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Abstract number: S2-541
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Heavy Ion Aacceleration and Self-Generated Waves in Coronal Shocks

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Particles accelerated in coronal-mass-ejection (CME) driven shocks are currently considered to be the primary component of large solar energetic particle (SEP) events. Using a Monte Carlo method with self-consistent Alfvénic turbulence we have simulated the diffusive shock acceleration of minor ions and protons. We find that the effect minor ions have on wave generation is small but non-negligible. The simulations show a cut-off energy dependence on the charge-to-mass ratio to be $(Q/A)^{1.5}$, i.e., different from previous analytical estimates based on wave-generation by protons alone and using simplifying assumptions on the form of the wave spectrum at low wavenumbers. The minor ions in the simulation also exhibit harder energy spectra than protons, especially during early phases of acceleration, which we identify as a result of the time-dependence of the coupled particle acceleration and wave generation.