Activities for ET site studies

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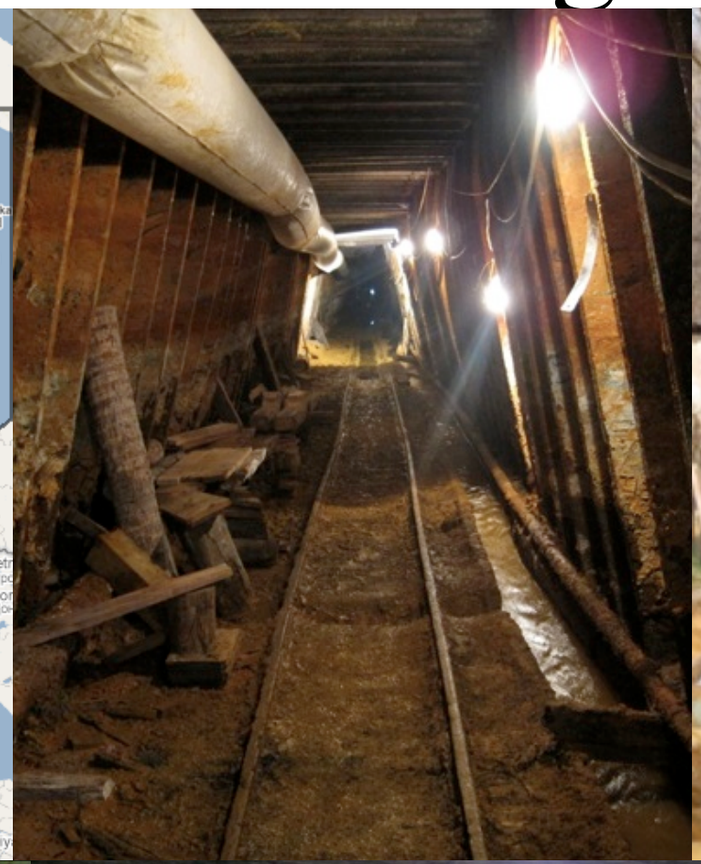
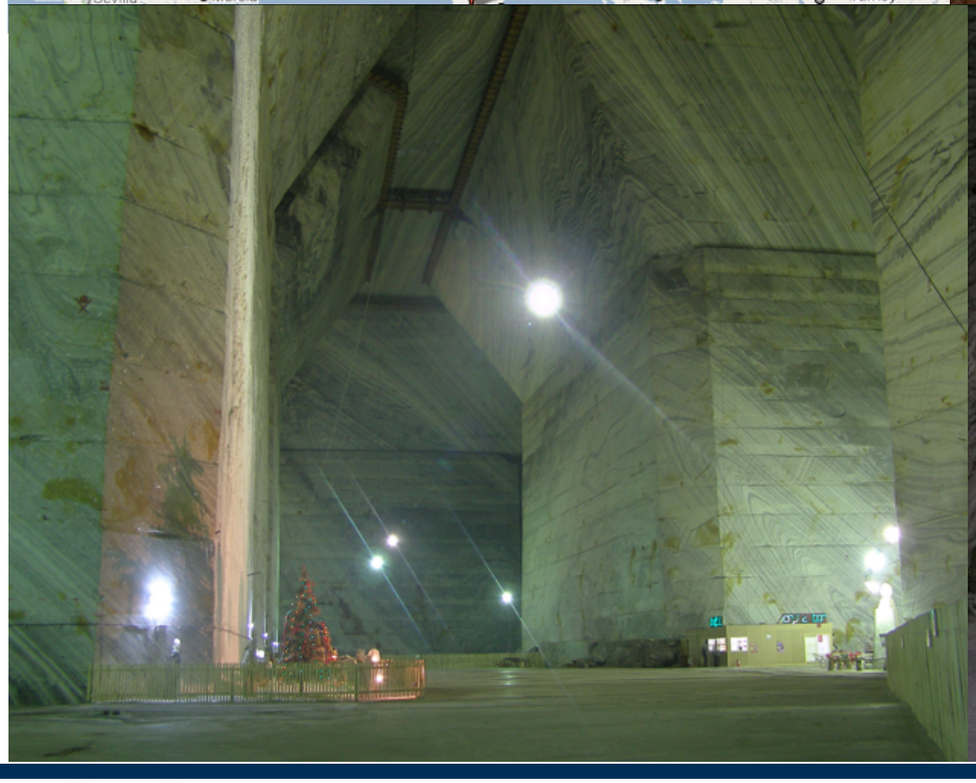
Occasion: GWADW 2013

NIKHEF

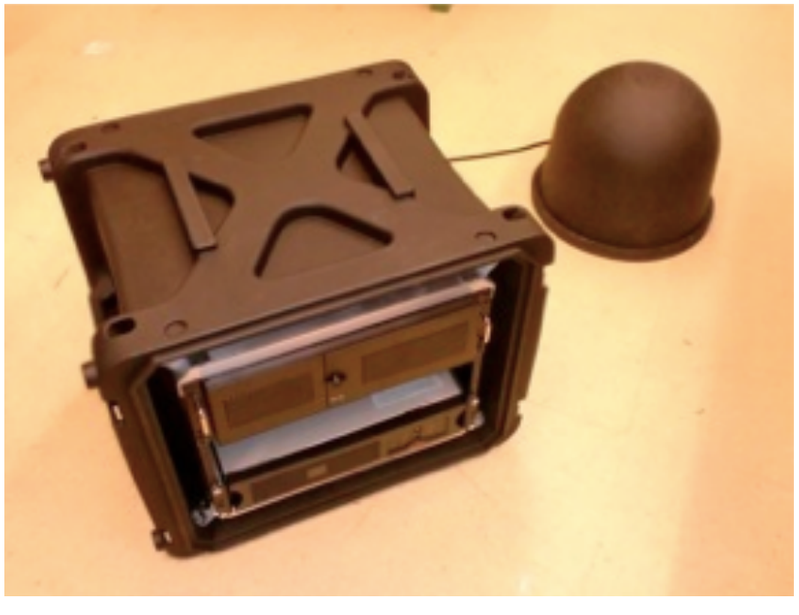
ET EINSTEIN TELESCOPE

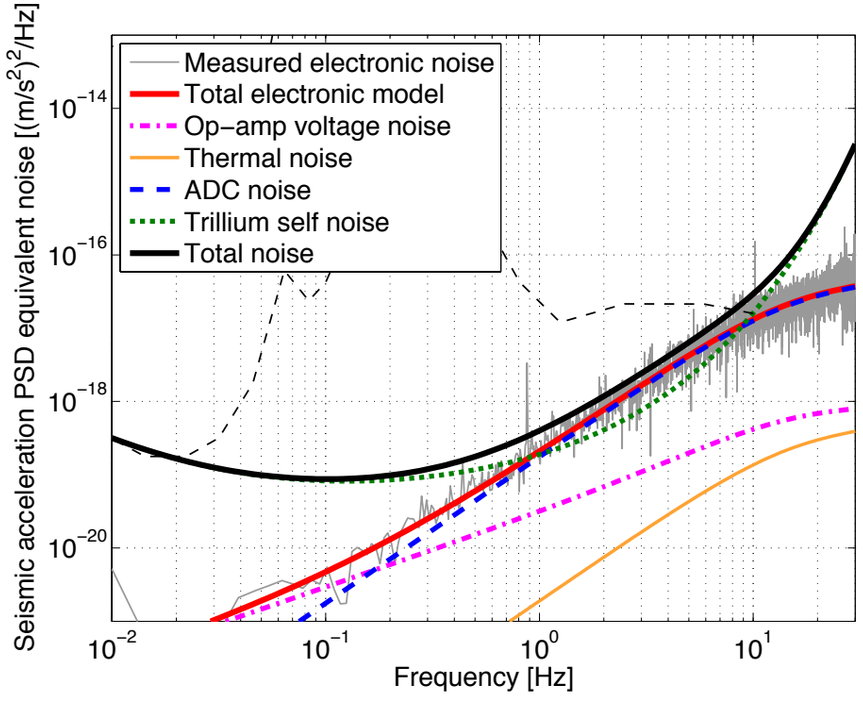
Our site search throughout Europe

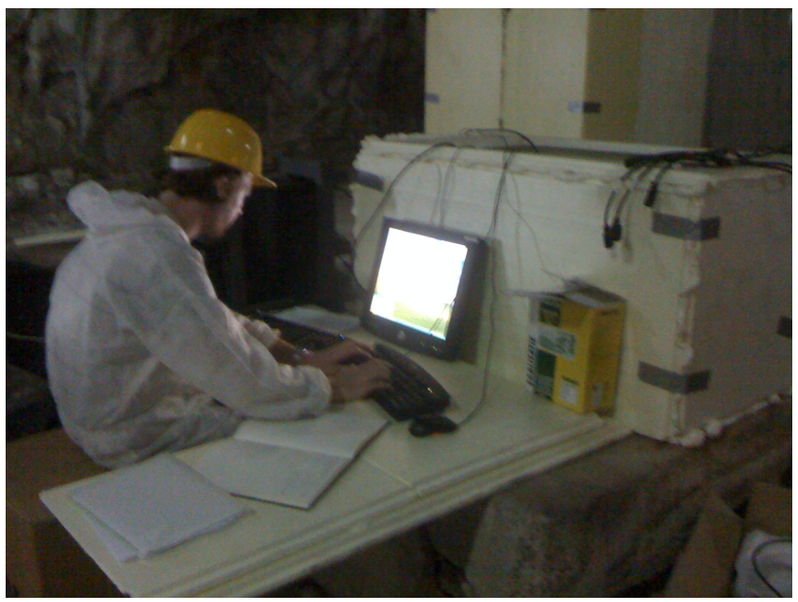


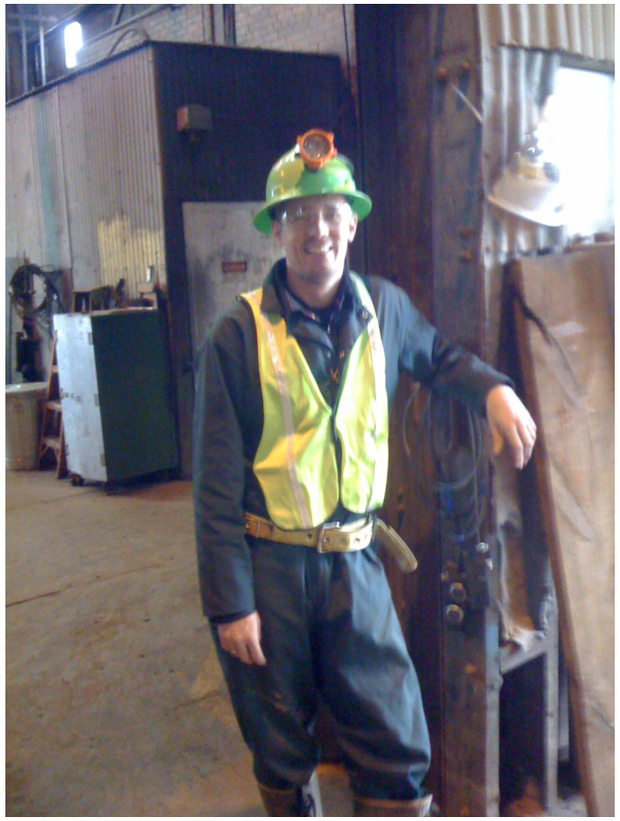


Our site search throughout Europe







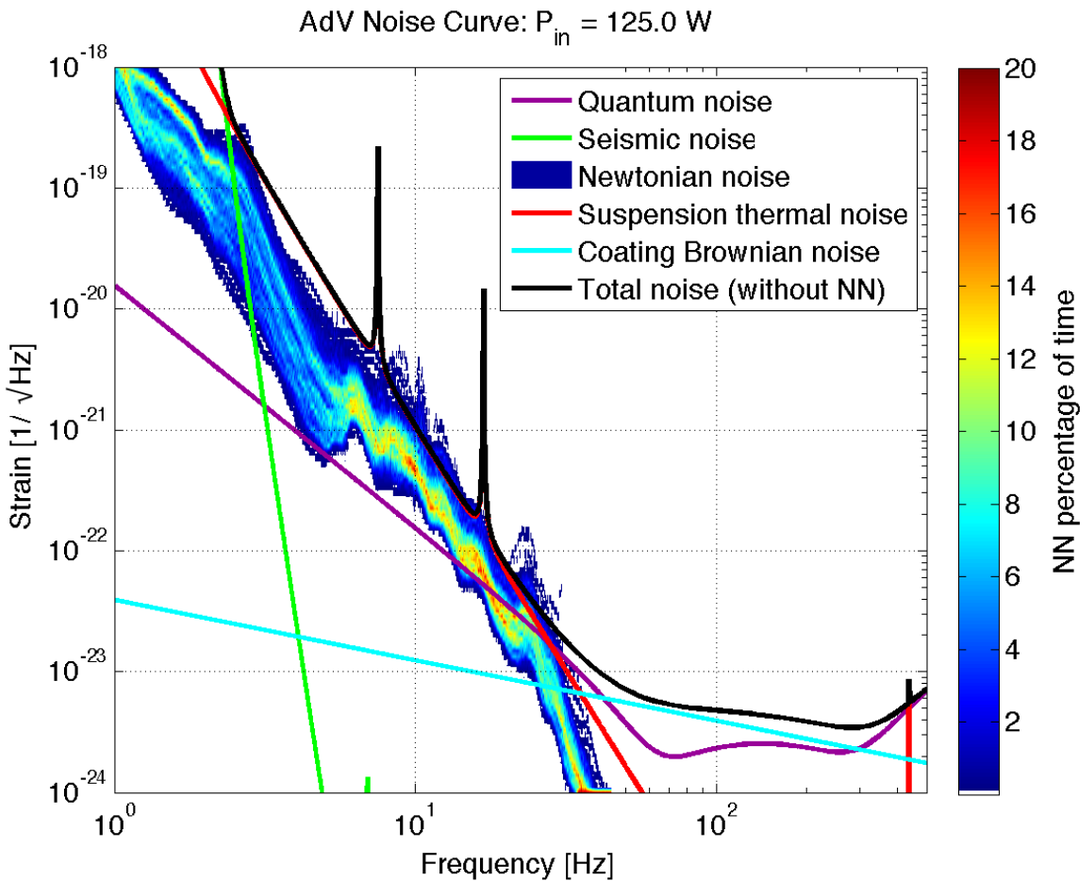


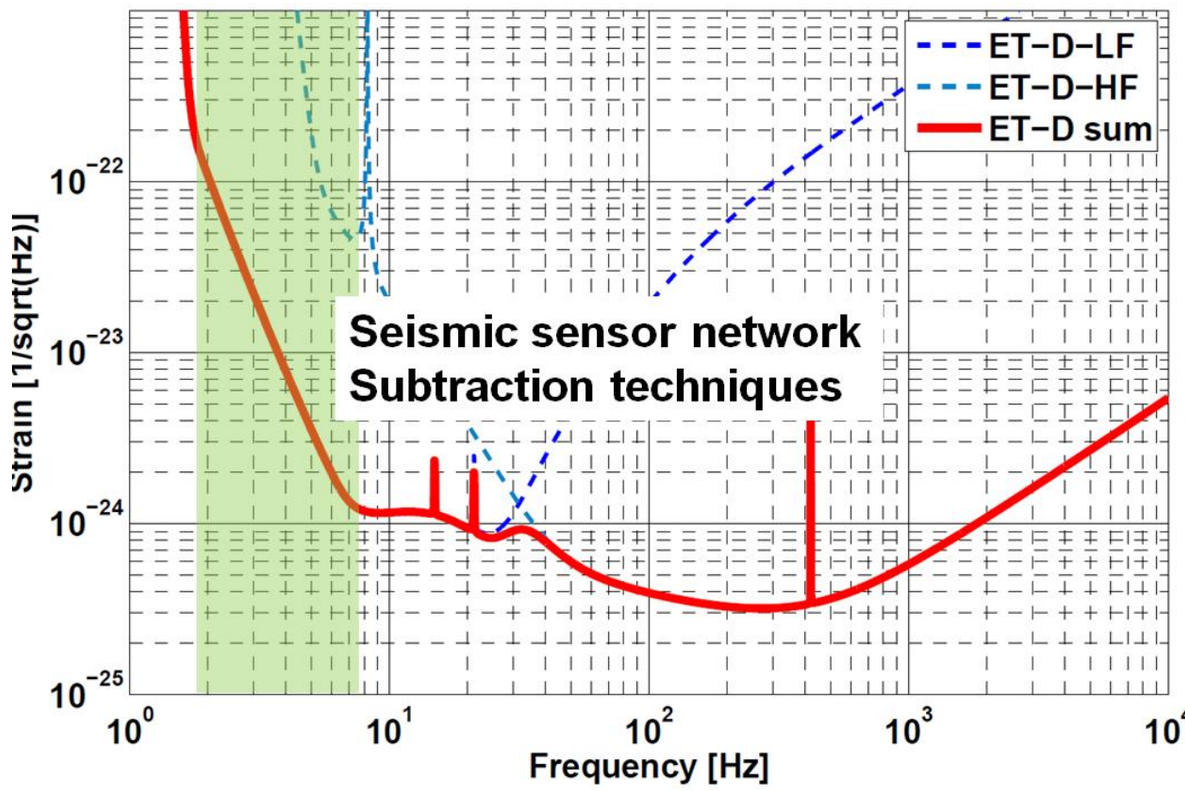
What makes a good site?

- Low seismic PSD:

$$\sqrt{P_{xx}(f)} = 5 \times 10^{-10}/f^2 \quad [\mathrm{m}/\sqrt{\mathrm{Hz}}], \quad 1 < f < 10 \text{ Hz}$$

- This corresponds to an RMS displacement of 0.1 nm @ 2 Hz.
- Soil dispersion and seismic correlations



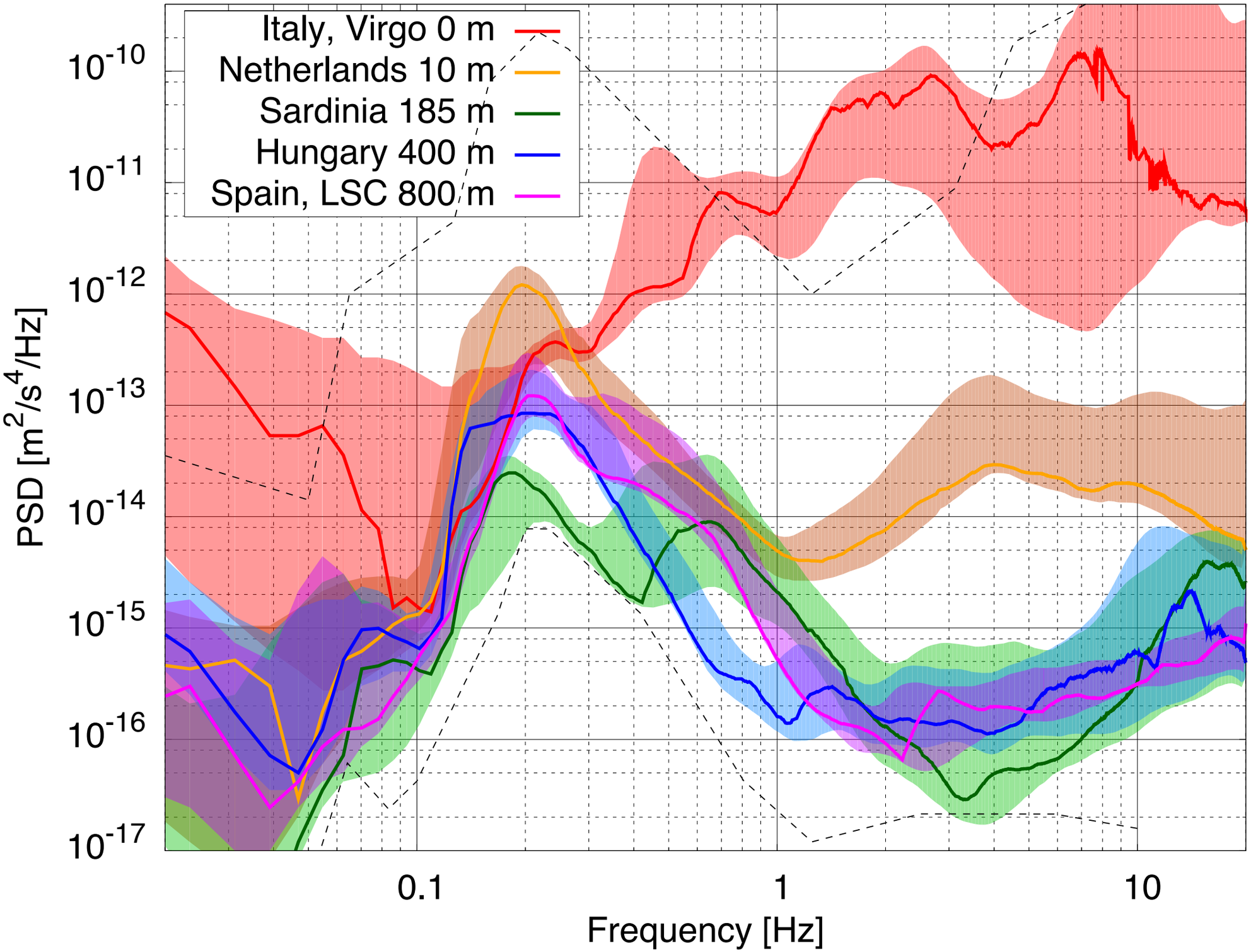


⇒ Since we would like to using subtraction techniques for NN suppression it will be of great importance to also characterize the soil coherence.

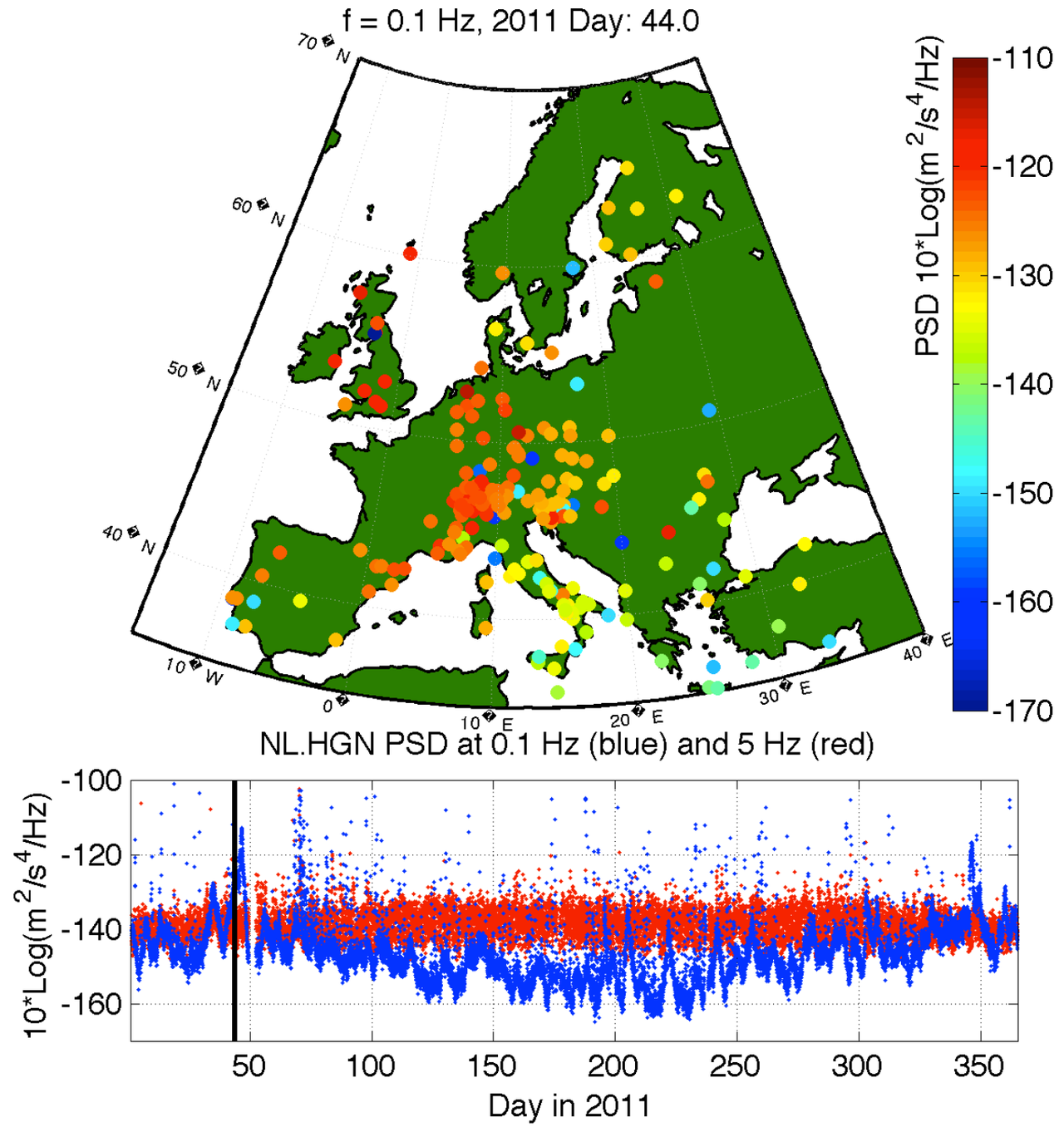
18 measurement sites in 11 countries

Location	Depth [m]	Elev. [m]	Seis. RMS [nm] ($f_c = 2$ Hz)	Basic geological description
Spain	900	1600	0.070	Hard rock
- LSC, Canfranc				
Italy	185	205	0.077	Hard rock
- Sardinia				
Hungary	400	400	0.082	Hard rock
- Gyöngyösoroszi	70	400	0.12	
France	1750	1000	0.10	Hard rock
- Frejus				
Japan	1000	358	0.11	Hard rock
- Kamioka				
Finland	0	185	0.11	Surface rock
- Sumiainen				
Italy	1400	970	0.13	Hard rock
- Gran Sasso				
Germany	95	850	0.20	Granite
- Black forest				
USA	1250	350	0.21	Hard rock
- Homestake mine	610	990	0.39	
Romania	190	195	0.25†	Salt
- Slănic-Prahova				
Germany	35	455	0.70	Hard rock
- Moxa				
Netherlands	10	135	1.07	Surface rock
- Heimansgroeve				
Belgium	230	-205	2.10	Clay
- Mol				
USA	0	142	3.79	Sedimentary rock
- LIGO, Hanford				
Germany	0	64	4.03	Sedimentary rock
- GEO600, Sarstedt				
USA	0	-7	4.34	Sedimentary soil
- LIGO, Livingston				
Italy	60	-30	9.24†	Salt
- Sicily				
Italy	0	52	26.8	Sedimentary soil
- Virgo, Pisa				

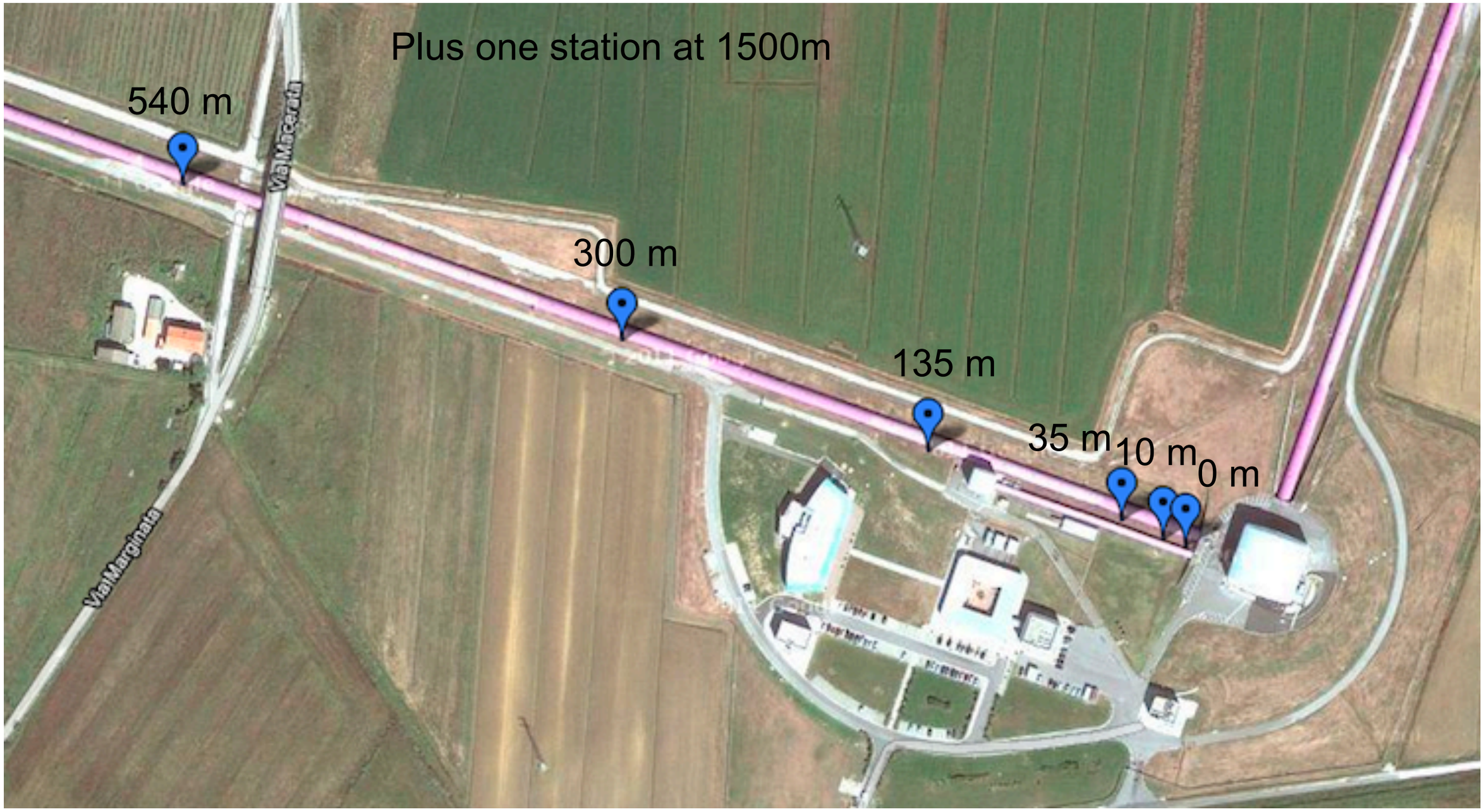
Site comparison



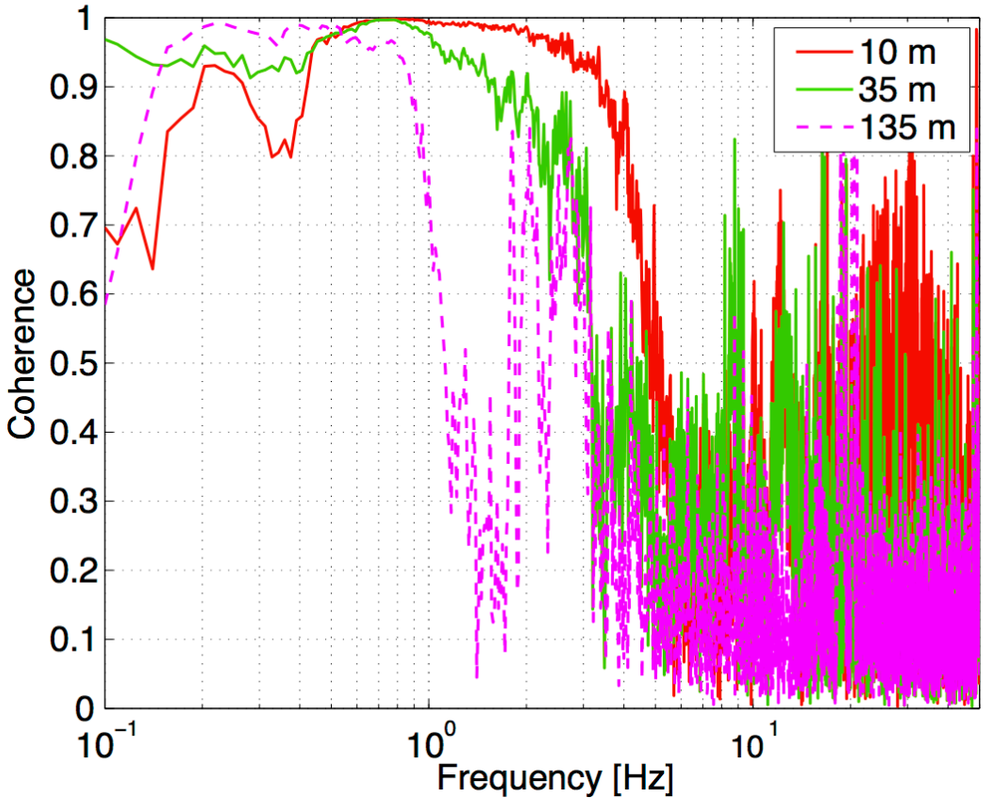
VEBSN data @ Heimansgroeve

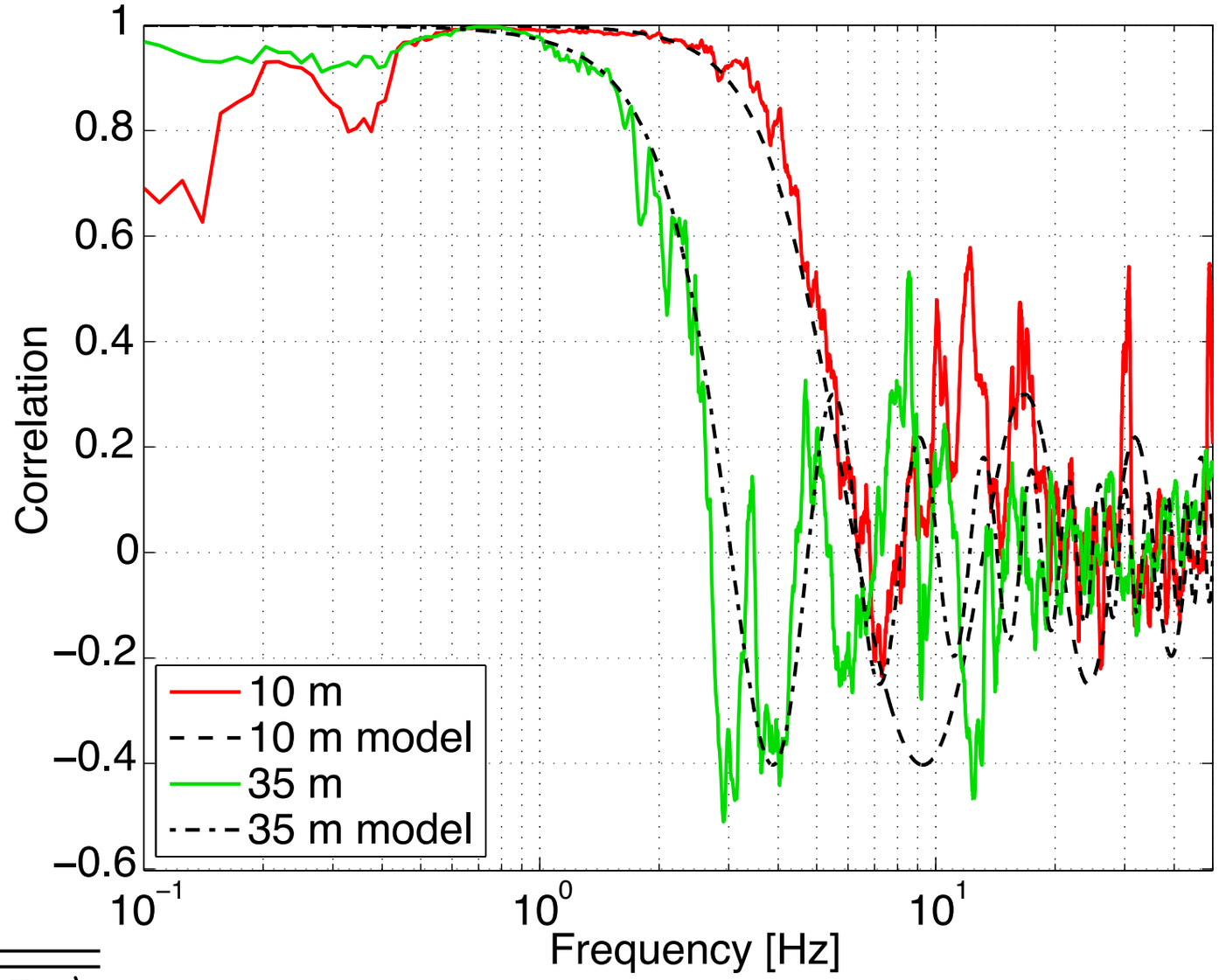


Correlation measurements (week 26, 2012)



Correlation and coherence





Seismic complex correlation:

$$K_{12} = \frac{\langle X_1 X_2^* \rangle}{\sqrt{\langle X_1 X_1^* \rangle \langle X_2 X_2^* \rangle}}$$

X_n = Fourier transformed displacement of sensor n

$*$ = Complex conjugate

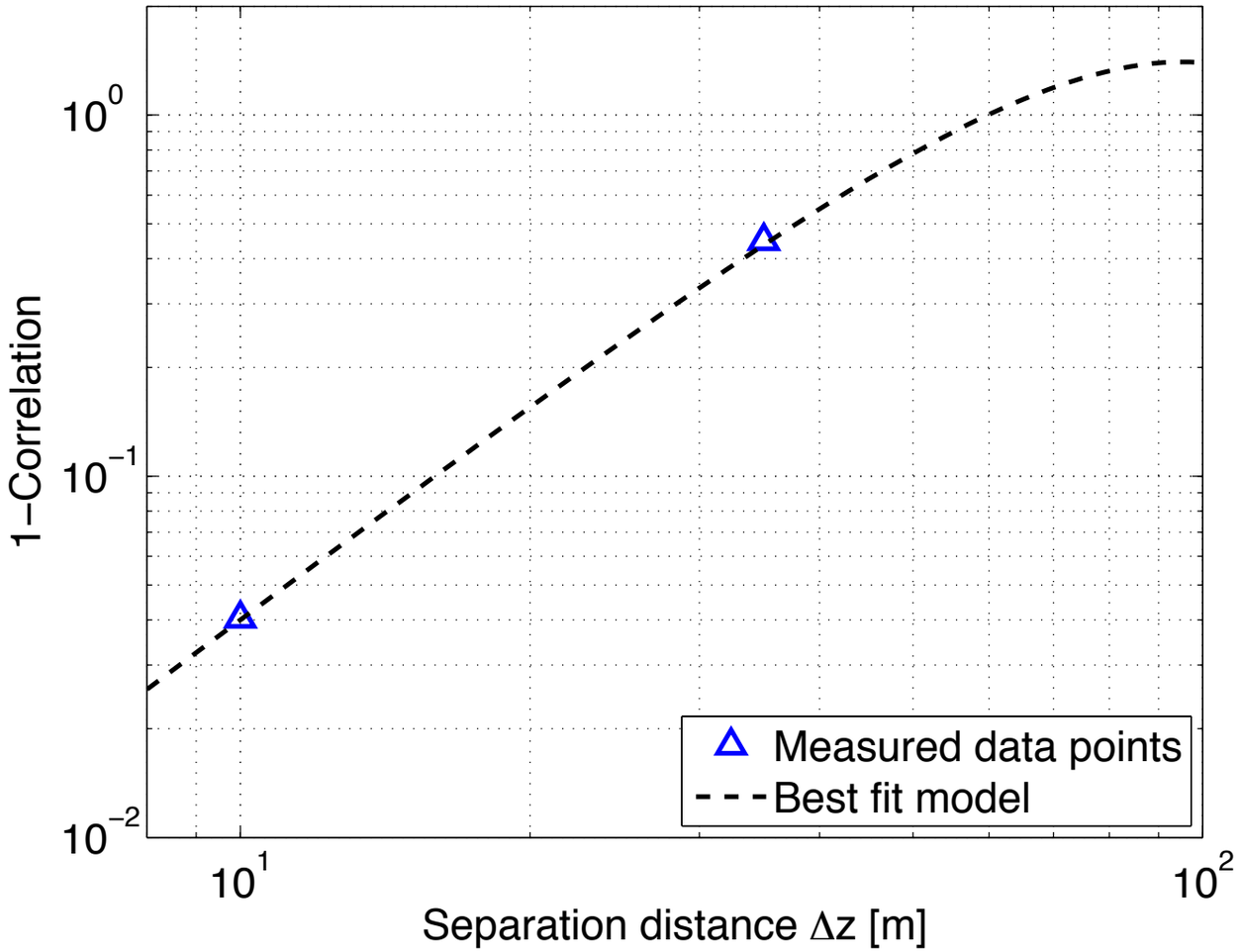
$\langle \cdot \rangle$ = Ensemble average

Extracting velocity information from the data

We can try to fit the correlation using velocity as the only free parameter:

$$Re[K_{12}(\omega)] = J_0[\omega \Delta z / c_r(\omega)]$$

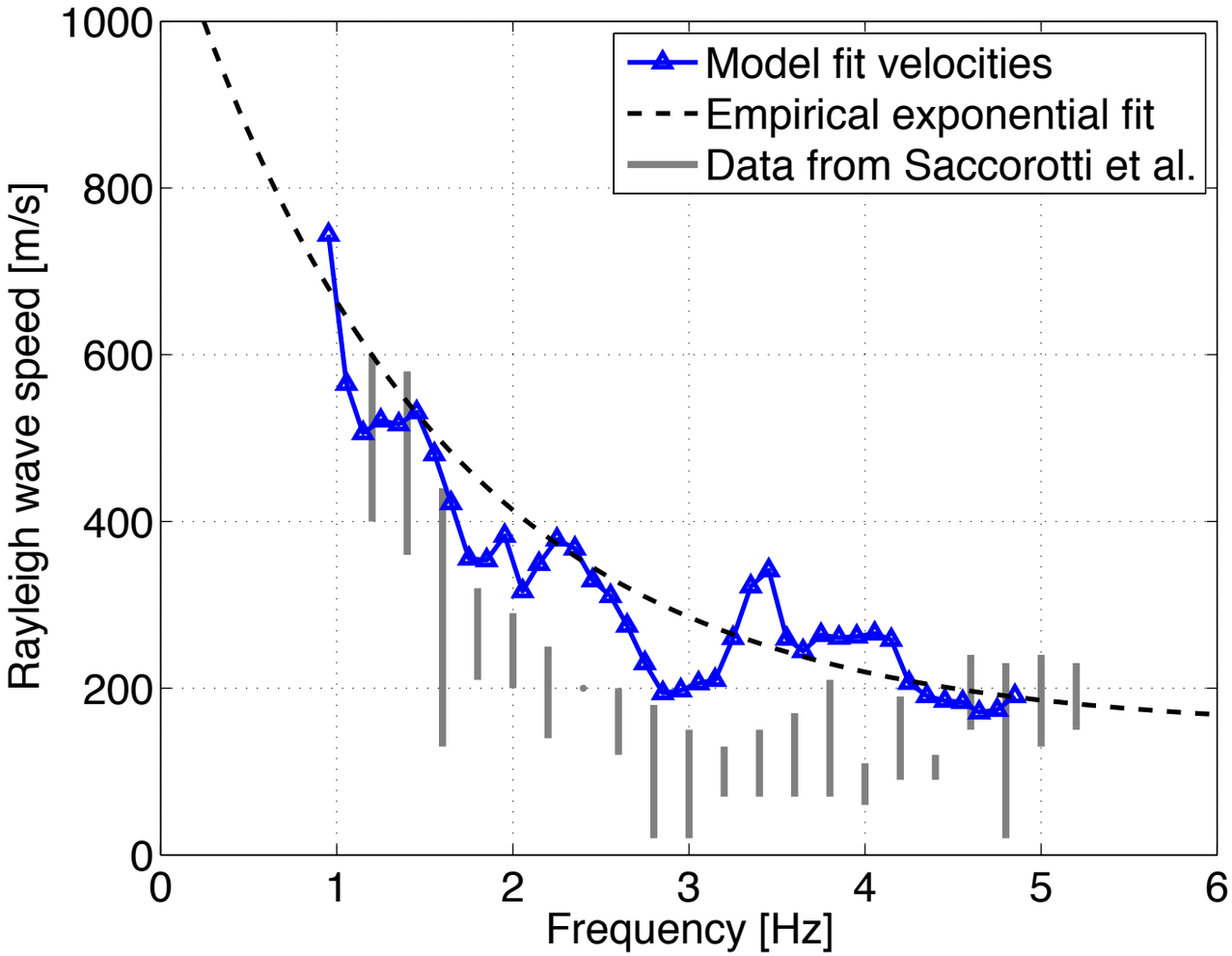
Velocity fit example using 2.35 Hz data



The resulting measured velocity profile gives an exponential fit

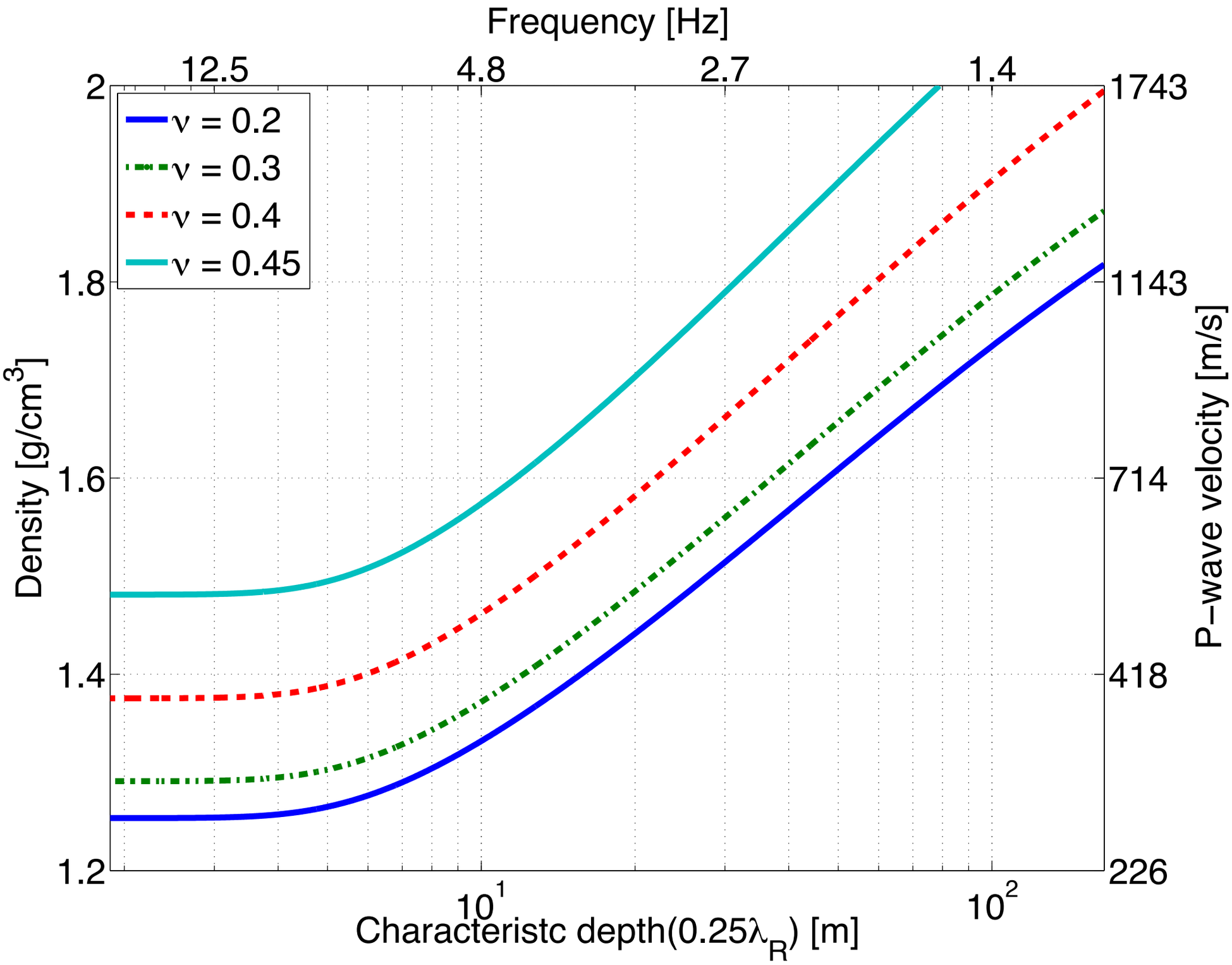
$$c_R(f) = 150 + 1000e^{-f/1.5}$$

Extracting the fd Rayleigh wave speed

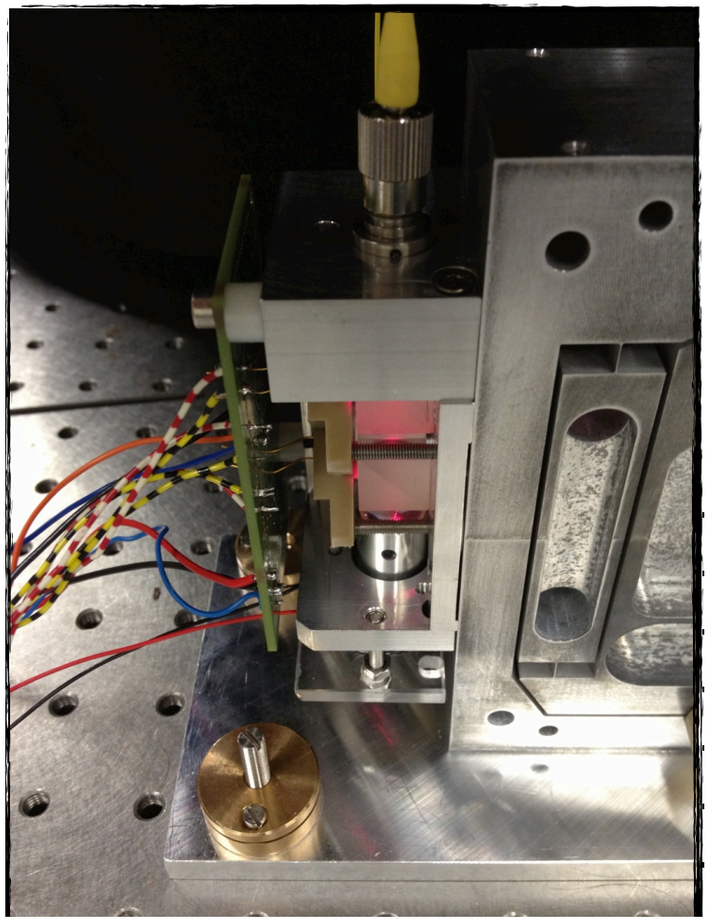


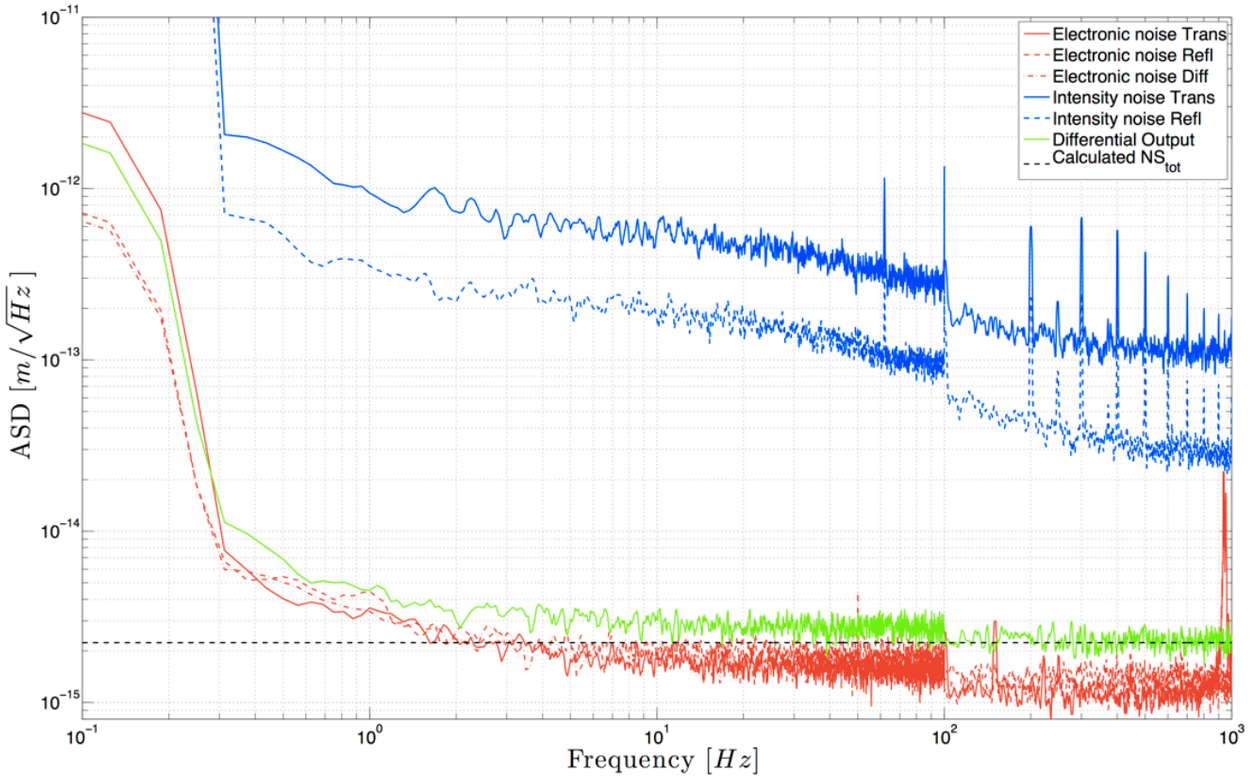
G. H. F. Gardner, L. W. Gardner, and A. R. Gregory. Formation velocity and density—the diagnostic basics for stratigraphic traps. Geophysics, 39(6):770–780, 1974.

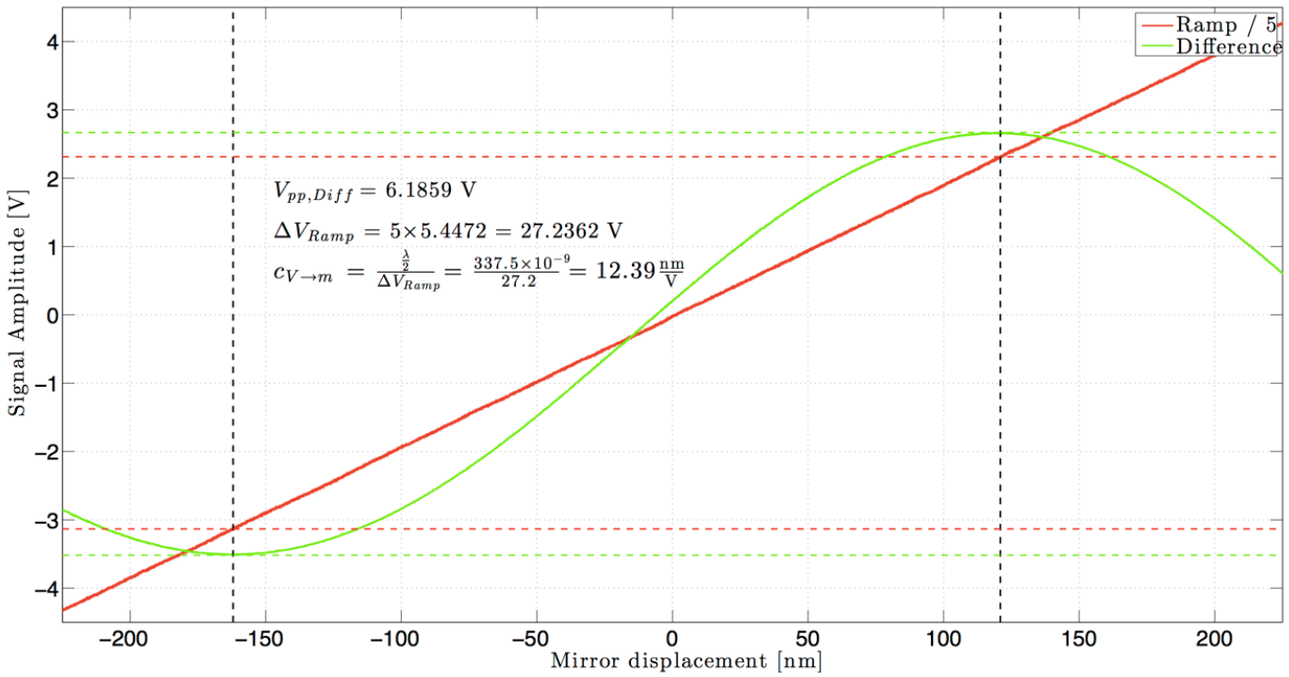
Extracting soil density information

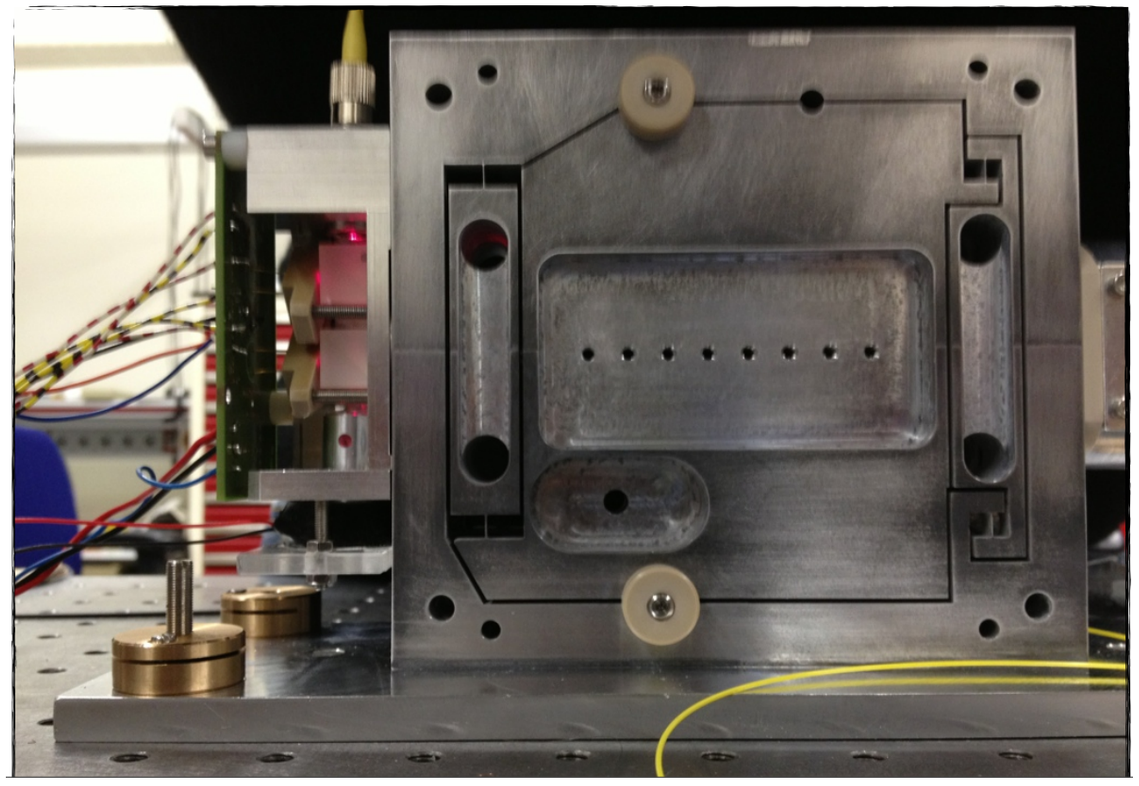


Work done on sensing arrays









Summary

- We concluded the preliminary site selection program
- We aim to start long-term site characterizations, where we map soil characteristics like coherence.
- For this, we are developing various seismic sensors aimed for Newtonian noise subtraction schemes.
- By the end of this year we aim to have our first sensor grid up and running.