# Jánossy Underground Research Laboratory

FuSe
TESTING FUNDAMENTAL PHYSICS WITH SEISMOLOGY

## VESZTERGOMBI HIGH-ENERGY PHYSICS LAB

Gergely Gábor Barnaföldi
HUN-REN Wigner RCP



cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY
Funded by the European Union

# History of Cosmic Rays

- The electroscope loses its charge
  - Monk Wulf (1909): experiments at school and in nearby sandstone quarries.
  - The rock itself was originally suspected, but the loss was slower down in the quarry.
  - University of Paris + Eiffel Tower: the radiation is stronger at altitude
  - Viktor Hess (1912): balloon measurements up to 6 km. (Nobel Prize: 1936)
  - Carl Anderson: positron (1932)
  - Powell: muons are heavy electrons (1947)
  - Pierre Auger, Lajos Jánossy

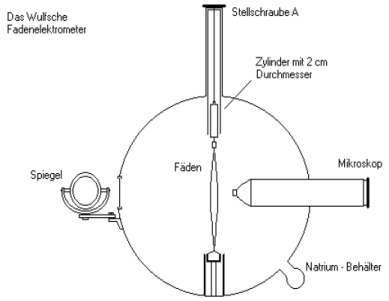
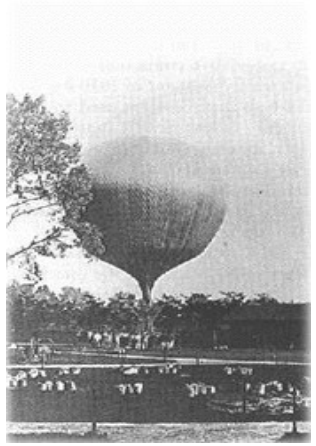
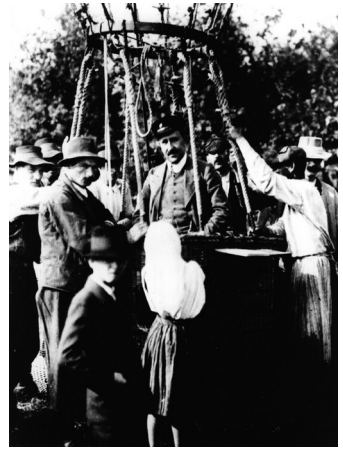


Fig. 2: Wulf electrometer.







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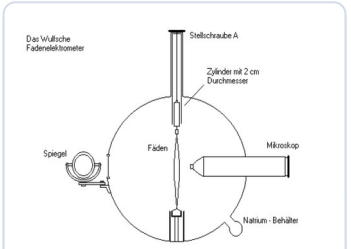
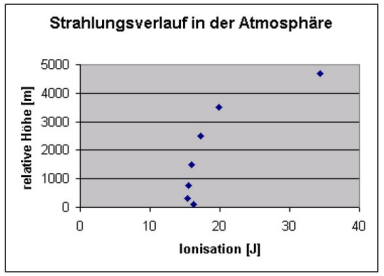
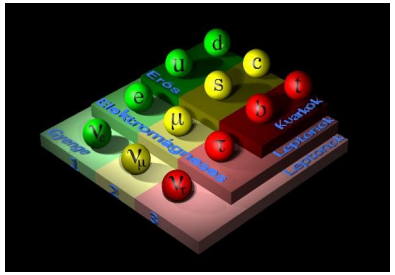
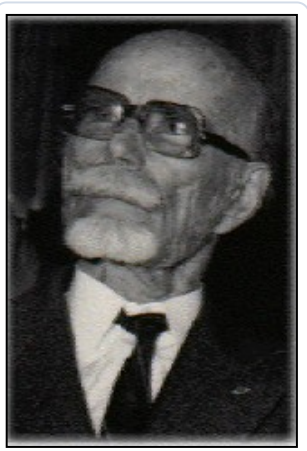


Fig. 2: Wulf electrometer.







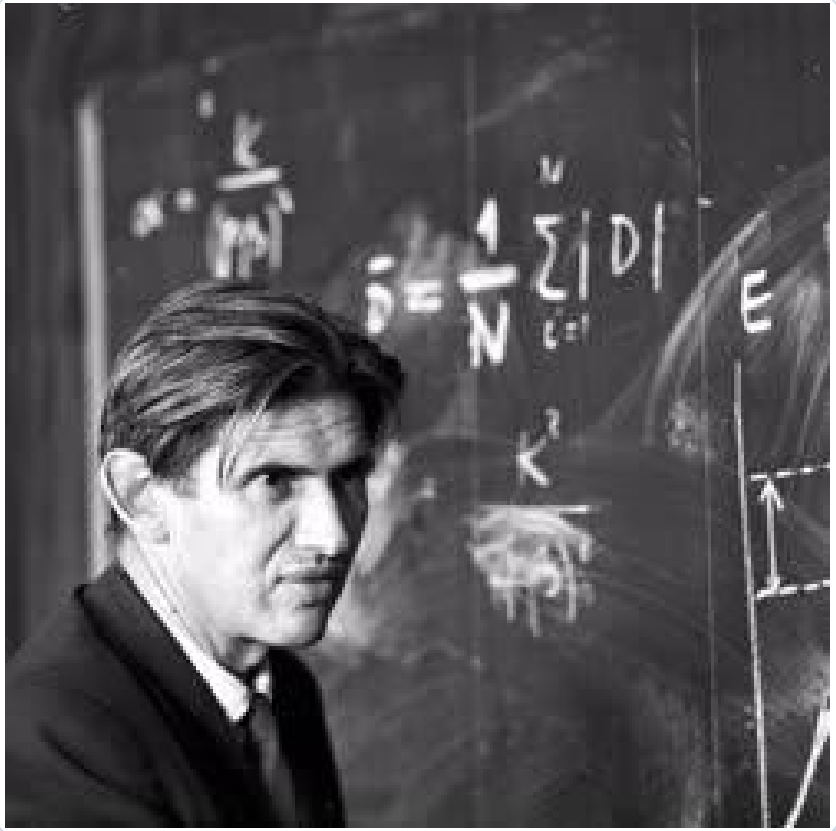
# Lajos Jánossy (1912-1978)

**Beginning of his career:**

- Germany, England, Ireland
- experiment and theory
- cosmic rays,  Geiger's coincidence

**Later:**

- application of probability and calculus to experimental results in nuclear physics and particle physics
- Jánossy densities



https://en.wikipedia.org/wiki/Lajos_J%C3%A1nossy

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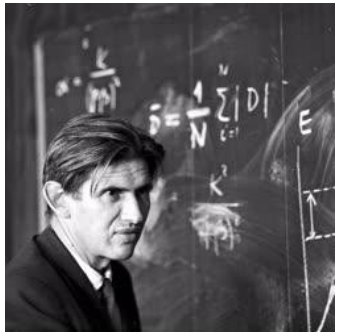
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- theory of relativity
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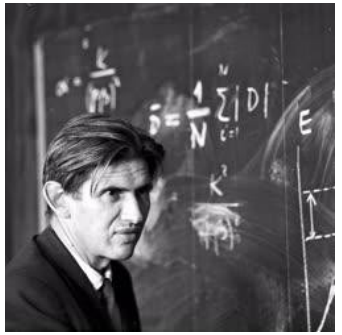
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**Last one and a half decades of his theoretical activity:**

- hydrodynamic model of quantum mechanics and the interpretation problems of the theory of relativity
- education and promotion of physics, organization of public science







https://en.wikipedia.org/wiki/Lajos_J%C3%A1nossy

# Introduction

The laboratory was originally built for cosmic particle measurements at the Central Research Institute for Physics (Budapest, Hungary)



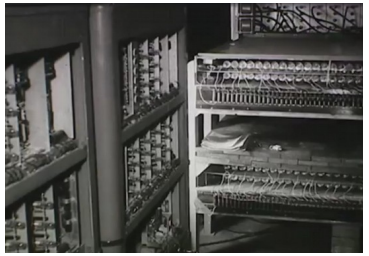
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- 1951: the laboratory was ready for experiments
- 1951-1952: early years
  - Geiger-Müller tubes and a Wilson cloud chamber were built
  - reproduction of the results of foreign experiments (e. g. measuring the lifetime of μ-mesons produced in the upper atmosphere)
  - investigations of large-scale cosmic showers
  - examination of cosmic background radiation was the only method to get new results at experimental high energy particle physics
- 1990-2010: the laboratory was abandoned
- 2010: renovations: renewing the building and upgrading the infrastructure
  - Muon tomography measurements were started









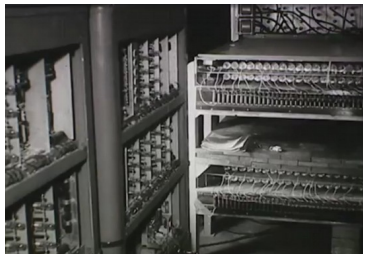
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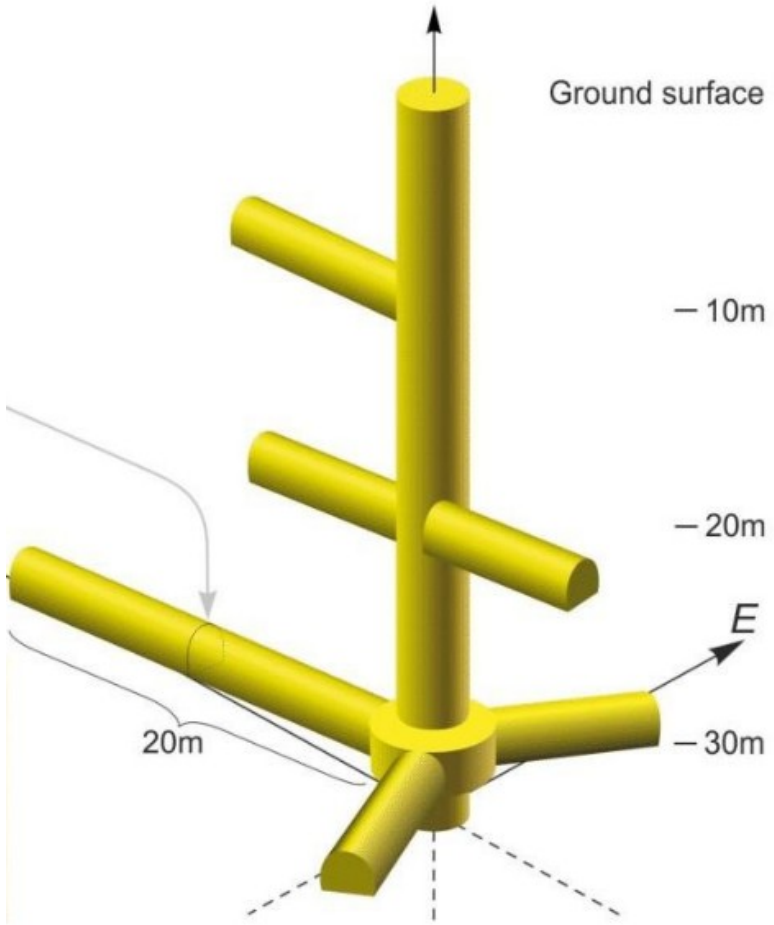






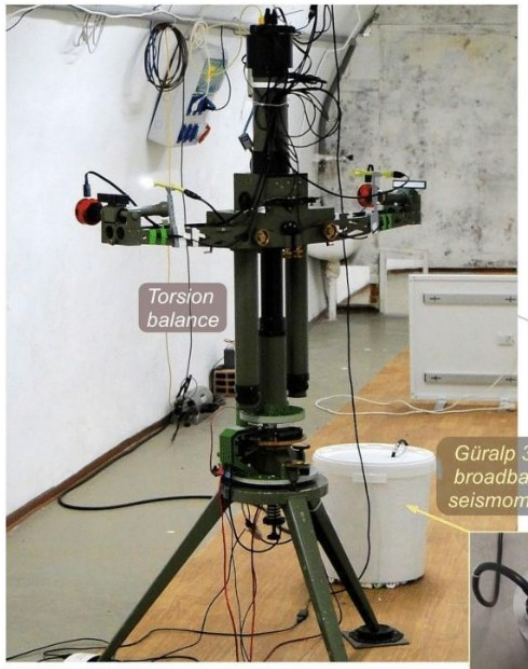
# Structure and Infrastructure

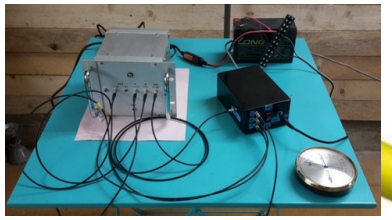
- 30m below the ground in Dachstein-type limestone
- The useful area of  the lab is 150 sqm on 3 levels
  - 20 sqm at level -1,
  - 2x20 sqm at level -2
  - 2x20 sqm + 50sqm at level -3.
- 40 cm thick walls made from concrete for nuclear reactors
- air conditioning, uninterruptible power supply, internet and service/rescue telephone availability
- the site ideal for measurements that need low cosmic background
- also appropriate for other measurements that require stable temperature and low environmental- and seismic noise level
- physical environment is monitored by temperature-, pressure- and humidity sensors together with a seismometer and an infrasound microphone.
- full CAD model & density map is available



# Ongoing Experiments

**Infrasound and seismology**






**Re-measurement of the Eötvös Experiment**

**Cosmic Muography, muon tomography**



**High Purity Germanium (HPGe) Radiation Detector**



**Radon detection**

# Re-measurement of the Eötvös Experiment

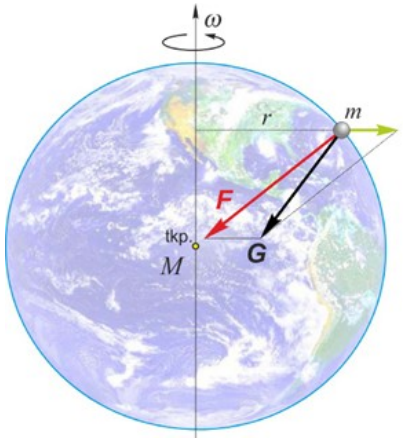
- weak equivalence principle
- gravito-gradiometers
- gradient effect

**Fifth force mystery:**

$$V = \gamma \frac{mM}{r}\left(1 + \alpha e^{-r/\lambda}\right)$$

$$m_S = m_T + \eta_A \frac{E_A}{c^2}$$





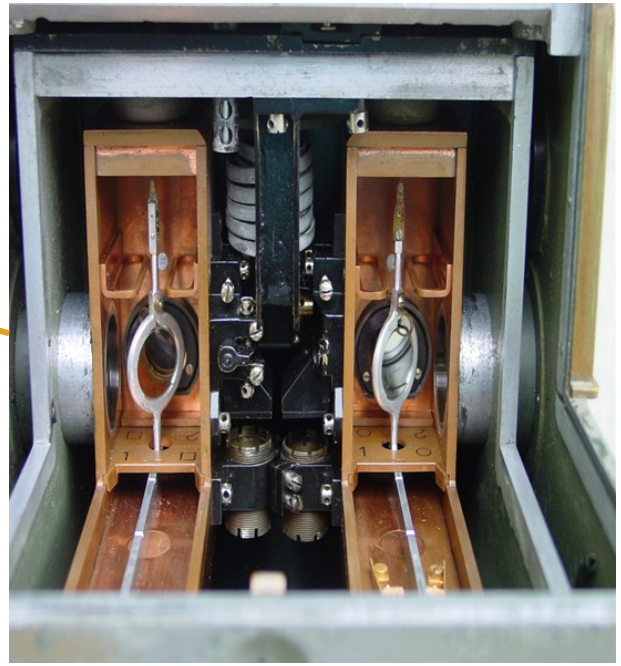




http://tudtor.kfki.hu/eotvos1/onehund.html

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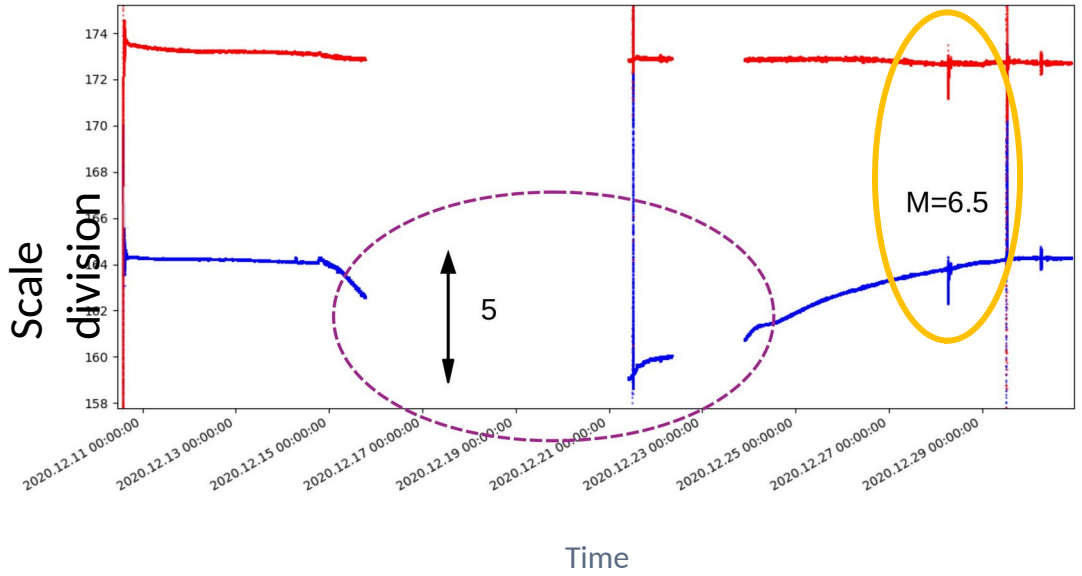


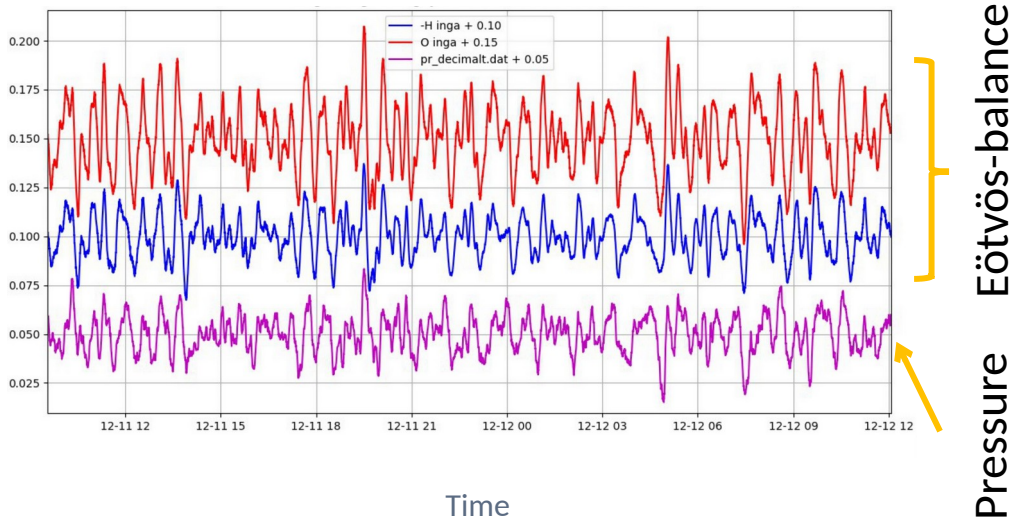


# Re-measurement of the Eötvös Experiment

## Earthquake detection



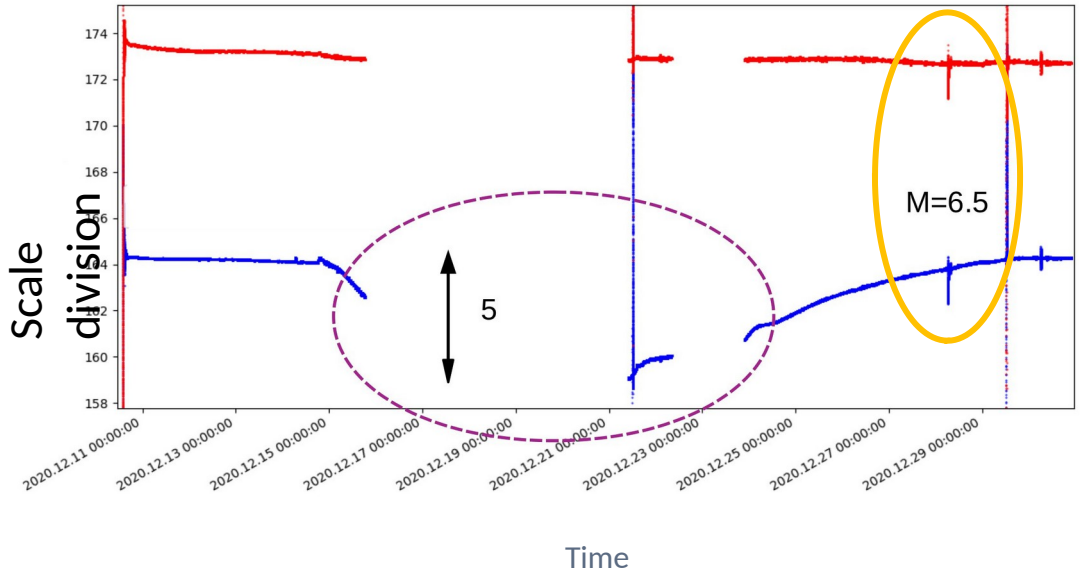

## Pressure sensitivity



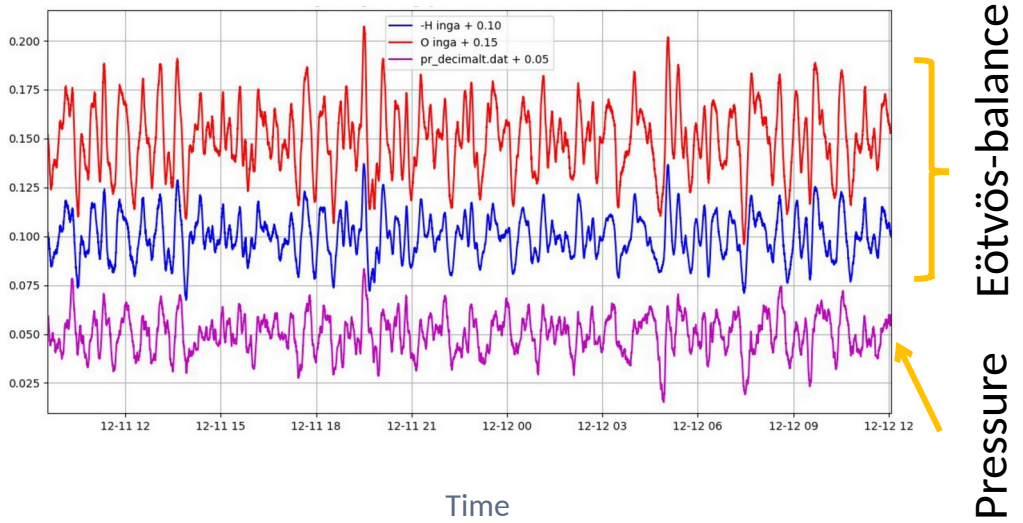

Refs: *PoS* FFK2019 (2020) 041, Contribution to: FFK2019, 041; *PoS* FFK2019 (2020) 042; *Eur.Phys.J.ST* 228 (2019) 8, 1693-1743; *Class.Quant.Grav.* 34 (2017) 11, 114001

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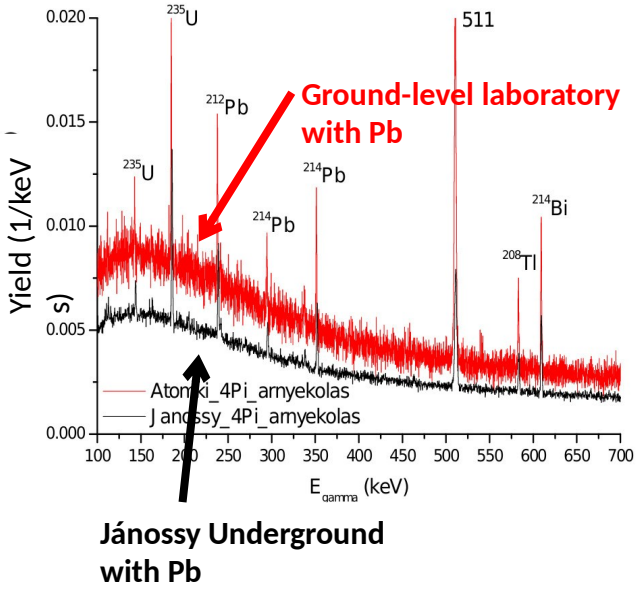
# Low-background Radiation Measurements

High-purity Germanium (HPGe) detector:

- Nucleon synthesis measurements in weak decay channels with low radiation background
- Measurement of radiation decay anomaly
- Radon measurements with stable and variable environmental conditions
- Remote-controlled, automatized long-range measurements (Canberra + Lynx DSP)

Refs: Activation thick target yield measurement of $^{100}$Mo(α,n)$^{103}$Ru for studying the weak r-process nucleosynthesis (PRC104 035804 (2021)



# Muon tomography developments

Cosmic muon radiography & tomography:

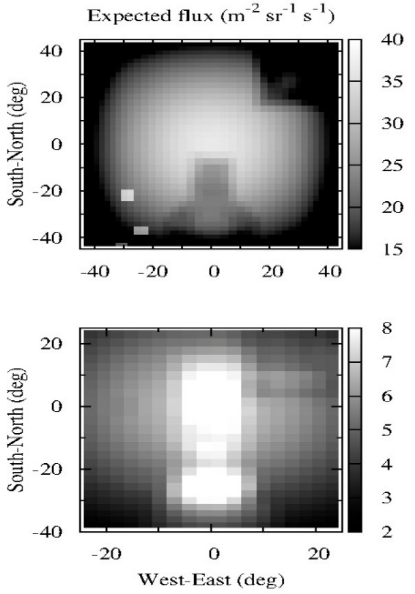
- Developments and test of the ReGaRD's innovative portable muontomograph
- Environmental applications: unknown cave searches, online volcanic activity monitoring
- Industrial application: building & civil engineering structural measurements by cosmic muons

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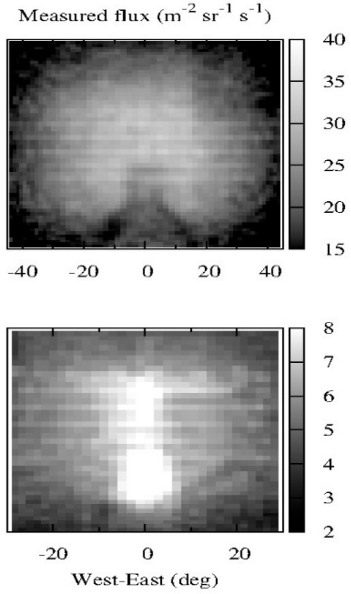
https://www.nature.com/articles/s41598-018-21423-9



**Monte Carlo model**




**Muon measurement**



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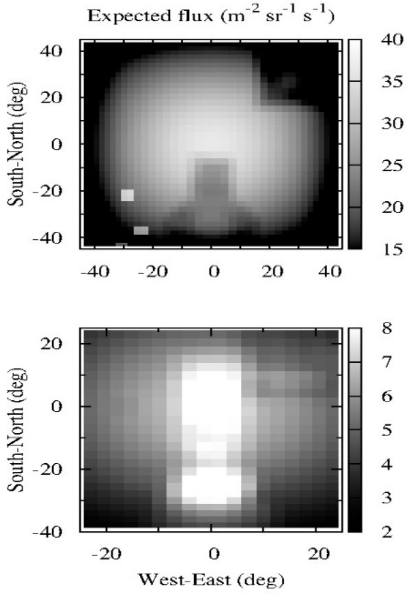
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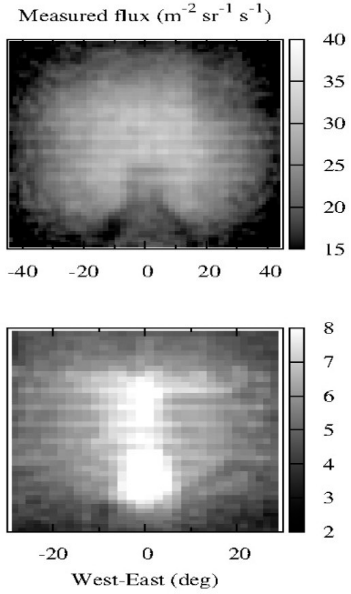
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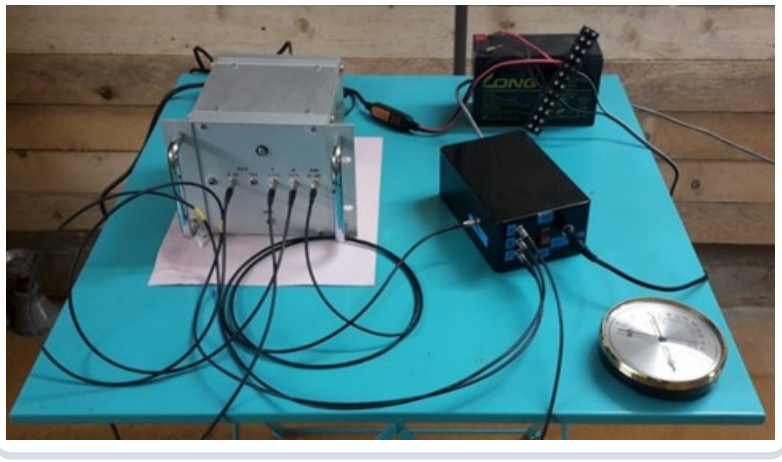

**Muon measurement**



# Infrasound and seismology

Güralp seismometer and a custom-made(Atomki, Hungary) infrasound microphone is operated:

- To explore the origin of noises of different measurements
- To study the behaviour of infrasound and seismic background noise 30 m below the ground.
- To see the attenuation of the noises at different depths



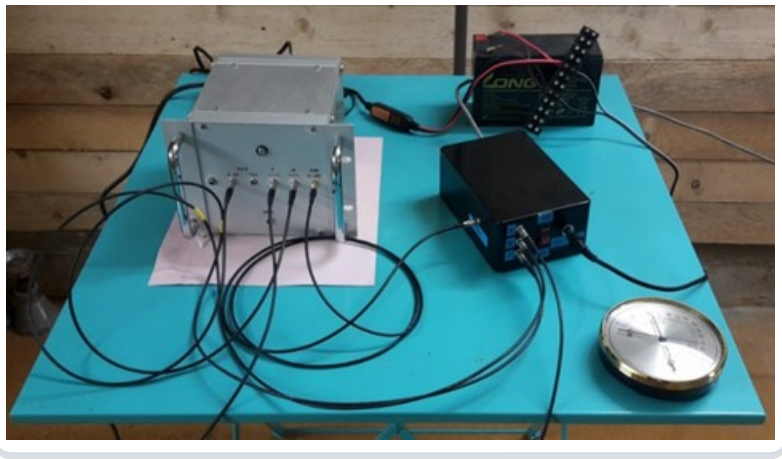



Acta Geodaetica et Geophysica, 54\2:301-13, 2019

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Acta Geodaetica et Geophysica, 54\2:301-13, 2019

# JURLAB: Results

**Jánossy Underground Research Laboratory (JURLAB):**

- Gravitational measurements with Eötvös pendulum
- Seismic measurements (Guralp + national network)
- Infrasound measurements (ATOMKI & Wigner R&D)
- Cosmic Muography & Muon tomography (ReGaRD)
- Low-radiation background measurements (HPGe)
- Radon measurements (solid state & Radon Det)

HUN REN | wigner

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Physics Letters B 00 (2021) 1–9
ELSEVIER

Activation thick target yield measurement of $^{100}$Mo($\alpha$,n)$^{103}$Ru for studying the weak r-process nucleosynthesis

T. N. Szegedi[a,b], G. G. Kiss[a], P. Mohr[a], A. Psaltis[c], M. Jacobi[c], G. G. Barnaföldi[d], Gy. Gyürky[a], T. Szücs[a], A. Arcones[c,e]

[a]Institute for Nuclear Research (ATOMKI), H-4001 Debrecen, Bem sqr. 18/c, Hungary

PHYSICAL REVIEW C **104**, 035804 (2021)

**Activation thick target yield measurement of $^{100}$Mo($\alpha$, $n$) $^{103}$Ru for studying the weak *r*-process nucleosynthesis**

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**Report on a pre-earthquake signal detection by enhanced Eötvös torsion balance**

L. Völgyesi [1], Gy. Tóth [1], Gy. Szondy [2], B. Kiss [3], E. Fenyvesi [4], G.G. Barnaföldi [4], Cs. Égető [1], P. Lévai [4], E. Imre[5], M. Pszota[5,6], P. Ván [4,7*]

Eur. Phys. J. Special Topics **228**, 1693–1743 (2019)
© The Author(s) 2019
https://doi.org/10.1140/epjst/e2019-900153-1

THE EUROPEAN PHYSICAL JOURNAL SPECIAL TOPICS

Review

**Long term measurements from the Mátra Gravitational and Geophysical Laboratory**

P. Ván[1,4], G.G. Barnaföldi[1], T. Bulik[7], T. Biró[2], S. Czellár[3], M. Cieślar[9], Cs. Czanik[2], E. Dávid[1], E. Debreceni[1], M. Denys[7], M. Dobróka[15], E. Fenyvesi[3], D. Gondek-Rosińska[7], Z. Gráczer[2], G. Hamar[1], G. Huba[1], B. Kacskovics[1], Á. Kis[2], I. Kovács[2], R. Kovács[1,4], I. Lemperger[2], P. Lévai[1], S. Lökös[12,13], J. Mlynarczyk[14], J. Molnár[3], N. Singh[7], A. Novák[2], L. Oláh[1,11], T. Starecki[6], M. Suchenek[6], G. Surányi[10], S. Szalai[2], M.C. Tringali[7], D. Varga[1], M. Vasúth[1,*], B. Vásárhelyi[5], V. Wesztergom[2], Z. Wéber[2], Z. Zimborás[1], and L. Somlai[1]

**Decay rate measurements with a $^{137}$Cs radioisotope source at Jánossy Underground Research Laboratory (Csillebérc, Hungary)**

Edit Fenyvesi,[a,b,*] Gergely G. Barnaföldi,[a] Gábor Gy. Kiss[b] and Dénes Molnár[a]

IOP Publishing Classical and Quantum Gravity
Class. Quantum Grav. **34** (2017) 114001 (22pp) https://doi.org/10.1088/1361-6382/aa69e3

**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[3], D Gondek-Rosinska[10], Z Gráczer[2], G Hamar[1], G Huba[1], Á Kis[2], R Kovács[1,5], 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[1,5], B Vásárhelyi[6], V Wesztergom[2] and Z Wéber[2]

**Mitigation of the effect of changes of atmospheric pressure on gravity detectors: preliminary results obtained with microphones at the Sos Enattos mine**

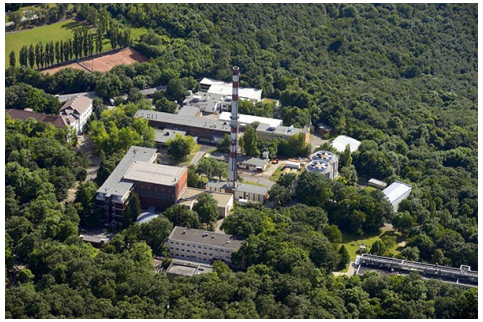
E Fenyvesi,[a,b,c,*] T Bulik,[b] M Cieślar,[b] S Czellár,[c] R de Rosa,[d,e] D D'Urso,[f,g] D Gondek-Rosińska,[h] B Király,[c] J Molnár,[c] L Naticchioni,[i] M Pietrzak[b] and M Suchenek[b,h]

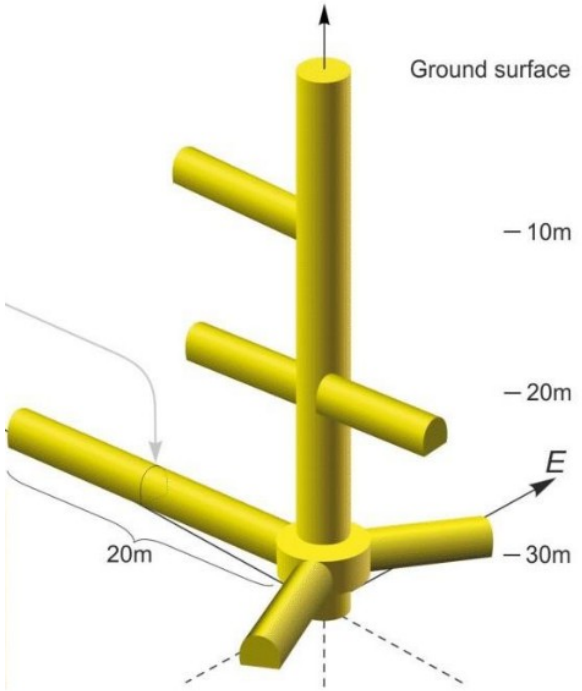
[a]HUN-REN Wigner Research Centre for Physics, Konkoly-Thege Miklós út 29-33., 1121 Budapest,

# JURLAB: Summary & Contacts

**Jánossy Underground Research Laboratory:**

- Open national infrastructure
- Remote control
- Automatized measurements
- Minimized human activity
- Controlled environmental parameters in laboratory






**Contact:**
Edit Fenyvesi: fenyvesi.edit@wigner.hu
Gergely Gábor Barnaföldi: barnafoldi.gergely@wigner.hu

https://www.wigner.hu/

FuSe
TESTING FUNDAMENTAL PHYSICS WITH SEISMOLOGY

# Thanks to COST Action CA24101 & NKFIH MEC_26 154797

Memorandum of Understanding for the implementation of the COST Action "Testing Fundamental Physics with Seismology" (FuSe) CA24101

The main aim and objective of the Action is to bridge fundamental physics and Earth scientists, focusing on seismic data's potential to uncover new physics. Through interdisciplinary collaboration, advanced methodologies, and SME engagement, it advances understanding of Earth's structure, astrophysical phenomena, and improves natural catastrophe alert systems.

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