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## Multi-spacecraft observations of widespread solar proton transport in the heliosphere

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We present multi-spacecraft observations of widespread solar energetic protons and discuss on the proton acceleration and transport in the wide spread events. Based on the list prepared by Dr. Seiji Yashiro from NASA for the past PSTEP-SEP-CDAW2 workshop in 2019; <https://sites.google.com/view/pstep-sep-cdaw2/home>, we have investigated wide spread solar proton events and found following signature; i.e. heliographic source of the solar proton distributes in a wide range from -180 degrees to 180 degrees with respect to the central meridian longitude. The bottom figure demonstrates the dependence of the onset time delay of the solar proton after the solar flare upon the heliographic position of source flares. Delay time seems shorter for the western source cases than that for eastern source cases. The shortest delay time was 15 min. and the location of source flare was 100 deg. west in this case. These solar proton events associated CMEs, and the speed of the ejected CMS exceeds 900 km/sec for all cases. By using multi-spacecraft observation data, we have examined the deference of onset times at each spacecraft in detail. In some cases, onset times of the arrived solar protons at each spacecraft were quite similar even though the locations of the spacecraft were quite far. Closer inspection revealed that the solar flare occurred around the sector boundary of the solar magnetic field, where the neutral current sheet structure likely exists. When the energetic solar protons are emitted into the heliospheric neutral sheet structure, these solar protons easily spread widely, resulting in the widespread solar energetic protons as shown in the figure.

Figure caption: The dependence of the time-delay of the solar proton arrival after the solar flare upon the heliographic position of source flares.

