Computational Modeling of Synergies Across Wavelengths

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Synergies Across Wavelengths: Multiple Probes & Calibration

CMB Lensing

(**e.g.** Lesgourgues et al. 2006; Pullen et al. 2016; CMB-S4; Modi et al. 2017; Schmittfull & Seljak 2017)

Photo-z Distributions with Cross-correlations

Spectroscopic Surveys & 21-cm

(e.g. Newman 2008; McQuinn & White 2013; Newman et al. 2015; Alonso et al. 2017**)**

21cm Intensity Mapping

(e.g., Chang et al. 2008; Bull et al. 2015; Alonso et al. 2015; Alonso & Ferreira 2015; Xu et al. 2016; Obuljen et al. 2017; White & Padmanabhan 2017**)**

Cluster Counts & Mass - Observable Calibration

(**e.g.**, Allen et al. 2011; von der Linden et al. 2014; Hoekstra et al. 2014; Shirasaki et al. 2015)

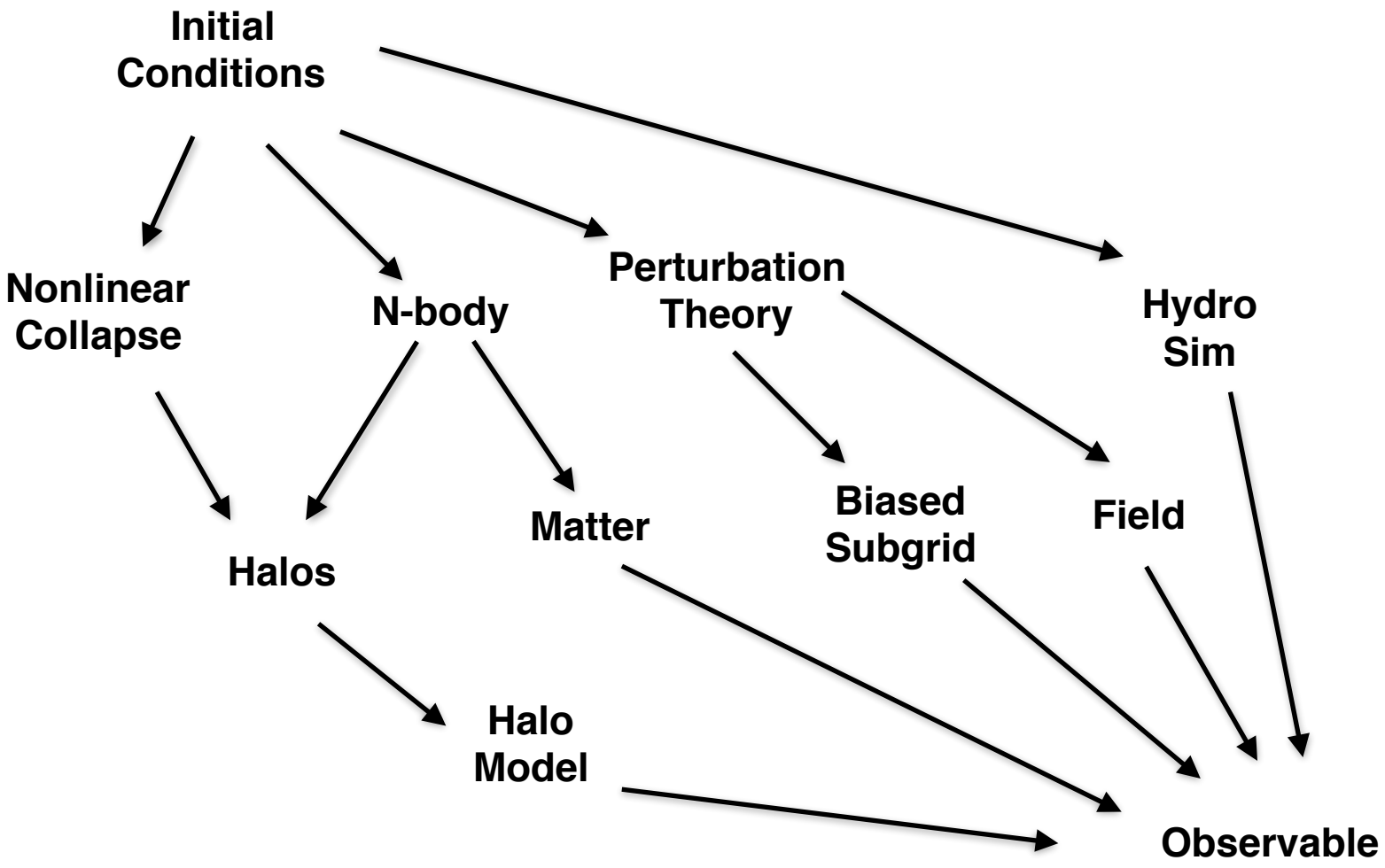
Cosmic Infrared Background

(**e.g.**, Smith et al. 2012; Sherwin & Schmittfull 2015; Larsen et al. 2016; Tucci et al. 2016)

Sunyaev-Zel'dovich

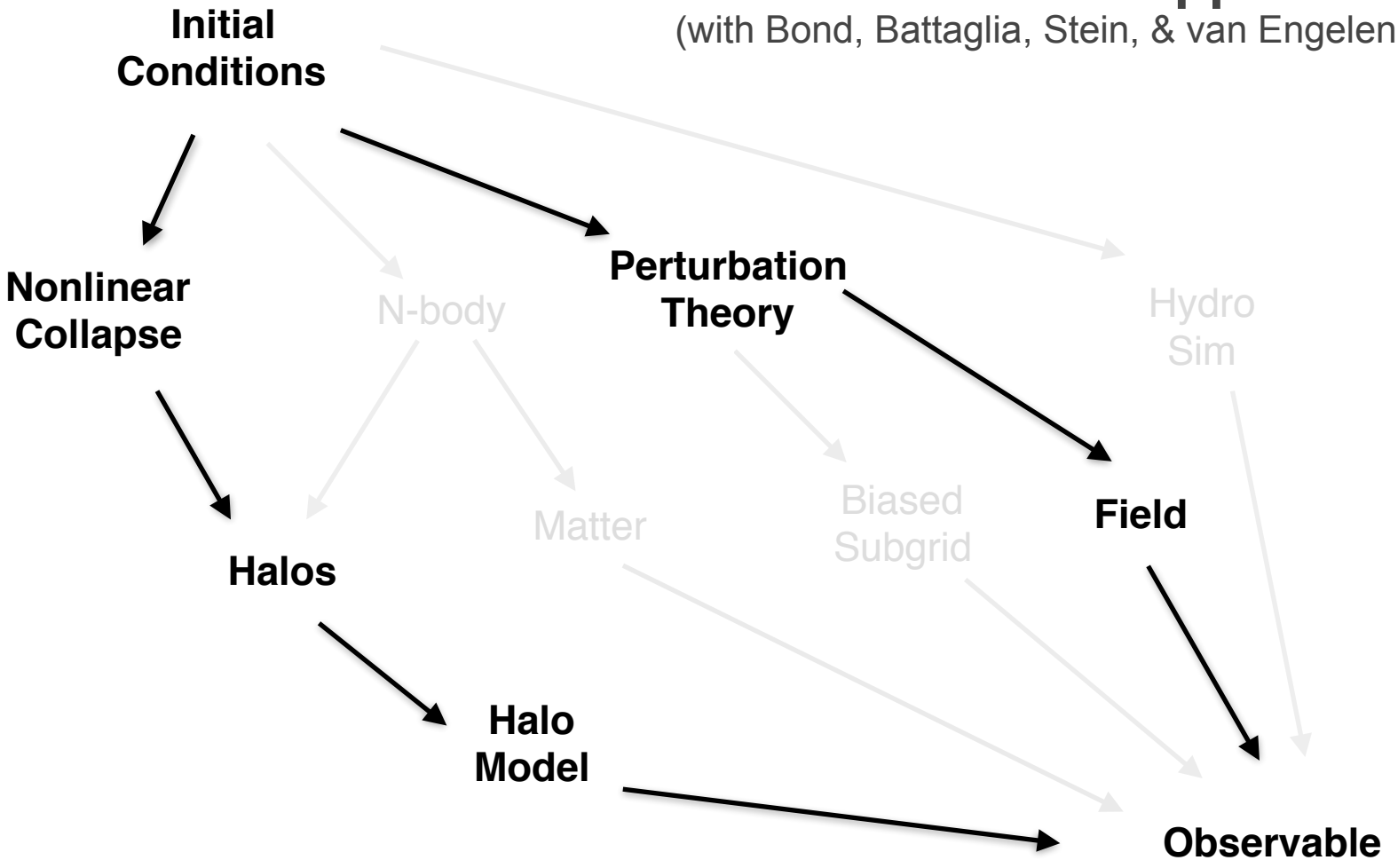
(**e.g.**, Mueller et al. 2015; Mueller et al. 2015; Alonso et al. 2016; Madhavacheril et al. 2017)

Multiple Paths for Sky Simulations



Fast CMB Secondary Mocks with Peak Patch Approach

(with Bond, Battaglia, Stein, & van Engelen)



Fast Large Scale Structure Mocks with the Peak Patch Approach (with Bond, Battaglia, Stein, & van Engelen)

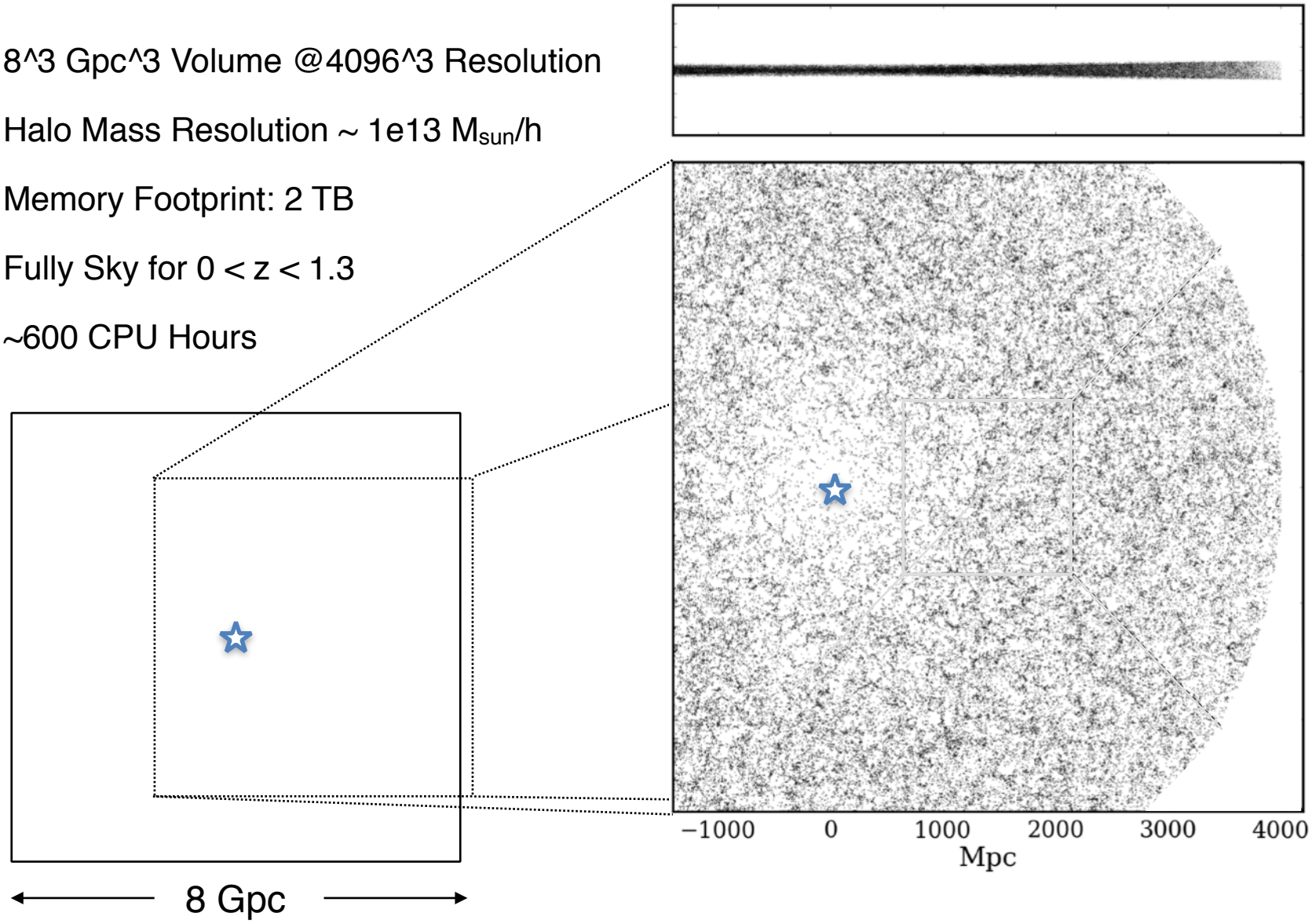
8^3 Gpc^3 Volume @4096^3 Resolution

Halo Mass Resolution ~ 1e13 M_{sun}/h

Memory Footprint: 2 TB

Fully Sky for $0 < z < 1.3$

~600 CPU Hours



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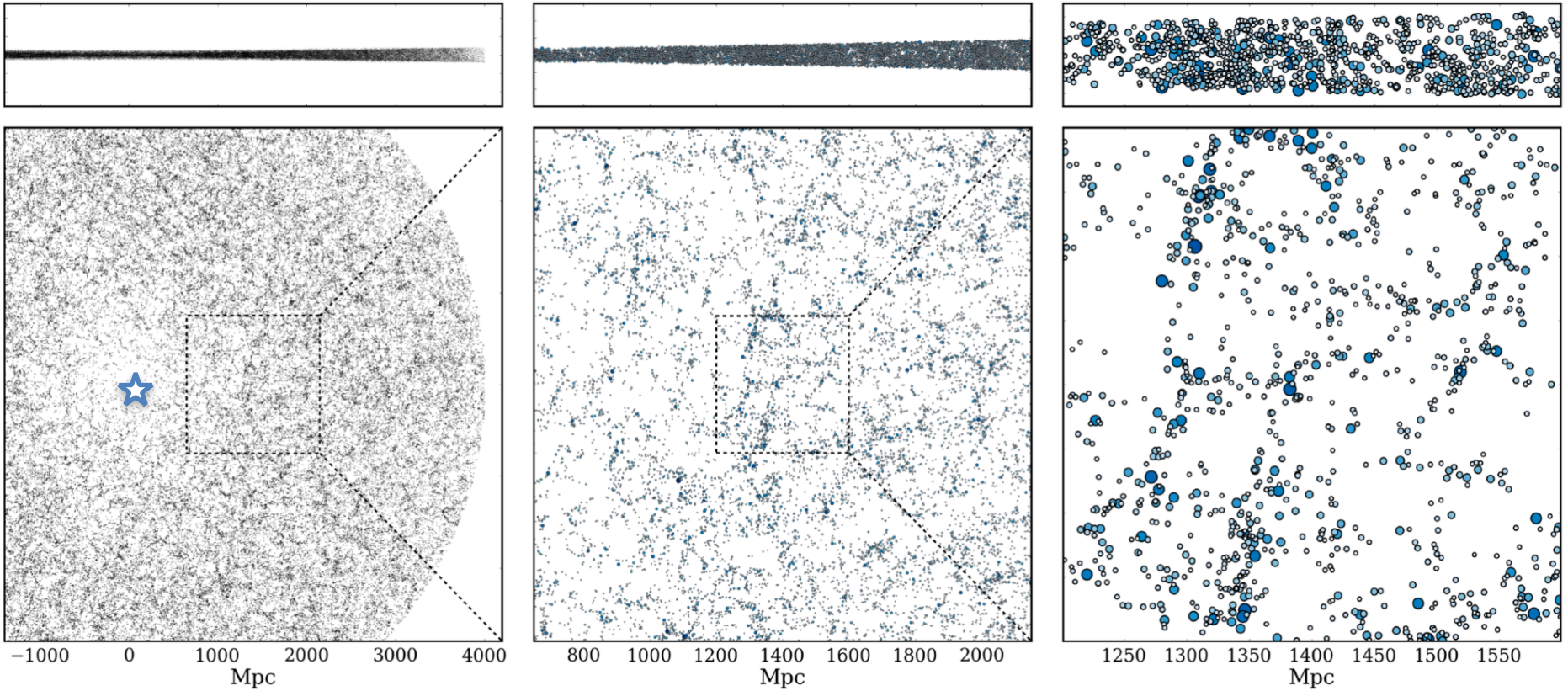

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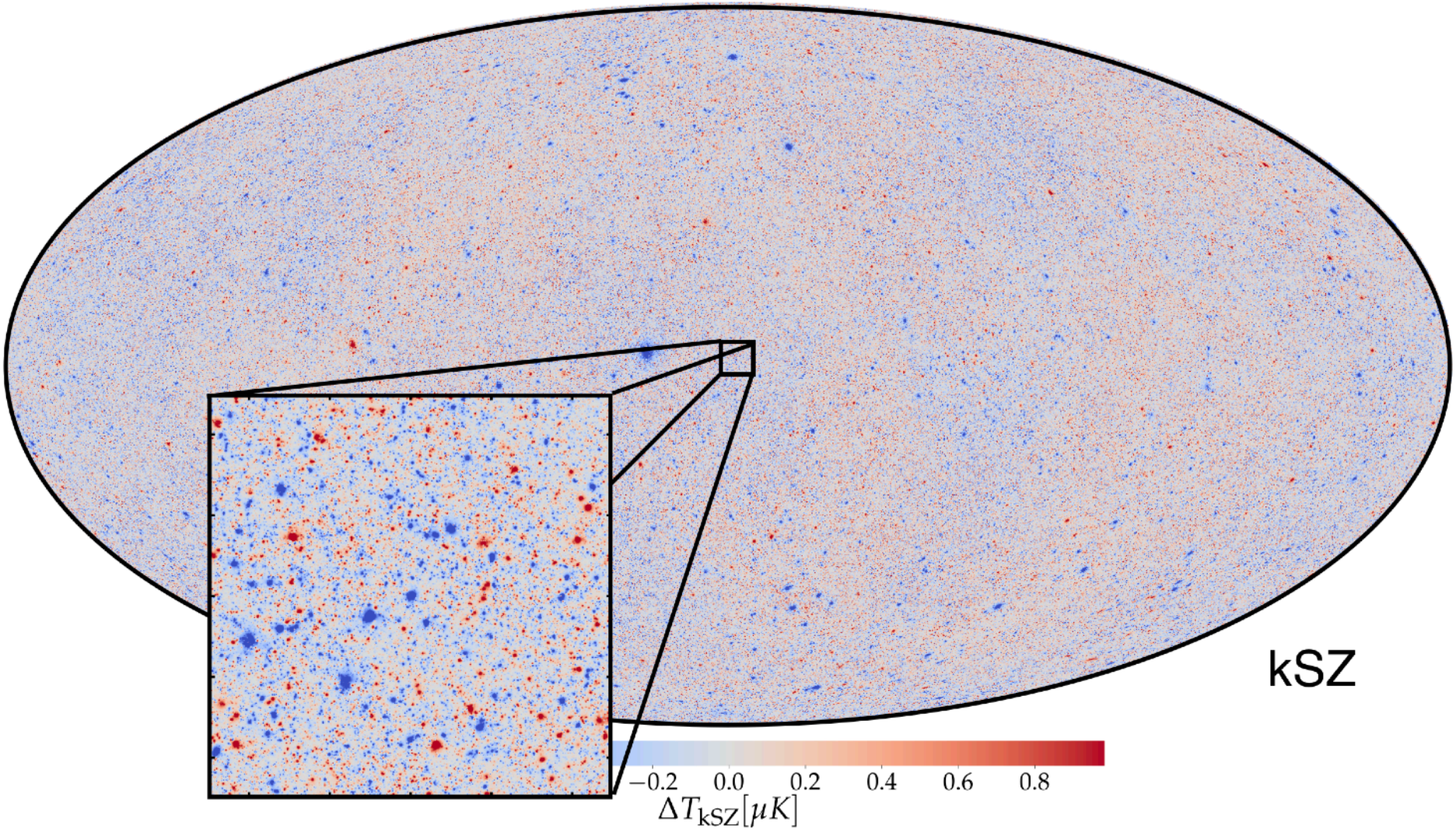

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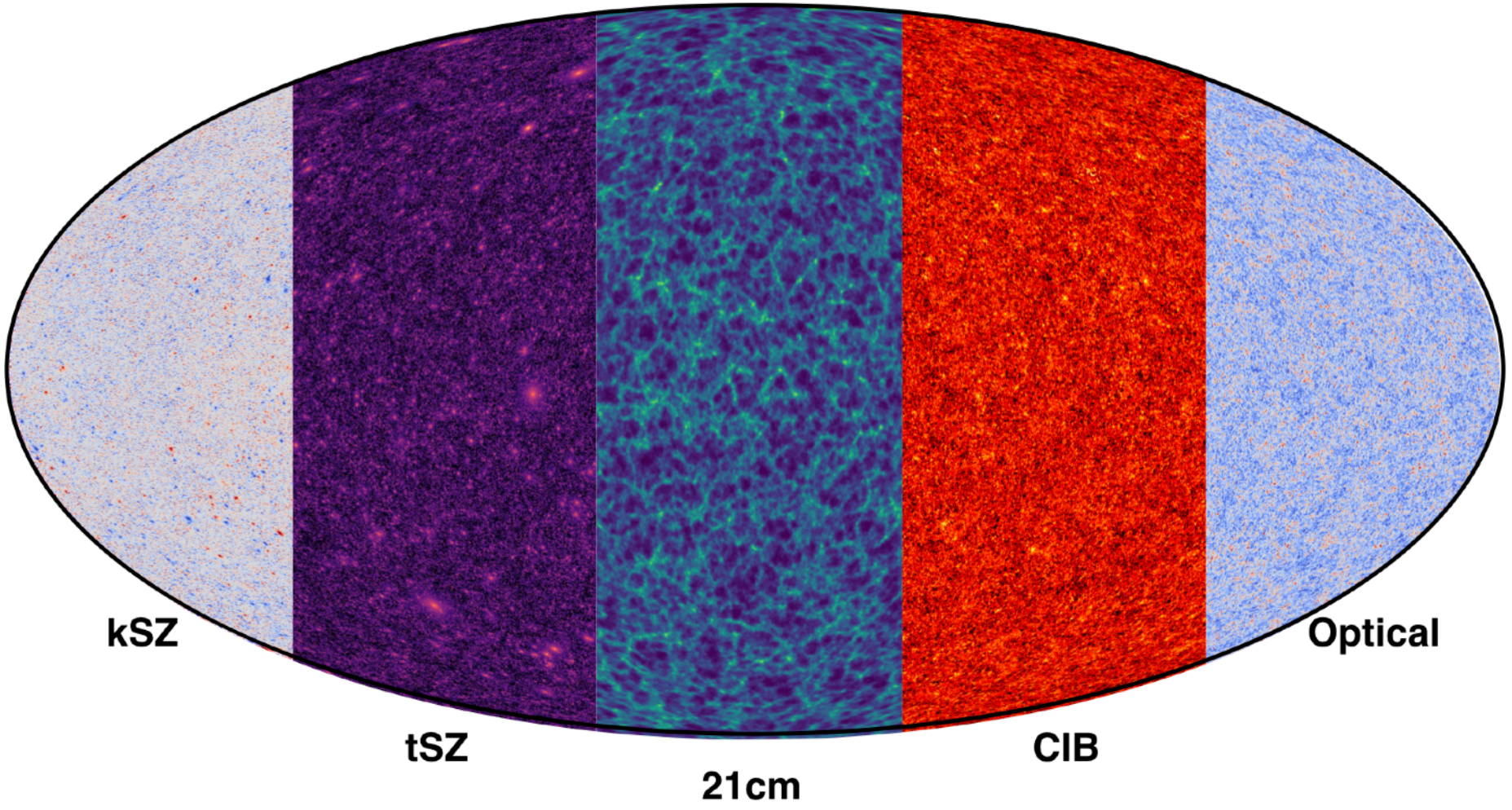
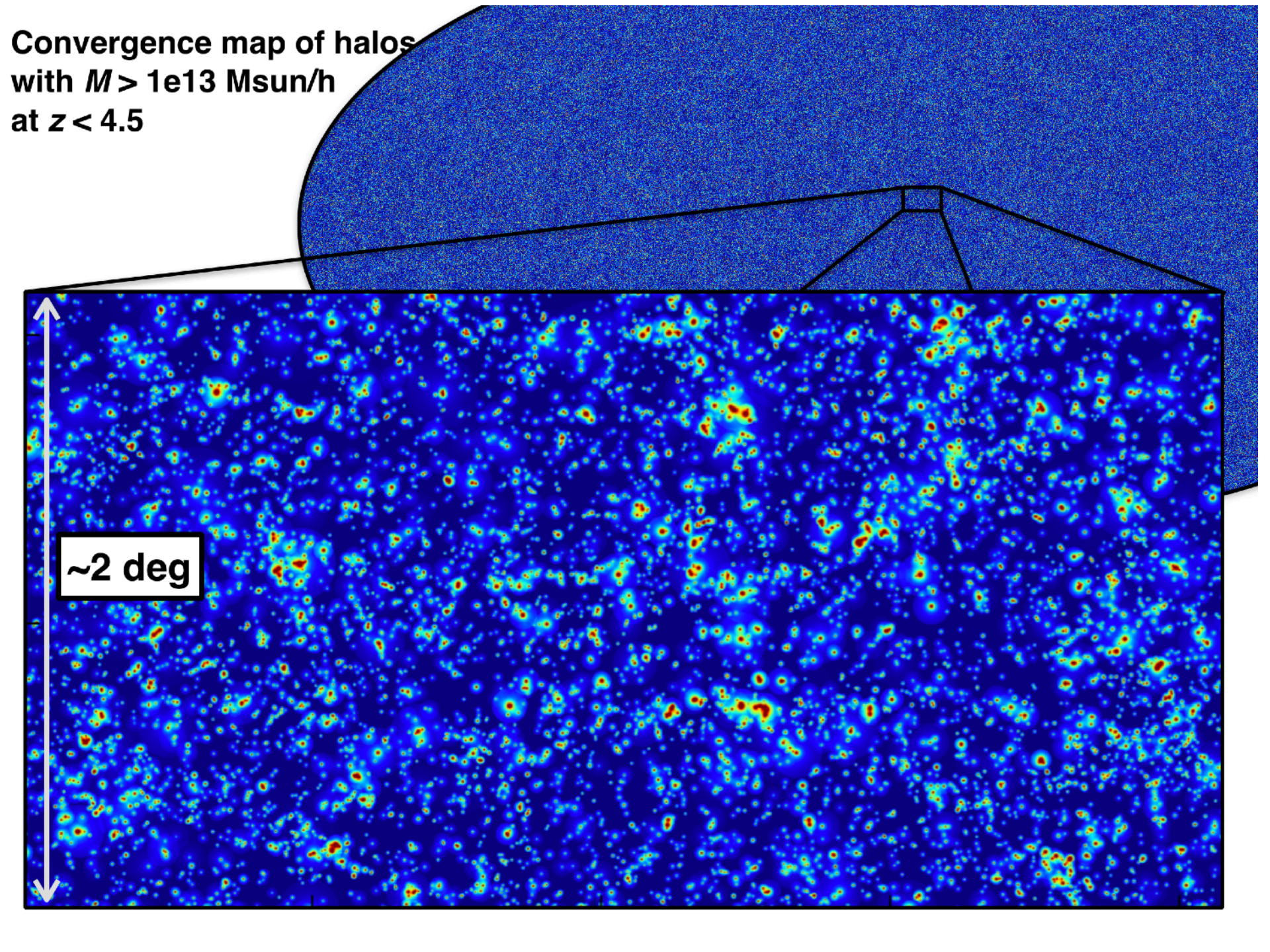
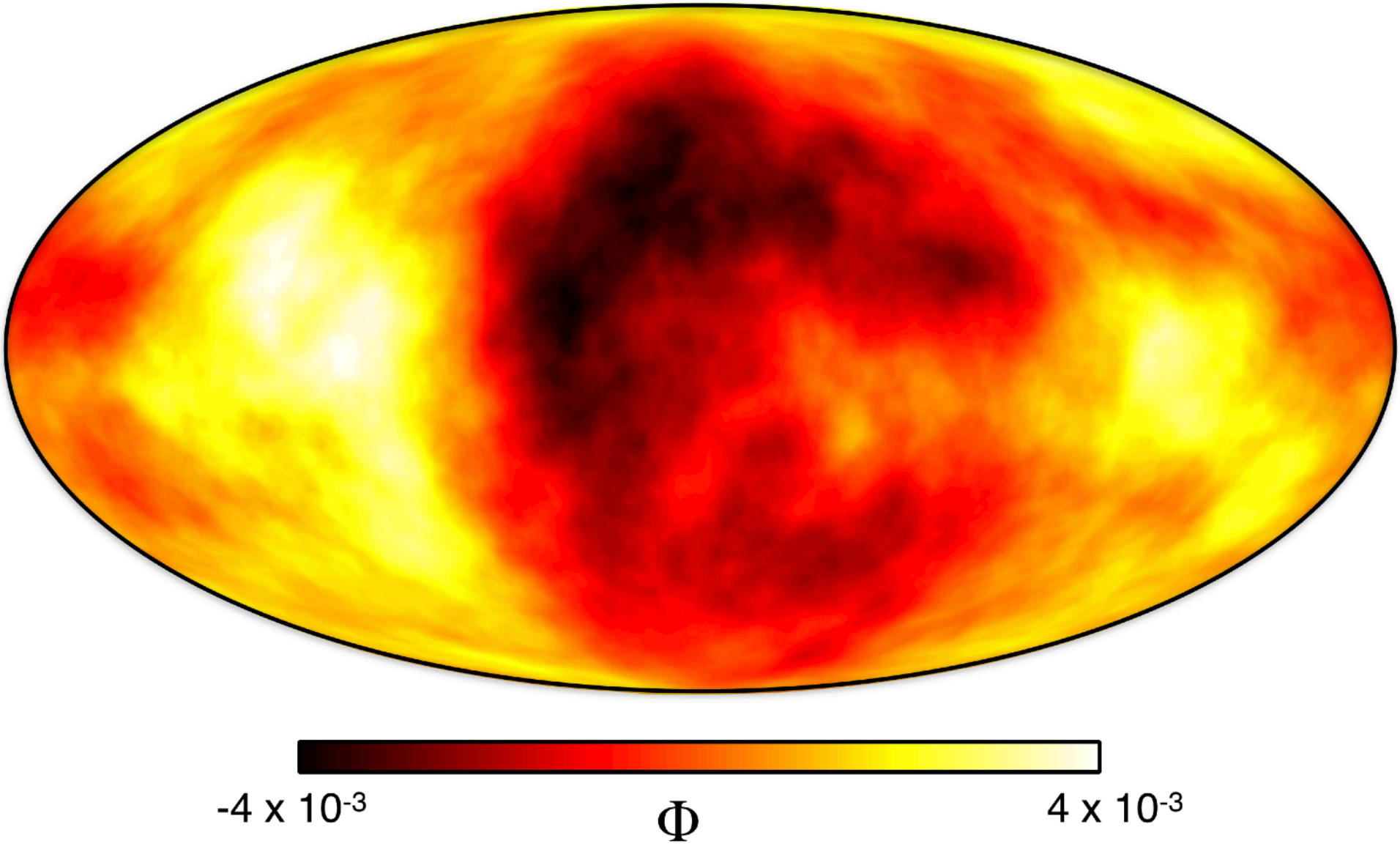
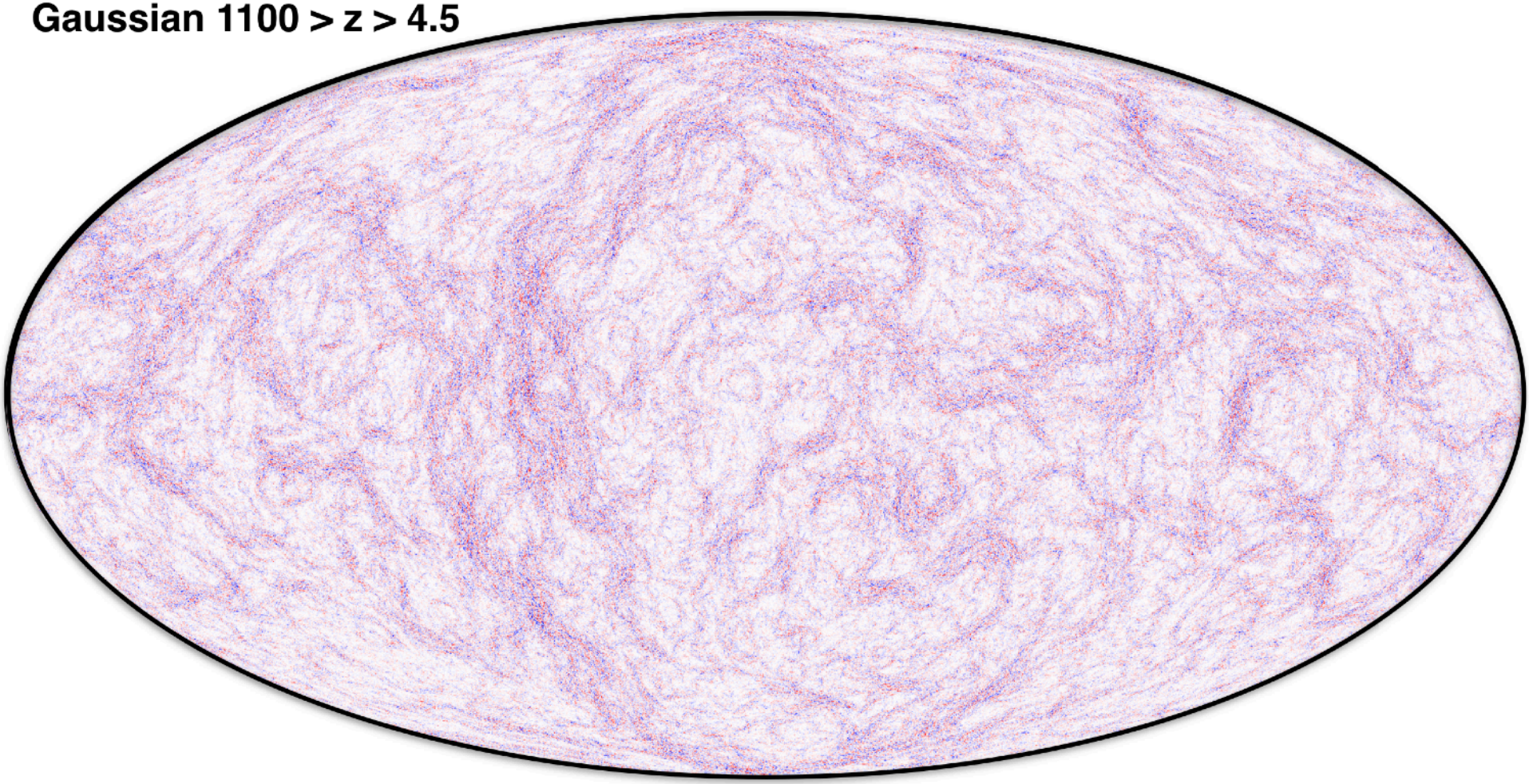



Convergence map of halos
with $M > 1e13$ Msun/h
at $z < 4.5$
~2 deg

Total Lensing Potential
Including Field



Difference Map of Lensed and Unlensed CMB including 2LPT Field + Halos + uncorrelated Gaussian 1100 > z > 4.5



-2.6 x 10^{-4} δT [μK] 2.6 x 10^{-4}

Modeling Scale-dependent 21-cm Bias from UVB Fluctuations

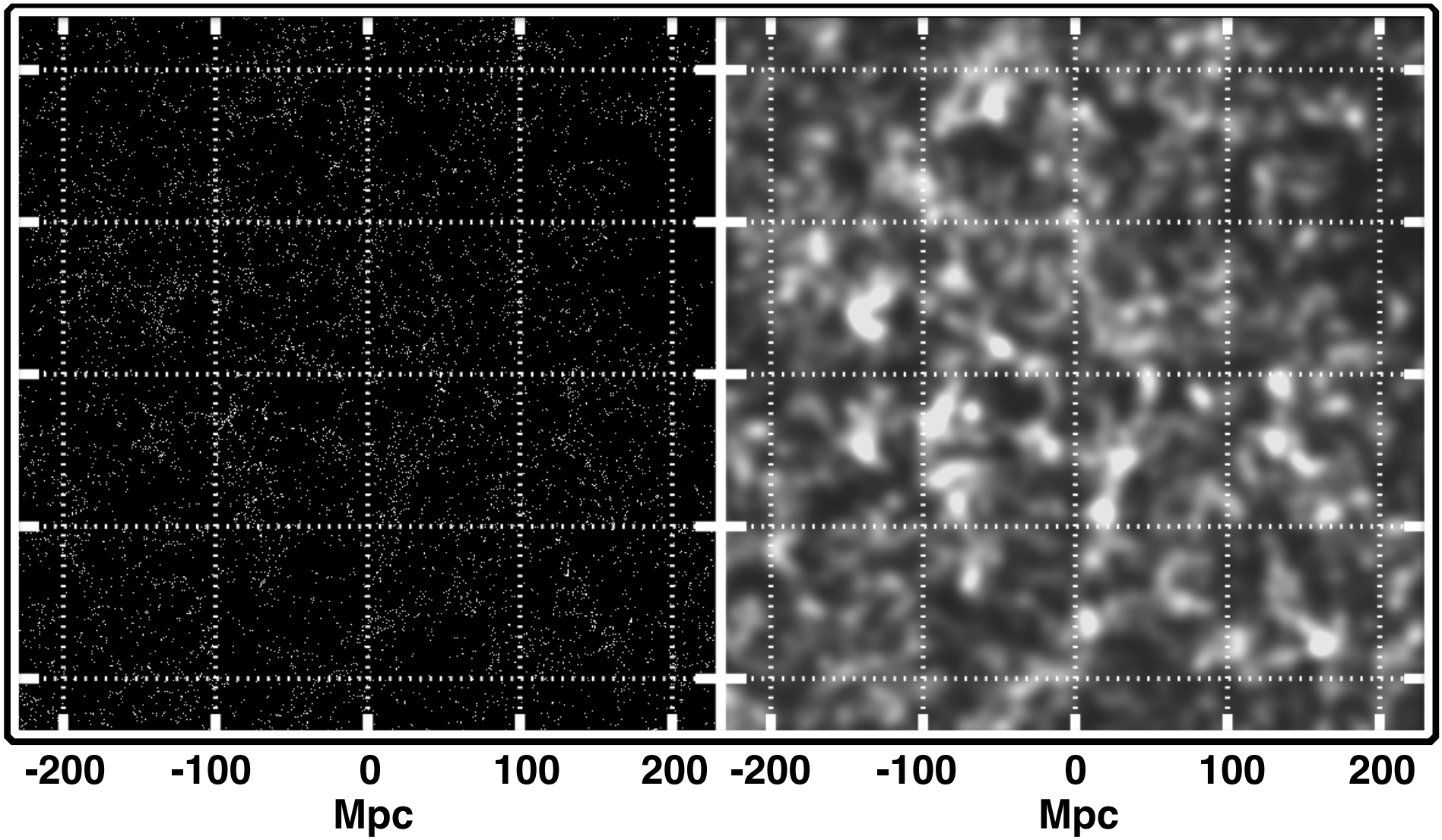
(with Villaescusa-Navarro)

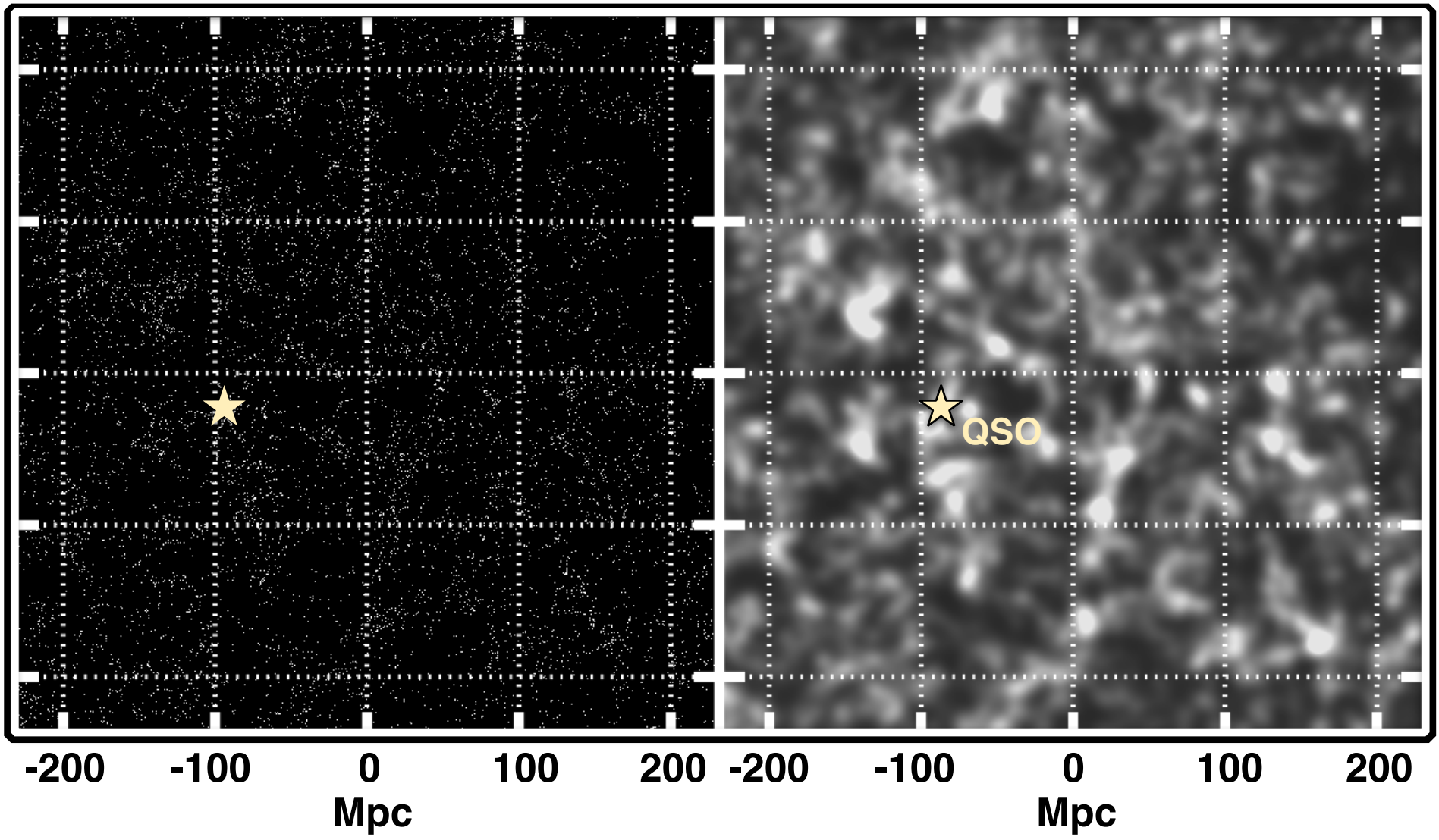
Possible Sources of Large-Scale Scale-dependent Bias:

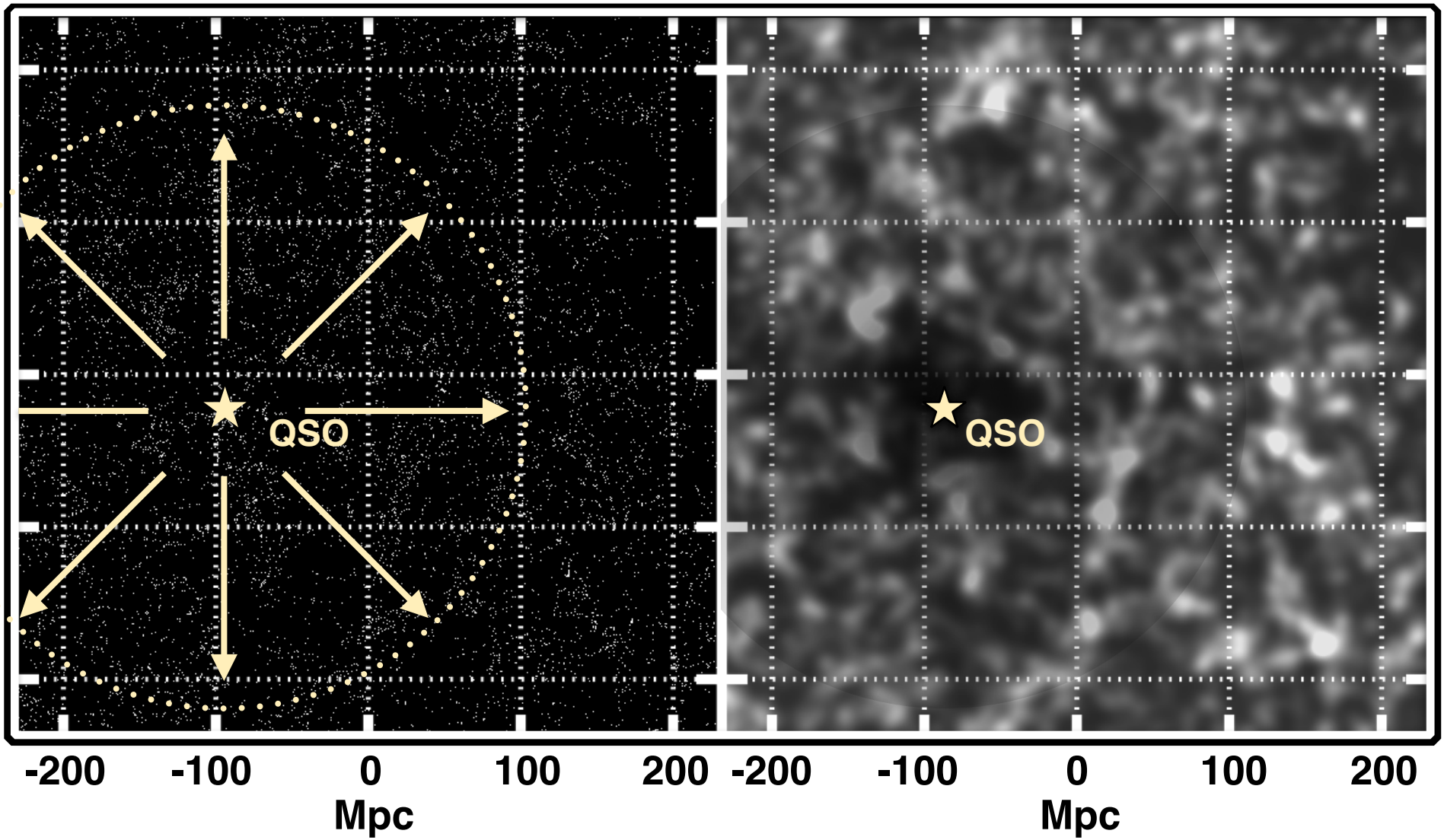
1. Intrinsic Halo Bias
2. Neutrino Halo Bias
3. **Correlated UVB fluctuations**

First two can be modeled accurately with N-body simulations or PT

Effect of UVB More Difficult to Model


DM Halos
21-cm
-200
-100
0
100
200
Mpc
-200
-100
0
100
200
Mpc


DM Halos
21-cm
QSO
-200
-100
0
100
200
Mpc
-200
-100
0
100
200
Mpc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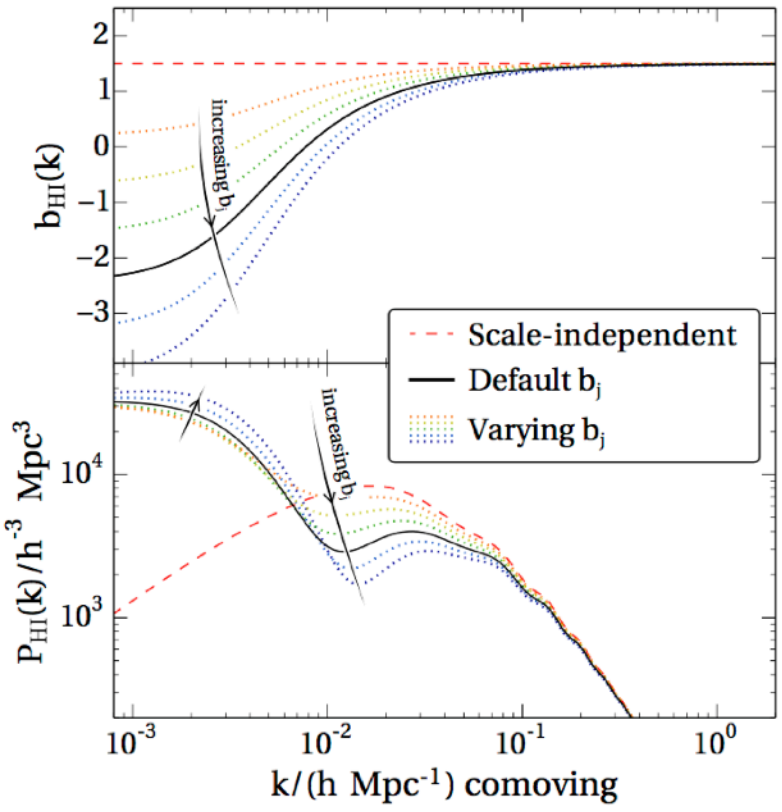
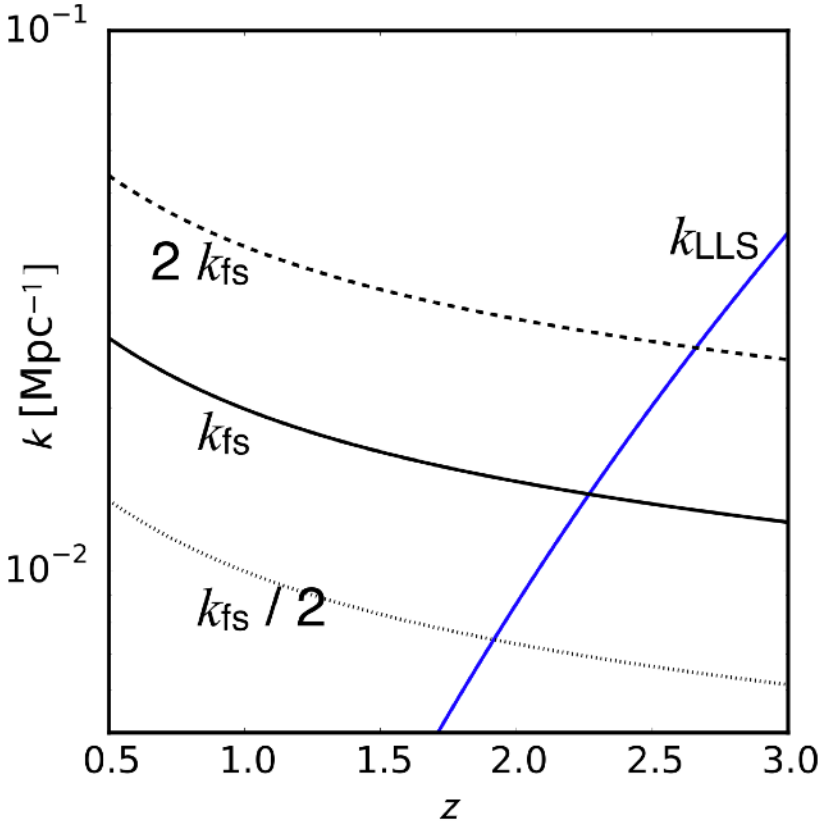
0
100
200
Mpc
Mpc

Modeling Scale-dependent 21-cm Bias from UVB Fluctuations

(with Villaescusa-Navarro)

Large Scale HI Power Could be Strongly Affected by Fluctuations in the Ionizing Background





Pontzen (2014)

Modeling Scale-dependent 21-cm Bias from UVB Fluctuations

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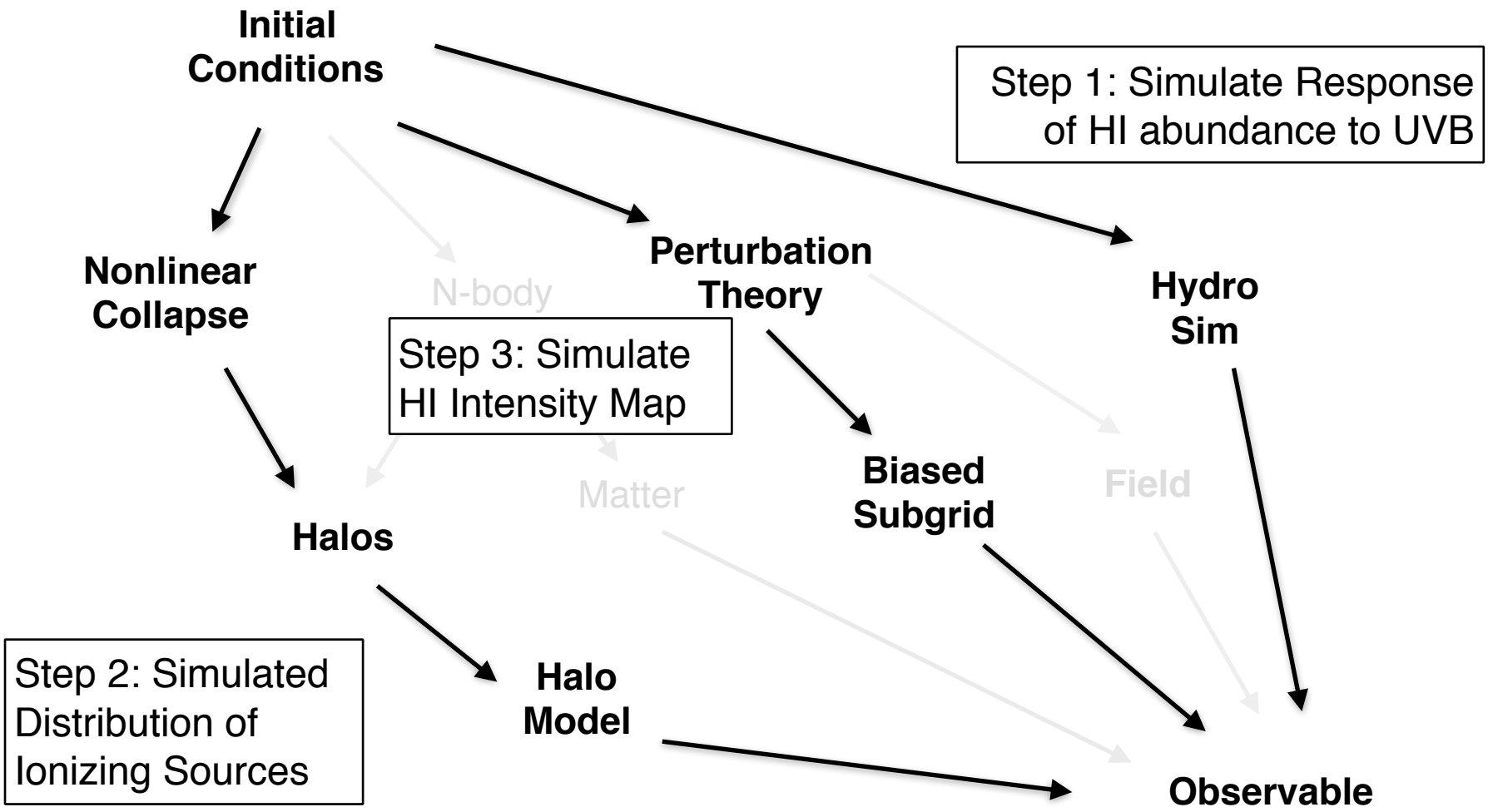

Modeling Scale-dependent 21-cm Bias from UVB Fluctuations

(with Villaescusa-Navarro)

Initial Conditions

Step 1: Simulate Response of HI abundance to UVB

Nonlinear Collapse

N-body

Perturbation Theory

Hydro Sim

$$\tilde{\delta}^{J}_{\rm HI}(\mathbf{k},z) = \frac{\partial \ln n_{\rm HI}}{\partial \ln J}(z)\delta_J(\mathbf{k},z) \equiv -b_{\rm HI,J}(z)\tilde{\delta}_J(\mathbf{k},z)$$

Halo Model

Observable

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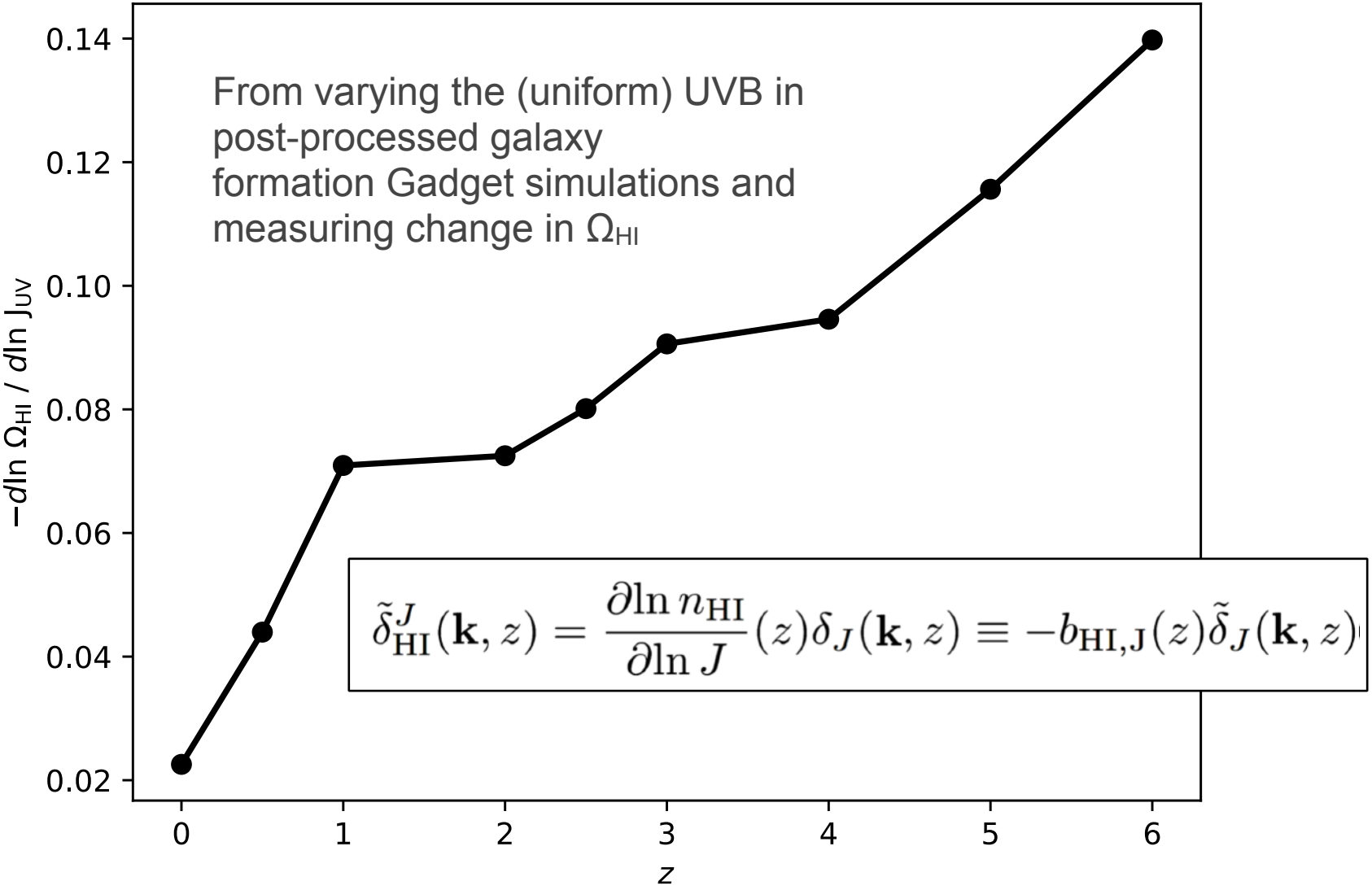
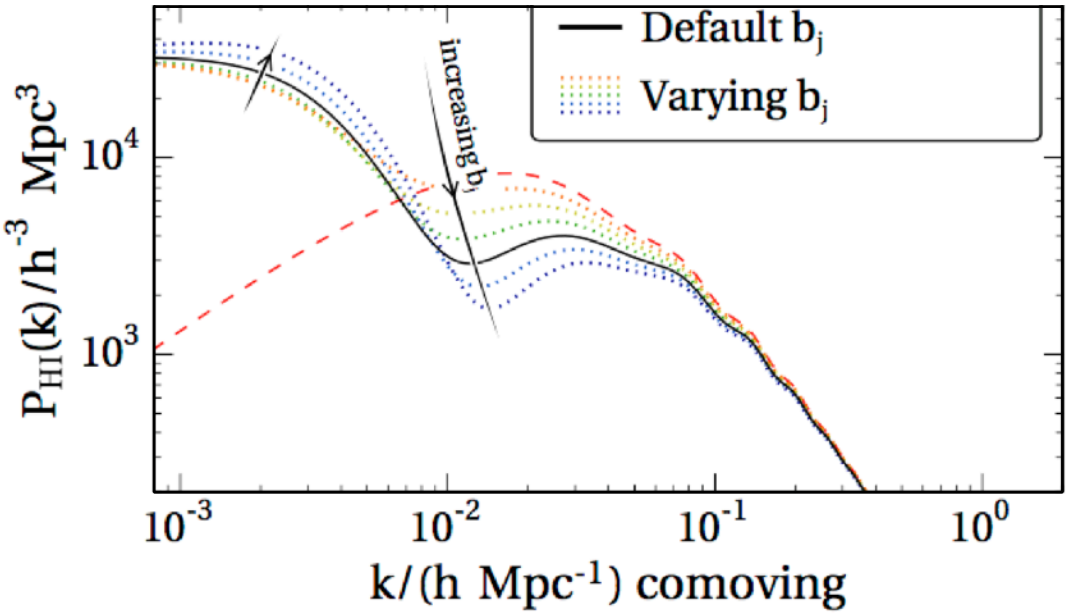
Halo Model

Observable

Scale-dependent 21-cm Intensity Maps from UVB Fluctuations

(with Villaescusa-Navarro)





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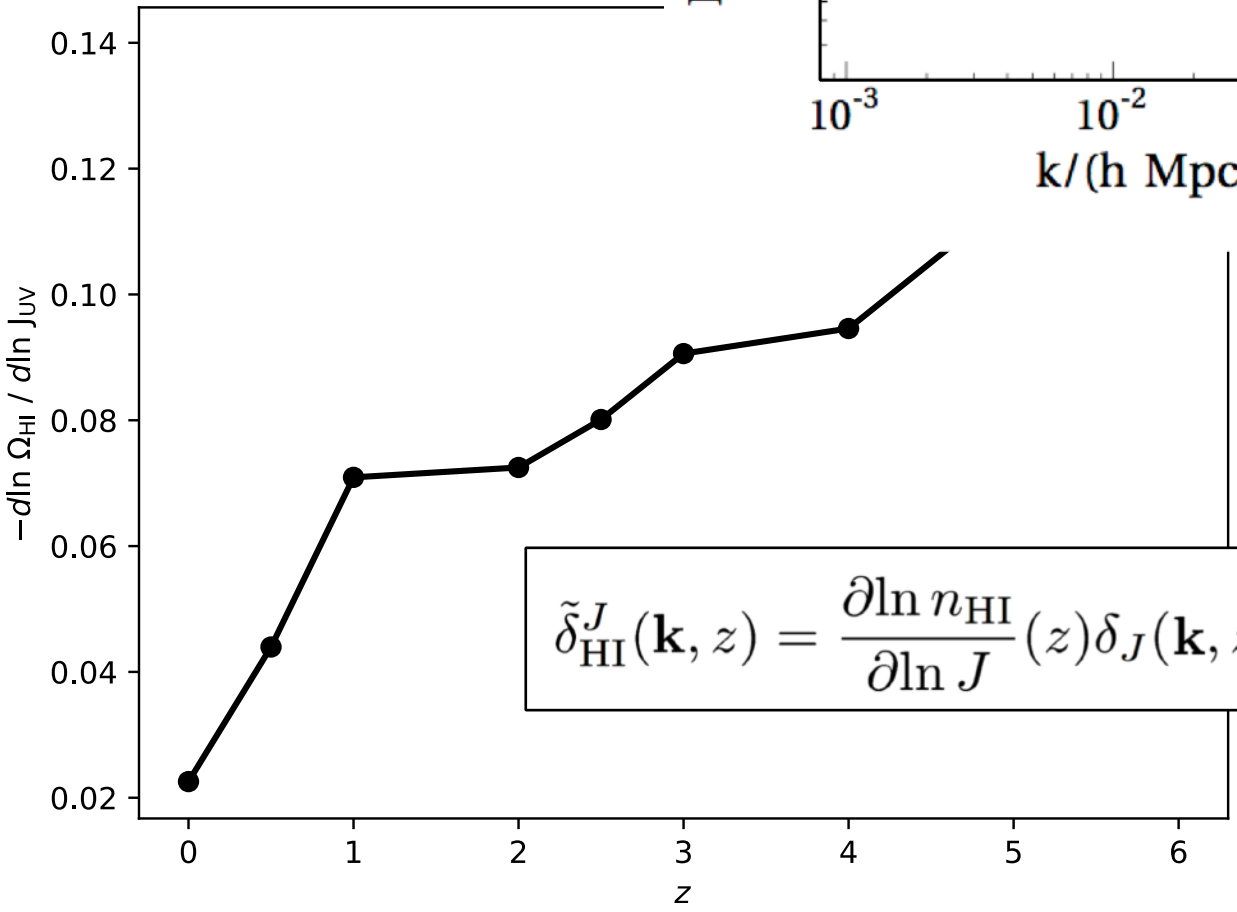

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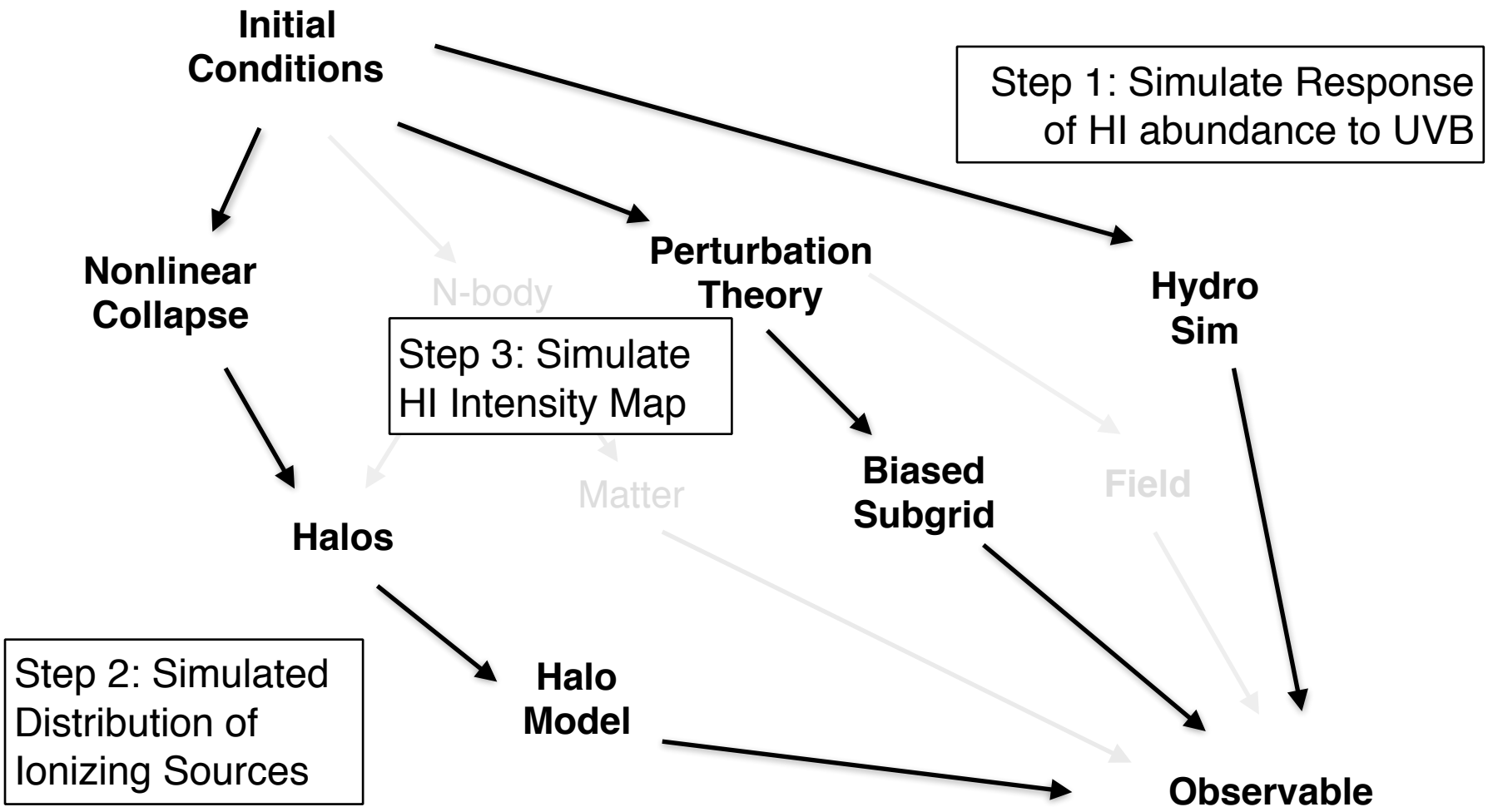

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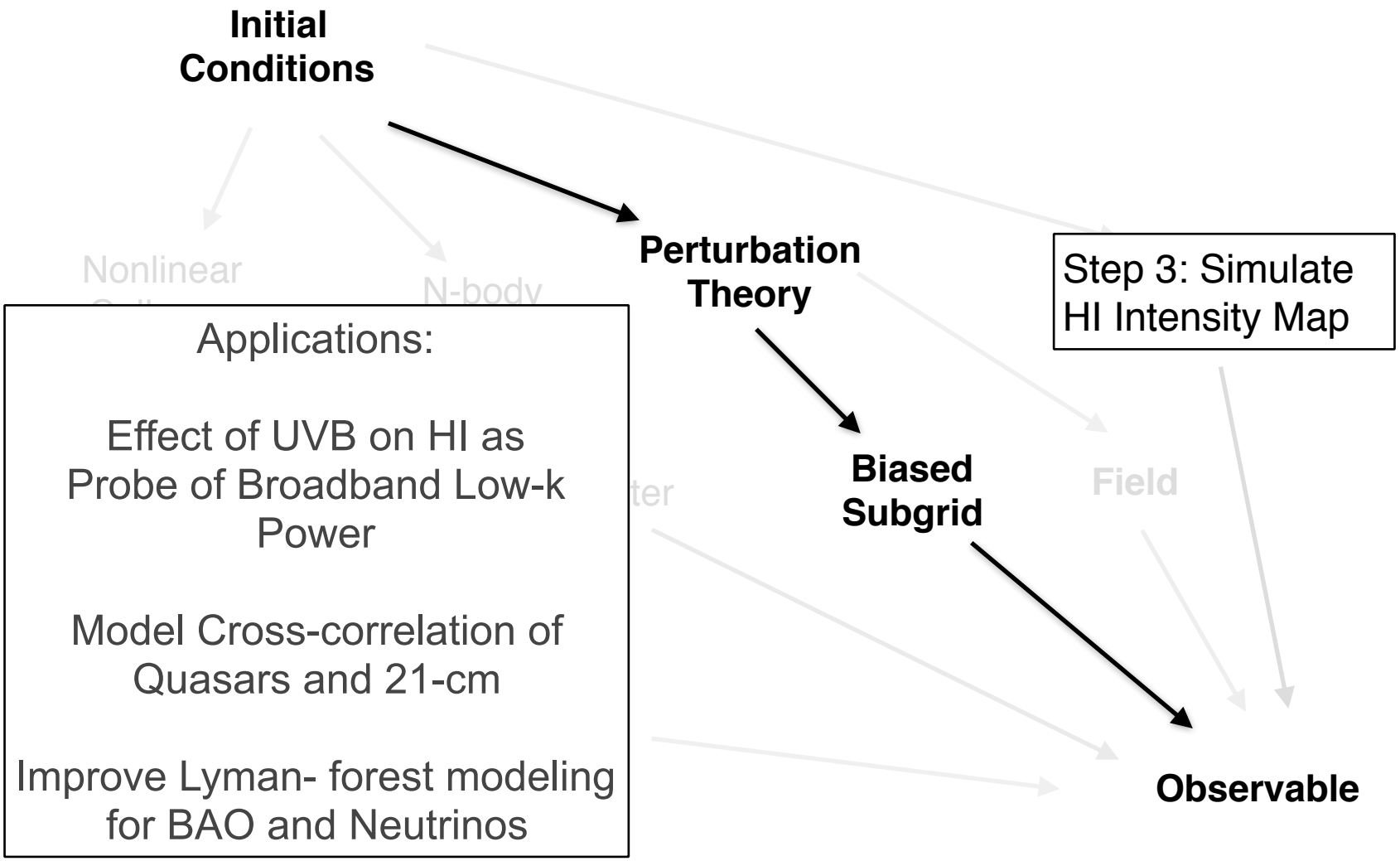
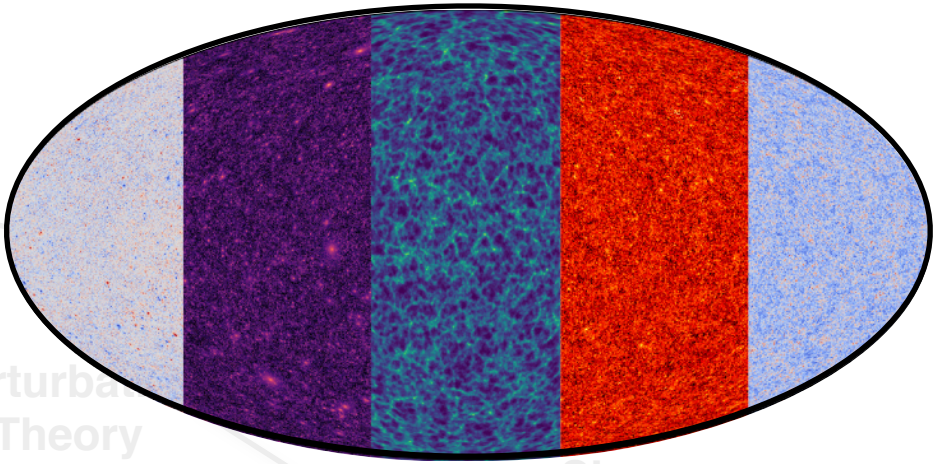


Wish List for Synergistic Sky Simulations Across Wavelengths



Goal:
Facilitate joint analysis of simulated data for validation, calibration, and correlation across multiple probes

Phase coherence of ICs through uniform data structure:

* Open-source libraries for efficient random fields
* Adaptive / multi-scale & hierarchical in structure
* Support for non-Gaussianity

Standardized formats and conventions for observables

* Spectroscopic samples
* Colors
* Lensing shear / convergence
* Line Intensity maps / catalogs
* Diffuse