STEREO Science Highlight

Longitudinal Extent of ^{3}He-rich Solar Energetic Particle Events Near 1au

Ho, G. C., Mason, G. M., Allen, R. C., Kouloumvakos, A., Wimmer-Schweingruber, R. F., Rodríguez-Pacheco, J.
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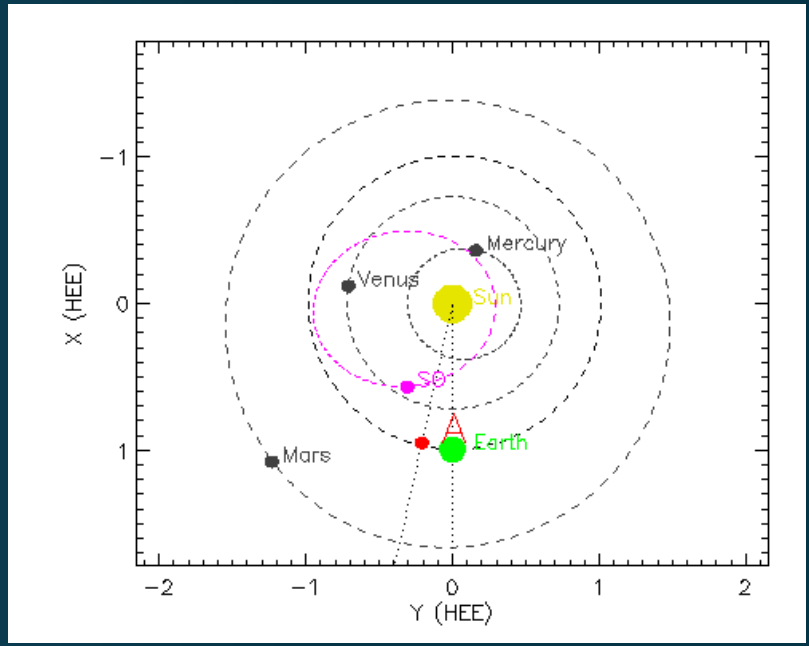
Background

- Knowing the angular extent of various types of solar energetic particle (SEP) events is essential to better understand the physical mechanism associated with particle acceleration and transport and to forecast key radiation risks in interplanetary space.
- ^{3}He-rich SEP events are energetic particle events where the ratio of ^{3}He to ^{4}He is enhanced as compared to the solar wind value, often by several orders of magnitude. They are typically associated with type III radio bursts.
- The longitudinal extent of ^{3}He-rich SEP events had been unknown as multiple simultaneous measurements are needed to determine it. This is critical to determining where they originate from on the Sun.

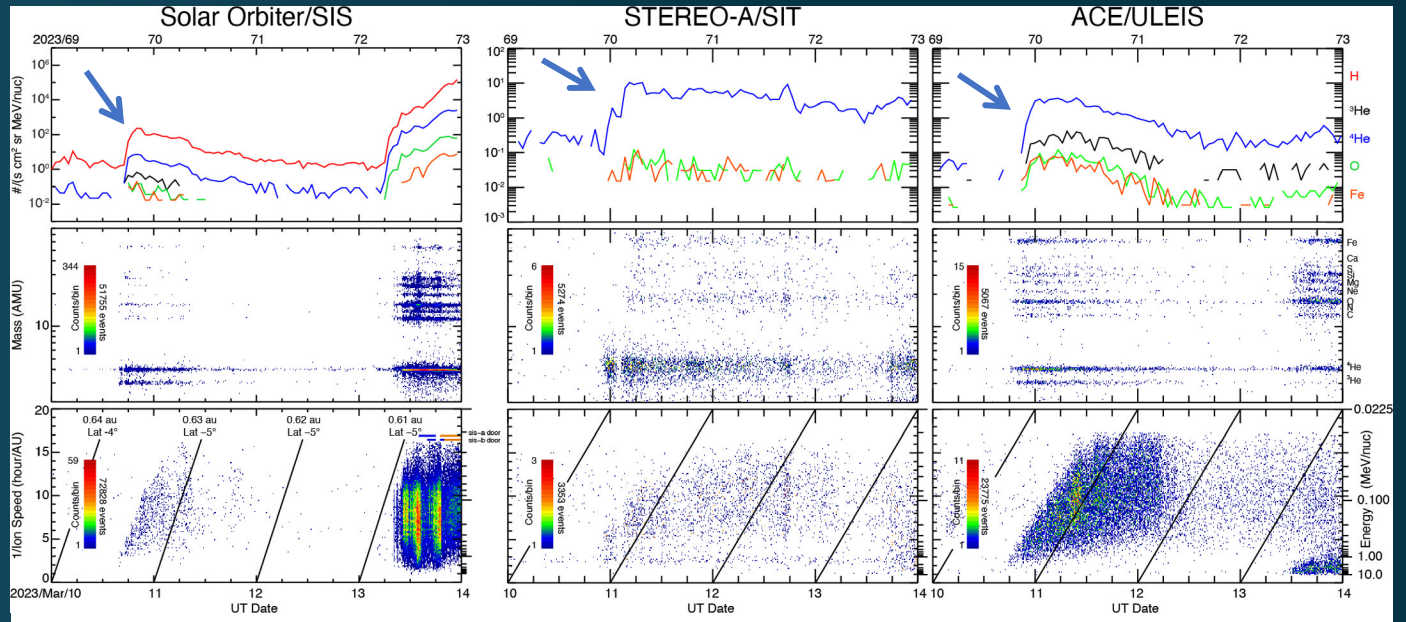


Above: STEREO-A (red), Earth (ACE, green) and Solar Orbiter (purple) positions on 2023 March 10. *Credit: Where is STEREO page (NASA)*

Analysis

- ^{3}He-rich SEP events were identified using STEREO-A, ACE and Solar Orbiter from 2022 November to 2023 March for particles with energy of a few 100s of keV per nucleon using the following missions/instruments
  - STEREO-A/Suprathermal Ion Telescope (SIT)
  - ACE/Ultra-low-energy Ion Spectrometer (ULEIS)
  - Solar Orbiter/Suprathermal Ion Spectrograph (SIS)

Fifteen events were measured by at least one spacecraft, but only five by two or three spacecraft.



Above: Energetic ion measurements from Solar Orbiter/SIS, STEREO-A/SIT, and ACE/ULEIS (left to right) from 2023 March 10–14, showing an ^{3}He-rich event detected by the three spacecraft on 2023 March 10. The top panels show time intensity plots of ~200 keV nucleon^{-1}ions from each of the three instruments. The red trace shows the proton intensity, blue the ^{4}He, black the ^{3}He, green the O, and orange the Fe. The middle panels show mass spectrograms for heavy ions (helium and heavier) for up to 10 MeV nucleon^{-1} ; and the lower panels show the inverse-velocity measurements of heavy ions (C–Fe). *Credit: adapted from Ho et al., ApJ, 2024*

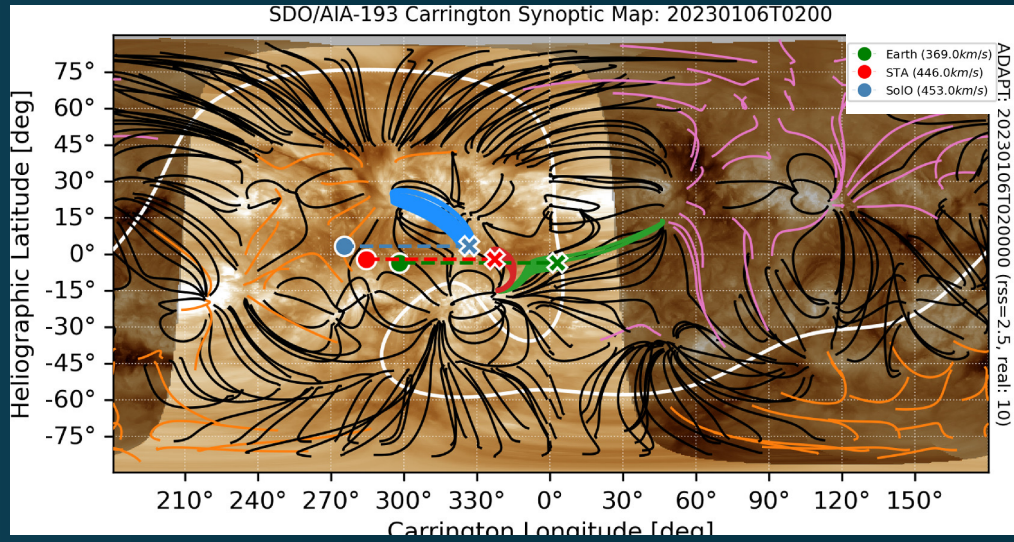
Findings

Taking into account the source region of the events at the Sun, spacecraft which are connected to within 30° of the source region are likely to measure the ^{3}He-rich SEP events, spacecraft beyond 30° are not.

For most simultaneously observed events the spacecraft footpoint is less than ~30° in angular separation from the source region.

This confirms that the source of these ^{3}He-rich SEP events is narrow in longitudinal extent, perhaps from a small reconnection event at the boundary of an active region

The study also confirms that there can be remnant material from impulsive solar flares that spreads the ^{3}He over wide longitudes at 1 au and can last for about 10 days.



Above: Connectivity map produced for the 2023 January 6 ^{3}He-rich event overlaid on an SDO/AIA 193 Å Carrington map. The locations of the different spacecraft are indicated by the circles, and the footpoint location of the Parker spiral to the source surface at 2.5 $R_\odot$ is depicted with the cross. Colored lines from the crosses show connection to model magnetic field lines in the corona. The white line is the modeled HCS. *Credits*: adapted from Ho et al., ApJ, 2024

Publication Information

- Publication information
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