

Space Radiation Transport Code Development: 3DHZETRN

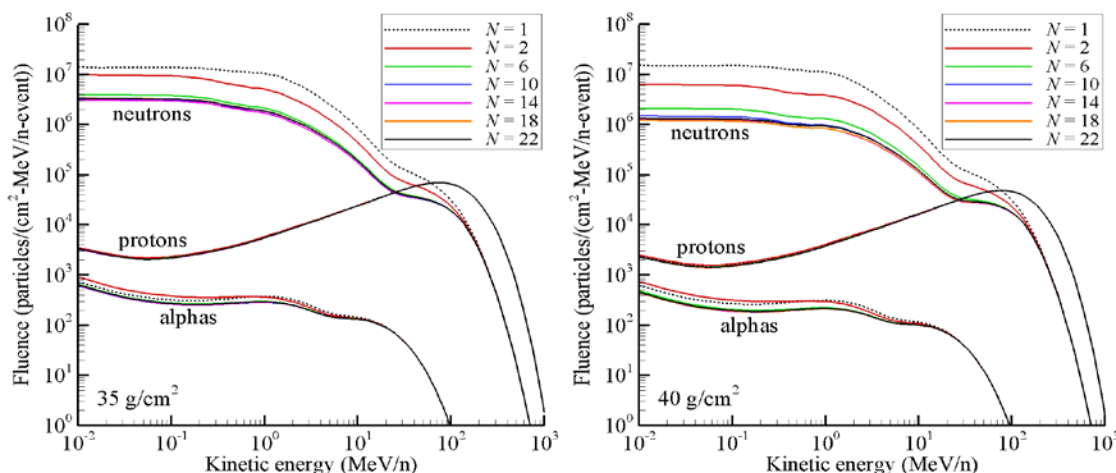
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The space radiation transport code, HZETRN, has been used extensively for research, vehicle design optimization, risk analysis, and related applications. One of the simplifying features of the HZETRN transport formalism is the straight-ahead approximation, wherein all particles are assumed to travel along a common axis. This reduces the governing equation to one spatial dimension allowing enormous simplification and highly efficient computational procedures to be implemented. Despite the physical simplifications, the HZETRN code is widely used for space applications and has been found to agree well with fully 3D Monte Carlo simulations in many circumstances. Recent work has focused on the development of 3D transport corrections for neutrons and light ions ($Z \leq 2$) for which the straight-ahead approximation is known to be less accurate. Within the development of 3D corrections, well-defined convergence criteria have been considered, allowing approximation errors at each stage in model development to be quantified. The present level of development assumes the neutron cross sections have an isotropic component treated within N explicit angular directions and a forward component represented by the straight-ahead approximation. The $N = 1$ solution refers to the straight-ahead treatment, while $N = 2$ represents the bi-directional model in current use for engineering design. The figure below shows neutrons, protons, and alphas for various values of N at locations in an aluminum sphere exposed to a solar particle event (SPE) spectrum. The neutron fluence converges quickly in simple geometry with $N > 14$ directions. The improved code, 3DHZETRN, transports neutrons, light ions, and heavy ions under space-like boundary conditions through general geometry while maintaining a high degree of computational efficiency. A brief overview of the 3D transport formalism for neutrons and light ions is given, and extensive benchmarking results with the Monte Carlo codes Geant4, FLUKA, and PHITS are provided for a variety of boundary conditions and geometries. Improvements provided by the 3D corrections are made clear in the comparisons. Developments needed to connect 3DHZETRN to vehicle design and optimization studies will be discussed. Future theoretical development will relax the forward plus isotropic interaction assumption to more general angular dependence.



Particle spectra at detector locations 35 g/cm² (left pane) and 40 g/cm² (right pane) from top of aluminum sphere (diameter 40 g/cm²) exposed to 1956 Webber SPE spectrum for different N in 3D transport solution.