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Radiograaff, a proton irradiation facility for radiobiological studies at a 4MV Van de Graaff accelerator

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A horizontal beam facility for radiobiological experiments with medium-energy protons has been setup at the 4MV Van de Graaff accelerator of the Institut de Physique Nucléaire de Lyon. At this energy, the Relative Biological Effectiveness (RBE) of protons may amount to 2-7 [Belli 1998], platform constitutes thus a tool to study the specific effects of high-LET radiations to cells. For such macroscopic-irradiation facilities, the dose distribution over the cell samples has to be uniform with accuracy better than ±5% and a controlled dose rate (2 Gy/min for clinical interest). The range of protons in the sample has to be controlled to ensure a track-segment irradiation protocol.
A homogeneous irradiation field with a suitable proton flux is obtained by means of two collimators (various sizes) and two Au-scattering foils arrangements set 62 cm apart from each other. The last arrangement is set 120 cm upstream from the irradiation area. A monitoring chamber contains a movable Faraday cup, a movable quartz beam viewer for controlling the position and the intensity of the initial incident beam, four scintillating fibers for beam monitoring during the irradiation of the cell samples, and is ended by a thin aluminized mylar window (12 µm thick) for the beam extraction in air. The set-up was simulated by the GATE v6.1 Monte-Carlo platform.
The facility performance were tested with 3.5 MeV protons using a silicon PIPS detector, placed in air in the same position as the biological samples to be irradiated, for proton energy measurement, fluence-homogeneity evaluation and flux calibration. With this double scattering system, a fluence heterogeneity of ±3% over a circular field of 20 mm diameter was obtained. A preliminary biological experiment was performed to test protocols with two Human Head and Neck Squamous cell lines carcinoma with quite different radiosensitivities. Cells were irradiated at 2Gy with a dose rate of 2Gy/min. DNA Double Strand Break induction and repair, were measured by scoring the γH2AX foci. Results will be presented and discussed.

[Belli 1998] "RBE-LET relationships for cell inactivation and mutation induced by low energy protons in V 79 cells: further results at the LNL facility"M. Belli et al. , International Journal of Radiation Biology 74, no. 4 (1998): 501–509.

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