Jánossy Underground Research Laboratory and the ongoing projects

(Vesztergombi Laboratory of High-energy Physics)

Gergely Gábor Barnaföldi[1], Edit Fenyvesi[1], Dezső Varga[1]

[1]Wigner Research Centre for Physics (Budapest, Hungary)

1st CREDO Visegrad Workshop 2024

15-17 January 2024

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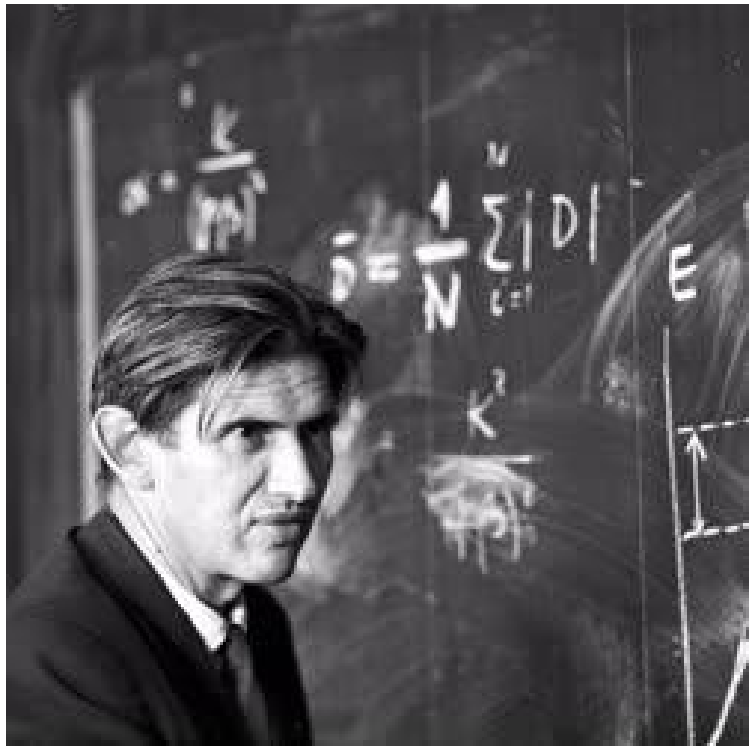
Lajos Jánossy (1912-1978)

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



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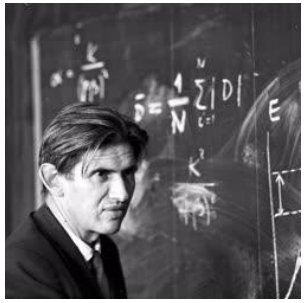
- focused on theoretical problems of quantum mechanics, the dual character of light
- theory of relativity
- Carried out a famous low-intensity interference experiment



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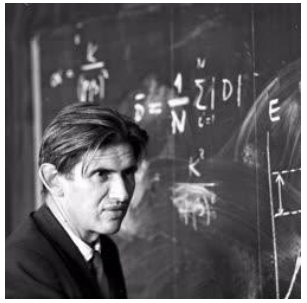
Last one and a half decades of his theoretical activity:

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



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Introduction

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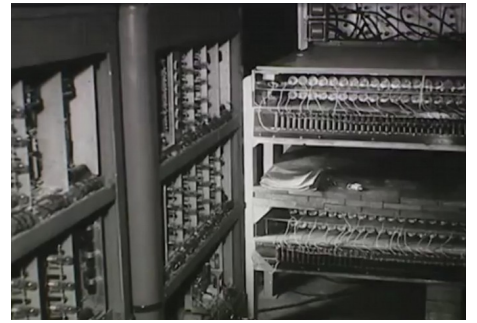
- 1951: the laboratory was ready for experiments
- 1951-1952: early years
  - Geiger-Müller tubes and a Wilson cloud chamber were built
  - reproduction of the results of foreign experiments (e. g. measuring the lifetime of μ-mesons produced in the upper atmosphere)
  - investigations of large-scale 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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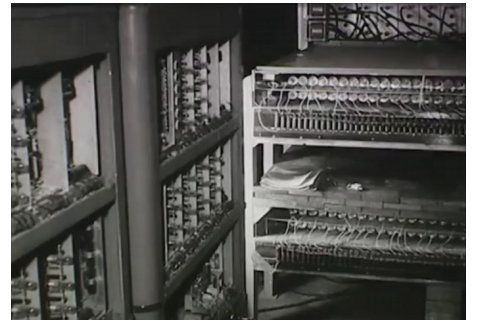
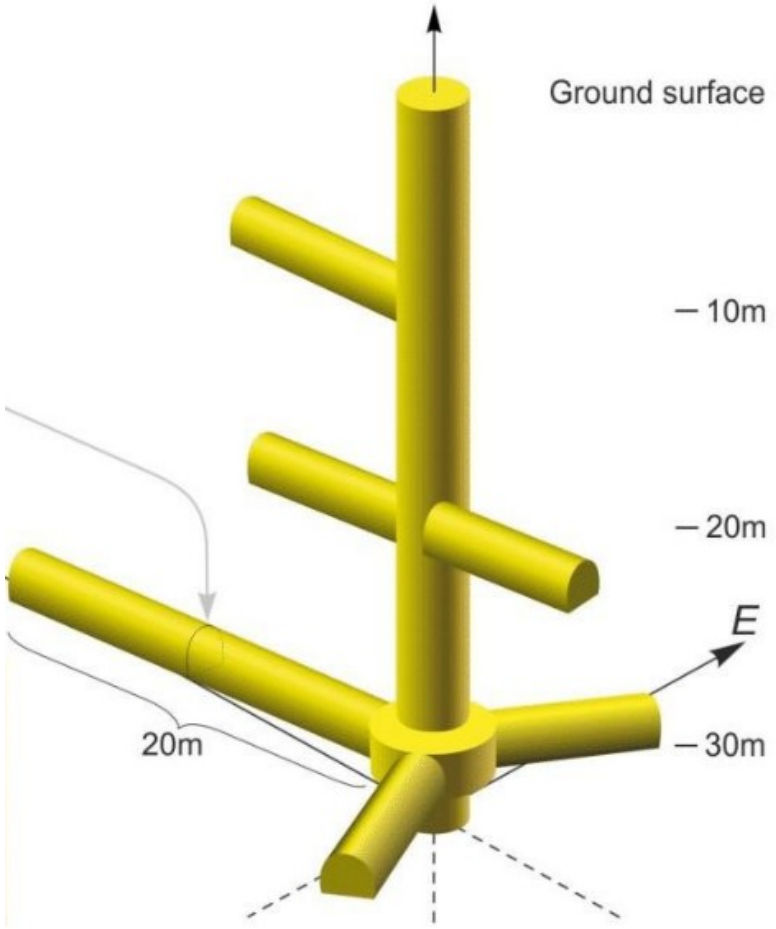


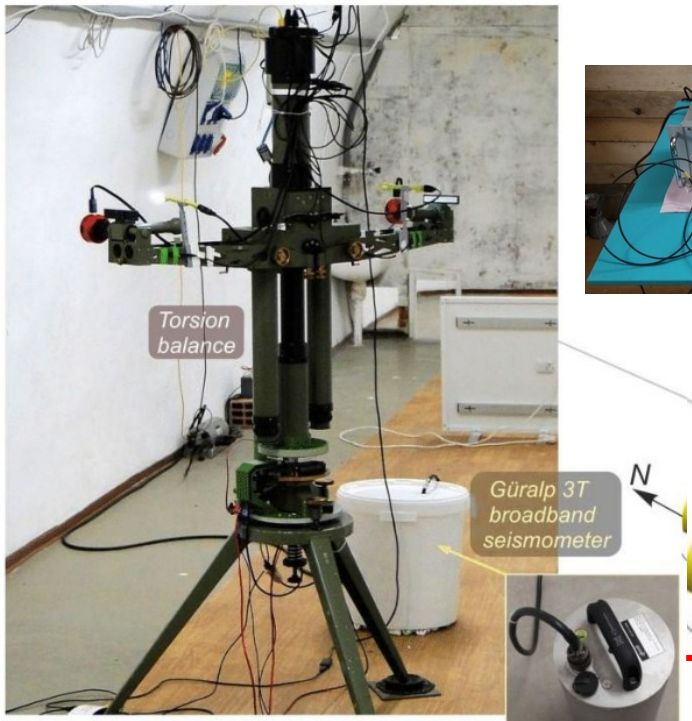

Structure and Infrastructure

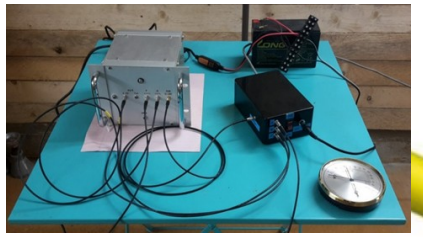
- 30m below the ground in Dachstein-type limestone
- The useful area of the lab is 150 sqm on 3 levels
  - 20 sqm at level -1,
  - 2x20 sqm at level -2
  - 2x20 sqm + 50sqm at level -3.
- 40 cm thick walls made from concrete for nuclear reactors
- air conditioning, uninterruptible power supply, internet 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 awailable



Ongoing Experiments

Infrasound and seismology





Re-measurement of the Eötvös Experiment

Radon detection

Cosmic Muogaphy, muon tomography

High Purity Germanium (HPGe) Radiation Detector

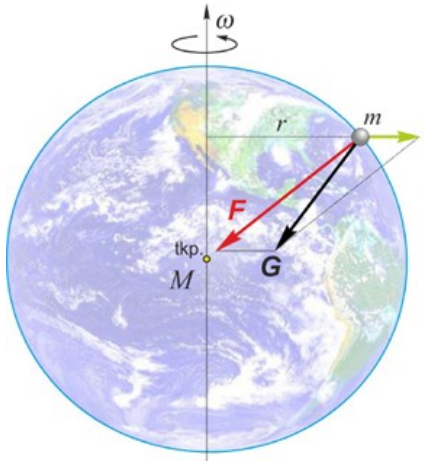
Re-measurement of the Eötvös Experiment

- weak equivalence principle
- gravito-gradiometers
- gradient effect

Fifth force mistery:

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

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



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

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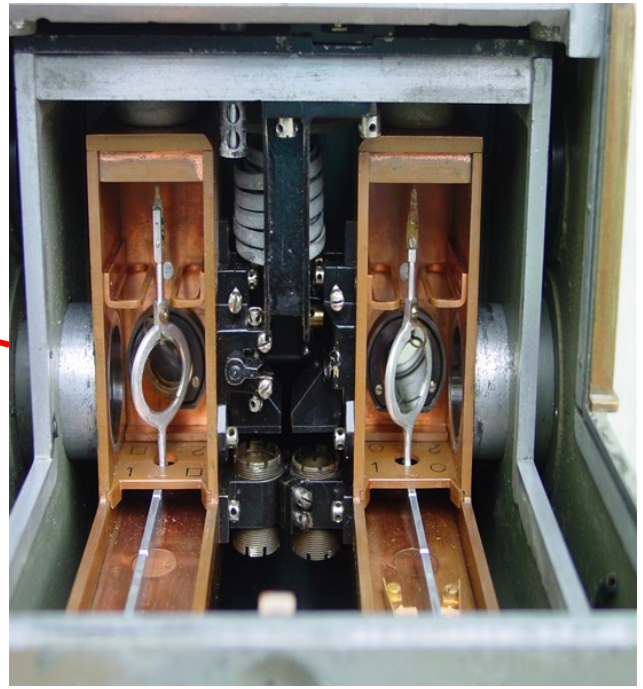
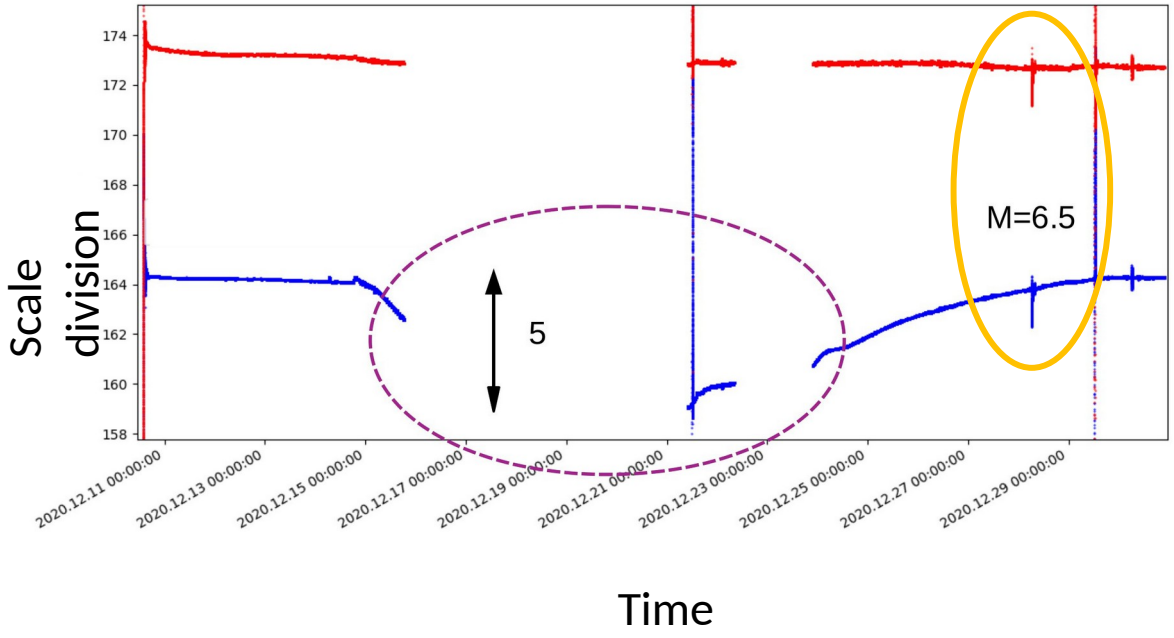
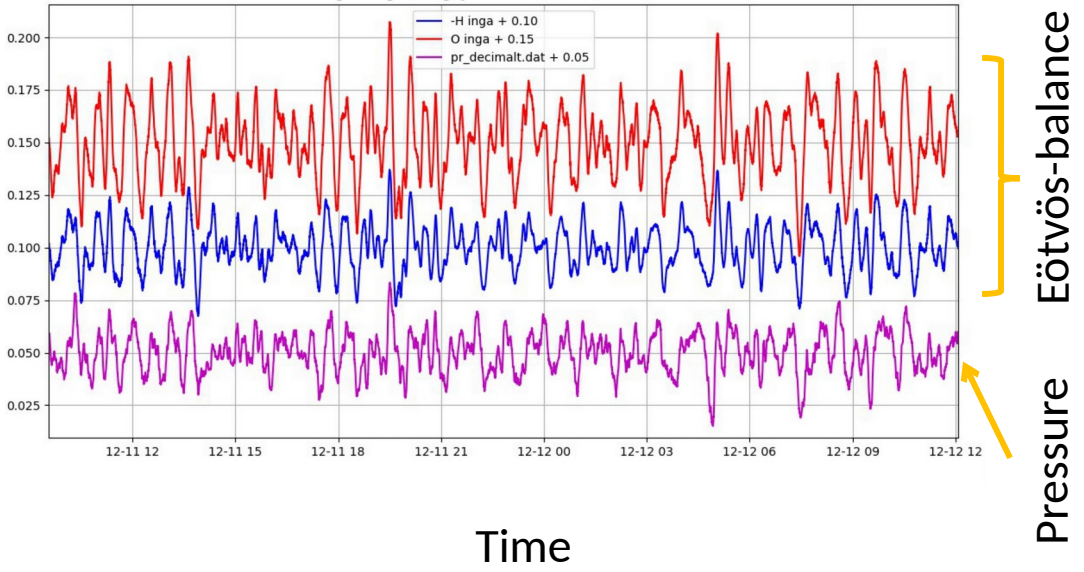


Re-measurement of the Eötvös Experiment

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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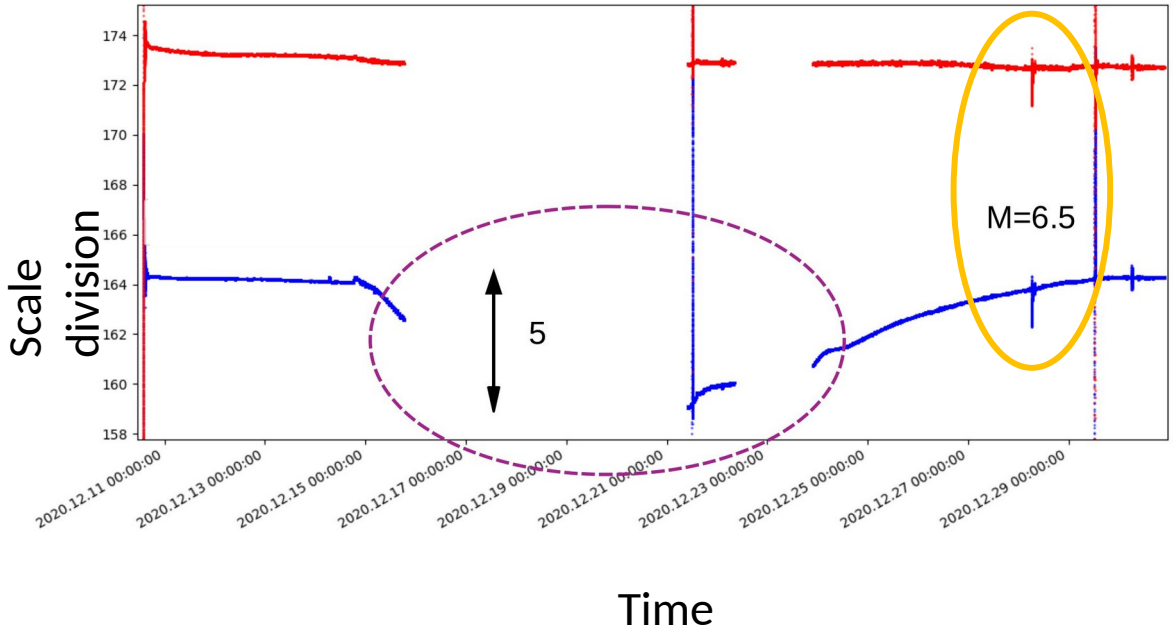

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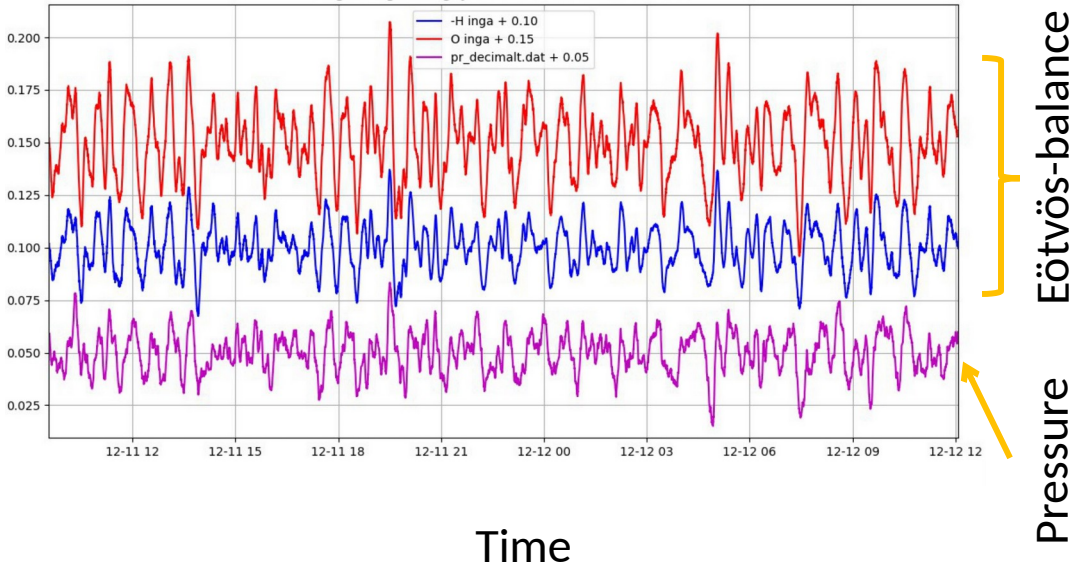

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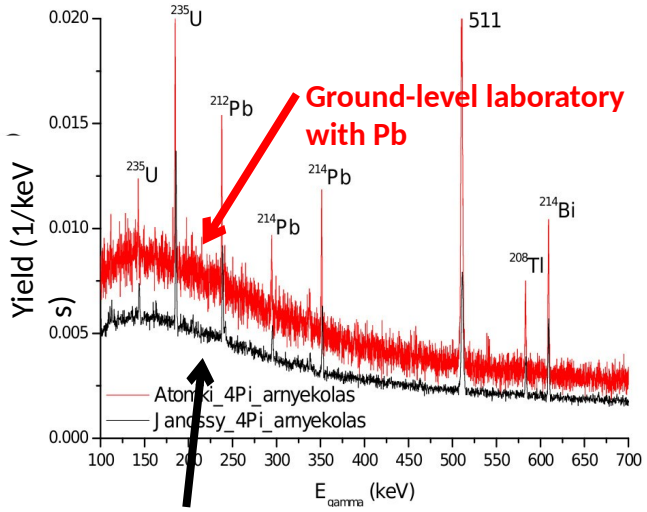
Low-background Radiation Measurements

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)



Jánossy Underground with Pb

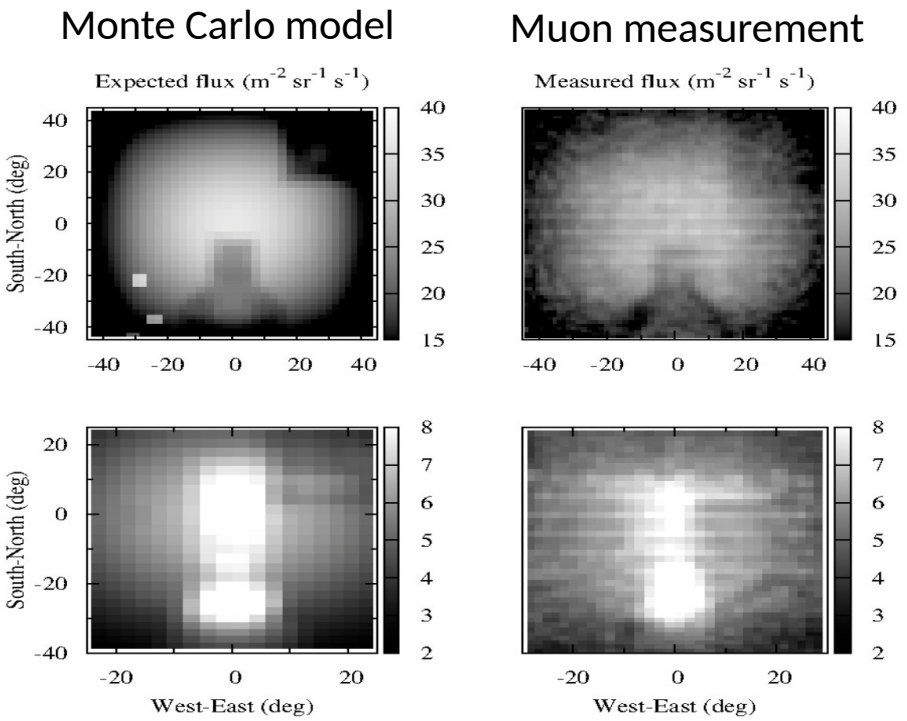
Refs: Activation thick target yield measurement of $^{100}Mo(\alpha,n)^{103}Ru$ for studying the weak r-process nucleosynthesis (PRC104 035804 (2021)

Muon tomography developments

Cosmic muon radigraphy & tomography:

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

Refs: *Adv.High Energy Phys.* 2013 (2013) 560192, *PoS* NICXIII (2015) 129; *Nucl.Instrum.Meth.A* 689 (2012) 60-69
https://www.nature.com/articles/s41598-018-21423-9



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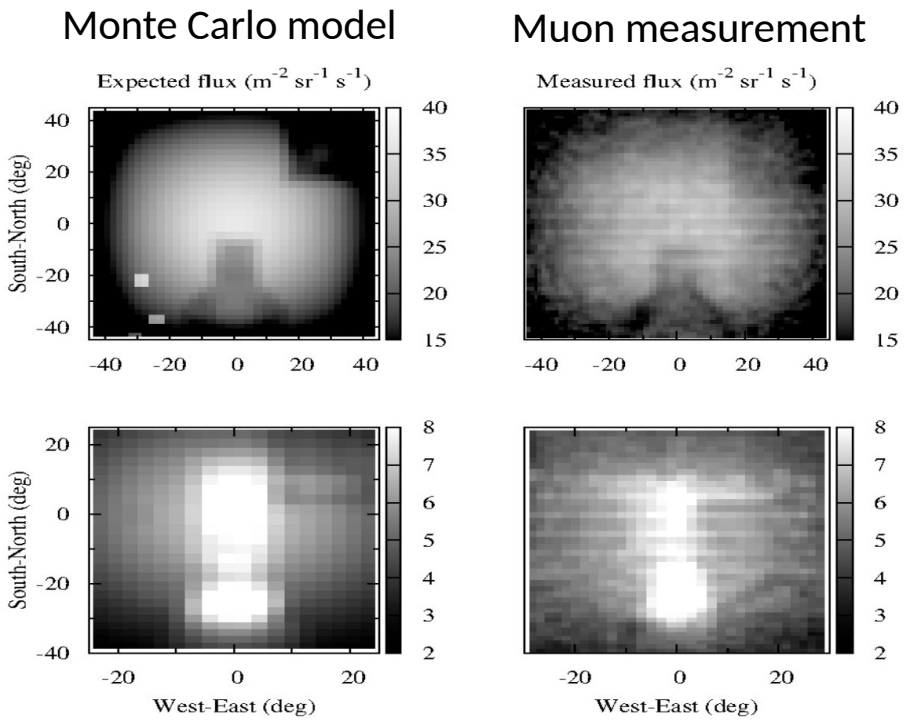
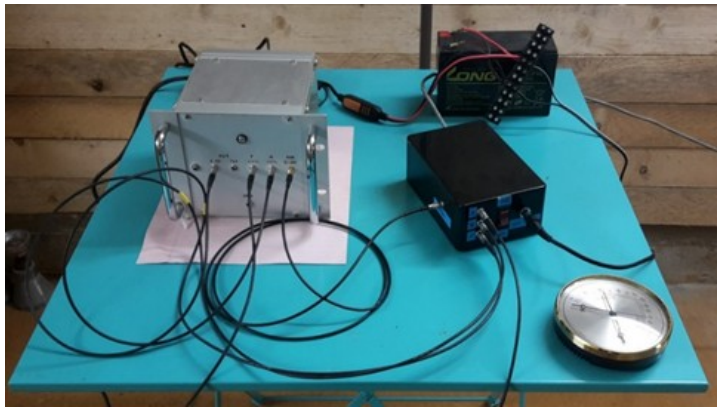
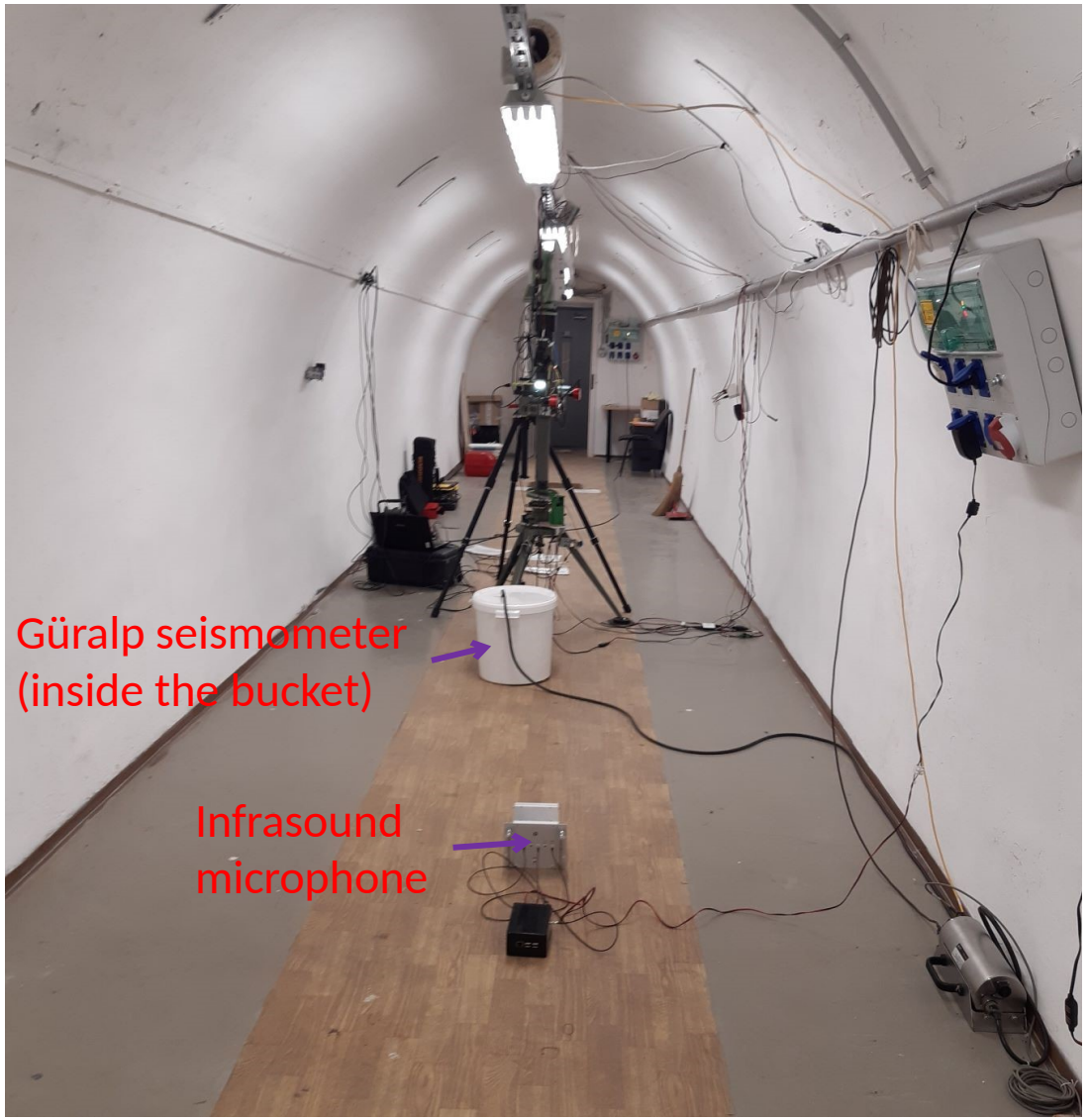


Infrasound and seismology

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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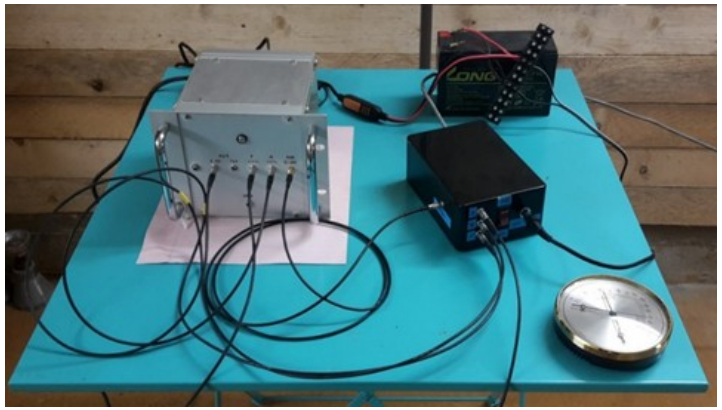

Acta Geodaetica et Geophysica, 54\2:301-13, 2019

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 mesurements (HPGe)
- Radon measurements (solid state & Radon Det)

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Physics Letters B 00 (2021) 1–9
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Activation thick target yield measurement of ^{100}Mo(α,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(α, n) ^{103}Ru for studying the weak *r*-process nucleosynthesis

T. N. Szegedi,[1,2] G. G. Kiss,[2,*] P. Mohr,[2] A. Psaltis,[3] M. Jacobi,[3] G. G. Barnaföldi,[4] T. Szücs,[2] Gy. Gyürky,[2] and A. Arcones[3,5]

[1]University of Debrecen, H-4001 Debrecen, Hungary

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[4,6], P. Ván [4,7*]

Eur. Phys. J. Special Topics **228**, 1693–1743 (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,a], 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

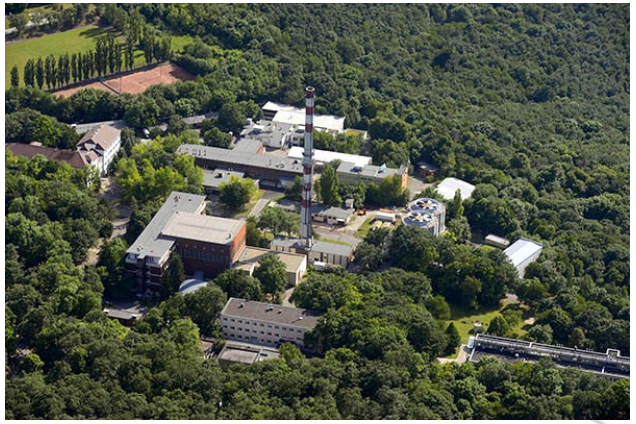
E Fenyvesi,[a,b,c,*] T Bulik,[b] M Cieślar,[b] S Czellár,[c] R de Rosa,[d,e] D D'Urso,[f,g] D Gondek-Rosińska,[h] B Király,[c] J Molnár,[c] L Naticchioni,[i] M Pietrzak[b] and M Suchenek[b,h]

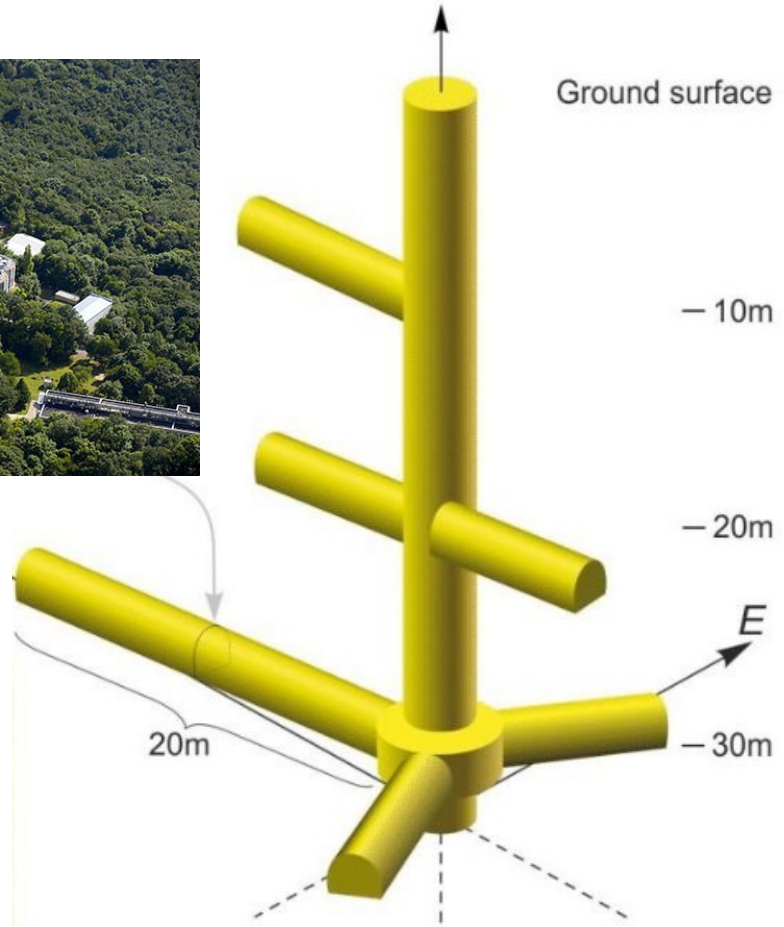
[a]HUN-REN Wigner Research Centre for Physics, Konkoly-Thege Miklós út 29-33., 1121 Budapest,

JURLAB: Summary & Contacts

Jánossy Underground Research Laboratory:

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





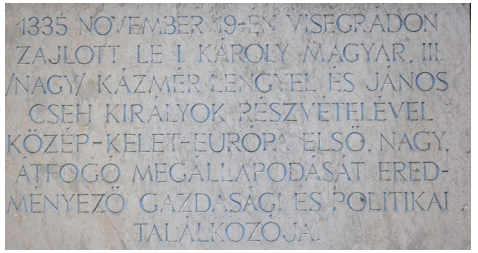
Contact:
Edit Fenyvesi: fenyvesi.edit@wigner.hu
Gergely Gábor Barnaföldi: barnafoldi.gergely@wigner.hu

https://www.wigner.hu/

Dziękuję bardzo!
Ďakujem veľmi pekne!
Moc děkujeme, díky!
Köszönöm szépen!

Why Visegrad 4?

19. November 1335.
The most important diplomatic event in Central Europe of the 14th century, Casmir III of Poland and John I of Bohemia came to the royal court of Charles of Hungary in Visegrád to form an alliance



15. February 1991.
The alliance traces its origins to the summit meetings of president of the Czech and Slovak Federative Republic, Václav Havel, the President of the Republic of Poland, Lech Wałęsa, and the Prime Minister of the Republic of Hungary, József Antall, in the Hungarian castle town of Visegrád.