Lunar occultation of the diffuse radio sky

Preliminary results from cycle 1 data

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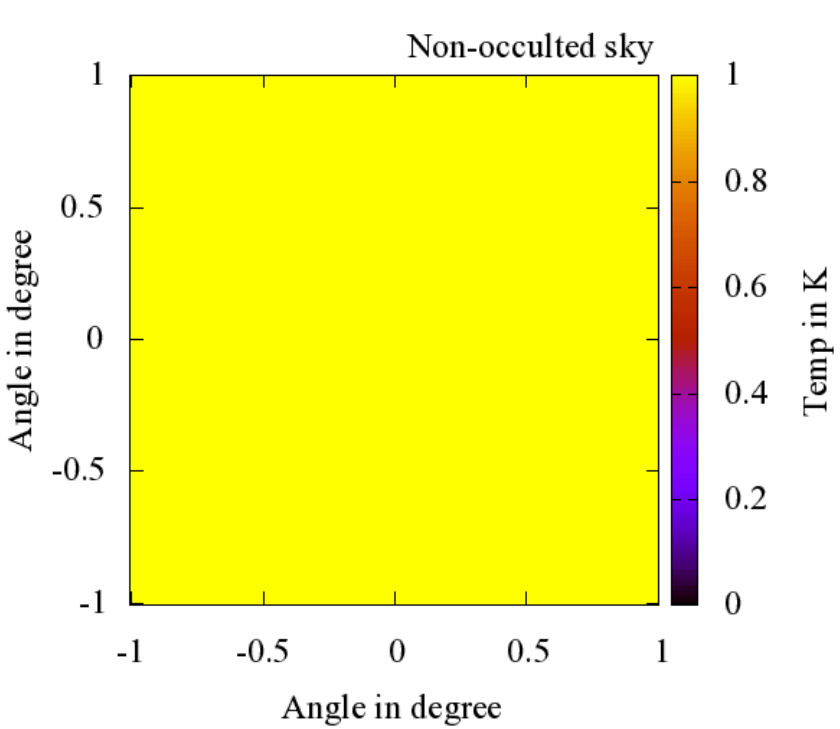
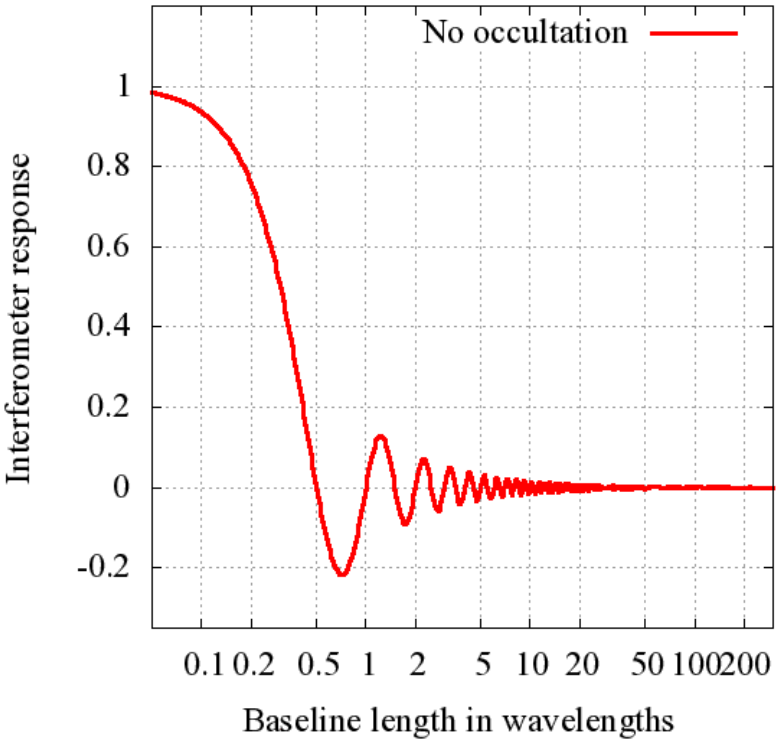
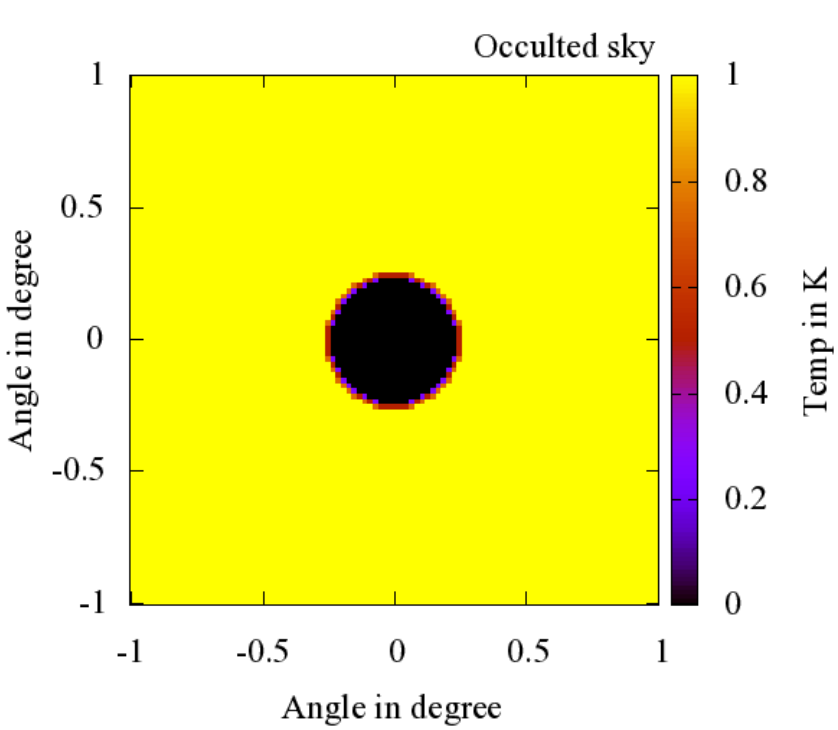
Occultation as seen by an interferometer

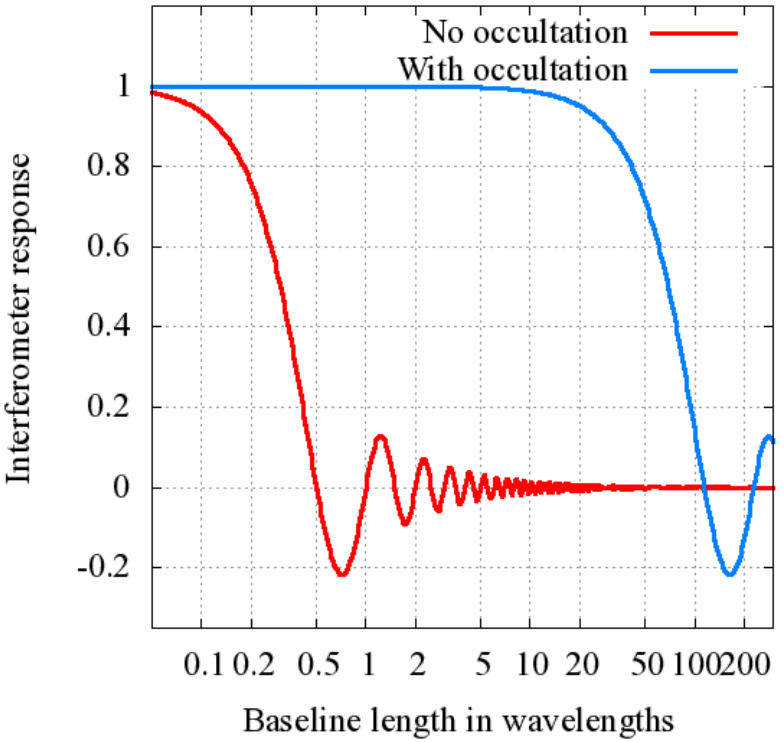




Hence the adage: A radio interferometer cannot measure a global signal

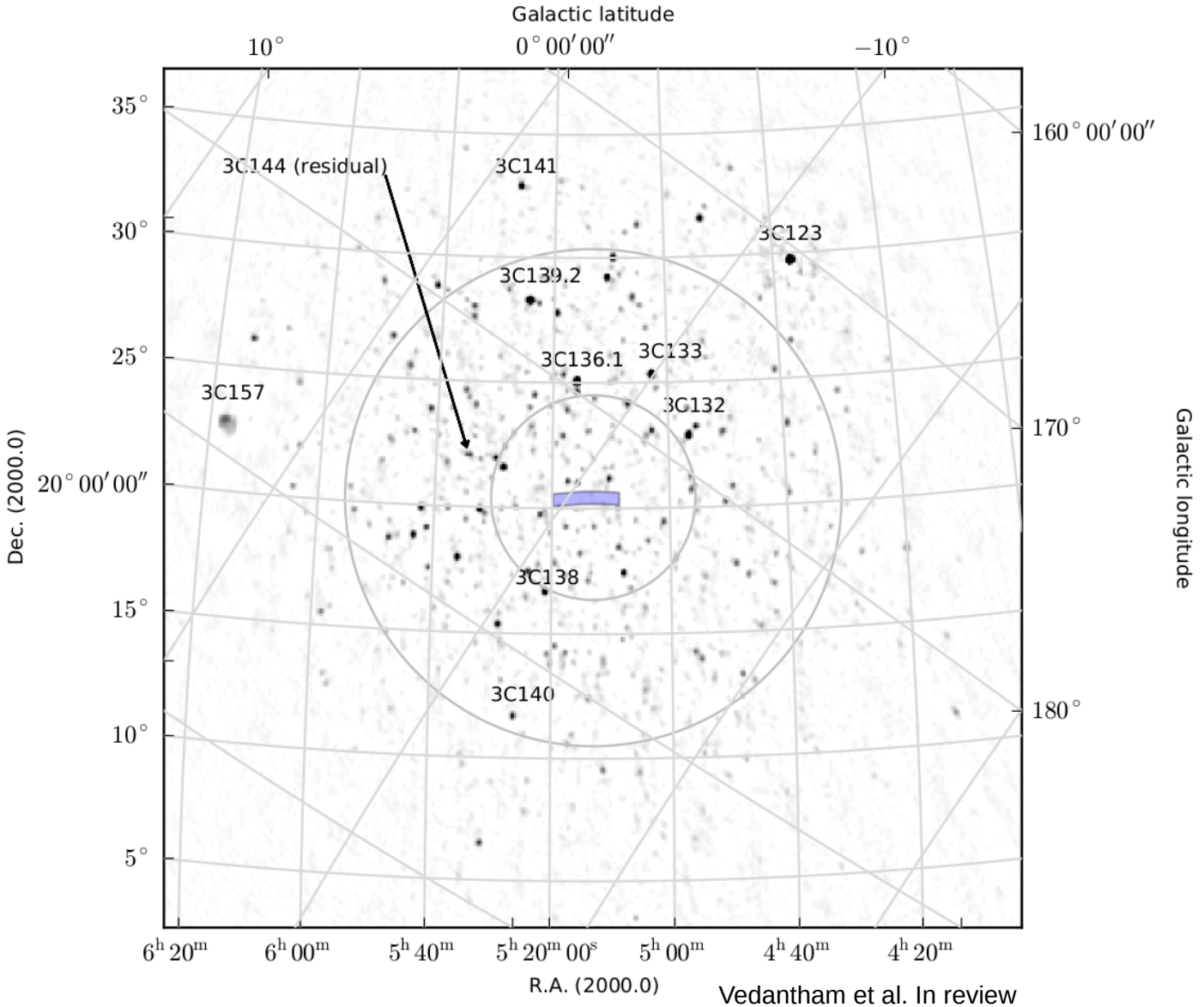
Occultation as seen by an interferometer





But .... interferometers measure the brightness difference between the occulting object T_M and the background T_B

LOFAR commissioning data



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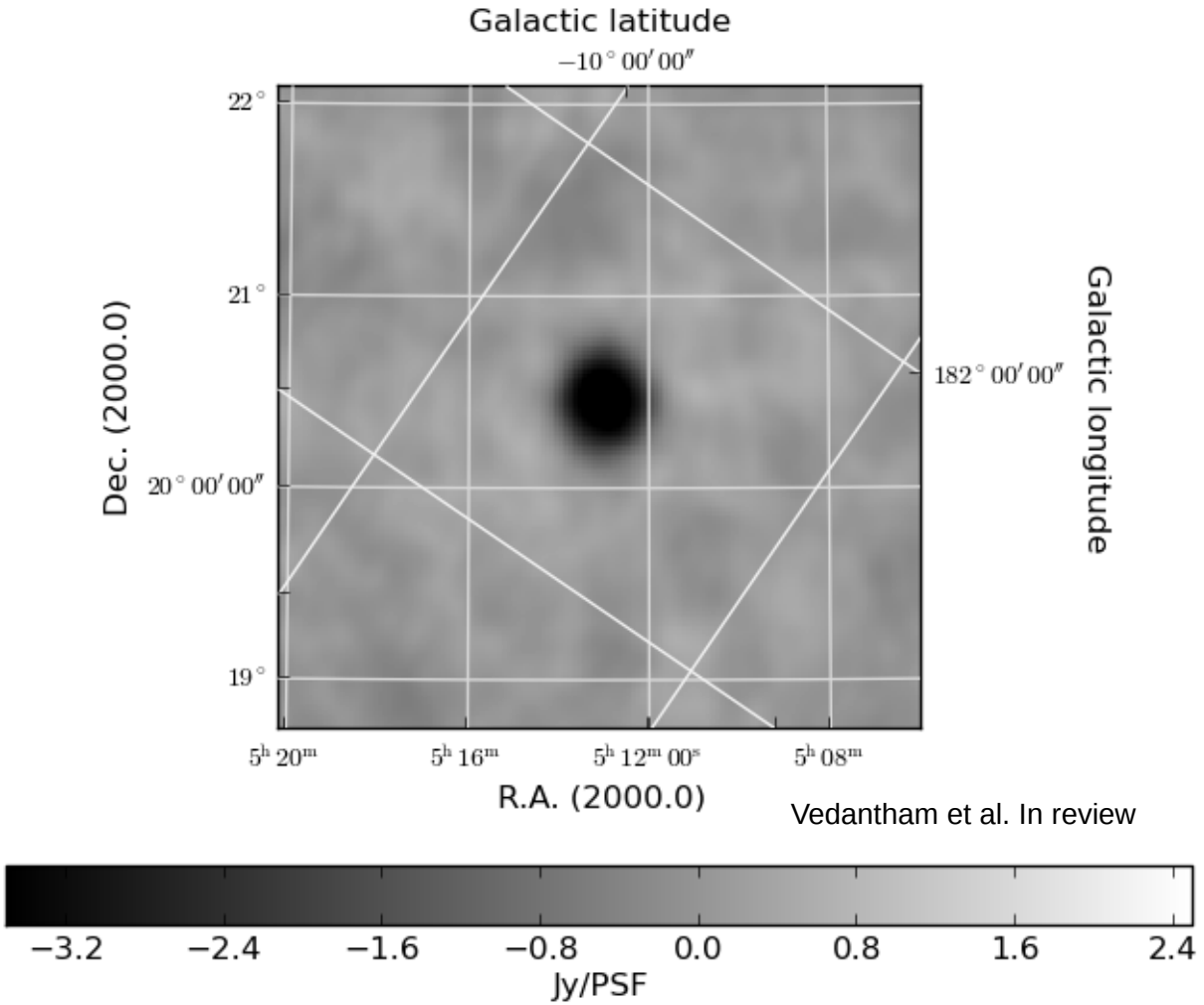
OBSERVATIONS

Freq range : 35 to 85 MHz
Date : 2012-12-26
Exposure : 7 hours

stations : 24 core (~ 3 km)

A hole in the sky !



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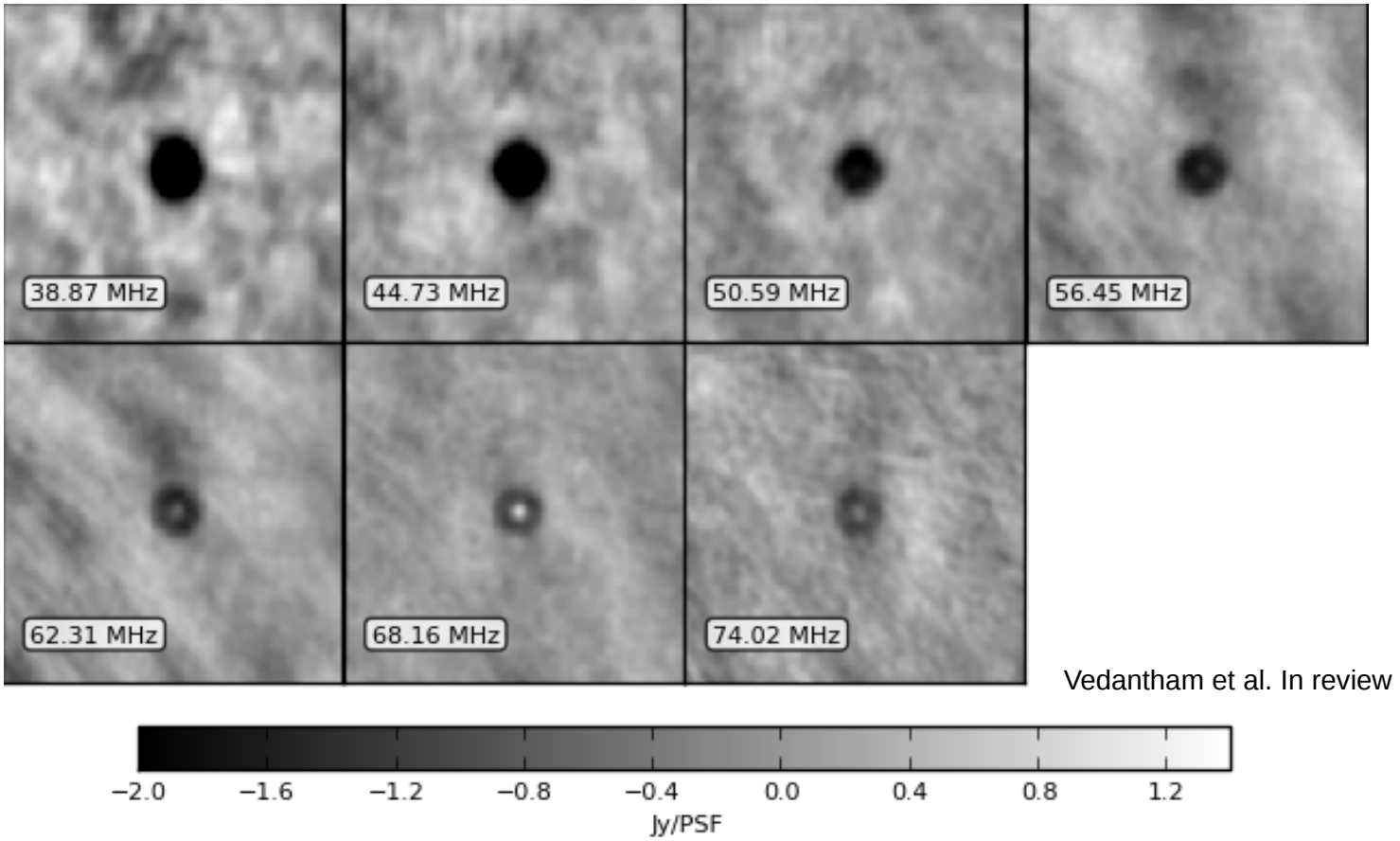
Freq range = 35 to 50 MHz (continuum)

PSF = 10 arcmin

Image plane noise = 140 mJy/beam

First detection of diffuse galactic emission by observing its occultation by the moon.

A hole in the sky



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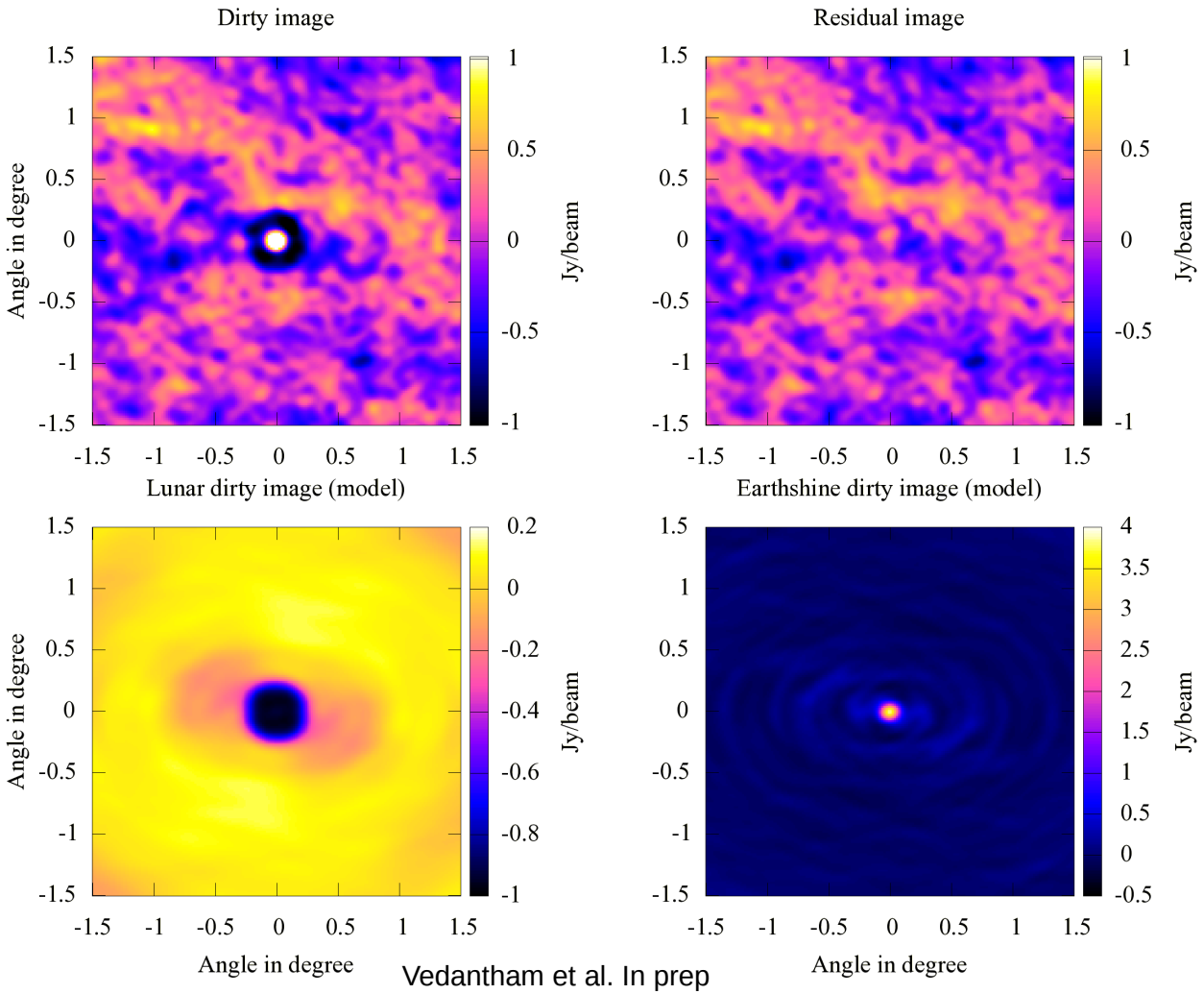
Reflected RFI (Earthshine) images to the center of the lunar disc, due to specular nature of reflection

Removing Earthshine



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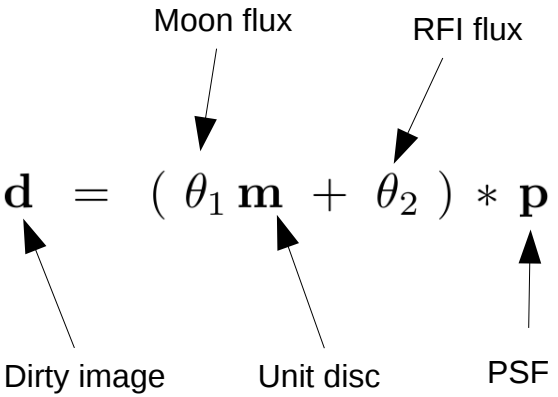
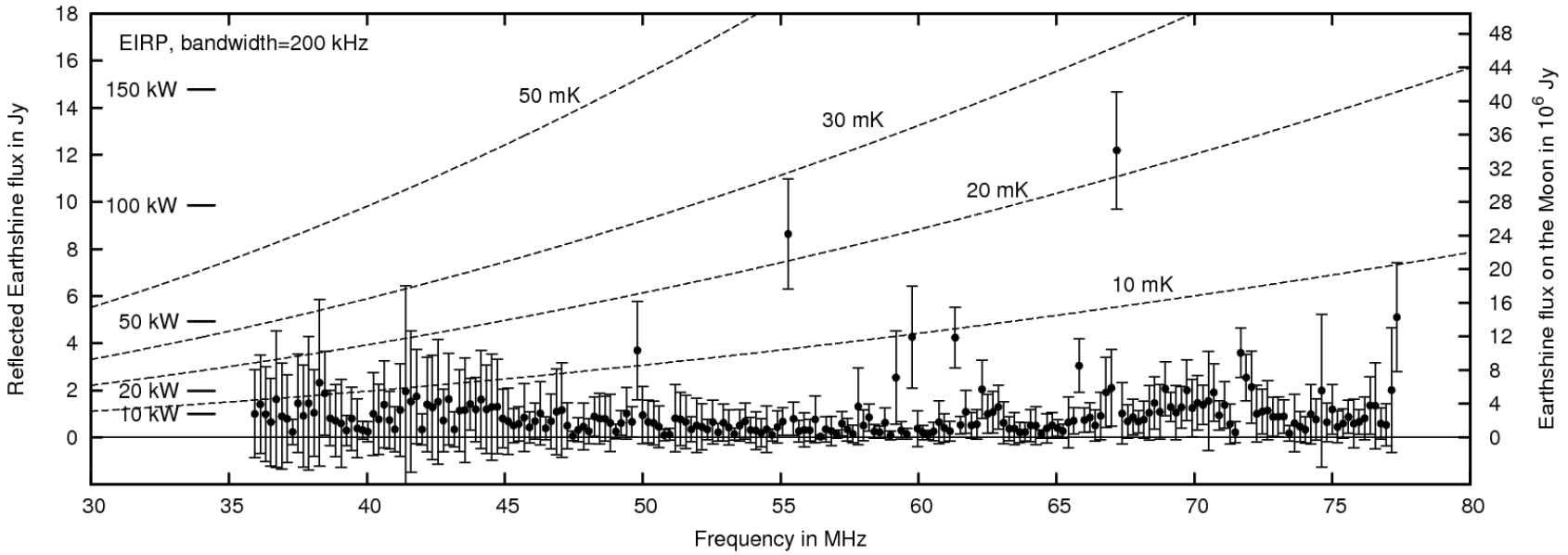


Reflected Earthshine can me mitigated using information in longer baselines

Spectrum of Earthshine



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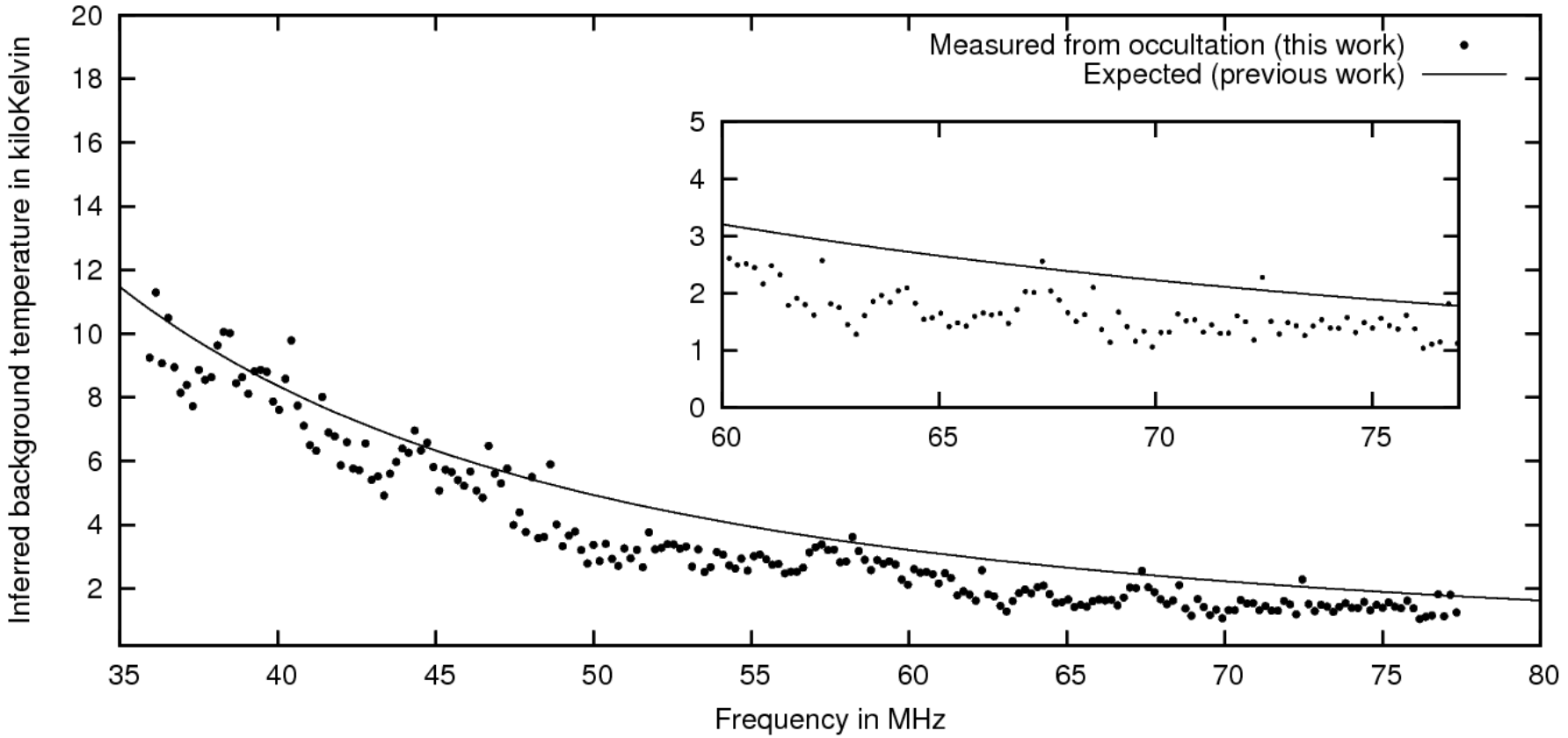
Moon based dark-ages experiment will require > 80 dB of isolation (conservative) from Earthshine

Spectrum of occulted Galactic emission



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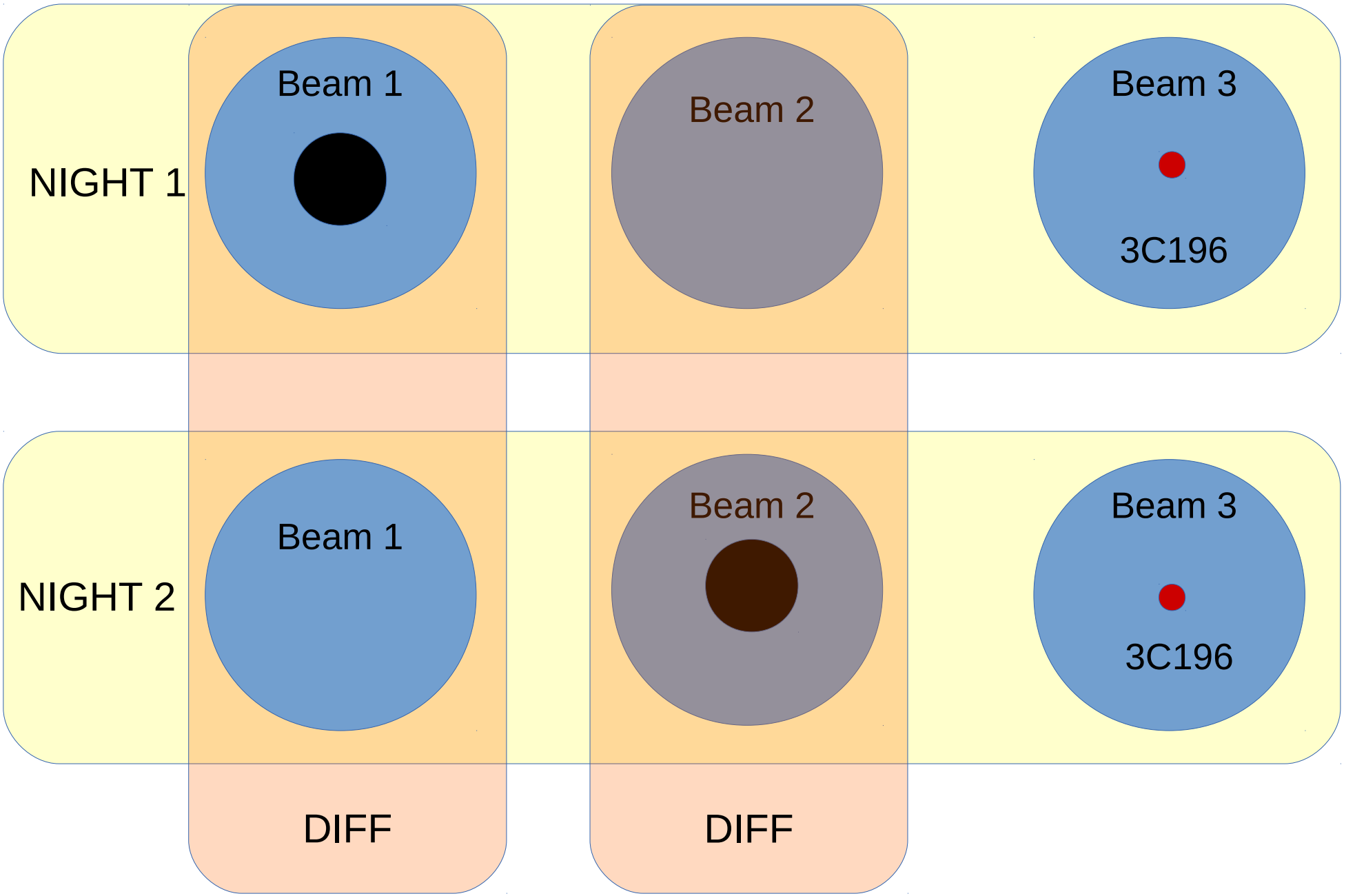
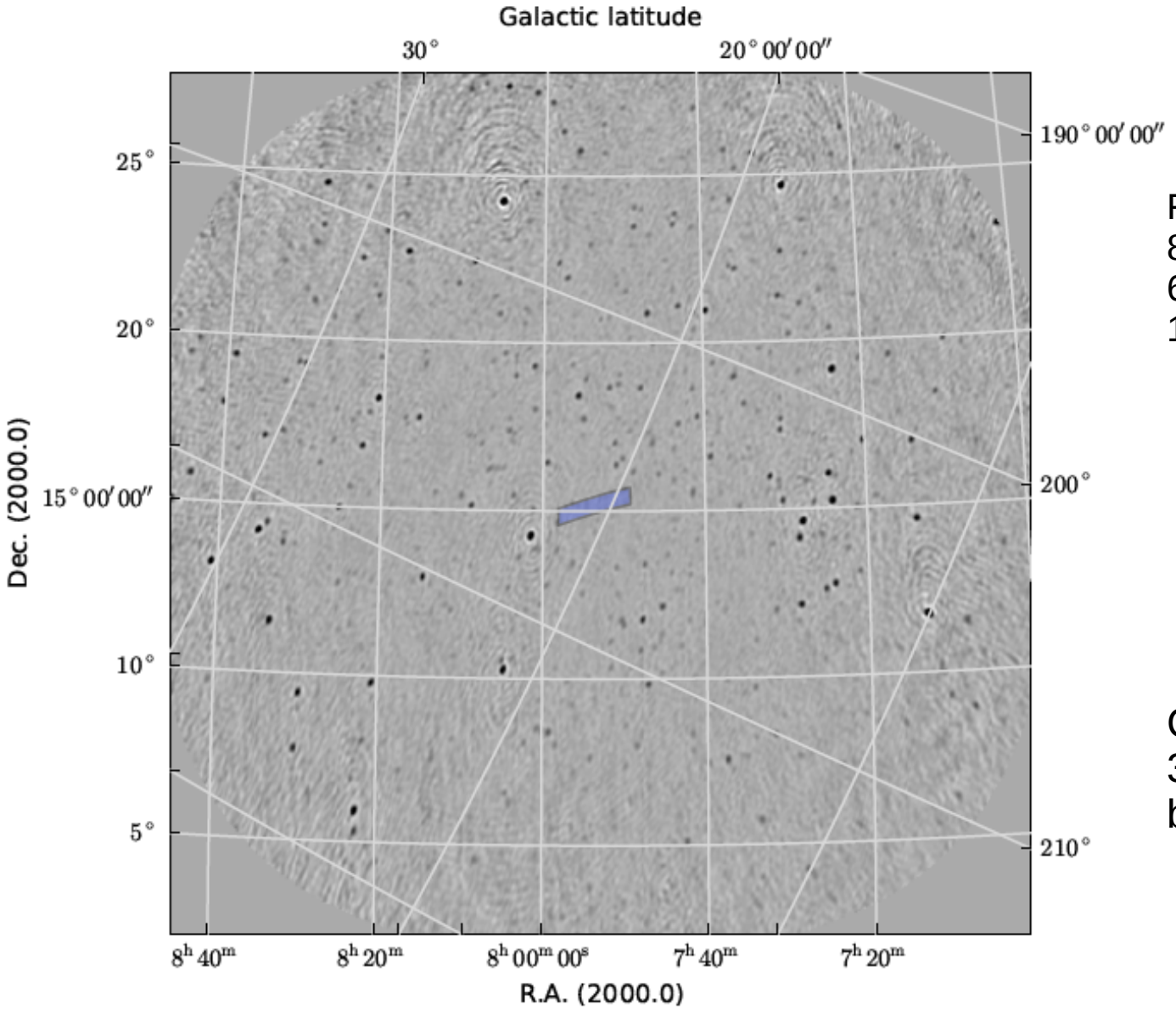
Sidelobe confusion was the dominant systematic --- need for (i) better field, (ii) inter-night differencing

Plan for cycle 1



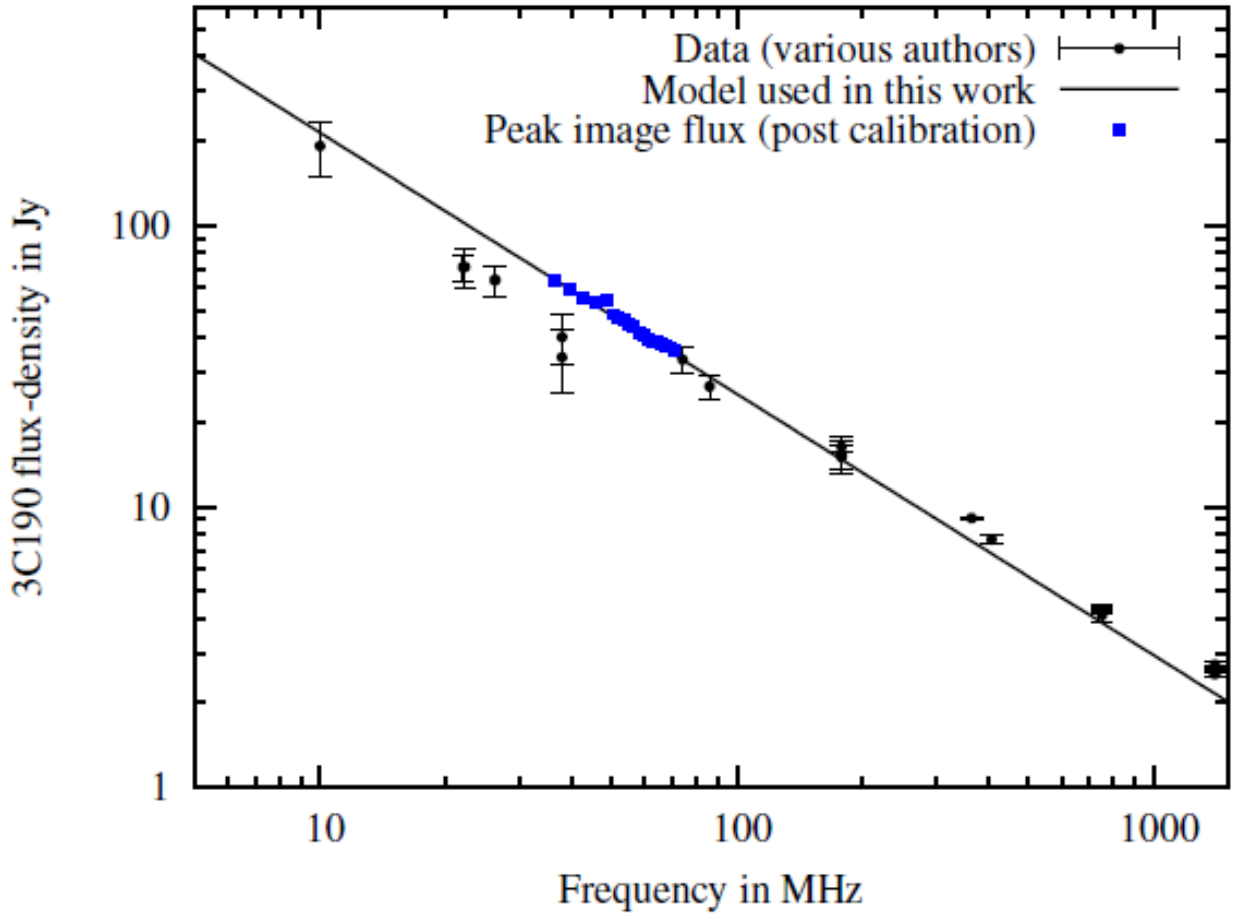
Lunar field -1



Freq: 37 MHz
8 sub-bands (200kHz each)
6 hour synthesis
10λ to 300λ baselines

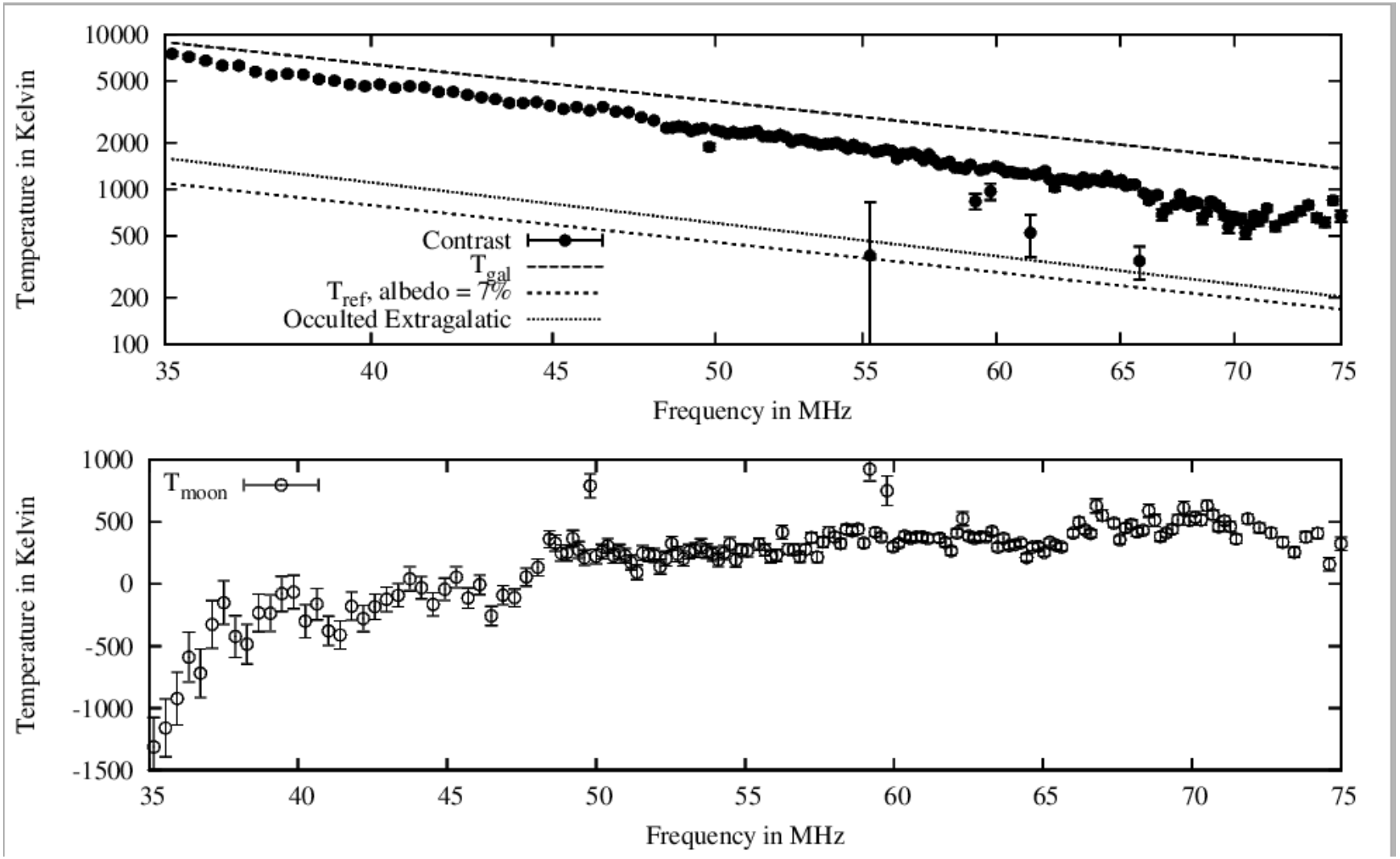
Calibration transfer from 3C196 not possible – primary beam not known :(

In-field calibration



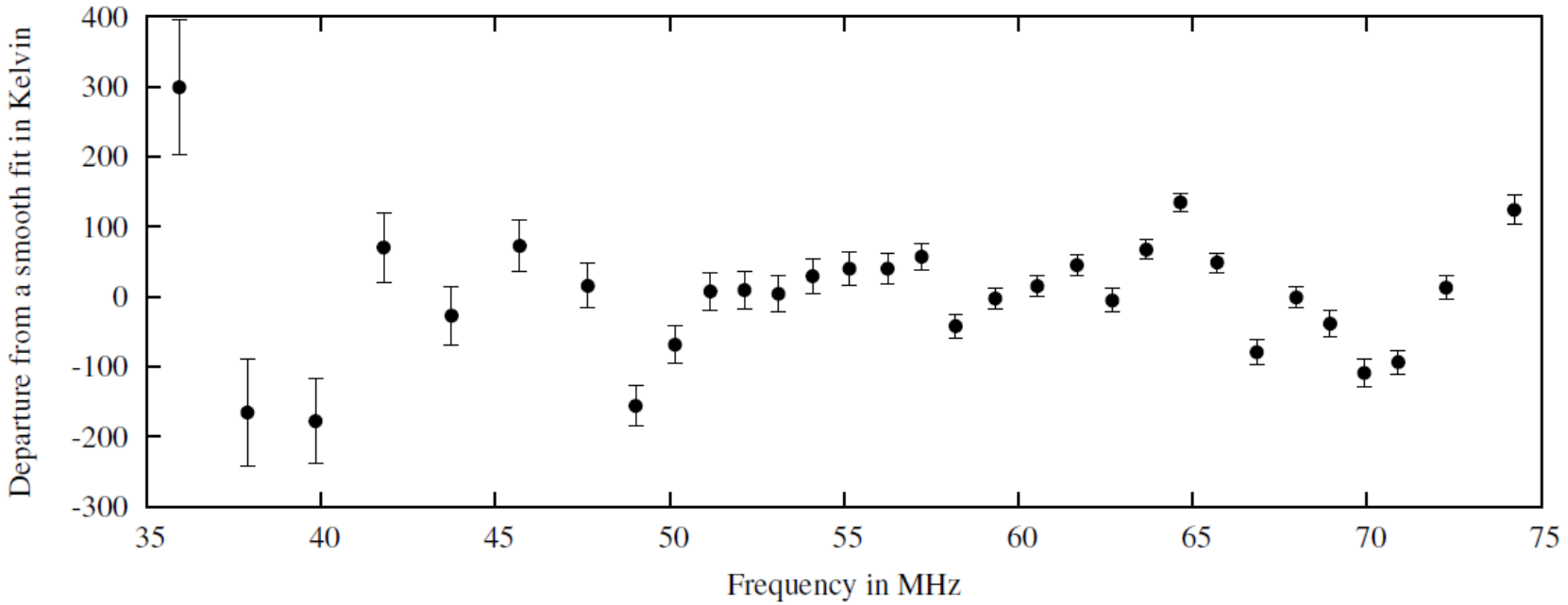
4 bright 3C source with well determined spectral index + ~20 VLSS sources with -0.8 spectral index

Spectra are order(s) of magnitude better than commissioning



Spectra are order(s) of magnitude better than commissioning

Fitting now in the uv plane –> better handling of errors



Conclusions and future work

Moon-background contrast spectra → significant improvement

We can start to do some very interesting science now

Lunar temperature evolution?

Limits on Extragalactic background temperature?

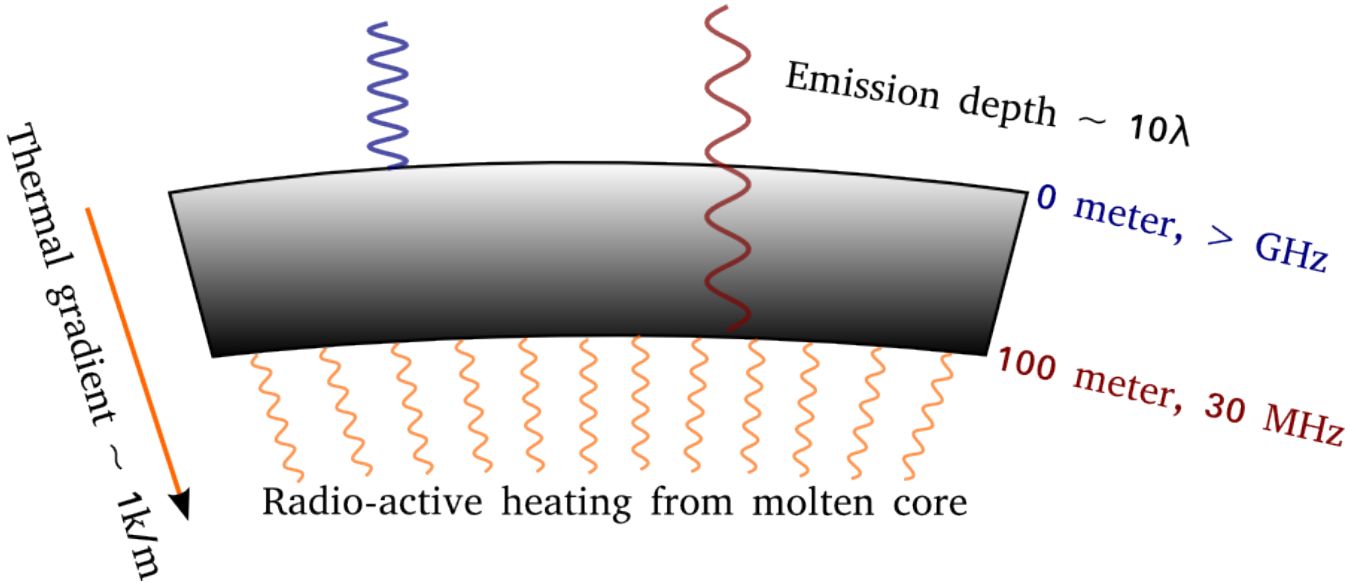
Process other field for cross validation of systematics

HBA data (in hand) will give large frequency baseline for spectral fitting

New LBA data on 2 nights from March 1st and 2nd 2015!

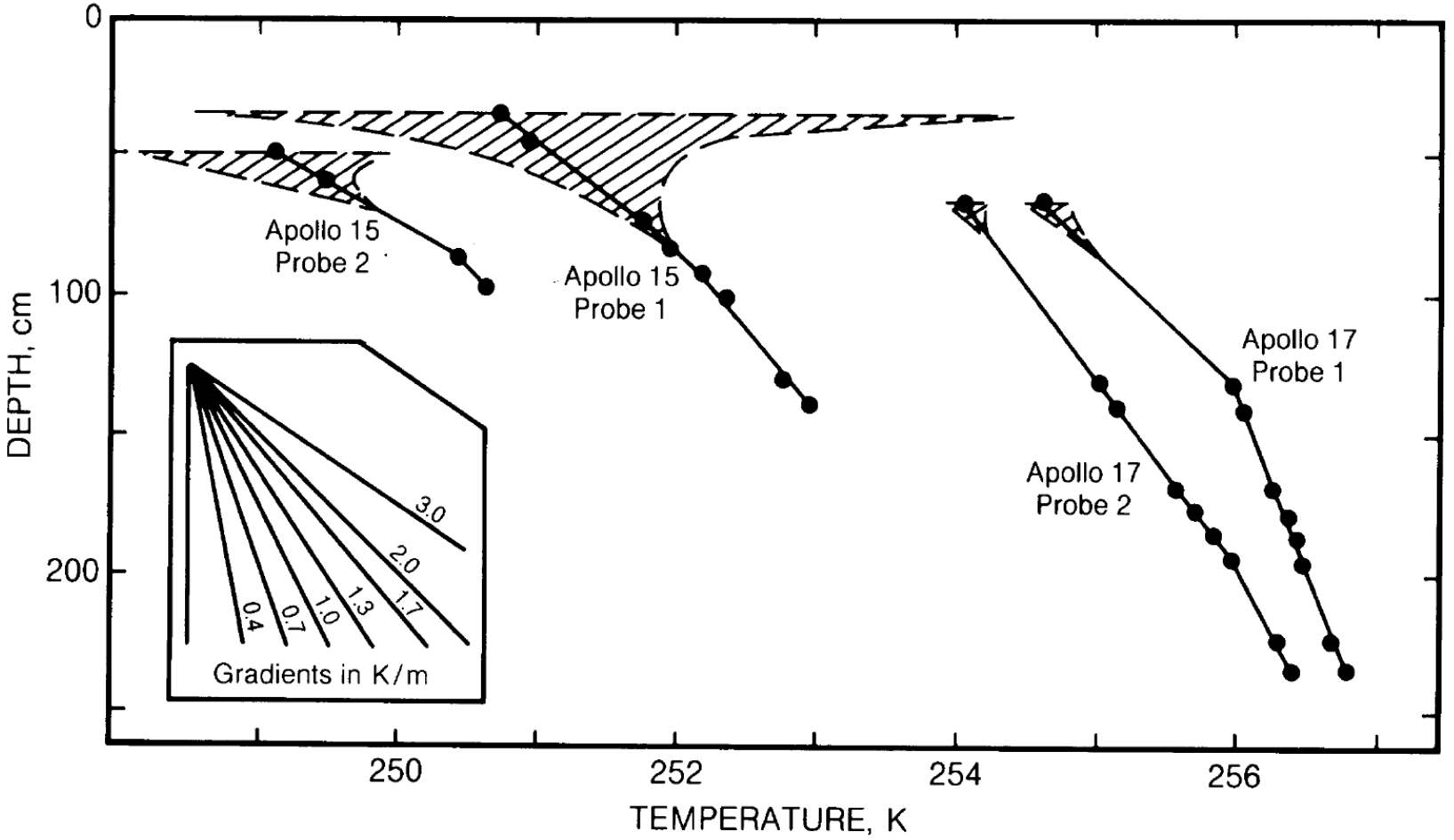
EXTRA SLIDES

What is the brightness temperature of the Moon ?



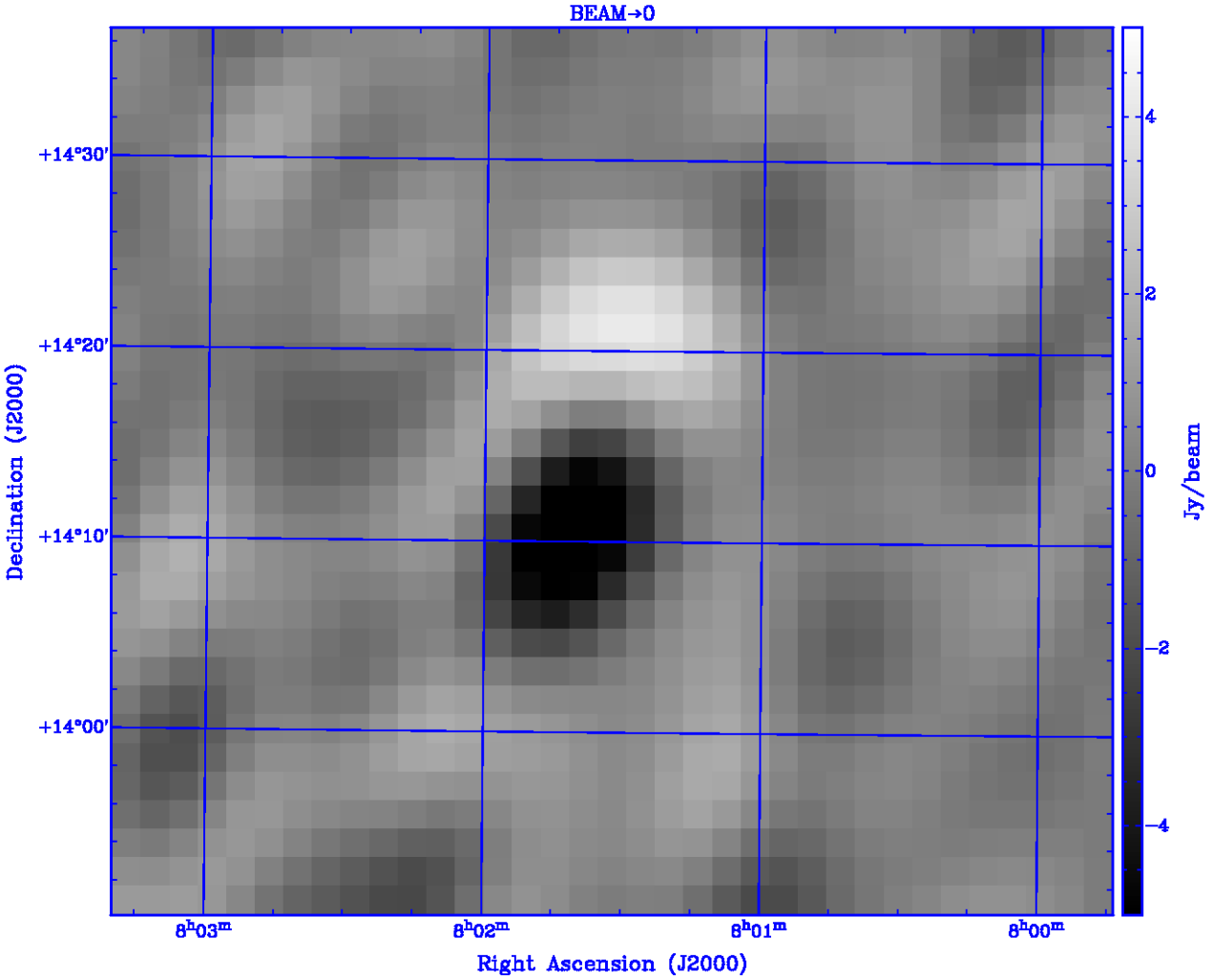
Thermal uncertainties in current data~5-10 K level. Must be able to detect lunar heat flow !

Apollo in-situ measurements



1 Kelvin/meter corresponds to 100 K brightness temperature increase at 30 MHz

Differential ionospheric refraction



Sources do not line up on different nights at ~ few arcmin level

Lunar occultation → outlook

Novel lunar science within reach! (very exciting)

Implement ionospheric refraction correction, establish a reliable flux scale

Detect polarization from the lunar limb (in High Band, VLA 1 meter)

Measure lunar temperature spectrum from ~30 MHz to ~300 MHz.

Nagging problem in all low-frequency observations → we are not hitting the thermal noise limit! Why?