Does the ‘nightly mean’ in NCP visibilities come from cross-coupling between antennas?

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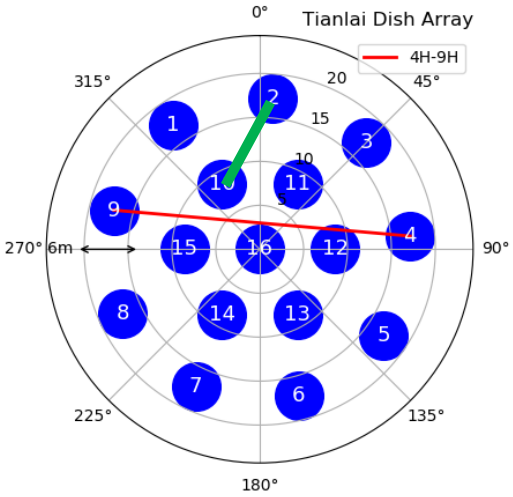
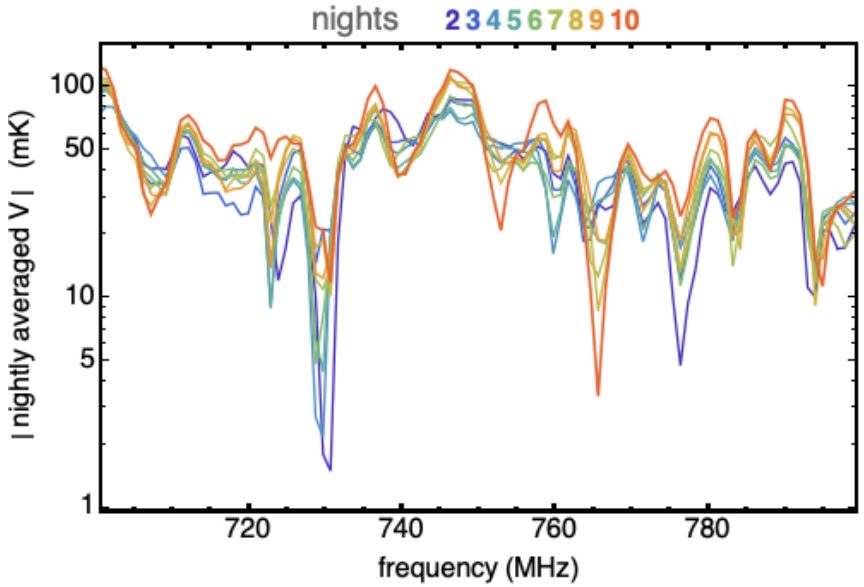
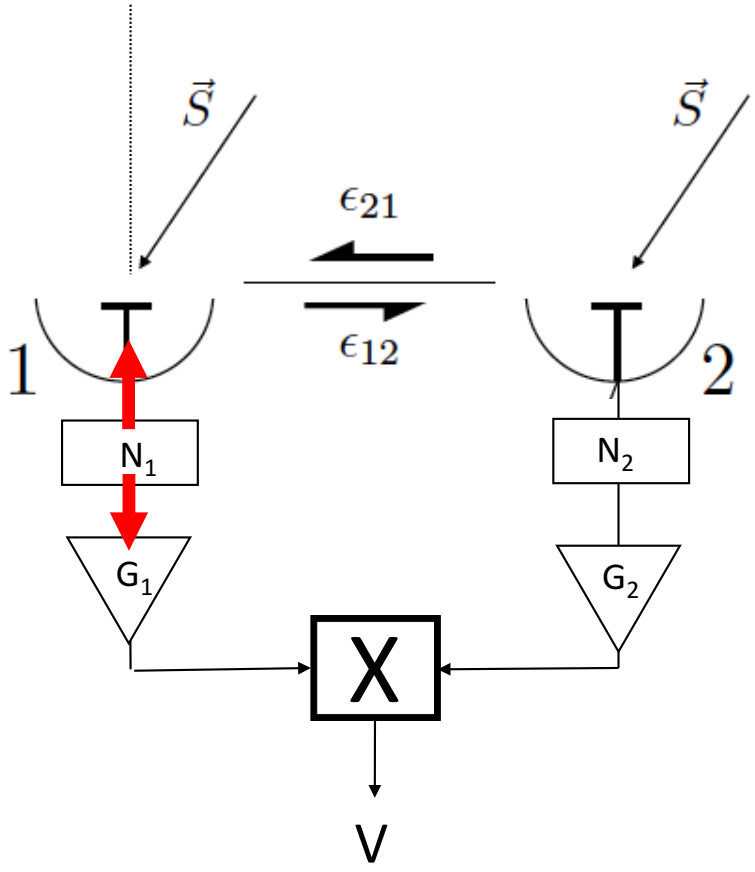
9 July 2020



Baseline
2V-10V





arXiv:1909.11732v1
Kern et al. *Mitigating internal instrument coupling for 21 cm cosmology I: temporal and spectral modeling in simulations*

N_1 represents noise generated by receiver 1. It is the amplitude of a voltage wave that travels, backwards, out of antenna 1 as well as forwards, through receiver 1.
Noise power is proportional to N_1^2 and is equivalent to the noise temperature, T_{N1} (temperature is proportional to electrical power).

The voltage coupling coefficient from antenna 1 to 2 is ε_{12}.
(The power coupling coefficient, which is what CST gives us, in dB, is ε^2_{12}.)

In an ideal instrument, with no cross-coupling, N_1 and N_2 do not produce a DC output from the correlator. (They do produce noise, though.)

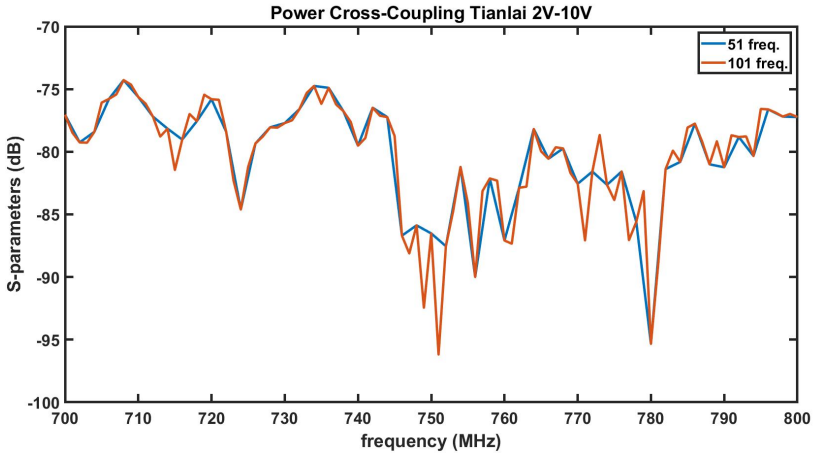
The contribution to the visibility, V, from the noise voltage, N_1, coupling to antenna 2 is approximately

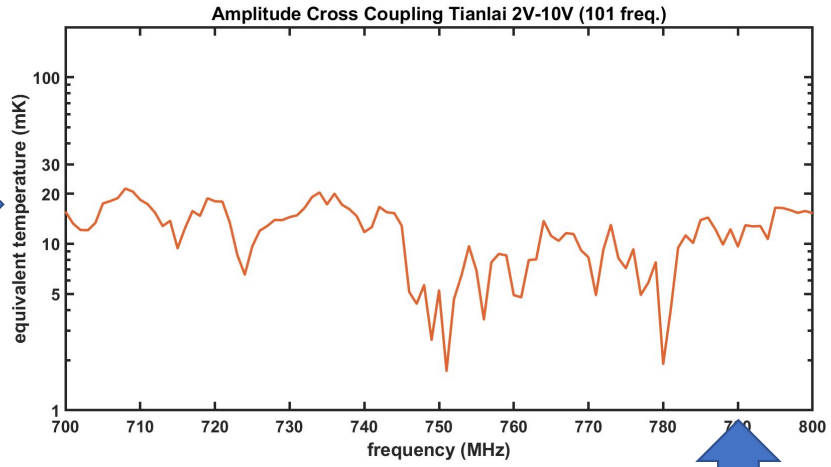
$$N_1 G_1 \text{ X } N_1 \varepsilon_{12} G_2 \sim T_{N1} \varepsilon_{12} G_1 G_2$$

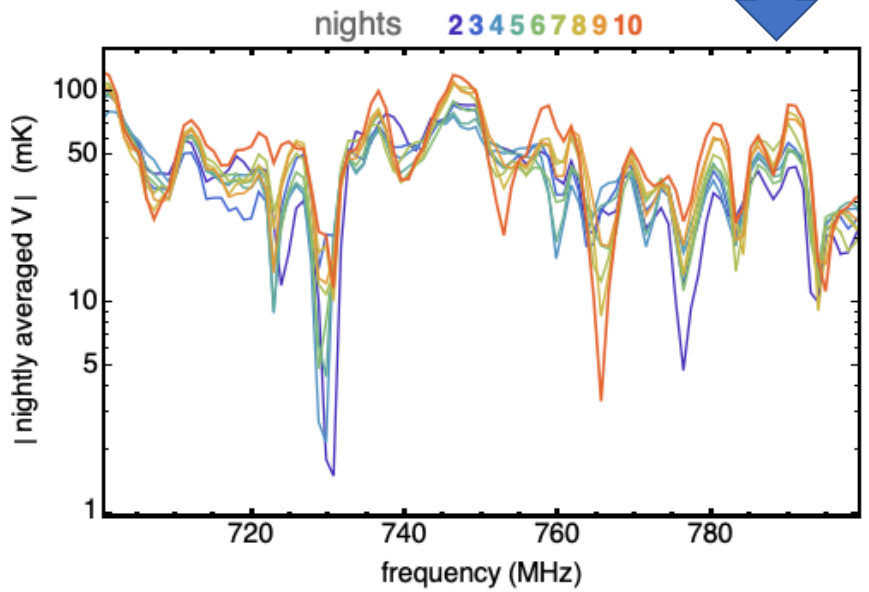
(There's a similar contribution from N_2.)

T_{N1} ~ 100 K. CST sims are finding $\varepsilon^2_{12} \sim 10^{-7}$, $\varepsilon_{12} \sim 10^{-3.5}$ so the contribution to the visibility from N_1 ~ 100 x $10^{-3.5} \sim 30$ mK, which is roughly what appears in Fig 28 of the dish paper.

Including N_2 should double the effect.


Power Cross-Coupling Tianlai 2V-10V
51 freq.
101 freq.
S-parameters (dB)
frequency (MHz)


Amplitude Cross Coupling Tianlai 2V-10V (101 freq.)
equivalent temperature (mK)
frequency (MHz)


nights 2 3 4 5 6 7 8 9 10
| nightly averaged V | (mK)
frequency (MHz)

Next steps for cross-coupling simulation

- Use more accurate values for Tsys for each receiver, including frequency dependence.
- Repeat calculation for more baselines.
- Does magnitude of the simulated and measured ‘nightly mean’ decrease with baseline length?