

IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)  
Radiation Fields, Effects and Risks in Human Space Missions (5)

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## PERSONAL RADIATION SHIELDING FOR DEEP SPACE MISSIONS

**Abstract**

Protecting astronauts from space radiation is one of the main critical issues in space exploration, especially in view of future missions, where an increase in mission duration will require an improvement in the protection strategies. While Galactic Cosmic Rays (GCRs) have a stochastic long-term health effects, exposure to strong Solar Particle Events (SPEs) can lead to deterministic ways to endanger astronaut's life and to mission failure.

Currently, passive radiation shielding approaches represent the sole available technology to effectively protect humans from SPEs. In recent years several studies have been conducted based on the utilization of resources already available on board, such as water, food and waste to be used as a protection. These studies propose different types of wearable, portable and personal multifunctional radiation shielding devices as promising solutions. This paper discusses the performance of each shielding methods and provides comparative analysis on protection to the critical body parts during Intra-Vehicular Activities (IVA).

It is discussed the use of different lightweight and low atomic mass ( $Z$ ) materials and their performance and propose a spacesuit concept for protection. Two different concepts for radiation protection so as to increase the number of 'safe days' in space are studied. The property of a High-Density Polyethylene (HDPE) Helmet to lower the effective dose equivalent absorbed by the brain is discussed.

The first solution presented is a 2 mm thick HDPE Suit. This concept provides both radiation shielding in combination with wearable water bags with thicknesses in the range of 2 to 6 cm, and improvement in counteracting the observed vision problems affecting astronauts. The analysis shows a reduction of effective dose equivalent absorbed by the Blood Forming Organs (BFO) in comparison mentioned in the literature. It is also analyzed an alternative concept of a suit with the insertion of low  $Z$ -high density boron nitride fillers (BN) in the HDPE of the suit in combination with boron doped HDPE jacket. This concept provides also a mitigation of the secondary neutron doses caused by GCRs interactions with materials. The results obtained using literature-based inputs show that a 30% of BN inserted into the jacket leads to a 42% reduction in the proton ranges (100 MeV assumed in the calculations) with respect to water.