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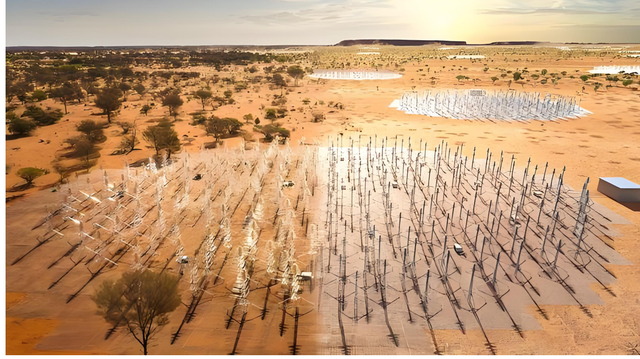

Constrain Primordial non-Gaussianity with the 21 cm Power Spectrum & Bispectrum from the Epoch of Reionization

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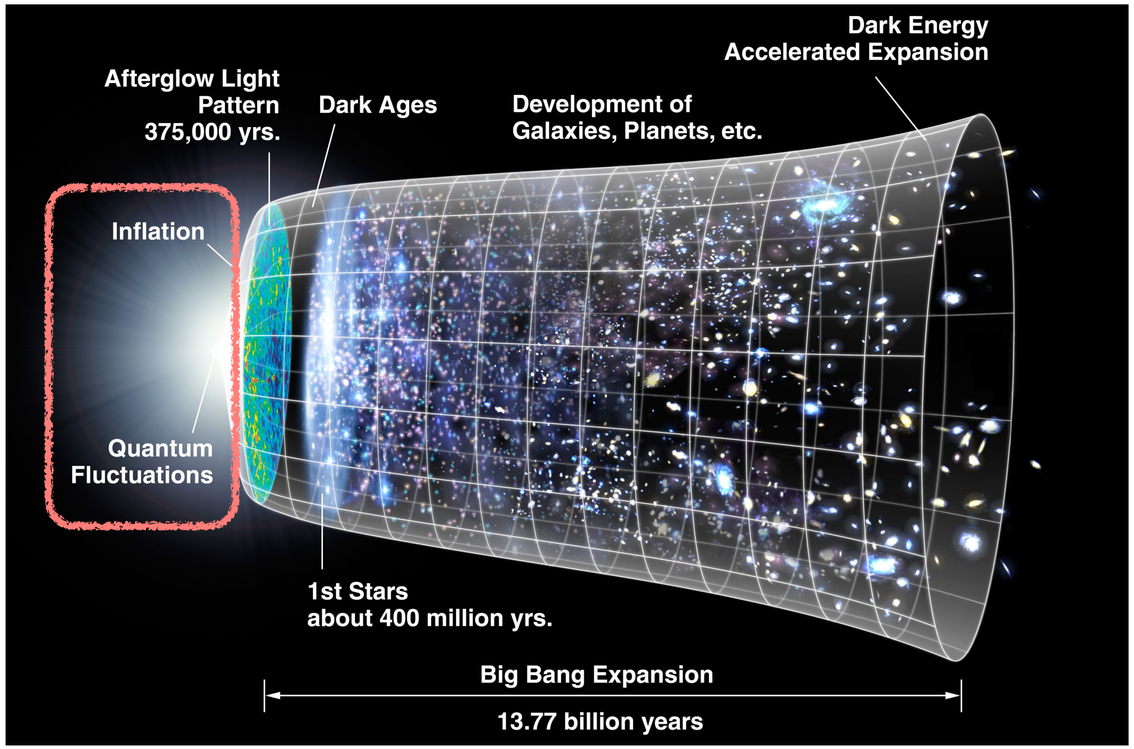
Collaborators: Prof. Yi Mao (茅奕, Tsinghua), Zhenyuan Wang (王震远, Penn State)

SKA CD-EoR Science Team Meeting 2024

2024.7.17

Primordial non-Gaussianity(PNG)

PNG helps us to explore inflation models & primordial physics.



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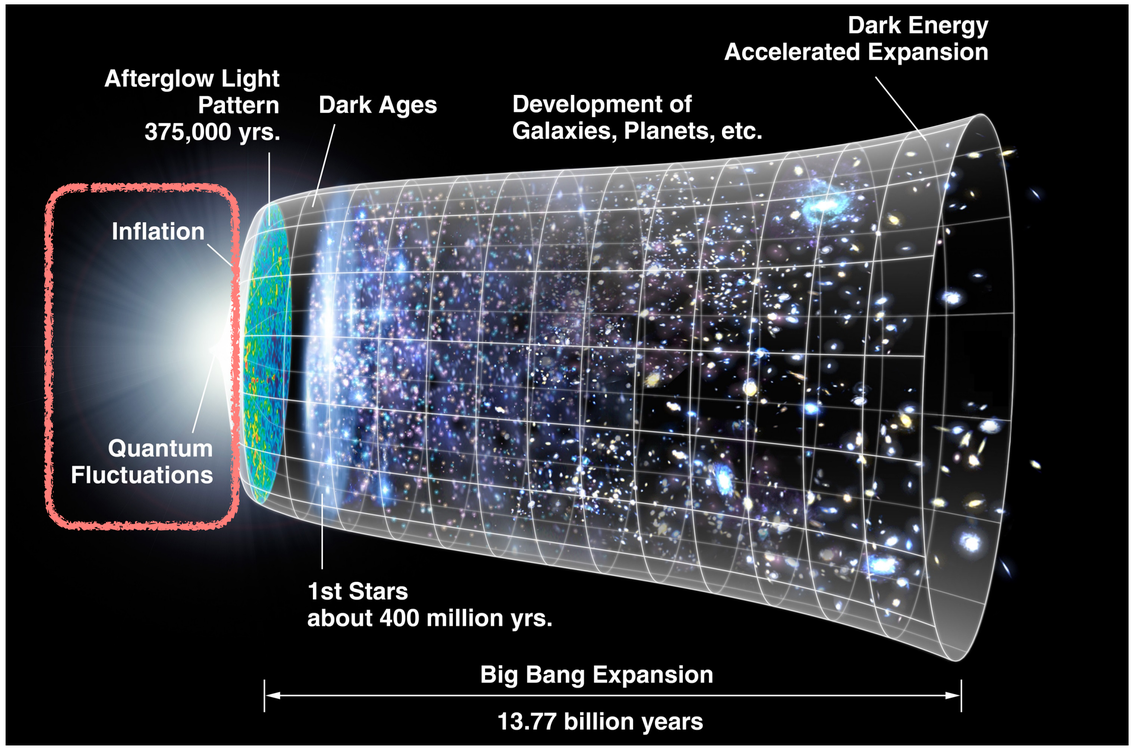
Local type Primordial Non-Gaussianity

$$\phi(x) = \phi_G(x) + f_{\mathrm{NL}}\left[\phi_G^2(x) - \left\langle \phi_G^2(x) \right\rangle\right]$$



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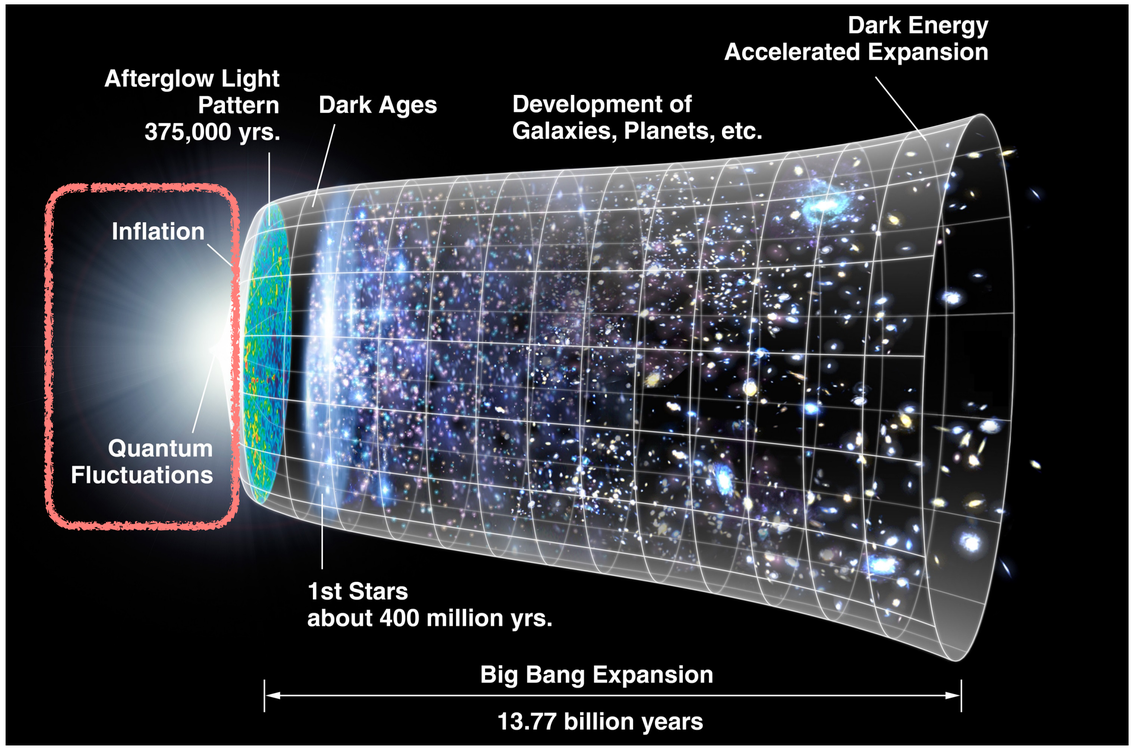
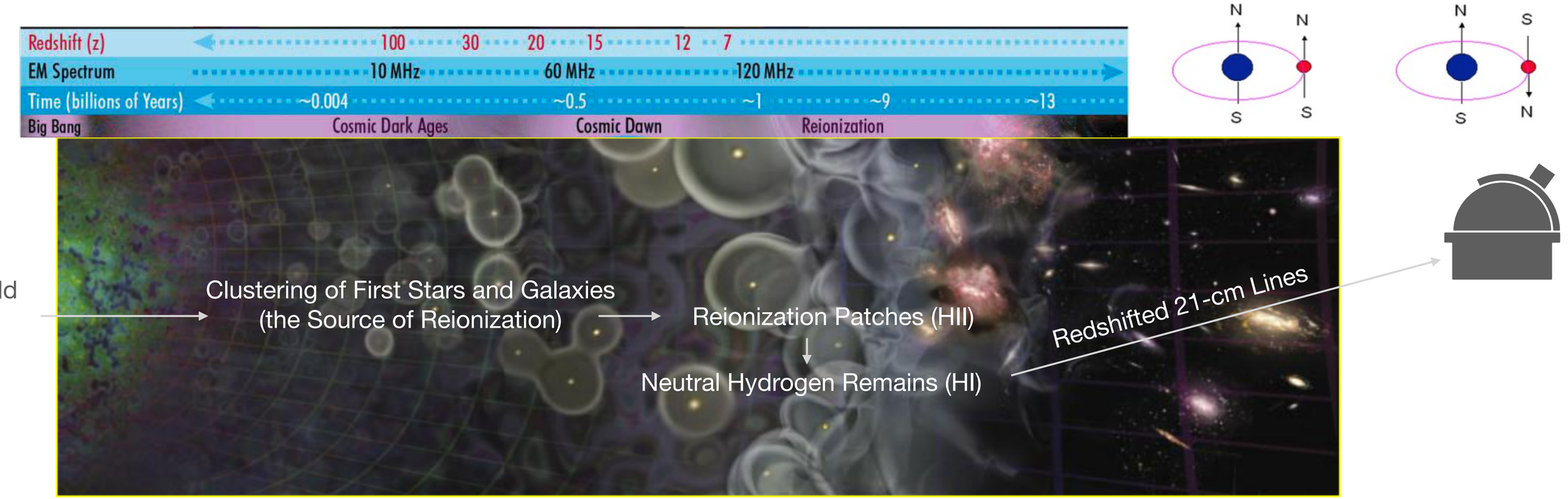
- Planck18, CMB BS: $f_{\rm NL} = -0.9 \pm 5.1$
- Galaxy Survey for large-scale structure(LSS):
  - current: O(100)~O(10)
  - next-generation: O(10)~O(1)



Detect PNG with 21 cm Signal

21 cm is the most potential probe for PNG.

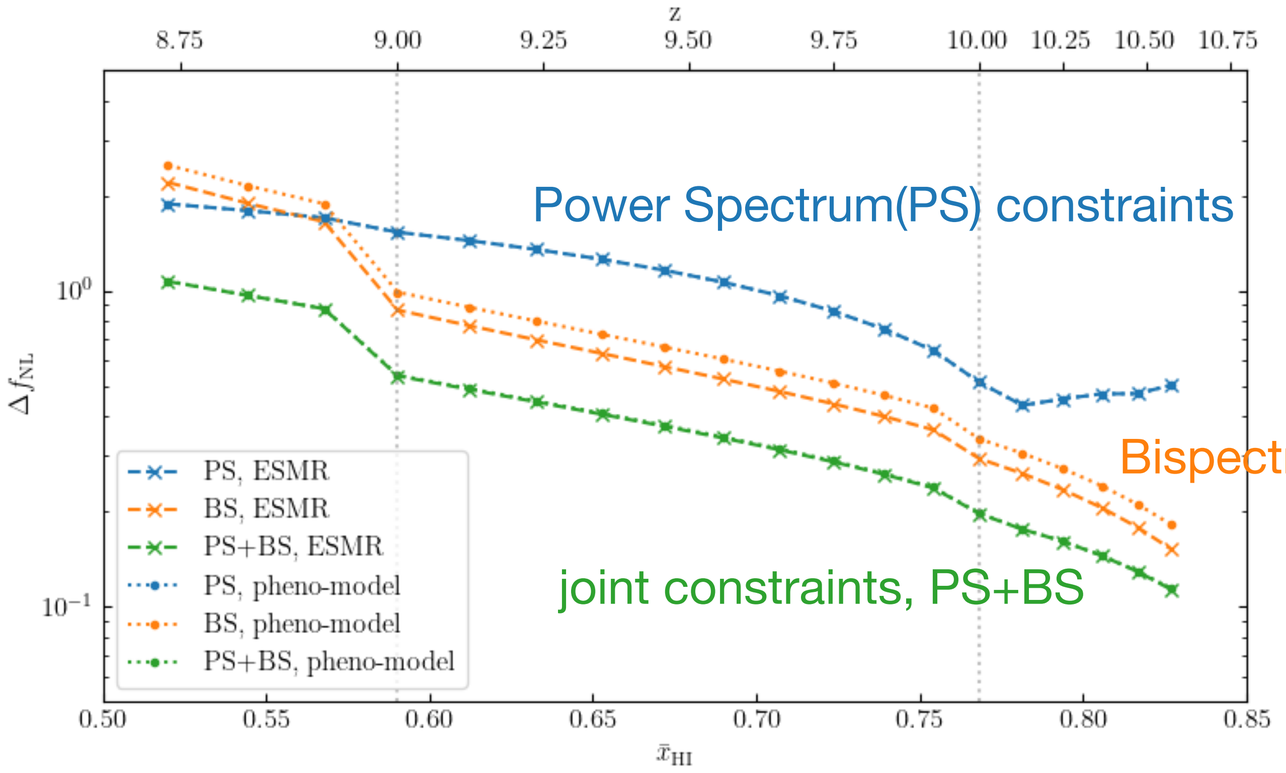


adapted from A. Loeb, 2006, *Scientific American,* 295, 46

PNG Constraints at Different Redshift

BS constraints are more potential than PS at high-z.

1-sigma error constraint of fNL



Power Spectrum(PS) constraints

Bispectrum(BS) constraints

joint constraints, PS+BS

Zhao, Wang & Mao, in prep.

PNG Constraints at Different Redshift

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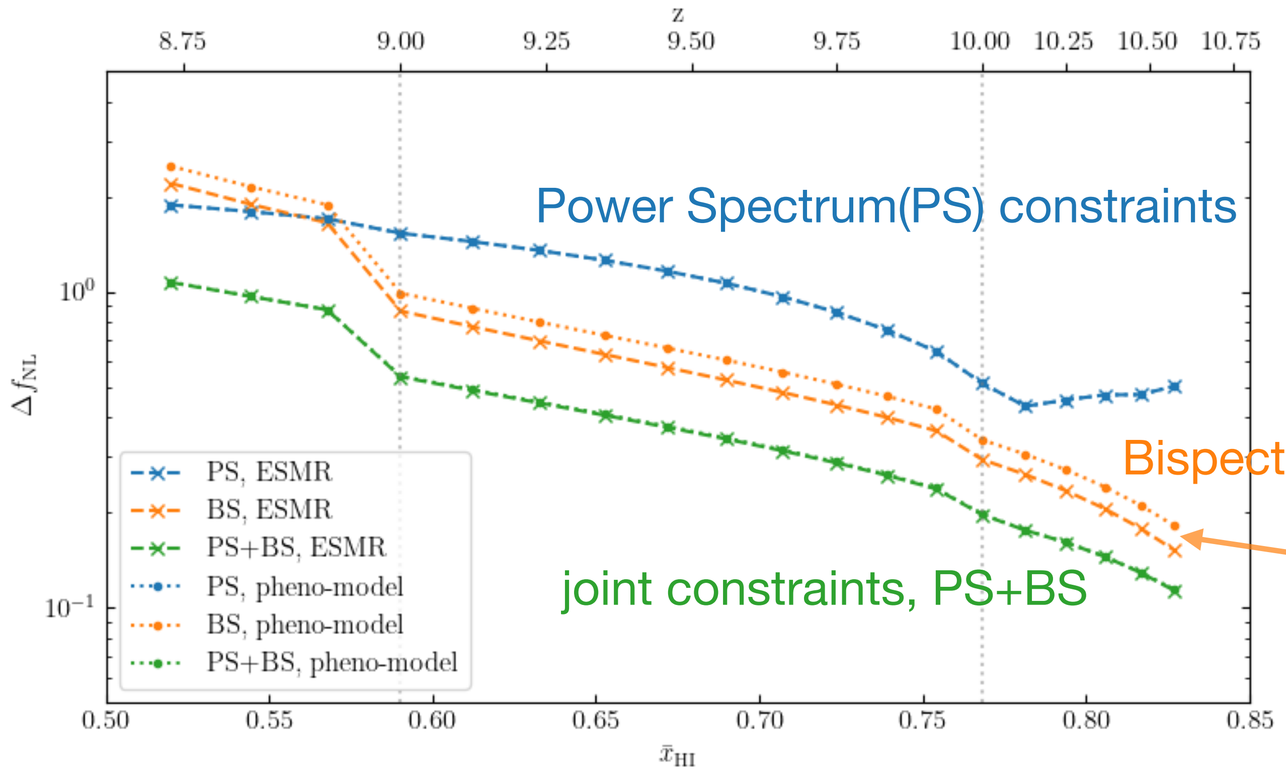
1-sigma error constraint of fNL



- Phenomenological (“pheno”-) model: $\lambda_\alpha = \{f_{\rm NL}, x_{\rm HI}(z_j), b_1(z_j), b_2(z_j)\}$
- ESMR model: $\lambda_\alpha = \{f_{\rm NL}, \zeta_{\rm ESMR}, T_{\rm vir}\}$

- Models of EoR (eg. ESMR) are meaningful in the BS constraints.

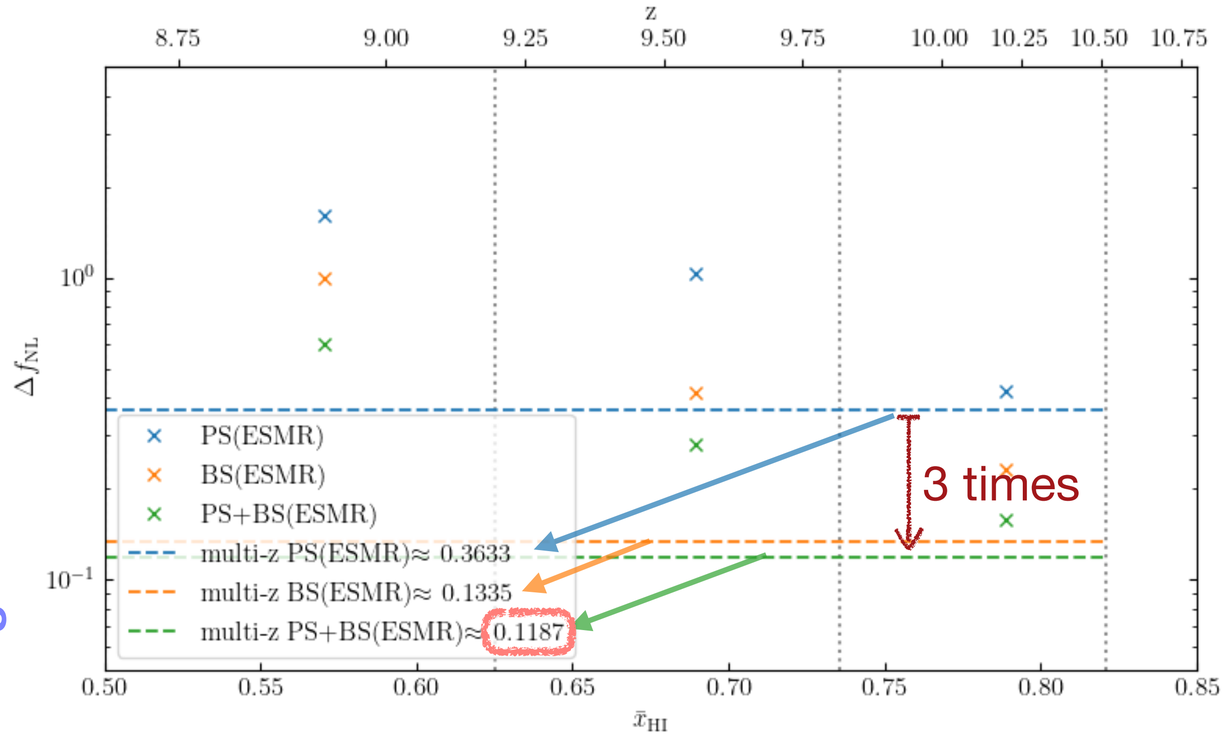
Zhao, Wang & Mao, in prep.

Multi-Epoch Constraints

BS helps improving the PS constraints.

- Omniscope (Cosmic-Variance-Limited)

1-sigma error constraint of fNL



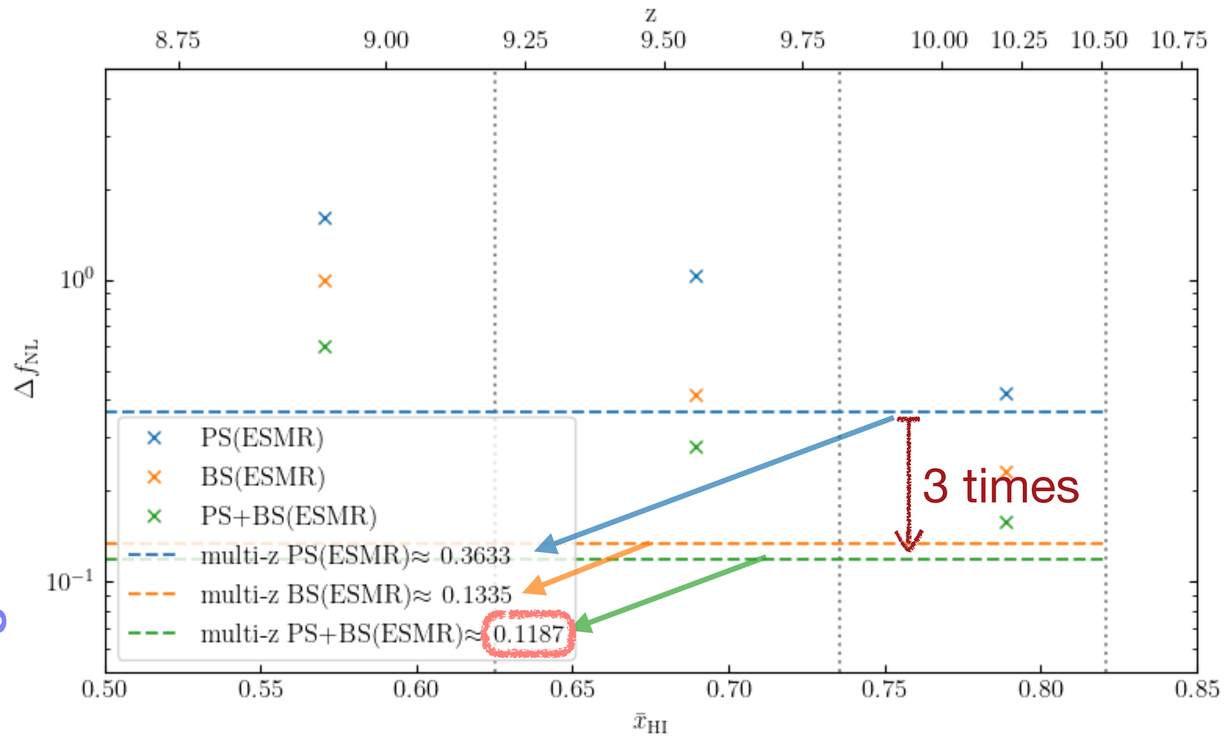
Zhao, Wang & Mao, in prep.

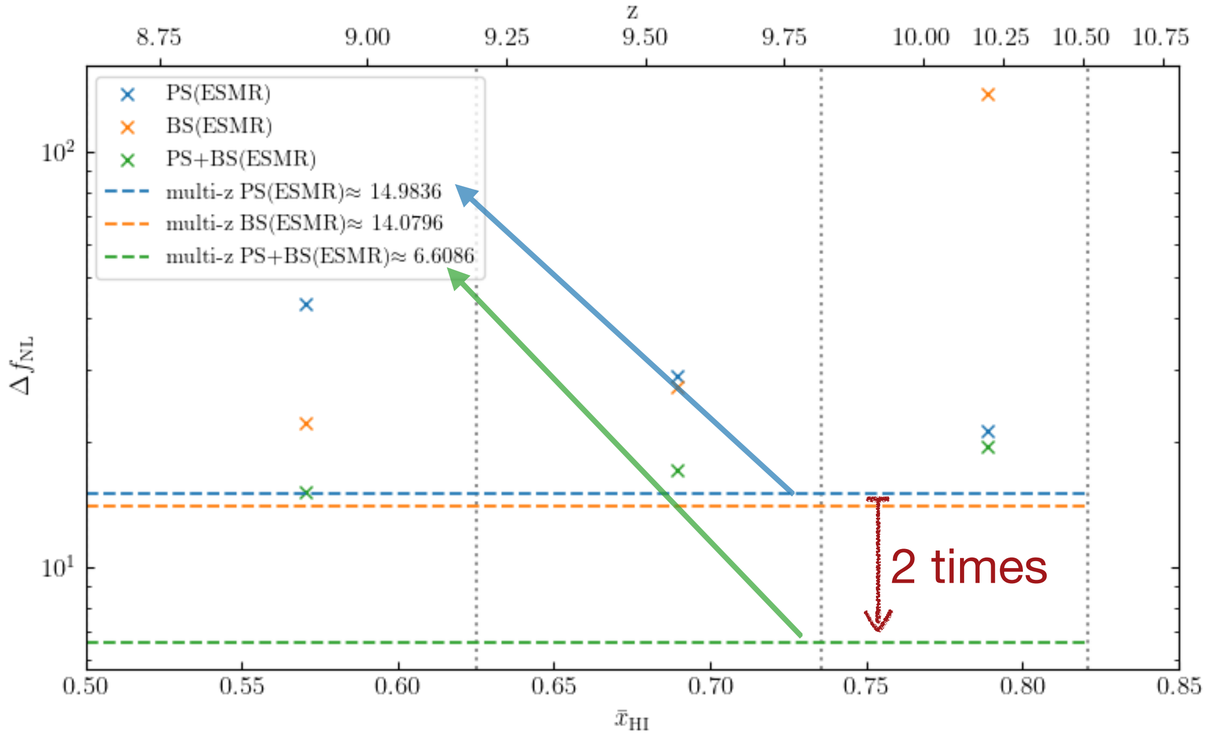
Multi-Epoch Constraints

BS helps improving the PS constraints.

- Omniscope (Cosmic-Variance-Limited)
- SKA2-LOW (as 4X core part of SKA1-LOW)

1-sigma error constraint of fNL



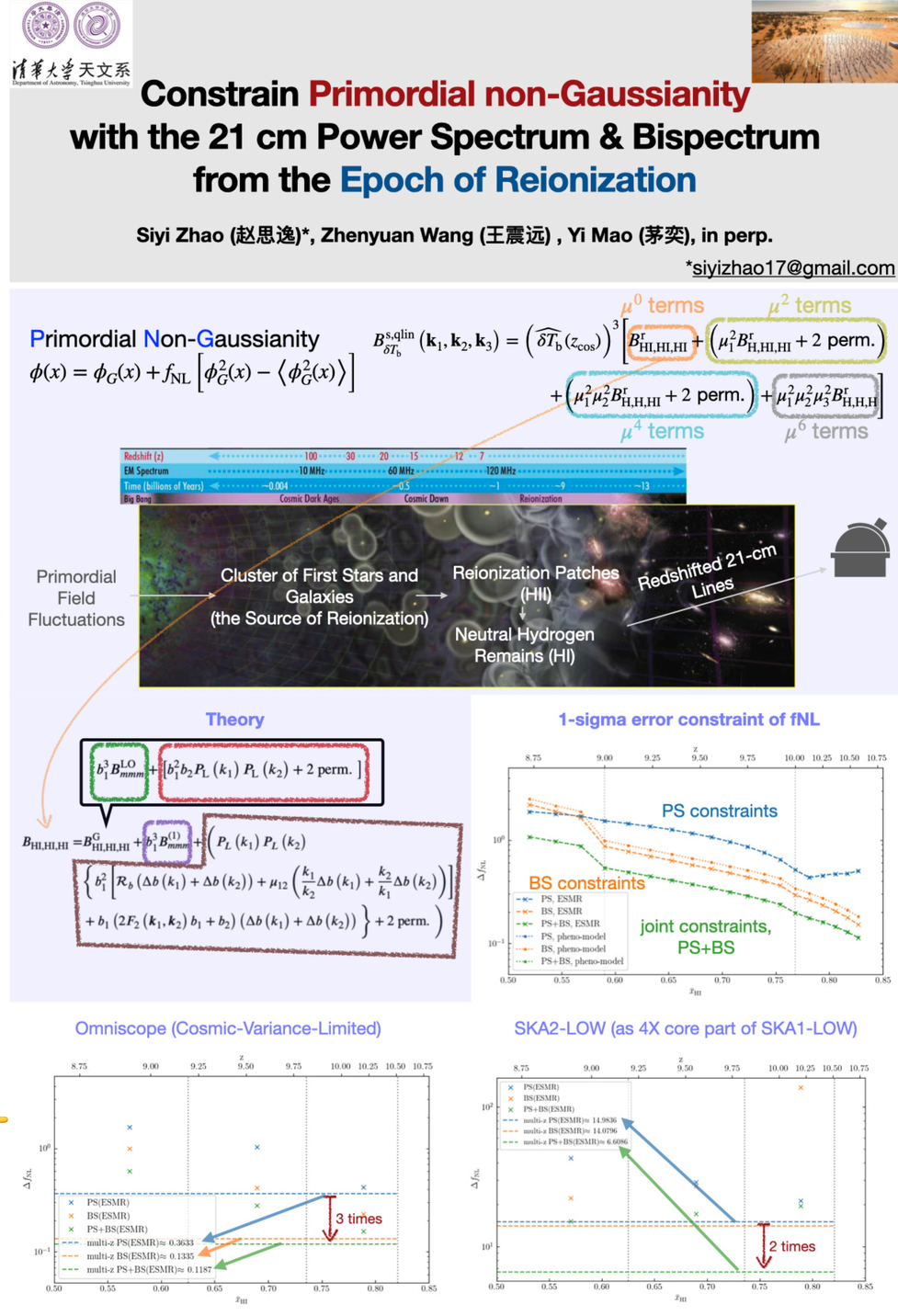


Zhao, Wang & Mao, in prep.

Summary

- Constraints on PNG will help us to choose inflation models and explore primordial physics. (Background)
- We study the 21 cm BS from EoR as a probe of local type PNG.
- Our forecast shows that 21 cm BS will improve the constraints on PNG from power spectrum(PS) by a factor of 2-3.
  - For a cosmic-variance-limited experiment, 21-cm BS is a better probe for PNG than PS, and can constrain PNG to $\Delta f_{\rm NL} \simeq 0.12$.

Welcome to my poster! 👉

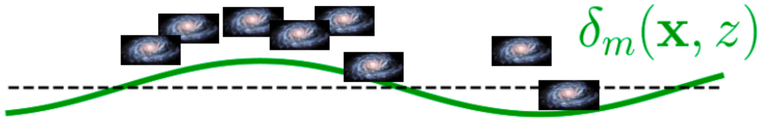


Back-Up

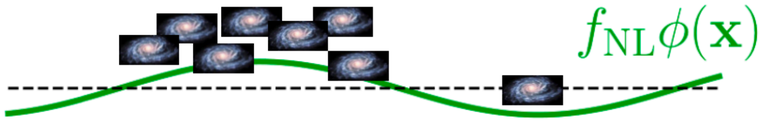
Constrain PNG with PS

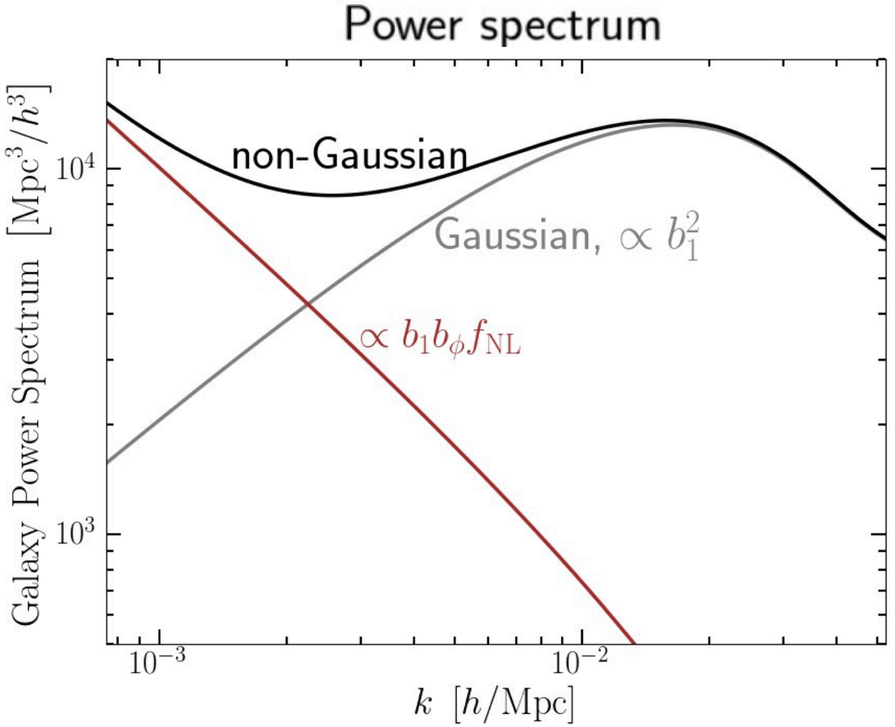
$$\delta_{\rm g}(\boldsymbol{x}, z) \supset b_1(z)\delta_m(\boldsymbol{x}, z) + b_\phi(z) f_{\rm NL}\phi(\boldsymbol{q})$$

How many more galaxies form inside large-scale total mass perturbations?



How many more galaxies form inside large-scale primordial grav. potentials?





Slides from Alex Barreira

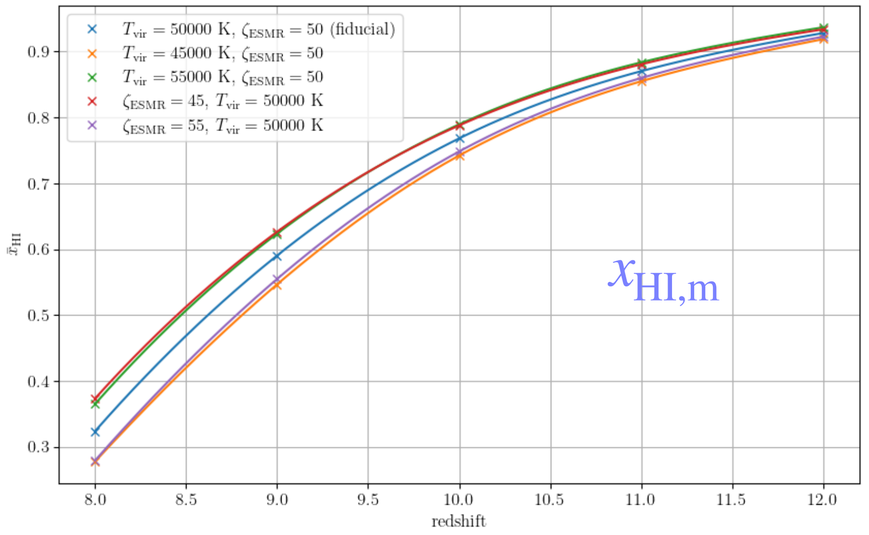
Back-Up

Bias Model

$$\delta_{\rho_{\rm HI}}(\boldsymbol{x}) = b_1\delta_m(\boldsymbol{x}) + \frac{1}{2}b_2\delta_m^2(\boldsymbol{x})$$

Fitting EoR history and bias parameters from simulations.

- simulation: 21cmFAST
- box length = 1000Mpc
- low resolution cell number: 512 x 512 x 512
- redshift = [8, 9, 10, 11, 12]
- $T_{\rm vir} = 50000{\rm K} \pm 10\,\%$
- $\zeta = 50 \pm 10\,\%$
- 20 realizations



Zhao, Wang & Mao, in prep.

- k_max = 0.15 /Mpc