COMPARISSON OF USING THE PROPORTIONAL AND SCINTILLATION DETECTORS FOR MEASURING OF GAMMA RADIATION IN ENVIRONMENT

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Abstract. An analysis of particular possible contributions of the background in the environment for gamma radiation measuring is made in the paper. There are compared the fundamental facilities of scintillation and proportional detectors and their expediency for measuring in the environment. Comparative measuring for ratio signal/noise for scintillation and proportional detector are made in the next part. Theoretical comparisons of possibilities of using with ionization chambers, but without experiment are made in conclusion, too.

Keywords: scintillation detectors, proportional detectors, background components, gamma radiation measuring, detector efficiency

1 Introduction

At various manufacturing action and converting technologies in nuclear research, power engineering and in health service can come to increasing radiation level of the natural background, or escape of artificial radionuclides. At the environment state control it is necessary to make an analysis of the impact of the natural background on the measuring of the possible escape of the artificial radionuclides. An analysis of the contribution of particular background effects at the measuring of dose rate equivalent of the gamma radiation is made.

At the measuring in the natural environment it is necessary to choose properly the measuring detector outgoing from experience with long-term measuring. Concurrently the detector properties as the sensitivity, stability, temperature dependence, etc should be taken into account. Results of the long-term measurements with proportional detectors are presented at the beginning. In the further part the properties of proportional detectors with scintillation detectors from the point of view sensitivity, efficiency ratio signal noise to background are compared. Comparisons and feasibility of using the scintillation and proportional detectors for various situations are made in conclusion.

2 Long-term continual measurements with proportional detector

Long-term continual measurements of dose rate equivalent for the natural background of the gamma radiation are shown as follows. The contributions of particular causes of the natural gamma background fluctuations were assessed. The measurements were made with precisely calibrated sound in its all measuring range, for dose rate equivalent H*(10).

Spatial dose equivalent t H(10) or H* in a definite point is a dose equivalent, which would be induced by a corresponding arranged and expanded field in depth d = 10 mm in standard sphere with radius directed against the direction of field configuration. Dosimetry apparatus with isotropic response and calibrated in units H* will measure correct, when the field will be* *enough uniformed in the ranges of apparatus detection volume and when the apparatus will made so that in its response will included the contribution of dependence on energy of particles from backscatter (standard sphere, body) and attenuation in layer d = 10 mm.*

The requirement for sound choice with necessary sensitivity follows from the measured results. Particular effects of various contributions of natural backgrounds are analyzed.

The dose rate equivalent for most regions in all continents from the gamma radiation is usually in the range 70 – 130 $nSv.h^{-1}$ [1]. About 80% – 90% of this radiation creates the terrestrial component, 10 – 15% the cosmic component and about 2 – 3% comes from the air. The terrestrial component is created basically by these 4 primordial radionuclides ^{40}K, ^{87}Rb, ^{226}Ra, ^{232}Th and natural uranium.

Cosmic radiation is created by high energetic mions and their secondary particles photons, which are accurately detectable in the field atmosphere ground. The artificial radioactivity, caused by man, has under normal conditions no significant contribution to enhancement of the natural background of the gamma radiation.

The natural background measurements of the gamma radiation were made by sound with very wide measuring range and low detection threshold. The intelligent sound RS 03 [2] is displayed on the figure 1.

Fig. 1. Intelligent sonde RS 03/232

Measured value:	H*(10) (Sv.h^{-1}) – dose rate equivalent in depth 10 mm under layer
Measuring range:	From 10 nSv.h^{-1} till 10 Sv.h^{-1}
Relative uncertainty:	< 5% in all measuring range
Energetic dependence:	±20%, 70 – 1500 keV for ^{137}Cs
Temperature range:	From –30 till +70 °C
Detection efficiency:	4 imp.s^{-1} by 100 nSv.h^{-1}
Gas filling:	Argon, methan
Output signal through interface:	RS-232, or RS-485
Own memory ROM: Detector dimensions:	1200 words (measured data) Φ 60 × 200 mm

Tab. 1 The most important technical data of the sonde RS 03/232 [2]

The whole measuring range from 10 nSv/h up to10 Sv/h is covered by only one proportional detector without band switching in the measuring range. The intelligent sound has certificate from the Slovak Metrological Institute in Bratislava.

3 Measuring results and discussion

Analyzing the typical record of dose rate equivalent, we can see measuring results (Fig. 2, [5]), that the background of the radiation level is not constant. It is a one month (November 2006) continual record of the gamma radiation with the above mentioned detector situated on the roof of the Pedagogical faculty building of the Trnava University in Trnava.

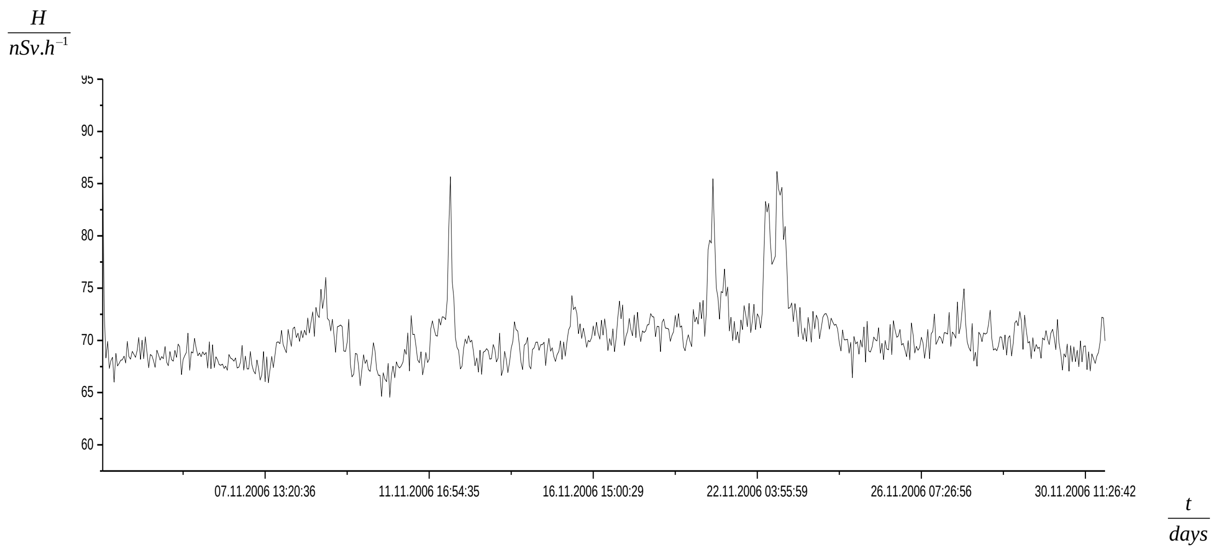

Fig. 2. One month course of dose rate equivalent in November 2006 for one hour measuring interval.

This apparent disturbance is caused by the gamma background radiation. Decisive problem of record evaluation is the identification of artificial radioactivity in the environment. Because of identification of less amount of the gamma radiation, we must make a correct interpretation and explanation of natural fluctuations. Although, we do not know the main mechanisms which influence the level of natural gamma dose rate radiation, we can identify sudden changes of artificial gamma dose rate equivalent contribution with "admissible" detection threshold.

On the basis of the evaluations of the existing measurements it is possible to elaborate a certain instruction of classifying and assessment of the measuring point in order to predict the influence of local specific effects on the measuring the gamma dose rate equivalent [3].

4 Comparison of proportional and scintillation detector properties

The table 2 shows experimental comparison of detection properties of scintillation and proportional detectors. A radioactive etalon ^{60}Co with activity 13,4 kBq was used for comparative measurements. The detector described in more detail in [2] was used as a proportional detector. The standard NaI(Tl) scintillation crystal Φ 100 × 100 mm was used as a scintillation detector. The background value measured by scintillation detector is B_{sc}= 135,6 imp.s^{-1}. The background value measured by proportional detector B_{pr}= 4,0512 imp.s^{-1}.

Adequately long measuring time with sufficient statistics was chosen for measurements with scintillation and proportional detector so that the measuring uncertainty to be in the range 1 to 3%.

D[mm]	ΔE[keV]	1,56	0,56	N/B [imp.s^{-1}]	(N-B)/B	
500	400 – 1600	1,15	0,152			NaI.scint. detector
1000	400 – 1600	156,3	20,7			
500	400 – 1600	6,16	2,1088	1,52	0,52	Proport. detector
1000	400 – 1600	4,6	0,5488	1,.135	0,135	

Tab. 2

D is the distance between detector and cobalt-60 etalon. ΔE is the window energetic breadth with scintillation and proportional detector. N is the total counting rate of the measured impulses, B counting rate of the background impulses.

Table 2 shows, that the scintillation detector has an immensely higher impulse counting rate, so we can measure with better statistics. The ratio of the signal N and useful signal (N-B) to background is for both detector types comparable.

5 Conclusion

The possibility of proportional detector increasing enables increasing the measuring sensitivity (measuring system sensitivity), thereby it is possible to approach to higher sensitivity, to the sensitivity level of scintillation detectors. We have the advantage of better temperature dependence and stability of the proportional detectors. The proportional detectors are more suitable for measuring in the environment because they have no photomultiplier, which is very sensitive about shaking and temperature changes. The scintillation detectors have their foundation and advantage under ideal laboratory conditions. Higher number of detectors means higher recorded impulse count rate, better measuring statistics. At the same time higher number of detectors can be used not only for detection, but for radiation source localisation. The analysis of this possibility and the experimental verification was described in more detail in the paper [4], [5].

In the following we compare impulse counting rate used from our proportional detectors with impulse counting rates from plastic scintillators and anorganic scintillators NaI(Tl) and CsI(Tl).

Plastic scintillators delivered by various producers have volume in the range from 20 to 40 liters. Proportionally with volume growths naturally the counting rate from detector. At the level of the natural background (cca 80 to 100 $nSv.h^{-1}$) the number of impulses on dependence from scintillator volume is in the range 2 000 to 3 000 $imp.s^{-1}$

Anorganic scintillator with dimensions Φ 100 × 150 NaI(Tl), or Cs(Tl) at radiation on the background level gives count rate ~ 1000 $imp.s^{-1}$.

Proportional detector RGM200/sta (1 piece) with volume 5,65 liter with dimensions Φ 60 × 2000 mm at the level of the natural background gives ~ 60 $imp.s^{-1}$. Technical parameters of this detector are quite equivalent with parameters of the intelligent sound RS 03/232 besides the sensitivity, that depends on and is proportional to detector volume. Using 12 pieces of these detectors we get impulse cont rate 720 $imp.s^{-1}$, what is comparable with plastic and anorganic scintillators.

From the long-term measurements we got survey about possible individual sources of contribution to the natural gamma radiation background in the environment. It was made not only qualitative but quantitative analyses of particular contributors and more detailed for gamma background in the paper [5].

The table 1 shows that scintillation detector from measuring statistic point of view is more suitable. When we consider other measuring properties and requirements we can state that the proportional detector with respect to its stability, temperature dependence, shaking resistance is more suitable for measuring in the natural environment outside laboratory conditions. Also the scintillator detectors can be used successfully for short-time measurements outside the laboratory. According to the measurement in the natural environment we must choose the detector selection. In most cases of natural background measurements proportional detector seems to be more suitable with respect to stability, temperature dependence and reliability. A quality proportional detector with its parameters approaches significantly to parameters of ionization chamber and what concerning to the price for commercial purposes it is significantly more advantageous.

We can see that from existing long-term experience with proportional detector in the environment that in future it is necessary to be engaged more deeply in effect (radon daugther products wash-out effect). It is expected, that information will be interesting about rain influence on the shape and size of fluctuation peaks. We shall have to search relations among rain duration, intensity and shape, size, with symmetry, slope, fall of peak fluctuation. It will be interesting and useful to make an analysis of measuring time influence (time sampler) on the run of time dependence (mainly peaks) of dose rate equivalent.

References

[1] HÚŠŤAVA, Š. Analýza a meranie jednotlivých zložiek pozadia prírodného žiarenia gama. In. *Acta Facultatis Paedagogicae Universitatis Tyrnaviensys, Séria C, Trnava* 2001 ISBN 80-89074-11-1, str. 43 – 47.

[2] *MANUAL OF COMPANY BITT TECHNOLOGY GMBH FOR GAMMA METER RS 03/X*, Wiener Strasse 70, A-2104 Spillern, Austria, 2009.

[3] HÚŠŤAVA, Š. Dlhodobé kontinuálne pozorovanie príkonu dávkového ekvivalentu prírodného pozadia žiarenia gama, In. *Konferencia* 9*. Banskoštiavnické dni 2007, Súčasné úlohy Environmentalistiky a Rádioenvironmentalistiky*, Banská Štiavnica 2007, ISBN 978-80-228-1786-8, str. 112 – 117.

[4] HÚŠŤAVA, Š., HALADA, L. Využitie veľkoobjemových proporcionálnych detektorov na detekciu zdrojov žiarenia gama. In. *6. Banskoštiavnické dni 2004*, *Súčasné úlohy Environmentalistiky a Rádioenvironmentalistiky 6. – 8. 10. 2004*, Banská Štiavnica str. 55 – 61. ISSN 1336-300X.

[5] HÚŠŤAVA, Š., HALADA, L. : Monitoring of Radioactivity in Environment by Proportional Detector RS 03, The Natural Radiation Environment 8th International Symposium (NRE VIII) Buzios, Rio de Janiero, Brazil 7. – 12. October 2007 , AIP Conference Proceedings issued by American Institut of Physics Melwille, New York, 2008, p. 138-143, ISBN 978-0-7354-0559-2, ISSN 0094-243X.