Targeted irradiation of mammalian cells using a heavy-ion microprobe

Heiss M, Fischer BE, Jakob B, Fournier C, Becker G, Taucher-Scholz G
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The existing focusing heavy-ion microprobe at the Gesellschaft für Schwerionenforschung in Darmstadt (Germany) has been modified to tenable the targeted irradiation of single, selected cells with a defined number of ions. With this setup, ions in the range from helium to uranium with linear energy transfers (LETs) up to ~ 15,000 keV/μm can be positioned with a precision of a few micrometers in the nuclei of single cells that are growing in culture on a thin polypropylene film. To achieve this accuracy, the microbeam traverses a thin vacuum window with minimal scattering. Electron emission from that window is used for particle detection. The cells are kept in a specially designed dish that is mounted directly behind the vacuum window in a setup allowing the precise movement and the imaging of the sample with microscopic methods. The cells are located by an integrated software program that also controls the rapid deflection and switching of the beam. In this paper, the setup is described in detail together with the first experiments showing its performance. We describe the ability of the microprobe to reliably hit randomly positioned etched nuclear tracks in CR-39 with single ions as well as the ability to visualize the ion hits using immunofluorescence staining for 53BP1 as a marker of DNA damage in the targeted cell nuclei.