Measurements of Receiver Stability

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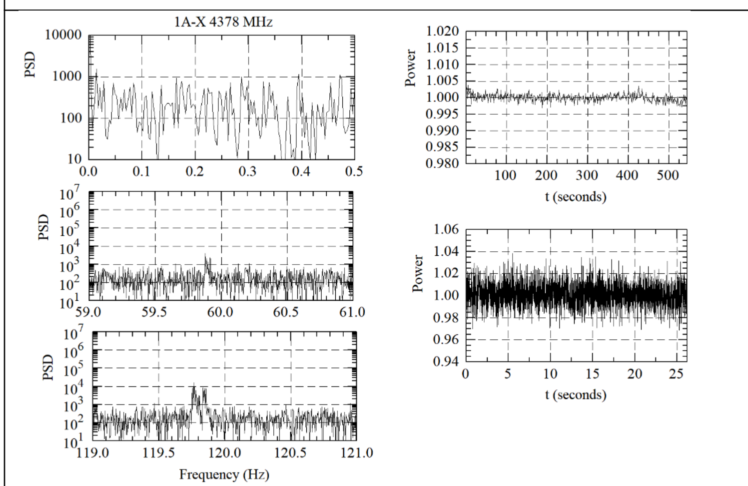
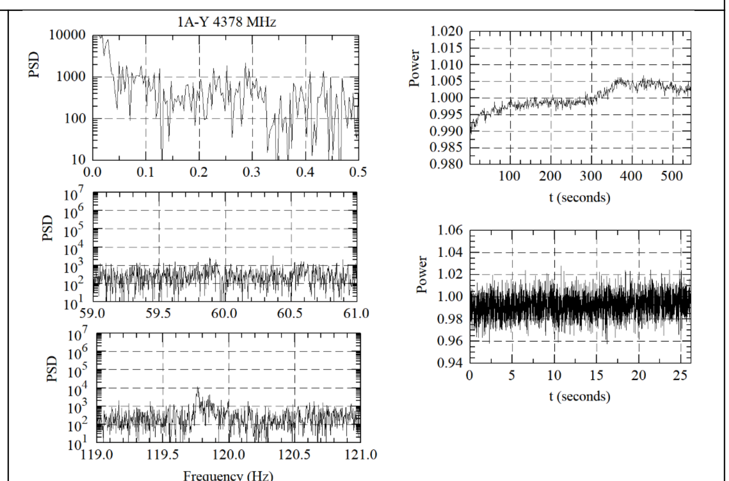
Summary of the detected power and power drifts for the 10 antennae and polarization that were involved in the experiment. All taken from the power vs time centered at 4378 MHz. The time series has 0.001092 sec time resolution, 500,000 samples (i.e 546 seconds duration)

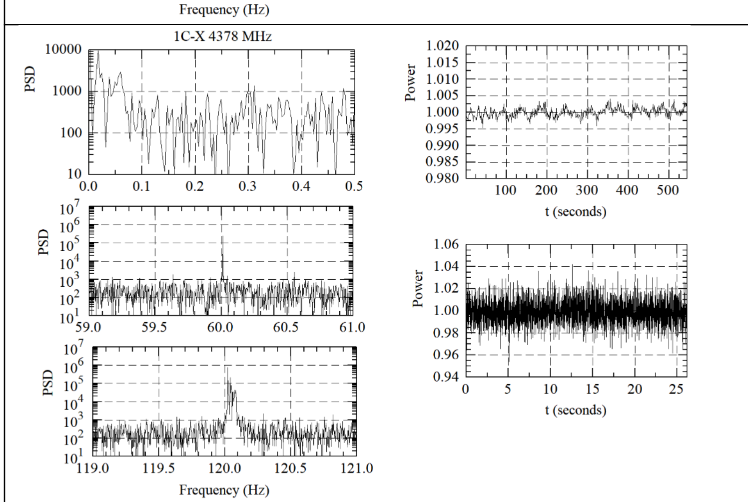
Left three plots in each cell of the table : Subsections of Power Spectra near 0, 60, and 120 Hz. 60 and 120 Hz shows the varying power from system to system of what we are assuming is microphonics from the cryo-coolers. The subsections near zero gives the long-term stability. Only the first 262144 points in the time series were used to create the PSDs.

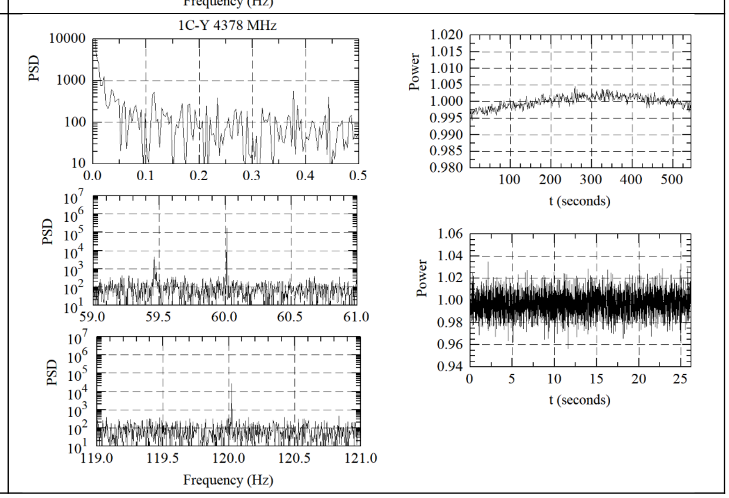
Right-top plot in each cell of the table : The time series of power for the full 546 seconds, smoothed to 1 sec time resolution. Shows time drifts in detectedpower that are longer than 1 sec.

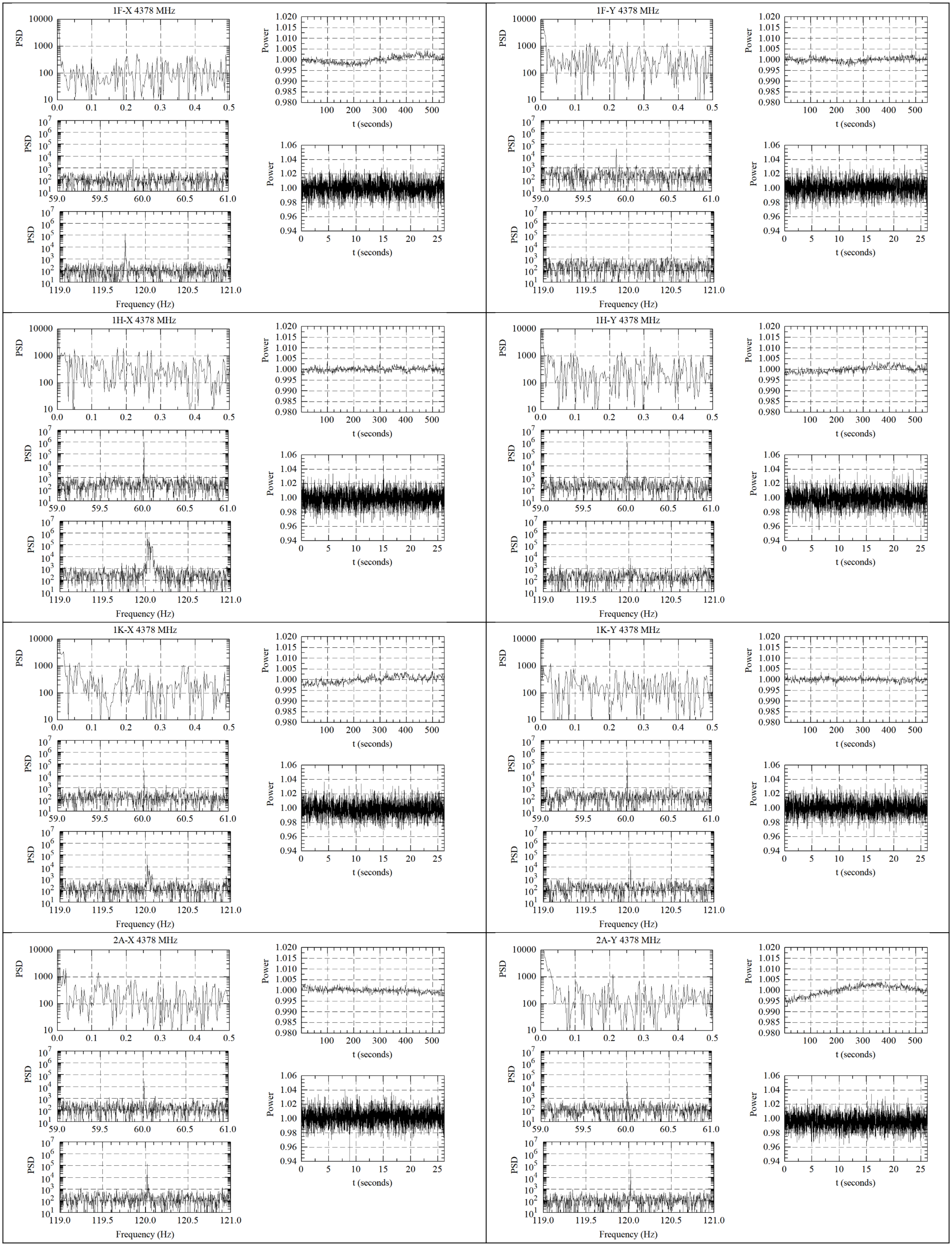
Left-lower plots in each cell of the table : The time series of power for the first 26 seconds, smoothed to 0.01 seconds. Shows the short-term changes in the detected power.



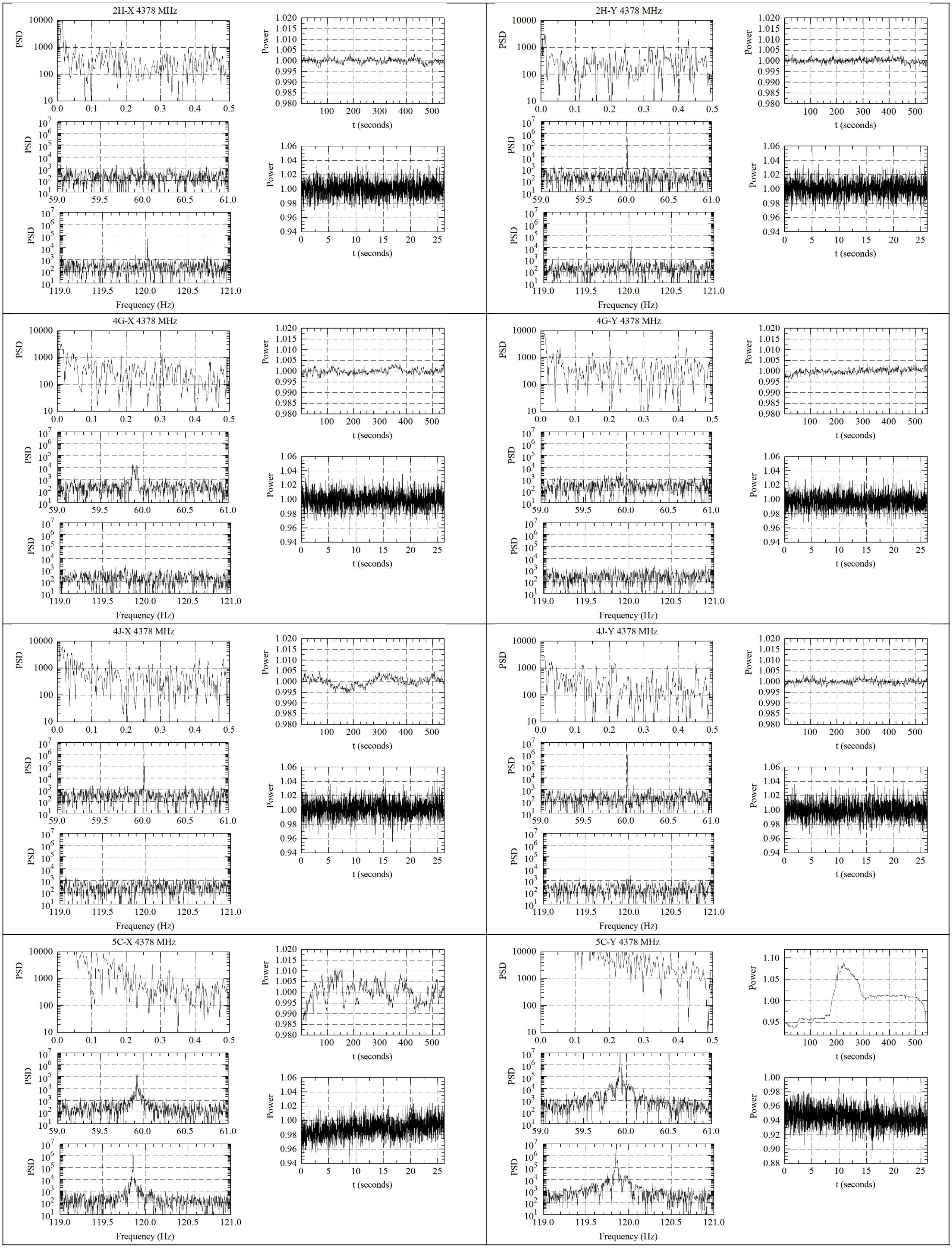








1F-X 4378 MHz
1F-Y 4378 MHz
1H-X 4378 MHz
1H-Y 4378 MHz
1K-X 4378 MHz
1K-Y 4378 MHz
2A-X 4378 MHz
2A-Y 4378 MHz
PSD
Power
Frequency (Hz)
t (seconds)


2H-X 4378 MHz
2H-Y 4378 MHz
4G-X 4378 MHz
4G-Y 4378 MHz
4J-X 4378 MHz
4J-Y 4378 MHz
5C-X 4378 MHz
5C-Y 4378 MHz
PSD
Power
Frequency (Hz)
t (seconds)

To quantify the power changes in the above plots, I'll use the standard way engineers analyze and present system stability:

$$\frac{\sigma_P}{\langle P \rangle} = k \sqrt{\frac{1}{\Delta \nu \cdot \tau} + \left(\frac{\Delta G}{G}\right)^2}$$

$$\tau = N \cdot t_{Sample}$$

$\Delta\nu$ = bandwidth of the time series;

τ = the time over which data are averaged, the integration time

$\Delta G/G$ = represents the magnitude of power changes, whatever the cause.

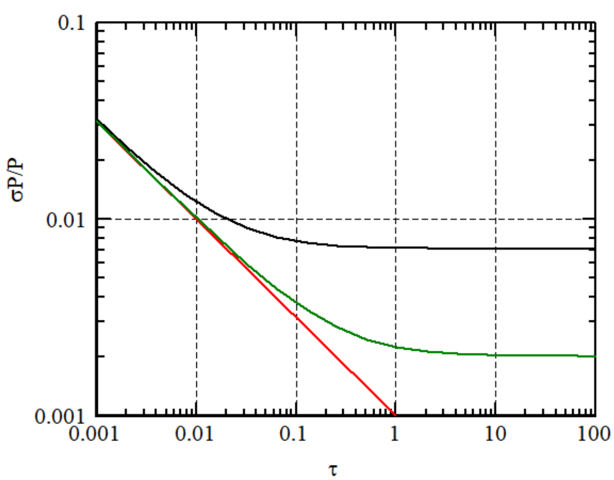
σ_P = the rms of the time series, smoothed to the integration time, τ

<P> = mean value of the time series

t_{Sample} = hardware sample time, 0.001092 sec in our case

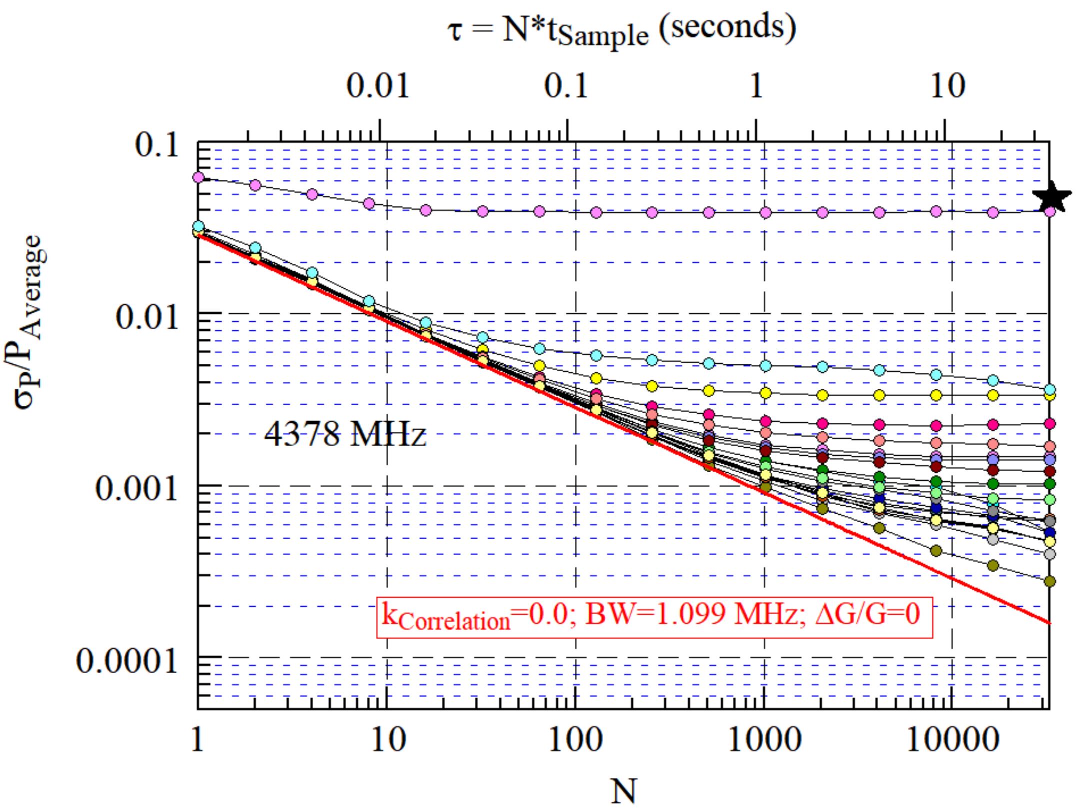
$N = \tau/ t_{Sample}$, the amount by which P is smoothed to derive σ_P

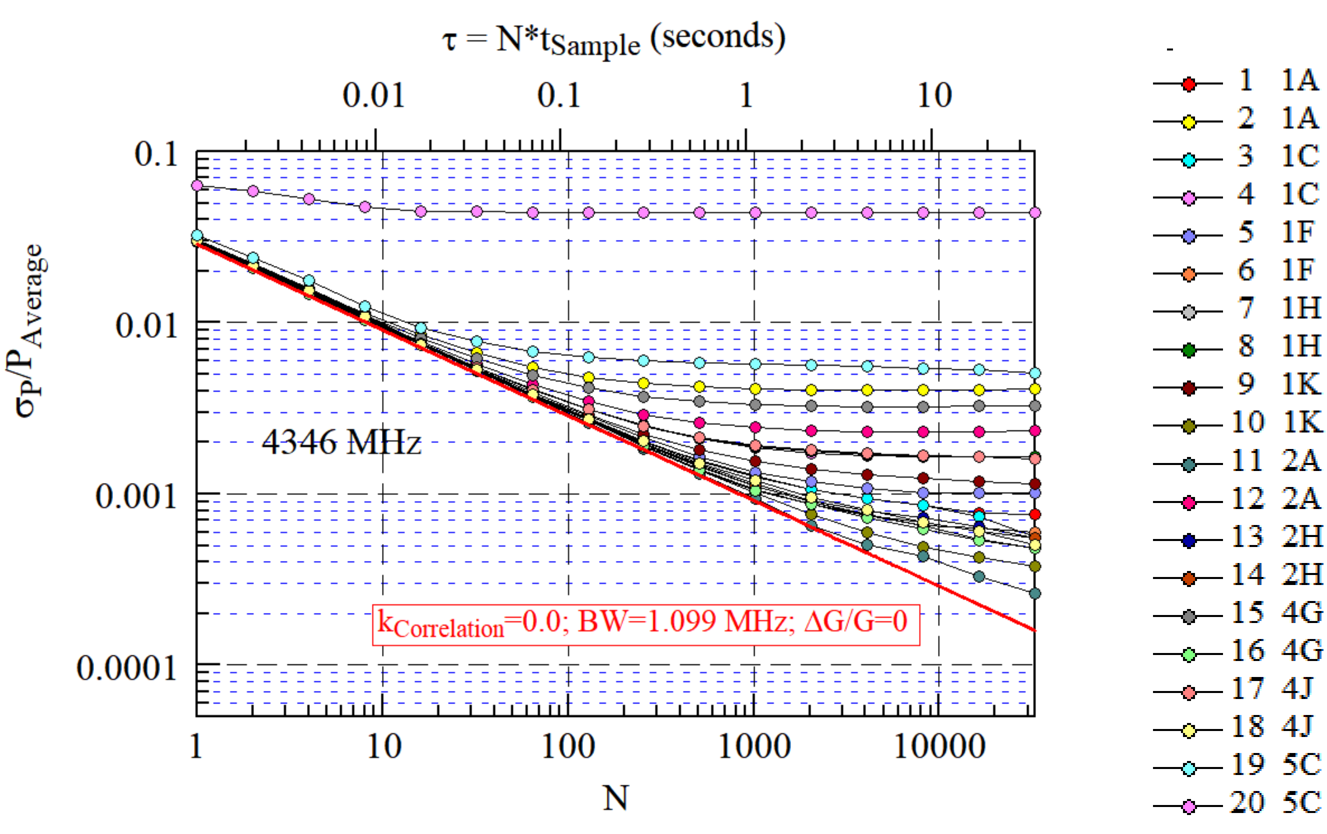
We expect to see, as we vary the amount of smoothing, N, that the fractional noise σ_P/<P> will change as in the following made-up examples. Red is for $\Delta G/G=0$, Green is for $\Delta G/G=0.002$, Black is for $\Delta G/G=0.007$.



At τ longer than some value, the fractional noise no longer decreases with inverse root time and the sensitivity can get no better than $\Delta G/G$. $\Delta G/G$ is, thus, is the sensitivity limit for long observations.

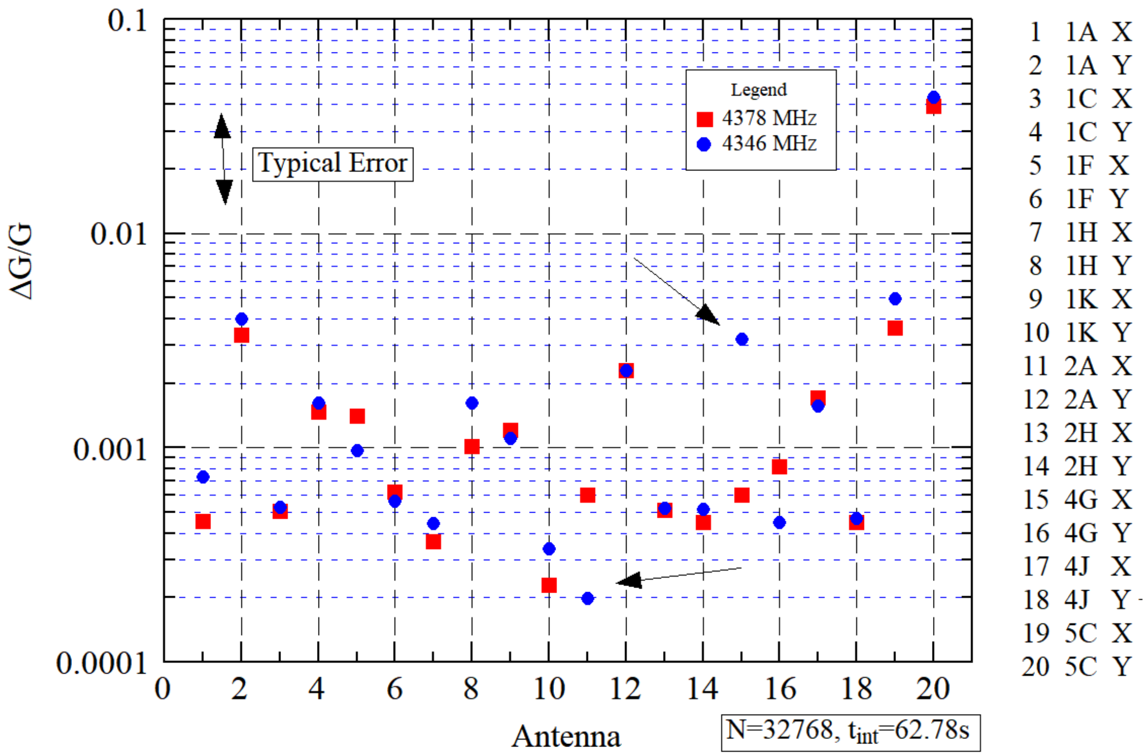
Below shows σ_P/<P> where I've varied the smoothing of the time series of detected powers by N = 2, 4, 8, …, 32768. The plots are for 4378 and 4346 MHz. Analyzing a second frequency allows us to check grossly on our choice of frequencies. The red line is theoretical, based on the known smoothing, sample time, and bandwidth and using $\Delta G/G = 0$ (i.e., a perfect radiometer).



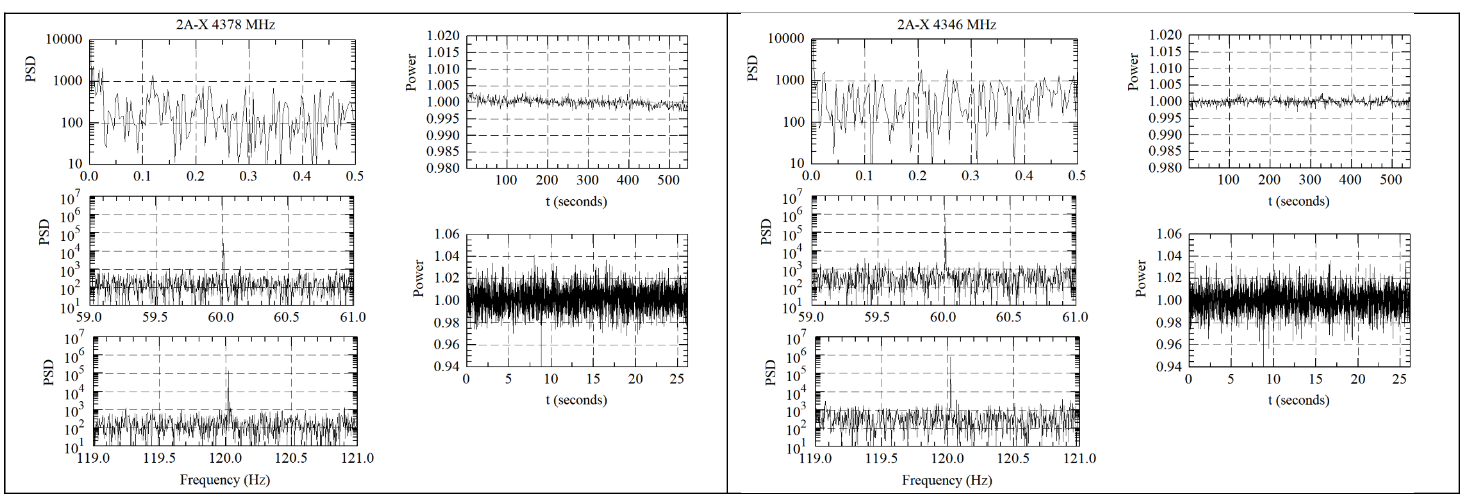


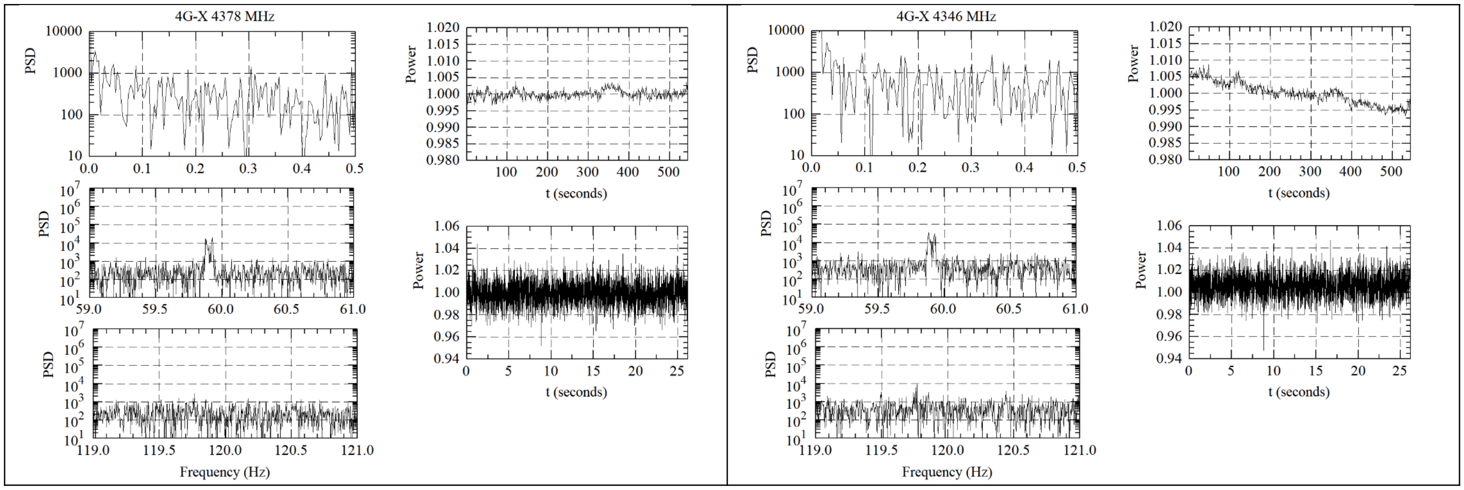
All systems, except 5C-Y follow the shape of the model. The star in the first plot is an estimate of ΔG/G from the tipping and both Moon observations suggested for all of the systems plotted. The various systems have a wide range of sensitivity limits, but only 5C has the sensitivity limit implied by the tipping and Moon observations.

Other than 5C, the last 2 plots are somewhat difficult to use to determine which systems have lower sensitivity limits. To help with the interpretation, I fit the expected radiometer model to the data in the above plots to derive ΔG/G for all systems and for the two frequencies, indicated by red and blue symbols..



In my experience, any system with a ΔG/G < 0.001 is considered good. All but 2A-X and 4G-X have the same ΔG/G at the two frequencies. Below are plots, in the same form as the first set, that compare power series for 2A-X and 4G-X at 4346 and 4378 MHz. The 'knee' near zero in the PSD for 2A-X slightly extends further to the right at 4378 MHz than at 4346. 4G-X has a larger drift in power at 4346 MHz than at 4378 MHz.




4G-X 4378 MHz
PSD
Power
t (seconds)
Frequency (Hz)
4G-X 4346 MHz