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A Maverick GLE: The Relativistic Solar Particle Event of December 13, 2006

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Abstract: Ground Level Enhancements are more likely to occur when the Sun is very active. The most recent GLE was a maverick. It occurred near solar minimum, but it was a large event by historical standards, with a peak increase exceeding 70% at some stations. This paper reports initial observations of the GLE of December 13, 2006 based on data returned by the *Spaceship Earth* neutron monitor network.

Introduction

Spaceship Earth is a multi-national array of polar neutron monitors optimized for measuring the angular distribution of solar cosmic rays [1]. Figure 1 displays the geographical distribution of the *Spaceship Earth* array, together with the range of asymptotic viewing directions for each station.

On December 13, 2006, an unusual large near-solar-minimum Ground Level Enhancement (GLE) was observed after a 4B solar flare at 0220 UT, at S06 W24, accompanied by an X3.4 X-ray event and type II and IV radio bursts. This report presents initial observations of the December 13, 2006 GLE and briefly outlines our plans for further analysis.

Spaceship Earth Observations

For each neutron monitor in the *Spaceship Earth* network, one-minute-averaged raw counting rates were used. These were pressure-corrected to sea level (760 mm Hg) using the method of Duggal [2], and the intensity was expressed as a percent increase above the pre-event intensity of Galactic cosmic rays.

As shown in Figure 2, the stations of *Spaceship Earth* displayed a rapid rise in count rates starting at about 0250 UT on December 13, 2006, with peaks ranging from about 20% (numerous stations) to 77% (Apatity), depending on the asymptotic viewing direction of the monitor.

Discussion

Our standard method for modeling GLE particle transport involves (1) fitting count rates recorded by individual *Spaceship Earth* stations (sometimes supplemented by additional stations when available) to a model of the cosmic ray angular distribution (e.g., first-order anisotropy), (2) computing moments (density, anisotropy vector, second-order Legendre coefficient) of the angular distribution, and (3) fitting the moments as a function of time to numerical solutions of the Boltzmann transport equation. This method has been successfully employed in modeling the major GLE of Solar Cycle 23, and we have reported results for the Bastille event [3], Easter event [4], "Halloween" event [5], and the enormous January 20, 2005 event [6].

At the time of writing, modeling of the December 13, 2006 maverick GLE is in progress. Results will be presented at the conference.

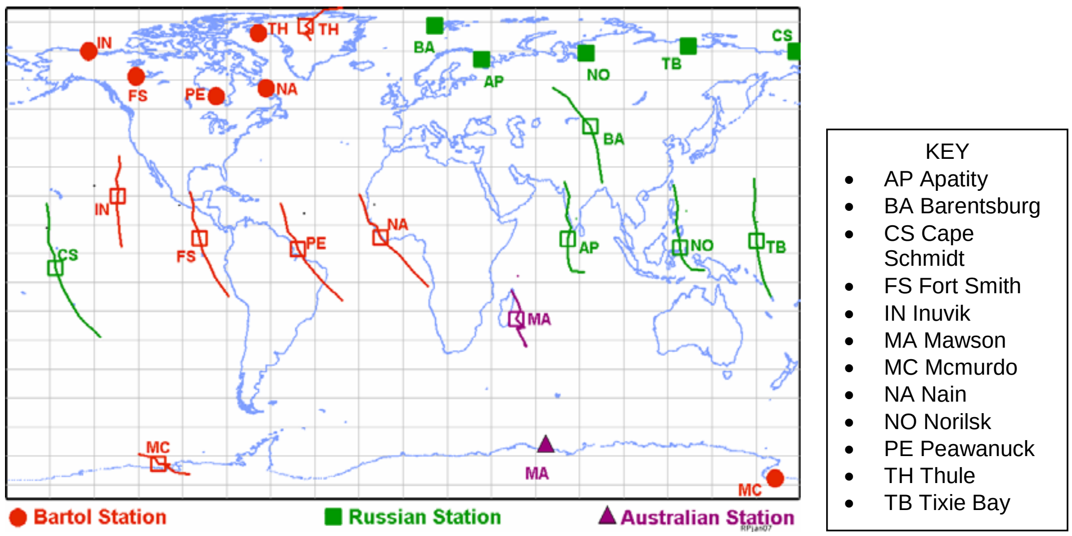

Figure 1: *Spaceship Earth* is a 12-station neutron monitor network optimized to measure the angular distribution of ~1 GeV solar cosmic rays. It was assembled by upgrading and linking 8 existing stations, and building 4 new ones to fill in gaps. Average viewing directions (open squares) and range (lines through squares) are separated from station geographical locations (solid symbols) because particles are deflected by Earth's magnetic field. The zenith at each geographical location along the lines represents the viewing direction in interplanetary space for a particular particle rigidity.

Acknowledgements

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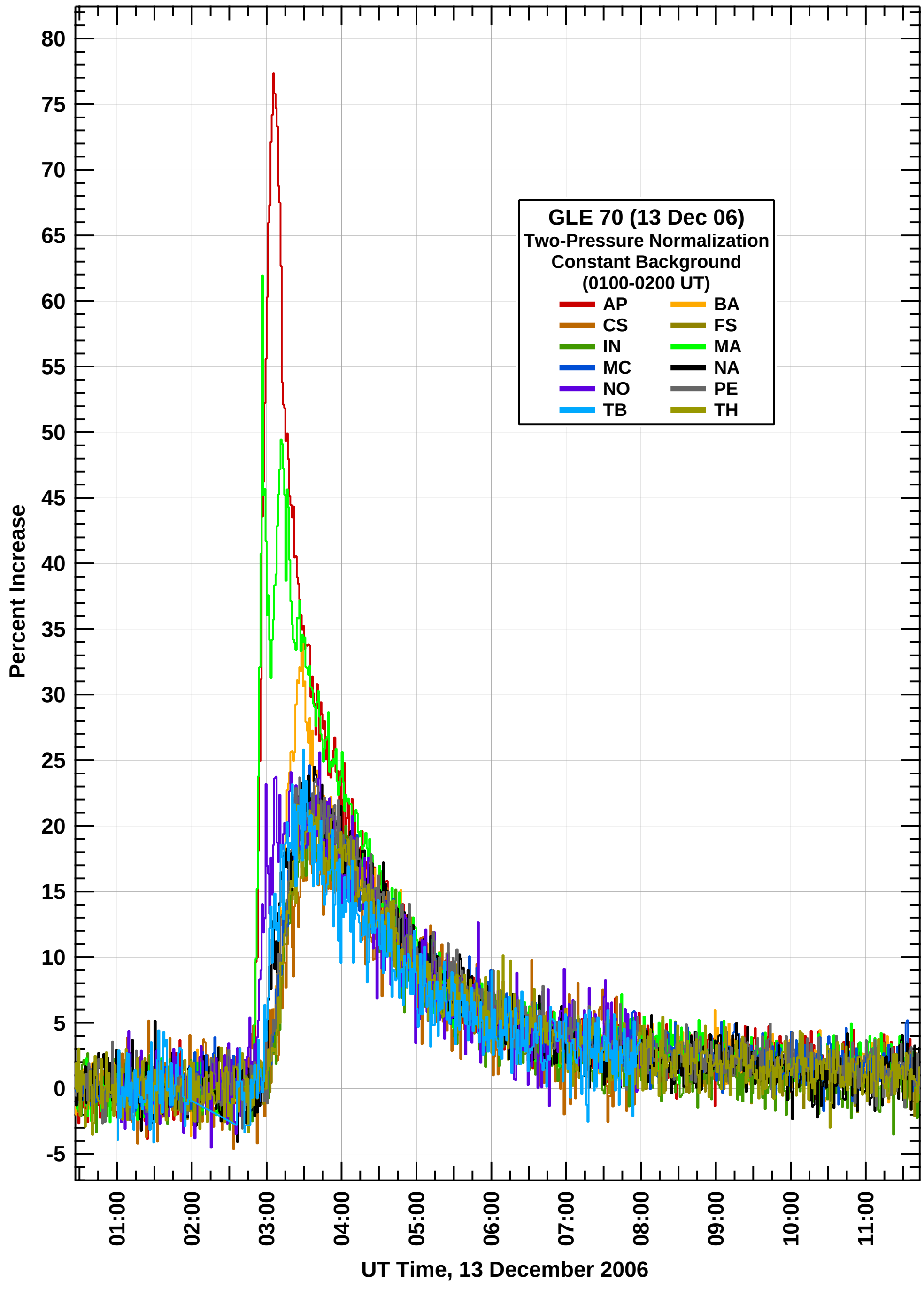

Figure 2: On December 13, 2006, the Sun emitted cosmic rays of sufficient energy and intensity to increase radiation levels on the surface of Earth. This figure presents observations of the event made by the *Spaceship Earth* neutron monitor array. Individual station count rates were corrected to sea level using two pressure coefficients [2], and intensity was expressed as a percent increase above the pre-event Galactic background.