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Self-consistent Monte-Carlo modeling of the November 10, 2012 energetic storm particle event

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Fluxes of solar energetic particles (SEPs) are associated with solar flares and coronal/interplanetary shock waves. In the case of shocks, particles are thought to get accelerated to high energies via the diffusive shock acceleration mechanism. In order to be efficient, this mechanism requires an enhanced level of magnetic turbulence in the vicinity of the shock front, in particular, in the so-called foreshock region upstream of the shock. This turbulence enhancement can be produced self-consistently, i.e., by the accelerated particles themselves via streaming instability. This idea underlies the SOLar Particle Acceleration in Coronal Shocks (SOLPACS) Monte-Carlo simulation code, which we developed earlier to simulate acceleration of protons in coronal shocks. In the present work, we apply SOLPACS to model an energetic storm particle (ESP) event measured by the STEREO A spacecraft on November 10, 2012. All but one main SOLPACS input parameters are fixed by the in-situ plasma measurements from the spacecraft. Comparison of a simulated proton energy spectrum at the shock with the observed one then allows us to fix the last simulation input parameter related to efficiency of particle injection to the acceleration process. Subsequent comparison of simulated proton time-intensity profiles in a number of energy channels with the observed ones shows a very good correspondence throughout the upstream region. Our results give support for the quasi-linear formulation of the foreshock. This research has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870405 (EUHFORIA 2.0).