Estimation of effective doses for radiation cancer risks on ISS, Lunar, and Mars missions with space radiation measurements

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Radiation protection practices define the effective dose as a weighted sum of equivalent dose over major sites for radiation cancer risks. Since a crew personnel dosimeter does not make direct measurement of effective dose, it has been estimated with skin-dose measurements and radiation transport codes for ISS and STS missions. The Phantom Torso Experiment (PTE) of NASA's Operational Radiation Protection Program has provided the actual flight measurements of active and passive dosimeters which were placed throughout the phantom on STS-91 mission for 10 days and on ISS Increment 2 mission. For the PTE, the variation in organ doses, which is resulted by the absorption and the changes in radiation quality with tissue shielding, was considered by measuring doses at many tissue sites and at several critical body organs including brain, colon, heart, stomach, thyroid, and skins. These measurements have been compared with the organ dose calculations obtained from the transport models. Active TEPC measurements of lineal energy spectra at the surface of the PTE also provided the direct comparison of galactic cosmic ray (GCR) or trapped proton dose and dose equivalent. It is shown that orienting the phantom body as actual in ISS is needed for the direct comparison of the transport models to the ISS data. One of the most important observations for organ dose equivalent of effective dose estimates on ISS is the fractional contribution from trapped protons and GCR. We show that for most organs over 80% is from GCR. The improved estimation of effective doses for radiation cancer risks will be made with the resultant tissue weighting factors and the modified codes.