

Solar Energetic Particles (SEP), Solar Modulation and Space Radiation: New Opportunities in the AMS-02 Era

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X Flares and AMS-02 SEP Events at the Maximum of Cycle 24

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Abstract

23 instrument systems on 7 space flight missions were used during 2014 to examine solar flare activity over the period 15 February 2011 to 26 September 2014 which includes the maximum of sunspot cycle 24. Subsequently additional data from 5 other missions were added to this set. Owing to the increase in research assets available during this period and the use of new orbits and technology, the composite database has unique spatial and temporal coverage of solar flare activity. Included in this data set are 33 X-class flare events, 21 high energy SEP events detected by the AMS-02 device integrated into the ISS, and a several long duration high energy gamma-ray events detected by FERMI. Also included in this set are 12 geomagnetic events ($DST < -100$ nT), and one GLE solar cosmic-ray event.

Integrated soft x-ray fluxes, image time sequences, and difference image sequences of the disk, coronal mass ejection features, 14 mHz–10 kHz radio burst data and proton flux were examined for each of 61 events (33 X-flares, 23 M flares and 18 backside) with the aim of developing a characteristic observational model, focusing on LCPF, CME, Type III radio burst events, and SEP detections. This work outlines the parallels and differences detected between X-class flares and AMS-02 SEP events of this sample.

In 33 of 33 cases EUV running difference sequences of Fe XII disk images show the initiation of an LCPF at or near the time of flare onset. Bubble-type CME's frequently occurred after X-flare initiation. In 28 of 32 cases the SWAVES instruments on the STEREO A, B, and WIND spacecraft detected Type III radio bursts coincident in time with the X-flare initiation. In the case of 5 X-flares and 6 AMS-02 events, proton enhancements were detected at all 1AU spacecraft locations, indicating event scales of a fraction of the solar system.

In the case of the 21 AMS-02 events the LCPF and subsequent bubble-type CMEs were detected for all AMS-02 events. This type of flare associated event exhibited radio burst duration of > 2.5 hrs. AMS-02 events of this sample are poorly (or uncorrelated) with LCPF velocity, CME velocity or estimates of CME kinetic energy. AMS-02 events of this sample were characterized as 6 X-class flares, 11 M-class flares with a remaining 4 flares not observed or characterized by GOES (backside). NOAA x-ray class appears to be unrelated to AMS-02 event maximum energy. All AMS-02 events exhibit Type-III radio burst duration of > 2.5 hours (10 kHz contour). This appears to be a sufficient condition for AMS-02 SEP events. X- and M-class radio burst duration of flares used in this study are generally found to be shorter than 2.5 hrs. This distinction may prove useful for further SWx investigation.

Author: Dr FISHER, Richard (GSFC Heliophysics Science Division)

Co-authors: YAMASHIRO, Bryan (U. of Hawaii); ROCK, Kristine (Retired); Dr BINDI, Veronica (U. of Hawaii)

Presenter: Dr FISHER, Richard (GSFC Heliophysics Science Division)

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