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TITLE COMPOSITION AND ENERGETICS OF SOLAR FLARE PARTICLE EVENTS MEASURED BY SATELLITES, 1989-91

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Composition and Energetics of Solar Flare Particle Events Measured by Satellites, 1989–91

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ABSTRACT

The Synchronous Orbit Particle Analyzer (SOPA), on board the satellite 1989-046 and others, has detected ions from carbon through nickel at energies from 2 to 50 MeV in the great solar energetic particle events of the current solar cycle. Energetic protons from the same events have been detected by the Charged Particle Analyzer (CPA) on board the satellite 1984-129 and others.

We present here a collection of data from these various instruments that includes events of 1989, 1990, and 1991. We demonstrate the association of the events detected by the satellites with solar flares, and examine local solar wind features that in some instances alter the flux. We determine the ionic composition of the events, and compare these compositions among the various events and with those found in events of previous solar cycles. We obtain time-histories of the energetic particle fluxes, resolved both by ion species and by energy range. These detailed histories are of use, in conjunction with other data, in determining the parameters of the acceleration region.

The SOPA (Synchronous Orbit Particle Analyzer) detector, which is currently operating on satellites 1989-046 and 1990-095, and which will be flying on other geosynchronous orbit satellites, promises to be a fine tool for the detection of solar-flare accelerated ions. In this paper we show selected time profiles of some of the solar-energetic-particle events of 1989 through 1991. This instrument has been described by Belian *et al.* (1991), in which the response of the instrument to the event of October 1989 was also reported.

The instrument is a two-element solid-state detector, and provides mass discrimination for ions via the *dE/dx* vs *E* pulse-height-analysis technique. Figure 1 illustrates a laboratory calibration run for a similar detector, where data points for beams of Fe, Si, Al, O, N, C are compared to curves from the TRIM Monte Carlo simulation code (Ziegler *et al.* 1985).

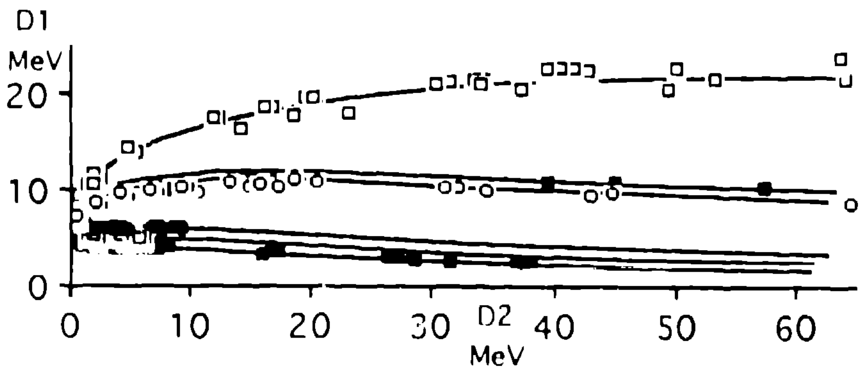

Figure 1. Calibration pulse-height-analysis data for a SOPA instrument similar to that on satellite 1989-046 together with curves from the TRIM code. The symbols represent data from beams of Fe, Si, Al, O, N, and C from the Van de Graaf facility at Los Alamos.

The SOPA detector on 1989-046 became operational in September 1989, and was therefore on line during the great solar energetic particle events of late October 1989. Figure 2 gives a time profile of the ions counted by SOPA during those events, broken down into the three principle ion mass groups. Clearly, this is an intense series of events, rich in heavy elements. There are four distinct flux enhancements in this event, one beginning on day 292, another on day 295, a third on day 297 and a fourth on day 302.

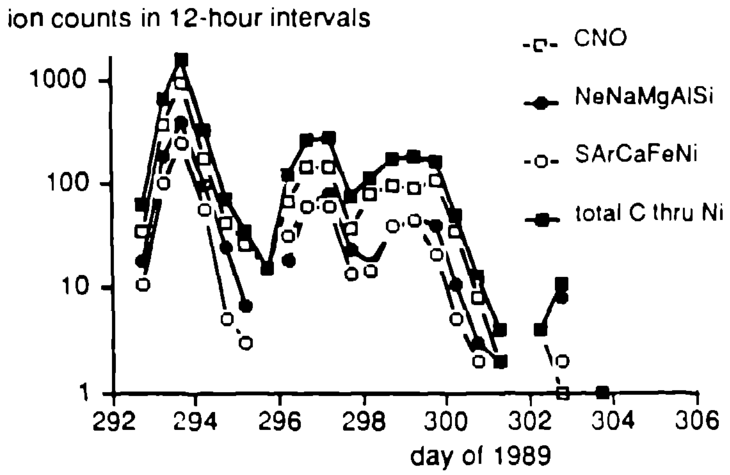

Figure 2. Time history of the 12-hour accumulations of pulse-height-analysis data from the SOPA instrument on spacecraft 1989-046 during the October 1989 events. Ion species identifications were made using synthetic pulse-height analysis curves from the TRIM Monte Carlo code, using a calibration similar to that shown in Figure 1.

Proton data for the same period from the CPA (Charged Particle Analyzer) on spacecraft 1984-129, (Reeves *et al.* 1991) is shown in Figure 3. The same four pulses are seen, marked **A**, **C**, **D**, and **E**, and the beginnings of each of these pulses are coincident with the times of X-ray flares (Speich, 1990). In addition there is another sharp enhancement in the proton flux, marked **B**, that is probably of local origin. The history of the heavy ion flux in Figure 2 clearly follows along with the proton flux history in Figure 3, indicating that all species are accelerated by the same events, presumably associated with the X-ray flares. These data are discussed more completely in Belain *et al.* (1991).

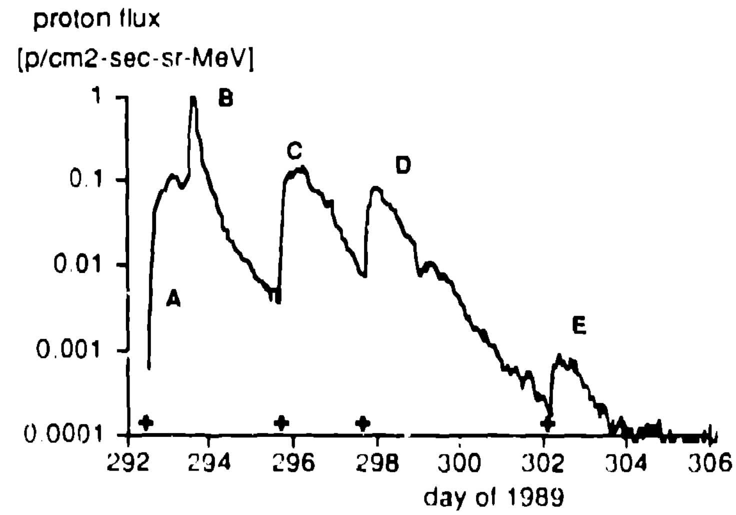

Figure 3. Hourly averaged fluxes from the CPA instrument on spacecraft 1984-129 of protons with energies above 10 MeV during the October 1989 events. The symbols **A** through **E** are labels for the proton flux enhancements during the event, all associated with solar X ray flares except **B**, which is presumably a local phenomenon.

Heavy ion data from more recent events of the present solar cycle are presented in Figures 4 through 6, in format similar to Figure 2. Figure 4 shows a small event in April 1990, Figure 5 shows the event of late January 1991, and Figure 6 shows the large event of March 1991.

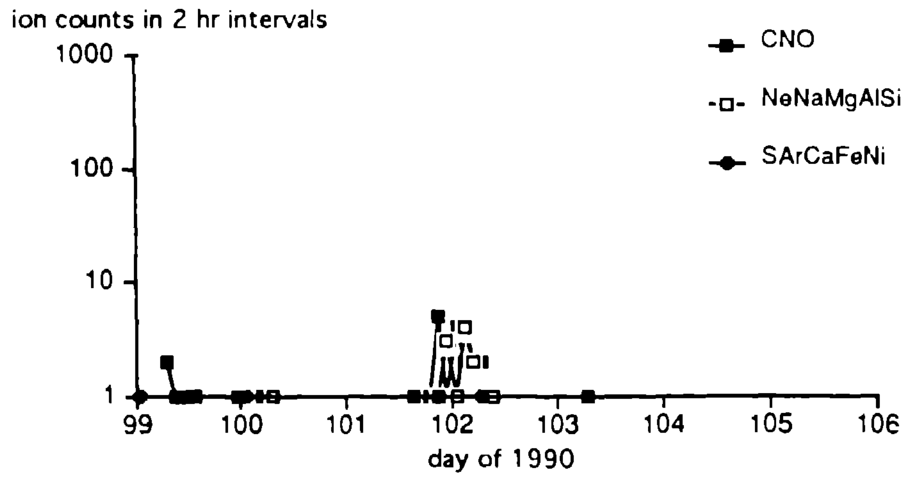

Figure 4. Two-hour counts of heavy ions detected by the SOPA instrument on spacecraft 1989-046 during the small solar energetic particle event of April 1990.

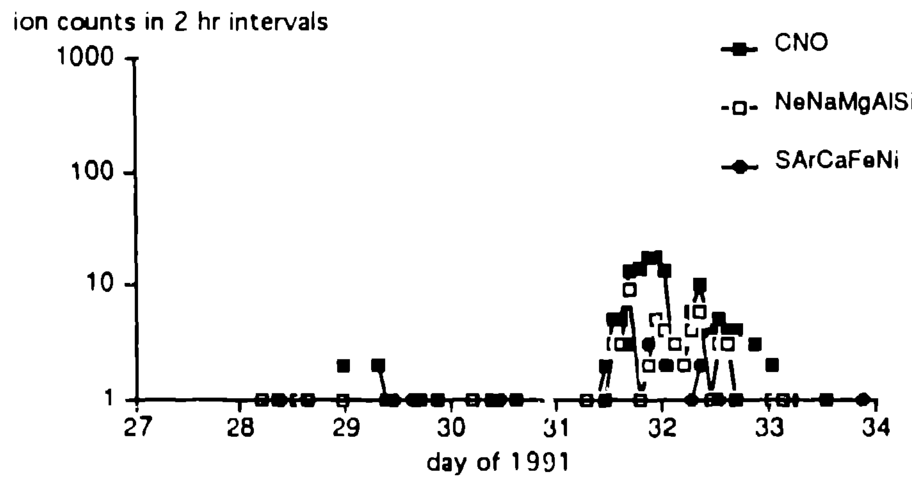

Figure 5. Two-hour counts of heavy ions detected by the SOPA instrument on spacecraft 1989-046 during the solar energetic particle event of January-February 1991.

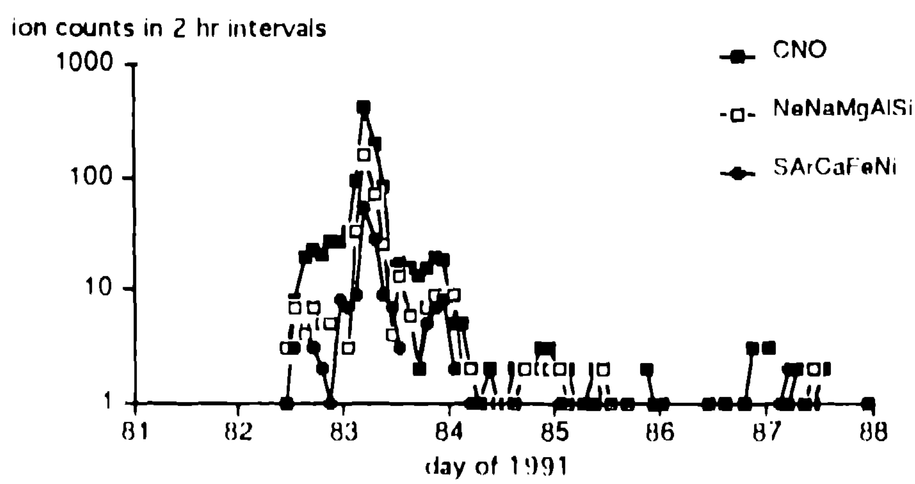

Figure 6. Two-hour counts of heavy ions detected by the SOPA instrument on spacecraft 1989-046 during the large solar energetic particle event of March 1991.

Acknowledgments

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