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The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Metro RADON

AN INTRODUCTION TO THE METRORADON PROJECT METROLOGY FOR RADON MONITORING

H. Wiedner, on behalf of the MetroRadon consortium

BEV - Bundesamt für Eich- und Vermessungswesen

BEV Bundesamt für Eich- und Vermessungswesen

EURADOS Winter School – 14 February 2019

The MetroRADON Project

- Metrology research project: Radon monitoring
- Started 01 June 2017
- Duration: 3 years
- 17 European partner institutions
- EMPIR project
- Organised by EURAMET
- Co-funded by the European Union‘s Horizon 2020 programme and the EMPIR Participating States

EURAMET, as the Regional Metrology Organisation (RMO) of Europe, has 37 member countries. It leads cooperation of National Metrology Institutes (NMI) with nearly 6000 metrologists in the development of the European metrology infrastructure and services. It represents Europe in the international metrology forum of the CGPM (General Conference of Weights and Measures).

www.euramet.org

European Metrology Programme for Innovation and Research

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

part of Horizon 2020, the EU Framework Programme for Research and Innovation

EMPIR calls (2014 - 2020): total budget of 600 M € (300 M € from the participating states and up to 300 M € from the European Commission using Article 185 of the European Treaty)

EMPIR Joint Research Projects (JRPs) the EU's Grand Challenges in **Health, Energy, Environment and Industry**, and to progress fundamental measurement science

EMPIR Work Programme
Call Scope – Metrology for Environment (2016)

Document: P-PRG-GUI-033 Version: 1.0
Approved: EMPIR Committee 2015-12-01

This Call again focuses on metrological research to improve the quality of data to stimulate technological innovation, and to disseminate traceability to, and make traceable measurements in, the field. It also aims to underpin other environmental research initiatives through collaborative metrological research and development. It addresses both local environmental challenges such as those related to:

- contamination of water, air and soil
- radiation measurement and protection, and acoustic noise
- local pollutions and emissions measurements
- monitoring of key parameters to detect local climate evolution

and global metrological challenges for climate monitoring such as those related to:

- the essential climate variables of the atmosphere, land and water, including their constituents, contamination, transport and other parameters, and their time evolution and comparability
- emission control; measurement of gases and particles that have an effect on climate and health
- validated remote sensing data and products for environmental and climate monitoring, taking into account ground based instrumentation networks
- measurements in extreme environments and challenging conditions

Needs for the project

- ***European Council Directive 2013/59/EURATOM (EU-BSS)***

- The EU member states
  - are required to ensure that levels of relevant activity concentration laid down in the EU-BSS do not exceed 300 Bq/m^3
  - obliged to transpose the EU-BSS into national legislation by 2018
  - have to consider several items when preparing their national radon action plan
  - define approaches, data and criteria to be used for establishment of radon priority areas

- **Reliable calibration and measurement methods** of activity concentrations between about 100 Bq/m^3 and 300 Bq/m^3
- Significant improvement of the **metrological infrastructure** for calibrations in Europe
- **Harmonisation** of radon concentration measurements
- Different methods to define the geogenic radon potential of an area need to be **compared and standardised**

Scope

- **EURATOM-BSS:**
  - requires developing Rn action plans whose aim is reduction of Rn exposure
  - includes, among other, reference values and delineation of Rn priority areas

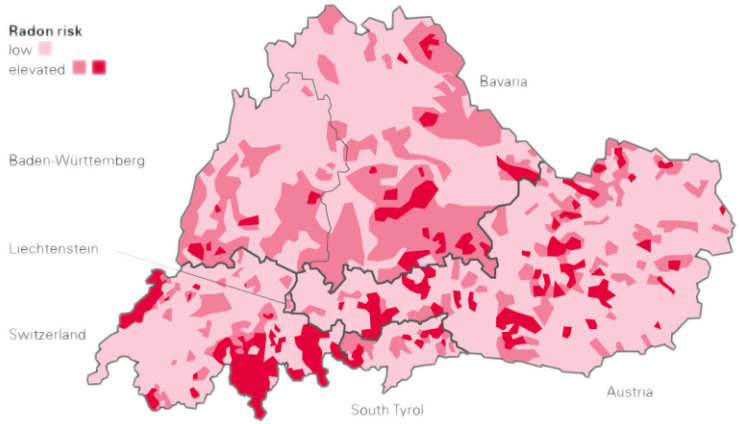
- **This implies QA**, in, among other:
  - measuring Rn (+Tn) concentrations incl. calibration in order to be able to verify **compliance with reference levels**;
  - methodology of determination of quantities which serve as geogenic **radon potential** or its proxies;
  - methodology of determination of **radon priority areas**.

Put together:

QA of “consumer end products” (compliance with rules, assignment of areas to degree of Rn priority, etc.) implies QA of the “supply chain” which leads to them (calibration, measurement etc.)

Main goals of the JRP

- Creation of a **coordinated metrological infrastructure** for radon monitoring and radon mapping in Europe suitable for the requirements of the **radon action plan** requested by the new European Directive
- Enable **SI traceable monitoring** of radon at low radon activity concentrations (≤ 300 Bq/m³), including calibration and radon mapping, essentially facilitating the **harmonised implementation of the new EU-BSS in Europe**
- Investigation of the **influence of thoron** on radon measurements and calibrations
- **Harmonisation** of indoor radon and soil exhalation radon measurements
- Development of new methodologies for identification and characterization of radon priority areas in Europe



Relative radon risk map of Austria, Liechtenstein, Switzerland and parts of Germany and Italy.
Source: Swiss Confederation

Work beyond the state of the art

- A **traceability validation of existing European radon calibration facilities** will be performed. At present, secondary standards are calibrated at relatively high activity and are not adequately traceable to one primary radon gas standard
- The JRP will carry out **traceable inter-comparisons** on the quantities surface soil radon exhalation rate and radon concentrations in soil gas
- **Development of a unified index of geogenic Rn hazard:** consistent picture of susceptibility to geogenic Rn across Europe
- As a novelty, **methods for retrospective radon measurement by compact discs (CDs) and DVDs will be evaluated** for their potential to define radon priority areas.
- **New techniques** for measurement of radon exhalation from soil based on liquid scintillation counting of polymers and track-etching of CDs for indoor air retrospective radon measurement will be developed and evaluated
- **Evaluation of the sensitivity of radon monitors and detectors to thoron** with traceability to a primary thoron standard

Impact

- **Improvement of radiation protection and public health** due to reliable radon measurements as a basis for effective radon risk mitigation and prevention against radon progeny induced lung cancer in Europe and, therefore, **decreasing the lung cancer risk due to radon in Europe**
- The JRP will help to **establish** a basic European **metrological infrastructure** so that sound monitoring of radon becomes possible
- Provision of **harmonised metrological standards** for radon monitoring and radon protection in Europe, thus allowing comparison and merging of data sets
- **Provision of reliable radon mapping** methods for the **delineation of potential radon priority areas** in Europe
- **Enhance competitiveness of European building industry**
- **Coordination** of European calibration facilities regarding knowledge exchange
- **Development of the lead of European metrological facilities** in low-level radon monitoring and air-borne radon activity concentrations measurements
- **Development of advanced radon instrumentation**, resulting in a world-wide technological lead of European manufacturers

Internal funded partners

National Metrology Institutes and Designated Institutes, from countries that have made a financial commitment to the Programme

no.	Participant Type	Short Name	Organisation legal full name	Country
1	Internal Funded Partner	BEV-PTP	Physikalisch-Technischer Pruefdienst des Bundesamt fuer Eich- und Vermessungswesen	Austria
2	Internal Funded Partner	BFKH	Budapest Főváros Kormányhivatala	Hungary
3	Internal Funded Partner	CEA	Commissariat à l'énergie atomique et aux énergies alternatives	France
4	Internal Funded Partner	CMI	Cesky Metrologicky Institut	Czech Republic
5	Internal Funded Partner	IFIN-HH	Institutul National de Cercetare-Dezvoltare pentru Fizica si Inginerie Nucleara "Horia Hulubei"	Romania
6	Internal Funded Partner	PTB	Physikalisch-Technische Bundesanstalt	Germany
7	Internal Funded Partner	STUK	Sateilyturvakeskus	Finland
8	Internal Funded Partner	VINS	Institut Za Nuklearne Nauke Vinca	Serbia

External funded and unfunded partners

External funded partners: All other legal entities established in:

- The Member States of the European Union, including their overseas departments
- The Overseas Countries and Territories (OCT) linked to Member States
- The countries automatically eligible for Horizon 2020 funding
- The countries associated to Horizon 2020

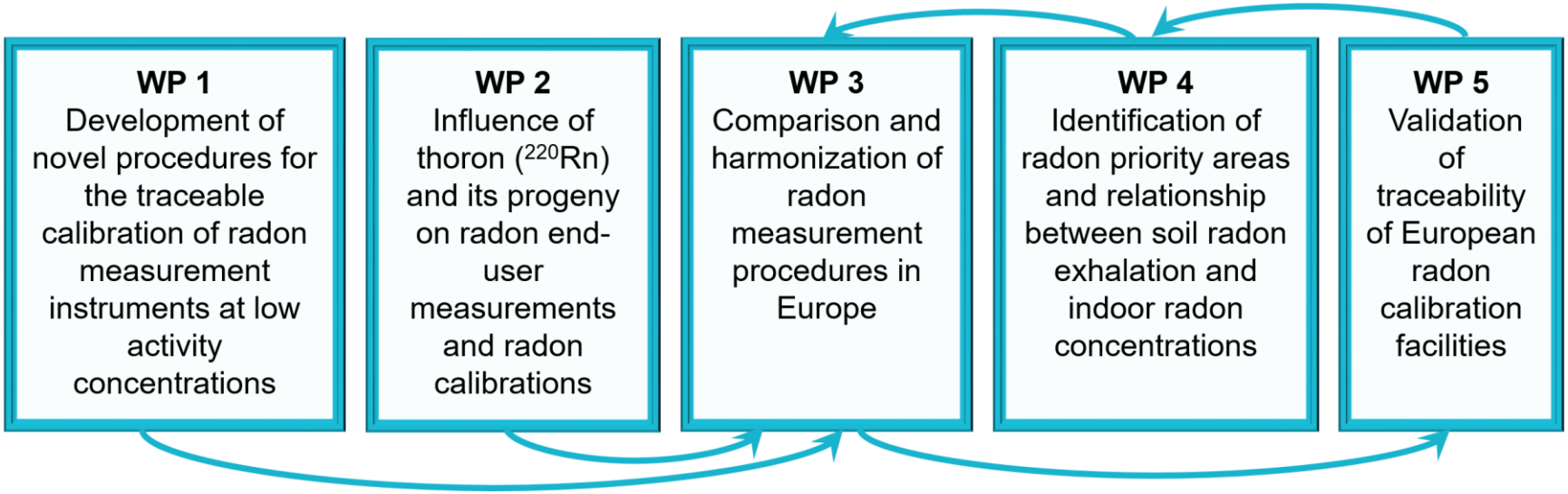
9	External Funded Partner	AGES	Oesterreichische Agentur fuer Gesundheit und Ernaehrungssicherheit GmbH	Austria
10	External Funded Partner	BfS	Bundesamt fuer Strahlenschutz	Germany
11	External Funded Partner	CLOR	Centralne Laboratorium Ochrony Radiologicznej	Poland
12	External Funded Partner	IRSN	Institut de Radioprotection et de Surete Nucleaire	France
13	External Funded Partner	JRC	JRC - Joint Research Centre - European Commission	European Commission
14	External Funded Partner	SUBG	Sofiiski Universitet Sveti Kliment Ohridski	Bulgaria
15	External Funded Partner	SUJCHBO	Státní ústav jaderné, chemické a biologické ochrany, v.v.i.	Czech Republic
16	External Funded Partner	UC	Universidad De Cantabria	Spain
17	Unfunded Partner	METAS	Eidgenössisches Institut für Metrologie METAS	Switzerland

The MetroRADON Consortium

MetroRADON – main objectives

- Novel procedures for the **traceable calibration** of radon (^{222}Rn) measurement instruments from 100 Bq/m^3 to 300 Bq/m^3 with **relative uncertainties ≤ 5 %** (k = 1)
- New radioactive **reference sources** with stable and known radon emanation rates
- **Influence of thoron (^{220}Rn) and its progeny on radon end-user measurements** and radon calibrations
- **Comparison of existing radon measurement procedures in different European countries**
- **Optimisation the consistency of indoor radon measurements and soil radon exhalation rate** measurements across Europe
- Analysis and development of methodologies for the **identification of radon priority areas**
- Development of the **concept of a Radon Hazard Index** (RHI)
- Relationship between **soil radon exhalation** rates and **indoor radon concentrations**
- Validation of the **traceability of European radon calibration facilities**
- To publish **guidelines and recommendations** on metrologically sound calibration and
- Measurement procedures for the determination of **radon concentration in air**

MetroRADON Work Package Structure



WP 1

Development of novel procedures for the traceable calibration of radon (^{222}Rn) measurement instruments at low activity concentrations (100 Bq/m^3 to 300 Bq/m^3) with relative uncertainties ≤ 5 % (k=1)

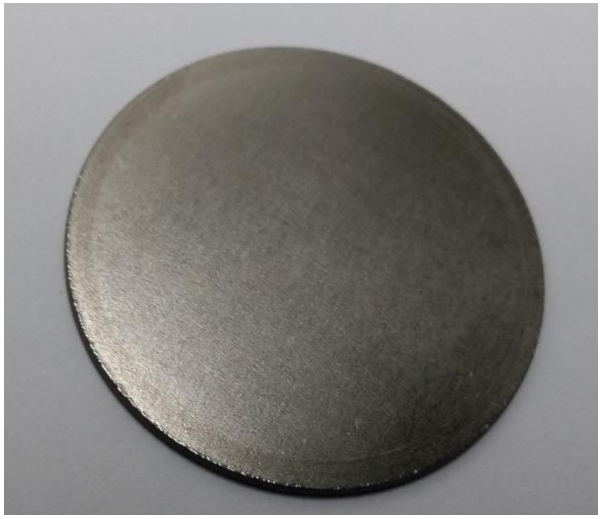
- Task 1.1: Development of new ^{222}Rn and ^{220}Rn radioactive reference sources with stable and known radon emanation capacity
- Task 1.2: Comparison of existing radon gas primary standards at European NMIs/DIs in the few kBq range
  - According to CCRI(II) rules
  - Starting soon – register until end of February for participation
- Task 1.3: Establishment of constant ^{222}Rn radon activity concentrations in reference chambers and calibration of radon measurement instruments

First Results – Design of new sources

Flow-through source, CMI

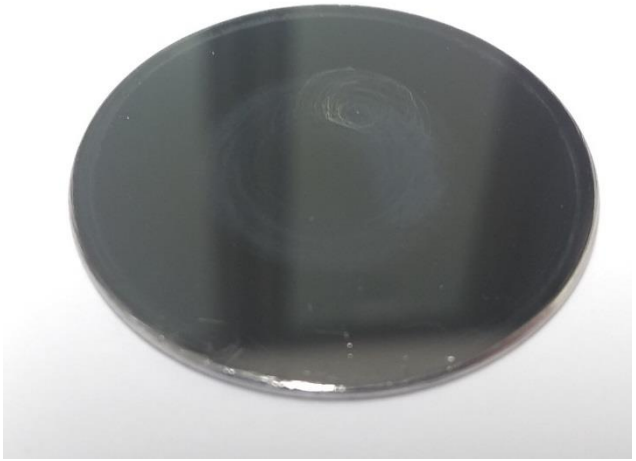
Implanted Source, PTB

Implantation of mass-resolved Ra-226 at 30 keV into W and Al



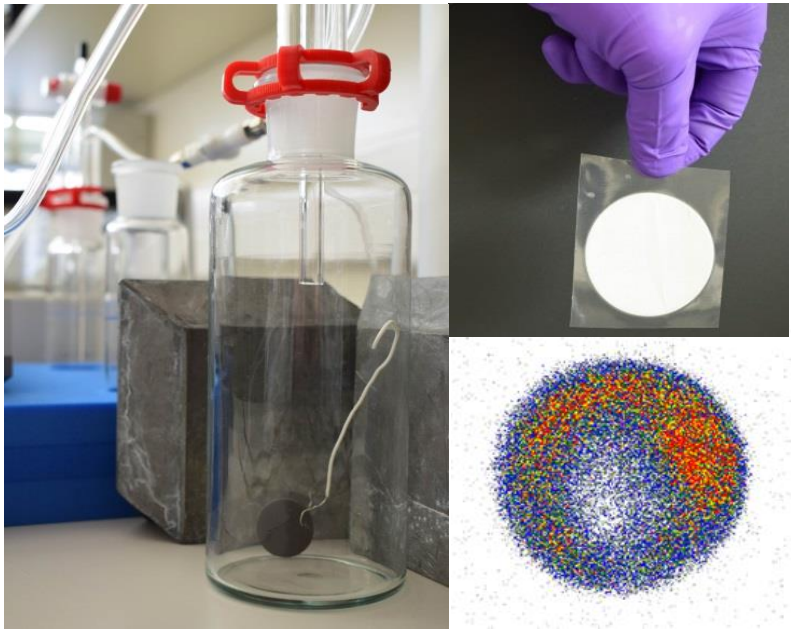
Electrodeposited Source, PTB

Deposition at
30 V < U < 200 V

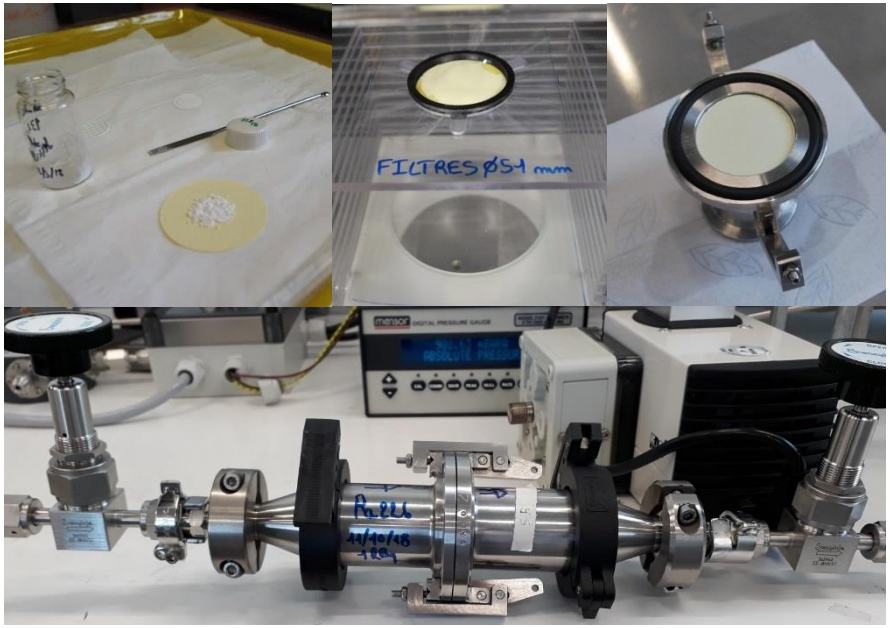


First Results – Design of new sources

Chemisorption, JRC

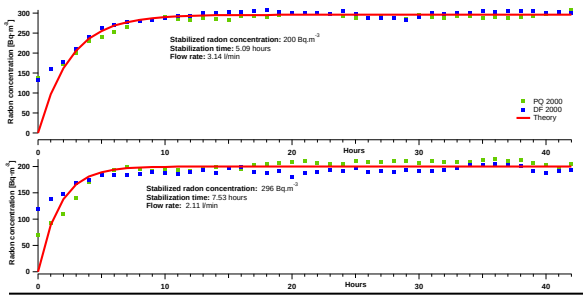


^{220}Rn flow-through source, CEA



First Results – Use of new sources

- Installed in radon chambers
- Establishment of constant and traceable ^{222}Rn activity concentrations
- Evaluation of
  - stability and reproducibility of atmospheres under environmental conditions
  - stable and repeatable radon atmospheres in the range between 100 Bq/m³ and 300 Bq/m³
- Goal: Development of novel traceable calibration procedures



WP 2

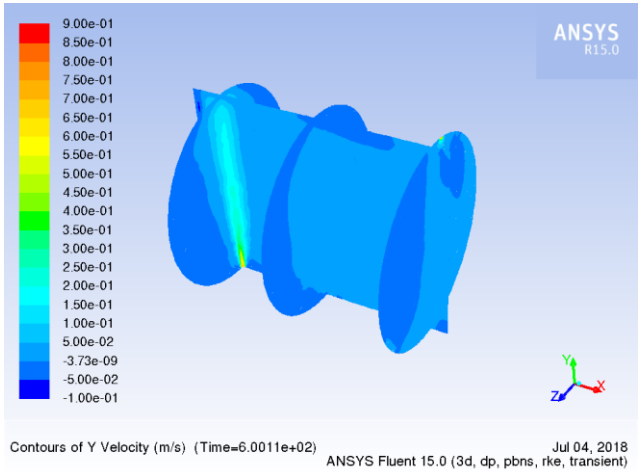
Influence of thoron (^{220}Rn) and its progeny on radon end-user measurements and radon calibrations

- Task 2.1: Ensuring traceability of the secondary thoron reference instruments used in the experimental research to the primary thoron measurement system at IRSN

- Task 2.2: Investigation of the influence of thoron on radon measurements and calibrations
  - because Tn can introduce errors in Rn determination in certain techniques

- Task 2.3: Development of techniques to reduce the influence of thoron on radon measurements and calibrations

First Results – Homogeneity testing of thoron atmosphere



Numerical Modelling

ANSYS package v. 15 to 18
Geometry : SPACECLAIM
Mesh : Meshing
Flow solver : FLUENT

LSC of aerogel

SSNTDs of LR-115/II

Accepted abstract ICRM'19

METHODS FOR EXPERIMENTAL STUDY OF HOMOGENITY IN ^{220}RN CALIBRATIONS

K. Mitev[1,*], P. Cassette[2], D. Pressyanov[1], S. Georgiev[1], Ch. Dutsov[1], N. Michielsen[3], B. Sabot[2]

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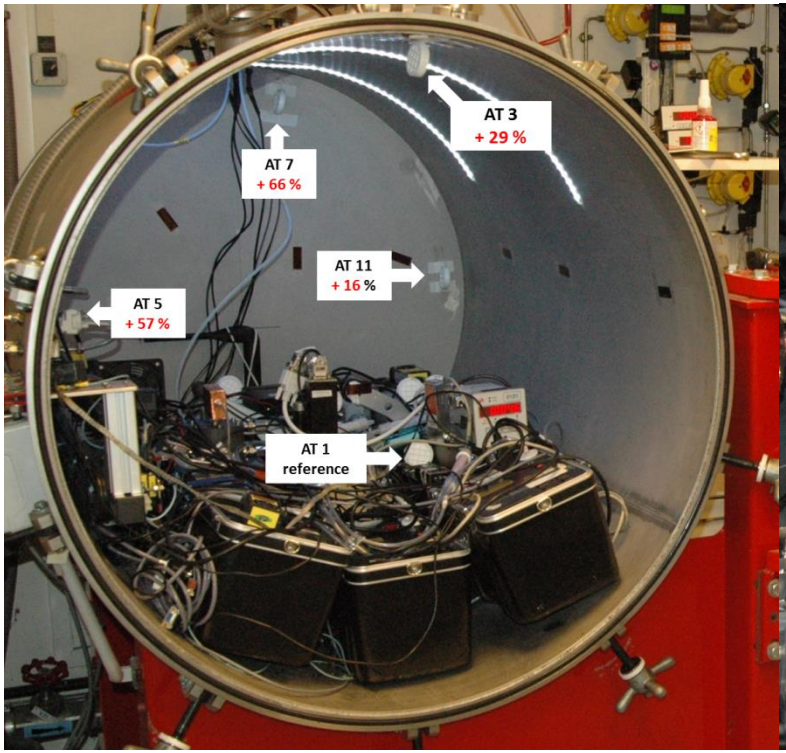
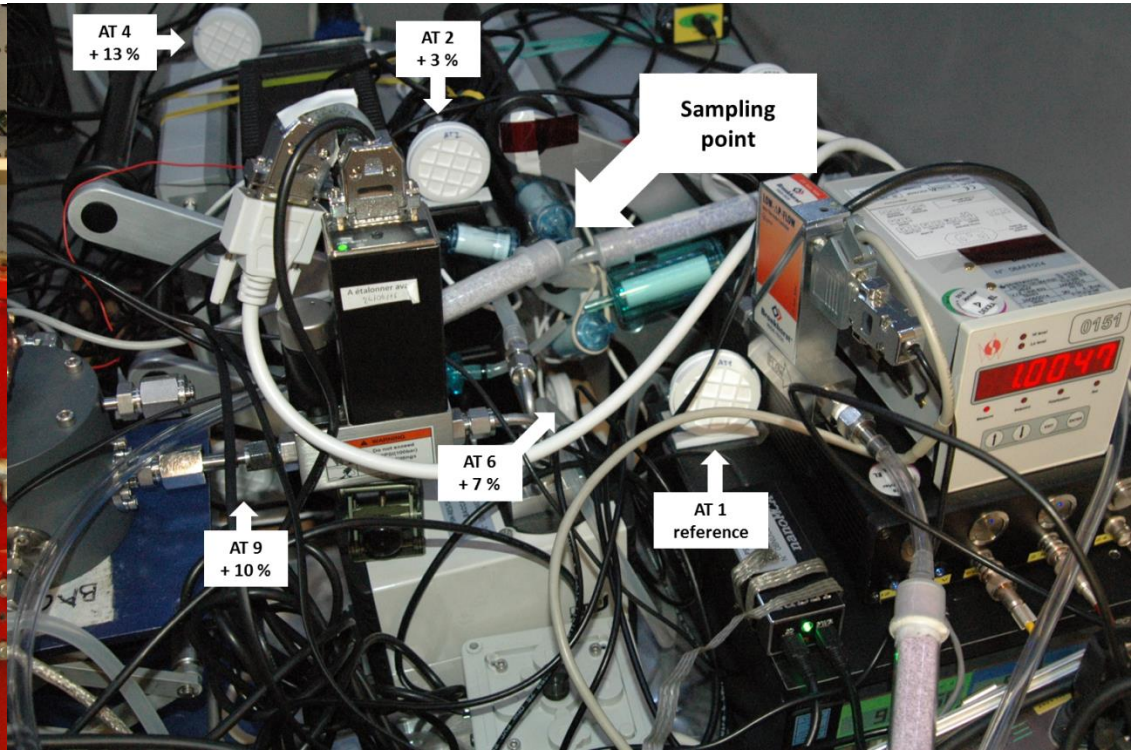
[2] *CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), 91191 Gif-sur-Yvette Cedex, France*
[3] *Institut de Radioprotection et de Sûreté Nucléaire (IRSN), 92262 Fontenay aux Roses, France*

Keywords: Thoron calibration, thoron homogeneity, LSC, nuclear track detectors

First Results – Calibration of radon/thoron monitors



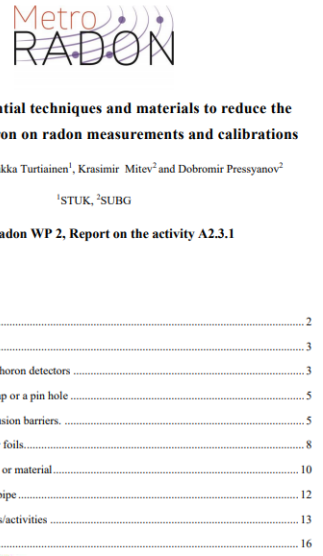


The ratio between the thoron activity concentrations and the reference activity concentration have been found close to one for the AlphaGUARD and around 0.6 for the RAD7.

First Results – Field measurements to assess influence of thoron

First Results – Testing of thoron barriers

- Review of more than 60 scientific/technical publications to identify main methods to discriminate thoron →Report available on MetroRADON website
- Criterion for selection of thoron barriers in terms of “transmission factor” (R):
  R(thoron) << 1; R(radon) ≈ 1
- R of polymer foils can be significantly dependent on the temperature
- Quantitative data obtained for 11 polymeric materials



Review of potential techniques and materials to reduce the influence of thoron on radon measurements and calibrations

Olli Holmgren[1], Tuukka Turtiainen[1], Krasimir Mitev[2] and Dobromir Pressyanov[2]

[1]STUK, [2]SUBG

MetroRadon WP 2, Report on the activity A2.3.1

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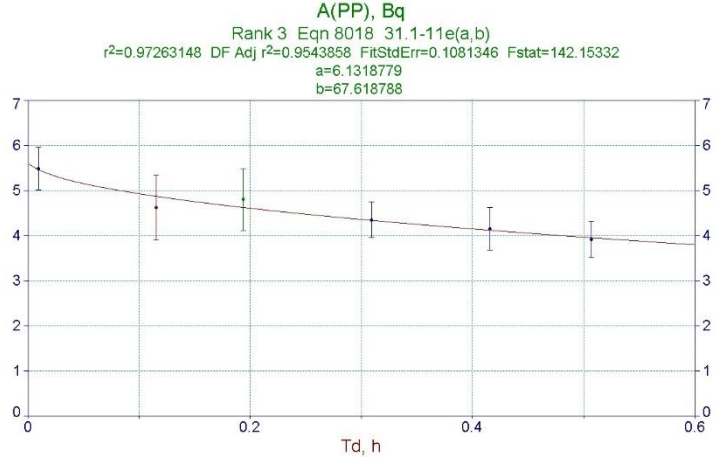


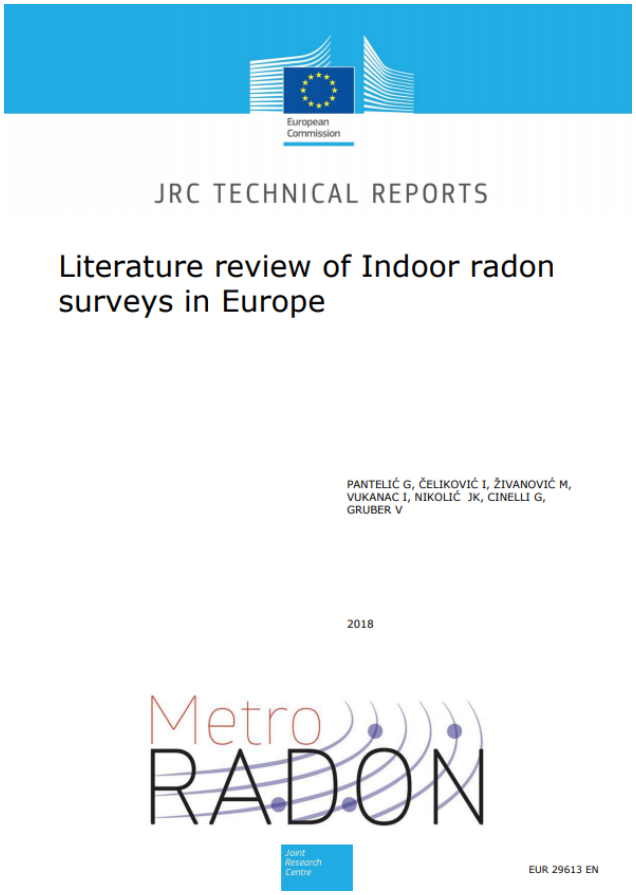
WP 3

Comparison and harmonisation of radon measurement methodologies in Europe

- Task 3.1: Overview and analysis of indoor radon surveys in Europe
- Task 3.2: Overview and analysis of geogenic radon surveys in Europe
- Task 3.3: Comparison of indoor radon and geogenic radon measurements under field conditions - different protocols and procedures exist
- Task 3.4: Development of options for harmonisation of indoor and geogenic radon data including practical examples to ensure comparability between data generated following different methodology

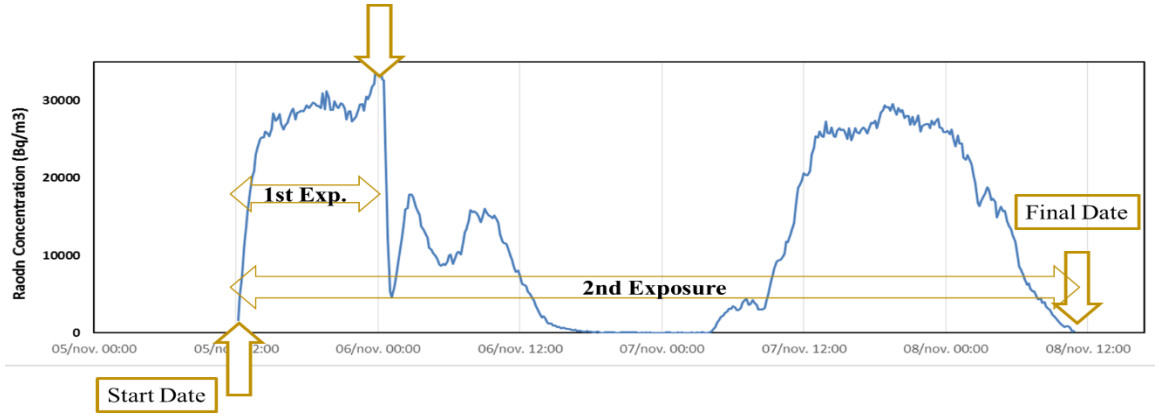
First Results – Analysis of indoor radon surveys in Europe

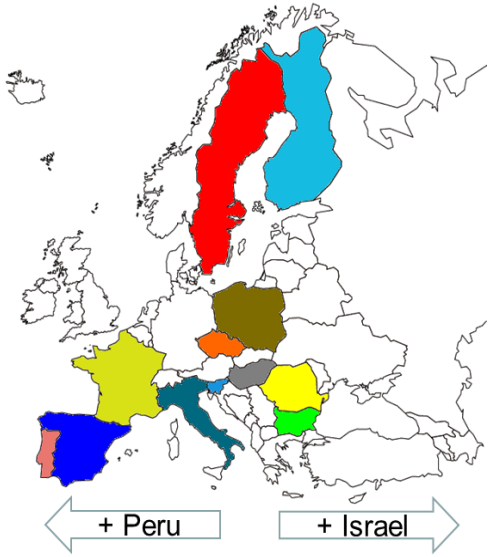
- Literature review of Indoor radon surveys in Europe published as JRC Technical Report
- Questionnaires on indoor and geogenic radon surveys – results available soon!



First Results – Intercomparison Exercise

- Radon exposure in air for active and passive Rn detectors
- Radon in soil and radon exhalation from soil
- Maximum participants reached
- Results available soon!





WP 4

Radon priority areas (RPAs) and the development of the concept of a "geogenic radon hazard index" (RHI)

- Task 4.1: Evaluation of the concepts for the definitions of radon priority areas
  - different concepts have been proposed and partly implemented

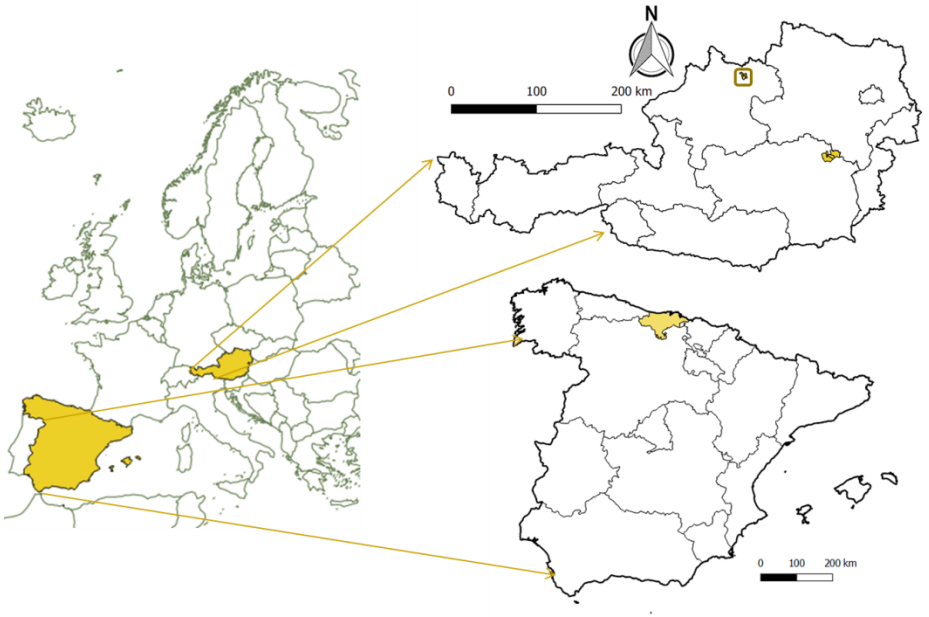
- Task 4.2: Relationship between indoor radon concentration and geogenic radon
  - as a base to classify Rn priority areas based on geogenic quanities

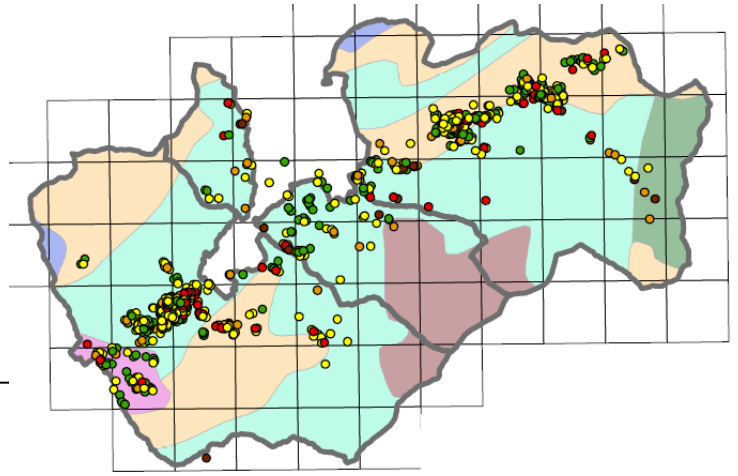
- Task 4.3: New developments in estimation of radon priority areas
  - performance of CDs for measurement of geogenic Rn, classification questions, uncertainty etc.

- Task 4.4: Harmonisation of radon priority areas across borders
  - how to deal with inconsistencies resulting from different Rn priority area definitions

First Results – Radon Mapping Exercise

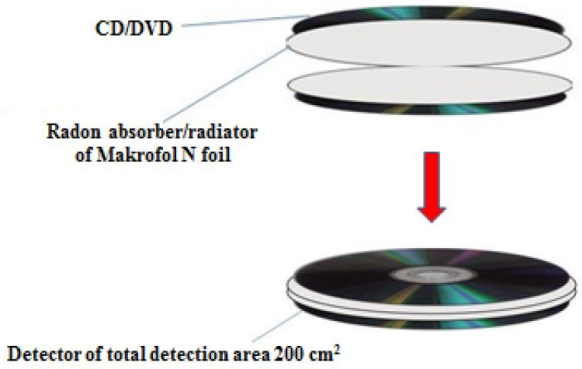
- Each participant applied their usual methodology for the identification of radon priority areas
- 6 participants
- Results available soon!





First Results – CDs/DVDs as radon detectors

- Use of CDs/DVDs as (retrospective) radon detectors
- Long-term exposure of CDs started in September 2017
- Measured range ^{222}Rn concentration range:
  < 10 Bq/m^3 – 147 300 Bq/m^3
- Development of modified detector using Makrofol N



WP 5

Validation of traceability of European radon calibration facilities

- Task 5.1: Selection and evaluation of European radon calibration facilities for validation of traceability

- Task 5.2: Validation of traceability, performance and precision of European radon calibration facilities in the range from 300 Bq/m3 to 10 000 Bq/m³

- Task 5.3: Validation of traceability of European radon calibration facilities at stable radon atmospheres in the range from 100 Bq/m³ to 300 Bq/m³

First Results – Intercomparison exercise

- Questionnaire for identification and evaluation of European radon calibration facilities
- Validation Exercise in the range from 300 Bq/m³ – 10 000 Bq/m³ ongoing
  - Calibration at 400 Bq/m³, 1 000 Bq/m³ and 6 000 Bq/m³
  - AlphaGUARD reference instrument sent to all participants to perform calibration
  - Institutes use their usual calibration methods

PART 1/2: LABORATORY

Address, tel. no. and e-mail, scientists/operators, contact person:

What is the legal form of your laboratory or the superior organization to which your laboratory belongs? (e.g. national metrological institution, state authority (other than national metrological institution), other public-law organization, private organization)

In case of a public-law or private organization:
What is the main business field (e.g. education and training, environmental protection, public health, occupational health and safety)?

Are calibration procedures accredited by some institution? ☐ Yes ☐ No

If yes: *Which institution is it?*

Is your accreditation built on the requirements according to standard ISO/IEC 17025, ISO/IEC 9000, or both?

Please specify the basis of your accreditation if none of these standards are applied.

What is the scope of your accreditation?

Please state the date of accreditation and your accreditation mark (code, number).

Please provide a copy of your calibration certificate and the scope of your accreditation. (If both are available via internet, a reference is sufficient.)

Would you like to participate in validation of traceability of European radon calibration facilities performed within the project MetroRADON? ☐ Yes ☐ No

Other comments:

WP 6: Creating Impact

Task 6.1 Knowledge transfer
Task 6.2 Training
Task 6.3 Uptake and exploitation

Improvement of radiation protection and public health

- establishment of a basic European metrological infrastructure
- improved coordination of European calibration facilities
- harmonized metrological standards for radon monitoring and radon protection
- reliable radon mapping methods for the delineation of potential radon priority areas
- enhance competitiveness of European building industry
- development of European metrological facilities in low-level radon monitoring and air-borne radon activity concentrations measurements
- development of advanced radon instrumentation, resulting in a world-wide technological lead of European manufacturers

End users: regulators, radiological protection bodies and policy makers

standards developing organisations: ISO/TC45, CEN/TC351, ISO/TC85, CENELEC/TC 45, IAEA

accredited **laboratories** and instrumentation **manufacturers**

First results

- At least 10 conference presentations – already 28 presentations held!
- At least 10 peer reviewed papers – 1 paper published, several in the submission/preparation stage

- Several workshops for interested stakeholders planned in the last 6 months of the project (December 2019 – May 2020)

You are invited to collaborate or to follow the project

hannah.wiedner@bev.gv.at

www.metroradon.eu

Register for the project newsletter on our website

ResearchGate:

MetroRADON - Metrology for Radon Monitoring (EMPIR 16ENV10)

F. J. Maringer · Philippe Cassette · Nathalie Michielsen · Show all 41 collaborators

Goal: 1. Development of novel procedures for the traceable calibration of radon (222Rn) measurement instruments at low activity concentrations (100 Bq/m3 to 300 Bq/m3) with relative uncertainties ≤ 5 % (k=1)