

Background measurements in the underground labs: Gran Sasso, Modane and Boulby

Jan Kisiel

Institute of Physics, University of Silesia, Katowice, Poland

(kisielj@us.edu.pl)

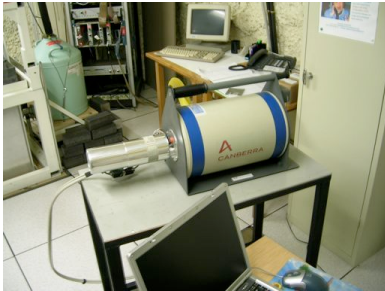
(in collaboration with: J.Dorda and D.Malczewski
University of Silesia)

What have been done?

- Gran Sasso Lab. (December 2004):
in-situ measurements, radon emission from the surface, water samples measurements,
- Boulby Lab. (August 2005, August 2006):
in-situ measurements in 10 locations, radon emission from the surface, rock samples measurements,
- Modane (LMS) Lab. (July 2006):
in-situ measurements in 6 locations, radon emission from the surface, water samples measurements, rock samples measurements.

EXPERIMENTAL SET-UP (in-situ measurements)

The radioactivity background from natural and antropogenic radionuclides has been measured *in situ* using a portable gamma-ray spectroscopy workstation (Modane and Boulby: Canberra, Gran Sasso: Ortec)

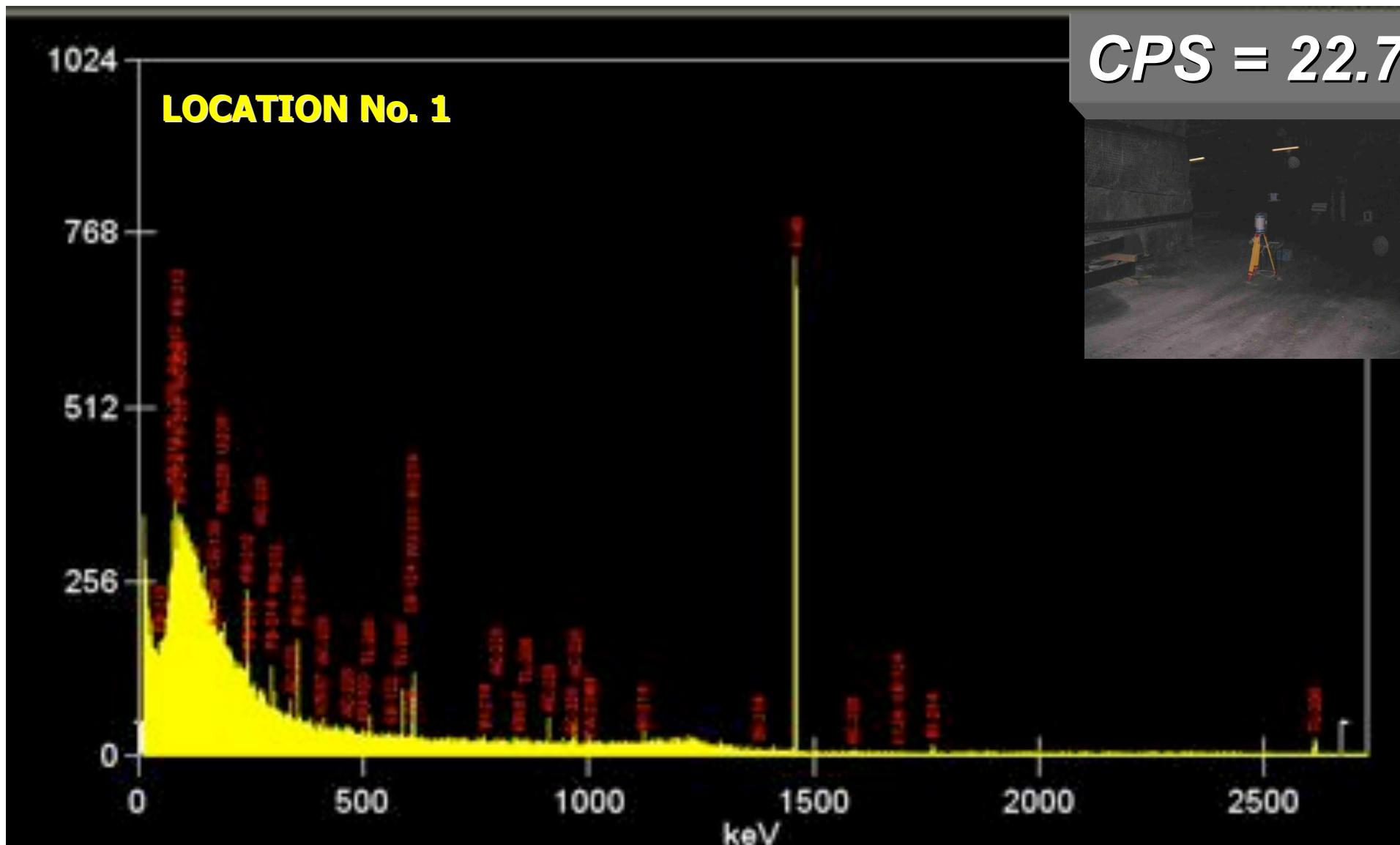


Both consists of a HPGe detector (32% efficiency, crystal length 59mm and diameter 57mm) with cryostat mounted on a tripod, multichannel buffer and a laptop. The resolutions are: 0.6keV at 122keV and 1.5keV at 1.33MeV. They differ in the software used for the: (1) efficiency calibration, and (2) determination of radionuclides and their activities.

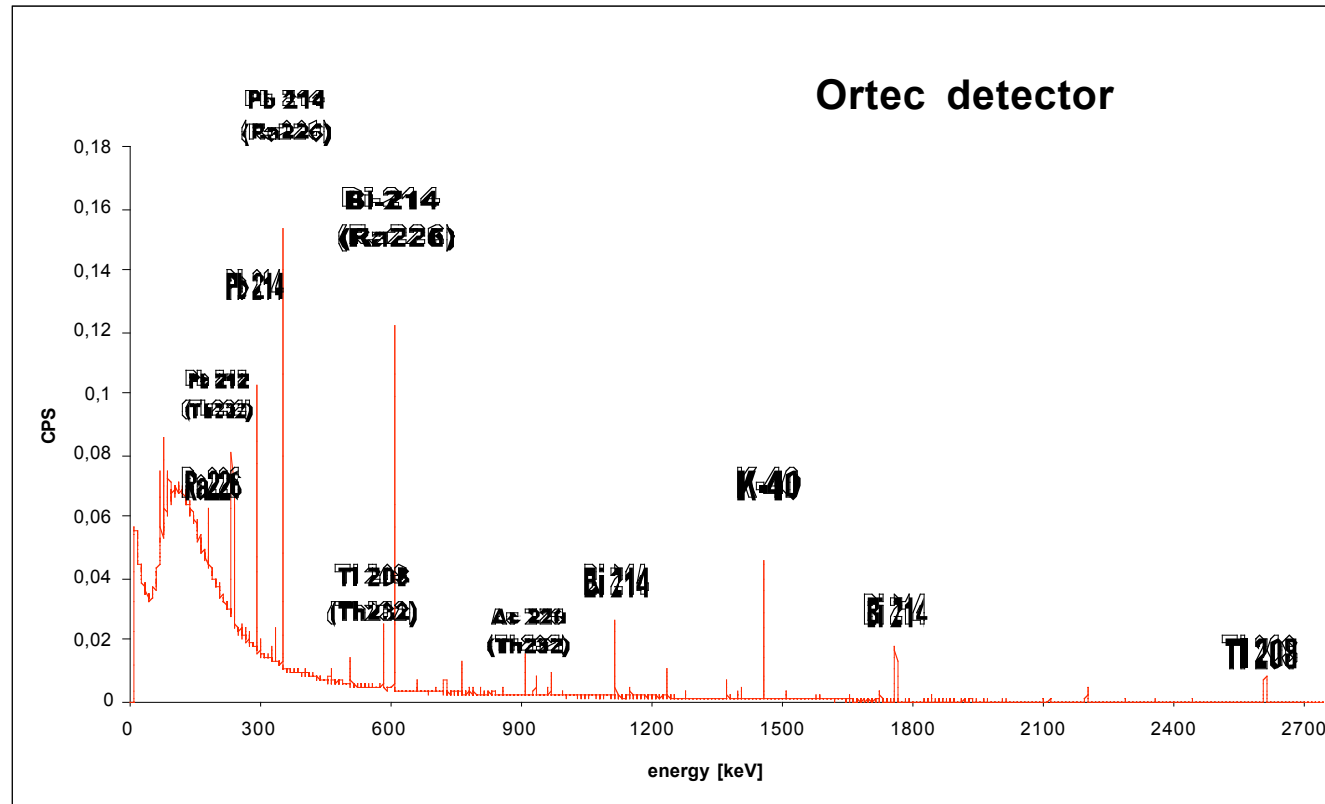


NUCLIDE	⁴⁰ K	²²⁶ Ra (²³⁸ U)	²²⁸ Ac (²³² Th)
ACTIVITY (Bqkg ⁻¹)	103	1.75	1.49
UNCERTAINTY	2	0.14	0.12

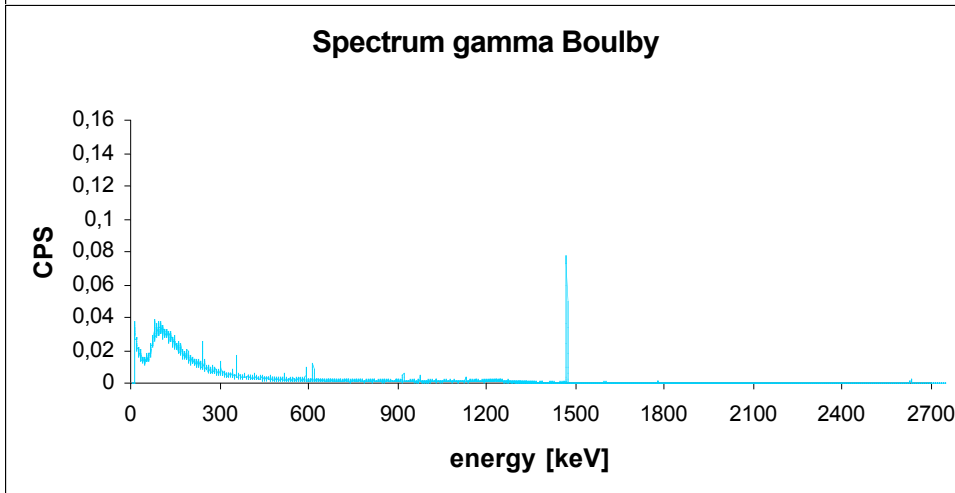
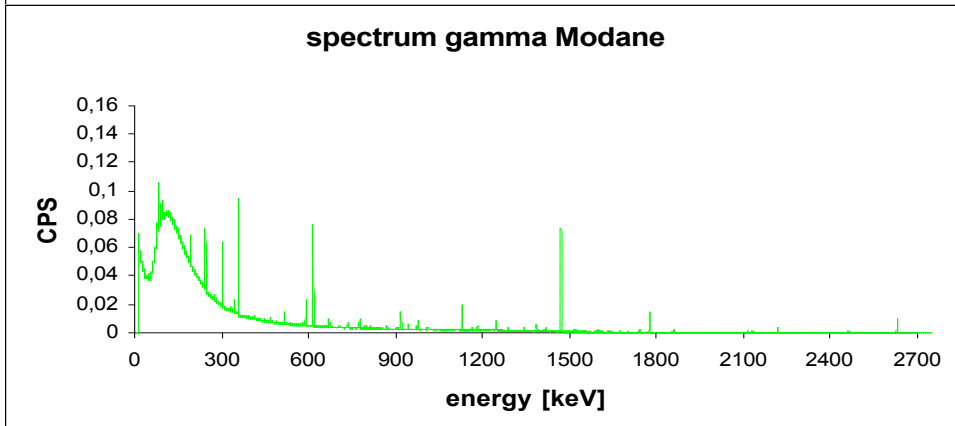
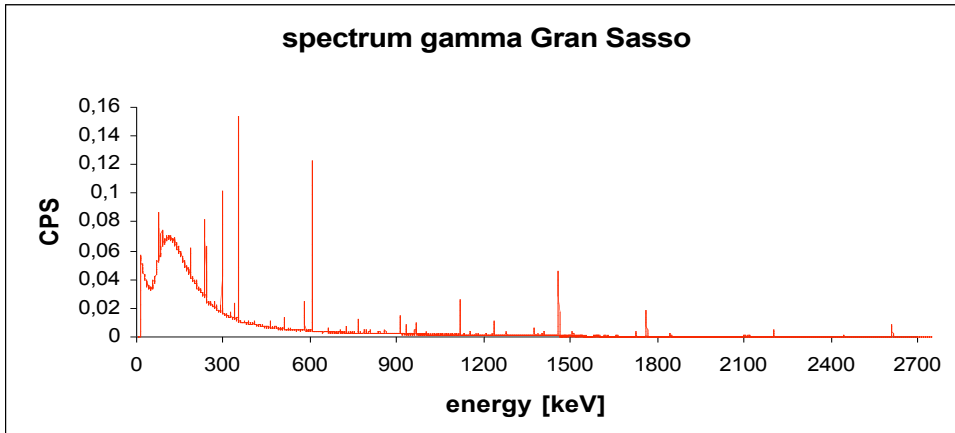
Boulby,
transportation hall,
Canberra detector



Gamma spectrum Gran Sasso (hall B), 2004



Comparison of gamma spectra: Gran Sasso, Modane and Boulby



Integral background counting rates
50 – 2700 keV
[CPS/keV*kg]

Gran Sasso 57.68

Modane 66.06

Boulby 23.83

In-situ measurements in Gran Sasso, Modane and Boulby: net cps for three components of the spectrum.

	^{214}Bi [609keV] (^{226}Ra)	^{228}Ac [911keV] (^{232}Th)	^{40}K [1460keV]
Gran Sasso	0.487 ± 0.002	0.048 ± 0.003	0.268 ± 0.002
Modane	0.322 ± 0.003	0.062 ± 0.004	0.438 ± 0.003
Boulby	0.042 ± 0.002	0.023 ± 0.002	0.470 ± 0.003

Results of in situ measurements in Gran Sasso, Modane and Boulby (M1 ORTEC software used for the spectra analysis)

	Izotop	Gran Sasso (Italy) Hall B (2004)	Modane (France) Hall NEMO (2006)	Boulby (UK) Transport hall (2006)
		[Bq/kg]	[Bq/kg]	[Bq/kg]
⁴⁰ K	K40 1460 keV	92.4 ± 1.1	150.5 ± 2.9	162.0 ± 2.5
	Pb212 238 keV	7.9 ± 0.2	7.8 ± 0.4	2.8 ± 0.5
²³² Th	Ac228 338 keV	7.7 ± 1.3	8.6 ± 2.4	5.7 ± 3.5
	Ac228 911 keV	7.3 ± 0.4	7.4 ± 1.0	2.7 ± 0.6
	Pb214 295 keV	32.5 ± 0.5	22.2 ± 1.8	4.7 ± 1.9
	Pb214 352 keV	30.8 ± 0.7	21.4 ± 0.4	3.3 ± 0.5
²²⁶ Ra	Bi214 609 keV	30.3 ± 0.3	21.0 ± 0.3	2.6 ± 0.5
	Bi214 1120 keV	29.8 ± 1.2	21.5 ± 0.7	6.7 ± 3.3
	Bi214 1764 keV	28.0 ± 0.5	22.3 ± 1.0	2.6 ± 0.3

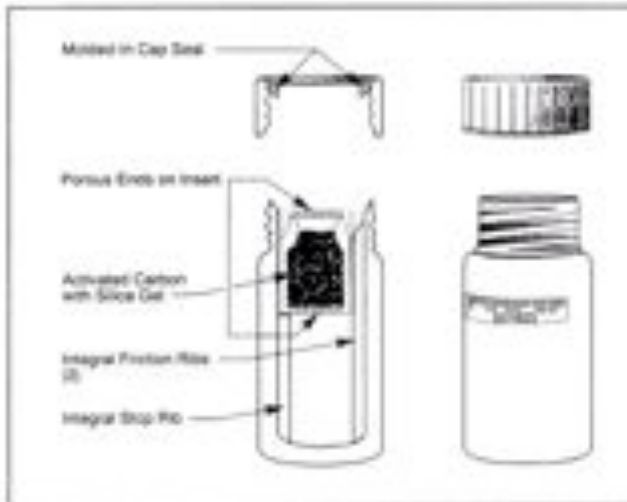
^{222}Rn concentration in the air

(2 methods of measurement)

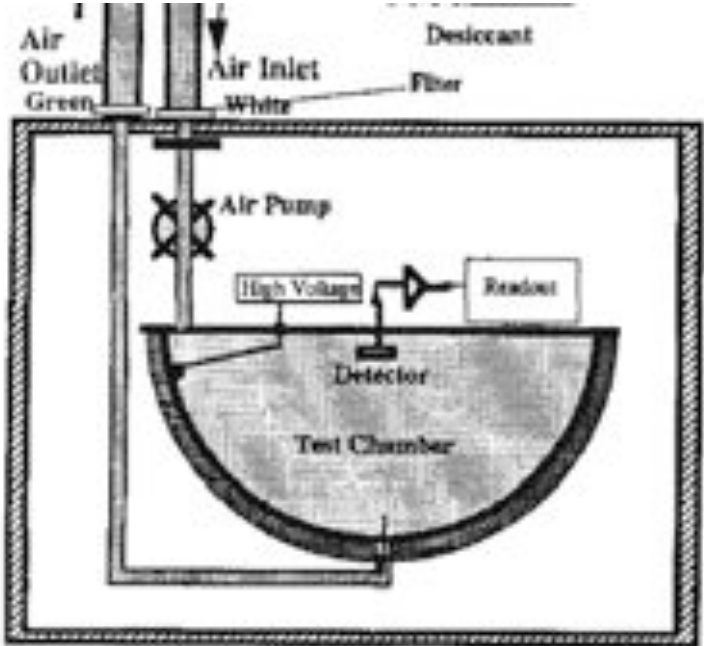
- Pico-Rad method (Insta-Fluor scintillator, activate carbon, 48h exposure, 12 measurements in Halls A, B and C of Gran Sasso Lab)
- DurrIDGE RAD7 detector in sniff mode, 48-hours protocol, 1 hour intervals, measurements in Modane and Boulby Labs

LSC COUNTER

Active Carbon Detector PicoRad



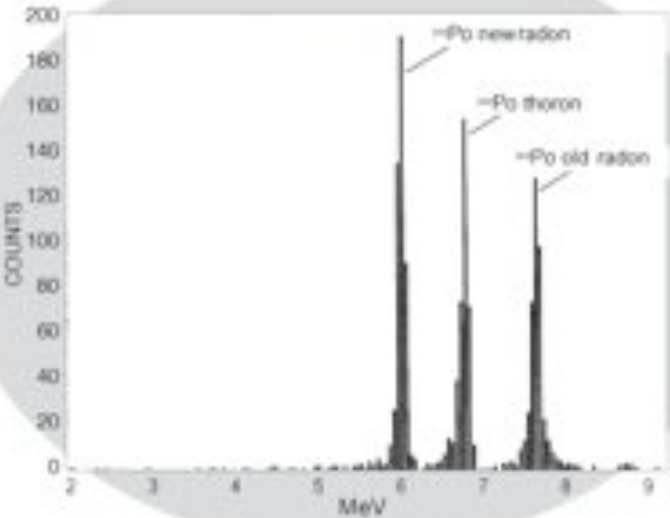
RAD7 detector



RAD7



High Resolution Alpha Energy Spectrum



^{222}Rn [Bq/m ³]	Boulby			Rad 7
	Hall JIF –left	Hall JIF center1	Hall JIF center2	Hall transport.
average	2.44 ± 0.39	2.79 ± 0.47	3.71 ± 0.41	4.70 ± 0.41
max	3.60	4.50	4.79	9.57
min	0.30	1.64	2.69	2.70
^{222}Rn [Bq/m ³]	Modane			Rad 7
	Hall NEMO	Hall electr.	Hall EDELWISE	Hall HPGe
average	7.64 ± 0.38	11.24 ± 0.56	10.01 ± 0.51	10.54 ± 0.57
max	13.8	18.0	18.0	16.2
min	2.39	3.6	5.4	6.58

Gran Sasso	Hall B					PicoRad
	1	2	3	4	5	6
Bq/m ³	170.4 ± 5.0	174.0 ± 5.0	189.6 ± 5.2	193.2 ± 5.3	297.6 ± 7.7	194.4 ± 5.3

	Hall A			Hall C		
	7	8	9	10	11	12
Bq/m ³	189.6 ± 5.2	187.2 ± 5.2	160.8 ± 4.8	249.6 ± 7.0	246.0 ± 6.9	324.0 ± 8.1

LNGS measurements, Dec'2004

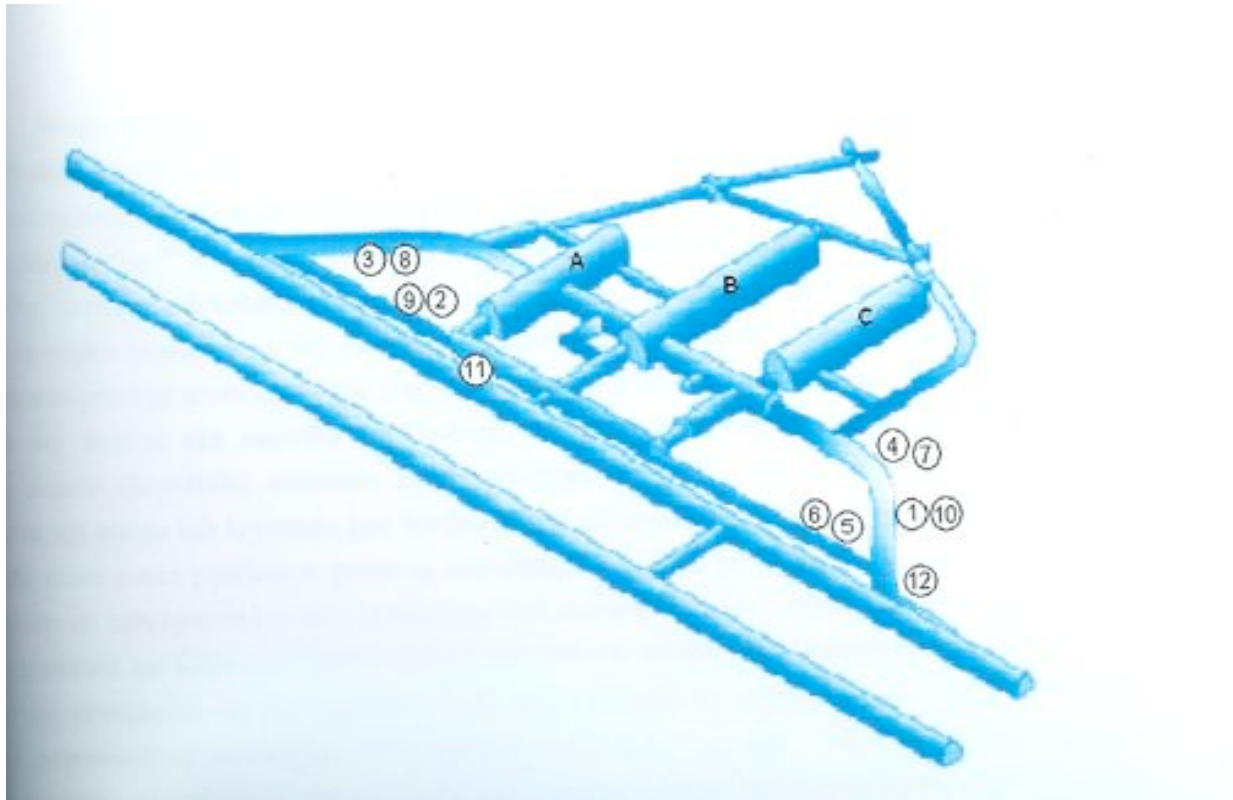
²²²Rn concentration in the water

Liquid scintillator method (measured with Wallac 1414 WinSpectral liquid scintillation Counter, in Katowice),
12 measurements – see map)

Sample	1	10	2	9	3	8
Bq/dm ³	6.1 ± 0.4	6.5 ± 0.4	9.3 ± 0.5	9.4 ± 0.5	4.4 ± 0.3	4.3 ± 0.3

Sample	4	7	5	6	11	12
Bq/dm ³	11.4 ± 0.6	10.2 ± 0.5	5.8 ± 0.4	6.0 ± 0.5	5.0 ± 0.4	5.4 ± 0.4

LNGS, Dec'2004: map of water samples measurements



^{226}Ra and ^{228}Ra in the water

The water samples for the ^{226}Ra and ^{228}Ra concentration measurements were collected and transported to the laboratory. The radium isotopes have been removed from the water by using the method of co-precipitation barium carrier and by removing daughters. Precipitated sediments of BaSO_4 and RaSO_4 were mixed with scintillation gel in the scintillation vial, and were analyzed with Winspectral Liquid Scintillation Counter (**LSC**).

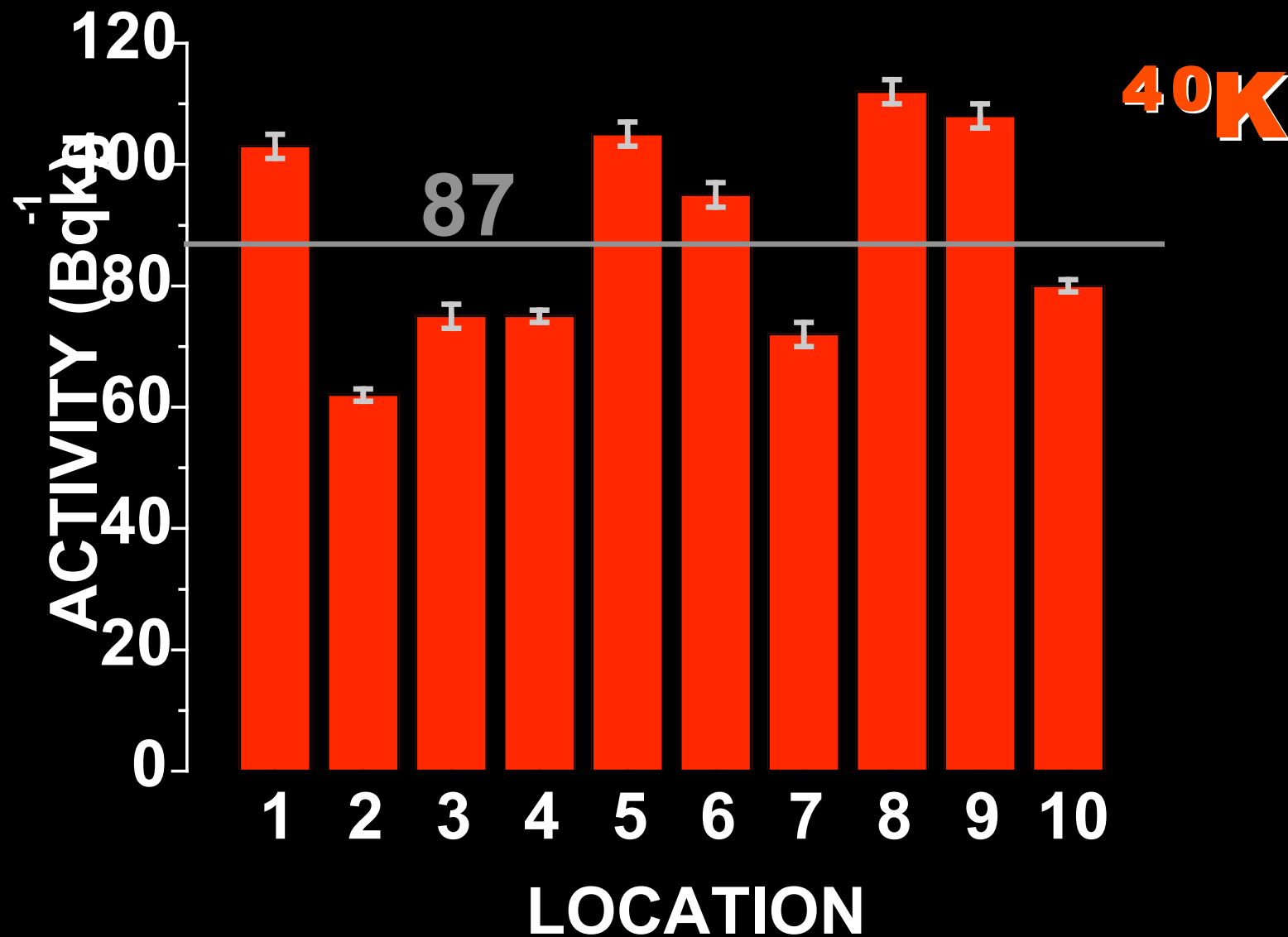
	^{226}Ra [Bq/dm ³]	^{228}Ra [Bq/dm ³]
MODANE sample 1 Hall „NEMO”	0.012 ± 0.002	0.015 ± 0.005
MODANE sample 2	< 0.008	0.015 ± 0.005
Gran Sasso	< 0.025	< 0.06

Future plans (2007):

One or two in-situ measurements in 2007 (Canfranc and Gran Sasso):

- use of two portable detectors: EG&G (ORTEC) and GX3020 (Canberra Industries),
- possibility of measurements in different geometries, with the minimum detectable activity of about 0.1Bq/kg,
- radon emission measurements,
- rock and water samples measurements.

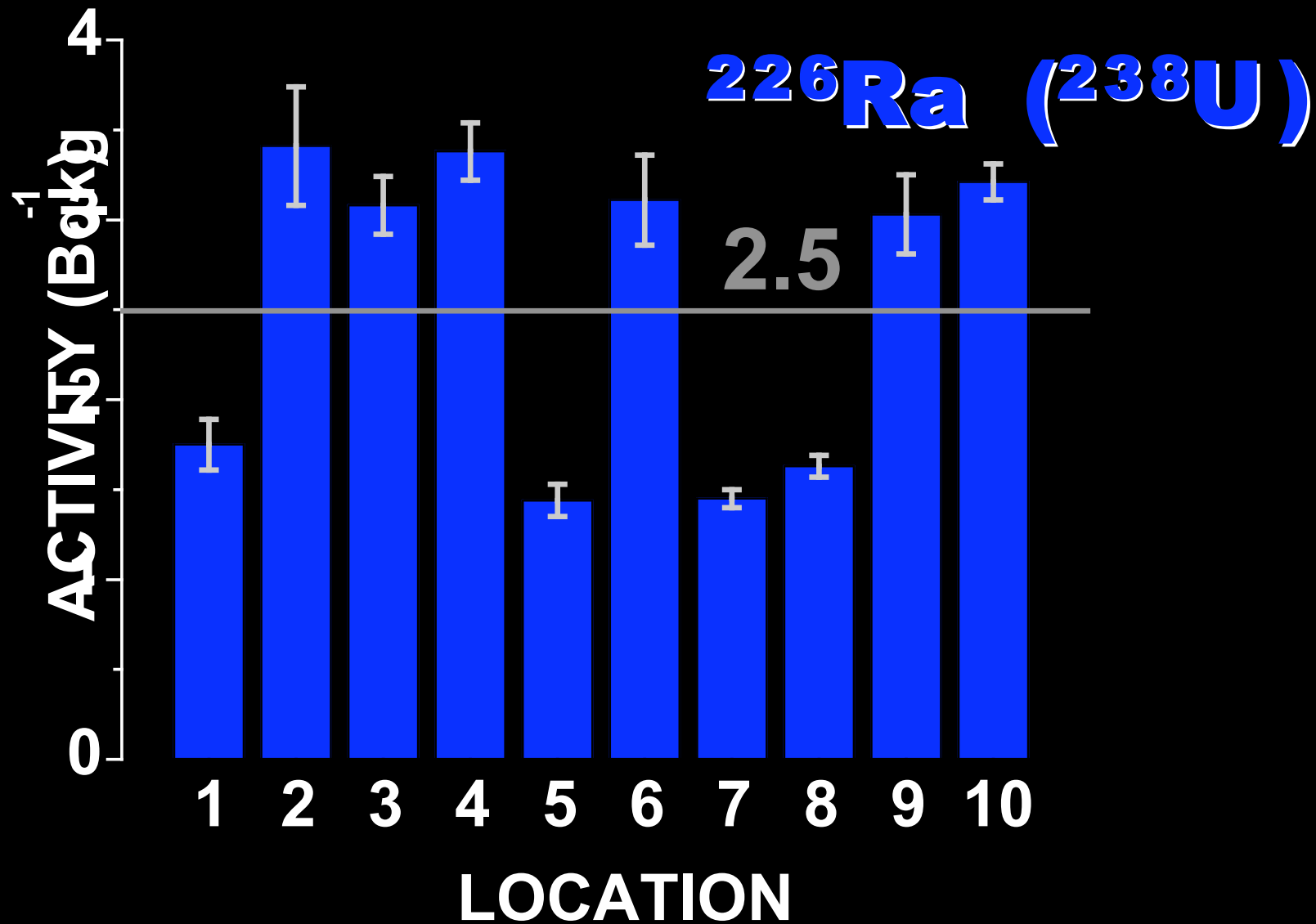




$^{40}\text{K}_{\text{outside}} = 93 \pm 16$

$^{40}\text{K}_{\text{inside}} = 85 \pm 18$

$^{40}\text{K}_{\text{LAB}} = 93 \pm 13$



$^{226}\text{Ra}_{\text{outside}} = 1.8 \pm 0.6$ $^{226}\text{Ra}_{\text{inside}} = 3.2 \pm 0.2$ $^{226}\text{Ra}_{\text{LAB}} = 3.2 \pm 0.1$

Radon measurements in Boulby: results

- Mean (from 48 hours measurement) values:
 - H area: $2.3 \pm 1.7 \text{ Bq/m}^3$
 - JIF area 1 (Box2): $2.5 \pm 1.4 \text{ Bq/m}^3$
 - JIF area 2 (transport hall): $4.2 \pm 1.9 \text{ Bq/m}^3$
 - JIF area 3 (main lab): $2.5 \pm 1.9 \text{ Bq/m}^3$
- Conclusions:
 - mean values are „practically” the same

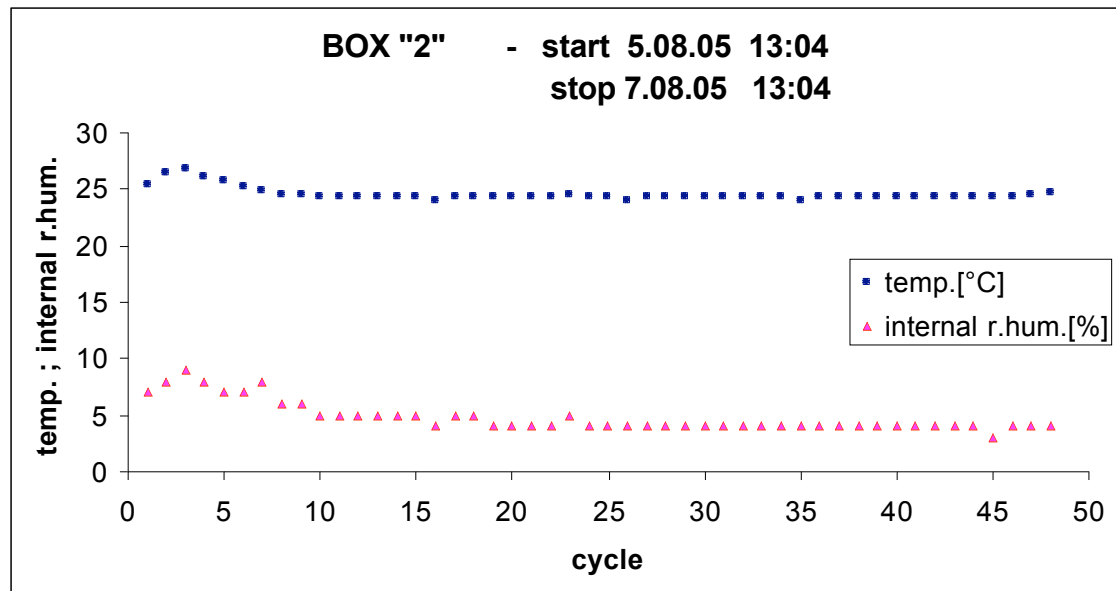
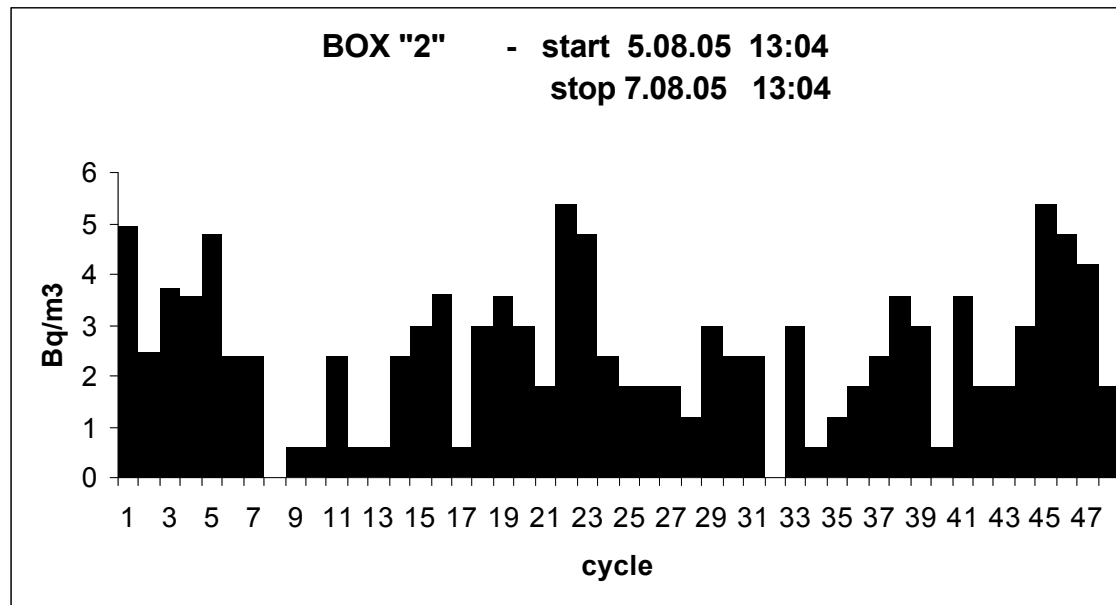
Radon ^{222}Rn measurements in Boulby:

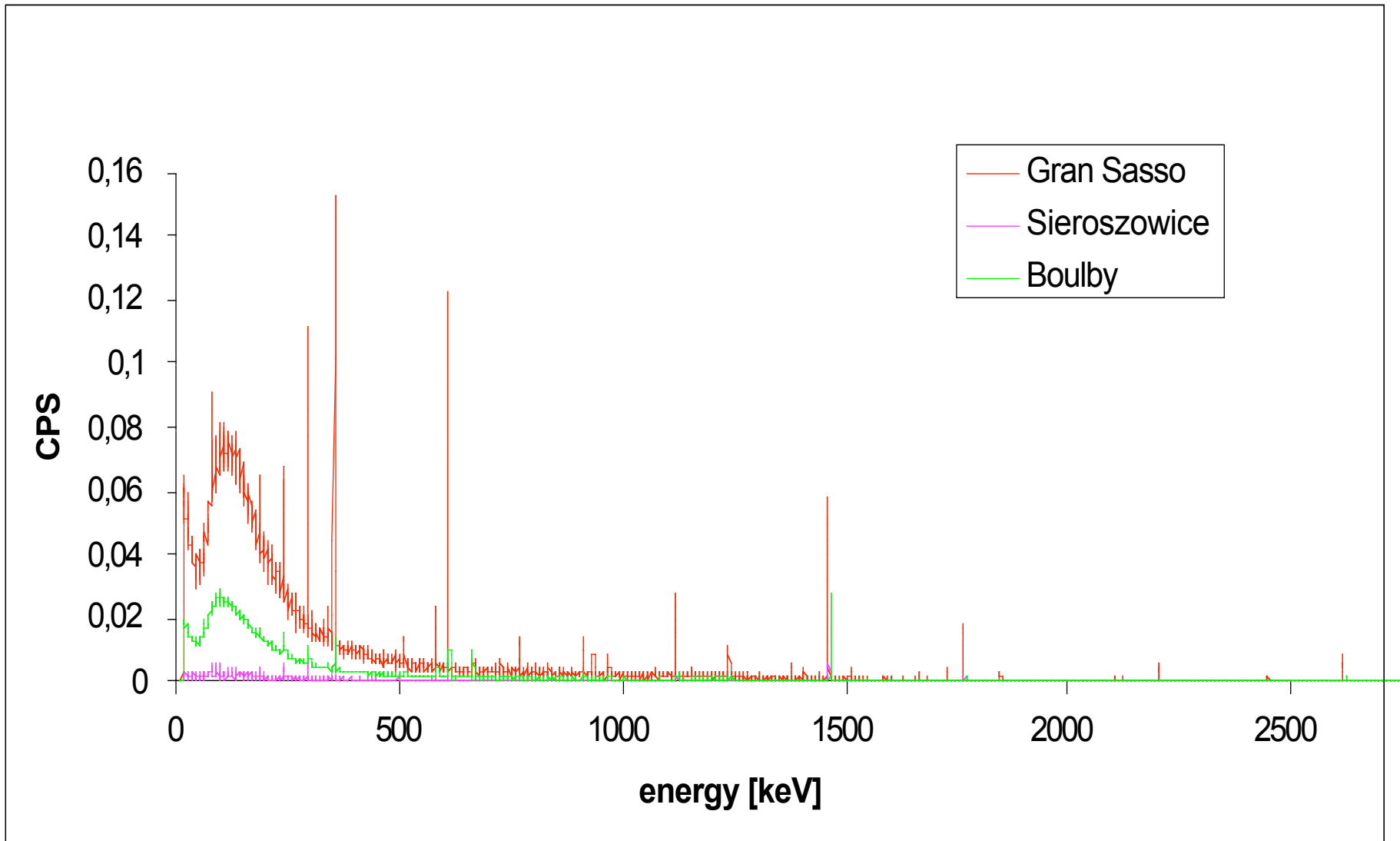
- DurrIDGE RAD7 detector has been used in its sniff mode:
 - looks at the 6MeV alpha particles from the ^{218}Po decay,
 - variations of radon emission has been monitored by using 48-hours protocol, 1 hour intervals,
 - checks of „internal humidity” (detector works correctly if internal humidity < 10%)
 - measurements in 4 points: 3 in JIF area + 1 in H area.

In situ measurements: GS, Boulby and Sieroszowice

	^{226}Ra Bq/kg	^{214}Pb Bq/kg (^{226}Ra)	^{214}Bi Bq/kg (^{226}Ra)	^{212}Pb Bq/kg (^{232}Th)	^{228}Ac Bq/kg (^{232}Th)	^{40}K Bq/kg
Gran Sasso	35 ± 3	32 ± 1	29 ± 1	7.9 ± 0.2	7.2 ± 0.5	94 ± 1
Boulby	< 8	5.3 ± 1.8	4.5 ± 1.2	2.1 ± 0.2	2.6 ± 0.8	89.8 ± 1.3
Sieroszowice	< 8	4.2 ± 2.3	2.5 ± 0.9	0.8 ± 0.4	0.7 ± 0.3	9.2 ± 1.7

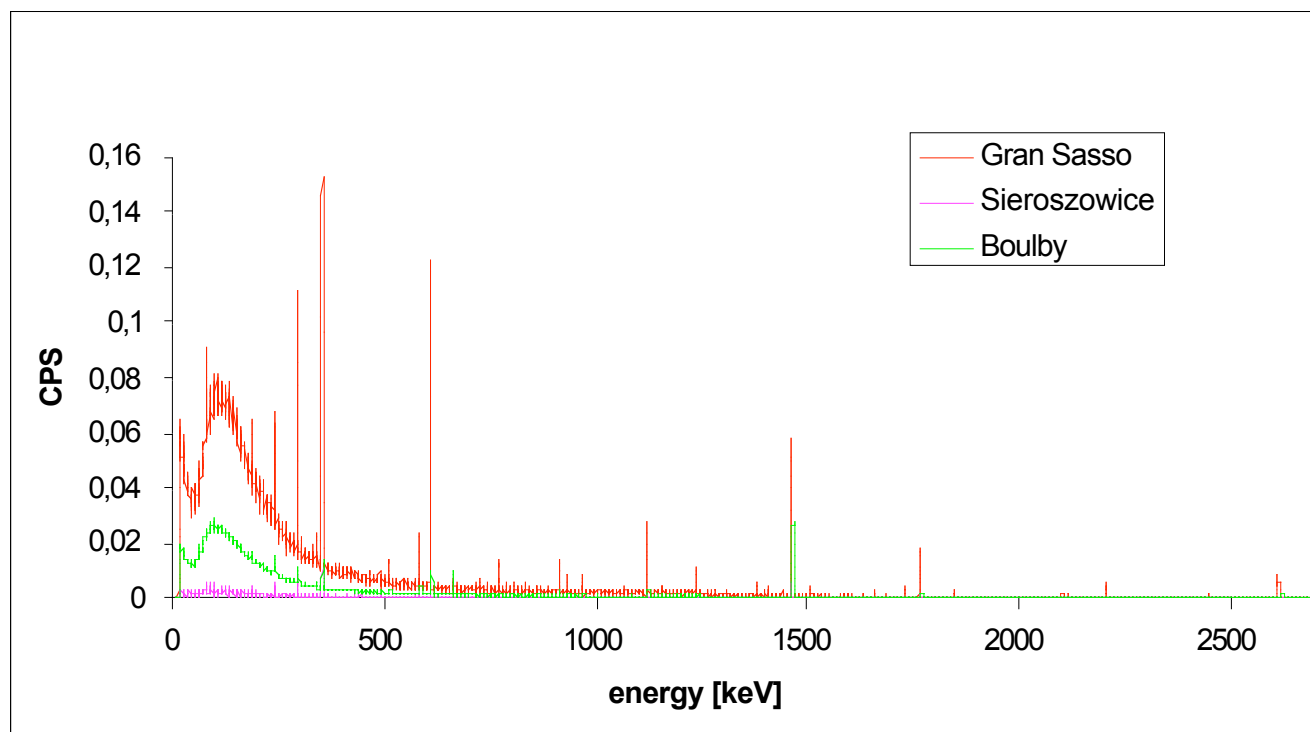
Radon measurements: Boulby 2005





Net Count Rate [cps] – in situ measurements

	Peak	Peak	Peak
	Bi214-609 keV (Ra226)	Ac228-911 keV (Th232)	K40 - 1460 keV
Gran Sasso	0.487 ± 0.002	0.048 ± 0.003	0.268 ± 0.002
Boulby	0.068 ± 0.002	0.016 ± 0.001	0.262 ± 0.002
Sieroszowice	0.038 ± 0.003	0.006 ± 0.001	0.020 ± 0.003



**In situ measurements: GS, Boulby, Sieroszowice
Integral background counting rates**

Energy [keV]	Gran Sasso	Boulby	Sieroszowice
50-2700	57.68 (0.05)	17.00 (0.01)	2.30 (0.02)

Wyniki z pomiarów in situ

	²²⁶ Ra	²¹⁴ Pb	²¹⁴ Bi	²¹² Pb	²²⁸ Ac	⁴⁰ K
	Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg	Bq/kg
Boulby						
Hala B	35 ± 3	32 ± 1	29 ± 1	7.9 ± 0.2	7.2 ± 0.5	94 ± 1
Sieroszowice	< 8	4.2 ± 2.3	2.5 ± 0.9	0.8 ± 0.4	0.7 ± 0.3	9.2 ± 1.7

Integral background counting rates

Energia [keV]	Gran S. h. cz. I	Gran S. h. cz. II	Siero-szowice	Boulby
40-2700	49.80	52.20	2.02	0.0
40-630	43.27	45.22	1.69	0.0
630-700	0.67	0.68	0.03	0.0
700-2700	5.85	6.10	0.30	0.0