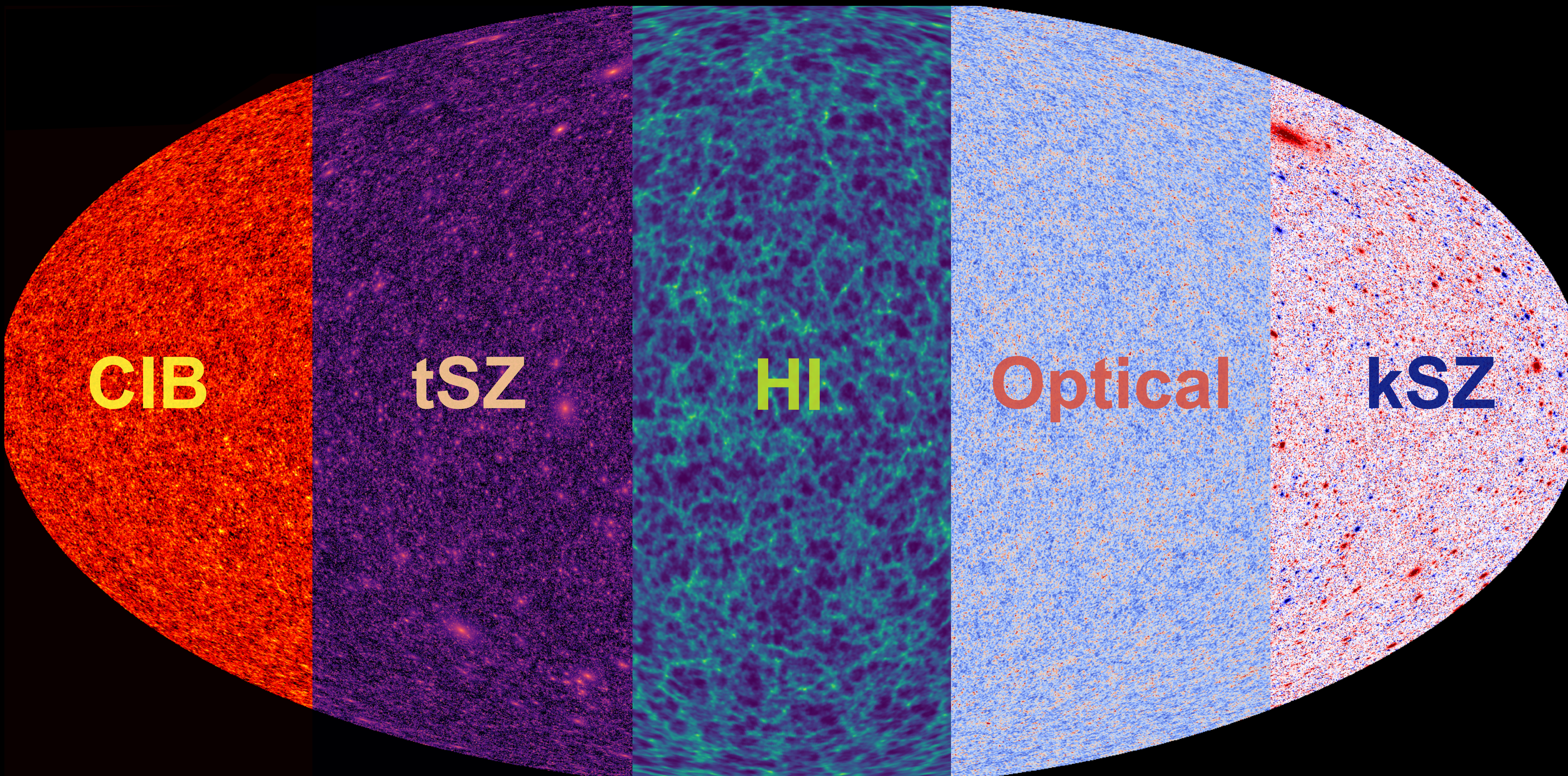
Primordial non-Gaussianity with Large Scale Structure

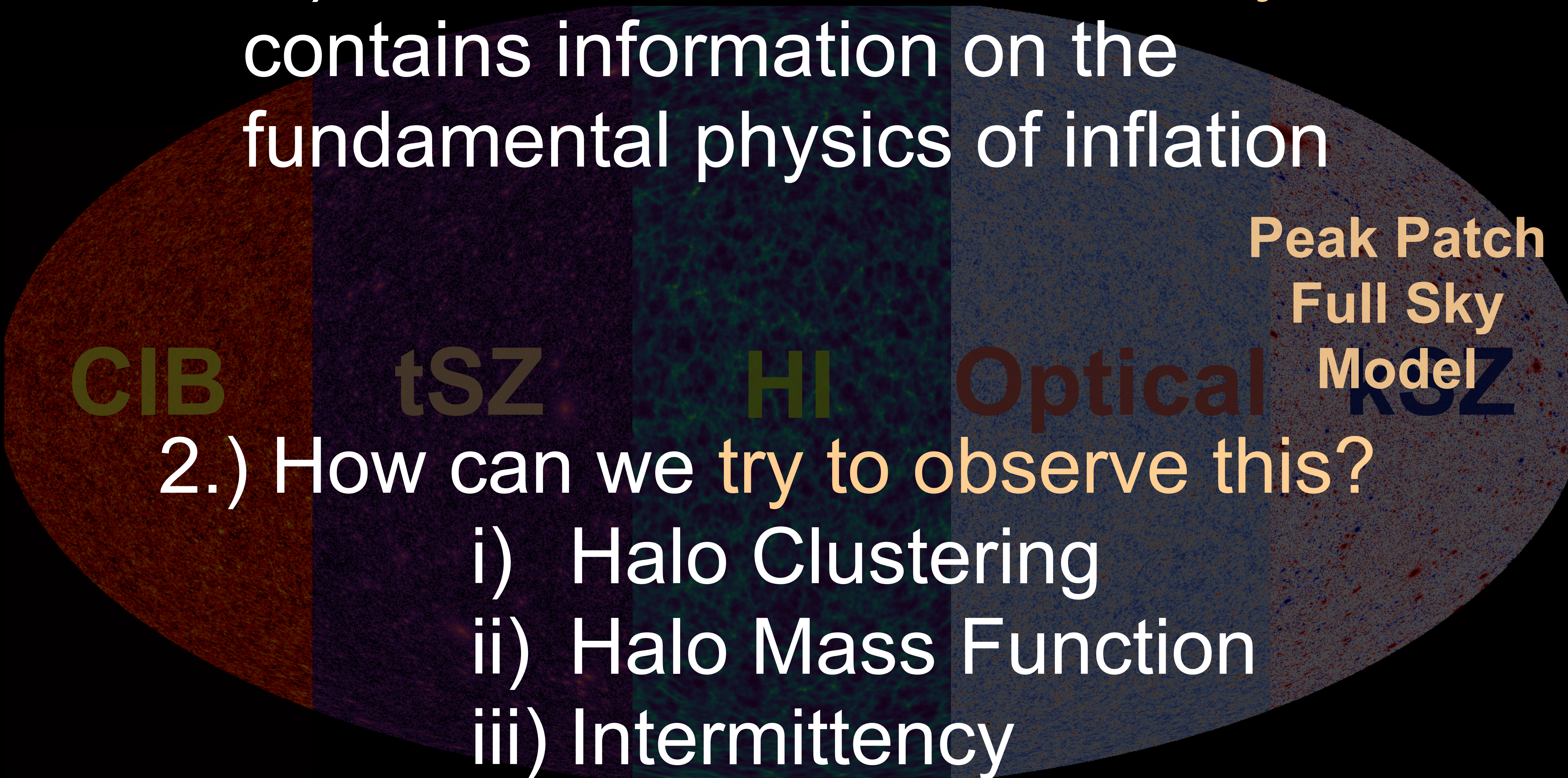


CITA ICAT
Canadian Institute for Theoretical Astrophysics
L'institut Canadien d'astrophysique théorique

George Stein

Collaborators: Dick Bond, Marcelo Alvarez, Zhiqi Huang, Phillipe Berger

1.) Primordial non-Gaussianity contains information on the fundamental physics of inflation



Peak Patch Full Sky Model

2.) How can we try to observe this?

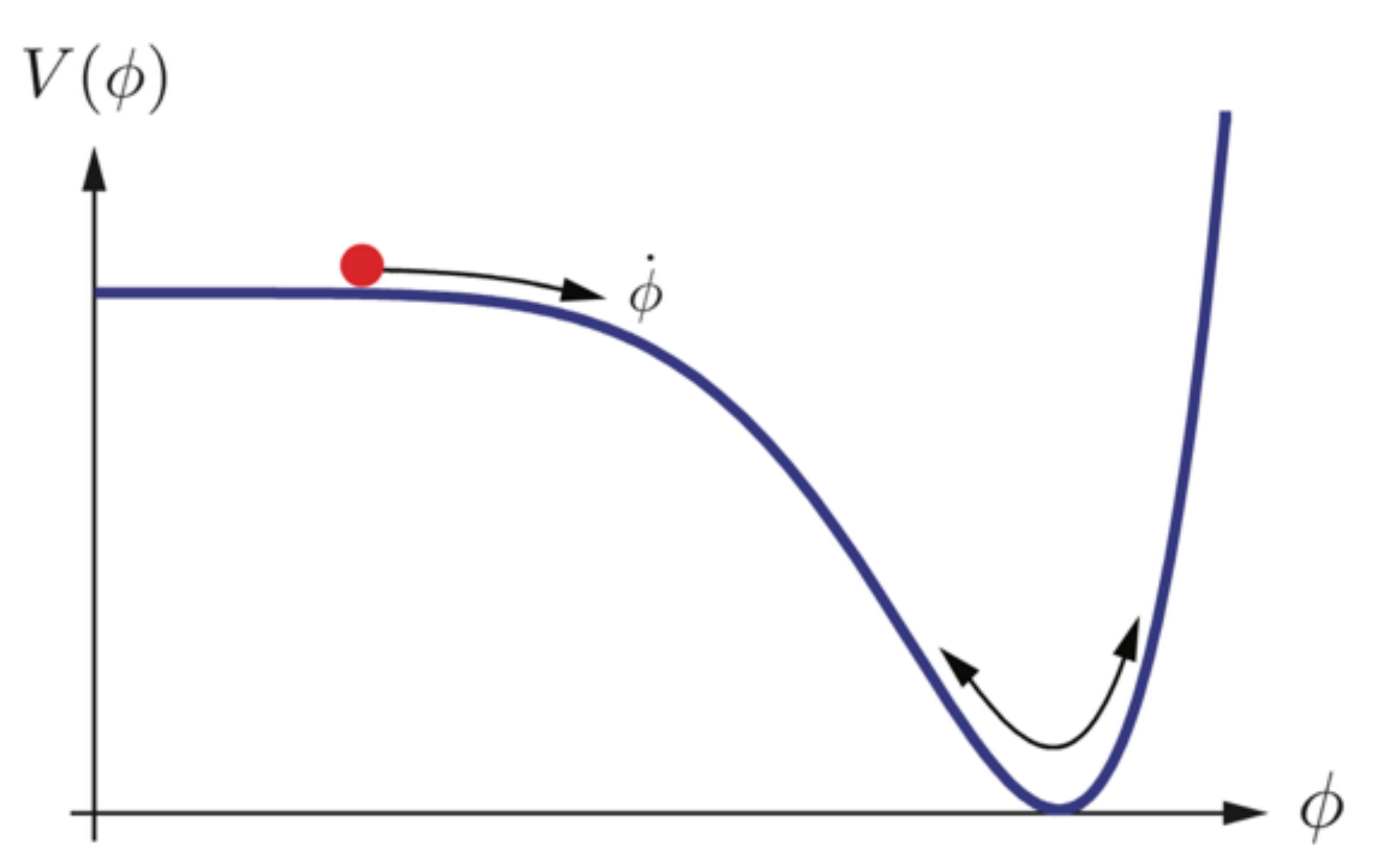
i) Halo Clustering
ii) Halo Mass Function
iii) Intermittency

Φ

Classical Inflation

Single-Field Slow-Roll

- Motion of inflaton drives accelerated expansion
- Simple & Computable



Credit: Daniel Baumann

$$\mathcal{L}_\Phi = -\frac{1}{2}(\partial\Phi)^2 - V(\Phi)$$

Single-Field Slow-Roll Predicts:

Gaussian Initial Conditions

~Scale Invariant

Classical Inflation

Single-Field Slow-Roll

- Motion of inflaton drives accelerated expansion
- Simple & Computable

Credit: Daniel Baumann

$$\mathcal{L}_\Phi = -\frac{1}{2}(\partial\Phi)^2 - V(\Phi)$$

σ χ

Multi Field Inflation

~~Single Field~~ *Slow-Roll*

1. Spectator Field σ
   - Local non-Gaussianity f_{NL}
   - Scale dependent bias

$$\Phi(x) = \phi(x) + f_{NL}(\phi^2 - <\phi^2>)$$

Salopek and Bond (1990)
Komatsu et al. (WMAP)
Dalal et al. (2008)
Grossi et al. (2009)
Pillepich et al. (2009)

2. Non-Inflaton Light Field χ
   - Intermittent non-Gaussianity

$$\zeta(x) = F_{NL}(\chi(x))$$

Bond, Frolov, Huang, Kofman (2009)

Case Study 1:

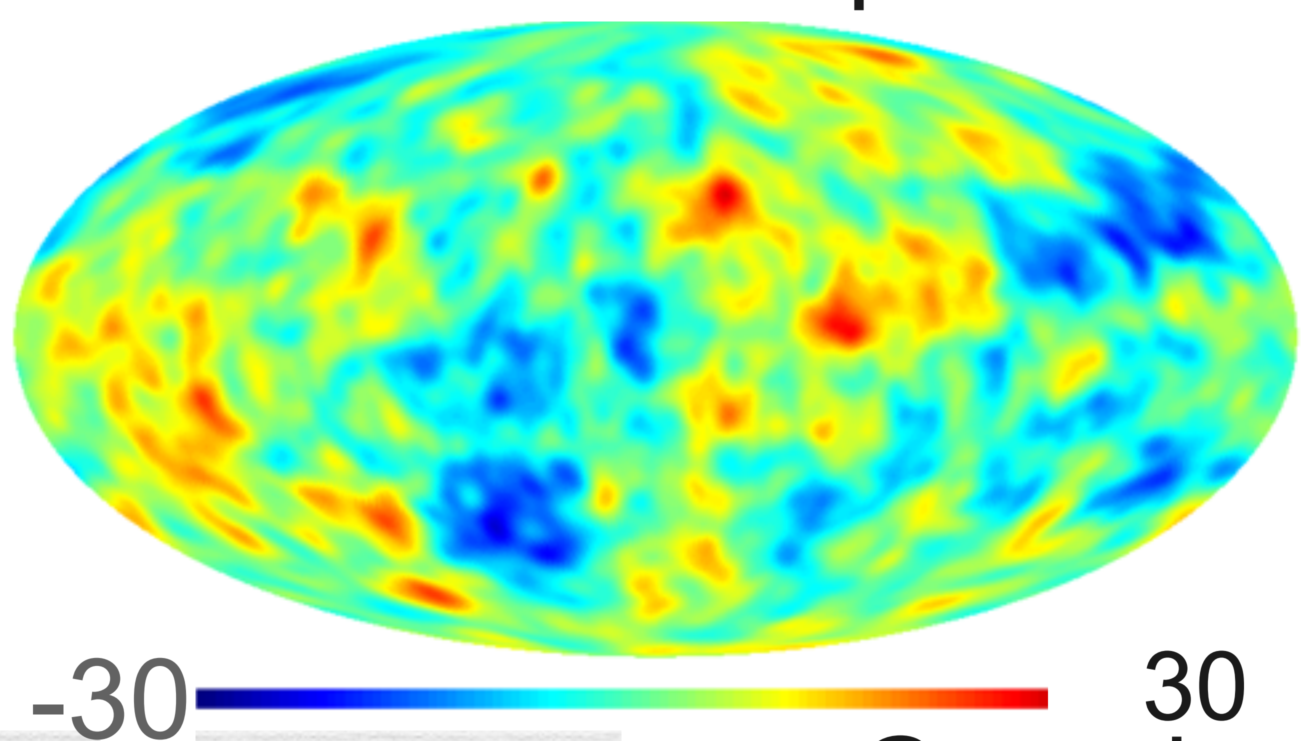
"Classic" Local f_{NL}

Case Study 2:

Intermittent non-Gaussianity

CMB Example: Gravitational Potential Maps

Gaussian Component



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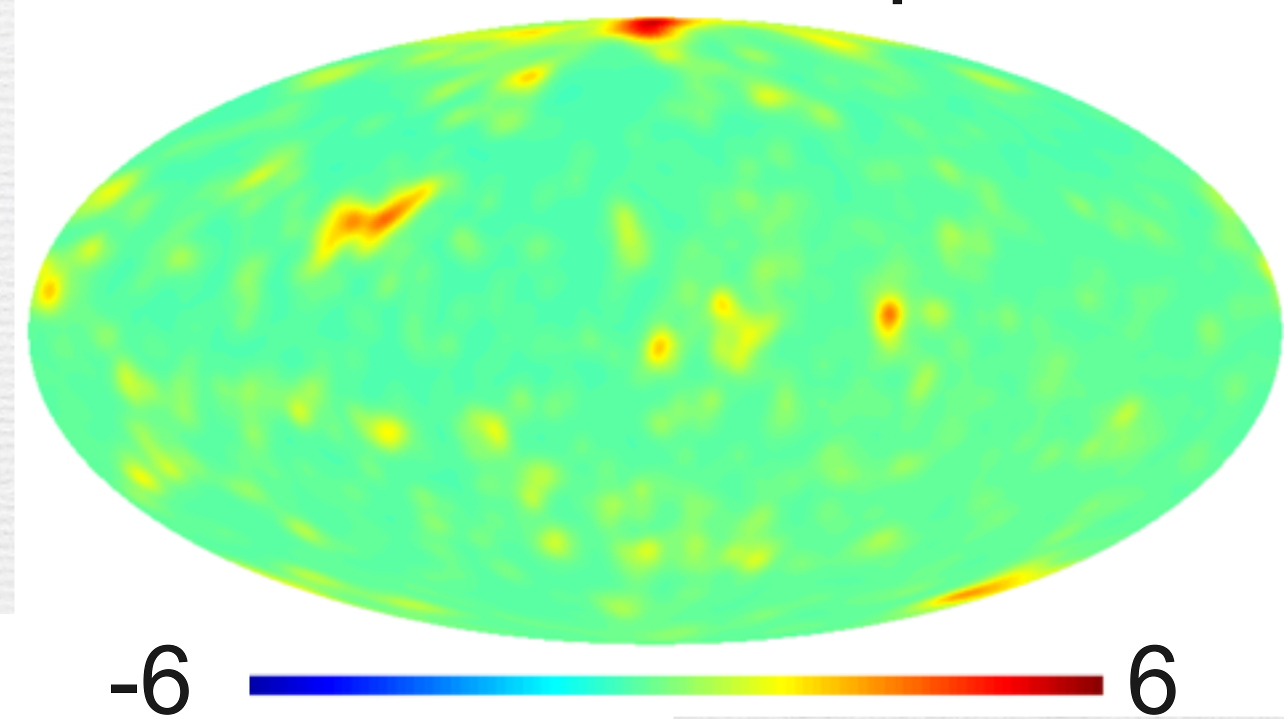
Intermittent Component



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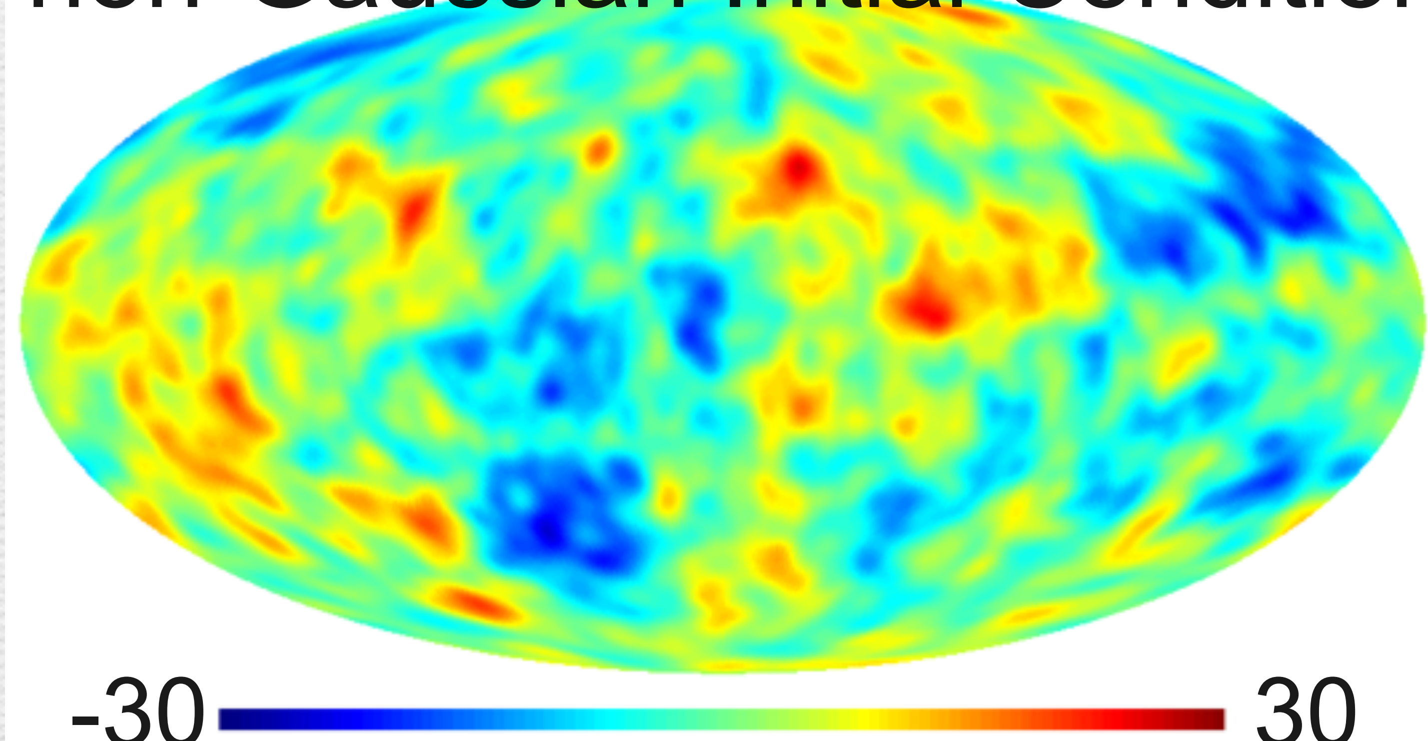
non-Gaussian Initial Conditions



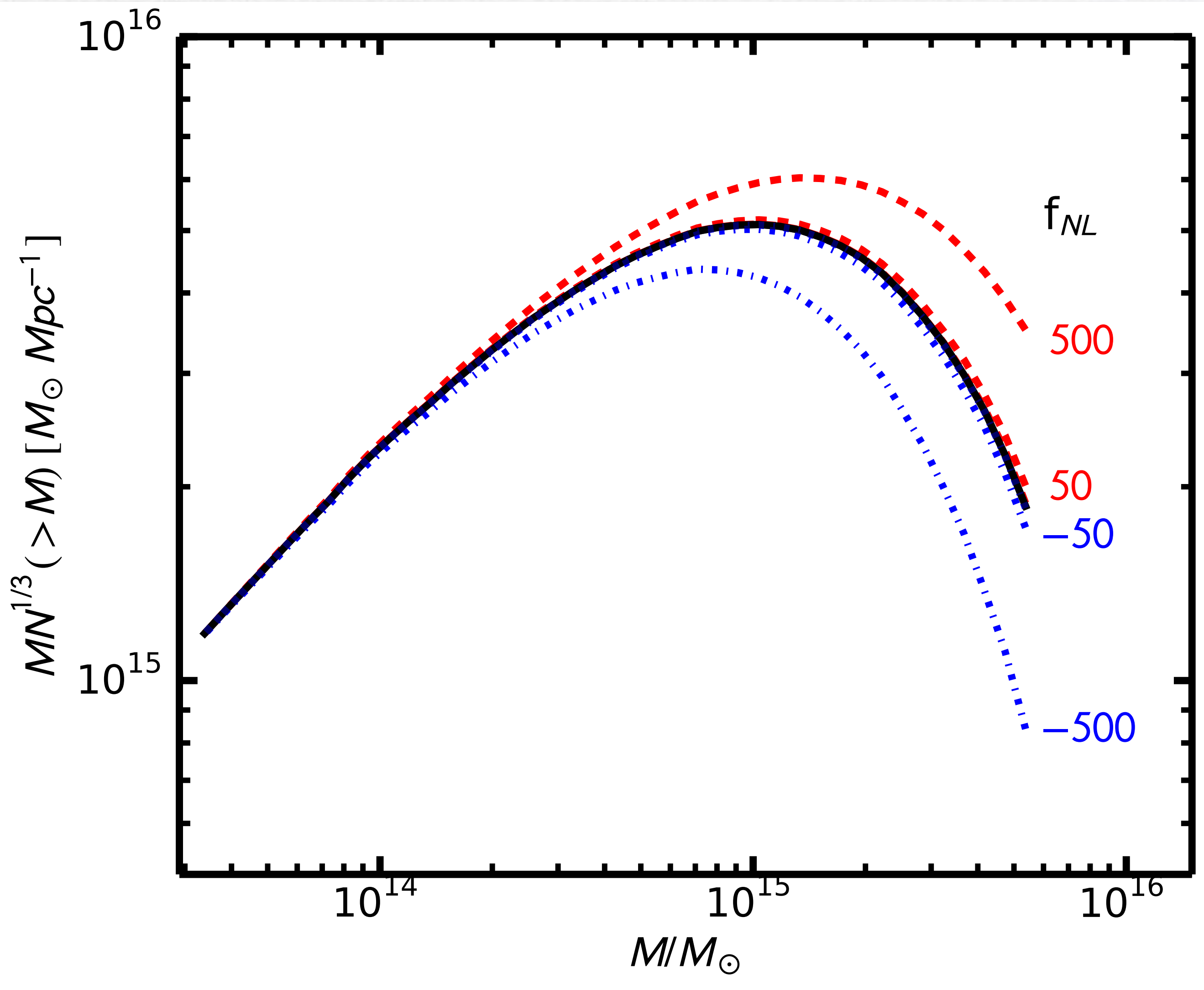
Bond, Frolov, Huang, Kofman (2009)

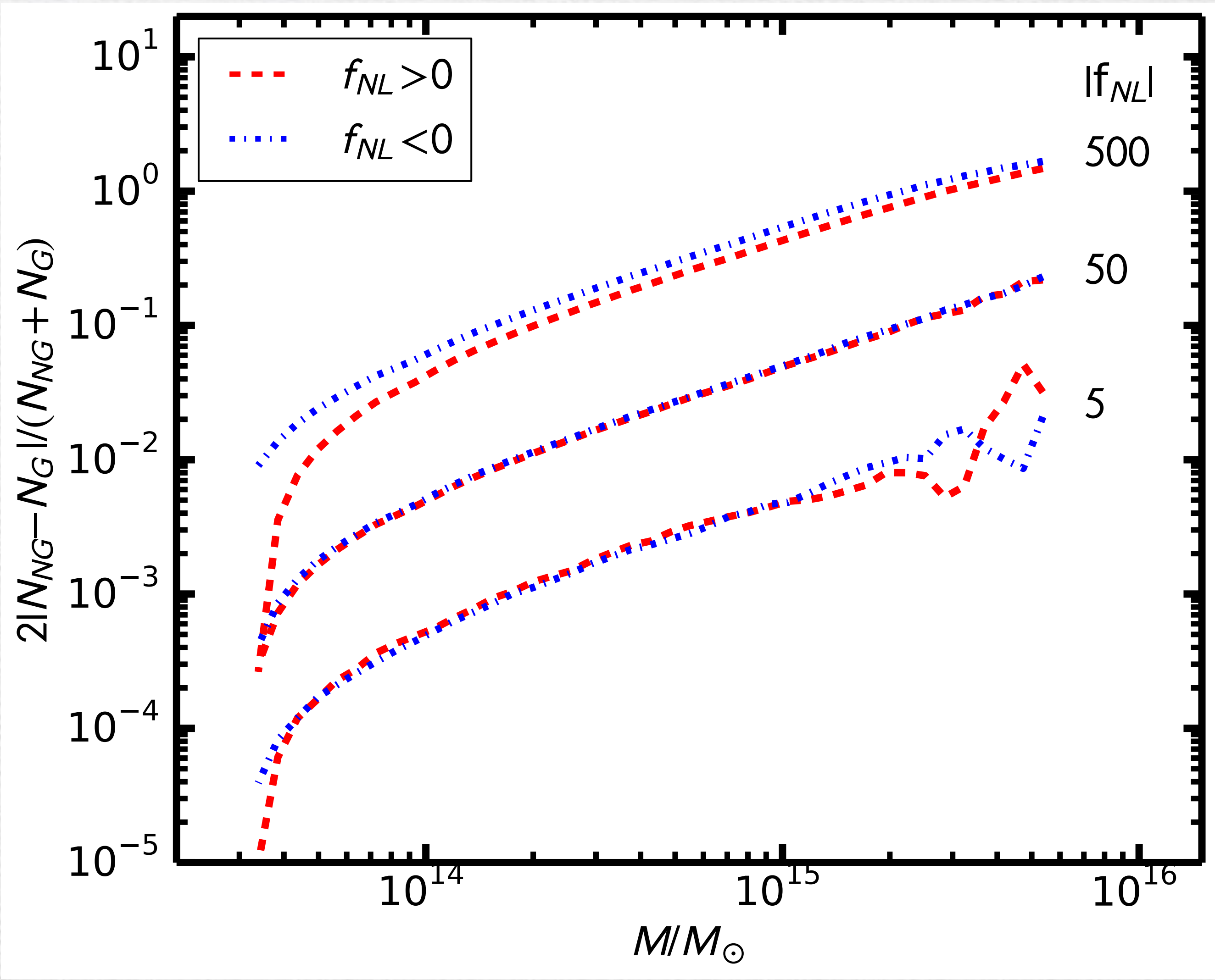
Halo Mass Function is strongly affected only for large f_{NL}

Local non-Gaussianity

$$\Phi(x) = \phi(x) + f_{NL}(\phi^2 - <\phi^2>)$$

Peak Patch Sims: 2048 Mpc box, 1024^3 cells
900 realizations, ~3 mins each on 64 cores





Instead look at power spectrum and scale dependent bias

Local non-Gaussianity

$$\Phi(x) = \phi(x) + f_{NL}(\phi^2 - <\phi^2>)$$

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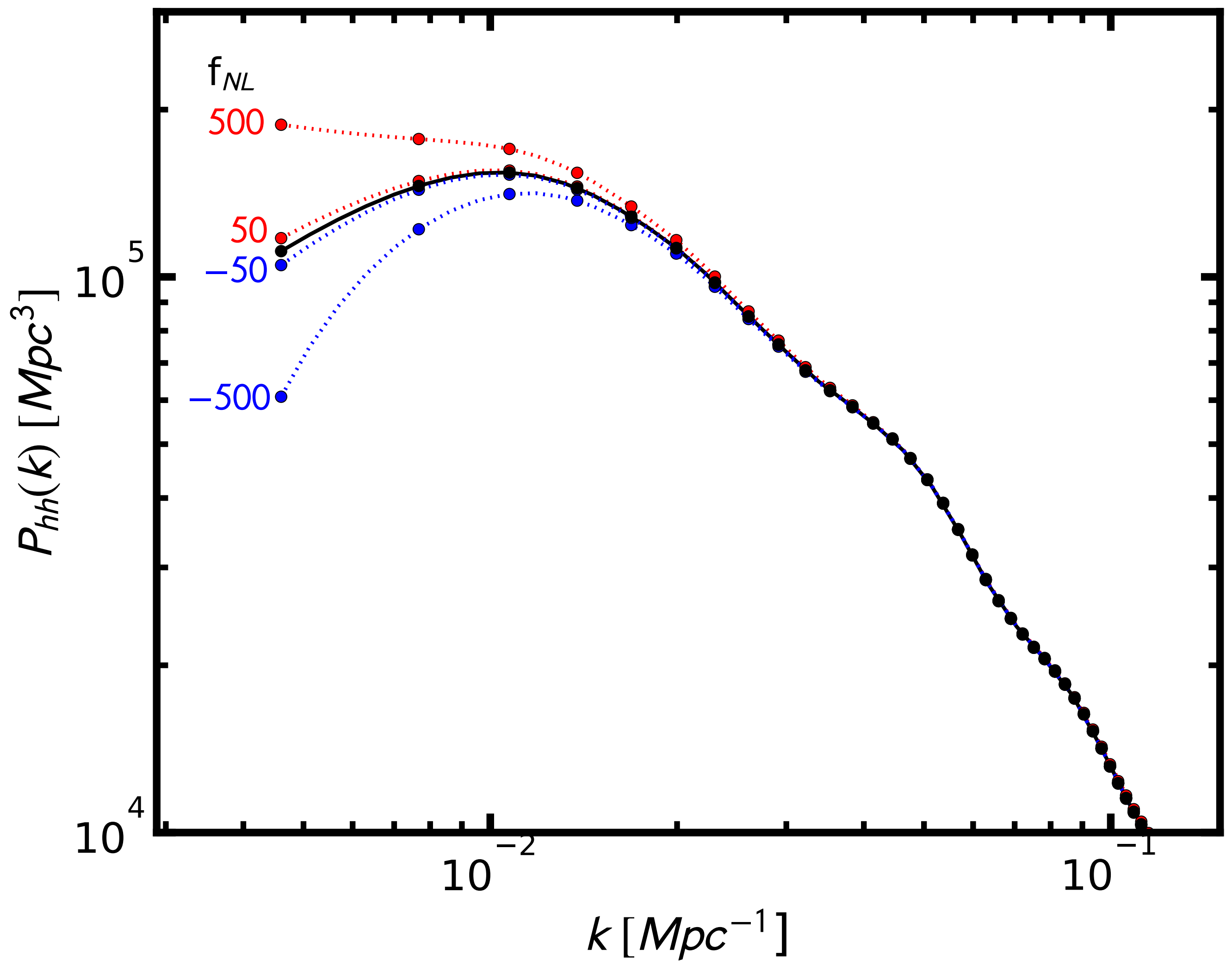
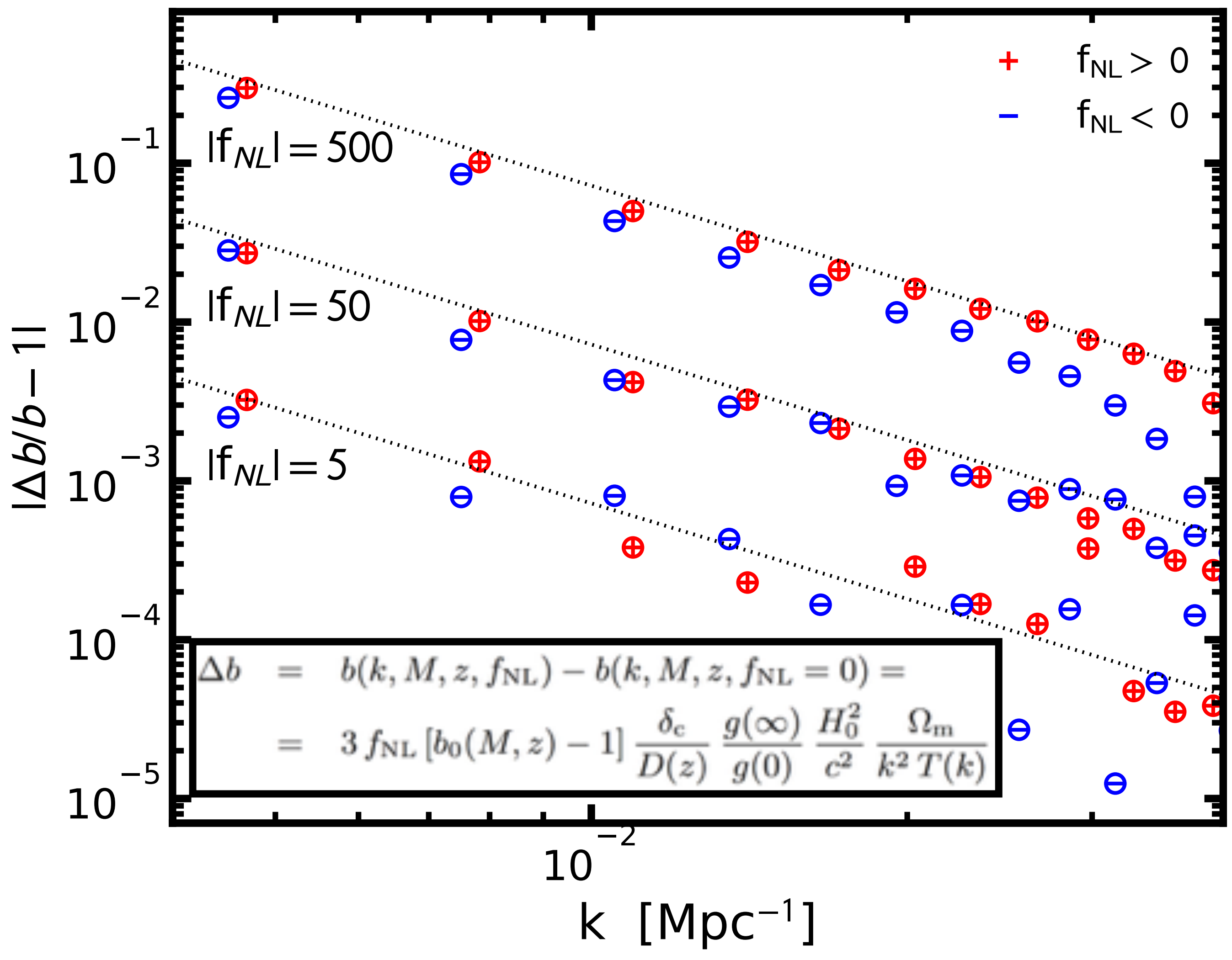
900 realizations, ~3 mins each on 64 cores





Local non-Gaussianity effects:

1.) Increased (decreased) number of most massive halos for $f_{NL} > 0$ (< 0)

2.) Scale Dependent Bias ~$1/k^2$ at low k

These have been seen before - but not to such high halos masses or for such large volumes

Peak Patch Method Viable for NG simulation

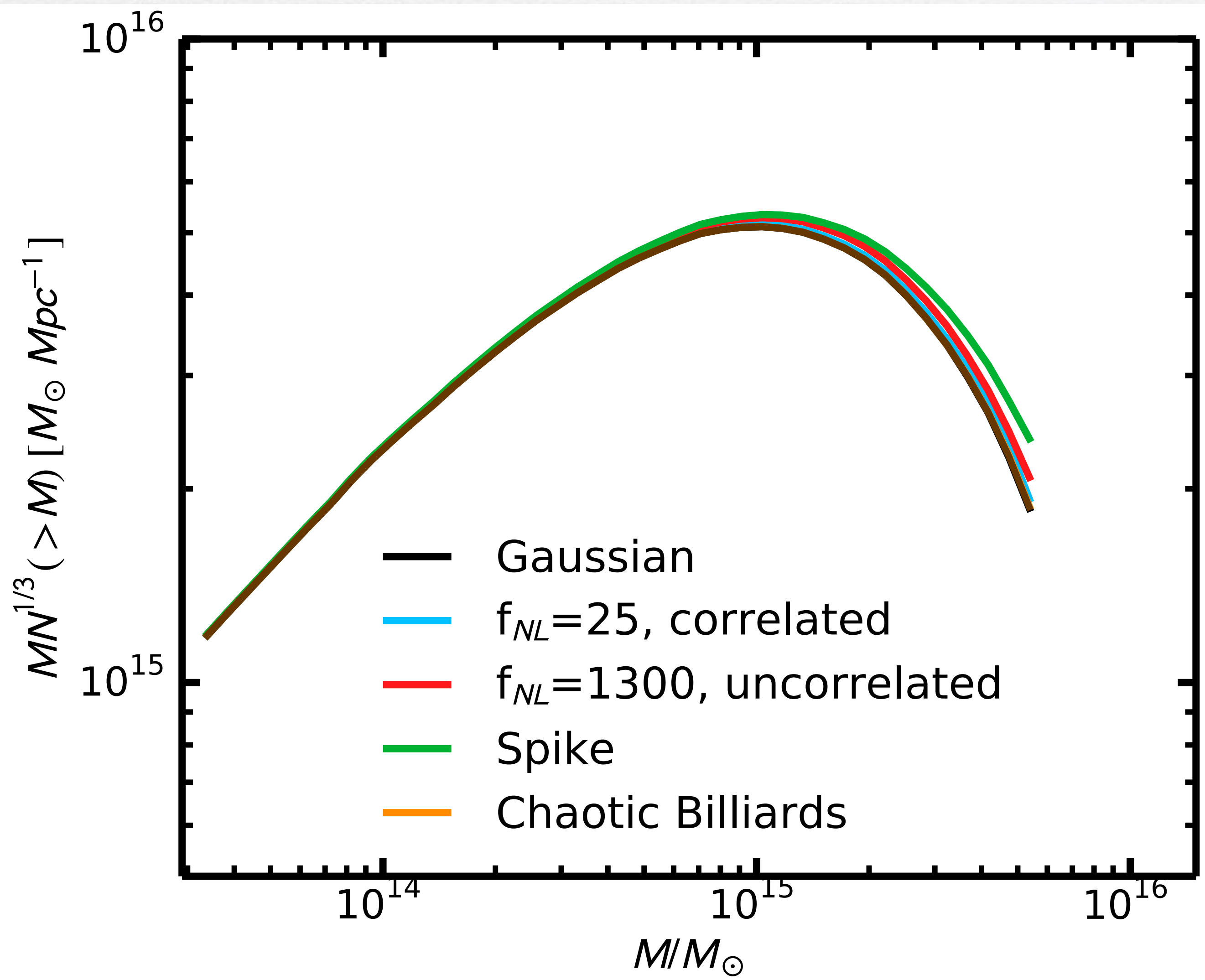
Intermittent non-Gaussianity

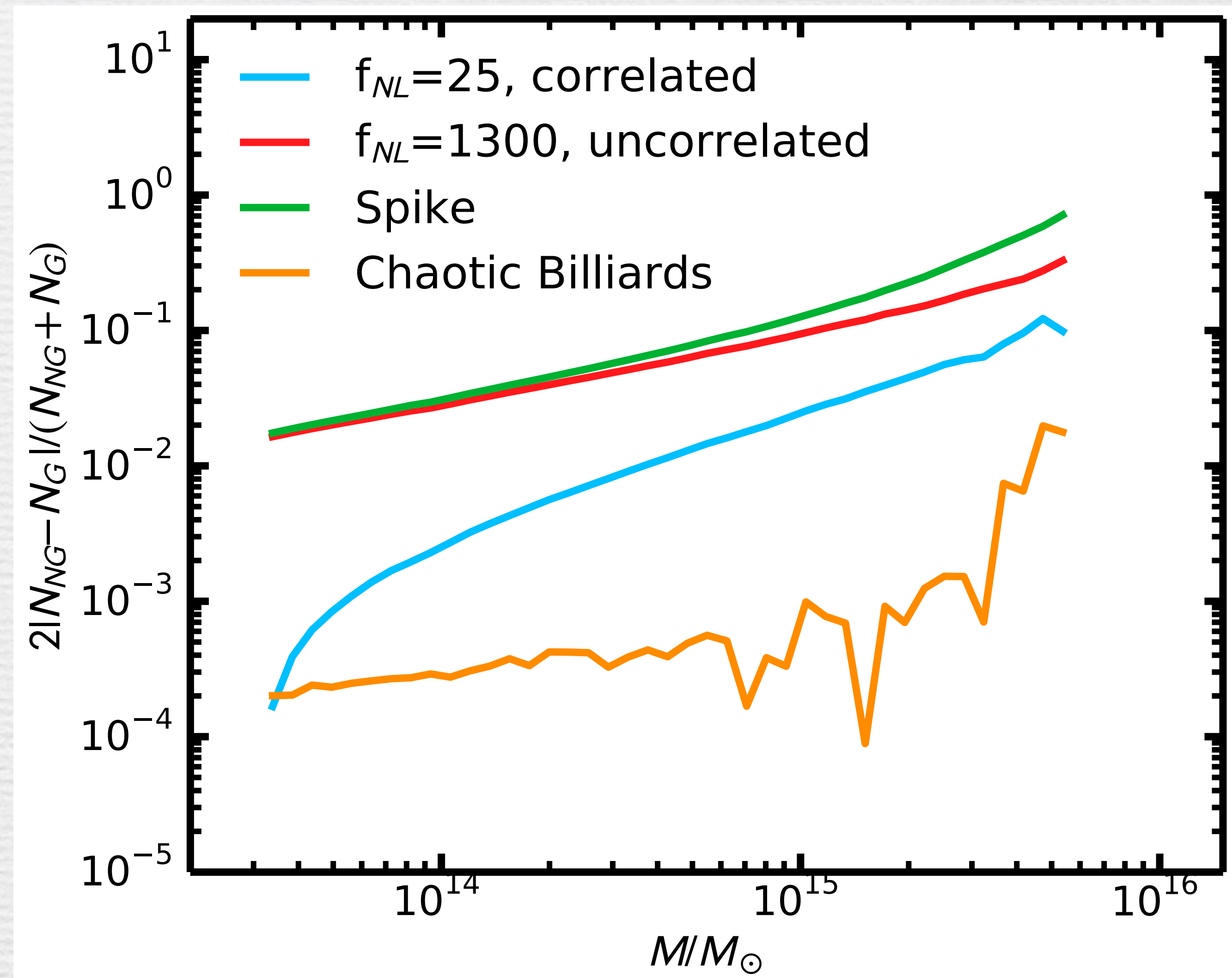
$$\zeta(x) = F_{NL}(\chi(x))$$

Halo Mass Function is weakly affected for intermittent cases

Peak Patch Sims: 2048 Mpc box, 1024^3 cells

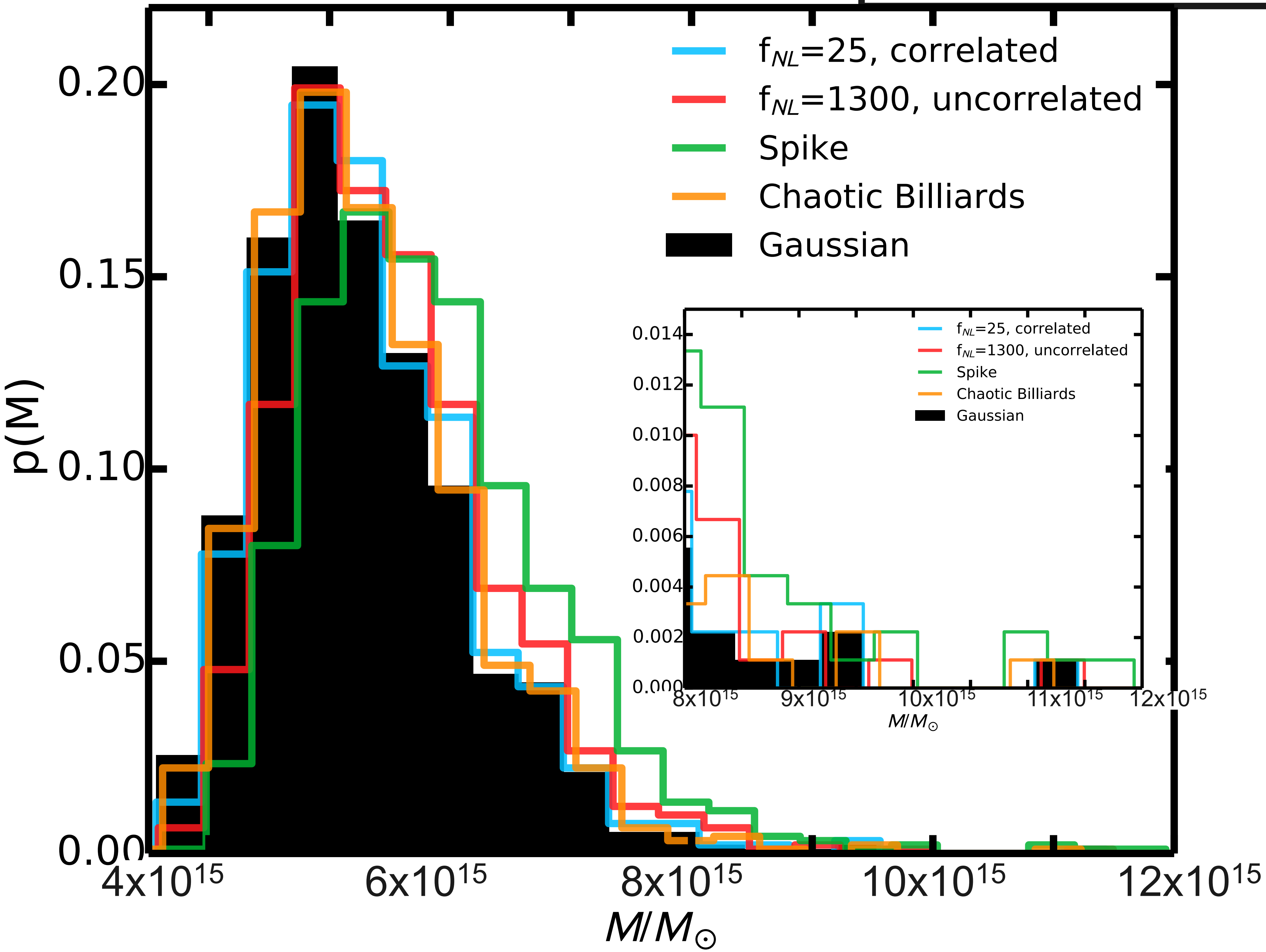
900 realizations, ~3 mins each on 64 cores





Single Largest Halo Statistics Indeterminate

Intermittent non-Gaussianity



non-Gaussianity in a Full-Sky Lightcone

8 Gpc box, 4096^3 cells

Wall clock ~10 mins each on 1024 cores

Full-sky light cone with ~60 million halos

Complete for $M_{halo} > 3 \times 10^{13}$ M_{sun}

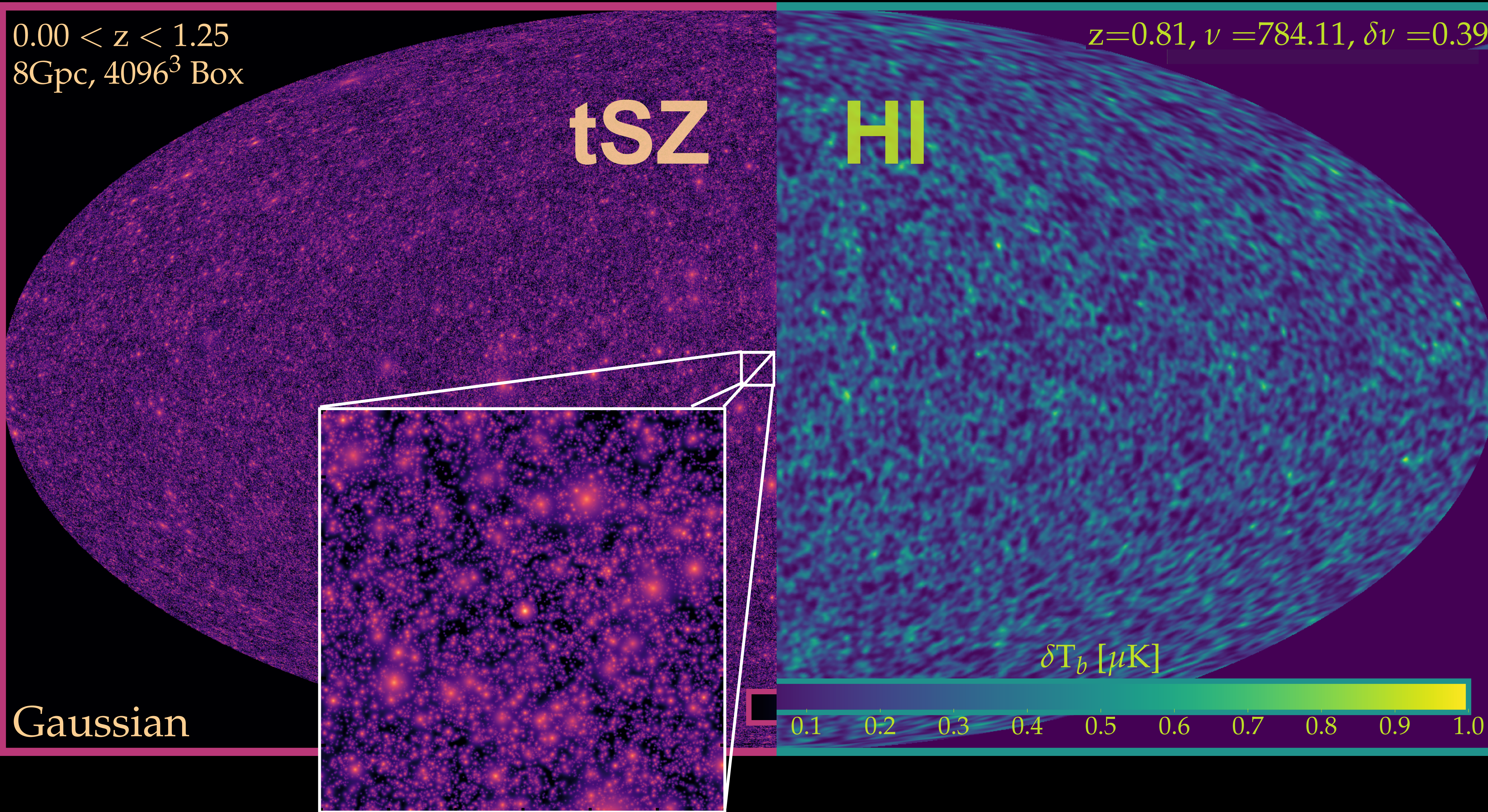
f_{NL} , f_{NL} uncorrelated, Spike, Chaotic Billiards

Battaglia et al. (2012) fits for Pressure Profiles

Matt Young - Poster

Subgrid Halos + Neutral Hydrogen Prescription

Phillipe Berger



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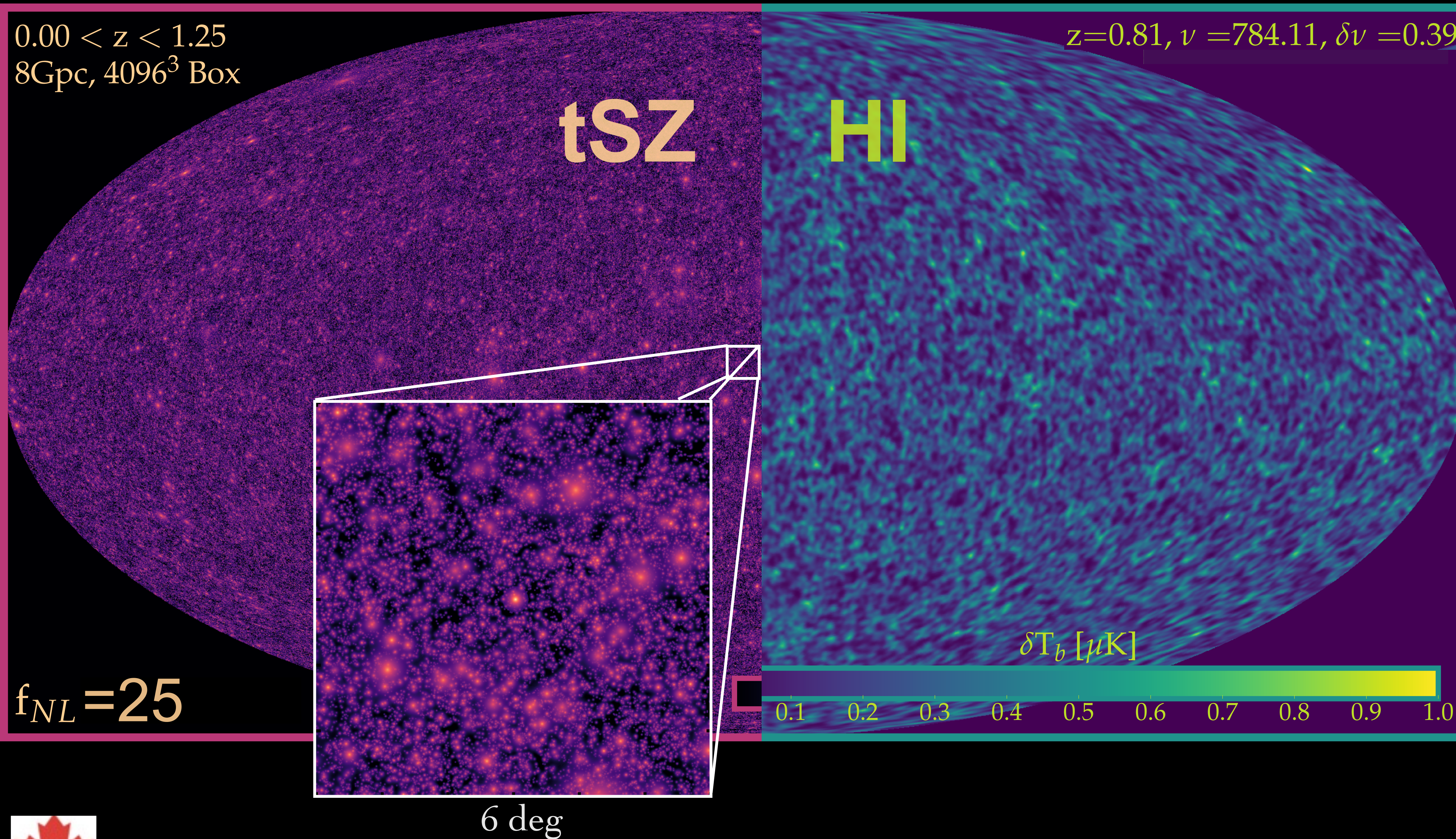

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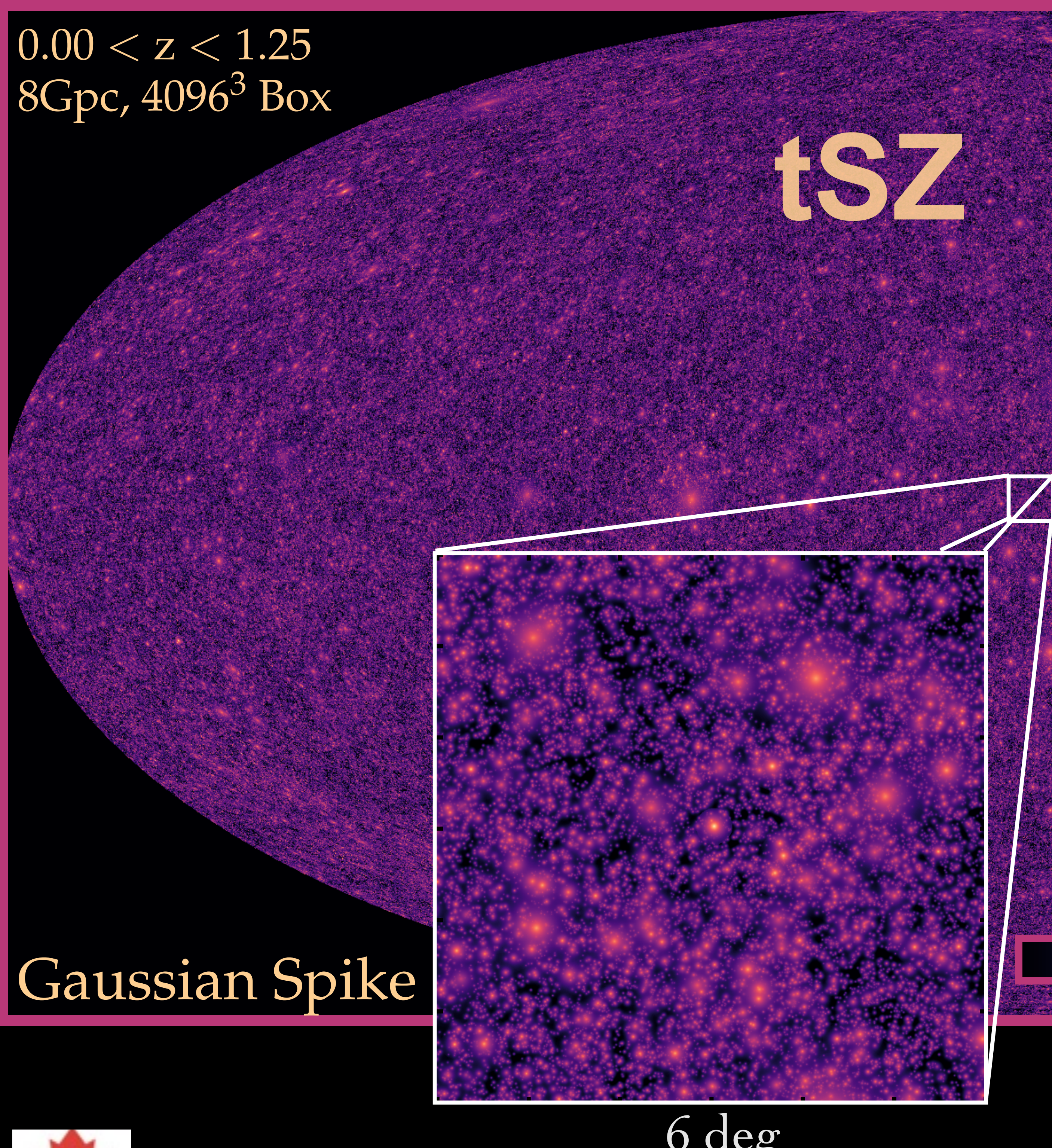
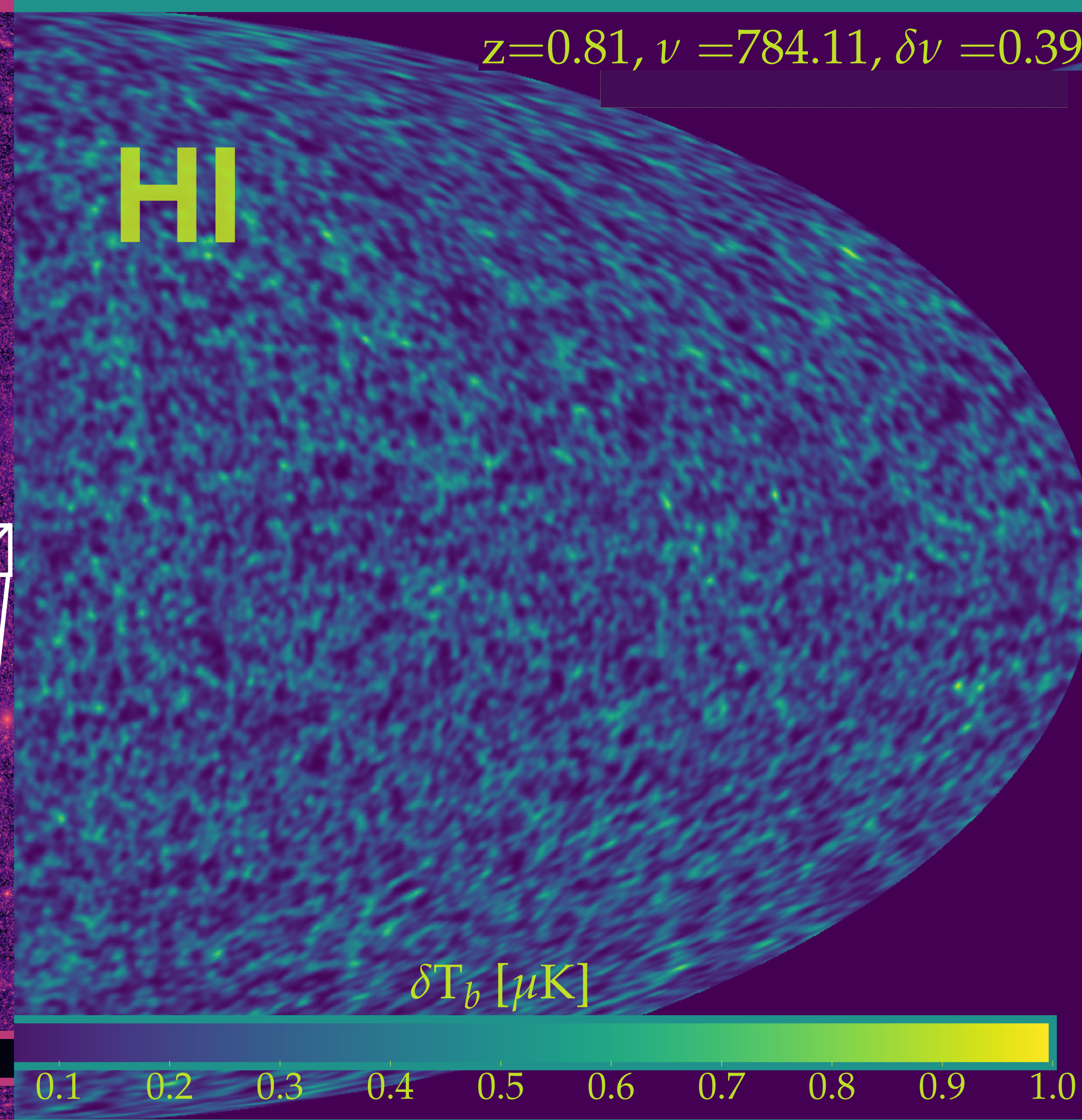


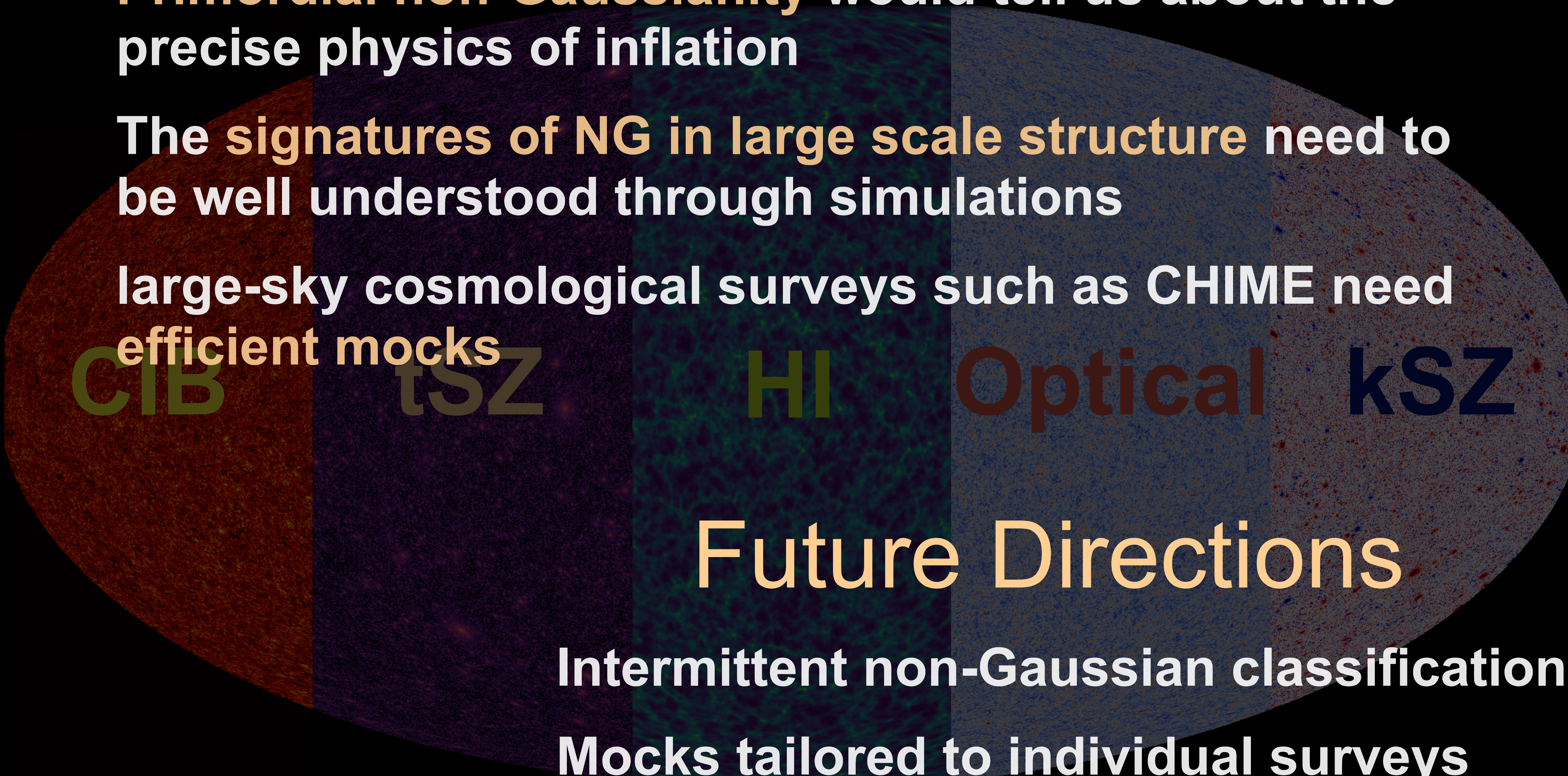


Summary

Primordial non-Gaussianity would tell us about the precise physics of inflation

The **signatures of NG in large scale structure** need to be well understood through simulations

large-sky cosmological surveys such as CHIME need **efficient mocks**



Future Directions

Intermittent non-Gaussian classification

Mocks tailored to individual surveys