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A new experimental setup to measure absolute cross section for electron emission from atoms, molecules or nanoparticles upon ion collisions

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Synopsis A newly developed crossed beam experimental setup that utilizes a velocity map imaging technique to simultaneously measure both emission energy and angle of electrons ejected from atoms, molecules or nanoparticles upon ion collision will be presented. The incident ion beam is produced at the GANIL facility with incident energies from a few keV to a few MeV and the target beam density is monitored by a quartz crystal microbalance allowing for estimating absolute single or double differential cross sections.

Electron emission following ion collisions with atoms or molecules has been studied for several decades to better understand fundamental ionization mechanisms (soft collisions, binary encounter...) [1] but also for its wide range of applications including radiation cancer therapy. In particular, electron emission might explain the efficiency of nanoparticles (NP) when used as radiosensitizers, to enhance tumor destruction [2]. However, the abundance and energy of these electrons have never been measured. In this project, we aim to quantify electron emission from various targets (atoms, biomolecules and NP) following ion beam irradiation.

To do so, the target beam crosses orthogonally the projectile ion beam produced by the GANIL beamlines with typical kinetic energies from a few keV to a few MeV. Emitted electrons with energies up to 200 eV are extracted and analyzed by a multi-electrode velocity-map-imaging (VMI) spectrometer. By monitoring the target density, the projectile ion beam intensity and the beam overlap with the use of a quartz crystal microbalance and an ion beam profiler, we are able to estimate absolute double (vs. energy and angle) or single (vs. energy) differential cross sections for electron emission.

The setup allows us to produce a wide range of target beams. A supersonic jet source allows for measuring electron emission from noble gas atoms, e.g. the well-defined electrons from autoionizing states of Ar⁺ emitted in the range from 1 eV to 20 eV are used for calibration purposes. With the use of an effusive cell, we were also able to produce in the gas phase a steady effusive beam of biomolecules (e.g. uracil) as well as metallic atoms (e.g. silver). Moreover,

we are developing a nebulizer – aerodynamic lens system dedicated to experiments on metallic nanoparticles of various sizes (from nm to few tenths of nm).

In this contribution, we will present the development and characterization of the set-up in particular the design of the new NP source.

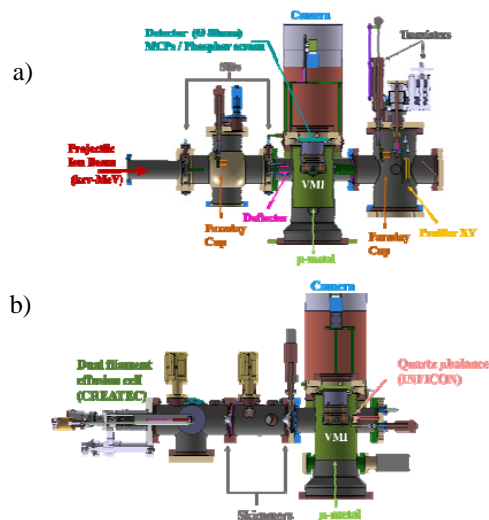


Figure 1. Outlines of the experimental setup : a) Projectile beam section, and b) Target beam section with an effusive cell installed.

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