Upconversion at the Hanford 4k

November 10, 2006

Abstract

Tests on the Livingston interferometer in August 2006 indicate that the upconversion noise seen in the LIGO 2km and 4km interferometers arises from a $F \propto 1/f^2$ noise force local to the magnet and coil actuators. The noise depends on the coil drive current like $\sqrt{f_{drive}}$ for frequencies between 1 and 10 Hz. By modifying the local damping and ASC suspension notches for the H1 test masses with the goal of reducing coil currents, we effected a decrease in the excess DARM_ERR noise between 40 and 100 Hz. The reduced noise had a $F \propto 1/f^2$ force law similar to the tests at Livingston. Further improvements can be made to H1, and similar improvements should be made ot H2 and L1 with the aim to reduce the coil current RMS.

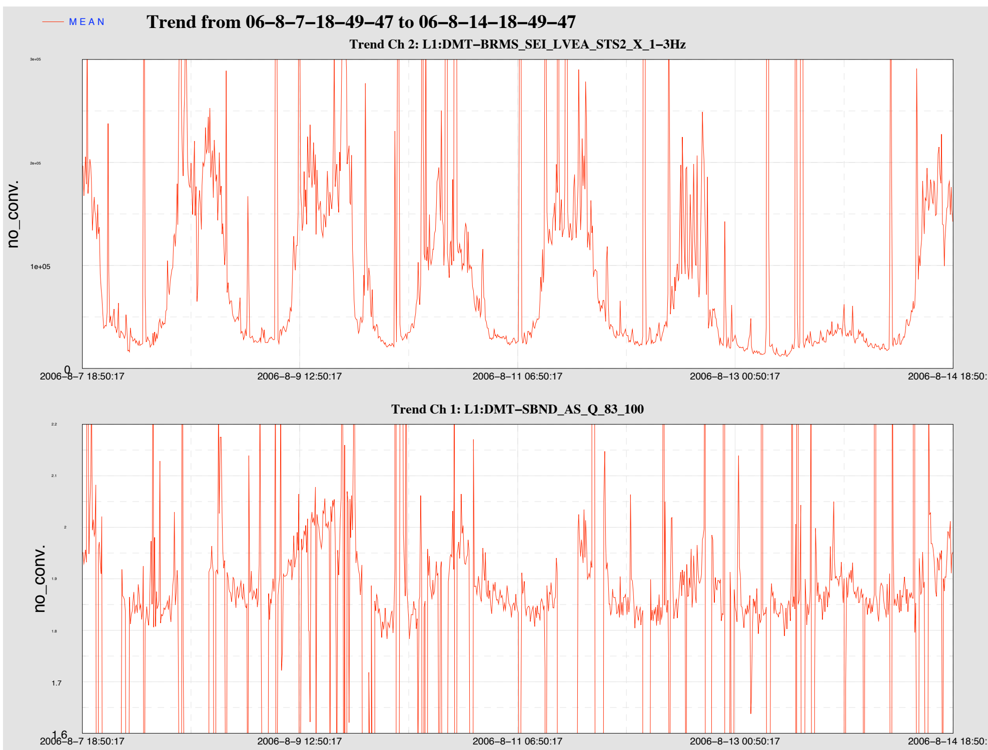

Figure 1: One week trends of the LLO seismic and gravity wave channels. The 1-3 Hz shows a daily period of increase that is reflected in the 83-100 Hz band.

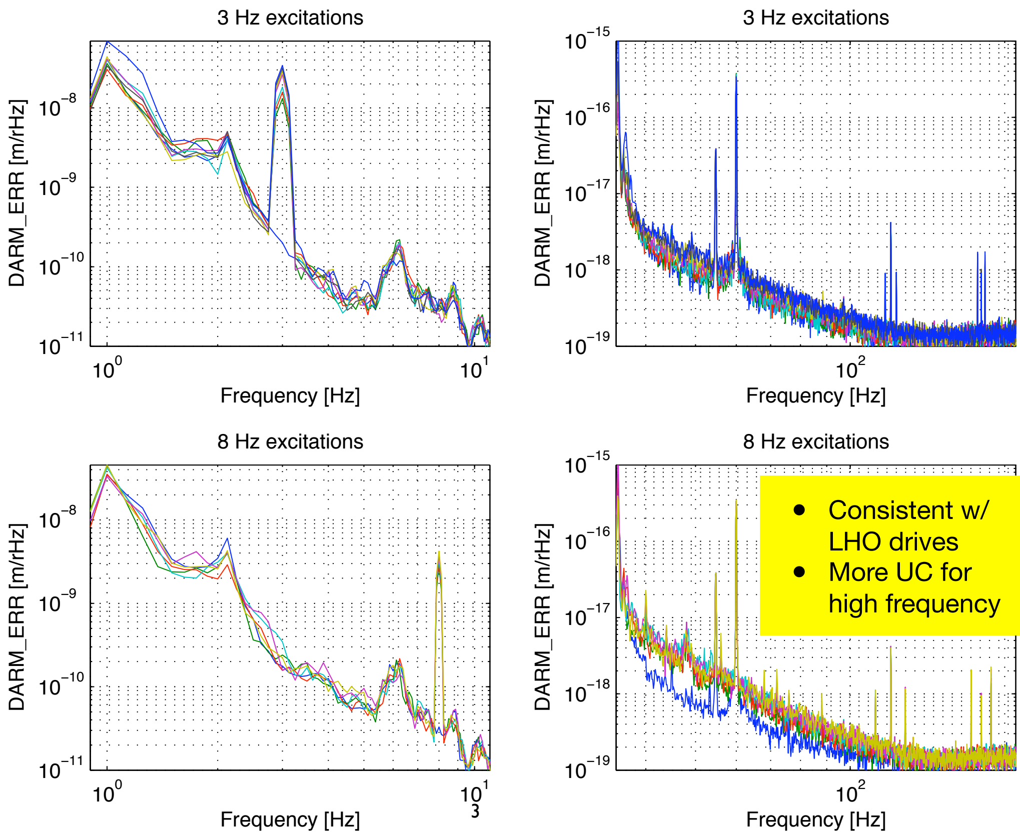

Figure 2: We tested L1 in August by injecting narrowband sinewaves into L1:ETMX-LSC_EXC and L1:ETMY-LSC_EXC at frequencies fro 3 to 10 Hz. The injections all showed a displacement noise varying like $1/f^4$.

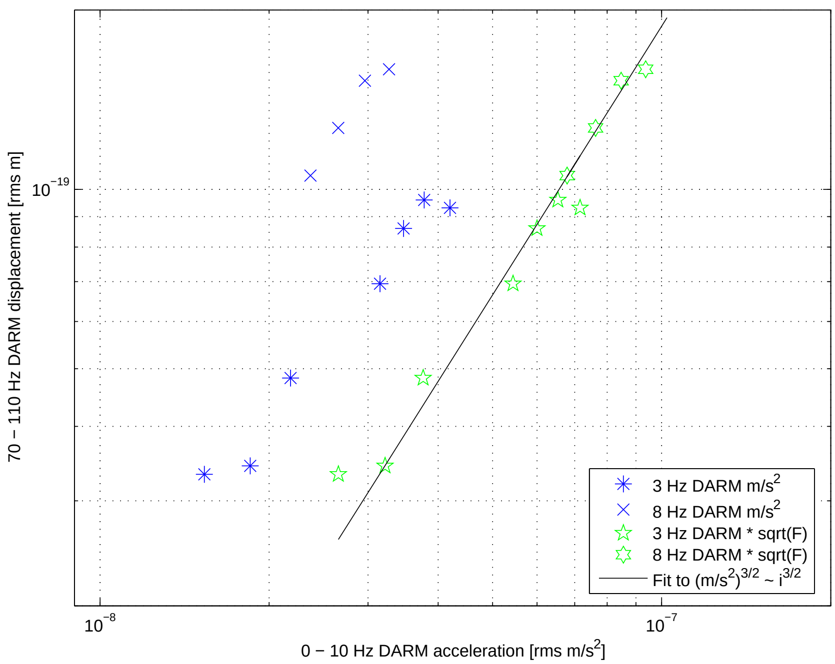

Figure 3: We took good amplitude sweeps for 3 Hz and 8 Hz injections. The degree of upconversion between the two cases is inconsistent unless you assume a $\approx \sqrt{F}$ frequency dependence and a $\approx i^2$ drive dependence. This needs more data to nail down.

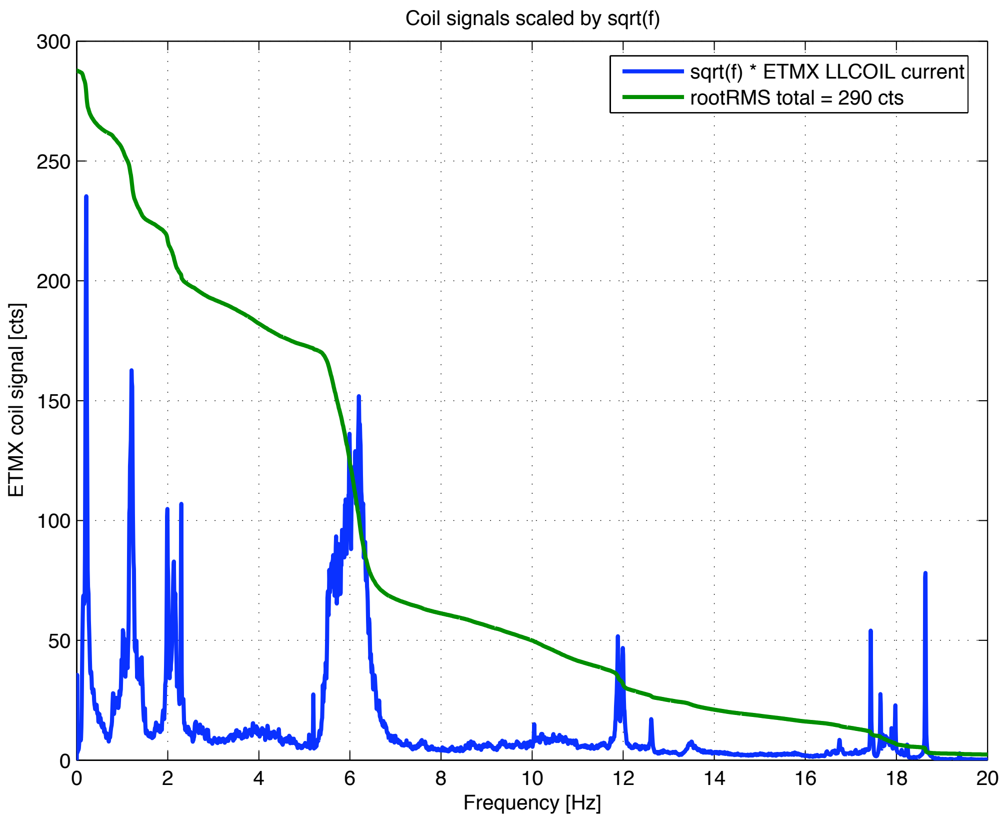

Figure 4: In light of the Livingston measurements in which the upconversion noise was seen to scale with the drive frequency like $\sqrt{f_{drive}}$, this plot shows the total ETMY coil signal multiplied by $\sqrt{f}$ and the corresponding RMS. The 6 Hz structure is seen to take a much larger fraction of the RMS, roughly 100 counts out of 290 counts.

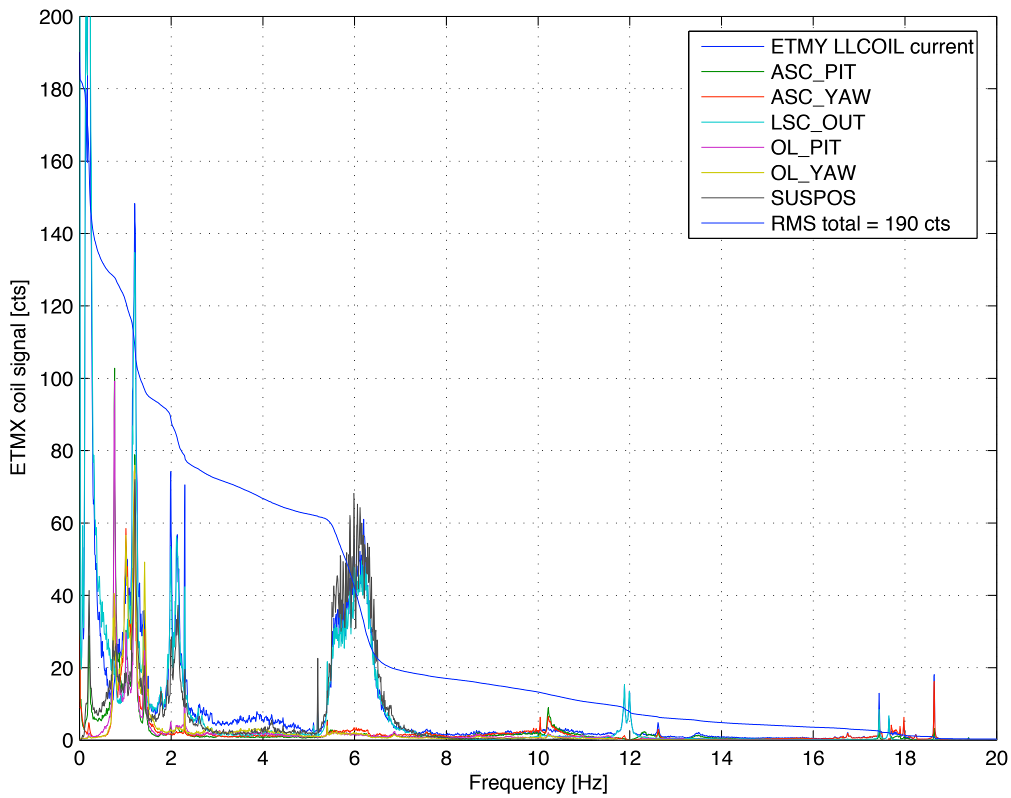

Figure 5: A power budget of the signals being sent to H1_ETMY_LLCOIL_IN. Each trace is a power spectrum of the output of the corresponding filter bank and does not correctly account for the coherences between signal paths. However, of particular concern is the broad 6 Hz resonance associated with BSC stack modes. Of the total coil RMS of 190 counts, $\approx$ 50 cts is associated with the 6 Hz modes. The dominant contributors to the 6 Hz modes are the SUSPOS and LSC loops, suggesting that the local damping filters are adding seismic motion to the test masses which the LSC loops must then cancel. This has particular effect on the Input test masses which receive no LSC signal.

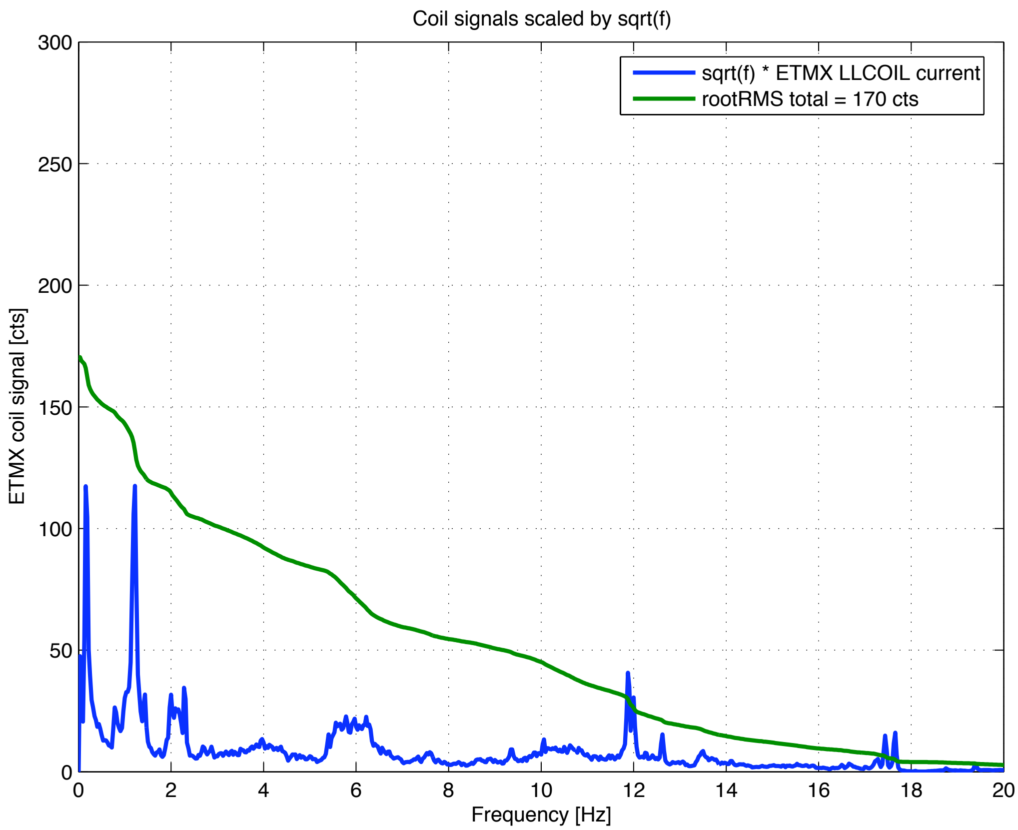

Figure 6: The ETMY Coil currents, scaled by $\sqrt{f}$, using modified H2-style SUSPOS filters and with the SUSPOS gain reduced by a factor of 2. The 6 Hz structure has been greatly reduced from 100 counts to 10 counts, and the total weighted RMS has been reduced from 290 counts to 170 counts. The IFO successfully locks with the lower damping gain and resulting higher pendulum Q. A more drastic, and potentially more beneficial solution, is to disable the damping filters on the ETMs once the IFO has acquired lock. Also, new damping filters with notches at the 6 and 10 Hz BSC modes have been successfully tested on H2 and could be installed on H1.

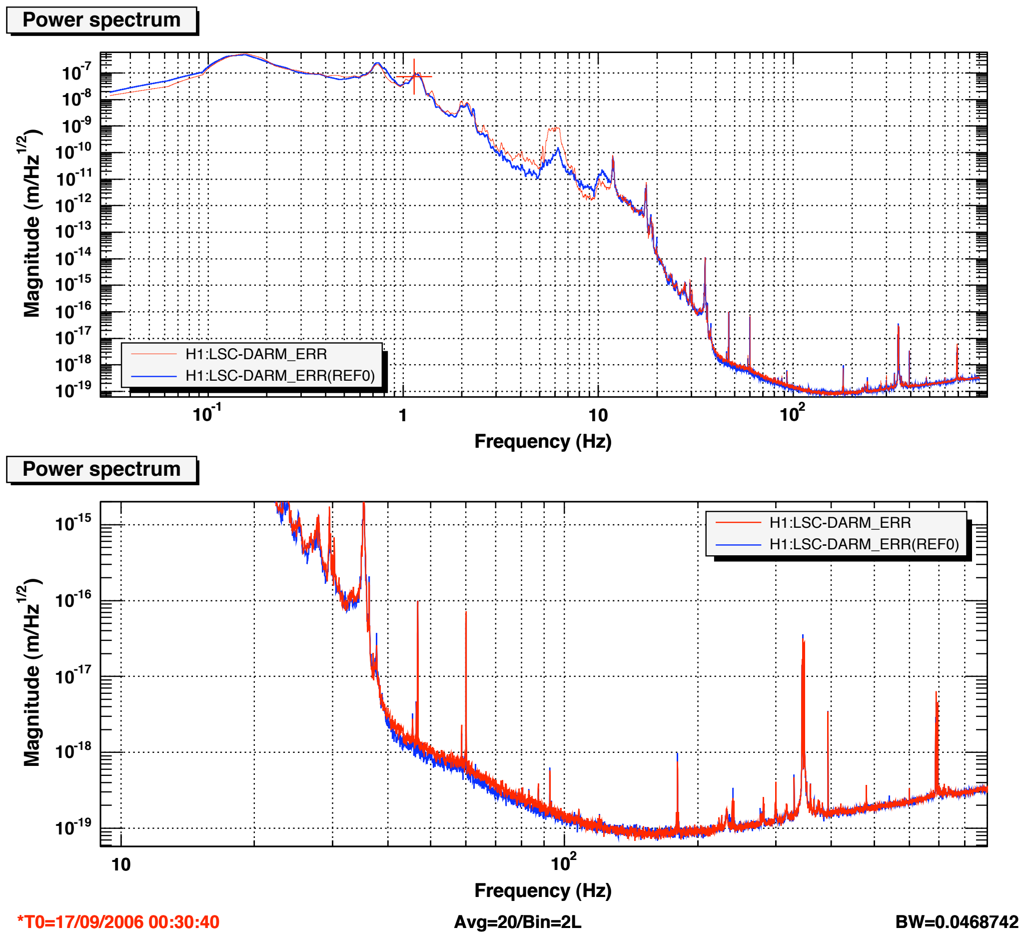

Figure 7: The H1 calibrated DARM_ERR spectrum with new (and permanently installed) ASC notches, the temporarily installed H2 style damping filters, and the damping gain divided by two, compared to a time with the standard old style damping filters. The top panel shows the effect on the low frequency DARM spectrum - The 6 Hz monstrosity is reduced at the expense of an excess at 10 Hz. The lower panel shows the improvement in the mystery noise region; a broad band reduction in the noise from 40 to 100 Hz. These two spectra were taken 2 hours apart from each other.

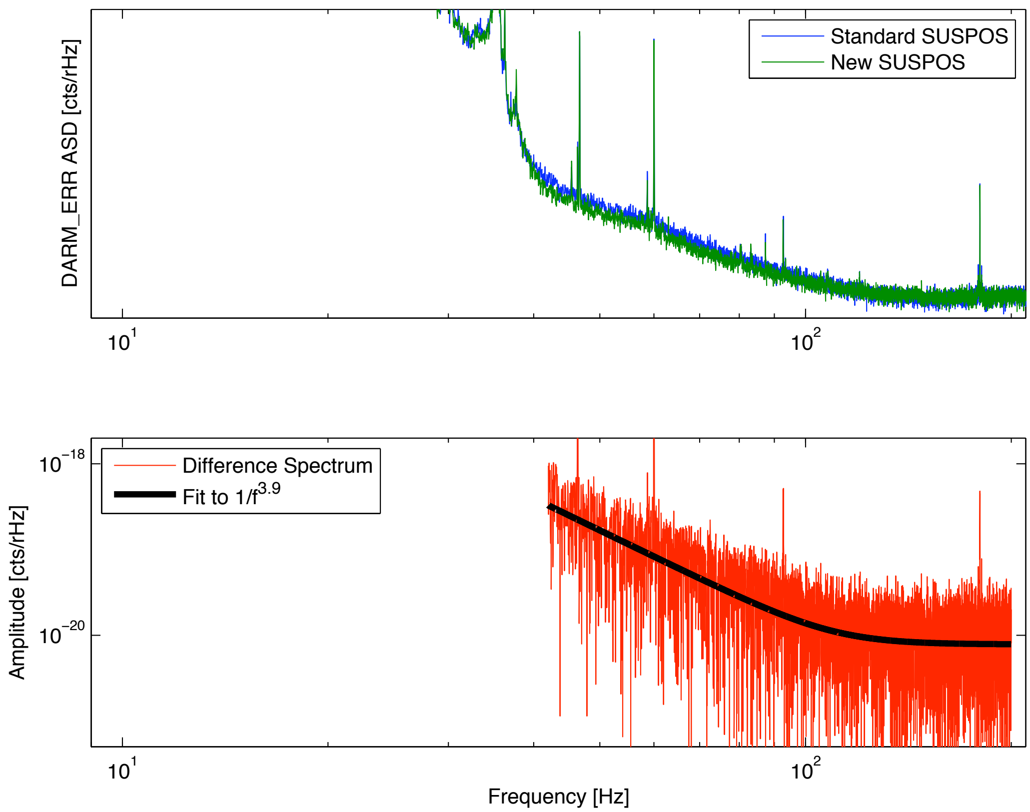

Figure 8: The difference between calibrated H1 DARM_ERR spectra with and without the H2-style filters. The noise is well fit with a $1/f^4$ power law between 40 and 120 Hz. This fit has 3 free parameters: the background level (which should be calculated but wasn't), the noise amplitude and the power law index. The LLO test data also showed a strong $1/f^4$ power law when the noise was generated by loud, narrow-band excitations and the noise was significantly larger.

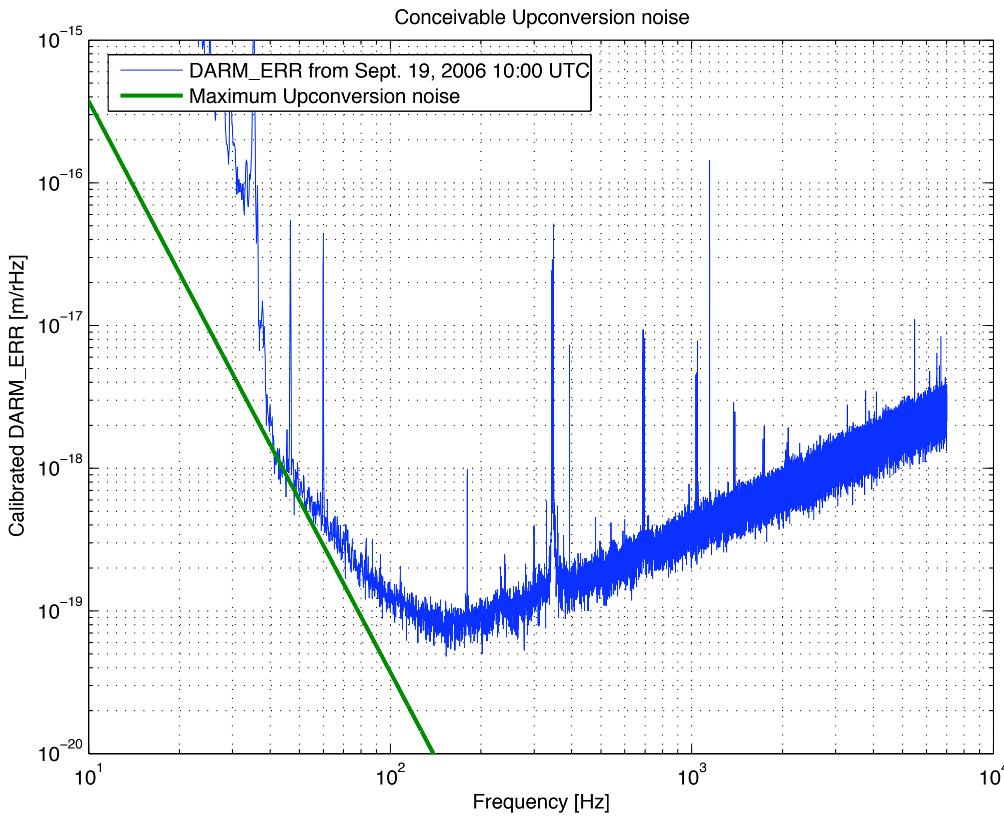

Figure 9: We can maximally estimate the upconversion contribution to the DARM_ERR spectrum by calculating the maximum amount of $1/f^4$ noise to consistent with the spectrum. In practice, this is equivalent to setting the noise at 40 Hz to be entirely due to upconversion. The current H1 noise budget from Sept 24th has the MICH noise contribution at 40 Hz looking like $1/f^4$. Does MICH see the upconversion noise as well? We will try to empirically model the variation and coupling of the noise in order to create an appropriate noise budget term.