

TECHNICAL REPORT

Vibration Measurements in the XTD1 Tunnel

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Purpose

This report describes vibration measurements in an X-ray free-electron laser (FEL) tunnel at the European XFEL. The purpose of these measurements was to study the vibration level in the empty tunnel and then compare it with other measurements before major installations were completed.

Methodology

A seismometer from Guralp Systems was placed inside the distribution (switchyard) tunnel XDT1 about 50 metres from the exit in the east–west orientation (along the path of the tunnel). Measurements were made over the weekend of 22–23 October 2011 (starting on Friday, 21 October, at 13:30, and finishing on Monday, 24 October, at 12:30), when no tunnel boring or other heavy construction work was being done.

The raw data were analysed by means of a Python module written by Gerd Wellenreuther, a beamline scientist in the Hard X-Ray Micro / Nano-Probe (P06) group at the PETRA III experiment hall of Deutsches-Elektronen Synchrotron (DESY) in Hamburg. After running the module, we got a plot of the raw data, which was $v(t)$ [$\mu\text{m/s}$] versus time, $s(t)$ [μm] and $a(t)$ [$\mu\text{m/s}^2$], as well as the corresponding power spectral distributions, $\text{PSD}(v(t))$ [$(\mu\text{m/s})^2/\text{Hz}$], $\text{PSD}(s(t))$ [$\mu\text{m}^2/\text{Hz}$], and $\text{PSD}(a(t))$ [$(\mu\text{m/s}^2)^2/\text{Hz}$].

Comparison

To compare our measurements, we plotted PSD(s(t))[$\mu\text{m}^2/\text{Hz}$] at the XTD1 tunnel together with other measurements (Figure 1).

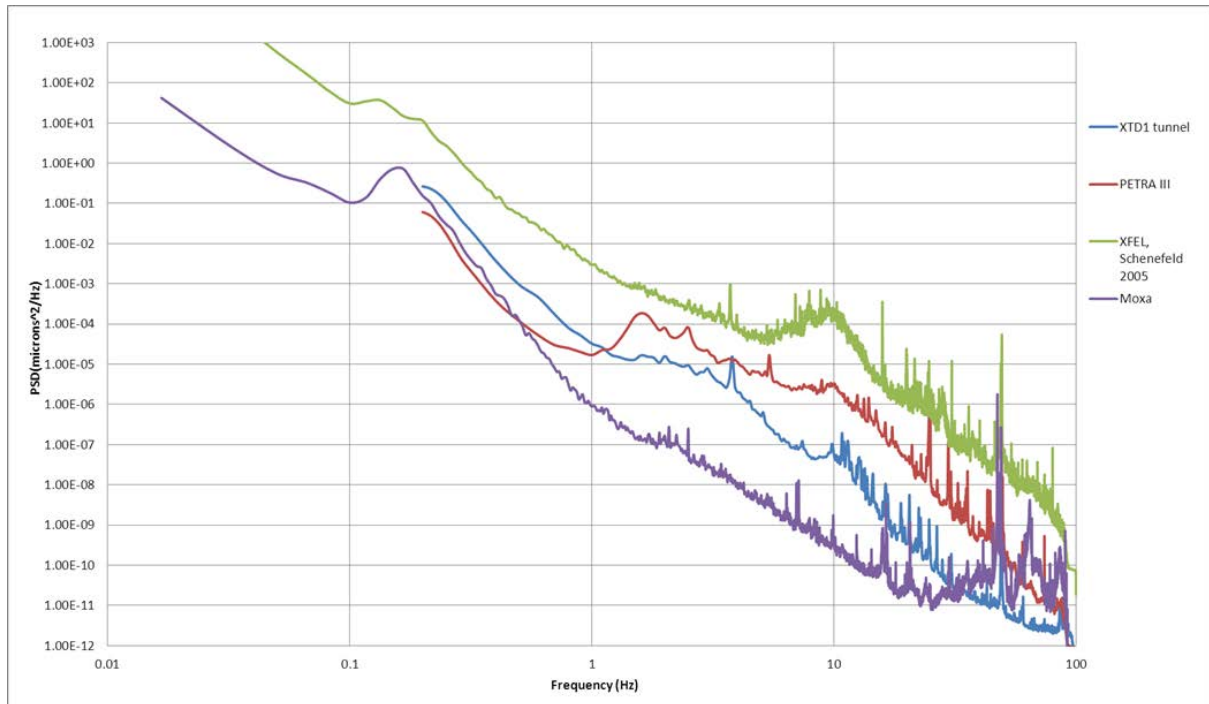


Figure 1: Power spectral density of vertical ground motion. Blue: XTD1 tunnel during a quiet period in 2012. Red: PETRA III experiment floor in 2011 (measurement by Gerd Wellenreuther). Green: Schenefeld (in the location of the current XTD1 tunnel) in 2005. Indigo: Geodynamic Observatory Moxa (an extremely quiet location) in 2004 at Friedrich-Schiller-University Jena. The measurements in Schenefeld and Jena were made by DESY (data obtained from http://vibration.desy.de/sites_measured/).

Earthquake

During the measurement period on Sunday, 23 October, at 10:41 UTC (12:41 in Hamburg), an earthquake of magnitude 7.2 occurred in Turkey. This event was also recorded in our measurements (Figure 2).

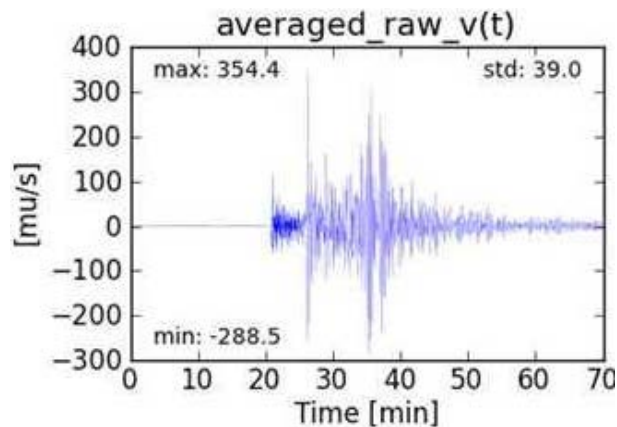


Figure 2: Graph of the velocity of the vibrations during the earthquake (vertical component, z) on 23 October 2011

A jump was observed in the amplitude of the vibrations from a few $\mu\text{m/s}$ to a few hundred $\mu\text{m/s}$ as the earthquake began.

For purposes of comparison, PSD(v(t)) during a quiet period for all of the components (vertical, east–west, and north–south) was plotted together with the vertical component during the earthquake (Figure 3).

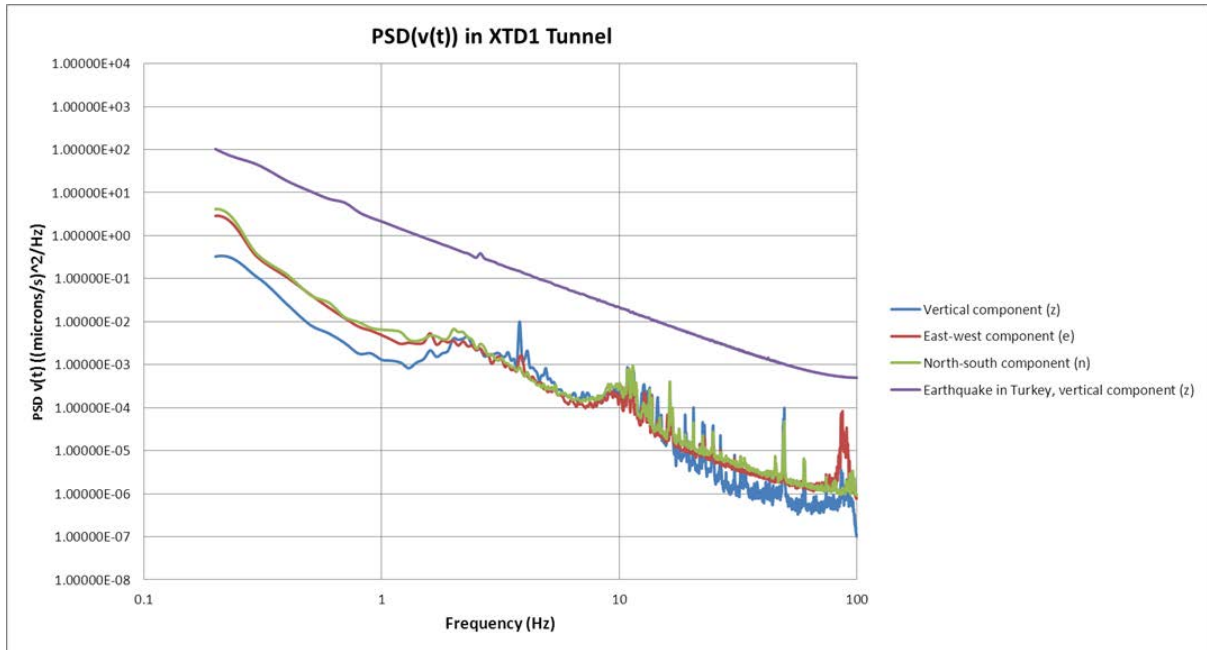


Figure 3: Power spectral density of the vibration velocity for a quiet period and during the earthquake in Turkey on 23 October 2011

Conclusion

The graphs in Figure 1 show that the level of vibrations in the XDT1 tunnel is currently lower than that in the PETRA III experiment hall and also lower than those of previous measurements at the Schenefeld site. Characteristic peaks at 10 Hz and 50 Hz can be observed. Also, when looking at the plot from PSD(v(t)) in Figure 3, one can see that there is a peak at 80 Hz along the tunnel (red curve).