IONIZING RADIATION HAZARDS ON THE MOON.  T. Straume, Radiation & Space Biotechnologies Branch, Space Biosciences Division, NASA Ames Research Center, MS 236-07, Moffett Field, CA 94035

The radiation environment on the lunar surface is complex. Radiation includes charged particles from hydrogen to iron, and a myriad of secondary radiations, including neutrons produced by charged particle interactions with the surface of the Moon. During periods of low-solar activity, the major contributor is galactic cosmic radiation (GCR), which is composed primarily of high-energy protons in the GeV range. GCR also includes heavier charged particles ranging from helium to iron nuclei. During periods of high-solar activity (approximately 11 year cycle) the probability for a significant solar particle event (SPE) is elevated. A large SPE produce very intense charged particle radiation composed almost entirely of protons below 150 MeV.

High-energy GCR radiation is very penetrating and therefore difficult to shield. For example, a 1 GeV proton has a range of about 2 m in regolith and secondaries produced by those primary particles will penetrate even deeper. In contrast, the much lower energy solar protons are easier to shield, and can even be significantly reduced by a lunar extravehicular activity (EVA) spacesuit. In addition to their penetration power, the high-energy particles from GCR produce substantially more secondary radiation via spallation reactions in spacecraft materials and lunar regolith. In some cases, these secondary radiations are more damaging biologically than the primary radiations. Hence, shielding of GCR radiation poses a challenge for long-term space travel as well as for human habitation on the Moon.

During non-SPE solar minimum conditions, the dose-equivalent rate in interplanetary space is estimated to be in the 0.5 to 1.4 Sv/y range [1]. Due to shielding by the Moon, the dose-equivalent rate on the lunar surface is estimated to be less than in interplanetary space. Lunar surface dose modeling is complicated by terrain topography and secondary radiations produced in the lunar regolith. It has been estimated that the combined primary and secondary radiation on the surface of the Moon may result in an effective dose-equivalent exposure of about 0.3 Sv/y [2], which is not expected to result in significant short-term risk, but may increase the long-term stochastic health risks that are associated with radiation exposure. This assumes no significant SPEs during the mission. Because these doses are primarily from GCR, they are unlikely to be substantially reduced by shielding.

In contrast, SPEs pose a different challenge. Although protons from SPEs can be more readily shielded, they pose a substantial acute health risk for astronauts exposed during lunar EVA. For example, if astronauts had been EVA on the moon during the August 1972 SPE they could have received 15 Sv to the skin and 2 Sv to the marrow [3]. These doses could have resulted in acute radiation health effects and would have greatly exceeded the current 30-day dose limits established for LEO of 1.5 Sv for skin and 0.25 Sv for marrow. Published measurements and calculations focused on the lunar radiation environment and implications for hazards to astronauts will be discussed.

References: