Radon passive detectors intercomparison in the field: radiometric characterisation of the sites

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Intercomparison's working group:

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3 different sites

1- workplace on the ground floor in Ivrea (TO)

2- workplace on the basement in Ivrea (TO)

3- dwelling in Valle del Cervo (BI)

A list of problems can influence radon measurements in the field

with passive detectors:

Temperature, humidity, lightness

Dose rate

Altitude

Long period of measurement

(Ageing, fading, and track overlap in CR39, descharge of electrets)

Thoron

Equilibrium factor

Minimum exposure detectable

Calibration

using a continuous radon monitor instead should be added:

Background of the instruments

Long period (electronic problems: memory, AC Adapter…)

We have found the same difficulties
to obtain the reference values

So we used in the field
4 radon continuous monitors and CR39 passive detectors
calibrated in ENEA INMRI

plus other instruments
were tested in different radon and thoron chambers

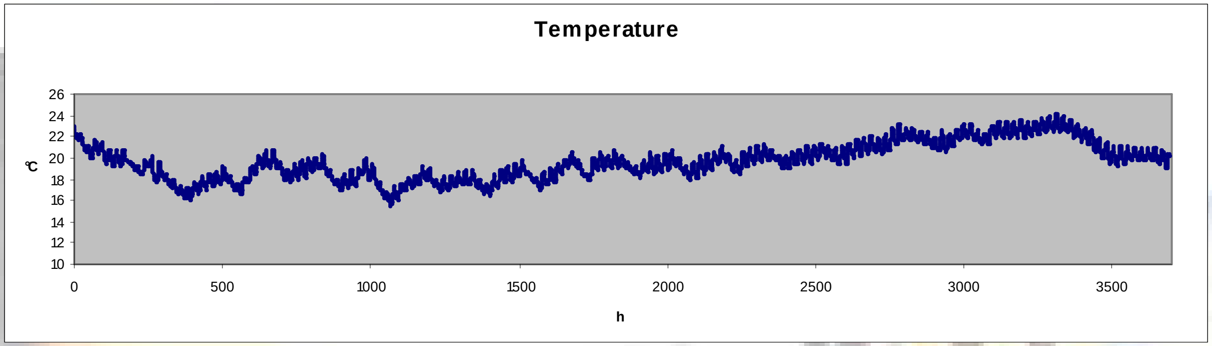
Beginning of the exposures: brainstorming

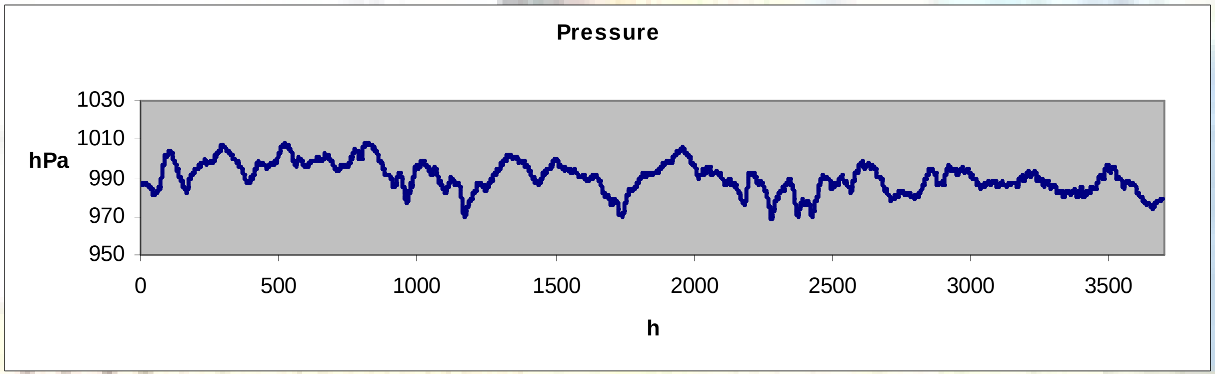
Exposure 1:

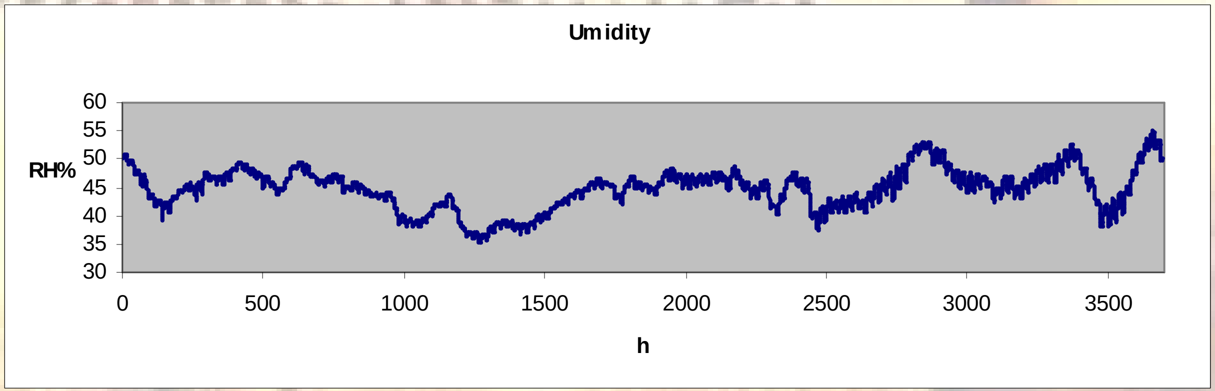
workplace on the ground floor in Ivrea (TO)

altitude 253 m
above sea level
*****
dose rate during storage:
64 nGy/h ± 13%
dose rate during exposure:
73 nGy/h ± 10%
(TLD100)
*****
equilibrium factor: 0.53
(spot measurements with EQF3220)
*****
temperature: 20 °C
pressure: 989 hPa
humidity rel.: 45 %
(climatic data gathered by radon monitors)

Exposure 1: climatic data







Exposure 1: critical points

Long period of measurement
(Ageing, fading)

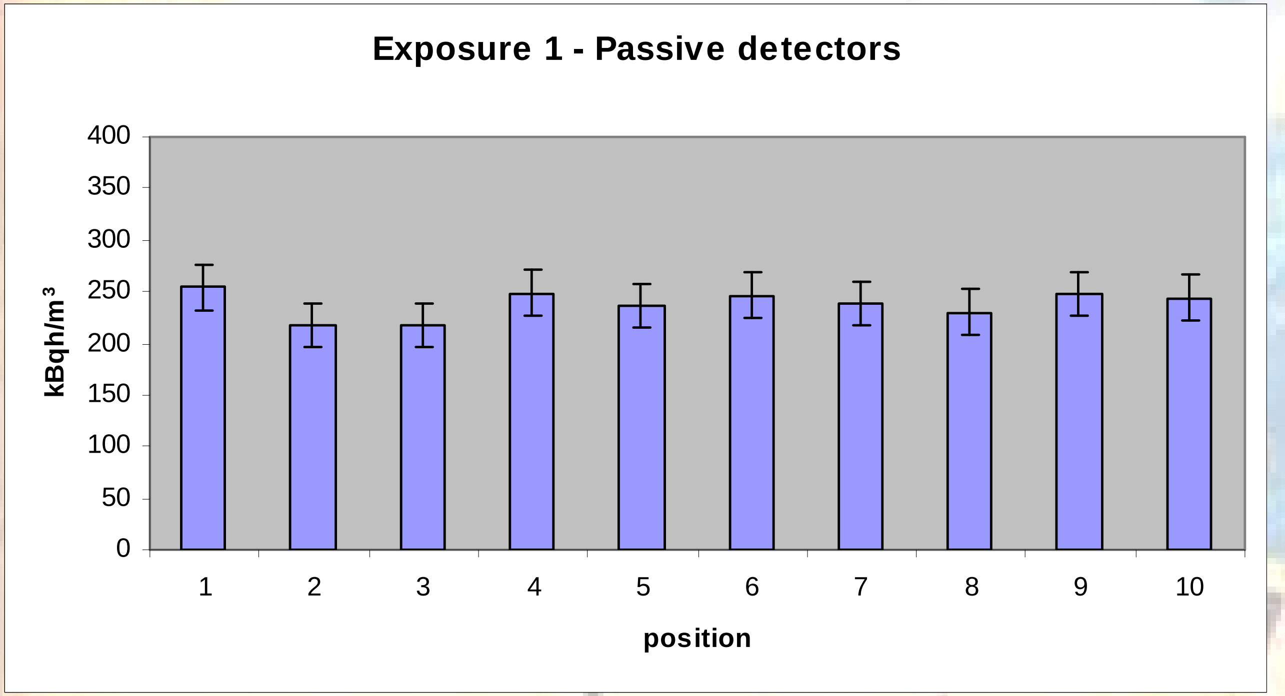
Low concentrations

Minimum exposure detectable

Calibration and
Background of the monitors

Exposure 1:

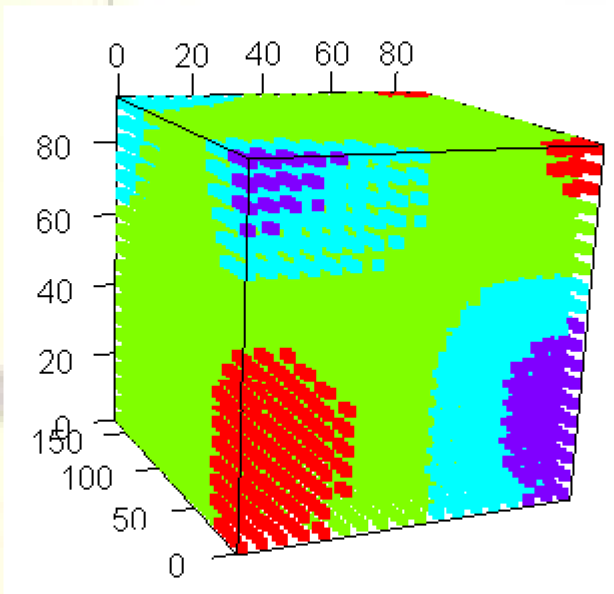
Reference passive CR39 detectors

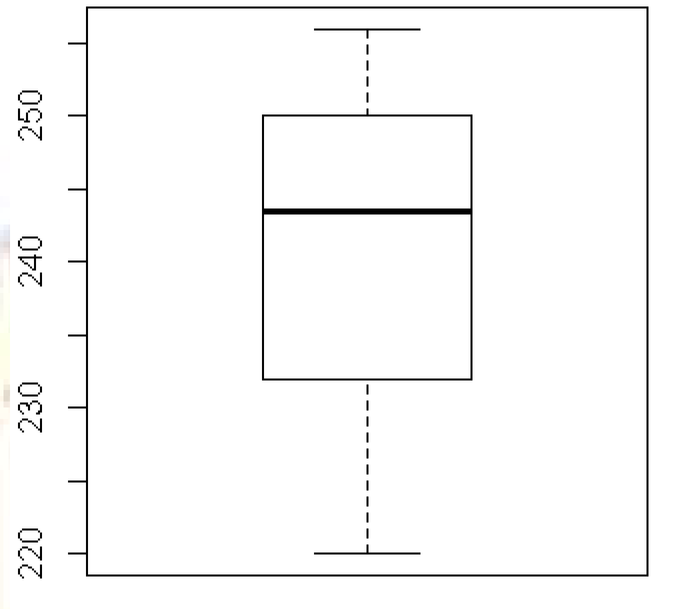


Rn CR39 detectors kBqh/m^3	unc. kBqh/m^3
254	22
218	21
218	20
249	22
236	21
247	22
239	21
230	22
248	21
244	22

Radon exposure Passive detectors kBqh/m^3	Metrological and statistical Uncertainty 1σ kBqh/m^3
238	22

Exposure 1: homogeneity of radon concentrations



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        Shapiro-Wilk normality test

data:  (rifer$var)
W = 0.90771, p-value = 0.2656
```

Standard deviation ≅ uncertainty of a singol detector

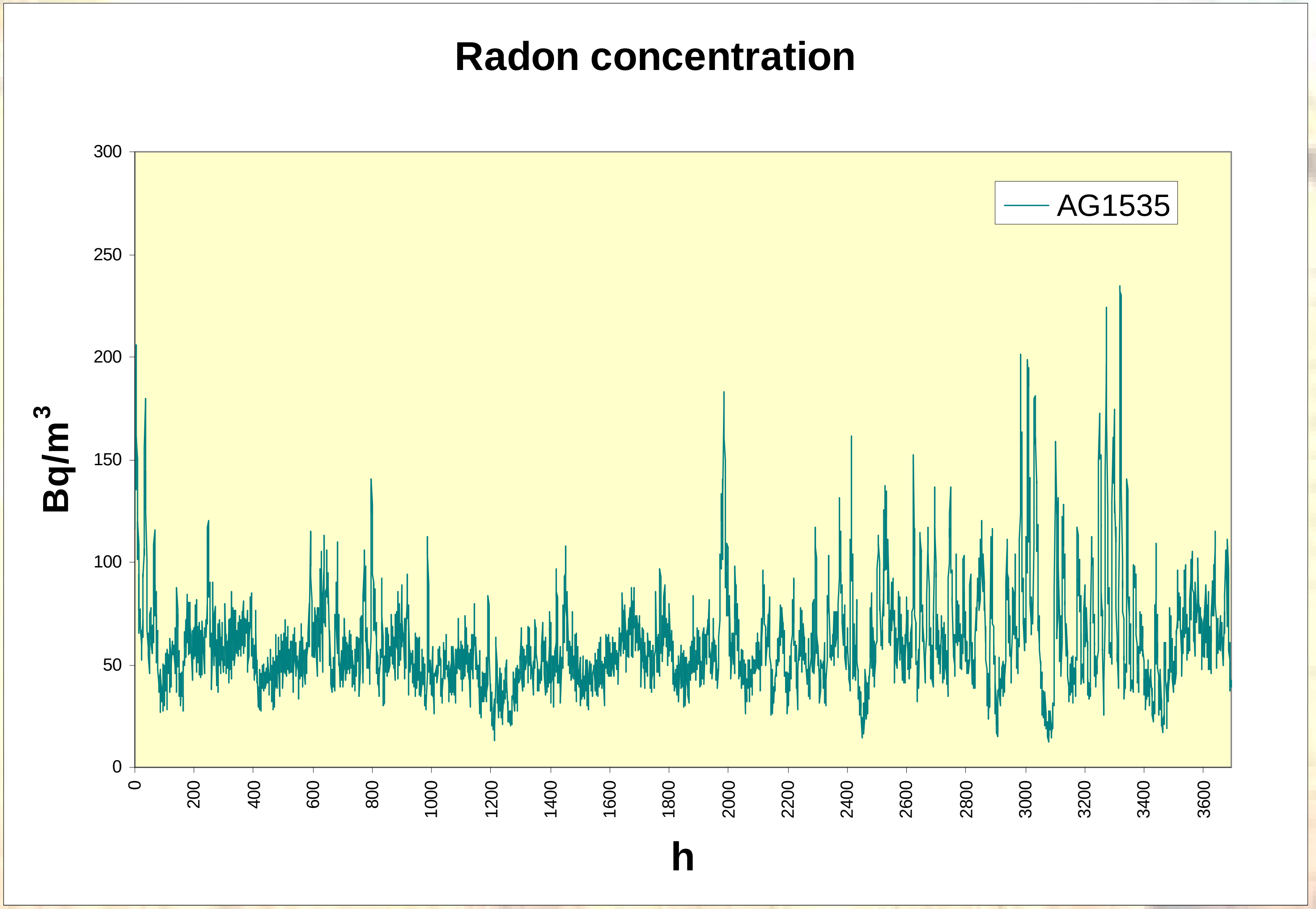
Exposure 1

Continuous radon monitors

During the exposure

Storage of the transits in 2 double radon proof bags

Exposure 1: radon concentration



Exposure 1

Reference continuous radon monitors

Radon exposure $kBqh/m^3$	Metrological and statistical Uncertainty 1σ $kBqh/m^3$	Radon Concentration Bq/m^3	Metrological and statistical Uncertainty 1σ $kBqh/m^3$
225	50	61	13

Exposure 2:

workplace on the basement in Ivrea (TO)

altitude 253 m
above sea level

*

dose rate during storage:
64 nGy/h ± 13%
dose rate during exposure:
106 nGy/h ± 12%
(TLD 100)

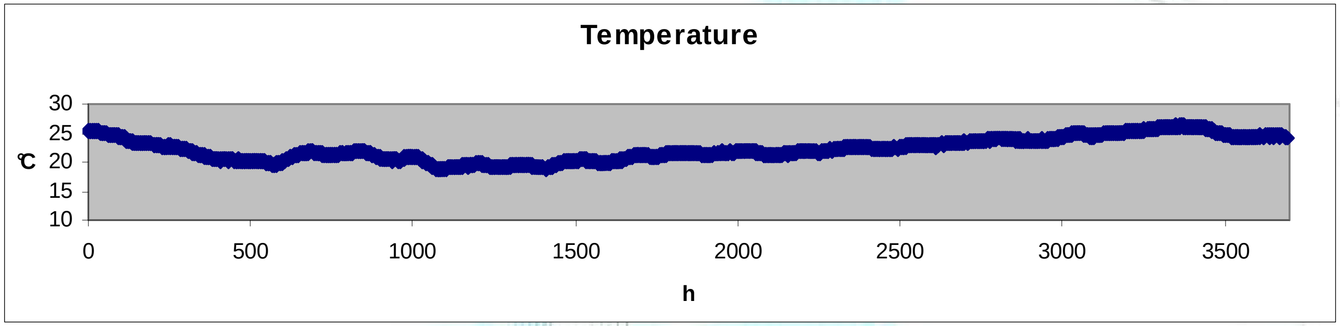
*

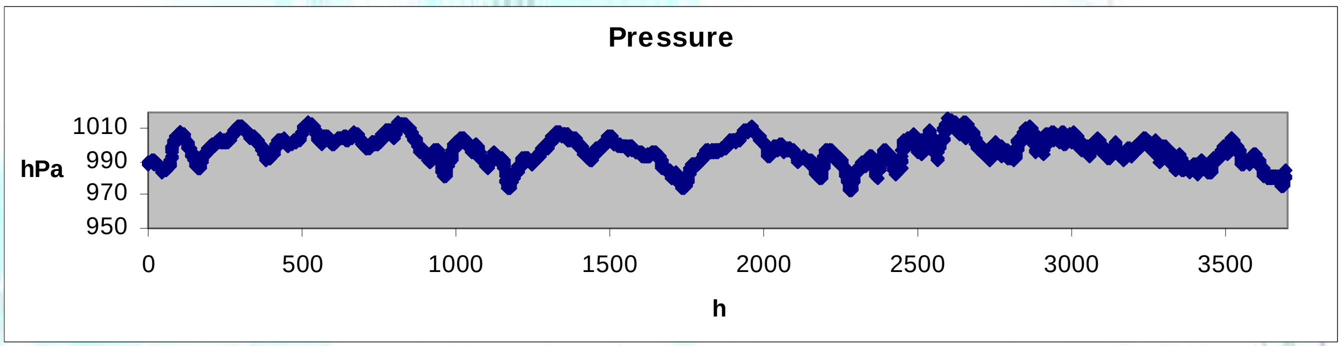
equilibrium factor: 0.56
(spot measurements EQF)

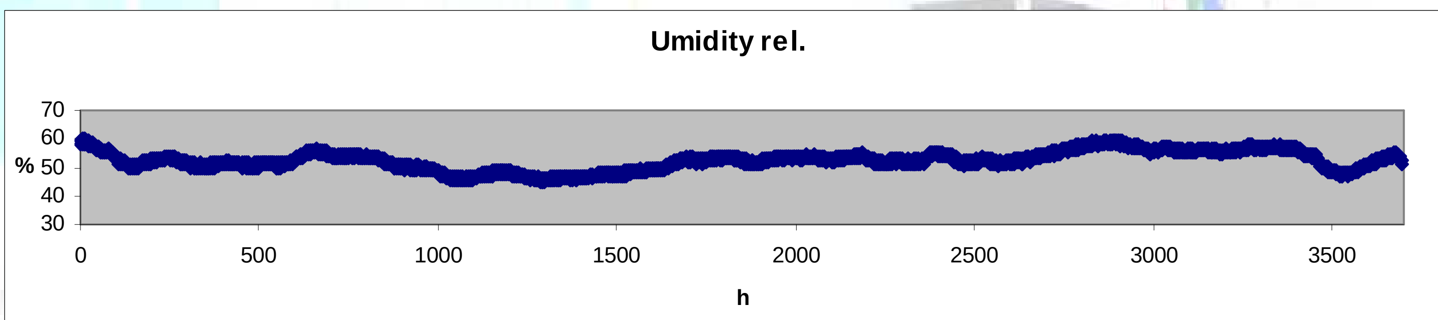
*

temperature: 21°C
pressure: 997 hPa
humidity RH%: 52
(climatic data gathered by radon monitors)

Exposure 2: climatic data







Exposure 2: critical points

Long period of measurement
(Ageing, fading)

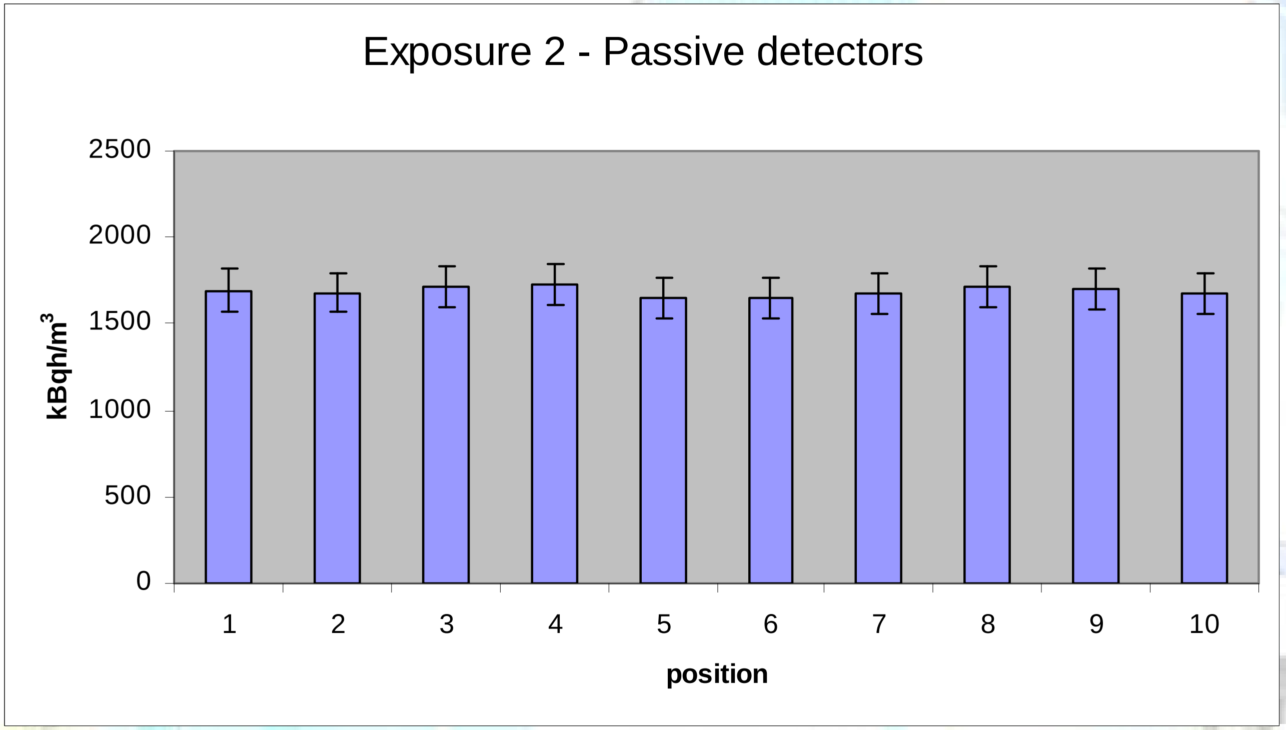
High concentrations

Minimum exposure detectable

Calibration and
Background of the monitors

Exposure 2

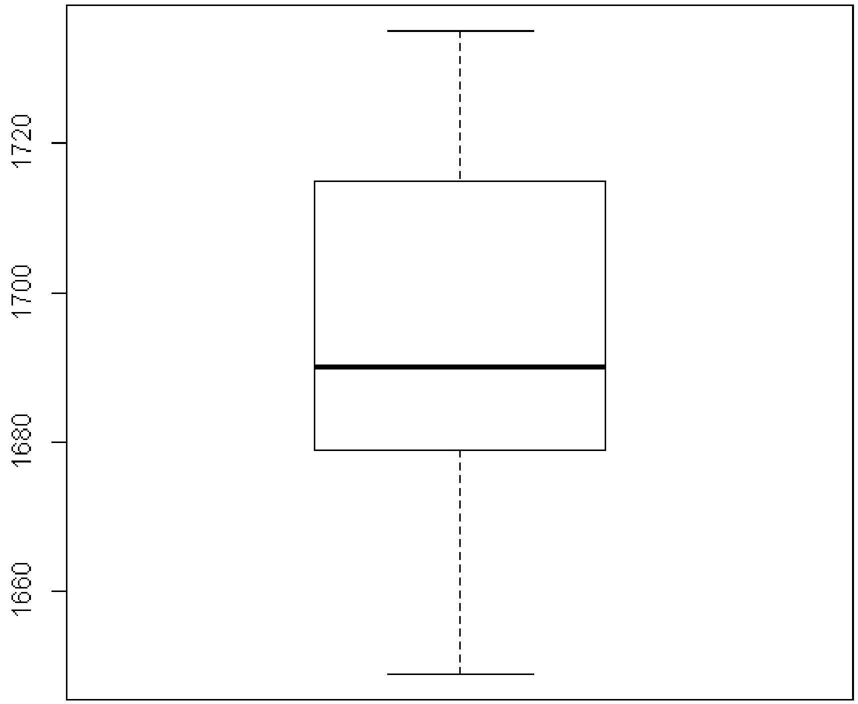
Reference passive radon detectors

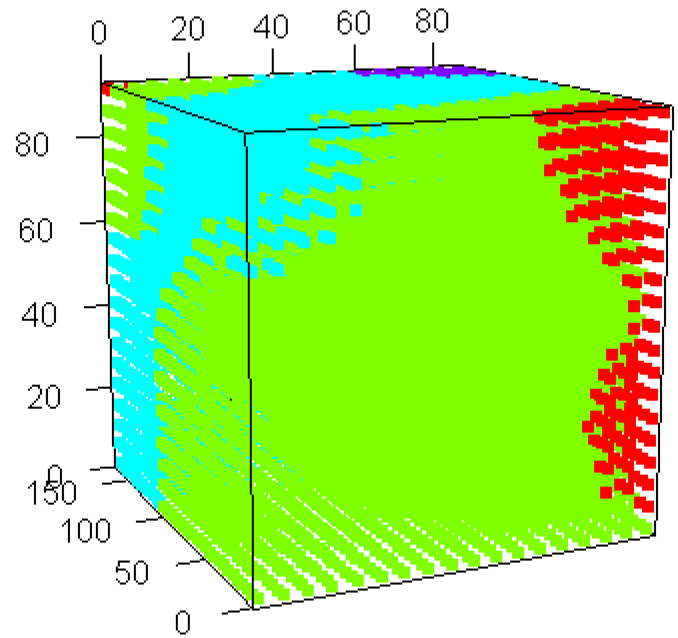


Rn CR39 detectors kBqh/m³	unc. kBqh/m³
1694	119
1681	117
1716	119
1733	119
1649	116
1646	117
1681	118
1713	119
1706	119
1677	121

Radon exposure Passive detectors kBqh/m³	Metrological and statistical Uncertainty 1σ kBqh/m³
1690	121

Exposure 2: homogeneity of radon concentrations



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Shapiro-Wilk normality test

W = 0.95273, p-value = 0.7008
```

Standard deviation ≅ uncertainty of a singol detector

Exposure 2

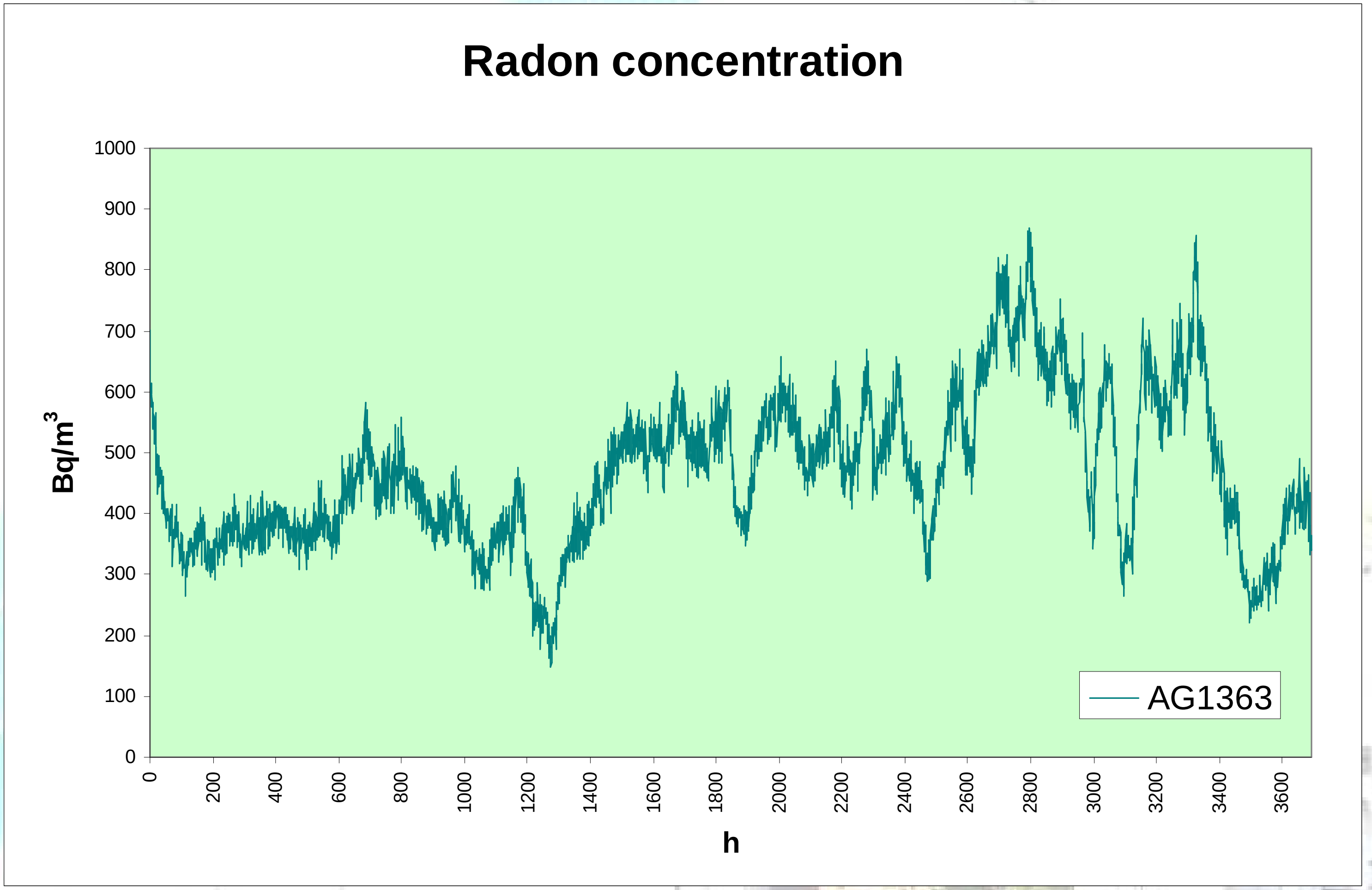
Continuous radon monitors

During the exposure

Storage of the transits in 2 double radon

proof bags

Exposure 2


Radon concentration
Bq/m3
h
AG1363
1000
900
800
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600

Exposure 2

Reference continuous radon monitors

Radon exposure kBqh/m³	Metrological and statistical Uncertainty 1σ kBqh/m³	Radon Concentration Bq/m³	Metrological and statistical Uncertainty 1σ kBqh/m³
1731	152	469	41

Exposure 3:

A dwelling in Valle del Cervo (BI)

altitude 846 m above sea level

*****

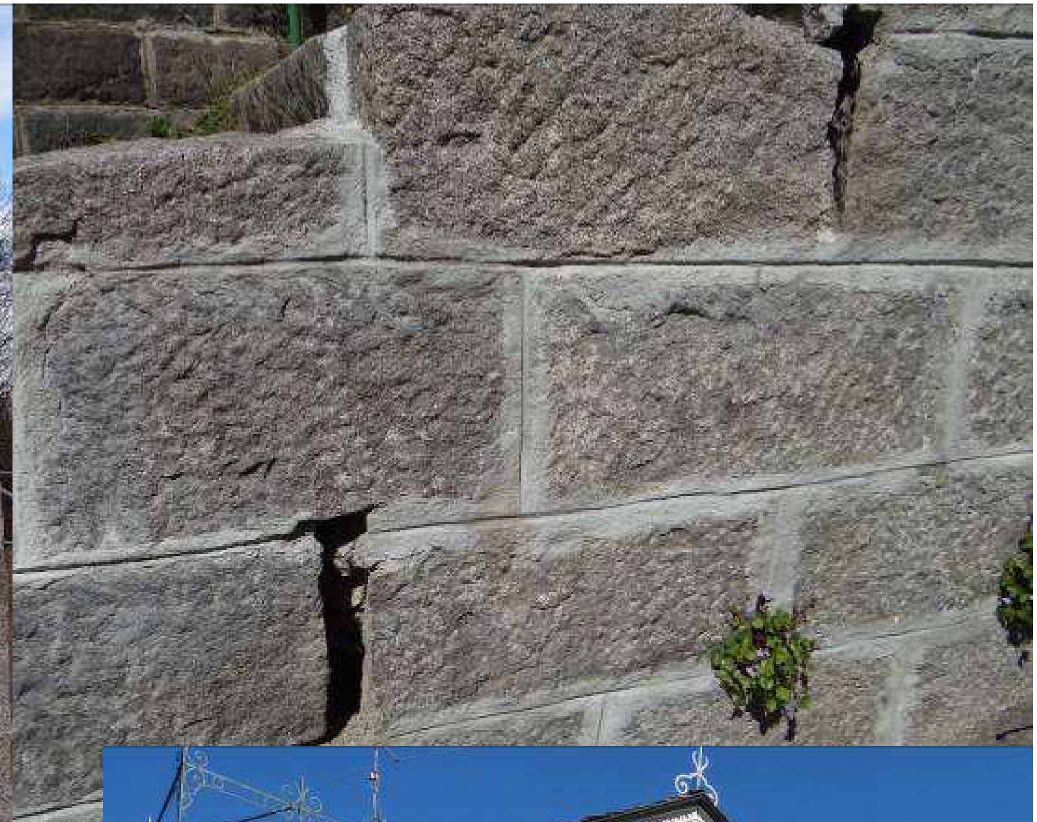
dose rate during storage:
64 nGy/h ± 13%
dose rate during exposure:
inhomogeneus
(TLD 100)

*****

equilibrium factor: 0.15
(continuous measurements with EQF)

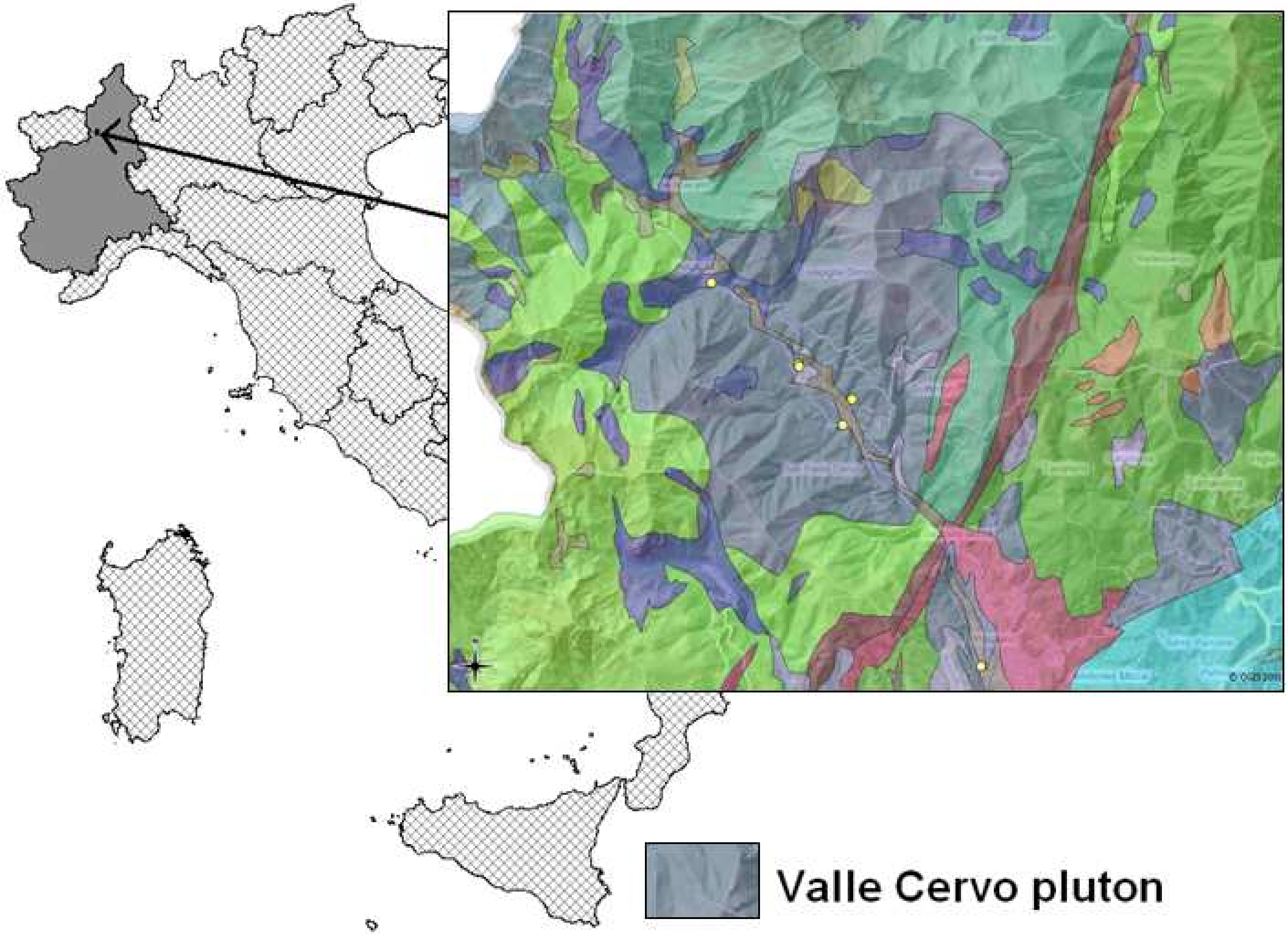
*****

temperature; 13.2°C
pressure: 916 hPa
humidity rel%: 75 %
(climatic data gathered by radon monitors)

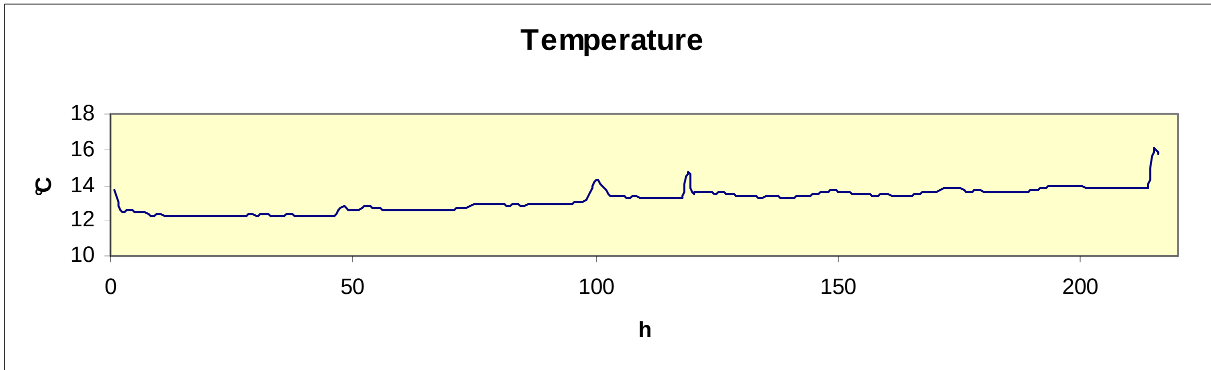


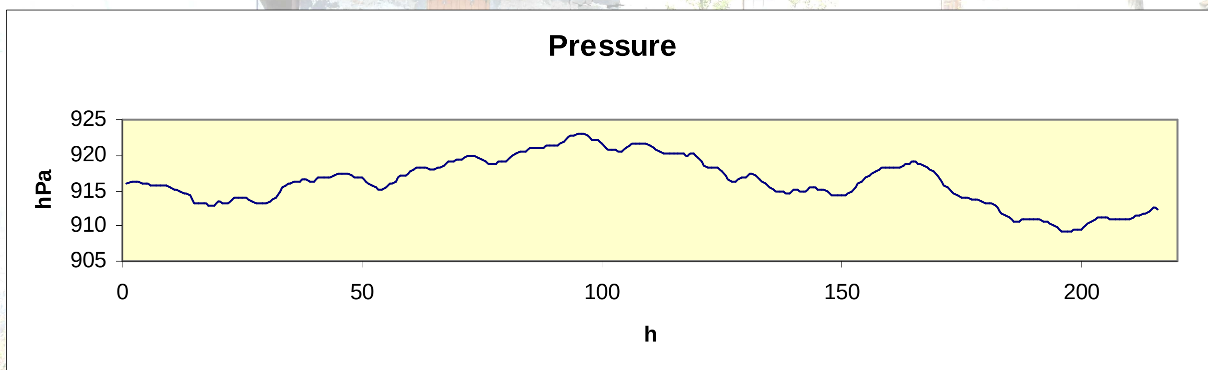
Sienite della Balma

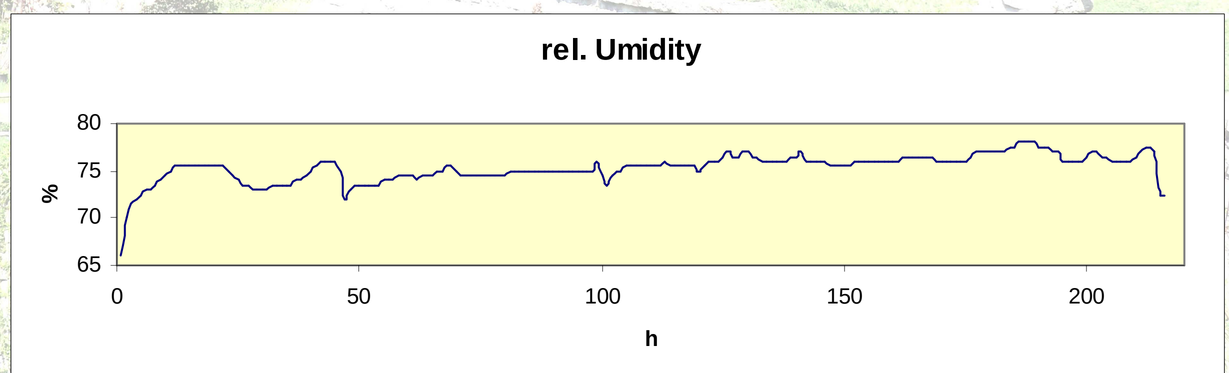
Exposure 3: geology and lithology



Exposure 3: climatic data

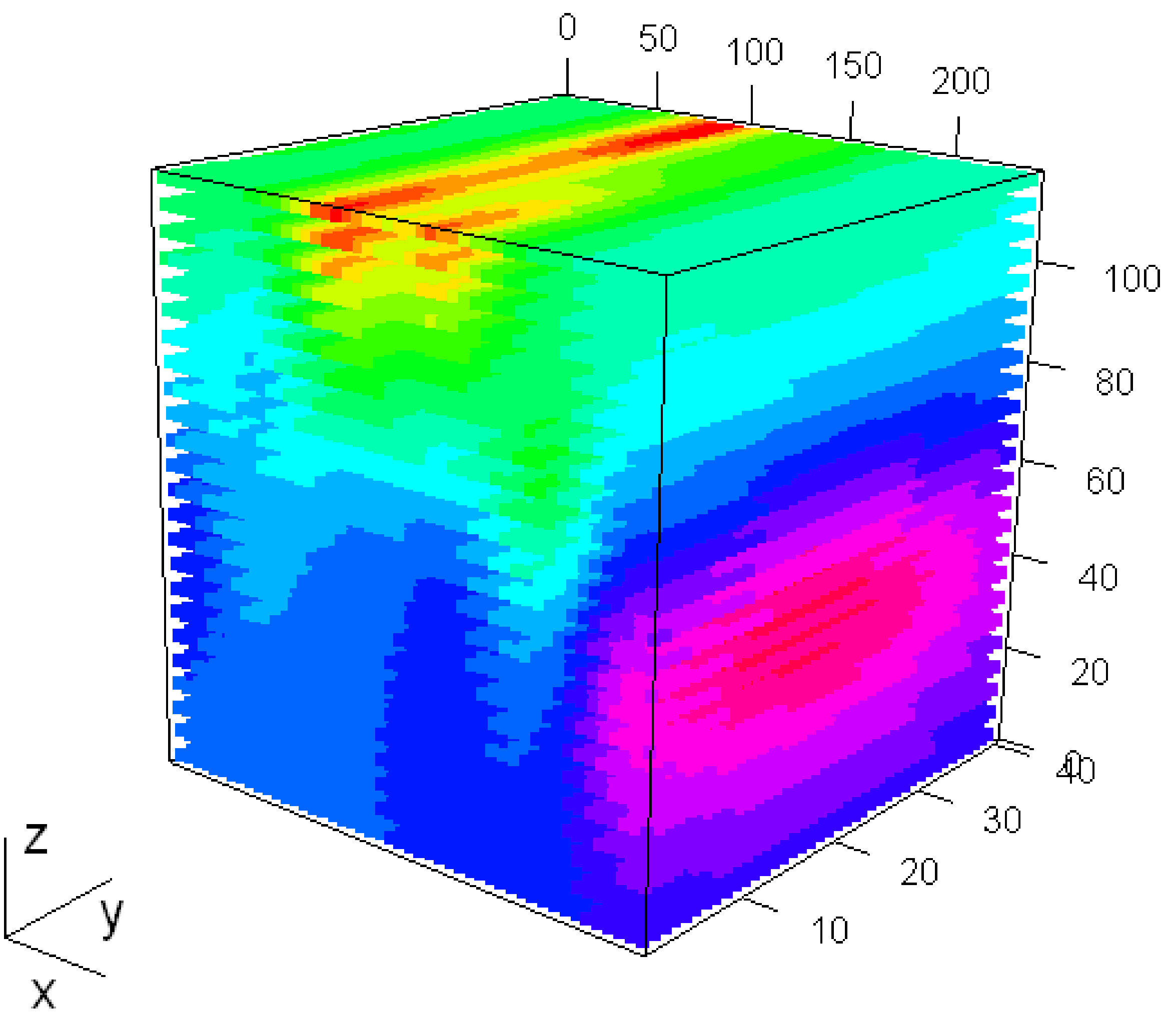






Exposure 3: inhomogeneity of gamma dose rate

The gamma dose rate in air changes for each SET of dosemeters



Exposure 3: critical points

Humidity

*

High dose rate

*

Altitude

*

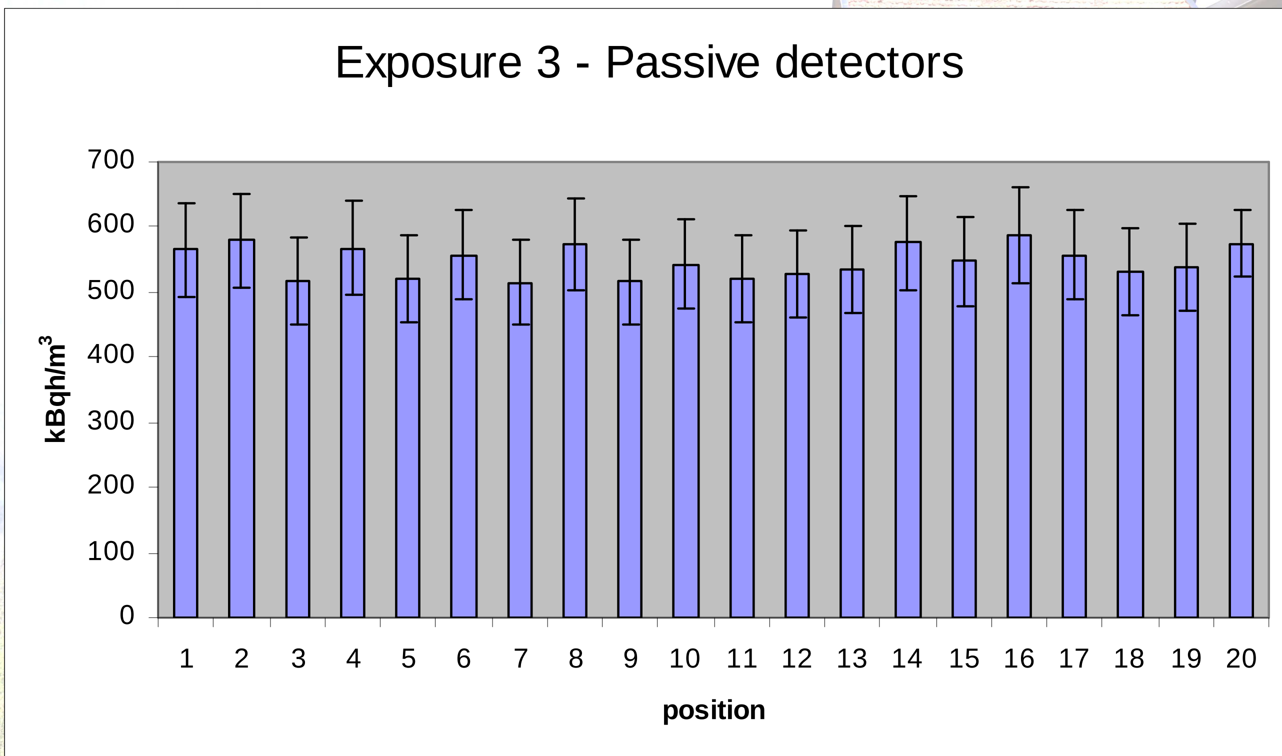
High thoron concentrations

*

Calibration (radon and thoron)

Exposure 3:

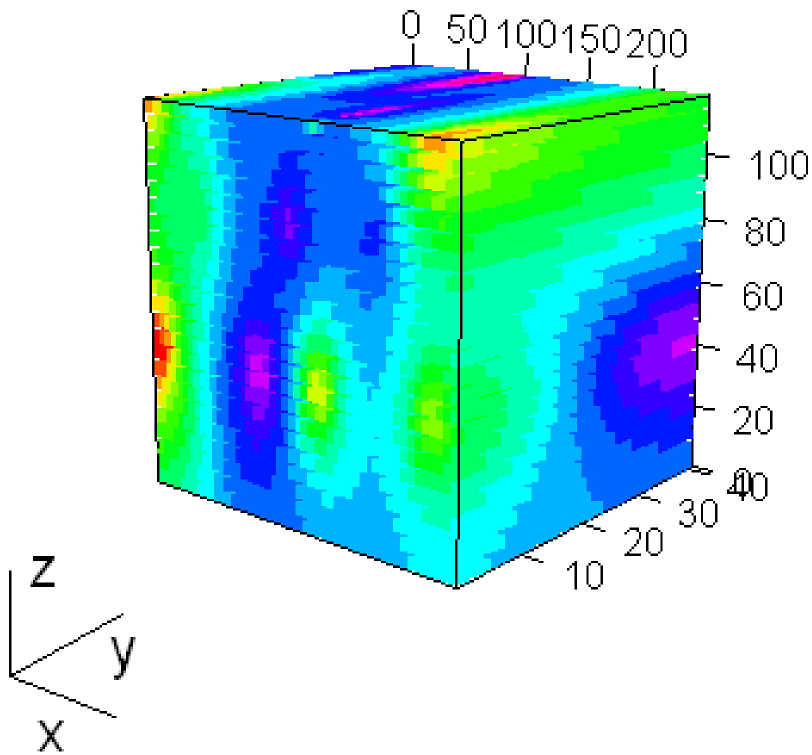
Reference passive CR39 detectors

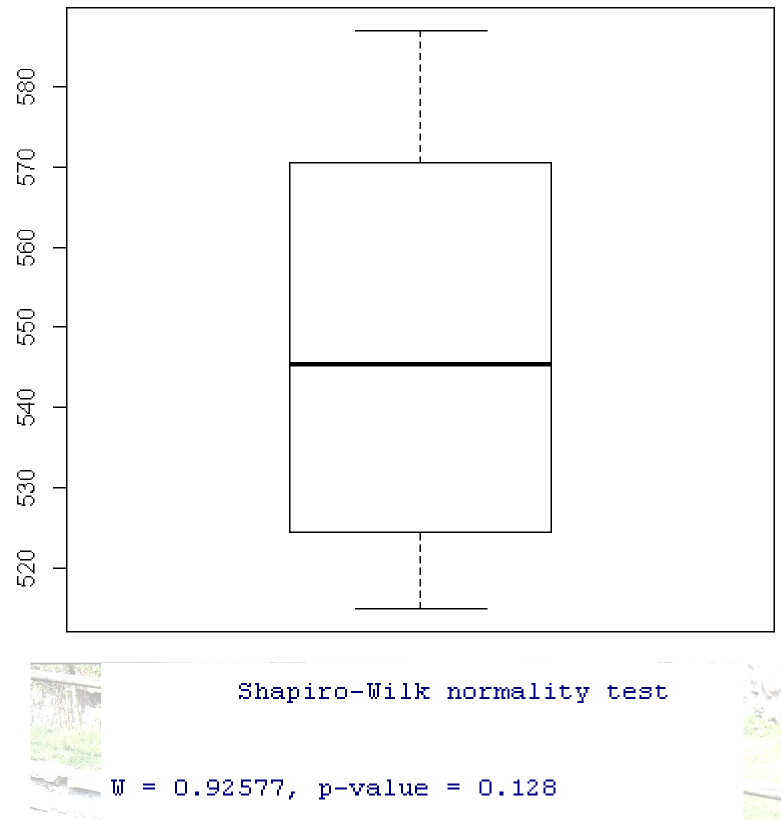


Radon exposure Passive detectors kBqh/m^3	Metrological and statistical Uncertainty 1σ kBqh/m^3
547	73

Rn CR39 detectors kBqh/m^3	unc. kBqh/m^3
565	71
579	72
517	66
568	71
521	66
557	70
515	66
573	72
516	66
543	69
522	66
527	67
535	68
577	72
548	69
587	73
557	70
532	67
539	68
574	51

Exposure 3: homogeneity of radon concentrations



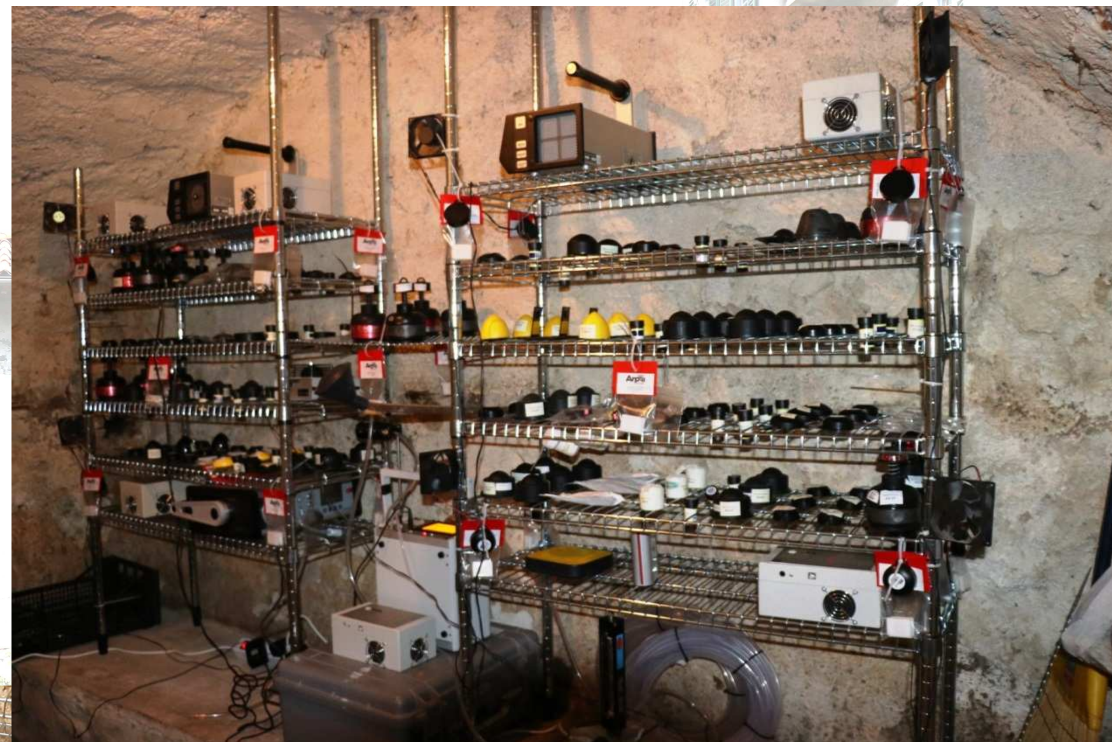


Standard deviation ≅ uncertainty of a singol detector

Exposure 3

Continuous radon monitors

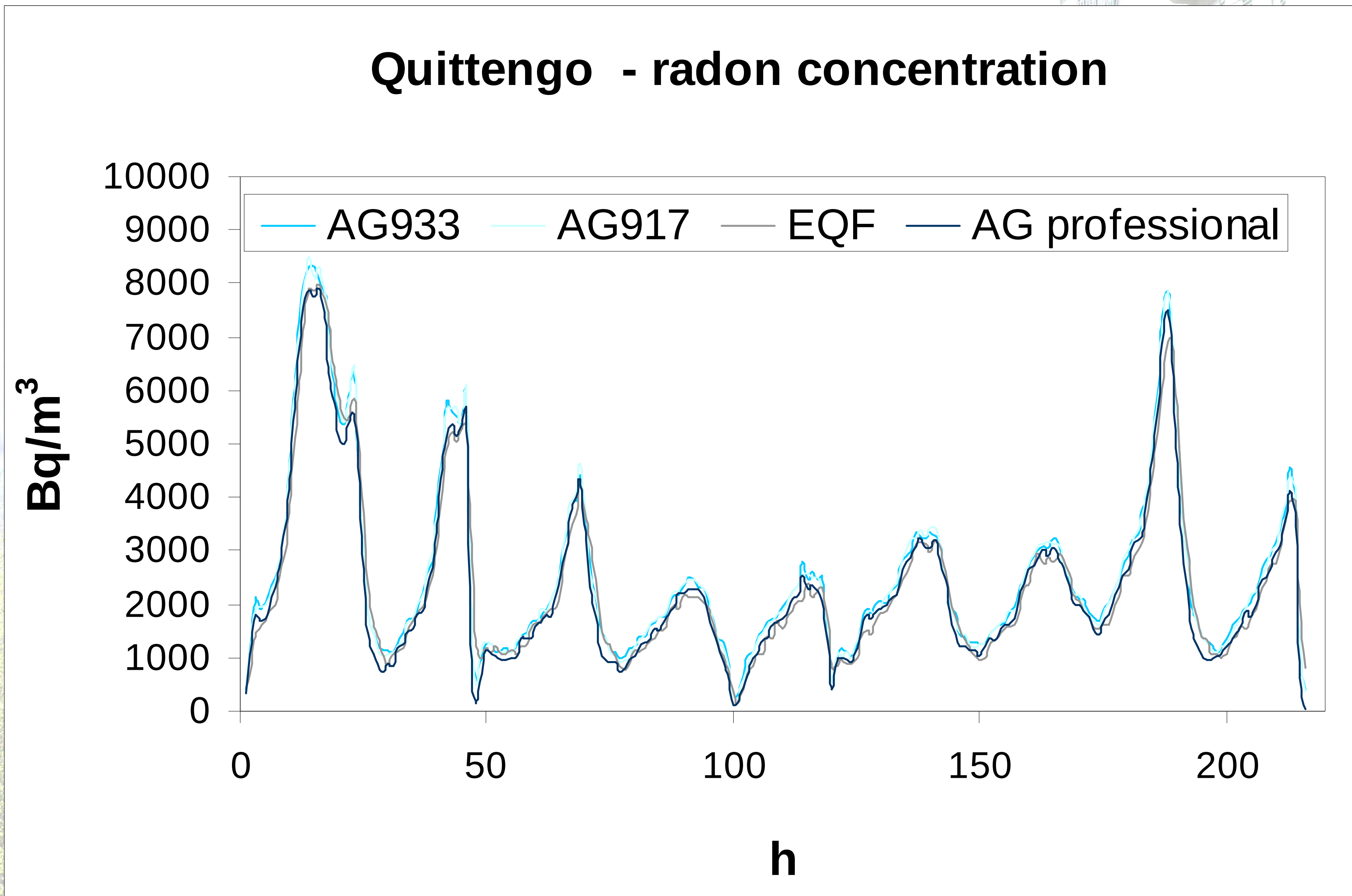
During the exposure



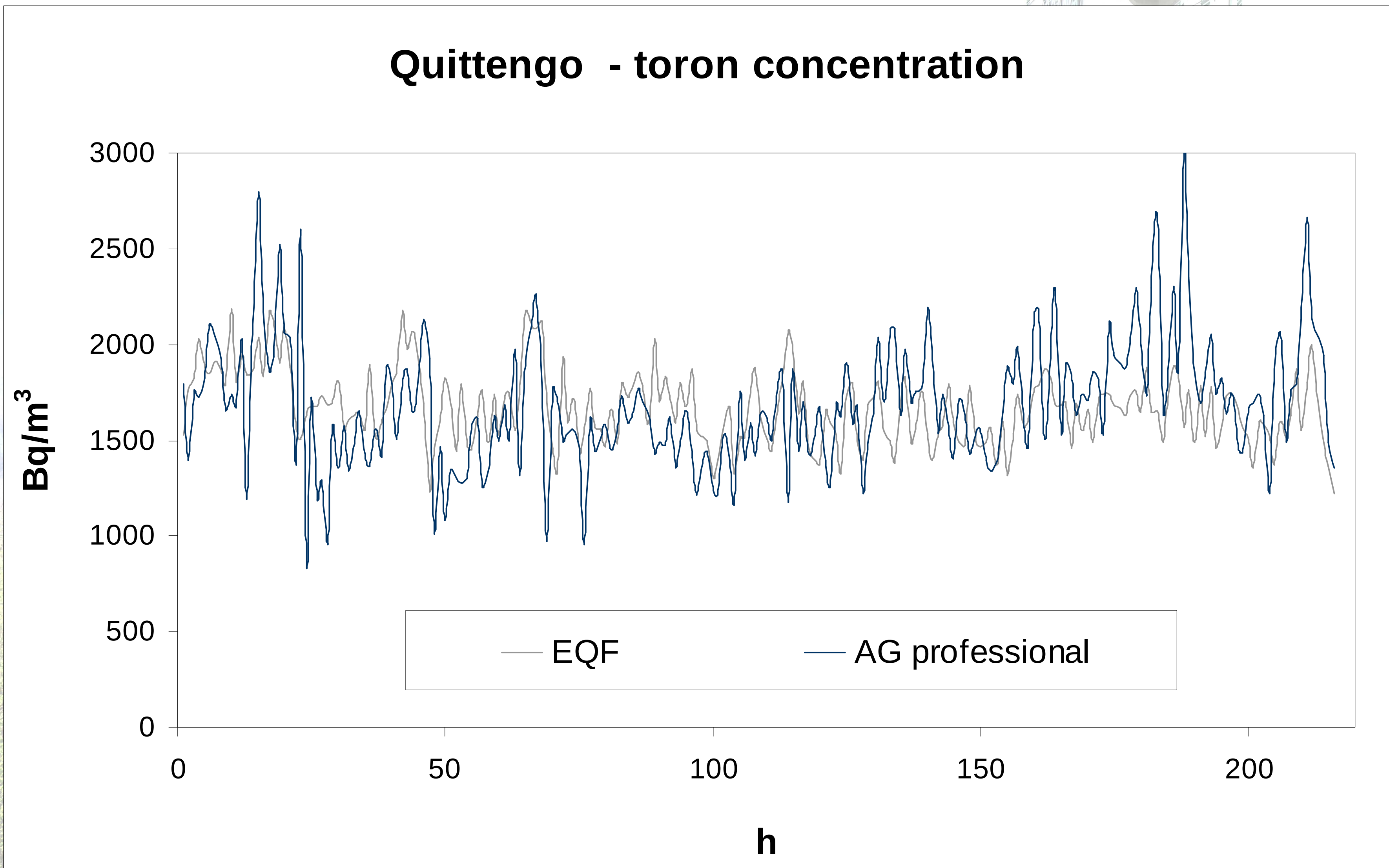
A special thanks to Prof. Piergiorgio Albertazzi

Storage of transits in radon proof bags in Ivrea

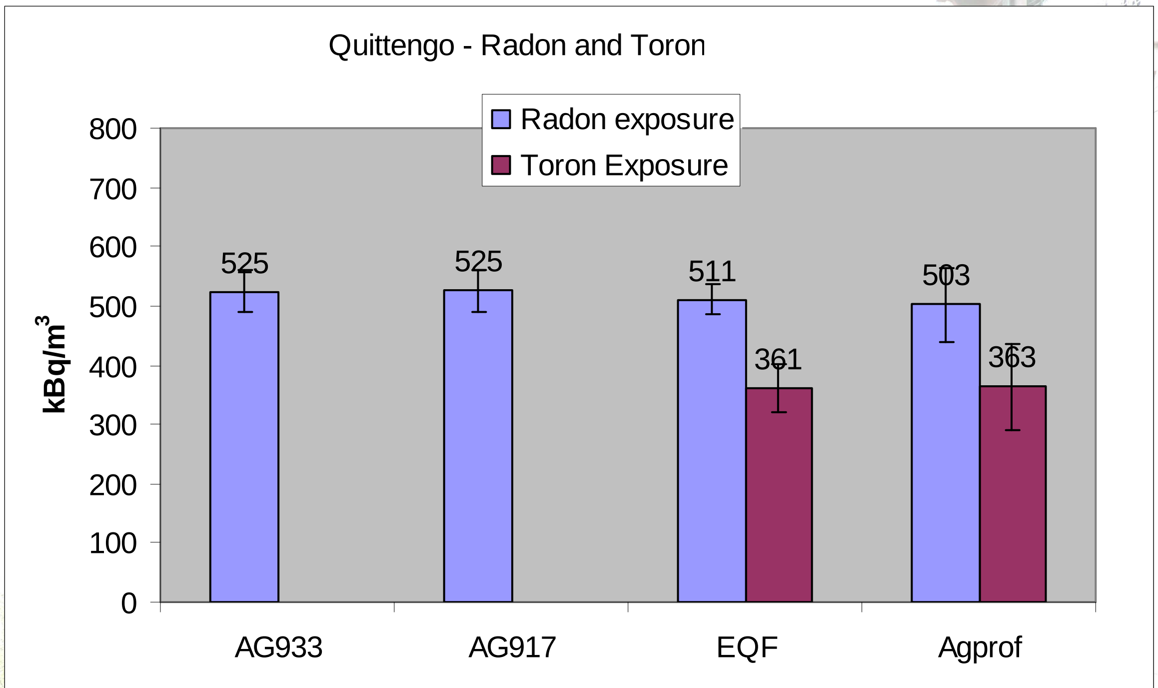
Exposure 3: radon concentration



Exposure 3: thoron concentration



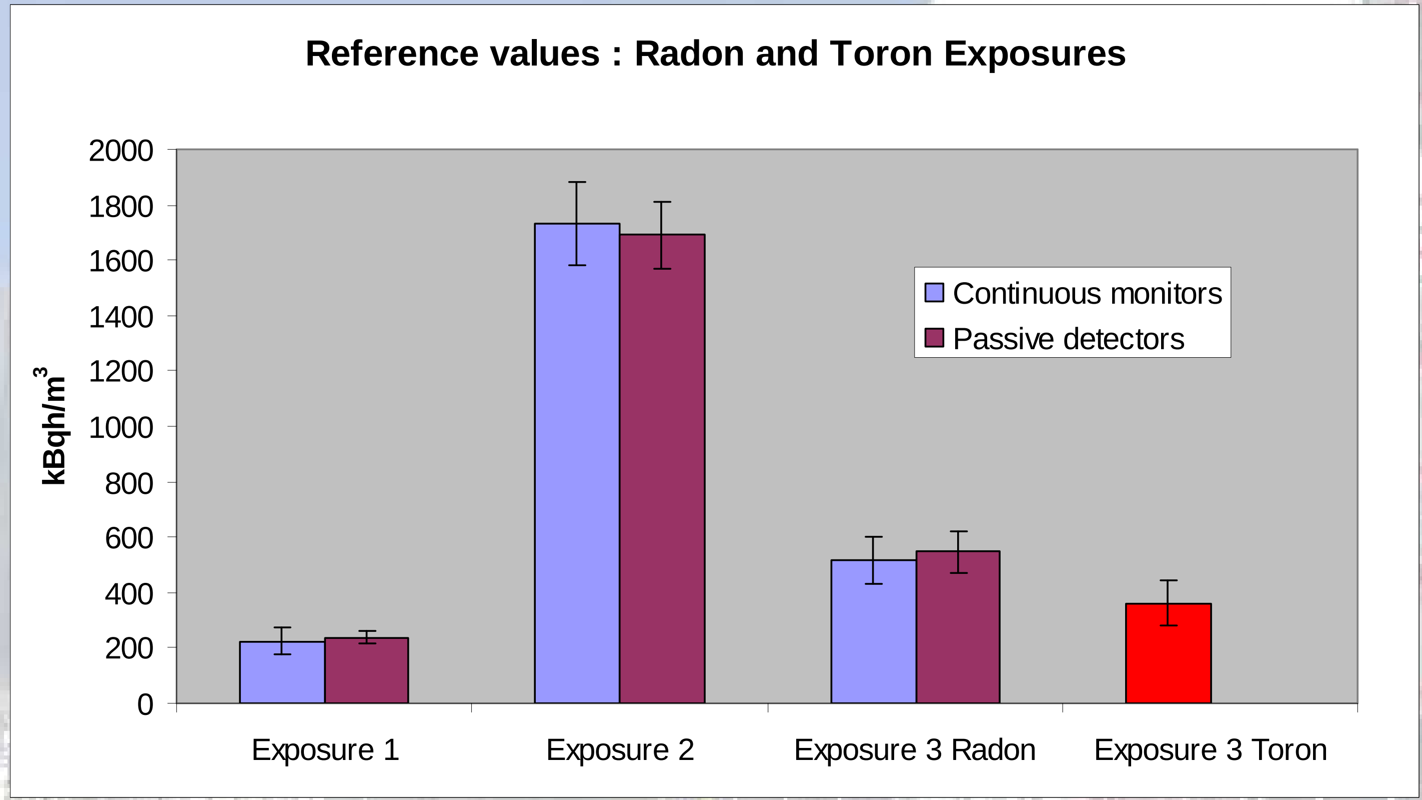
Exposure 3: reference continuous monitors



Radon exposure kBqh/m³	Metrological and statistical Uncertainty 1σ kBqh/m³	Radon Concentration Bq/m³	Metrological and statistical Uncertainty 1σ kBqh/m³
516	85	2399	394

THORON exposure kBqh/m³	Metrological and statistical Uncertainty 1σ kBqh/m³	THORON Concentration Bq/m³	Metrological and statistical Uncertainty 1σ kBqh/m³
362	84	1685	389

Conclusions



	Continuous monitors kBqh/m³	unc. (k=1) kBqh/m³	Passive detectors kBqh/m³	unc. (k=1) kBqh/m³
Exposure 1 Radon	225	50	238	22
Exposure 2 Radon	1731	152	1690	121
Exposure 3 Radon	516	85	547	73
Exposure 3 Thoron	362	84		


Thank you