ARMON (Atmospheric Radon MONitor)

Roger Curcoll, Claudia Grossi, Arturo Vargas

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

Horizon 2020
European Union Funding
for Research & Innovation

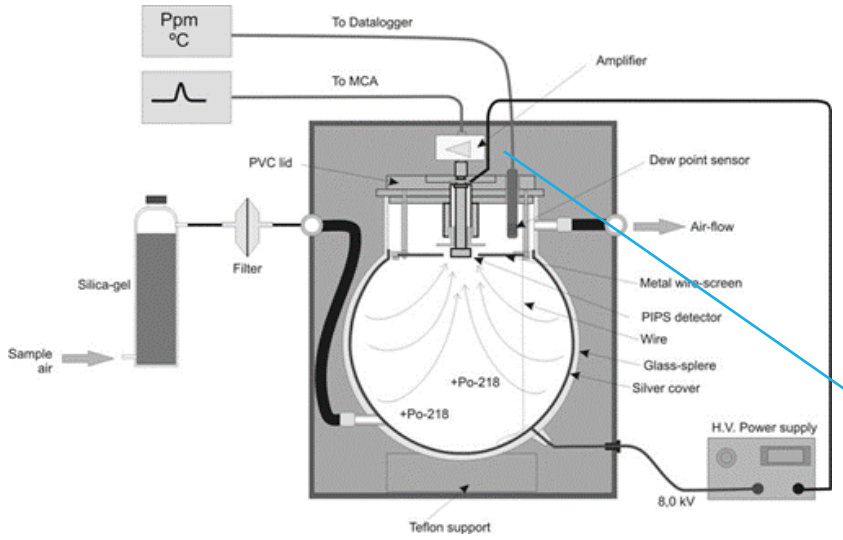
trace Radon

UPC
UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

ARMON. Operation pinciple

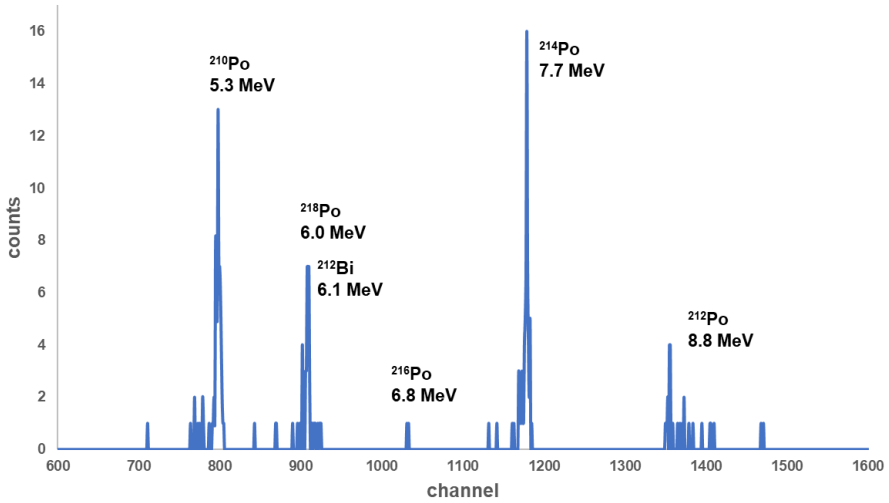
The Atmospheric Radon MONitor (ARMON)

Operation principle: Electrostatic collection of ^{218}Po and ^{216}Po from ^{222}Rn and ^{220}Rn respectively on an alpha detector



ARMON v1.0 [Grossi et al., 2012; Vargas et al., 2015]

- *Designed, built and calibrated at the INTE-UPC (radon chamber)*



Full alpha spectra analysis (No black box).

- No overlapping of ^{210}Po counts;
- Detection of ^{218}Po and ^{214}Po counts (^{222}Rn progeny) and ^{212}Po and ^{216}Po counts (^{220}Rn progeny):
  => possibility to measure thoron concentration.

GHG emissions estimation

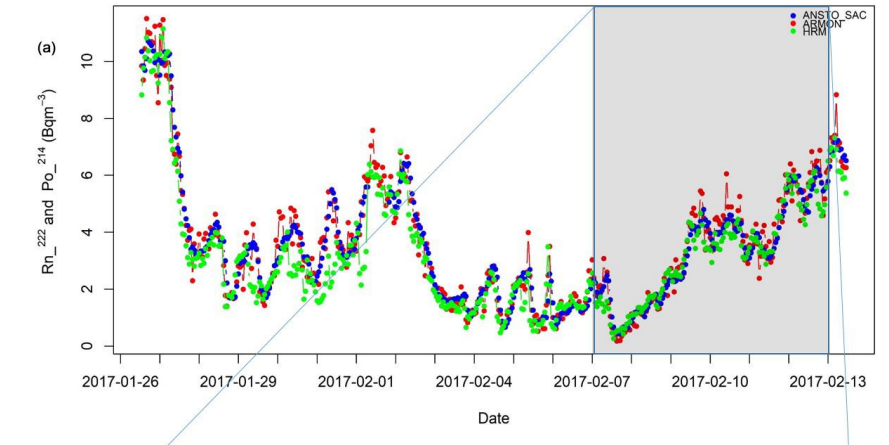
Good agreement of the ARMON when compared with others research atmospheric radon monitors (HRM and ANSTO 1500L) based on different measurement principles.

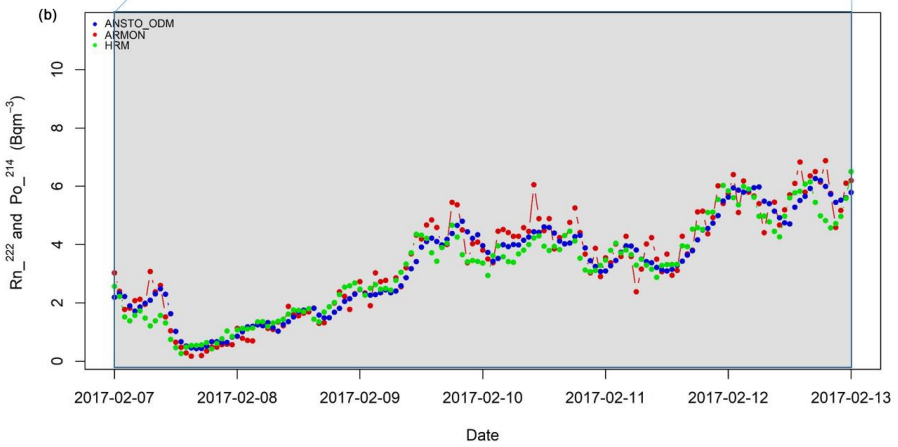
Atmos. Meas. Tech., 13, 2241–2255, 2020
https://doi.org/10.5194/amt-13-2241-2020

Atmospheric Measurement Techniques

Intercomparison study of atmospheric ^{222}Rn and ^{222}Rn progeny monitors

Claudia Grossi[1,2], Scott D. Chambers[3], Olivier Llido[4], Felix R. Vogel[5], Victor Kazan[4], Alessandro Capuana[6], Sylvester Werczynski[3], Roger Curcoll[7,8], Marc Delmotte[4], Arturo Vargas[1], Josep-Anton Morguí[7,9], Ingeborg Levin[6], and Michel Ramonet[4]





Atmospheric studies with ARMON v1.0 in Spanish stations

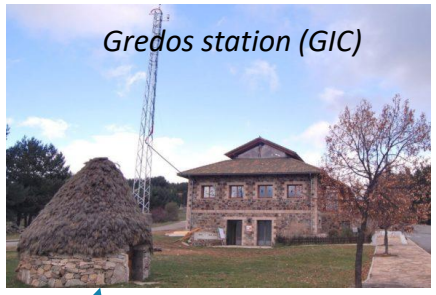
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Horizon 2020 European Union Funding for Research & Innovation

Atmospheric Chemistry and Physics Open Access EGU

Study of the daily and seasonal atmospheric CH_4 mixing ratio variability in a rural Spanish region using ^{222}Rn tracer

Claudia Grossi[1,a,b], Felix R. Vogel[2], Roger Curcoll[1,c], Alba Àgueda[1,d], Arturo Vargas[3], Xavier Rodó[1,4,e], and Josep-Anton Morguí[1,5,c]



Barcelona station (BCN)

Contents lists available at ScienceDirect

Atmospheric Environment

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

Radon behavior investigation based on cluster analysis and atmospheric modelling

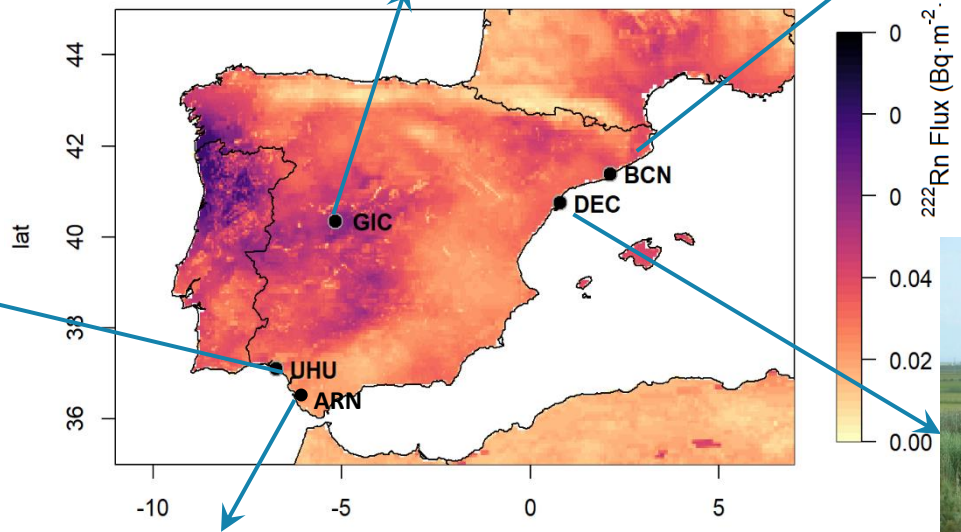
I. Gutiérrez-Álvarez[a,*], J.L. Guerrero[a], J.E. Martín[a], J.A. Adame[b], A. Vargas[c], J.P. Bolívar[a]

Journal of Environmental Radioactivity 145 (2015) 1–9

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

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



The role of mesoscale meteorology in modulating the ^{222}Rn concentrations in Huelva (Spain) – impact of phosphogypsum piles

M.A. Hernández-Ceballos [a], A. Vargas [b,*], D. Arnold [c], J.P. Bolívar [d]

Contents lists available at SciVerse ScienceDirect

Radiation Measurements

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

Delta de l'Ebre station (DEC)

Atmospheric ^{222}Rn concentration and source term at *El Arenosillo* 100 m meteorological tower in southwest Spain

C. Grossi [a], D. Arnold [a,b], J.A. Adame [c], I. López-Coto [d], J.P. Bolívar [d], B.A. de la Morena [c], A. Vargas [a,*]

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

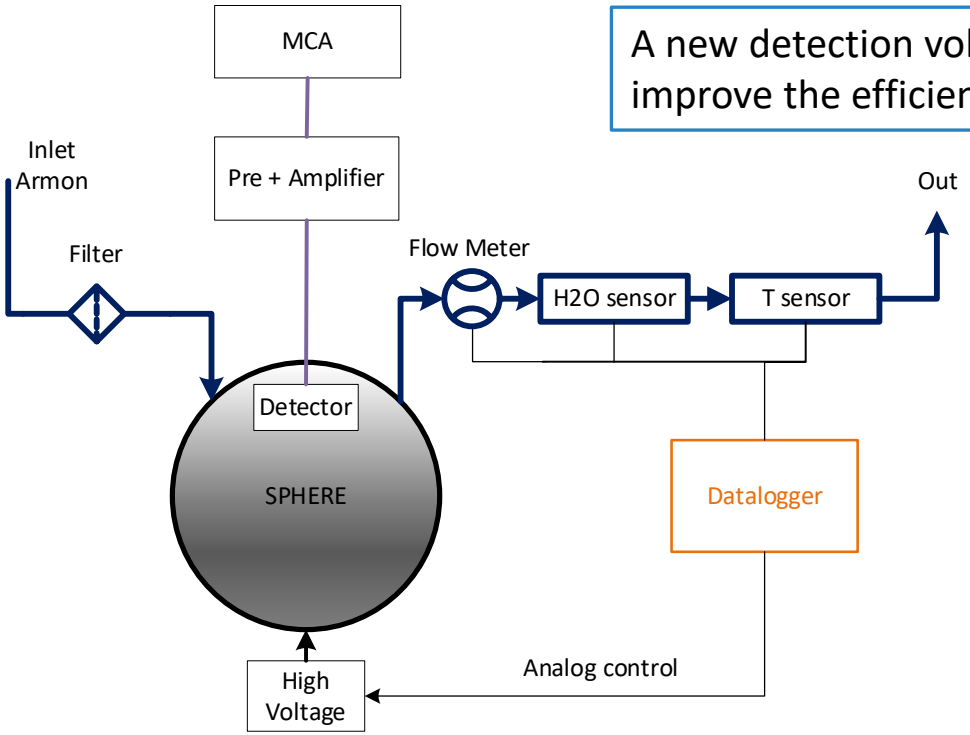
journal homepage: www.elsevier.com/locate/jenvrad

Analysis of the vertical radon structure at the Spanish "El Arenosillo" tower station

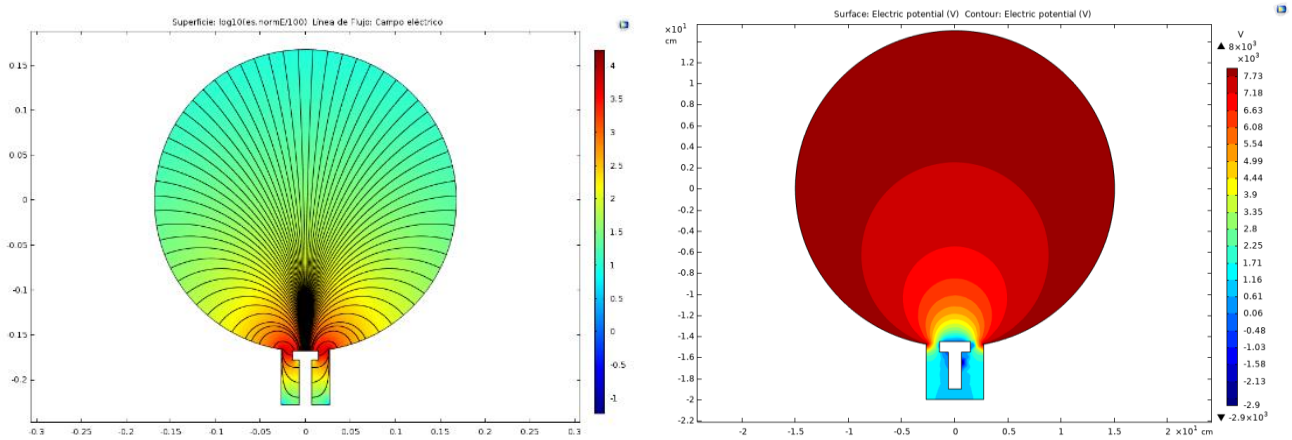
A. Vargas [a,*], D. Arnold [b], J.A. Adame [c], C. Grossi [d], M.A. Hernández-Ceballos [e], J.P. Bolivar [f]

ARMON v2.0

- A new version of the ARMON v2.0 was designed, built and characterized in the framework of MARE^{2}A and traceRadon projects
- Objectives of the new system: ***Efficiency improvement, Portability/robustness, User friendly, Real Time Data available online***



A new detection volume shape was designed in order to improve the efficiency of the instrument



Simulation of electric field created within the detection volume applying different potentials.

ARMON v 2.0: Portability/robustness

EMPIR
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States
EURAMET
Horizon 2020
European Union Funding
for Research & Innovation

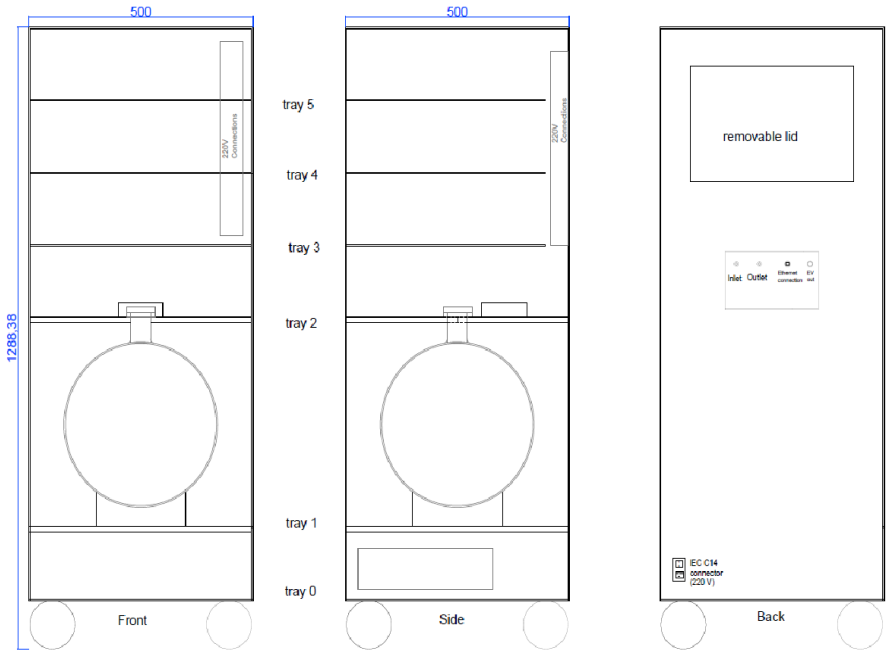
Installation in a flying case box of **50*50*130 cm^3**.

Wheels for easy transportation

Instruments in removable trays

Inlet and outlet located at the back.

Ethernet connection and ventilation holes.



laptop

Electronics & data logger

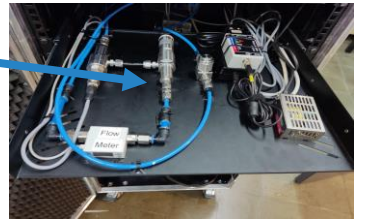
MCA

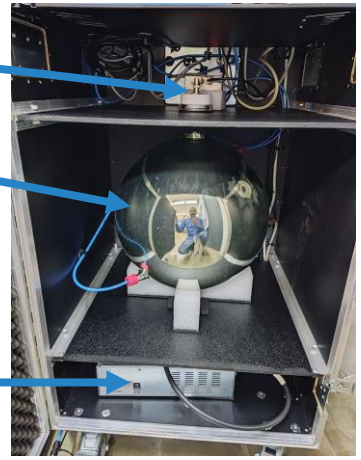
Flow, RH and T sensors

Pre-amplifier + amplifier

Detection volume

High voltage

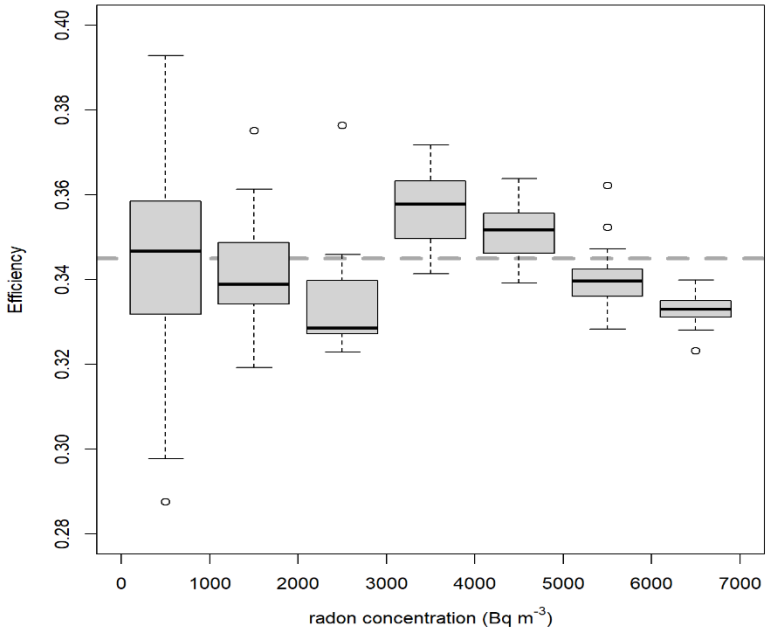




Calibration (ARMON v. 2.0)

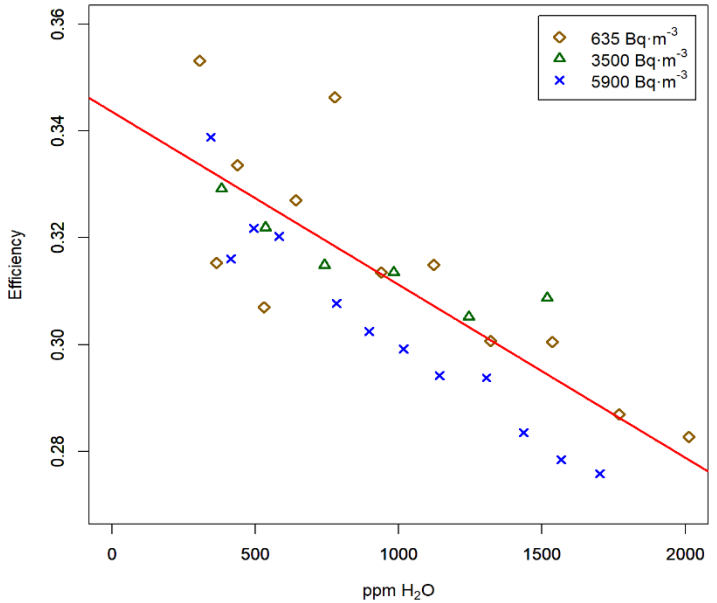
EMPIR
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States
EURAMET
Horizon 2020
European Union Funding for Research & Innovation

- First calibration was done at at INTE radon chamber.
- Calibration at PTB going on since November 2022

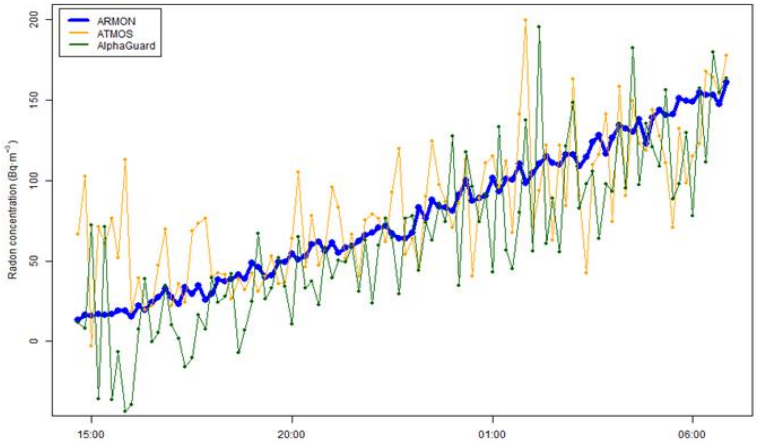


Calibration with ATMOS monitor
(range 0-6500 Bq·m^{-3})

Dependence of the Po collection efficiency on the water content of the sample



Water vapour calibration
(range 0-2000 ppm)



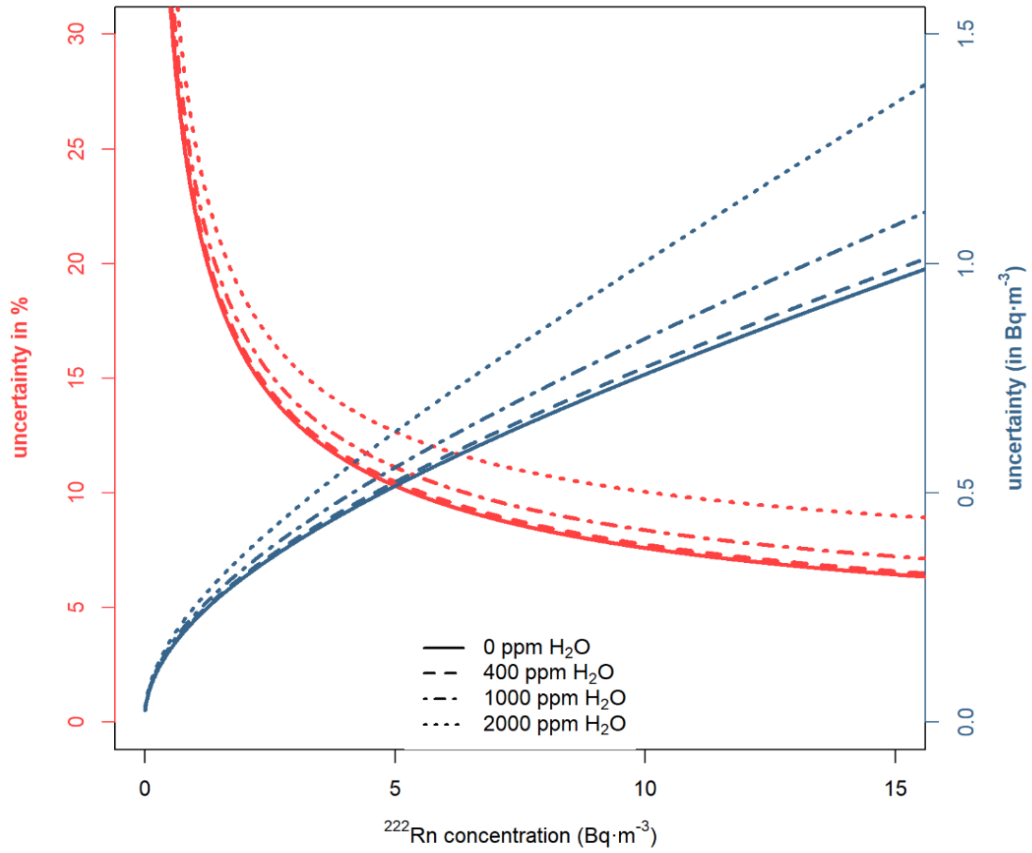
Building up comparison
(with ATMOS and AlphaGuard)

Evaluation of uncertainties (according GUM)

Quantity	Estimate	Type	Standard uncertainty	Probability distribution		Sensitivity coefficient	Contribution to the standard uncertainty
X_i	x_i		$u(x_i)$			c_i	$u_i(y)$
nc_{Po218}	nc_{Po218}	A	$\sqrt{nc_{Po218}}$	Normal		$\frac{C_p \cdot C_T}{t \cdot F_{cal}}$	$c_i u(x_i)$
nc_{Po212}	nc_{Po212}	A	$\sqrt{nc_{Po212}}$	Normal		$-\frac{C_p \cdot C_T}{t \cdot F_{cal}} \cdot \frac{36}{64}$	$c_i u(x_i)$
$Fcal0$	0.35 (cpm per Bq·m^{-3})	B	0.01 (3%)*	Normal		$-\left[\frac{nc_{Po218}}{t} - \left(\frac{nc_{Po212}}{t} \cdot \frac{36}{64}\right)\right] \cdot \frac{C_p \cdot C_T}{(F_{cal0} - b \cdot [H_2O])^2}$	$c_i u(x_i)$
b	3.2·10^{-5} (ppm^{-1})	B	0.4·10^{-5} (1)	Normal		$\left[\frac{nc_{Po218}}{t} - \left(\frac{nc_{Po212}}{t} \cdot \frac{36}{64}\right)\right] \cdot \frac{C_p \cdot C_T \cdot [H_2O]}{(F_{cal0} - b \cdot [H_2O])^2}$	$c_i u(x_i)$
$[H_2O]$	~254 ppm	B	20%·$[H_2O]$ + 1ppm (2)	Normal		$\left[\frac{nc_{Po218}}{t} - \left(\frac{nc_{Po212}}{t} \cdot \frac{36}{64}\right)\right] \cdot \frac{C_p \cdot C_T \cdot b}{(F_{cal0} - b \cdot [H_2O])^2}$	$c_i u(x_i)$
P	~1000 hPa	B	0.3 hPa (3)	Normal		$-\left[\frac{nc_{Po218}}{t} - \left(\frac{nc_{Po212}}{t} \cdot \frac{36}{64}\right)\right] \cdot \frac{C_T \cdot P_{ref}}{F_{cal} \cdot P^2}$	$c_i u(x_i)$
T	~298 K	B	0.15 + 0.002*T (2)	Normal		$\left[\frac{nc_{Po218}}{t} - \left(\frac{nc_{Po212}}{t} \cdot \frac{36}{64}\right)\right] \cdot \frac{C_P}{F_{cal} \cdot T_{ref}}$	$c_i u(x_i)$
C_{Rn}	**3.4 Bq·m^{-3}**	**Combined uncertainty (u) (Bq·m^{-3})**					**0.42 Bq·m^{-3}**

Decision threshold: a^*=0.043 Bq·m^{-3}

Detection limit $a^{\#}$= 0.132 Bq·m^{-3}

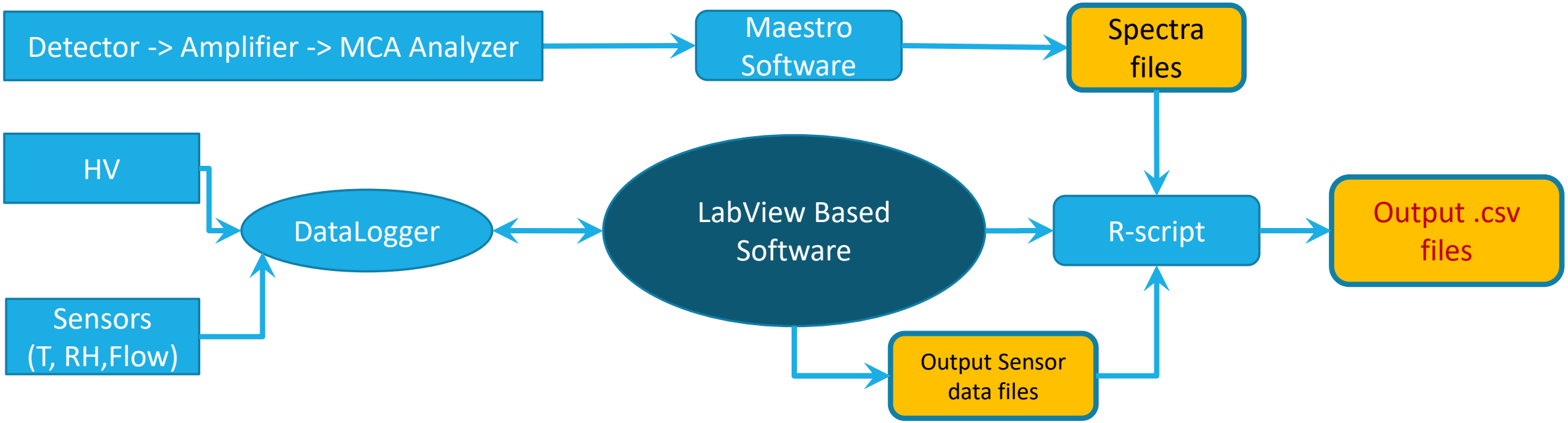


***Absolute** and **relative** uncertainty (Bq·m^{-3})*

ARMON v 2.0: User friendly, remote control and Real Time data

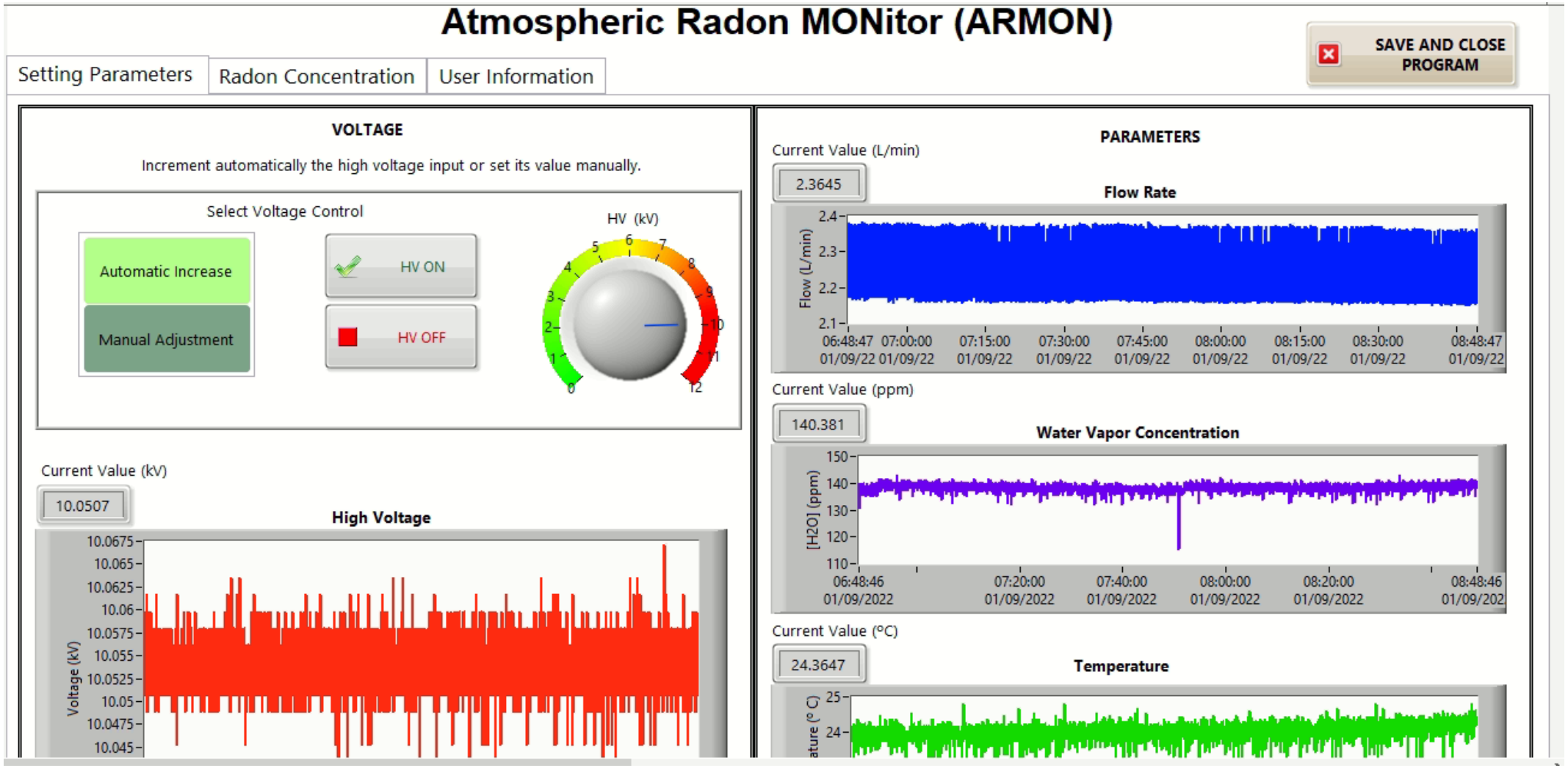
EMPIR
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States
EURAMET
Horizon 2020
European Union Funding
for Research & Innovation

- User friendly software (labview based) for a full control of instrument parameters and measurement jobs.
- Real time control and monitoring of operative parameters (high voltage applied, temperature, humidity, flow)
- Easy remote access
- Automatically save data for all parameters
- Real time calibrated ^{222}Rn concentration data visualization
- Notifications by email (e.g. when humidity is too high or no new spectras are being recorded).

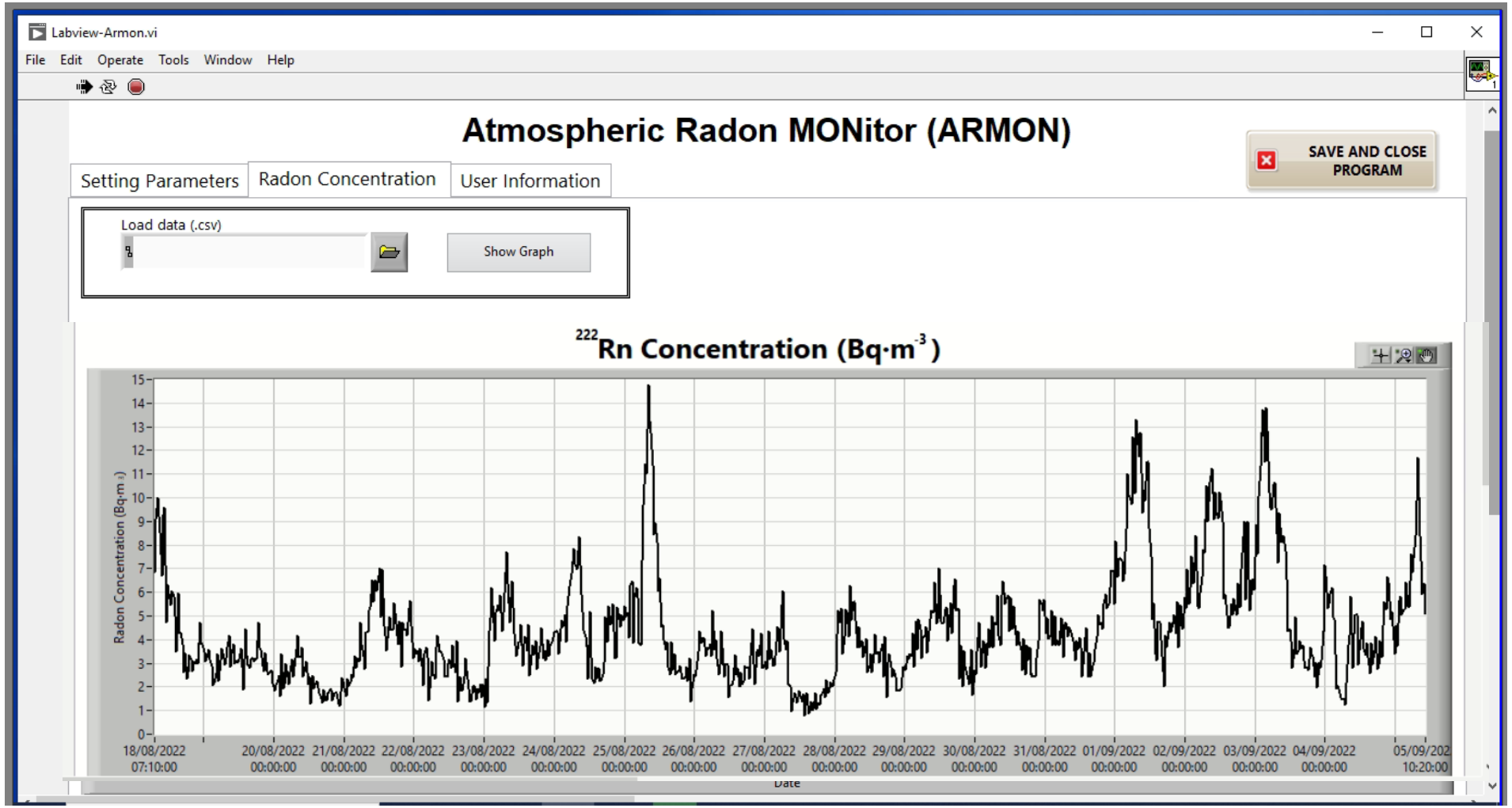


ARMON v 2.0: User friendly, remote control and Real Time data

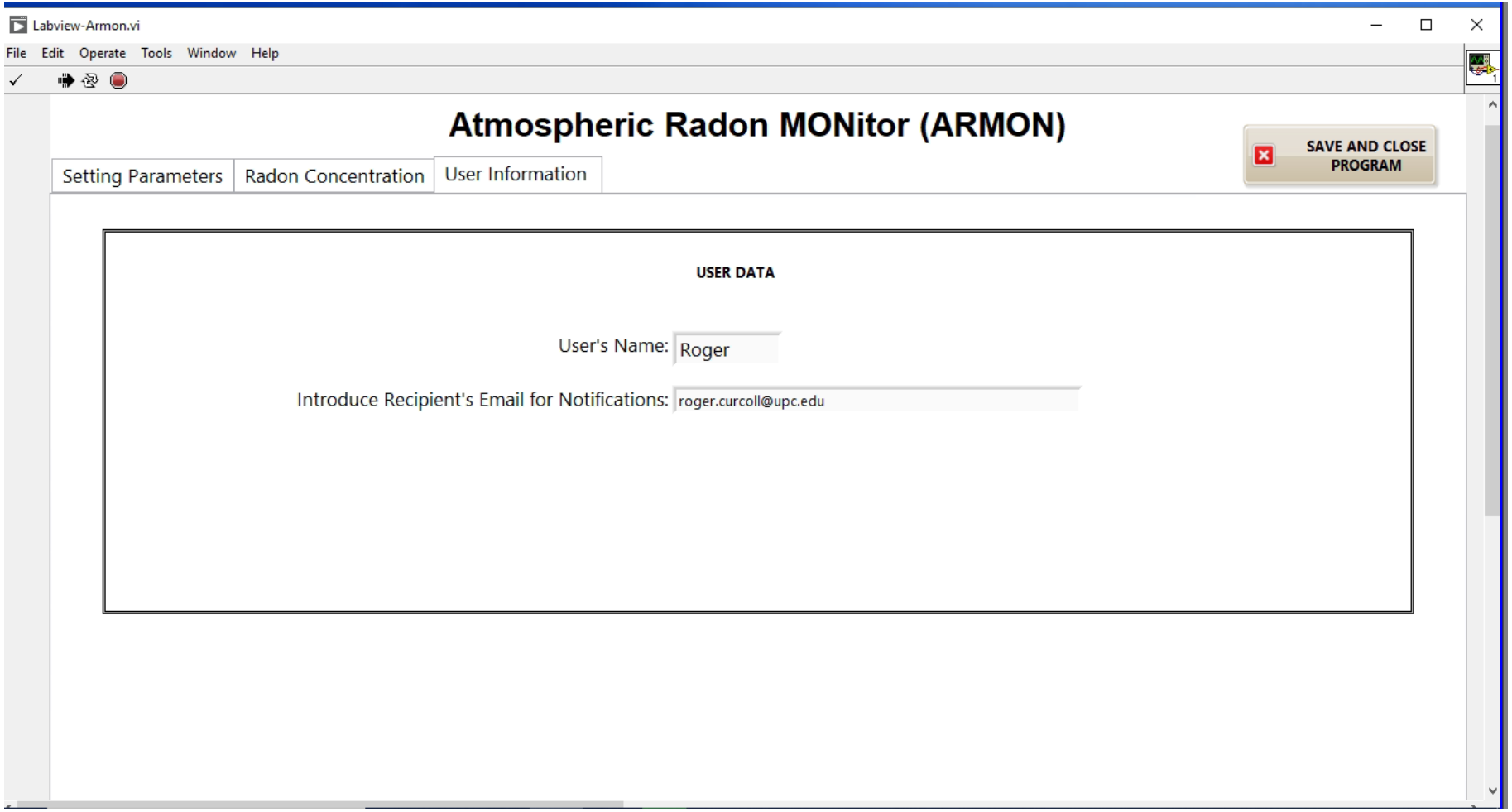
EMPIR
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States
EURAMET
Horizon 2020
European Union Funding
for Research & Innovation



ARMON v 2.0: User friendly, remote control and Real Time data



ARMON v 2.0: User friendly, remote control and Real Time data



EMPIR
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States
EURAMET
Horizon 2020
European Union Funding
for Research & Innovation

- A high sensitivity radon instrument with a complete alpha spectra analysis of radon and thoron progeny was designed and built at the UPC (ARMON).
- The ARMON has been largely used in several stations in Spain for atmospheric studies and estimation of GHG fluxes.
- The new version of this instrument is robust, portable, 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 is till being calibrated at the PTB facility since November 2022. A full budget of the uncertainties has been done according the GUM.
- The new ARMON was compared with a new two filter 200 L monitor from ANSTO at different height above the ground and at different stations (Germany and France) in the framework of the traceRadon project.