THE OPTIMIZATION OF TRANSMISSION OF THE INTERNAL CONVERSION ELECTRON SPECTROMETER BY USING THE CST PARTICLE STUDIO CODE*

Ł. Janiak, J. Andrzejewski, J. Perkowski, J. Samorajczyk

Faculty of Physics and Applied Computer Science, University of Lodz
Pomorska 149/153, 90-236 Łódź, Poland

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The impact of different magnetic field configurations on efficiency of internal conversion electron spectrometer was studied. The CST Particle Studio code allows to simulate electron trajectories in a highly inhomogeneous magnetic field produced by set of permanent magnets. It is shown that the suitable selection of permanent magnets can significantly improve electron transmission.

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1. Introduction

The internal conversion electron spectroscopy is complementary to the gamma-ray spectroscopy and both together provide one of the most powerful methods for the nuclear structure studies. The magnetic internal conversion electron spectrometer was designed and constructed at the University of Lodz [1]. The main goal to build this kind of device was to determine multipolarity of excited states of atomic nuclei, especially observation of E0 transitions. Furthermore, this spectrometer is an ideal instrument for comprehensive study of K-isomers states. The future plan of our group is to perform investigation of multipolarity of short lived states above isomeric state. Thus, improvement of characteristics of the spectrometer is required.

2. Electron spectrometer

The spectrometer combines two magnetic fields for separation and transportation of electrons from the target positions to the silicon detector. The

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transportation field is produced by a set of permanent magnets in a form of coaxial rings. The separation of electrons from positrons is possible by using permanent magnets of quasi-mini-orange form [1]. The electron spectrometer was equipped in the new 12-segmented Si(Li) detector manufactured by Dr. W. Czarnacki and his team at the National Centre for Nuclear Research. Active total area of new detector is equal to about 60 cm^2. Detectors were cooled by Peltier modules arranged in two levels. Owing this solution, 1% of energy resolution for 1 MeV electron is achieved.

During the "in-beam" experiments, the gamma and X-ray fluxes were suppressed by a lead absorber inserted between the detector and the target. The mechanical design of the spectrometer allows it to combine with multi-detector gamma-ray spectrometer EAGLE at the Heavy Ion Laboratory of the Warsaw University. The scheme of the internal conversion electron spectrometer is shown in Fig. 1. Several valuable results have been obtained using this spectrometer. For example, some transitions and multipolarities were determined for the first time [1, 2, 3].

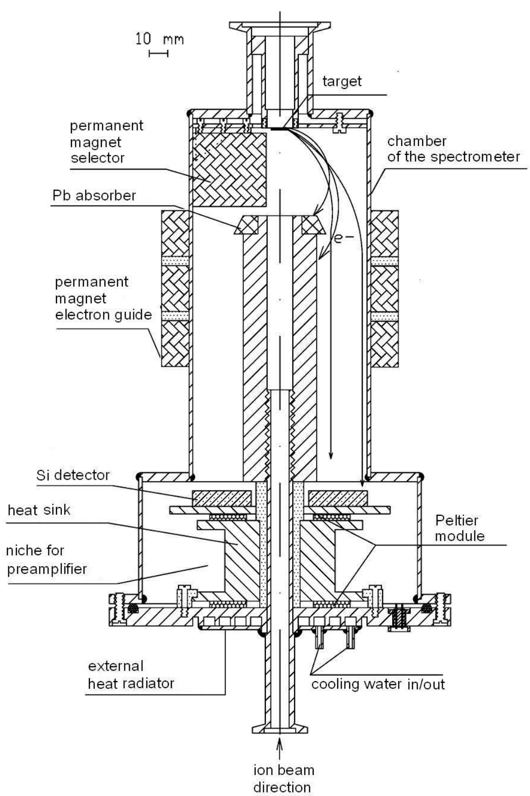
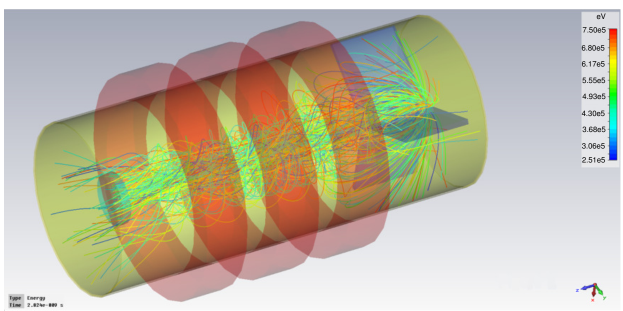


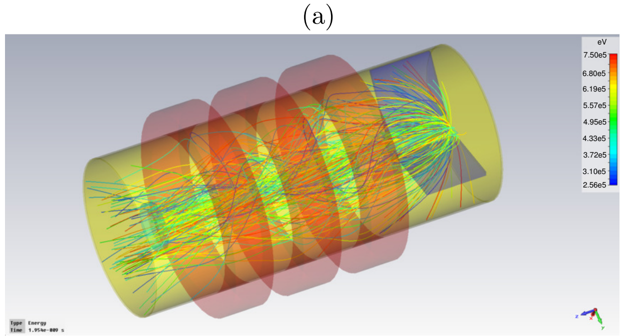
Fig. 1. A schematic drawing of the internal conversion electron spectrometer.

3. Simulations

The main goal for optimizing the parameters of this spectrometer was to improve its transmission and eliminate delta electrons and positrons. For this purpose, the magnetic field and trajectories were simulated using the CST Particle Studio software [4]. This code is a special tool for the fast and accurate analysis of charged particle dynamics in 3D electromagnetic fields. Furthermore, CST make possible observation of electron trajectories. The results of simulations of the electron trajectories in the old configuration and the new (best) configuration selected from many simulations are presented in Fig. 2 (a) and 2 (b) respectively. The position of magnets is shown as shadow. The electrons with different energies are labelled with a colour palette. The trajectories of electrons in the old magnetic configuration are close to the centre of the spectrometer and thus they can easily hit the aluminium tube located there (see Fig. 1 and 2 (a)). The Fig. 2 (b) shows that for new configuration of magnetic fields many more electrons can reach detector. The simulations were performed to maximize the electron transmission, firstly by using different materials for the transporting mag-



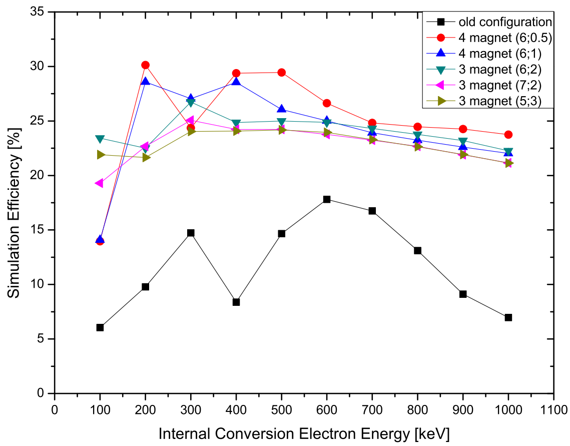
(a)



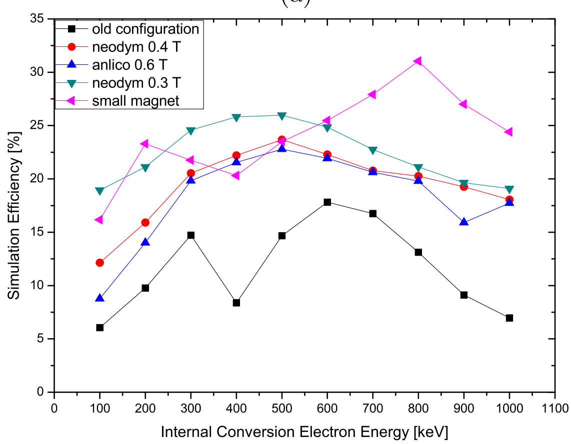
(b)

Fig. 2. Simulated trajectories of electrons (a) old configuration of the spectrometer (many electrons hit ion pipe) (b) new configuration (a lot more electrons reach the detector).

nets. The materials differ from each other mainly by a magnetic induction. The influence of magnetic material species on efficiency of the spectrometer is presented in Fig. 3 (a). Secondly, the simulations were performed also to optimize transmission on geometry of the transporting magnets. The results received from these simulations are presented in Fig. 3 (b). The numbers in brackets show the distance between the transporting magnets and the target (the source of electrons) and the gap between each magnet ring, respectively.



(a)



(b)

Fig. 3. Simulations of the efficiency as a function of energy (a) for the different magnetic induction of transporting magnets (b) for different geometry of the transporting magnets.

Figure 4 shows comparison of simulation results for the old configuration of the magnetic field of the spectrometer, with the experimental values for various settings of magnets for electrons of 976 keV energy. The CST code allowed us to simulate transmission between the source (target) and position of the detector without taking into account response from the detector. In such situation a significant difference for efficiency between simulation and experiment, apparent from effects such as backscattering or thickness of the entrance window detector.

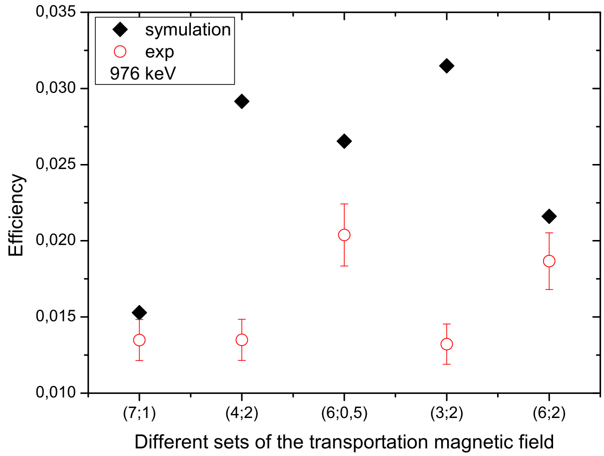


Fig. 4. Comparison the results of simulation for the old configuration with experimental values for the different settings of transportation magnets for electrons of 976 keV energy.

4. Conclusion

The simulations clearly show that changing of the arrangement of the transporting permanent magnets induce considerable improvement of the spectrometer efficiency, as shown in Fig. 3 (a). Thus it is possible to determine multipolarity of excited states observed with low intensity as well as K-isomer populated with a small cross section.

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