DNA Fragmentation and DSB correlation Induced in Human Fibroblasts by Accelerated ^{56}Fe Ions of Differing Energies

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HZE particles from space radiation raise an important protection concern during long-term astronauts' travels. Although these particles are less abundant than protons, they are more effective in damaging biological systems. It is thought that this is due to the frequent production of spatially correlated DNA damaged sites, particularly double strand breaks (DSB), since this correlation can strongly affect the repair capability of the cells.

In this work we have studied the DNA fragmentation induced in human fibroblasts by accelerated ^{56}Fe ions of four different energies, i.e., 115 MeV/u, 414 MeV/u, 1 GeV/u and 5 GeV/u, and by gamma-rays, used as reference radiation. DNA fragmentation was studied in various size ranges, varying from 1 to 5700 kbp, using Pulsed or Constant Field Gel Electrophoresis. The DSB yields have been derived from fragmentation in the overall range as well as in the two ranges 1-23 and 23-5700 kbp.The overall DSB yield slightly increased with the ion energy, maily due to the contribution of the 23-5700 kbp fragments, while that of small fragments (1-23 kbp) was almost constant. Accordingly, the relative biological effectiveness (RBE) for DSB induction increased with energy from about 1.3 at 115 MeV/u to about 1.8 at about 5 GeV/u, i.e. less than the RBE for chromosome aberration and cell inactivation.

The degree of spatial correlation of DSB was evaluated through the departure from the randomness of the fragment distribution with a simple theoretical tool that we have recently introduced. To this aim a parameter, R, was used, related to the probability of inducing DNA fragments of relatively small sizes. It was found that R increases markedly on decreasing the particle energy (or increasing their LET). Moreover, DSB correlation is dose-dependent, decreasing when dose increases, probably due to fragments produced by different, uncorrelated, tracks.

Taken together these data indicate that the spatial correlation of DSB seems to reflect, better than the DSB yield itself, the differences in biological effectiveness for

chromosome aberration and cell inactivation between gamma-rays and energetic iron ions.