A CONSTRAINT ON THE 21-CM SIGNAL AT Z=20 FROM VLA OBSERVATIONS

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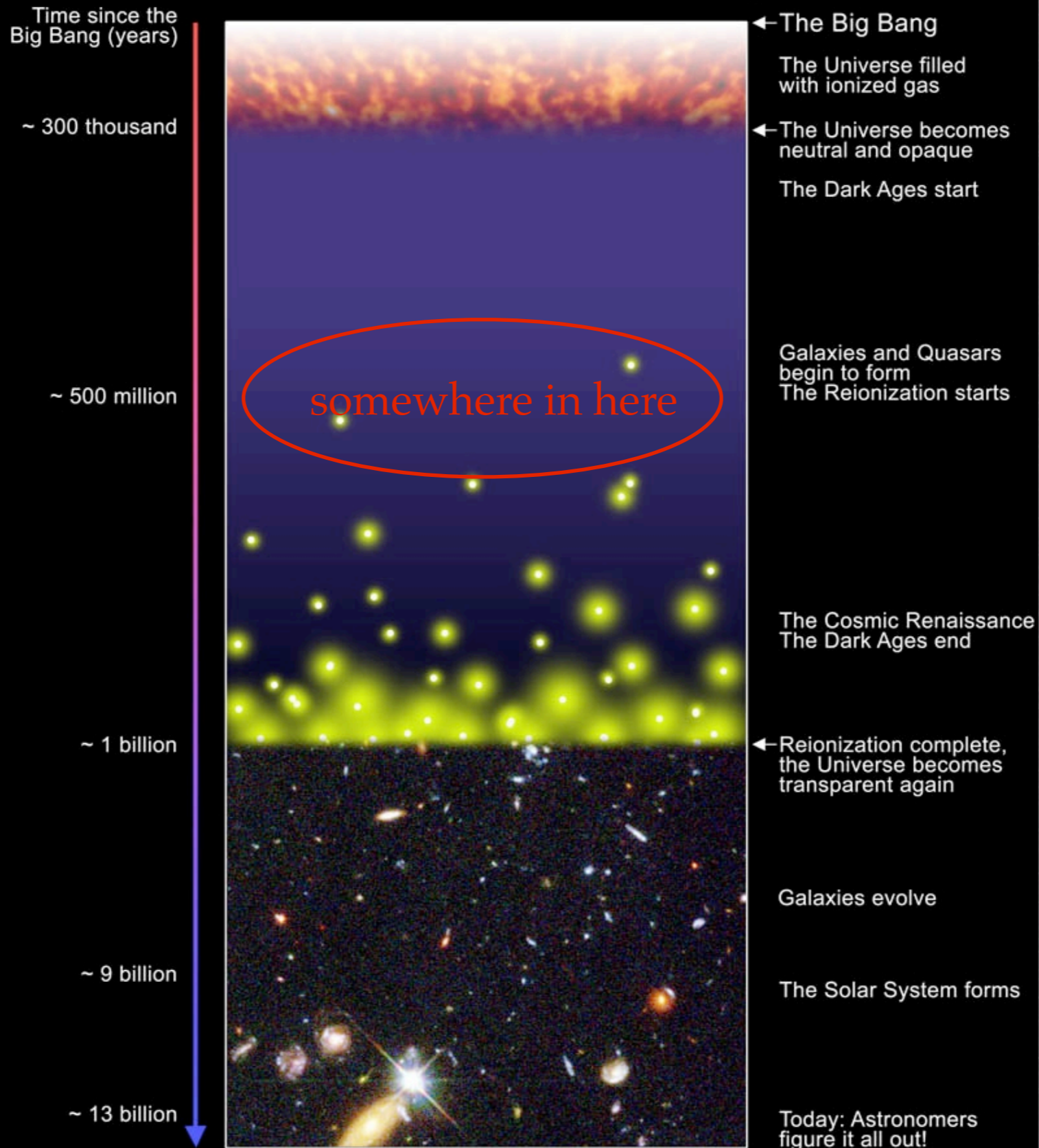
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CONTEXT

- **High redshift 21-cm signal**: primary target of Lunar Radio Array (LRA), earthbound low-ν arrays (PAPER, LWA, MWA, LOFAR, SKA).

- z=6-14

  - Epoch of Reonization

  - 21 cm in emission

- $15 < z < 30$

  - First heating and ionizing sources (stars and QSOs)

  - 21-cm in absorption relative to the CMB.

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

OBSERVATIONS
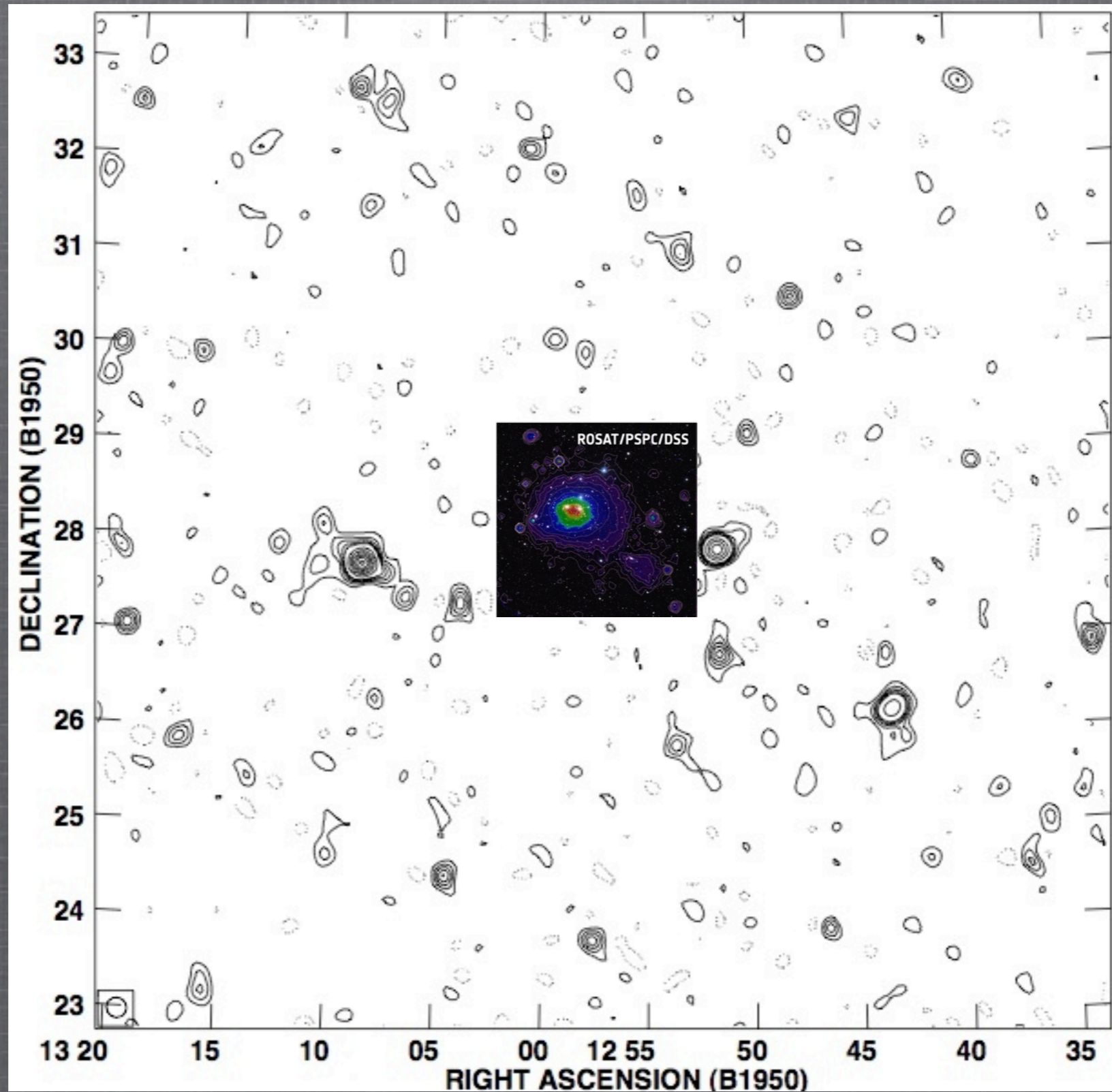
- Redshift z=20 (74 MHz)

- 10 degree field centered on Coma

- VLA D-config, 2.5 hours

- Predicted 21-cm absorption signal at z=20 ranges from $\delta T \approx 10$ to 10^3 mK, depending on the source of heating/ionization. (Alvarez, et. al 2010, Dalal & Pen 2010)

The Coma Cluster at 74 MHz

Subtract out 74 MHz emission from the Coma Cluster:
Find the power spectrum of the residuals. This gives the 21-cm signal at z=20

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THE POWER SPECTRUM

$$C(u) \simeq \left(\frac{\lambda^2}{2k_B \Omega_B} \right)^2 |V(\vec{u})|^2$$
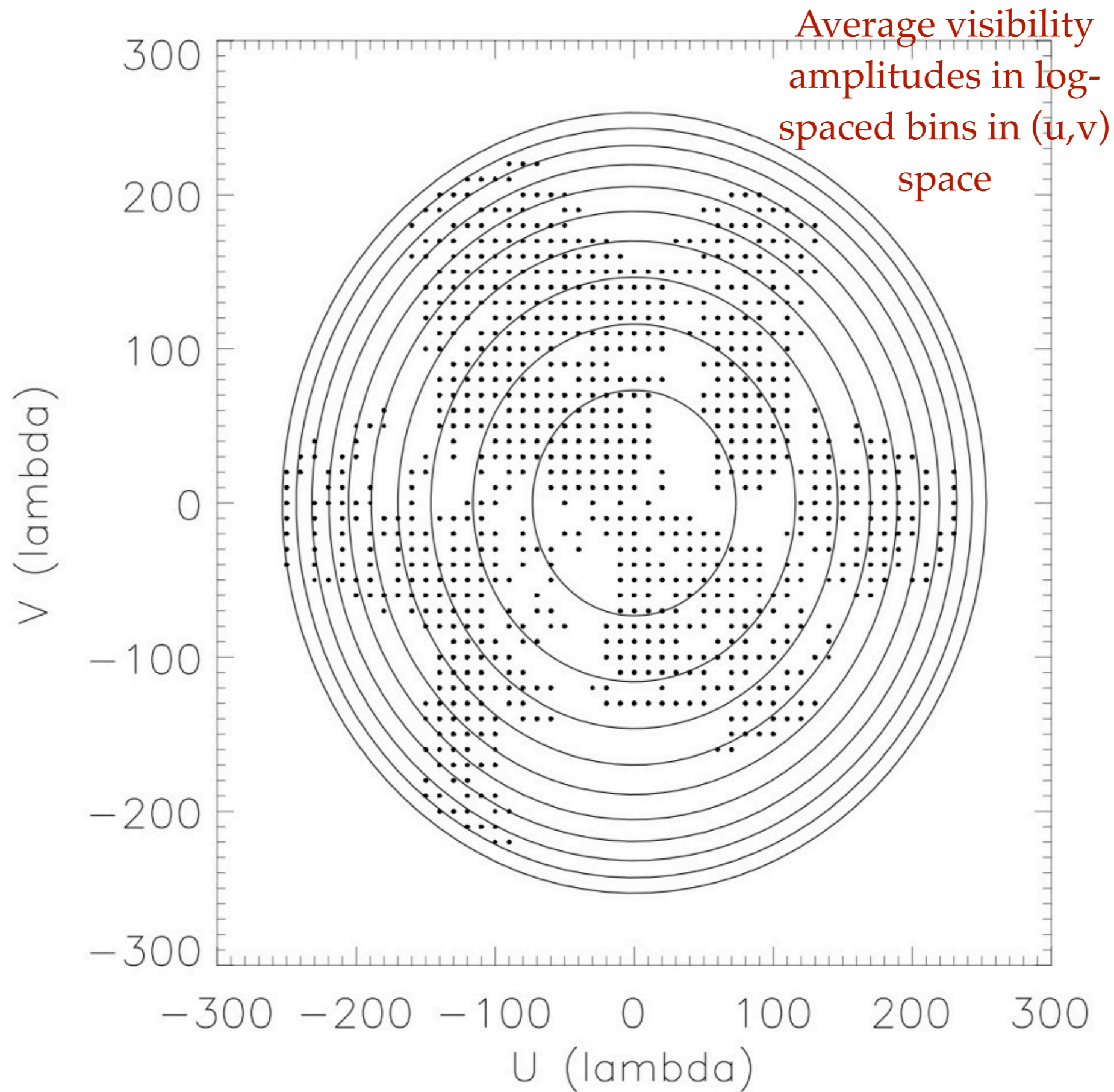
{Power spectrum in K²}   {Rayleigh-Jeans}   {visibility amplitude in Jy}
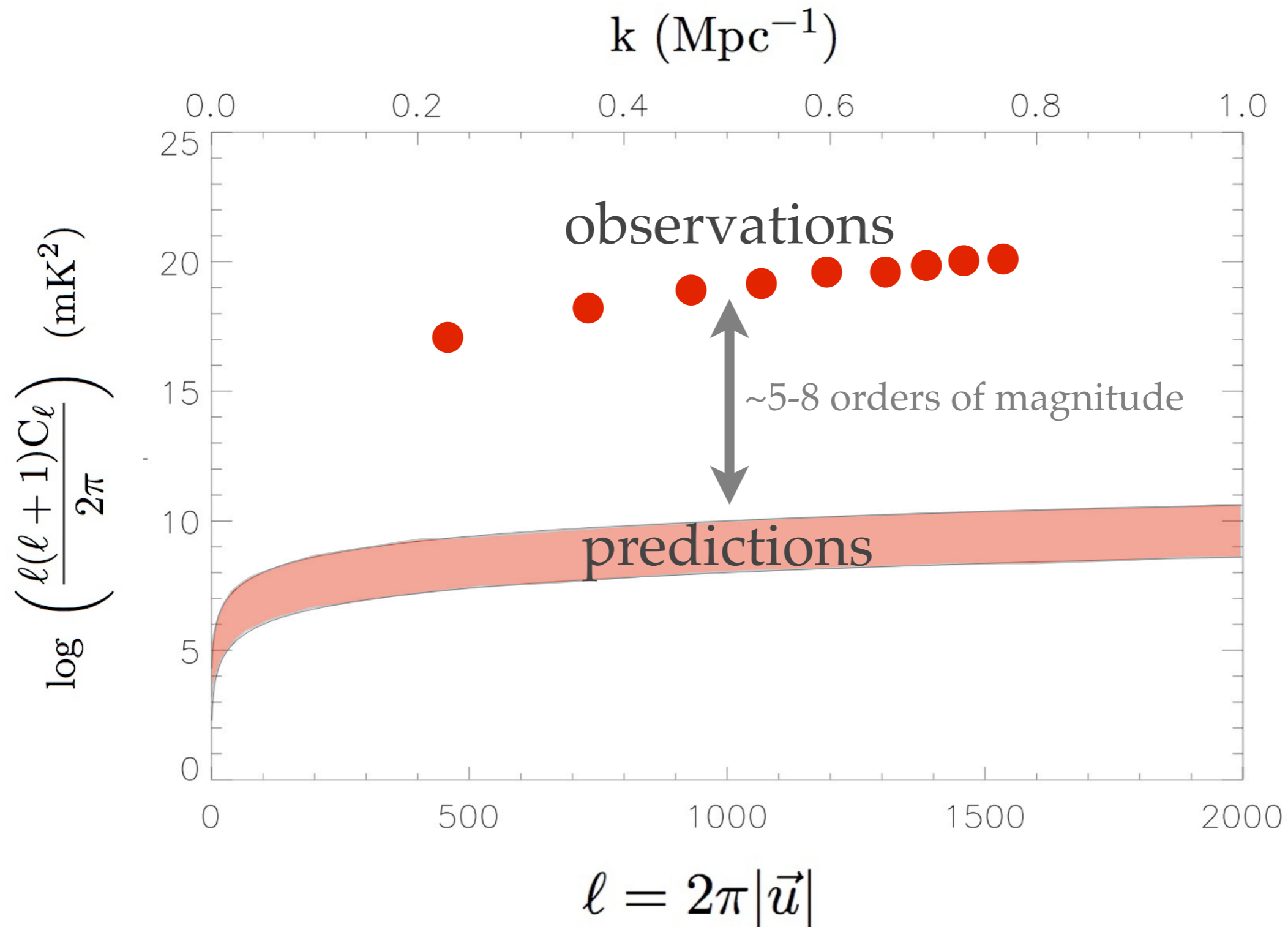
$$u = \sqrt{u^2 + v^2}$$

{position in (u,v) plane}

$$\Omega_B = \frac{\pi \theta^2}{4ln2}$$

{primary beam solid angle}

Average visibility amplitudes in log-spaced bins in (u,v) space

RESULTS

- Upper limit of order $\delta T \approx 10^6$ to 10^8 mK.

- Comparable to the constraint placed by PAPER project at z=10 (Parsons et al. 2010).

POWER SPECTRUM

FUTURE PROSPECTS

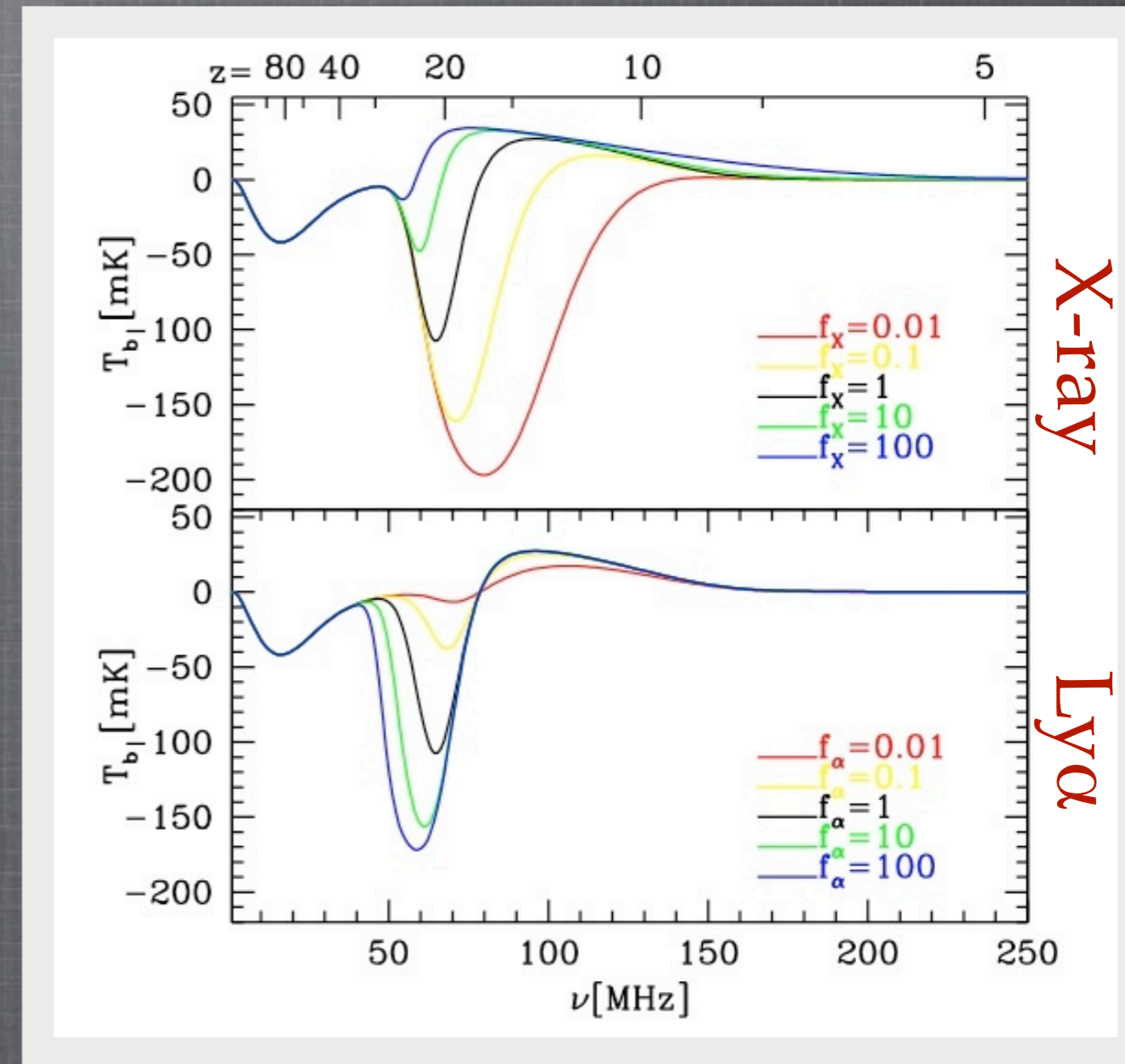This type of data can also constrain X-ray and Lyα emissivity from the first stars.

VLA: Δν=1.6 MHz: Not wide enough to constrain emissivities.

EVLA: should have Δν≈16 MHz

LWA:
Δν≈20 MHz
multiple beam pointing -> lots of observation time

(Pritchard & Loeb 2010)