

Purpose: To use NASA radiation transport codes to compare astronaut organ dose equivalents resulting from solar particle events (SPE), geomagnetically trapped protons, and free-space galactic cosmic rays (GCR) using phantom models representing Earth-based and microgravity-based anthropometry and positioning.

Methods: The University of Florida hybrid adult phantoms were scaled to represent male and female astronauts with 5th, 50th, and 95th percentile heights and weights as measured on Earth. Another set of scaled phantoms, incorporating microgravity-induced changes, such as spinal lengthening, leg volume loss, and the assumption of the neutral body position, was also created. A ray-tracer was created and used to generate body self-shielding distributions for dose points within a voxelized phantom under isotropic irradiation conditions, which closely approximates the free-space radiation environment. Simplified external shielding consisting of an aluminum spherical shell was used to consider the influence of a spacesuit or shielding of a hull. These distributions were combined with depth dose distributions generated from the NASA radiation transport codes BRYNTRN (SPE and trapped protons) and HZETRN (GCR) to yield dose equivalent. Many points were sampled per organ.

Results: The organ dose equivalent rates were on the order of 1.5-2.5 mSv per day for GCR (1977 solar minimum) and 0.4-0.8 mSv per day for trapped proton irradiation with shielding of 2 g cm⁻² aluminum equivalent. The organ dose equivalents for SPE irradiation varied considerably, with the skin and eye lens having the highest organ dose equivalents and deep-seated organs, such as the bladder, liver, and stomach having the lowest.

Conclusions: The greatest differences between the Earth-based and microgravity-based phantoms are observed for smaller ray thicknesses, since the most drastic changes involved limb repositioning and not overall phantom size. Improved self-shielding models reduce the overall uncertainty in organ dosimetry for mission-risk projections and assessments for astronauts.

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