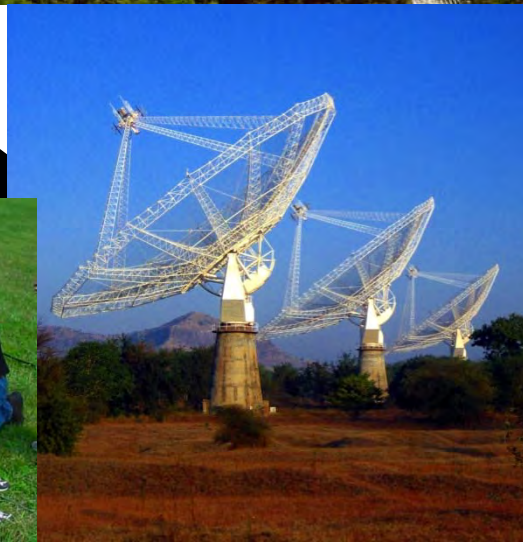
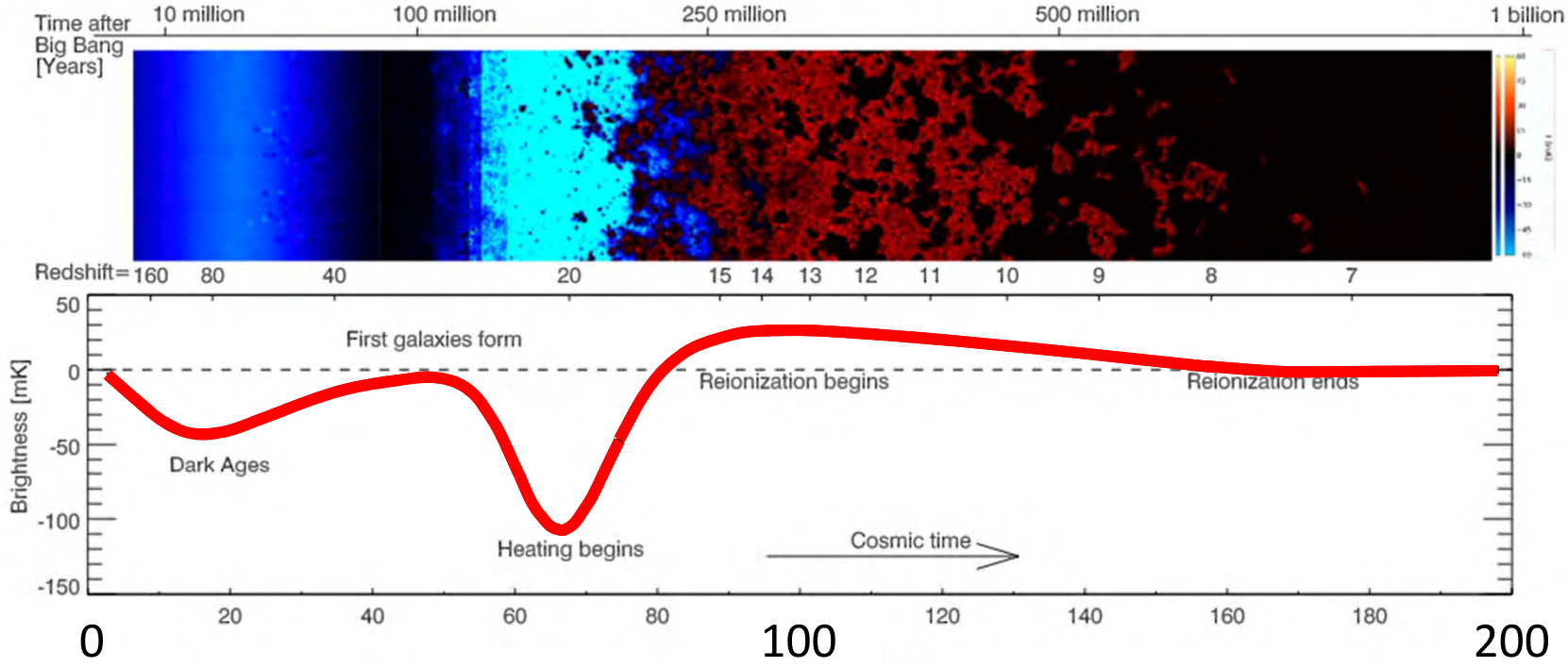
Pursuit of Primordial Hydrogen



Radio Spectrum from 0 – 200 MHz:

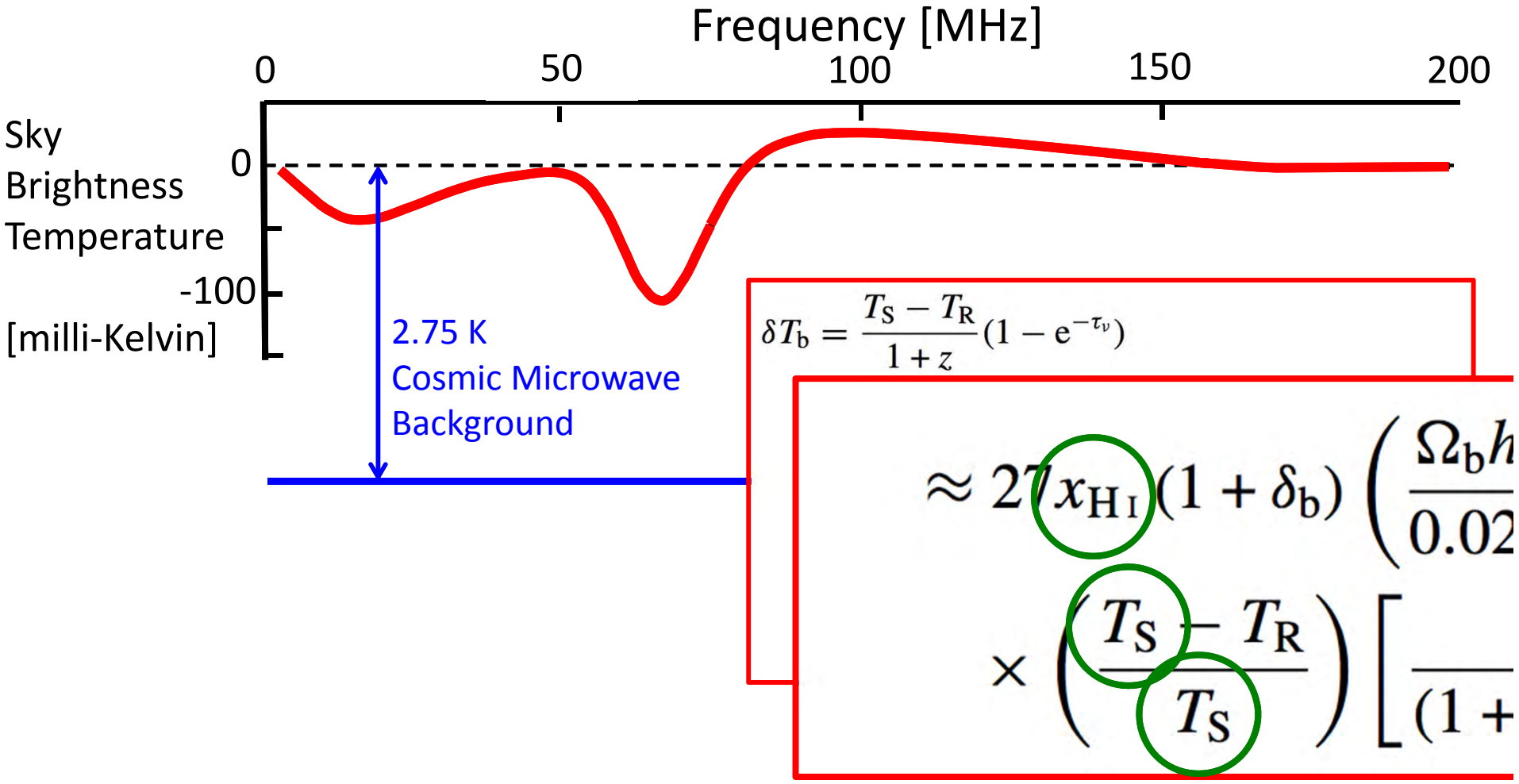
absorption & emission in 21cm line



* Cautionary Note *

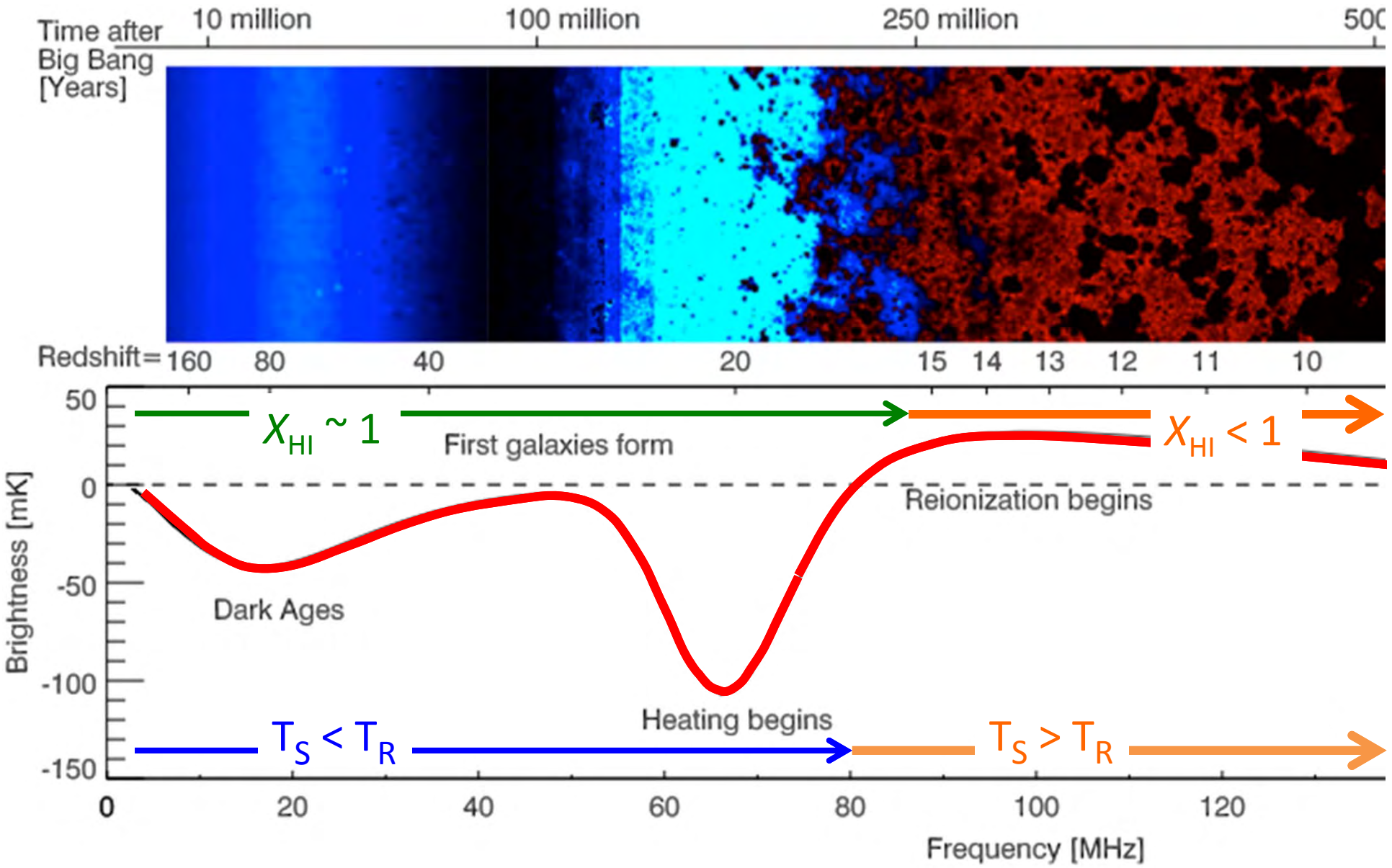
Radio Spectrum from 0 – 200 MHz:

absorption & emission in 21cm line



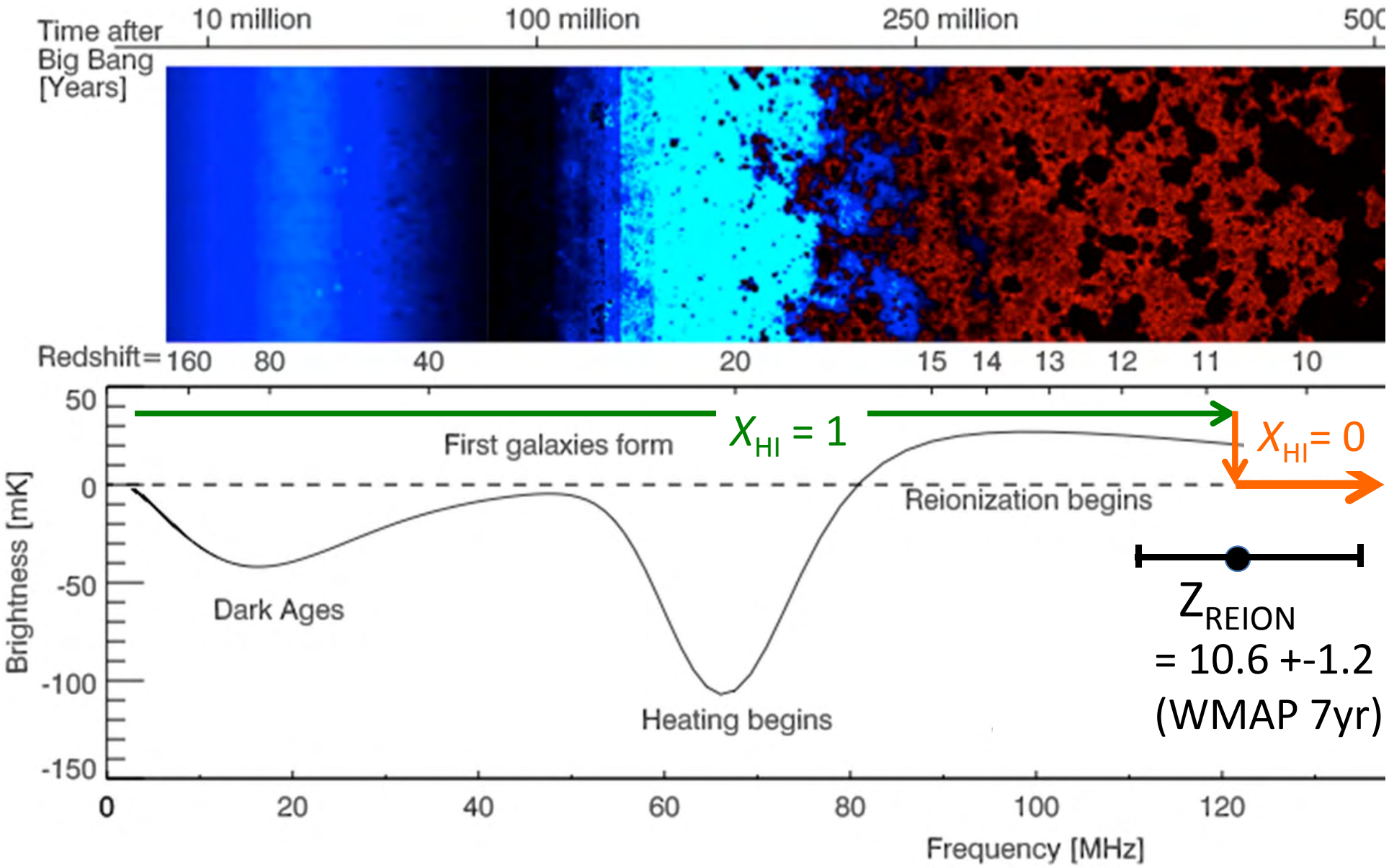
Radio Spectrum from 0 – 200 MHz:

absorption & emission in 21cm line



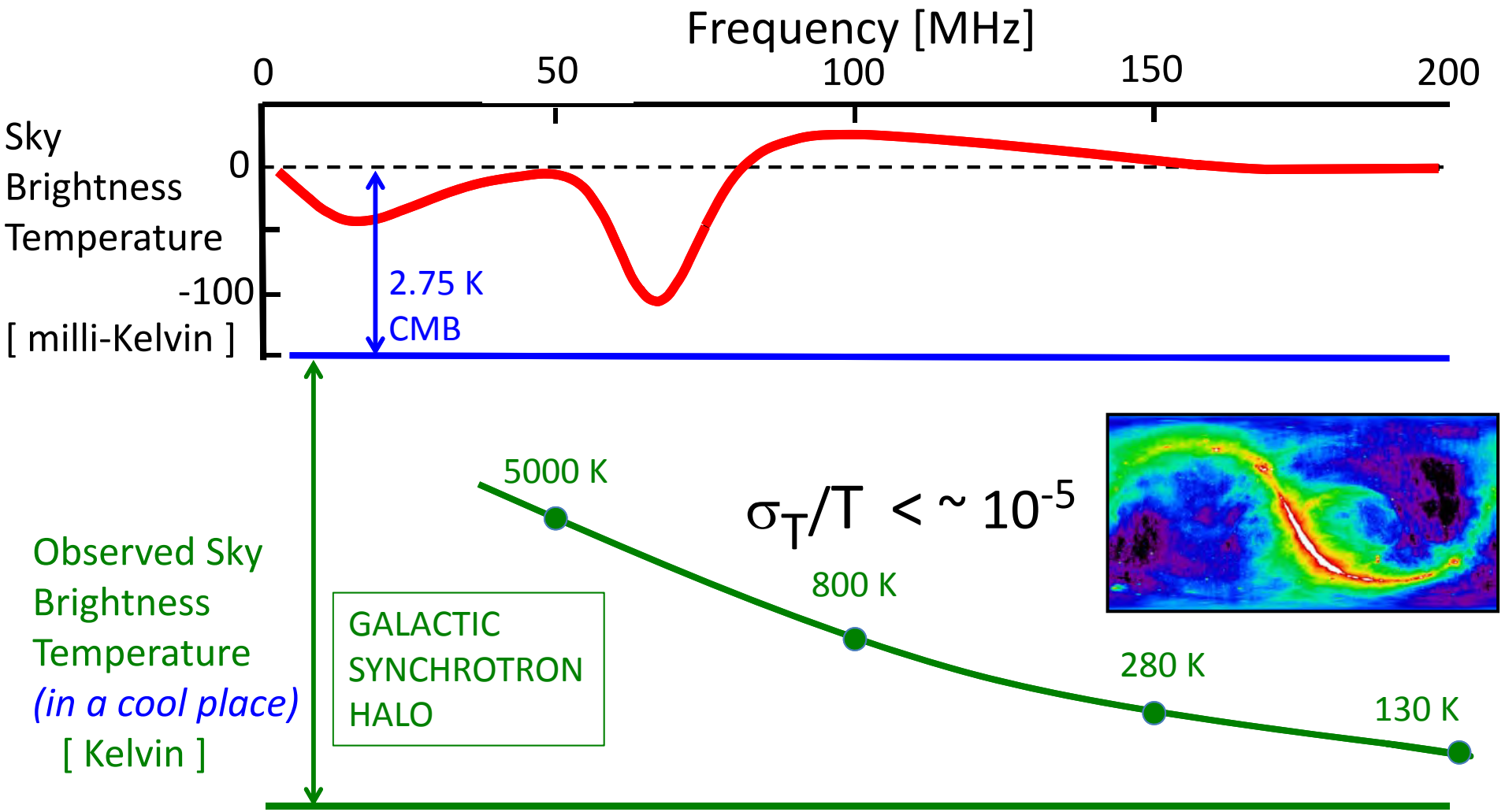
Radio Spectrum from 0 – 200 MHz:

absorption & emission in 21cm line



Radio Spectrum from 0 – 200 MHz:

Scary, Scary, Scary Experiment



Literature Trail

2000 Tozzi, P.; Madau, P.; Meiksin, A.; Rees, M. J., ApJ...528..597
Radio Signatures of H I at High Redshift: Mapping the End of the ``Dark Ages''

1997 Madau, **Meiksin**, **Rees**, ApJ...475..429
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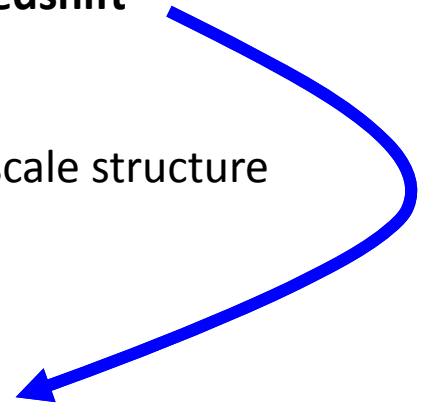
Spectral appearance of non-uniform gas at high Z



1999 Shaver, Windhorst, Madau, de Bruyn, Astron. Ap. 345, 380–390
Can the reionization epoch be detected as a global signature in the cosmic background?

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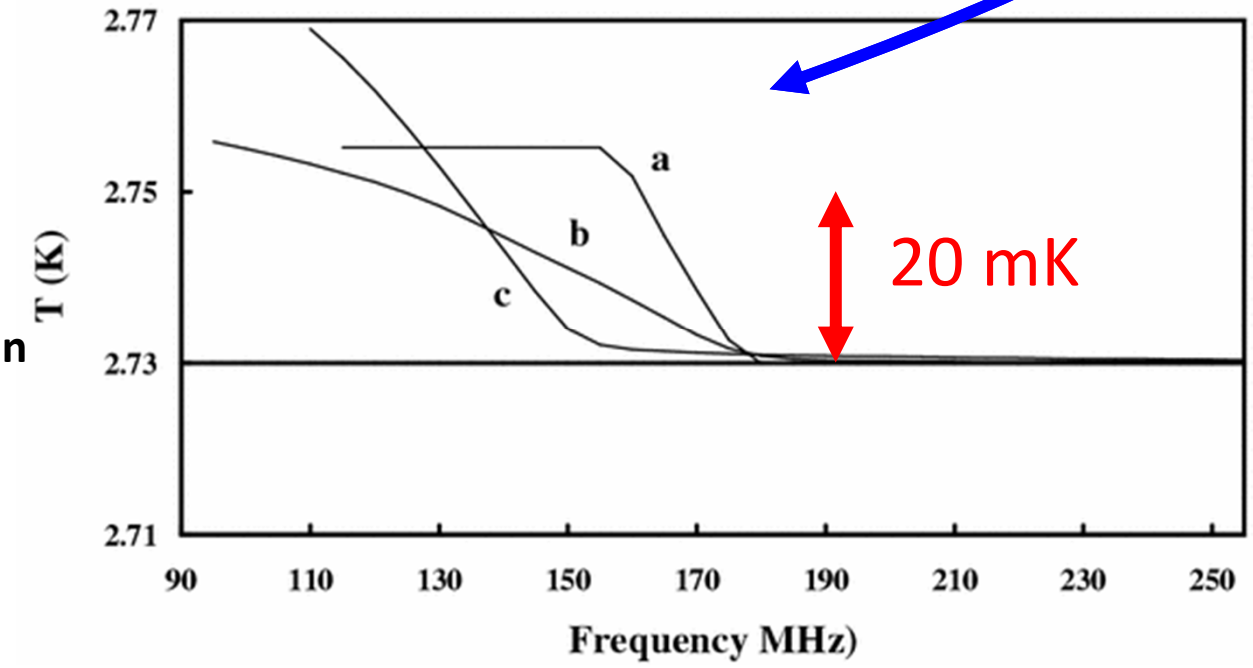

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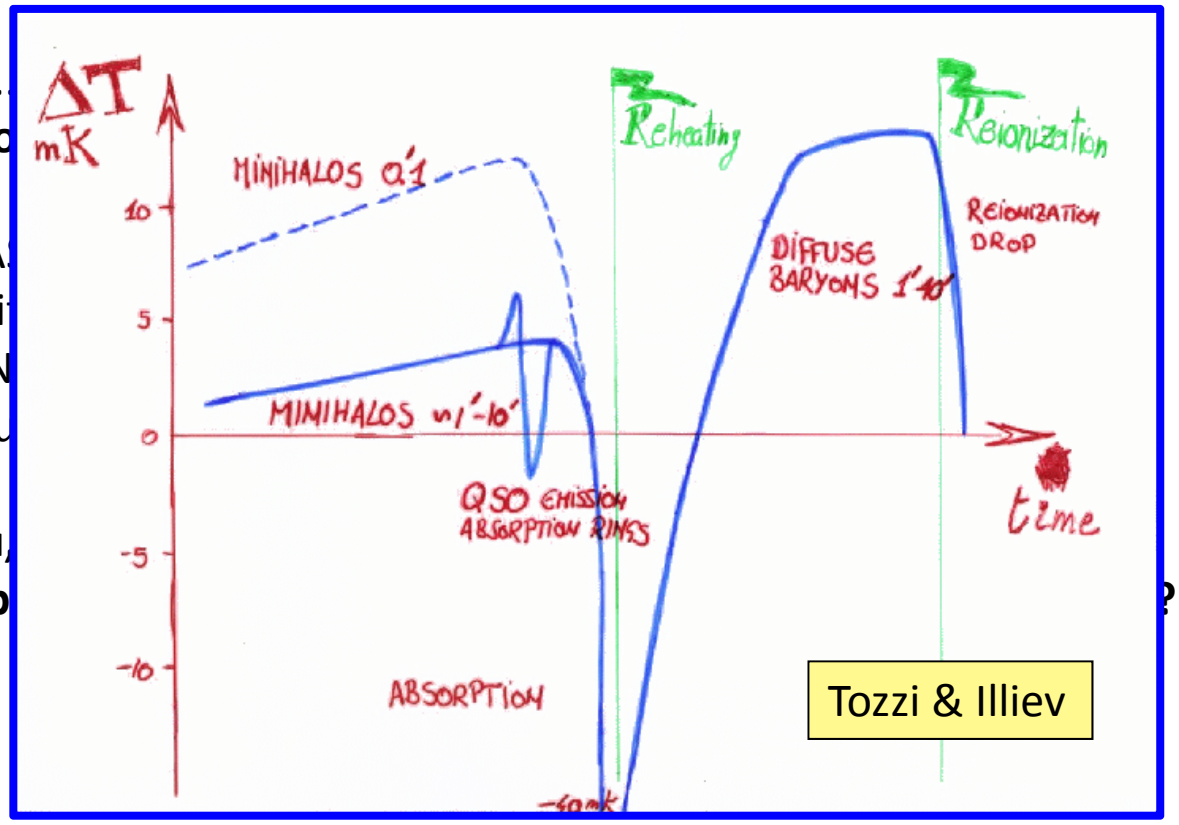
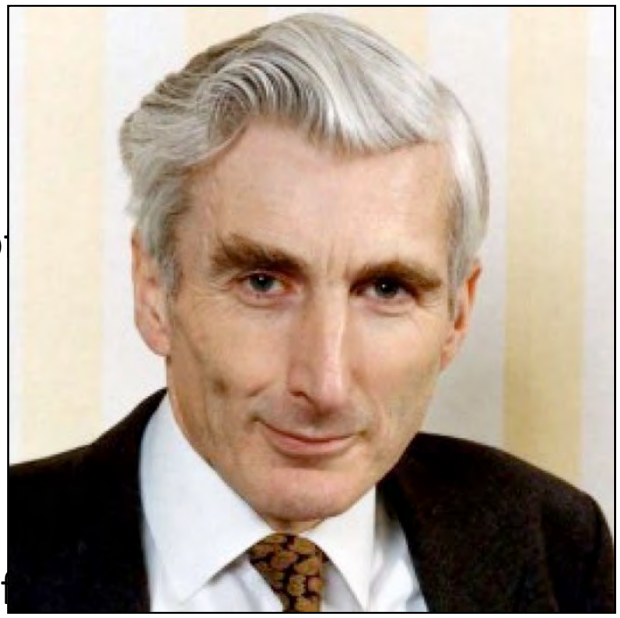


Literature Trail



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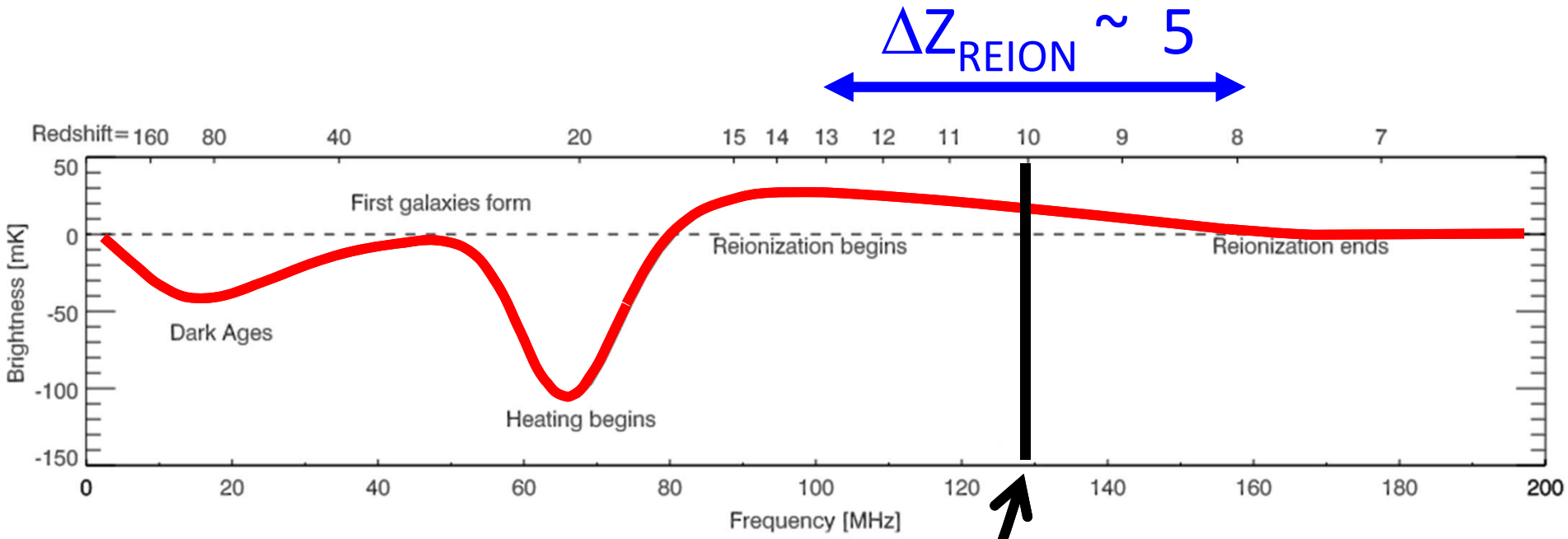
Spectral appearance of non-uniform gas at high Z

- "Dark Age"
- $\Delta Z_{REION} > \sim 1$

Radio Spectrum from 0 – 200 MHz:



Current Global HI 21cmLine State of the Art:

A lower limit of $\Delta z > 0.06$ for the duration of the reionization epoch,

Judd D. Bowman & Alan E. E. Rogers,

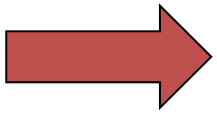
796 | NATURE | VOL 468 | 9 DECEMBER 2010

Integration times ?

bw = 1 MHz

Tsys = Tsky = 250 K

$\Delta T = 2\ mK = 800/\sqrt{(1\ MHz \times 2\ \tau)}$



$\tau = 20$ hours

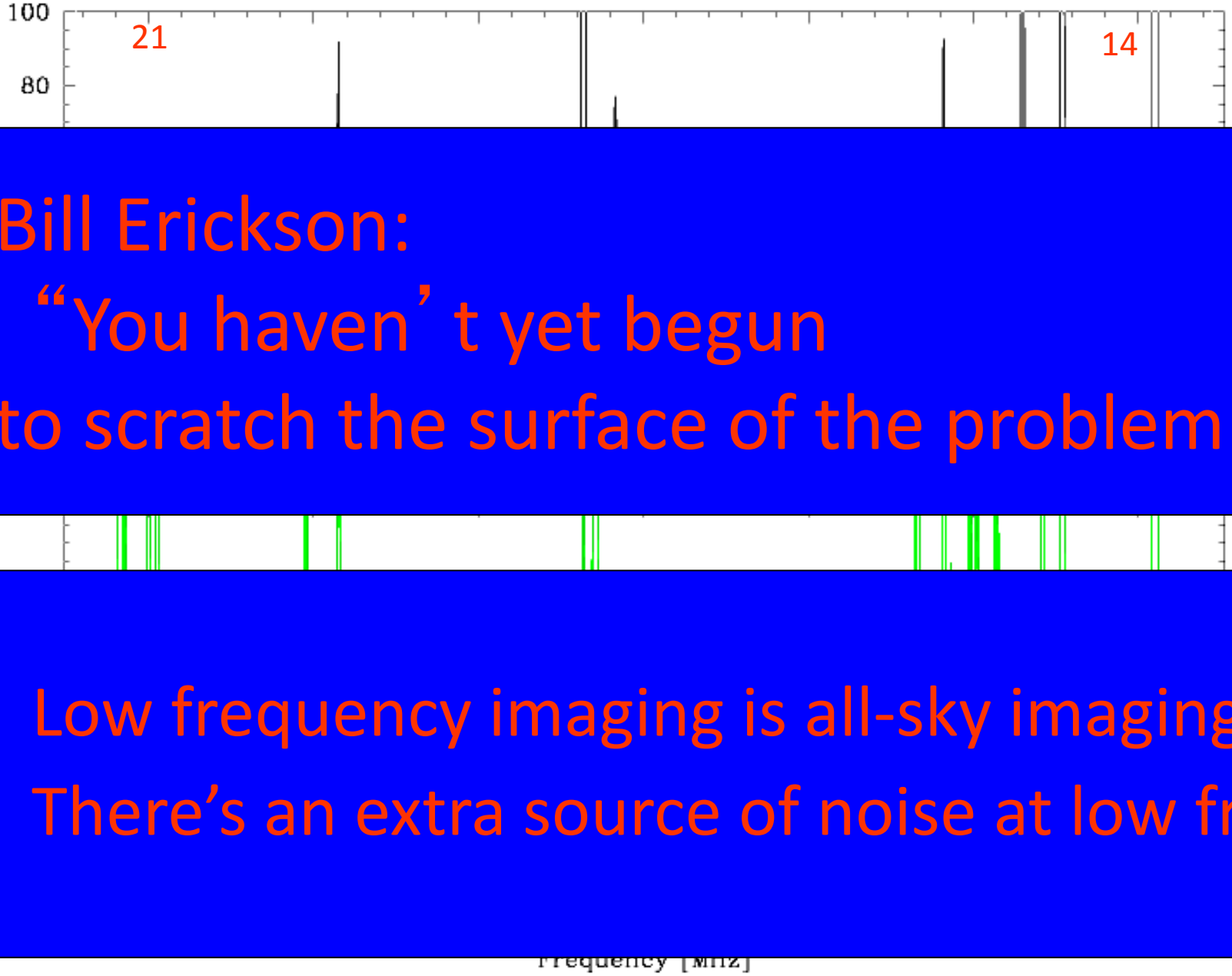
“The Z=20 Expt”

JR, FB, et al

74 MHz feed

“The Z=20 Expt”

“The Z=20 Expt”: I.



Bill Erickson:
“You haven’t yet begun
to scratch the surface of the problem”

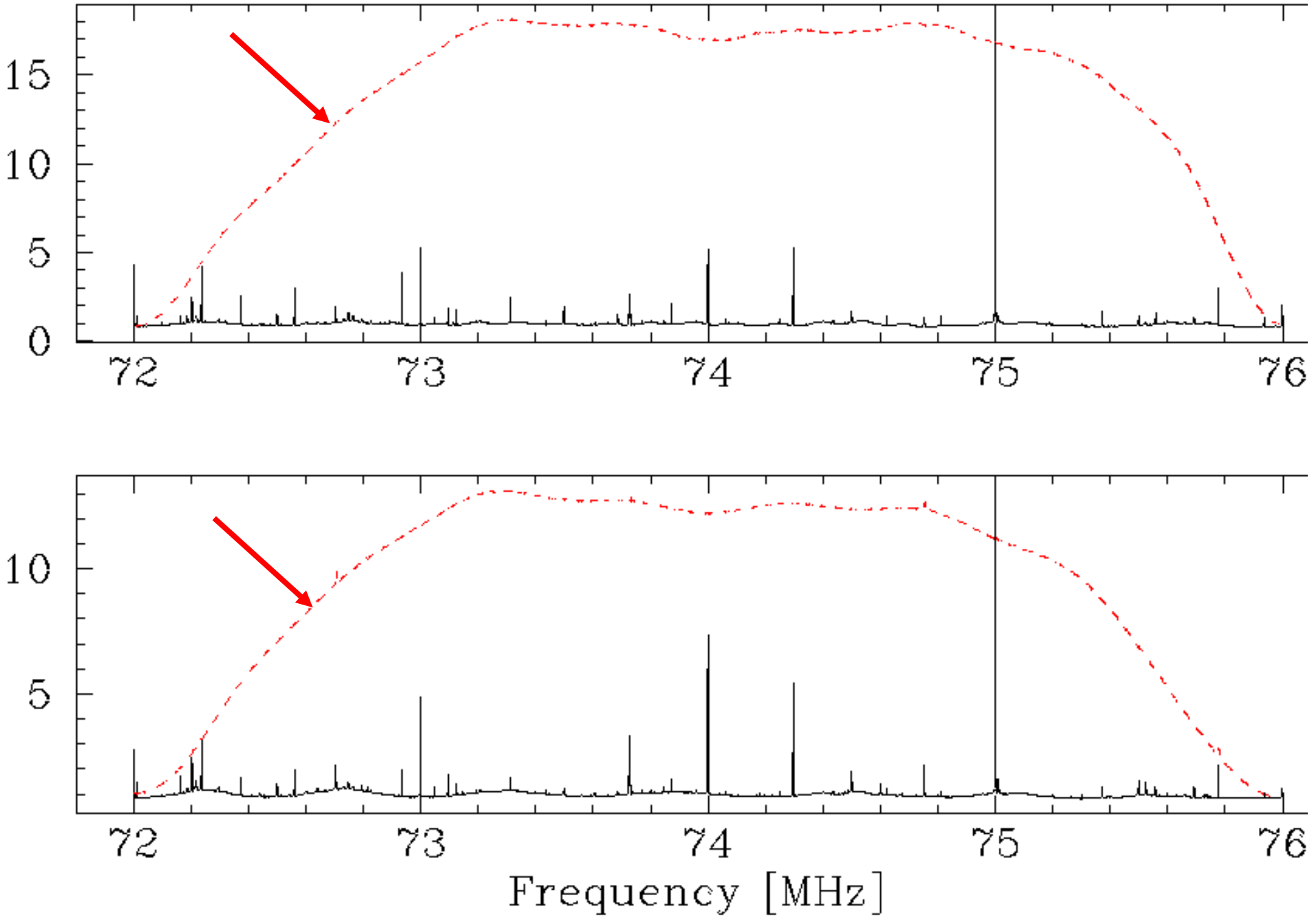
- Low frequency imaging is all-sky imaging
- There’s an extra source of noise at low freq…

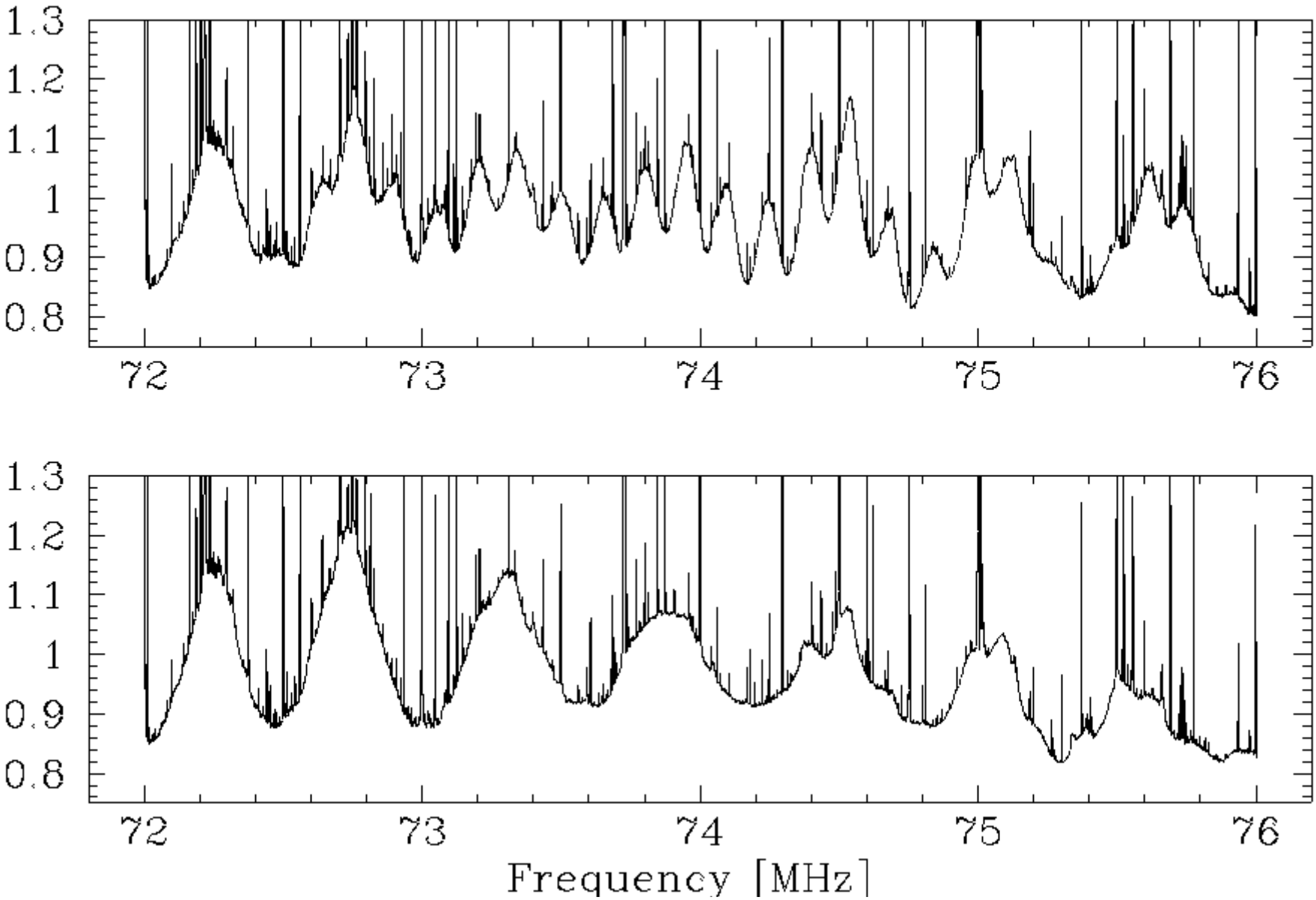
“The Z=20 Expt”: II.

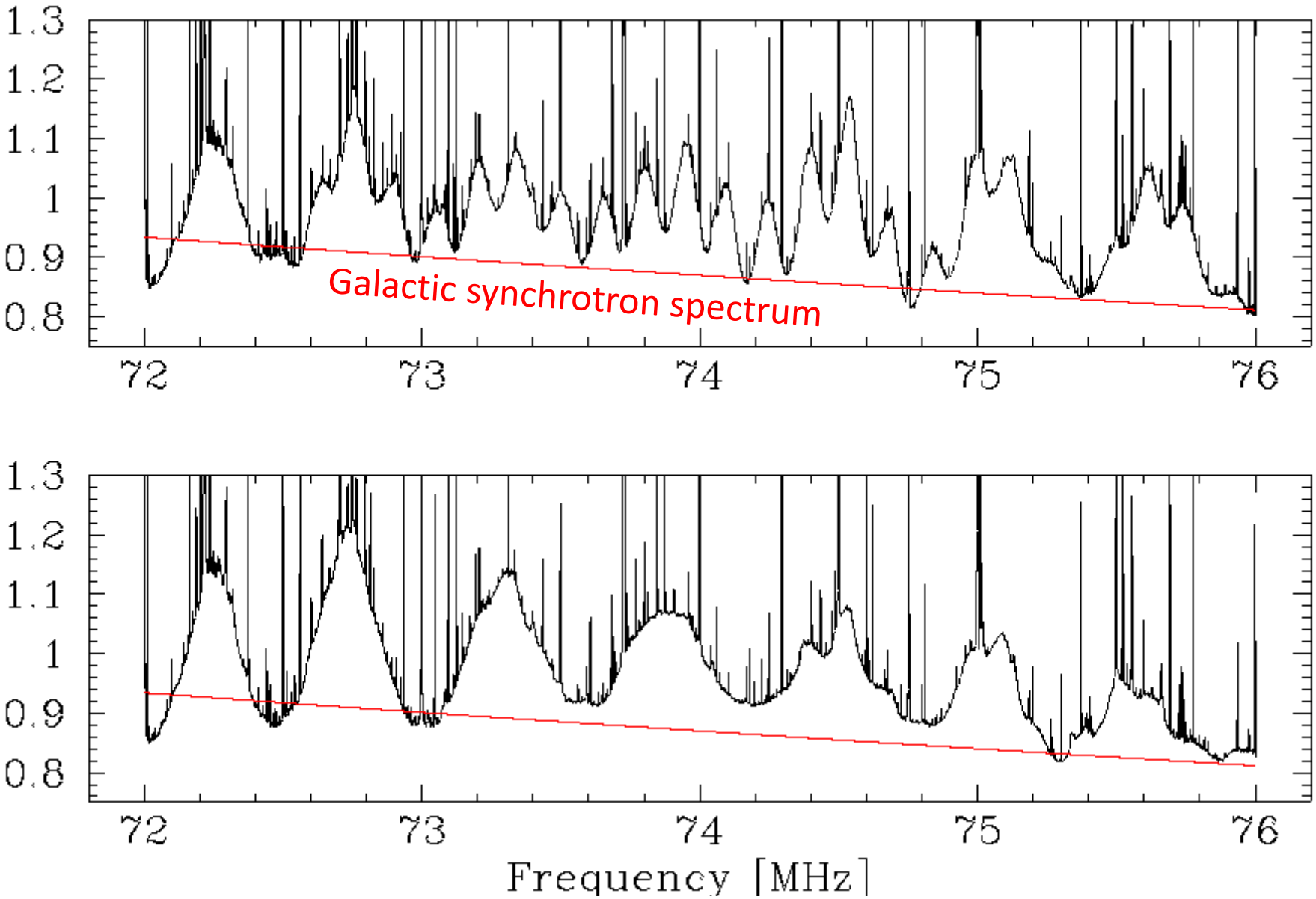
4 MHz bandwidths

8192 channels per polarisation

Passband filters (from load scan) and RFI (from sky scan)

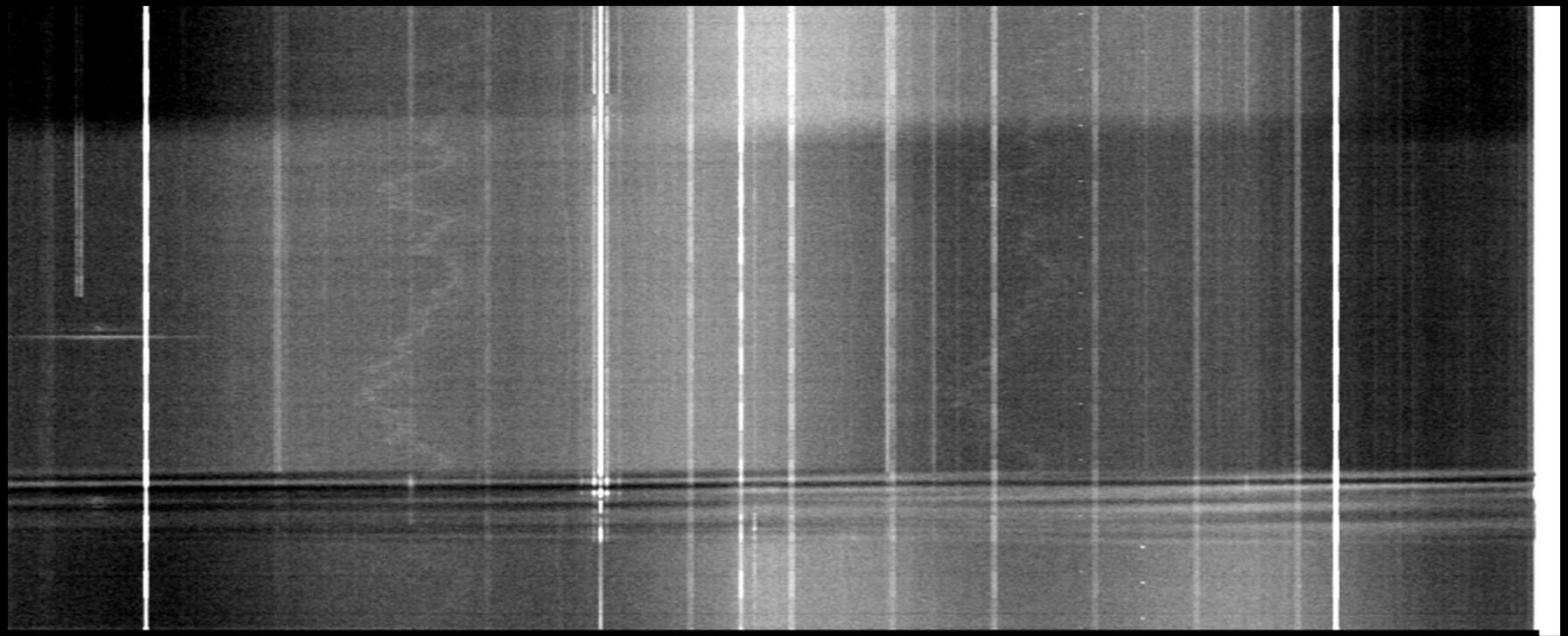



1.3
1.2
1.1
1
0.9
0.8
72
73
74
75
76
1.3
1.2
1.1
1
0.9
0.8
72
73
74
75
76
Frequency [MHz]


1.3
1.2
1.1
1
0.9
0.8
72
73
74
75
76
Galactic synchrotron spectrum
1.3
1.2
1.1
1
0.9
0.8
72
73
74
75
76
Frequency [MHz]

50 minutes

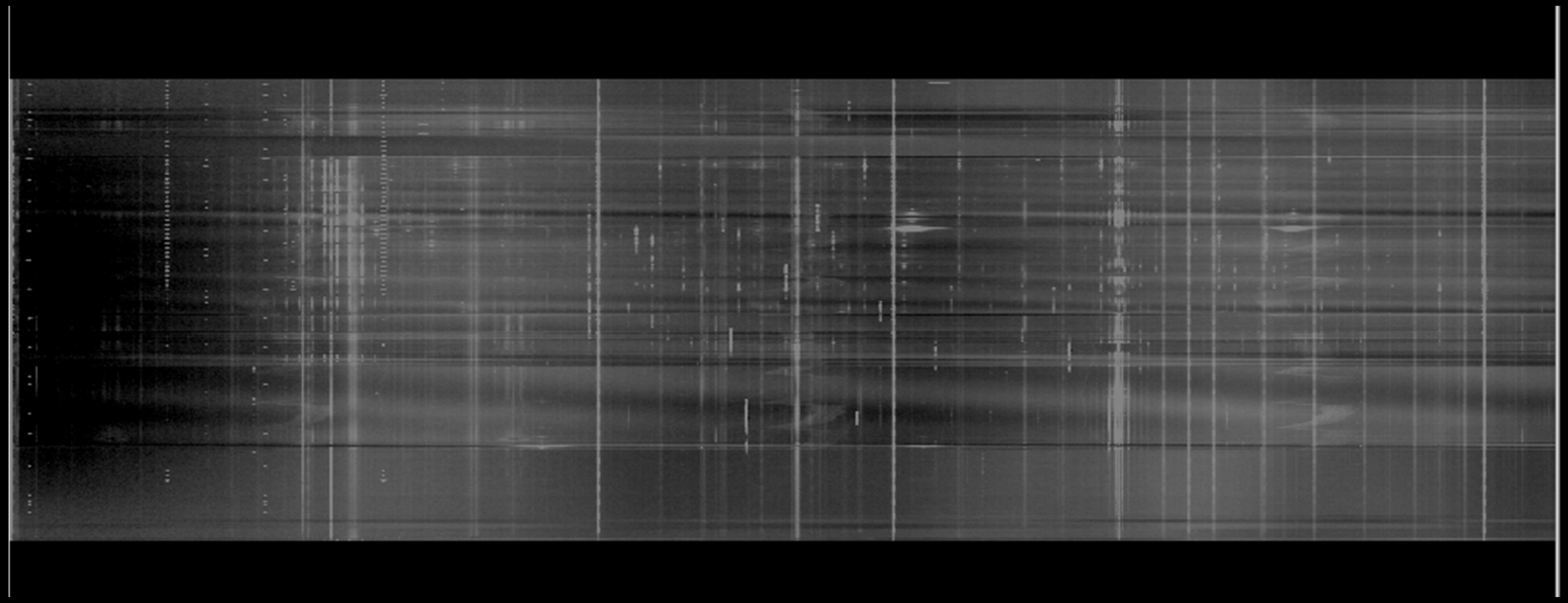
Full Resolution: 5 sec, 1 KHz



72.5 MHz

73 MHz

17 Hours (1 scan in 20)



72 MHz

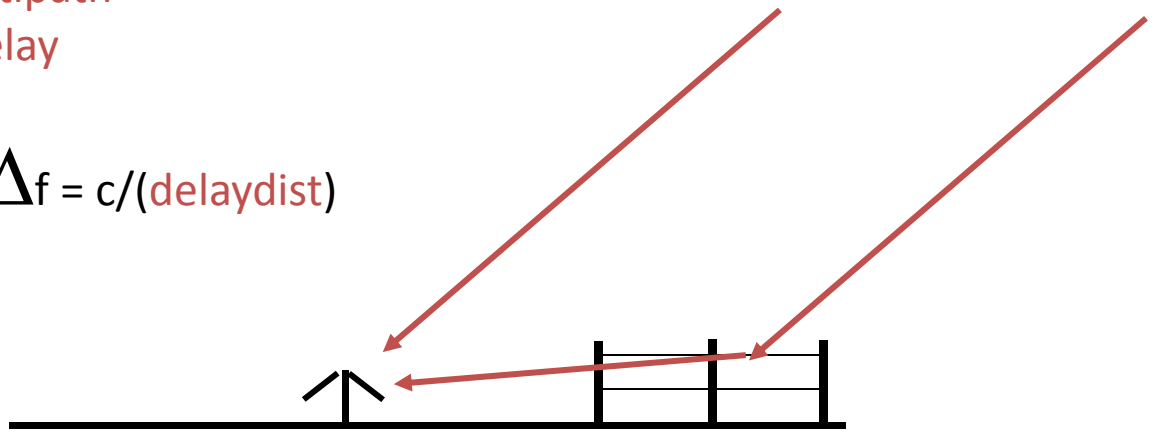
73 MHz

"You've begun to scratch the surface of the problem"

Scattered radiation – Multipath and Cable Impedance Mismatch

multipath + delay

$\Delta f = c/(\text{delaydist})$



Small, simple…

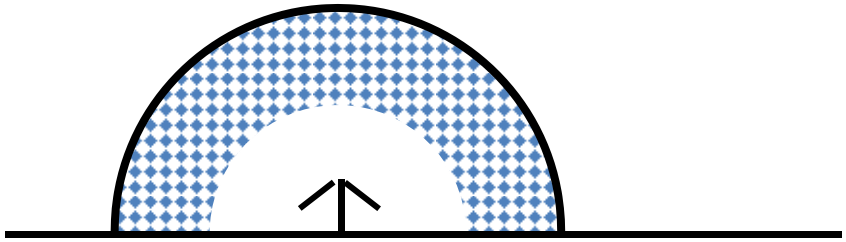
< 1m dipole… in big empty area

Small, simple…

Calibration ?

“Thermal Igloo”

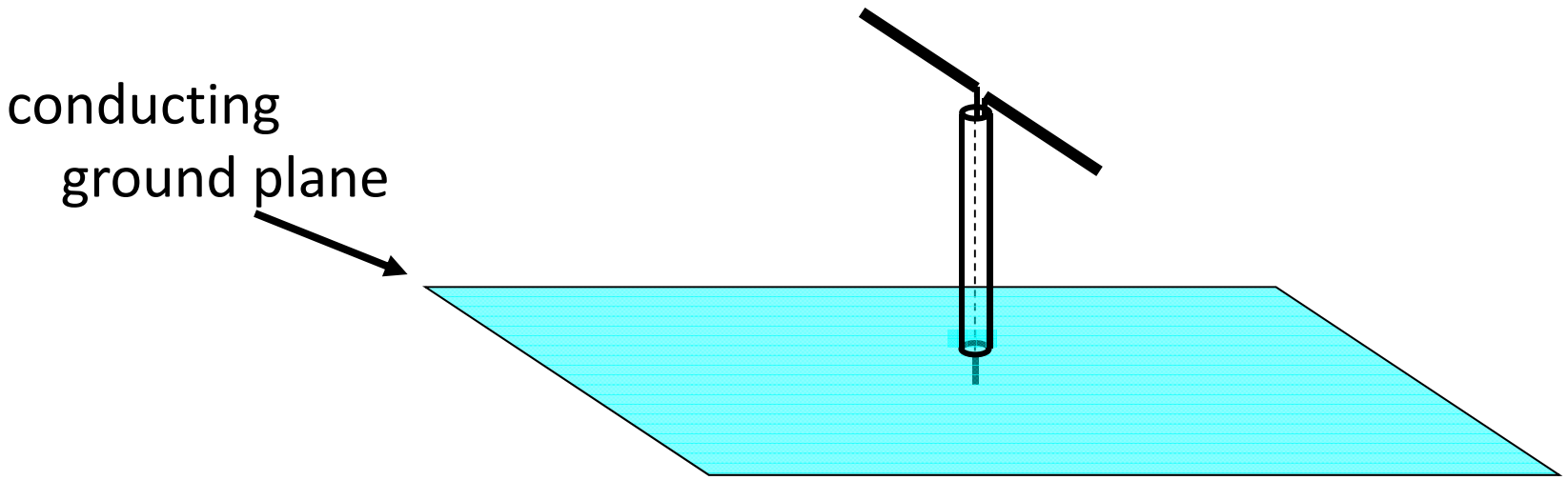
- made of absorbing foam



⇒ ~300 K

Spectrally smooth artificial sky

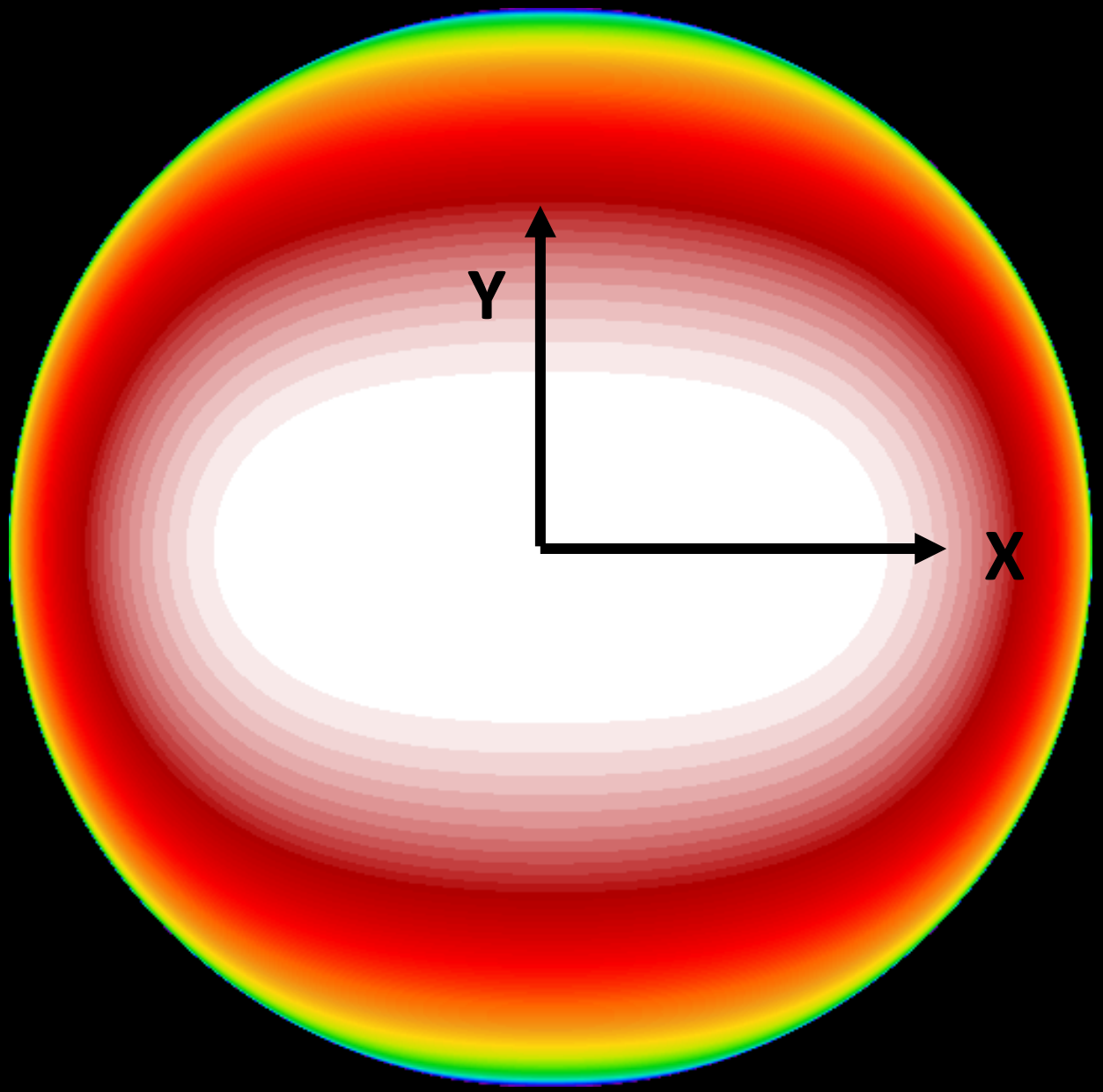
Dipole + ground plane

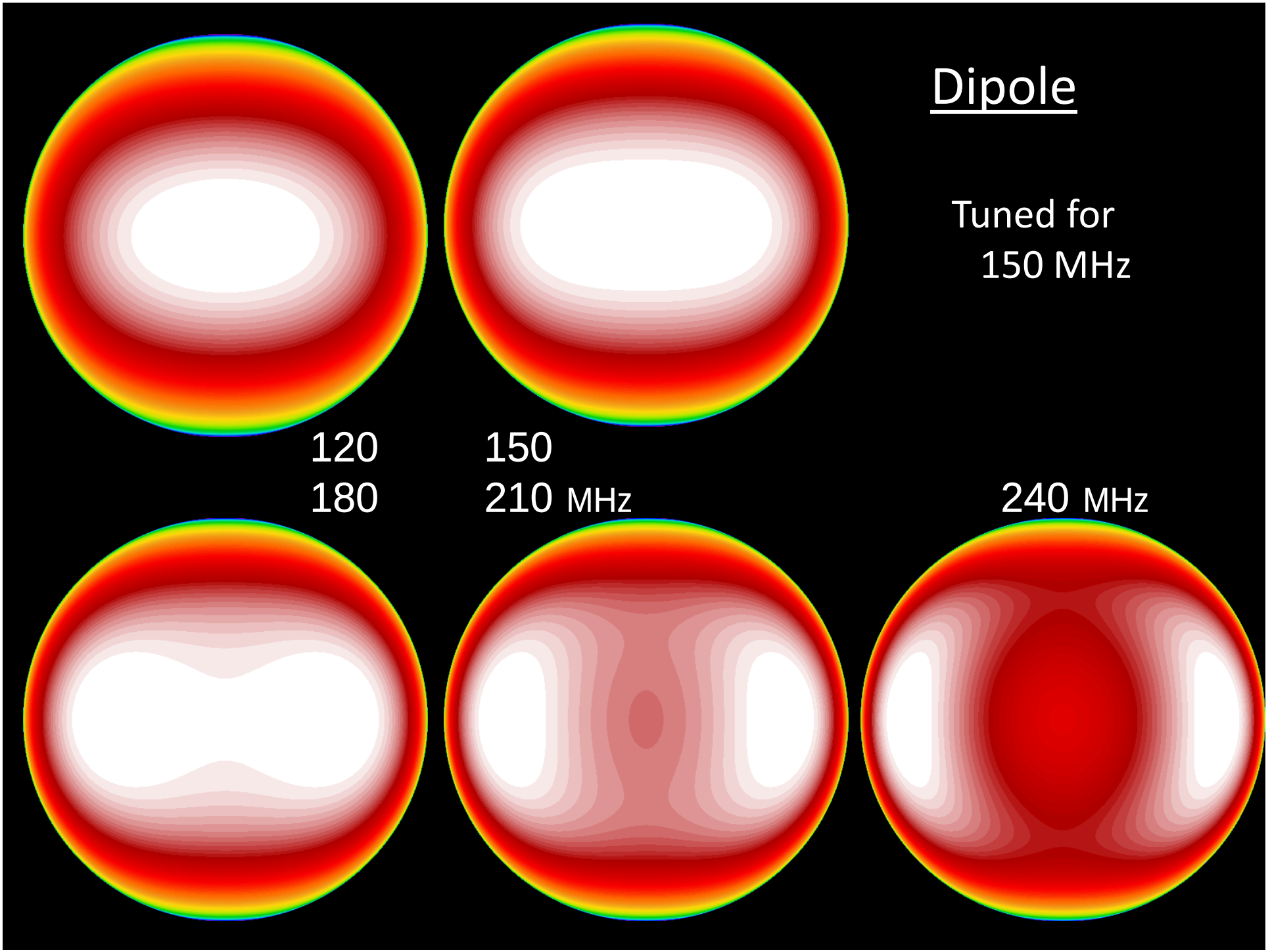


Dipole

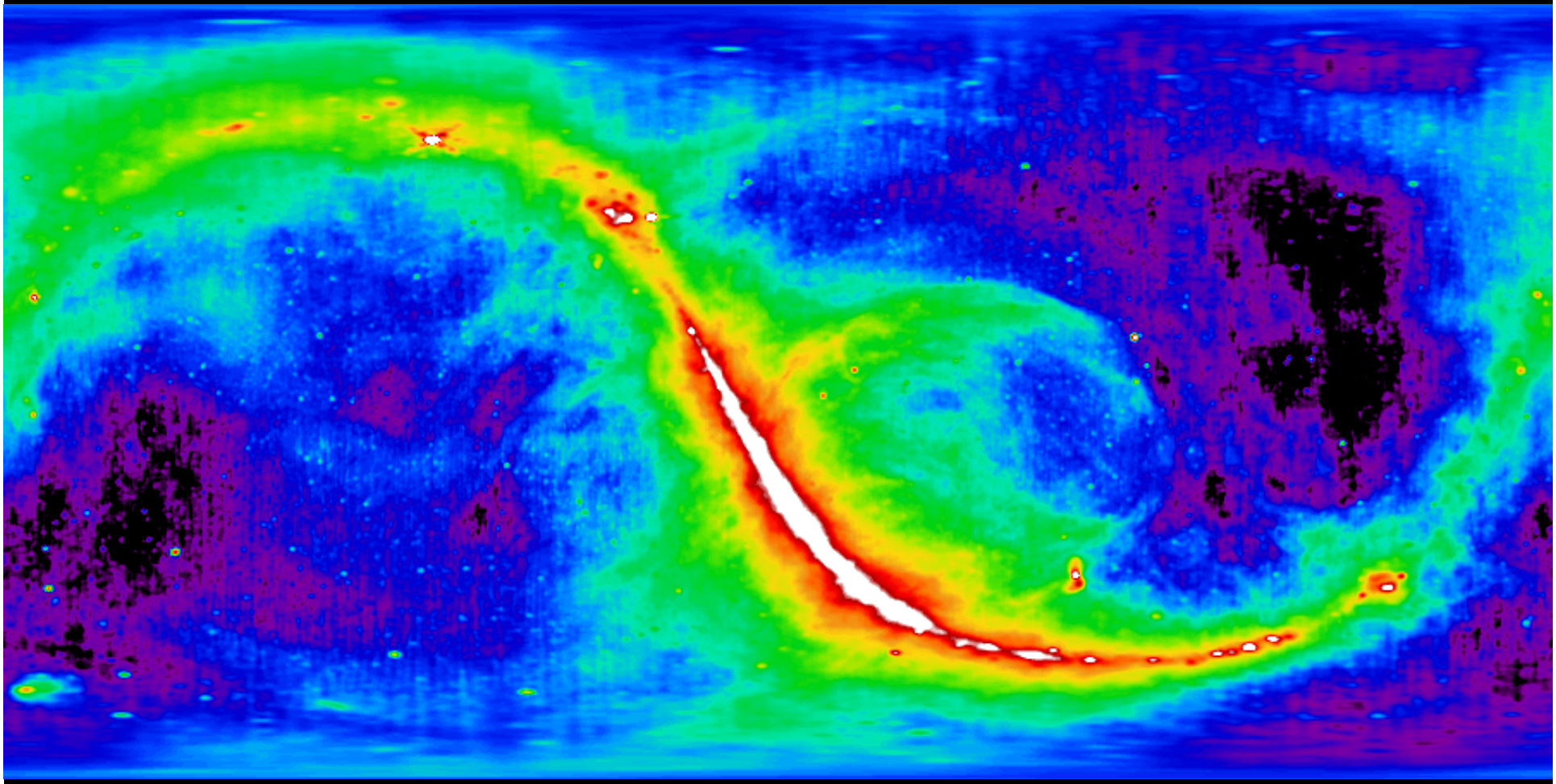
over ground plane

Tuned for 150 MHz



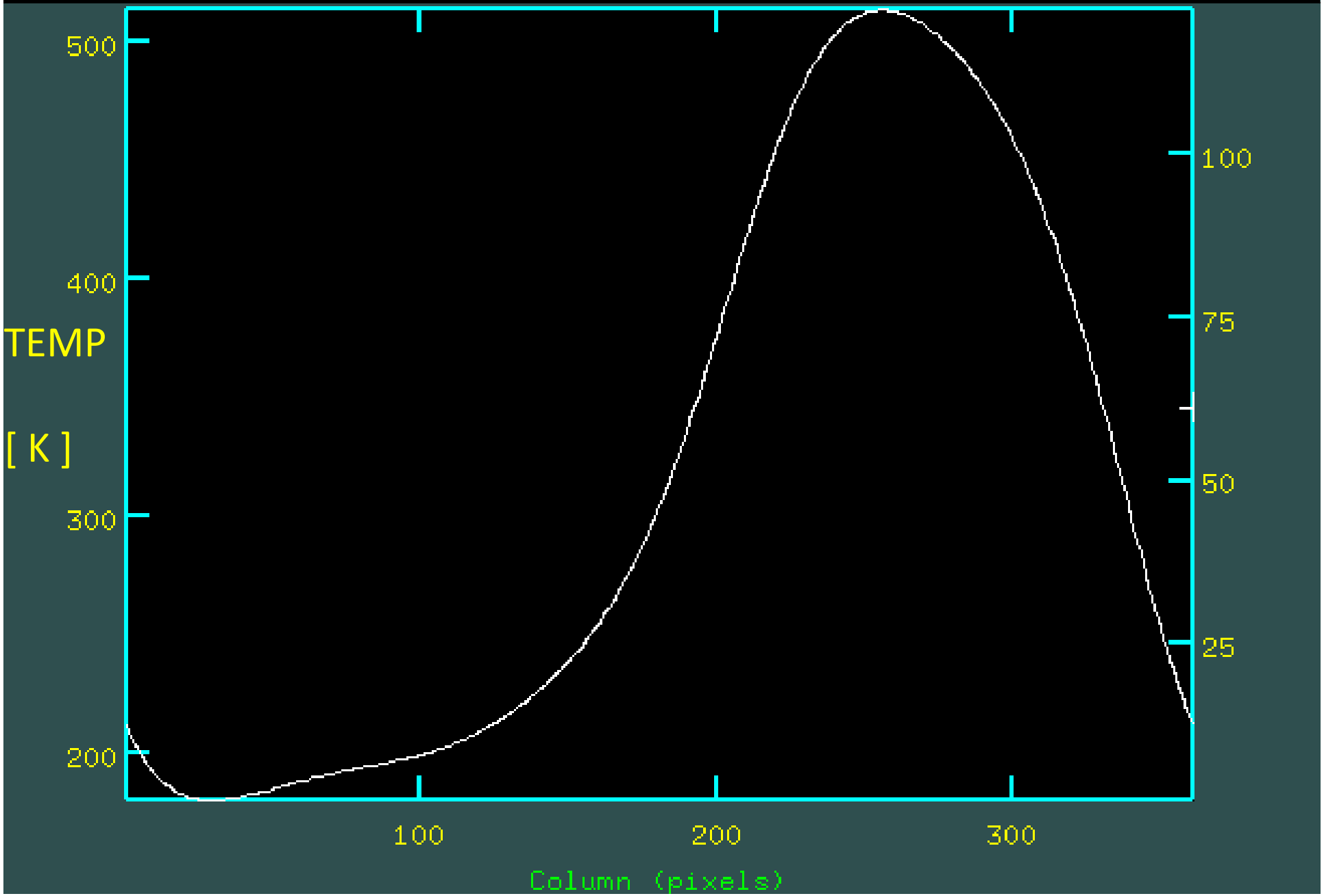

Dipole
Tuned for
150 MHz
120
150
180
210 MHz
240 MHz

Radio sky in 408 MHz continuum (Haslam et al)



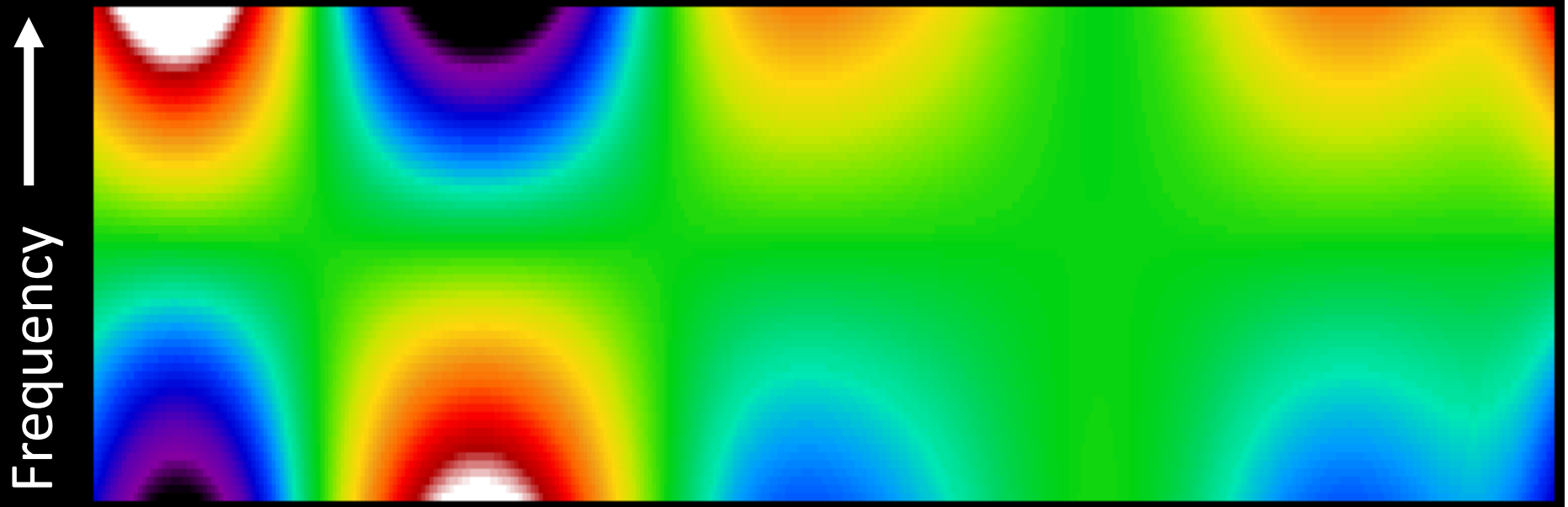
Response of dipole to sky: Frequency - Time

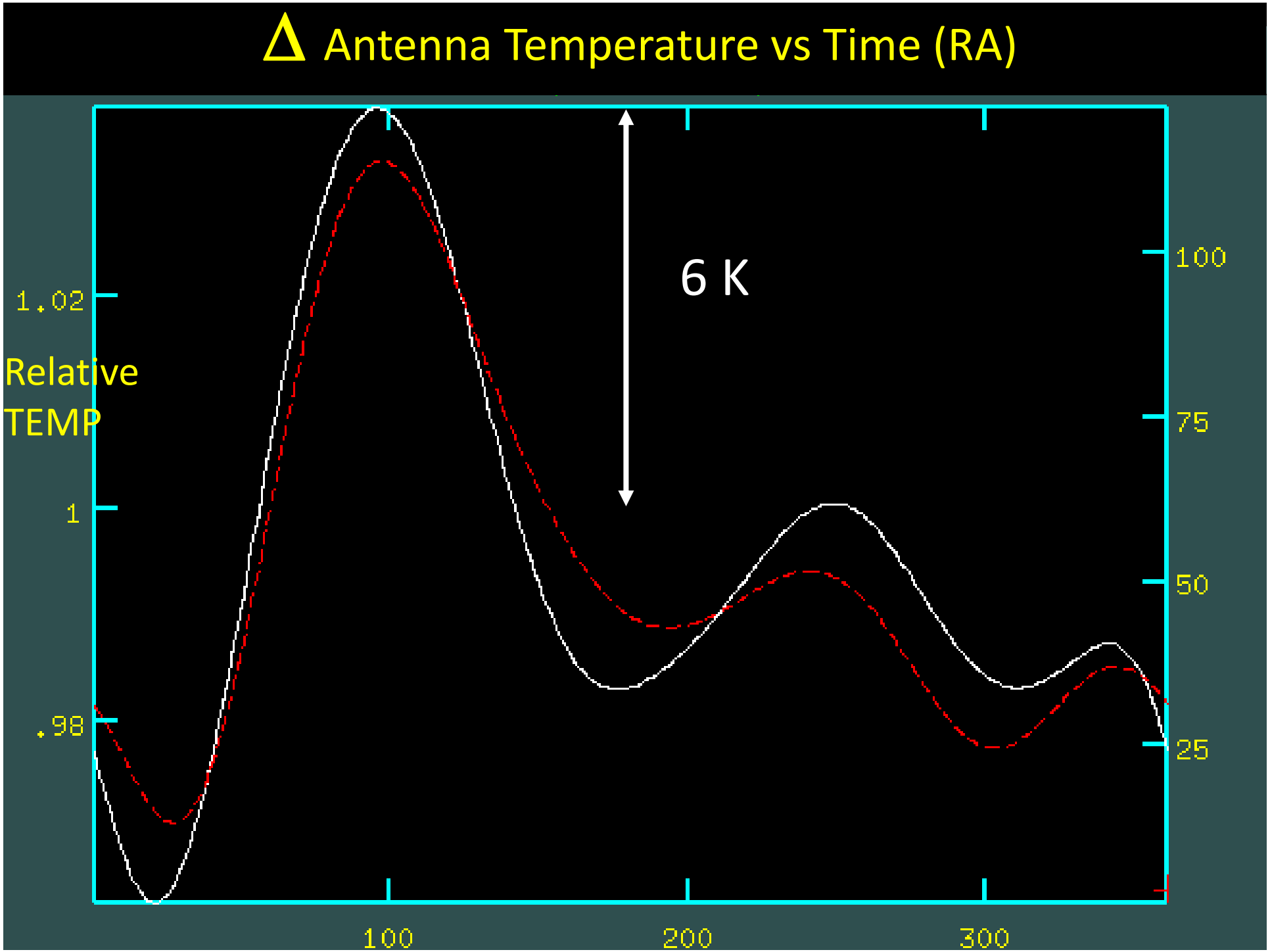
Antenna Temperature vs Time (RA)



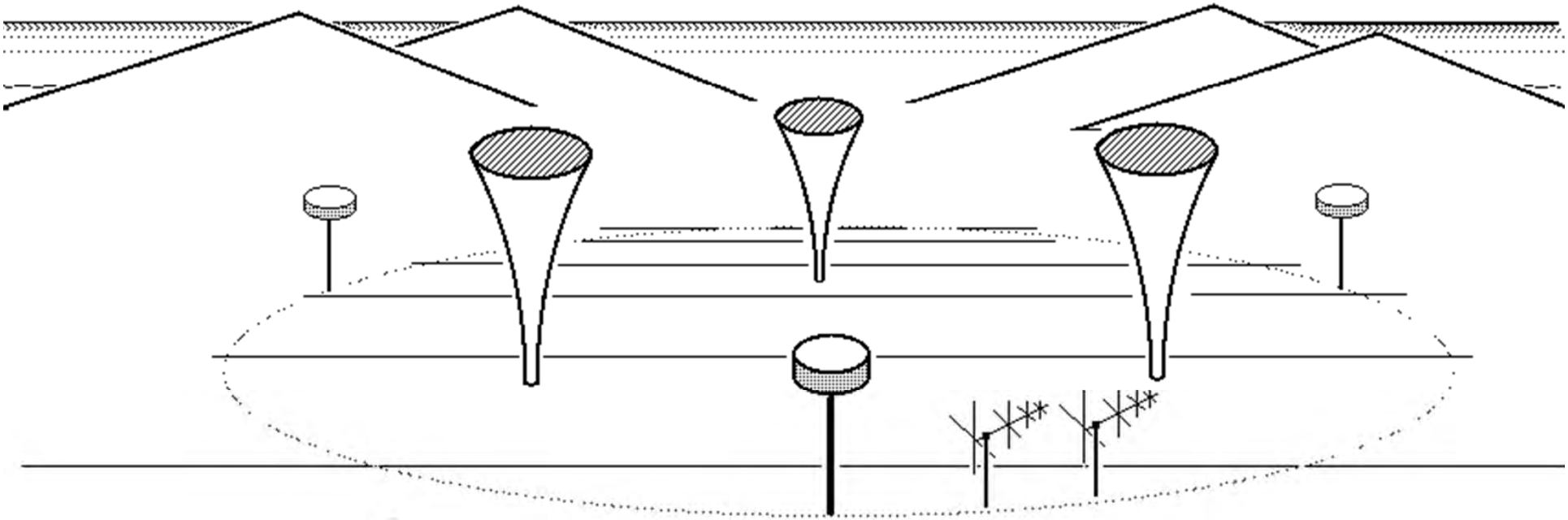
Response of dipole to sky: Frequency - Time

After "baselining" -- like crazy

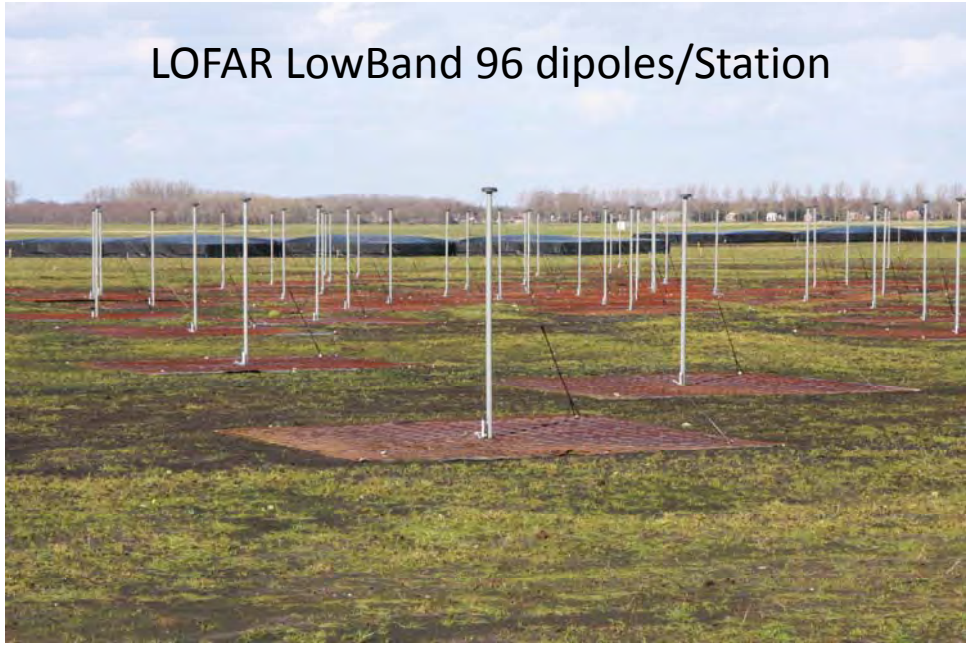


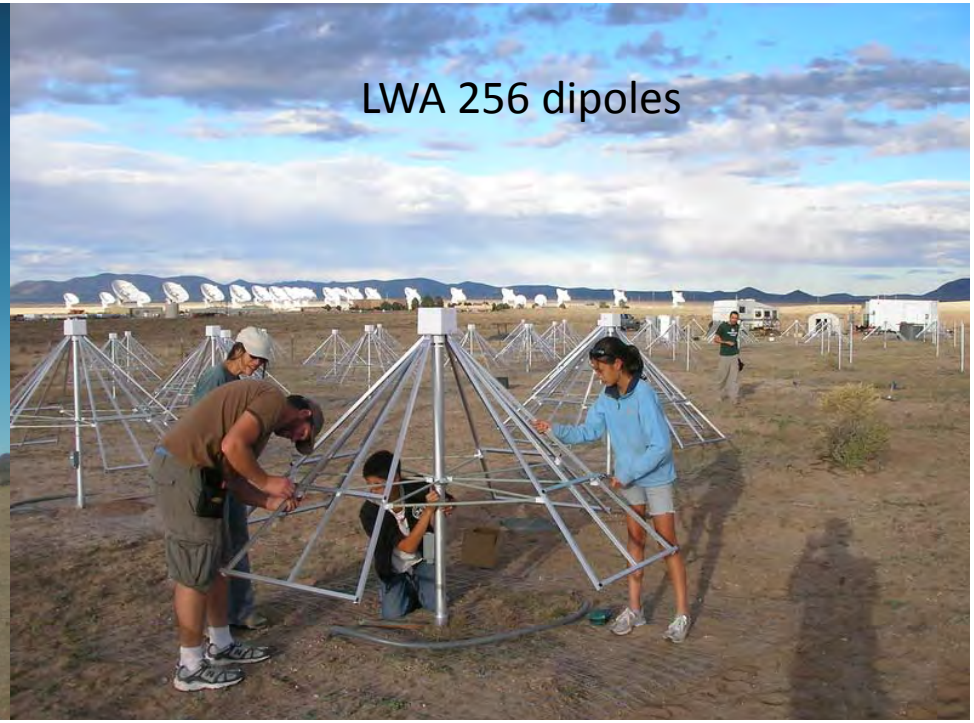

Δ Antenna Temperature vs Time (RA)
6 K
Relative
TEMP
1.02
1
.98
100
75
50
25
100
200
300

minimal array - with rfi and sun sensors



- Sparse Array of Small antennas
- Digitize at antenna
- Wide Bandwidth 100+ MHz
- Calibrate G(f) using array - use passbands on AC spectra



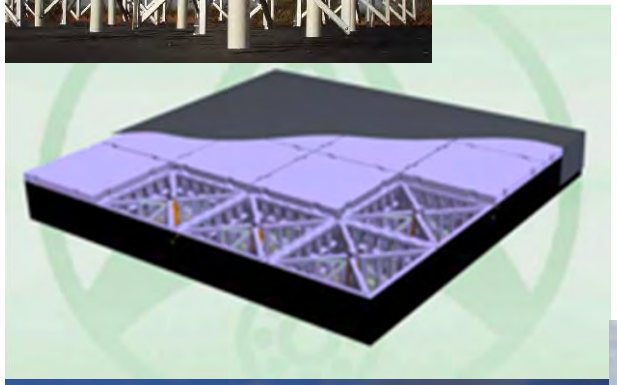


Conclusion:

We have scratched

the surface of

the problem.



Let's get on with

the show!