# The Metro Radon project as support for the implementation of the EURATOM Basic Safety Standards

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INTERNATIONAL CONFERENCE ON RADIATION APPLICATIONS
In Physics, Chemistry, Biology, Medical Sciences, Engineering and Environmental Sciences
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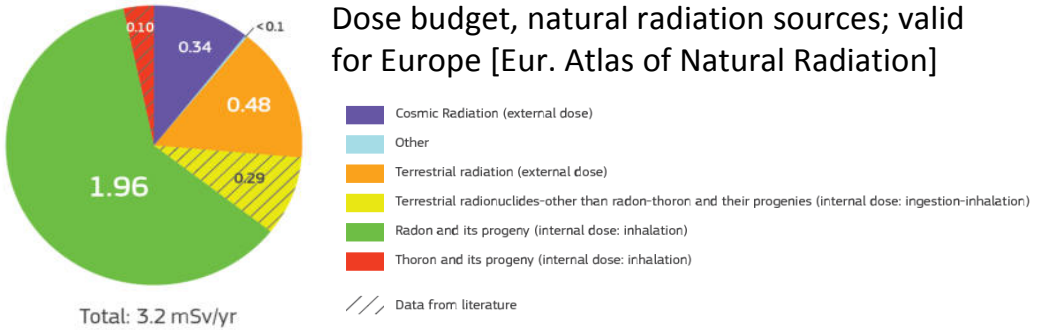
# Content

- **Motivation**
- **EURATOM-BSS**
- **Metro Radon: philosophy and structure**
- **Some results**

# Motivation

- Indoor radon: on average, most important contribution to dose from ionizing radiation




- Risk proven by epidemiological studies
  In Europe estimated about 62,000 lung cancer fatalities per year attributed to Rn [Gaskin et al., Envir. Health Perspectives 125, 5 (2018)].
- Consequence: Limit Rn exposure by regulations, where possible
- For EU: EURATOM Basic Safety Standards (BSS)
- Decisions in Rn policy to ensure compliance with BSS can be economically & politically costly → must be QAed
- Rely on technical steps from measurement to data evaluation, which must be QAed.
- Deficiencies identified → research projects to fill the gaps.

# EURATOM-BSS

**EURATOM Basic Safety Standards (BSS)**

Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2014:013:TOC (OJ L, 17.01.2014)


mandatory for EU member states (MS): has to be transposed into national law

**Articles dealing with Radon**

- Reference level (RL) = 300 Bq/m³ for workplaces (Art.54) and dwellings (Art.74).
- National Rn Action Plan (Art. 103): to be established by MS, to deal with Rn risk, considering annex XVIII; Rn prevention and RPA.
- Radon priority areas (RPA) (Art. 103) = areas where the annual mean Rn concentration is expected > RL in a significant number of buildings. RPAs to be identified. Motivated by priority principle.
- Art.54: Measurements in workplaces to be carried out in RPA in basement and ground floor room, and considering annex XVIII.
- Art.74: MS shall "promote action" to identify dwellings > RL and "encourage" remediation. MS shall ensure information about indoor Rn exposure, health risks, importance of measuring and possibilities for remediation.
- Revision, update acc. state of knowledge (Preamble 6&11)

Annex XVIII:

Details about Rn Action plan

- Priority principle (§6)
- Ensure administrative efficiency (§5,11,12)
- Indoor Rn survey and RPA methodology (§1,2)
- Identification of relevant workplaces (§3)
- Remediation and prevention (§7,8,11)
- Communication, information, public awareness (§10)
- Review of action plan (§9)

Long-term goal: reduction of lung cancer attributable to Rn

# Metro Radon - structure

*6/2017 – 5/2020, funded by EU Horizon 2020 programme; Organised by EURAMET (Regional Metrology Organisation of Europe); 350 person-months, 2.26 M€.*

**Structure of Metro Radon: 7 Work Packages (WPs)**

1. Novel procedures for traceable calibration of radon ($^{222}$Rn) measurement instruments at low concentrations = 100-300 Bq/m³, with <5% uncertainty (k=1).
   Reference sources, comparison of Rn gas standards, constant Rn conc. in reference chambers
2. Influence of thoron ($^{220}$Rn) on Rn measurement and calibration
3. Comparison and harmonization of Rn measurement procedures in Europe
   Meta-information about Eur. indoor & geogenic Rn surveys, intercomparisons exercises, problem of inconsistencies and possible harmonization
4. Radon priority areas (RPA)
   Definitions, estimation, uncertainty, relationship indoor – geogenic Rn, Rn extremes, geogenic Rn hazard index (GRHI), retrospective methods
5. Validation of traceability of European Rn calibration facilities
6. Creating impact
   Knowledge transfer, stakeholders, training
7. Management & coordination

Metro RADON

WP 1,2,5: classical metrology, WP 3+4: link to BSS requirements.

Details of WPs and WP tasks in http://metroradon.eu/

# Overall goals at end of project and beyond

**Main goal: QA in the chain**
**calibration → measurement → evaluation → Rn map → decision**

- WP 1: A metrological gap in Europe is closed by realizing traceable radon reference atmospheres in the activity concentration range from 100-300 Bq/m³, while minimising uncertainties.
- WP 2: Thoron/progenies sensitivity on radon monitors under real conditions and consequences for design of radon surveys are known and possible technical solutions to correct thoron related bias on radon monitors are available.
- WP 3: Overview of radon situation within EU MS and approaches to improve harmonisation of indoor and geogenic data that exist, to harmonise the radon protection standards of the EU citizens.
- WP 4: Methodologies to identify RPA are analysed and further developed to assist MS in the implementation of a quality assured delineation of RPA.
- WP 5: Information about the validation of traceability of the European radon calibration facilities and recommendations on calibration and measurement procedures exist.

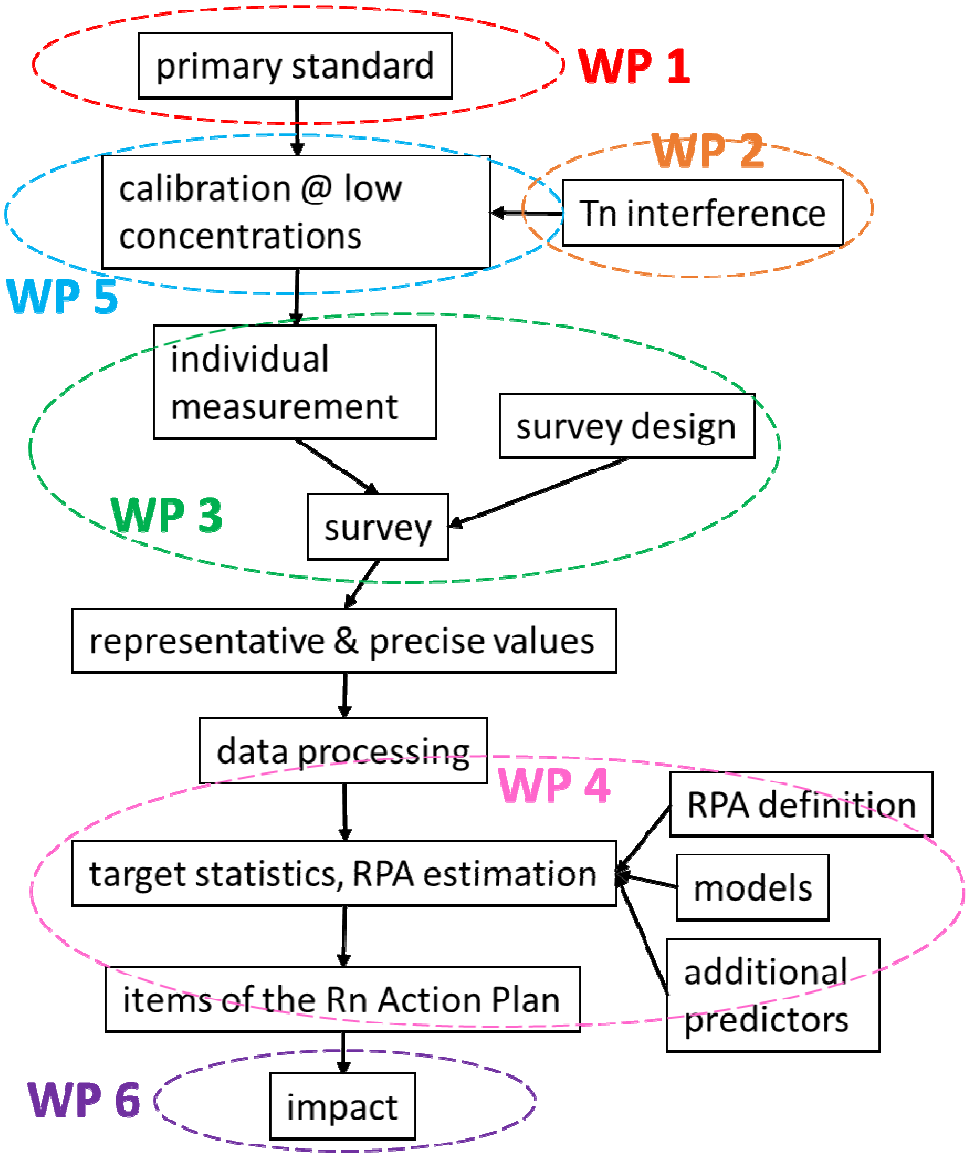
# Metro Radon rationale

"supply chain" which leads to a QAed "end product", e.g.,

- Decision about compliance with Reference Levels;
- Delineation of Radon Priority Areas satisfying a certain level of confidence;
- …
- general: Items of Rn Action Plan

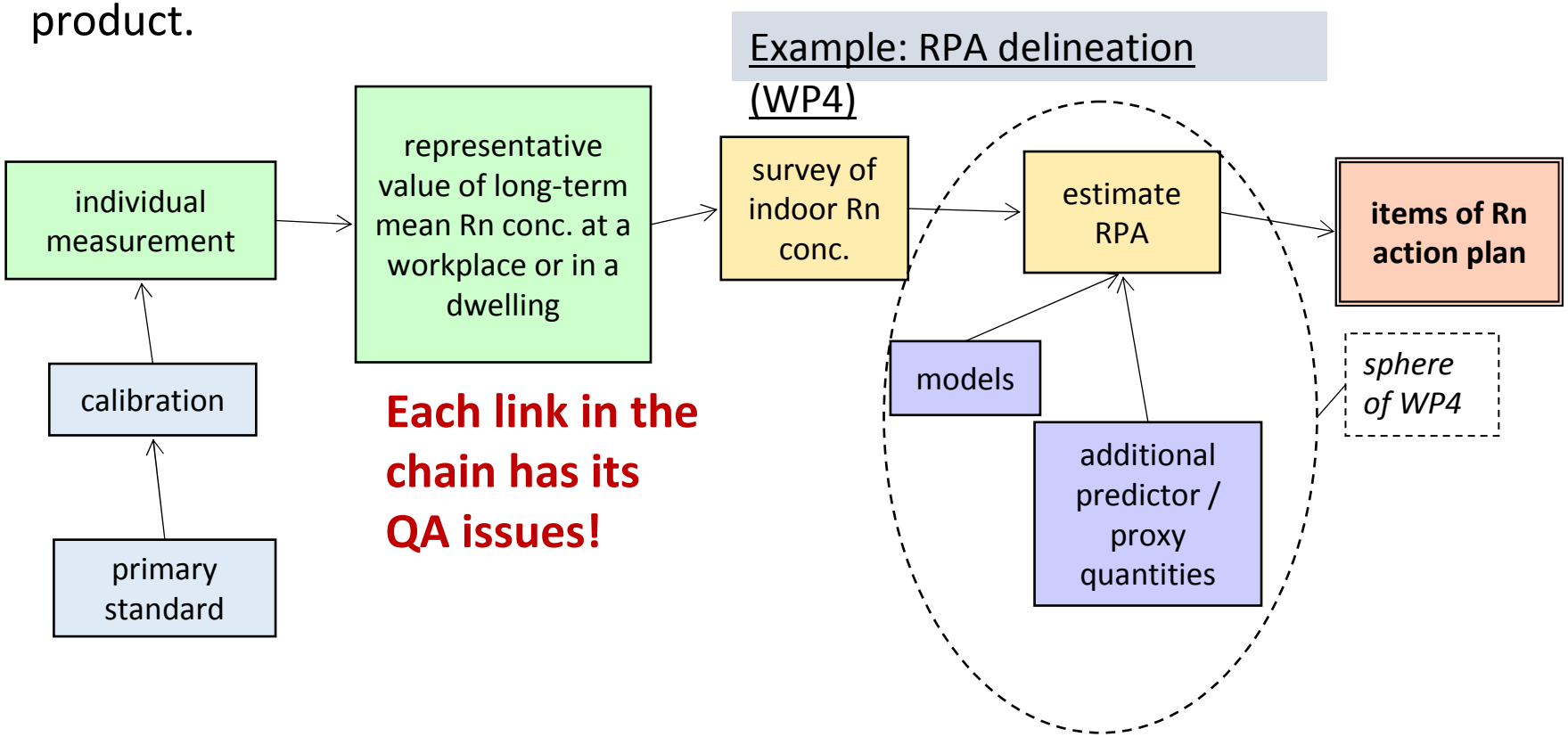
⇒ **All links of the chain must be quality assured!**

From the point of view of BSS, not a particular value of Rn conc. is the requested end product, but certain action.



# “Supply Chain”

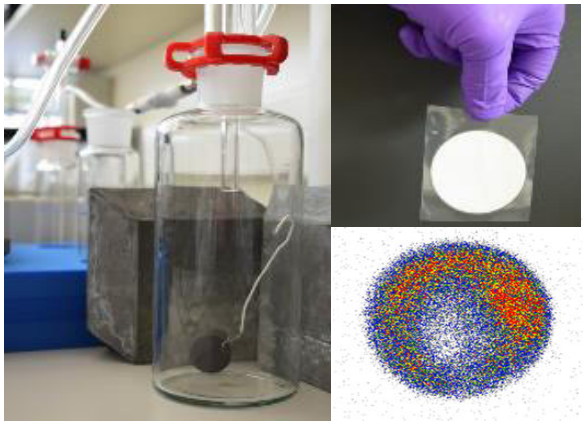
- Pathway from correctly measured individual Rn concentrations to a reliable end-user product, i.e. items of Rn action plans aimed to reduce Rn exposure.
- For the overall purpose of reduction of Rn exposure, one is not interested in actual Rn concentrations; but these being correctly measured, is a condition of the validity of all subsequent aggregation steps, which serve the end-user product.



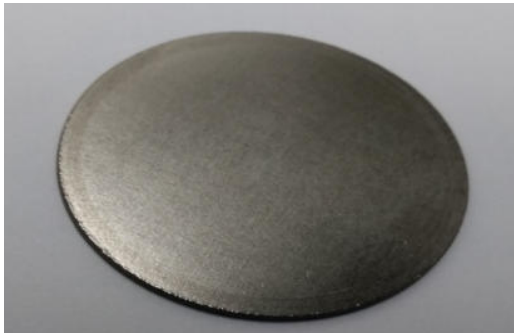
# Selected results: WP 1

## Design and use of new sources

### Chemisorption, JRC



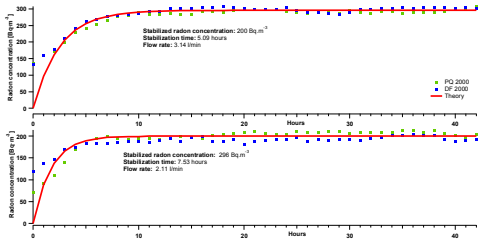
### Implanted Source, PTB



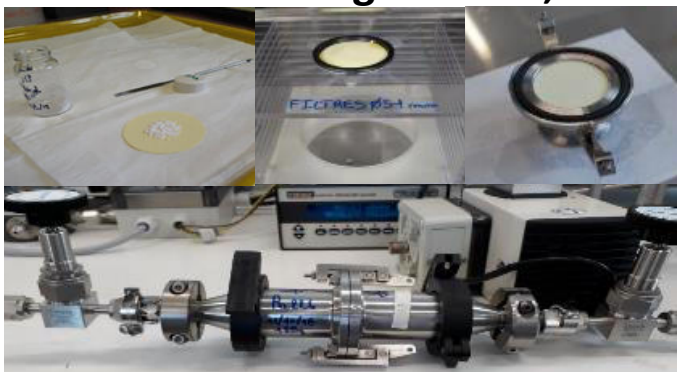
### Flow-through source, CMI

### New sources in chambers

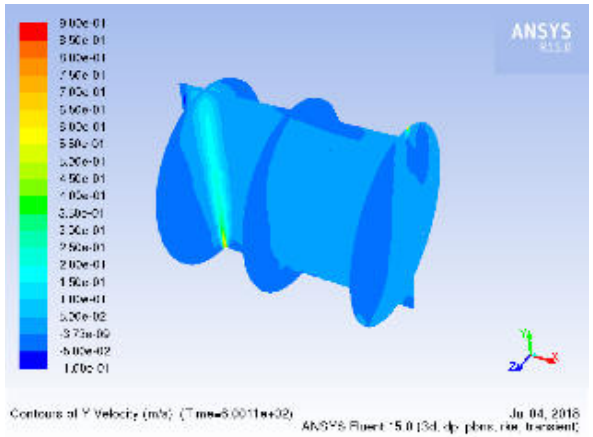
Evaluate stable and repeatable Rn-atmospheres in range 100-300 Bq/m³



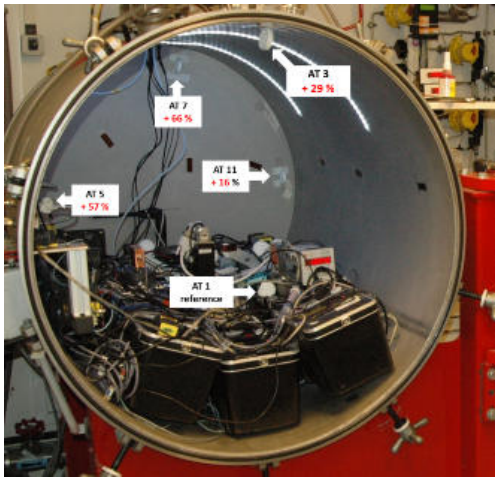

### $^{220}$Rn flow-through source, CEA



# Selected results: WP 2



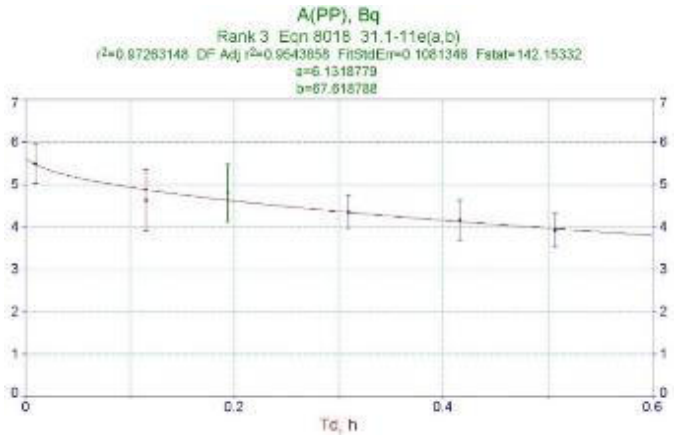

**Homogeneity testing of Rn-220 atmosphere** (Sofia University)




**Calibration of radon/thoron monitors**

BACCARA chamber, IRSN

**Field measurements to assess influence of thoron** (BEV)




**Testing of Rn-220 barriers**

- literature review (report available);
- quantitative data obtained for 11 polymeric materials (Sofia University)

Report: Review of potential techniques and materials to reduce the influence of thoron on radon measurements and calibrations; http://metroradon.eu/wp-content/uploads/2018/07/Review-techniques-to-reduce-influence-of-thoron.pdf

# Selected results: WP 3 / 1

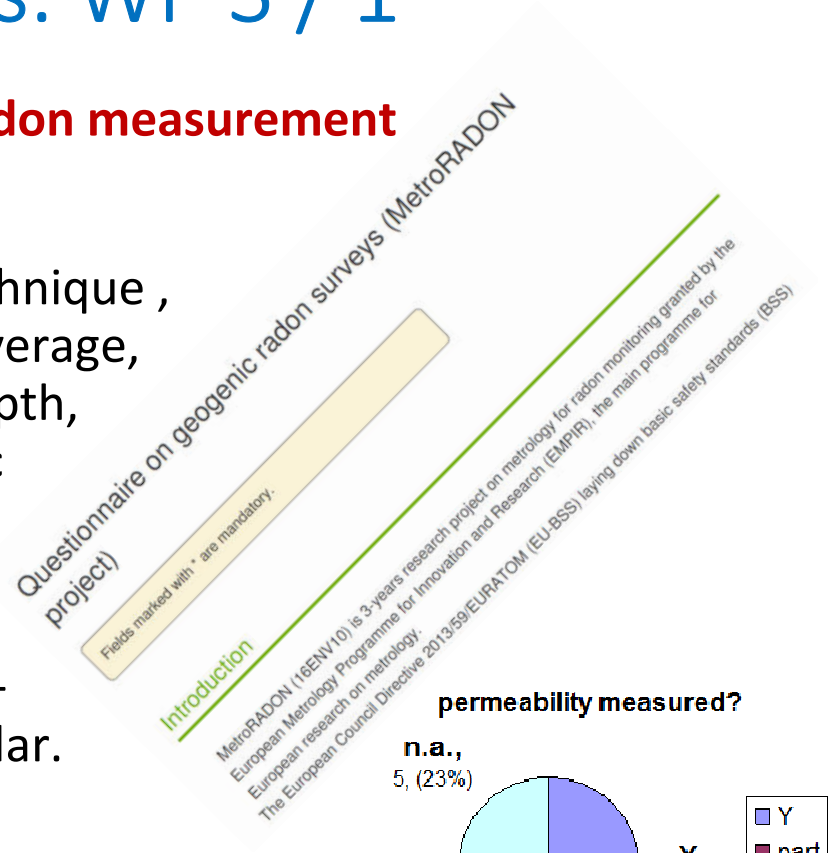
## Questionnaires on indoor and geogenic radon measurement

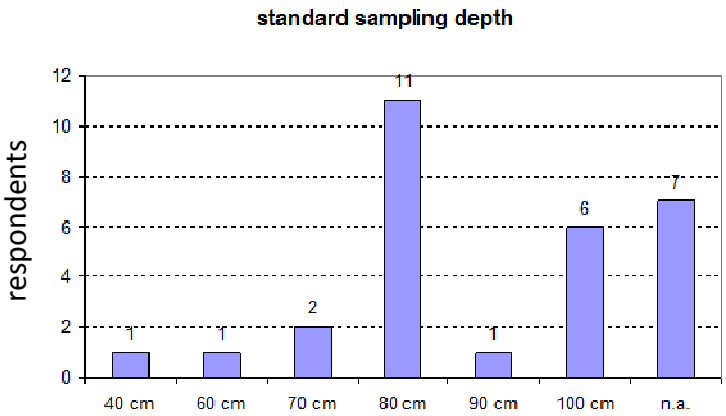
Example: geogenic questionnaire

Questions about sampling & measuring technique , number of samples available, territorial coverage, definition of “sampling point”, sampling depth, permeability measurement, other geogenic quantities, etc.

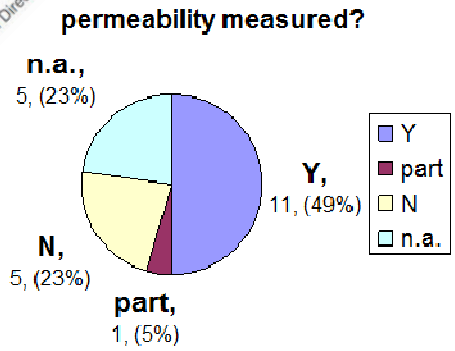
Institutions from 19 countries responded.

Considerable methodological differences! – Even if most use the Czech protocol or similar.




Evidently, this causes harmonization problems (comparability, interpretability of values)

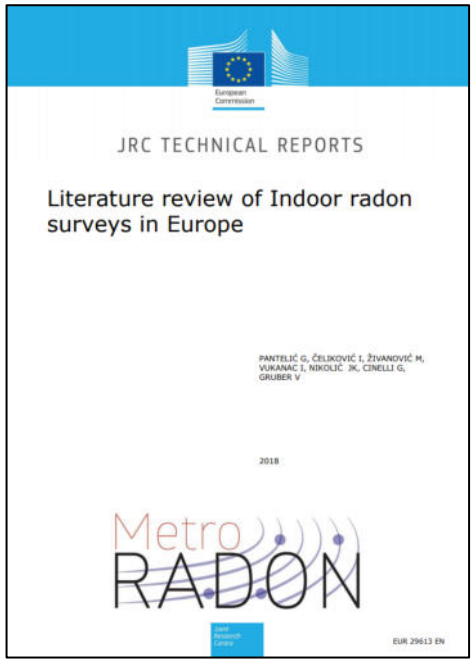



Ground Permeability is necessary to calculate the empirical geogenic radon potential (GRP)

# Selected results: WP 3 / 2

## Literature Review of Indoor Radon surveys in Europe

Published as JRC technical report; paper JENVRAD (VINS)



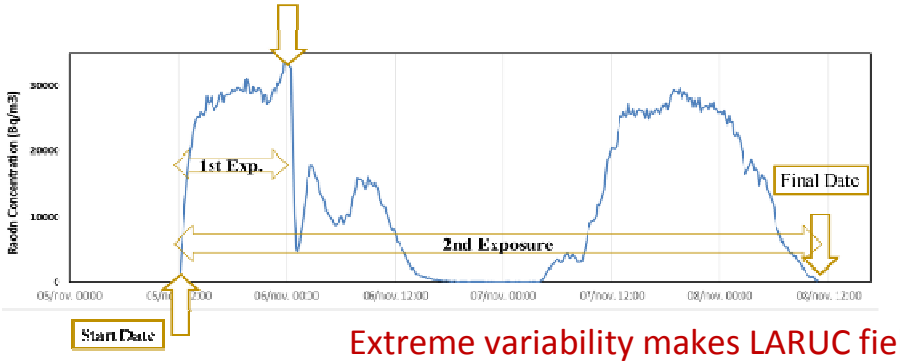

Report: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC114370/jrc114370_final_metroradon_jrc114370.pdf

## Intercomparison exercise under field conditions

LARUC, Spain (UC);

20 participants

Field lab: Building on the grounds of a former U mine




Extreme variability makes LARUC field lab in Saelices El Chico a perfect study site

Report: http://metroradon.eu/wp-content/uploads/2019/05/Report_WP3_3_3_MetroRADON_Intercomparison_final-1.pdf

# Selected results: WP 4 / 1

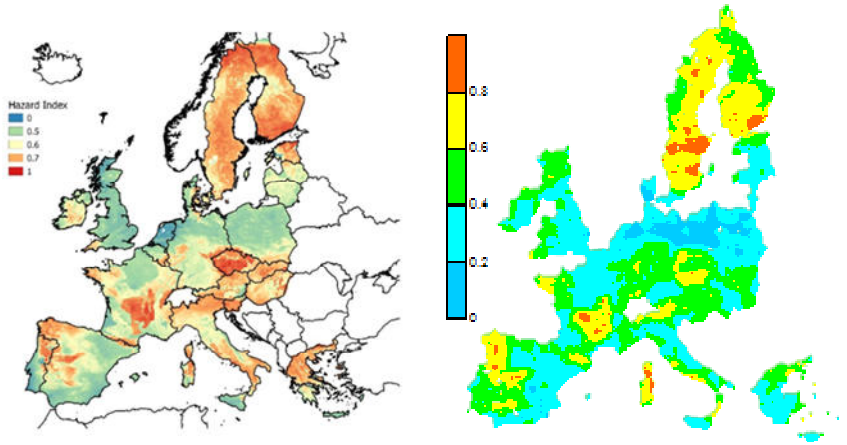
## The Geogenic Radon Hazard Index GRHI

- Concept:
  - A universally applicable tool to quantify the susceptibility of an area to geogenic Rn;
  - A quantity which measures the contribution of geogenic factors to the potential risk that exposure to indoor Rn causes;
  - A quantity which measures the availability of geogenic Rn at surface level;
  - A measure of "Rn proneness" or “Rn priorityness” of an area due to geogenic factors.
  - It shall serve as quantity to compare the geogenic radon hazard at different locations. A European GRHI map can be generated which may serve to delineate radon priority areas on European scale.
- Properties:
  - The GRHI should be independent of regionally available datasets;
  - still, if possible taking advantage of the information contained in them;
  - it should be applicable irrespective borders.
  - Most importantly, it should be an optimal predictor for the geogenic contribution to indoor Rn.

2 trials with different methods:

- Left: MARS machine learning, predictors: petrography, hydrogeological classes, hydraulic conductivity soil type, silt and clay content, available water capacity, coarse fraction, bulk density, geographical location.
- Right: GLM, predictors: simplified geology, fine fraction, soil pH, bulk density, K2O and ln(U) conc.

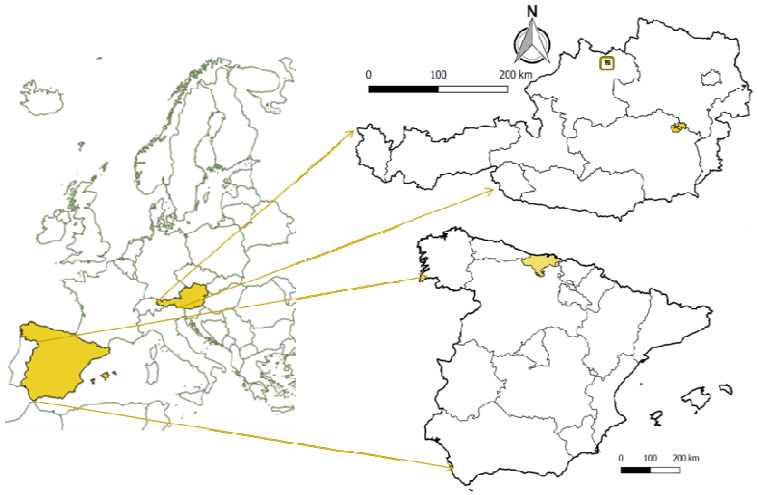
Patterns quite similar!

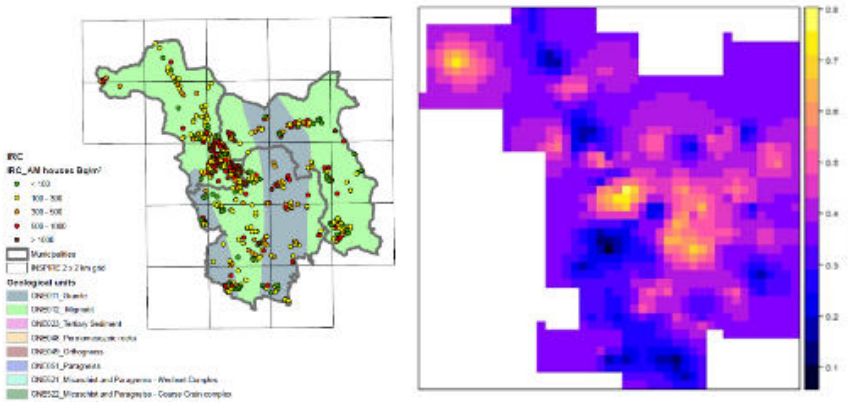


# Selected results: WP 4 / 2

## Radon mapping exercise

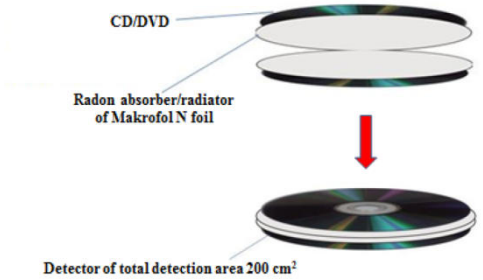
3 regions in Austria and Spain, different size, different Rn characteristic; employ different mapping methods (AGES)



## Testing of CD/DVDs as retrospective radon detectors for radon mapping

Improvement of methodology (Sofia University) and long-term exposure at LARUC (UC); Usability for RPA delineation?




# Selected results: WP 5

**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.)***

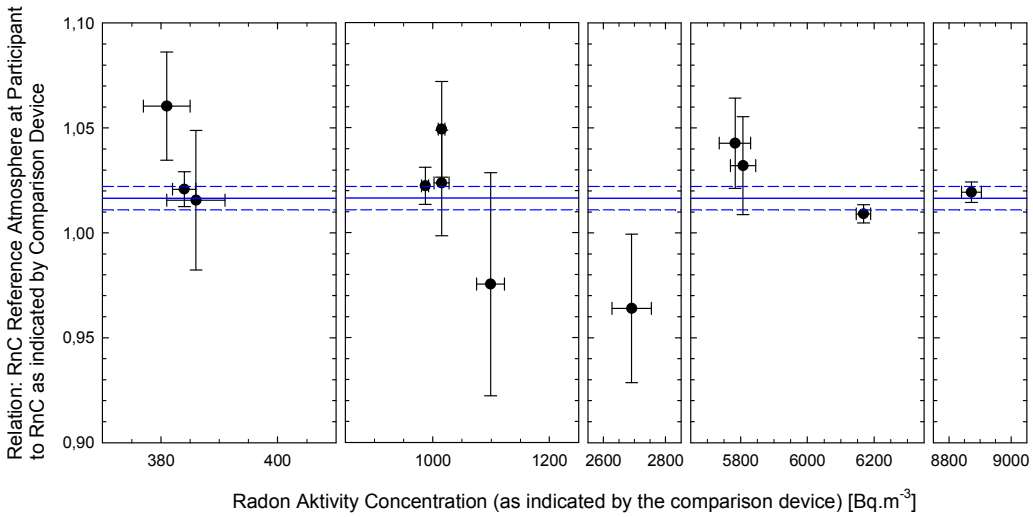
***Would you like to participate in validation of traceability of European radon calibration facilities performed within the project MetroRADON?*** ☐ Yes ☐ No

***Other comments:***

**Questionnaire for identification and evaluation of European radon calibration facilities** (CMI)

**Intercomparison exercise with reference instrument in different calibration facilities**

(Alpha Guard, 400, 1000, 6000 Bq/m³), BfS

# Achievements WP 6 - Impact

- Target: at least 10 conference presentations (status 9/2019: about 30)
- At least 10 peer reviewed papers (status 9/2019: 5 published, several in prep.)
- 2 newsletters per year (status: 4 newsletters and status reports; next: Autumn 2019) – subscription at website!
- Newsletter, reports, presentations, papers etc. – available at website: www.metroradon.eu


- Research Gate

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)

# WP 6 – Impact / 2

## Stakeholder involvement

- National Authorities
- European and International Bodies (IAEA, WHO, ERA, ICRP, IRPA, HERCA, EURADOS etc.)
- Standard Bodies and Committees
- Industry: Industry Interest Group has been formed, workshop summer 2019 (PTB)

## Workshops & training for interested stakeholders in 2020:

- Workshop for results of WP2/WP3/WP4; combined with JRC-workshop (national authorities, scientific sector)
  *25.-28. February 2020, Vienna (AGES, JRC)*
- Workshop for results of WP1/WP2/WP5
  (industry, authorities, scientific sector)
  *12. May 2020, Berlin (PTB)*
- Training seminar for radon instrument calibration and measurements WP2/WP5 (end users)
  *13. May 2020, Berlin (UC)*

**You are invited to collaborate and to follow the project!**

17 partners, 9 collaborators

# Participants

- AGES - Austrian Agency for Health and Food Safety & National Radon Centre
- BEV – Austrian metrology institute
- BFKH – Hungarian metrology institute
- BfS – German radiation protection authority
- CEA – French atomic energy commission, Laboratoire Henri Becquerel = national metrology institute
- CLOR - Polish central laboratory for radiological research
- CMI – Czech metrology institute
- EURADOS – European Radiation Dosimetry Group
- IFIN-HH – Romanian metrology institute
- INAIL – Italian national institute for labour security
- IRSN – French radioprotection authority
- ISS – Italian health institute,
- JRC – Joint Research Centre of the European Commission
- Life-RESPIRE consortium
- LNR Coimbra – Laboratory for natural radioactivity, university Coimbra, Portugal
- METAS – Swiss metrology institute
- PTB – Physikalisch-technische Bundesanstalt
- Radonova, Sweden
- SMU – Slovak institute of metrology
- STUK – Finnish radiation & nuclear safety authority
- SUBG – Sofia university, Bulgaria
- SÚJCHBO – Czech National Institute for Nuclear, Chemical, and Biological Protection
- UBB – Babes Bolyai university, Cluj, Romania
- UC – University of Cantabria, Spain; LARUC – Laboratory of radioactivity
- UNS – University Novi Sad, Serbia
- VINC – Vinča institute of Nuclear Science, Serbia

# Thank you!



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Metro RADON

http://metroradon.eu/