BigBOSS and Primordial Non-gaussianities (fnl)

with collaborators:

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Shirley Ho

Lawrence Berkeley Lab

11/18/09, BigBOSS collaboration meeting

Outline

- What is fnl?
- What have we done with LSS and fnl?
- What would BigBOSS do for fnl?
  - —Galaxy and QSO powerspectrum
  - —Galaxy and QSO bispectrum
  - —Lyman alpha forest
    - Lya flux spectra with different non-gaussianities
    - How about with redshift space distortions?
- Other cool things to do with Lya forest:
  - —Lya BAO

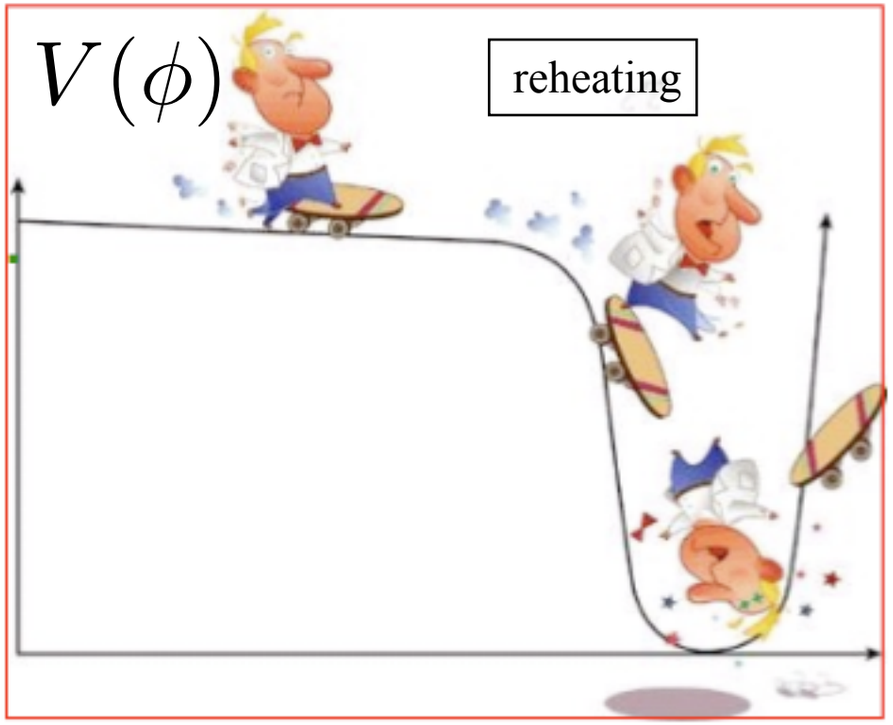
What is fnl?

—Non-gaussianities in Early Universe

parameterize how much non-linear corrections are there to the potential

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

Primordial potential (assumed to be gaussian random field)



← Inflation →

What is fnl?

—Non-gaussianities in Early Universe

parameterize how much non-linear corrections are there to the potential

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

Primordial potential (assumed to be gaussian random field)

Non-Gaussianity from Inflation

f_{NL} ~ 0.05 canonical inflation (single field, couple of derivatives)

(Maldacena 2003, Acquaviva etal 2003)

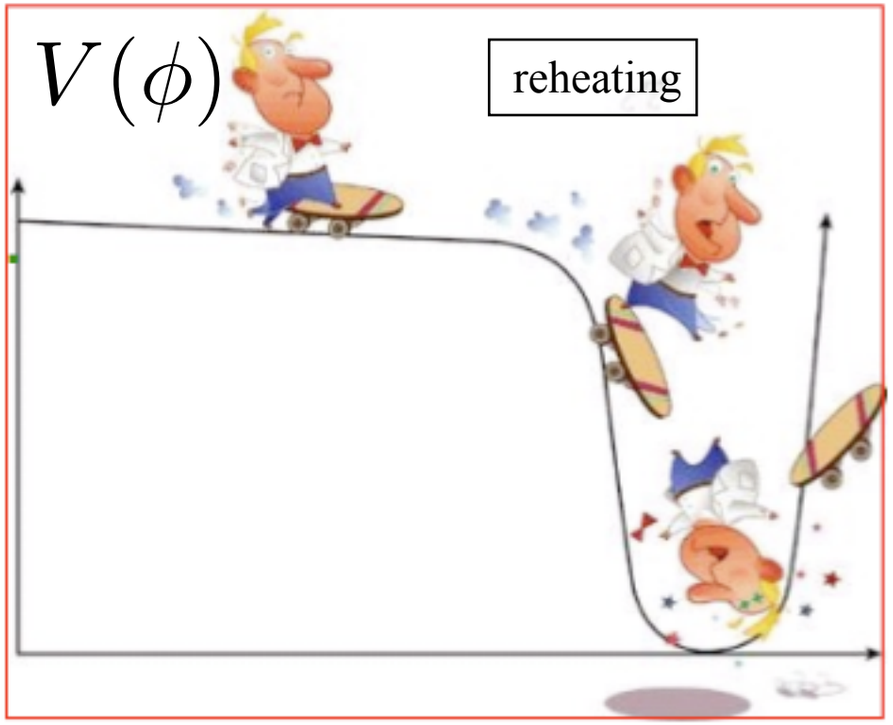
f_{NL} ~ 0.1--100 higher order derivatives

DBI inflation (Alishahiha, Silverstein and Tong 2004)

UV cutoff (Craminelli and Cosmol, 2003)

f_{NL} >10 curvaton models (Lyth, Ungarelli and Wands, 2003)

f_{NL} ~100 ghost inflation (Arkani-Hamed et al., Cosmol, 2004)

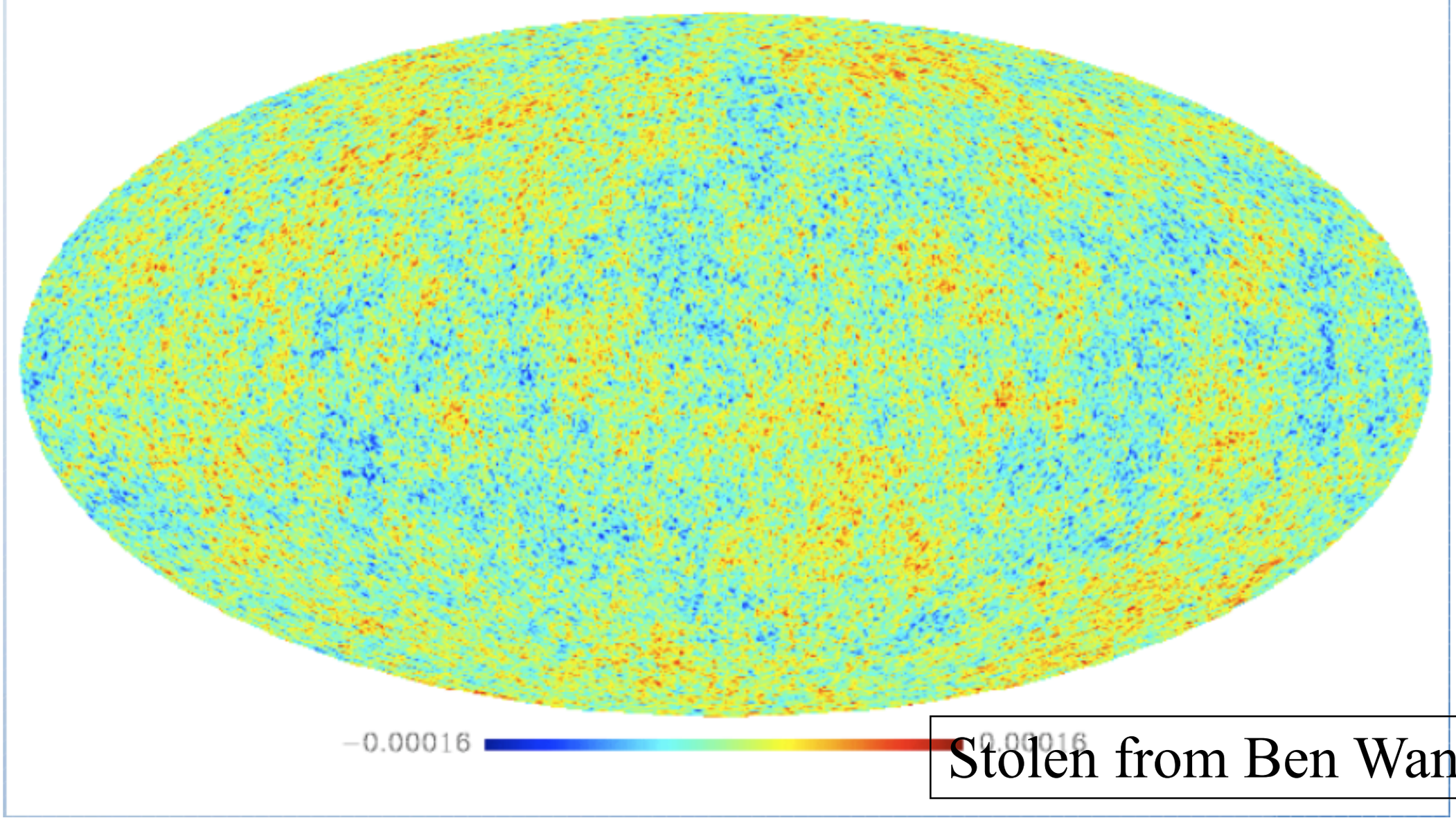


Inflation

On the CMB side:

what do Primordial Non-Gaussianities do?

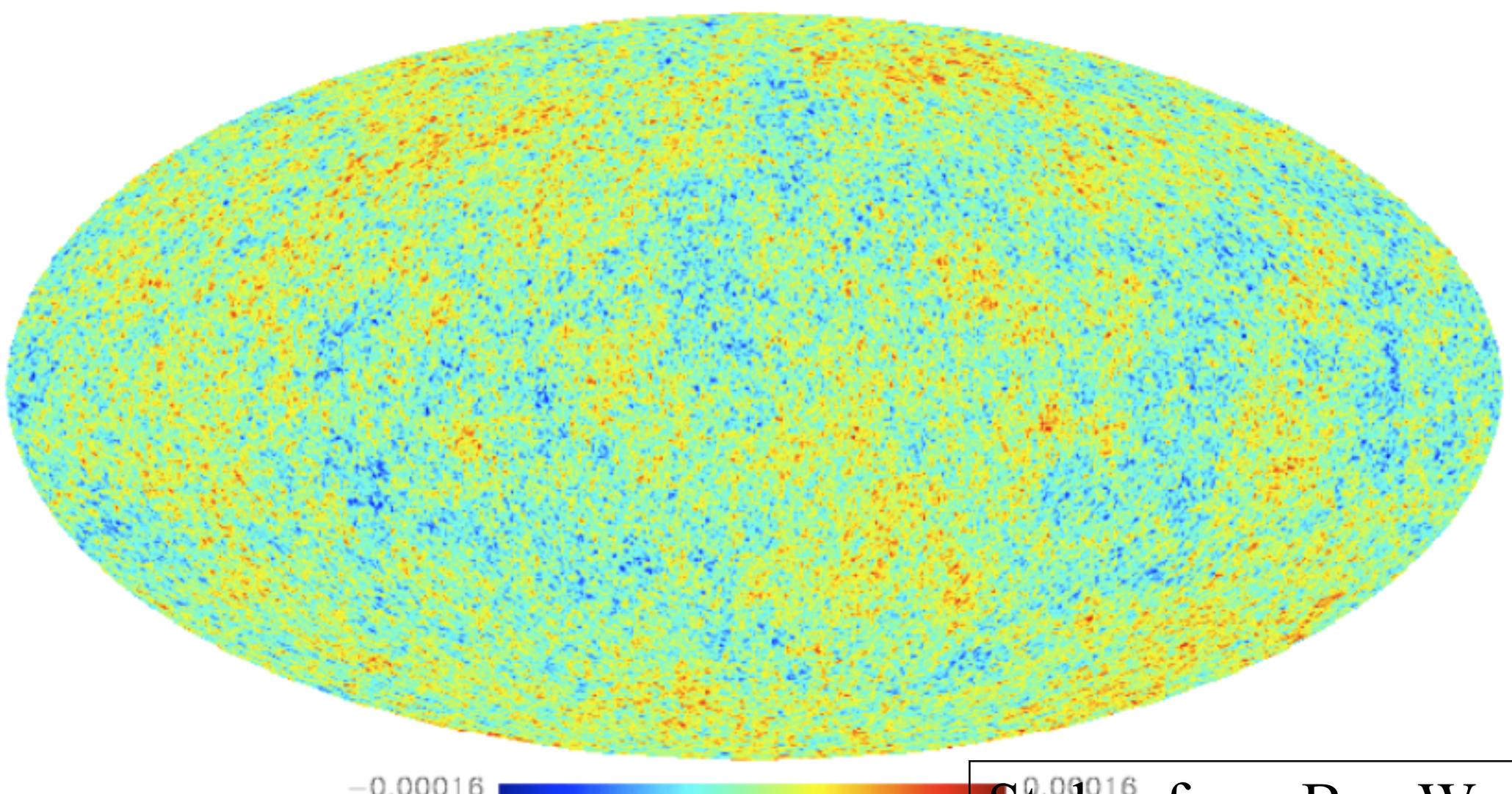
$$f_{NL}=0$$



Stolen from Ben Wandelt

On the CMB side:
what do Primordial Non-Gaussianities do?

$$f_{NL} = 10^1$$

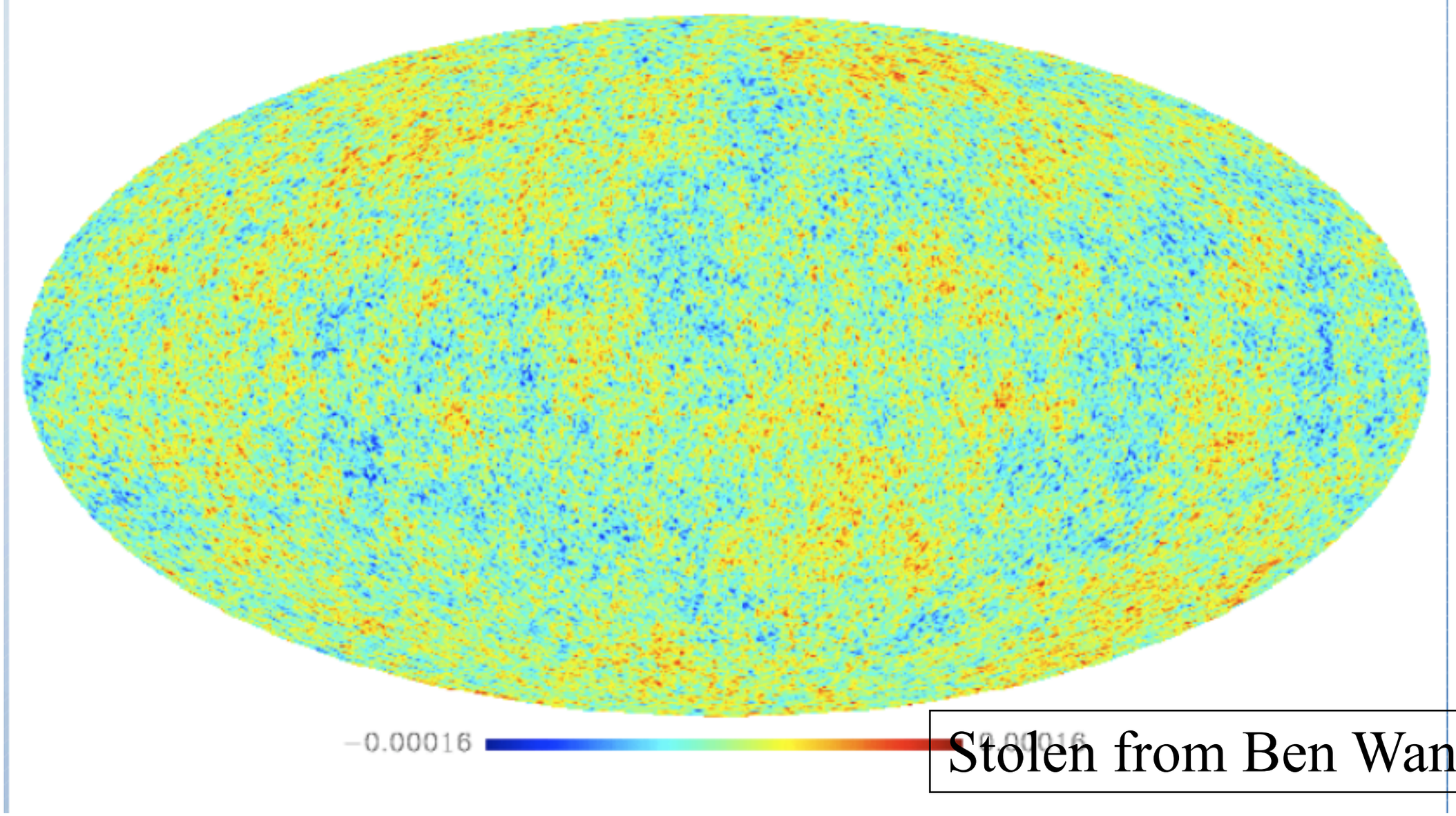


Stolen from Ben Wandelt

On the CMB side:

what do Primordial Non-Gaussianities do?

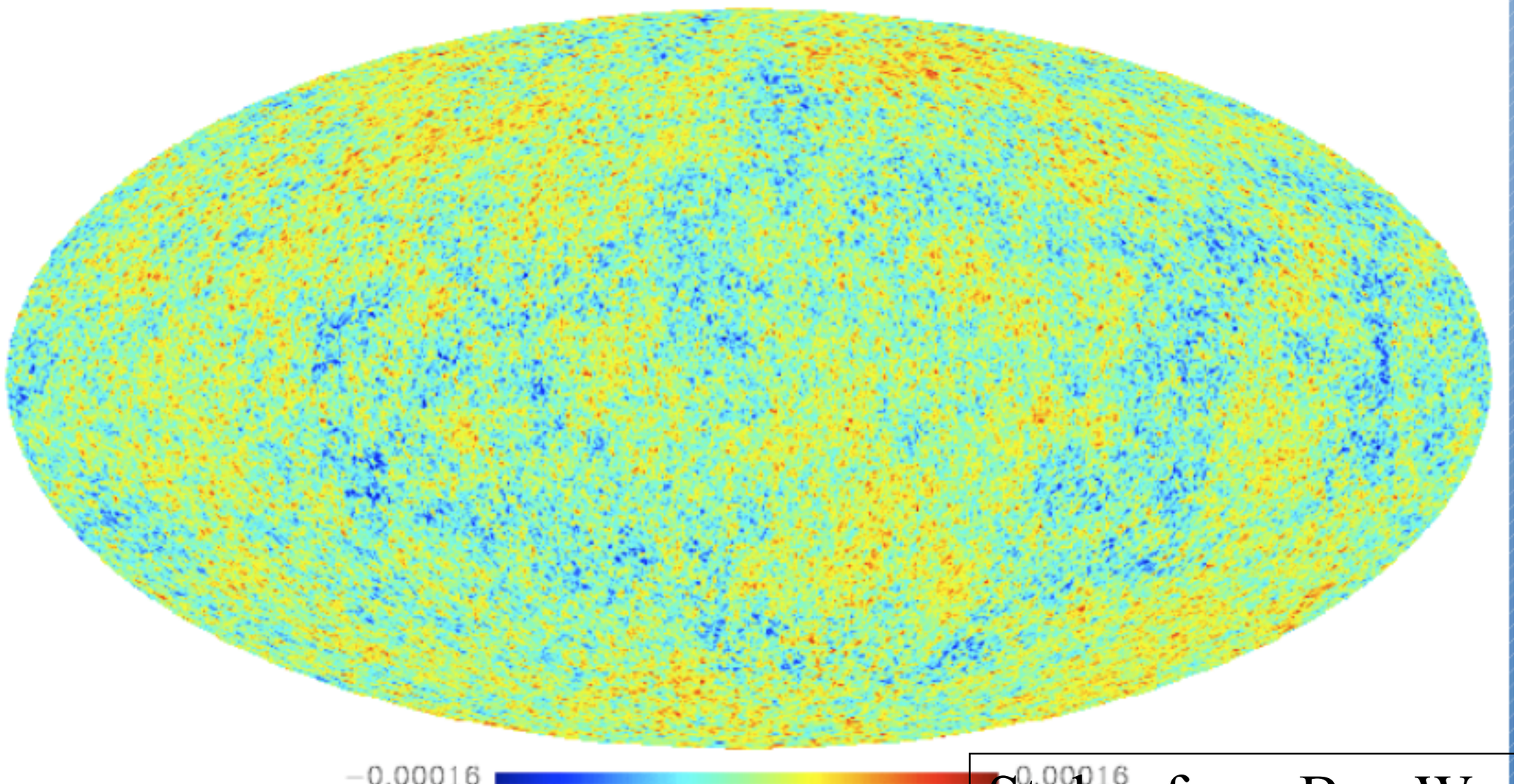
$$f_{NL} = 10^2$$



Stolen from Ben Wandelt

On the CMB side:
what do Primordial Non-Gaussianities do?

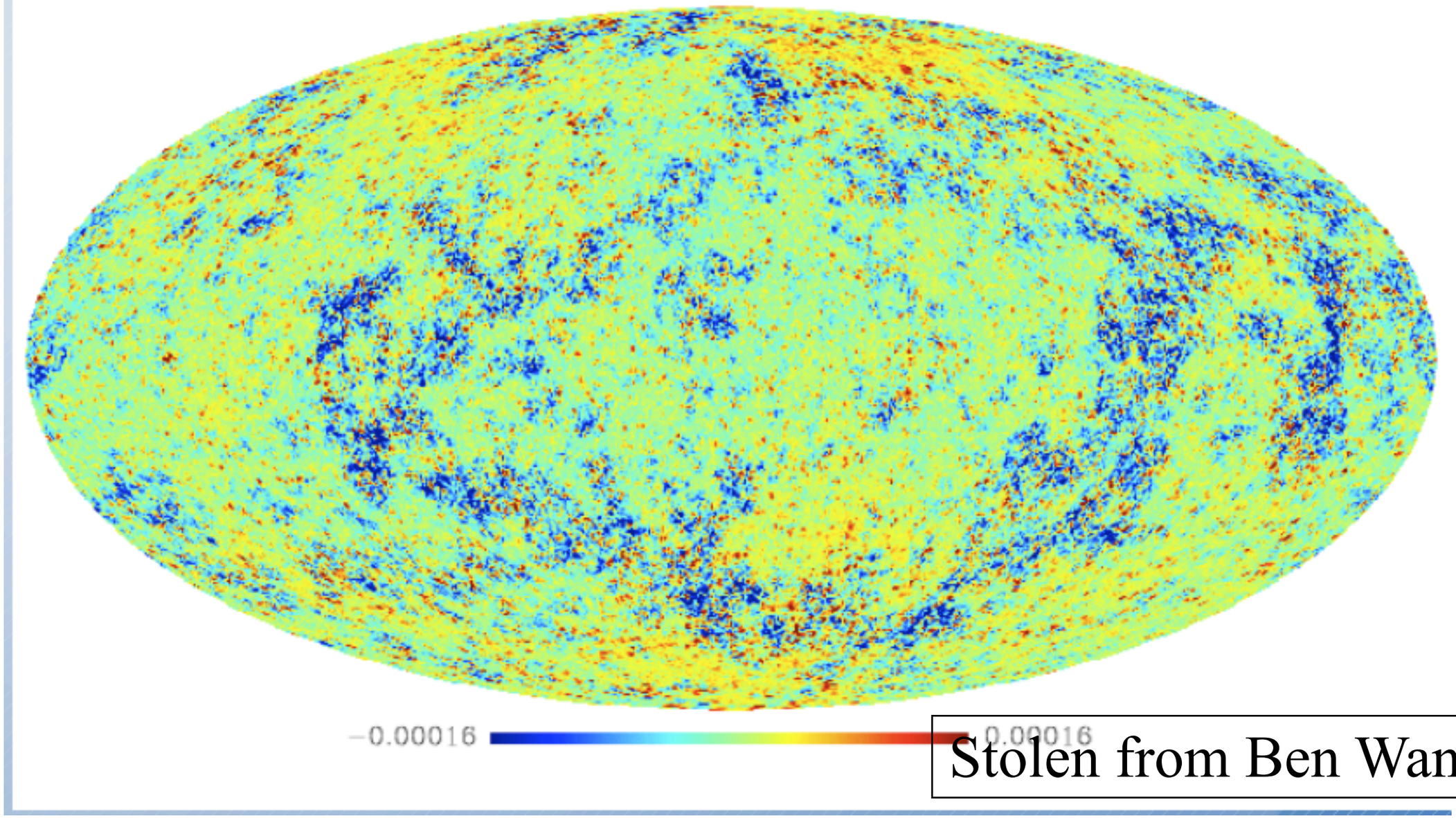
$$f_{NL} = 10^3$$



Stolen from Ben Wandelt

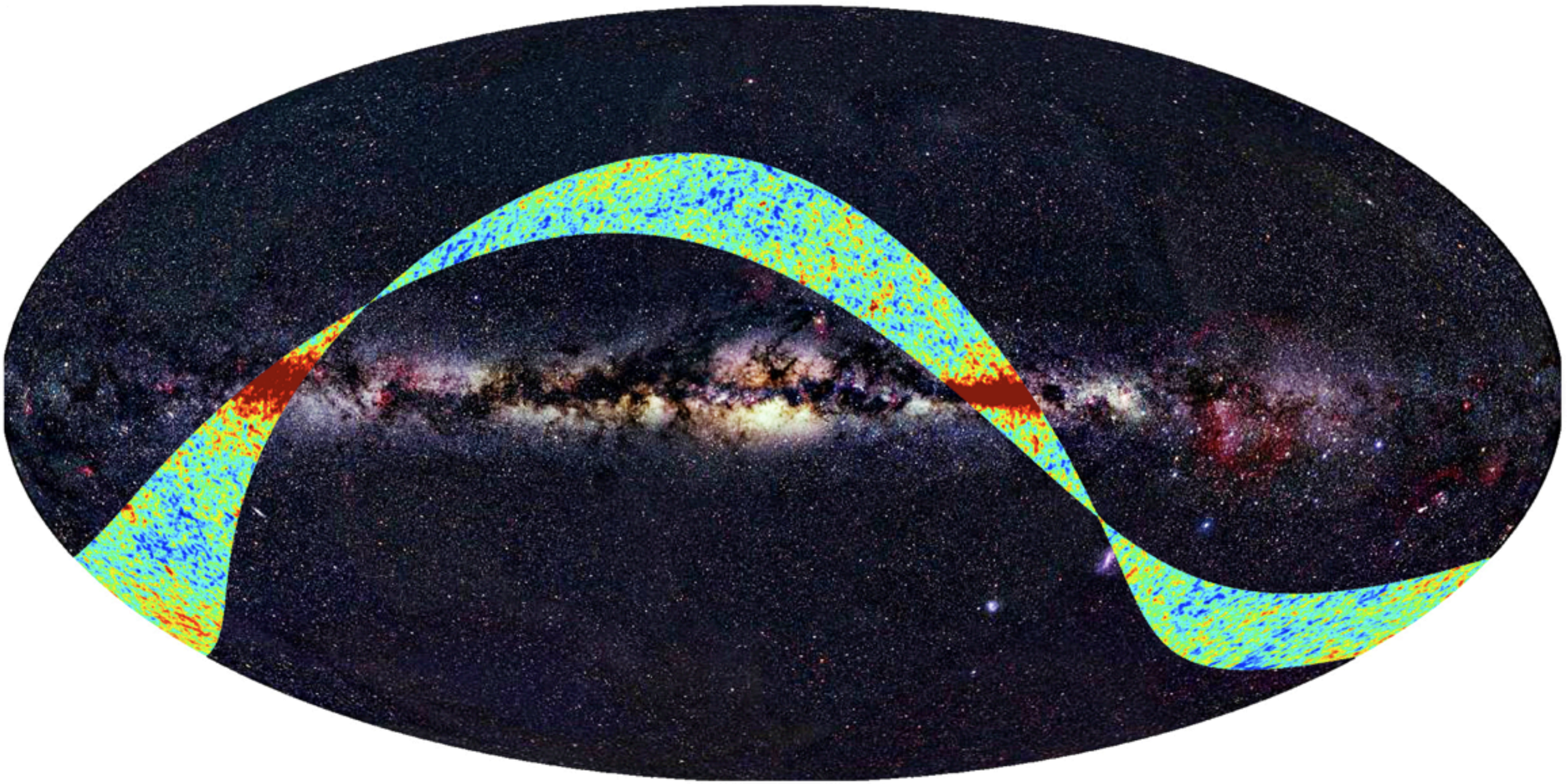
On the CMB side:
what do Primordial Non-Gaussianities do?

$$f_{NL} = 10^4$$



Stolen from Ben Wandelt

On the CMB side:
what do Primordial Non-Gaussianities do?

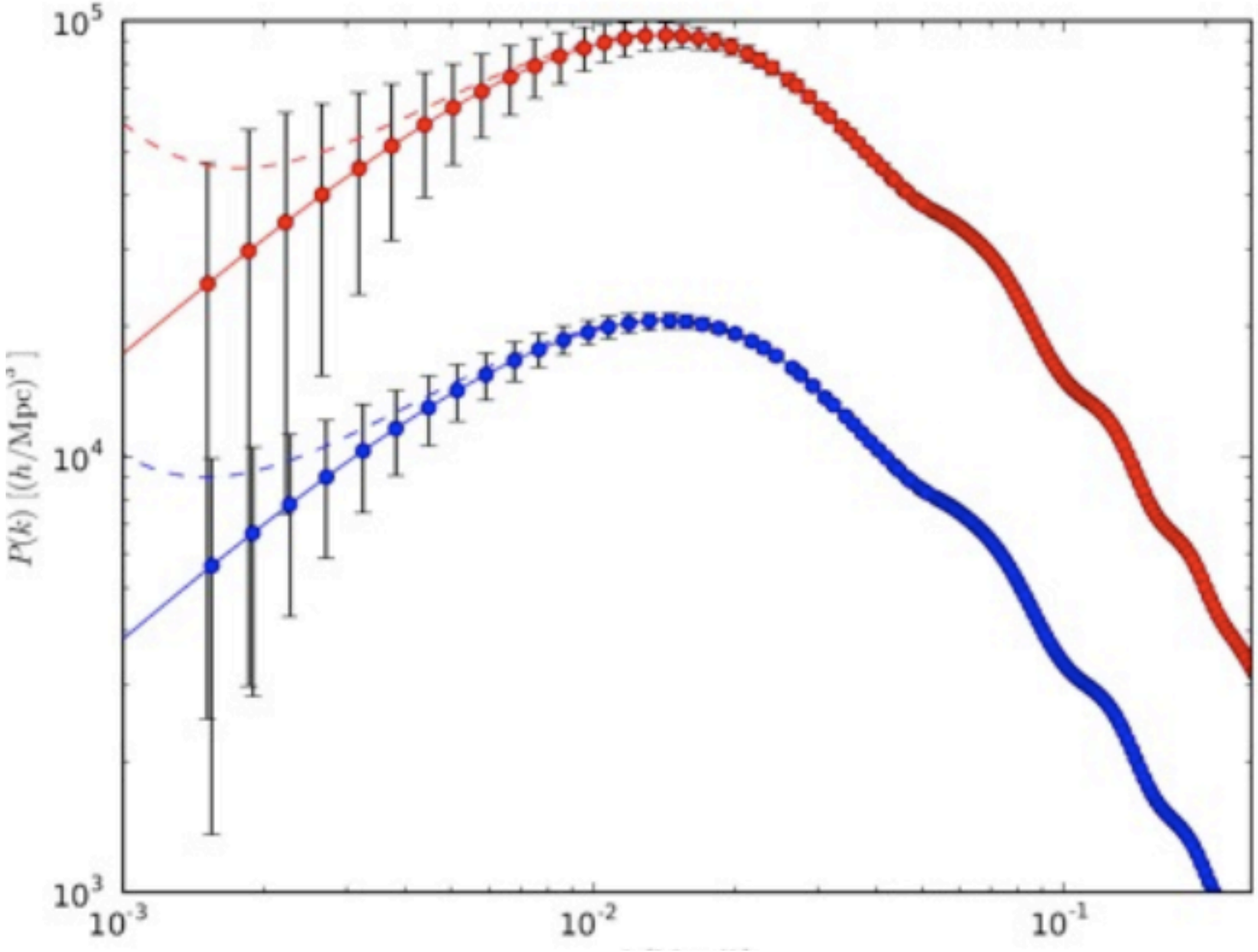


Planck collaboration

On the Galaxy side: What do primordial non-gaussianities do?

P(k) (Mpc/h)^3

$f_{NL} = 5$



Courtesy slide from Anze Slosar

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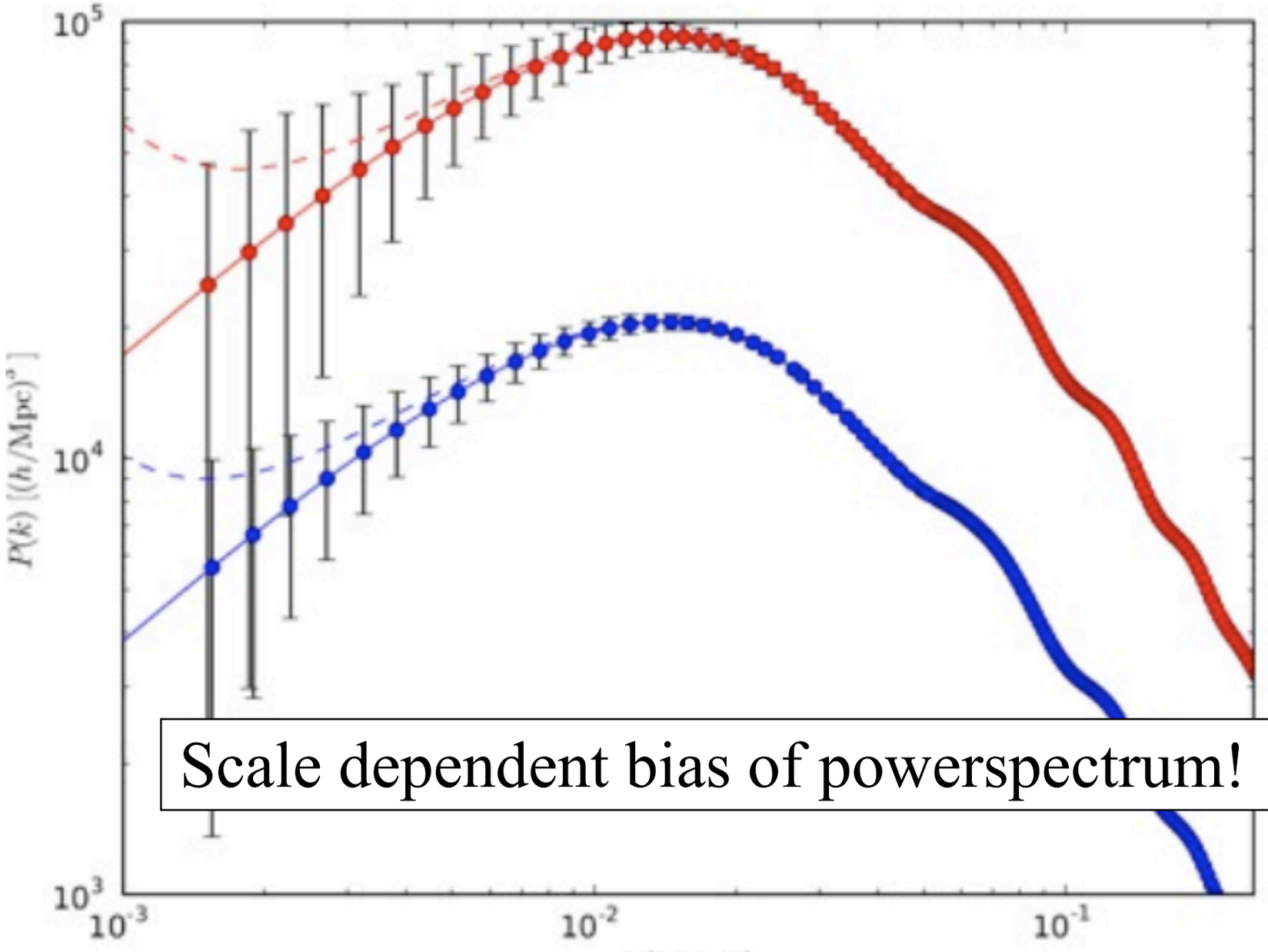
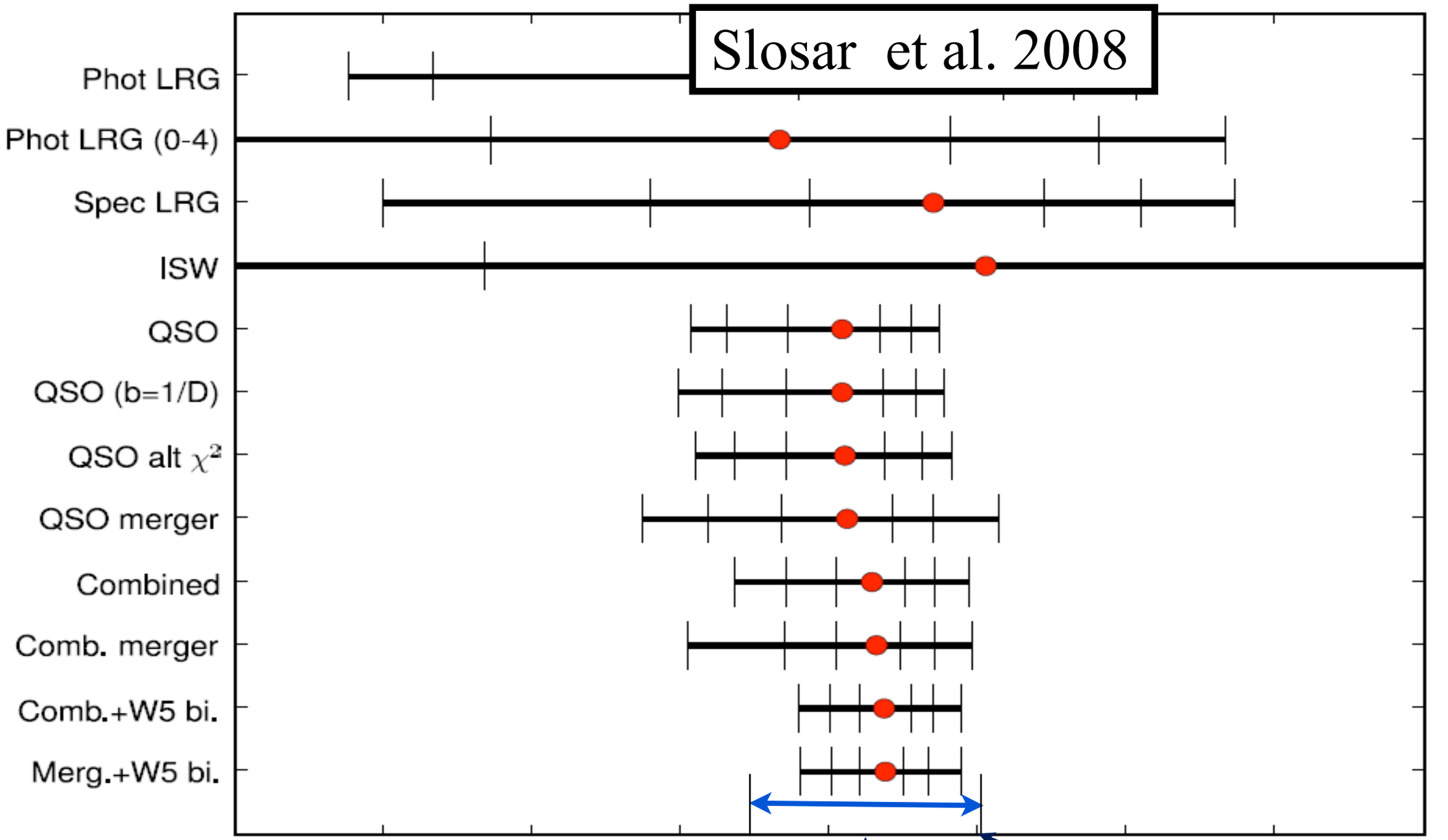


Scale dependent bias of powerspectrum!

Courtesy slide from Anze Slosar

What have we done with LSS and fnl?



Best current CMB measurement

What would BigBOSS do for fnl?

- **Highly improved constraints from the following:**
  - **—Galaxies powerspectrum, bispectrum**
  - **—Quasars powerspecturm, bispectrum**
  - **—Lyman-alpha forest powerspectrum, bispectrum**
  - **—Integrated Sachs Wolfe Effect (with CMB)**
  - **—...**

BigBOSS and fnl: Powerspectrum

	Redshift	Bias	$\delta(f_{NL})$
BOSS-LRG	0.3-1	2	18
BigBOSS-LRG	0.3-0.7	2	7
BigBOSS-Emission Line Galaxies	0.7-2	1.5	5
BigBOSS-QSOs	1-2	1.5	5
BigBOSS-QSOs	2-3.3	2	3

Carbone et al (2009) , Courtesy code from Anze Slosar

BigBOSS and fnl: Powerspectrum

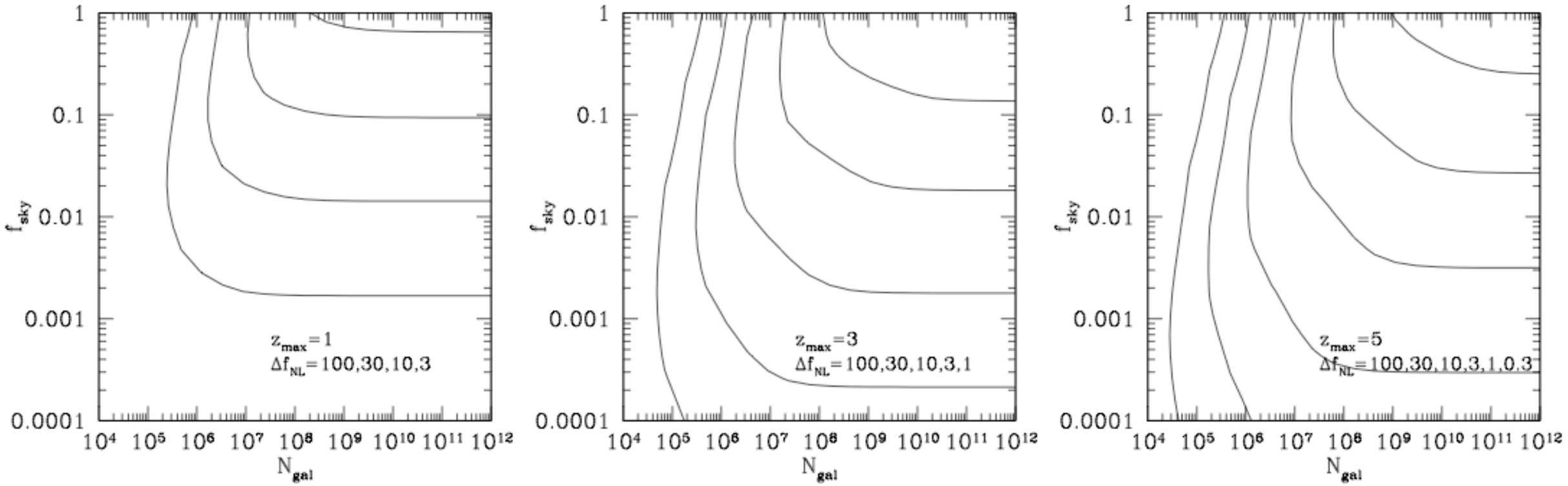


FIG. 6: The expected precision for the measurement of local primordial non-gaussianity, using the auto-power spectrum of a galaxy survey (in lieu of any survey systematics). The contours show the expected precision as a function of the survey sky coverage, f_{sky}, and the number of galaxies in the survey, N_{gal} (assuming uniform comoving galaxy number density and $b_{gal} = 2$), for $z_{max} = 1, 3, 5$.

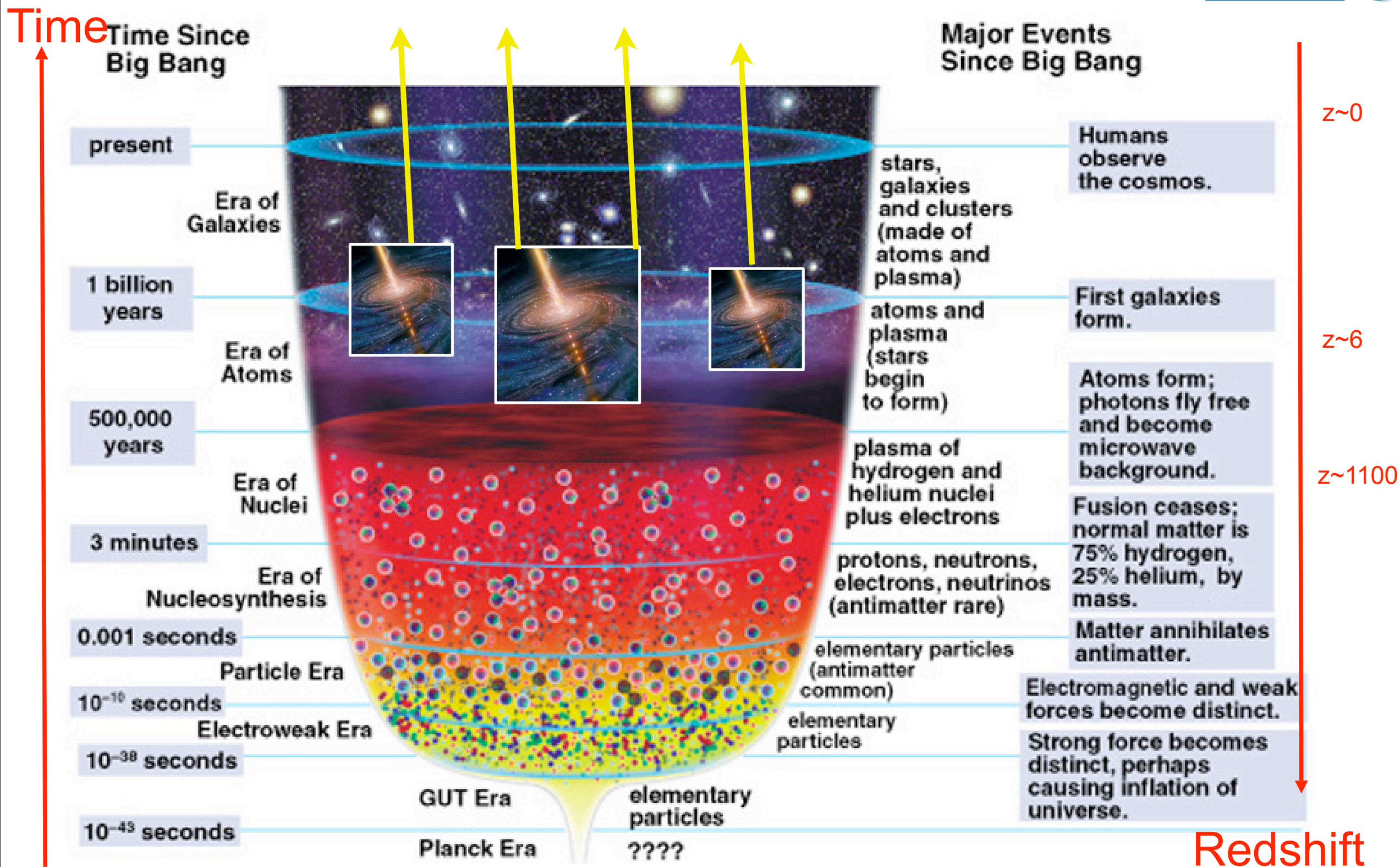
Afshordi et al. 2008

BigBOSS and fnl: Galaxy and QSO bispectrum?

	Redshift	Bias	$\delta(f_{NL})$ Unmarginalized Error
BOSS-LRG	**0.3-1**	**2**	**~3**
BigBOSS-LRG	**0.3-0.7**	**2**	**~1 (0.92)**
BigBOSS-Emission Line Galaxies	**0.7-2**	**1.5**	**~1 (0.5)**
BigBOSS-QSOs	**1-2**	**1.5**	**~1**
BigBOSS-QSOs	**2-3.3**	**2**	**~3 (changed due to number density change)**

Courtesy from Donghui Jeong and Eiichiro Komatsu

How about Lyman Alpha Forest?



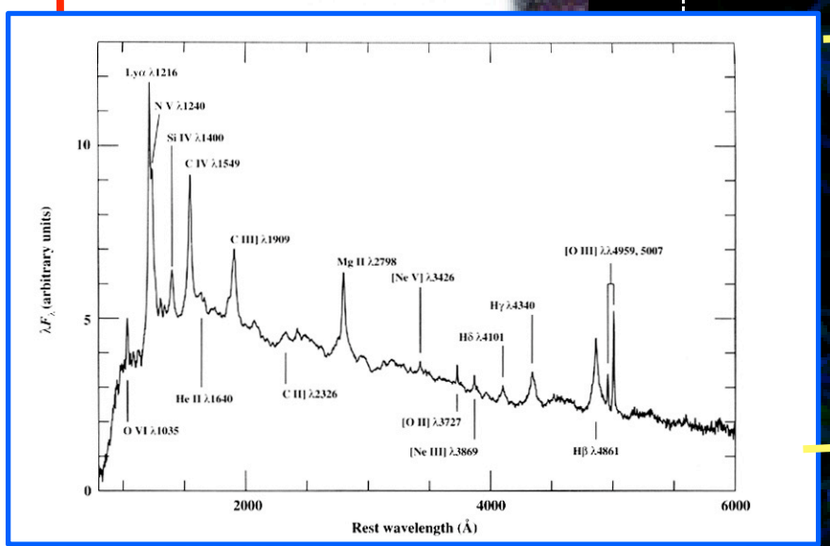
Lyman Alpha Forest: what is it?

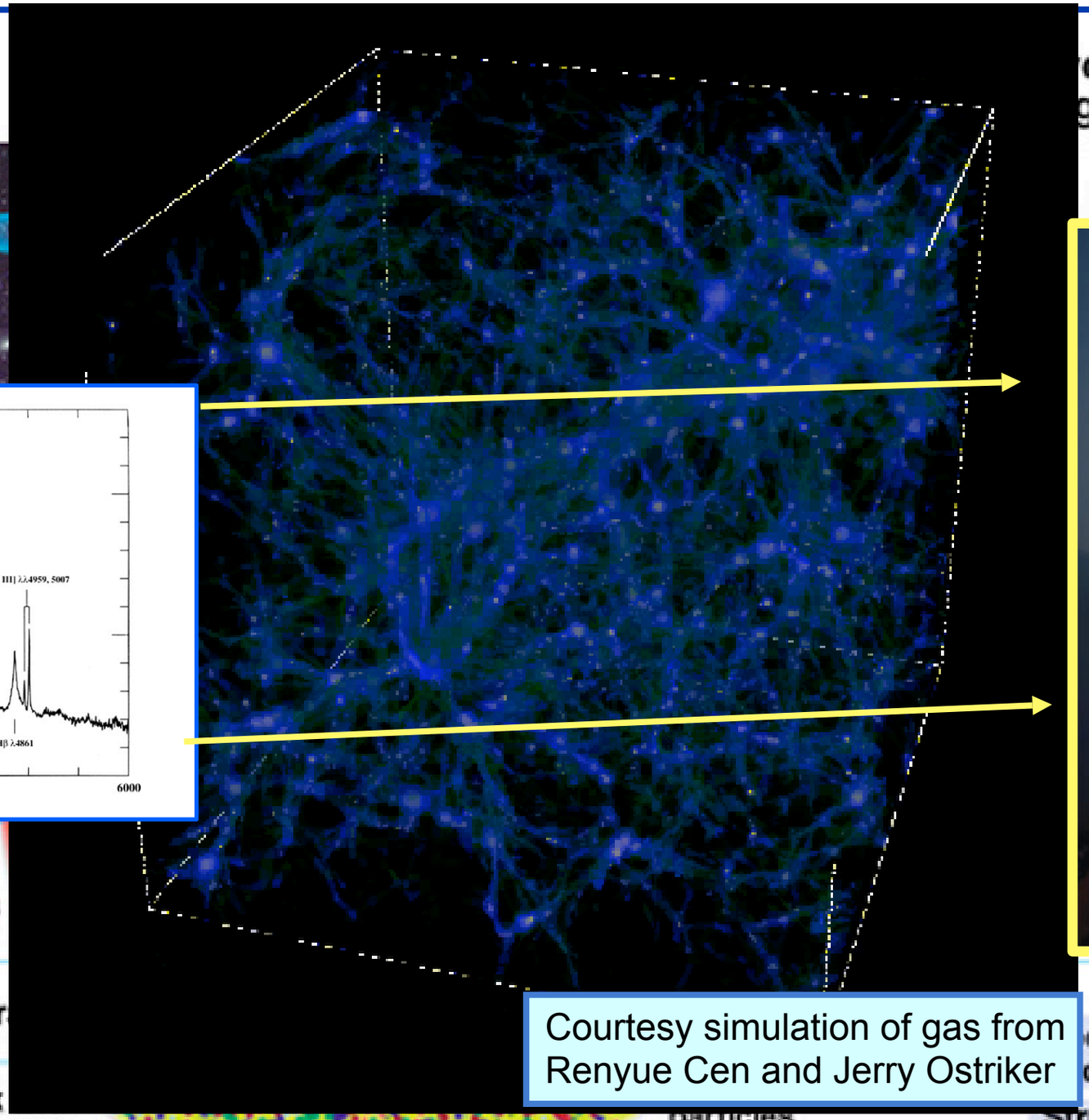
Time

Time Since Big Bang

present

Era of Galaxies





Courtesy simulation of gas from Renyue Cen and Jerry Ostriker

z~0

Era of Nucleosynthesis

0.001 seconds

Particle Er

10^{-10} seconds

Electroweak

10^{-38} seconds

GUT Era

elementary particles

10^{-43} seconds

Planck Era

????

antimatter.

ctromagnetic and weak ces become distinct.

Strong force becomes distinct, perhaps causing inflation of universe.

Redshift

Lyman Alpha Forest: what is it?

Time

Time Since Big Bang

present

Era of Galaxies

Era of Nucleosynthesis

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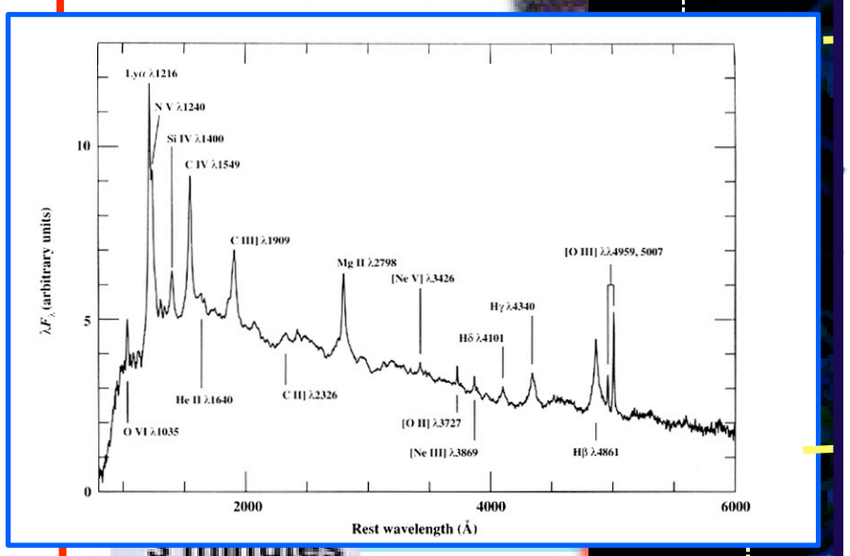
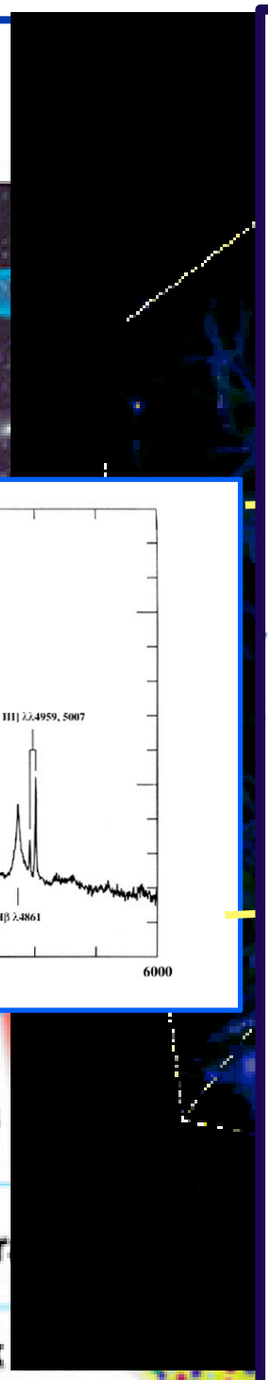




flux (amount of light)

emission

wavelength λ →

One absorbing cloud close by

flux (amount of light)

emission

absorption

wavelength λ →

Several absorbing clouds

flux (amount of light)

emission

absorption

wavelength λ →

ents

g Bang

z~0

Humans

antimatter.

ctromagnetic and weak

ces become distinct.

Strong force becomes distinct, perhaps

Courtesy image from Joanne Cohn's website

Redshift

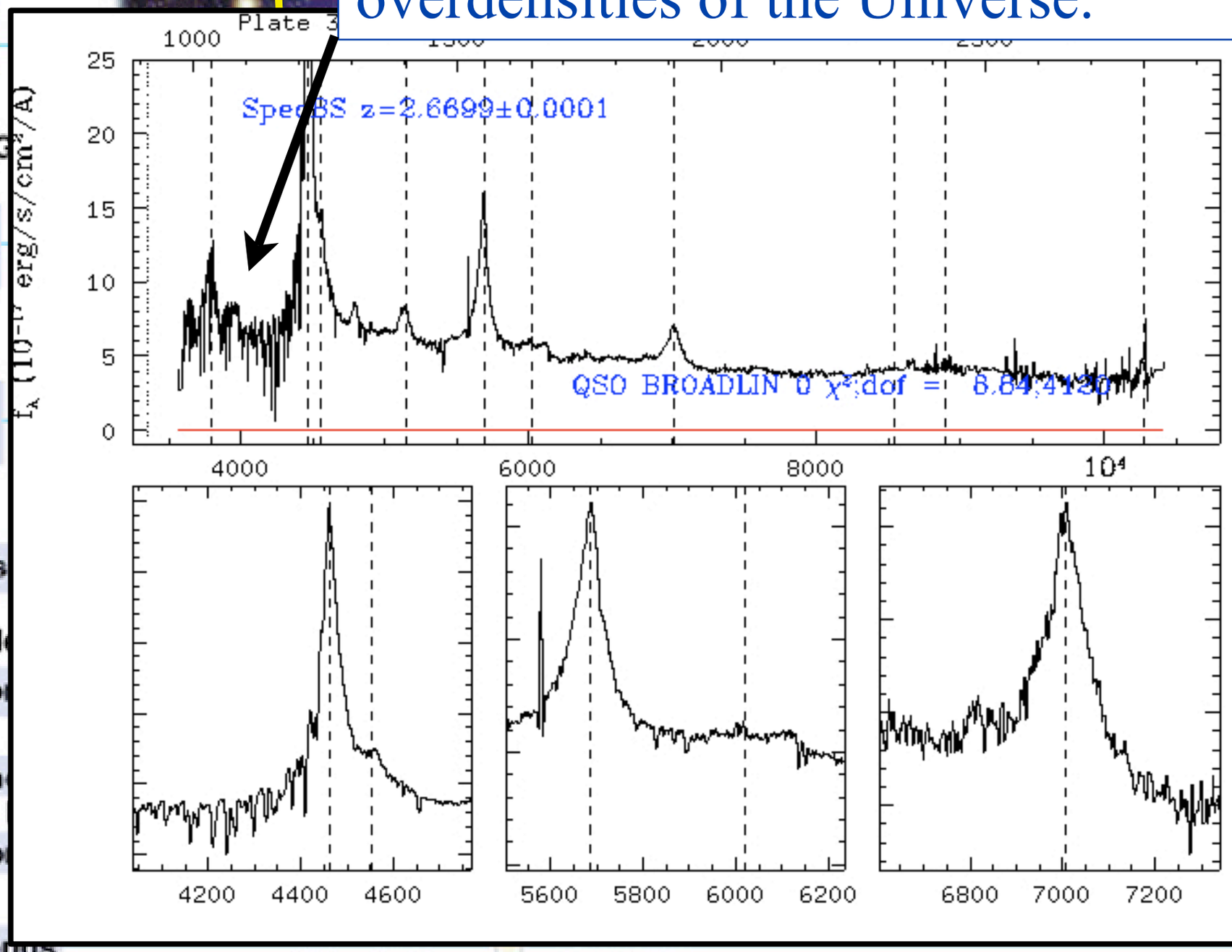
Lyman Alpha Forest: what is it?

Time

Time Since Big Bang

Flux

Locates the Neutral Hydrogen, thus overdensities of the Universe.



present

1 billion years

500,000 years

3 minutes

Nucl

0.001 seco

10^{-10} secon

10^{-38} seco

10^{-43} seconds

Planck Era

????

smos.

laxies

form;
ns fly free
come
wave
round.

ceases;
matter is
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lium, by

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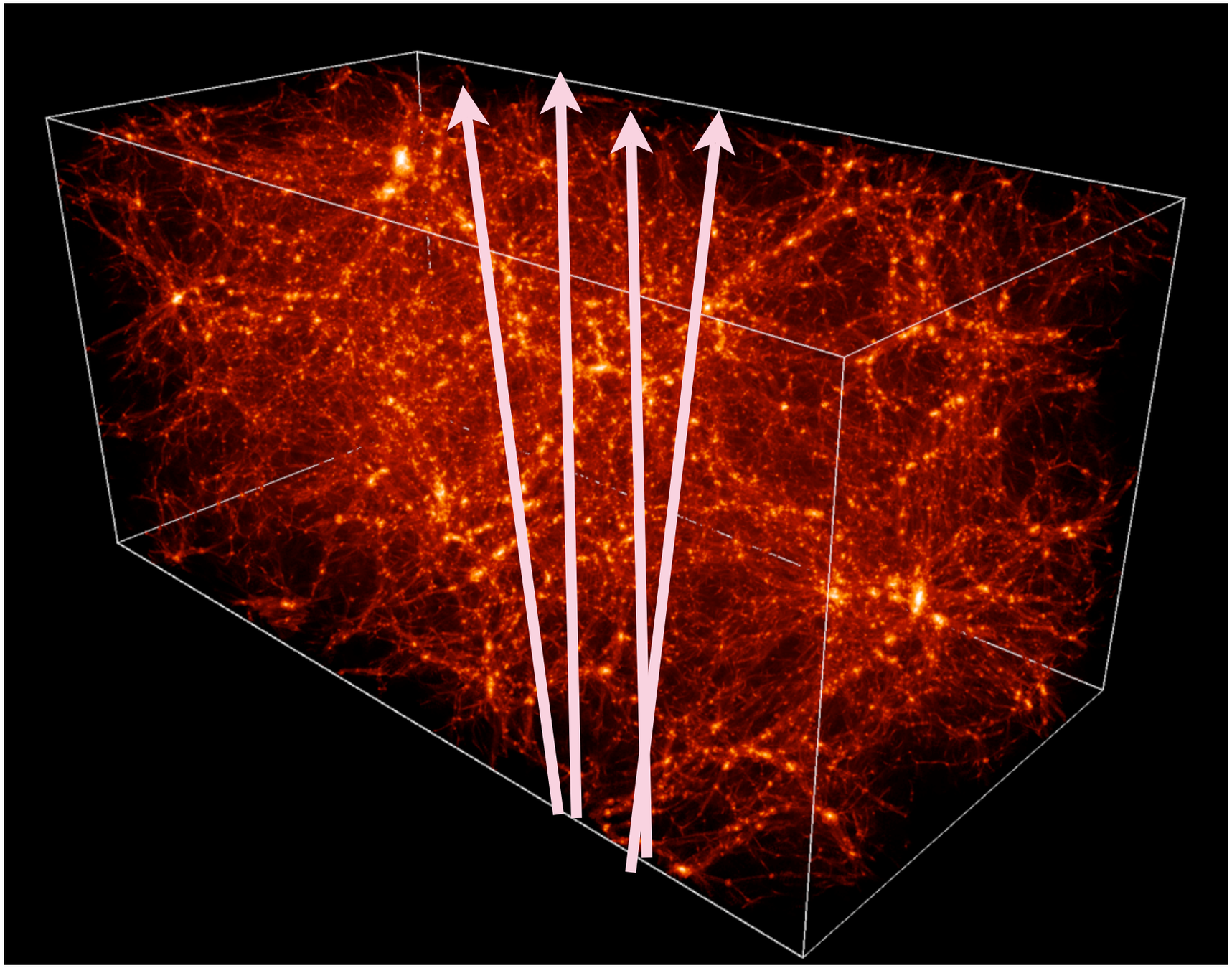
z~0

z~6

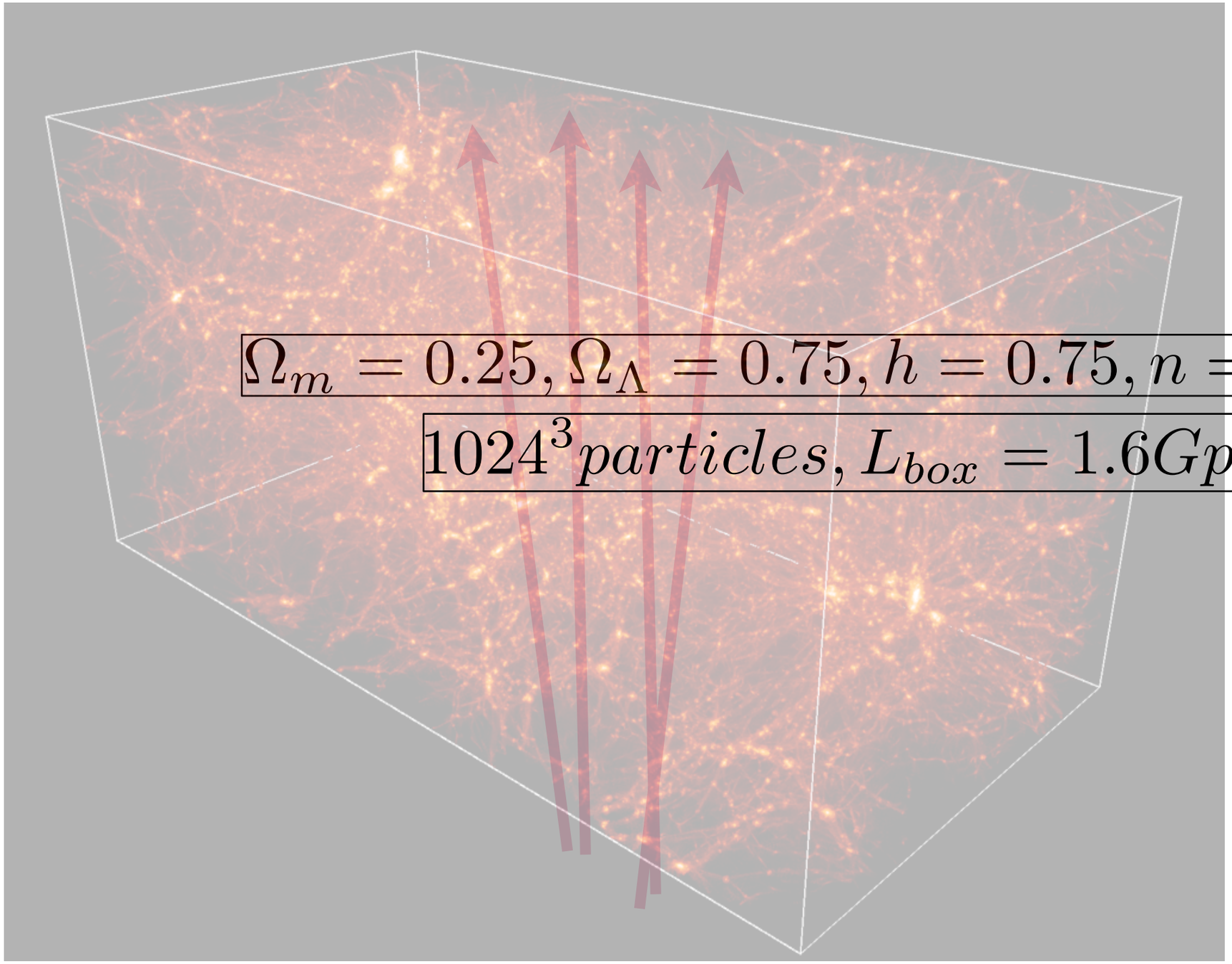
z~1100

Redshift

Lyman Alpha Forest: what can it do?



Lyman Alpha Forest: what can it do?



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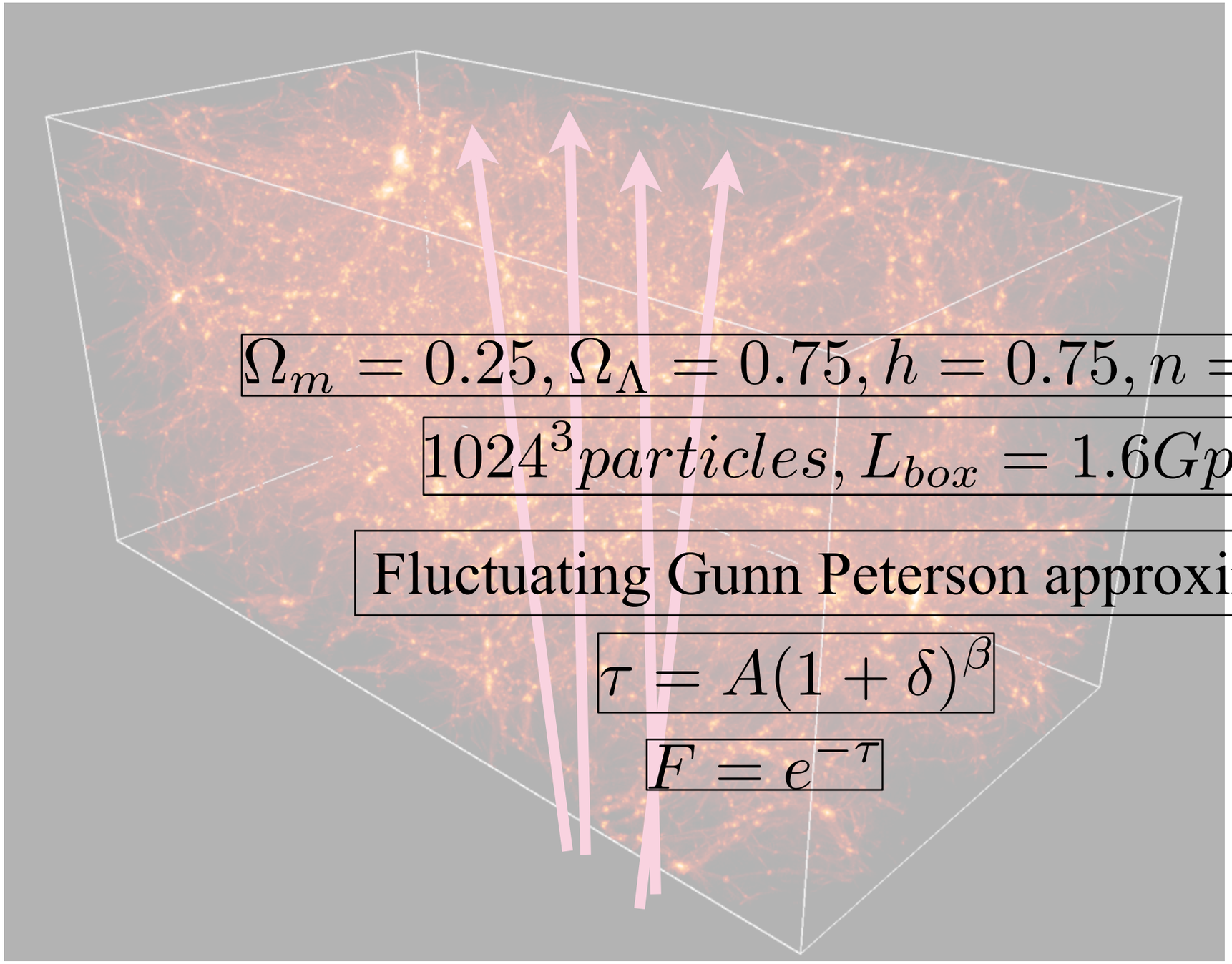


$$\Omega_m = 0.25, \Omega_\Lambda = 0.75, h = 0.75, n = 0.97, \sigma_8 = 0.8$$

$$1024^3 particles, L_{box} = 1.6 Gpc/h$$

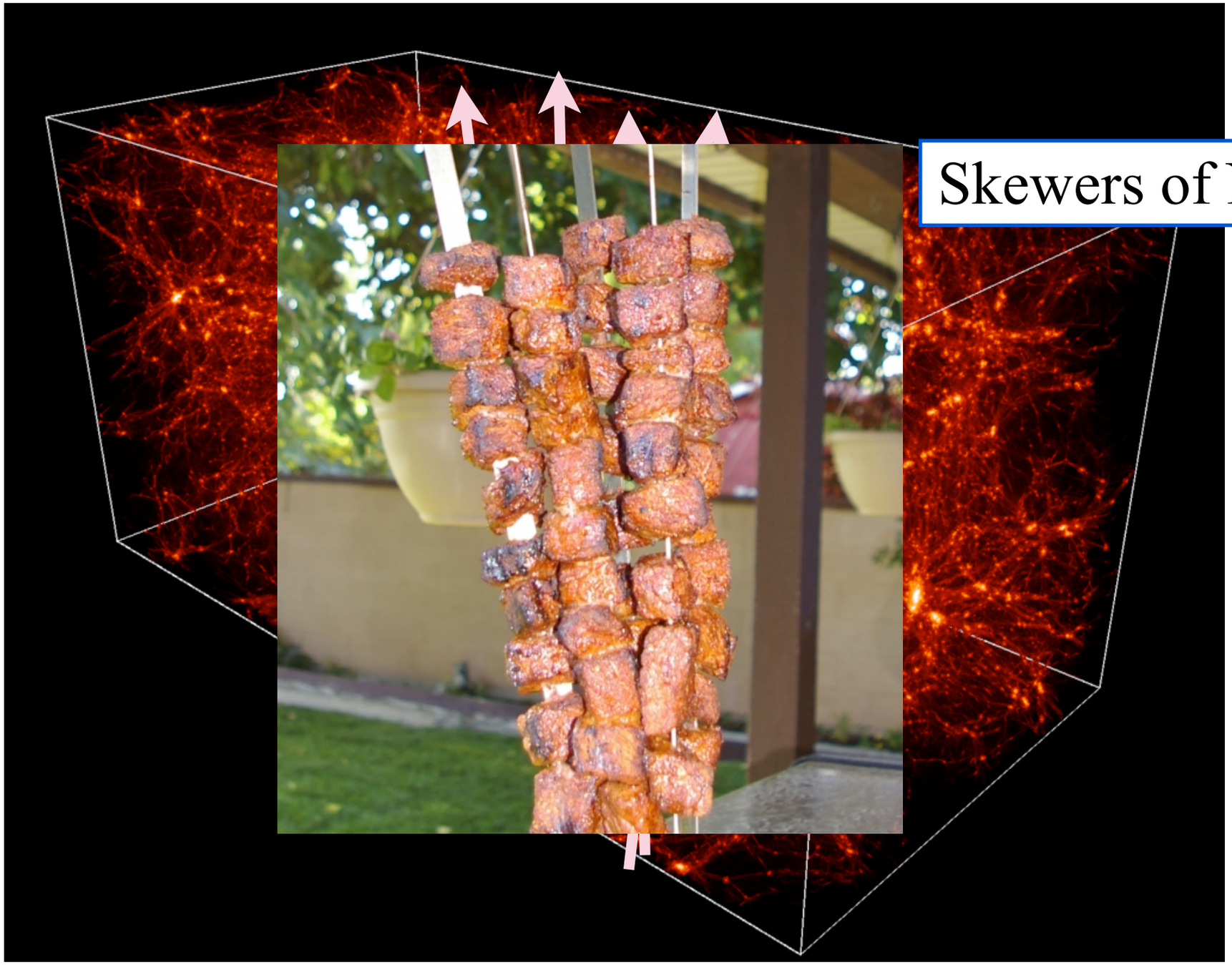
Fluctuating Gunn Peterson approximation

$$\tau = A(1+\delta)^\beta$$

$$F = e^{-\tau}$$

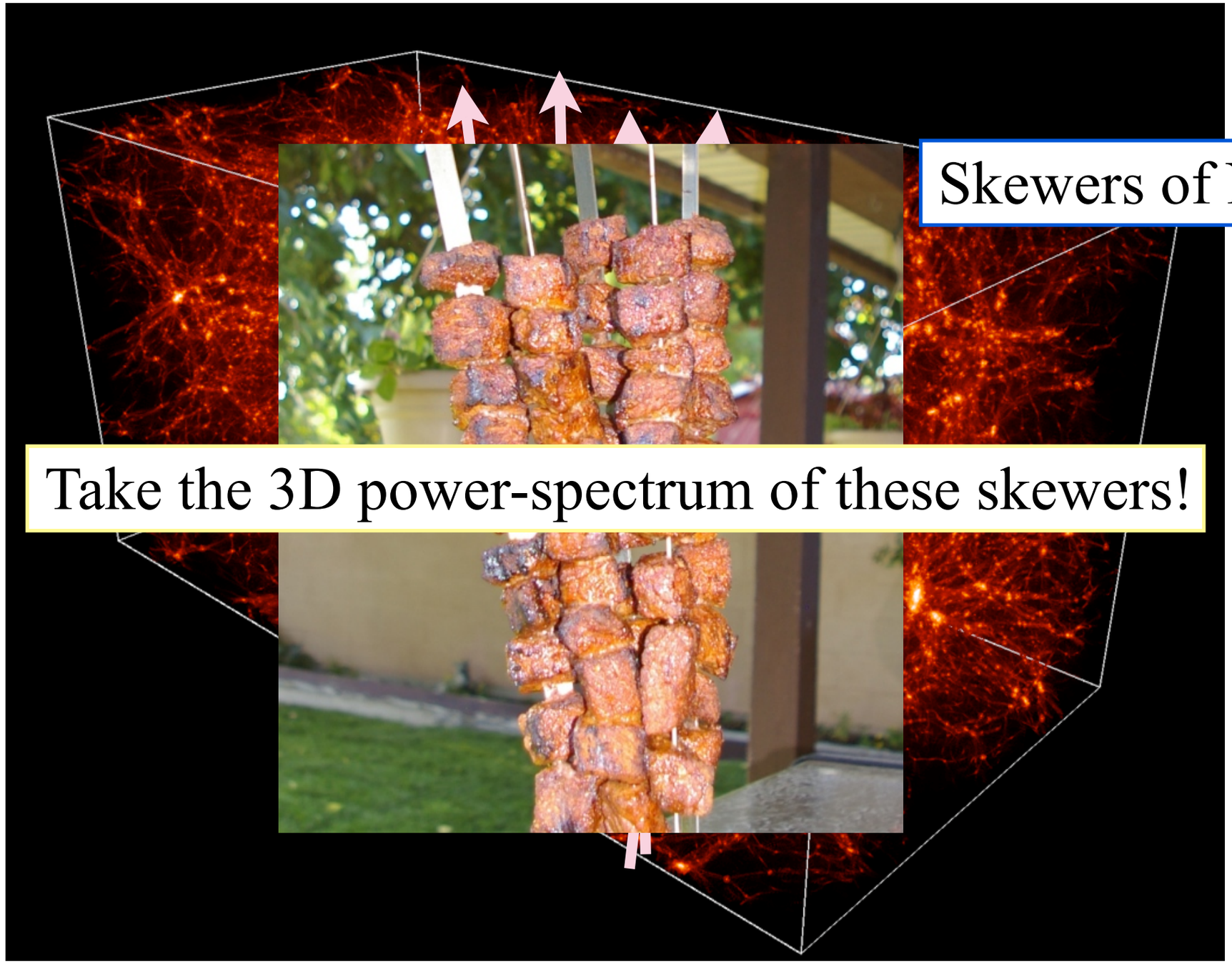
Lyman Alpha Forest: what can it do?

- **Primordial Non-gaussianities via Lyman alpha forest**



Skewers of Neutral Hydrogen

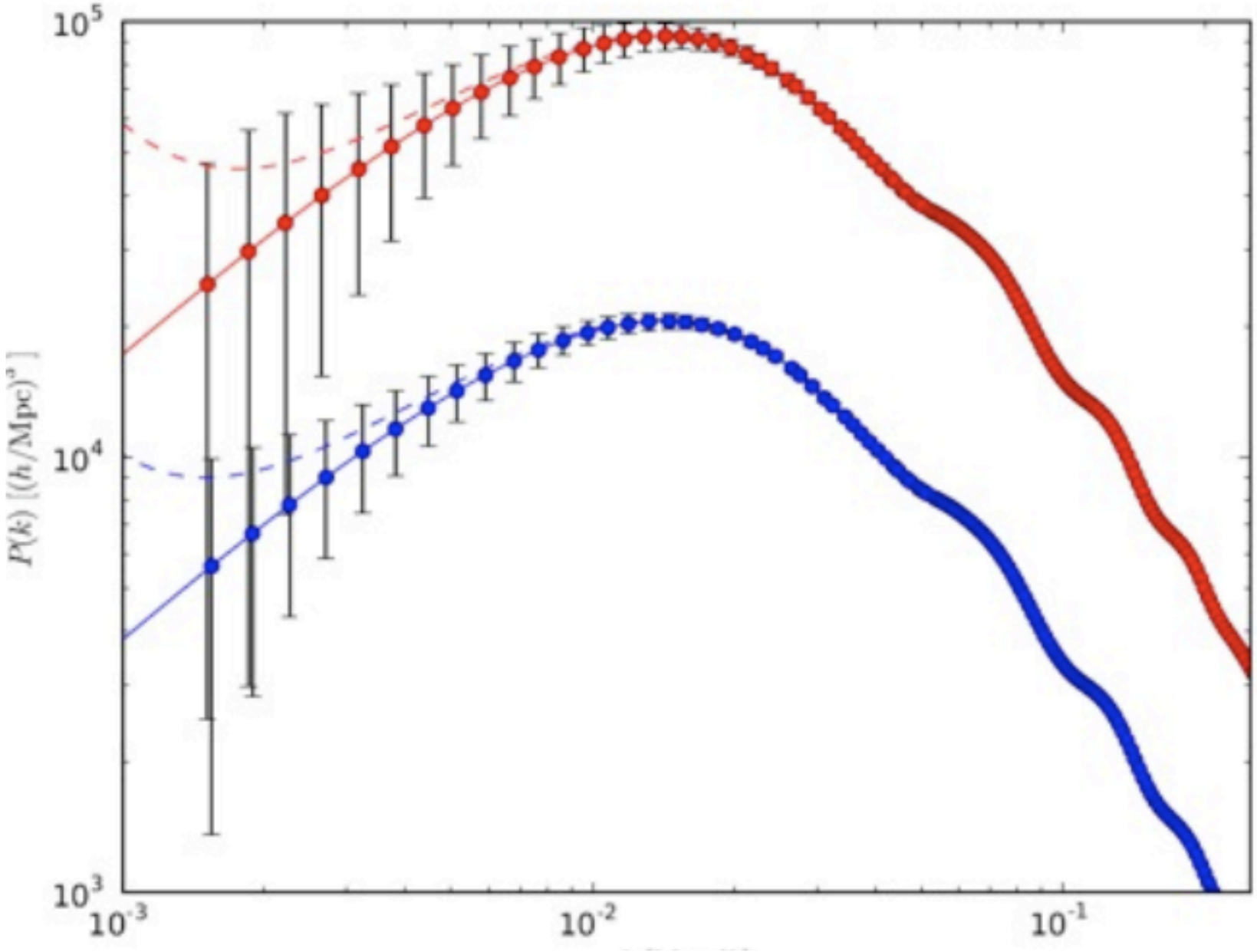
Lyman Alpha Forest: what can it do?



Skewers of Neutral Hydrogen

Take the 3D power-spectrum of these skewers!

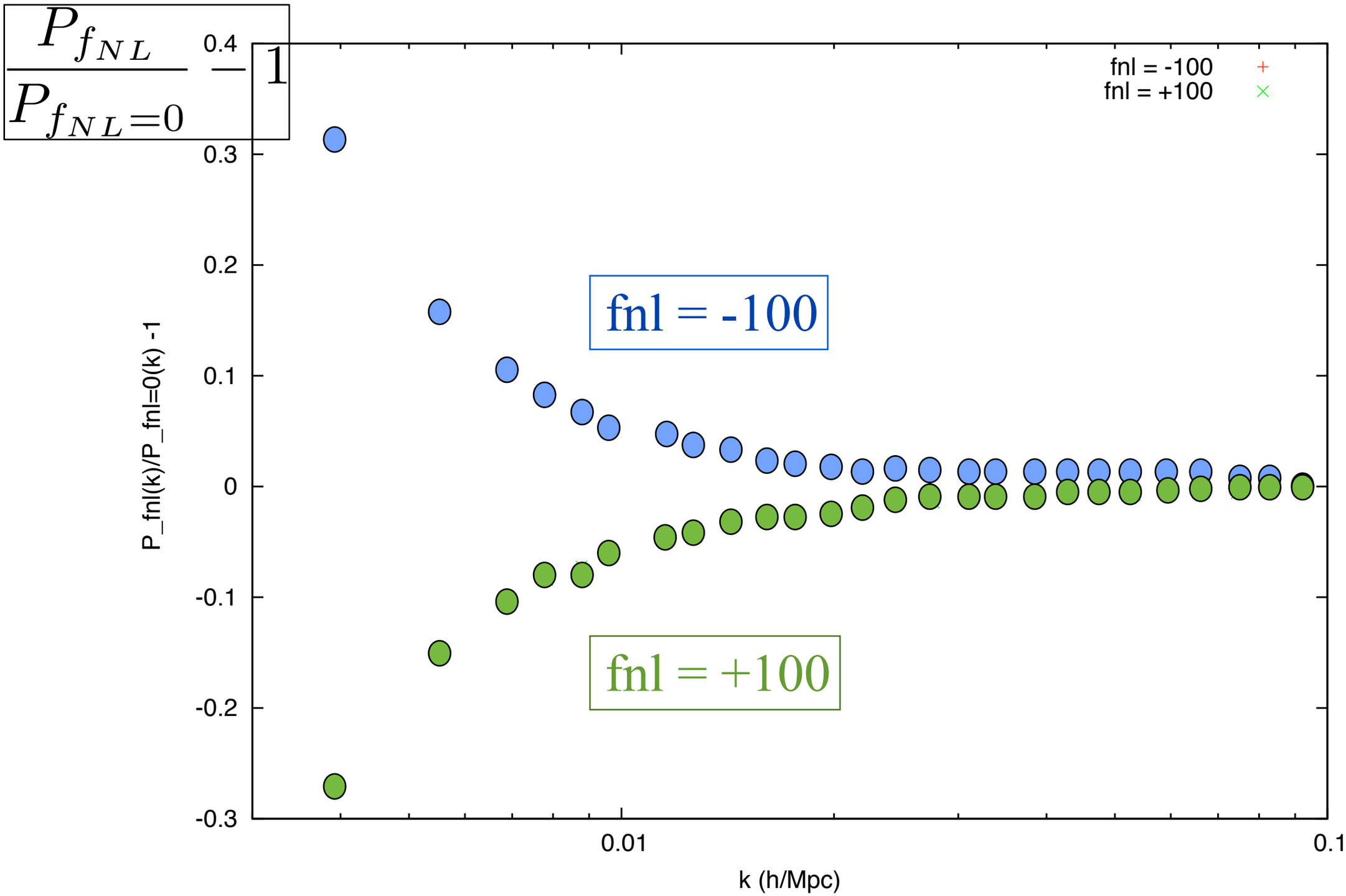
P(k) (Mpc/h)^3



k (h/Mpc)

Courtesy slide from Anze Slosar

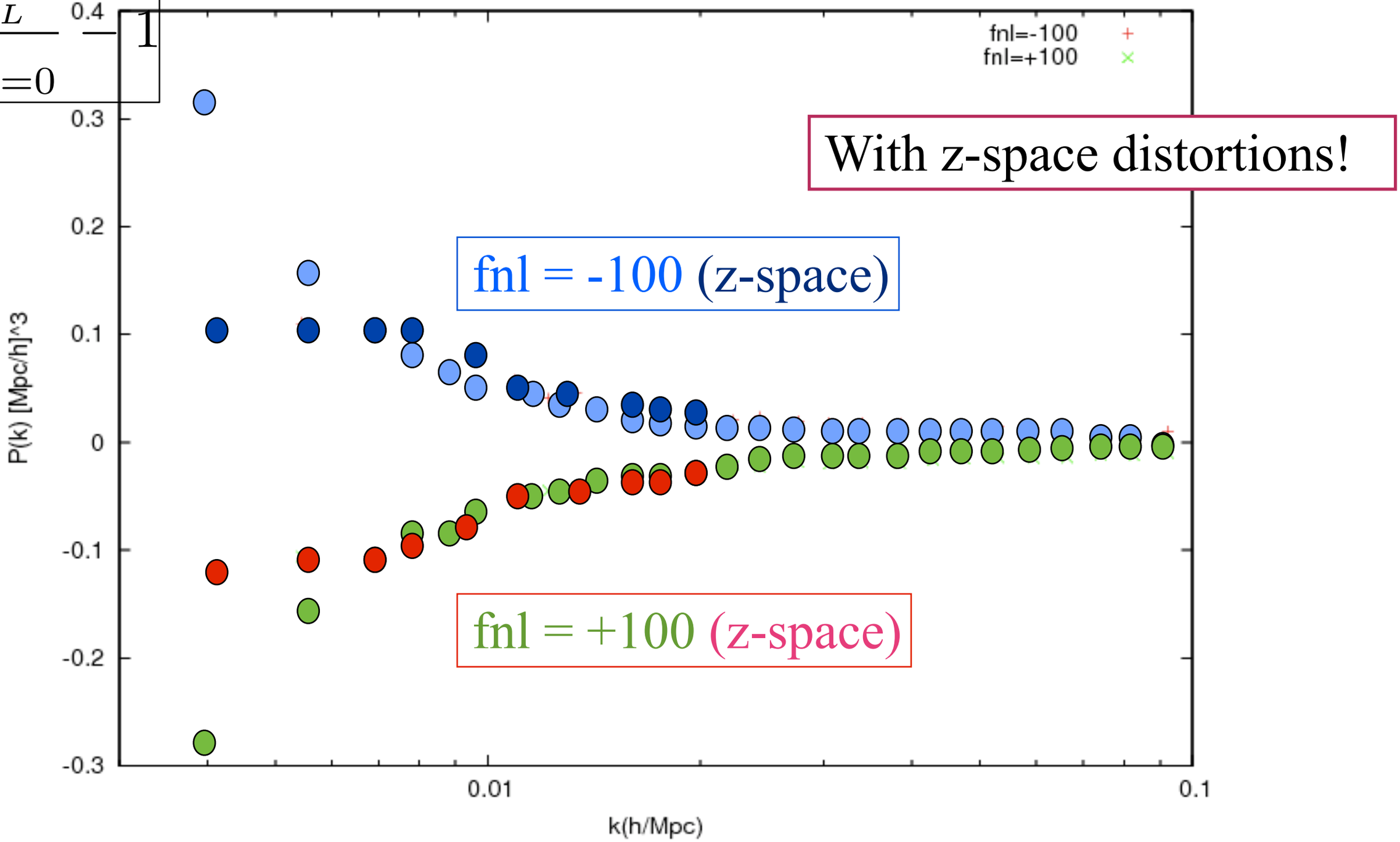
What can we do with Lya and fnl?



Ho, Slosar, Seljak & Desjacques (in prep)

What can we do with Lya and fnl?

$$\frac{P_{f_{NL}}}{P_{f_{NL}=0}} - 1$$



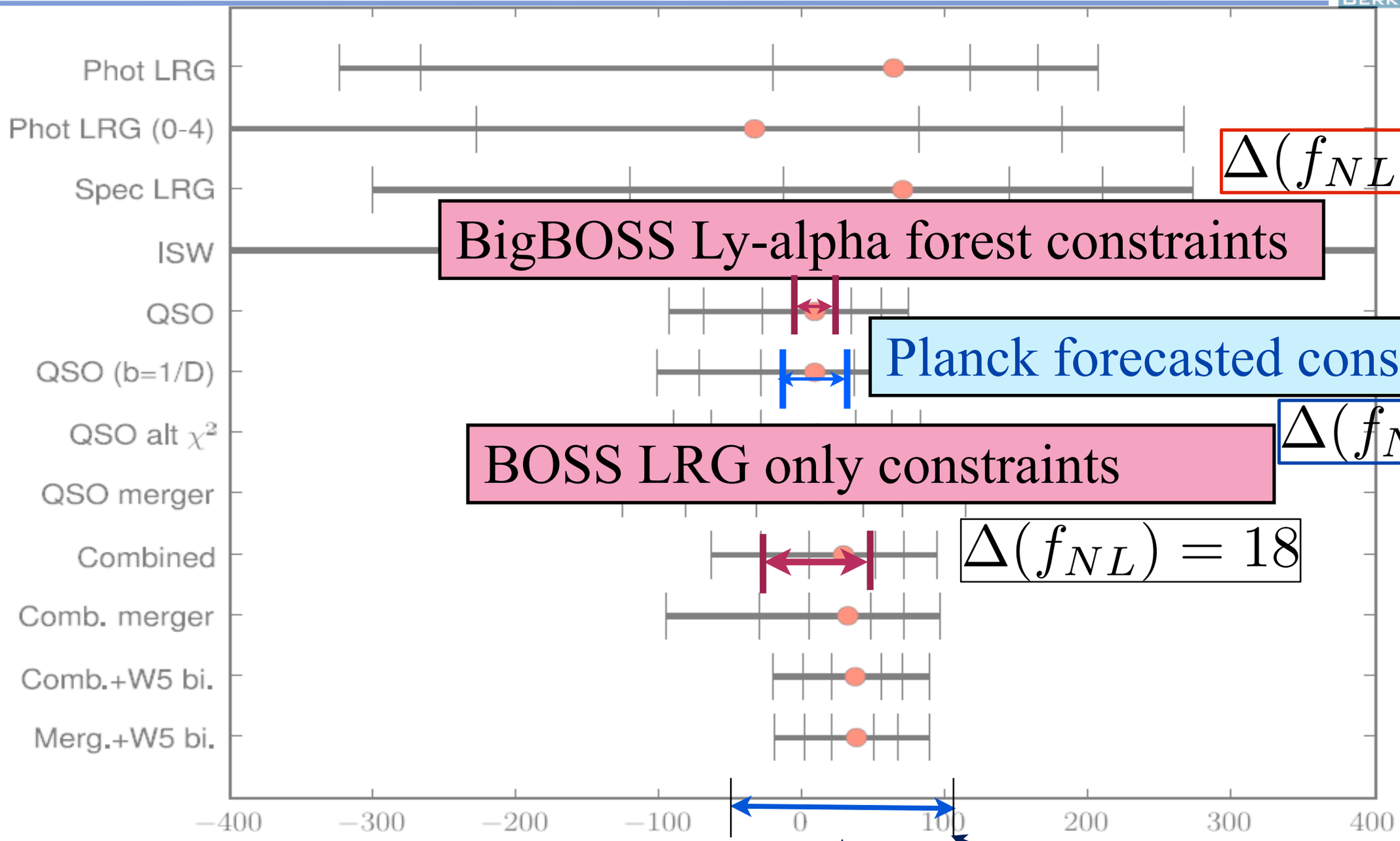
With z-space distortions!

fnl = -100 (z-space)

fnl = +100 (z-space)

Ho, Slosar, Seljak & Desjacques (in prep)

What can we do with Lya and fnl?
—Non-gaussianities in Early Universe



Best current CMB measurement

Ho, Slosar, Seljak & Desjacques (in prep)

canonical inflation

curvaton models, DBI inflation

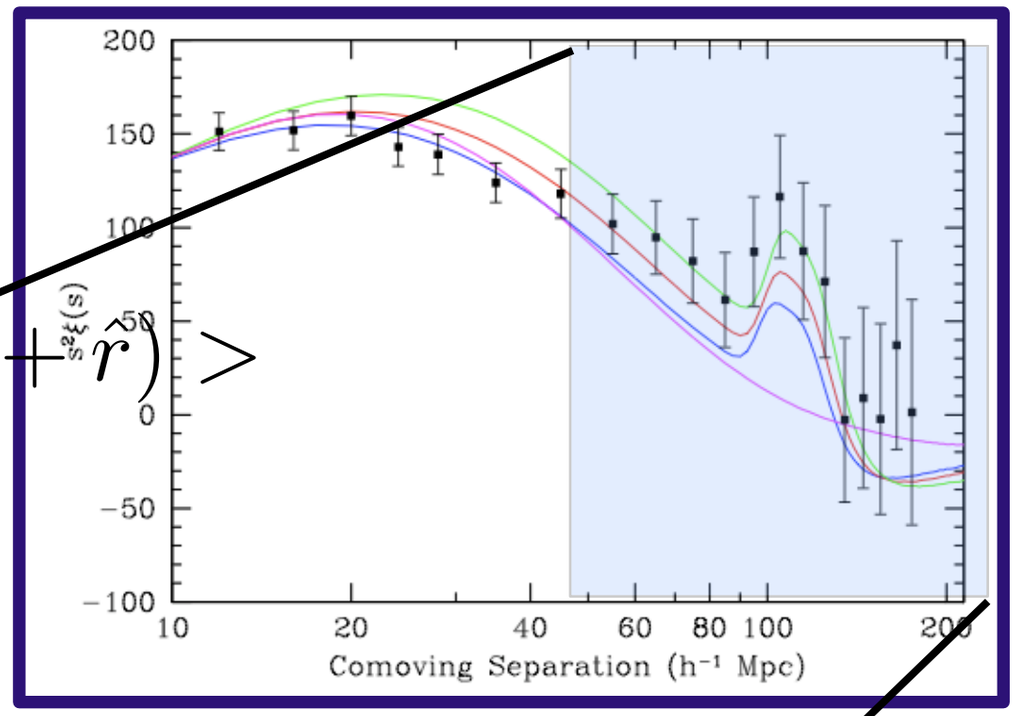
ghost inflation

Other cool things you can do with Lya forest: Lyman Alpha Forest BAO

- **Dark Energy via Baryon Acoustic Oscillations**

—the correlation function:

$$\xi_f(r) = < \delta_f(\hat{x}) \delta_f(\hat{x} + \hat{r}) >$$



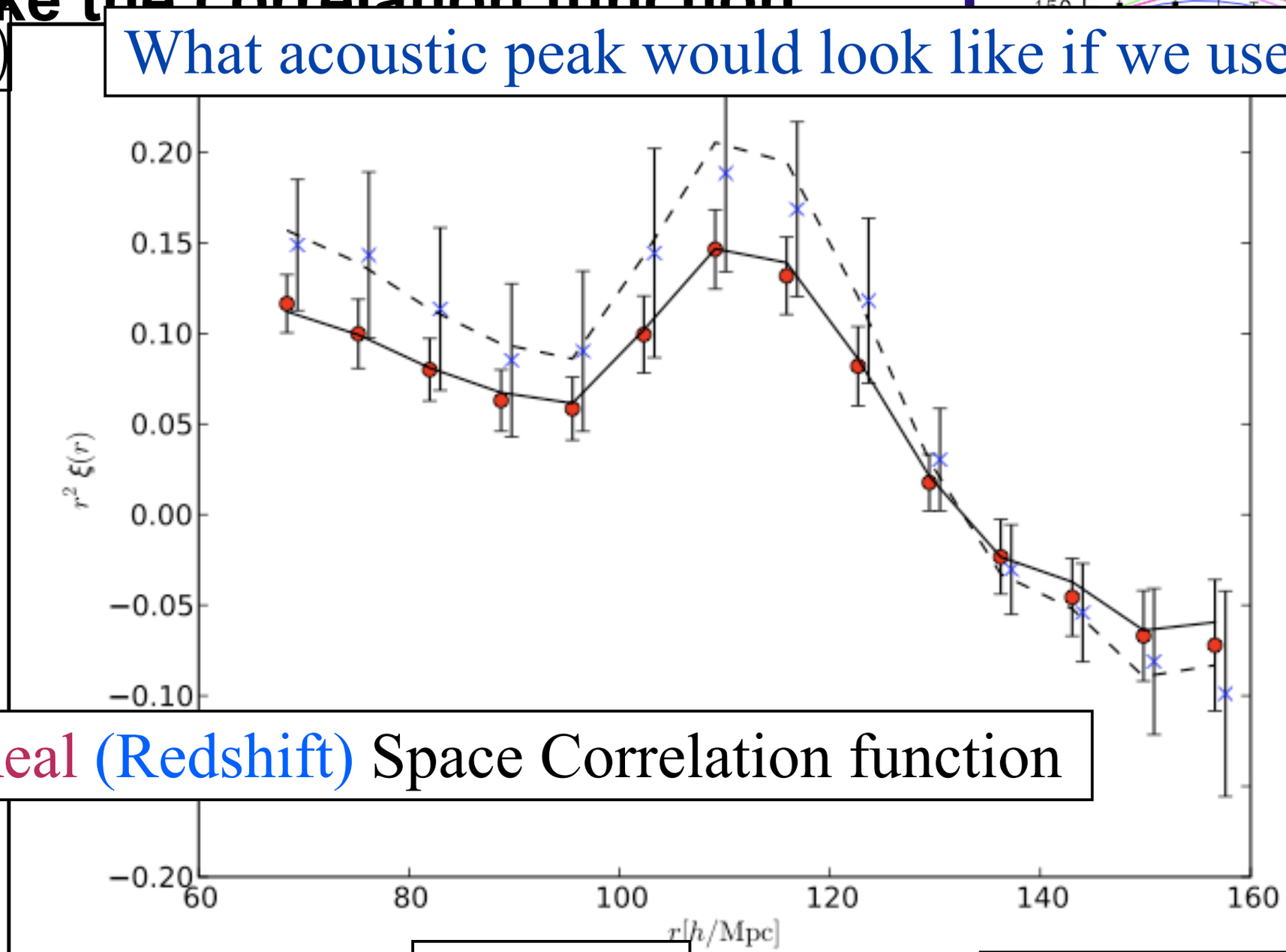
Other cool things you can do with Lya forest: Lyman Alpha Forest BAO

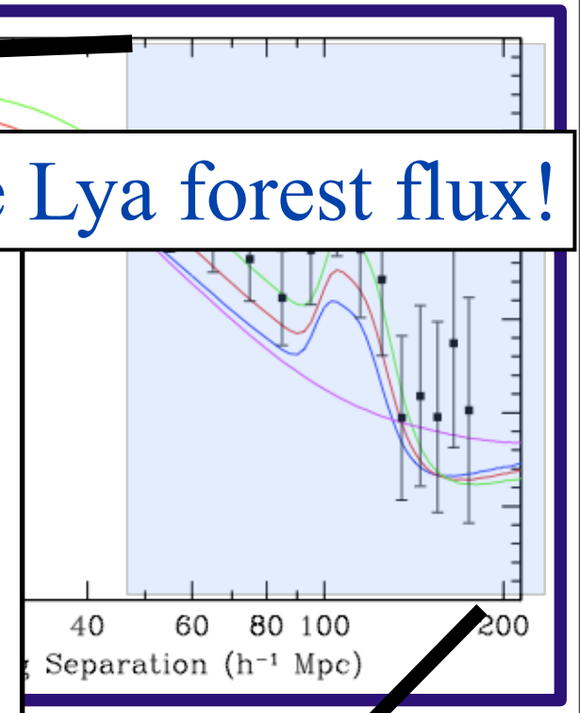
- **Dark Energy via Baryon Acoustic Oscillations**

take the correlation function:

$r^2\xi(r)$

What acoustic peak would look like if we use Lya forest flux!





Flux Real (Redshift) Space Correlation function

r (h/Mpc)

Slosar, Ho, White & Louis (2009)

Lyman alpha forest BAO: S/N estimates

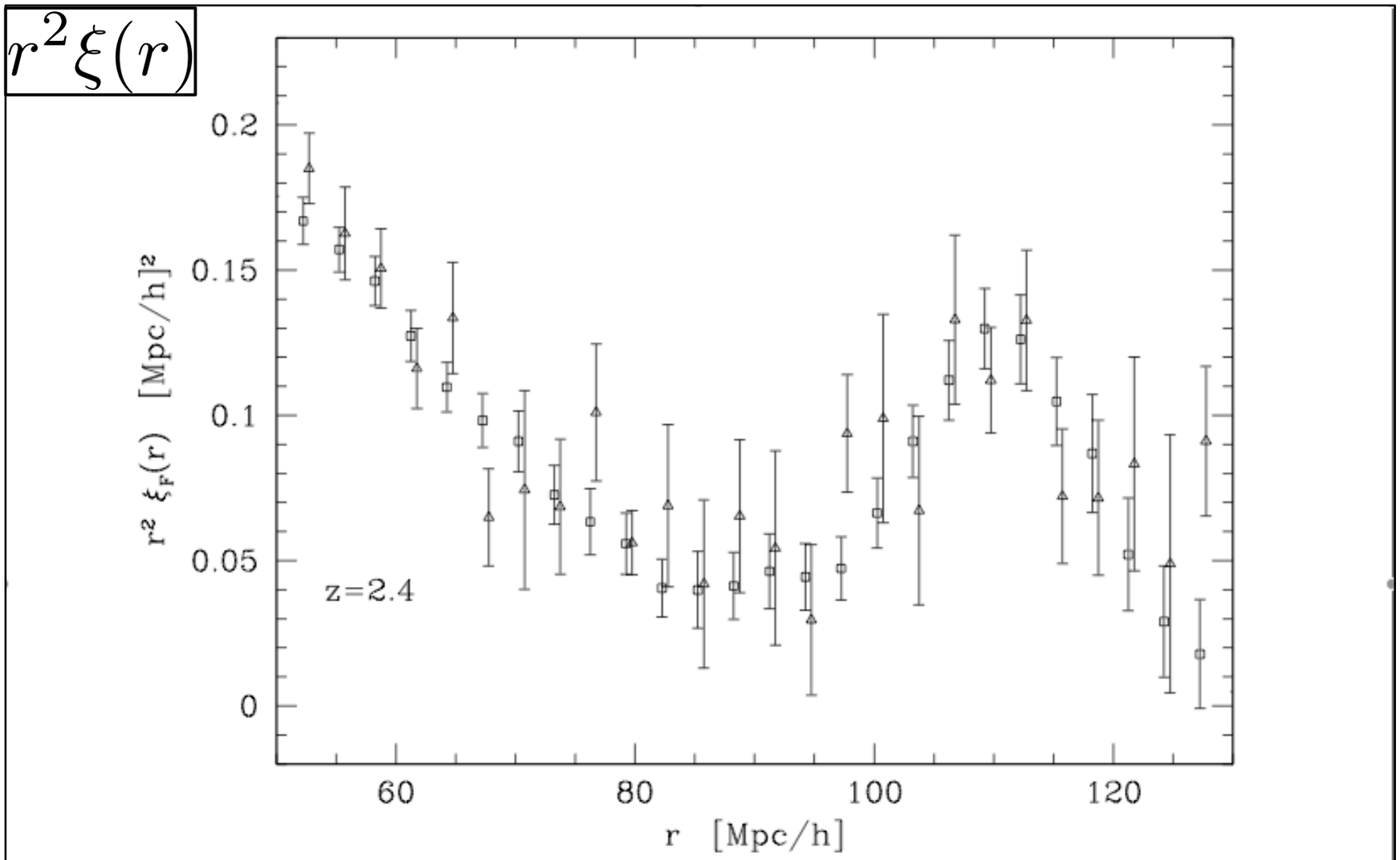


FIG. 7.— The redshift space, flux correlation function for the spectra with no noise (squares) and including noise with $S/N = 1$ per h^{-1}Mpc (which is close to 1 per Å; triangles). The errors are estimated by bootstrapping the 9 boxes.

r (h/Mpc)

White et al. (in prep)

Conclusion

- What would BigBOSS do for fnl?
  - —Galaxy and QSO powerspectrum
  - —Galaxy and QSO bispectrum
  - —Lyman alpha forest
    - Lya flux powerspectra with different non-gaussianities
    - How about with redshift space distortions?
- Other cool things you can do with Lya forest:
  - —Lya forest BAO