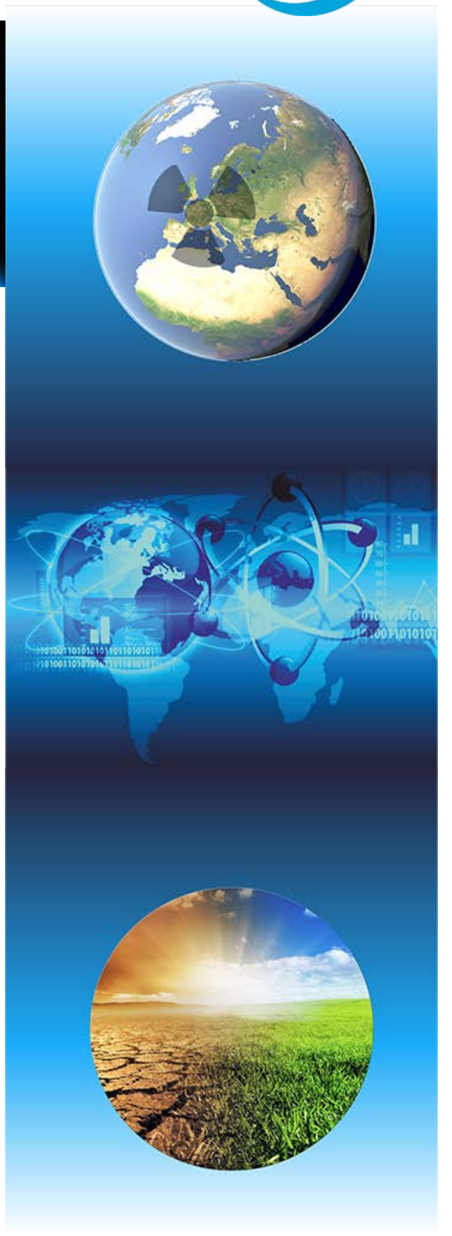
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Radon metrology for use in climate change observation and radiation protection at the environmental level

19ENV01 traceRadon



Coordinator: Annette Röttger

EURAMET TC-IR annual meeting 2023

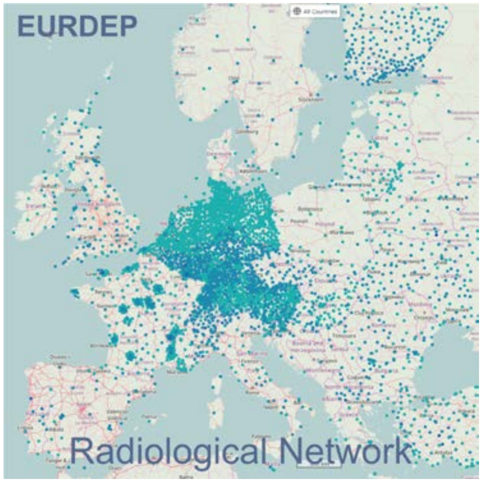
EURAMET Highlights in 2022

20 events targeted an external audience in 2022

EURAMET, Highlights in 2022 by J. Stenger

*This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. **19ENV01 traceRadon** denotes the EMPIR project reference.*

Introduction - 1



Climate change is one of the greatest challenges of our time.

The temperature rise of the atmosphere of our planet, due to the greenhouse effect, is caused by the increase of GHG emissions.

- ICOS: Monitoring of GHG emissions, the dispersion of GHGs and the resulting GHG concentrations in air, is of utmost importance for appropriate climate change mitigation measures.
- EURDEP: Collection and exchange of radiological monitoring data between participating countries of the radiation in the environment.

Both networks could profit from radon measurements at the outdoor level. But **traceability to the SI system** is not established yet.

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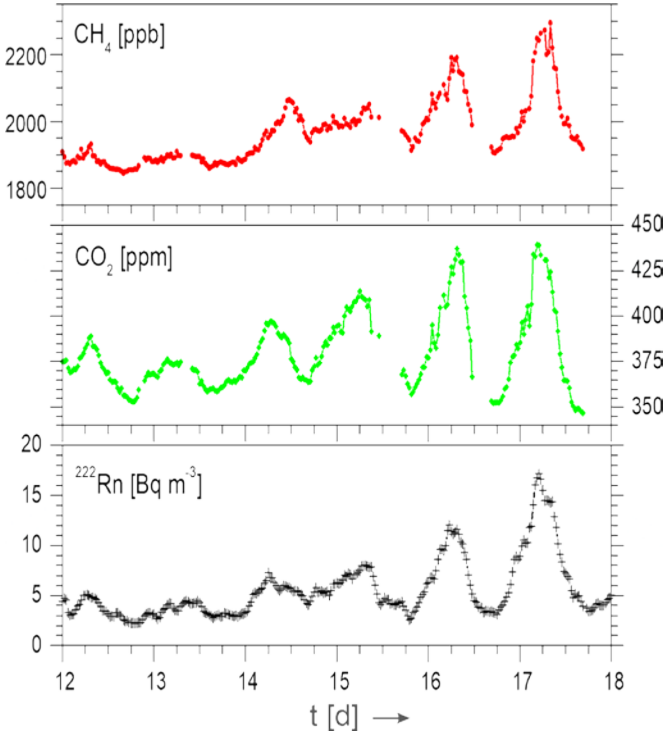
Introduction - 2

Why is Radon an issue in **climate observation**?

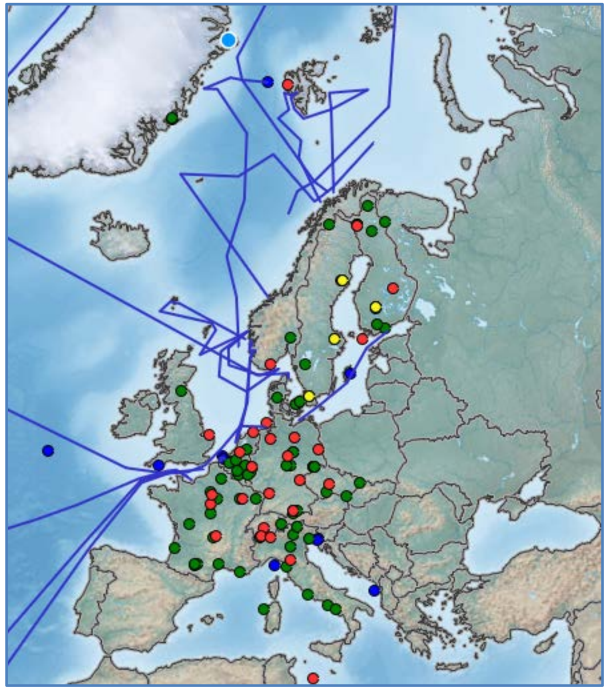
- ➢ GHG **flux measurements** are difficult though GHG concentration measure-ments are established.
- ➢ With radon activity concentration and radon flux measurements GHG fluxes can be **traced**!



ICOS Atmospheric Station Specifications:

Radon monitor: "At the present stage, Radon-222 measurements are not mandatory in ICOS. However, Radon-222 is recognized as a very valuable measurement, in particular for trace gas flux estimates."

- ➢ Determine source terms of GHG



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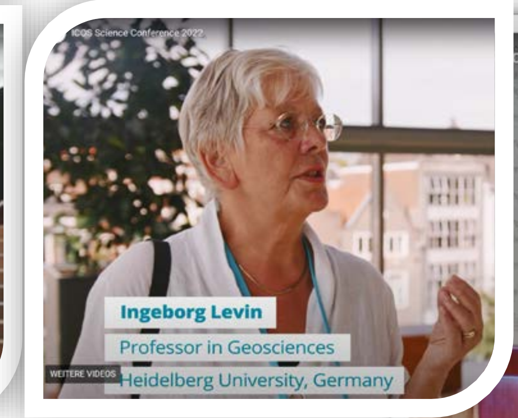
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

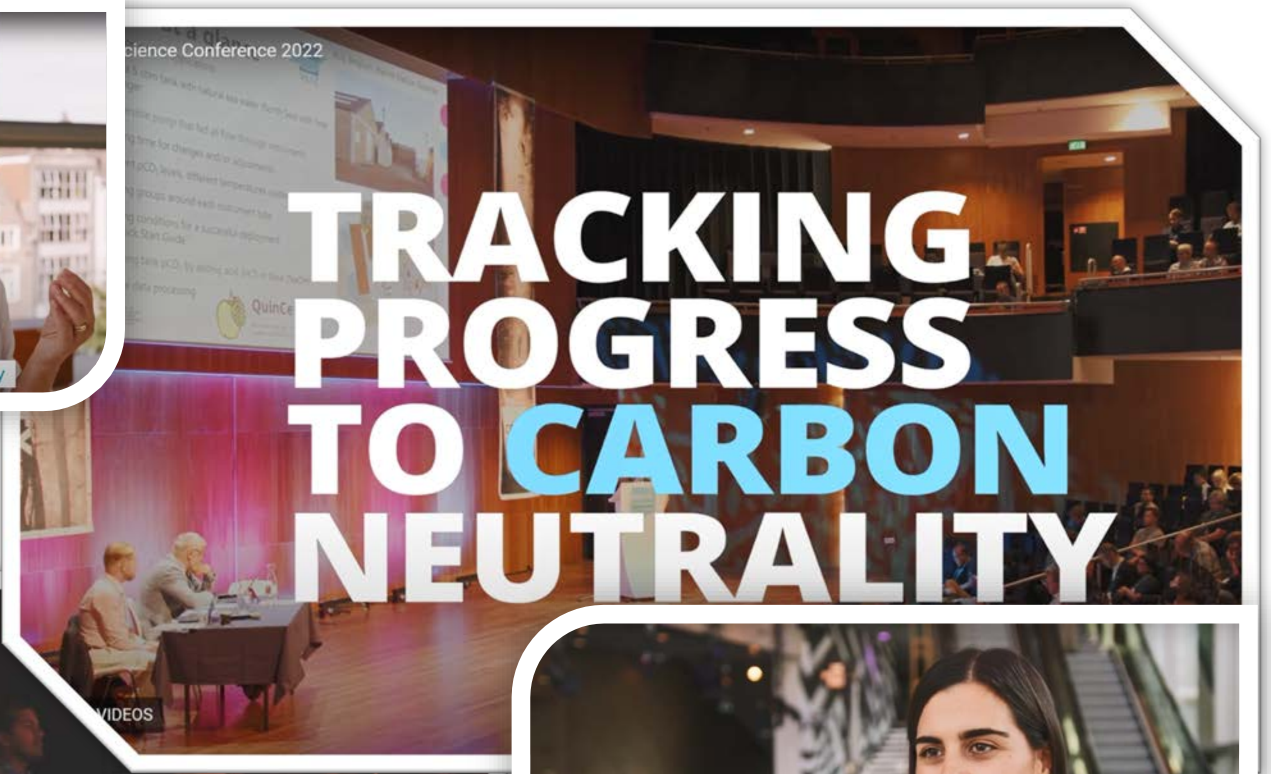
ICOS Scientific Conference 2022

traceRadon

EURAMET



https://www.icos-cp.eu/event/1242



This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. ***19ENV01 traceRadon*** *denotes the EMPIR project reference.*

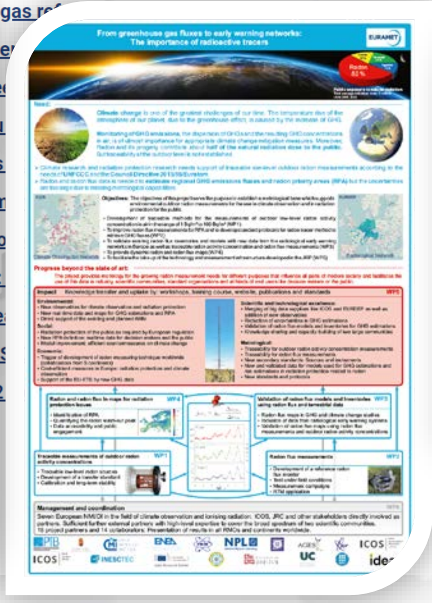
Metrology for climate action

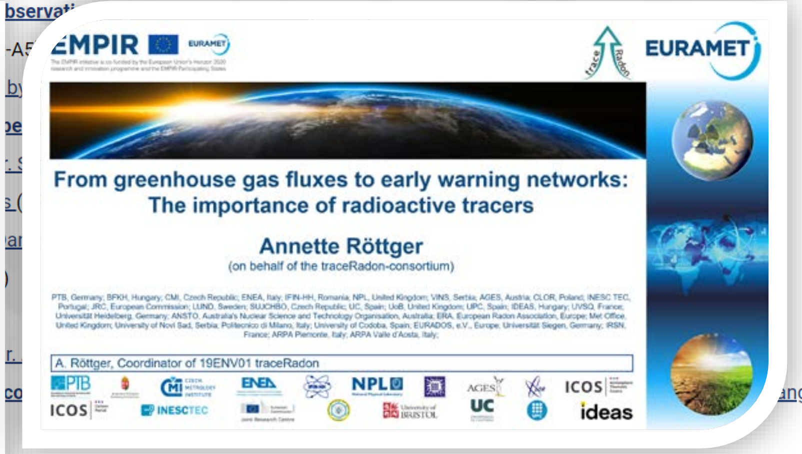
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

Theme 2: Accuracy requirements for atmospheric composition measurements across economic sectors, and temporal and spatial scales

Pre-recorded presentations

- Primary Standards, Reference Materials, and Uncertainty Analysis for the Measurement of Greenhouse Gases by Mrs./Ms. Christina Cecelski (T2-A1)
- From greenhouse gas fluxes to early warning networks: The importance of radioactive tracers by Dr. Annette Röttger (T2-A2)
- Accurate measurements of greenhouse gases – what we can learn from over 100 audits in 25 years by Dr. Christoph Zellweger (T2-A3)
- Meeting the deman… e gas r… bservati…
- Quantifying rel… ve… -A5
- Developments … re… by
- Calibration of … tu… pe
- Key role of pu… as…
- Developing Gu… m… s (
- Accelerated te… tio… ar
- Innovative con… s:
- Evaluation of s… he…
- Assessment o… ES… r.
- Quantifying co… 02… co… ang (T2-A14)



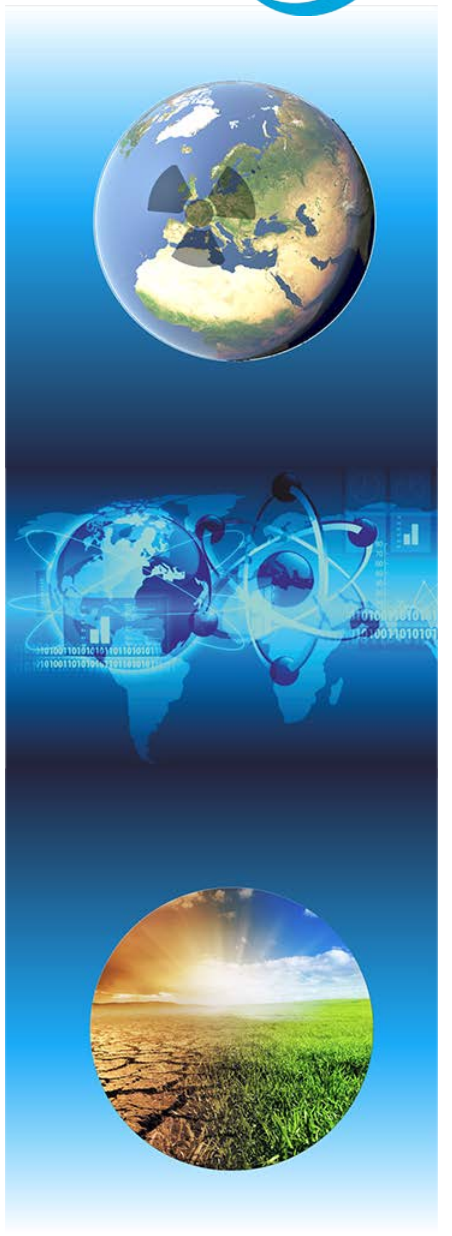


Bureau International des Poids et Mesures

WORLD METEOROLOGICAL ORGANIZATION

EURAMET

Partners



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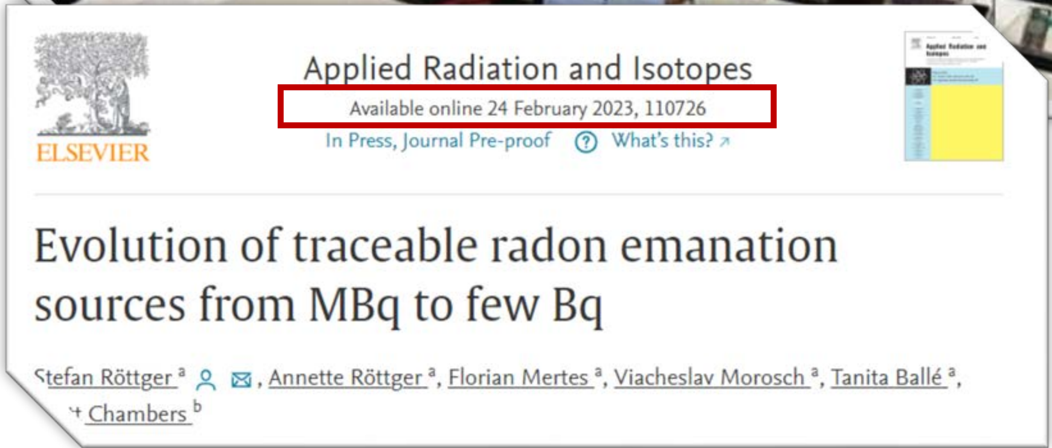
ICRM-LLRMT 2022

Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

Plenary session, S. Röttger

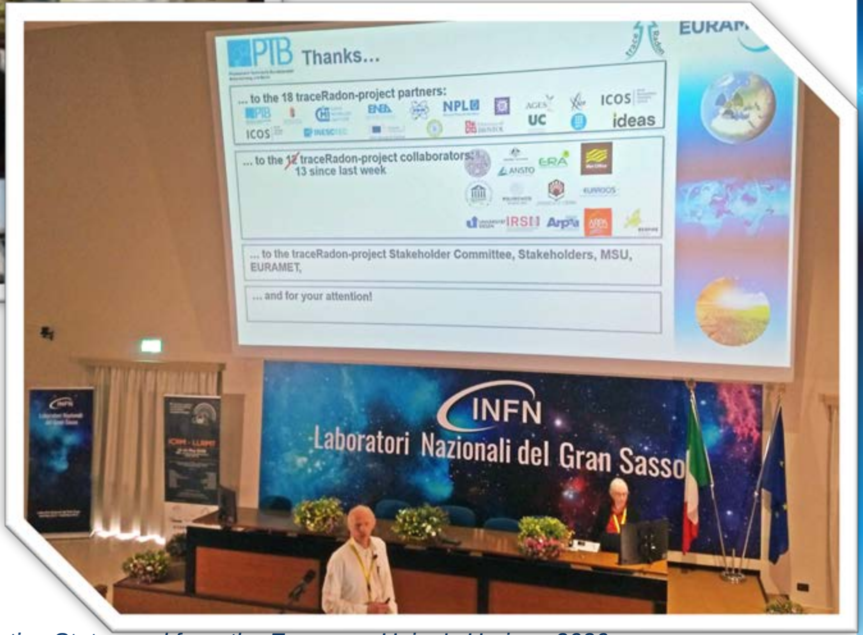

Applied Radiation and Isotopes
Available online 24 February 2023, 110726
In Press, Journal Pre-proof What's this?

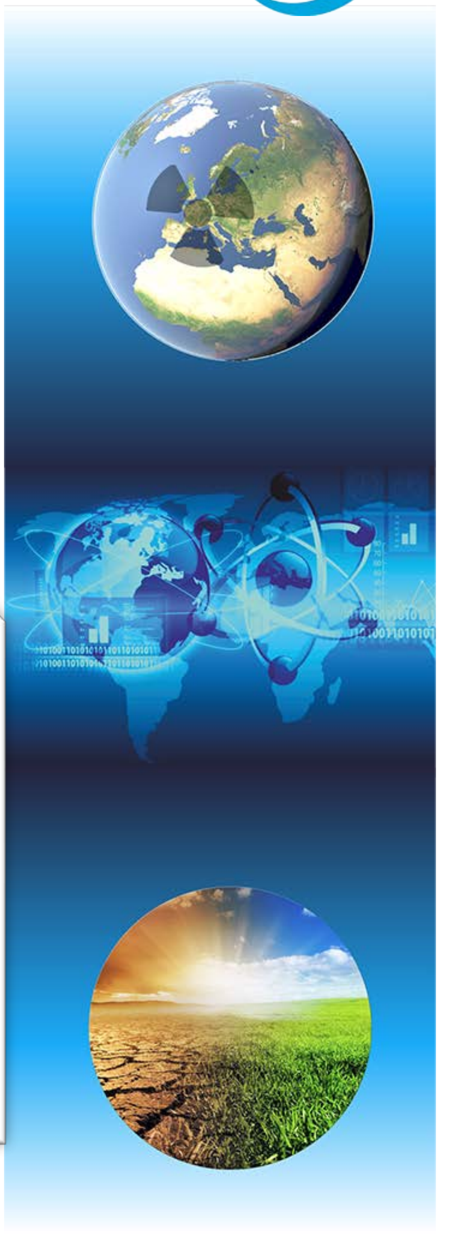
ELSEVIER

Evolution of traceable radon emanation sources from MBq to few Bq

Stefan Röttger [a], Annette Röttger [a], Florian Mertes [a], Viacheslav Morosch [a], Tanita Ballé [a], ...t Chambers [b]

ICRM - LLRMT





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Achievements – 1: New activity standards

Adv. Geosci., 57, 37–47, 2022
https://doi.org/10.5194/adgeo-57-37-2022

Advances in Geosciences
Open Access

Radon metrology for use in climate change observation and radiation protection at the environmental level

Stefan Röttger[1], Annette Röttger[1], Claudia Grossi[2], Arturo Vargas[2], Ute Karstens[3], Giorgia Cinelli[4], Edward Chung[5,6], Dafina Kikaj[5], Chris Rennick[5], Florian Mertes[1], and Ileana Radulescu[7]

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[4]European Commision, Joint Research Centre, Ispra 21027, Italy
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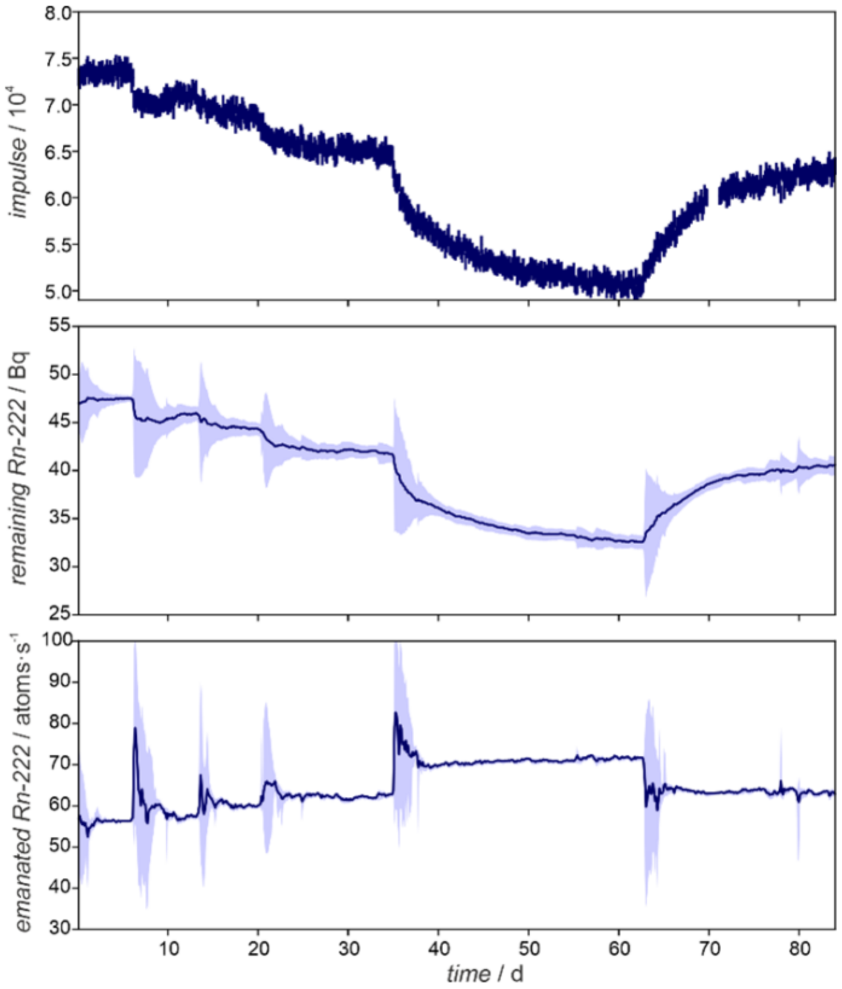
[6]School of GeoSciences, University of Edinburgh, Edinburgh, United Kingdom
[7]Department of Life and Environmental Physics, Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Bucharest, Ilfov, 077125, Romania

Correspondence: Stefan Röttger (stefan.roettger@ptb.de)

Received: 1 December 2021 – Revised: 11 February 2022 – Accepted: 11 February 2022 – Published: 10 March 2022



https://adgeo.copernicus.org/articles/57/37/2022/adgeo-57-37-

*This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. **19ENV01 traceRadon** denotes the EMPIR project reference.*

Achievements – 2: New calibrations

OPEN ACCESS
IOP Publishing
Measurement Science and Technology
Meas. Sci. Technol. 32 (2021) 124008 (13pp)
https://doi.org/10.1088/1361-6501/ac298d

New metrology for radon at the environmental level

Annette Röttger[1,*], Stefan Röttger[1], Claudia Grossi[2], Arturo Vargas[2], Roger Curcoll[2], Petr Otáhal[3], Miguel Ángel Hernández-Ceballos[4], Giorgia Cinelli[5], Scott Chambers[6], Susana Alexandra Barbosa[7], Mihail-Razvan Ioan[8], Ileana Radulescu[8], Dafina Kikaj[9], Edward Chung[9,10], Tim Arnold[9,10], Camille Yver-Kwok[11], Marta Fuente[11], Florian Mertes[1] and Viacheslav Morosh[1]

[1] Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany
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[4] Department of Physics, University of Córdoba, 14071 Córdoba, Spain
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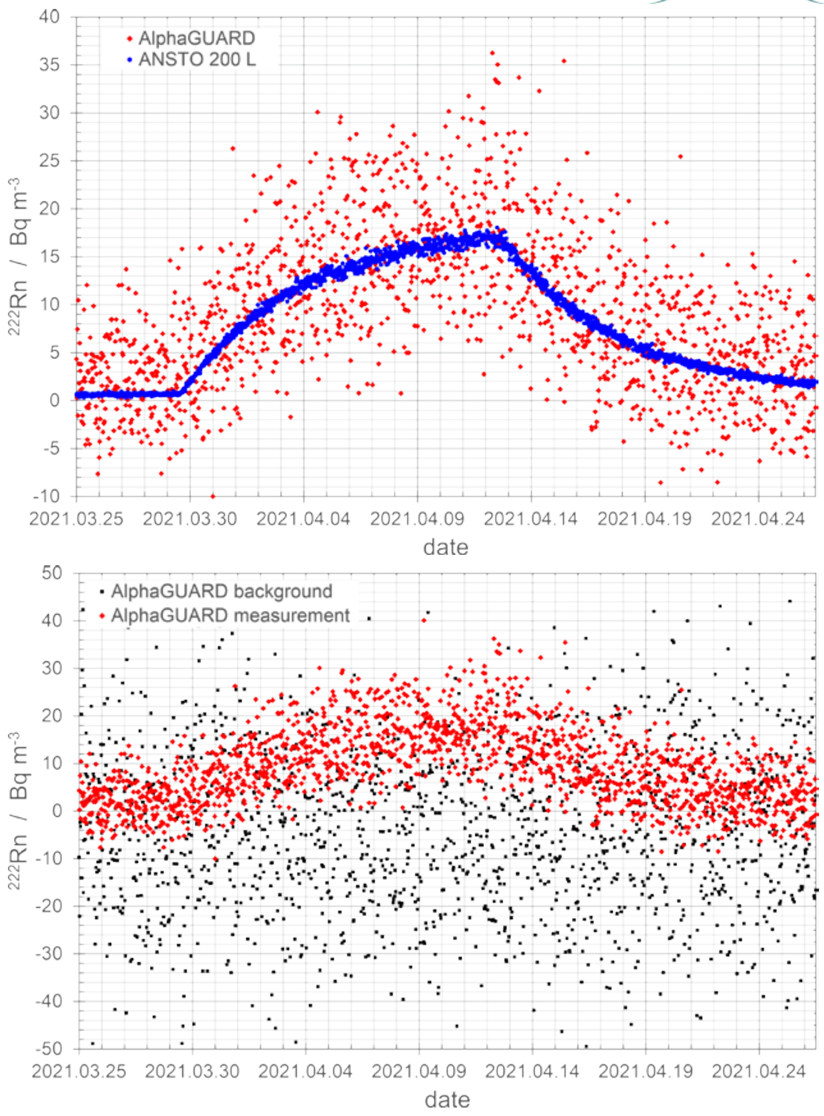
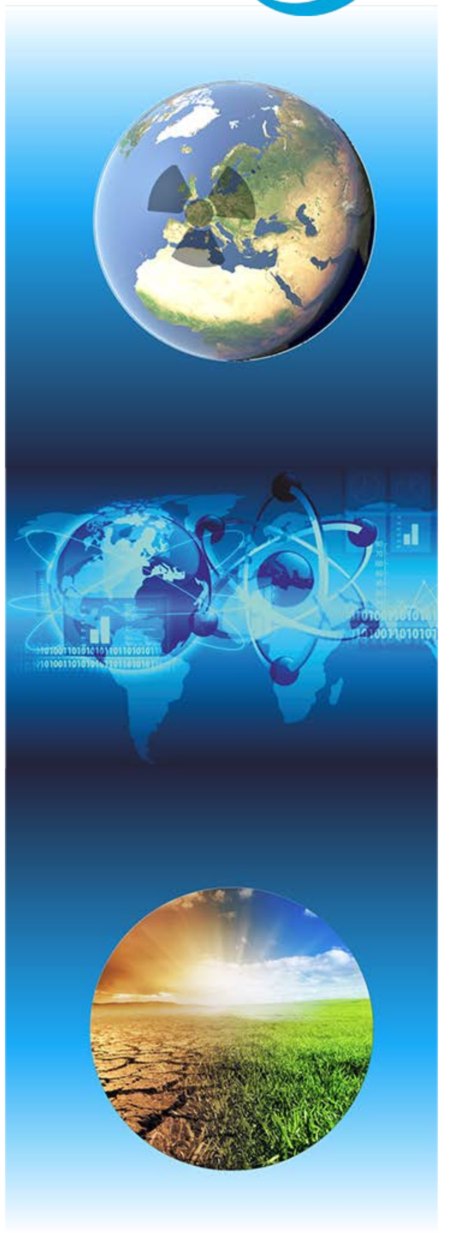
Accepted for publication 23 September 2021
Published 8 October 2021

CrossMark





https://iopscience.iop.org/article/10.1088/1361-6501/ac298d

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Achievements – 3: New comparisons

Nuclear Inst. and Methods in Physics Research, A 1021 (2022) 165927

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Inter-comparison of commercial continuous radon monitors responses

I. Radulescu [a,*], M.R. Calin [b], A. Luca [a], A. Röttger [c], C. Grossi [d,e], L. Done [f], M.R. Ioan [a]

[a] *Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering IFIN-HH, Department of Radioisotopes and Radiation Metrology (DRMR), 30 Reactorului Street, 077125, Magurele, Romania*
[b] *Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering IFIN-HH, Department of Life and Environmental Physics (DFVM), 30 Reactorului Street, 077125, Magurele, Romania*
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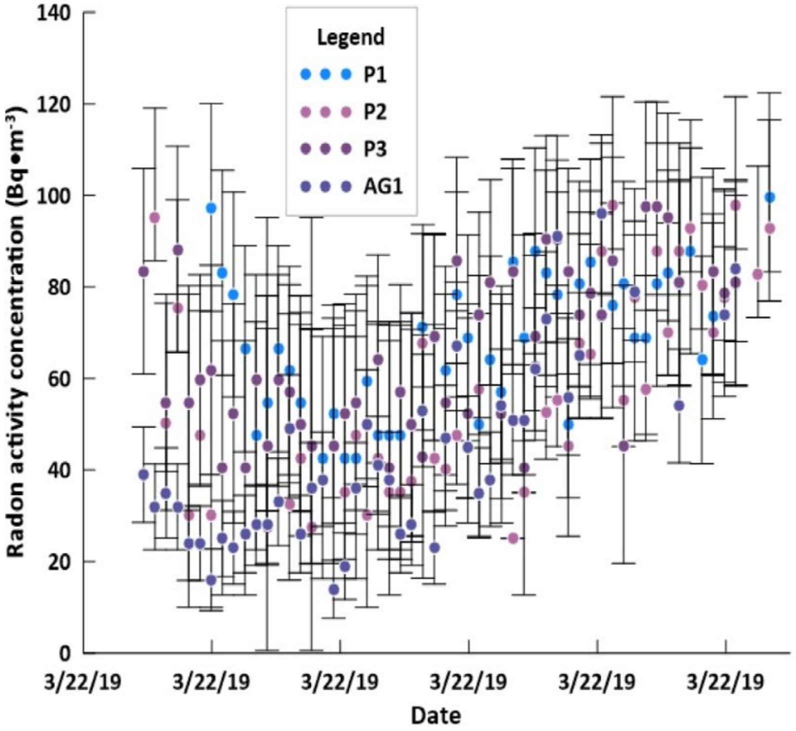
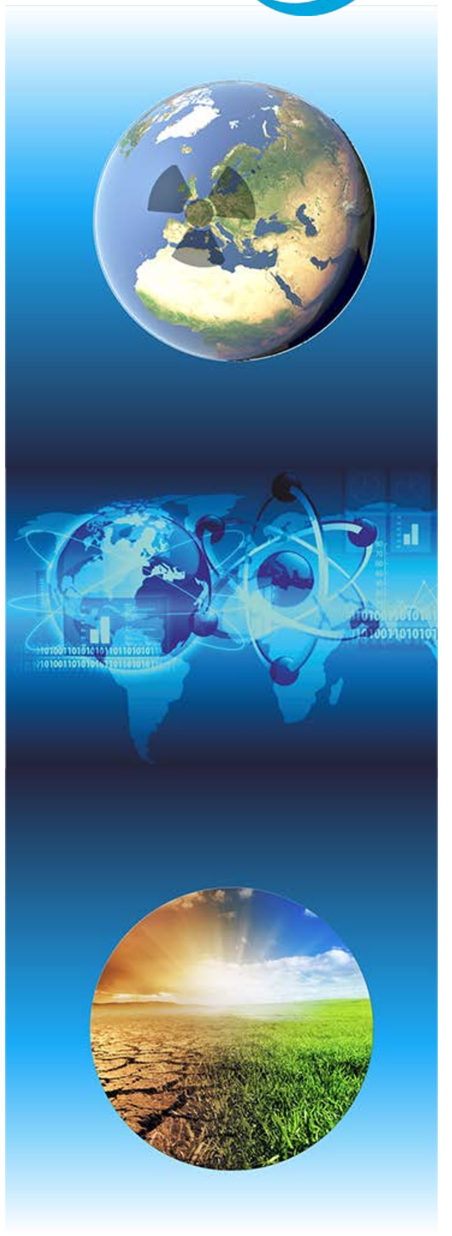
[f] *Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering IFIN-HH, Department of Radioactive Waste Management (DMDR), 30 Reactorului Street, 077125, Magurele, Romania*

https://doi.org/10.1016/j.nima.2021.165927





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Achievements – 4: Advanced technology

Applied Radiation and Isotopes 181 (2022) 110093

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Ion implantation of ^{226}Ra for a primary ^{222}Rn emanation standard

Florian Mertes [a,*], Nina Kneip [b], Reinhard Heinke [b], Tom Kieck [b], Dominik Studer [b], Felix Weber [b], Stefan Röttger [a], Annette Röttger [a], Klaus Wendt [b], Clemens Walther [c]

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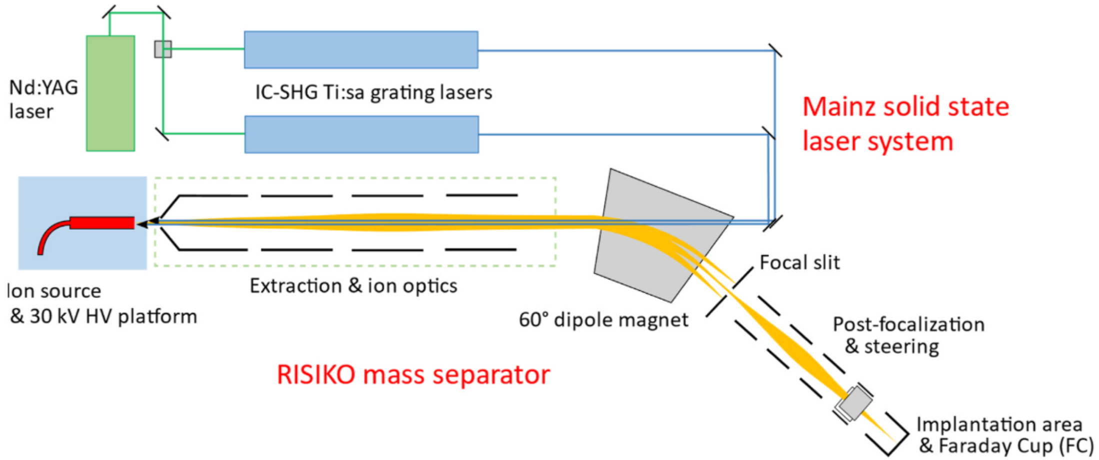
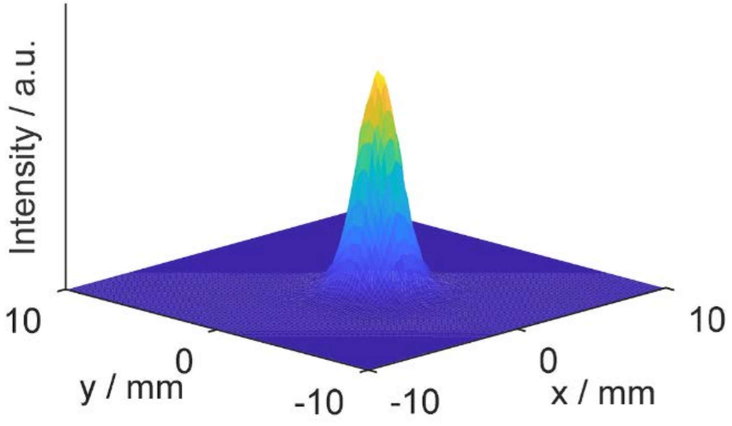
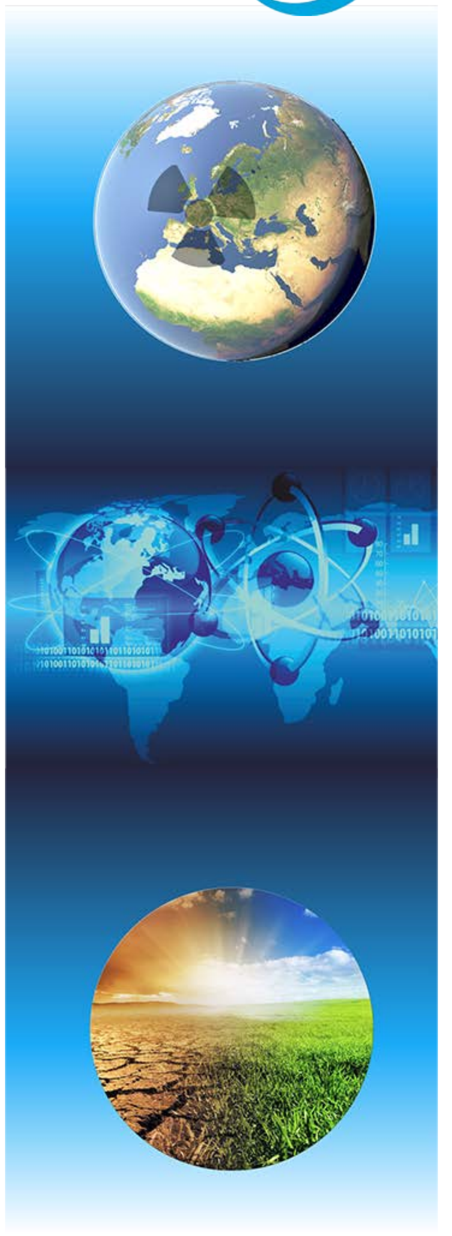
https://doi.org/10.1016/j.apradiso.2021.110093







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Achievements – 5: New innovation

International Journal of
Environmental Research and Public Health

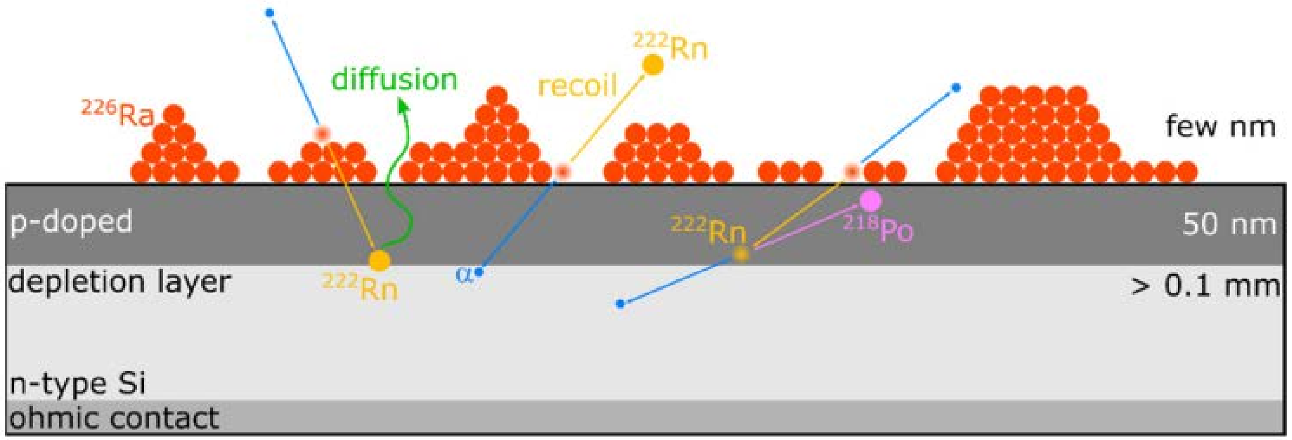
MDPI

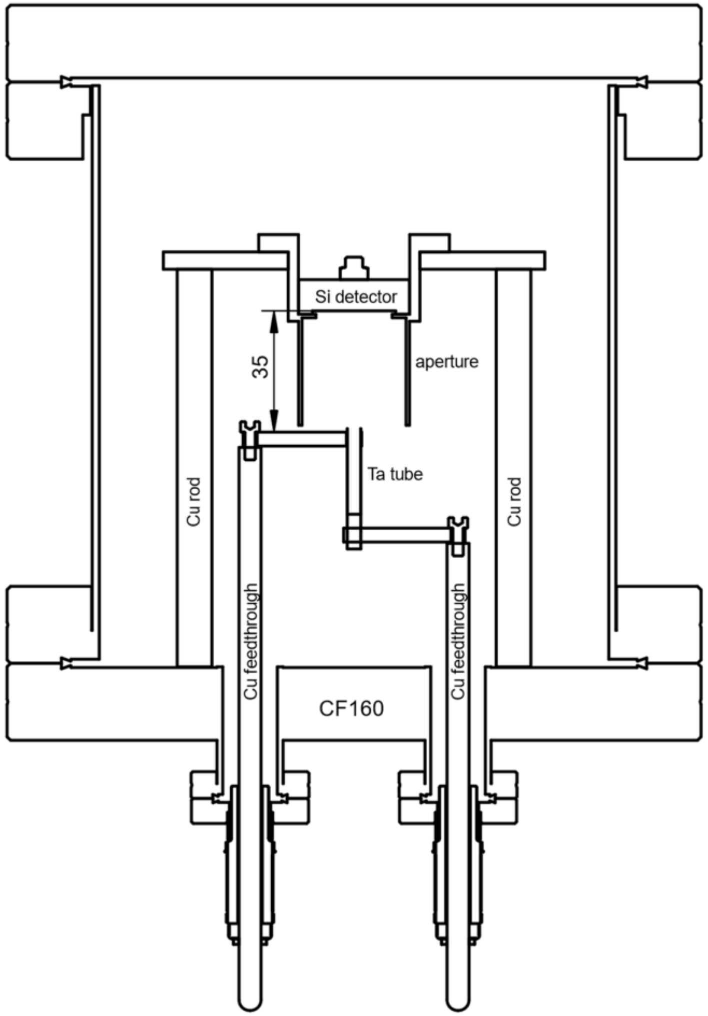
Article

Development of ^{222}Rn Emanation Sources with Integrated Quasi 2π Active Monitoring

Florian Mertes *, Stefan Röttger and Annette Röttger

Physikalisch-Technische Bundesanstalt, National Metrology Institute, 38116 Braunschweig, Germany; stefan.roettger@ptb.de (S.R.); annette.roettger@ptb.de (A.R.)
* Correspondence: florian.mertes@ptb.de





https://doi.org/10.3390/ijerph19020840

This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. ***19ENV01 traceRadon*** *denotes the EMPIR project reference.*

Achievements – 6: New field instrument

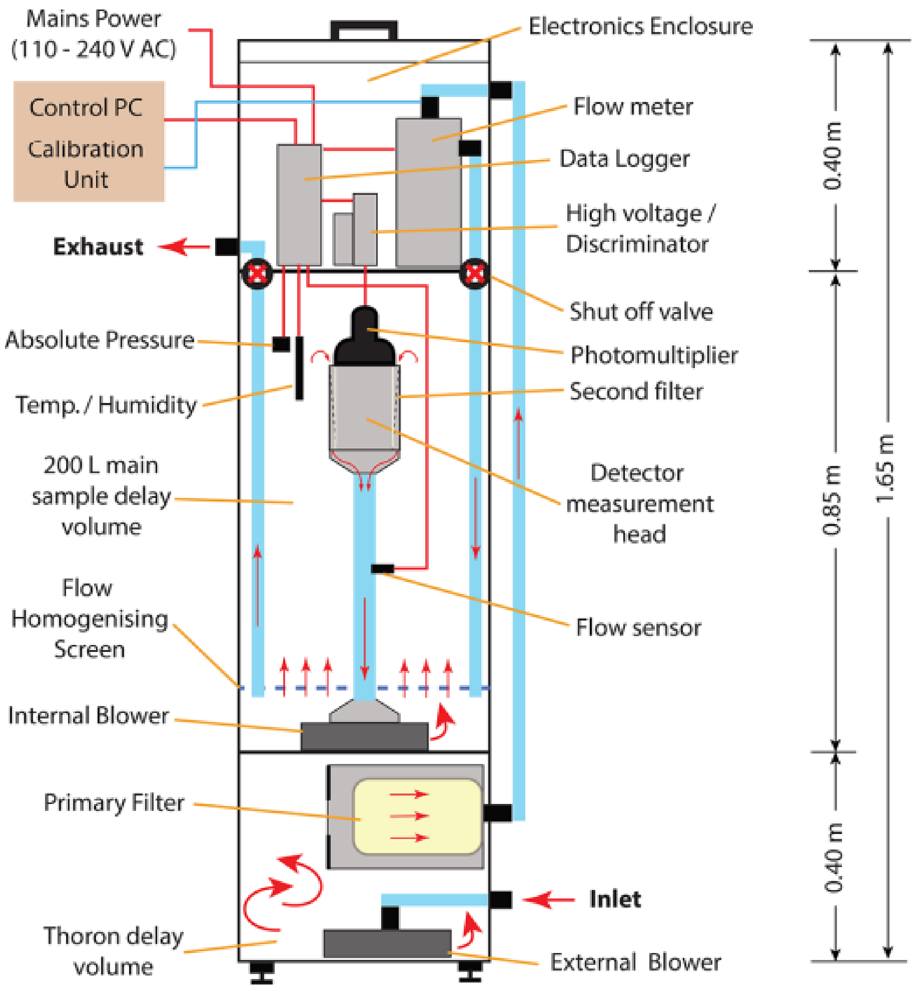
Adv. Geosci., 57, 63–80, 2022
https://doi.org/10.5194/adgeo-57-63-2022

Advances in Geosciences
Open Access
EGU

Portable two-filter dual-flow-loop ^{222}Rn detector: stand-alone monitor and calibration transfer device

Scott D. Chambers[1], Alan D. Griffiths[1], Alastair G. Williams[1], Ot Sisoutham[1], Viacheslav Morosh[2], Stefan Röttger[2], Florian Mertes[2], and Annette Röttger[2]

[1]Environmental Research, ANSTO, Lucas Heights, 2234, Australia
[2]Ionizing Radiation, Physikalisch-Technische Bundesanstalt, Braunschweig, 38116, Germany



https://doi.org/10.5194/adgeo-57-63-2022

This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. ***19ENV01 traceRadon*** *denotes the EMPIR project reference.*

Achievements – 7: New approaches for member states

International Journal of *Environmental Research and Public Health*

MDPI

Review

Outdoor Radon as a Tool to Estimate Radon Priority Areas—A Literature Overview

Igor Čeliković [1], Gordana Pantelić [1], Ivana Vukanac [1], Jelena Krneta Nikolić [1], Miloš Živanović [1], Giorgia Cinelli [2,3,*], Valeria Gruber [4], Sebastian Baumann [4], Luis Santiago Quindos Poncela [5] and Daniel Rabago [5]

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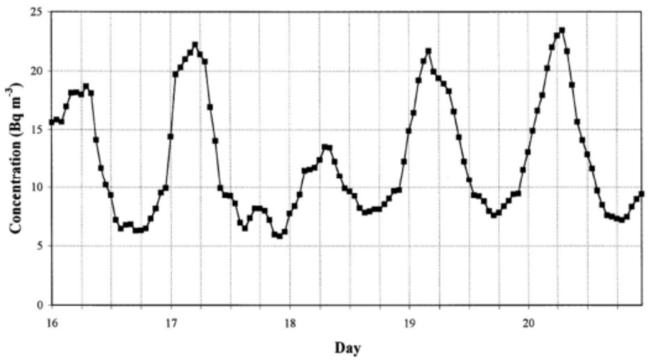
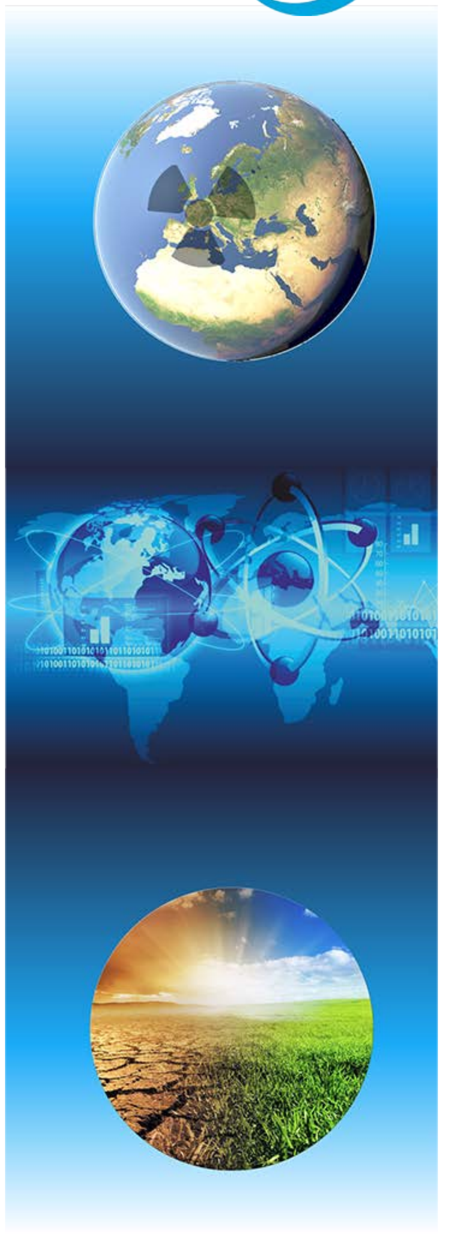
3 Laboratory of Observations and Measurements for the Climate and the Environment, National Agency for New Technologies, Energy, and Sustainable Economic Development (ENEA), 90141 Palermo, Italy
4 Austrian Agency for Health and Food Safety, Department for Radon and Radioecology, 4020 Linz, Austria; valeria.gruber@ages.at (V.G.); sebastian.baumann@ages.at (S.B.)
5 Radon Group, University of Cantabria, 39011 Santander, Spain; luis.quindos@unican.es (L.S.Q.P.); daniel.rabago@unican.es (D.R.)
* Correspondence: giorgia.cinelli@enea.it

https://doi.org/10.3390/ijerph19020662



Country	No. of. Locations	Descriptive Statistics				Map
		Season	Range [Bq m^{-3}]	GM (AM) [Bq m^{-3}]	GSD [Bq m^{-3}]	
USA, Missouri [94]	82	Annual	11–110	25	1.5	Yes
USA, Iowa [83]	111	Annual	7–55	29	1.4	Yes
Minesota [83]	64	Annual	4–55	19	1.8	Yes
Turkey [77]	47 30	Winter Summer	19–63.5 7–28	(34.10) (15.34)		
Slovenia [45]	60	Annual	3.7–41.0	11.8		Yes
China [79]	101	Annual	3.6–23.9	(9.3)		
China [89]	165	Annual	3–50	13.2 (14)		No
Serbia [46]	56	Annual	<244	49 (57)	1.8	No
England [95]	69	Annual		6	2	
Norway [82]	82	Winter Summer	4–13 8–210	(5–13) (29–82)		No
Lebanon [81]	24	Summer Autumn Winter	3.2–47.6 1.0–57.0 0.2–66.3	(19.7) (16.1) (13.4)		No.
Ireland [92]	18	Annual	4.2–7.7	(5.6)		No
Japan [78]	696	Annual	1.8–35.3	5.9 (6.1)		No
Germany [85]	173	Annual	3–31	9	1	Yes
Iceland [91]	1	May-july		1.6		No
Malta [73]	3	Summer	0.8–3.6			No
Cyprus [97]	12	August	2–134	9 (11)		No
East Asia [96]	20	3 months	5.3–17.0	(10.7)		No
Syria [102]	36	10 min.	5–66	21 (25)		No
Montenegro [93]	Theor. 1	Annual Annual	6–11 13 ± 4	 (13)		 No
Spain [101]	25	Annual	1.2–15.8	(5.2)		No



This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. ***19ENV01 traceRadon*** *denotes the EMPIR project reference.*

Achievements – 8: Field intercomparisons

International Journal of
Environmental Research and Public Health

MDPI

Article

Intercomparison of Radon Flux Monitors at Low and at High Radium Content Areas under Field Conditions

Daniel Rábago [1], Luis Quindós [1,*], Arturo Vargas [2], Carlos Sainz [1], Ileana Radulescu [3], Mihail-Razvan Ioan [3], Francesco Cardellini [4], Marco Capogni [4], Alessandro Rizzo [5], Santiago Celaya [1], Ismael Fuente [1], Marta Fuente [6], Maria Rodriguez [2] and Claudia Grossi [2]

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2 Laboratory of 222Rn Studies, Institut de Tècniques Energètiques, Universitat Politècnica de Catalunya, 08028 Barcelona, Spain; arturo.vargas@upc.edu (A.V.); maria.dolores.rodriguez@upc.edu (M.R.); claudia.grossi@upc.edu (C.G.)
3 Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, 077125 Magurele, Romania; rileana@nipne.ro (I.R.); razvan.ioan@nipne.ro (M.-R.I.)
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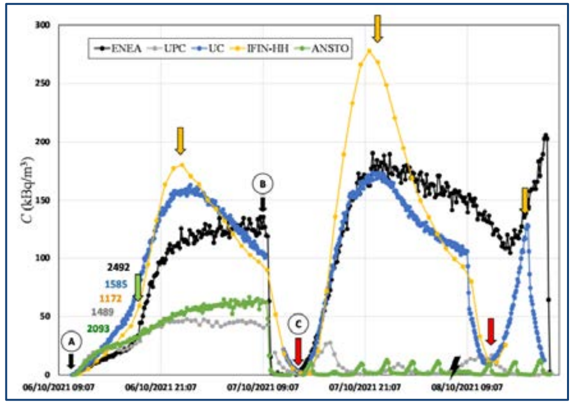

*This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. **19ENV01 traceRadon** denotes the EMPIR project reference.*

Achievements – 9: New maps

atmosphere MDPI

Review

Overview of Radon Flux Characteristics, Measurements, Models and Its Potential Use for the Estimation of Radon Priority Areas

Igor Čeliković [1], Gordana Pantelić [1], Ivana Vukanac [1], Jelena Krneta Nikolić [1], Miloš Živanović [1], Giorgia Cinelli [2,*], Valeria Gruber [3], Sebastian Baumann [3], Giancarlo Ciotoli [4], Luis Santiago Quindos Poncela [5] and Daniel Rábago [5]

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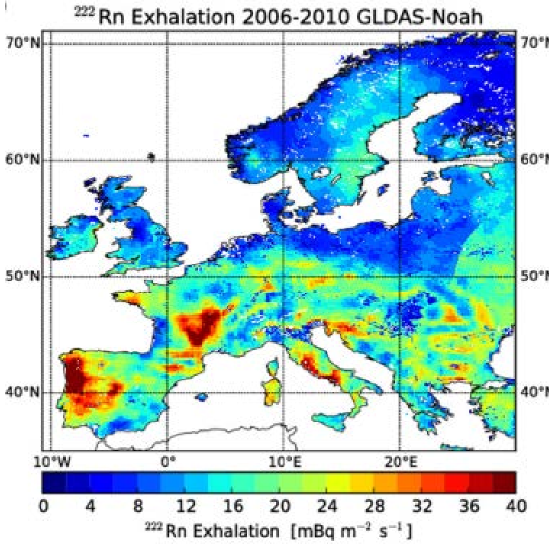

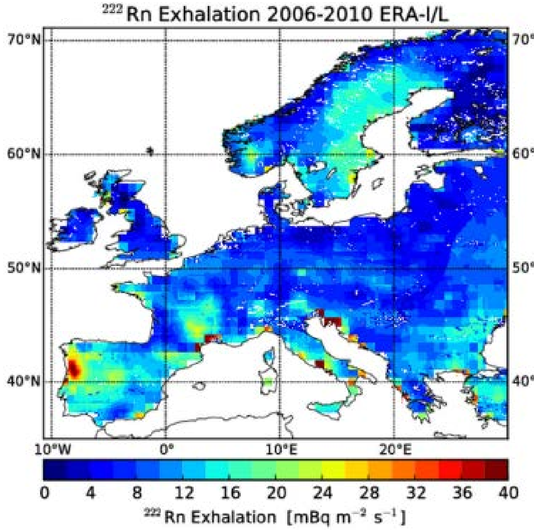

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Achievements – 10: Campaigns for authorities

VILNIUS TECH
Vilnius Gediminas Technical University

Journal of Environmental Engineering and Landscape Management
ISSN 1648–6897 / eISSN 1822-4199
2022 Volume 30 Issue 3: 370–379
https://doi.org/10.3846/jeelm.2022.17411

ANALYSIS OF THE RADON CONCENTRATIONS IN NATURAL MINERAL AND TAP WATER USING LUCAS CELLS TECHNIQUE

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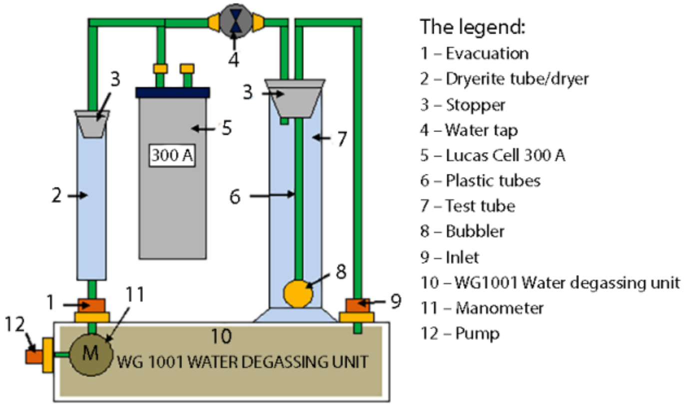

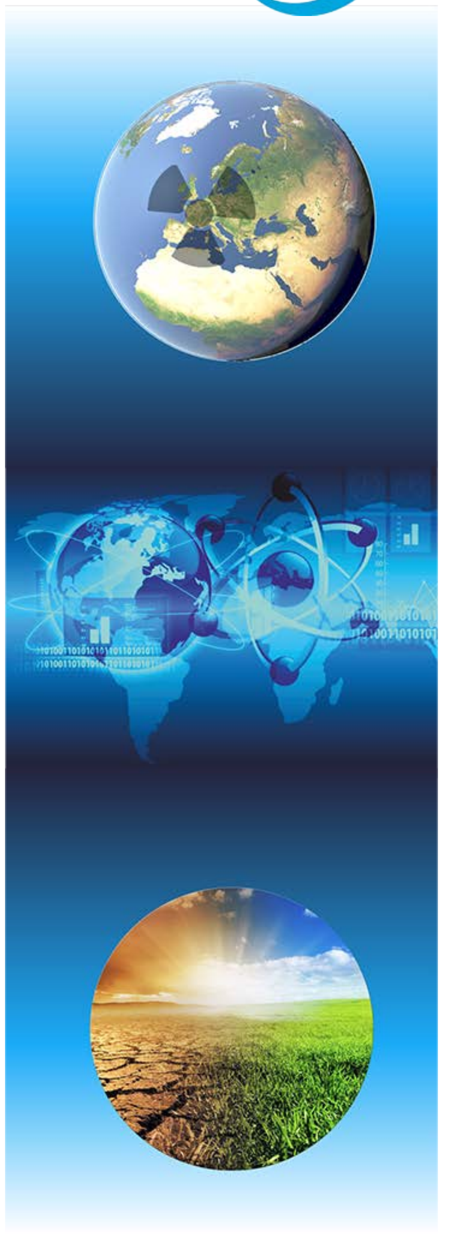

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Worldwide collaboration

Last continent reached: Antarctica!

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1. Mertes, F et. al.: D3.3 Approximate sequential Bayesian filtering to estimate Rn-222 emanation from Ra-226 sources from spectra, https://doi.org/10.5162/SMSI2021/D3.3
2. Röttger, A. *et al: New metrology for radon at the environmental level 2021 Meas. Sci. Technol.* 32, 124008, https://doi.org/10.1088/1361-6501/ac298d
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5. Čeliković, I. et. al.: Outdoor Radon as a Tool to Estimate Radon Priority Areas - A Literature Overview, Int. J. Environ. Res. Public Health 2022, 19, 662, https://doi.org/10.3390/ijerph19020662
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11. Čeliković, I.; Pantelić, G.; Vukanac, I.; Nikolić, J.K.; Živanović, M.; Cinelli, G.; Gruber, V.; Baumann, S.; Ciotoli, G.; Poncela, L.S.Q.; Rábago, D. Overview of Radon Flux Characteristics, Measurements, Models and Its Potential Use for the Estimation of Radon Priority Areas. Atmosphere 2022, 13, 2005, https://doi.org/10.3390/atmos13122005

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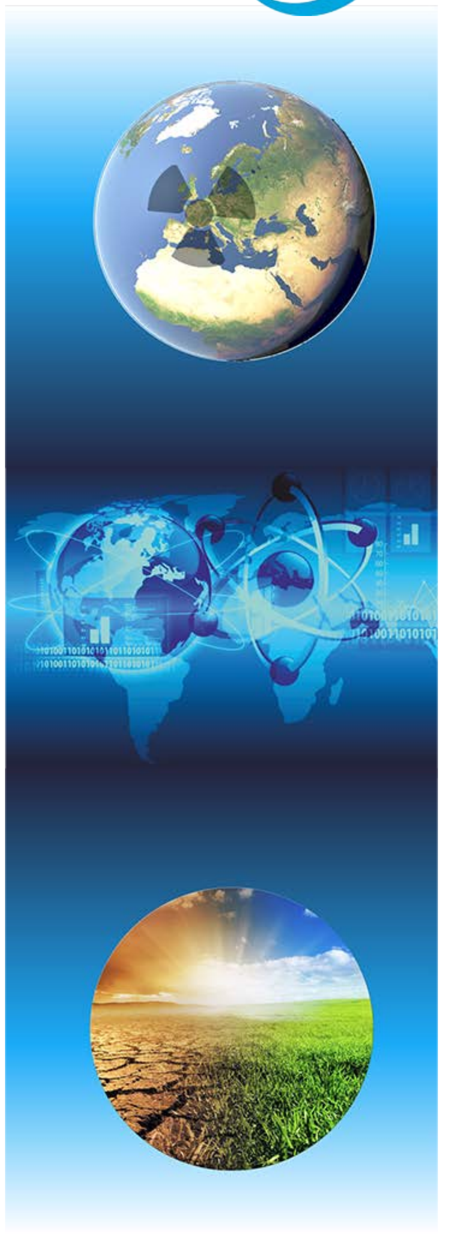

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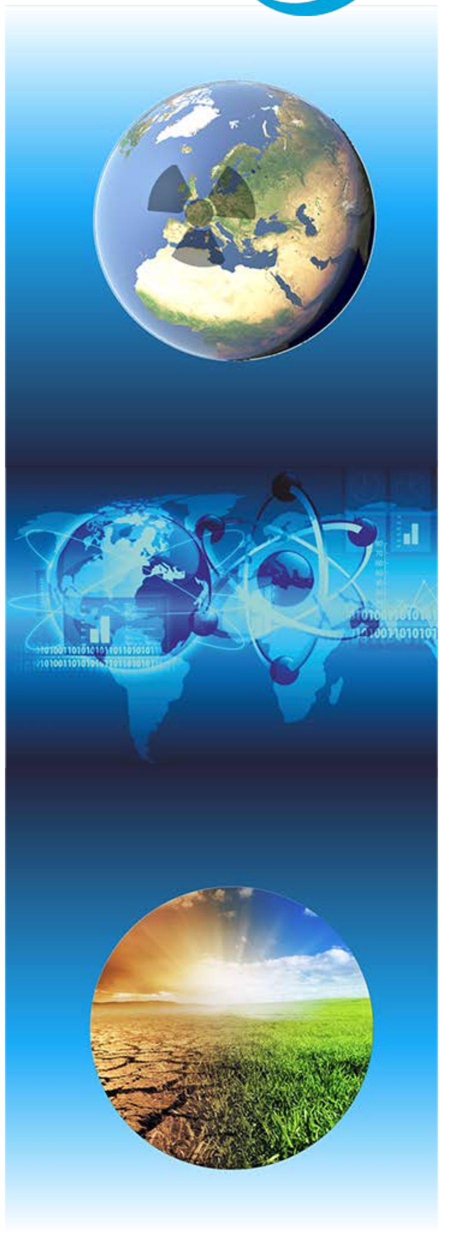
Summary

The key targets to be reached by the end of this project (and to be exploited in the 5 years that follow the end of the project) are as follows:

- **New SI traceability** for measurement quantities used in climate observation and radiation protection;
- **New customer calibration services** for new types of measurement and new types of device. To develop a first standard protocol for the application of the radon tracer method (RTM) to enable retrieval of greenhouse gas fluxes at atmospheric climate gas monitoring stations and to use radon flux data for the identification of Radon Priority Areas (RPA);
- To **validate current radon flux models and inventories** by the new traceable measurements of radon activity concentration and radon flux. To support the validation with dosimetric and spectrometric data from the radiological early warning networks in Europe;
- To provide easy to use **dynamic radon and radon flux maps** for climate change research and radiation protection in line with Council Directive 2013/59/EURATOM, including their use to identify RPA and radon wash-out peaks;
- To facilitate the **take up of the technology and measurement infrastructure**.



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Thanks…

… to the traceRadon-project partners:

… to the traceRadon-project collaborators:

… to the traceRadon-project Stakeholder Committee, Stakeholders, MSU, EURAMET,

… and for your attention!