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Ionic charge states: a clue for the understanding of the location of the source region of solar energetic particles

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With the experiments SEPICA onboard ACE and STOF onboard SOHO, the determination of heavy ion ionic charge states has been extended to the suprathermal energy range of $\sim$ 0.02–0.70 MeV/n. For events correlated with interplanetary shocks the ionic charge states in this energy range are mostly compatible with solar wind (SW) charge states or differ from SW charge states, e.g. for Fe, by only 1–2 charge units. However, in all SEP events of short duration, low intensity and enrichment in heavy ions (previously called Impulsive Events), we find significantly higher ionic charge states of $\sim$10–12 (Mg), $\sim$11–14 (Si) und $\sim$14–20 (Fe), with a significant increase of the mean ionic charge in this energy range by several charge states for Fe. This large increase of the mean ionic charge with energy at E $<$ 1 MeV/nuc can be best explained by additional ionization of the ions by charge stripping in a sufficiently dense environment, during or after the acceleration. We compare the measured mean ionic charge of Mg, Si, and Fe with model calculations including the effect of energy dependent ionization and recombination. To explain the strong increase of the mean Fe charge state at E $<$1 MeV/nuc the acceleration region in these Impulsive Events must be in the lower corona, at altitudes $< 2\ R_S$.