

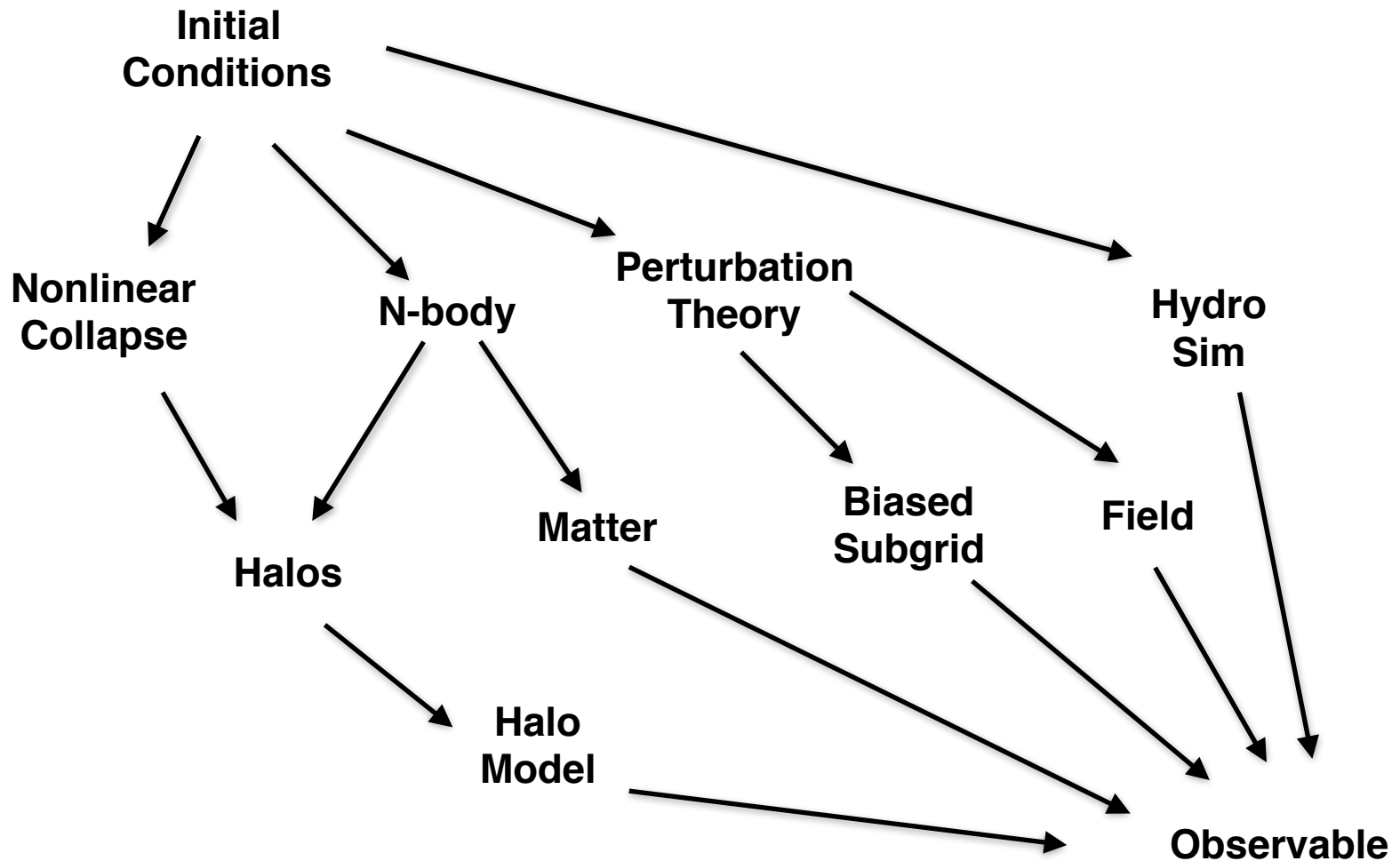
# Computational Modeling of Extragalactic CMB Foregrounds

**Marcelo Alvarez**

UC Berkeley / LBNL

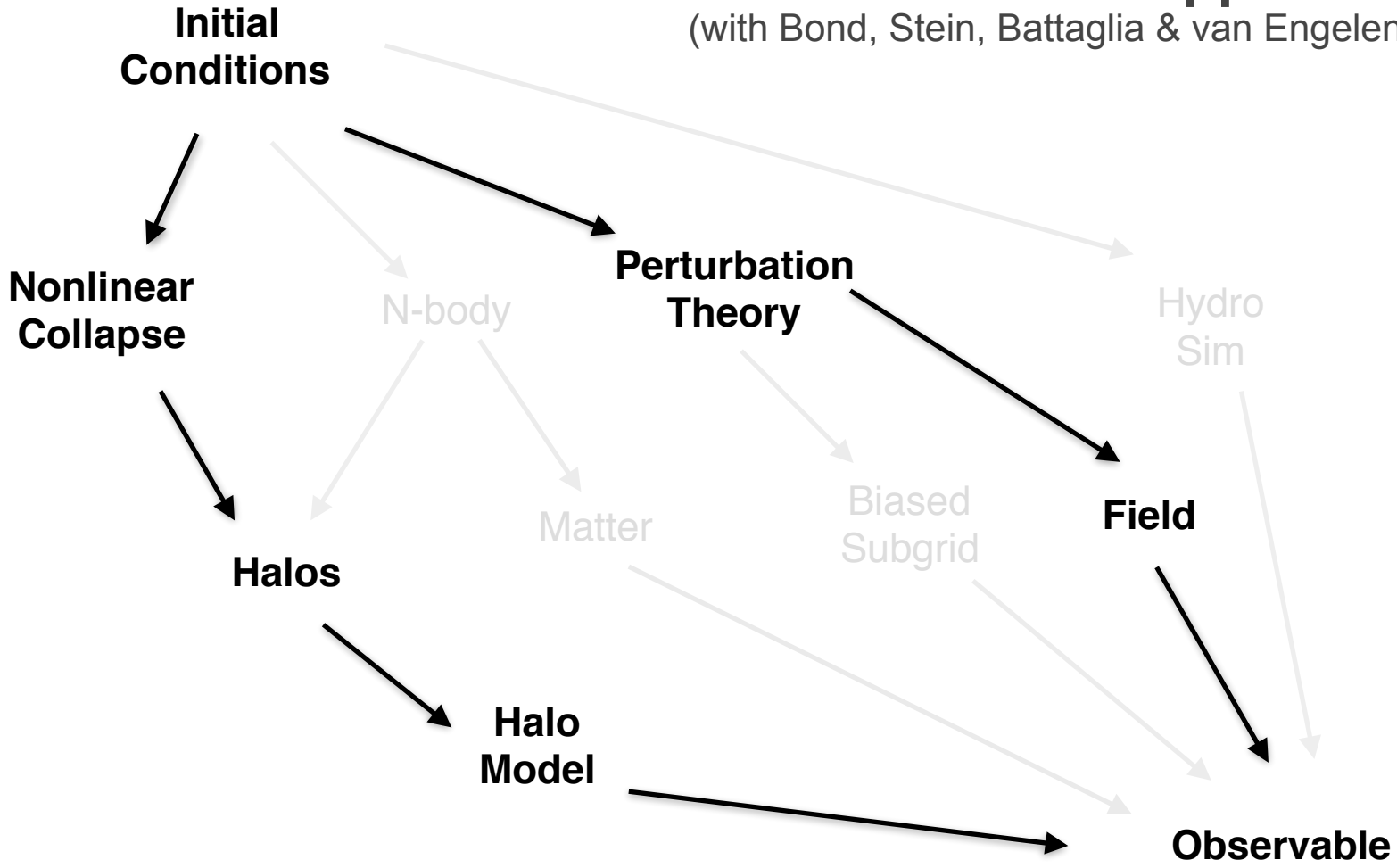
*CMB Foregrounds Workshop  
University of California, San Diego  
November 30, 2017*

# Multiple Paths for Extragalactic Sky Models



# Fast CMB Secondary Mocks with Peak Patch Approach

(with Bond, Stein, Battaglia & van Engelen)



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

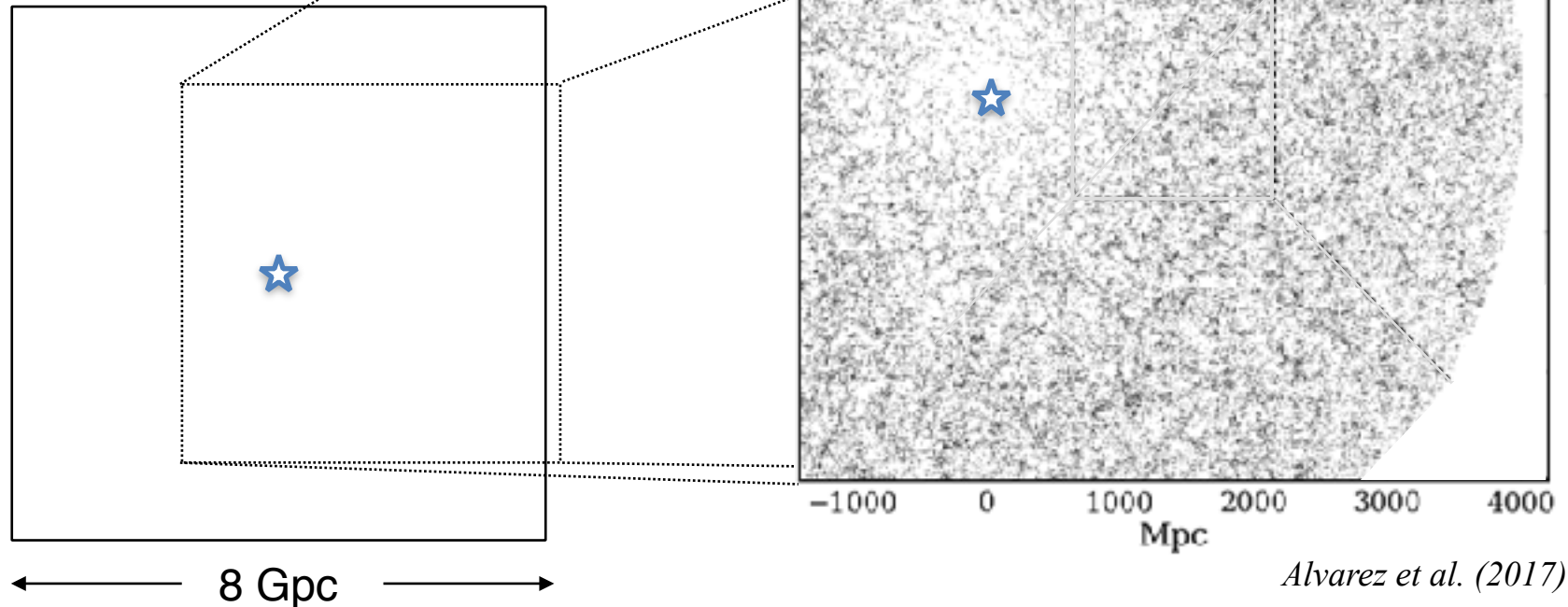
$8^3 \text{ Gpc}^3$  Volume @  $4096^3$  Resolution

Halo Mass Resolution  $\sim 1e13 M_{\text{sun}}/h$

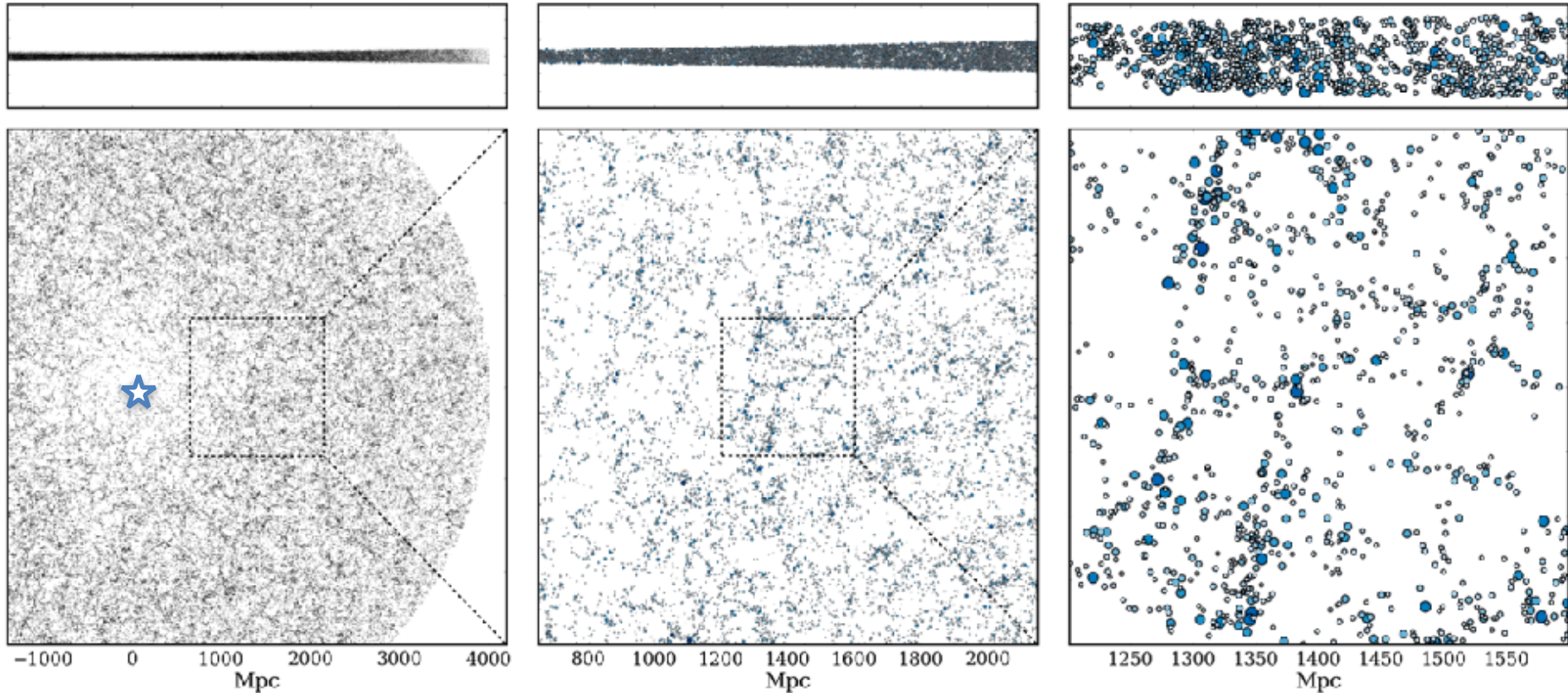
Memory Footprint: 2 TB

Fully Sky for  $0 < z < 1.3$

$\sim 600$  CPU Hours

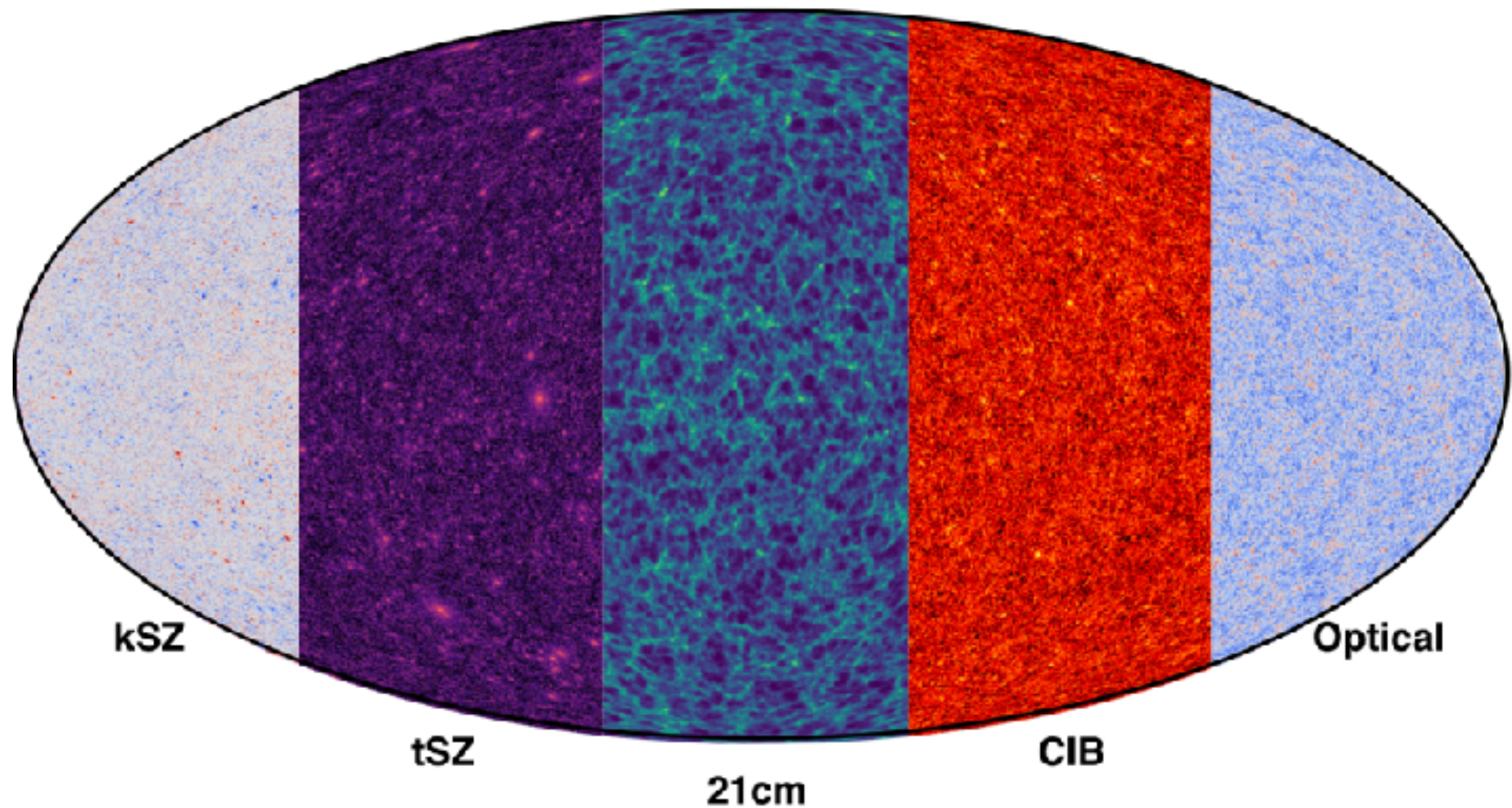


# Fast Large Scale Structure Mocks with the Peak Patch Approach (with Bond, Stein, Battaglia & van Engelen)



*Alvarez et al. (2017)*

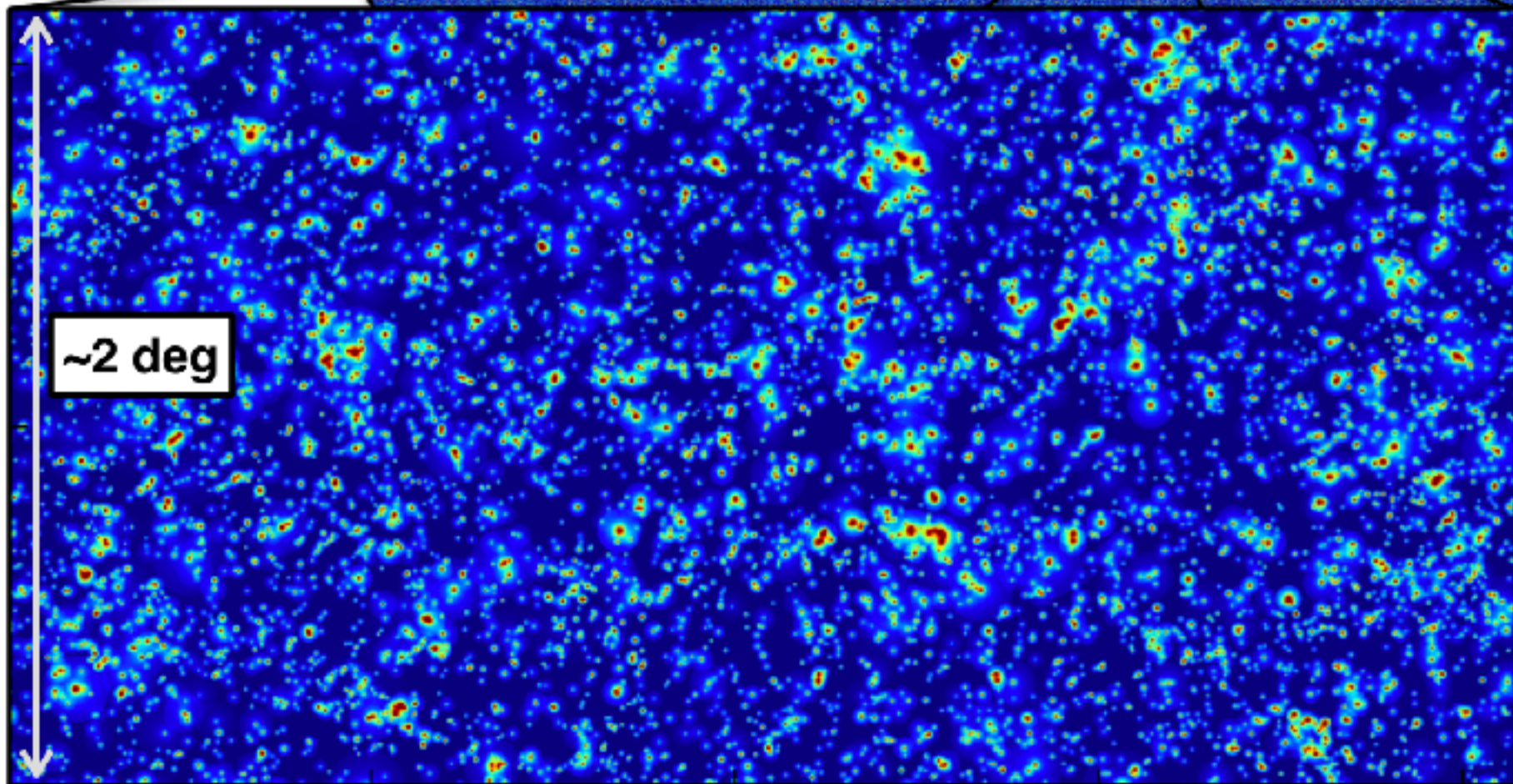
# Fast Large Scale Structure Mocks with the Peak Patch Approach (with Bond, Stein, Battaglia & van Engelen)



# CMB Lensing Mocks to $z=4.5$

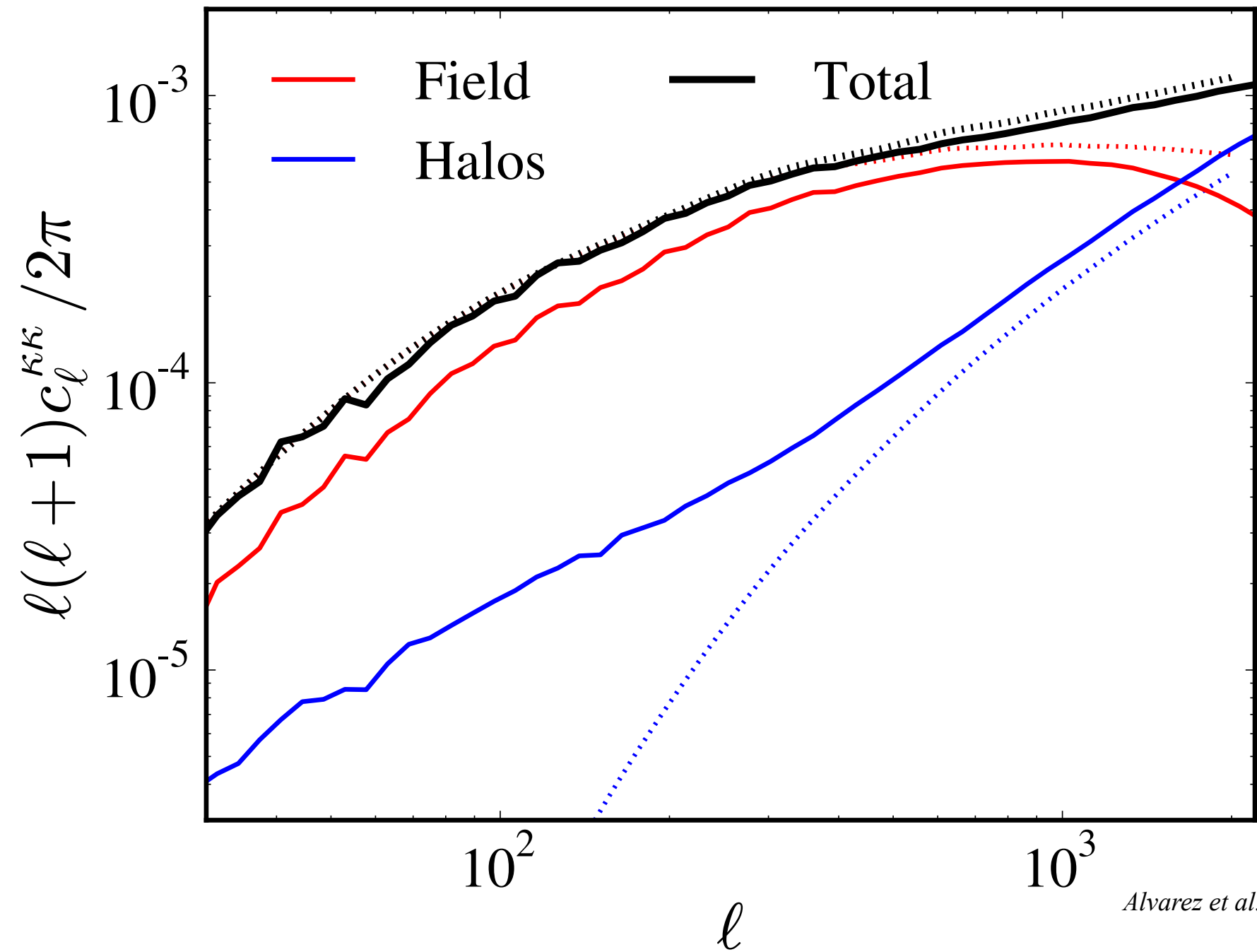
$16^3 \text{ Gpc}^3$  volume  
 $8192^3$  resolution  
 $0 < z < 4.5$   
 $M > 2 \times 10^{13} M_{\text{sun}}$

Fast Full Sky CMB Convergence Maps with the  
Peak Patch Approach (with Bond, Stein, Battaglia & van Engelen)

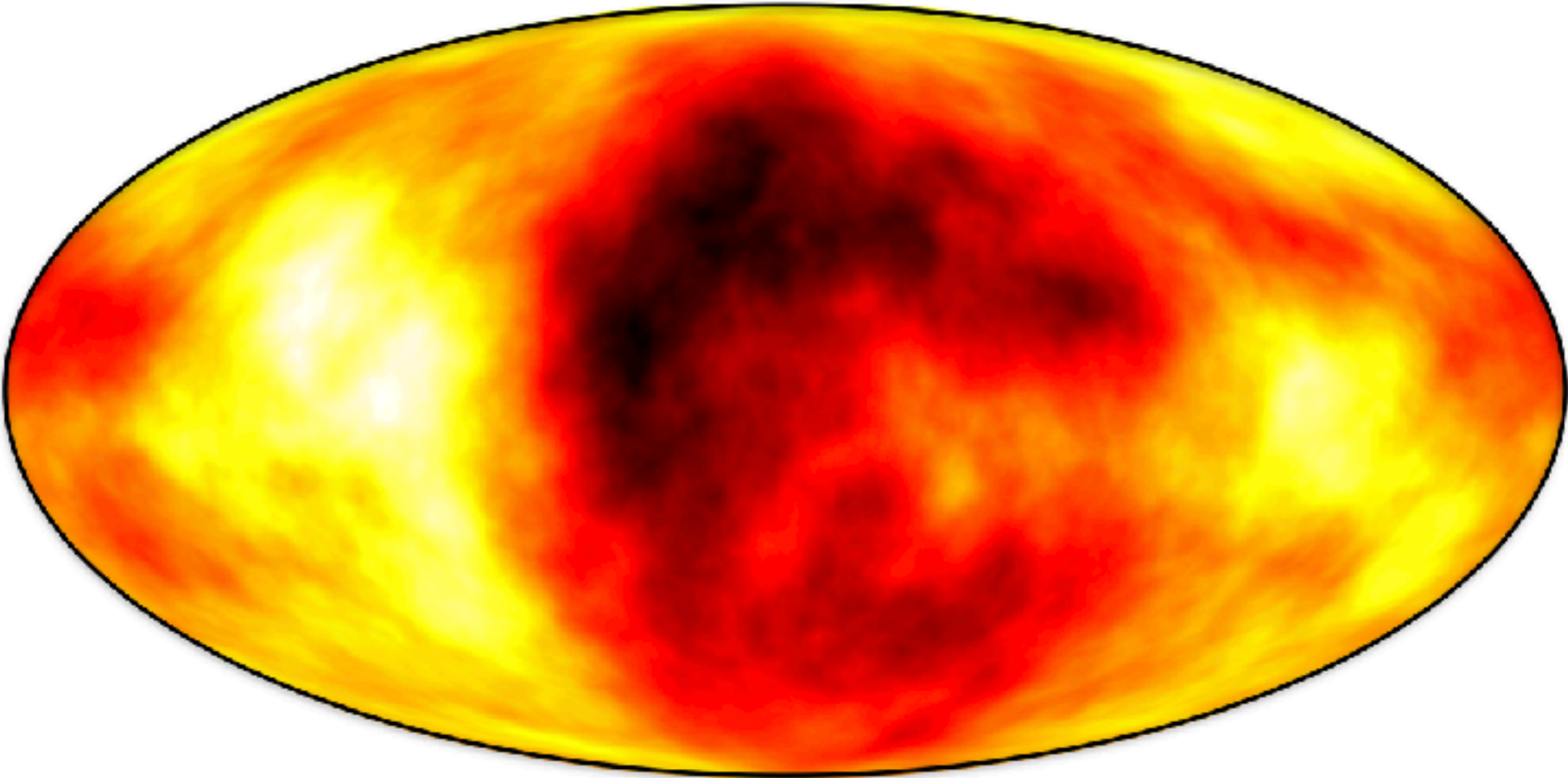


~2 deg

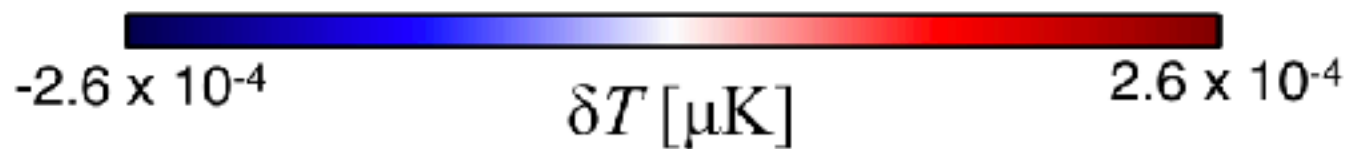
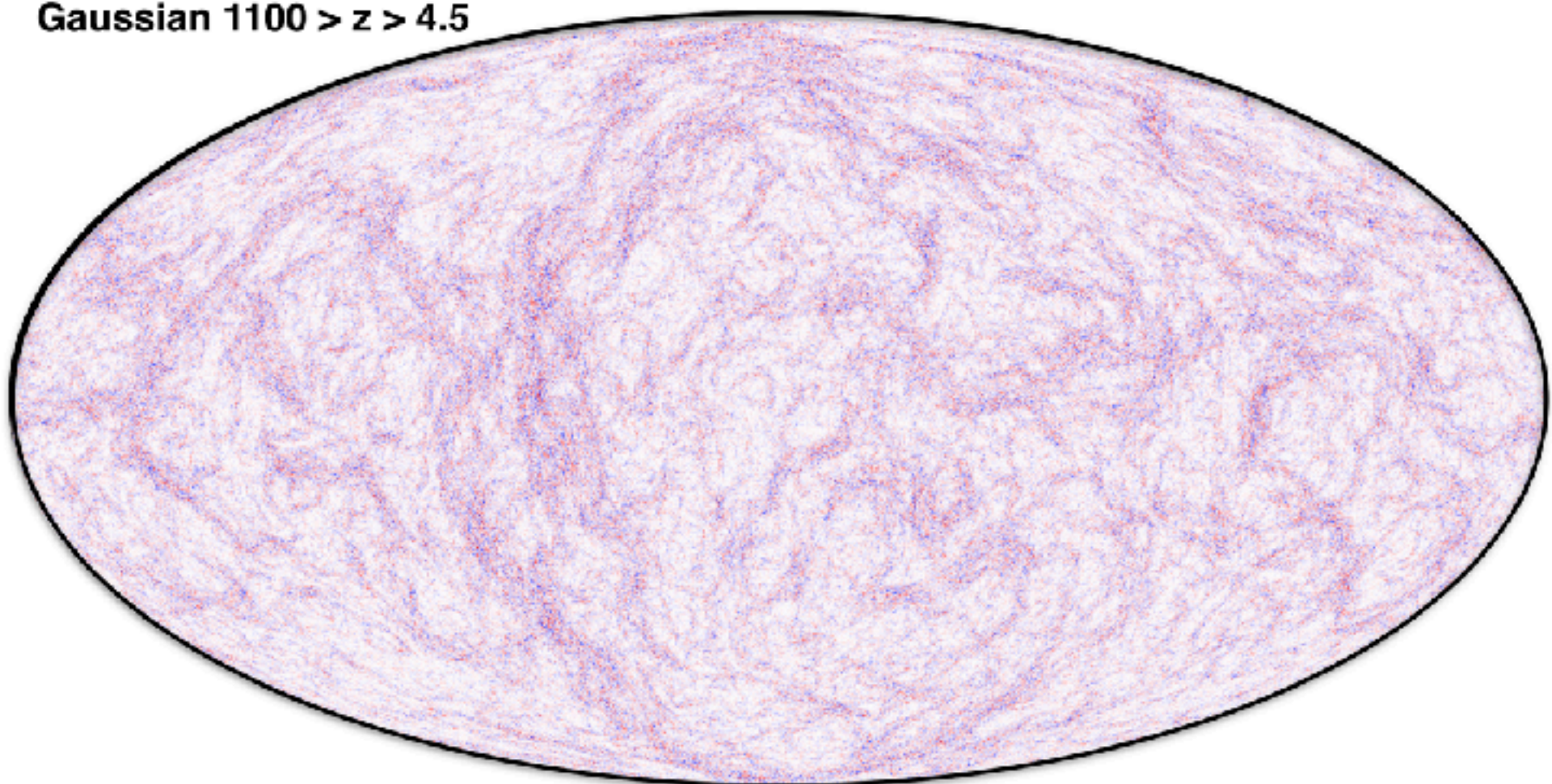


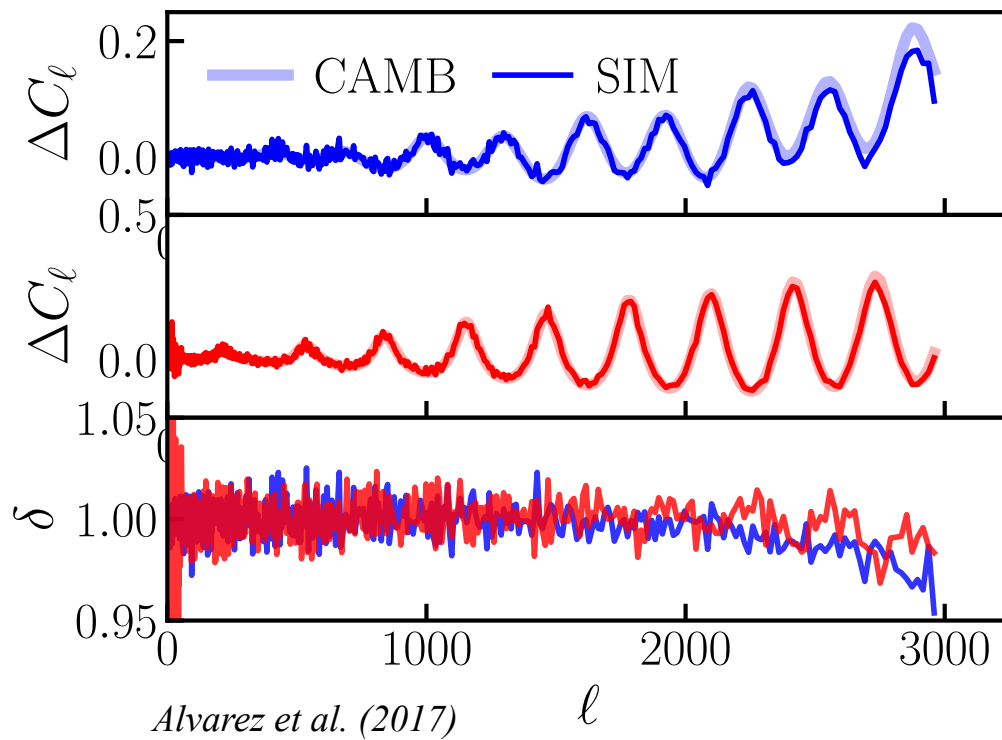
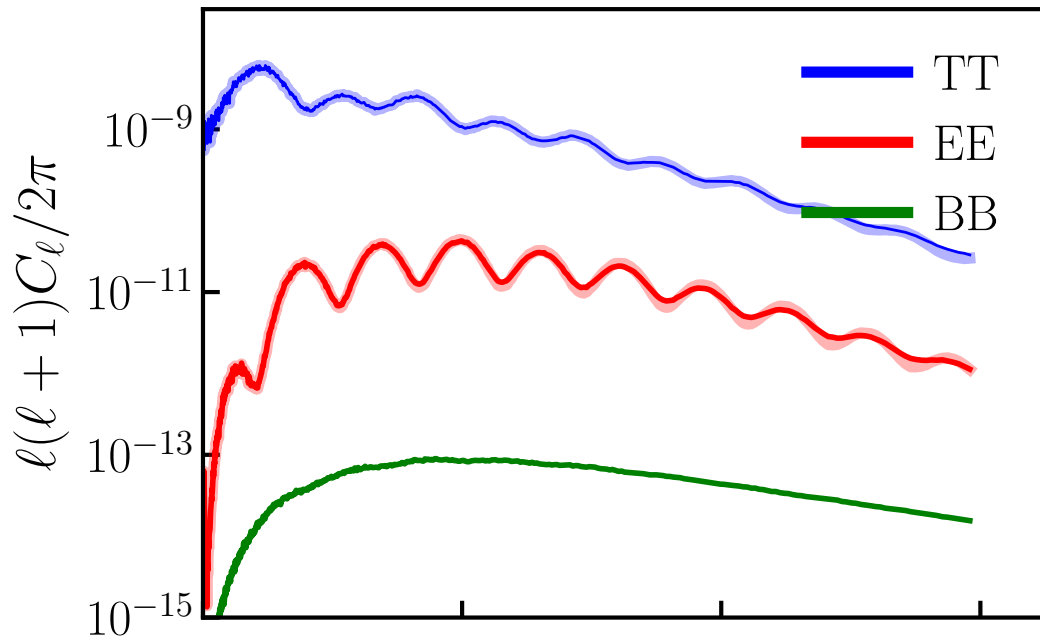


**Total Lensing Potential  
Including Field**

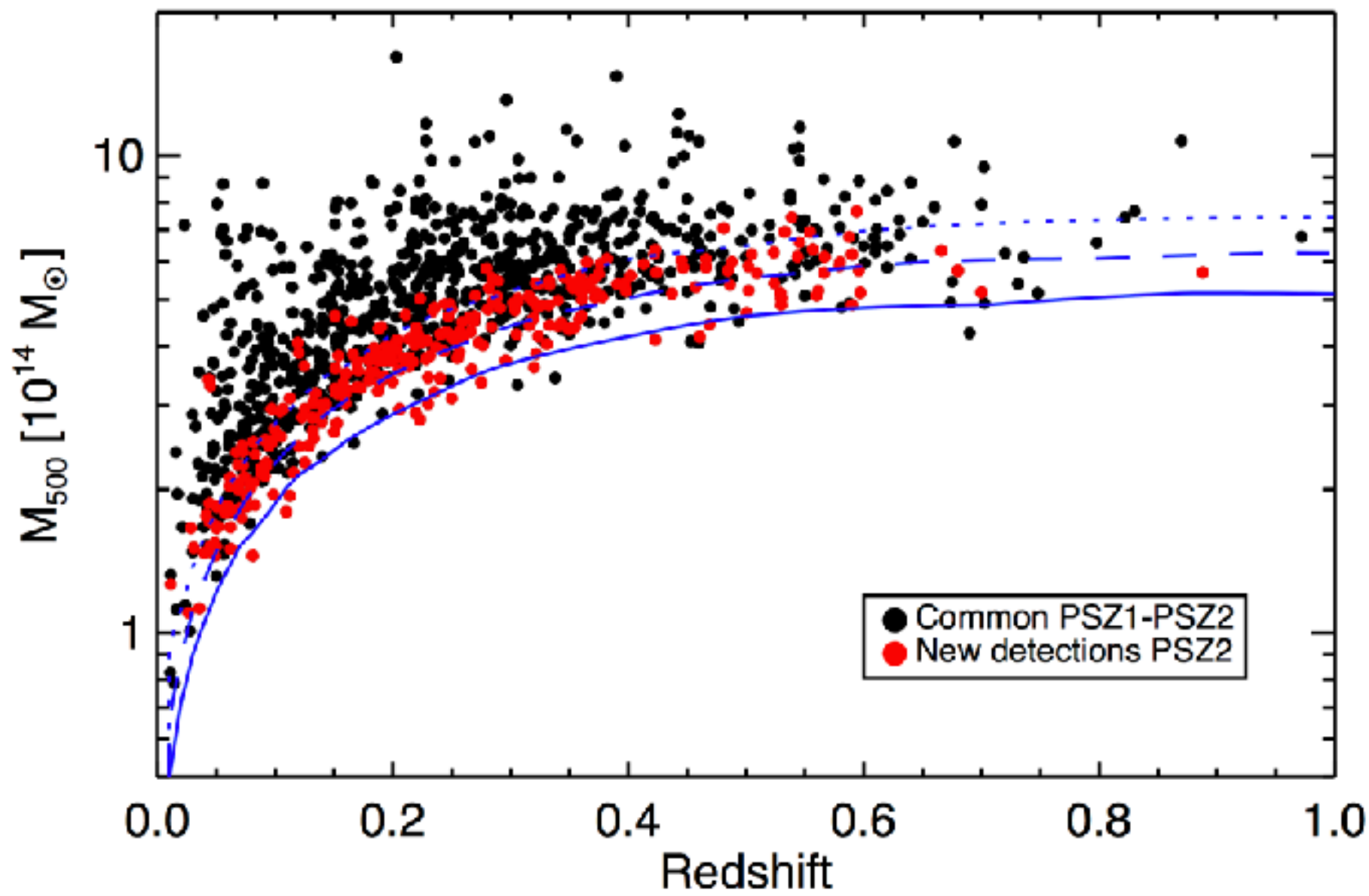


**Difference Map of Lensed and Unlensed CMB  
including 2LPT Field + Halos + uncorrelated  
Gaussian  $1100 > z > 4.5$**

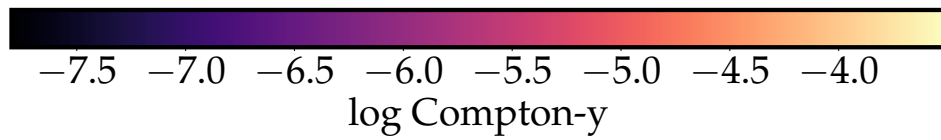
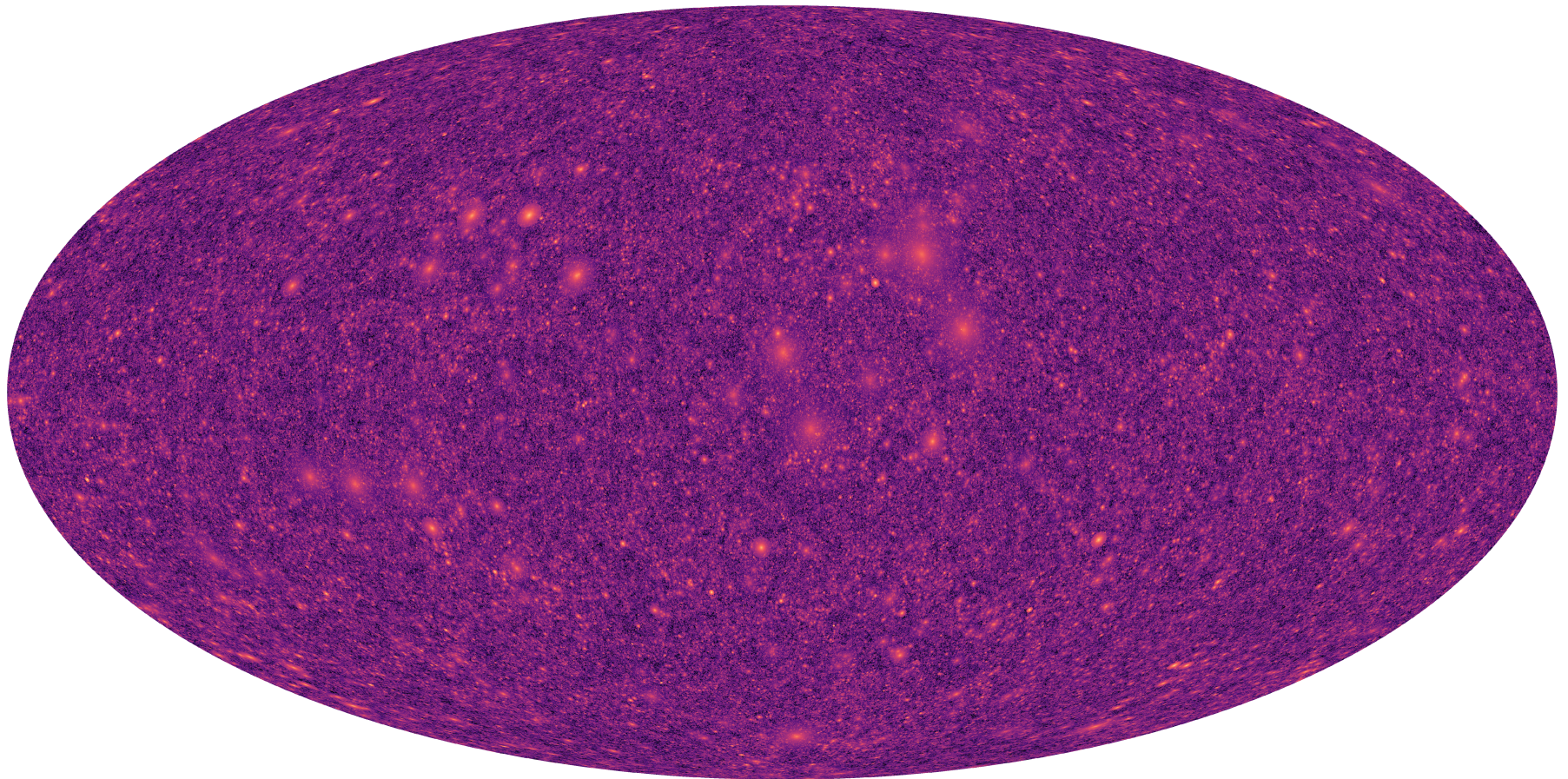




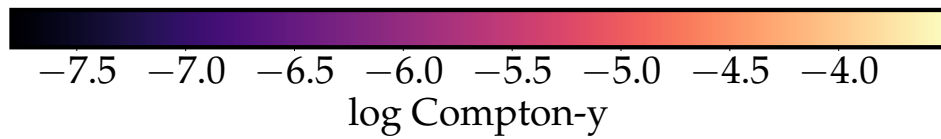
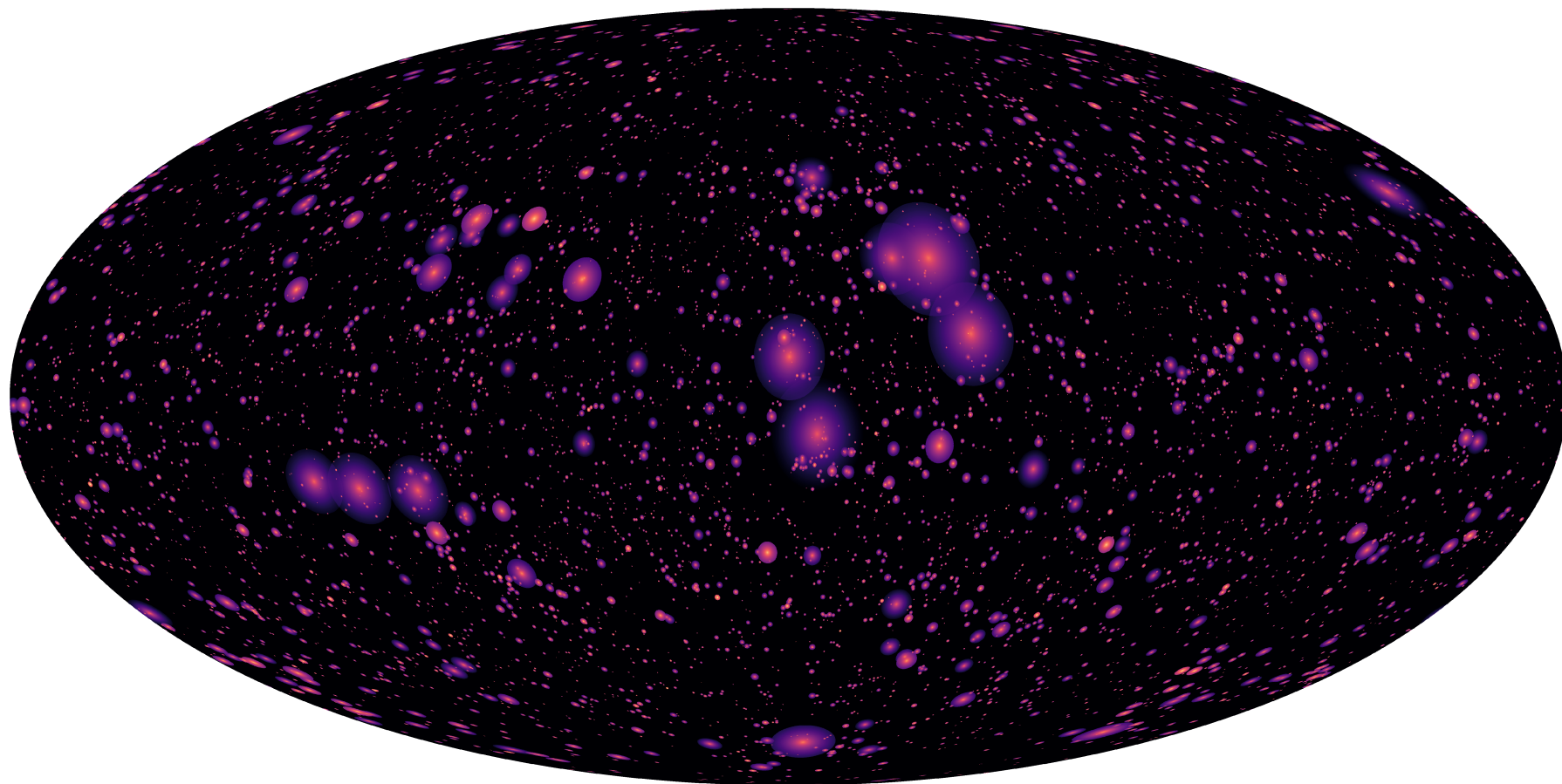
Comparison to  
Planck Cluster tSZ x CIB



All Clusters

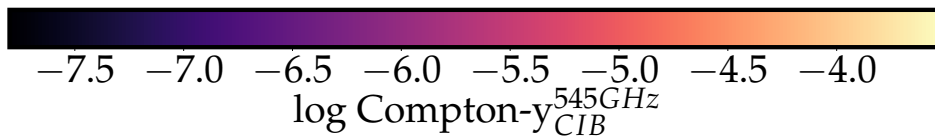
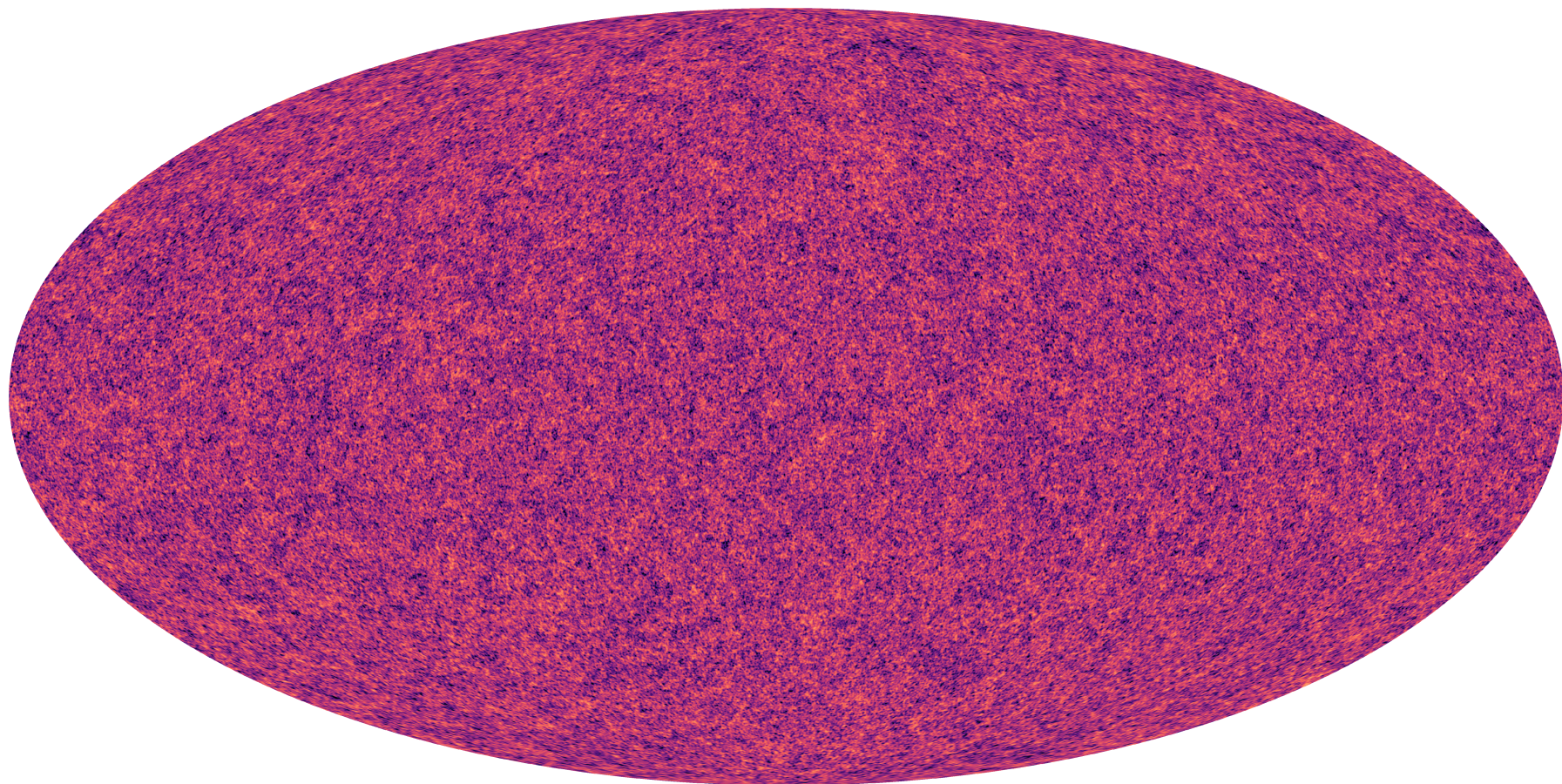


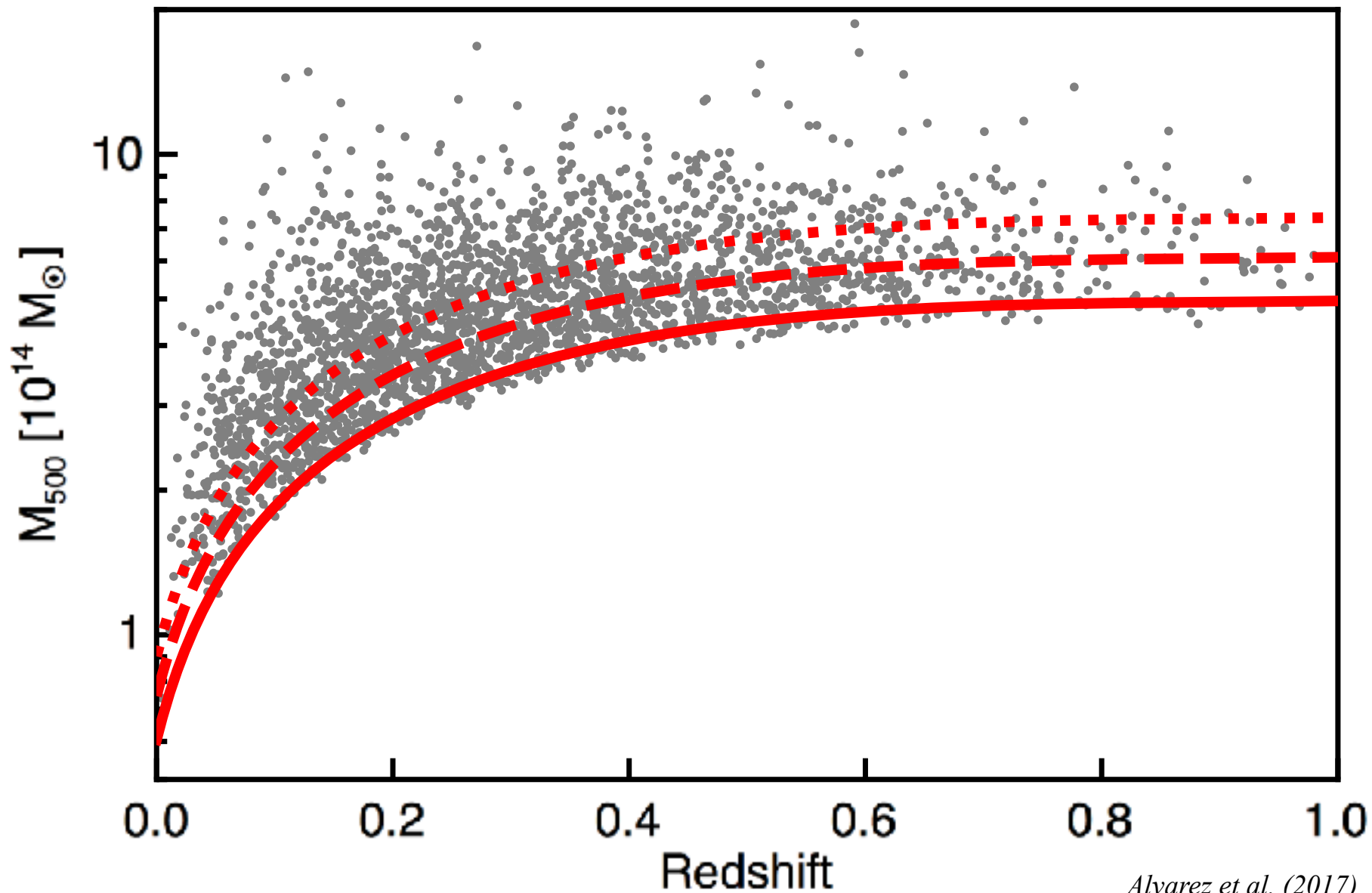
PSZ2 Only





CIB @545 GHz



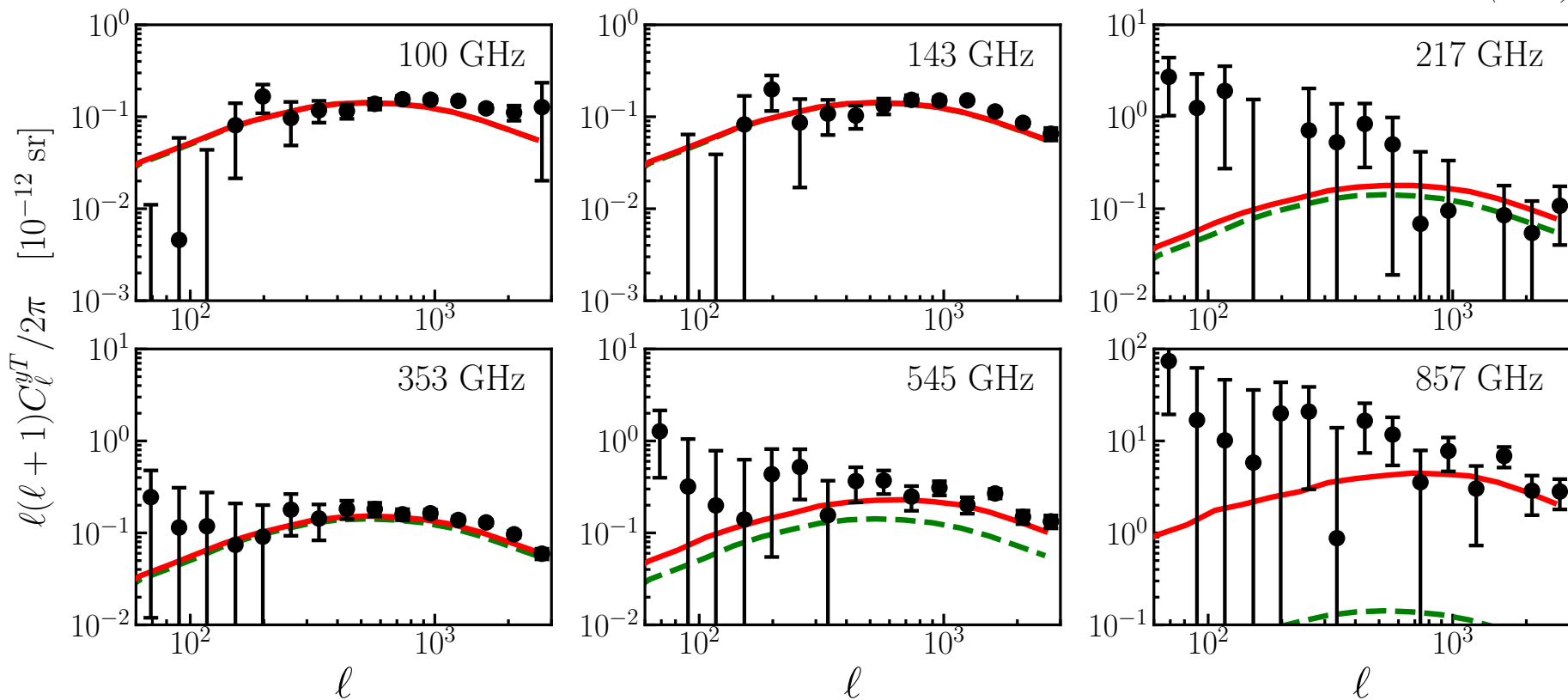


*Alvarez et al. (2017)*

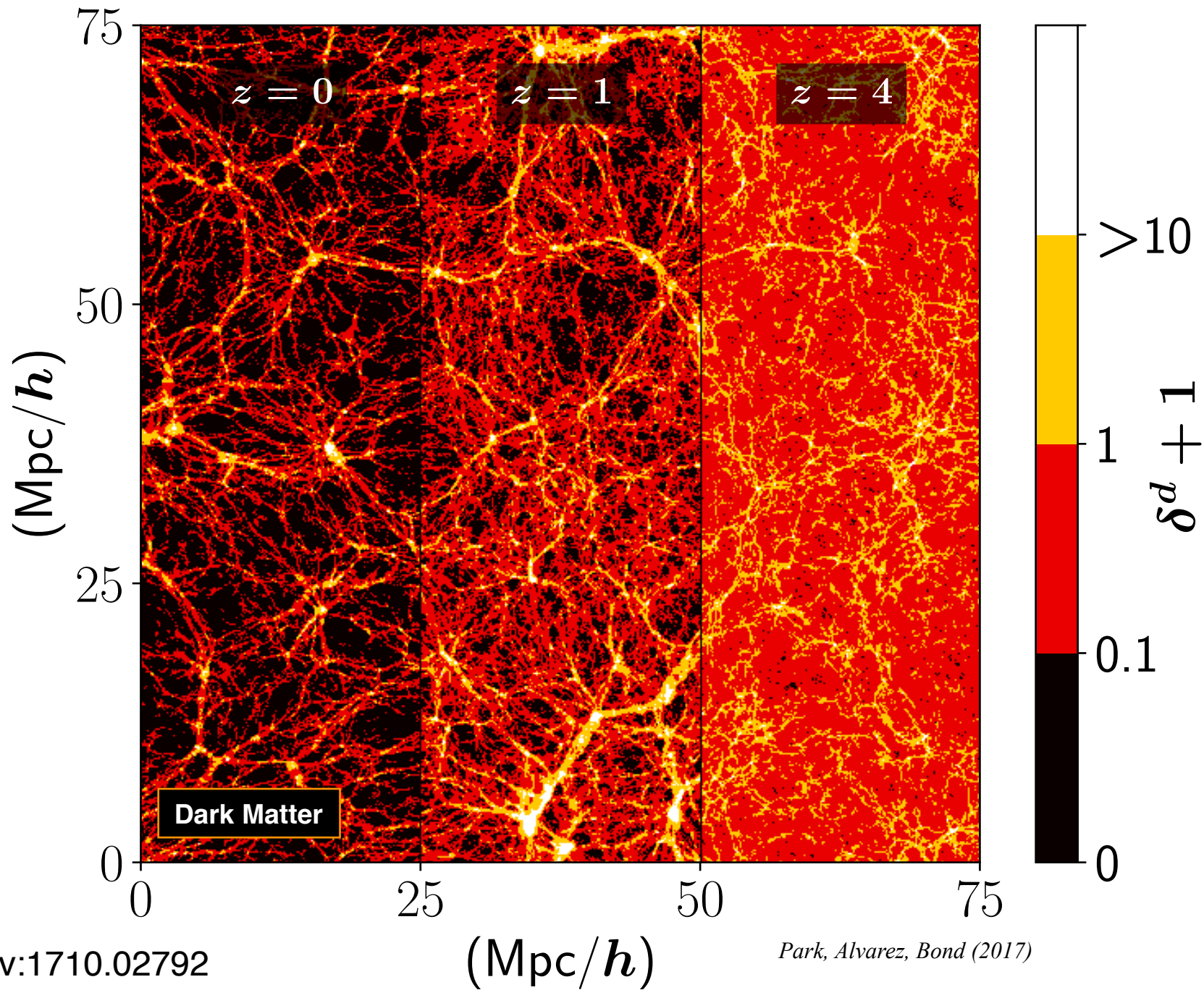
—  $y_c \times (y_c + I_{\text{CIB}})$

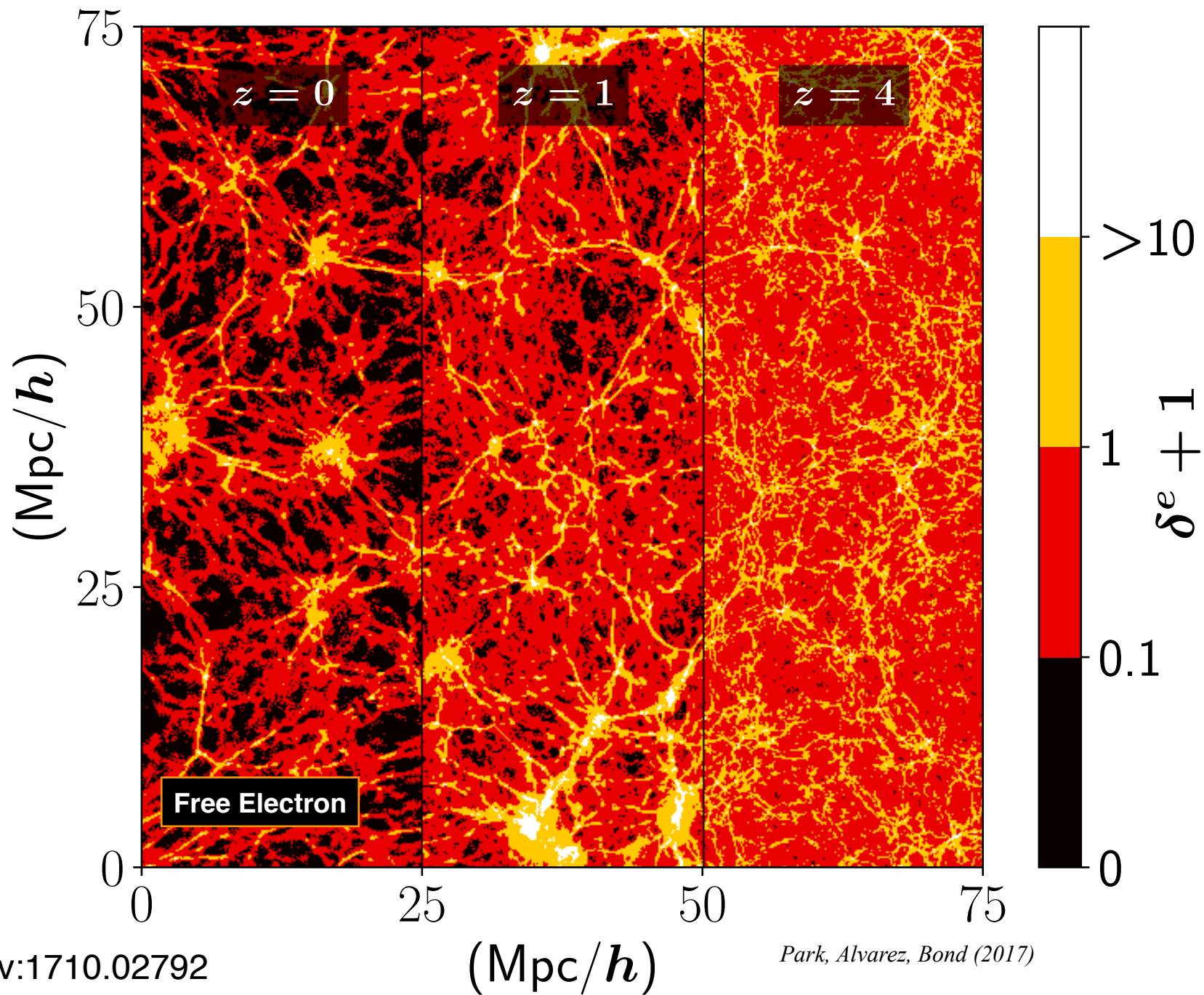
- - -  $y_c \times y_c$

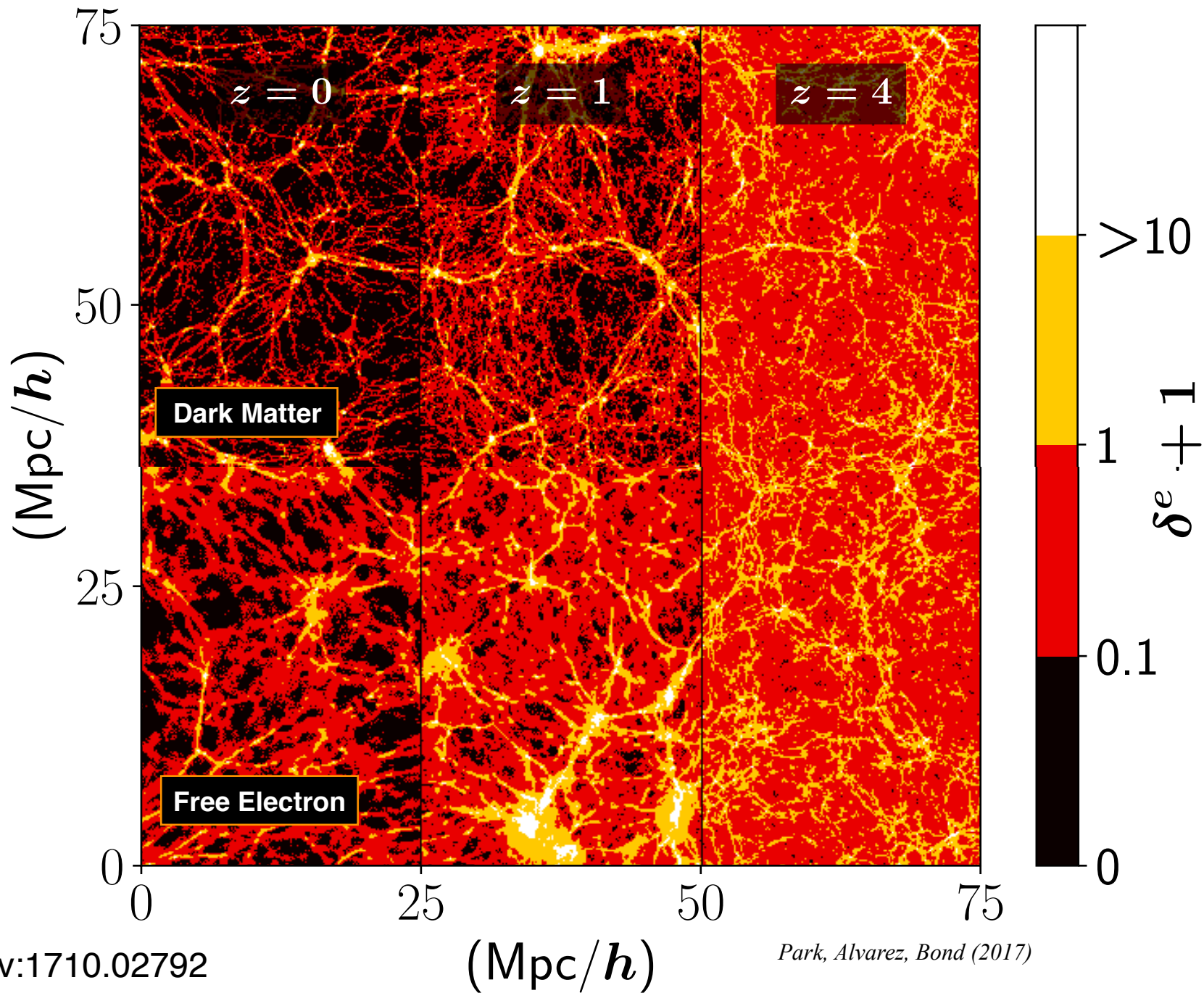
*Alvarez et al. (2017)*

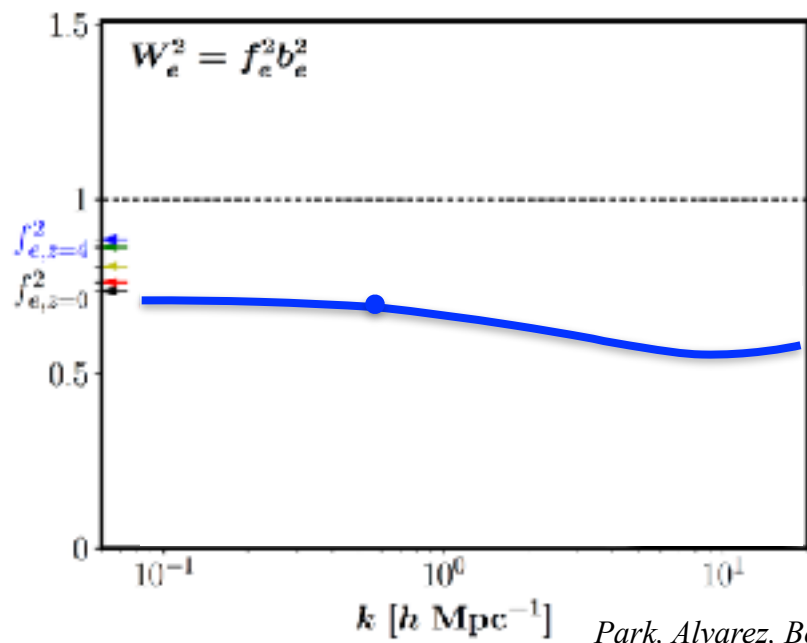
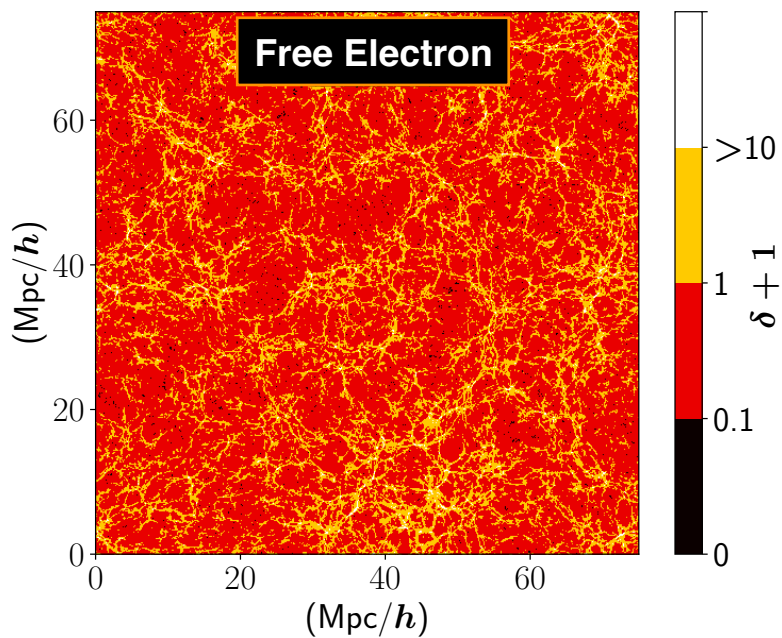
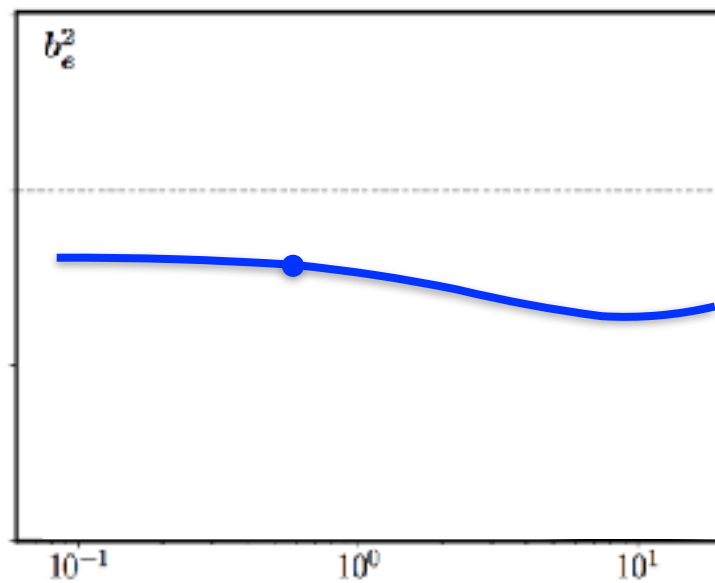
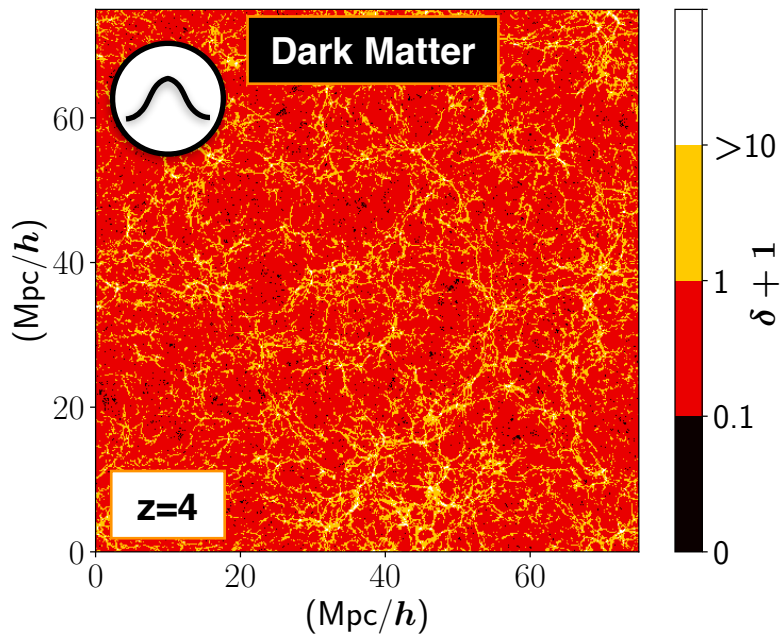


# Using Hydro Sims to Model Small Scale kSZ Physics

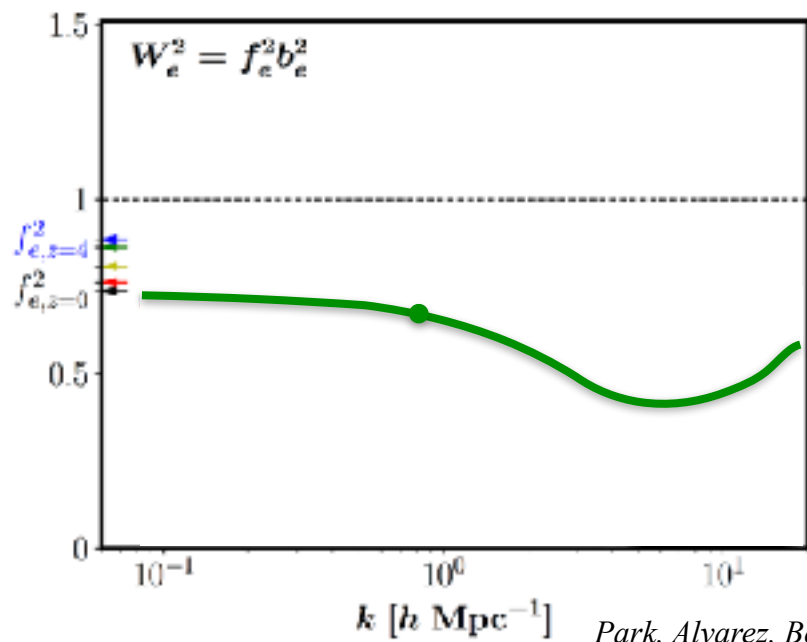
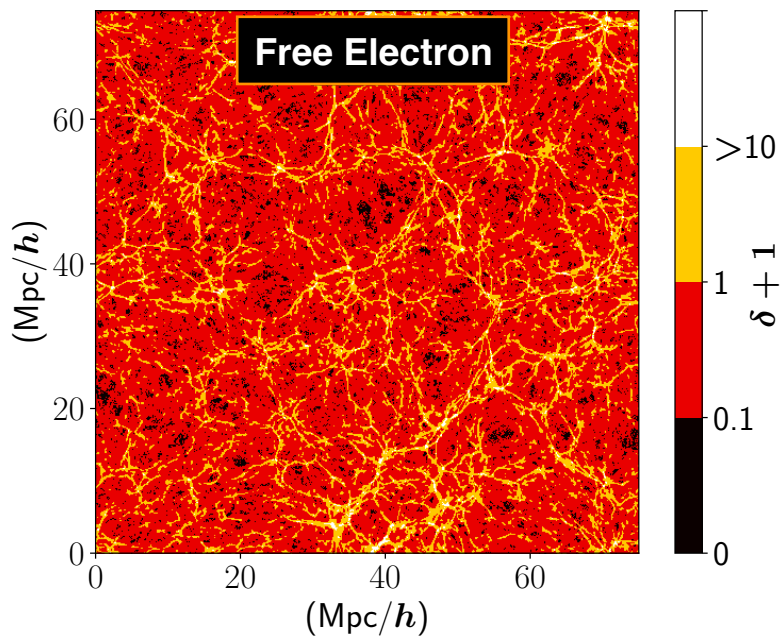
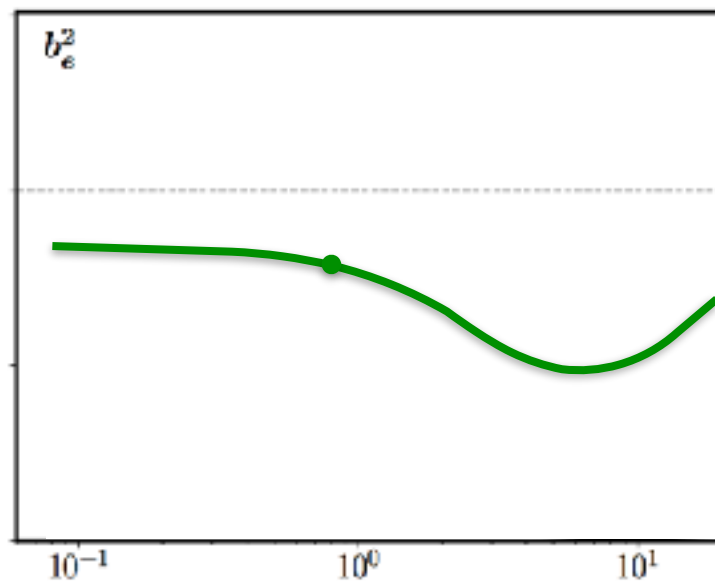
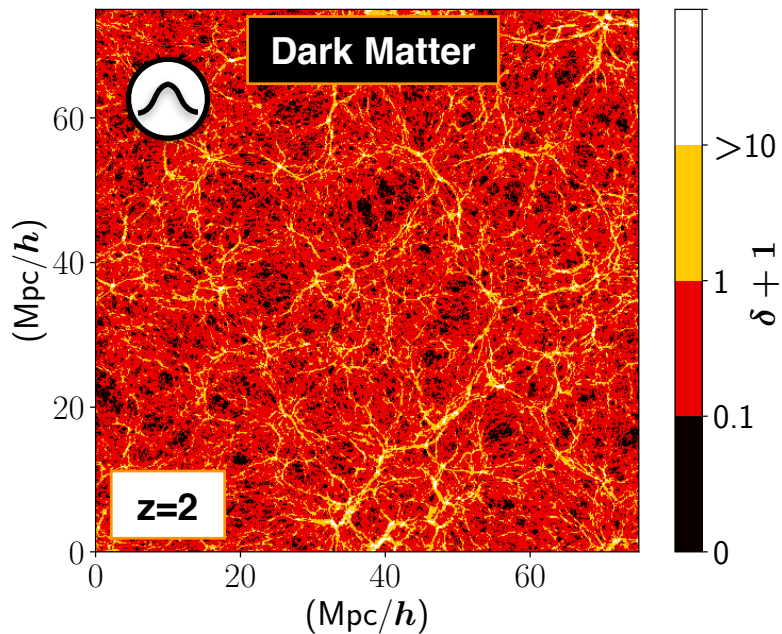


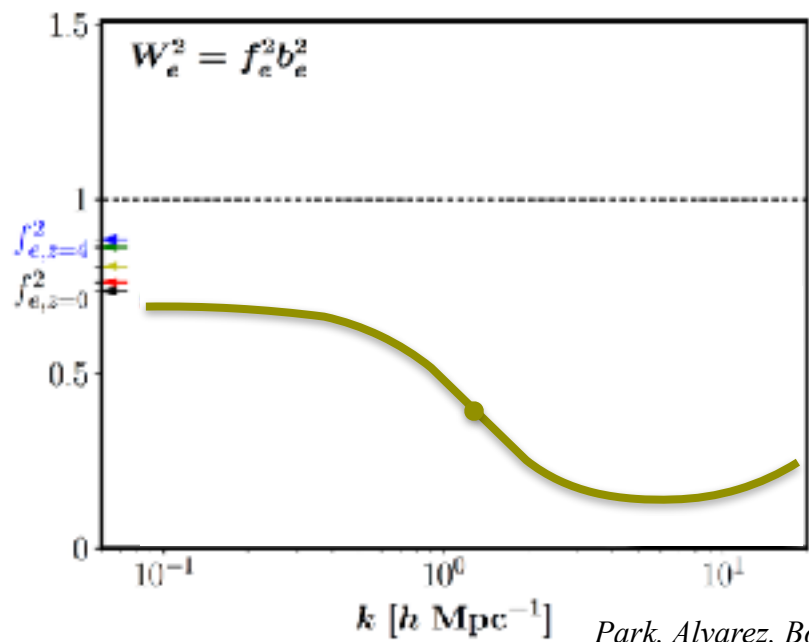
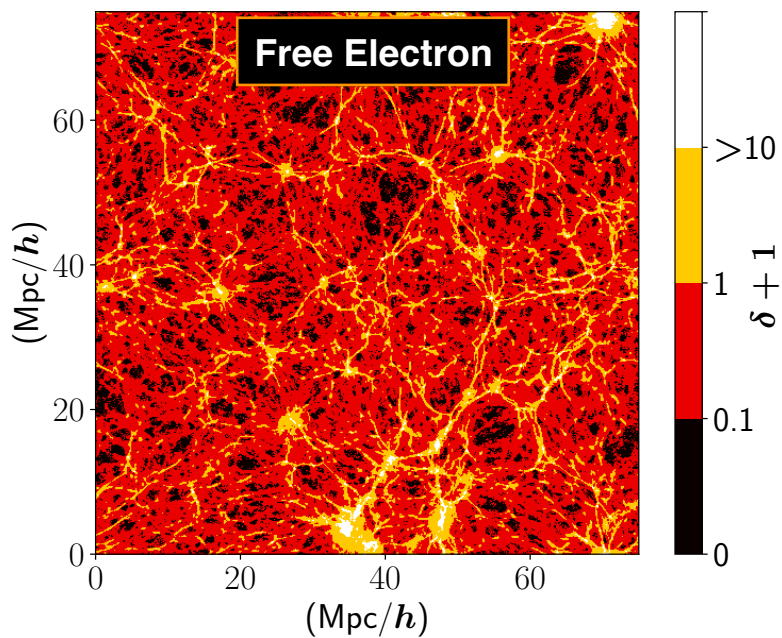
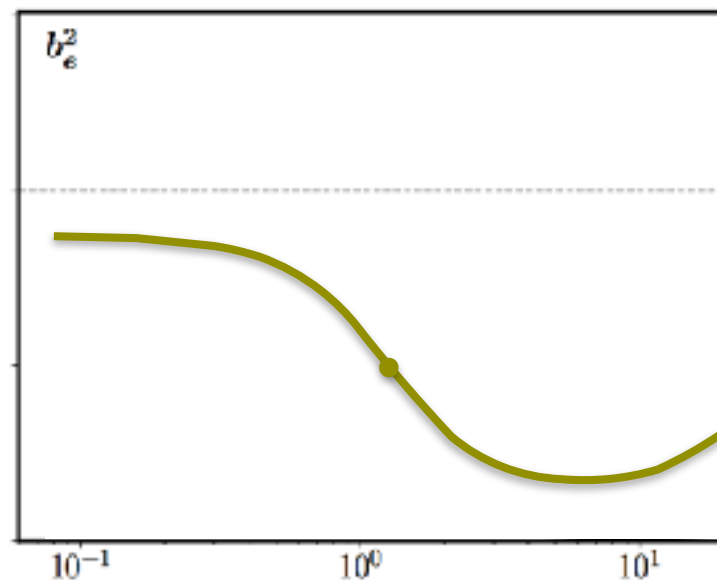
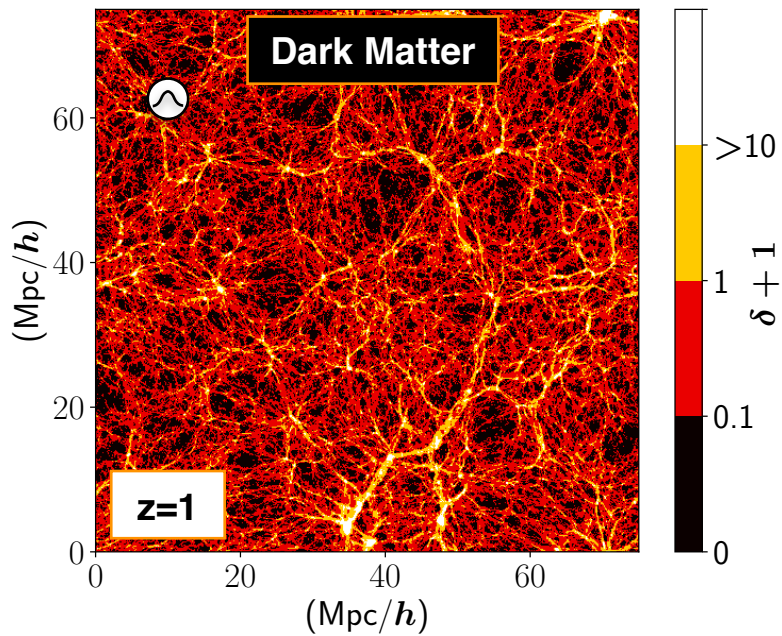


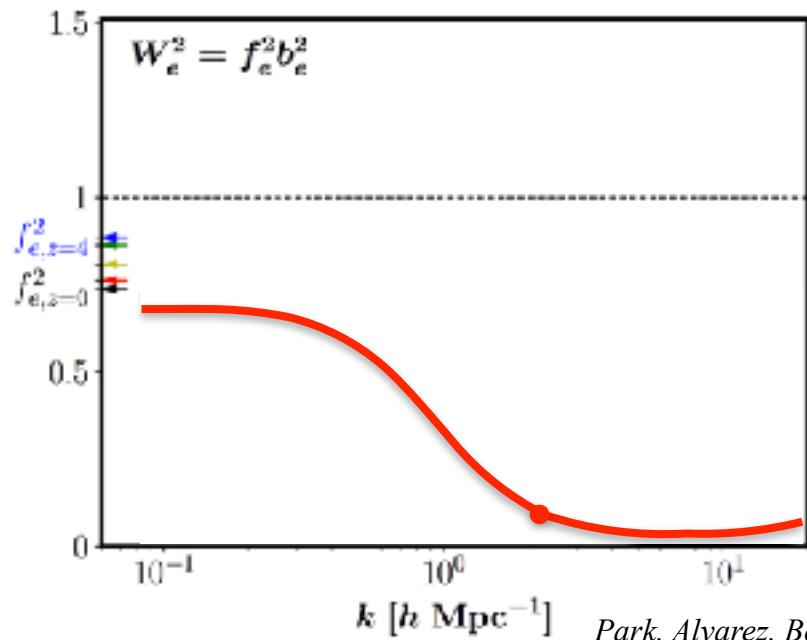
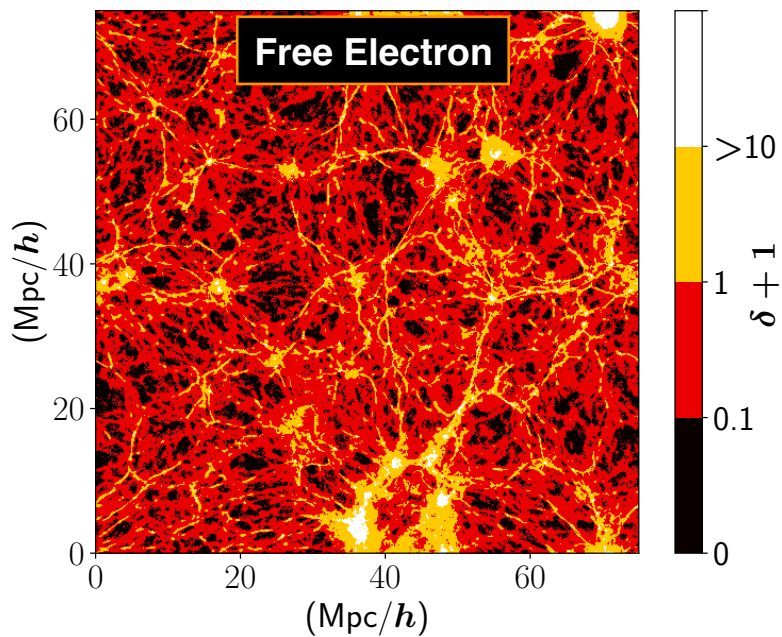
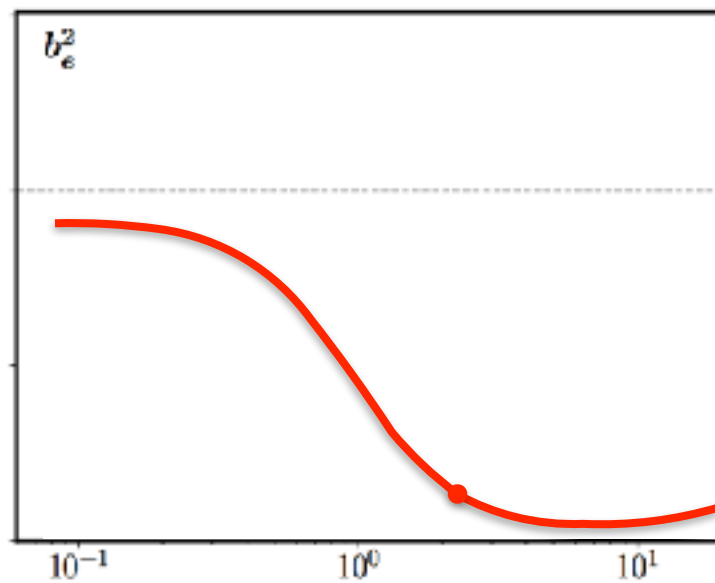
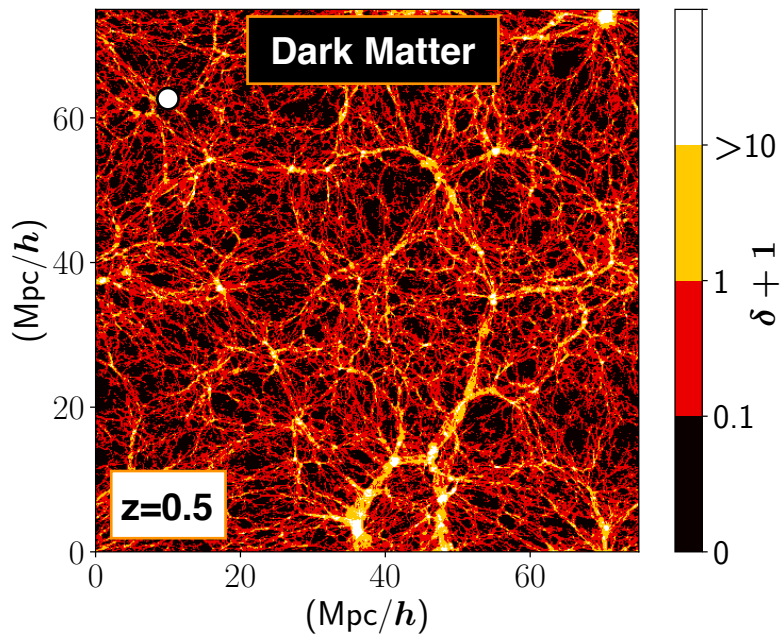


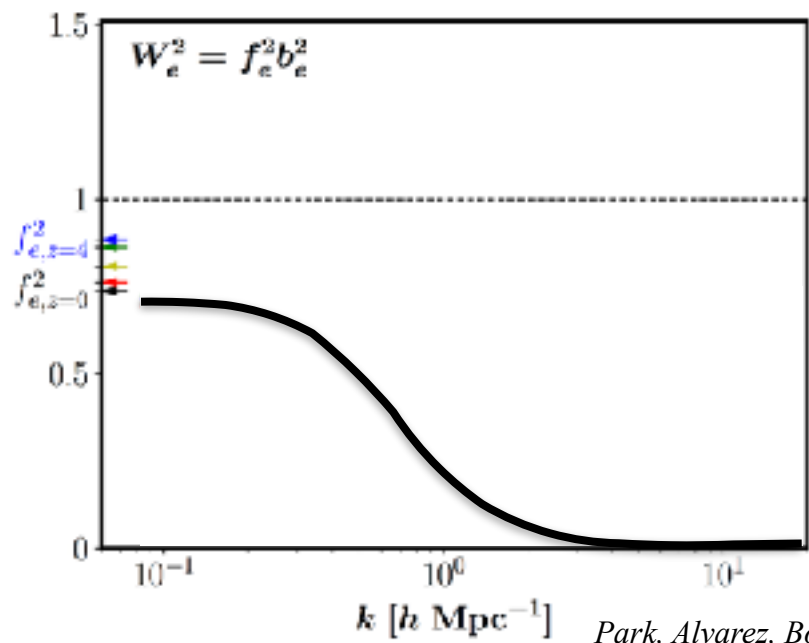
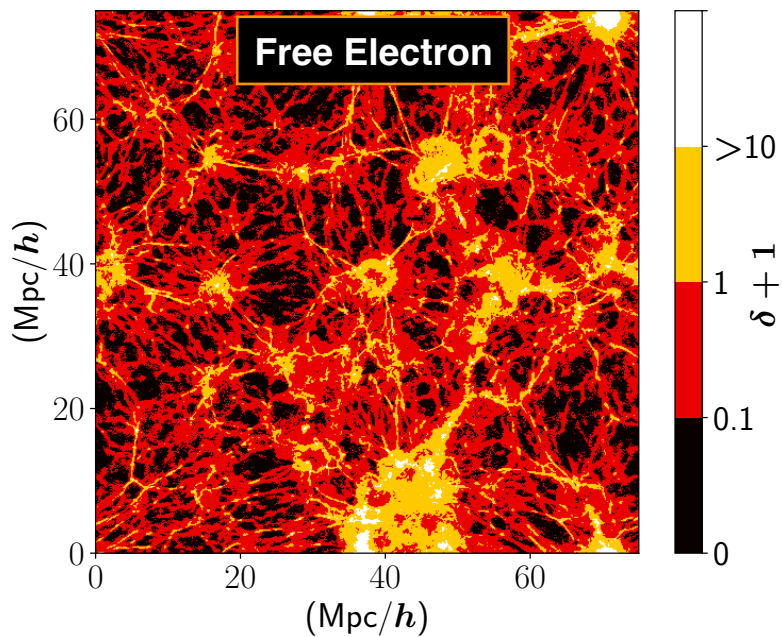
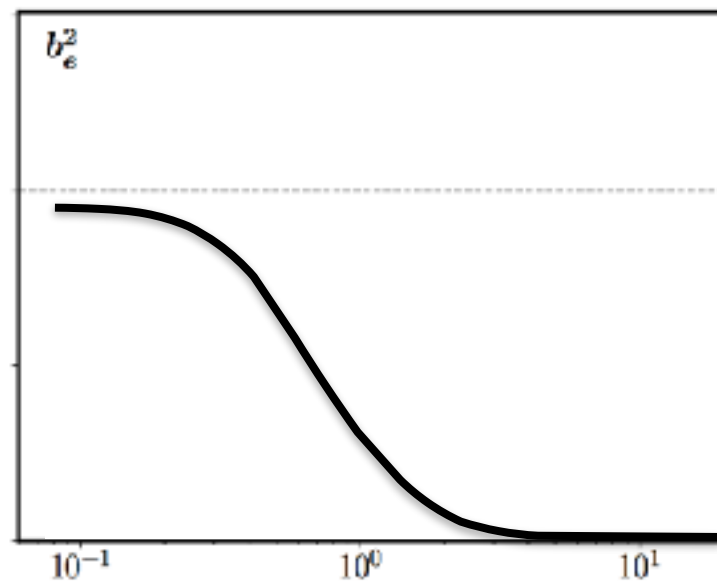
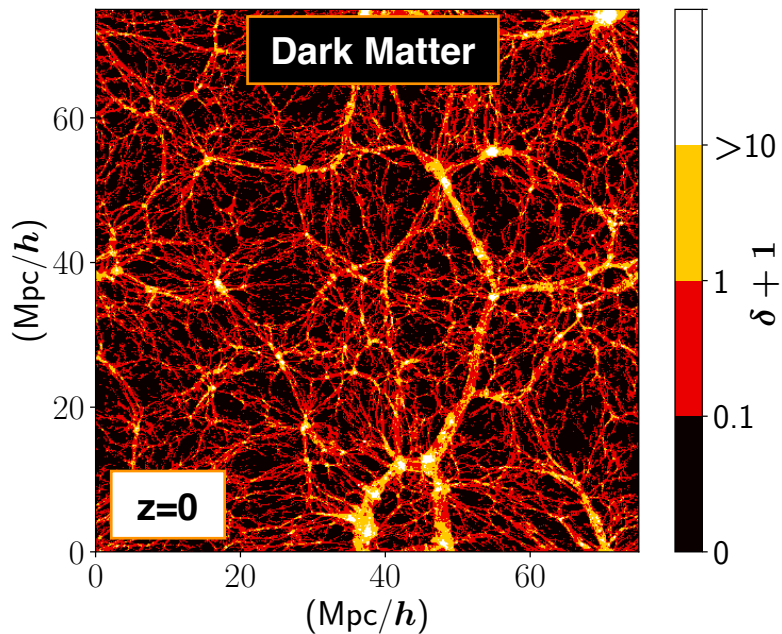


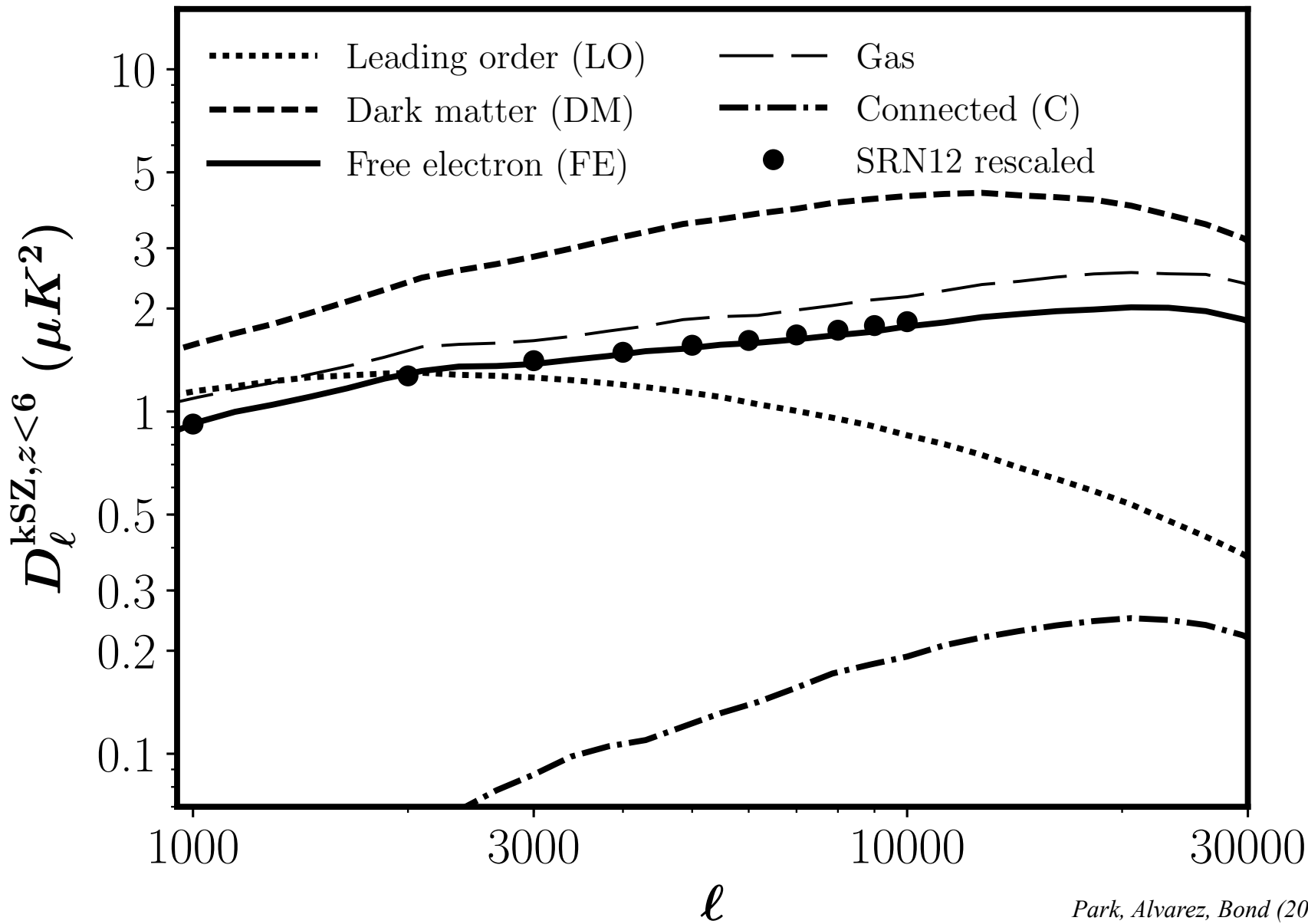




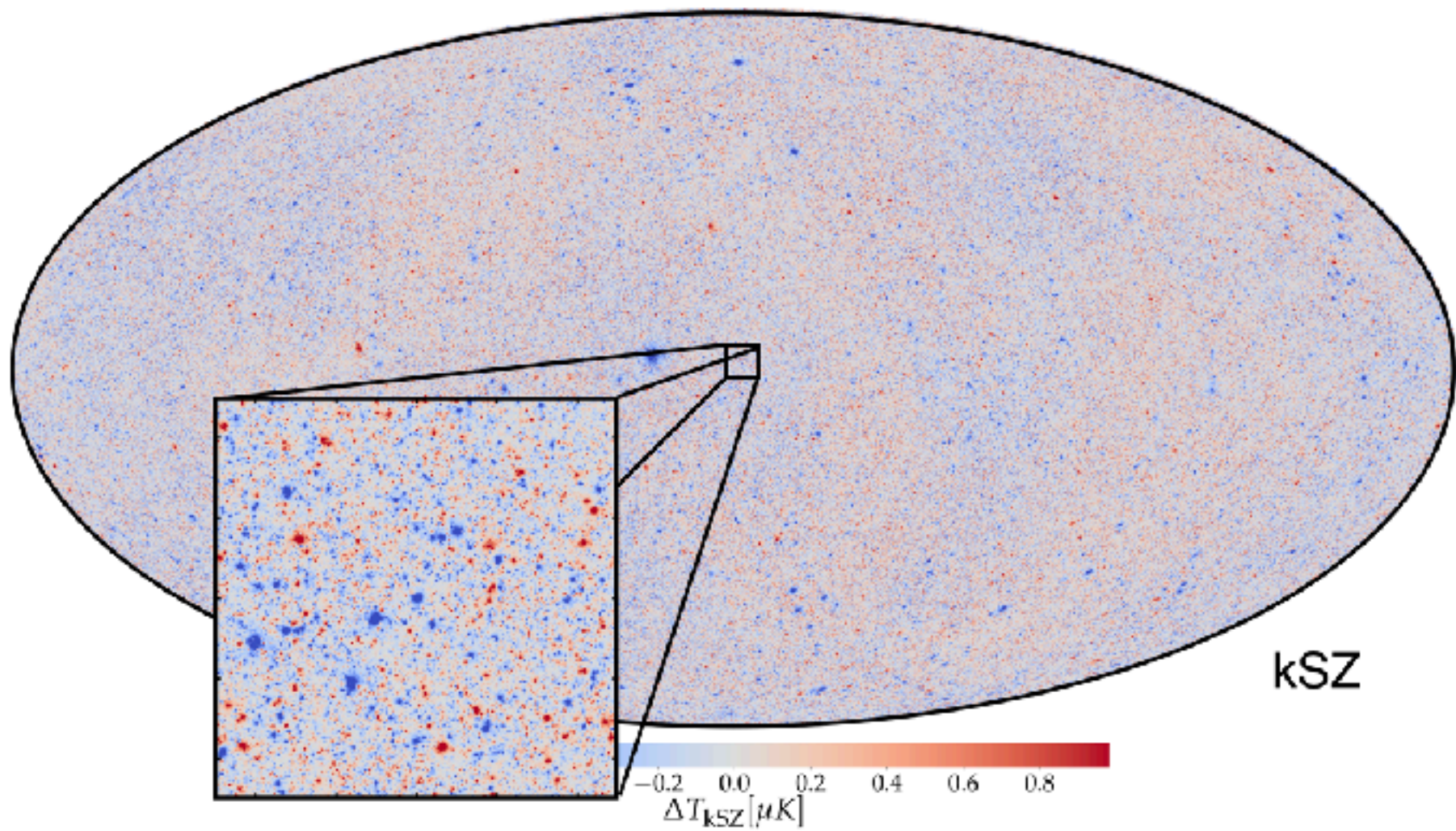


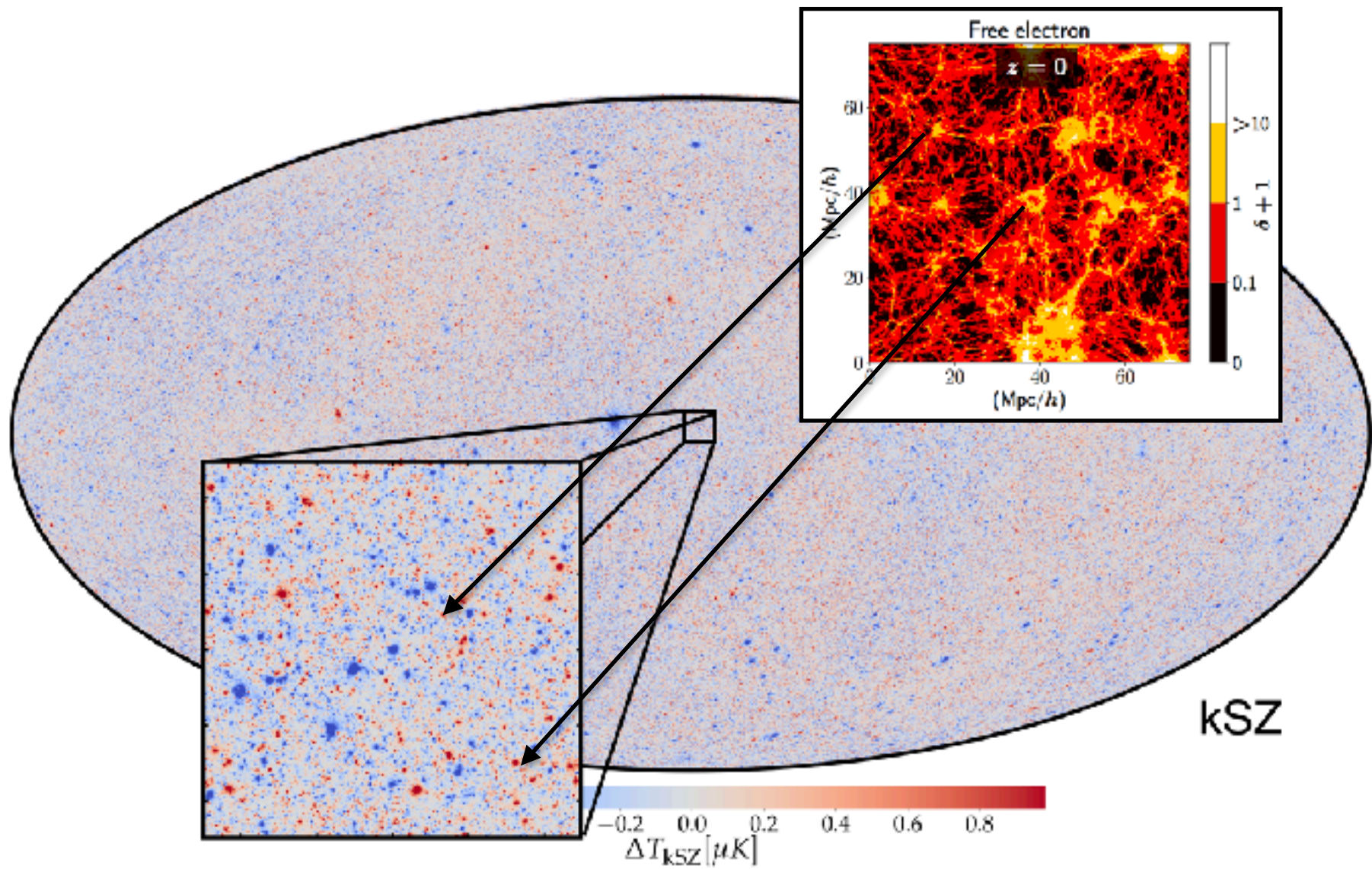






*Park, Alvarez, Bond (2017)*



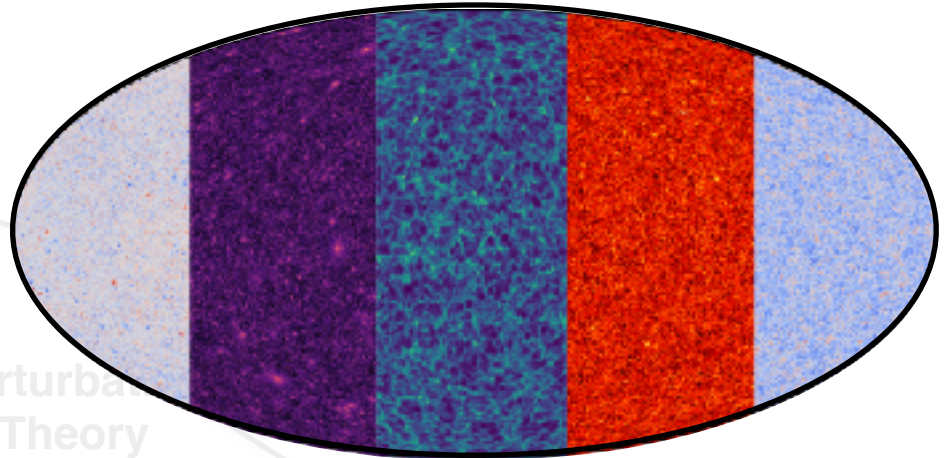


# Wish List for Extragalactic CMB Foreground Models

Initial

## Goal:

Unified model for Extragalactic CMB Sky that spans the range of realistic foregrounds **and** is consistent with current observations



## Physical realism

- Variation of galaxy SED within clusters
- Environmental dependence and assembly bias of SED
- Orientation of matter, galaxies, electron pressure and momentum in clusters with large scale structure and dependence on feedback

## Empirical tests

- tSZ / kSZ / CIB bispectra and trispectra
- Cross-correlations with galaxy surveys
- Scaling relations
- Targeted observations of individual clusters

Sim