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Use of incident and reflected solar particle beams to trace the topology of magnetic clouds

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Occasionally, large solar energetic particle (SEP) events occur inside magnetic clouds (MCs). In this work the onset time analysis, the peak intensity analysis, and the decay phase analysis of SEPs are used to investigate two large SEP events inside MCs: the 1998 May 2 and 2002 April 21 events. The onset time analysis of non-relativistic electrons and ∼MeVnucleon-1 heavy ions exhibits the stability of the magnetic loop structure during a period of a few hours in the events examined. The joint analysis of pitch-angle distributions (PADs) and peak intensities of electrons indicates that in the April event the reflected particles with nearly zero pitch-angle at 1 AU could reach the vicinity of the Sun, implying that the magnetic loop was a magnetic bottle connected to the Sun with both legs. In contrast, in the May event the magnetic mirror was formed by a compressed field enhancement behind the interplanetary shock driven by a preceding coronal mass ejection, being consistent with its open field line topology. We have also measured the anisotropy characteristic of SEPs in the solar wind frame. At the MC boundary the PADs of both non-relativistic electrons and ∼MeVnucleon-1 heavy ions are nearly isotropic, suggesting a diffusive transport environment of SEPs there.

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