Comparison of seismic noise in ETpathfinder and VIRGO

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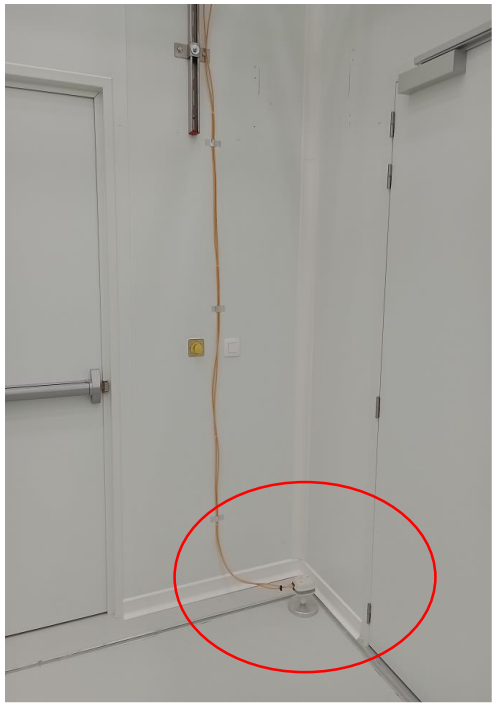
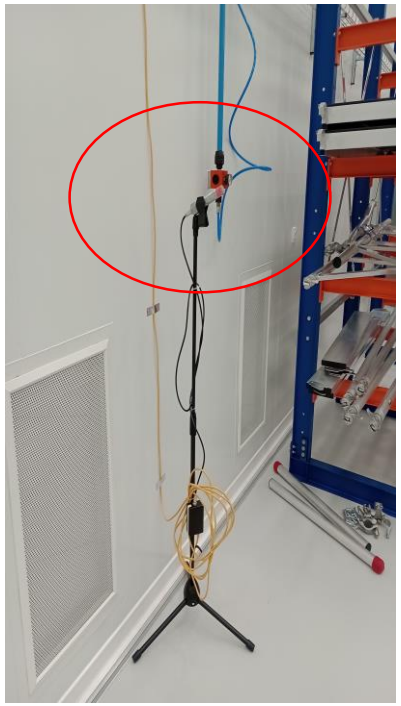
ET pathfinder - installation

- The installation took place between 19 and 23 February 2024
- Spare sensor from Virgo installation, 13 seismic sensors and 10 infrasound sensors






Seismic Sensors

- Based Innoseis seismic sensors with additional data acquisition and synchronization circuit
- Spares from Virgo installation

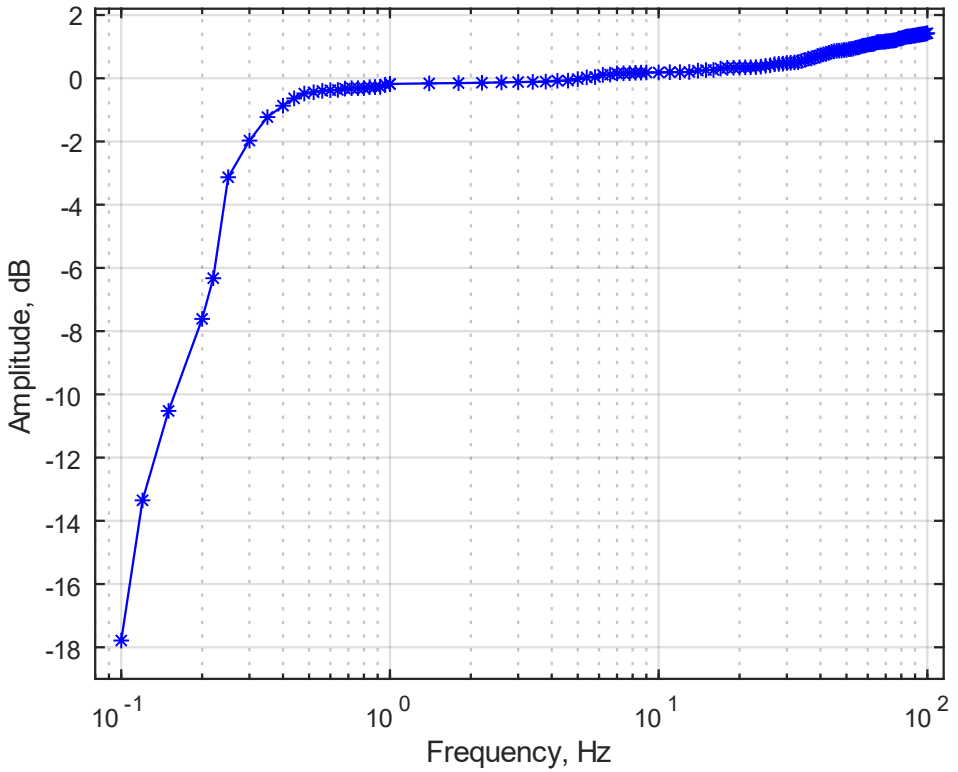
Characteristic:

- Based on 4.5 Hz, geophone
- Sampling frequency 500 Hz, 24 bit of data

- Require ethernet cat. 7 cable
- Ethernet + PoE + timing and sync in one cable

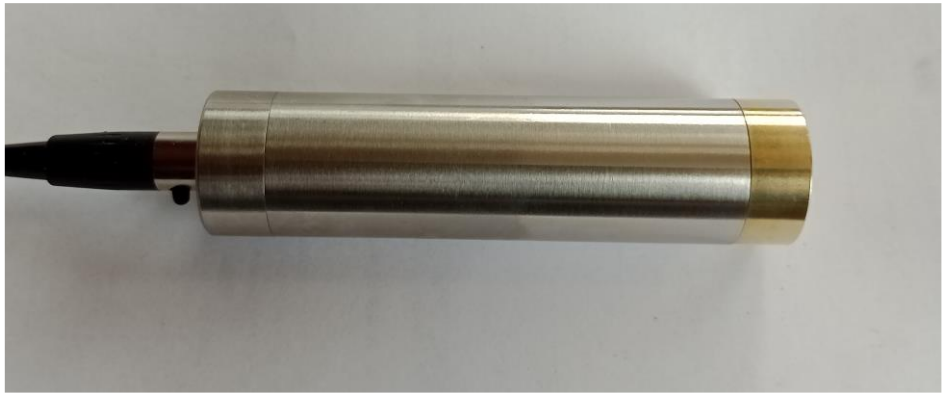
Infrasound microphones - Astrocent

- Developed by the Astrocent CAMK
- Frequency range from 0.1 Hz to 120 Hz
- Sensitivity: 2.5 mV/Pa (distortion max. 1.0 dB)
- Sampling 500 Hz, 24 bit ADC

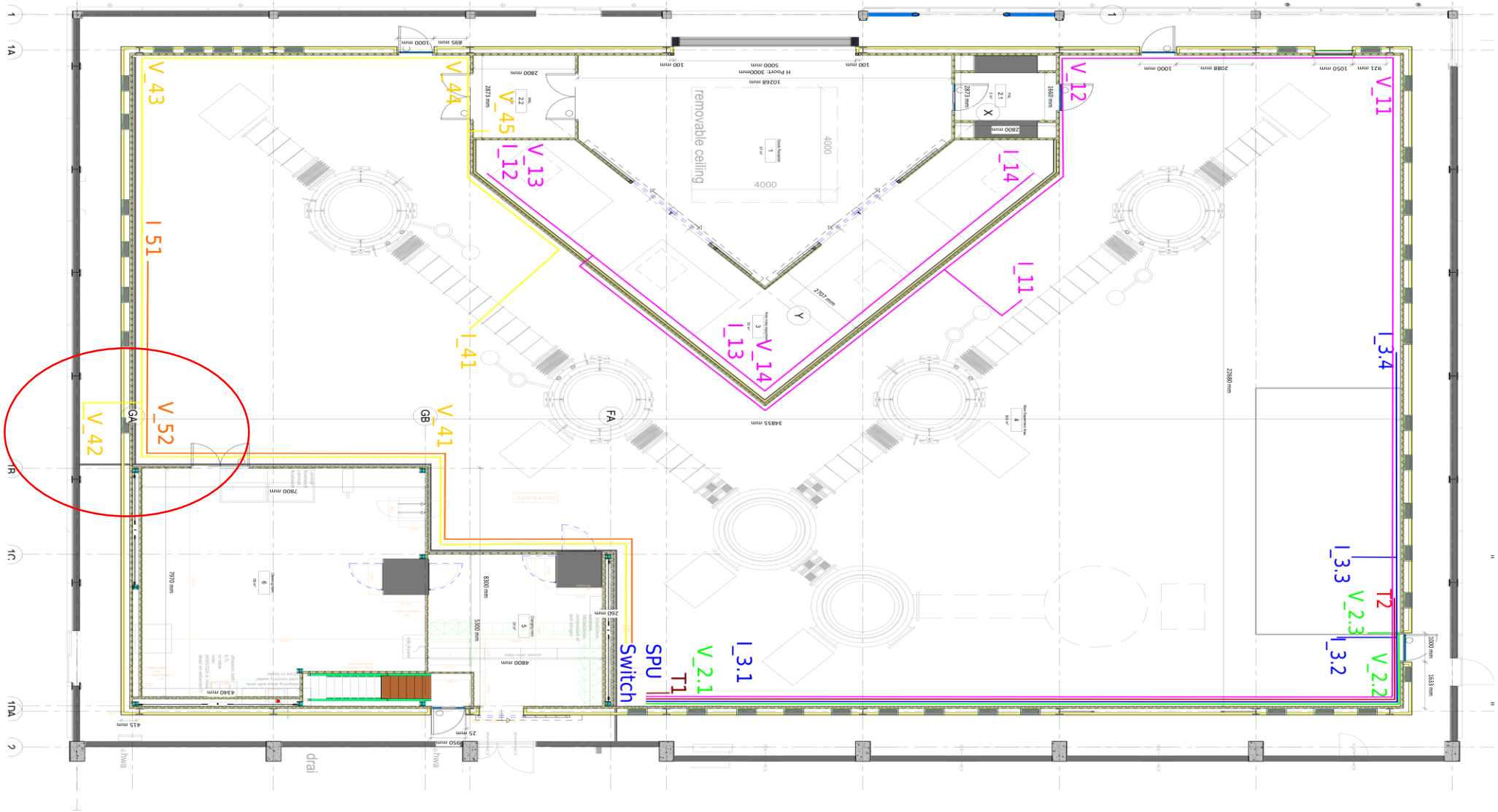


Version 1

Next version 2 (next generation)

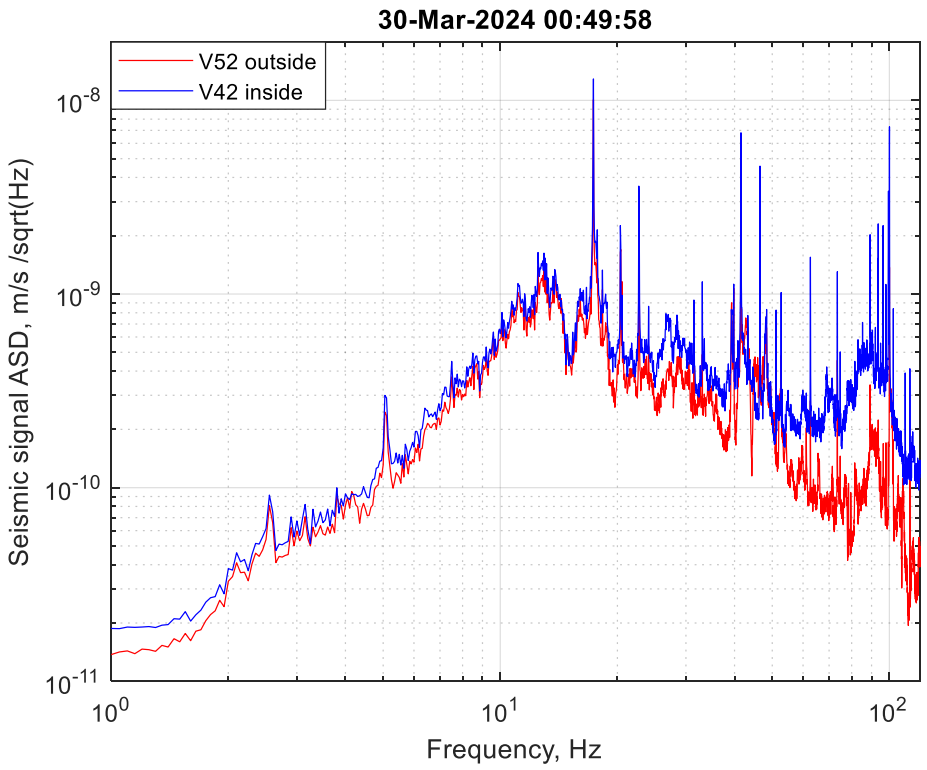


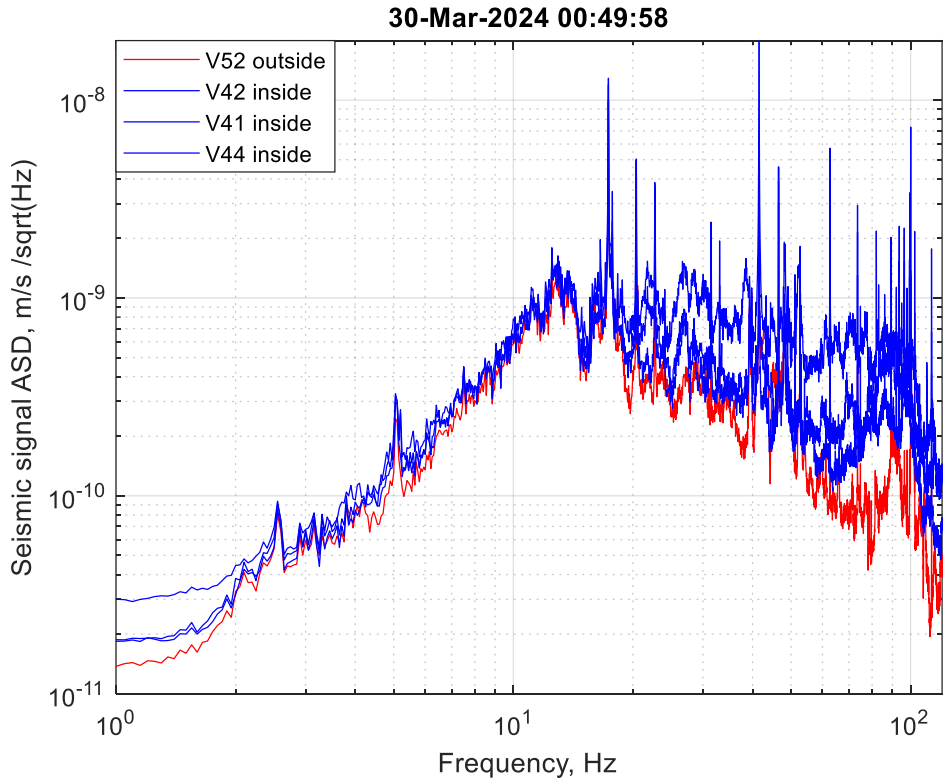
ET pathfinder - sensors installation map



Sensors outside V42 vs inside V52 - ET pathfinder

- Seismic data divided into fragments each 66.6667 minutes
- Seismic noise is lower outside the hall then inside - there is suspicion that the pump is continuously running inside the cleanroom on the test bench near V42
- Especially noticeable in the frequency range above 10 Hz
- Only one sensor outside (to check its functionality) - we have swapped V42 and V52 (30.04.2024)





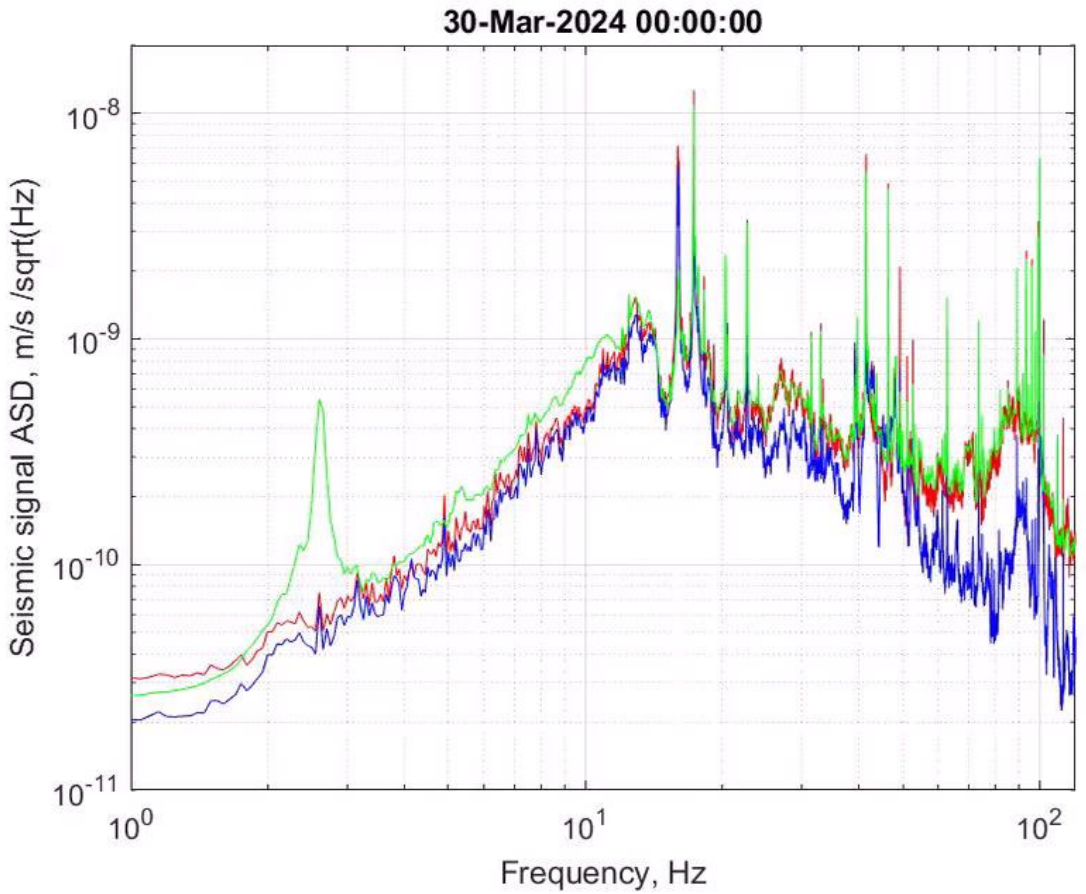
Seismic signal ASD, day and night - ET pathfinder

- Frequency range till 120 Hz

Amplitude Spectral Density (ASD):

- **green** - 24 hours averaged sensor V52 (inside)
- **red** - sensor V52 (inside)
- **blue** - sensor V42 (outside)

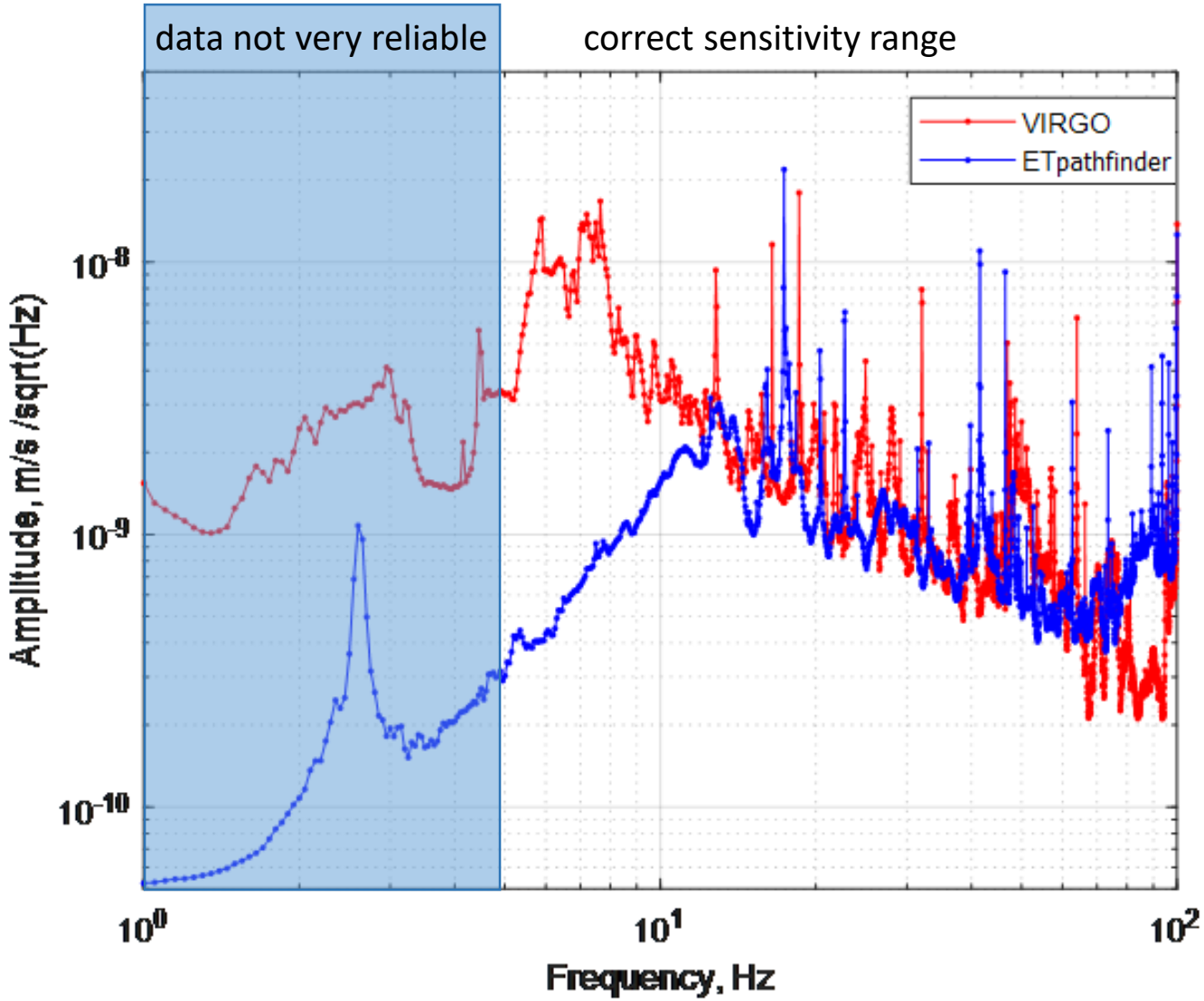
- From about 10 p.m. to 9-10 a.m. the ASD is below the average, from 10 a.m. the ASD is above the average
- Additional artifacts such as a signal appearing at a frequency of 2.5 Hz. Outside the sensor band (lower than 4.5 Hz) but strong enough to be visible



Seismic signal ASD: VIRGO & ET pathfinder

- Data from VIRGO and ET pathfinder
- 24 hours of data divided into 20 second fragments, ASD calculated and then averaged
- Geophone specific sensitivity range from 4.5 Hz

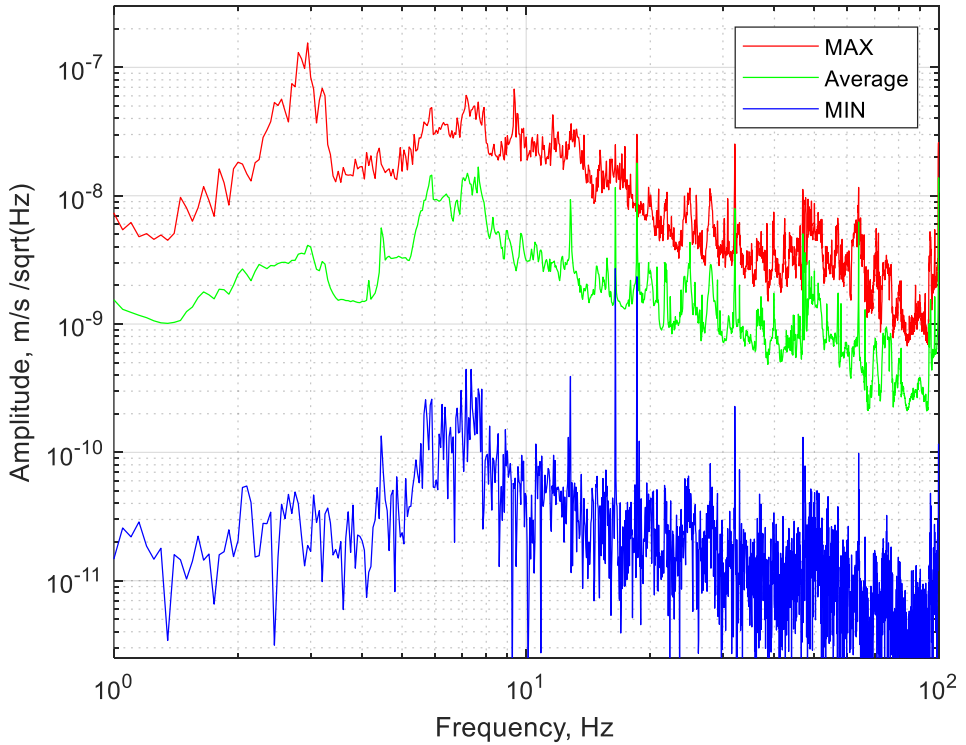
- Both ASD are very similar to each other, especially in the range of frequency from 10 Hz to almost 100 Hz



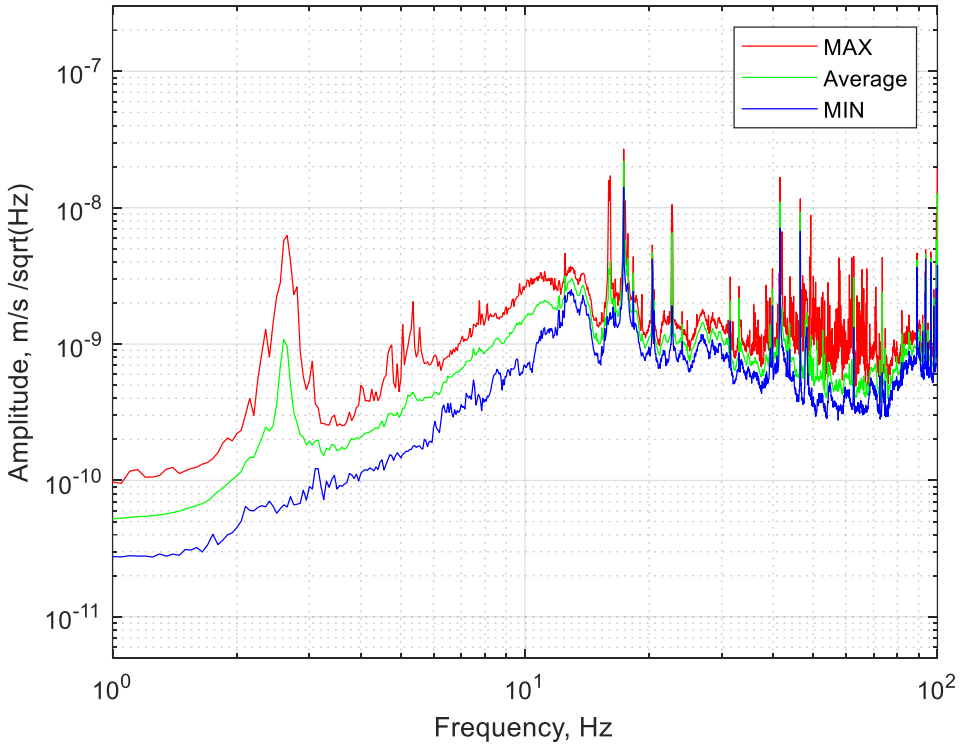
Seismic signal ASD: VIRGO & ET pathfinder

- The same data shown in a different way, same data 24 hours, ASP calculated with 20 second fragmesnt
- Maximum value in the plot (red), average (green), minimum (blue)
- The signal level strongly depends on the analysis method and the length of the averaging window, the time from which the data comes
- ASD shape very similar in both places

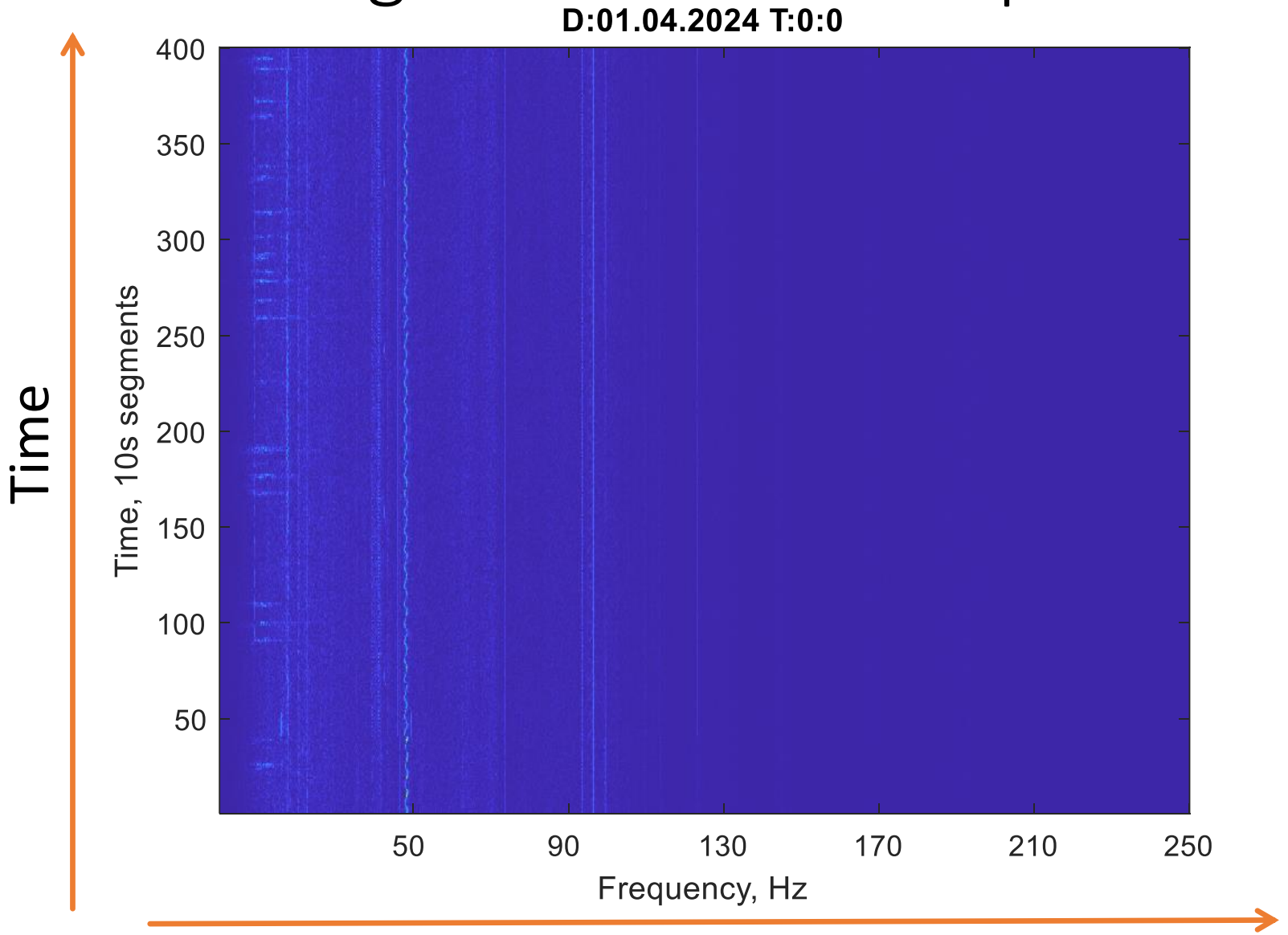
VIRGO



ET pathfinder



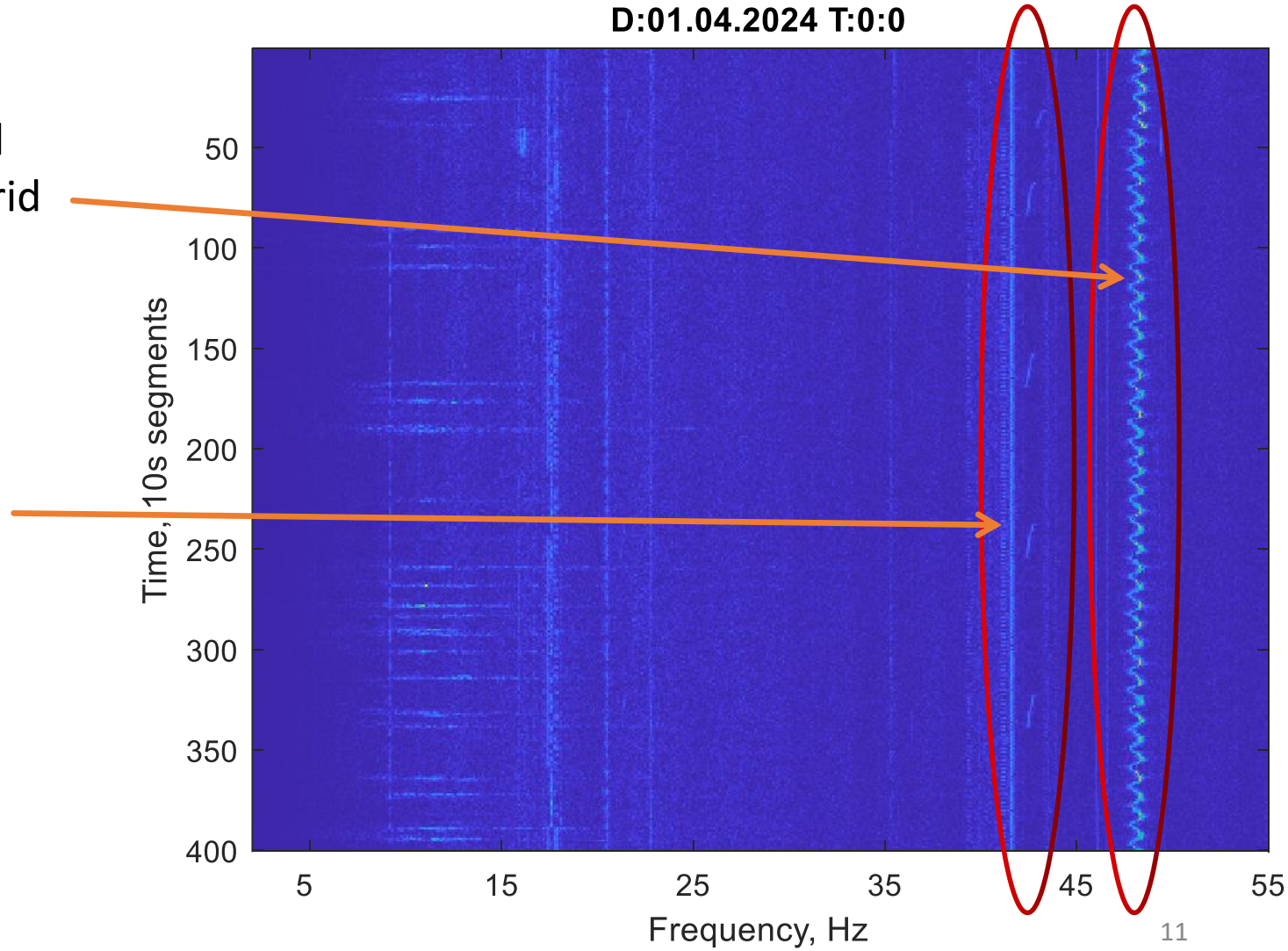
Seismic noise changes over time - ET pathfinder



Seismic noise changes over time - ET pathfinder

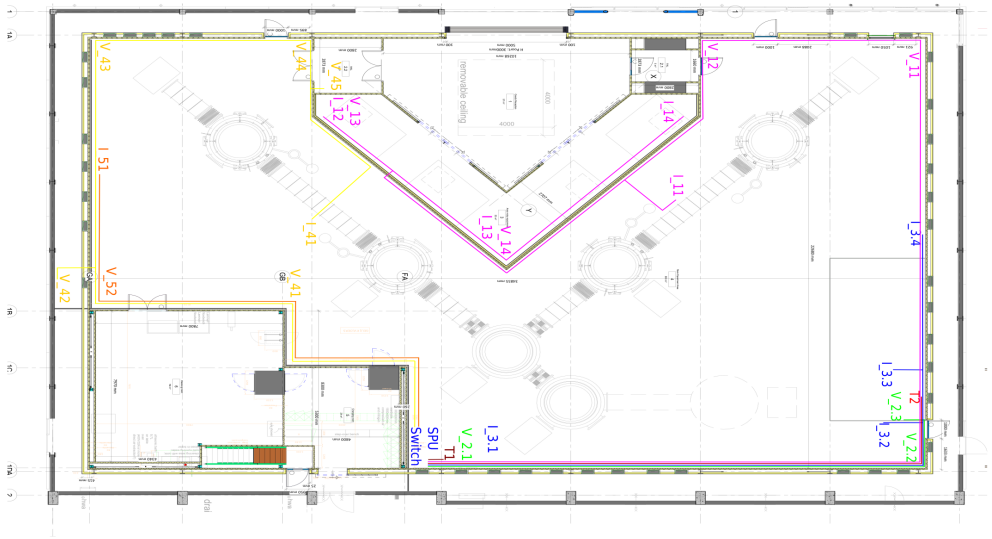
- Dominant frequencies present in all files: from 48 to 49 Hz - similar to grid frequency, but lower
- Fix frequency 41.5 Hz, 46.1 Hz, 46.8 Hz

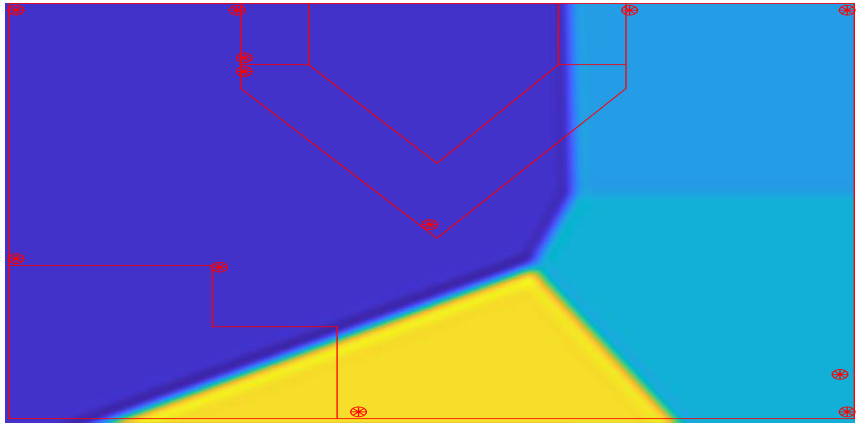
- Air conditioning/ventilation around 43 Hz every 1 minute?



Seismic field reconstruction, noise distribution - ET pathfinder

- Based on 13 seismic sensors, map of seismic noise depending on the sensor position
- Red stars – sensor locations on the map
- Noise spectral density from frequency range 0.1 till 30 Hz
- Brighter colors higher noise level, darkers lower noise level
- The strongest noise is characterised by the sensor placed in the lower part of the map. The noise level of the rest of the sensors is very similar to each other





Conclusions

- From about 10 p.m. to 9-10 a.m. the ASD is below the average, from 10 a.m. the ASD is above the average - similarly in VIRGO, night has lower noise than day time
- VIRGO and ET pathfinder ASD are very similar to each other, especially in the range of frequency from 10 Hz to almost 100 Hz
- The sensor (geophone) frequency range allows to determine the noise level from 4.5 Hz, below 4.5 Hz only high-amplitude interference can be observed. In VIRGO in the frequency range from 4.5 to 10 Hz the seismic noise is slightly higher
- ET pathfinder - the seismic noise background seems to be more stable (more than in VIRGO), additional noise sources appear periodically

Seismic and infrasound data - ET pathfinder

- Seismic and infrasound data are available at: **https://intra.astrocent.camk.edu.pl/ETpathfinder**
- function reading data from a GWF file, 20 lines of code

```
function data = gwf_read(file_name, channel)
frame_size = 500;
fprintf('File: %s ', file_name);
fileID = fopen(file_name);
fseek(fileID, 0, 'eof'); file_size = ftell(fileID); fseek(fileID, 0, 'bof');
fprintf('size: %d ', file_size);
data_char = fread(fileID, file_size, 'uint8=>char'); fseek(fileID, 0, 'bof');
idx = strfind(data_char', channel);
frames_max = (length(idx)-1)/2;
fprintf('frames %f ', frames_max );
data = zeros((length(idx)-1)/2, frame_size);
if length(idx) > 2
    z = 0;
    for j = 2:2:length(idx)-1
        fseek(fileID, idx(j) + length(channel) + 5*4, 'bof' );
        z = z + 1;
        data(z, :) = fread(fileID, frame_size, 'int');
    end
end
fclose(fileID);
```

- Searching for the sensor name, ASCII name in the binary file (e.g. "sen:V11"), binary data 20 bytes after
- Sensor map with names and locations:

https://intra.astrocent.camk.edu.pl/ETpathfinder/Floorplan_Layout-1.pdf