Recent Measurements in Support of Space Radiation Transport Model Development

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High energy nuclei in the galactic cosmic radiation are a significant contributing factor to radiation risk to humans in space. The ambient space radiation field is modified by passage through materials and human tissue, and the effects of materials and astronauts' bodies on the internal radiation environment will be a constraint on the design of future spacecraft and lunar and planetary habitats. Understanding these effects requires a combined experimental and modeling effort. At particle accelerators data can be gathered rapidly under controlled conditions for well-defined materials and structures, and while access to accelerators is limited, it is much easier to obtain than access to space. On the other hand, it is not possible at accelerators to replicate the mixed radiation present in space, operational spacecraft have complex internal structures that are difficult to install at an accelerator, and new shielding materials are constantly being proposed. Consequently, a great deal of effort is going into modeling radiation transport in materials. Model calculations and measurements complement one another: the models can be used to identify materials with desirable radiation transport characteristics and to rapidly evaluate different shielding configurations, the most promising of which can then be tested at accelerators. Reducing the uncertainties in the model calculations is crucial: the greater the uncertainty, the greater the weight penalty in the form of increased shielding thickness dictated by the ALARA (**A**s **L**ow **A**s **R**easonably **A**chievable) principle of radiation protection practice.

The mission of the SRSP Measurements Consortium is to provide the data to make the models as accurate and precise as required. Accurate nuclear fragmentation cross sections are needed to ensure that the models get the underlying physics right, and measurements of particle fragmentation and transport in proposed shielding materials are needed to validate the models. The consortium is working closely with a theory consortium to prioritize and carry out the data gathering and analysis, and with NASA-supported materials scientists to measure radiation transport in proposed shielding materials. We are also collaborating with scientists and engineers at several institutions, including NASA-Johnson Space Center and the Japanese Aerospace Exploration Agency (JAXA), to systematically evaluate the response of space radiation detectors to heavy ions. Measurements are being made at the NASA Space Radiation Laboratory (NSRL), the Brookhaven National Laboratory Alternating Gradient Synchrotron (AGS), the Heavy Ion Medical Accelerator at Chiba (HIMAC) and the Loma Linda University Medical Center proton synchrotron.

I will review the measurements made by the Consortium thus far, and give examples of the methods and results, including recent measurements with heavy ions at energies of 3, 5 and 10 GeV/nucleon at the BNL AGS.