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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

Atmospheric radon concentrations campaigns within the EMPIR 19ENV01 traceRadon project: the ARMON monitor

C. Grossi, R. Curcoll and A. Vargas
in collaboration with WP1 participants

EURADOS WG3 Annual Meeting 2022

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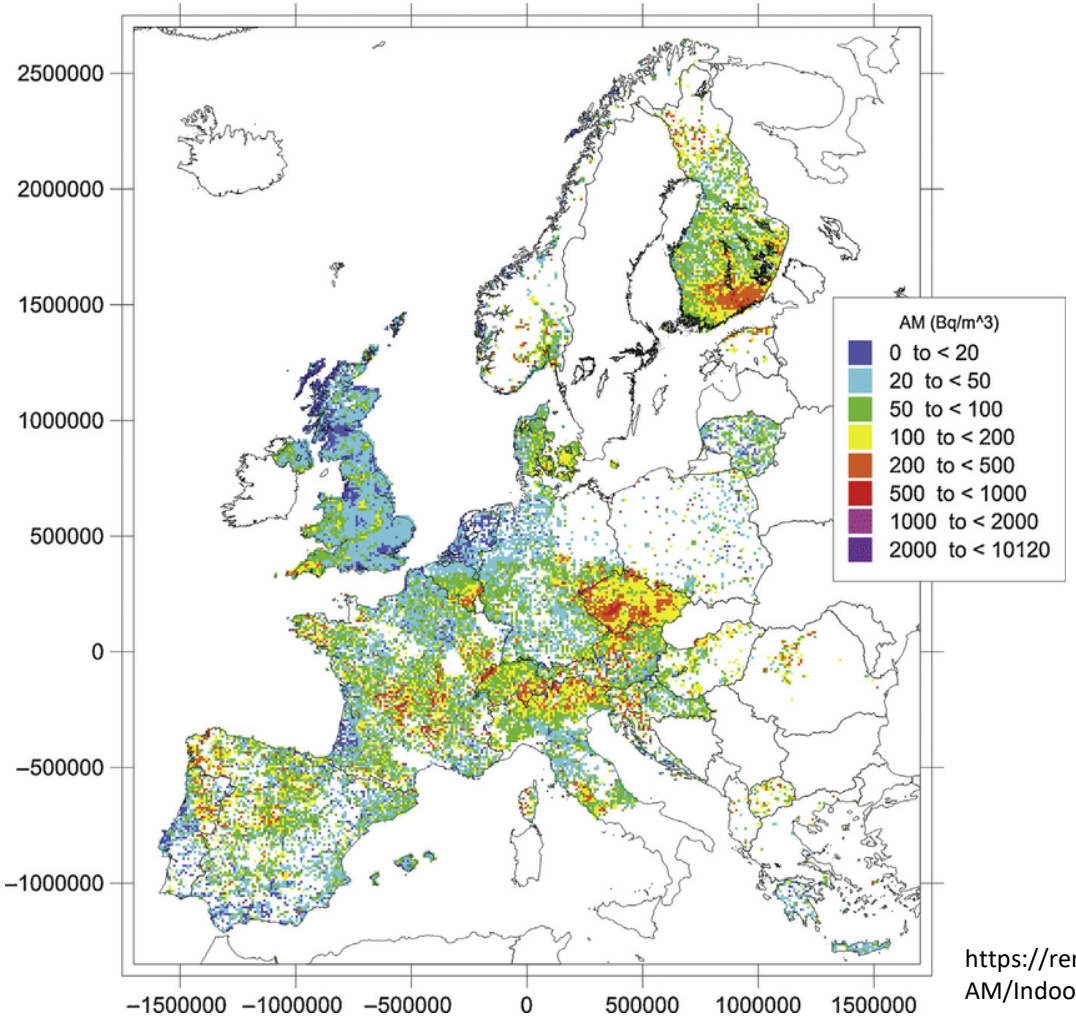
Contents of this talk:

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

First need: Identification of Radon Prone Areas (RPAs)



2013/59/EURATOM – Article 103(3)

'Member States shall identify areas where the radon concentration (as an annual average) in a significant number of buildings is expected to exceed the relevant national reference level.'

Problem

Only sparse and not harmonized indoor radon concentrations measurements are available due they are money and time consuming

https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation/Digital-Atlas/Indoor-radon-AM/Indoor-radon-concentration

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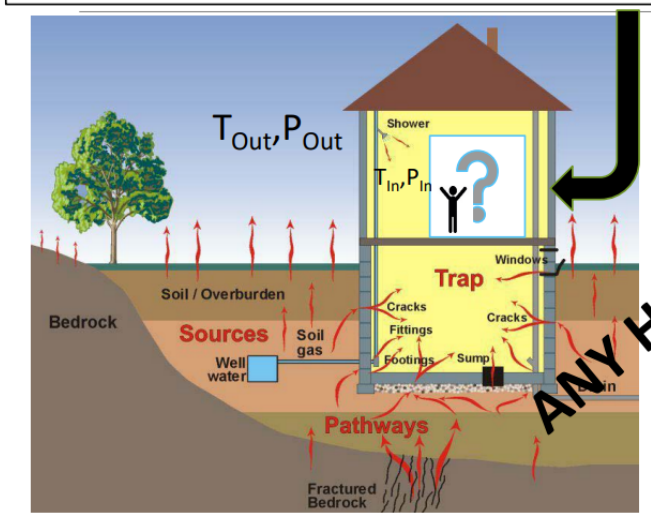
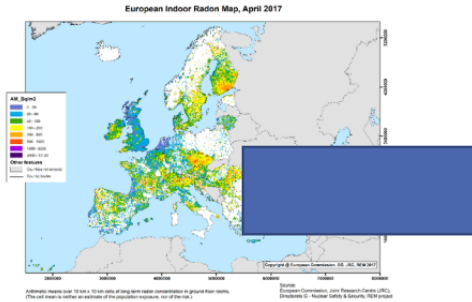
The main aim is knowing the indoor ^{222}Rn concentrations at which the people are exposed in old building or may be exposed in new building

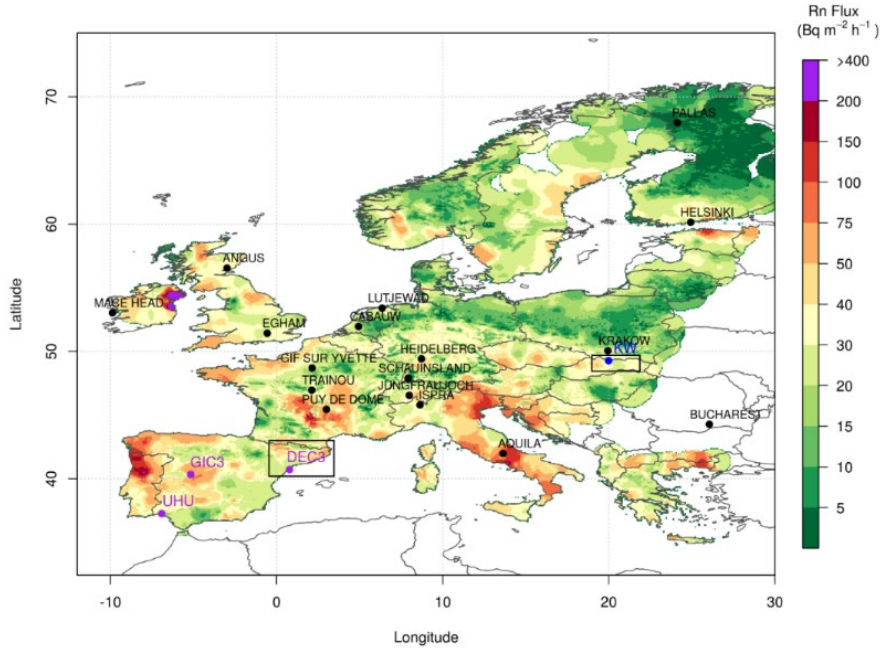


EXPERIMENTAL LONG-TERM CONTINUOUS MEASUREMENTS ARE TOO DEMANDING FOR PRESENT BUILDINGS AND NOT FEASIBLE FOR FUTURE BUILDING

ANY HELP ?



https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation/Indoor-radon-AM/Indoor-radon-concentration



Grossi et al., 2016, doi: 10.1002/2016JD025196

We could use outdoor (atmospheric) radon measurements as proxy of indoor data or to calculate radon exhalation maps (by inverse modelling)!!!!

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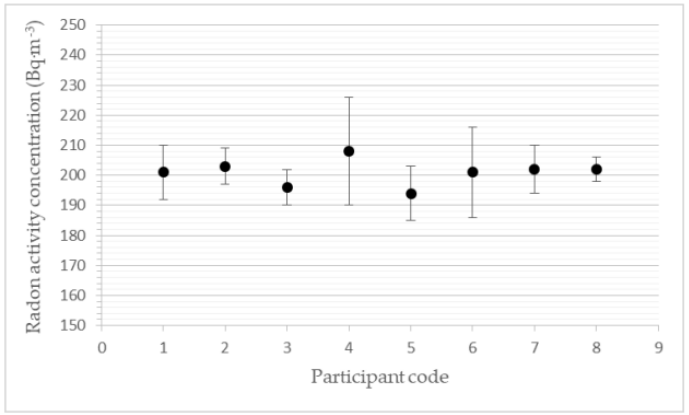
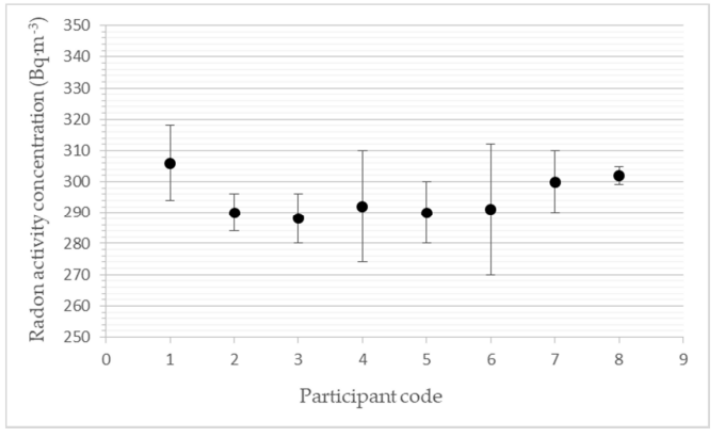
Second need: High quality indoor radon concentrations below 200 Bq m^{-3}

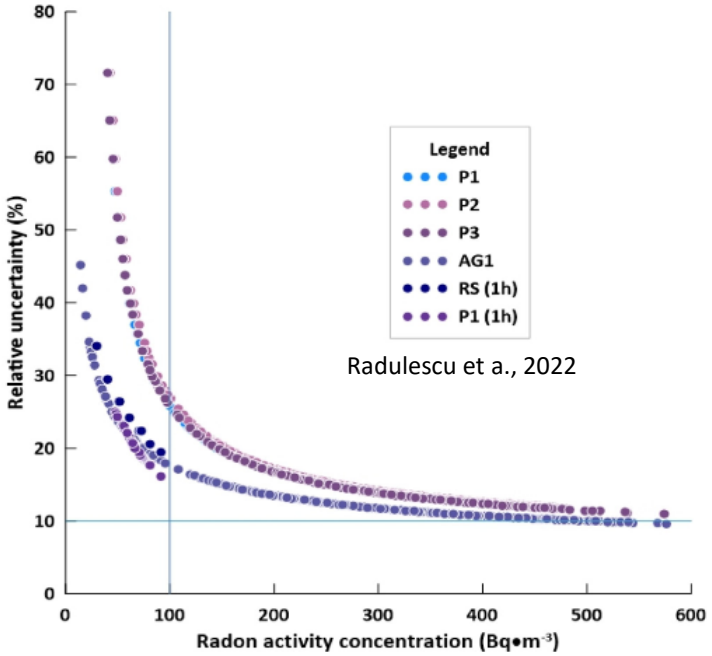




Othal et al, 2022; https://doi.org/10.3390/ijerph19105810

Metro RADON

U_i between 2% and 9% (expanded relative error of the mean?)



Radulescu et a., 2022

Problem

So far we do not have any available metrology chain for radon activity concentrations below 200 Bq m^{-3}. In addition commercial radon monitor data has a huge uncertainty for low concentrations.

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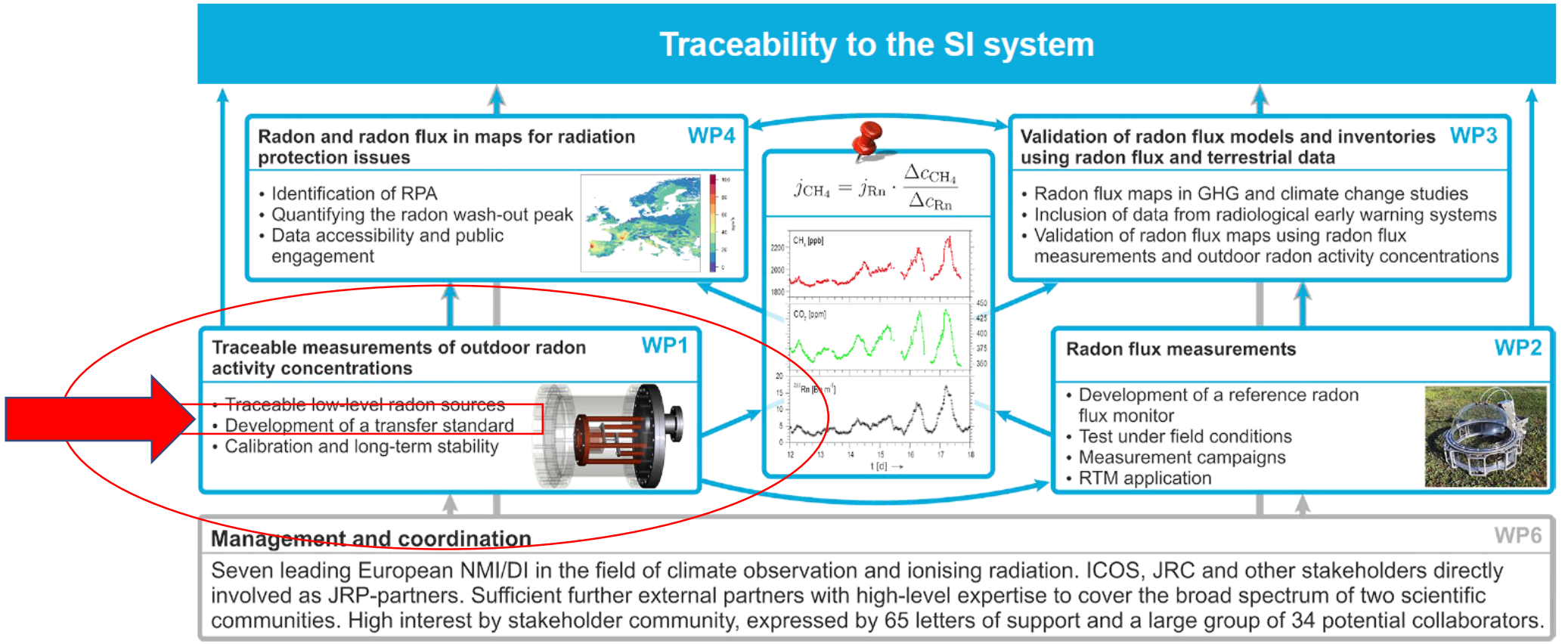
The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements

The traceRadon Project started in 2020



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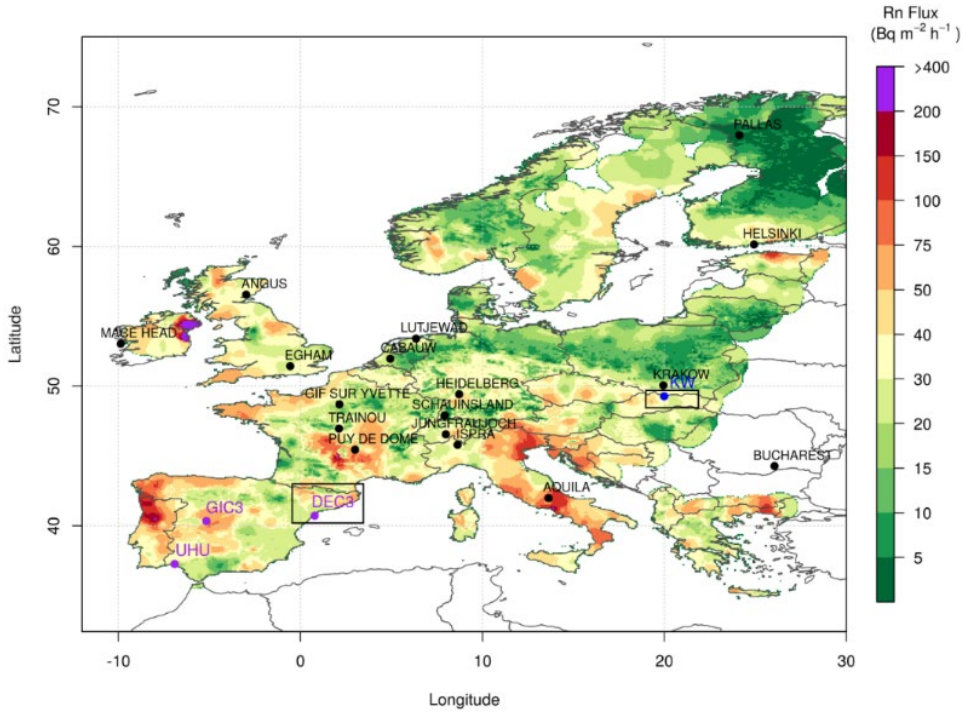
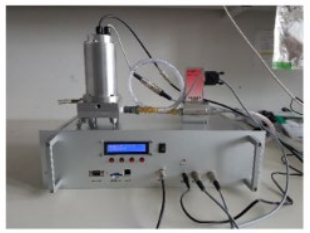
The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements

A literature study carried out in the framework of the WP1 (Task 2) of the traceRadon Project shows the existence of research monitors able to measure really low radon concentrations in air (few hundreds of mBq m^{-3}) with a counts uncertainty in the order of 10% (k=1)



Most frequent used atmospheric radon measurements techniques in Europe

HEIDELBERG MONITOR (Levin et al., 2002)



1-filter method
- portable
- ^{214}Po and need to assume an equlibrium factor between $^{214}Po/^{222}Rn$

ANSTO MONITOR (Zahorowski et al., 2004)

1500 L dual flow loop, two filter radon detector

2-filters
-Large volume
-^{222}Rn decay products with large error associated for low concentrations

ARMON (Grossi et al., 2012)

- Electrostatic collection
- Portable (20 L)
- ^{218}Po and ^{216}Po from ^{222}Rn decay only in the detection volume

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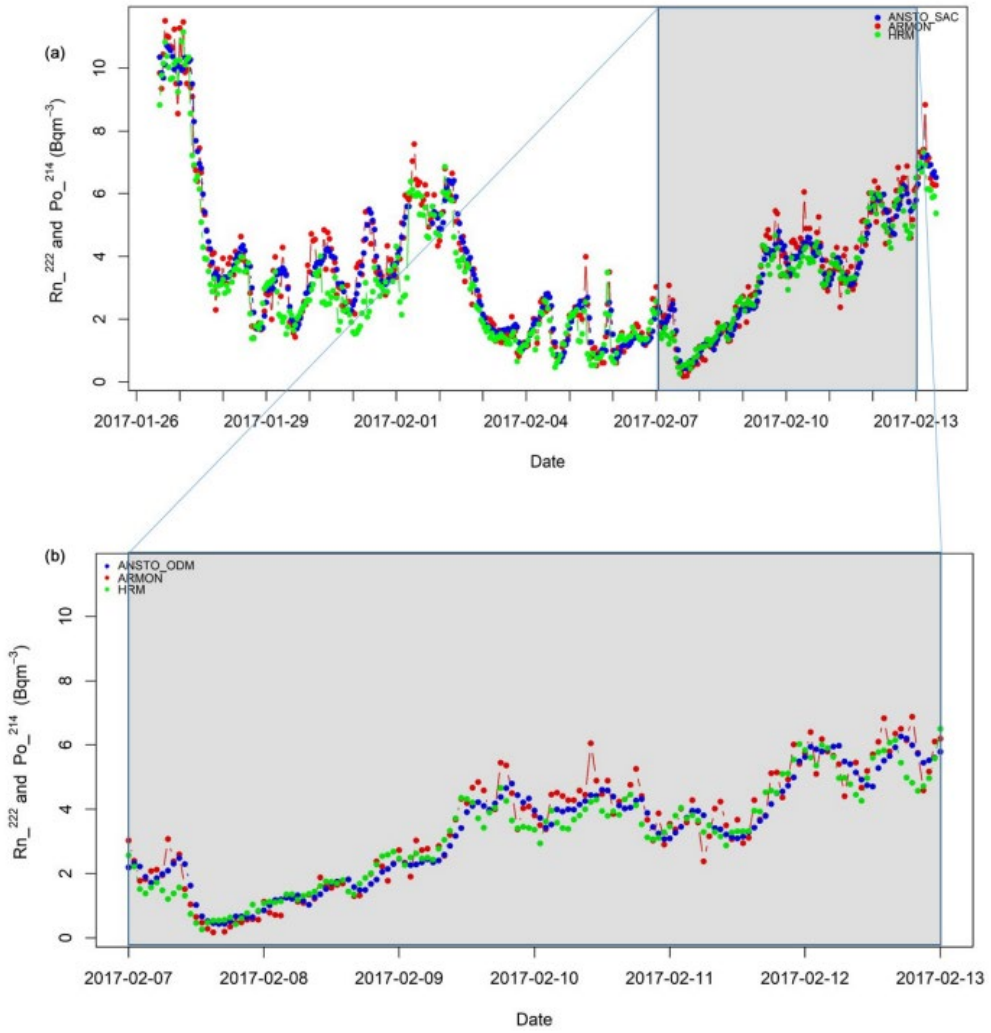
The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements



HRM, ARMON and ANSTO 1500L Monitors were previously compared in the south of Paris by short-term comparison campaigns and results were really satisfactory

Grossi, C. et al., Atmos. Meas. Tech., 13, 2241–2255, https://doi.org/10.5194/amt-13-2241-2020, 2020.

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The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements

Requirements for the new Transfer Standard instrument

Table 2. Matrix of recommended properties for the in-field application of a transfer standard radon monitor for atmospheric measurements.

Property	Recommended range for in field applicability
Environmental temperature T (°C)	−25 to +50 °C
Environmental relative humidity rH (%)	10 % to 100 %
Atmospheric pressure p (hPa)	620 to 1030 hPa
Measurable atmospheric radon activity concentration c_A (Bq m^{-3})	1 to 200 Bq m^{-3}
Sensitivity k (counts per 60 s per Bq m^{-3})	>0.3 (60 s Bq m^{-3})$^{-1}$
Total uncertainty u (%) for activity higher than 0 Bq m^{-3} and less than 100 Bq m^{-3} within 1 h ($k = 2$)	<20 %
Detection Volume V (m^3) and weight G (kg)	<1 m^3 <70 kg

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

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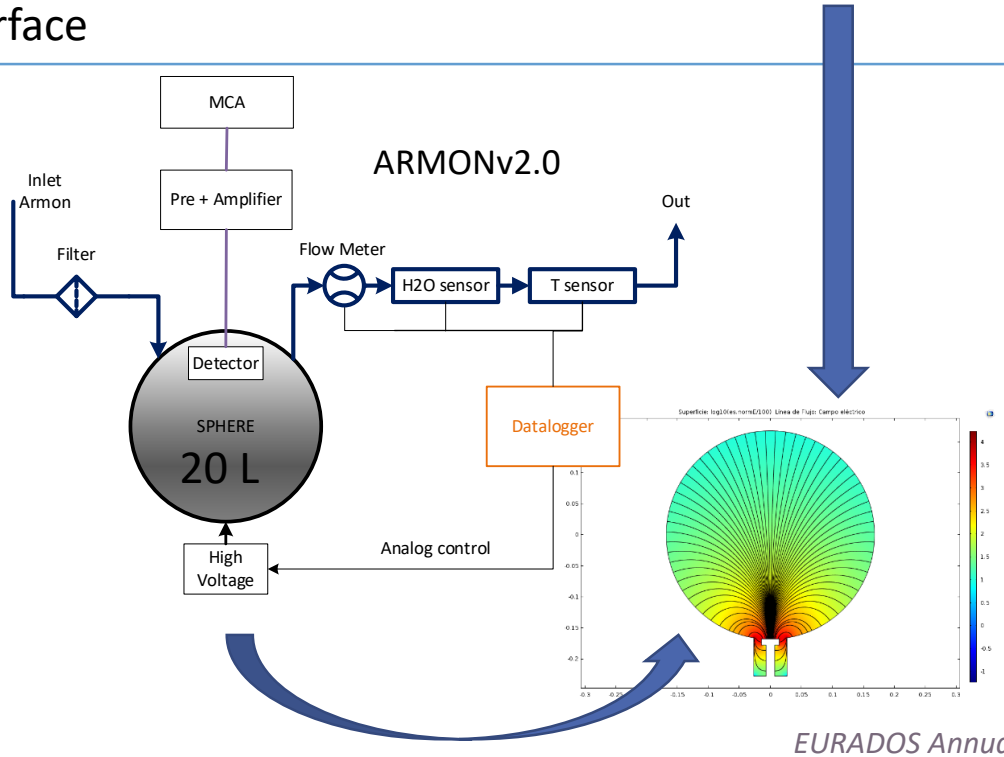
The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements

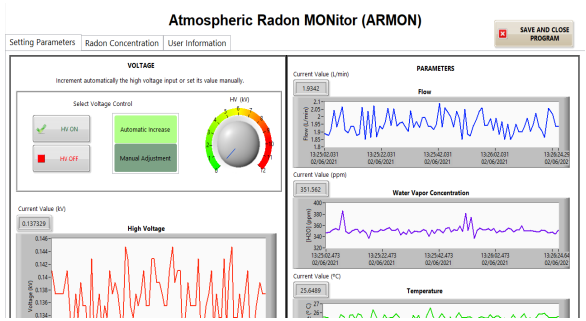
Atmospheric Radon MONitor (ARMON): TS instrument

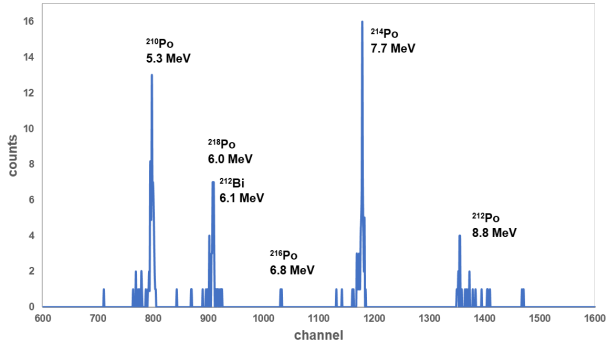
To be used for in situ atmospheric radon monitor calibration or as secondary standard monitor in radon calibration facilities (traceRadon)

Electrostatic collection of ^{218}Po and ^{216}Po on a PIPs detector surface



- Allows radon and thoron measurements
- Zero background thanks to it high spectra resolution
- Full alpha spectra analysis
- Real time data visualization





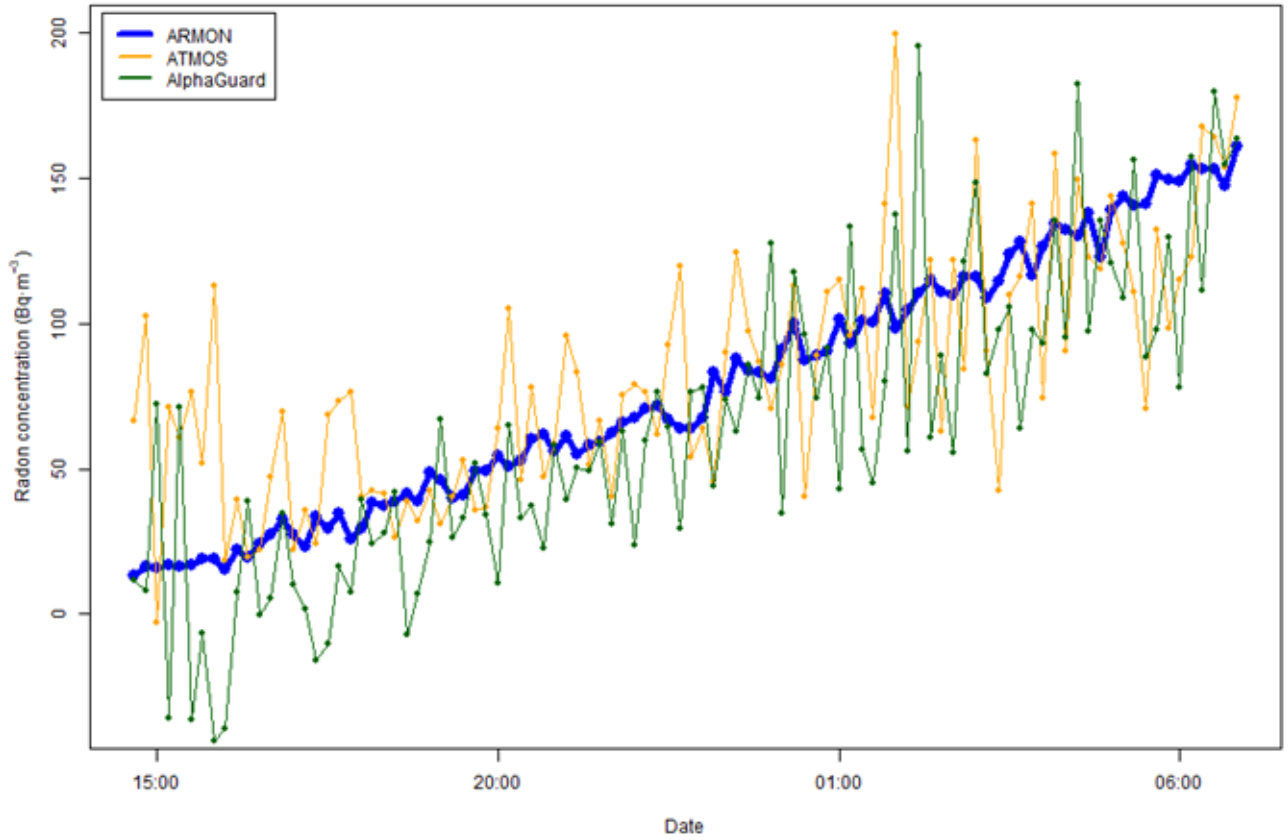
The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements

ARMONv2.0

INTE Radon chamber

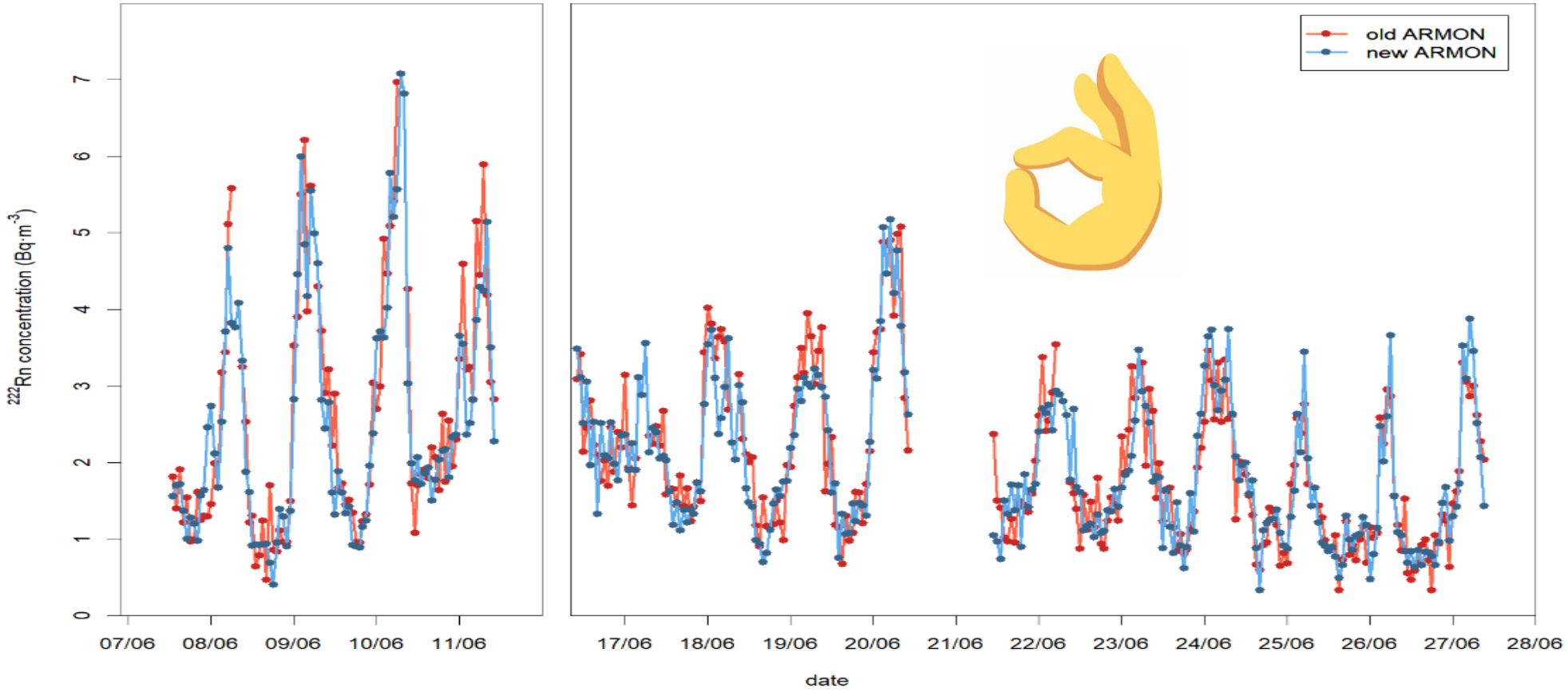
AlphaGuard

ATMOS



The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements

The ARMONv2.0 was compared with a previous ARMON model



- **Intercomparison** at ETSEIB-UPC roof with an older ARMON (07-28/06/2021)

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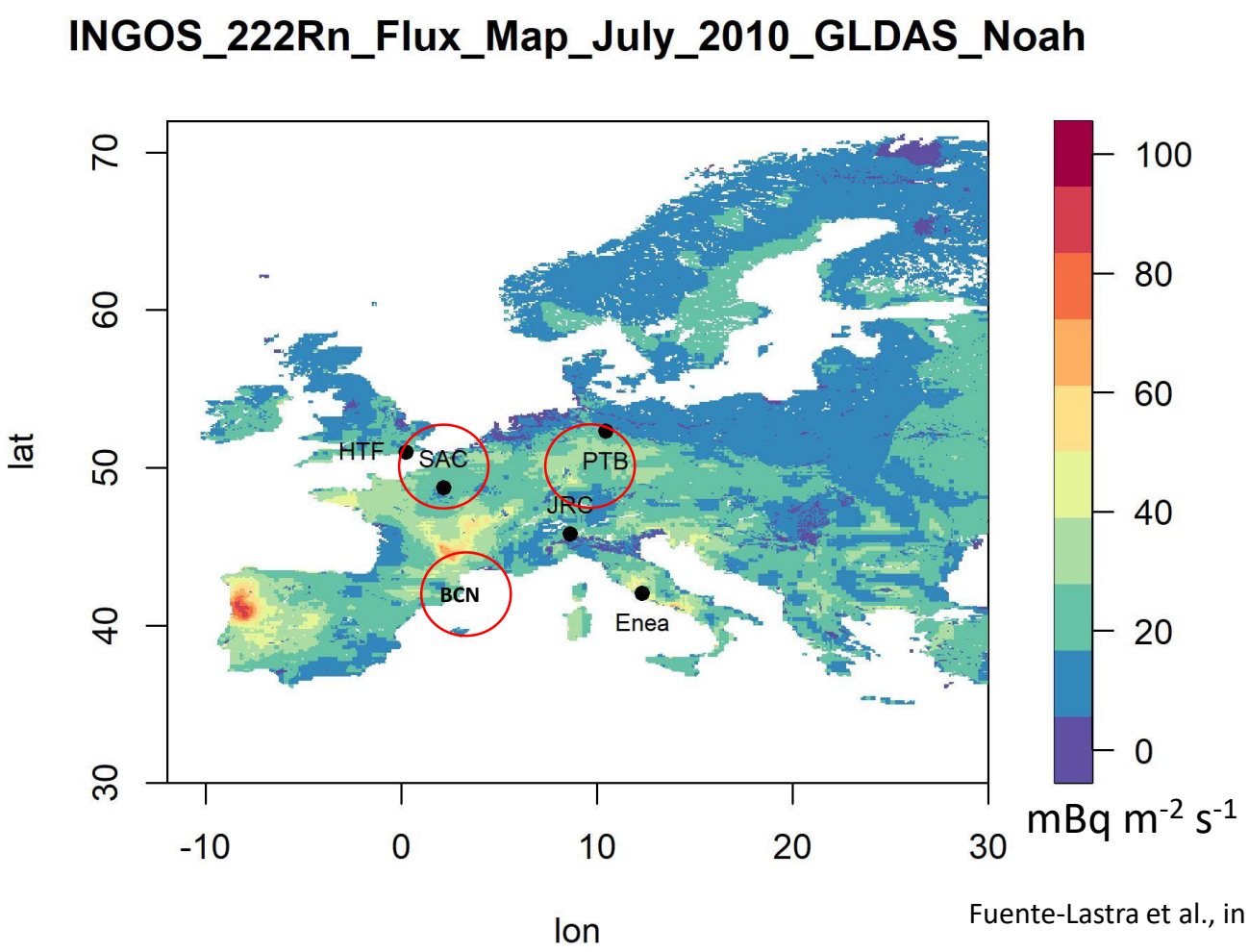
The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements



Fuente-Lastra et al., in preparation

The ARMON v2.0 is being now compared with a new ANSTO monitor (200 L) at two stations (SAC and PTB)

ARMON v2.0 at SAC

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trace Radon

EMPIR

EURAMET

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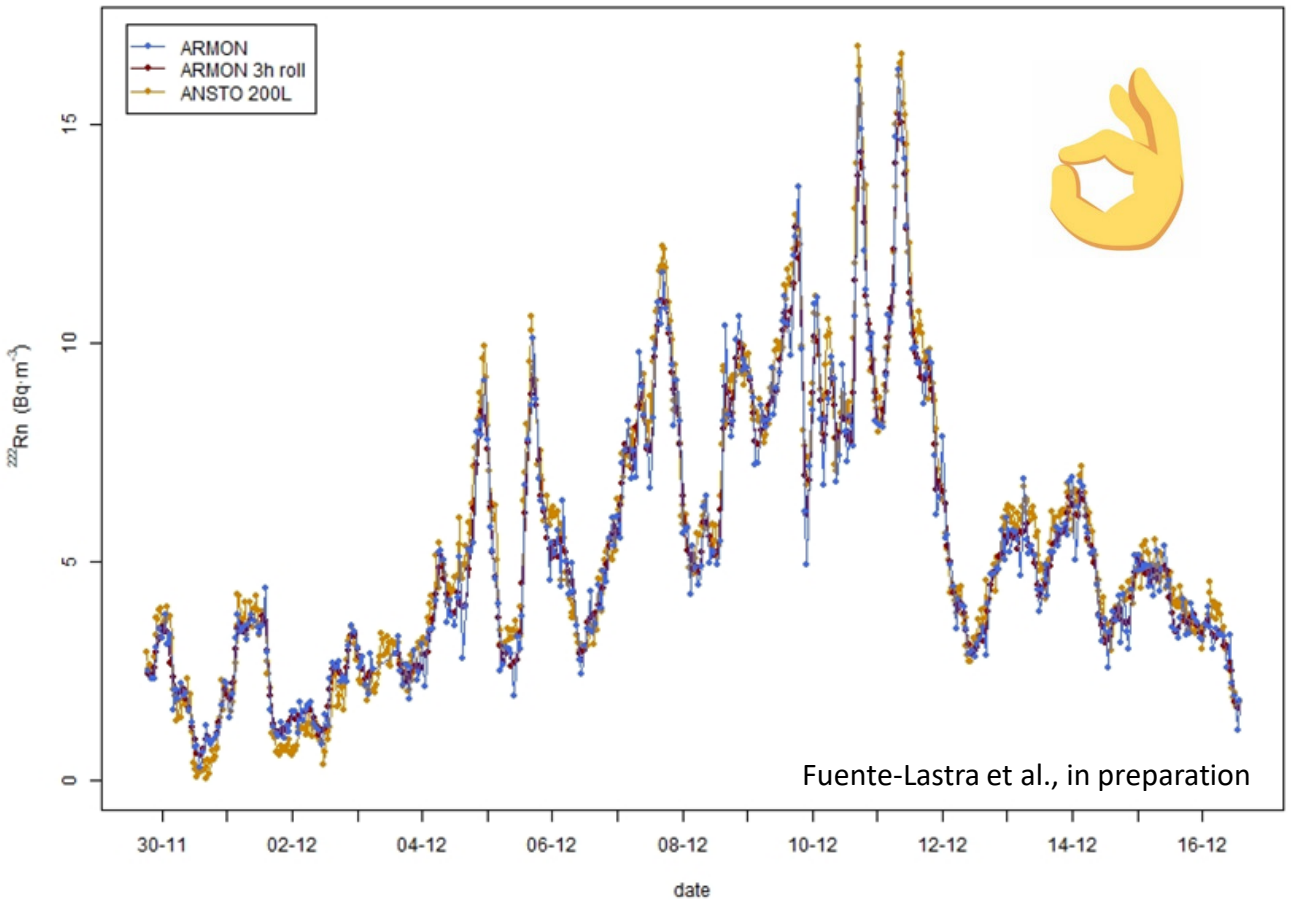
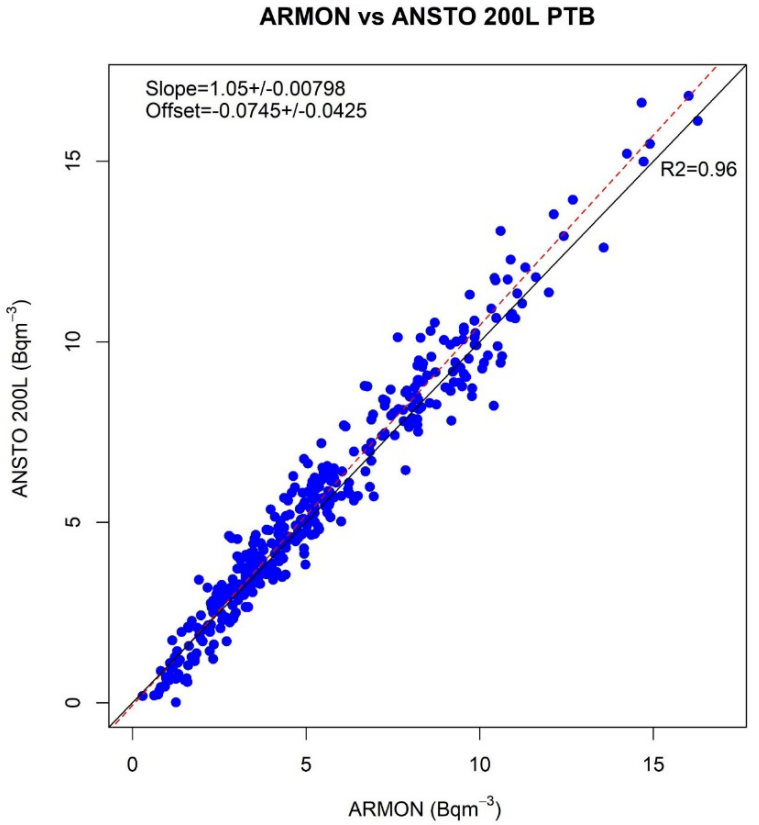
The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements

ARMON v2.0 and ANSTO 200L at PTB (1 m above ground level)



Fuente-Lastra et al., in preparation



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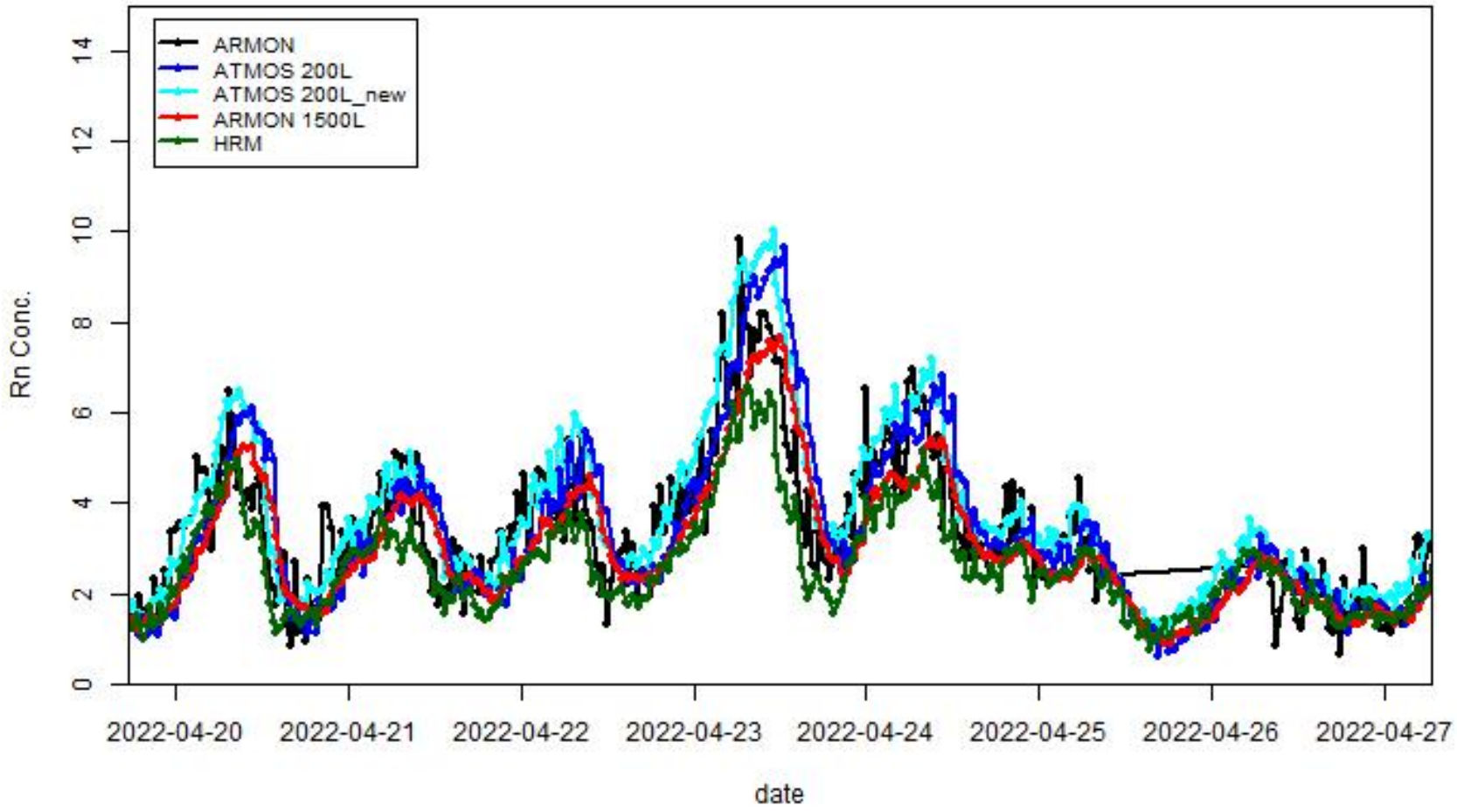
The Solution: Design and build a full metrology chain for outdoor radon activity concentration measurements

ARMON v2.0, HRM, ANSTO 1500 L and ANSTO 200L at SAC (100 m above ground level)



Sampling line experienced several problems (mainly leakages) and data are currently under analysis

Fuente-Lastra et al., in preparation

Conclusions and Next steps:

- Atmospheric radon activity concentrations may help to identify Radon Prone Areas and they could be used as proxy for indoor radon concentrations;
- Currently there are not available commercial radon monitors able to measure really low radon concentrations with small uncertainties;
- The project traceRadon wants to offer a complete metrology infrastructure for atmospheric radon measurements including a transfer standard instrument to calibrate instrument in situ at atmospheric stations or to be used as secondary standard within radon calibration facilities;
- A new high sensitivity radon instrument was designed and built at the Universitat Politecnica de Catalunya. This instrument is robust, portable, allows a complete alpha spectra analysis of radon and thoron progeny and offers to the users remote control and real time data of all variables;
- The instrument ARMON v2.0 was calibrated at the UPC radon chamber and it will be calibrated at the PTB facility in September 2022 within the project traceRadon;
- The new ARMON 20L is being compared with a new two filter 200 L monitor from ANSTO at different heights above the ground and at different stations (Germany and France) in the framework of the traceRadon project;
- A full uncertainties budget of the new ARMON is going to be performed by UPC and PTB.

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Thank You

ClaudiaGrossi4

EURADOS Annual Meeting WG3 -21st June, 2022 Belgrade