Modeling and experimental validation of radiation-cell interaction in radiotherapy by photon activation of gold nanoparticles

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Rachel Delorme[1], Mathieu Agelou[1], Hélène Elleaume[2], Christophe Champion[3]

1 CEA,LIST, Laboratoire de Modélisation, Simulation et Systèmes, F-91191 Gif-sur-Yvette cedex
2 INSERM U836, European Synchroton Radiation Facility (ESRF), ID17 Grenoble
3 Laboratoire de Physique Moléculaire et des Collisions, Université Paul Verlaine de Metz

Contact : rachel.delorme@cea.fr

Malignant brain tumours represent a few percents of adult cancers and are the most frequent for children. Because of the delicate location, the radio sensitivity of healthy brain and the presence of the blood brain barrier, the current treatments for some of these brain cancers are not efficient. An innovative approach using X-rays in addition with heavy elements, as iodine or gold nanoparticles, seems to open a promising way.

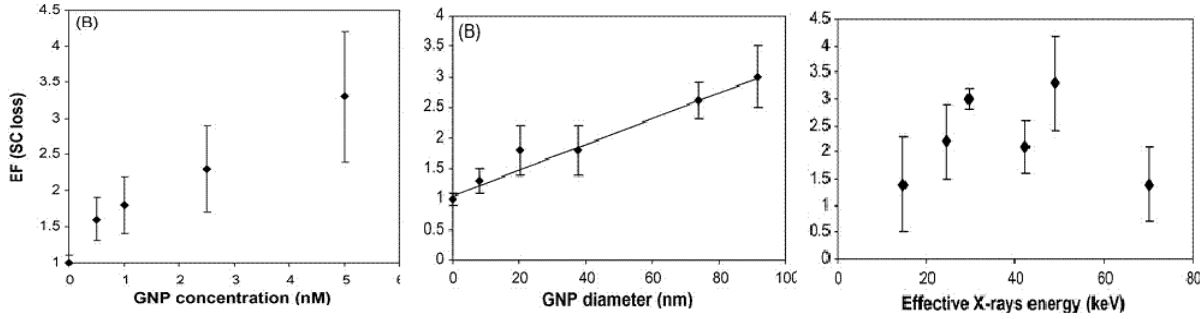

Figure 1 : Radiosensitization with gold nanoparticles (E. Brun et al., 2009)

Such technique is developed at the medical beam line of European Synchrotron Radiation Facility using monochromatic X-rays in the 50-100 keV range for the treatment of resistant solid tumours such as high-grade gliomas. With this approach, a localized dose enhancement can be obtained from photoelectric effect on heavy elements introduced in the target volume. However, the physical processes and biological impact of the photon activation of heavy elements are not well understood. The experimental results can not be explained from macroscopic dose calculations, the radio-induced damages at the cell level have to be considered.

The aim of this work is to model and simulate, with a Monte Carlo transport code, the interaction between radiations and cells or DNA in presence of heavy elements and to compare the results with experimental measurements carried out in two partner laboratories: laboratoire des Lésions des Acides Nucléiques at CEA of Grenoble and the INSERM team of the beam line dedicated to medical studies at ESRF. To this end, we first started to study the characteristics of the gold nanoparticles under various conditions of irradiation, for instance looking at the spectra of secondary electrons created and the deposited dose at a micrometer level around a nanoparticle. In a second hand, we will look into a more realistic model close to the experimental conditions in order to see potential correlation between a physical process modelled and a radiobiological result obtained with the experiments made at ESRF.

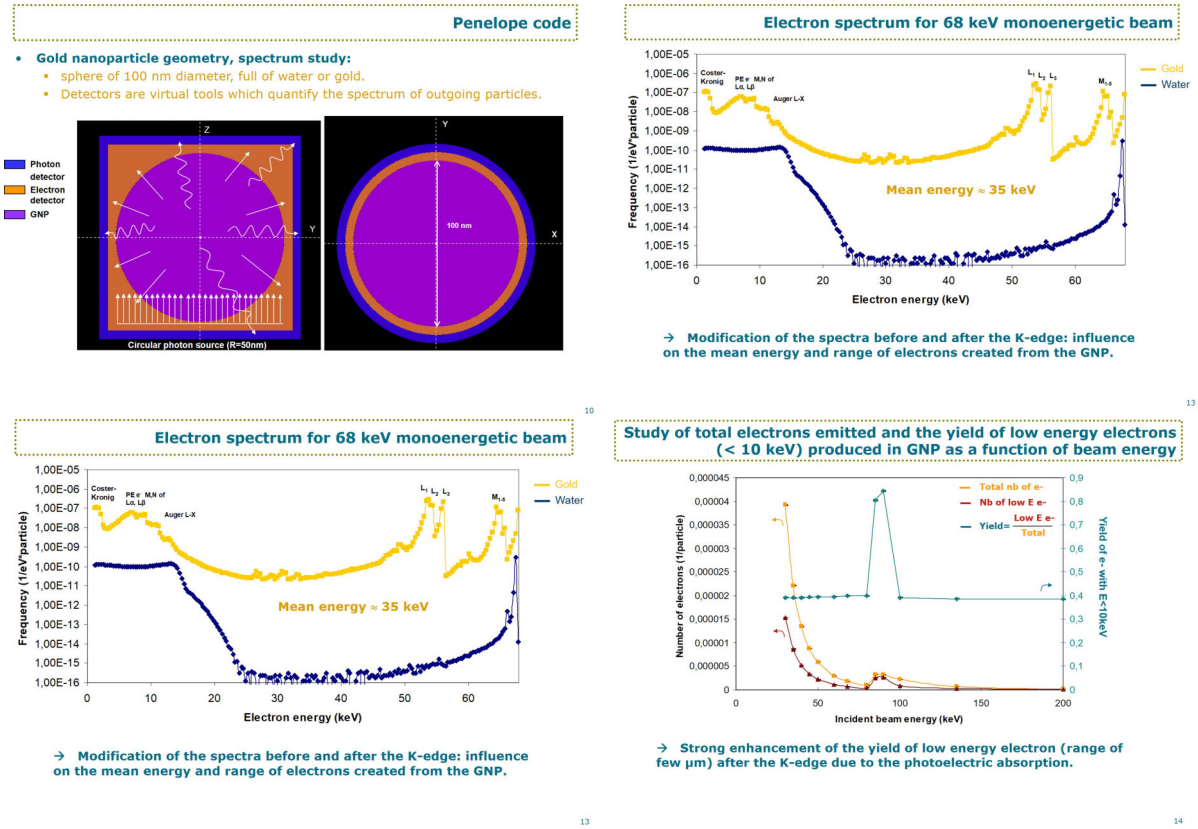

Figure 2 : Study of the characteristics of the gold nanoparticles under various conditions of irradiation

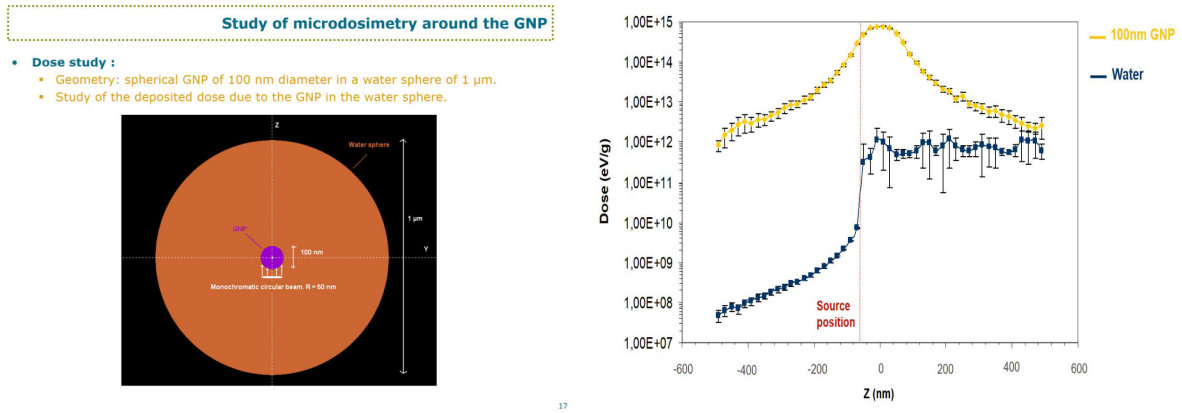

Figure 3 : Study of microdosimetry around the gold nanoparticles