The prospects of creation of well-type xenon gamma-ray spectrometer

2016 J. Phys.: Conf. Ser. 675 042039

(http://iopscience.iop.org/1742-6596/675/4/042039)

The prospects of creation of well-type xenon gamma-ray spectrometer

D Petrenko, Z Uteshev, A Novikov, A Shustov, K Vlasik, I Chernysheva, M Smirnova, K Krivova, V Dmitrenko and S Ulin
National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe highway 31, Moscow, 115409, Russia

E-mail: denis.petrenko.dp@gmail.com, kfvlasik@mephi.ru, vvdmitrenko@gmail.com, seulin@gmail.com, zmuteshev@mephi.ru

Abstract. Possibility of creation of a well-type gamma detector based on xenon gamma-ray spectrometer was shown. The results of modelling of xenon well-type detectors are presented.

1. Introduction

The development of modern technologies depends on the methods and equipment. One of the modern equipment, which is used as in scientific research and in industry is well-type detector. In this paper we study the possible characteristics of the well-type xenon detector.

2. Results of modelling of xenon well-type detector

To evaluate the possible characteristics of the xenon well-type detector it was simulated using Geant4. The model used to calculate the characteristics of the detector is shown in figure 1.

Figure 1. Model of xenon well-type detector. Model has the following parameters:

- Density of xenon - 0.3 g/cm^3
- The internal diameter - 30 mm
- The external diameter - 150 mm
- Grid length - 102 mm
- Grid diameter - 60 mm

Based on the presented model of the detector the calculated dependence of the efficiency versus gamma rays energy was obtained. The results are shown in figure 2. For comparison, figure 3 shows

the experimental 2 liter high presser xenon detector (HPXe detector) efficiency for a point source at a distance of 20 cm. Experimental points are fitted by function:

$$\eta(E) = \left(a + \frac{b}{E} \right)^{1/2} \quad (1)$$

The comparison shows that theoretically well-type gamma ray xenon detector has higher efficiency than the HPXe detector. This is most pronounced for energies below 100 keV. Comparison of experimental and calculated data by efficiency of HPXe detector was considered in the [1]. The modern 2 liter HPXe detector was described in the [2].

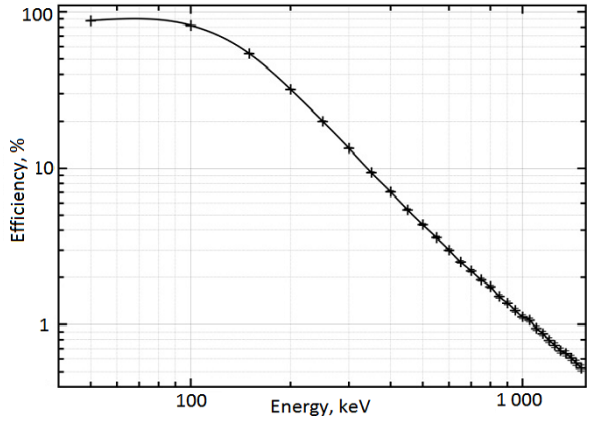

Figure 2. The calculated dependence of the efficiency versus gamma rays energy for xenon well-type detector. Points of calculated dependence are connected by spline curve.

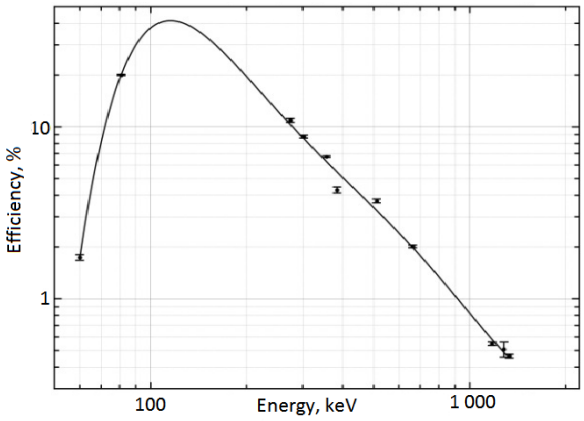

Figure 3. The experimental 2 liter HPXe detector efficiency for a point source at a distance of 20 cm. Solid line is fit of experimental data with equation (1).

Based on the assumption that the energy resolution of the well-type xenon gamma ray detector for energy 662 keV will be 2.5% spectrum for the ^{137}Cs was calculated (see figure 4). For comparison, figure 5 shows the experimental 2 liter HPXe detector spectrum for a point ^{137}Cs source at a distance of 20 cm. The energy resolution of the 2 liter HPXe detector is equal to 2.2% for ^{137}Cs. The spectra of the 2 liter HPXe detector have strongly pronounced peak of the backscatter, which complicates the analysis of the spectra at low energies. The calculated spectra of xenon well-type detector has not strongly pronounced peak of the backscatter.

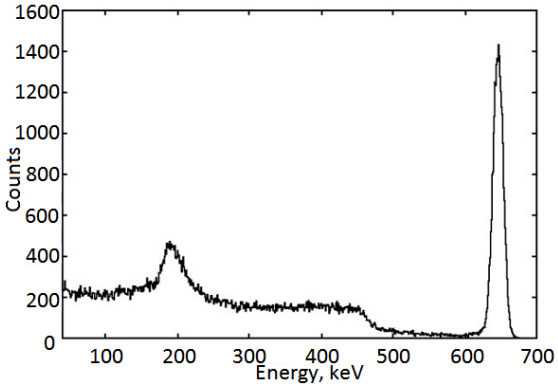

Figure 4. The calculated ^{137}Cs (662 keV) spectrum for well-type xenon detector. Energy resolution (FWHM) is equal to 2.5%.

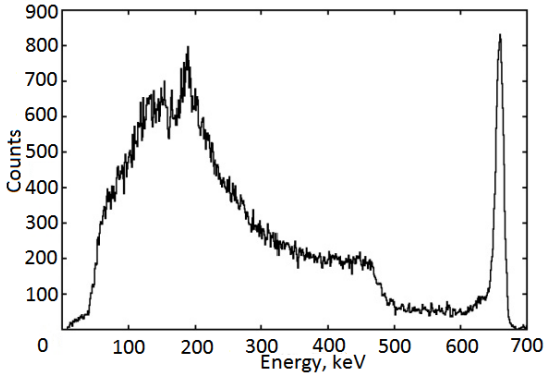

Figure 5. The experimental 2 liter HPXe detector spectrum for a point source ^{137}Cs at a distance of 20 cm. Energy resolution (FWHM) is equal to 2.2%.

3. Conclusion

Modern well-type gamma rays detectors implemented mainly on scintillation crystals and semiconductor devices. Each of these types has fundamental shortcomings. The semiconductor detectors are expensive; at the same time detectors based on scintillation crystals have not good energy resolution for modern application. Today development of low cost well type detector with high energy resolution based on one of these principles of operation is impossible. It can be concluded that it is necessary to develop a detector on different physical principles. Shown results suggest that the well-type xenon gamma ray detector will be able to provide better energy resolution than scintillation detectors at a low manufacturing cost. However, these results need to be verified experimentally.

Acknowledgments

Authors acknowledge partial support from MEPhI Academic Excellence Project (contract № 02.a03.21.0005, 27.08.2013).

References

[1] Veresenko V S A *et al.* 2015 (in Russian) *Proc. Science Session MEPhI-2015* **1** 174 (original Russian title: *Nauchnaya sessiya MEPhI-2015 Sbornik nauchnyh trudov*)
[2] Novikov A *et al.* 2014 New modification of xenon gamma-ray detector with high energy resolution *Opt. Eng.* **53** (2) 021108