Radiosensitizers in ion beam therapy: Measure of absolute cross section for emitted electrons from biomolecules and metallic nanoparticles upon ion collision using a Velocity Map Imaging spectrometer

The use of radiosensitizers, including high-Z nanoparticles (Ag, Au, Gd), was proposed to enhance the effects of ionizing radiation in ion beam therapy. The mechanism responsible for such an efficiency enhancement is the important release of electrons from the nanoparticles (NPs) triggered either by the primary ion beam or by secondary charged particles created along the track (see Figure 1). These electrons may then interact directly with biomolecules. Even at low energy (below ionization threshold), electrons can induce molecular damage via Dissociative Electron Attachment. They can also produce highly reactive species such as hydroxyl radicals (OH•) from the surrounding water molecules.

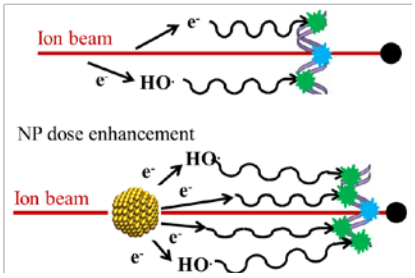

Figure 1: Electron emission from NPs

We propose to quantify this low energy electron emission by providing absolute cross sections in order to better understand the intrinsic properties of NPs under irradiation and the physical processes leading to the efficiency enhancement of radiation damage.

To do so, a new crossed beam apparatus has been developed: the target beam crosses orthogonally the projectile ion beam (keV to MeV kinetic energy) produced by the GANIL beamlines. Emitted electrons with energies up to 200 eV are extracted and focused onto a position sensitive detector (microchannel plates (MCPs) coupled to a phosphor screen) using a multi-electrodes VMI spectrometer (Figure 2). After recontruction of the 2D image recorded by the camera, we can extract the electron yield as a function of energy or scattering angle or both. By monitoring the target density, projectile ion beam intensity and the beams overlap with the use of a commercial quartz crystal microbalance and an ion beam profiler, we are able to estimate absolute double or single differential cross sections for electron emission. The setup allows us to produce a wide range of target beams. With the use of an effusive cell, we are able to produce in the gas phase a steady effusive beams of biomolecules (e.g. uracil, adenine) as well as metallic atoms (e.g. silver). And we have just developped the new NPs source : metallic NPs are put into the gas phase from a solution using an atomizer. Passing through the series of apertures of an aerodynamic lens (ADL), they are confined axially and partially separated from the carrier gas to produce a well-collimated NP beam.

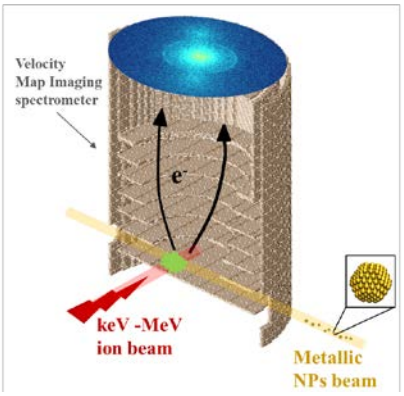

Figure 2: VMI spectrometer

The student will participate in the characterization of the new NPs beam source in particular the determination of the beam density. He (or she) will also participate in measurement and analysis of absolute cross section of electron emission from biomolecules upon H+ collision during the measurement campaign of Autumn 2019 on the low energy (keV) beamline facility in GANIL.

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