LCLS-TN-12-4

Results of Vibration Study for LCLS-II Construction in FEE, Hutch 3 LODCM and M3H[1]

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To study the influence of LCLS-II construction on the stability of the LCLS-I x-ray beam a series of machinery was brought to SLAC to different locations to simulate a variety of construction activities. To study their effects a series of sensors and instruments were observed during simulated construction activities. A subset of these sensors and their observations are described in this report.

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Contents

1 Instrumentation

1.1 Teledyne S-13 Seismometer

Sensitivity: 629 Volts / meter / second
Natural Freq.: 0.75 - 1.1 Hertz, nominally 1.0 Hz

Installed horizontally and vertically on the floor in the FEE in front of M1H (see Figure 1).

Figure 1: S-13 seismometers in FEE in front of M1H mirror.

1.2 Sercel L4C Sensors

Sensitivity: 276.8 Volts / meter / second
Natural Freq.: 1.0 Hz

Horizontal sensors were installed at:

- Top M1H Mirror
- Top M2H Mirror
- Top M3H Mirror (see Figure 2)
- Floor M3H Mirror
- Top LODCM XPP (see Figure 3)

One Vertical Sensor was installed on top of the LODCM in the XPP (see Figure 3)

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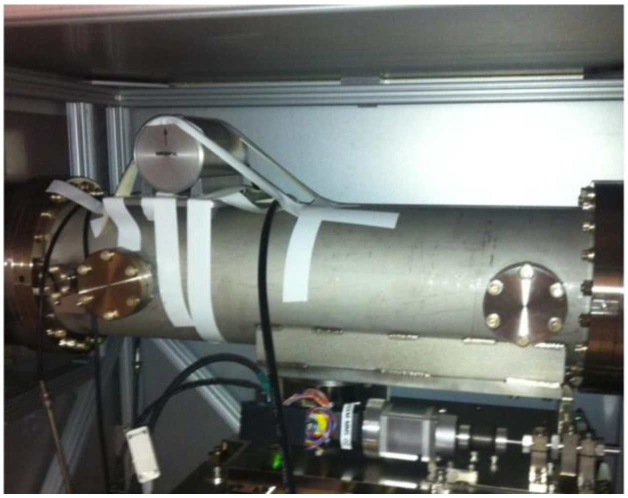

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Figure 2: Typical L4C seismometer installation on a M3H mirror.

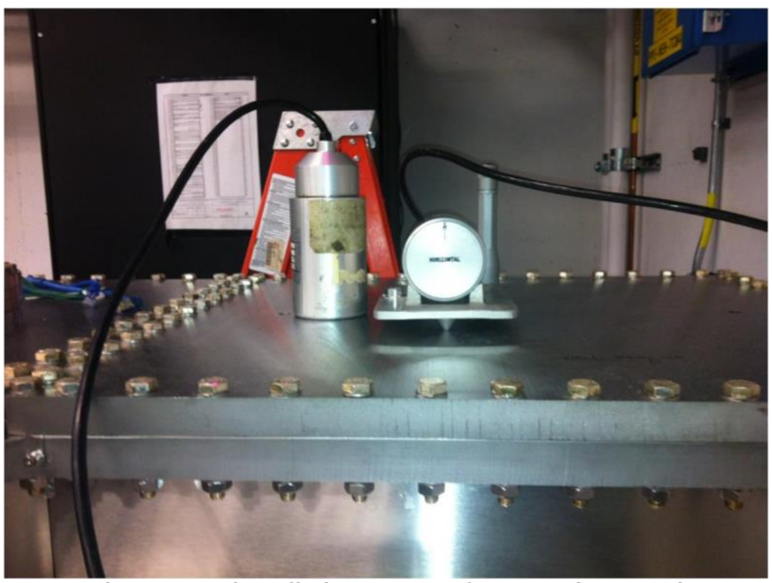

Figure 3: Seismometer installation on top of LODCM in XPP; the sensors were placed above the upstream crystal.

2 Measurements

Measurements were taken with 2048 Hz sampling rate and a duration of 2 minutes per measurement. Two different data acquisition units were used (National Instruments Model 9234 (24 Bit), National Instruments Model SCC-68 (16 Bits)) on two different computers to collect the data from the 8 sensors. The measurements were initiated manually and are not synchronized. During the study 138 measurements sets were recorded.

2.1 Maximum Velocity

As a first indicator the data were analyzed for the peak velocities measured, this gave a general idea which activities might have highest impact on the instruments, see Figure 4 and Figure 5.

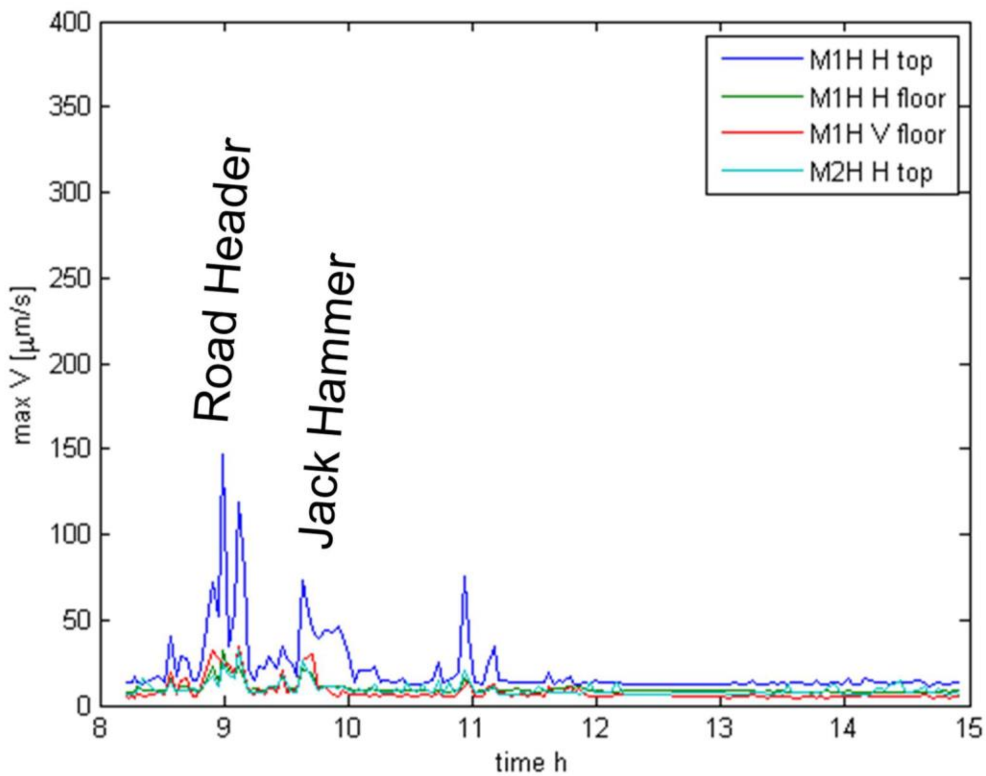

Figure 4: Peak raw (velocity) sensor readings FEE.

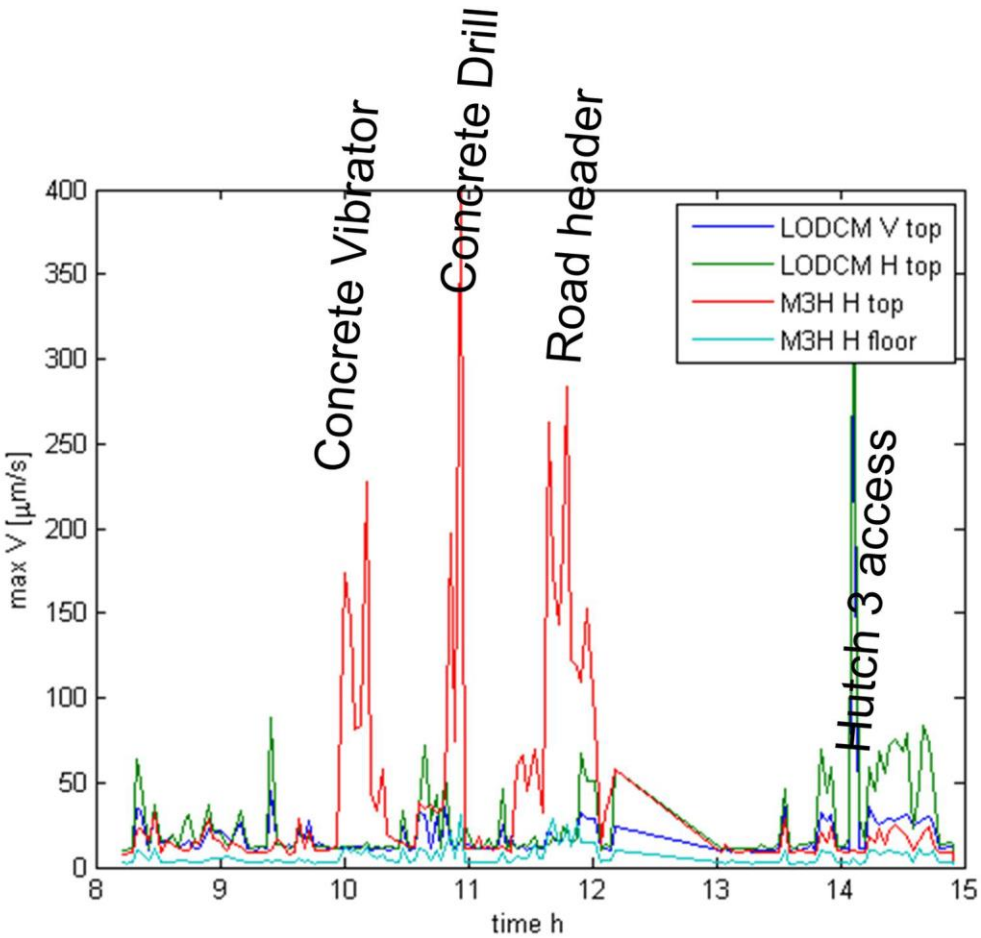

Figure 5: Peak raw (velocity) sensor readings LODCM and M3H.

2.2 Frequency analysis of results

Looking at the measurement files it showed that the construction activities produced single events rather than a continuous signal. To get single events rather than analyzing everything at once the two minute data sets were further split up in 10 second intervals before using a Fast Fourier Transformation (FFT) with a Hanning filter.

In the example below a typical dataset was analyzed. In Figure 6 the raw measurements are shown, only a short burst of excitation is visible with peaks of up to 400 µm/sec vibrations. Integrating the velocities over time produces position data for the individual sensors (Figure 7) in this case the sensor on top of M3H moved +/- 2 µm. Analyzing the 10 second interval with FFT showed a broad spectrum excitation around 38 Hz.

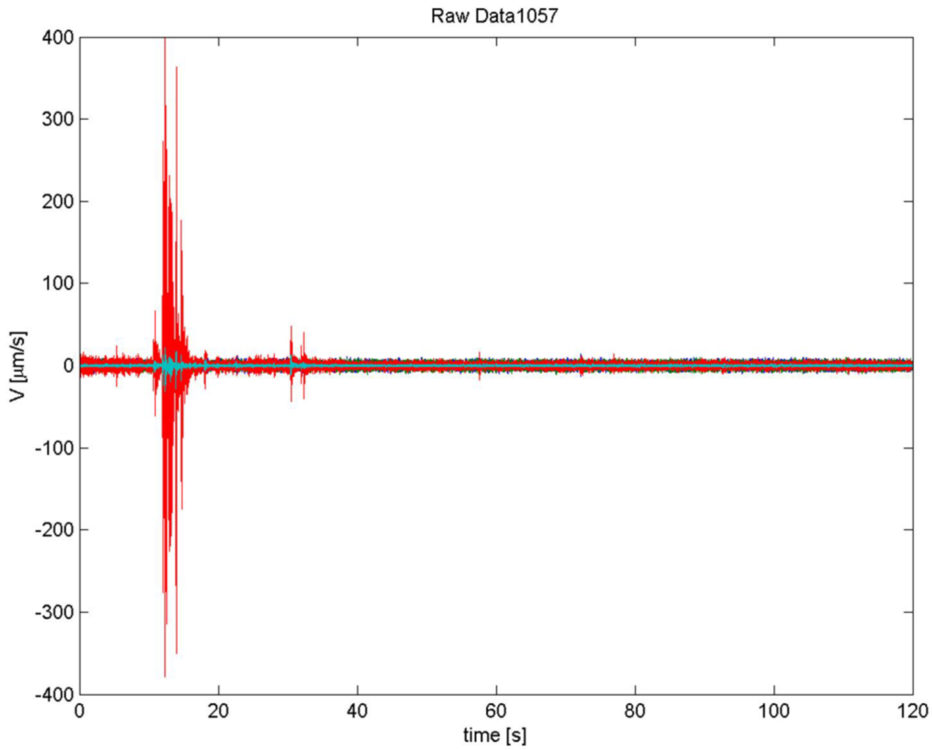

Figure 6: Raw data for 10:57am XRT, short excitation due to concrete drilling.

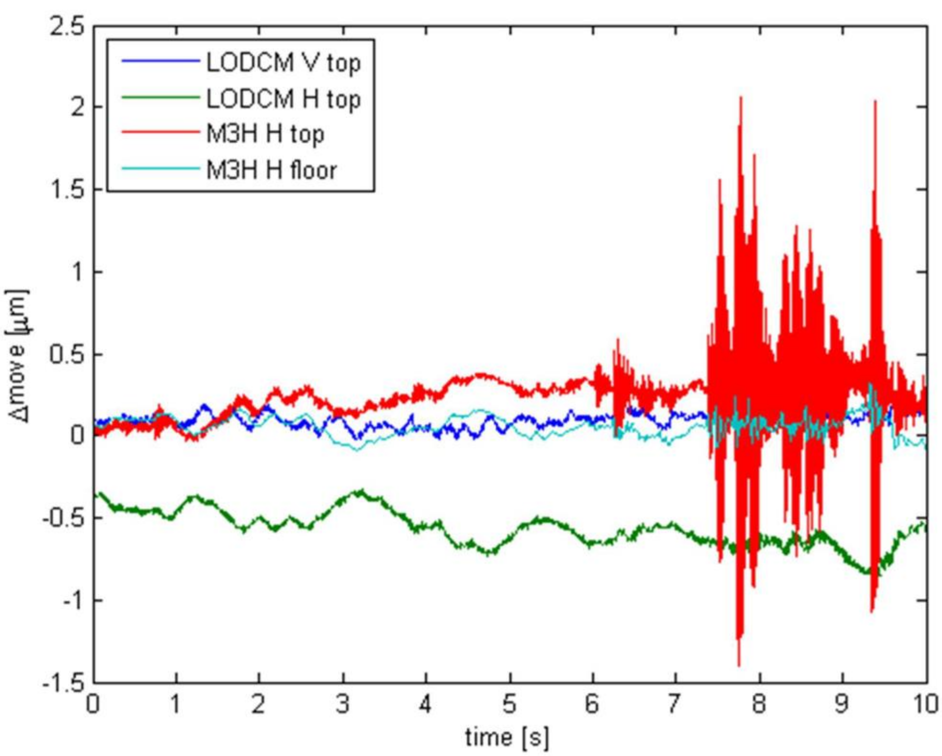

Figure 7: Integrated raw data value to calculate displacement, 10 seconds sample size.

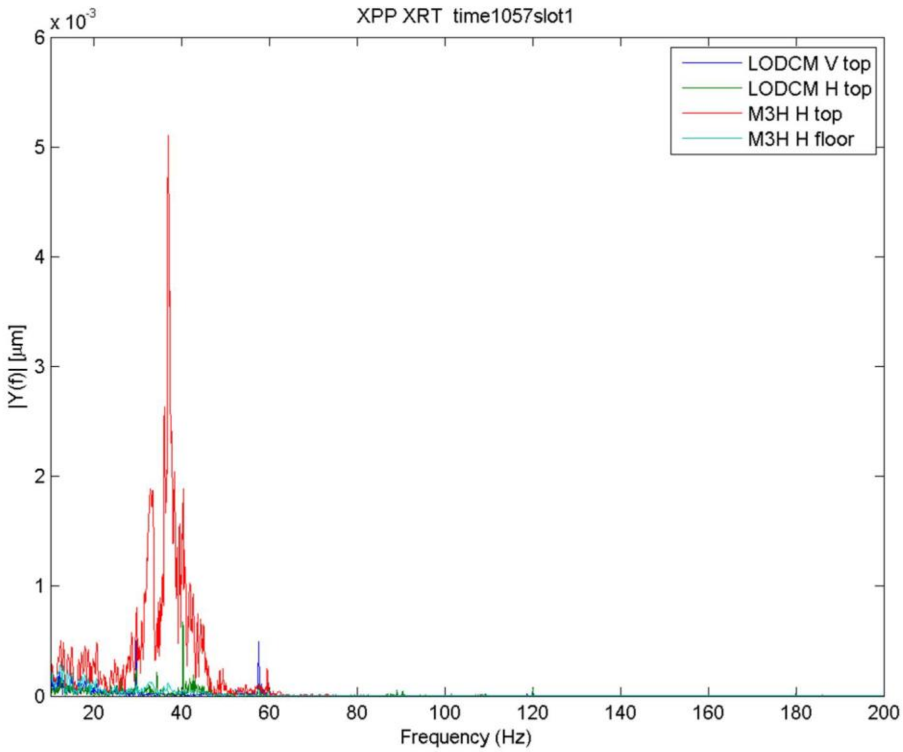

Figure 8: FFT analysis of raw data sample in Figure 7.

3 Results

The frequencies at which we found the main excitation are not necessarily the natural frequency at which the mirrors oscillate, but rather the frequency that it is driven through the construction noise.

- Horizontal Sensor on top of M2H

The sensor on M2H saw the least amount of vibration of all sensors on top of the mirrors. The main excitation at this stand occurs at 20 Hz. Only during road header operations and concrete vibrator operation occurred excitations of 0.1 µm.

ξ Horizontal Sensor on top of M1H

The sensor on M1H saw vibration of up to 1.0 µm amplitude. The main excitation at this stand occurs at 30 Hz with smaller amplitudes at 23 and 46 Hz.

- Horizontal Sensor on top of M3H

The sensor on M3H saw the most amount of vibration of up to 1.5 µm. The frequency spectrum measured at the position of the sensor was wider than on any other sensor ranging from 35-40 Hz with a sideband at 50 Hz.

ξ Sensors on top of LODCM in XPP hutch

The sensors on the LODCM saw vibrations with amplitudes of up to 0.1 µm. The main frequency of the measured data for the horizontal data was at 40 Hz for the vertical sensor it was 30 and 60 Hz.

- Sensors on the floor