



Workshop: the second radon-in-field international intercomparison for passive measurement devices: dwellings and workplaces

INAIL

Results of the 2nd radon in field international intercomparison

Part 1

F. Leonardi, R. Trevisi

¹ *INAIL- National Institute for Insurance against Accidents at Work, Italy*

General Information (1)

The scope of the **first** radon-in-field international intercomparison helded in Lurisia in 2014 was to evaluate performances of radon dosemeters in atmosphere with very high radon concentration and severe environmental conditions. Dosemeters were exposed for short periods between a couple of days and 2 weeks.

The **second** radon-in-field international intercomparison for passive measurement devices was focused on specific issues concerning measurements of radon concentration data in field. In particular:

- Effect of long time sampling at low and high radon levels
- Effect of the simultaneous presence of radon and thoron

General Information (2)

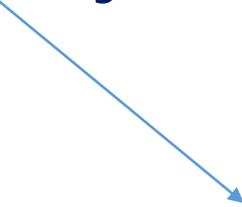
- Each set of devices (18) was split into three different groups (subset). About each subset, 3 devices were exposed and 3 were used as transit.
- First 2 groups (12 devices) were exposed in two different workplaces, characterized by different radon levels, for 6 months.
 - **The results will provide suggestions about the effects of fading.**
- Other 6 devices were exposed for a shorter period (about 10 days) in a dwelling with high levels of radon and thoron.
 - **The results will be used to evaluate the effects of the simultaneous presence of radon and thoron.**

General Information (3)

In order to gather information about laboratories procedures in term of managing data and to analyze the reliability of passive devices, the participants had to provide results both in terms of **radon exposure** of each device and the **radon activity concentration of the sub-set**.



to evaluate passive devices
response



to evaluate the laboratories
performances

Laboratorio - Laboratory	
--------------------------	--

Informazioni generali - Informations **Sheeta risultati - results table**

Site of exposure - Site of exposure	Defi ambientali - Exposure conditions	Codice proprio del laboratorio - code Laboratory	Codice dosimetro - device code	Gruppi di esposizione - groups of exposure	Data arrivo dosimetri ad h/m/a - date of arrival of the devices to h/m/a	Inizio esposizione - start exposure	Fine esposizione - end exposure	Data spedizione dosimetri ai partecipanti - date of the dispatch to participants	Esposizione (senza sottrazione del tratto) - Rn exposure (without subtraction of the track) kBq·h·m ⁻³	Incertezza esposizione - uncertainty kBq·h·m ⁻³ (k=1)	Esposizione TORON (facoltativo) - TORON exposure kBq·h·m ⁻³ (optional)	Incertezza esposizione (facoltativo) - uncertainty kBq·h·m ⁻³ (k=1) (optional)	Concentrazione radon stimata per sito di misura - best estimate expressed as mean of radon concentration for site Bq·m ⁻³	Incertezza concentrazione - uncertainty of concentration Bq·m ⁻³ (k=1)
1 ufficio al piano terra - office on the ground floor	quota 253 m s.l.m. rate di dose nel locale stoccaggio: 64 nGy/h ± 13% rate di dose durante l'esposizione: 73 nGy/h ± 10% fattore di equilibrio: 0,53 temperature: 20°C pressione: 969 hPa umidità RH%: 45 % - altitude 253 m above sea level dose rate during storage: 64 nGy/h ± 13% dose rate during exposure: 73 nGy/h ± 10% equilibrium factor: 0.53 temperature: 20 °C pressure: 969 hPa humidity RH%: 45 %	MB1265	01A01	Rn-bassa - low exposure	05/10/2016	25/11/16 10:00	25/4/17 14:00		247	18			60	3
		MB1267	01A02						235	17				
		MB1569	01A03						240	18				
		MB1270	01A04	transiti - transit devices of the site 1					24	8				
		MB1272	01A05						22	7				
		MB1274	01A06						17	7				
2 magazzino interrato - storage room on the basement	quota 253 m s.l.m. rate di dose nel locale stoccaggio: 64 nGy/h ± 13% rate di dose durante l'esposizione: 106 nGy/h ± 12% fattore di equilibrio: 0,56 temperature: 21°C pressione: 997 hPa umidità RH%: 52 % - altitude 253 m above sea level dose rate during storage: 64 nGy/h ± 13% dose rate during exposure: 106 nGy/h ± 12% equilibrium factor: 0.56 temperature: 21°C pressure: 997 hPa humidity RH%: 52 %	MB1276	01A07	Rn-media - medium exposure	05/10/2016	25/11/16 10:00	25/4/17 14:00	09/05/17	1652	80			456	14
		MB1277	01A08						1773	94				
		MB1278	01A09						1579	90				
		MB1285	01A10	transiti - transit devices of the site 2					13	7				
		MB1294	01A11						11	6				
		MB1295	01A12						25	7				
3 cantine seminterrate - wine cellar on the basement	quota 646 m s.l.m. rate di dose nel locale stoccaggio: 64 nGy/h ± 13% rate di dose durante l'esposizione: 1090 nGy/h ± 9% fattore di equilibrio: 0,15 temperature: 13,2°C pressione: 915 hPa umidità RH%: 75% - altitude 646 m above sea level dose rate during storage: 64 nGy/h ± 13% dose rate during exposure: 1090 nGy/h ± 9% equilibrium factor: 0.15 temperature: 13,2°C pressure: 915 hPa humidity RH%: 75 %	MB1300	01A13	Rn + Toron	05/10/2016	5/4/17 12:00	14/4/17 11:00		572	35			2633	96
		MB1301	01A14						578	35				
		MB1309	01A15						636	30				
		MB1313	01A16	transiti - transit devices of the site 3					30	7				
		MB1314	01A17						29	6				
		MB1315	01A18						27	6				

Note	
------	--

General Information (4)

Comments:

- About >90% of participants provide all information required.
- Some laboratories reported details on their managing data procedures in case of outliers.
- Although the “results table” file was protected, some laboratories modified it and provided results in a different format.
- Some laboratories did not report activity concentration values but only the exposure values.
- Some laboratories made mistakes filling in the form for example exchanging values of exposure and concentration.

General Information (5)

- 50 laboratories from 15 Countries subscribed the participation to the intercomparison: 48 of them provided results
- A total of 66 sets of passive dosimeters: 13 laboratories sent 2 sets and 3 sent 3 sets

List of Countries participating to the 2017 Intercomparison

Italy	33
Argentina	1
<i>Australia</i>	1
<i>Bulgary</i>	1
<i>Finland</i>	1
France	2
<i>Greece</i>	1
<i>Hungary</i>	2
<i>Ireland</i>	1
<i>Lithuania</i>	1
<i>Russia</i>	1
Slovenia	1
Spain	1
Sweden	1
Turkey	1

Note: In Italic new countries respect to 2014 Intercomparison

List of Countries participating to the 2014 Intercomparison

Italy	34
Spain	3
France	2
Germany	1
Austria	1
Slovenia	1
Sweden	1
Turkey	1
Argentina	1
Albania	1

General Information (6)

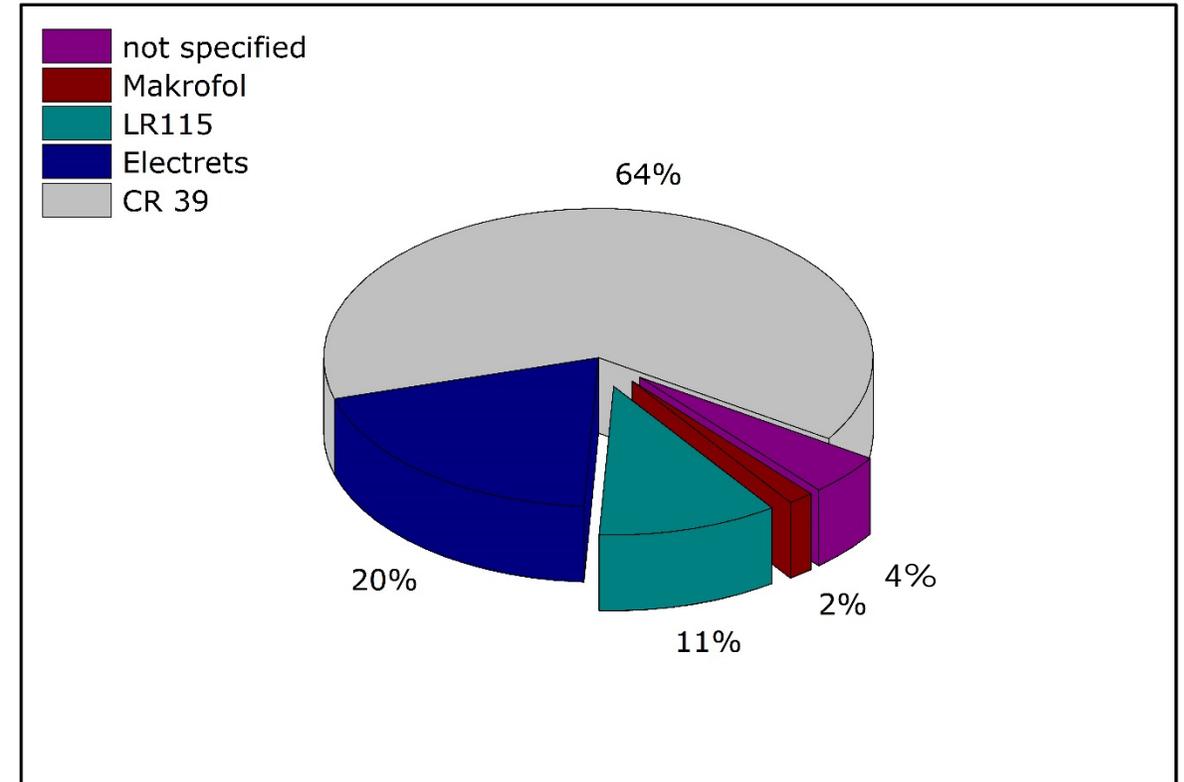
Passive devices had as detector mainly:

□ SSNDT (76%), in particular:

- 42 CR39 (64%)
- 7 LR115 (11%)
- 1 Makrofol (1%)

□ 13 Electrets (20%)

□ 3 not specified (4%)



Results (1)

In this presentation we give an overview of the results expressed as radon concentration.

Dataset:

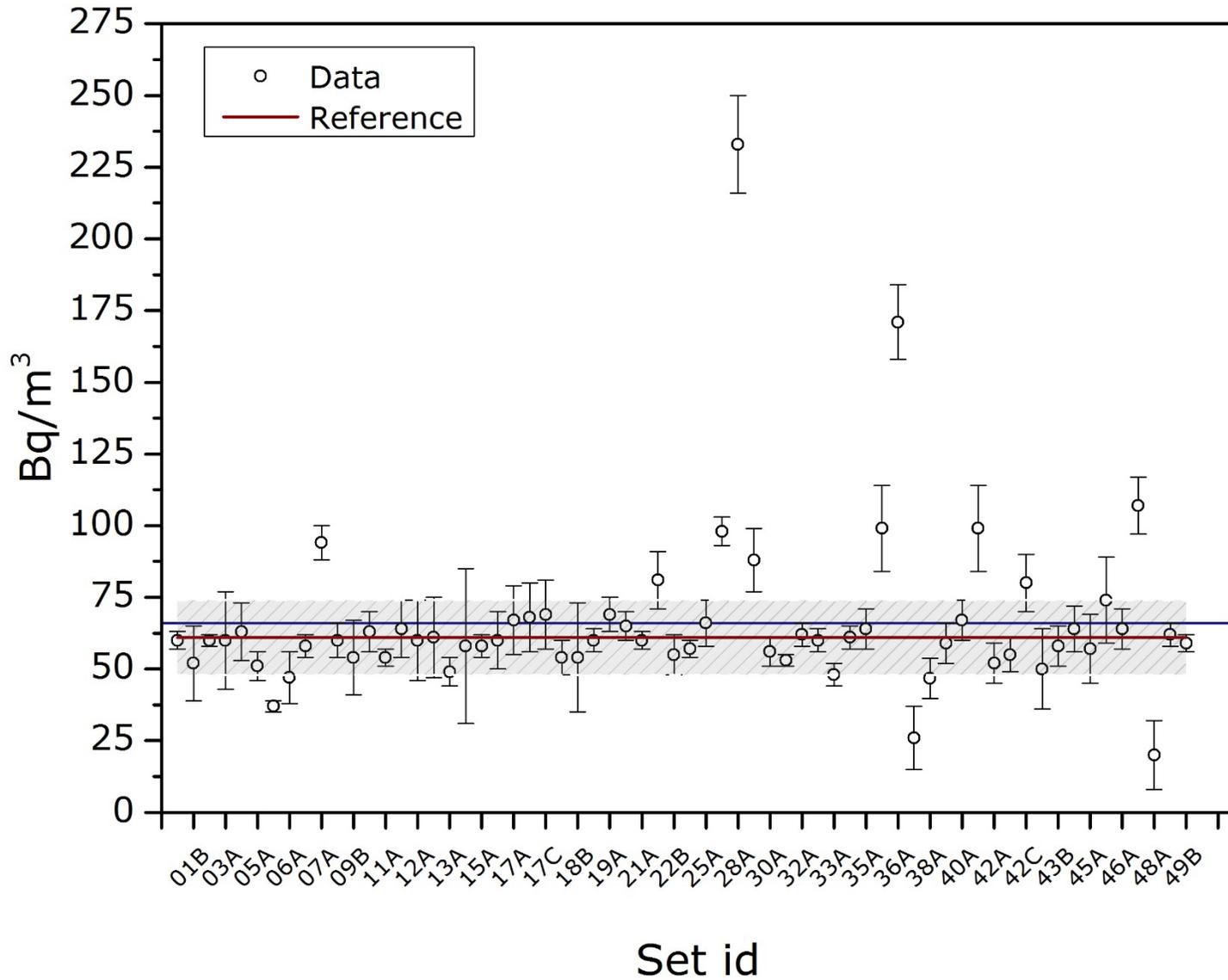
- 64 results in term of radon concentration (2 laboratories gave results only in term of radon exposure).
- Regarding the 3rd exposure (radon and thoron) 59 results in term of radon concentration.
- 2 laboratories provided also values of thoron exposure.

Results (2)

For each exposure, data analysis considers:

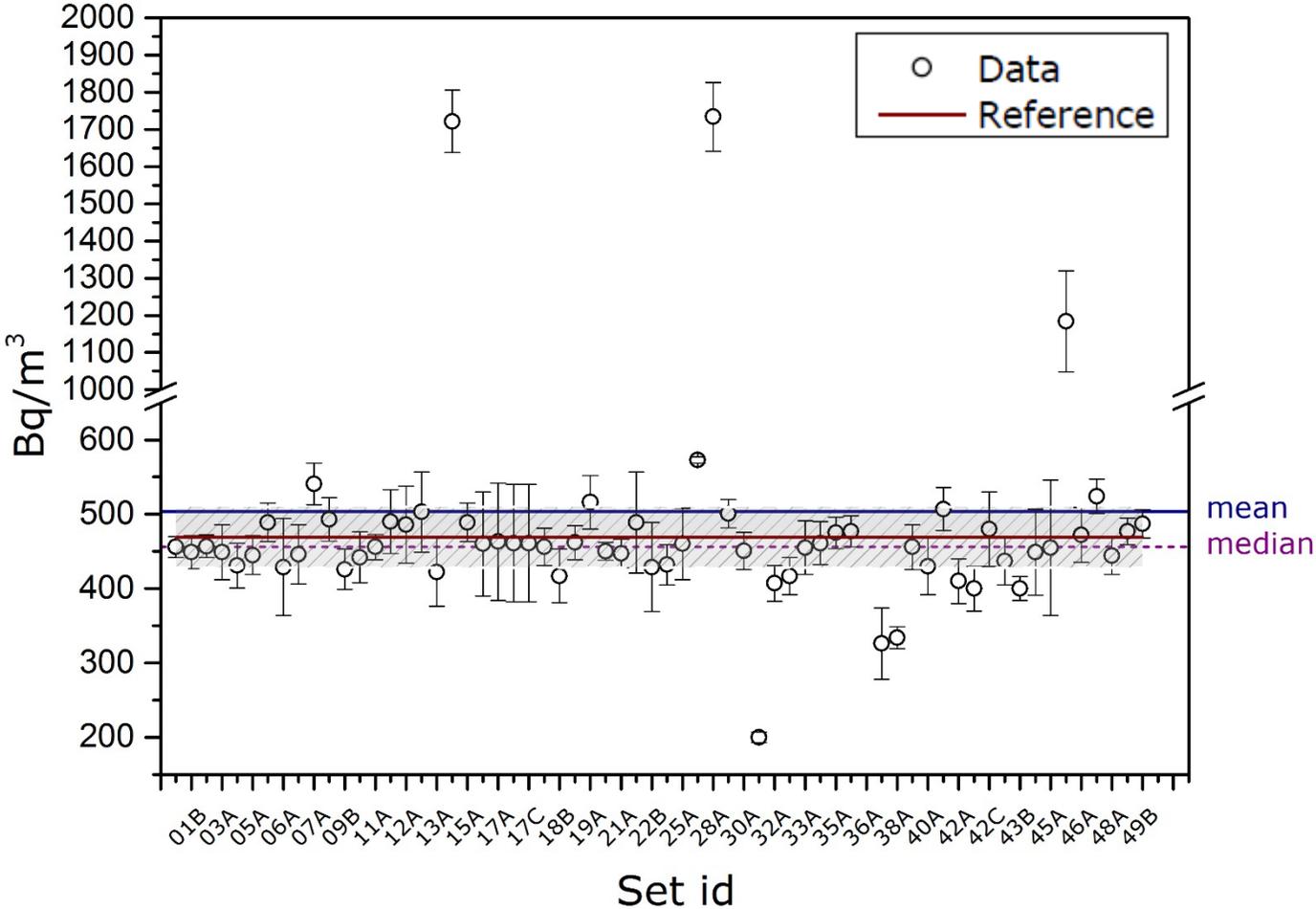
- Radon concentration values of each set with the associate uncertainty
- Overall radon concentration average as arithmetic mean of values from all sets
- Overall median
- REF
- z-score
- Analysis of results based on the of passive devices type

Results: 1st exposure site (1)



	Ref. ± unc. (k=1)	Mean ± SD	Median
mean	Bq/m ³		
	61 ± 13	66 ± 29	60

Results: 2nd exposure site (2)



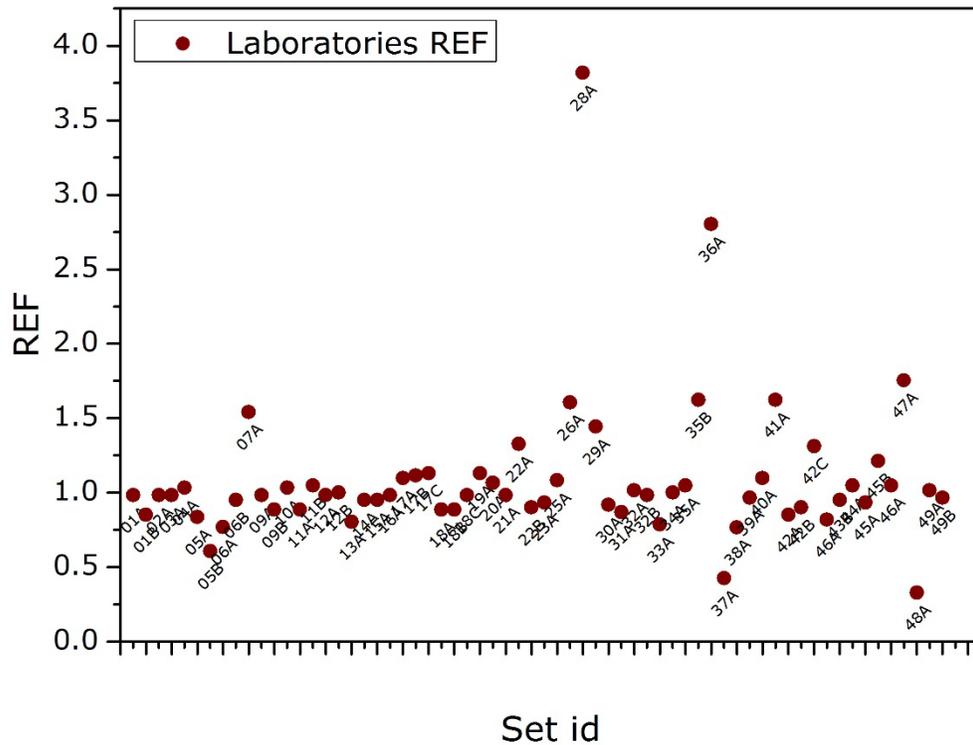
Ref. ± unc. (k=1)	Mean ± SD	Median
Bq/m ³		
469 ± 41	504 ± 247	456

Results: REF (1)

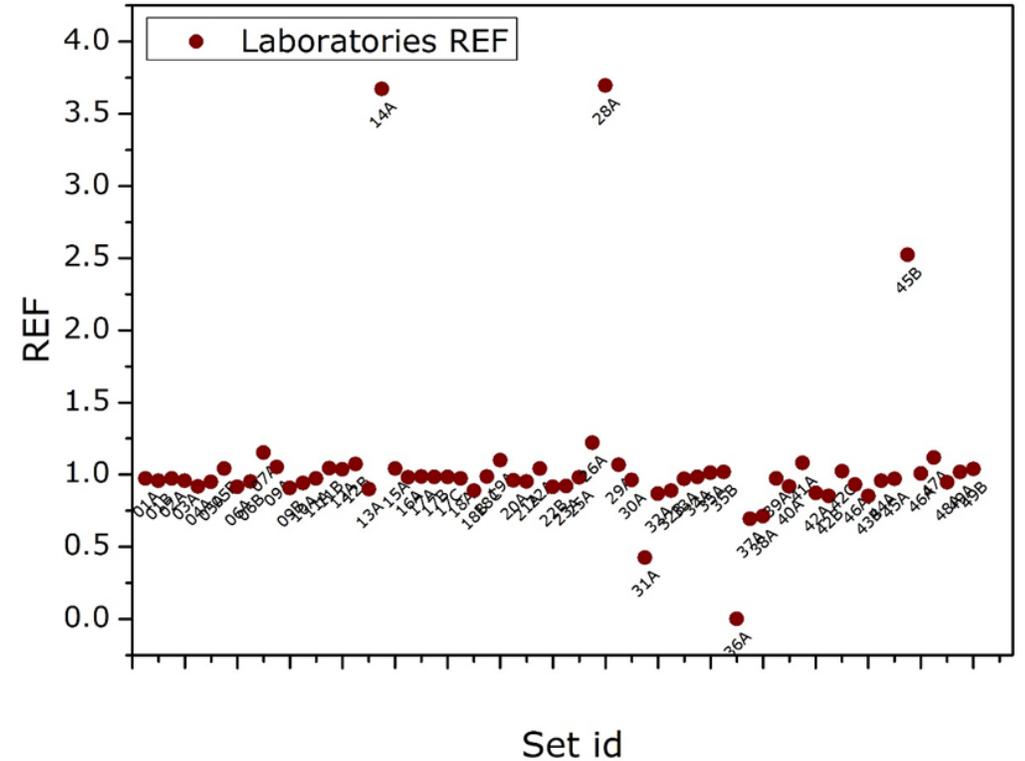
- REF is defined as the ratio between the radon concentration given by laboratories (ID) and the reference value

$$REF = C_i / C_R$$

1st exposure site

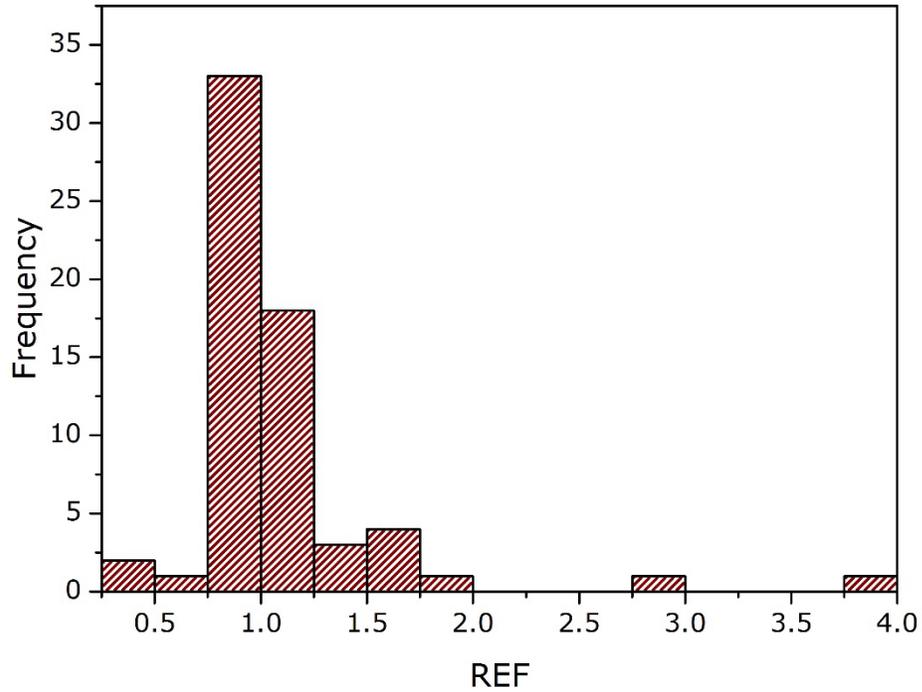


2nd exposure site

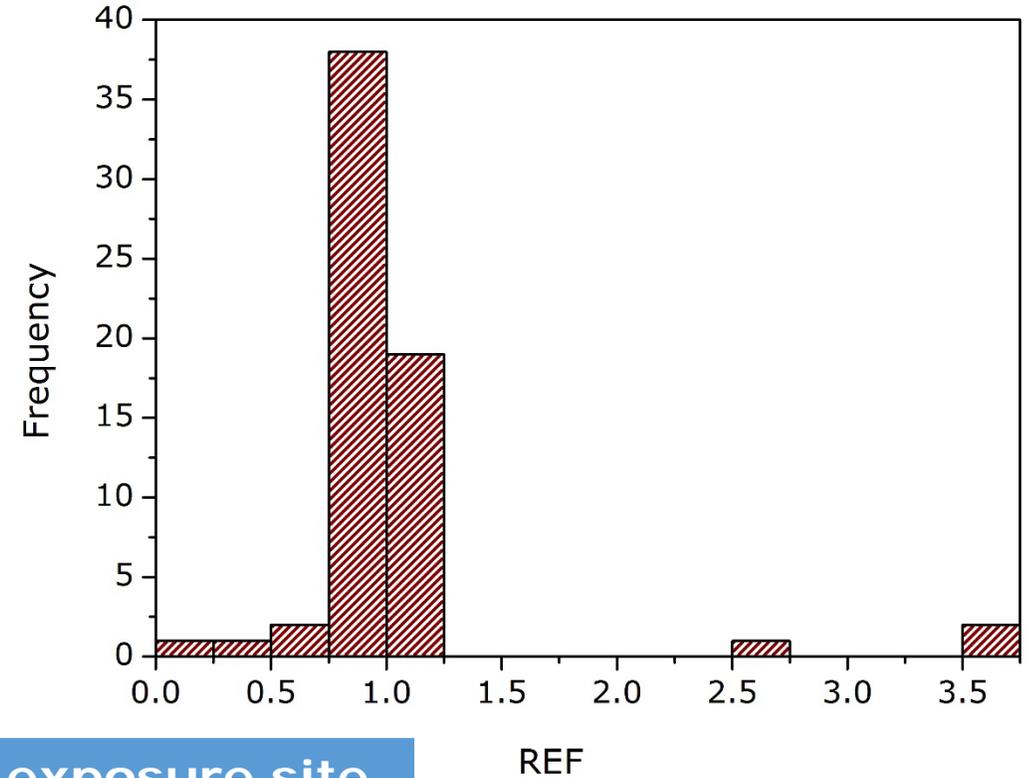


Results: REF (2)

1st exposure site



2nd exposure site



	1 st exposure site	2 nd exposure site
REF < 1	36	42
REF > 1	28	24
0.85 < REF < 1.15	44 (69%)	55 (86%)

Results: z-score (1)

z-score is defined by the following equation:

$$Z_i = \frac{C_i - C_R}{\sigma_R}$$

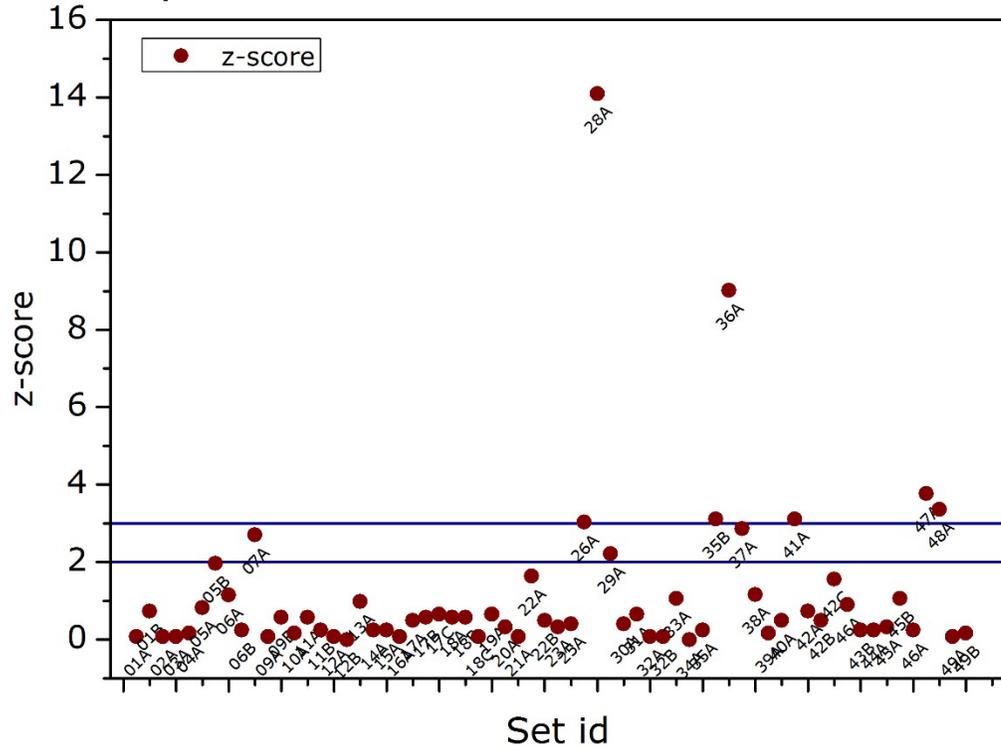
σ_R is the standard deviation for proficiency assessment. *In our case σ_R was set as 20% of the reference value.*

Data have been discussed using the z-score according to the ISO standard 13528:2005

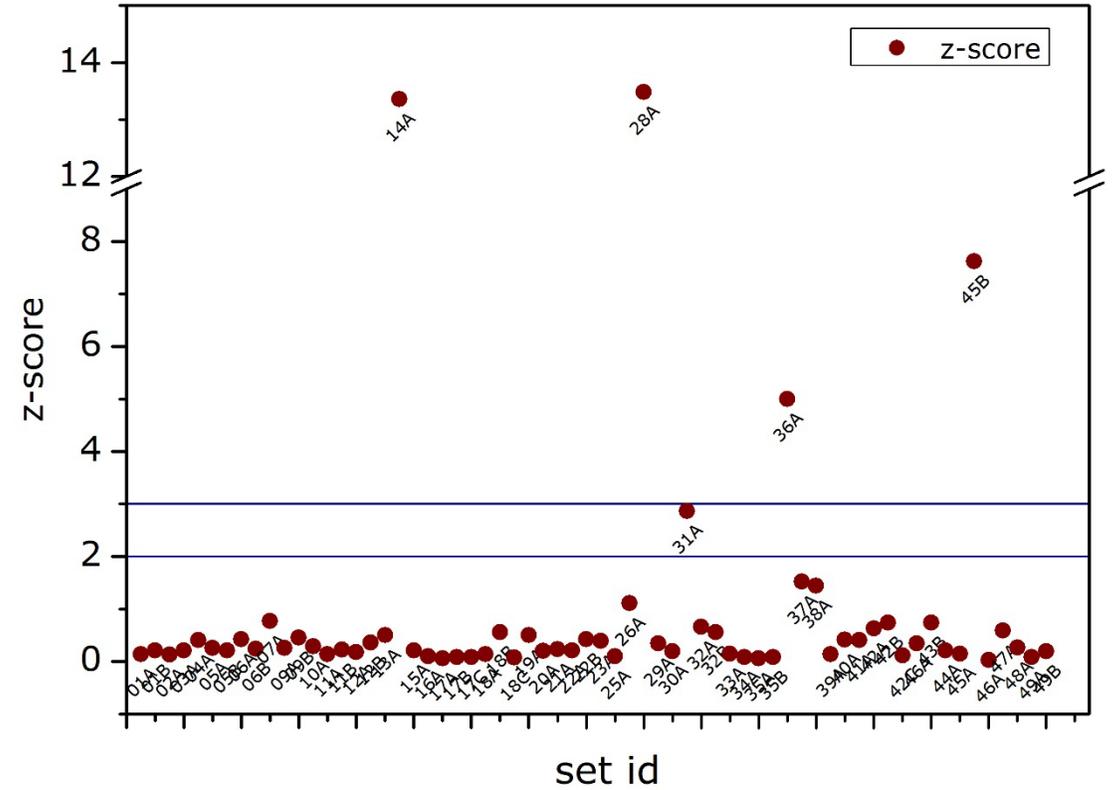
- Results with $z < 2$ are considered acceptable
- Results with $2 < z < 3$ are not completely acceptable
- Results with $z > 3$ are not acceptable

Results: z-score (2)

1st exposure site



2nd exposure site



	1 st exposure site	2 nd exposure site
$z < 2$	54	59
$2 < z < 3$	3	1
$z > 3$	7	4

Results: comparison between electrets and SSNTD performances

1st exposure site

Reference value 61 ± 13 Bq/m ³	SSNTD	Electrets
Number of sets	51	13
Arithmetic mean	64 Bq/m ³	74 Bq/m ³
Median	60 Bq/m ³	60 Bq/m ³
z-score < 2	90%	62%
2 < z-score < 3	4%	8%
z-score > 3	6%	30%
0.85 < REF < 1.15	73%	54%

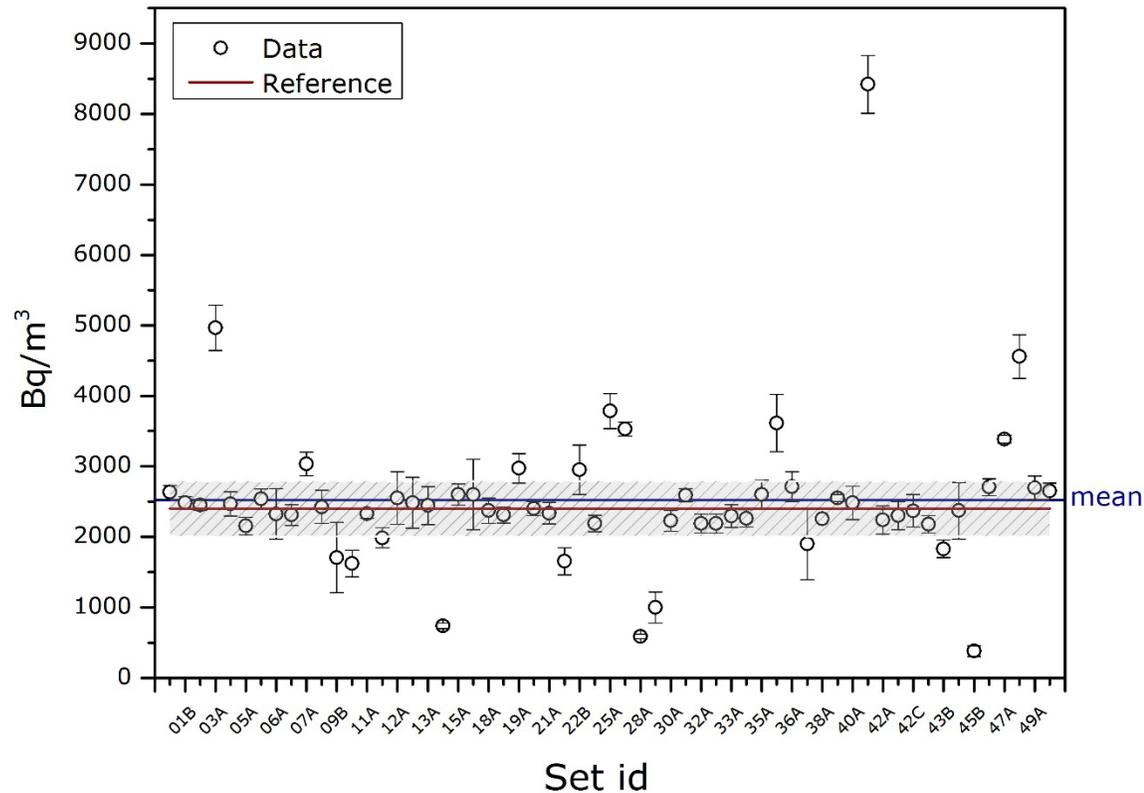
Results: comparison between electrets and SSNTD performances

2nd exposure site

Reference value 469 ± 41 Bq/m ³	SSNTD	Electrets
Number of sets	51	13
Arithmetic mean	514 Bq/m ³	460 Bq/m ³
Median	456 Bq/m ³	458 Bq/m ³
z-score < 2	92%	92%
2 < z-score < 3	2%	-
z-score > 3	6%	8%
0.85 < REF < 1.15	84%	92%

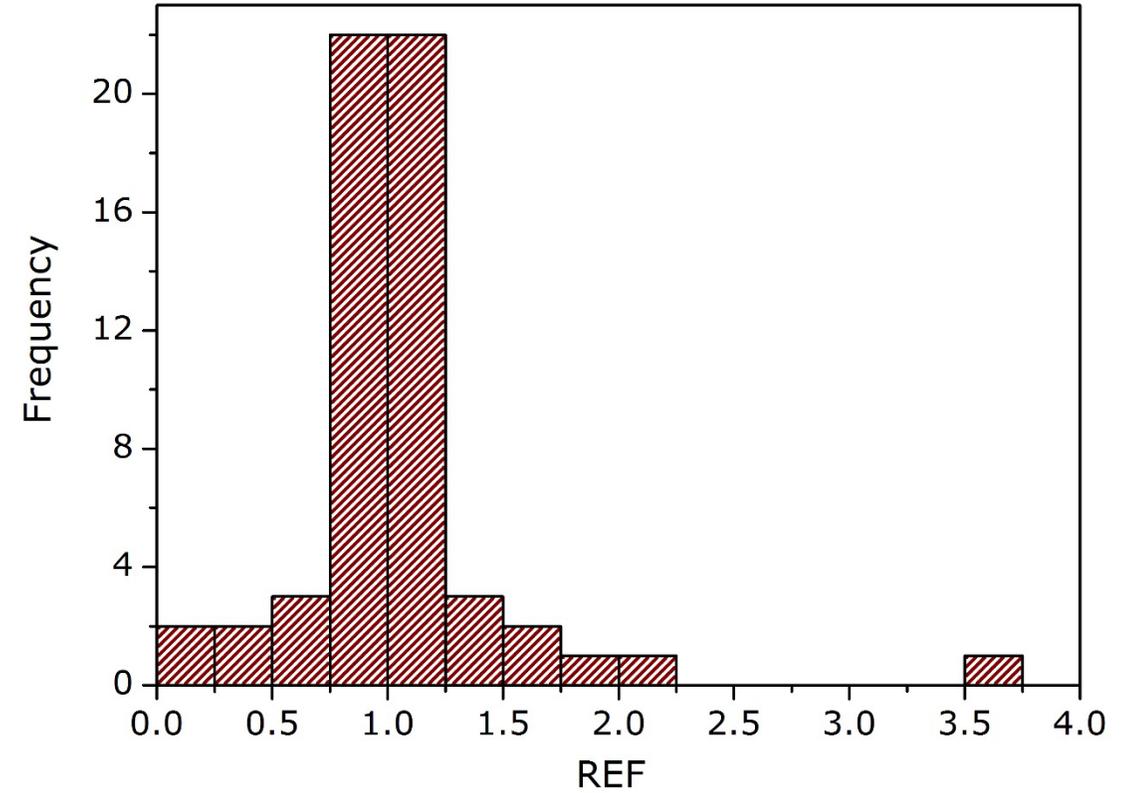
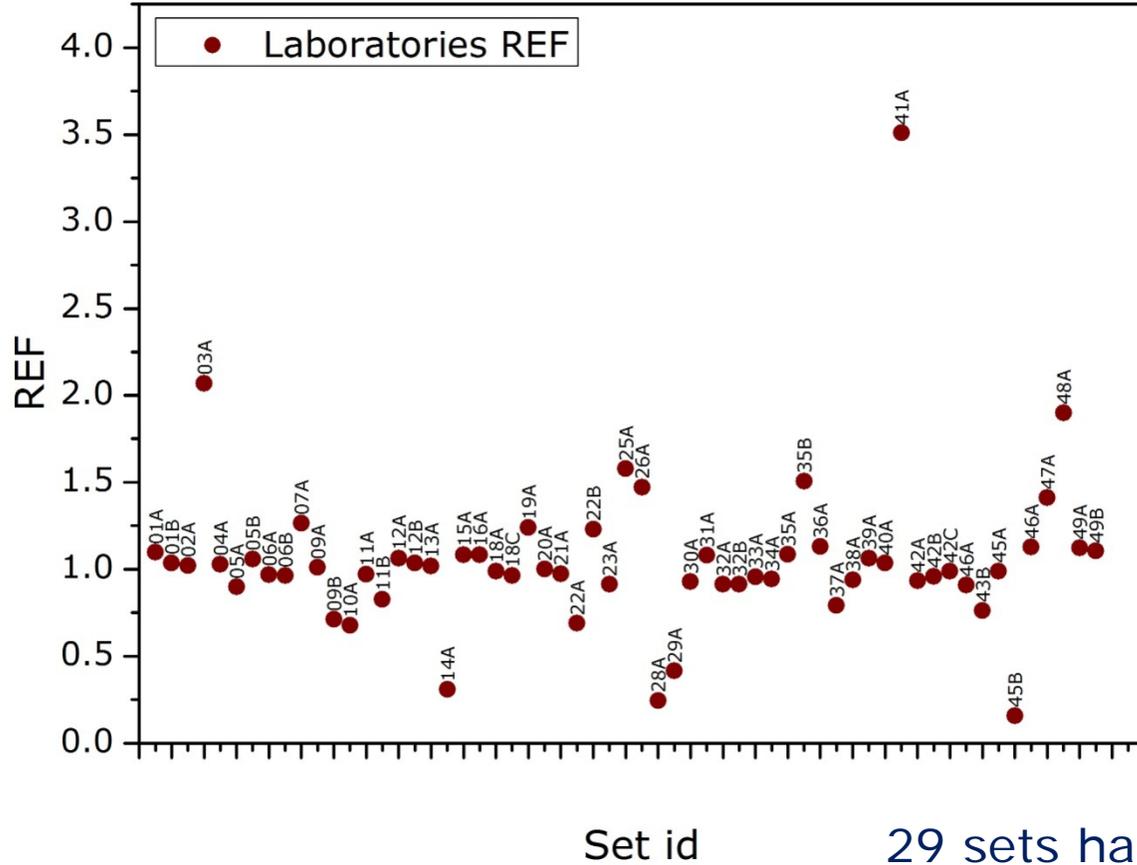
Results: Radon-Thoron exposure site

Data presented are referred to radon concentration values in the exposure site. Some laboratories give also information about thoron exposure but this data are not reported or analyzed in this presentation.



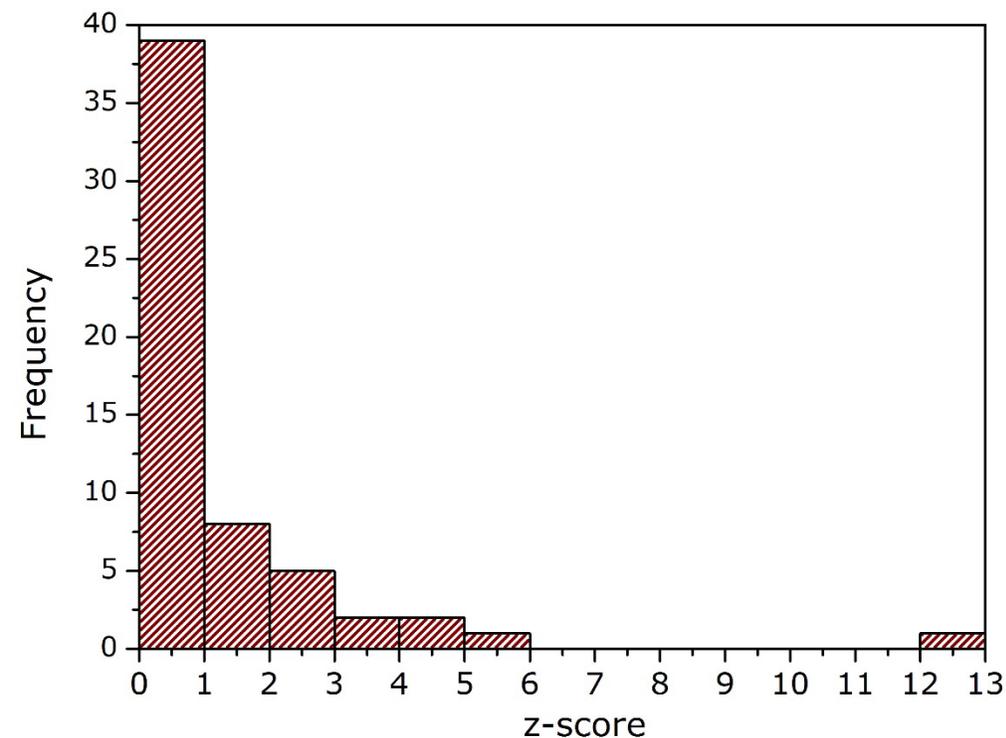
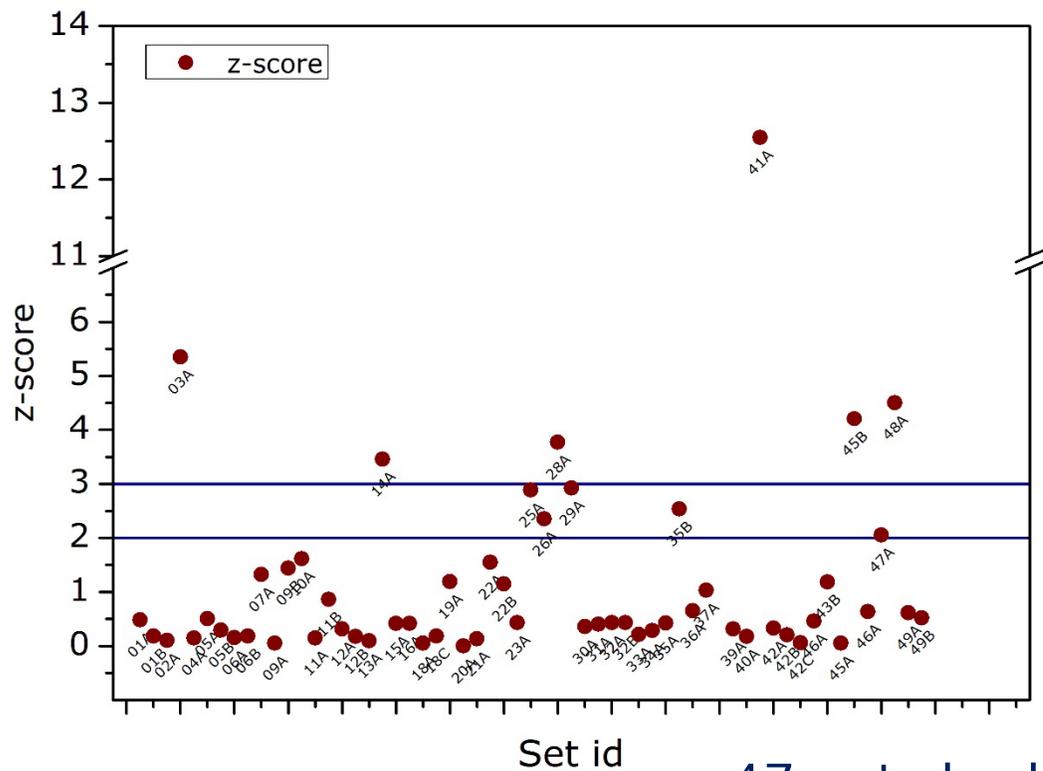
Ref. \pm unc. Bq/m ³	Mean \pm sd Bq/m ³	Median Bq/m ³
2399 \pm 394	2524 \pm 1089	2400

Results: REF



29 sets had results with $REF < 1$
30 sets had results with $REF > 1$
39 sets (66%) had $0.85 < REF < 1.15$

Results: z-score



47 sets had results with $z < 2$
5 set had results with $2 < z < 3$
6 sets had $z > 3$

Results: radon-thoron exposure site Comparison between electrets and SSNTD performances

Reference value 2399 ± 394 Bq/m ³	SSNTD	Electrets
Number of sets	48	12
Arithmetic mean	2312 Bq/m ³	3419 Bq/m ³
Median	2372 Bq/m ³	2833 Bq/m ³
z-score < 2	90%	50%
2 < z-score < 3	4%	25%
z-score > 3	6%	25%
0.85 < REF < 1.15	73%	33%

Conclusions (1)

- This Intercomparison confirm the interest of radon laboratories in such exercise.
- Comparing the 2014 Lurisia Intercomparison, the number of participants slightly increased with a higher number of foreign laboratories (European and non).
- The request of giving results also in term of radon concentration were positively accepted: the analysis let us understand laboratory procedure in case of unexpected events or results happening during a measurement.
- The SSNTD is still the most used detector (76%)

Conclusions (2)

➤ Observing the z-score results:

	Z<3
1° exposure site	89%
2° exposure site	94%
Radon-Thoron exposure site	86%

Thoron interference?

➤ Comparing performances of SSNTD and electrets:

	SSNTD 0.85<REF<1.15	Electrets 0.85<REF<1.15
1° exposure site	73%	54%
2° exposure site	84%	92%
Radon-Thoron exposure site	73%	33%

Thoron interference?
Humidity?

75% in this site

Conclusions (3)

Looking at overall radon concentration results, no particular effect of long time sampling (*fading*) has been observed.

Conversely, the simultaneous presence of radon and thoron could affect the accuracy in particular in case of electrets, although the simultaneous interference of humidity cannot be neglected.

Conclusions (4)

Evaluation of uncertainties:

- 1st exposure site (low radon conc.) 3%-60% with a mean of 14%
- 2nd exposure site 1%-20% with a mean of 8%
- Radon-thoron exposure site 2%-29% with a mean of 9%

? Every one used for the evaluation of the uncertainty $k=1$?

Further evaluations about the reliability of passive radon devices and the lab procedure of data analysis will be done after the discussion on radon exposure results.

THANK YOU FOR THE ATTENTION