Monte Carlo Simulations of Gamma-ray Interactions with Scintillators*

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Gamma-ray spectroscopy is one of the diagnostic tools to study processes in plasma tokamaks. The gamma radiation is emitted during deexcitation of nuclei produced in reactions between, e.g., the plasma and targets like the walls etc. The observed gamma energies for deexcitation of, e.g., ^{10}Be are from 2.5 MeV and ^{10}B from 0.4 MeV. Such radiation could be measured with a scintillator detector. In the experimental spectrum there are peaks corresponding to certain well known reaction channels but there are also peaks of unknown origin. Independently, measurements are made in a well defined geometry with a scintillator and a gamma-ray source. From these measurements the properties of the scintillators are derived: intrinsic energy resolution, non-proportional relationship between the energy of the detected radiation and the light yield, decay time, and efficiency [1]. The measured properties of the scintillators are input parameters to simulations since nothing better than the experimental values are available.

A program based on the Geant4 code [2] was used to simulate the interaction of gamma radiation in a user defined geometry. In particular, the processes of gamma absorption and light generation, observed when a gamma ray is passes through a scintillator, are simulated.

In Fig. 1 the setup used in the simulations is shown.

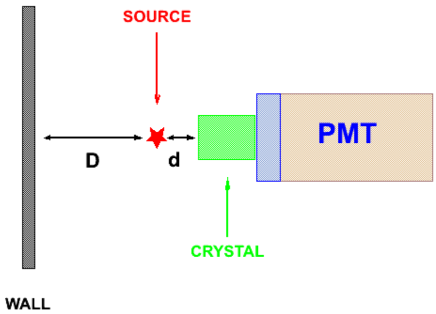

Fig. 1 *Simulation setup, D – distance between the wall and the source, d – between the source and the scintillation crystal.*

The presented simulations were performed for a scintillator made of CsI with dimensions 10×10×5 cm^3 and 10×10×5 mm^3. The point-like ^{137}Cs source with the 4π emission of a 661.7 keV γ-ray was used in the simulations. The measured energy resolution, defined as the full width at half maximum (FWHM) of the Gaussian function with a fit between 600 and 720 keV, equal to 6% was used in the simulations. The ^{137}Cs source was placed on the crystal surface.

In Fig. 2 a comparison of simulations performed for crystals described above is shown. The wall was made of lead and the distance from the wall to the source was equal to 10 cm. The peak-to-Compton ratio depends on the crystal size and for the smaller scintillator is a factor of ~7 larger than for the bigger one.

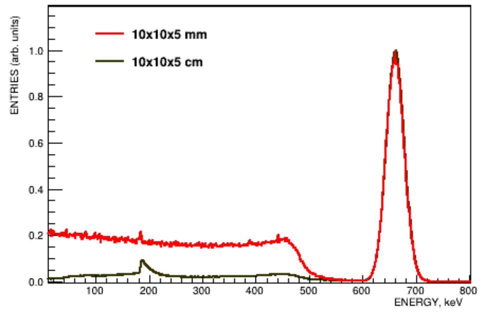

Fig. 2 *Monte Carlo simulated spectra with a ^{137}Cs source for CsI scintillators with dimensions 10×10×5 mm^3 and 10×10×5 cm^3.*

From the simulated spectra shown in Fig. 3, it is concluded that the wall material has only a small influence on the peak-to-Compton ratio.

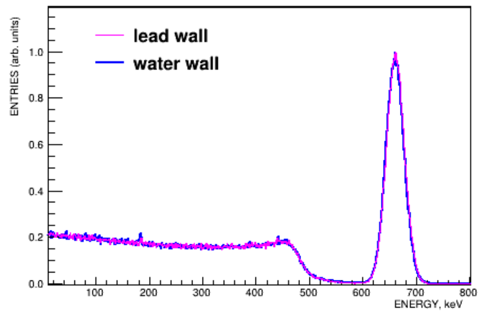

Fig. 3 *Monte Carlo simulated spectra with a ^{137}Cs source for CsI scintillators with dimensions 10×10×5 mm^3 for walls made of lead and water, placed 10 cm from the source.*

References

[1] P. Sibczyński *et al.*, this Annual Report: Characterization of $CeBr_3$ Scintillator in Gamma Spectrometry
[2] GEANT4: NIM A506 (2003) 250-303, IEEE 53 (2006) 270-278, http://geant4.cern.ch

* This work was partially supported by the EURATOM Fusion Project FU07-CT-00061