Atomic Radiations in Nuclear Decay

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When an atom is ionized by removing an electron from an inner atomic shell, the residual atom is in an excited state. Relaxation back to the ground state occurs rapidly via radiative and non-radiative processes. Radiative processes are those involving the emission of characteristic X-rays. Non-radiative processes, often referred to as Auger processes, result in the emission of Auger, Coster-Kronig (CK), and super-CK electrons. The full relaxation is a multi-step process. The so called *"vacancy cascade"* treatment in electronic rearrangement was first introduced in 1967 by Krause and Carlson [1] and produced a good agreement between theoretical and experimental results for charge distribution resulting from irradiation of krypton by Mo K X-rays.

Electron capture and internal conversion emission are the two nuclear processes resulting atomic vacancies. While the energy of the atomic radiations is a small fraction of the energy released in nuclear decay, due to their high energy deposit along their tracks, low energy Auger electrons have the potential to be used for targeted tumor therapy [2]. While significant advances were made in the last 4 decades in the radiation therapy using ionizing radiations, the use of Auger electrons in the clinical practice is still a long-standing research goal. The accurate knowledge of the Auger electron yields is far from complete. The urgent requirement to improve our knowledge has been highlighted recently by the International Nuclear Data Committee (INDC) operated under the auspices of the International Atomic Energy Agency (IAEA) [3].

In this paper we present a new Monte Carlo model based on sophisticated nuclear and atomic physics computations to treat the relaxation process involving all atomic shells and the influence of multiple vacancies created in the propagation of the atomic vacancies.

[1] M. Krause and T. Carlson, Phys. Rev. **158** (1967) 18.
[2] F. Buchegger, et al., Eur. J. of Nuclear Medicine and Molecular Imaging **33** (2006) 1352.
[3] A.L. Nichols *et al.*, *Summary Report Technical Meeting on Intermediate-term Nuclear Data Needs for Medical Applications: Cross Sections and Decay Data*, IAEA Nuclear Data Section (2011), INDC(NDS)-0596.