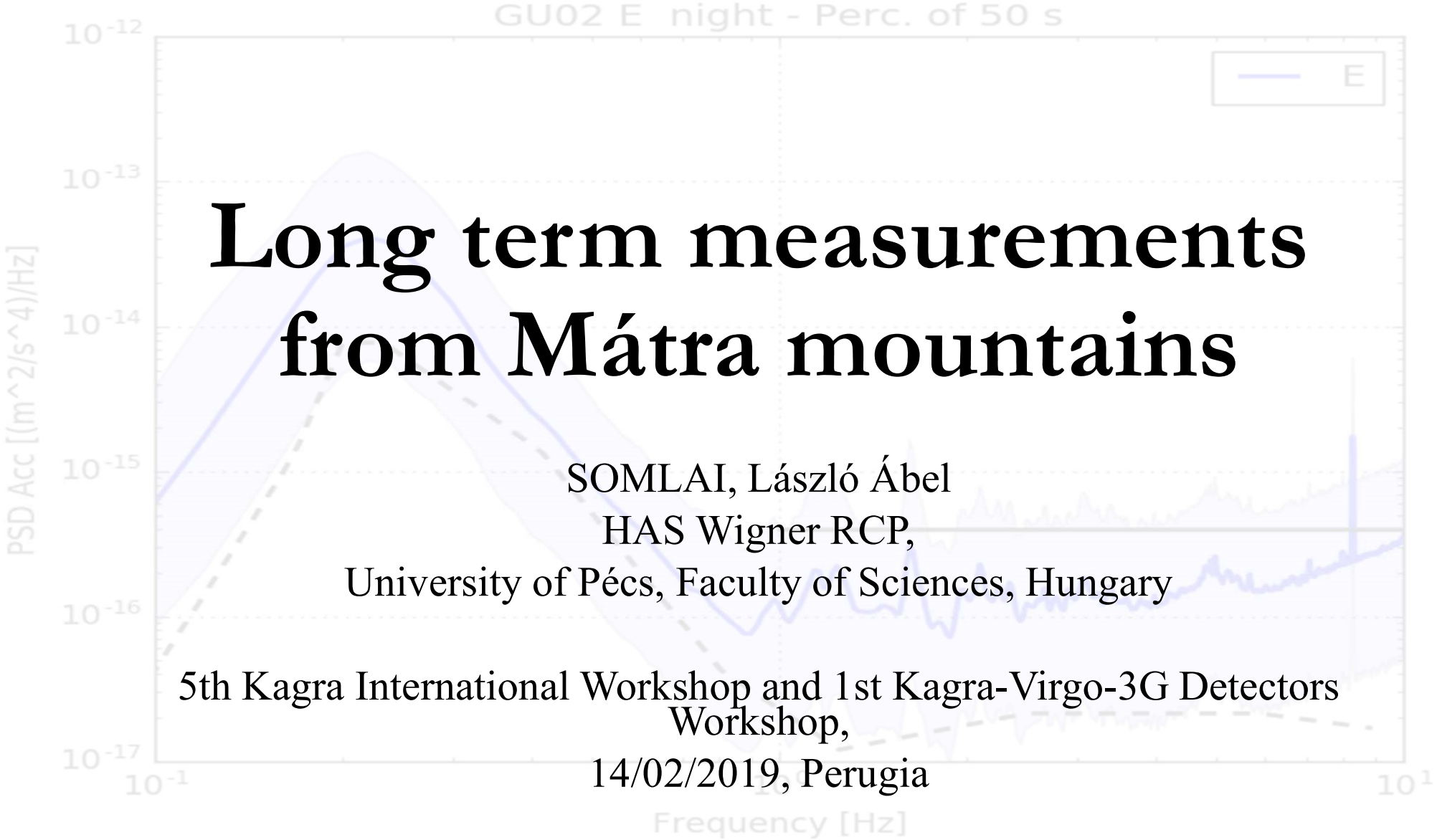


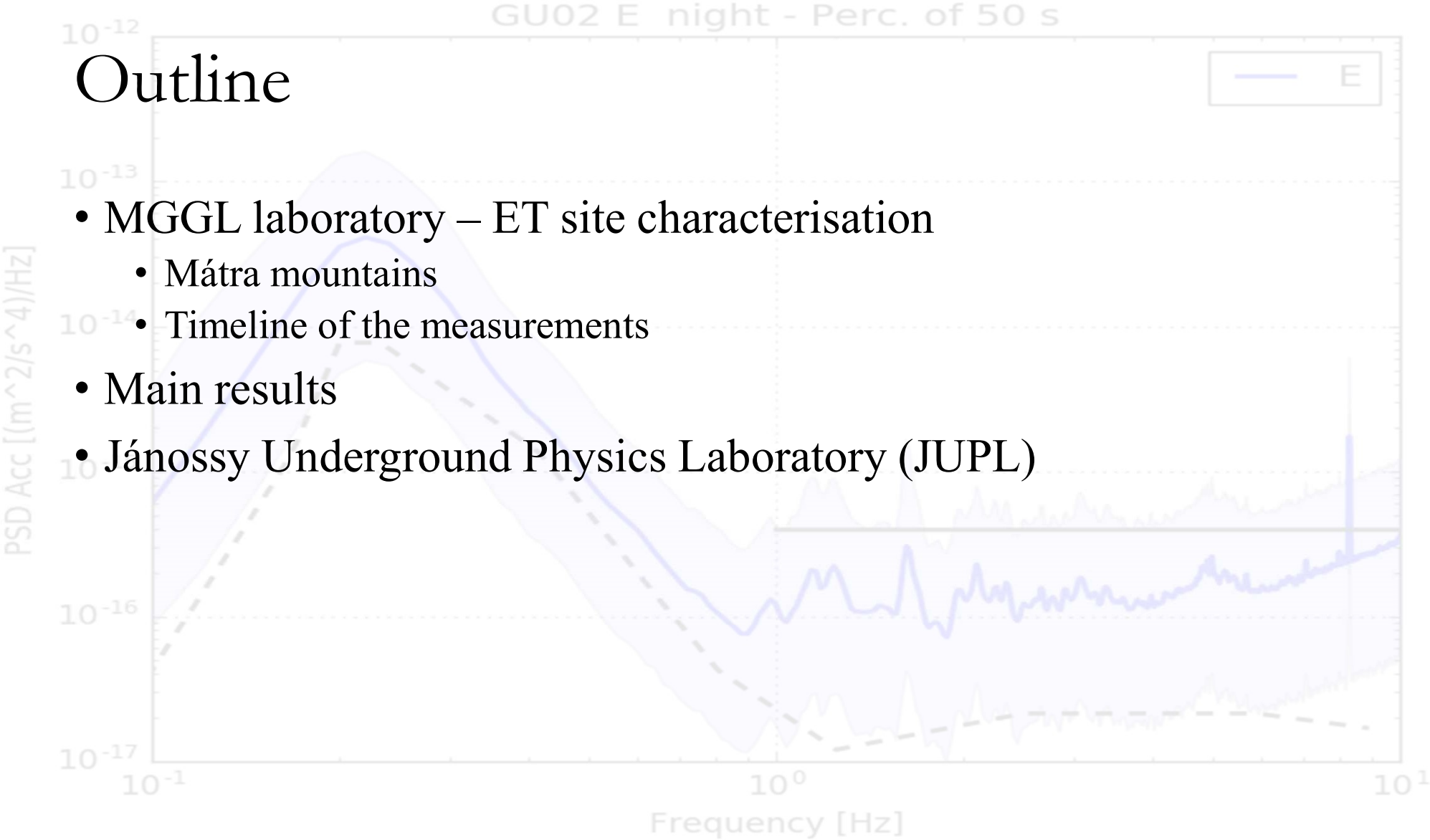
Long term measurements from Mátra mountains

SOMLAI, László Ábel
HAS Wigner RCP,
University of Pécs, Faculty of Sciences, Hungary

5th Kagra International Workshop and 1st Kagra-Virgo-3G Detectors Workshop,
14/02/2019, Perugia

Outline

- MGGL laboratory – ET site characterisation
  - Mátra mountains
  - Timeline of the measurements
- Main results
- Jánossy Underground Physics Laboratory (JUPL)



MGGL

The Mátra Gravitational and Geophysical Laboratory is **to collect and to study data** from Mátra mountains

- Collaboration (31 participants) with many Institutions
  - Wigner FK
  - MTA CSFK GGKI
  - Atomki
  - Univ. of Miskolc
  - BME
  - ELTE
  - Univ. of Warsaw
  - Univ. Of Zielona Góra

- Report of the first data collection period,

(arXiv:1610.07630)

IOP Publishing — Classical and Quantum Gravity

Class. Quantum Grav. **34** (2017) 114001 (22pp)

First report of long term measurements of the MGGL laboratory in the Mátra mountain range

G G Barnaföldi[1], T Bulik[8,9], M Cieslar[8], E Dávid[1], M Dobróka[4], E Fenyvesi[5], D Gondek-Rosinska[10], Z Gráczer[2], G Hamar[1], G Huba[1], Á Kis[2], R Kovács[1,3], I Lemperger[2], P Lévai[1], J Molnár[3], D Nagy[3], A Novák[2], L Oláh[1], P Pázmándi[1], D Piri[2], L Somlai[1], T Starecki[7], M Suchenek[7], G Surányi[11], S Szalai[2], D Varga[1], M Vasúth[1], P Ván[1,3], B Vásárhelyi[6], V Wesztergom[2] and Z Wéber[2]

[1] MTA Wigner Research Centre for Physics, Institute of Particle and Nuclear Physics, 1121 Budapest, Konkoly Thege Miklós út 29-33, Hungary
[2] MTA Research Centre for Astronomy and Earth Sciences, Geodetic and Geophysical Institute, H-9400, Sopron, Csatkai E. u. 6-8, Hungary
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[9] Instituto de Astronomía, Universidad Nacional Autónoma de México, Apartado Postal 877, Ensenada, Baja California, 22800, Mexico
[10] Janusz Gil Institute of Astronomy, University of Zielona Góra, Licealna 9, 65-407 Zielona Góra, Poland
[11] MTA-ELTE Geological, Geophysical and Space Science Research Group, 1117 Budapest, Pázmány Péter s. 1/c, Hungary

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Accepted for publication 29 March 2017
Published 28 April 2017

Abstract

Matra Gravitational and Geophysical Laboratory (MGGL) was established near Gyöngyösoroszi, Hungary in 2015, in the cavern system of an unused ore mine. The laboratory is located 88 m below the surface, with the aim of measuring and analysing the advantages of the underground installation's

” First report of long term measurements of the MGGL laboratory in the Mátra mountain range”, Class. Quantum Grav. **34** (2017) 114001

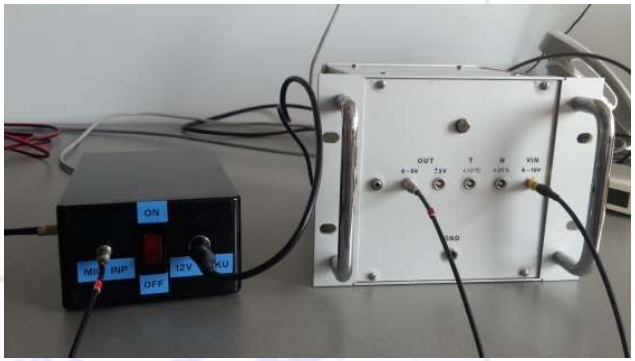
Mátra mountains (location)

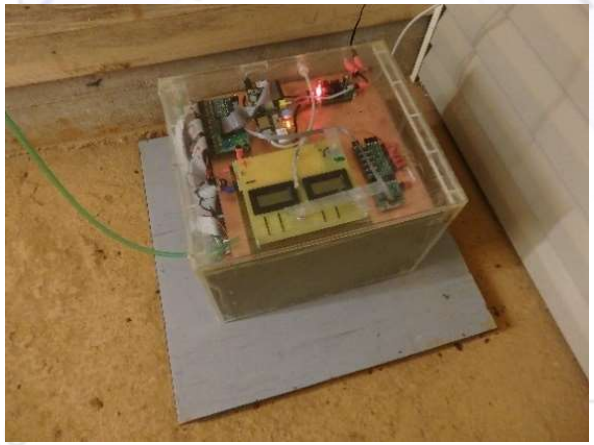
We are here

remediation

MGGL instruments and experiments

- Guralp CMG-3T seismometer
- Seismometer from the Warsaw University
- Infrasound detector
- Lemi-120 magnetometer
- Muon detector (Muontomograph)

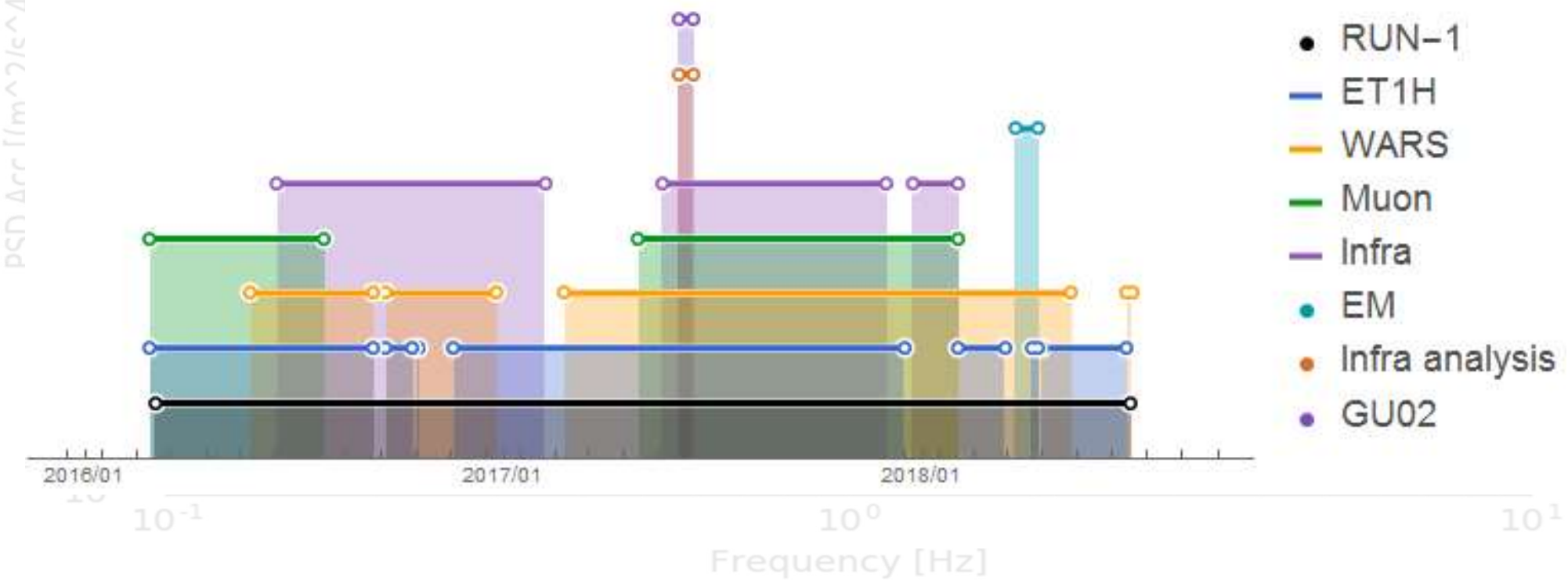




Timeline

More than 2 ys of seismic data avialable to study
More than a year of muon and infra

RUN-0: ArXiv:1610.07630
RUN-1: ArXiv:1811.05198



Seismicity of the Mátra Mountains and the surrounding areas

- The seismic activity is low [1]
- Seismic hazard was studied [2]
- Hazard values using Euro-Mediterranean Seismic Hazard Model (ESHM13)

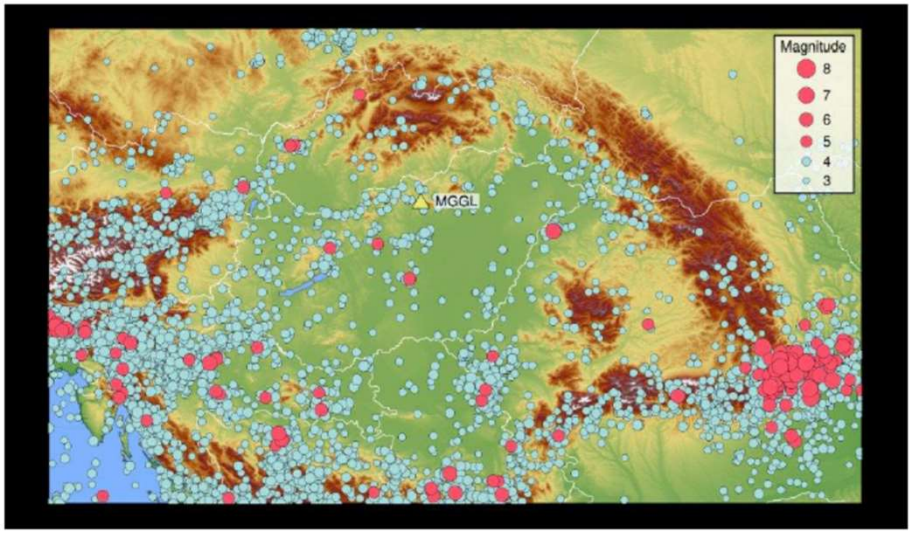


FIGURE 3. Seismic activity in the Carpatho-Pannonian area. The triangle shows the location of the MGGL. The circles mark the epicentres of the known earthquakes occurred between the years 1800 and 2010. Blue circles: earthquakes with magnitudes $3.0 \leq M < 5.0$, red circles: earthquakes with magnitudes $M \geq 5.0$.

TABLE 1. Observed maximum ground displacement values for frequencies larger then 1 Hz in the case of four characteristic events.

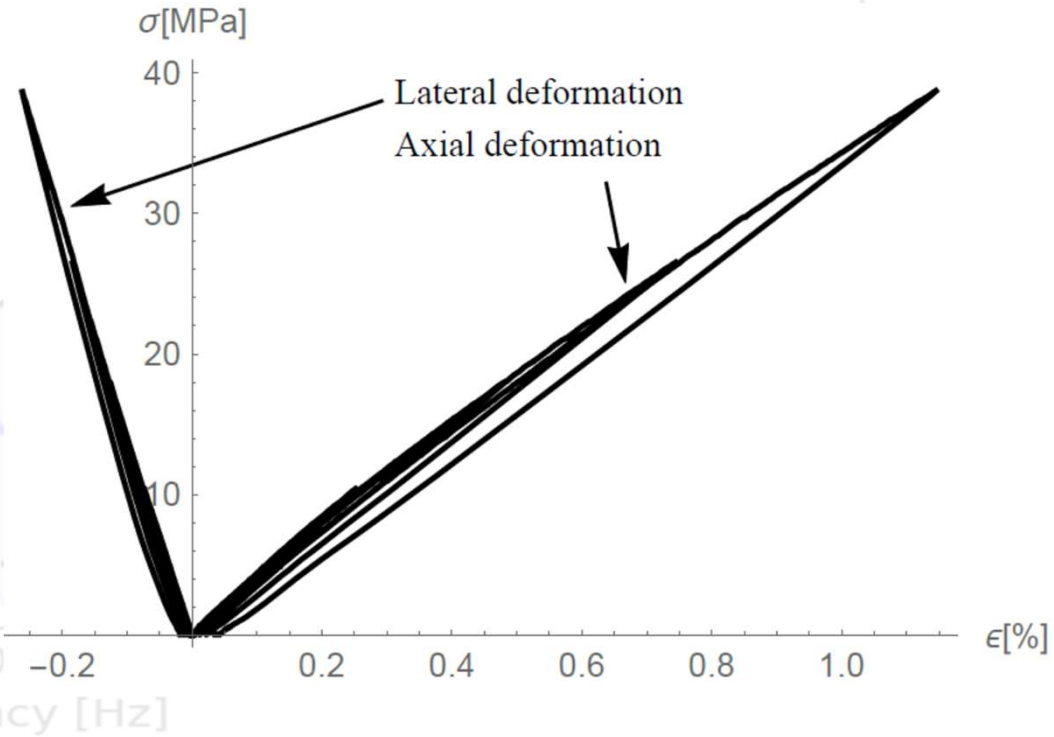
Station	Event	Z [μm]	N [μm]	E [μm]
ET1H	2016-05-10 10:47 (explosion; Gyöngyössolymos; dist= 7.4 km)	0.88	0.66	0.53
ET1H	2017-05-30 10:43 (explosion; Kisnána; dist=21.5 km)	0.10	0.07	0.08
ET1H	2017-06-22 11:21 (explosion; Recsk; dist=16.8 km)	0.34	0.78	0.43

[1] MTA CSFK GGI, Earthquake Catalogue, Geodetic and Geophysical Institute, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, Sopron, Hungary, 2018.
[2] D. Giardini et al. Mapping Europe's seicmic hazard. Transactions American Geophysical Union, 95(29):261-262,2014

Rheology results

Rock rheology (Elastic and rheological properties of andesite from Gyöngyösoroszi)

- Hard andesitic rocks of Mátra are more than viscoelastic → more refined **NN self-gravity** models, tunnel convergence, in situ rock stress
- Direct and **pointed laboratory measurements** of dynamic and static elasticity coefficients
- Preliminary results for relaxation times are: 10-50s



EM results

Electromagnetic study on the signal attenuation in the ELF range

- Study Schumann resonances (surface and ~140 m deep subsurface station)
- Calculated bulk resistivity at the Schumann resonance frequency 387Ωm → 4% decrease

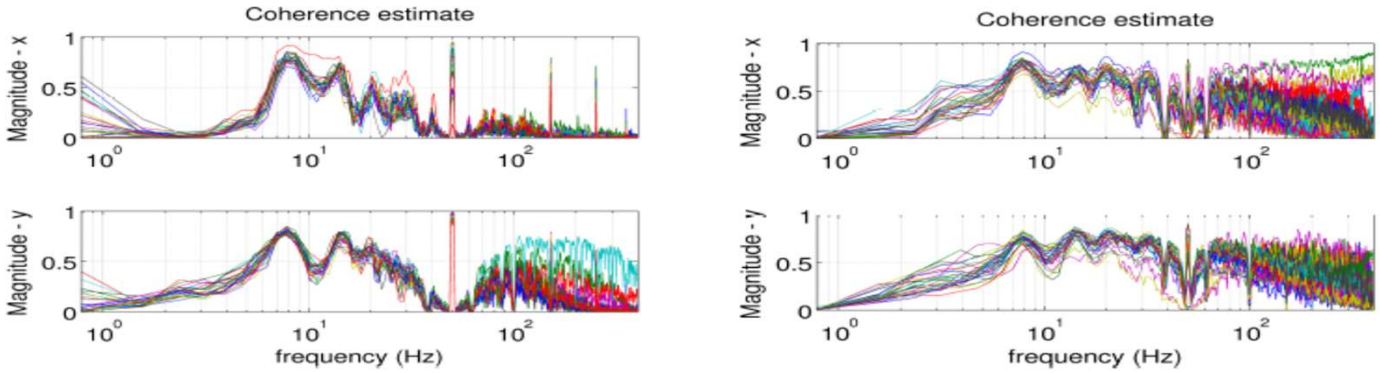
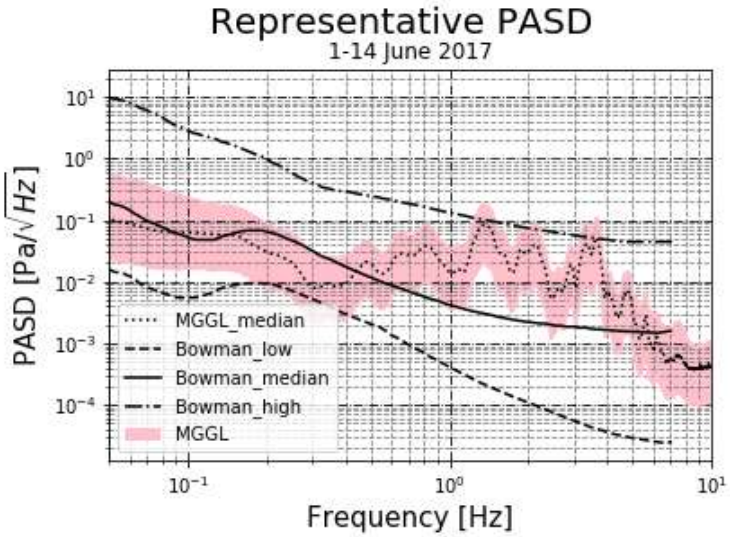
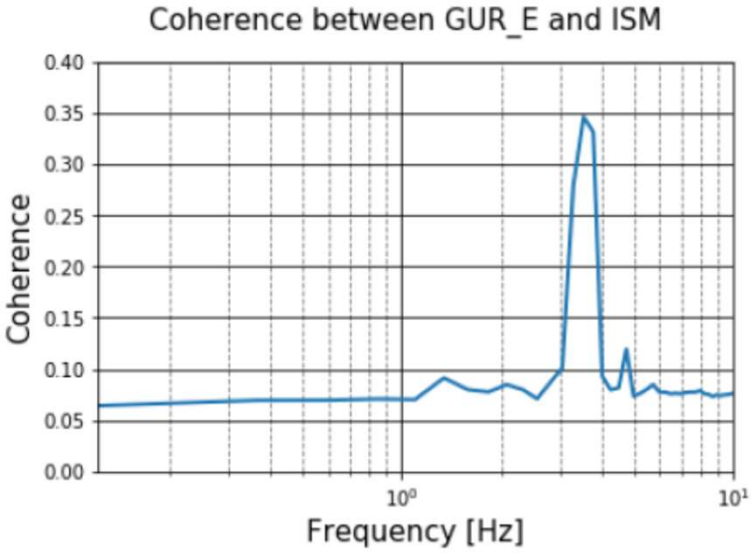


FIGURE 24. The coherence of magnetic variation in relation of both subsurface-Hylaty *(left)* and surface-Hylaty site *(right)* indicates definite correlation at the first three Schumann frequencies.

Infrasound results

- The high peaks between 0.6-5 Hz caused by the AC system
- Cavity noises from nearby shaft
- Coherence with the seismic data

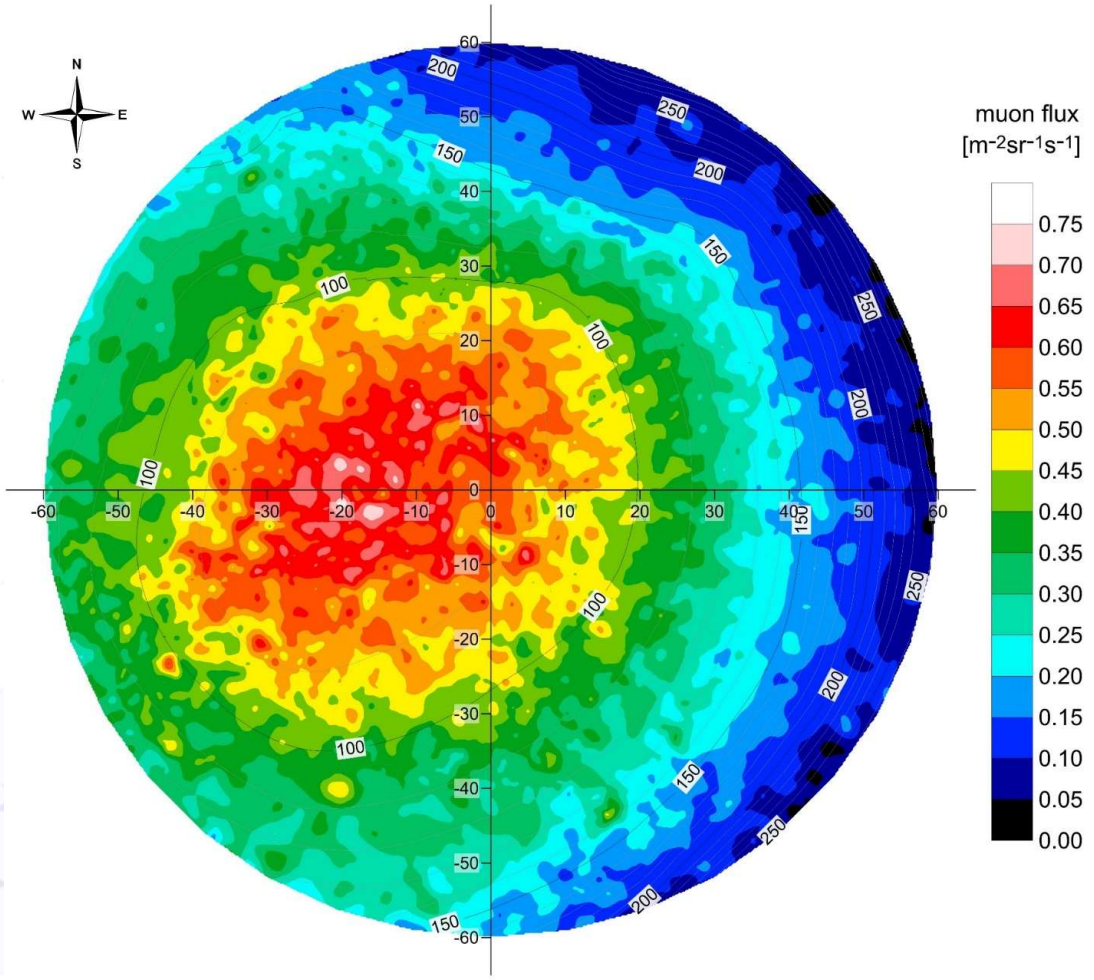




Muon results

Cosmic muon flux measurements

- The rock density map correlates well with the unexplored and mined areas above the MGGL
- Rock density: 2600 ± 100 kgm^-3

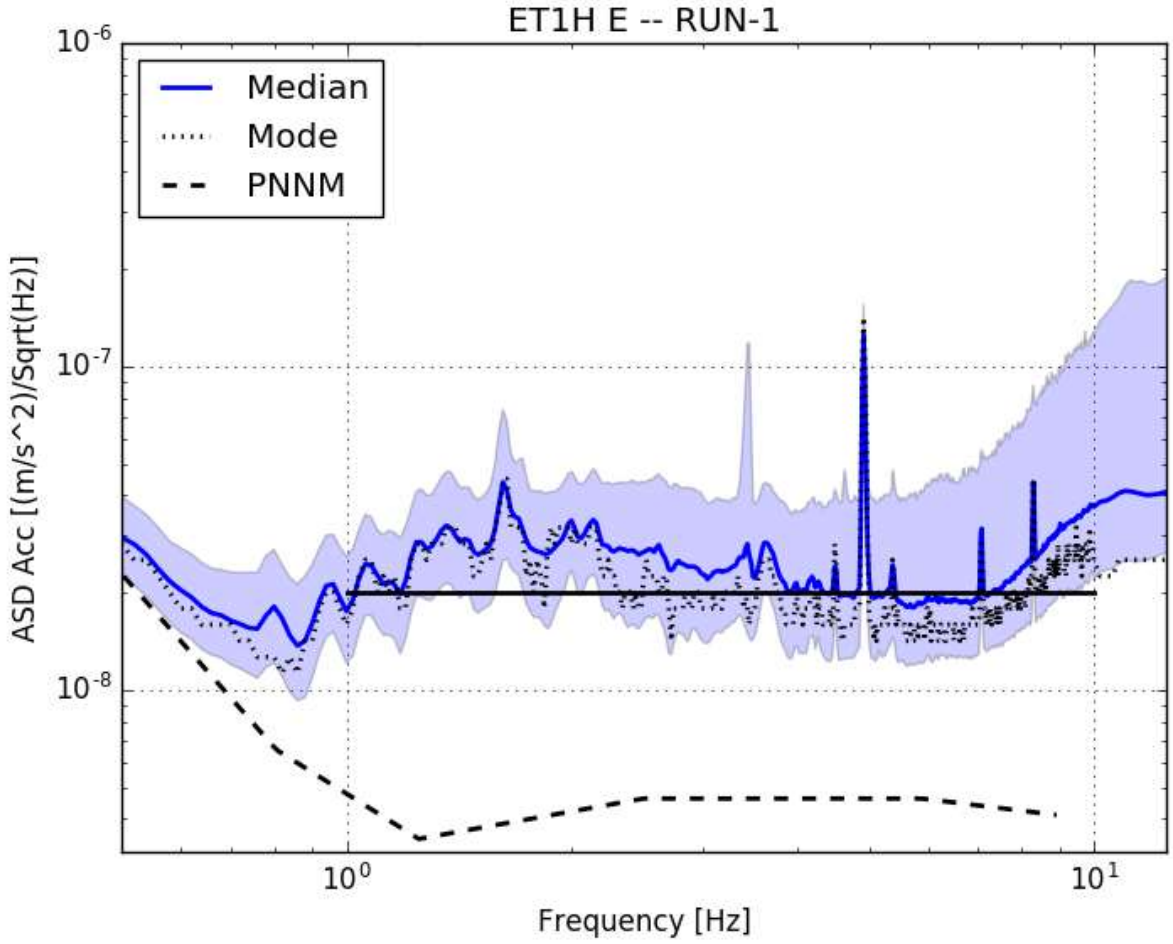


Long term seismic results

Seismic study:

- Long term measurements (almost 2 ys of data)
- Use intrinsic averaging

Methodology ArXiv:1810.06252



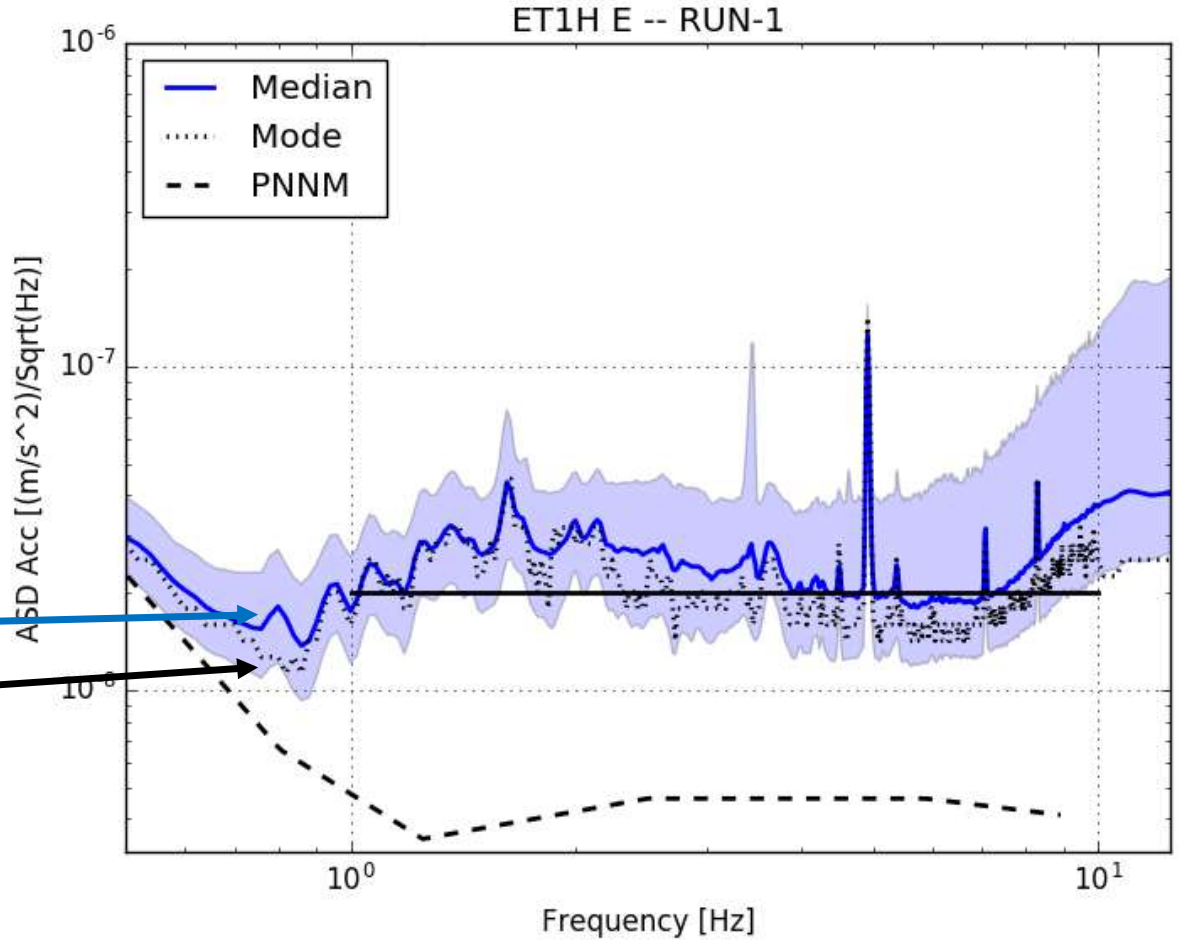
Long term seismic results

Seismic study:

- Long term measurements (almost 2 ys of data)
- Use intrinsic averaging
- Mode/Median

Median (50th percentile)

Mode (most often)



Long term seismic results

Seismic study:

- Long term measurements (almost 2 ys of data)
- Use intrinsic averaging
- Study annually, seasonally changes

ET1H ~88m depth

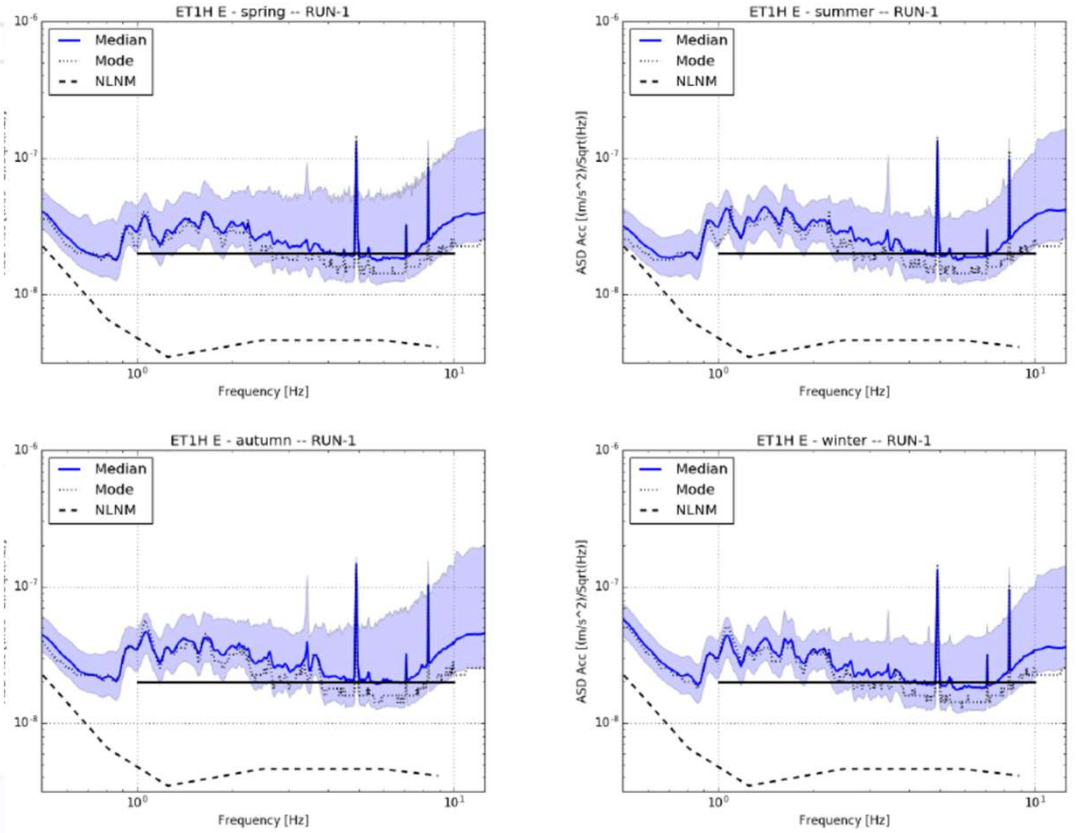


FIGURE 11. The acceleration ASD of the different seasons for a horizontal component calculated is shown here from whole-day periods. The solid blue and the dotted black lines indicate the median and the mode of the data, respectively. The borderlines of the blue colored area are the 10^{th} and 90^{th} percentiles. The Black Forest line is solid black and the dashed black lines are NLNM curves.

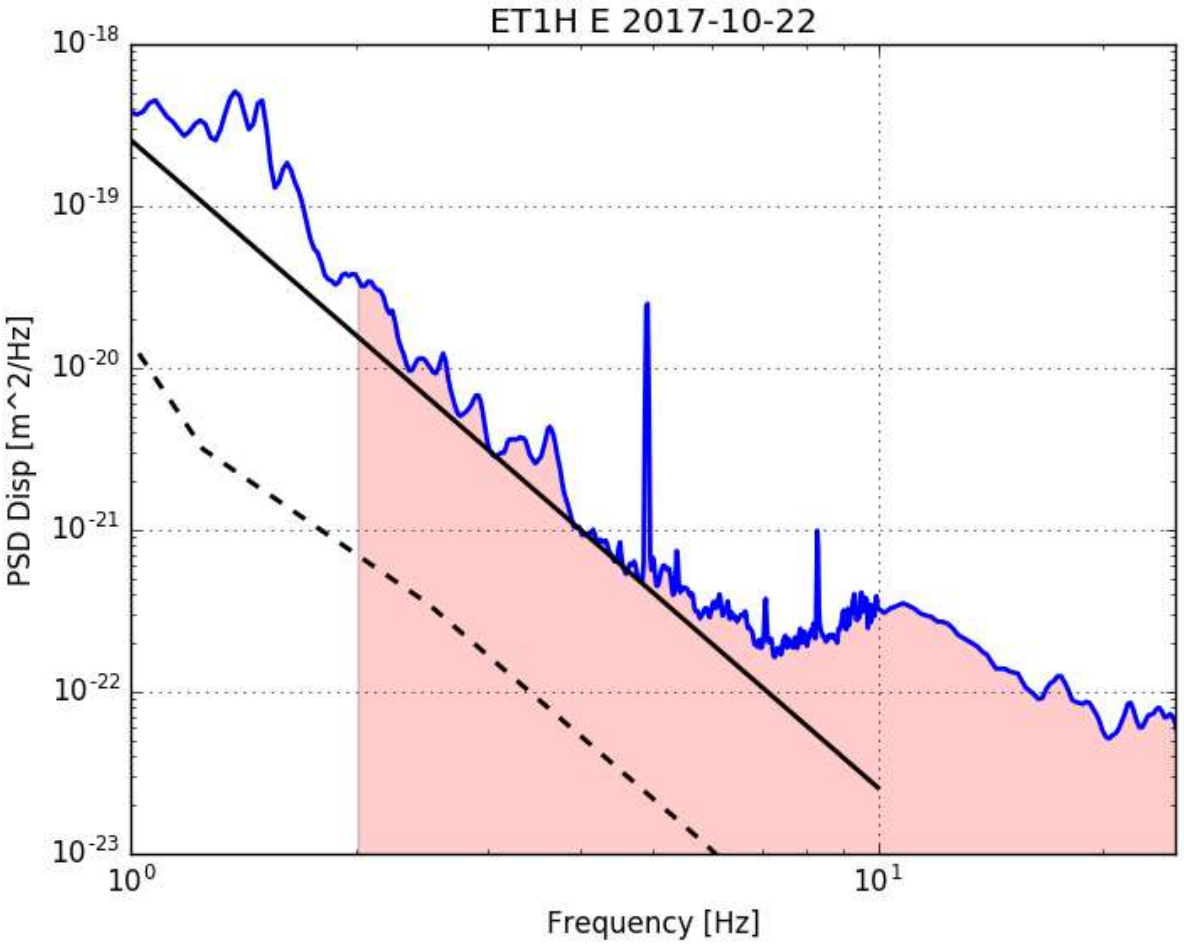
Long term seismic results

Calculate

- rms_2Hz
- rms_2-10Hz and
- rms_1-10Hz

Expresses different properties:

- Cultural/human noise
- Sea/ocean



Long term seismic results

Calculate

- rms_2Hz
- rms_2-10Hz and
- rms_1-10Hz

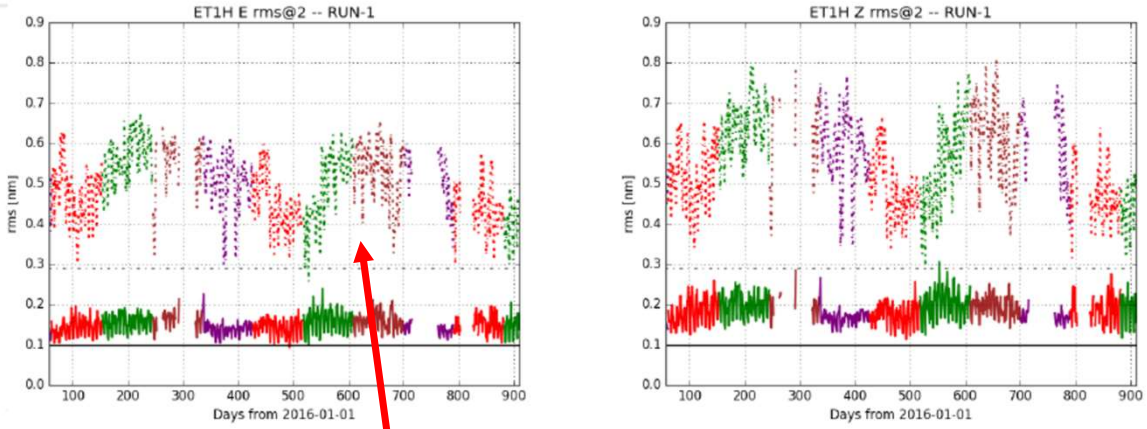


FIGURE 12. The timeline of the daily rms values for the whole Run-1 in a horizontal and in the vertical direction. In the figures the mode related rms_{2Hz} is the solid line and the rms_{1-10Hz} from median is the dashed one. The colours red, green, brown and purple are for the spring, summer, autumn and winter periods, respectively. The solid and dashed black lines are the referential Black Forest values, $rms_{2Hz} = 0.1nm$ and $rms_{1-10Hz} = 0.29nm$.

Seasonally changes for the rms_1-10Hz

Night period	rms_{2Hz}	rms_{2-10Hz}	rms_{1-10Hz}
E	0.0748	0.0752	0.217
N	0.0746	0.0732	0.213
Z	0.0625	0.0619	0.304
Working period	rms_{2Hz}	rms_{2-10Hz}	rms_{1-10Hz}
E	0.143	0.135	0.318
N	0.150	0.135	0.326
Z	0.135	0.121	0.431

TABLE 10. The calculated rms values in nm for the night and working periods of the GU02 station, according to Fig. 16.

Long term seismic results

Calculate

- rms_2Hz
- rms_2-10Hz and
- rms_1-10Hz

Night period	rms_{2Hz}	rms_{2-10Hz}	rms_{1-10Hz}
E	0.0748	0.0752	0.217
N	0.0746	0.0732	0.213
Z	0.0625	0.0619	0.304
Working period	rms_{2Hz}	rms_{2-10Hz}	rms_{1-10Hz}
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TABLE 10. The calculated *rms* values in *nm* for the night and working periods of the GU02 station, according to Fig. 16.

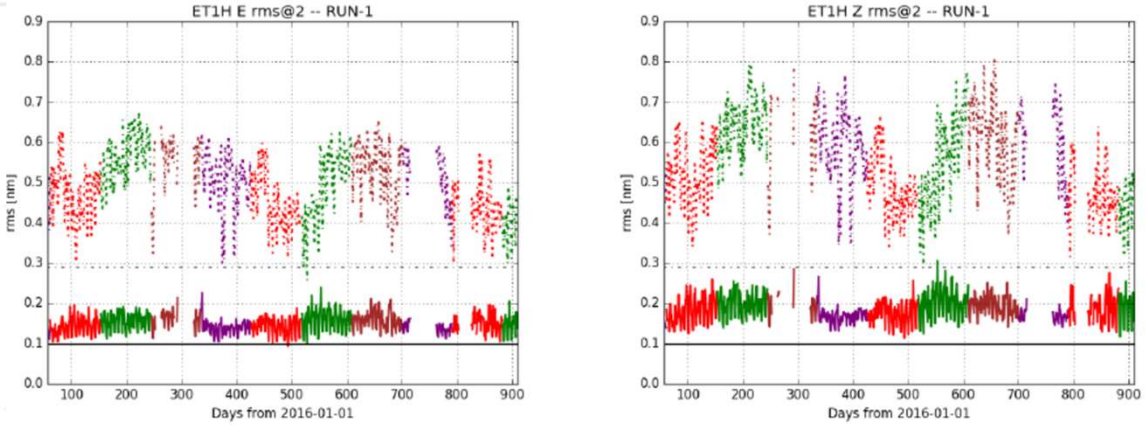


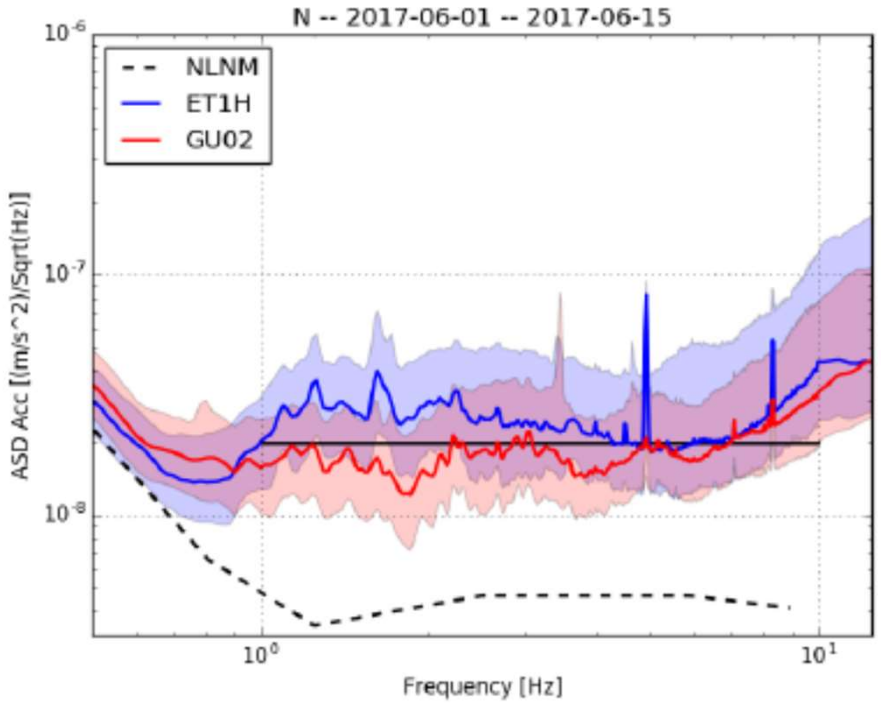
FIGURE 12. The timeline of the daily *rms* values for the whole Run-1 in a horizontal and in the vertical direction. In the figures the mode related rms_{2Hz} is the solid line and the rms_{1-10Hz} from median is the dashed one. The colours red, green, brown and purple are for the spring, summer, autumn and winter periods, respectively. The solid and dashed black lines are the referential Black Forest values, $rms_{2Hz} = 0.1nm$ and $rms_{1-10Hz} = 0.29nm$.

Long term seismic results

Study of 2 years ArXiv:1811.05198

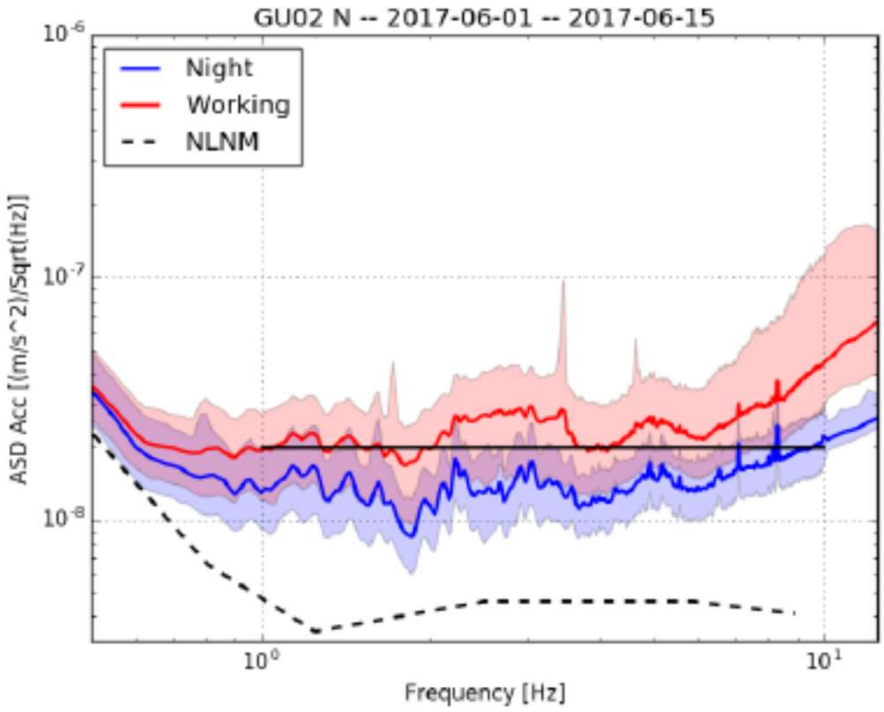
ET1H ~88m depth

GU02 ~404m depth



GU02 Night

GU02 Working



Long term seismic results

Seismometer of the Warsaw University:

- 654 days were analysed (day, night, working period)
- Cumulative rms_2Hz was calculated

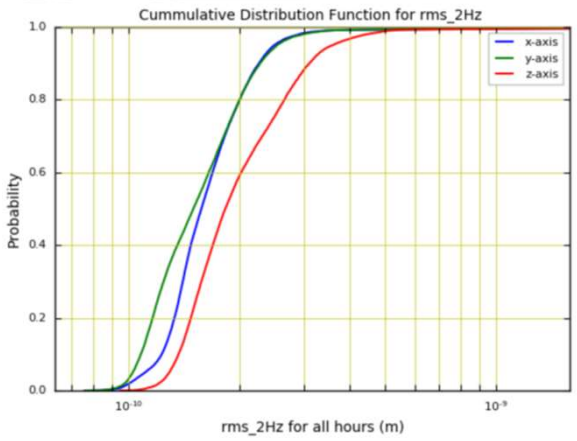


FIGURE 21. The cumulative distributions of the hourly rms_{2Hz}. We present the results for the three directions.

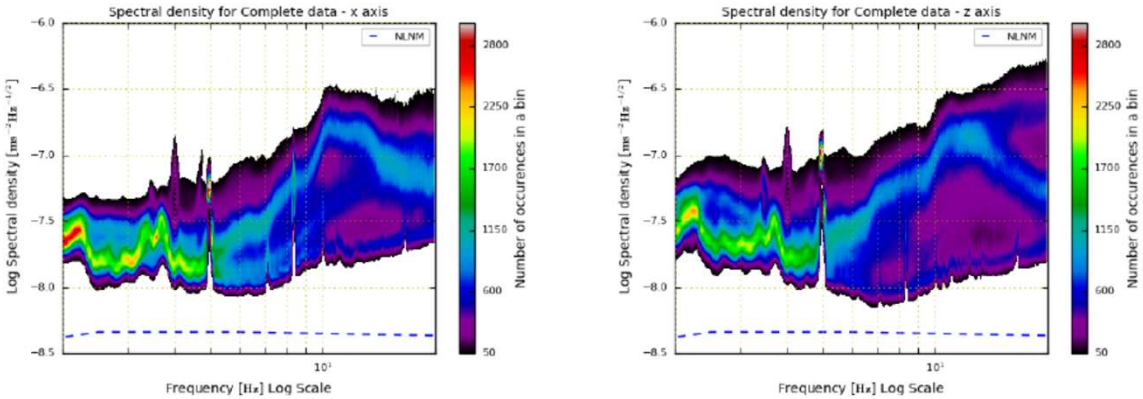


FIGURE 18. The density plots of the spectra in the vertical and horizontal directions. The blue dashed line is the NLNM.

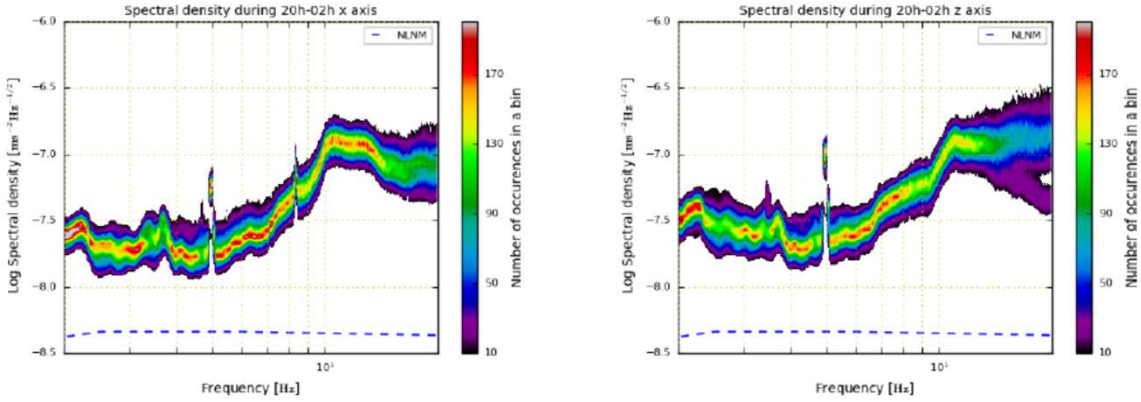
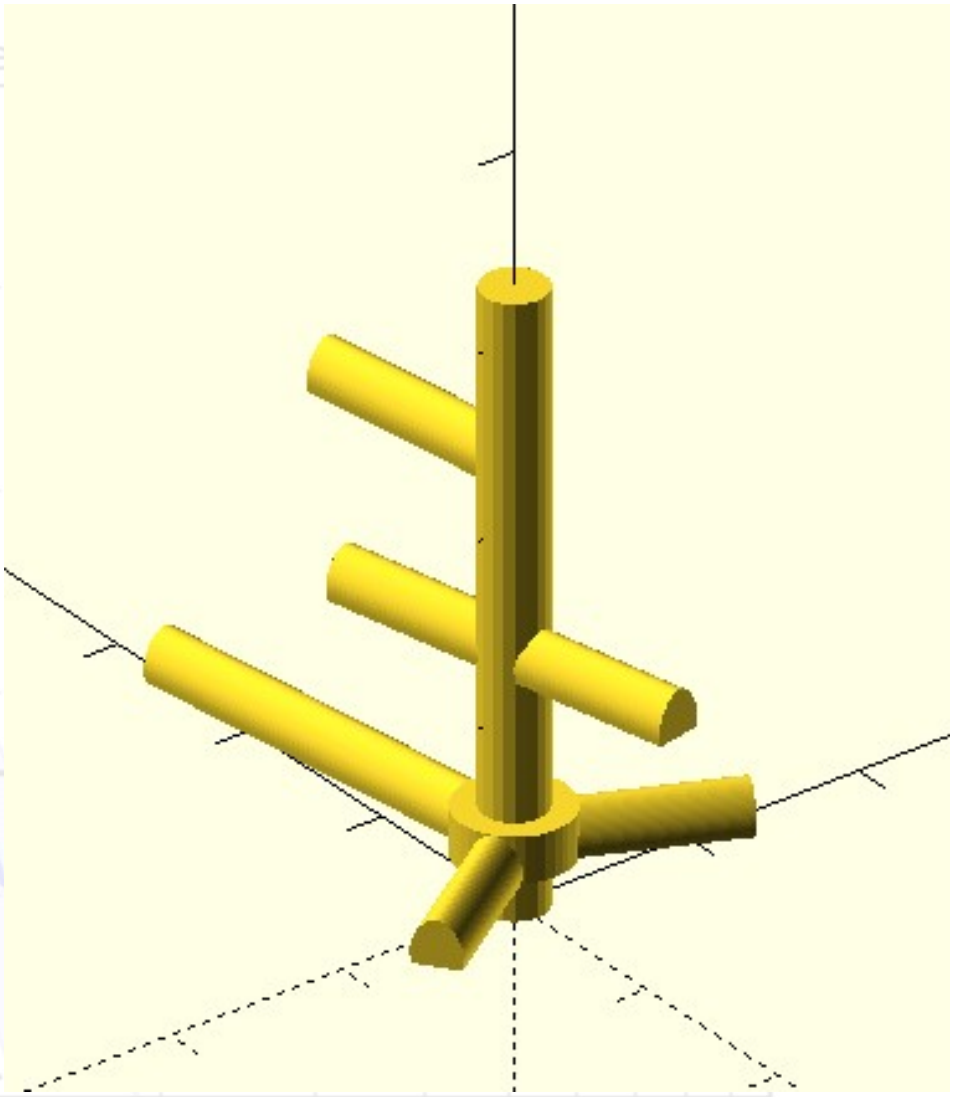


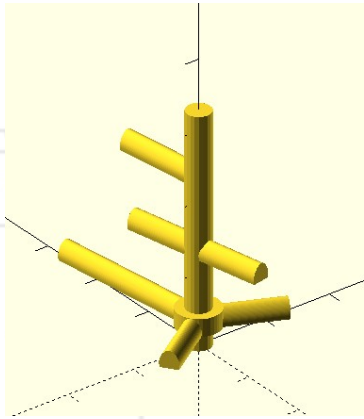
FIGURE 20. The daily variation of the seismic noise for the off work-shifts in the mine: corresponding to the time between 20:00 and 02:00 hours UTC. The blue dashed line is the NLNM.

Jánossy Underground Physics Laboratory

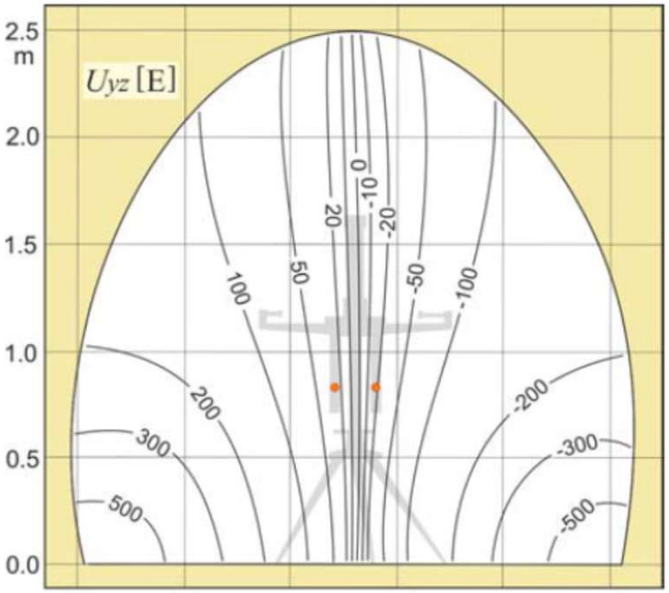
- Wigner RCP, Budapest (out of the city, campus)
- About 30m deep , 10-20 m horizontal tunnels
- Tunnels each 10 m
- How to use it?



JUPL

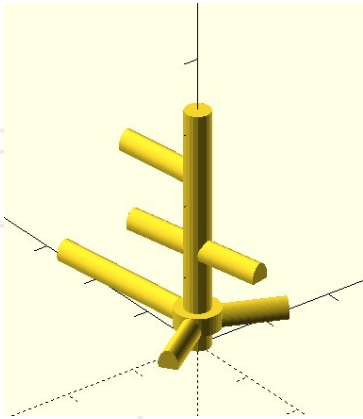


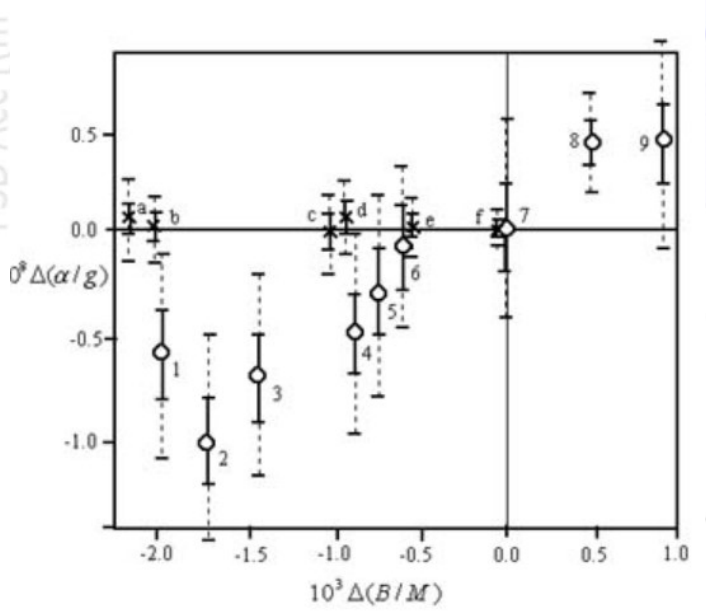
- Year 2019 is Eötvös year for physicists in Hungary *(2019 is the 100th anniversary of the death of the great Hungarian physicist, Loránd Eötvös)*
- We want to remeasure the Eötvös-Pekár-Fekete experiment



JUPL

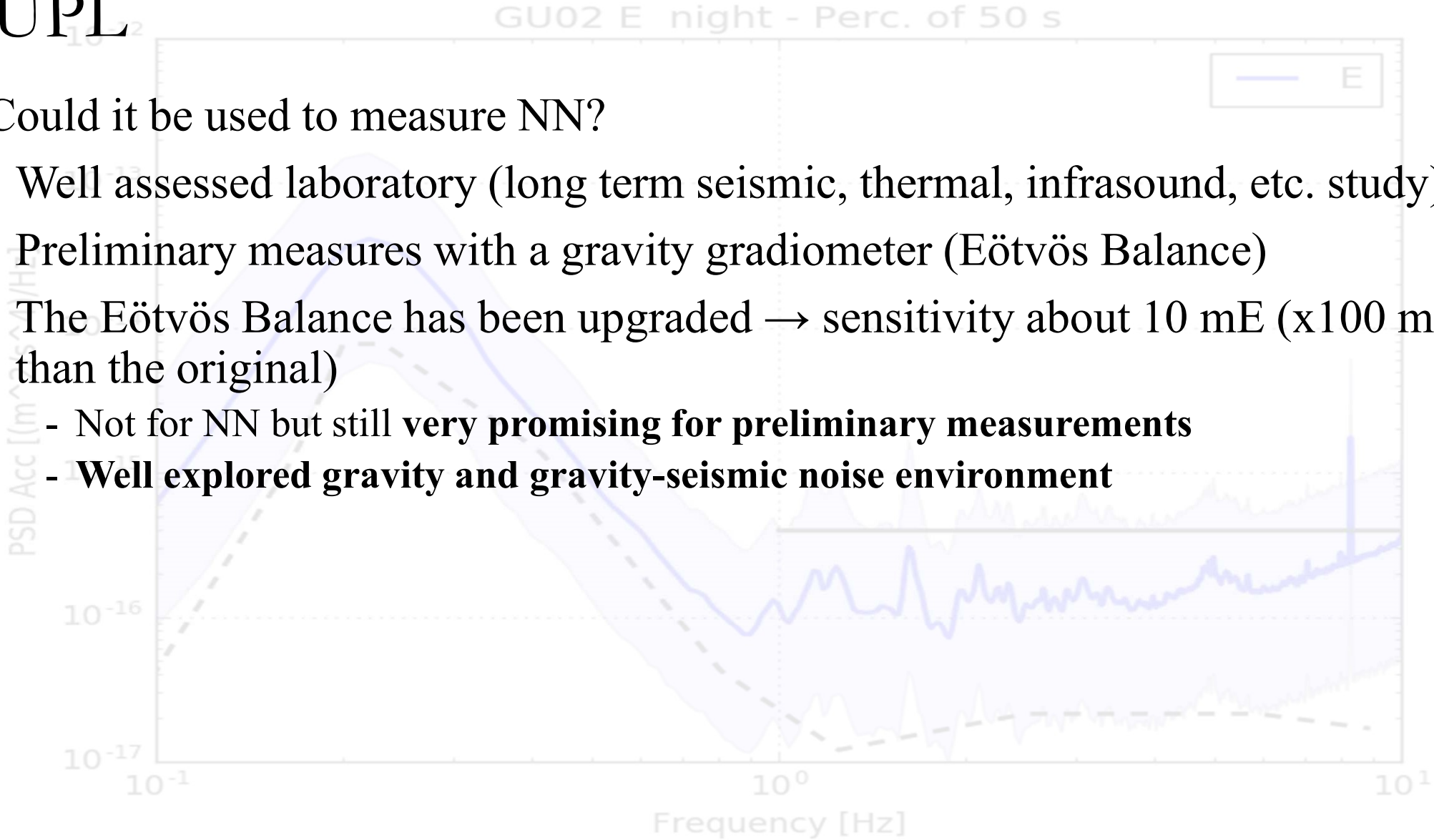
- Year 2019 is Eötvös year
- We want to remeasure the Eötvös-Pekár-Fekete experience → **Fischbach, Fifth force**, still mysterious





See: http://tudtor.kfki.hu/eotvos1/onehund.html and/or ArXiv:1901.11163, 1803.04720

JUPL



Could it be used to measure NN?

- Well assessed laboratory (long term seismic, thermal, infrasound, etc. study)
- Preliminary measures with a gravity gradiometer (Eötvös Balance)
- The Eötvös Balance has been upgraded → sensitivity about 10 mE (x100 more than the original)
  - Not for NN but still **very promising for preliminary measurements**
  - **Well explored gravity and gravity-seismic noise environment**

Thank you for your attantion!

Acknowledgments

G. G. BARNAFÖLDI, Zs. BERNÁT, T. BULIK, M. CIESLAR, E. DÁVID, M. DOBRÓKA, E. FENYVESI, D. GONDEK ROSINSKA, Z. GRÁCZER, G. HAMAR, G. HUBA, Á. KIS, R. KOVÁCS, I. LEMPERGER, P. LÉVAI, J. MOLNÁR, D. NAGY, A. NOVÁK, L. OLÁH, P. PÁZMÁNDI, D. PIRI, P. RACSKÓ, Á. ROMÁN†, L. SOMLAI, T. STARECKI, M. SUCHENEK, G. SURÁNYI, S. SZALAI, P. VÁN, D. VARGA, B. VÁSÁRHELYI, P. VASS, M. VASÚTH, Z. WÉBER, V. WESZTERGOM

Nitrokemia Zrt. (Á. VÁRADI és V. ROFRITS),

Geofaber Zrt.,

N. MITSUI