The Radio SZ Effect

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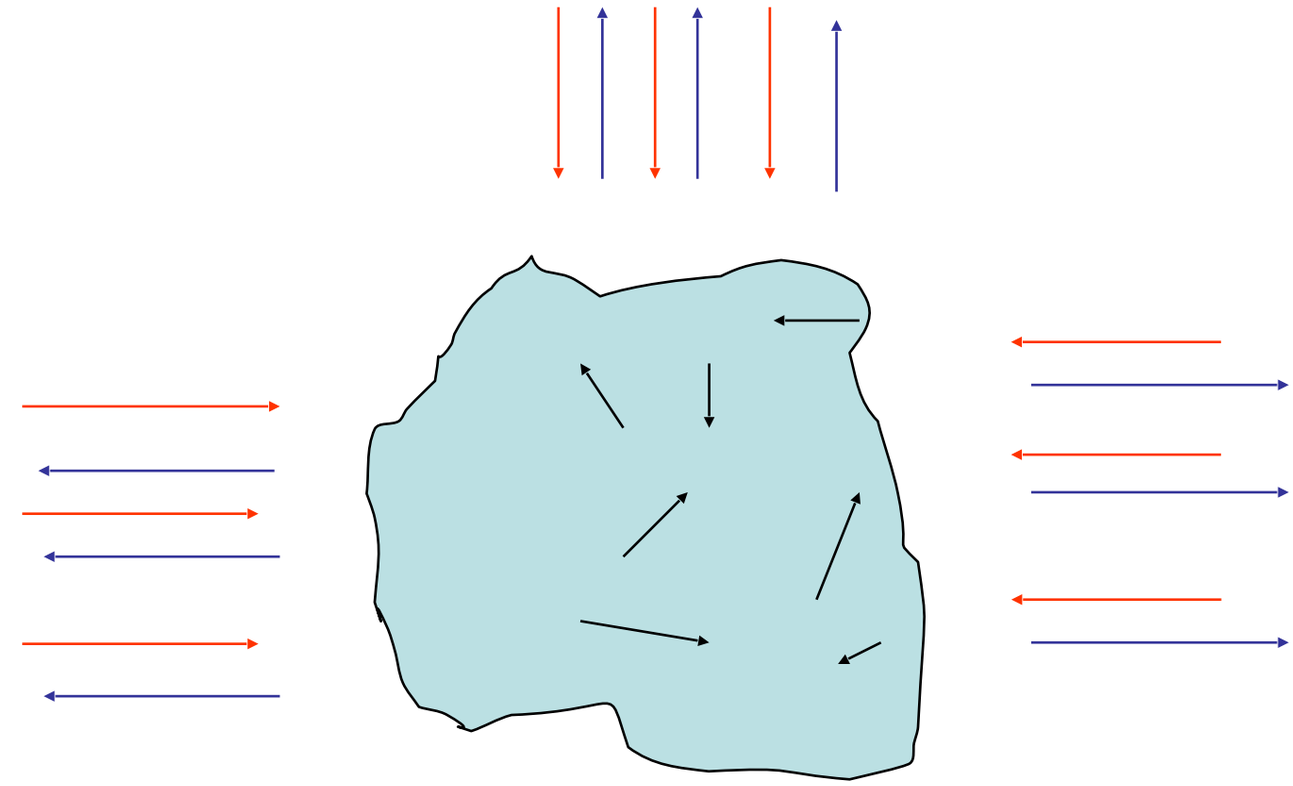
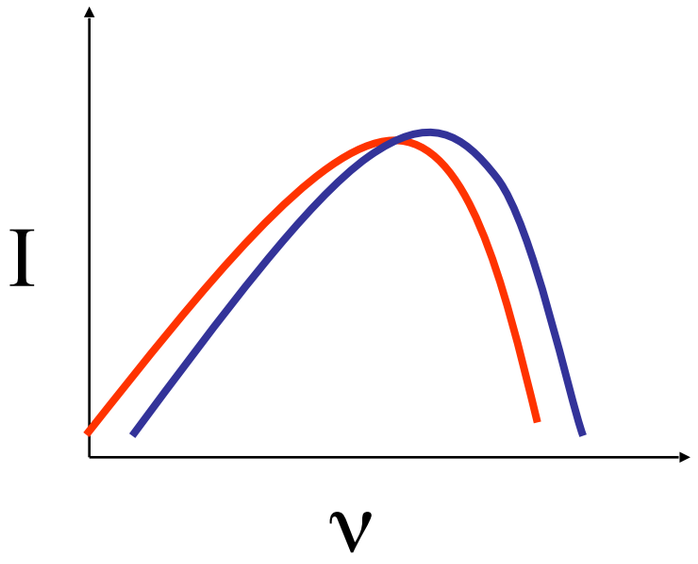
with Jens Chluba, Elizabeth Lee

Lee, Chluba & Holder 2112.10666
Holder & Chluba 2110.08373

Thermal Sunyaev-Zel'dovich Effect

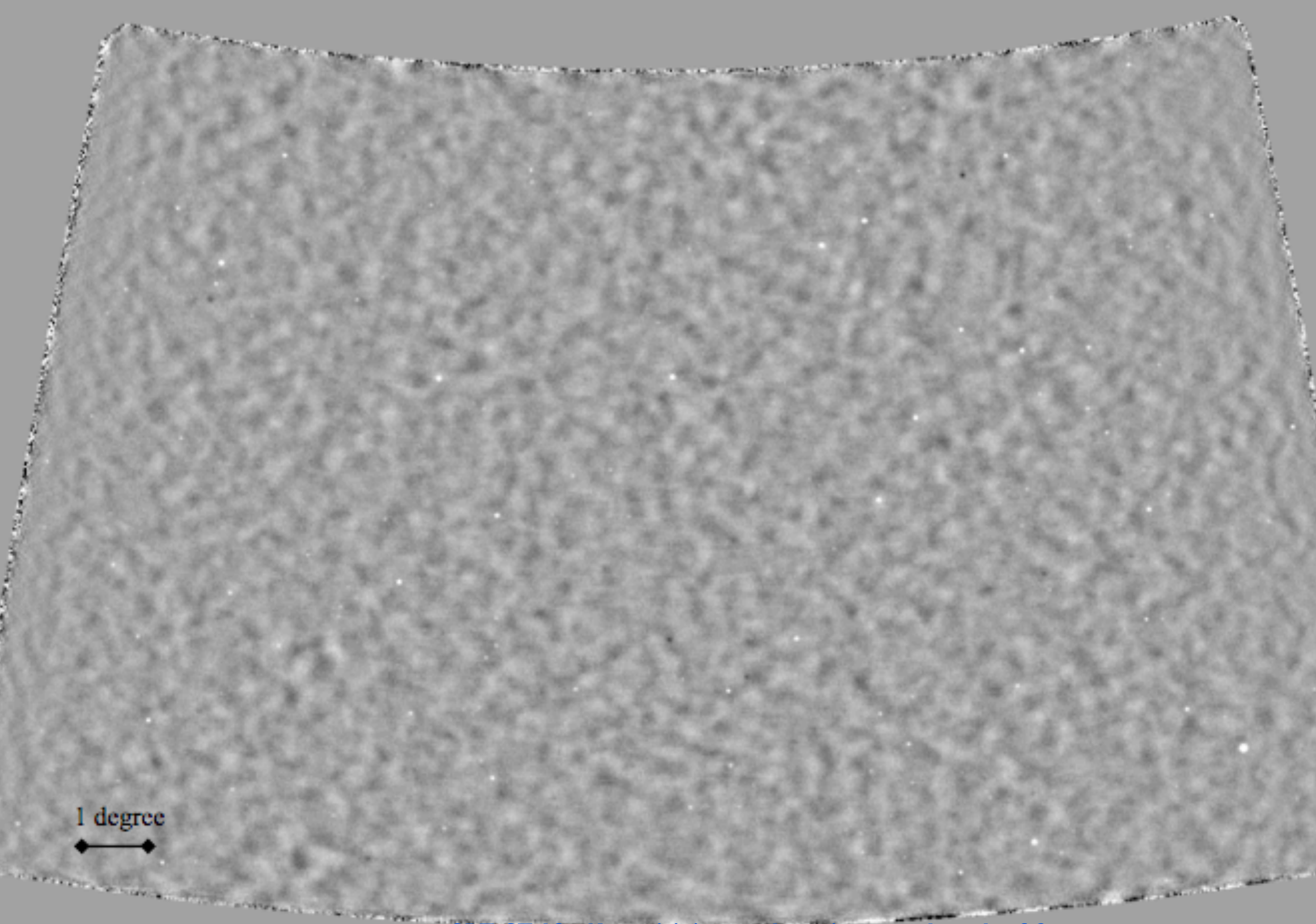




Optical depth: $\tau \sim 0.01$

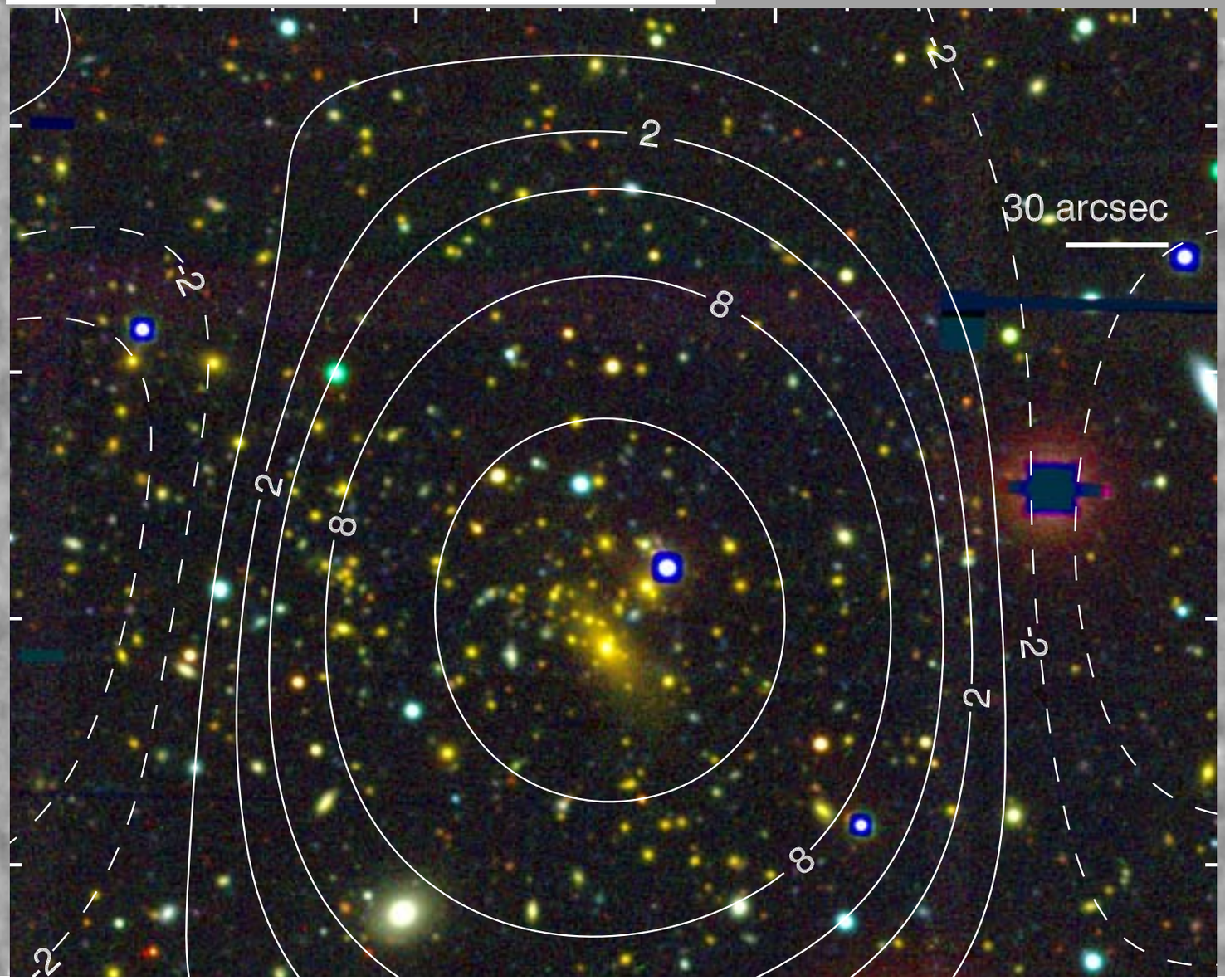
Fractional energy gain per scatter: $\dfrac{kT}{m_e c^2} \sim 0.01$

Typical massive cluster signal: ~500 uK



SPT-SZ 18 uK sensitivity at observing wavelength of 2 mm
(current SPT-3G noise <5 uK)

Image by Will High in recent paper by Williamson et al



patch of isolated cosmic fog

One of the heaviest objects in the universe
$>10^{15}$ solar masses

1 degree

Radio SZ Effect

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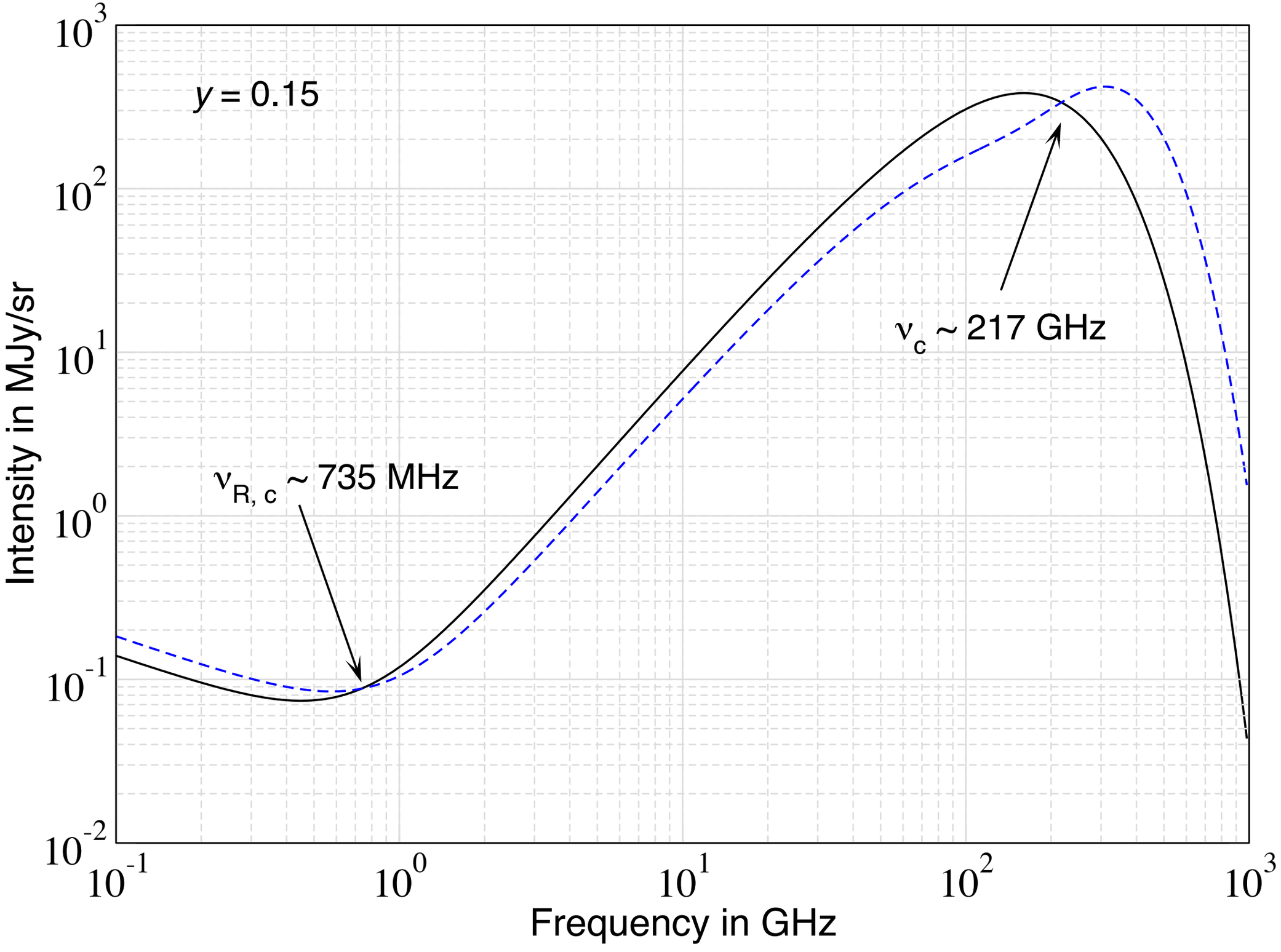

Impact of radio background amplitude

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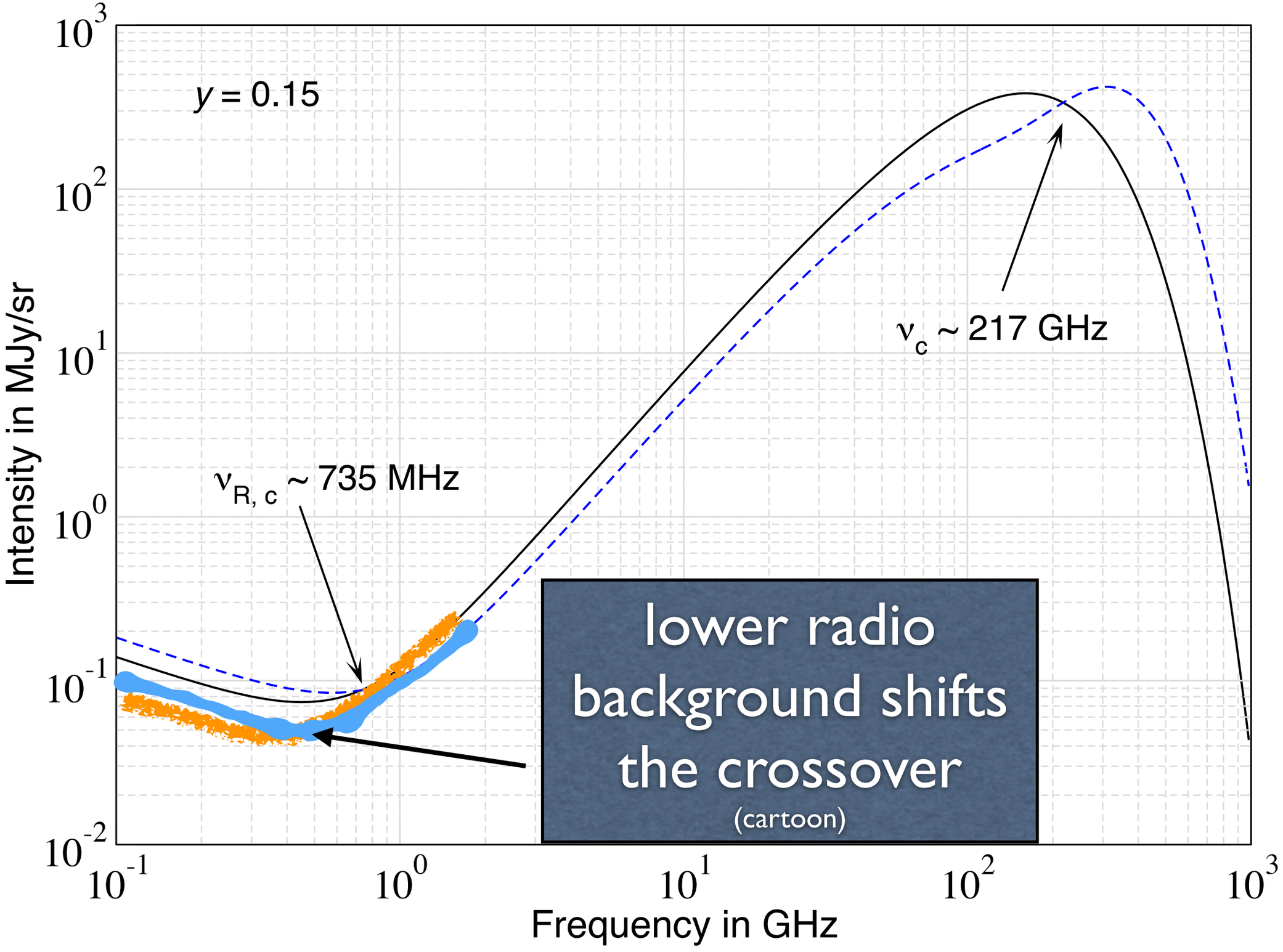
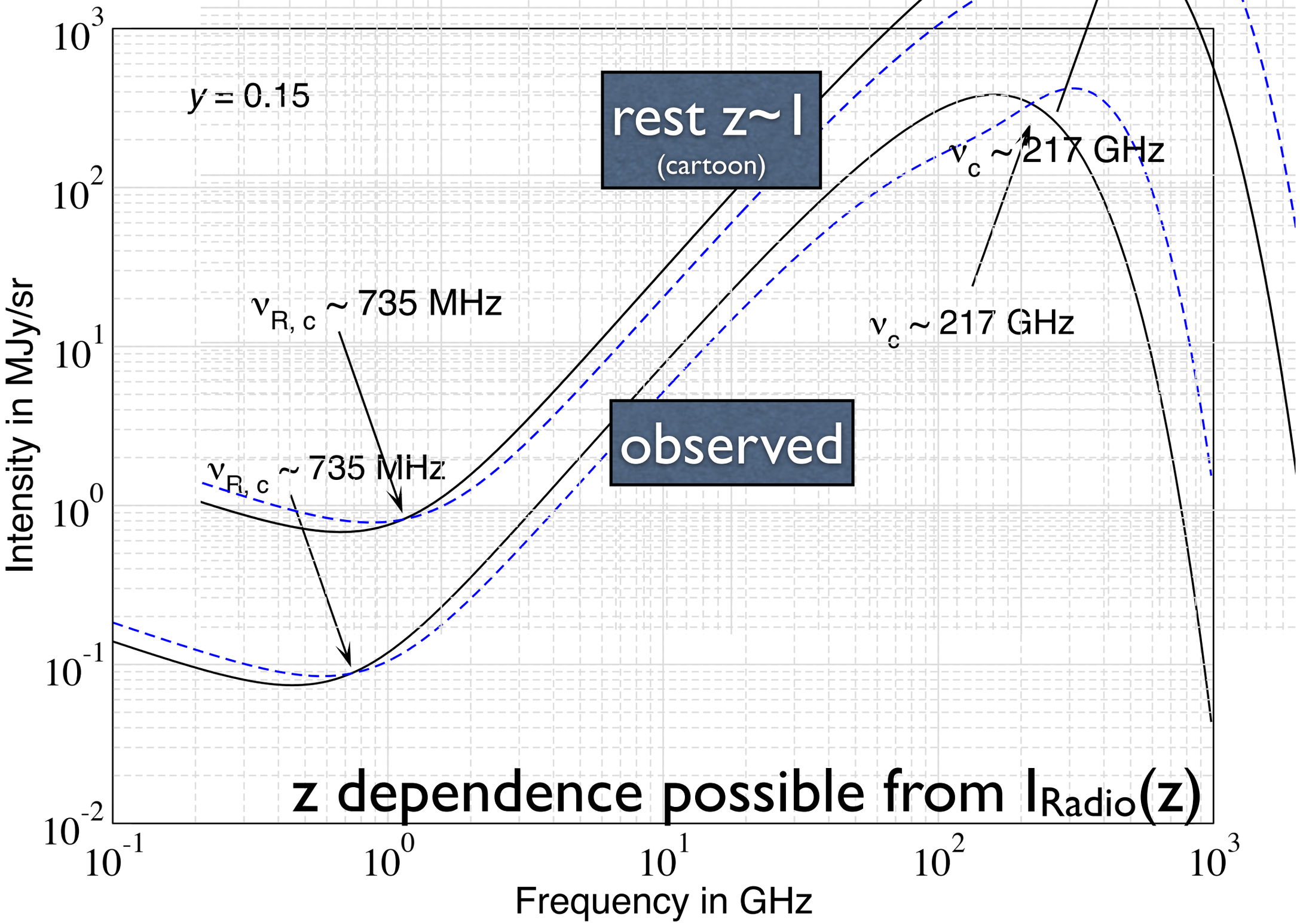
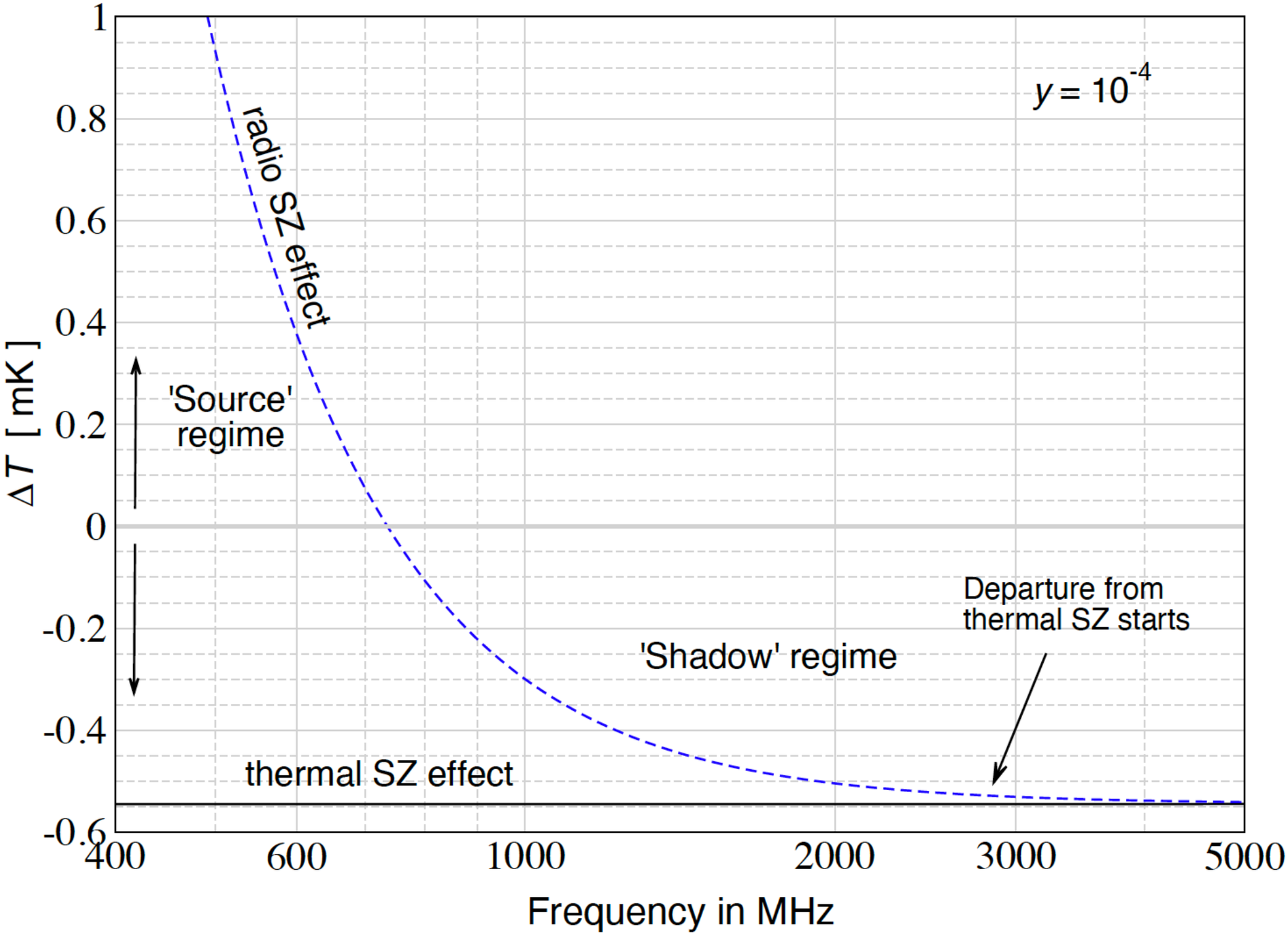


Distortion redshifts, along with spectrum



Combined CMB + Radio SZ



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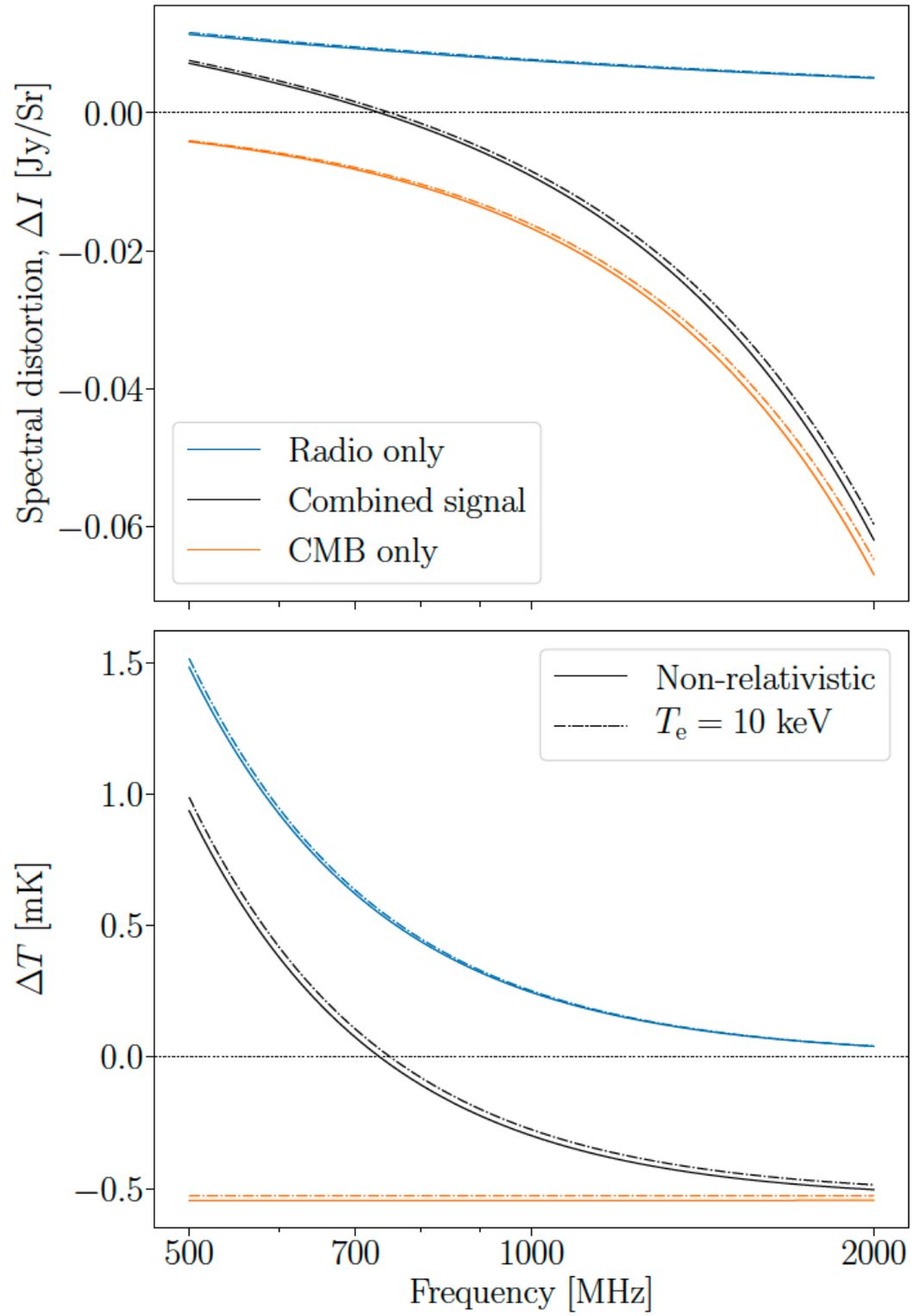
Effects of temperature & bulk velocity

- just like regular CMB thermal SZ, there are corrections due to gas temperature ("relativistic corrections" and bulk velocity (kinematic or kinetic SZ)



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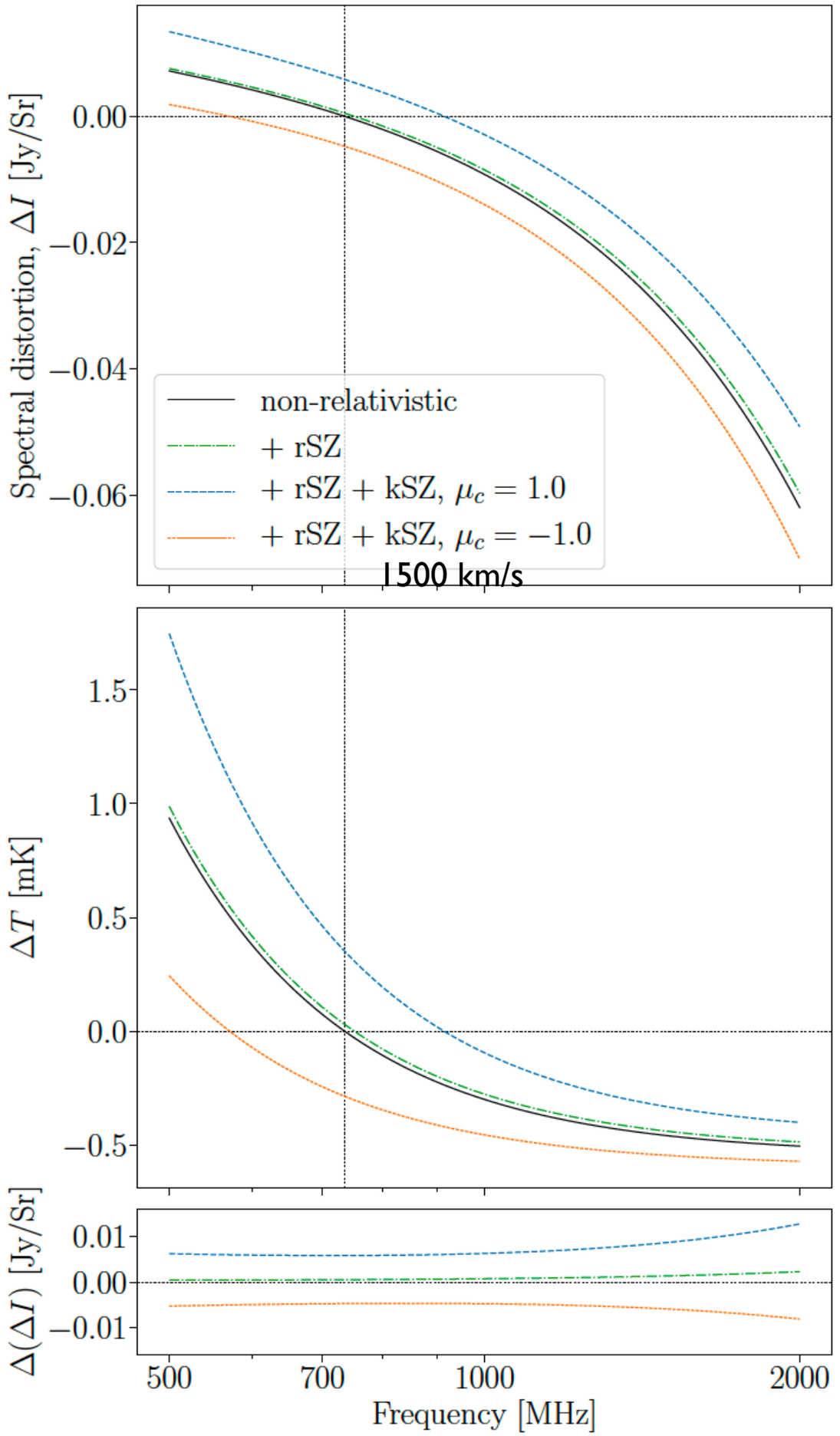

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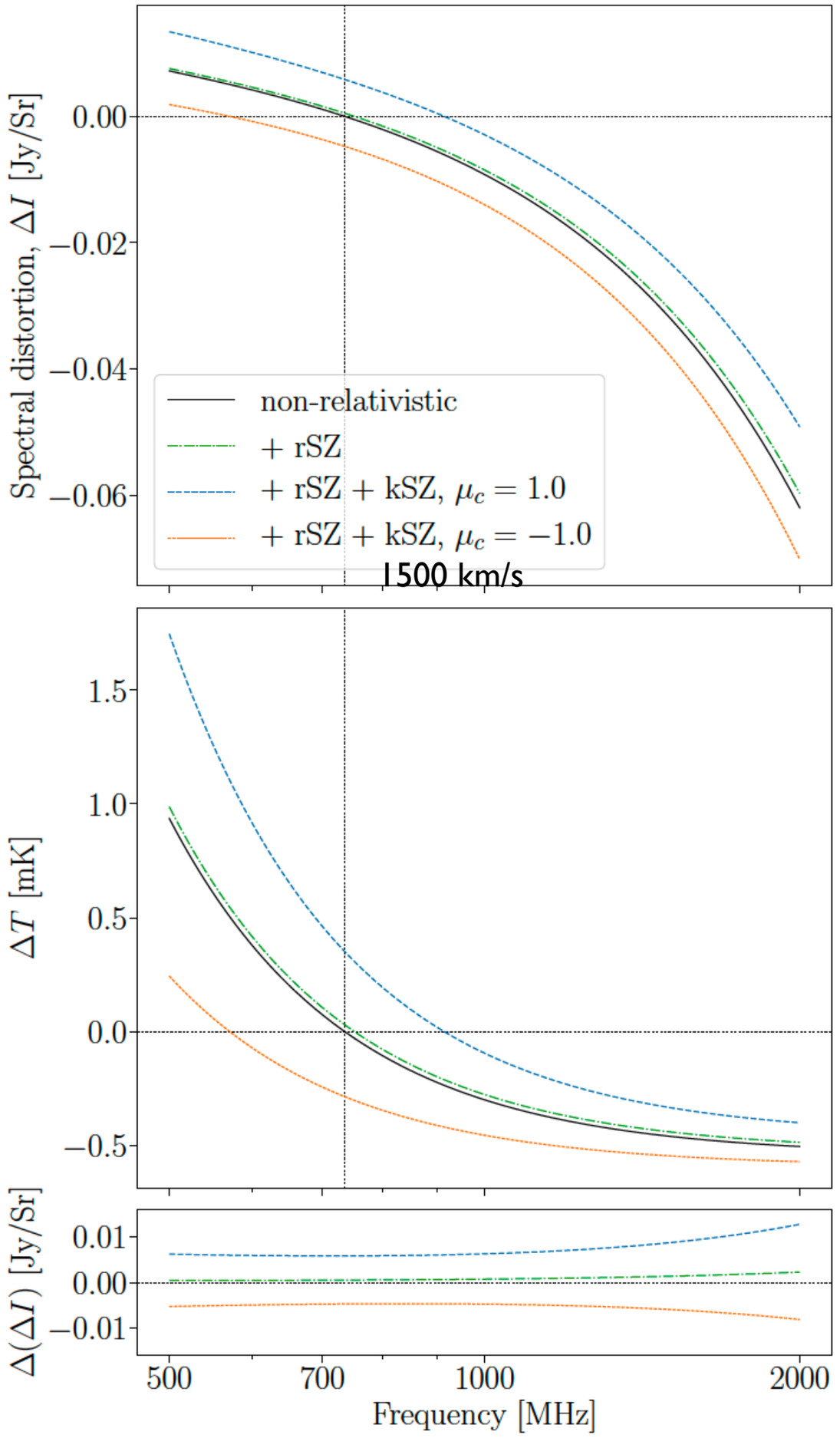
Redshift tomography

- measuring radio tSZ for clusters at different z probes buildup of radio background at lower z
- cross-correlating with high-z galaxies + measuring CMB kSZ allows radio kSZ to probe buildup of radio background



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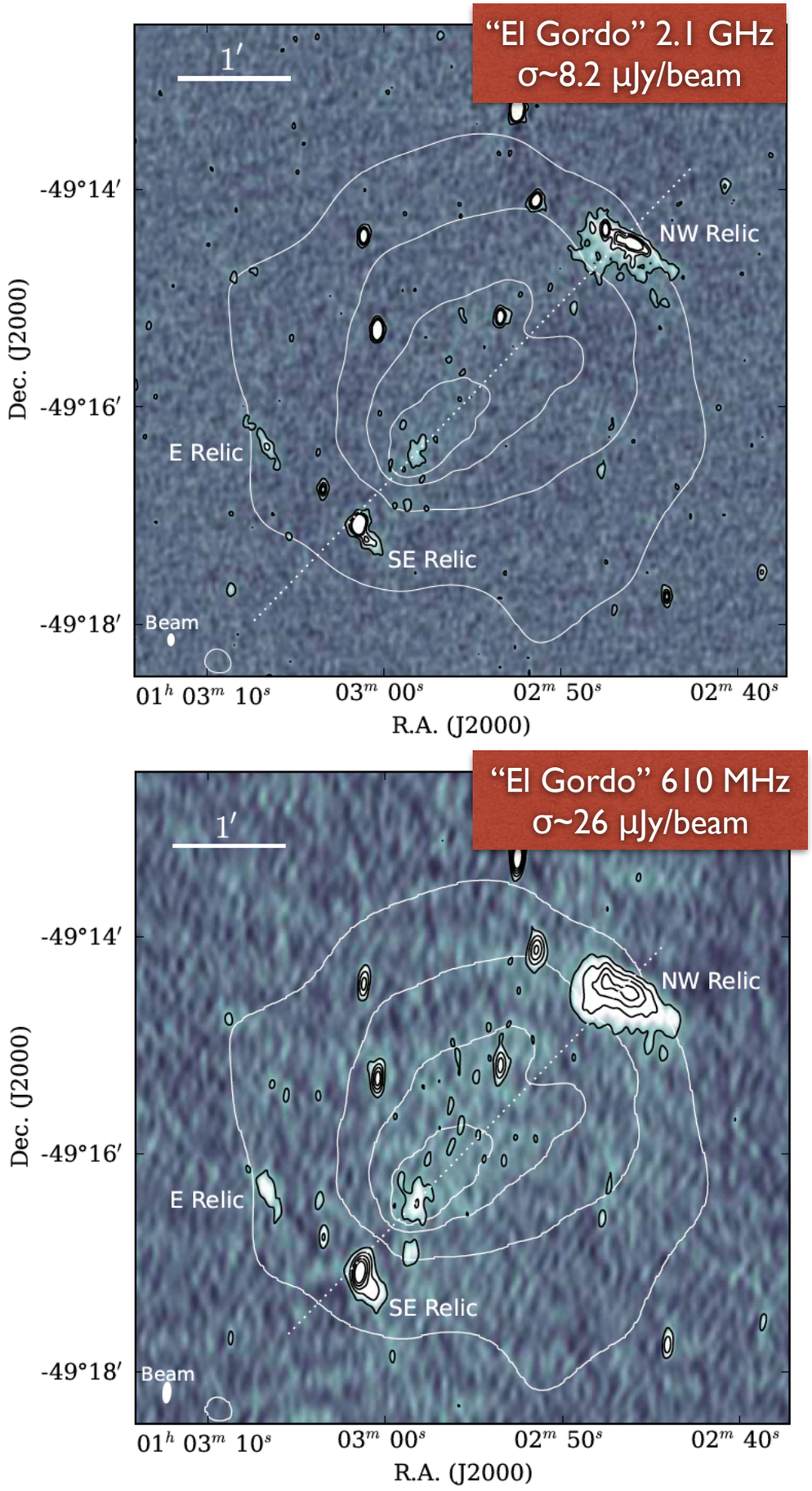
Detectability

- in terms of *detector noise*, easy! (mK for big clusters)
  - bandwidth 50 MHz for 6h: $\sqrt{\Delta\nu\Delta t} \sim 10^6$
  - ~mJy sensitivity required
- cluster-correlated radio halos, radio relics, radio sources poorly understood and not small



Lindner et al 2014

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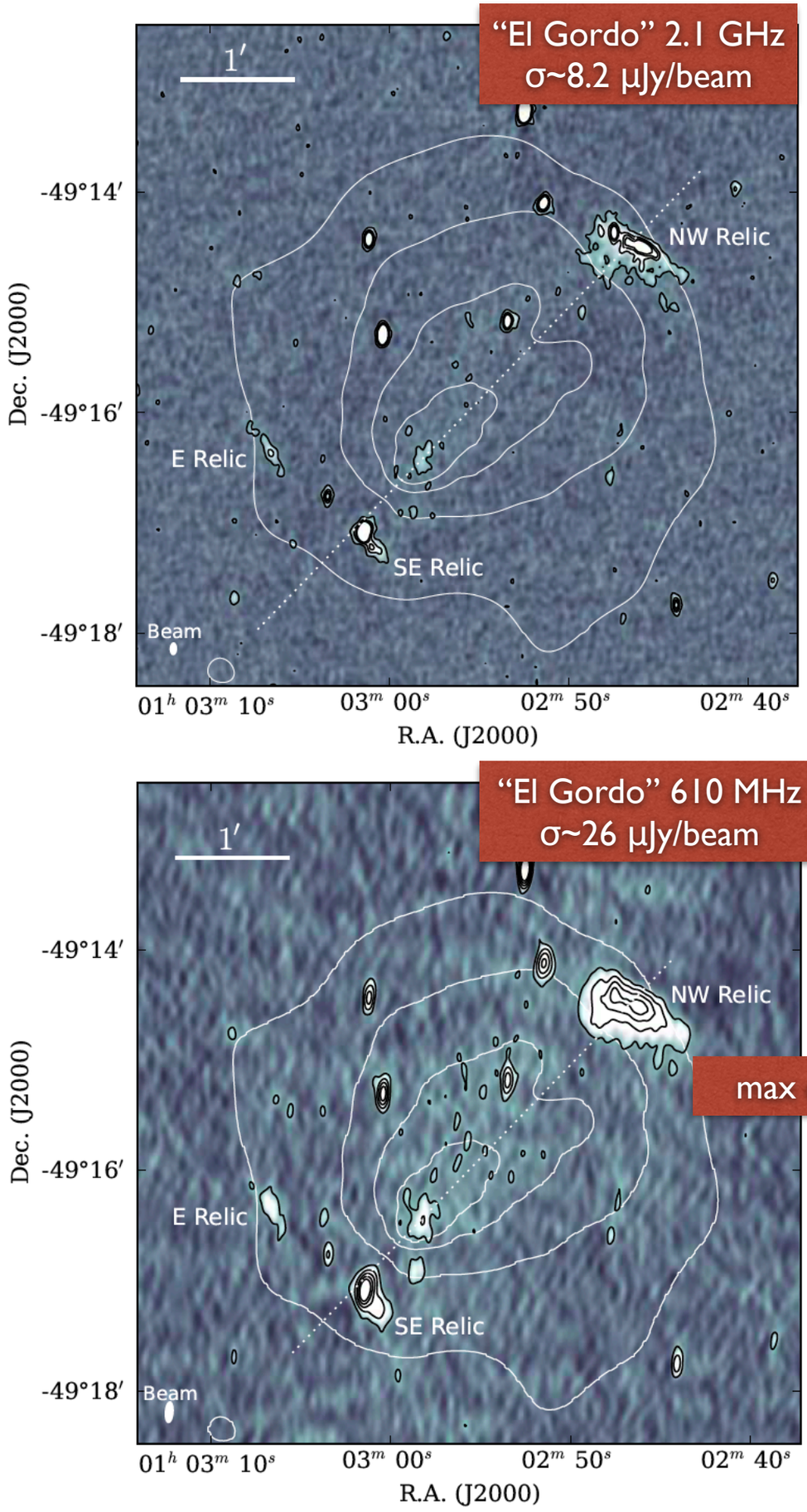

Lindner et al 2014

Best strategy?

- how to use cluster-correlated nature:
  - use Planck y-map to do large scale cross-correlation with large-scale radio maps
  - use Planck/SPT/ACT images of individual clusters as y templates for targeted radio observations
  - do on-cluster vs off-cluster differences
- nearby or distant clusters (e.g., Coma or Planck cluster catalog?)
- work near null or do higher precision at higher frequencies where cluster-correlated effects could be smaller?

Summary

- there should be a radio thermal SZ effect, just like for the CMB (also same effect for CIB, also kSZ and relativistic SZ)
- measurement would allow determination of the local mean radio background at the location of clusters
- effect is readily accessible in terms of S/N, but cluster-correlated emission could complicate efforts