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
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Sungwook E. Hong
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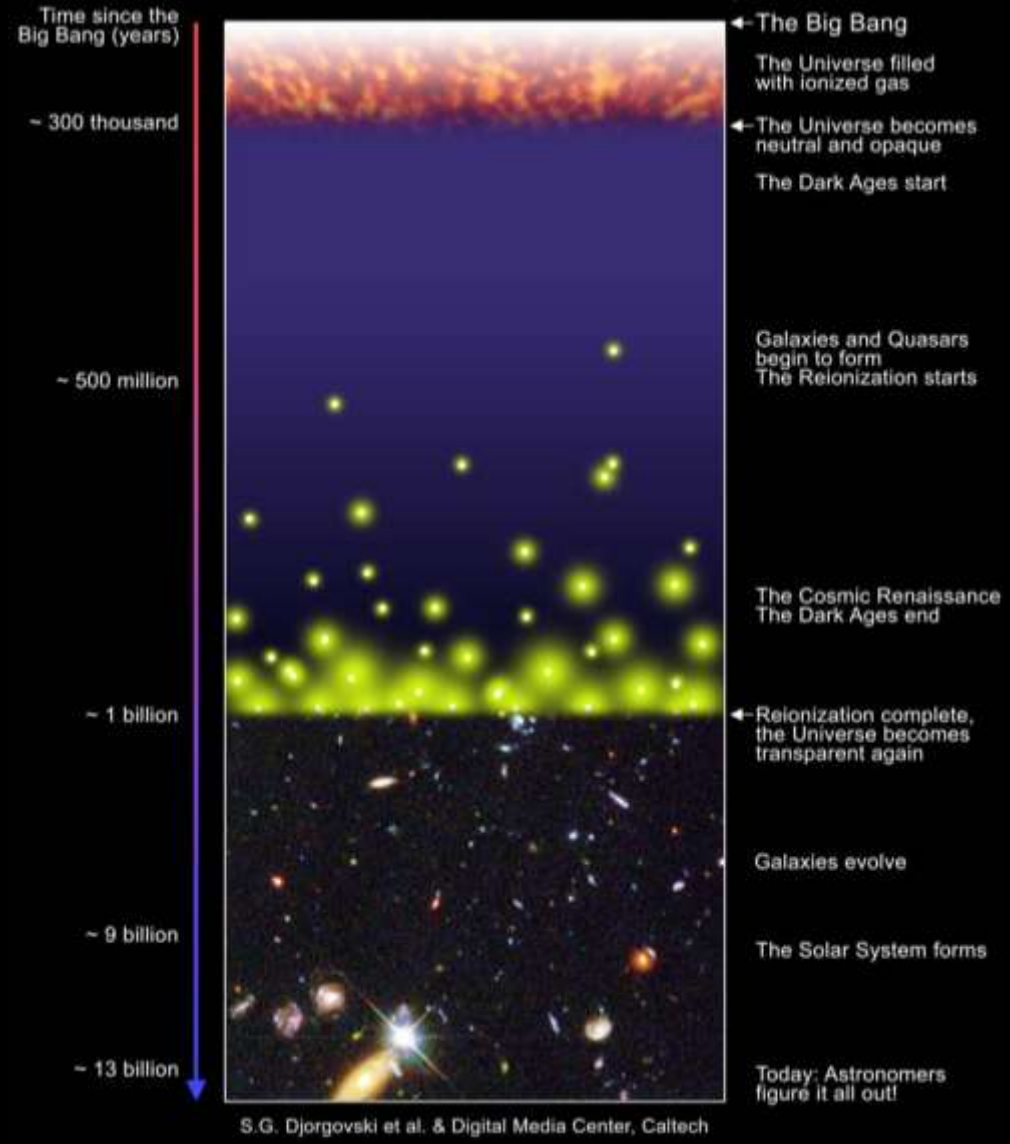
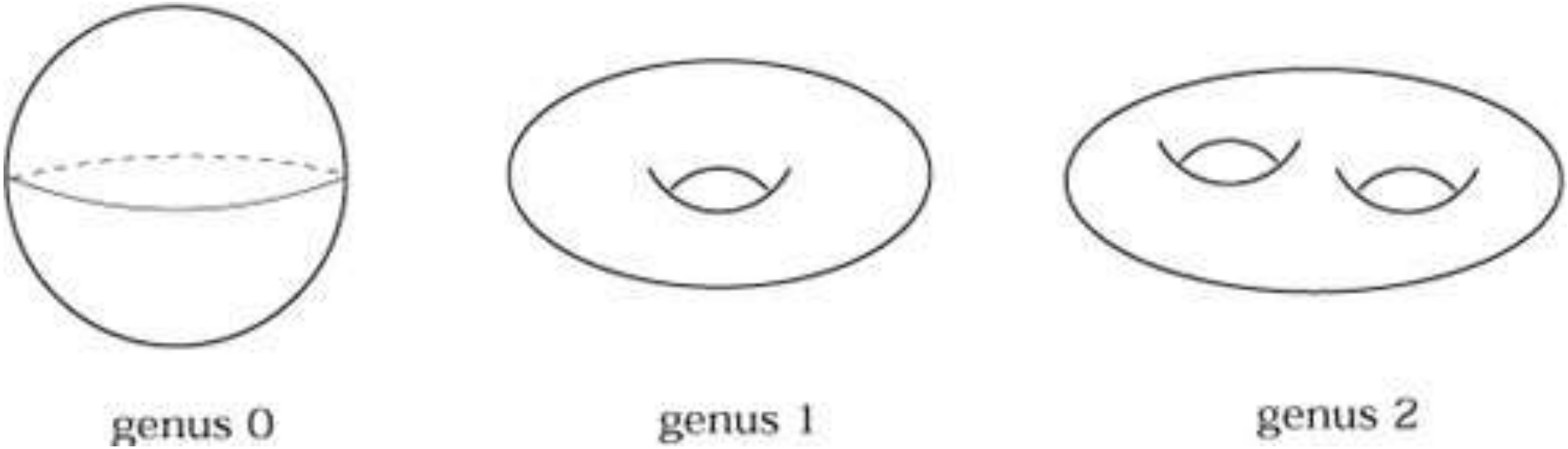
Cosmic reionization



- 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!

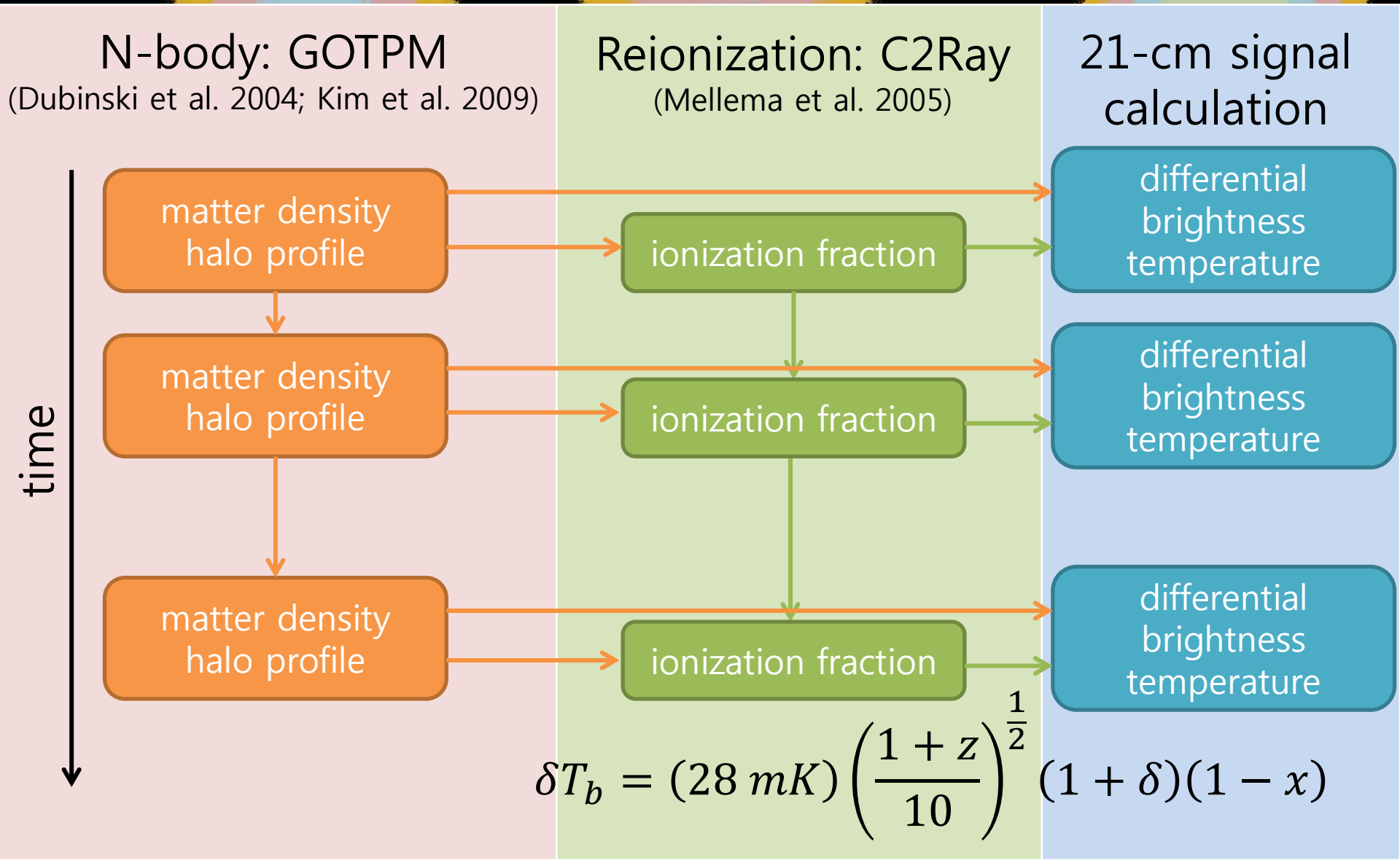
2D genus?



2D genus = (hot spots) – (cold spots)

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

Simulations



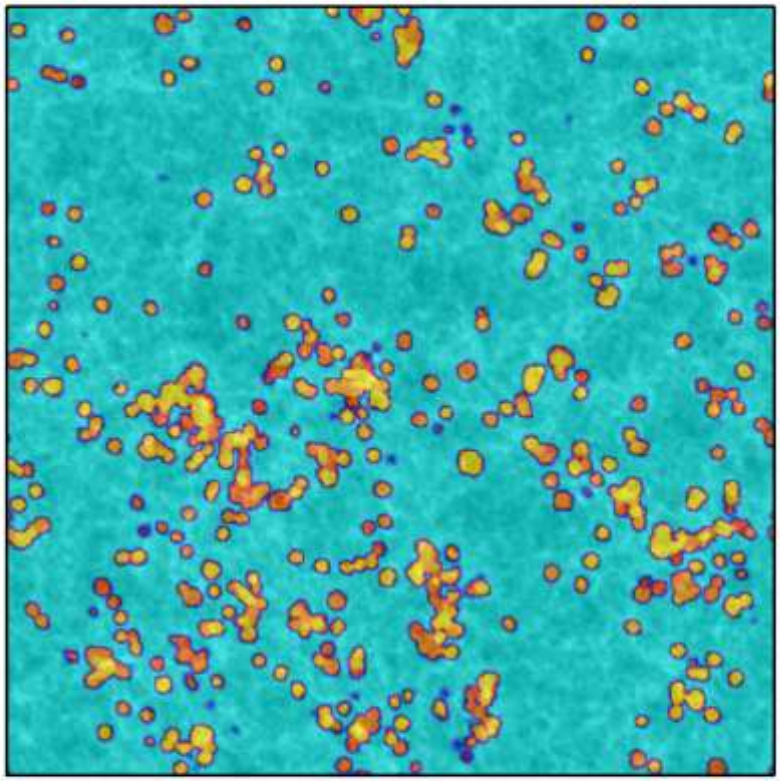
$$\delta T_b = (28\,mK)\left(\frac{1+z}{10}\right)^{\frac{1}{2}}(1+\delta)(1-x)$$

Simulations

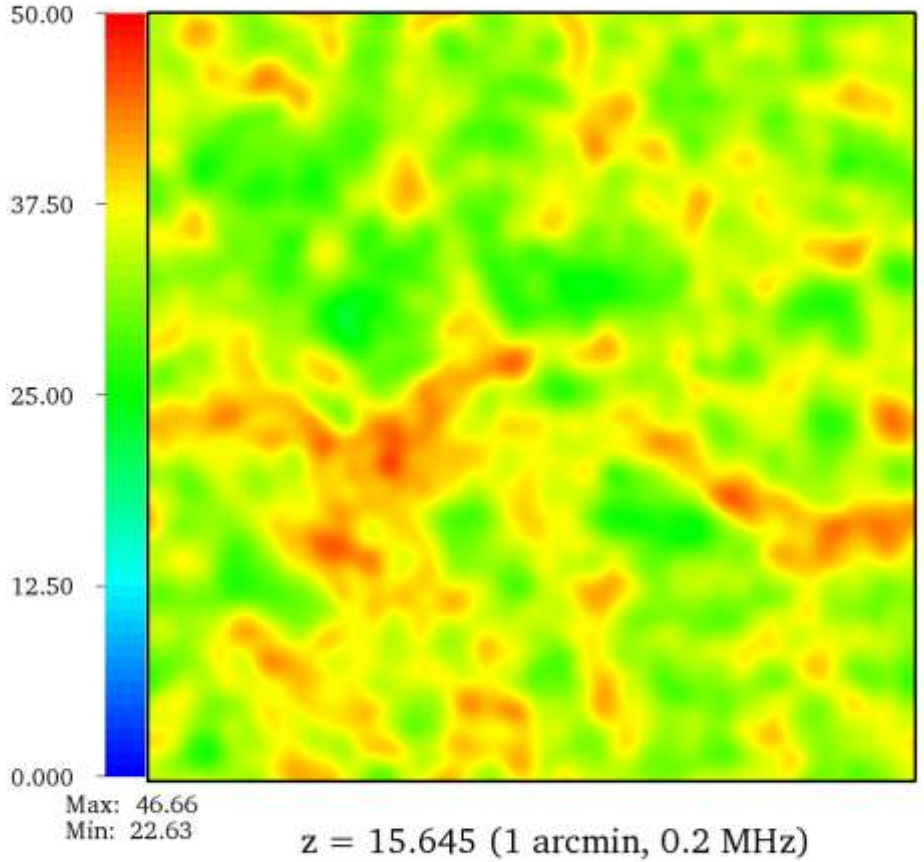
- N-body simulation
  - ΛCDM model with WMAP 5yr parameters
  - 2048^3 particles
  - 66 Mpc/h box (~30′ at z = 14)

- Reionization simulation
  - 256^3 mesh
  - 4 source property models
    - 2 for high-mass halos only ($M > 10^9\ M_{sun}$)
    - 2 for high-mass and low-mass halos ($10^8 < M/M_{sun} < 10^9$)

Mock 21-cm sky map

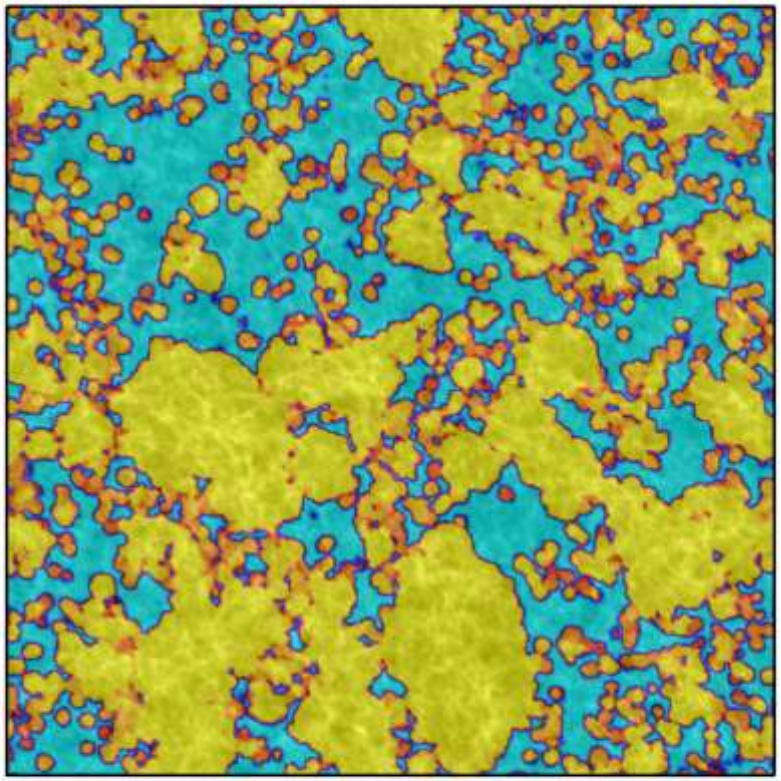


z = 15.645 (x_v = 0.04)

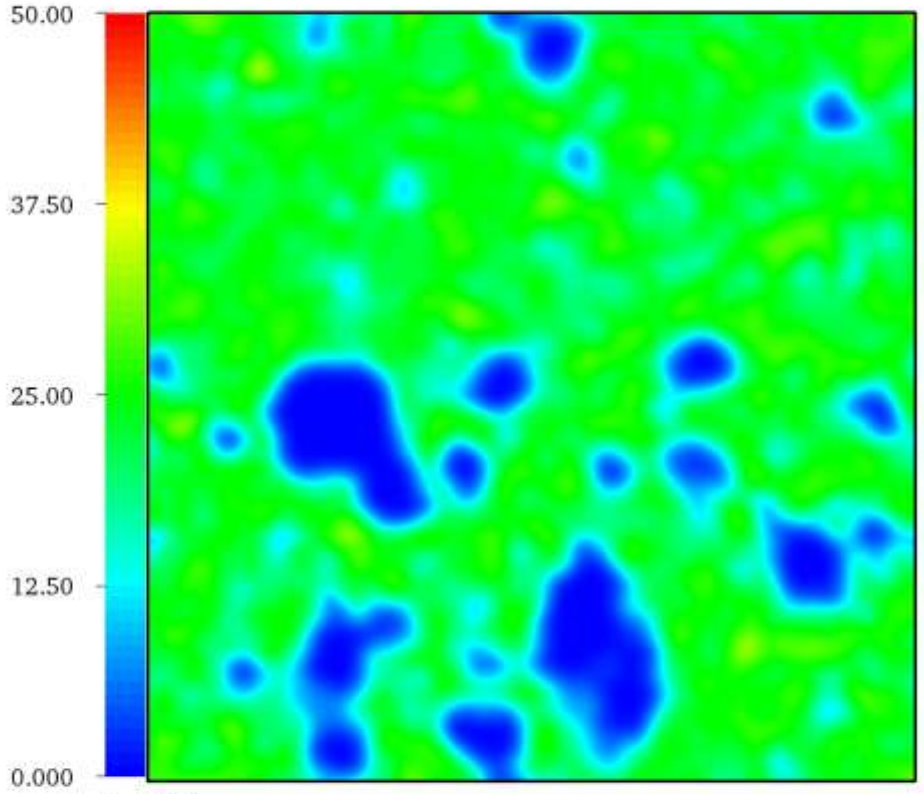


z = 15.645 (1 arcmin, 0.2 MHz)

Mock 21-cm sky map

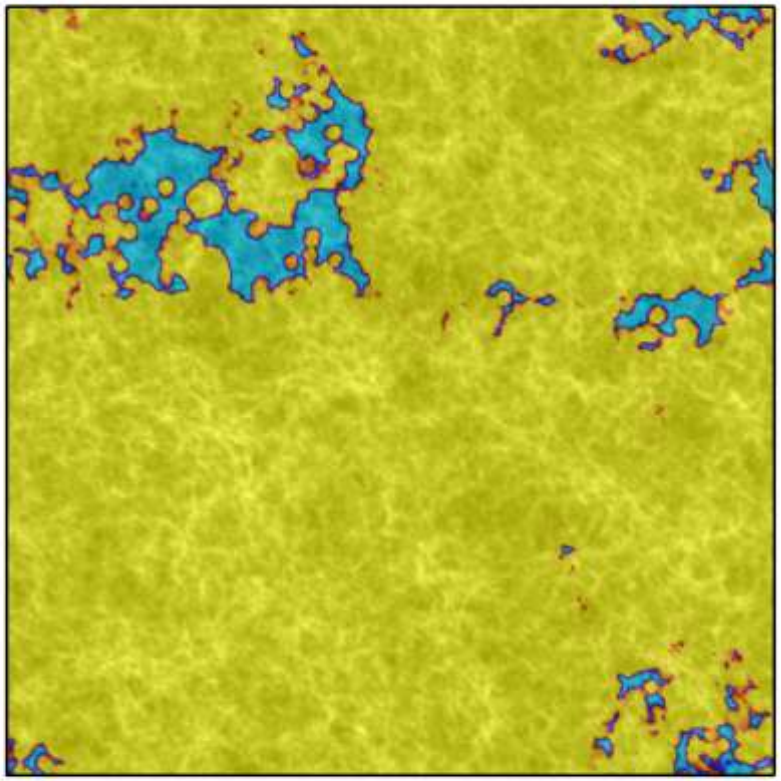


z = 12.184 (x_v = 0.4)

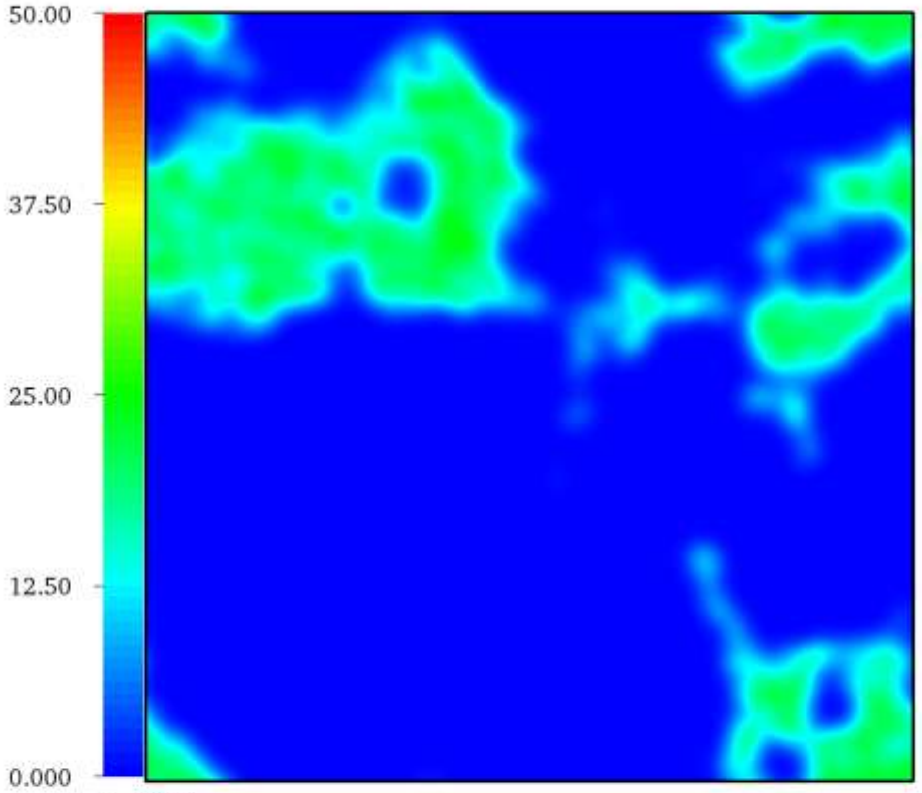


z = 12.184 (1 arcmin, 0.2 MHz)

Mock 21-cm sky map

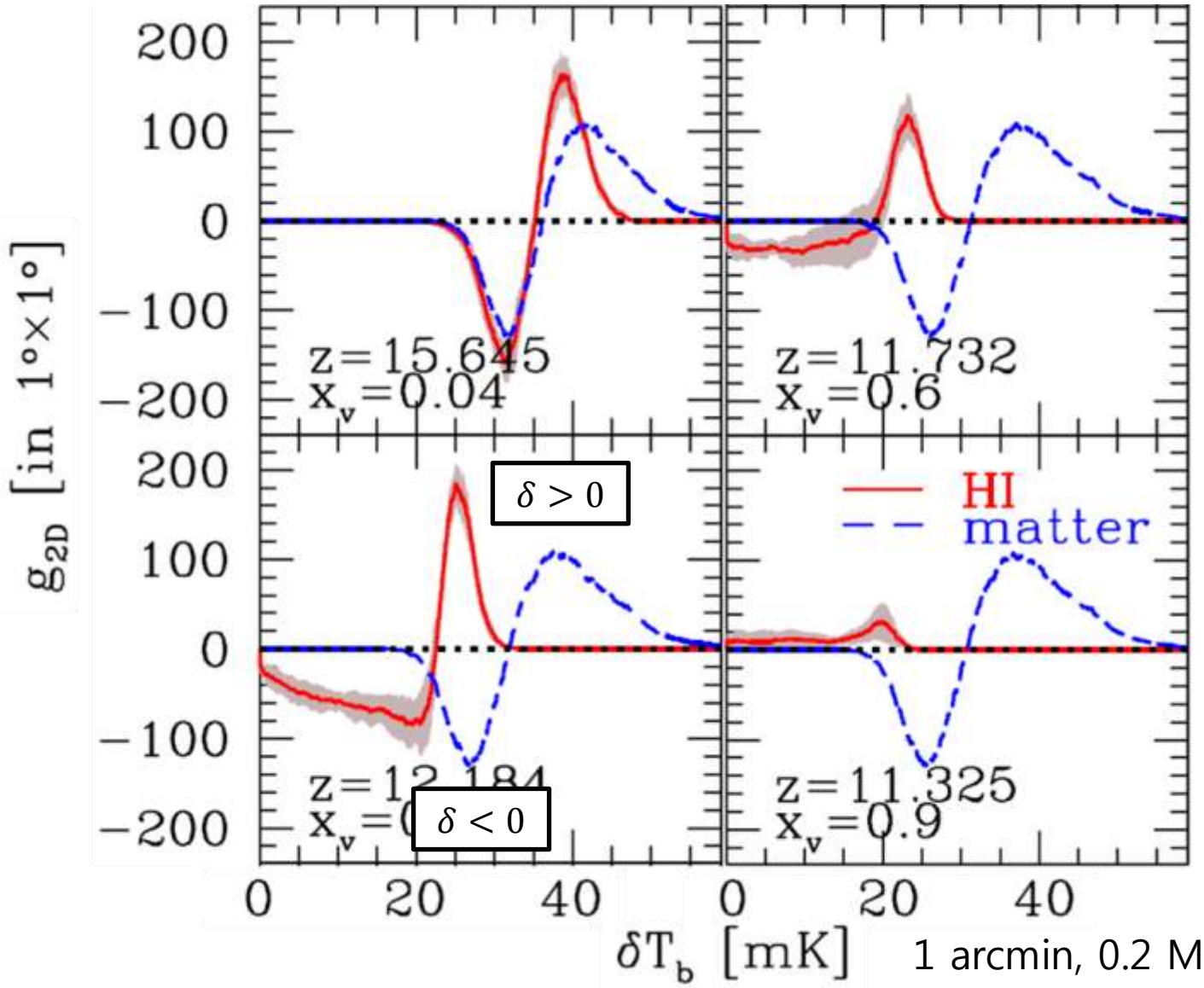


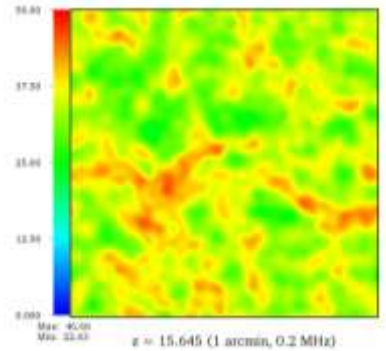
z = 11.325 (x_v = 0.9)

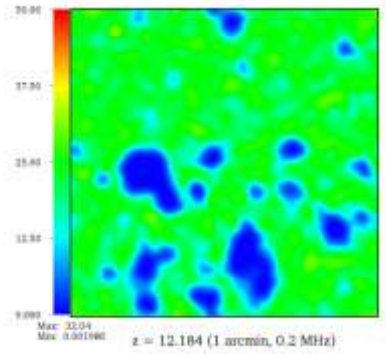


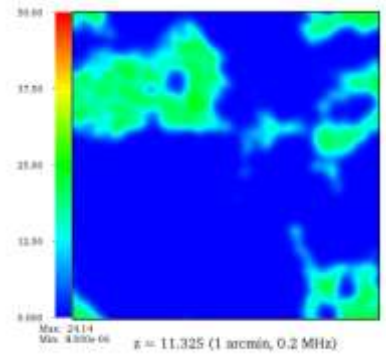
z = 11.325 (1 arcmin, 0.2 MHz)

2D genus: evolution process



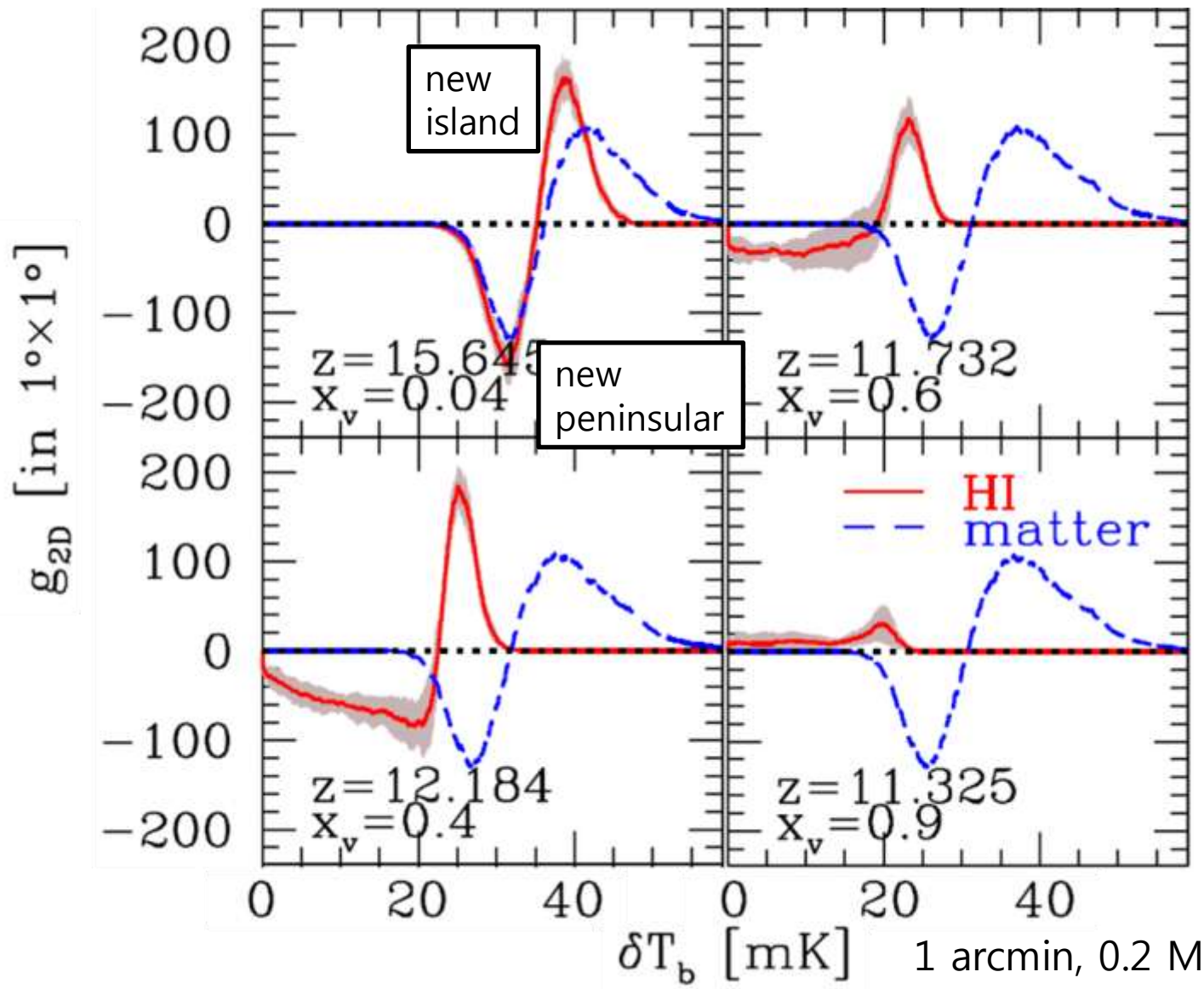


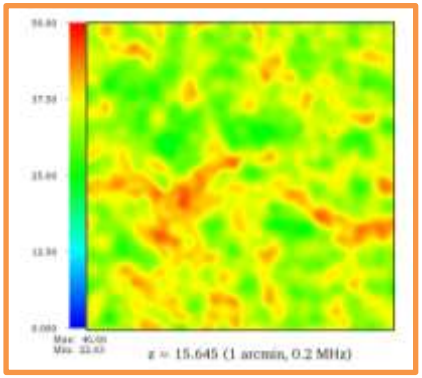


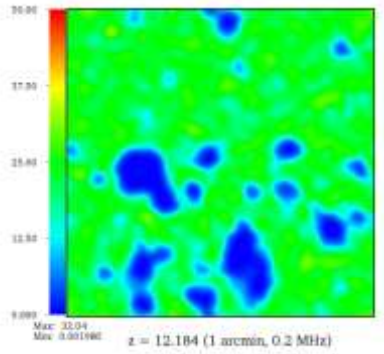


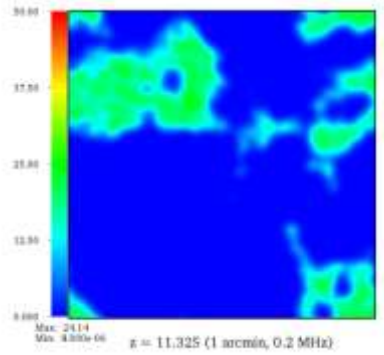
1 arcmin, 0.2 MHz

2D genus: evolution process









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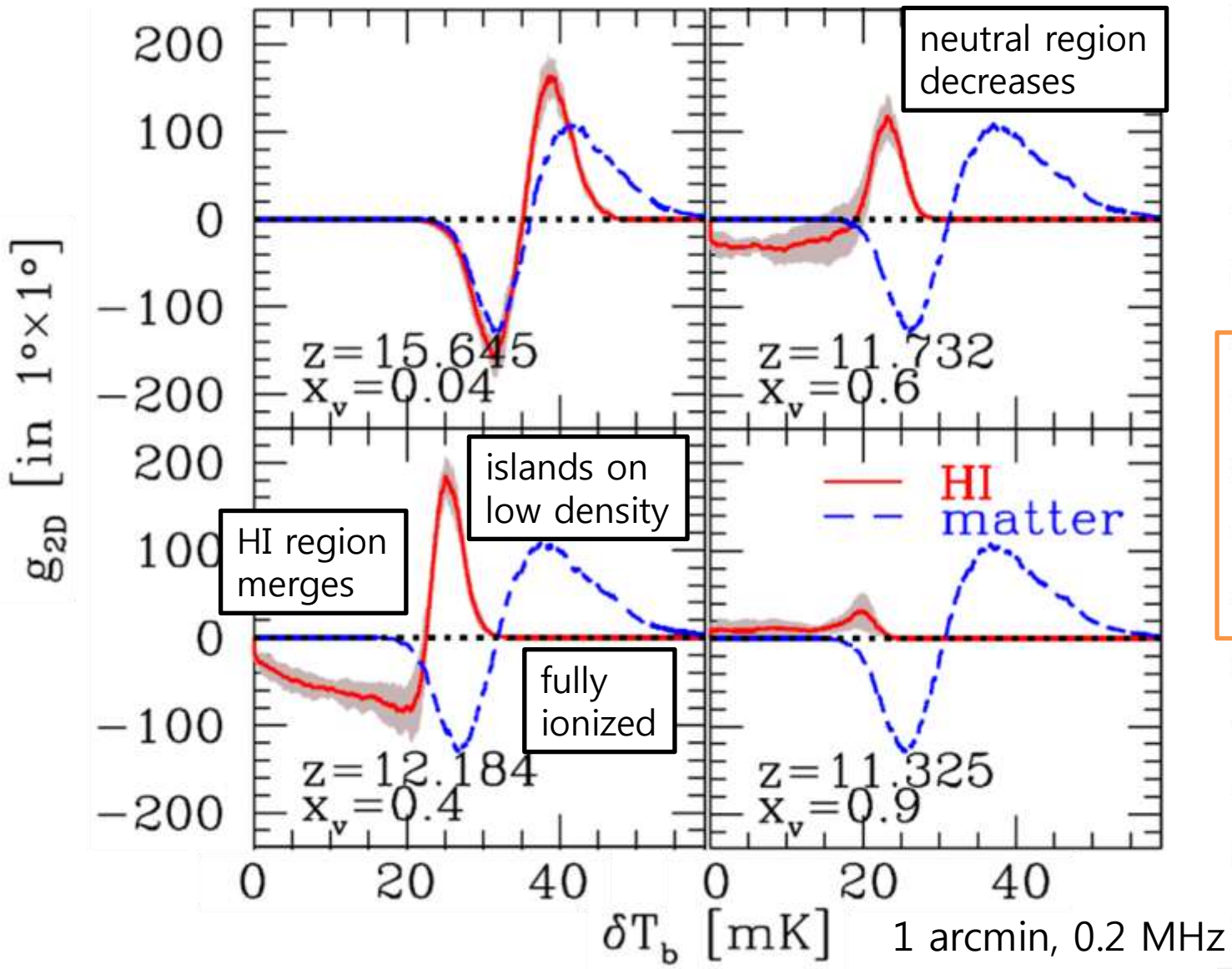
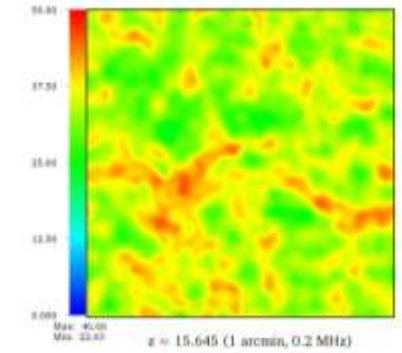
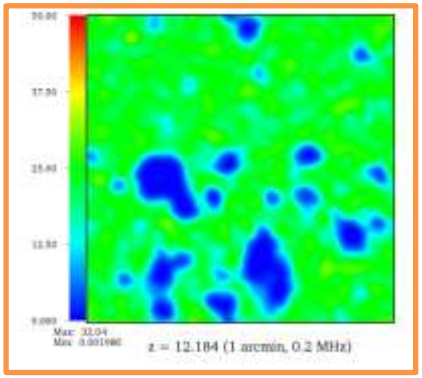
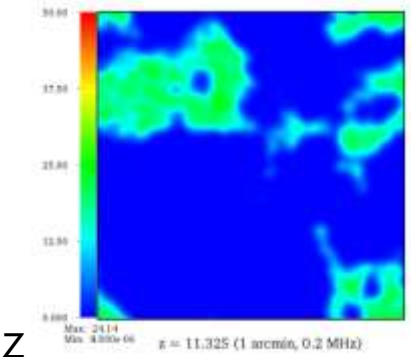


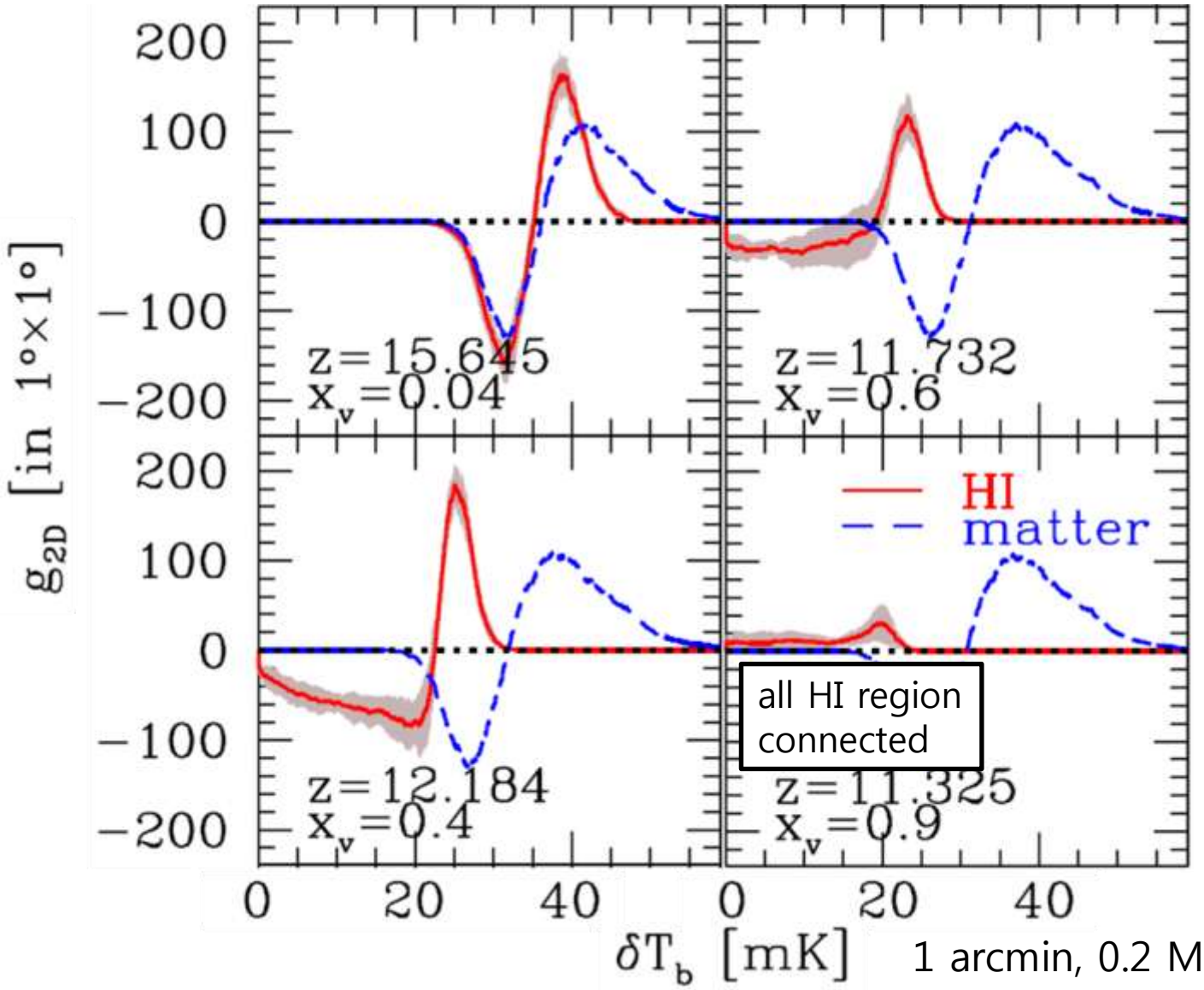


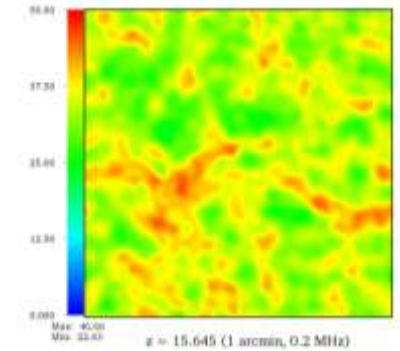


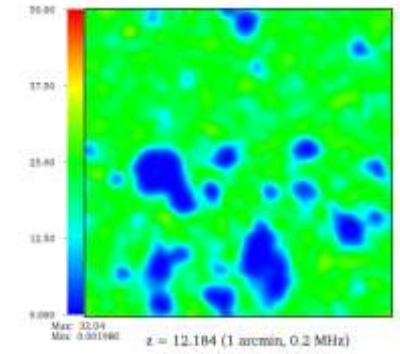


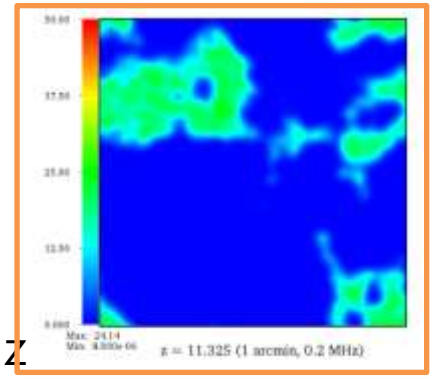
1 arcmin, 0.2 MHz

2D genus: evolution process



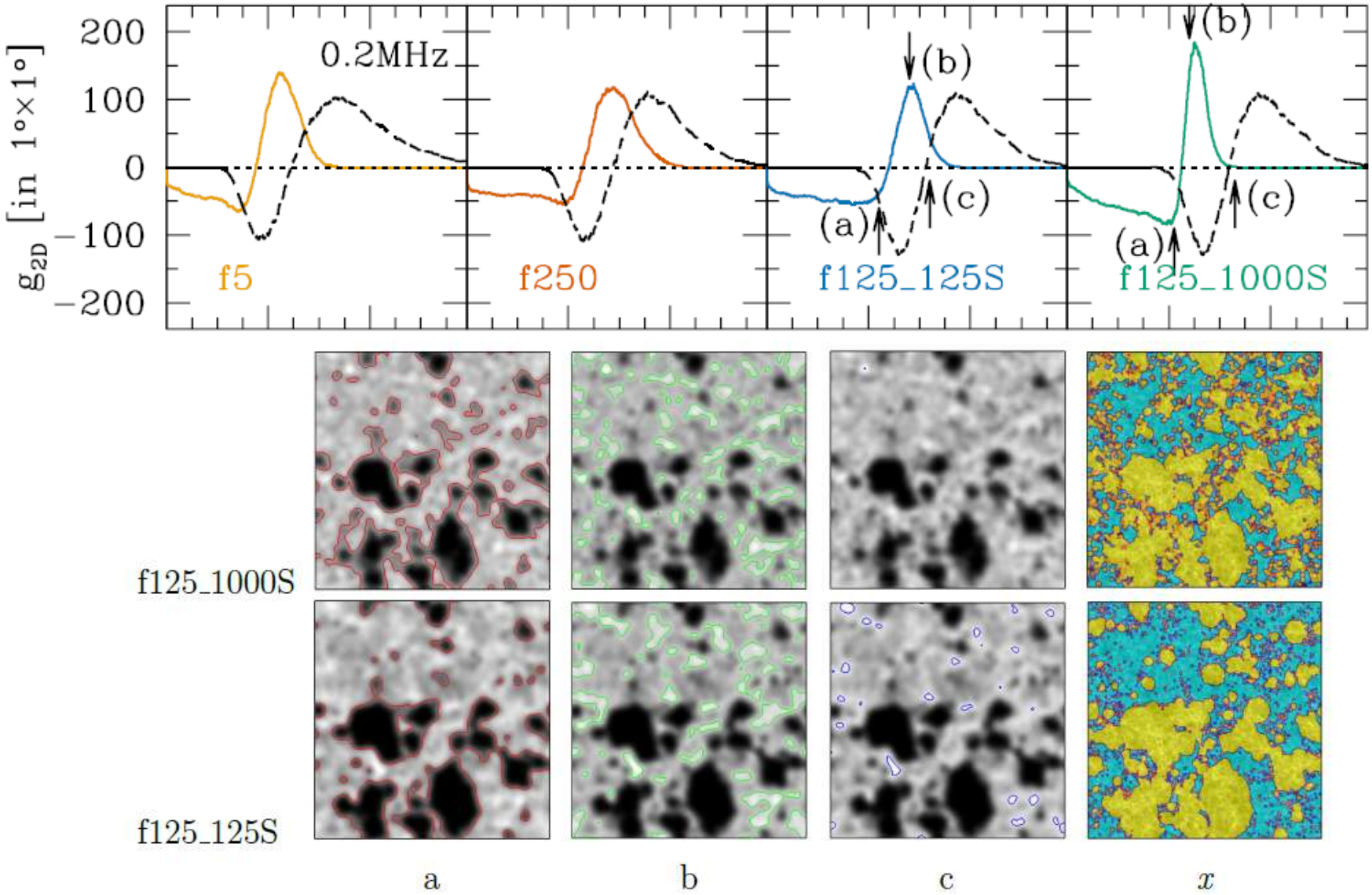




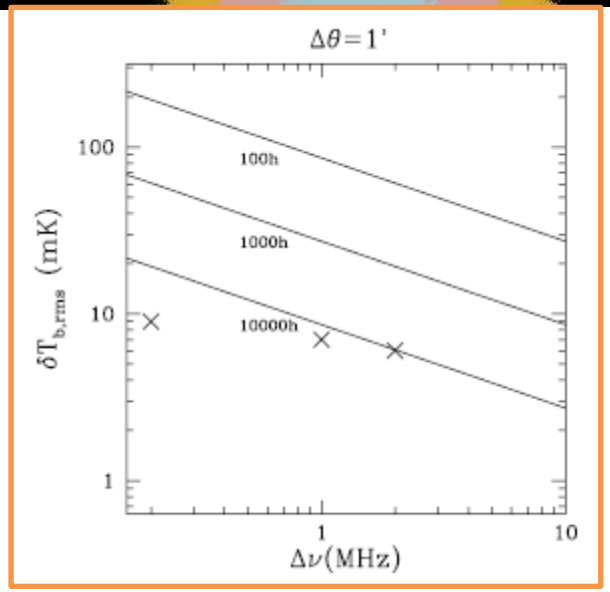


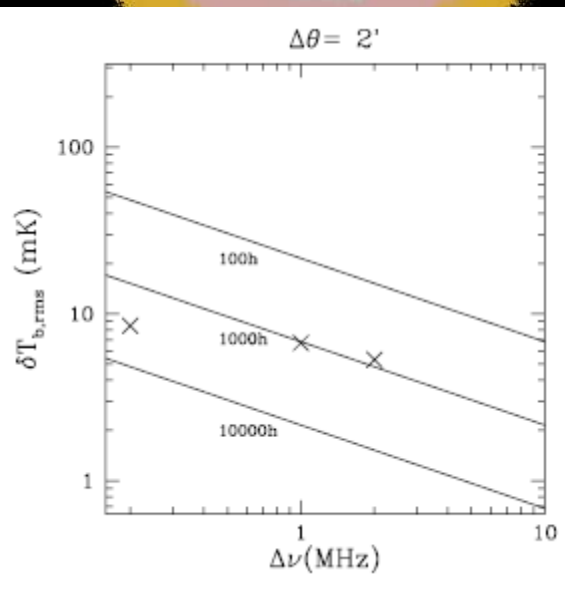
1 arcmin, 0.2 MHz

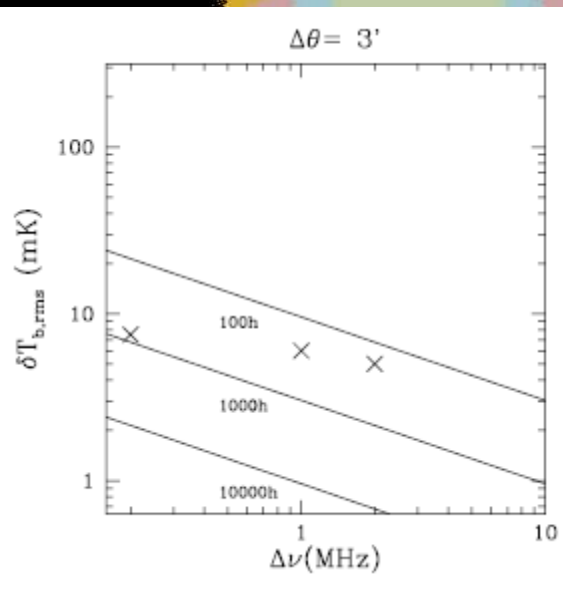
2D genus: model dependency

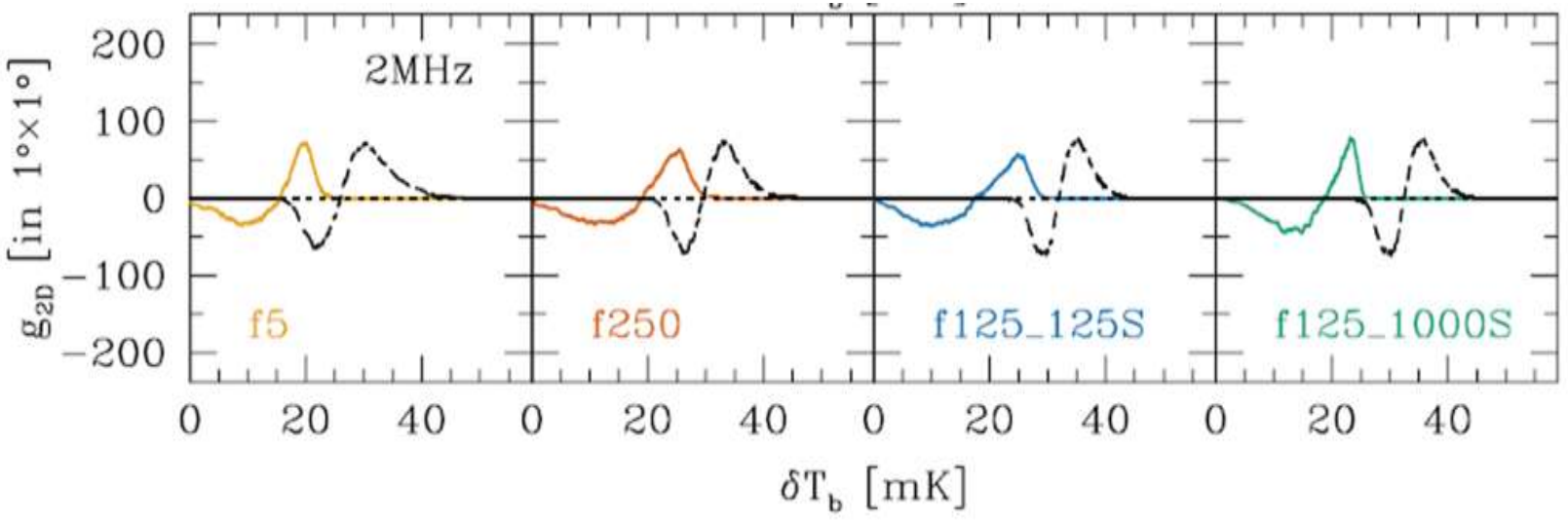


Sensitivities









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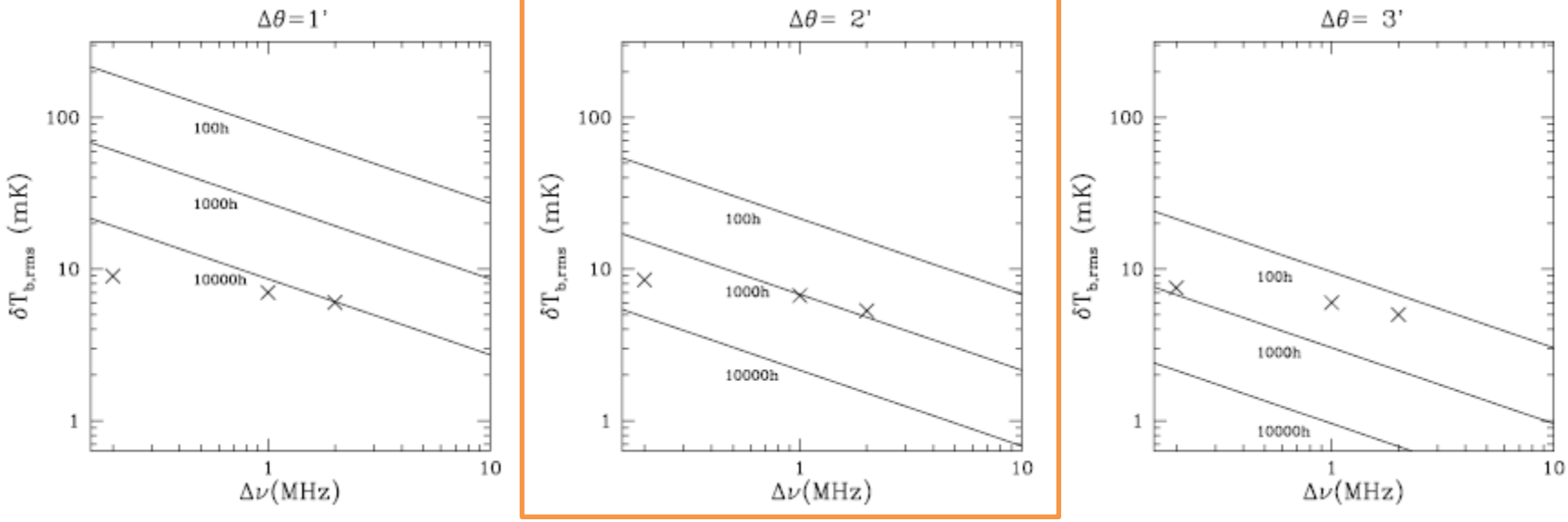

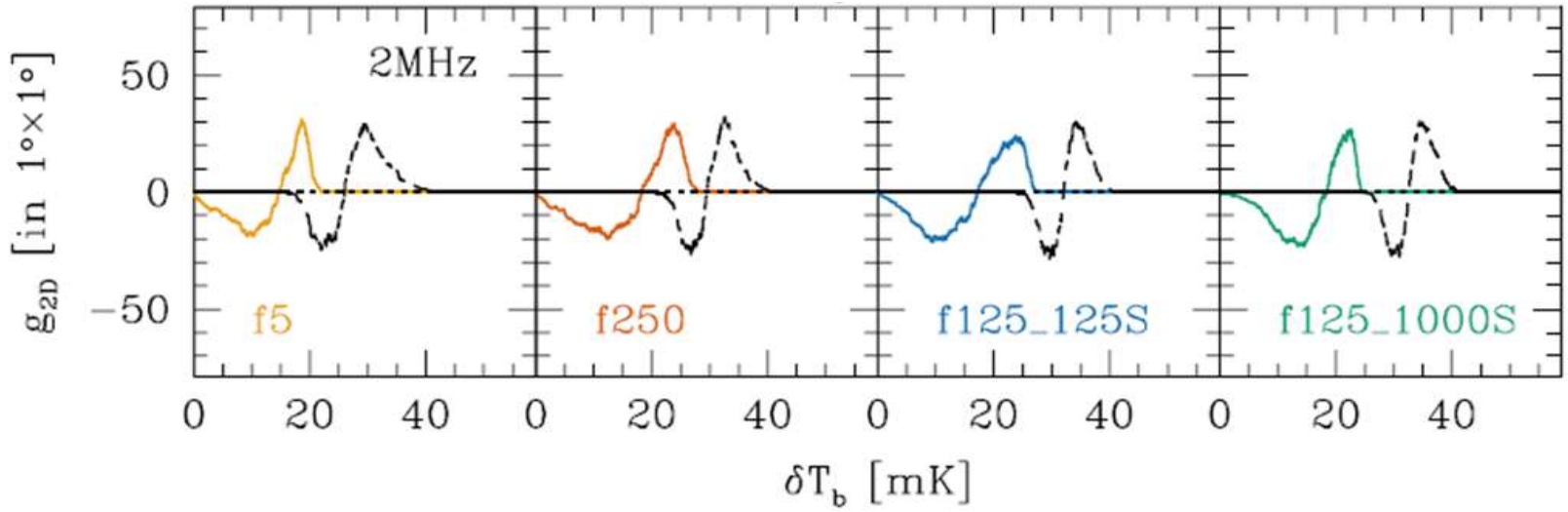

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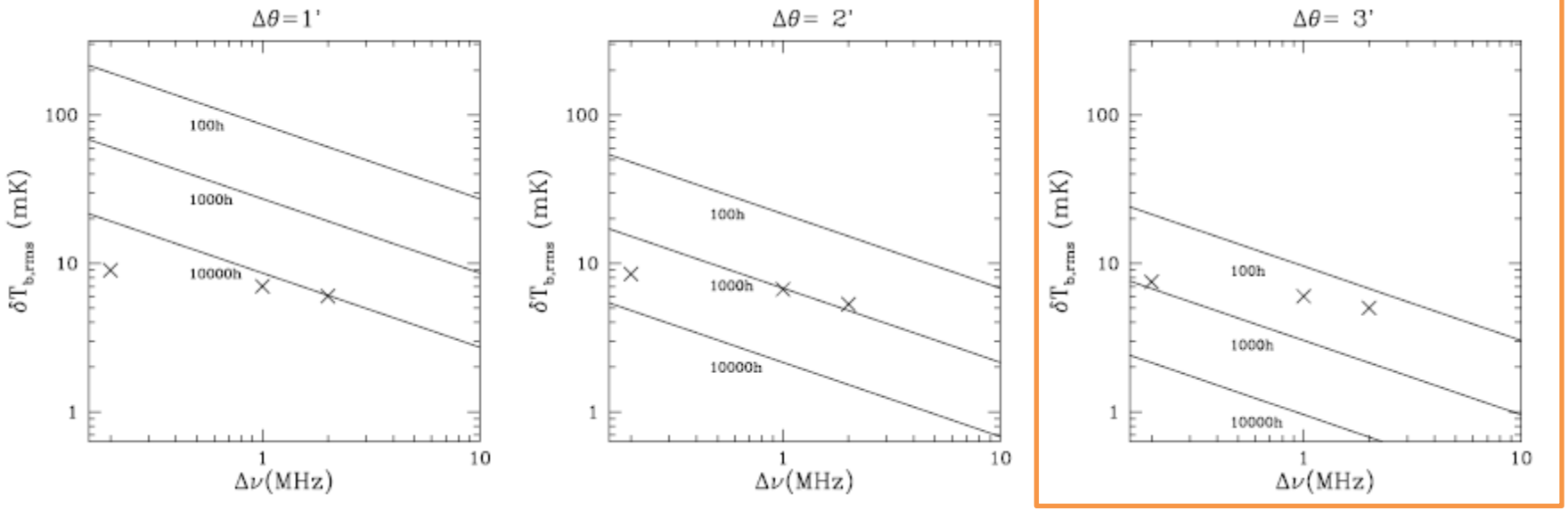

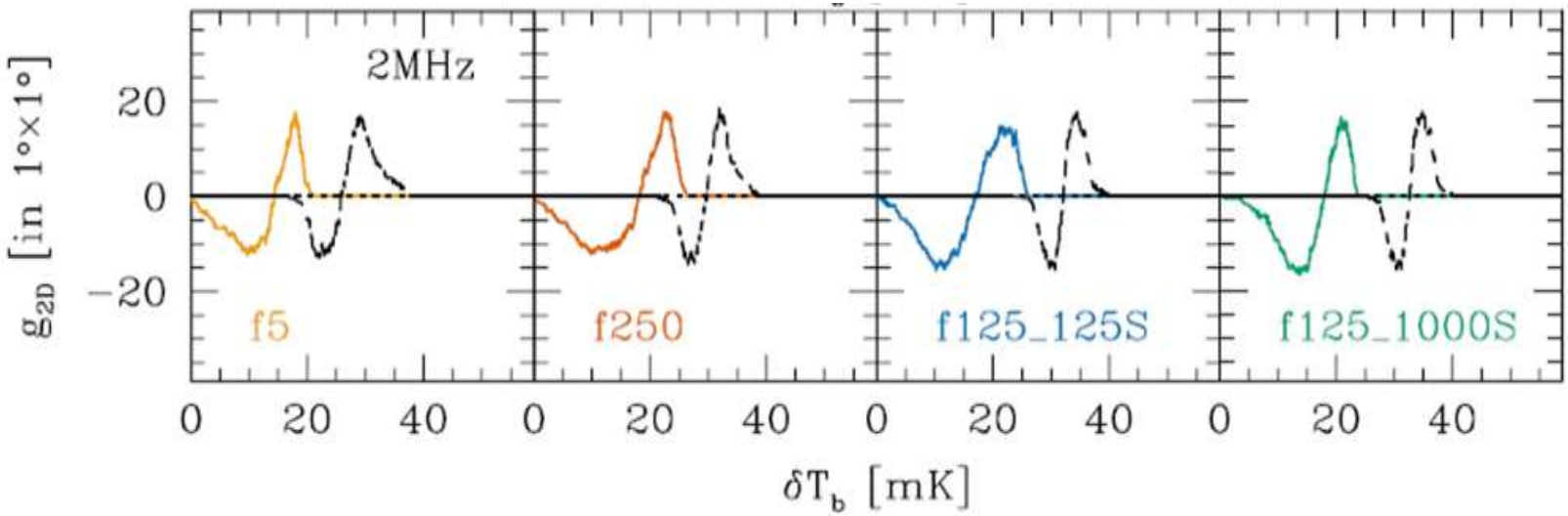

Summary

- 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