Characteristics of natural radiation background at the Callio Lab (Finland) performed within the BSUIN project

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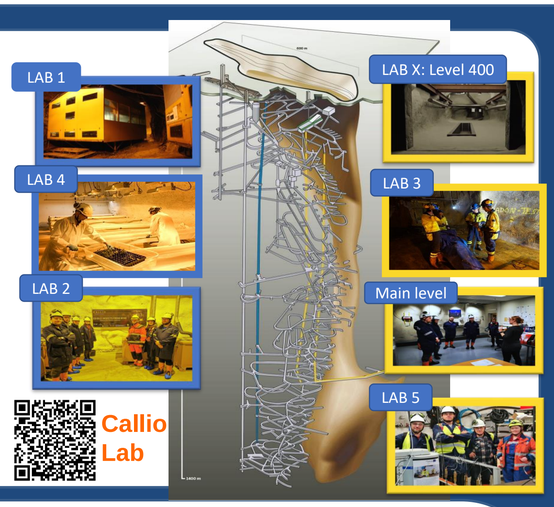
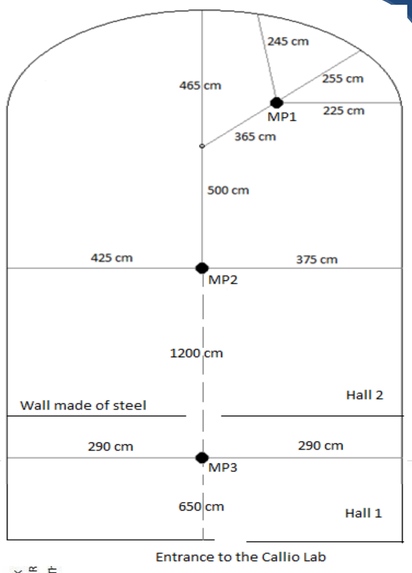
Introduction

Determination the natural background radiation (NBR) in underground localizations is necessary to describe them for possible use, not only for physics experiments. The NBR measurements were performed in Callio Lab 2, located in the Pyhäsalmi Mine (Finland) at a depth of 1436 m (~4000 m w.e.) within the felsic volcanic bedrock, where a volcanogenic massive sulphide deposit occurs. The Callio Lab is one of the six underground laboratories participating in the Baltic Sea Underground Innovation Network (BSUIN).



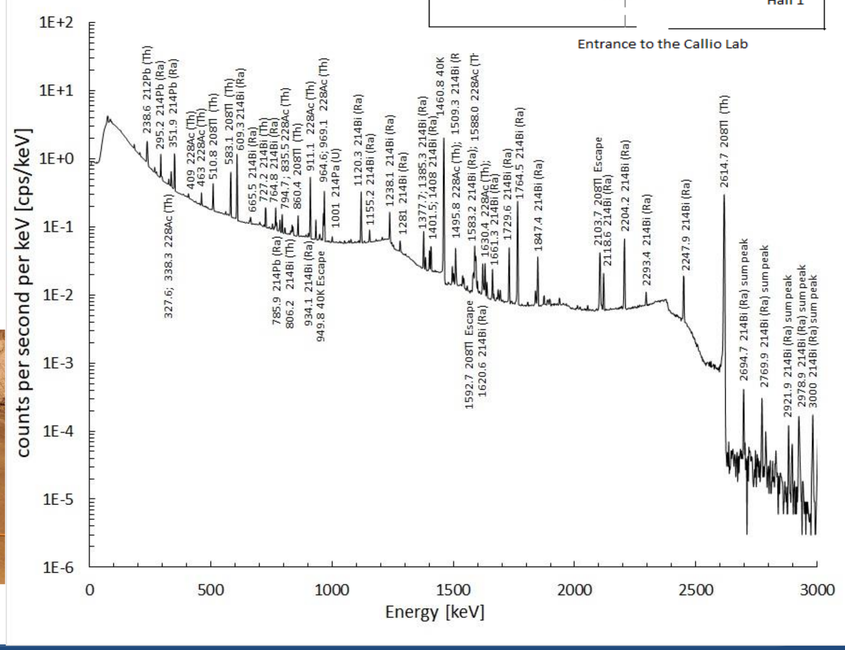
In-situ measurements

In-situ measurements were done near the far right corner of the experimental hall (Hall 2 (9 m x 15 m x 8 m), MP1) in Lab 2. A γ-ray high-purity germanium (HPGe) semiconductor spectrometer and a RAD7 electronic radon detector were used. The figure shows 48-hour gamma spectrum collected at MP1 localization. Additionally, two more measurements (localizations MP2 and MP3) have been performed at the central points of Halls 2 and 1. The integral count up to 2700 keV is equal to 654 ± 26 s^{-1}, the photon flux density, assessed on the base of full-energy peaks, is equal to 12.7±1.5 $cm^{-2}s^{-1}$ whereas the total effective dose is equal to 0.158 ± 0.029 μSv/h (all values at MP1).



The concentration of ^{222}Rn has been determined using RAD7 air-analyser with 1-h sampling time (for 24-48 h) and did not show any time-dependent structure. The measured concentration of ^{222}Rn was 213.3 Bq/m^3 ± 11% at MP1 localization.

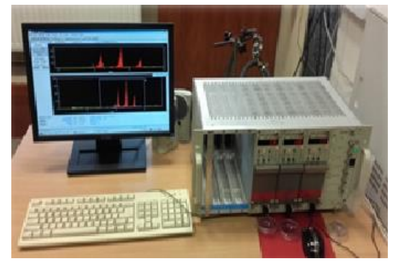
In-situ γ measurement (by using HPGe detector) and radon concentration in air (by using RAD7) at MP1



Laboratory analysis

Rock and water samples were collected in and outside the Lab 2 and were analysed using liquid scintillation α/β counter (LSC), α and γ spectrometry techniques in the Institute of Physics University of Silesia in Katowice (Poland). Before the α measurements of uranium in rock and water samples, and radium in water samples with LSC technique the appropriate radiochemical procedures were applied [1-3].

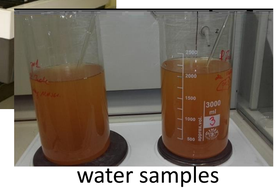
The concentrations of uranium isotopes in rock samples varied from 1.4 ± 0.2 Bq/kg to 211 ± 10 Bq/kg and from 1.6 ± 0.2 Bq/kg to 212 ± 10 Bq/kg for $^{234,238}U$, respectively. The concentrations of isotopes (estimated by using HPGe detector) varied greatly depending on the place of sample collection in Lab 2. The mean values of 45.6 ± 68.5 Bq/kg, 25.3 ± 20.8 Bq/kg and 453.8 ± 339.6 Bq/kg for concentrations of ^{226}Ra, ^{232}Th and ^{40}K, respectively, were estimated [4].



α- spectrometer 7401VR c

Rock sample prepared for α and γ measurements

1414 WinSpectral α/β LSC counter



water samples

The uranium ^{238}U concentrations were below 0.5 mBq/L for water samples collected in Hall 2 Lab 2, and 0.53 ± 0.05 μg/L for water sample collected outside Callio Lab 2. All water samples showed disequilibrium between $^{234,238}U$ isotopes (in underground water it is a common phenomenon). All water samples showed ^{226}Ra, ^{228}Ra concentrations above the detection limits [4]. This may indicate that there are favorable conditions for water to receive the radium isotopes from reservoir rocks or rocks are rich in radioactive content.

References

[1] J. Suomela, Method for Determination of U-Isotopes in Water," Swedish Radiation Institute, Stockholm, 1993.

[2] C. W. Sill, Precipitation of actinides as uorides or hydroxides for highresolution alpha spectrometry, Nuclear and Chemical Waste Management, vol. 7, no. 3, pp. 201-215, 1987.

[3] Polish Norm PN-89/ZN-70072, Radium isotopes determination in water with LSC method. Wydawnictwa Normalizacyjne Alfa, 1989.

[4] K.Polaczek-Grelik et al., 2020, Nuclear Instruments and Methods (accepted for publication)