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Precision in Terrestrial Soft-Error-Rate Estimation Using Acceleration Factors Obtained at an 18 MeV Proton Accelerator-Driven Neutron Source

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With the ongoing miniaturization, high integration, and low power consumption of semiconductor devices, soft errors caused by cosmic-ray neutrons in terrestrial environments have become a concern. The soft error rate in the terrestrial environment can be quantitatively estimated from the soft error rate measured with an accelerator-driven neutron source and the acceleration factor that is defined as the ratio of the soft error rate in an accelerator environment to that in the terrestrial environment. For large-scale accelerator neutron sources with energy spectra that closely represent the shape of the terrestrial neutron energy spectrum, the acceleration factor remains constant regardless of the semiconductor device. In contrast, for compact accelerator-driven neutron sources (CANSs) with energy spectra below about 10 MeV, the effect of the energy dependence of soft error cross-sections varies across devices, resulting in device-dependent variations in the acceleration factor.
To assess the validity for estimating terrestrial soft error rates using CANSs, we measured the variation in acceleration factors for six types of SRAM-based FPGAs with design rules below 100 nm using an 18 MeV proton cyclotron neutron source. Although the acceleration factor showed variations across devices, these variations were found to be within the same order of magnitude and could be explained by differences in the energy dependence of soft error cross-sections for each device. Therefore, we conclude that we can adopt this accelerator to evaluate terrestrial soft error rates with precision within an order of magnitude regardless of the devices.

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