Heavy-ion microbeams and bystander effect studies at JAEA-Takasaki

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During a long-term space mission, astronauts are constantly exposed to space radiation, especially of various kinds of heavy charged particles (energetic heavy ions) at low dose and low dose rate. Heavy charged particles transfer their energy to biological organisms through high-density ionization along the particle trajectories. The population of cells exposed to a very low dose of high-LET heavy particles contains a few cells hit by a particle, while the majority of the cells receive no radiation damage. At somewhat higher doses, some of the cells receive two or more events according to the *Poisson* distribution of ion injections. This fluctuation of particle trajectories through individual cells makes interpretation of radiological effects of heavy ions difficult.

Therefore, we have established a single cell irradiation system, which allows selected cells to be individually hit with defined number of heavy charged particles, using a collimated heavy-ion microbeam apparatus at JAEA-Takasaki. This system has been developed to study radiobiological processes in hit cells and bystander cells exposed to low dose and low dose-rate high-LET radiations, in ways that cannot be achieved using conventional broad-field exposures. Individual cultured cells grown in special dishes were irradiated in the atmosphere with a single or defined numbers of 18.3 MeV/amu ^{12}C, 13.0 or 17.5 MeV/amu ^{20}Ne, and 11.5 MeV/amu ^{40}Ar ions. Targeting and irradiation of the cells were performed automatically according to the positional data of the target cells microscopically obtained before irradiation. The actual number of particle tracks that pass through target cells was detected with prompt etching of the bottom of the cell dish made of ion track detector TNF-1 (modified CR-39).

Besides direct investigation of cell-to-cell communications such as “bystander effects”, that is, radiation effects transmitted from hit cells to neighboring un-hit cells, using Chinese hamster ovary cells and normal human foreskin fibroblast AG01522 cells, radiobiological studies on Tobacco BY-2 protoplasts and germline cells of the nematode *Caenorhabditis elegans* are in progress. The outlines of these studies will be introduced, and the current status of the development of focused heavy-ion microbeam from AVF cyclotron at JAEA-Takasaki will also be discussed.