Detectability of contributions to the galaxy bispectrum

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Expert Guidance

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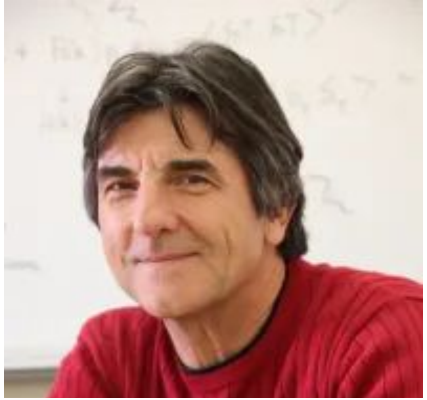

Roy Maartens
University of the Western Cape

Background papers

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Local primordial non-Gaussianity in the relativistic galaxy bispectrum

arXiv:2011.13660

Roy Maartens[1,2], Sheean Jolicoeur[1], Obinna Umeh[2],
Eline M. De Weerd[3], Chris Clarkson[3,1]

Detecting the relativistic galaxy bispectrum

arXiv:1911.02398

Roy Maartens[1,2], Sheean Jolicoeur[1], Obinna Umeh[2],
Eline M. De Weerd[3], Chris Clarkson[3,1,4], Stefano Camera[5,6,1]

Detectability of contributions to the Galaxy Bispectrum

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- We investigate the potential of detecting contributions to the galaxy bispectrum
- In reality, the Universe is not Gaussian: Non-linear evolution of structures and gravitational dynamics, Primordial non-Gaussianity, etc.
- Require higher order statistics such as the Bispectrum

$$\langle \delta_g(\mathbf{k}_1)\delta_g(\mathbf{k}_2)\delta_g(\mathbf{k}_3)\rangle = (2\pi)^3 \mathrm{B}_g(\mathbf{k}_1, \mathbf{k}_2, \mathbf{k}_3)\delta^D(\mathbf{k}_1 + \mathbf{k}_2 + \mathbf{k}_2)$$

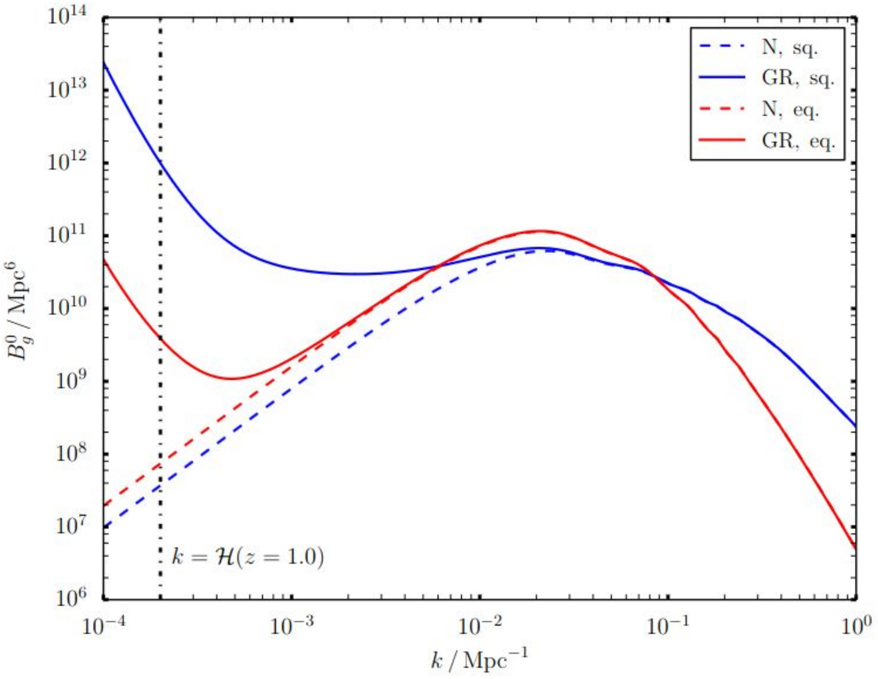
Relativistic effects and local primordial non-Gaussianity

- Implications of gravity mean what we observe is a distorted view of reality
- Source of non-Gaussianity in the observed galaxy distribution
- More accessible in the bispectrum than in the power spectrum
- Apart from RSD, relativistic corrections only appear at second order in perturbations

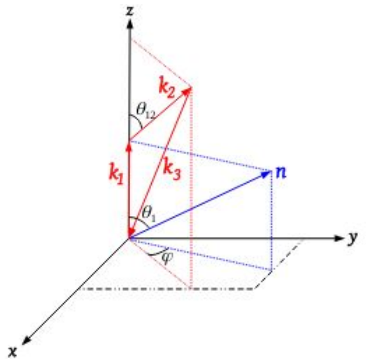
Relativistic Galaxy Bispectrum

$$B_g(\boldsymbol{k}_{123}) = \mathcal{K}^{(1)}(\boldsymbol{k}_1)\,\mathcal{K}^{(1)}(\boldsymbol{k}_2)\,\mathcal{K}^{(2)}(\boldsymbol{k}_{123})\,P(\boldsymbol{k}_1)\,P(\boldsymbol{k}_2) + 2 \circlearrowleft$$

$$\mathcal{K}^{(i)} = \mathcal{K}^{(i)}_{\mathrm{N}} + \mathcal{K}^{(i)}_{\mathrm{GR}}$$



From Umeh et al 1610.03351



- Monopole of the bispectrum for squeezed and equilateral triangles
- Shows a significant difference at larger scales i.e small k
- This paper also demonstrated how these effects can mimic signatures of PNG

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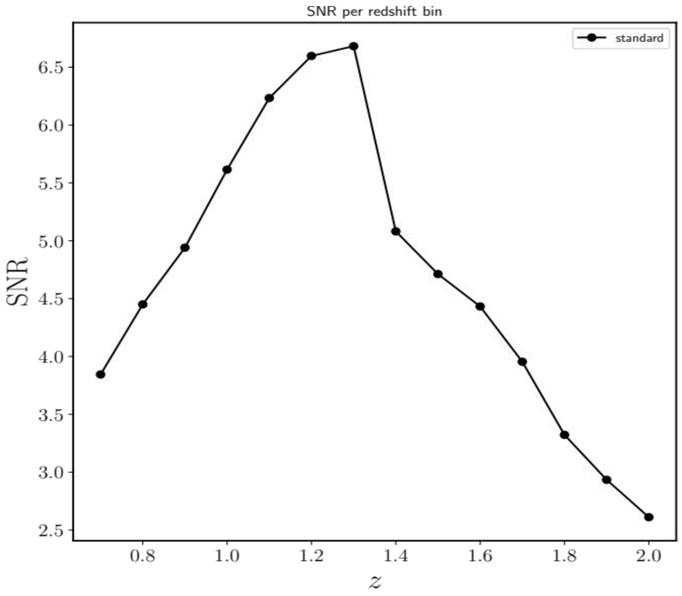
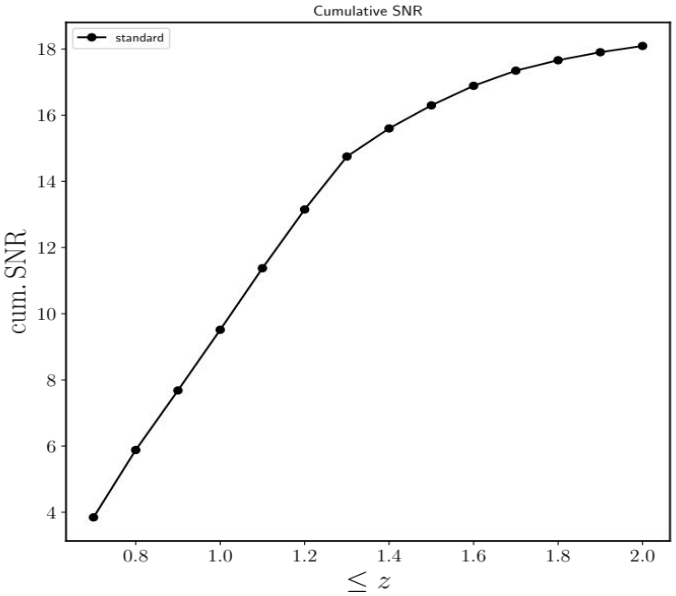
Signal-to-noise Ratio

$$\left(\frac{S}{N}\right)^2_{\mathrm{D}} = \sum_{k_a,\mu_1,\varphi} \frac{B_{g\mathrm{D}}\, B^*_{g\mathrm{D}}}{\mathrm{Var}[B_{g\mathrm{N}}]}\,.$$

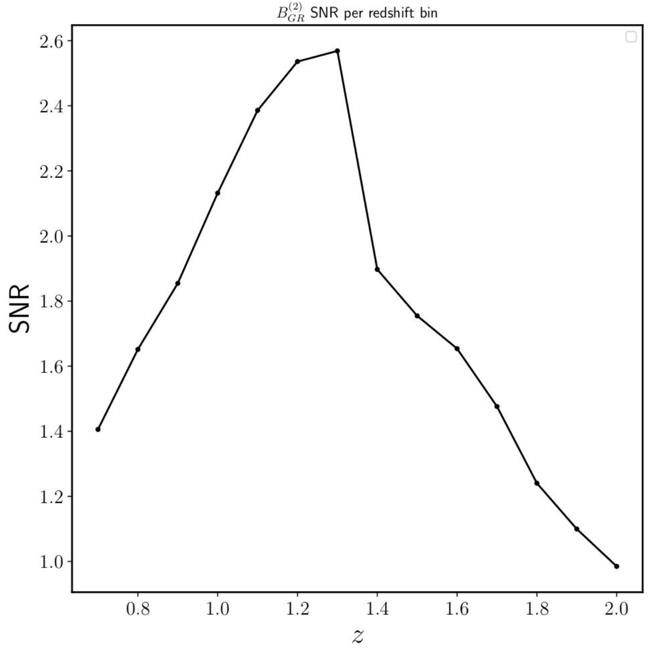


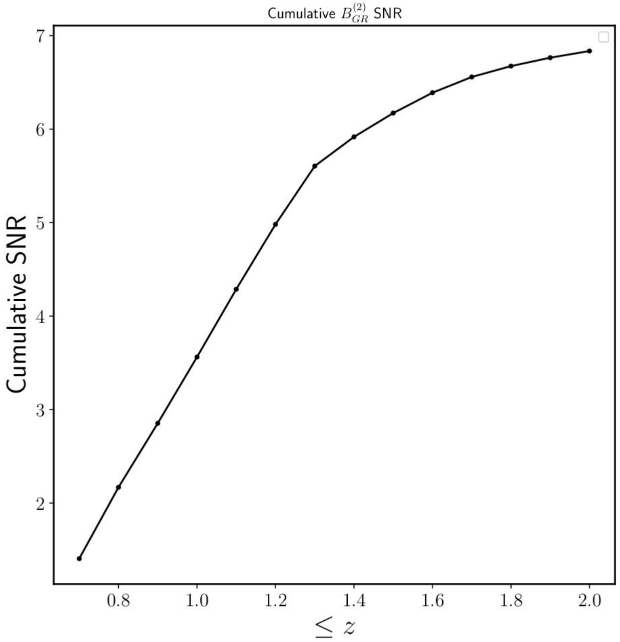


Following Martins et al 1911.02398

Signal-to-noise Ratio

$$\left(\frac{S}{N}\right)^2_{GR^{(2)}} = \sum_{k_a,\mu_1,\varphi} \frac{\left(B_g - \left(B_N + B_{GR^{(1)}}\right)\right)\left(B_g - \left(B_N + B_{GR^{(1)}}\right)\right)^*}{\mathrm{Var}[B_{gN}]}$$

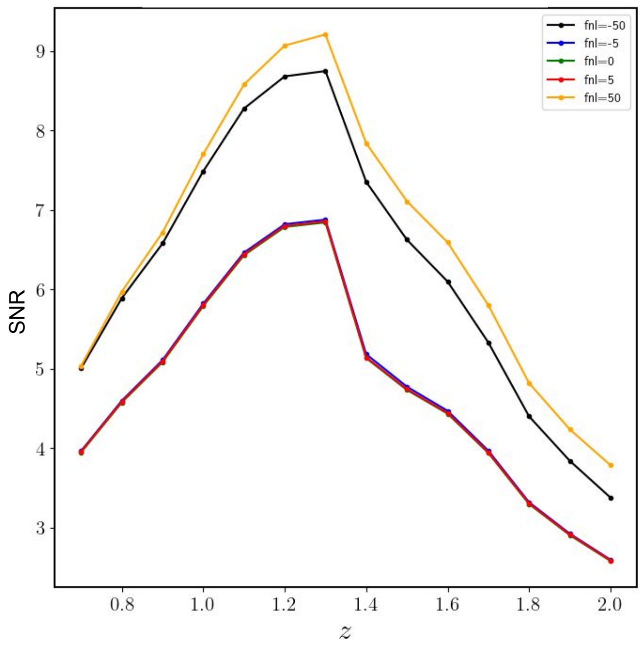


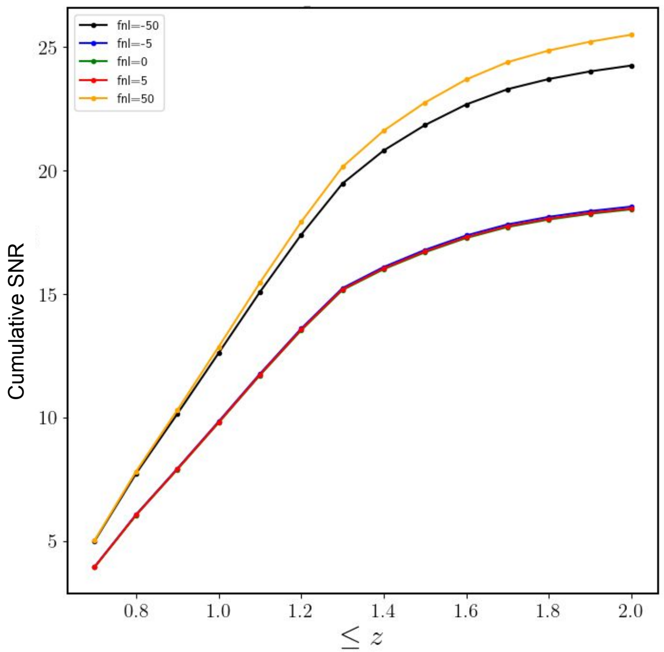


Local Primordial Non-Gaussianity

- Contributions from local Primordial non-Gaussianity (PNG)

$$\mathcal{K}^{(i)} = \mathcal{K}_{\rm N}^{(i)} + \mathcal{K}_{\rm GR}^{(i)} + \mathcal{K}_{\rm nG}^{(i)}$$





Marginal errors

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- We want to see how precisely we can measure the local PNG and relativistic contributions

Fisher matrix formalism:

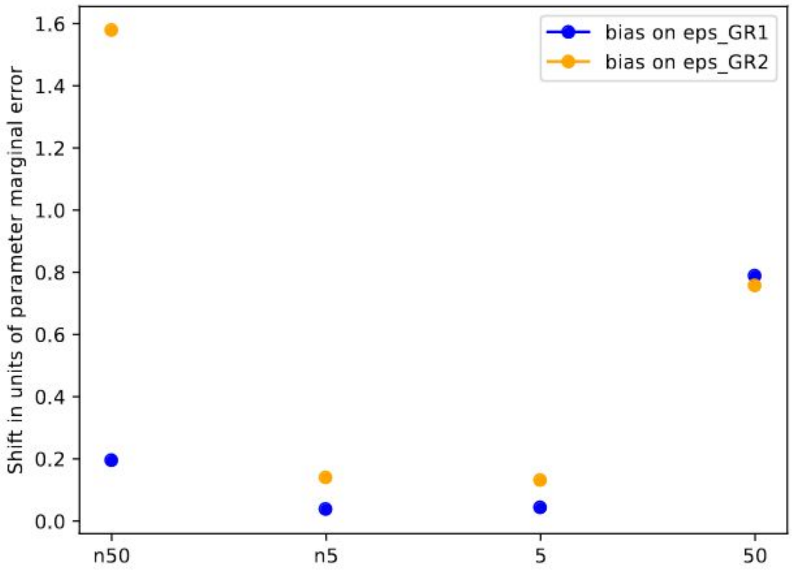
$$F_{\alpha\beta} = \sum_{z,k_a,\mu_a,\varphi} \frac{\partial_{(\alpha} B_g \, \partial_{\beta)} B_g^*}{\mathrm{Var}[B_g, B_g]}$$

- From this we can get the marginal errors on our parameters $\theta = \{\epsilon_{\mathrm{GR}}^{(1)}, \epsilon_{\mathrm{GR}}^{(2)}, f_{\mathrm{NL}}\}$

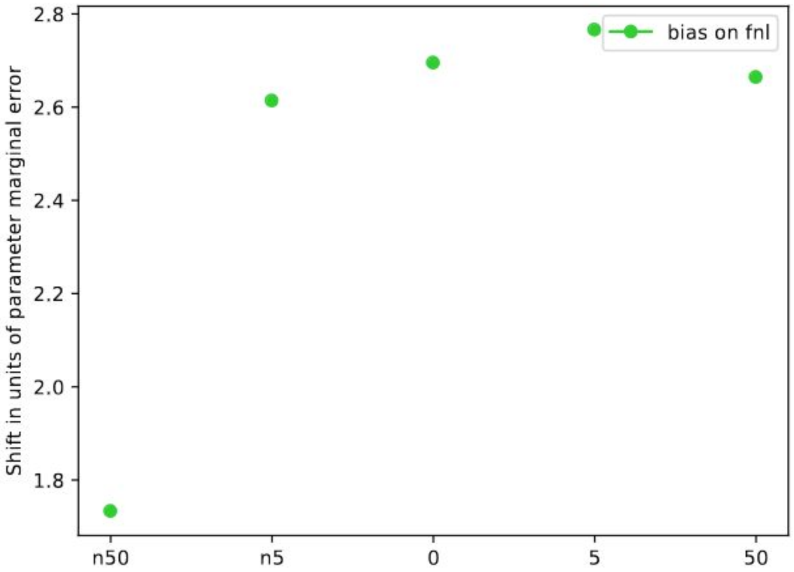
$$\sigma_\alpha = \sqrt{\left(\mathsf{F}^{-1}\right)_{\alpha\alpha}}$$

- We obtain the marginal errors:
  - σ_εGR1~0.1, consistent with the literature
  - σ_εGR2~0.25, novel result
  - σ_fnl~3, consistent with the literature

Bias on parameters



Uncertainty on f_NL makes little difference to the observed value we get on the relativistic contributions



Uncertainty on Relativistic contributions would impact our observed value of fnl significantly.

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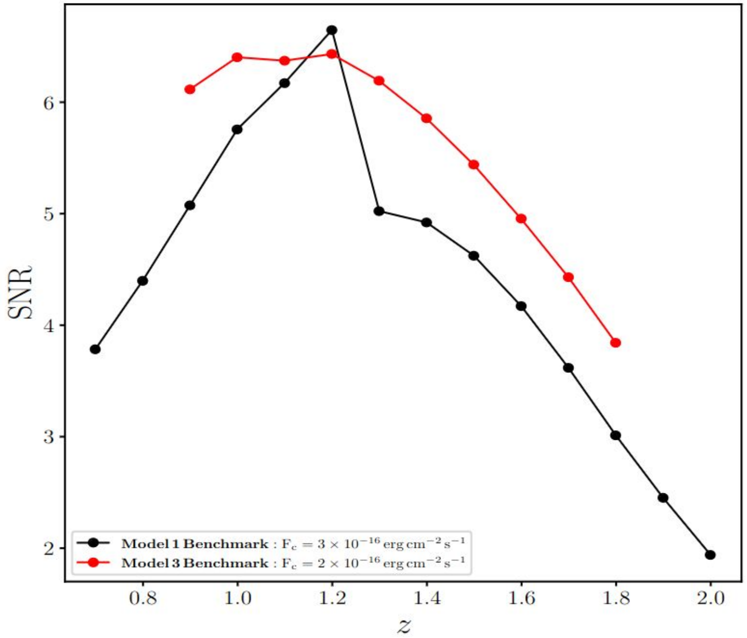
Thank you.

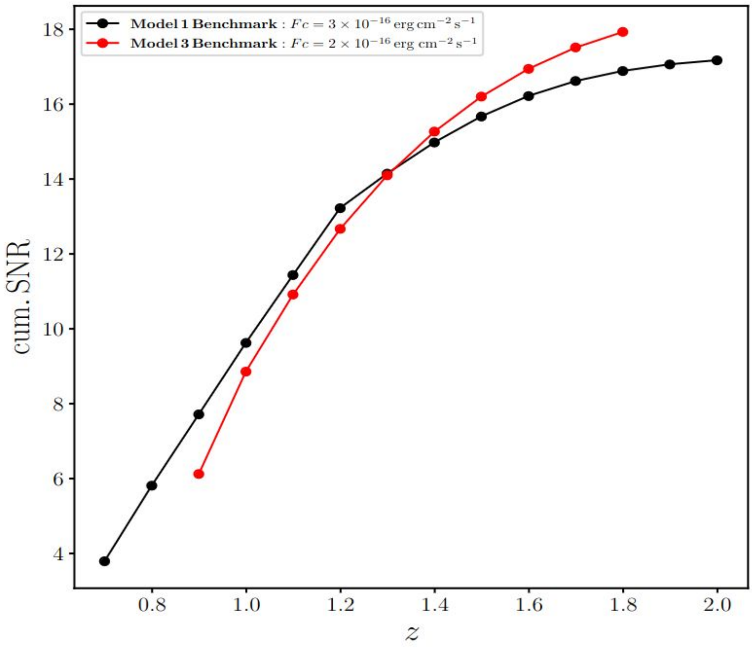
Any questions?

Backup slides

Signal-to-noise Redone

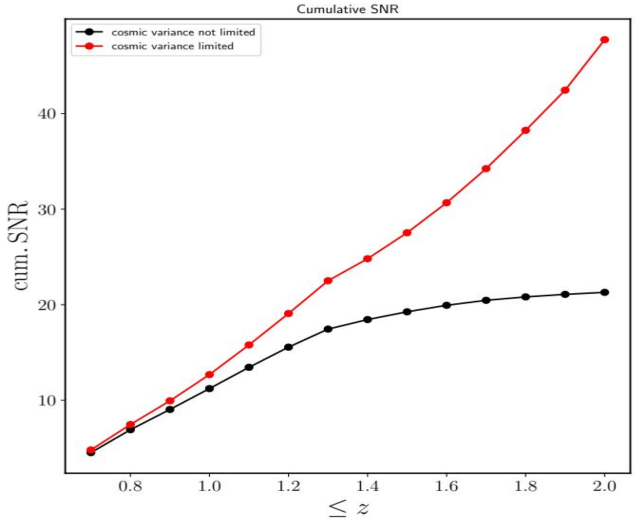
- Discontinuity in luminosity function causes steep drop in signal at z~1.3
- Check against an improved luminosity model with updated Euclid specs



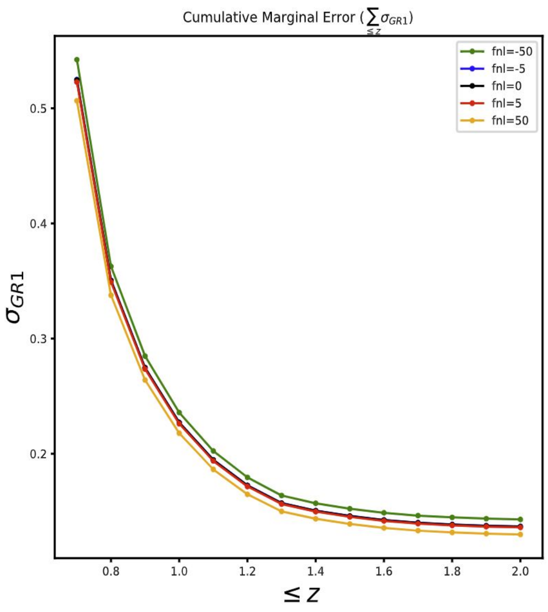


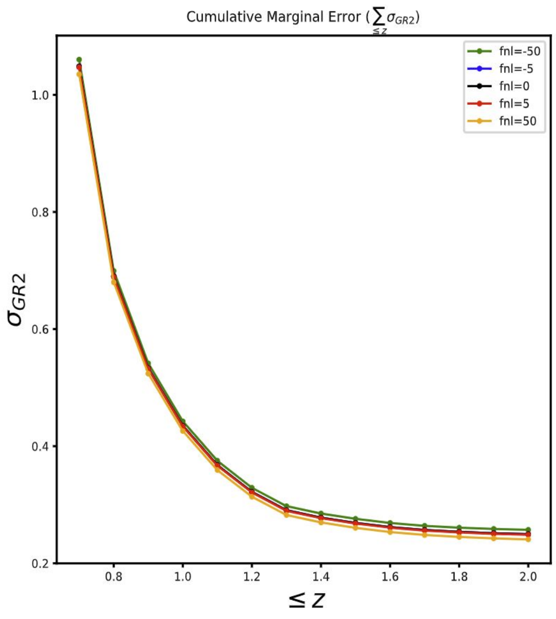
Cosmic Variance and shot noise

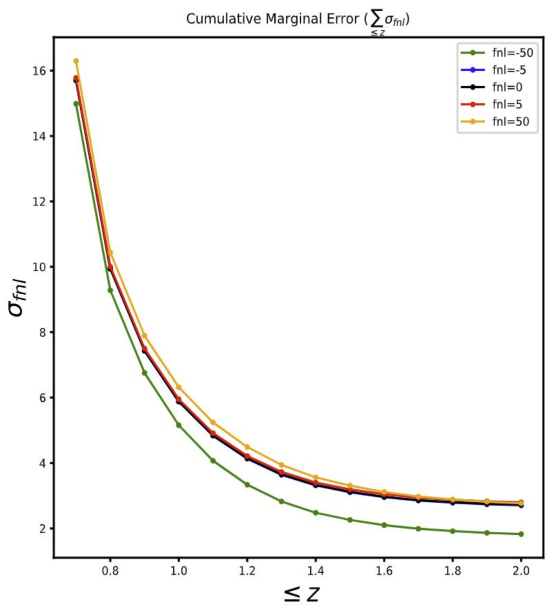
- Our local universe is not homogeneous, this causes an uncertainty in observational estimates of average galaxy densities
- As we go to higher redshift, this variance decreases as we have access to larger volumes
- However, at these larger volumes, the number of galaxies is sparse and so the signal is suppressed, we call this galaxy shot noise.
- Here we showcase the limitation of galaxy shot noise on the SNR of the Doppler bispectrum



Cumulative Marginal errors







Constraints on parameter values

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