Large scale structure to measure Primordial non Gaussianity

- Part I

  Primordial non Gaussianity (PNG)

  Bias

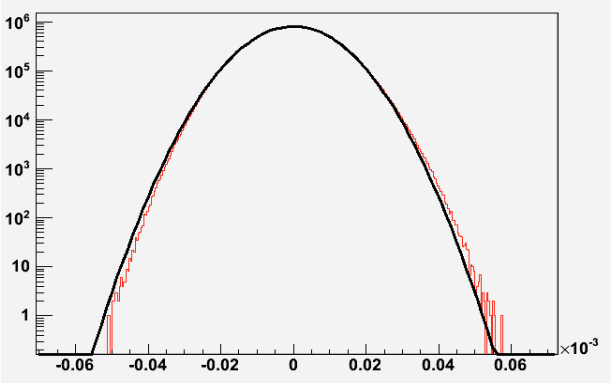
- Part II

  scale dependent bias and PNG

  - T. Giannantonio and W. Percival, 1312.5154
  - N. Dalal et al., 0710.4560
  - J.A. Peacock astro-ph/0309240 (section 6)
  - T. Padmanabhan, structure formation in the universe,
  - T. Giannantonio, C. Porciani et al. 2011

part I summary

Primordial Non Gaussianity



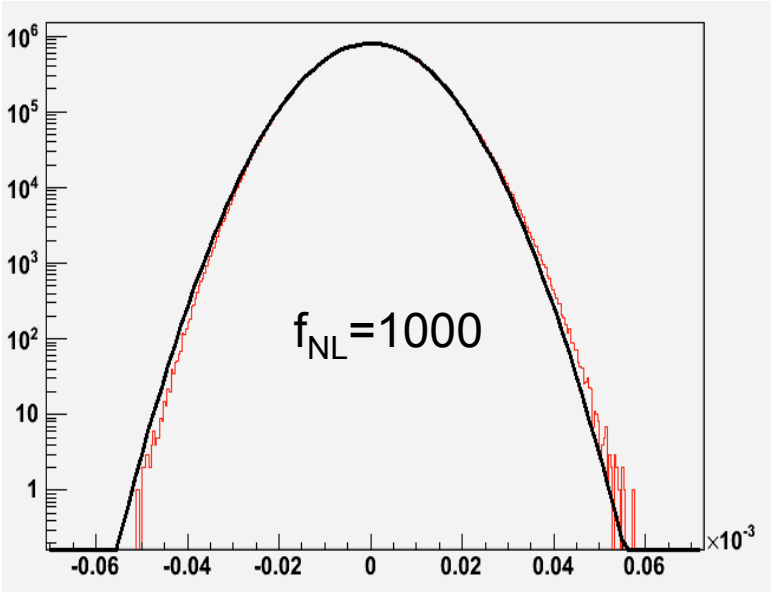
- Is the pdf Gaussian for potential or density fluctuation at early time ?
- Studying PNG in the CMB or in LSS (large scale structures) -> test of early universe
- local non Gaussianity

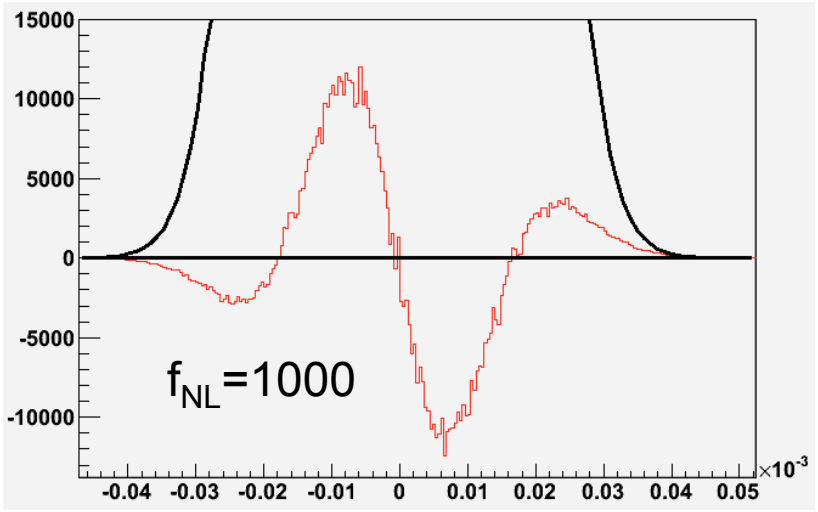
$$\Phi(x) = \phi(x) + f_{NL}\left[\phi^2(x) - \langle\phi^2\rangle\right]$$

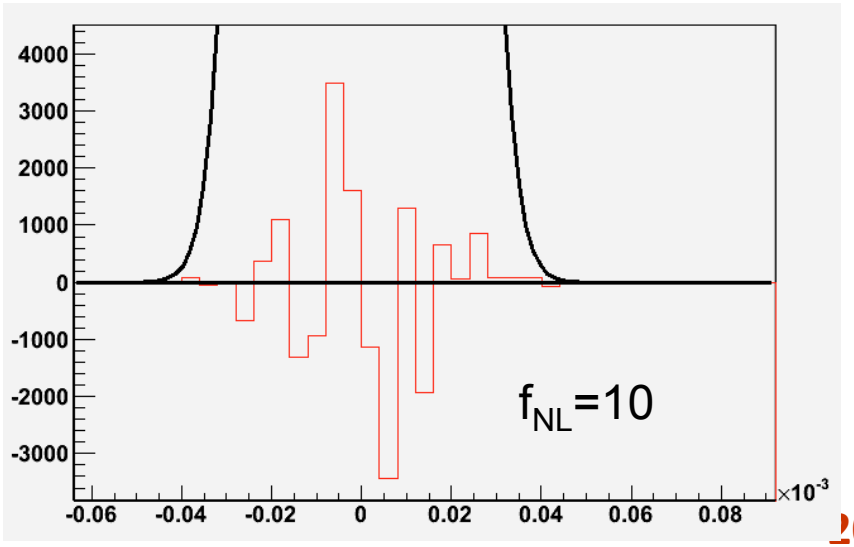
- Planck f_{NL} = 2.7+- 5.8

effect of non zero f_{NL}

- 5 10^7 pixels (Planck)







- skewness $\gamma_1 = E[(x-\mu)^3/\sigma^3]$

f_{NL} = 10 :

γ_1 = 0.0006 +- 0.0003

PNG and n-point statistics

- for a Gaussian field : (2n-1)point ξ are zero
- spectrum corresponds to 2 pt ξ
  bi-spectrum corresponds to 3 pt ξ
- non-zero bi-spectrum => PNG

what is bias ?

- We measure tracers (X) of matter

  in Fourier space bias b(k):

  $\delta_X(k) = b(k)\,\delta(k)$ $\quad$ $P_X(k) = b^2(k)\,P(k)$

- on large scale b is a priori expected to be independent of k

- bias is local if $\delta_X(x_0)$ depends only on $\delta(x_0)$

  non-local $\Leftrightarrow$ scale dependent

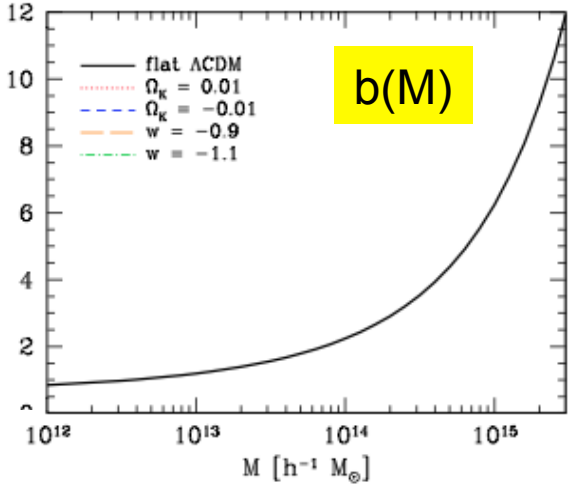
- high density regions more correlated than the average

cluster and galaxy bias

- Press-Schechter: DM halo of mass M : $b(\nu) = 1 + \frac{\nu^2 - 1}{\delta_c}$

  δ_c =1.686 and ν(M) increases with M

  $M^* = 3\ 10^{12}\ h^{-1}\ M_\odot$ such that $\nu(M^*) = 1$



- Haloes more massive than M^* have b > 1

  -> b > 1 for clusters

- Galaxies first produced in massive haloes, then $\Omega_m < 1$ and they are not produced in lower mass haloes

  -> galaxy can also have b > 1

Scale dependent bias and PNG

N. Dalal et al., 0710.4560

effect of local PNG on bias

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

$$\nabla^2\Phi_{\rm NG} = \nabla^2\phi + 2f_{\rm NL}[\phi\nabla^2\phi + |\nabla\phi|^2]$$

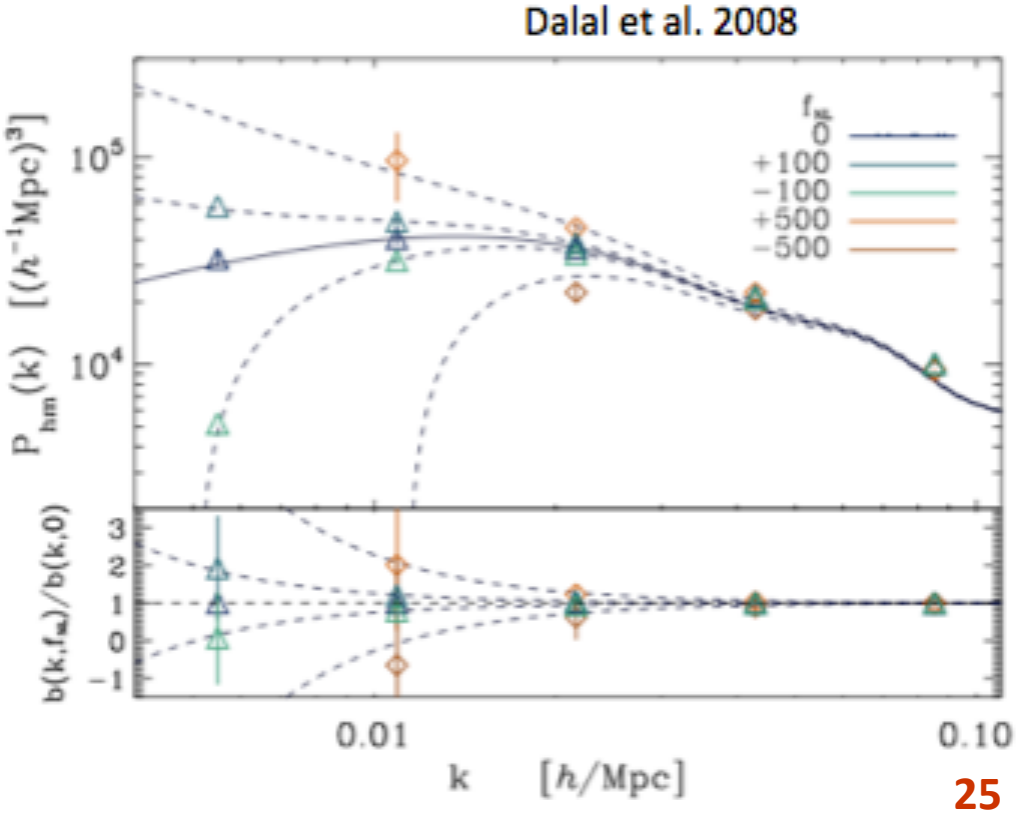
- assuming near a peak and using Poisson equation

  $\delta_{NG} = \delta\,[1+2f_{NL}\phi\,]$

=> additional bias :

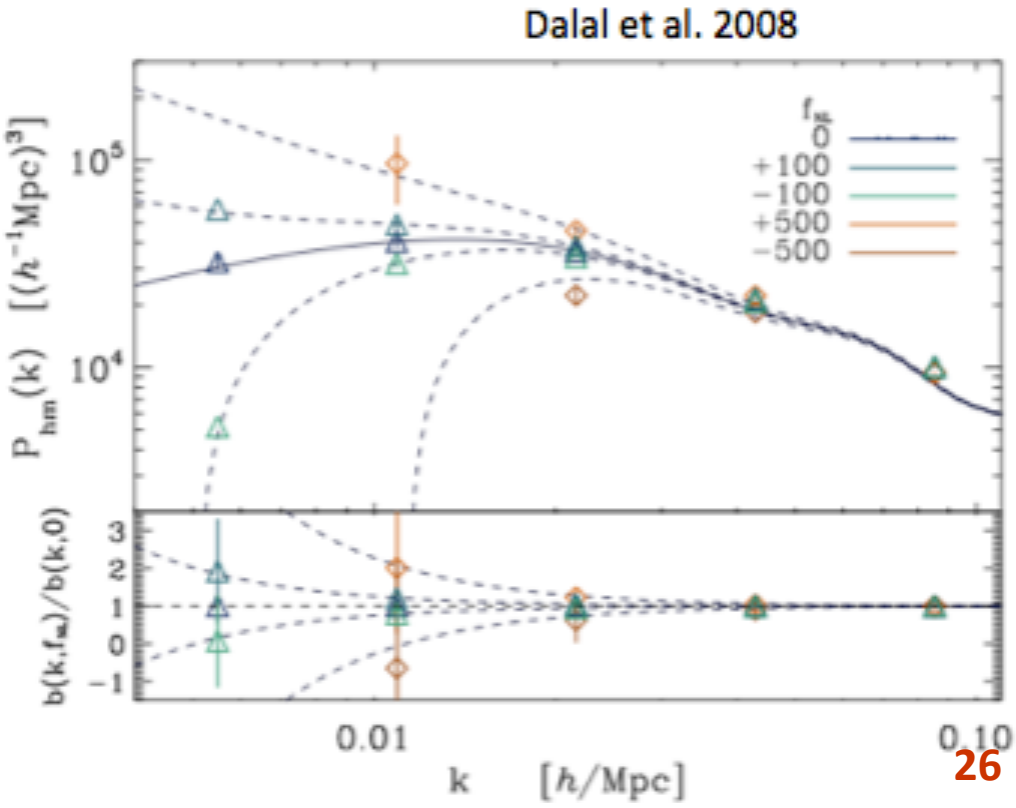
$\Delta b(k) \sim (b-1)\, f_{NL} / k^2$

- confirmed by simulations



degeneracies ?

- non linear effects -> k-dependent bias at high k
- PNG effects at small k
  -> quasar survey
- also P(k) turnover
  f_{NL} correlated with Ω_m



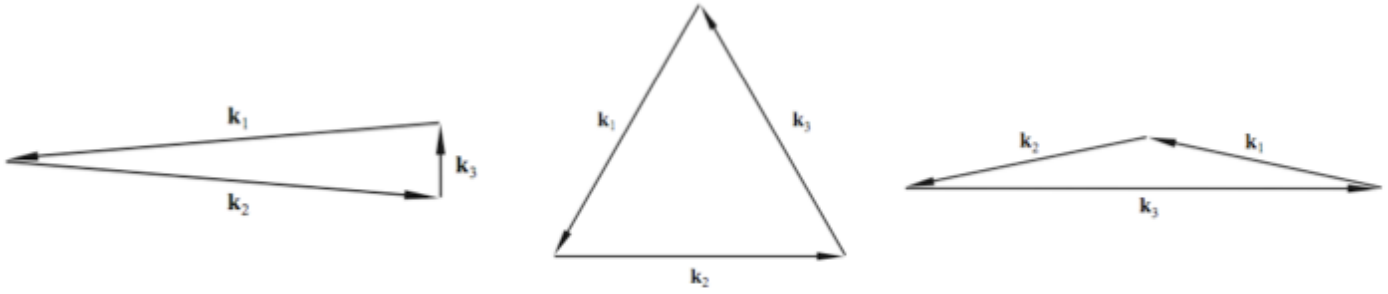
constraints on f_{NL}

- all sky, "cosmic variance limited" survey, up to z=0.7
  -> $\Delta f_{NL} \sim 10$

- cross-correlation between CMB T and LSS
  due to ISW
  combined ISW analyses (2008) should give $\Delta f_{NL} \sim 60$

  Dalal et al. 2008

shape of PNG -> Galaxy bias



Squeezed (local) Equilateral Folded

- Local:
  $\Delta b \approx 1/k^2$ as k-> 0
- Orthogonal ($B_{ort}=-2B_{fol}+B_{eq}$):
  $\Delta b \approx 1/k$
- Equilateral:
  $\Delta b \approx$ constant

Desjacques, Jeong & Schmidt 2011a,b

Scoccimarro et al. 2011

Schmidt & Kamionkowski 2010

Wagner et al. 2010

Euclid forecast

- This is only 2-pt statistics ! (no bispectrum)

Probe	Δf_{NL} local		Δf_{NL} orthogonal		Δf_{NL} equilateral	
	EUCLID	+ Planck	EUCLID	+ Planck	EUCLID	+ Planck
Weak lensing	73	27	9.6	3.5	34	13
2D clustering	5.8	5.5	38	9.6	140	37
3D clustering	4.1	4.0	54	11	220	35
Lensing + clustering	4.7	4.5	4.0	2.2	16	7.5

- clustering is efficient mainly for local case
- weak lensing ?
- also $\Delta n_{fnl} = 0.12$

Giannantonio, Porciani et al. 2011

using correlation between CMB lensing and LSS

T. Giannantonio and W. Percival, 1312.5154

using correlation between CMB lensing and LSS

- scale dependent galaxy bias ⇔ PNG
- observational systematics for P(k) on large scale
- using cross-correlation reduces systematics

  correlate galaxy with CMB T (ISW)

Giannantonio and Percival :

correlate galaxy with matter power from CMB lensing

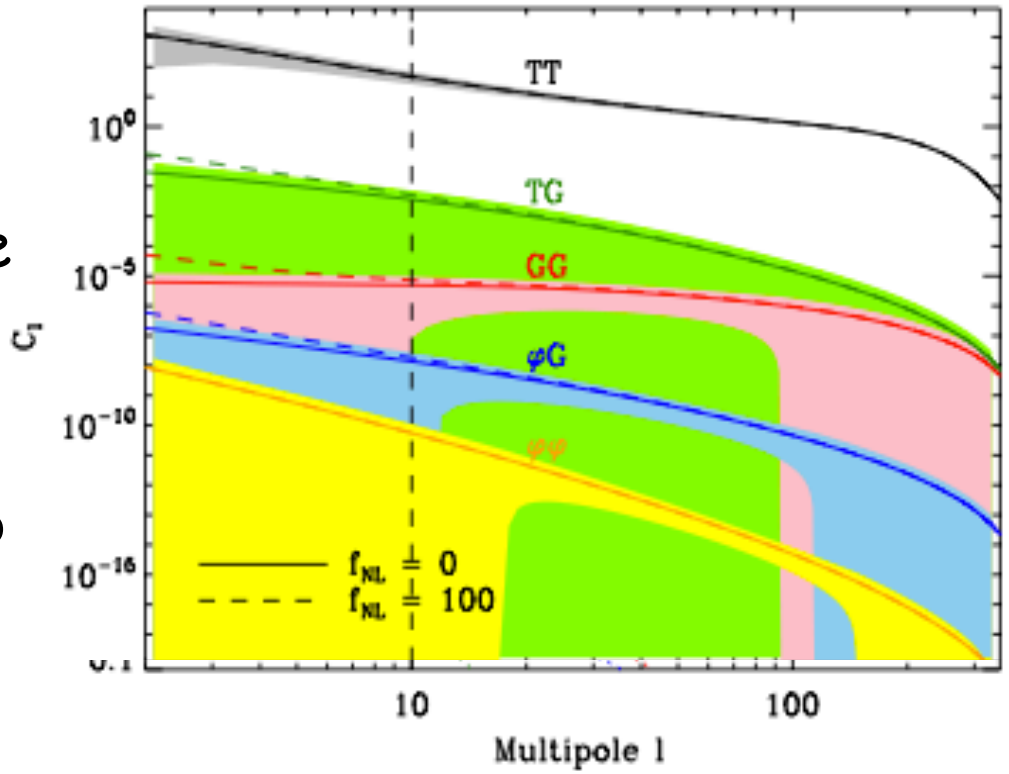
effect of PNG on C_l

For NVSS survey (1.4 GHz) + Planck

- uncertainty:
  cosmic variance
  + shot noise
  + intrinsic lensing noise

PNG :

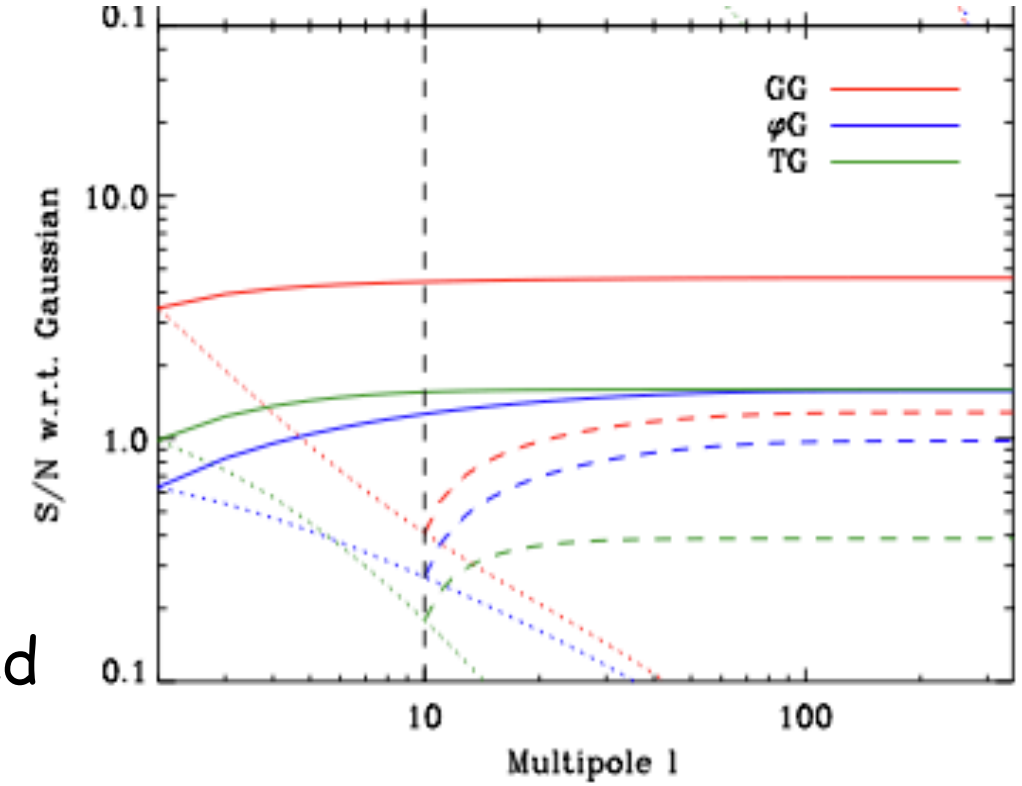
- no effect on TT and $\phi\phi$
- more effect on GG



constraining power on f_{NL}

S/N of the difference between Gaussian and NG model

- per multipole ……..
- cumulative S/N ___
- cumulative S/N
  starting l = 10 ----



- with all modes ϕG

nearly as good as TG

- Not too much affected

by removing low l modes

results

- Planck + WMAP
- Planck lensing map
  l < 10 removed
- l < 10 seen on mocks

Data: Planck TT, WP, and	Priors	$f_{\rm NL}$ (68%)
GG	b_0^i, κ_i	12 ± 23
TG	b_0^i, κ_i	46 ± 68
φG	b_0^i, κ_i	12 ± 71
Mock all-l φG	b_0^i, κ_i	± 53
GG	none	15 ± 29
$GG + TG$	none	14 ± 25
$GG + \varphi G$	none	11 ± 23
$GG + \varphi G + TG$,	none	12 ± 21
Mock all-l, $GG + \varphi G + TG$	none	± 19
as above, no intrinsic noise	none	± 14

Conclusions

- PNG probe the early Universe
- PNG result in a scale dependent bias of LSS

  $1/k^2$ for local PNG -> large scale
- using only 2-pt statistics of LSS provides good constraints on PNG
- cross correlation with CMB T add information

  and less sensitive to systematics
- cross correlation with CMB lensing can also be used