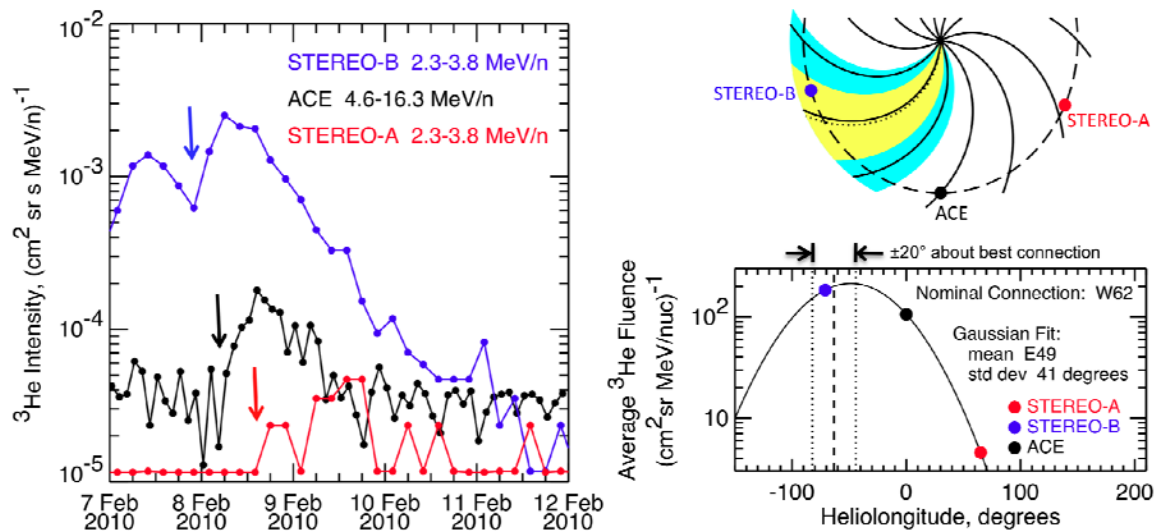


ACE News #137 -- December 30, 2010

Broad Longitudinal Spread of ^3He from Impulsive Solar Energetic Particle Events



Left: Individual ^3He -rich SEP events have been seen on STEREO and ACE even when the spacecraft are separated by over 100° of longitude. This is surprising since earlier studies indicated that these events have an approximately Gaussian distribution with $1\sigma \approx 20^\circ$ about the magnetic connection site (top right: yellow $\pm 20^\circ$, cyan $\pm 40^\circ$). We see a large intensity decrease with increasing longitude separation (bottom right) so events far from the source may have fallen below detectability thresholds in prior studies. In any case these observations show that magnetic connection to small flare sites can cover unexpectedly large longitudes.

In a widely held view of impulsive solar energetic particle (SEP) events, particle acceleration is powered by magnetic reconnection and ions and electrons can sometimes escape into the heliosphere on open field lines participating in the reconnection event. Studies of the longitudes of solar flares associated with single-spacecraft detections of SEP events containing ^3He , a commonly used indicator of impulsive events, found a relatively narrow distribution with a 1σ width $\sim 20^\circ$ (e.g., Reames 1999), which has been attributed to a point-like injection at the Sun.

Using data from the SIS and ULEIS instruments on ACE and the LET instruments on the two STEREO spacecraft we have investigated the longitudinal spread of energetic ^3He in individual SEP events, with the surprising result that coincident detections at ACE and at one of the STEREOs are common even when they are separated by nearly 90° in heliolongitude. In addition, impulsive events have occasionally been observed at all three spacecraft, as illustrated in the left-hand figure where the separation between the STEREOs was 136° . The sketch shows the spacecraft and flare locations and the Parker spiral magnetic field. ACE and STEREO-A are located outside the yellow and cyan shaded regions that indicate $\pm 20^\circ$ and $\pm 40^\circ$ spreads about the field line connected to the flare site. The detection of ^3He at STEREO-A, $>6\sigma$ away from the best-connected longitude, is completely unexpected based on the prevailing model of SEP escape from a point-like acceleration region.

It is notable that the observed ^3He intensity was a factor ~ 40 lower at STEREO-A than at the well-connected location of STEREO-B. The fluence of 2.3 to 3.8 MeV/nuc ^3He shows a strong dependence on longitude (lower right figure). If this proves to be a common feature of impulsive SEP events it might account for the significantly narrower longitudinal distributions found in the single-spacecraft studies: for a given detection threshold, small events, which are the most common, will be detected only over a limited range of longitudes. The physical mechanism responsible for the particle transport over a wide range longitudes and for the angular dependence of the SEP event intensities remains to be understood. The possible roles of flux tube expansion between the photosphere and the source surface, distortion of the heliospheric field by coincident CMEs, and transport associated with large-scale waves in the corona should be examined.

This item was contributed by Mark Wiedenbeck (JPL/Caltech), Glenn Mason (APL), and Christina Cohen (Caltech). Address questions and comments to mark.e.wiedenbeck@jpl.nasa.gov. For an archive of earlier ACE News items please see: http://www.srl.caltech.edu/ACE/ACENews/ACENews_Archives.html