Light- and Heavy-ion microbeam facilities for "single-ion single-cell" irradiations at the INFN-Laboratori Nazionali di Legnaro

Silvia GERARDI, Roberto CHERUBINI

INFN-Laboratori Nazionali di Legnaro, Viale dell'Università 2, I-35020 LEGNARO (Padova), Italy

silvia.gerardi@lnl.infn.it, roberto.cherubini@lnl.infn.it

Charged particle microbeams provide a unique method to control precisely the dose and its localisation within the mammalian cell contributing to investigate and elucidate the biological effects of low-dose exposures down to limit of one-particle per cell. Such a kind of tool allows addressing a number of important radiobiological processes in ways that cannot be achieved using conventional broad-beam irradiation, which has the inherent experimental limitation imposed by the random Poisson-distributed particle hitting.

We have designed, developed and set-up an original horizontal single-ion microbeam facility for individual mammalian cell irradiations installed at the broad-beam Radiobiology Facility of the INFN-LNL 7MV CN Van de Graaff accelerator, delivering protons, deuterons, helium-3, helium-4 ion beams in an LET range from 7 to 180 keV/μm [1,2]. The ion beam is collimated in air down to a section of 2-3μm diameter by means of appropriate pinholes. A semi-automatic cell visualization and an automatic cell positioning and cell revisiting system, based on an inverted phase contrast optical microscope and on X-Y translation stages with 0.1μm positioning precision, has been developed. As a distinctive feature and pioneering choice of our apparatus, cell recognition as well as cell revisiting is performed without using fluorescent staining and UV light. An especially designed stainless steel Petri dish, with a very thin (20μm) cell chamber, is used to keep cells in vertical position, in wet and sterile conditions during irradiation; the bottom and cover of the dish being in mylar (6 μm thick). Particle detection in air, behind the biological sample, is based on a silicon detector while in-air beam profile and precise hit position measurements are accomplished by a custom-made high resolution and high sensitivity cooled-CCD camera and Solid State Nuclear Track detectors, respectively, at the same cell position. A fast beam deflection system based on an electrostatic deflector (150ns response time), driven by a trigger signal from the silicon detector, switches off the beam when the pre-set number of particles per cell is delivered. A particle counting rate of less than 1 ion/sec can be reached.

A similar facility is now under development to be installed at the heavy-ion ($6<A<20$; E = few - 20 MeV/n) broad-beam Radiobiology Facility [3] of the XTU-Tandem-ALPI accelerator complex of the INFN-LNL.

[1] Gerardi S. et al. Radiat. Res. **161**(2004)93.
[2] Gerardi S. et al., Radiat. Res. **164**(2005) 586-590
[3] Cera F. et al., *Annual Report 1993, INFN - Laboratori Nazionali di Legnaro, LNL-INFN(Rep)-081/94, 128-129*