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Initial Fe/O Enhancements in Large, Gradual, Solar Energetic Particle Events: Observations from Widely-Separated Spacecraft, Wind and Ulysses

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Composition measurements are a powerful tool in investigating the acceleration and transport processes that govern the production solar energetic particles (SEPs). A wide array of observational evidence indicates that shocks driven by fast coronal mass ejections are the dominant acceleration mechanism in large, so-called gradual SEP events. However, in some gradual events, the Fe/O ratio above a few MeV/nucleon sometimes shows a very strong enhancement at the beginning of the event, with Fe/O $\sim$ 1, as typical of impulsive SEP events, in which particle acceleration at reconnections sites (such as flares) are believed to dominate. Some researchers have attributed these initial Fe/.O enhancements to a direct flare component; others have explained it in terms of rigidity-dependent SEP transport. We examine this controversy using observations of initial Fe/O enhancements in two large SEP events in 2001 by Wind at L1 and by Ulysses at high heliolatitudes and beyond 1.6 AU. We also examine the implications of these observations to the controversy about how SEPs reach high heliolatitudes, either by cross-field diffusion or by latitudinal expansion of the CME-driven shock. This work has been supported by the NASA Heliophysics Guest Investigator Program under DPR NNH09AK79I and has received funding from the European Commission FP7 Project COMESEP (263252).