Seismic studies at Sos Enattos and other ET candidate sites

Tomek Bulik, Mariusz Suchenek, Neha Singh, Dorota Rosinska
Bartosz Idzkowski, Marek Cieslar, Tomek Starecki, Grzegorz Nieradka

Big thanks to Luca Loddo and the entire Sos Enattos team!

European Funds Smart Growth
FNP Foundation for Polish Science
European Union European Regional Development Fund

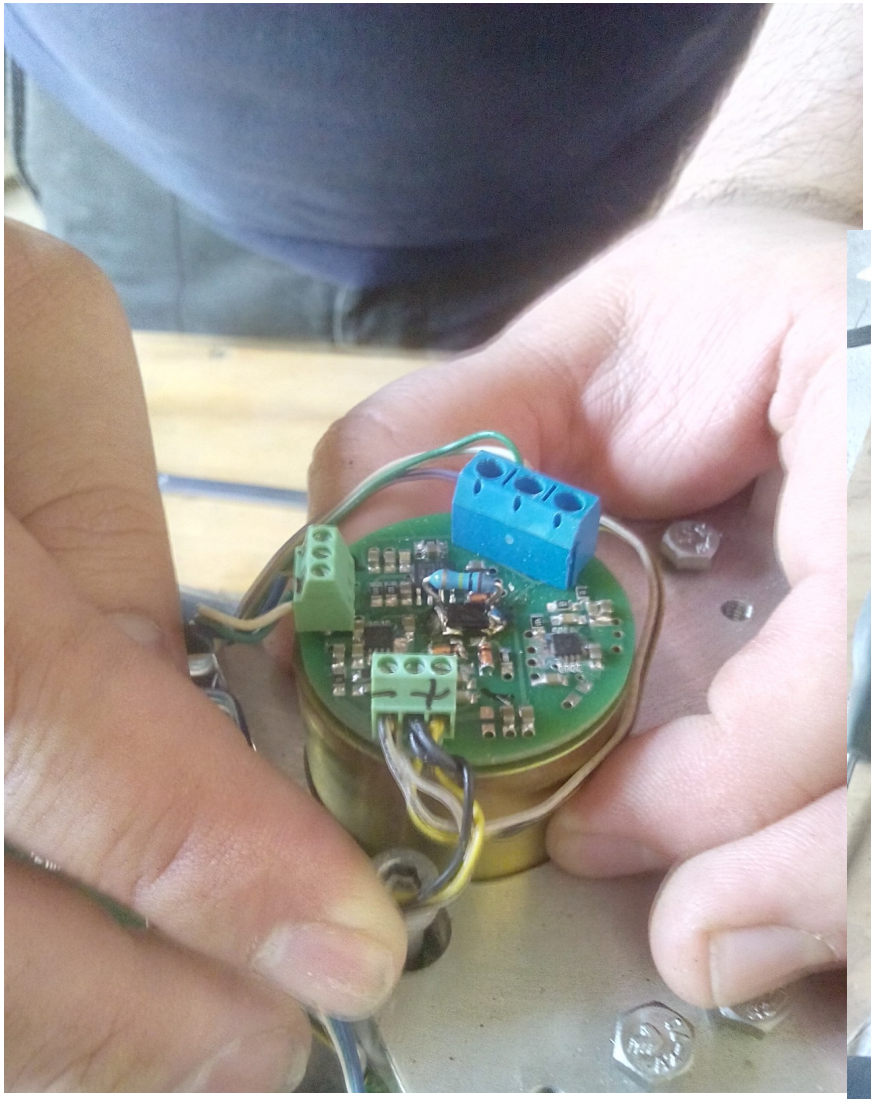
The project

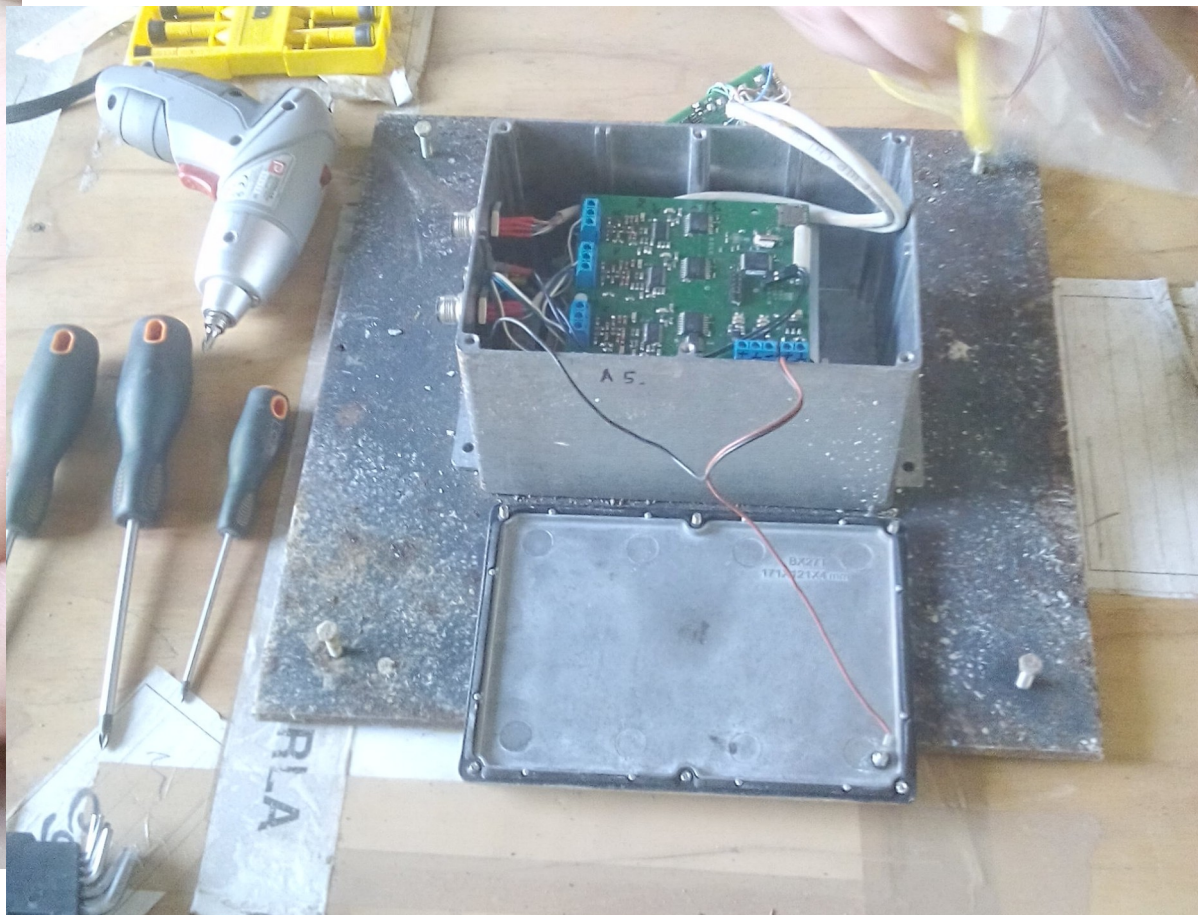
- Design and build low cost seismic sensors
- Make them work with time synchronisation
- Deploy them at candidate sites
- Gather as much data as possible
- Characterize and compare sites

The sensor

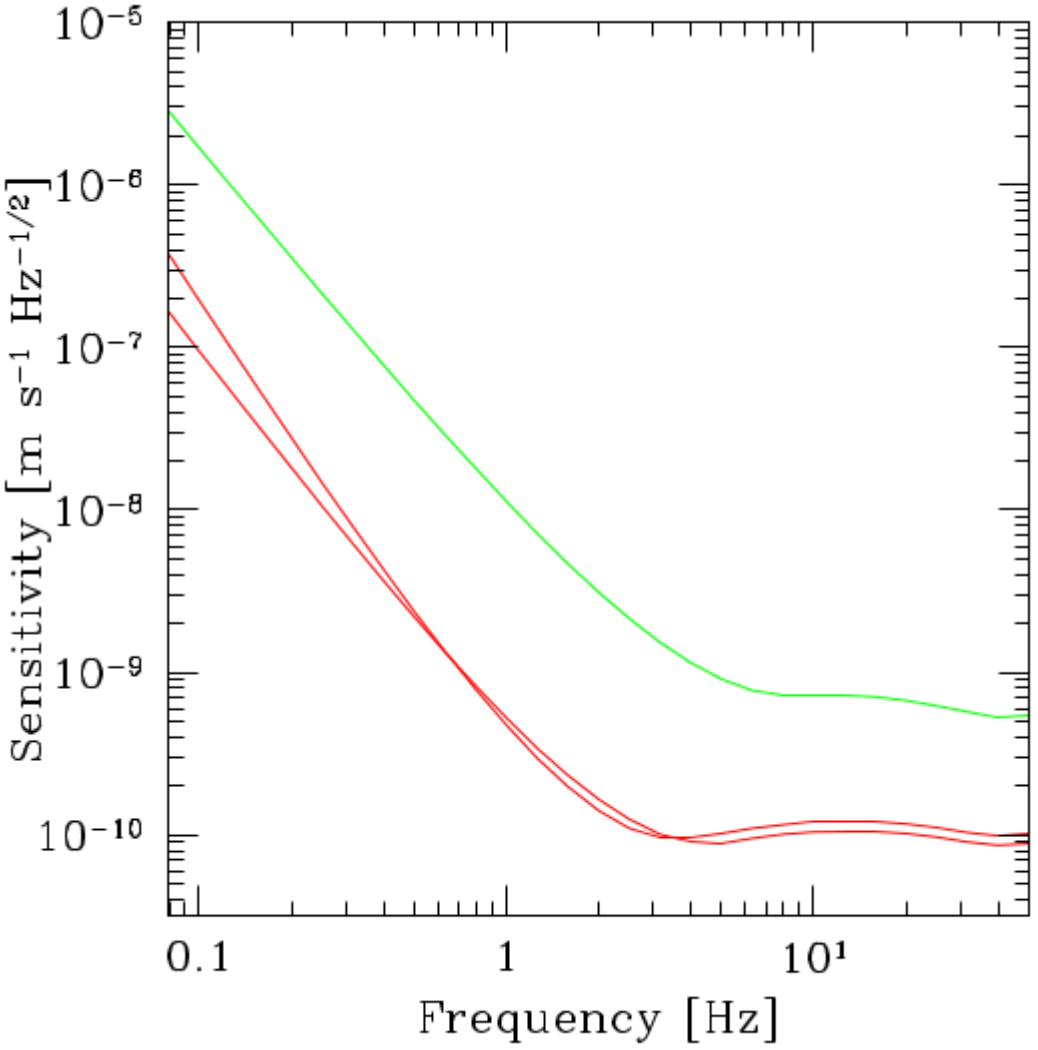
- Based on 2.5 Hz geophones
- Custom electronics
- Connected in series for data acquisition and time synchronization
- Data gathered to a PC and also on SD cards in each sensor

Seismic sensors





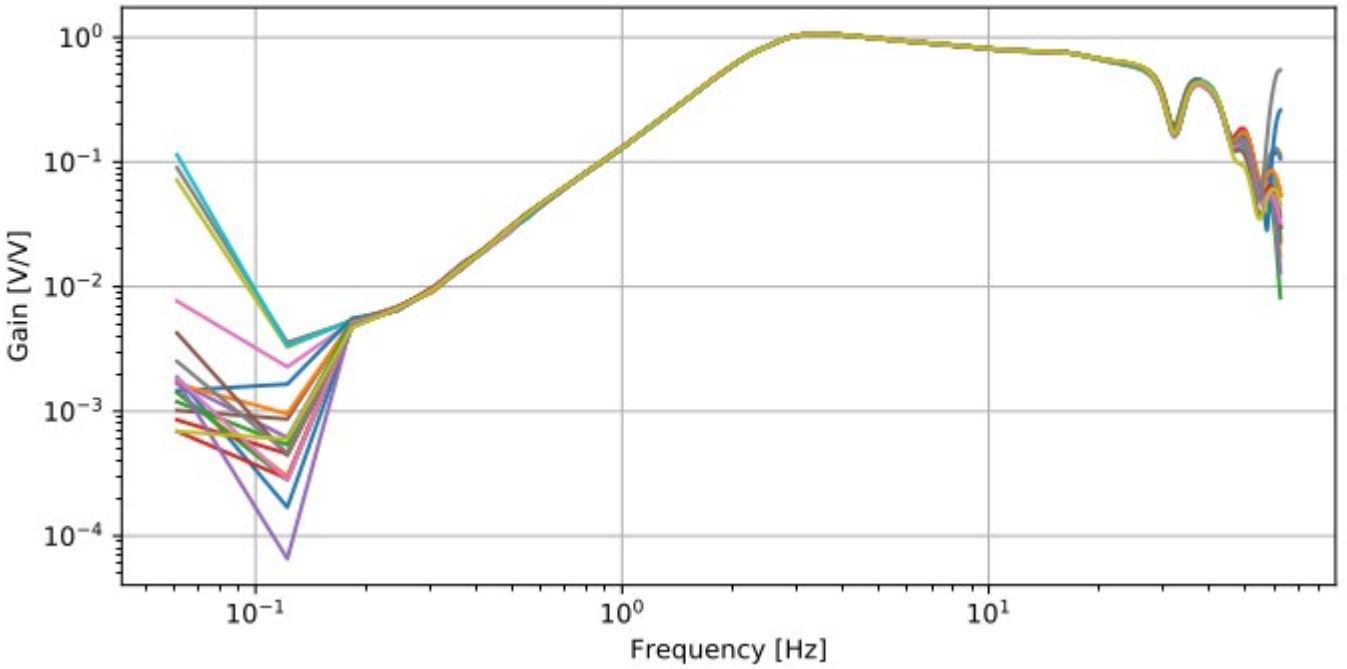
Sensitivity estimate



4.5Hz geophone
(not used)

Vertical and horizontal
sensors

Uniformity of sensors



Gain of the sensor in realtion to Trilium 120 QA

Driven by a realtively hi amplitude signal in Warsaw.

Son Enattos mine

ingresso rampa (+306)

Salerno station

1 sismometers

2° sismometer
distance = 110m

Rome station

3° simometer
distance = 130m

4° sismometer
distance=100m

rampa

5° sismometer
distance=98m

LIV. 2 INCROCIATORE +223

6° sismometer
distance =97m

7° sismometer
distance =105m

LIV. +222

LIV. +218

FORNELLO DI COLLEGAMENTO
LIV. +218 / LIV. +222 (Q. +228)

LIV. +218

LIV. +222

LIV. +222

LIV. +222

IGEA SPA
INTERVENTI GEO AMBIENTALI

MINIERA SOS ENATTOS

PERCORSO SOTTERRANEO

Disegnato
SETTORE CARTOGRAFICO

Resp. Tecnico

LUGLIO 2015

scala 1 : 1.000

Data acquisition

- Amount of data accumulated:
- Sardinia - 4358 h from seven sensors underground and 1580h on the ground
- Ksiaz - 4150 h
- Hungary – 20078 h
- Spain – 4227 h

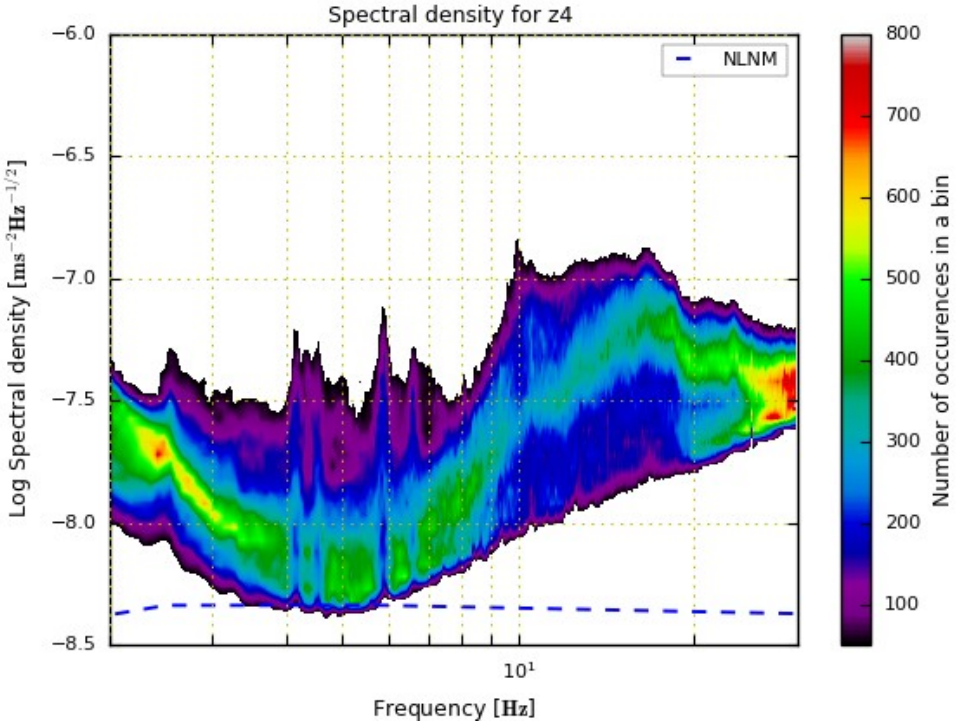
Data analysis

- Seismic spectra
  - Spectra
  - Daily variabiality
- Quake analysis

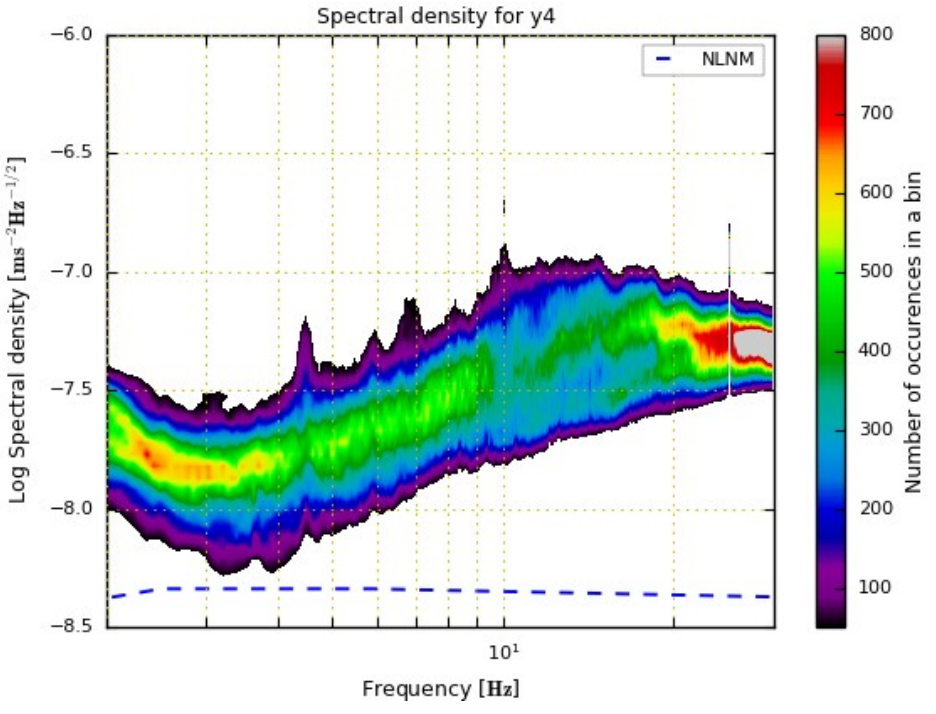
Sos Enattos - spectra

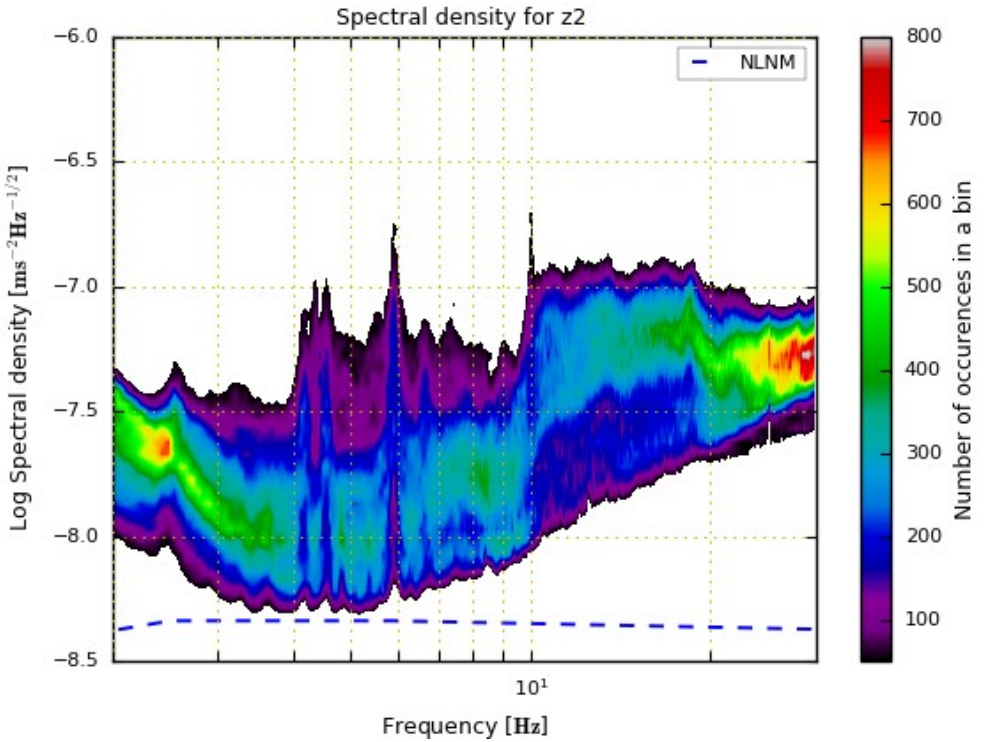
- 7 sensors, 3 axis each
- 1 sensor on the surface

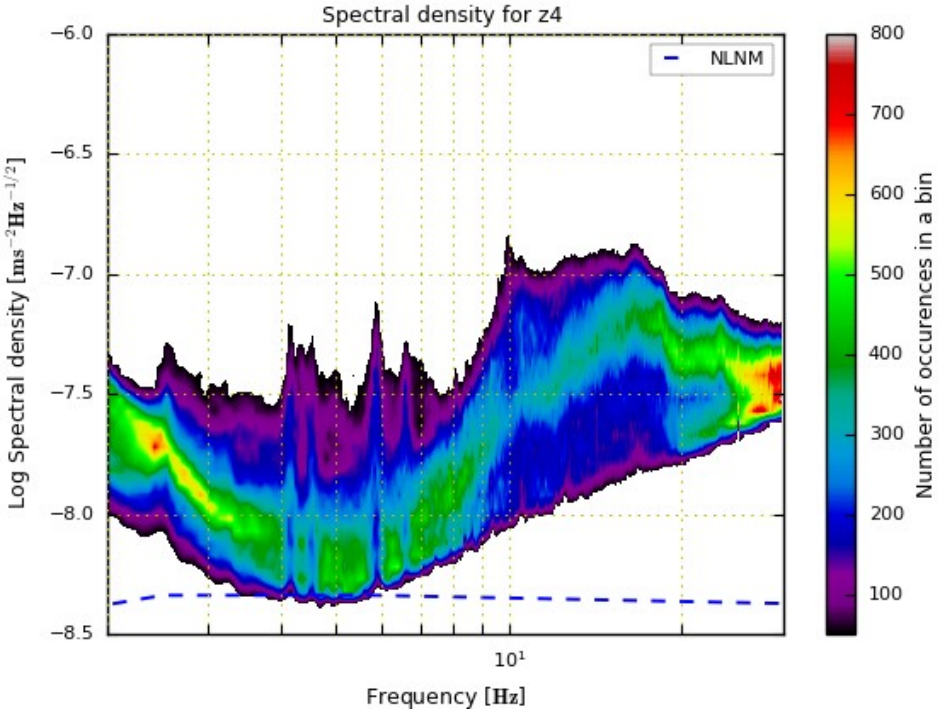
Vertical accleration spectrum

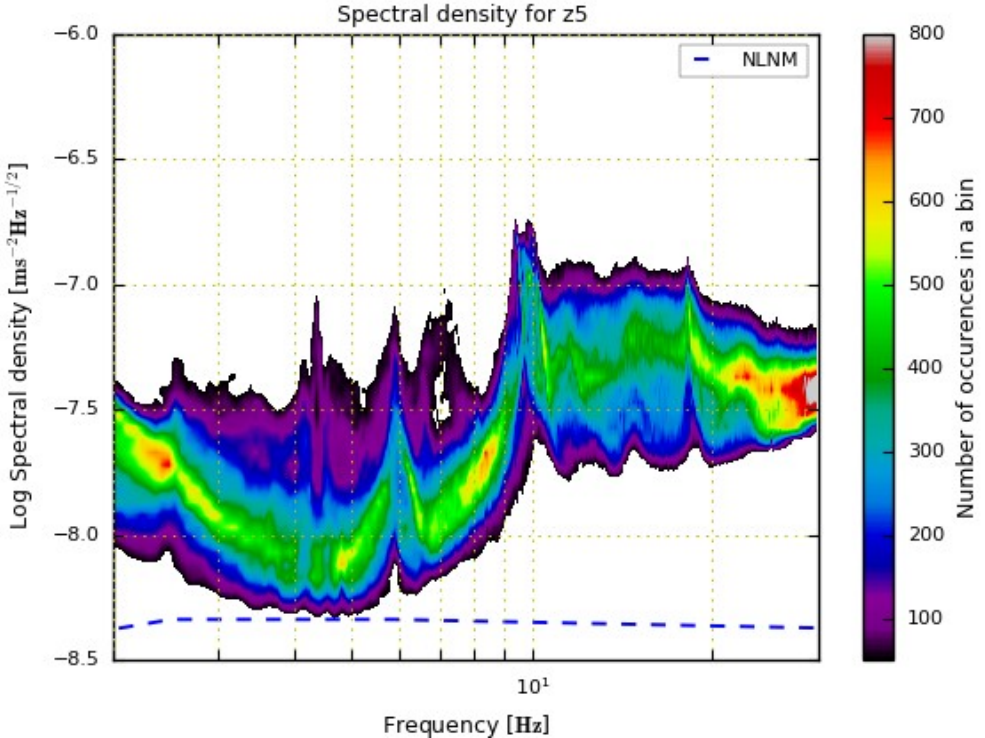


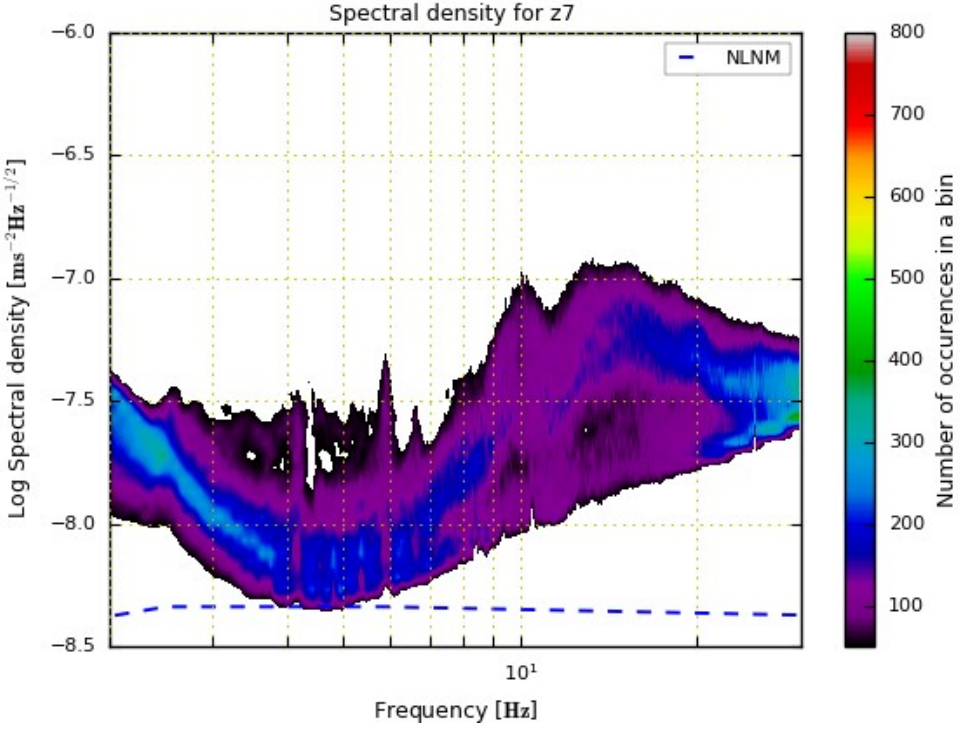
Horizontal acceleration spectrum

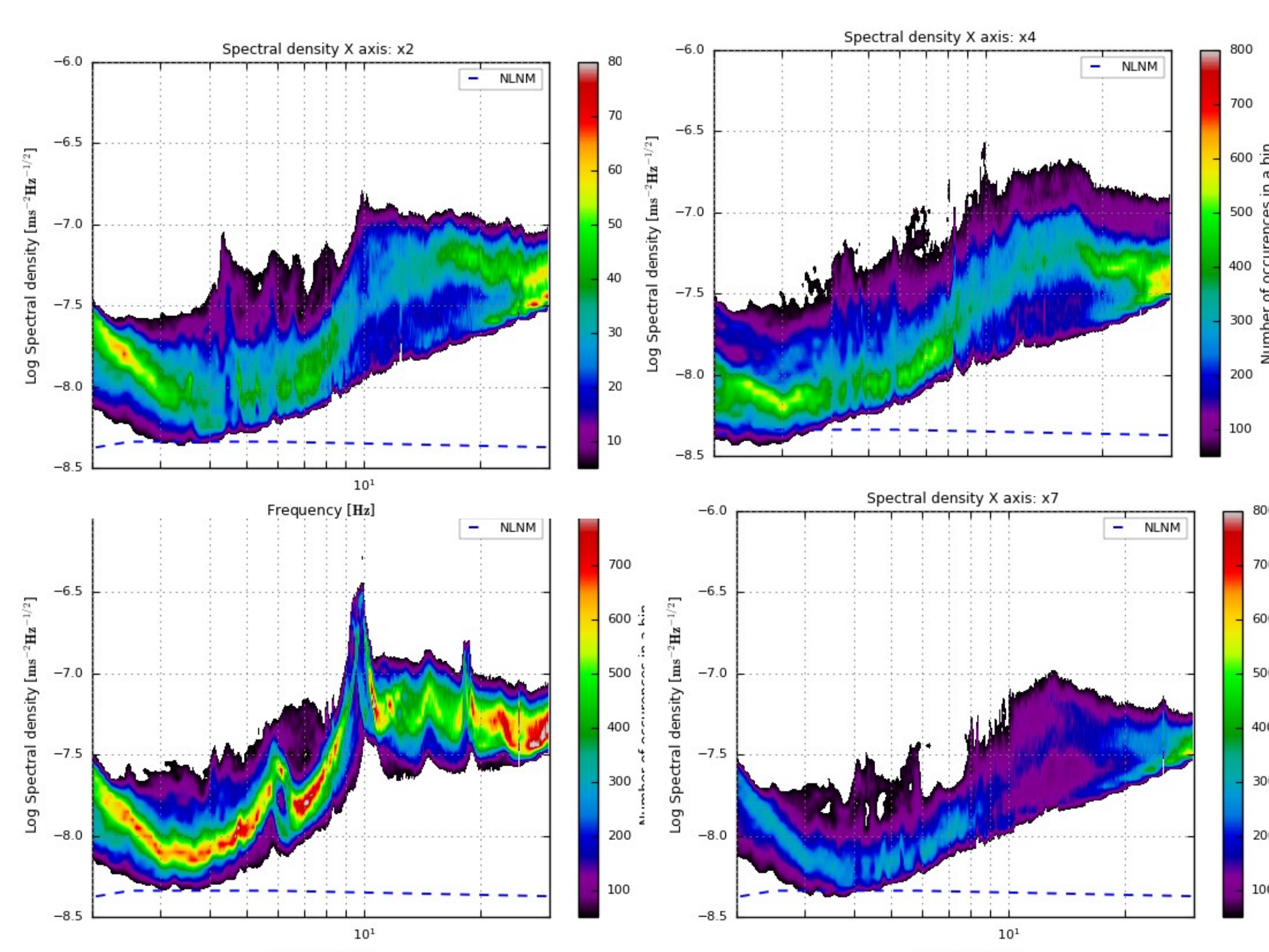



Spectral density for z2
NLNM
Log Spectral density [ms^{-2}Hz$^{-1/2}$]
Frequency [Hz]
Number of occurences in a bin


Spectral density for z4
NLNM
Log Spectral density [ms^{-2}Hz$^{-1/2}$]
Frequency [Hz]
Number of occurences in a bin

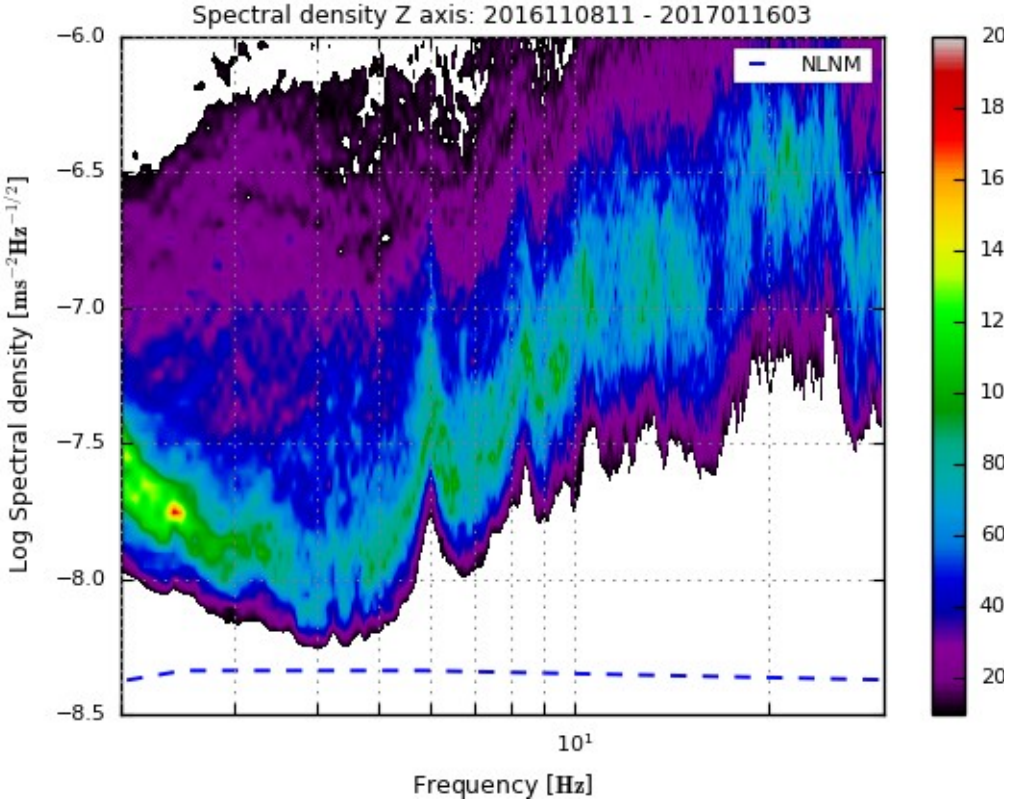

Spectral density for z5
NLNM
Log Spectral density [ms^{-2}Hz$^{-1/2}$]
Frequency [Hz]
Number of occurences in a bin


Spectral density for z7
NLNM
Log Spectral density [ms^{-2}Hz$^{-1/2}$]
Frequency [Hz]
Number of occurences in a bin

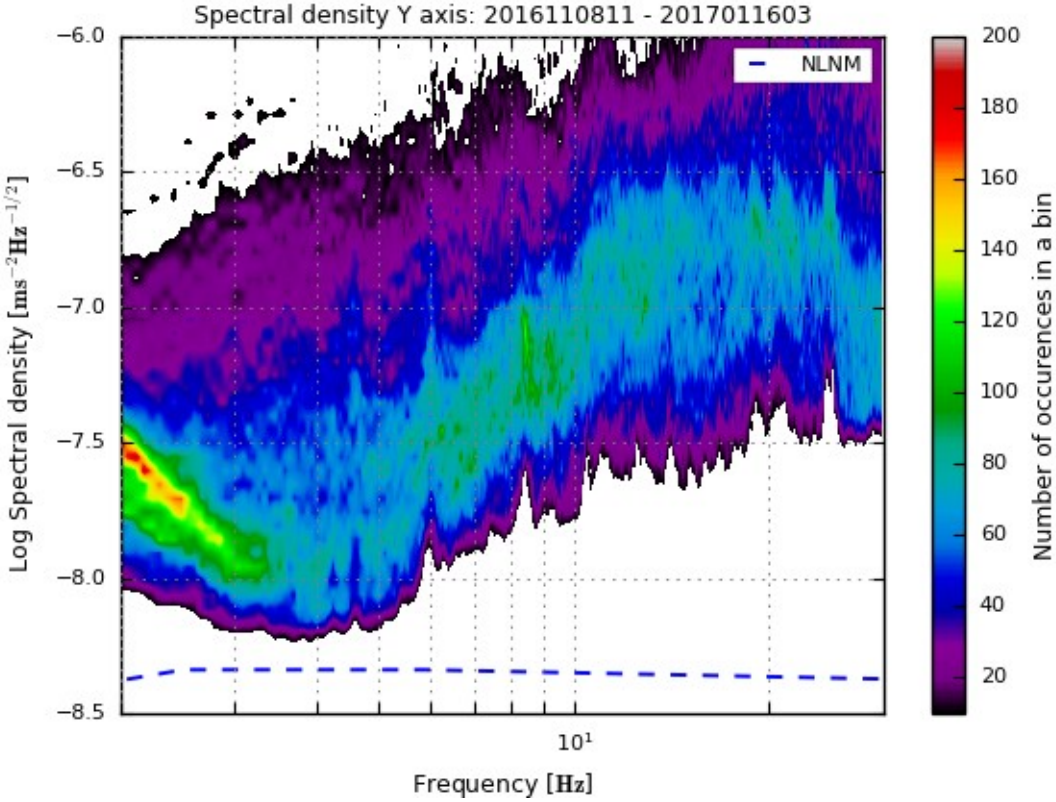

Spectral density X axis: x2
Spectral density X axis: x4
Spectral density X axis: x7
NLNM
Log Spectral density [ms^{-2}Hz$^{-1/2}$]
Frequency [Hz]
Number of occurrences in a bin
−6.0
−6.5
−7.0
−7.5
−8.0
−8.5
10^1

Surface spectra

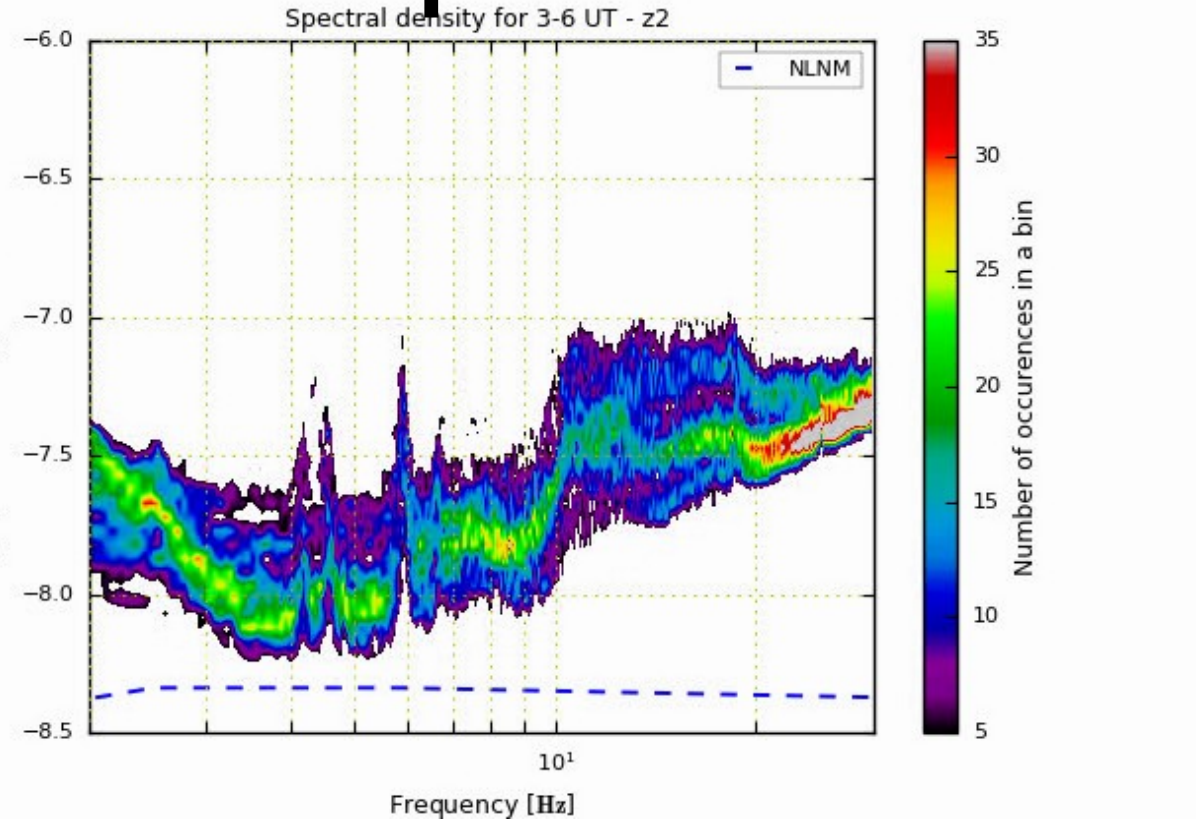
Vertical:



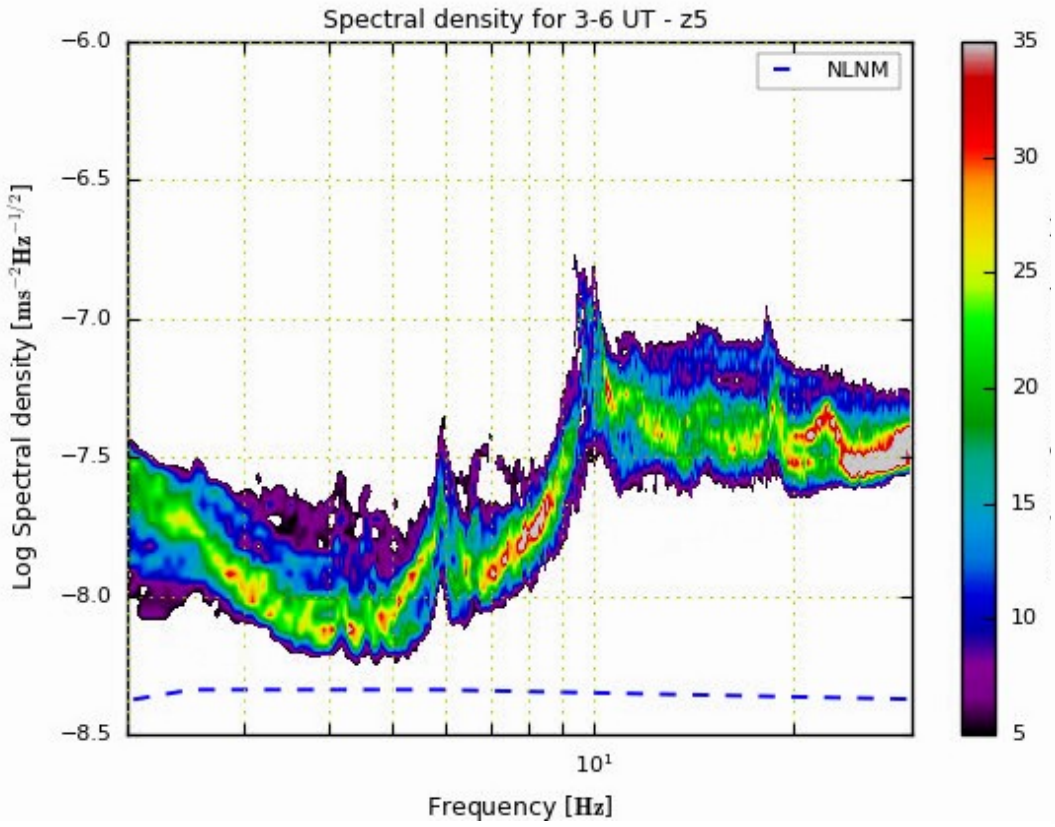
Horizontal:

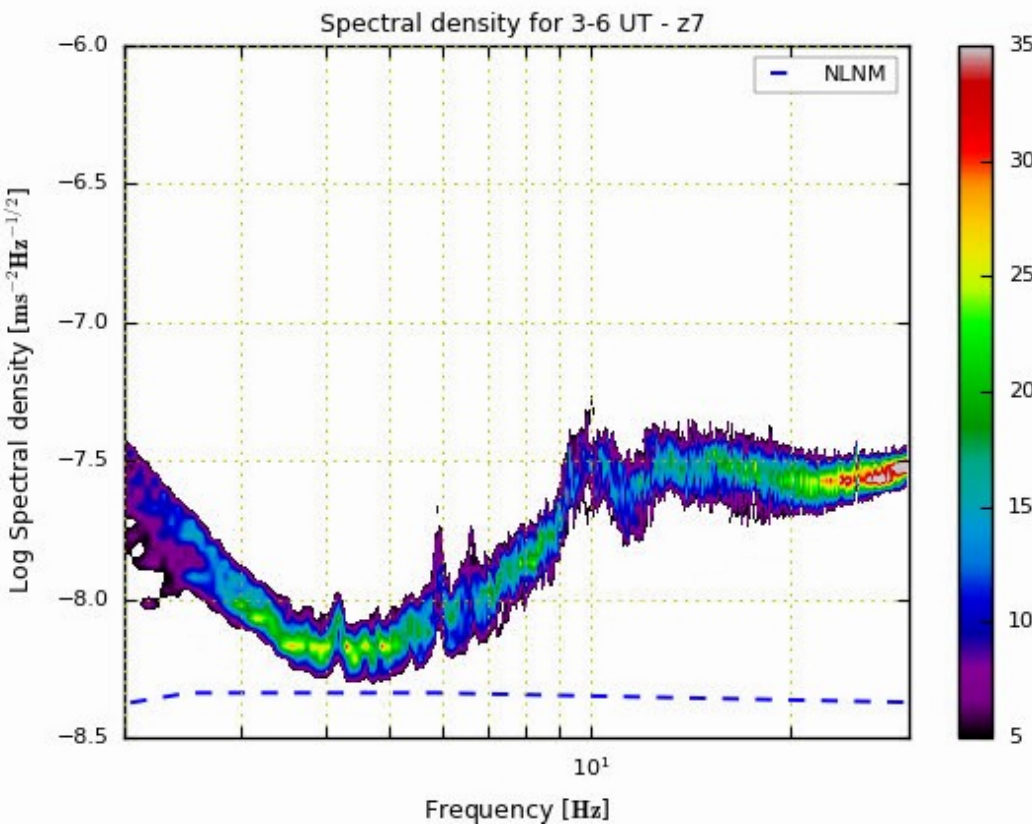


Dependence on location

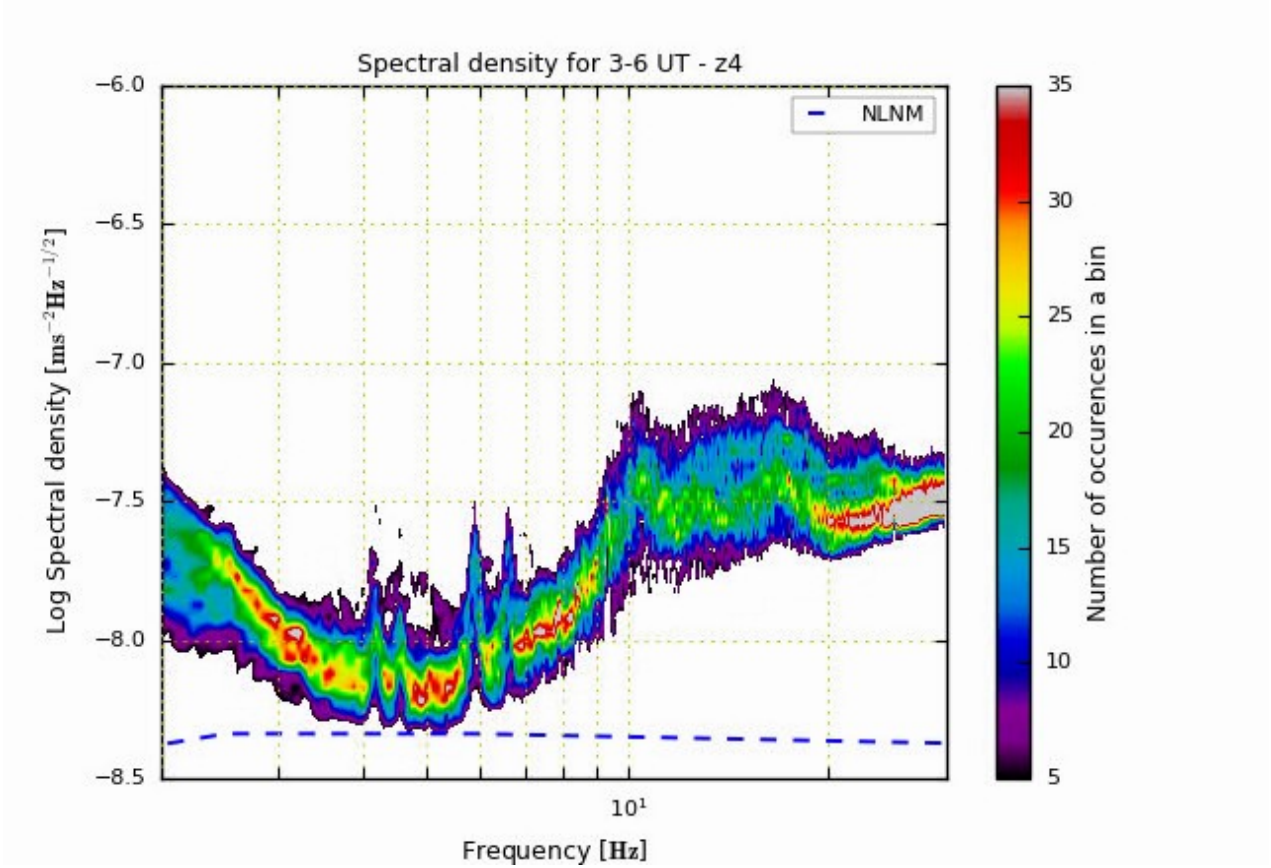


Dependence on location

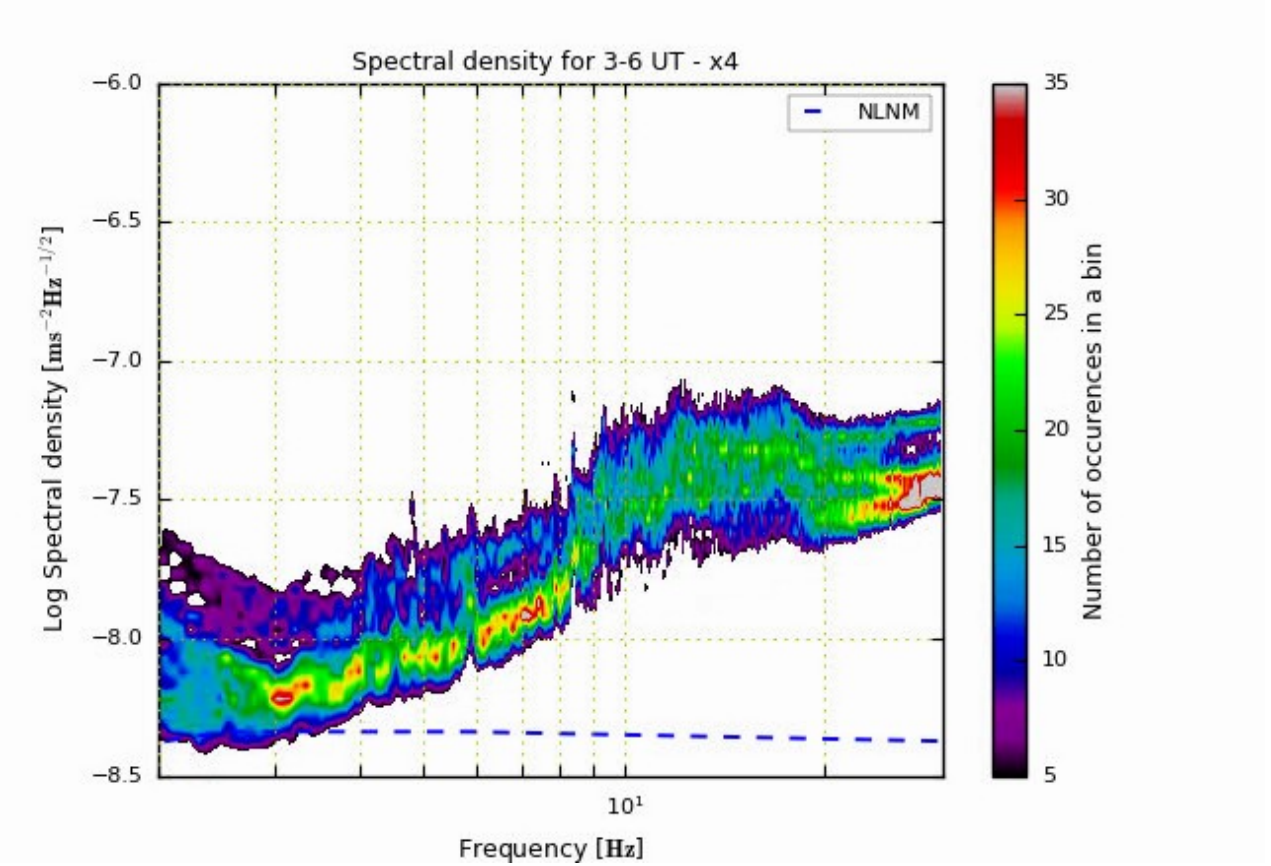




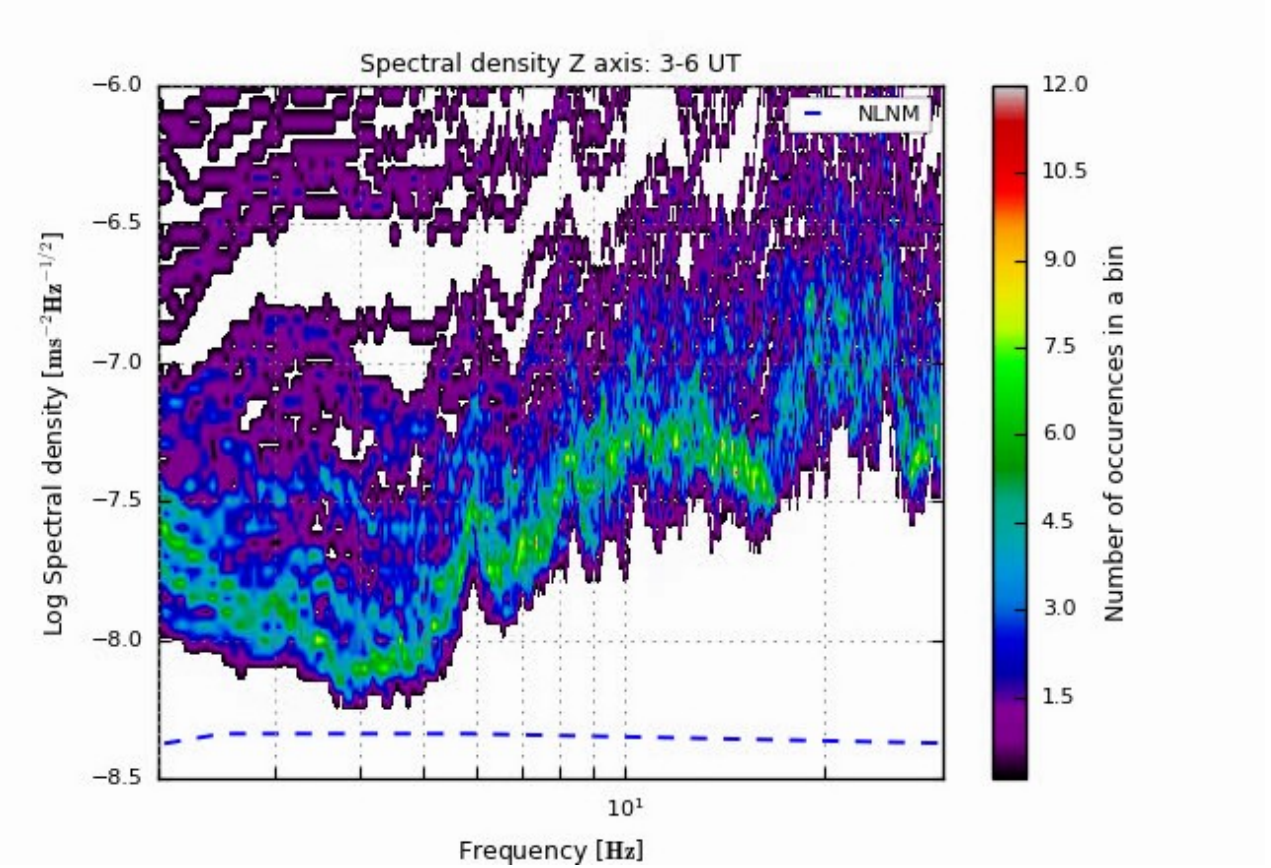
Daily variability: undeground



Daily variability: undeground



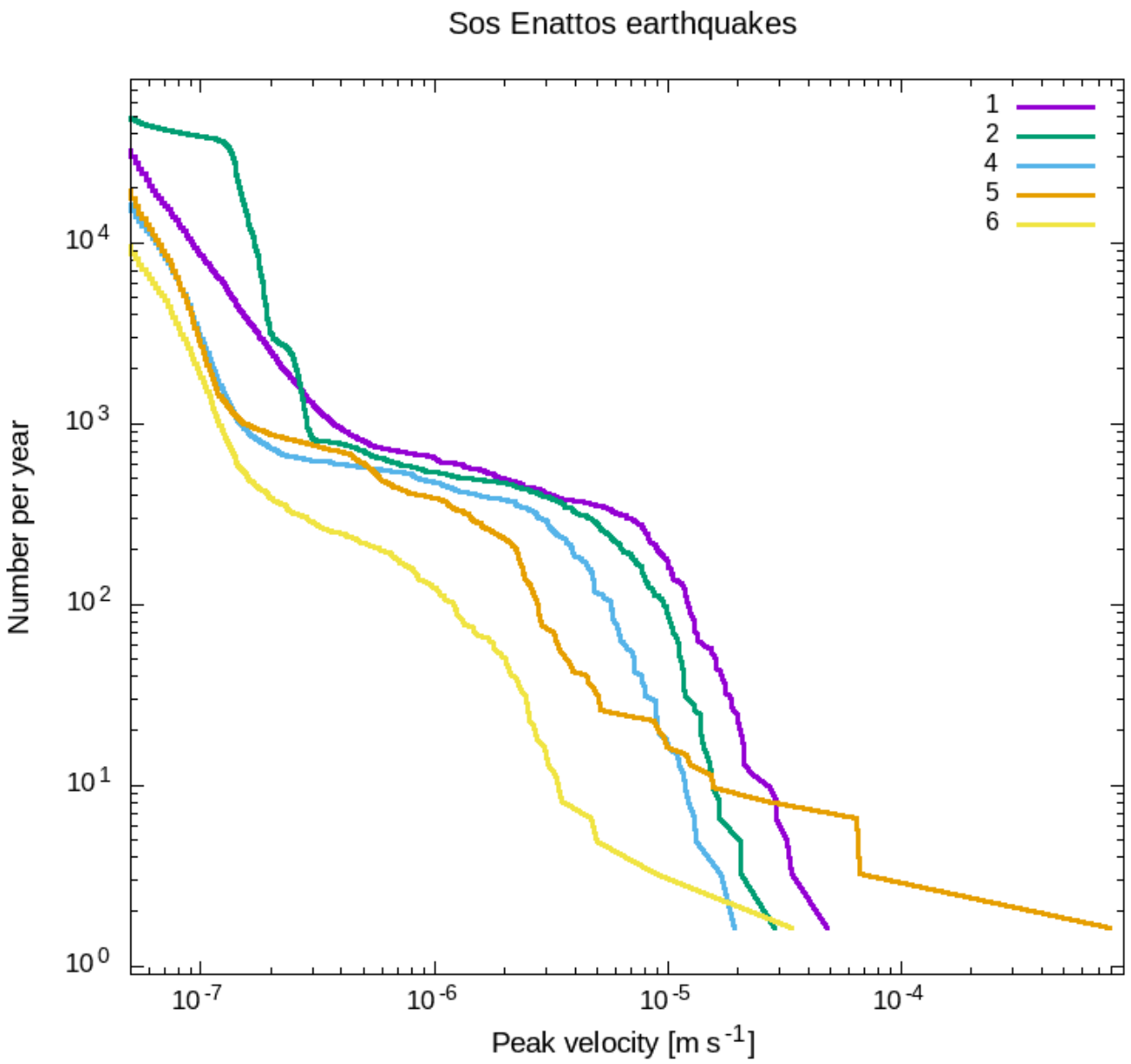
Daily variability: surface



Earthquake analysis

- Analyze 1 sec pieces of data
- Look for maxima in 3d velocity in each segment
- Define earthquake as segment with maximum above 0.5 micrometer/s
- Define earthquake as a set of such segments followed by at least one minute quiet time
- Find list of events for each site

Sos Enattos


Sos Enattos earthquakes
Number per year
Peak velocity [m s-1]
1
2
4
5
6
10^4
10^3
10^2
10^1
10^0
10^-7
10^-6
10^-5
10^-4

Other lessons learned

- Environment:
  - Underground humidity humidity, chemistry
  - Forms of life: rodents

Summary and next steps

- Seismic noise is really low!
- Glitchiness smaller than other sites

- Correlation analysis
- Study of the NLM floor
- Underground NN noise testing array
- Infra-sound field characterization