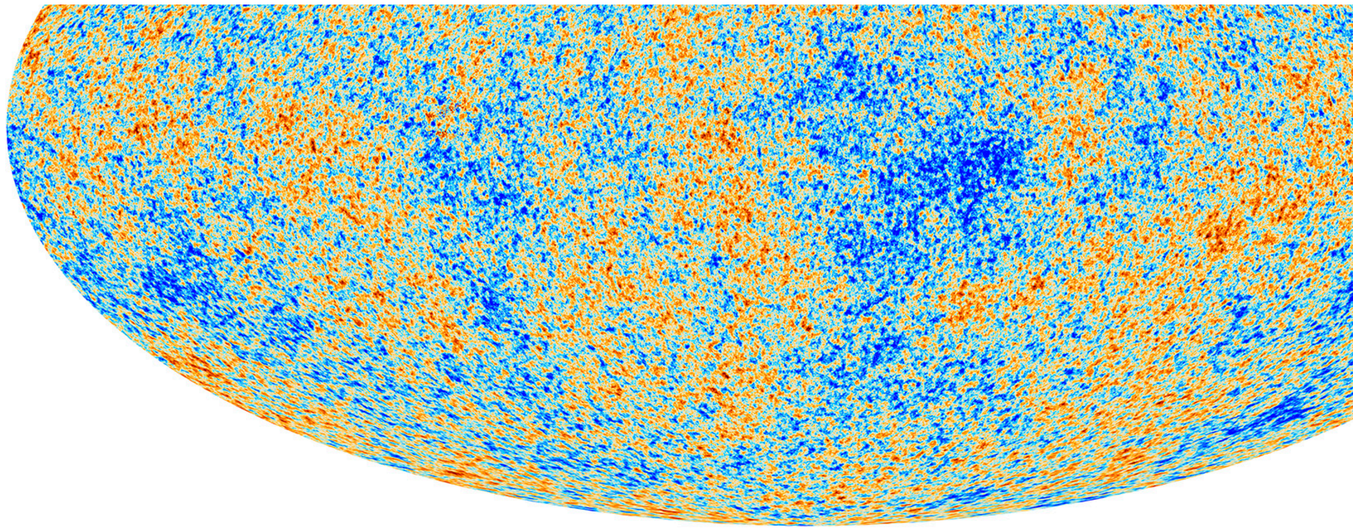
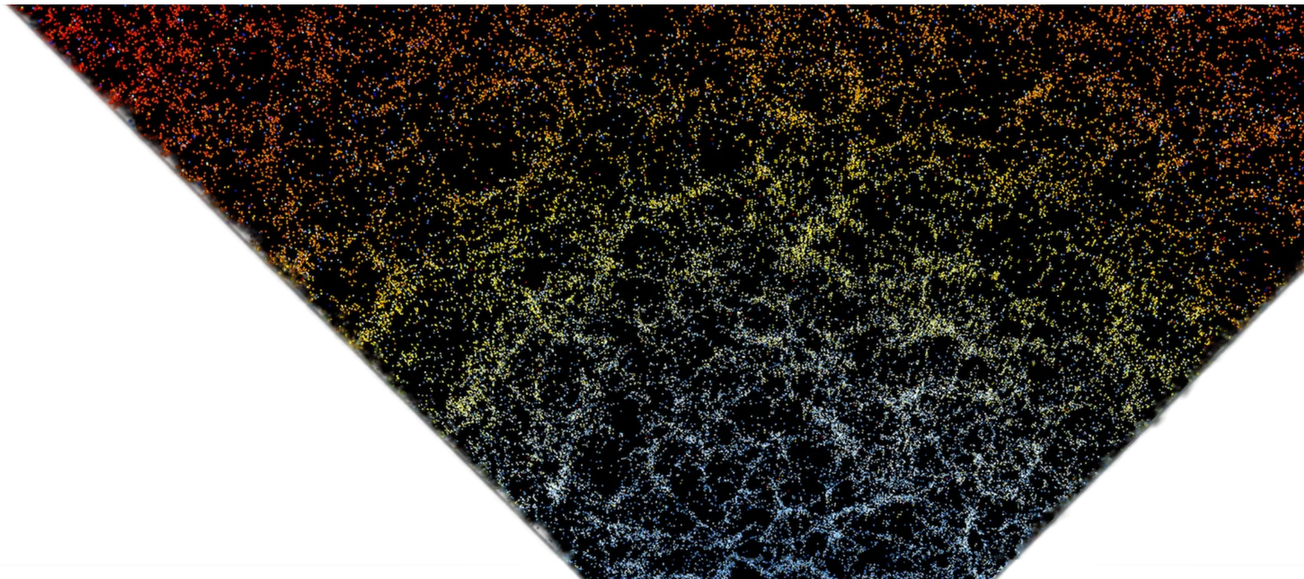


# Forecasts on primordial non-Gaussianity with SPHEREx

## Effects of photometric redshift errors




Chandra Shekhar Saraf

In Collaboration With David Parkinson

Korea Astronomy and Space Science Institute

cssaraf@kasi.re.kr



11th KIAS Workshop on Cosmology and Structure Formation, Gyeongju

October 27 - November 1, 2024

# Primordial non-Gaussianity

- Inflation in widely accepted to explain the observed statistical isotropy and homogeneity in the Universe.

  (Guth 1981; Linde 1982; Albrecht & Steinhardt 1982)

- The characteristics of the field(s) that drove inflationary expansion remains unknown.

# Primordial non-Gaussianity

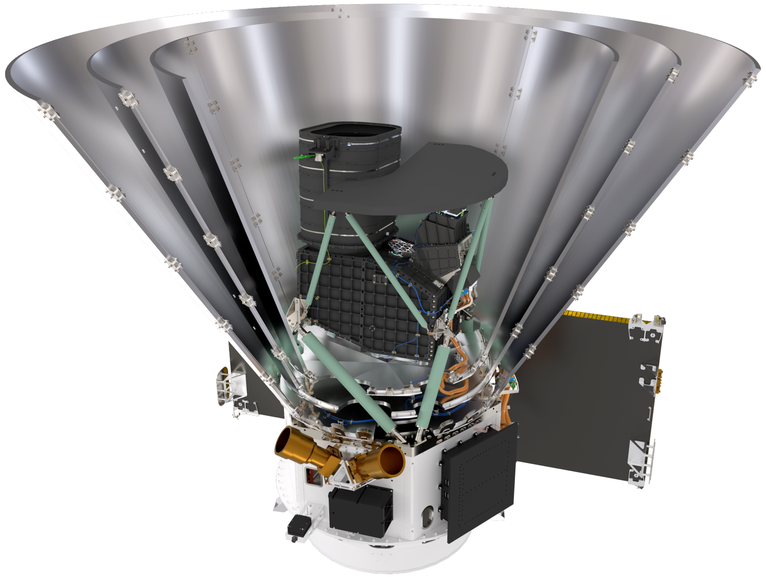
- Inflation in widely accepted to explain the observed statistical isotropy and homogeneity in the Universe. (Guth 1981; Linde 1982; Albrecht & Steinhardt 1982)
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- CMB and LSS suggest Gaussian and scale invariant primordial fluctuations (Komatsu et al. 2003; Tegmark et al. 2004; Guth & Kaiser 2005)
- Alternative inflationary models predict different levels of non-Gaussianity in primordial gravitational field.

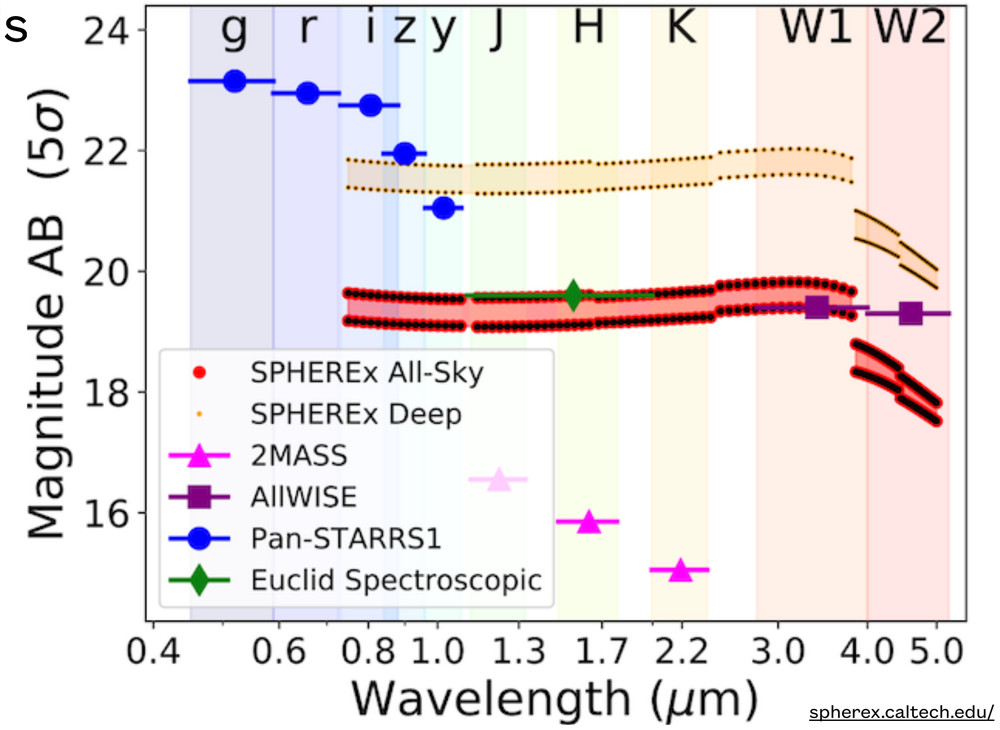
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- CMB and LSS suggest Gaussian and scale invariant primordial fluctuations (Komatsu et al. 2003; Tegmark et al. 2004; Guth & Kaiser 2005)
- Alternative inflationary models predict different levels of non-Gaussianity in primordial gravitational field.
- In simplest form, local primordial non-Gaussianity is parameterised by non-linear coupling constant $f_{NL}$ (Komatsu & Spergel 2001)
- $\Phi = \phi + f_{NL}[\phi^2 - \langle\phi^2\rangle]$, $\Phi$ is the primordial curvature perturbation and $\phi$ is a Gaussian random field.

# SPHEREx

- Spectro-Photometer for the History of the Universe, Epoch of Reionization, and Ices Explorer (SPHEREx)
- NASA Medium Explorer mission (JPL, Caltech, KASI)
- All-sky near-infrared survey with 102 fine photometric bands
- Wavelength coverage: $0.75 - 5.0\,\mu$m
- Four all-sky coverages in nominal 25 months mission
- Scheduled to launch in early 2025






spherex.caltech.edu/

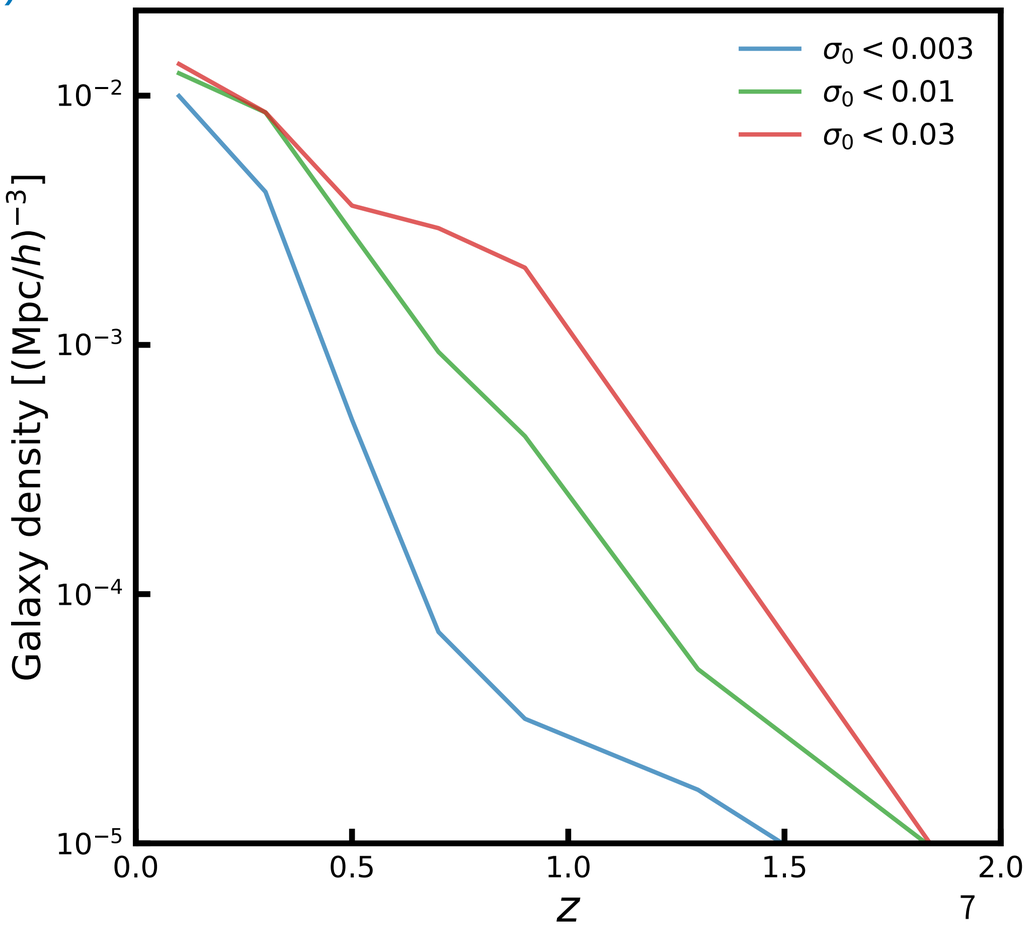
# Simulation setup

- Inputs: galaxy bias evolution, $f_{NL}$, true redshift distribution and angular correlation

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- Inputs: galaxy bias evolution, $f_{NL}$, true redshift distribution and angular correlation
- 500 log-normal simulations using GLASS code (Tessore et al. 2023)
- Photometric redshifts assuming Gaussian error distribution
- 13 disjoint redshift bins between $0 \leq z \leq 1.3$
- Compute angular power spectra in every redshift bin
- Compute redshift error distribution $p(z_t - z_p \,|\, z_p)$
- Estimate galaxy bias and $f_{NL}$

from Dore et al. 2016



# Theoretical Power Spectrum

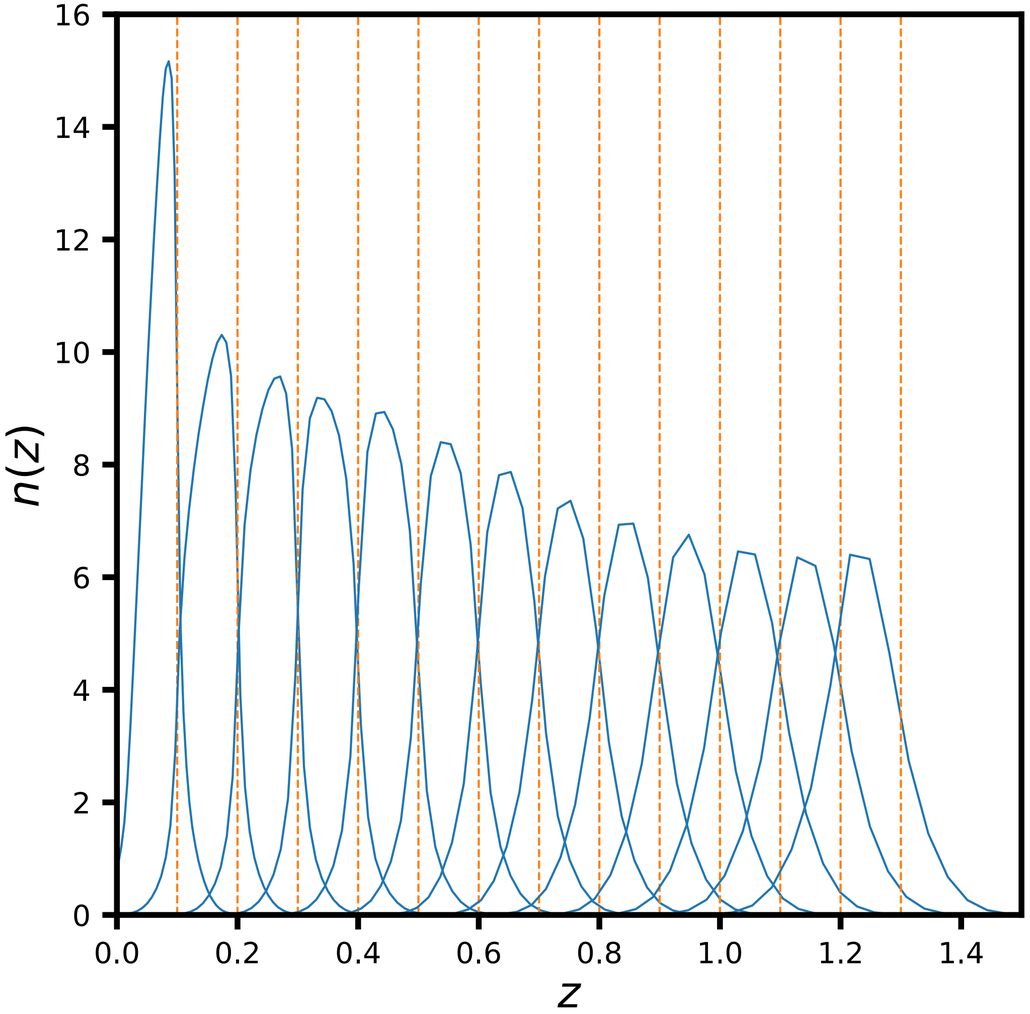
$$C_\ell^{gg} = \frac{2}{\pi}\int_0^\infty \frac{dk}{k} k^3 P(k)\,|\,\Delta_\ell^g(k)\,|^2 + N_\ell^{gg}$$

convolution

Galaxy density kernel: $\Delta_\ell^g(k) = \int dz\, b(k,z)\frac{dN}{dz}\, D(z)\, j_\ell(k\chi)$

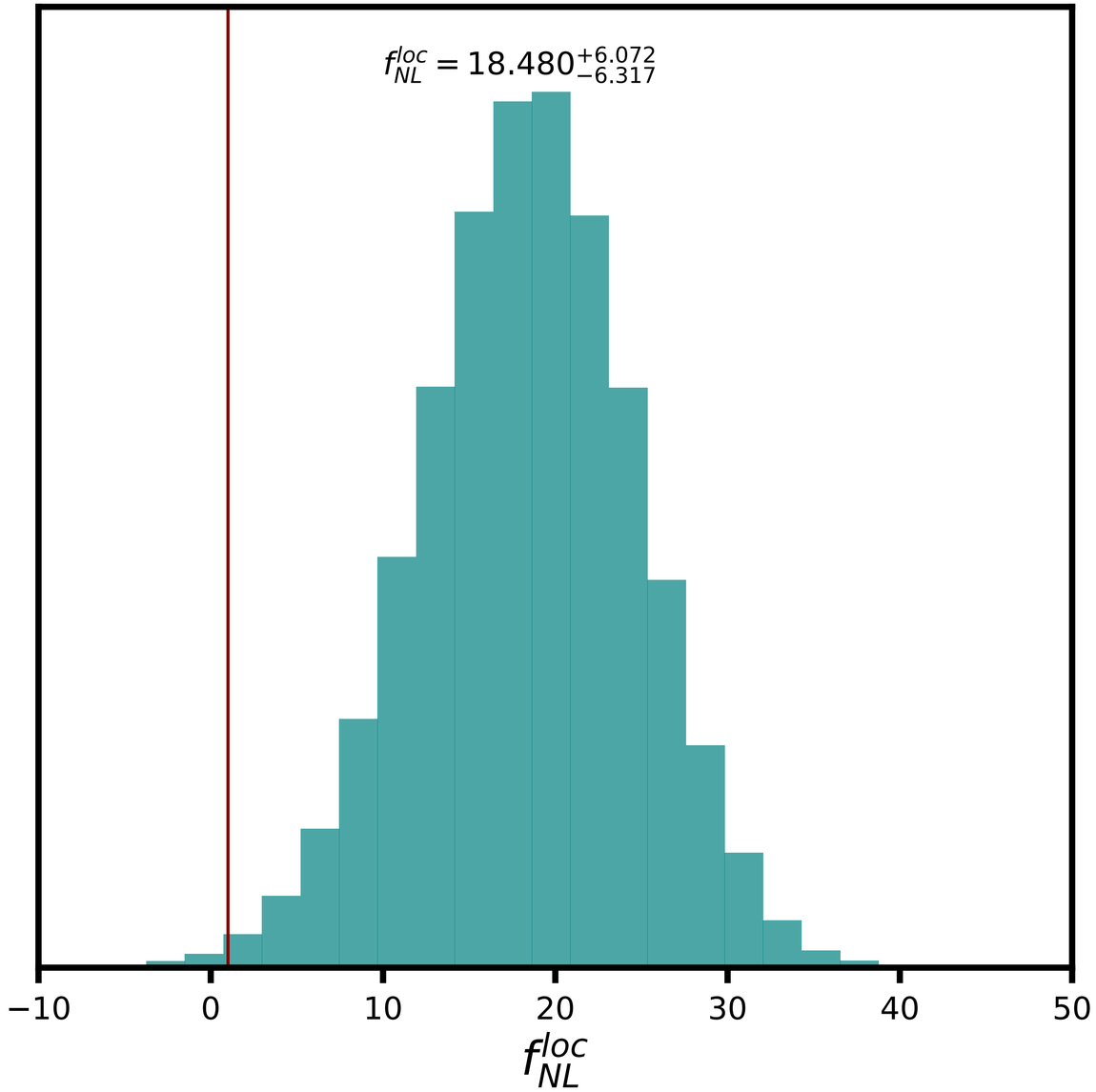
Galaxy bias: $b(k,z) = b_G(z) + f_{NL}(b_G(z) - 1)\,\delta_c \frac{3\Omega_m H_0^2}{k^2 T(k)\, D(z)}$

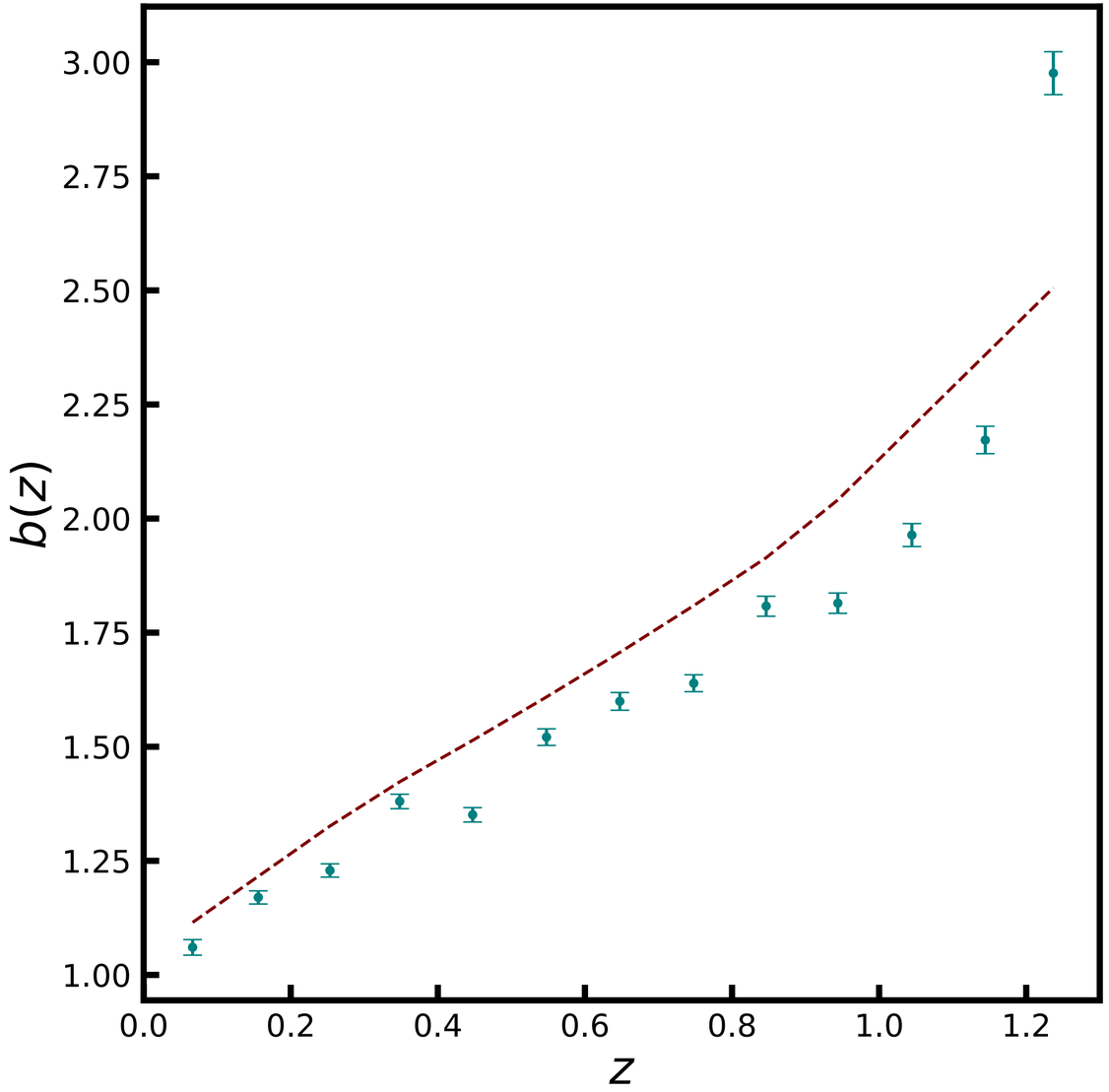
free parameters



# Results

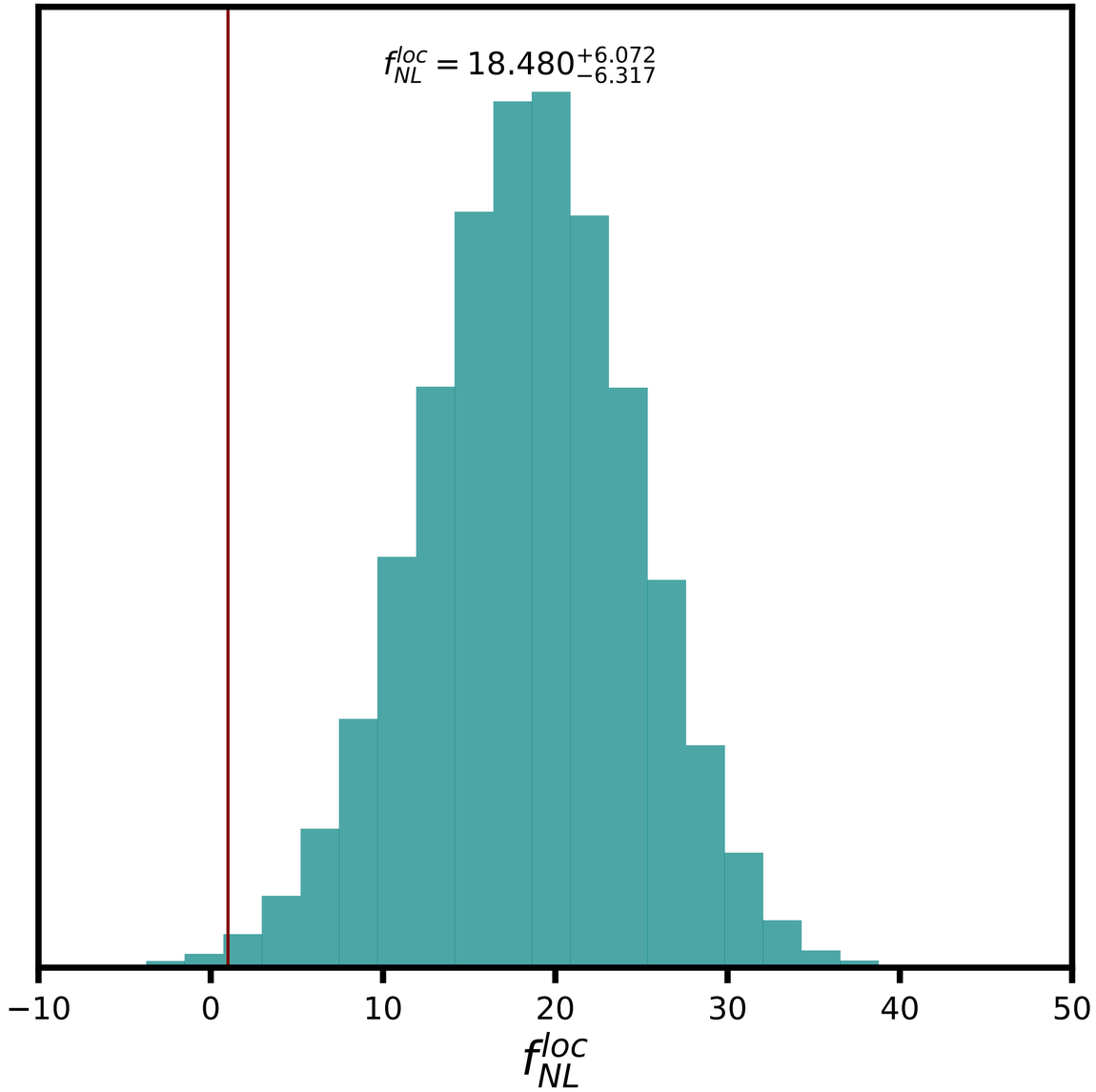
# Parameters with photo-z errors



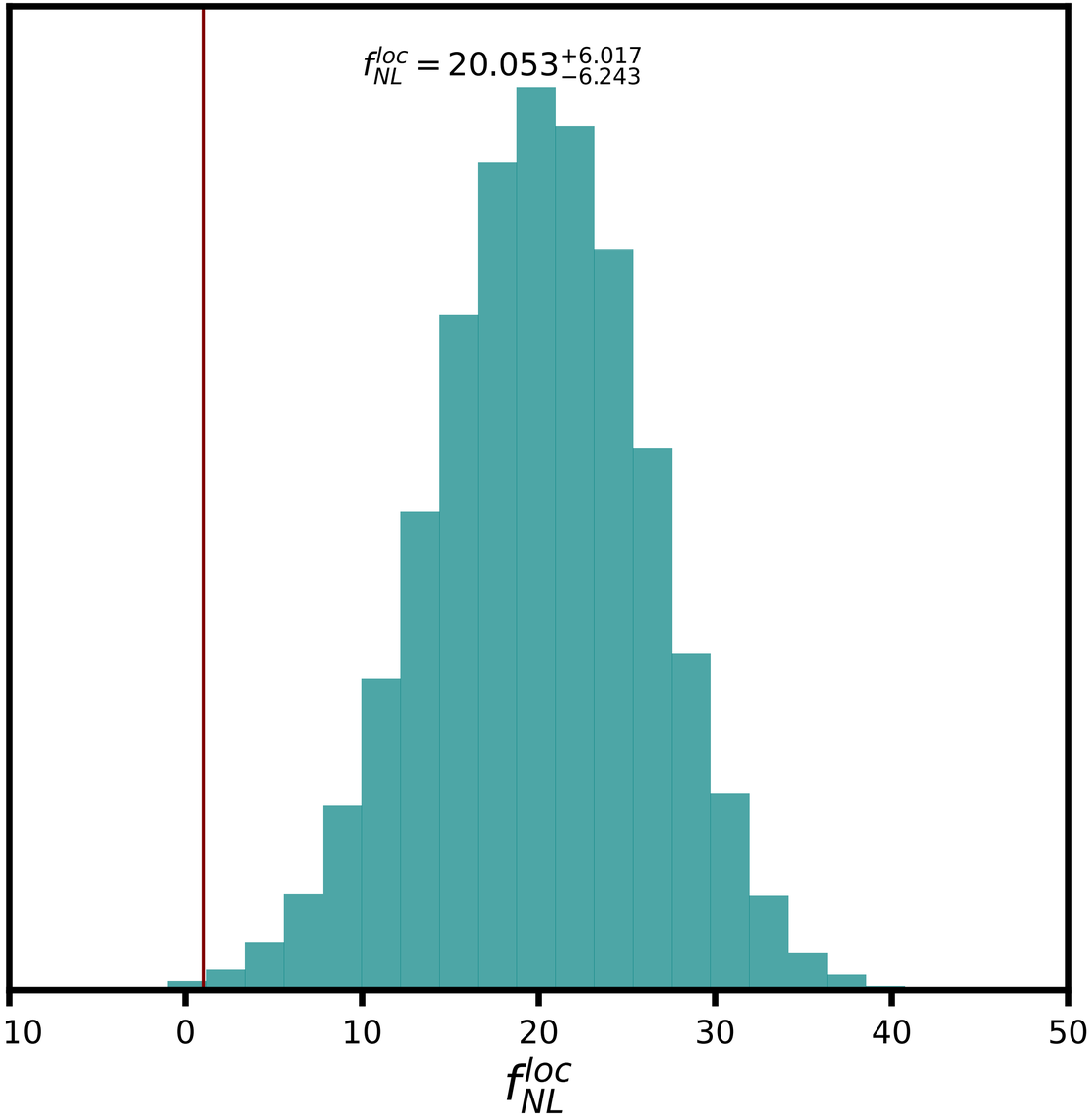



# Is dN/dz wrong?

from convolution




from catalogue



# Redshift bin mismatch

CSS and Paweł Bielewicz, 2024a; 2024b

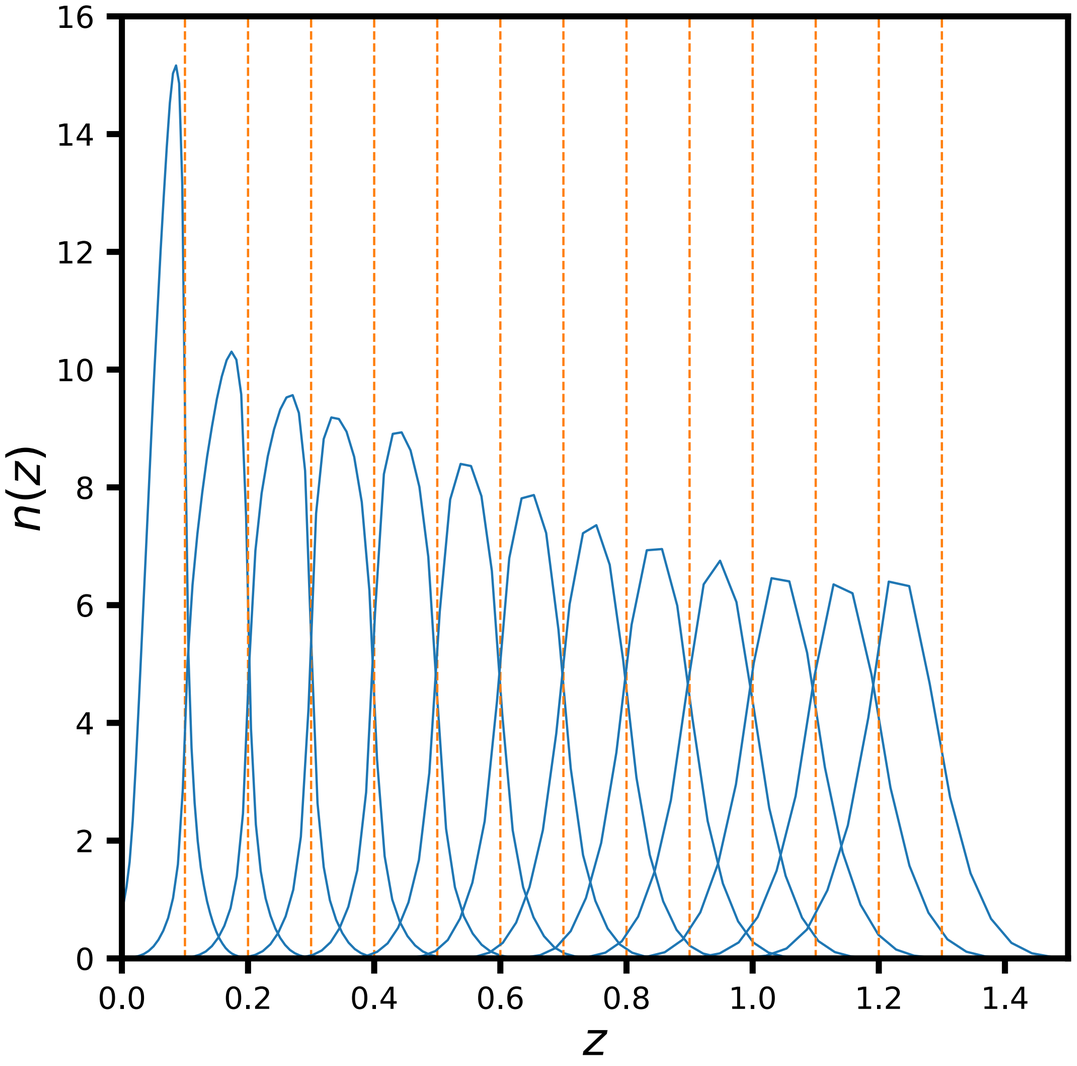
from photometric bins

(Zhang et al., 2010)

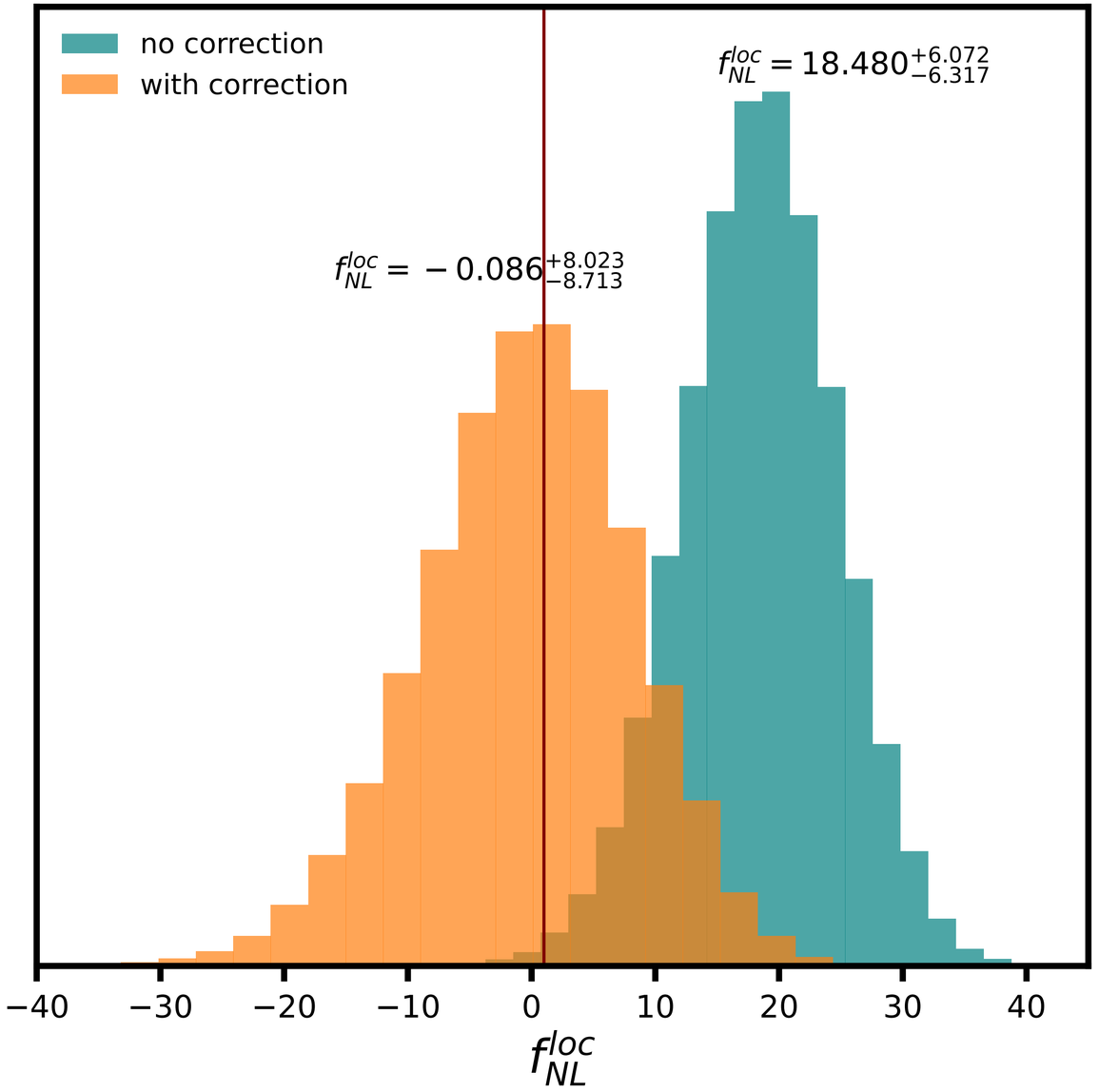
$$C_{ij}^{gg,\mathrm{Ph}}(\ell) = \sum_k P_{ki} P_{kj} C_{kk}^{gg,\mathrm{Tr}}(\ell)$$

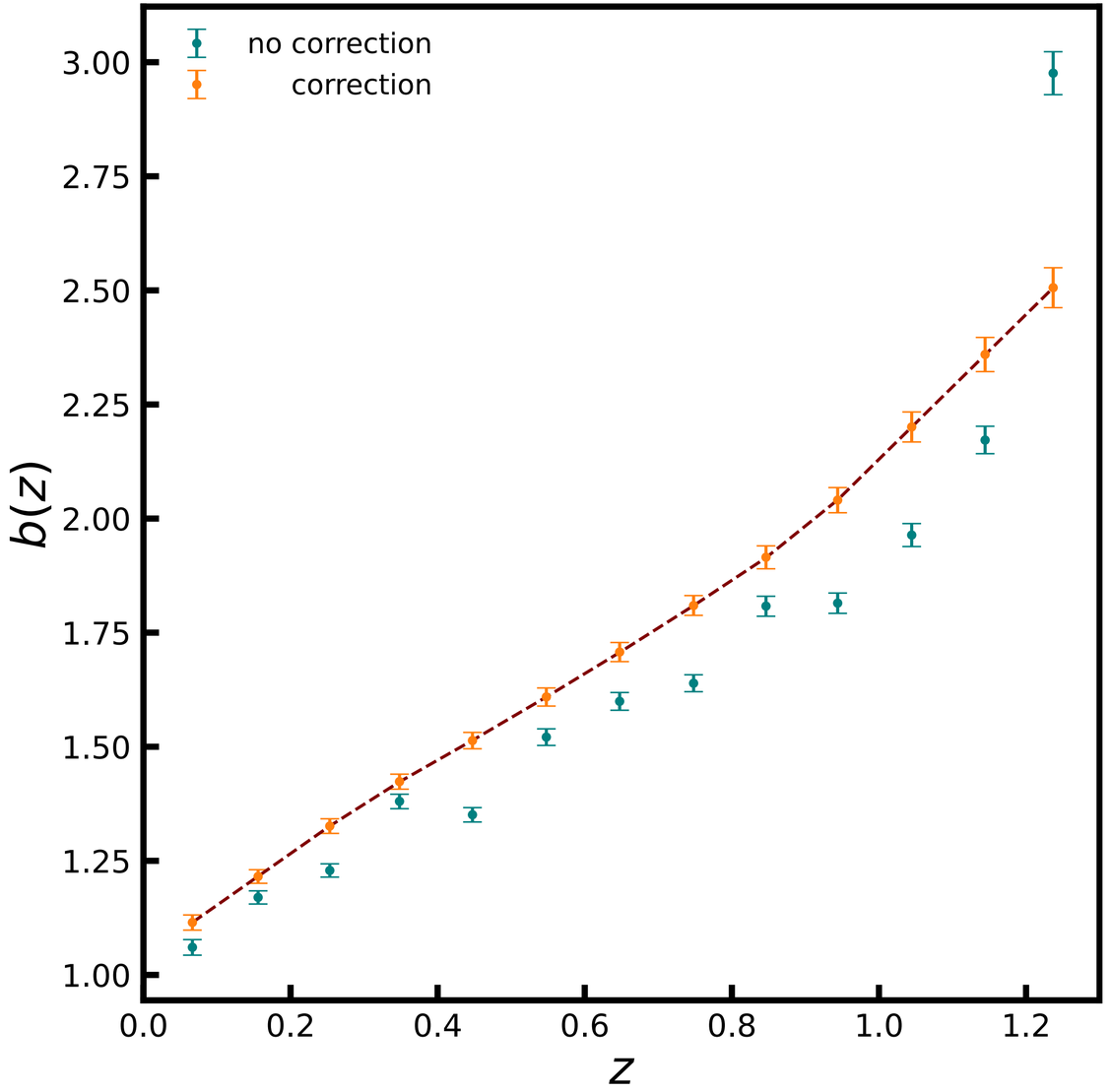
from true bins (unknown)

Scattering matrix: $P_{ij} \equiv \frac{N_{i\to j}}{N_j^{\mathrm{Ph}}}$ (unknown)

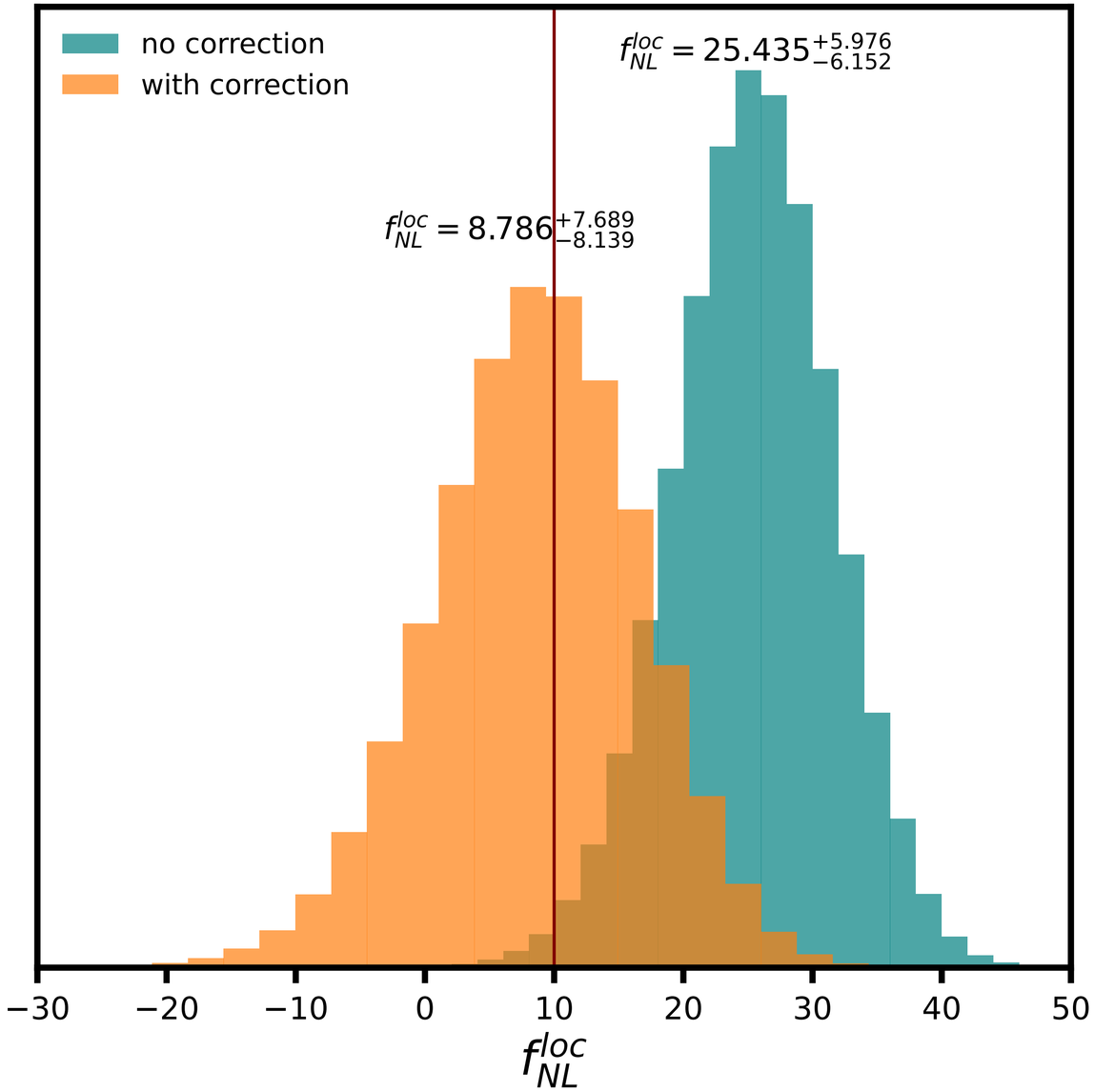


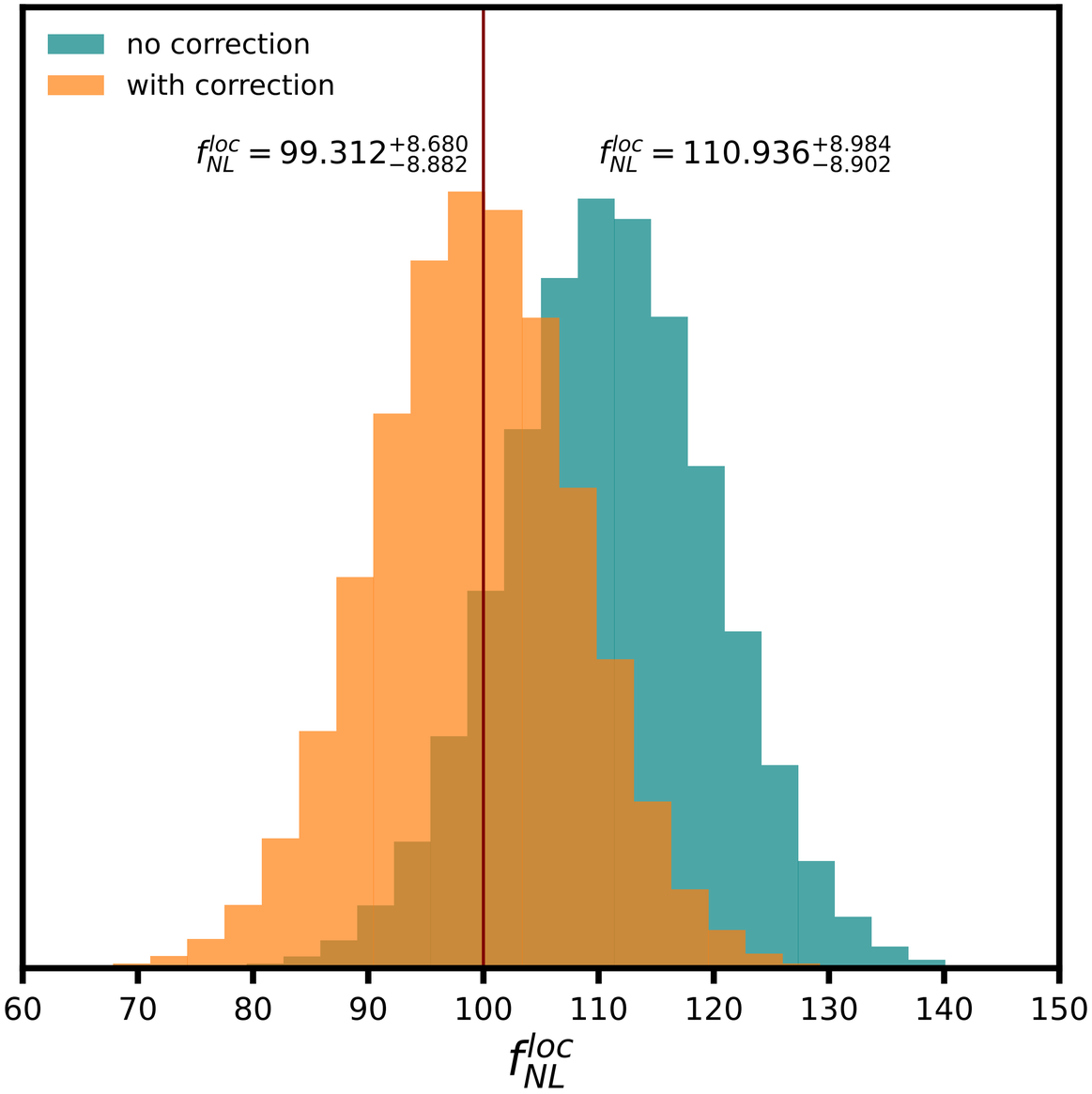
# Parameters with scattering matrix



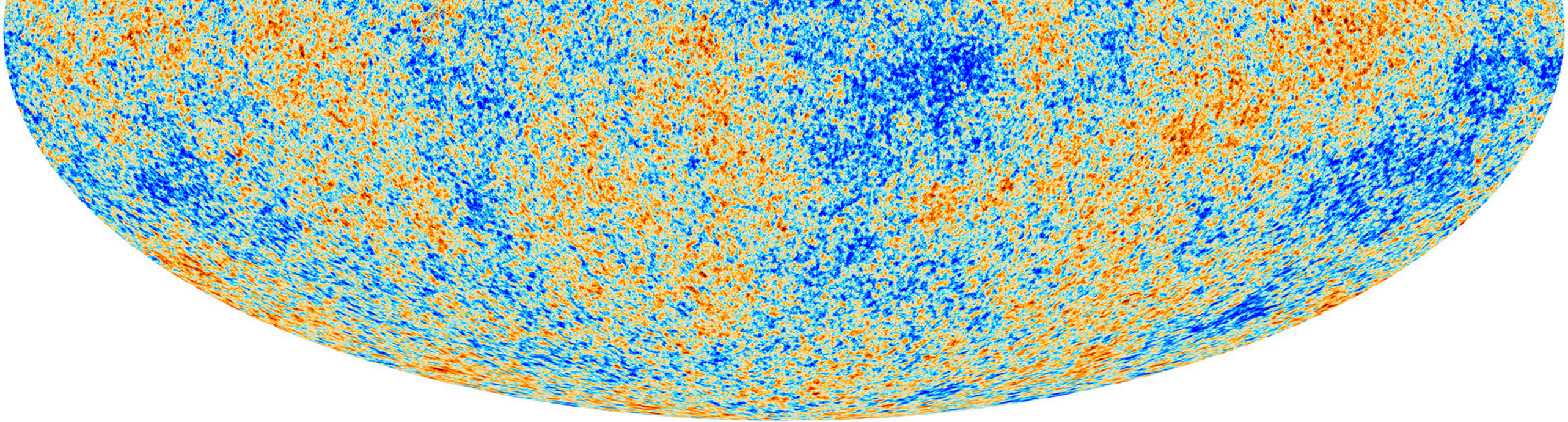
# Different $f_{NL}$



# Summary

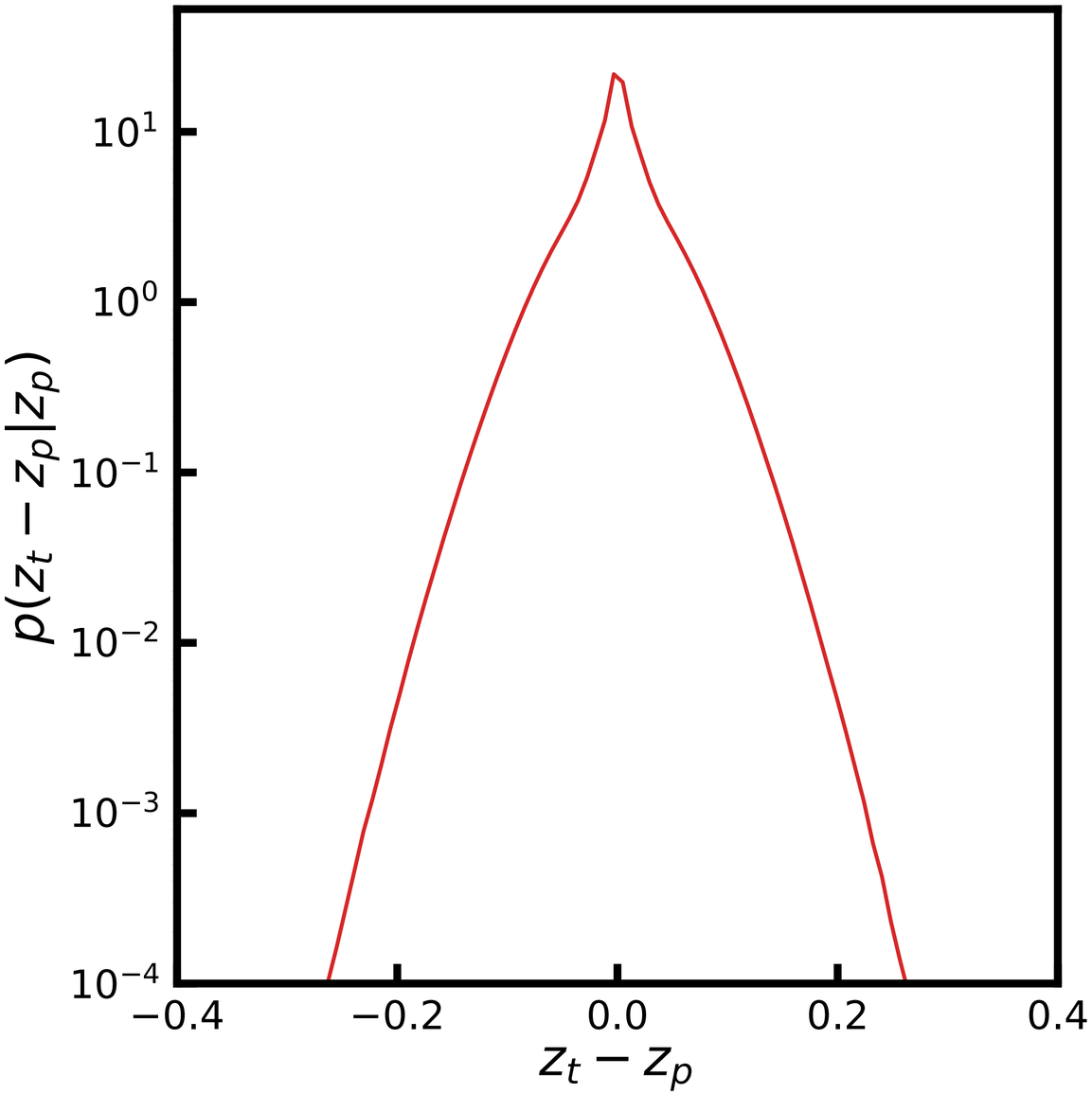
- Tomographic cross-correlation are powerful probes to estimate primordial non-Gaussianity.
- $\sigma(f_{NL}) \sim 6 - 9$ can be achieved with SPHEREx power spectra alone.
- We must be cautious of galaxies ending in wrong redshift bins.
- Redshift bin mismatch can lead to $1 - 3\,\sigma$ deviation on $f_{NL}$ parameter.
- Our scattering matrix formalism can be used to correct for bin mismatch.



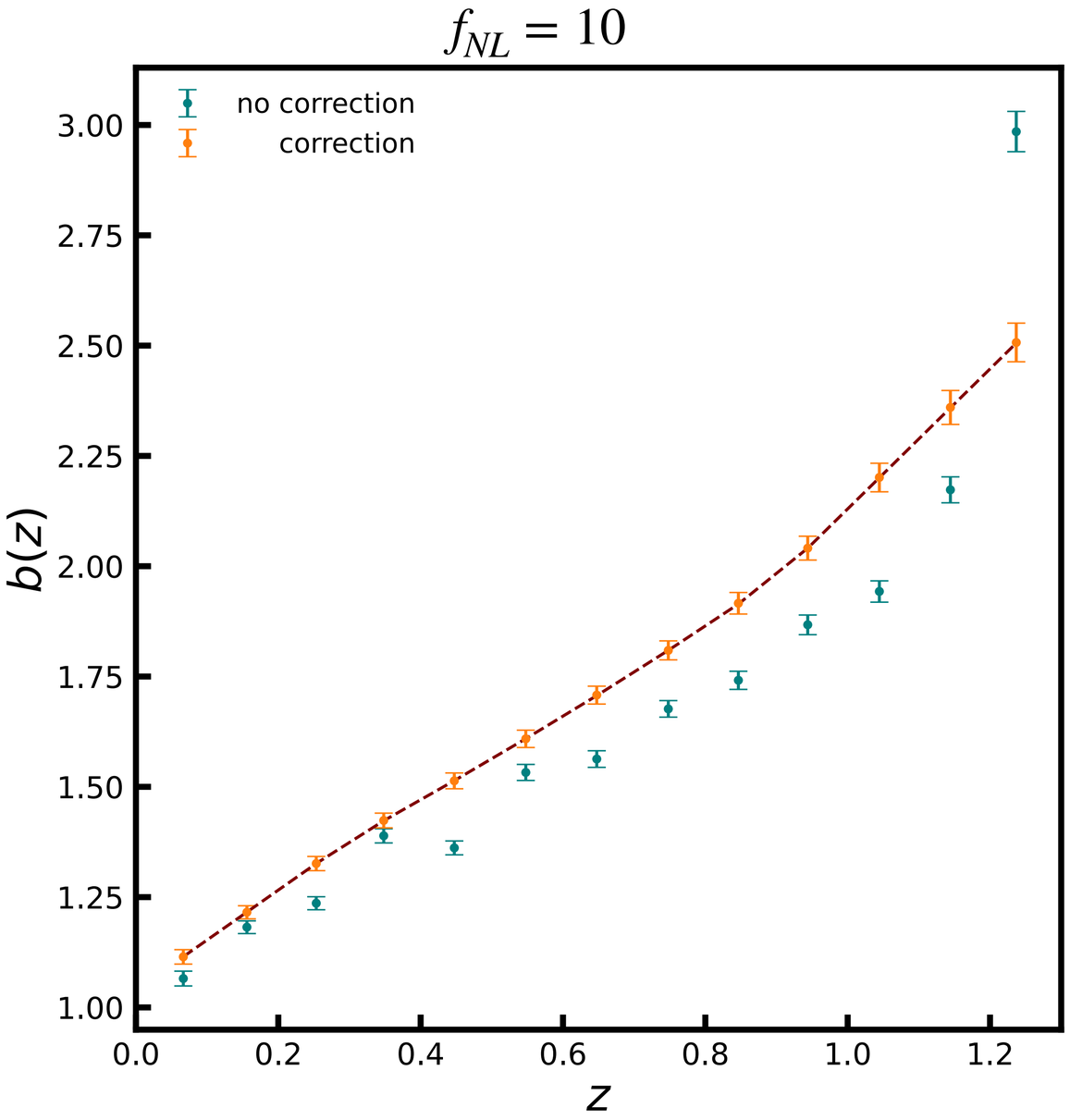
# THANK YOU

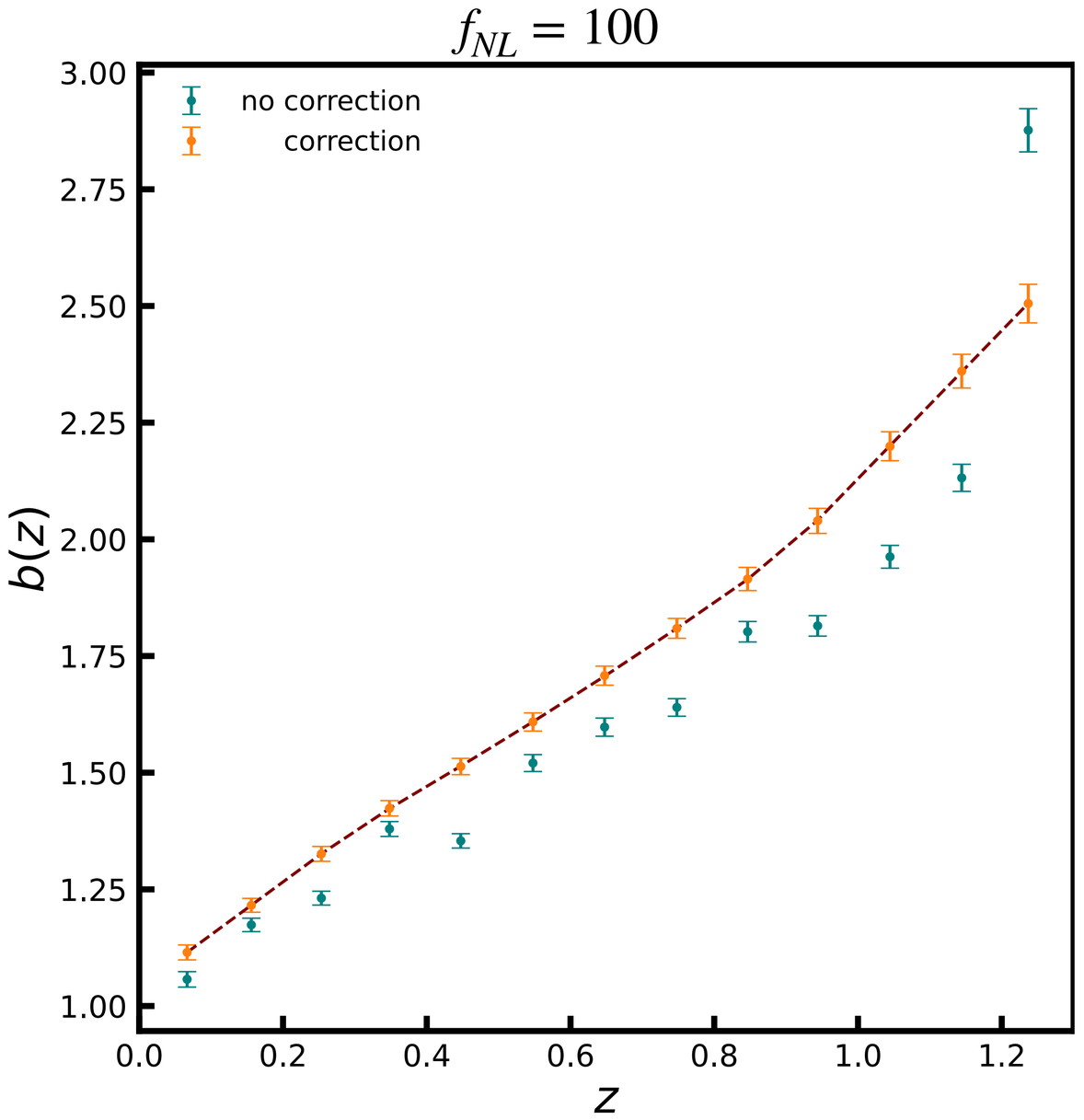
# Extras

# Redshift error distribution

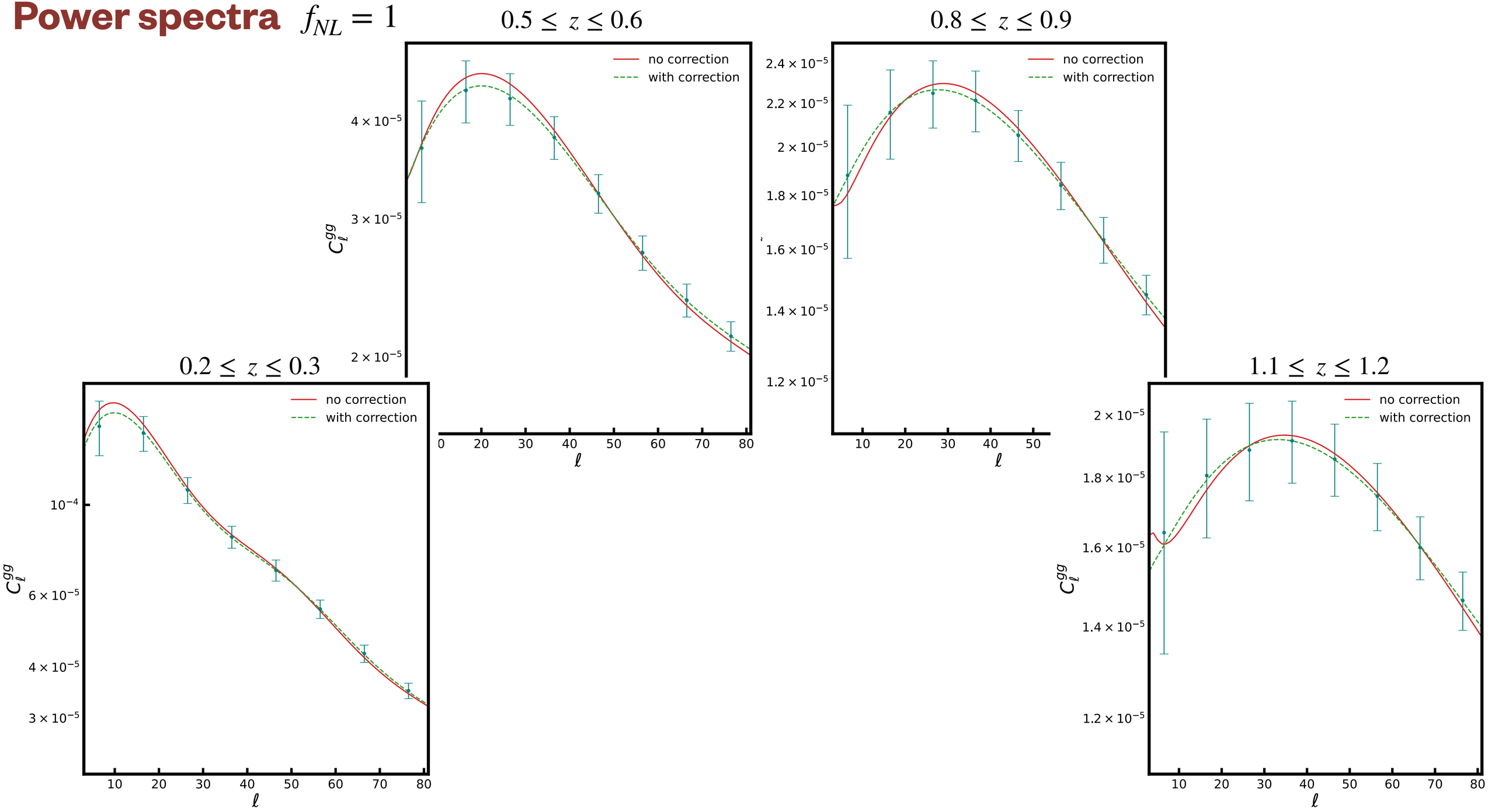


# Galaxy bias

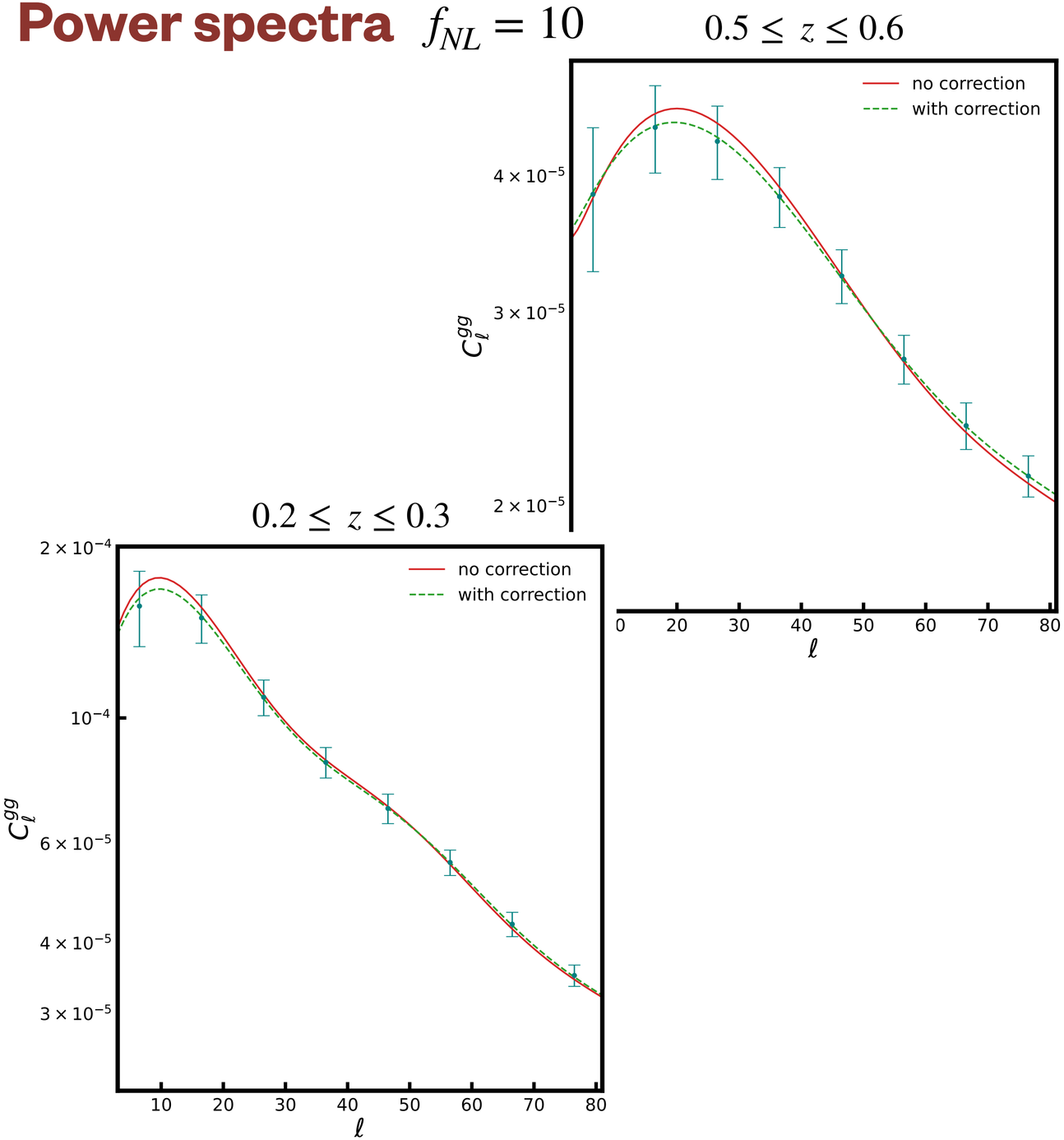

$f_{NL} = 10$
no correction
correction
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
b(z)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
z


$f_{NL} = 100$
no correction
correction
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
b(z)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
z

# Power spectra $f_{NL} = 1$

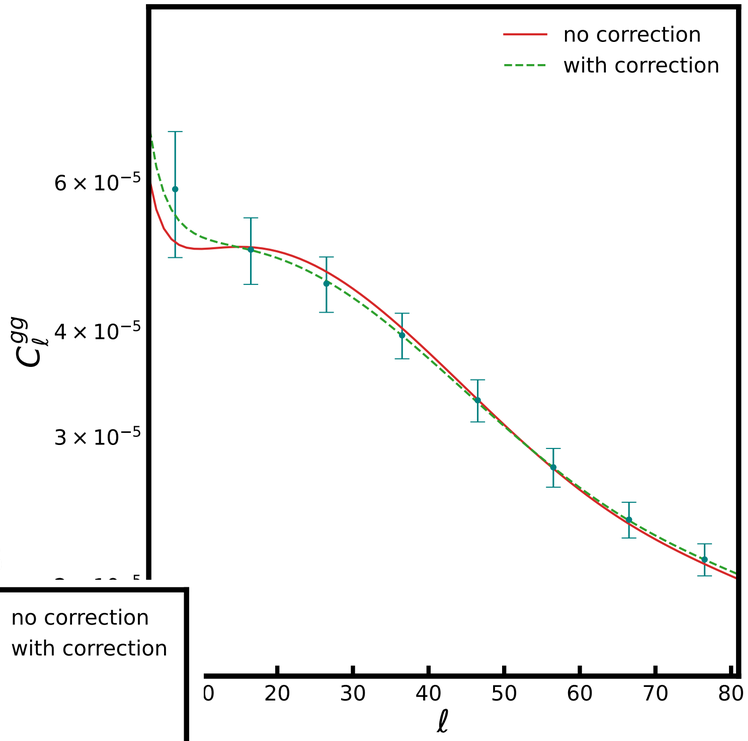


# Power spectra $f_{NL} = 10$

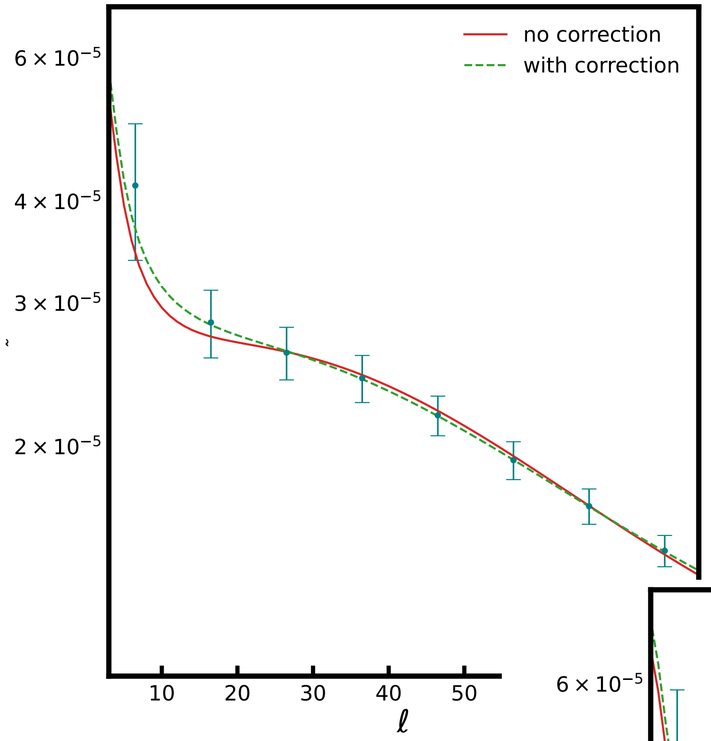


# Power spectra $f_{NL} = 100$

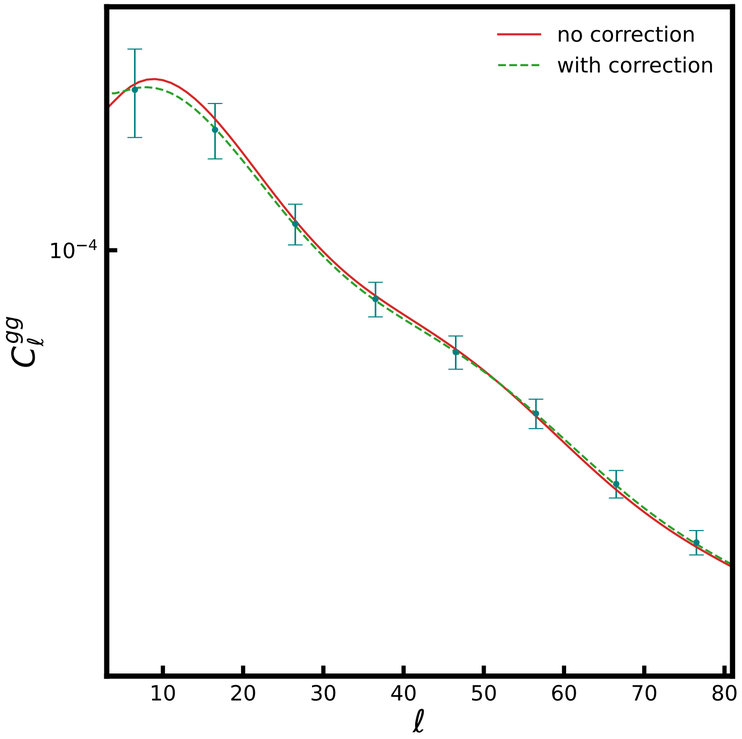
$0.5 \leq z \leq 0.6$



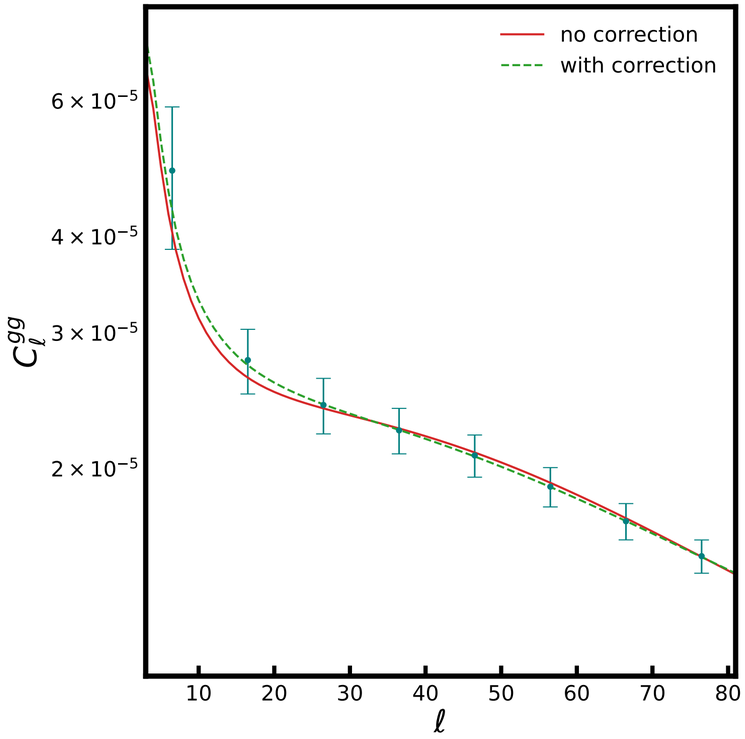

$0.8 \leq z \leq 0.9$



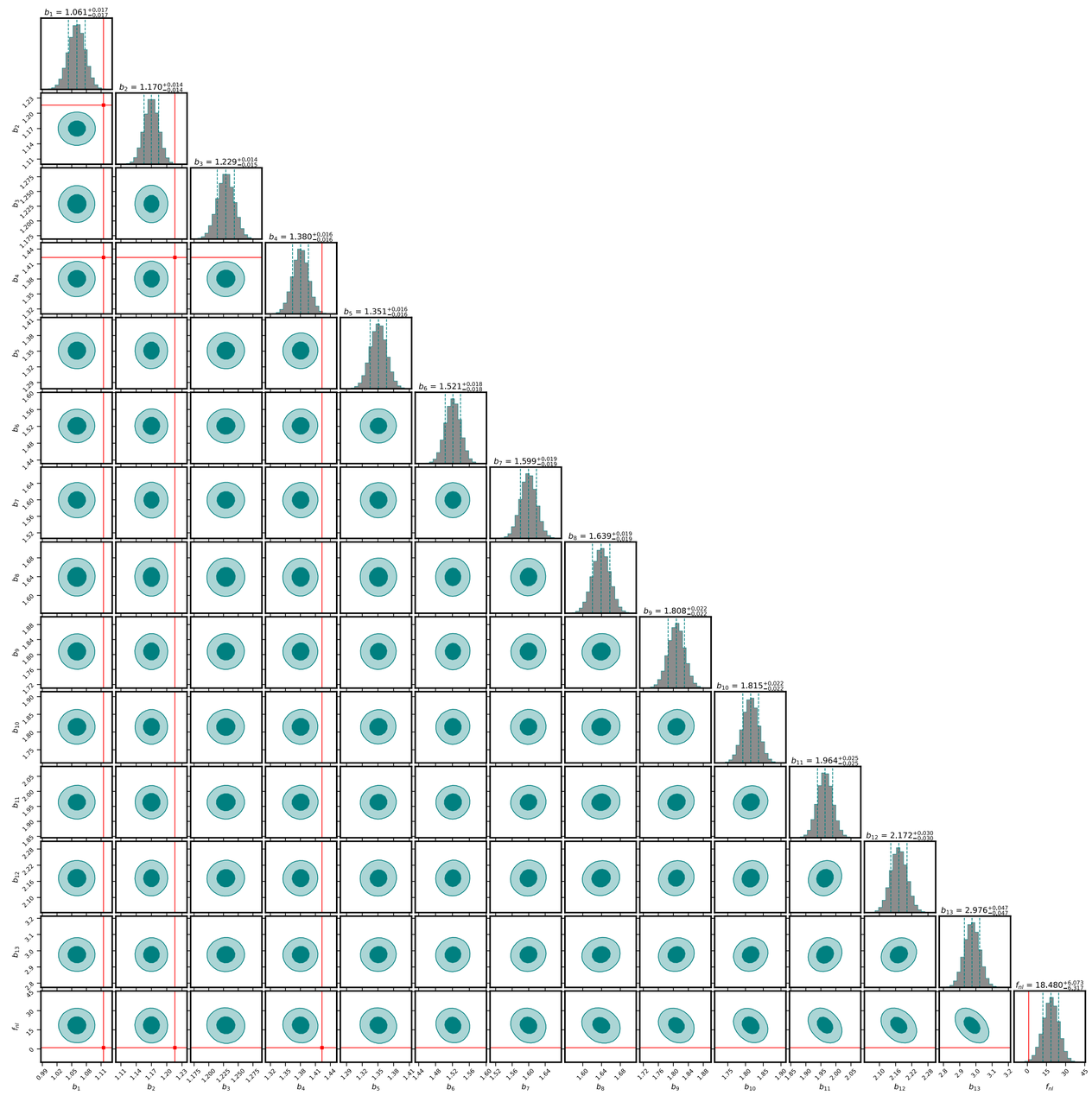

$0.2 \leq z \leq 0.3$

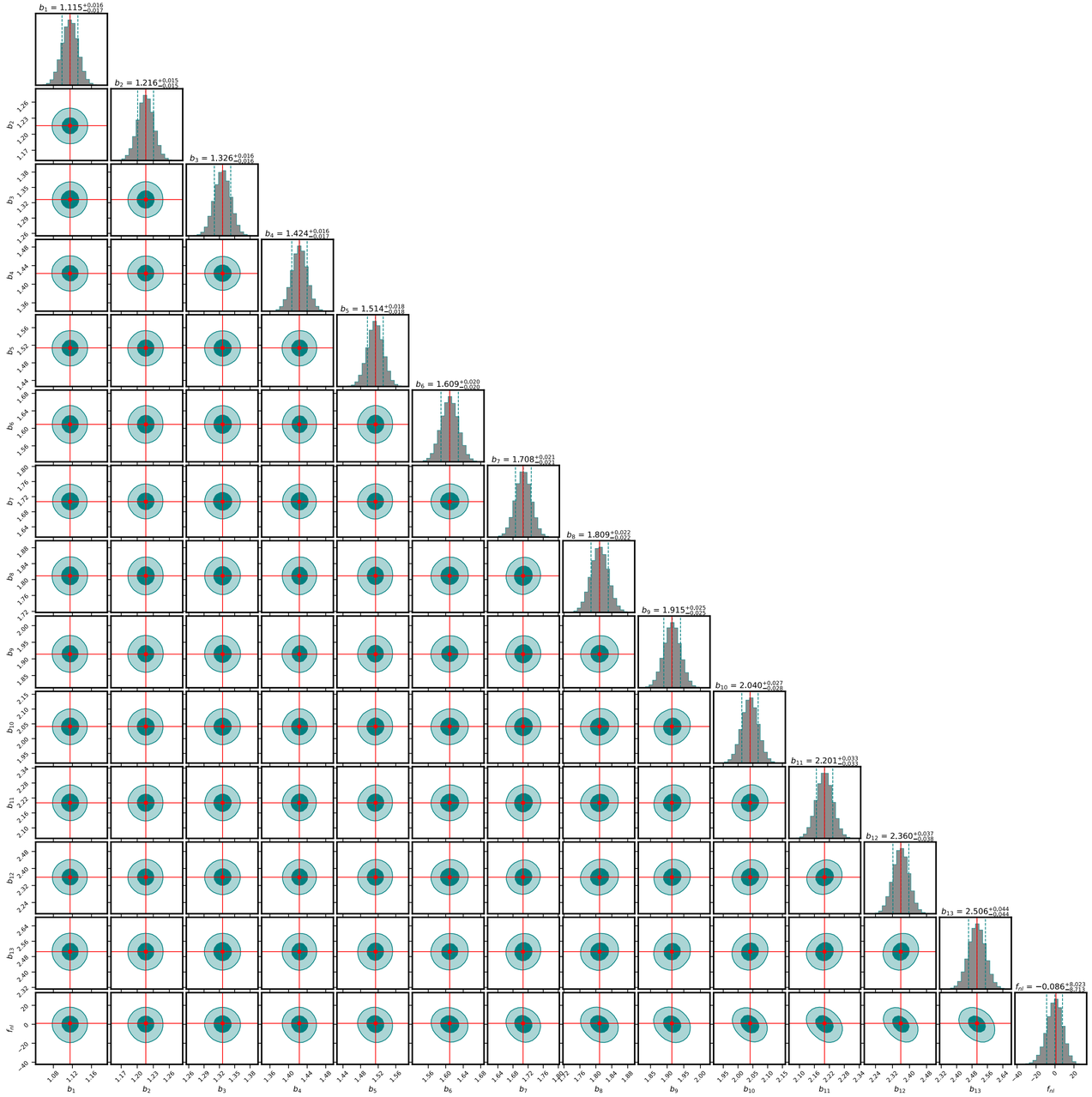



$1.1 \leq z \leq 1.2$



# Full likelihood, $f_{nl} = 1$



# Full likelihood, $f_{nl} = 10$

