



ENVIRONMENTAL NOISE MEASUREMENTS AT SOS ENATTOS

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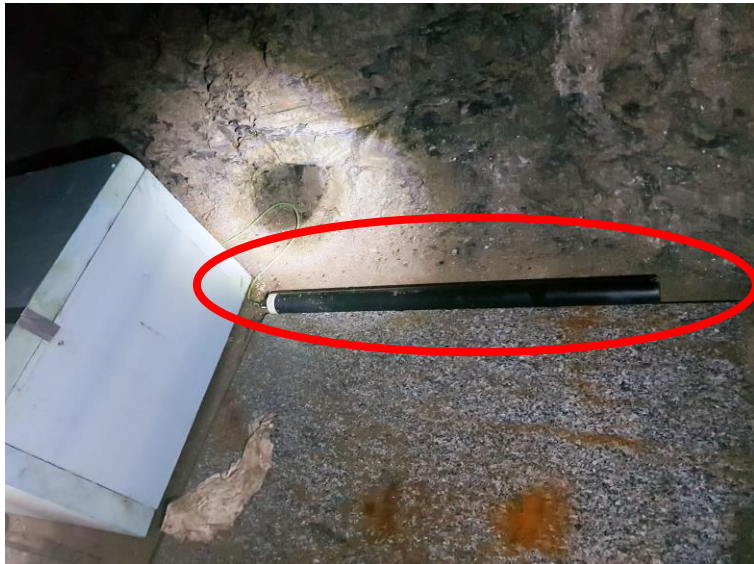
Outline

- Status of Environmental Monitoring at Sos Enattos
- Focus on Magnetic Noise Measurements
 - Motivation
 - Comparison with Virgo
 - Surface vs Underground
 - In Time Analysis
- Next steps

Status of EnvMon at Sos Enattos

First Probes

- The first probes were a magnetometer (Metronix MFS-06) and a microphones (Bruel&Kjaer 4193) both on loan from Virgo.
- The probes were installed in June 2019 at level 2 (-111 m):
 - The magnetometer is still working;
 - The microphone data taking lasted only one day;



Status of EnvMon at Sos Enattos

First Results

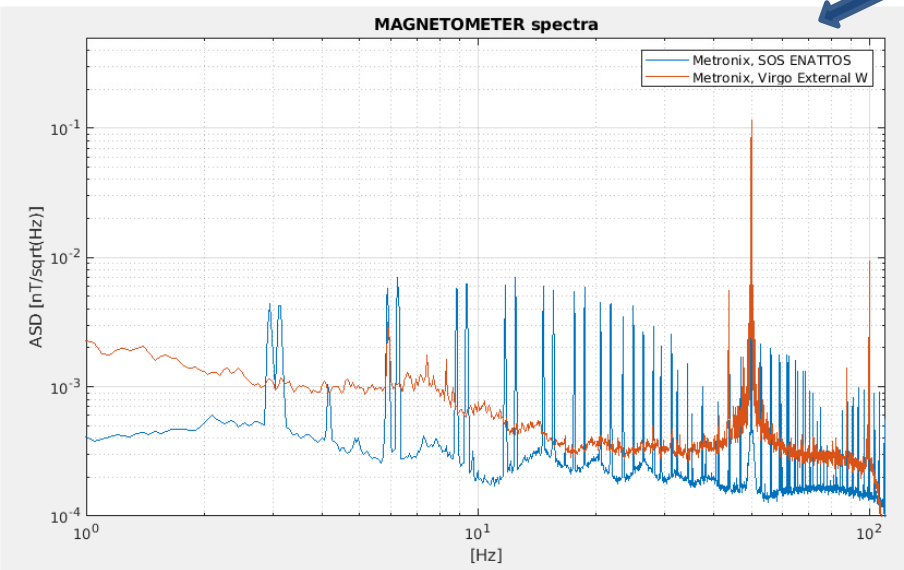
- Encouraging results from the initial measurements, in terms of noise floor;

Magnetic Noise:

Very good floor noise

Lot of lines in the initial measurement (Removed by a careful isolation from very local disturbances).

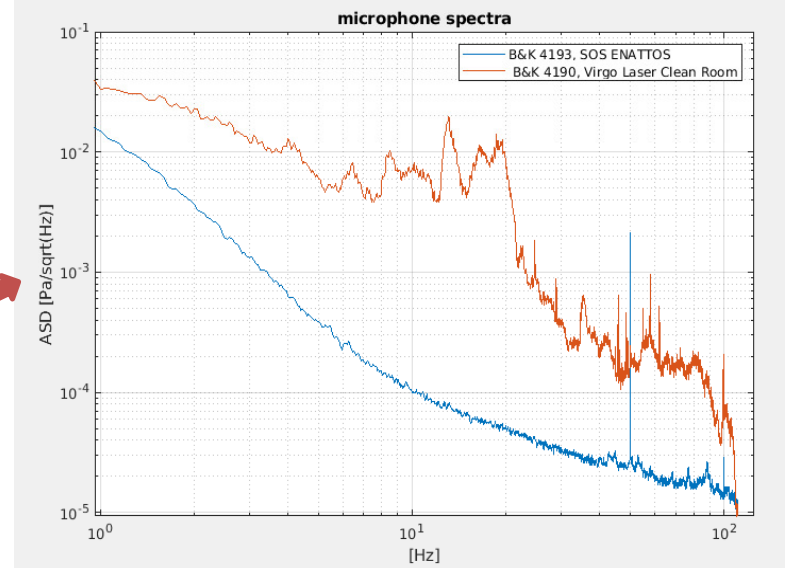
Comparison with a **Virgo** external magnetometer



Acoustic Noise:

Already close to the probe intrinsic noise.

Comparison with the **Virgo** microphone in the Laser LAB



Status of EnvMon at Sos Enattos

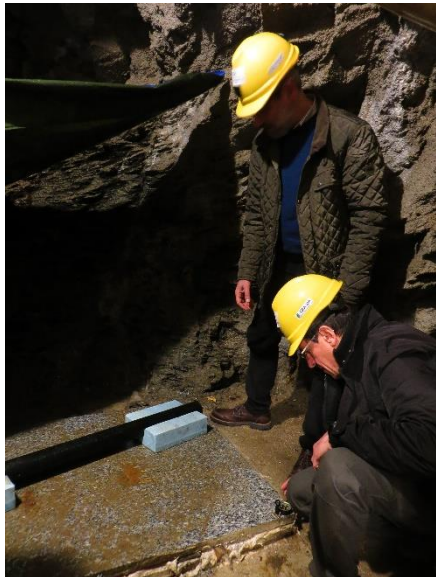
Current status

- Up to now a number of probes have been brought at Sos Enattos:
 - a broadband induction coil magnetometer, model MFS-06, from METRONIX, operating at -111 m.
 - a weather station, model Vantage Pro2 from DAVIS, operating in surface and connected to its own console located in the SarGrav control room.
 - a broadband induction coil magnetometer, model MFS-06e, from METRONIX, operating in surface (close to the SarGrav surface lab).
 - a free-field condenser microphone, model 47AC from GRAS, optimized for infrasound measurement (0.09 Hz – 20 kHz), equipped with a driving amplifier, model 12AL (GRAS).
 - a free-field condenser microphone, model 46AZ from GRAS, optimized for low frequency measurement (0.5 Hz – 20 kHz), equipped with a driving amplifier, model 12AL (GRAS).

Status of EnvMon at Sos Enattos

Current status

- Currently, only the magnetometers (level -2 and surface) and the weather station are active;
- Other probes will be installed during the next year;



Check of the deep magnetometer alignment



Installation of the surface magnetometer



Status of EnvMon at Sos Enattos

Weather Station

- The station is regularly collecting data since Jun 6 2020
- Data summary available on web

Sos Enattos, Lula, Sardegna, Italy

29/11/2020 12:30:00

Monthly Reports:

[RSS](#)

Yearly Reports:

Current Conditions

Outside Temperature **12,5°C**
Heat Index **12,3°C**
Wind Chill **12,5°C**
Dew Point **11,6°C**
Humidity **94%**
Barometer **1011,4 mbar (N/A)**
Wind **3 km/h NNE (22°)**
Rain Rate **0,00 cm/h**
Rain Today **0,05 cm**
Inside Temperature **16,4°C**
Inside Humidity **57%**

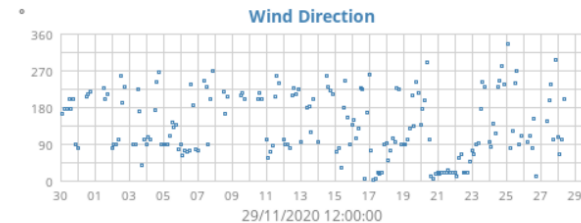
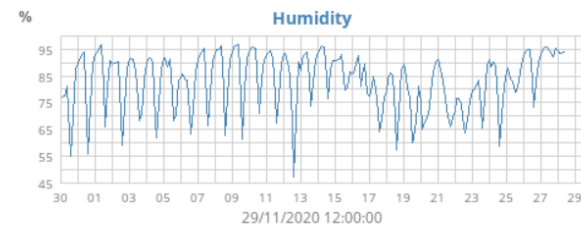
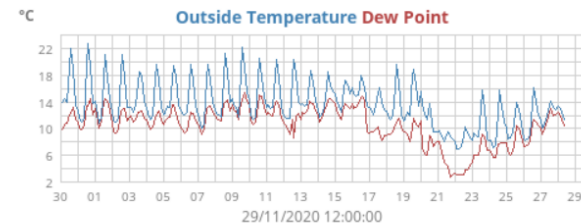
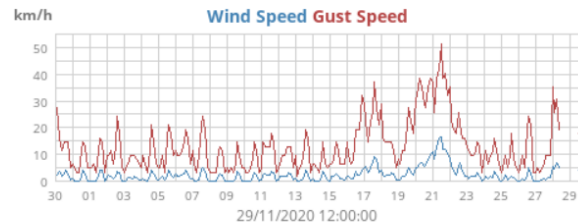
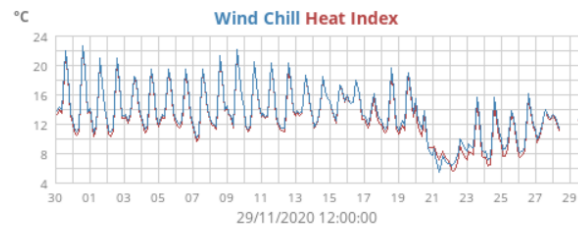
Celestial

Sunrise **07:22:44**
Sunset **16:58:36**
Moon Phase **Full**
99%

High/Low

	Today	Month
Outside Temperature	13,1 12,3	22,7 °C 6,3
Heat Index	12,9	22,5 °C
Wind Chill	12,3	2,5 °C

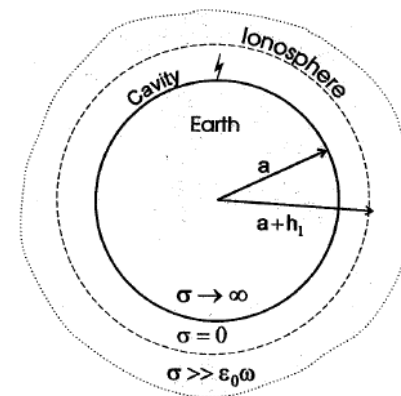
History: [Day](#) [Week](#) [Month](#) [Year](#)



Magnetic Noise Measurements

Motivation

- The noise from natural or anthropogenic electromagnetic fields can affect the sensitivity of a gravitational wave interferometer in different ways:
 - Direct coupling with magnet actuators of the mirror and suspension systems;
 - Coupling with electronic devices managing the interferometer;
- A special role, among the possible noise sources, is played by the Schumann resonances: a world-wide electromagnetic field sustained by the lightning discharges between the Earth surface and the ionosphere.



Magnetic Noise Measurements

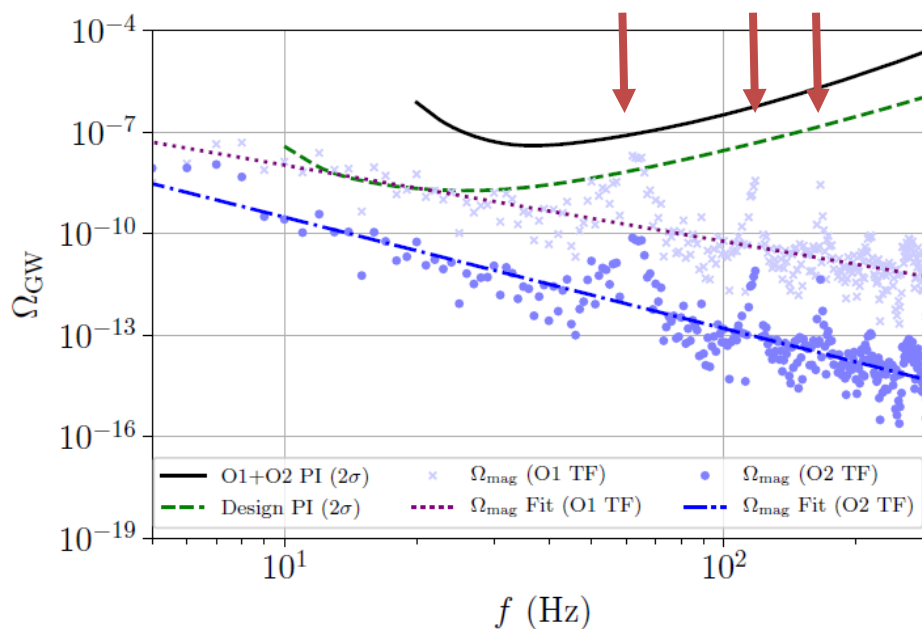
Motivation

- Due to their global character, the Schumann resonances could set a strong limit in the detection capability of selected class of sources;
- This is particularly important for the measurement of the stochastic background, assuming a non-correlated noise between far detectors.

Correlated magnetic noise between two LIGO magnetometers, expressed in terms of Ω_{GW} :

$$\Omega_{\text{GW}}(f) = \frac{f}{\rho_c} \frac{d\rho_{\text{GW}}}{df}$$

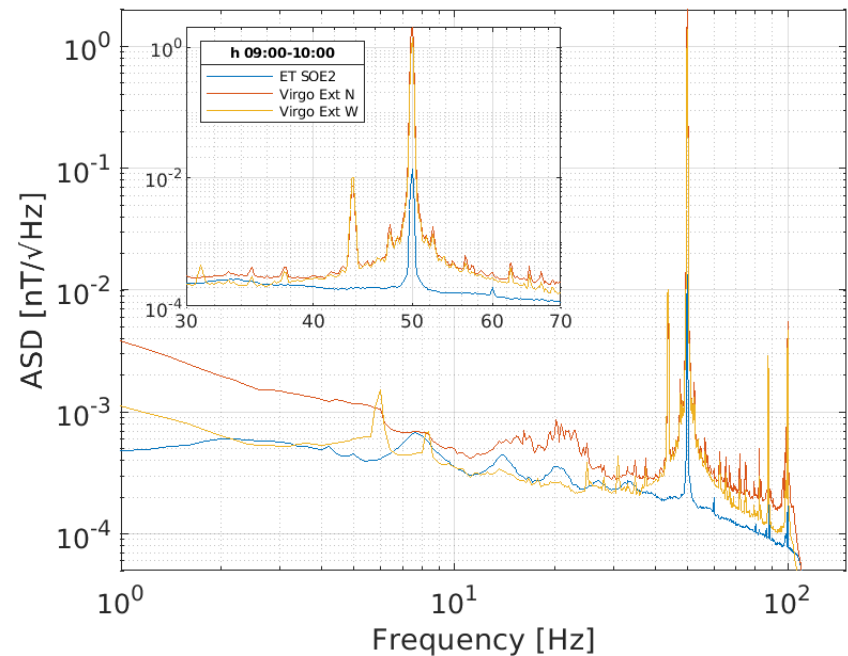
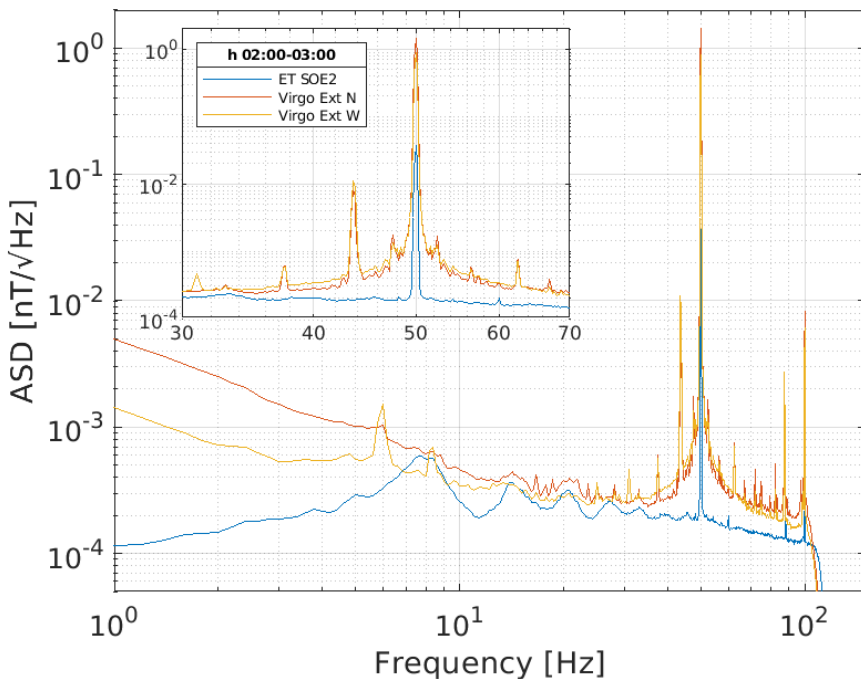
*LIGO-Virgo Collaborations:
Search for the isotropic stochastic background
using data from Advanced LIGO's
second observing run
arXIV:1903.02886*



Magnetic Noise Measurements

Comparison with Virgo

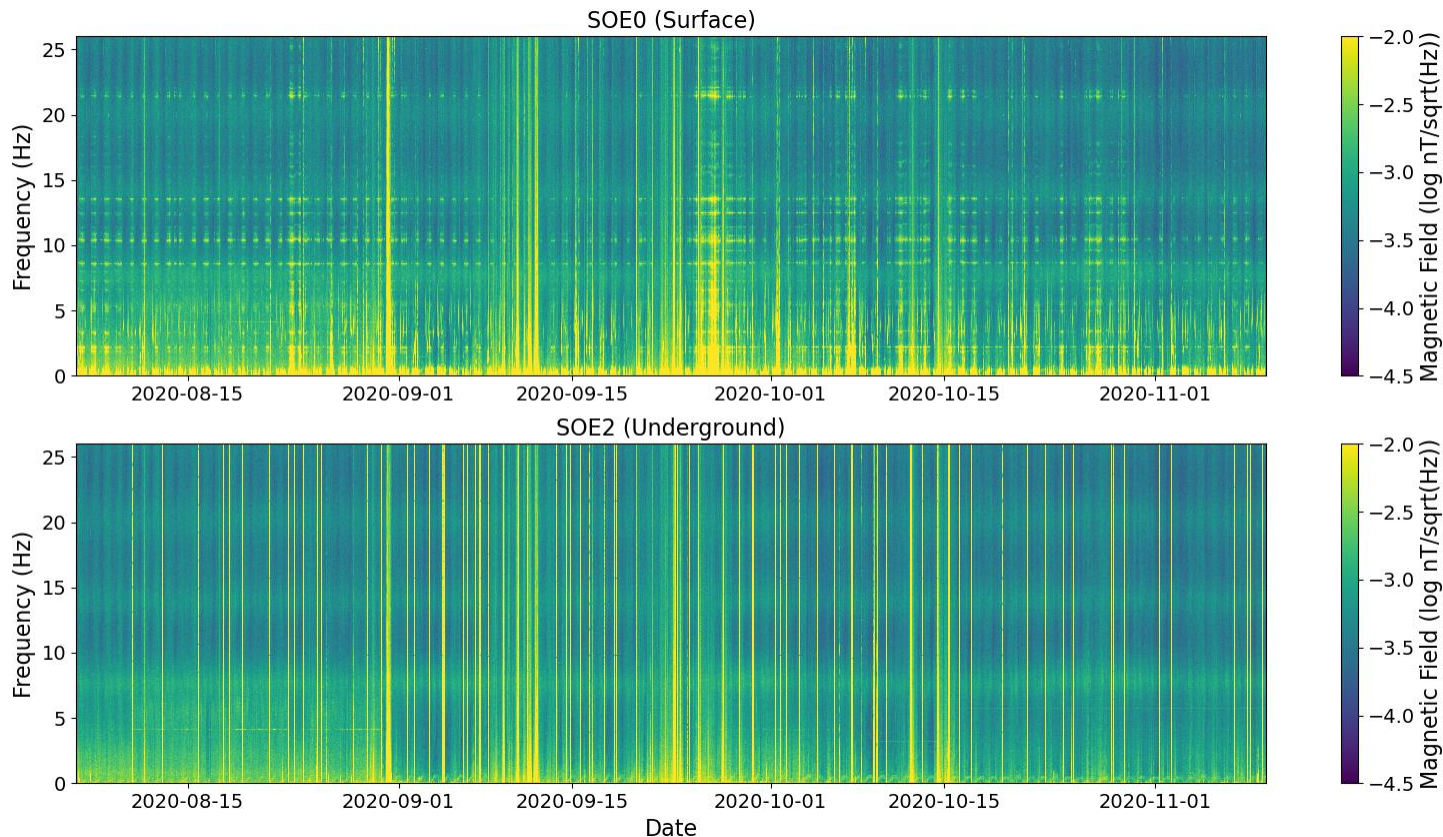
- Comparison performed during night and at morning;
- Lower noise at low frequency during night;
- Schumann resonances are well visible underground.



Magnetic Noise Measurements

Surface vs. Underground comparison

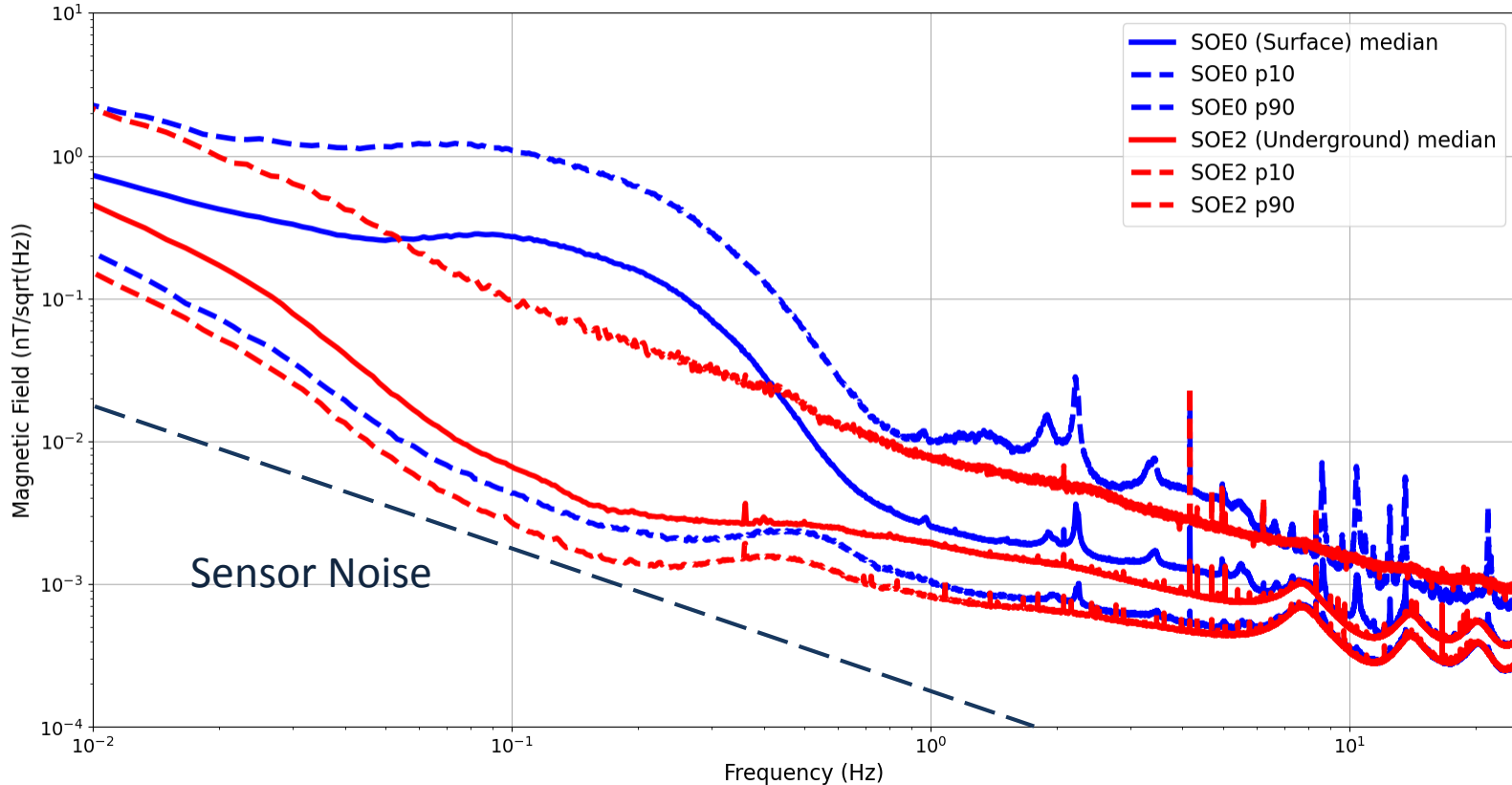
- From August 6 to November 9 2020 data from the surface magnetometer were available.
- Very quiet data at SOE2



Magnetic Noise Measurements

Surface vs. Underground comparison

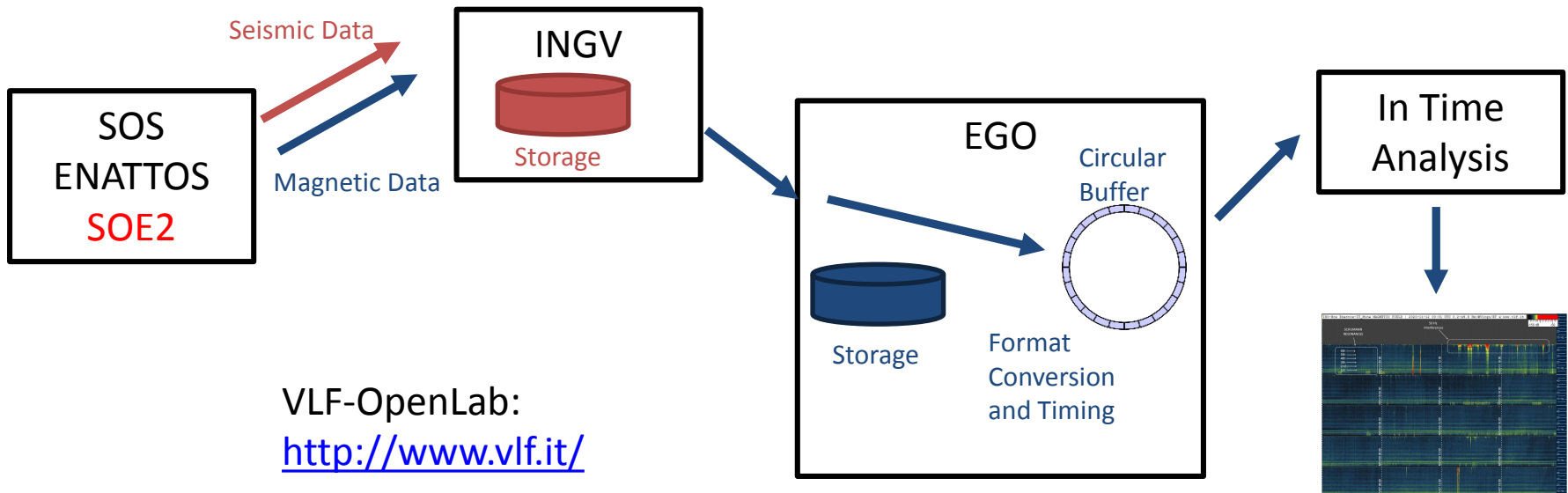
- ADS Statistics for 96 days;
- SOE2 median close to SOE0 p10 at low frequency;
- SR visible during quiet period also in surface;



Magnetic Noise Measurements

Data repository and transmission

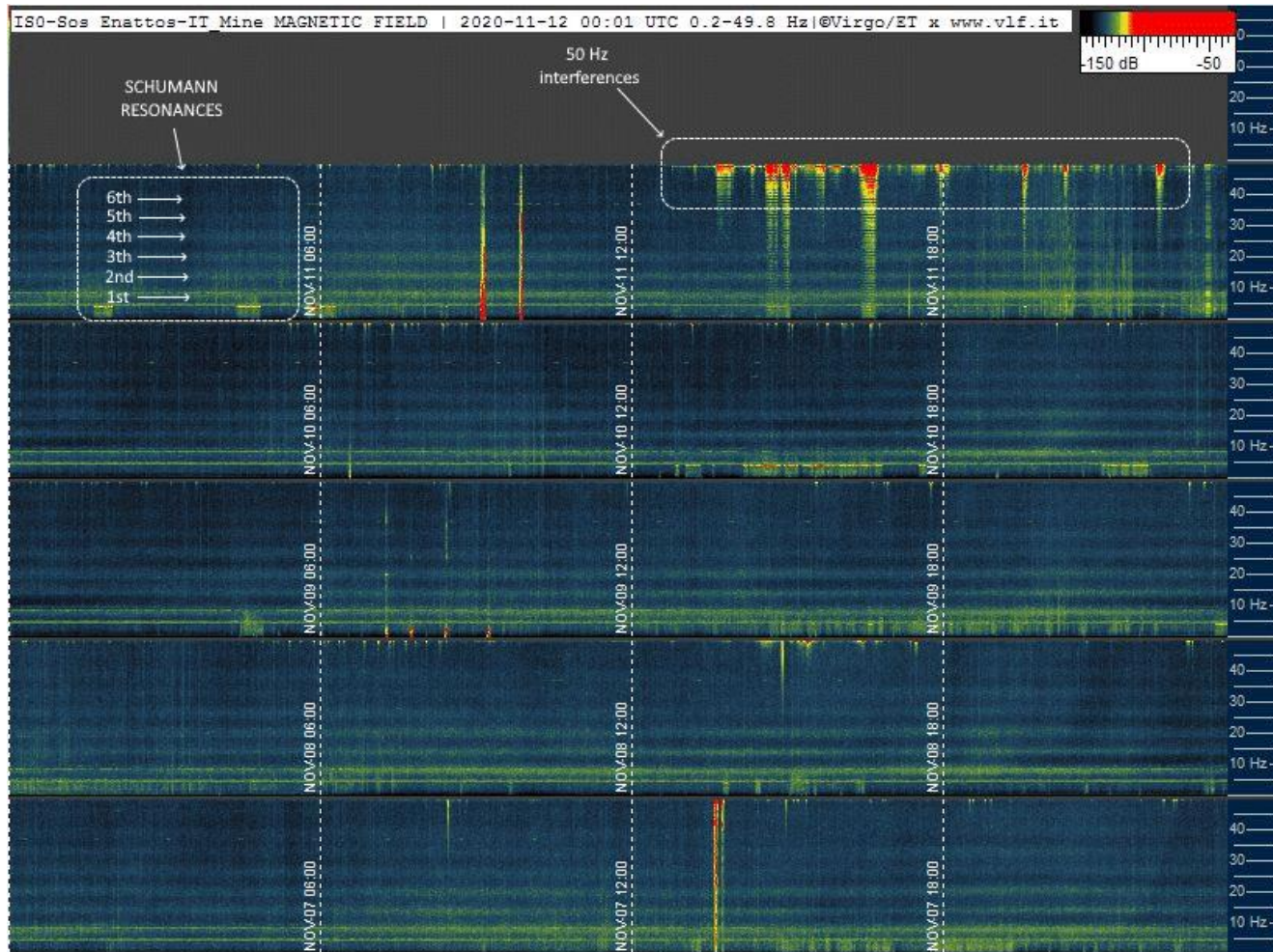
- Data from the underground magnetometer are sent to INGV together with the seismic signals from SOE2;
- Magnetic data are then stored at EGO (mseed format);
- Finally they are sent to VLF-OpenLab for the in-time analysis (wav format);



Magnetic Noise Measurements

In time analysis

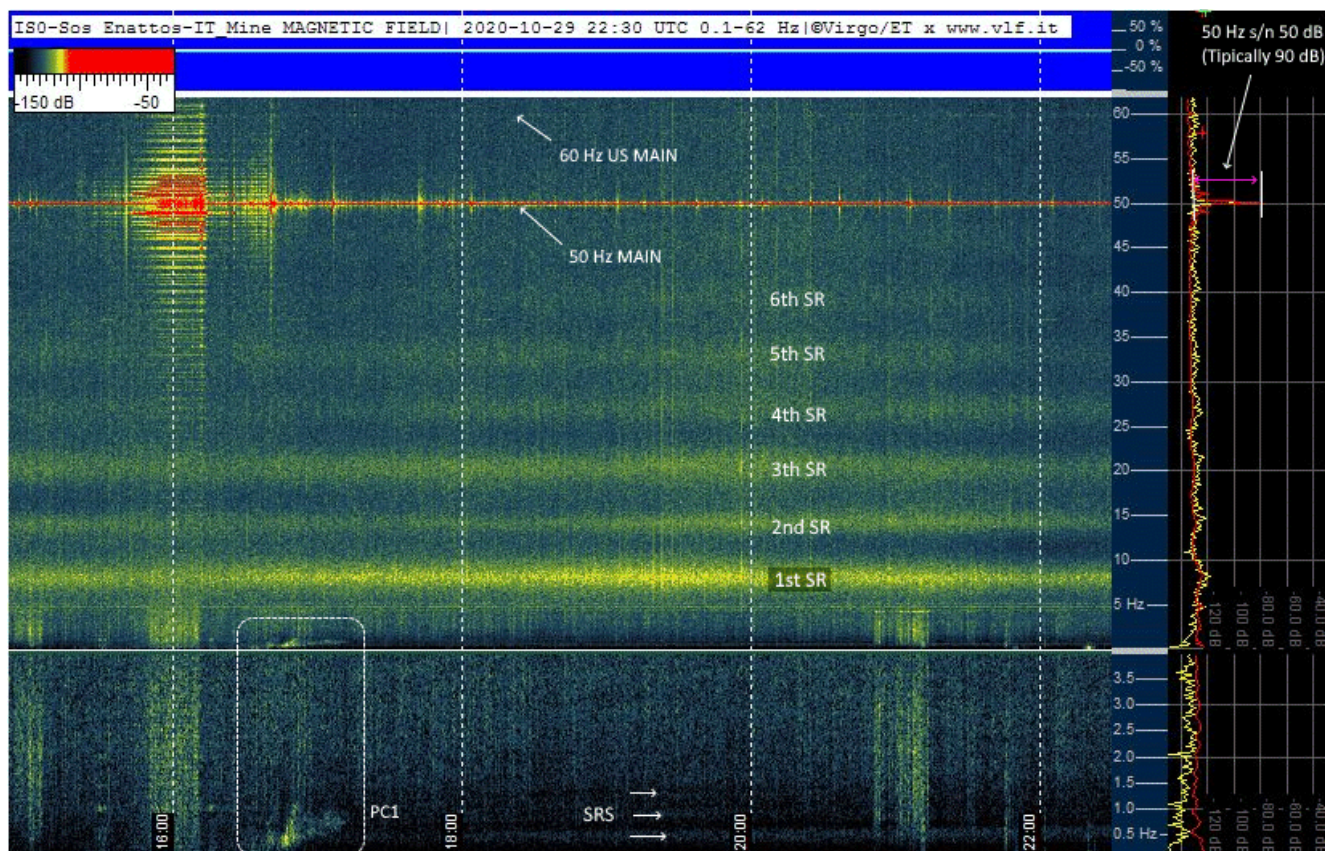
- Spectrogram with 5 days data (7-11 November 2020)



Magnetic Noise Measurements

In time analysis

- A detail showing SR (up to 6th), 50 Hz disturbances, a Magnetic Pulsation (PC1) and Spectral Resonance Structures (SRS)



Next Steps

Beginning of next year

- Restart data collection from surface magnetometer;
- Installation of the microphones: initially in surface, inside the control room for test, and then at level -2 for correlation with seismometer;
- Installation of a third magnetometer in SEO3;

Middle 2021

- Installation of external magnetic monitoring station (3 axis and autonomous DAQ) for long term measurement campaign at the three vertex;
- Installation of microphones at SEO1 and SOE3



Conclusions

- Installation of the Environmental Monitoring Infrastructure ongoing;
- Up to now only weather station and underground magnetometer are regularly stored;
- The EM noise is very low, as expected, if compared with other instrumented sites, like Virgo;