RadoNorm
Managing risks from radon and NORM

Feedback on radiation protection for NORM facilities and underground workplaces

Kateřina Navrátilová Rovenská
SURO, Czech Republic & RadoNorm Partner

Challenges in applying the radiation protection system in the management of NORM and radon
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This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 900009.

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RadoNorm project

- Title: Towards the effective radiation protection based on improved scientific evidence and social considerations – focus on radon and NORM
- 20 Member States, 57 Beneficiaries, 60 month (end date 31. 8. 2025)
- Objectives:
  - To support EU member states in the **implementation of the European Basic Safety Standards (BSS)**.
  - To significantly **reduce scientific, societal as well as technical uncertainties** in all steps of the radiation risk management cycle for radon and NORM (Naturally Occurring Radionuclide Material).
  - To **improve radiation protection** by:
    - initiating, supporting and performing multidisciplinary, innovative, integrated **research and technical development**.
    - integrating **education and training** in the research and development work of the project.
    - **disseminating the project achievements** to the public, regulatory authorities, policy makers and other stakeholders.

For more info see https://www.radonorm.eu/

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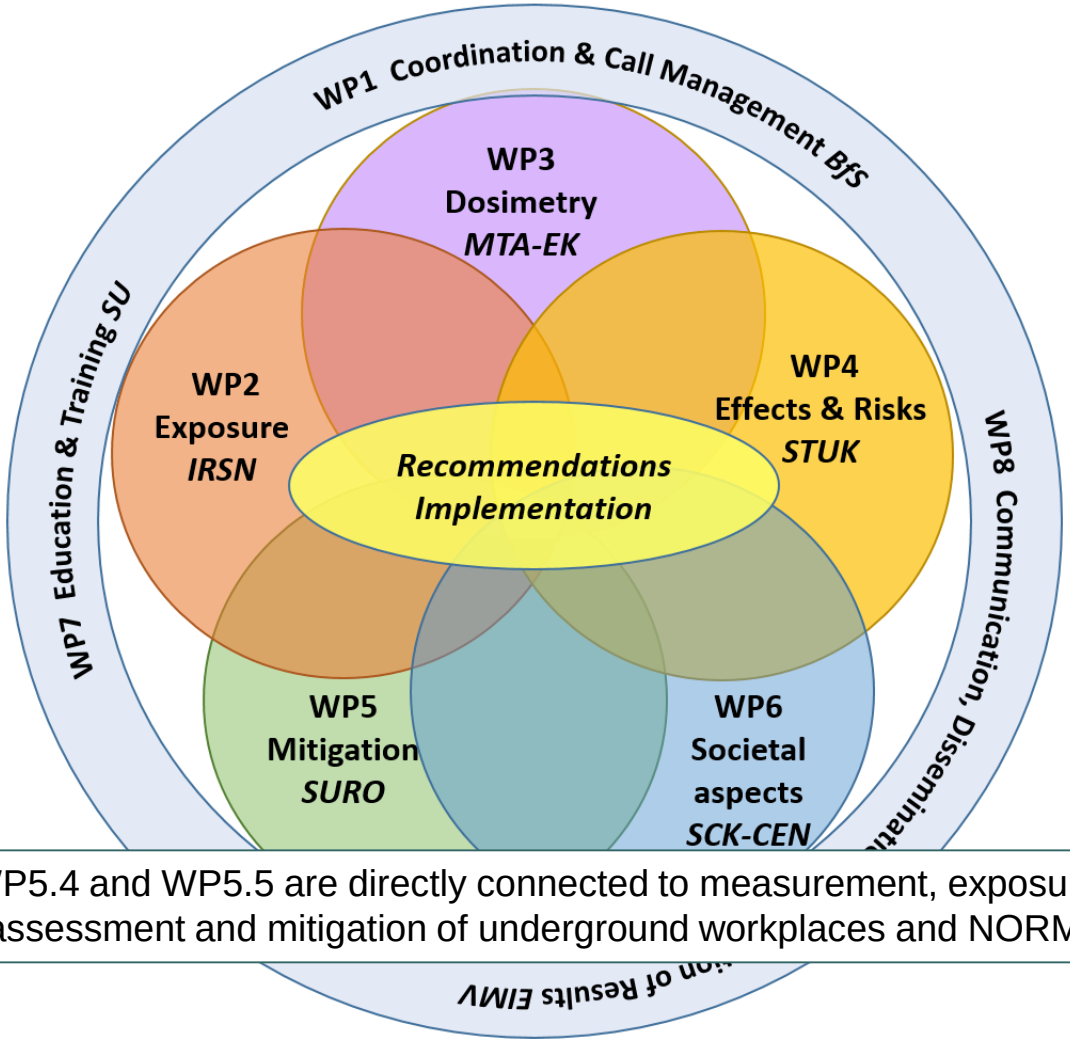
Work Packages in RadoNorm



WP5.4 and WP5.5 are directly connected to measurement, exposure assessment and mitigation of underground workplaces and NORM

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Characterisation of the situation - Collection of data

- Sufficient and reliable data to describe the situation at the workplace
  - Identification of sources of exposure
    - radon and radon progenies concentrations during the presence of workers and their variability;
    - other sources of exposure and their variability;
    - other factors influencing the assessment of exposure and their variability;
    - parameters of measurement devices
      - uncertainty, response time, operating conditions, …
  - Identification of exposure pathways
  - Workers' behaviour
    - Time spent at the workplaces, typical activities at the workplace, …

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Underground workplaces

- Which quantities are typically measured at underground workplaces?
  - RadoNORM WP5.4 survey – radon concentration, gamma dose rate, if necessary also humidity, temperature, radon progenies, thoron and unattached fraction
  - Environment monitoring used rather than personal dosimetry
    - Short term workplaces, randomly visited workplaces may be a challenge

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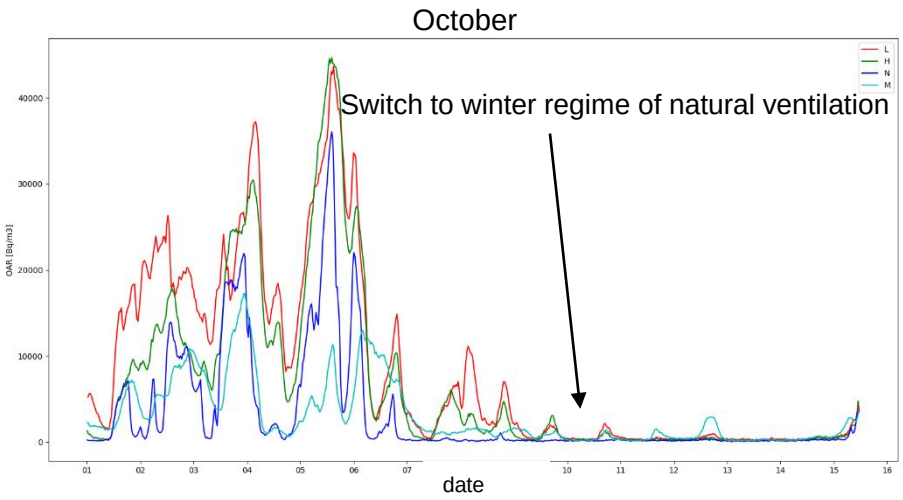
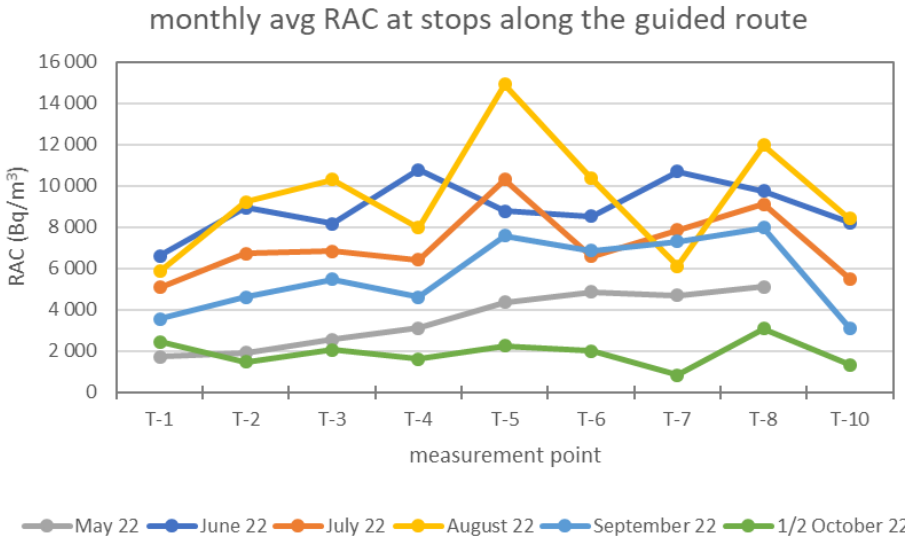
Underground workplaces

- Selection of measurement points
  - where and how many
- Duration of measurement
  - should respect the seasonal variability of RAC
  - depends on presence of workers





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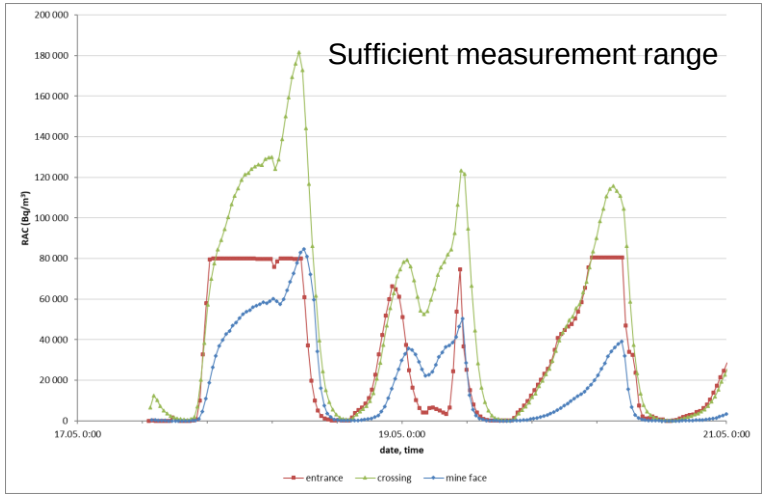
How to select from detectors/monitors?



- Define parameters important for concrete workplace and measurement based on the purpose of measurement
  - Sensitivity of the detector (counts per unit radon activity)
  - Time resolution (minutes, hours, days)
  - Spectrometric capabilities of the detector
  - Stability of results under different conditions (radon/thoron interference, stability of signal in high relative humidity)
  - Operating ranges
  - Stability of background
  - Data storage and data processing, connectivity
  - Energy consumption, batteries
  - Size, weight, robustness of the case
  - Cost
  - …

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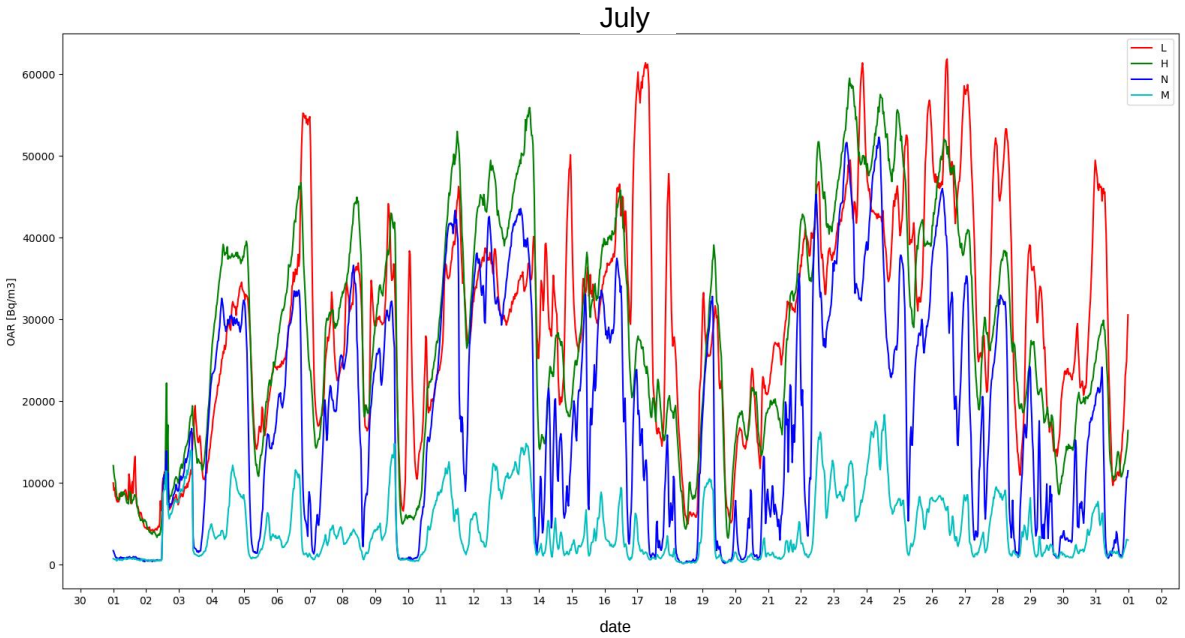
Frequent rapid and steep changes of radon activity concentration at several measurement points located in the mine chambers



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Estimation of dose from radon and radon progenies

- Dose conversion coefficient (DCF)
  - ICRP65
  - ICRP137
    - Site specific DCF
    - In ICRP 137, Chapter 12.7, para. (667), ICRP recommends 10 mSv per WLM for buildings and underground mines, and in para. (668), ICRP recommends 20 mSv per WLM for tourist caves. However, if **aerosol conditions are different** from assumed reference values, then site-specific dose coefficients can be calculated based on **sufficient and reliable data**. “
  - UNSCEAR

  - EU-RAP study (analysis of EU MS and the UK Radon action plans):
    - ICRP 137 implemented in 15 countries, e.g. Austria, Belgium, Bulgaria;
    - ICRP 137 under discussion in 5 countries, e.g. Spain, Ireland, Portugal;
    - ICRP 65 used in 2 countries, UK, Germany;
    - reference to ICRP 115+126 in 1 country, Sweden.

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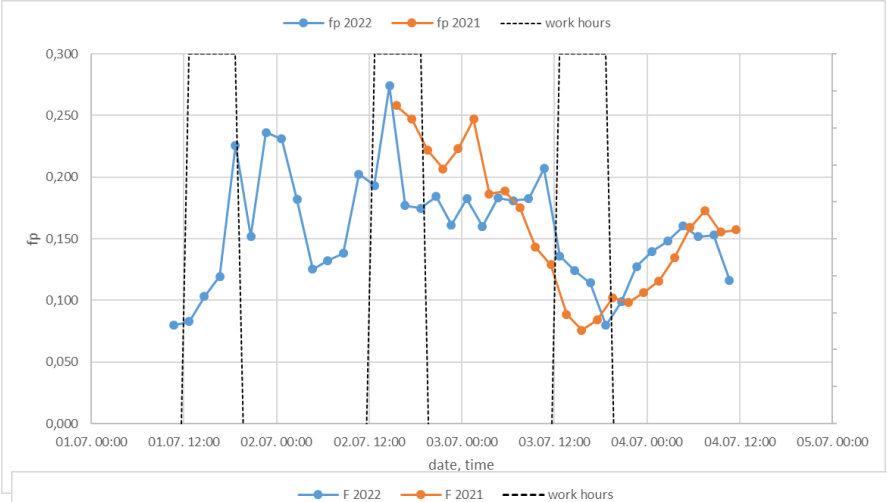
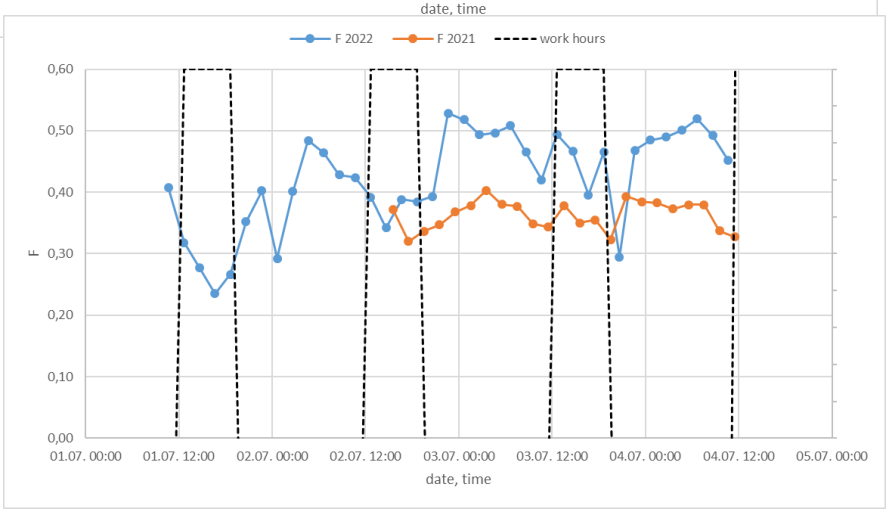
Site specific DCF

Variation of unattached fraction during day and between years





- Calculation described in Annex A of Publication 137 and should be used if „*in cases where aerosol conditions are significantly different from typical conditions, and where sufficient and reliable aerosol data are available to warrant such calculations*.“ (para 611 ICRP137)
- Measured values of f_p and F
  - **sufficient and reliable data** (during the stay of workers)
    - metrological traceability ?
    - how long data sets ?
    - should the measurement be repeated in different seasons, years?

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NORM workplaces

- Well established procedures to describe permanent workplaces.
- Temporary, short term workplaces
  - e.g. cleaning of gas piping, replacement of filtration material in water treatment facilities, demolition or reconstruction of NORM workplaces incl. which become NORM workplace thanks to these construction works, etc.;
  - Environment monitoring or personal dosimetry?
    - National requirements on presence of radiation protection expert at the workplace during the work should be considered;
    - Acceptable level of conservativism
- Legacy sites

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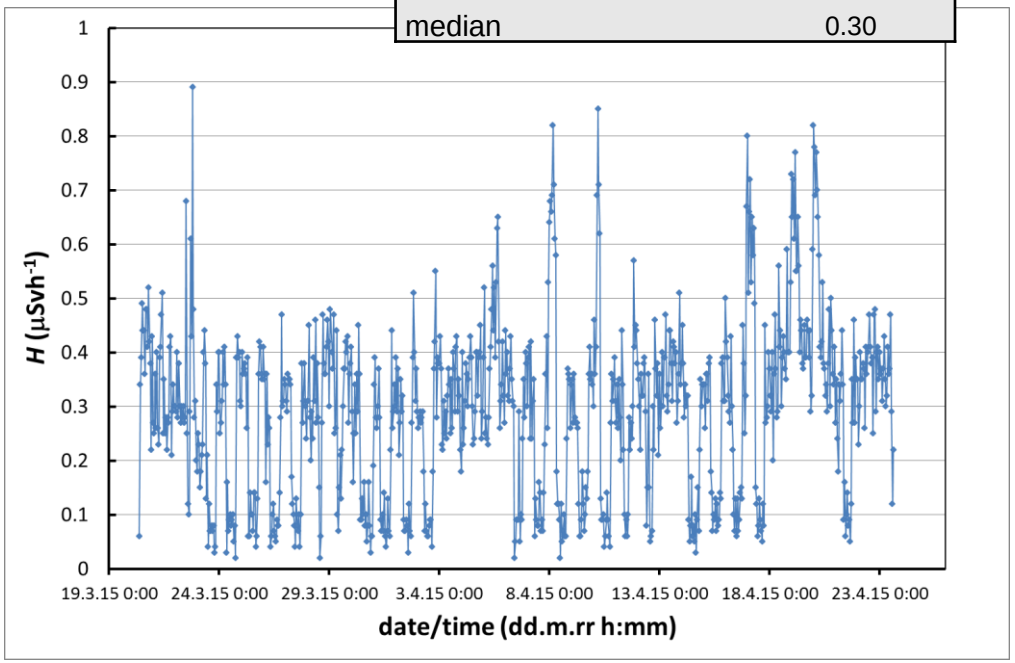
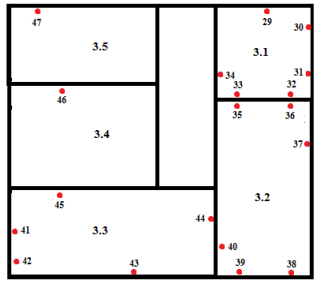
Personal dosimetry

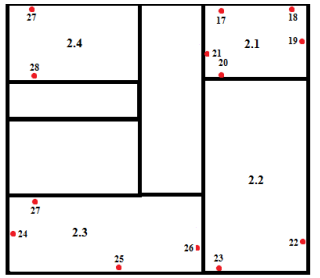
Descriptive statistics Hp(10) (µSv/h)	
mean	0.29
standard deviation	0.16
minimum	0.02
maximum	0.89
median	0.30

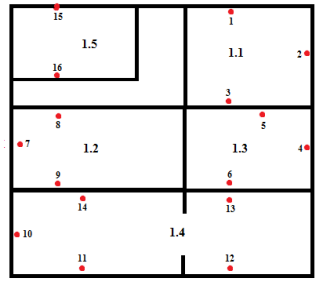


On site measurement

Descriptive statistics H*(10) (µSv/h)			
	3rd floor	2nd floor	1st floor
mean	0,45	0,53	0,48
standard deviation	0,13	0,13	0,18
minimum	0,30	0,30	0,30
maximum	0,70	0,70	0,90
median	0,45	0,55	0,40







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Legacy sites

- Monitoring can be a challenge
  - Continuous measurement (e.g. Ramonis modular system, continuous monitors connectable to IoT)
  - Spot measurements (various handheld detectors/spectrometers, grab sampling for Rn)

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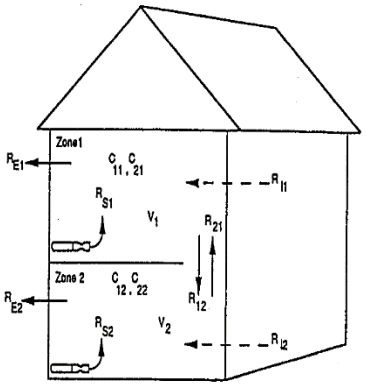
Objectification of results – Air exchange rate

- Objectification of results of radon measurement to the minimum hygienic air exchange rate (0.3 1/h).
- Tool of the radon diagnostics for identification radon pathways and radon entry rate.
- Assessment of exfiltration-infiltration from the outside – improvement in dose assessment in case of plume contamination.
- Air exchange rate measurement - **Method applied**:
  - Perfluorocarbon tracer (PFT) technique allows calculation of the average air exchange rate and interzonal airflows in multizonal buildings.
  - Tracer gas ***i*** (C_i) is constantly injected into the compartment (i.e. room(s) or storey) with defined and well know entry rate driven just by diffusion.
  - Detection tubes with proper sorbent are used to absorb tracer gas.
  - Gas chromatograph GS Agilent equipped with a proper chromatographic column to distinguish mixture of used tracer gases and electron capture (EC) and flame ionization (FI) detector is used as the evaluation unit. Helium is used as a carrier gas.
  - Number of compartments equals to the number of tracer gases used. SURO is capable to carry out measurements and distinguish between 7 different tracer gases.



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Family house, radon diagnosis for the court

- Object: family house, single storey building built in 2016.
- In the heating season 2017, 2month long integral radon measurement was performed, RAC were above RL (RL for newly built houses was 200 Bq/m^3).
- Next, one week measurement done by the electret detectors showed the same results.
- The owners decided to fil a lawsuit against the construction company and to request the remediation – to reach RAC below the RL.
- The court asked SURO for the expert opinion.

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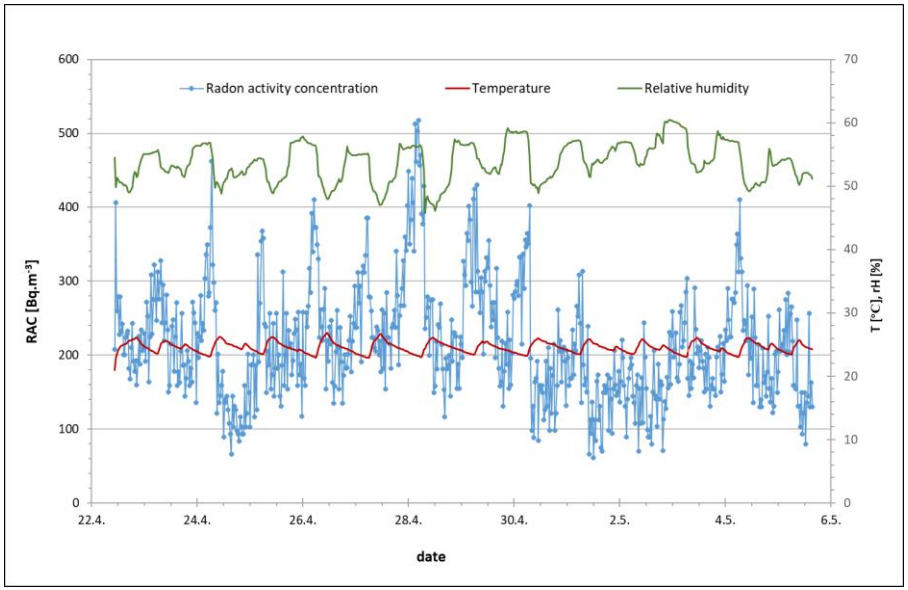
Family house, radon diagnosis for the court

- Measurements using radon monitors were performed
- Conditions: April, building was occupied

- Results:
  - mean RAC were about 200 Bq/m^3 (192 – 218 Bq/m^3),
  - maxima in the childern´s room at night was above 400 Bq/m^3



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Family house, radon diagnosis for the court

- Simultaneously, ACH measurements were performed
- Conditions: for ACH 1 compartement was used

- Results:
  - mean ACH was quite low (0,121 ± 0,025 h^{-1})
  - after recalculating the RAC to standard ventilation (0.3 h^{-1}), RAC equals to 77 – 88 Bq/m^3

- **No remediation was necessary**, only higher ventilation should be used

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- Detailed measurement at the workplace is the first step towards the exposure assessment and to the design of effective remedial measure (if necessary).

Thank you for your attention

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