

PRELIMINARY GROUND MOTION MEASUREMENTS AT LNF SITE FOR THE SUPER B PROJECT *

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Abstract

Following previous measurements [1], more detailed preliminary ground motion measurements have been performed at the LNF site for the Super B project site characterization [2].

First, results of vertical ground motion measurements done during 18 hours are shown in order to get an idea of the evolution of the ground motion amplitude with time.

Secondly, measurements of ground motion (in the 3 directions of space) were performed at different locations on surface in order to evaluate and to compare the influence of various vibration sources.

Then, results of ground motion coherence measured for different distances at two locations close to each other but with soft and rigid floor are compared. These measurements are also compared to the ones done in the ATF2 beam line [3] where a special floor was built for stability [4]. By this way, the results reveal that the LNF is a good site to use ground motion coherence properties for stability like it has been done for ATF2 [5].

SET-UP

Measurements have been performed at different locations of the LNF site (see Fig. 1). Each location has been chosen in order to compare the influence of concretes and various vibrations sources.

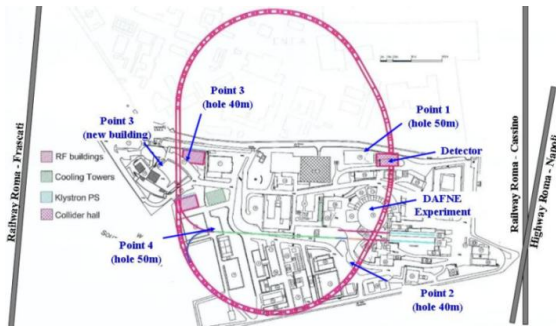


Figure 1: Layout of the LNF site and its future collider with the different measurement strategic points.

Ground motion has to be measured in the frequency range of about [0.1; 100] Hz. Note that below 1Hz, ground motion is due to earth motion, mostly to the micro seismic peak and above 1Hz, ground motion is due to cultural noise, that is to say human activities [6].

However, a beam-based feedback in accelerators is usually used to stabilize directly the beam below 0.1Hz (and often at higher frequencies) and amplitude of ground

motion is very low above 100Hz even for a noisy site.

In order to measure vertical ground motion in this wide frequency range, geophones and accelerometers are needed [7] [8] (see table 01).

Table 1: Vibration Sensors Used for the Study

Types of vibration sensor	Electromagnetic geophone	Piezoelectric accelerometer
Model	Guralp CMG-40T	Endevco 86
Company	Geosig	Brüel & Kjaer
Sensitivity	1600V/m/s	10V/g
Range [Hz]	[0.033; 50]	[0.01; 100]
Direction	3	1

Considering the very low internal noise of the geophones [9], their high sensitivity and the spectrum of the ground velocity [8], geophones were consequently used from 0.2Hz up to 50Hz and accelerometers from 50Hz to 100Hz for the ground motion analysis (see Fig. 2).



Figure 2: Layout of the set of measurements.

Sensor data were acquired by the PULSE acquisition system [10] with amplifiers. This setup guarantees a very low noise of the measurement chain [8] and allows very accurate measurements of ground motion even for a quiet site. Note that calculations of the Power Spectrum Density (PSD), the Coherence and the Integrated Root Mean Square (RMS) are described in [8].

GROUND MOTION AMPLITUDE WITH TIME

In order to analyze the evolution of the amplitude of ground motion with time, ground motion measurements have been performed during 18 hours. The site chosen is the basement of the new guest house (point 3) with a rigid floor and near the main road.

In order to analyze the influence of the different vibration sources, the PSDs of the ground motion was integrated in different bandwidths (see Fig. 3).

*Work supported by the Agence Nationale de la Recherche of the French Ministry of Research (Programme Blanc, Project ATF2-IN2P3-KEK, contract ANR-06-BLAN-0027)
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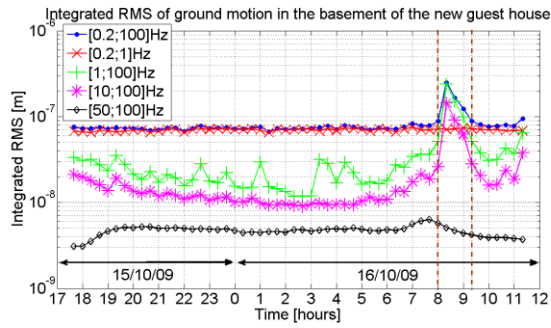


Figure 3: RMS of ground motion versus time at point 3 integrated in different bandwidths

These results show that traffic due to the rush hour between 8h and 9h, [3; 30] Hz can highly increase ground motion [11] (more than a factor 10) and that the amplitude of ground motion due to the micro seismic peaks [0.2; 1] Hz vary from 65 to 76 nm, which is low but may be much higher on a longer time scale.

GROUND MOTION AMPLITUDE AT DIFFERENT LOCATIONS

On surface

Amplitude of ground motion has been measured on surface at the point 1, 2 and 3 (figure 01) the day during non rush hours in order to allow a good comparison between them. Note that for point 3, measurements were performed on the parking and on the basement of the new guest house (see Fig. 4).

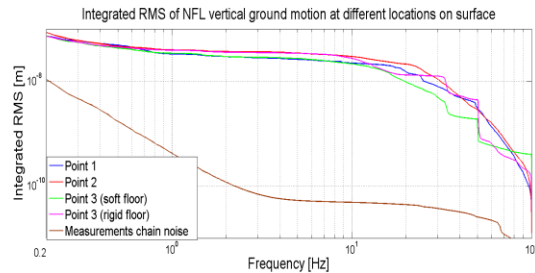


Figure 4: Integrated RMS of vertical ground motion for different locations on surface at the LNF.

The results show that the amplitude of motion is almost the same for these four locations: around 70-80nm above 0.2Hz and around 30-35nm above 1Hz.

In order to compare ground motion in the vertical and horizontal directions, integrated RMS of ground motion have been calculated from measurements done simultaneously in the three directions at point 1 and afterwards at point 2 (see Fig. 5).

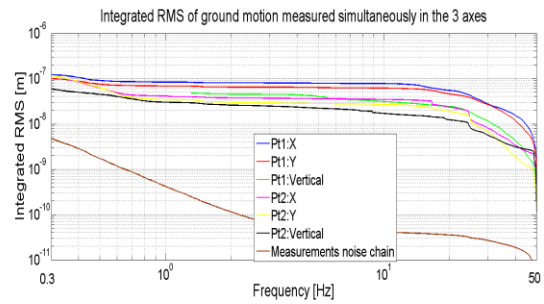


Figure 5: Integrated RMS of ground motion in the three directions at point 1 and 2

For both points, horizontal ground motion is not so much higher than vertical ground motion compared to horizontal tolerances which should be much less strict than the vertical one. In fact, the nominal horizontal beam size should be 160 times larger than the vertical one ($\sigma_x^* = 5.657 \mu\text{m}$ and $\sigma_y^* = 35 \text{nm}$ [2]).

Comparison Between Surface and Underground

At point 1, vertical ground motion has been measured simultaneously on the surface and in the hole of 50m depth with Endevco accelerometers (Fig. 6). In fact, Guralp geophones were too large to be put inside the hole whose diameter is of 70 mm.

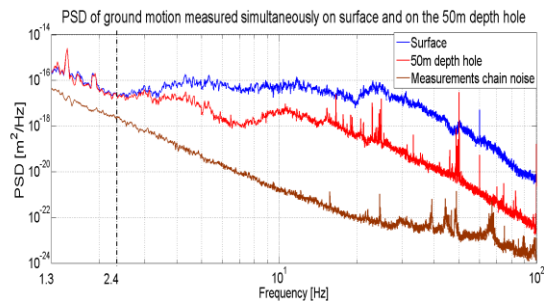


Figure 6: PSD of ground motion (on the surface and inside the 50m depth hole)

It can be clearly observed that vibrations are damped in the hole above 2.4Hz (beginning of human activities). Above 20Hz, the factor of damping goes up to 20.

All these results show that cultural noise is really well attenuated in depth.

GROUND MOTION COHERENCE

Measurements of ground motion coherence were performed in the vertical direction at point 3 on the parking (soft floor) and on the basement of the new guest house (rigid floor) in order to confirm the importance of a rigid floor for stability. Then, these measurements have been compared to the ground motion coherence measurements done on the ATF2 beam line where a special floor was built for stability.

The computed frequency where the coherence highly falls under a value of 0.8 is indicated for each distance (see Fig. 7).

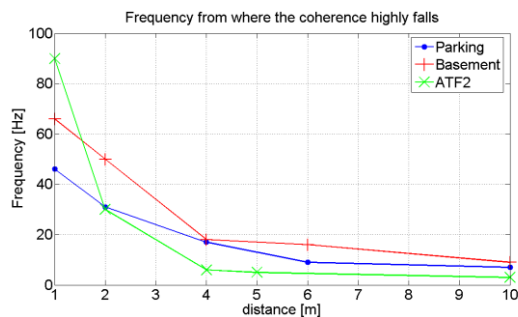


Figure 7: Frequency from where ground motion coherence highly falls for measurements.

This figure clearly shows that the basement floor keeps the coherence at higher frequency than the parking floor, which confirms that a rigid floor is very important for good ground motion coherence.

Moreover, the basement floor is really better than the ATF2 floor for ground motion coherence even if the guest house basement is not so stiff and also there are empty volumes below. This shows that the ground of the LNF is very promising for good coherence properties.

CONCLUSION

Preliminary measurements of ground motion at the LNF site give already very important results.

First, vertical measurements of ground motion have been performed during 18 hours on surface at point 3 (near a main road). The results have showed that the traffic can increase ground motion to very high levels at the LNF site. As a consequence, measurements have been thus done simultaneously on surface and inside a hole of 50m depth in order to analyze if ground motion is less subject to cultural noise in underground. Results clearly show that ground motion is well attenuated in depth from 1 Hz up to at least 100Hz (cultural noise).

The amplitude of vertical ground motion was also measured during non rush hours on surface in three other locations situated in the proximity of various sources of vibrations. It was observed to be quite the same from one point to another.

Note also that measurements of ground motion simultaneously done in the three directions show that horizontal ground motion is not much higher than the vertical one compared to horizontal tolerances which should be much less strict than the vertical one.

Finally, measurements of ground motion coherence have been done for different distances at point 3, on the parking whose floor is soft and on the basement of the new guest house whose floor is rigid. The results confirm that a rigid floor keeps the coherence up to higher frequencies than a soft floor.

Moreover, a comparison has been done between these measurements and measurements of ground motion coherence done in the ATF2 beam line where a special floor was built for stability. Results show that the basement floor of the LNF new guest house keeps the

coherence at much higher frequencies than the floor of ATF2 although it was not built for stability.

As a conclusion, the LNF can be a very good site for an accelerator with beam size at the nanometer scale if the tunnel is built by taking into account two specifications: the tunnel should be underground and the floor of the tunnel should be rigid.

FUTURE PROSPECTS

Other holes are planned to be made all around the future site of Super B in order to do other measurement campaigns. In this prospect, a waterproof accelerometer support was developed in order to measure in the holes even if there is humidity inside them (Fig. 8).



Figure 8: Developed waterproof accelerometer support.

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