Auger electrons emitted from metallic nanoparticles under proton irradiation*

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The goal of radiation therapy is to deliver the maximum possible effective dose to the tumour while sparing the surrounding healthy tissue. Metallic nanoparticles (NPs) are of recent scientific interest as they might help to enhance the effective dose ration between tumour tissue and healthy tissue. Metallic NPs accumulate preferably in tumour tissue and high Z (Z: atomic number) materials provide a promising source for many low-energy electrons. For high Z materials, the emission of Auger electron cascades is a possible decay channel after irradiation. For one primary ionization event it is therefore likely that a large amount of electrons is emitted. Electrons with energies below 100 eV have short ranges and can lead to high localized damage, thus enhancing the effectiveness of the dose.

The GSI track structure Monte Carlo (MC) code TRAX [1, 2, 3, 4], whose main purpose is to properly describe creation and transport of low-energy electrons, has been further extended to allow the description of Auger electron cascades. Furthermore, cross sections have been assessed to properly describe electron creation and transport in metallic materials like gold, silver, platinum, gadolinium and iron. With these cross sections, including electron energies down to a few electron Volts, it is possible to calculate the paths of electrons on the nanometer scale. Electrons inside and outside metallic nanoparticles can be analyzed.

Calculations have been performed for 80 MeV proton projectiles and nanoparticles with a radius of 22 nm. It has been observed, that for NPs consisting of atomic Pt and Au, the number of emitted Auger electrons and cascades is much higher than for Gd. Spectra of emitted Auger electrons show, that a large number of Auger electrons with energies below 100 eV are emitted for Pt and Au. For Pt and Au, the absolute Auger electron yields are higher than for Gd and Auger electrons from different transitions can be observed. For Gd, almost all emitted Auger electrons have an energy of around 150 eV.

More details on these calculations and the resulting local dose in the surrounding tissue can be found in [4].

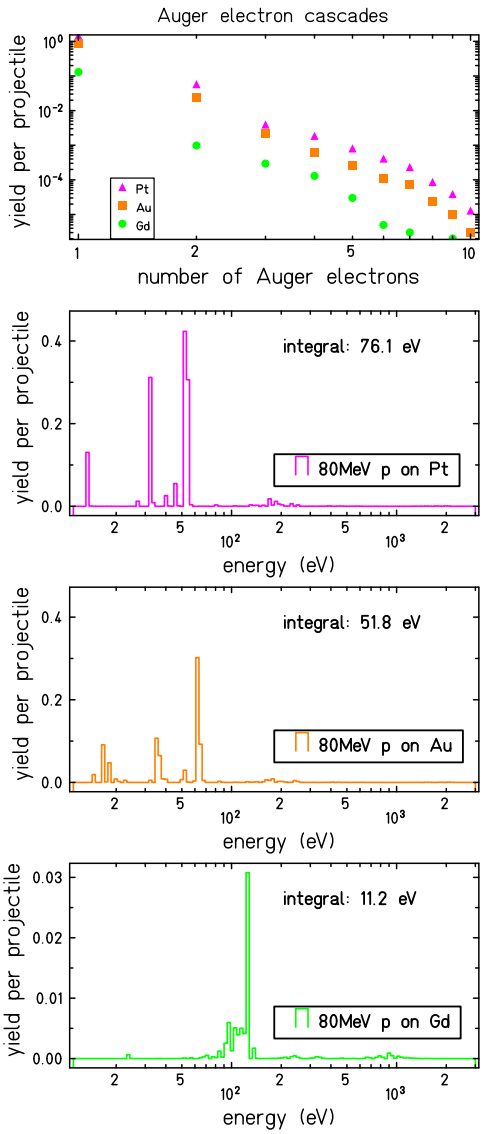

Figure 1: Comparison of Auger electron cascade distributions for Pt, Au and Gd (top panel) for 80 MeV protons incident on NPs with a radius of 22 nm. Below: spectra of Auger electrons created inside NPs made out of Pt, Au or Gd (from second to bottom panel).

References

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