Detecting the global EoR signal from observations of the Moon with an extended MWA

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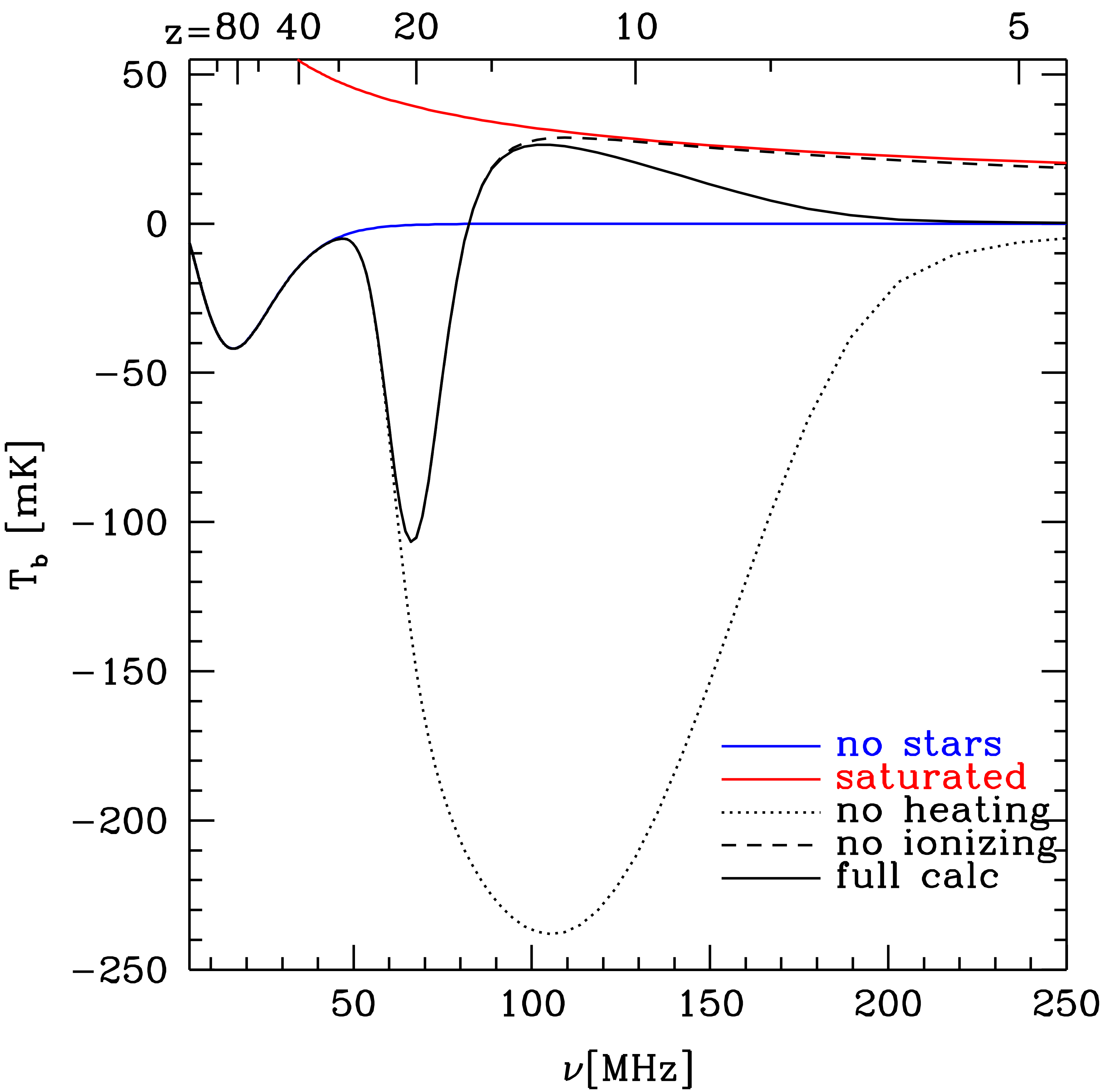
MWA MURCHISON WIDEFIELD ARRAY

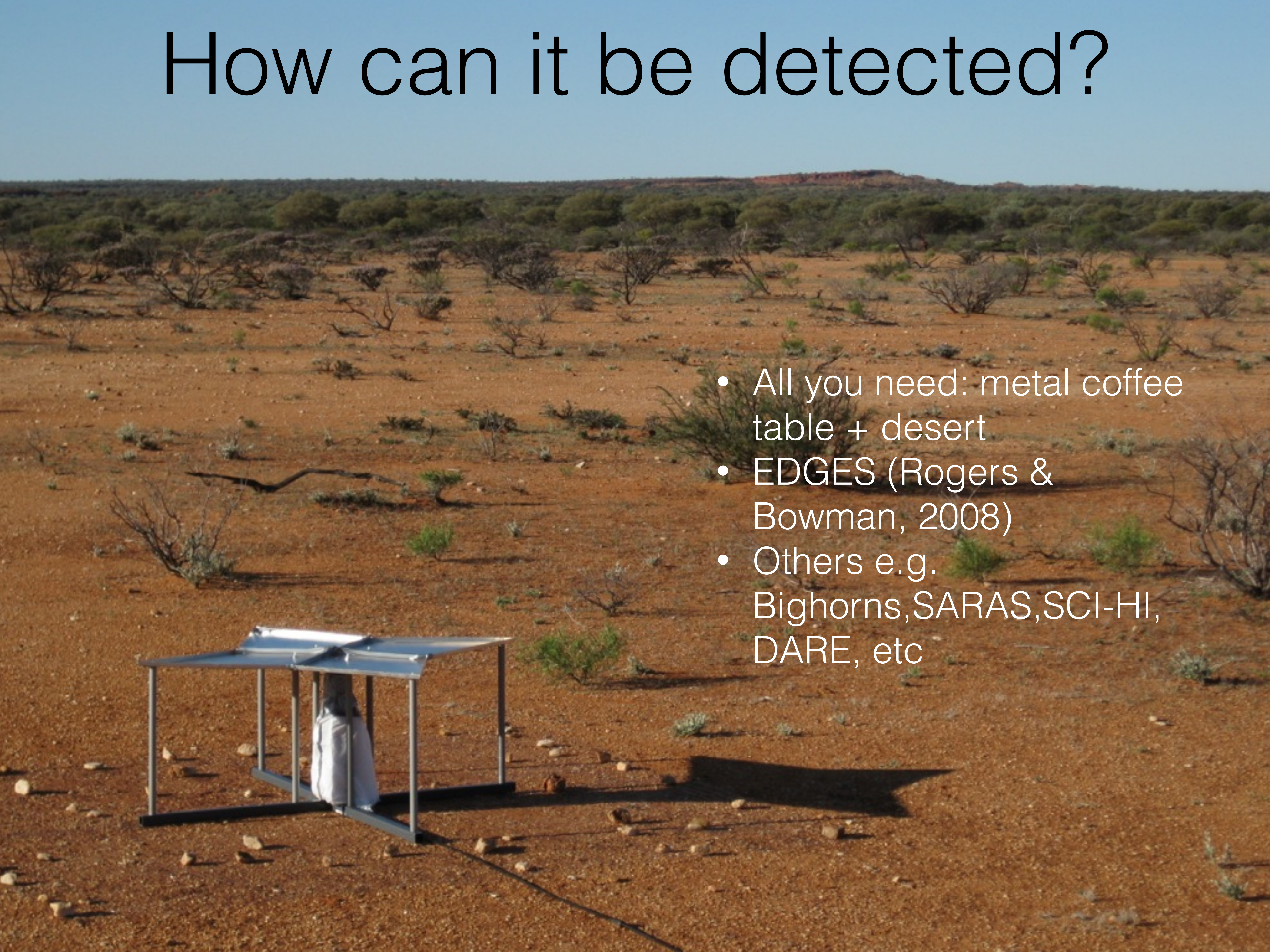
CAASTRO ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

The global EoR signal



- When did reionisation start?
- How long did it take?
- What were the sources responsible for reionisation?

Pritchard & Loeb (2010)


How can it be detected?
• All you need: metal coffee table + desert
• EDGES (Rogers & Bowman, 2008)
• Others e.g. Bighorns,SARAS,SCI-HI, DARE, etc

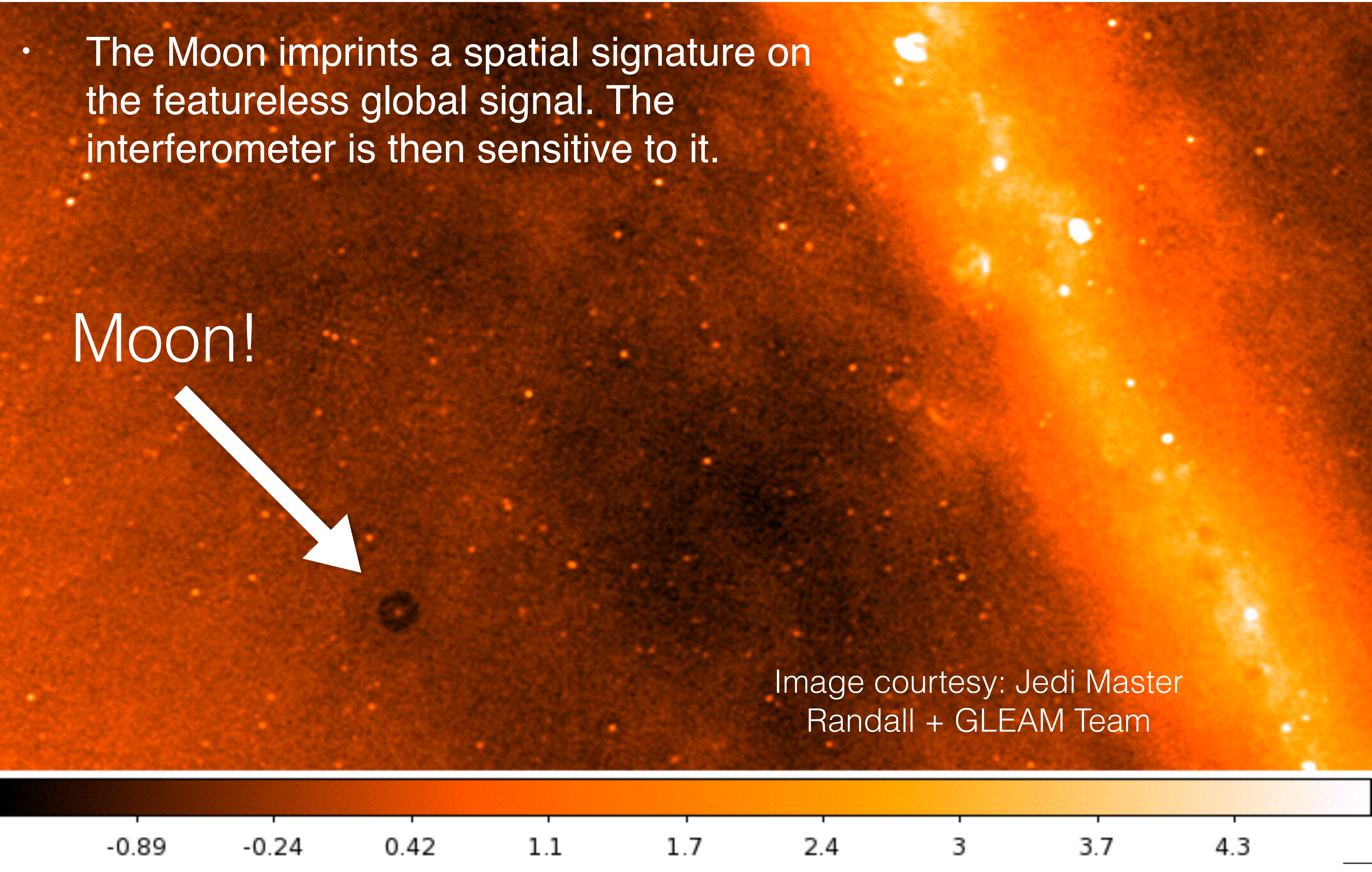
Problems with single-dipole experiments

- Absolute calibration is difficult
- Receiver noise - frequency structure
- Collective reflected RFI from satellites! Could be a show-stopper (Vedantham et al. 2014)

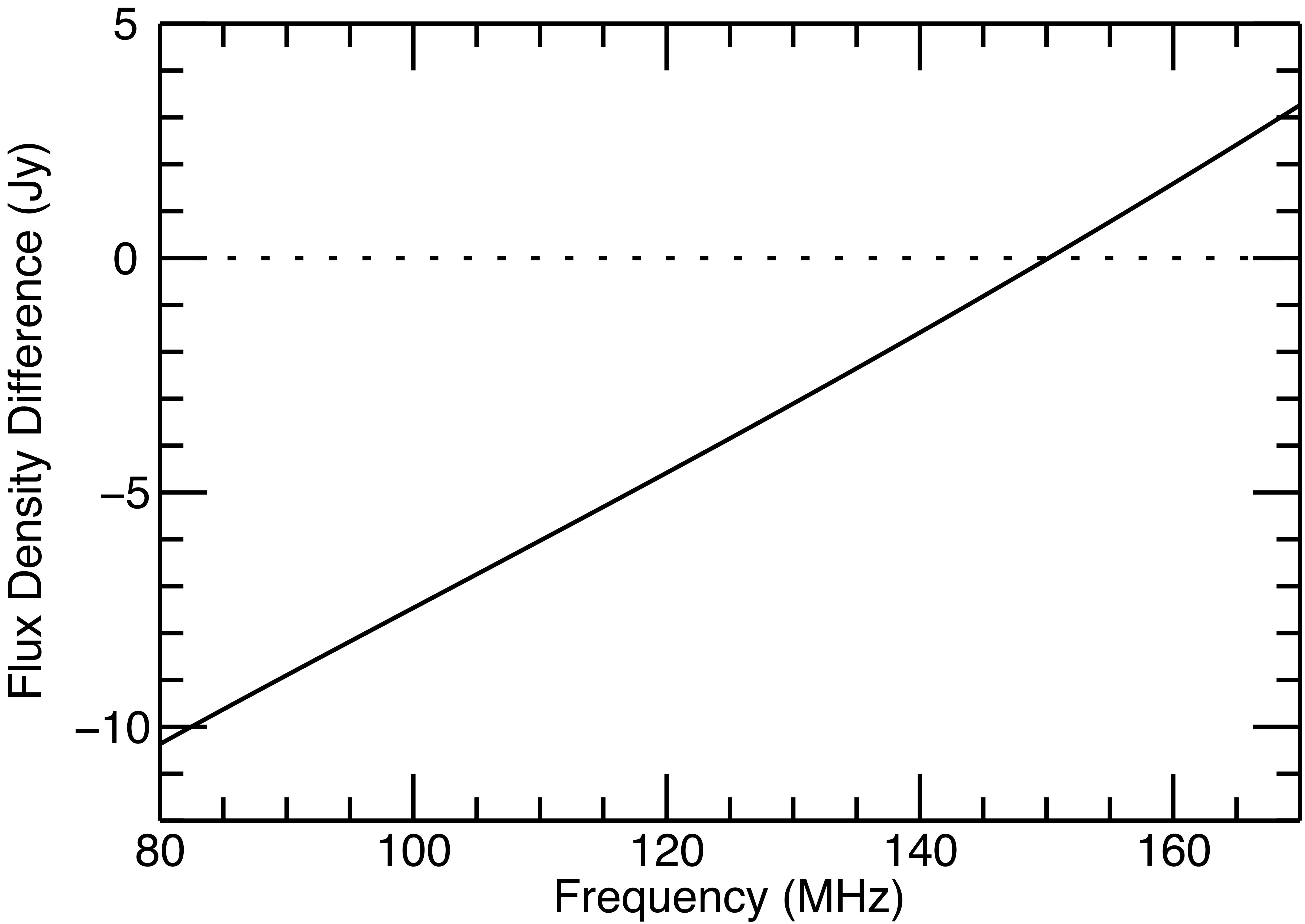
Using an interferometer?… are you nuts?!!

- Advantages of using an interferometer:
  - Receiver noise is uncorrelated
  - Reflected satellite RFI can be isolated
  - Foreground subtraction
- But interferometers not sensitive to a spatially-featureless global signal
- Unless ….

The Moon!



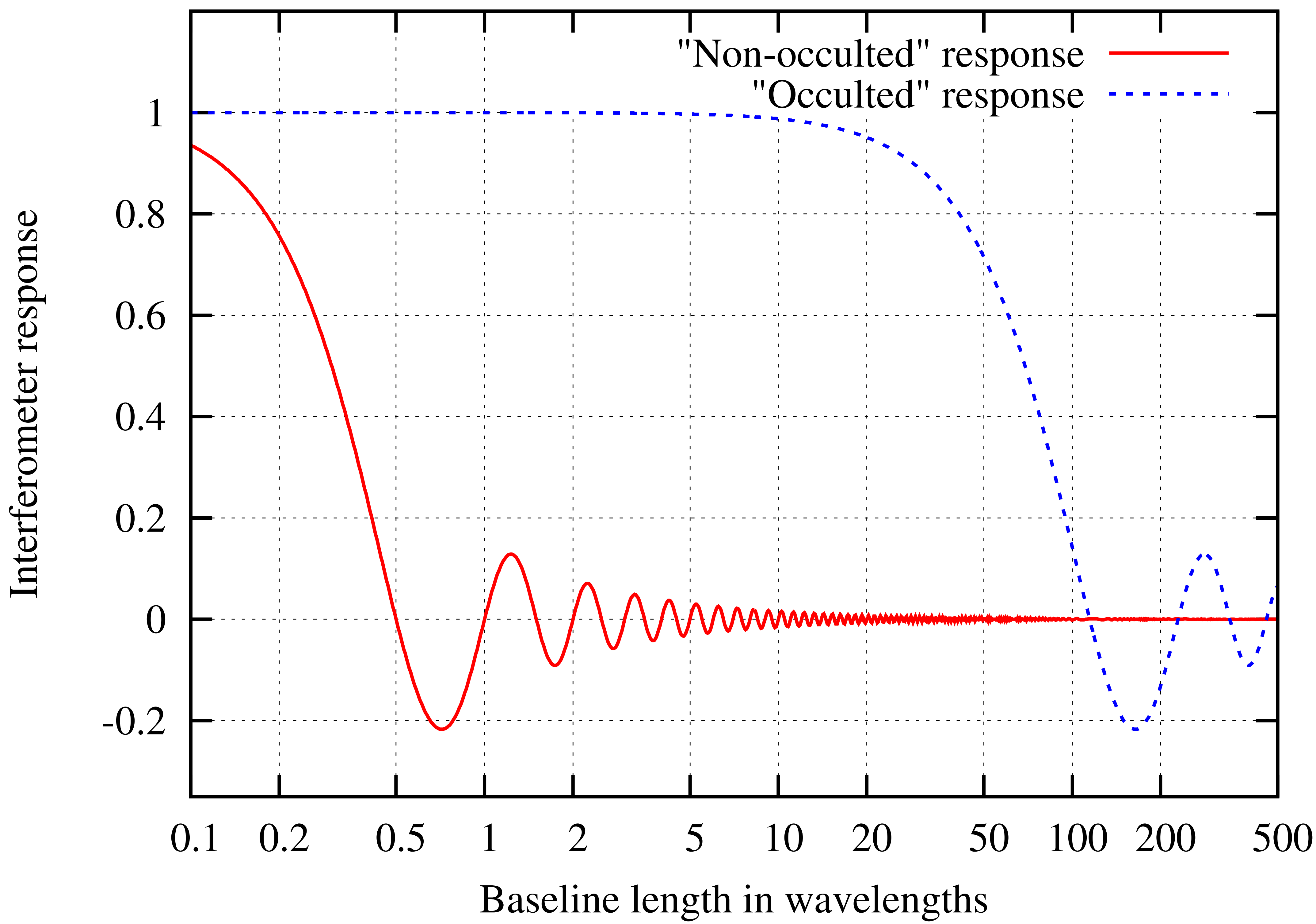
The Moon imprints a spatial signature on the featureless global signal. The interferometer is then sensitive to it.
Moon!
Image courtesy: Jedi Master Randall + GLEAM Team
-0.89
-0.24
0.42
1.1
1.7
2.4
3
3.7
4.3



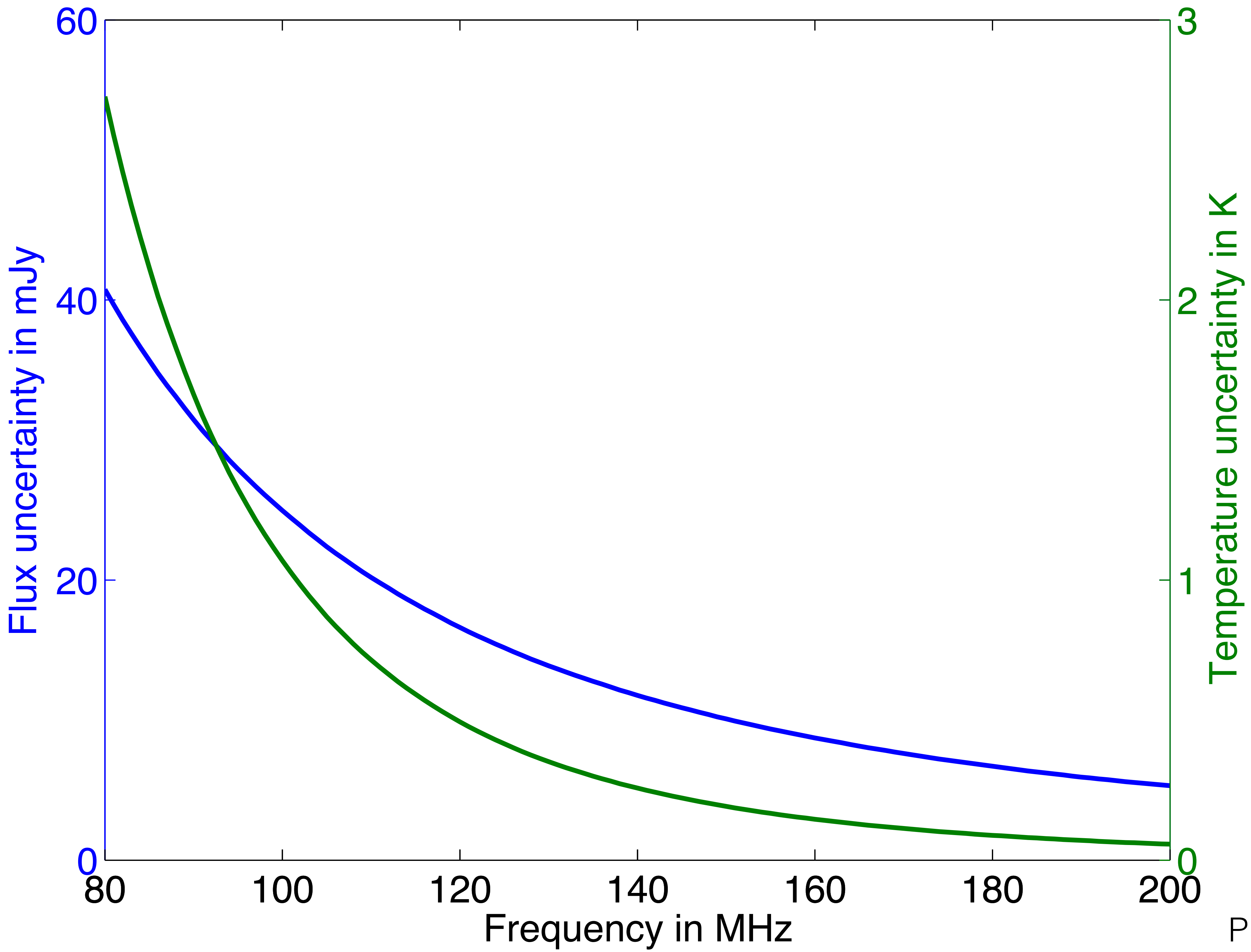
A colour version of this figure is available in the online edition of the journal*

*Joke stolen from J-P Macquart

Interferometer response



Sensitivity to Tmoon-Tsky



- MWA 128T
- 1 hr
- 1 MHz

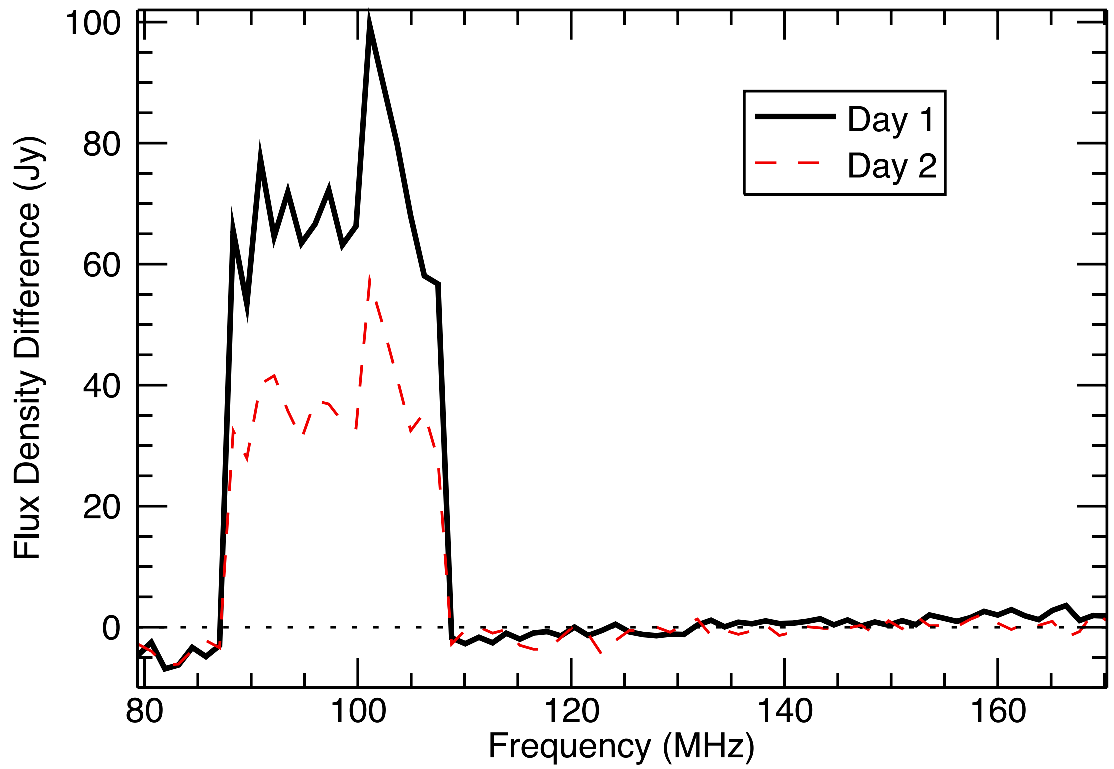
- Can also constrain the thermal properties of the Moon: DARE

Plot courtesy H. Vedantham

Problems

- Reflected RFI (concentrated in centre of disk).
- Only limited observing windows (60 hours in 2015A) where Moon is positioned favourably. Covering 4 frequency bands means 15 hours integration time.
- Less sensitivity than LOFAR HBA.
- Signal is larger < 80 MHz - best chance of detection.

Earthshine



McKinley et al. 2013

Earthshine

- Point source in centre of disk is due to reflected RFI from Earth (not actually an Alderaan-destroying laser)

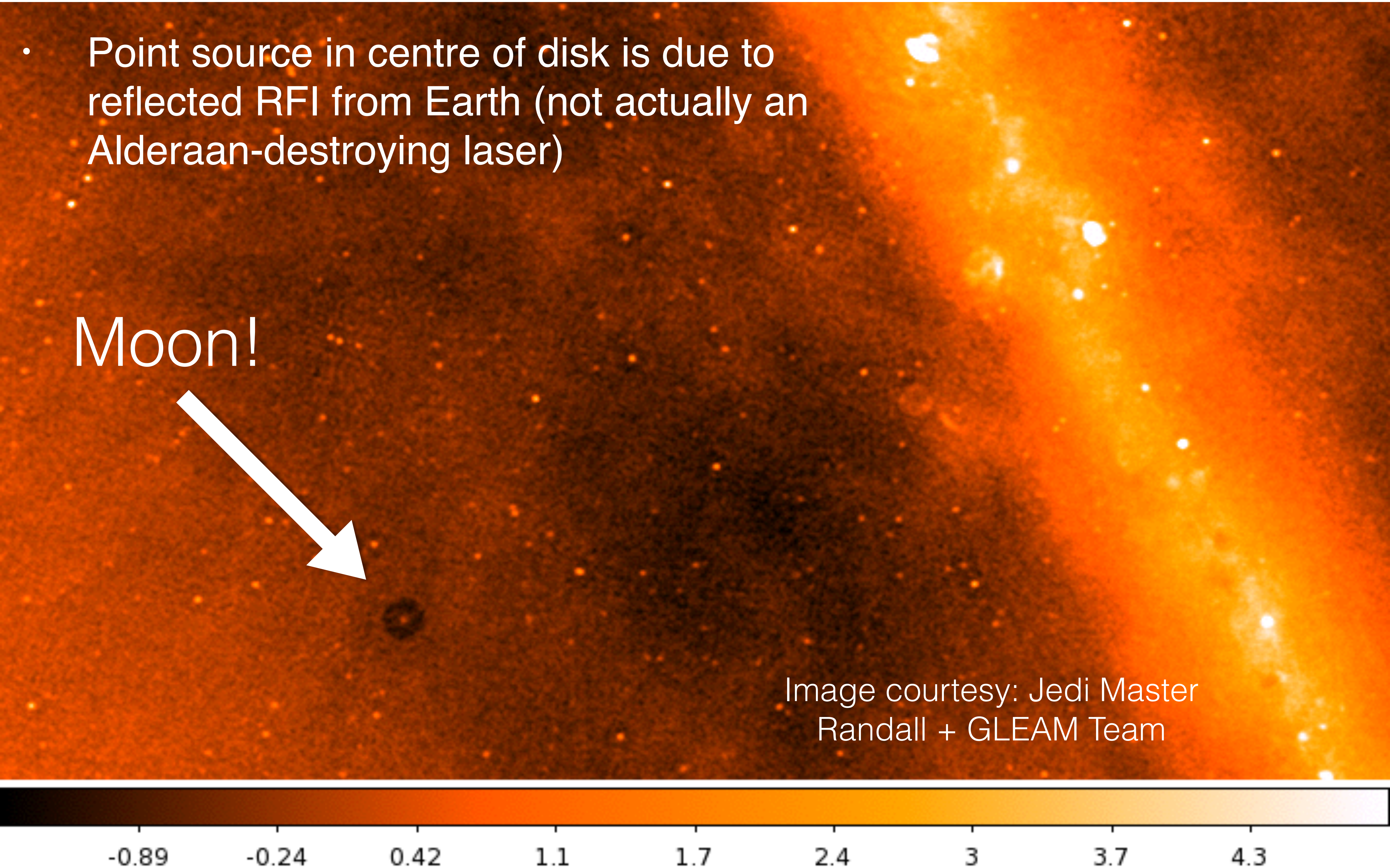
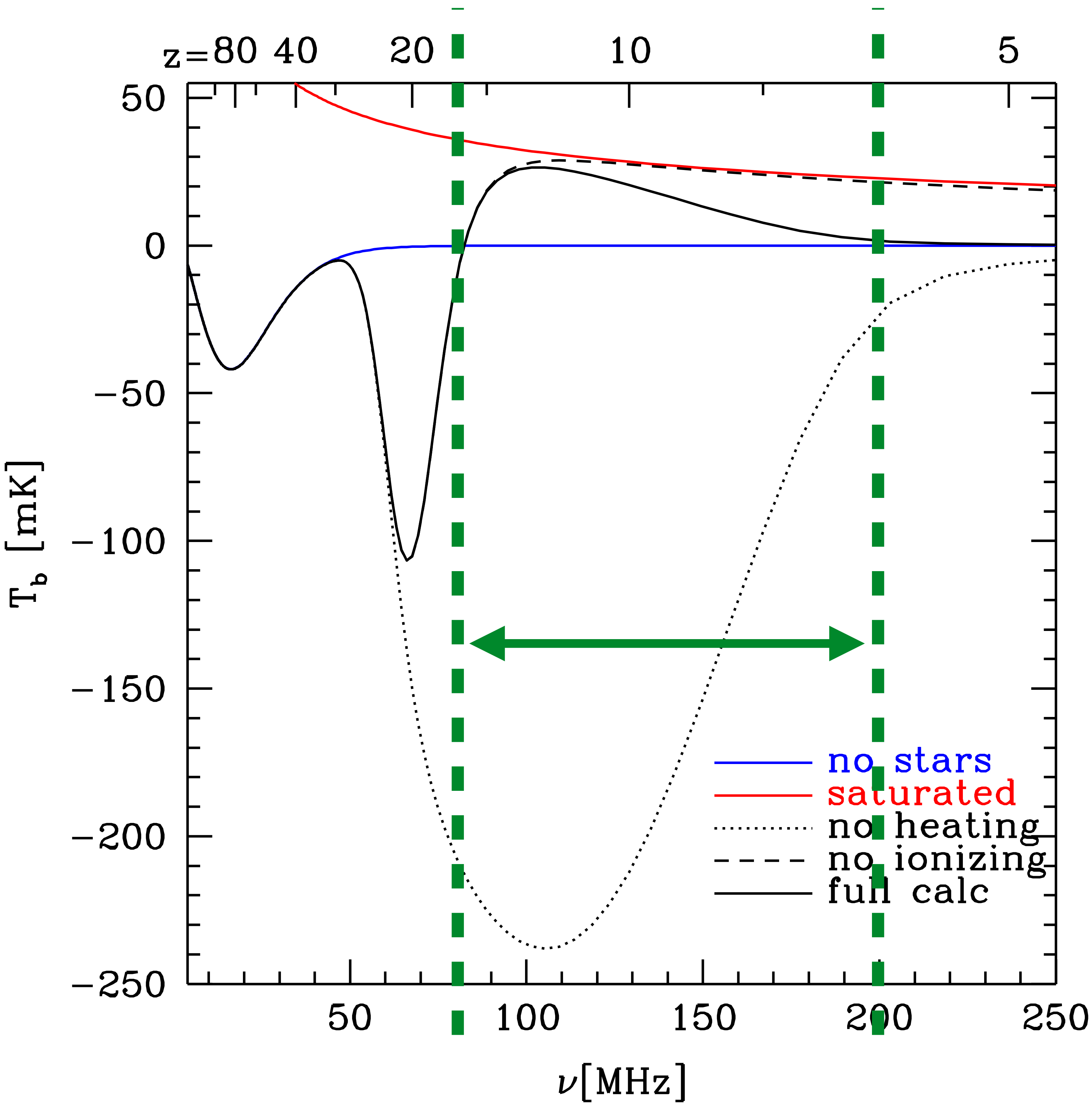


Image courtesy: Jedi Master Randall + GLEAM Team

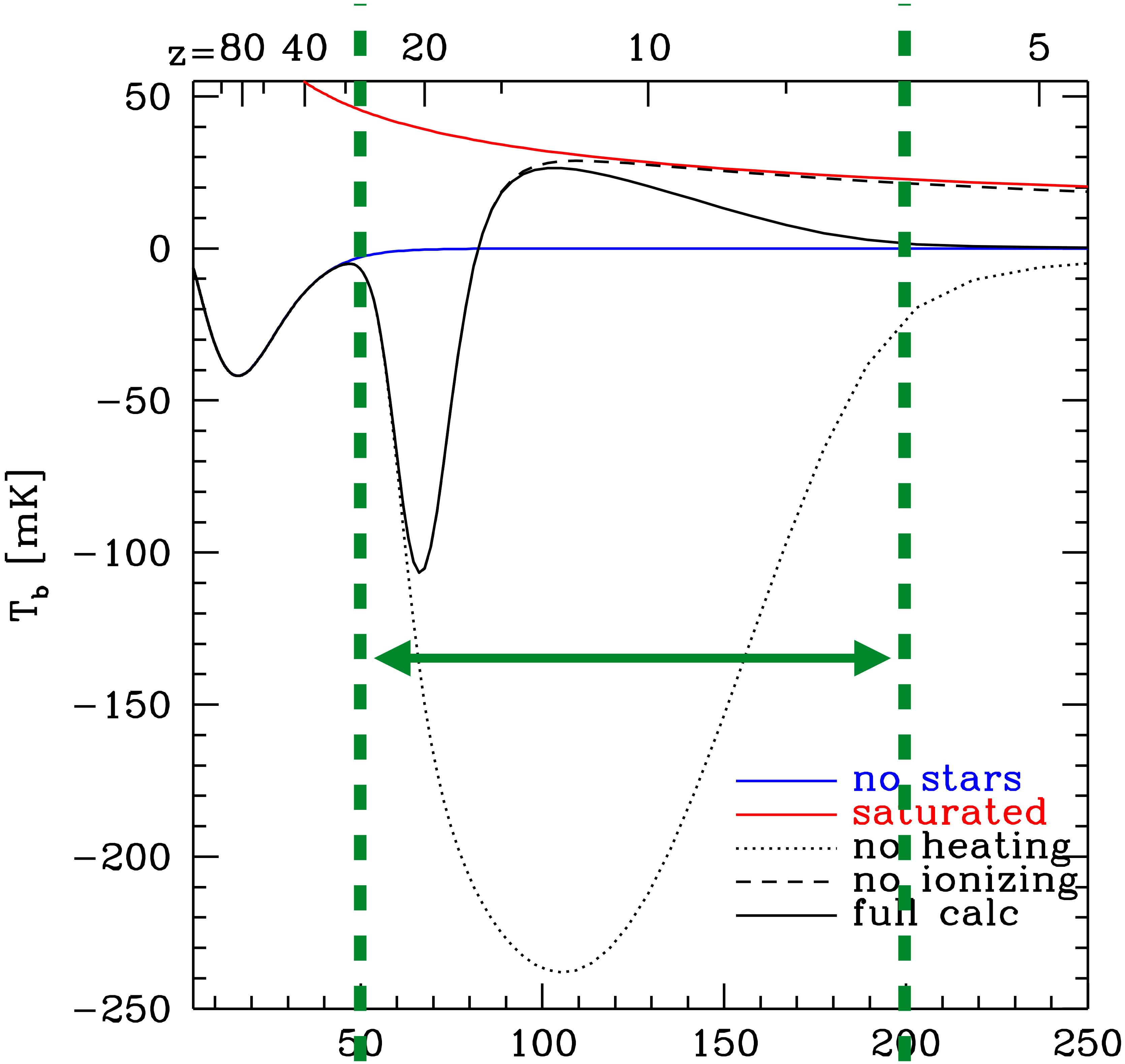
Frequency Range and BW



- 30.72 MHz inst. BW
- 80-200 MHz requires 4 observing bands
- Miss strongest signal

pritchard & Loeb (2010)

Frequency Range and BW



- Extending to 50 MHz allows us to detect the 'trough'
- 200 MHz inst. BW would allow us to cover the whole range. Maximising use of available 'Moon time'.

pritchard & Loeb (2010)

How an extended MWA improves the experiment

- Almost everything under discussion here helps us!
- More short baselines - increased sensitivity to (Tm-Ts) signal
- Lower min freq (~50 MHz) - observing where the largest signal is expected
- Longer baselines (allows us to still resolve the Moon adequately to exclude RFI, even at 50 MHz)
- More instantaneous BW - don’t need to cycle through 4 frequency bands in an hour - more efficient use of the limited observing windows, less time spent observing calibrators.

So please build:

- 200 MHz instantaneous BW
- 50 - 250 MHz
- 6 km baselines
- bunch of extra tiles in the core
- I thought of a catchy new name:
    - **EMWA** (extended MWA)