Ground-based Measurements of Primordial non-Gaussianity with μ-distortions

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Probing non-gaussianities

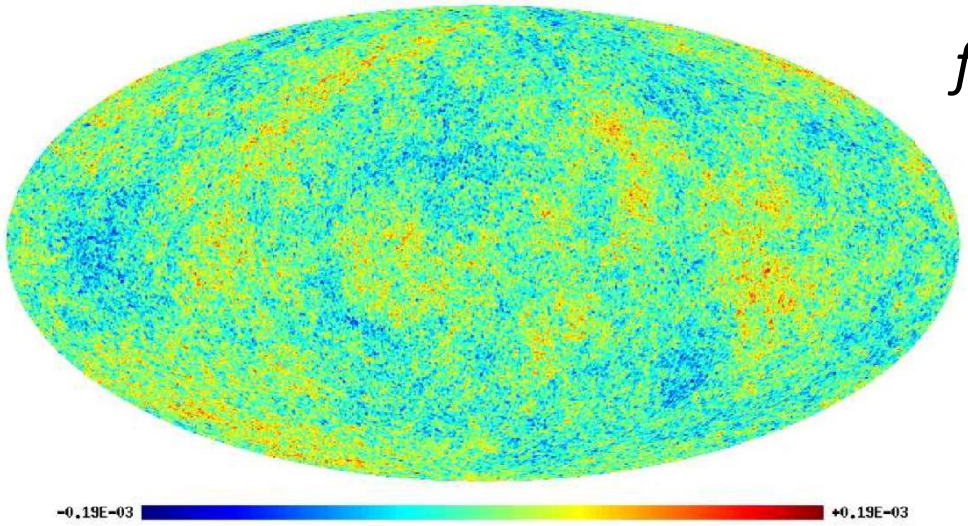
Can characterize based on how much they deviate from $\Phi_G \sim 10^{-5}$

$$\Phi = \Phi_G + f_{NL}\Phi_G^2$$

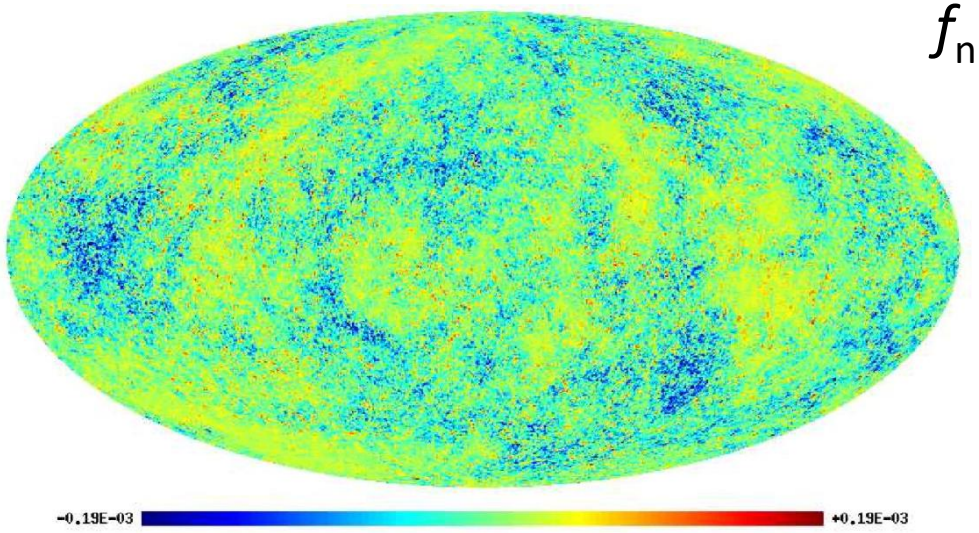
Some level of non-gaussianities expected in slow roll inflation ($f_{NL} \sim 1 - n_s$)

Planck 2018 places constraints on large-scale NG ($k = 0.05\ Mpc^{-1}$) of $f_{NL} < 10$

$f_{nl} = 0$



$f_{nl} = 3000$



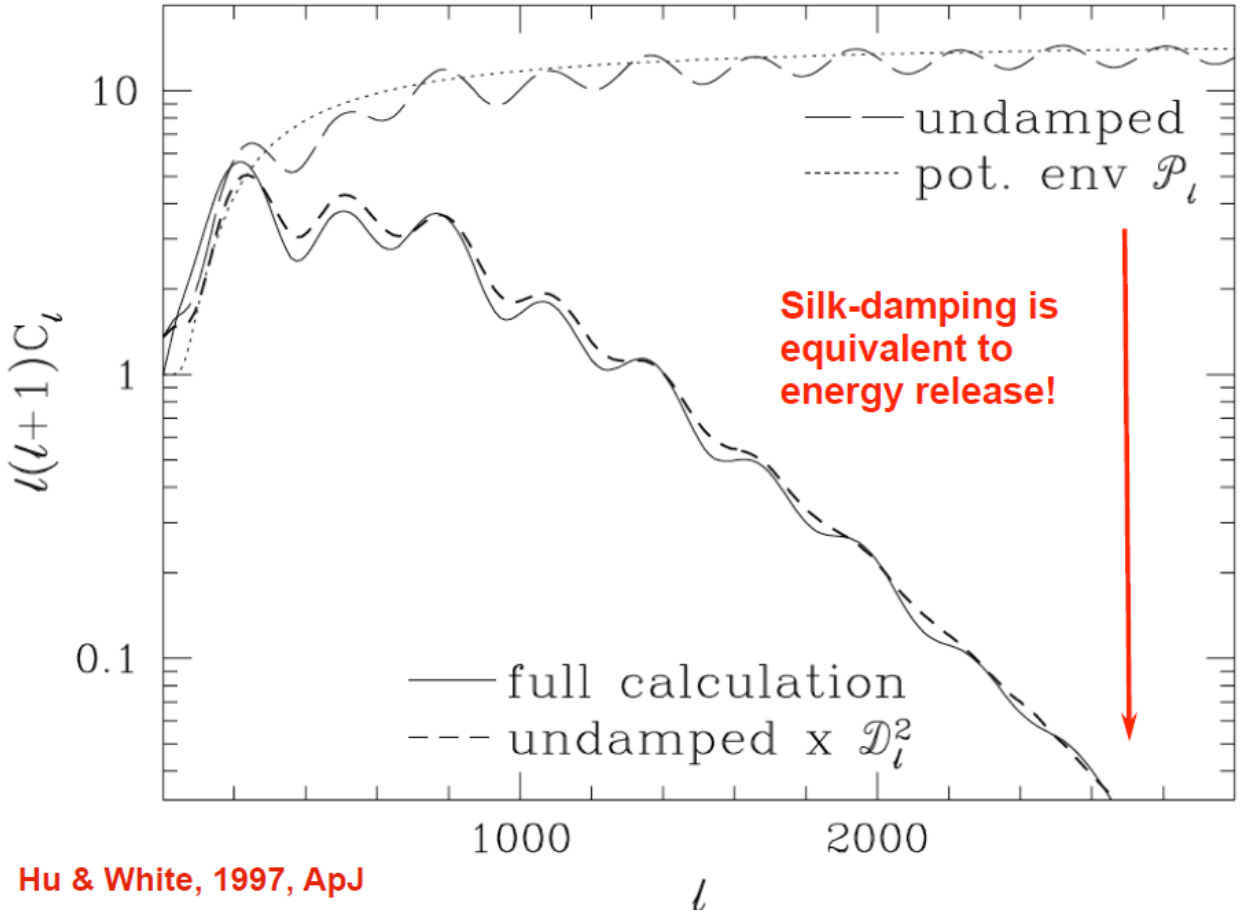
Liguori et al. (2003)

Small-scale power spectrum

Diffusion damping smooths anisotropies and reduces small-scale power

Since we are not at equilibrium, fewer photons than in a blackbody → energy release

$$\frac{\delta E}{E} = \int \frac{d\mathrm{k}}{2\pi} k^2 P(k) W(k)$$



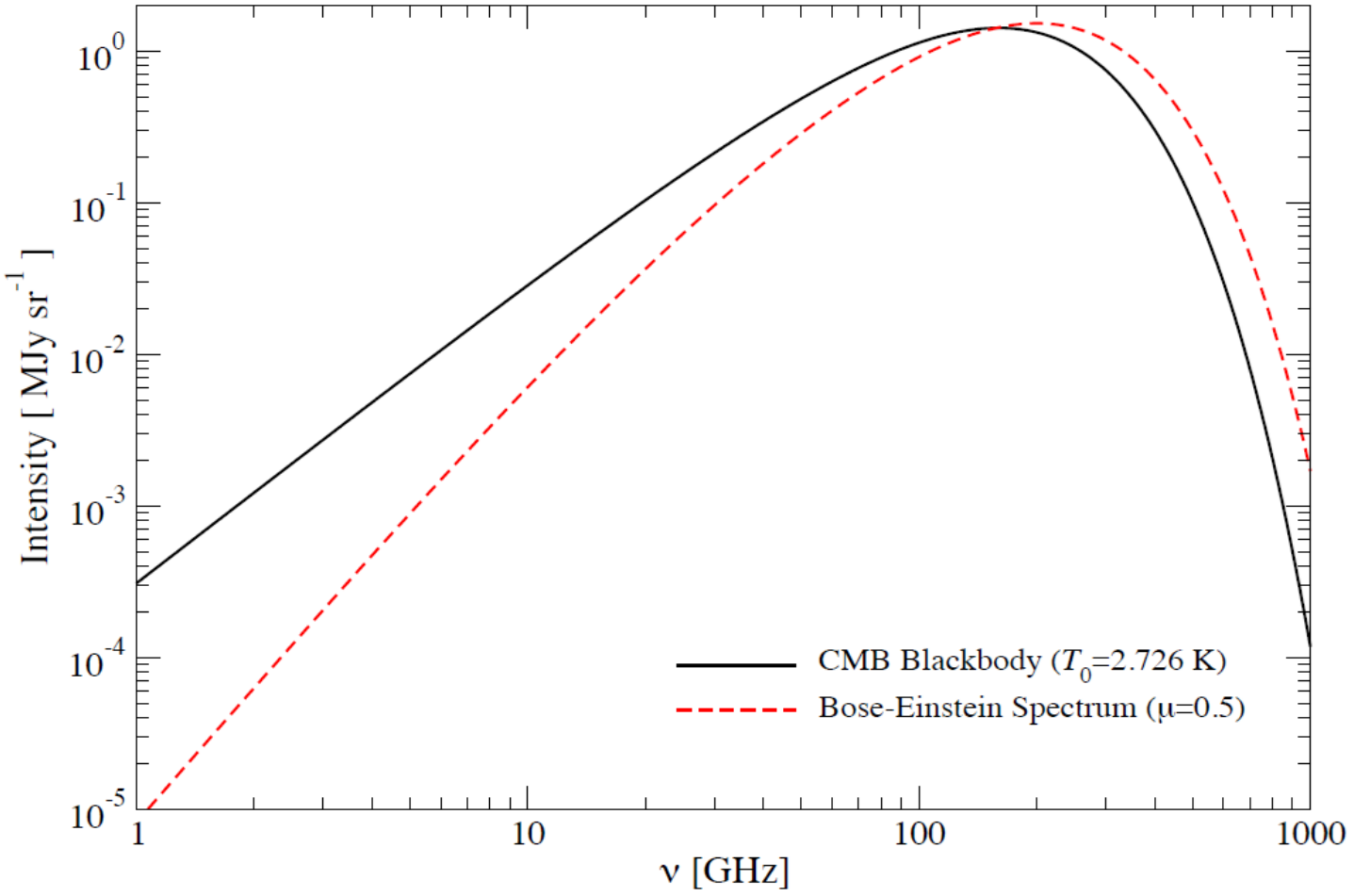
Hu & White, 1997, ApJ

For redshifts above $z > 2 \times 10^6$, energy injections are thermalized through temperatures shifts

For $z < 2 \times 10^6$, energy injections induced spectral distortions, such as μ-distortions

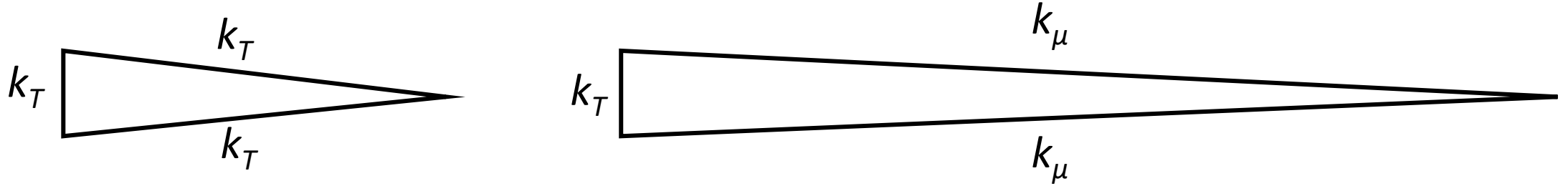
$$\mu \approx 1.4\, \delta E / E$$

μ traces the amount of small-scale power!



Non-Gaussianity from μ-distortions

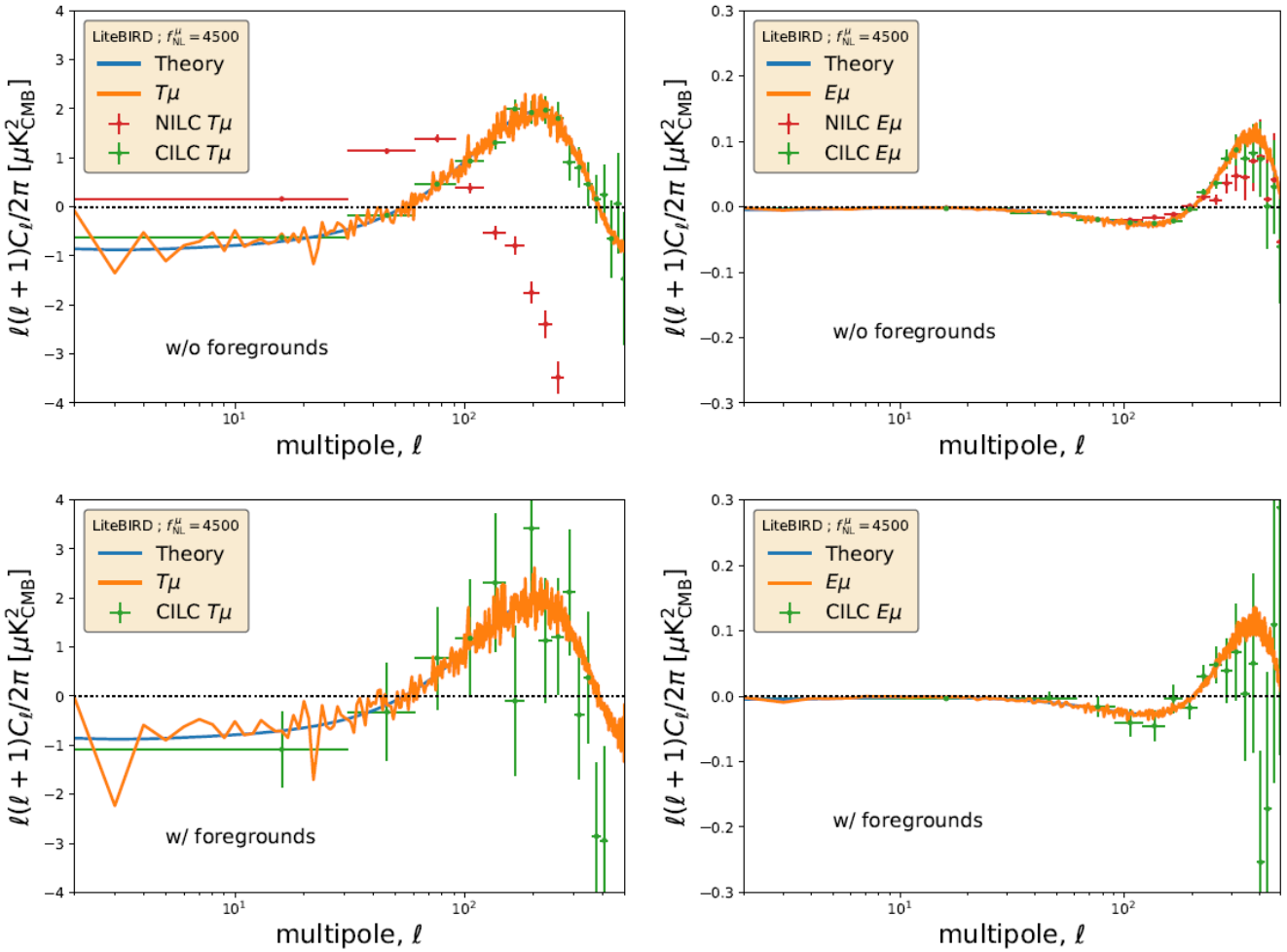
Anisotropies in μ exist if there's long-wavelength enhancement of the amplitude of small-scale power (i.e. a "squeezed-limit" NG)



$\langle TTT \rangle$ $\langle \mu T \rangle$

μ-distortions are useful for probing non-gaussianity at small scales ($k \approx 740\ Mpc^{-1}$)

Observation with a space-based instrument



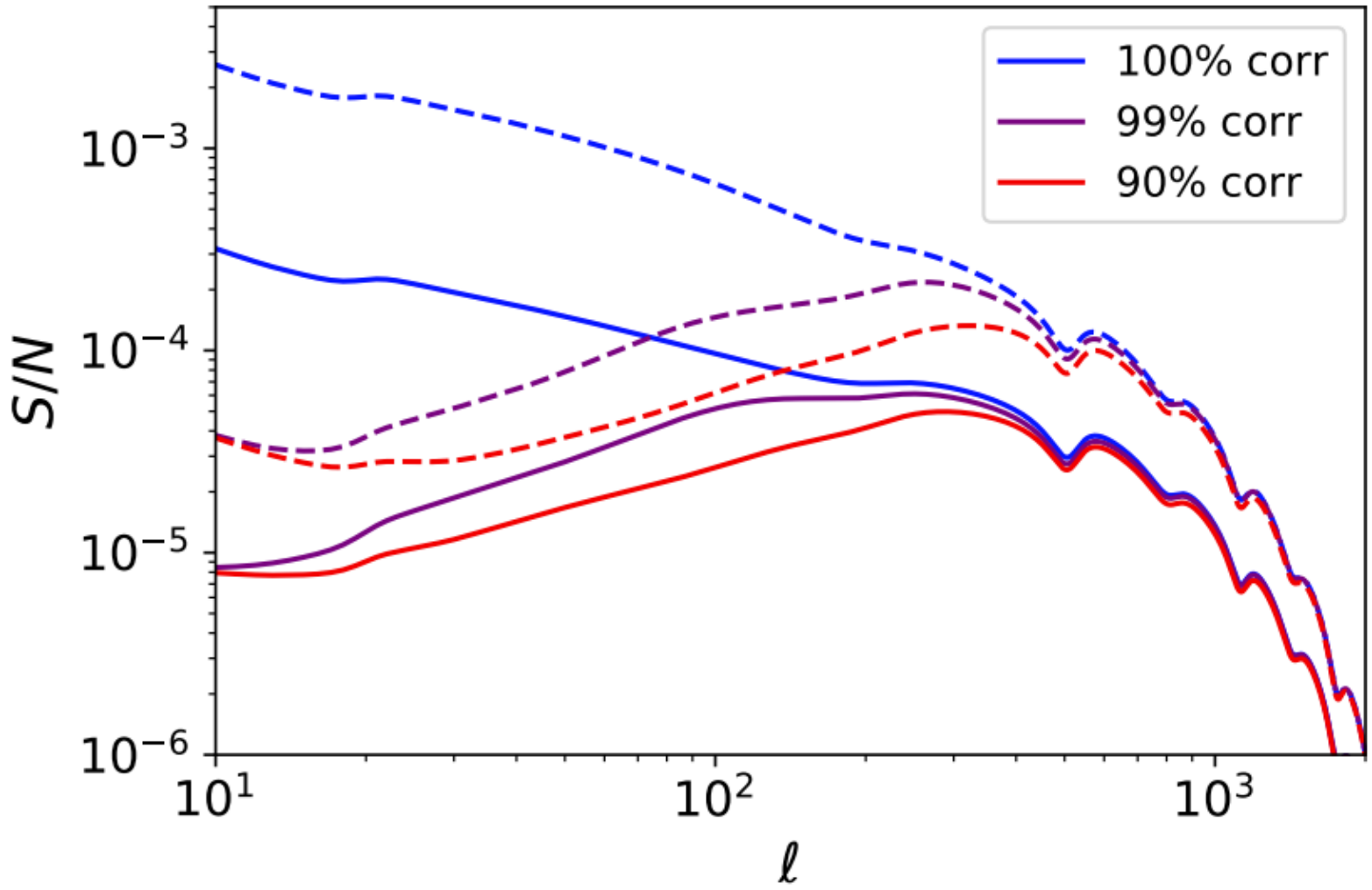
No foregrounds:
$\sigma(f_{\rm NL}) \sim 62$

Foregrounds:
$\sigma(f_{\rm NL}) \sim 824$

Remazeilles et al (2021)

Observations with a Ground-based instrument

Atmosphere weakens our low-ℓ signal



Atmospheric correlation (S4-Deep, $\mu = 2 \times 10^{-8}$, "null" SZ)	$\sigma(f_{NL})$, no foregrounds	$\sigma(f_{NL})$ w/ foregrounds
No atmosphere	68	477
100% correlated	72	479
99% correlated	**246**	**804**
90% correlated	364	995
70% correlated	458	1162

Improving constraints for ground-based surveys

- More frequency channels
- Since most of LiteBIRD's signal is at low- ℓ, while S4 is at high- ℓ, potential for joint constraints
- Exploring how low-frequency, radio surveys (SKA) could provide further improvements