Uncertainty Analysis in Space Radiation Protection

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Abstract: Space radiation is comprised of high energy and charge (HZE) nuclei, protons, and secondary radiation including neutrons. The uncertainties in estimating the health risks from galactic cosmic rays (GCR) are a major limitation to the length of space missions, the evaluation of potential risk mitigation approaches, and application of the ALARA principle. For long duration space missions, risks may approach radiation exposure limits, therefore the uncertainties in risk projections become a major safety concern and methodologies used for ground-based works are not deemed to be sufficient. NASA limits astronaut exposures to a 3% risk of exposure induced death (REID) and protects against uncertainties in risks projections using an assessment of 95% confidence intervals in the projection model. We discuss NASA's approach to space radiation uncertainty assessments and applications for the International Space Station (ISS) program and design studies of future missions to Mars and other destinations. Several features of NASA's approach will be discussed. Radiation quality descriptions are based on the properties of radiation tracks rather than LET with probability distribution functions (PDF) for uncertainties derived from radiobiology experiments at particle accelerators. The application of age and gender specific models for individual astronauts is described. Because more than 90% of astronauts are never-smokers, an alternative risk calculation for never-smokers is used and will be compared to estimates for an average U.S. population. Because of the high energies of the GCR limits the benefits of shielding and the limited role expected for pharmaceutical countermeasures, uncertainty reduction continues to be the optimal approach to improve radiation safety for space missions.

Keywords: Radiation risks, space radiobiology, radiation risks for never-smokers