LIGO

PROPERTIES OF ANTHROPOGENIC SEISMIC NOISE IN LIVINGSTON

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LSC Meeting @ Hanford August 16, 2001

LIGO

Issues

- Spiky seismic noise 1 - 3 Hz band

  related to human activity

  coincident with transmission peak in test mass isolation stack

  precludes interferometer lock during work day

  Rayleigh surface waves: vertical/horizontal = 1.5/1, 200 - 300 meters/sec

  worst at y end, appears as wide band noise through narrow band filter

- Most likely growing with epoch, tracking population

  1988 LSU survey: not evident

  1995 Rohay study: about 1/2 as large and 1/2 rate of today

  need to include margin in fix

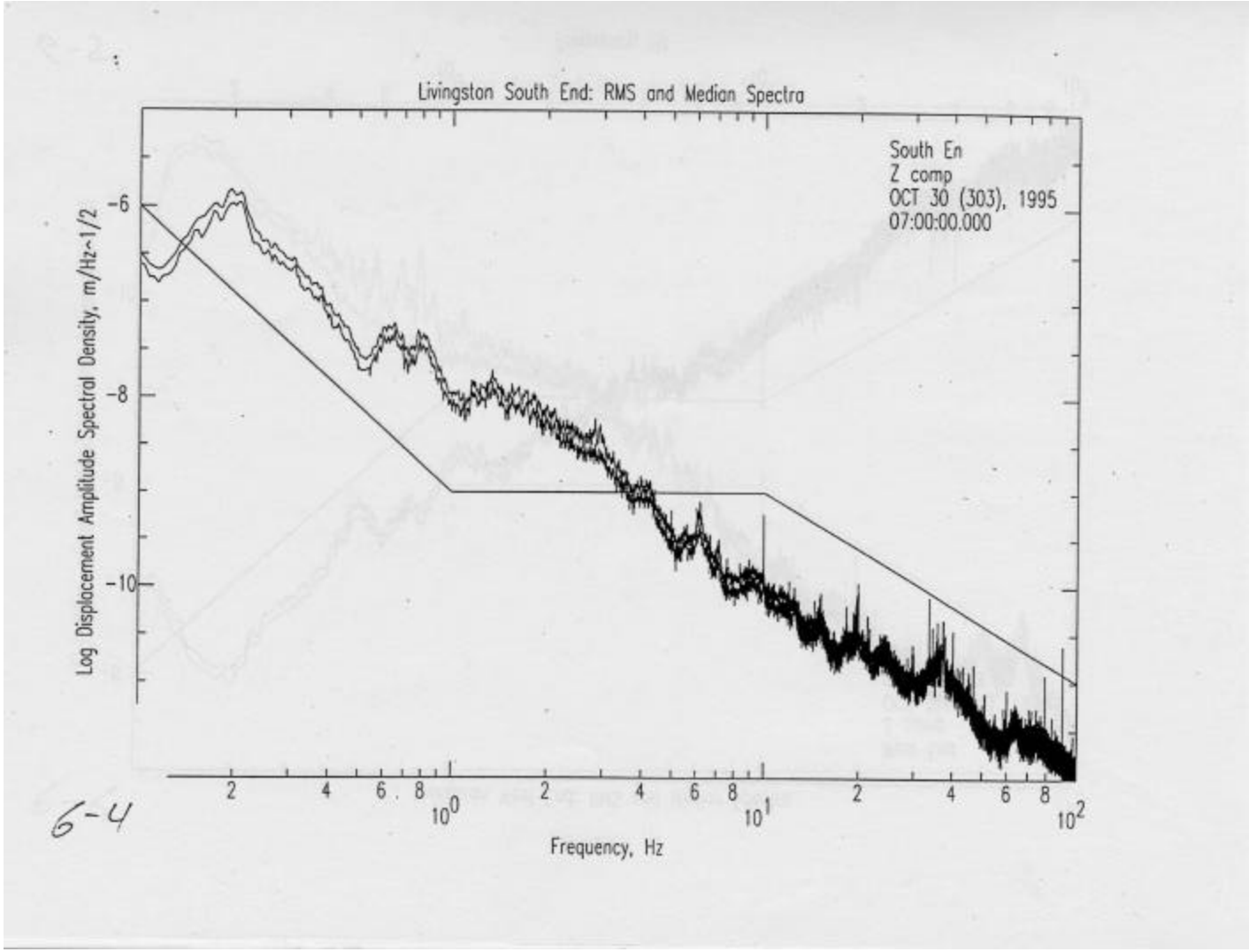
- Strategy to deal with the noise

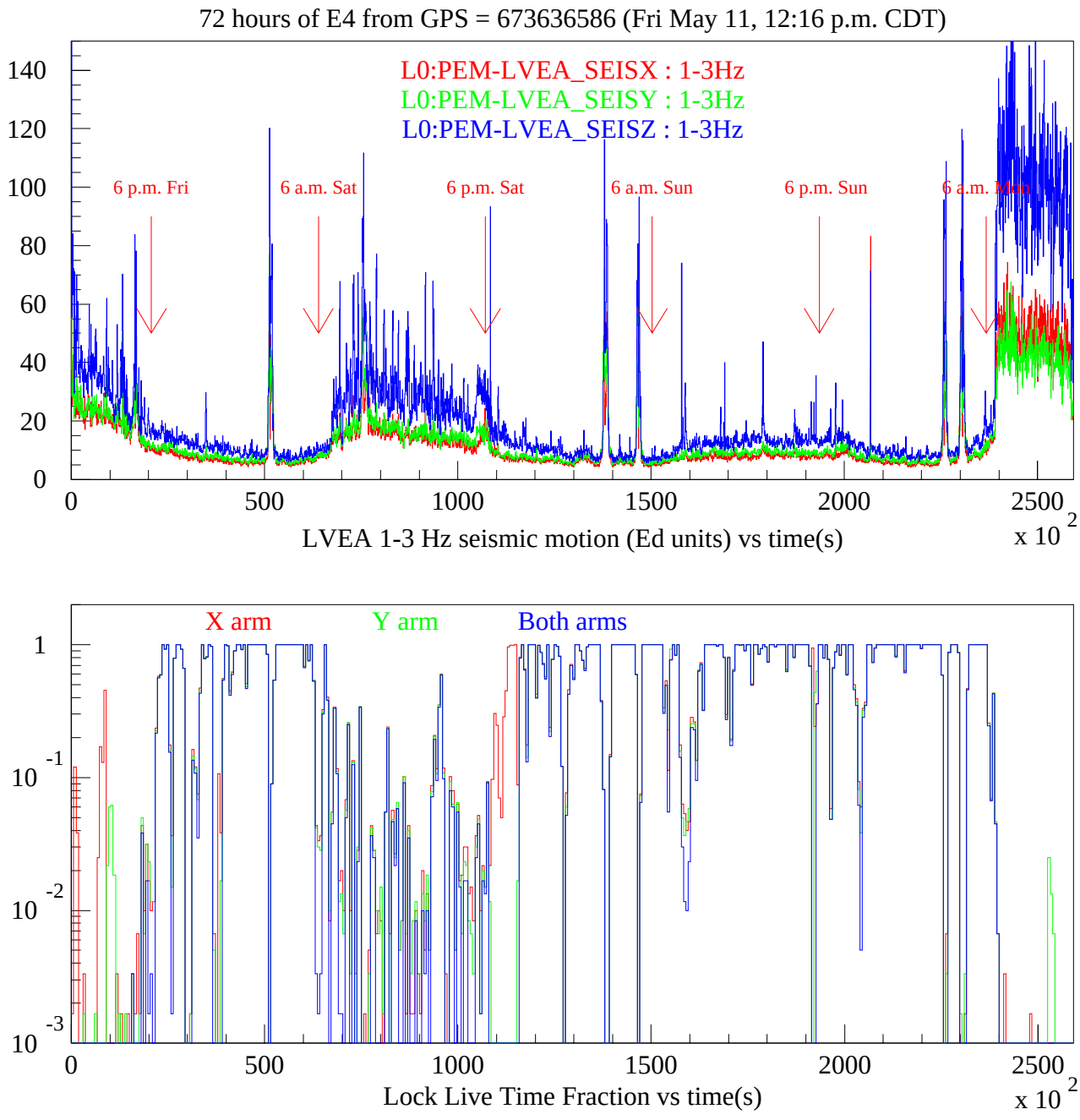
  higher peak current controller: short term, adds noise

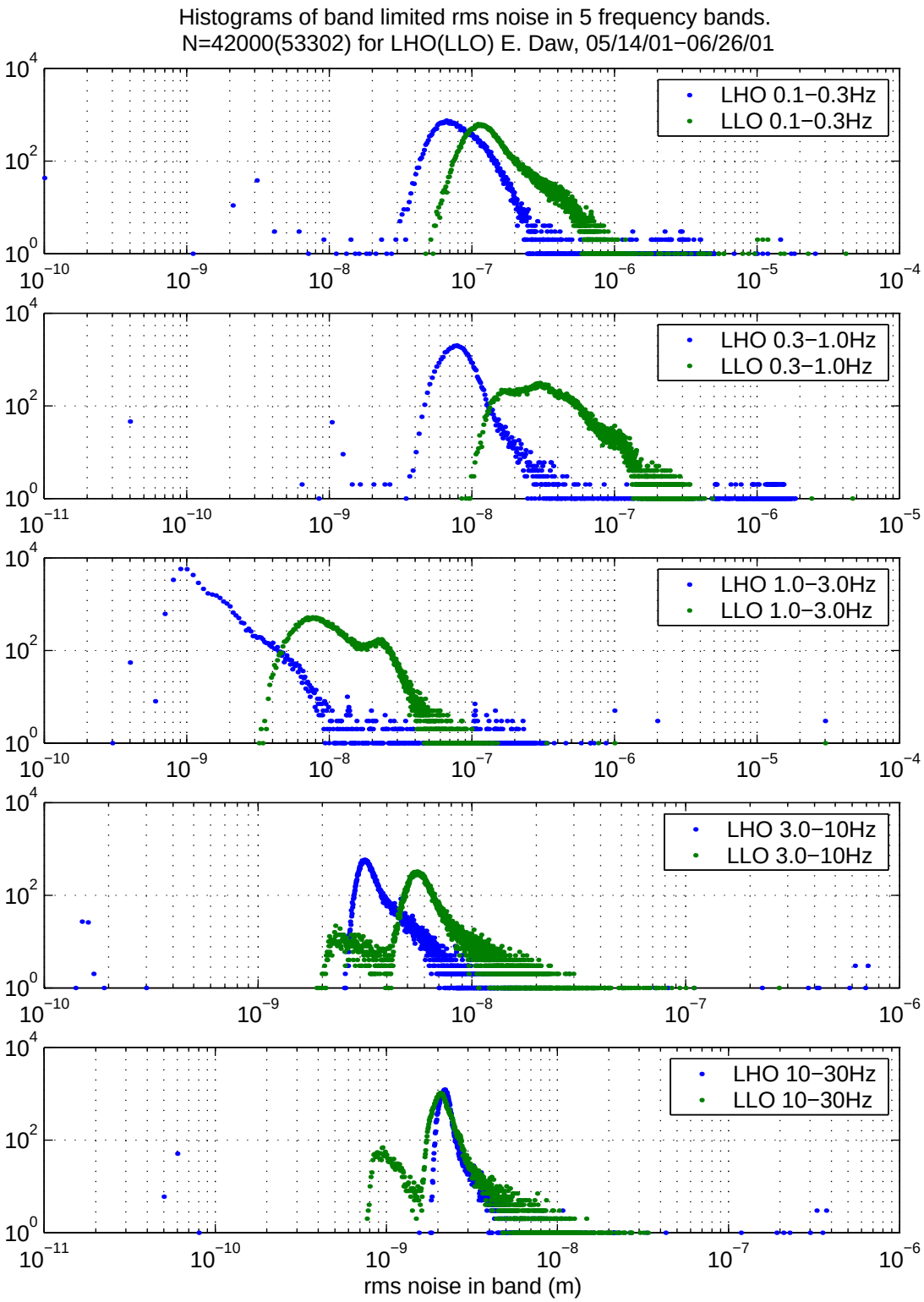
  active external isolation: short study, feedback, feed forward…….

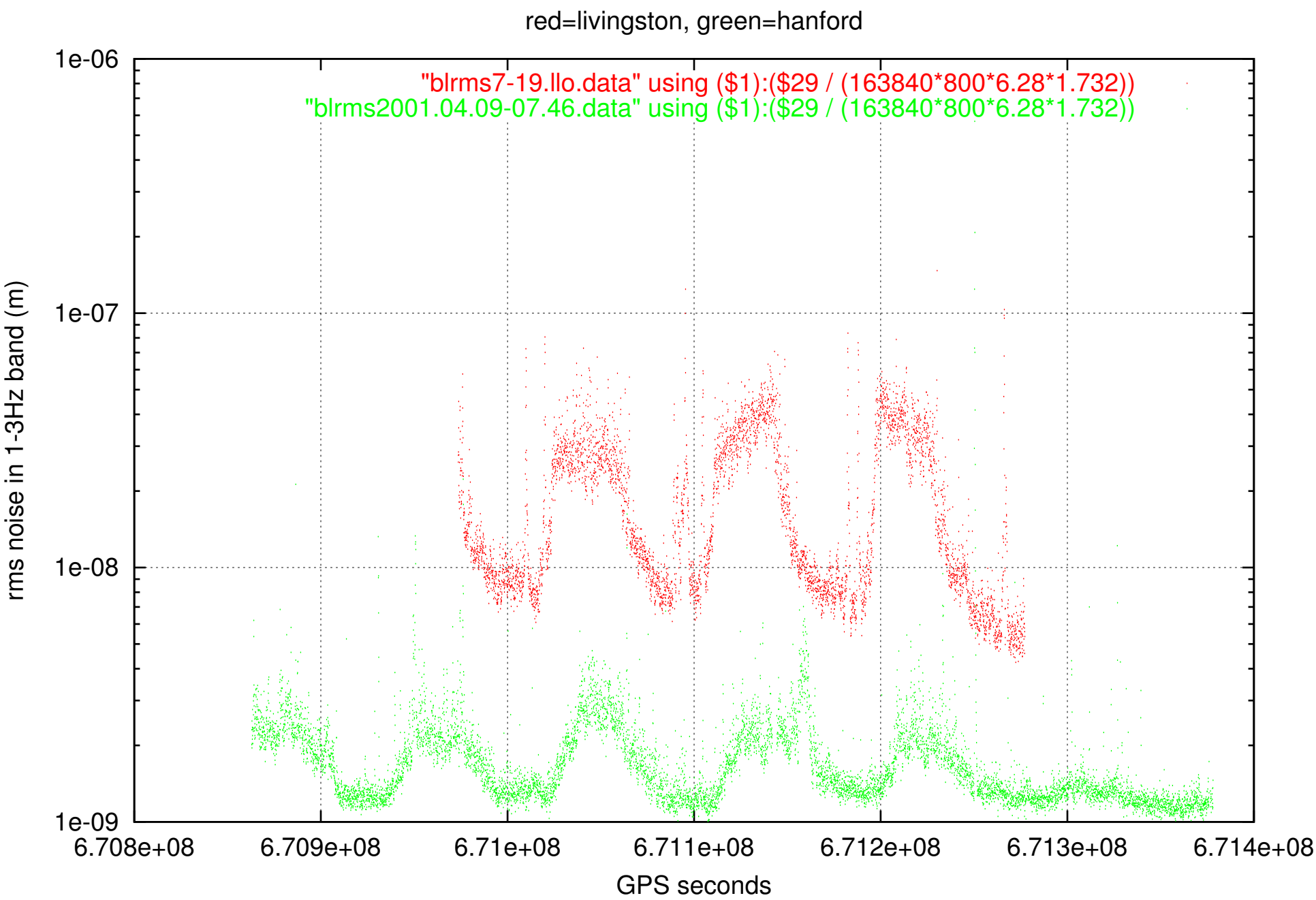
  need to be installed before reaching design sensitivity - 1 year

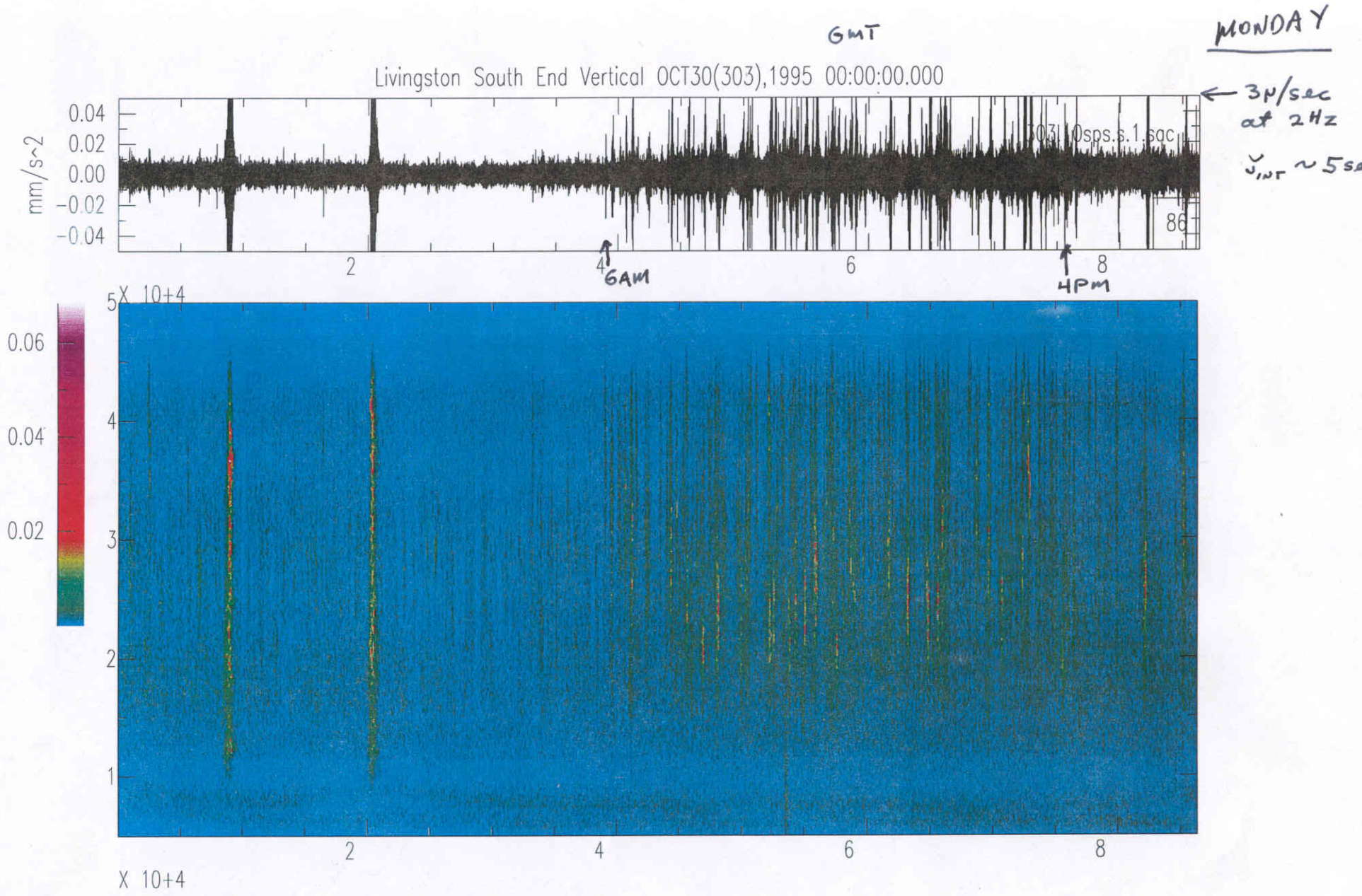
Initial Seismic Measurements Prior to Construction



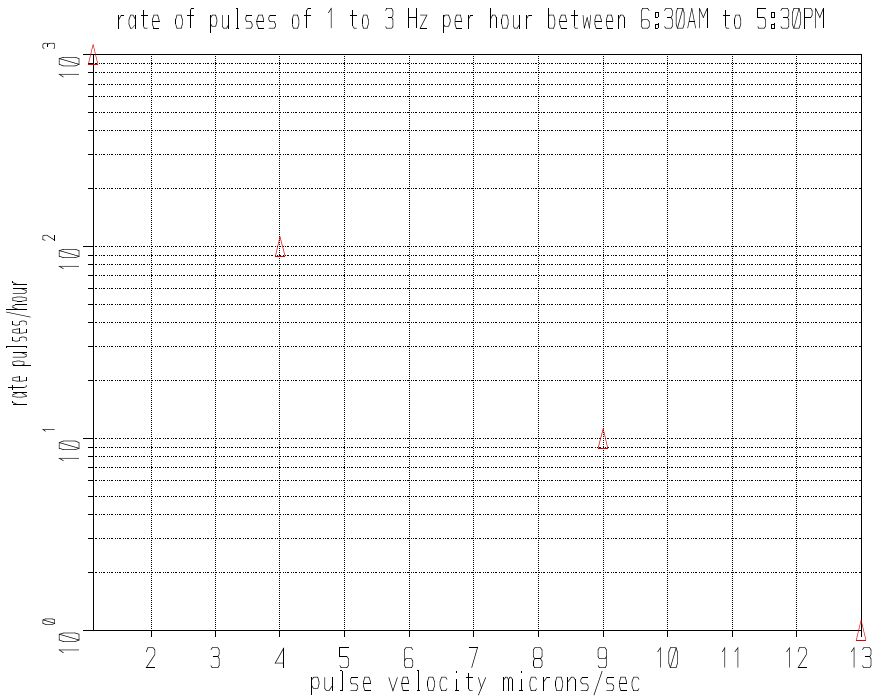

72 hours of E4 from GPS = 673636586 (Fri May 11, 12:16 p.m. CDT)
L0:PEM-LVEA_SEISX : 1-3Hz
L0:PEM-LVEA_SEISY : 1-3Hz
L0:PEM-LVEA_SEISZ : 1-3Hz
6 p.m. Fri
6 a.m. Sat
6 p.m. Sat
6 a.m. Sun
6 p.m. Sun
6 a.m. Mon
140
120
100
80
60
40
20
0
0
500
1000
1500
2000
2500
LVEA 1-3 Hz seismic motion (Ed units) vs time(s)
x 10 2
X arm
Y arm
Both arms
1
10 -1
10 -2
10 -3
0
500
1000
1500
2000
2500
Lock Live Time Fraction vs time(s)
x 10 2


Histograms of band limited rms noise in 5 frequency bands.
N=42000(53302) for LHO(LLO) E. Daw, 05/14/01−06/26/01
LHO 0.1−0.3Hz
LLO 0.1−0.3Hz
LHO 0.3−1.0Hz
LLO 0.3−1.0Hz
LHO 1.0−3.0Hz
LLO 1.0−3.0Hz
LHO 3.0−10Hz
LLO 3.0−10Hz
LHO 10−30Hz
LLO 10−30Hz
rms noise in band (m)

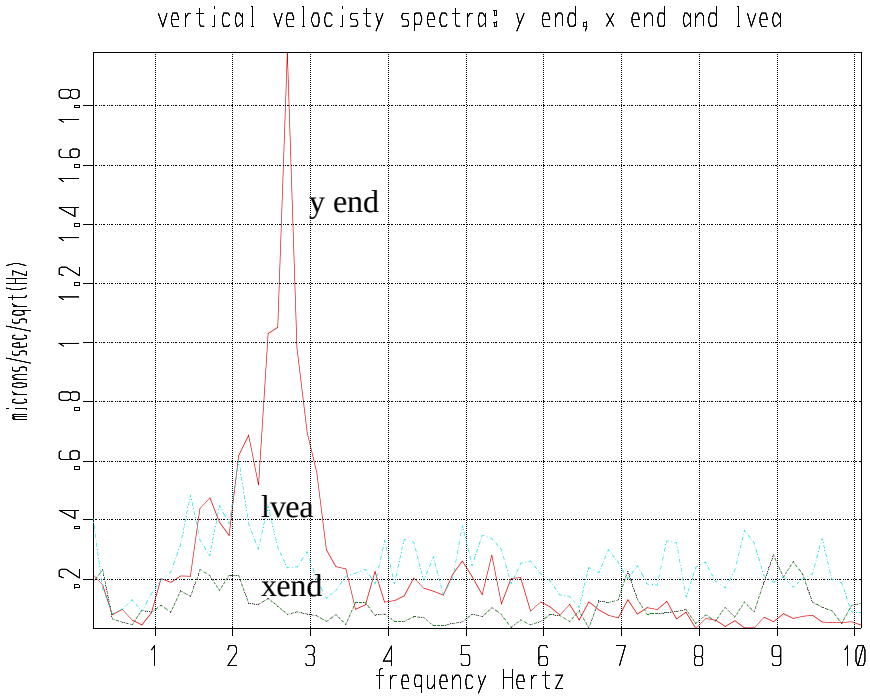

red=livingston, green=hanford
"blrms7-19.llo.data" using ($1):($29 / (163840*800*6.28*1.732))
"blrms2001.04.09-07.46.data" using ($1):($29 / (163840*800*6.28*1.732))
rms noise in 1-3Hz band (m)
1e-06
1e-07
1e-08
1e-09
6.708e+08
6.709e+08
6.71e+08
6.711e+08
6.712e+08
6.713e+08
6.714e+08
GPS seconds

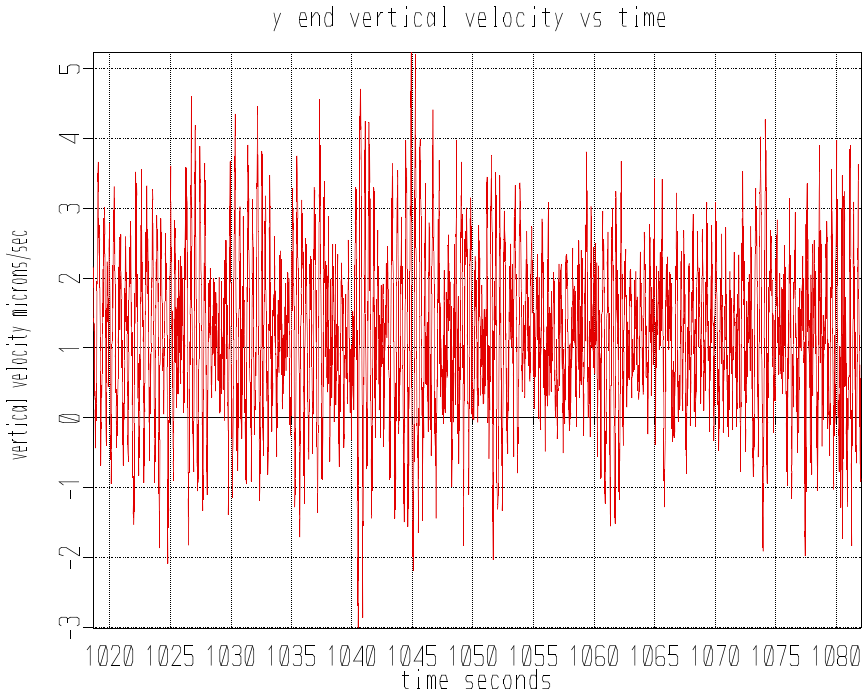


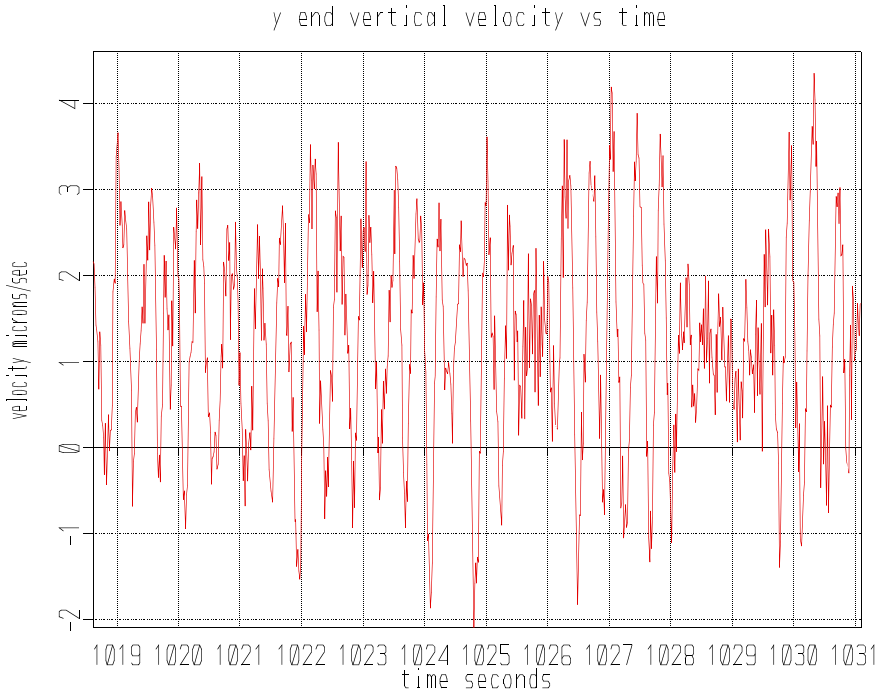
ALAN ROHAY DATA

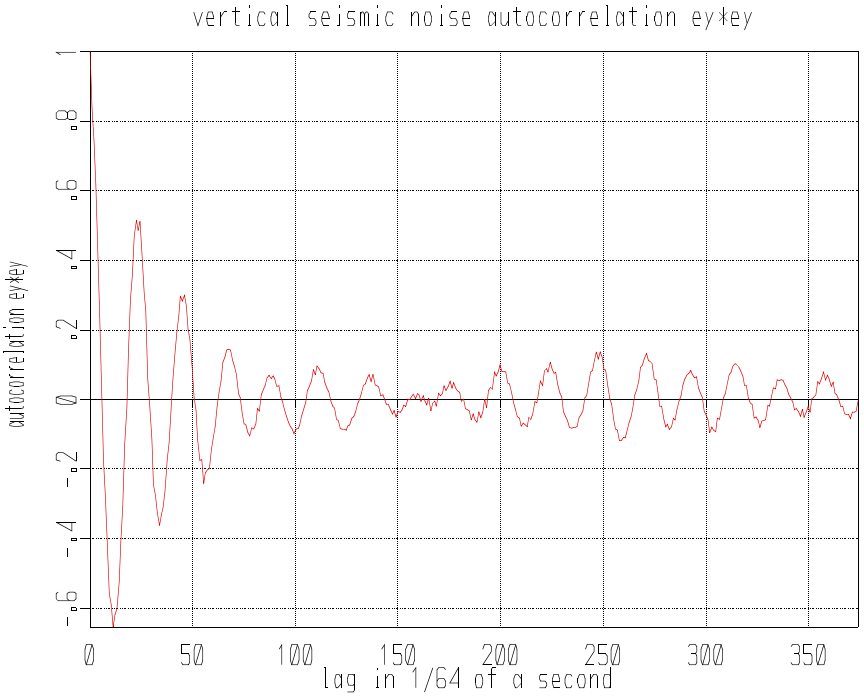


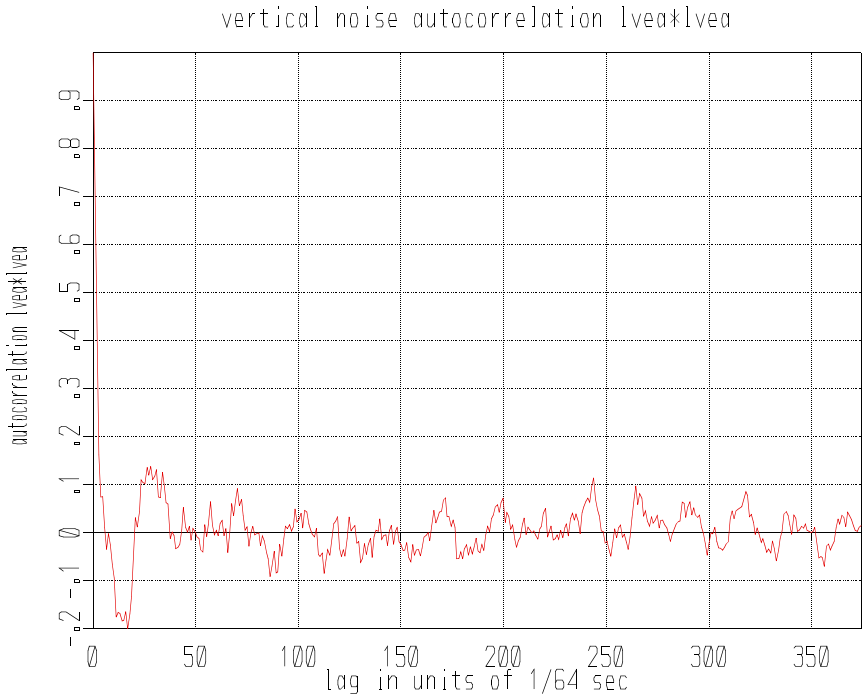
Vertical velocity at the y end station

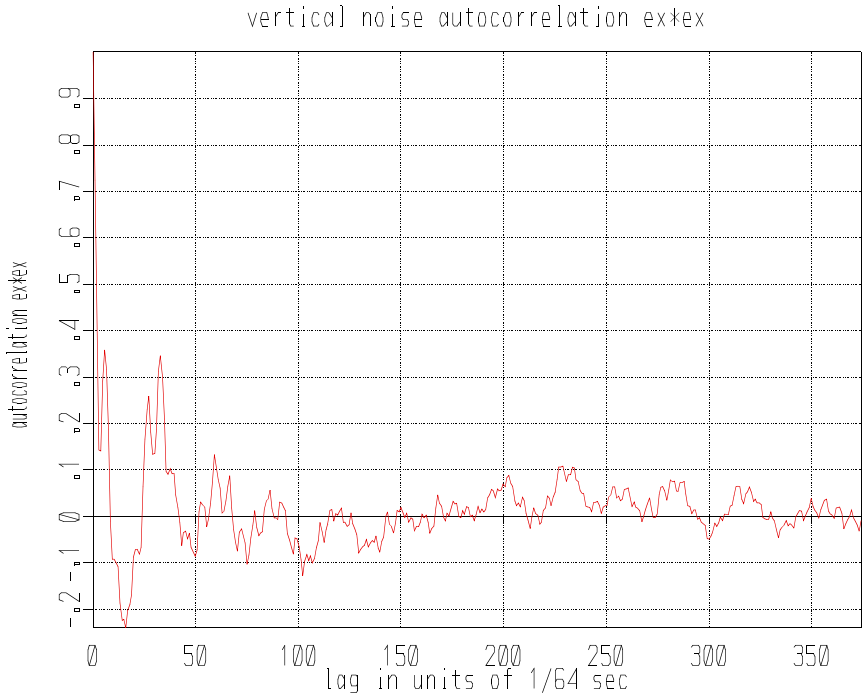

vertical velocisty spectra: y end, x end and lvea
microns/sec/sqrt(Hz)
.2
.4
.6
.8
1
1.2
1.4
1.6
1.8
y end
lvea
xend
1
2
3
4
5
6
7
8
9
10
frequency Hertz

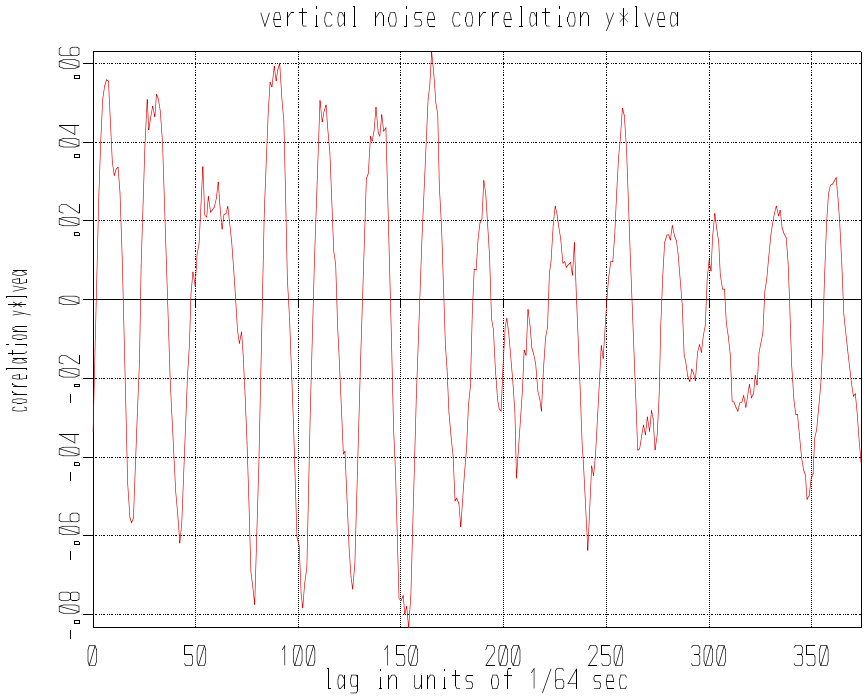

y end vertical velocity vs time
vertical velocity microns/sec
5
4
3
2
1
0
-1
-2
-3
1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080
time seconds

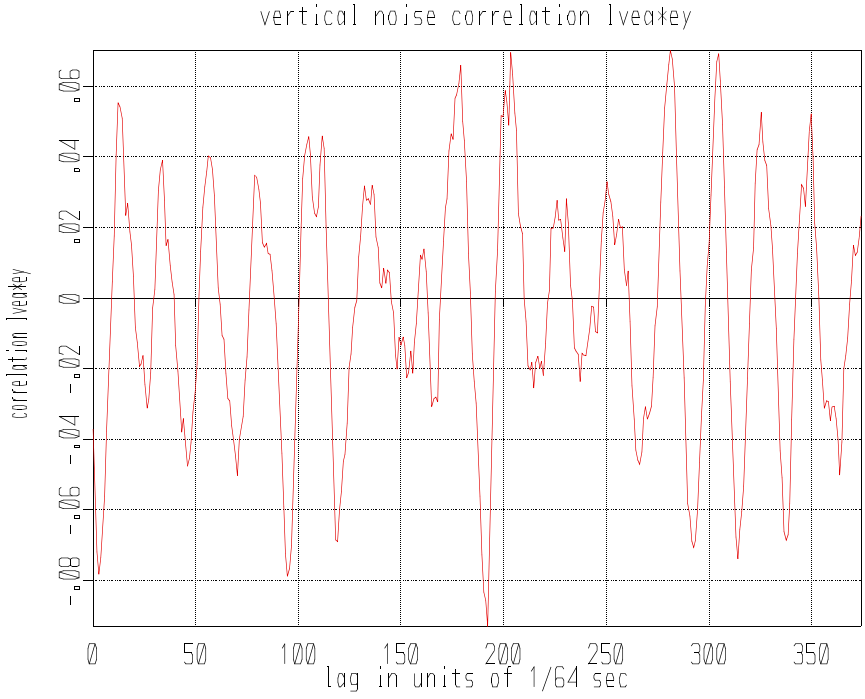

y end vertical velocity vs time
velocity microns/sec
4
3
2
1
0
-1
-2
1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031
time seconds

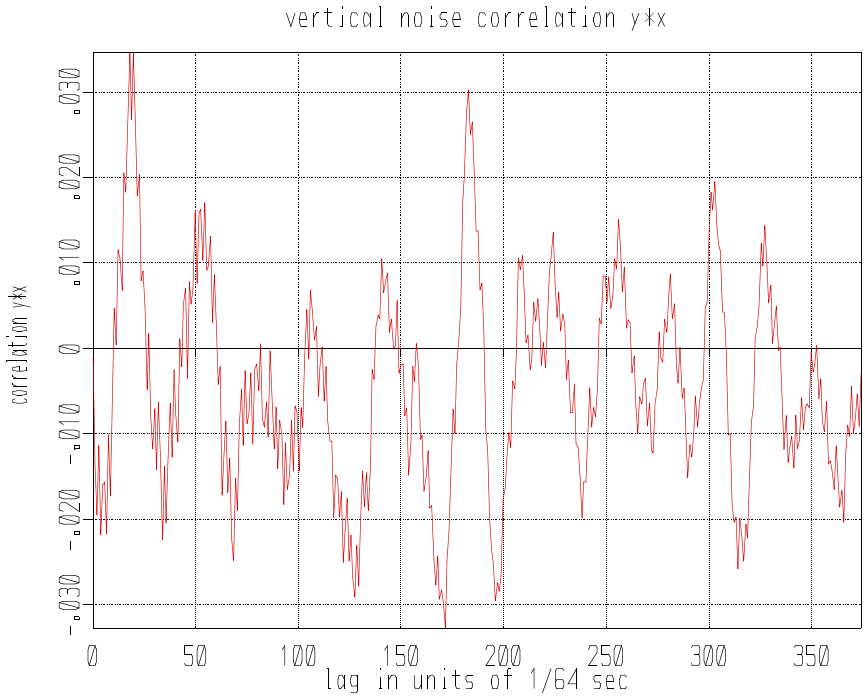

vertical seismic noise autocorrelation ey*ey
autocorrelation ey*ey
1
.8
.6
.4
.2
0
-.2
-.4
-.6
0
50
100
150
200
250
300
350
lag in 1/64 of a second

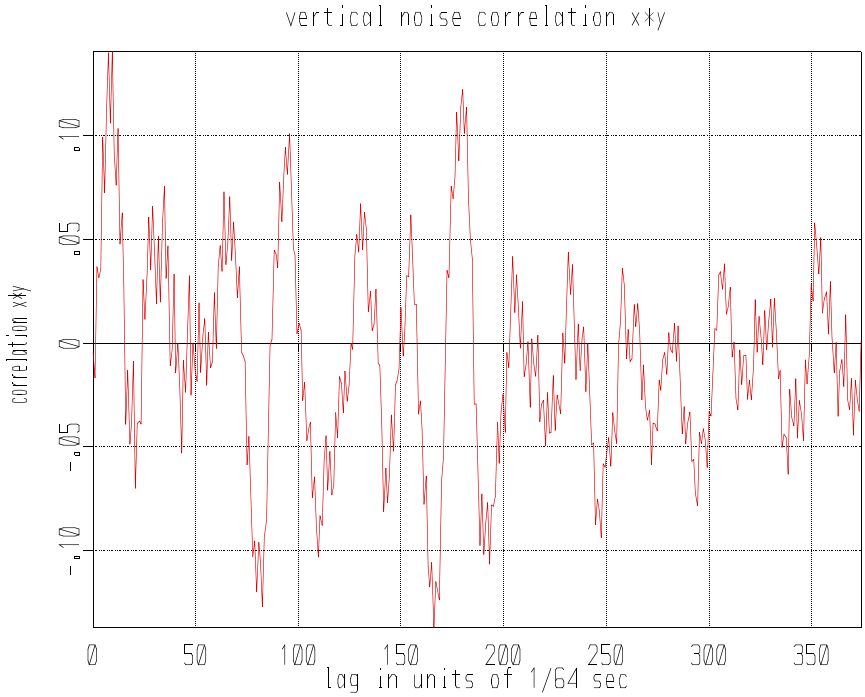

vertical noise autocorrelation lvea*lvea
autocorrelation lvea*lvea
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
-.1
-.2
0
50
100
150
200
250
300
350
lag in units of 1/64 sec

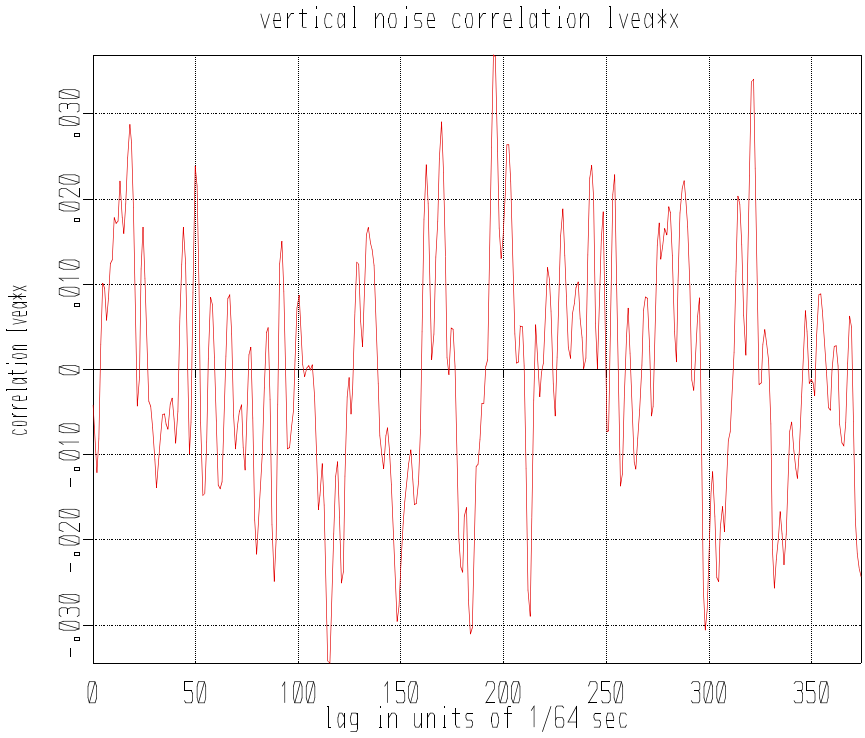

vertical noise autocorrelation ex*ex
autocorrelation ex*ex
-.2
-.1
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
0
50
100
150
200
250
300
350
lag in units of 1/64 sec

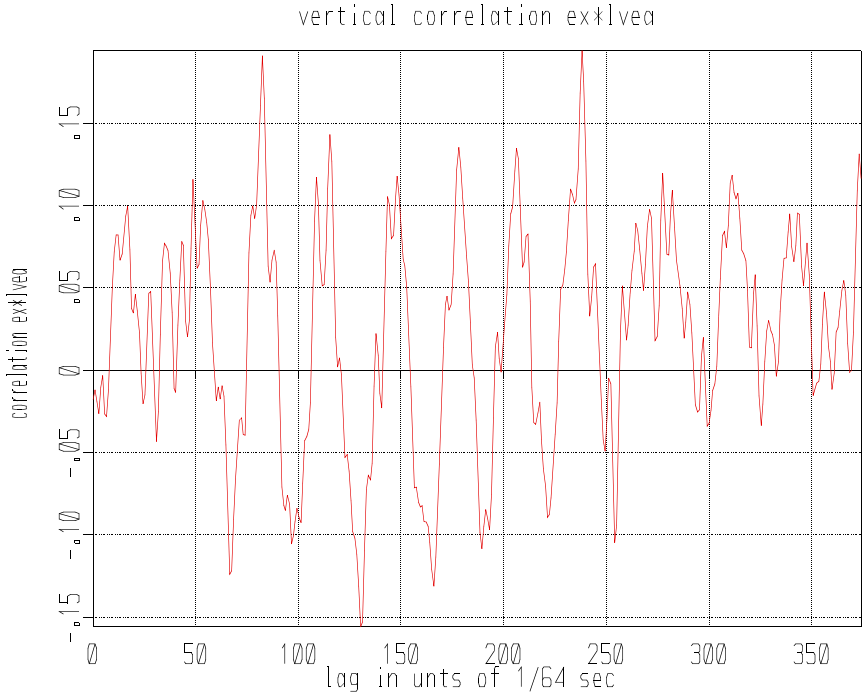

vertical noise correlation y*lvea
correlation y*lvea
.06
.04
.02
0
-.02
-.04
-.06
-.08
0
50
100
150
200
250
300
350
lag in units of 1/64 sec


vertical noise correlation lvea*ey
correlation lvea*key
.06
.04
.02
0
-.02
-.04
-.06
-.08
0
50
100
150
200
250
300
350
lag in units of 1/64 sec


vertical noise correlation y*x
correlation y*x
-.030
-.020
-.010
0
.010
.020
.030
0
50
100
150
200
250
300
350
lag in units of 1/64 sec


vertical noise correlation x*y
correlation x*y
-.10
-.05
0
.05
.10
0
50
100
150
200
250
300
350
lag in units of 1/64 sec


vertical noise correlation lvea*x
correlation lvea*x
.030
.020
.010
0
-.010
-.020
-.030
0
50
100
150
200
250
300
350
lag in units of 1/64 sec


vertical correlation ex*lvea
correlation ex*lvea
.15
.10
.05
0
-.05
-.10
-.15
0
50
100
150
200
250
300
350
lag in unts of 1/64 sec

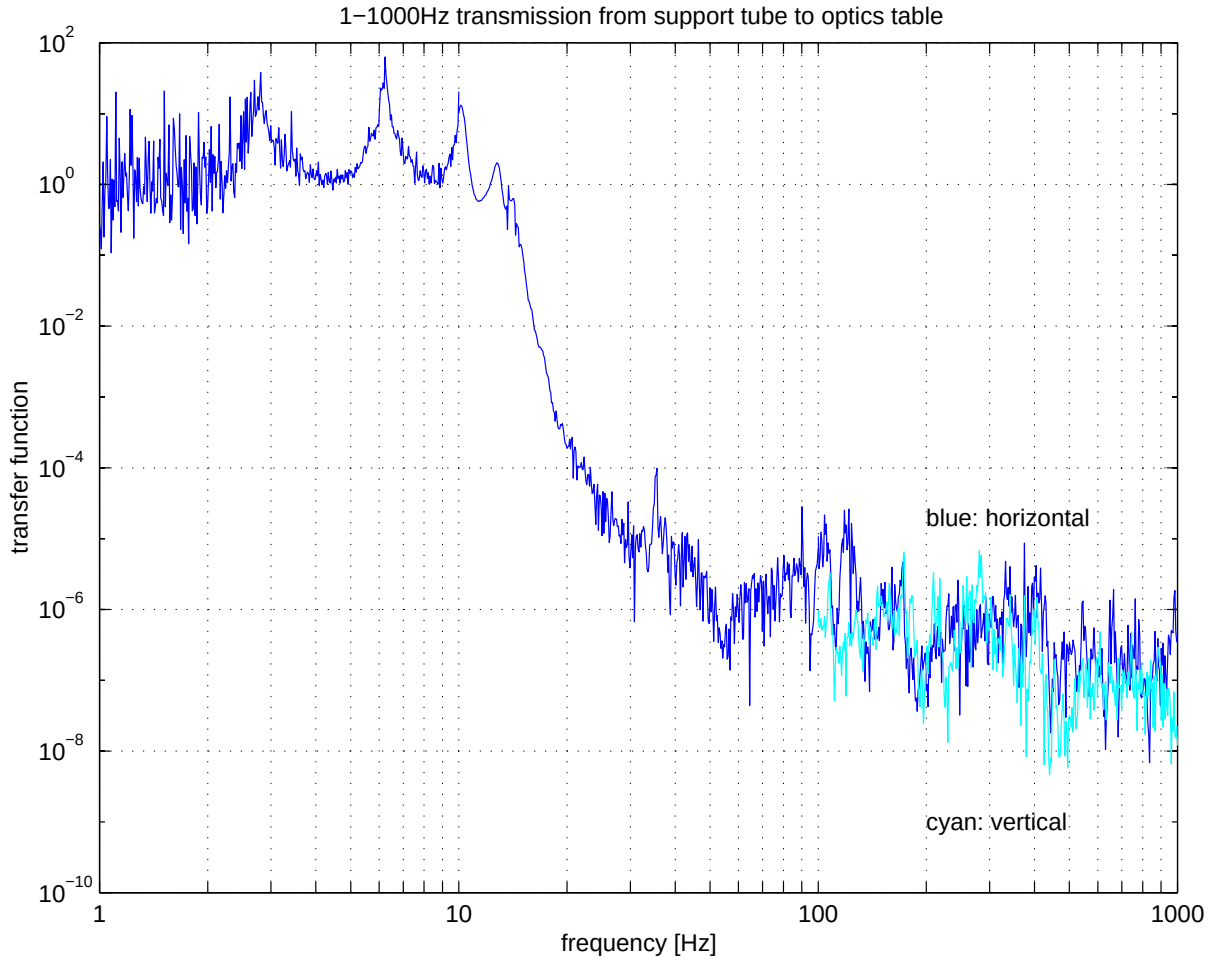


Figure 4.1: Transmission from support tube to optics table of BSC 3. Horizontal and vertical refer to shaker motion (driving force), acceleration was measured vertically off-axis on the optical table (refering to the usual notation, components are T_{zz} and T_{zx} for vertical-vertical (blue) and horizontal-vertical (cyan), respectively).

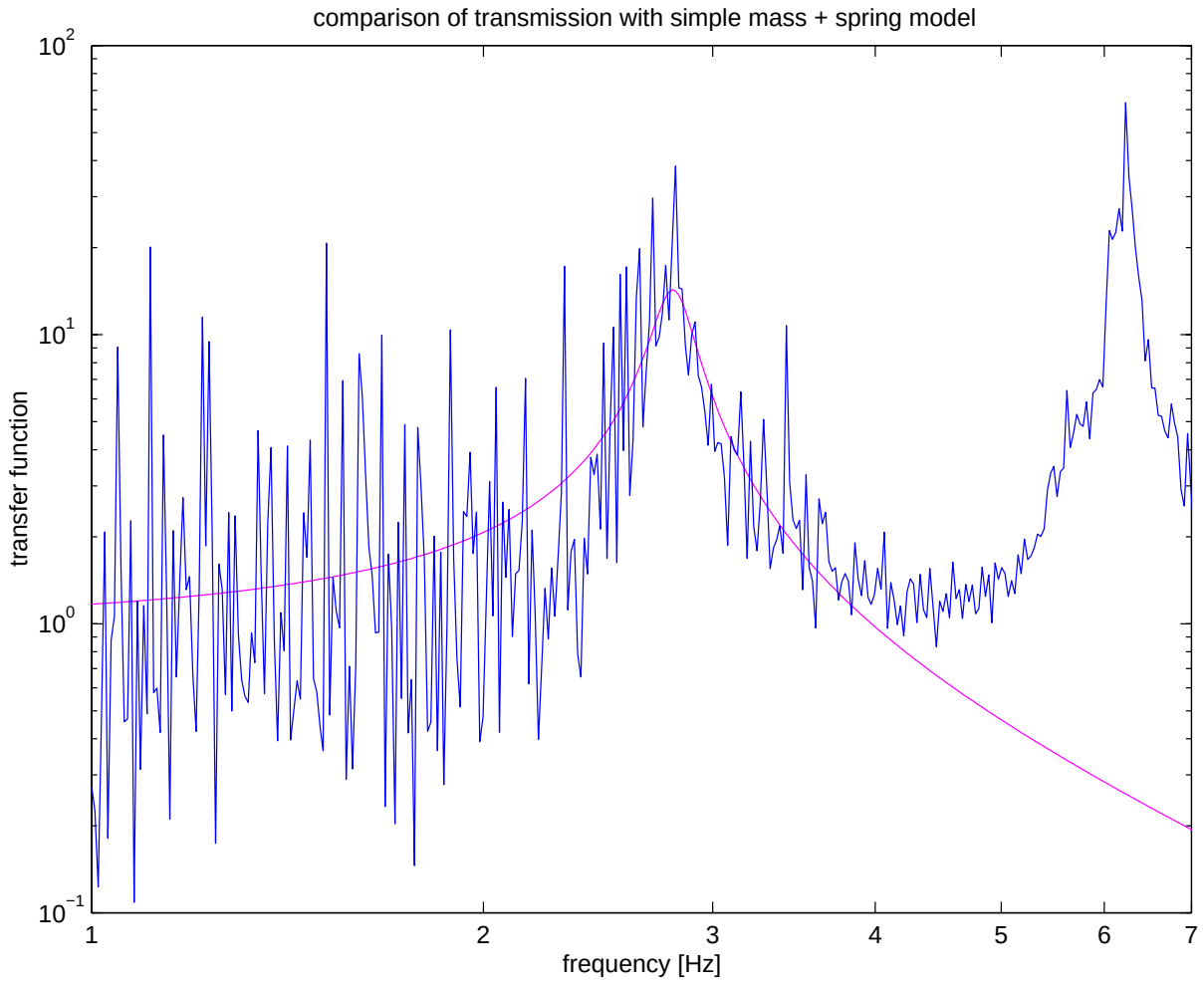
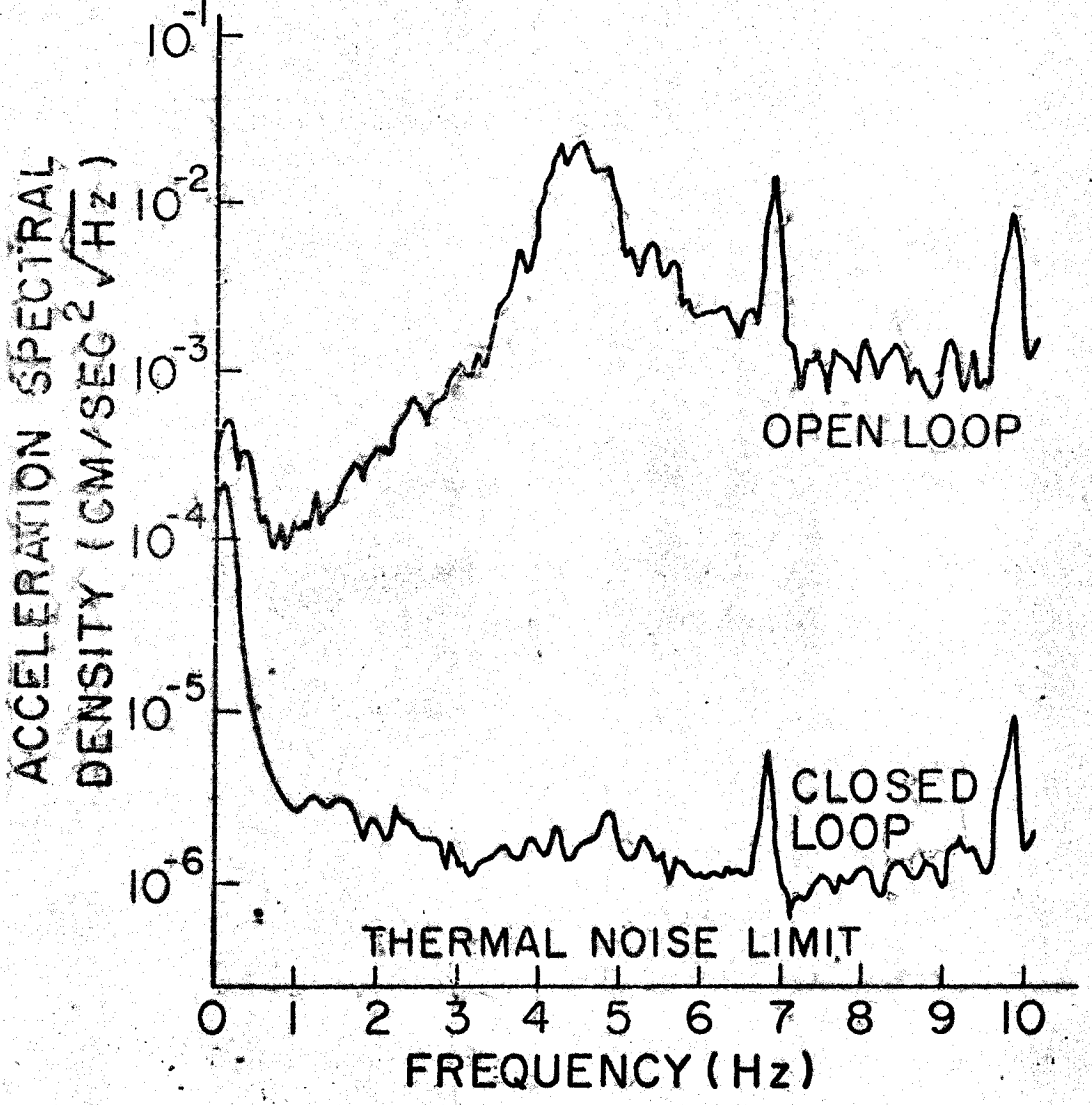
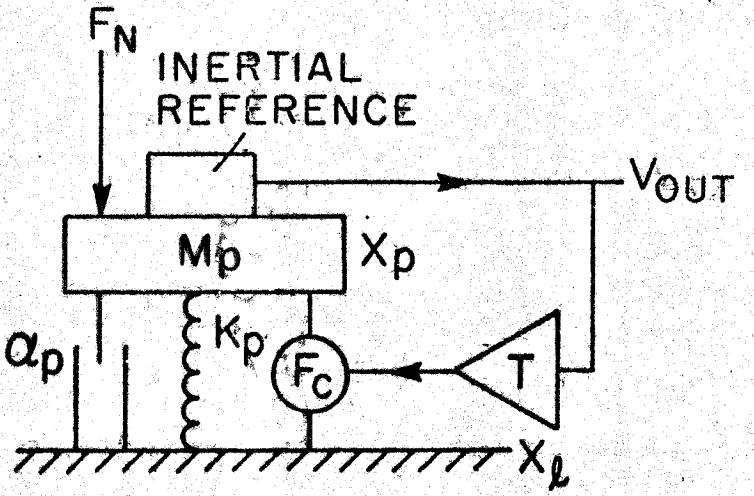
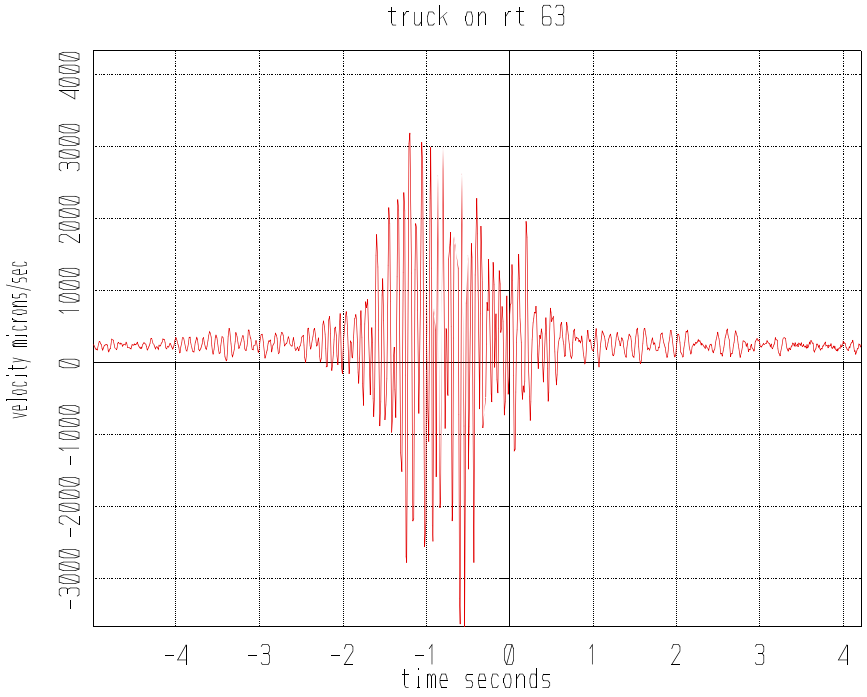


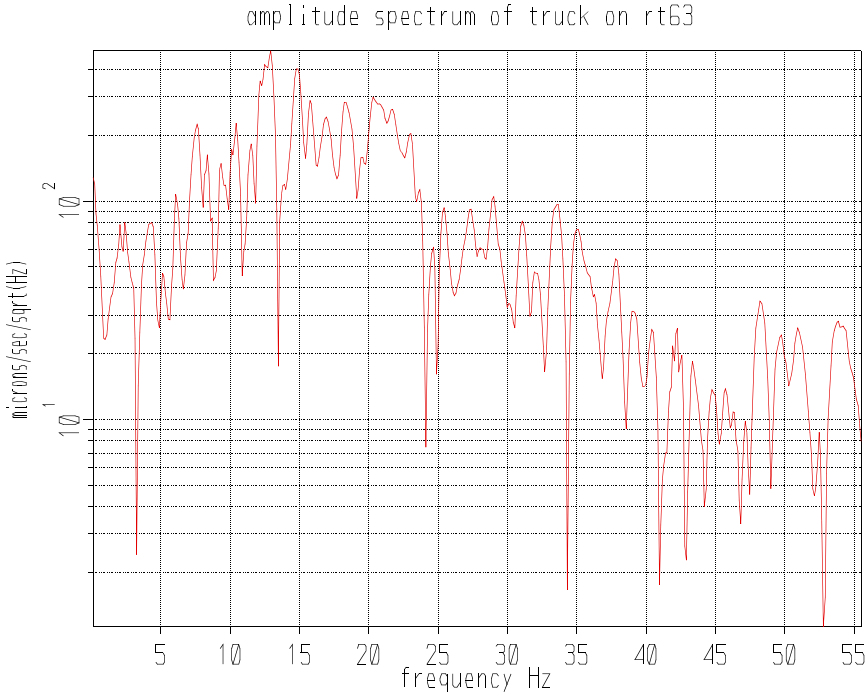
Figure 4.5: The model with Q = 5 is shown alone, now with the wings of the resonance peak included.


ACCELERATION SPECTRAL DENSITY (CM/SEC^2/$\sqrt{Hz}$)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
OPEN LOOP
CLOSED LOOP
THERMAL NOISE LIMIT
0 1 2 3 4 5 6 7 8 9 10
FREQUENCY (Hz)


F_N
INERTIAL REFERENCE
V_{OUT}
M_p
X_p
K_p
α_p
F_c
T
X_l

P. SAULSON


truck on rt 63
velocity microns/sec
-3000 -2000 -1000 0 1000 2000 3000 4000
-4 -3 -2 -1 0 1 2 3 4
time seconds


amplitude spectrum of truck on rt63
microns/sec/sqrt(Hz)
10 1
10 2
5 10 15 20 25 30 35 40 45 50 55
frequency Hz