



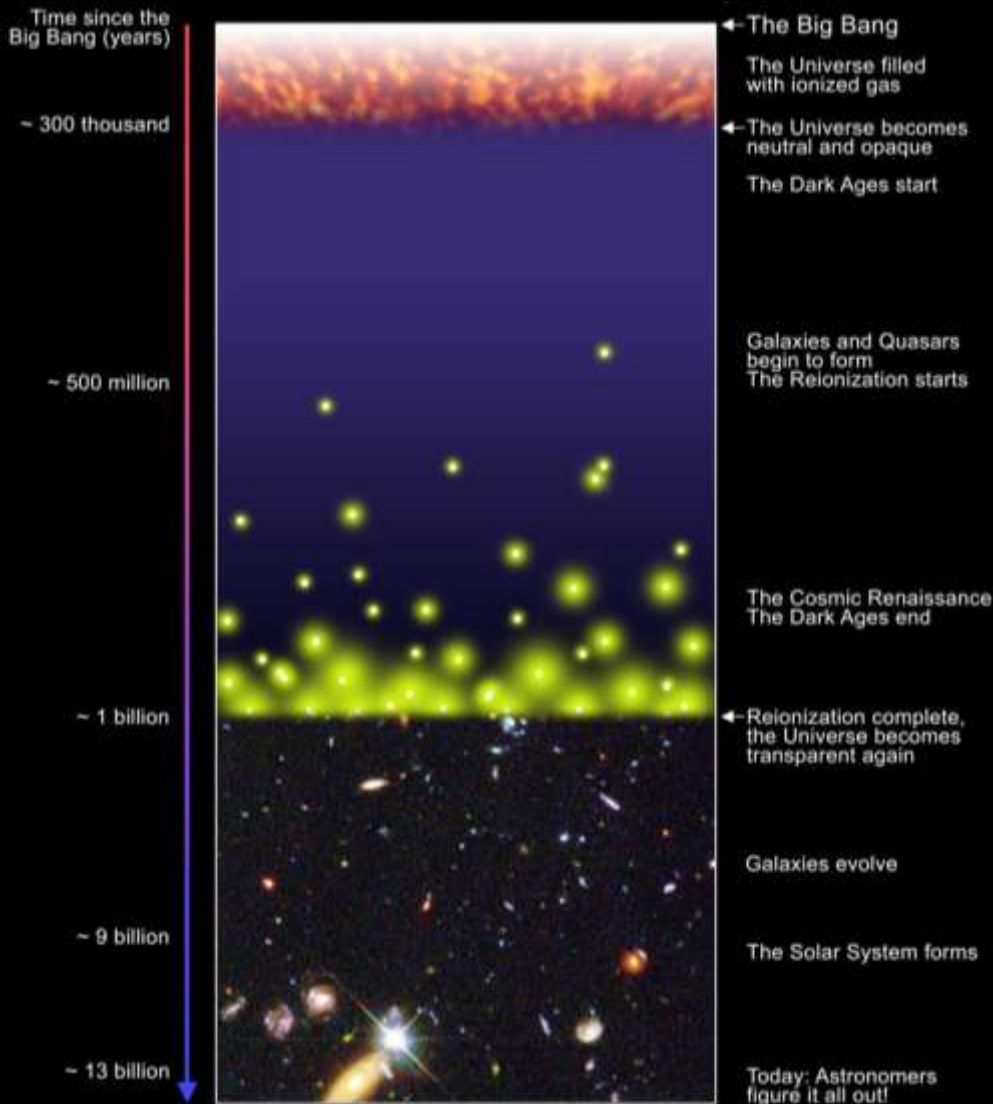
2D genus topology of 21cm differential brightness temperature during cosmic reionization

K. Ahn, S.E. Hong, C. Park, J. Kim, I.T. Iliev and G. Mellema
submitted to ApJ, arXiv:1008.3914

Sungwook E. Hong
2010 RESCEU/DENET summer school



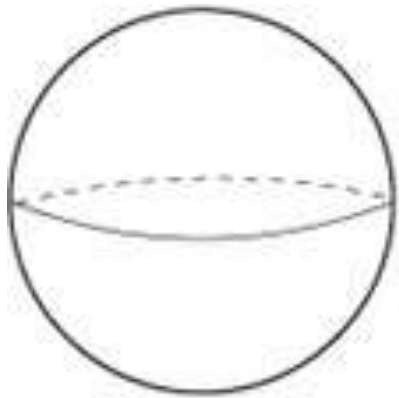
Cosmic reionization



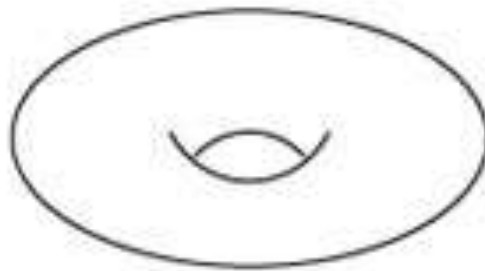
S.G. Djorgovski et al. & Digital Media Center, Caltech

- 21cm detection
 - LOFAR, MWA, SKA, ...
 - No direct detection yet
- Theoretical study
 - Semi-analytic or full numerical
 - Properties of radiation source as input parameter
- Need many analysis method!

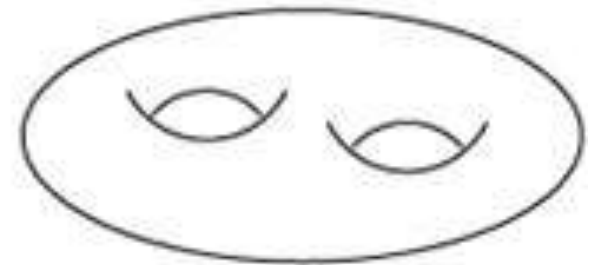
2D genus?



genus 0



genus 1



genus 2

2D genus = (hot spots) – (cold spots)

(Melott et al. 1989; Gott et al. 1990; Colley & Gott 2003; Gott et al. 2007)

Simulations

N-body: GOTPM

(Dubinski et al. 2004; Kim et al. 2009)

Reionization: C2Ray

(Mellema et al. 2005)

21-cm signal calculation

matter density halo profile

matter density halo profile

matter density halo profile

ionization fraction

ionization fraction

ionization fraction

differential brightness temperature

differential brightness temperature

differential brightness temperature

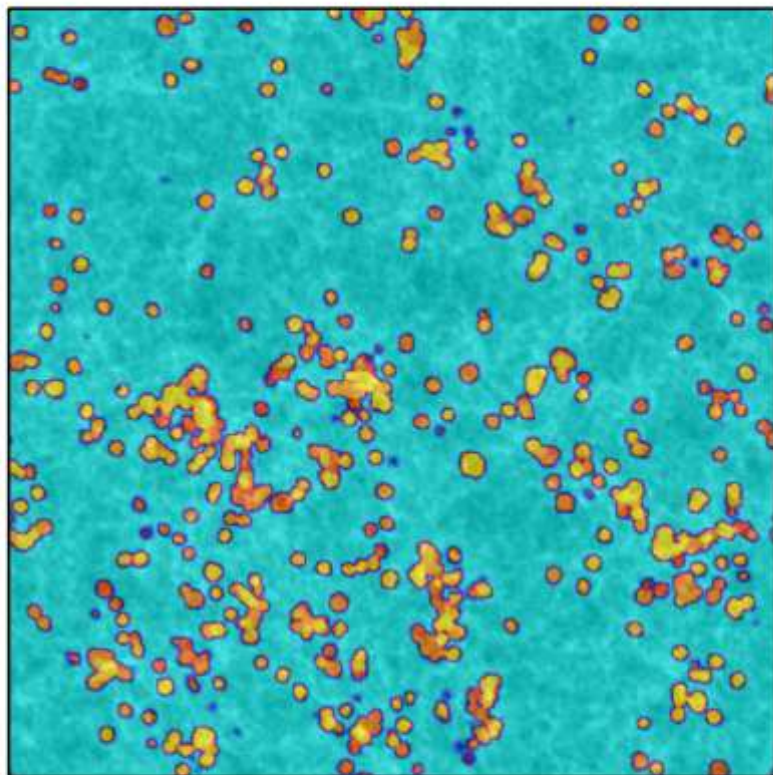
$$\delta T_b = (28 \text{ mK}) \left(\frac{1+z}{10} \right)^{\frac{1}{2}} (1+\delta)(1-x)$$

time

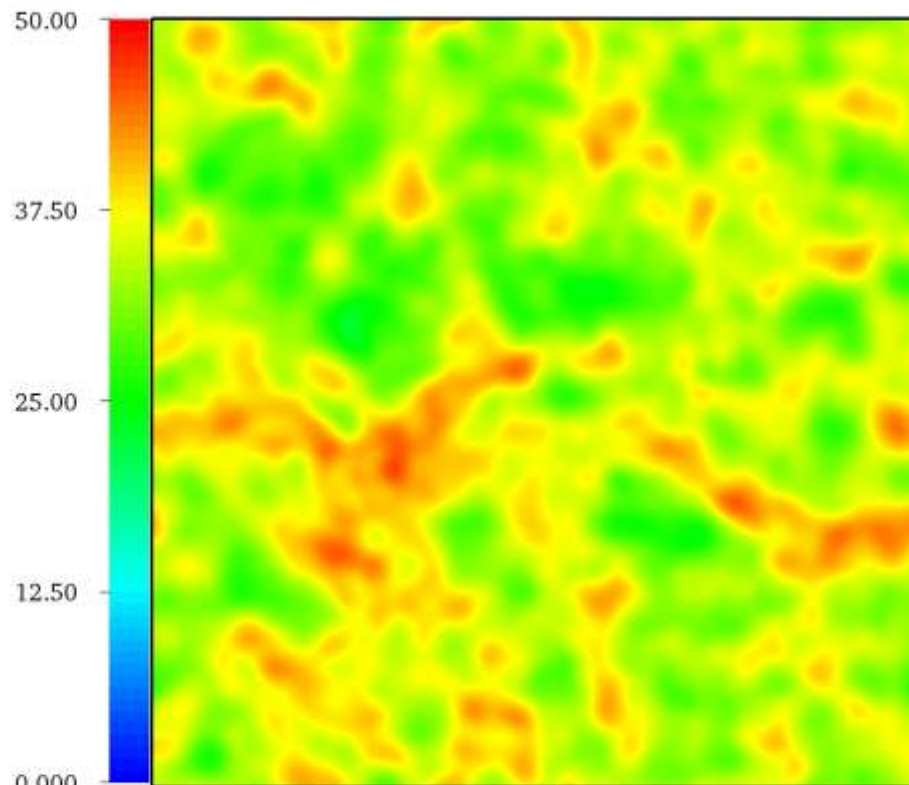
Simulations

- N-body simulation
 - Λ CDM model with WMAP 5yr parameters
 - 2048^3 particles
 - 66 Mpc/h box ($\sim 30'$ at $z = 14$)
- Reionization simulation
 - 256^3 mesh
 - 4 source property models
 - 2 for high-mass halos only ($M > 10^9 M_{\text{sun}}$)
 - 2 for high-mass and low-mass halos ($10^8 < M/M_{\text{sun}} < 10^9$)

Mock 21-cm sky map



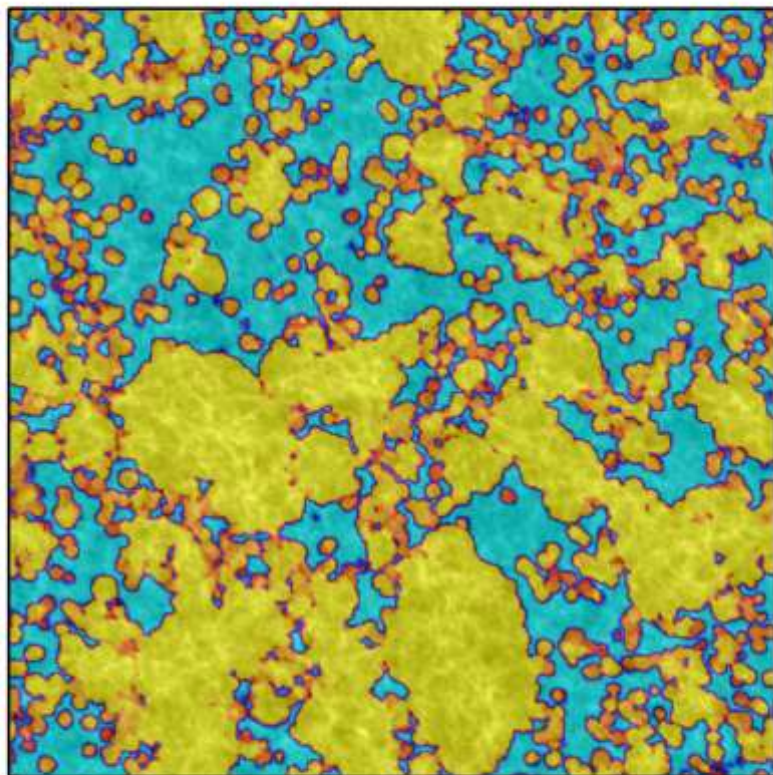
$z = 15.645$ ($x_v = 0.04$)



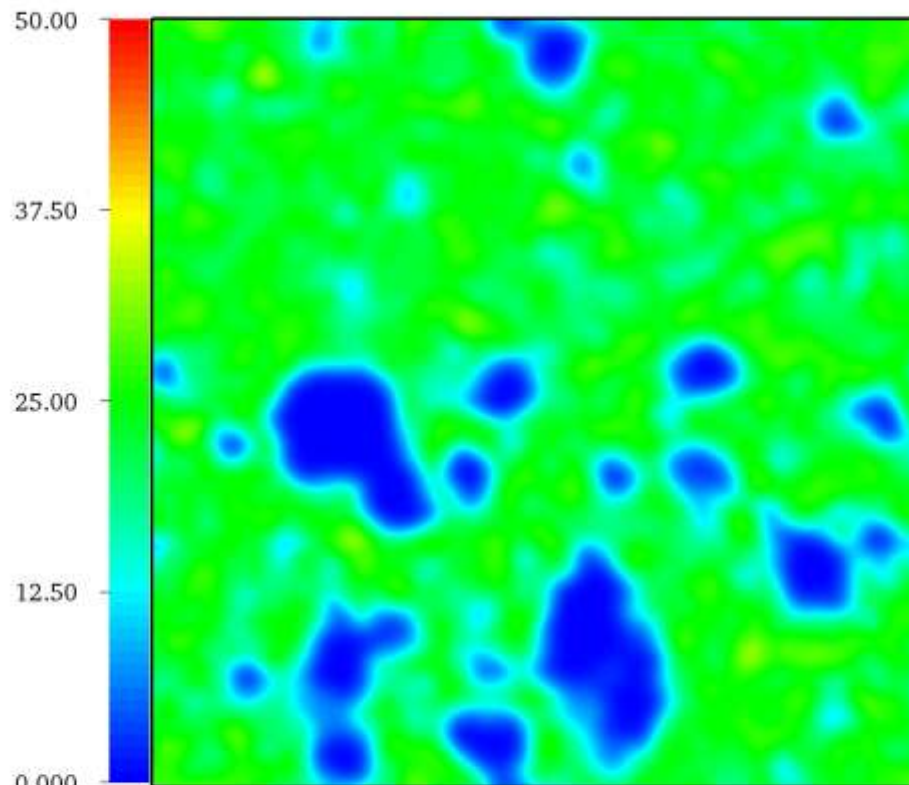
Max: 46.66
Min: 22.63

$z = 15.645$ (1 arcmin, 0.2 MHz)

Mock 21-cm sky map



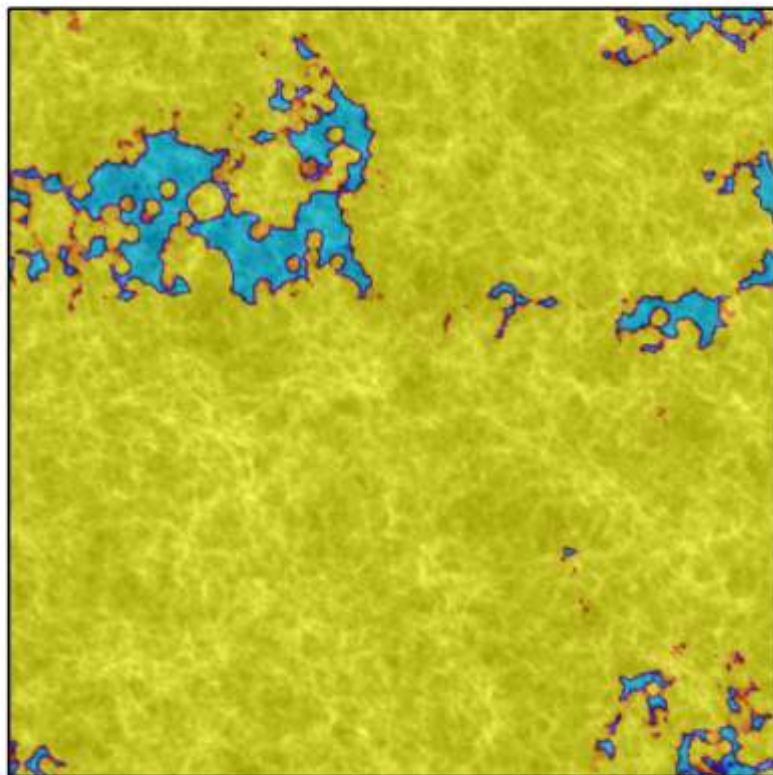
$z = 12.184$ ($x_v = 0.4$)



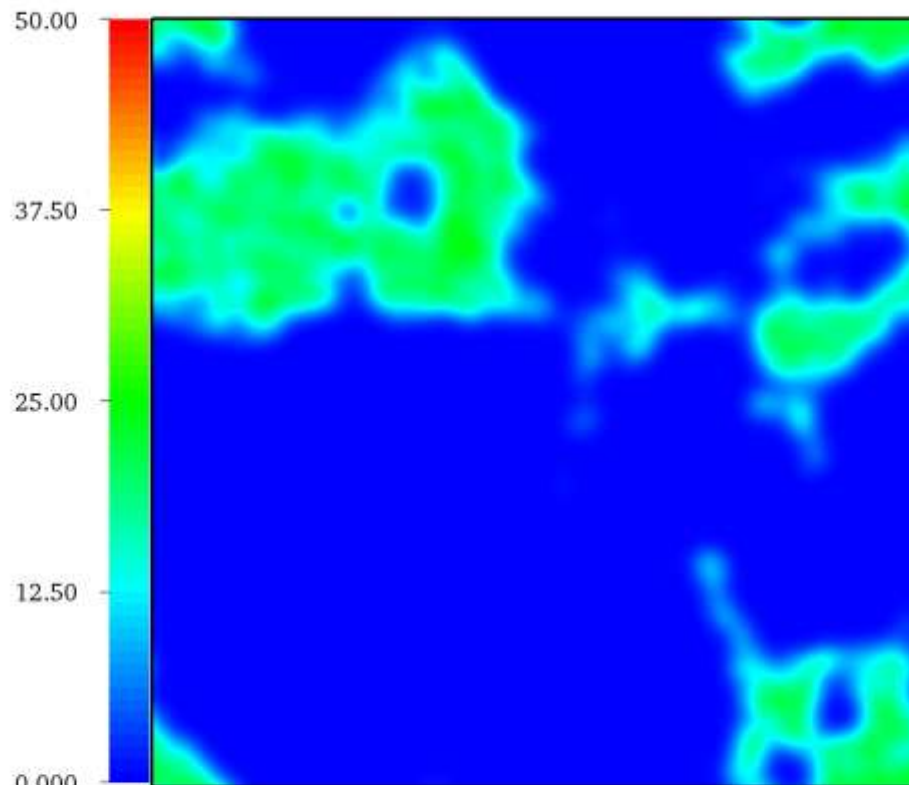
Max: 32.04
Min: 0.001980

$z = 12.184$ (1 arcmin, 0.2 MHz)

Mock 21-cm sky map



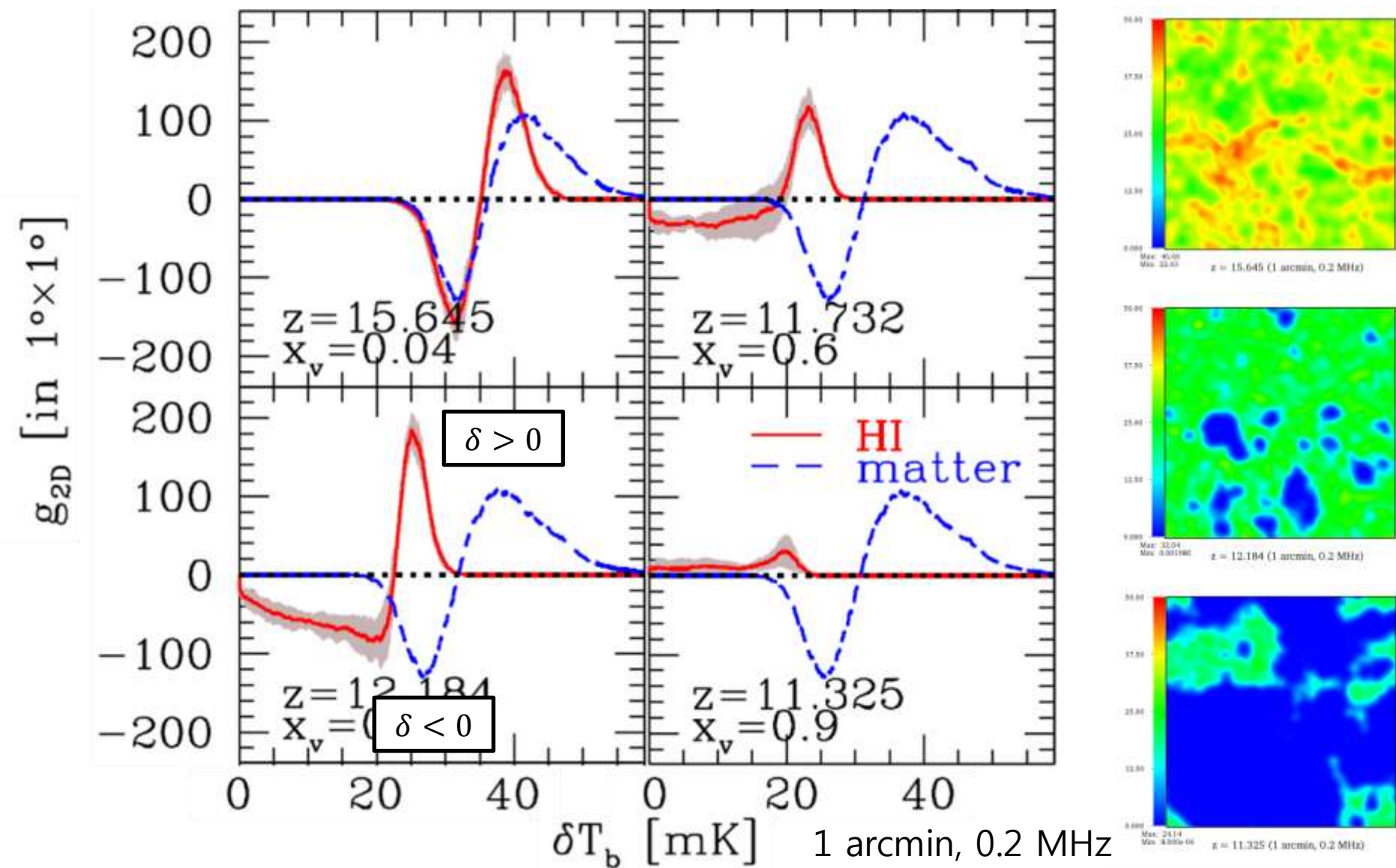
$z = 11.325$ ($x_v = 0.9$)



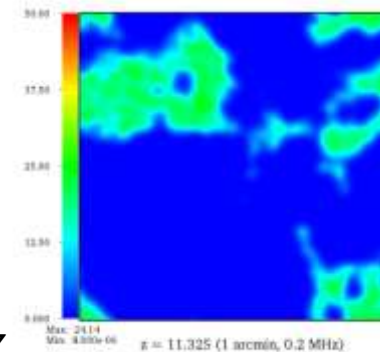
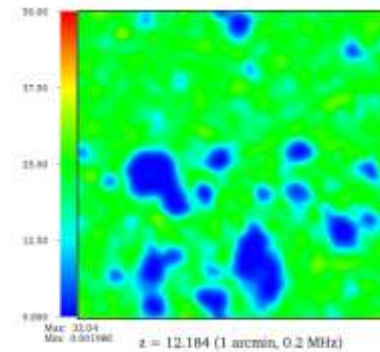
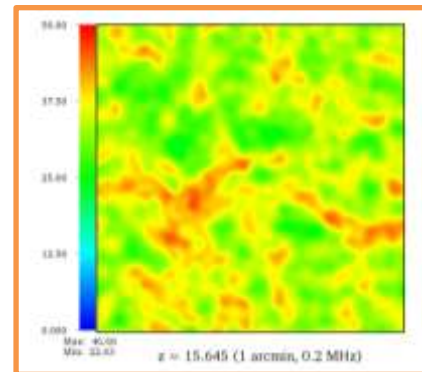
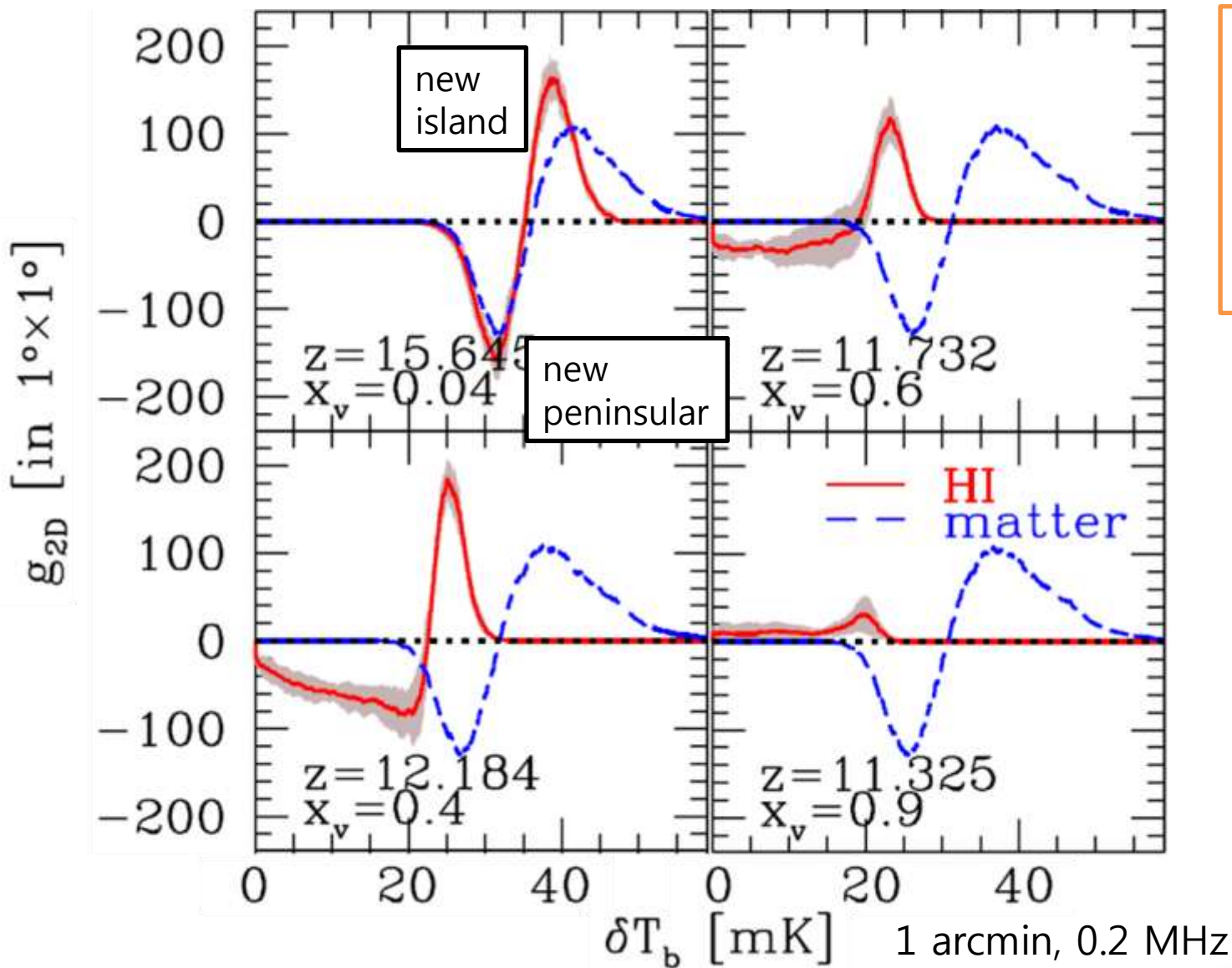
Max: 24.14
Min: 8.000e-06

$z = 11.325$ (1 arcmin, 0.2 MHz)

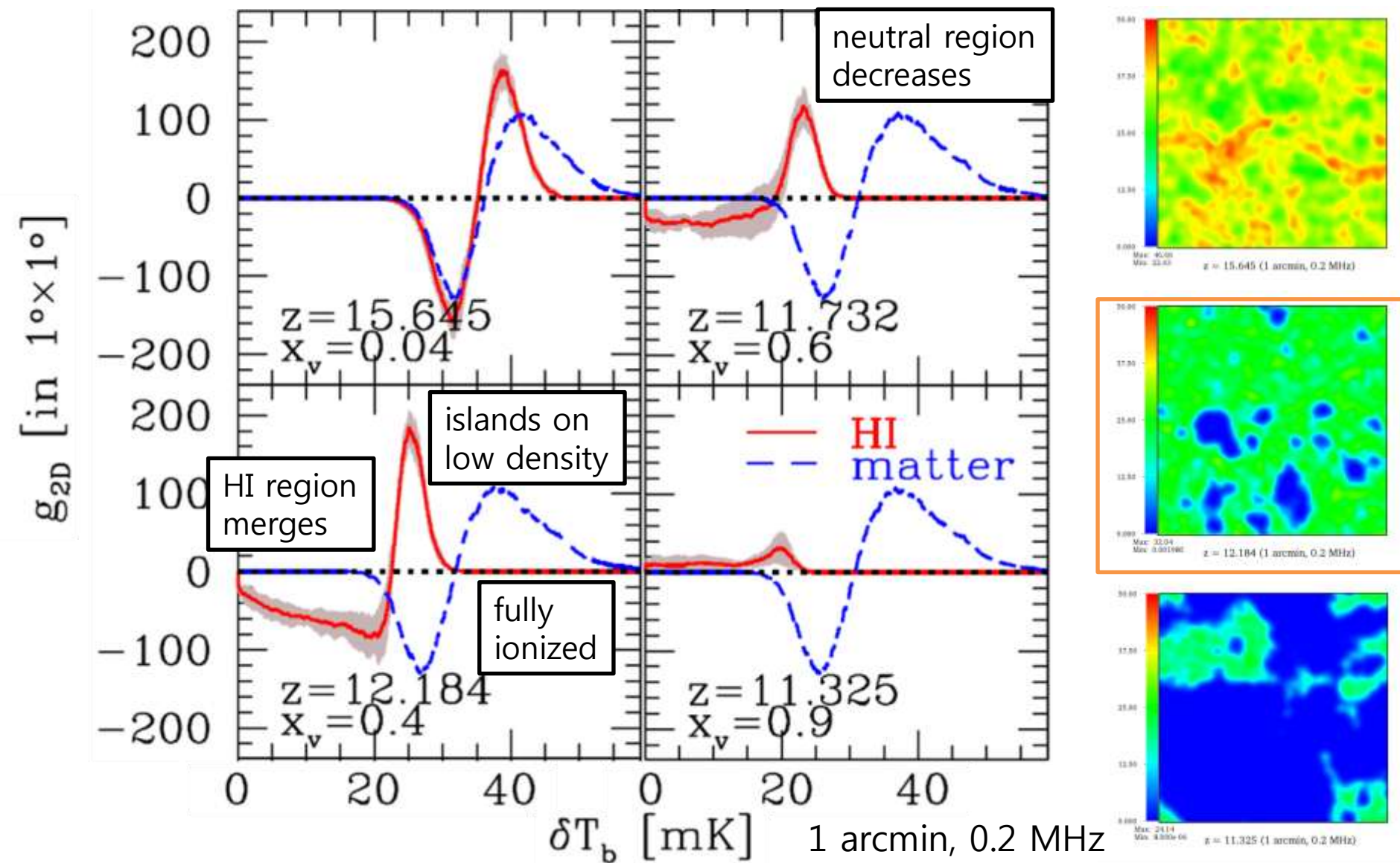
2D genus: evolution process



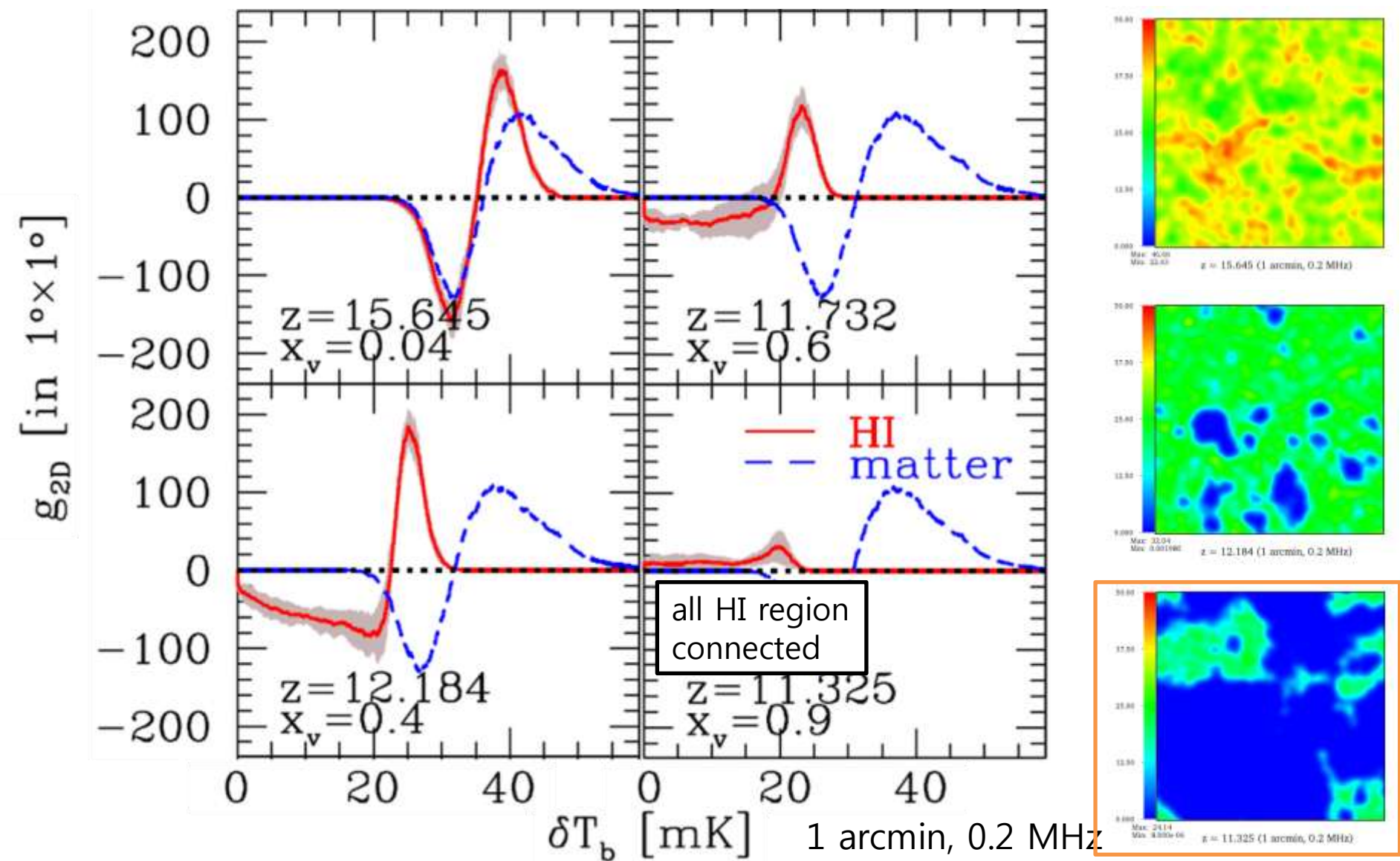
2D genus: evolution process



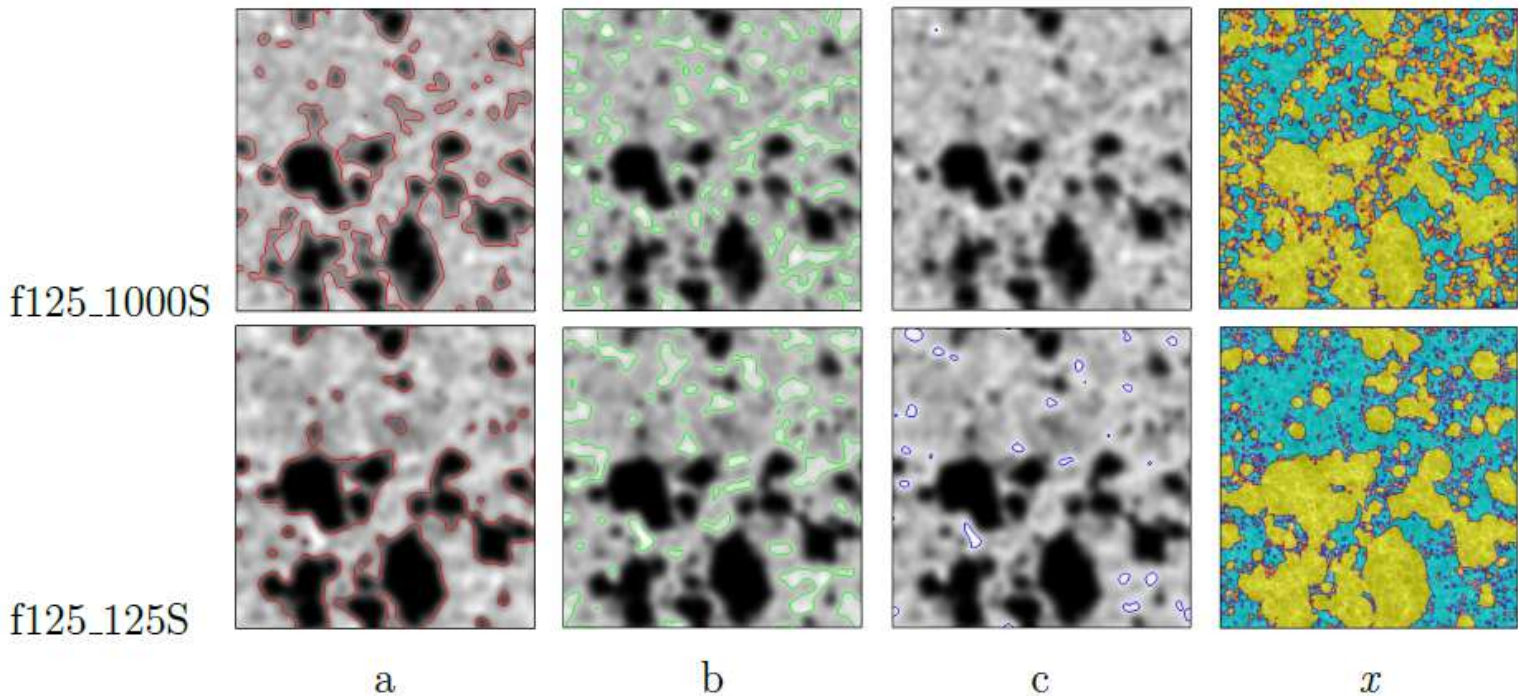
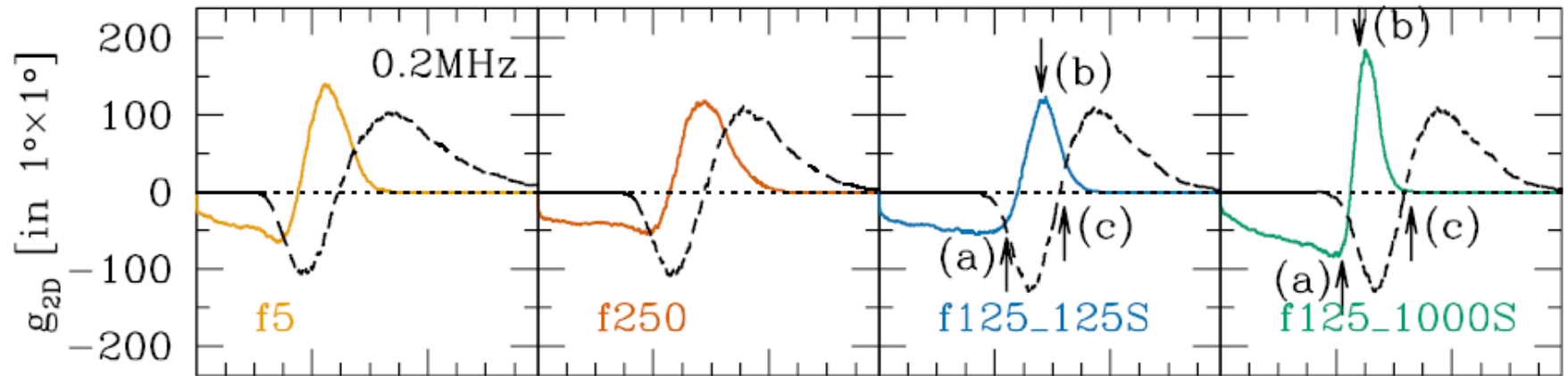
2D genus: evolution process



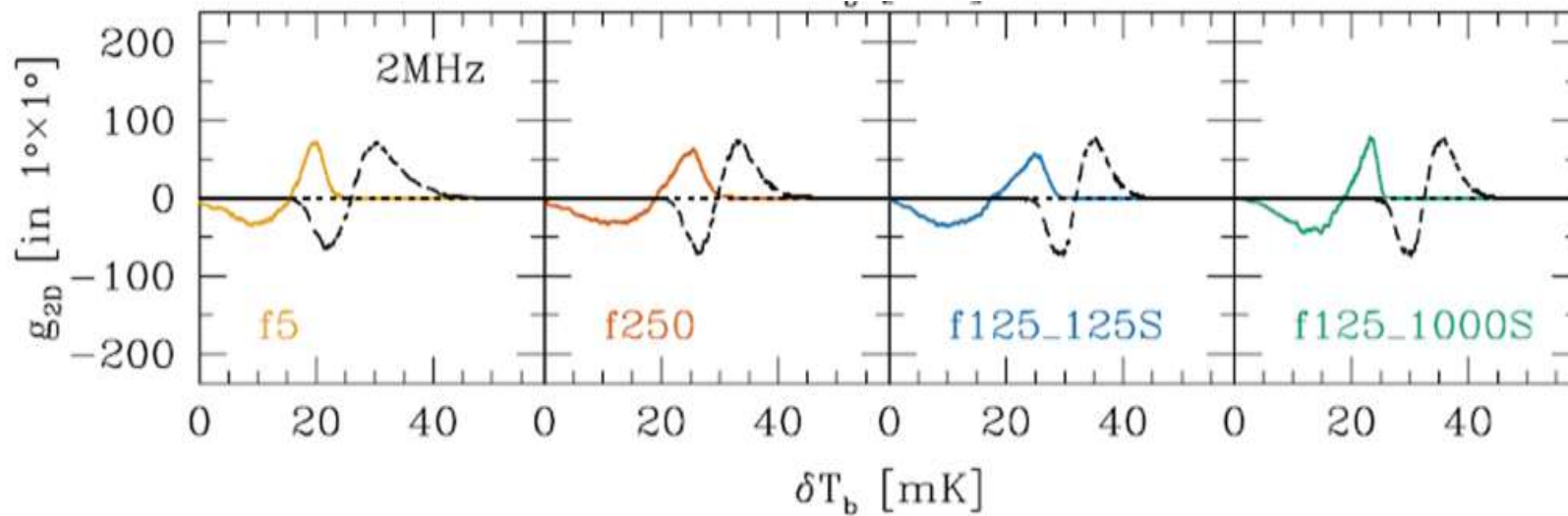
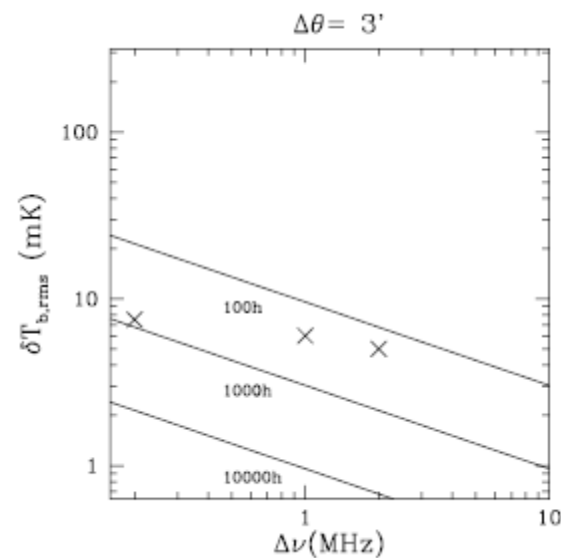
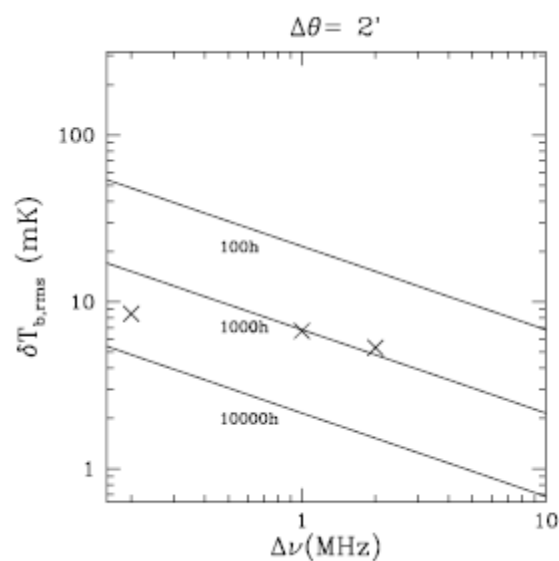
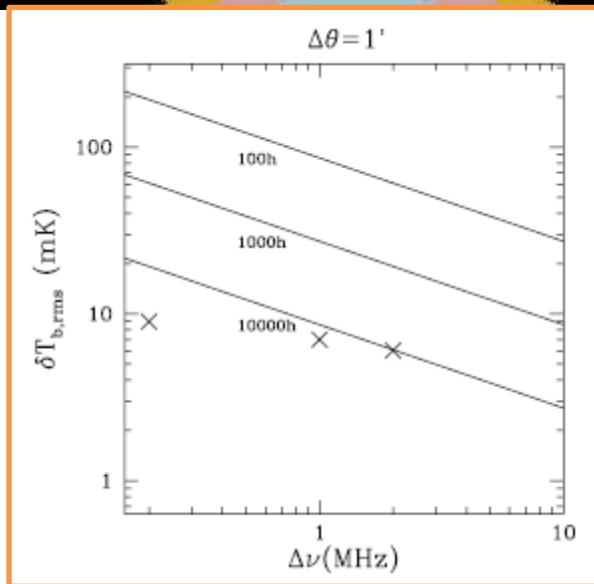
2D genus: evolution process



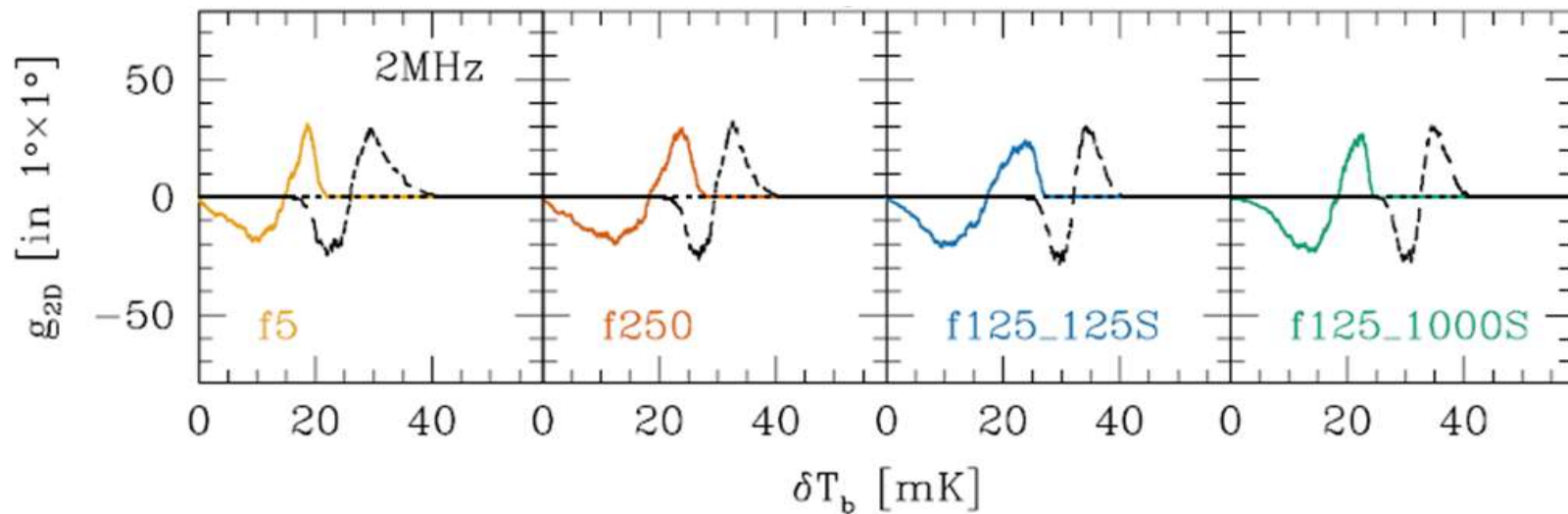
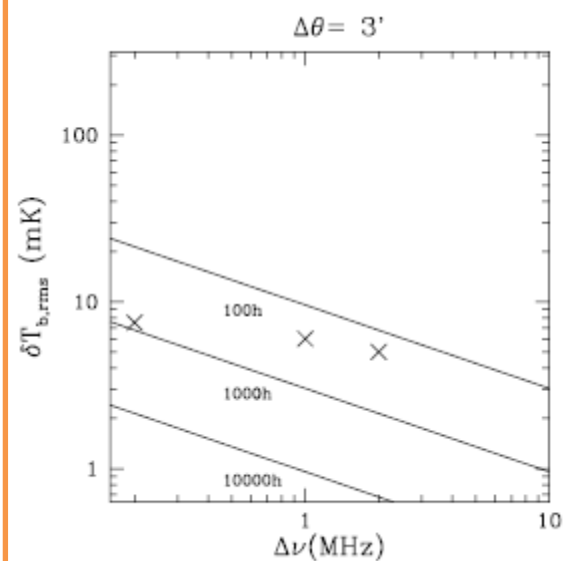
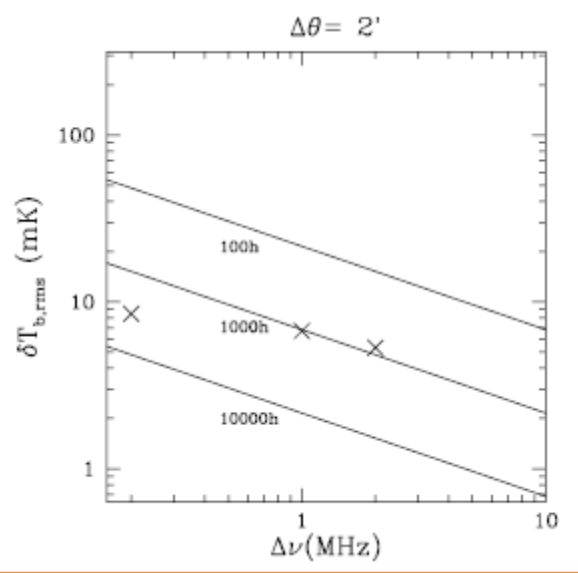
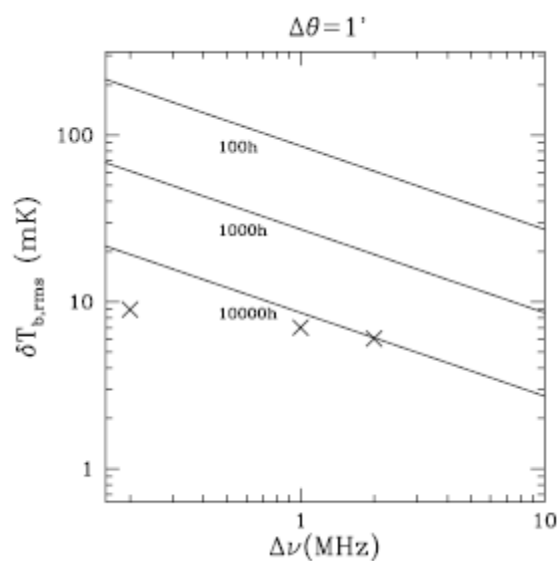
2D genus: model dependency



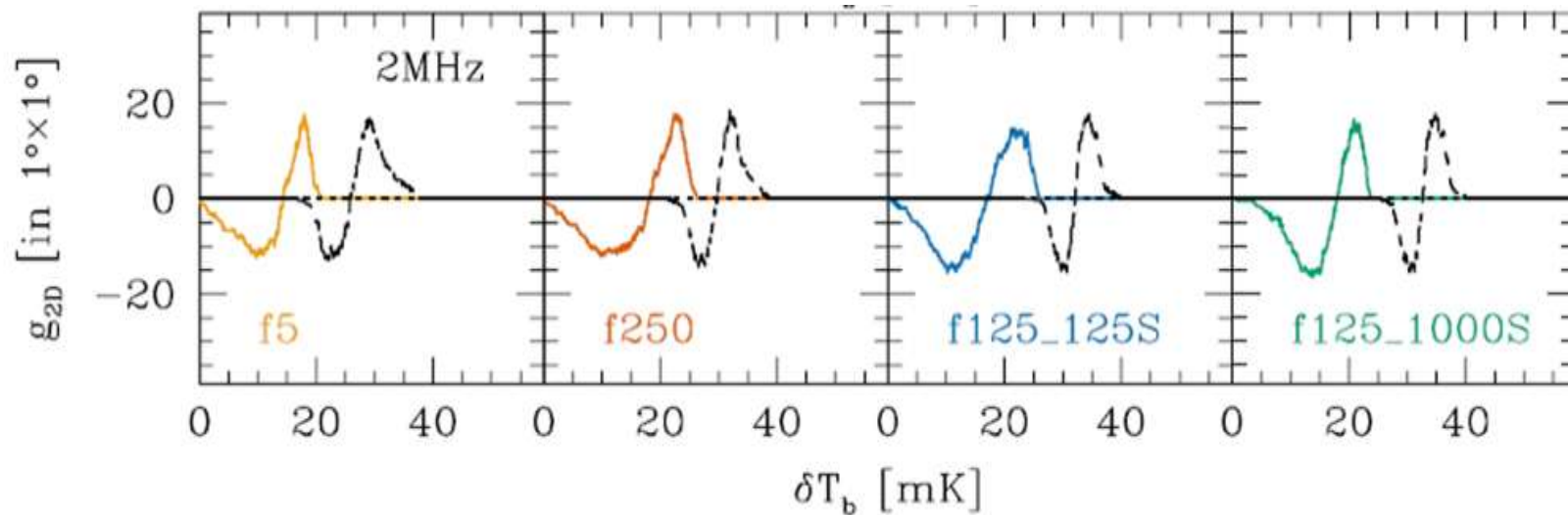
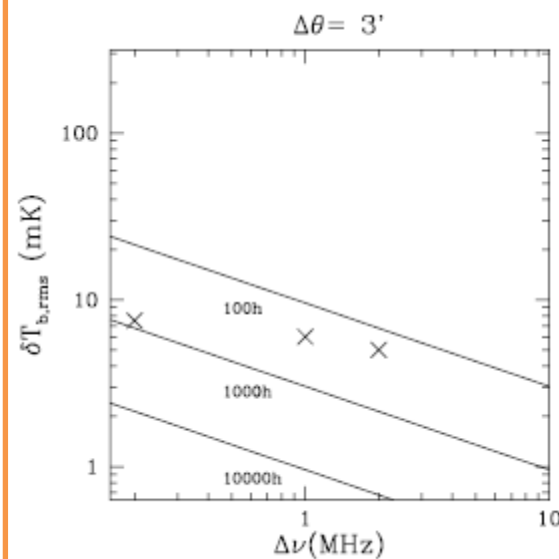
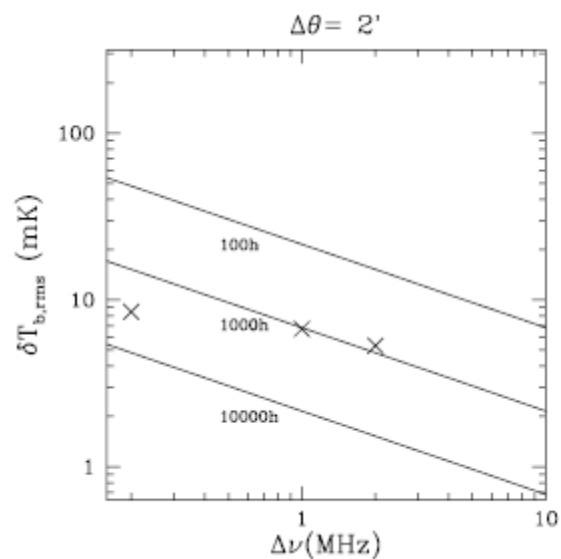
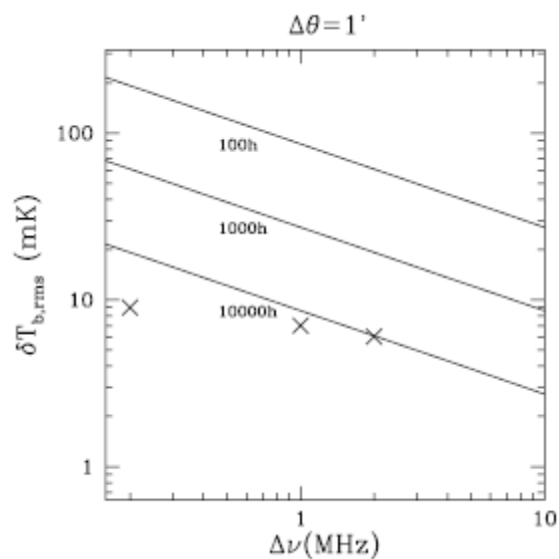
Sensitivities



Sensitivities



Sensitivities



Summary

- 2D genus curve clearly shows the evolution of the reionization process.
- 2D genus method can be used to discriminate between various scenarios.
- SKA will be able to produce data suitable for the 2D genus analysis, with
 - Integration: 100 ~ 1000 hours
 - Beam size: 2 ~ 3 arcminutes
 - Bandwidth: 2 ~ 3 MHz