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On the origin of relativistic solar particle events

Karl-Ludwig Klein
Observatoire de Paris, LESIA, Meudon, France (ludwig.klein@obspm.fr)

The highest energies of solar energetic nucleons detected in space or through gamma-ray emission in the solar atmosphere are in the GeV range. Where and how the particles are accelerated is still controversial. The most debated candidate processes are related to magnetic reconnection and to the shock wave driven by a fast coronal mass ejection (CME). We search for observational indications on the acceleration site, via comparative analyses of the timing of relativistic solar protons, observed by neutron monitors on the Earth, and electromagnetic emissions of the associated eruptive solar activity. Radio emissions in different phases of the related flare and at different wavelengths are used as a tracer of electron acceleration in the corona, and as a rough description of the injection function of relativistic protons into the interplanetary medium. The predicted arrival time at 1 AU is compared with the time profiles observed by neutron monitors. We show evidence that distinct periods of particle acceleration in the corona, including the impulsive phase of the flare and post-eruptive acceleration during the relaxation of the magnetically stressed corona, display consistent features with the neutron monitor time histories. This suggests that magnetic reconnection during different phases of an eruptive event in the solar corona contributes to the acceleration of relativistic protons. A key example of these features is the relativistic solar particle event of 20 January 2005.