A Multi-Tracer Approach to Primordial non-Gaussianity

CITA ICAT
Canadian Institute for Theoretical Astrophysics
L'institut Canadien d'astrophysique théorique

George Stein

Collaborators: J.R. Bond, M. Alvarez, Z. Huang, P. Berger

Introduction

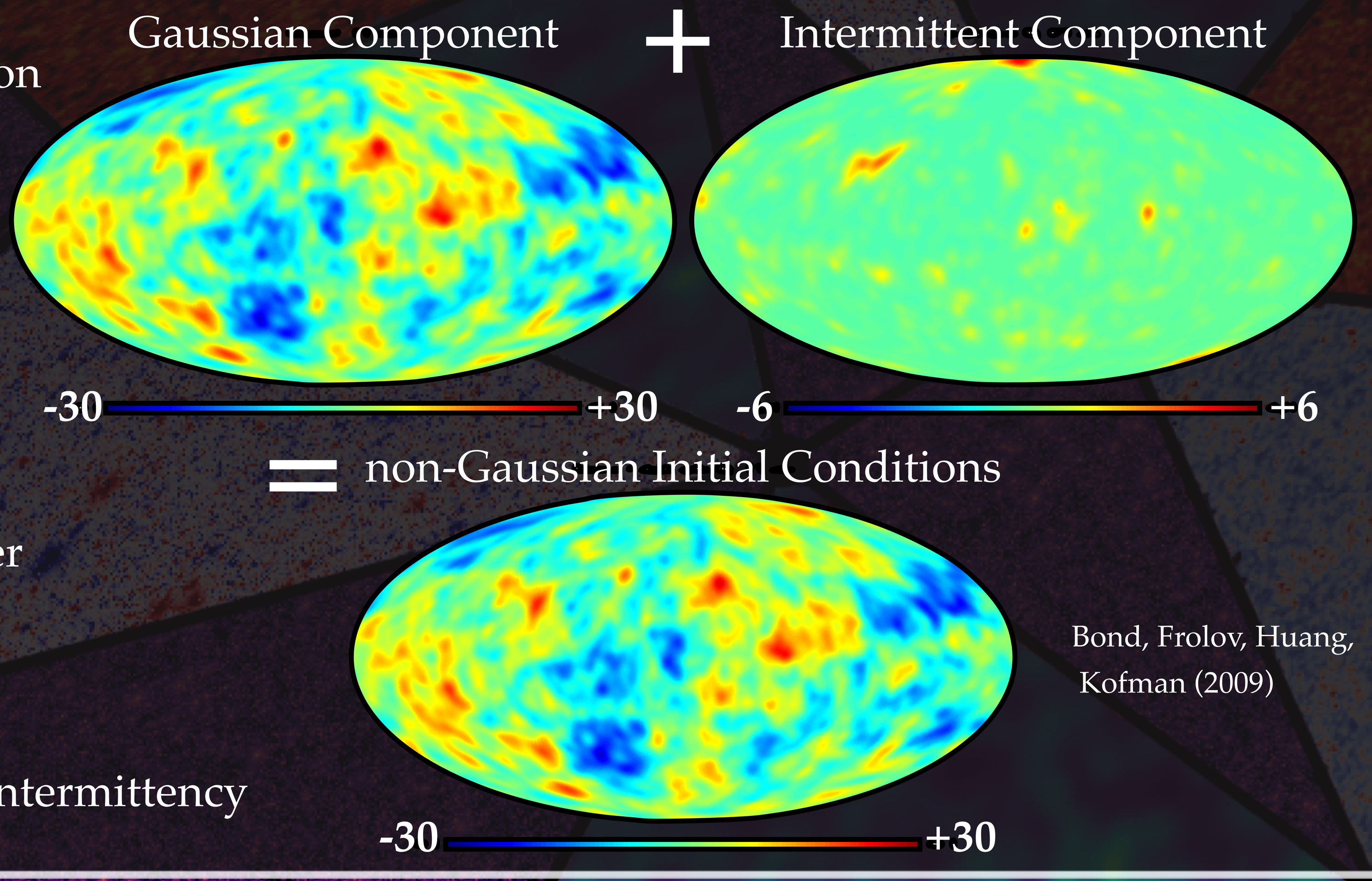
Single-field, slow-roll inflation predicts nearly Gaussian random initial density fluctuations. Therefore, detecting any primordial non-Gaussianity (NG) would provide invaluable information on the physical processes in the early universe. We focus on NG from multi field models

To date the Cosmic Microwave Background (CMB) has provided the strongest constraints on the level of non-Gaussianity, but the Large Scale Structure (LSS) of the universe has the potential to provide drastic improvements on these constraints through future and current surveys.

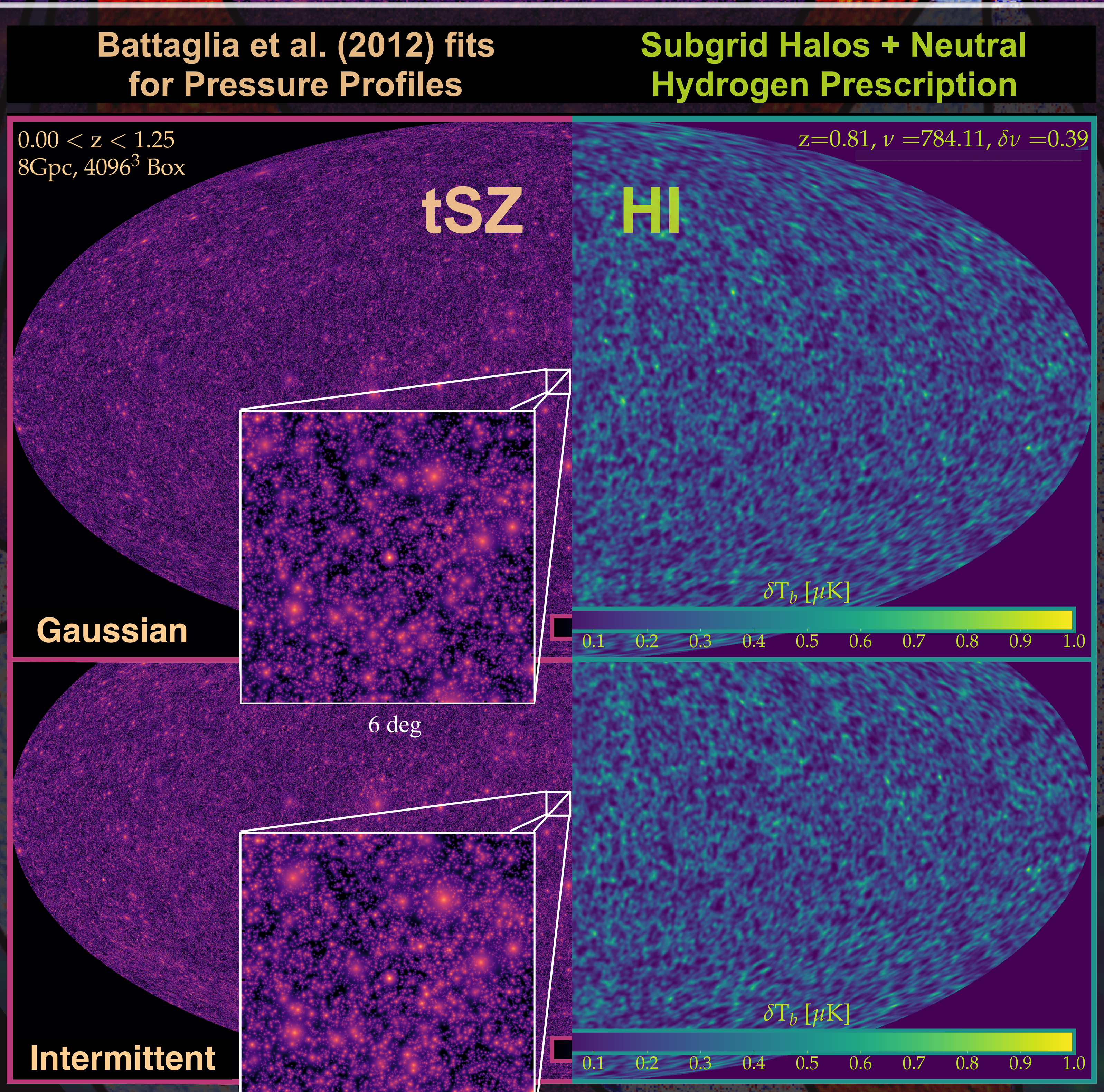
We use the modern Peak Patch algorithm, a monte carlo method to generate mock dark matter halo catalogues, to explore the detectability of both intermittent (spatially sporadic) and conventional perturbative varieties of non-Gaussianity in LSS.

Key Observables: i.) Halo Clustering ii.) Halo mass function iii.) largest virialized objects iv.) Intermittency

CMB Example: Gravitational Potential Maps



Bond, Frolov, Huang, Kofman (2009)



Non-Gaussianity in a full-sky lightcone. The intermittent case has a clear increase in structure when compared to the Gaussian.
8 Gpc box, 4096^3 cells. Wall clock ~10 mins each on 1024 cores. ~60 million halos. Complete for $M_{halo} > 3 \times 10^{13}$ M_{sun}

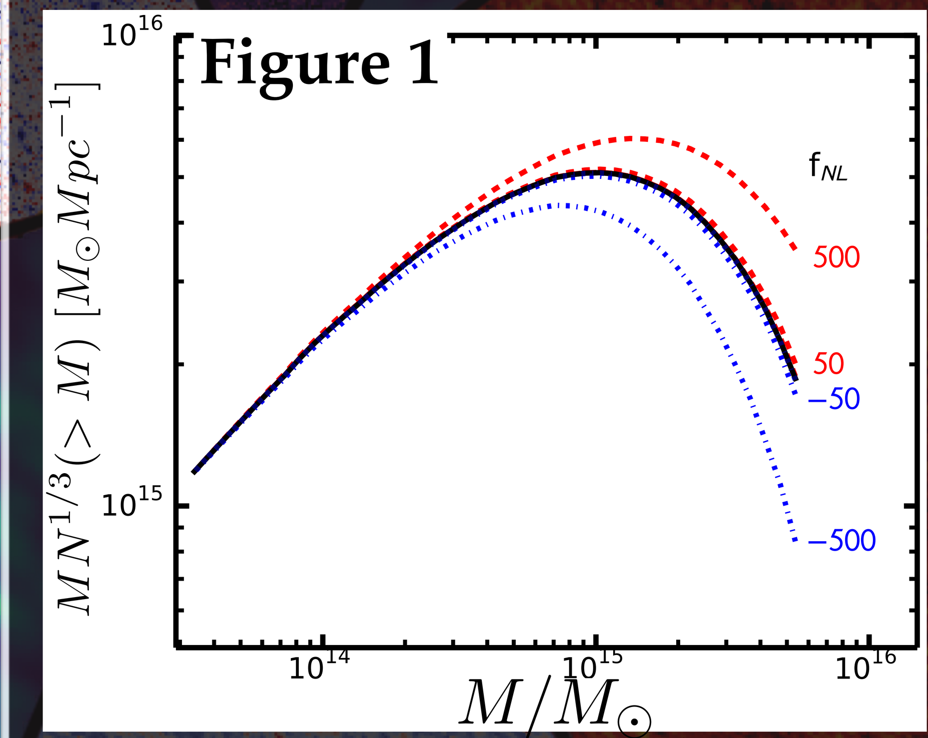
Results I - Local non-Gaussianity

Arises from a class of models known as "spectator field" models

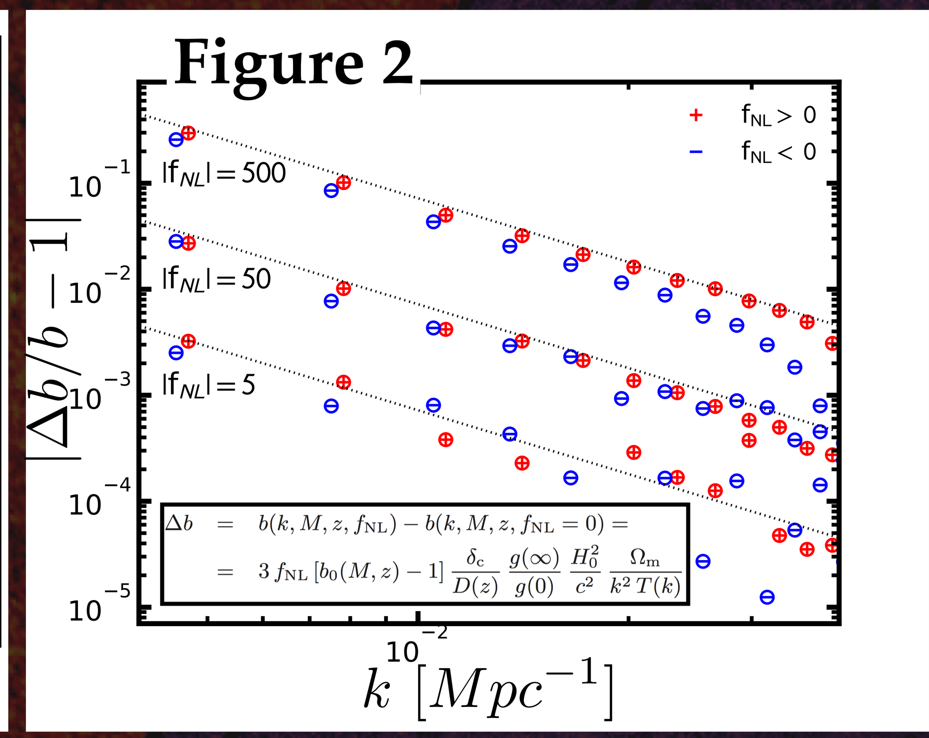
- Inflation still driven by the inflaton field
- The spectator field has subdominant energy during inflation, but contributes to curvature perturbations at the end
- Level of non-Gaussianity parameterized by the scalar f_{NL}

$$\Phi_{NG}(x) = \phi(x) + f_{NL}(\phi^2(x) - <\phi^2>)$$

Peak Patch Simulations:
900 realizations of a 2048 Mpc, 1024^3 cell box for each of the 7 chosen f_{NL} values. ~3 mins each on 64 cores



Mean halo mass function for each set of 900 runs. The black line is the Gaussian universe case. Strong changes are only seen for large values of f_{NL}

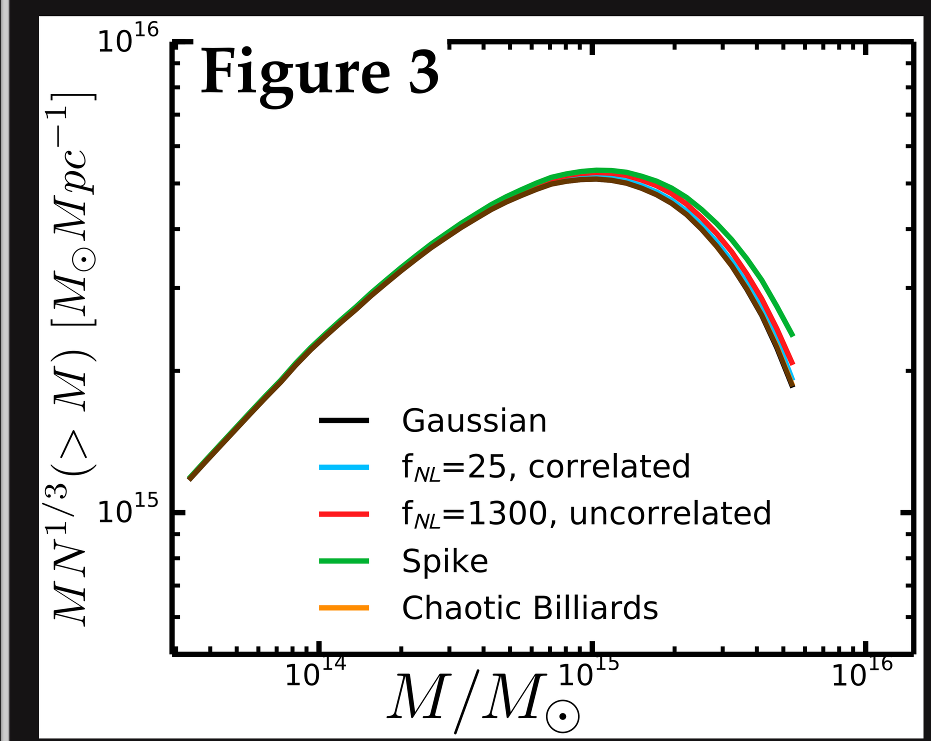


Scale dependent bias is apparent even for small values of k. This is very promising for future LSS surveys

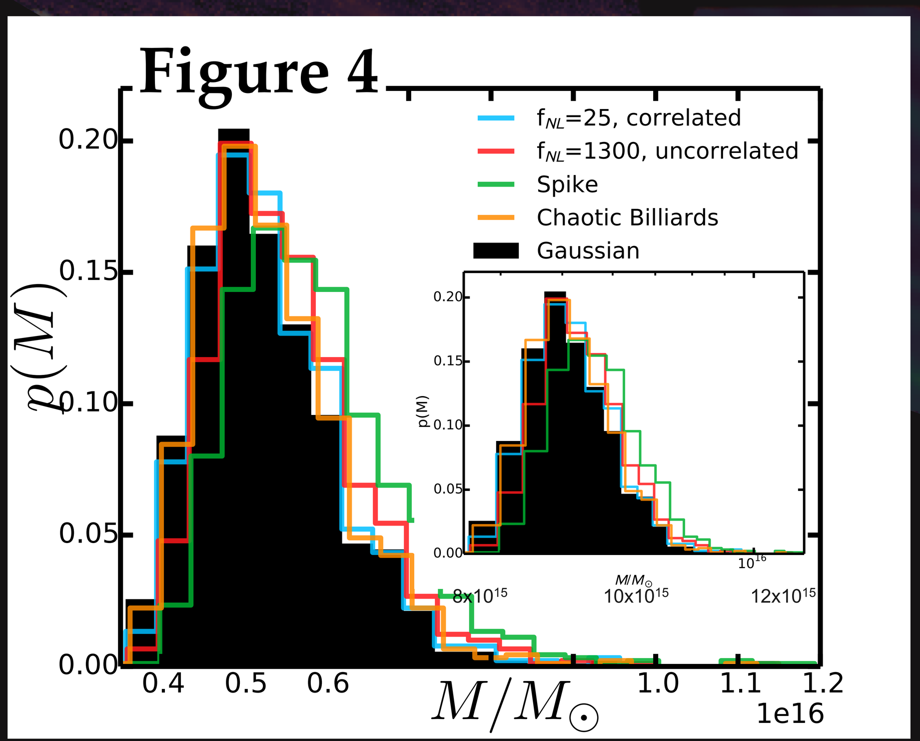
Results II - Intermittent non-Gaussianity

Arise from "Chaotic Billiards" models

- NG from post-inflation preheating behaviour of a non-inflaton light field



Mean halo mass function for each set of 900 runs



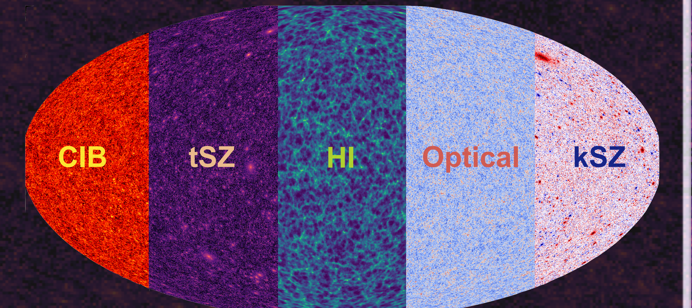
Histogram of single largest halo from each realization

Conclusions

- The signatures of non-Gaussianity in large scale structure need to be well understood through simulations
- large-sky cosmological surveys such as CHIME need efficient mocks
- The Peak Patch method is a great tool for LSS investigation

Future Directions

- Intermittent non-Gaussian classification
- Mocks tailored to individual surveys



References

1) Salopek, D. S.; Bond, J. R., Physical Review D (Particles and Fields), Vol42, I12, 1990, pp.3936-3962
2) E. Komatsu, D. N. Spergel and B. D. Wandelt, Astrophys. J. 634, 14 (2005)
3) N. Dalal, O. Dor´e, D. Huterer, and A. Shirokov, Phys.Rev., vol. D77,p. 123514, 2008.
4) Grossi, M., Verde, L., Carbone, C., Dolag, K., Branchini, E.et al., Mon.Not.Roy.Astron.Soc., 398, 321-332, (2009)
5) Pillepich, A., Porciani, C., Hahn, Ol., Mon.Not.Roy.Astron.Soc., 402, 191-206, (2010)
6) J. R. Bond, A. V. Frolov, Z. Huang, L. Kofman, Phys. Rev. Lett. 103, 071301, (2009)
7) M. Alvarez et al., "Testing Inflation with Large Scale Structure: Connecting Hopes with Reality," 1412.4671