Constraining primordial non-Gaussianity from the cross-correlation of DESI LRGs and CMB lensing

Jose Bermejo-Climent

University of Rochester

"A Cosmic Window to fundamental Physics: primordial non-Gaussianity and Beyond"

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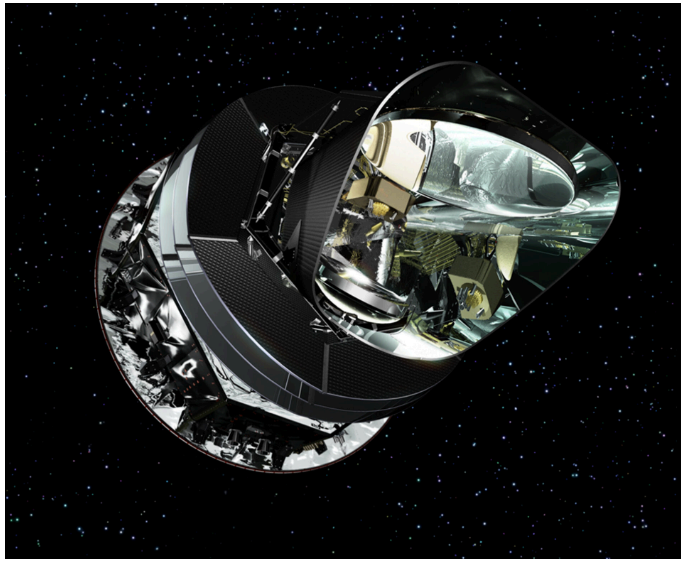
Introduction

- Cross-correlations between CMB and matter tracers depend on the galaxy bias and are therefore sensitive to $f_{\rm NL}$ local.
- In particular, theoretical predictions (e.g. Bermejo-Climent et al. 2021) show the capability of CMB lensing - galaxy clustering cross-correlation for constraining $f_{\rm NL}$ using the 2D angular power spectra:
    - C_ℓ^{GG}: galaxy-galaxy autocorrelation
    - $C_\ell^{\kappa G}$: lensing-galaxy cross-correlation
- What can we learn from DESI x *Planck* lensing?



Mayall 4-M telescope (DESI)
at Kitt Peak National Observatory, AZ

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Introduction

- DESI current status: ~1 year of spectra taken. It's already the largest 3D galaxy map ever done.
- DESI imaging legacy survey: a photometric survey used to select DESI spectroscopic targets, performed with 3 different telescopes.

  The legacy survey contains already tons of useful information for measuring PNG!

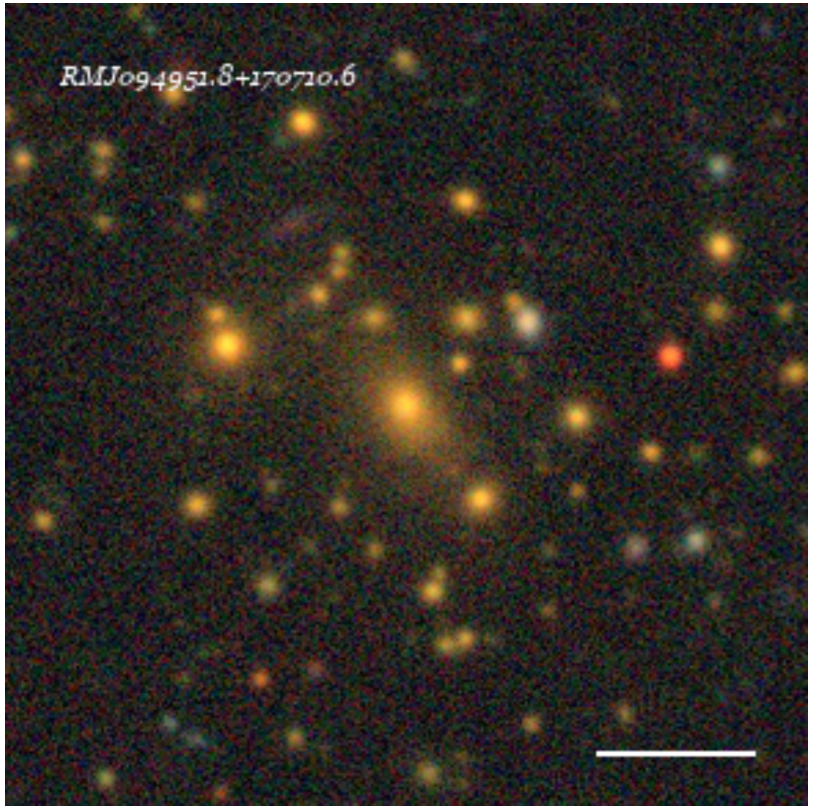

Image credits: legacysurvey.org

Datasets: LRG

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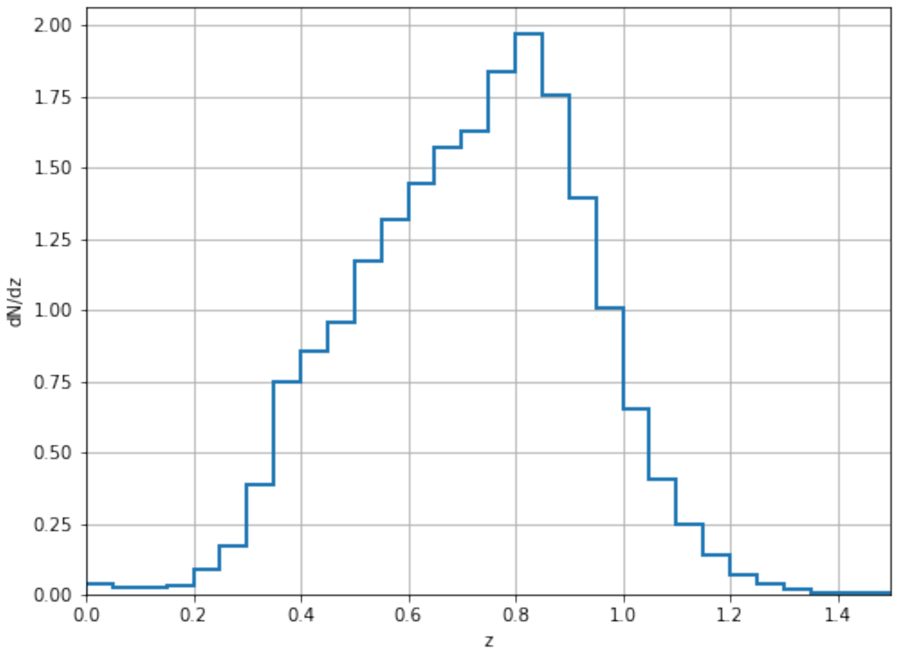
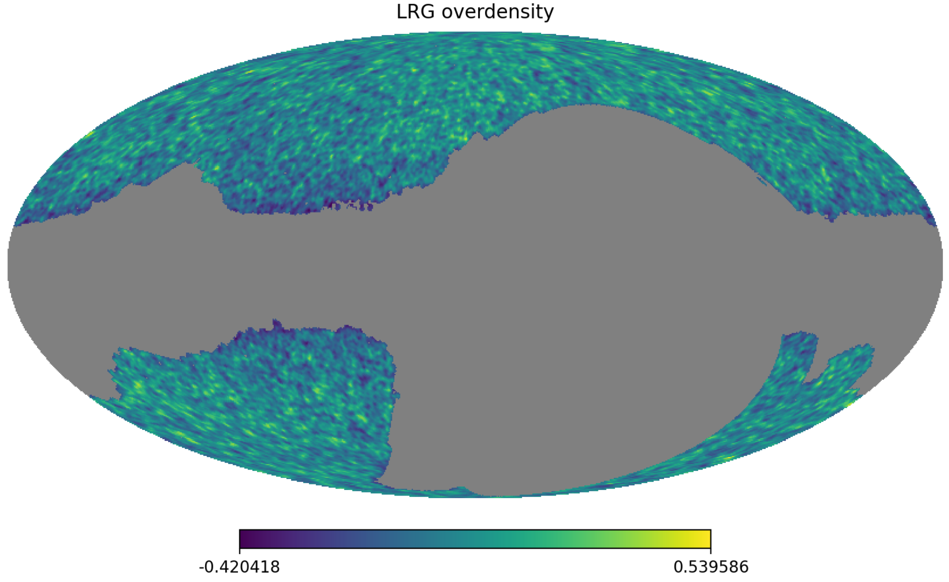
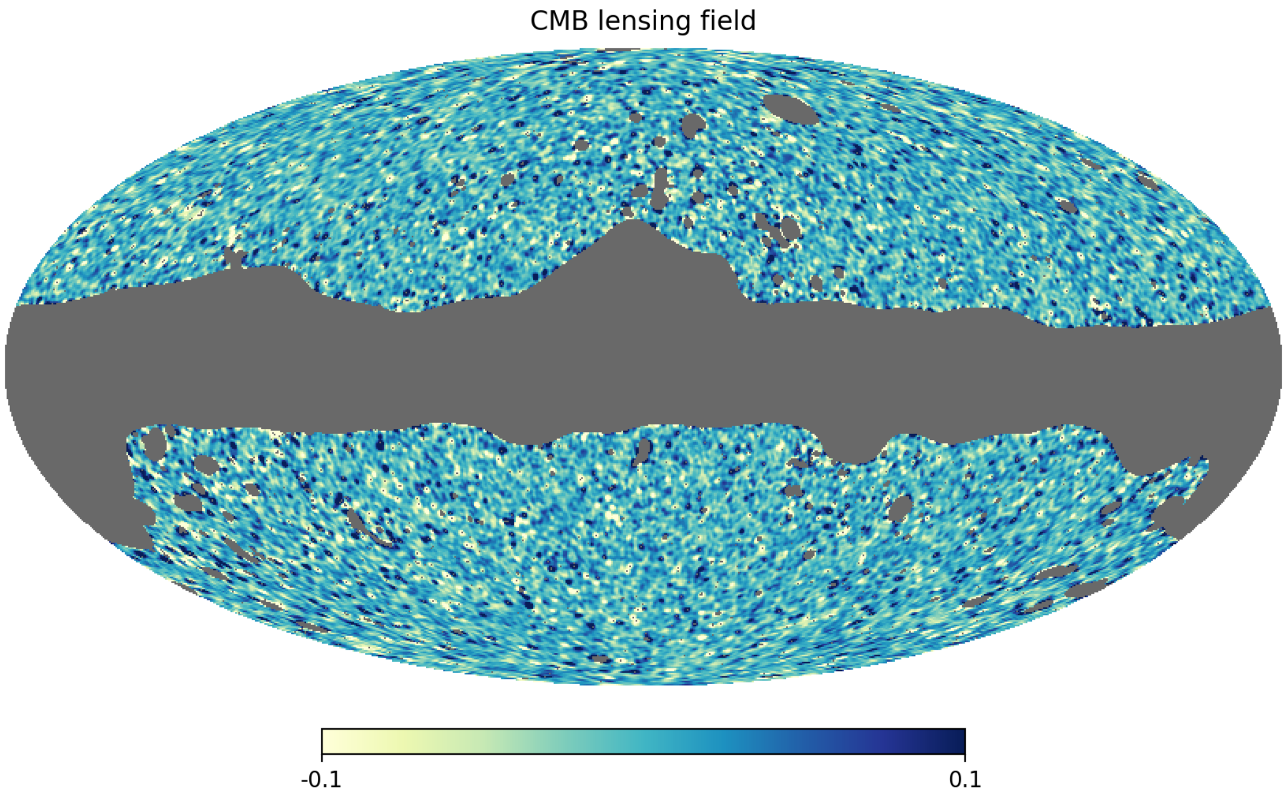
- Legacy survey: DR9 photometric Luminous Red Galaxies (LRG) catalog (R. Zhou et al. in prep.)
- The redshift distribution $\mathrm{d}N/\mathrm{d}z$ is calibrated using the spectroscopic LRG redshifts we already have measured.
- Cut for δ < -30° (no spectroscopic info): ~9 million galaxies, over ~16000 deg²





Datasets: CMB lensing

- The CMB lensing is correlated with galaxy maps as large structures are responsible for this effect
- CMB - galaxies cross-correlation so far detected with S/N ~ 80 using *Planck* (e.g. Krolewski et al. 2020)
- We use the *Planck* 2018 release SMICA DX12 CMB maps



Systematics mitigation

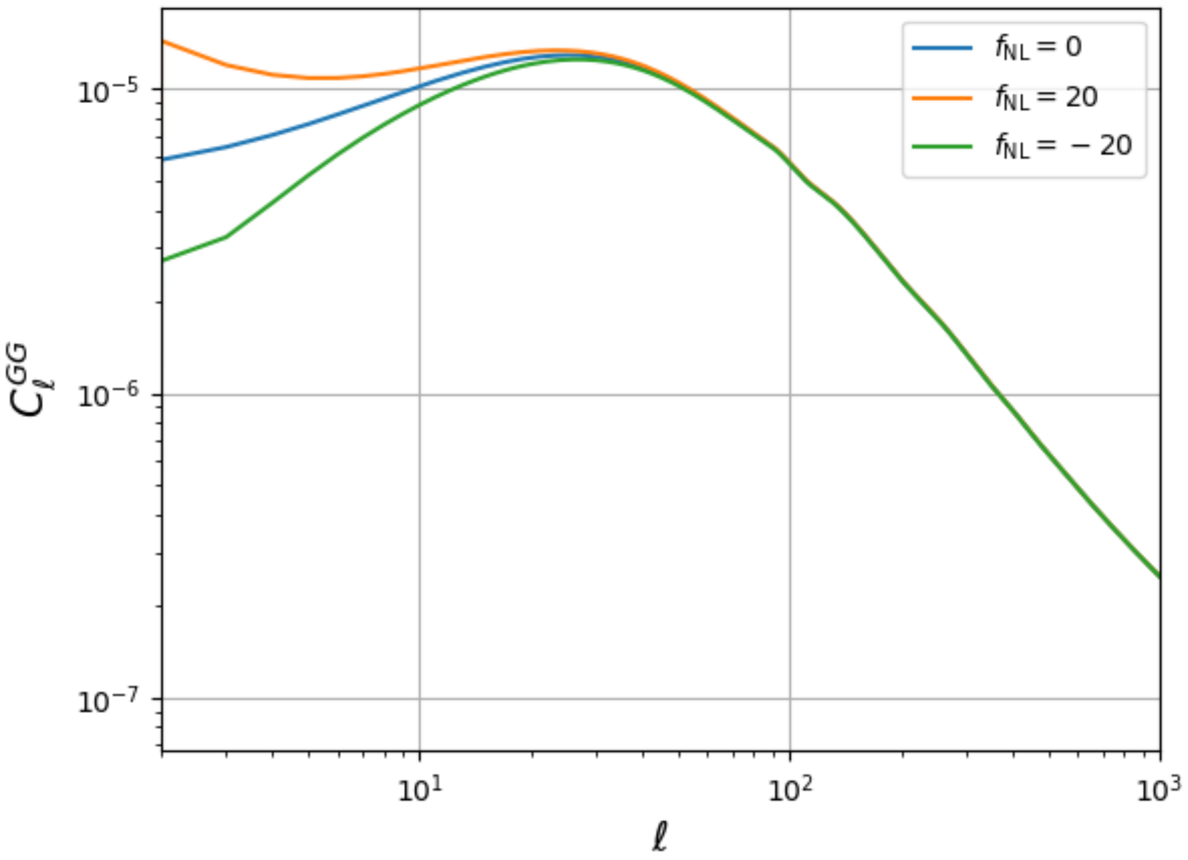
- Photometric systematics have an impact on the C_ℓ, in particular at large scales, where the $f_{\rm NL}$ signal is: uncorrected maps could likely bias results.

- We use ***SYSnet*** (by Mehdi Rezaie), a neural network code for systematics mitigation.

- Two approaches:

  - ***Extreme***: 13 feature maps included.

  - ***Conservative***: perform a feature selection based on features' correlation with the data.



Theoretical angular power spectra for different $f_{\rm NL}$ values

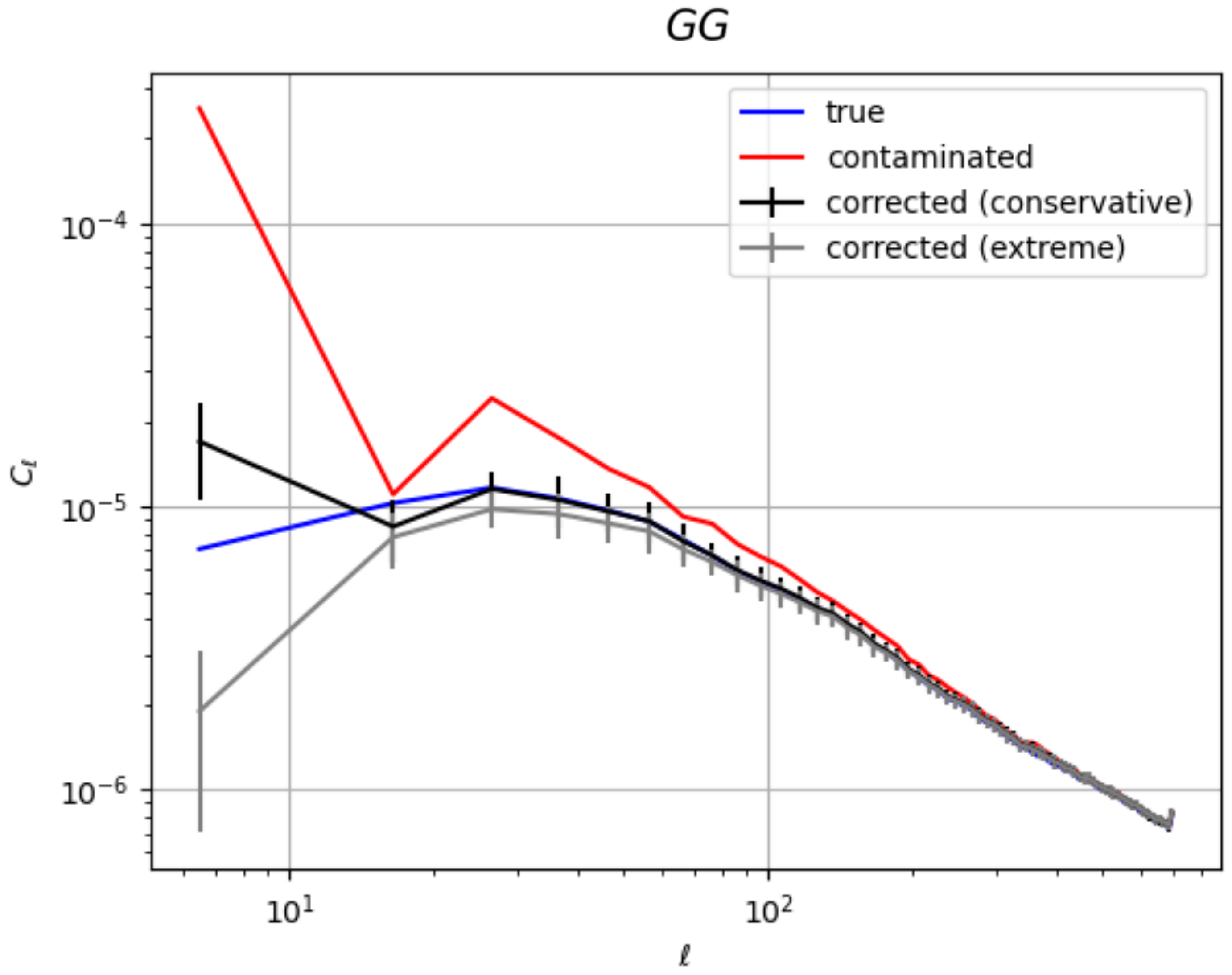
Systematics mitigation

- We test the neural network systematics mitigation code (*SYSnet*) with mocks:
    - 1) use ~100 LRG lognormal simulations (M. Rezaie) with known f_{NL}.
    - 2) apply *regressis* (E. Chaussidon) to add contamination to the mocks.
    - 3) run *SYSnet* on the contaminated mocks using the conservative and extreme settings.
    - 4) compare the output with the true power spectra.

Systematics mitigation

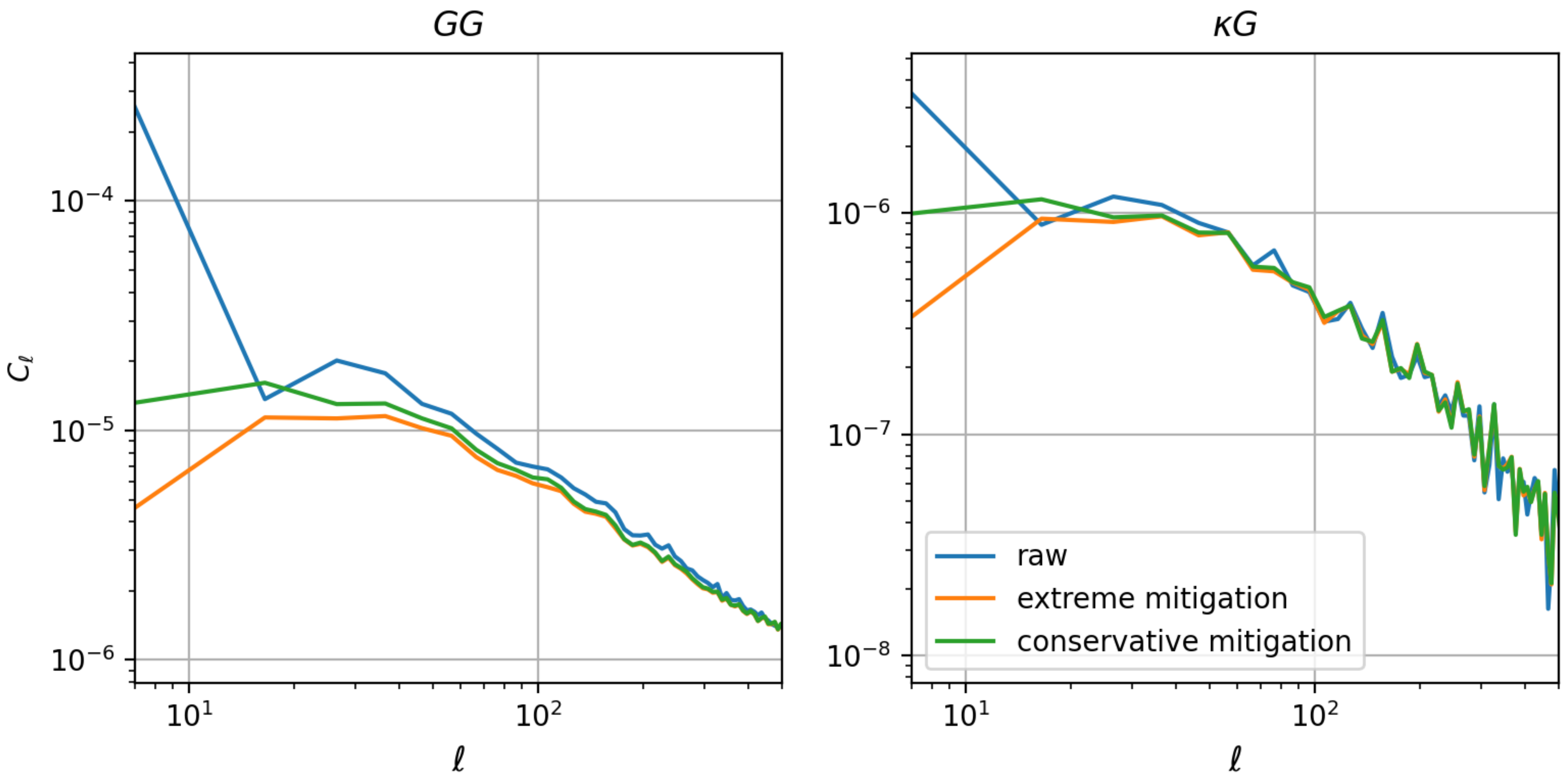
- Conservative approach seems to be closer to the true C_ℓ^{GG} power spectra, while extreme settings remove real clustering.

- Methodology under testing and development! Ongoing work:
    - Extension of this test to $C_\ell^{\kappa G}$ spectra with a new set of Gaussian correlated LRG and CMB lensing simulations.
    - Test the impact of the recipe choice in the parameters.



Systematics mitigation

- Data: $C_\ell^{\kappa G}$ is less sensitive to the systematics mitigation choice, but not fully independent.



Likelihood

- Observables: we compute the angular power spectra (C_ℓ^{GG},$C_\ell^{\kappa G}$) using the pseudo-C_ℓ approach from ***NaMaster*** (Alonso et al. 2019)

- Covariance matrix: full Gaussian covariance for a masked field in *NaMaster*

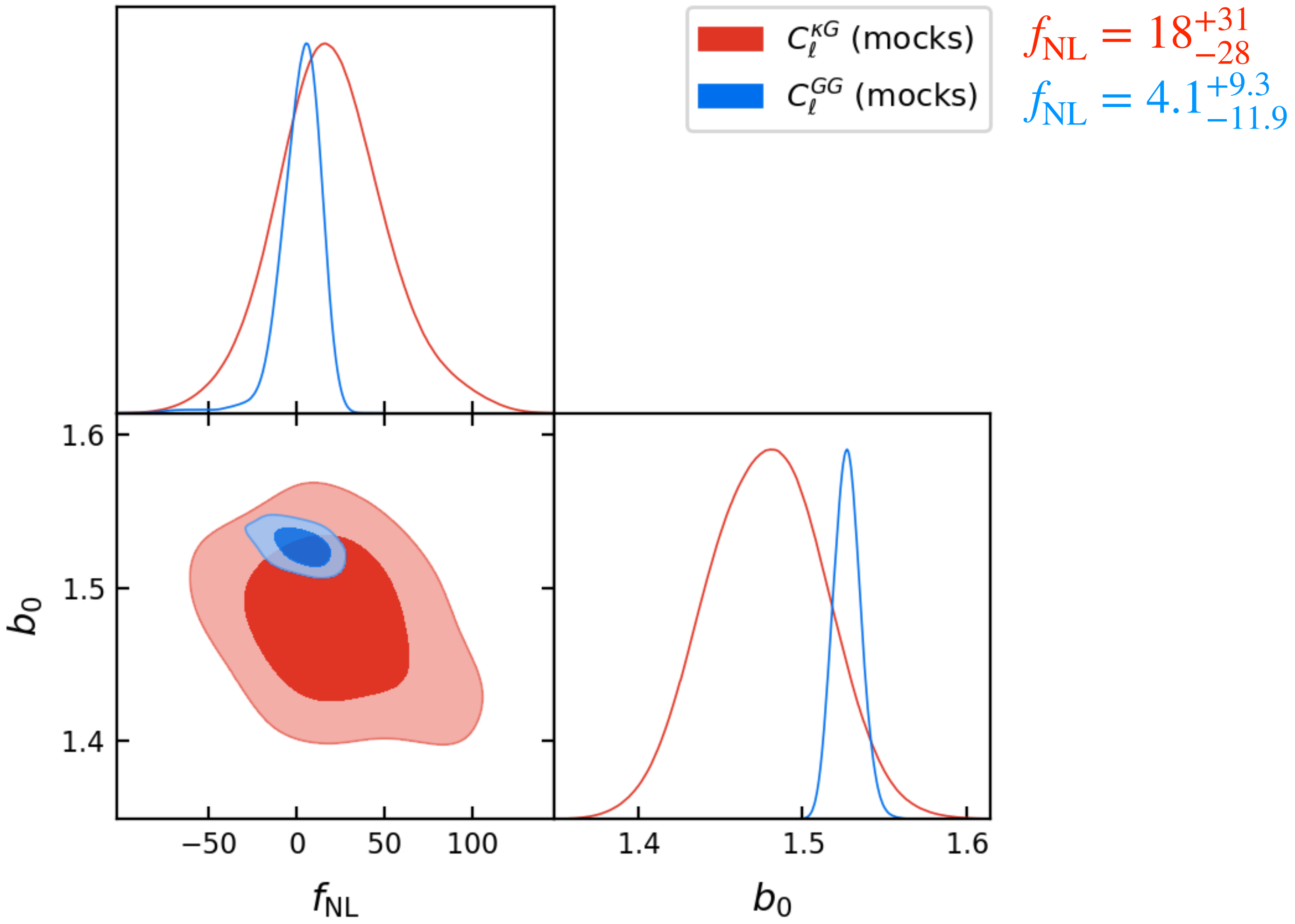
- Theoretical model: CAMB angular power spectra. Code modified to include a scale dependent bias induced by $f_{\rm NL}$.

$$\Delta b(k,z) = 2(b_g - p) f_{\rm NL} \frac{\delta_{\rm crit}}{\alpha(k)} \qquad \alpha(k) = \frac{2k^2 T(k) D(z)}{3\Omega_{\rm m}} \frac{c^2}{H_0^2} \frac{g(0)}{g(\infty)}$$

We assume $b_g(z) = b_0/D(z)$ with b_0 as free parameter, and p = 1 for LRG.

Parameter constraints

- We use the MCMC sampler *emcee*
- Parameters:
    - Sampled: $f_{\rm NL}$, b_0 and $N_{\rm shot}$ (for C_ℓ^{GG} only)
    - ΛCDM parameters fixed to *Planck* 2018 bestfit
- The code is tested with $f_{\rm NL}$ = 0 and $f_{\rm NL}$ = 100 mocks.



Conclusions and outlook

- CMB lensing - LRG cross-correlation offers a complementary and independent measurement of $f_{\rm NL}$ local.
  In particular, it's less sensitive to imaging systematics than LRG autocorrelation.

- A tomographic analysis using various redshift bins might be useful for improving $f_{\rm NL}$ constraints and understanding the bias z-dependence.

- Eventually, the combination with other tracers such as ELG and QSO will also improve the $f_{\rm NL}$ uncertainty.

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