Nowadays, about 100,000 patients have been treated with carbon or proton therapy systems. Even though already in clinical use, hadron therapy still suffers a lack of fundamental knowledge. For example, proton treatment planning systems (TPS) are relying on clinical data obtained in the past with X-rays and do not take into account the Linear Energy Transfer (LET) variation over the proton track. This could be solved with fundamental studies undertaken by an interdisciplinary team (e.g. biologists and physicists) having access to a particle accelerator.

The university of Namur (Belgium) has a Tandem accelerator, and few years ago we initiated two developments: a broad beam irradiation setup that’s can be used to measure cell response to hadrons, and a Monte-Carlo based computer program able to predict the survival fraction of cells irradiated with high LET particles.

In this seminar, we will describe here the current status of the predictive Monte Carlo code that models the in vitro irradiation of a cell monolayer with a monoenergetic broad beam of charged particles. Three cases are studied: the usual high dose response, the bystander effect and the low dose hypersensitivity (HRS). The program first models the broad beam irradiation and double strand breaks (DSB) are distributed among the cell population. Then, cells progress through the cell cycle and are allowed to repair, at a rate specific to each phase. For high doses, the G2 cell phase accumulation is triggered, allowing more time to repair, whereas for the low dose HRS region, the G2/M checkpoint is bypassed and cells undergo mitosis. Bystander effect is confined to non-hit cells only and is assessed using a dose-dependent probability. Physical and biological inputs, such as linear energy transfer, yield of double strand breaks (DSBs) or DSB repair kinetics are needed. Specific parameters related to low dose effects are required, such as cell and nucleus sizes, and proportion of cells in the different phases of the cell cycle.

Input parameters were determined for A549 lung denocarcinoma cells following irradiation with 10 keV/µm protons, 25 keV/µm protons and 100 keV/µm alpha particles. The simulation results are benchmarked against experimental data obtained with the setup installed on our particle accelerator.

This later one allows to irradiate confluent cells in monolayer with either p, alpha or carbon ions various ions at various dose rate and LET. A full description will also be provided.