Scale dependent bias from an inflationary bispectrum: a peak model approach

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*Mainly based on: MB & Desjacques, MNRAS **451** (2015) 3643 [arXiv:1501.04982]*

Scale dependent bias from an inflationary bispectrum: a peak model approach

Just another way to say I'll talk about
looking for primordial non-Gaussianity in LSS

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Motivation

My interest in primordial non-Gaussianity
is Sabino's "fault"

The Planck satellite

From my master thesis presentation in December 2011 (supervised by Nicola and Sabino)

The Planck satellite was launched in May 2009. The results for the observations of the CMB anisotropies will be publicly available soon. The most reliable forecast on f_{NL} and τ_{NL} for Planck are[††] (minimum error bars)

	f_{NL}	τ_{NL}
Planck	8	1550

Table: The minimum error bars at 1σ for f_{NL} and τ_{NL} for the Planck experiment.

[††] *J. Smidt et al., CMB Constraints on Primordial non-Gaussianity from the Bispectrum (f_{NL}) and Trispectrum (g_{NL} and τ_{NL}) and a New Consistency Test of Single-Field Inflation, Phys. Rev.* **D 81**, *Issue 12, id. 123007 (2011).*

Motivation

Today
(after Planck 2015 release)

$$f_{\rm NL}^{\rm local} = 0.8 \pm 5.0 \qquad @\,68\%\,{\rm CL}$$

Primordial non-Gaussianity is a still key-feature to discriminate among all the models of inflation

Planck 2015 results. XVII. Primordial non-Gaussianity, arXiv:1502.01592

Motivation

Today
(after Planck 2015 release)

now we do it with LSS surveys (e.g. EUCLID)

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

$$P_g(k) = \Big(b_1 + \Delta b_1(k)\Big)^2 P_m(k)$$

(can use bispectrum as well)

Dalal, Doré, Huterer & Shirokov, Phys. Rev. D, 77, 123514 (2008)

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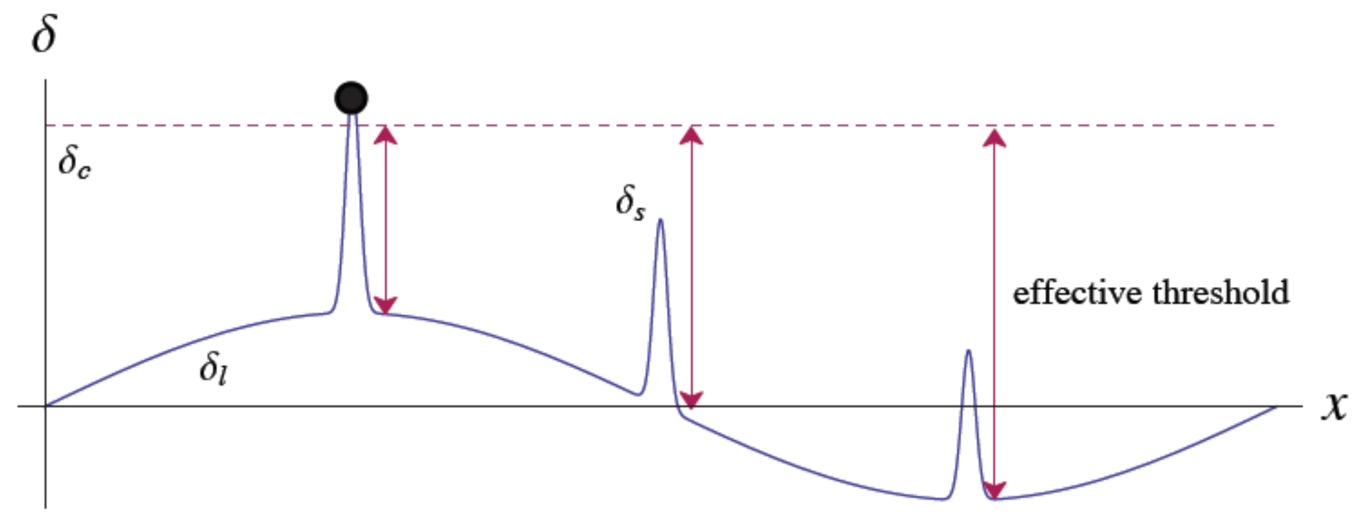
Galaxy biasing

Peak Background Split ansatz

$$\delta = \delta_{\rm L} + \delta_{\rm S}$$



long-wavelength field locally modulates threshold for collapse

$$\delta_g(\vec{x}, M, \delta_c) \equiv \frac{n_g(\vec{x}, M, \delta_c)}{\bar{n}_g(M, \delta_c)} - 1 \approx \frac{\bar{n}_g(M, \delta_c - \delta_{\rm L}(\vec{x}))}{\bar{n}_g(M, \delta_c)} - 1$$

$$\approx -\frac{1}{\bar{n}_g}\frac{d\bar{n}_g}{d\delta_c}\delta_{\rm L}(\vec{x}) + \ldots$$

$$b_1$$

$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$

Adding PNG

$$\Phi = \phi_{\mathrm{G}} + f_{\mathrm{NL}}\phi_{\mathrm{G}}^2$$

Local quadratic non-Gaussianity

PBS ansatz

$$\Phi = \phi_{\mathrm{L}} + f_{\mathrm{NL}}\phi_{\mathrm{L}}^2 + (1 + 2f_{\mathrm{NL}}\phi_{\mathrm{L}})\phi_{\mathrm{S}} + f_{\mathrm{NL}}\phi_{\mathrm{S}}^2$$

$\delta = \mathcal{M} \star \Phi$

$$\delta_{\mathrm{S}} \approx \mathcal{M} \star (1 + 2f_{\mathrm{NL}}\phi_{\mathrm{L}})\phi_{\mathrm{S}}$$

$\Delta b_1(k) \propto 2f_{\mathrm{NL}}\frac{b_{\mathrm{NG}}}{k^2}$

being $\mathcal{M}(k) = \frac{2}{3}\frac{k^2 T(k) D(z)}{\Omega_m H_0^2}$

Adding PNG

Long- and short-wavelength modes are now mixed, the effect is to modify the amplitude of the matter fluctuations

$$\sigma_8 \to (1 + 2 f_{\rm NL}\phi_{\rm L})\sigma_8 = \hat{\sigma}_8$$

$$\equiv b_{\rm NG}^{\rm PBS}$$

$$\delta_h(\vec{x}, M, \delta_c) \approx b_1\, \delta_{\rm L}(\vec{x}) + 2 f_{\rm NL} \frac{\partial \ln \bar{n}_h}{\partial \ln \hat{\sigma}_8} \phi_{\rm L}(\vec{x}) + \ldots$$

for universal mass function this is the well-known $\delta_c b_1^{\rm L}$

Matarrese & Verde, ApJ 684 (2008) L1

$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$

Wait a minute

we are assuming that the modulation in $\delta_{\rm S}$
affects the halo mass function $\bar{n}_h$ only through $\hat{\sigma}_8$
(that is the zeroth moment of $\delta_{\rm S}$)

$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$

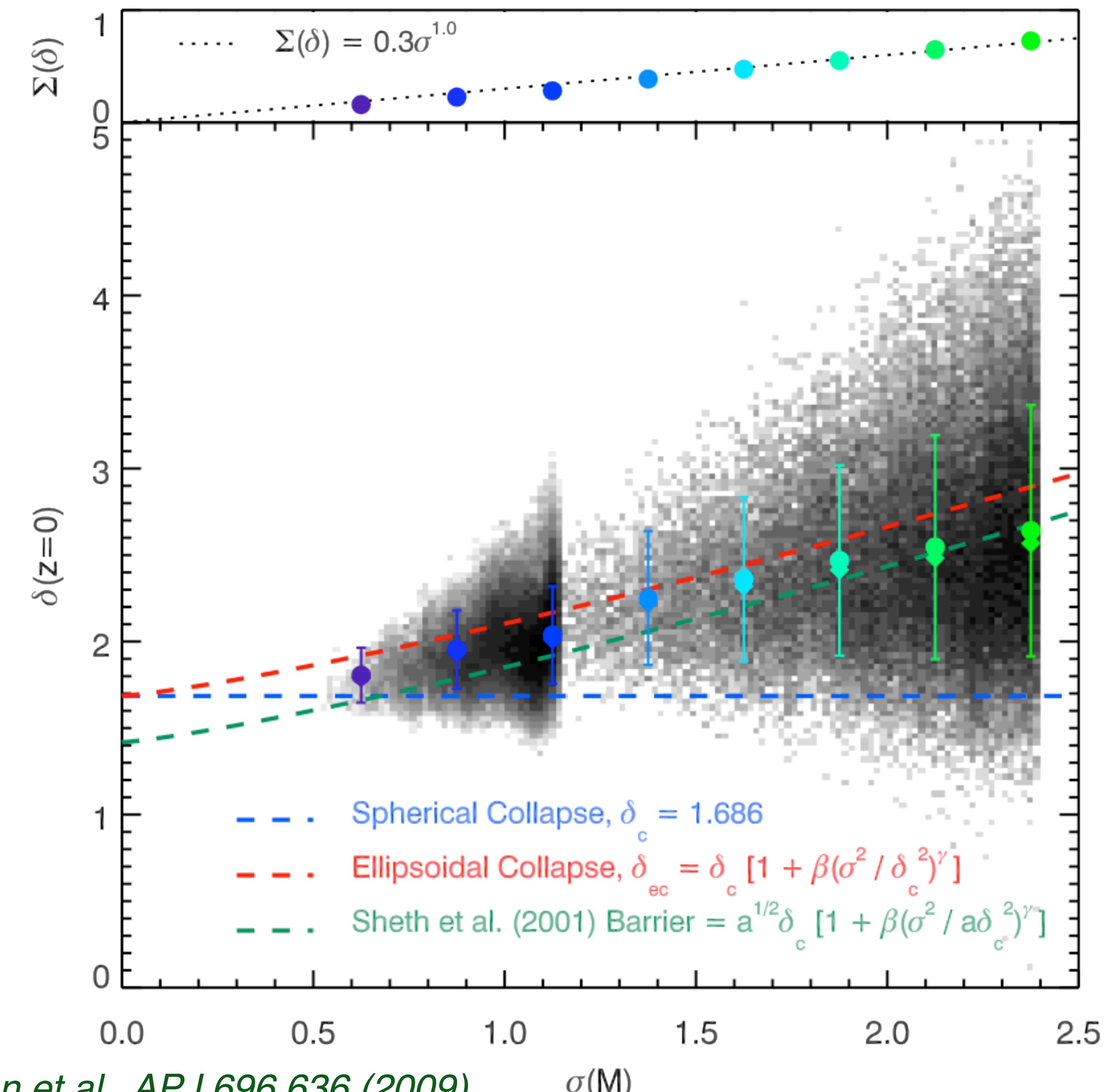
Barrier is "moving"

Collapse is triaxial
(at low masses)

Barrier is not flat
it grows with mass and it scatters

$\bar{n}_h$ depends on other quantities then only σ_0

$$\bar{n}_h(\delta_c, \{\sigma_i\})$$



$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$

Robertson et al., APJ 696,636 (2009)

Excursion Set Peaks

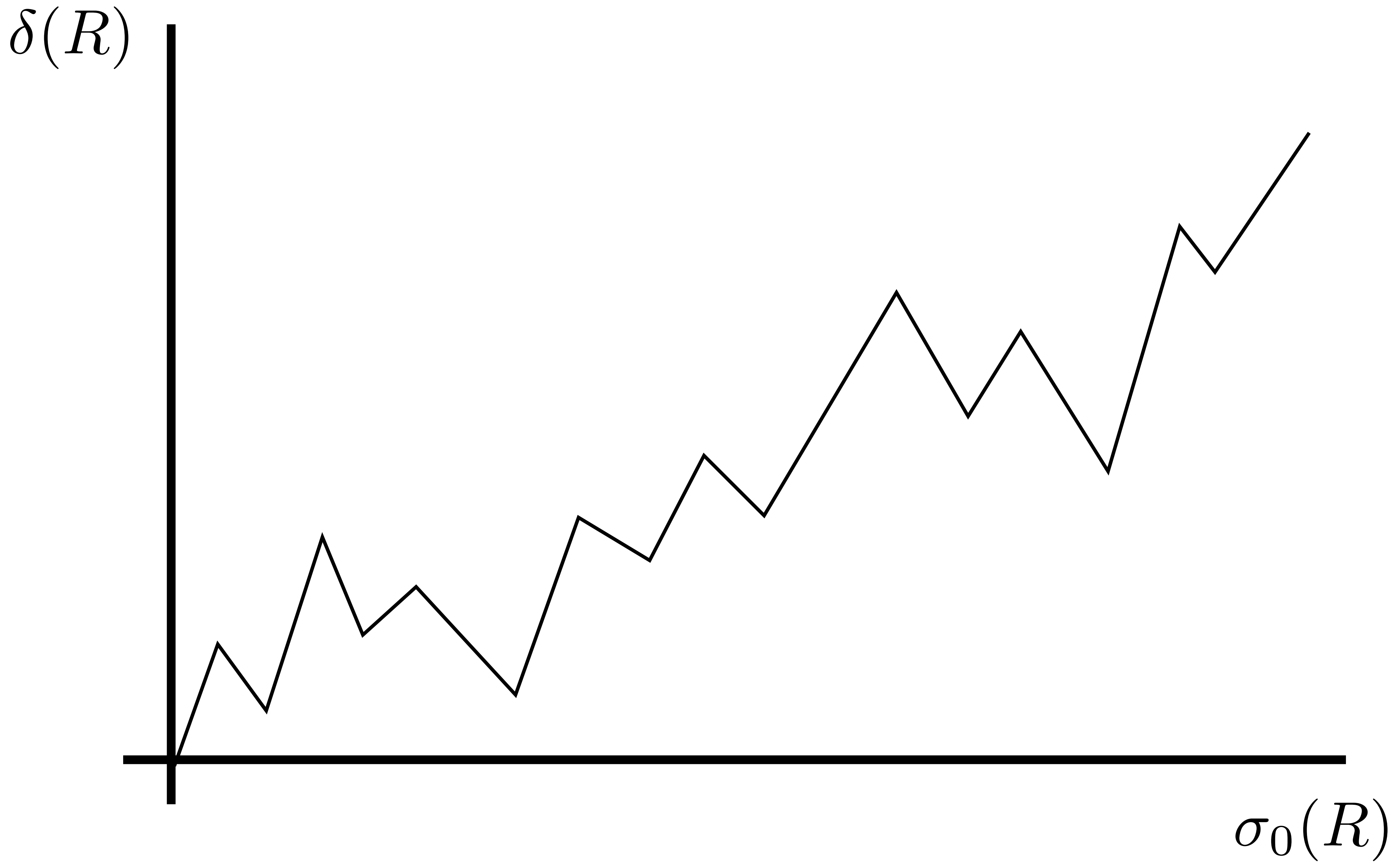
- **Peak model**: consider peaks of the initial matter density field and move them forward in time;
  Bardeen et al., Astrophys.J. 304 (1986) 15-61

- (Most) **halos will form around initial peaks**;
  Ludlow & Porciani, MNRAS 413,1961 (2011)

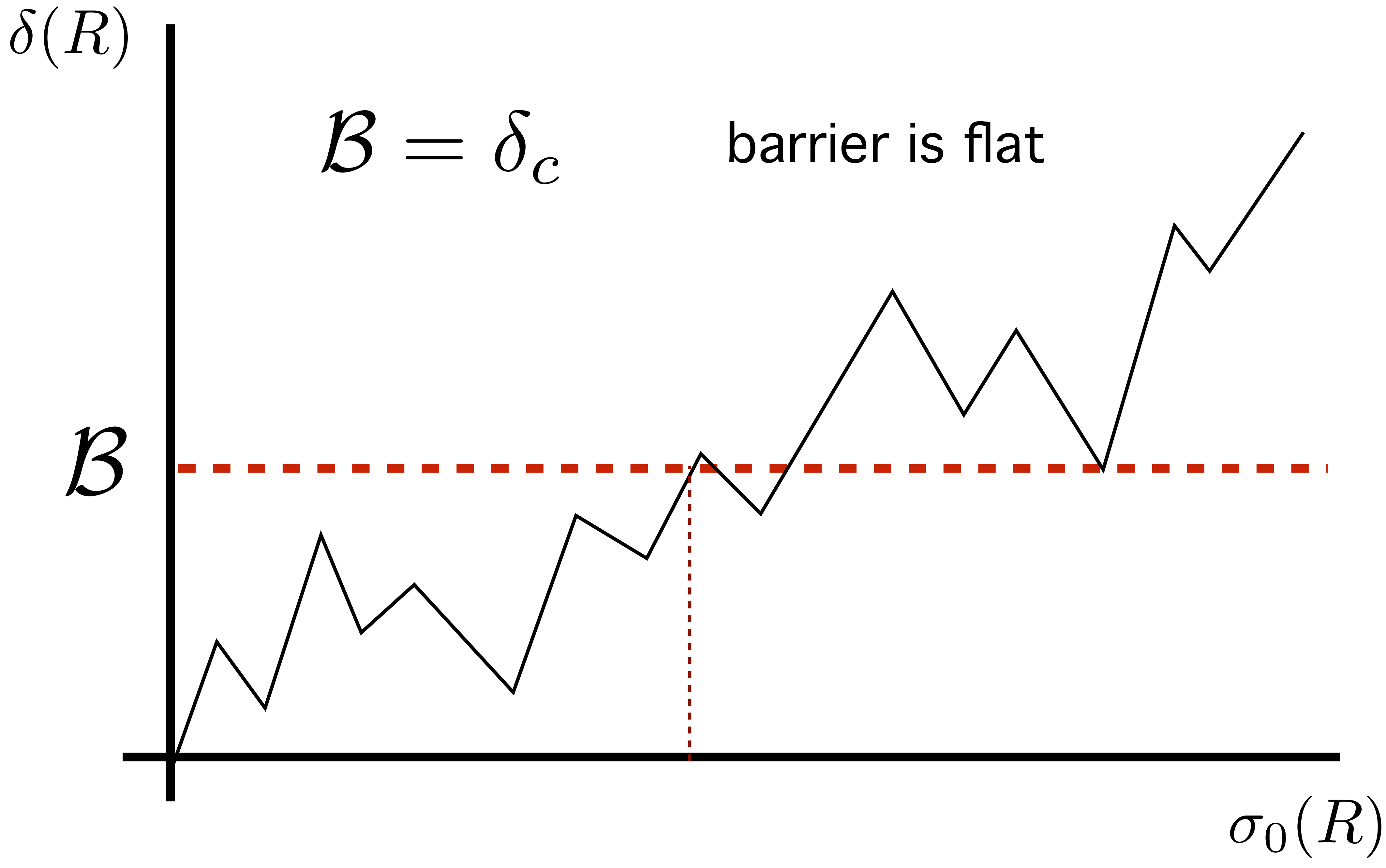
- Impose that **peaks** on a given smoothing scale are **counted only if they satisfy a first crossing condition.**
  Paranjape, Lam & Sheth, MNRAS 420, 1429 (2012)
  Paranjape, Sheth & Desjacques, MNRAS, 431, 1503 (2013)

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

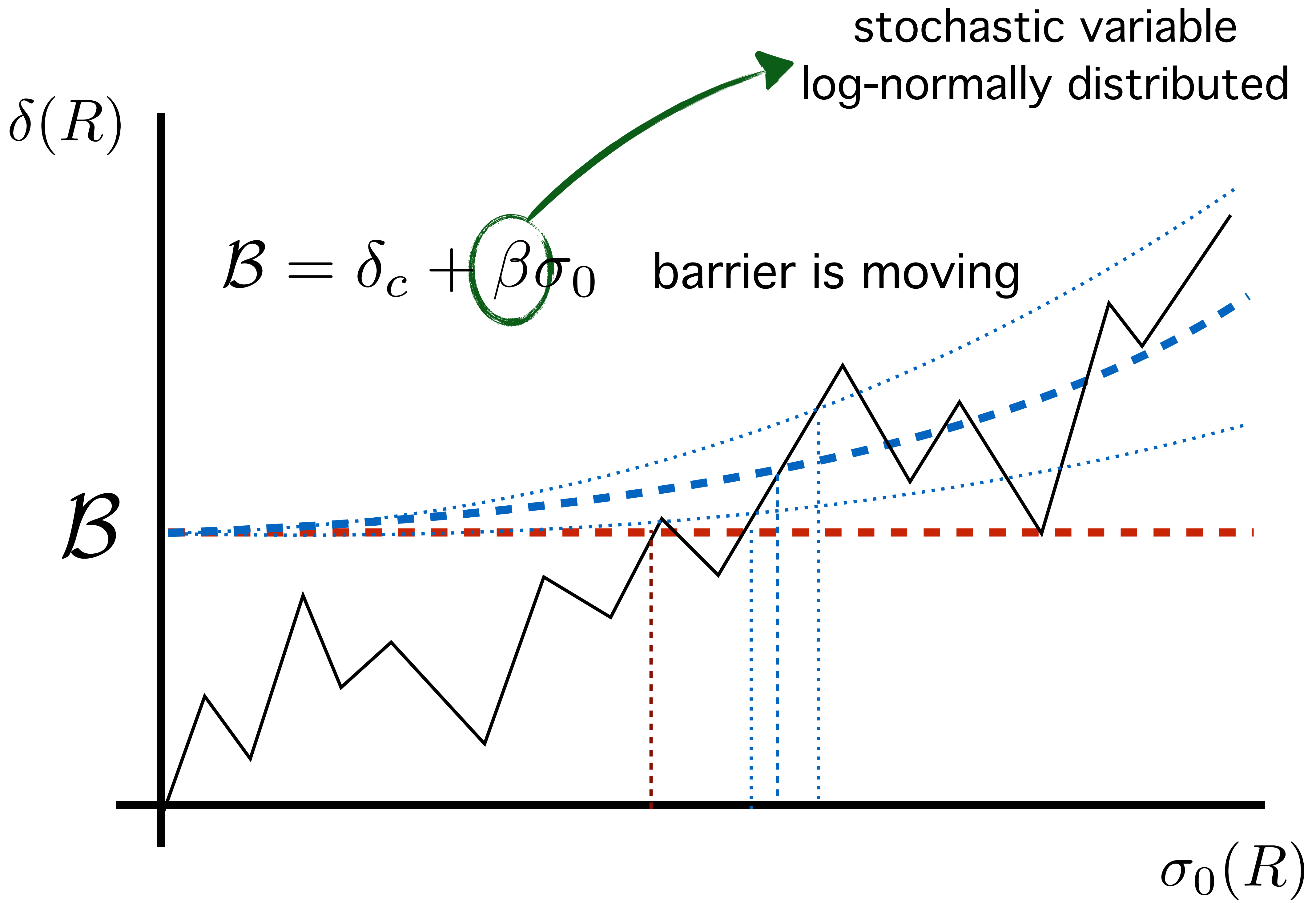
Excursion Set Peaks



Excursion Set Peaks



Excursion Set Peaks



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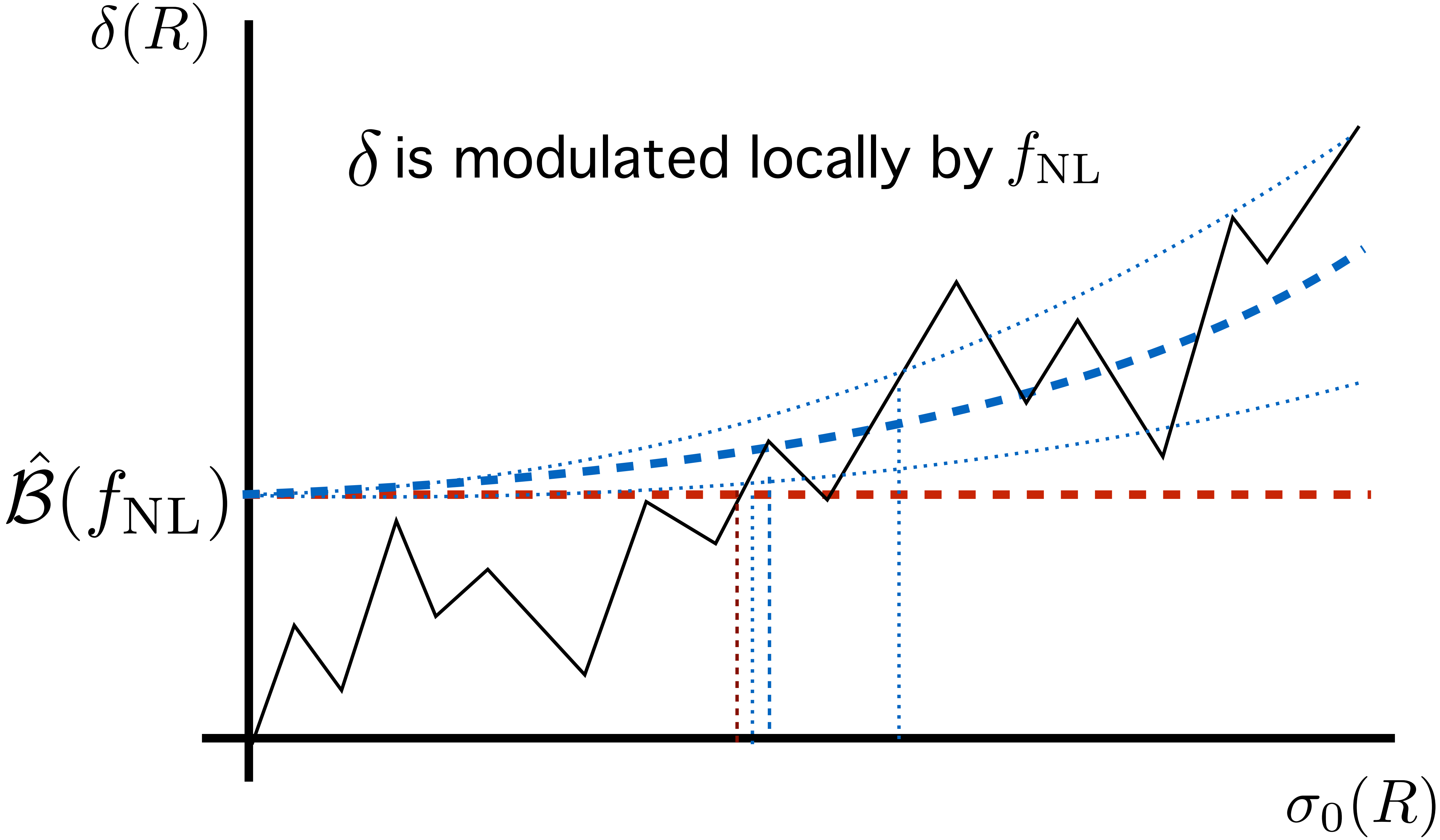
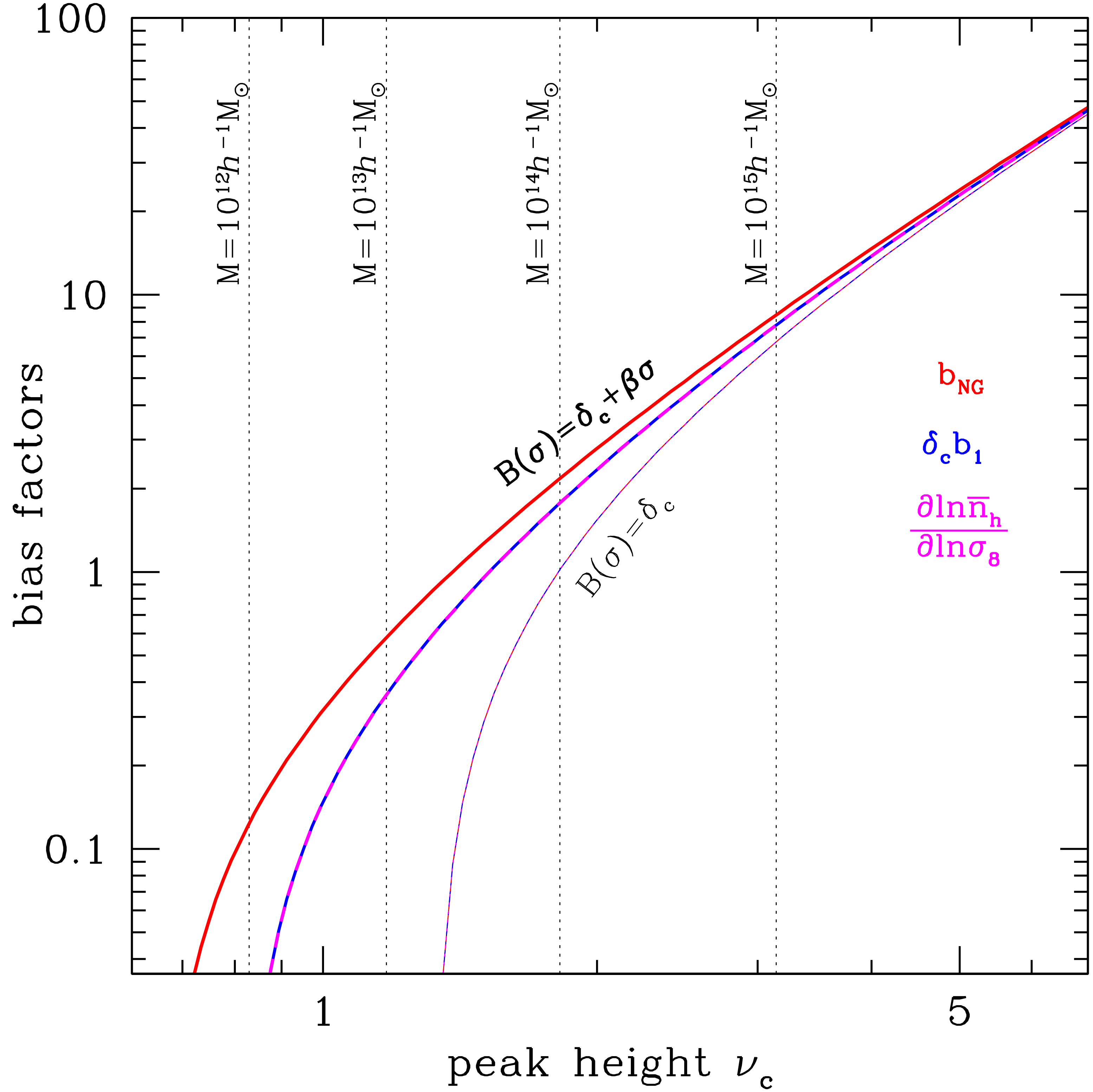
Excursion Set Peaks



$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$

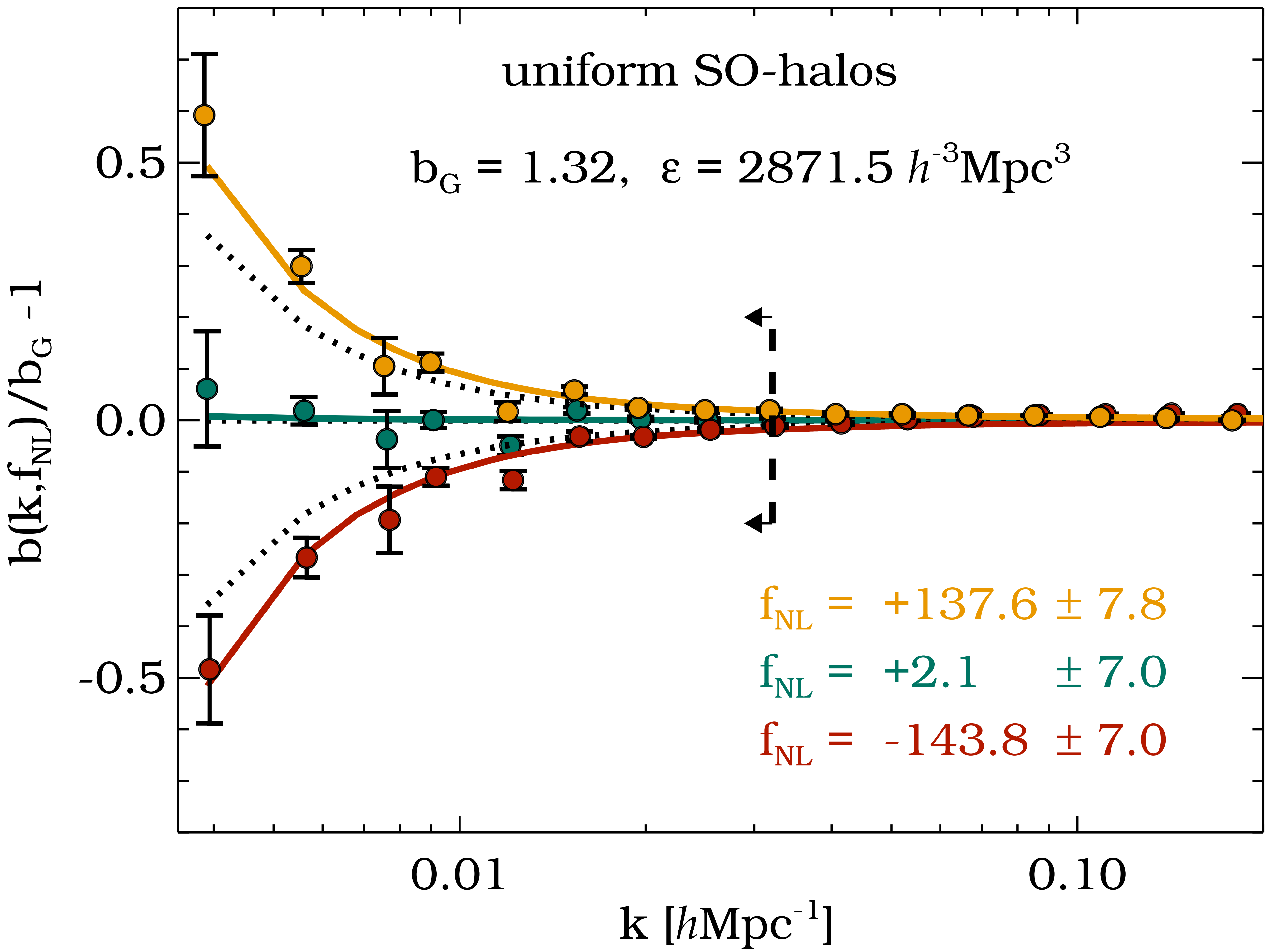
Flat vs Moving



$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

MB, Desjacques, MNRAS 451 (2015) 3643, arXiv: 1502.04982

Is this a problem?



Hamaus, Seljak & Desjacques, Phys.Rev. D84 (2011) 083509

$$\Delta b_1(k) \propto 2 f_{\rm NL} \frac{b_{\rm NG}}{k^2}$$

Take home message

Information about PNG will come from LSS and more specifically (mostly) from the scale dependent bias signature

If this information is not correctly theoretically modelled, it may be not correctly interpreted

Take home message

Including a (crude) moving barrier modifies the signal up to 40% wrt a constant barrier

N-body simulations can be used to measure this effect (both power spectrum and bispectrum)