LOW-LEVEL COINCIDENCE-ANTICOINCIDENCE GAMMA-RAY SPECTROMETRY

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Single detector low level counting spectrometry

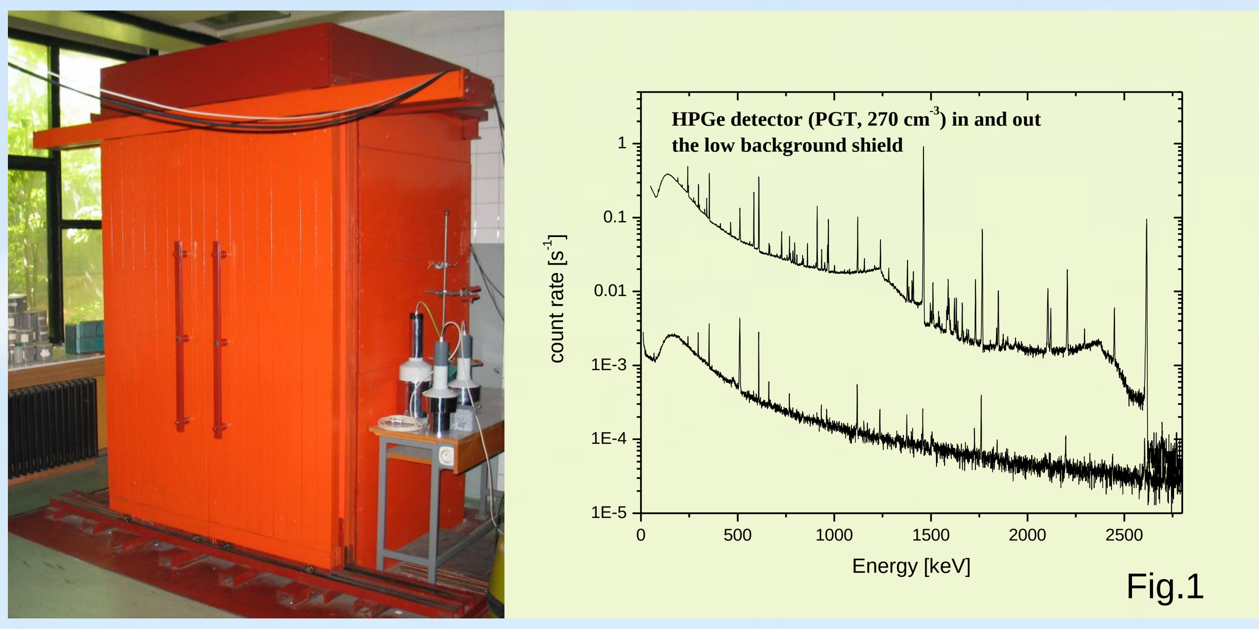


Fig.1

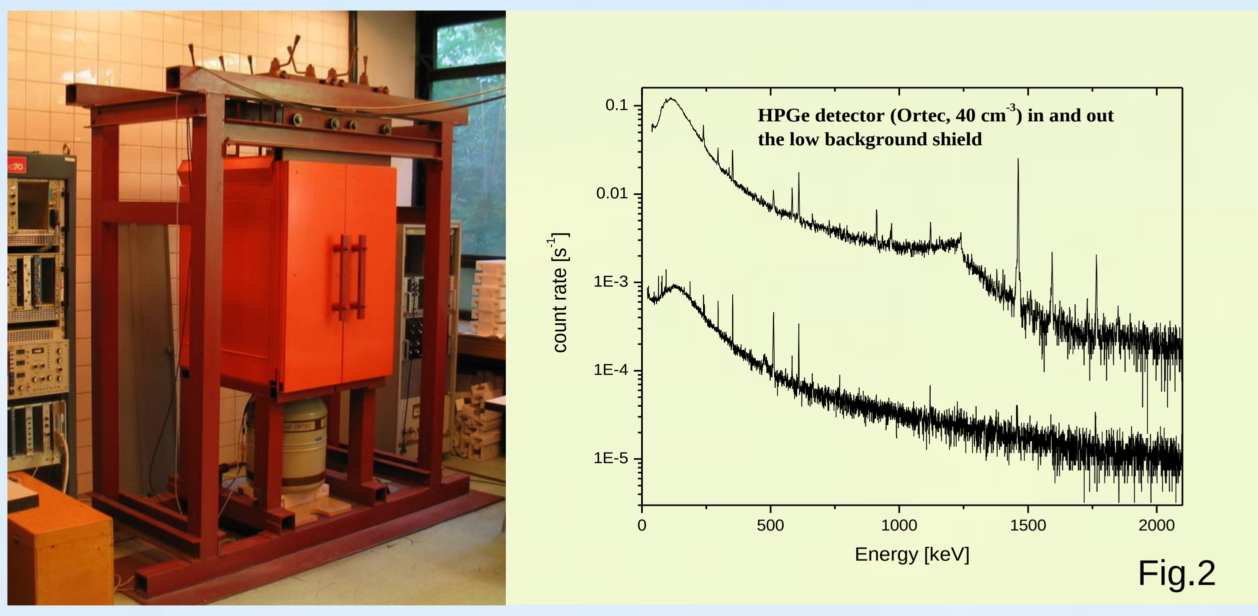


Fig.2

Single detector gamma ray spectra in and out the large (fig.1) and smaller (fig.2) low background shields

Many application required background radiation reduction. Background consist of hard and soft component of cosmic radiation and radiation of radionuclides around and inside the detector. Low level background shield with single detector arrangement enables to reduce contribution of soft component of cosmic radiation and partially contribution of radiation of surroundig radionuclides. Composition of layers of our shield is on fig.4. Big problem in large inner volume shield is the concentration of the radon and its daughters and their time variation. Also ^{40}K and ^{137}Cs from Chernobyl accident significantly contribute to background level. Typical application which need of low level backgroud is the measurement of atmospheric aerosols radioactivity, especially ^{137}Cs concentration in aerosols, which in present achieved very low level of $\mu Bq/m^3$ (fig. 3)

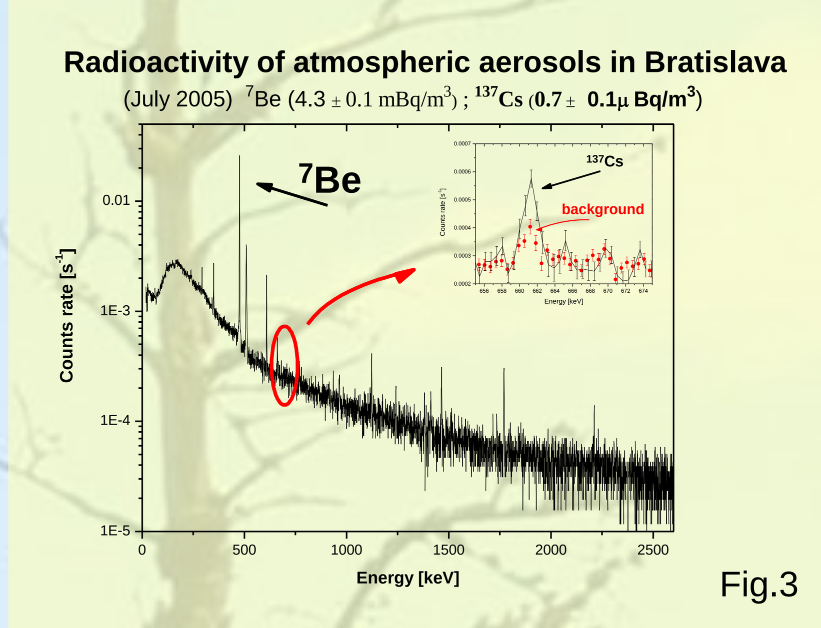


Fig.3

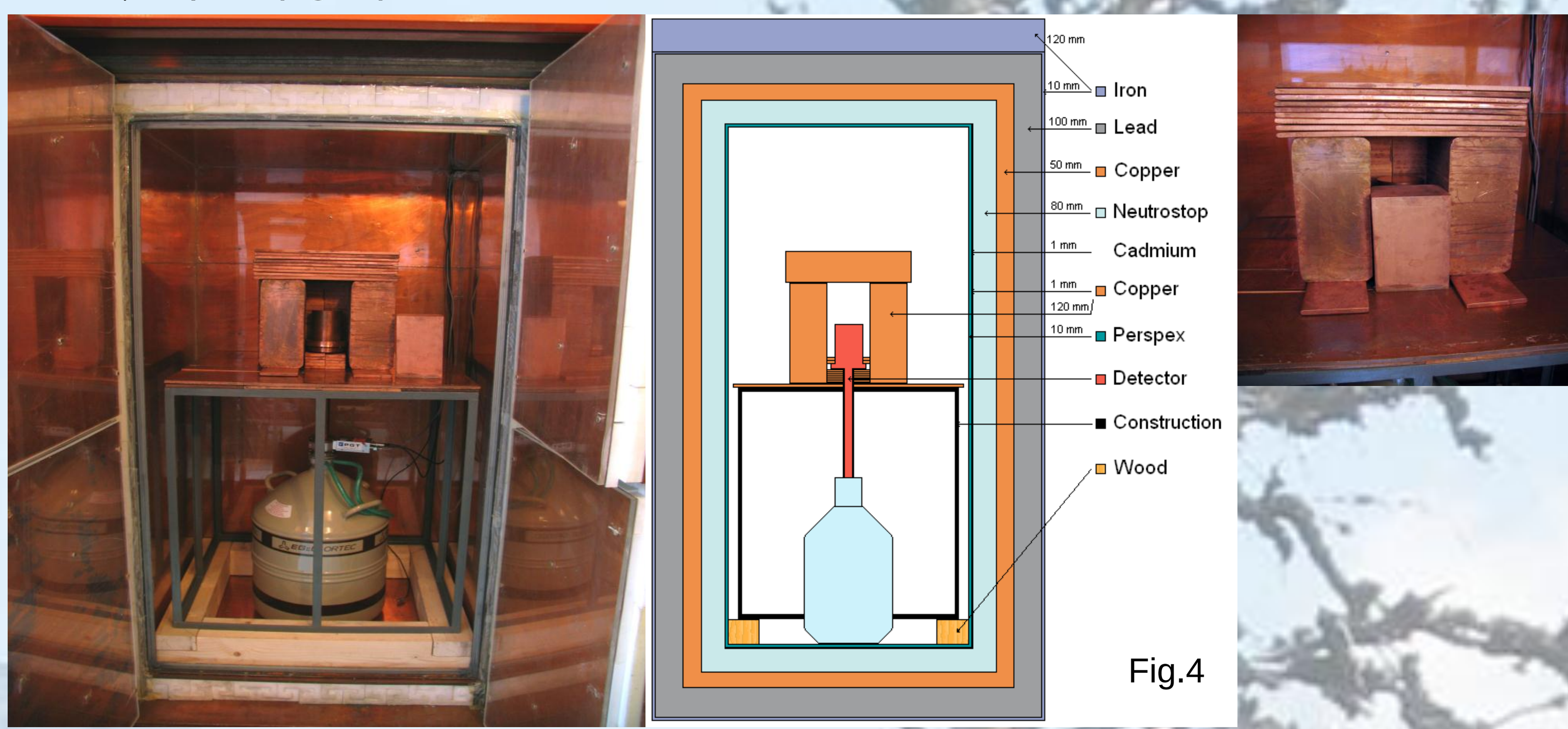


Fig.4

Radon problem in large inner volume low background shields

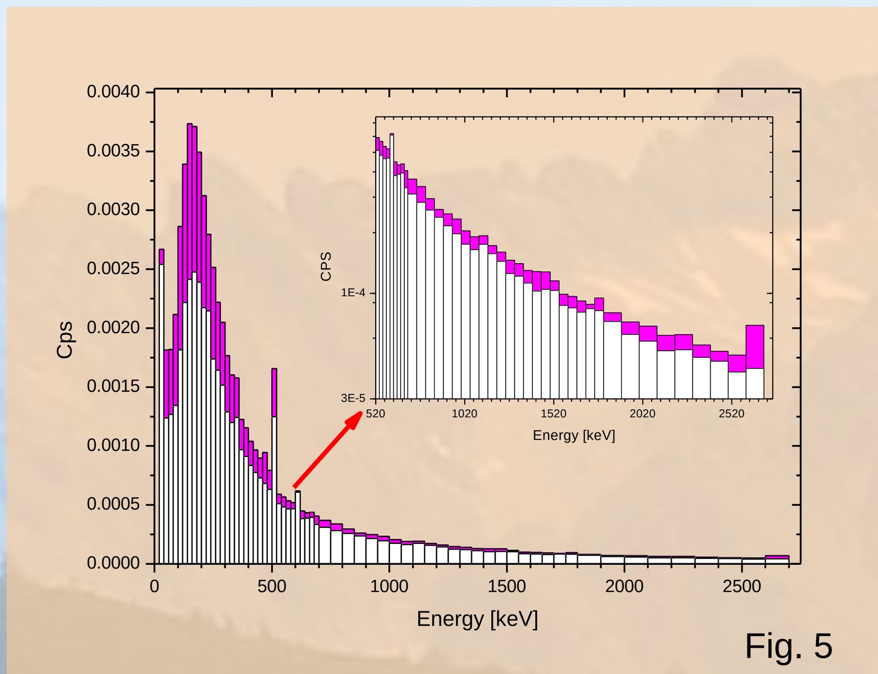


Fig. 5

Fig. 5 Comparison of level of background of HPGe detector (PGT, 270cm^3) inside the large shield without radon and its daughters reduction (violet color) and background level inside the Cu shield (fig.4) in large shield

Time variation of radon concentration in air may cause changing in background level in large inner volume low level background shield during the long time measurements. We tray two ways to eliminate radon (fig. 6) – 1. the inner volume of the shield was hermetically closed by the perspex plate with the sleeve for sample changing. The LN from the Dewar container was evaporated into closed inner volume.

– 2. around the HPGe detector was build the small shield from bricks from electrolyticall copper and so the volume of air around the detector was reduced.

The effect of this both solutions can bee see on fig. 6

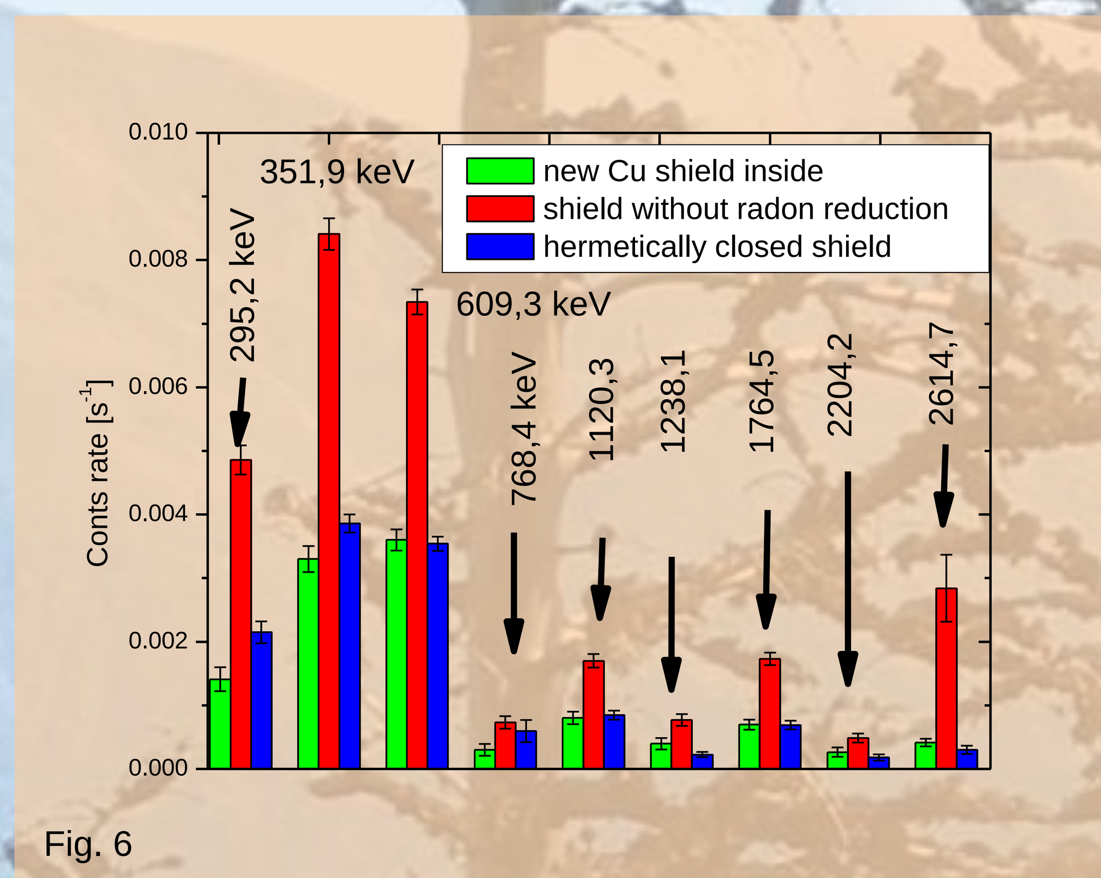
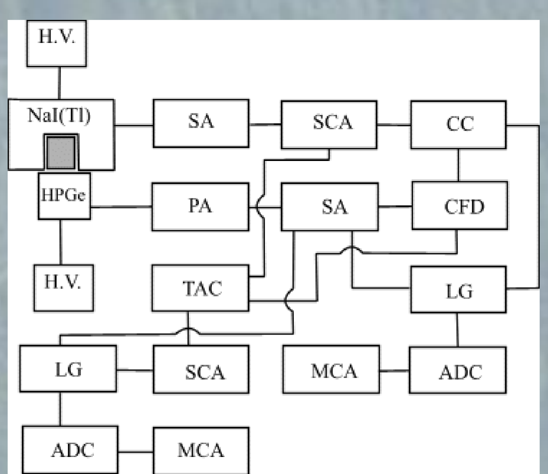


Fig. 6

Comparison of suppression of main radon daughters gama peaks in background of HPGe detector (PGT) in large inner volume shield, red colour – shield closed, but not hermetically, radon has free access to the shield from ouside, blue colour – shied hermetically closed, LN from Dewar container has been evaporated into shield volume, green colour – level of radon daughters inside the new Cu shield in the large shield (fig. 4)

Coincidence HPGe – NaI(Tl) spectrometry



The background reduction in ground surface laboratory is limited by level of cosmic radiation. Possibility to background reduction is using the coincidence or anticoincidence arrangement of detectors. Coincidence HPGe-NaI(Tl) spectrometer was used for determination of presence of ^{60}Co (with two cascade gamma lines 1173.2 keV and 1332.5keV) in IAEA marine fish flesh samples (fig.8 and tab.1,2)

Fig. 7 Schematic diagram of electronic circuits of coincidence spectrometer H.V. – high voltage power supply, SA –spectroscopic amplifier, SCA – single channel analyser, PA – preamplifier, CC – coincidence circuit, CFD – constant fraction discriminator, TAC – time to amplitude converter, LG - linear gate, ADC – analog to digital converter, MCA – multichannel analyser

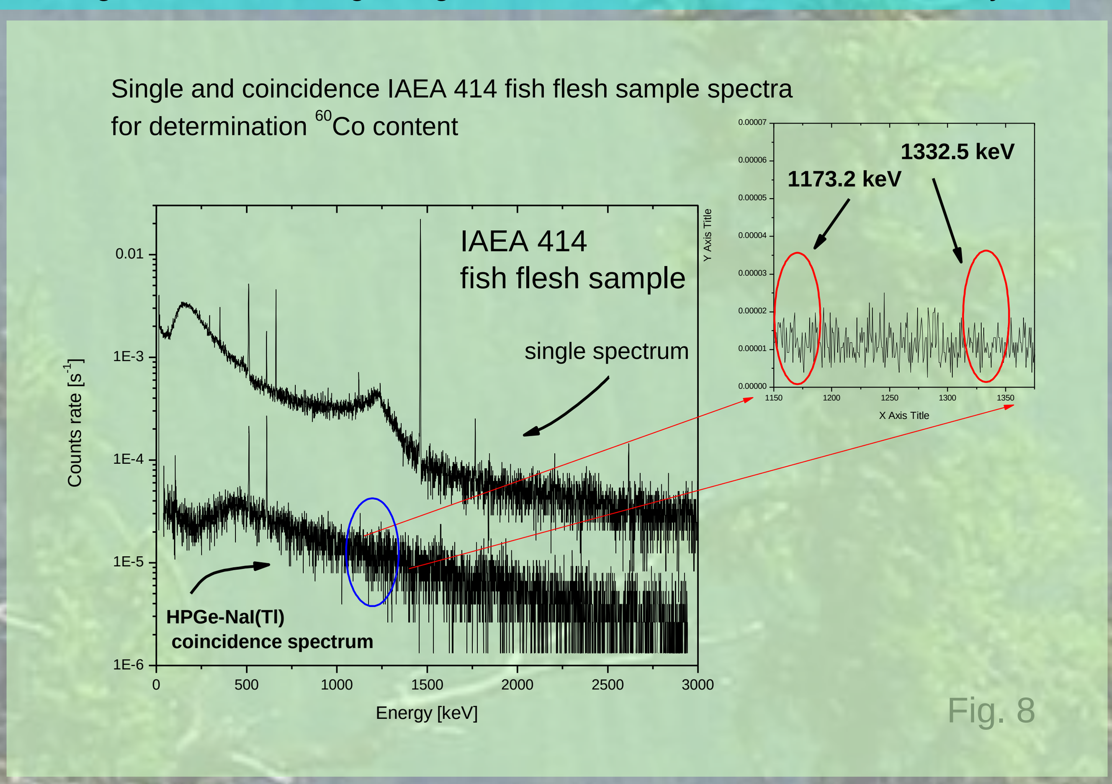


Fig. 8

Sample of single gamma ray spectrum of marine fish flesh measured for presence of ^{60}Co contamination in low background shield and coincidence spectrum of the same sample

Measurement of ^{60}Co in IAEA fish flesh samples

Tab 1. Measurements in single detector geometry

	IAEA 414 2002/554	IAEA 414 2002/587	IAEA 414 2002/598	IAEA 414 2002/609	HPGe background in IAEA geometry [Bq/kg]	single HPGe background [s^{-1}]
^{137}Cs [Bq/kg]	5.26 ± 0.38	5.20 ± 0.41	4.84 ± 0.35	5.00 ± 0.39	0.345 ± 0.025	0.0006 ± 2.2%
^{40}K [Bq/kg]	550.2 ± 34.1	552.6 ± 38.5	373.2 ± 25.7	556.9 ± 39.5	6.35 ± 0.45	8.06E-4 ± 9.5%
^{60}Co [Bq/kg]	< 0.25	<0.40	< 0.31	< 0.38	< 0.13	< 1.6E-4

Tab. 2 Measurements with coincidence HPGe-NaI(Tl) spectrometer

	^{60}Co [Bq/kg] Coincidence with NaI(Tl) 10x10 cm	^{60}Co [Bq/kg] Coincidence with NaI(Tl) 20x20 cm well	Time of measurement [min.]
IAEA 414 2002/609	< 0.19 (14091 min.)	< 0.16	10005
IAEA 414 2002/554	-	< 0.11	21478
IAEA 414 2002/587	-	< 0.22	5414
IAEA 414 2002/598	-	< 0.16	9375