GEMINI
8-M Telescopes
Project

TN-C-G0046

Wind Spectra for Gemini

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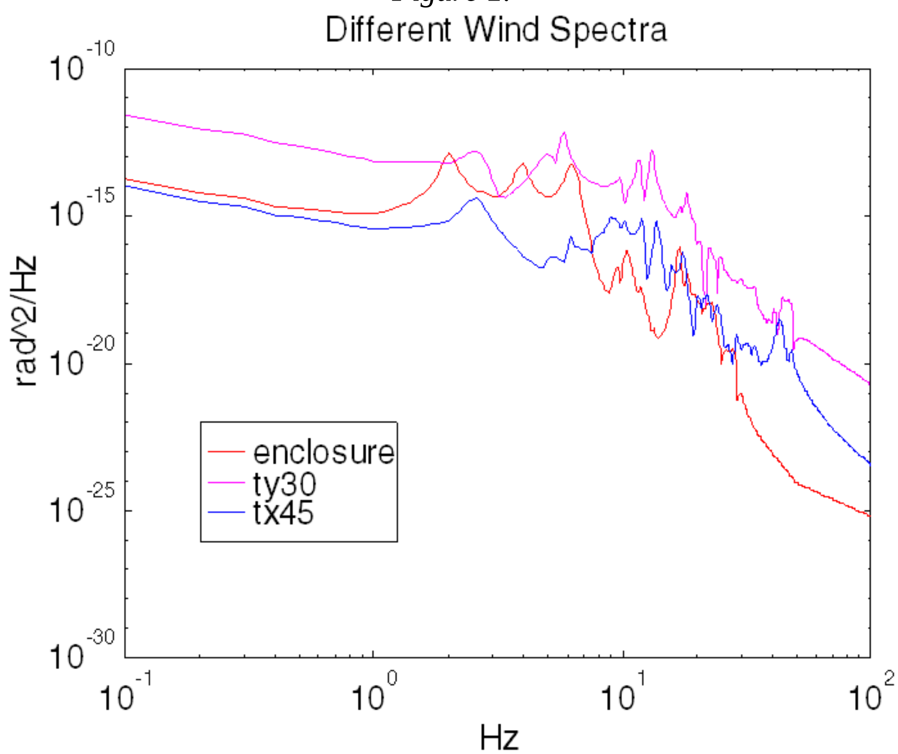
The basis for almost all of the wind spectra used by Gemini is work done by Mike Sheehan and Mike Burns. This has resulted in a number of wind spectra which can be combined in a number of ways to simulate worst case and typical conditions. There are calculated for the nominal 70th percentile wind conditions, 11 m/sec.

- encl - movement in focal plan due to wind shake of enclosure coupling to telescope
- tx45 - movement in focal plane with telescope at alt=45 and wind from side
- ty30 - movement in focal plane with telescope at alt=30 and pointing in to wind

Figure 1.

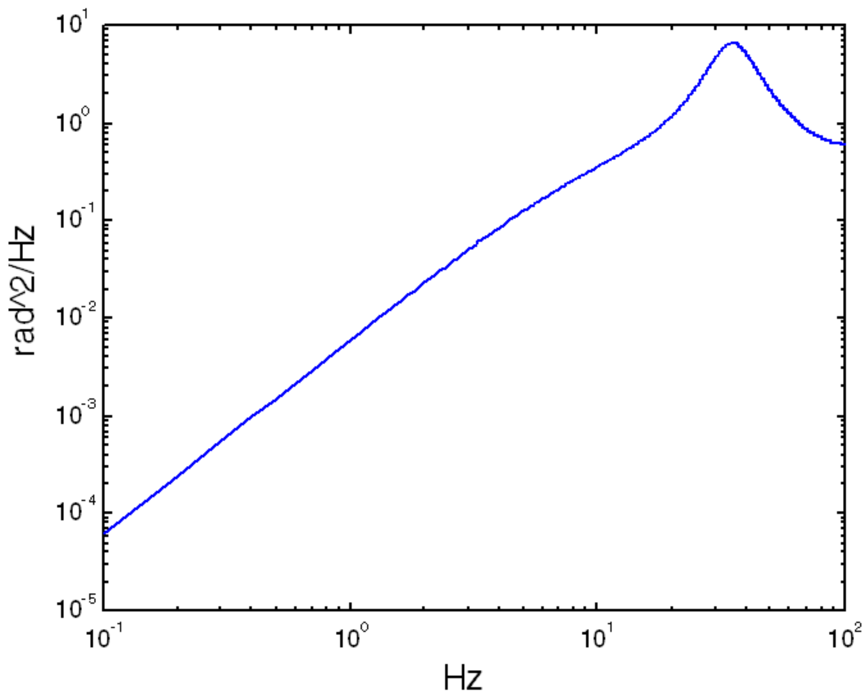


The uncompensated image motion due to these spectra are, individually:

- encl - 0.0720 arcsec RMS jitter in LOS
- tx45 - 0.0179 arcsec RMS jitter in LOS
- ty30 - 0.2323 arcsec RMS jitter in LOS

For the predicted performance of the Lockheed tip/tilt system we have the following filter function (assuming a 25 Hz closed loop band width for delivered system)

Figure 2.



The compensated image motion due to these spectra after the filter function are, individually:

- encl - 0.0217 arcsec RMS jitter in LOS
- tx45 - 0.0070 arcsec RMS jitter in LOS
- ty30 - 0.0825 arcsec RMS jitter in LOS

The worst case situation is pointing in to the wind with the telescope at an altitude of 30 degrees. In this case one would have the combination of ‘encl’ and ‘ty30’. However as the direct windshake drops very quickly as one goes up in altitude or as one goes away from pointing in to the wind this would not be typical.

A more typical case would be with the wind coming from the side and the telescope pointing at an altitude of 45 degrees (there is very little difference in the direct windshake from the side with altitude). In this case one would have a combination of ‘encl’ and ‘tx45’.

The uncompensated image motion due to these spectra are, individually:

- worst - 0.2432 arcsec RMS jitter in LOS
- typical - 0.0742 arcsec RMS jitter in LOS

The compensated image motion due to these spectra after the filter function are, individually:

- worst - 0.0853 arcsec RMS jitter in LOS
- typical - 0.0228 arcsec RMS jitter in LOS

Figure 1 - Comparison of Worst and Typical Cases - raw

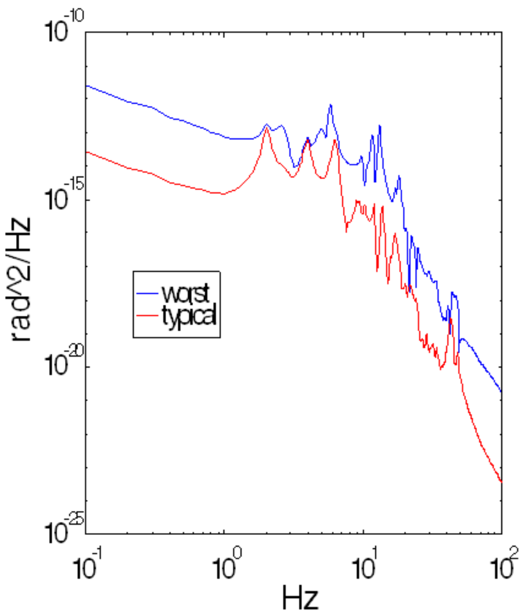
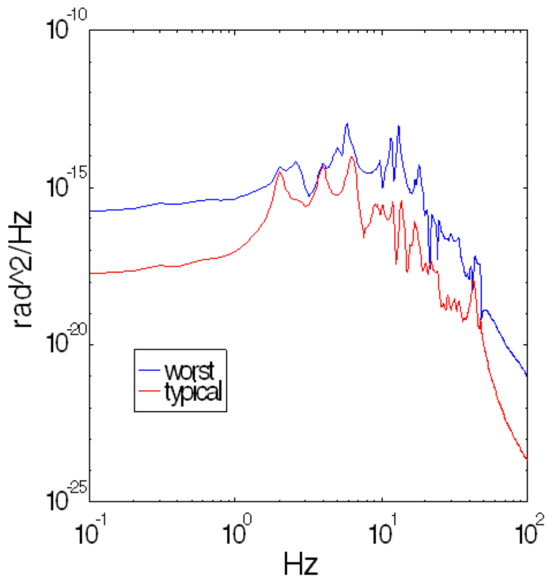


Figure 2 - Worst and Typical after Compensation by M2



However, it is not practical to use these original uncompensated and compensated power spectra to design systems as there are significant peaks and troughs in them which cannot be guaranteed to be present at those locations in the delivered system. In the worst case one could design a servo system which used notch filters t these predicted locations, only to find in reality that his was worse than no servo system at all !!

So we have derived spectrum models with the goal that they have the same spectral signature before and after compensation as well as similar RMS values.

Figure 4 - Actual and Fit for Worst Case after M2 Compensation

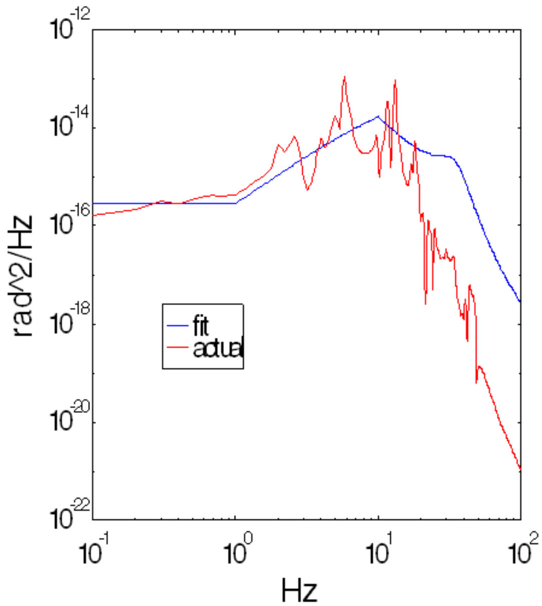
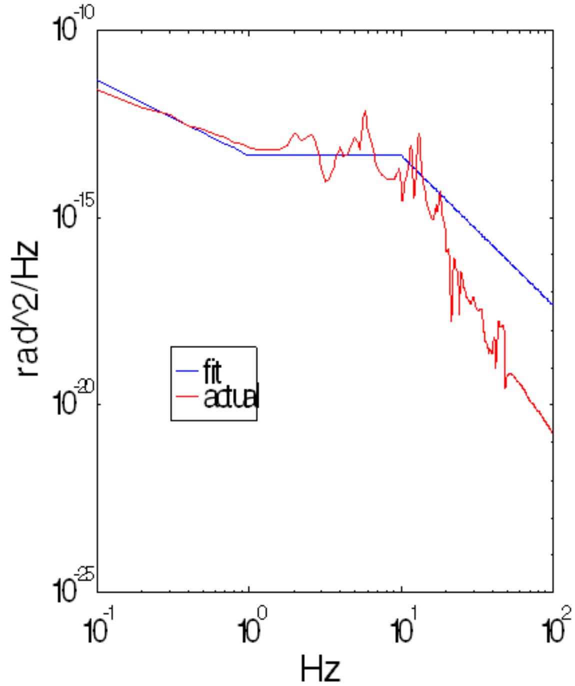


Figure 3 - Actual and Fit for Worst Case



For the worst case a comparison of the RMS values yields (in arcsec RMS jitter in LOS):

Table 1.

	Before Compensation	After Compensation
Actual	0.2432	0.0853
Fit	0.2357	0.0910

Figure 5 - Actual and Fit Data for Typical Case

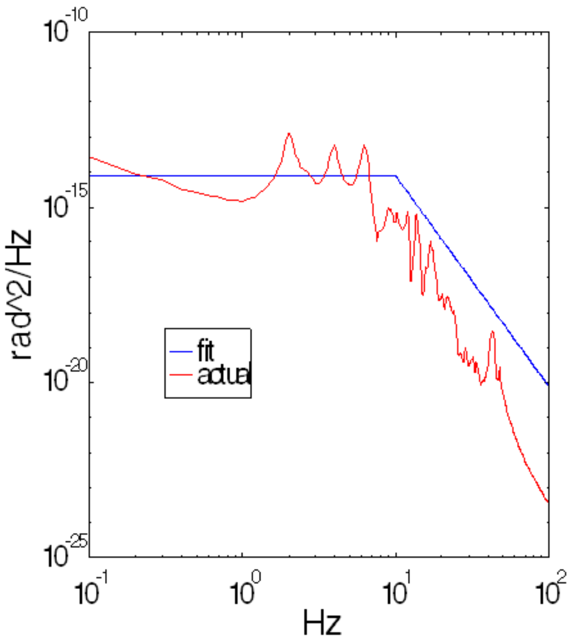
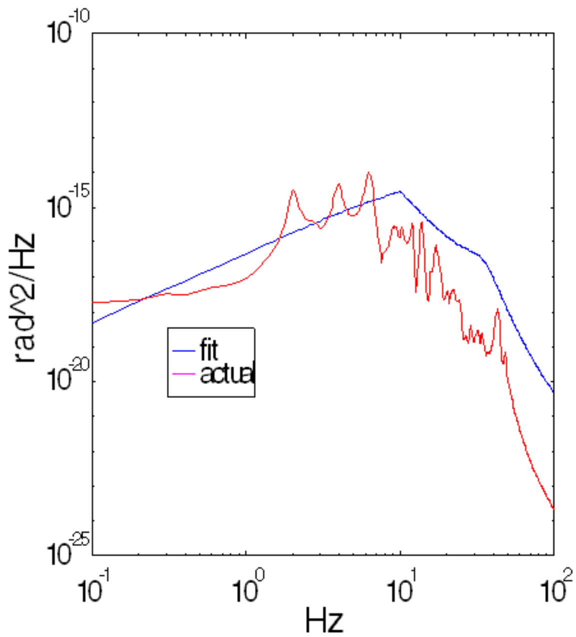


Figure 6 - Actual and Fit for Typical Case after M2 Compensation



For the typical case a comparison of the RMS values yields (in arcsec RMS jitter in LOS):

Table 2.

	Before Compensation	After Compensation
Actual	0.0742	0.0228
Fit	0.0638	0.0292

The actual fits used for the uncompensated power spectra are (the compensated spectra are just the uncompensated multiplied by the filter function.

Table 3.

	f < 1 Hz	1 Hz < f < 10 Hz	f > 10 Hz
Worst	$\frac{4.7e-14}{f^2}$	4.7e-14	$\frac{4.7e-10}{f^4}$
Typical	0.491e-14	0.491e-14	$\frac{0.491e-8}{f^6}$

A Better Wind Spectrum

It is possible to get a much better fit to the wind spectrum than is presented. In order tod this we will consider the typical wind case, and compare the RMS within the frequency bands of 0.1-1, 1-10, and 10-100 Hz. We will adjust the fit so that the sum of the variances within each band are a minimum for both before and after compensation.

It turns out that the best fit for the typical case is obtained with:

for f < 6.4 Hz P = 1.8576e-014
for f > 6.4 Hz

$$P = \frac{1.8576e-014 * 6.4^8}{f^8}$$

where P is measured in rad^2/Hz

Figure 7 - Finding the best fit

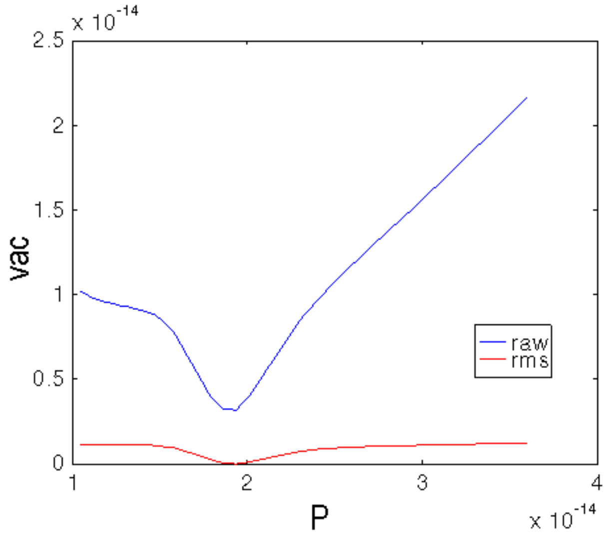


Table 4.

	Before Compensation	After Compensation
Actual	0.0742	0.0228
Fit	0.0758	0.0228

Figure 10 - fit to compensated typical

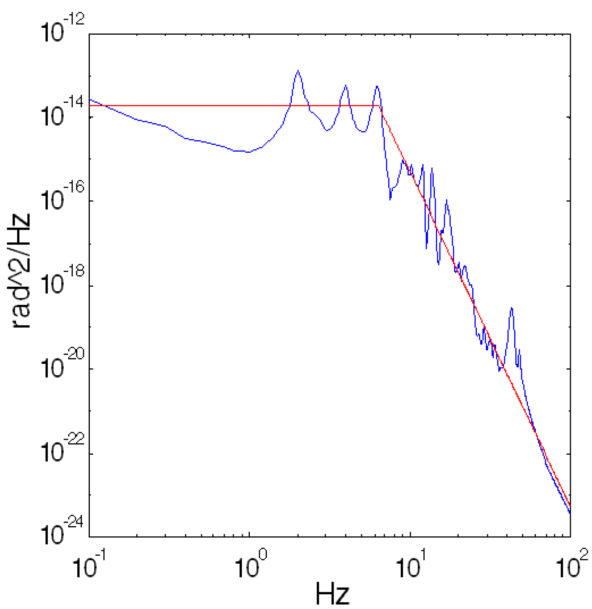
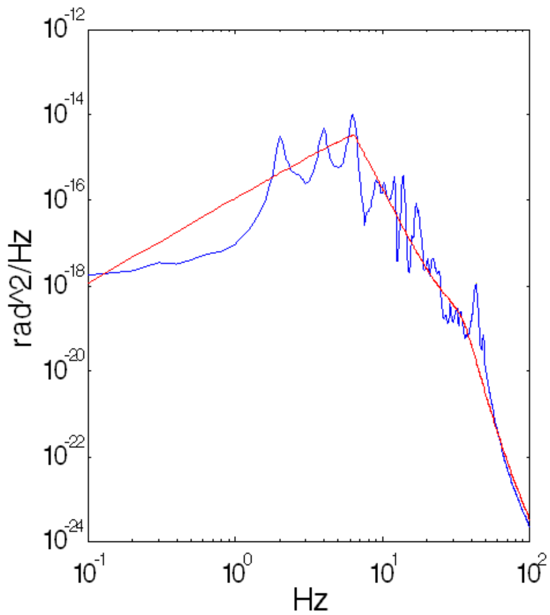


Figure 11 - Fit to uncompensated typical



Wind Spectra for Adaptive Optics

For this application it may still prove that the typical wind spectrum for 70th percentile wind conditions is too severe. In this case there it is possible to extrapolate what the wind spectrum would be for median wind conditions, 8.4 m/sec. We will assume that the power spectrum is proportional to V^4, as would be expected from first principles, then the power spectrum is multiplied by the factor 0.3401.

In this case the fit is:

for f < 6.4 Hz $\quad P = 1.8576e\text{-}014*0.3401\ \mathrm{rad}^2/\mathrm{Hz}$

for f > 6.4 Hz $\quad P = \dfrac{1.8576e-014*0.3401*6.4^8}{f^8}\ \mathrm{rad}^2/\mathrm{Hz}$

Table 5.

	Before Compensation	After Compensation
Actual	0.0433	0.0133
Fit	0.0442	0.0133

Figure 12.

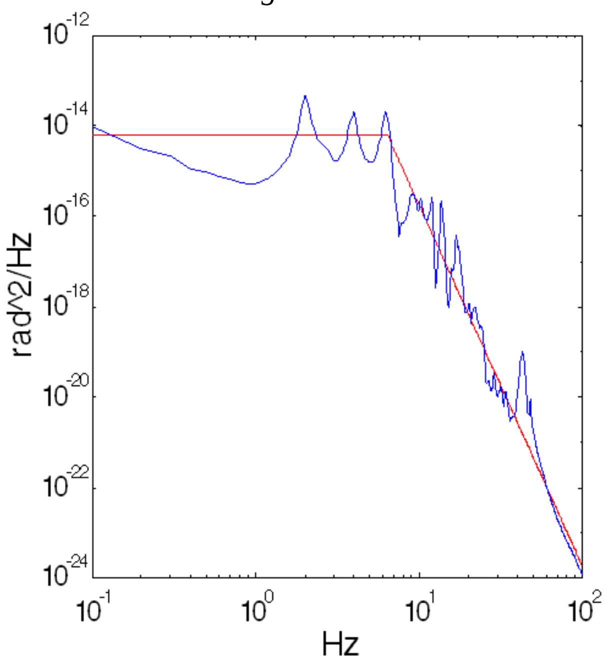


Figure 13.