Seismic Noise Coherence Measurements in Deep Salt Mines

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Overview

- Introduction
- Realmonte salt mine
- Measurement Set Up
- Results
- Next Step
- Conclusions

Introduction

One of the main problems involved in developing high sensitivity terrestrial interferometer for gravitational waves is the contribution of the newtonian noise in the low frequency region.

A partial solution to this problem can be obtained by building new detector underground in order to reduce the effect due to the surface waves.

In addition it is possible to arrange a set of seismic sensors in order to monitor and subtract the contribution of the newtonian noise from the interferometer output.

Introduction

To verify these hypothesis we perform a seismic noise data acquisition in a deep salt mine

The preliminary results of this survey are reported and the future foreseen steps.

Realmonte Salt Mine

The Realmonte salt deposit is located on the Southern coast of Sicily, about 4 km from Agrigento and 1 km from Porto Empedocle.

Realmonte Salt Mine

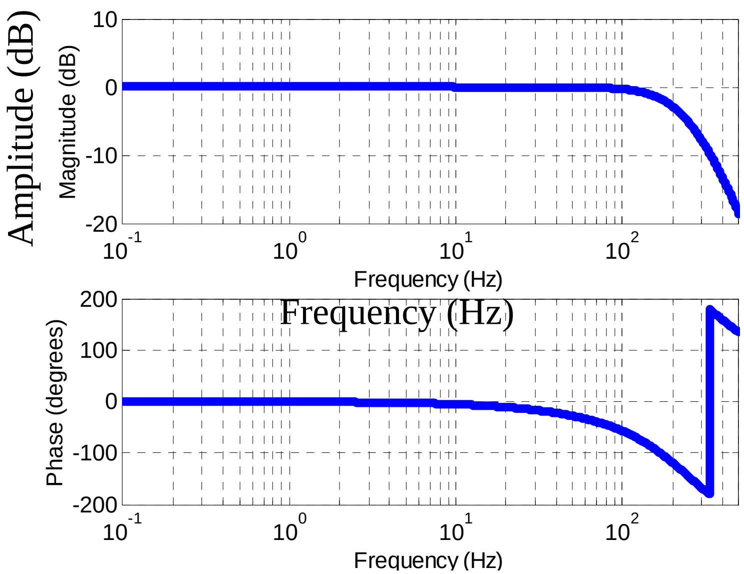
The layers of rock salt and kainite run underground in a line dropping from mountain to sea, with the rock salt layer acting as a roof to the kainite to a depth of 40 meters and a presence of NaCl of 97-98% pure.

Measurement Set Up

The measurement of the seismic noise inside the mine was performed using triaxial accelerometers model FBA ES-T (Episensors) from Kinemetrics:

Sensitivity: 40V/g

Bandwidth: 0.1 – 200 Hz



Measurement Set Up

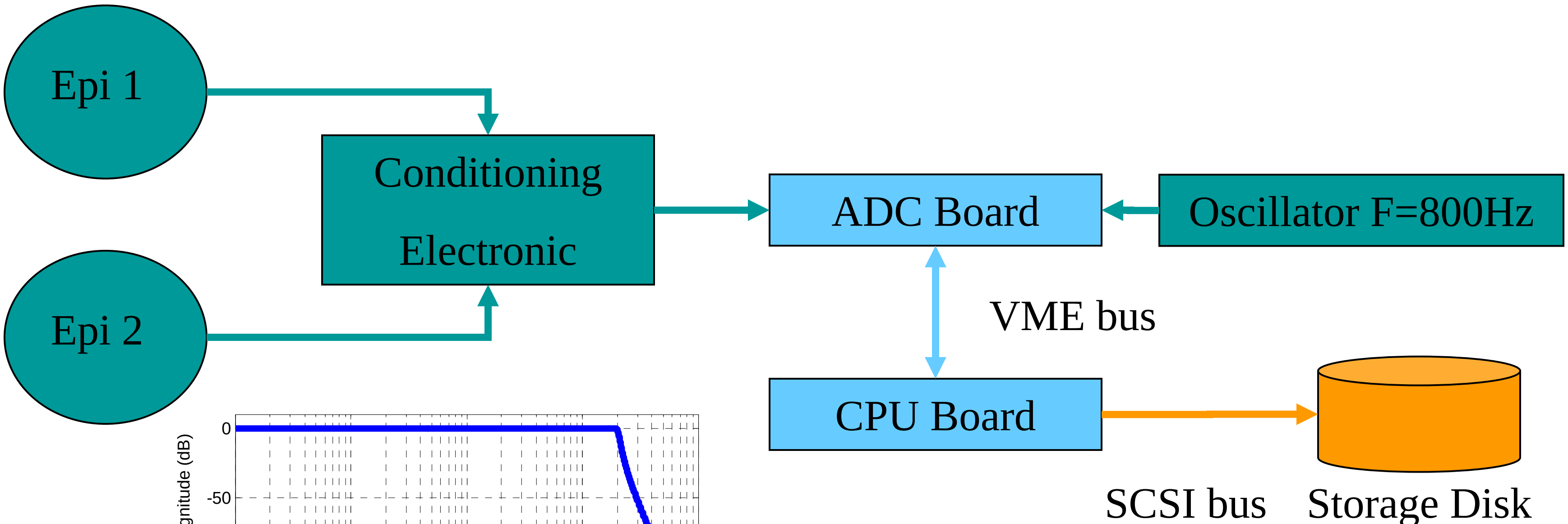
The data coming from the episensor were acquired by using a VME based digital acquisition system composed by:

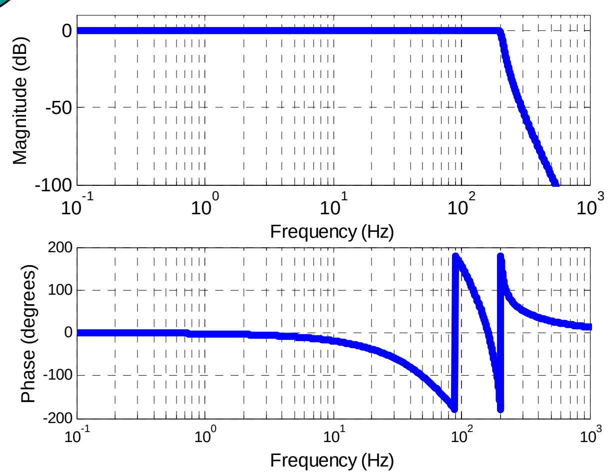
- 1 CPU board running LynxOs;
- 1 ADC board with 8 input channels and 16 bit resolution;
- 2 SCSI Disks, 9 Gb size, for storing data.

In order to match the episensor output and the ADC input dynamic ranges, and to avoid aliasing problems, a conditioning electronics with an amplifying (G=100) element and a filtering element (8^{th} order Chebyshev filter with cut off at 200 Hz).

Measurement Set Up

Each acquisition system was used to manage two episensors.

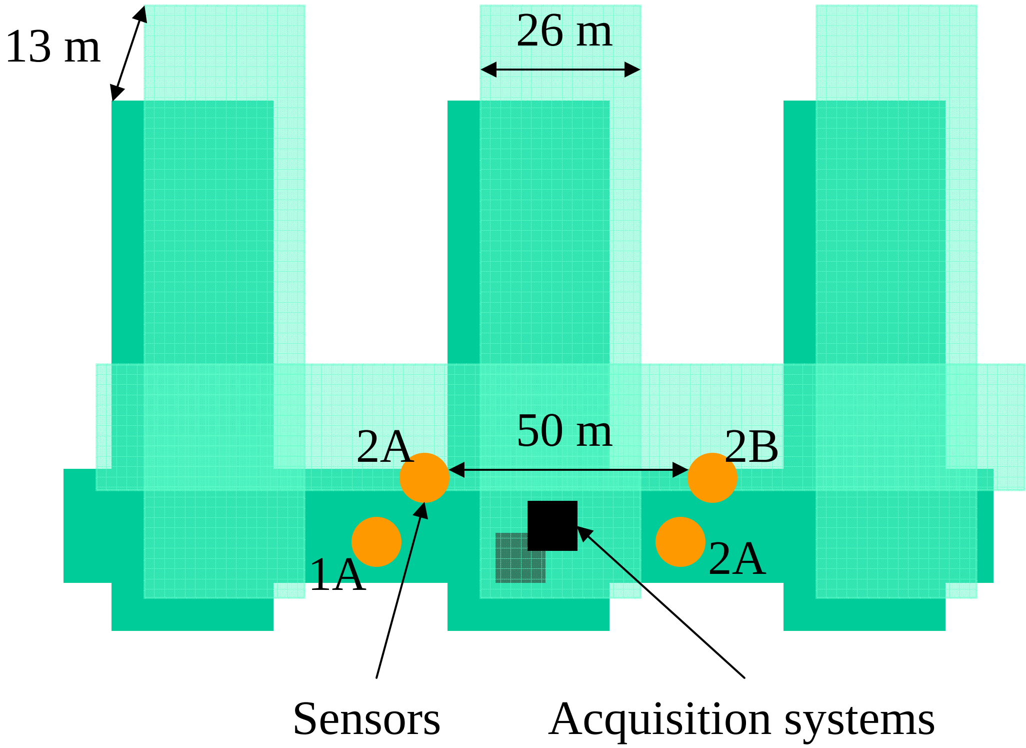




A local oscillator was used to provide the trigger for data acquisition. (No external synchronization)

Measurement Set Up

The measure was carried out by placing two acquisition systems in two caves at different depth in the mine.



Level 1: -141 m

Sensors: 1A, 1B

Level 2: -128 m

Sensors: 2A, 2B

Top view

Measurement Set Up

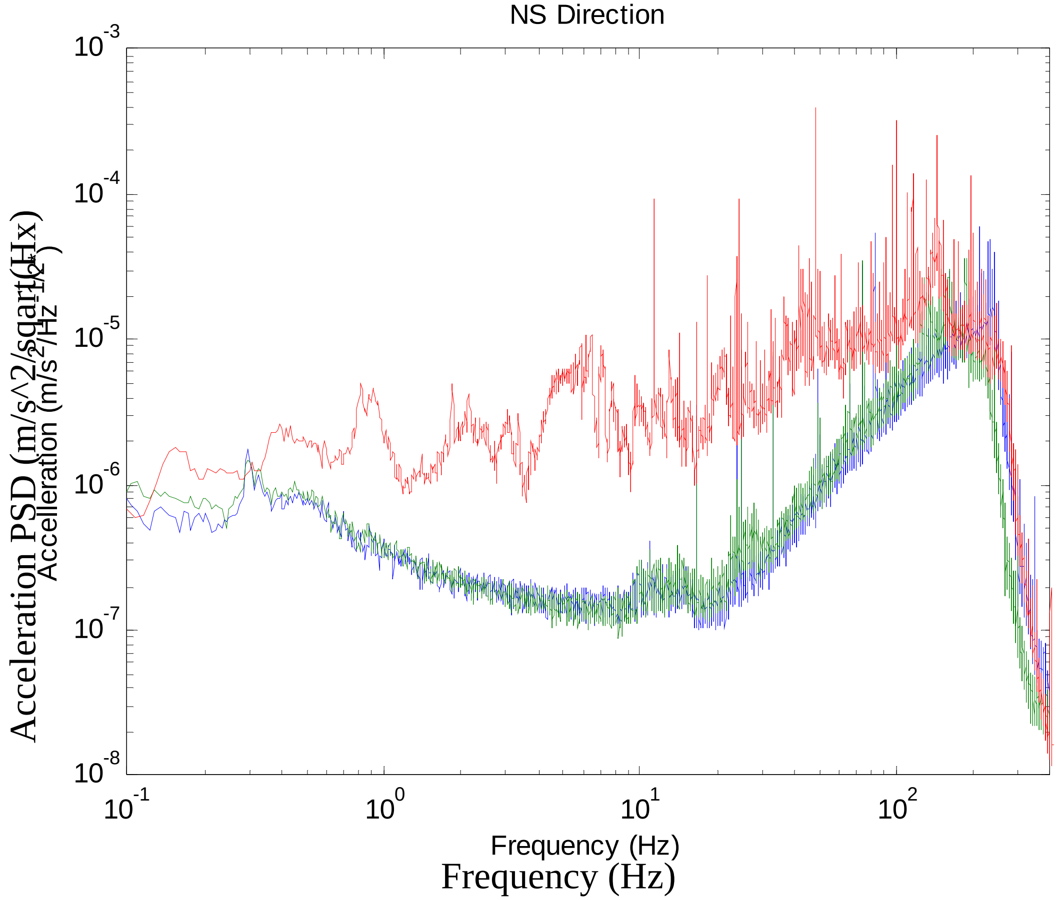
A single oscillator was used to trigger both the acquisition systems, in order to synchronize at least the data with themselves.

The acquisition was carried out starting from July 7 to August 1, 2004 (26 days), with a sampling frequency of 800 Hz.

A total of 12 seismic channels plus 2 monitor channels were acquired during this period.

Results

Power spectral density of acceleration inside the mine (NS)



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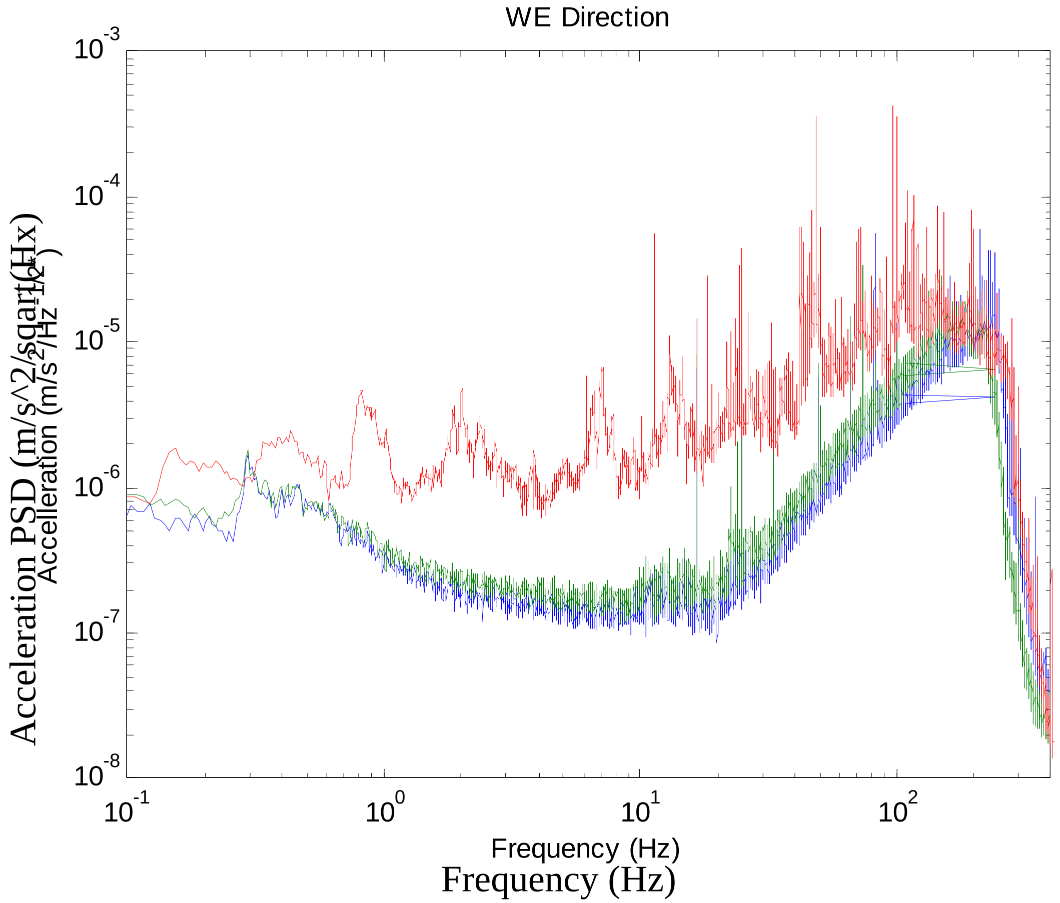
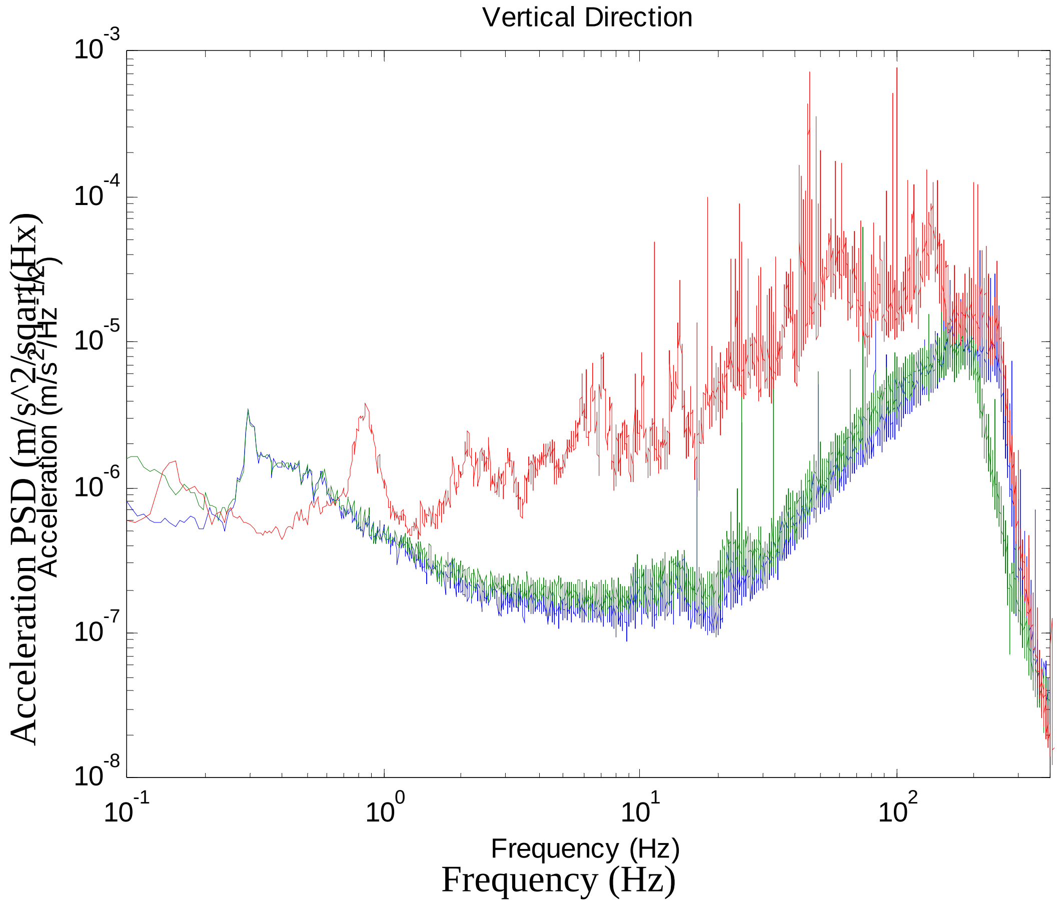
Results

Power spectral density of acceleration inside the mine EW



Results

Power spectral density of acceleration inside the mine (z)



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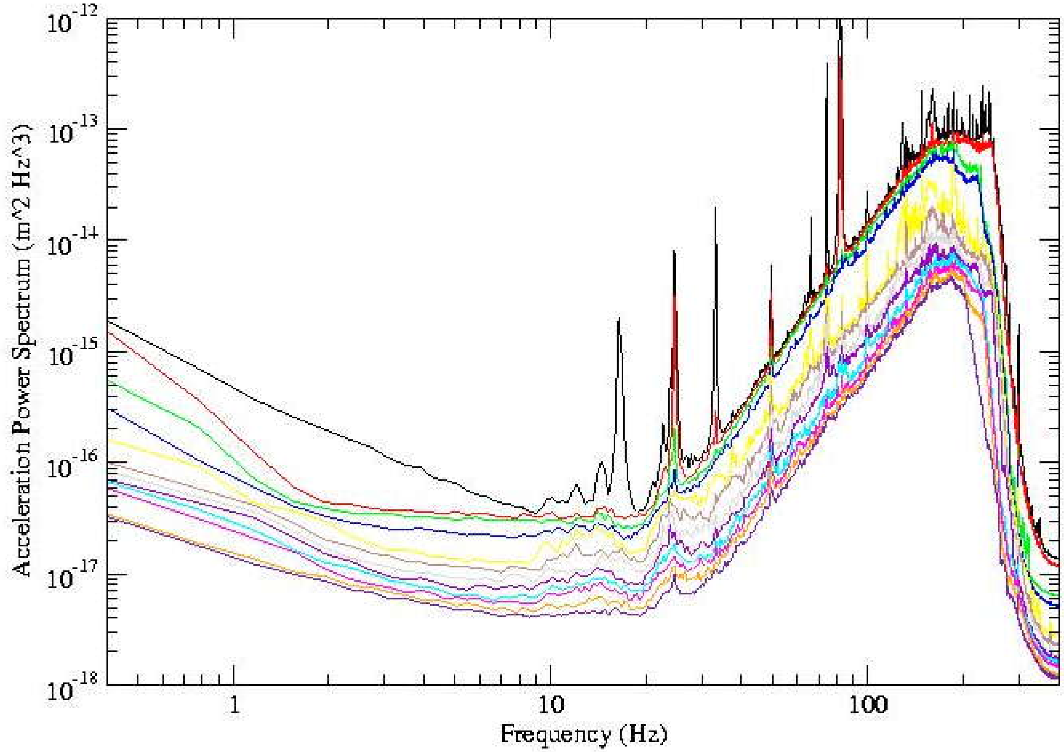
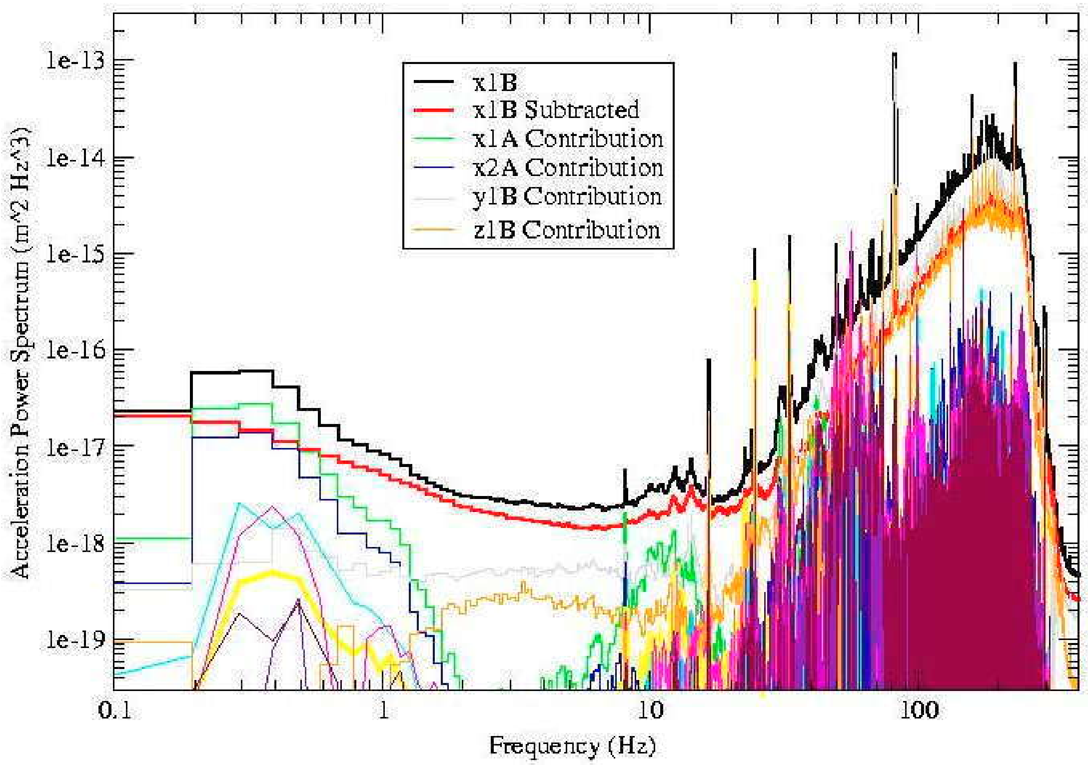
Results

Searching for seismic noise sources… (PCA)



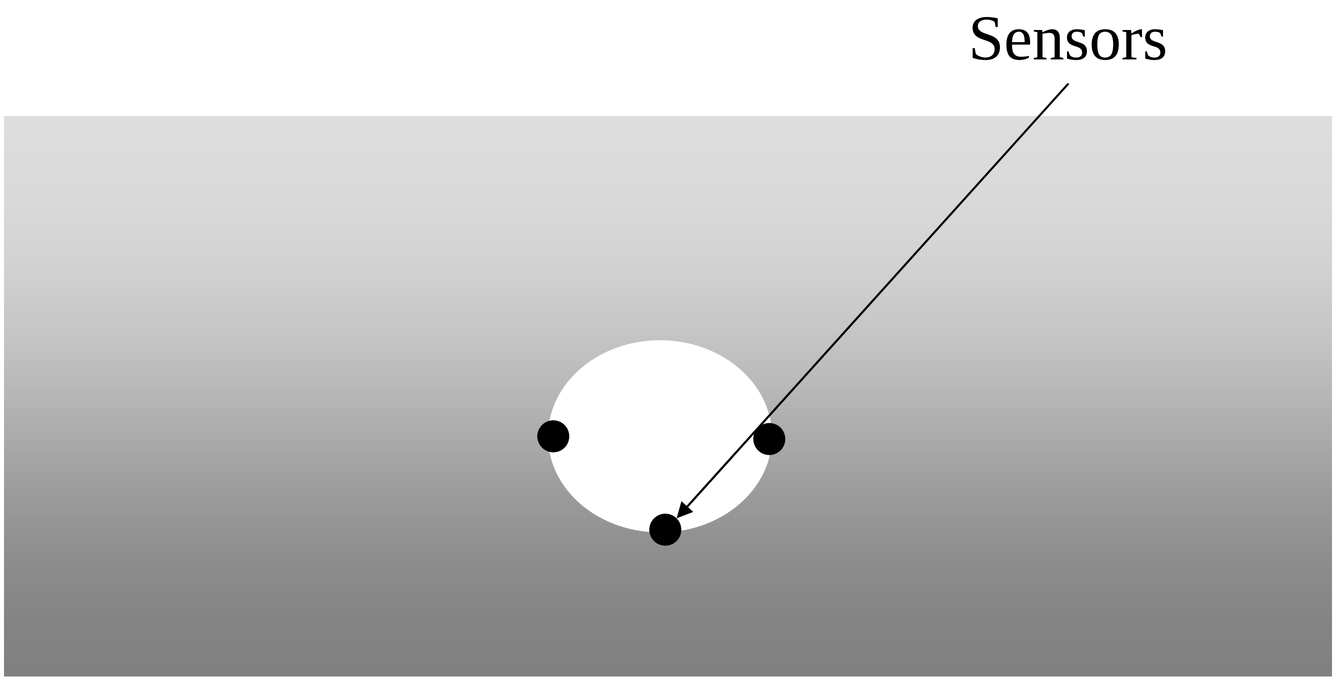
Results

Test of noise subtraction (multicoherence method)



Next Step

Arrangement of another acquisition system in a (possibly) spherical cave to optimize the noise subtraction procedure and to enhance the reduction of newtonian noise.



Conclusions

Building new interferometers underground can effectively enhance their sensitivity in the low frequency region.

The newtonian noise subtraction procedure can even increase this enhancement (if performed correctly).

Preliminary results on both this effects, base on experimental data, give us encouraging results.