Relativistic solar cosmic rays from GLE modeling studies (1956-2005)

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Relativistic solar cosmic rays consist mainly of protons with energy $\geq$0.5 GeV and carries information about physical processes on the Sun, interplanetary magnetic field (IMF), magnetosphere and atmosphere of the Earth. The main source of data on the relativistic solar protons (RSP) remains observations during GLE (Ground Level Enhancements) with ground based cosmic ray detectors. The worldwide neutron monitor (NM) network may be considered as a united multidirectional solar proton spectrometer in the relativistic energy domain. With the modeling of the NM responses to an anisotropic solar proton flux and comparing them with observations the parameters of primary solar protons: energetic spectrum, anisotropy and pitch angle distribution outside the magnetosphere can be obtained. The modeling technique has been improved recently by using modern magnetosphere models, and including into analysis the data of EAS arrays. The last ones having the great registration areas appeared to have better than neutron monitors effectiveness at primaries rigidities above 5 GV. The modeling analysis of 14 large GLEs occurred in the period 1956-2005 revealed existence of two distinct RSP populations (components): the early impulse-like intensity increase with exponential energy spectrum (prompt component, PC), and the late gradual increase with a softer energy spectrum of the power law form (delayed component, DC). The exponential spectrum may be an evidence of the acceleration by electric fields arising in the reconnecting current sheets in the corona. The possible source of DC particles can be stochastic acceleration at the MHD turbulence in expanding flare plasma. The modeling analysis of pitch-angle distributions and anisotropy dynamics allows studying RSP propagation in the IMF. So for example a propagation of RSP along large-scale loops of IMF created by CME's from preceding flares on the Sun was discovered.