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Atmospheric cutoff energies for cosmic rays registered by polar neutron monitors

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Similarly to the geomagnetic cutoff, which is the lower energy (magnetic rigidity) limit for particles that are able to pass the geomagnetic field and reach the Earth's atmosphere, there is the atmospheric cutoff. It represents the lower limit in energy for cosmic-ray particles propagating in the atmosphere and which can be registered on the ground by, e.g., neutron monitors. The atmospheric cutoff was previously estimated at the sea level as about 1 GV in rigidity, which is approximately 430 MeV in energy for protons. We calculated the atmospheric cutoff value for energetic protons over the range of altitudes from about 4500 m to 0 m above sea level, which corresponds to the depths from 600 to 1030 g/cm2, with: (a) Monte Carlo simulation of the cosmic ray cascade end (b) the altitude-dependent yield function of a standard neutron monitor 6NM64. The results agree with the earlier finding at sea level, though the yield function method shows more conservative, higher values of the cutoff compared to the cascade simulation method. It can be explained by the nature of the yield function, which takes into account the non-100% sensitivity of the detector to incident particles. Additionally, we calculated the effective atmospheric cutoff energies for two different conditions using the yield-function method, when only galactic cosmic rays are present, and when a strong solar energetic particle event happens. In this work, the case of GLE#05 was considered, which occurred on 23 Feb 1953. The resulting cutoff values for protons detected by polar neutron monitors are presented. It is shown that a strong solar energetic particle event can significantly reduce the atmospheric cutoff of a polar neutron monitor and the instrument is able to register particles with much lower energies than in the usual "galactic cosmic ray only" conditions.

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