Bias and the BORG likelihood

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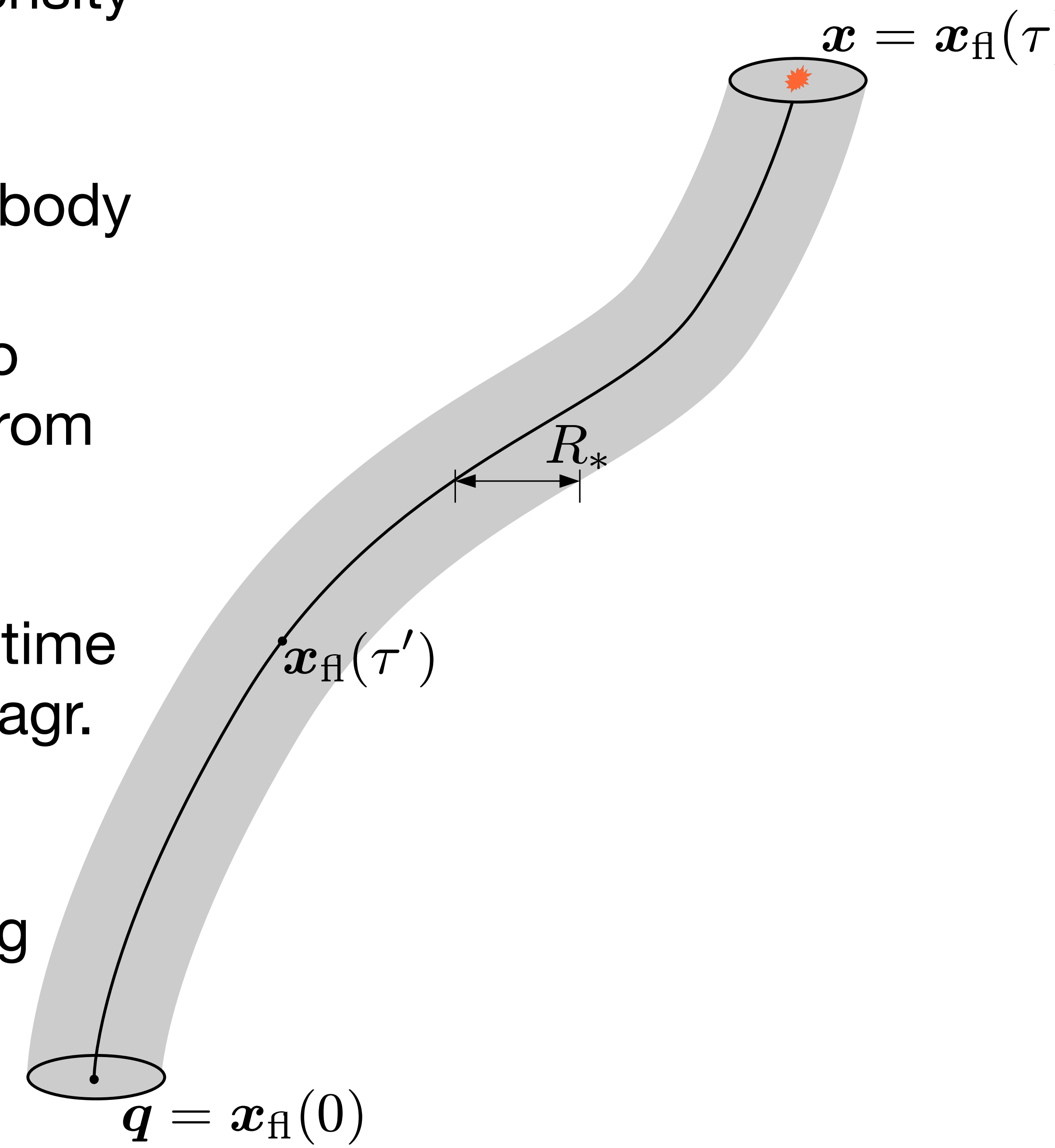
General considerations

- Problem: given realization of the nonlinear density field, how do we predict galaxy density field?
    - Here, neglect RSD; think of halos in N-body
- This problem is common to any attempt to infer cosmology from LSS - we look at it from slightly different angle
- Galaxy/halo formation happens over long time scales (Hubble) but small spatial scales (Lagr. radius, few Mpc)
    - Spatially local approximation as starting point - can include leading correction



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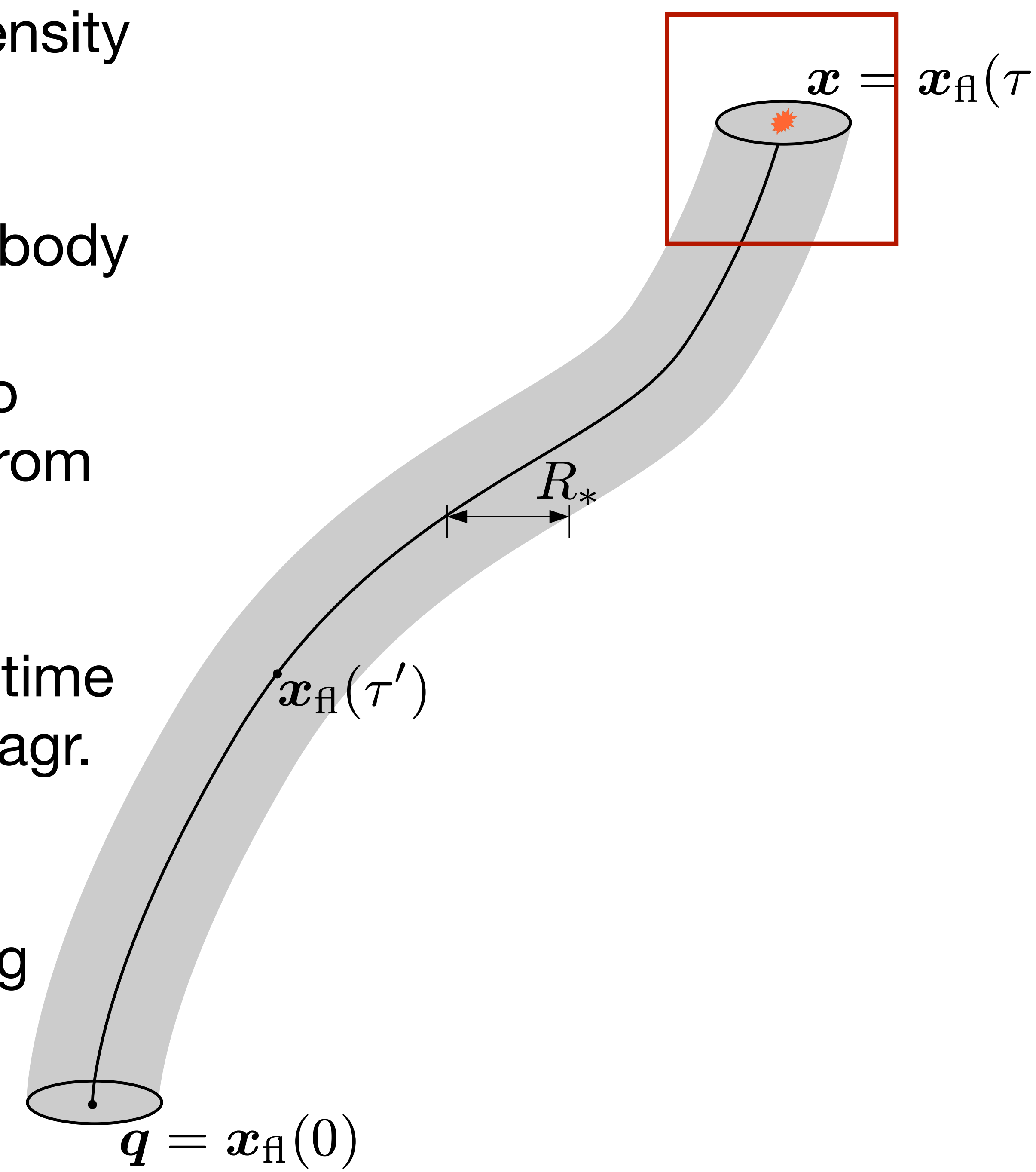


BORG likelihood

- Using local approximation, can generally be written as

$$P(\vec{\delta}_{\rm in},\theta) = P(\vec{\delta}_{\rm in}|\theta) \prod_{\alpha=1}^{N^3} \prod_{i=1}^{\infty} \left[\int dO_i \, \delta_D \left(O_i - O_{i,\alpha}^{\rm fwd}(\vec{\delta}_{\rm in}) \right) \right] \prod_k \left[\int d\vartheta_k \right] P(\vartheta) \, P_g(N_{g,\alpha}|\{O_k\}_{k=1}^{\infty}, \vartheta)$$

  - Where Oi are operators (fields): matter density δ, tidal field K_{ij}, …
  - Fields defined on discrete grid (index α,β,…)
  - θ : cosmological parameters; ϑ: bias parameters
- Key ingredient: conditional PDF $P_g(N_{g,\alpha}|\{O_k\}_{k=1}^{\infty}, \vartheta)$
  - In full generality, depends on infinitely many fields (time derivatives, due to history of galaxy formation)

BORG likelihood

Conditional PDF

$$P_g(N_g|\{O_k\}_{k=1}^{\infty}, \vartheta)$$

- Approaches so far:

  A. $P_g = \mathrm{Poisson}(N_g - F(\delta, \vartheta))$
  with "suitable" function F

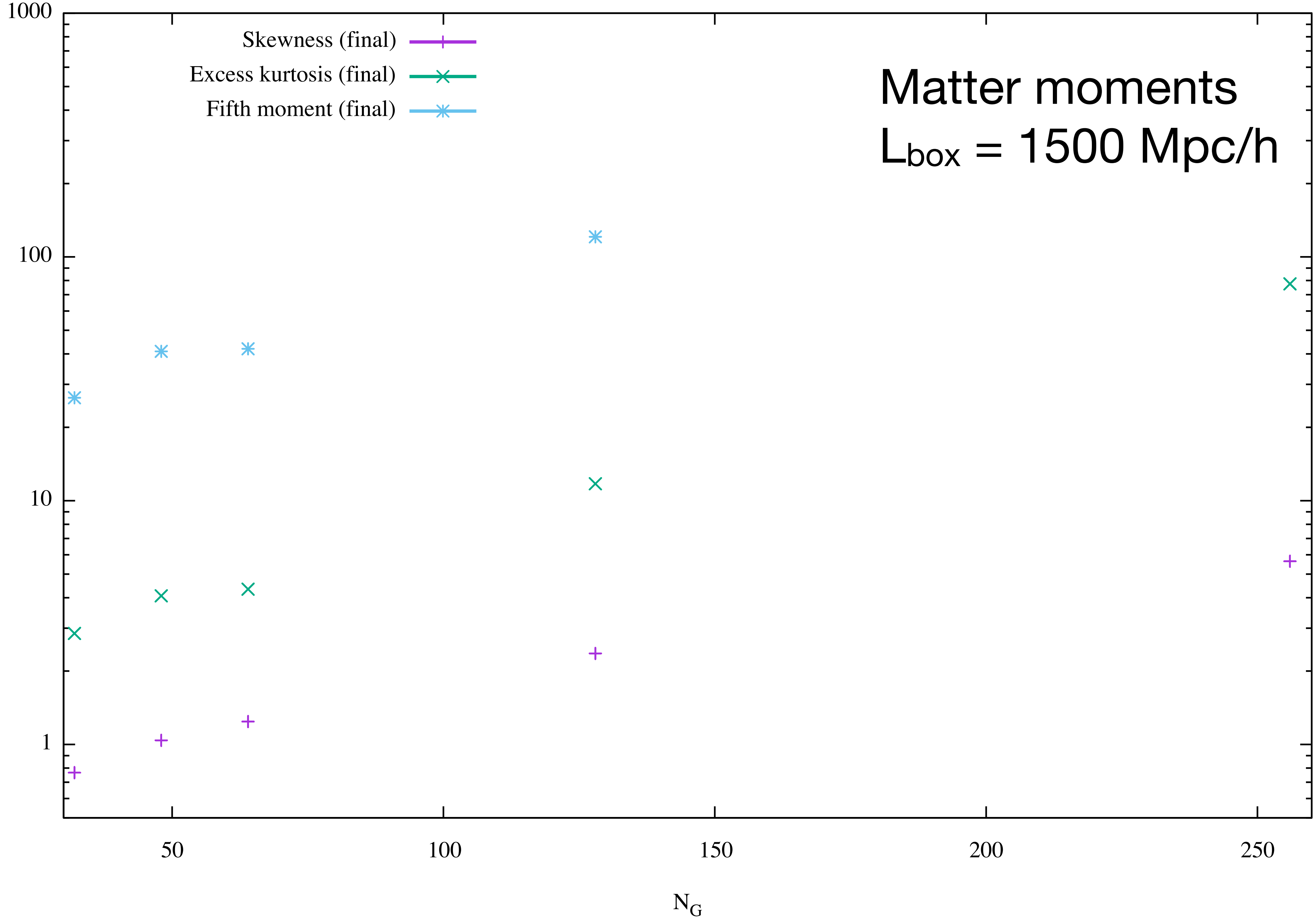
  B. Perturbative approach:
  $$P_g = \mathrm{PDF}(N_g - \bar{N}[1 + \delta_{g,\mathrm{det}}],\ \sigma[1 + c_\sigma \delta])$$
  $$\delta_{g,\mathrm{det}} = b_1 \delta + \frac{b_2}{2}\delta^2 + b_{K^2}(K_{ij})^2$$

- What is theoretical underpinning of these? Regime of validity?

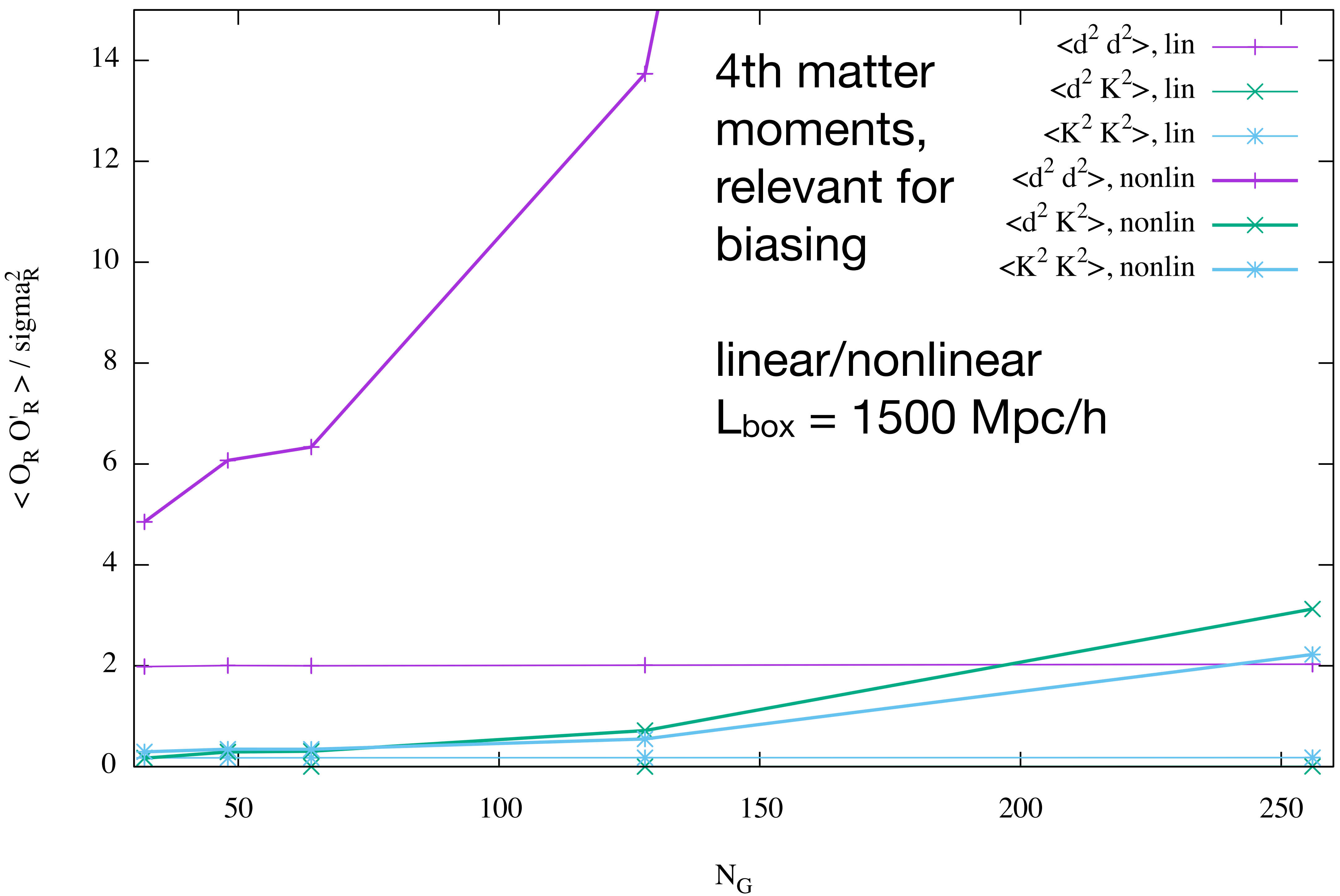
Limits of perturbative approach

- Think of expanding conditional PDF in moments
- Perturbative approach to conditional PDF assumes that higher moments are successively suppressed
- Not really the case for interesting cell sizes…

Limits of perturbative approach



Limits of perturbative approach



Some encouraging results

- Can show that a restricted conditional PDF

$$P_g(N_g|\delta, (K_{ij})^2, (K_{ij})^3;\ \vartheta)$$

is correct up to cubic order terms which are not local, i.e. involve derivatives of δ, K_{ij} between cells

  - Those should be suppressed because of cutoff of small scales

- Parameters ϑ cannot be analytically related to large-scale bias parameters measured from P(k), B(k1,k2,k3), …; however, bias parameters can be inferred by performing “peak-background split”

Summary and open questions

- Spatially local approximation, and results from general perturbative bias expansion, allow us to condense

$$P_g(N_g|O_1, O_2, \cdots O_{347}, \cdots ;\ \vartheta) \longrightarrow P_g(N_g|\delta, (K_{ij})^2, (K_{ij})^3;\ \vartheta)$$

- How well do we need to parametrize conditional PDF (how flexible, how many free parameters, …) ?

- How do we know it is parametrized sufficiently well ?