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Phantom Cosmic Ray Decreases and their Extraterrestrial Origins

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Galactic cosmic rays are extremely high energy charged particles accelerated at extra-solar sources such as supernovae, active galactic nuclei, quasars, and gamma-ray bursts. Upon arrival at Earth's atmosphere, they collide with air molecules to produce a shower of secondary particles. One product of this air shower is energetic neutrons, which can be detected at the Earth's surface. Neutron monitors have been routinely operating for more than half a century and have shown that the cosmic ray flux at the top of the atmosphere is modulated by the heliospheric magnetic field (HMF), both at solar cycle time scales and due to shorter-term HMF variations, such as result from coronal mass ejections (CMEs). When a CME passes over the Earth, the neutron monitor counts are reduced sharply and suddenly (in a matter of hours) due to the modulation of cosmic rays by the enhancement in the heliospheric magnetic field (HMF). Such a drop in neutron counts is known as a Forbush Decrease. We present examples of unusual Forbush Decreases where there is no disturbance in the HMF at Earth at the time, which we name 'Phantom Cosmic Ray Decreases' (PCRDs). For recent PCRD events, we examine STEREO in-situ data and in each case, we find a large CME in either STEREO-A or -B. We also study neutron counts for each event from a number of neutron monitors at different longitudes. Differences between the size of the cosmic ray decreases at different longitudes are shown to give information on the location of the cosmic ray modulation source. We thus propose that these PCRDs are caused by CMEs which have missed Earth but which are large and intense enough to block out galactic cosmic rays on trajectories toward Earth.