

Metrology: TGDR and radon

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CONTENT

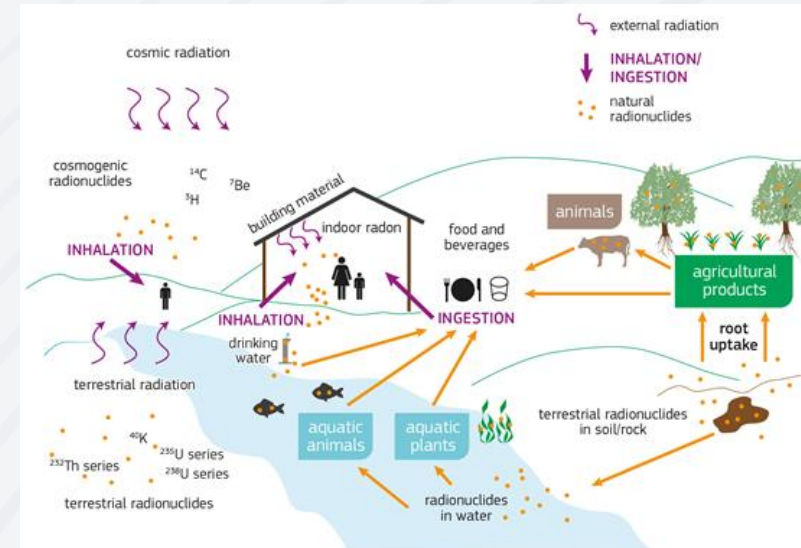
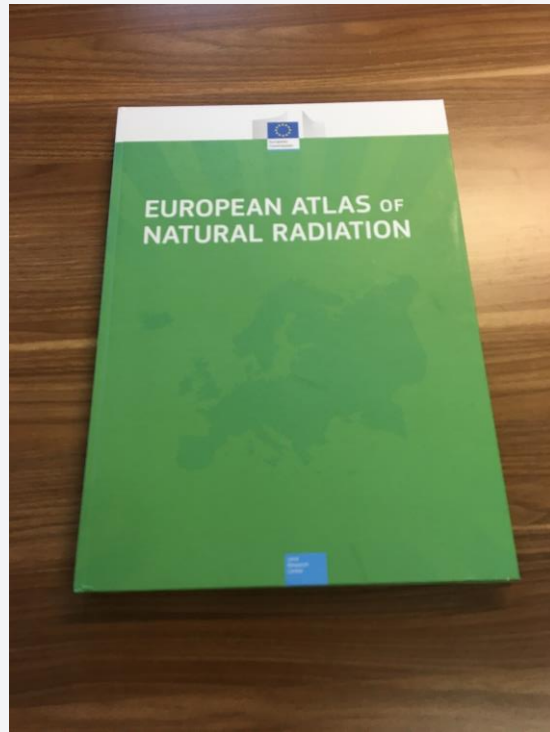
- Metrology: TGDR, Rn, Th
- ISO standards
- The need for high quality data: accreditation ISO 17025
- Challenges
- Final remarks and take aways



TGDR, Rn, Th

Metrology: TGDR, Rn, Th

ISO stan



European Commission, Joint Research Centre – Cinelli, G., De Cort, M. & Tollefsen, T. (Eds.), *European Atlas of Natural Radiation*, Publication Office of the European Union, Luxembourg, 2019.



TGDR, Radon and Thoron

TGDR

Variability of Terrestrial Dose rate

- ✓ Spatial
- ✓ Temporal

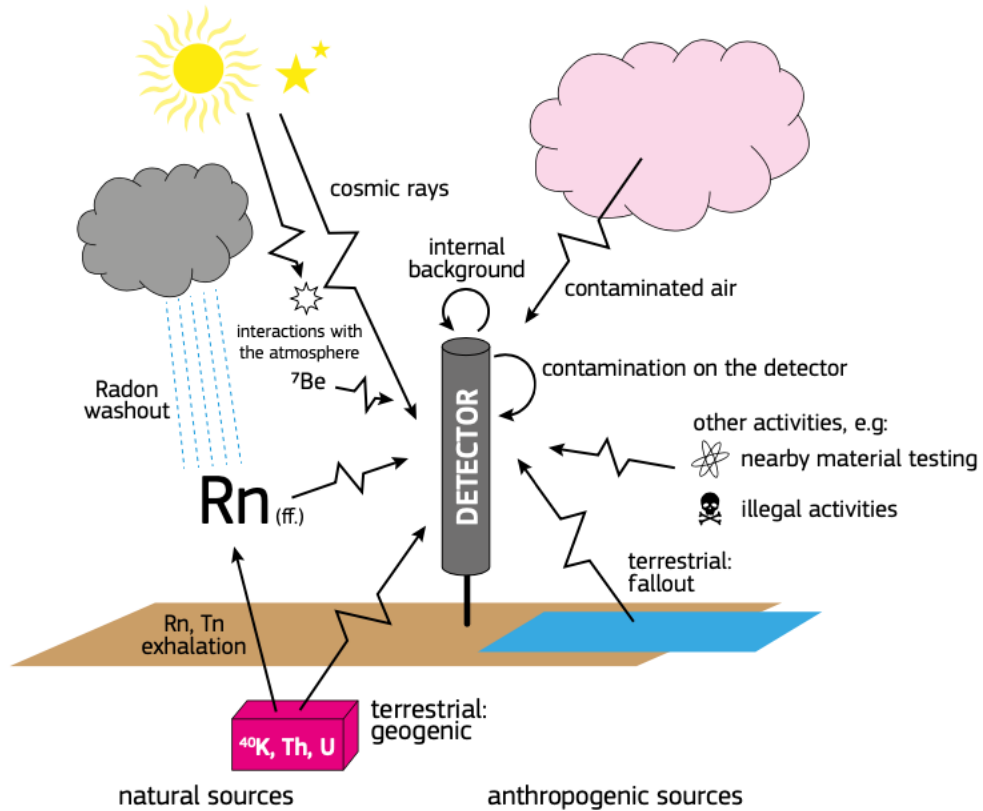


Figure 4-3.
Contributions to the dose rate recorded by a detector. Rn - radon (^{222}Rn),
Tn - thoron (^{220}Rn); see [Section 2.2.2](#) for details.
Source: Graph created by Peter Bossew.

How to measure TGDR?

INSTRUMENTS

INDIRECT
MEASUREMENTS

TGDR: INSTRUMENTS

Total count rate measurement: GM
counters

Gamma-ray spectrometry

Airborne gamma-ray spectrometry

TGDR: indirect measurements



Assumption I: Secular
equilibrium (series U and Th)

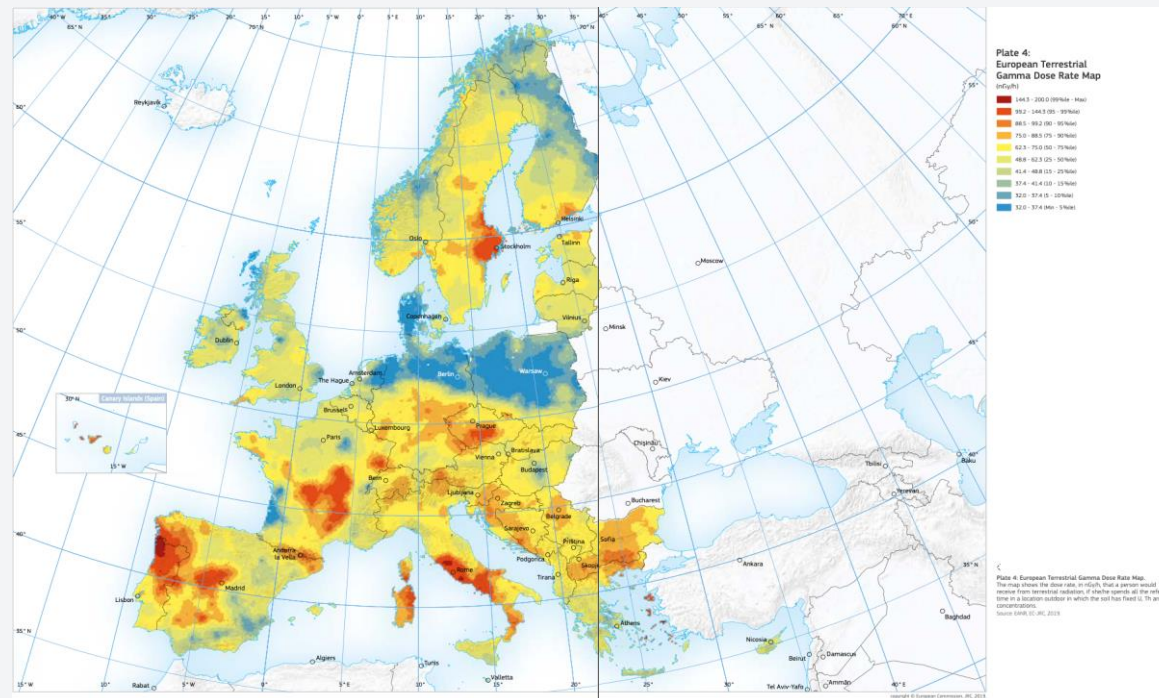


Assumption II: Homogeneity of
the soil

TGDR: indirect measurements

$$TGDR \text{ (nGy/h)} = 0.0417 \cdot C_K + 0.604 \cdot C_{Th} + 0.462 \cdot C_U$$

UNSCEAR, 2008



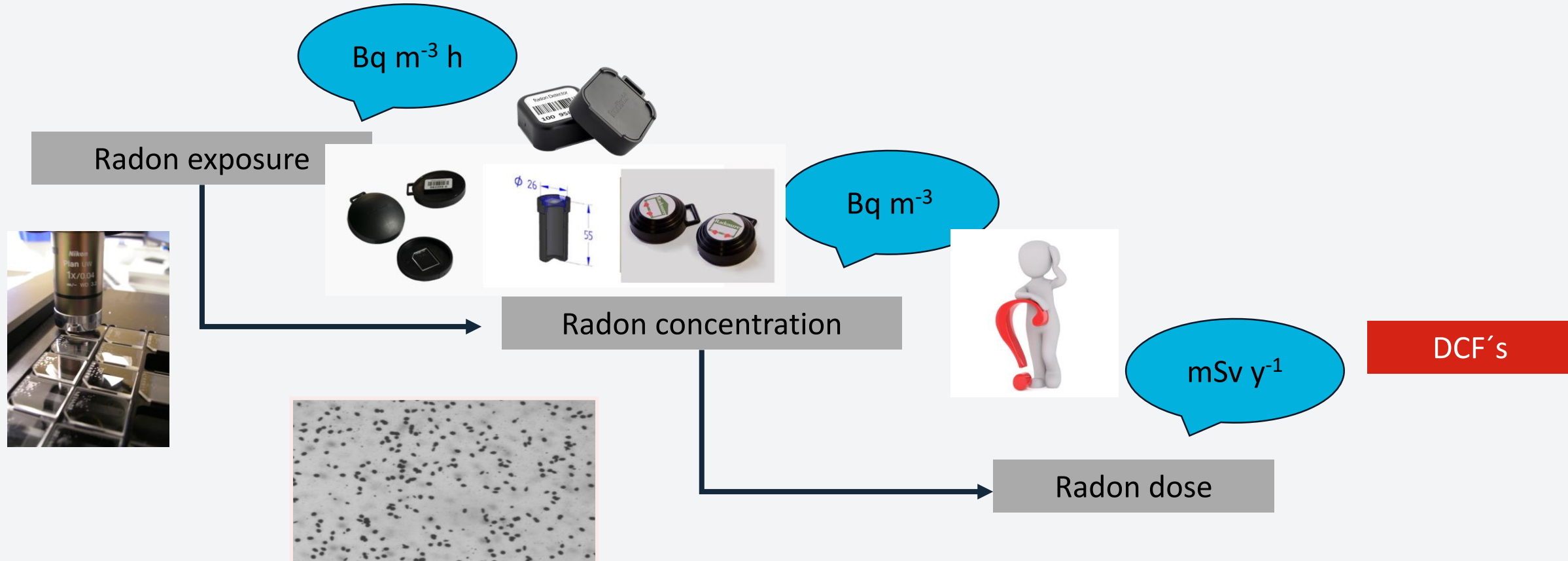
How can we
measure radon
(^{222}Rn & ^{220}Rn)?

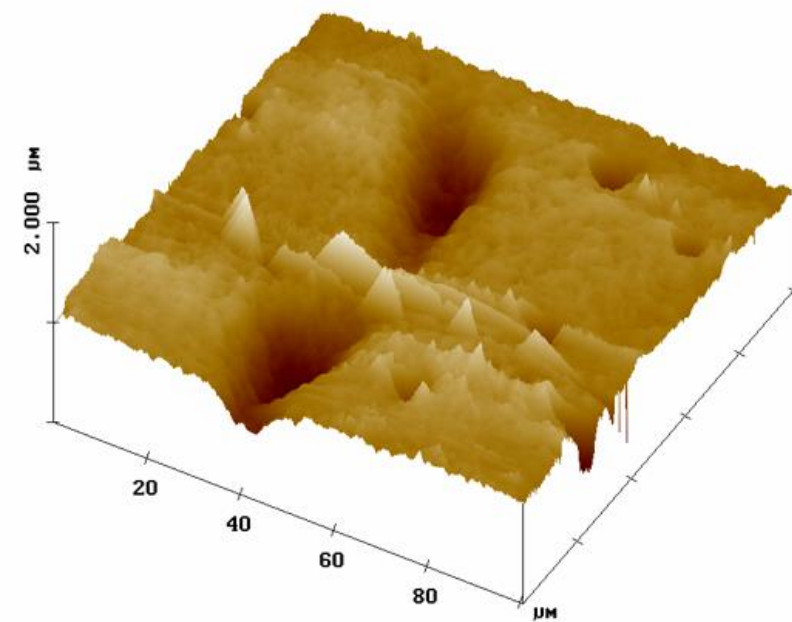
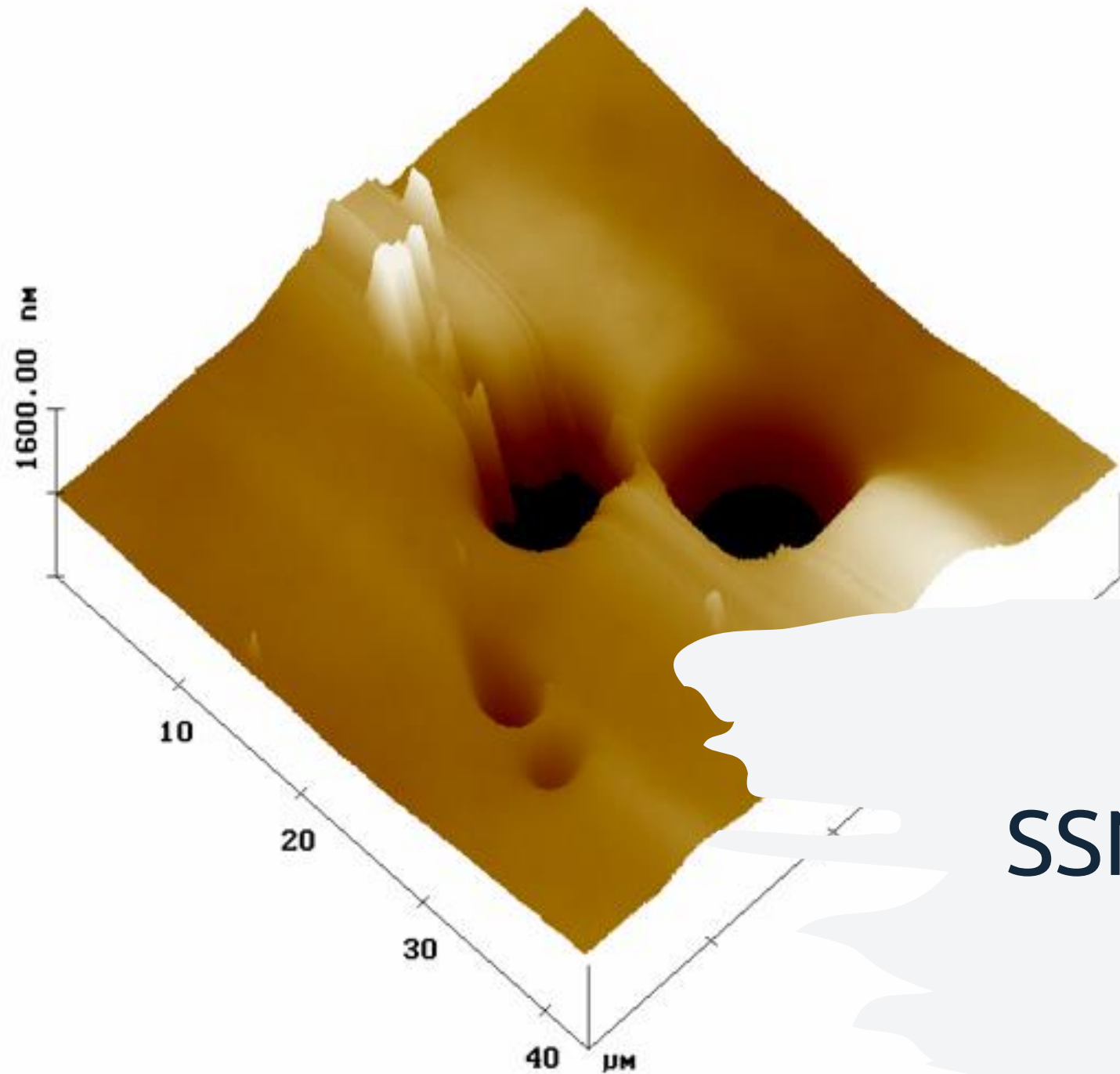
Passive systems

- SSNTD's (Solid State Nuclear Track Detectors)
- Activated charcoals
- LSC
- Electrets

Active systems

Radon measurements: passive systems





SSNTD's

Alpha-track detectors

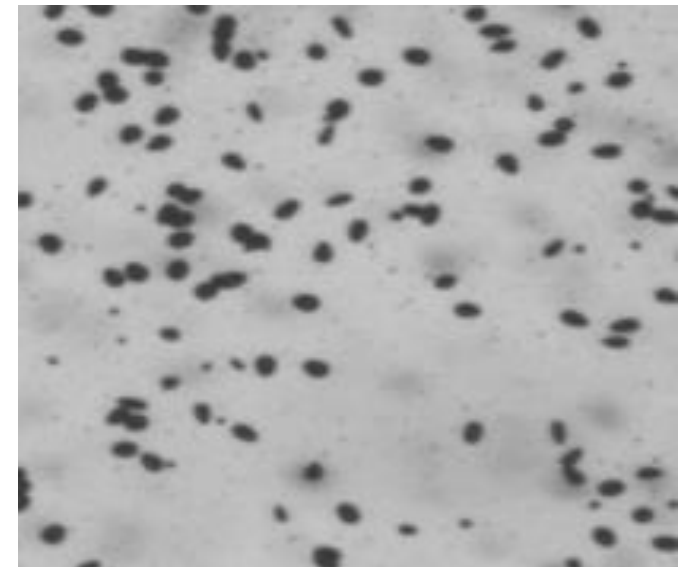
Function for measuring radon gas

Radon gas diffuses through a small gap between the top and the bottom parts of the detector housing. No radon-decay products from outside can enter the detector.

The diffusion time is long enough so that a possible contribution from thoron gas is neglectable

The detector housing is made of electrically conducting plastic to avoid problems with static charge.

Inside the detector, there is a CR-39 film which is sensitive to alpha decay. When the alpha particle hits the film, a small damage is made which could be magnified through etching and later counted in a microscope.



Alpha-track detectors advantages/disadvantages

Advantages

- Reliable technology which is insensitive for environmental parameters such as temperature, humidity and gamma radiation.
- Cheap measurements and simple to perform
- After etching, the tracks are fixed, and the alpha-track film can be checked afterwards.

Disadvantages

- Not possible to measure for shorter periods than a week (also a one-week measurement is difficult)
- Risk for additional exposure at storage and transport (sensitive to damages in the air-tight bag)
- Rather large investments to set up a measurement laboratory
- Radon is absorbed in the plastic in the detector holders. Risk for additional exposure if detectors are put in air-tight bags after short exposure times (< 2 weeks).

Radon measurements: active systems



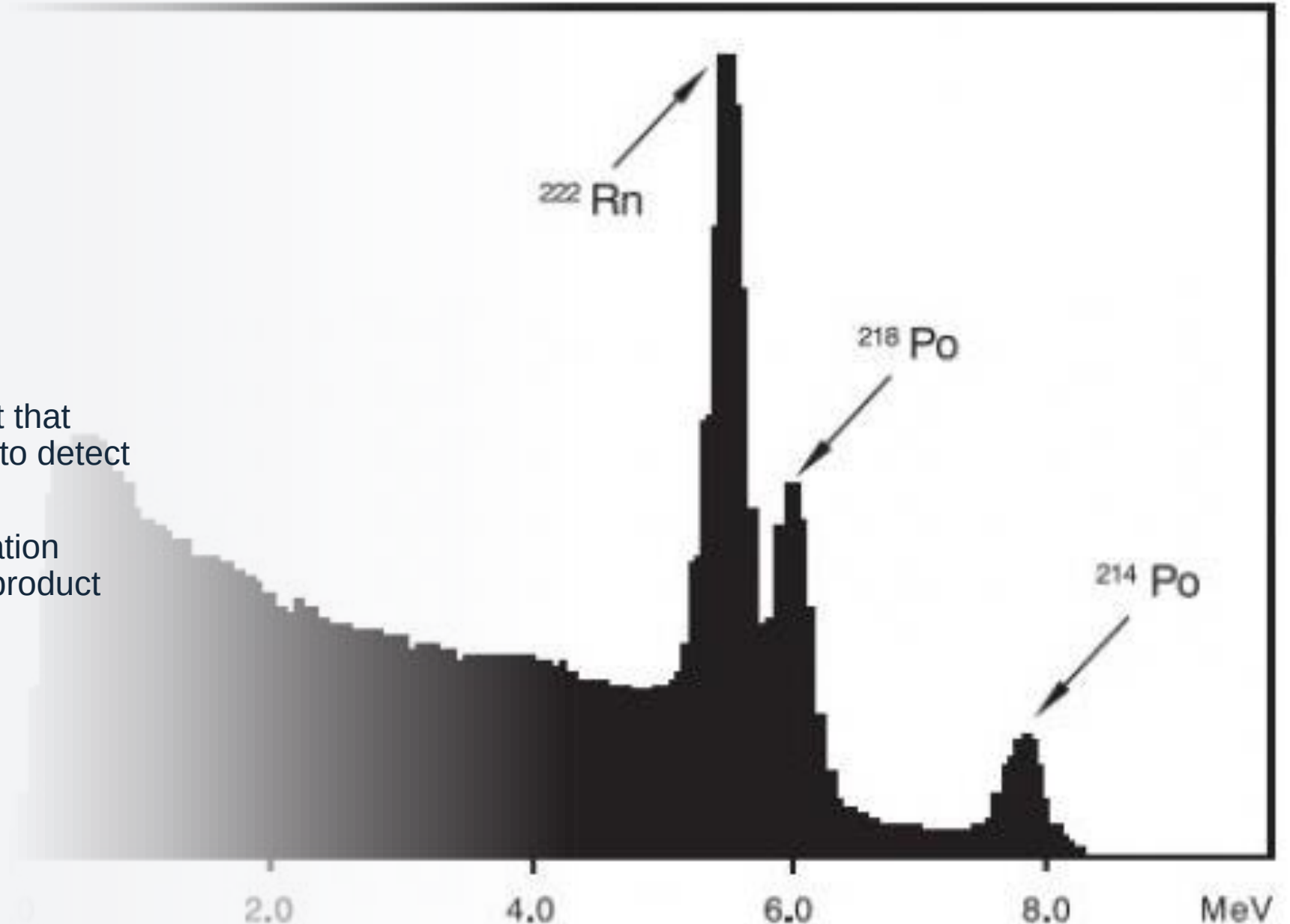
Ionisation chamber

Advantages

- Rapid response instrument that can be used, for example, to detect radon leakage.
- By analysing the disintegration energy, the disintegration product can be determined
- Time-resolved results

Disadvantages

- Expensive instrument



How does an ionisation chamber work?

- Radon gas is analysed by looking at all alpha decays of the Rn-222 chain.
- The chamber consists of an electrode structure
- alpha particles travel 4-4.7 cm in air
- Radon is pumped into the ionisation chamber
- Alpha radiation from radon gas and its decaying progeny ionise the air. The ion pairs formed accumulate with an electric field.
- The signal is amplified and processed before being spectroscopically classified.



GDR, Rn, Th

ISO standards

accreditation

Requirements on measurement protocols

– International standards

- Basic measurement requirement and standards as ISO 11665
- Quality assurance
- Calibration (details for alpha-track measurements)
- Detector performance requirements
- How should measurements be performed? National measurement protocols

Basic measurement requirements and standards (radon)

- What could be found in basic measurement standards?
- ISO 11665 (overview)
- ISO 11665-4 (integrating measurement methods)
- ISO 11665-8 (initial and additional investigations in buildings)
- ANSI/AARST MS-QA 2019 (Radon Measurement Systems Quality Assurance)
- Expression of results (confidence interval, lower limit of detection)

ISO 11665 – Measurement of radioactivity in the environment – Air: radon-222

- Part 1: Origins of radon and its short-lived decay products and associated measurement methods
- Part 2: Integrated measurement methods for determining average potential alpha energy concentration of its short-lived decay products.
- Part 3: Spot measurement methods of potential alpha energy concentrations of its short-lived decay products
- **Part 4: Integrated measurement method for determining average activity concentration using passive sampling and delayed analysis.**
- Part 5: Continuous measurement method of the activity concentration
- Part 6: Spot measurement method of the activity concentration
- Part 7: Accumulation method for estimating surface exhalation rate
- **Part 8: Methodologies for initial and additional investigations in buildings**

ISO standards gamma ray spec

ISO 20042:2019 Measurement of radioactivity -- Gamma-ray emitting radionuclides -- Generic test method using gamma-ray spectrometry

ISO 18589-3:2023 Measurement of radioactivity in the environment — Soil — Part 3: Test method of gamma-emitting radionuclides using gamma-ray spectrometry

ISO 19581:2017 Measurement of radioactivity -- Gamma emitting radionuclides -- Rapid screening method using scintillation detector gamma-ray spectrometry

IEC 60846-1:2009 Radiation protection instrumentation - Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation - Part 1: Portable workplace and environmental meters and monitors

IEC 60846-2:2015 Radiation protection instrumentation - Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation - Part 2: High range beta and photon dose and dose rate portable instruments for emergency radiation protection purposes

Methodology: ISO guideline GUM

How?

- Identify individual components of uncertainty
- Quantify

Individual components Type A

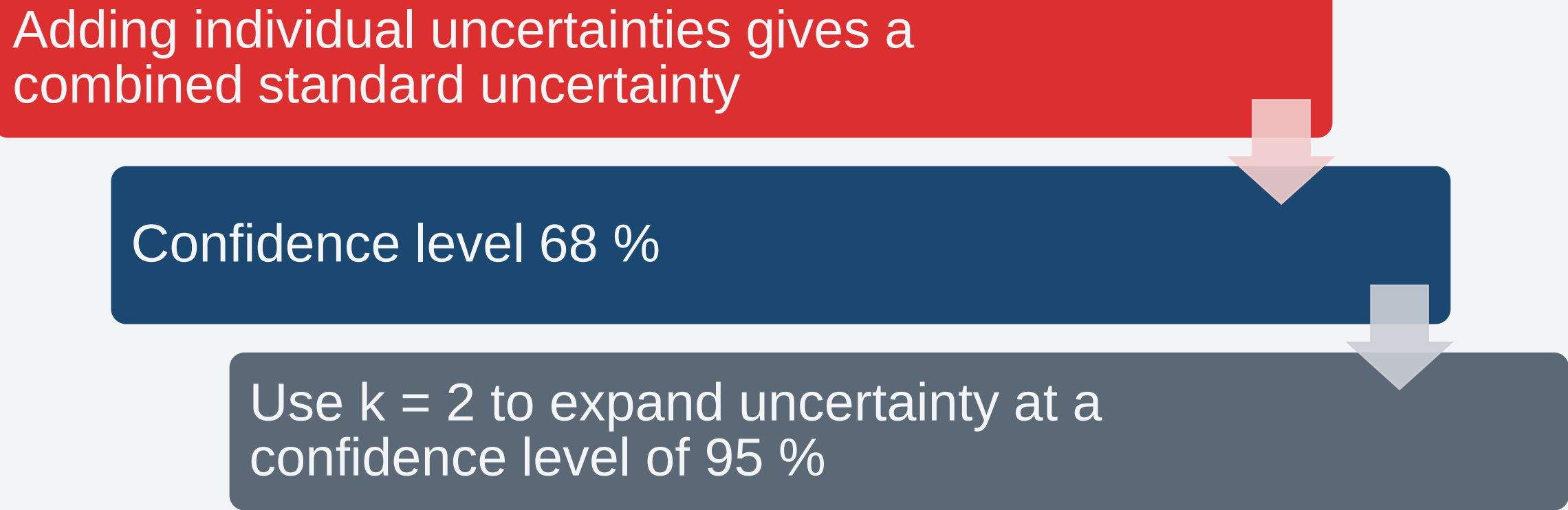
- those that are evaluated by statistical methods

Individual components Type B

- evaluated by other means such as the uncertainty quoted on a calibration certificate

Methodology: ISO guideline GUM

Adding individual uncertainties gives a combined standard uncertainty



```
graph TD; A[Adding individual uncertainties gives a combined standard uncertainty] --> B[Confidence level 68 %]; B --> C[Use k = 2 to expand uncertainty at a confidence level of 95 %];
```

Confidence level 68 %

Use $k = 2$ to expand uncertainty at a confidence level of 95 %

standards

Accreditation ISO 17025

challenges

ISO 17025 accreditation

Why do we need it?



Let's compare accreditation and NON-accreditation

Accreditation

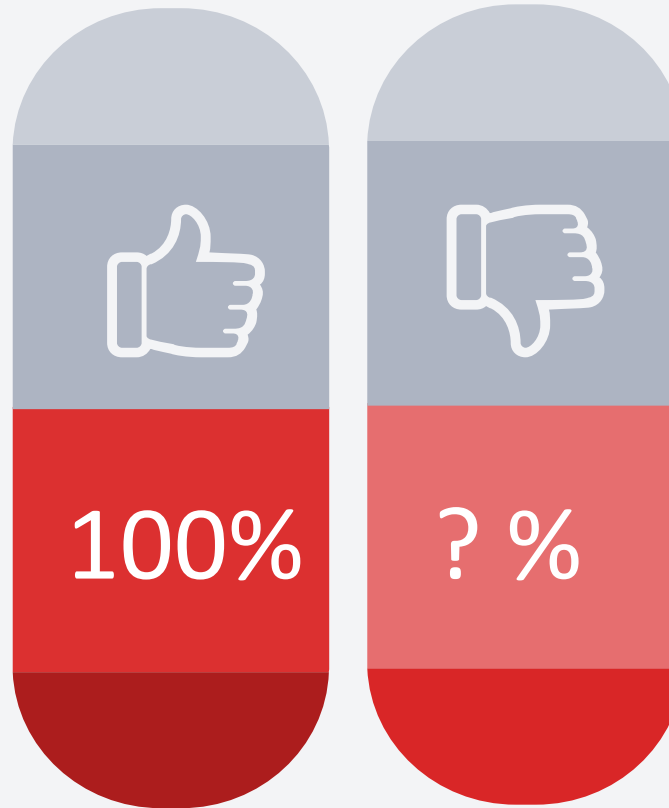
Competent staff

Necessary equipment and facilities

Equipment calibrated and maintained

Tests using validated procedures

STRICT QUALITY CONTROL



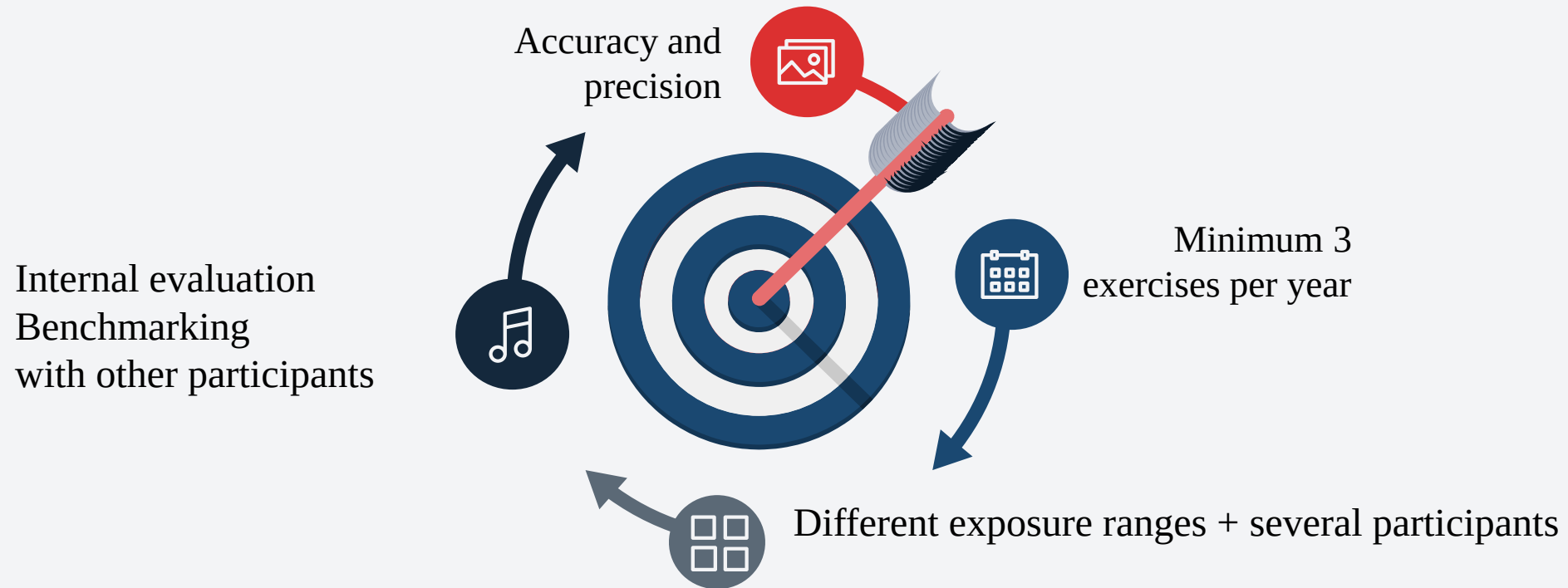
NO accreditation

...

Radon inter-comparisons

Radon Reference Chambers: BfS (Germany); SUPSI (Switzerland); PHE (UK); SURO (Czech Republic)

Proficiency test radon measurement

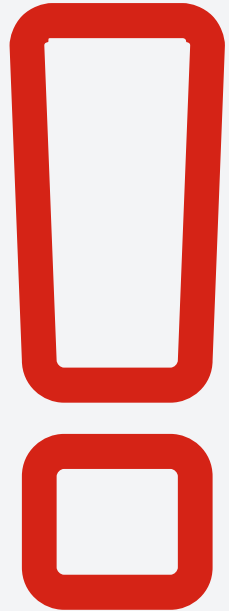


Advantages of laboratories with accredited services



TRACEABILITY

DO NOT forget



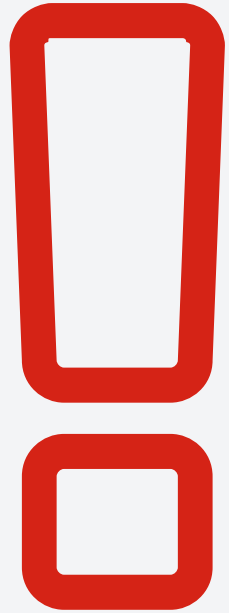
It is the test procedure that is
accredited



Laboratory is NOT accredited



DO NOT forget



European Data Protection Directive

on ISO 17025

challenges

final remarks and

Radon, 'From Rock to Risk' – The geogenic compartment

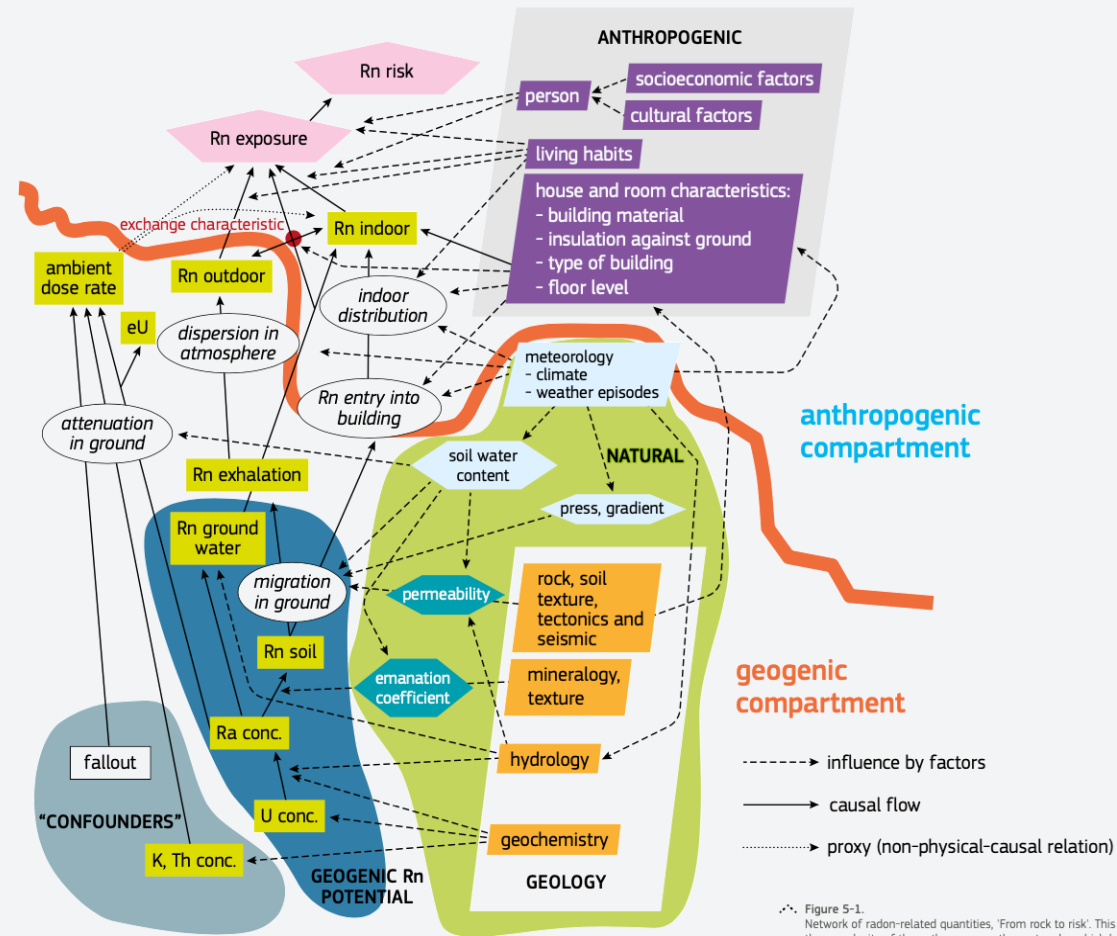


Figure 5-1.
Network of radon-related quantities, 'From rock to risk'. This graph intends to visualise the complexity of the pathway - or rather network - which leads from radon sources (ultimately uranium in the ground) to the risk which is caused by radon, controlled by many factors and interactions. These are of many kinds, essentially natural and anthropogenic factors. They act on all levels of the network with different strength, again controlled by other factors.
Source: Graph created by Peter Bossew.

European Commission, Joint Research Centre – Cinelli, G., De Cort, M. & Tollefsen, T. (Eds.), *European Atlas of Natural Radiation*, Publication Office of the European Union, Luxembourg, 2019.

HBRAs: hazard vs risk

- Spatial contrasts between geogenic radon hazard and collective radon risk.
- Majority of affected buildings in Germany located outside of geogenic hazard areas.
- Focusing only on high-radon buildings in hazard areas is inefficient for reducing collective risk.

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Radon hazard vs. radon risk - On the effectiveness of radon priority areas

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Hazard
Risk
Residential buildings
Lung cancer

ABSTRACT

The detrimental health effects of radon have been acknowledged by national and international legislation such as the European Union Basic Safety Standards (EURATOM-BSS Article 103/3) which requires member states to delineate radon priority areas. These radon priority areas are conventionally based on the concept of hazard by using indoor radon concentration or geogenic radon potential for its delineation. While this approach is efficient for finding many affected buildings with limited resources and, hence, reducing the individual risk, it is probably inefficient for reducing the collective risk if hazard and risk areas differ. In this study we map collective radon risk for Germany by linking information of geogenic radon hazard with exposure (residential building stock). The resulting map of affected residential buildings reveals distinct spatial contrasts compared to the hazard-based map. Further, an analysis based on hypothetical hazard zones elucidates that in Germany the vast majority of affected buildings (i.e., above threshold concentration) are located outside of areas of high and very high hazard. Consequently, in Germany, a radon policy focusing on areas of very high hazard only and within these areas on high concentration buildings only would presumably have no significant effect on the reduction of the total number of radon attributable lung cancer fatalities, i.e. less than 1% of annual radon attributable lung cancer fatalities. We conclude that for reducing the collective risk significantly, also complementary measures are of particular relevance.



HBRAAs: TGDR challenges

Uncertainties

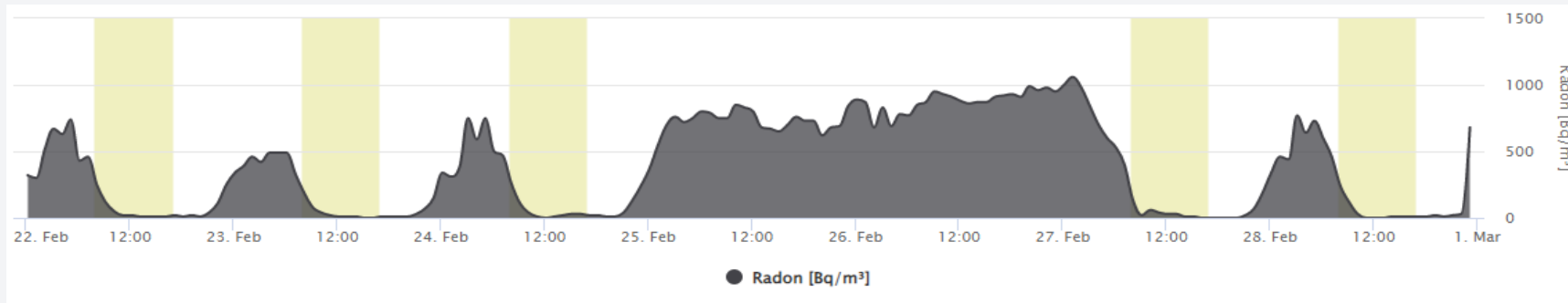
- Raw values are not always comparable: station and monitor level
- Homogenization of data processing

Mapping issues

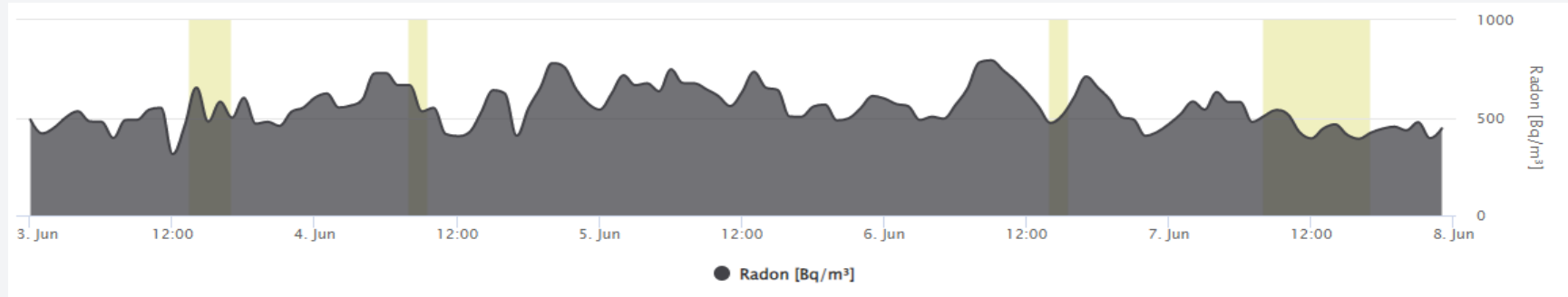
- Methodologically different data
- Area samples

Remote sensing

Variations of radon levels: **Workplaces**



Example – preschool with time-controlled mechanical ventilation

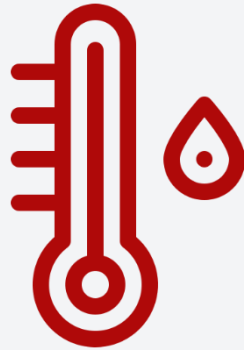


Example church with natural ventilation

What's the reason for variations on **Rn** concentration levels?



Pressure
Gradients



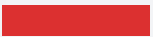
Temperature
Gradients



Weather
Conditions



Ventilation
Patterns



Big challenge: ISO standard on how to characterize HBRA? (Rn: 11665-8 Methodologies for initial and additional investigations in buildings)

Radon in soil

Final remarks and takeaways

1

How to measure TGDR and radon gas?
We have the tools

2

ISO standards help to compare results all
around the world

3

Accreditation ISO 17025 is important to
show evidence of good practices

4

Accreditation ISO 17025 is an important
investment on time and money for a
testing institution

5

Identified challenges: work in progress and
future

Thank you!

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