UL IN POLAND (?)

Workshop on EU Underground Laboratories

Jan Kisiel, University of Silesia in Katowice, Poland

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Locations under consideration for an underground laboratory in Poland

- Sieroszowice mine
- Lubin mine
- Salt Mine Kłodawa
- Salt Mine Bochnia
- Salt Mine Wieliczka
- other

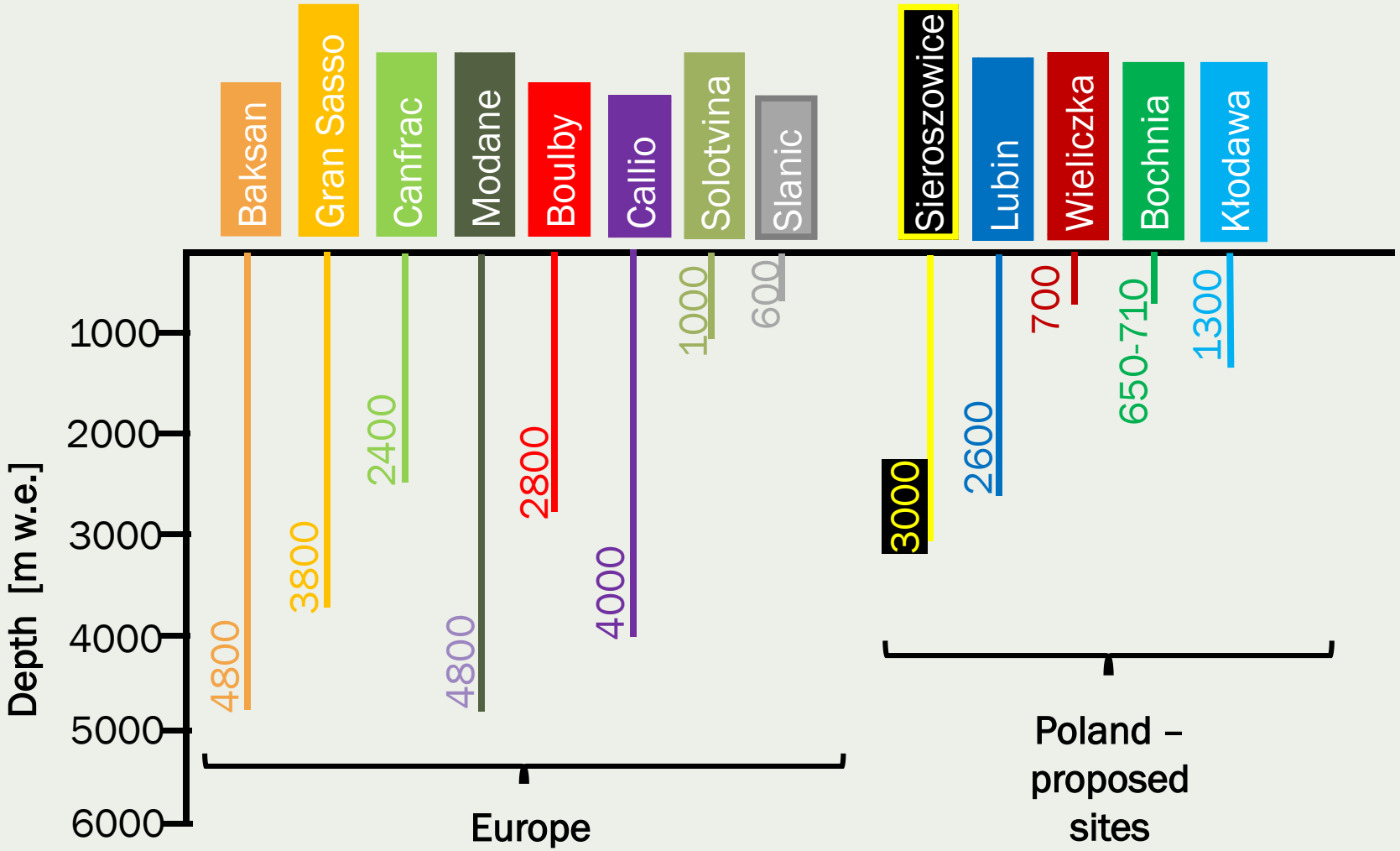
preliminary discussions with management and measurements of natural radioactivity are underway

The careful selection of the site will be based on accessibility, geological conditions (cavern stability), overall conditions in the mine, the level of natural radioactivity, …

It will be a multidisciplinary laboratory (not just physics).

Map of Poland with marked considered so far locations of an underground laboratory, https://www.google.pl/maps/

The depths of the proposed so far sites in Poland



Some recent history

- Work/actions towards underground laboratory in Poland
  - **2010 - *SUNLAB*** ***(S****ieroszowice* ***UN****derground* ***LAB****oratory):* the result of the work carried out as part of the preparation and subsequent implementation of the European ***LAGUNA project****,* the aim of which was to find the optimal location for a pan-European laboratory for neutrino studies and proton decay searches using one of the three types of giant detectors (water Cerenkov, Liquid Argon TPC, liquid scintillator).
    location - ***the Polkowice-Sieroszowice mine owned by the KGHM Polska Miedź S.A.; SUNLAB1 (small) located in the salt layer, and SUNLAB2 (large) located in anhydrite***
  - **2011 -** *entering SUNLAB on the Polish Road Map of Research Infrastructures (PRMRI)*
  - **2018 - *SUNLAB-LB*** ***(S****ieroszowice* ***UN****derground* ***LAB****oratory -* ***L****ow* ***B****ackground): entering SUNLAB-LB on the Polish Road Map of Research Infrastructures;*
    SUNLAB-LB was the successor of the SUNLAB project. Due to significant changes in the scientific program and the project team, a decision was made to withdraw the SUNLAB project from the PRMRI and submit a new application for SUNLAB-LB;
    location of SUNLAB-LB - ***the Polkowice-Sieroszowice mine, salt layer***
  - **2019 -** the *SUNLAB-LB* project was withdrawn from the PRMRI due to the changes in KGHM Polska Miedź S.A. operational plans, which may result in instability of the salt chambers in which the underground laboratory was to be located

Some very recent history

- 2017-2020: ***Project BSUIN (B**altic **S**ea **U**nderground **I**nnovation **N**etwork**).*** *The project aimed to develop the possibilities of underground laboratories to improve their service offer as innovative potential and to create a network of underground laboratories in the Baltic Sea Region, providing users, including small and medium-sized enterprises, with easy access and the environment for business development and innovation.*
- 3 Polish institutions (National Centre for Nuclear Research, the University of Silesia in Katowice, and KGHM Cuprum R&D Center) participated in the project. The KGHM mines infrastructure, well developed with hundreds of easily accessible kilometers of workings, in the BSUIN project, was called: ***Conceptual Lab development co-ordinated by KGHM Cuprum R&D center.***
- 2021: ***Project EUL (Empowering Underground Laboratories Network Usage) -*** continuation of the BSUIN project.

The map of the Baltic Sea Region showing the partner underground laboratories involved in the BSUIN and EUL projects, www.bsuin.eu

Now

- 2021-now
  On November 24, 2021, an informal meeting with the participation of people (not only physicists) interested in establishing an underground laboratory in Poland took place at the University of Silesia
  Institutions participating in the meeting:
  - Wroclaw University of Science and Technology
  - Space Research Center of the Polish Academy of Sciences
  - Jagiellonian University
  - Institute of Nuclear Physics Polish Academy of Sciences
  - National Center for Nuclear Research
  - University of Warsaw
  - Central Laboratory for Radiological Protection
  - KGHM CUPRUM Research and Development Center
  - National Atomic Energy Agency (PAA)
  - University of Silesia

The meeting triggered new activities aimed at establishing UL in Poland. Currently, talks with mine management, reconnaissance, and preliminary measurements of natural radioactivity in several underground locations in Poland are underway.

Measurements of natural radiation background in selected underground sites in Poland

- Measurements of natural radiation background (NRB) have been carried out in several underground sites in Poland by groups from several institutions:

  - The H. Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences
  - National Centre for Nuclear Research, branch in Łódź
  - Wrocław University of Science and Technology
  - University of Silesia in Katowice

- Some selected results are presented in the following slides.

NRB measurements in the Polkowice-Sieroszowice mine

Salt cavern Ps1

Measurement with a portable gamma spectrometer and HPGe detector, resolution 1.7 keV for the 1.33 MeV line, 30% detector efficiency, M1 geometry (2004)

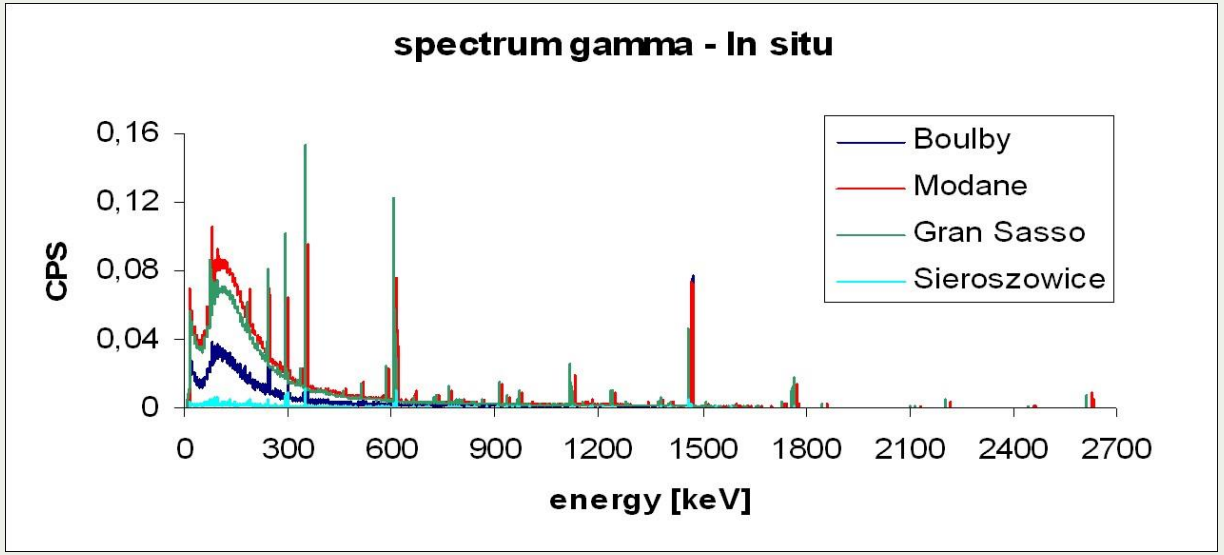
Counts per second in energy range 40-2700 keV

	[CPS/keV kg]
Sieroszowice	**2.30 (0.02)**
Gran Sasso	**57.68 (0.02)**
Modane	**66.06 (0.05)**
Boulby	**23.83 (0.03)**

Salt cavern Ps1

Measurements of salt and anhydrite samples (IFJ Kraków, 2006) using alpha spectrometry

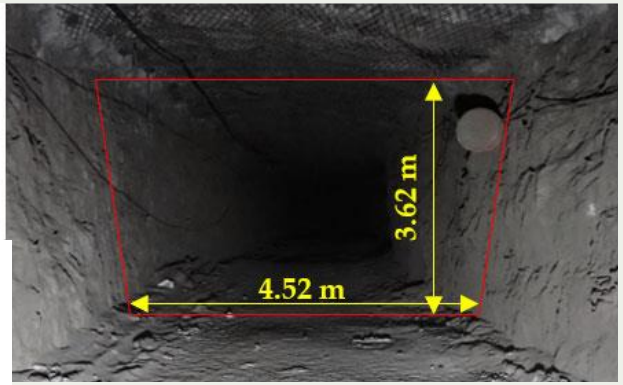
	Salt [Bq/kg]	Anhydrite [Bq/kg]
^{238}U	0.0165(0.0030)	0.82(0.10)
^{234}U	0.0225(0.0030)	0.76(0.09)
^{232}Th	0.008(0.001)	0.52(0.15)
^{40}K	4.0(0.9)	-
^{230}Th	-	1.26(0.24)



Kisiel, et al., Measurements of natural radioactivity in the salt cavern of the Polkowice-Sieroszowice copper mine, Acta Phys. Pol. B, 41 (7), 1813–1819, 2010

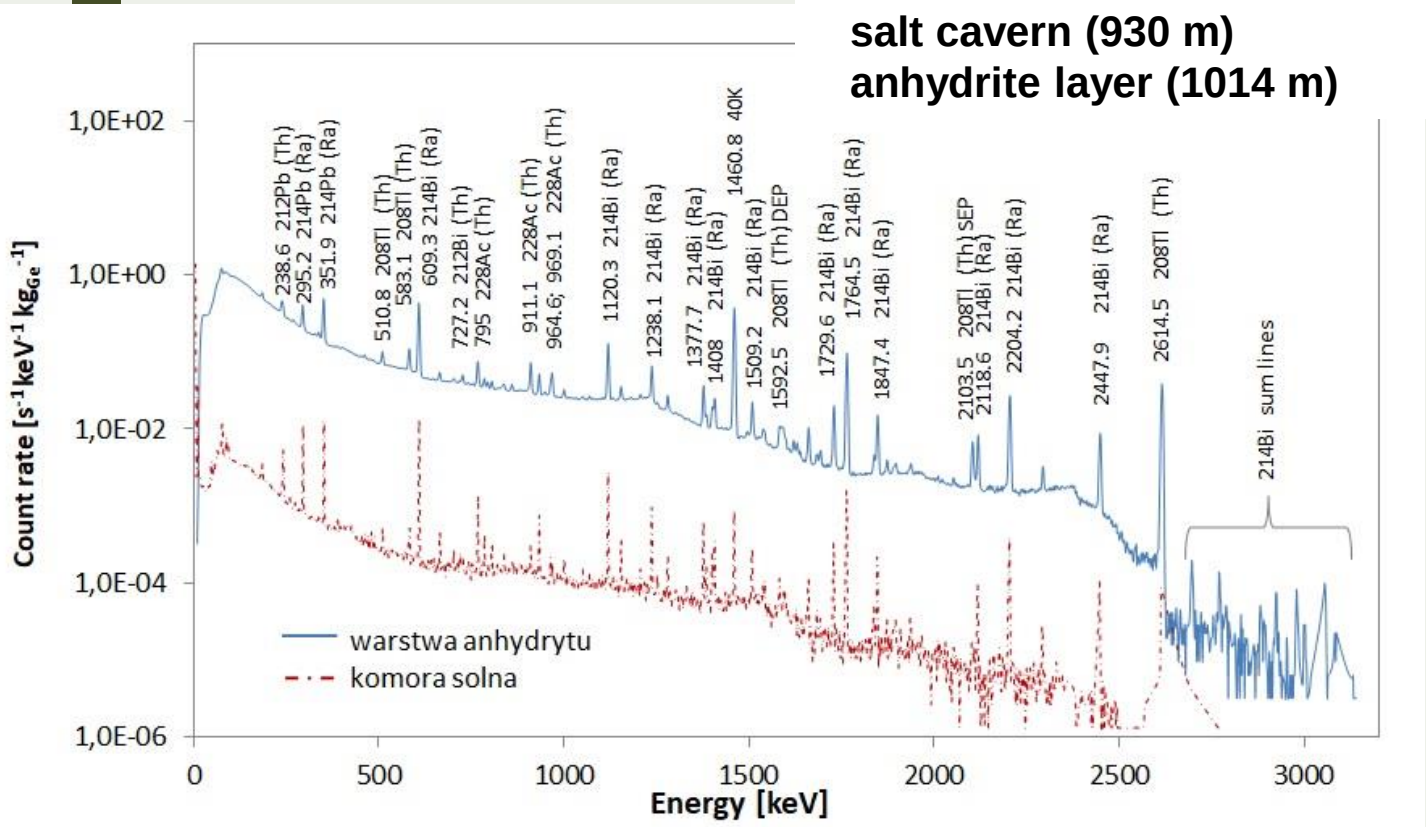
NRB measurements in the Polkowice-Sieroszowice mine

Mesurements in the anhydrite layer at a depth of 1014.4 m were carried out in 2020 as part of the BSUIN / EUL project



place of measurements – corridor in the anhydrite layer

	counts per second in energy range 40-2700 keV [CPS/keV kg]
salt cavern (930 m)	**2.30 (0.02)**
anhydrite layer (1014 m)	**114.25 (0.05)**



(a) measurement of thermal neutrons (helium counters)
(b) measurement of radon concentration in air (RAD7 radon monitor)
(c) measurement of gamma radiation using a portable gamma spectrometer and HPGe detector (resolution 2.1 keV for 1.33 MeV line, 40% detector efficiency)

Szkliniarz et al., Characteristics of Natural Background Radiation in the Polkowice-Sieroszowice Mine, Poland, Energies, 14, 4261, 2021

Comparison of natural radioactivity: salt cavern vs. corridor in the anhydrite layer

In-situ measurements:

	Gamma flux [$cm^{-2}s^{-1}$]	Counts per second [$keV^{-1}s^{-1}kg^{-1}$] 40-2700 keV	Effective dose rate [$\mu Sv\ h^{-1}$]	^{222}Rn [$Bq\ m^{-3}$]	Neutron flux [$cm^{-2}s^{-1}$]	Muon flux [$cm^{-2}s^{-1}$]
Salt cavern / 930 m	0.124±0.002 [a]	2.30±0.02 [b]	0.0018 [c]	12±4–49±8 [d]	–	–
Anhydrite layer / 1014 m	0.64±0.20 [a]	114.25±0.05 [a]	0.008±0.001 [a]	6.6 [e]	$(2.0±0.2)\times10^{-6}$ [f]	$2.8–5.5\times10^{-8}$ [g]

a - gamma spectrometry and the HPGe detector with 40 % detection relative efficiency
b - gamma spectrometry and the HPGe detector with 30 % detection relative efficiency
c - 78 pieces of high sensitive thermoluminescent MCP–N (LiF: Mg, Cu, P) detectors located on the chamber walls in several place
d - radon monitor – AlphaGuard
e - radon monitor – RAD7
f - helium counters
g - estimated based on empirical formulas

Laboratory measurements of salt and anhydrite samples:

	^{226}Ra [$Bq\ kg^{-1}$]	$^{228}Ra(^{232}Th)$ [$Bq\ kg^{-1}$]	^{40}K [$Bq\ kg^{-1}$]	^{234}U [$Bq\ kg^{-1}$]	^{238}U [$Bq\ kg^{-1}$]
Salt cavern	3.1±0.3 [a]	0.008–0.11±0.004 [b]	2.1±0.3-4.0 [c]	0.021-0.38±0.05 [b]	0.016±0.003-0.40±0.06 [b]
Anhydrite / 930 m	–	0.52 [b]	not identified [c]	0.76±0.24 [b]	0.82±0.09 [b]
Anhydrite / 1014 m	0.63±0.03–21.1±0.7 [c]	0.19±0.03–0.60±0.10 [c]	6.1±0.2–15.4±0.3 [c]	0.84±0.08-24.75±0.74 [b]	0.82±0.08-24.37±0.73 [b]

a - gamma spectrometry with HPGe detector, value estimated based on in situ spectra
b - alpha spectrometry
c - gamma spectrometry with HPGe detector

Kisiel, et al., Measurements of natural radioactivity in the salt cavern of the Polkowice-Sieroszowice copper mine, Acta Phys. Pol. B, 41 (7), 1813–1819, 2010
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Towards underground laboratory in Poland: next steps

- Cataloging the possible locations with their characteristics
- Establishing a consortium of institutions interested in the underground laboratory in Poland
- Submitting a new project to the Polish Road Map of Research Infrastructures

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Thank you for your attention