Modeling the dose distribution in a human brain structure using CT images on the surface of Mars

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One of the most important steps in the near-future space age will be a manned mission to Mars. Unfortunately, such a mission will cause astronauts to be exposed to unavoidable cosmic radiation in deep space and on the surface of Mars. Thus a better understanding of the radiation environment for a Mars mission and the consequent biological impacts on humans, in particular the human brains, is critical. To investigate the impact of cosmic radiation on human brains and the potential influence on the brain functions, we model and study the cosmic particle-induced radiation dose in a realistic head structure. Specifically speaking, 134 slices of computed tomography (CT) images of an actual human head have been used as a 3D phantom in Geant4 (GEometry ANd Tracking) which is a Monte Carlo tool simulating energetic particles impinging into different parts of the brain and deliver radiation dose therein. As a first step, we compare the influence of different brain structures (e.g., with or without bones, with or without soft tissues) to the resulting dose therein to demonstrate the necessity of using a realistic brain structure for our investigation. Afterwards, we calculate energy-dependent functions of dose distribution for the most important (most abundant and most biologically-relevant) particle types encountered in space and on Mars such as protons, Helium ions and neutrons. These functions are then used to fold with Galactic Cosmic Ray (GCR) spectra on the surface of Mars for obtaining the dose rate distribution at different lobes of the human brain. Different GCR spectra during various solar cycle conditions have also been studied and compared.