REIONIZATION : INFLUENCE ON LOW-MASS GALAXIES

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CLUES **09.05.2015**

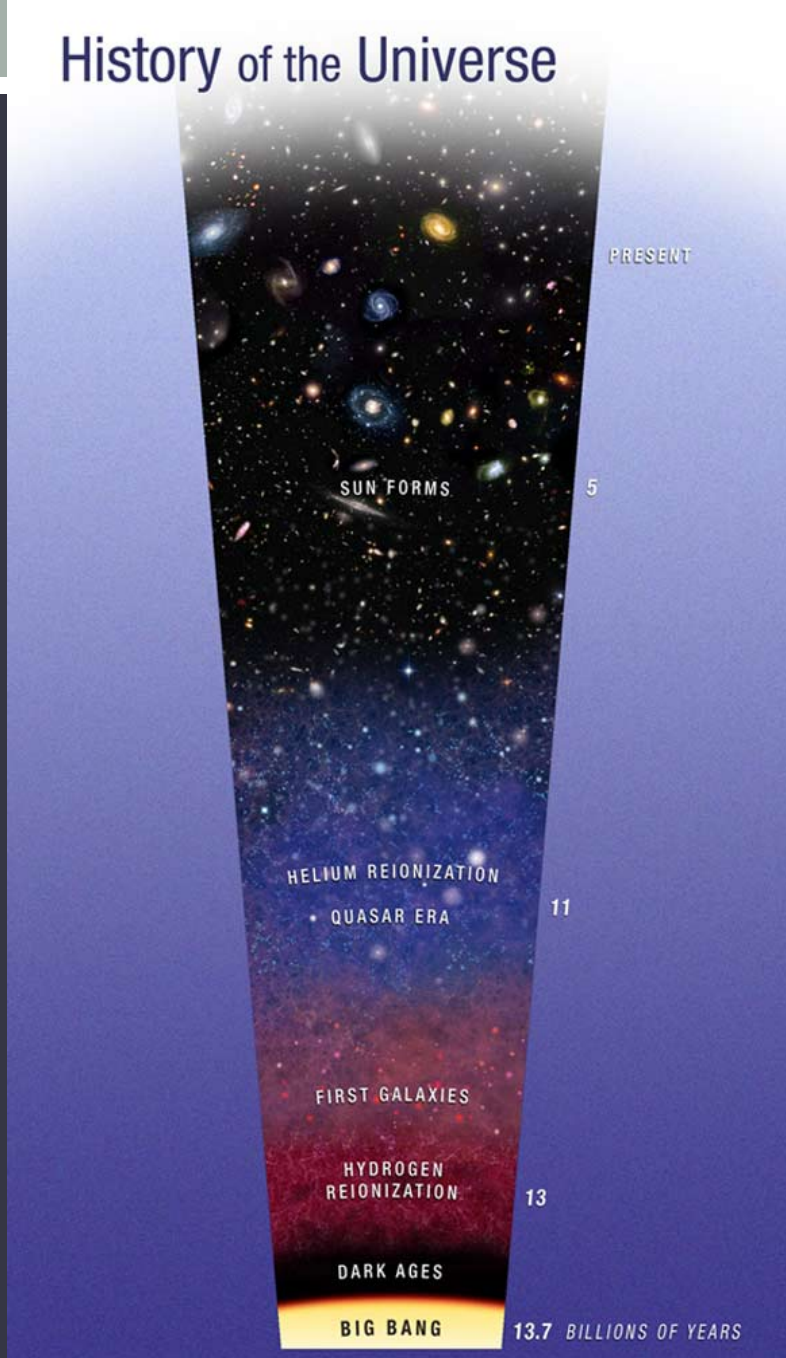
UNIVERSITY OF SUSSEX AT BRIGHTON

Reionization

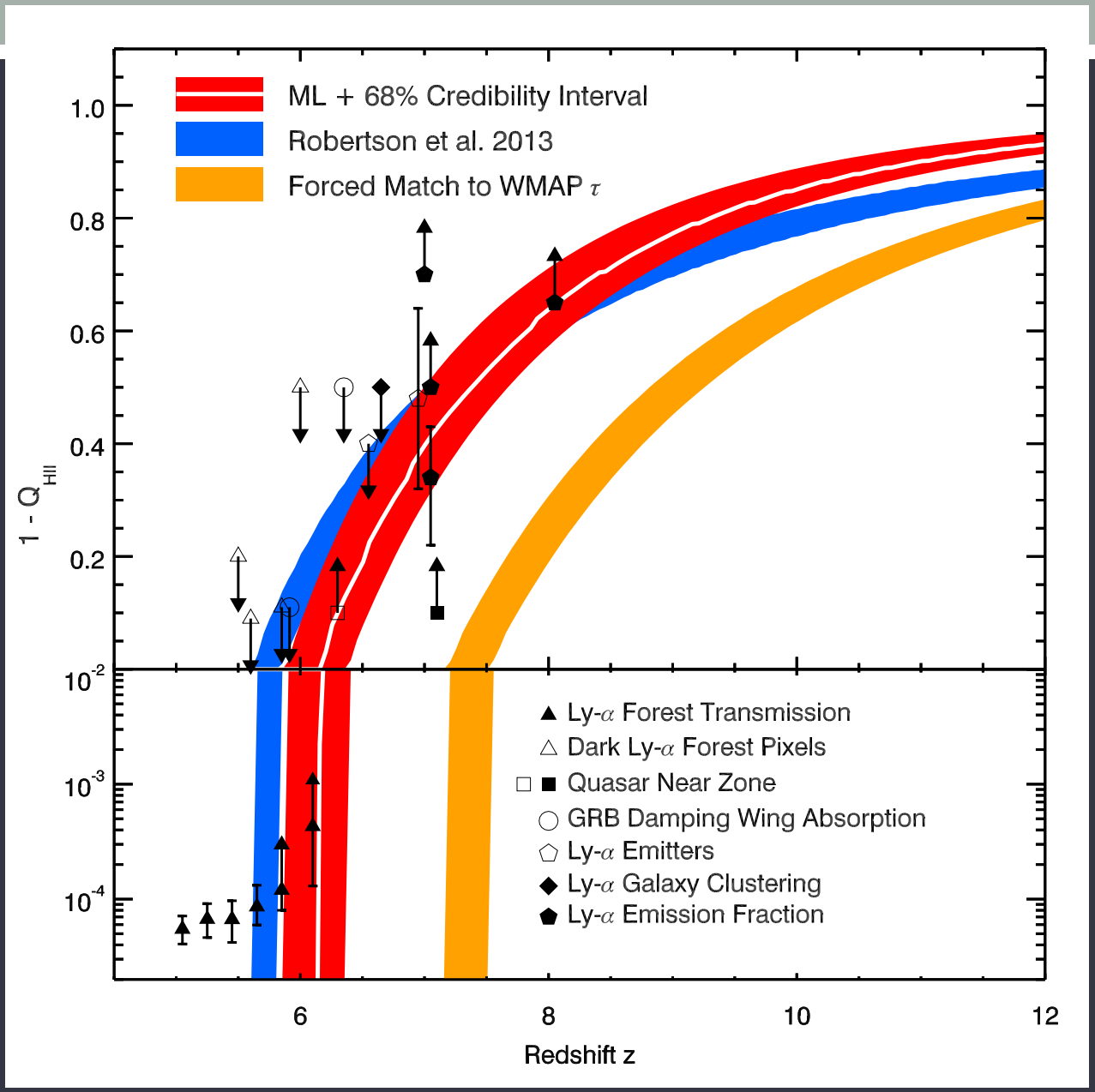
First stars, early galaxies, quasars as sources

This radiation ionizes HI and heats the IGM

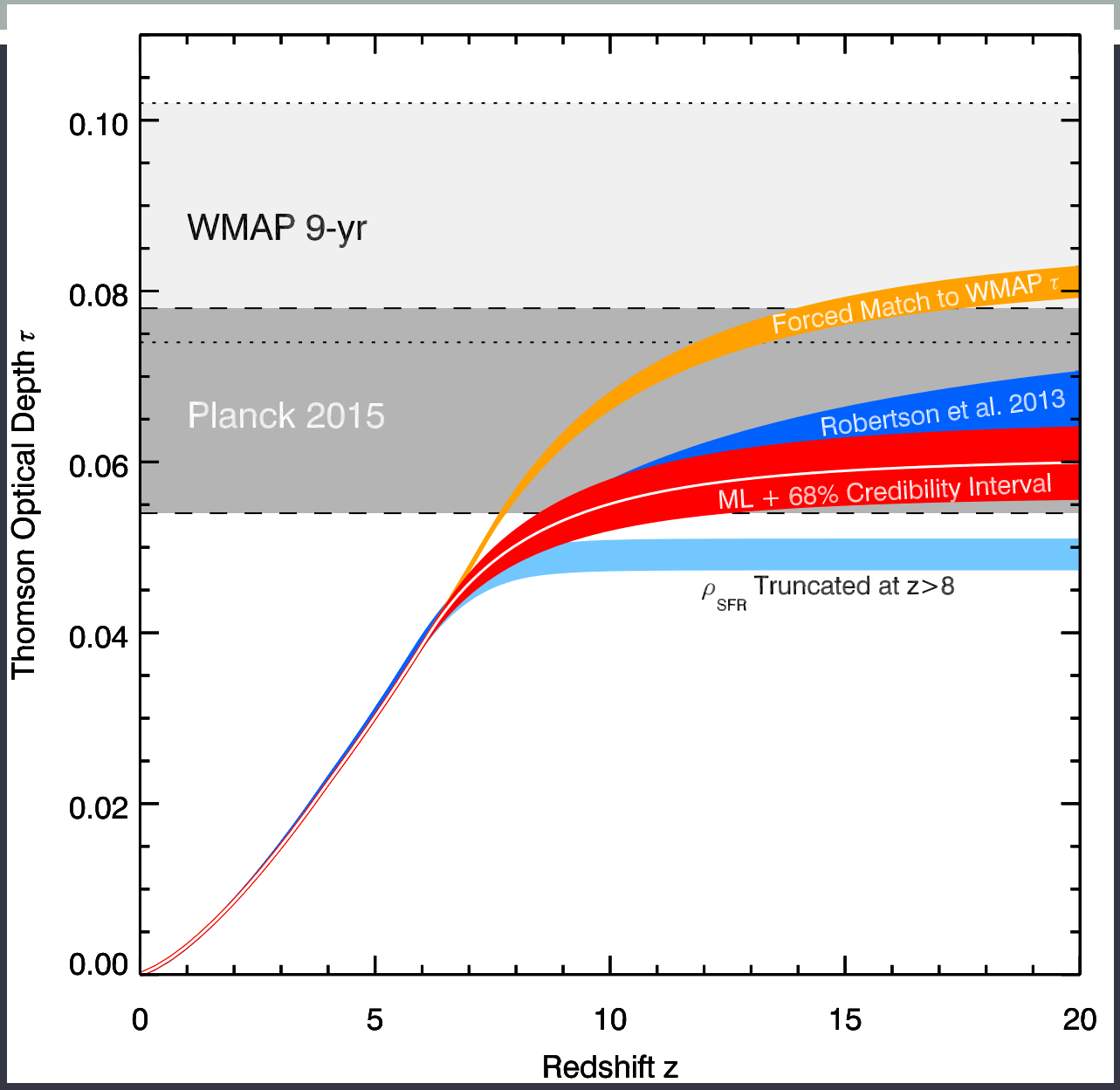
Extended and inhomogeneous process



NASA/ESA/A. Feild (STScI)



Richardson et al. (2015)



Richardson et al. (2015)

SOURCE MODELS

Ionizing Source Models

Stars and galaxies

live in dark matter halos

break into three categories:

high-M atomically cooling halos

($M_{HMACHs} > 10^9\ M_\odot$)

low-M atomically cooling halos

($10^8\ M_\odot < M_{LMACHS} < 10^9\ M_\odot$)

ignore anything below

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Photon production rate

N_γ α $f_\gamma M$, where f_γ depends on stuff

Radiative Feedback

Ionizing UV

Photoheats gas in IGM to ~10^4 K
Suppresses gas infall for low-mass halos
Self-regulation of galaxy/star formation

Science is hard

Four source models (plus or minus)

(1) only HMACHs

largest halos contribute

motivated mainly by resolution

galaxies that we know and love

(2) suppressed LMACHs

HMACHs always contribute

ionized region: no LMACHs

strong photoheating feedback

neutral region: higher efficiency

early stars release ionizing photons

Iliev et al (2006)

(3) partially suppressed LMACHs

ionized region: LMACHs suppressed
some star formation survives

neutral region: higher efficiency
mimic transition from PopIII to PopII

(4) gradually suppressed LMACHs

neutral region: same efficiency

do not guess early stars

ionized region: gradual depression of f_γ

mass-dependent

motivated by galaxy sims (Wise Cen 2012)

Start with N-body (CubeP^{3}M)

47 Mph/h:

1728^3 particles

3456^3 mesh

resolve 10^8 $M_\odot$

WMAP5 cosmo

244 Mph/h:

4000^3 particles

8000^3 mesh

resolve 10^9 $M_\odot$

+subgrid

244 Mph/h:

6912^3 particles

13824^3 mesh

resolve 10^9 $M_\odot$

+subgrid

Smooth and apply RT (C^2-Ray)

47 Mpc/h:

306^3 and 612^3 grids

244 Mpc/h:

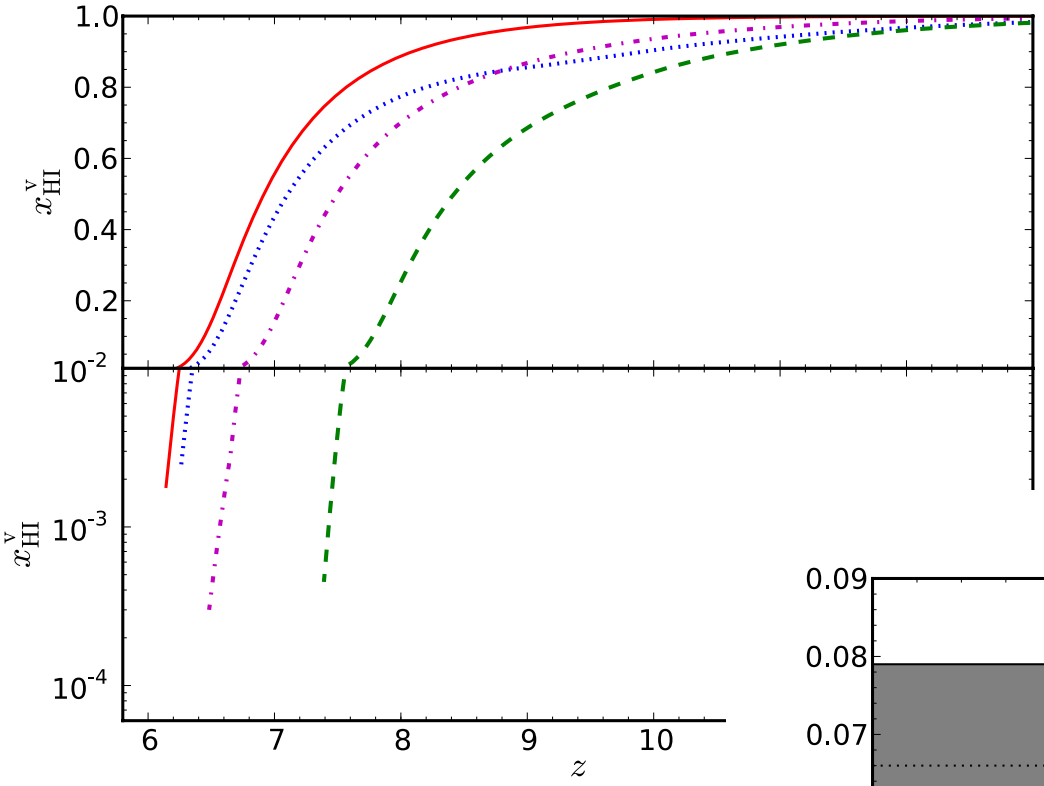
250^3 and 500^3 grids

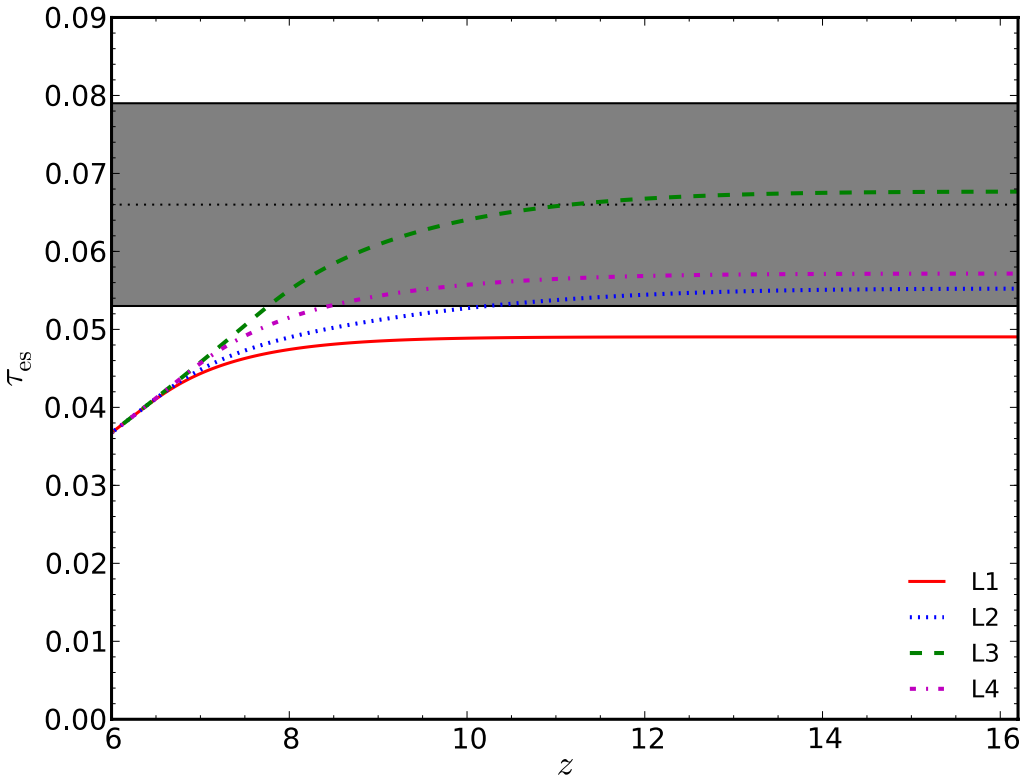
500 Mpc/h:

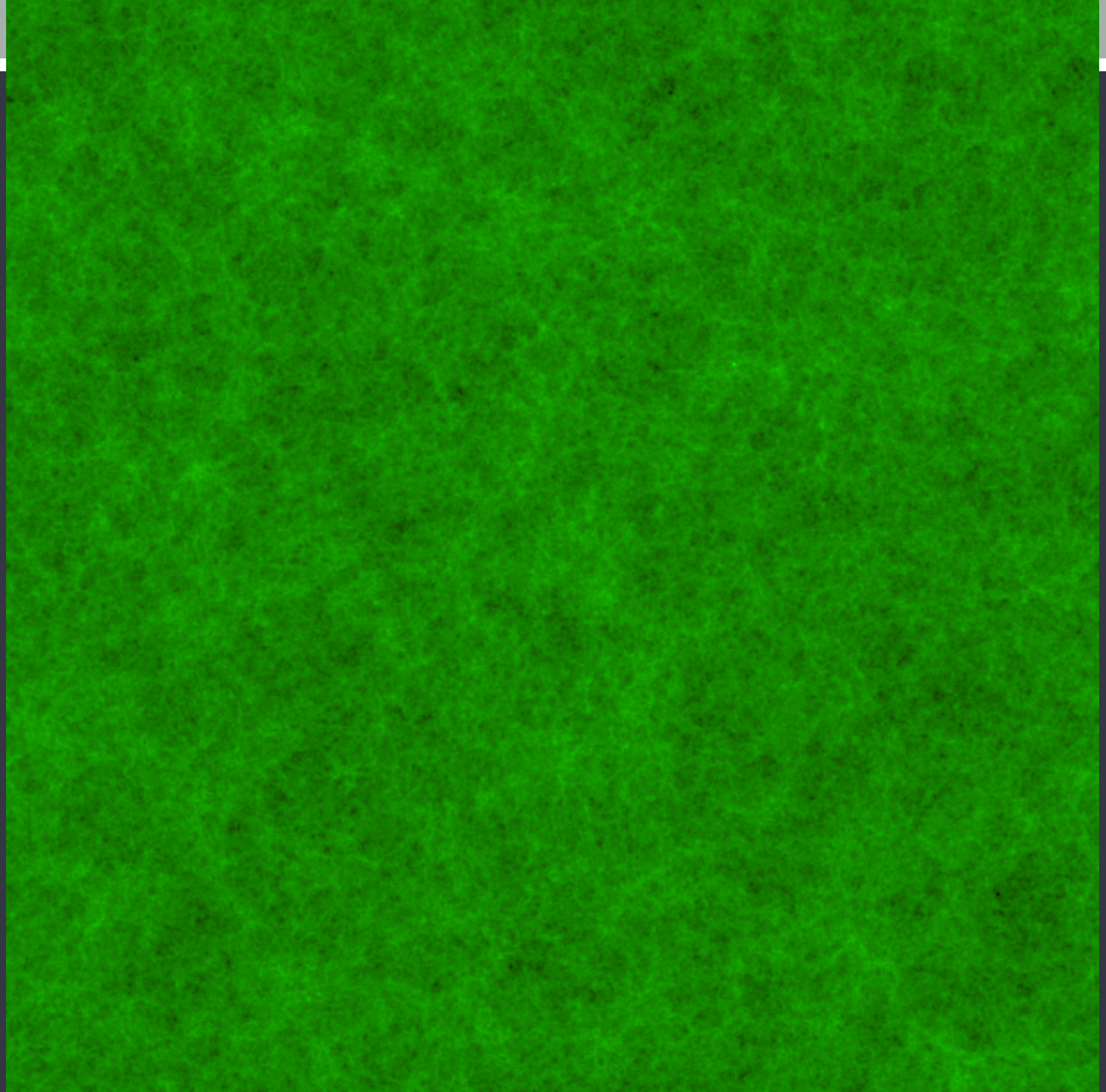
300^3 and 600^3 grids

$z = 7.480$ (47 Mpc/h, 612^3 grid)

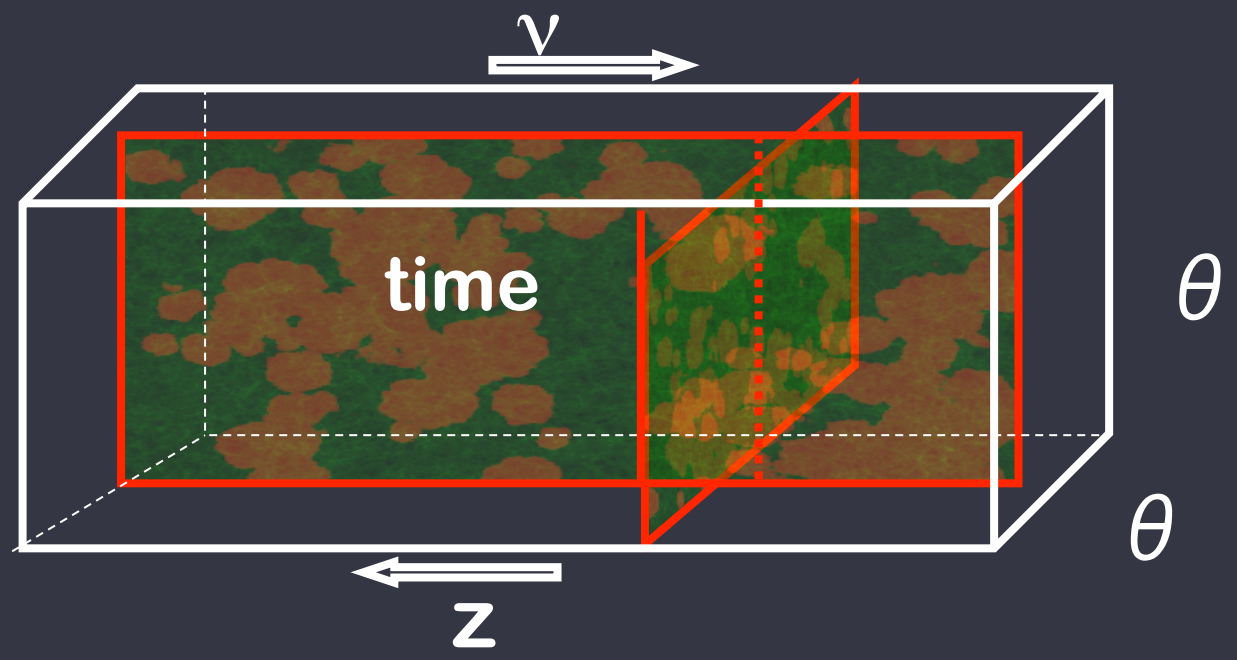
RESULT


1.0
0.8
0.6
0.4
0.2
10^{-2}
10^{-3}
10^{-4}
$x_{\rm HII}^{\rm v}$
6
7
8
9
10
z


0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
$\tau_{\rm es}$
6
8
10
12
14
16
z
L1
L2
L3
L4

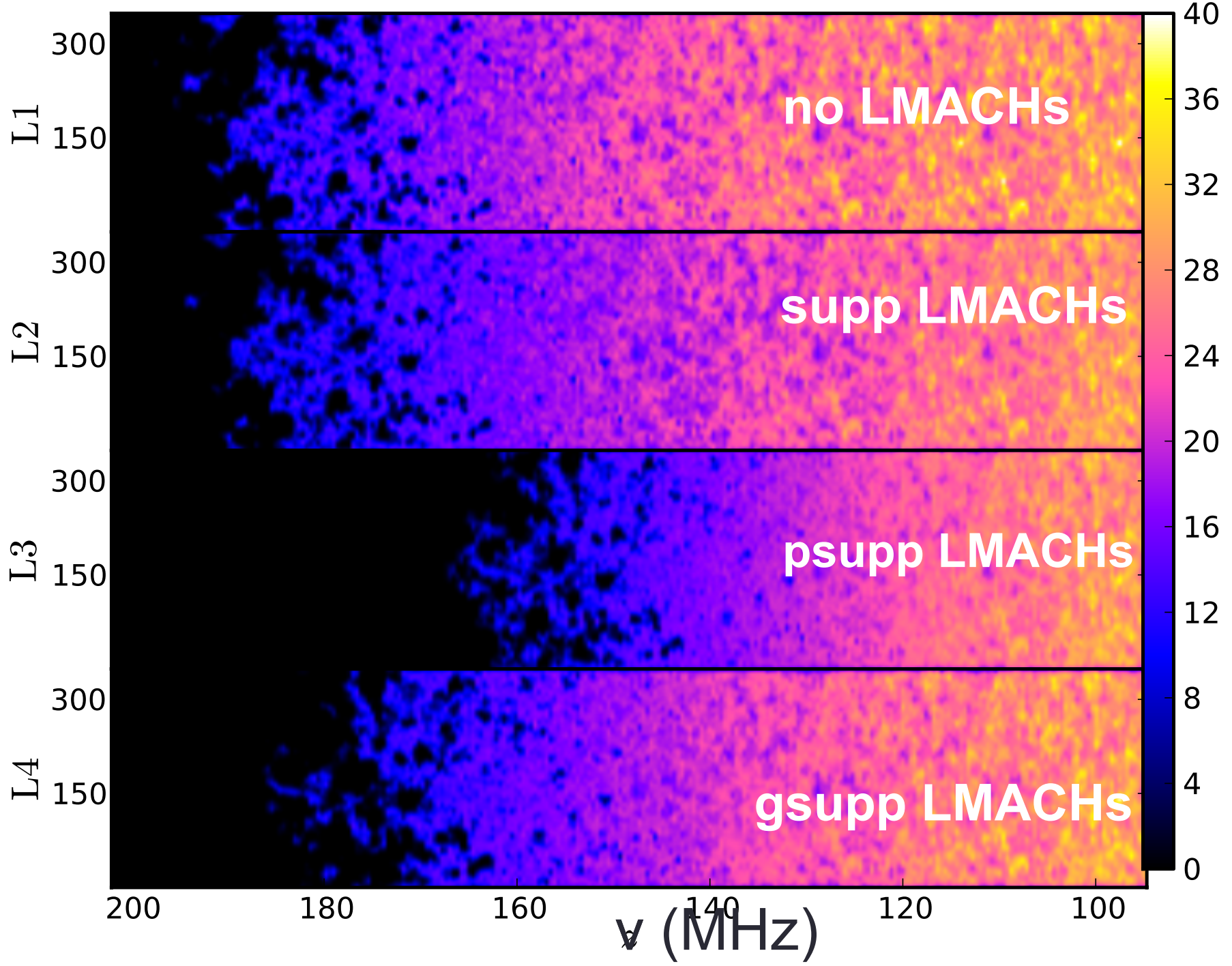


21-cm line of atomic hydrogen



$$\delta T_b = T_b - T_{CMB} \sim x_{HI}(1+\delta)(1+z)^{1/2}$$

for $T_s >> T_{CMB}$


no LMACHs
supp LMACHs
psupp LMACHs
gsupp LMACHs
L1
L2
L3
L4
300
150
200
180
160
140
120
100
ν (MHz)
40
36
32
28
24
20
16
12
8
4
0

LOCAL GROUP

Start with Gadget CLUES

64 Mpc/h

smooth to 256^3 and 512^3

run C^2-Ray with all source models

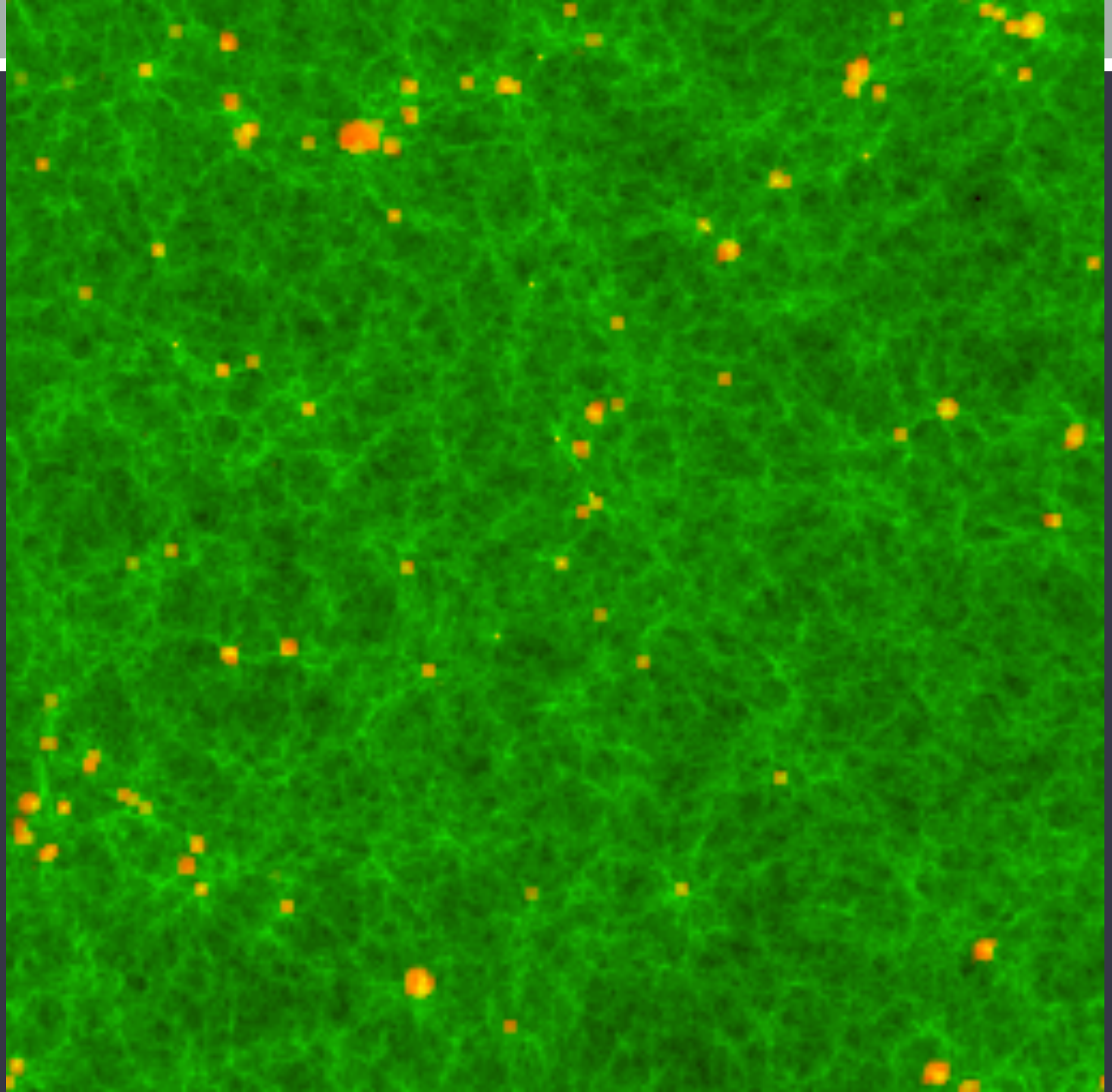
no need for subgrid physics

Questions

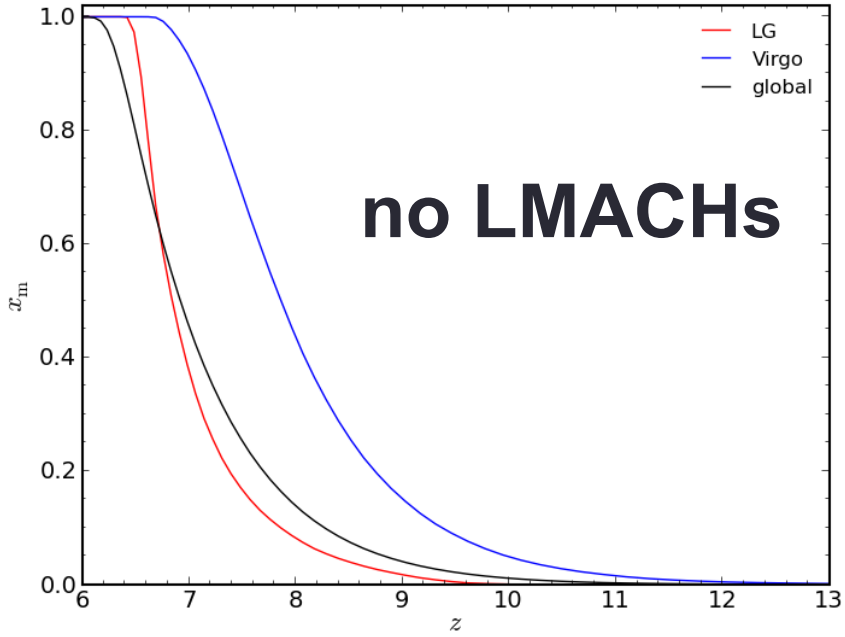
How does reionization affect LG?

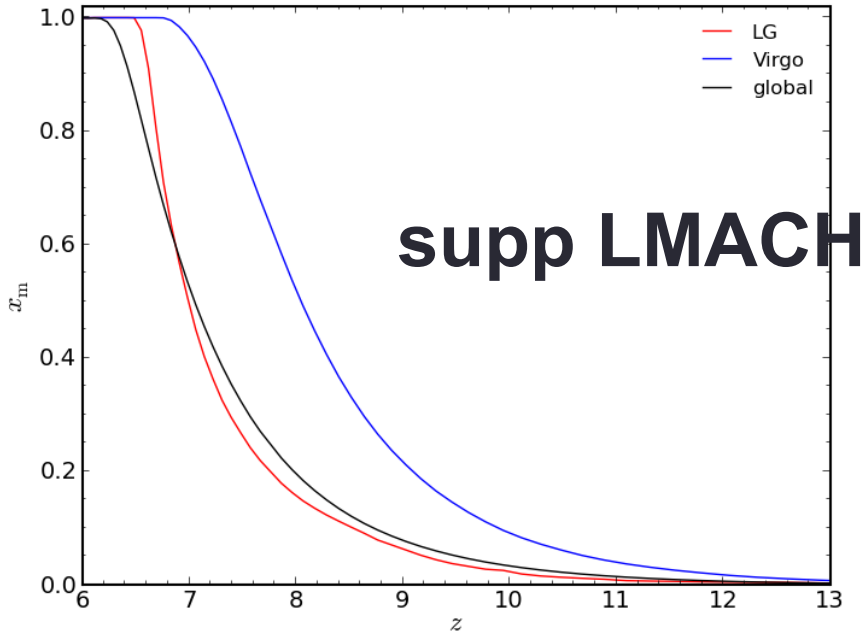
Inside out vs outside in?

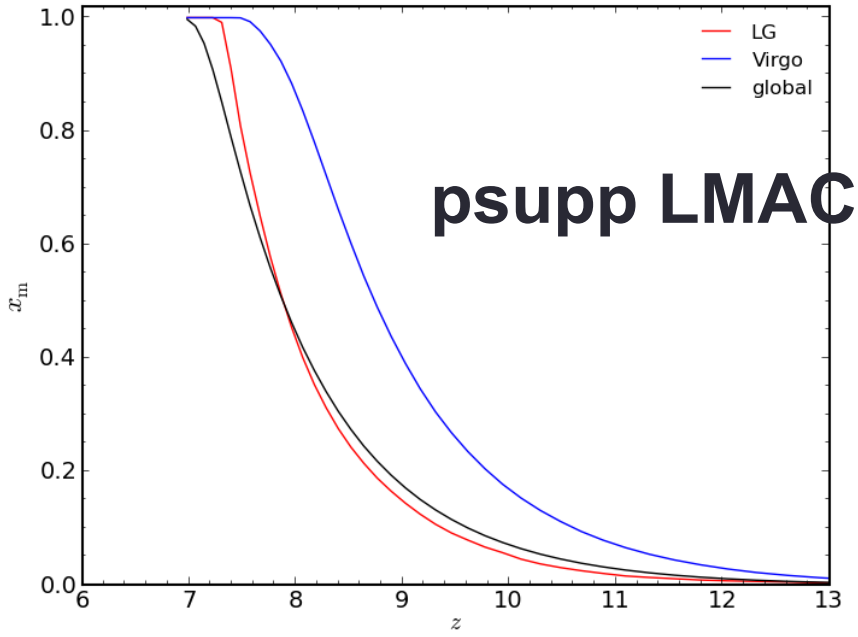
What happens locally compared globally?

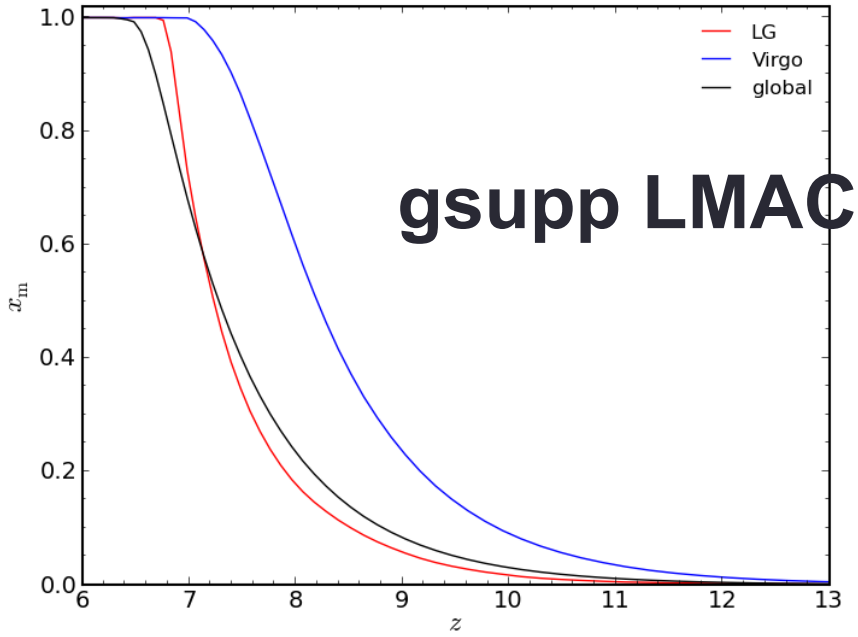


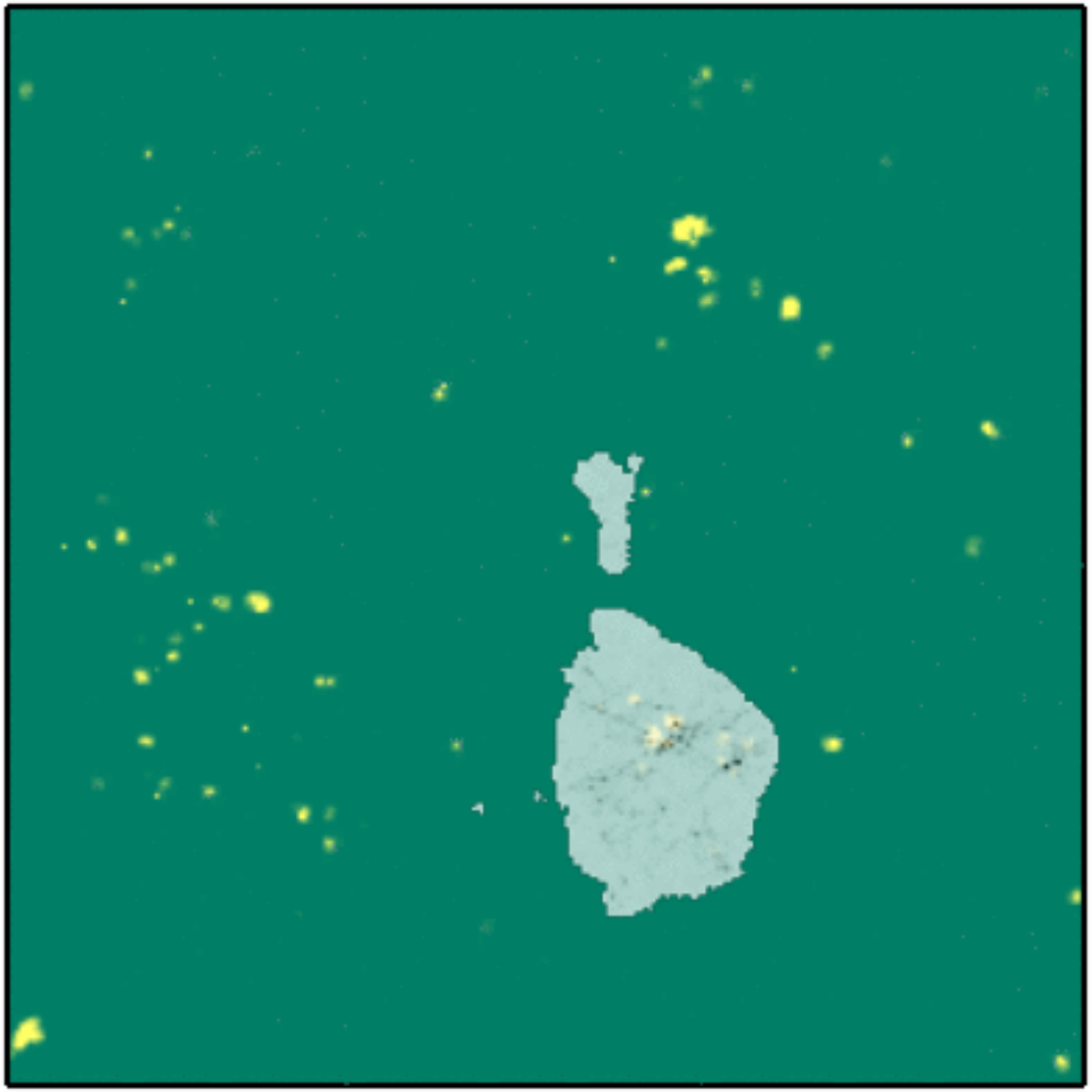
PRELIMINARY!!


no LMACHs
LG
Virgo
global
$x_{\rm m}$
z

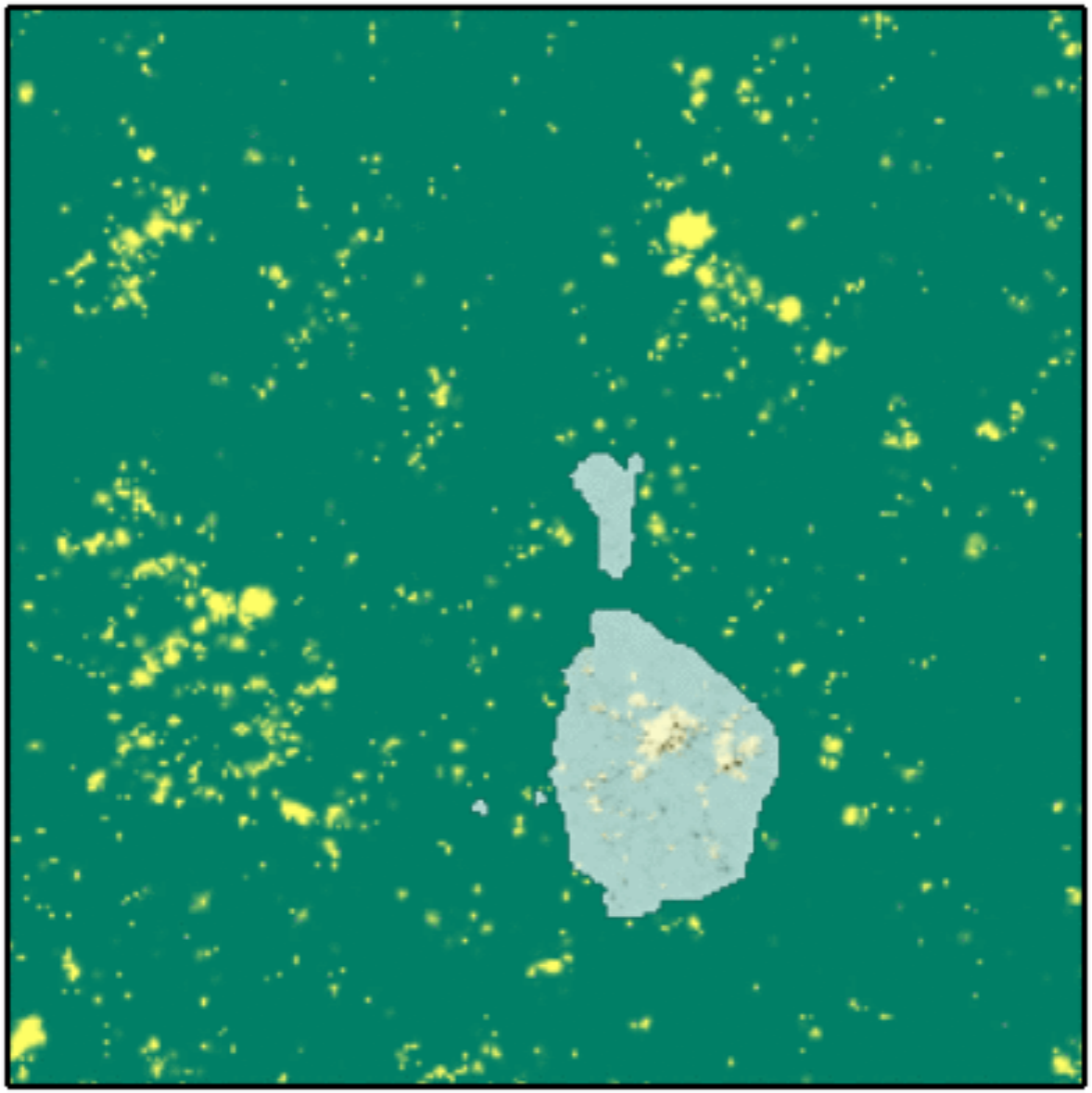

supp LMACHs
LG
Virgo
global
$x_{\rm m}$
z


psupp LMACHs
LG
Virgo
global
$x_{\rm m}$
z


gsupp LMACHs
LG
Virgo
global
$x_{\rm m}$
z



no LMACHs



psupp LMACHs