

Recent work with electronic radon detectors for continious Radon-222 monitoring

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Recent work with electronic radon detectors for continuous Radon-222 monitoring

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b) Paul Scherrer Institute, 5232 Villigen, Switzerland
c) Université Paris-Saclay, CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), F-91120 Palaiseau, France.

International Conference on Radiation Applications (RAP 2022) , 6-10 June 2022, Aristotle University of Thessaloniki, Greece.

Motivation

Towards *continuous*, metrologically assured, *real-time* monitoring of ^{222}Rn in dwellings and workplaces.







01

Significant number of electronic radon monitors have emerged in the last two decades.





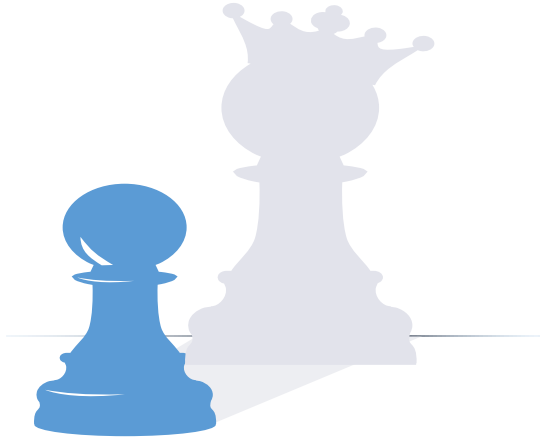
02

These detectors offer an interesting possibility for continuous radon monitoring in dwellings and workplaces



03

Can we perform long term (>1y), continuous measurements with these devices? How sensitive they are? How is it working for data collection, storage and analysis? Can we derive specific quantities with these devices (e.g. seasonal correction factors)? Can these be applied in radon mitigation activities, etc



Motivation

Table 2. Cross-interference signals for all cross-interference tests carried out at STUK and SUBG

Instrument	Tested at	s/n	Test dates	ICI (initial)	FCI (final)
AlphaE	STUK	000260	5–10 Jun 2019	6.5%[P]	9.3%[P]
			31 Jul–5 Aug 2019	8.9%[P]	12%[P]
	STUK	000542	11–17 Jun 2019	5.6%[P]	9.2%[P]
			31 Jul–5 Aug 2019	8.7%[n]	13%[n]
	STUK	000499	5–9 Dec 2019	5.7%[n]	8.6%[n]
AlphaE	SUBG	000499	14–17 Oct 2019	4.5%	13.7%
			22–28 Oct 2019	11.5%	17.0%
			16–20 Sep 2019	10.0%	17.1%
			26–30 Sep 2019	12.7%	18.7%
			4–8 Nov 2019	15.5%	20.2%
AlphaGuard PQ2000 Pro (10-min diffusion mode)	STUK	EF1641	6–9 Aug 2019	5.1–11%	7.2%
AlphaGuard PQ2000 (10-min diffusion mode)	STUK	EF0408	22–27 Jan 2020	4.6–9.2%	6.0%
AlphaGuard 2000 RnTn Pro	IRSN	EF2283	18–22 May 2018		1.1%
			22–24 May 2018		0.6%
RadonEye +[2]	STUK	PE21812110009	20–23 August 2019	28%	42%
	STUK	PE21904100016	28 Nov–1 Dec 2019	27%	37%
RadonEye +[2]	SUBG	PE21904100016	14–17 Oct 2019	32.6%	52.7%
			22–28 Oct 2019	38.7%	54.7%
			4–8 Nov 2019	18.7%	42.3%
Corentium Home	STUK	2403008304	20–24 Jun 2019		1.8%
			24–29 Jul 2019		2.5%
Airthings Wave	STUK	2900151289	28 Jun–2 Jul 2019		1.3%
			6–9 Aug 2019		2.3%
Airthings Wave Plus	STUK	2930	24–28 Jun 2019		2.7%
			24–29 Jul 2019		3.6%
Corentium Pro	STUK	2700007355	3–5 Sep 2018	0.2%	1.2%
		2700007357	3–5 Sep 2018	0.0%	1.6%
TSR3 – Fast mode	SUBG	16014	16–20 Sep 2019	1.0%	7.7%
			26–30 Sep 2019	1.2%	12.3%
TSR3 – Slow mode	SUBG	16014	22–28 Oct 2019	2.7%	15.3%
TSR4M – Fast mode	SUBG	19015	22–28 Oct 2019	6.2%	125%
			16–20 Sep 2019	-	127%
			26–30 Sep 2019	-	186%
			4–8 Nov 2019	11.2%	114%
TSR4M – Slow mode	SUBG	19015	22–28 Oct 2019	15.9%	85.8%
			16–20 Sep 2019	-	69.5%
			26–30 Sep 2019	7.9%	115%
			4–8 Nov 2019	18.7%	76.4%
DoseMan Fast Mode	IRSN	DM357	18–22 May 2018	11%	36%
			22–24 May 2018	18%	39%
DoseMan Slow Mode	IRSN	DM357	18–22 May 2018	14%	41%
			22–24 May 2018	26%	48%

JERA

Metro RADON

ORIGINAL RESEARCH

Testing of thoron cross-interference of continuous radon measuring instruments

Tuukka Turtiainen*[1], Krasimir Mitev[2], Rohafza Dehqanzada[1], Olli Holmgren[1] and Strahil Georgiev[2]

[1]STUK—Radiation and Nuclear Safety Authority, Helsinki, Finland; [2]Sofia University "St. Klimet Ohridski", James Bourchier Blvd, Sofia, Bulgaria

We purchased 36 RadonEye+2 (RE) detectors



Range: from 7 to 9,435 Bq/m3,

Wifi Access (each 10 min),

internal storage (1 hour measurement)

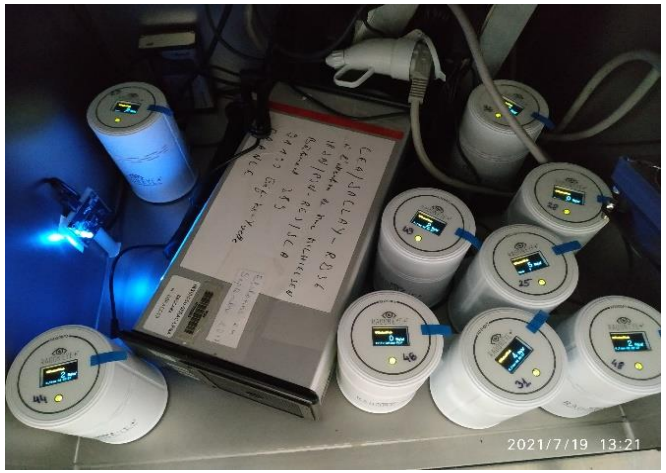
Courtesy to Tuukka Turtiainen from STUK for the useful discussions and the information provided for the various detectors.

Contents

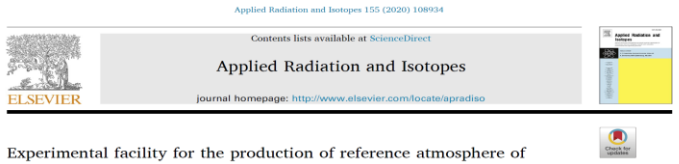
- Laboratory tests of the response of detectors
- Data collection, handling and analysis
- First results of real-time monitoring of radon dynamics with these detectors
- Summary

Laboratory tests of the response of RE detectors @ LNHB









Applied Radiation and Isotopes 155 (2020) 108934

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

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

Experimental facility for the production of reference atmosphere of radioactive gases (Rn, Xe, Kr, and H isotopes)

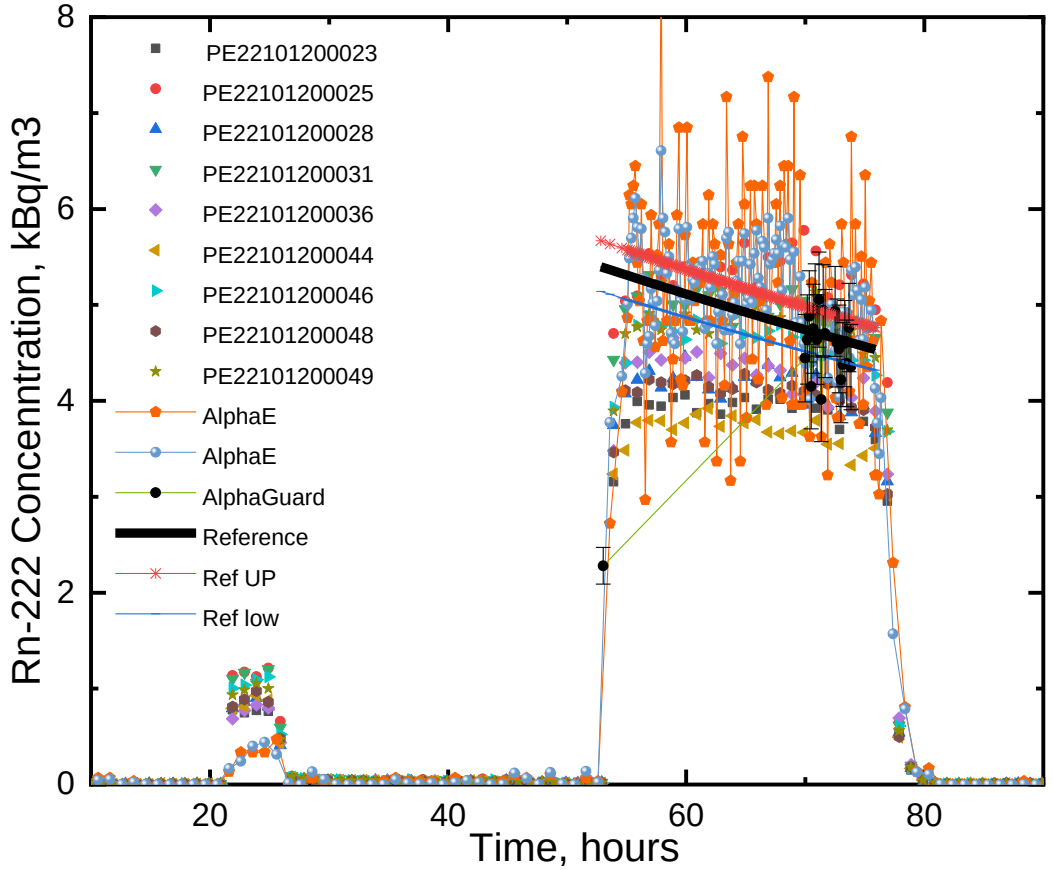
B. Sabot *, M. Rodrigues, S. Pierre

CEA, LIST, Laboratoire National Henri Becquerel (LNE-LNHB), 91191, Gif-sur-Yvette Cedex, France

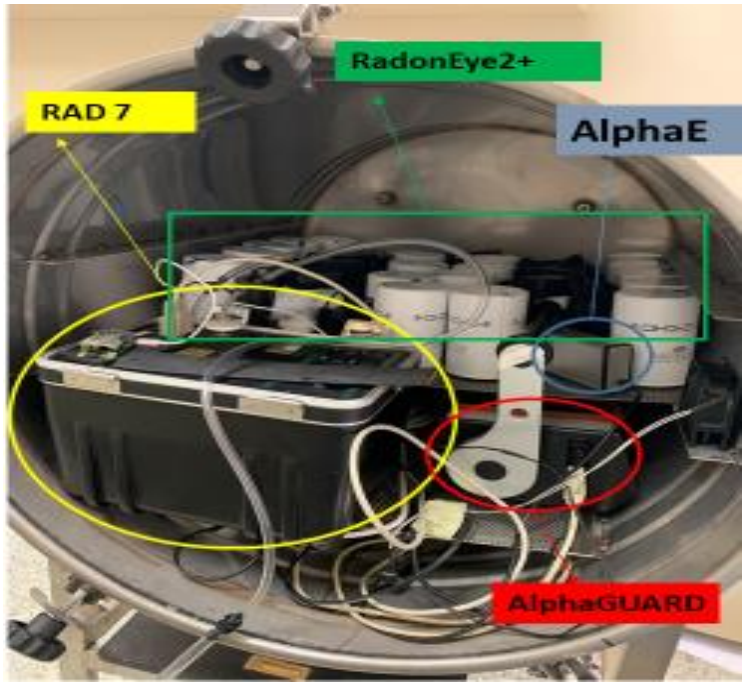


AlphaE Sensitivity:

3 cph at 100 Bq/m3



Laboratory tests of the response of RE detectors @ Sofia University







Journal of Environmental Radioactivity 166 (2017) 181–187

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

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

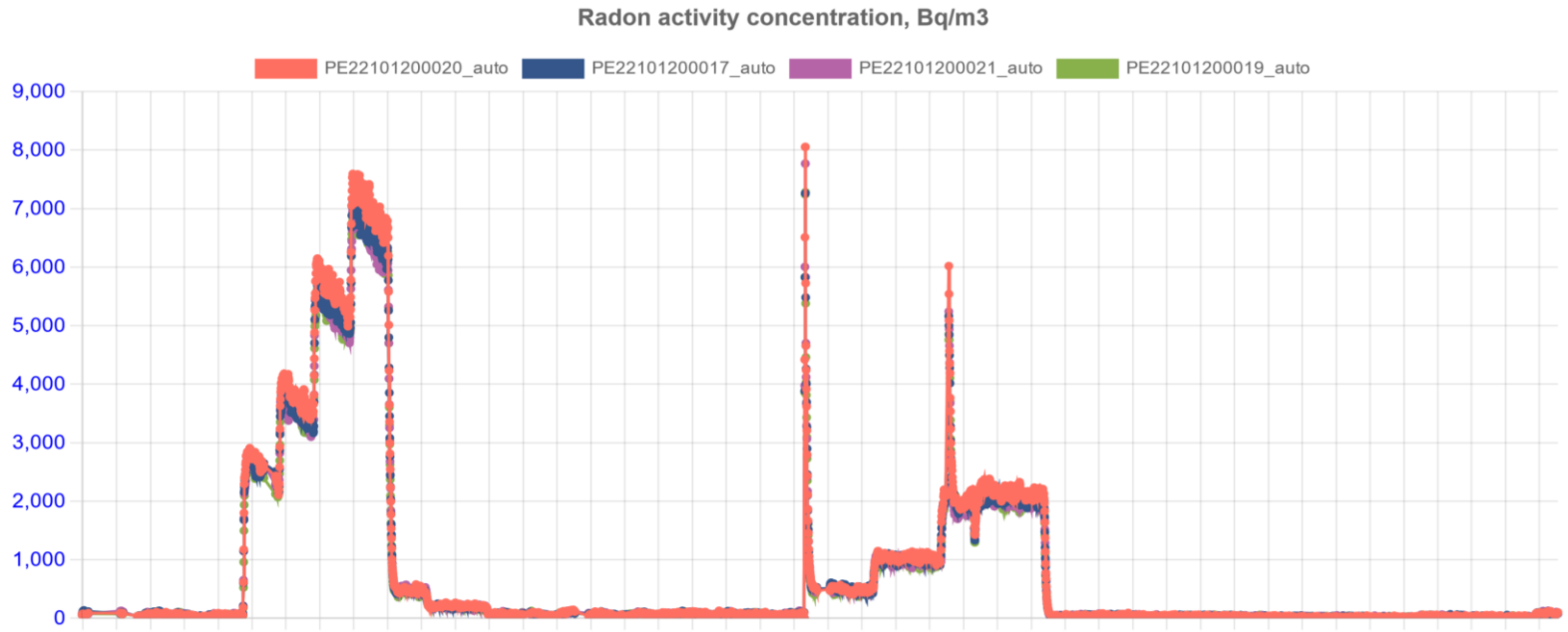
Laboratory facility to create reference radon + thoron atmosphere under dynamic exposure conditions

D. Pressyanov [a, *], K. Mitev [a], S. Georgiev [a], I. Dimitrova [a], J. Kolev [b]

[a] Faculty of Physics, Sofia University "St. Kliment Ohridski", Sofia 1164, Bulgaria
[b] Micon K Ltd., Varna 9000, Bulgaria

Upgraded:

- to host 40+ detectors
- Constant ^{222}Rn concentrations in the lower A_V range

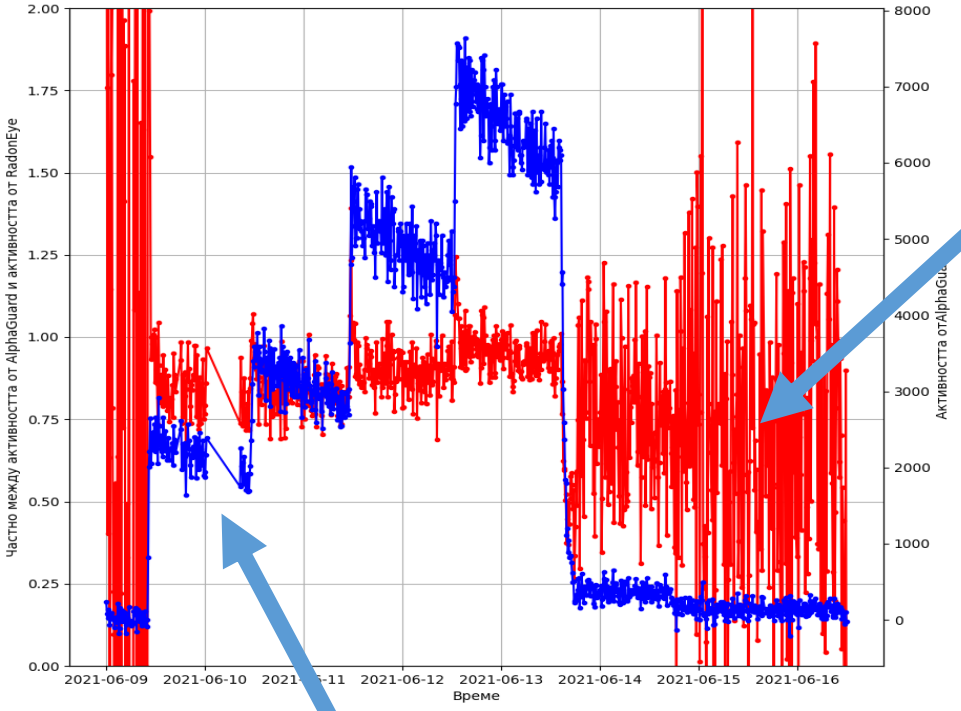


Results of the laboratory tests of the response of RadonEye+2 detectors

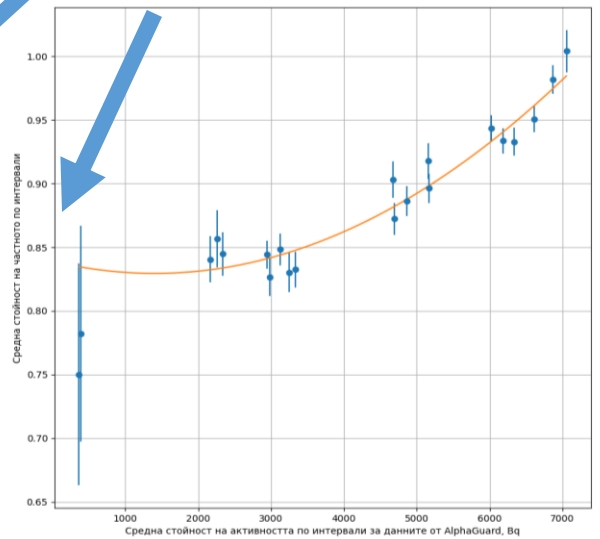
$$R = \frac{A_{V,ref}}{A_{V,RadonEye}}$$

Radon Eye No	AG LNHB	
	R	σ_R
PE22101200023	1.210	0.066
PE22101200025	0.876	0.056
PE22101200028	1.155	0.070
PE22101200031	0.959	0.052
PE22101200036	1.138	0.063
PE22101200044	1.306	0.074
PE22101200046	1.025	0.054
PE22101200048	1.159	0.061
PE22101200049	0.976	0.055

$\bar{R} = 1.09(14)$ @4.6 kBq/m^3



R



Radon activity concentration

Linear response in the range $0 - 3.5\ kBq/m^3$

Slight non − linearity in the range $3.5 - 7\ kBq/m^3$ (<15 %)

Data collection, handling and analysis – the SPIRAD database



Receives data from RE detectors every 10 minutes

SPIRAD Database

Collects and stores RE data

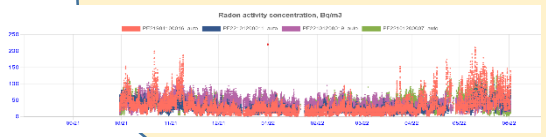
Shows real-time RE values to identify problems when last reading is not within 10 minutes

Possibility to plot data for radon activity, temperature and humidity measured by RE

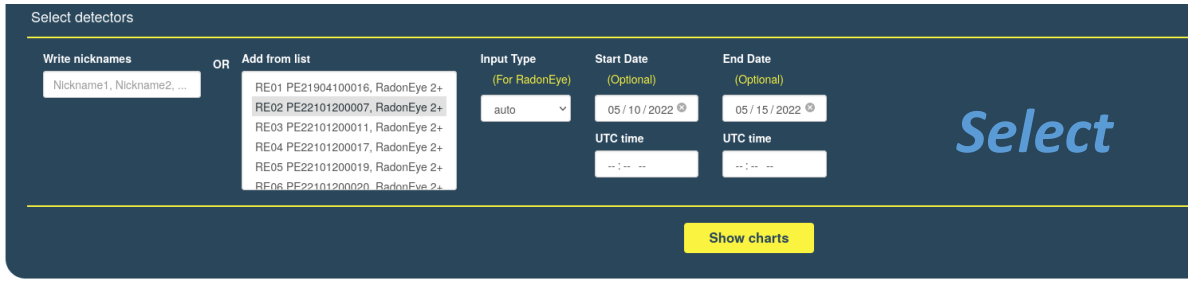
Possibility to upload 1 hour records downloaded from RE internal memory

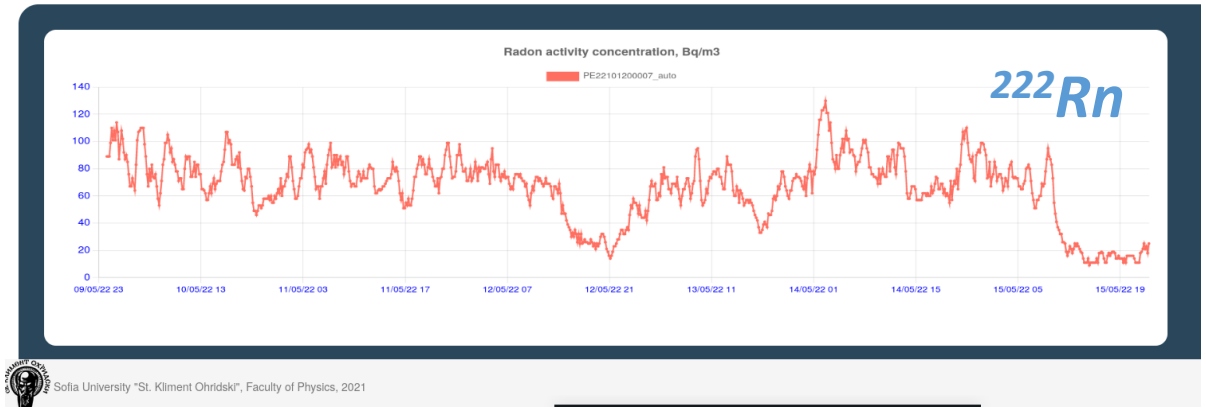
Manages active RE and their locations

Download individual or bulk RE data



Data collection, handling and analysis – the SPIRAD database



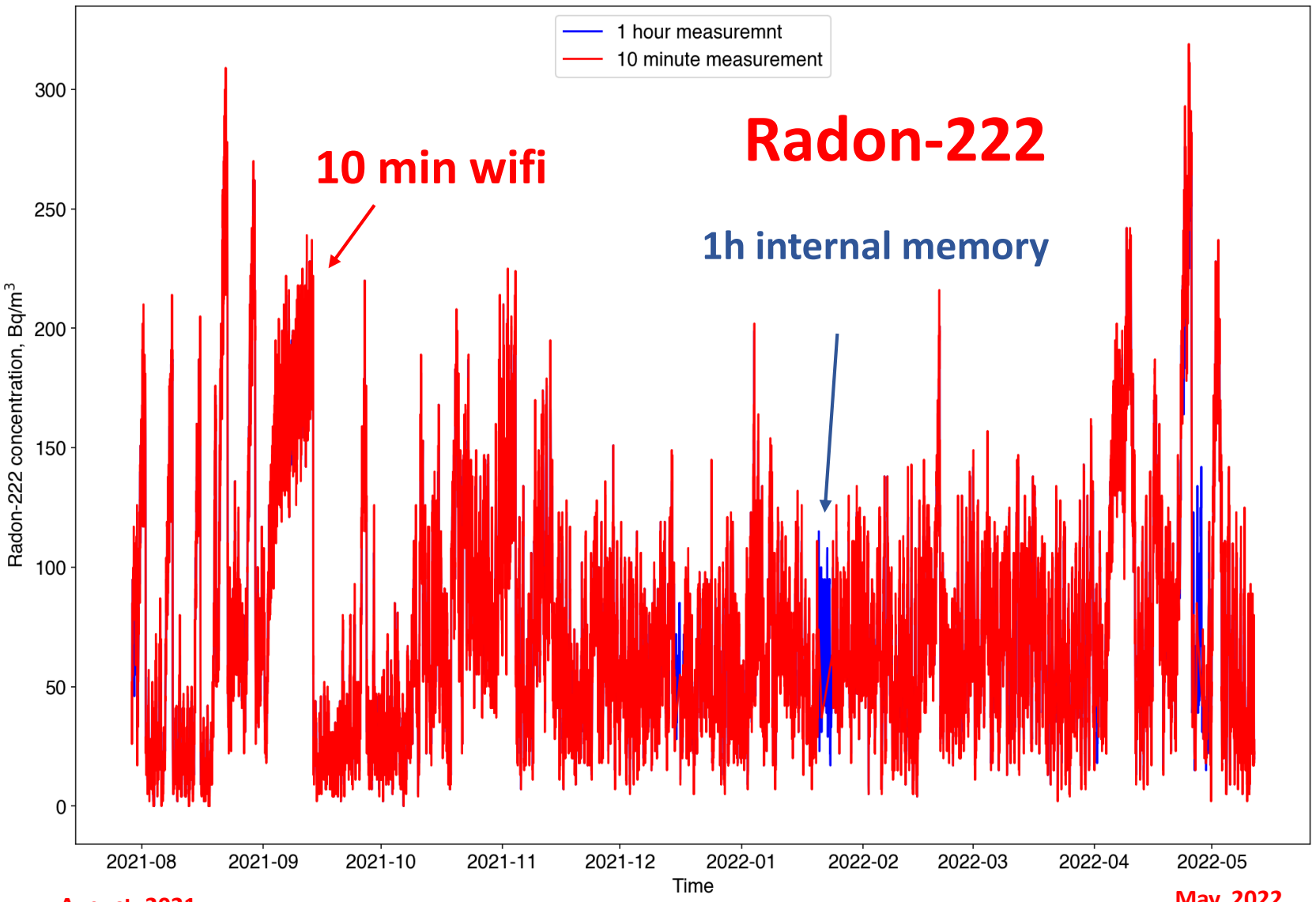


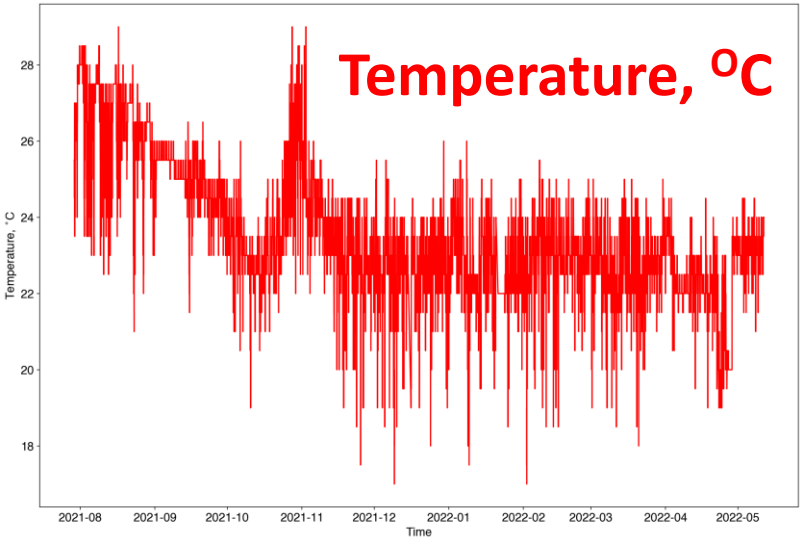


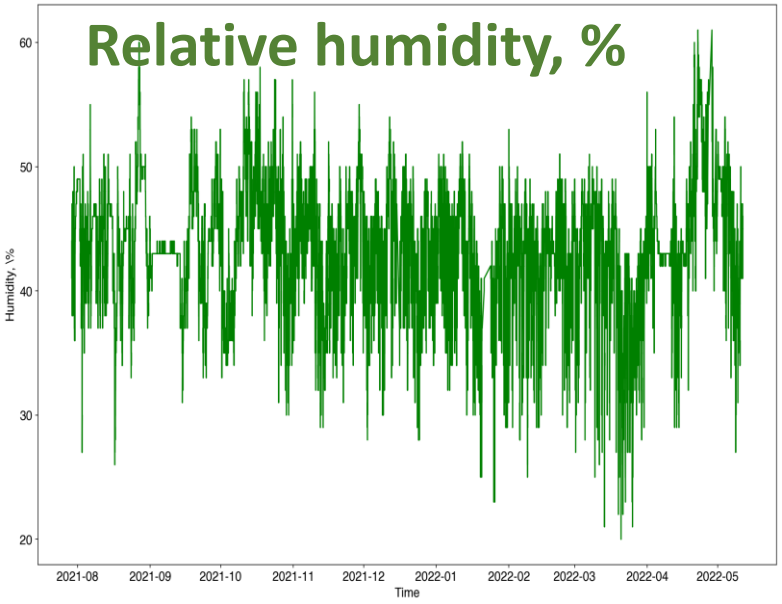


The SPIRAD database allows to output measurement data in formats convenient for application of machine learning algorithms, time series analysis, etc.

Results: Example from a measumerent in a house (10 months)







Results: Uptime & Active (>90% of the total time)

RadonEye +2 Wifi broadcasting (10 min reports, uptime >91% of the total time)

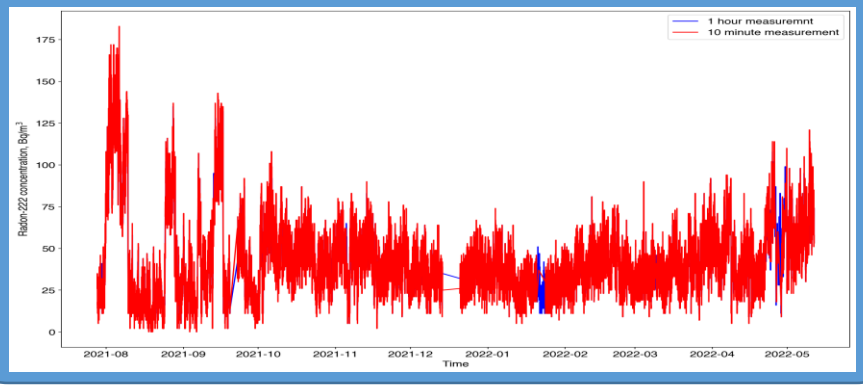
Det	date placed at location	started broadcasting	uptime	downtime	Uptime, %
RE07	2021-07-28 10:30:00	2021-07-28 11:08:03	263 days 20:21:37	23 days 10:37:39	91.8
RE11	2021-07-29 11:55:00	2021-07-29 11:55:28	264 days 23:17:55	21 days 06:54:43	92.6
RE16	2021-06-10 08:30:00	2021-06-10 10:07:45	314 days 23:03:15	19 days 07:30:10	94.2
RE19	2021-07-28 13:00:00	2021-07-28 13:29:37	272 days 22:46:30	14 days 05:47:23	95.0
RE33	2021-07-29 10:00:00	2021-07-29 11:28:06	272 days 01:00:43	14 days 05:38:42	95.0
RE34	2022-02-18 07:00:00	2022-02-18 09:30:13	75 days 23:44:43	6 days 08:53:51	92.3

RadonEye +2 internal memory (1 hour record , uptime >96% of the total time)

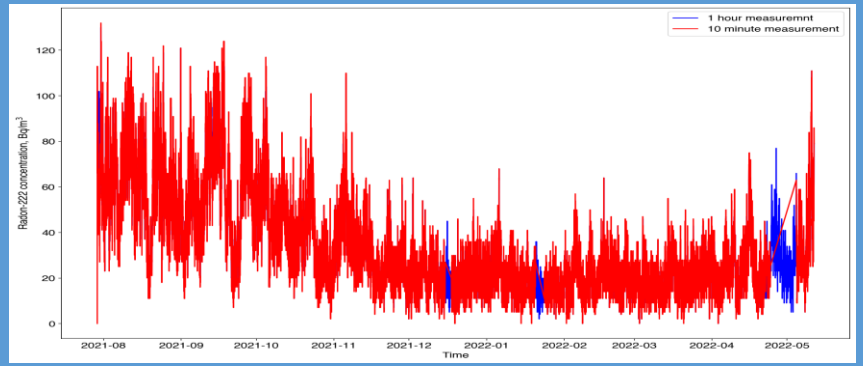
Det	date placed at location	started broadcasting	uptime	downtime	Uptime, %
RE07	2021-07-28 10:30:00	2021-07-28 11:08:03	270 days 03:41:22	10 days 20:07:50	96.14
RE11	2021-07-29 11:55:00	2021-07-29 11:55:28	285 days 13:24:31	0 days 14:57:11	99.78
RE33	2021-07-29 10:00:00	2021-07-29 11:28:06	285 days 16:26:00	0 days 10:53:24	99.84

Results: ^{222}Rn statistics (examples). Excellent agreement

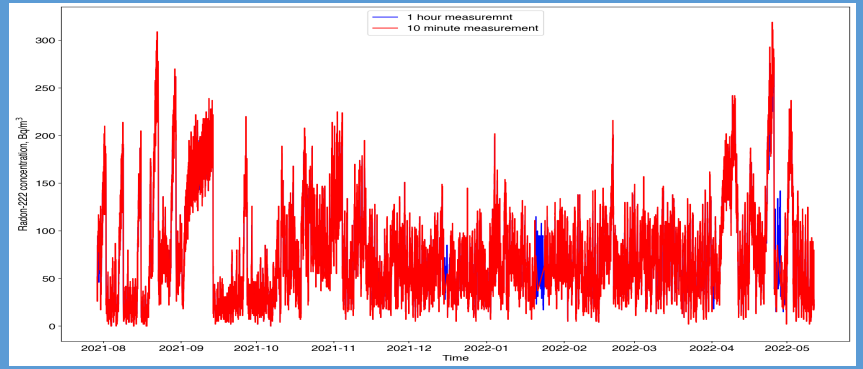
RE07	Wifi	Internal storage
	10 min measurements	1 h measurements
MEAN	42.5	42.6
STDEV	22.9	22.9
MEDIAN	39	39
MAD	12	12



RE11	Wifi	Internal storage
	10 min measurements	1 h measurements
MEAN	33.8	33.3
STDEV	21.6	21.4
MEDIAN	27	27
MAD	11	11

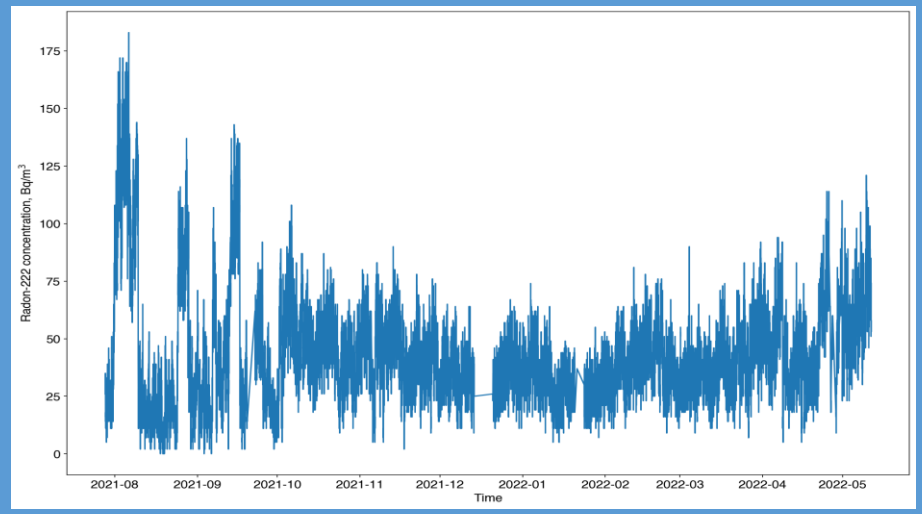


RE33	Wifi	Internal storage
	10 min measurements	1 measurements
MEAN	73.7	74.2
STDEV	49	49.5
MEDIAN	63	63
MAD	28	28

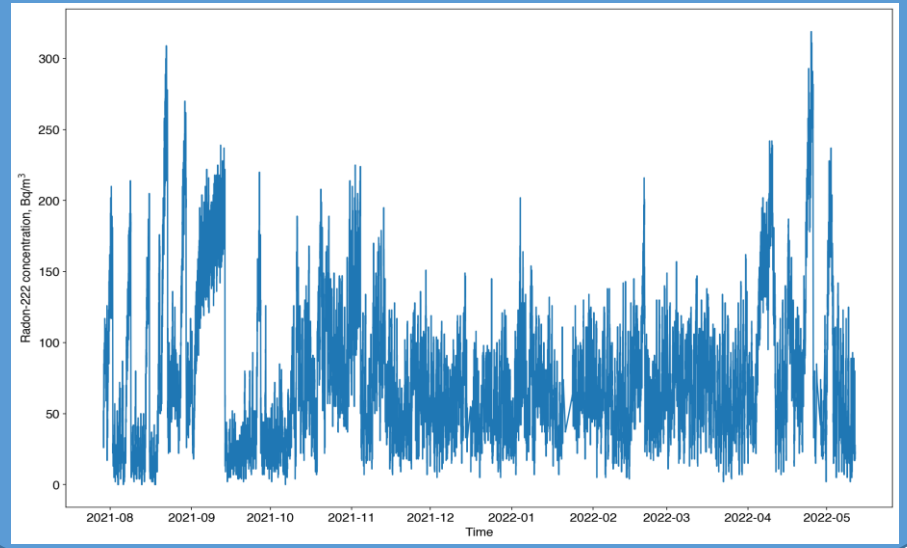


Results: Studies of seasonal ^{222}Rn dynamics (examples)

	RE07 (9 months measurements)			
	Autumn	Winter	All	Autumn/All
MEAN	41.8	35.1	42.5	0.984
STDEV	15.3	11	22.9	
STDEV MEAN	0.1	0.1	0.1	
MEDIAN	41	35	39	1.051
MAD	10	7	12	



	RE33(10 months measurements)			
	Autumn	Winter	All	Autumn/All
MEAN	68.4	65.7	73.7	0.928
STDEV	40.3	29.1	49	
STDEV MEAN	0.4	0.3	0.2	
MEDIAN	59	63	63	0.937
MAD	26	20	28	



Summary



01

The RadonEye+2 are good instruments for continuous radon monitoring

Calibration factor within 15% to the reference, linear below 3.5 Bq/m^3, slight non-linearity for radon concentrations in the interval 3.5-7 kBq/m^3

02

The online database is an important tool to collect, store and visualize radon data

Monitors and assures reliable operation and data storage. Creates warnings when the connection with the detectors is lost. Enables real time radon monitoring at many places

03

Excellent data collection efficiency

> 91 % uptime online, >96% uptime with internal storage. Convenient interface for data analysis (machine learning, AI, time series, etc.)

04

Provides reliable data for indoor radon dynamics, which is useful for various purposes

E.g. Evaluation of early average radon concentration, seasonal correction factors, radon correlation with environmental factors, etc..

ФОНД НАУЧНИ ИЗСЛЕДВАНИЯ
МИНИСТЕРСТВО НА ОБРАЗОВАНИЕТО И НАУКАТА



This work is supported by the Bulgarian National Science Fund under project "Surveillance and Perusal of Indoor Radon Dynamics (SPIRAD)"

contract KP-06-H48/3 from 26.11.2020.

Thank you for your attention.