Site characterization of station IV.LAV9 (LANUVIO) of Italian National Seismic Network

Working Group:	Date: April 2017
Fabrizio CARA **Giuseppe DI GIULIO** **Maurizio VASSALLO** **Giuliano MILANA** **Paola BORDONI** **Giovanna CULTRERA** **Alessia MERCURI** **Daniela FAMIANI** **Giorgia CARLUCCI**	
Subject: **Final report illustrating measurements, analysis and results for station IV.LAV9**	

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

1. Introduction

In this report, we present the geophysical measurements and the results obtained in the framework of the 2016 agreement between INGV and DPC, called *Allegato B2: Obiettivo 1 (Responsabile: C. Meletti) - TASK B: Caratterizzazione siti accelerometrici (Responsabili: P. Bordoni, F. Pacor)* for the characterization of sites of the Italian National Seismic Network (RSN) with accelerometers. Here the results for station IV-LAV9 are presented.

Geophysical measurements are 2D arrays or 1D linear array in active or passive configuration (MAWS) and provide results in terms of dispersion curves that are inverted to obtain shear-wave velocity (V_s) profiles for the studied area and suitable for assigning the EC8 class.

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

2. Geophysical investigations

Figure 1 shows the location of the stations used for the 2D array and the linear array.

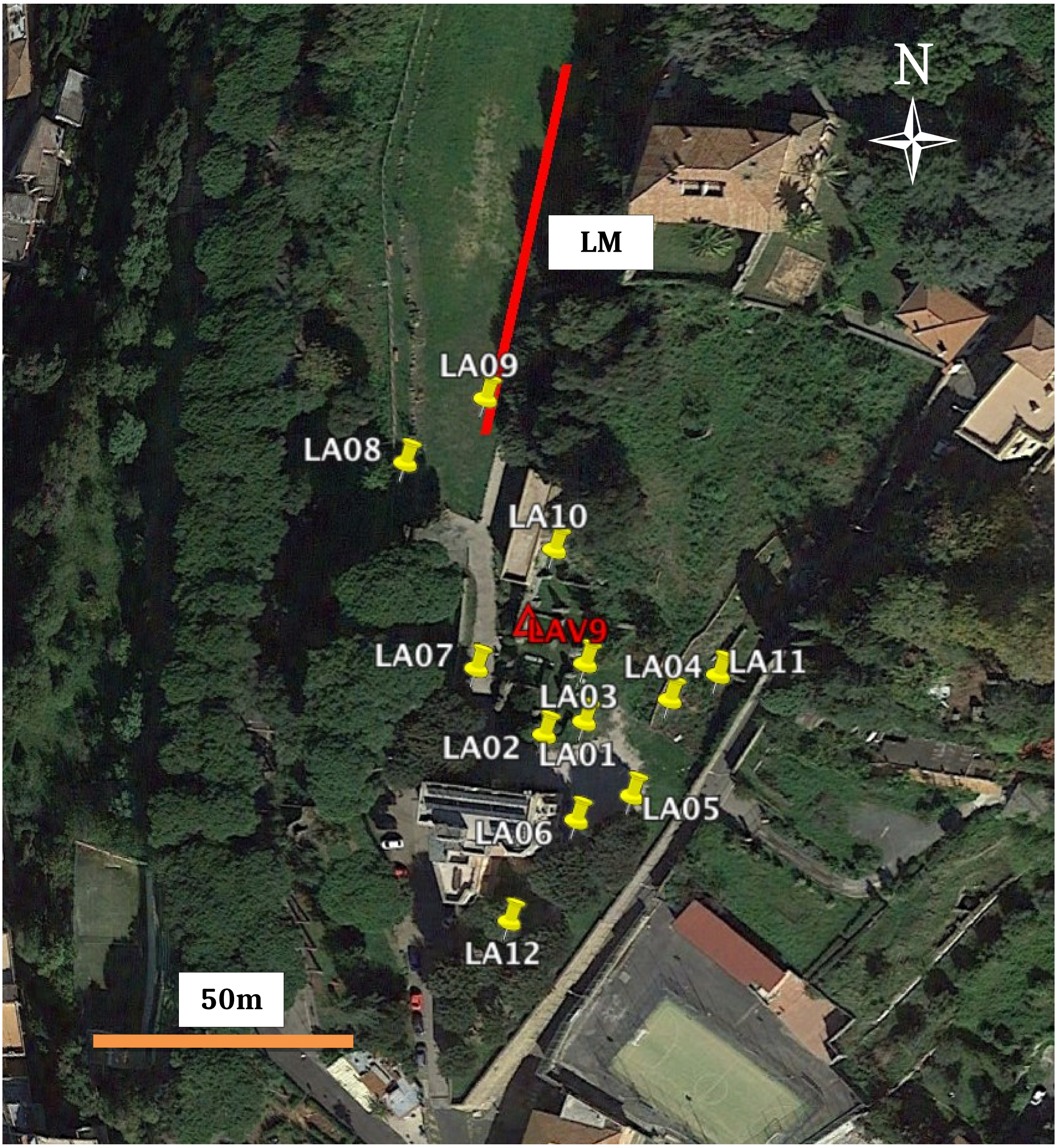

Figure 1: Map of the geophysical measurements performed at IV-LAV9 site. The yellow points are the twelve stations of the 2D array in passive configuration (all stations are equipped with Reftek R130 digitizer and Lennartz 3D-5sec velocimetric sensors); LM represents the location of the linear array in active and passive configuration. The linear array is performed using Geometrics Geode digitizers. The red triangle indicates station IV-LAV9.

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

2.1 ARRAY MEASUREMENTS RESULTS

A 2D array was performed using 12 single seismic stations equipped with Reftek 130 digitizers and Lennartz 3d-5s velocimetric sensors. The common noise recording lasted about 2 hours.

A view of the 2D passive array survey is shown in Figure 2.

The seismic sensors were positioned in a two-dimensional geometry with irregular spacing, as shown in Figure 2.

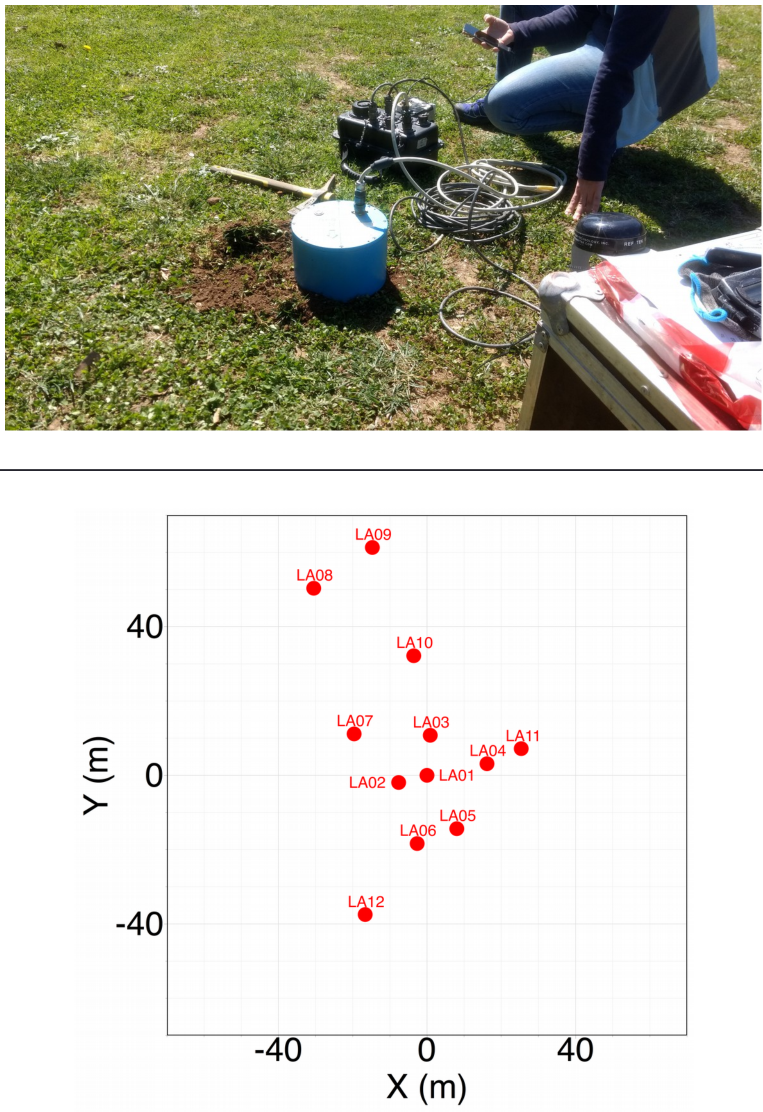

Figure 2: Top: installation of a station of the 2D array. Bottom: 2D Array geometry

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

The geometry of the array controls the response in terms of theoretical transfer function as described in Figure 3.

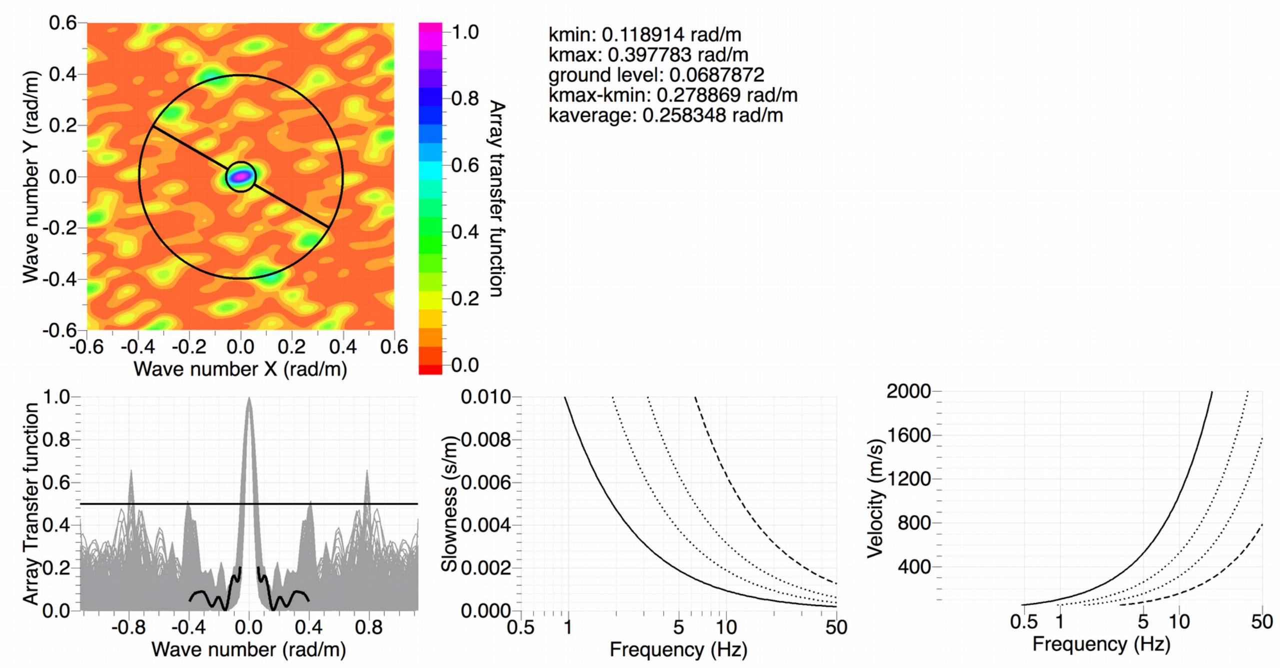

Figure 3: Theoretical Array Transfer function for the 2D array at IV-LAV9

In Figure 4 the average H/V curves of the 12 stations are overimposed each other. There is a good agreement except for station LA08 that shows a resonance frequency slightly higher than the others.

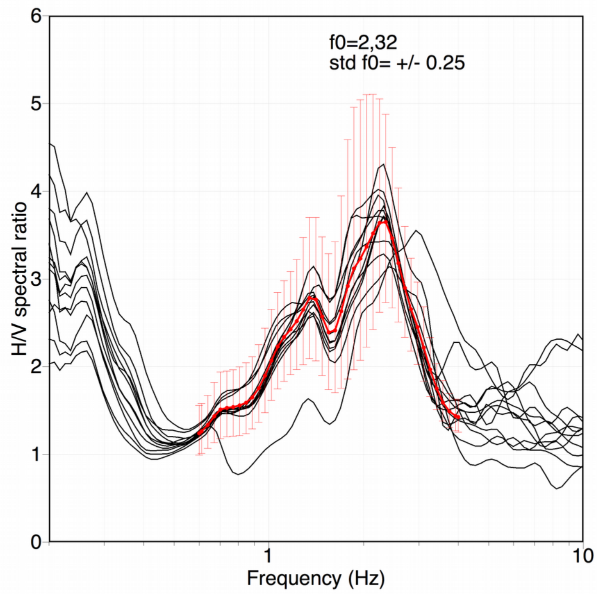

Figure 4: H/V curves of the 12 stations. The red curve is the average H/V curve in a frequency range considered as reliable for the inversion. The red bars estimate the uncertainty of the average H/V.

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

Data from the 2D array have been analysed in terms of FK analysis and high-resolution FK analysis. Because the two techniques lead to similar results, hereinafter we consider only the high-resolution FK method. For the analysis we used the code GEOPSY (http://www.geopsy.org). In Figure 5 the dispersion curve is shown.

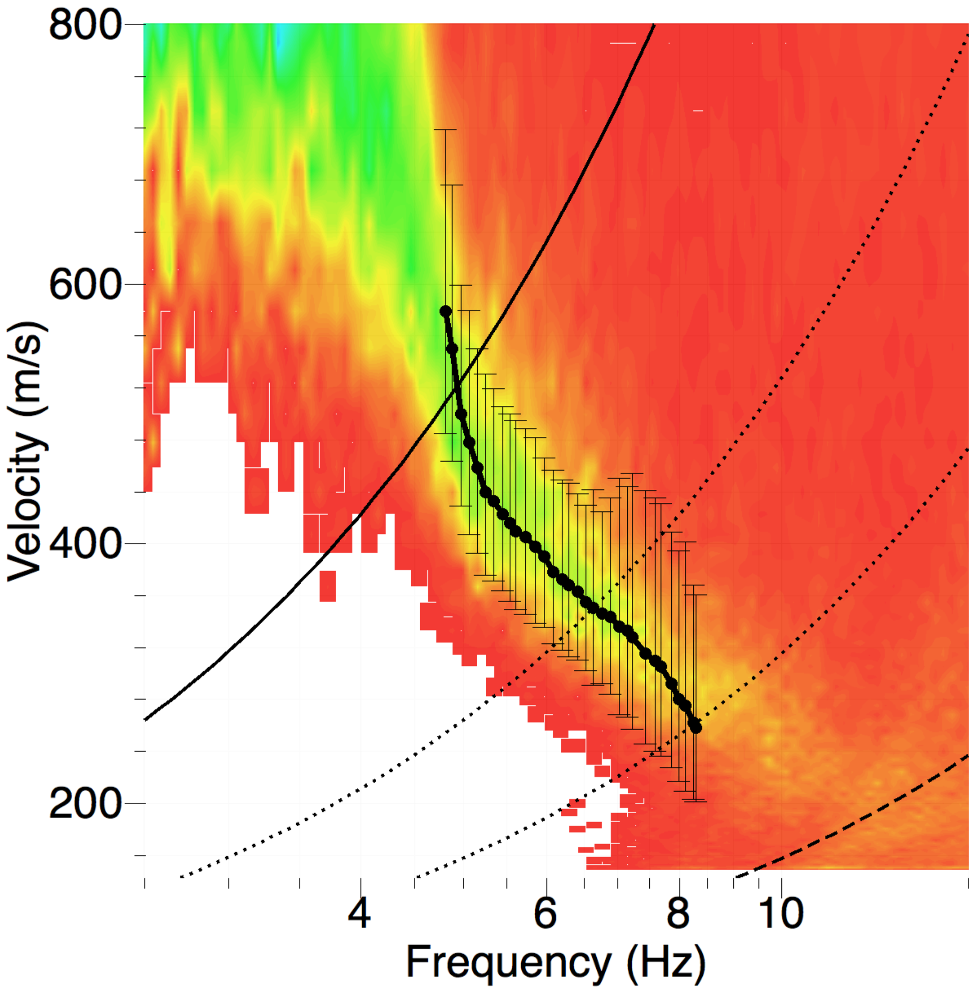

Figure 5: Picked dispersion curve in the velocity-frequency plan for the 2D array

We interpret and assume that the dispersion curve obtained with the 2D array is relative to the fundamental mode of the Rayleigh dispersive waves.

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

The spatial auto-correlation technique (MSPAC) was also applied to the passive data to obtain the auto-correlation curves (Figure 6).

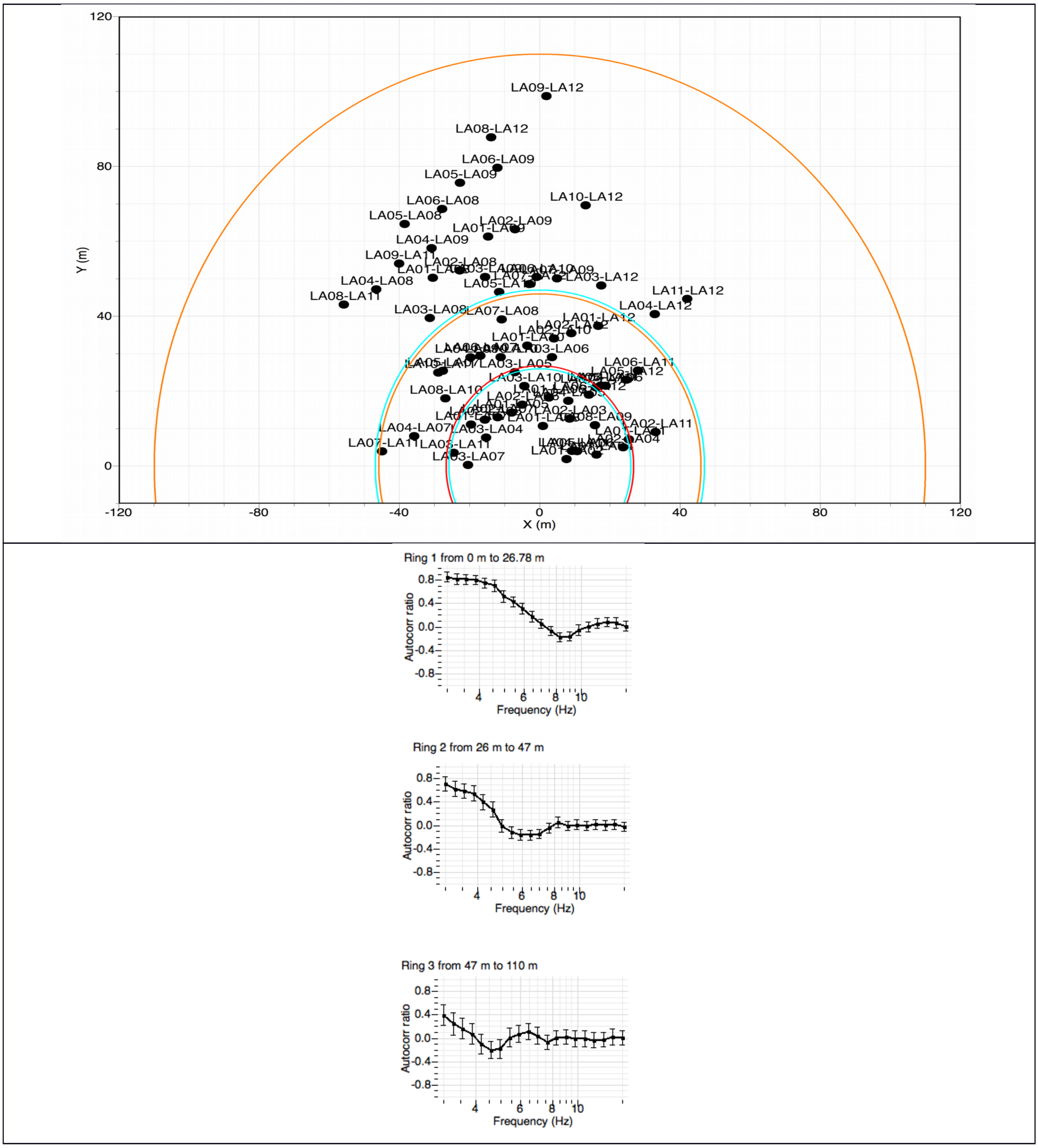

Figure 6: Top: selected rings for the MSPAC analysis. Bottom: autocorrelation curves for the three rings.

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

2.2 LINEAR ARRAY MEASUREMENTS RESULTS

MASW measurement LM

Figure 7 shows a close view of the MASW measurement.

Figure 7: MASW measurement view

General data from MASW measurement as well as the main parameters used for the spectral analysis are indicated hereafter.

General data

Date (mm/dd/yyyy) 29/04/2016

Traces

N. traces: 48

Duration [sec]: 1.5 for the active survey, 60 for the passive survey

Interdistance among geophones [m]: 1.5

Sampling [msec]: 0.125 for the active survey, 1.00 for the passive survey

Shots' location for the active survey [m from the first geophone]: -15, -5, -1, 35.25, 71.5, 75.5, 85.5

Number of shots for each location [#]: 3

Number of windows for the passive surveys [#]: 23

Shot source: body of 50kg falling down from a height of 2 mt (*)

(*) Courtesy of Università degli Studi Roma 3 - Roma

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

Spectral analysis

Minimum frequency [Hz]: 5 (active), 3 (passive)

Maximum frequency [Hz]: 60

Minimum velocity [m/sec]: 100

Maximum velocity [m/sec]: 1000

Main results from active and passive measurements in terms of dispersion curves are displayed in Figure 8.

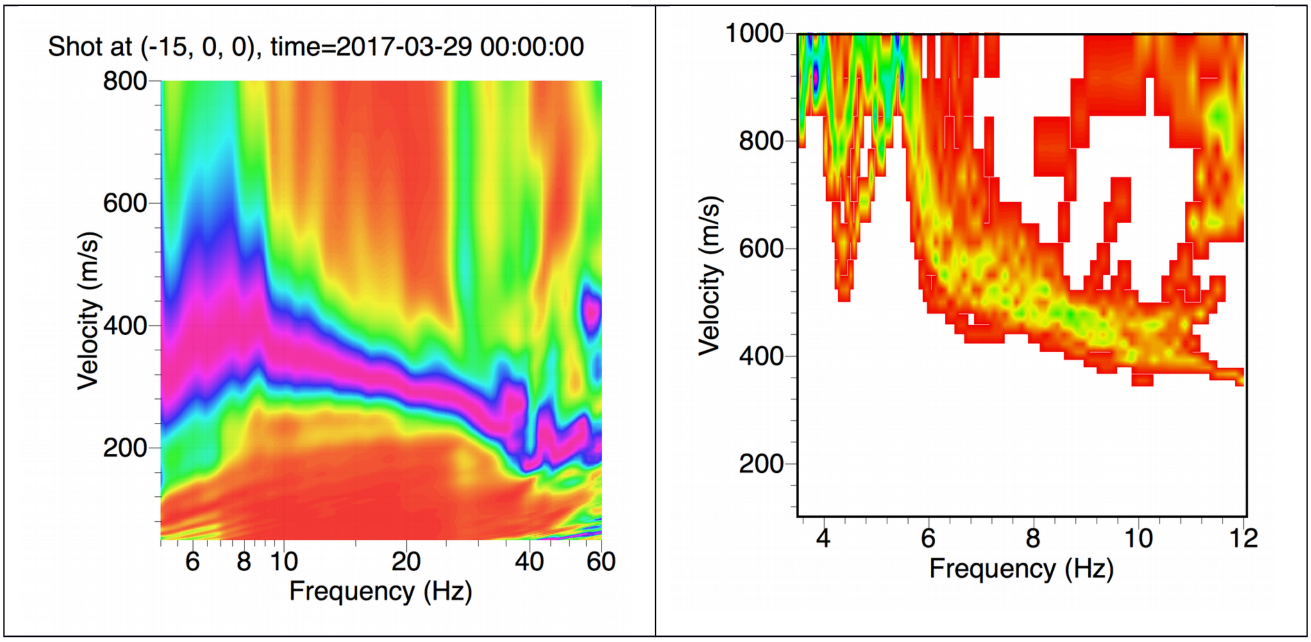

Figure 8: Velocity-frequency spectrum from MASW measurement (active on the left-hand side for a particular shot, passive on the right-hand side). Note that the two dispersion curves are not aligned and that the passive measurement does not add significative information at low frequency.

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

1.

3. V_s Model

Comparing the three dispersion curves coming from 2D array, 1D active and passive array (Figure 9), we observe that they are not aligned at all.

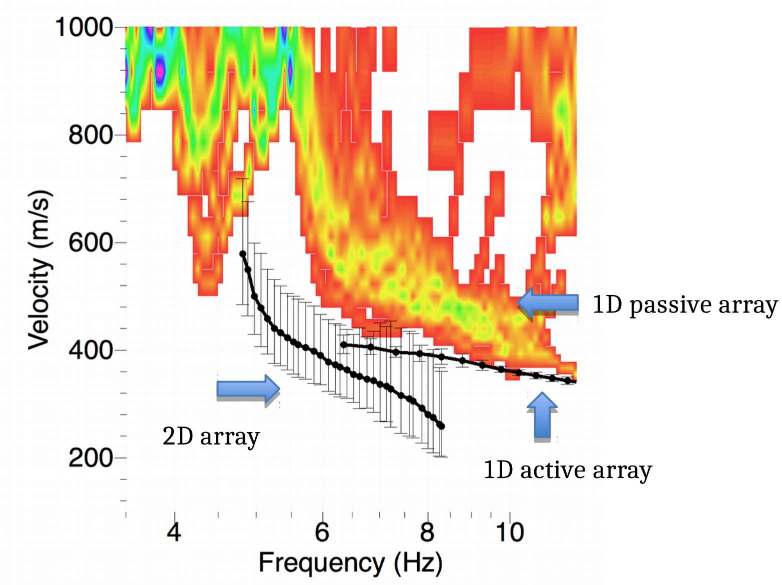

Figure 9: Comparison between the dispersion curves obtained with different methodologies

To proceed with the inversion, we assume the following hypothesis:

1) We do not consider as reliable the dispersion curve obtained with the 1D passive array
2) We consider the dispersion curve from 2D passive array as the fundamental mode of Rayleigh waves
3) We consider the dispersion curve from 1D active array as the first higher mode of Rayleigh waves

Moreover, we insert the additional targets:

1) Ellipticity curve as in Figure 4 (red curve)
2) Fundamental frequency as indicated in Figure 4 (F_o=2.32 Hz)
3) Autocorrelation curves obtained with the MSPAC analysis.

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

Figure 10 shows the comparison between the experimental targets and the ones expected for the best models coming from the inversion process.

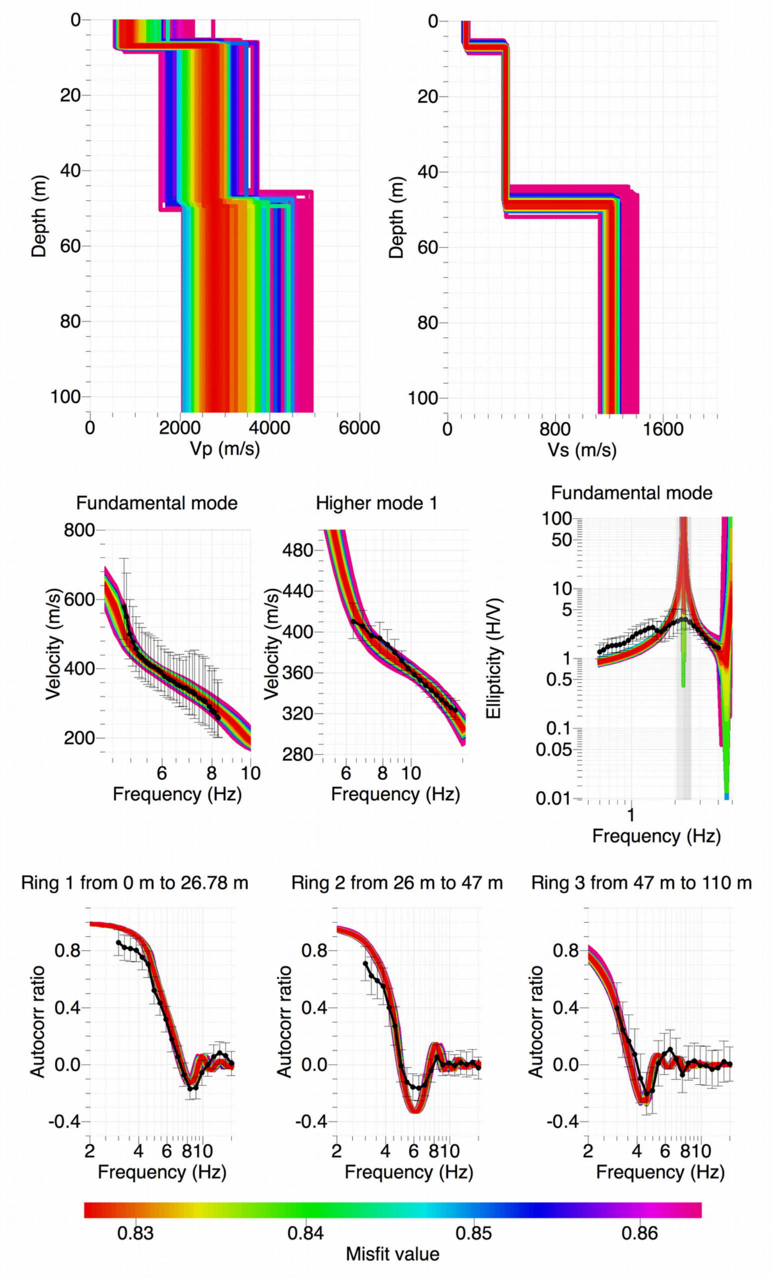

Figure 10: Inversion of the dispersion curves obtained with 2D passive and 1D active array, constrained with the H/V results as well as with the MSPAC autocorrelation analysis.

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

The best fit models of V_p and V_s are represented in Figure 11 and Tab 1.

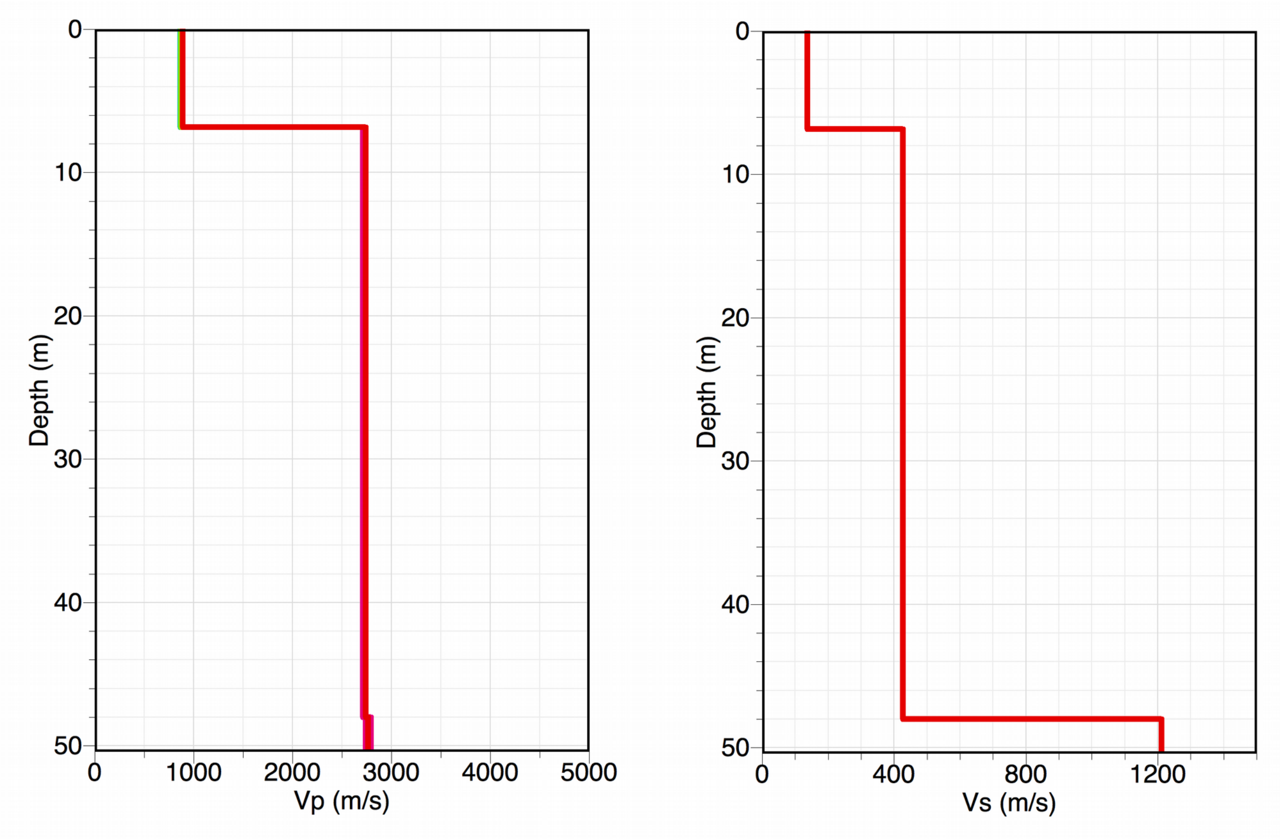

Figure 11: Best-fit models of Vp (left panel) and Vs (right panel) values

From	*To*	*Thickness (m)*	*V_s (m/s)*	*V_p (m/s)*
0	7	7	140	910
7	48	41	420	2760
48	?	?	1215	2820

Tab 1 Best-fit model

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

4. Conclusions

The H/V analysis for site IV-LAV9 shows a clear peak at about 2.3 Hz that may be related to a moderate impedance contrast at about 40-50 mt.

We can propose an interpretation of the velocity profile based on the general geological assessment of the area. The very first 5-10 meters could be linked to the presence of superficial landfill material. A second layer of about 40 mt could be related to poorly consolidate volcanic materials, and finally a stiffer layer, likely related to lava materials, should represents the seismic bedrock of this site.

The V_{s30} retrieved from the inversion of the dispersion curves is 286 m/s (Tab 2); therefore IV-LAV9 is classified as class C soil type in terms of NTC 08 seismic classification.

We have to take into account that the inversion process of the data array is poorly constrained by other independent information for this site, the results can change adding this info, if available.

V_{s30} (m/s)	***Soil class***
286	C

Tab 2: Soil Class

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

Disclaimer and limits of use of information

The INGV, in accordance with the Article 2 of Decree Law 381/1999, carries out seismic and volcanic monitoring of the Italian national territory, providing for the organization of integrated national seismic network and the coordination of local and regional seismic networks as described in the agreement with the Department of Civil Protection.

INGV contributes, within the limits of its skills, to the evaluation of seismic and volcanic hazard in the Country, according to the mode agreed in the ten-year program between INGV and DPC February 2, 2012 (Prot. INGV 2052 of 27/2/2012), and to the activities planned as part of the National Civil Protection System.

In particular, this document1 has informative purposes concerning the observations and the data collected from the monitoring and observational networks managed by INGV.

INGV provides scientific information using the best scientific knowledge available at the time of the drafting of the documents produced; however, due to the complexity of natural phenomena in question, nothing can be blamed to INGV about the possible incompleteness and uncertainty of the reported data.

INGV is not responsible for any use, even partial, of the contents of this document by third parties and any damage caused to third parties resulting from its use.

The data contained in this document is the property of the INGV.

[1] *This document is level 3 as defined in the "Principi della politica dei dati dell'INGV (D.P. n. 200 del 26.04.2016)"*

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019

Esclusione di responsabilità e limiti di uso delle informazioni

L'INGV, in ottemperanza a quanto disposto dall'Art.2 del D.L. 381/1999, svolge funzioni di sorveglianza sismica e vulcanica del territorio nazionale, provvedendo all'organizzazione della rete sismica nazionale integrata e al coordinamento delle reti sismiche regionali e locali in regime di convenzione con il Dipartimento della Protezione Civile.

L'INGV concorre, nei limiti delle proprie competenze inerenti la valutazione della Pericolosità sismica e vulcanica nel territorio nazionale e secondo le modalità concordate dall'Accordo di programma decennale stipulato tra lo stesso INGV e il DPC in data 2 febbraio 2012 (Prot. INGV 2052 del 27/2/2012), alle attività previste nell'ambito del Sistema Nazionale di Protezione Civile.

In particolare, questo documento1 ha finalità informative circa le osservazioni e i dati acquisiti dalle Reti di monitoraggio e osservative gestite dall'INGV.

L'INGV fornisce informazioni scientifiche utilizzando le migliori conoscenze scientifiche disponibili al momento della stesura dei documenti prodotti; tuttavia, in conseguenza della complessità dei fenomeni naturali in oggetto, nulla può essere imputato all'INGV circa l'eventuale incompletezza ed incertezza dei dati riportati.

L'INGV non è responsabile dell'utilizzo, anche parziale, dei contenuti di questo documento da parte di terzi e di eventuali danni arrecati a terzi derivanti dal suo utilizzo.

La proprietà dei dati contenuti in questo documento è dell'INGV.

[1]Questo documento rientra nella categoria di livello 3 come definita nei "Principi della politica dei dati dell'INGV (D.P. n. 200 del 26.04.2016)".

Cite as: Working group INGV of DPC-INGV 2016 agreement All. B2 Task B: Seismic characterization of accelerometric sites, doi: 10.5281/zenodo.824019