Simulation of DNA damage in human cells from space radiation using a physical model of stochastic particle tracks and chromosomes

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The formation of double-strand breaks (DSBs) and chromosomal aberrations (CAs) is of great importance in radiation research and, specifically, in space applications. We are presenting a recently developed model, in which chromosomes simulated by NASARTI (NASA Radiation Tracks Image) is combined with nanoscopic dose calculations performed with the Monte-Carlo simulation by RITRACKS (Relativistic Ion Tracks) in a voxelized space. The model produces the number of DSBs, as a function of dose for high-energy iron, oxygen, and carbon ions, and He ions. The combined model calculates yields of radiation-induced CAs and unrejoined chromosome breaks in normal and repair deficient cells. The merged computational model is calibrated using the relative frequencies and distributions of chromosomal aberrations reported in the literature. The model considers fractionated deposition of energy to approximate dose rates of the space flight environment. The merged model also predicts of the yields and sizes of translocations, dicentrics, rings, and more complex-type aberrations formed in the G0/G1 cell cycle phase during the first cell division after irradiation.