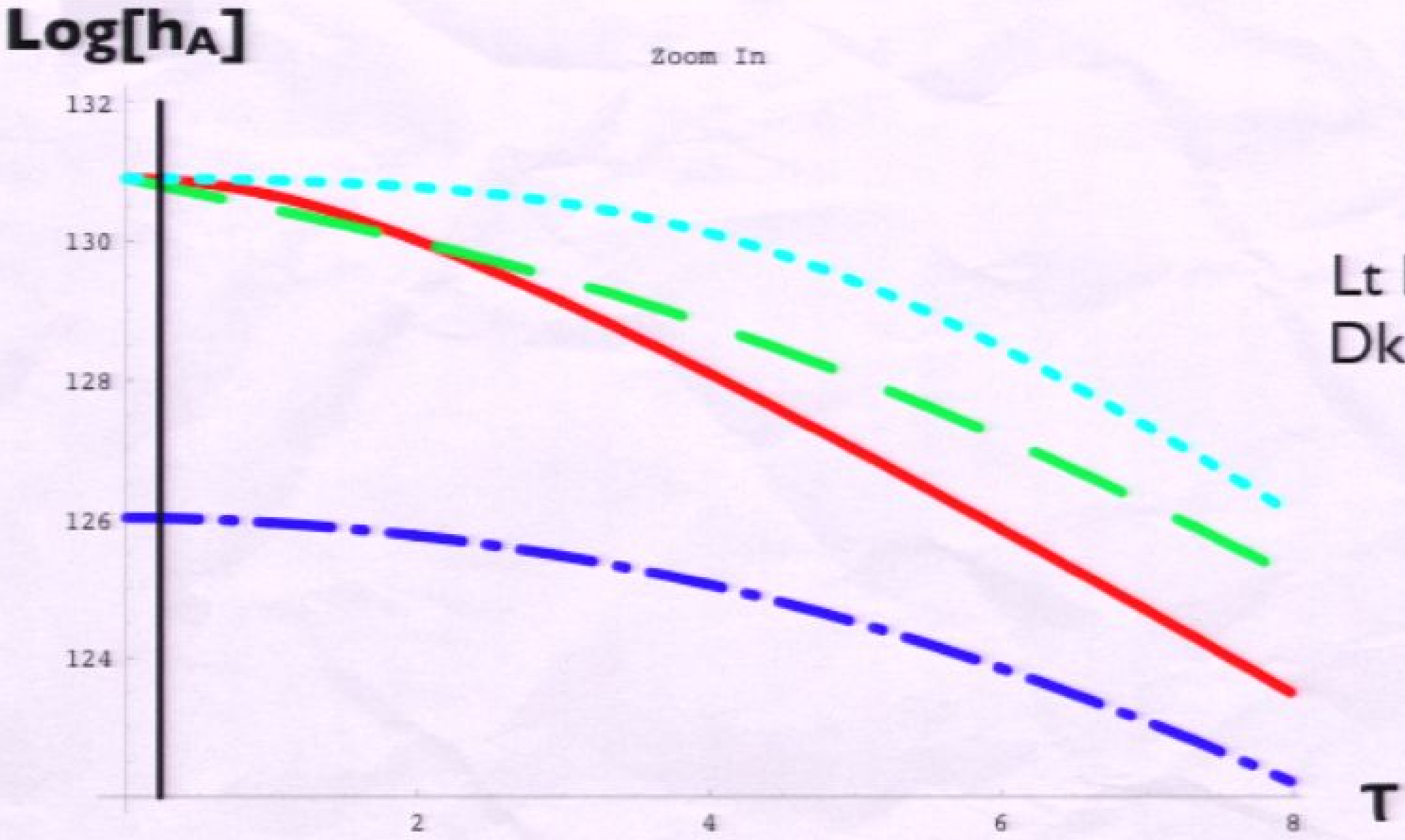
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
M=800

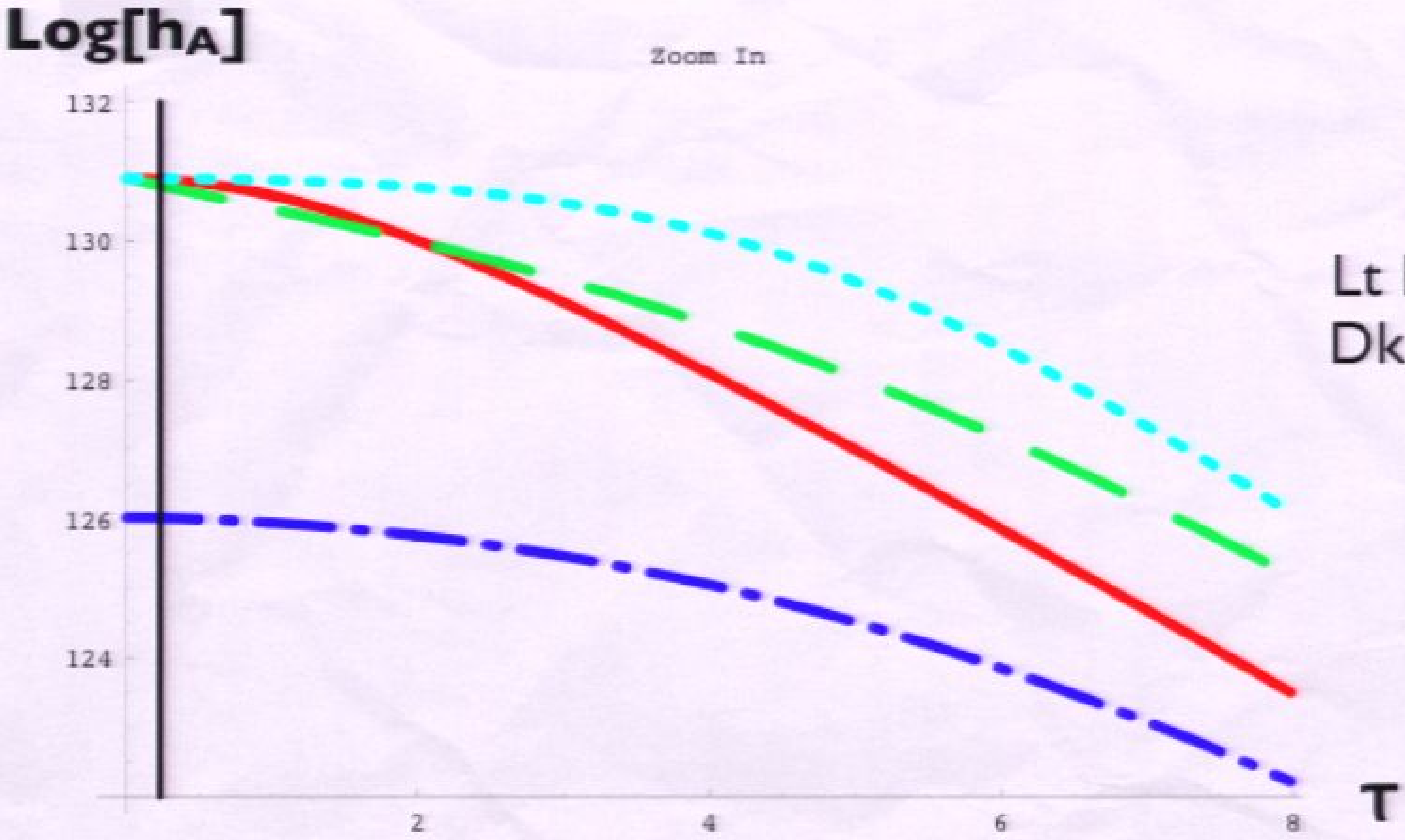
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

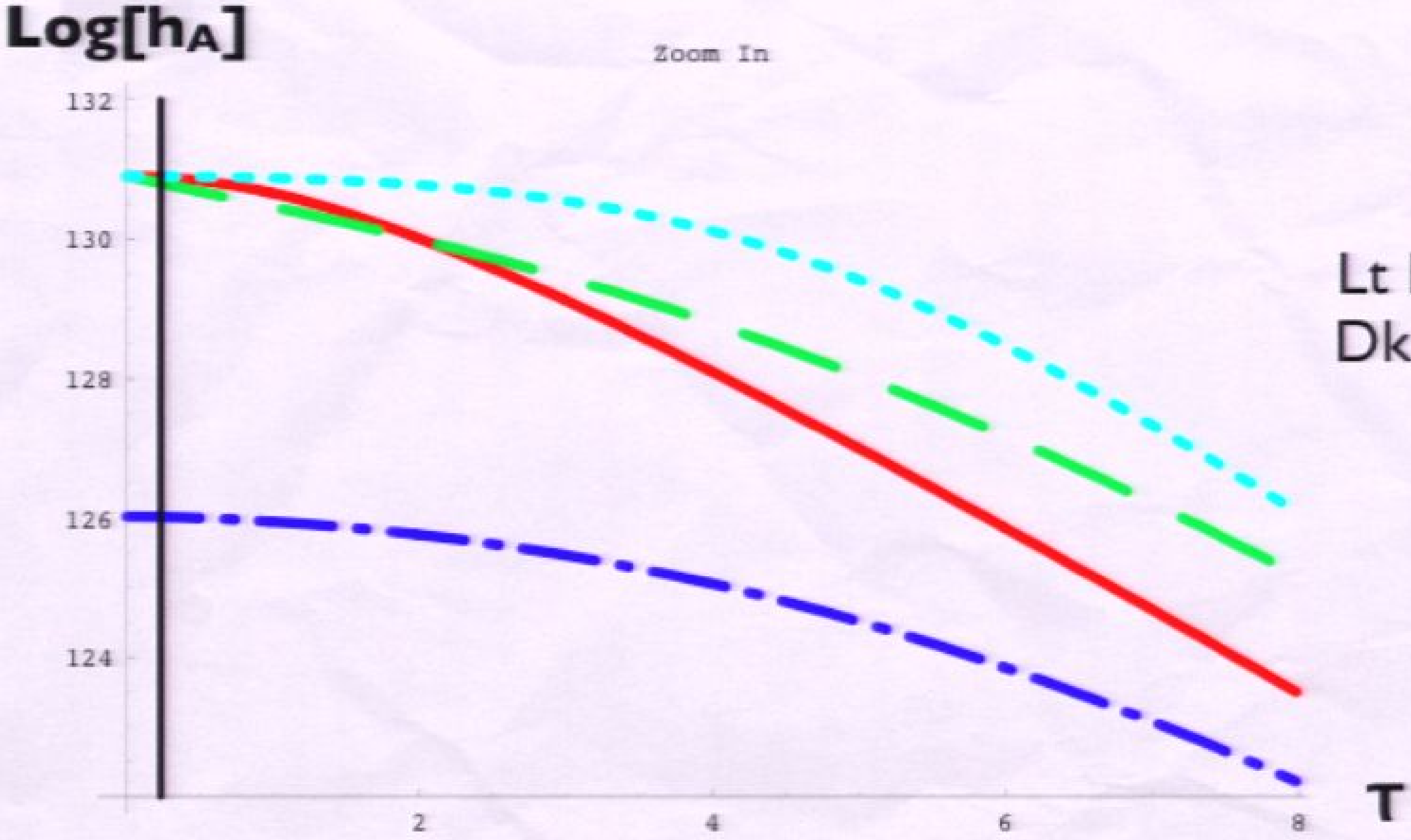
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
M=800

CHANGE IN SOUND SPEED TRACKS GEOMETRY

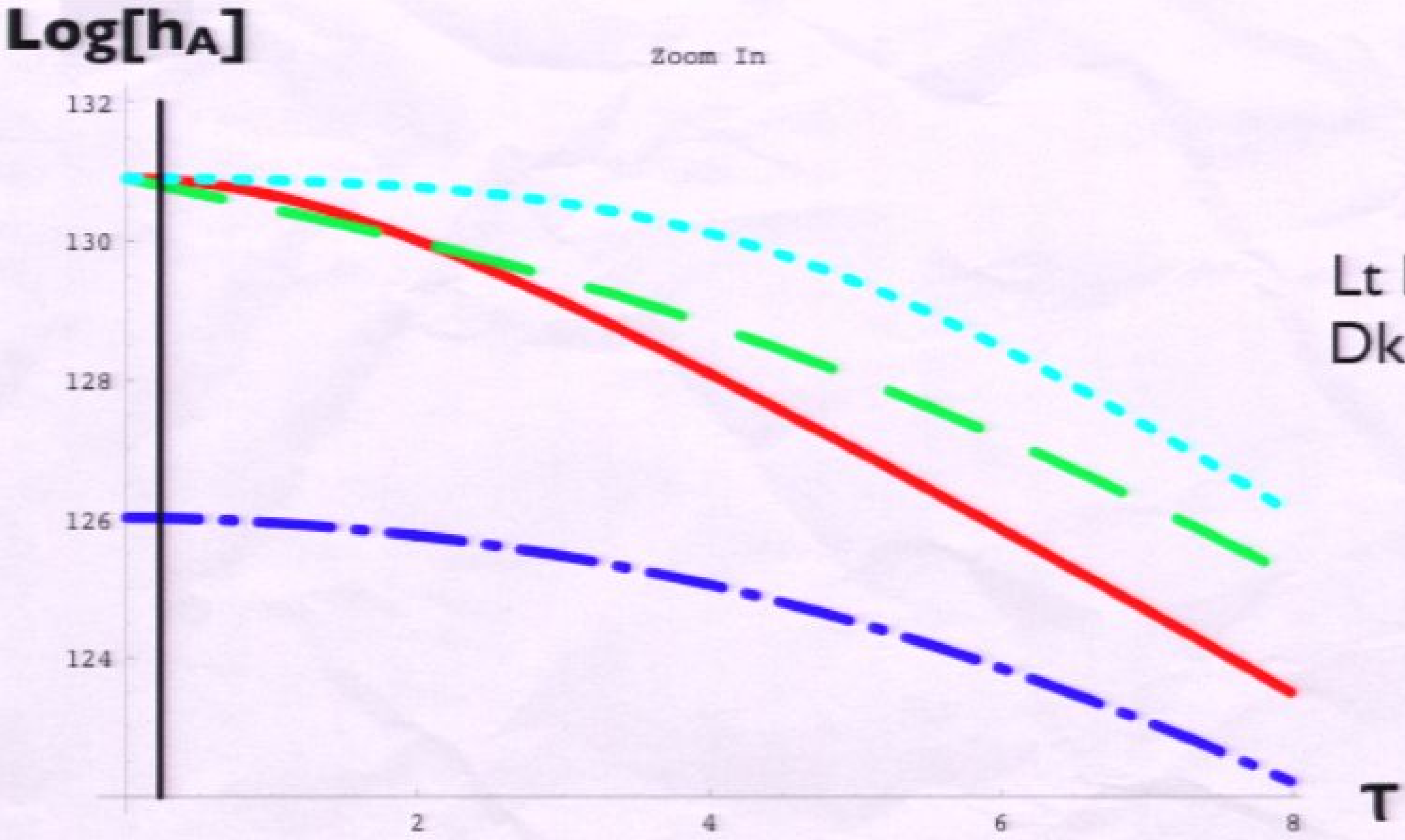


Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

N=10^6
M=800

PI, Oct. 30, 2007

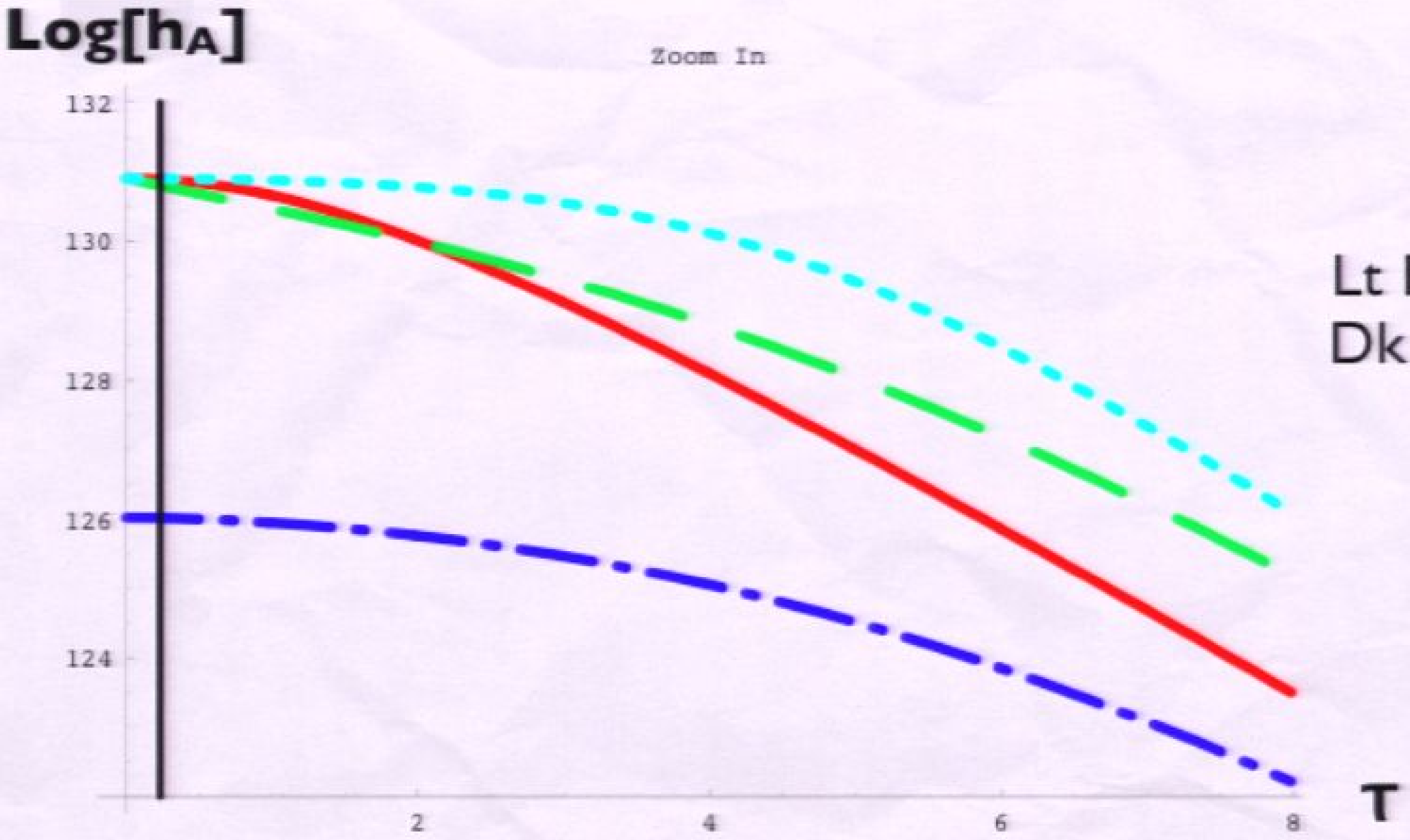
CHANGE IN SOUND SPEED TRACKS GEOMETRY



Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

$N=10^6$
$M=800$

CHANGE IN SOUND SPEED TRACKS GEOMETRY

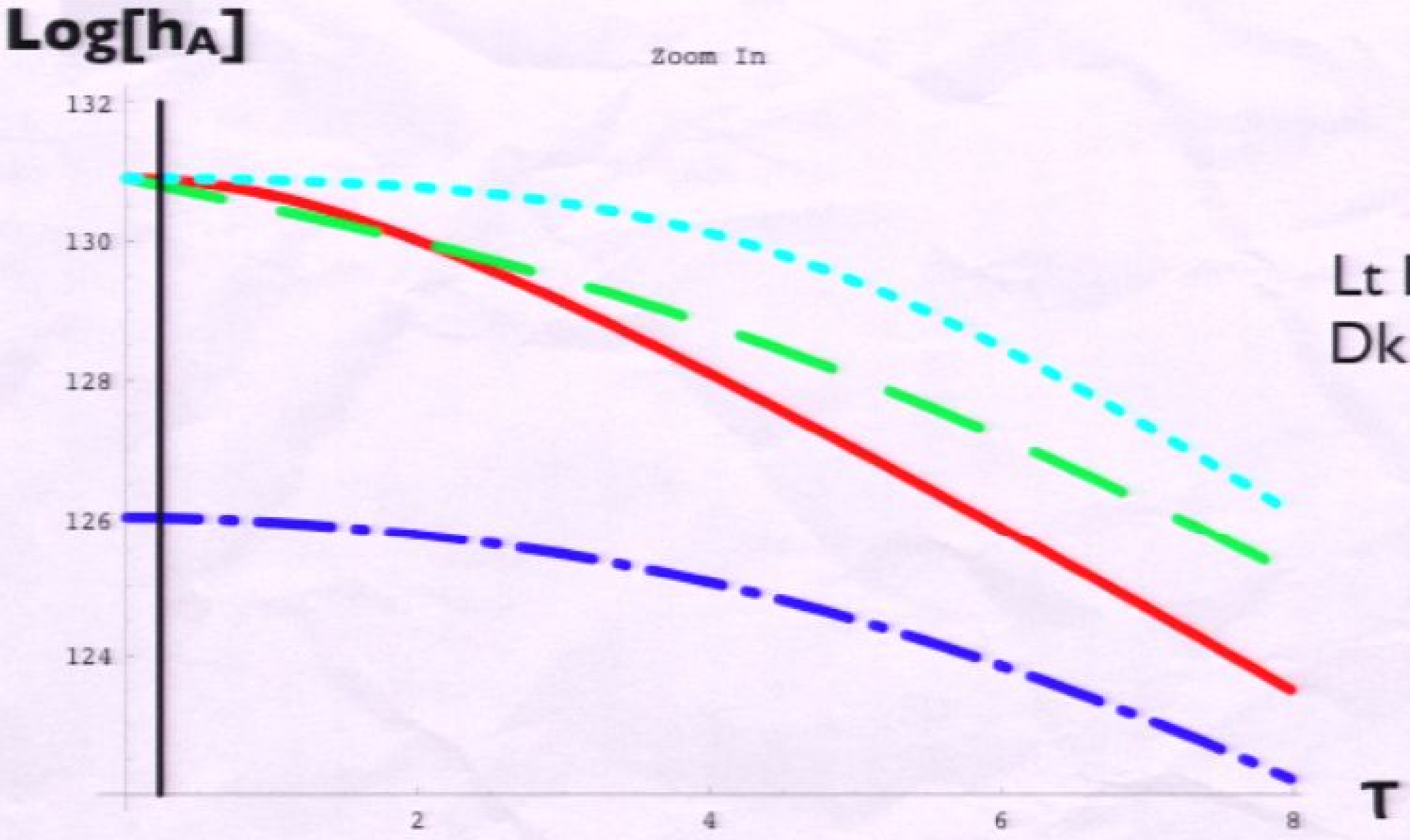


Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

N=10^6
M=800

PI, Oct. 30, 2007

CHANGE IN SOUND SPEED TRACKS GEOMETRY

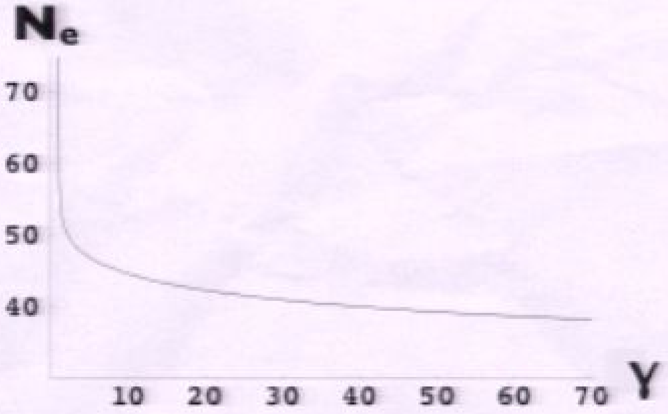


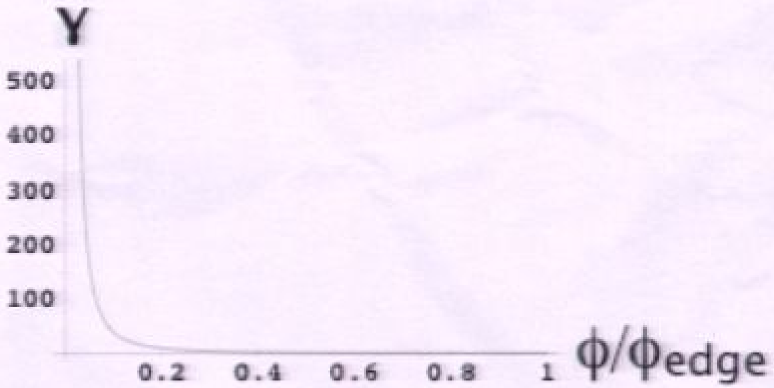
Red: KS
Green: AdS
Lt Blue: Mass Gap
Dk Blue: AdS+Log

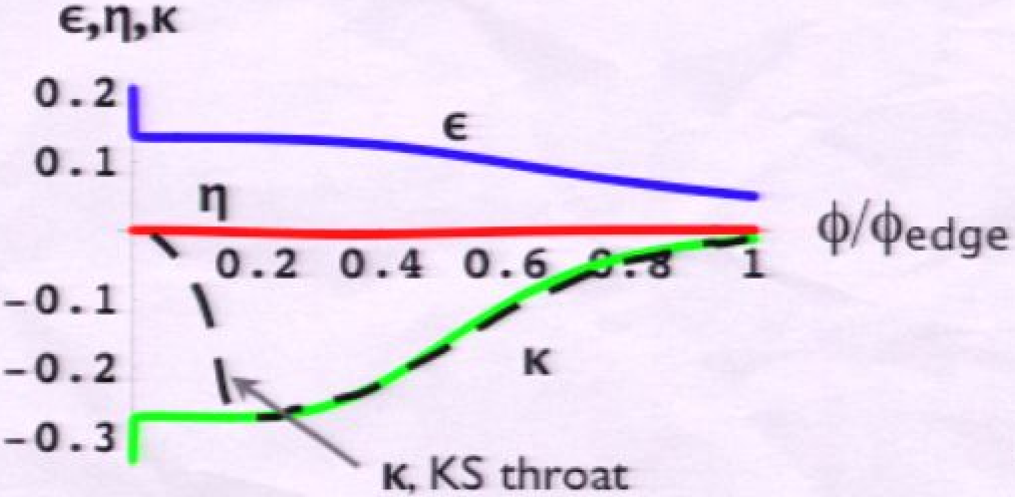
$N=10^6$
$M=800$

PI, Oct. 30, 2007

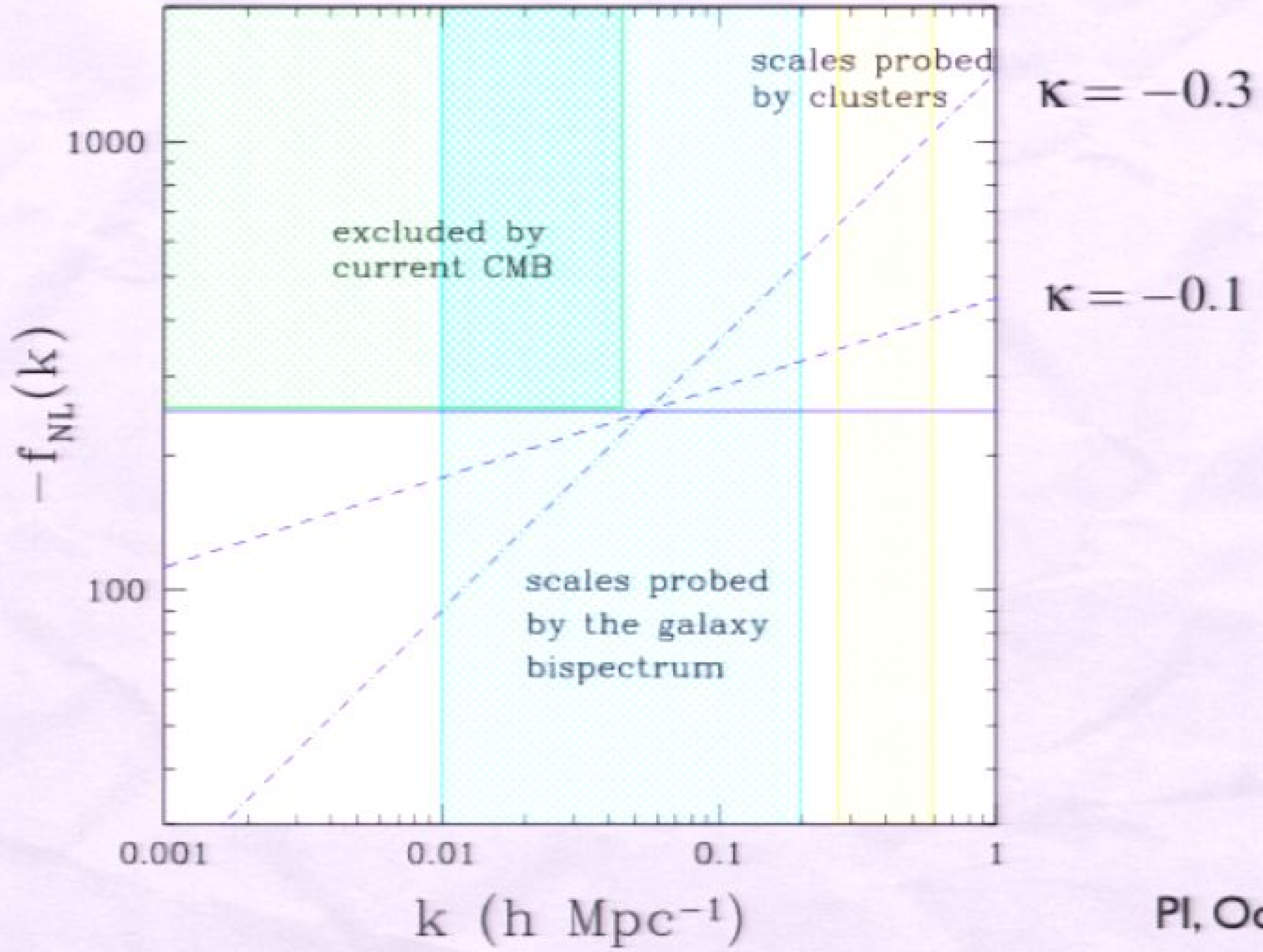
IN THE ADS THROAT





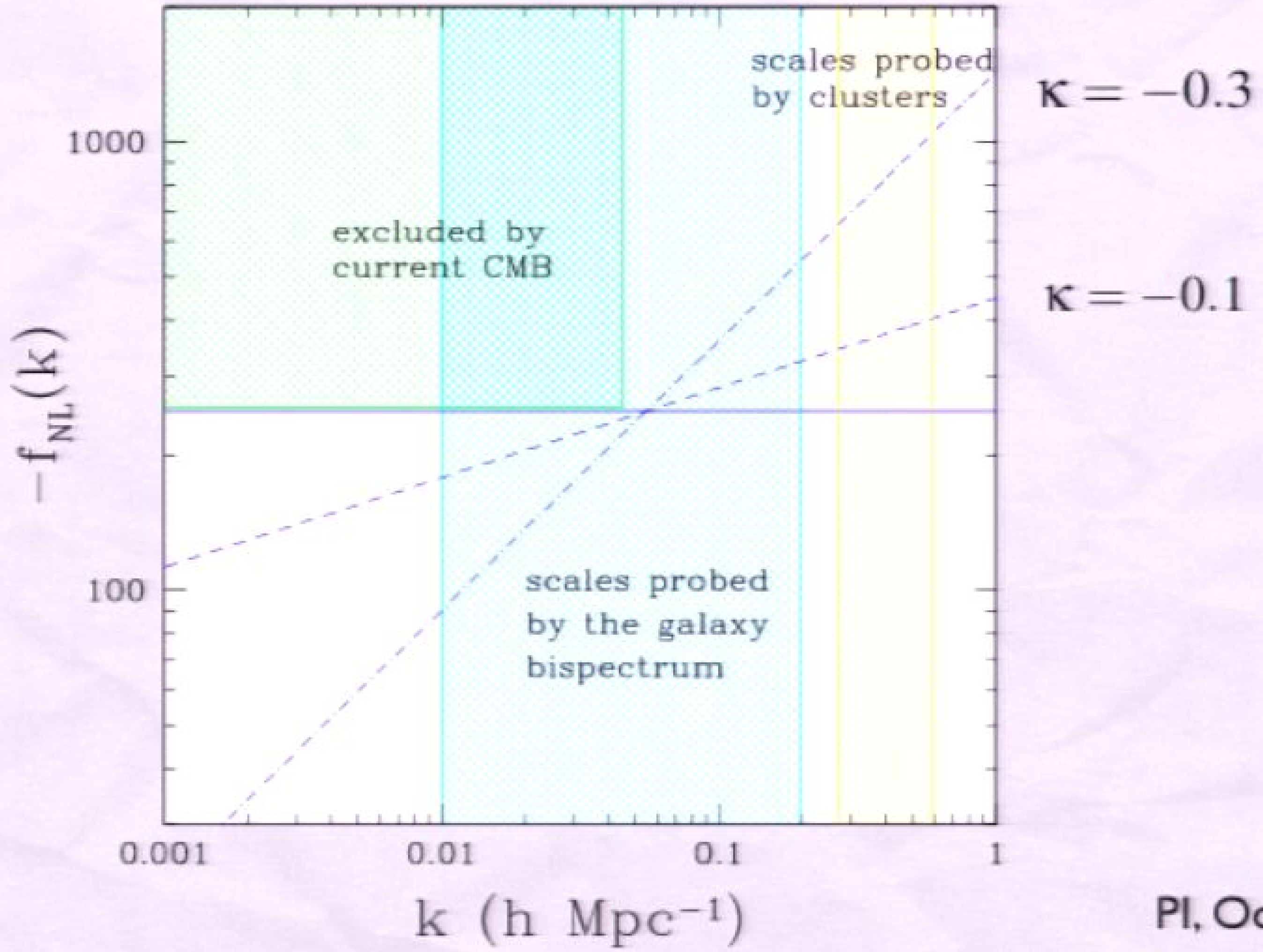


RELEVANT OBSERVATIONS

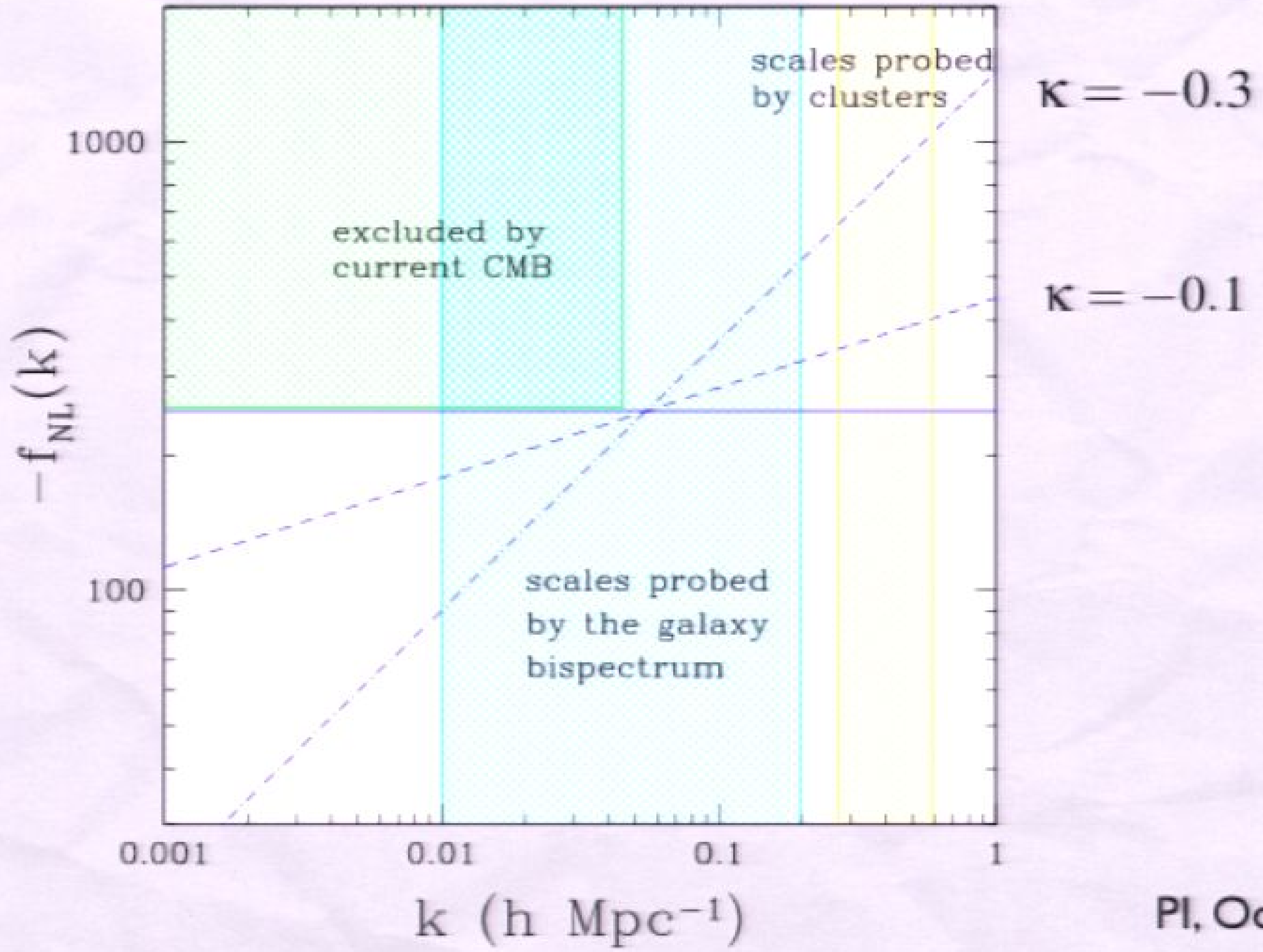


PI, Oct. 30, 2007

RELEVANT OBSERVATIONS

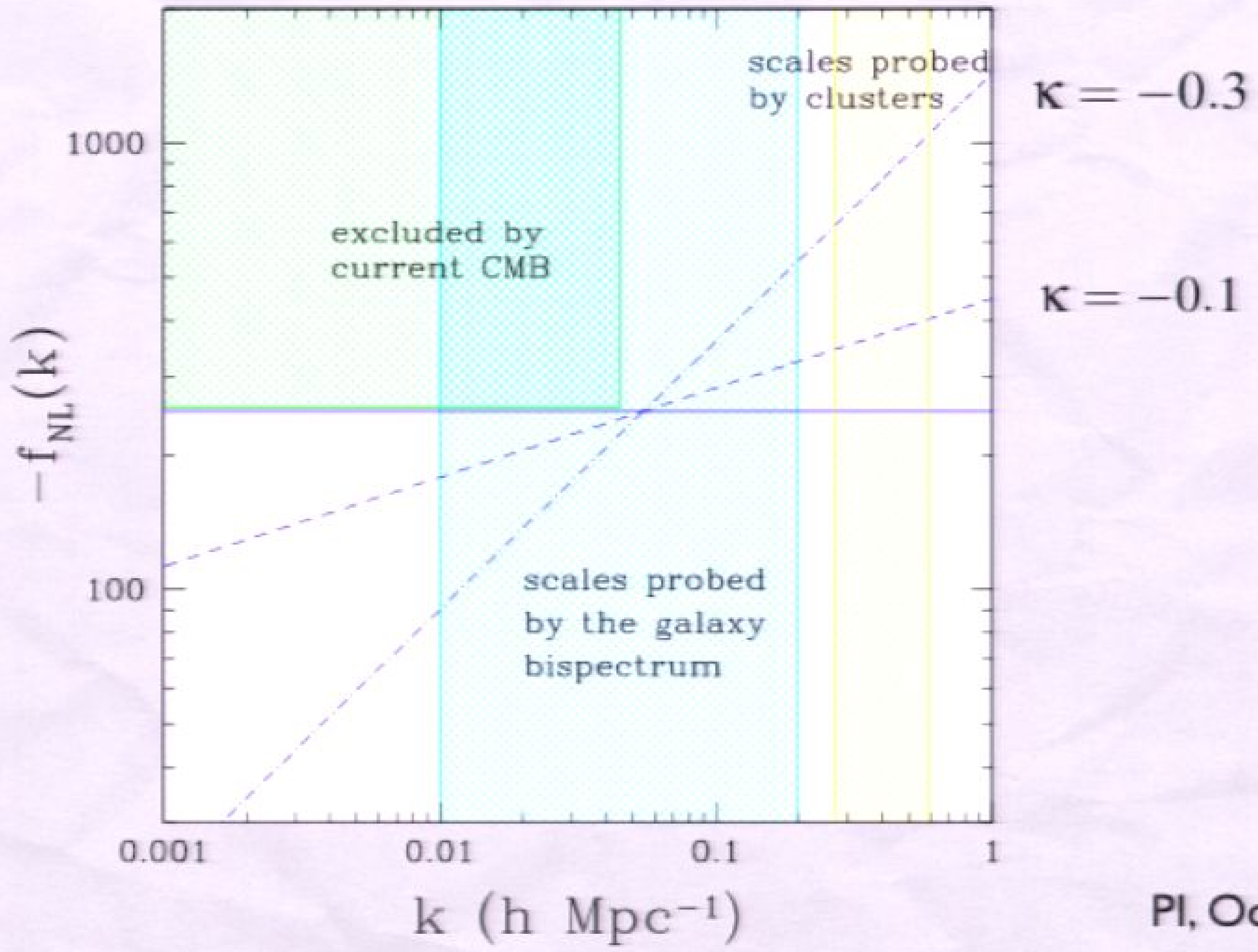


RELEVANT OBSERVATIONS

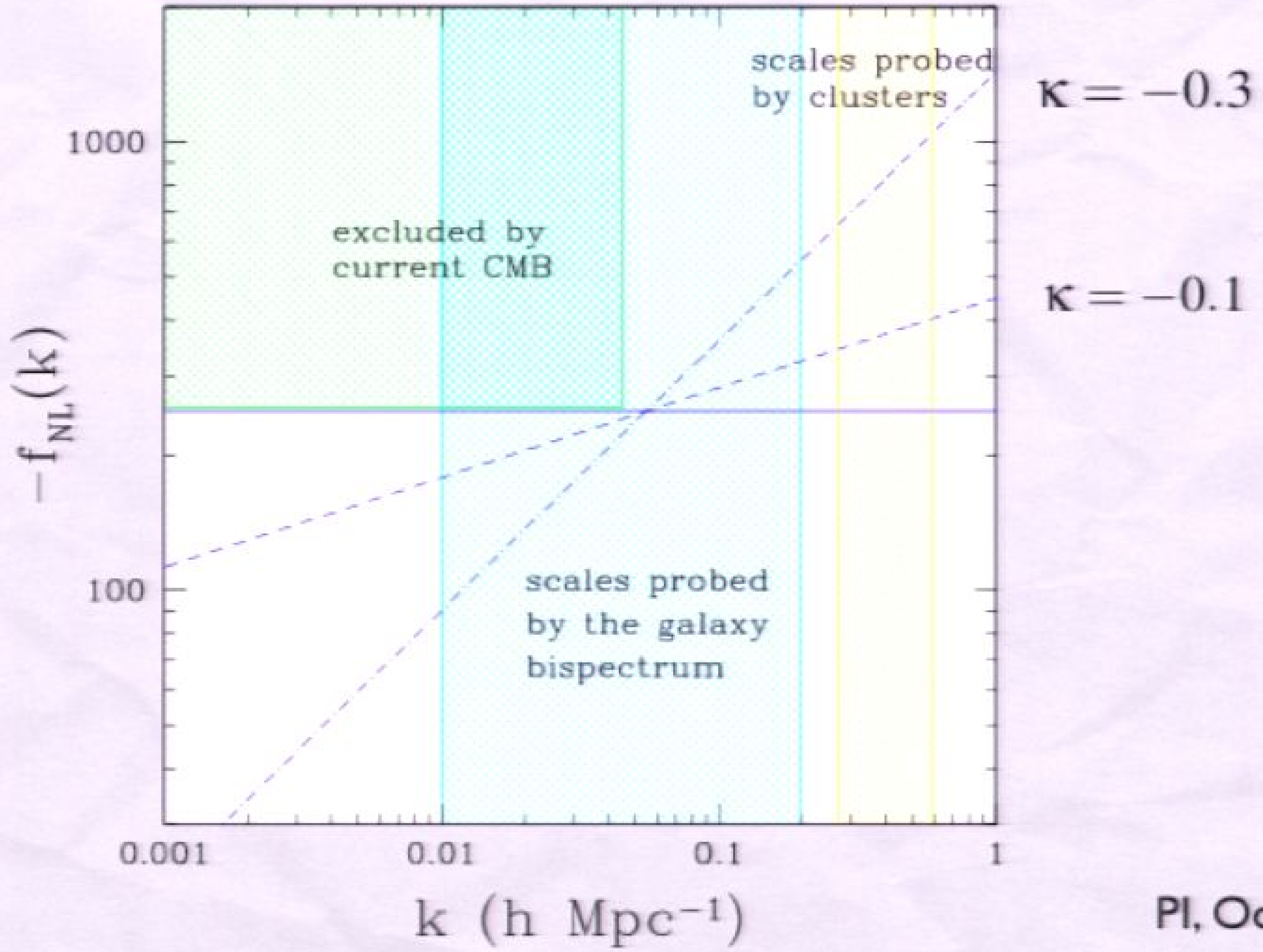


PI, Oct. 30, 2007

RELEVANT OBSERVATIONS

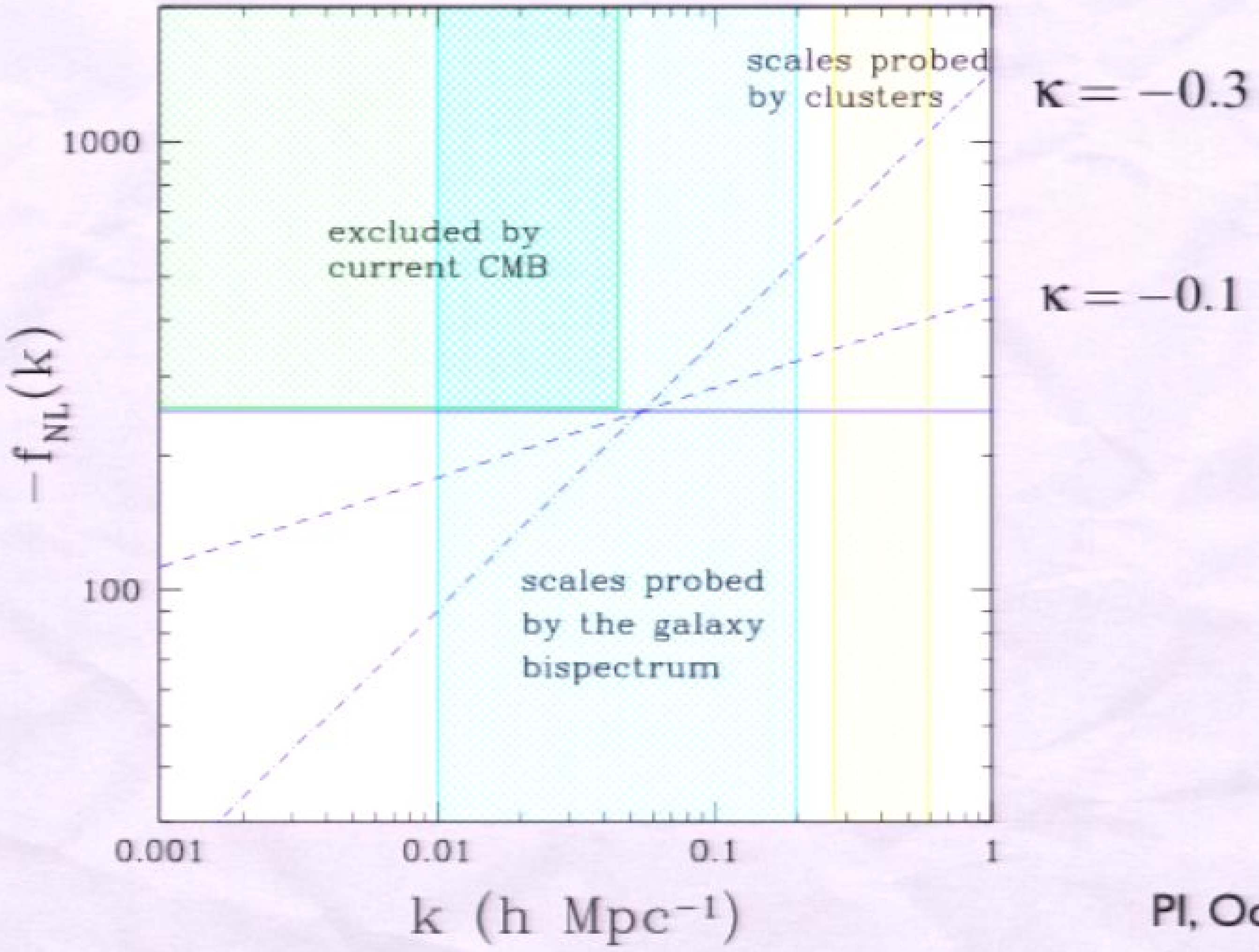


RELEVANT OBSERVATIONS



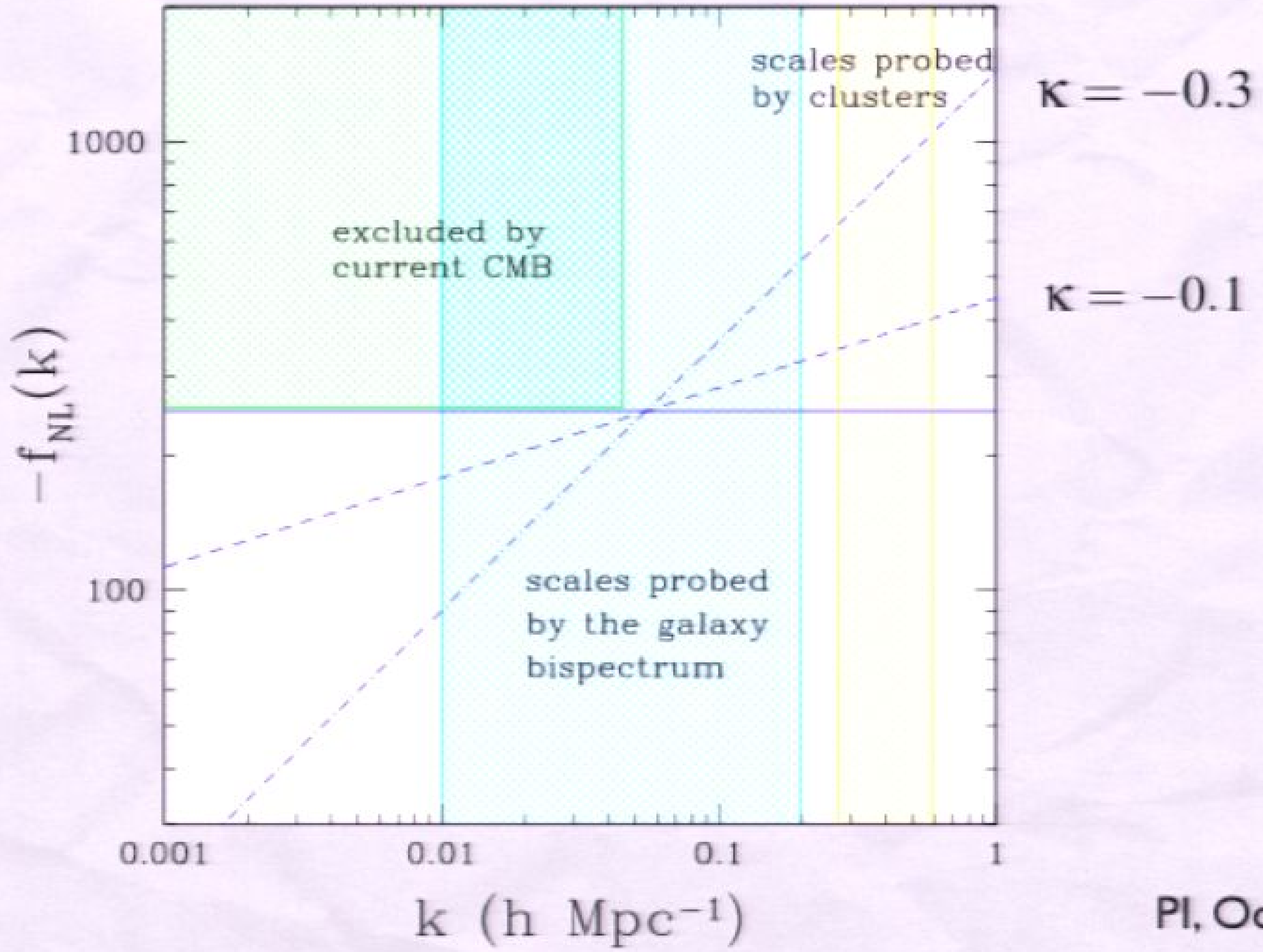
PI, Oct. 30, 2007

RELEVANT OBSERVATIONS



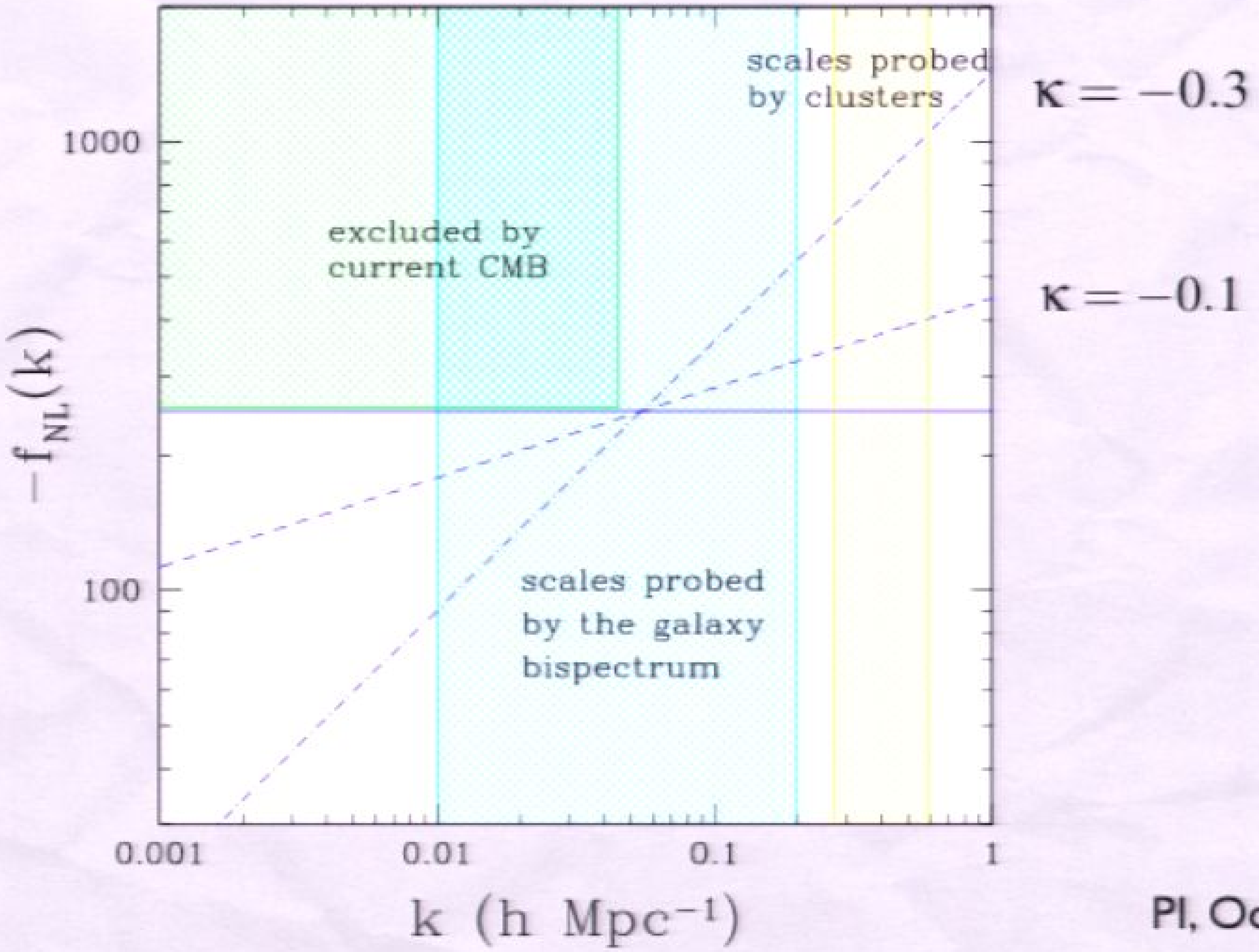
PI, Oct. 30, 2007

RELEVANT OBSERVATIONS

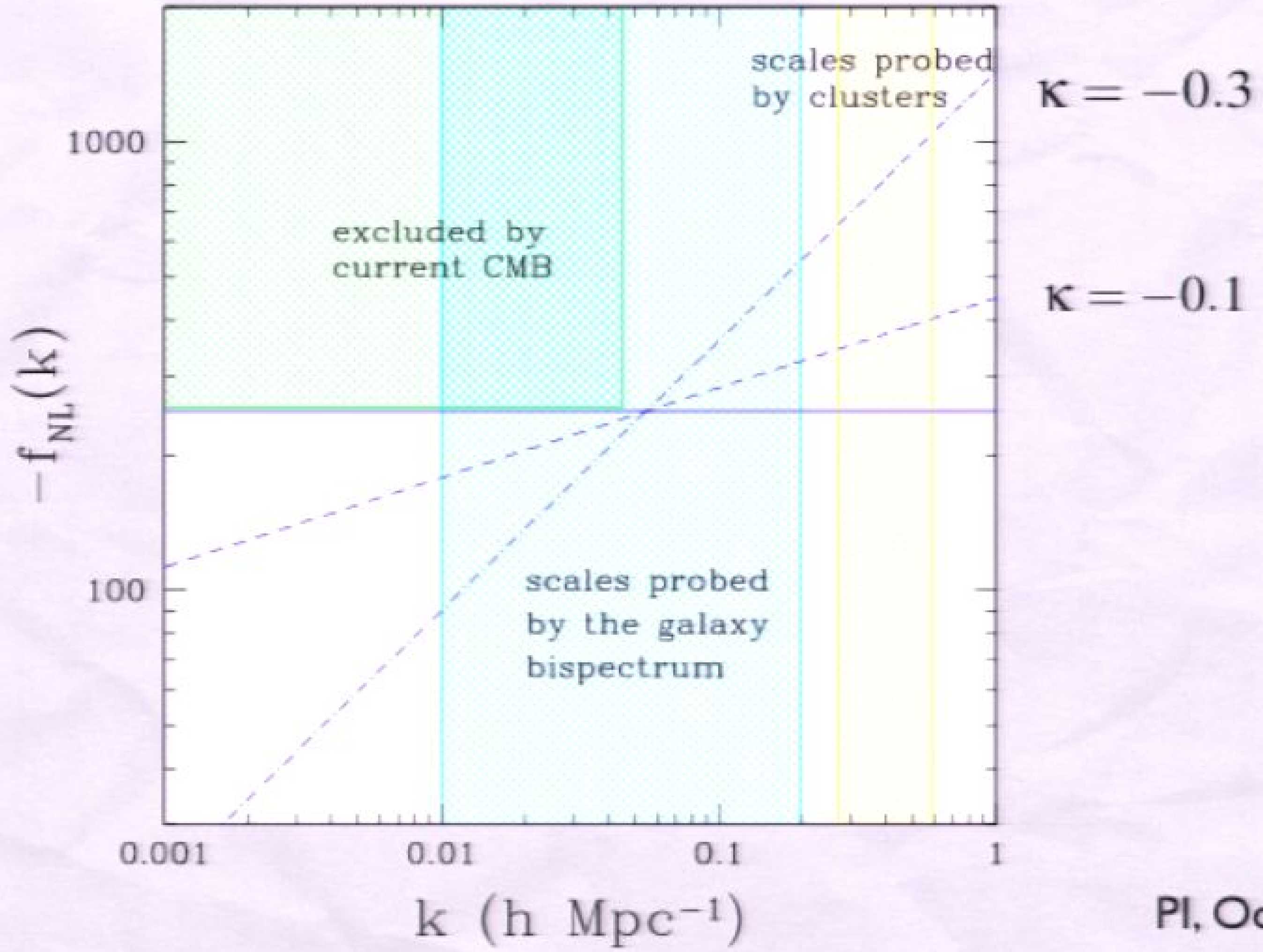


PI, Oct. 30, 2007

RELEVANT OBSERVATIONS

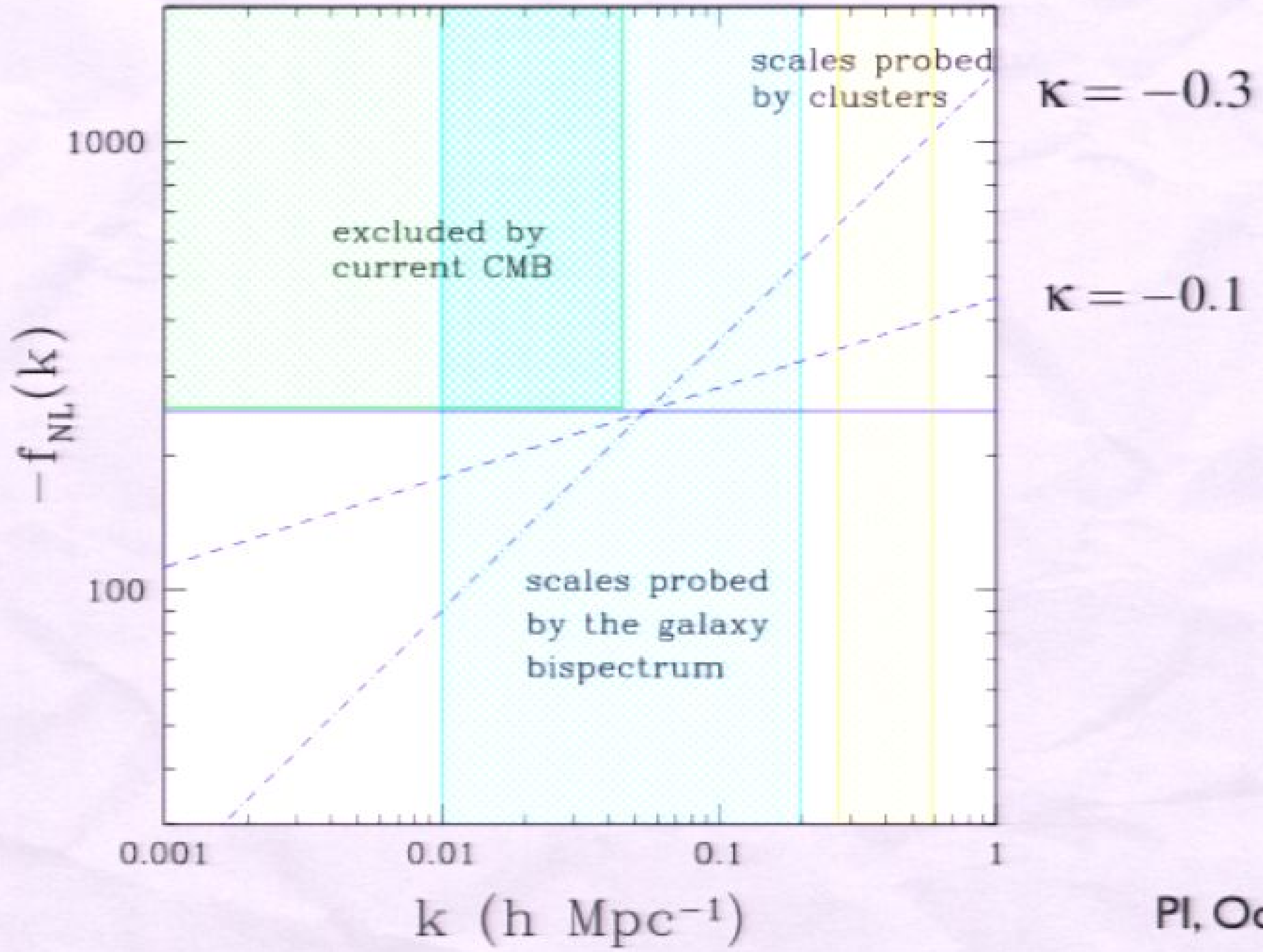


RELEVANT OBSERVATIONS



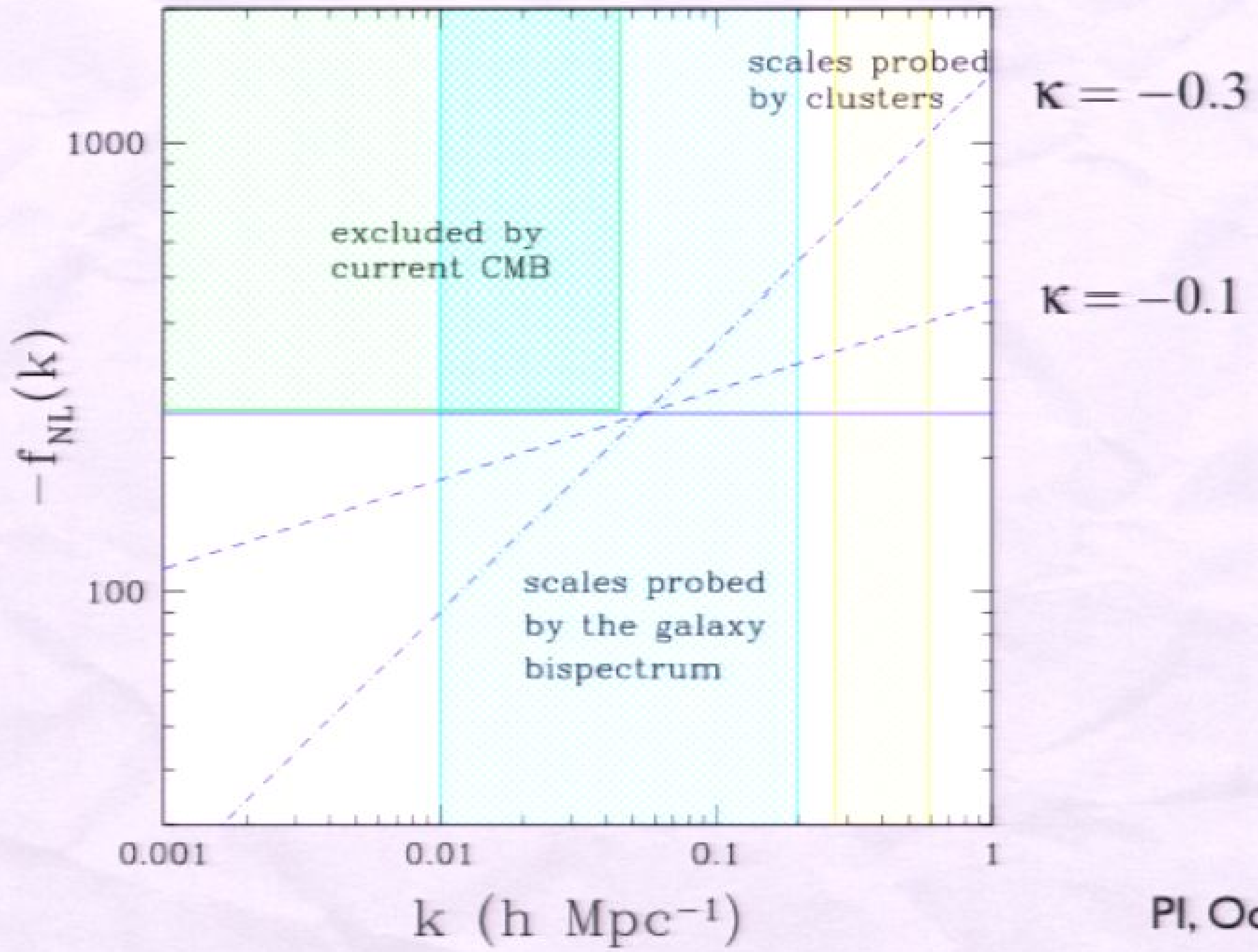
PI, Oct. 30, 2007

RELEVANT OBSERVATIONS

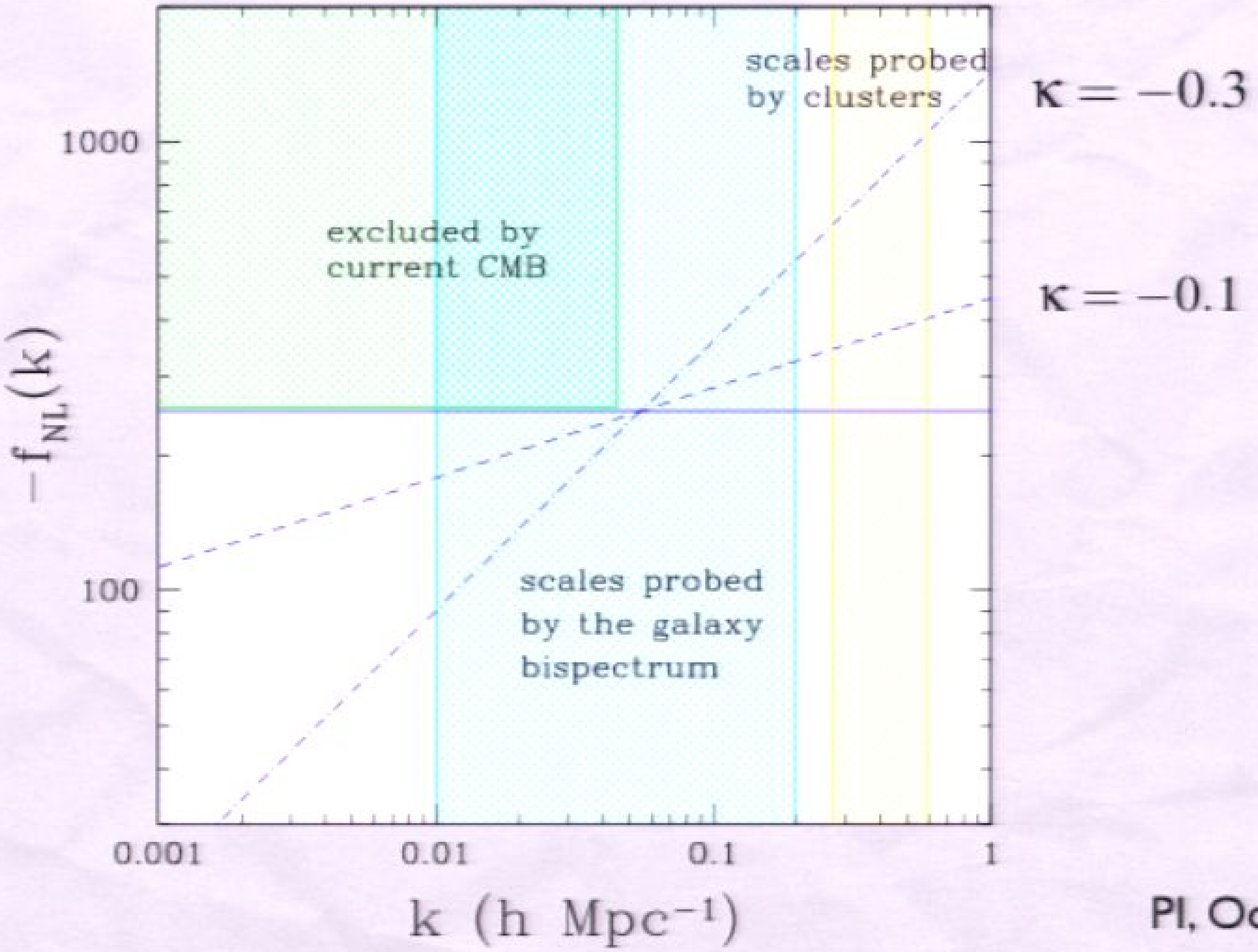


PI, Oct. 30, 2007

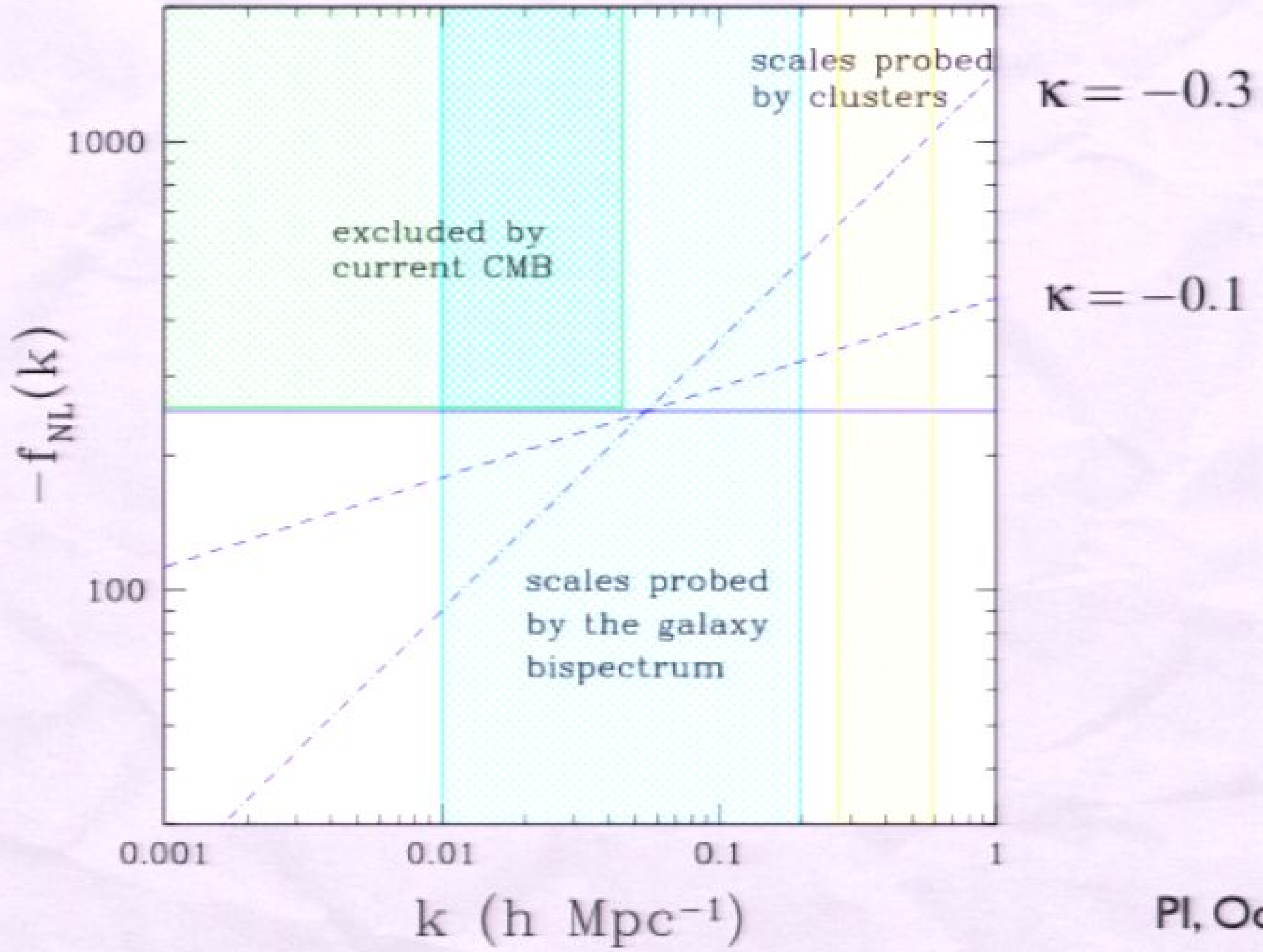
RELEVANT OBSERVATIONS



RELEVANT OBSERVATIONS

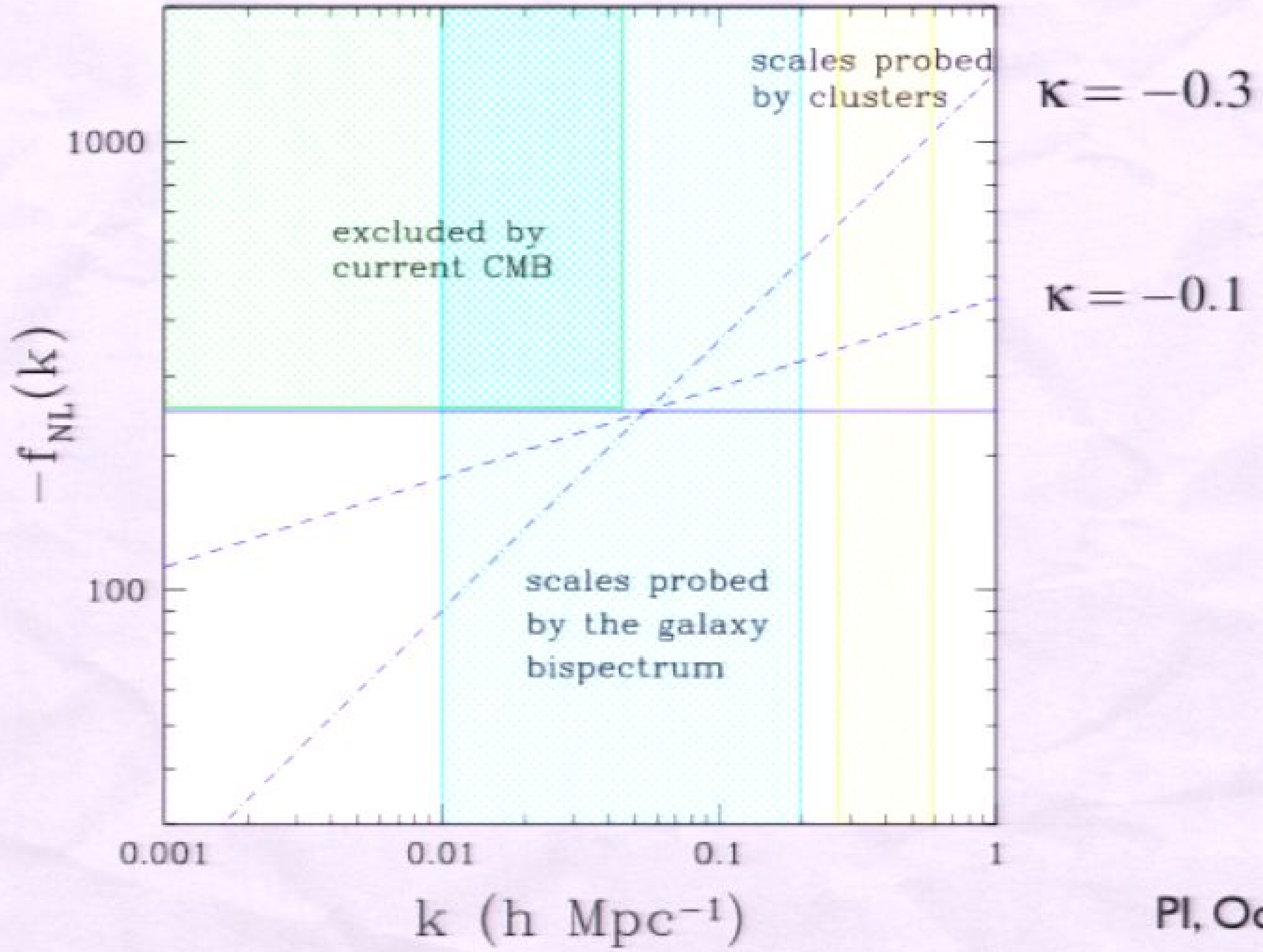


RELEVANT OBSERVATIONS



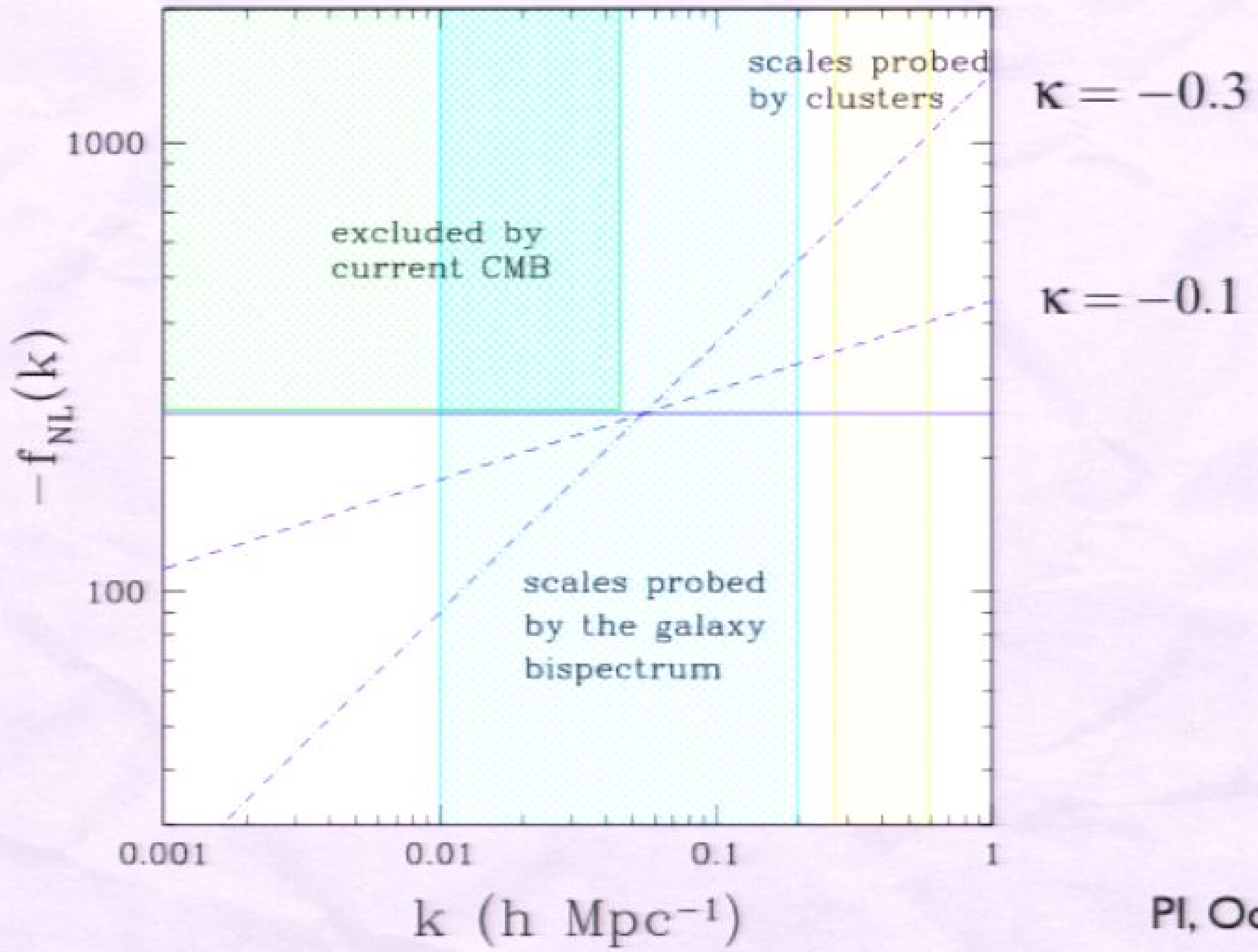
PI, Oct. 30, 2007

RELEVANT OBSERVATIONS

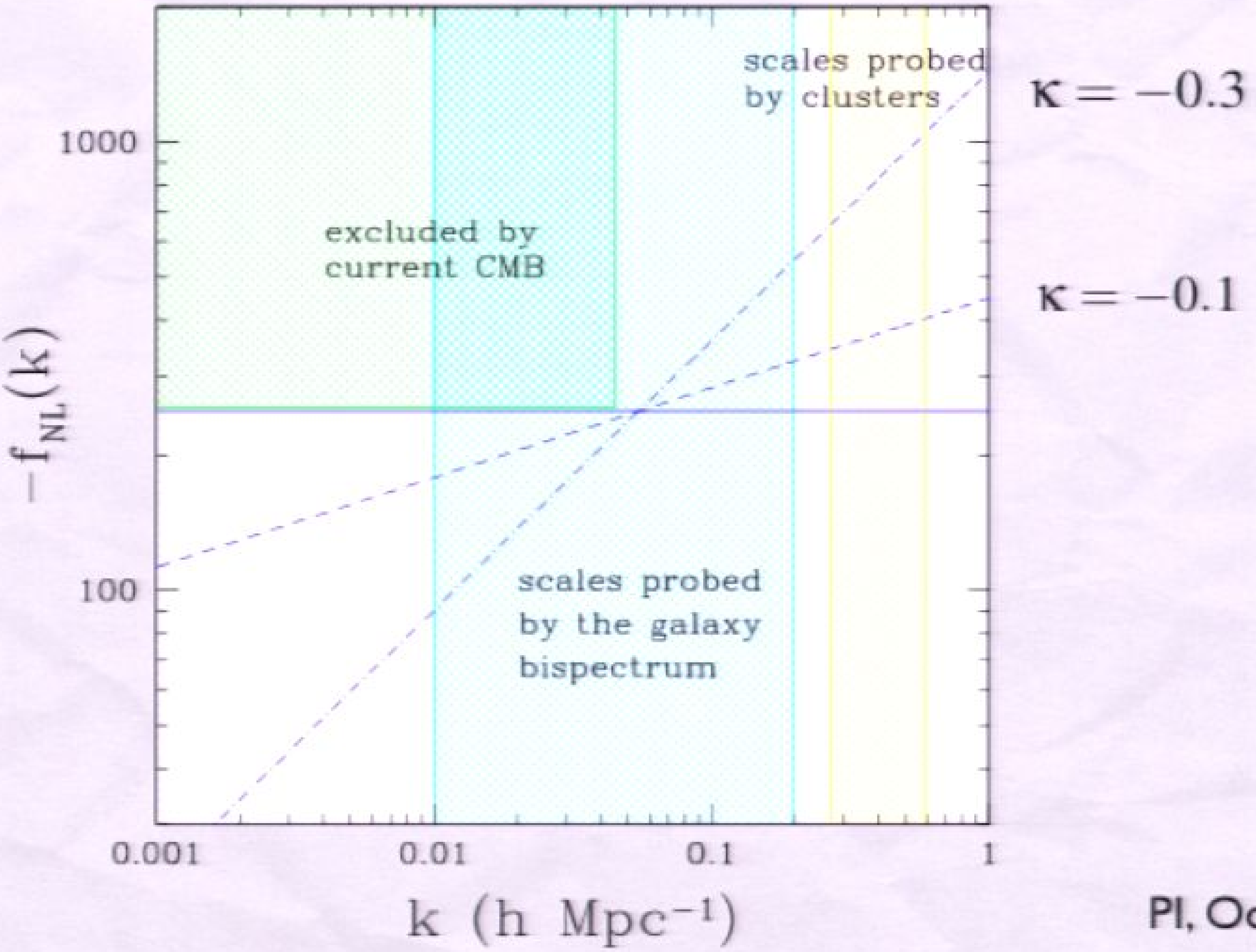


PI, Oct. 30, 2007

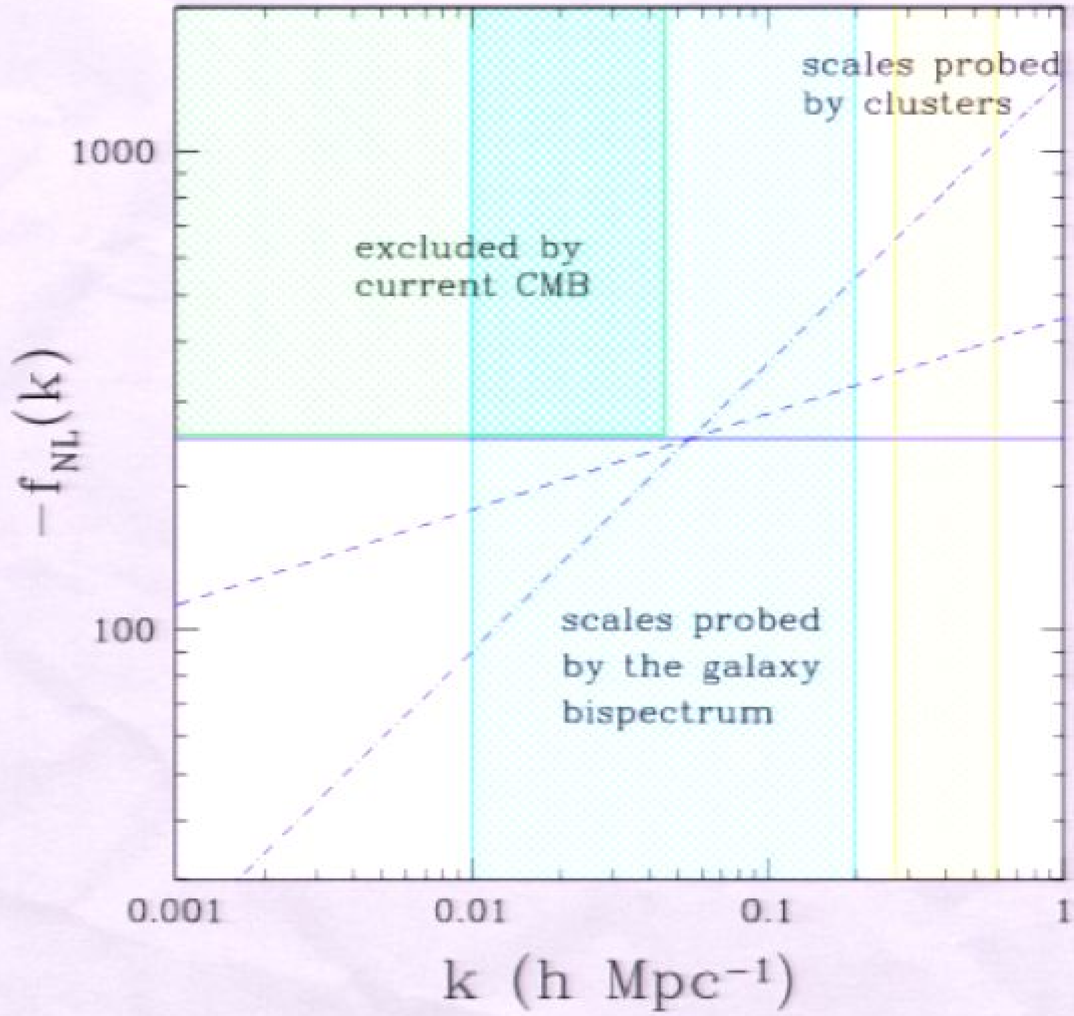
RELEVANT OBSERVATIONS



RELEVANT OBSERVATIONS



RELEVANT OBSERVATIONS

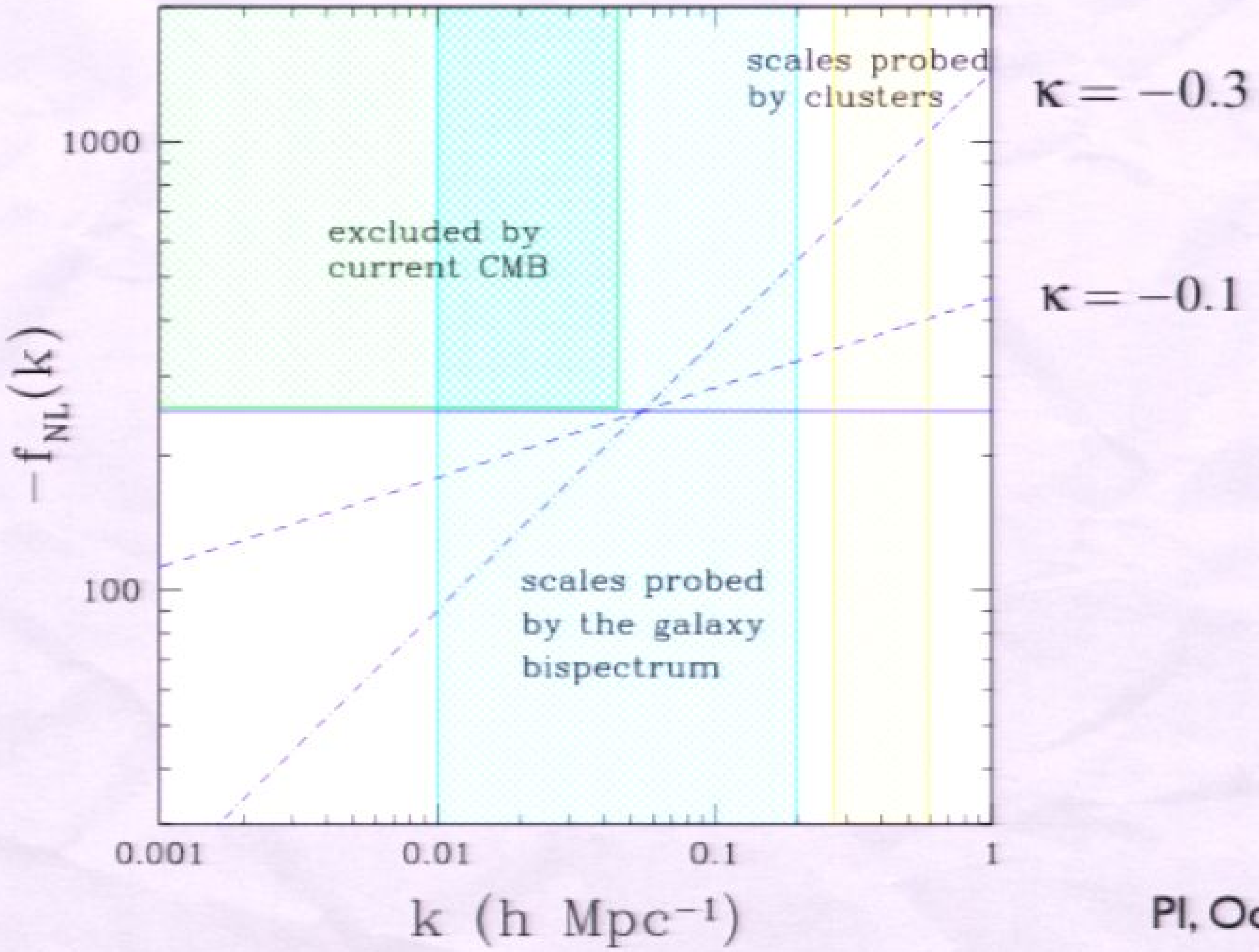


$\kappa = -0.3$

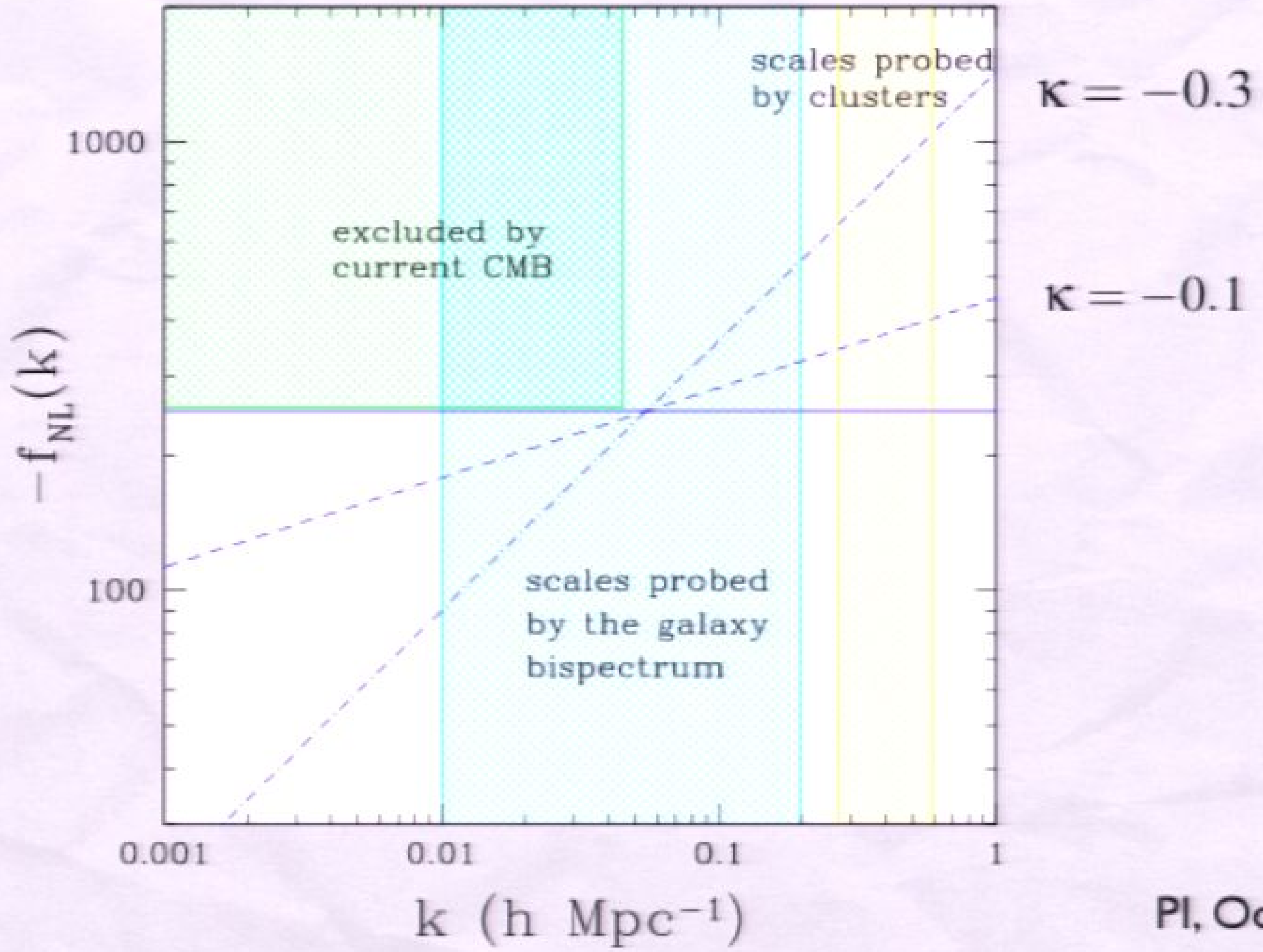
$\kappa = -0.1$

PI, Oct. 30, 2007

RELEVANT OBSERVATIONS

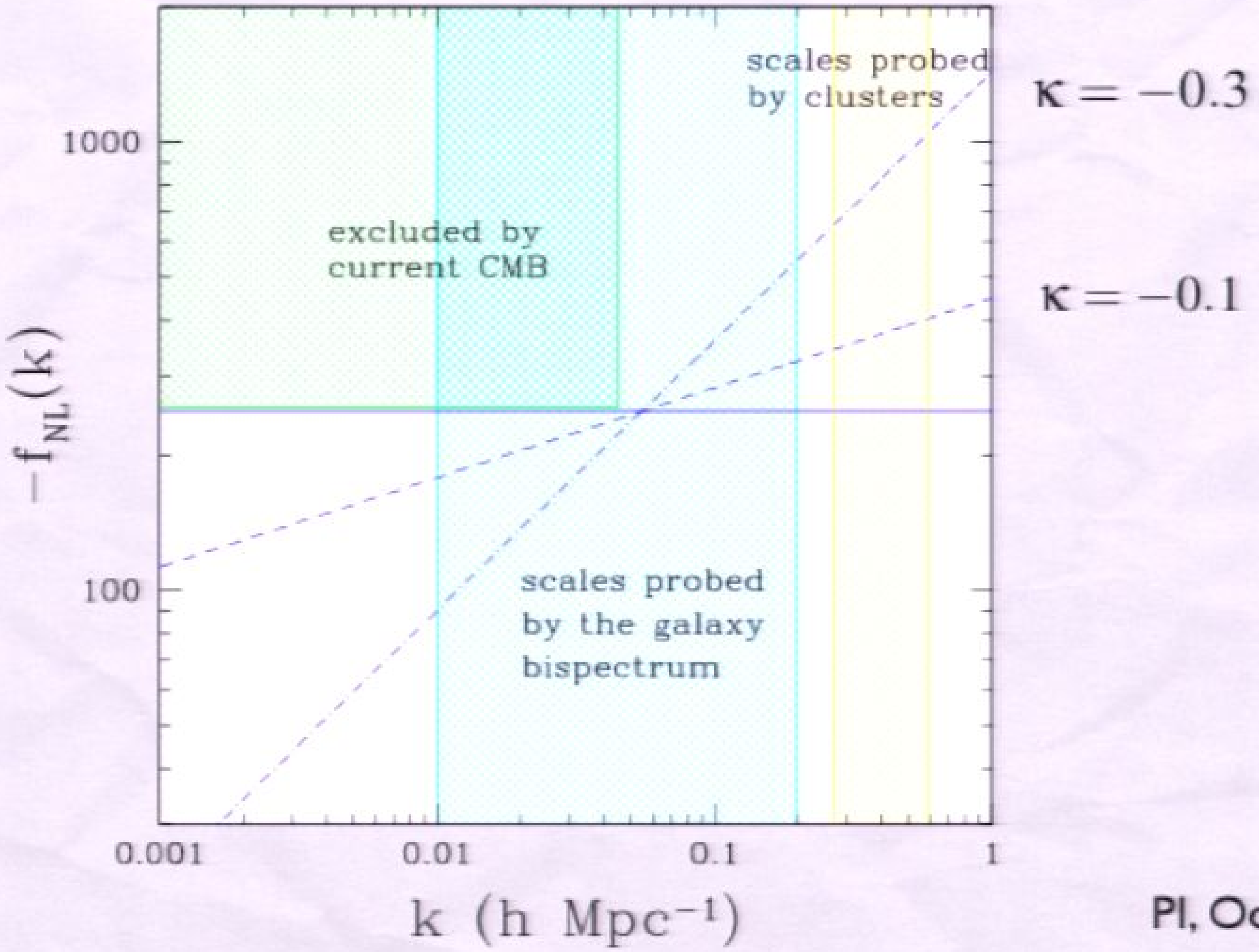


RELEVANT OBSERVATIONS



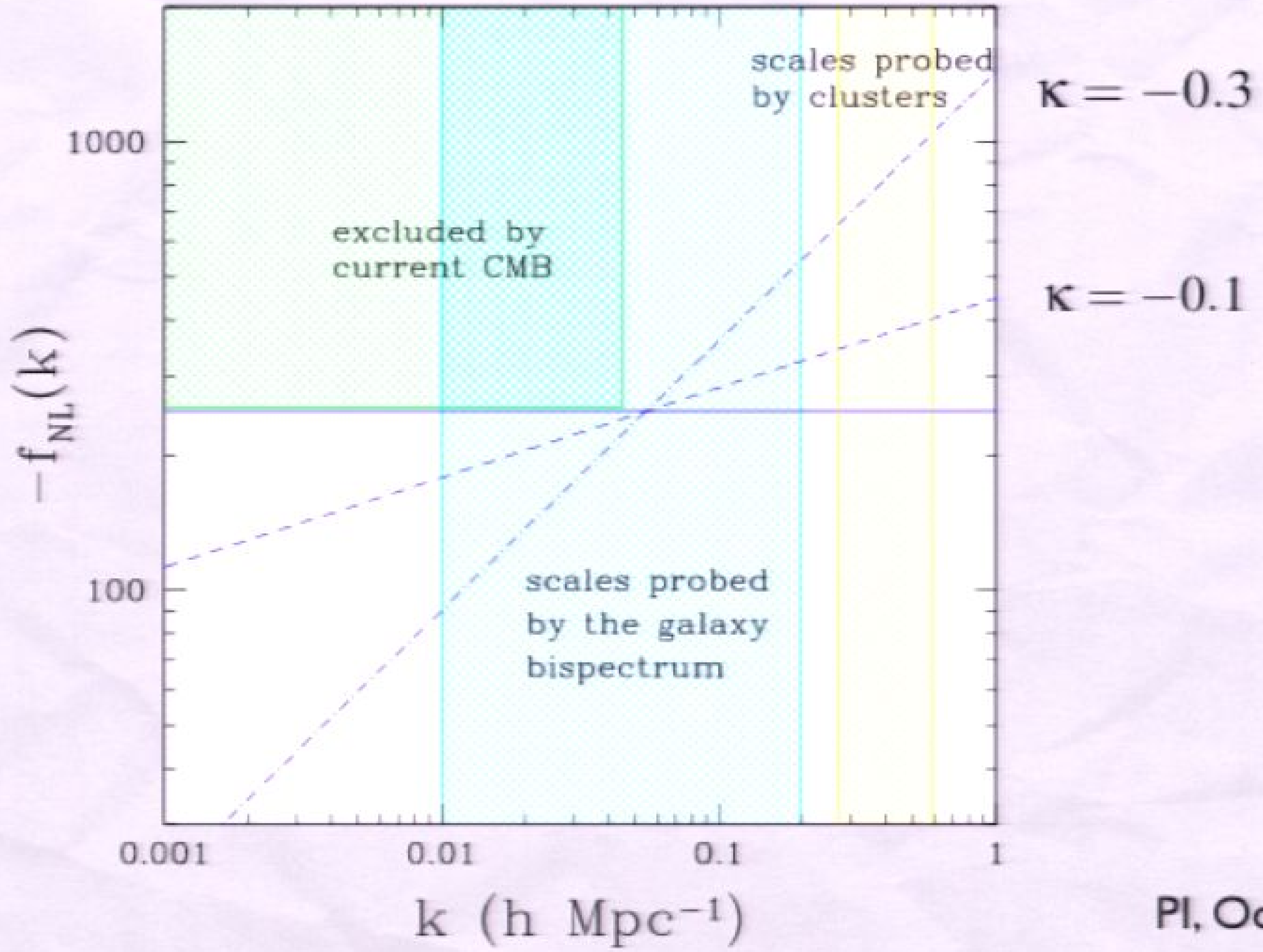
PI, Oct. 30, 2007

RELEVANT OBSERVATIONS



PI, Oct. 30, 2007

RELEVANT OBSERVATIONS



PI, Oct. 30, 2007

III. OBSERVATIONS: CLUSTERS

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

PI, Oct. 30, 2007

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial → Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial → Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

PI, Oct. 30, 2007

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial → Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial → Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density **n** of clusters with mass **M** and redshift **z**.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density **n** of clusters with mass **M** and redshift **z**.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

PI, Oct. 30, 2007

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.

- Need:

  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$

  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$

  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial → Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.

- Need:

  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$

  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$

  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density **n** of clusters with mass **M** and redshift **z**.

- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density n of clusters with mass M and redshift z.

- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

TO PREDICT CLUSTER COUNTS

- Want: number density **n** of clusters with mass **M** and redshift **z**.
- Need:
  - Primordial ⟶ Matter $\delta(k,a) \propto D(a)T(k)k^2\zeta(k)$
  - The probability distribution for density fluctuations: $\boxed{P(\delta)d\delta}$
  - A model for collapse

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$f_c = 2P(> \delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}$$

PI, Oct. 30, 2007

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

PI, Oct. 30, 2007

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}$$

PI, Oct. 30, 2007

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}$$

PI, Oct. 30, 2007

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

PI, Oct. 30, 2007

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

PI, Oct. 30, 2007

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3,M,z)}{\frac{dn_{PS}}{dM}(S_3=0,M,z)}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

NUMBER OF CLUSTERS

- Use a Press-Schechter approach:

$$\boxed{f_c = 2P(>\delta_c, M) = 2\int_{\delta_c}^{\infty} d\delta P(\delta, M)}$$

- The *mass function* gives the number density of clusters with mass between M and M+dM, at redshift z:

$$\boxed{\frac{dn}{dM}(M,z) = -2\frac{\bar{\rho}}{M}\frac{d}{dM}\left[\int_{\delta_c/\sigma(M)}^{\infty} d\nu P(\nu, M)\right]}$$

- Adjust to a more accurate collapse model (e.g. Sheth-Torman)

$$\boxed{\frac{dn_{NG}}{dM}(M,z) = \frac{dn_G}{dM}(M,z)\frac{\frac{dn_{PS}}{dM}(S_3, M, z)}{\frac{dn_{PS}}{dM}(S_3 = 0, M, z)}}$$

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle \delta^n \rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle \delta \rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle \delta^2 \rangle - \langle \delta \rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle \delta^3 \rangle - 3 \langle \delta^2 \rangle_c \langle \delta \rangle_c - \langle \delta \rangle_c^3$$

$$S_p \equiv \frac{\langle \delta^p \rangle_c}{\langle \delta^2 \rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \dots = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

NON-GAUSSIAN PDF

$$\boxed{\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta}$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$\boxed{S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

NON-GAUSSIAN PDF

$$\langle \delta^n \rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle \delta \rangle_c = \mu_1$$ (mean)

$$\kappa_2 = \langle \delta^2 \rangle - \langle \delta \rangle_c^2 = \sigma^2$$ (variance)

$$\kappa_3 = \langle \delta^3 \rangle - 3\langle \delta^2 \rangle_c \langle \delta \rangle_c - \langle \delta \rangle_c^3$$

$$S_p \equiv \frac{\langle \delta^p \rangle_c}{\langle \delta^2 \rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle \delta^n \rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle \delta \rangle_c = \mu_1 \qquad \textbf{(mean)}$$

$$\kappa_2 = \langle \delta^2 \rangle - \langle \delta \rangle_c^2 = \sigma^2 \qquad \textbf{(variance)}$$

$$\kappa_3 = \langle \delta^3 \rangle - 3 \langle \delta^2 \rangle_c \langle \delta \rangle_c - \langle \delta \rangle_c^3$$

$$S_p \equiv \frac{\langle \delta^p \rangle_c}{\langle \delta^2 \rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

NON-GAUSSIAN PDF

$$\boxed{\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta}$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$\boxed{S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S3: skewness

S4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\boxed{\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta}$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$\boxed{S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S3: skewness

S4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle \delta^n \rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle \delta \rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle \delta^2 \rangle - \langle \delta \rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle \delta^3 \rangle - 3\langle \delta^2 \rangle_c \langle \delta \rangle_c - \langle \delta \rangle_c^3$$

$$S_p \equiv \frac{\langle \delta^p \rangle_c}{\langle \delta^2 \rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness
S_4: kurtosis

NON-GAUSSIAN PDF

$$\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$ **(mean)**

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$ **(variance)**

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S3: skewness

S4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$ (mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$ (variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$ (mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$ (variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$ (mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$ (variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = ... = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

NON-GAUSSIAN PDF

$$\langle \delta^n \rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle \delta \rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle \delta^2 \rangle - \langle \delta \rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle \delta^3 \rangle - 3\langle \delta^2 \rangle_c \langle \delta \rangle_c - \langle \delta \rangle_c^3$$

$$S_p \equiv \frac{\langle \delta^p \rangle_c}{\langle \delta^2 \rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

NON-GAUSSIAN PDF

$$\boxed{\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta}$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$\boxed{S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle \delta^n \rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle \delta \rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle \delta^2 \rangle - \langle \delta \rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle \delta^3 \rangle - 3\langle \delta^2 \rangle_c \langle \delta \rangle_c - \langle \delta \rangle_c^3$$

$$S_p \equiv \frac{\langle \delta^p \rangle_c}{\langle \delta^2 \rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

NON-GAUSSIAN PDF

$$\boxed{\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta}$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$\boxed{S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S₃: skewness

S₄: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle\delta^n\rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta)\, d\delta$$

$$\kappa_1 = \langle\delta\rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle\delta^2\rangle - \langle\delta\rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle\delta^3\rangle - 3\langle\delta^2\rangle_c\langle\delta\rangle_c - \langle\delta\rangle_c^3$$

$$S_p \equiv \frac{\langle\delta^p\rangle_c}{\langle\delta^2\rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$

$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle \delta^n \rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle \delta \rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle \delta^2 \rangle - \langle \delta \rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle \delta^3 \rangle - 3\langle \delta^2 \rangle_c \langle \delta \rangle_c - \langle \delta \rangle_c^3$$

$$S_p \equiv \frac{\langle \delta^p \rangle_c}{\langle \delta^2 \rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S₃: skewness

S₄: kurtosis

PI, Oct. 30, 2007

NON-GAUSSIAN PDF

$$\langle \delta^n \rangle = \mu_n \equiv \int_{-\infty}^{\infty} \delta^n P(\delta) d\delta$$

$$\kappa_1 = \langle \delta \rangle_c = \mu_1$$

(mean)

$$\kappa_2 = \langle \delta^2 \rangle - \langle \delta \rangle_c^2 = \sigma^2$$

(variance)

$$\kappa_3 = \langle \delta^3 \rangle - 3\langle \delta^2 \rangle_c \langle \delta \rangle_c - \langle \delta \rangle_c^3$$

$$S_p \equiv \frac{\langle \delta^p \rangle_c}{\langle \delta^2 \rangle_c^{p-1}}$$

Cumulants

$$S_3^G = S_4^G = \ldots = 0$$
$$S_3^{(f_{NL})} = 6 f_{NL} + 8 f_{NL}^3 \sigma^2$$

S_3: skewness

S_4: kurtosis

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PI, Oct. 30, 2007

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PI, Oct. 30, 2007

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

PDF, CONTINUED

- Express the PDF as

$$\boxed{P(\delta_R)d\delta_R = \frac{d\delta_R}{2\pi i}\frac{1}{\sigma_R^2}\int_{-i\infty}^{i\infty} dy \exp\left[\frac{y\delta_R}{\sigma_R^2} - \frac{S(y)}{\sigma_R^2}\right]}$$

Smoothed on scale *R*

- Using the cumulant generating function

$$\boxed{S(y) = \sum_{p=2}^{\infty} S_p(R)\frac{(-1)^{p-1}}{p!}y^p}$$

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned}H_3(\nu) &= \nu^3 - 3\nu\\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3\\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu\end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2} \left[1 + \sigma \frac{S_3}{6} H_3(\nu) + \sigma^2 \left(\frac{S_4}{24} H_4(\nu) + \frac{S_3^2}{72} H_6(\nu) \right) + \ldots \right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered}H_3(\nu)=\nu^3-3\nu\\ H_4(\nu)=\nu^4-6\nu^2+3\\ H_5(\nu)=\nu^5-10\nu^3+15\nu\end{gathered}}$$

$$\boxed{\nu=\delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu) = \nu^3 - 3\nu \\ H_4(\nu) = \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu \end{gathered}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3-3\nu \\ H_4(\nu) &= \nu^4-6\nu^2+3 \\ H_5(\nu) &= \nu^5-10\nu^3+15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3-3\nu \\ H_4(\nu) &= \nu^4-6\nu^2+3 \\ H_5(\nu) &= \nu^5-10\nu^3+15\nu \end{aligned}}$$

$$\boxed{\nu=\delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu) = \nu^3 - 3\nu \\ H_4(\nu) = \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu \end{gathered}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu) = \nu^3 - 3\nu \\ H_4(\nu) = \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu \end{gathered}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1 + \sigma\frac{S_3}{6}H_3(\nu) + \sigma^2\left(\frac{S_4}{24}H_4(\nu) + \frac{S_3^2}{72}H_6(\nu)\right) + \ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3-3\nu \\ H_4(\nu) &= \nu^4-6\nu^2+3 \\ H_5(\nu) &= \nu^5-10\nu^3+15\nu \end{aligned}}$$

$$\boxed{\nu=\delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

***** Two kinds of approximations

- ignoring higher order cumulants

- size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants

- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu) = \nu^3 - 3\nu \\ H_4(\nu) = \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu \end{gathered}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3-3\nu \\ H_4(\nu) &= \nu^4-6\nu^2+3 \\ H_5(\nu) &= \nu^5-10\nu^3+15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu) = \nu^3 - 3\nu \\ H_4(\nu) = \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu \end{gathered}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants

- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu) = \nu^3 - 3\nu \\ H_4(\nu) = \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu \end{gathered}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2} \left[1 + \sigma \frac{S_3}{6} H_3(\nu) + \sigma^2 \left(\frac{S_4}{24} H_4(\nu) + \frac{S_3^2}{72} H_6(\nu) \right) + \ldots \right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

* Two kinds of approximations

- ignoring higher order cumulants
- size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- ✱ Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu)=\nu^3-3\nu$$
$$H_4(\nu)=\nu^4-6\nu^2+3$$
$$H_5(\nu)=\nu^5-10\nu^3+15\nu$$

$$\nu=\delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu)=\nu^3-3\nu \\ H_4(\nu)=\nu^4-6\nu^2+3 \\ H_5(\nu)=\nu^5-10\nu^3+15\nu \end{gathered}}$$

$$\boxed{\nu=\delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu) = \nu^3 - 3\nu \\ H_4(\nu) = \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu \end{gathered}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2} \left[1 + \sigma \frac{S_3}{6} H_3(\nu) + \sigma^2 \left(\frac{S_4}{24} H_4(\nu) + \frac{S_3^2}{72} H_6(\nu) \right) + \ldots \right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu)=\nu^3-3\nu$$
$$H_4(\nu)=\nu^4-6\nu^2+3$$
$$H_5(\nu)=\nu^5-10\nu^3+15\nu$$

$$\nu=\delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants

- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2} \left[1 + \sigma \frac{S_3}{6} H_3(\nu) + \sigma^2 \left(\frac{S_4}{24} H_4(\nu) + \frac{S_3^2}{72} H_6(\nu) \right) + \ldots \right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{gathered} H_3(\nu) = \nu^3 - 3\nu \\ H_4(\nu) = \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu \end{gathered}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$

$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$

$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

✱ Two kinds of approximations

- ignoring higher order cumulants
- size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3 - 3\nu \\ H_4(\nu) &= \nu^4 - 6\nu^2 + 3 \\ H_5(\nu) &= \nu^5 - 10\nu^3 + 15\nu \end{aligned}}$$

$$\boxed{\nu = \delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}} e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3-3\nu \\ H_4(\nu) &= \nu^4-6\nu^2+3 \\ H_5(\nu) &= \nu^5-10\nu^3+15\nu \end{aligned}}$$

$$\boxed{\nu=\delta/\sigma}$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

EDGEWORTH EXPANSION

$$\boxed{P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\ldots\right]}$$

(Smoothed)

$$\boxed{\begin{aligned} H_3(\nu) &= \nu^3-3\nu \\ H_4(\nu) &= \nu^4-6\nu^2+3 \\ H_5(\nu) &= \nu^5-10\nu^3+15\nu \end{aligned}}$$

$$\boxed{\nu=\delta/\sigma}$$

✱ Two kinds of approximations

- ignoring higher order cumulants

- size of ν

EDGEWORTH EXPANSION

$$P(\nu)d\nu = \frac{d\nu}{\sqrt{2\pi}}e^{-\nu^2/2}\left[1+\sigma\frac{S_3}{6}H_3(\nu)+\sigma^2\left(\frac{S_4}{24}H_4(\nu)+\frac{S_3^2}{72}H_6(\nu)\right)+\dots\right]$$

(Smoothed)

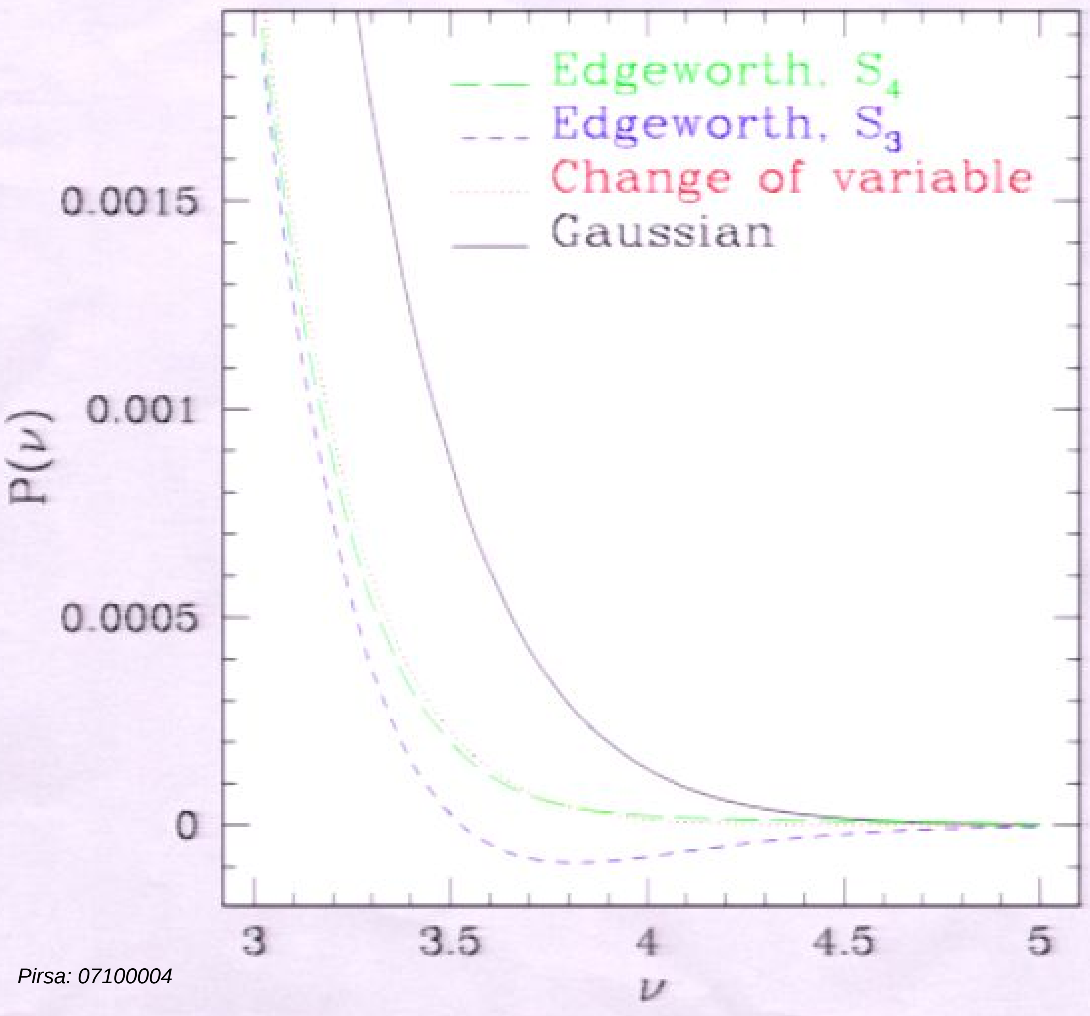
$$H_3(\nu) = \nu^3 - 3\nu$$
$$H_4(\nu) = \nu^4 - 6\nu^2 + 3$$
$$H_5(\nu) = \nu^5 - 10\nu^3 + 15\nu$$

$$\nu = \delta/\sigma$$

- Two kinds of approximations
  - ignoring higher order cumulants
  - size of ν

PI, Oct. 30, 2007

COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)

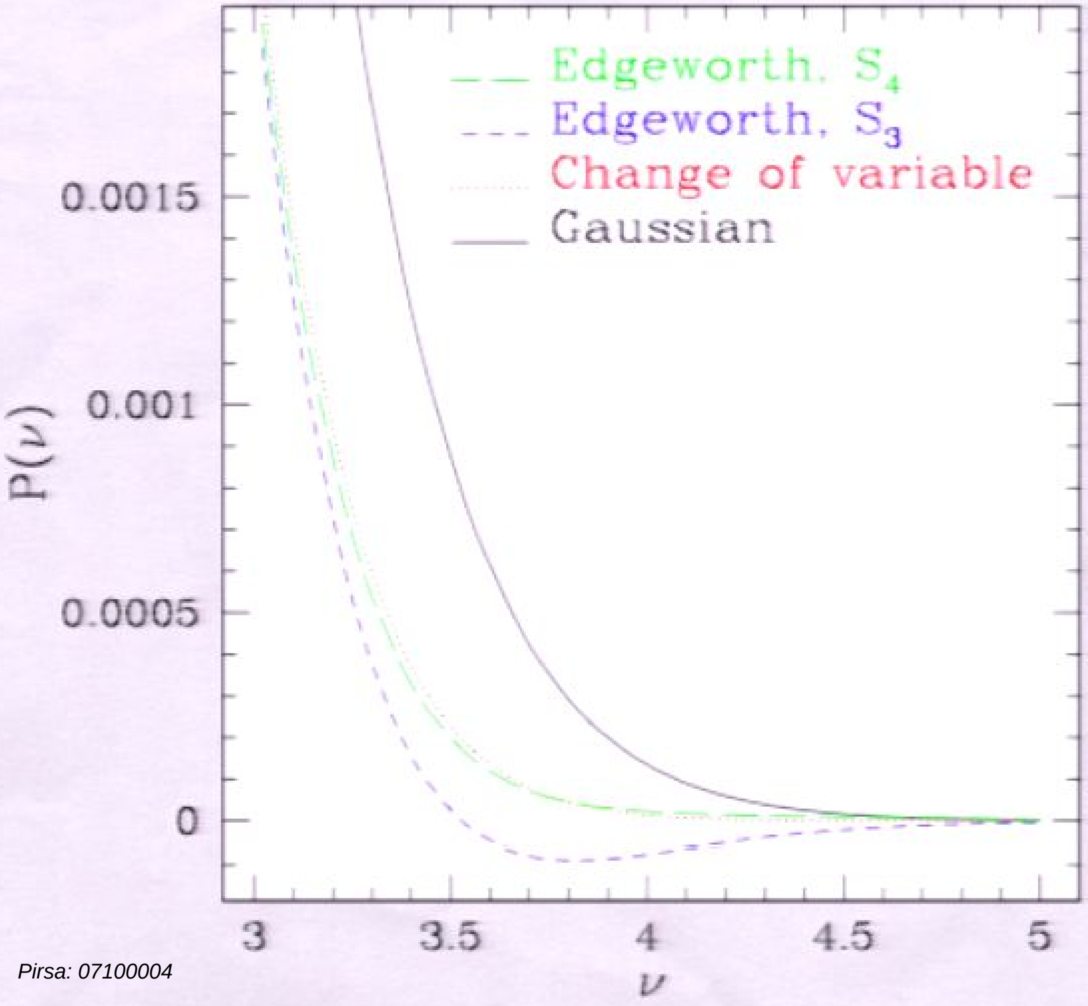


$$\sigma = 1$$

$$f_{NL} = -0.03$$

PI, Oct. 30, 2007

COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)

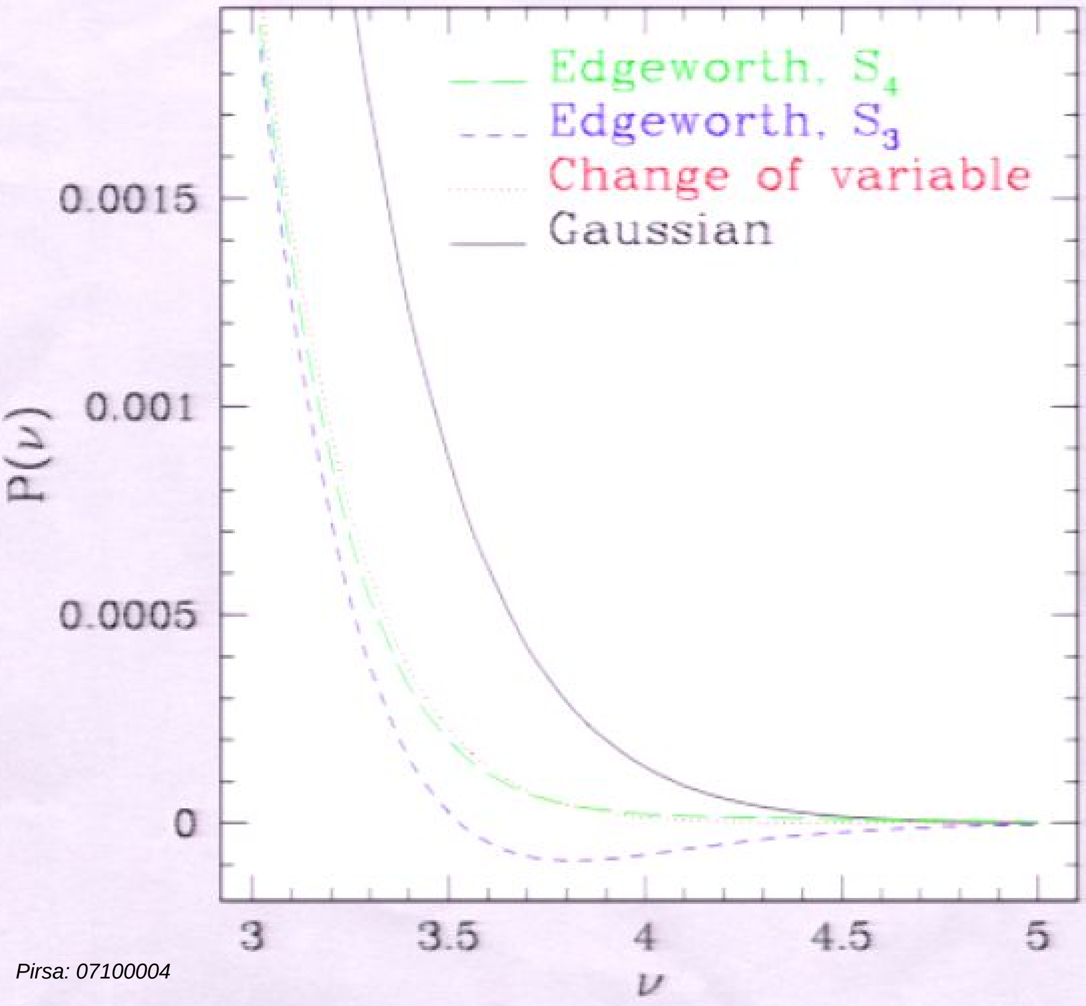


$$\sigma = 1$$

$$f_{NL} = -0.03$$

PI, Oct. 30, 2007

COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)

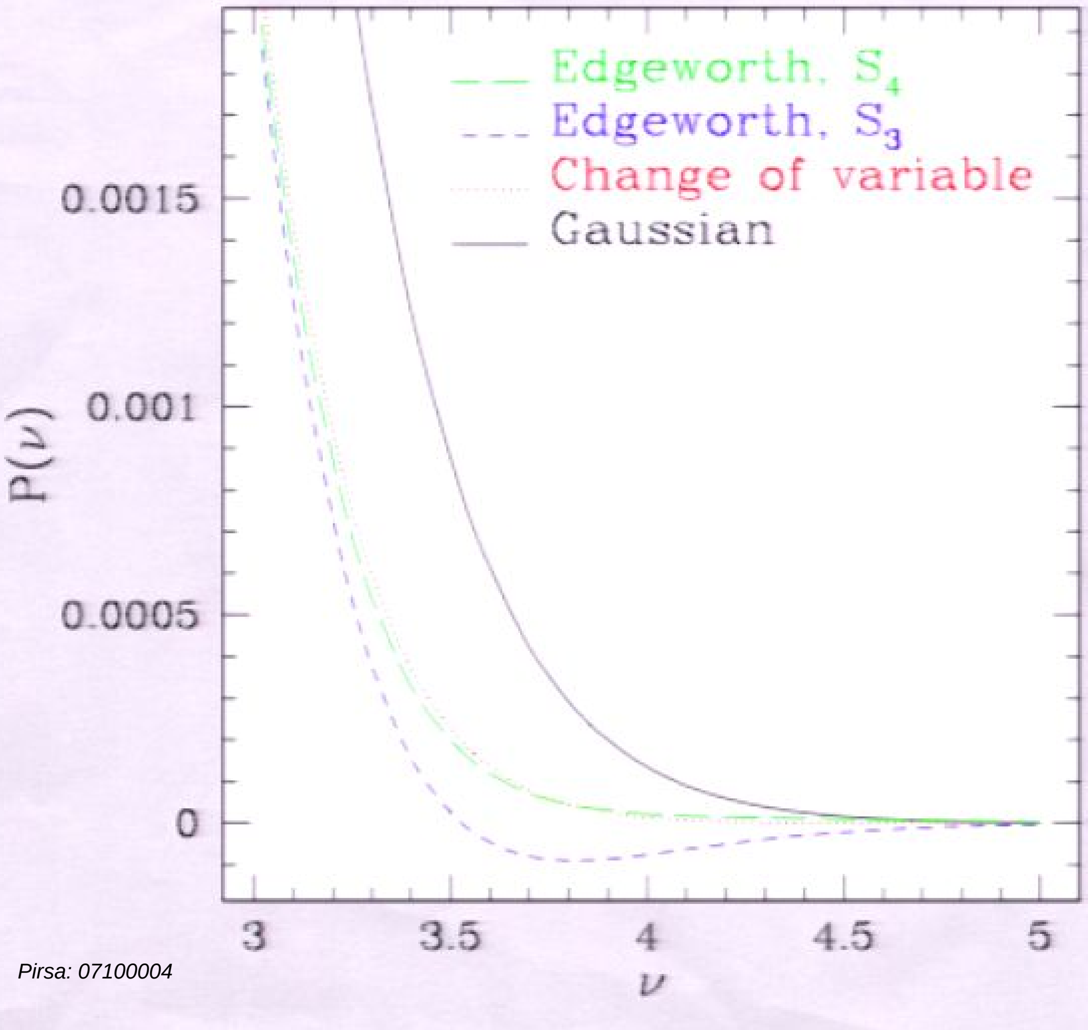


$$\sigma = 1$$

$$f_{NL} = -0.03$$

PI, Oct. 30, 2007

COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)

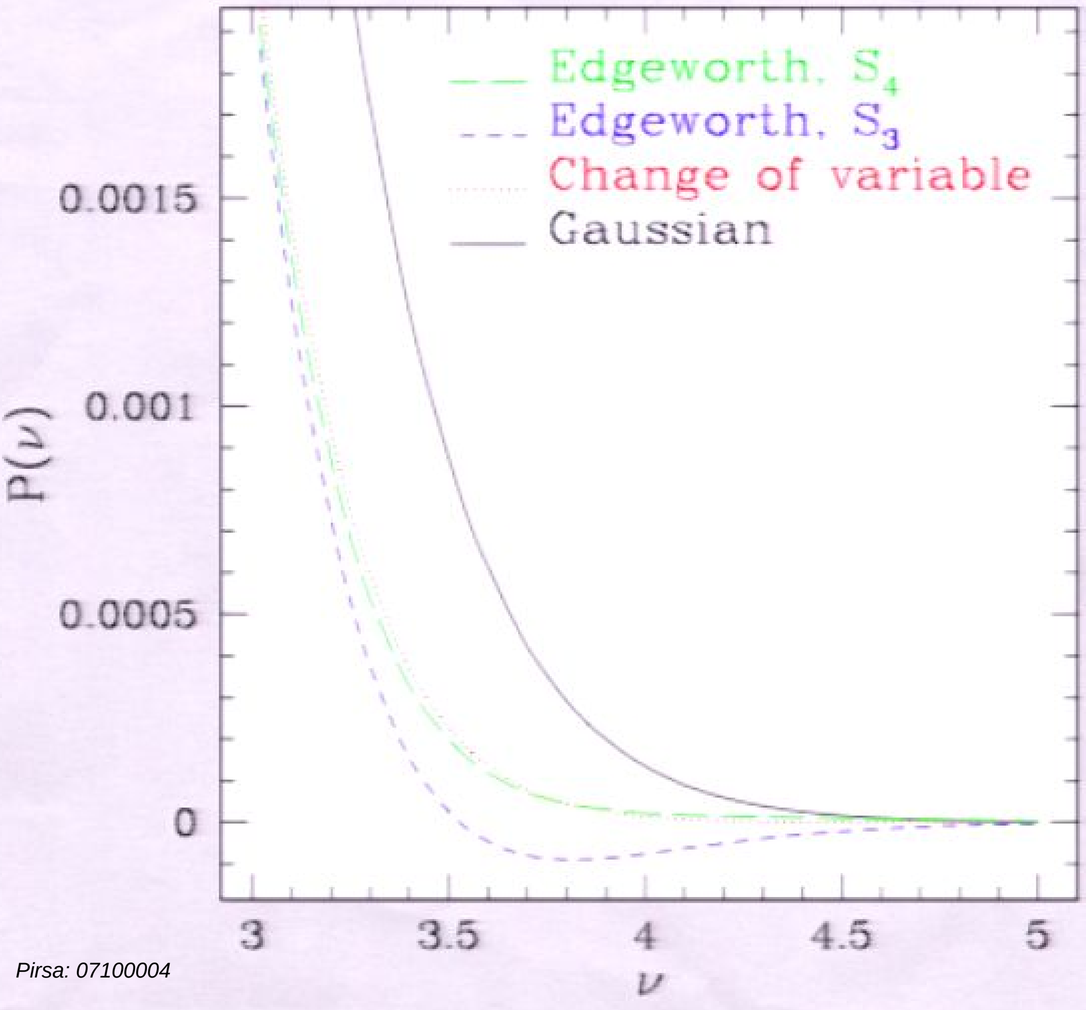


$$\sigma = 1$$

$$f_{NL} = -0.03$$

PI, Oct. 30, 2007

COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)

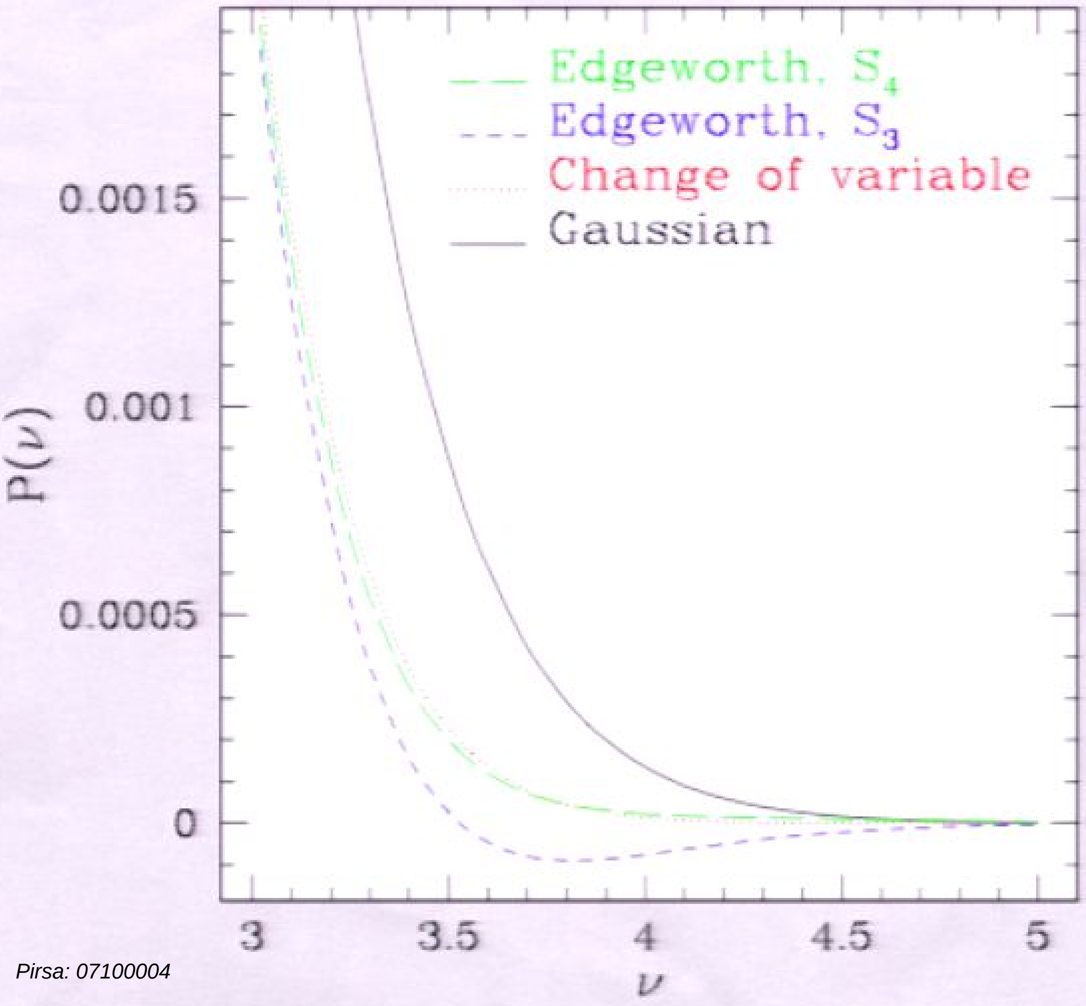


$$\sigma = 1$$

$$f_{NL} = -0.03$$

PI, Oct. 30, 2007

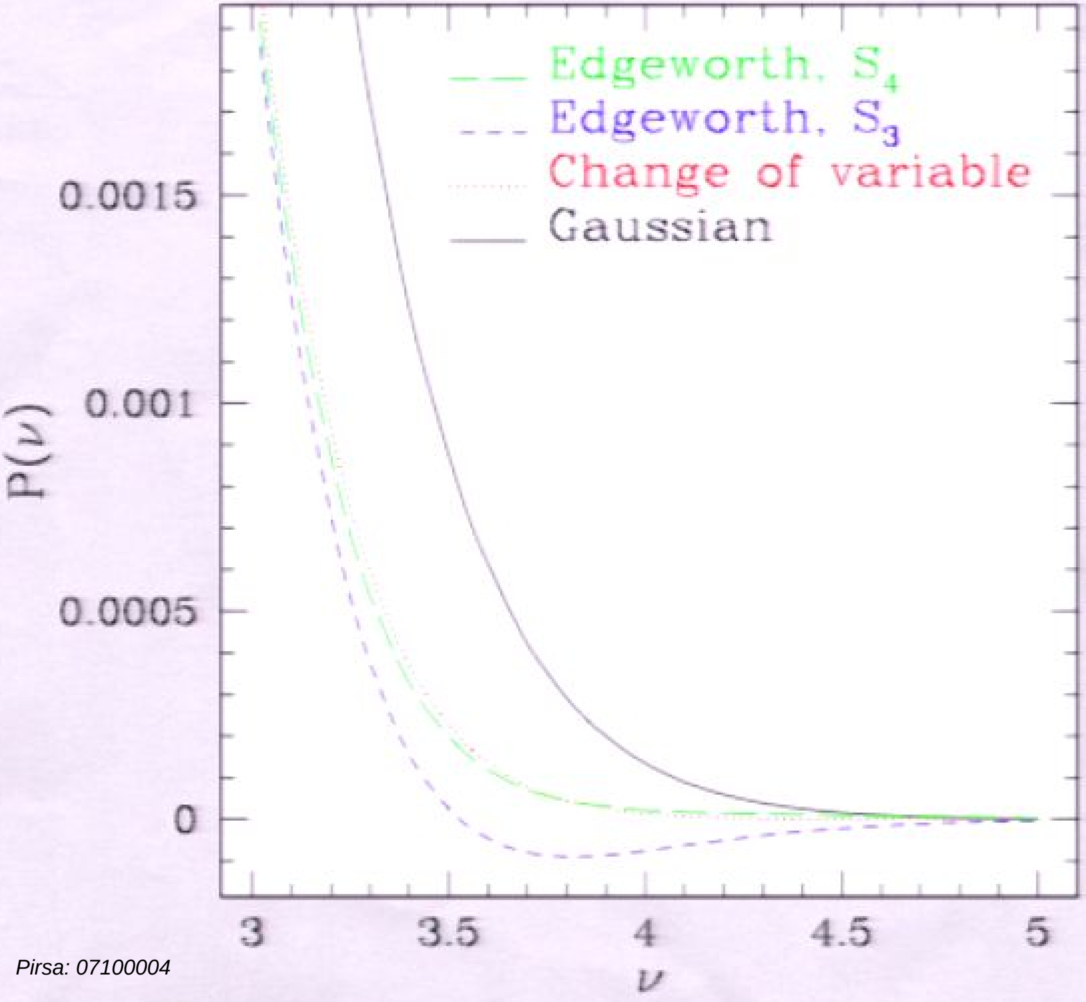
COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)



$$\sigma = 1$$

$$f_{NL} = -0.03$$

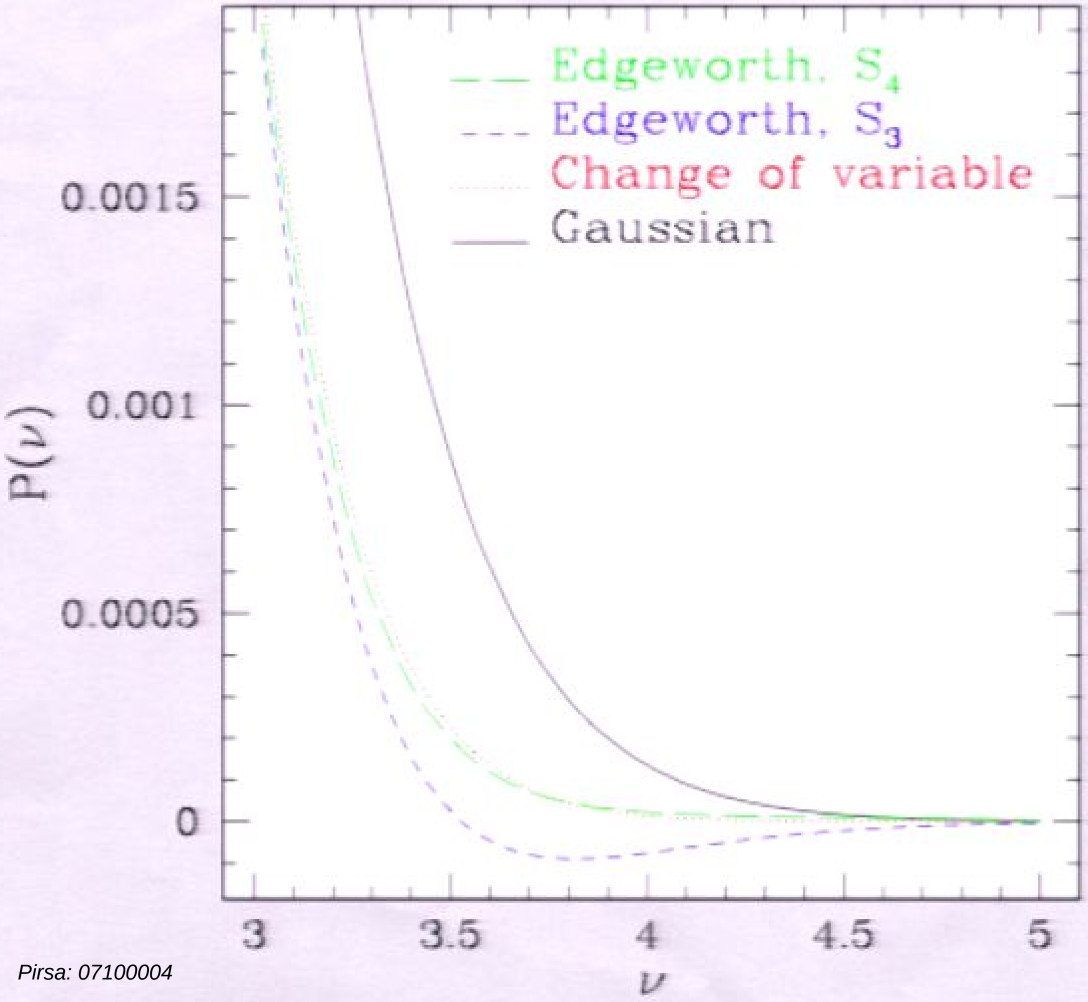
COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)



$$\sigma = 1$$
$$f_{NL} = -0.03$$

PI, Oct. 30, 2007

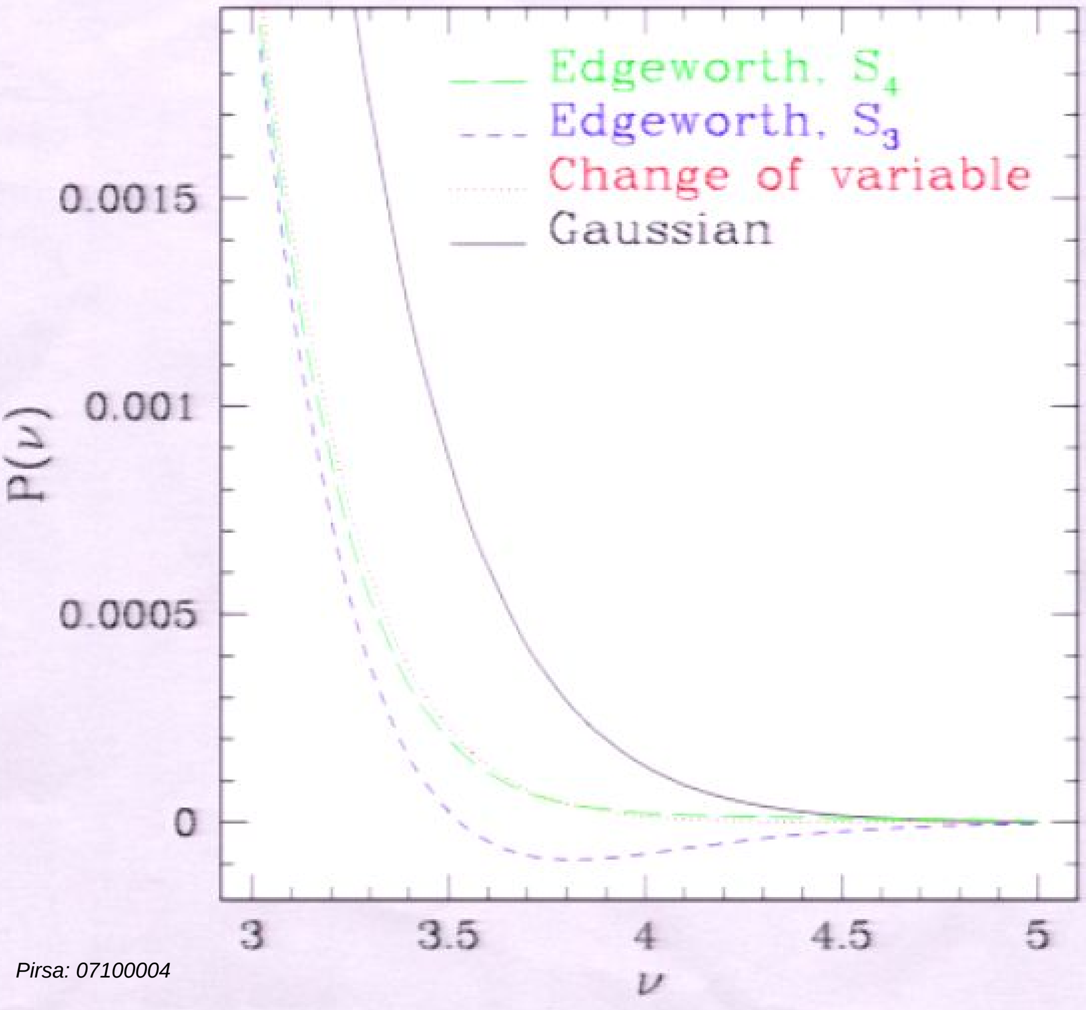
COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)



$$\sigma = 1$$

$$f_{NL} = -0.03$$

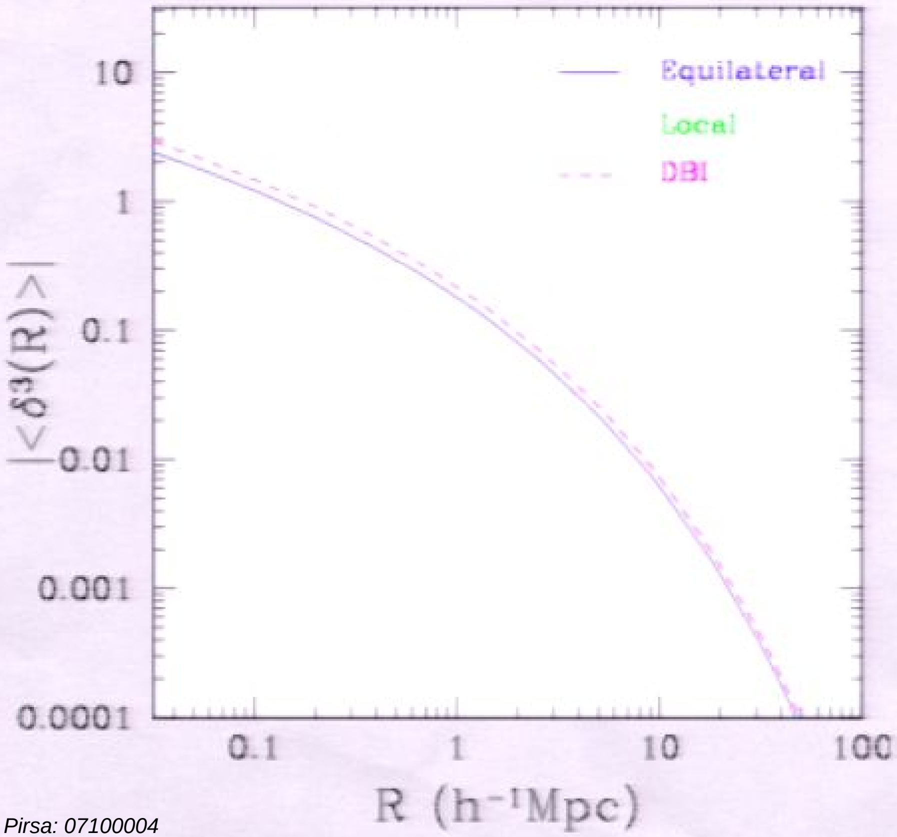
COMPARING DISTRIBUTIONS
(UNSMOOTHED, LOCAL MODEL)

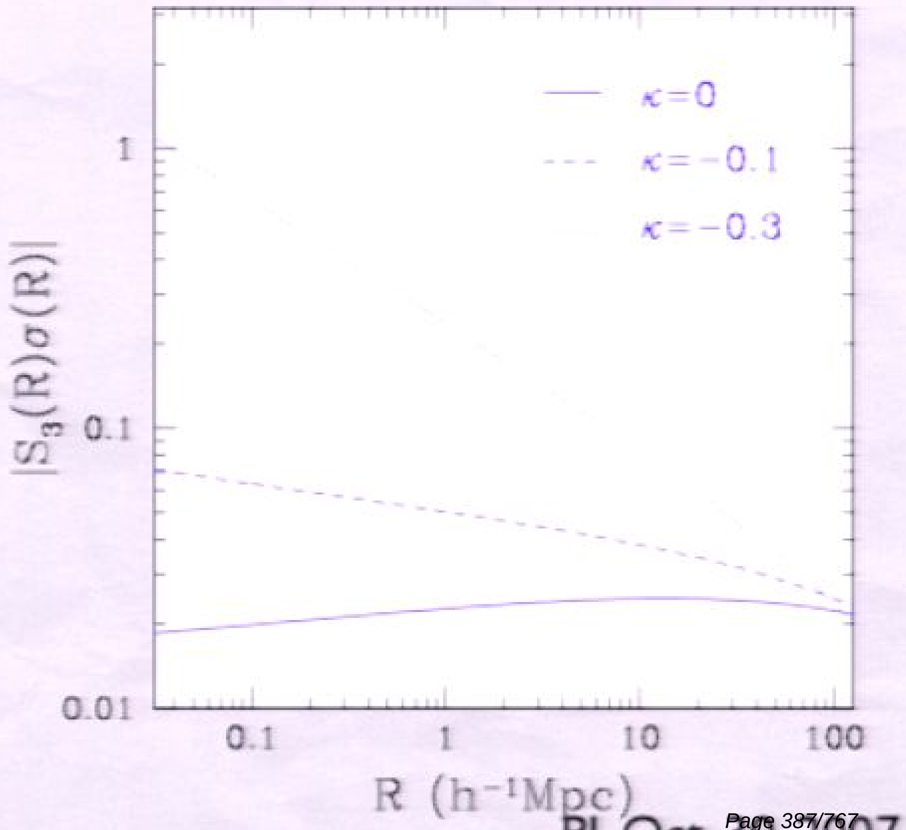


$$\sigma = 1$$

$$f_{NL} = -0.03$$

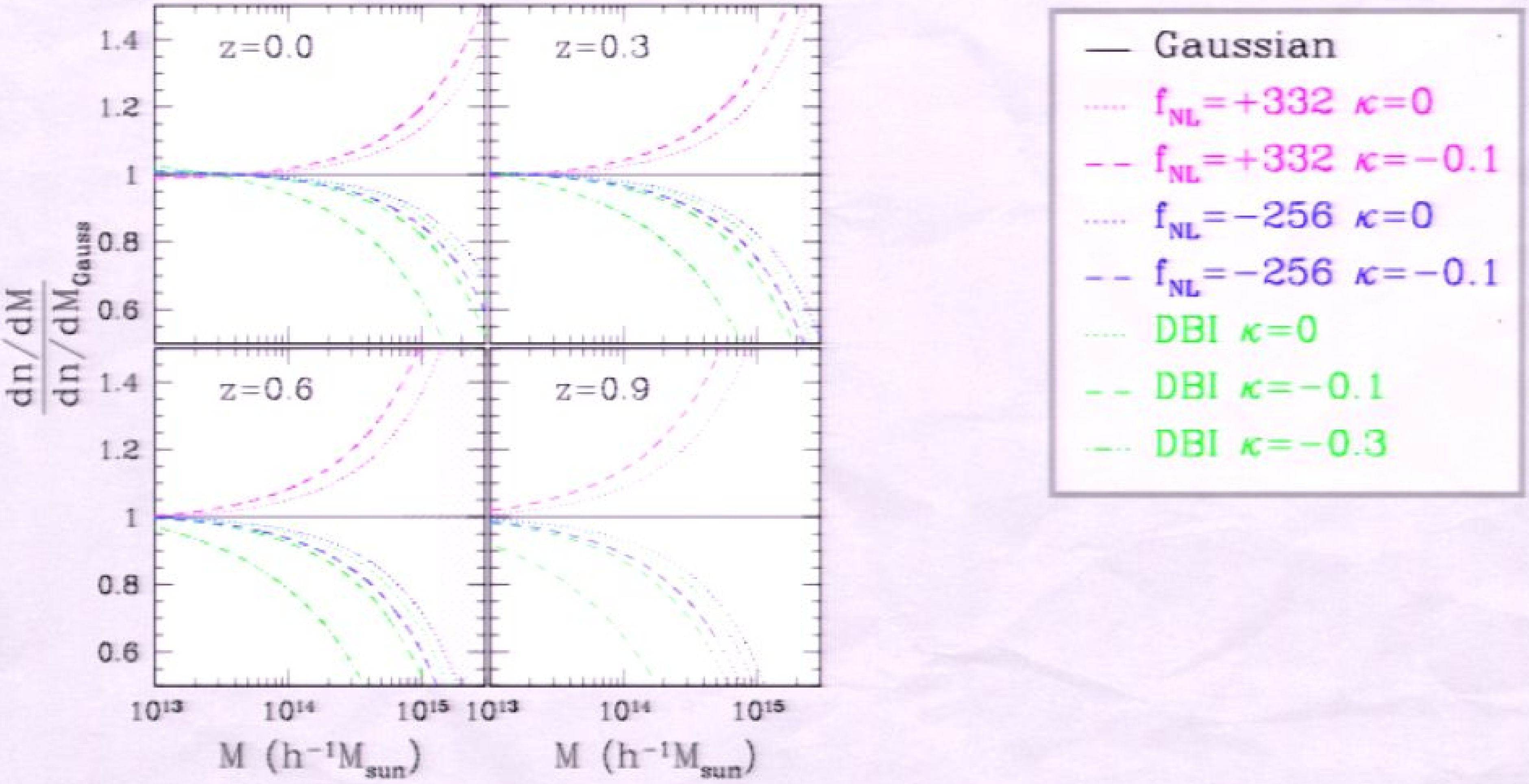
SMOOTHED SKEWNESS



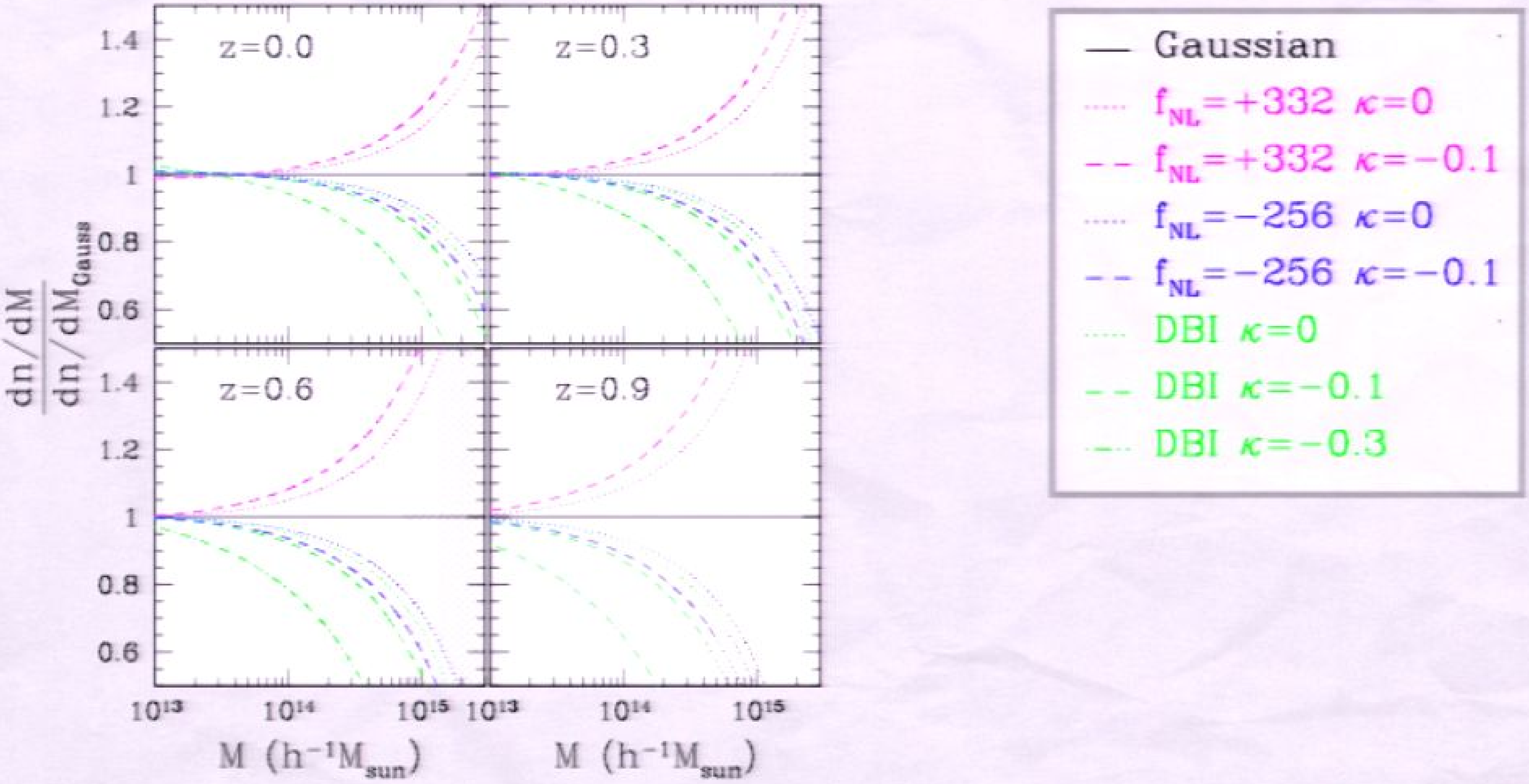


PI, Oct. 30, 2007

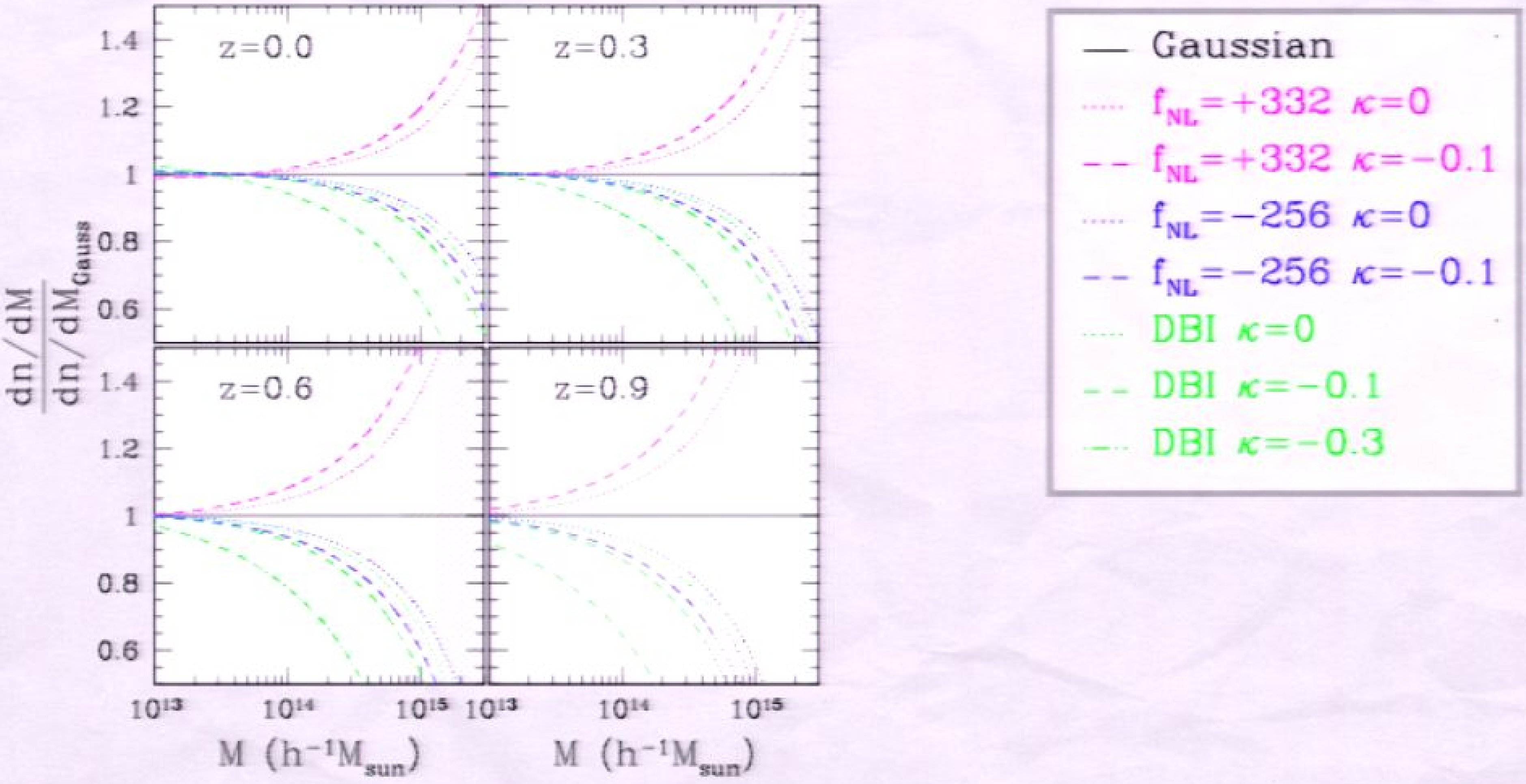
MASS FUNCTION



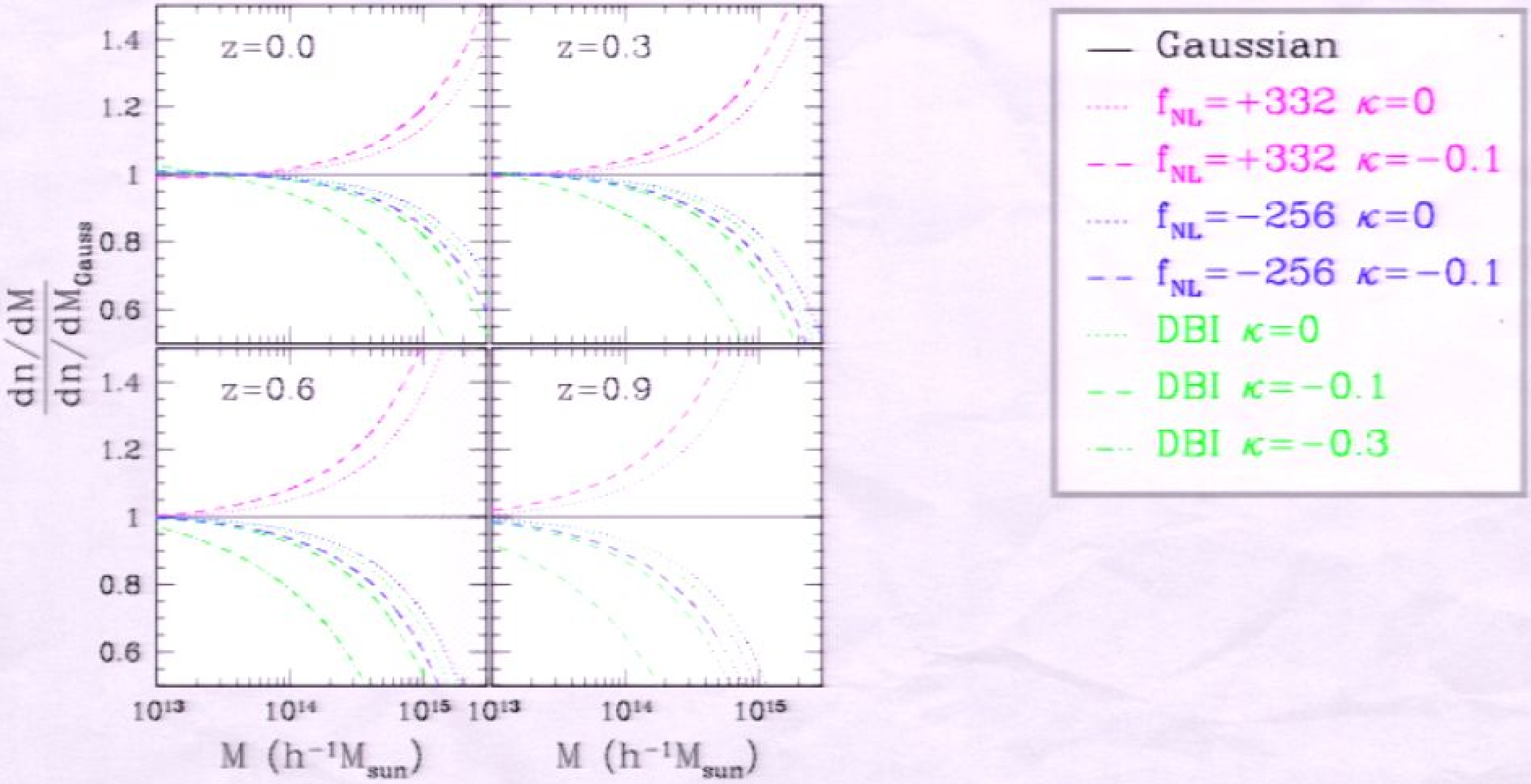
MASS FUNCTION



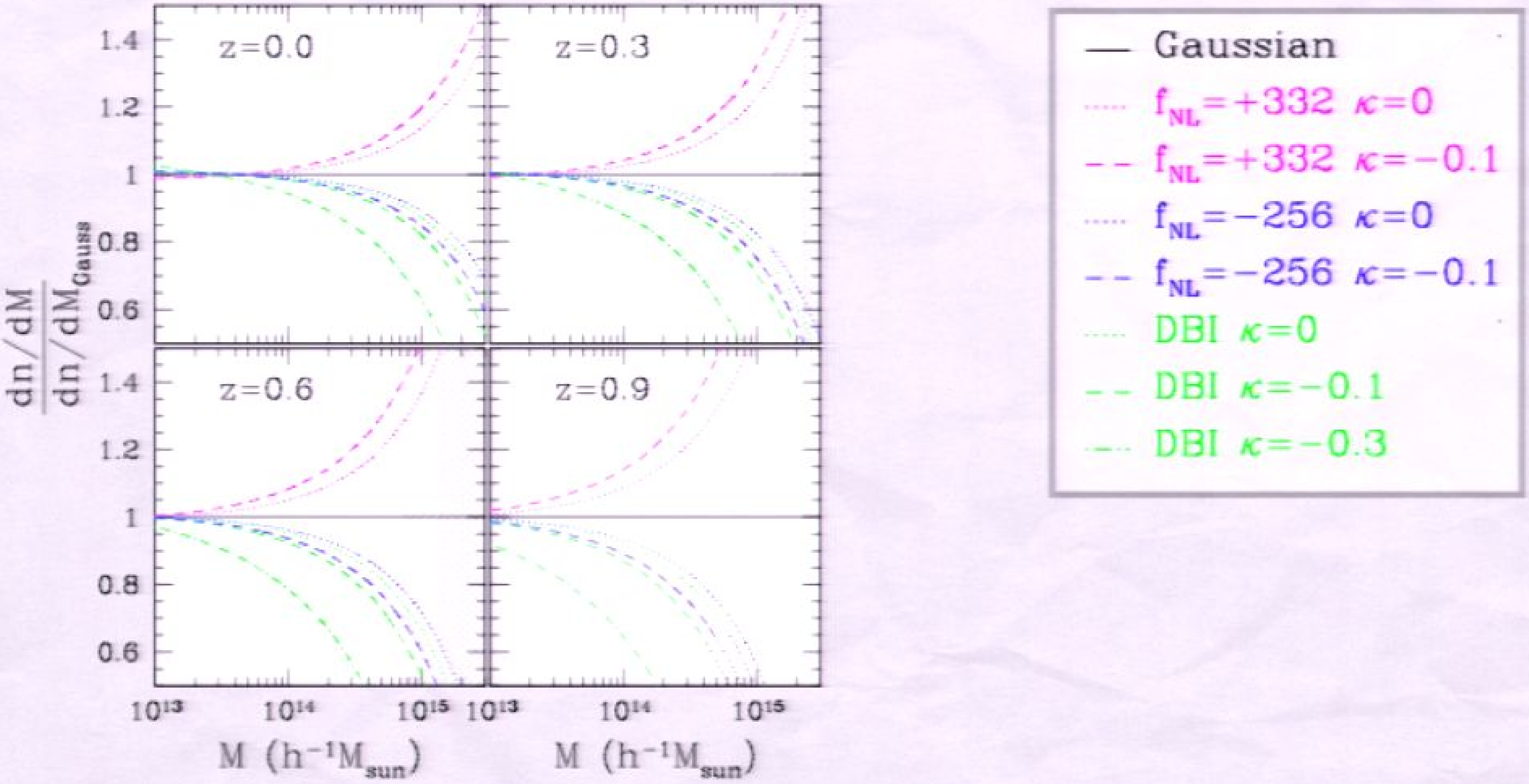
MASS FUNCTION



MASS FUNCTION

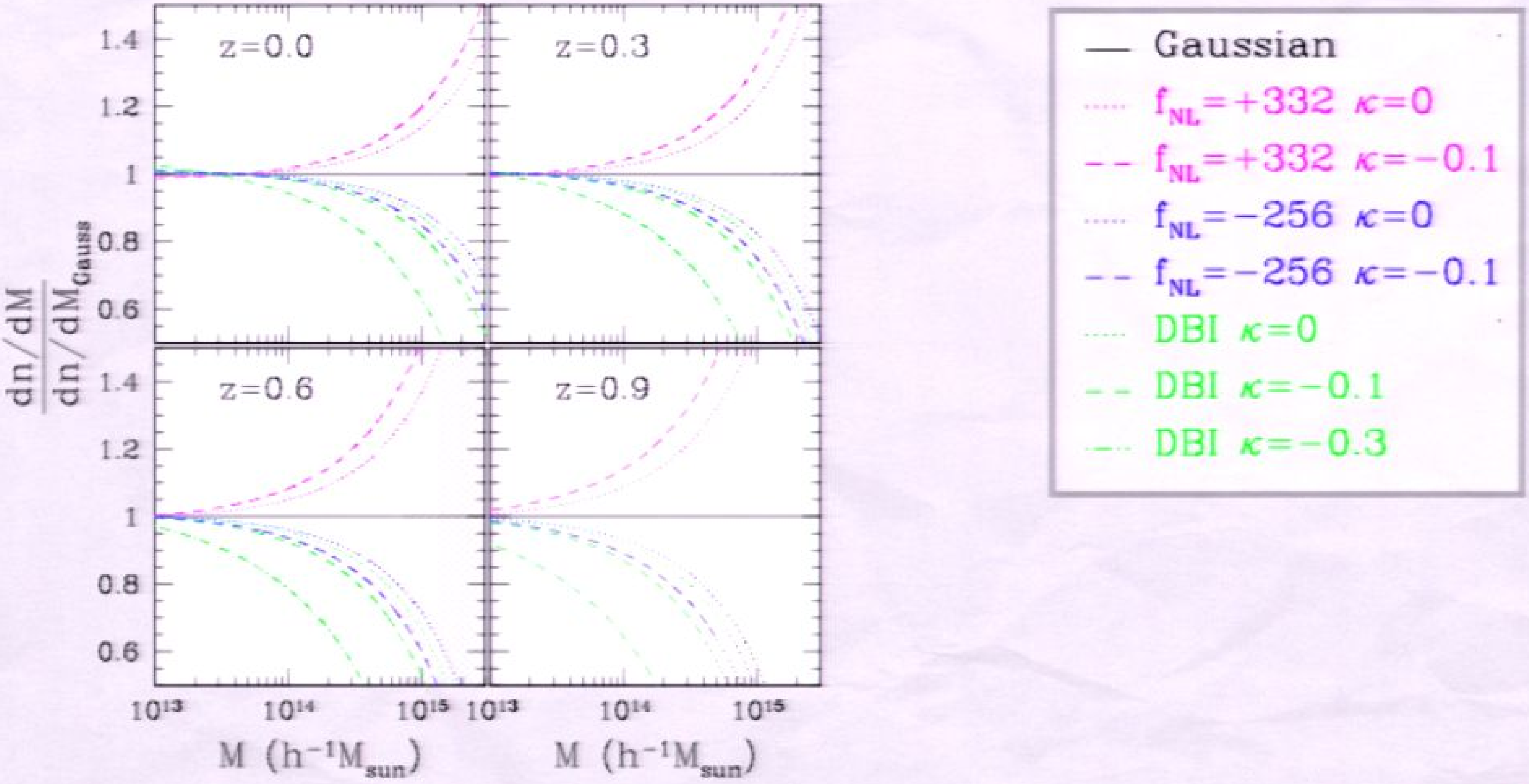


MASS FUNCTION

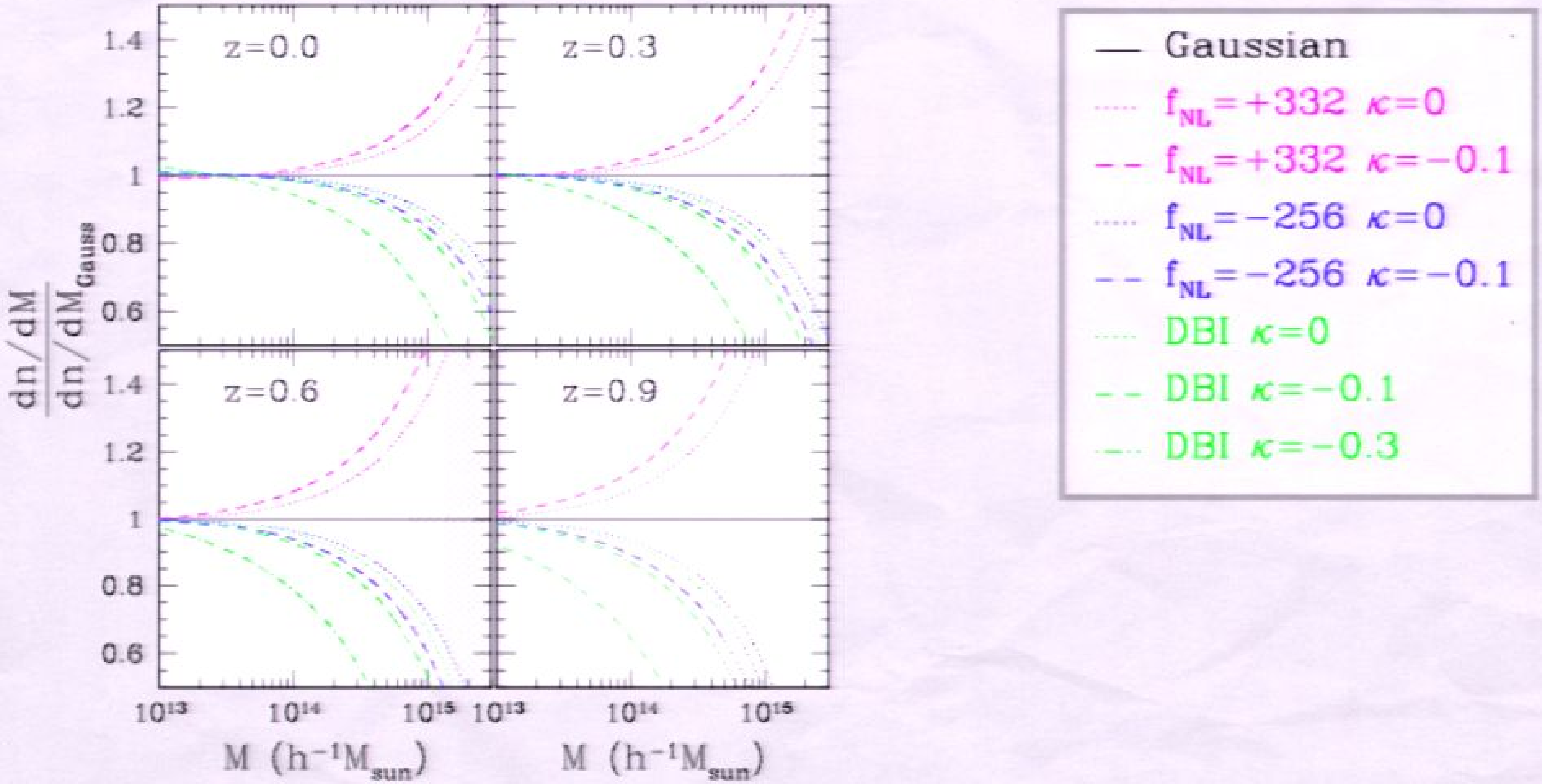


PI, Oct. 30, 2007

MASS FUNCTION

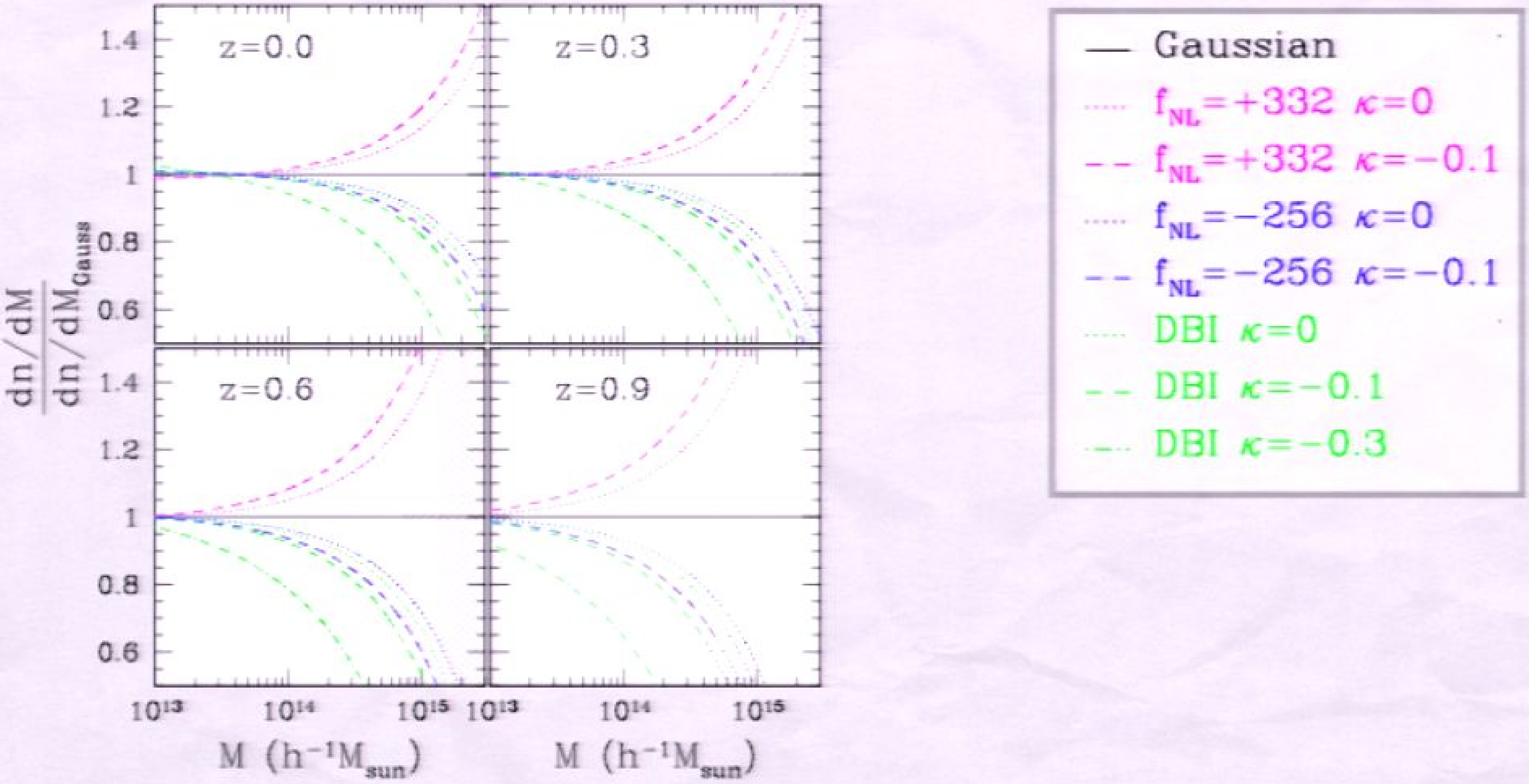


MASS FUNCTION



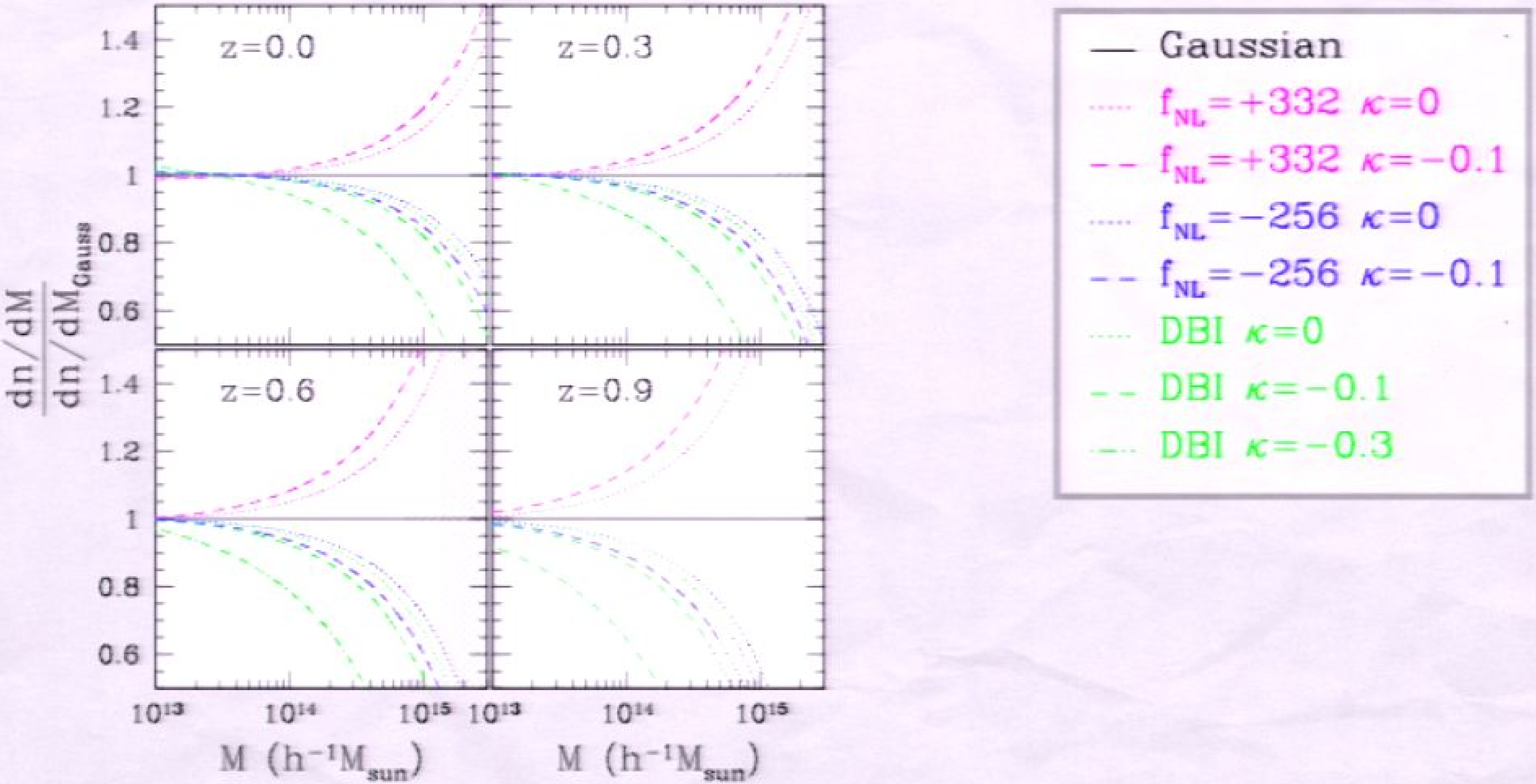
PI, Oct. 30, 2007

MASS FUNCTION



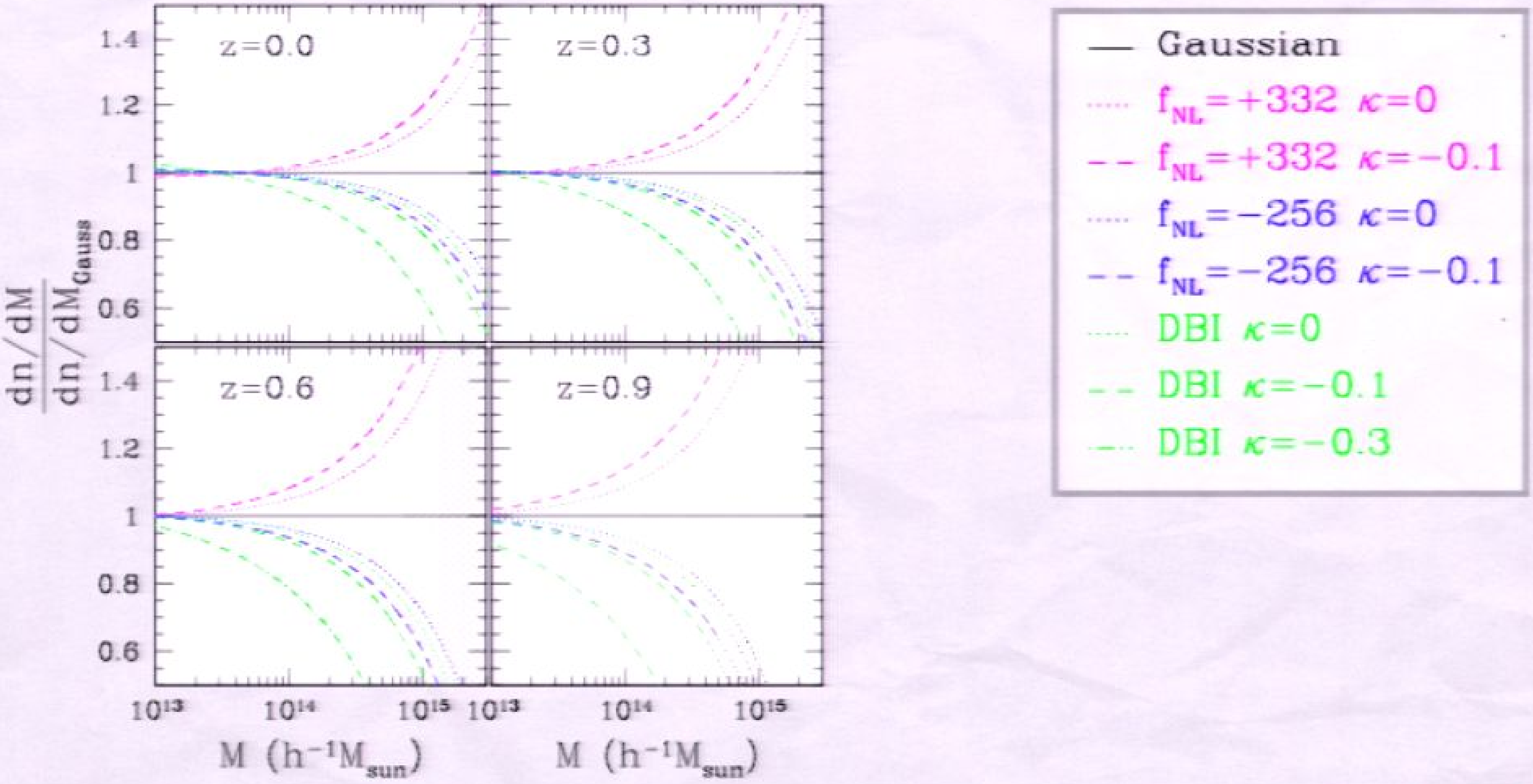
PI, Oct. 30, 2007

MASS FUNCTION

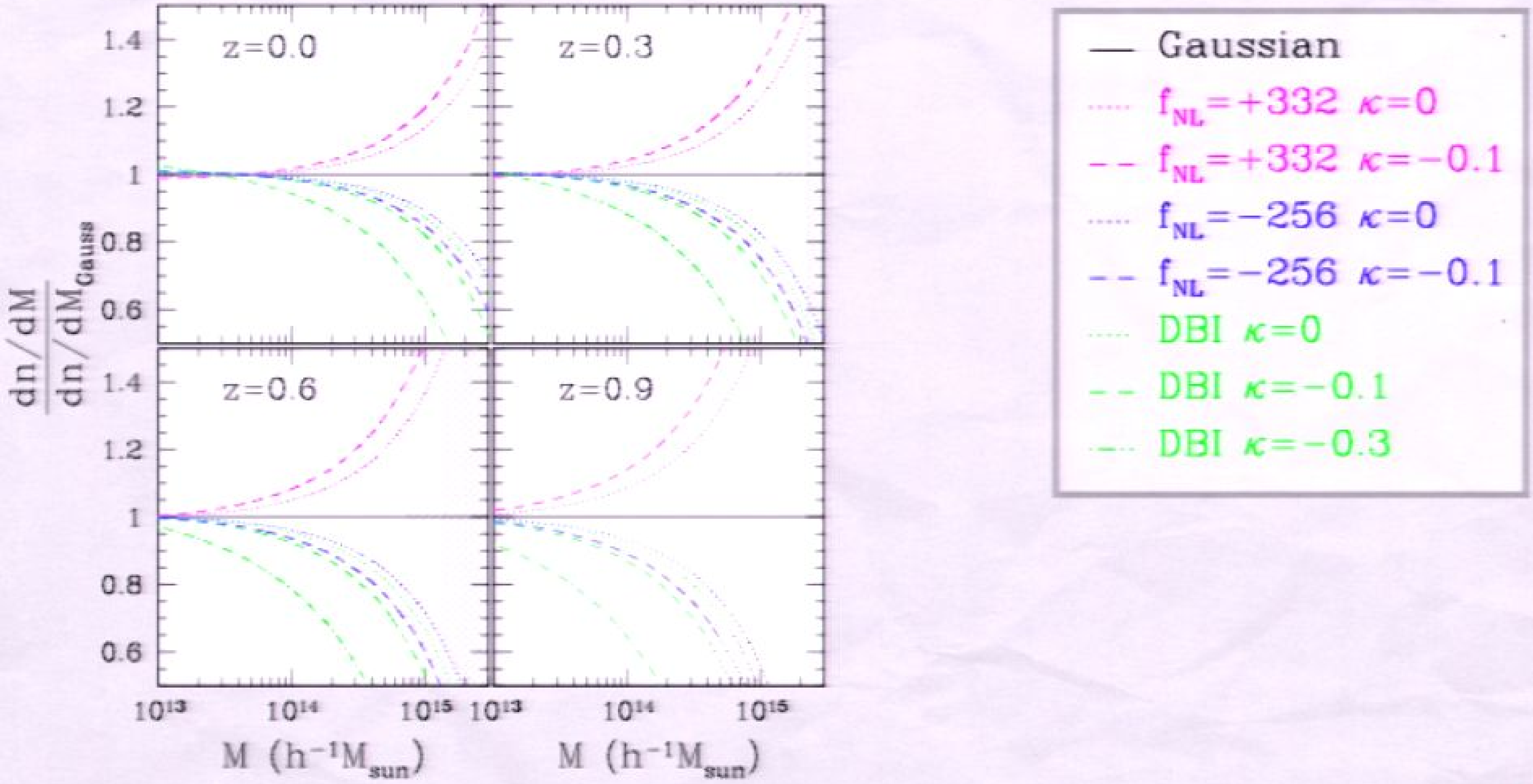


PI, Oct. 30, 2007

MASS FUNCTION

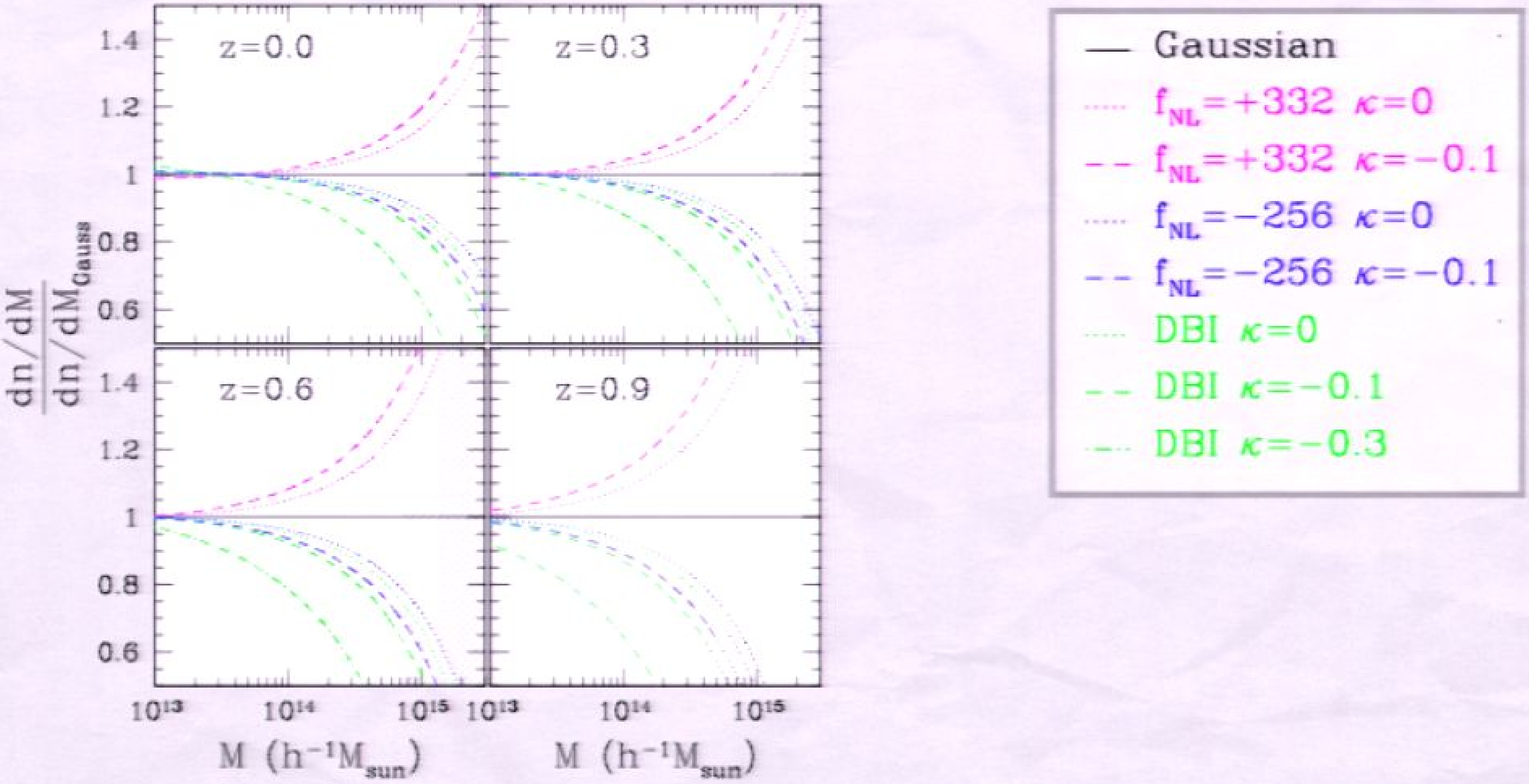


MASS FUNCTION



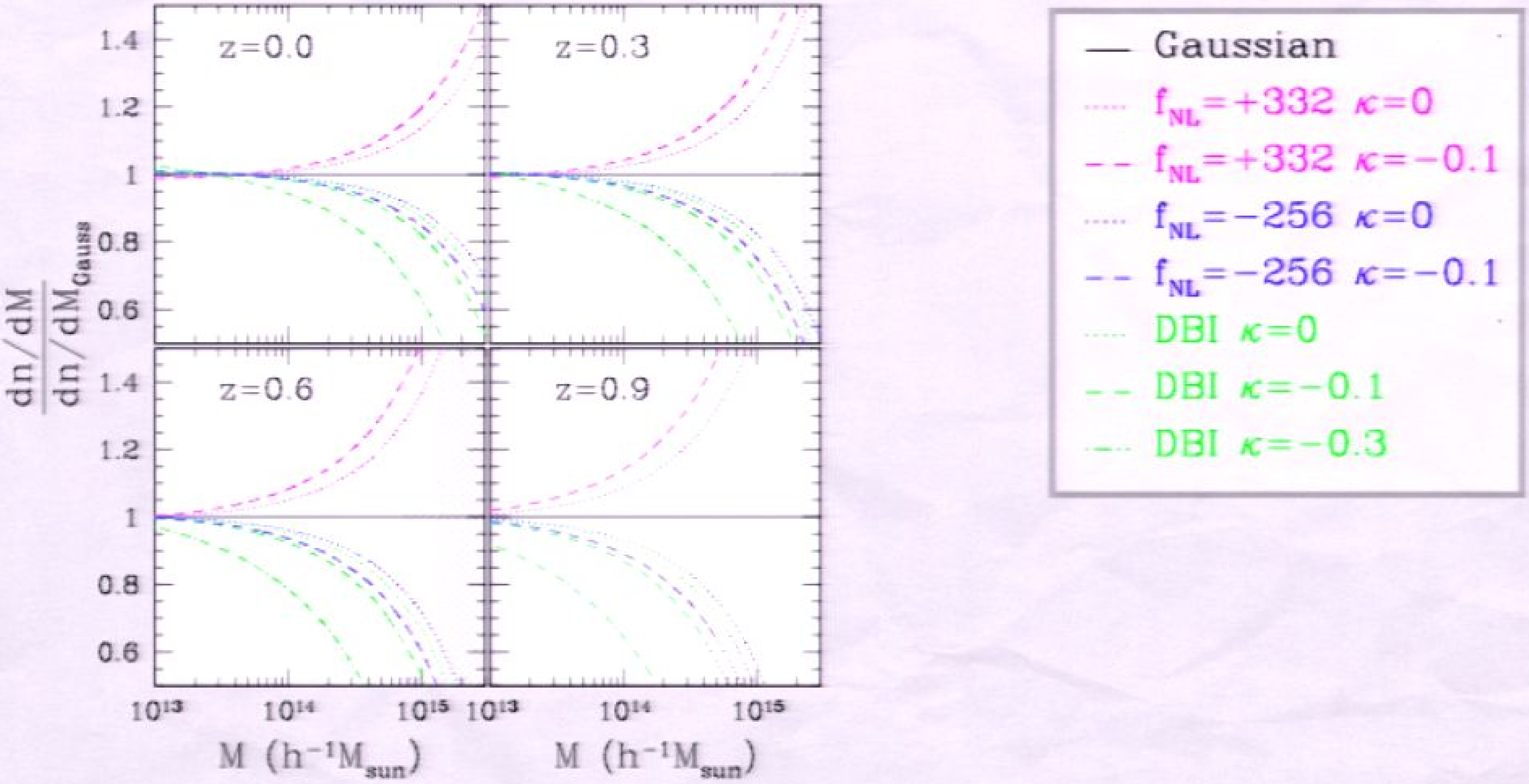
PI, Oct. 30, 2007

MASS FUNCTION



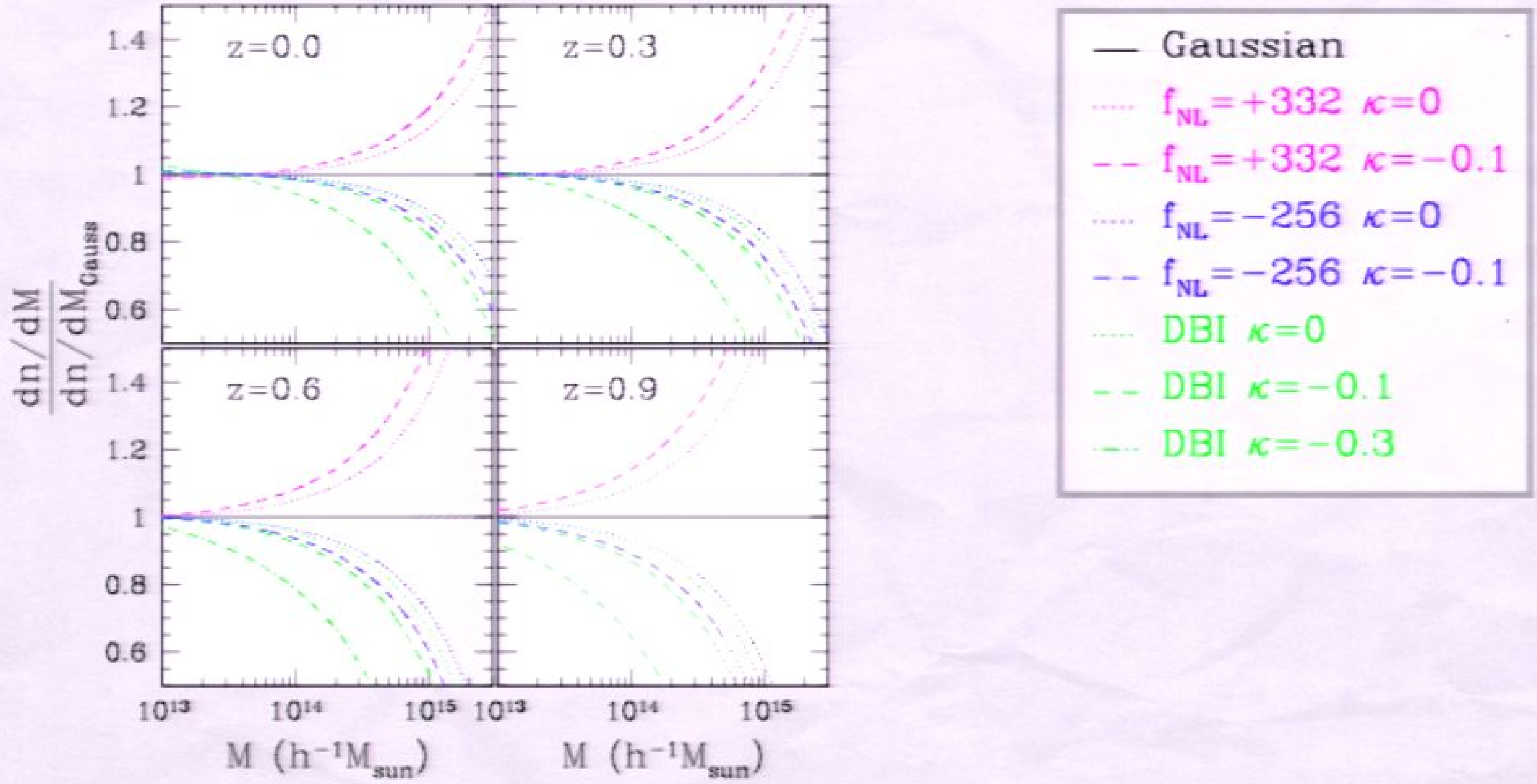
PI, Oct. 30, 2007

MASS FUNCTION



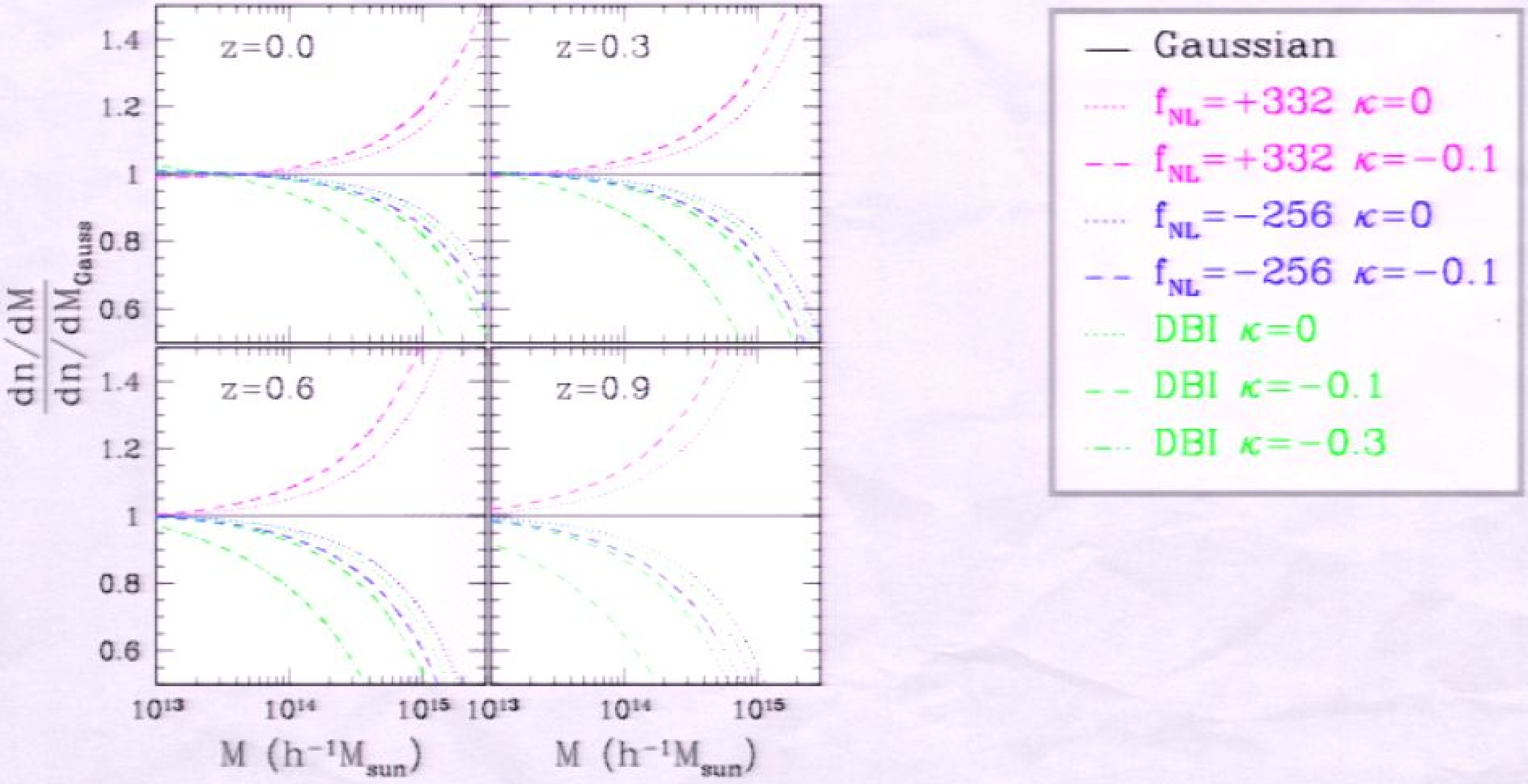
PI, Oct. 30, 2007

MASS FUNCTION

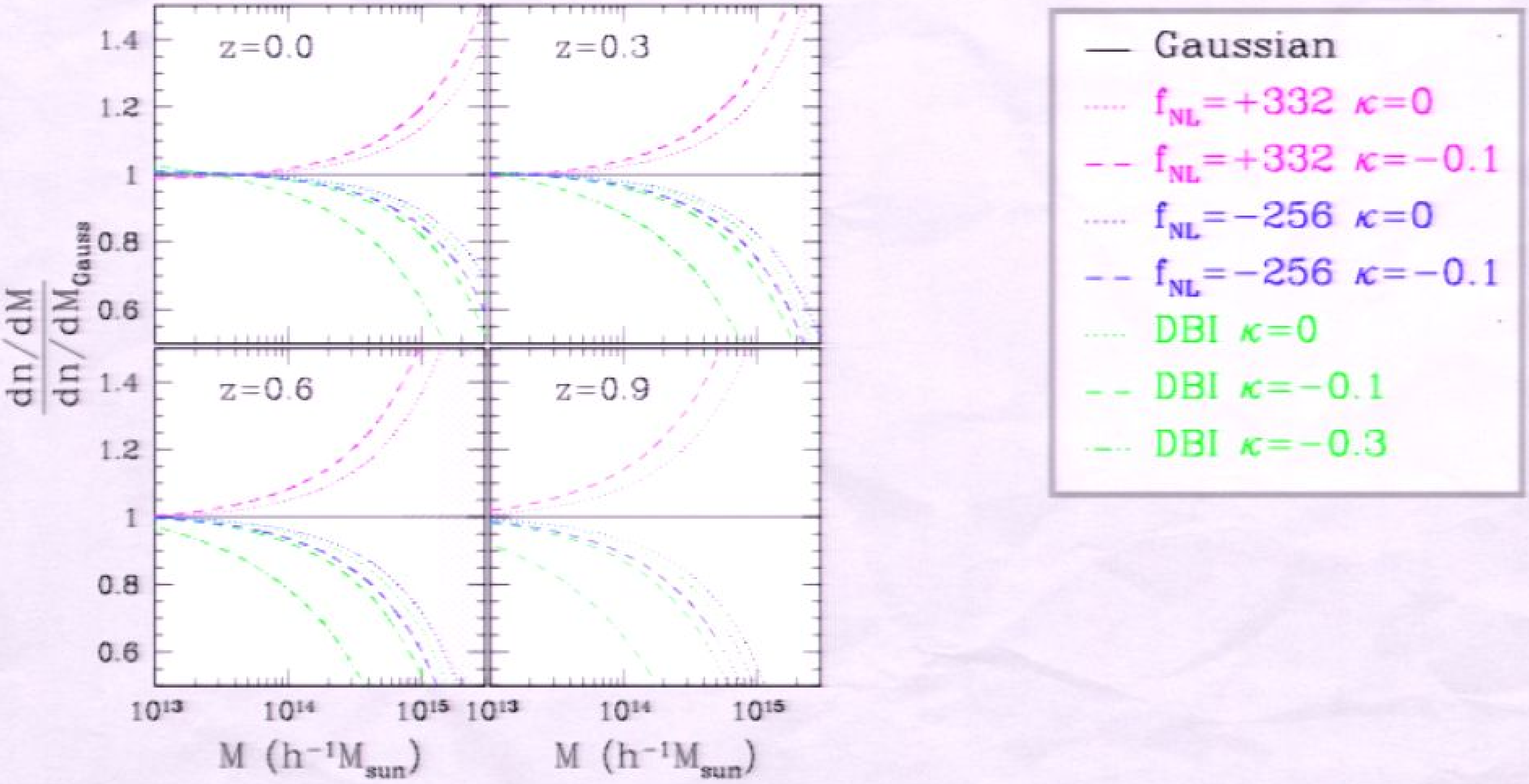


PI, Oct. 30, 2007

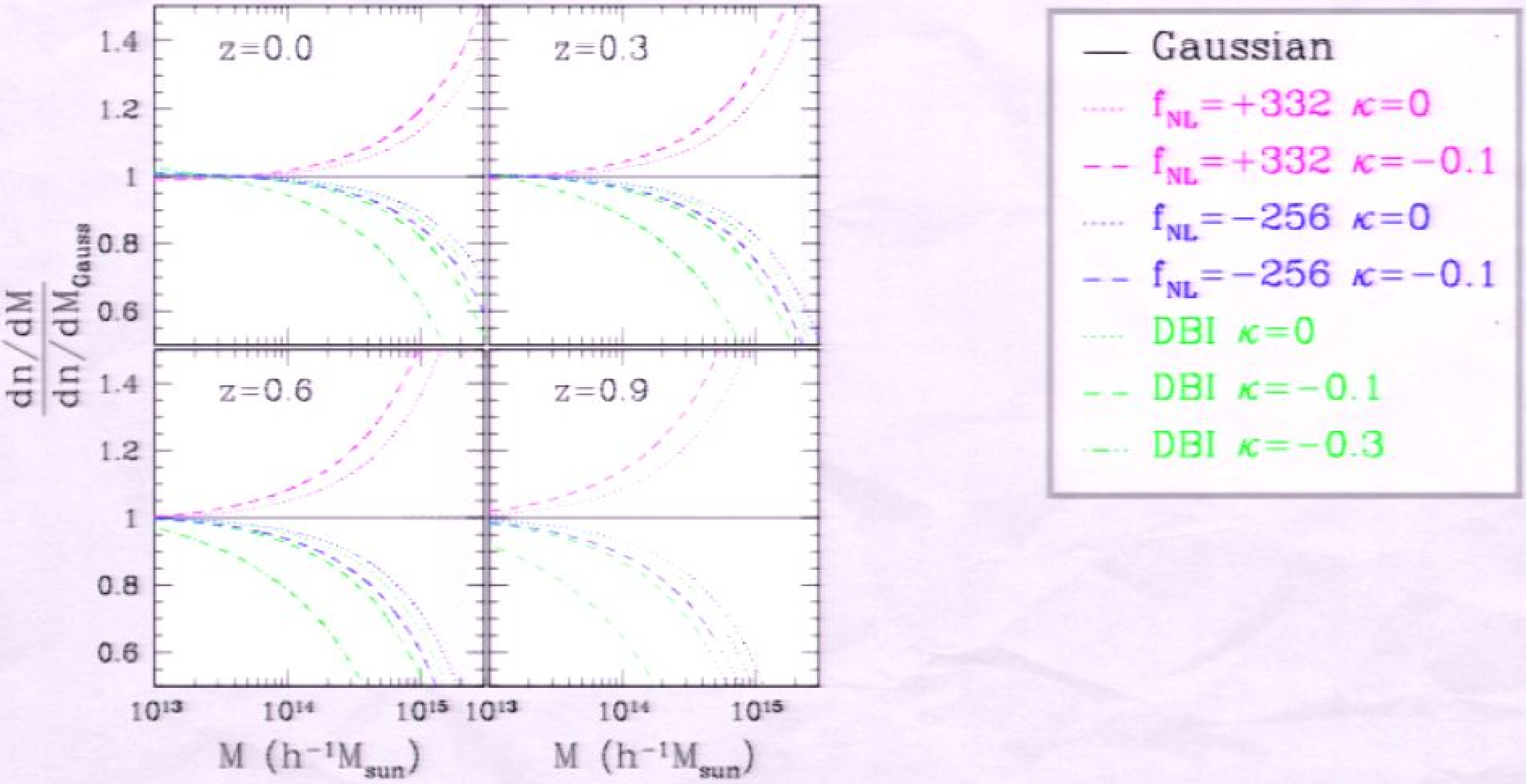
MASS FUNCTION



MASS FUNCTION

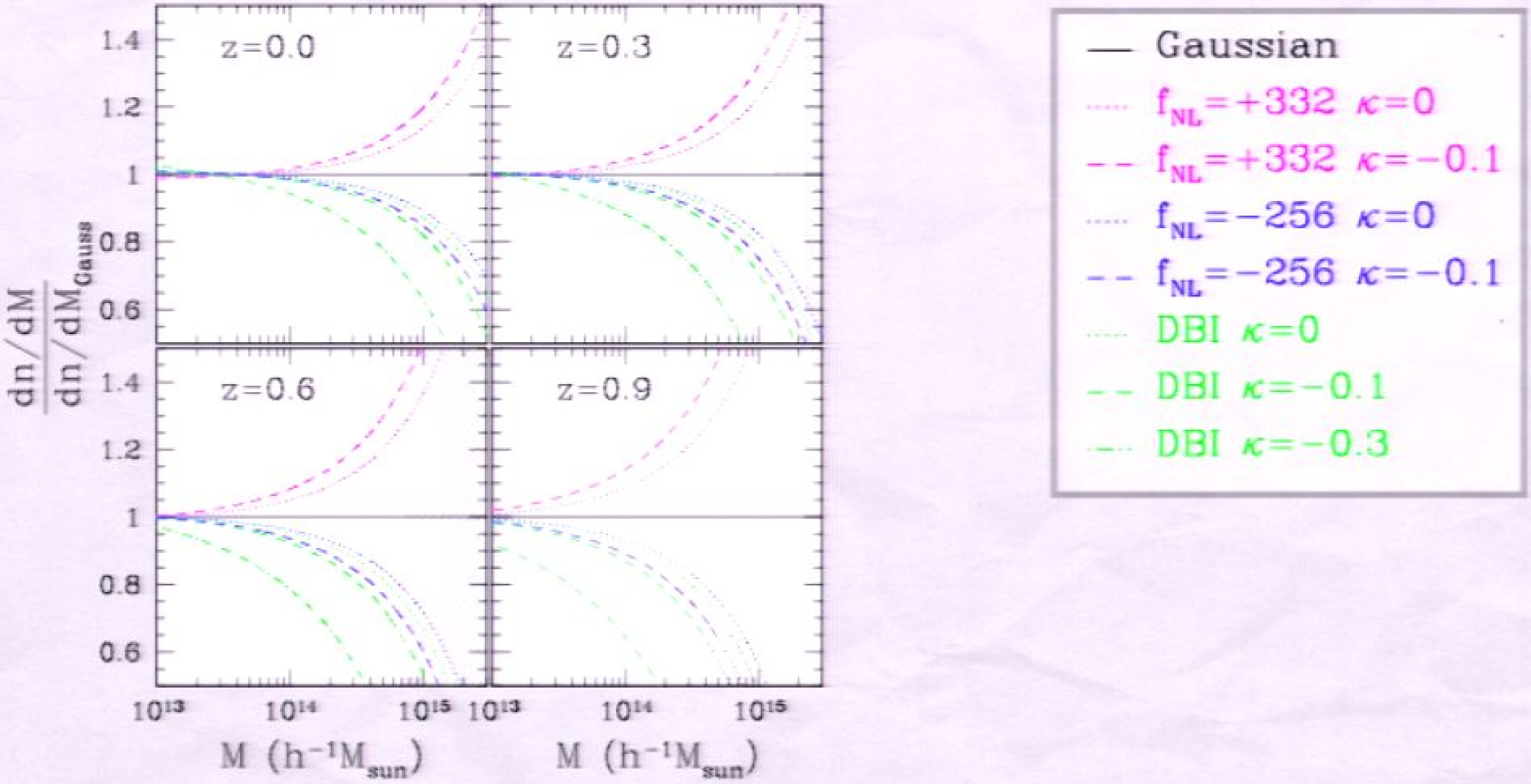


MASS FUNCTION



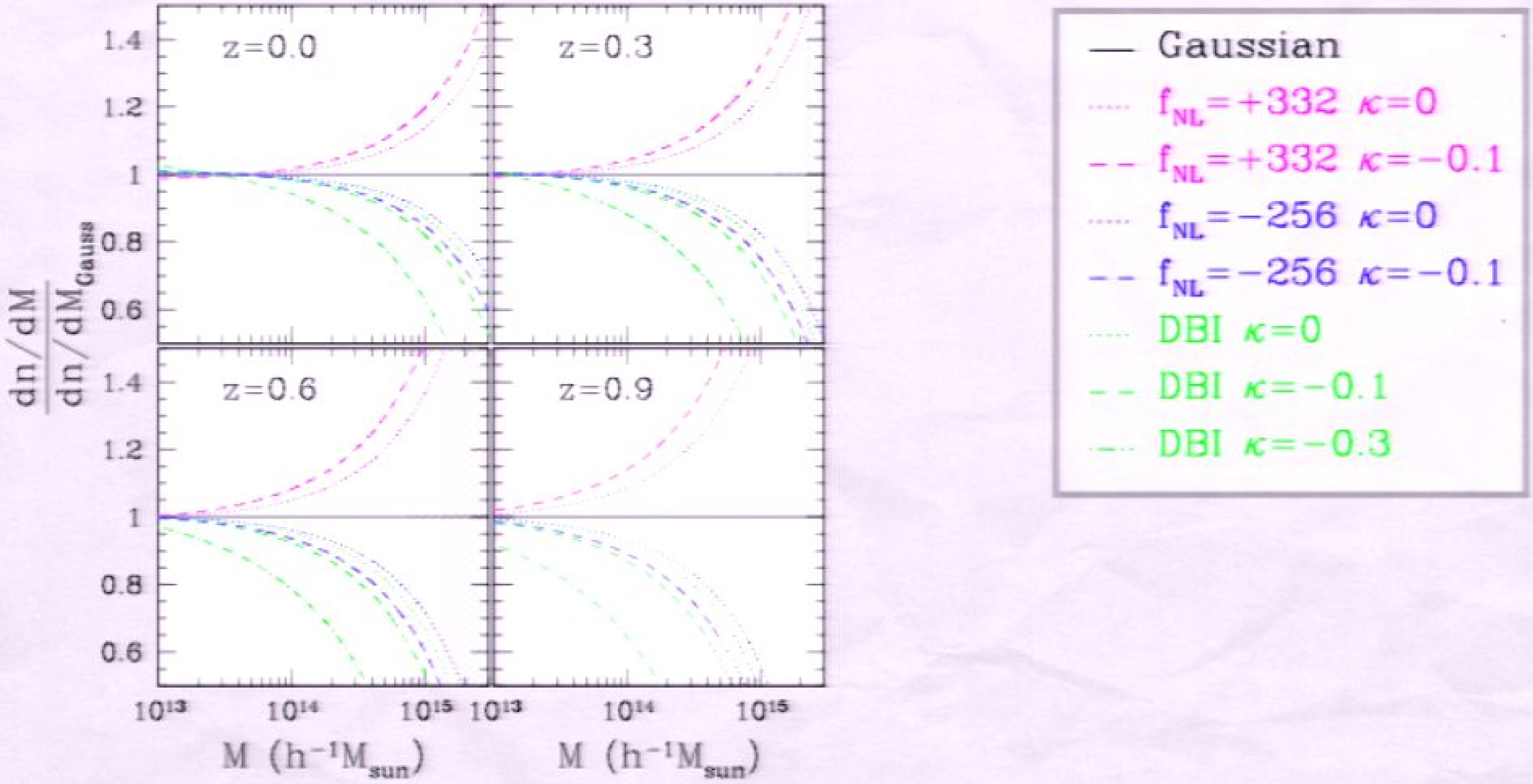
PI, Oct. 30, 2007

MASS FUNCTION



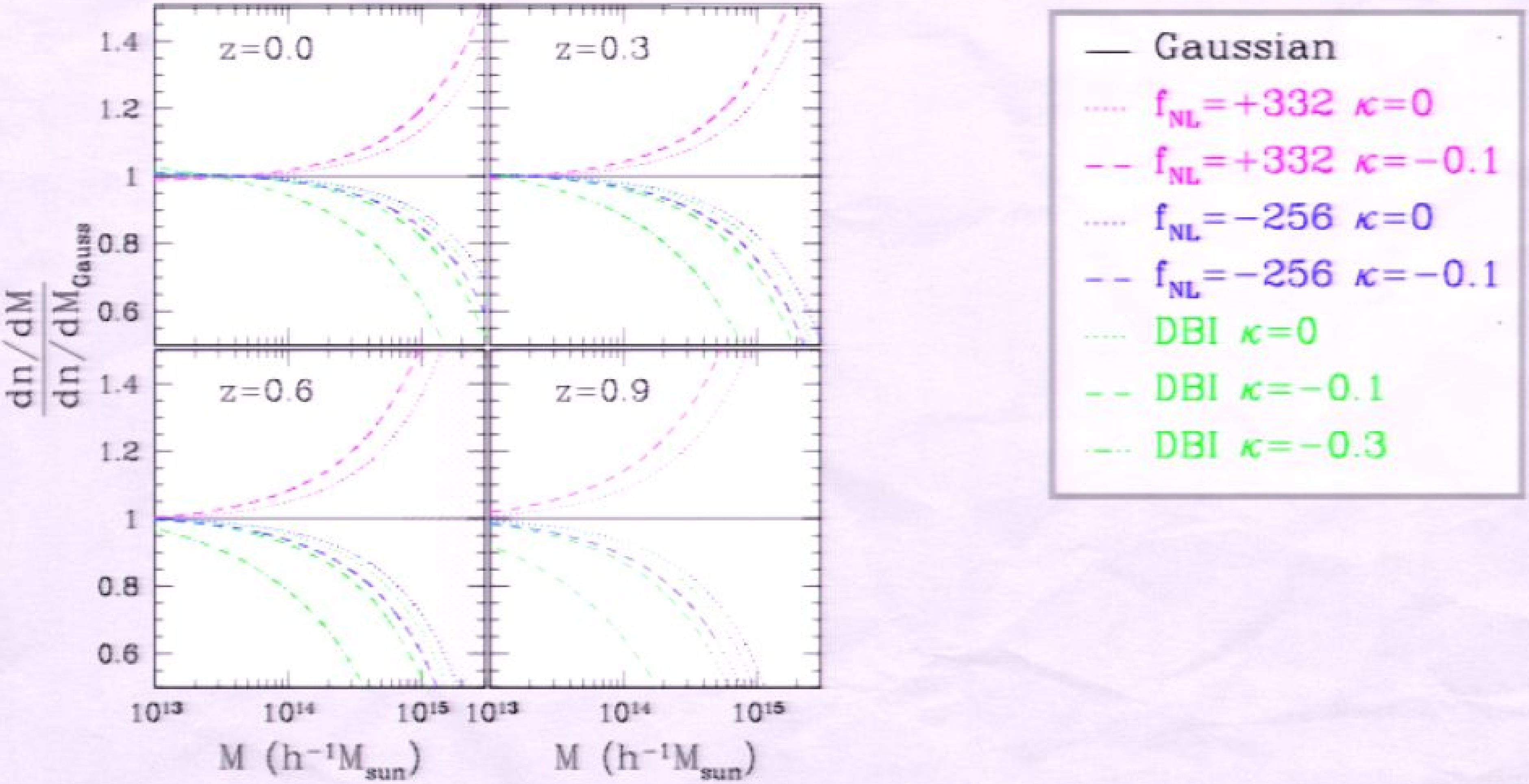
PI, Oct. 30, 2007

MASS FUNCTION



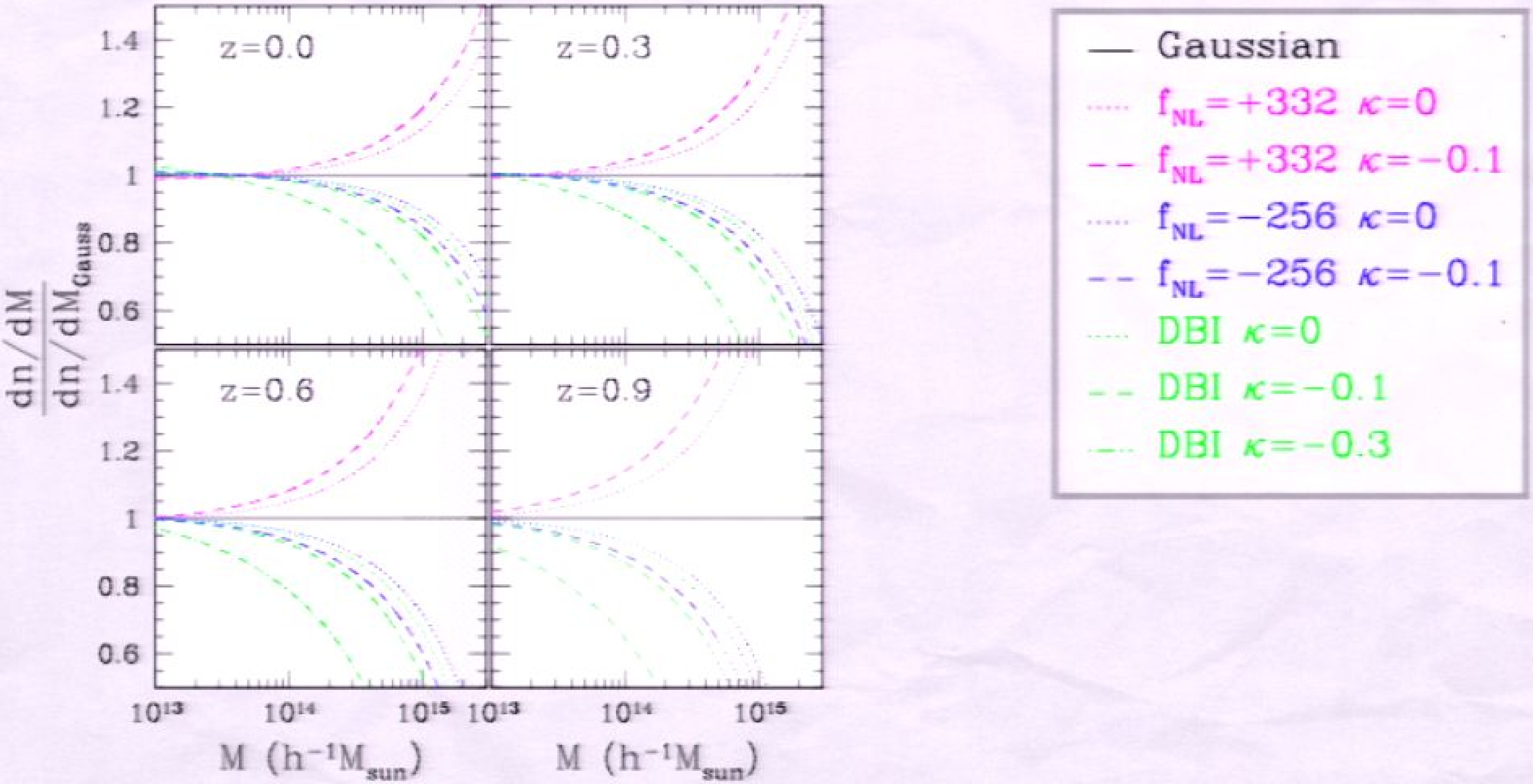
PI, Oct. 30, 2007

MASS FUNCTION

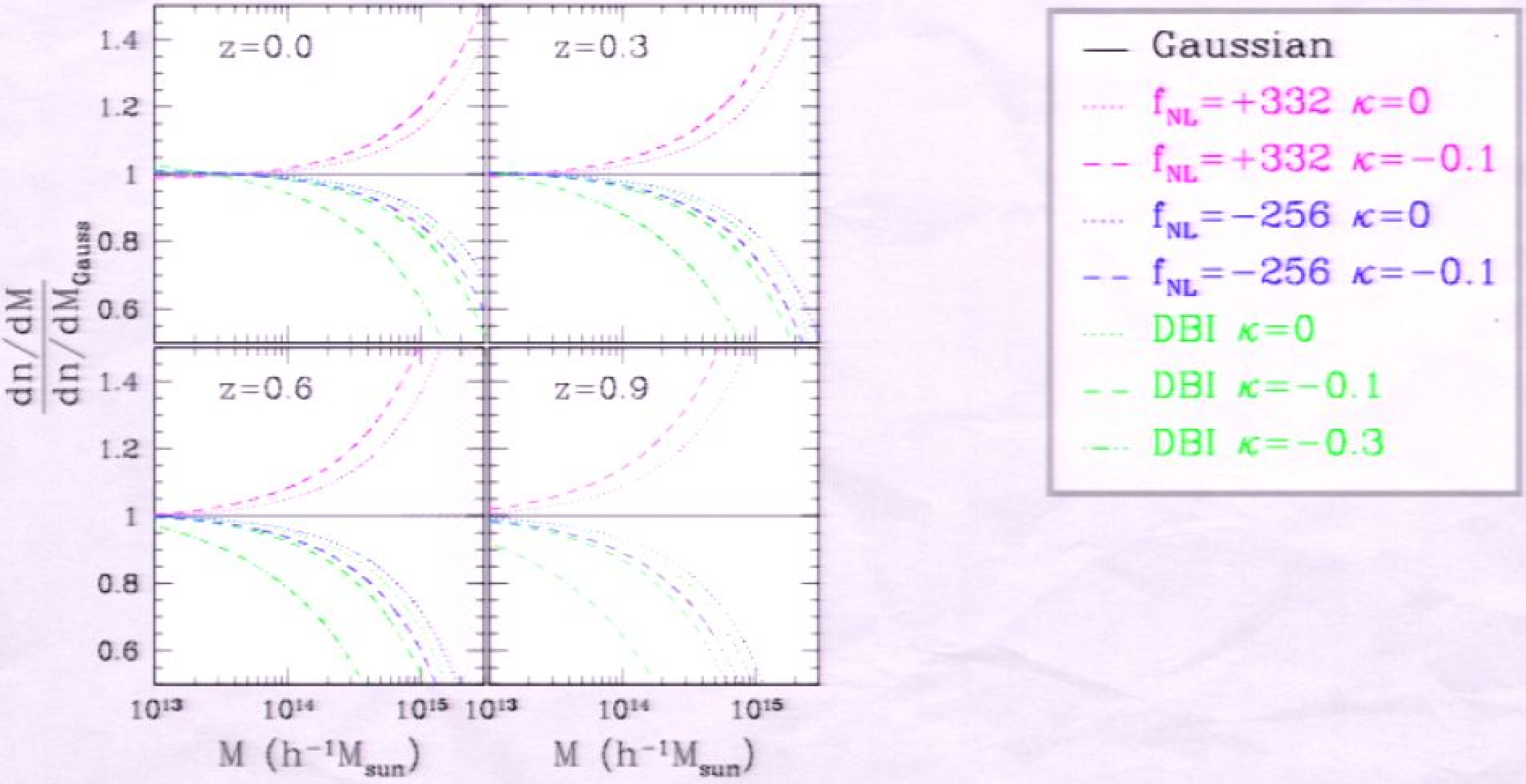


PI, Oct. 30, 2007

MASS FUNCTION

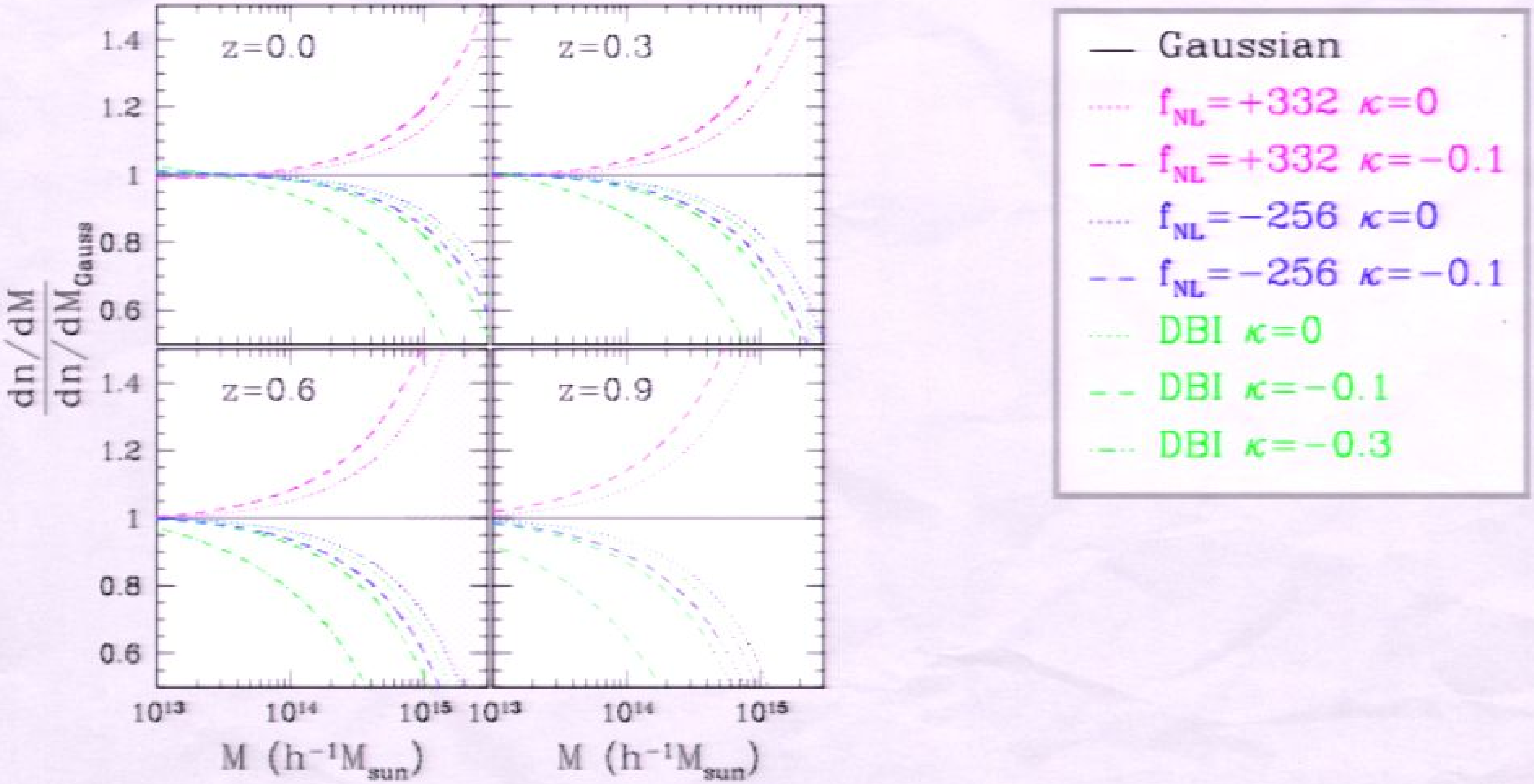


MASS FUNCTION

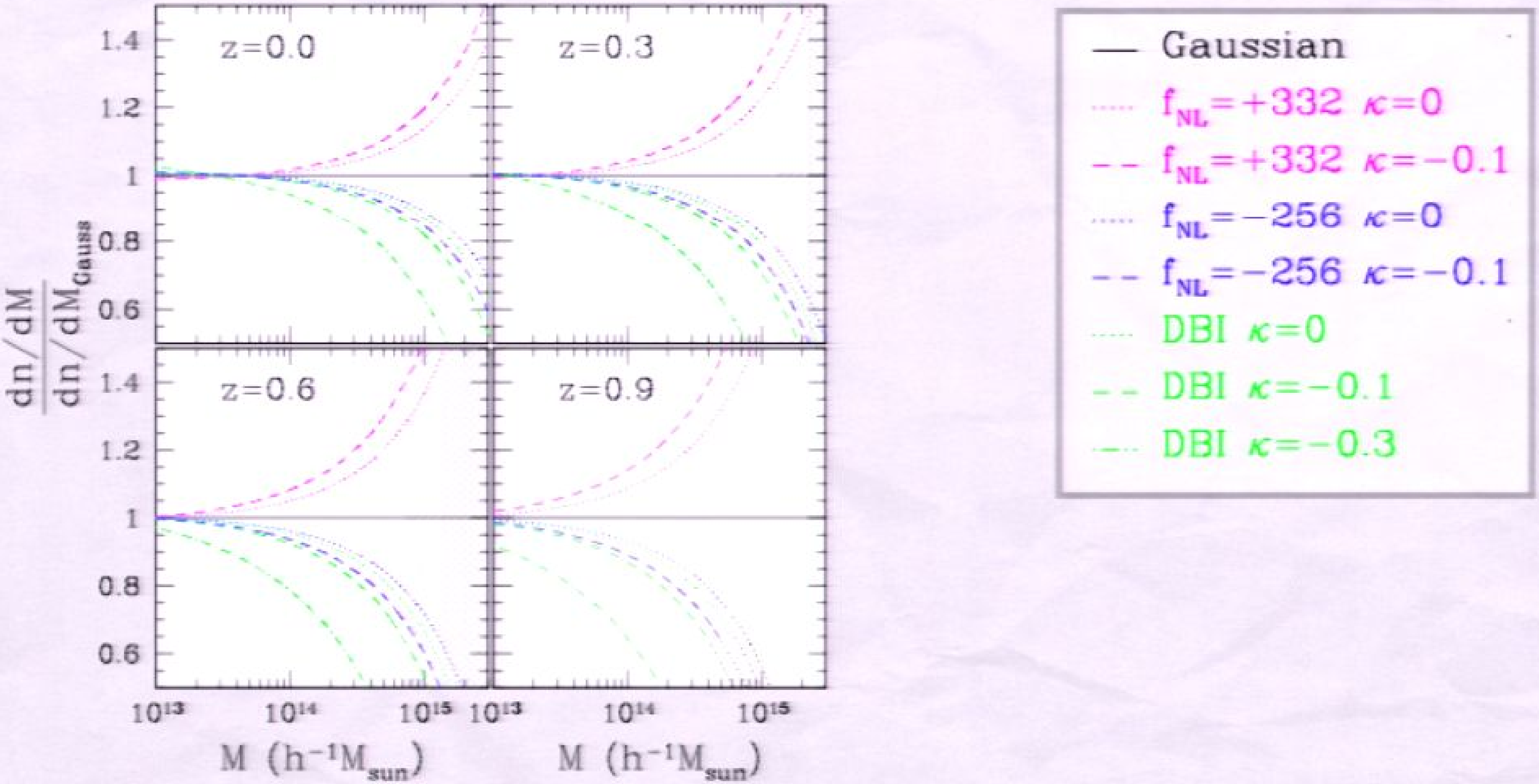


PI, Oct. 30, 2007

MASS FUNCTION

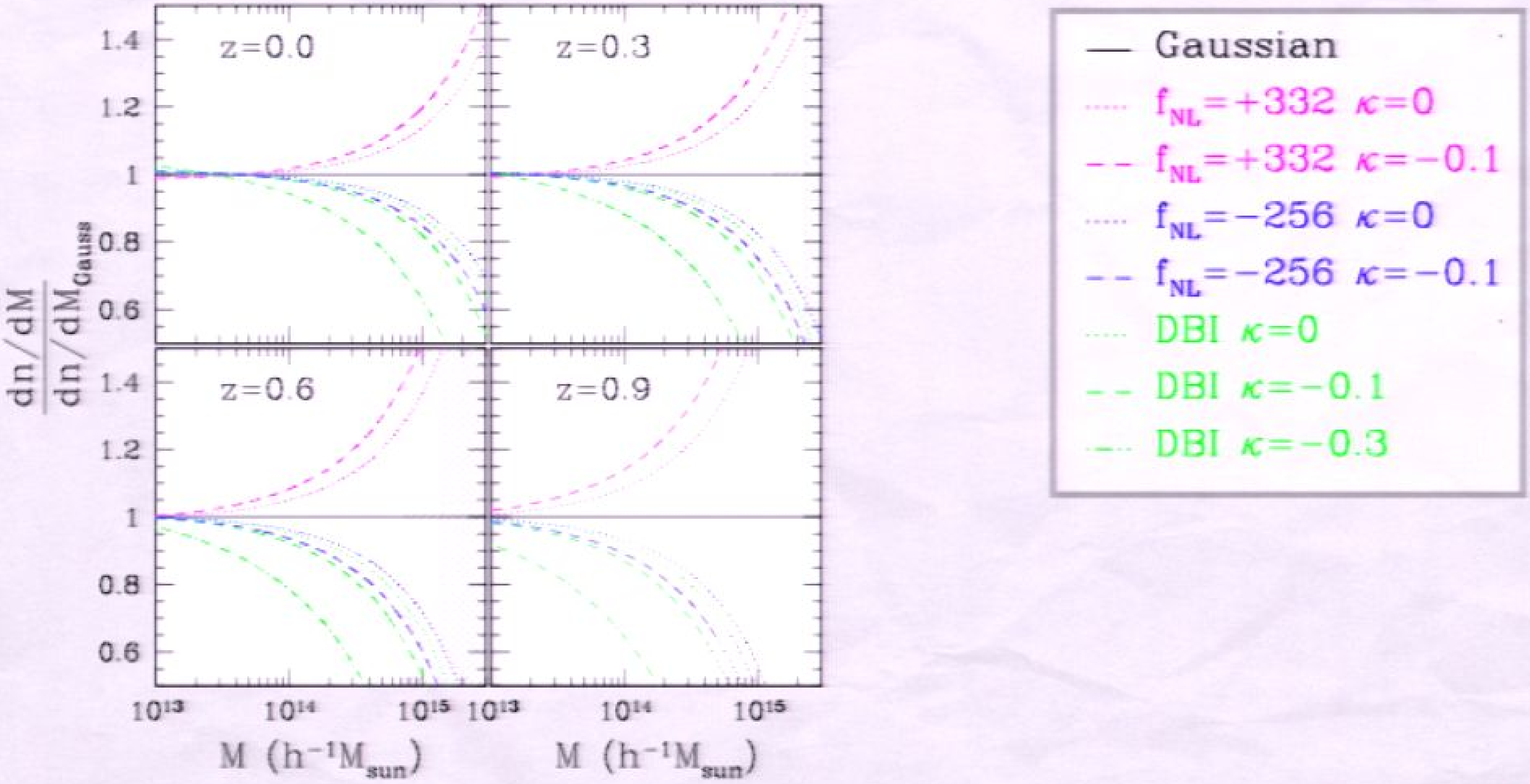


MASS FUNCTION

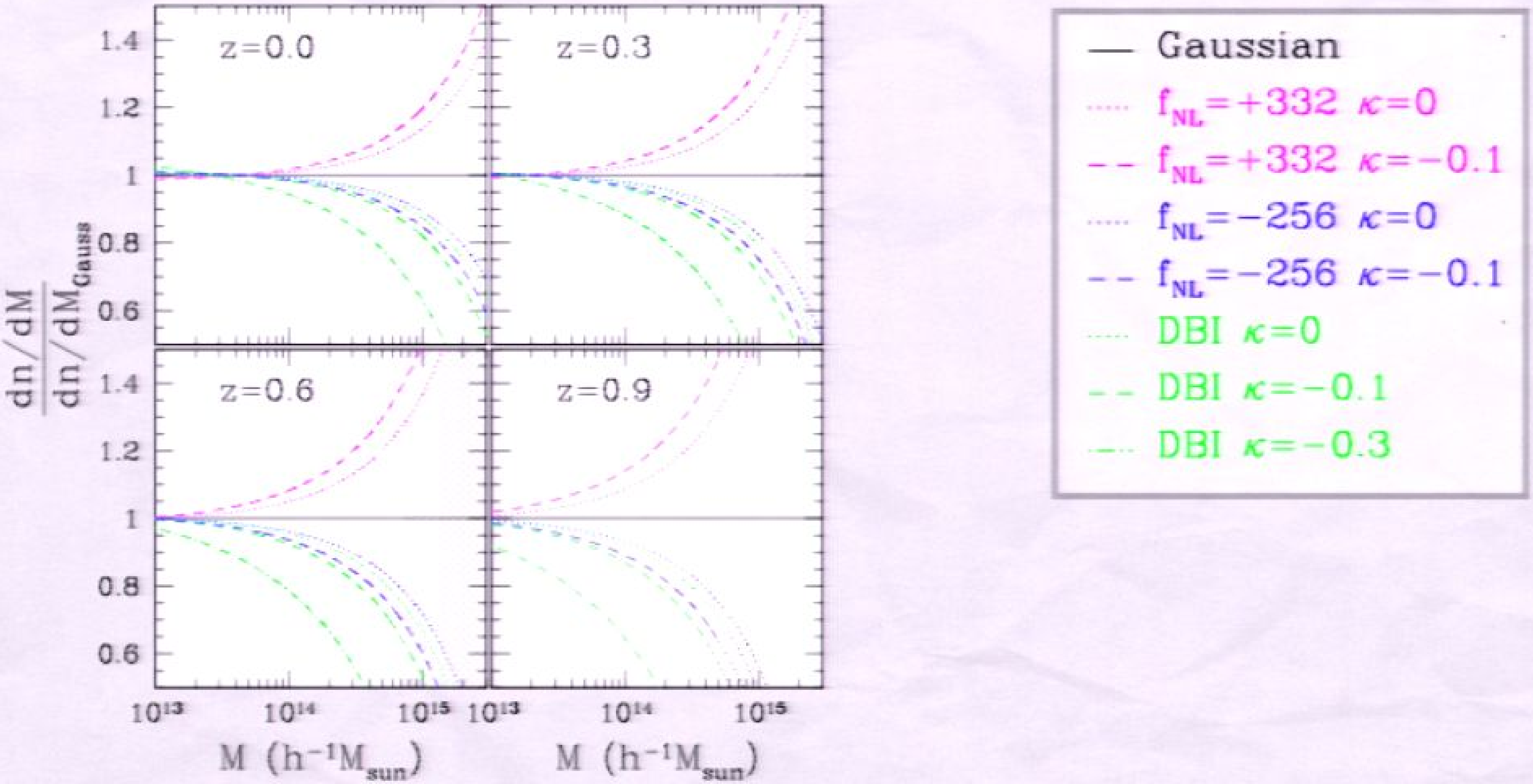


PI, Oct. 30, 2007

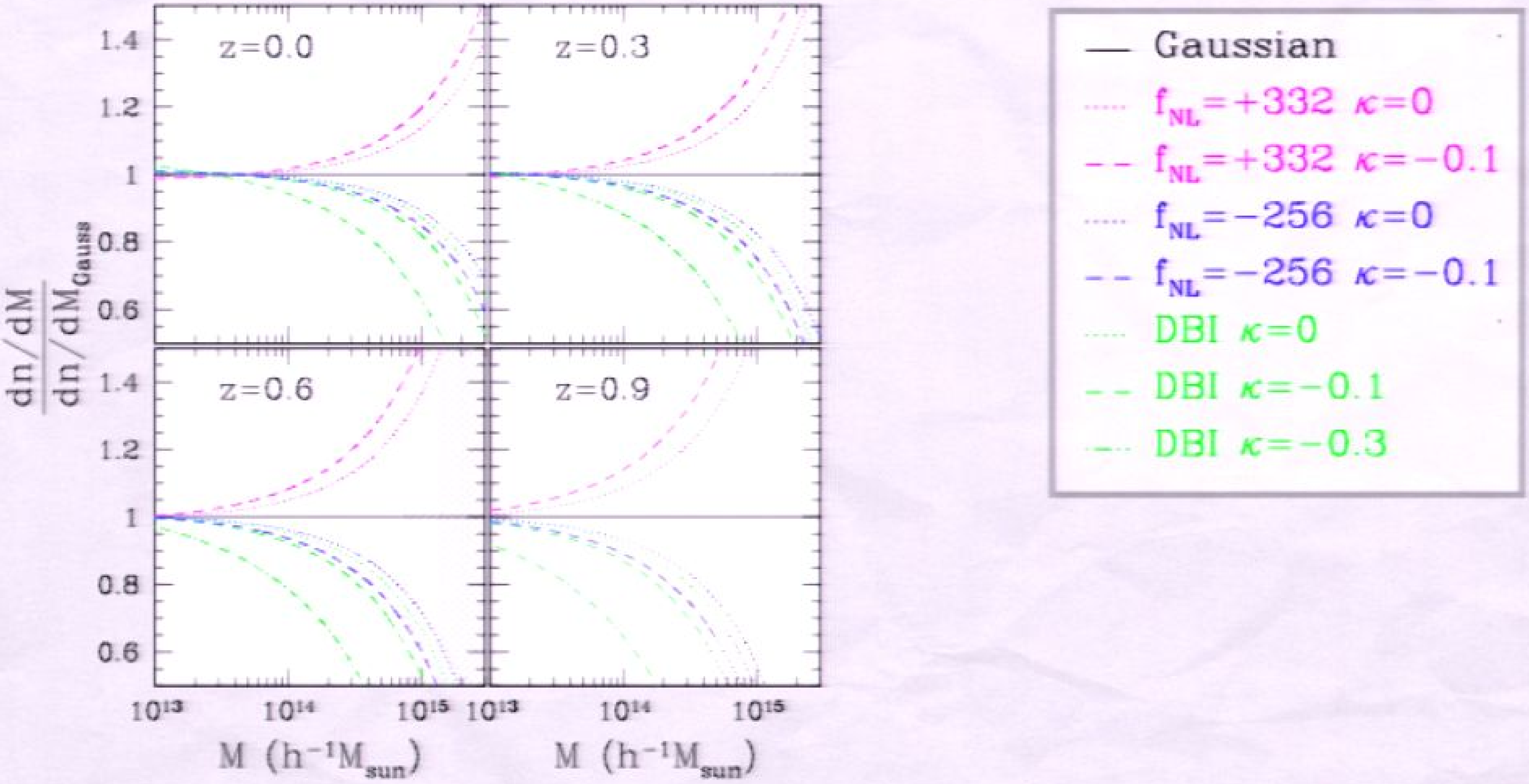
MASS FUNCTION



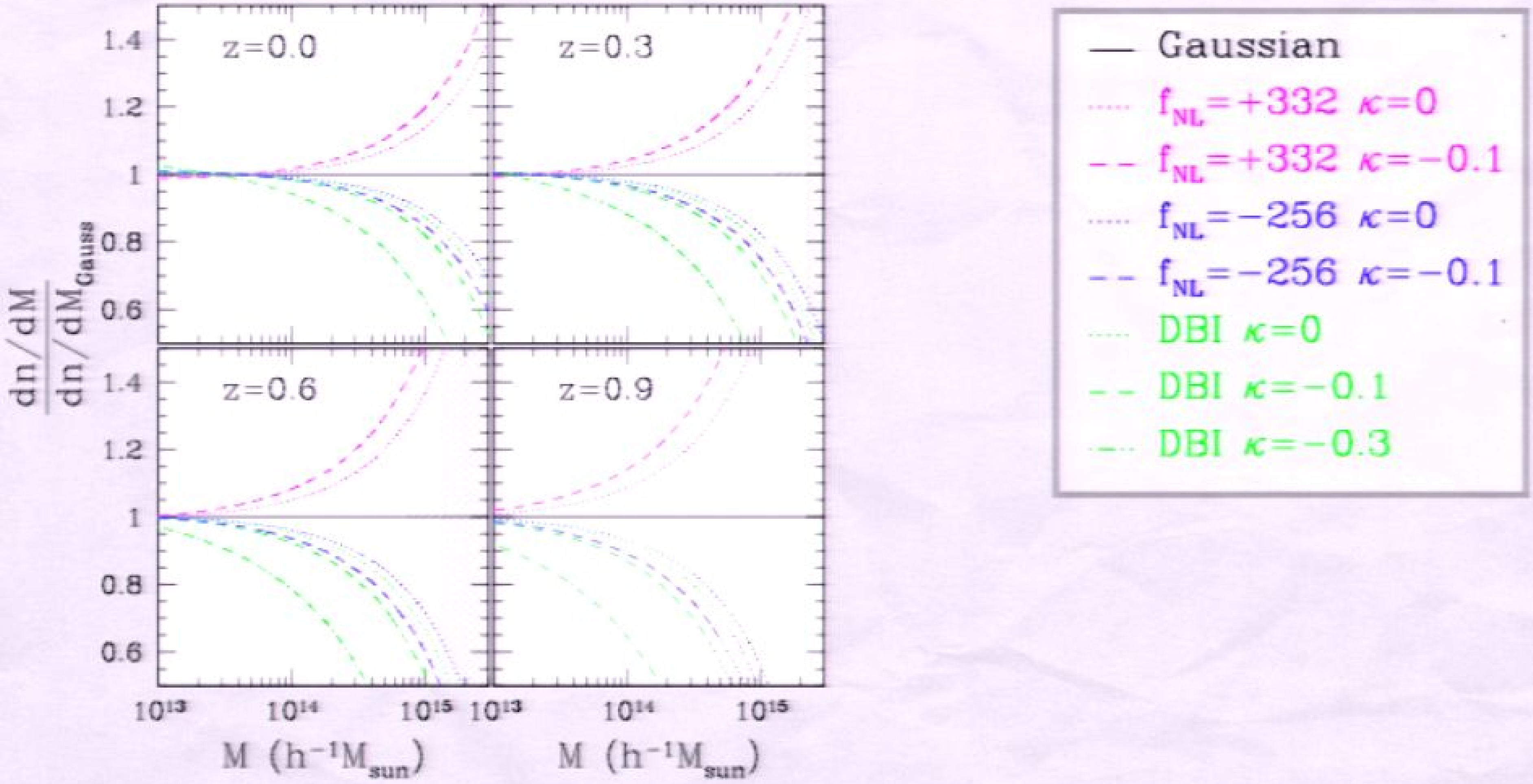
MASS FUNCTION



MASS FUNCTION

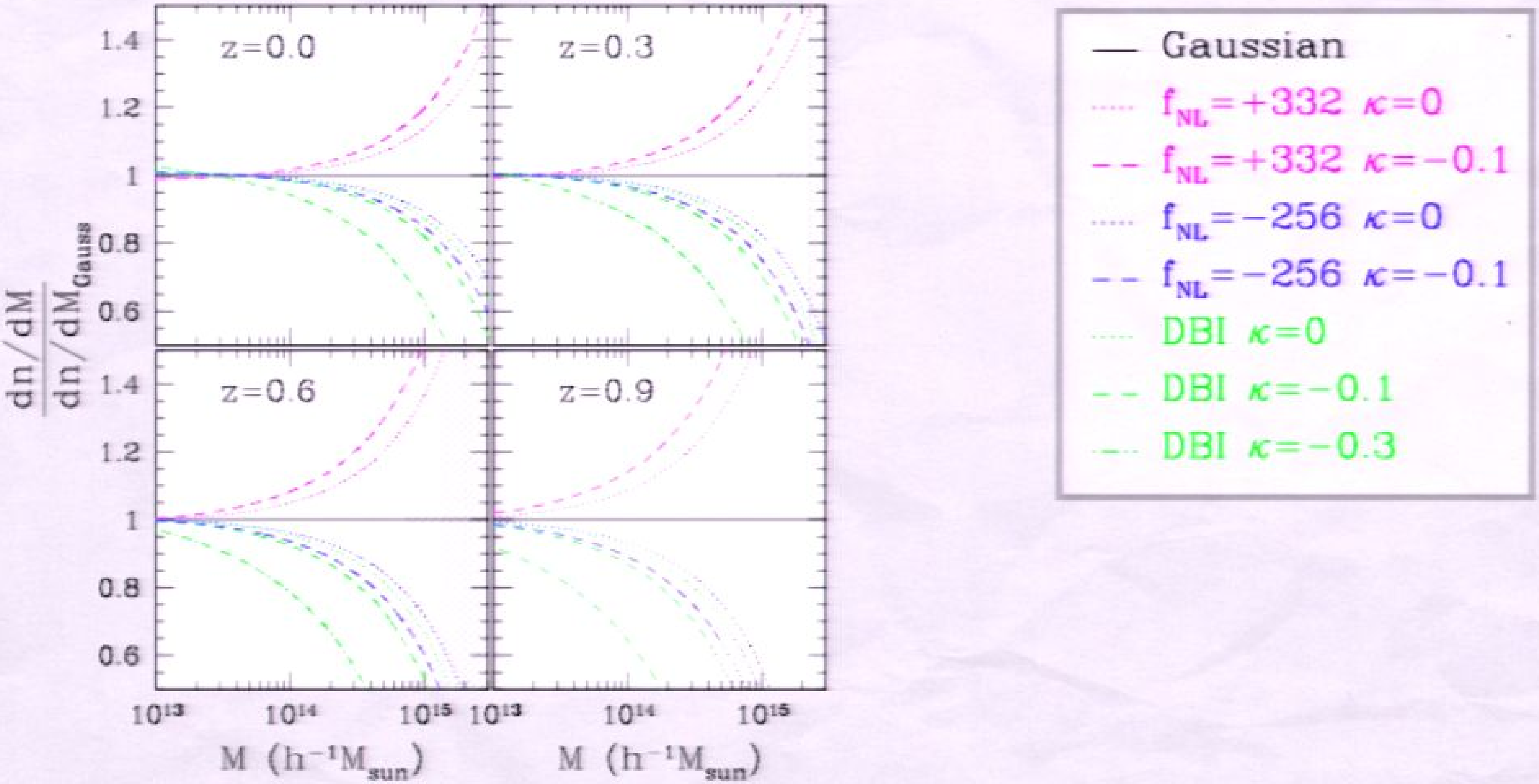


MASS FUNCTION



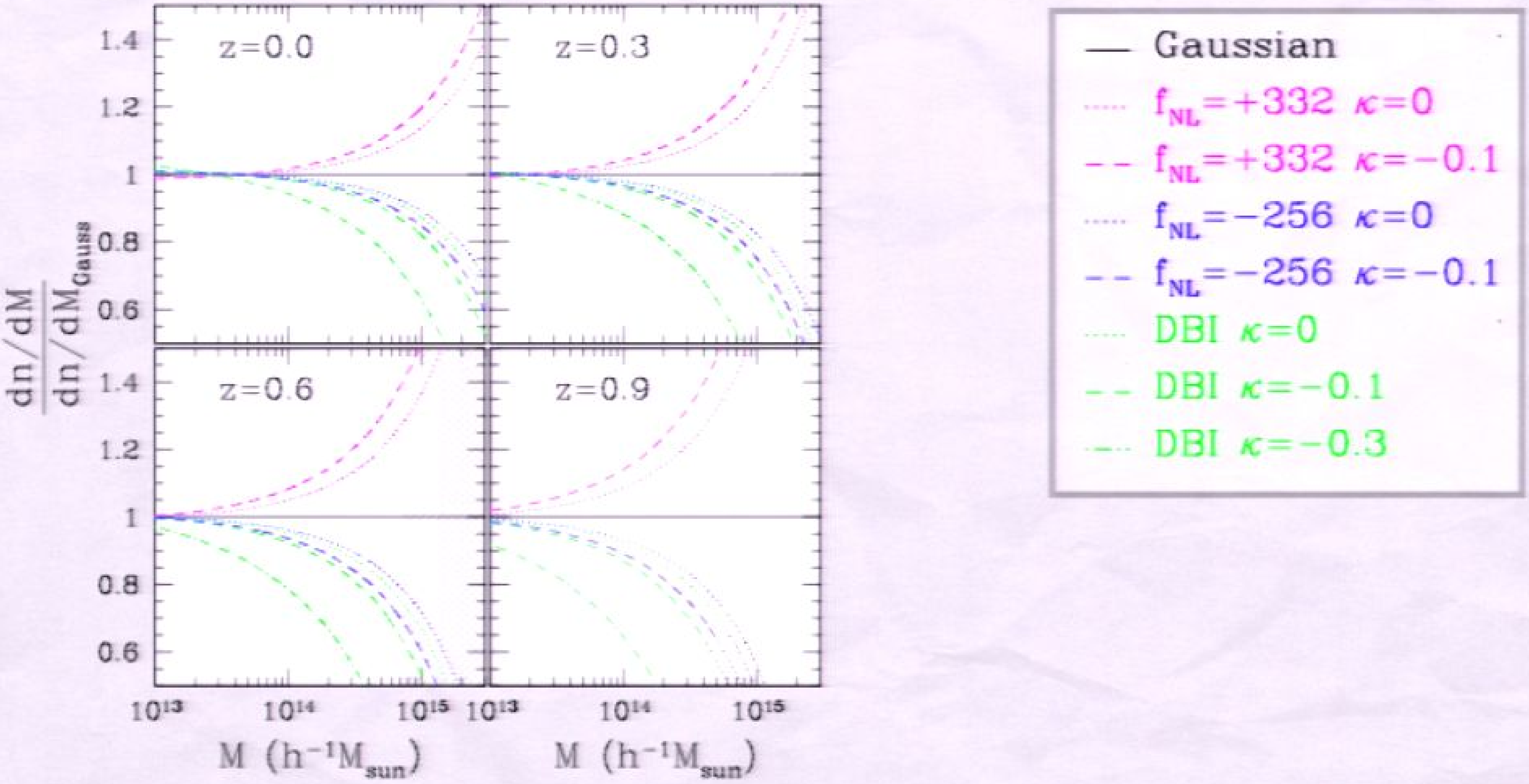
PI, Oct. 30, 2007

MASS FUNCTION

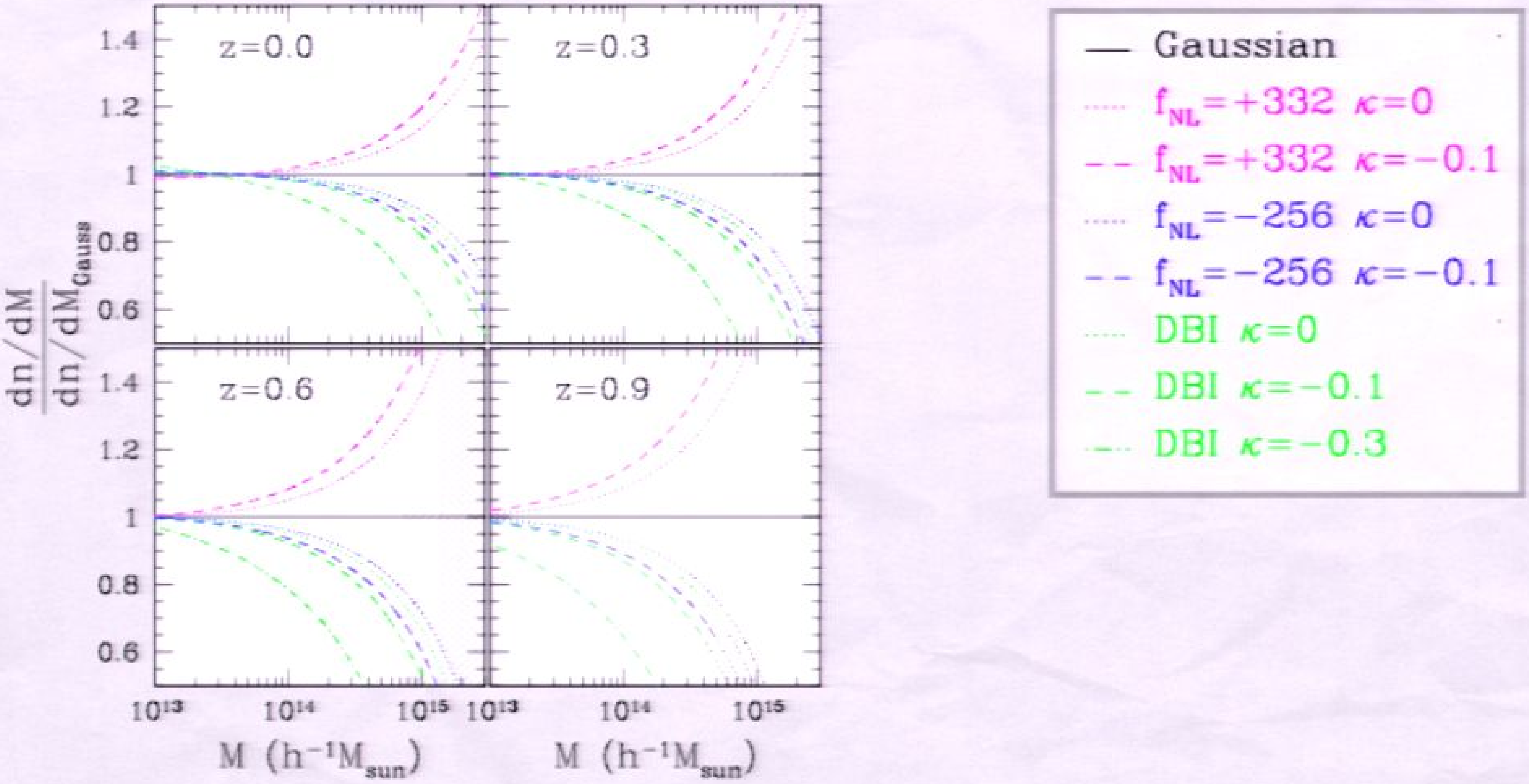


PI, Oct. 30, 2007

MASS FUNCTION

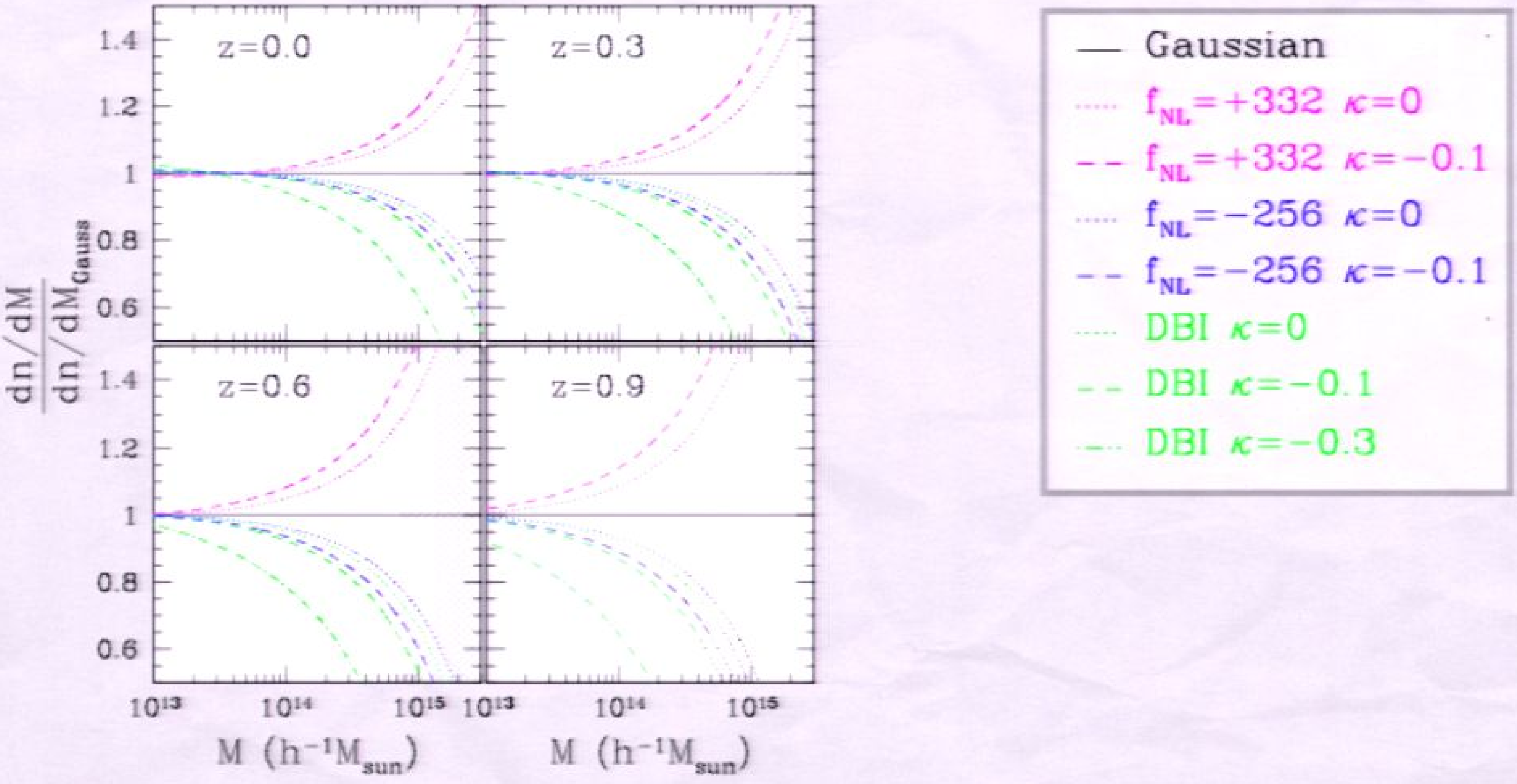


MASS FUNCTION



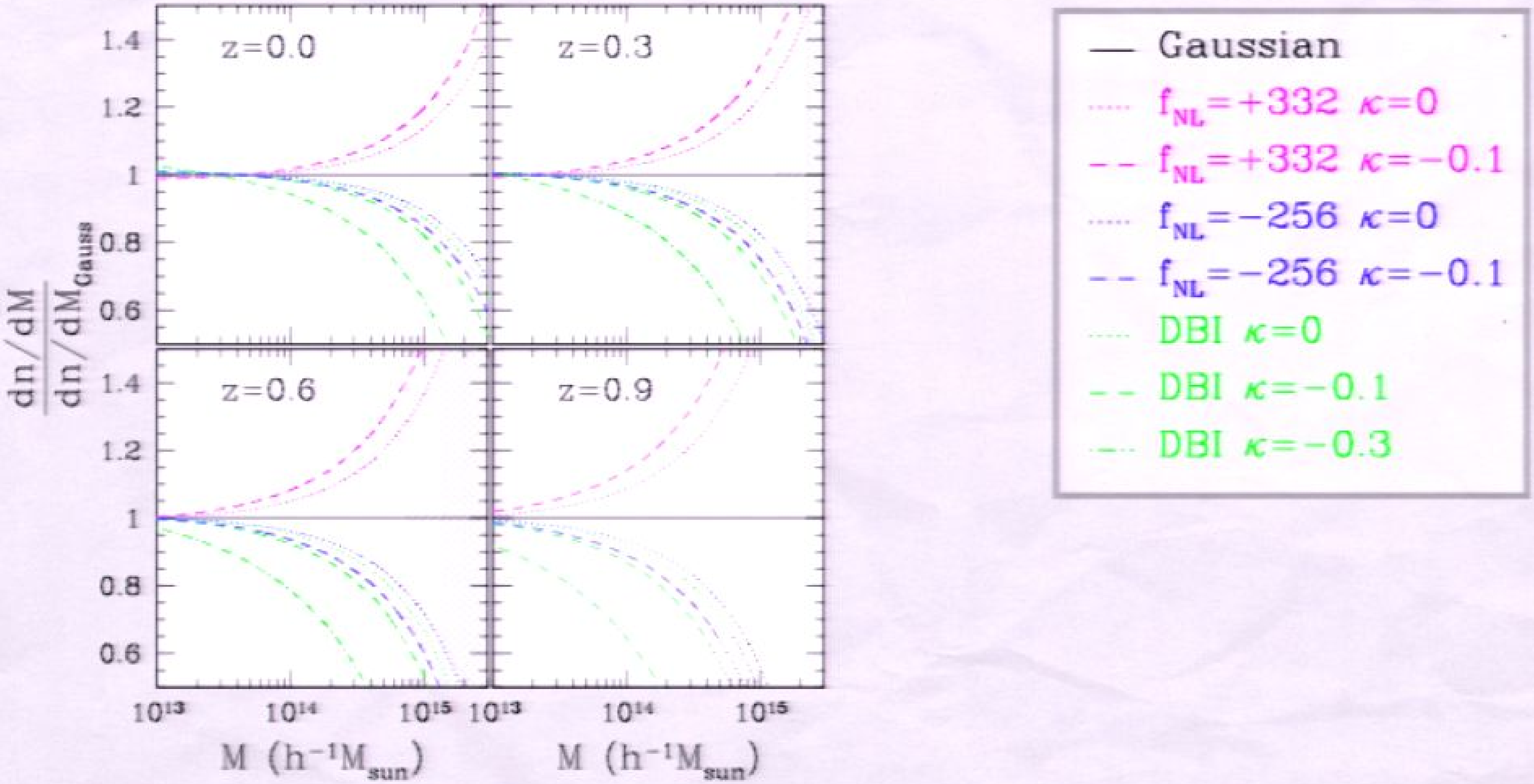
PI, Oct. 30, 2007

MASS FUNCTION

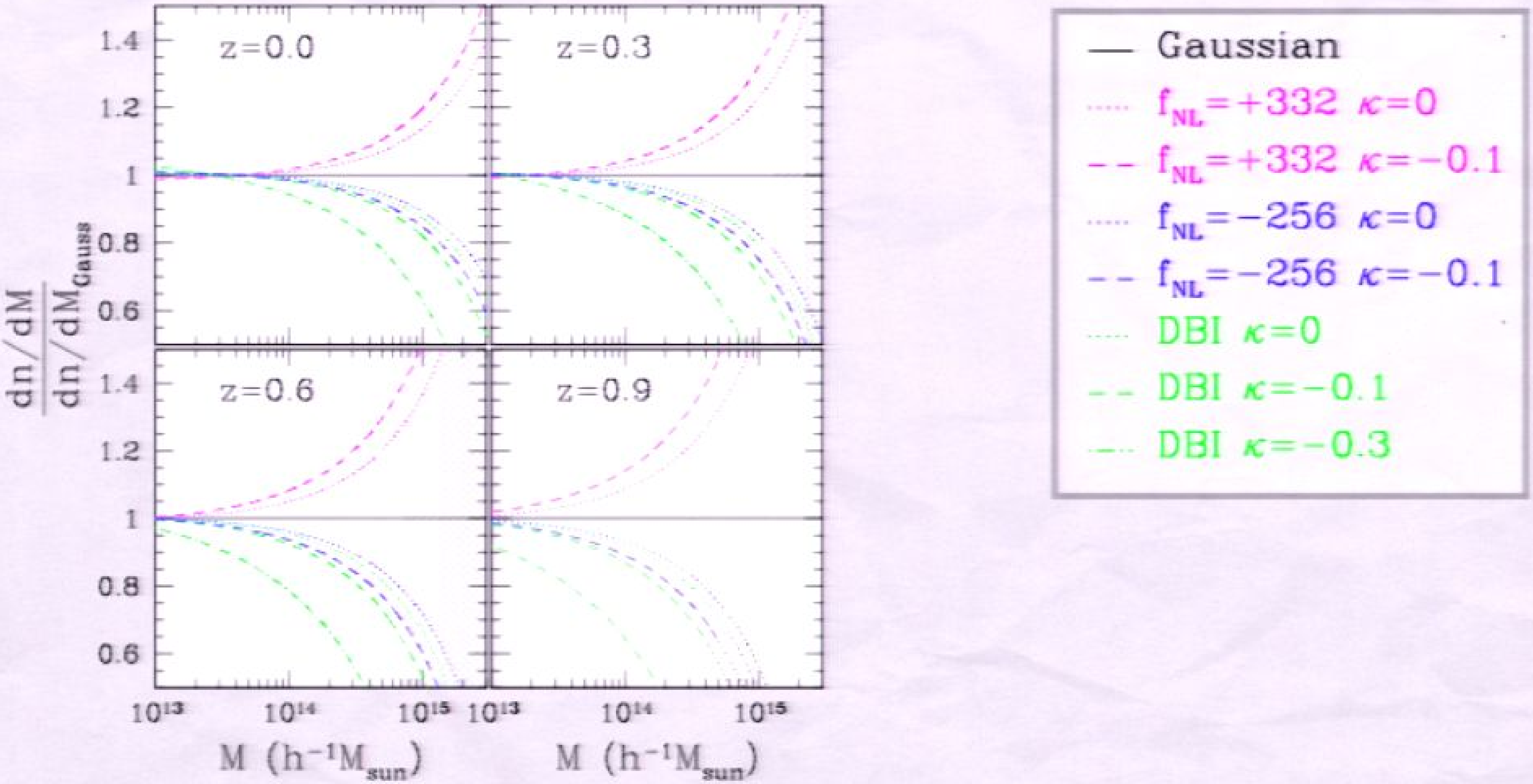


PI, Oct. 30, 2007

MASS FUNCTION

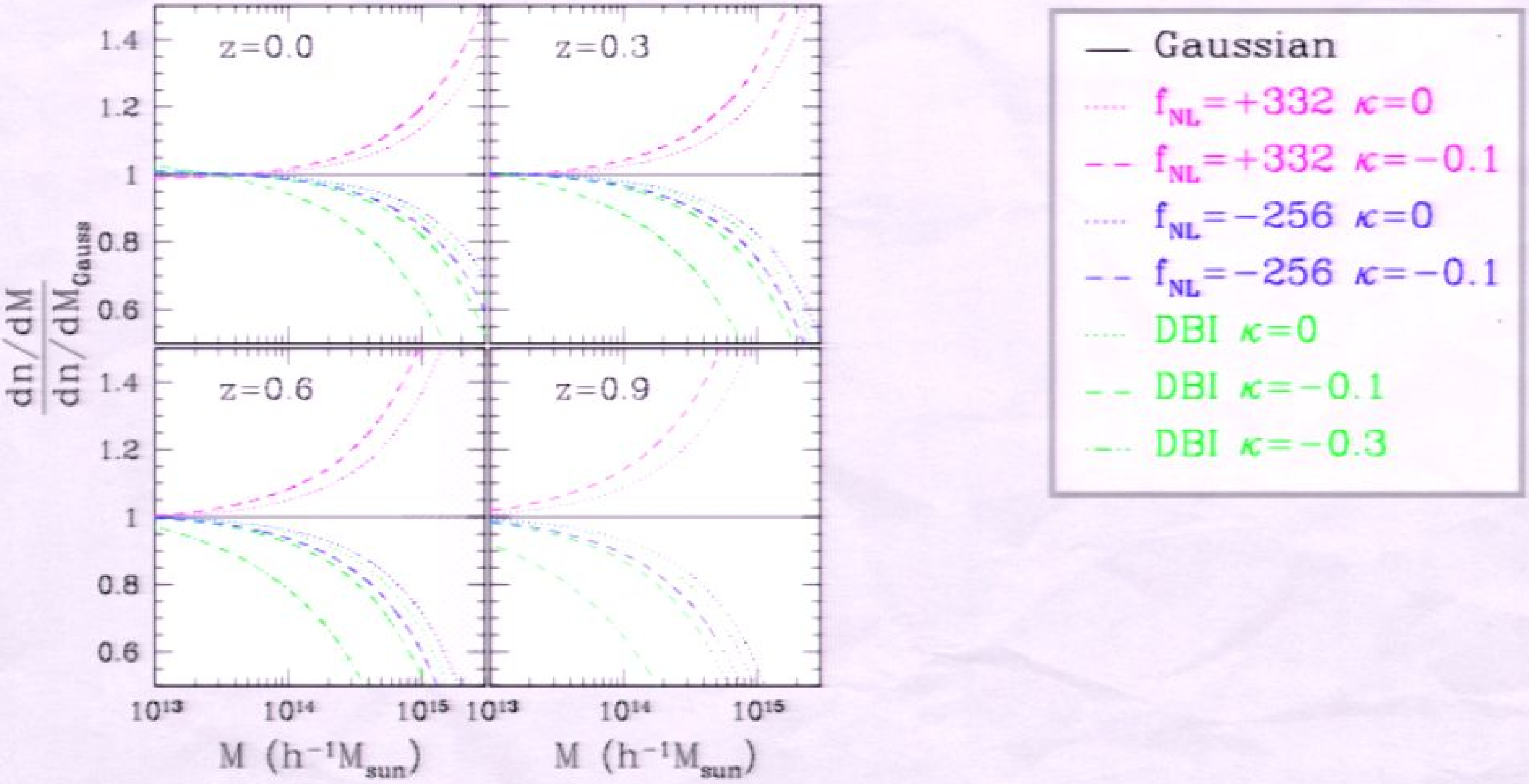


MASS FUNCTION

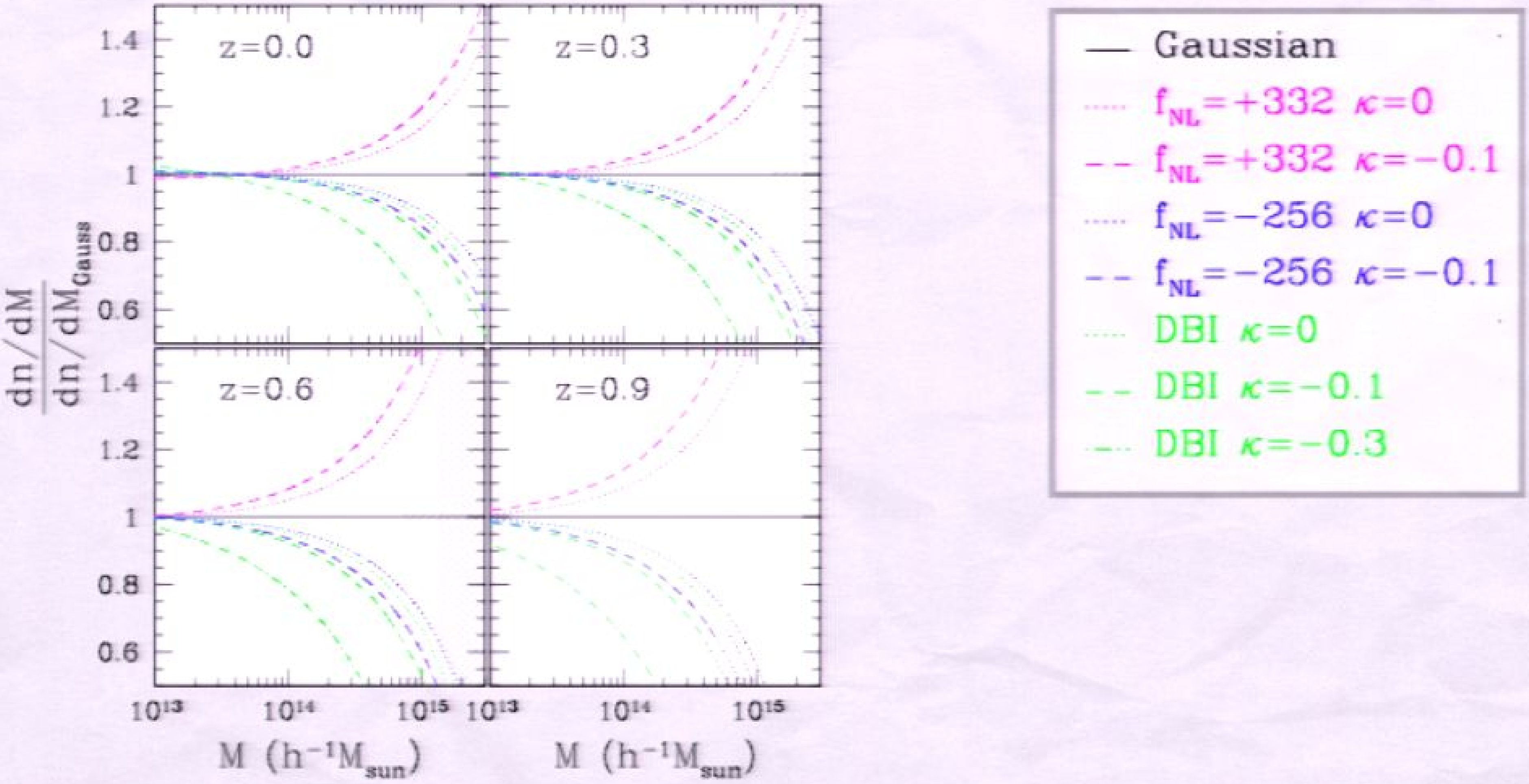


PI, Oct. 30, 2007

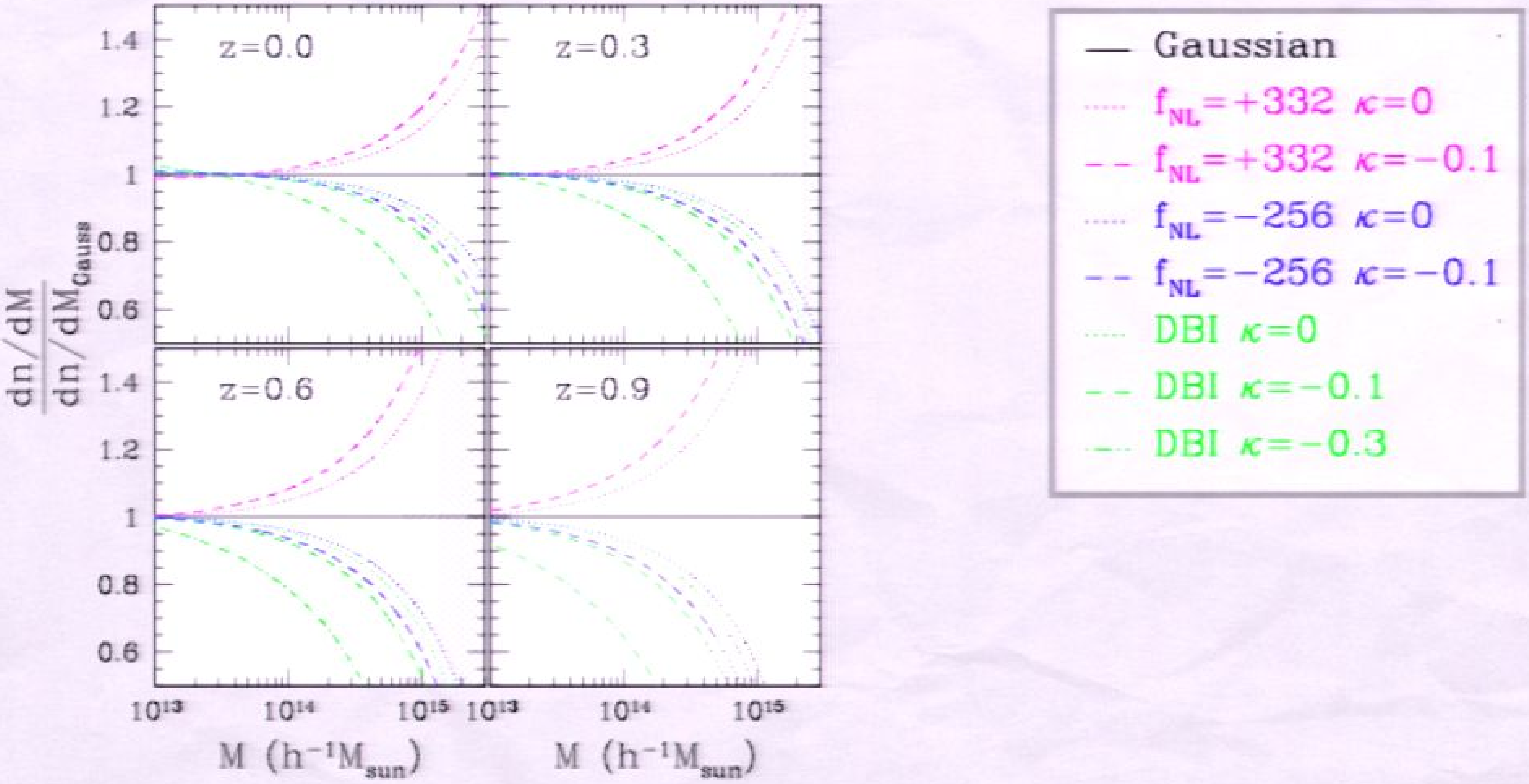
MASS FUNCTION



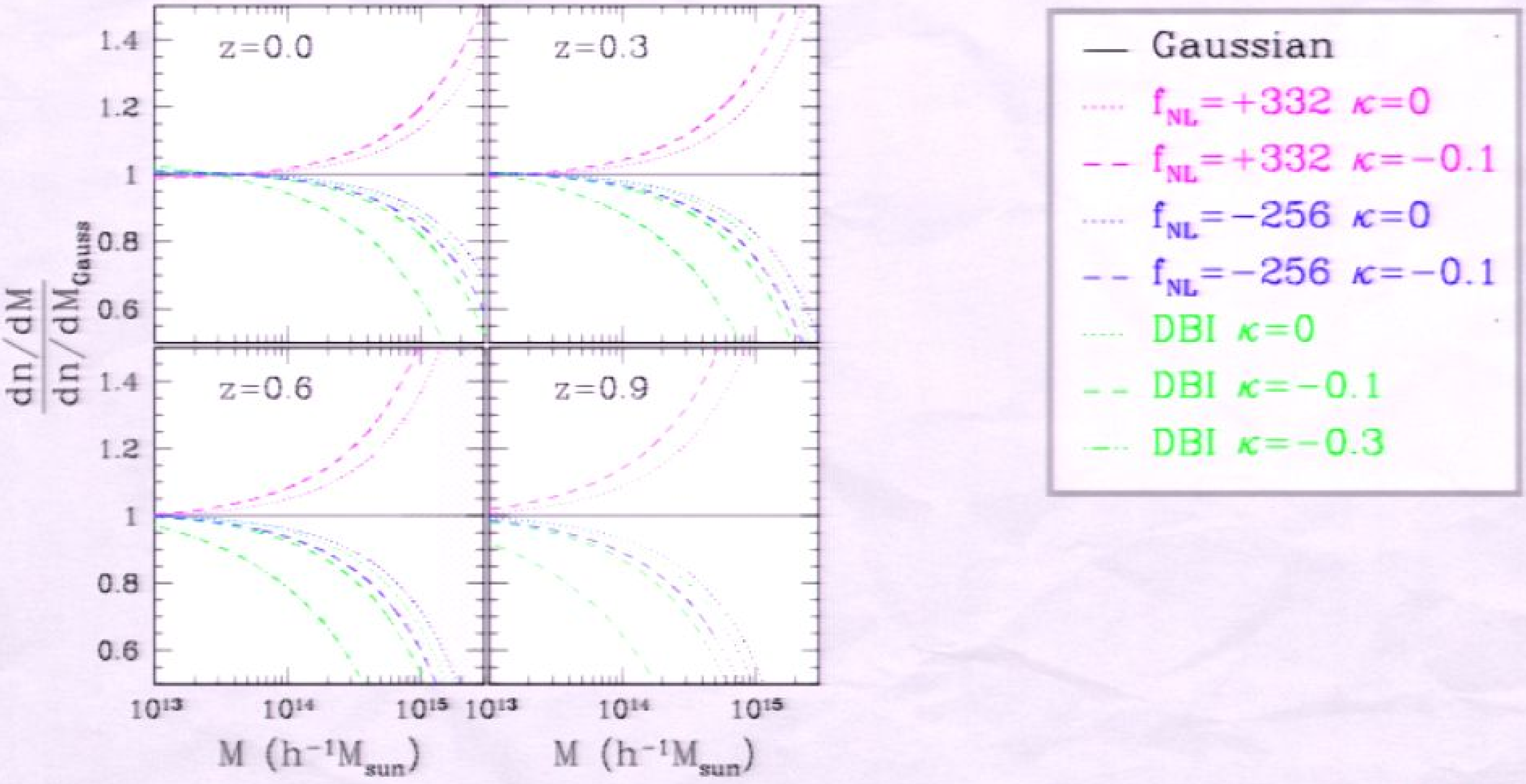
MASS FUNCTION



MASS FUNCTION

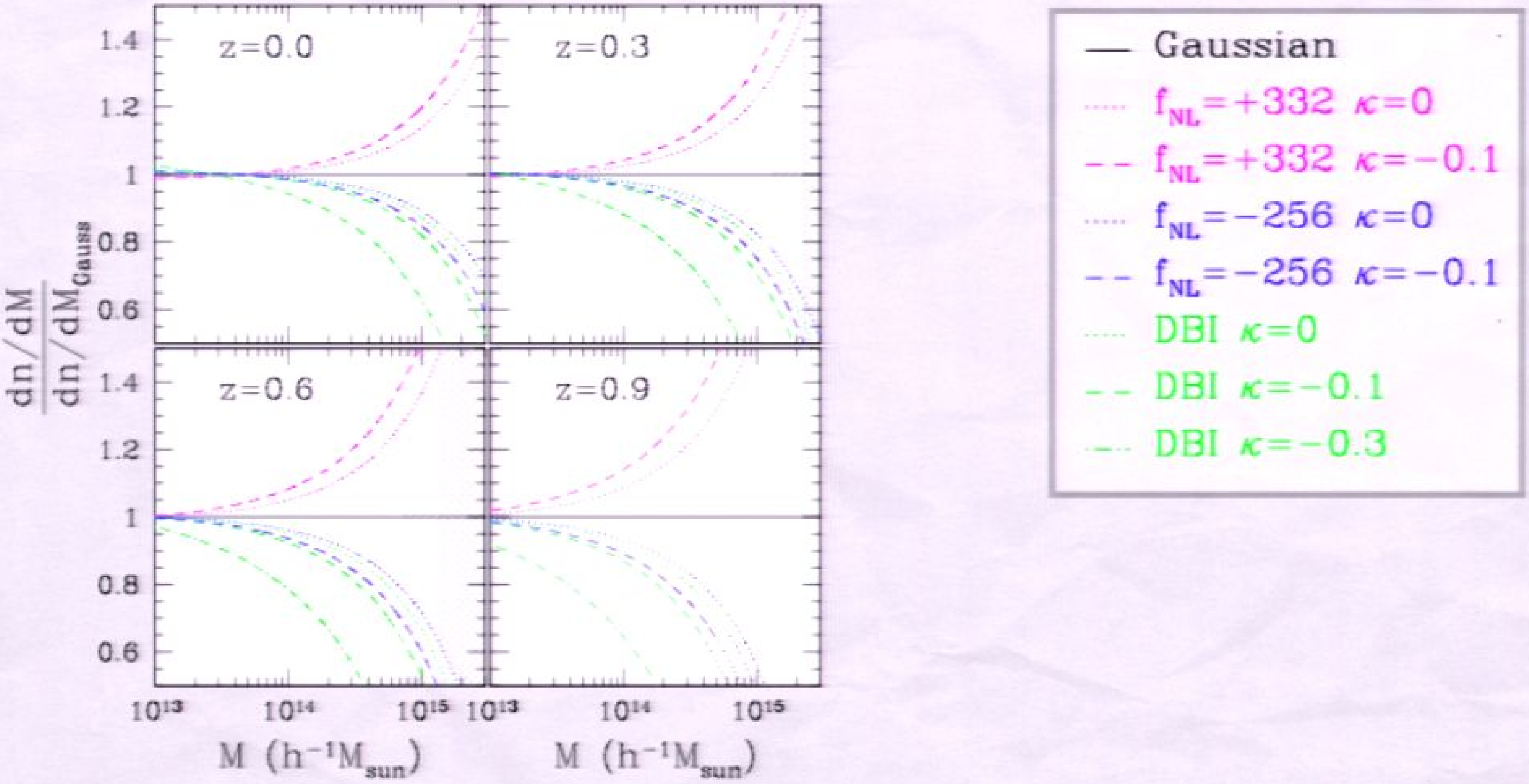


MASS FUNCTION



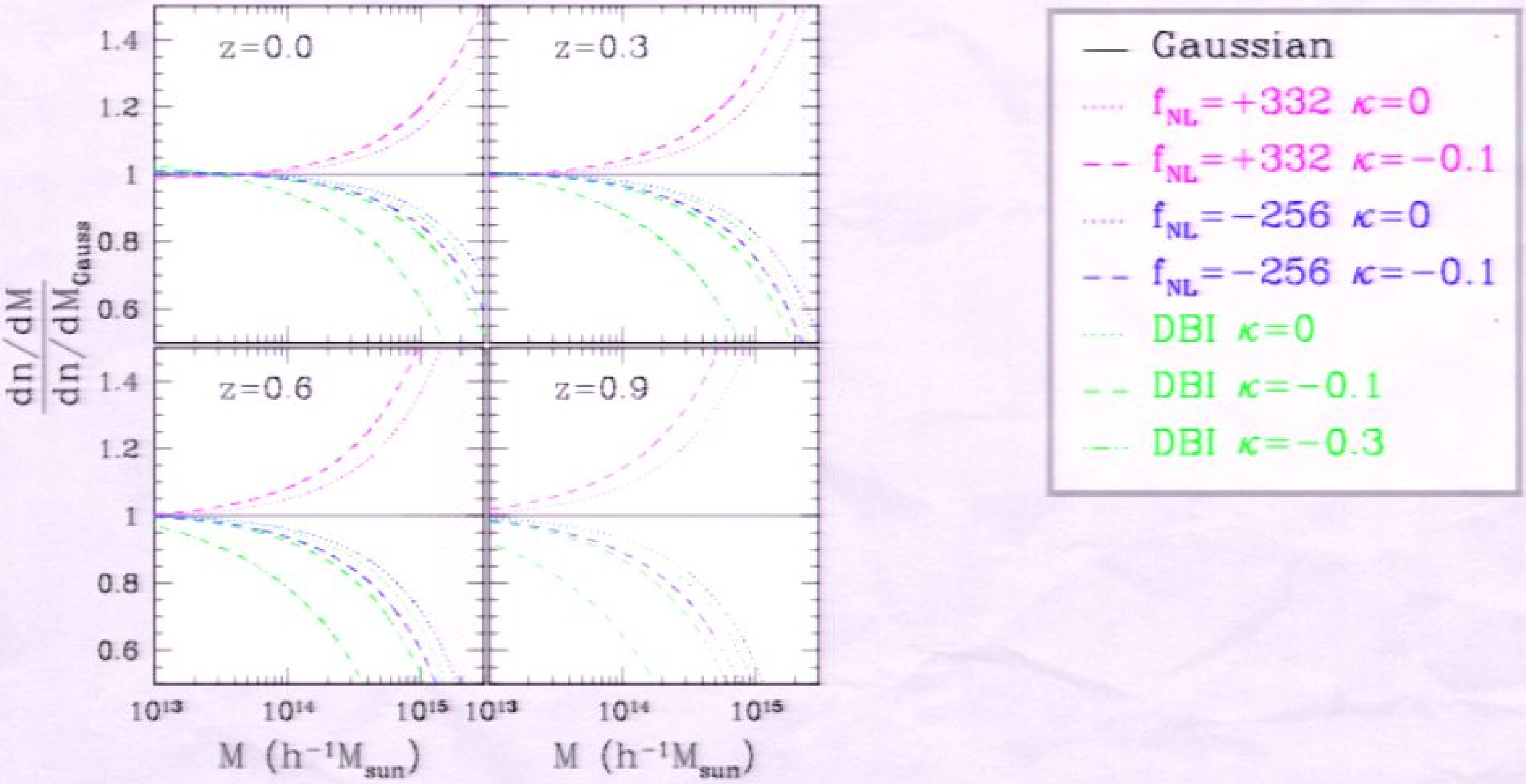
PI, Oct. 30, 2007

MASS FUNCTION

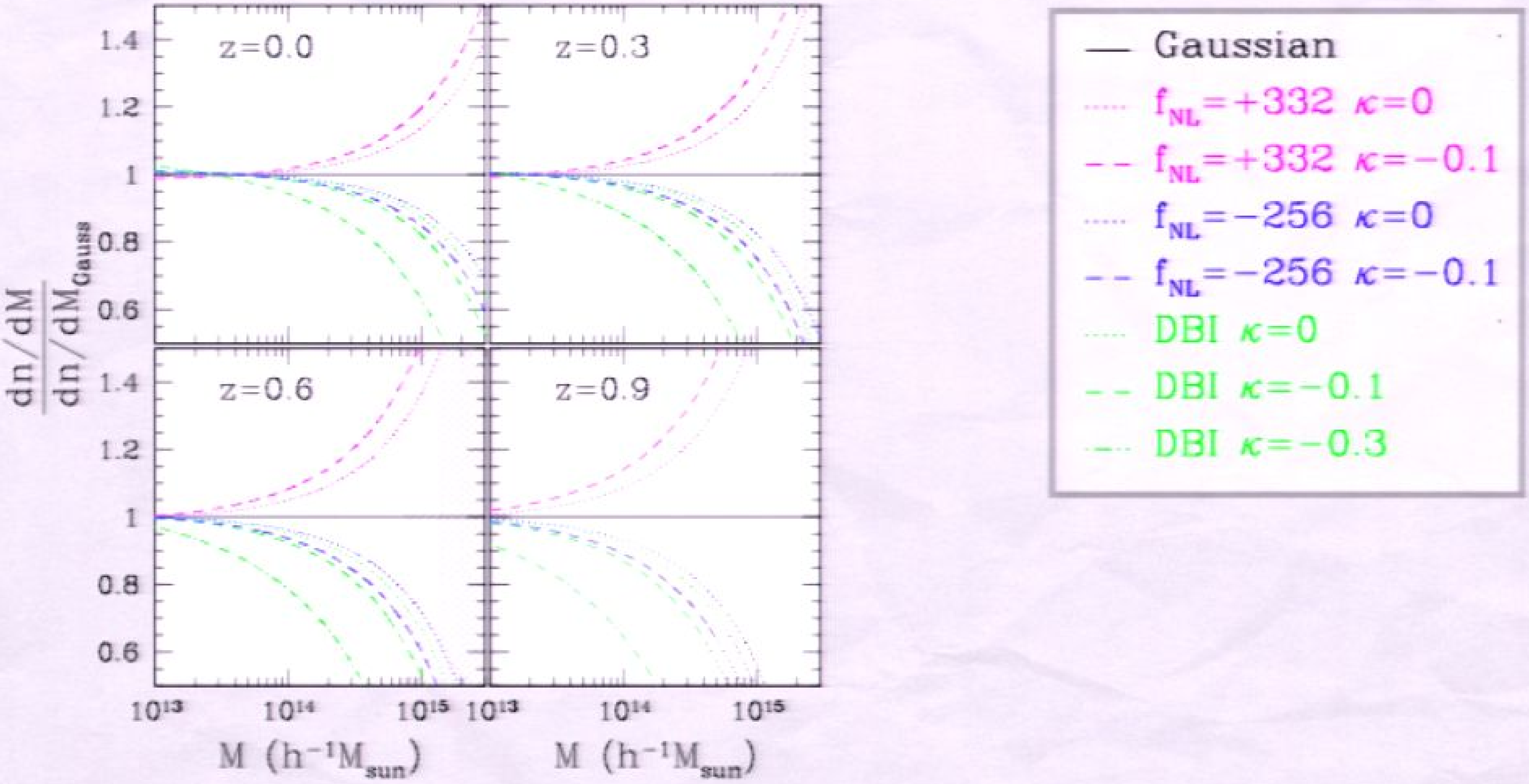


PI, Oct. 30, 2007

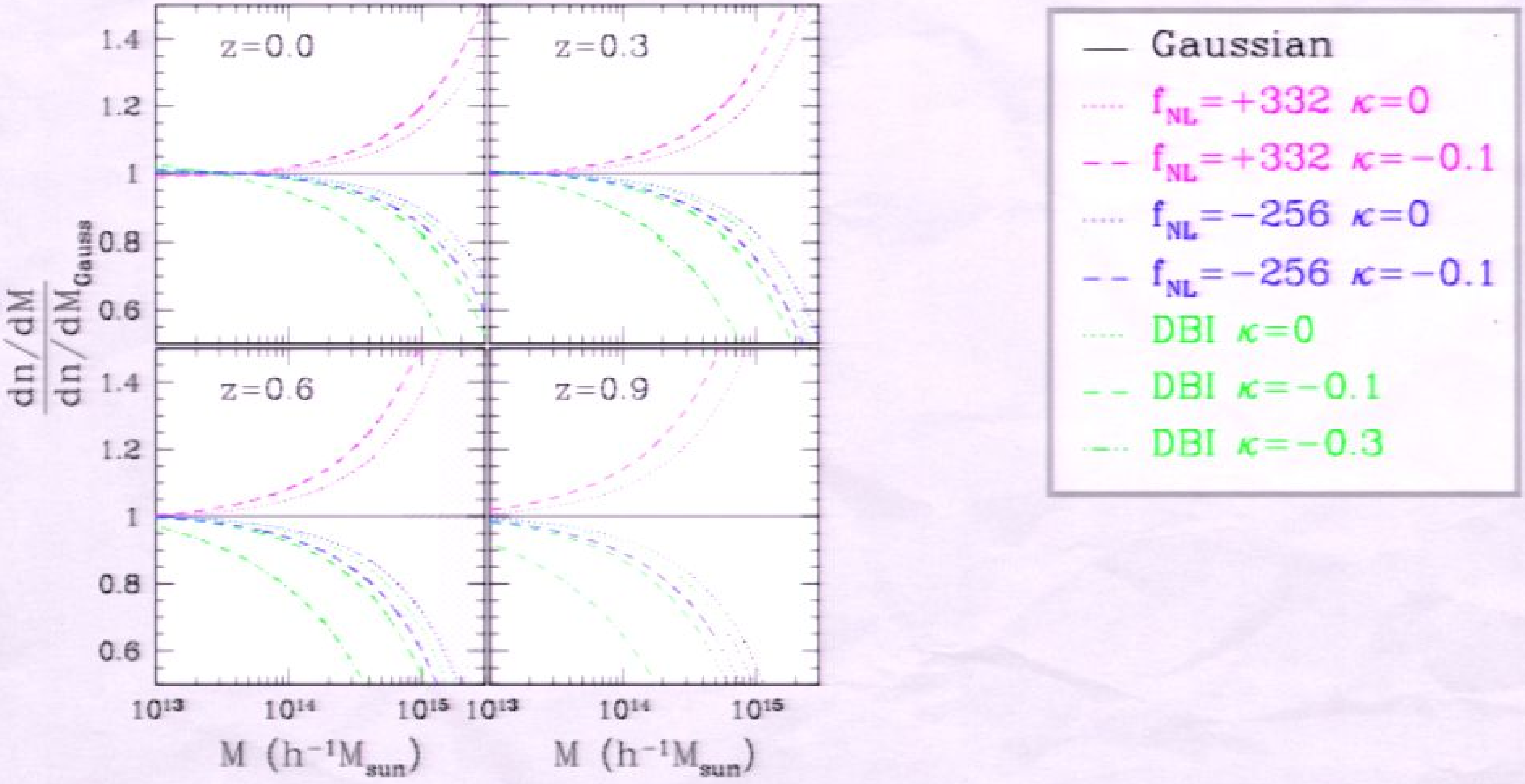
MASS FUNCTION



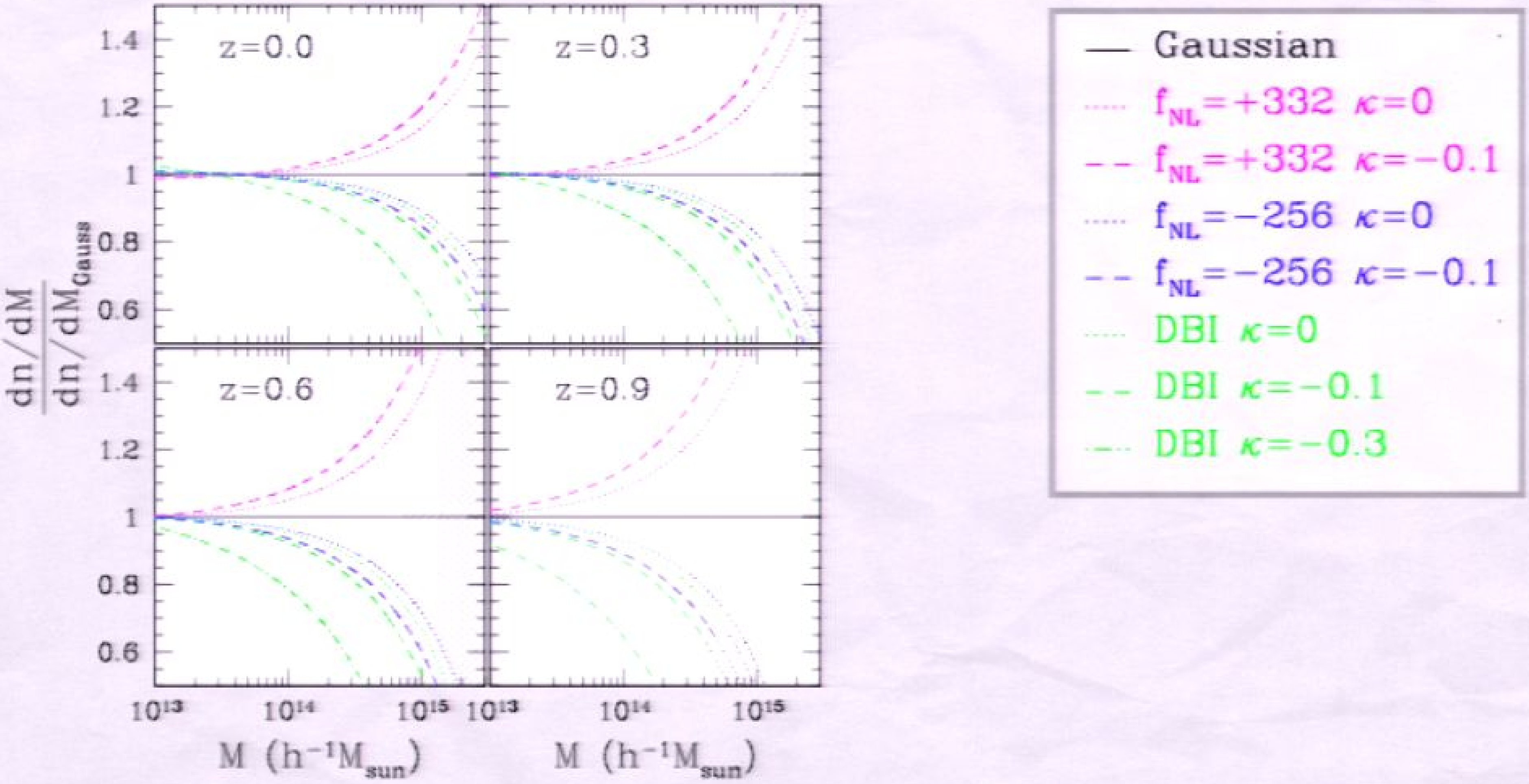
MASS FUNCTION



MASS FUNCTION

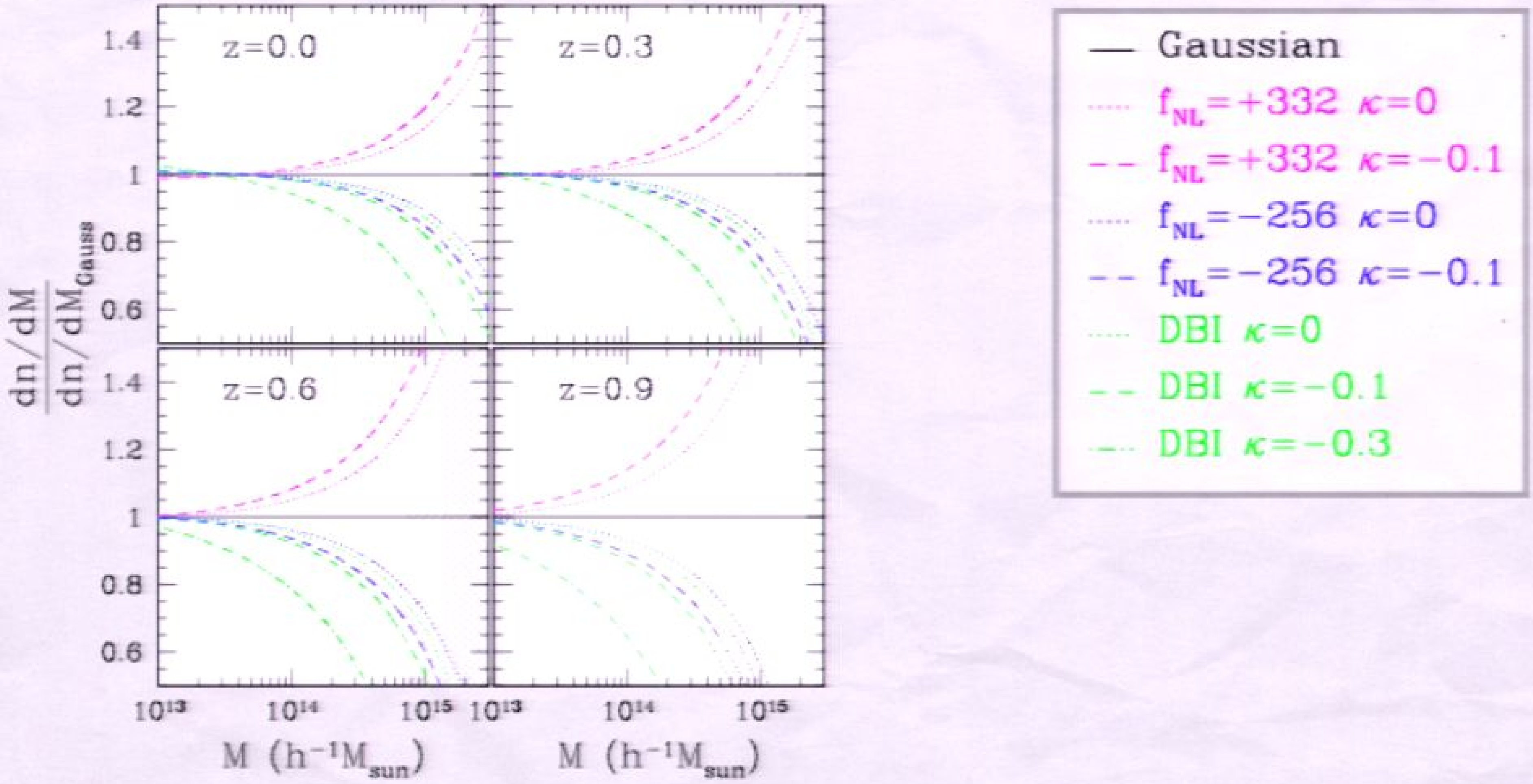


MASS FUNCTION



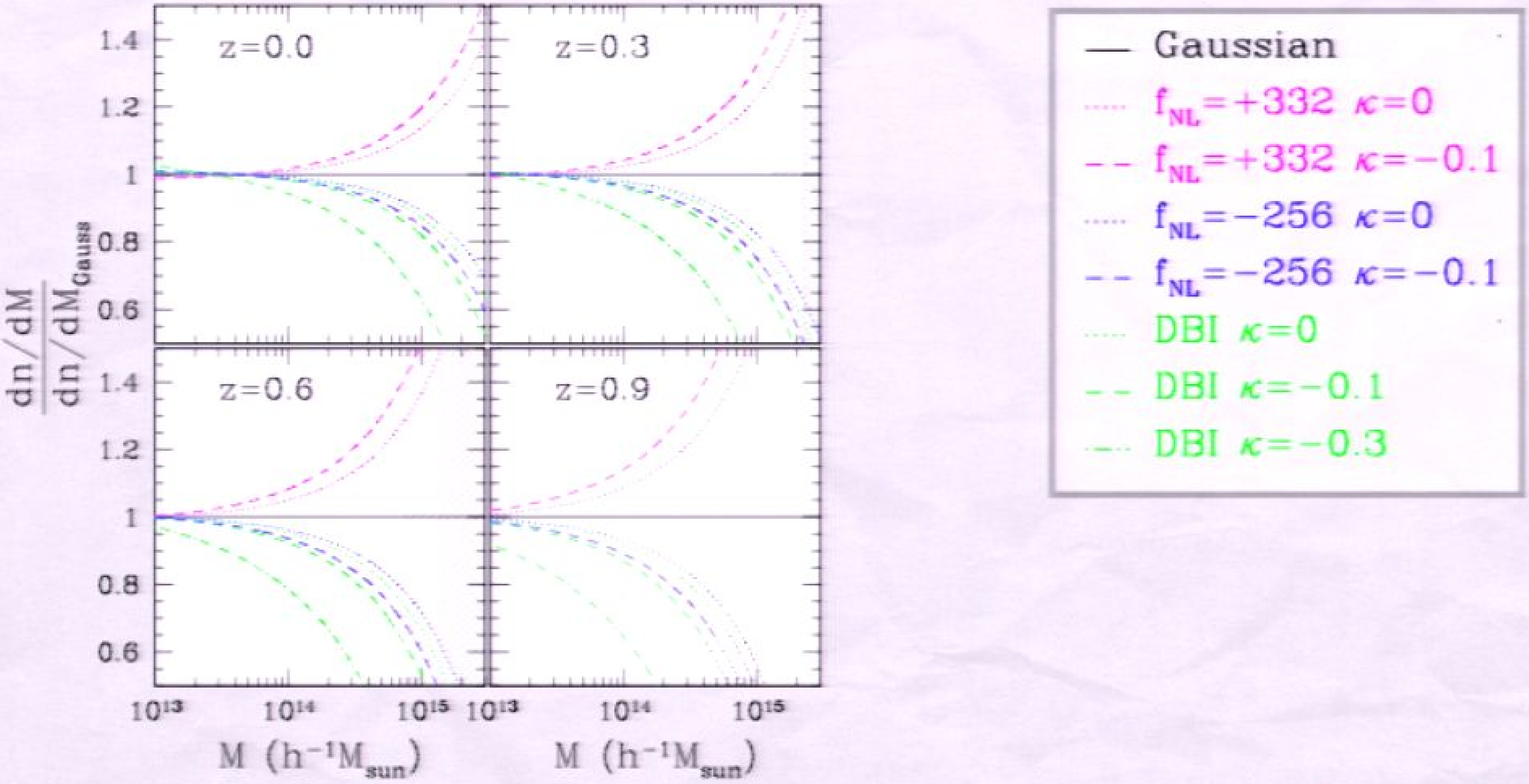
PI, Oct. 30, 2007

MASS FUNCTION

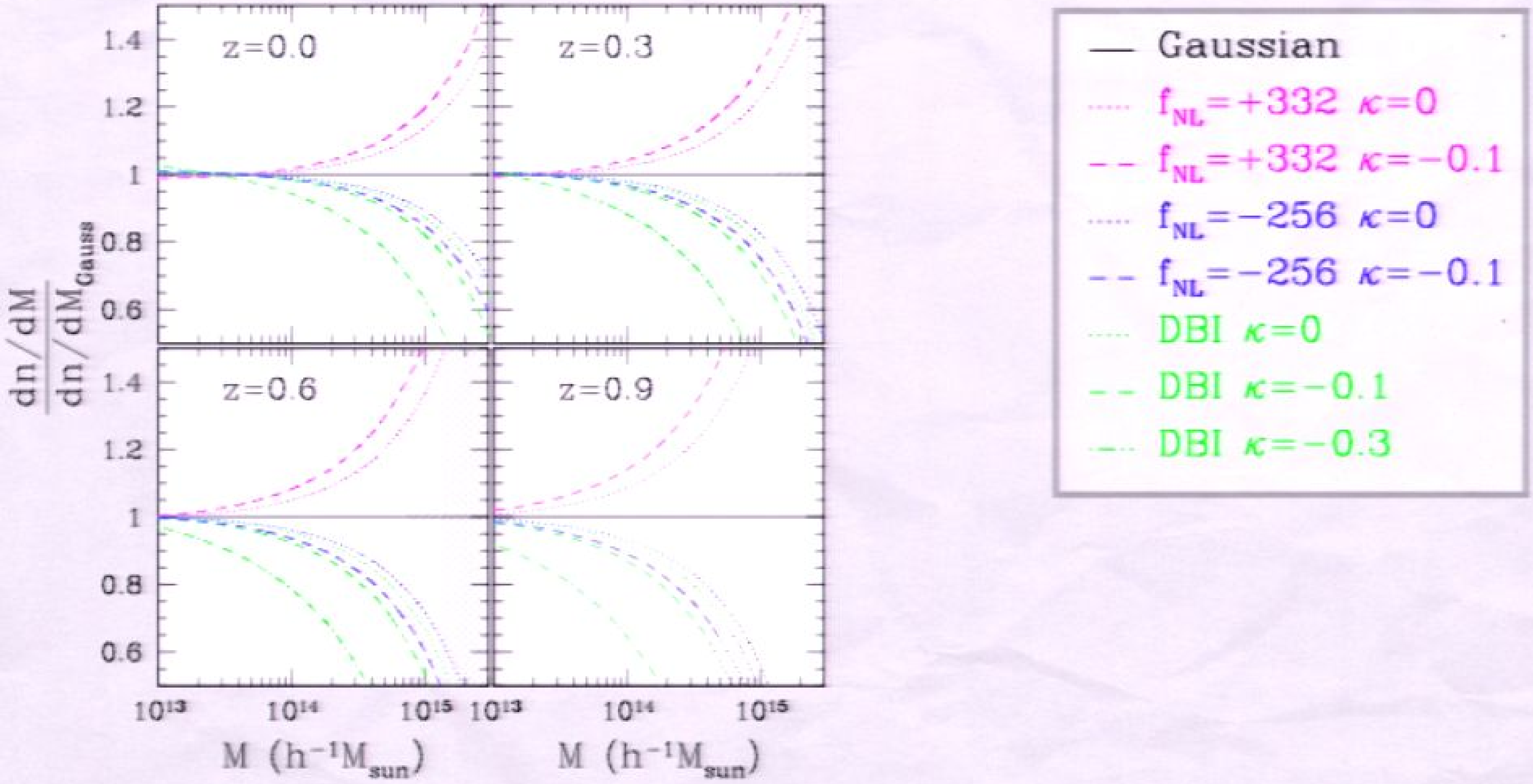


PI, Oct. 30, 2007

MASS FUNCTION

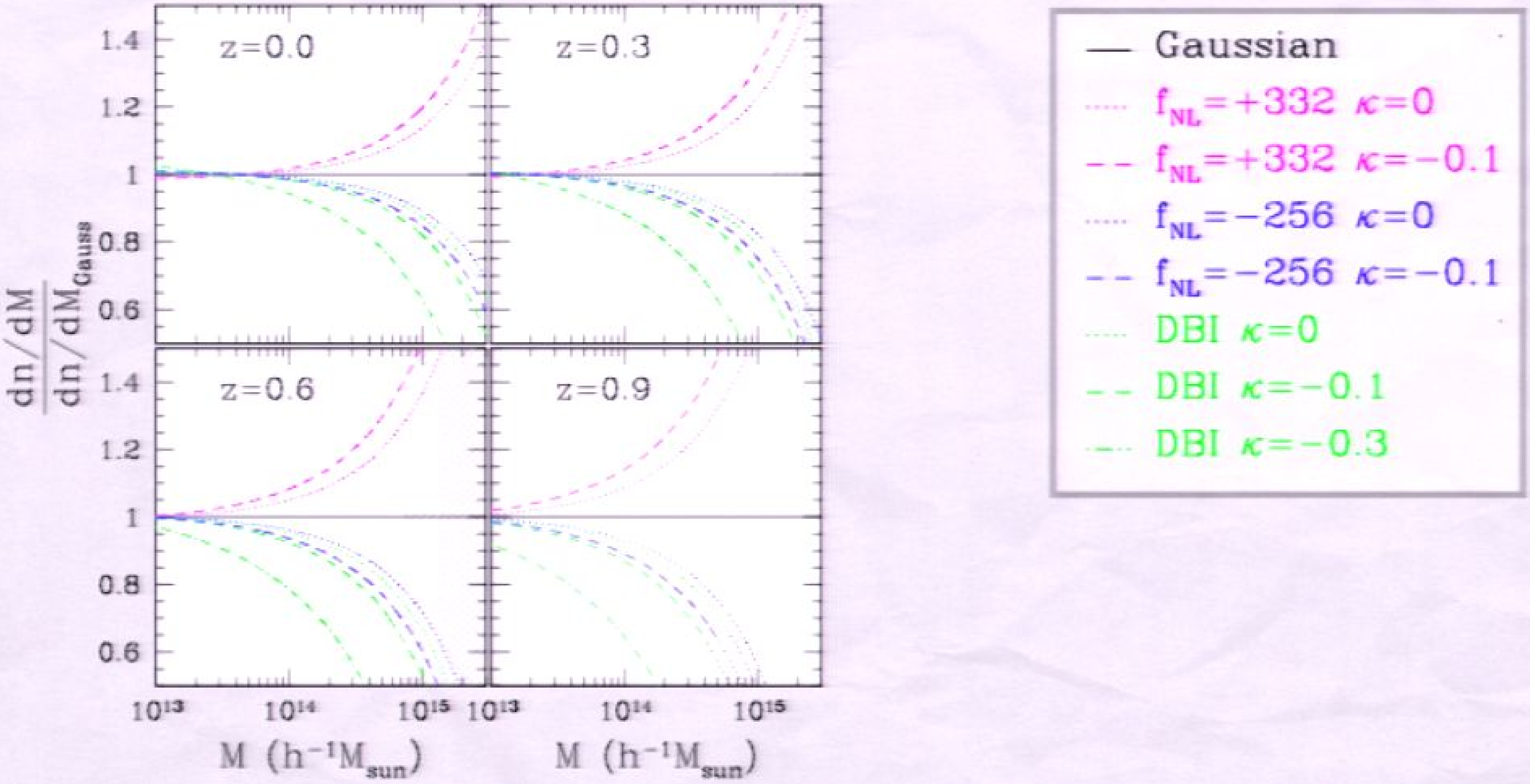


MASS FUNCTION

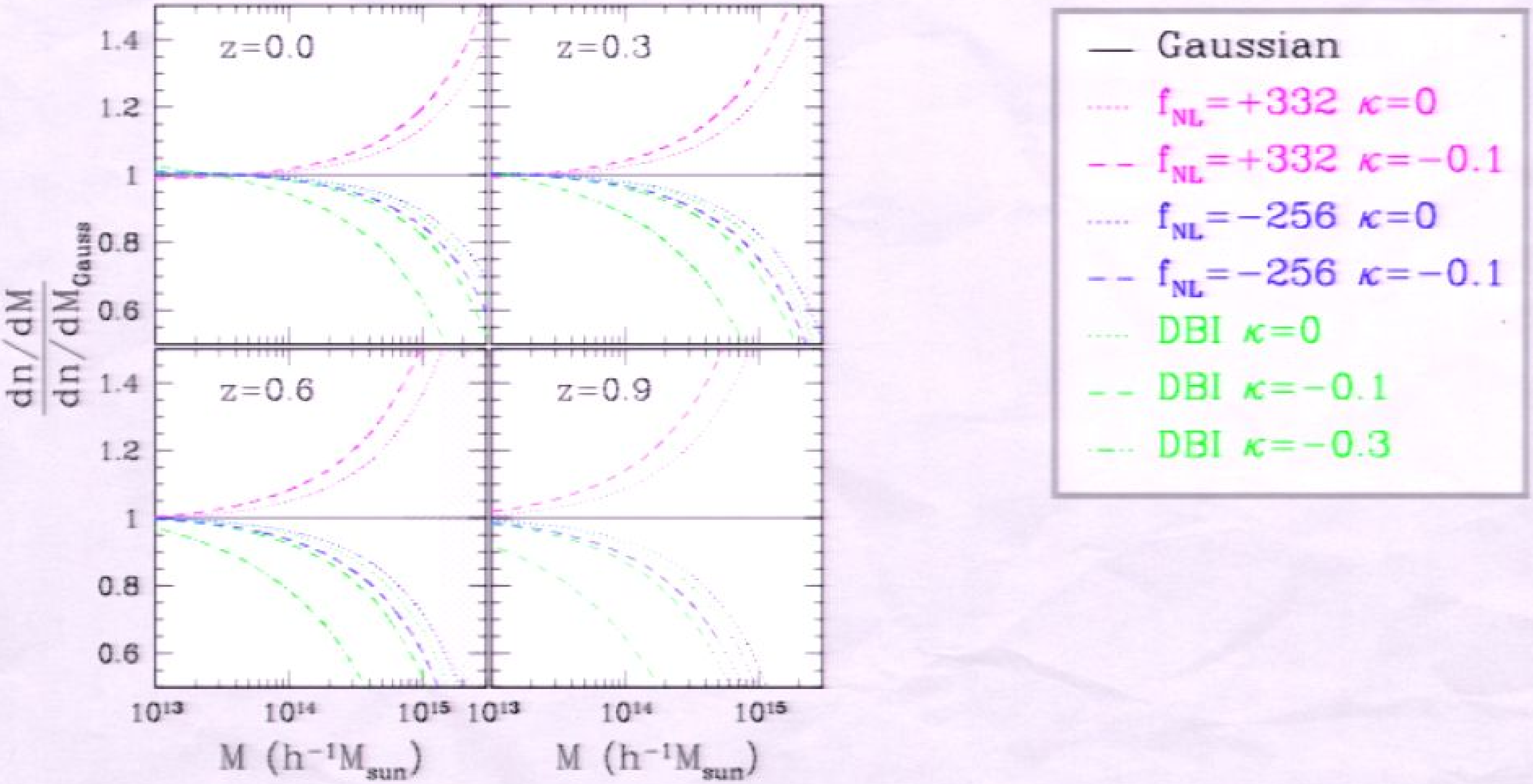


PI, Oct. 30, 2007

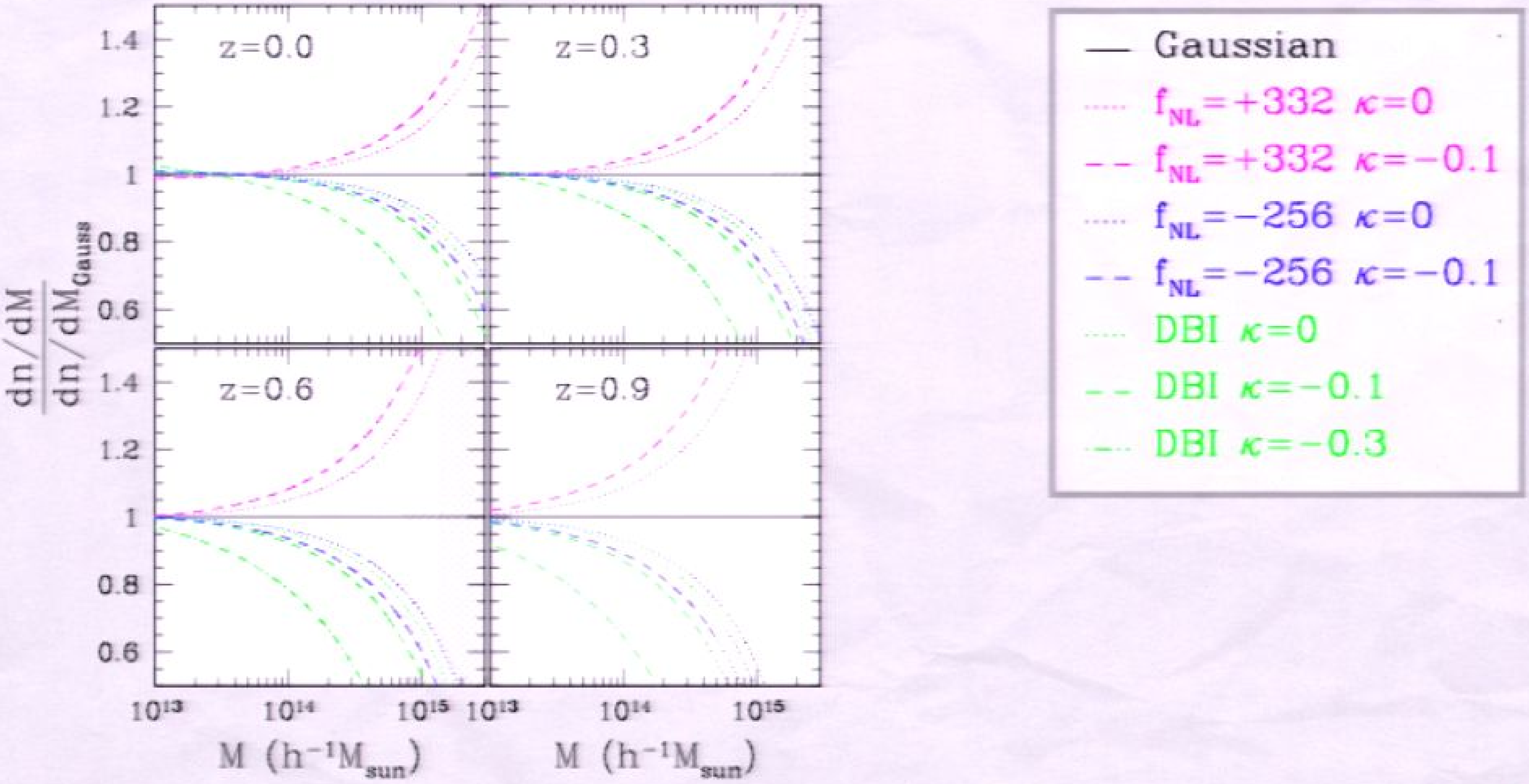
MASS FUNCTION



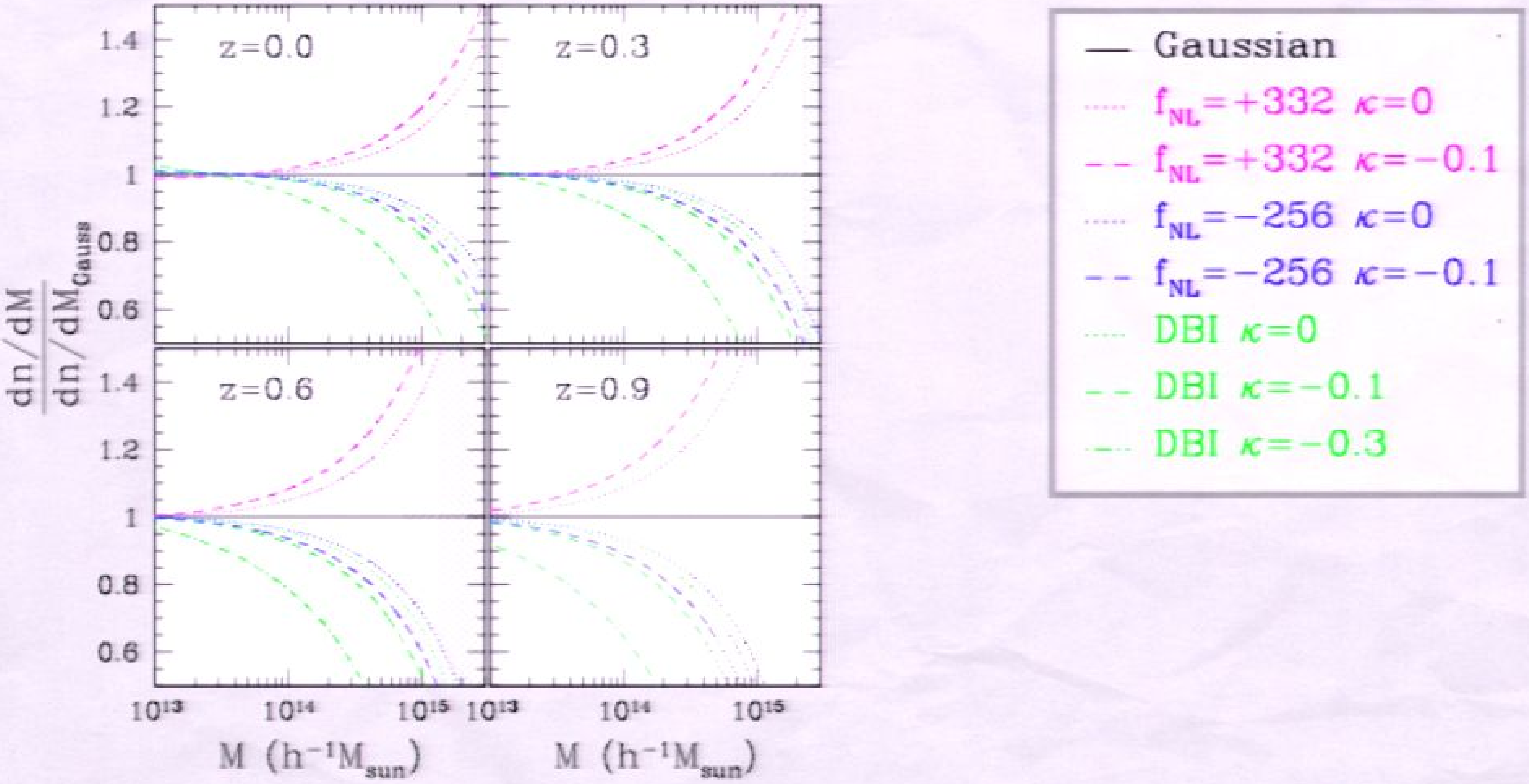
MASS FUNCTION



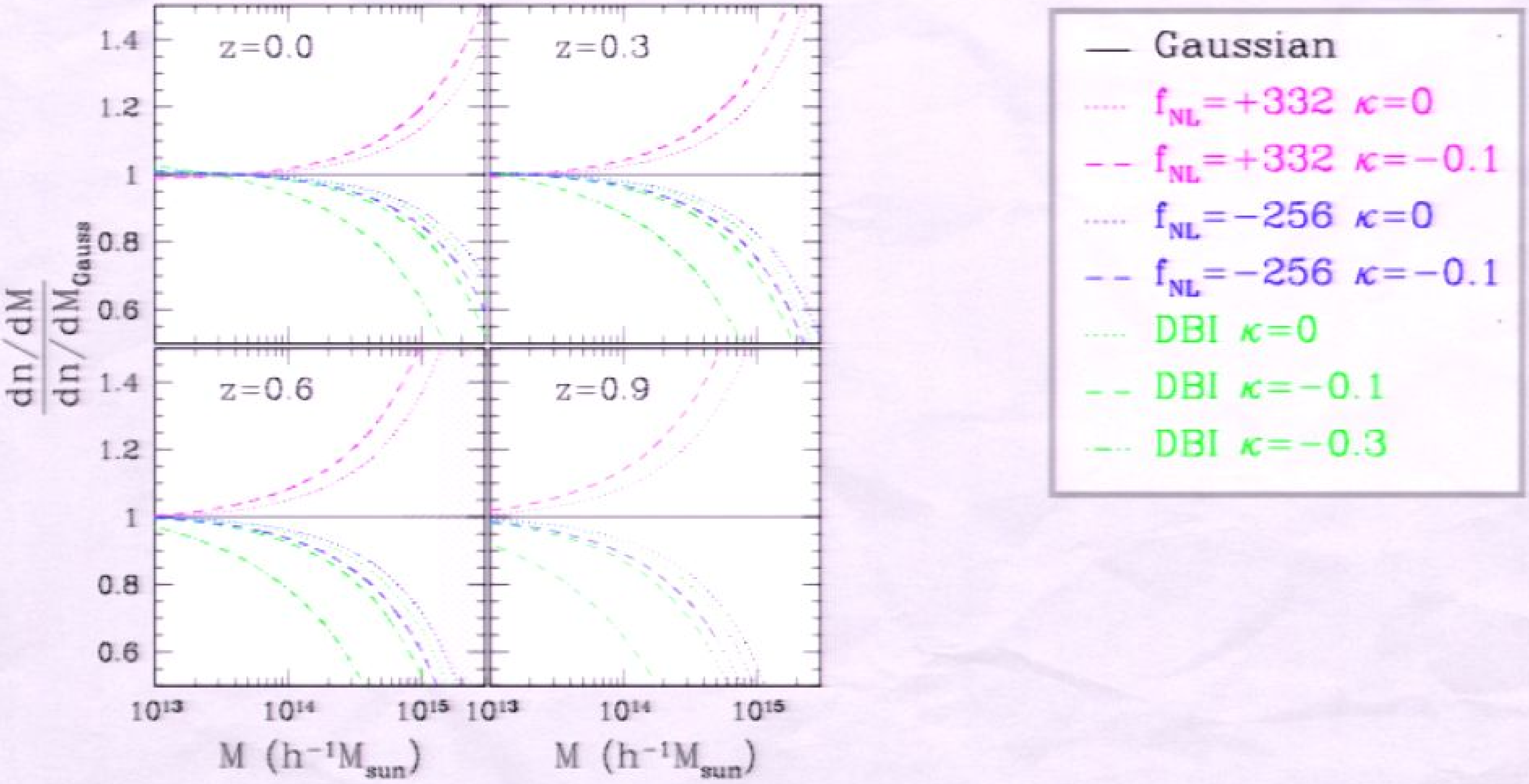
MASS FUNCTION



MASS FUNCTION

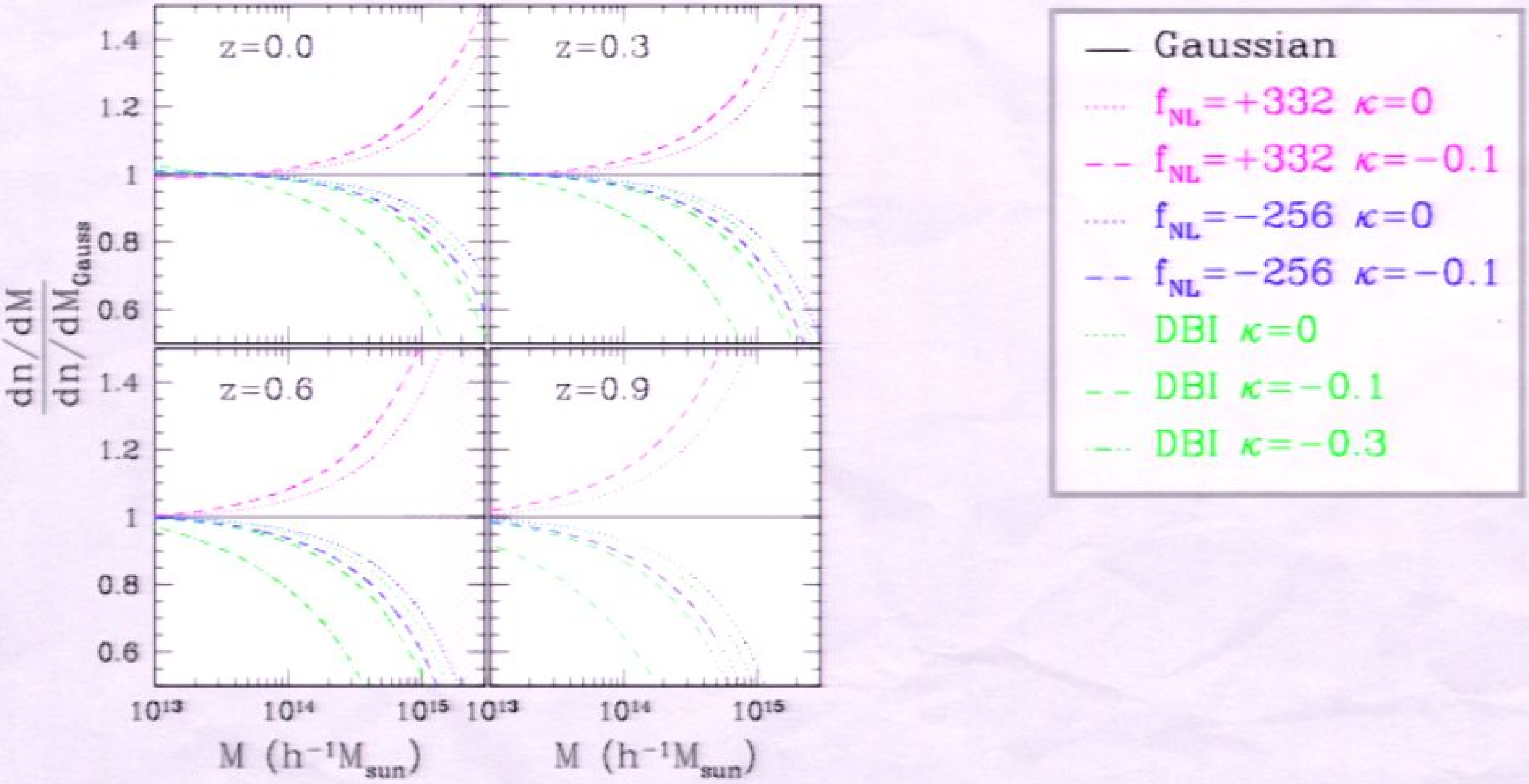


MASS FUNCTION

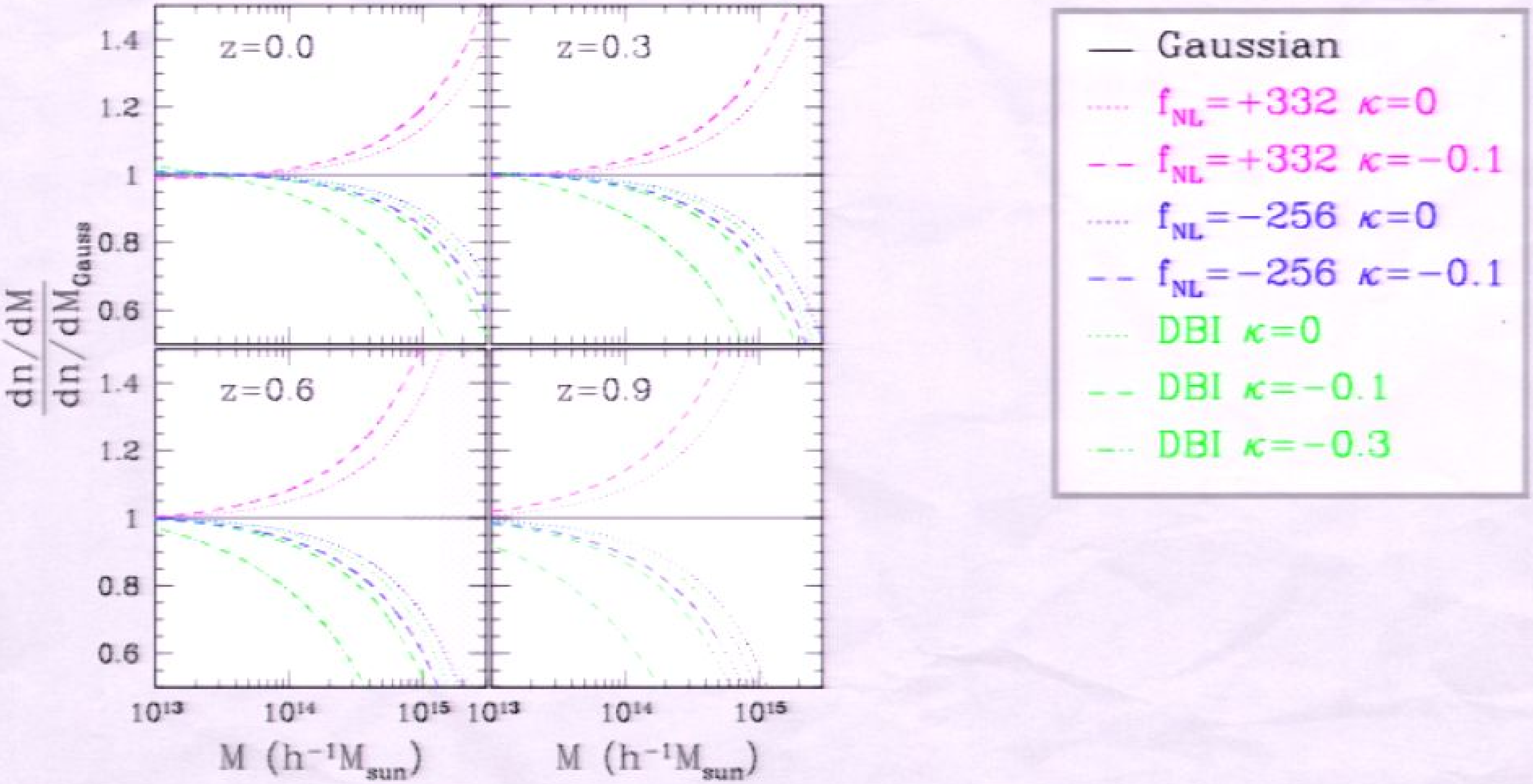


PI, Oct. 30, 2007

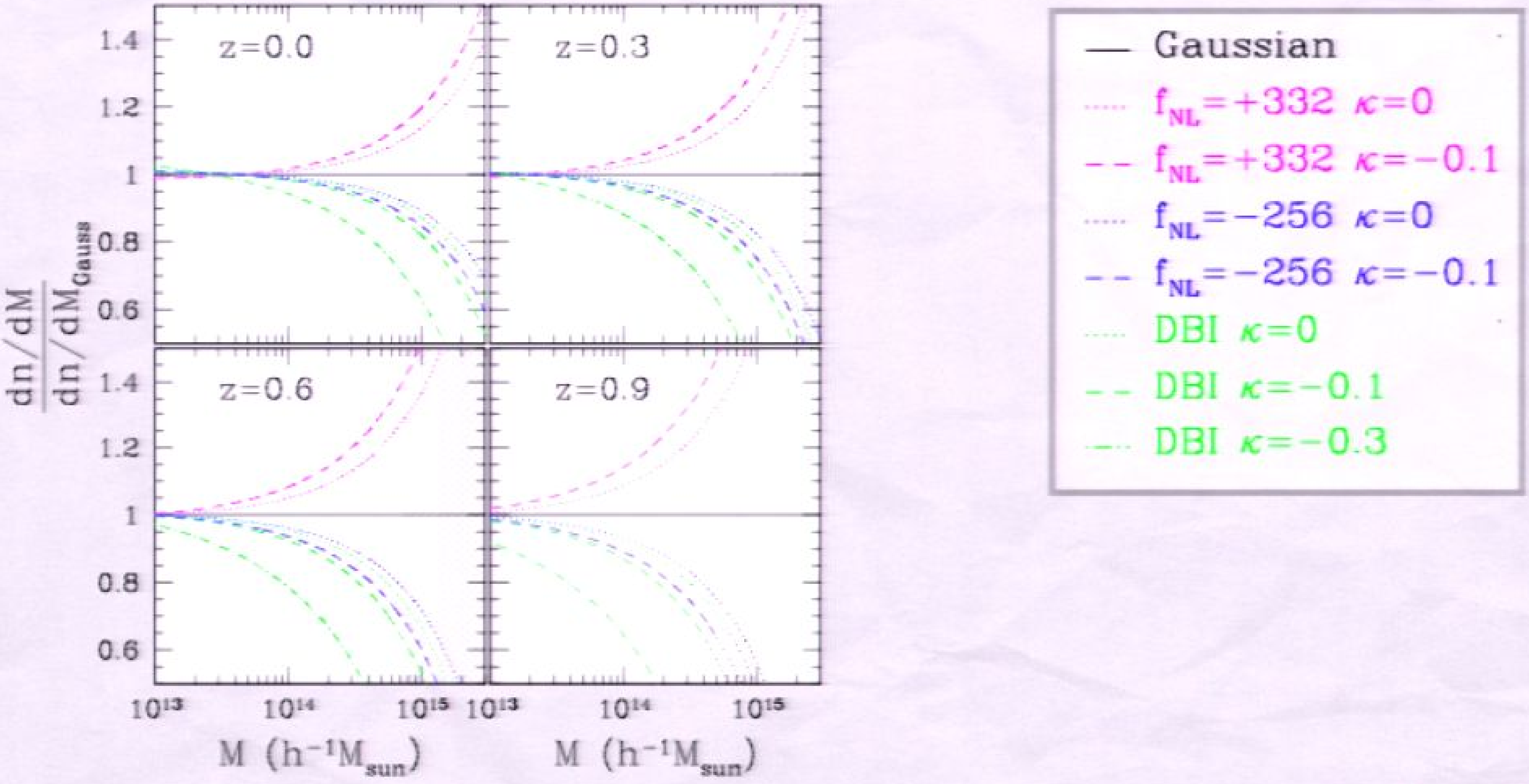
MASS FUNCTION



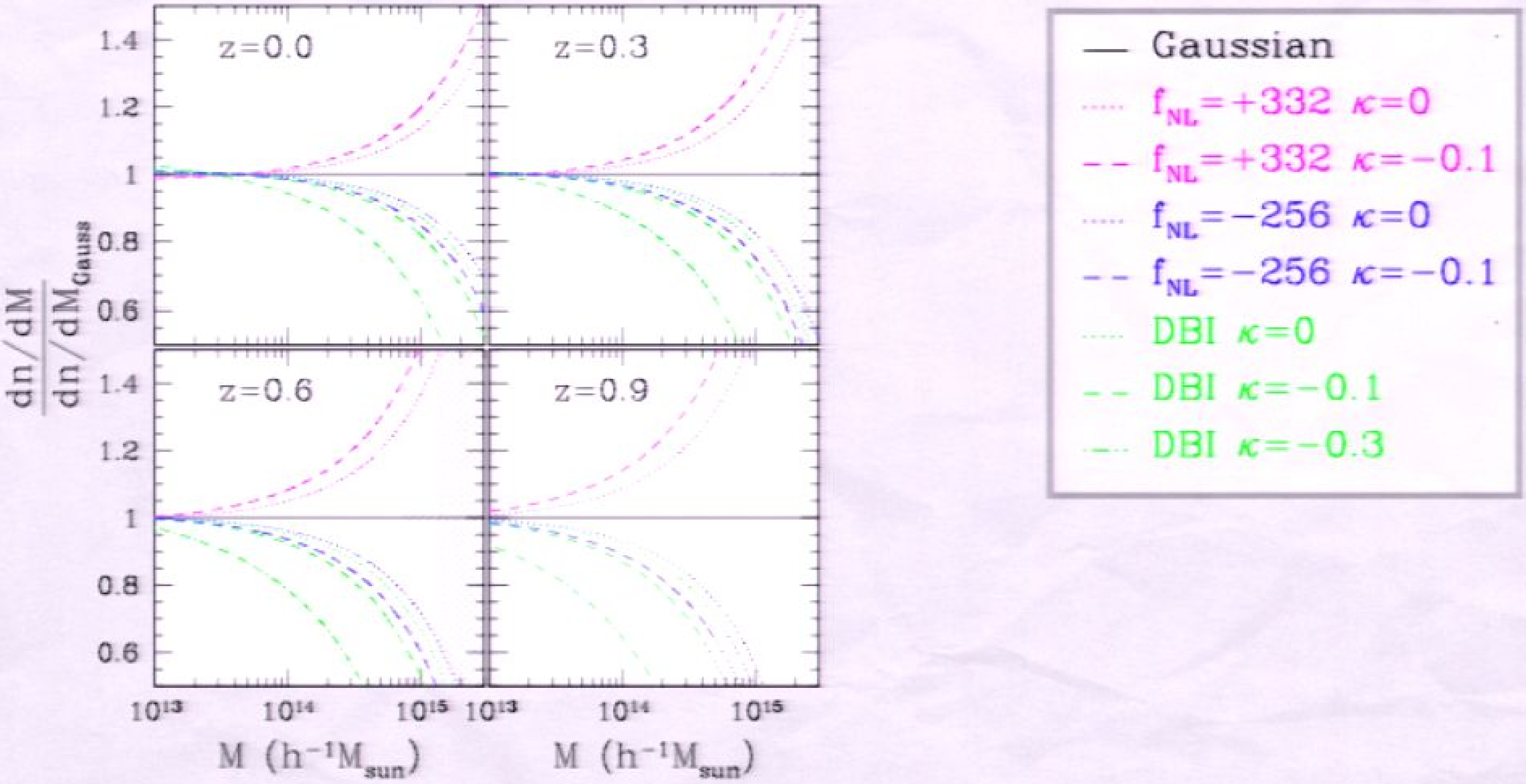
MASS FUNCTION



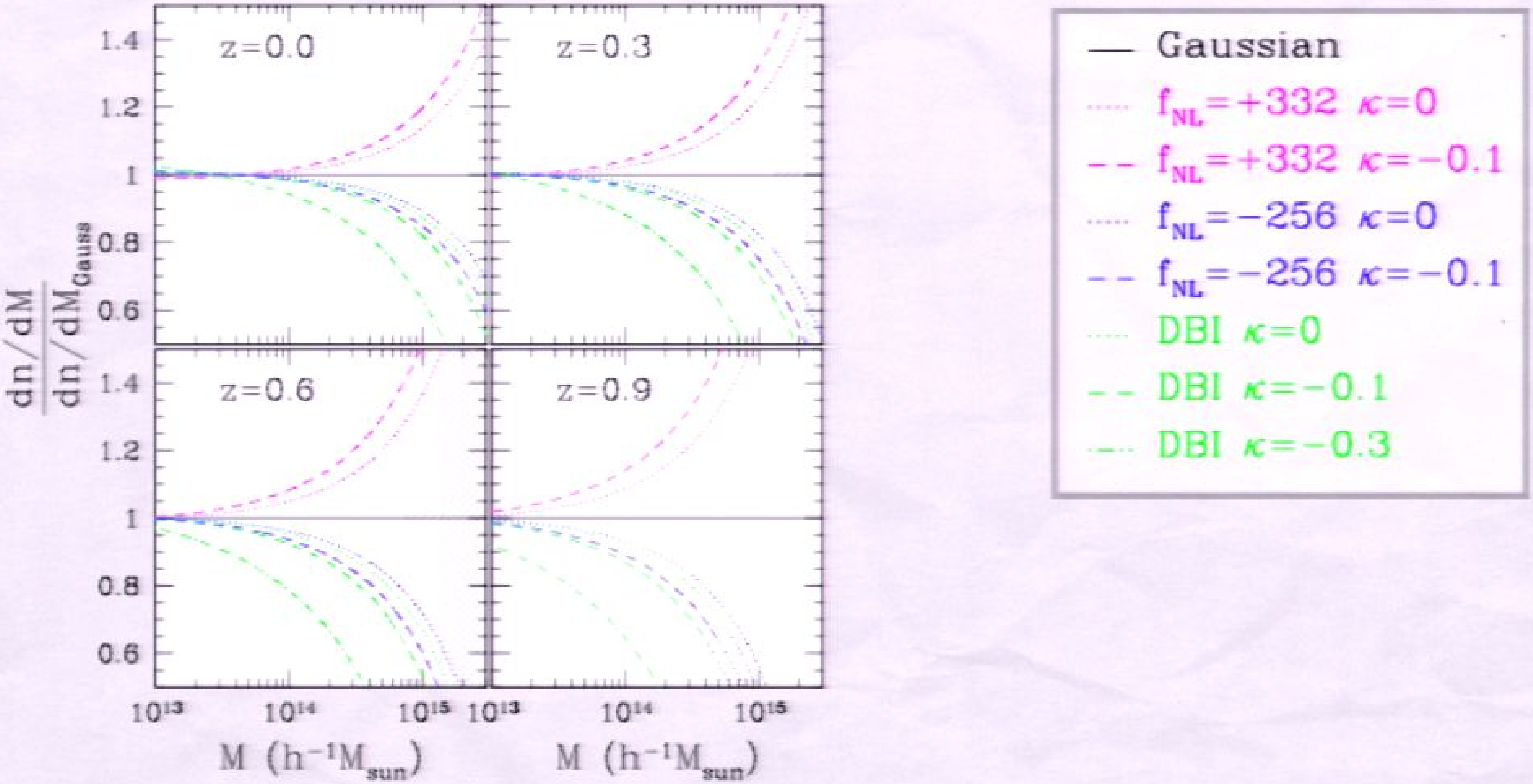
MASS FUNCTION



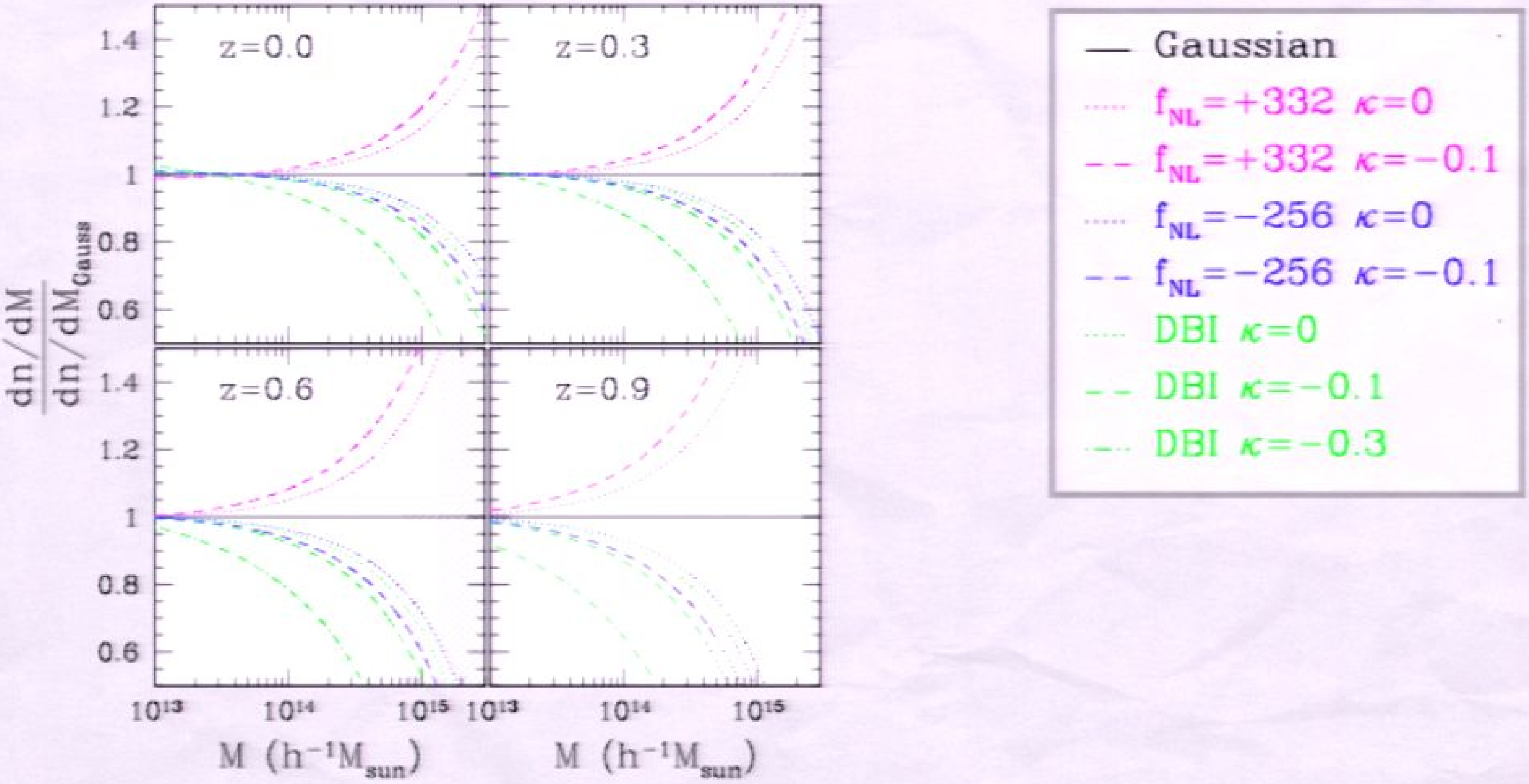
MASS FUNCTION



MASS FUNCTION

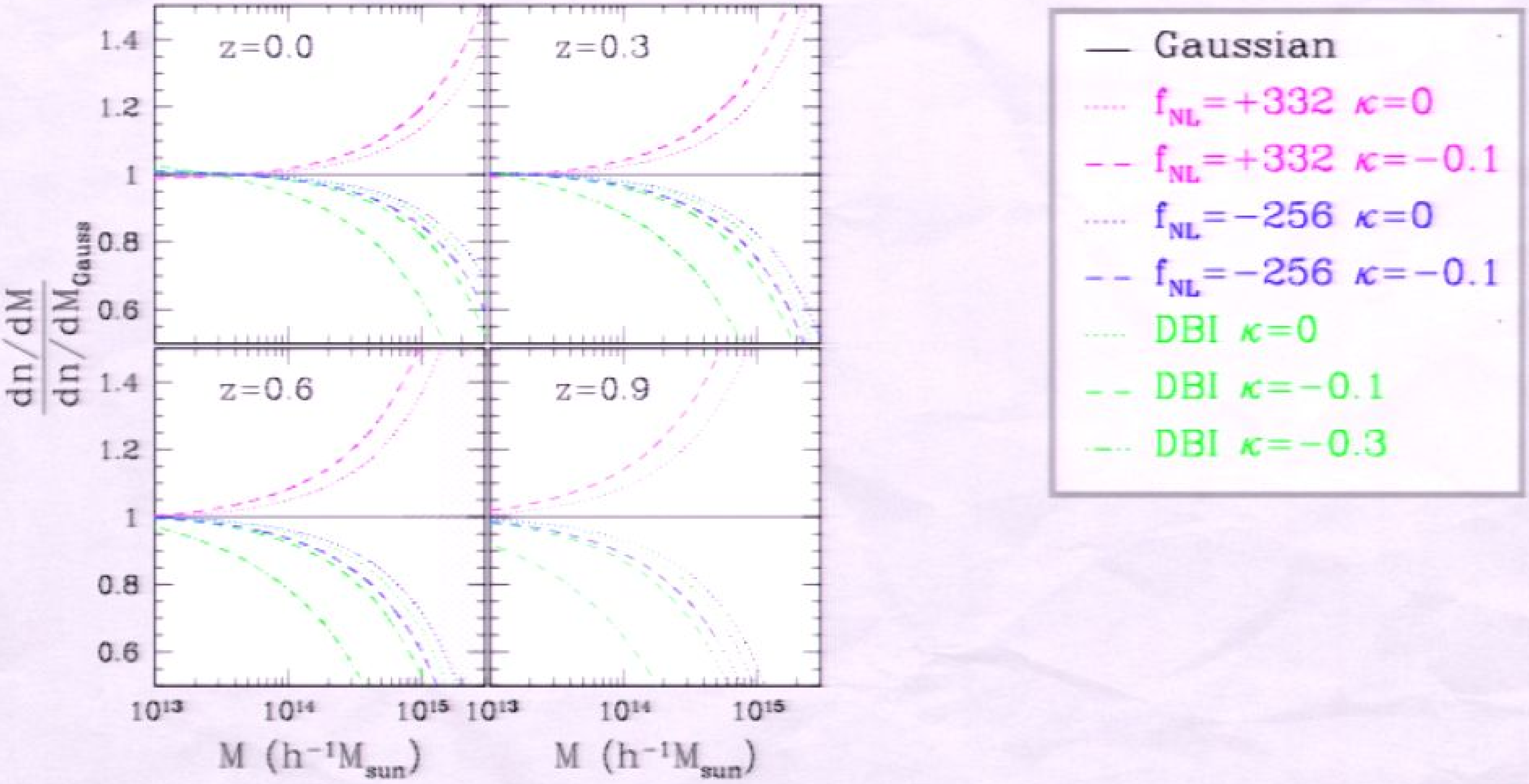


MASS FUNCTION

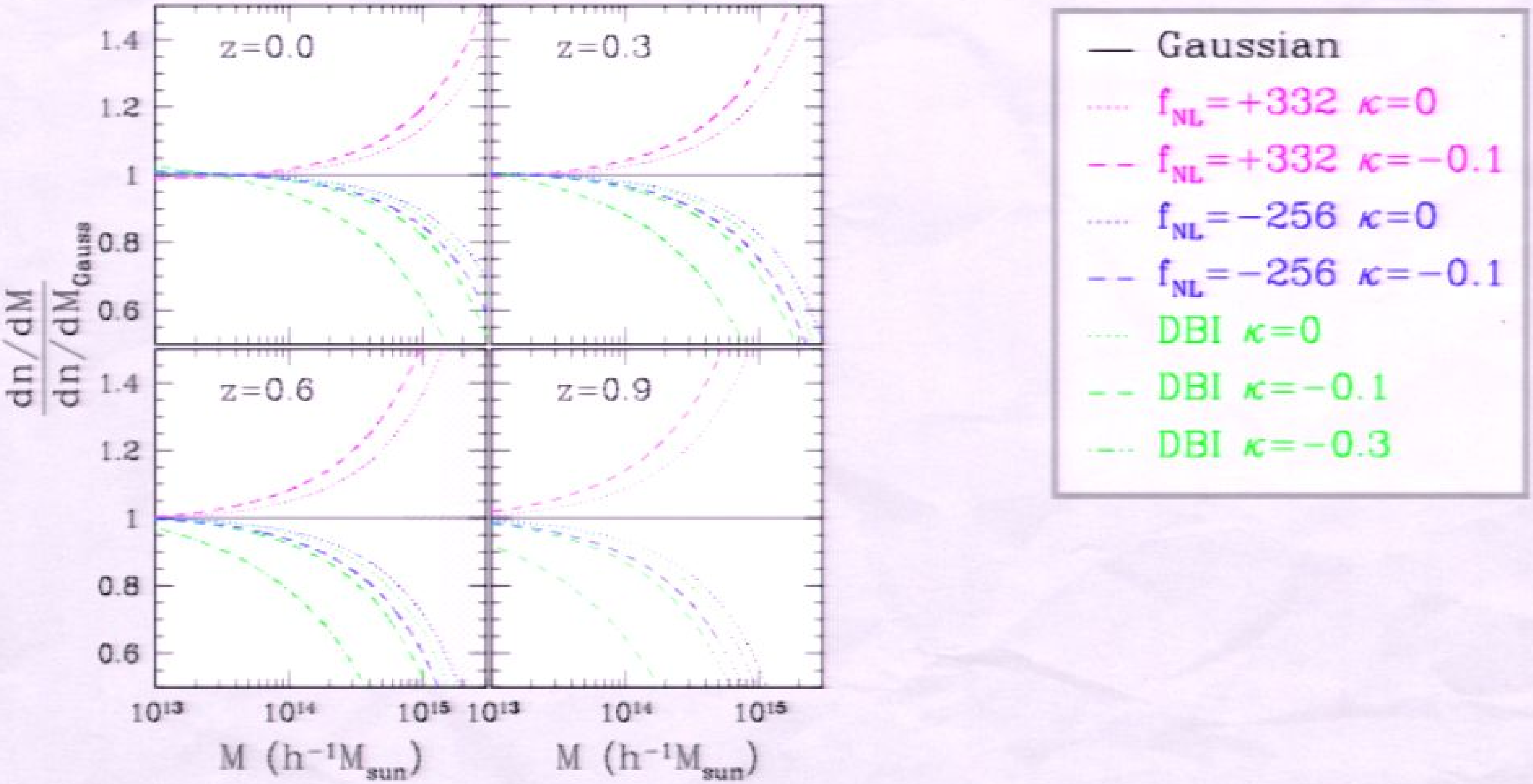


PI, Oct. 30, 2007

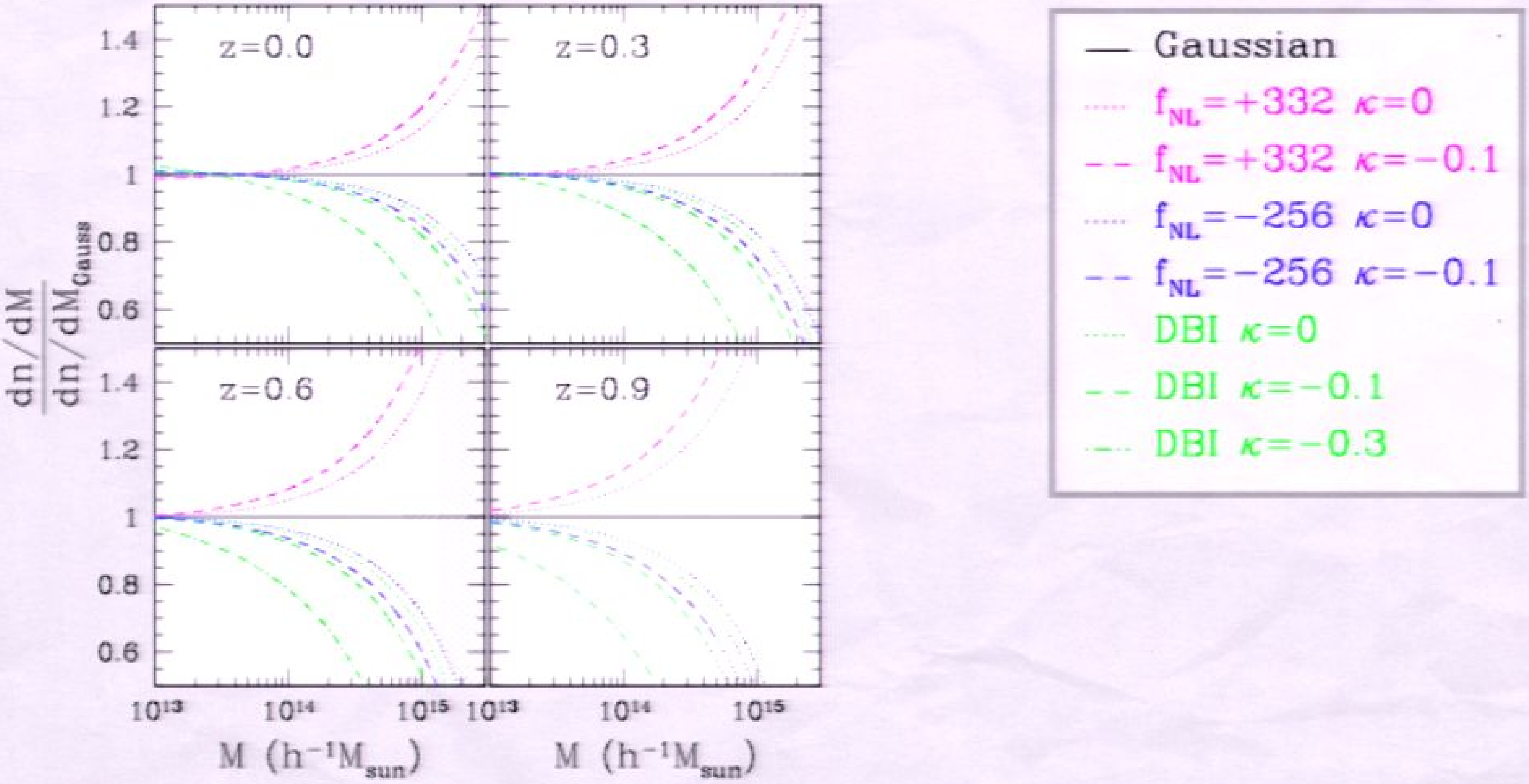
MASS FUNCTION



MASS FUNCTION

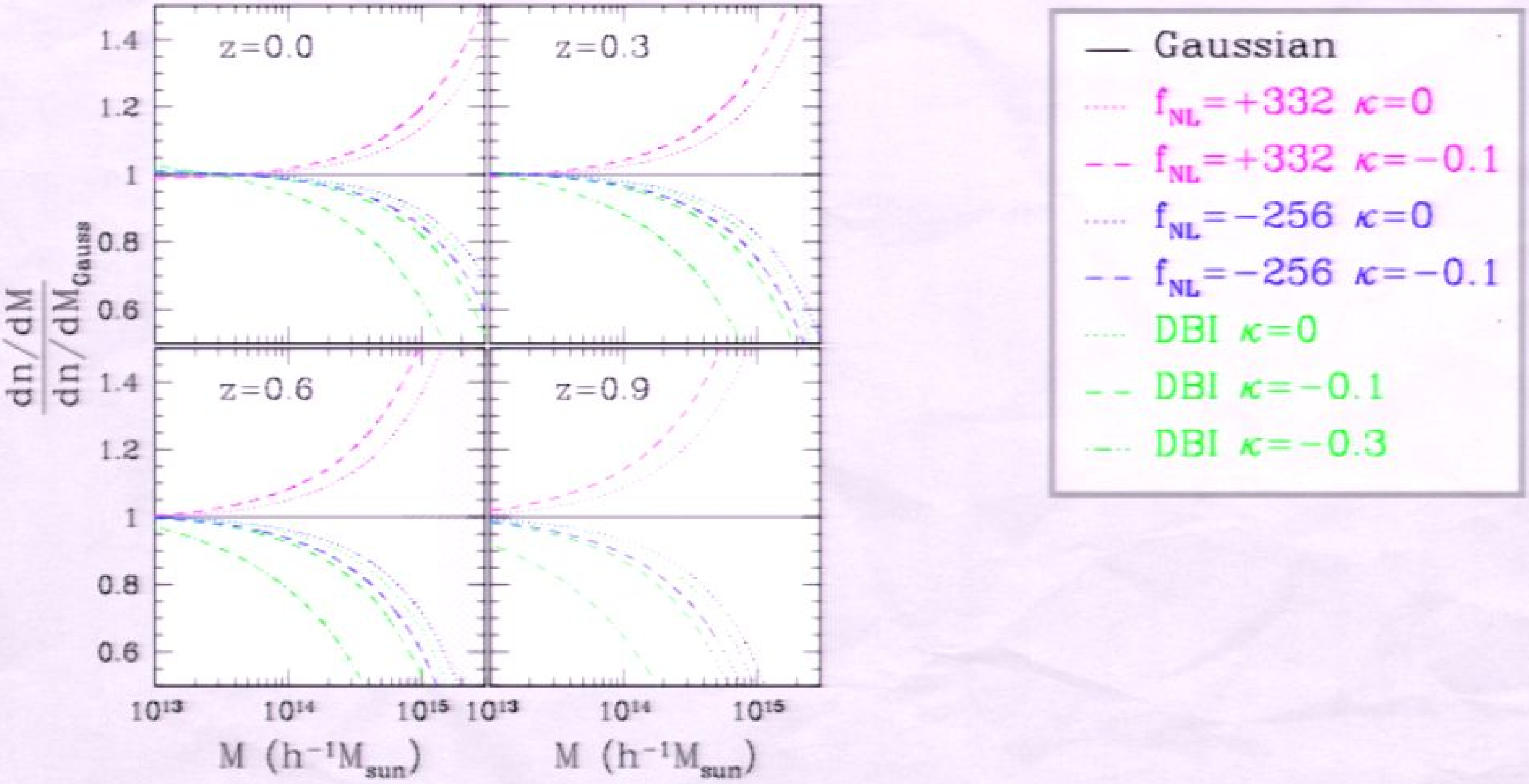


MASS FUNCTION



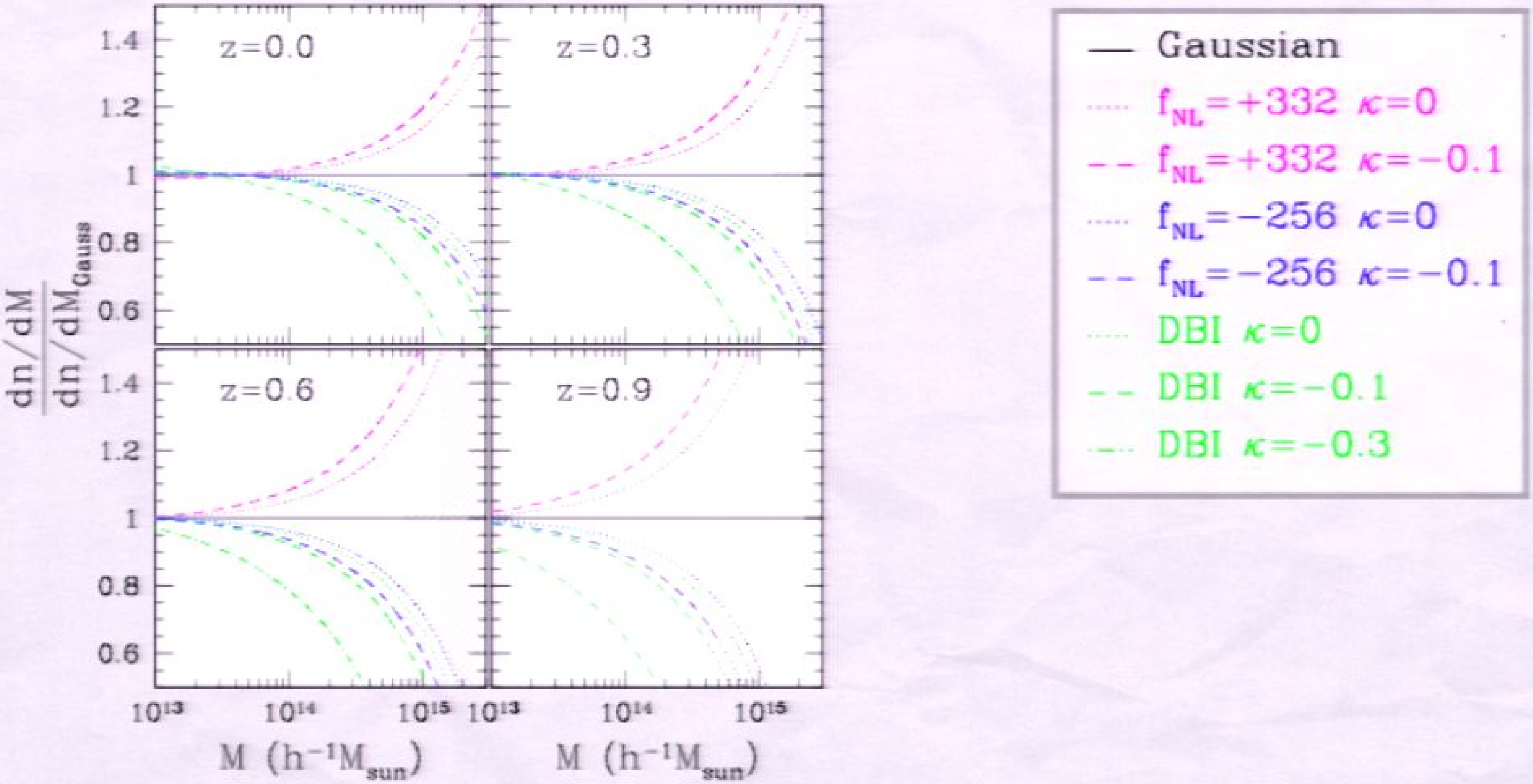
PI, Oct. 30, 2007

MASS FUNCTION

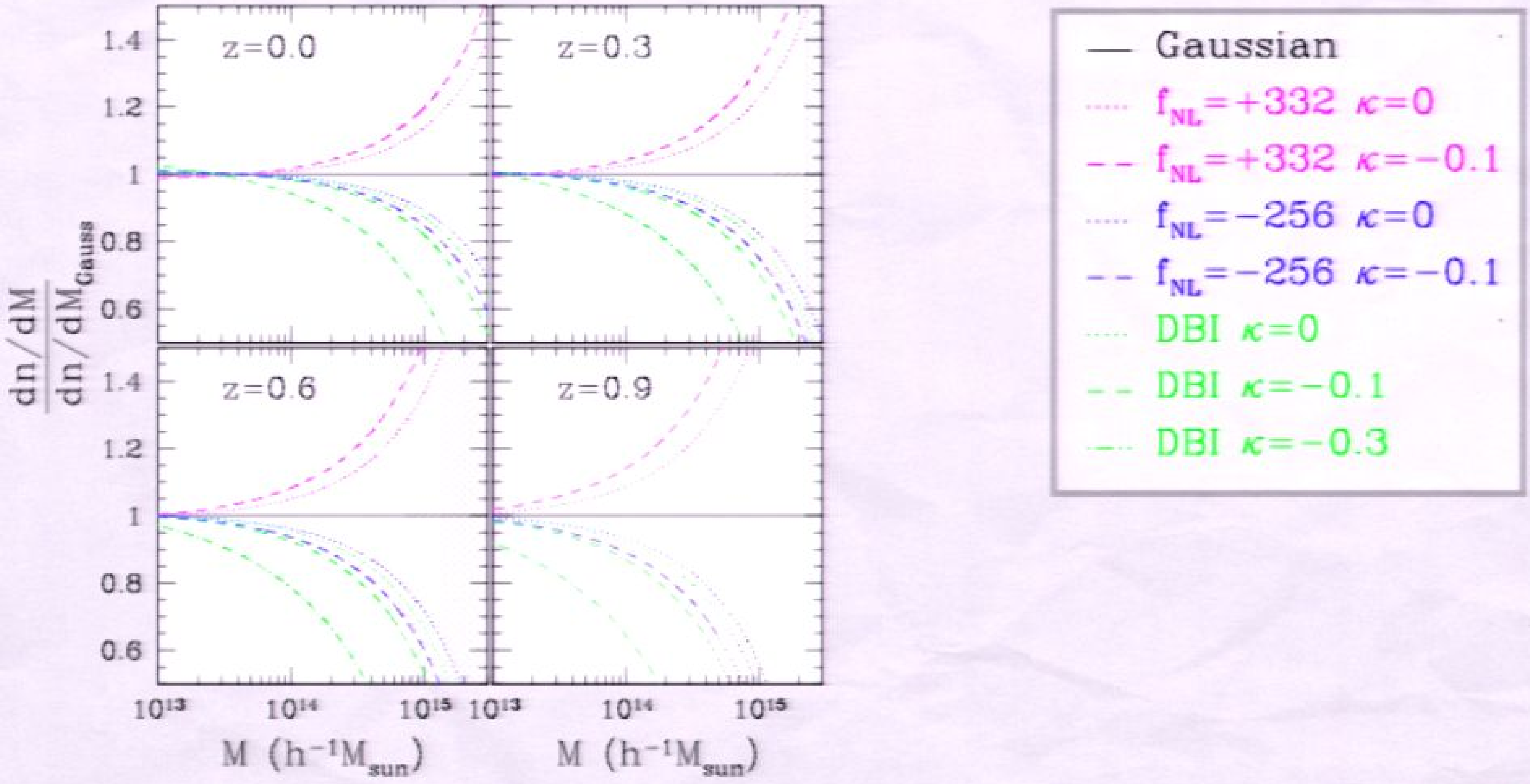


PI, Oct. 30, 2007

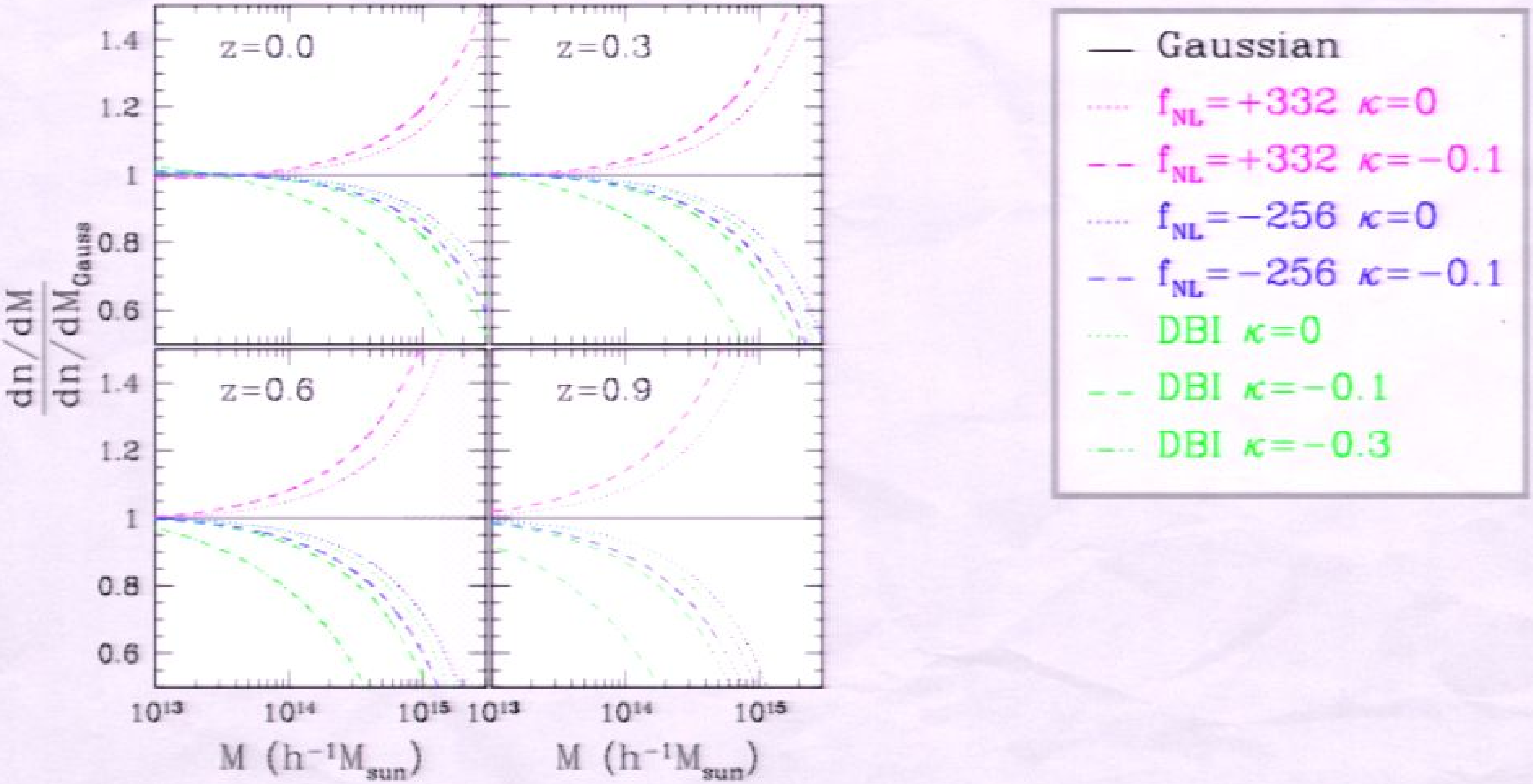
MASS FUNCTION



MASS FUNCTION

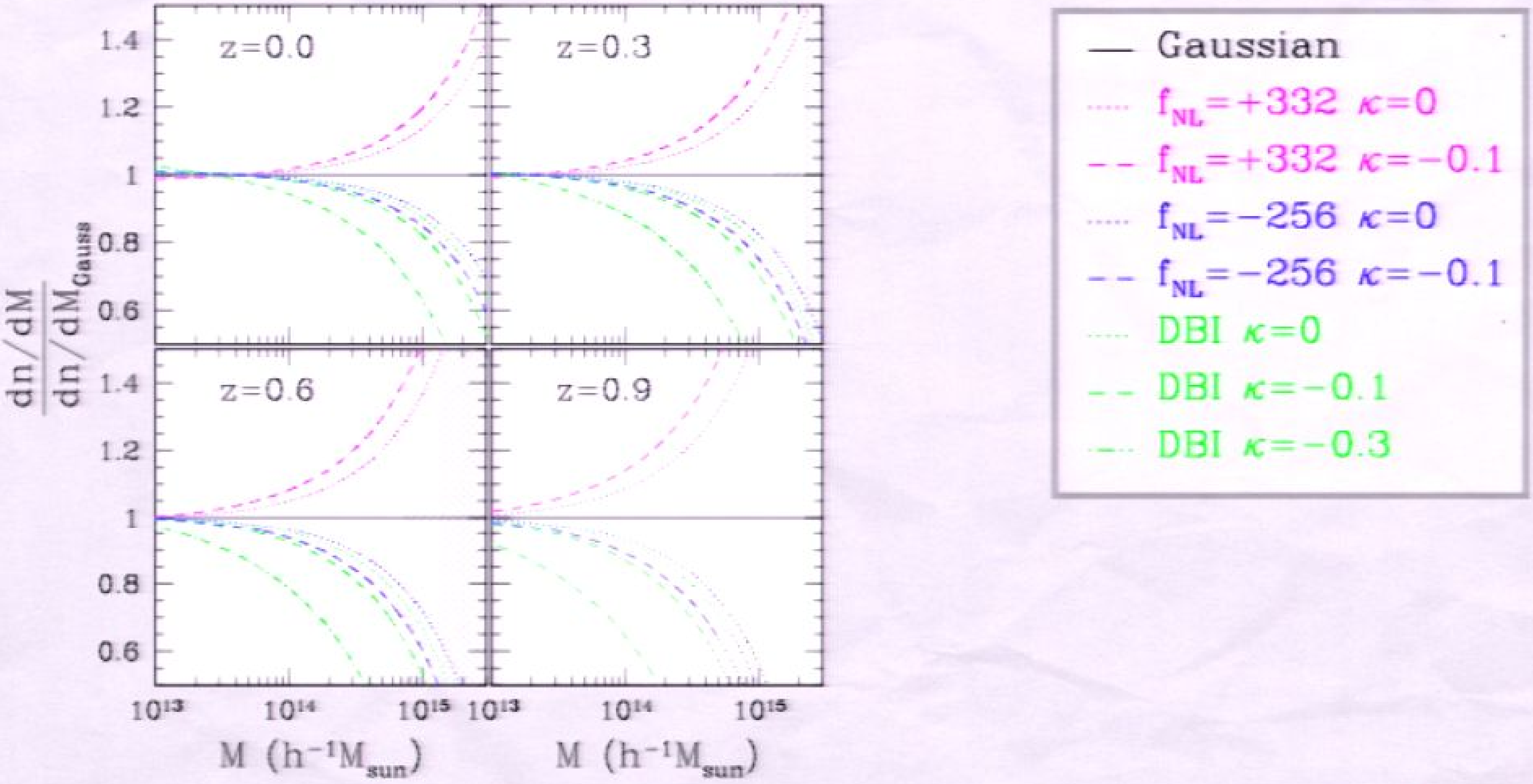


MASS FUNCTION



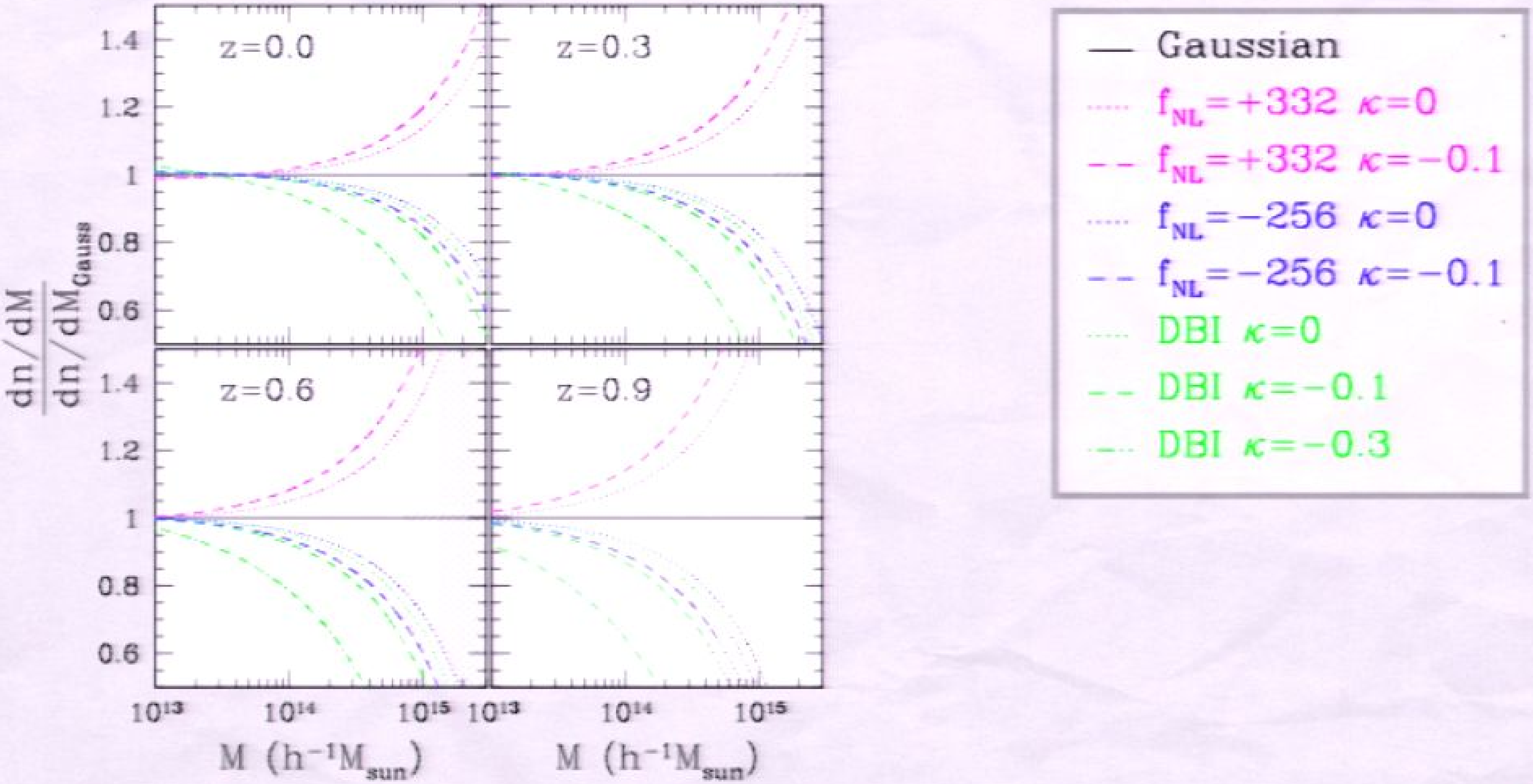
PI, Oct. 30, 2007

MASS FUNCTION

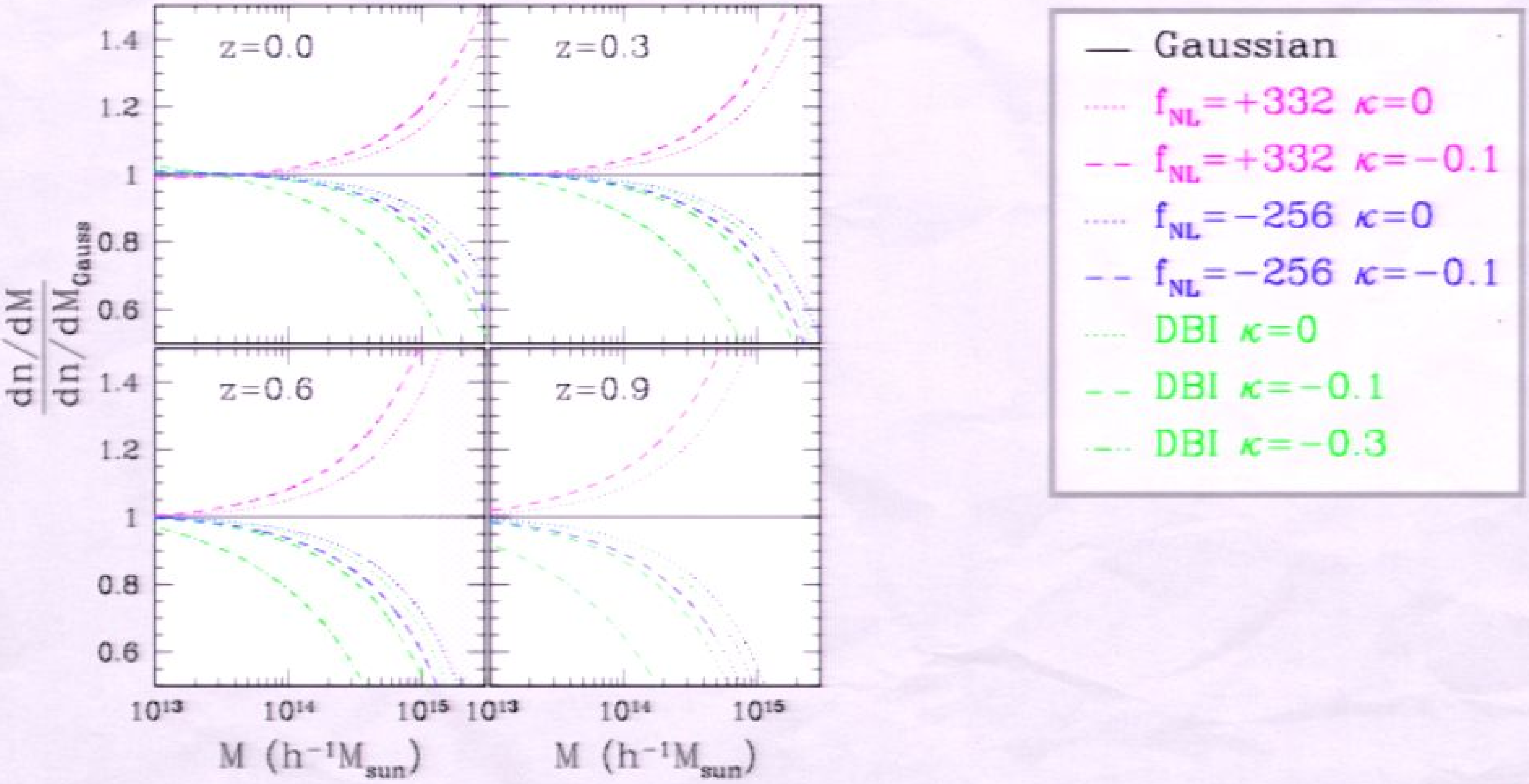


PI, Oct. 30, 2007

MASS FUNCTION

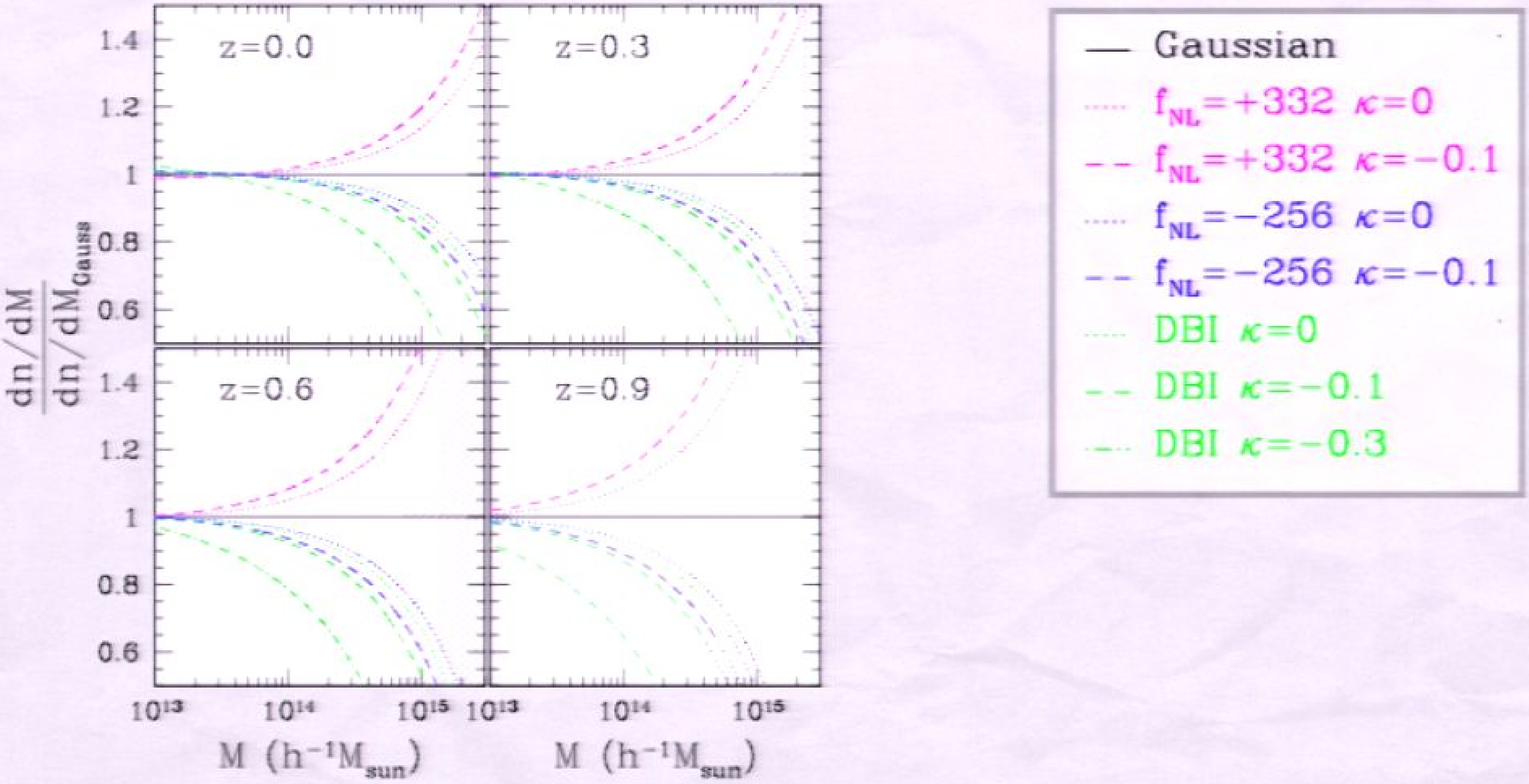


MASS FUNCTION

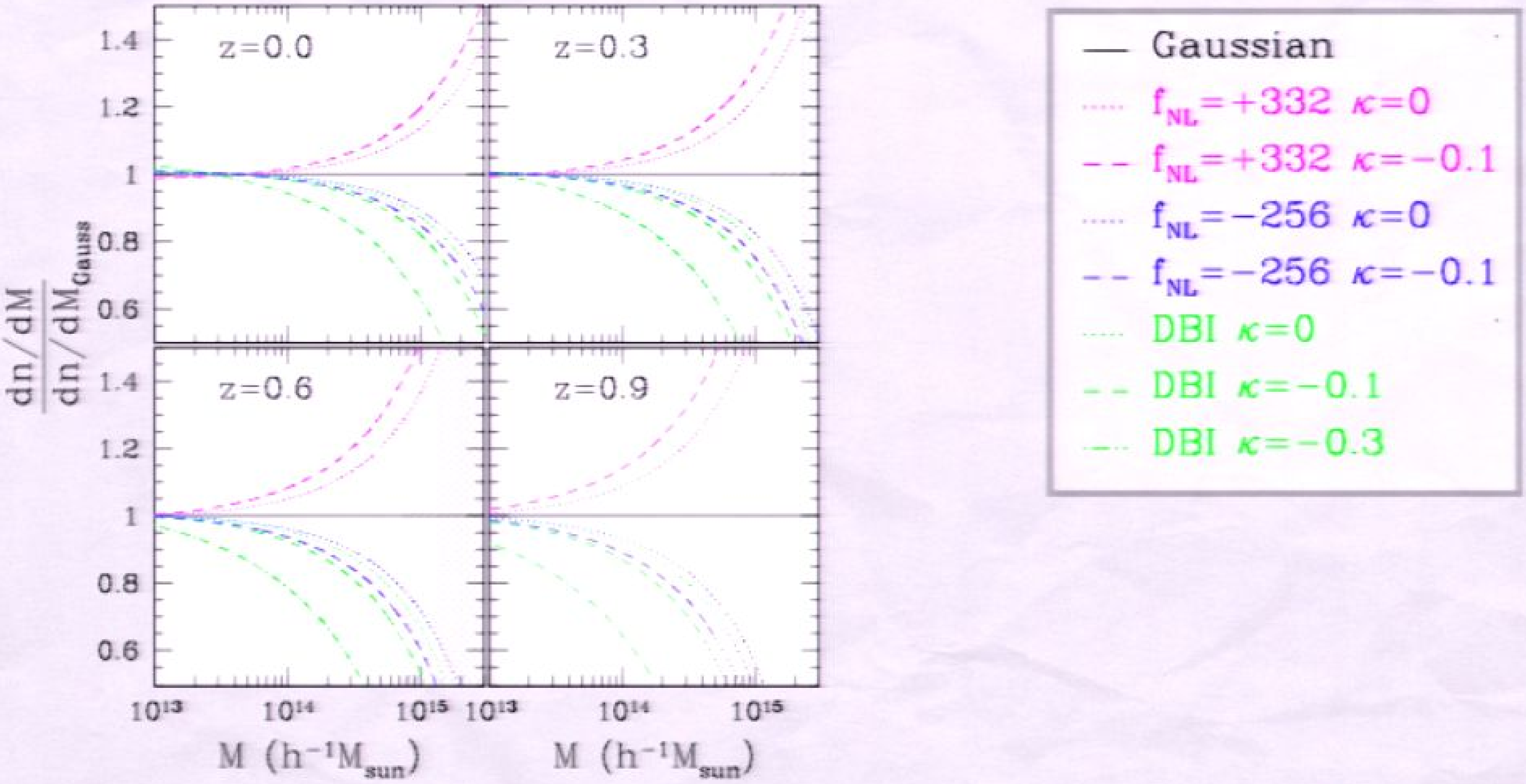


PI, Oct. 30, 2007

MASS FUNCTION

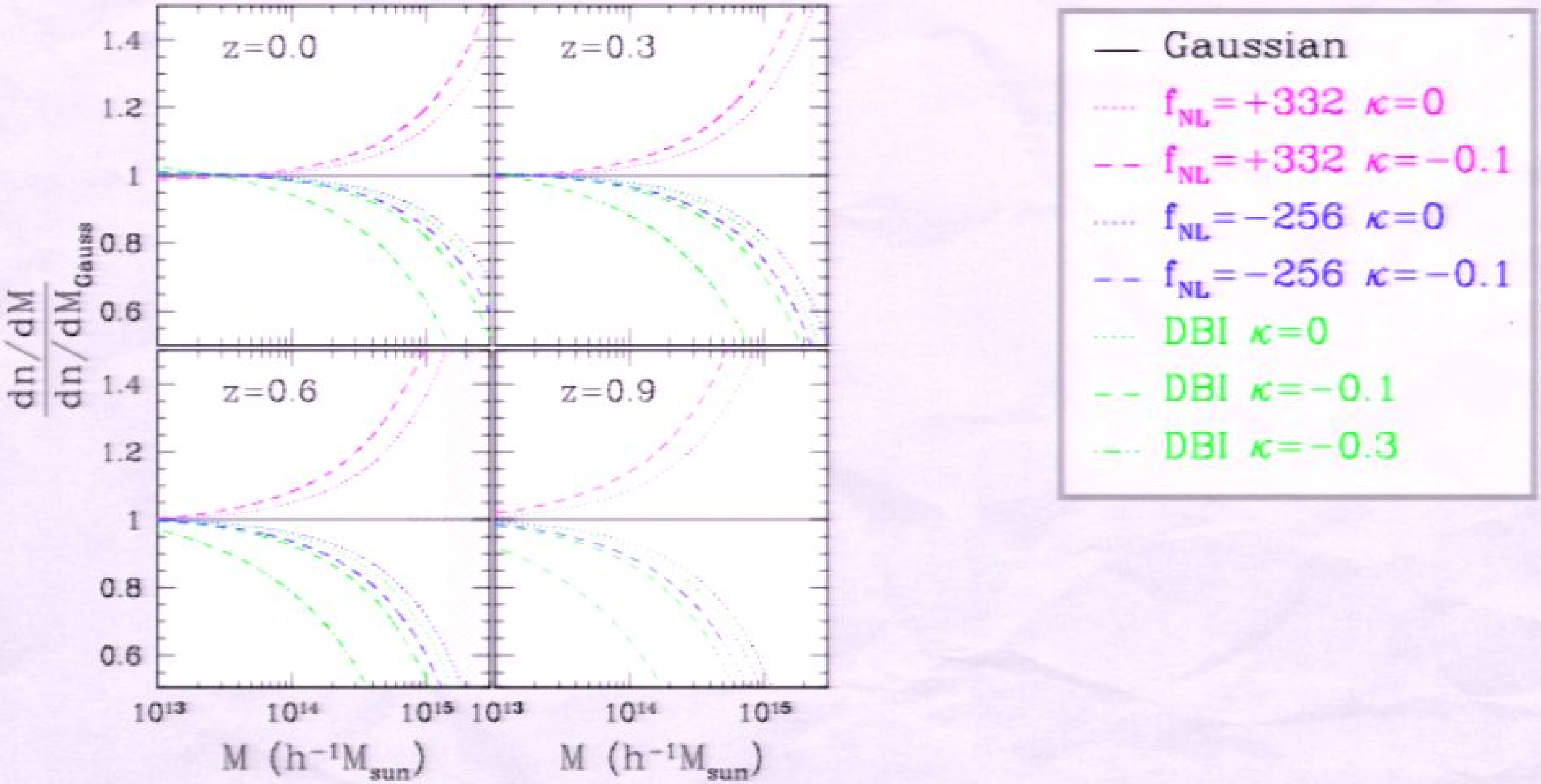


MASS FUNCTION

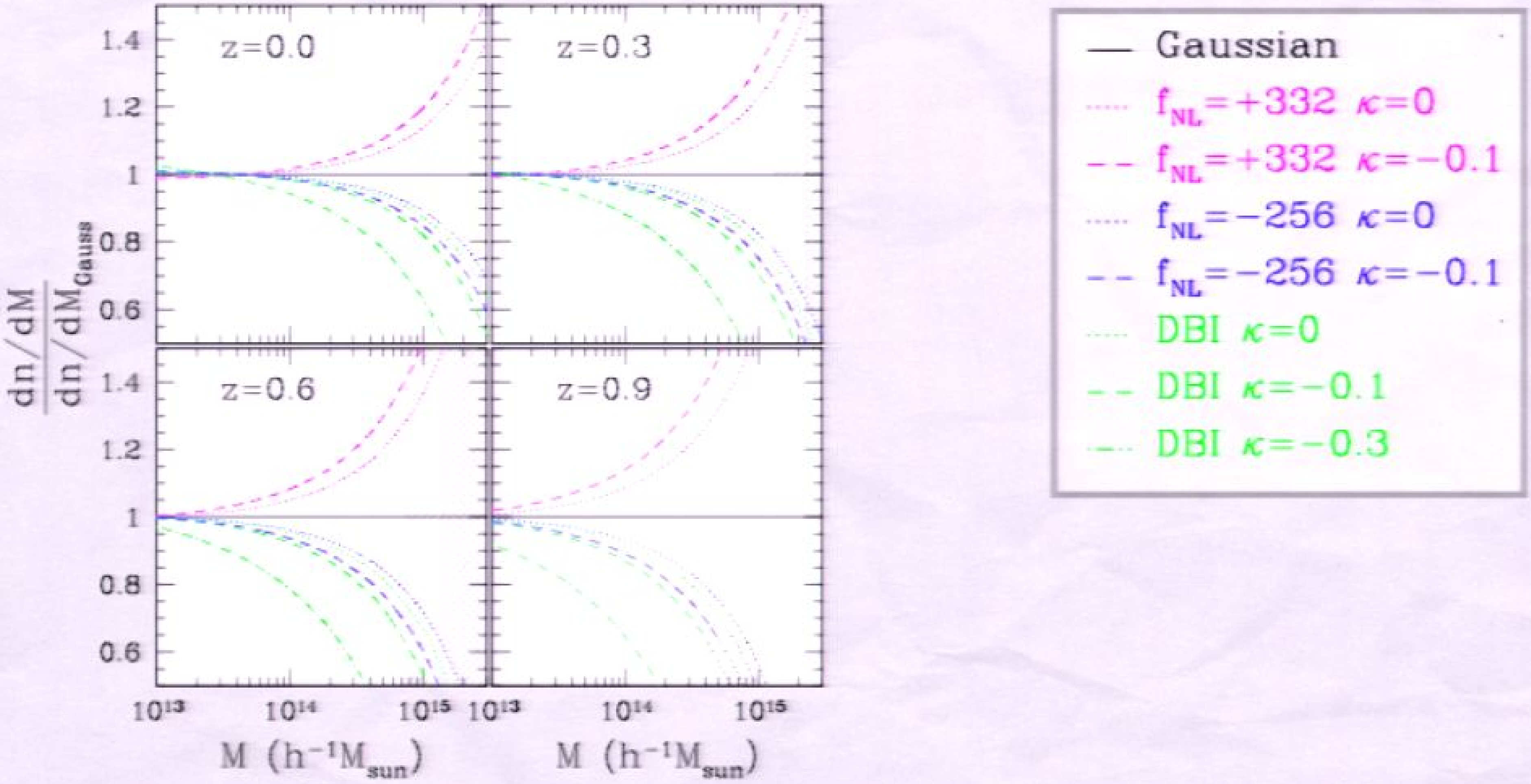


PI, Oct. 30, 2007

MASS FUNCTION

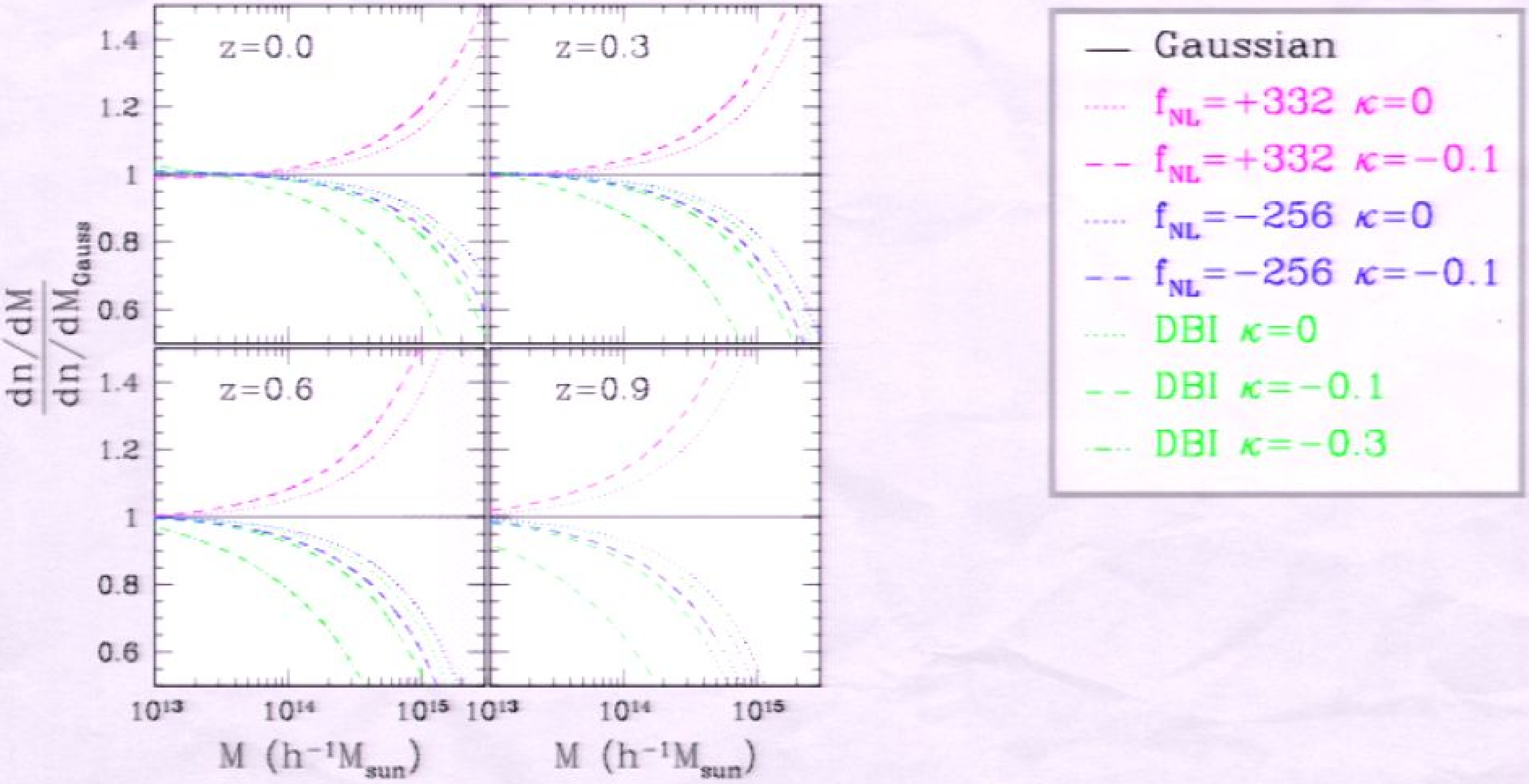


MASS FUNCTION

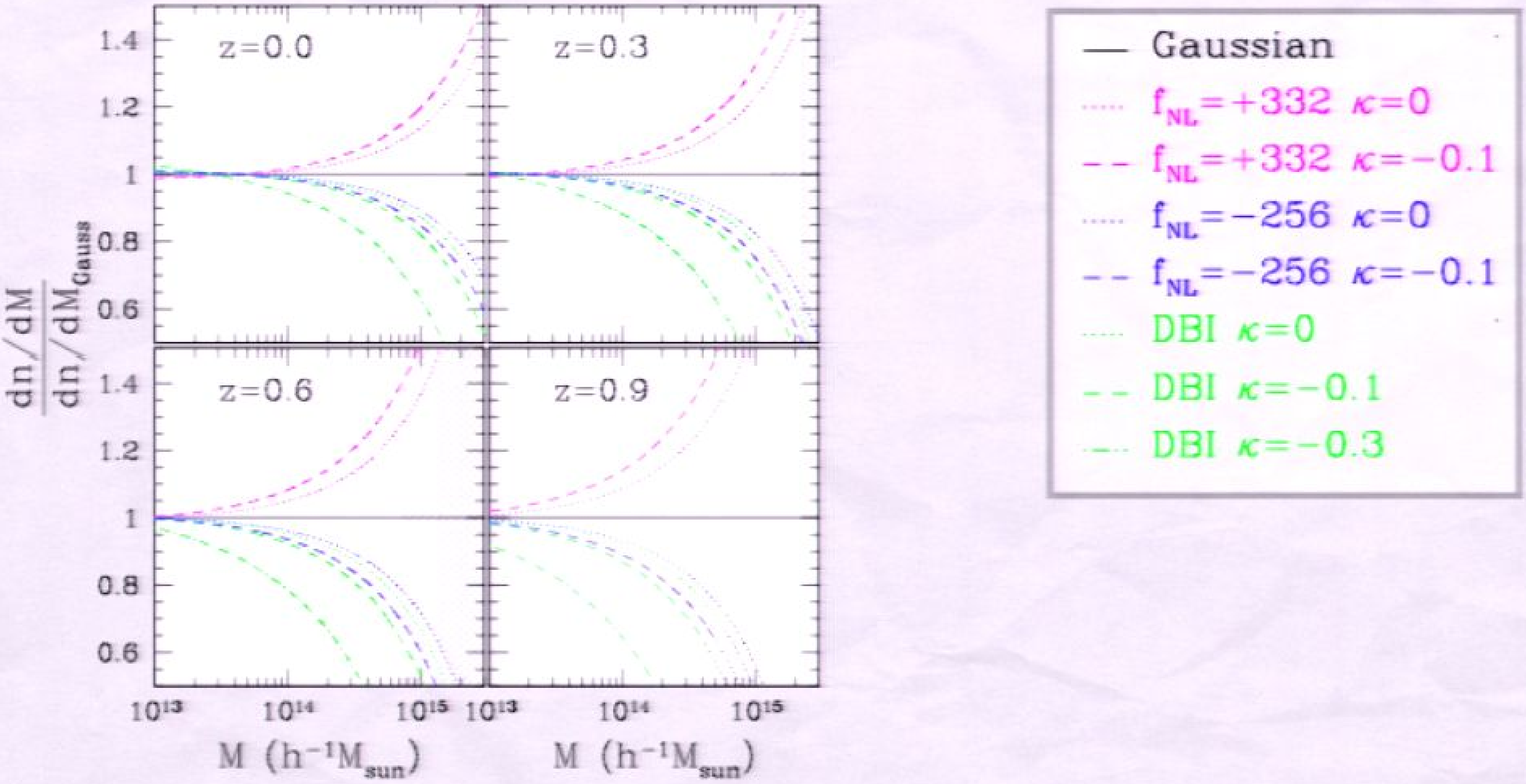


PI, Oct. 30, 2007

MASS FUNCTION

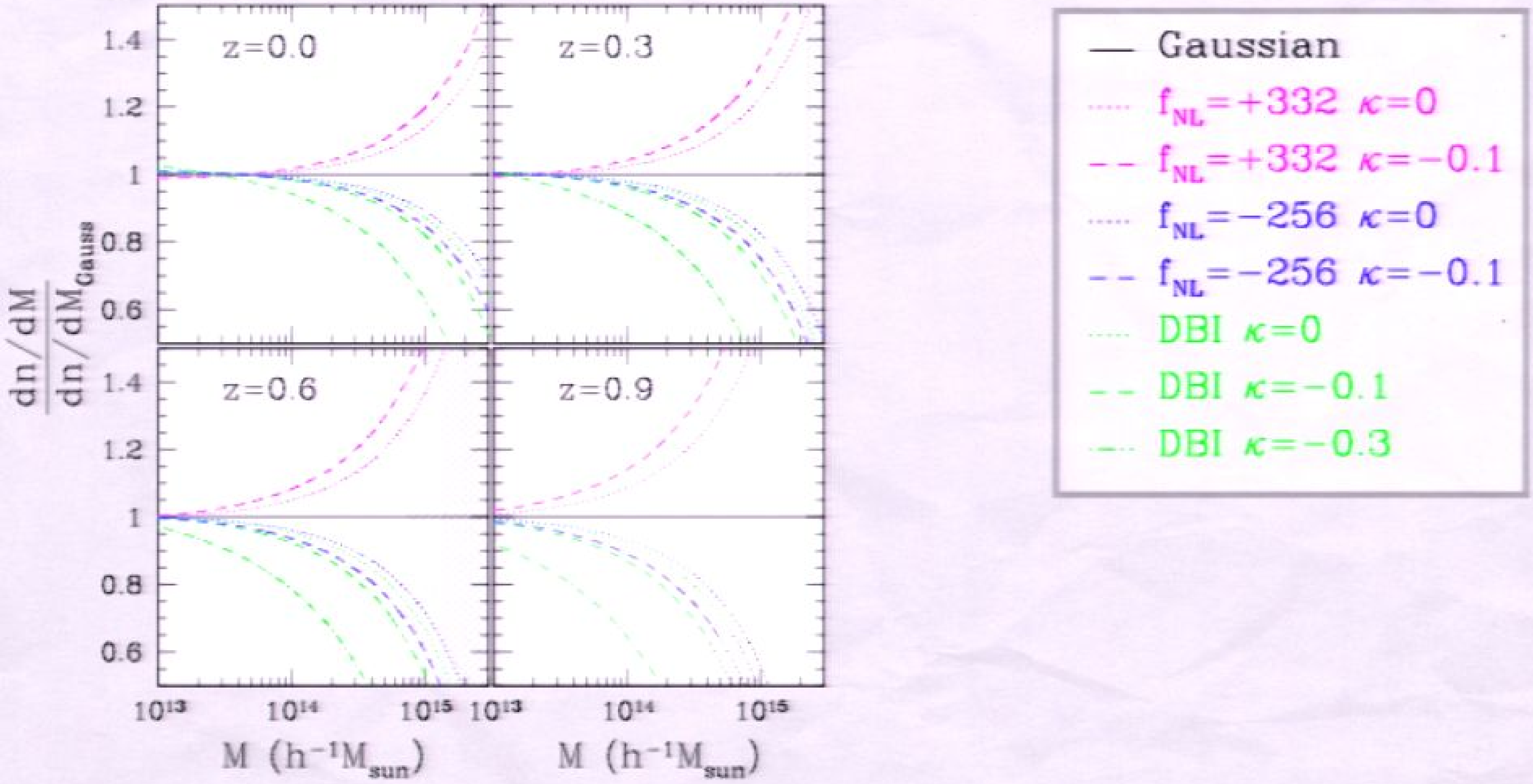


MASS FUNCTION

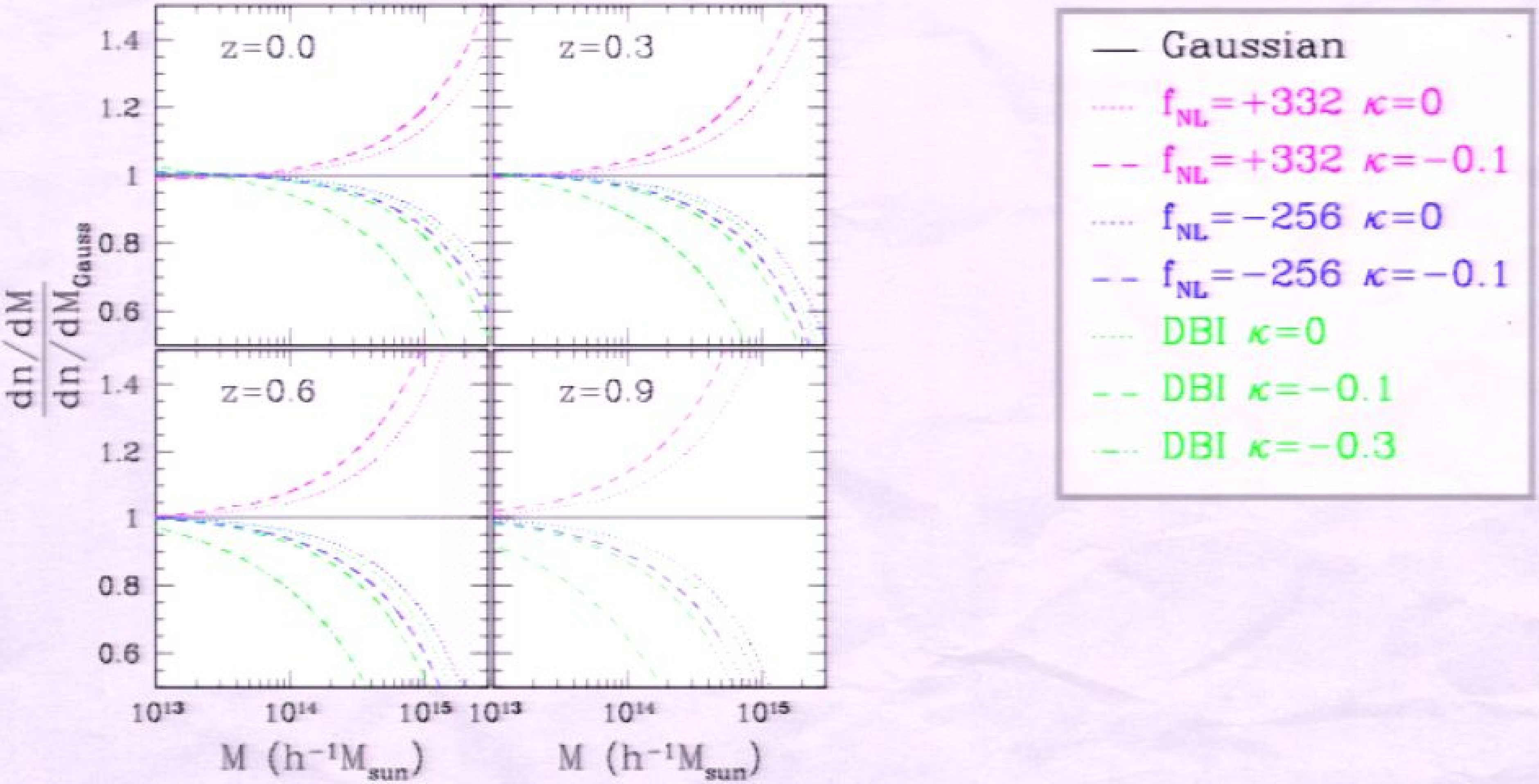


PI, Oct. 30, 2007

MASS FUNCTION

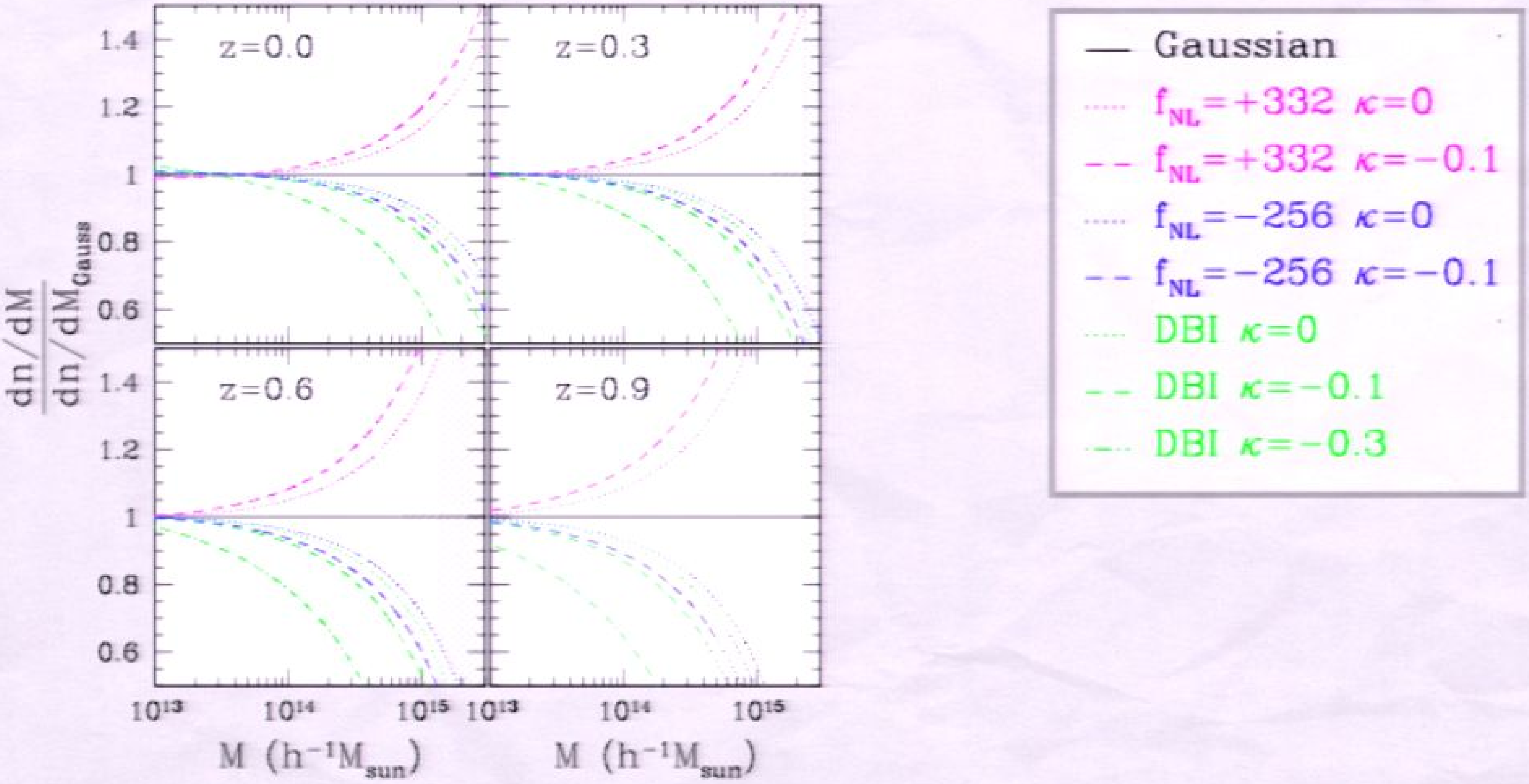


MASS FUNCTION



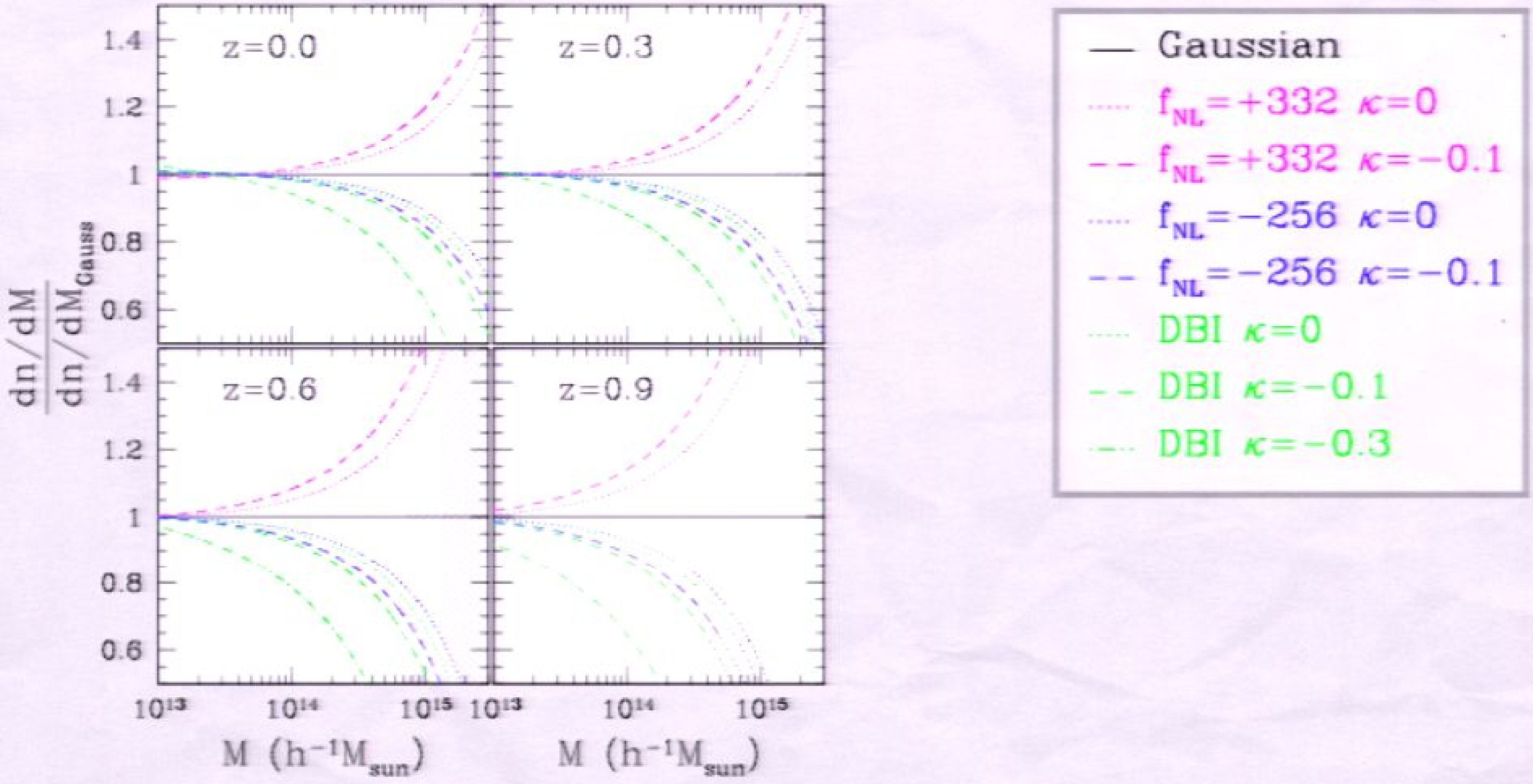
PI, Oct. 30, 2007

MASS FUNCTION



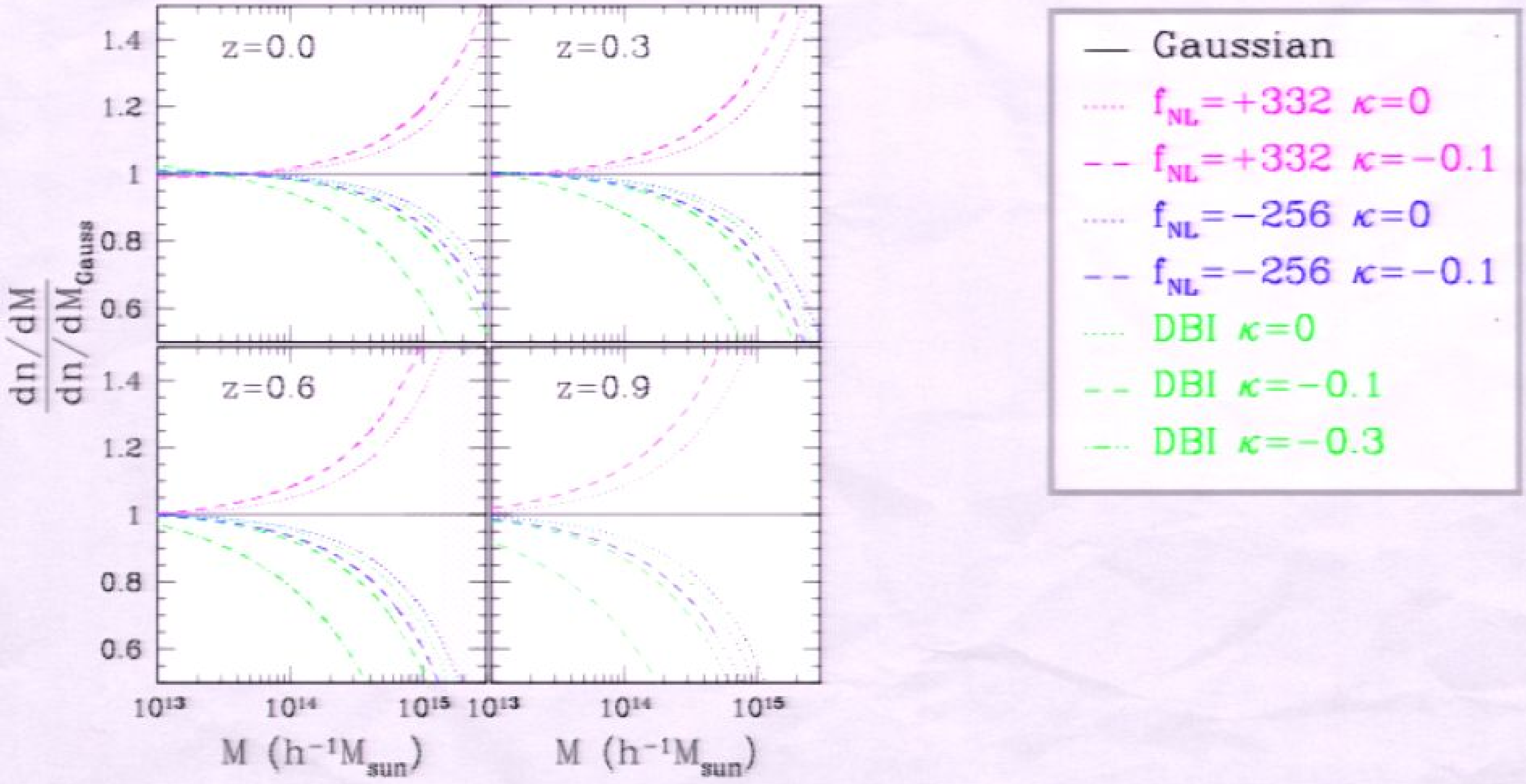
PI, Oct. 30, 2007

MASS FUNCTION



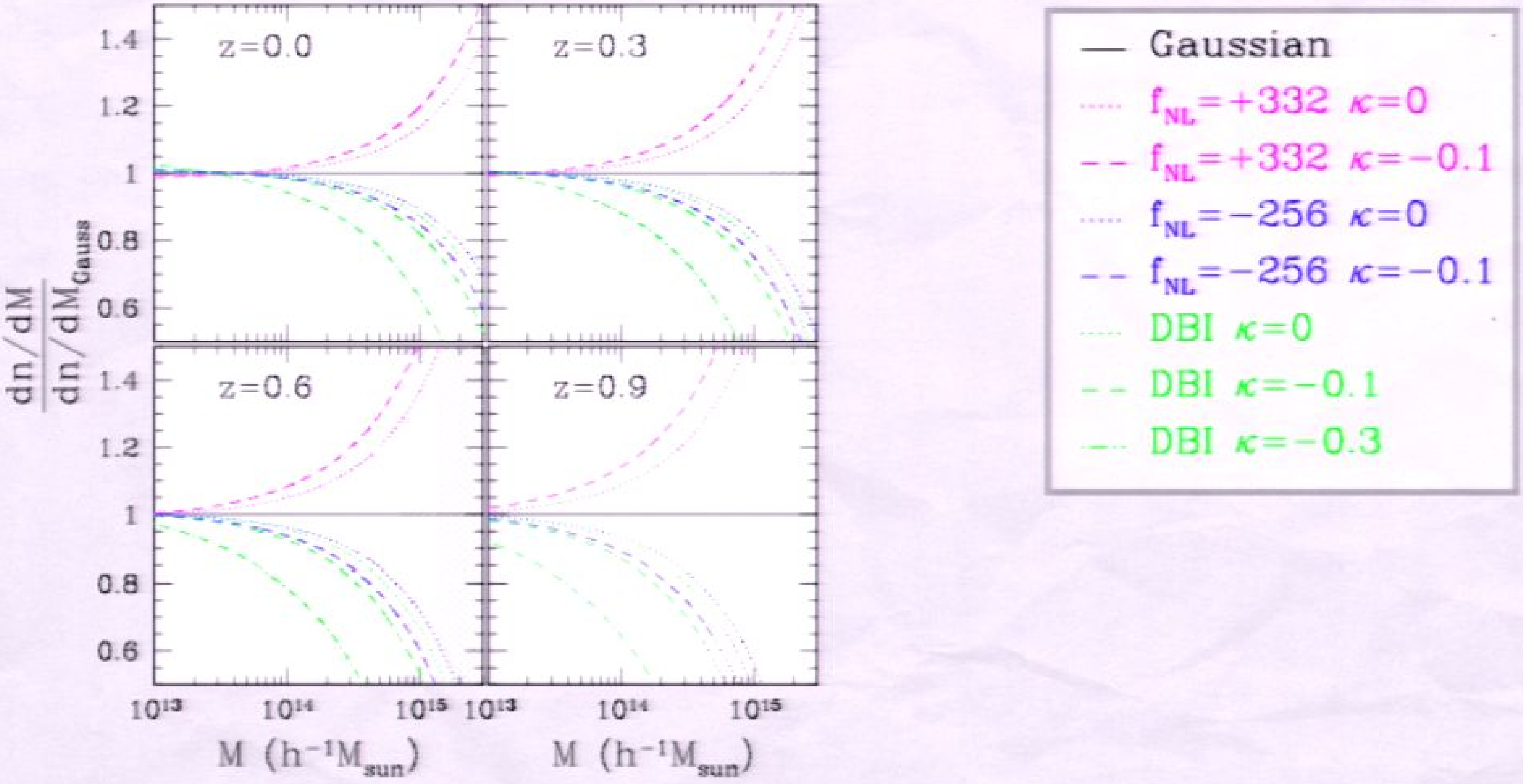
PI, Oct. 30, 2007

MASS FUNCTION



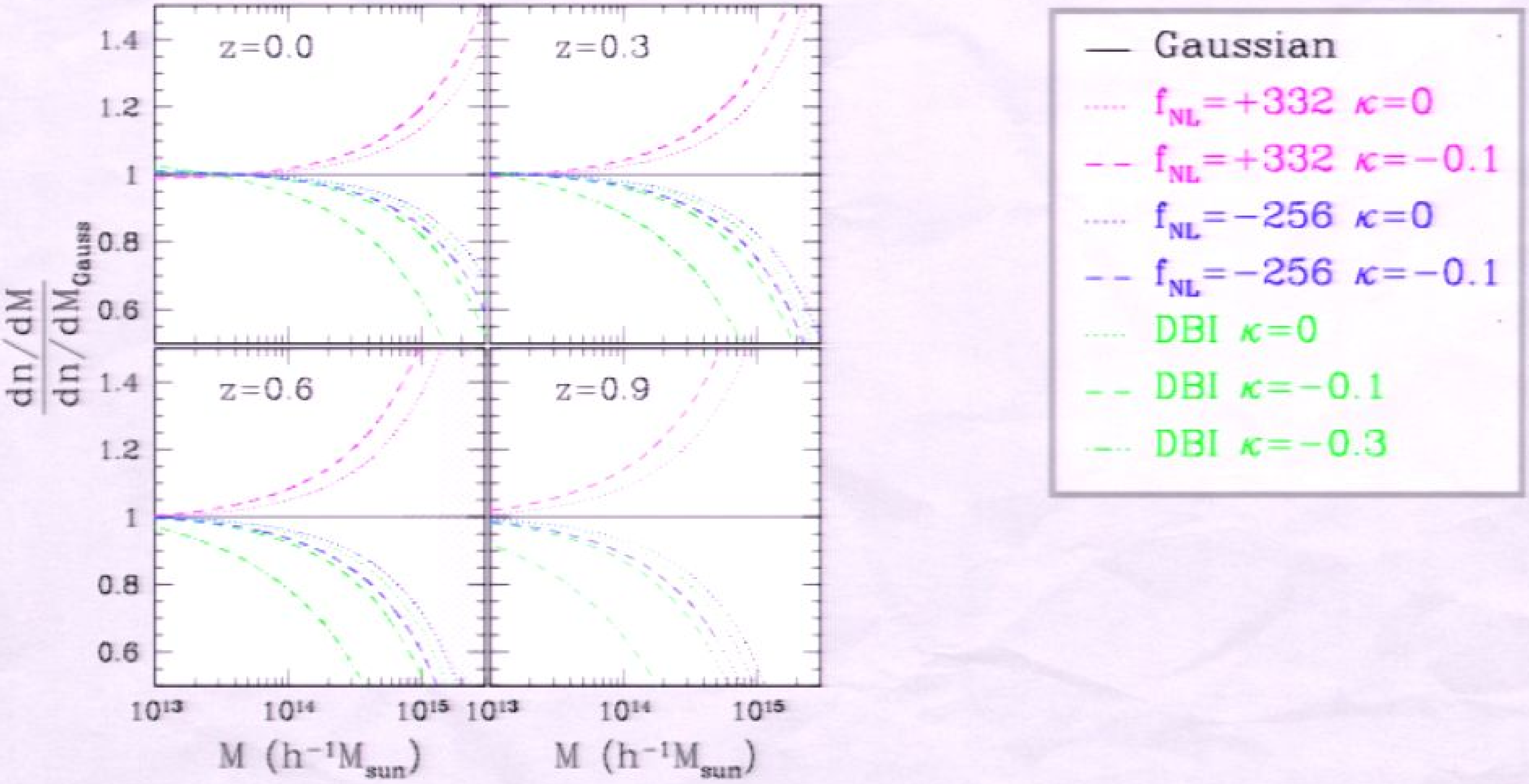
PI, Oct. 30, 2007

MASS FUNCTION



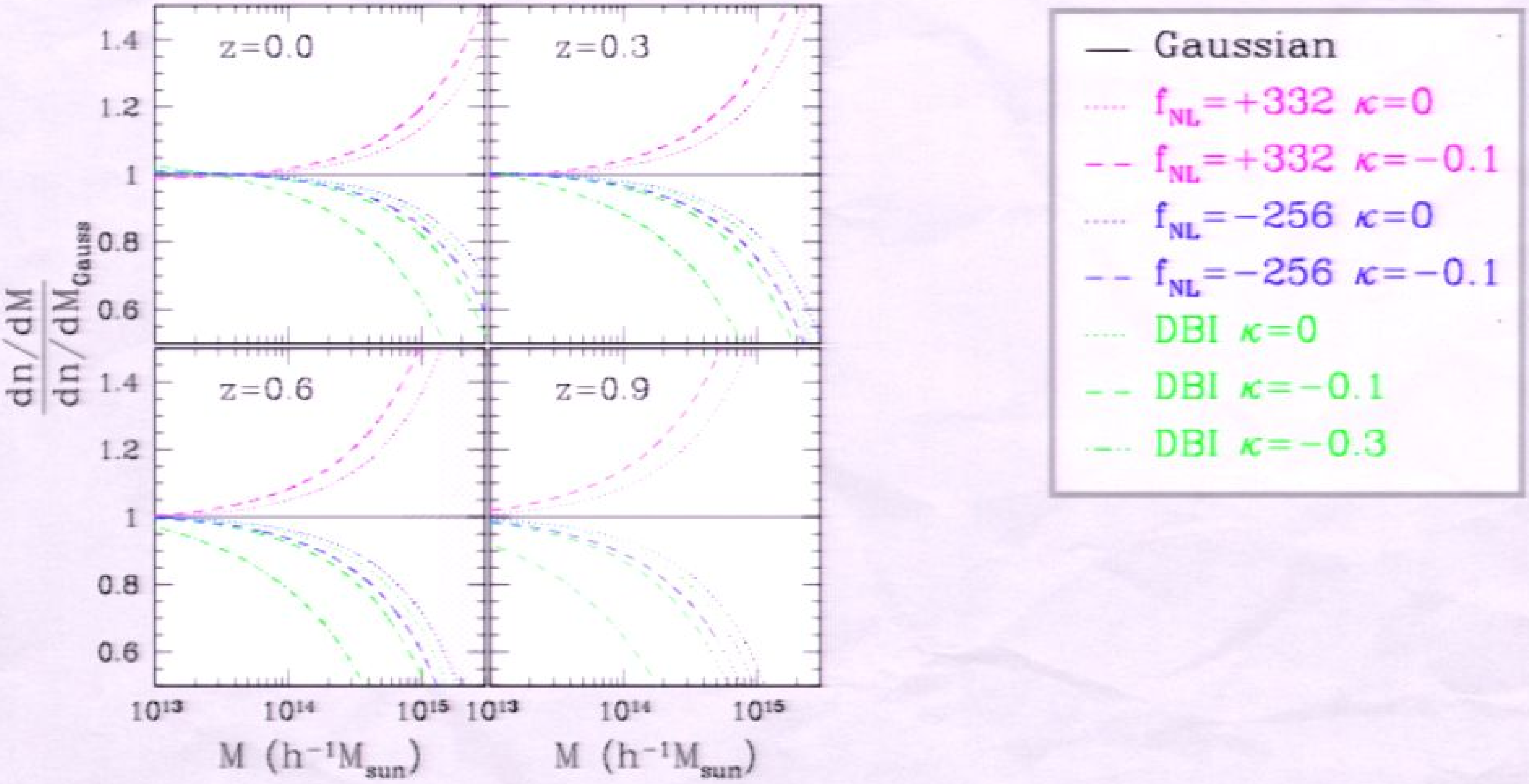
PI, Oct. 30, 2007

MASS FUNCTION

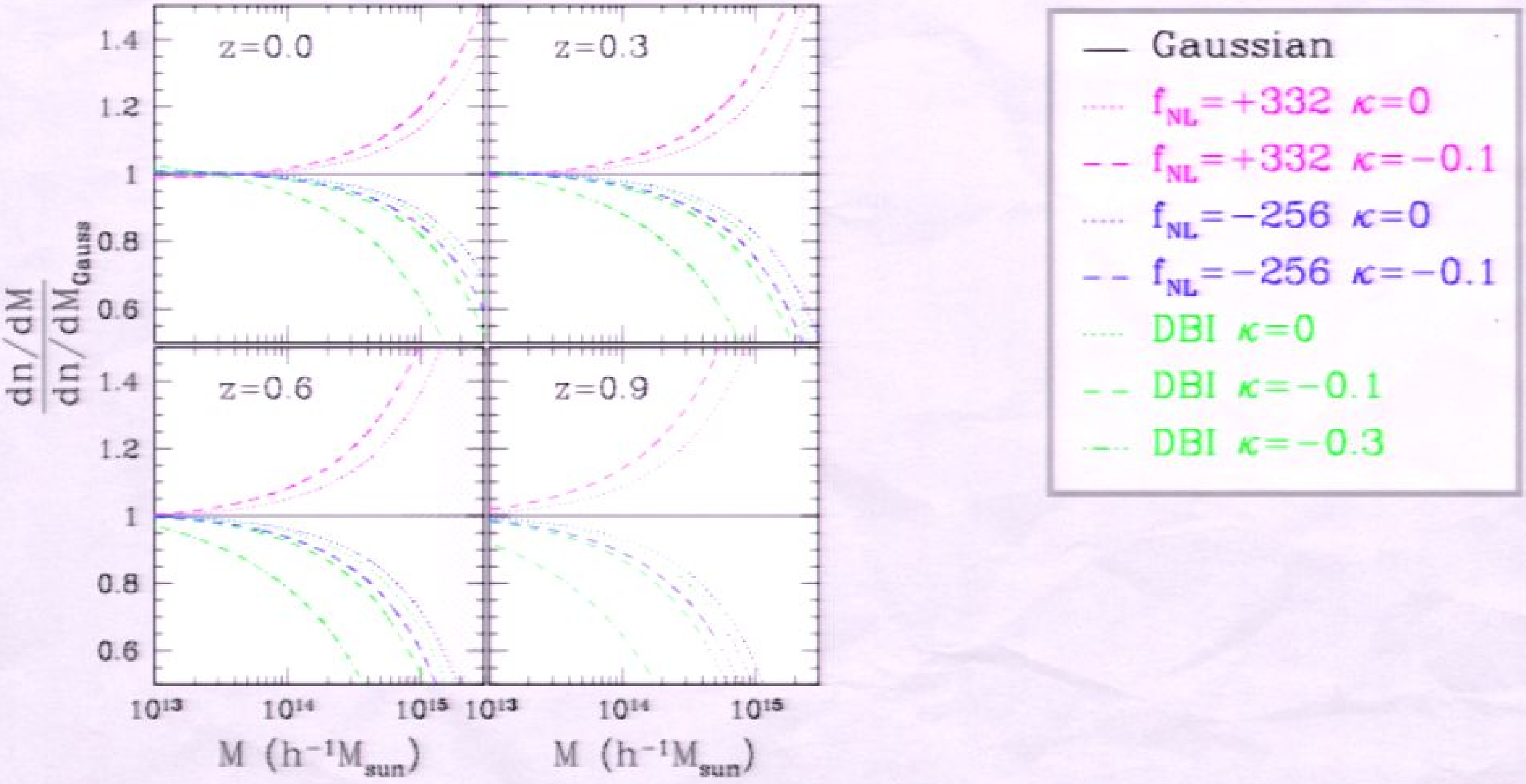


PI, Oct. 30, 2007

MASS FUNCTION

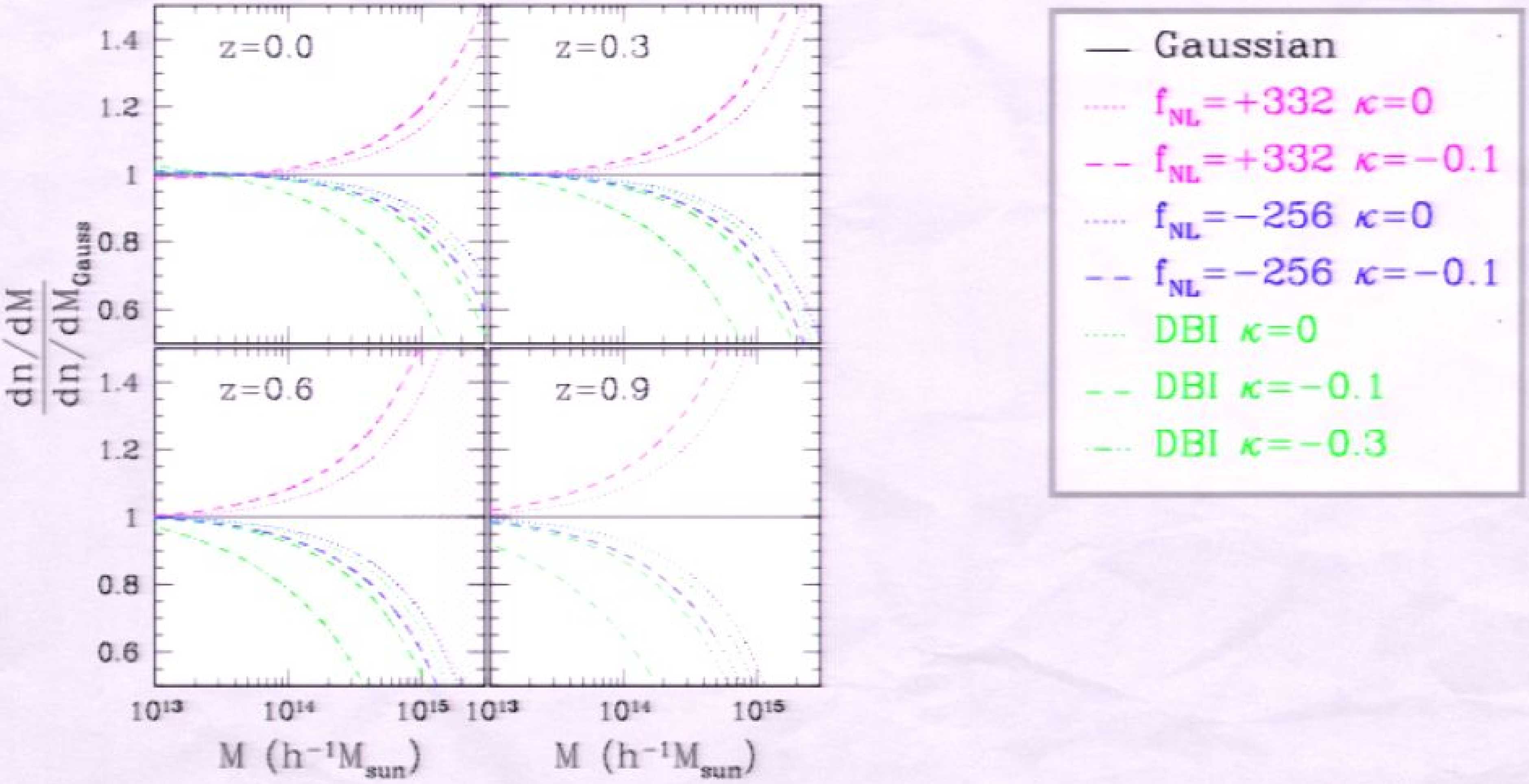


MASS FUNCTION

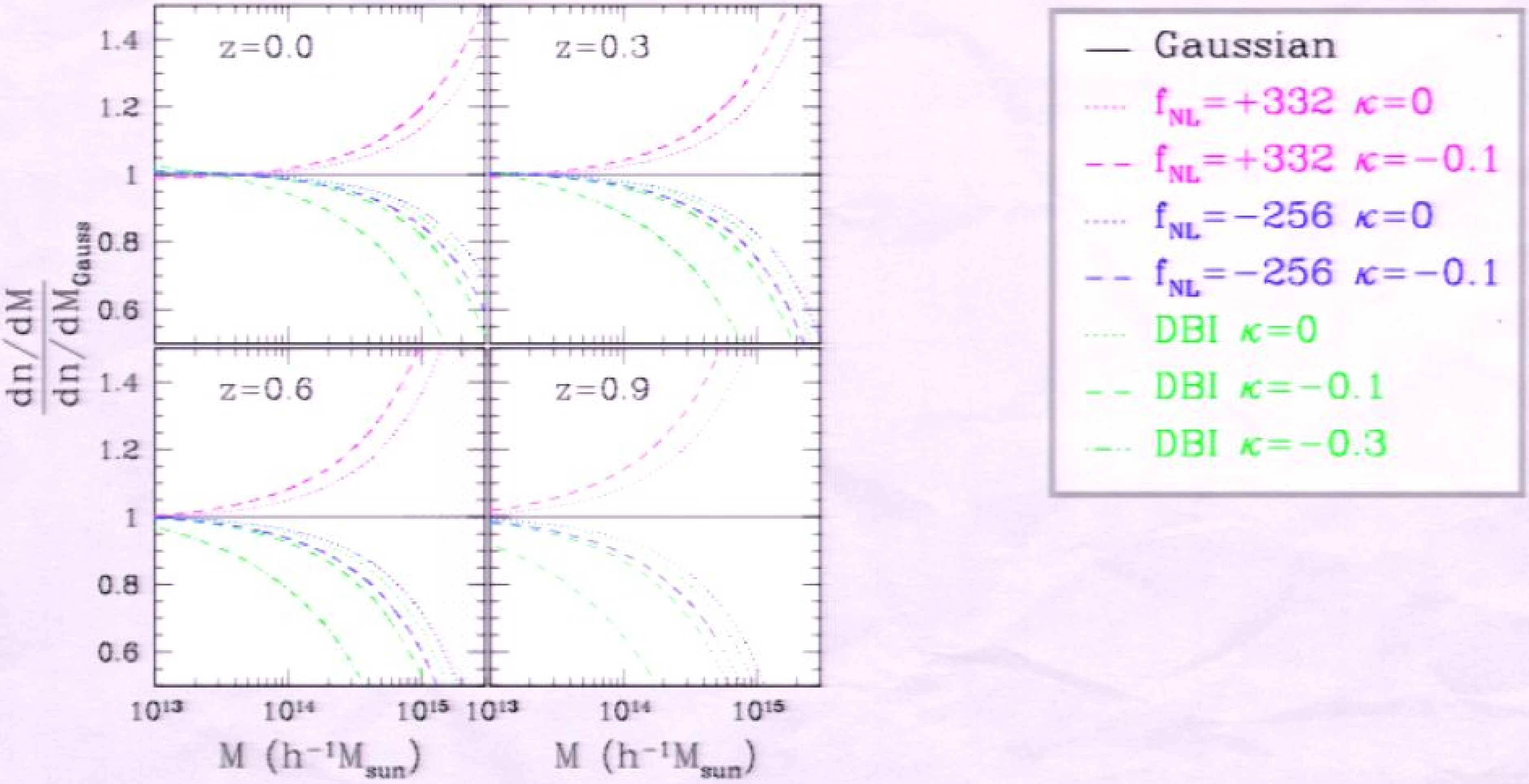


PI, Oct. 30, 2007

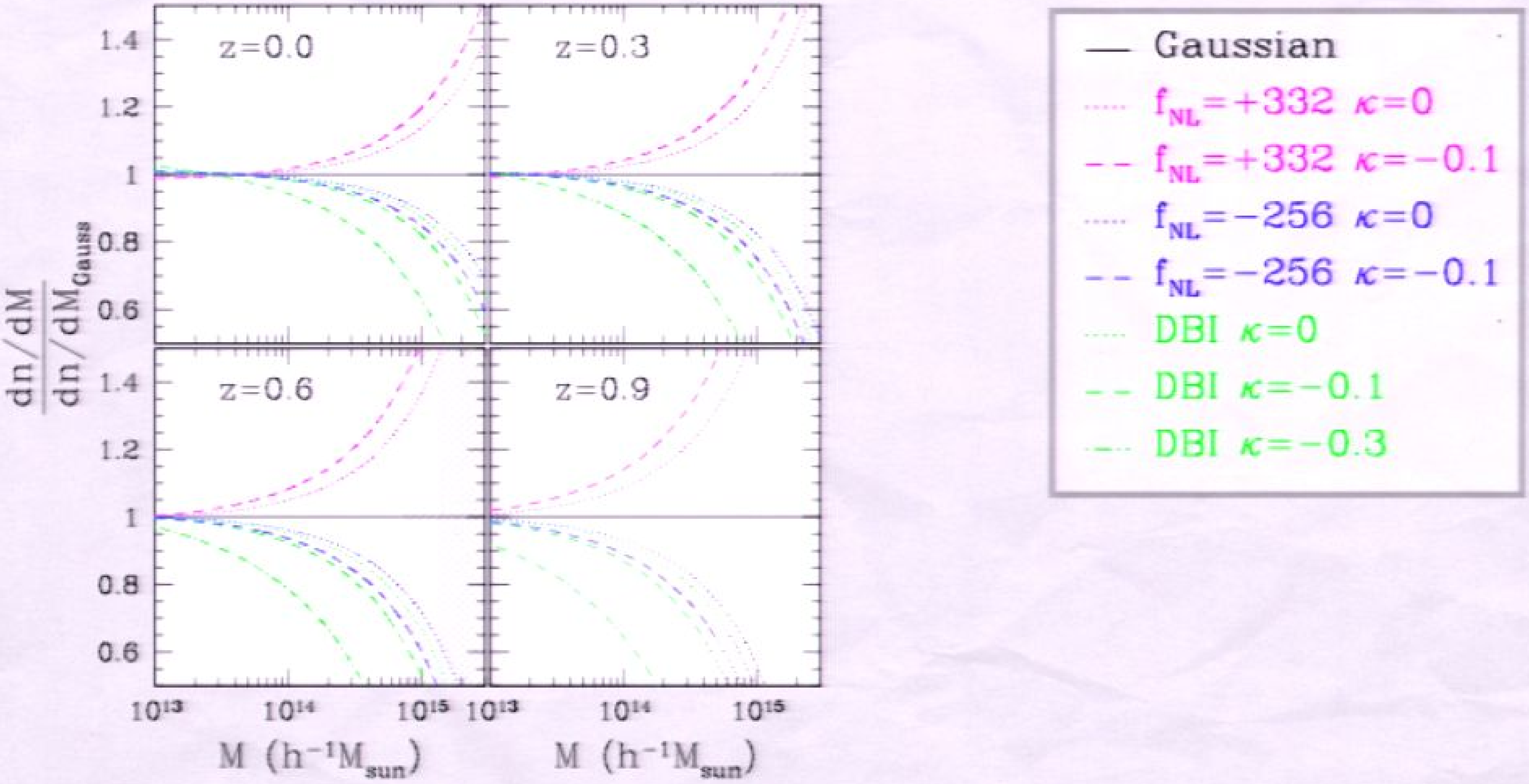
MASS FUNCTION



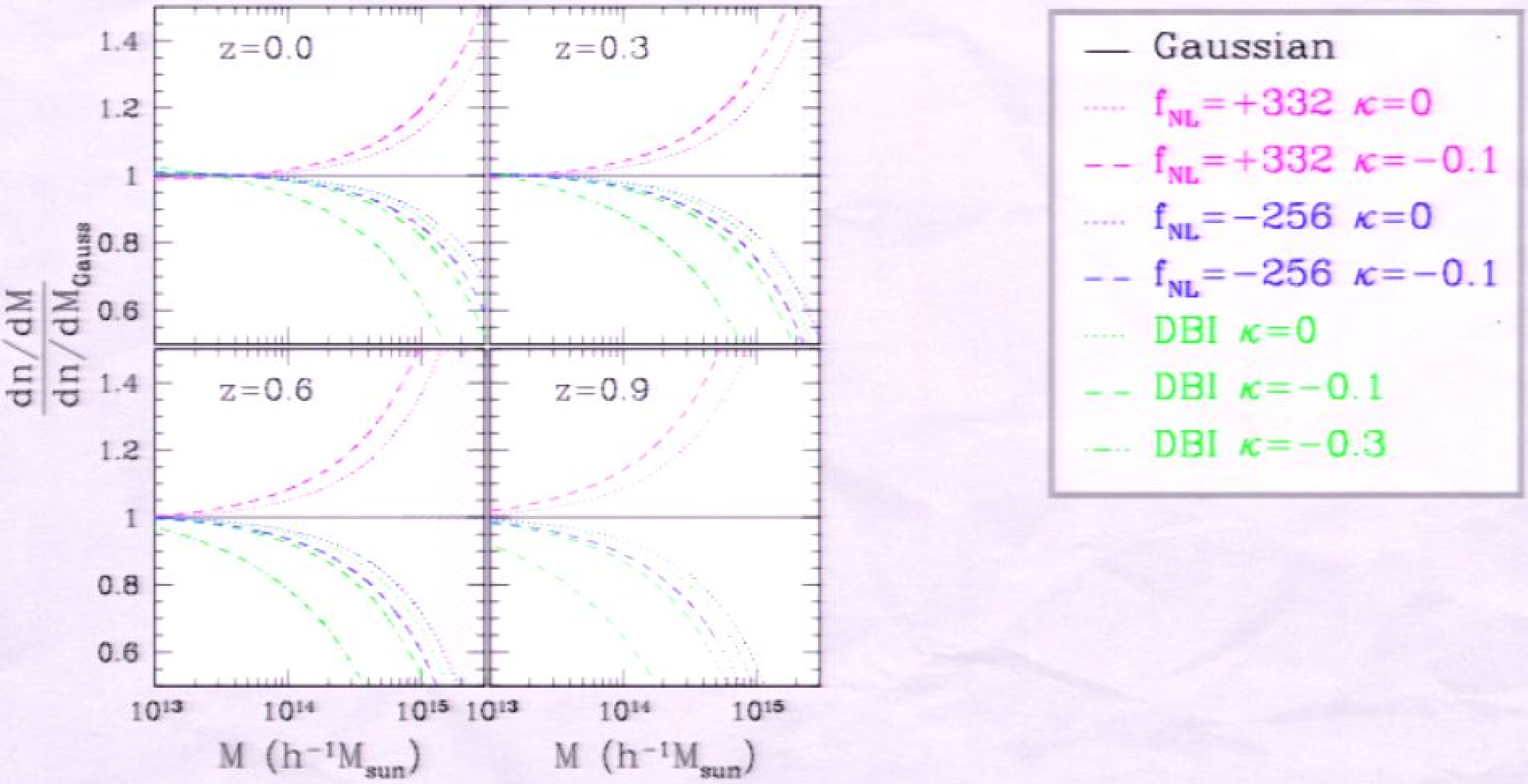
MASS FUNCTION



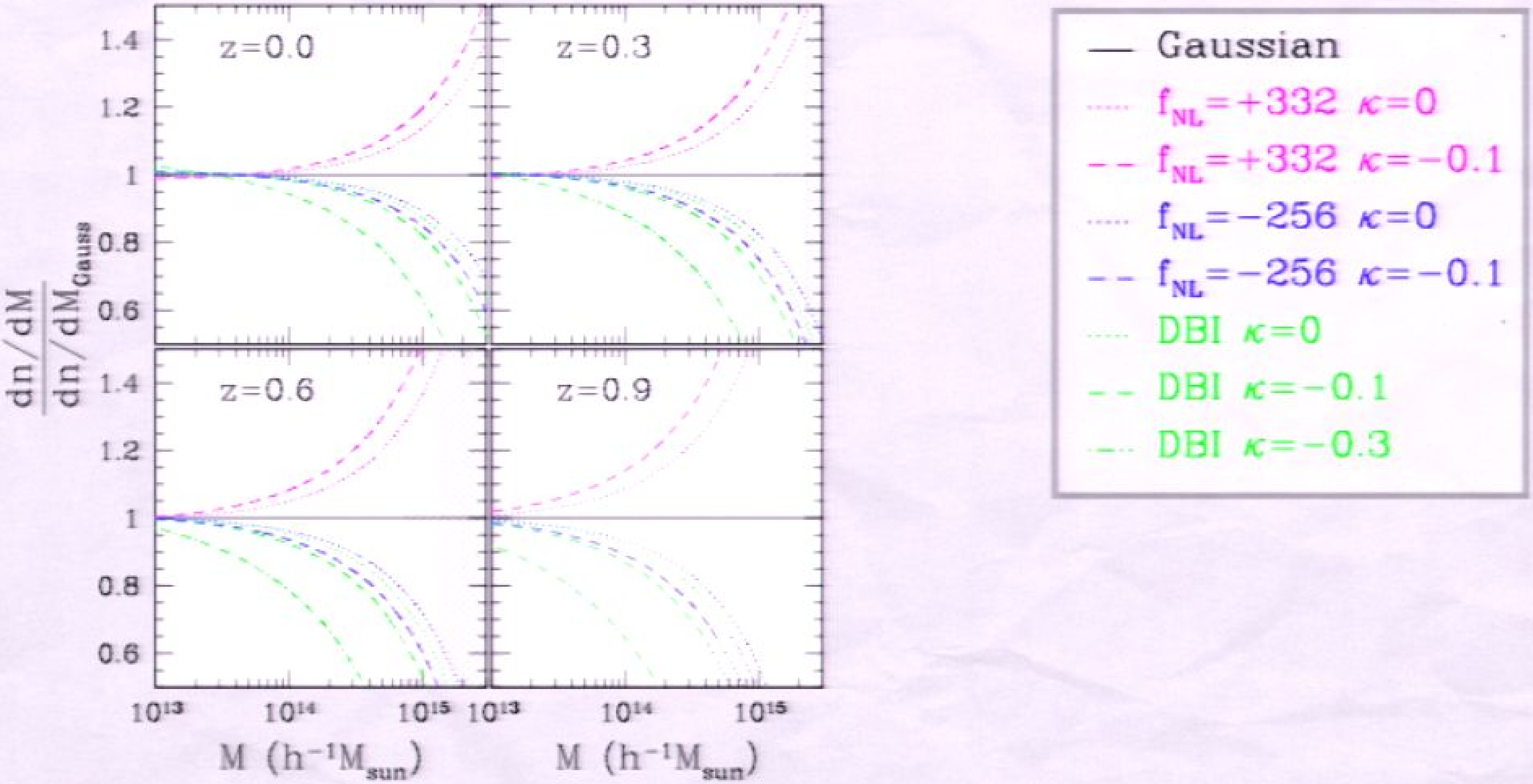
MASS FUNCTION



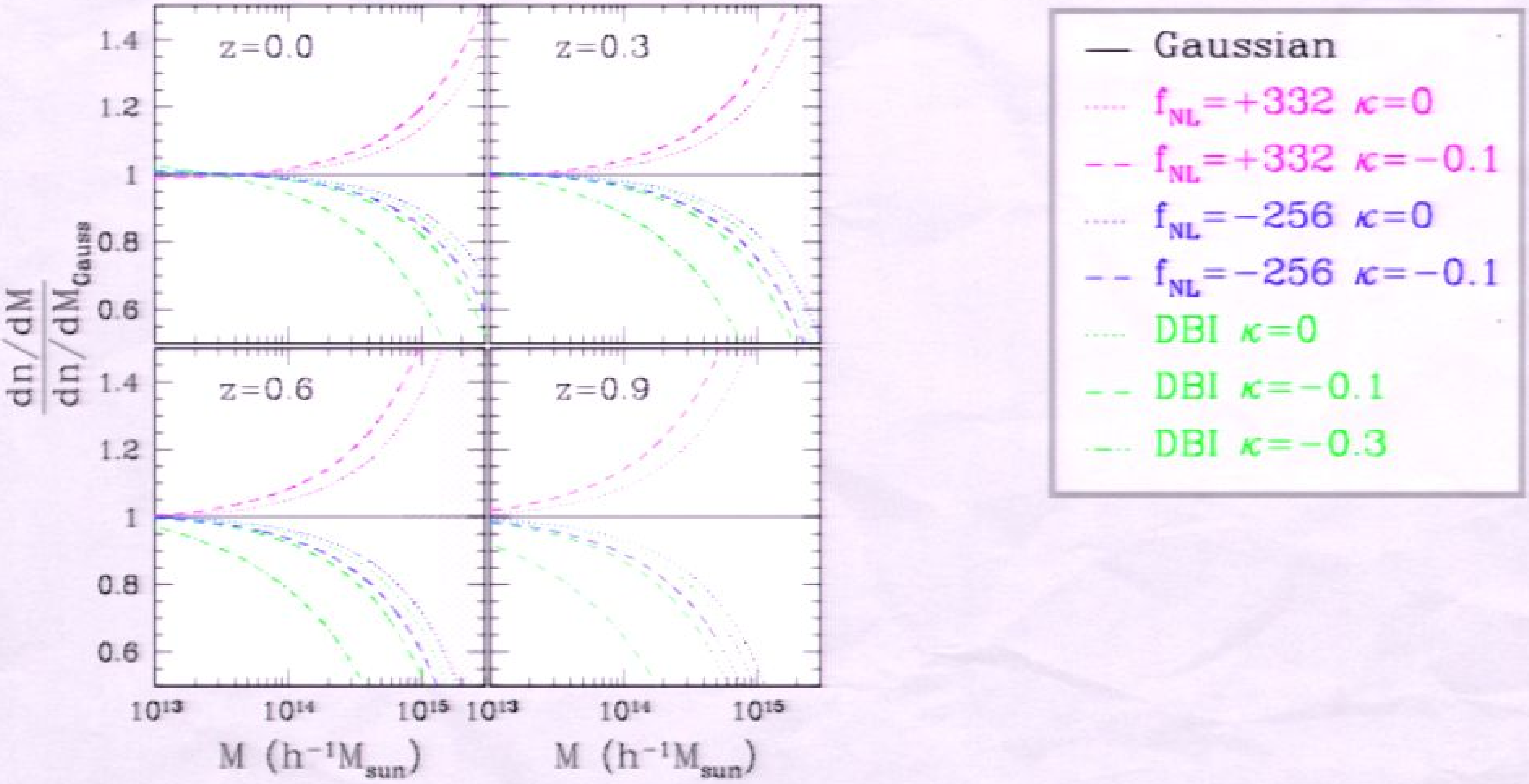
MASS FUNCTION



MASS FUNCTION

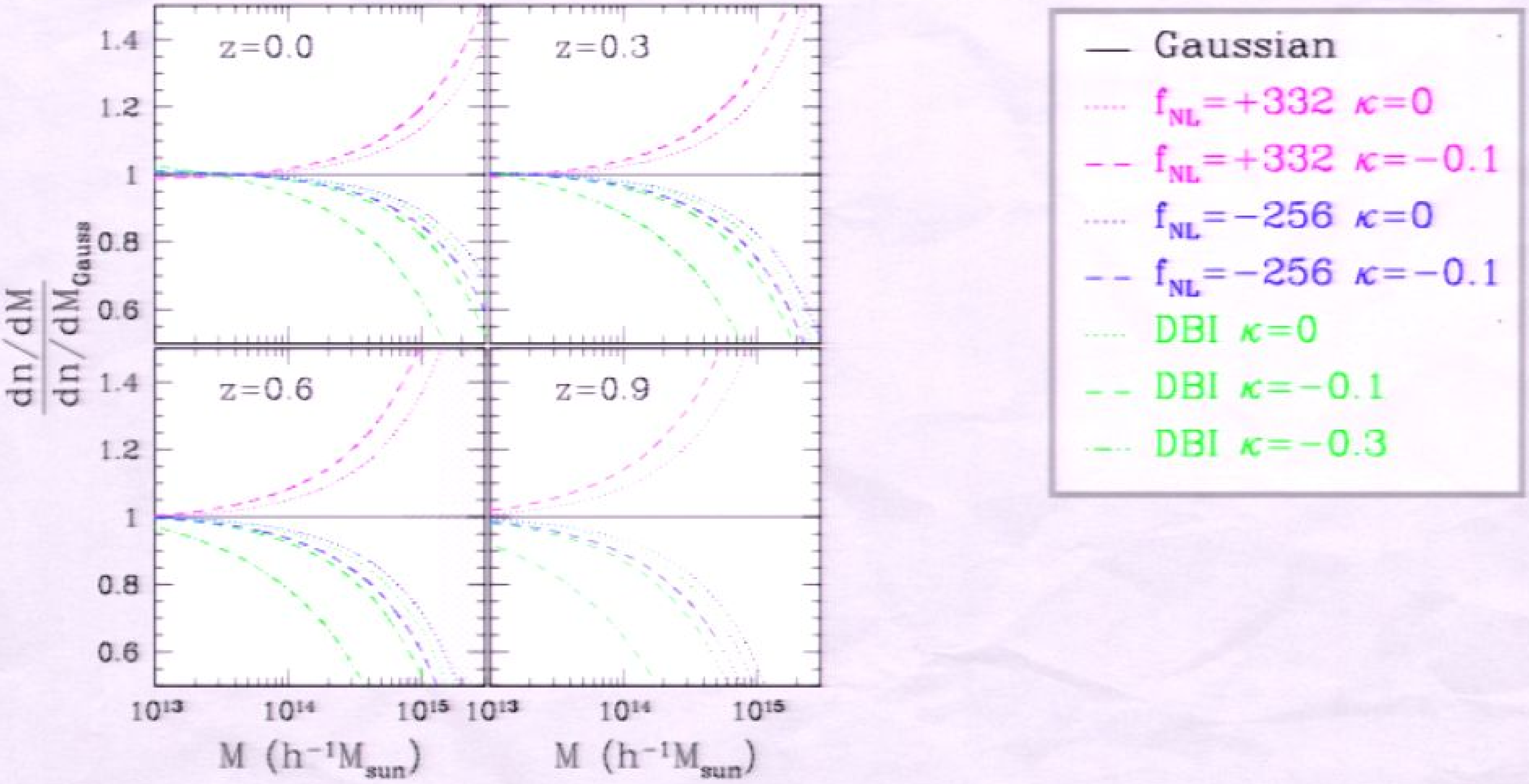


MASS FUNCTION

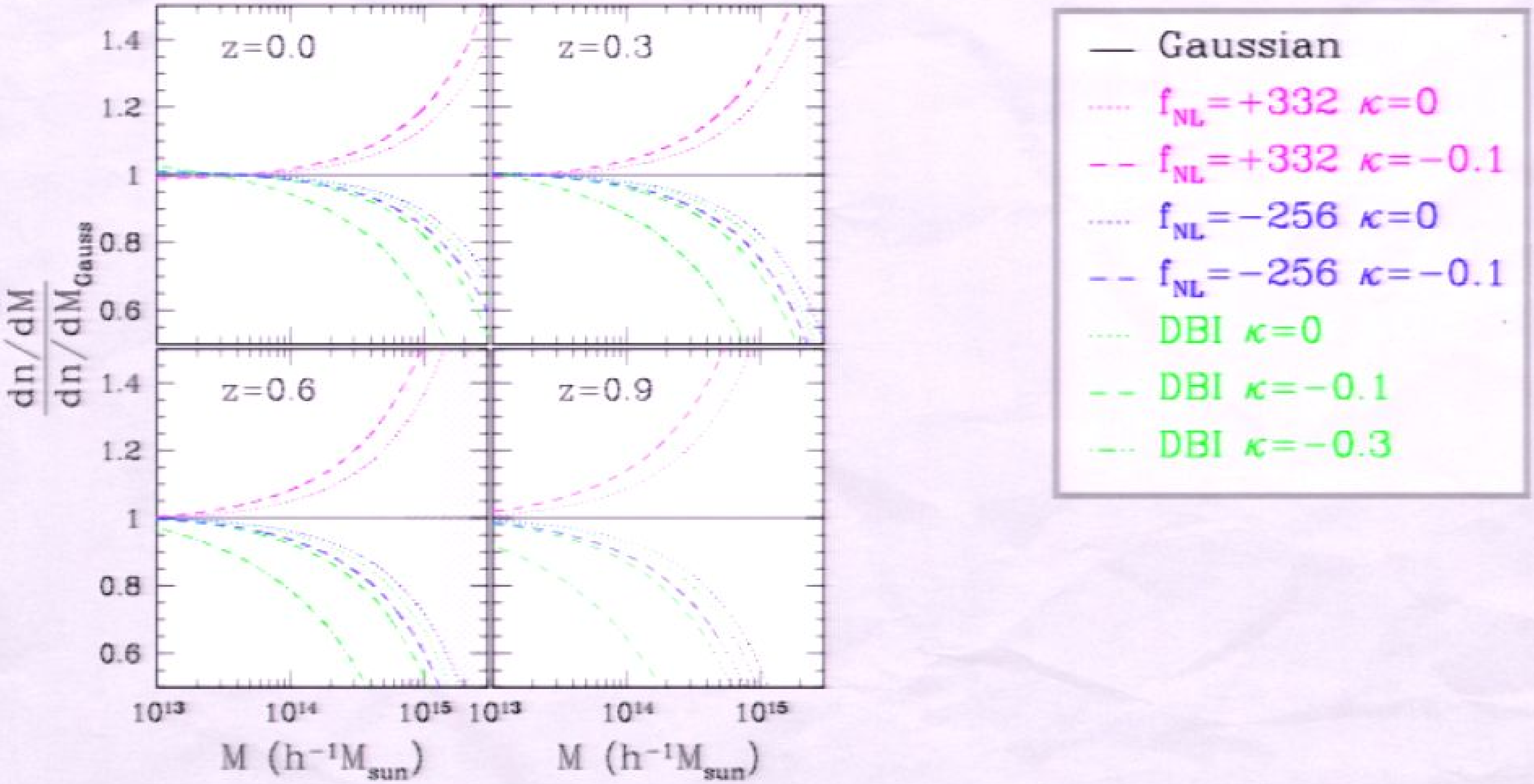


PI, Oct. 30, 2007

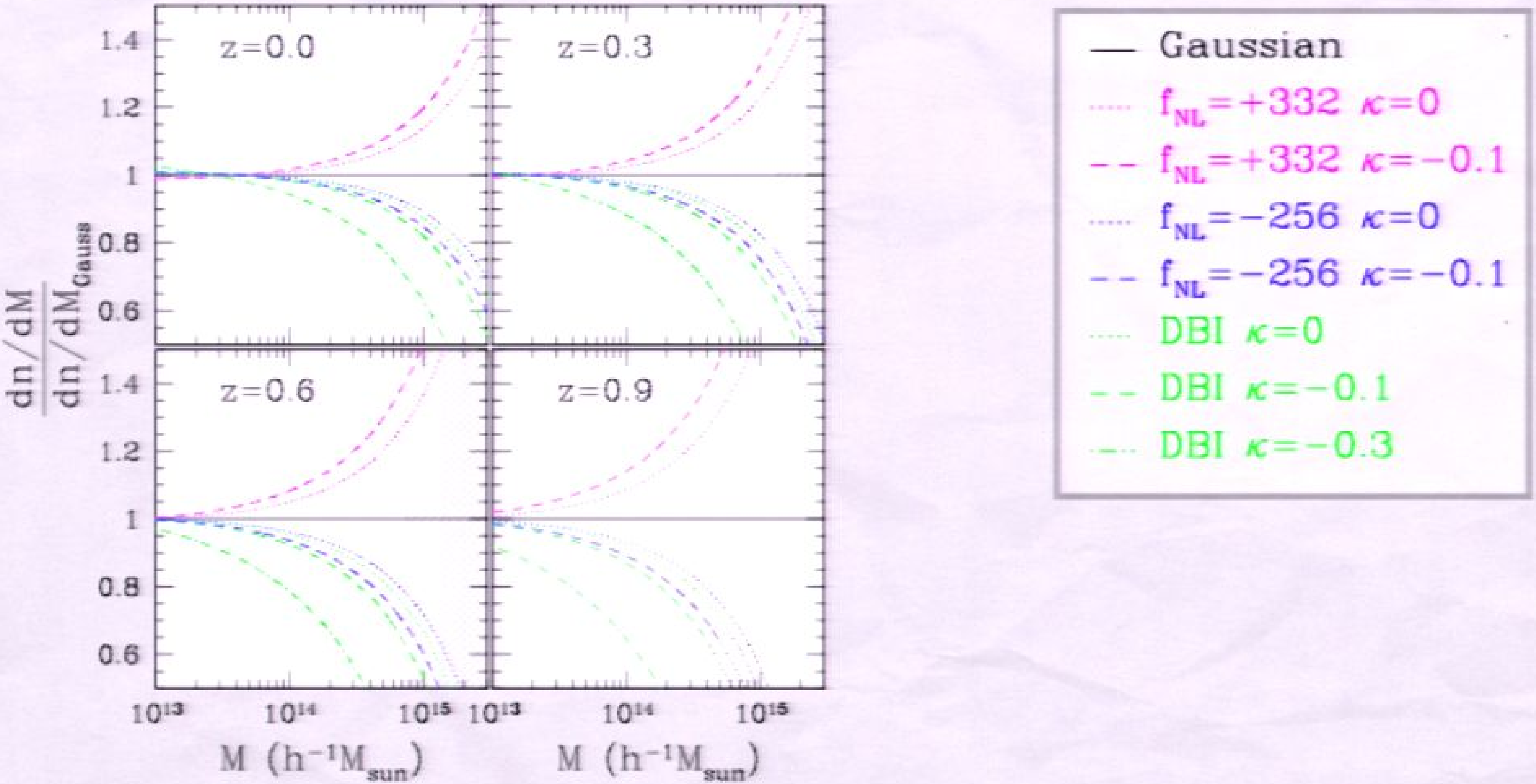
MASS FUNCTION



MASS FUNCTION

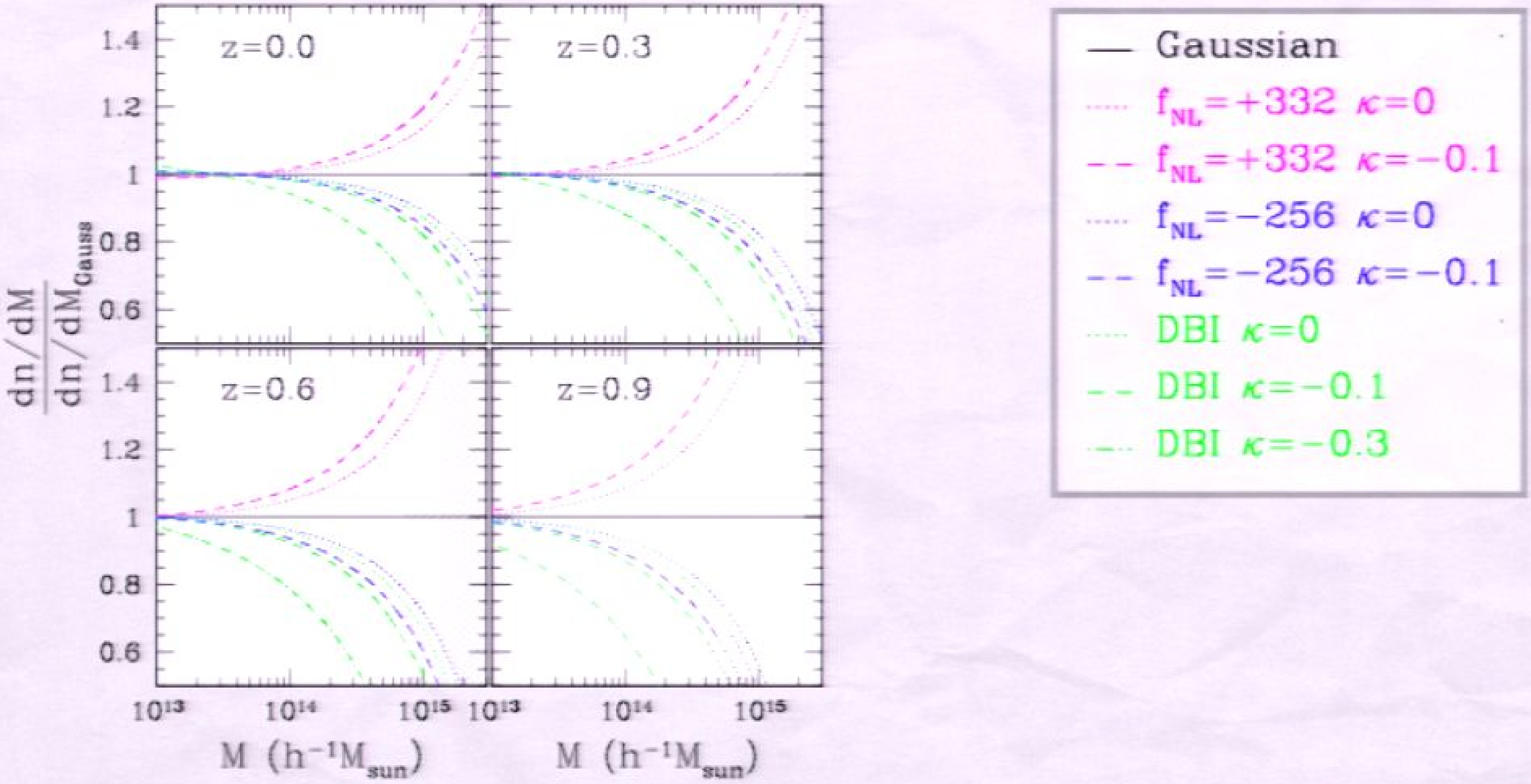


MASS FUNCTION

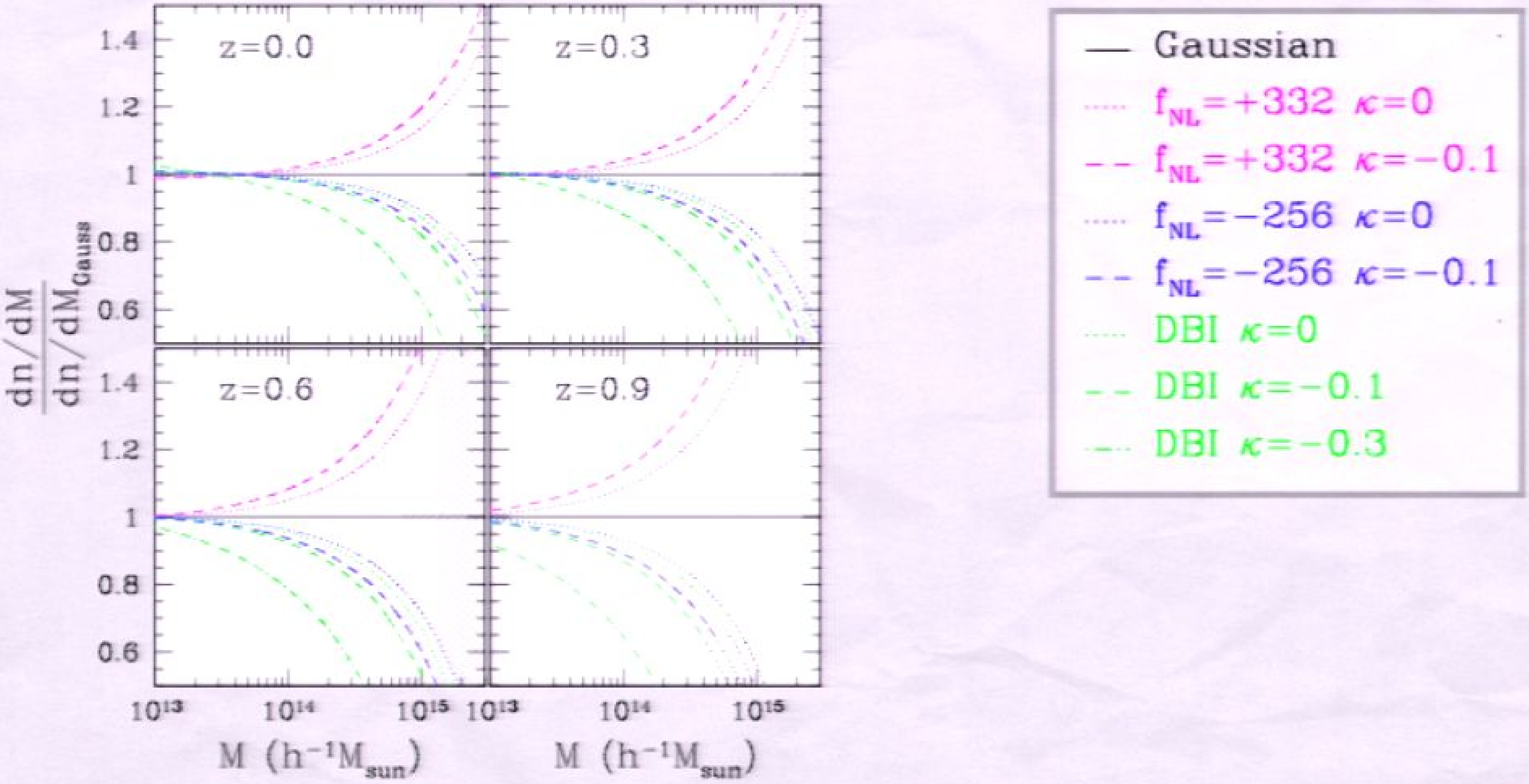


PI, Oct. 30, 2007

MASS FUNCTION

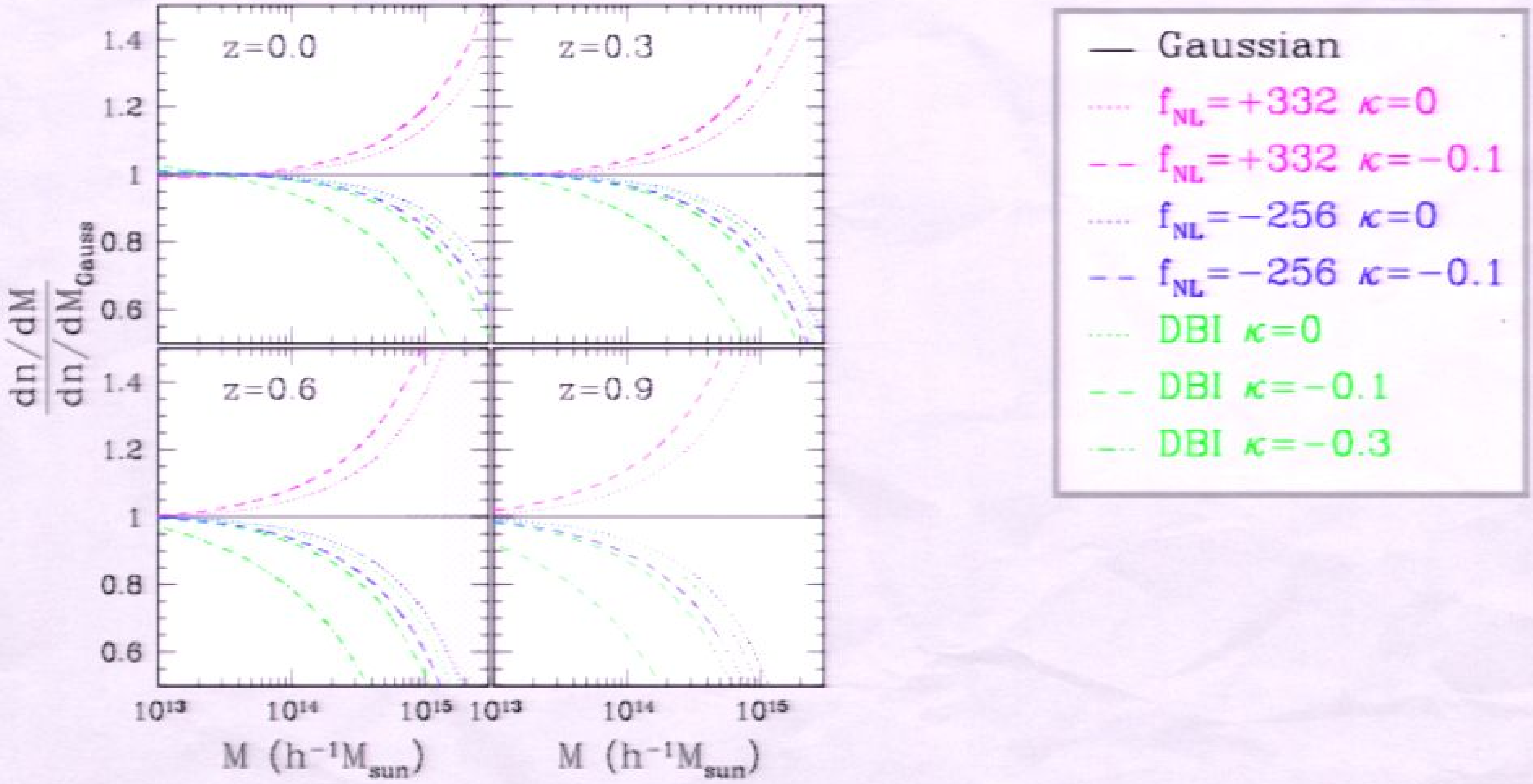


MASS FUNCTION



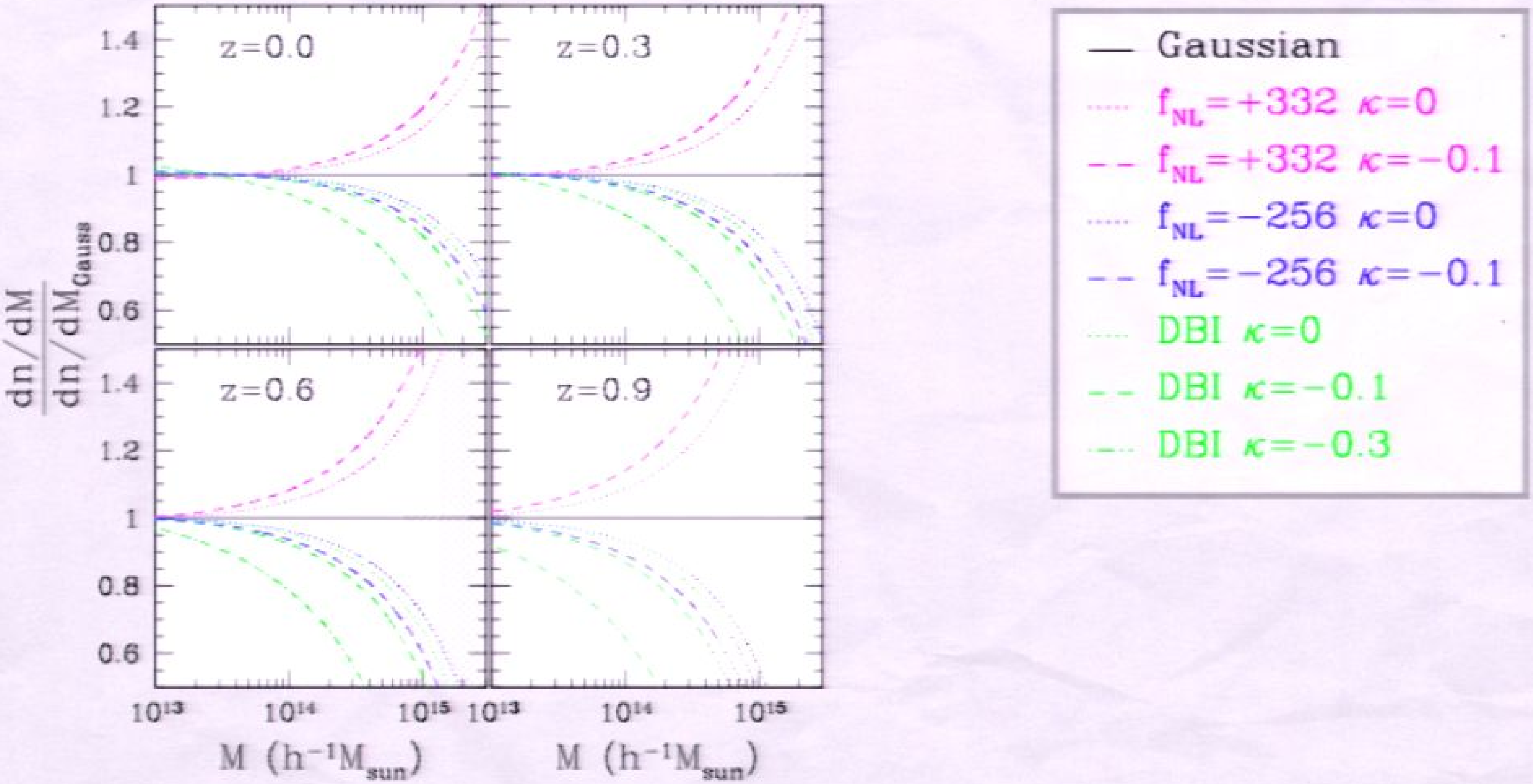
PI, Oct. 30, 2007

MASS FUNCTION

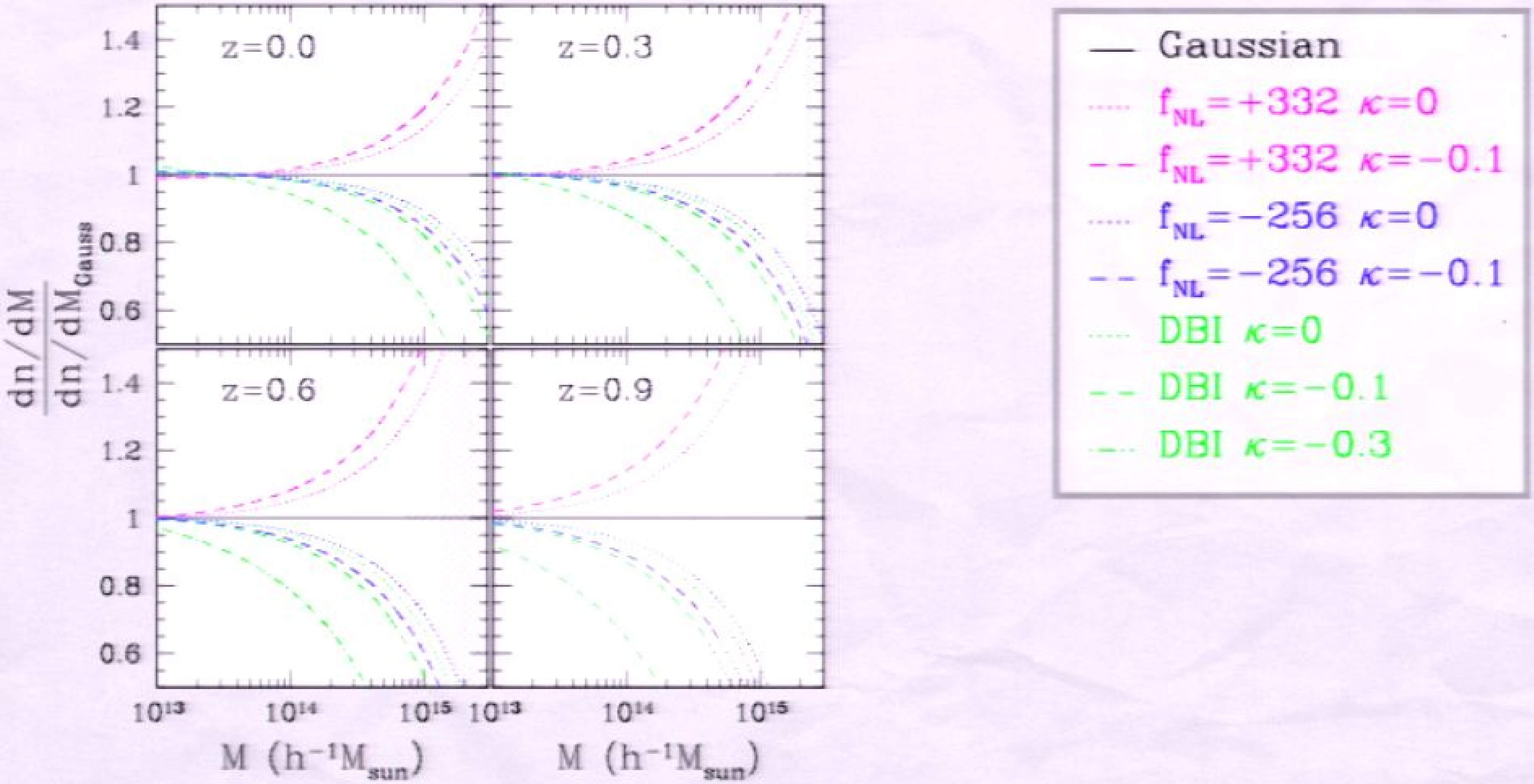


PI, Oct. 30, 2007

MASS FUNCTION

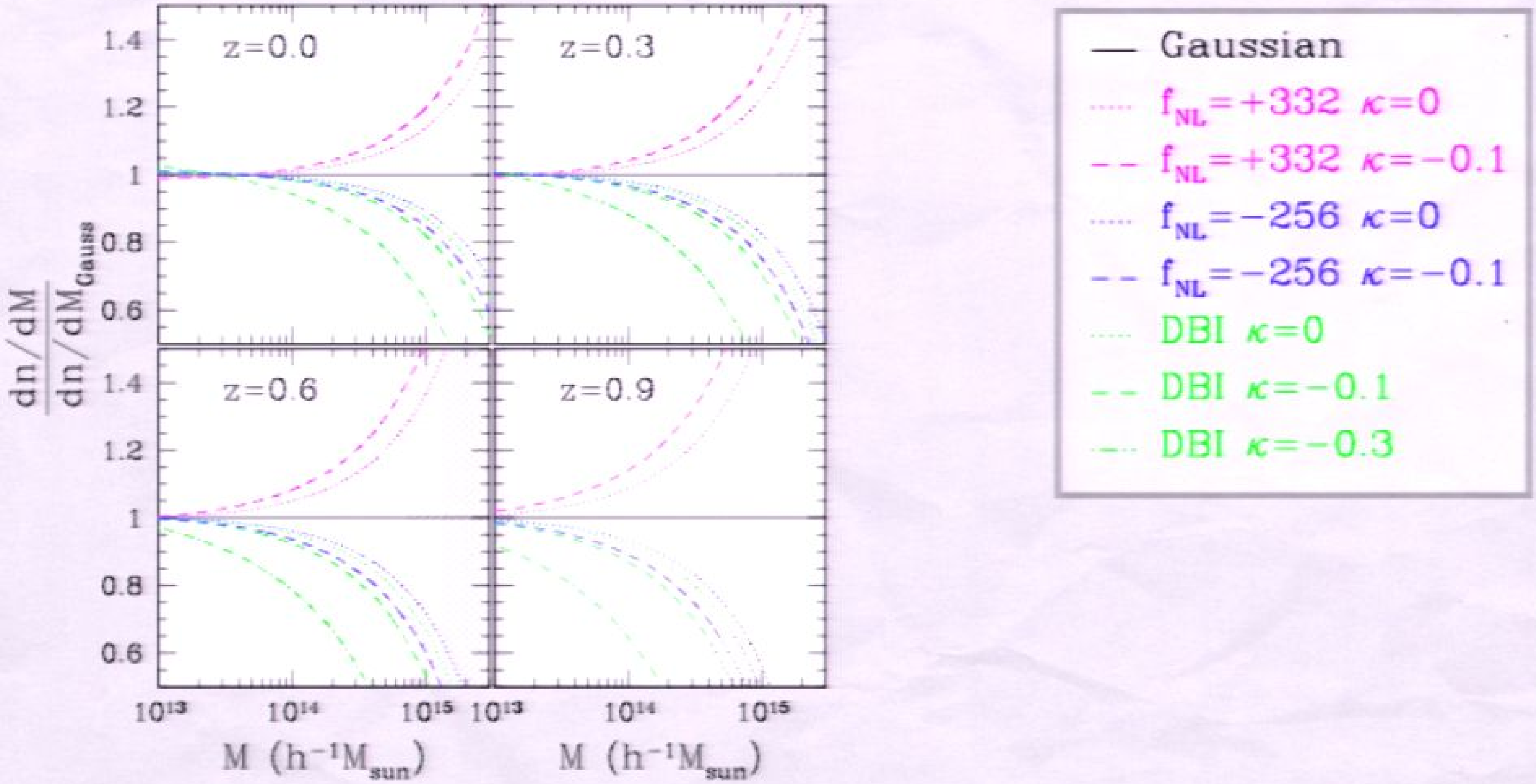


MASS FUNCTION

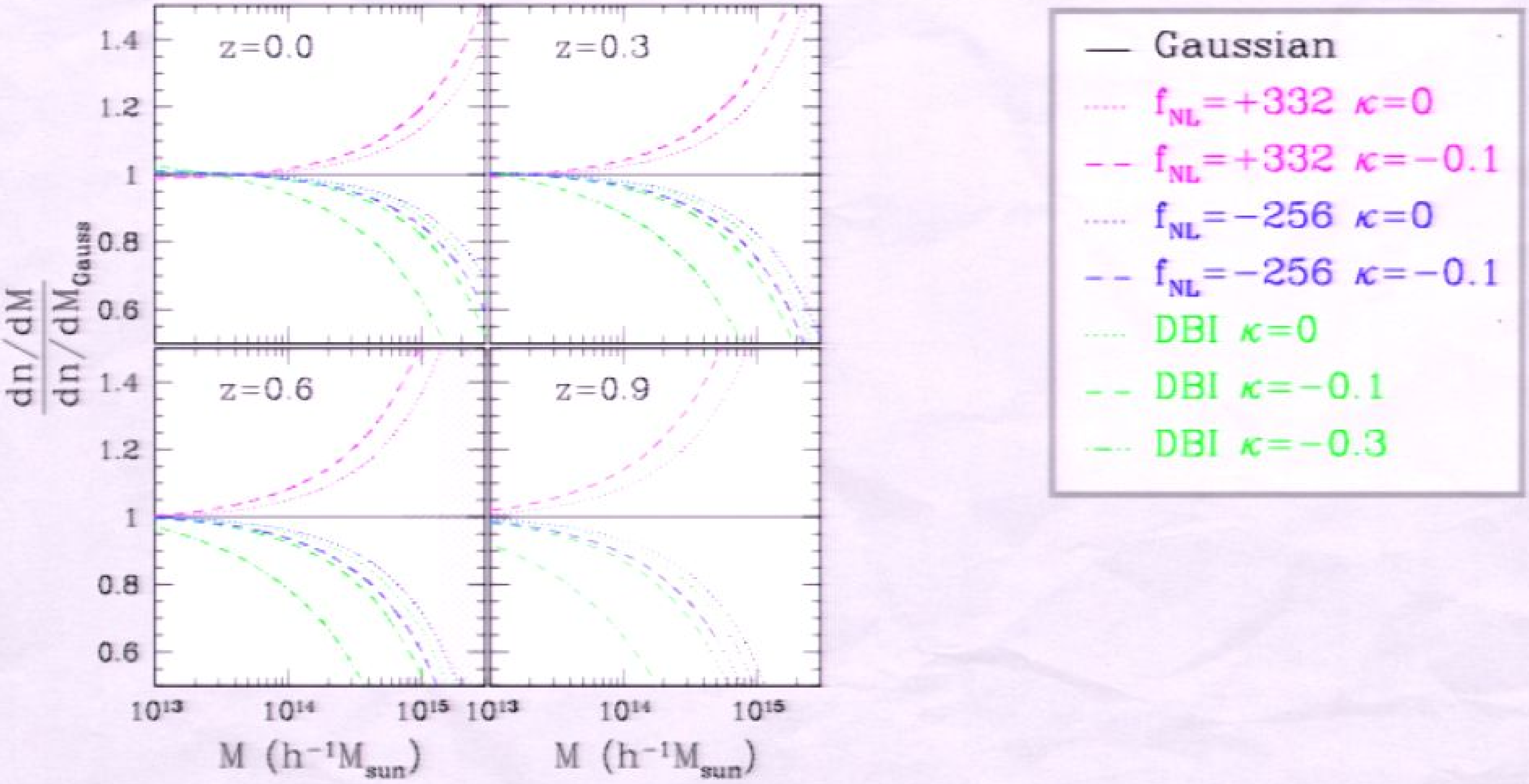


PI, Oct. 30, 2007

MASS FUNCTION

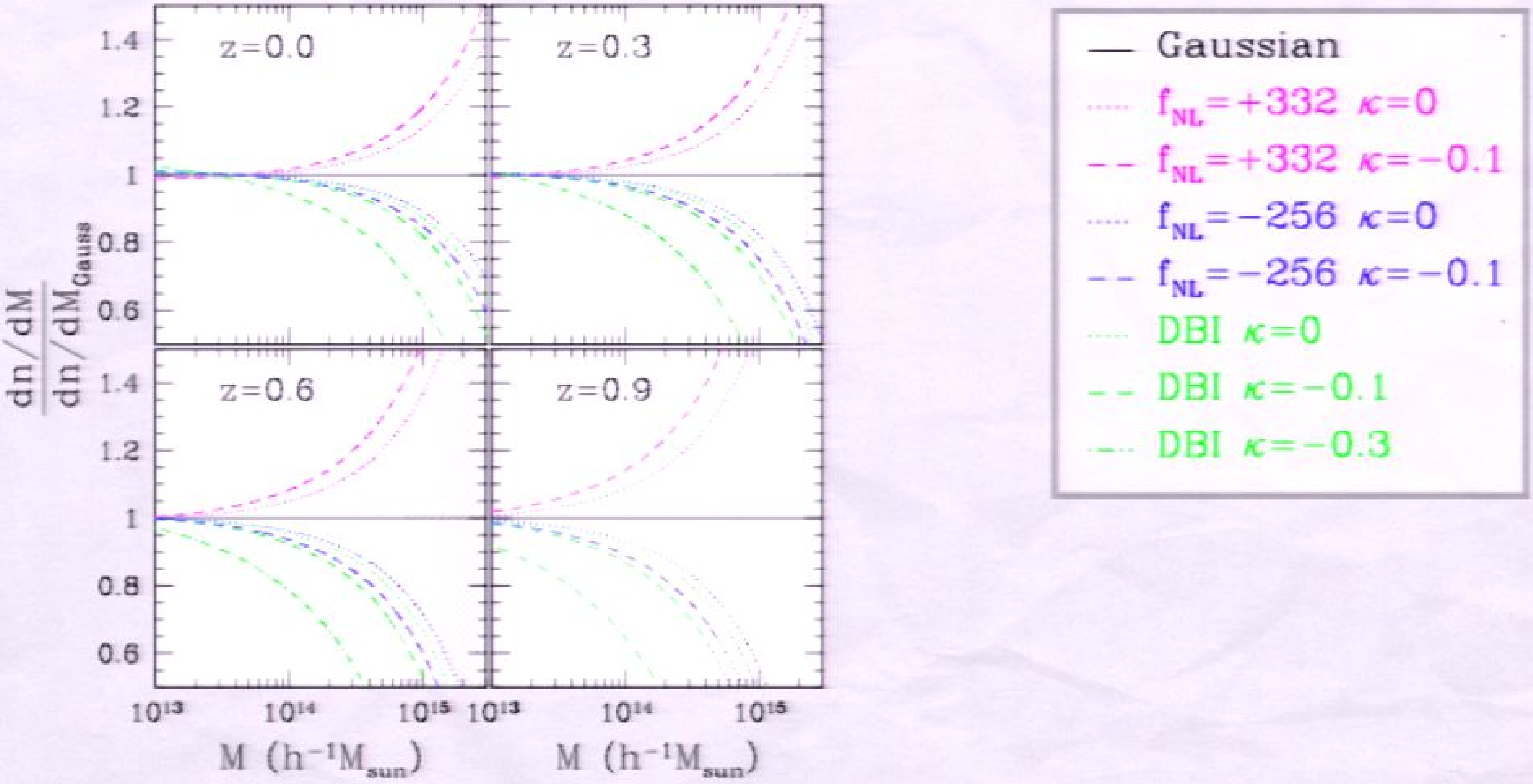


MASS FUNCTION

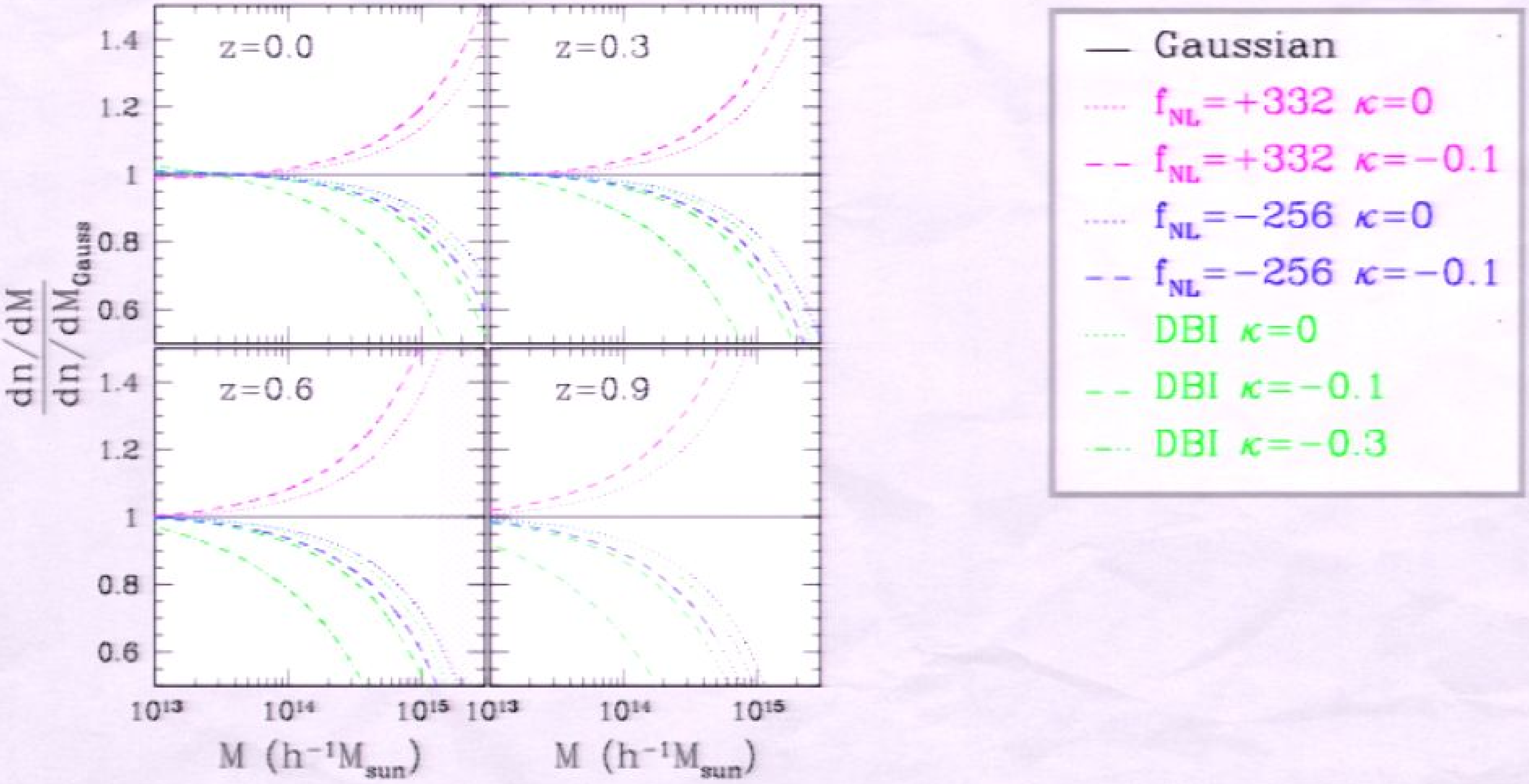


PI, Oct. 30, 2007

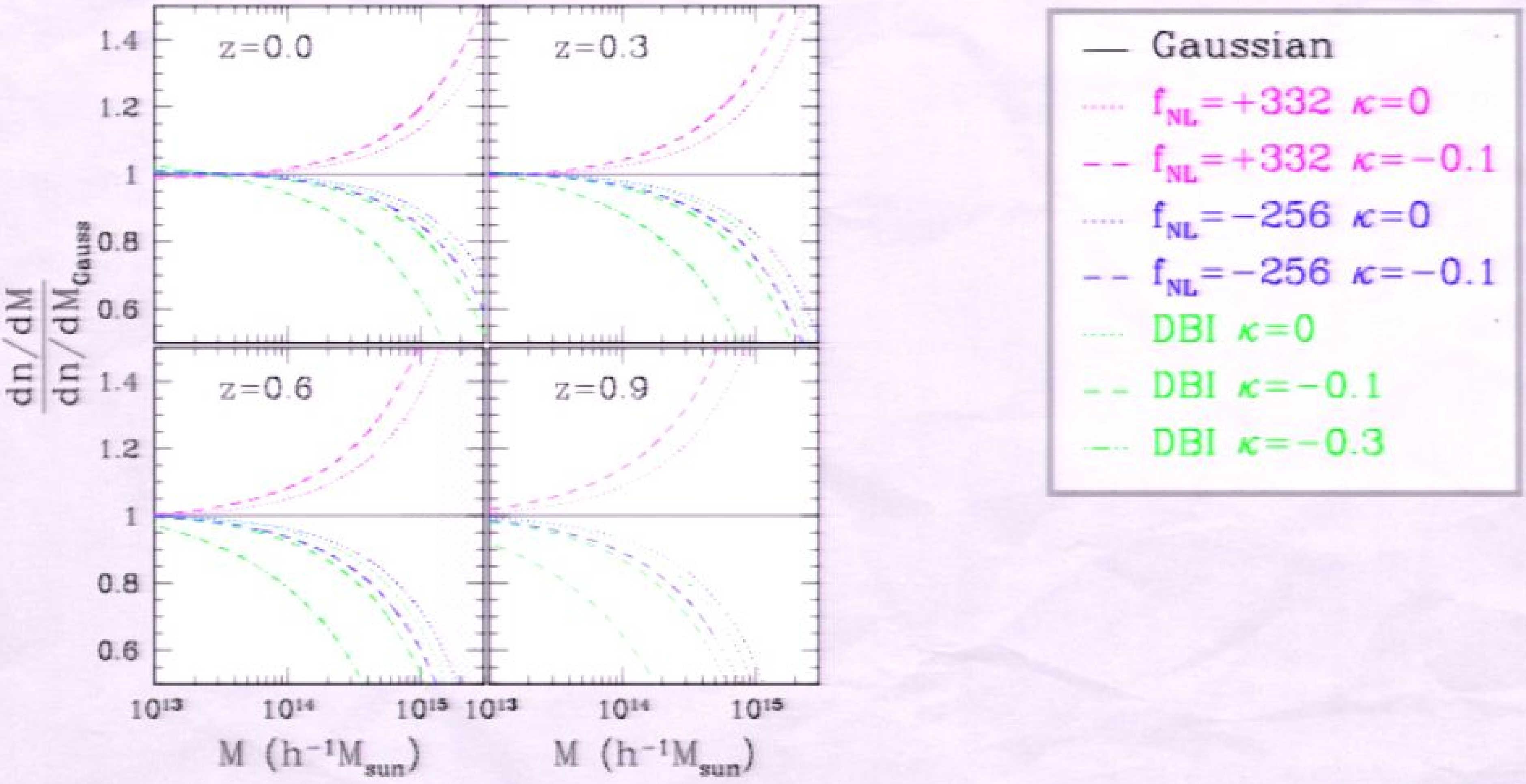
MASS FUNCTION



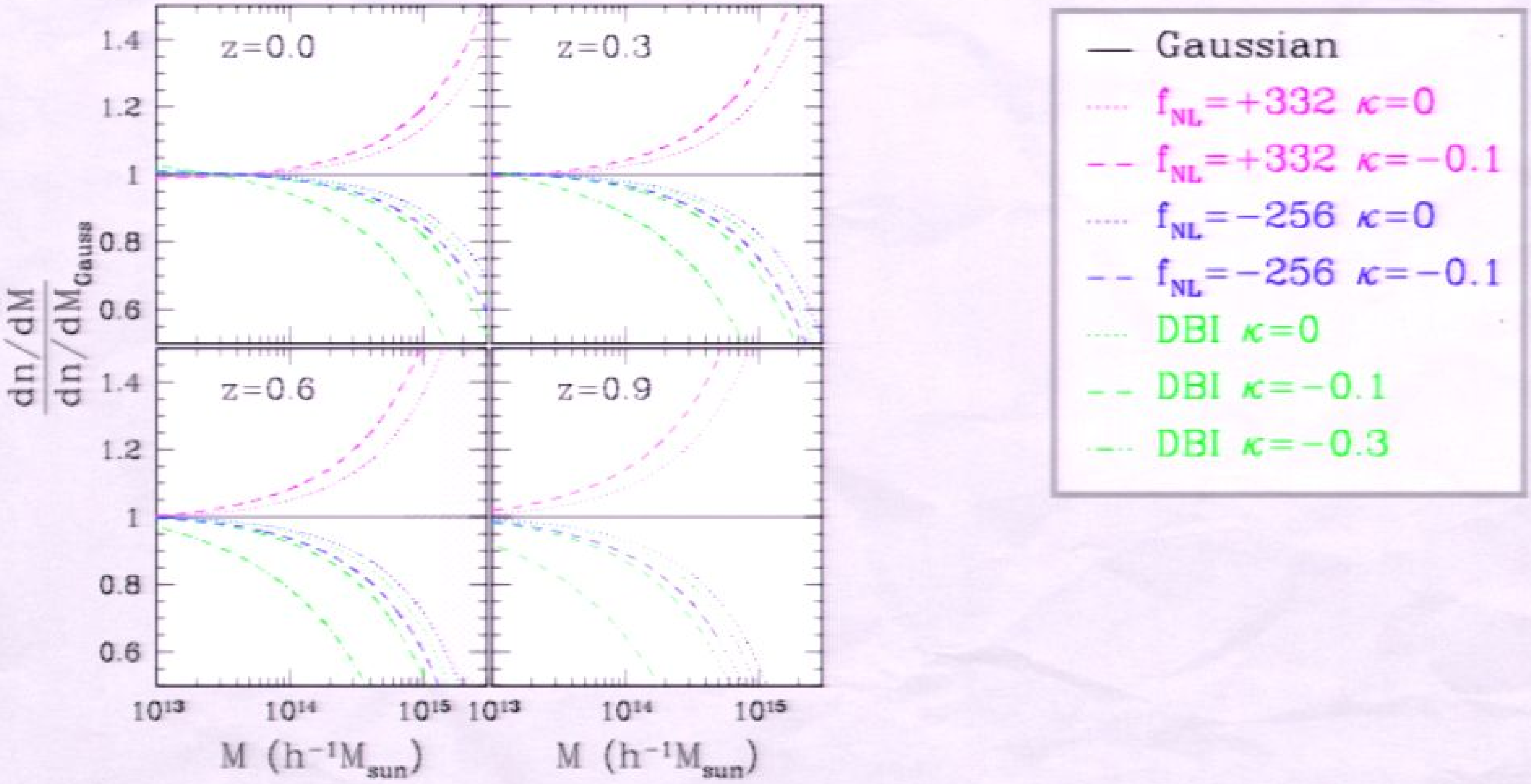
MASS FUNCTION



MASS FUNCTION

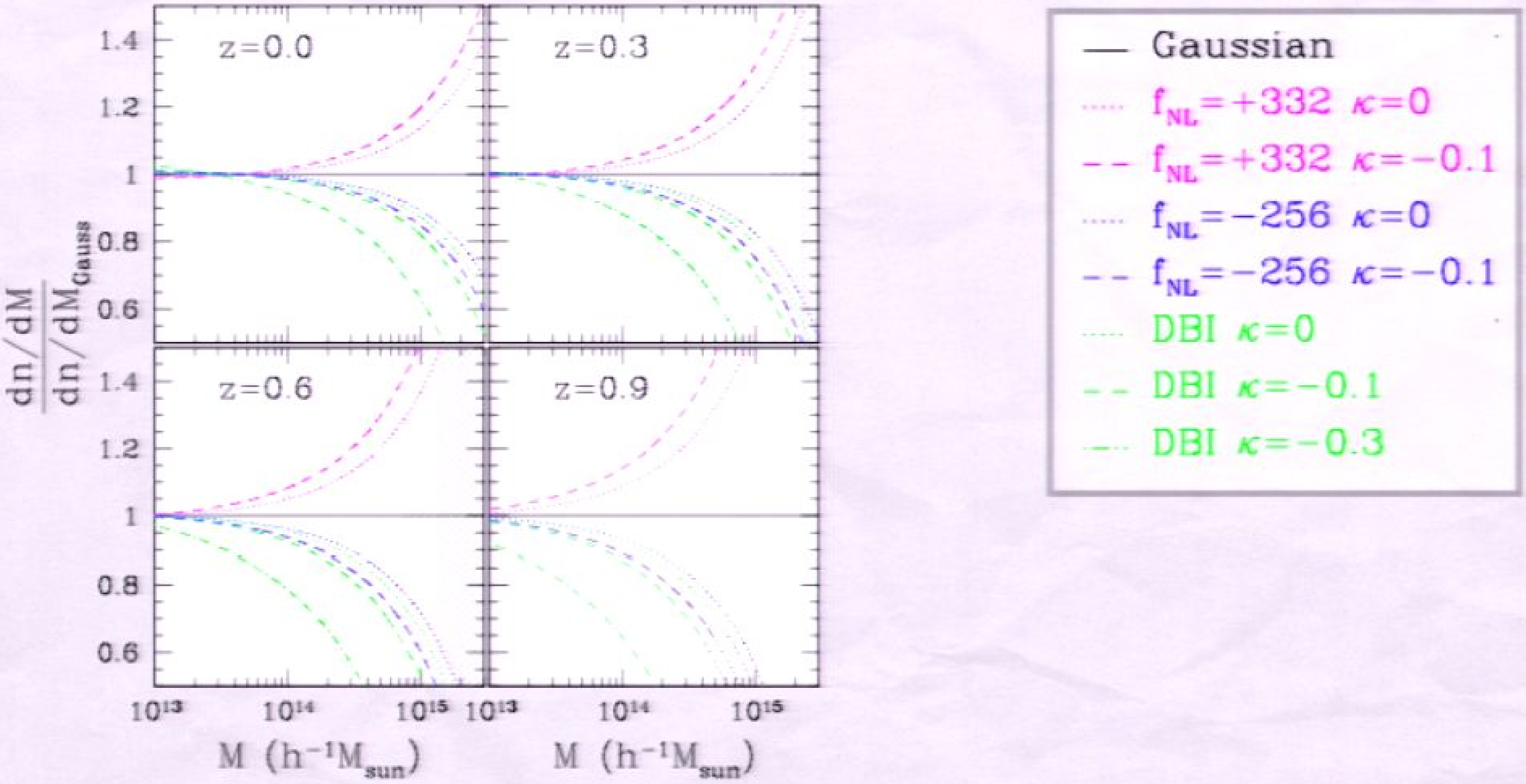


MASS FUNCTION

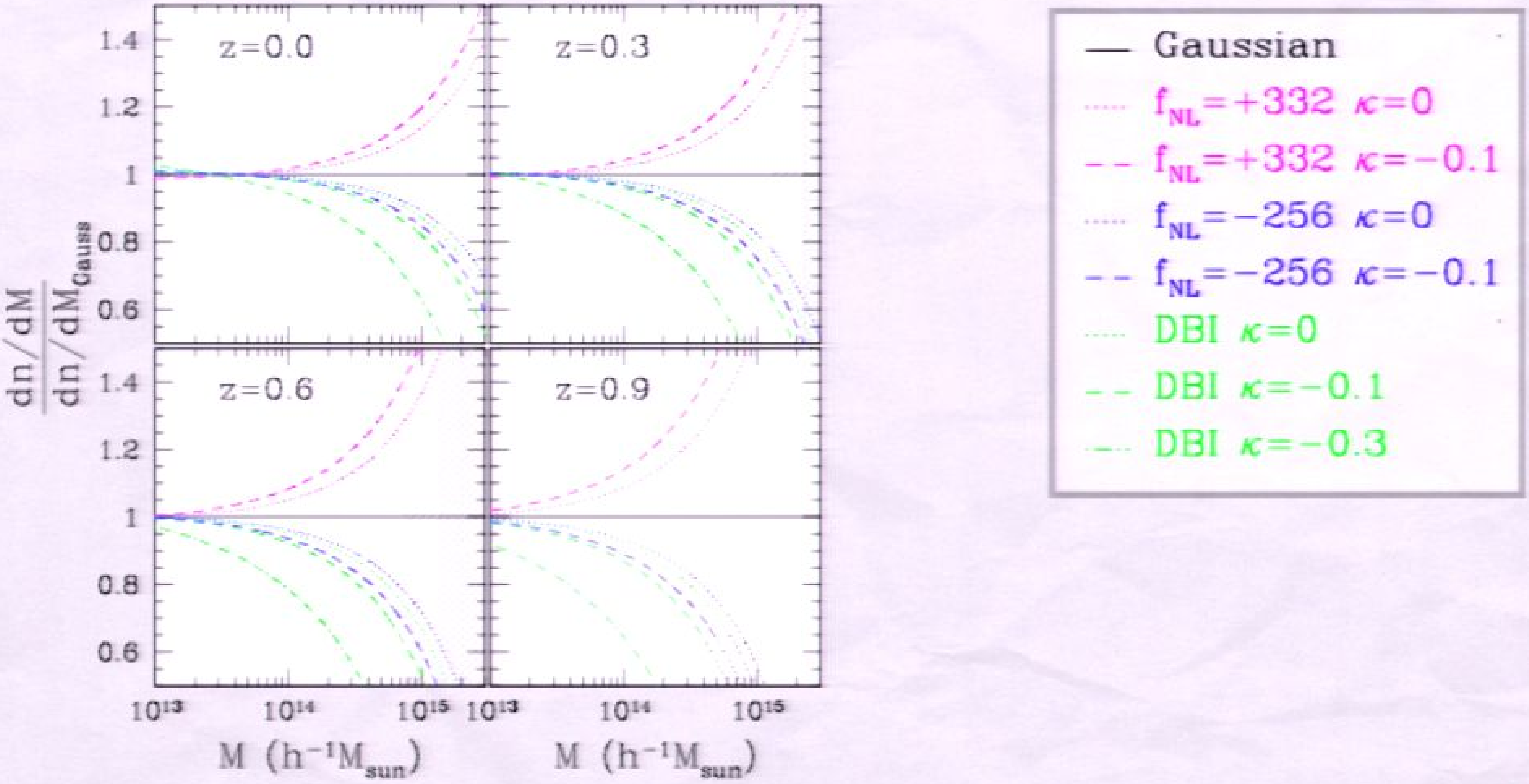


PI, Oct. 30, 2007

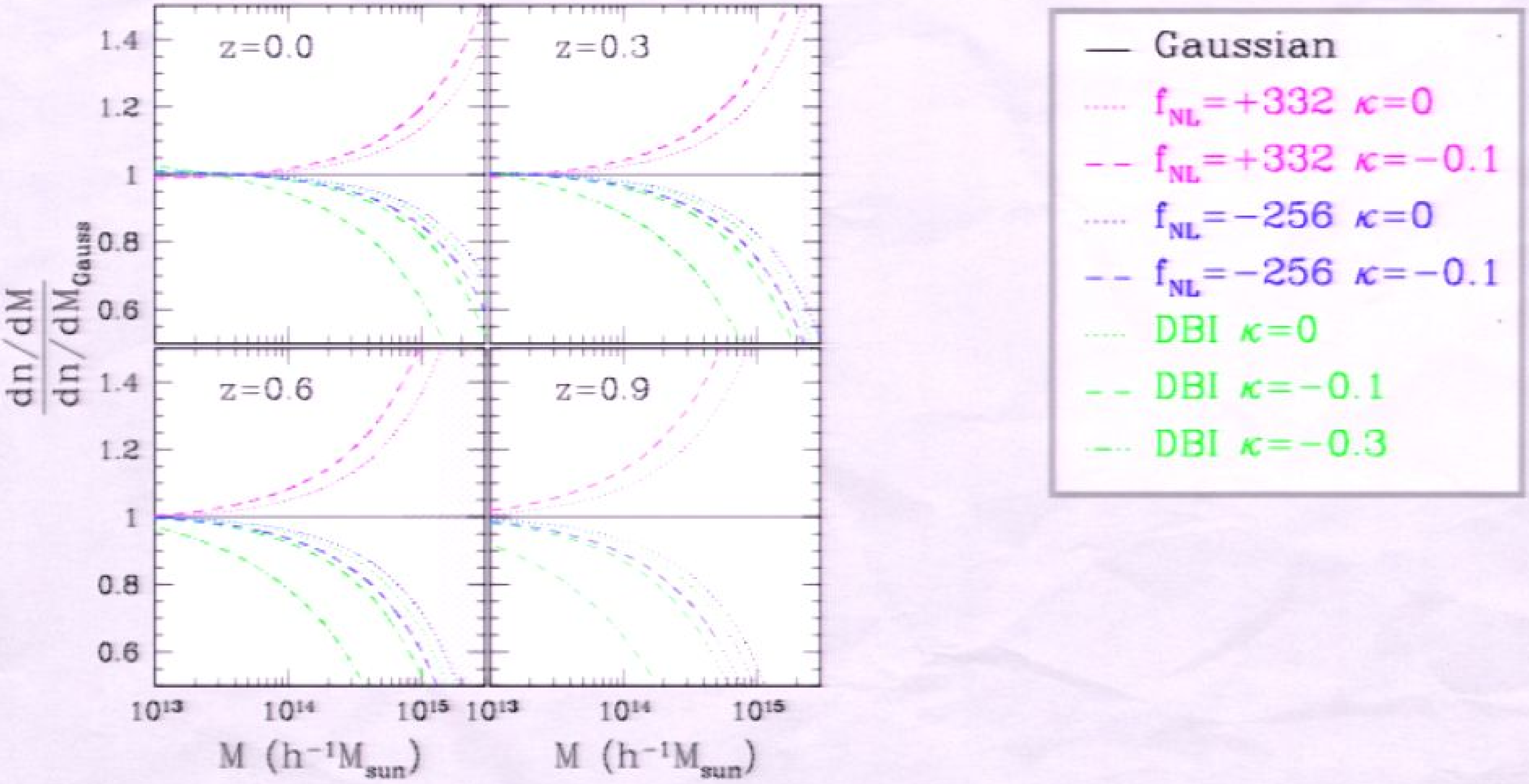
MASS FUNCTION



MASS FUNCTION

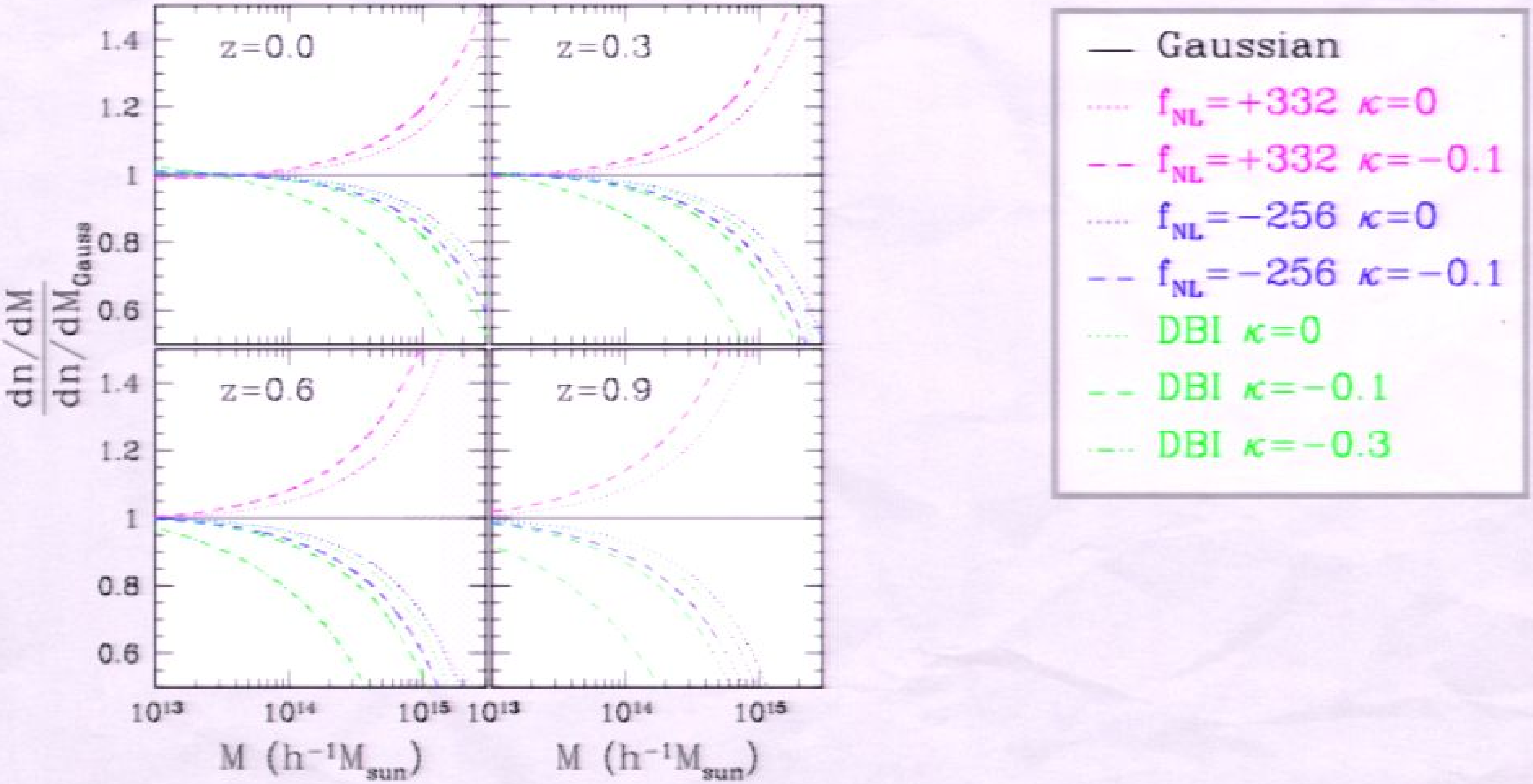


MASS FUNCTION



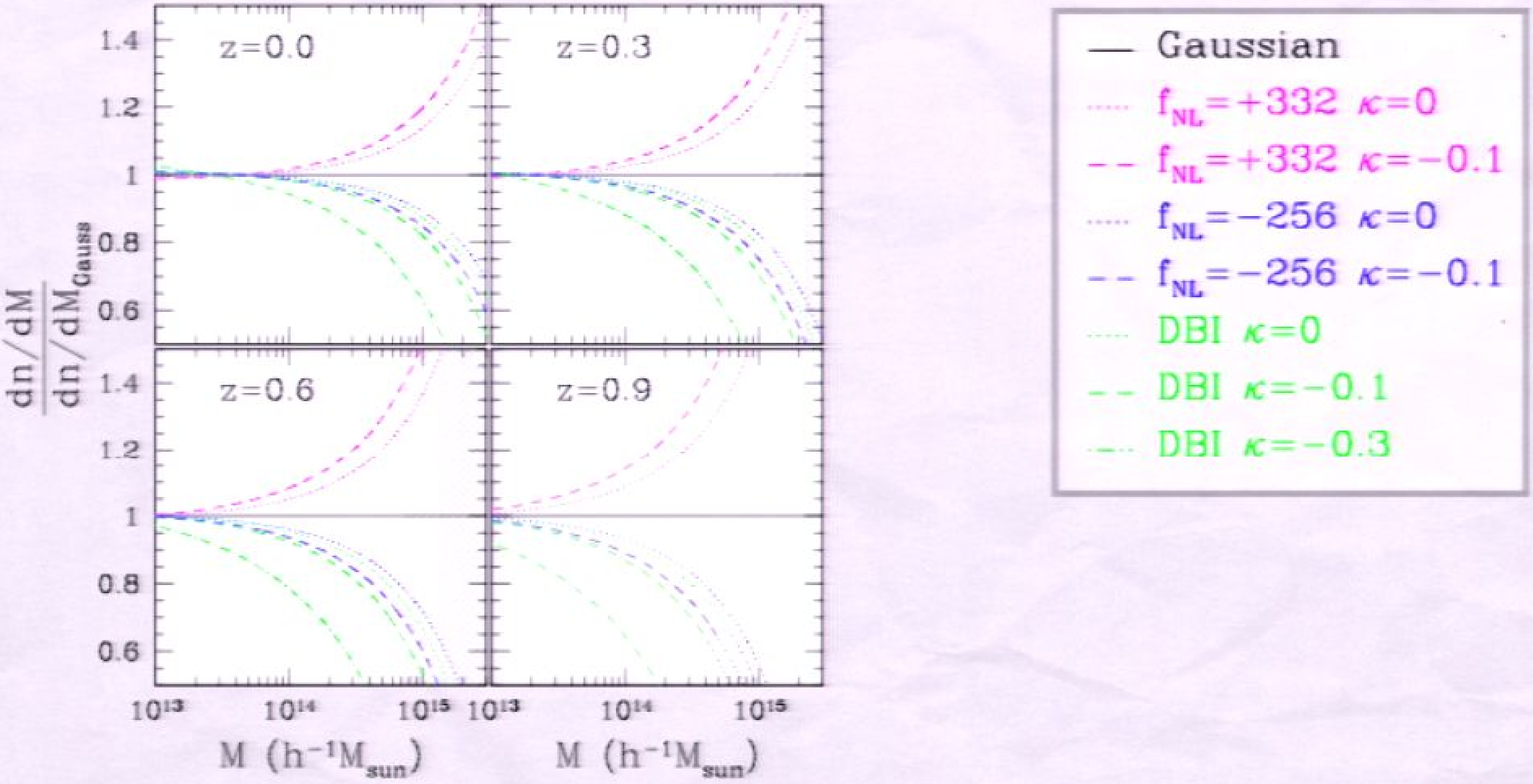
PI, Oct. 30, 2007

MASS FUNCTION

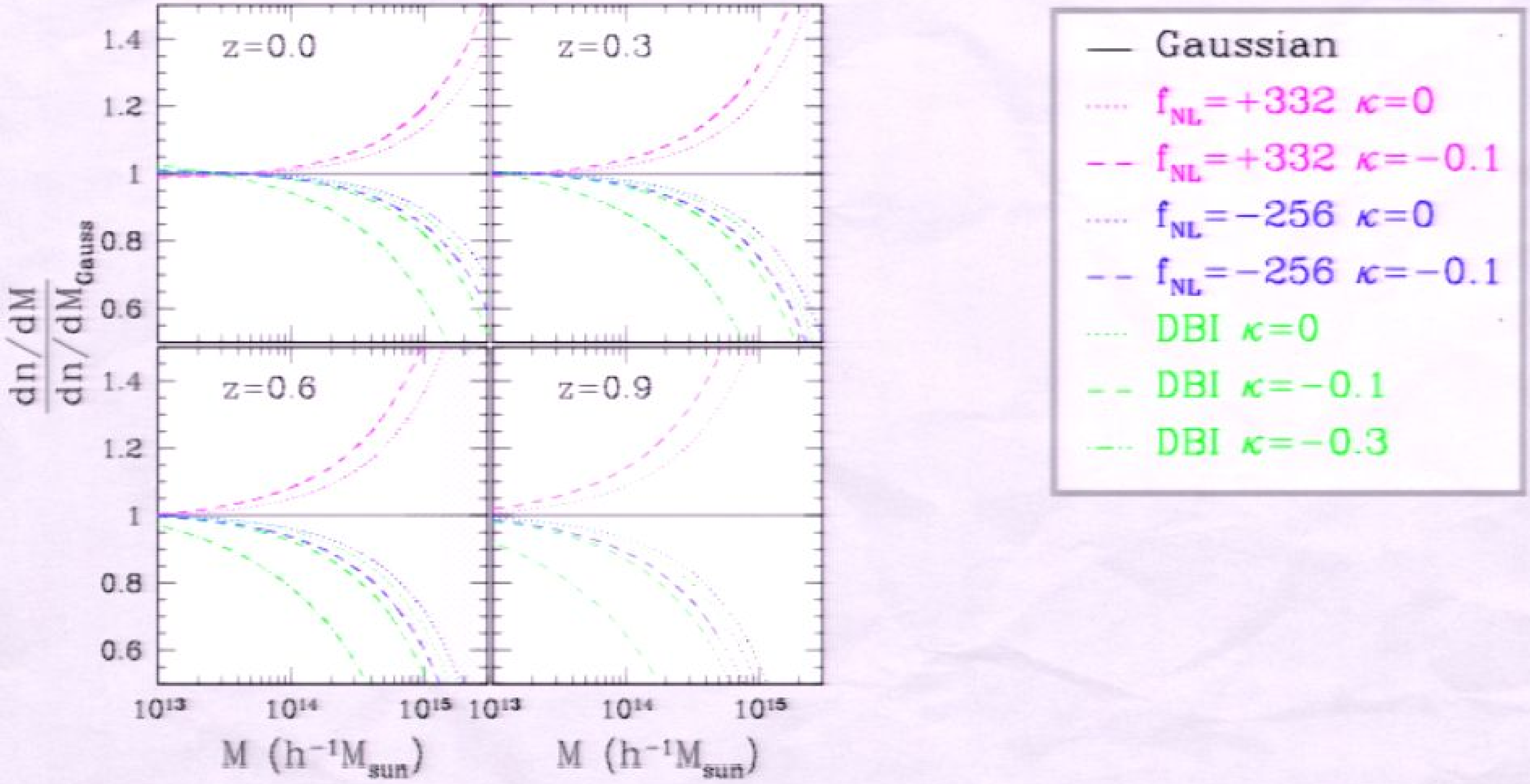


PI, Oct. 30, 2007

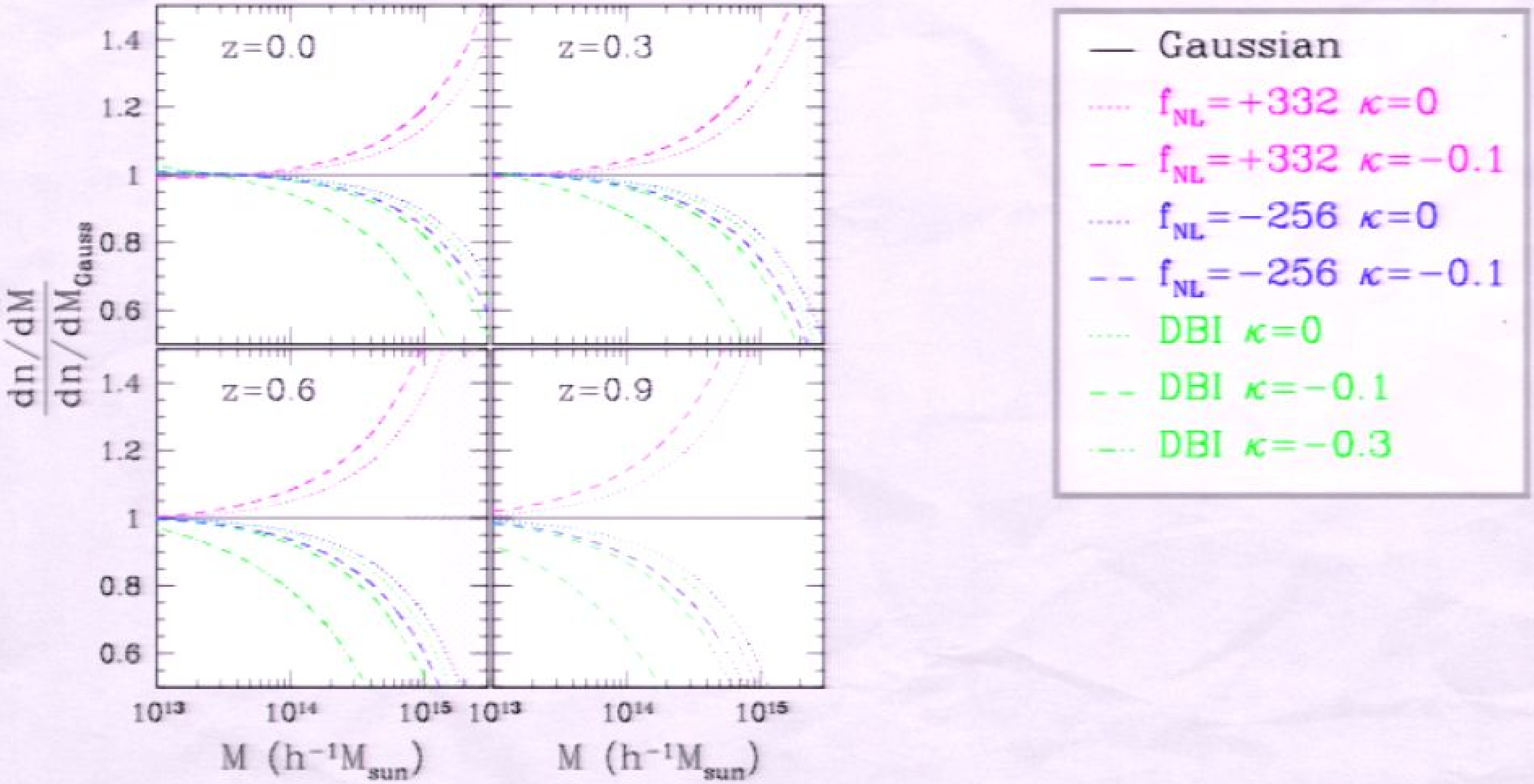
MASS FUNCTION



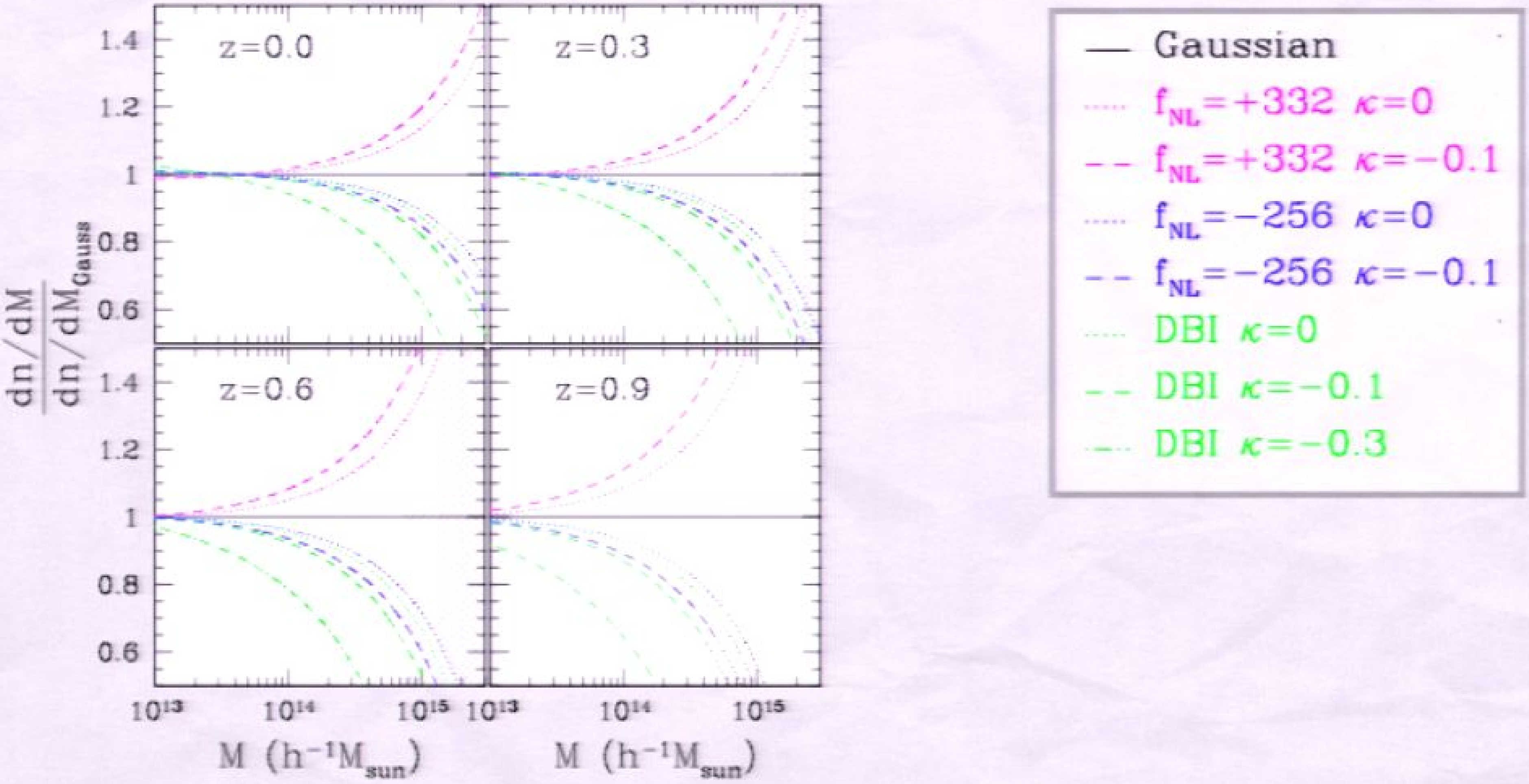
MASS FUNCTION



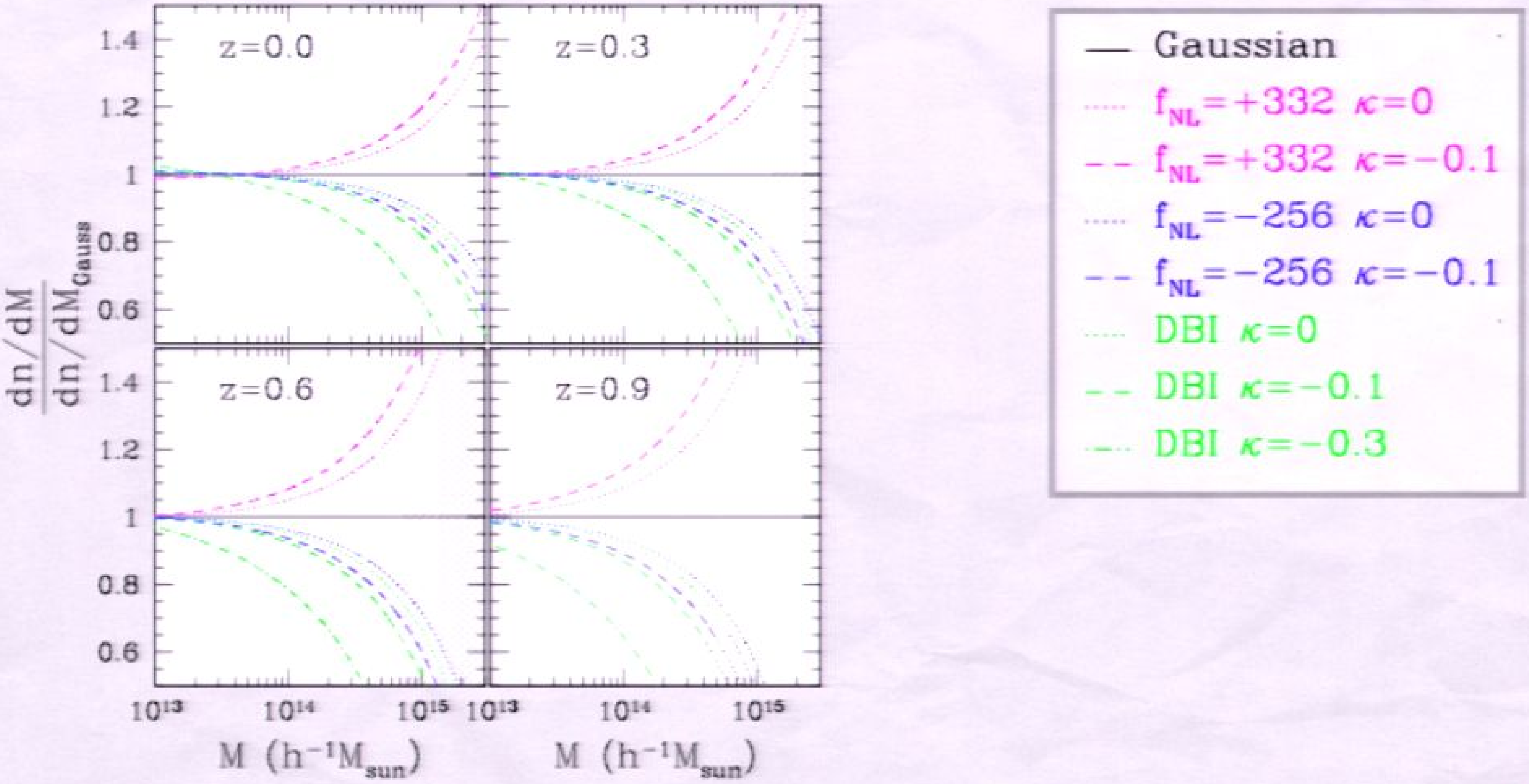
MASS FUNCTION



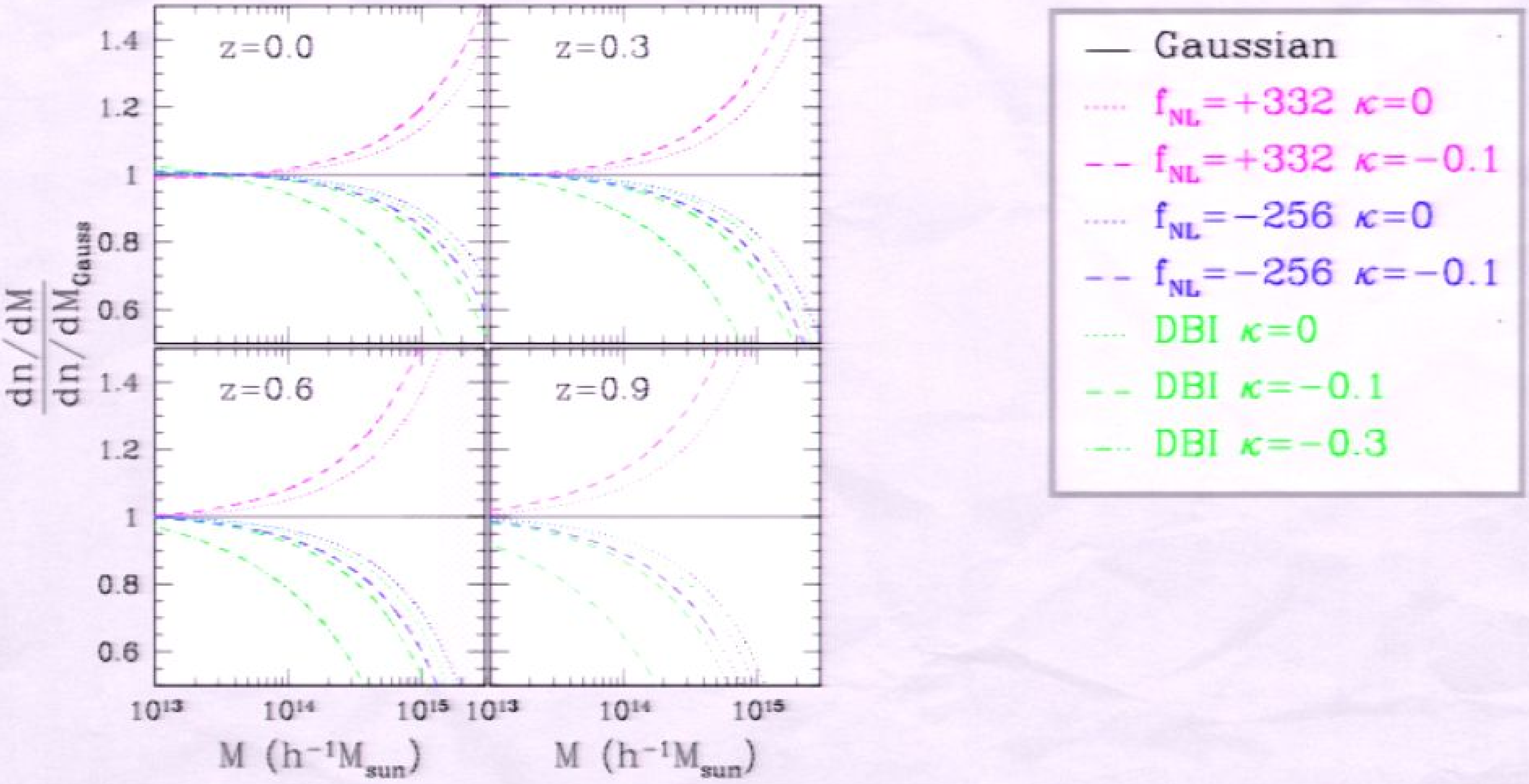
MASS FUNCTION



MASS FUNCTION

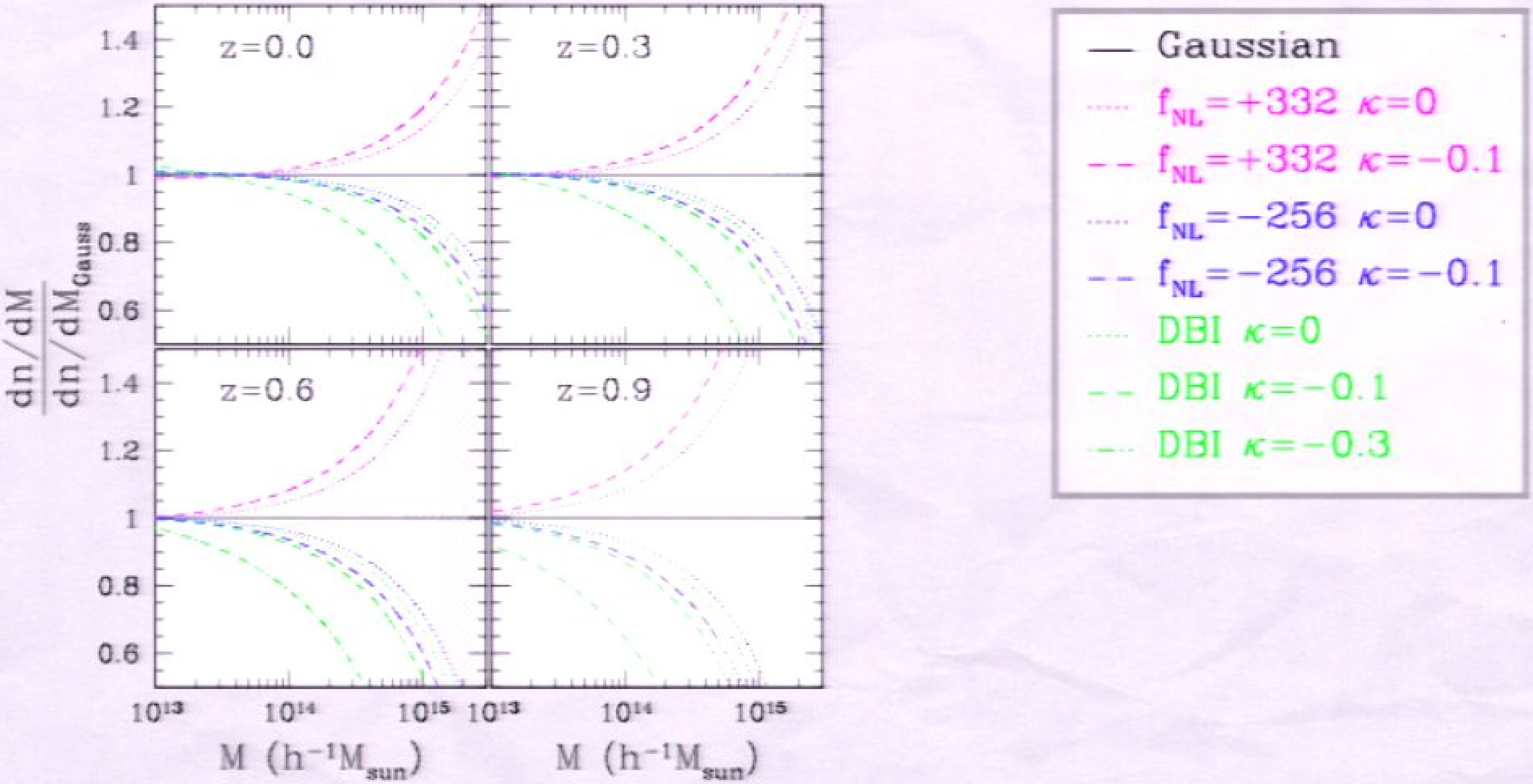


MASS FUNCTION

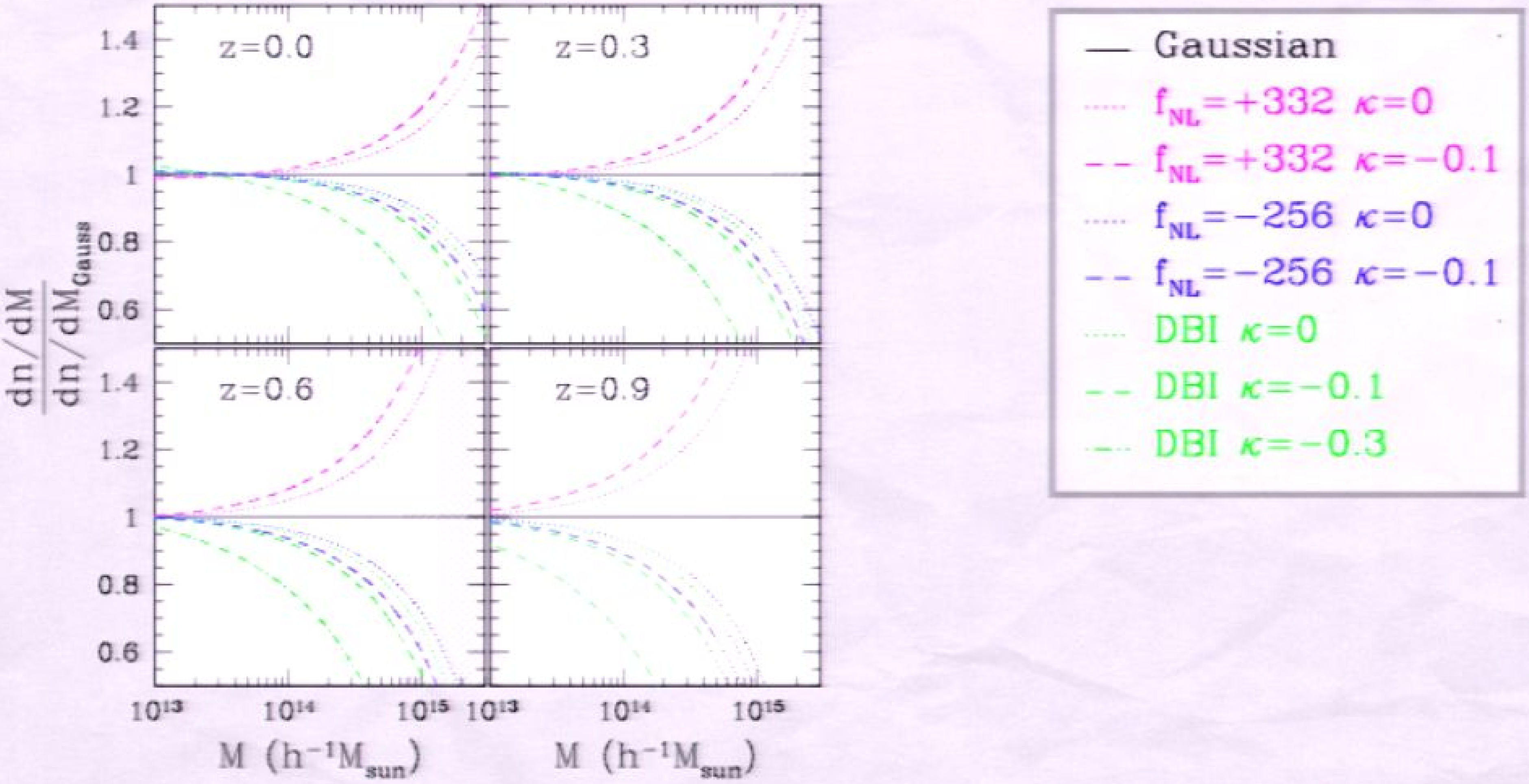


PI, Oct. 30, 2007

MASS FUNCTION

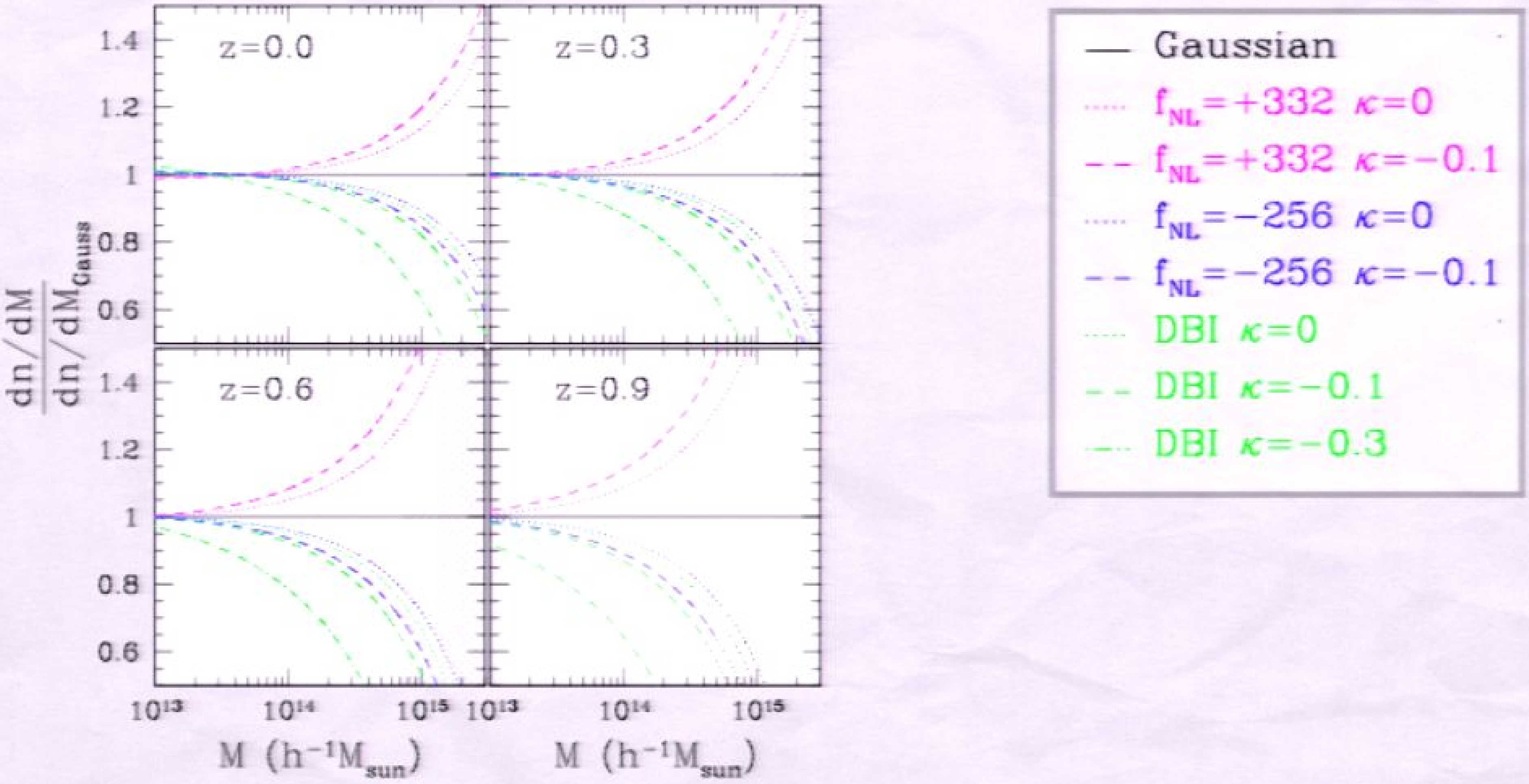


MASS FUNCTION



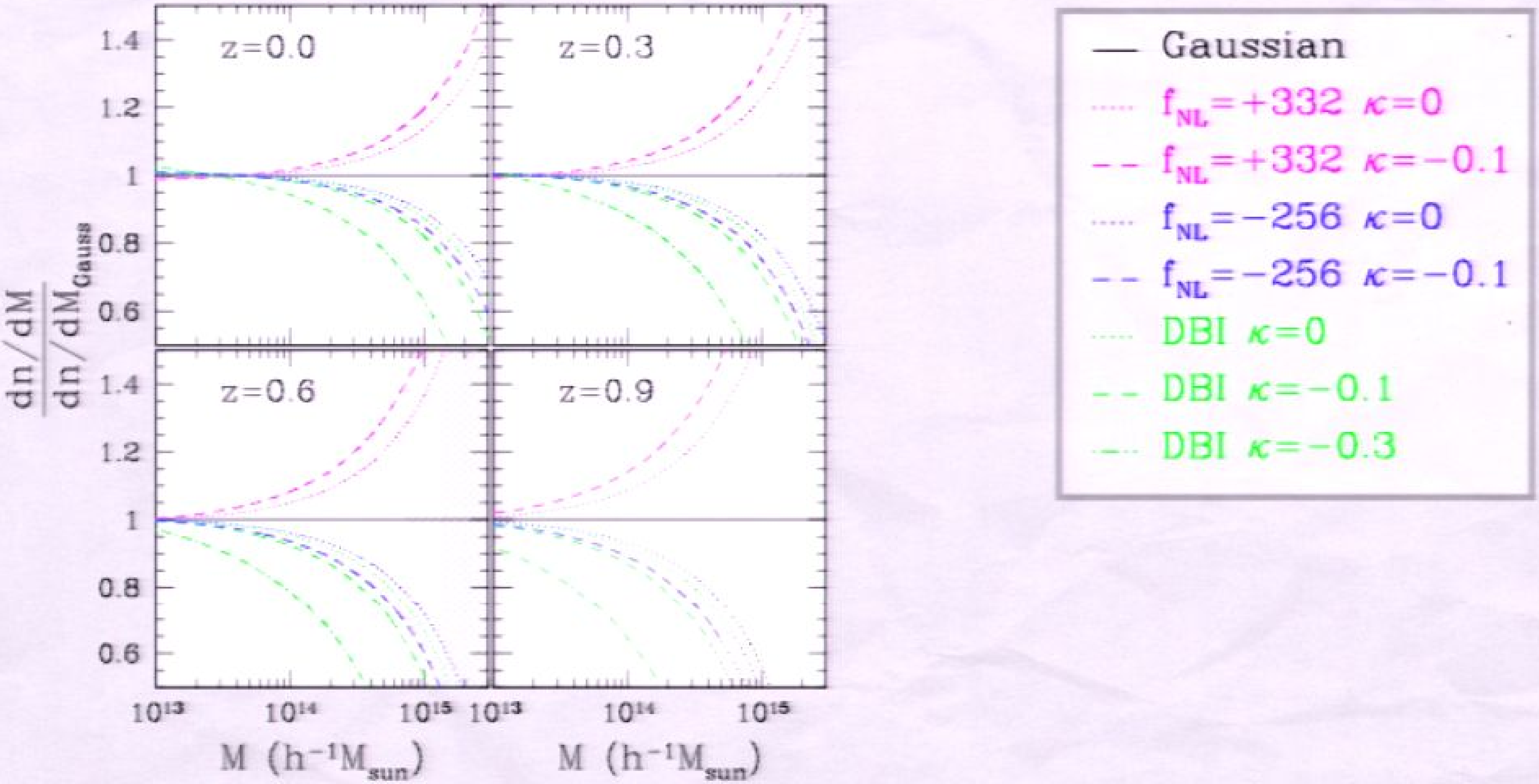
PI, Oct. 30, 2007

MASS FUNCTION

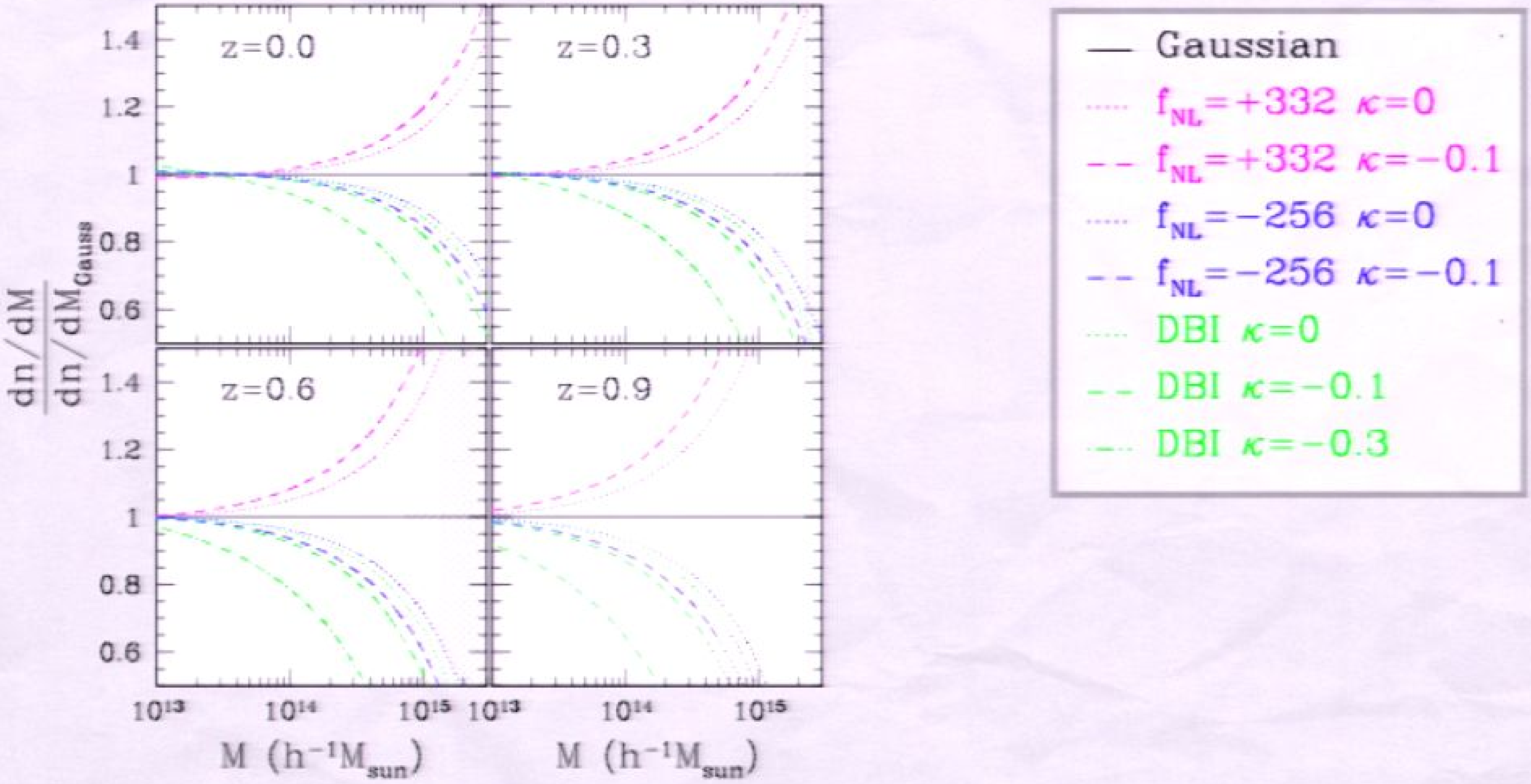


PI, Oct. 30, 2007

MASS FUNCTION

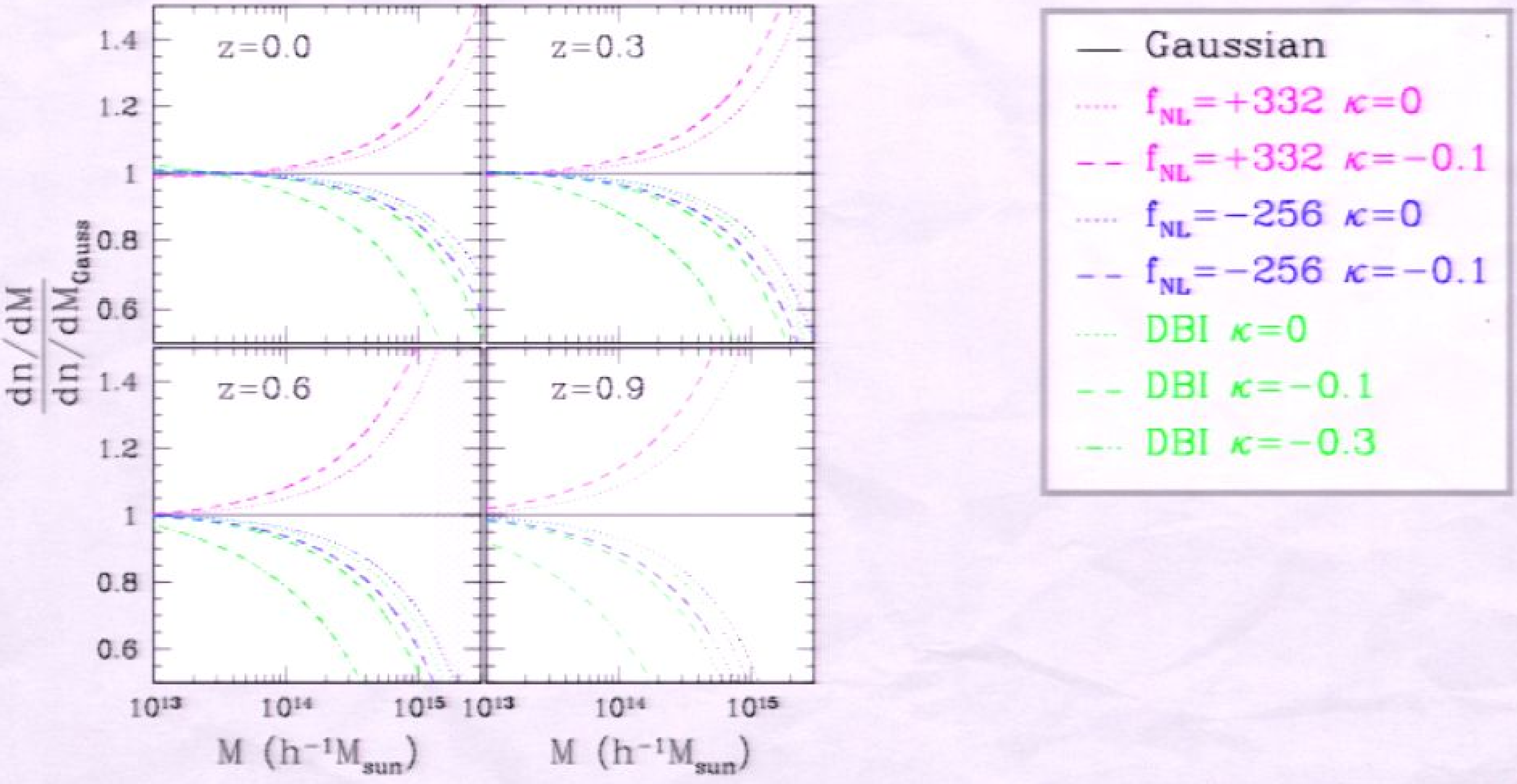


MASS FUNCTION



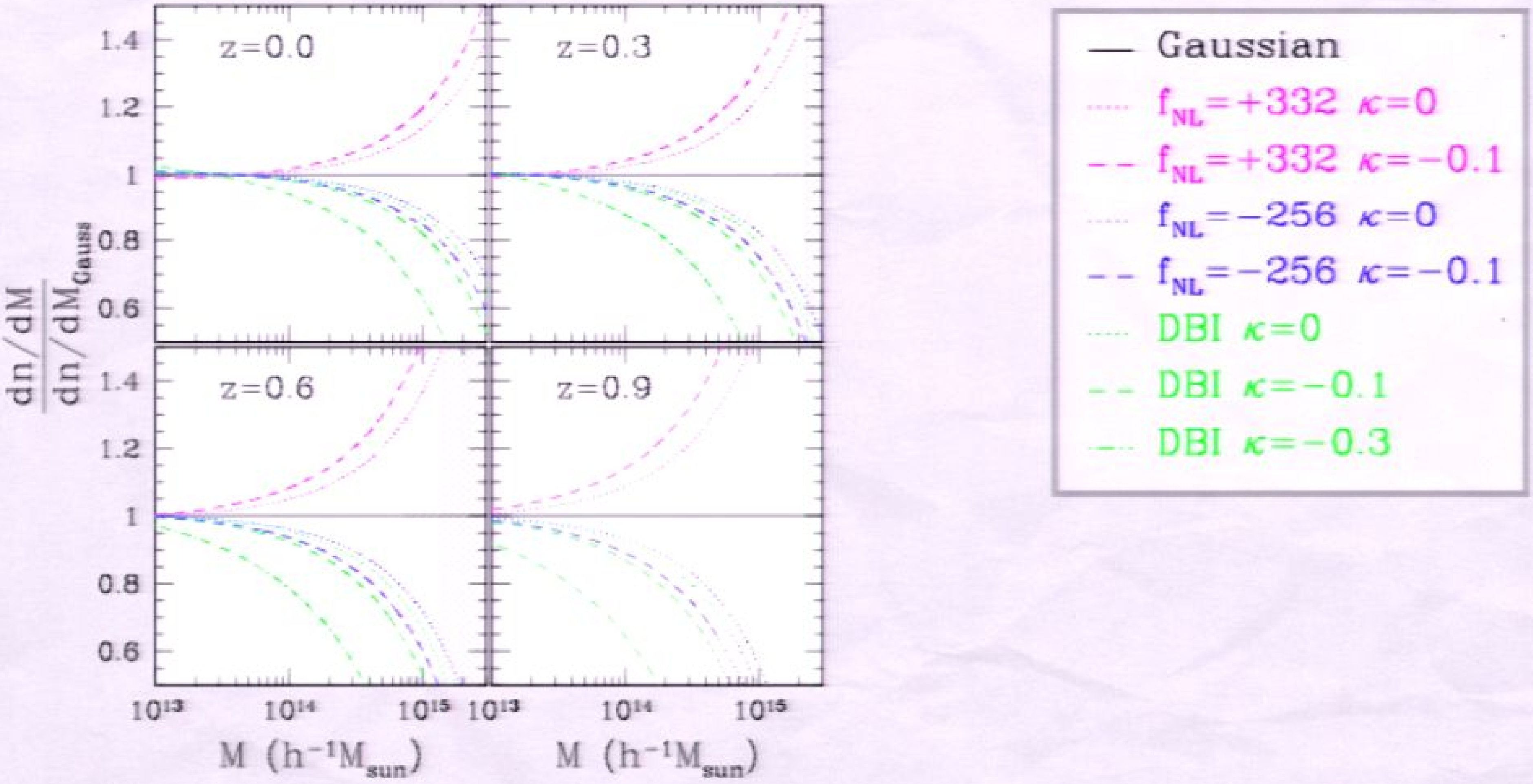
PI, Oct. 30, 2007

MASS FUNCTION

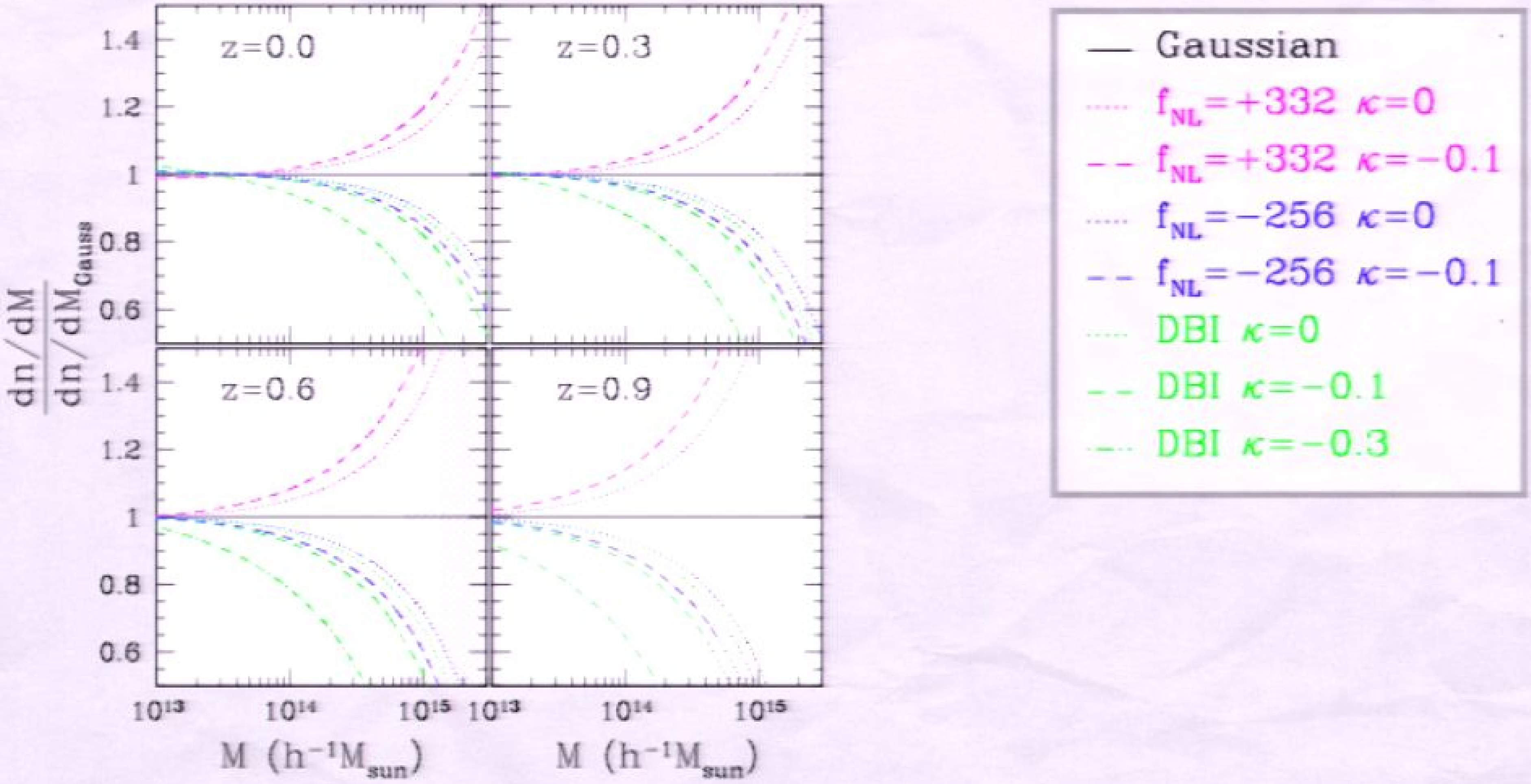


PI, Oct. 30, 2007

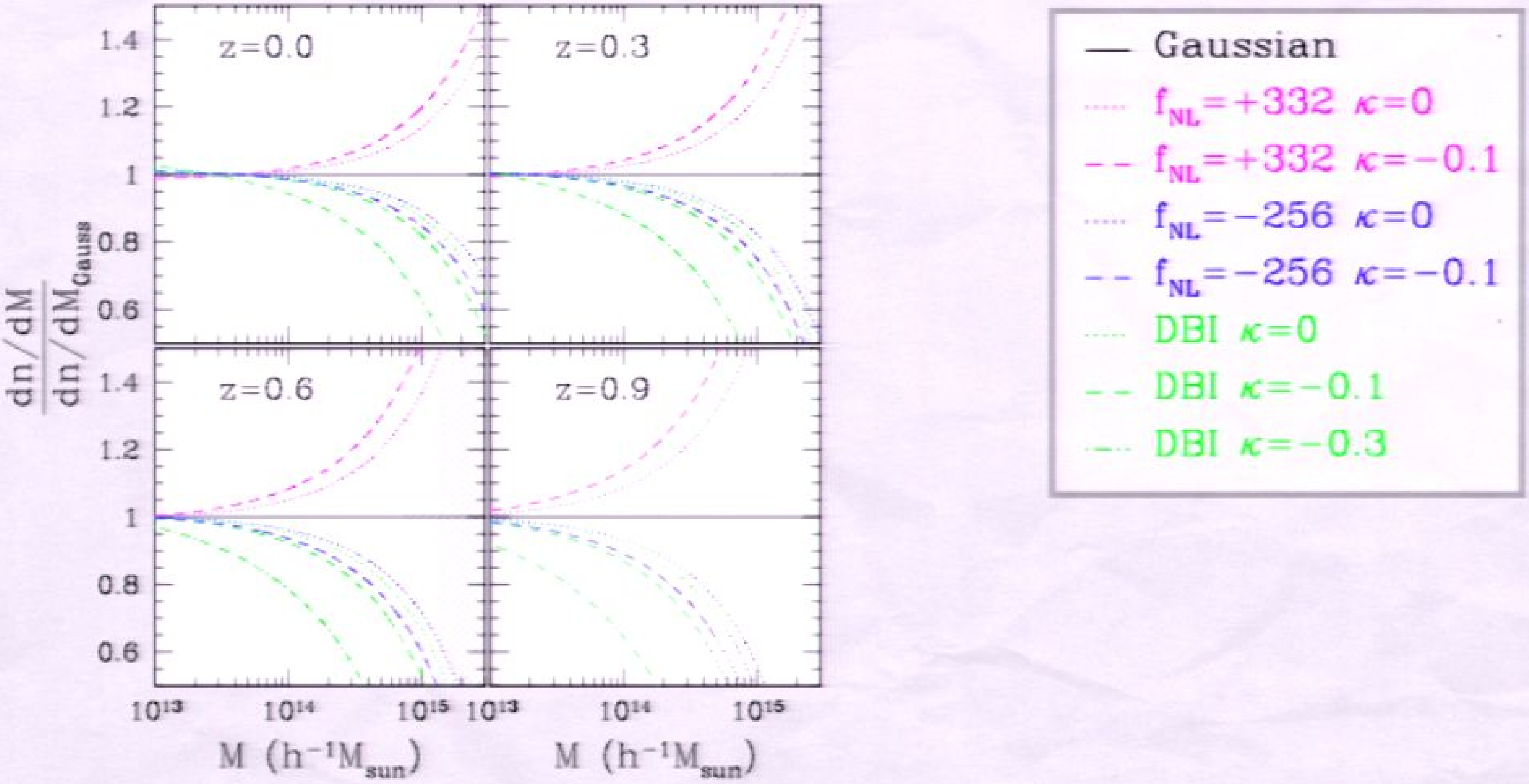
MASS FUNCTION



MASS FUNCTION

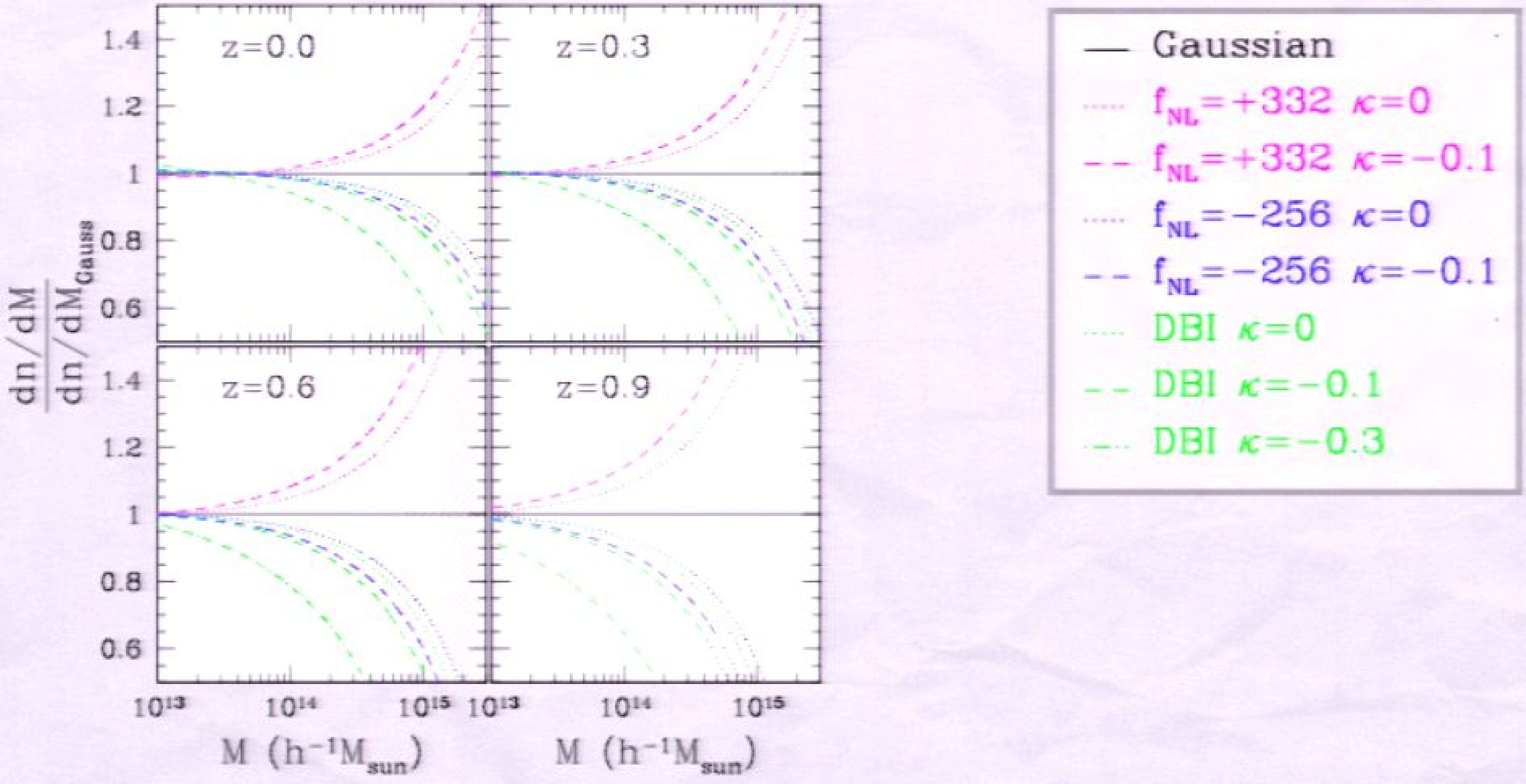


MASS FUNCTION

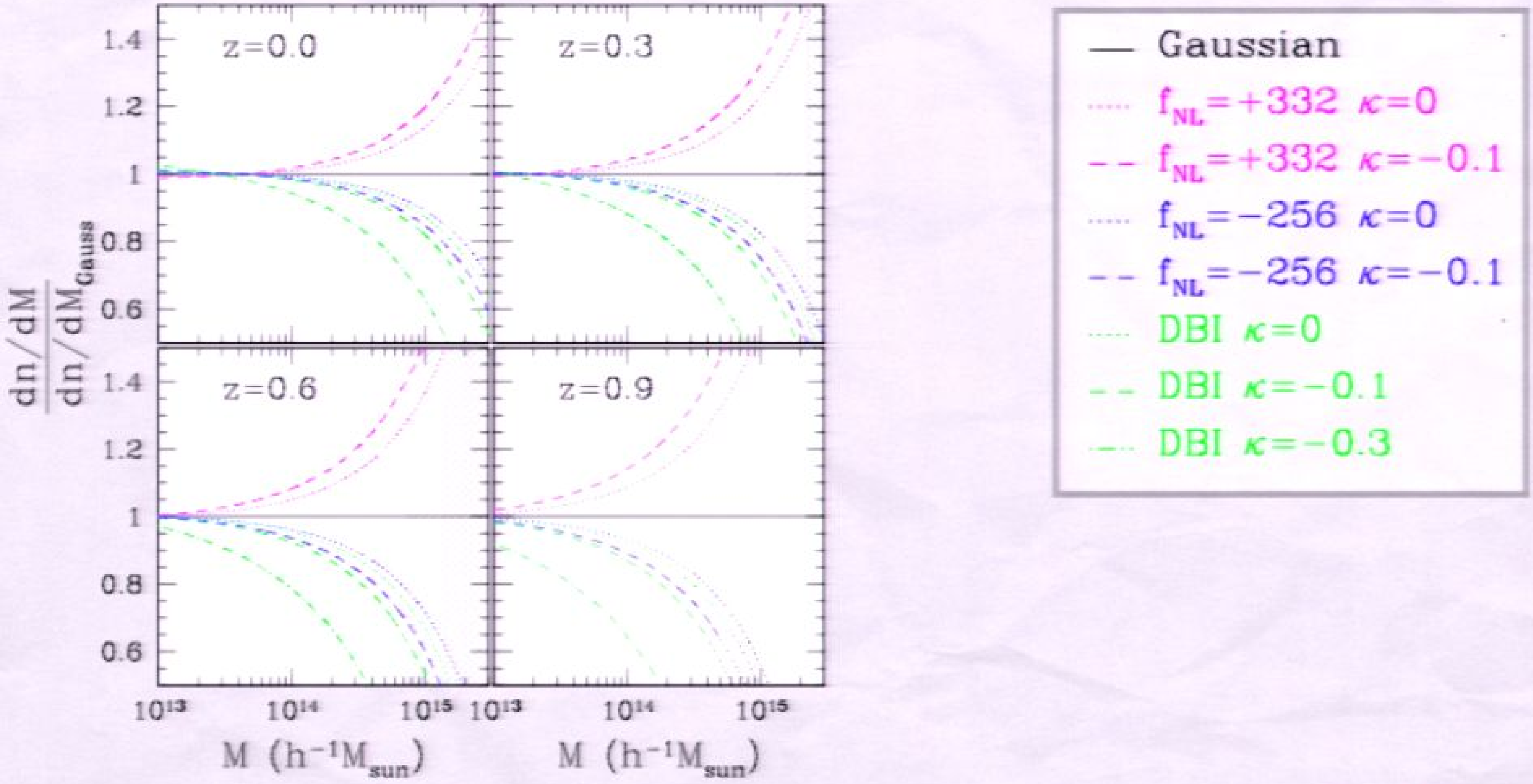


PI, Oct. 30, 2007

MASS FUNCTION

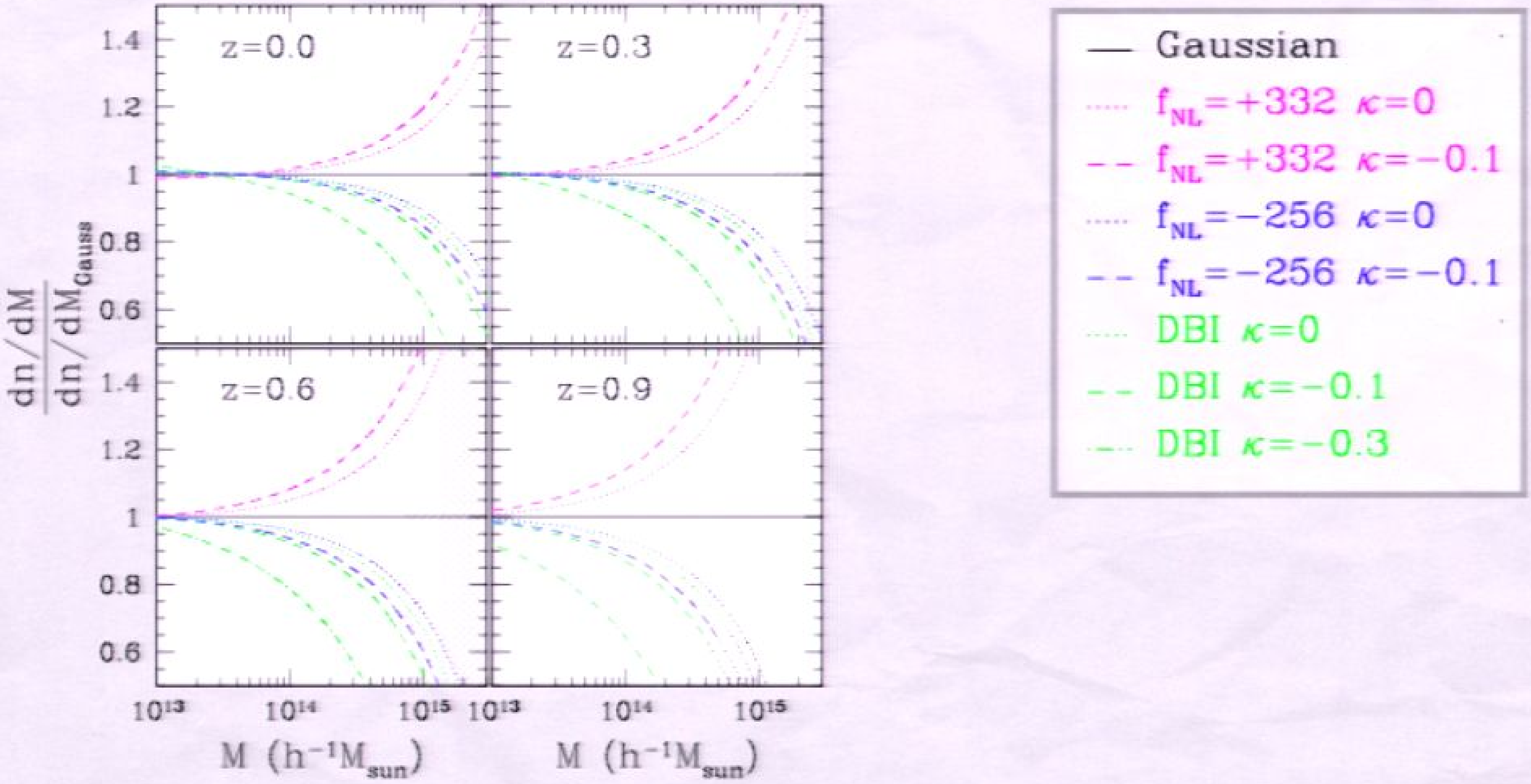


MASS FUNCTION

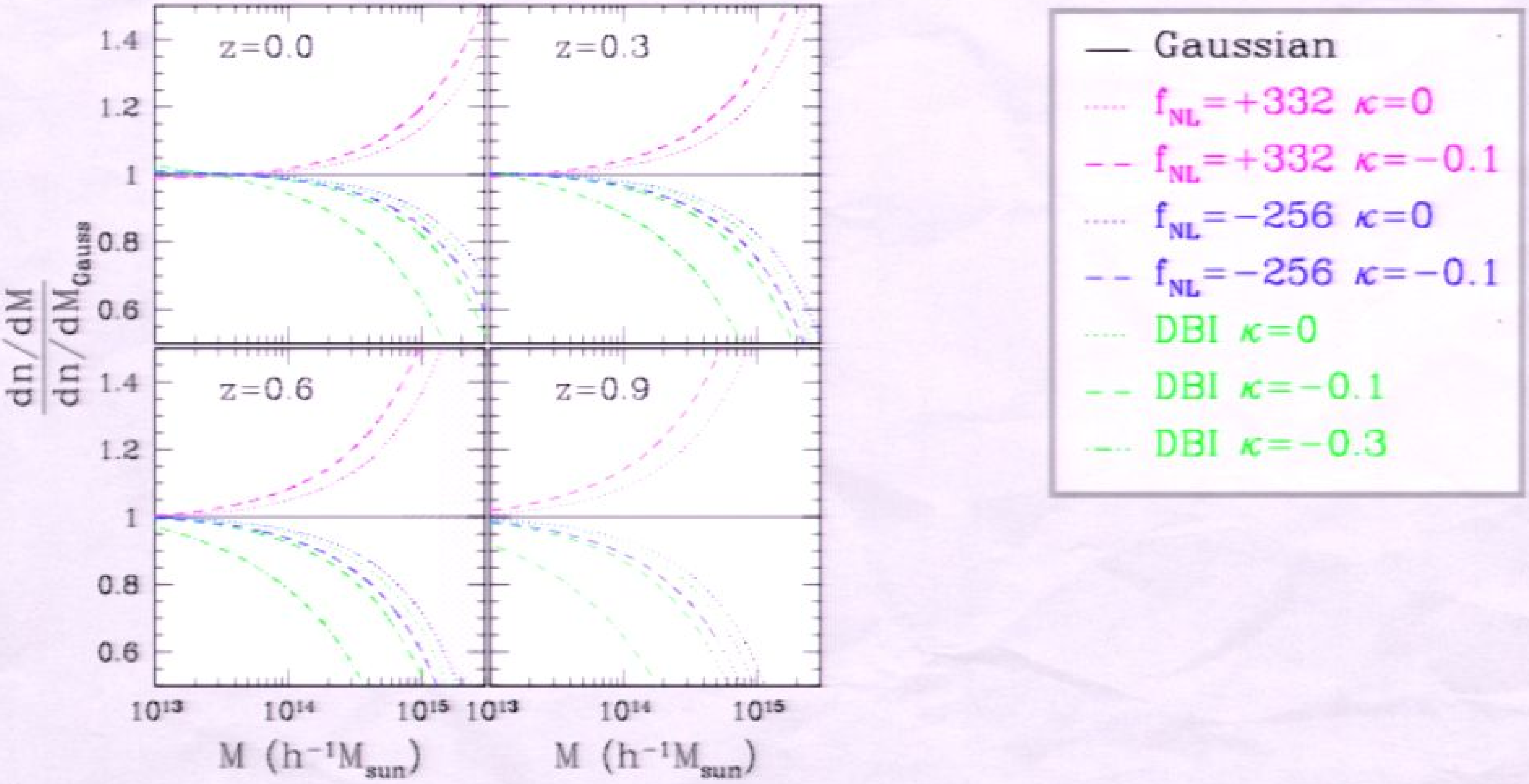


PI, Oct. 30, 2007

MASS FUNCTION

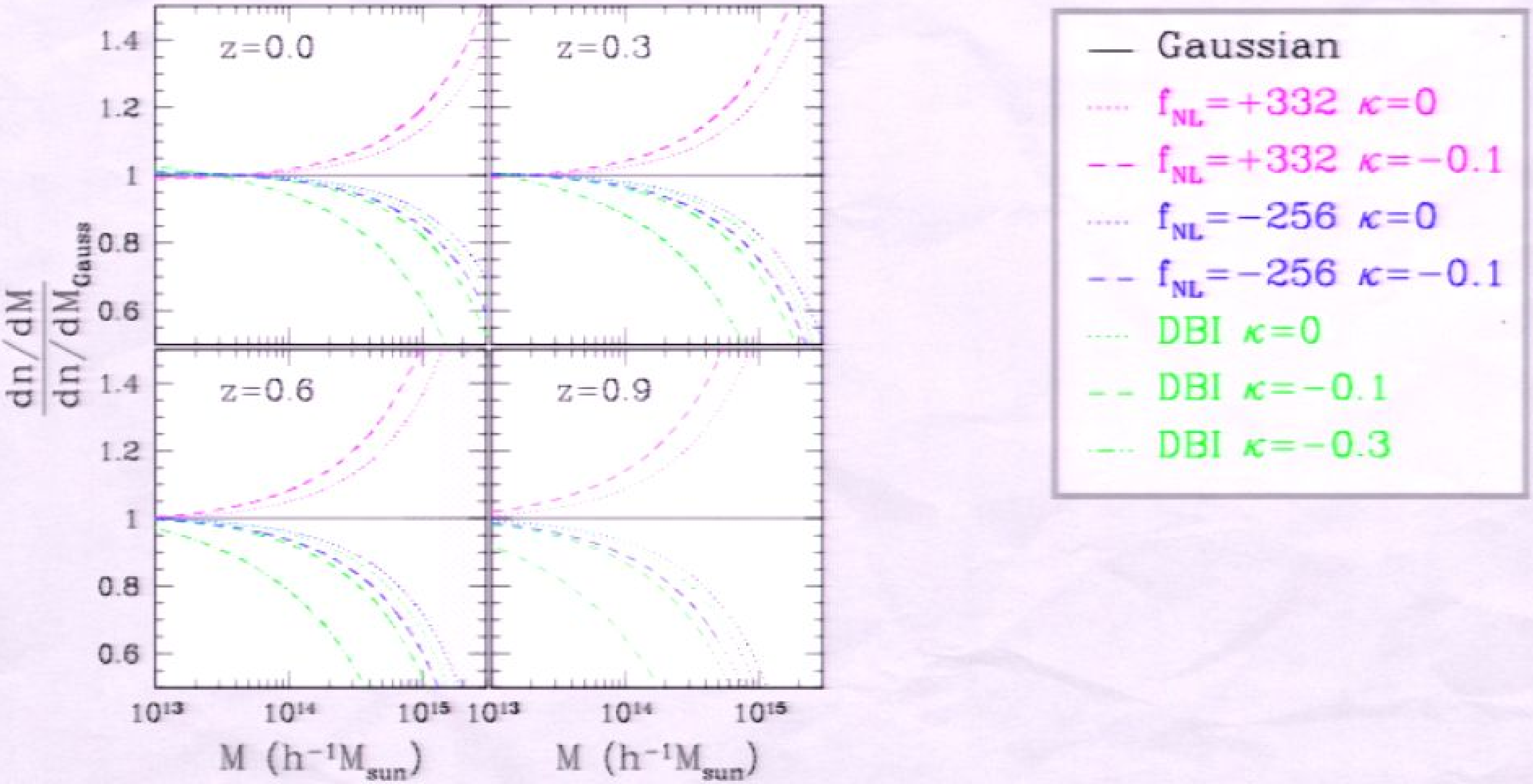


MASS FUNCTION

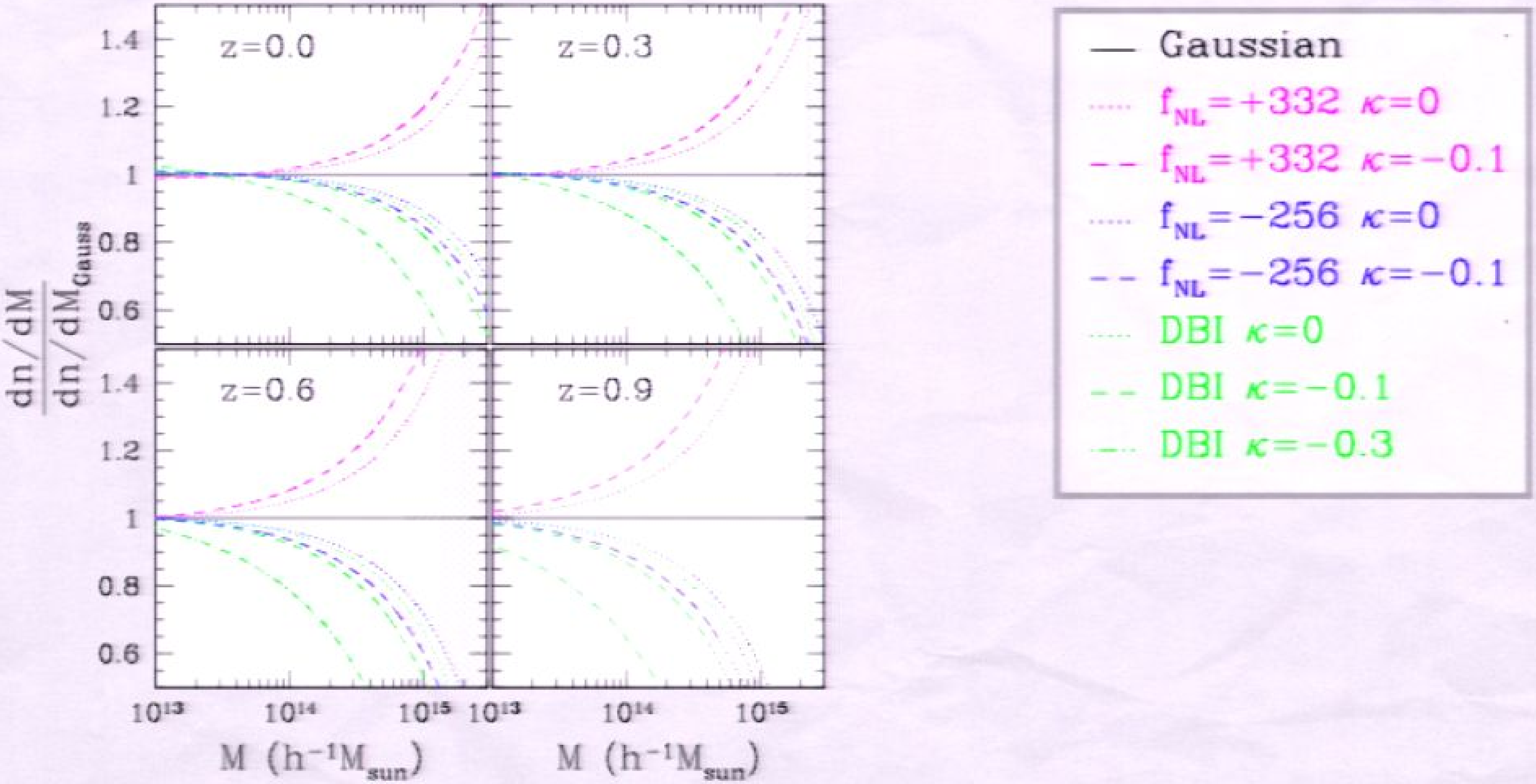


PI, Oct. 30, 2007

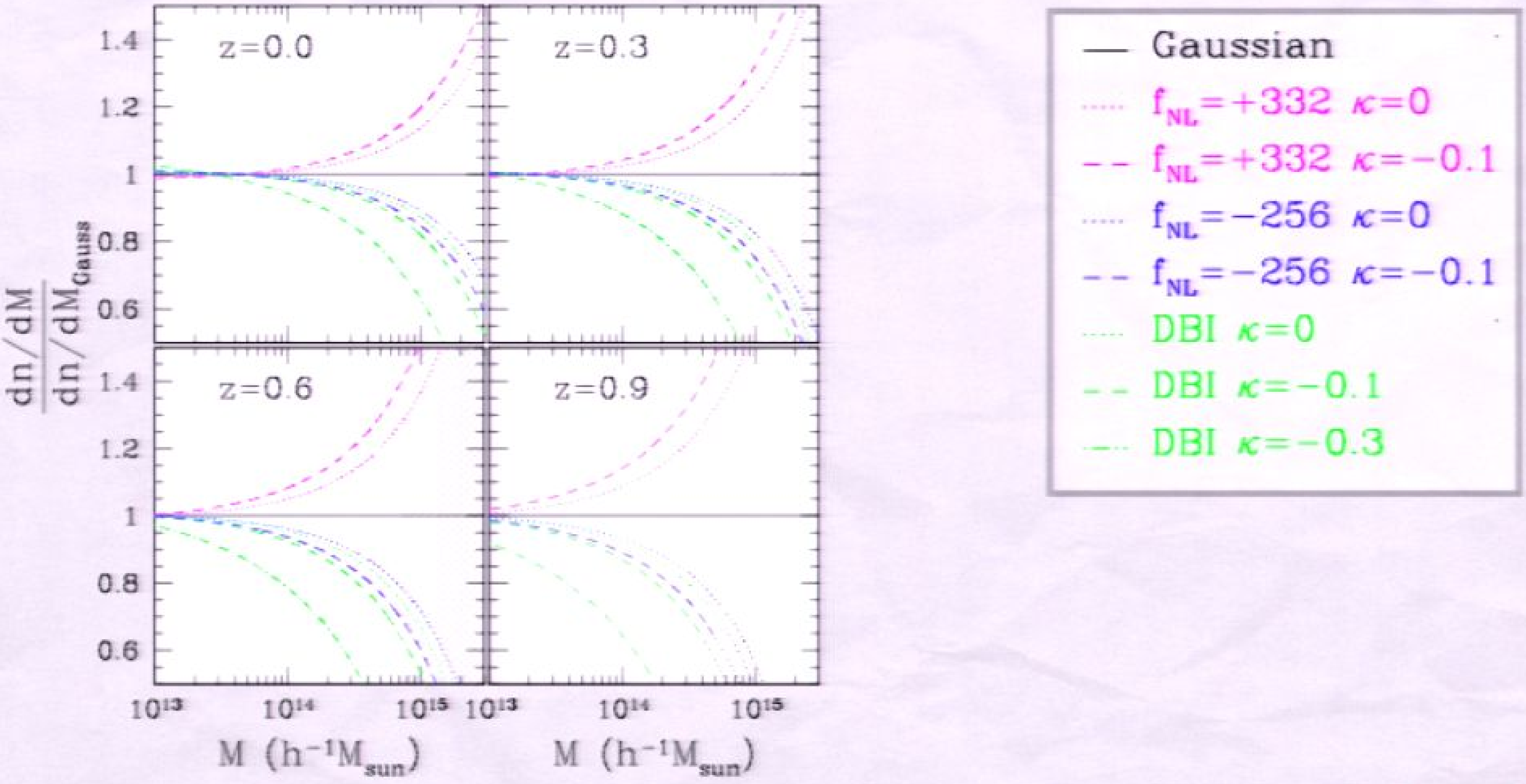
MASS FUNCTION



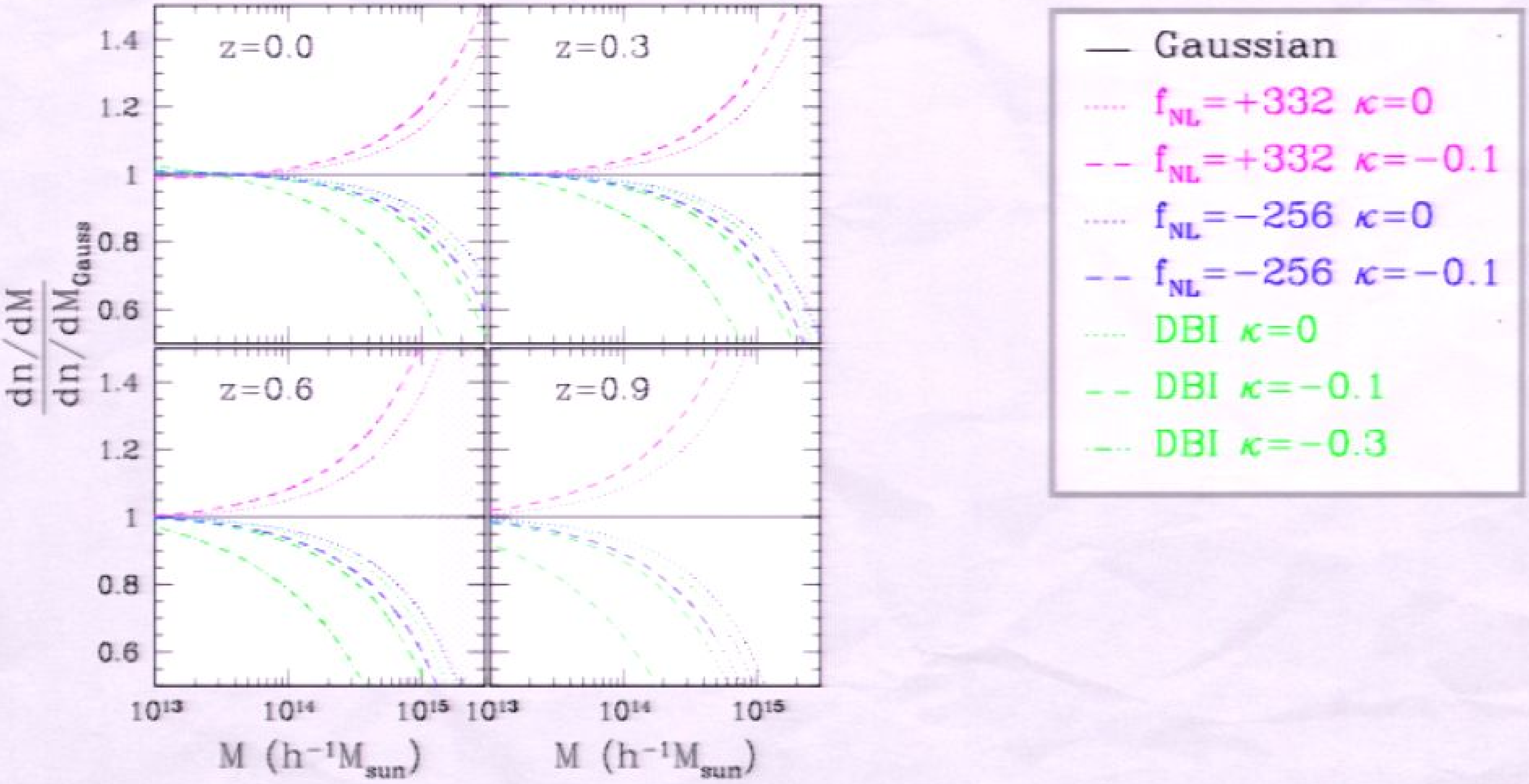
MASS FUNCTION



MASS FUNCTION

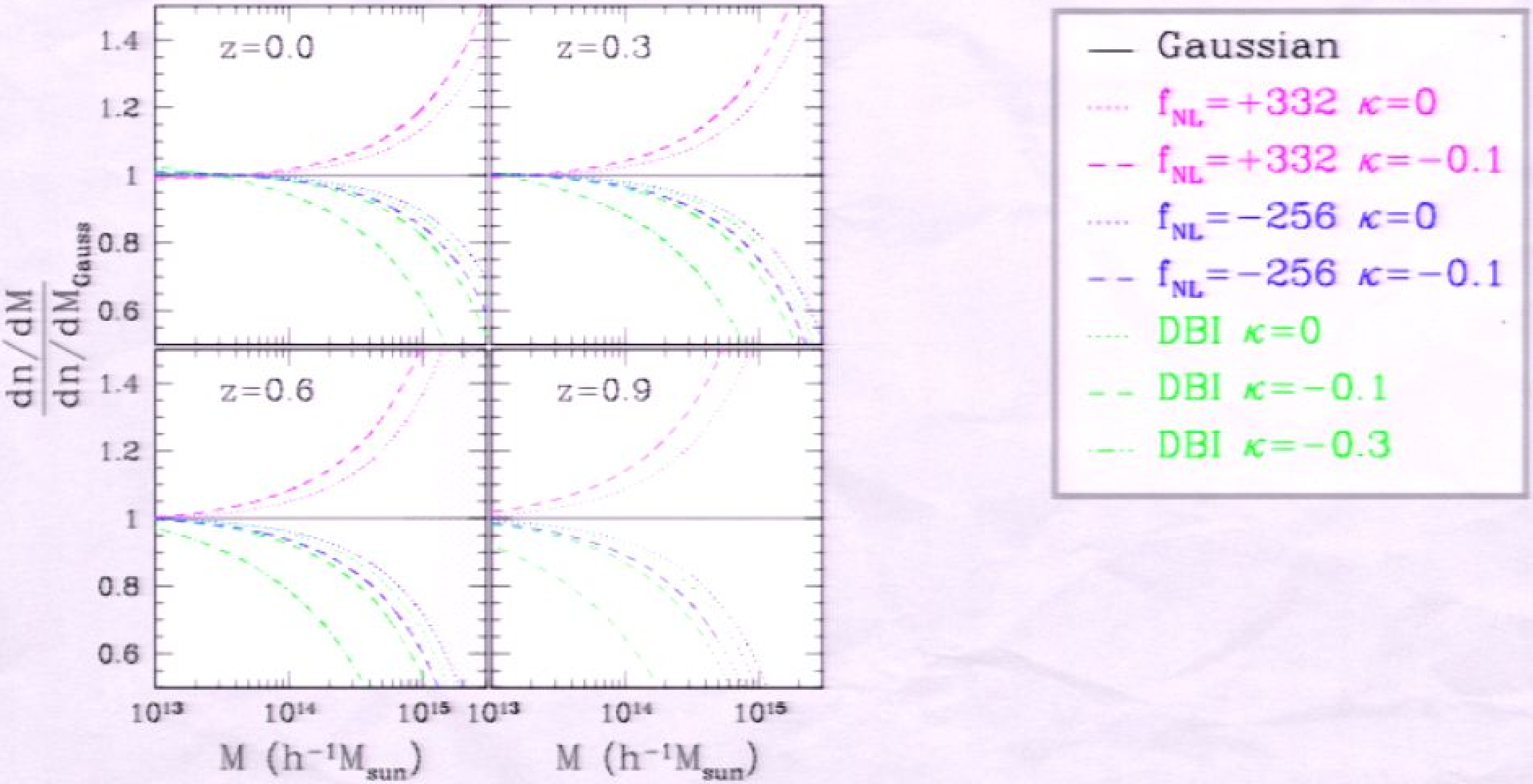


MASS FUNCTION

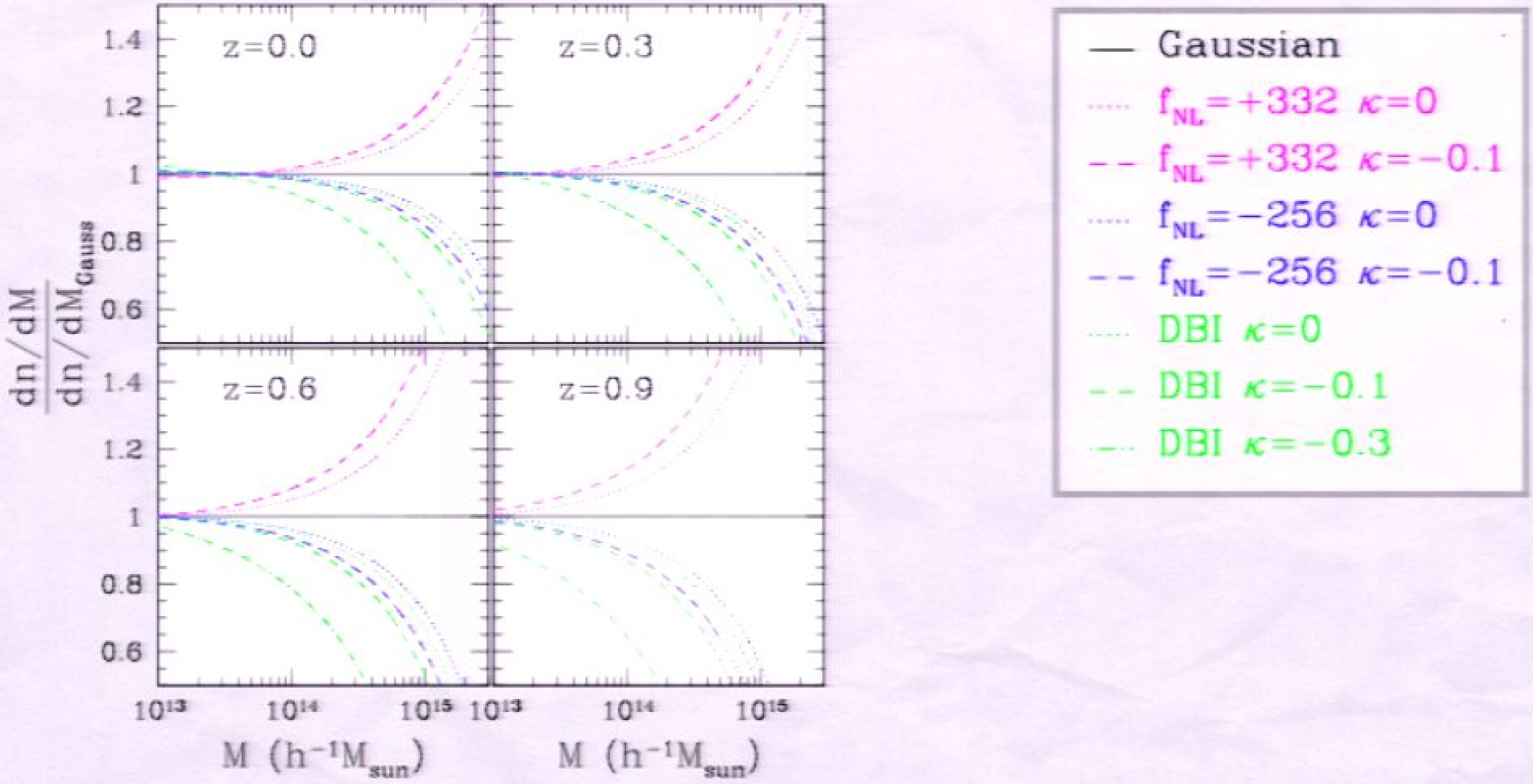


PI, Oct. 30, 2007

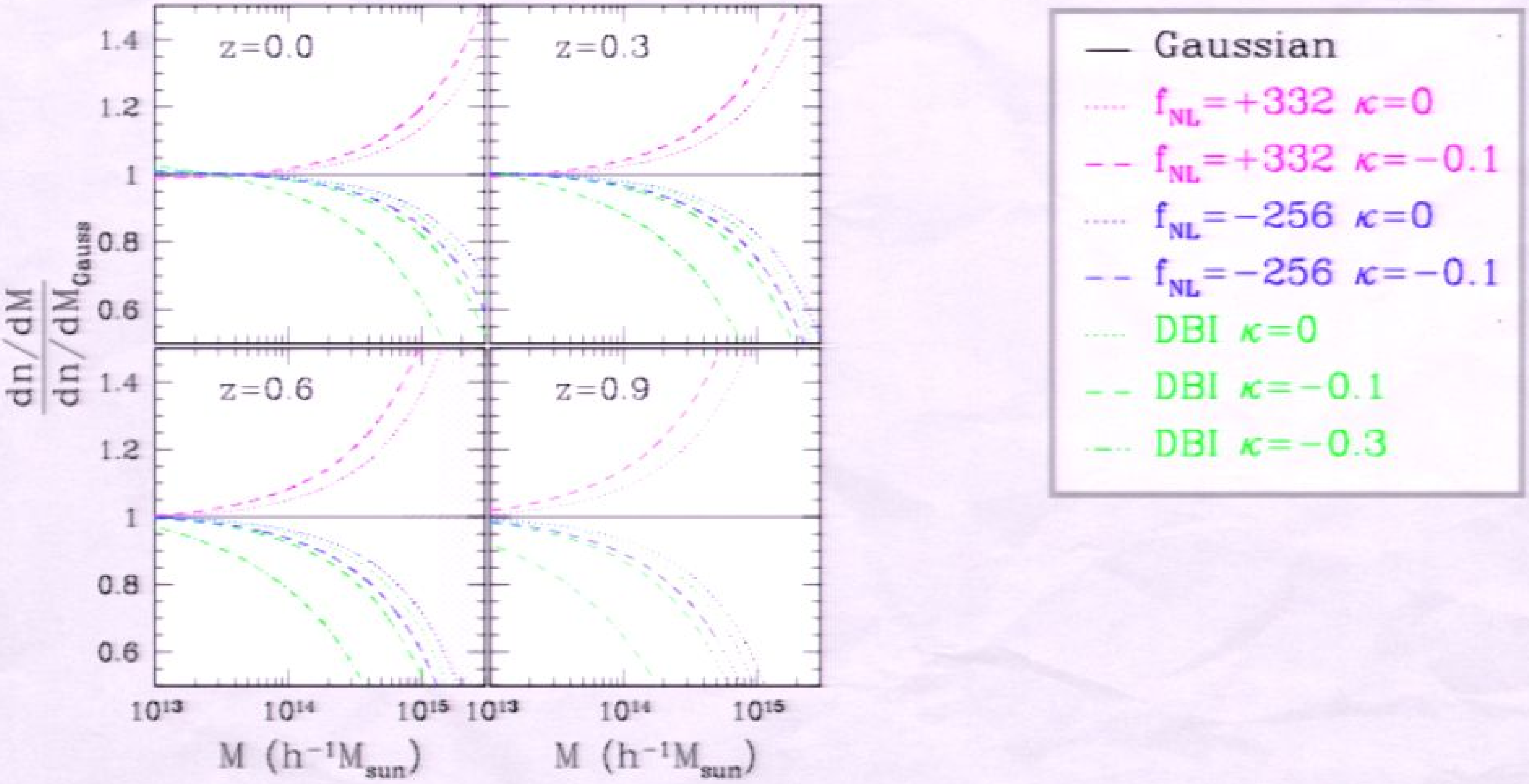
MASS FUNCTION



MASS FUNCTION

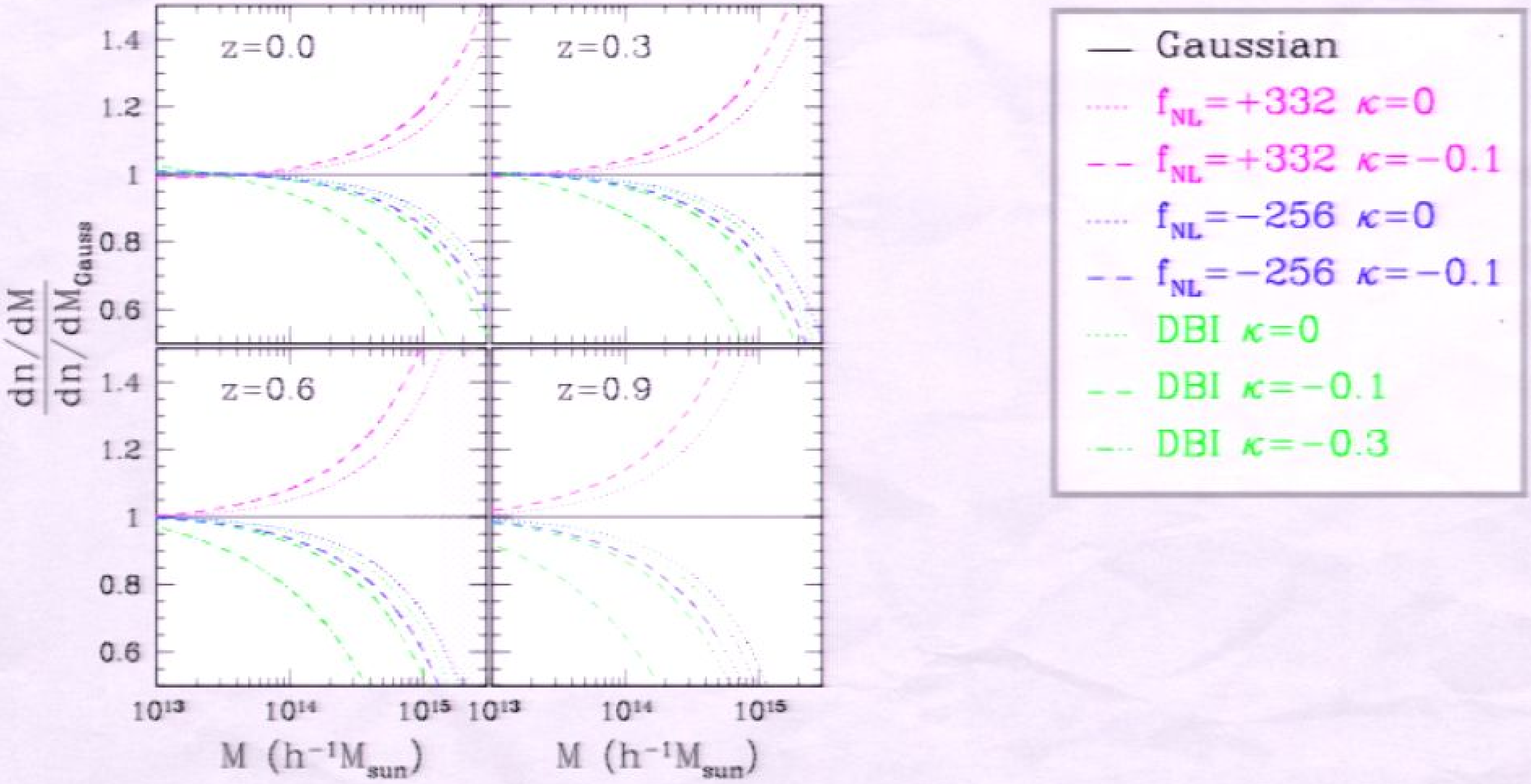


MASS FUNCTION

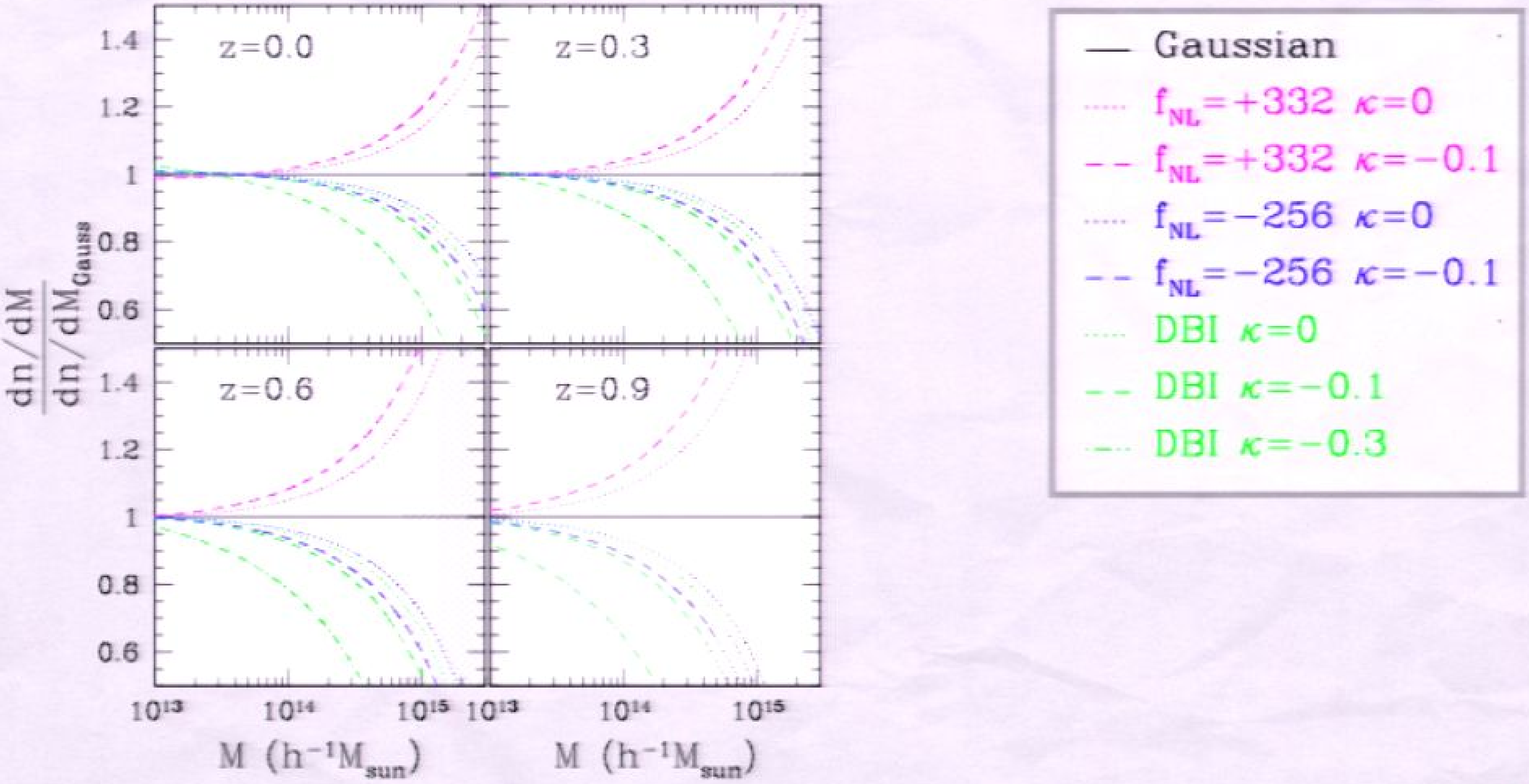


PI, Oct. 30, 2007

MASS FUNCTION

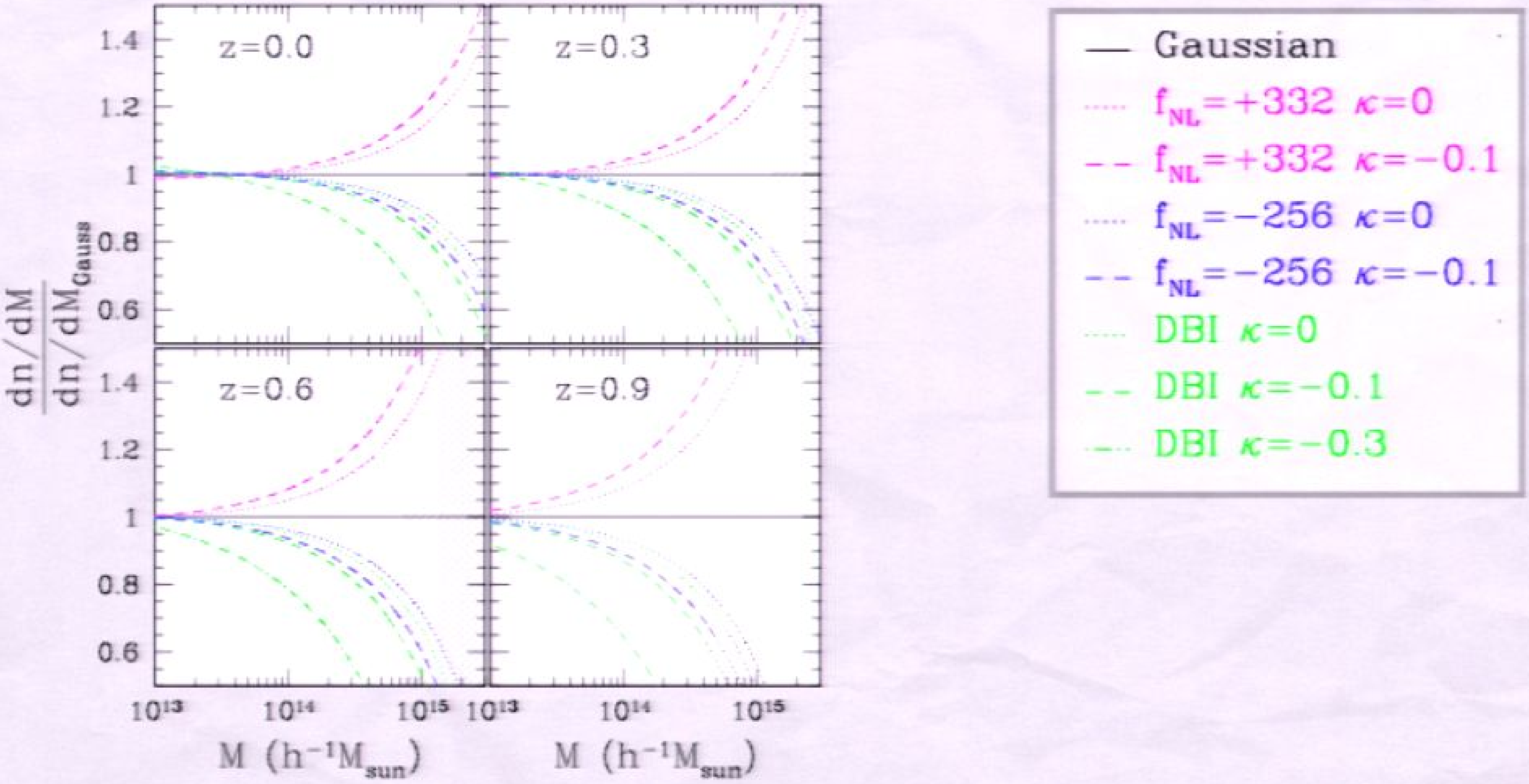


MASS FUNCTION

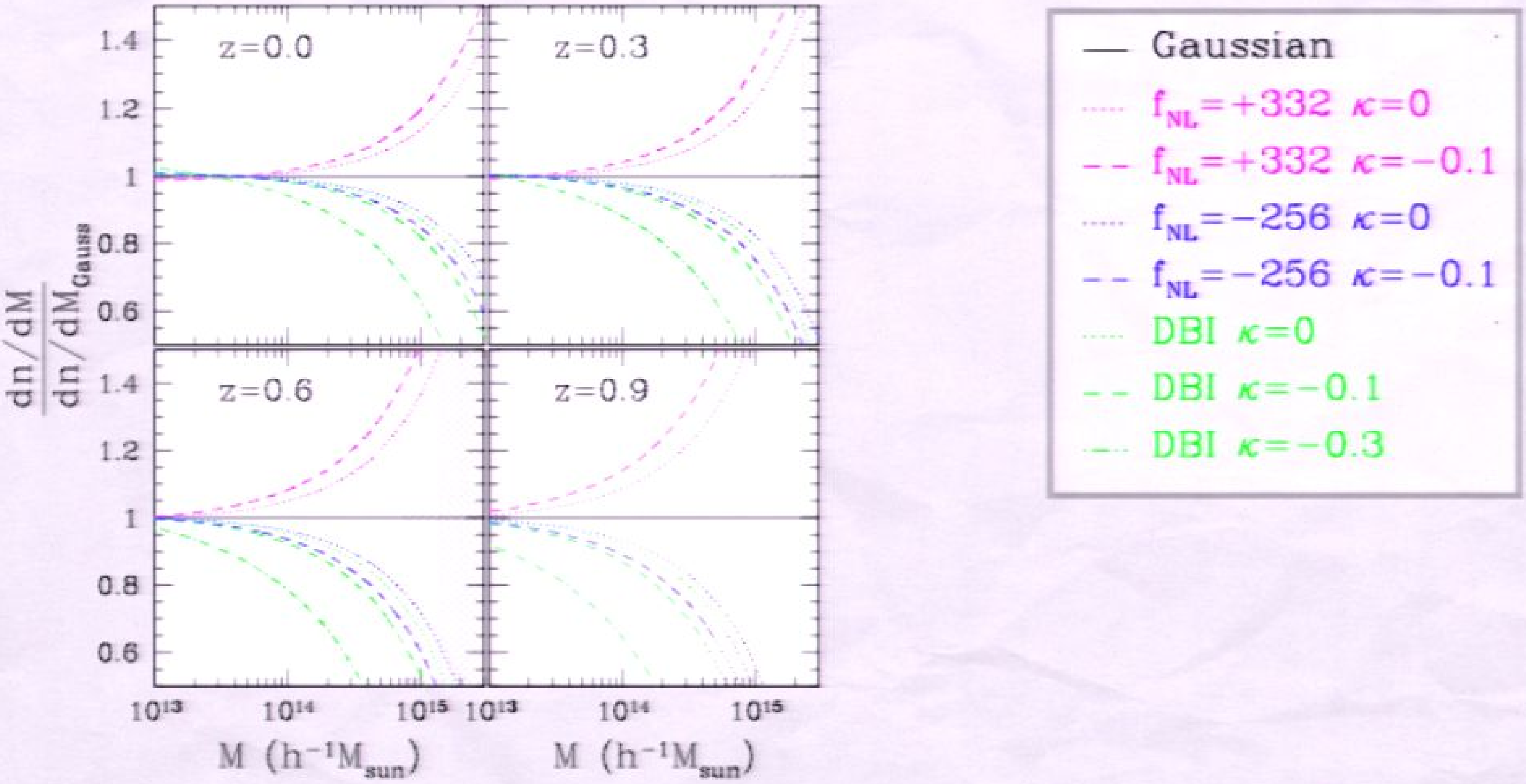


PI, Oct. 30, 2007

MASS FUNCTION

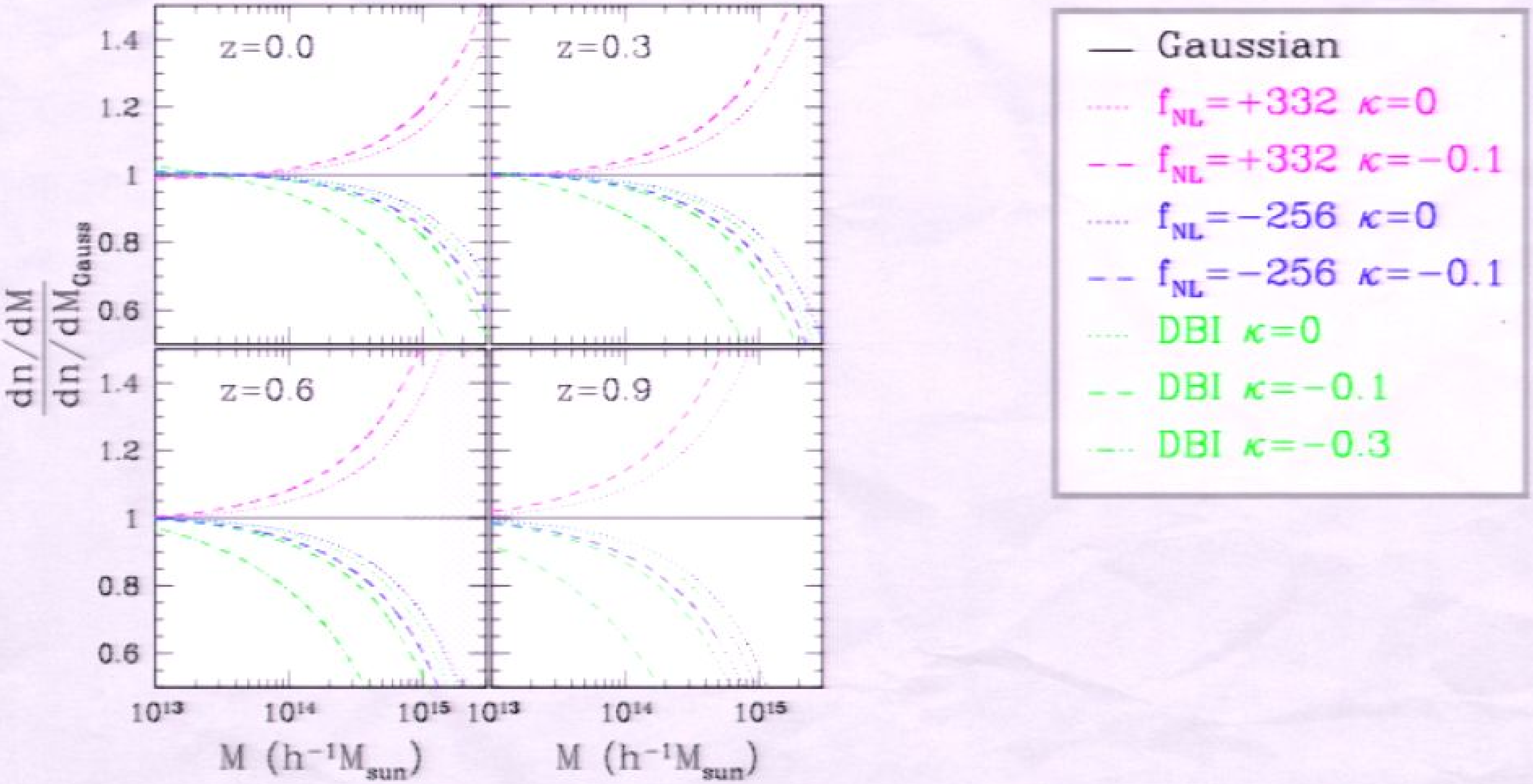


MASS FUNCTION

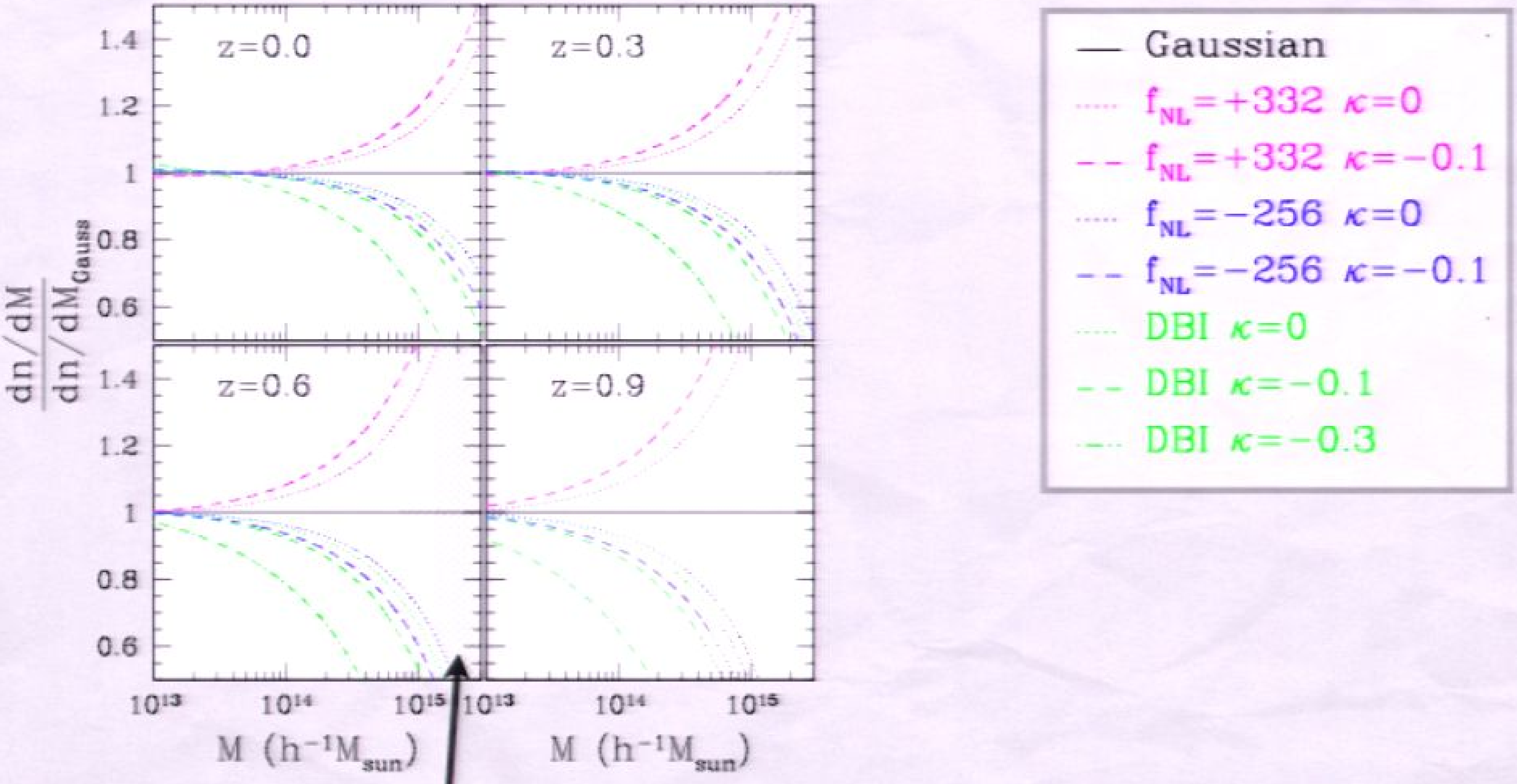


PI, Oct. 30, 2007

MASS FUNCTION

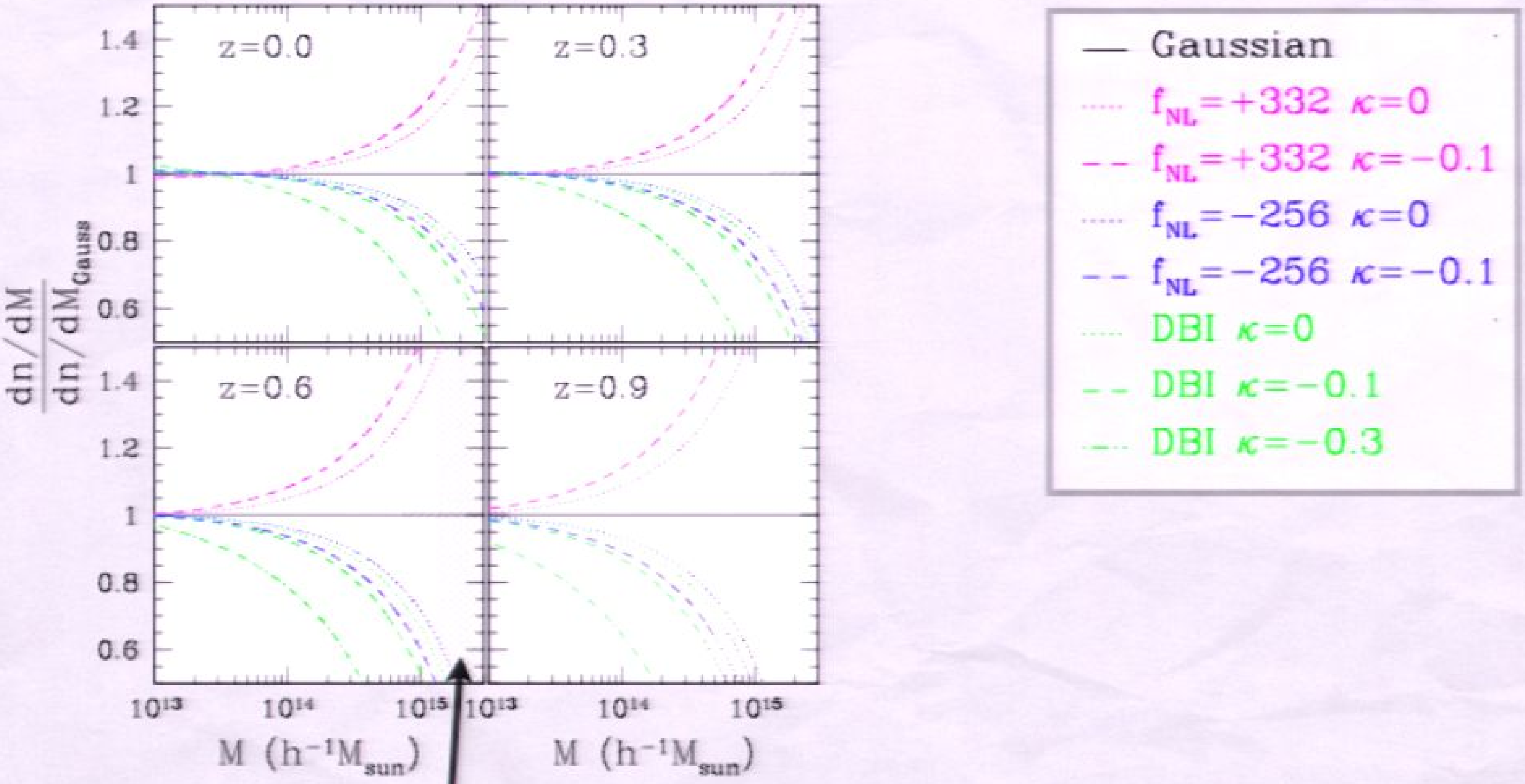


MASS FUNCTION



parameter-dependent regions where the PDF breaks down

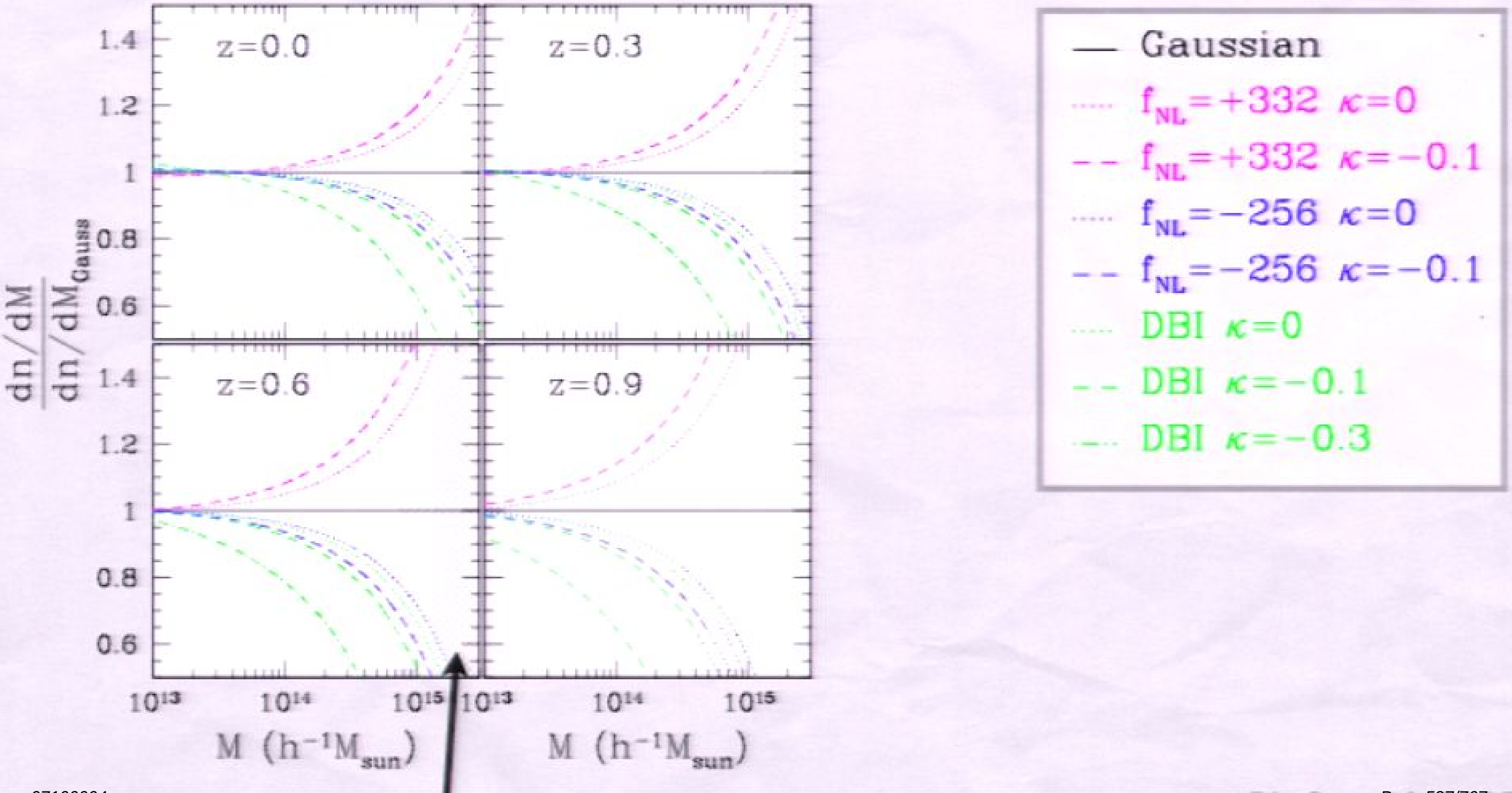
MASS FUNCTION



parameter-dependent regions where the PDF breaks down

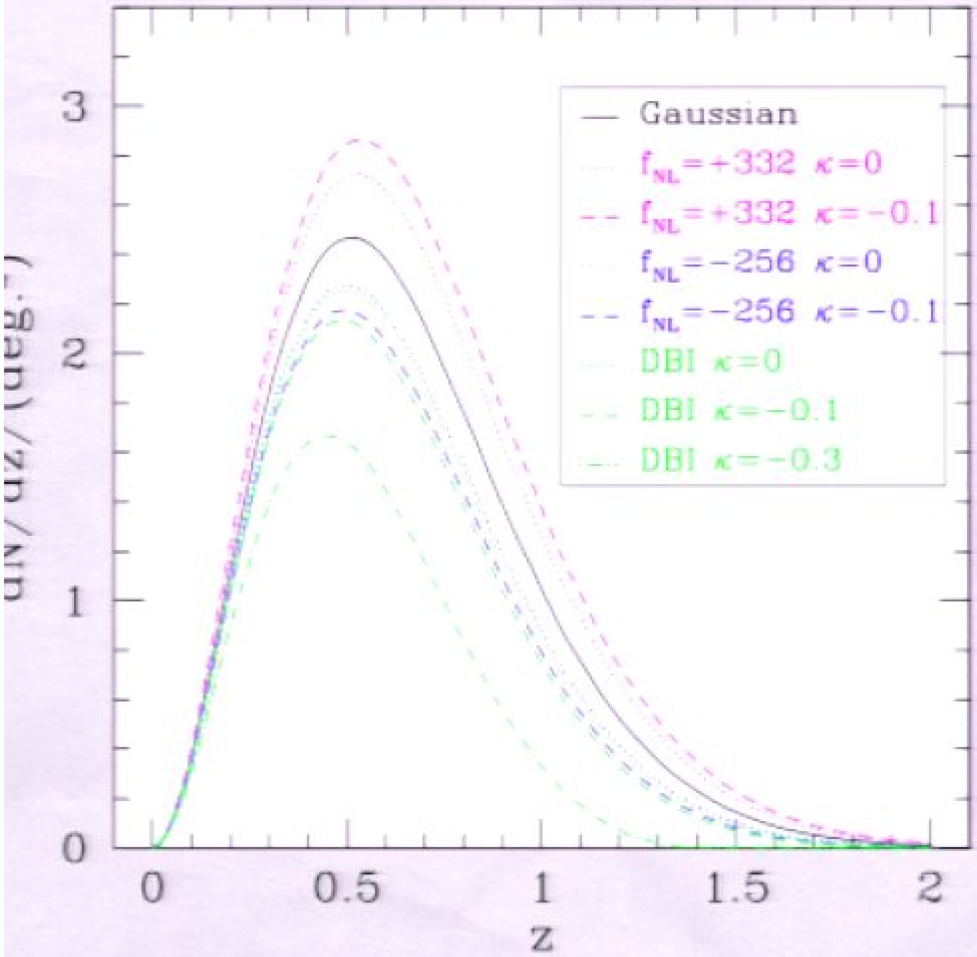
PI, Oct. 30, 2007

MASS FUNCTION



parameter-dependent regions where the PDF breaks down

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z



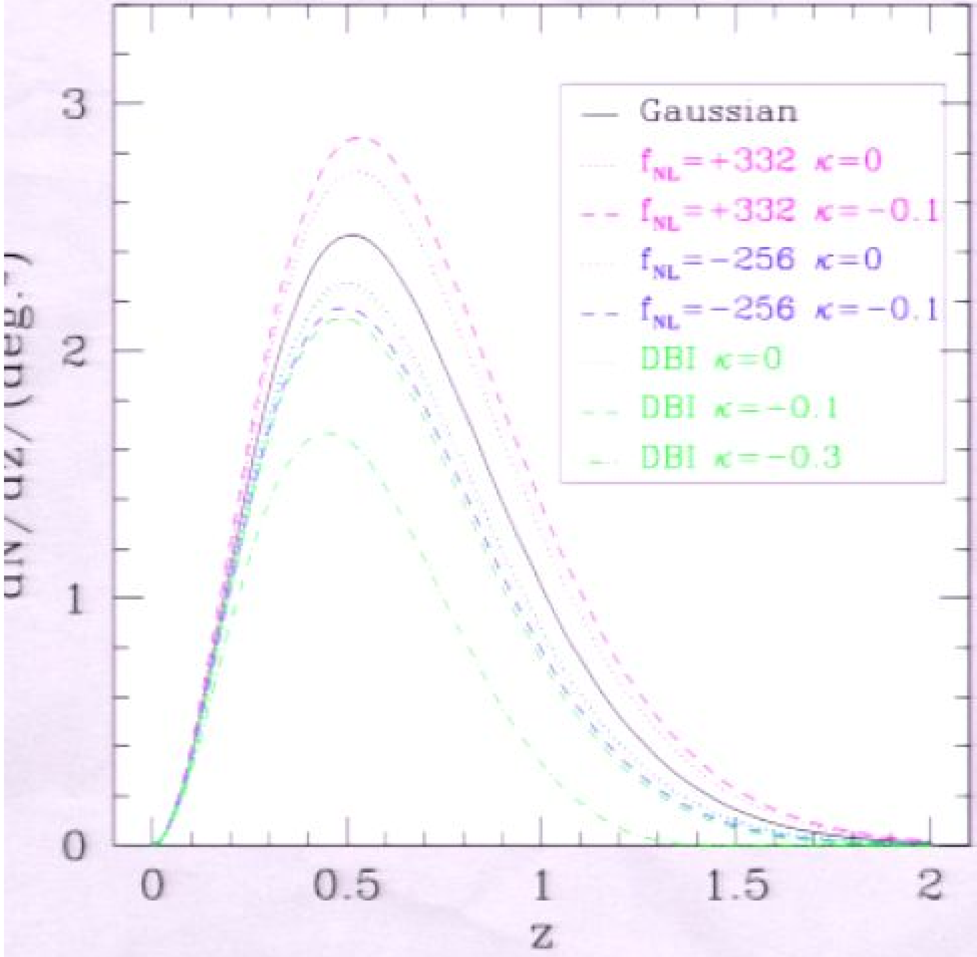
$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

PI, Oct. 30, 2007

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

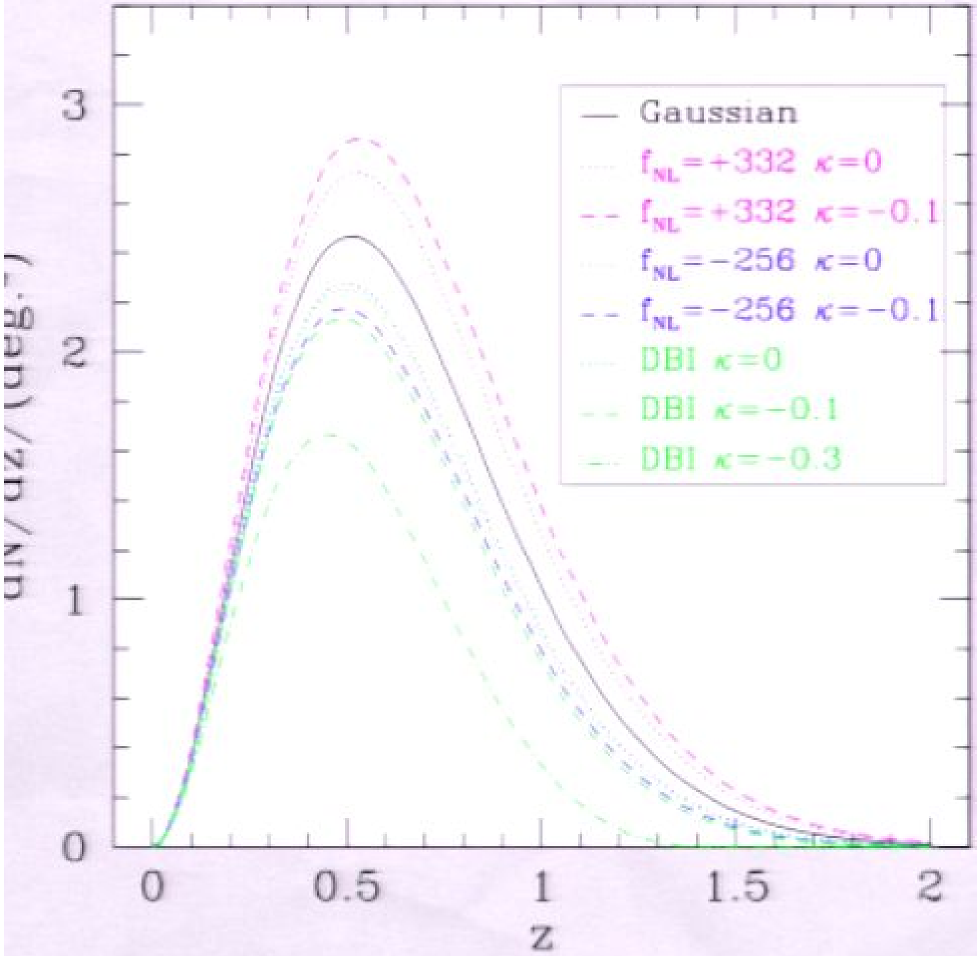


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

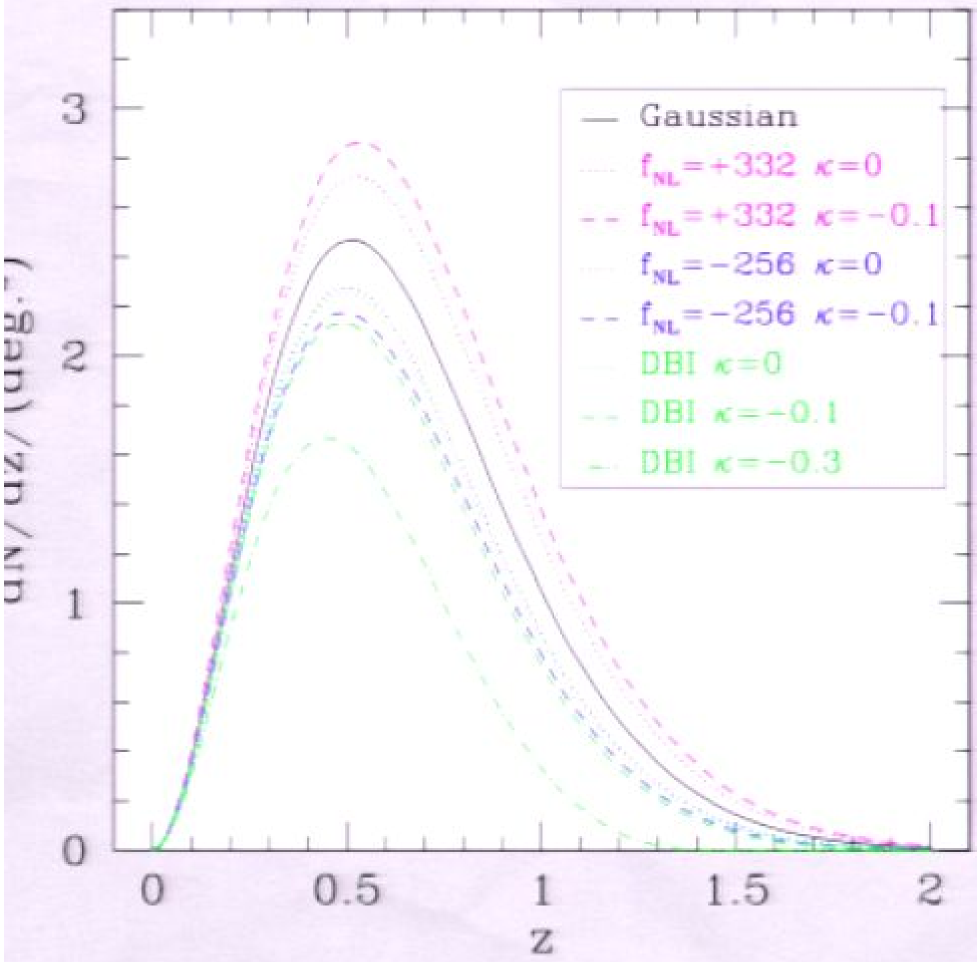


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM\frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z



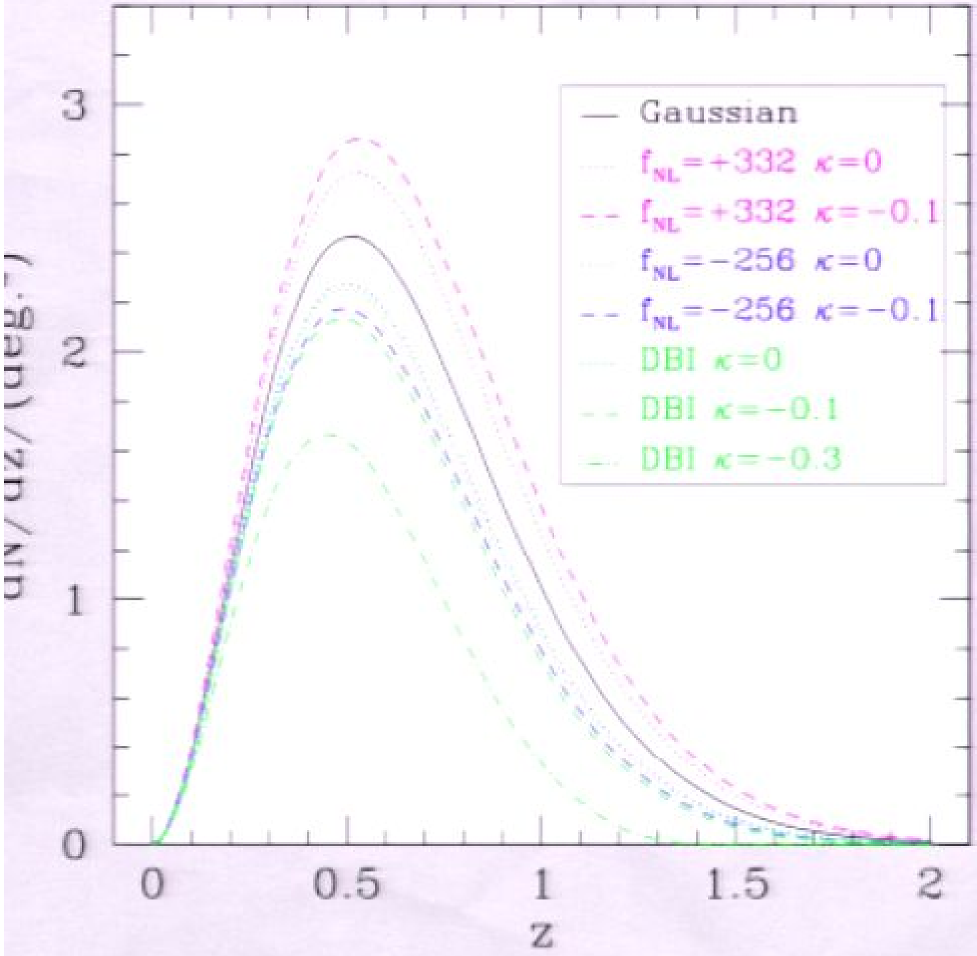
$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

PI, Oct. 30, 2007

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

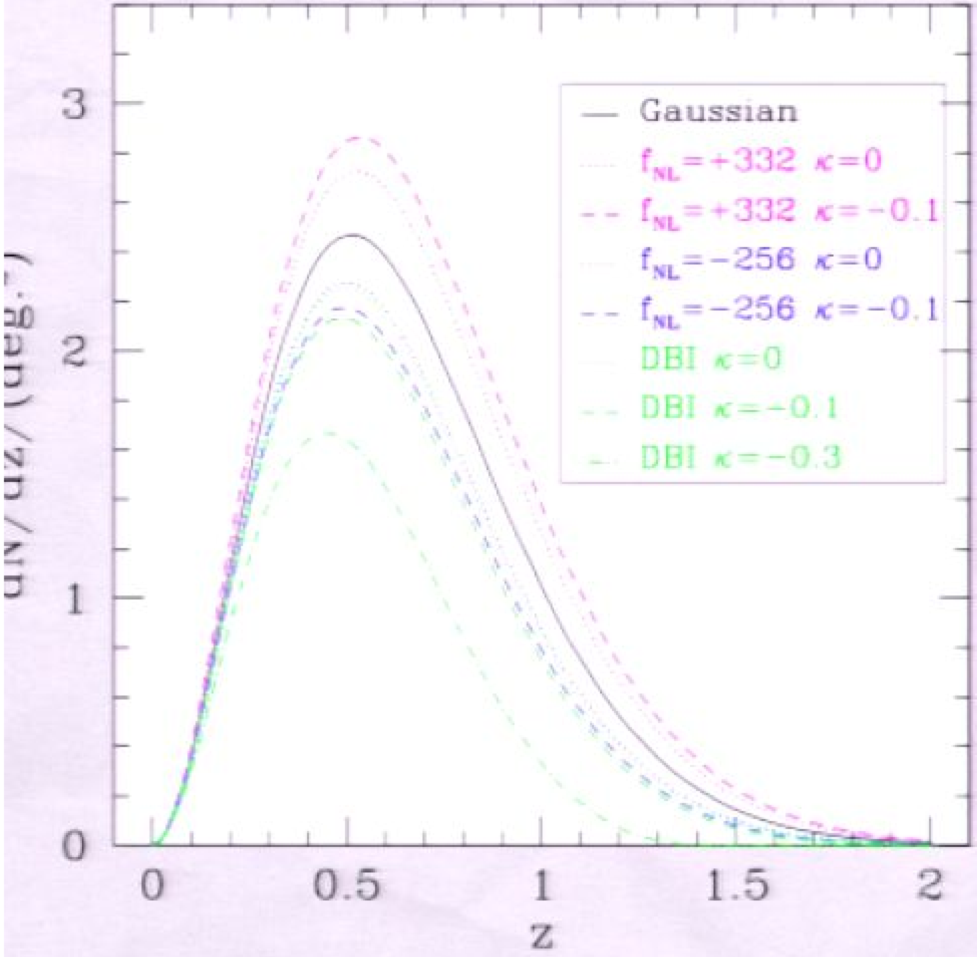


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

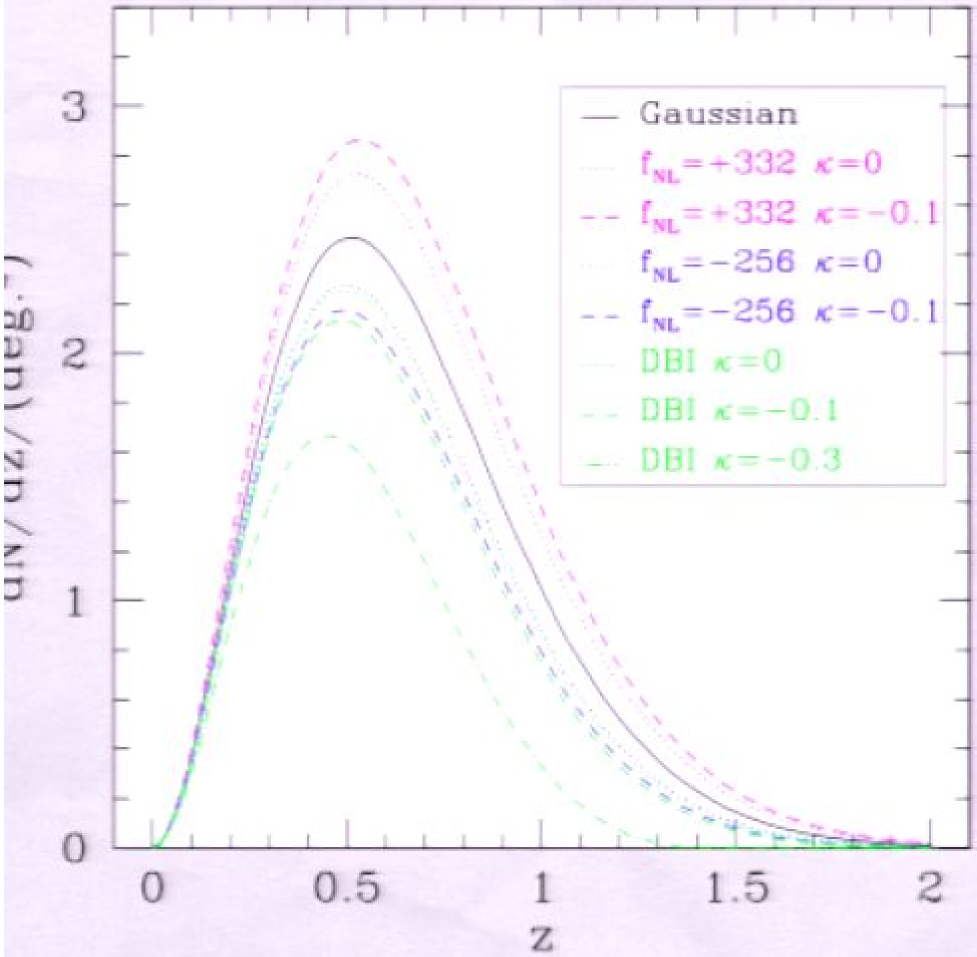


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

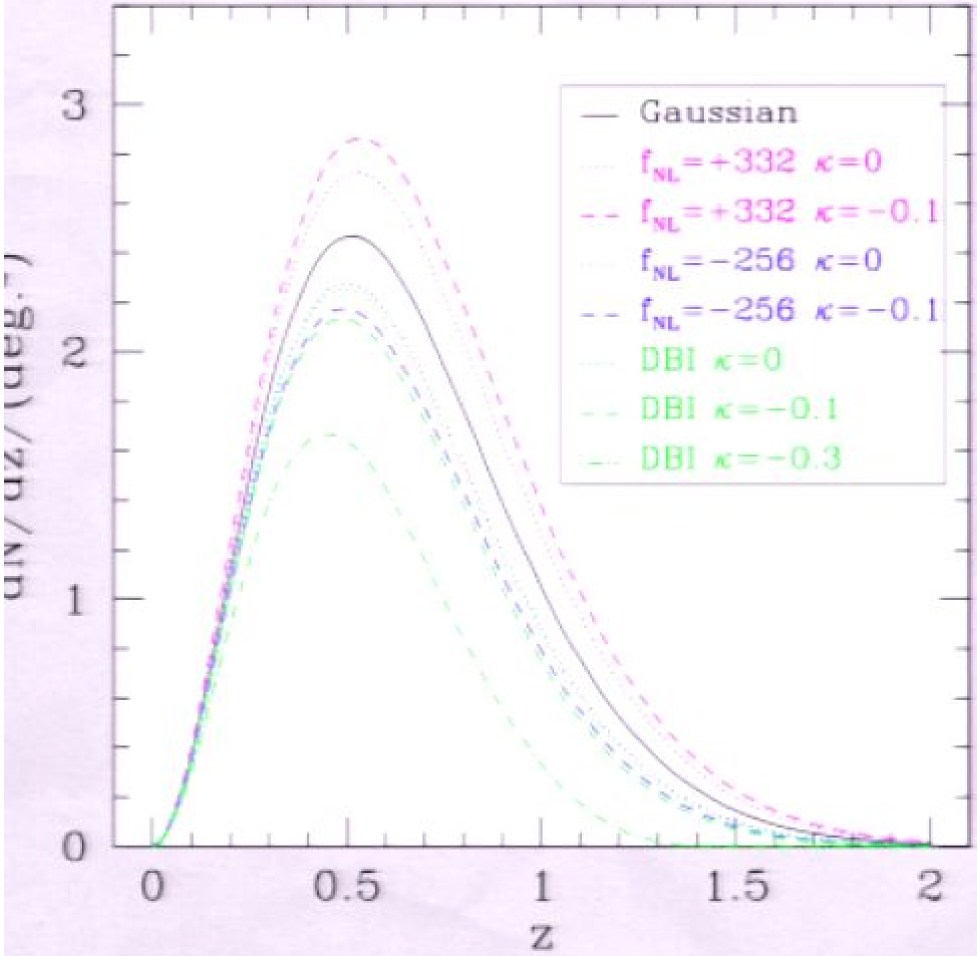


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z



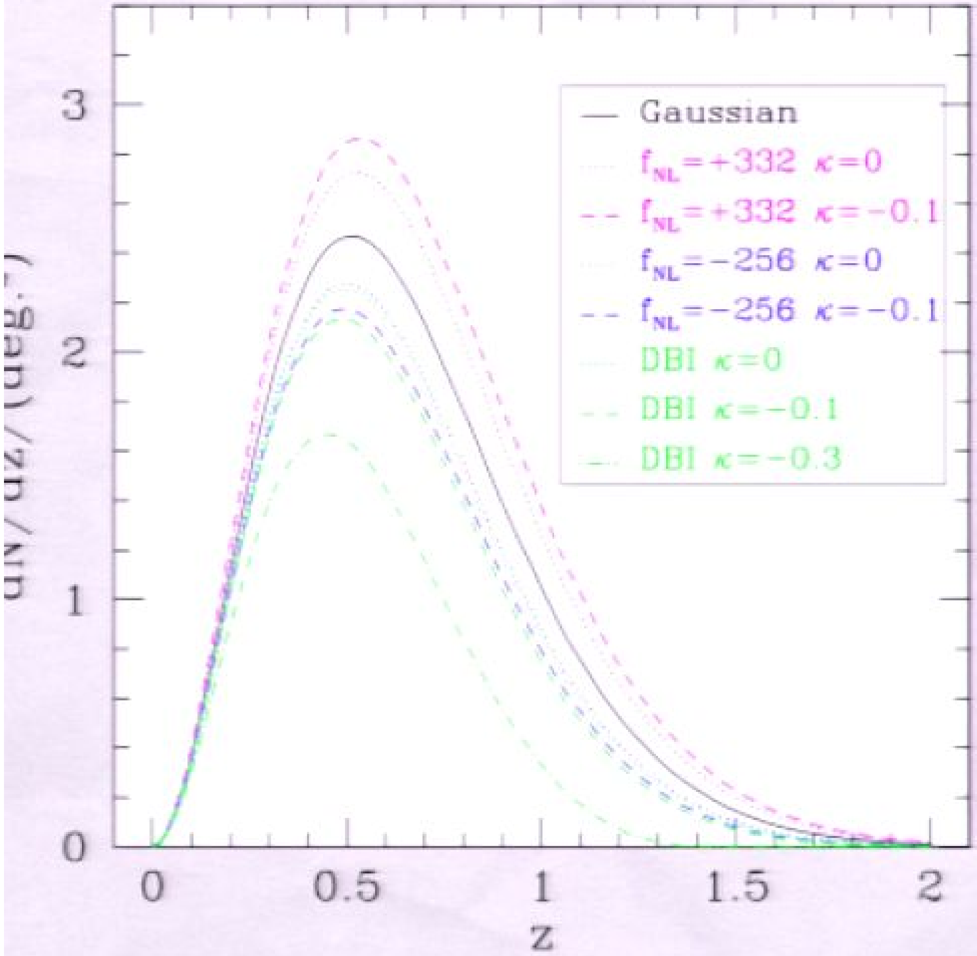
$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

PI, Oct. 30, 2007

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

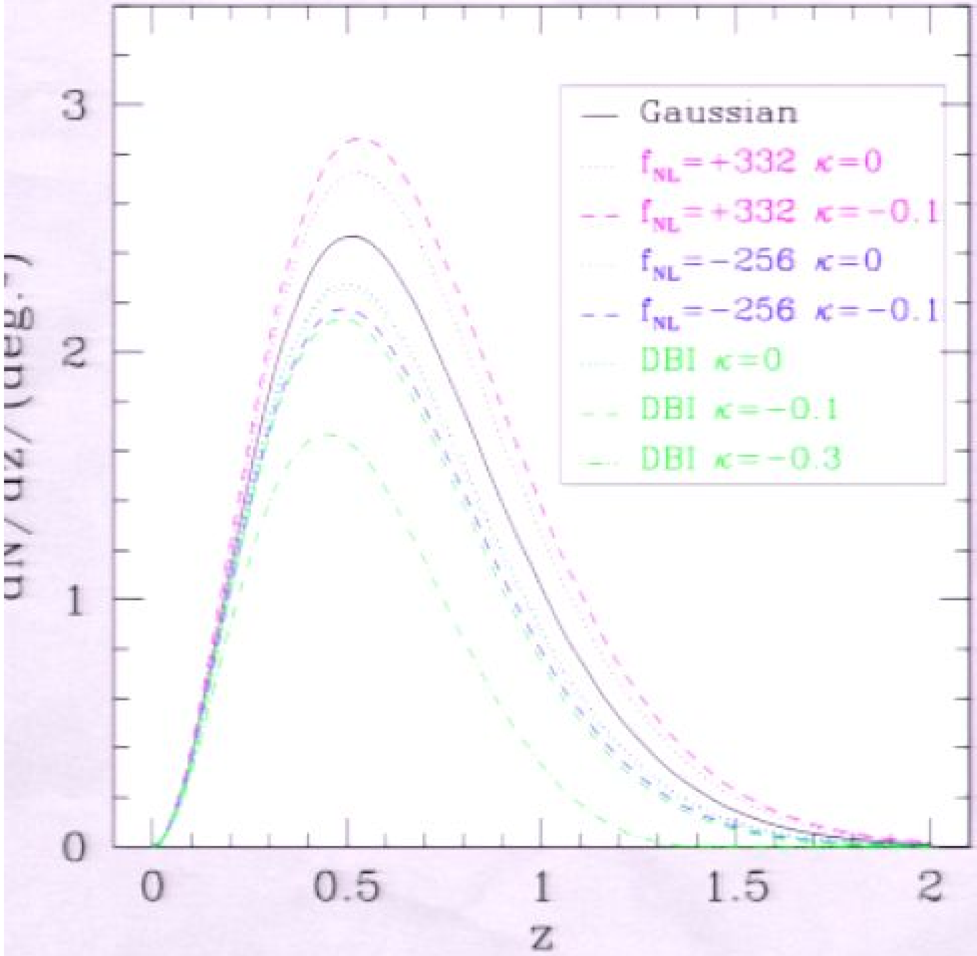


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM\frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

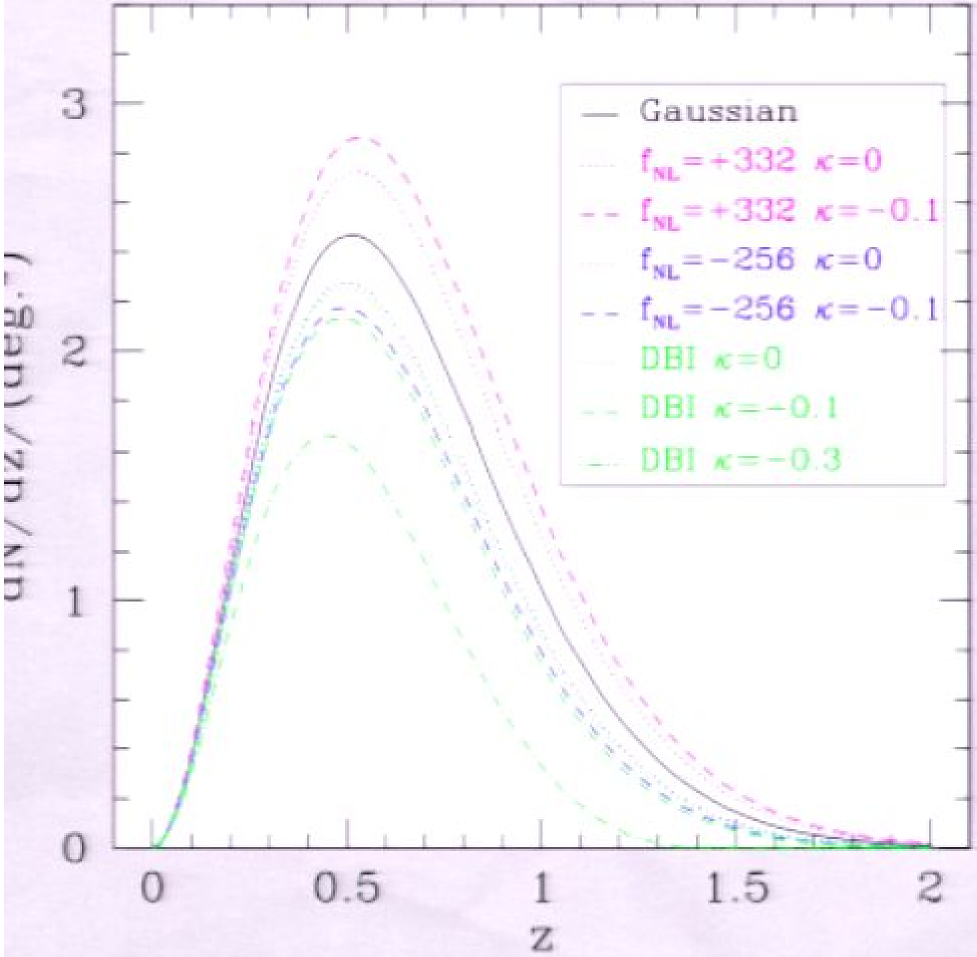


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M, z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z



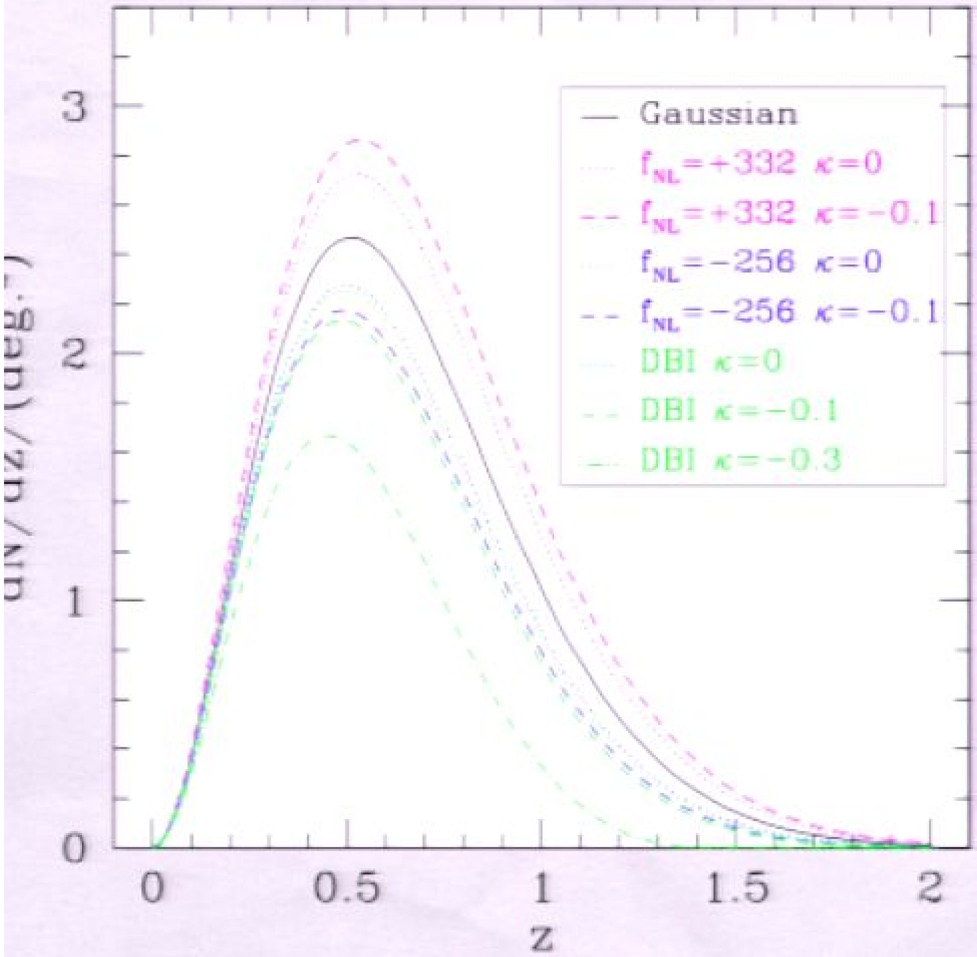
$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

PI, Oct. 30, 2007

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

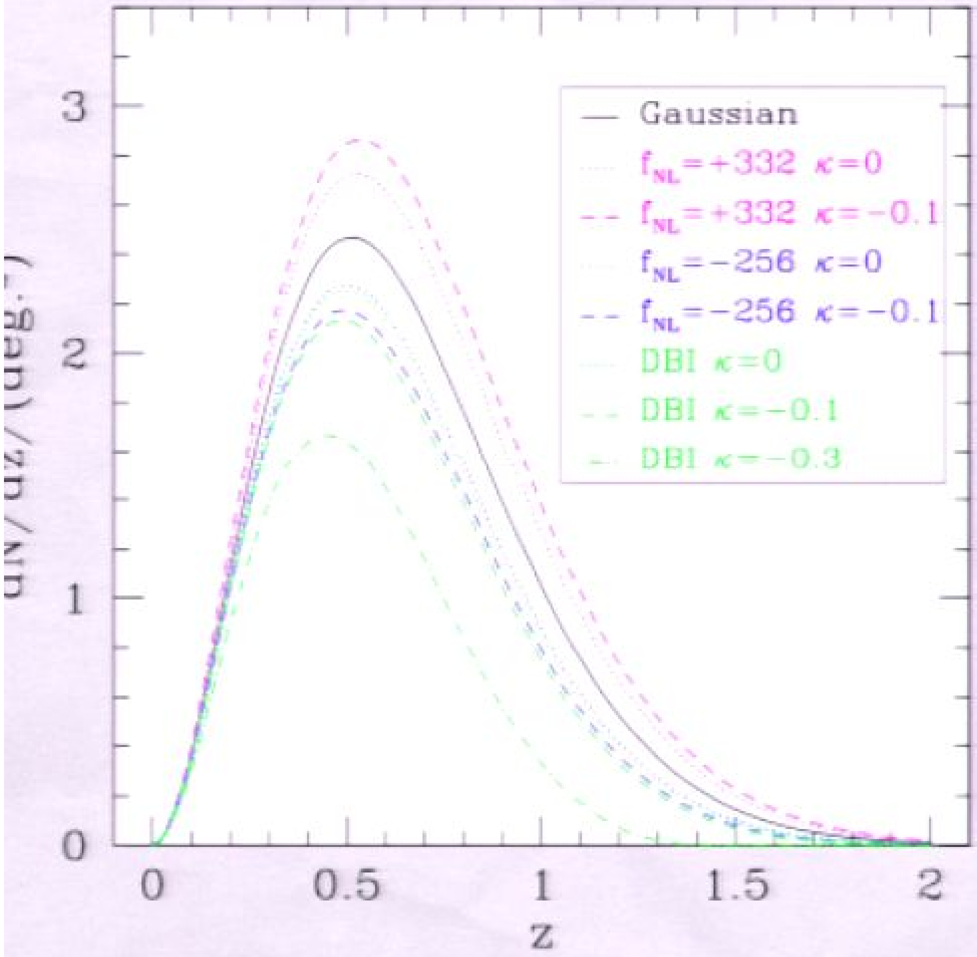


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

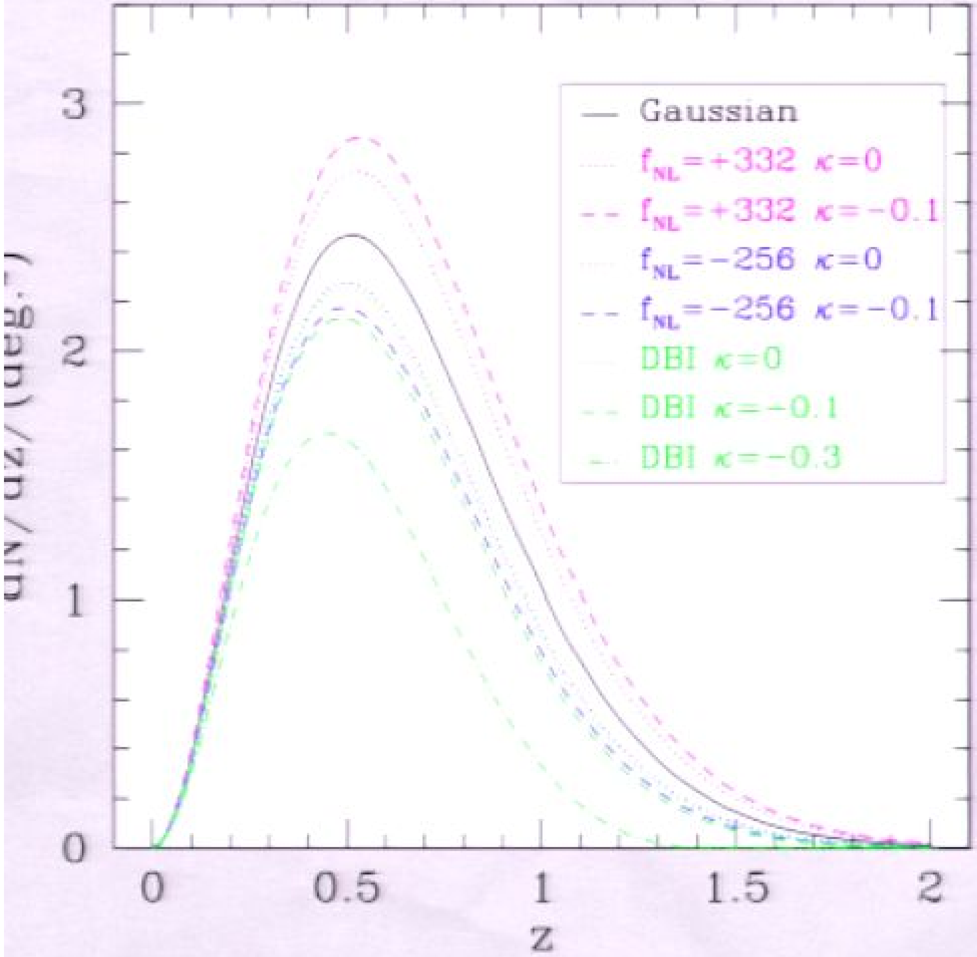


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

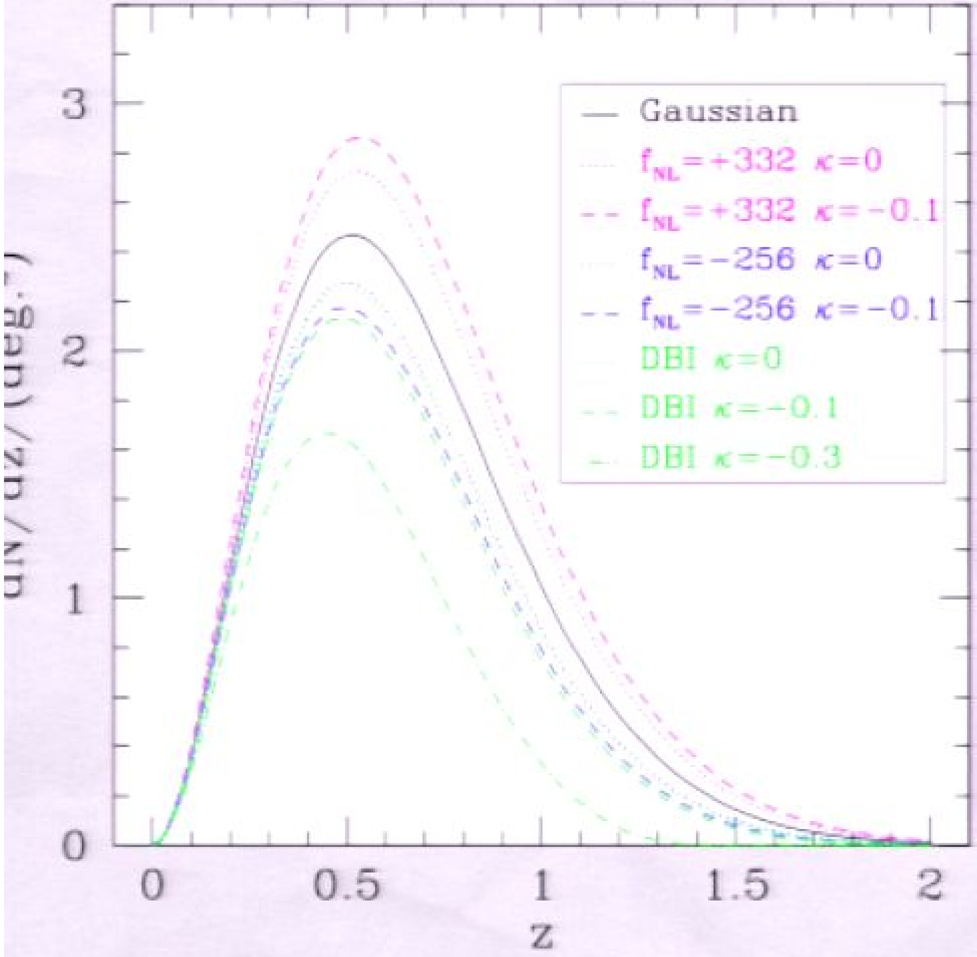


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

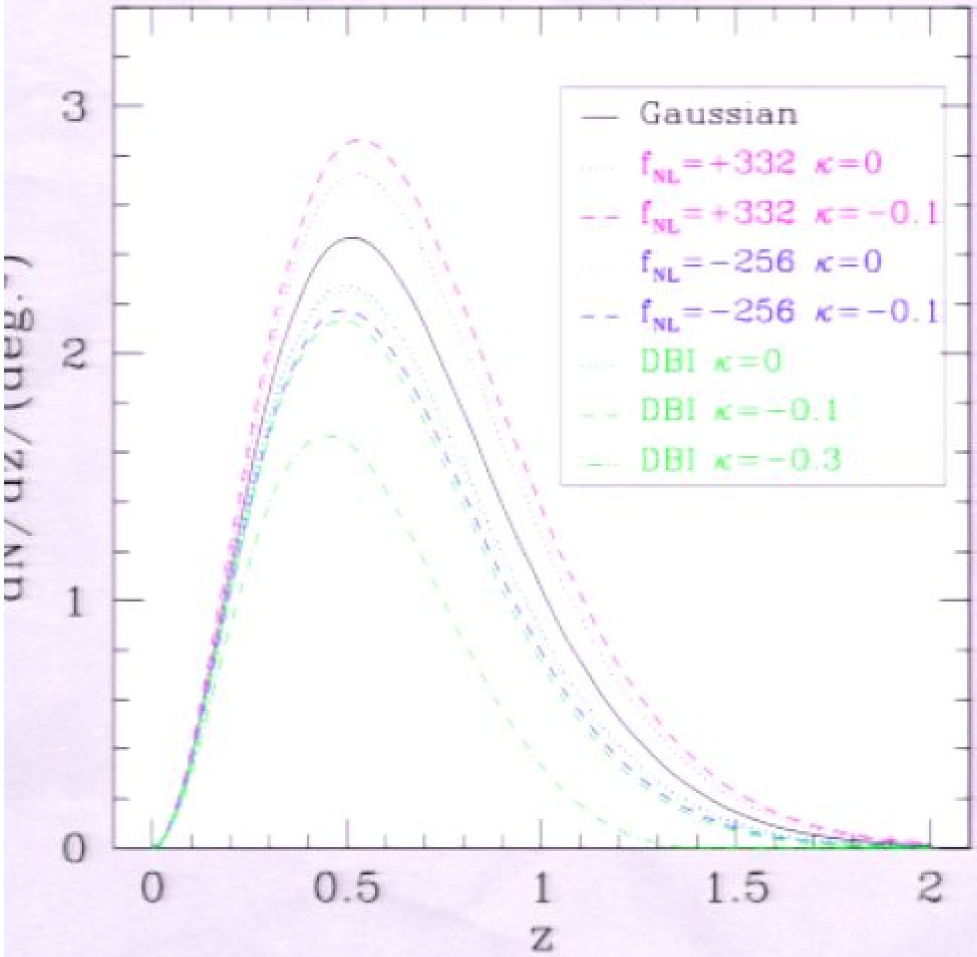


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

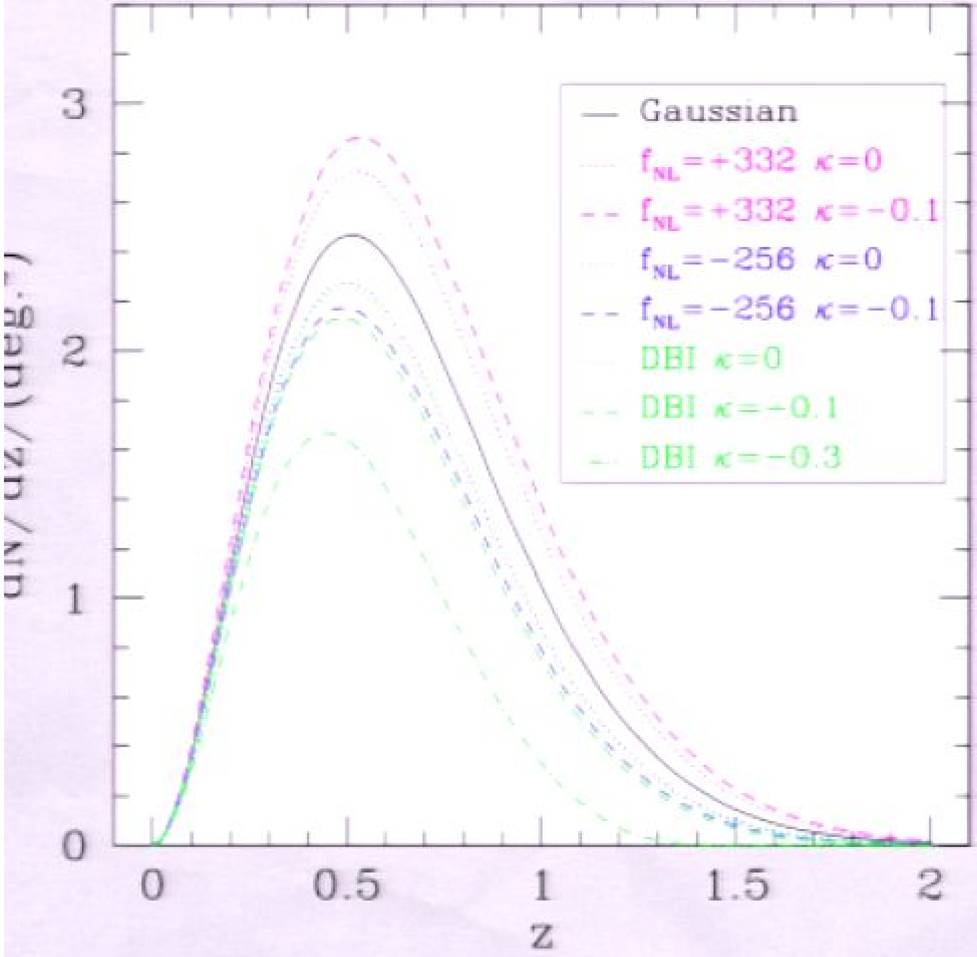


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

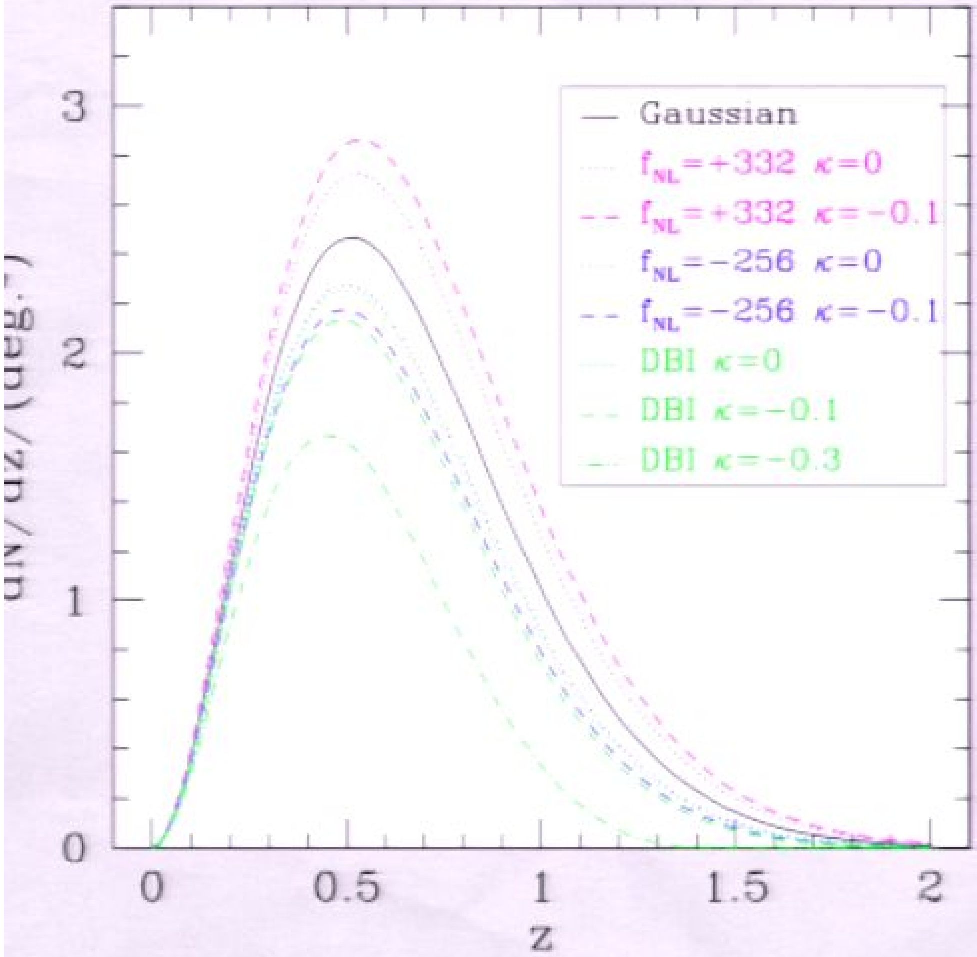


$$\frac{dN}{dz}(M>M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1}\times 10^{14}M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

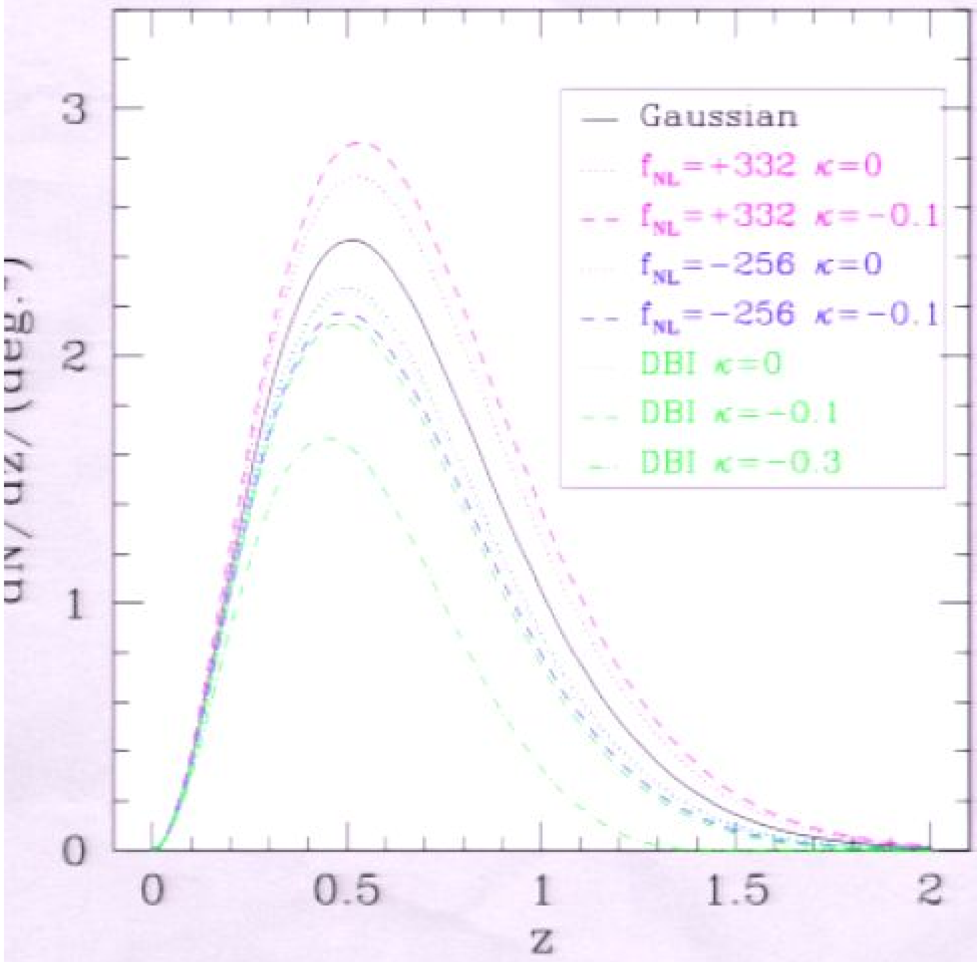


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM\frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

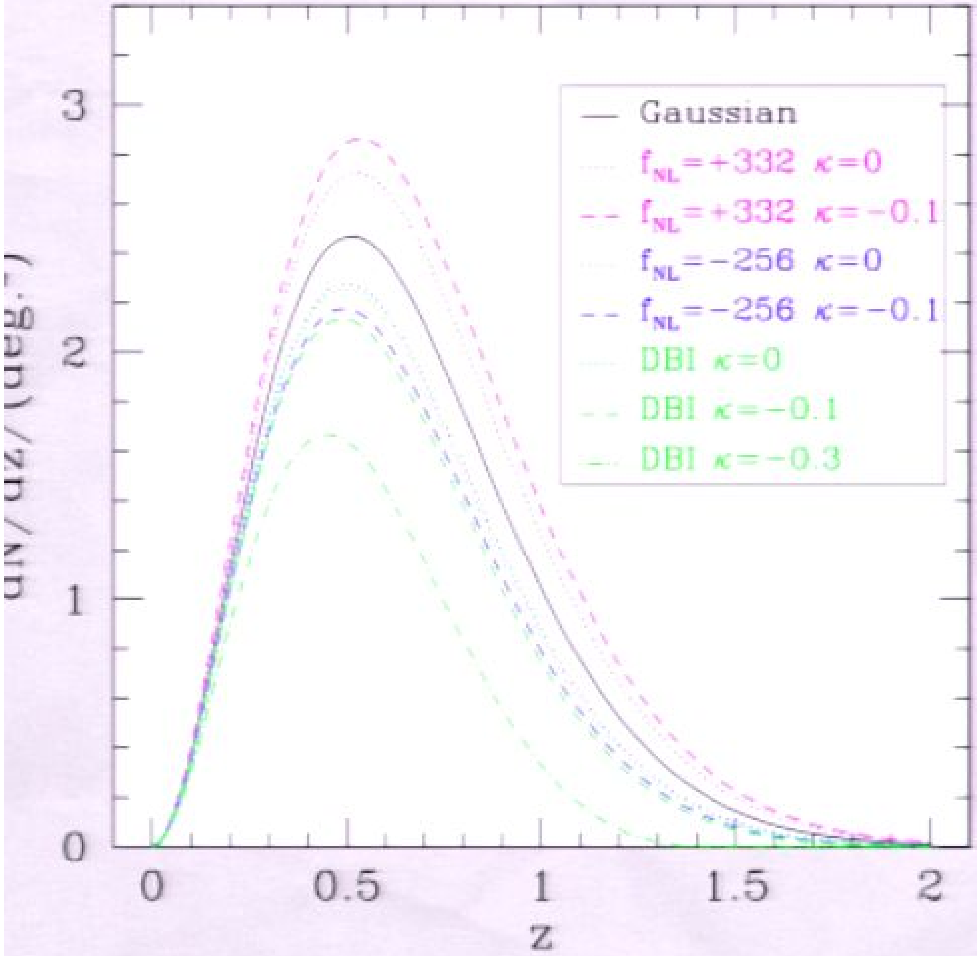


$$\boxed{\frac{dN}{dz}(M>M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM\frac{dn}{dM}(M,z)}$$

$$\boxed{\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2}$$

$$\boxed{M_{lim} = 1.75h^{-1}\times 10^{14}M_{sun}}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

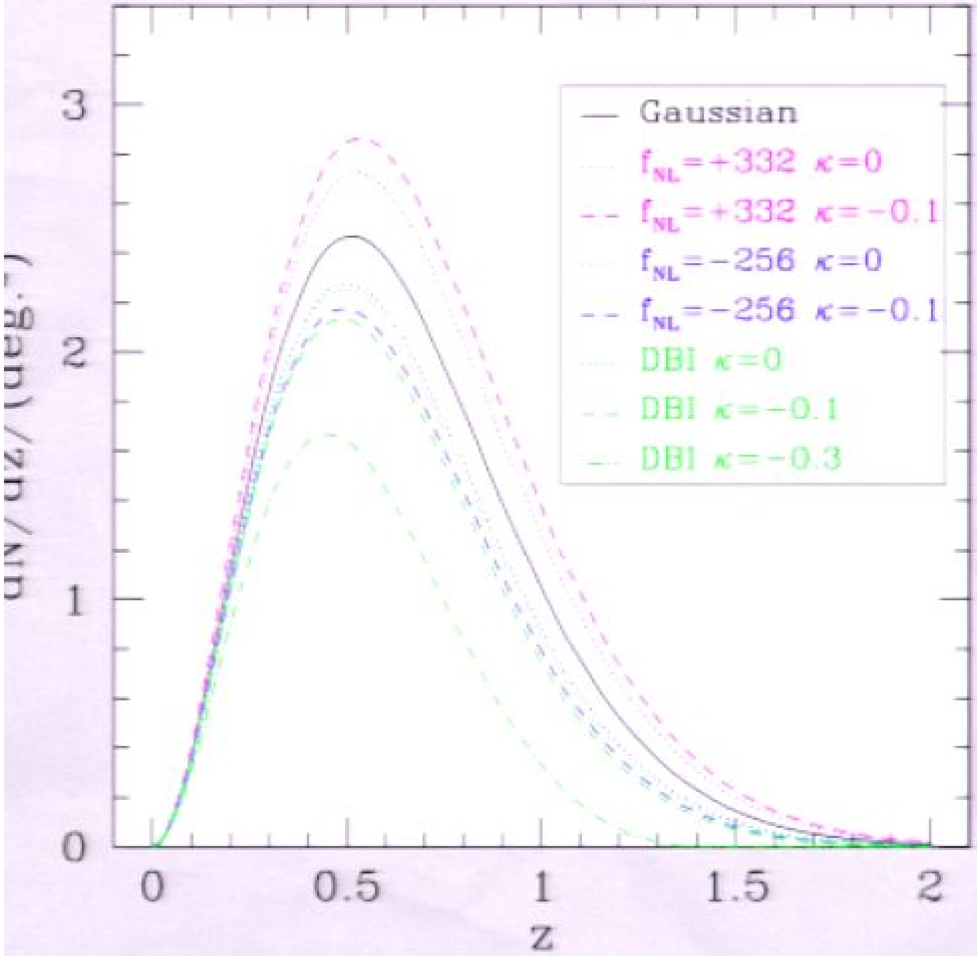


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

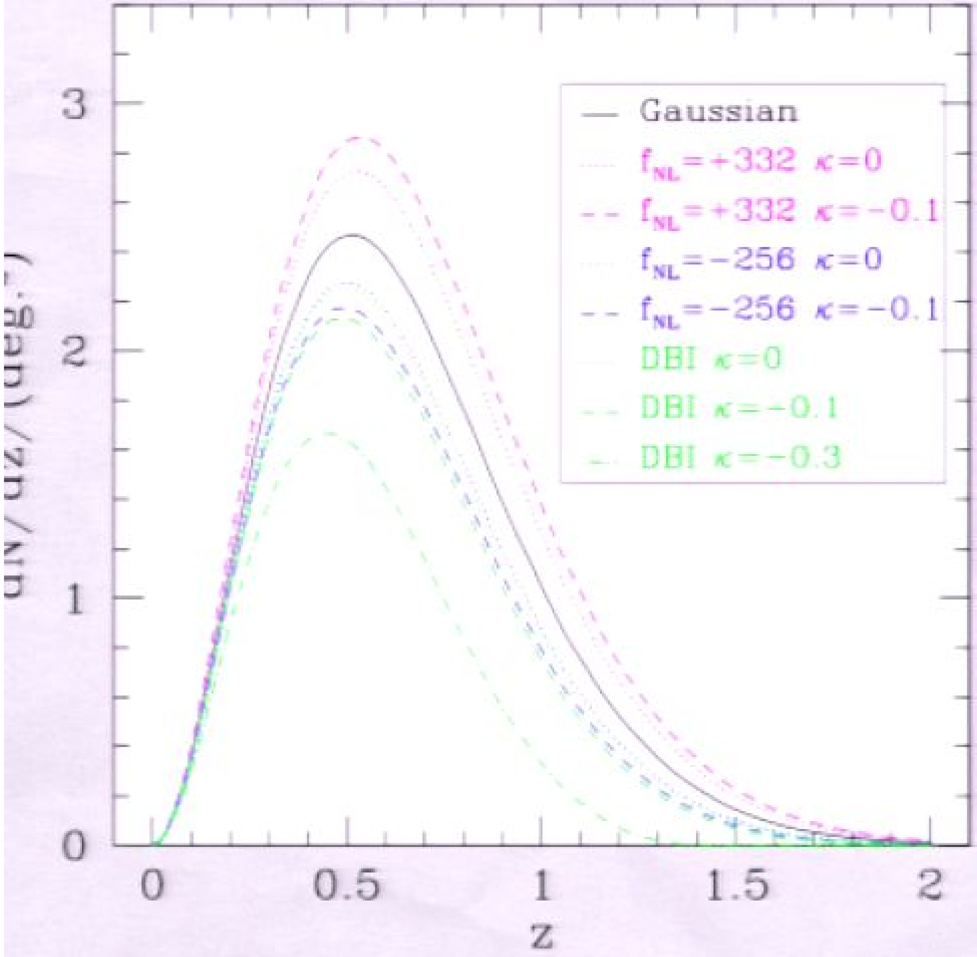


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z



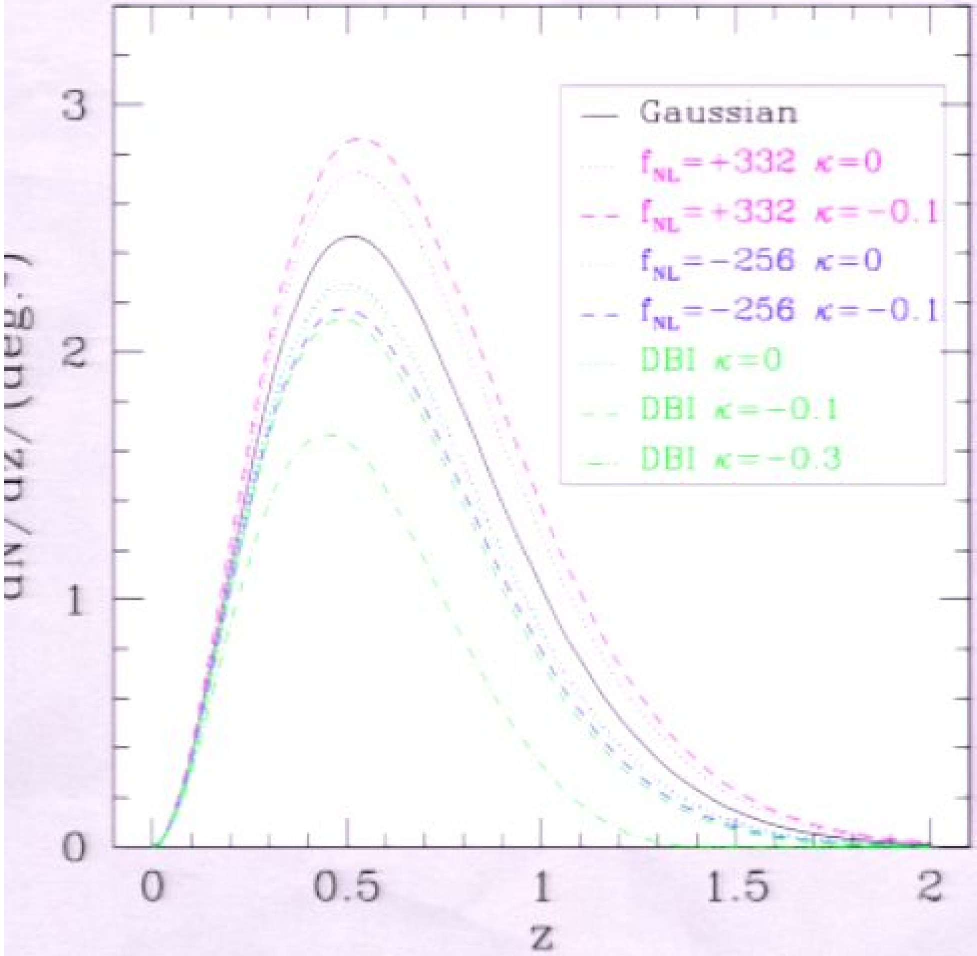
$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

PI, Oct. 30, 2007

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

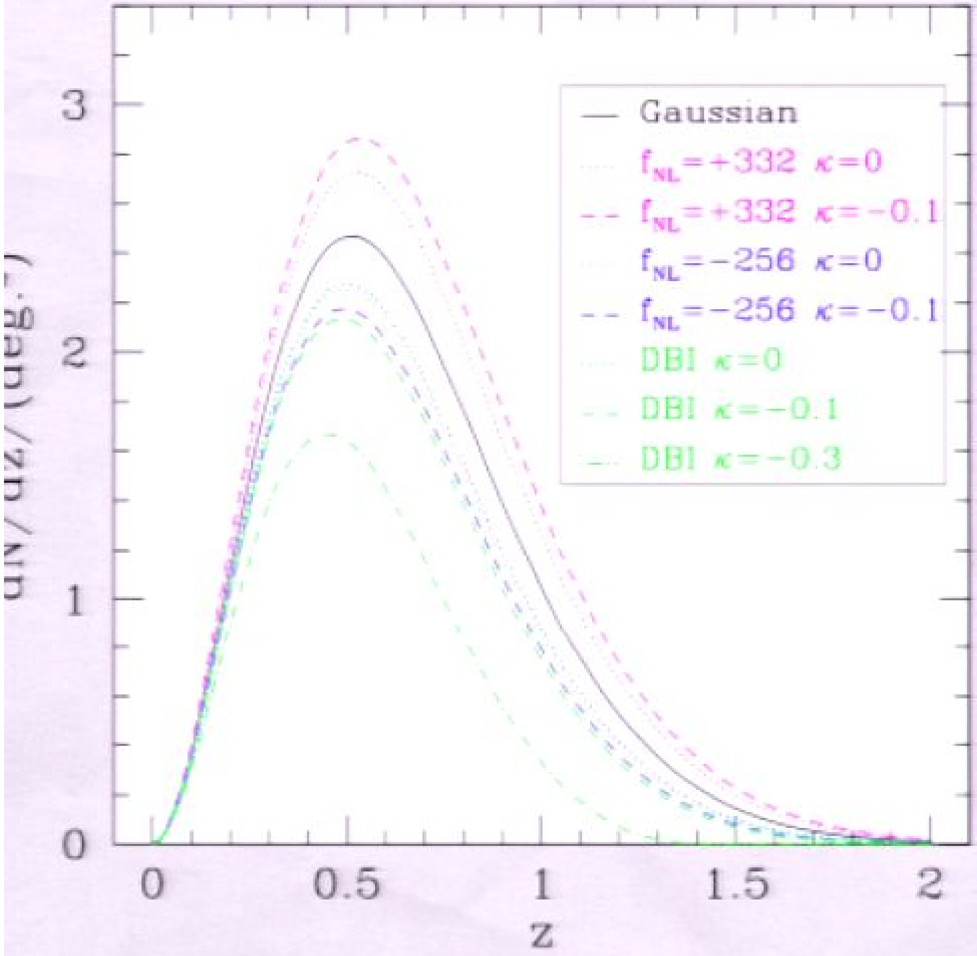


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z



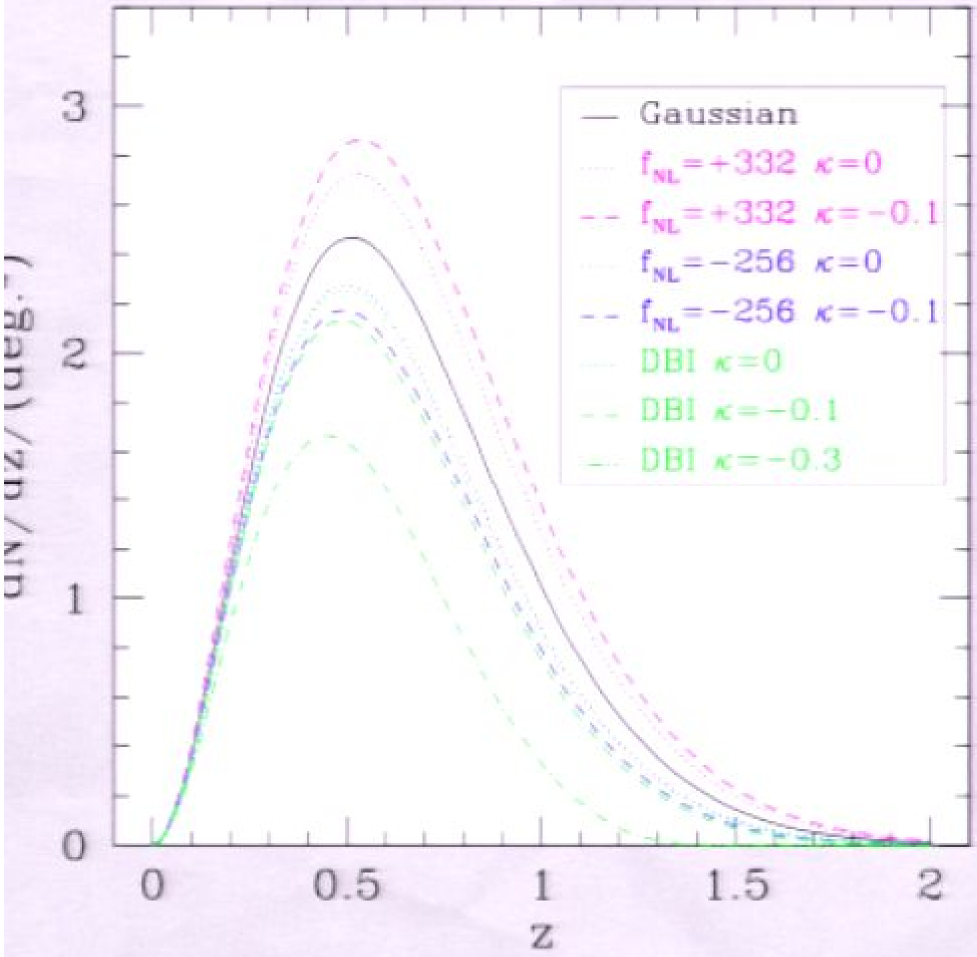
$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

PI, Oct. 30, 2007

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

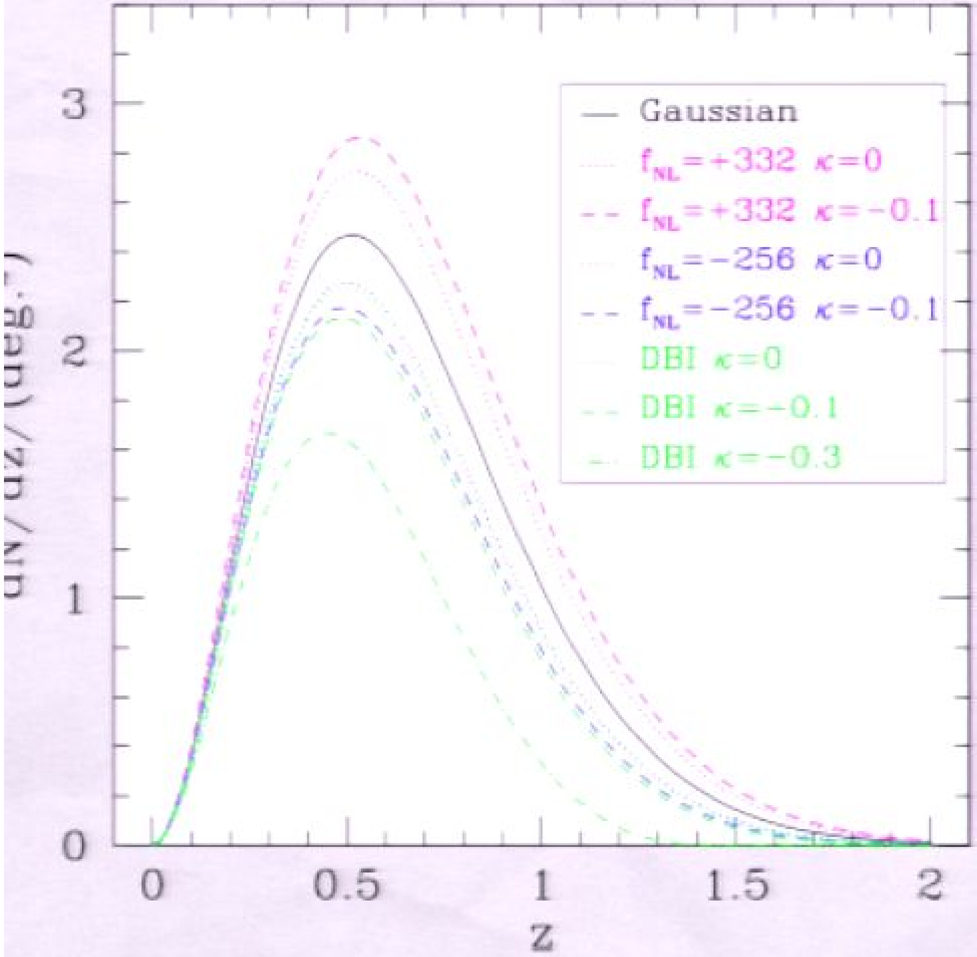


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

NUMBER OF MASSIVE CLUSTERS AT REDSHIFT Z

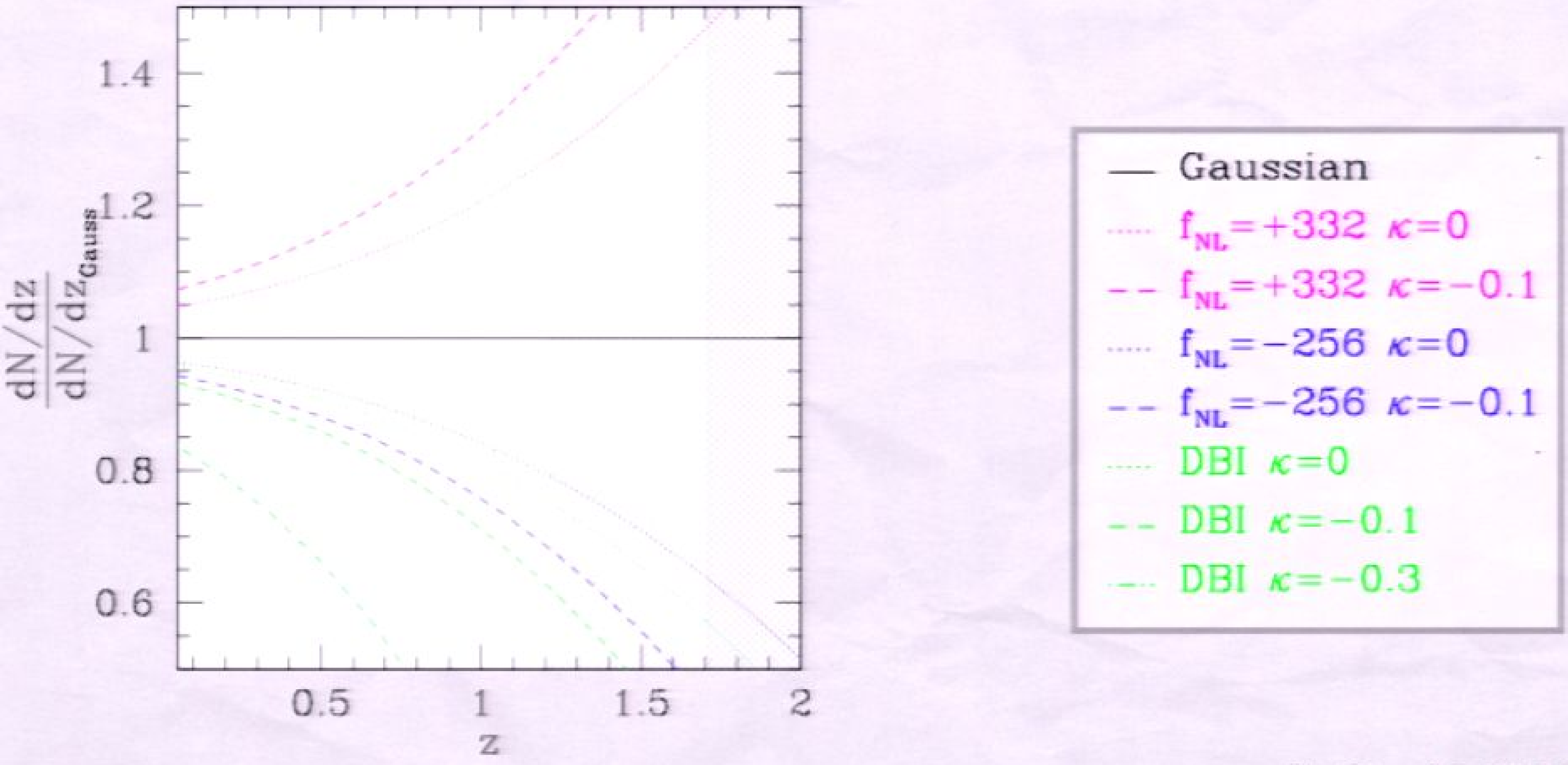


$$\frac{dN}{dz}(M > M_{lim}) = f_{sky}\frac{dV(z)}{dz}\int_{M_{min}}^{\infty} dM \frac{dn}{dM}(M,z)$$

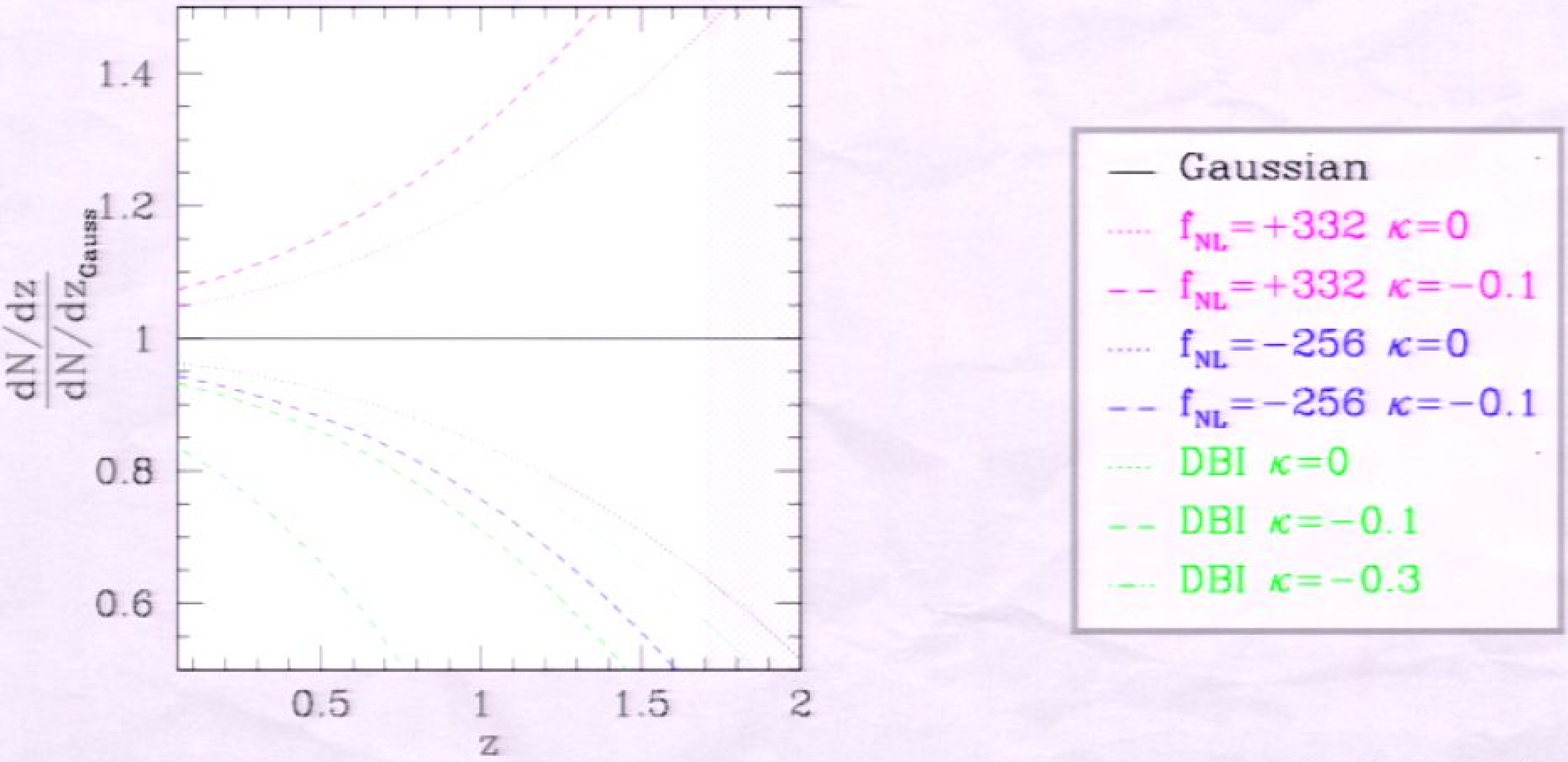
$$\frac{dV}{dz} = \frac{4\pi}{H(z)}\left[\int_0^z \frac{dz'}{H(z')}\right]^2$$

$$M_{lim} = 1.75h^{-1} \times 10^{14} M_{sun}$$ (SPT)

DEVIATION FROM GAUSSIAN

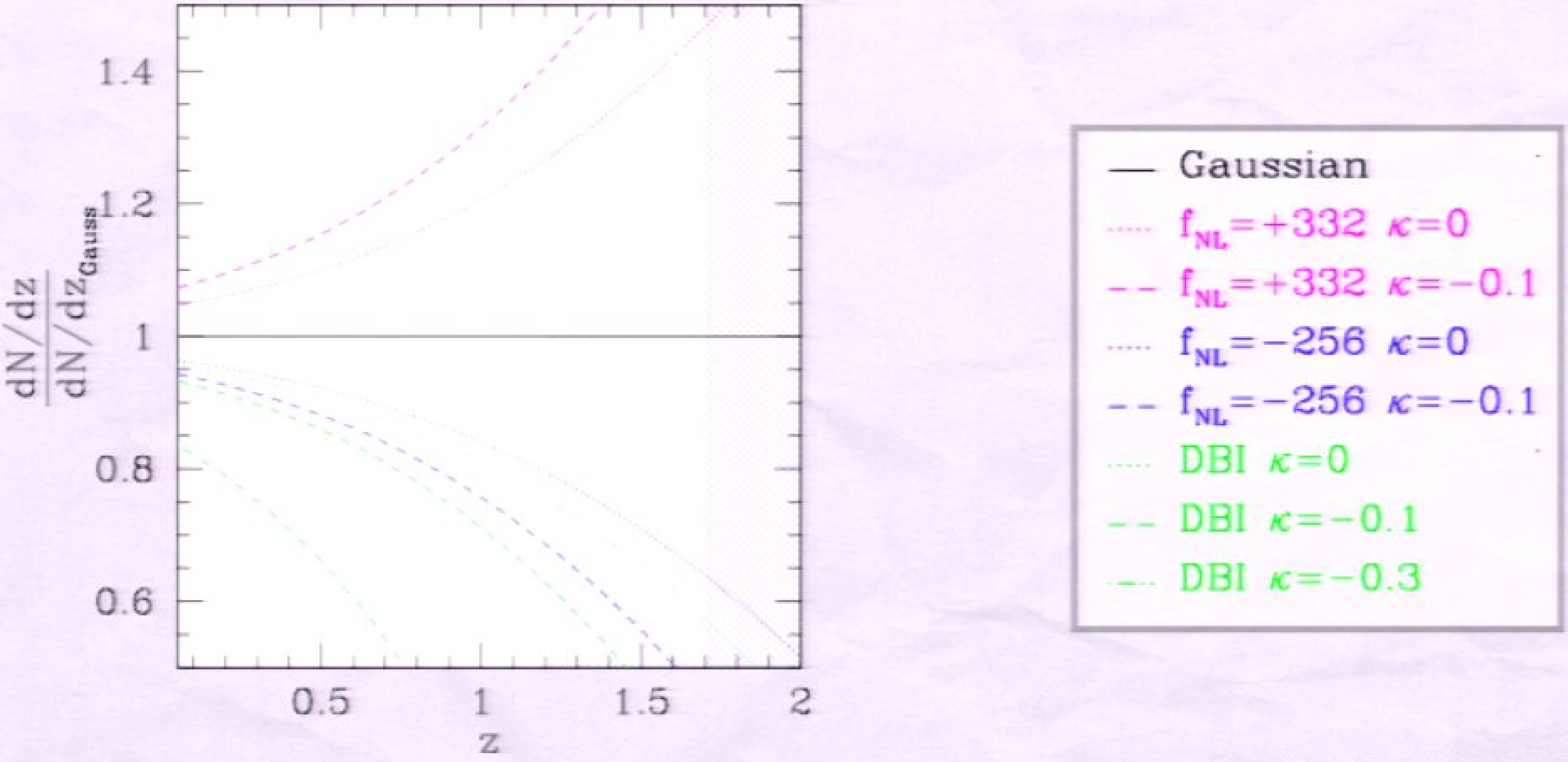


DEVIATION FROM GAUSSIAN



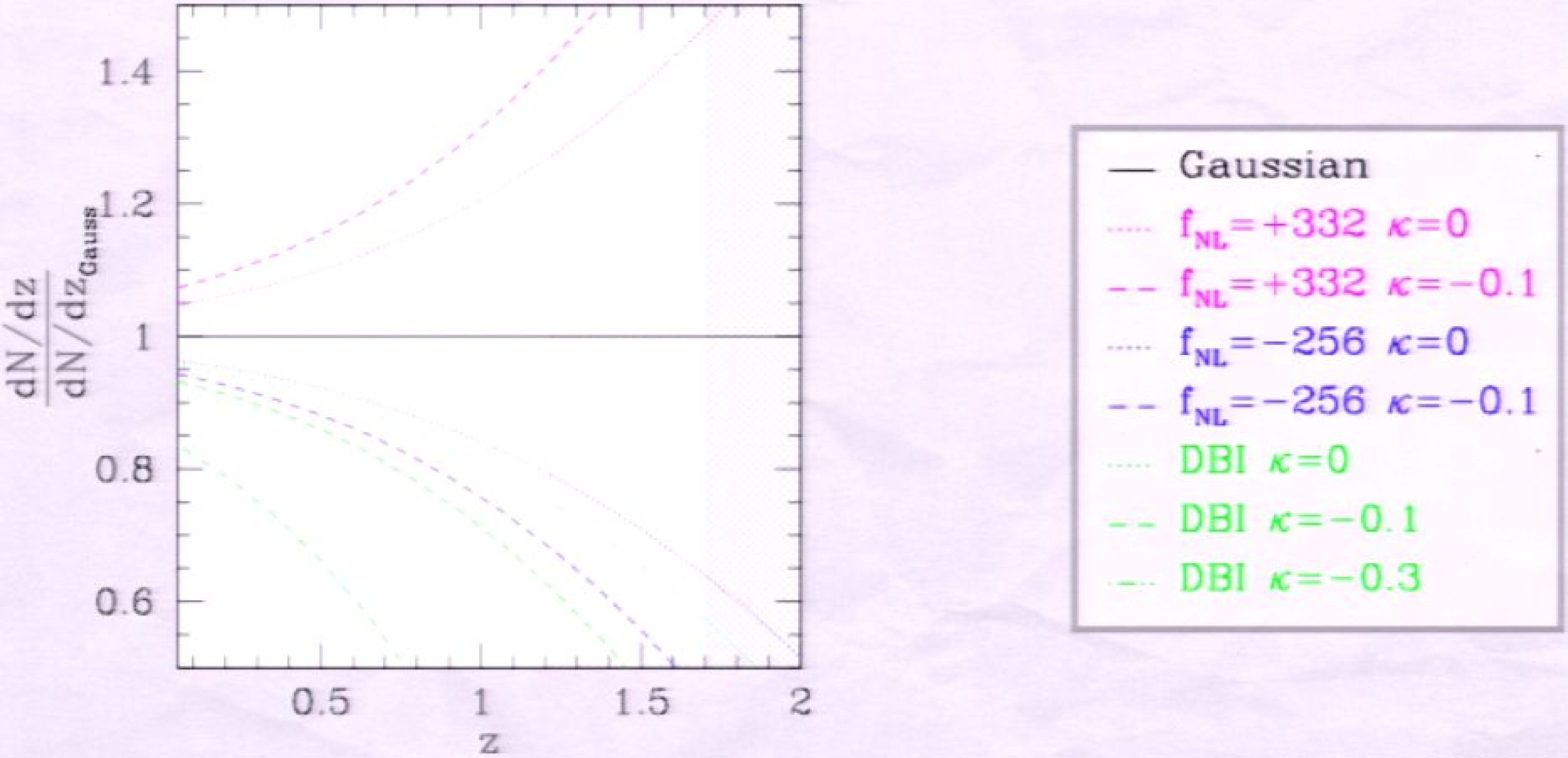
PI, Oct. 30, 2007

DEVIATION FROM GAUSSIAN

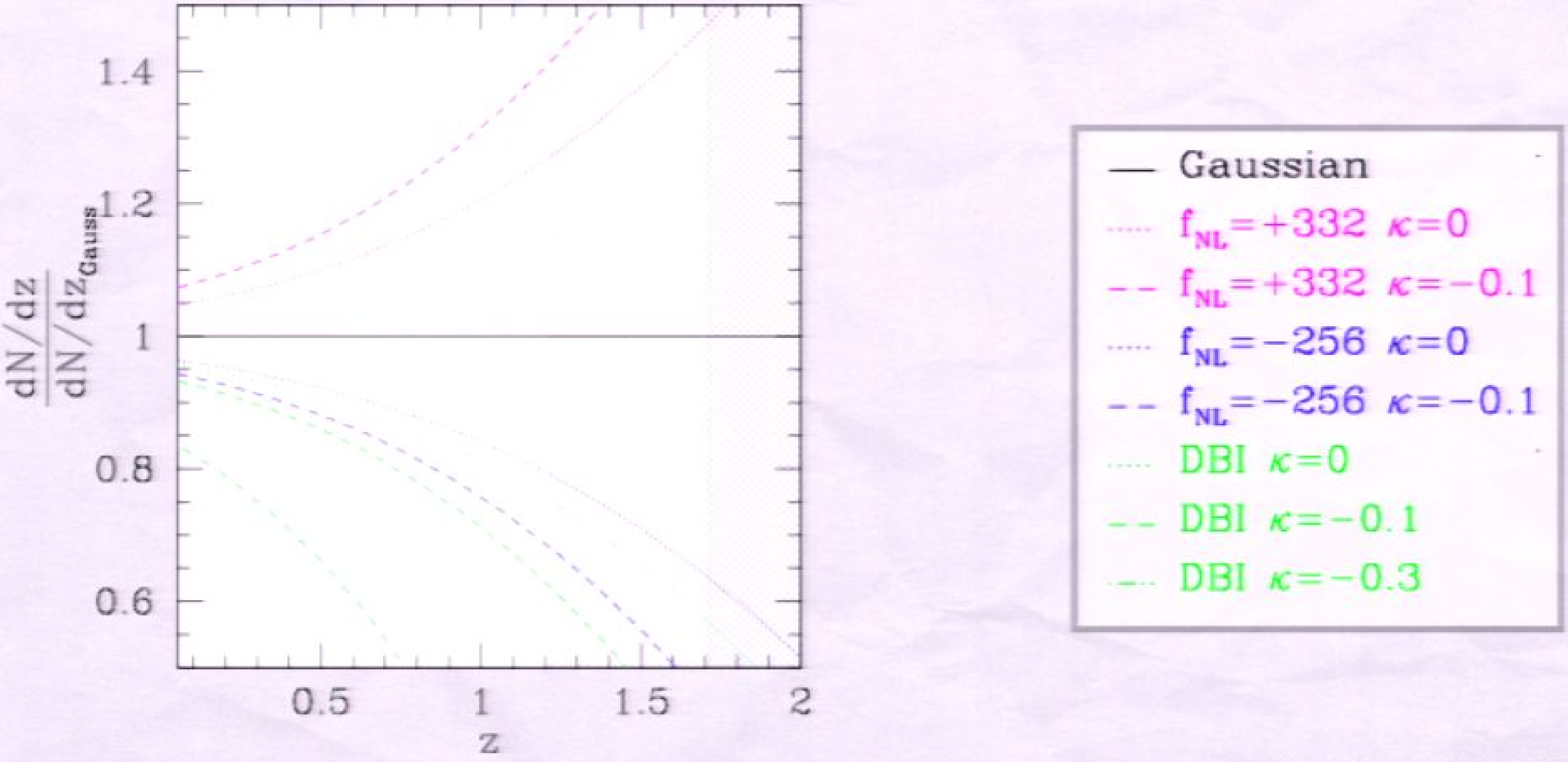


PI, Oct. 30, 2007

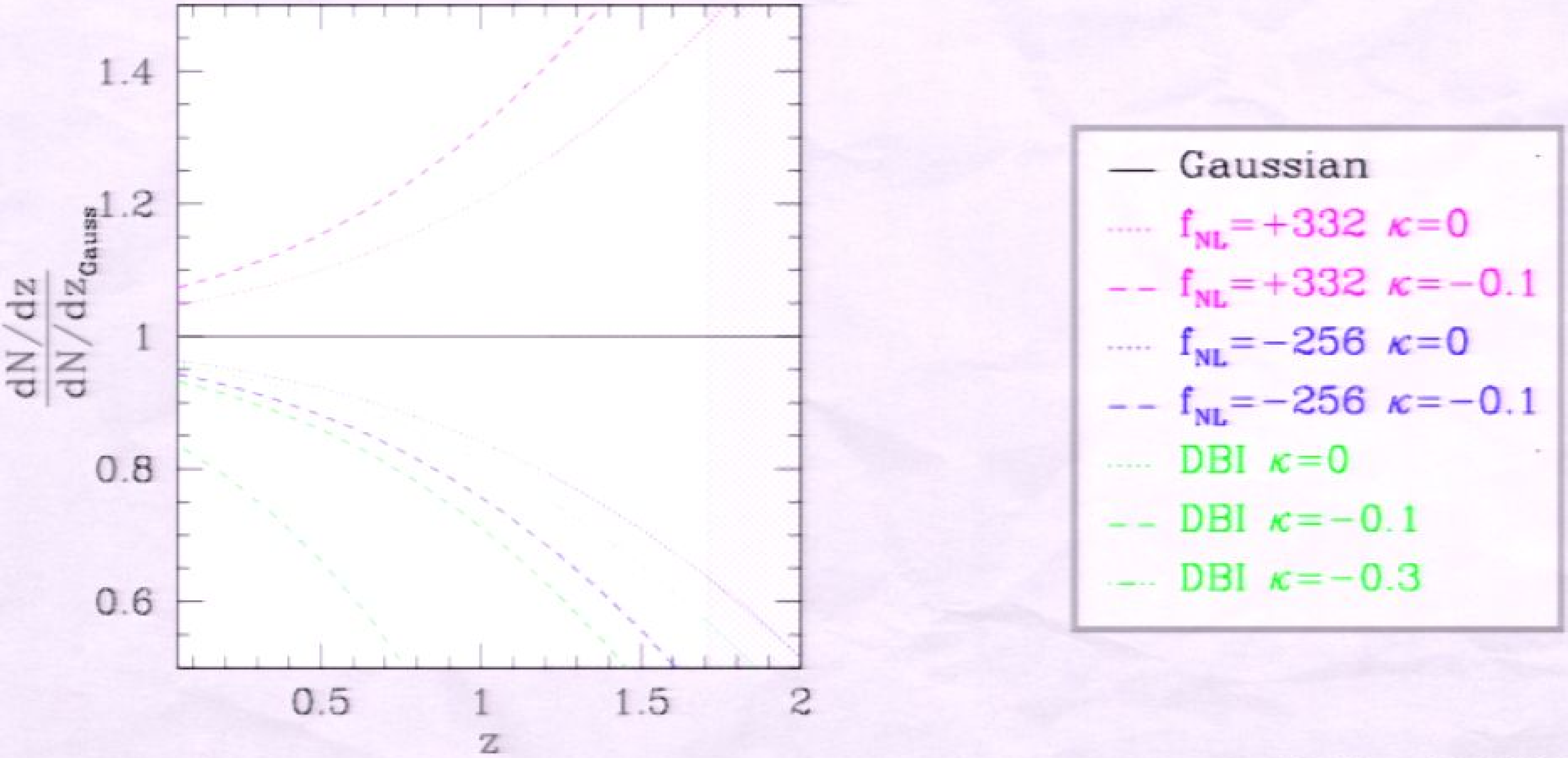
DEVIATION FROM GAUSSIAN



DEVIATION FROM GAUSSIAN

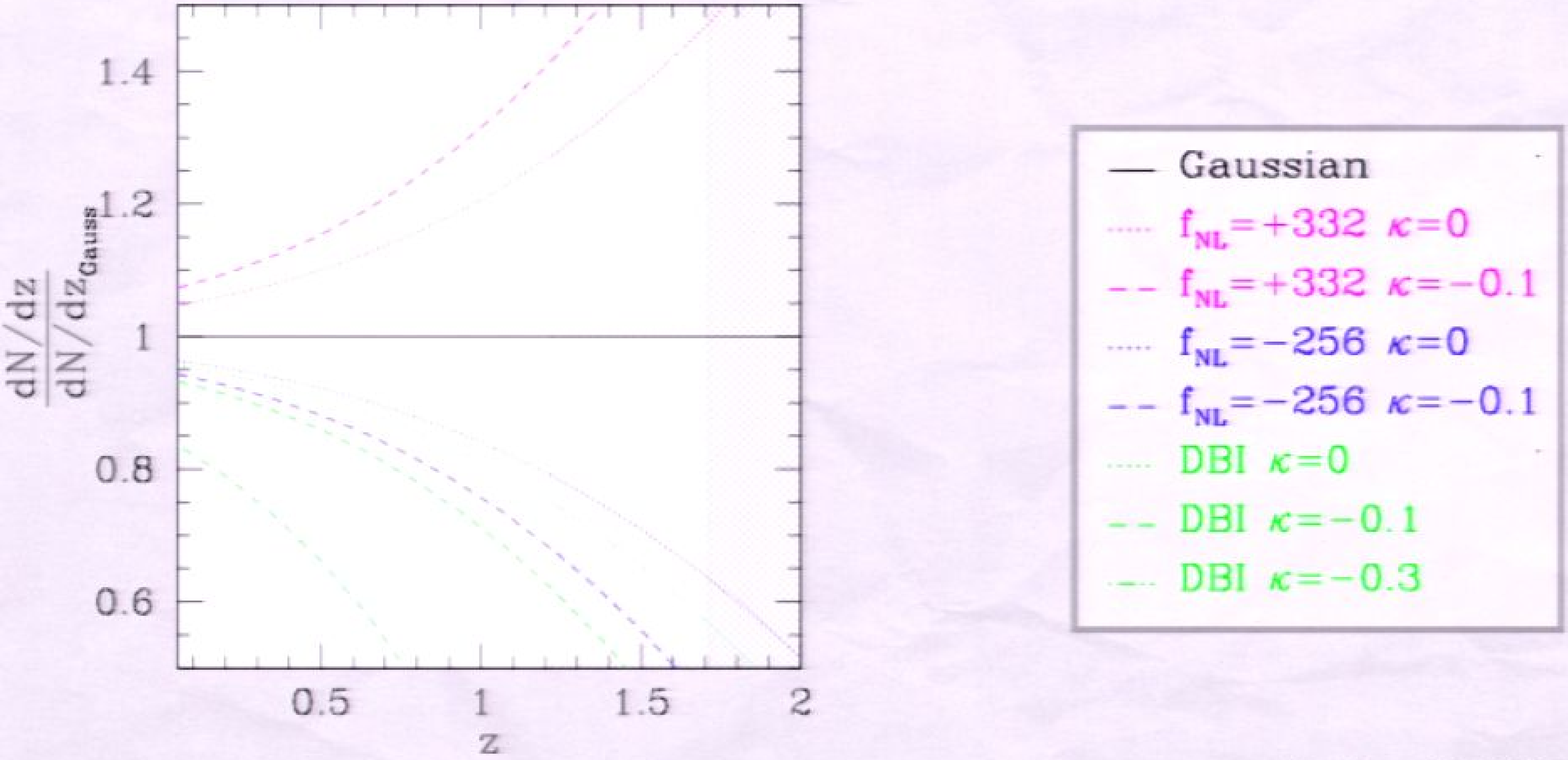


DEVIATION FROM GAUSSIAN



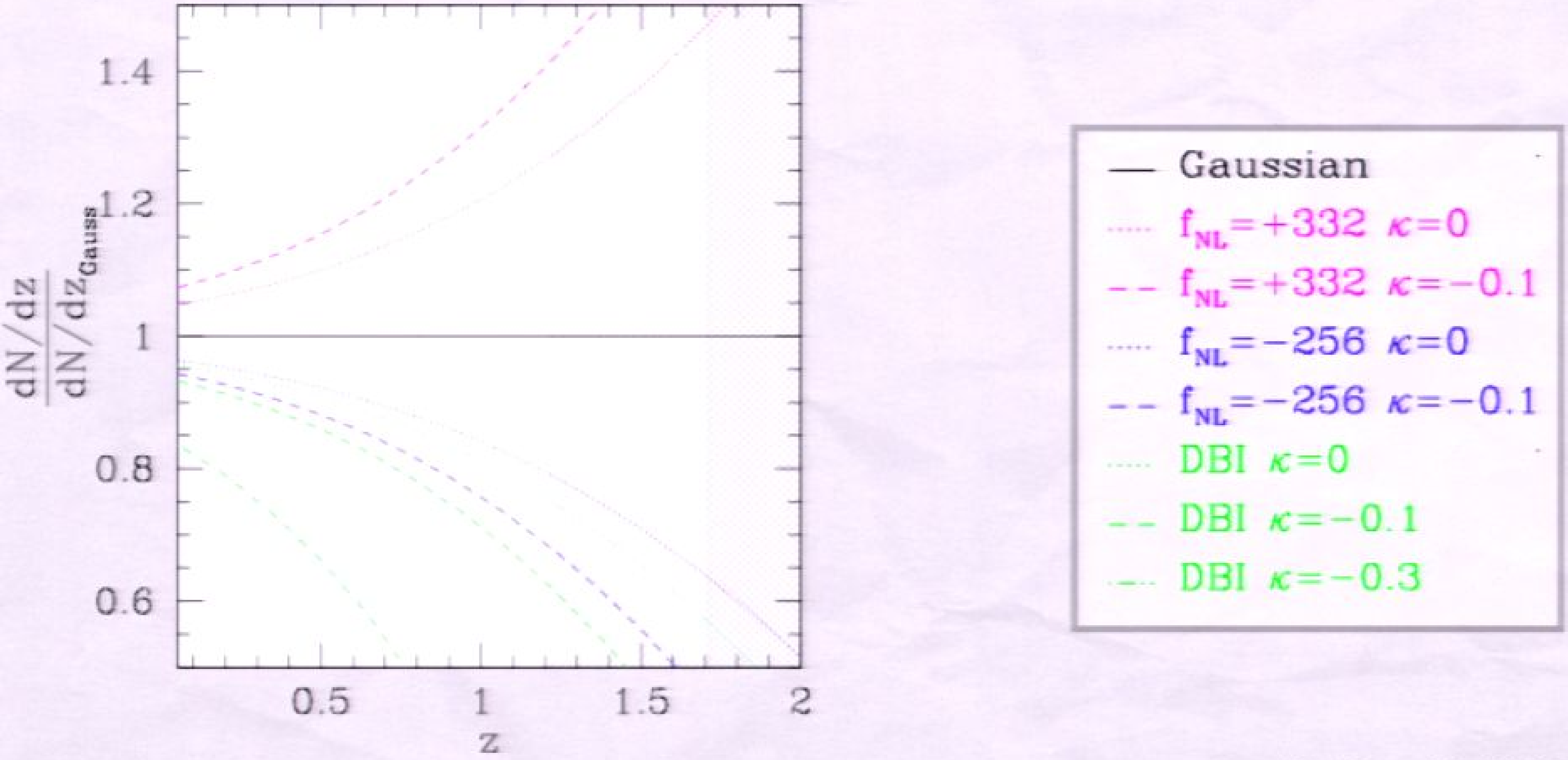
PI, Oct. 30, 2007

DEVIATION FROM GAUSSIAN



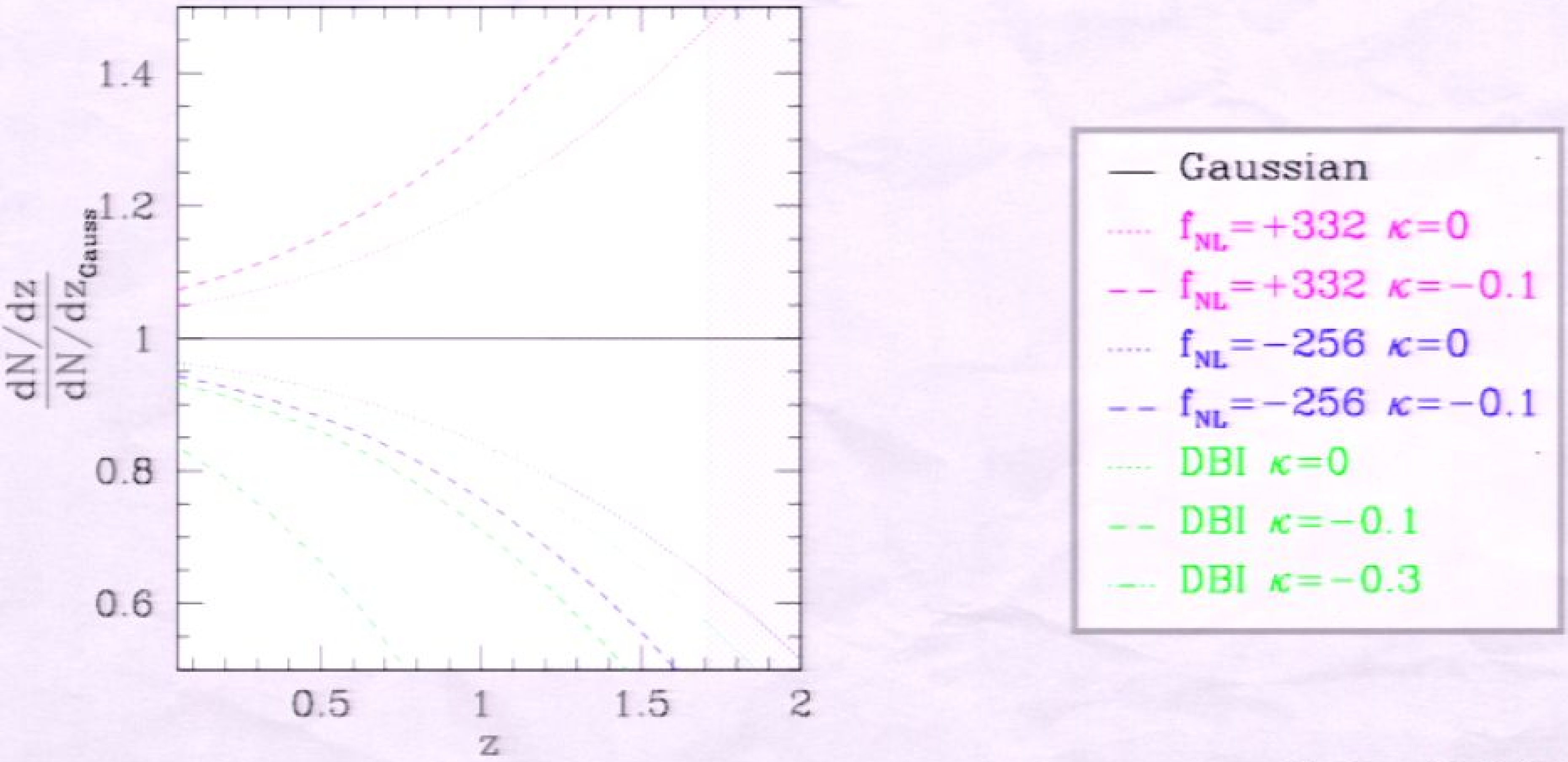
PI, Oct. 30, 2007

DEVIATION FROM GAUSSIAN

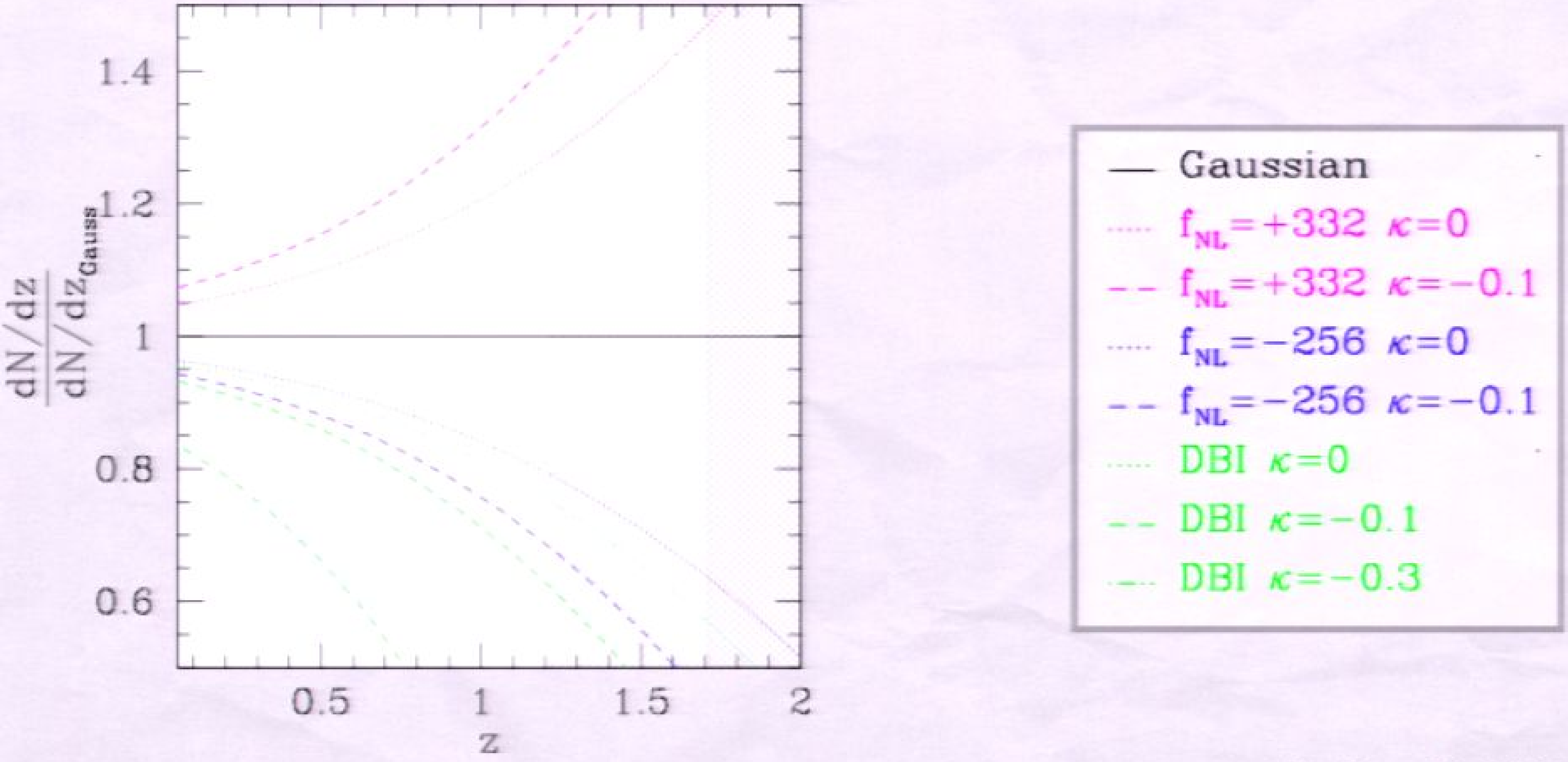


PI, Oct. 30, 2007

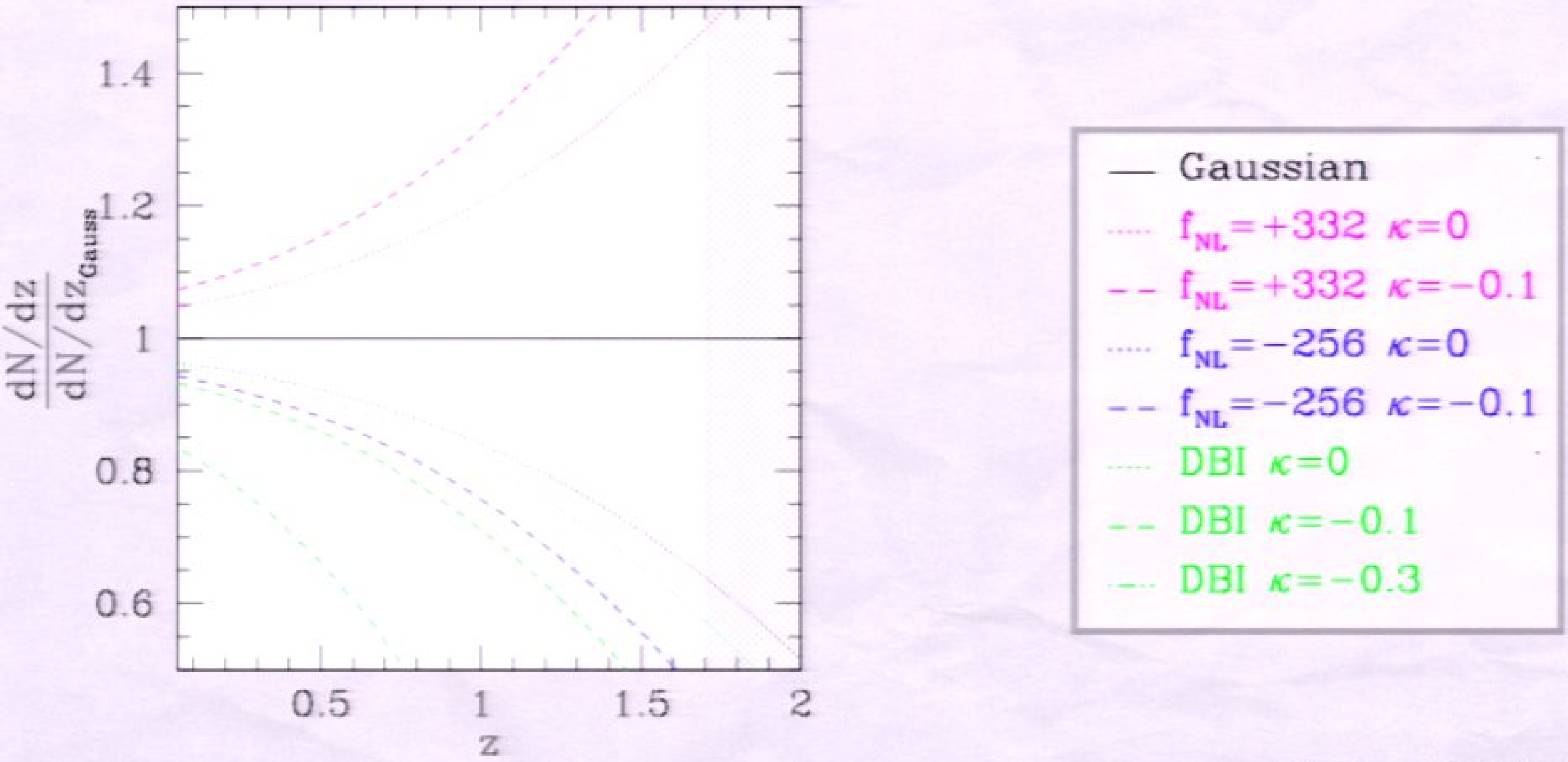
DEVIATION FROM GAUSSIAN



DEVIATION FROM GAUSSIAN

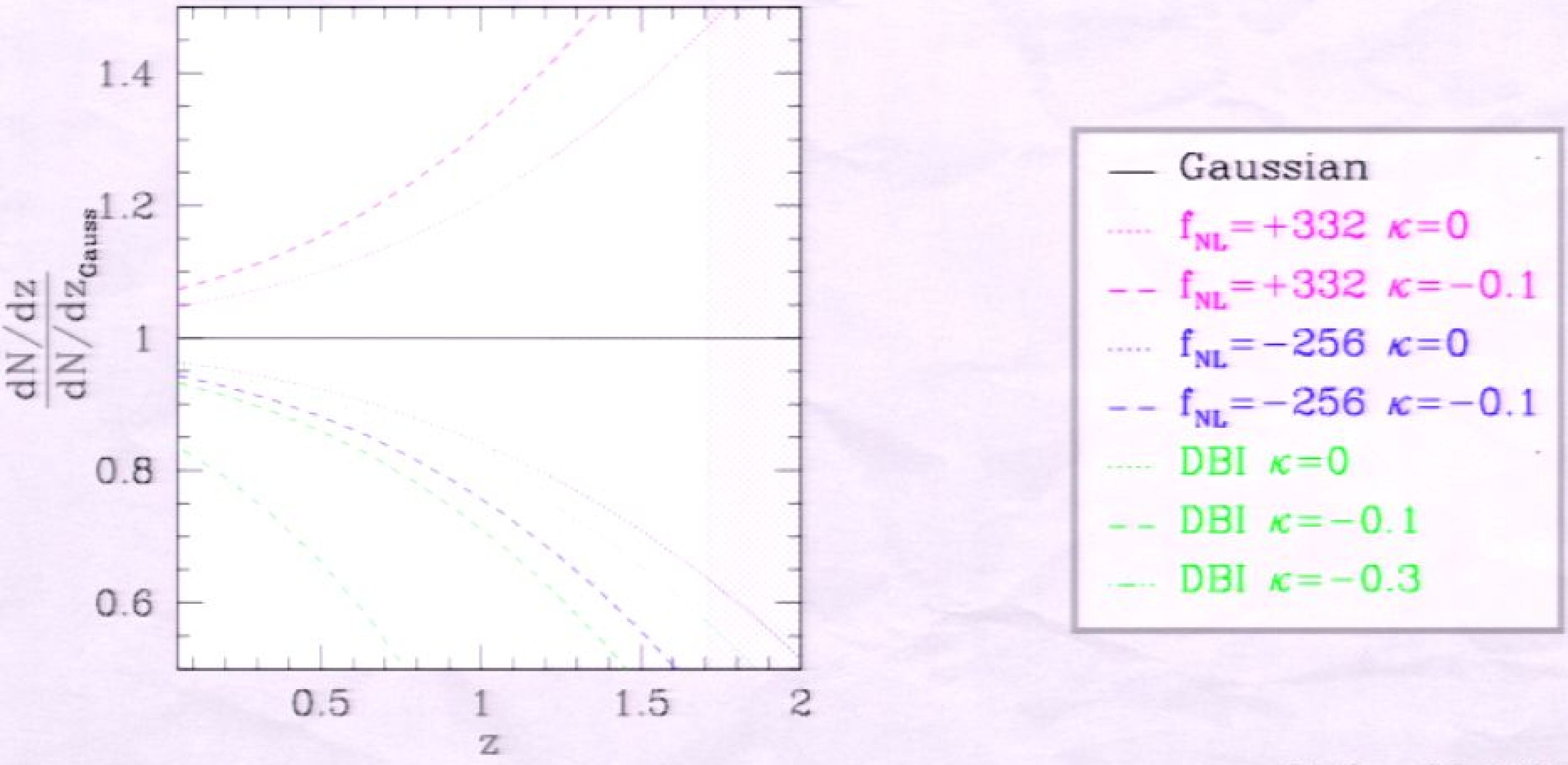


DEVIATION FROM GAUSSIAN

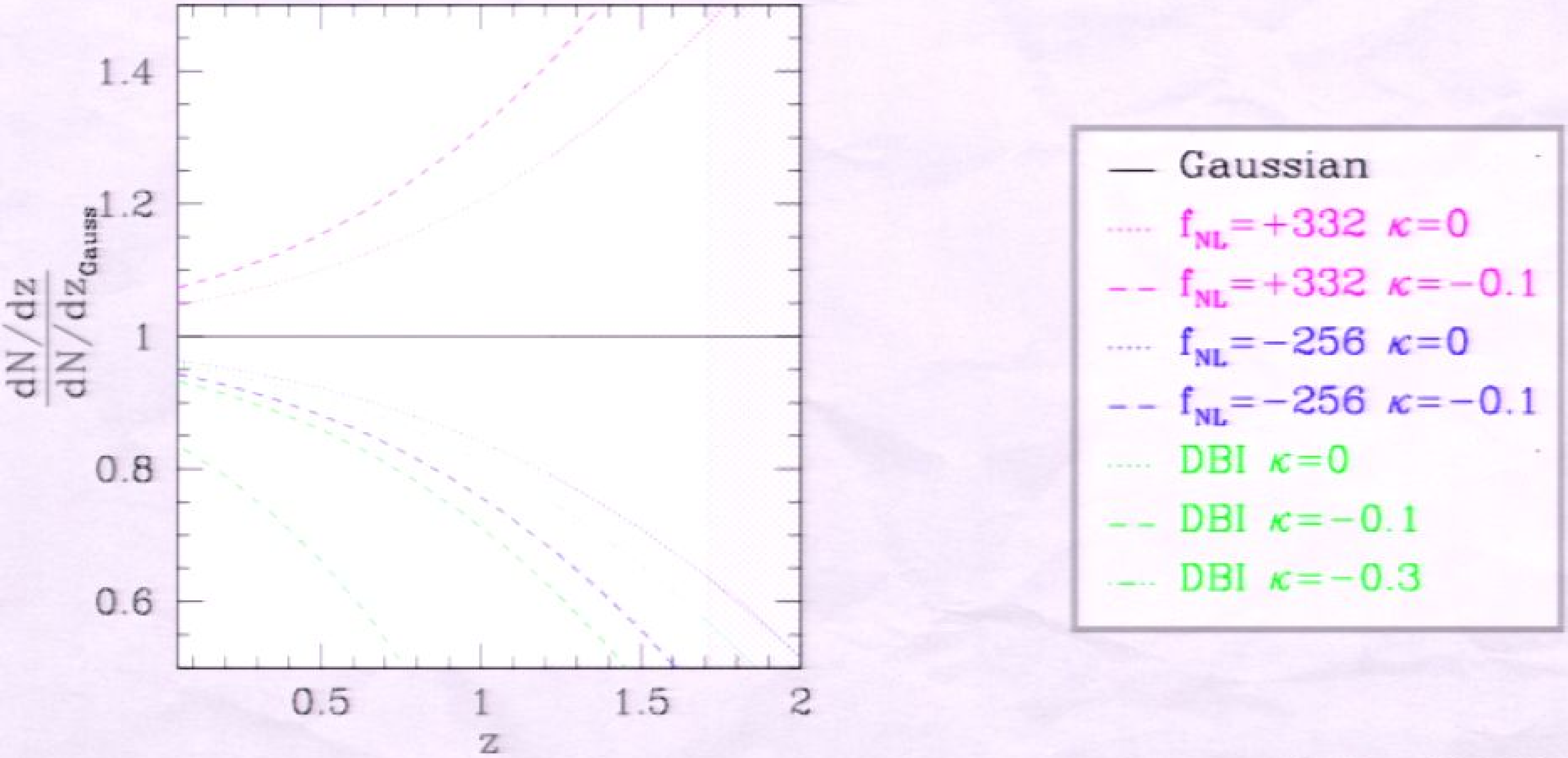


PI, Oct. 30, 2007

DEVIATION FROM GAUSSIAN

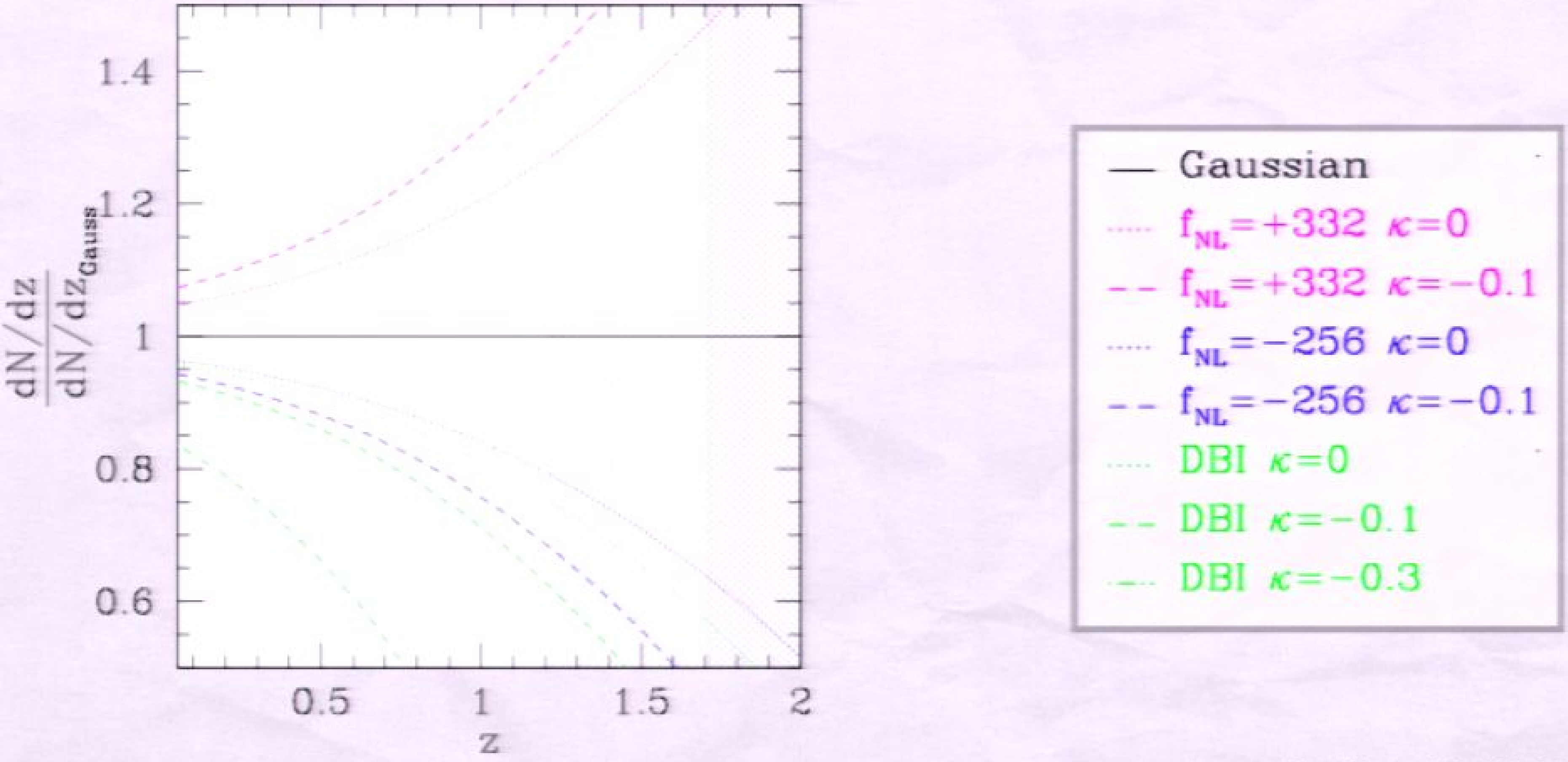


DEVIATION FROM GAUSSIAN



PI, Oct. 30, 2007

DEVIATION FROM GAUSSIAN



SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

(Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

(Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

(Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

(Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

(Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

PI, Oct. 30, 2007

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

(Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

(Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

PI, Oct. 30, 2007

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

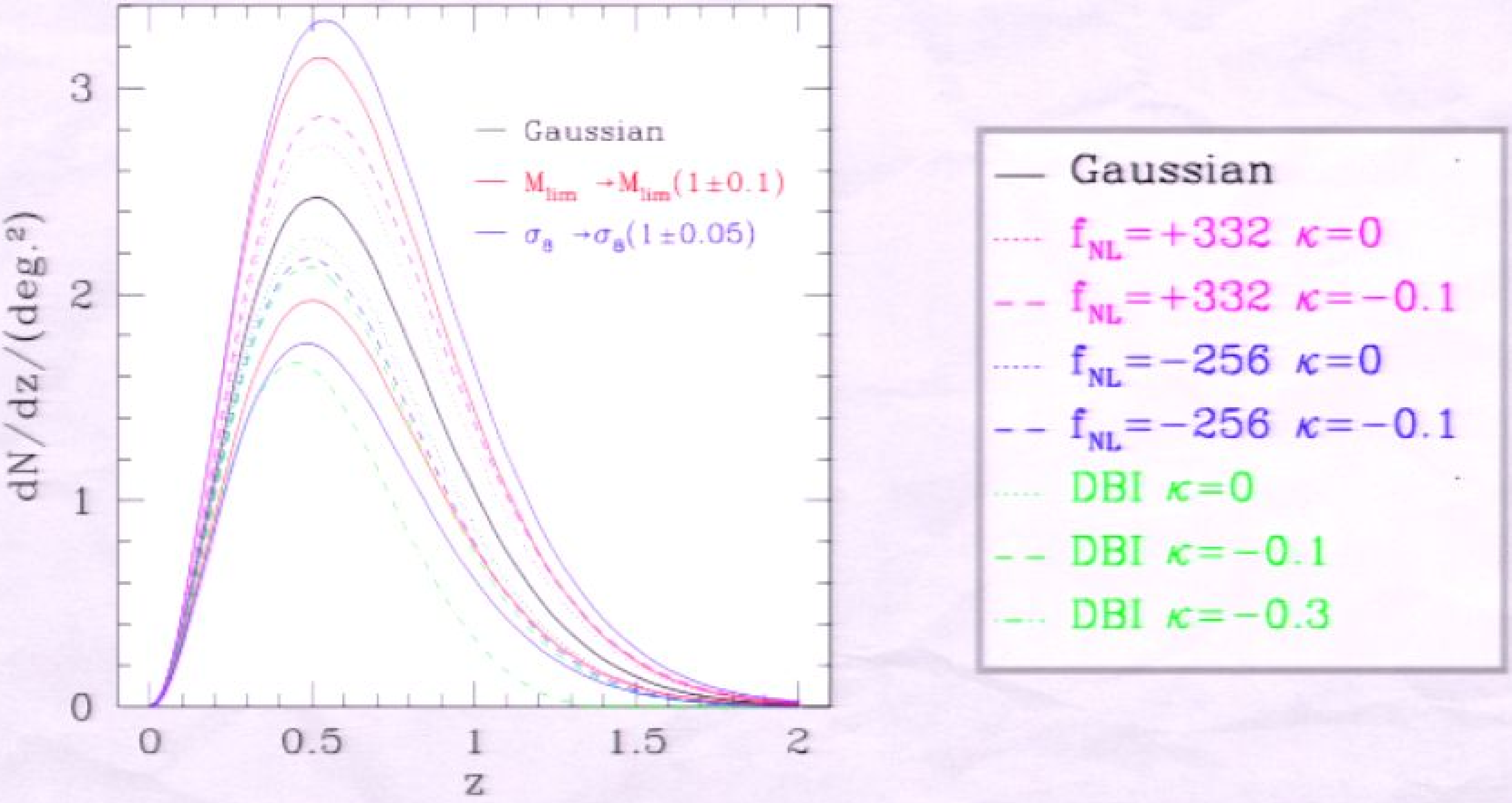
  (Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

SOME CONCERNS...

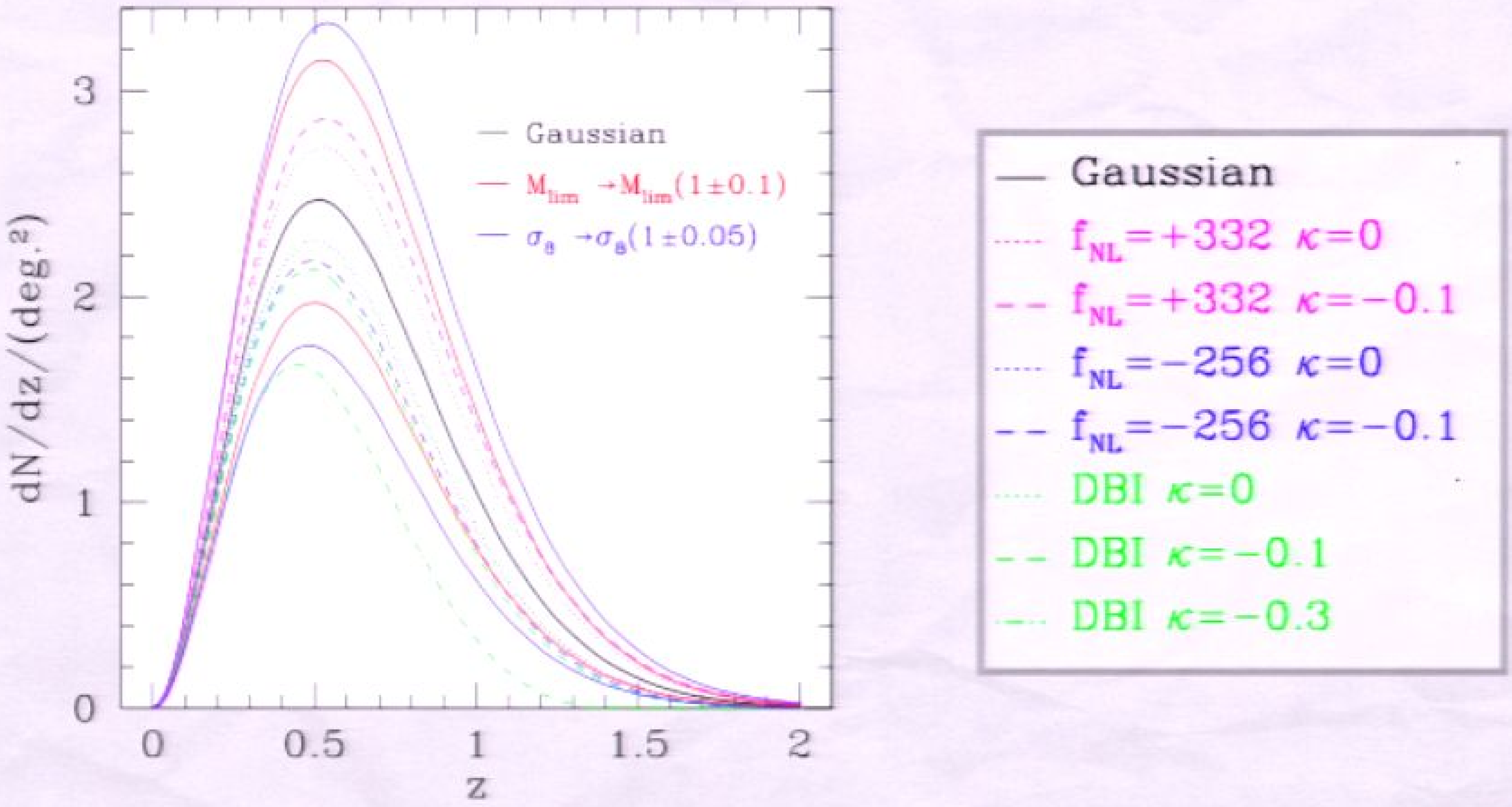
- Need to know cluster mass well
- Number of clusters is very sensitive to σ_8

(Analysis with scale-independent NG and dark energy done by Sefusatti et al, 2006; Mantz et al with X-ray detected clusters)

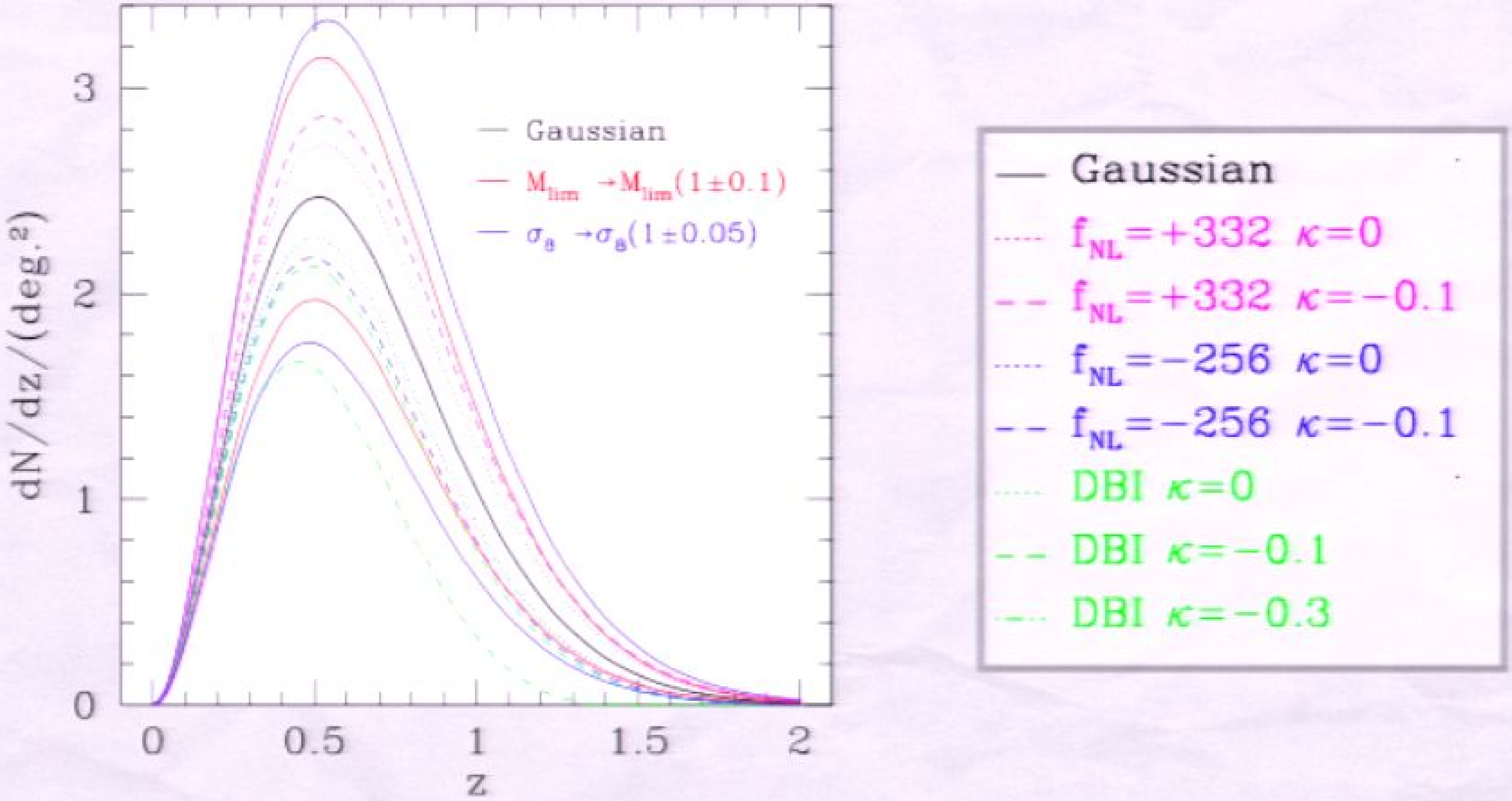
WITH MASS AND σ_8 UNCERTAINTY



WITH MASS AND σ_8 UNCERTAINTY

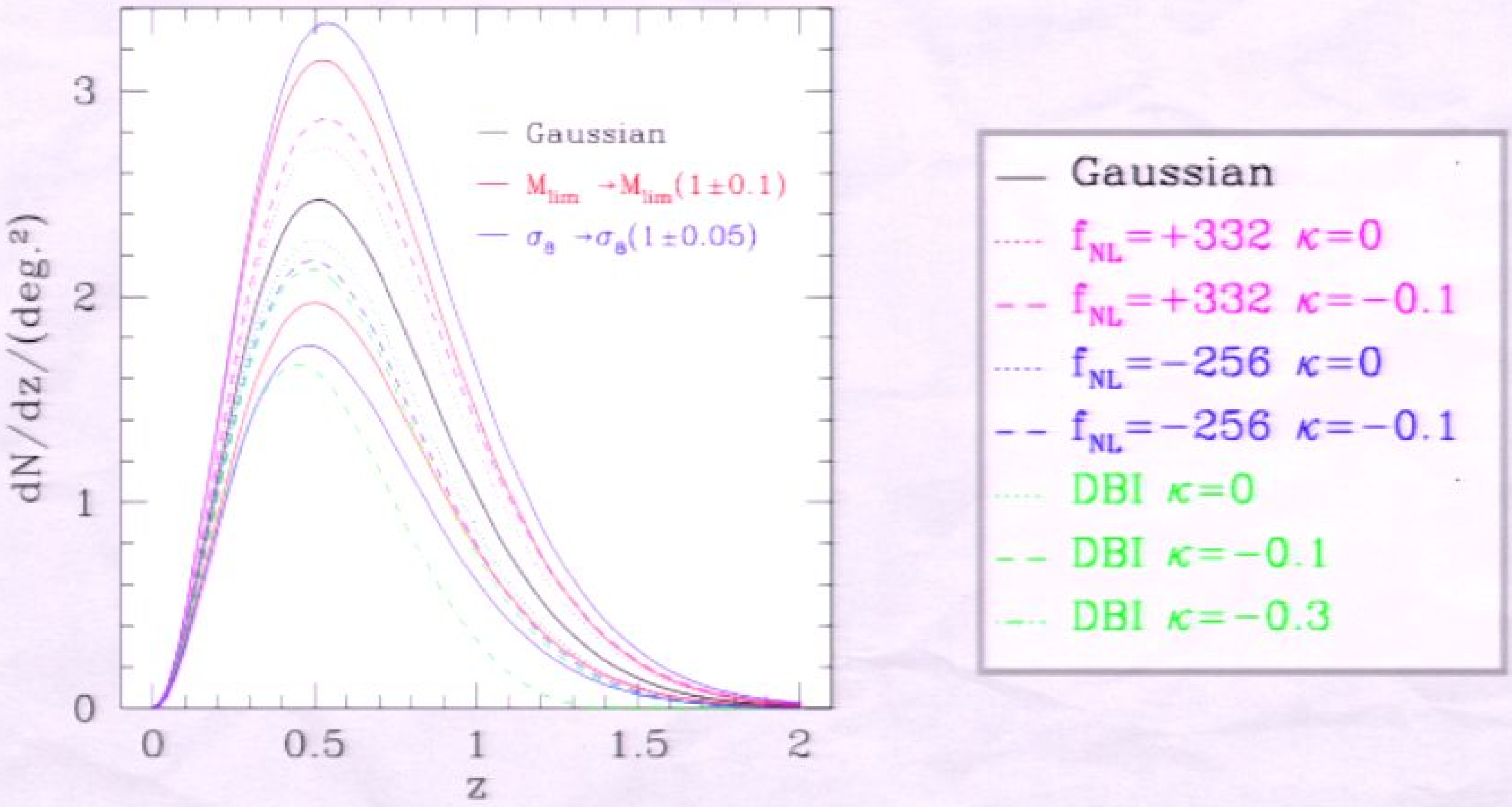


WITH MASS AND σ_8 UNCERTAINTY

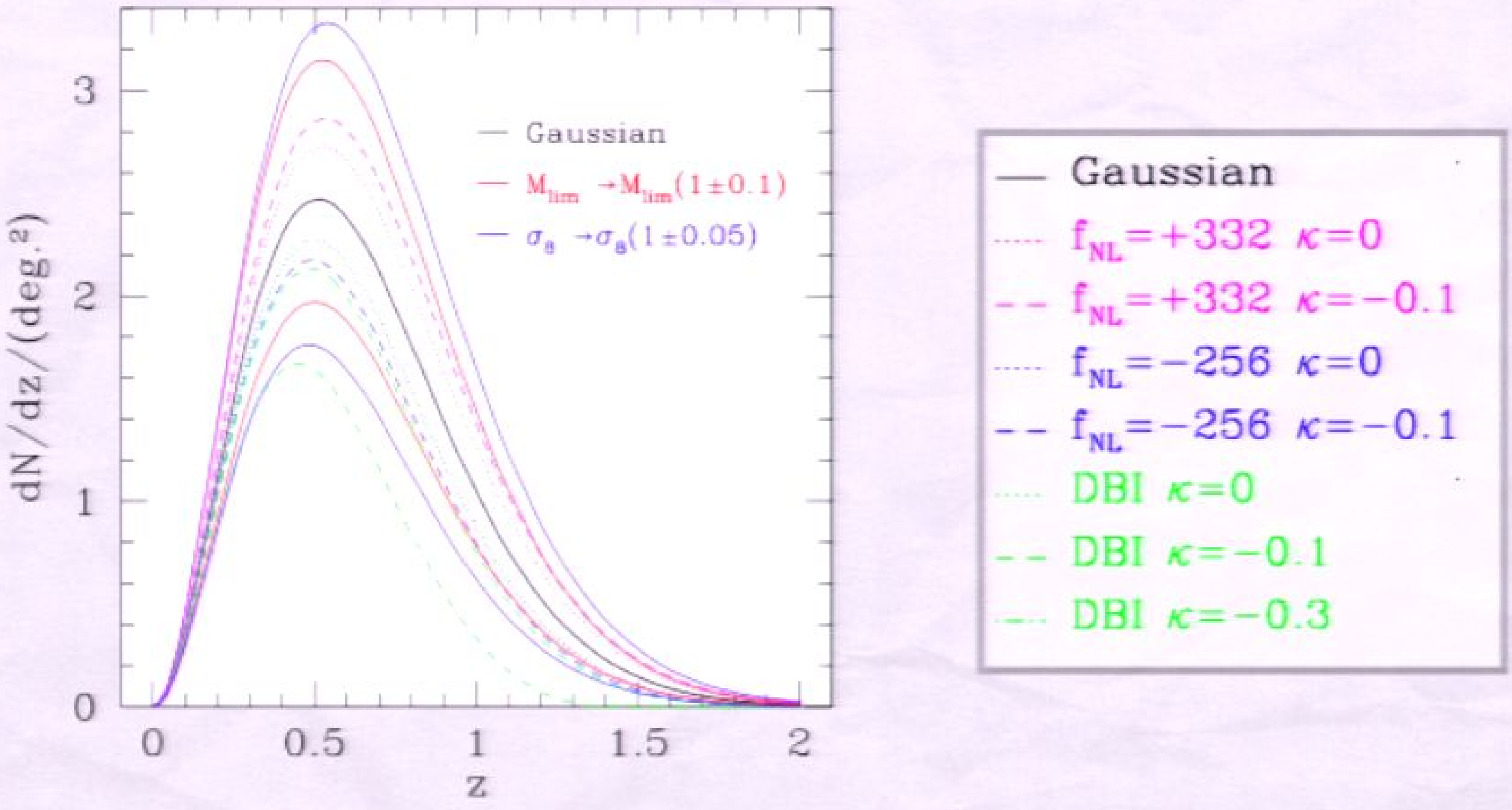


PI, Oct. 30, 2007

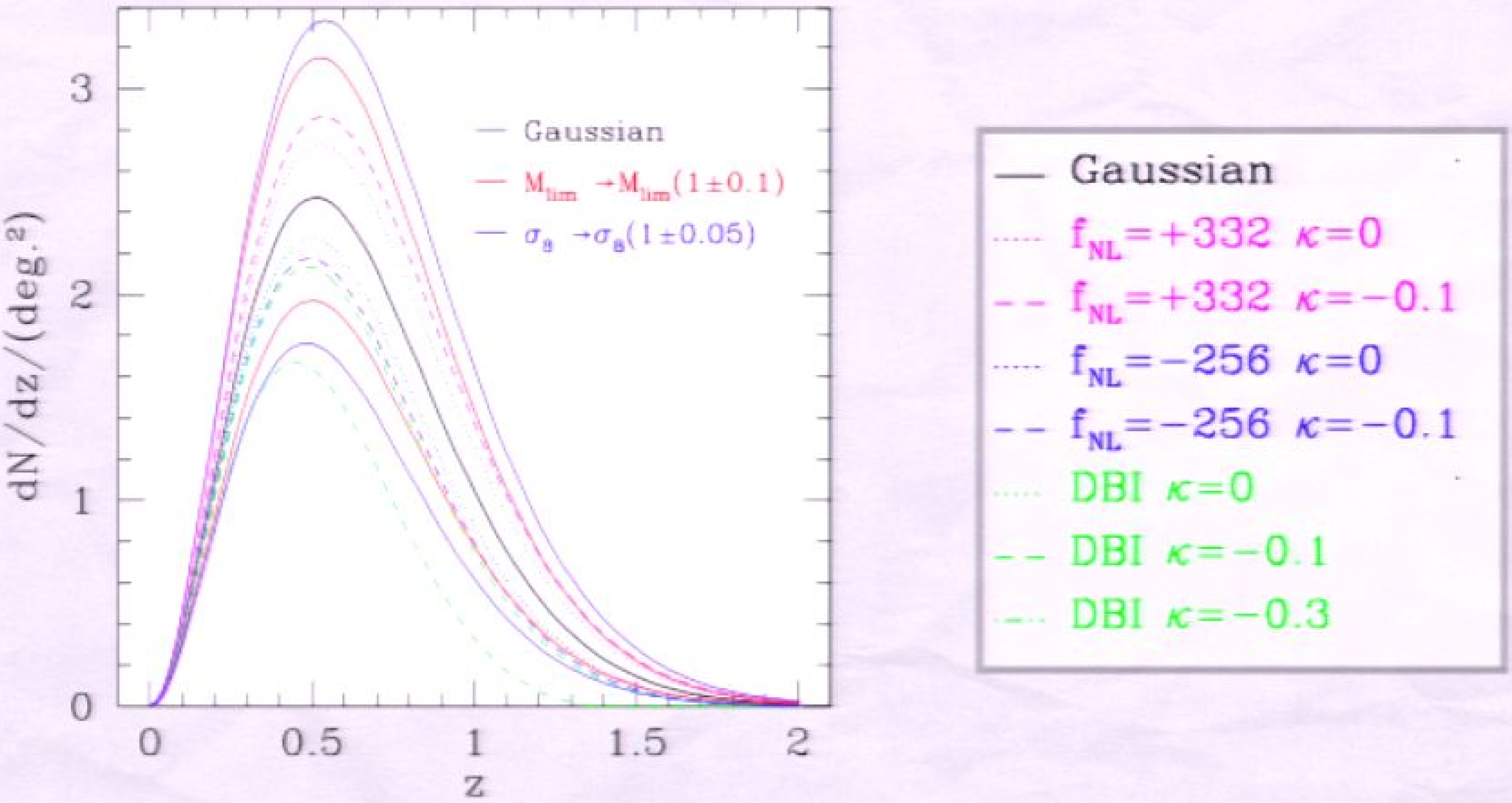
WITH MASS AND σ_8 UNCERTAINTY



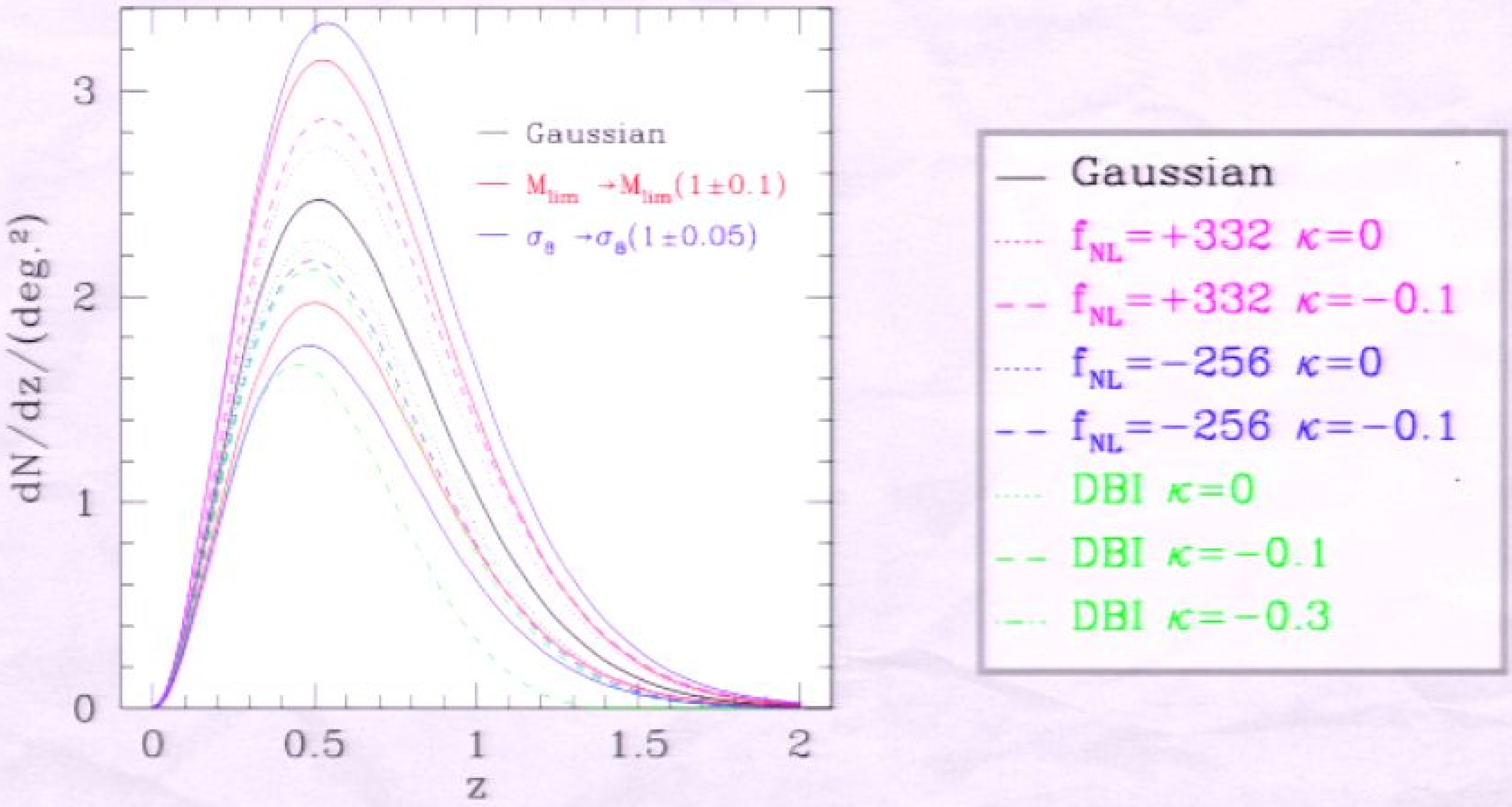
WITH MASS AND σ_8 UNCERTAINTY



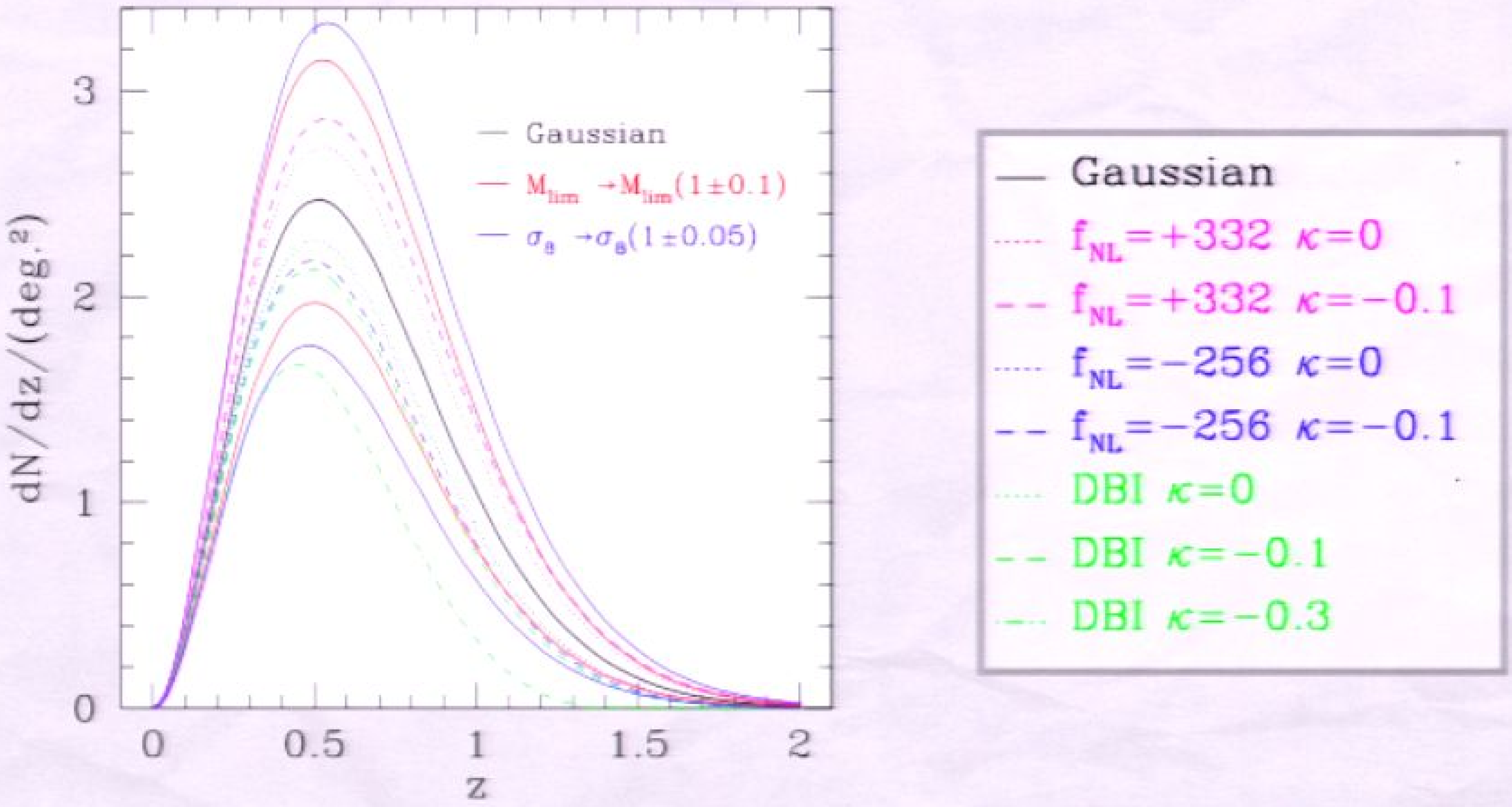
WITH MASS AND σ_8 UNCERTAINTY



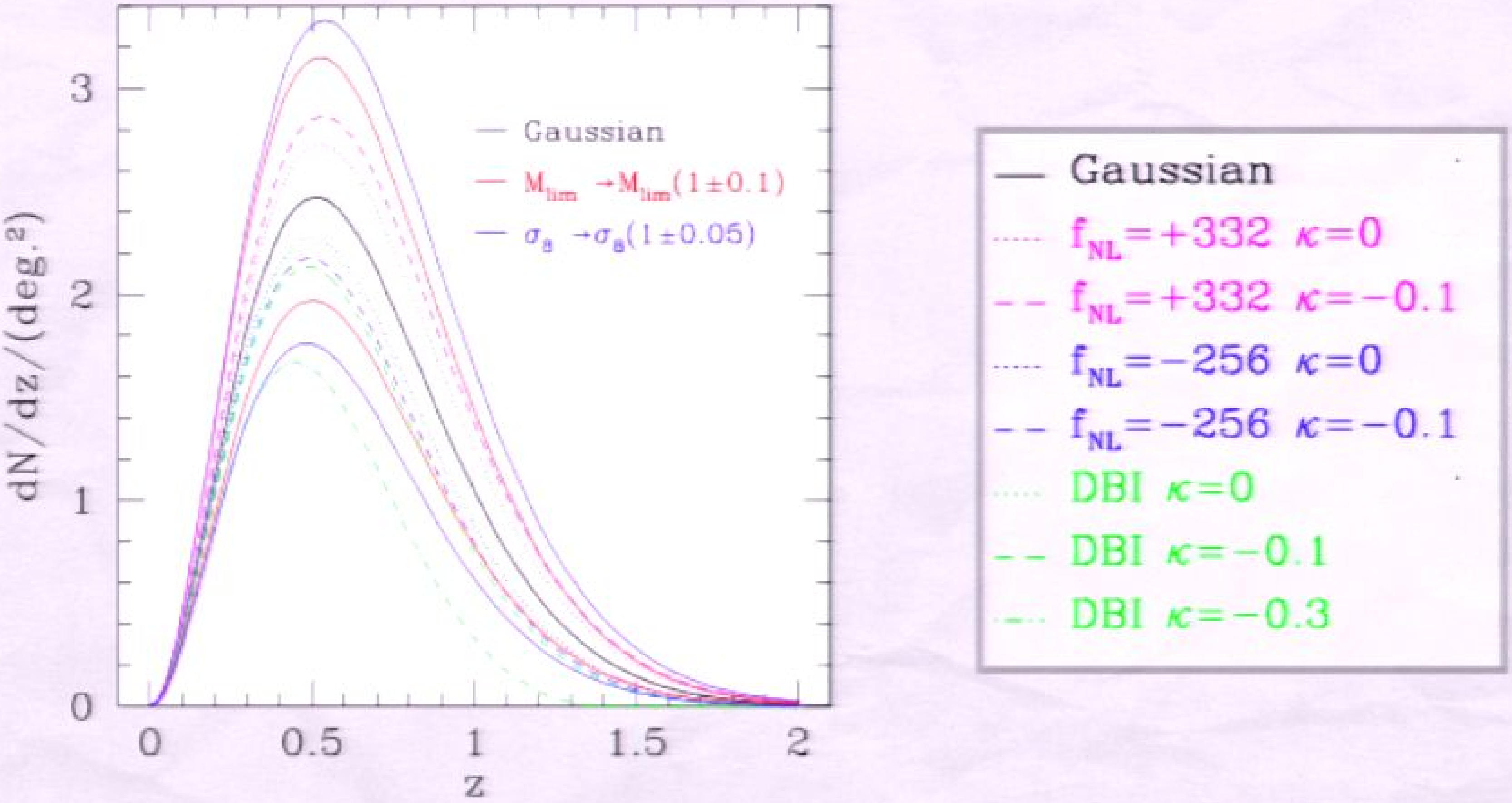
WITH MASS AND σ_8 UNCERTAINTY



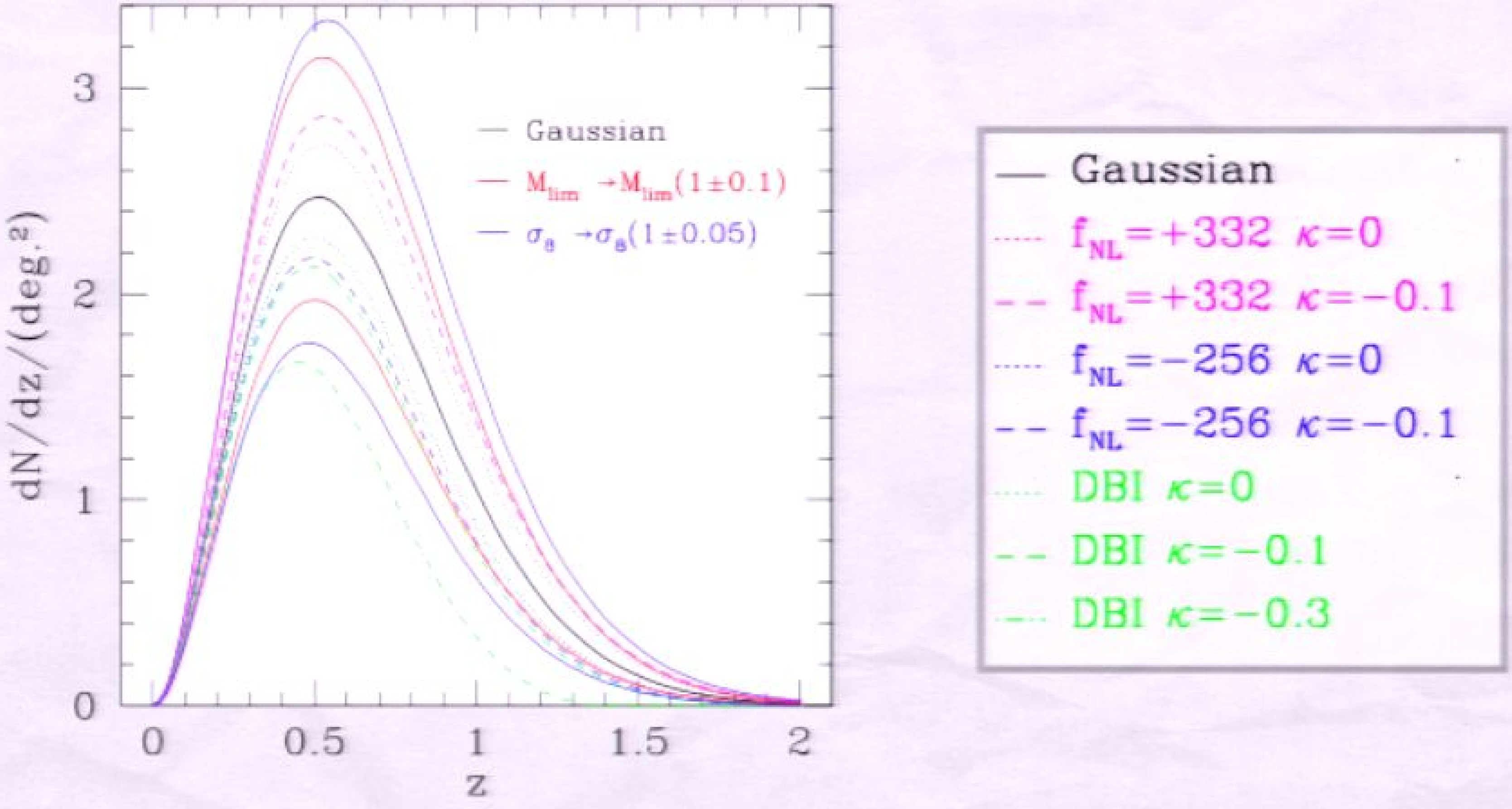
WITH MASS AND σ_8 UNCERTAINTY



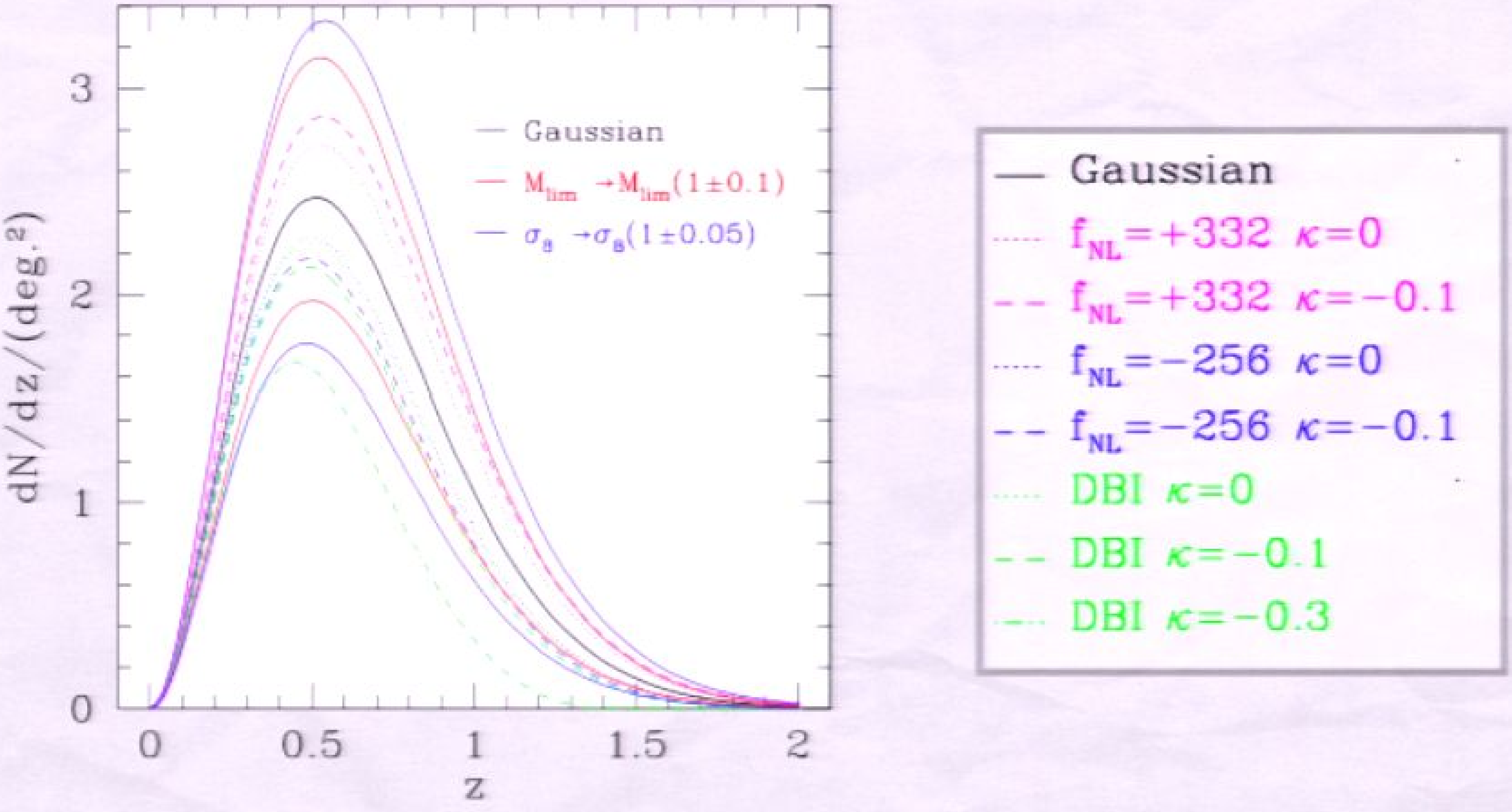
WITH MASS AND σ_8 UNCERTAINTY



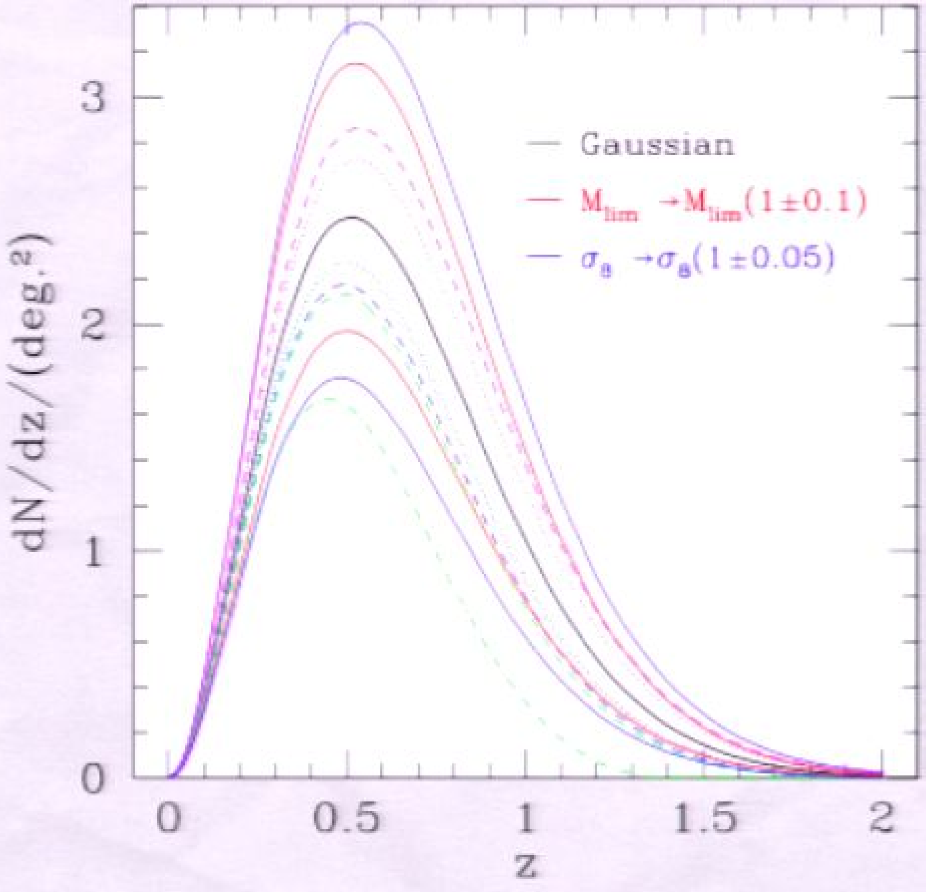
WITH MASS AND σ_8 UNCERTAINTY



WITH MASS AND σ_8 UNCERTAINTY



WITH MASS AND σ_8 UNCERTAINTY



— Gaussian

····· $f_{NL}=+332$ $\kappa=0$

-- $f_{NL}=+332$ $\kappa=-0.1$

····· $f_{NL}=-256$ $\kappa=0$

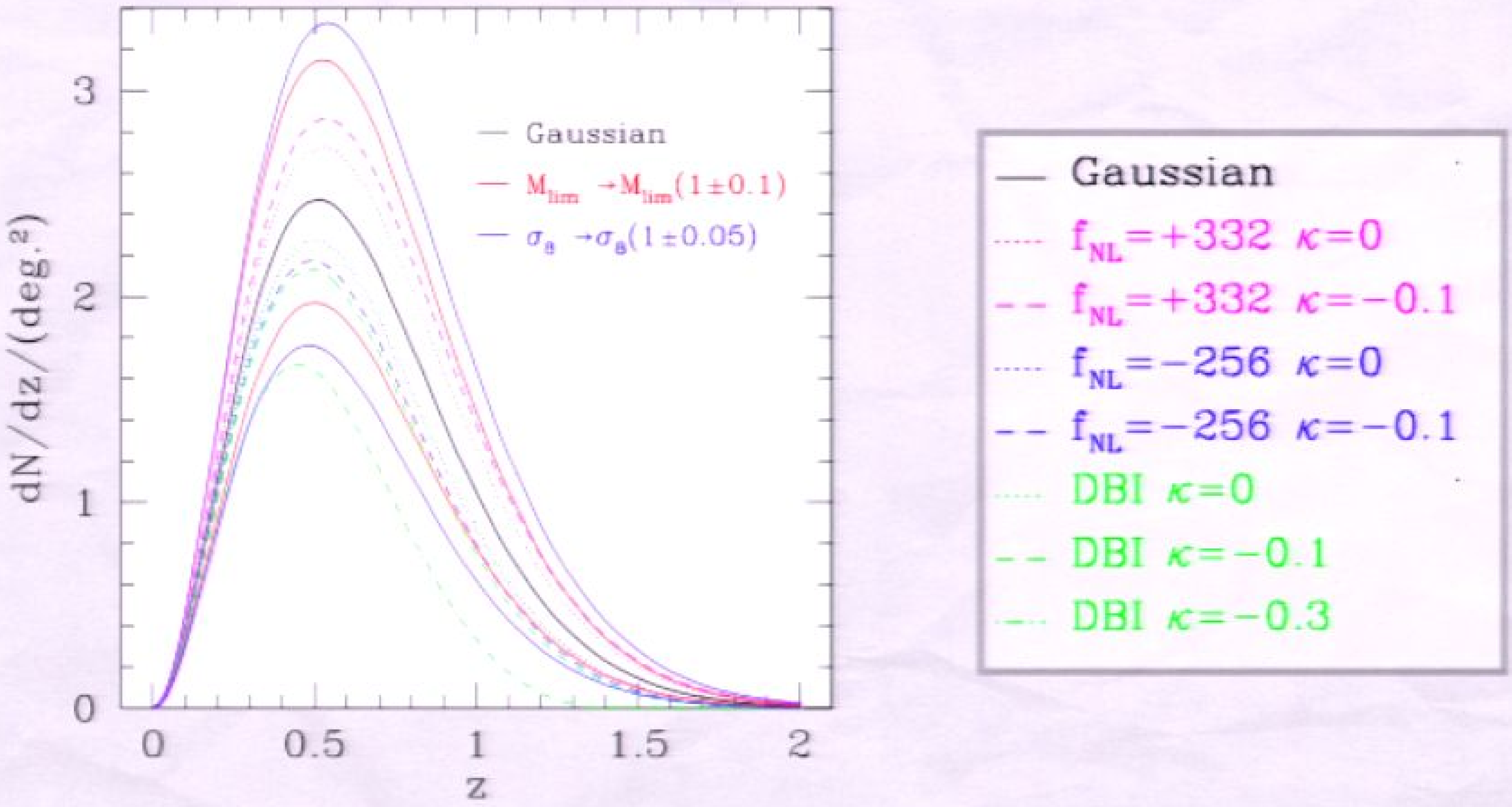
-- $f_{NL}=-256$ $\kappa=-0.1$

····· DBI $\kappa=0$

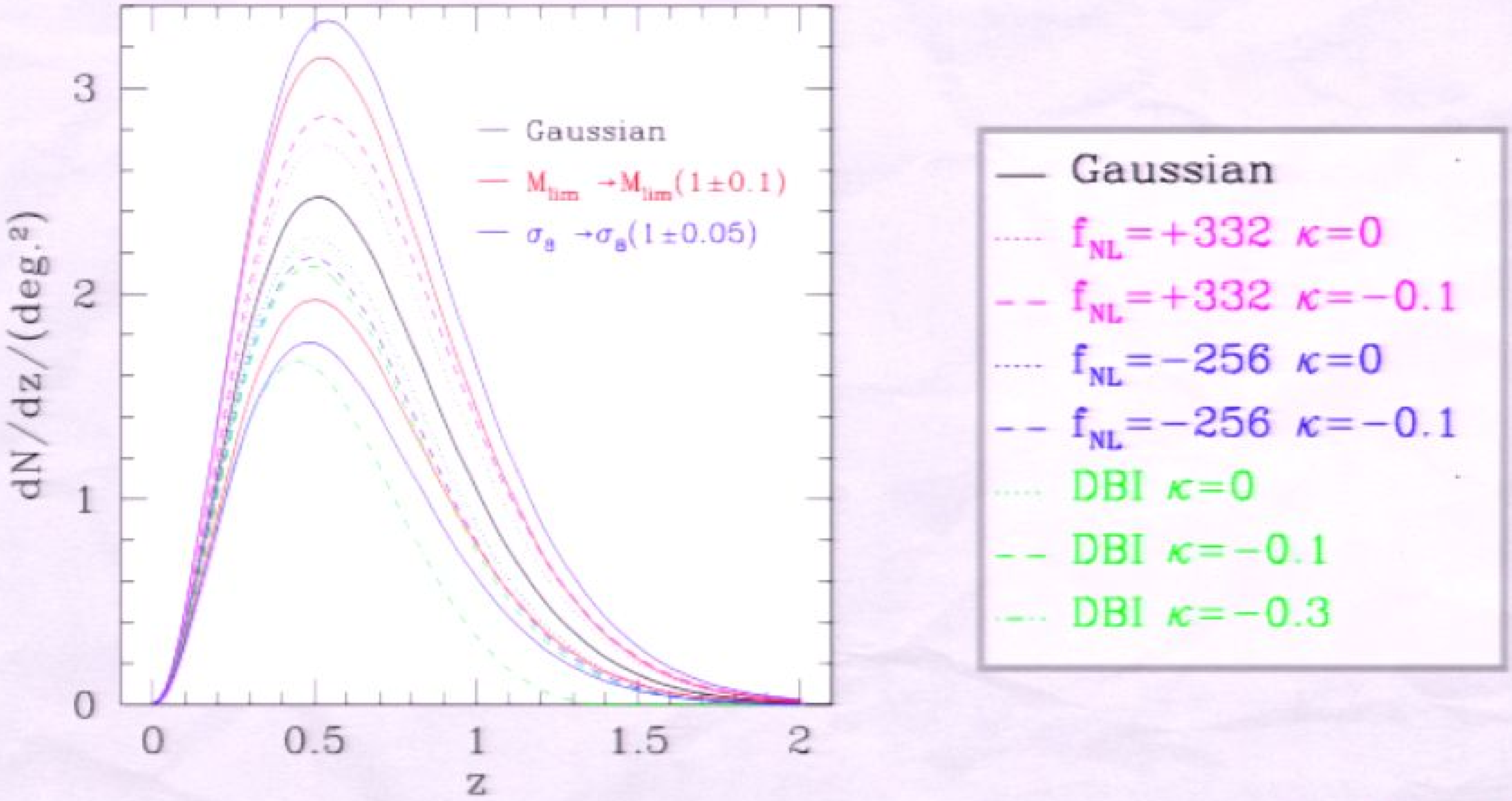
-- DBI $\kappa=-0.1$

-·- DBI $\kappa=-0.3$

WITH MASS AND σ_8 UNCERTAINTY

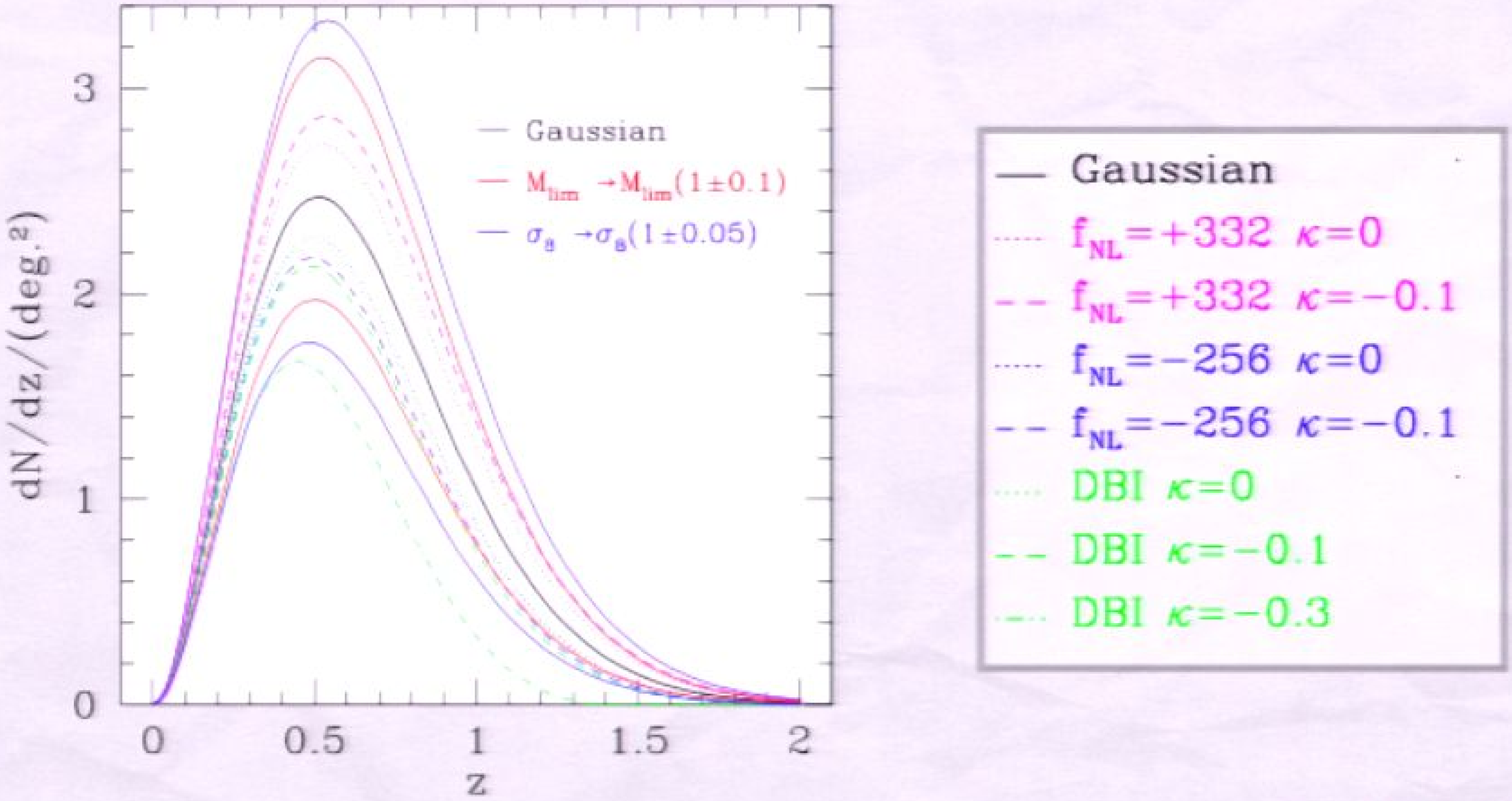


WITH MASS AND σ_8 UNCERTAINTY



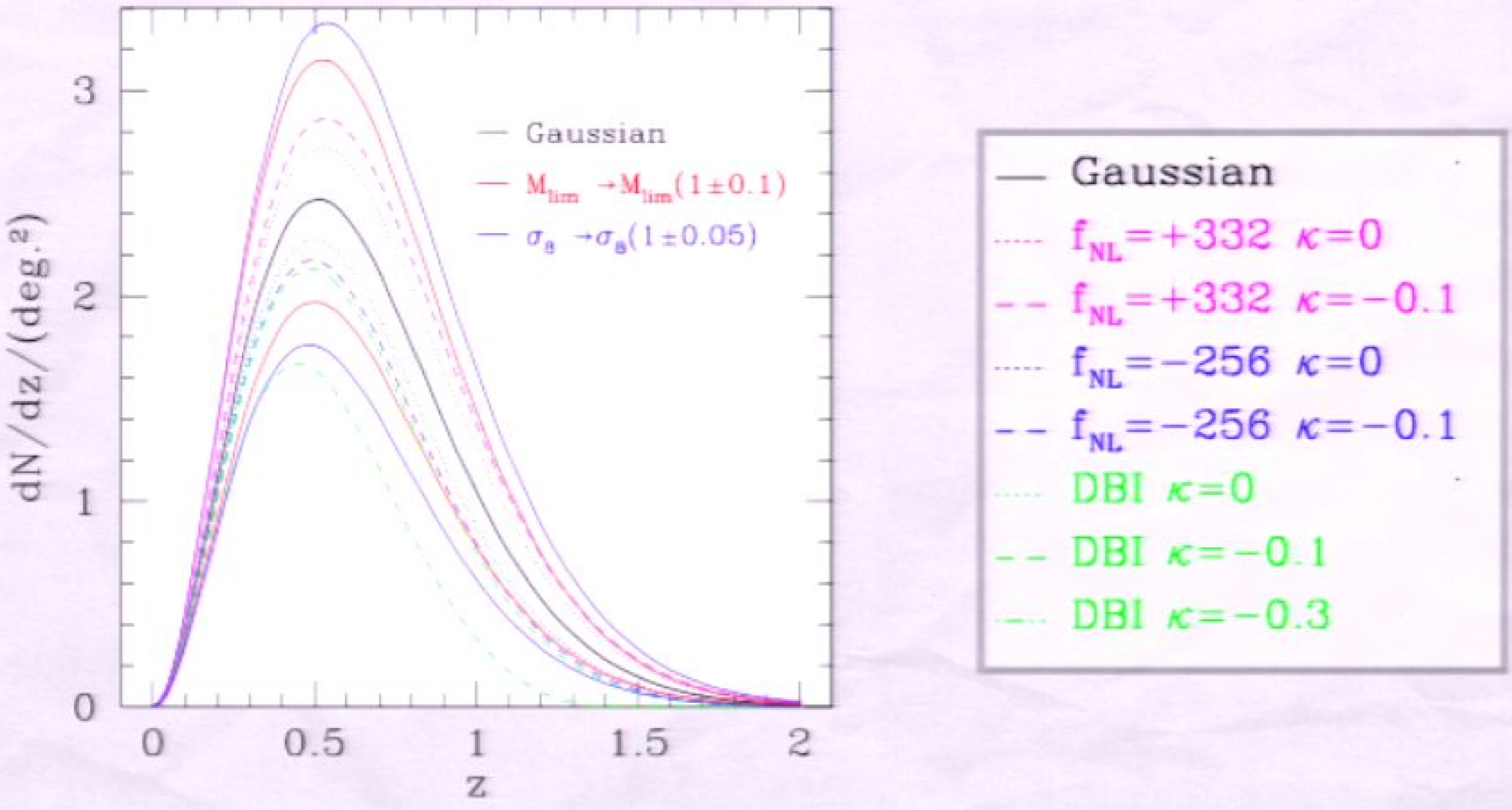
PI, Oct. 30, 2007

WITH MASS AND σ_8 UNCERTAINTY

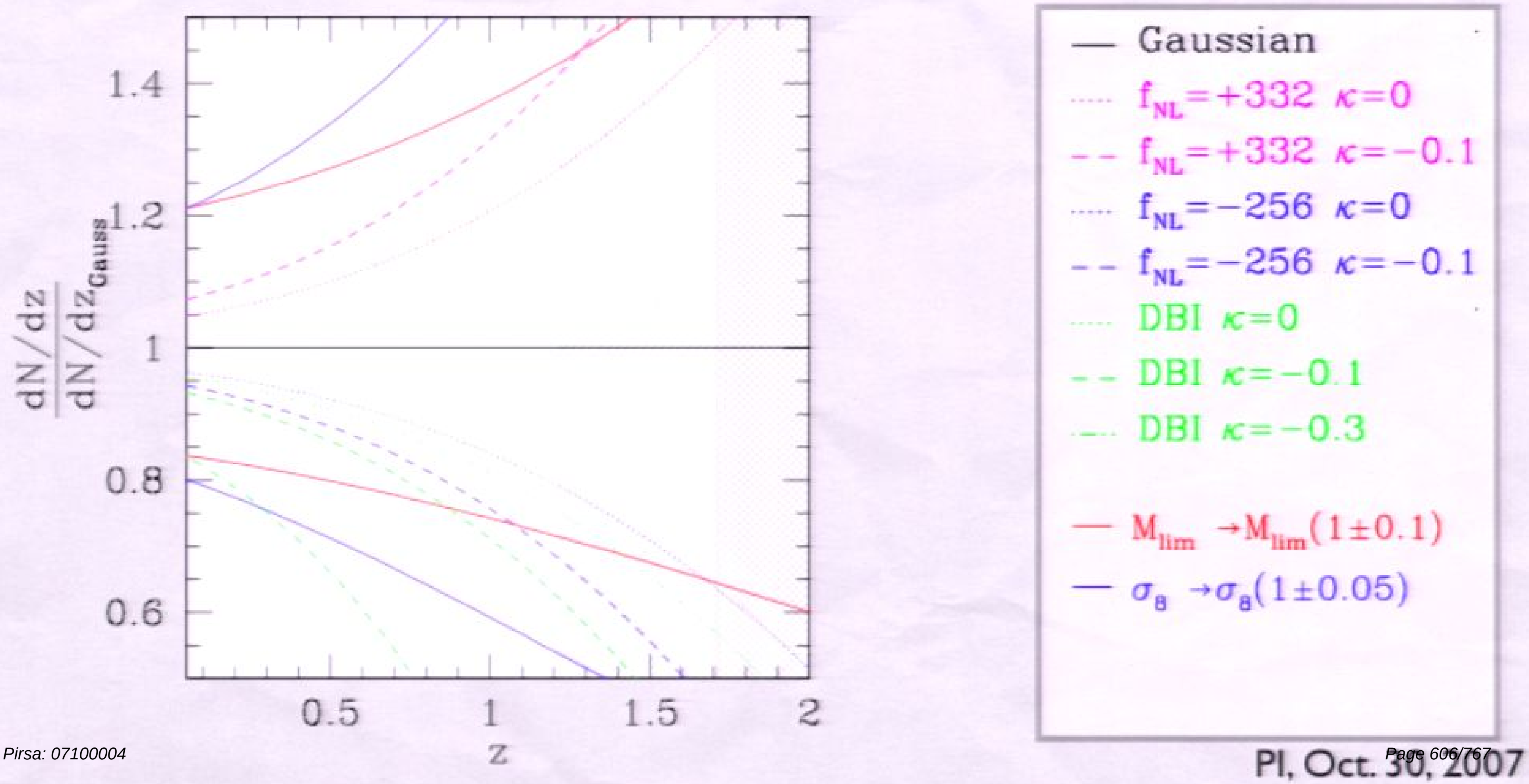


PI, Oct. 30, 2007

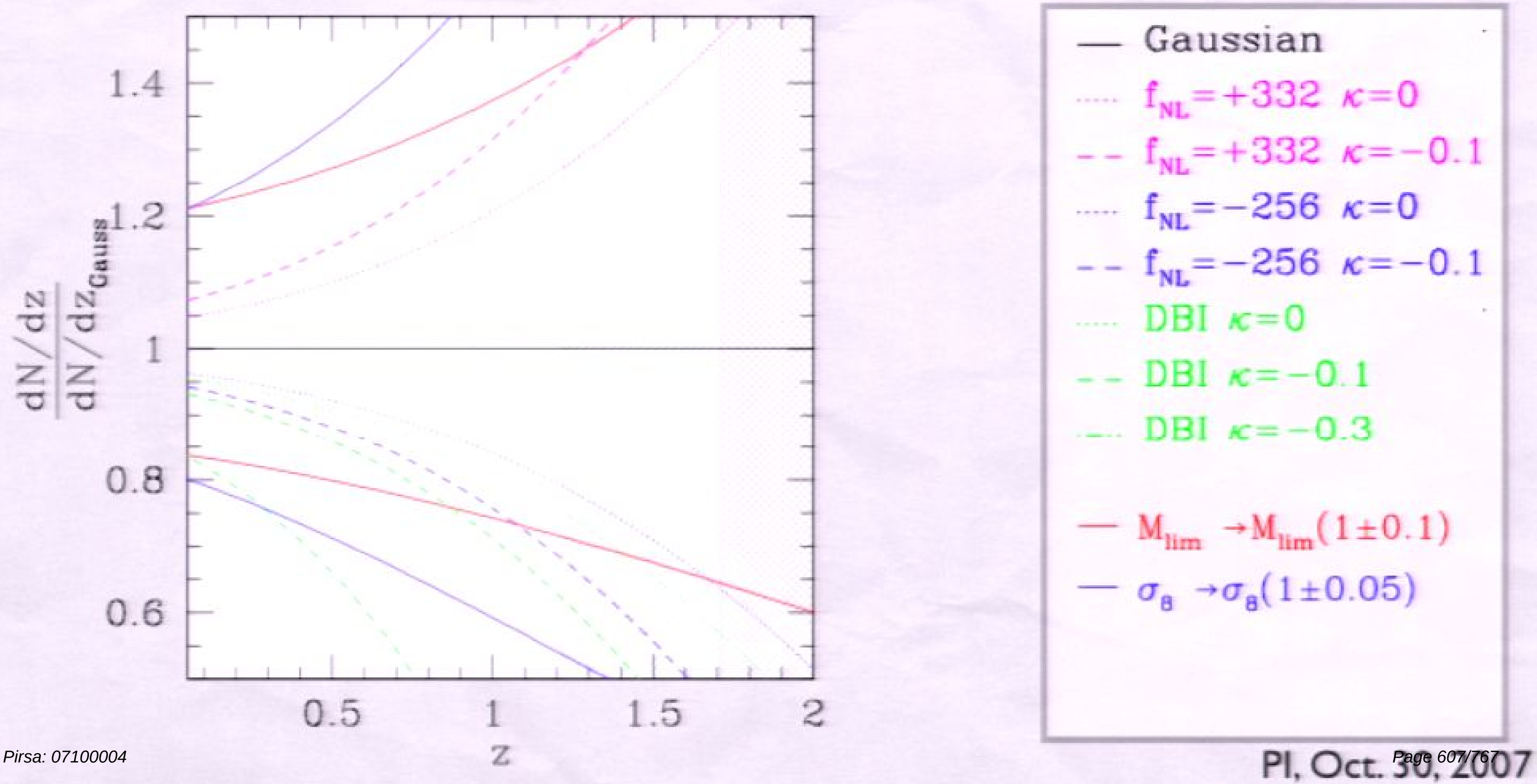
WITH MASS AND σ_8 UNCERTAINTY



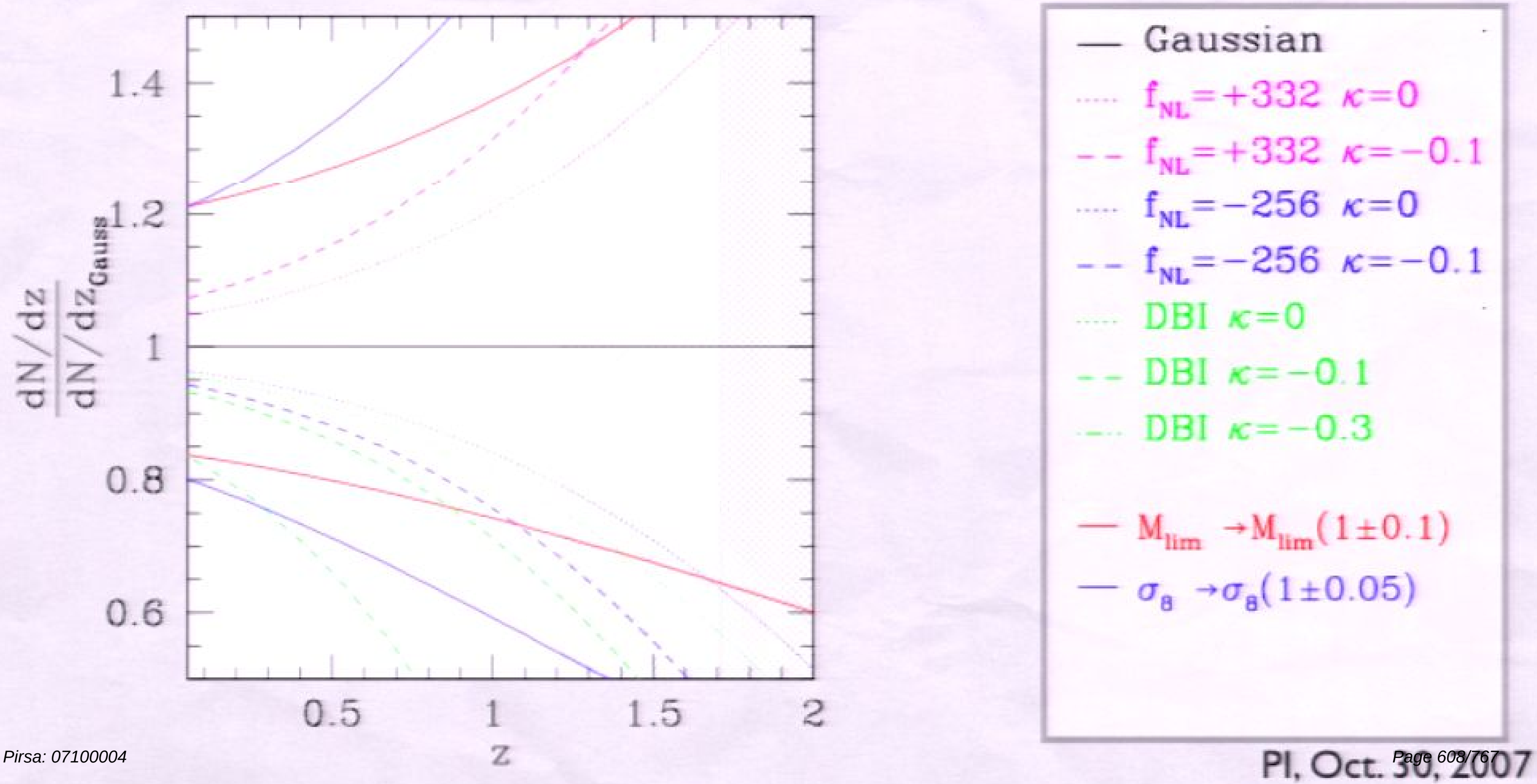
DEVIATION FROM GAUSSIAN



DEVIATION FROM GAUSSIAN

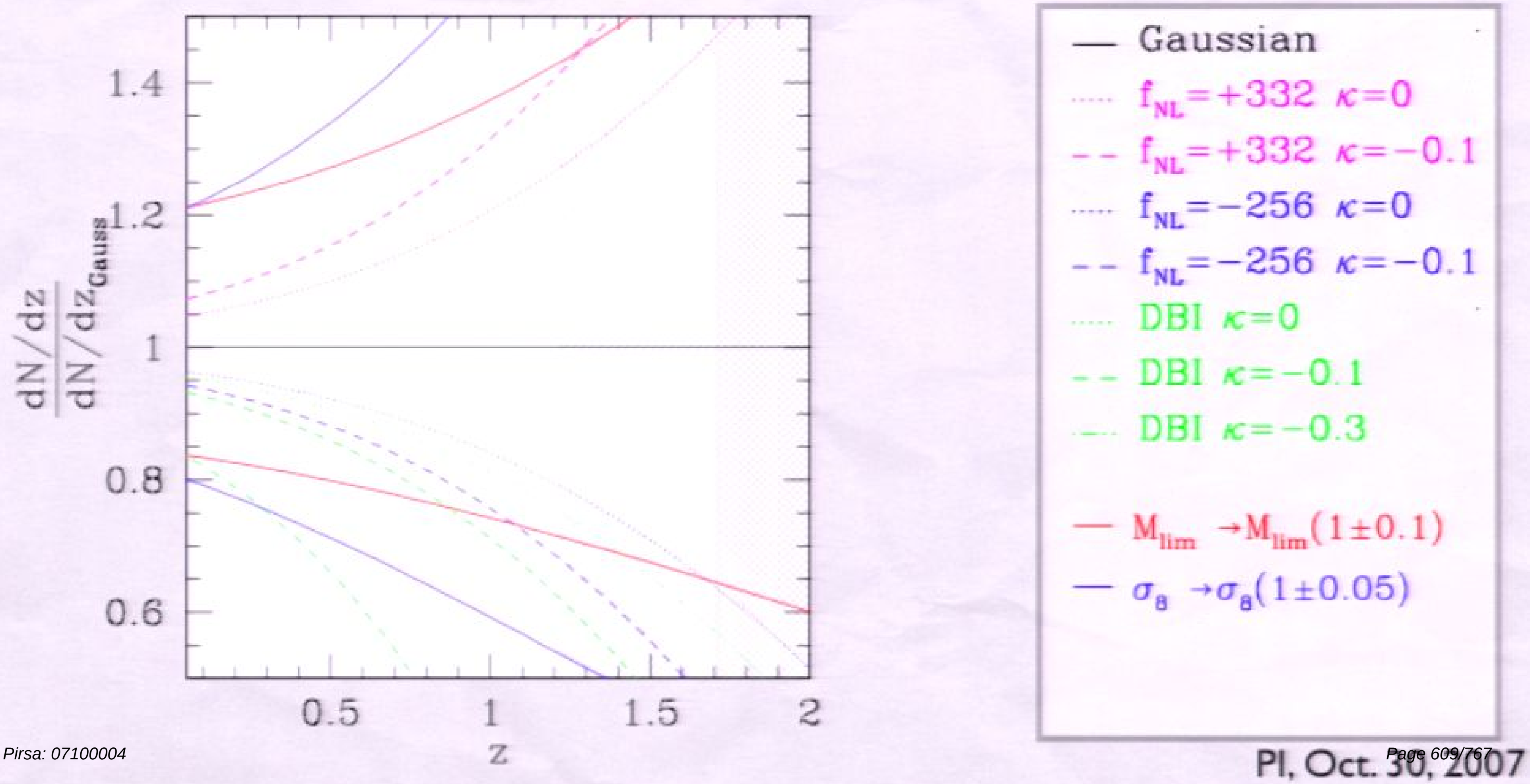


DEVIATION FROM GAUSSIAN



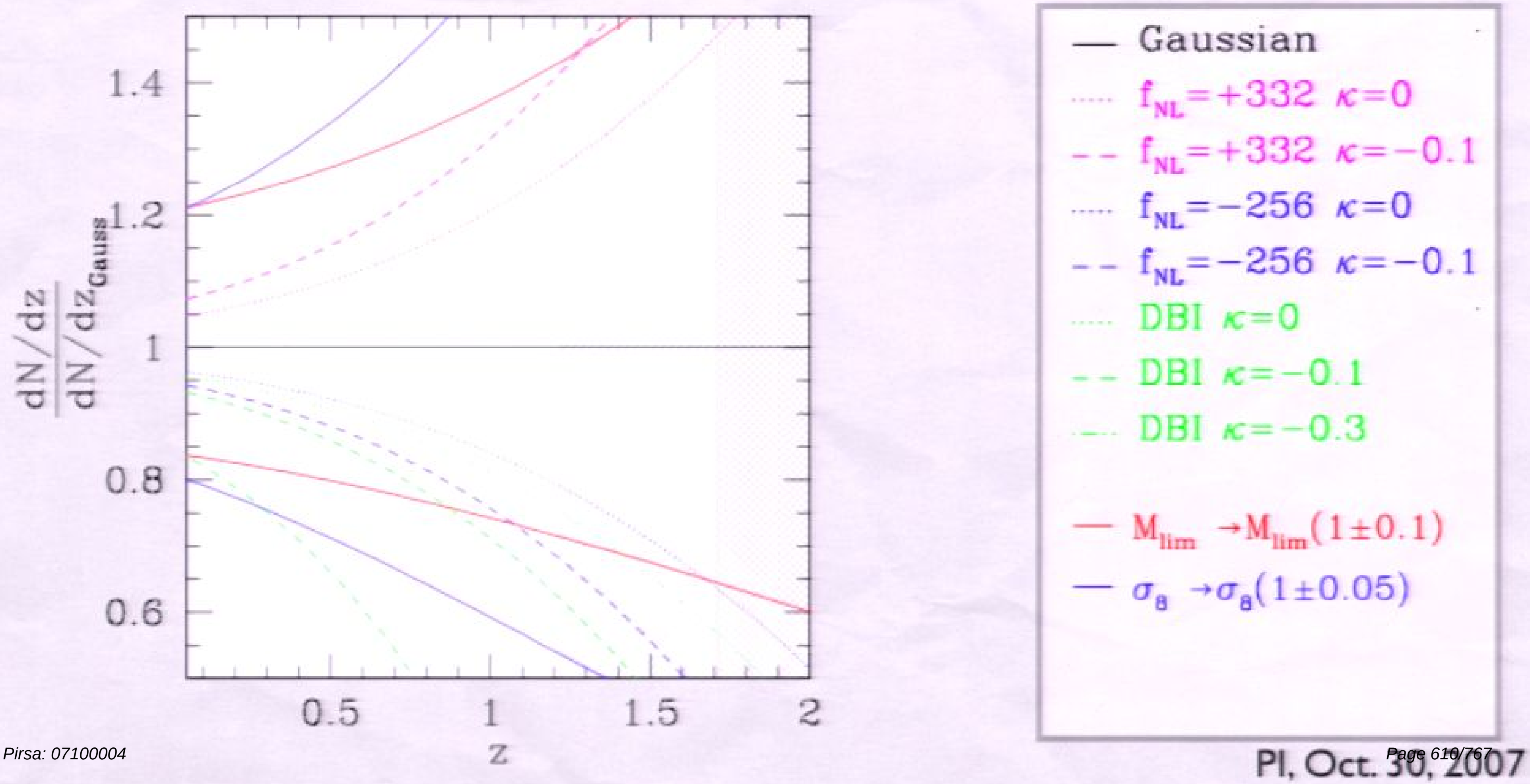
PI, Oct. 30, 2007

DEVIATION FROM GAUSSIAN



PI, Oct. 30, 2007

DEVIATION FROM GAUSSIAN



SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

PI, Oct. 30, 2007

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

PI, Oct. 30, 2007

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

PI, Oct. 30, 2007

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

PI, Oct. 30, 2007

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

PI, Oct. 30, 2007

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

SO HOW WELL CAN WE DO?

$f_{NL} = 38, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0080	0.029	0.027	150	1.86
Planck Priors				
0.0058	0.011	0.014	40	1.07

$f_{NL} = -256, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0071	0.029	0.025	150	0.17
Planck Priors				
0.0051	0.011	0.013	40	0.09

$f_{NL} = 332, \kappa = 0$

WMAP Priors				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.010	0.029	0.032	150	0.42
Planck Priors				
0.0066	0.011	0.015	40	0.21

preliminary

$(\Omega_m = 0.24, h = 0.73, \sigma_8 = 0.77, \kappa = 0)$

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38, \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256, \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332, \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

WITH MASS BINS

$f_{NL} = 38,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0058	0.018	0.013	143	1.64
Planck Priors, 3 Mass Bins				
0.0040	0.0095	0.0087	39.7	1.03

$f_{NL} = -256,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0039	0.019	0.0069	138	0.16
Planck Priors, 3 Mass Bins				
0.0034	0.0098	0.0059	39.5	0.08

$f_{NL} = 332,\ \kappa = 0$

WMAP Priors, 3 Mass Bins				
σ_{Ω_m}	σ_h	σ_{σ_8}	$\sigma_{f_{NL}}$	σ_κ
0.0063	0.020	0.017	147	0.28
Planck Priors, 3 Mass Bins				
0.0036	0.0096	0.0097	38	0.17

preliminary

IV. OBSERVATIONS: DARK MATTER (GALAXY) BISPECTRUM

IV. OBSERVATIONS: DARK MATTER (GALAXY) BISPECTRUM

IV. OBSERVATIONS: DARK MATTER (GALAXY) BISPECTRUM

IV. OBSERVATIONS: DARK MATTER (GALAXY) BISPECTRUM

IV. OBSERVATIONS: DARK MATTER (GALAXY) BISPECTRUM

IV. OBSERVATIONS: DARK MATTER (GALAXY) BISPECTRUM

IV. OBSERVATIONS: DARK MATTER (GALAXY) BISPECTRUM

IV. OBSERVATIONS: DARK MATTER (GALAXY) BISPECTRUM

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle \delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = B^{I}_{123} + B^{G}_{123} + \int d^3q F_2(k_1+k_2-q,-q)\, P^{I}_4(k_1,k_2,k_1+k_2+q,q)}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = B^I_{123} + B^G_{123} + \int d^3q F_2(k_1+k_2-q,-q)\; P^I_4(k_1,k_2,k_1+k_2+q,q)}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = B^I_{123} + B^G_{123} + \int d^3q F_2(k_1+k_2-q,-q)\; P^I_4(k_1,k_2,k_1+k_2+q,q)}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = B^I_{123} + B^G_{123} + \int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)}$$

BISPECTRUM

- Write the three point function as:

$$\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)$$

- Where there are several contributions:

$$B^{(0)}_{123} = B^I_{123} + B^G_{123} + \int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = B^{I}_{123} + B^{G}_{123} + \int d^3q F_2(k_1+k_2-q,-q)\; P^{I}_4(k_1,k_2,k_1+k_2+q,q)}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = \boxed{B^I_{123}} + \boxed{B^G_{123}} + \int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)}$$

Initial

Gravitationally Induced

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$B^{(0)}_{123} = \boxed{B^I_{123}} + \boxed{B^G_{123}} + \int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)$$

Initial

Gravitationally Induced

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = \underbrace{\boxed{B^I_{123}}}_{\text{Initial}} + \underbrace{\boxed{B^G_{123}}}_{\text{Gravitationally Induced}} + \underbrace{\boxed{\int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)}}_{\text{Linearly evolved initial trispectrum}}}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = B^{I}_{123} + B^{G}_{123} + \int d^3q F_2(k_1+k_2-q,-q)\, P^{I}_4(k_1,k_2,k_1+k_2+q,q)}$$

BISPECTRUM

- Write the three point function as:

$$\langle \delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)$$

- Where there are several contributions:

$$B^{(0)}_{123} = B^{I}_{123} + B^{G}_{123} + \int d^3q F_2(k_1+k_2-q,-q)\; P^{I}_{4}(k_1,k_2,k_1+k_2+q,q)$$

Initial

Gravitationally Induced

Linearly evolved initial trispectrum

BISPECTRUM

- Write the three point function as:

$$\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)$$

- Where there are several contributions:

$$B^{(0)}_{123} = B^{I}_{123} + B^{G}_{123} + \int d^3q F_2(k_1+k_2-q,-q)\, P^{I}_4(k_1,k_2,k_1+k_2+q,q)$$

Initial

Gravitationally Induced

Linearly evolved initial trispectrum

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = \underbrace{B^I_{123}}_{\text{Initial}} + \underbrace{B^G_{123}}_{\text{Gravitationally Induced}} + \underbrace{\int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)}_{\text{Linearly evolved initial trispectrum}}}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = \underbrace{B^I_{123}}_{\textbf{Initial}} + \underbrace{B^G_{123}}_{\textbf{Gravitationally Induced}} + \underbrace{\int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)}_{\textbf{Linearly evolved initial trispectrum}}}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = \underbrace{B^{I}_{123}}_{\text{Initial}} + \underbrace{B^{G}_{123}}_{\text{Gravitationally Induced}} + \underbrace{\int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)}_{\text{Linearly evolved initial trispectrum}}}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle \delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = \underbrace{B^I_{123}}_{\text{Initial}} + \underbrace{B^G_{123}}_{\text{Gravitationally Induced}} + \underbrace{\int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)}_{\text{Linearly evolved initial trispectrum}}}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$\boxed{B^{(0)}_{123} = \underbrace{B^I_{123}}_{\text{Initial}} + \underbrace{B^G_{123}}_{\text{Gravitationally Induced}} + \underbrace{\int d^3q F_2(k_1+k_2-q,-q)\, P^I_4(k_1,k_2,k_1+k_2+q,q)}_{\text{Linearly evolved initial trispectrum}}}$$

BISPECTRUM

- Write the three point function as:

$$\boxed{\langle\delta(\vec{k}_1)\delta(\vec{k}_2)\delta(\vec{k}_3)\rangle = (2\pi)^3\delta(\vec{k}_1+\vec{k}_2+\vec{k}_3)B(k_1,k_2,k_3)}$$

- Where there are several contributions:

$$B^{(0)}_{123} = \underbrace{\boxed{B^{I}_{123}}}_{\text{Initial}} + \underbrace{\boxed{B^{G}_{123}}}_{\text{Gravitationally Induced}} + \underbrace{\boxed{\int d^3q F_2(k_1+k_2-q,-q)\, P^{I}_{4}(k_1,k_2,k_1+k_2+q,q)}}_{\text{Linearly evolved initial trispectrum}}$$

REDUCED BISPECTRUM

- Less sensitive to ‘cosmology’ (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$
\begin{aligned}
Q(k_1,k_2,k_3,a) &= \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)} \\
&= \frac{4}{7}+\frac{6\,f_{NL}(k)}{5M(k,a)} \\
&= \frac{4}{7}+\frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}
\end{aligned}
$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

PI, Oct. 30, 2007

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$
\begin{aligned}
Q(k_1,k_2,k_3,a) &= \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)} \\
&= \frac{4}{7}+\frac{6\,f_{NL}(k)}{5M(k,a)} \\
&= \frac{4}{7}+\frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}
\end{aligned}
$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$
\begin{aligned}
Q(k_1,k_2,k_3,a) &= \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)} \\
&= \frac{4}{7}+\frac{6\,f_{NL}(k)}{5M(k,a)} \\
&= \frac{4}{7}+\frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}
\end{aligned}
$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to ‘cosmology’ (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

PI, Oct. 30, 2007

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$
\begin{aligned}
Q(k_1,k_2,k_3,a) &= \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)} \\
&= \frac{4}{7}+\frac{6\,f_{NL}(k)}{5M(k,a)} \\
&= \frac{4}{7}+\frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}
\end{aligned}
$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to ‘cosmology’ (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\,f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-
independent analysis)

REDUCED BISPECTRUM

- Less sensitive to 'cosmology' (σ_8):

$$Q(k_1,k_2,k_3,a) = \frac{B(k_1,k_2,k_3,a)}{P_L(k_1,a)P_L(k_2,a)+P_L(k_1,a)P_L(k_3,a)+P_L(k_2,a)P_L(k_3,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL}(k)}{5M(k,a)}$$

$$= \frac{4}{7} + \frac{6\, f_{NL,pivot}(k/k_{pivot})^{-2\kappa}}{5M(k,a)}$$

(see Sefusatti and Komatsu for scale-
independent analysis)

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

PI, Oct. 30, 2007

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

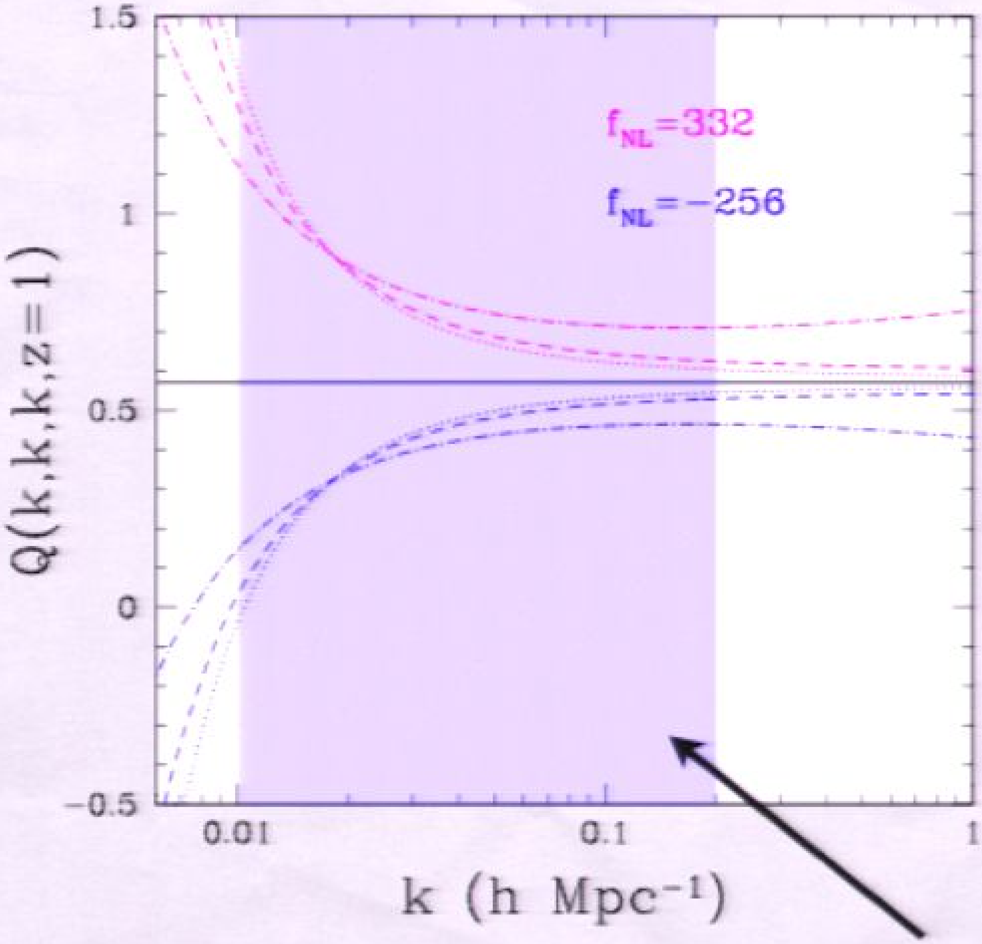
BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

BISPECTRUM - VS - CLUSTERS, CMB

- Need additional modeling parameters: Galaxy bias...
- Larger range of scales, but not as small scale as clusters
- Less dependence on σ_8
- More data than CMB, nearly as sensitive, higher z surveys are better

REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

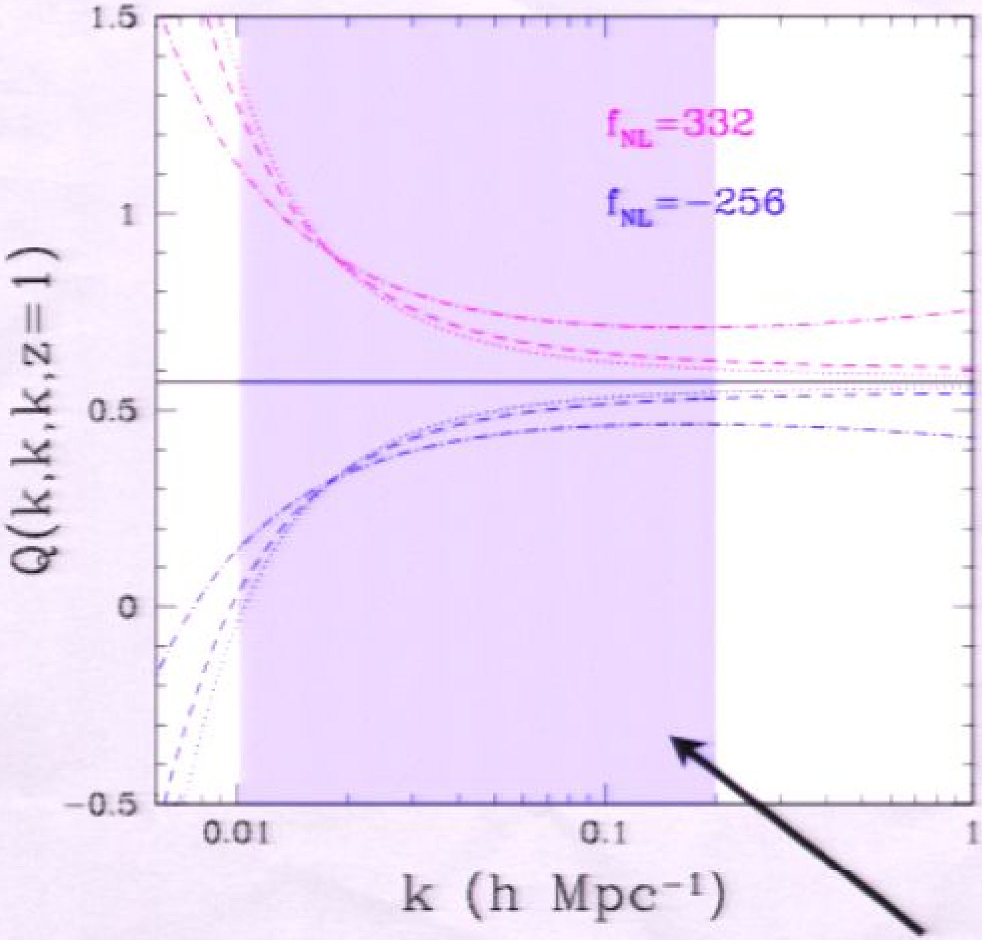
⋯⋯ $\kappa = 0$

- - - $\kappa = -0.1$

-·-·- $\kappa = -0.3$

Most accessible range

REDUCED BISPECTRUM



Most accessible range

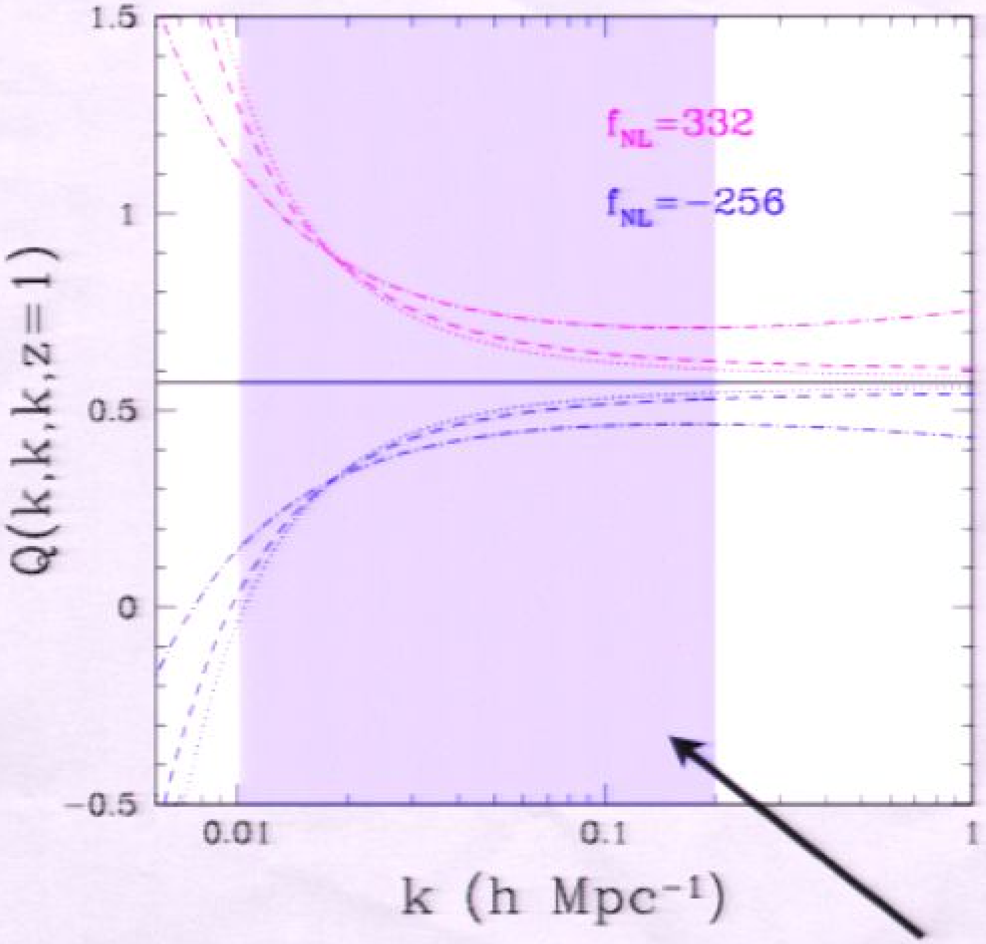
$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

········ $\kappa = 0$

- - - $\kappa = -0.1$

-·-·- $\kappa = -0.3$

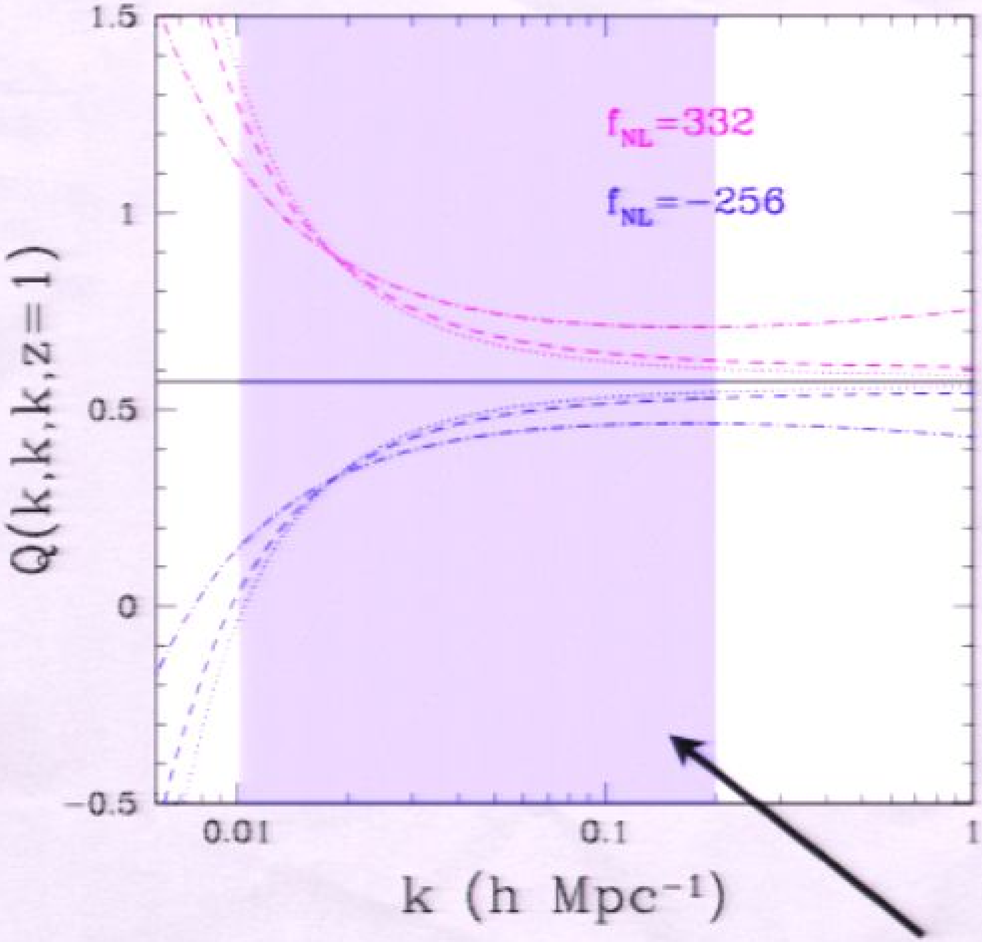
REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

Most accessible range

REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

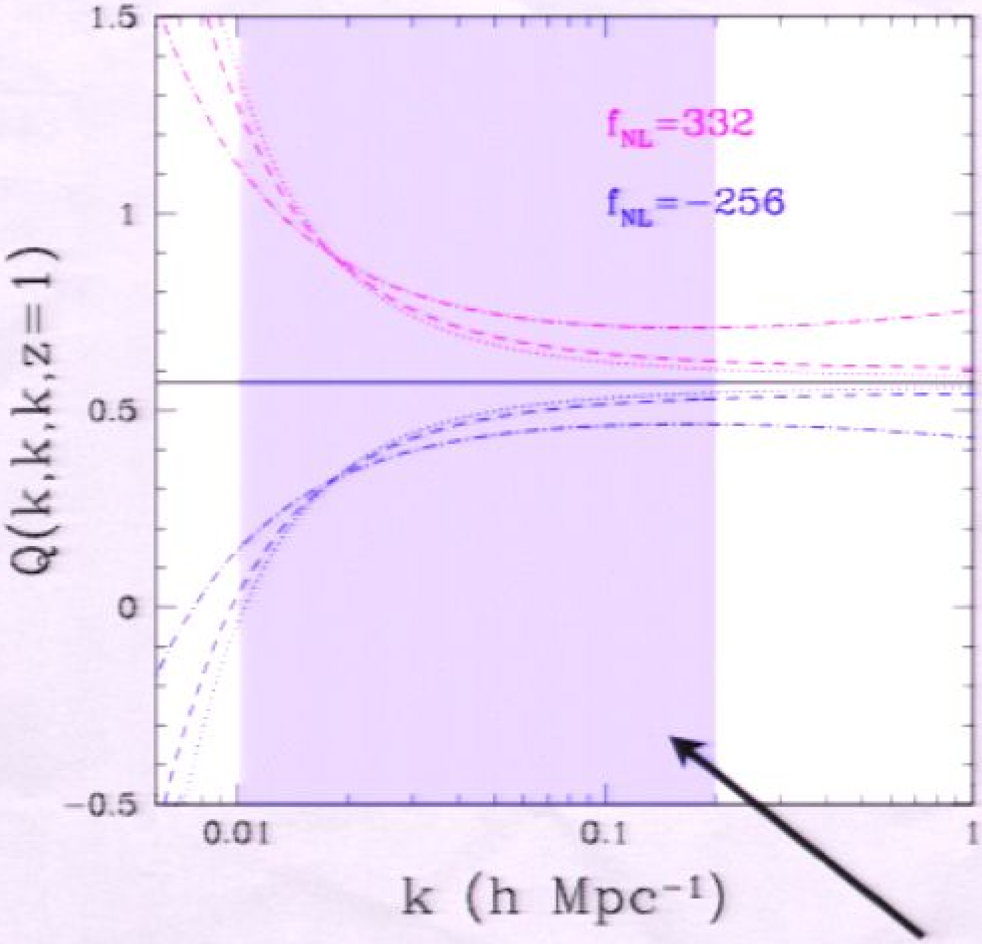
┈┈┈ $\kappa = 0$

- - - $\kappa = -0.1$

-·-·- $\kappa = -0.3$

Most accessible range

REDUCED BISPECTRUM



Most accessible range

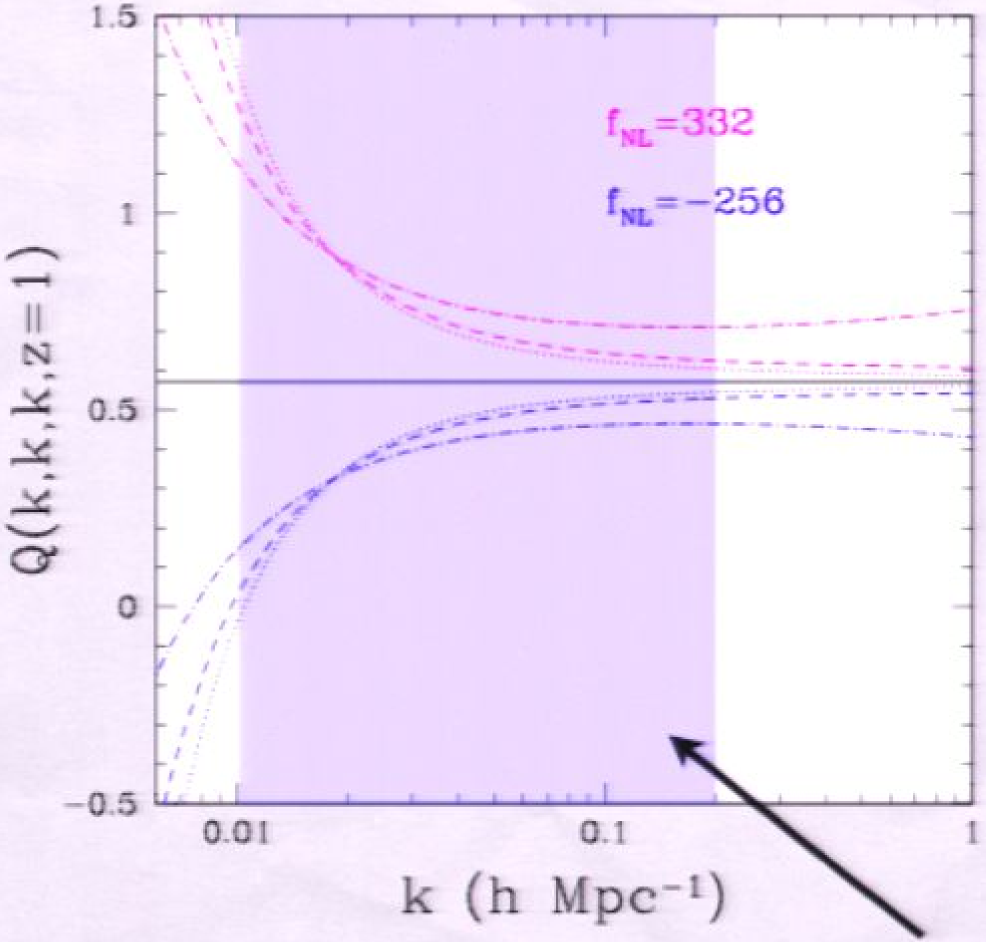
$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

┈┈┈ $\kappa = 0$

- - - $\kappa = -0.1$

-·-·- $\kappa = -0.3$

REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

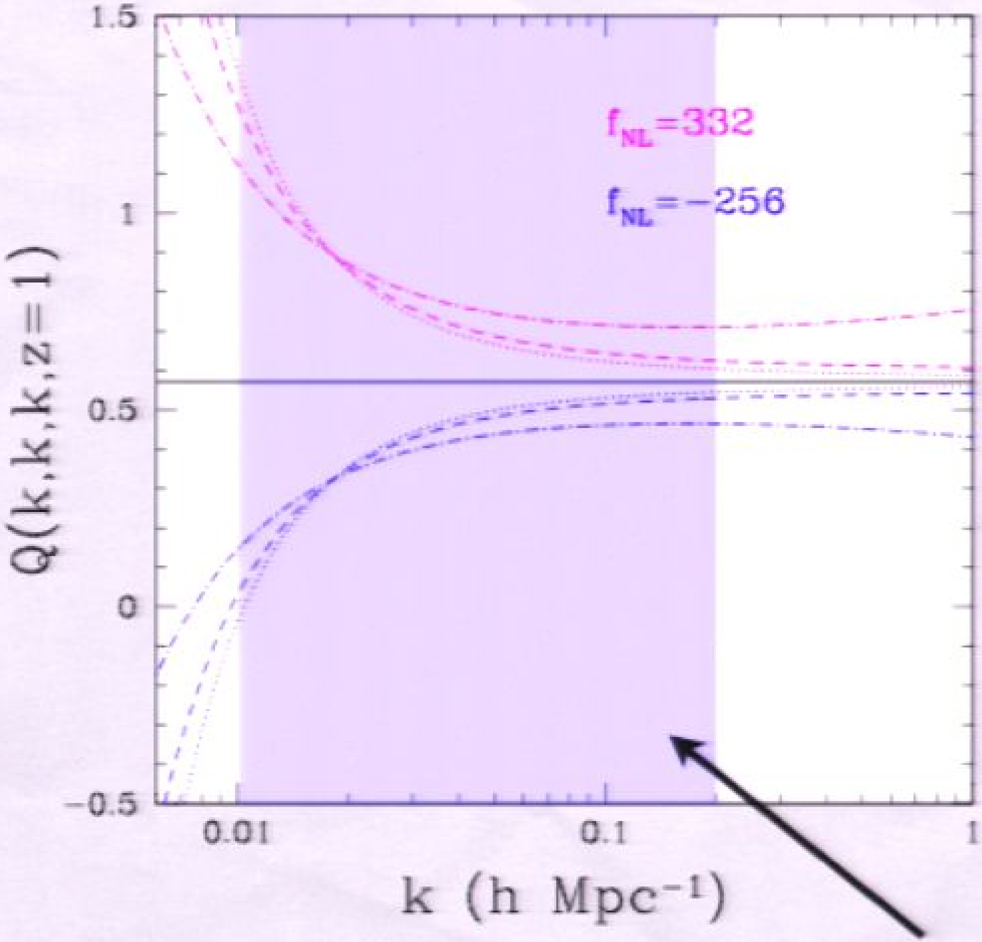
········ $\kappa = 0$

- - - $\kappa = -0.1$

-·-·- $\kappa = -0.3$

Most accessible range

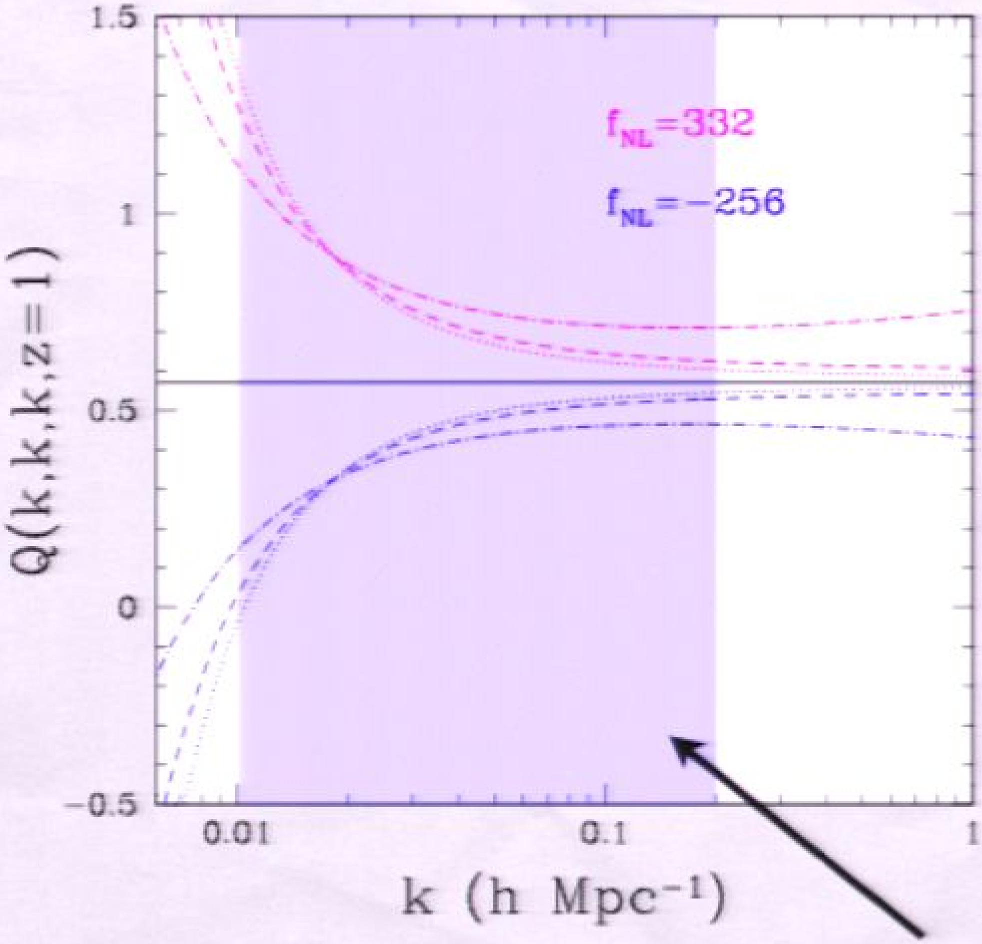
REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

Most accessible range

REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

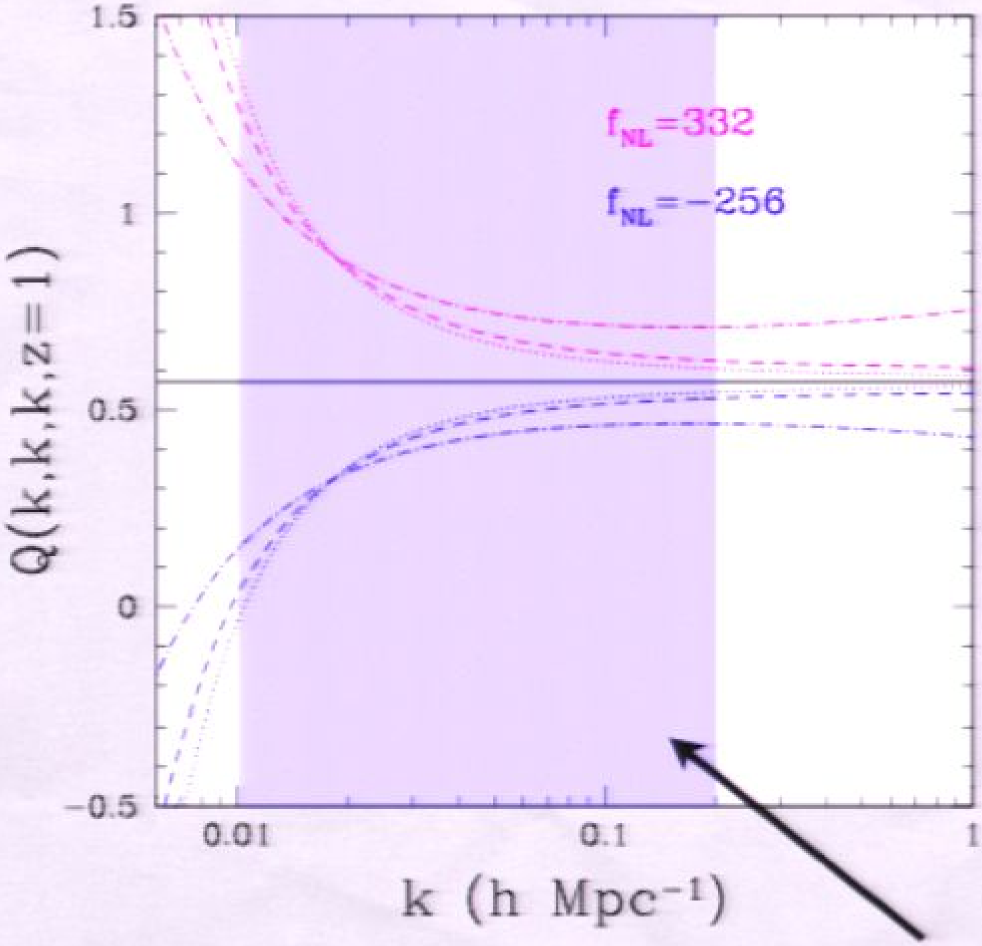
········ $\kappa = 0$

- - - $\kappa = -0.1$

-·-·- $\kappa = -0.3$

Most accessible range

REDUCED BISPECTRUM

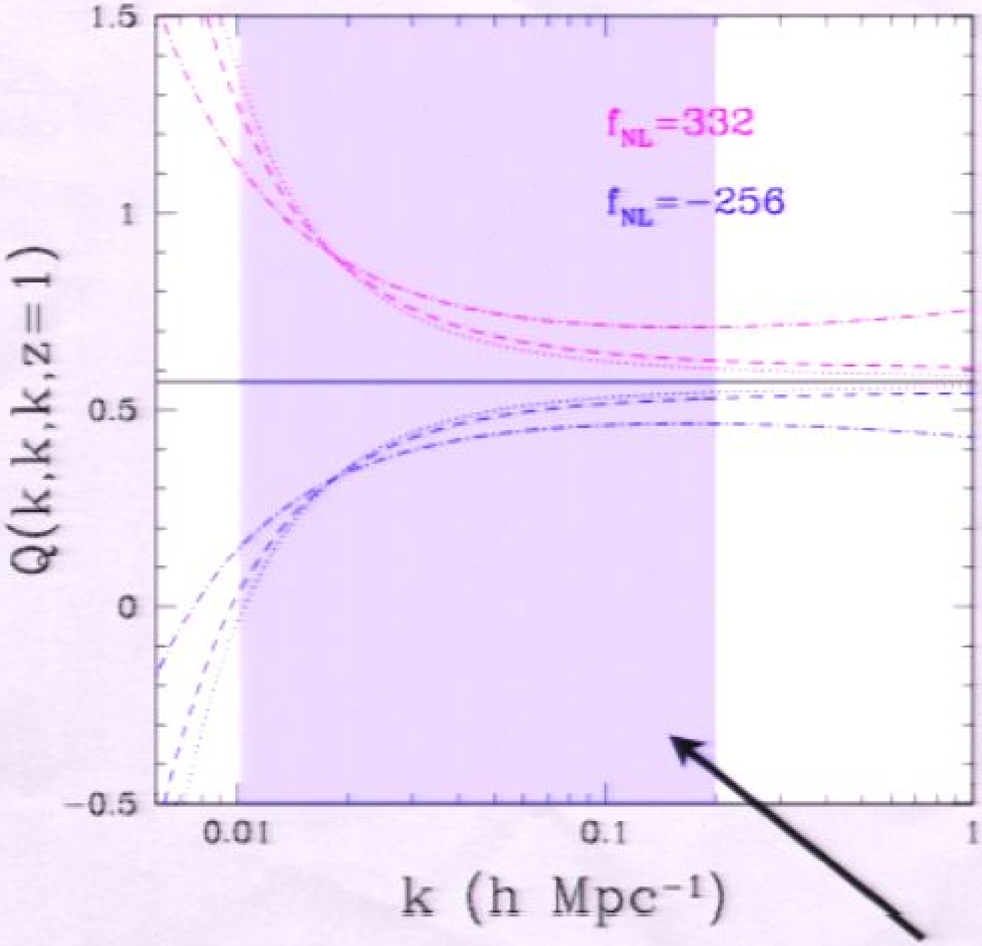


$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

Most accessible range

REDUCED BISPECTRUM

$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$



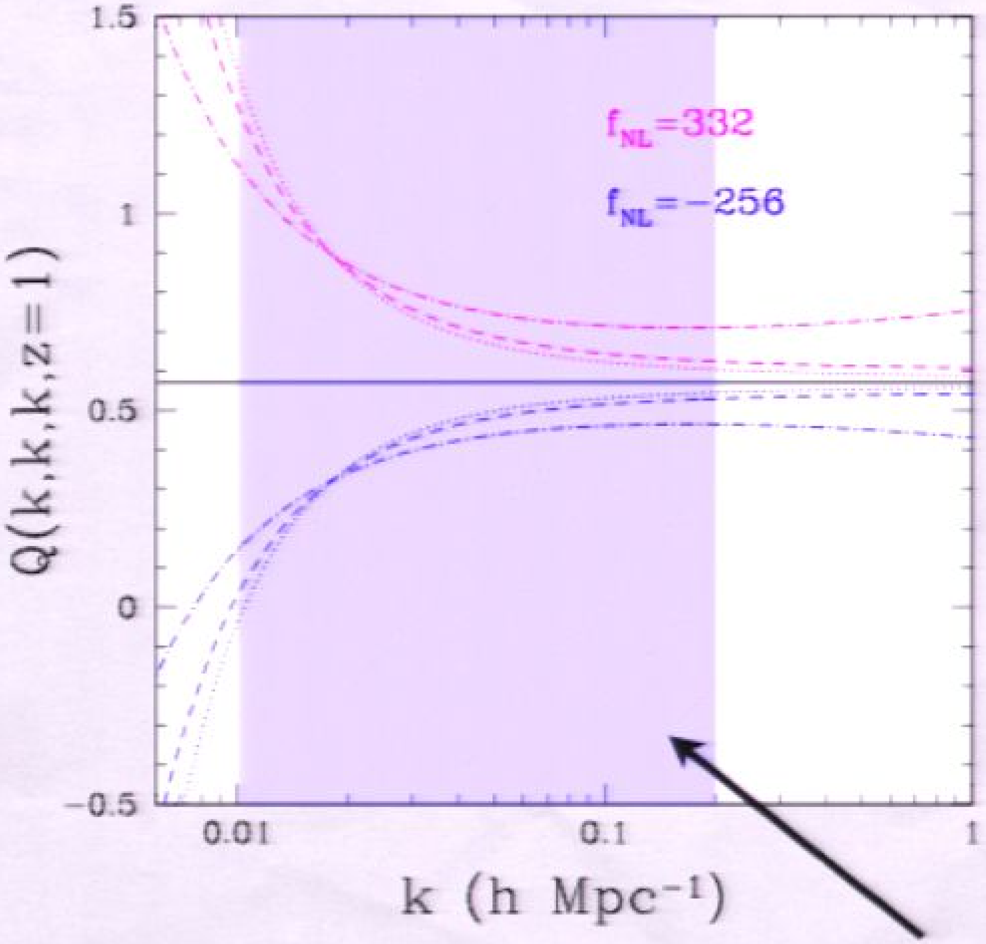
┈┈┈ $\kappa = 0$

- - - $\kappa = -0.1$

–·–·– $\kappa = -0.3$

Most accessible range

REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

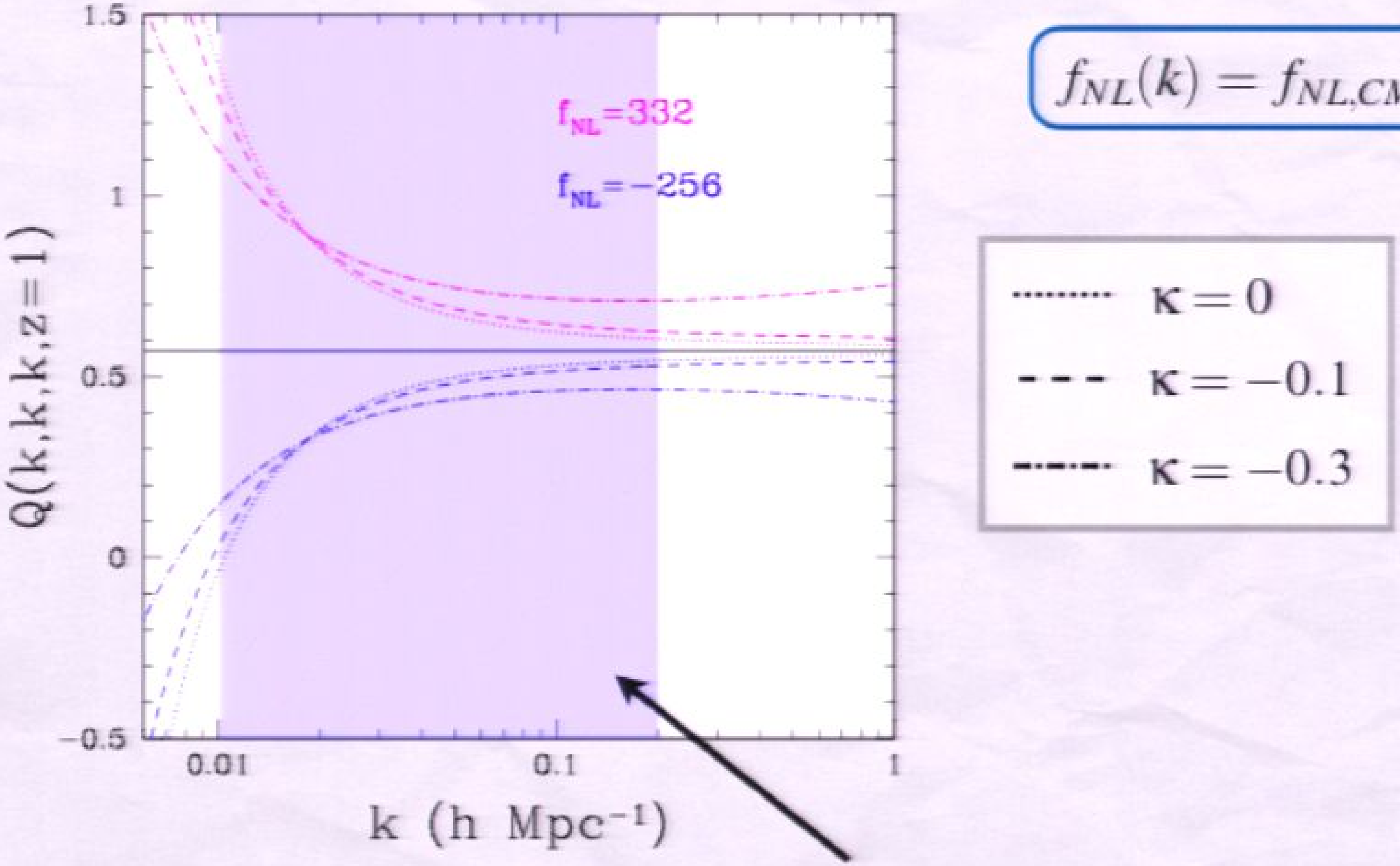
········	$\kappa = 0$
- - -	$\kappa = -0.1$
-·-·-	$\kappa = -0.3$

Most accessible range

PI, Oct. 30, 2007

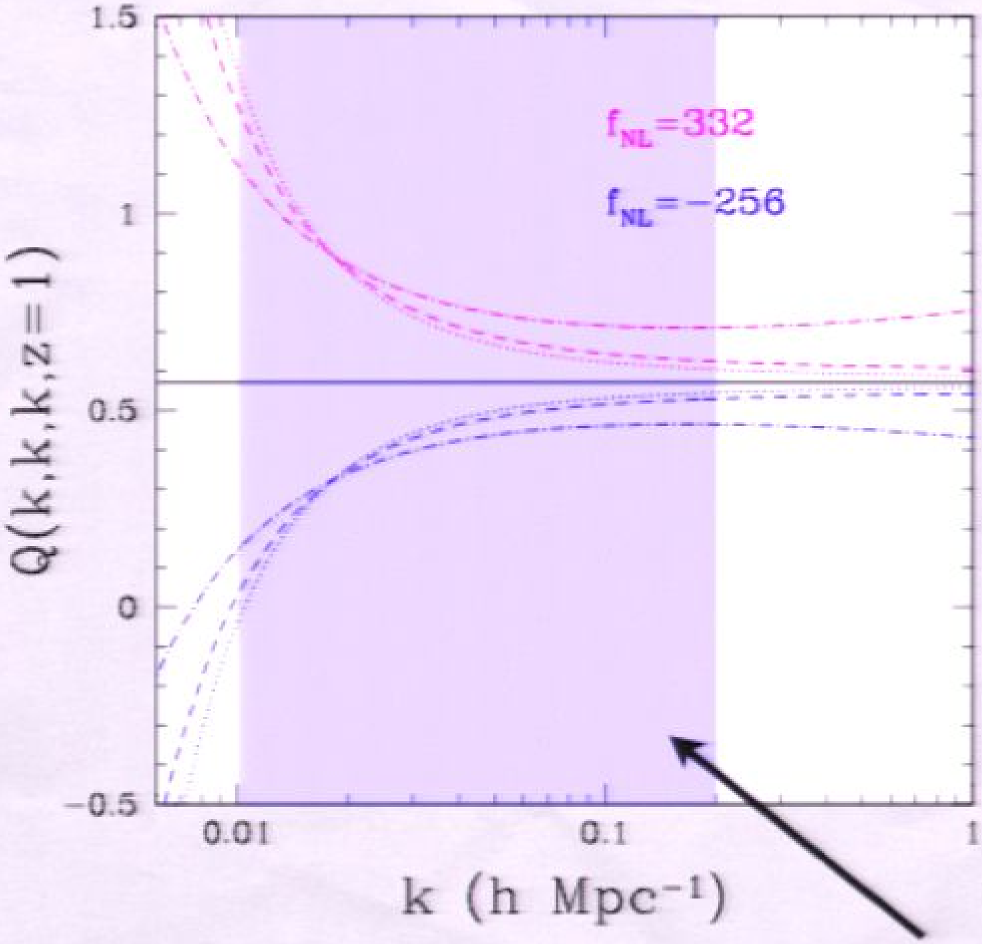
REDUCED BISPECTRUM

$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$



Most accessible range

REDUCED BISPECTRUM



Most accessible range

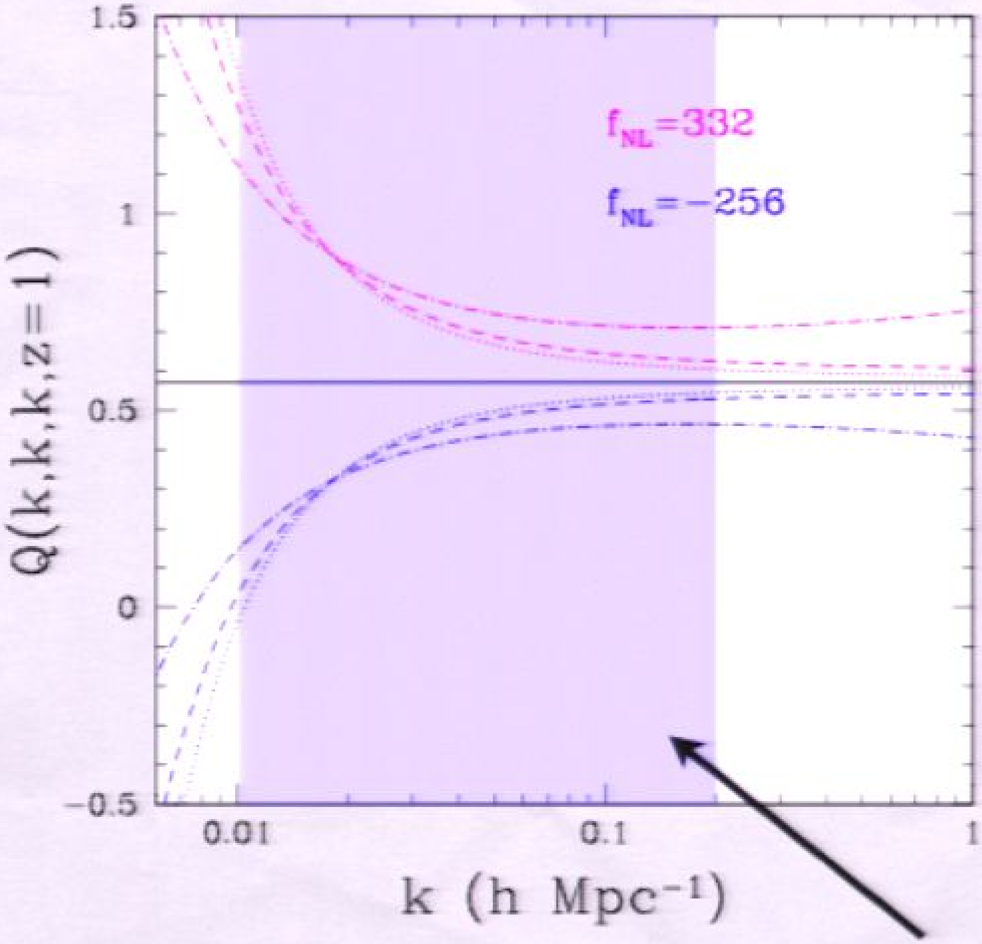
$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

········ $\kappa = 0$

- - - $\kappa = -0.1$

-·-·- $\kappa = -0.3$

REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

┈┈┈ $\kappa = 0$

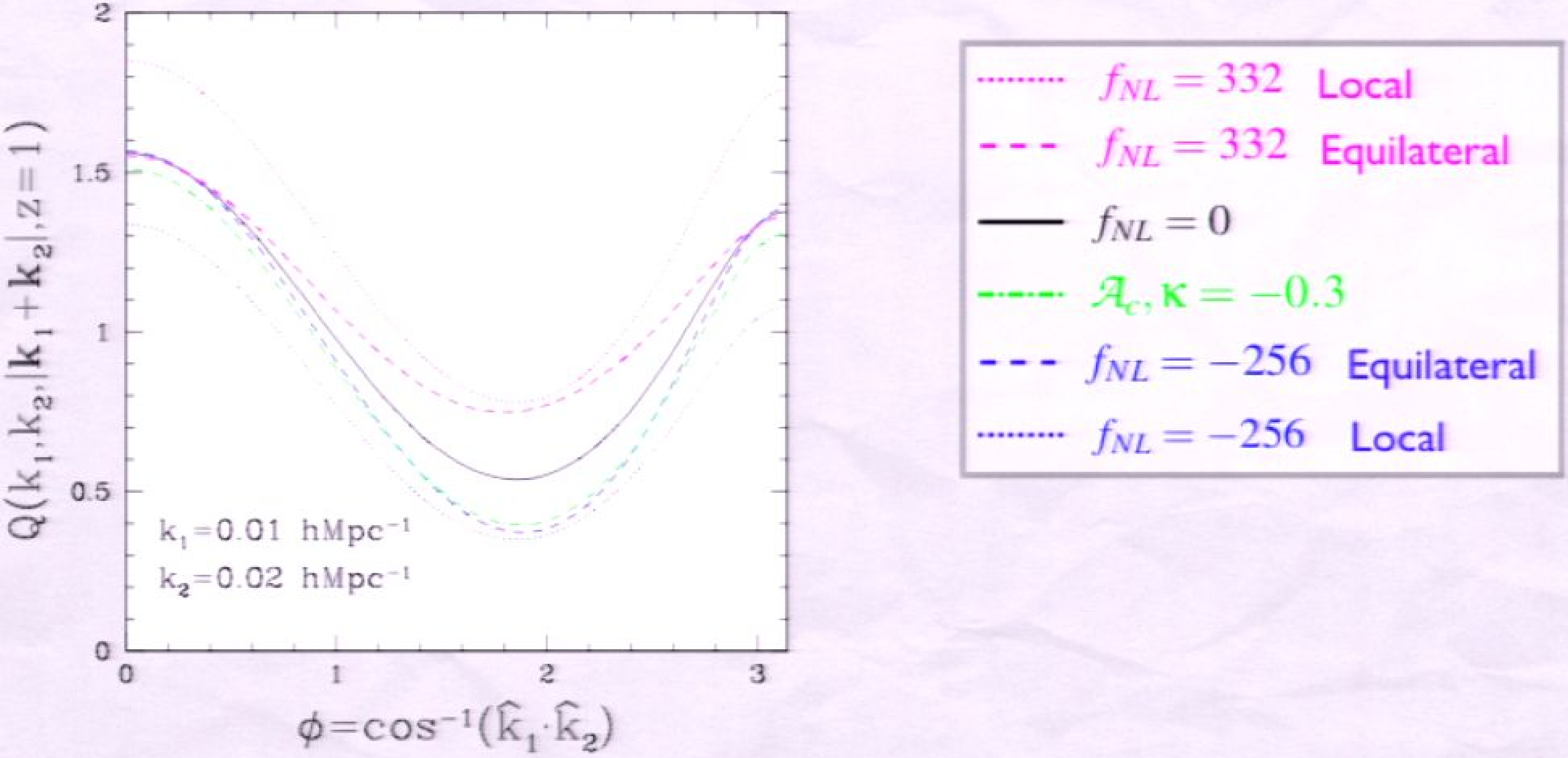
– – – $\kappa = -0.1$

–·–·– $\kappa = -0.3$

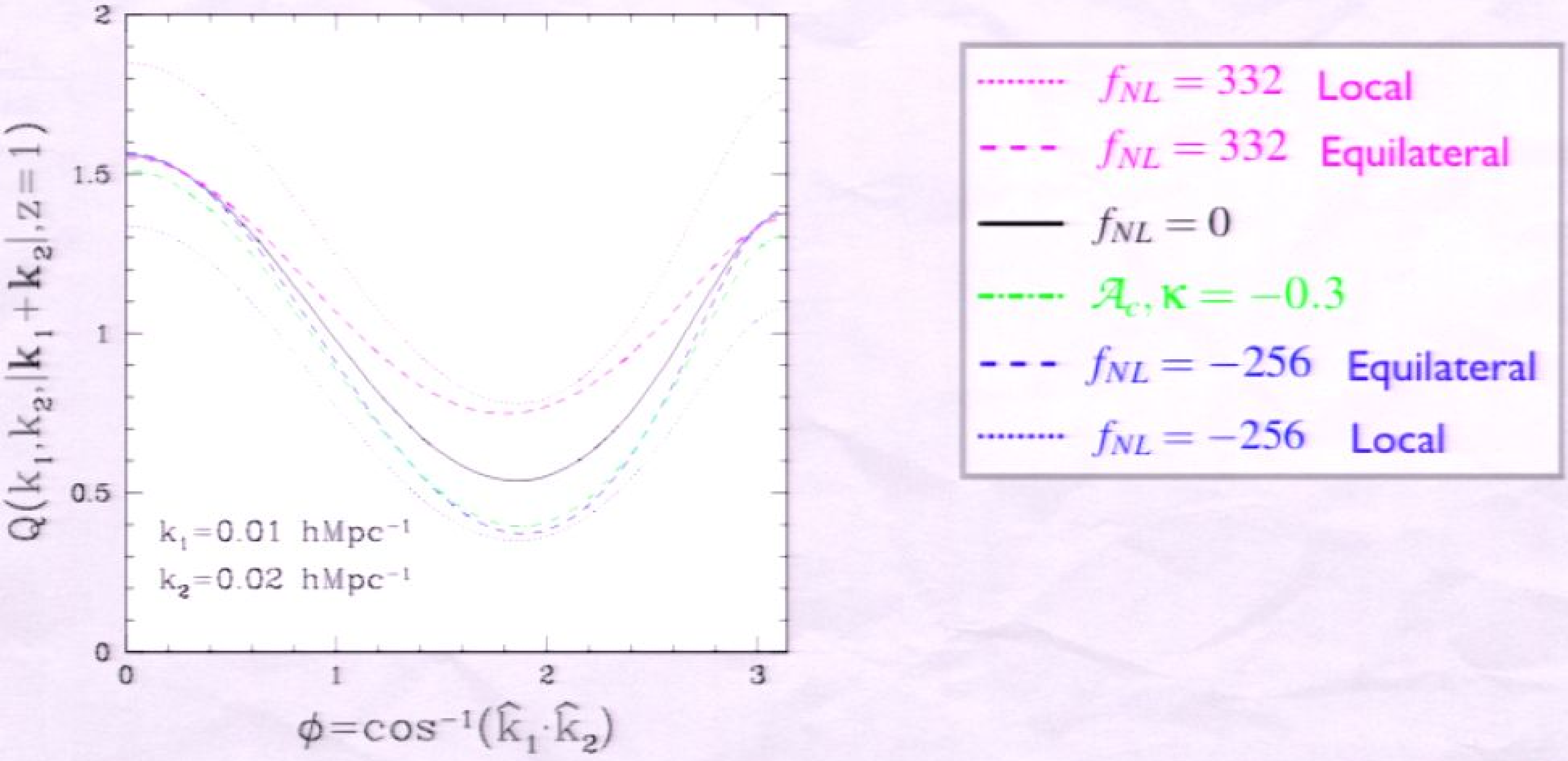
Most accessible range

PI, Oct. 30, 2007

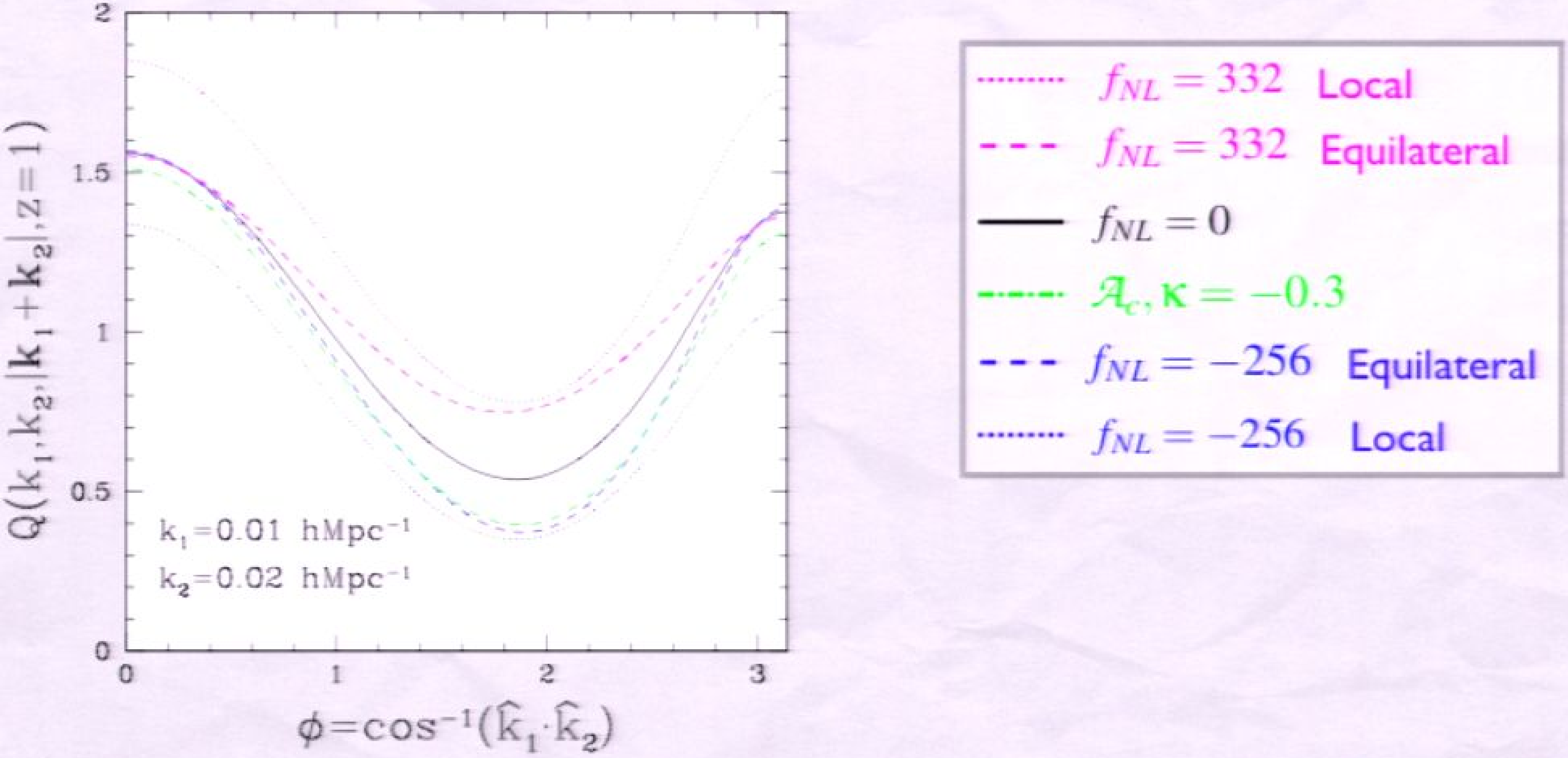
REDUCED BISPECTRUM



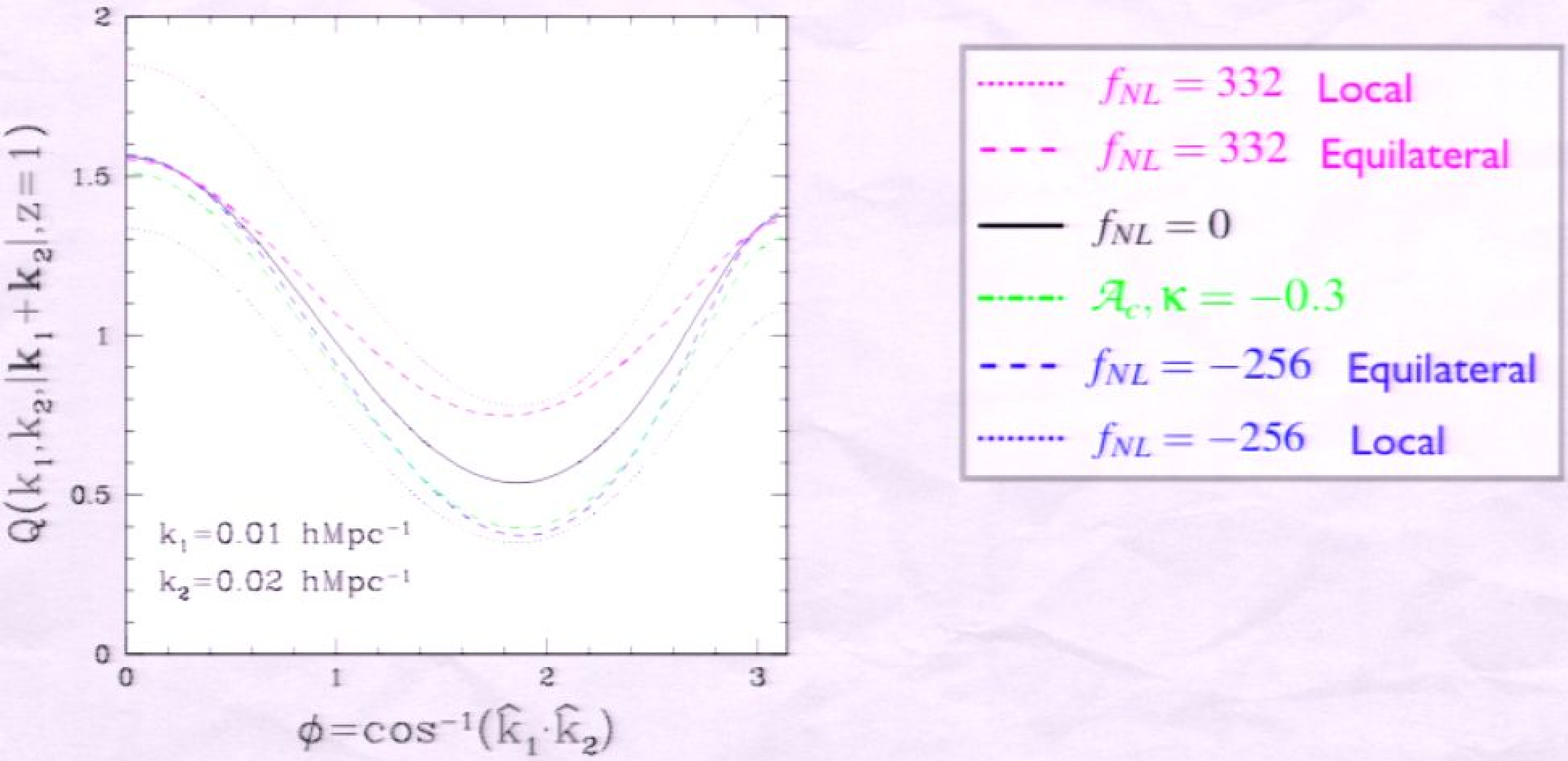
REDUCED BISPECTRUM



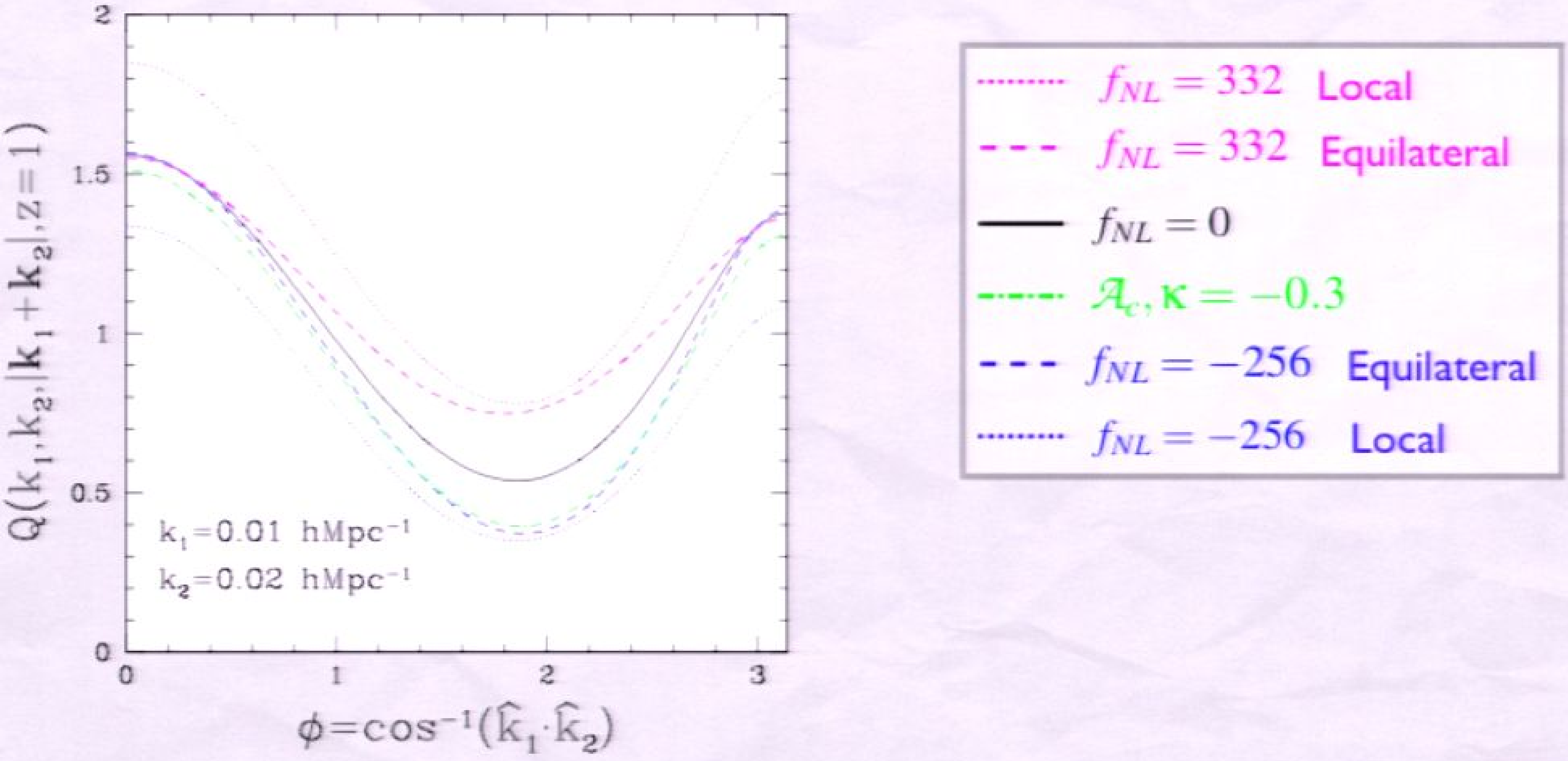
REDUCED BISPECTRUM



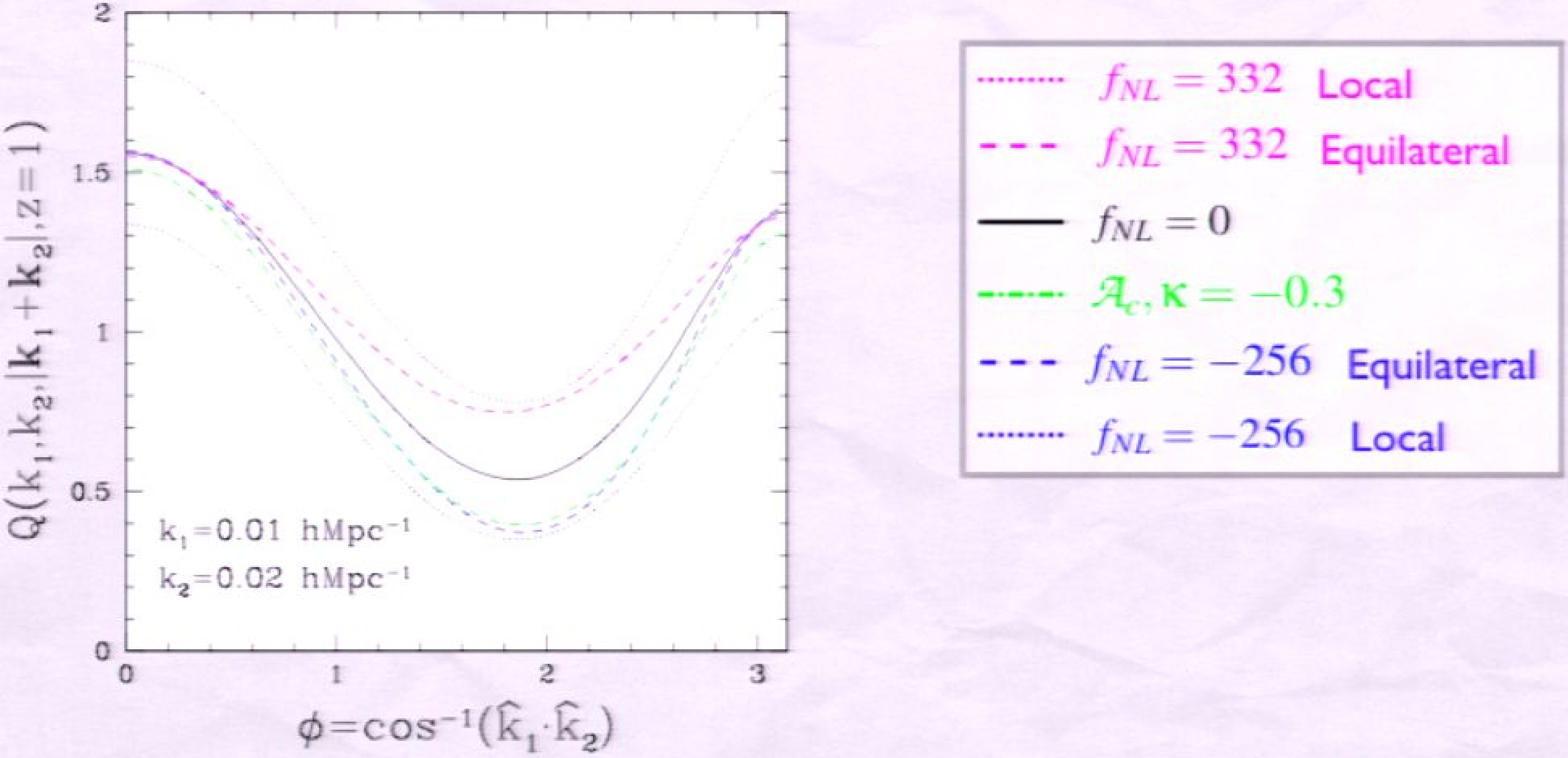
REDUCED BISPECTRUM



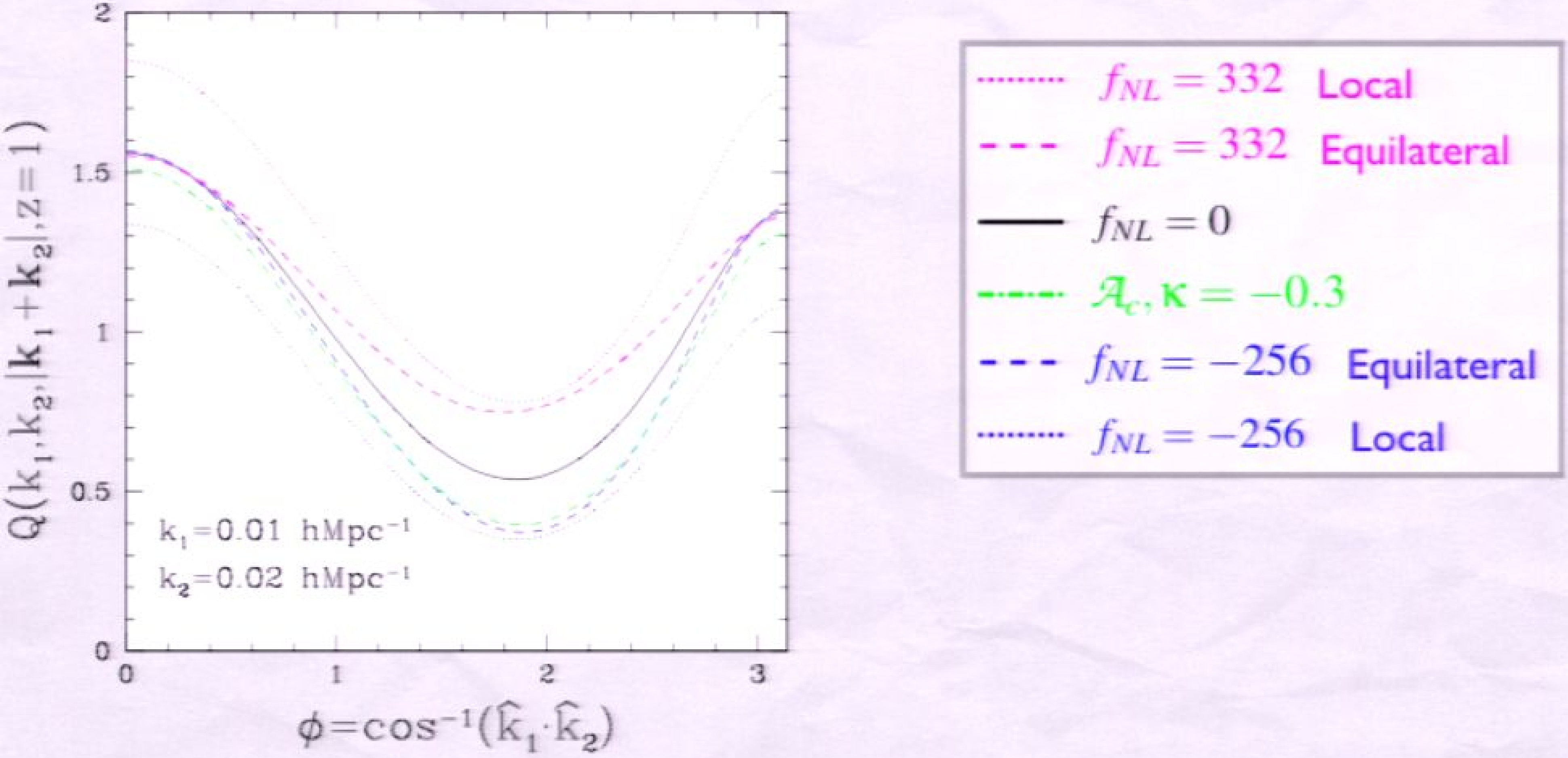
REDUCED BISPECTRUM



REDUCED BISPECTRUM

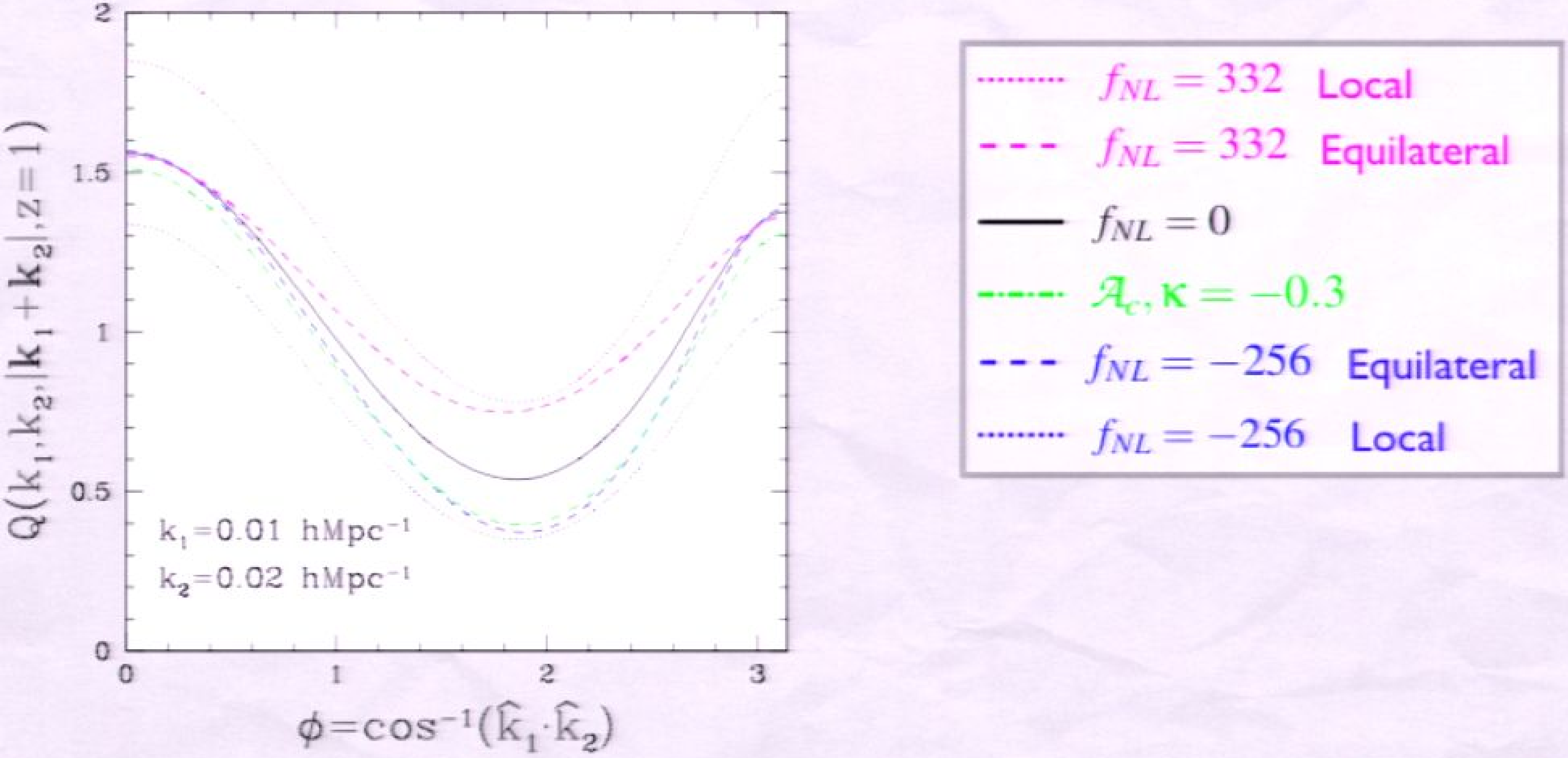


REDUCED BISPECTRUM

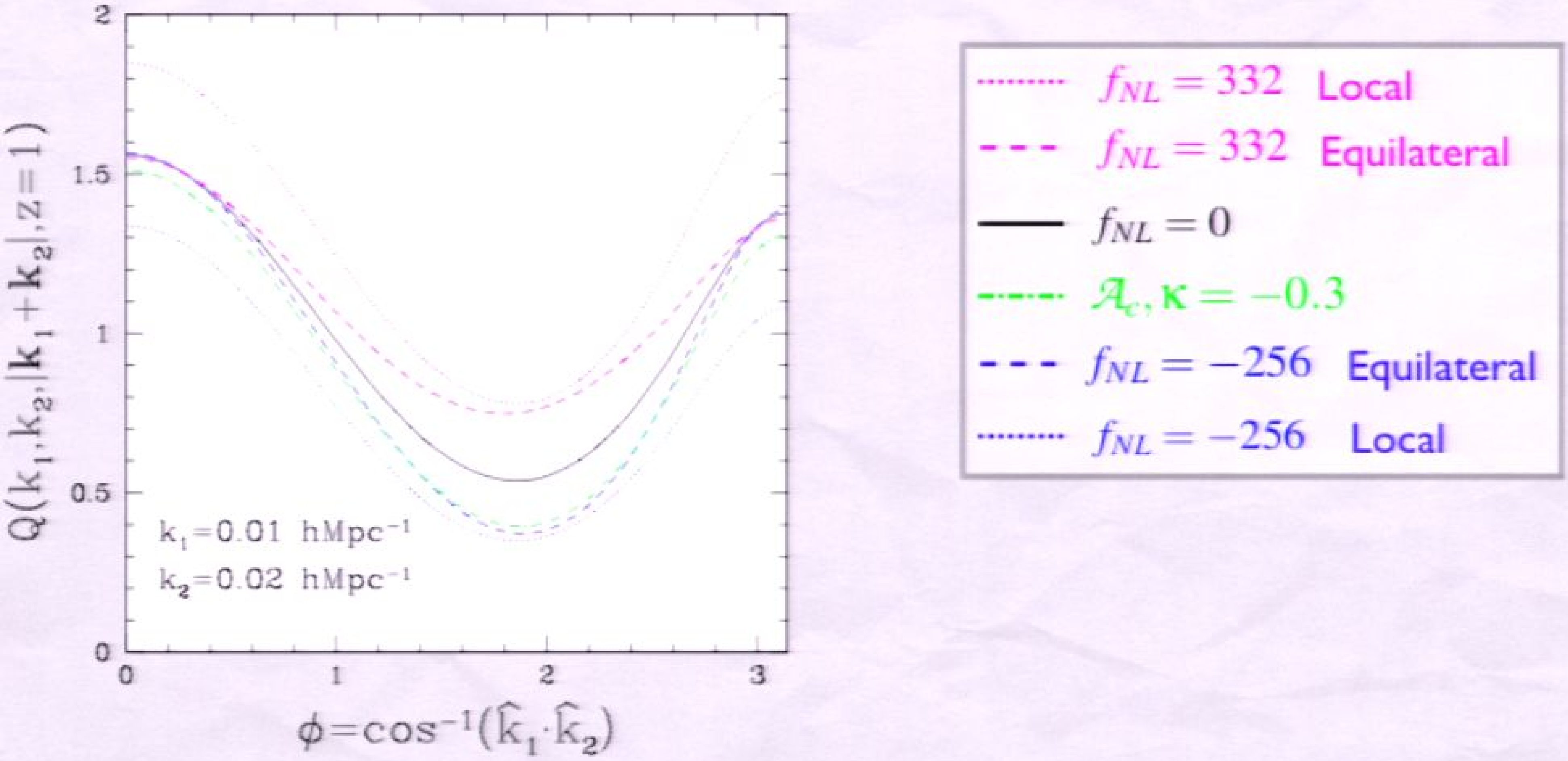


PI, Oct. 30, 2007

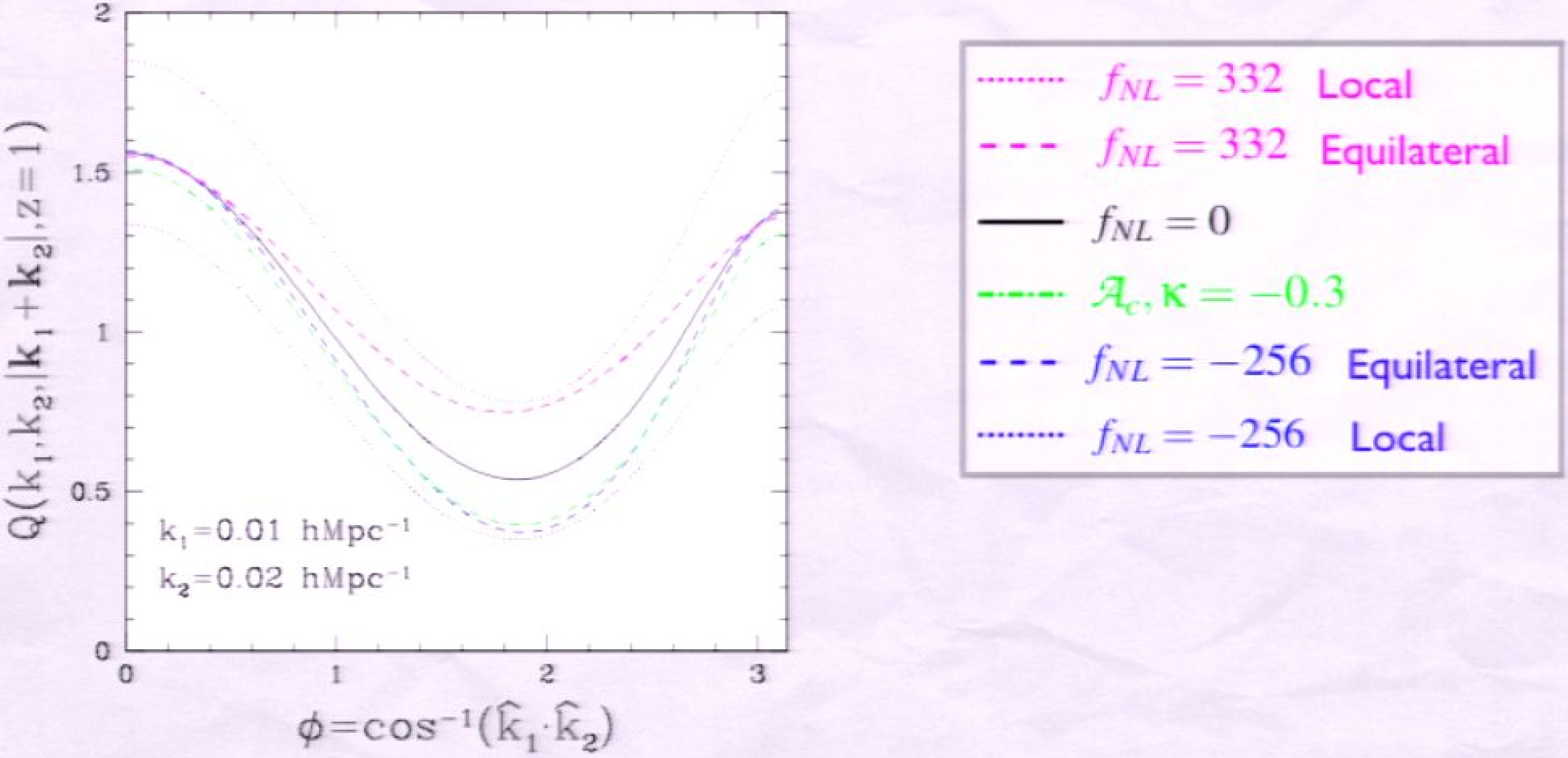
REDUCED BISPECTRUM



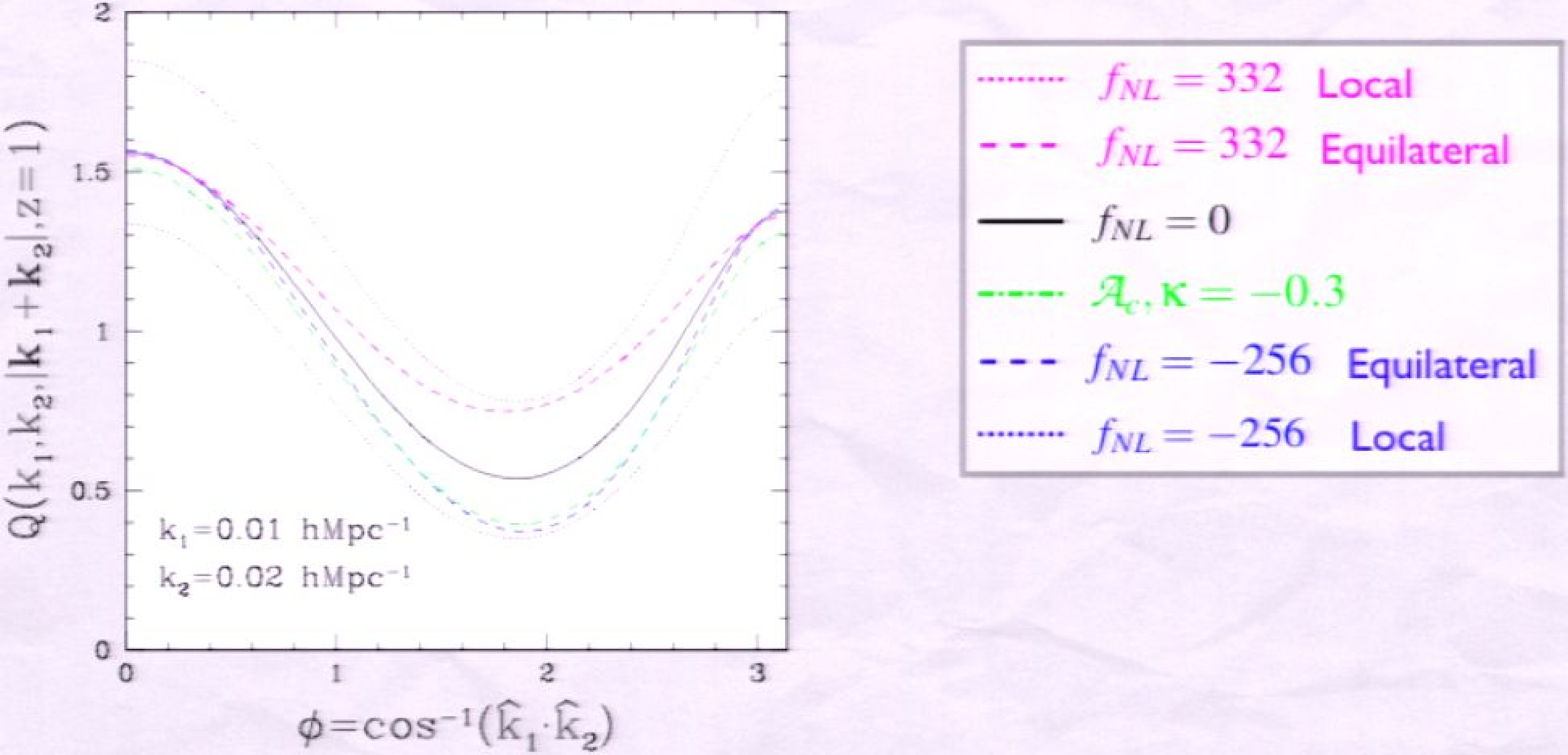
REDUCED BISPECTRUM



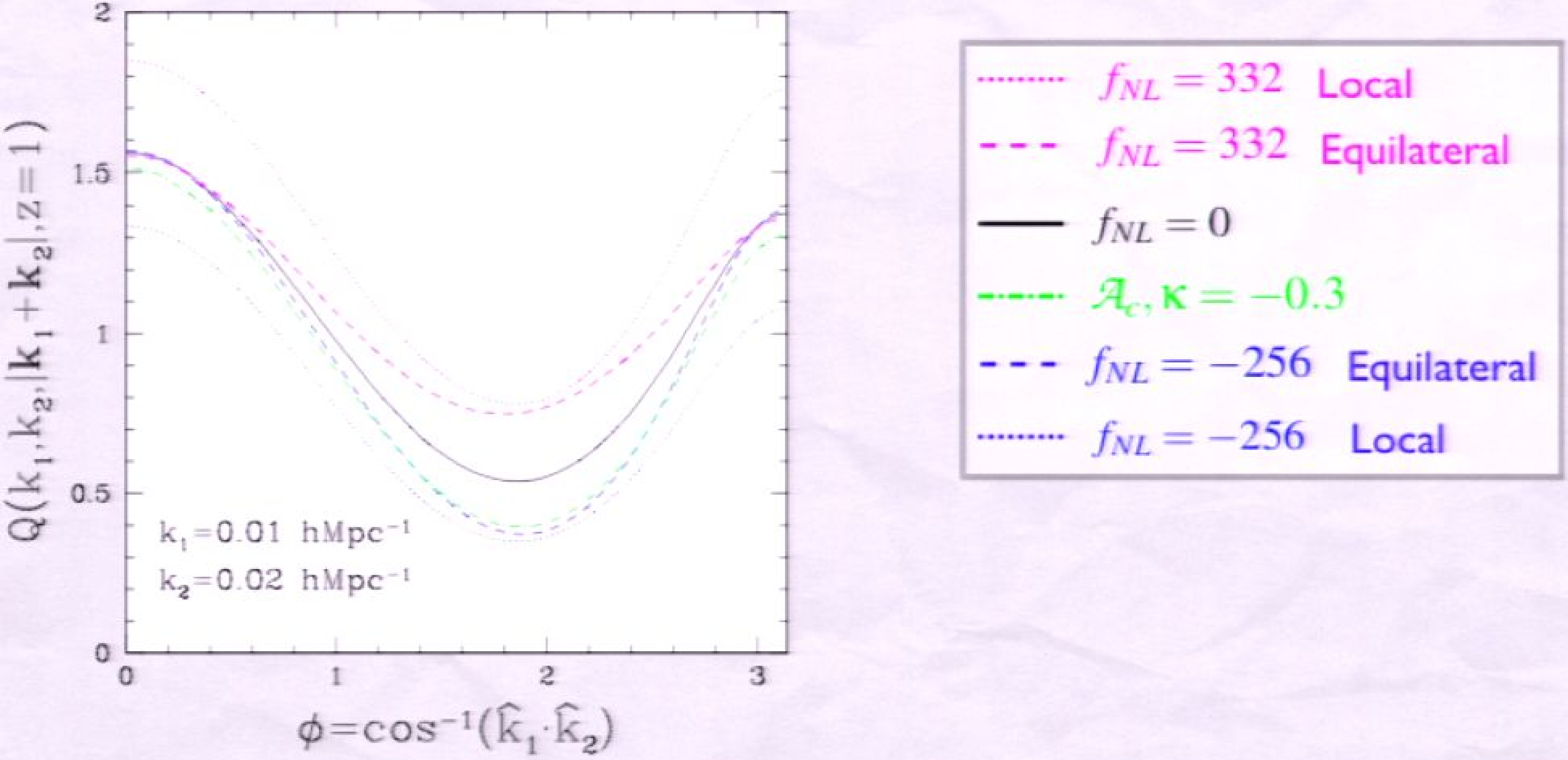
REDUCED BISPECTRUM



REDUCED BISPECTRUM

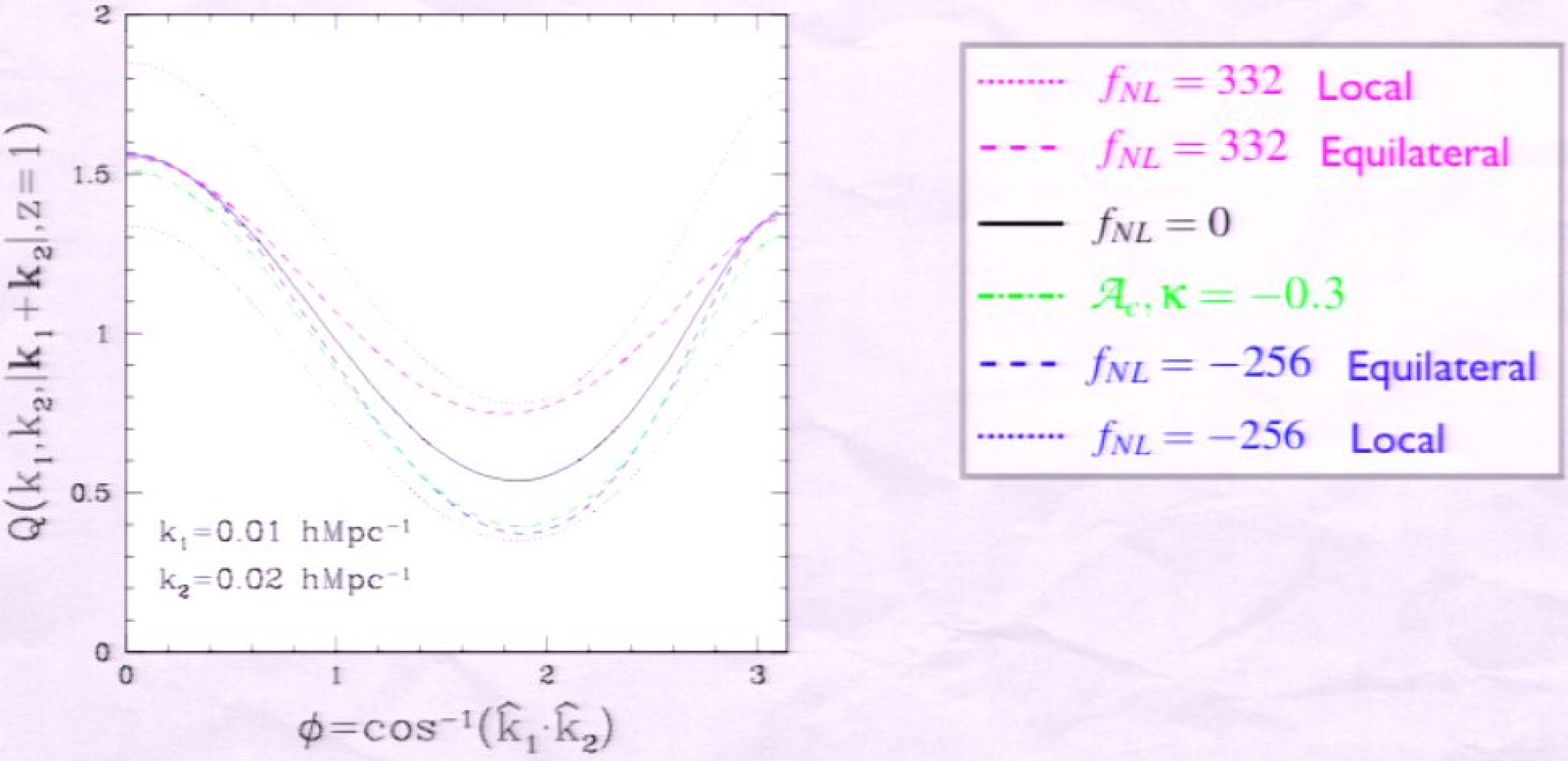


REDUCED BISPECTRUM

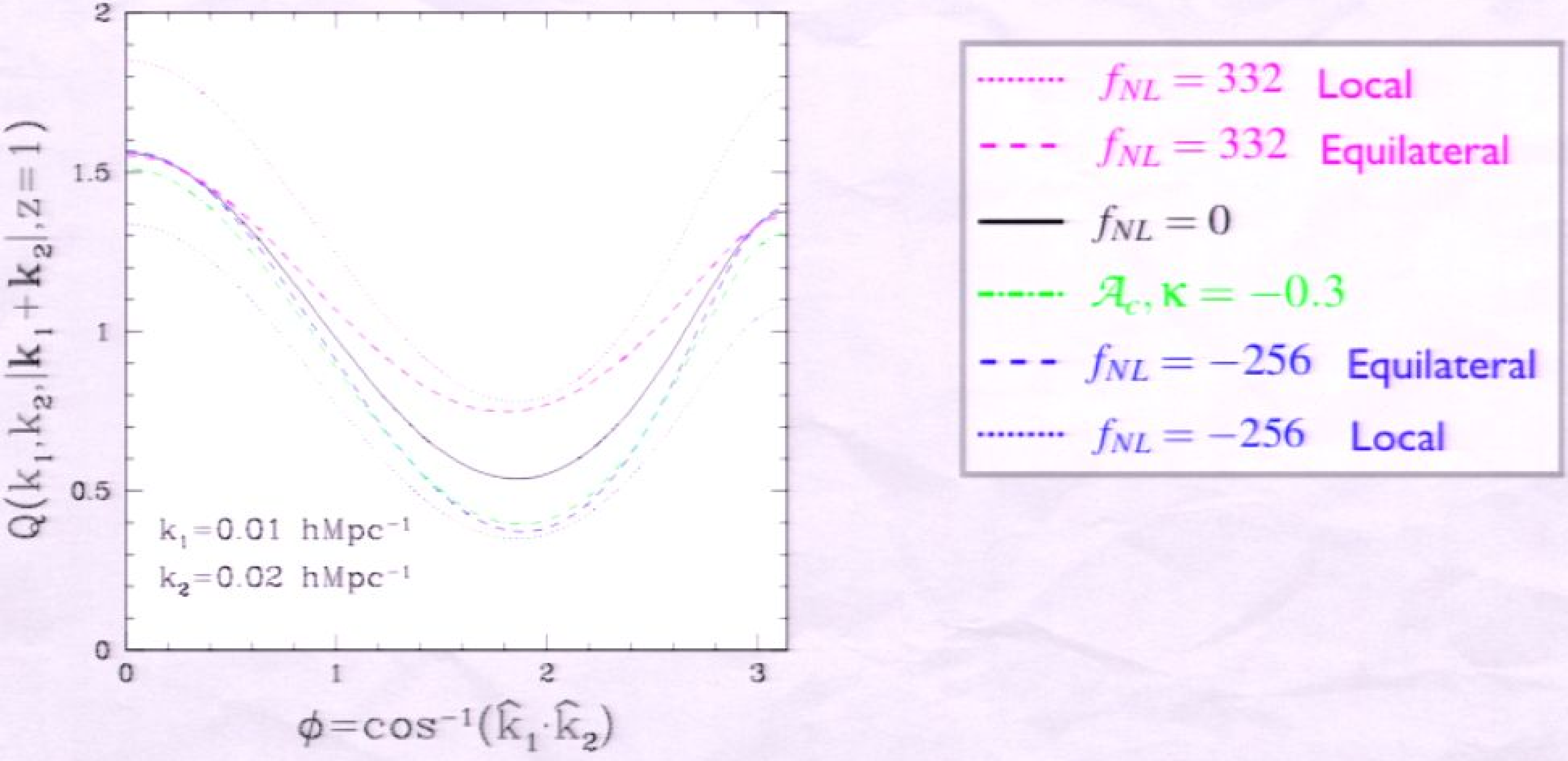


PI, Oct. 30, 2007

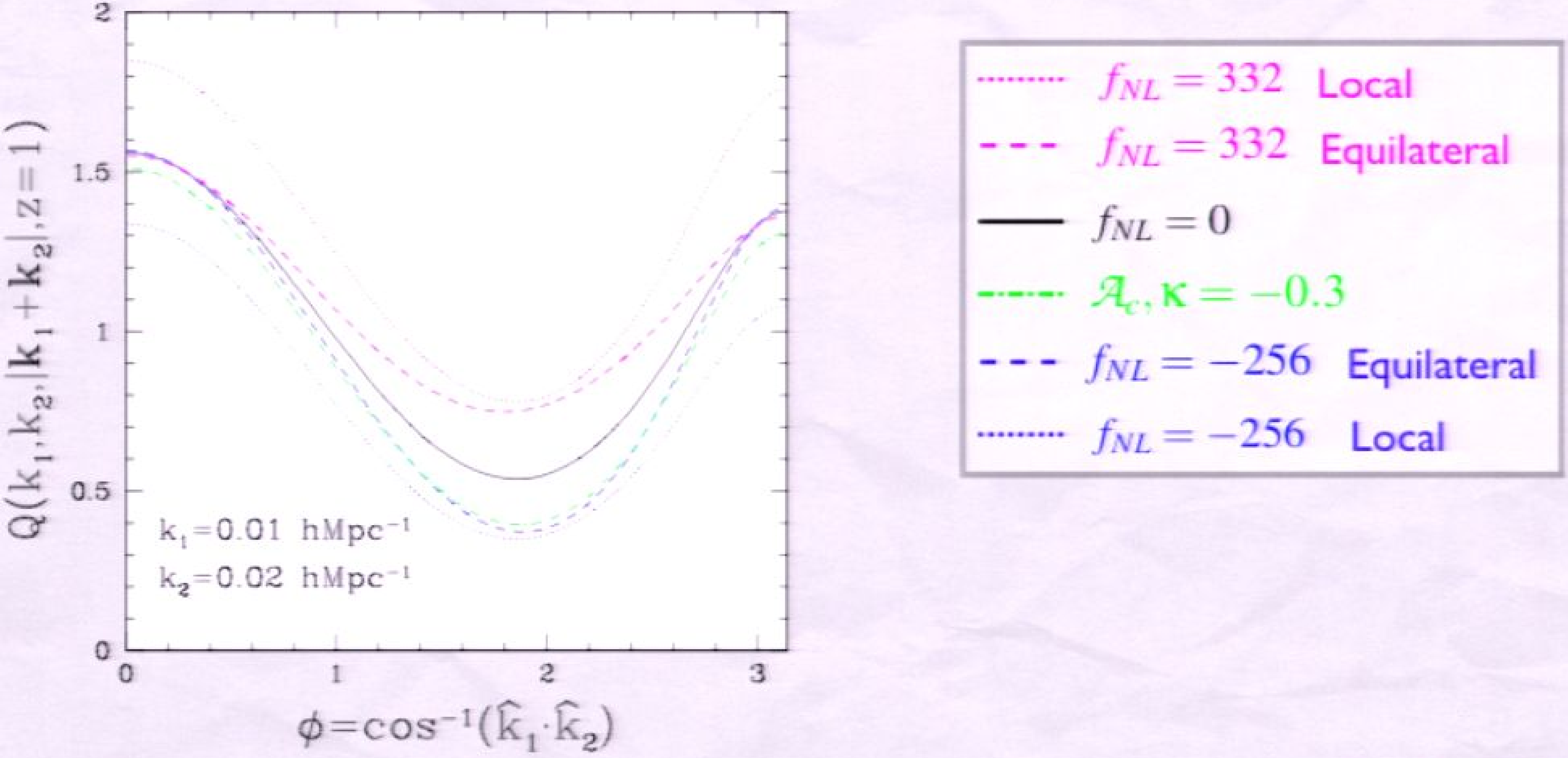
REDUCED BISPECTRUM



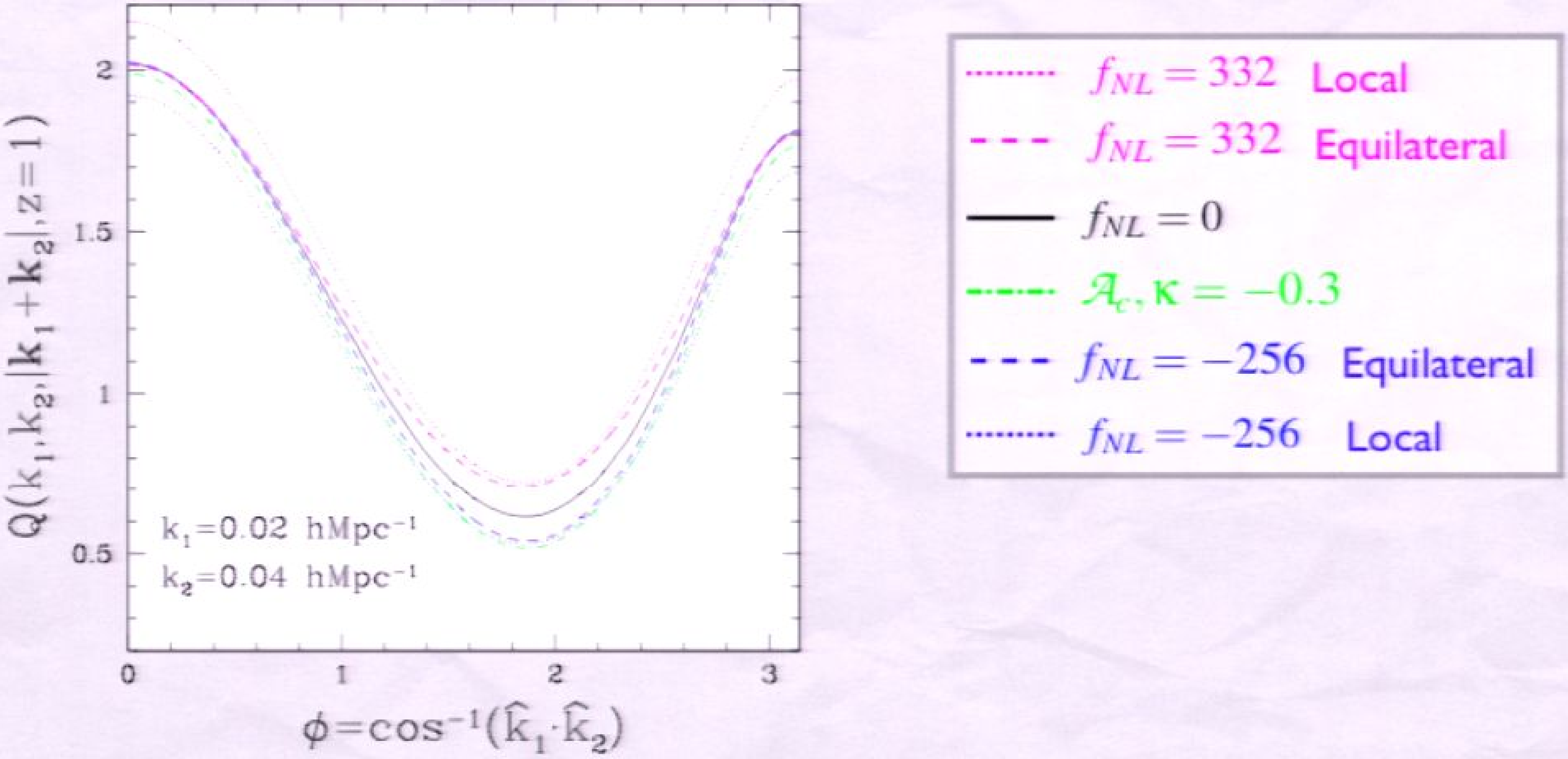
REDUCED BISPECTRUM



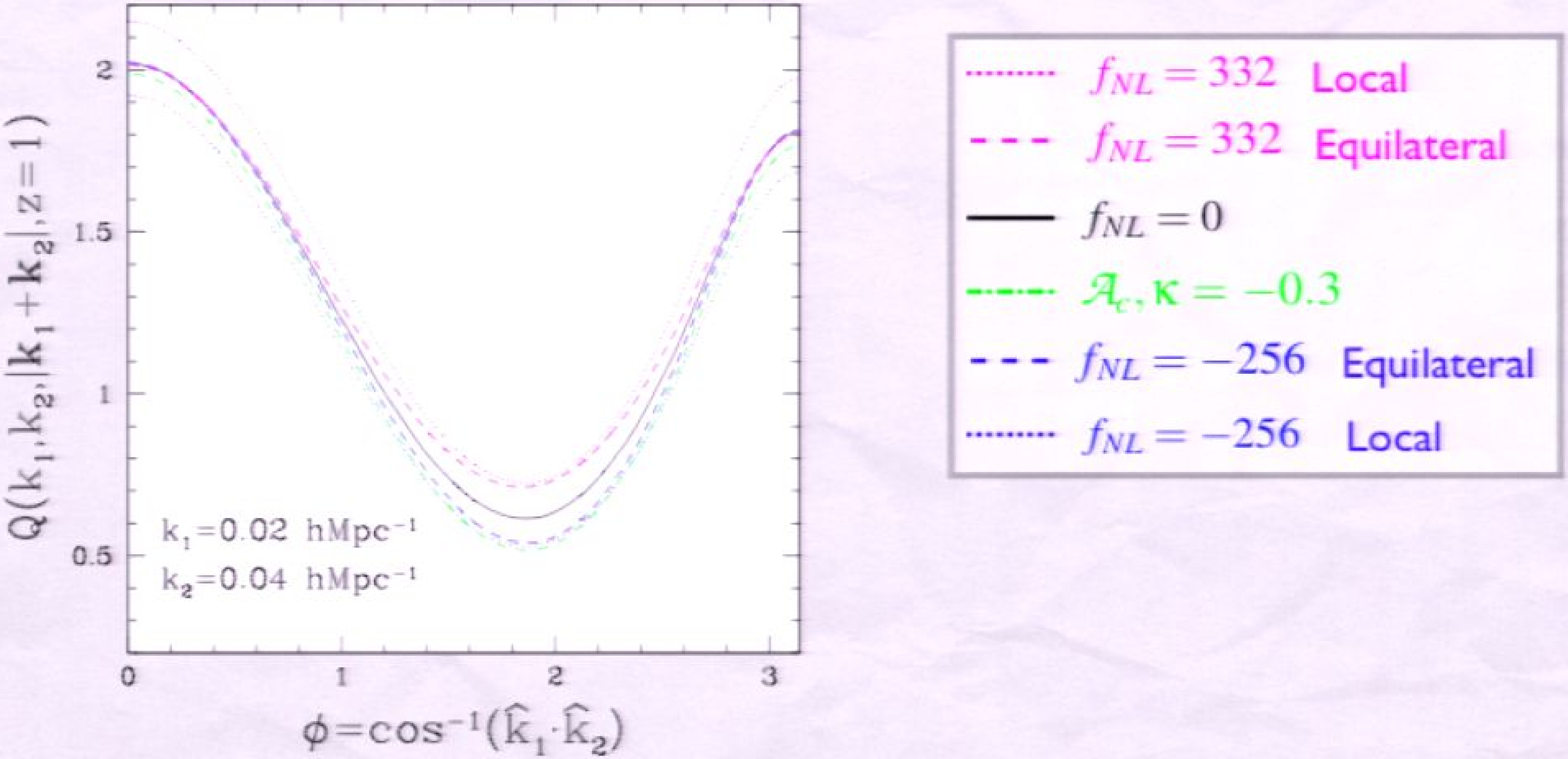
REDUCED BISPECTRUM



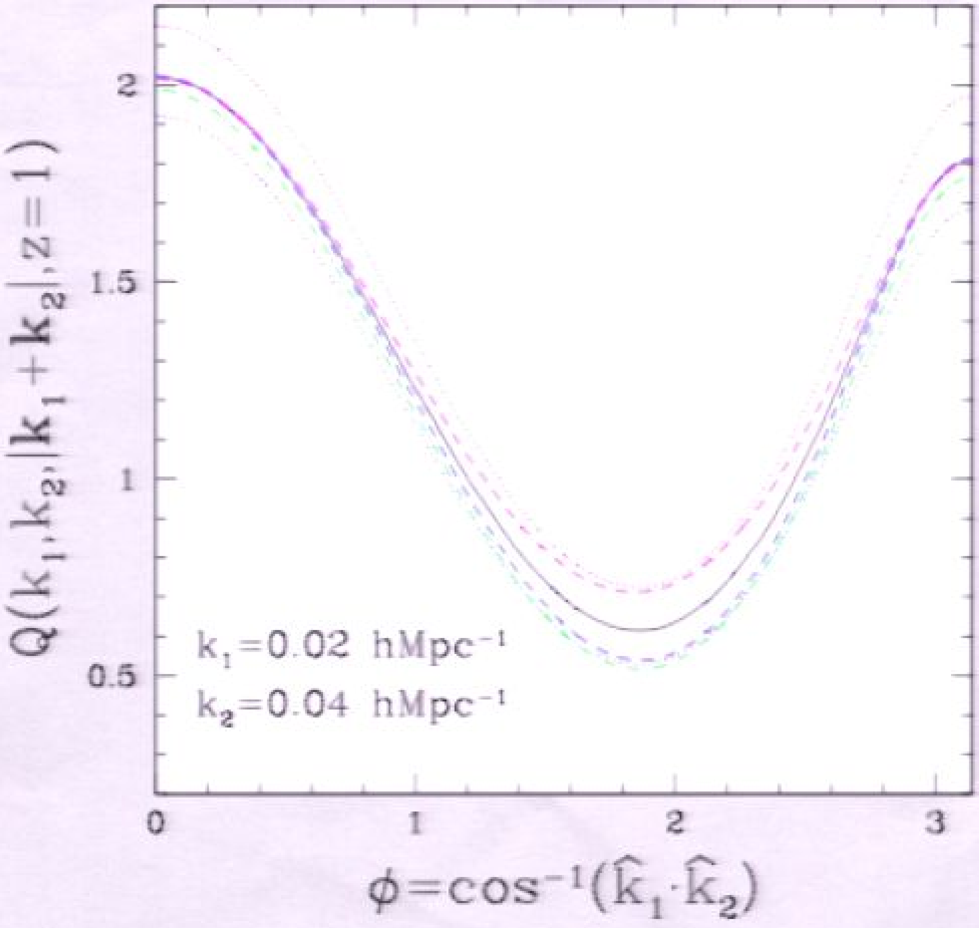
REDUCED BISPECTRUM



REDUCED BISPECTRUM

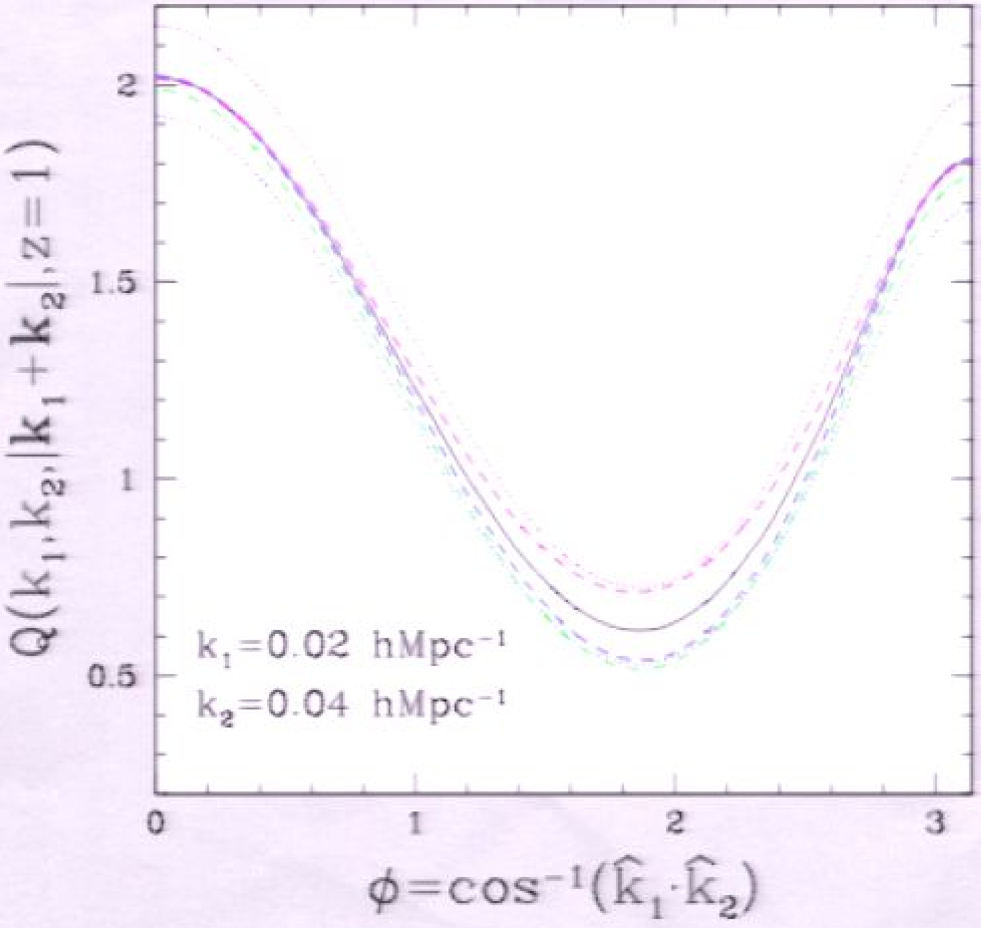


REDUCED BISPECTRUM



········ $f_{NL} = 332$ Local
- - - $f_{NL} = 332$ Equilateral
—— $f_{NL} = 0$
-·-·- $\mathcal{A}_c, \kappa = -0.3$
- - - $f_{NL} = -256$ Equilateral
········ $f_{NL} = -256$ Local

REDUCED BISPECTRUM



········ $f_{NL} = 332$ Local

- - - $f_{NL} = 332$ Equilateral

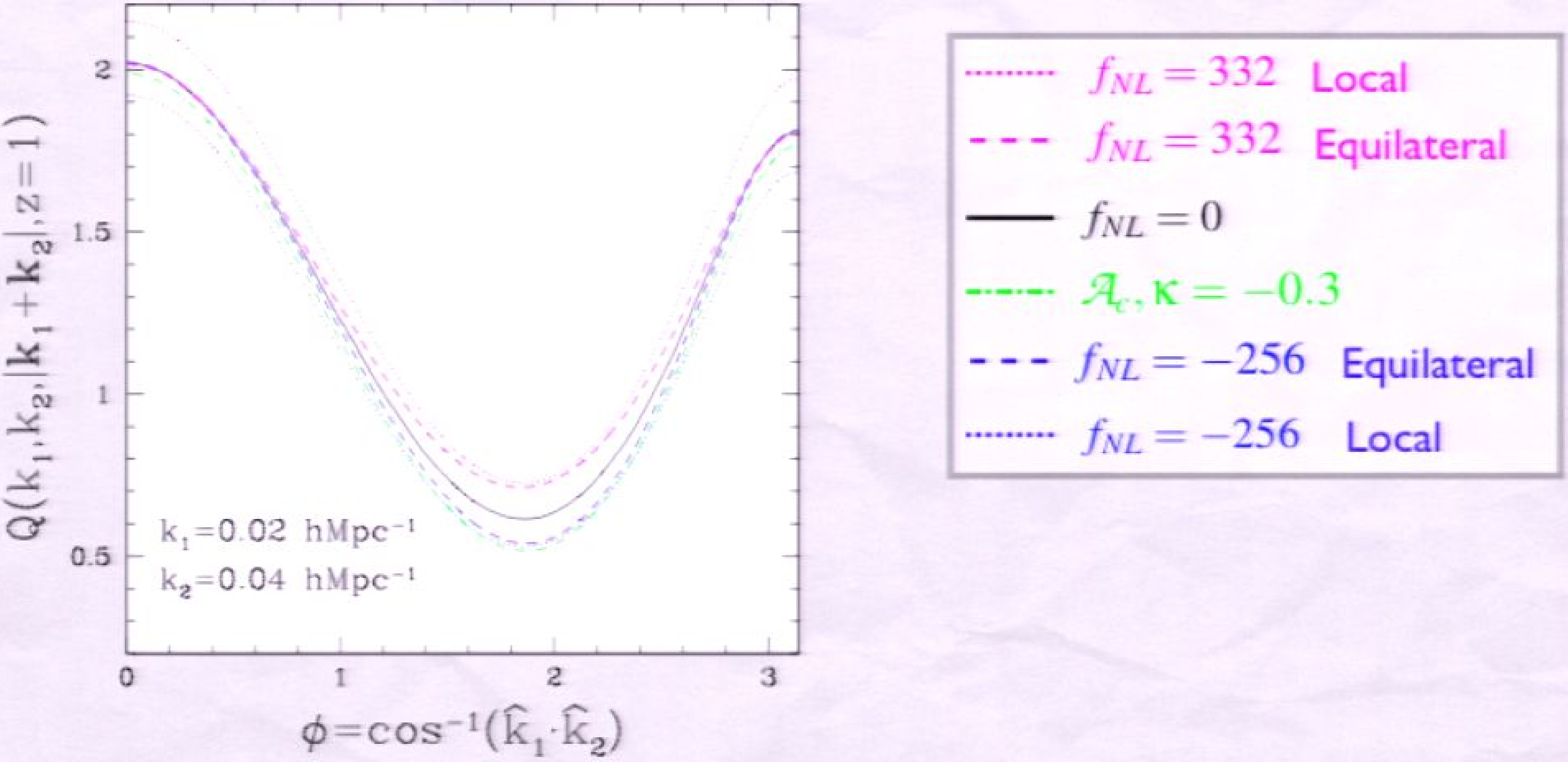
—— $f_{NL} = 0$

-·-·- $\mathcal{A}_c, \kappa = -0.3$

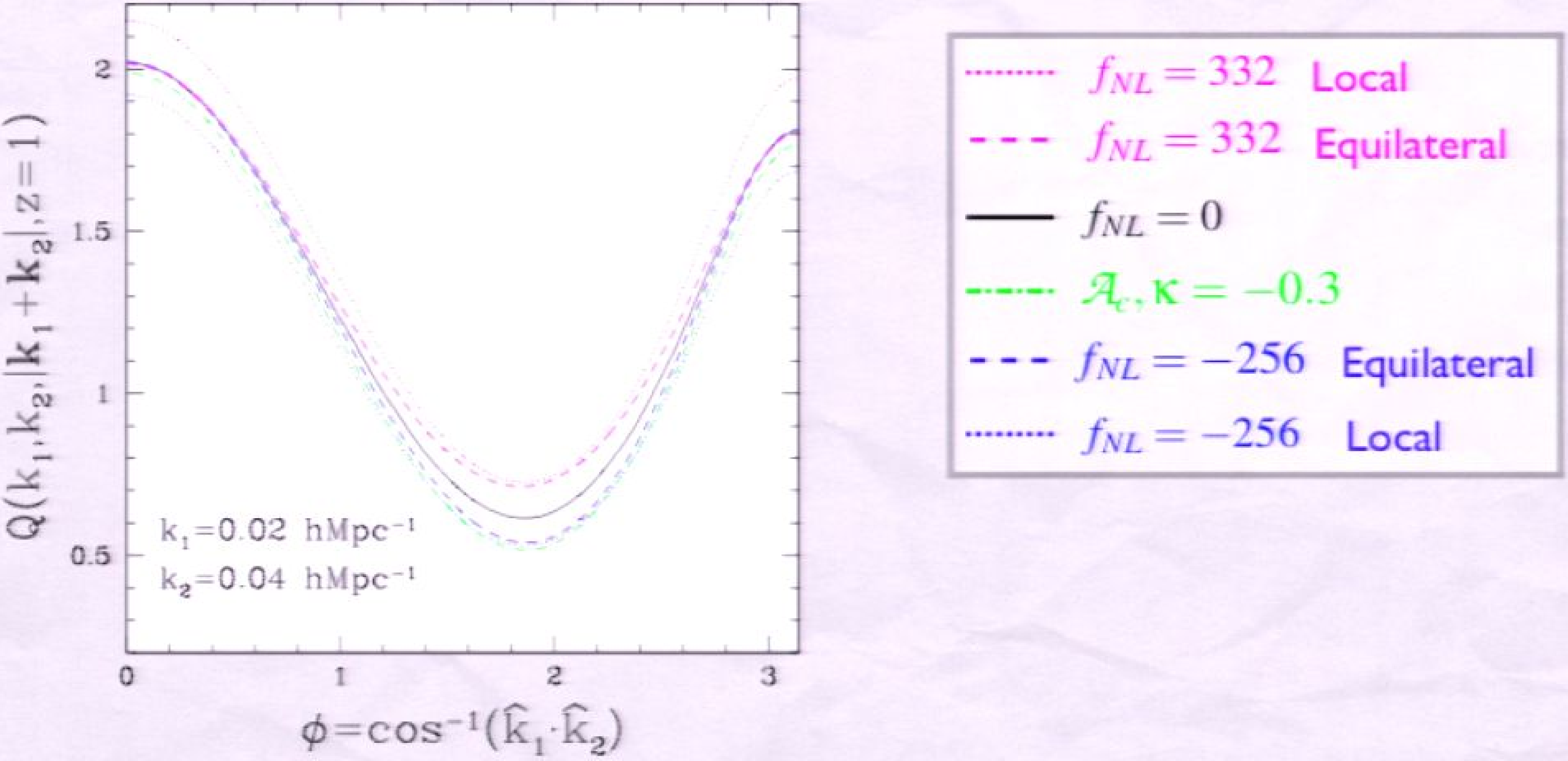
- - - $f_{NL} = -256$ Equilateral

········ $f_{NL} = -256$ Local

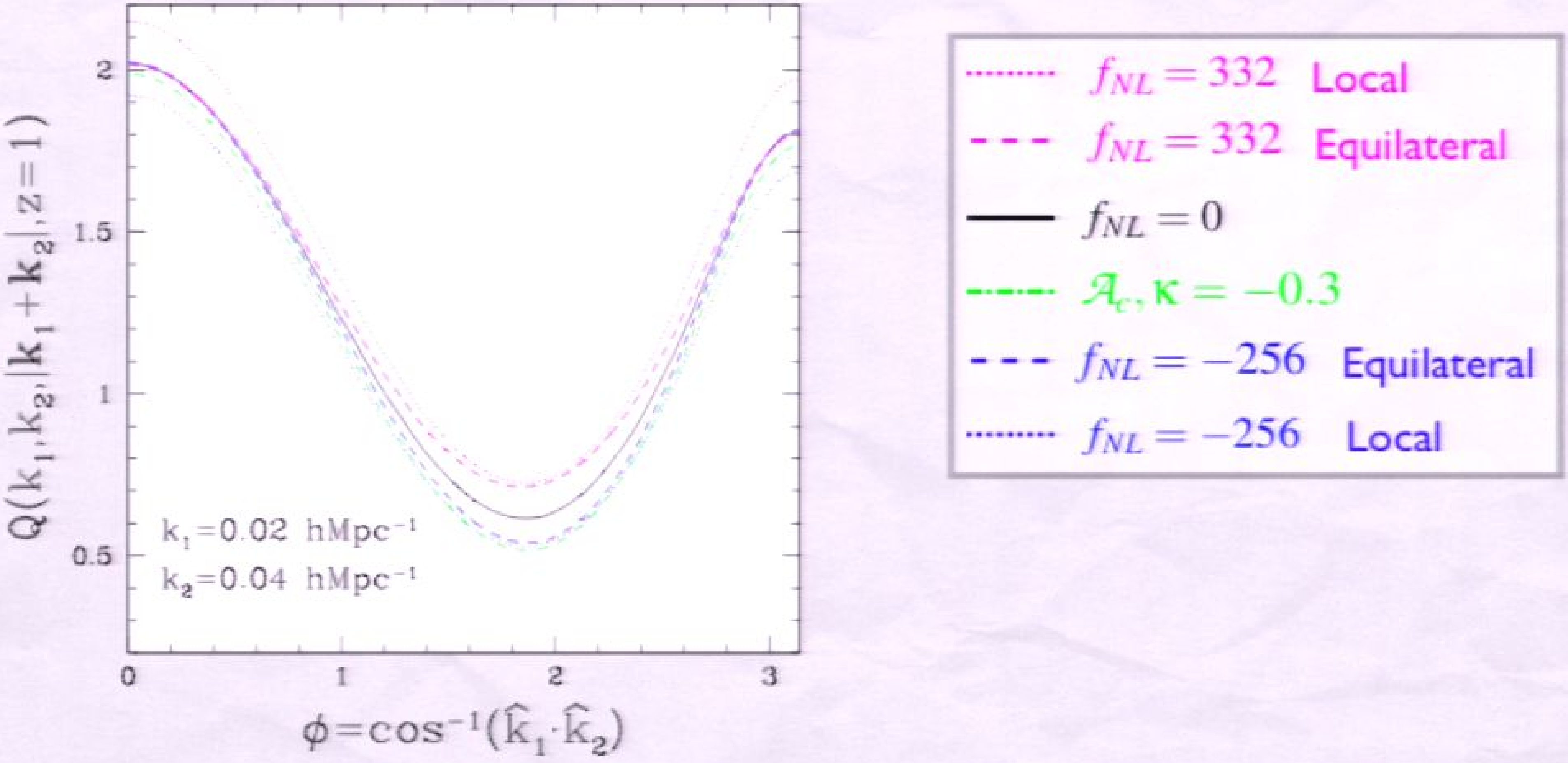
REDUCED BISPECTRUM



REDUCED BISPECTRUM

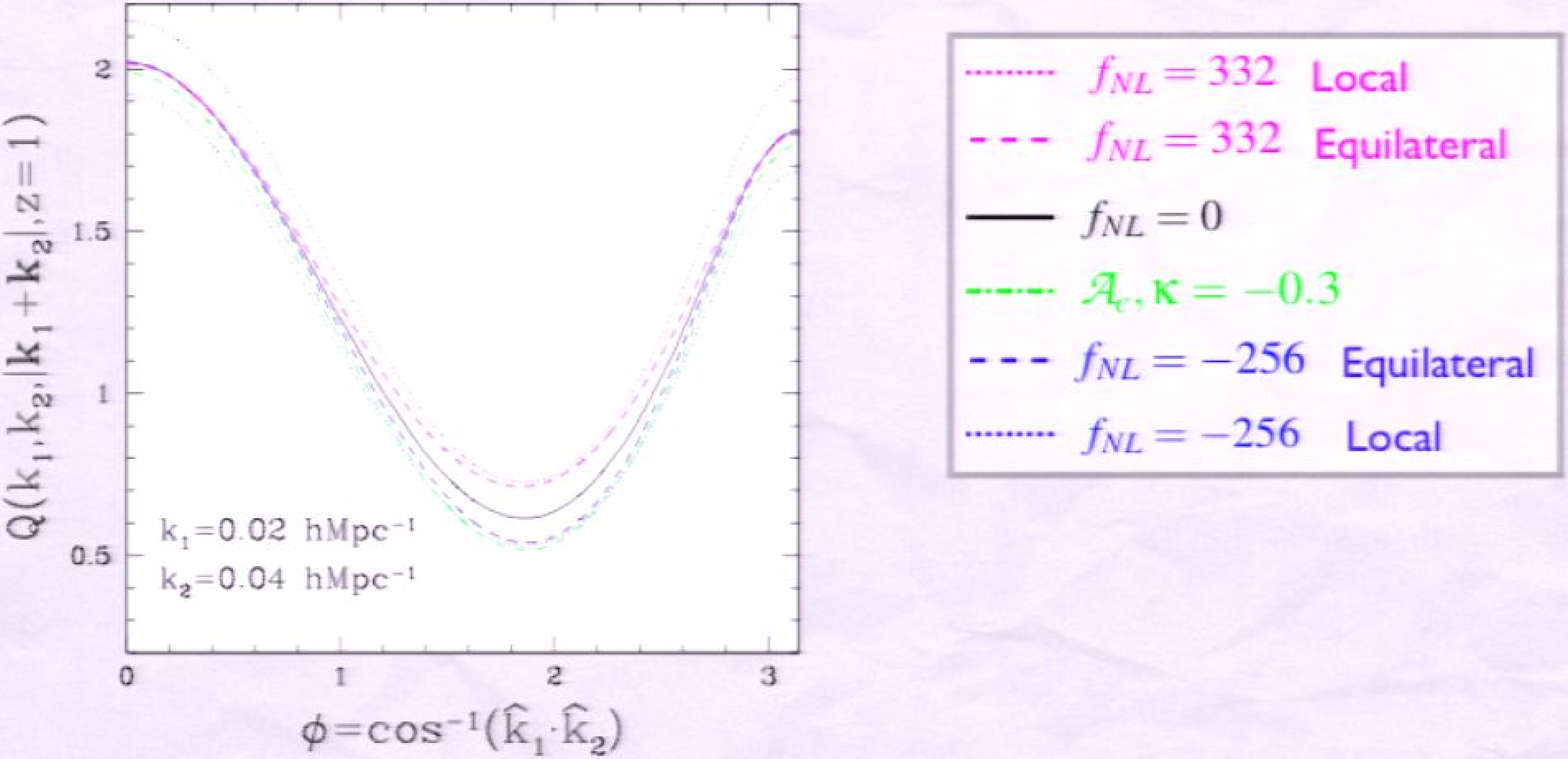


REDUCED BISPECTRUM



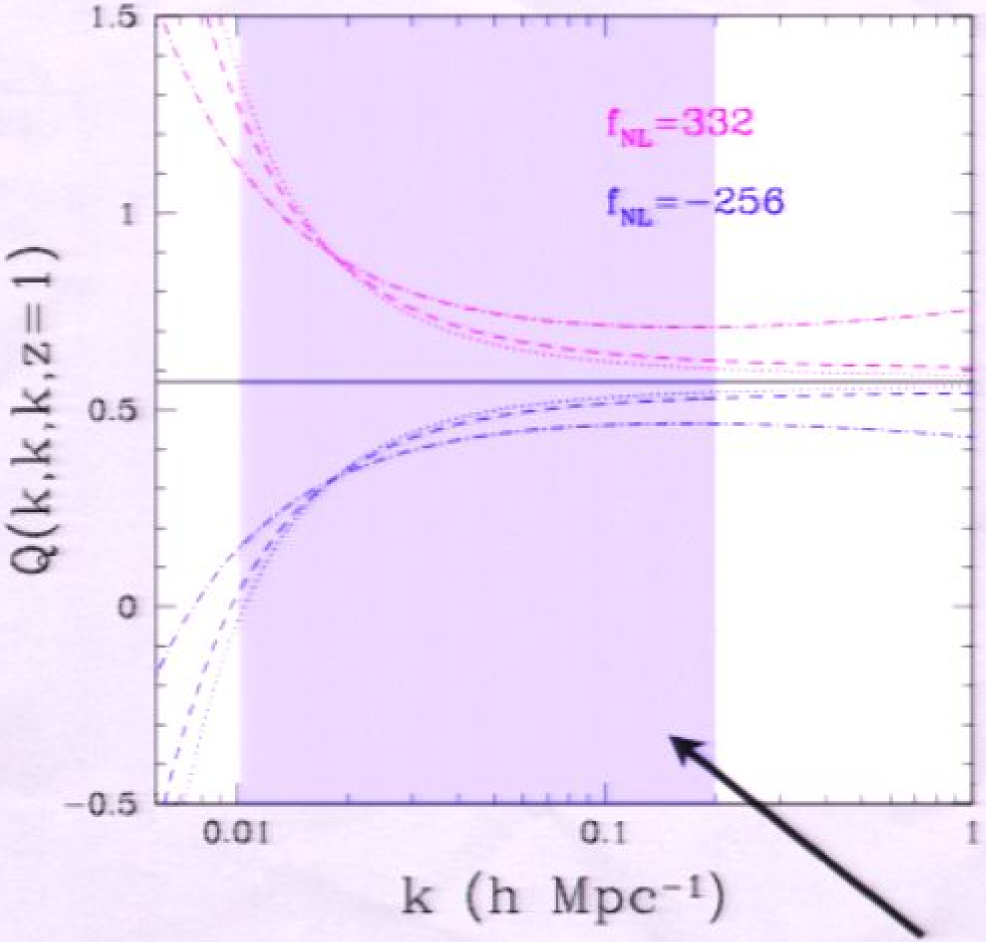
PI, Oct. 30, 2007

REDUCED BISPECTRUM



PI, Oct. 30, 2007

REDUCED BISPECTRUM



$$f_{NL}(k) = f_{NL,CMB}(k/k_{CMB})^{-2\kappa}$$

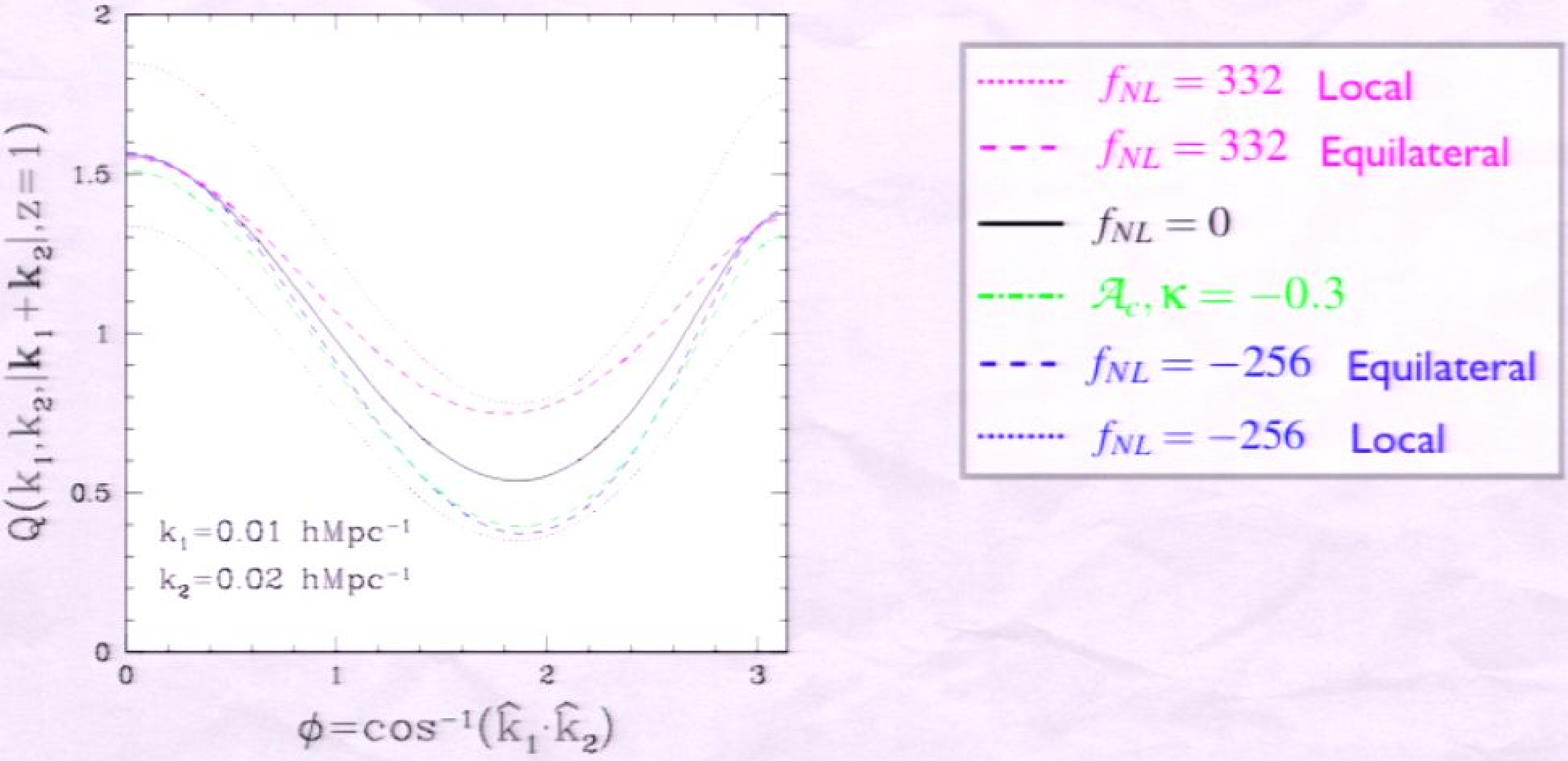
┈┈┈ $\kappa = 0$

‒ ‒ ‒ $\kappa = -0.1$

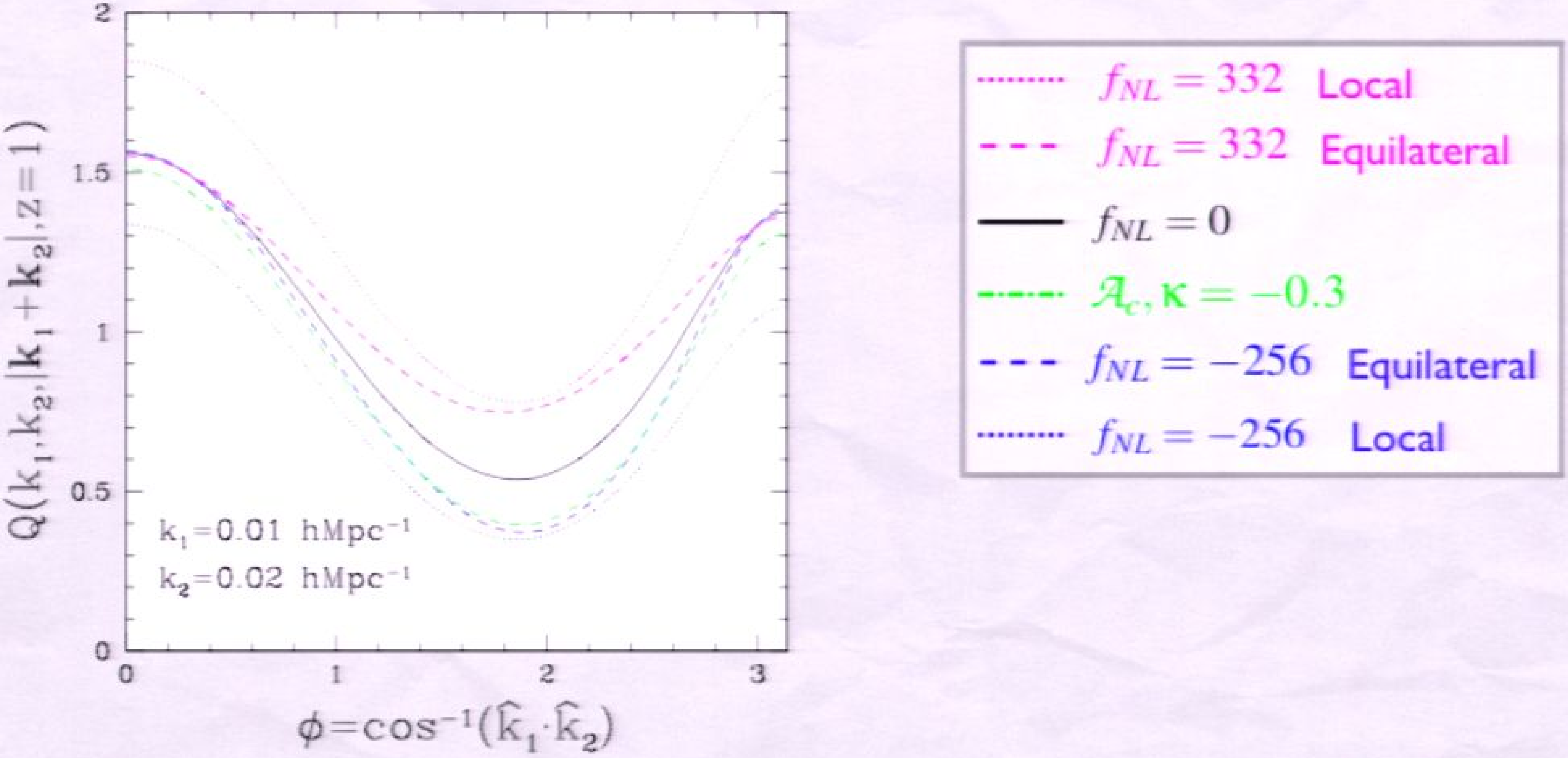
‒·‒·‒ $\kappa = -0.3$

Most accessible range

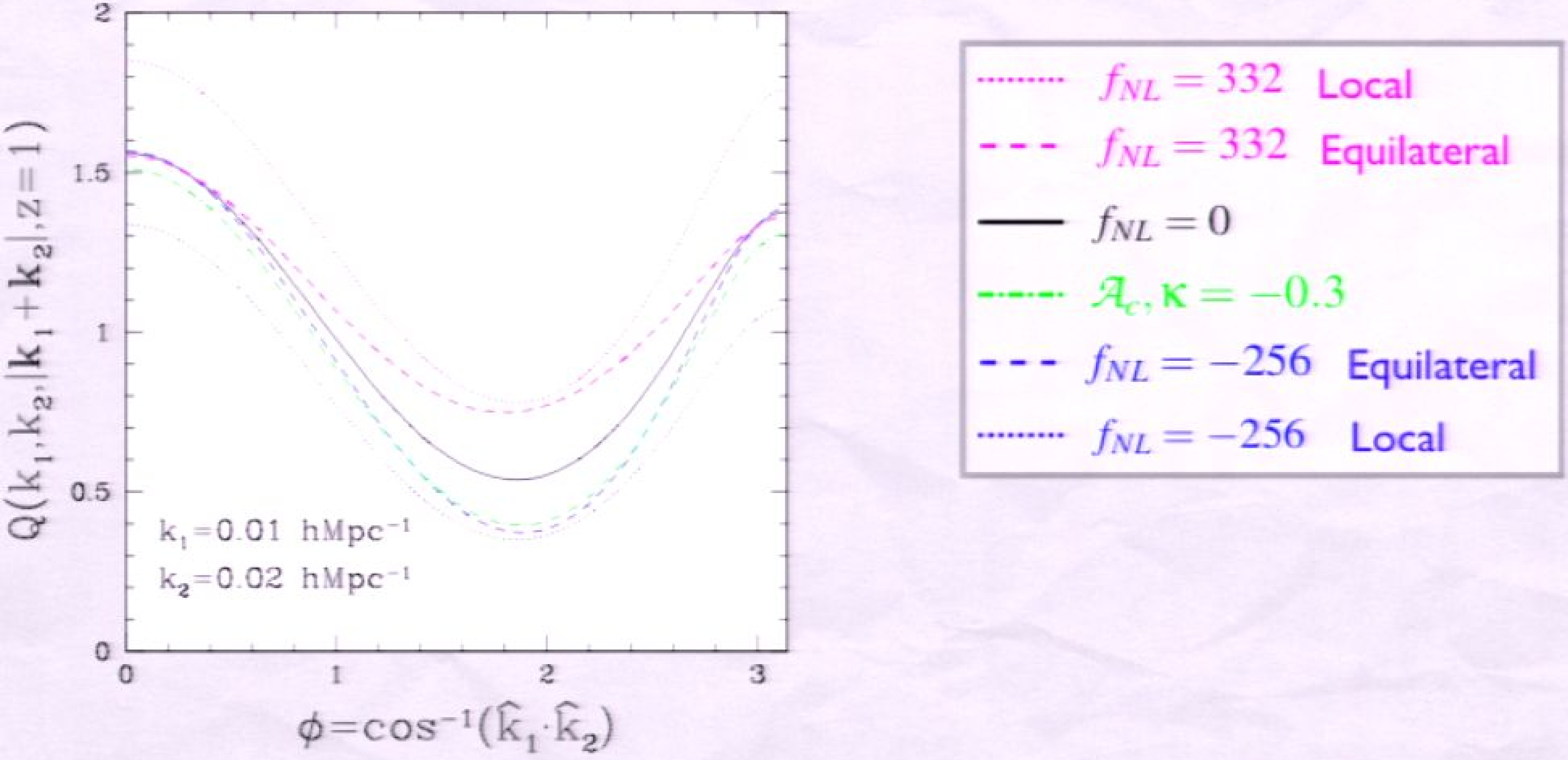
REDUCED BISPECTRUM



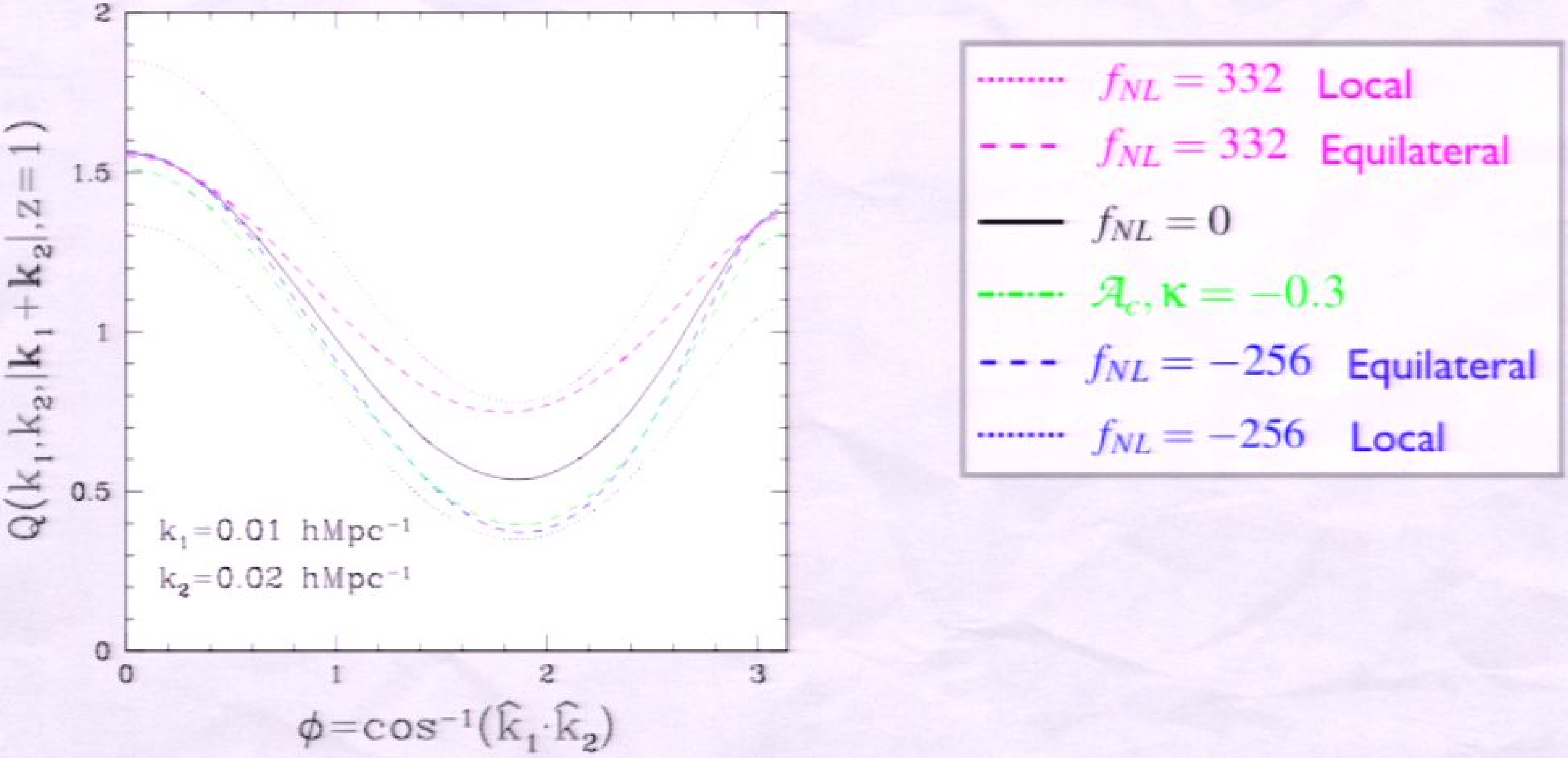
REDUCED BISPECTRUM



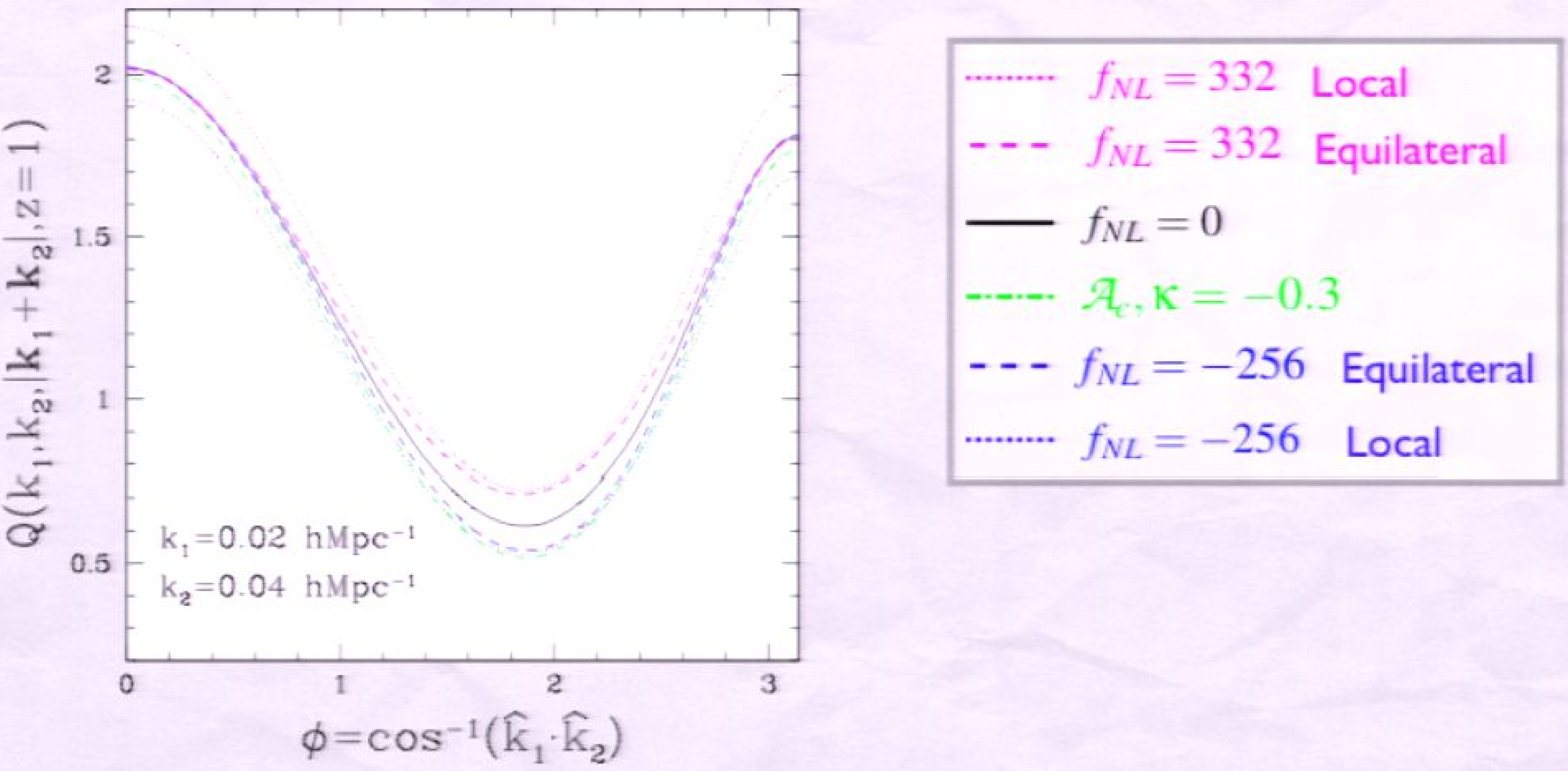
REDUCED BISPECTRUM



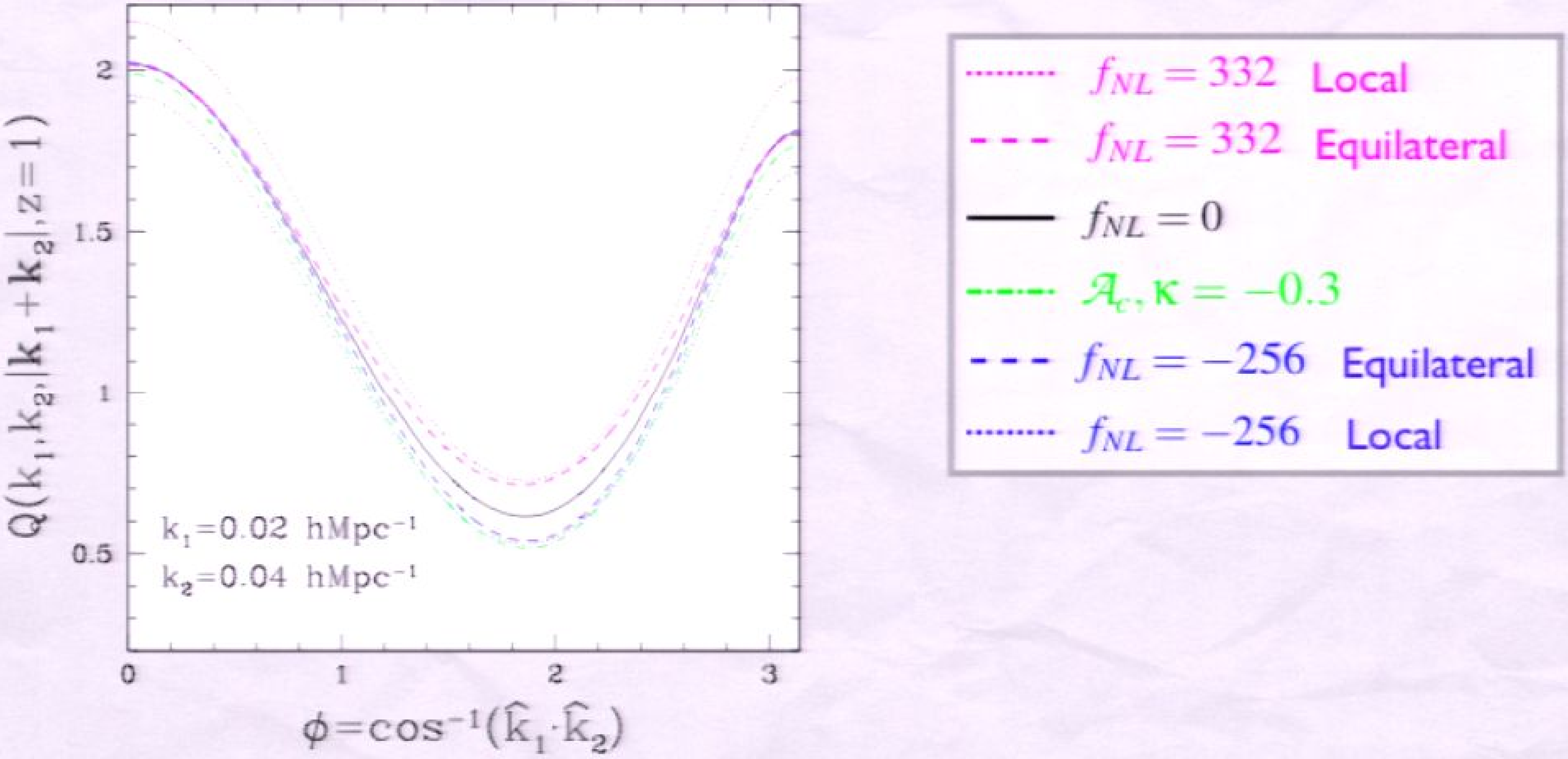
REDUCED BISPECTRUM



REDUCED BISPECTRUM



REDUCED BISPECTRUM



CONCLUSIONS

- Large and/or running non-Gaussianity is a signature of interesting inflationary physics (in DBI, NG tracks geometry)
- Scale-dependent non-Gaussianity is well-motivated and may be best tested on scales smaller than CMB
- Cluster measurements may soon be sensitive to NG with a large but reasonable running (30% change in mass function)
- Combining measurements from the CMB, galaxy bispectrum and cluster number counts can likely constrain a smaller running.

PI, Oct. 30, 2007

CONCLUSIONS

- Large and/or running non-Gaussianity is a signature of interesting inflationary physics (in DBI, NG tracks geometry)
- Scale-dependent non-Gaussianity is well-motivated and may be best tested on scales smaller than CMB
- Cluster measurements may soon be sensitive to NG with a large but reasonable running (30% change in mass function)
- Combining measurements from the CMB, galaxy bispectrum and cluster number counts can likely constrain a smaller running.

PI, Oct. 30, 2007

CONCLUSIONS

- Large and/or running non-Gaussianity is a signature of interesting inflationary physics (in DBI, NG tracks geometry)
- Scale-dependent non-Gaussianity is well-motivated and may be best tested on scales smaller than CMB
- Cluster measurements may soon be sensitive to NG with a large but reasonable running (30% change in mass function)
- Combining measurements from the CMB, galaxy bispectrum and cluster number counts can likely constrain a smaller running.

PI, Oct. 30, 2007

CONCLUSIONS

- Large and/or running non-Gaussianity is a signature of interesting inflationary physics (in DBI, NG tracks geometry)

- Scale-dependent non-Gaussianity is well-motivated and may be best tested on scales smaller than CMB

- Cluster measurements may soon be sensitive to NG with a large but reasonable running (30% change in mass function)

- Combining measurements from the CMB, galaxy bispectrum and cluster number counts can likely constrain a smaller running.

PI, Oct. 30, 2007

CONCLUSIONS

- Large and/or running non-Gaussianity is a signature of interesting inflationary physics (in DBI, NG tracks geometry)
- Scale-dependent non-Gaussianity is well-motivated and may be best tested on scales smaller than CMB
- Cluster measurements may soon be sensitive to NG with a large but reasonable running (30% change in mass function)
- Combining measurements from the CMB, galaxy bispectrum and cluster number counts can likely constrain a smaller running.

PI, Oct. 30, 2007

FUTURE DIRECTIONS

- Data available soon: SPT, SZA, MACS...
- Re-consider CMB constraints including scale-dependence
- N-body simulations with more general non-gaussian initial conditions?
- Other constraints?
    - Primordial Black Holes? (in progress)
    - Scale-Dependent Bias? (Dalal, Dore, Huterer, Shirokov)