Towards Explaining Galactic Cosmic Ray Modulation in a Dynamic Heliosheath

While traveling through the heliosheath (HS), Voyager 2 (V2) observed multiple sustained **flux depletions of galactic cosmic rays** (GCRs) on scales of months to years. It is still debated whether these modulation episodes were caused primarily by **spatial effects** related to differences in particle diffusion tied to the local magnetic field geometry or by **temporal effects** associated with transient solar wind structures advecting outward.

Science Question:

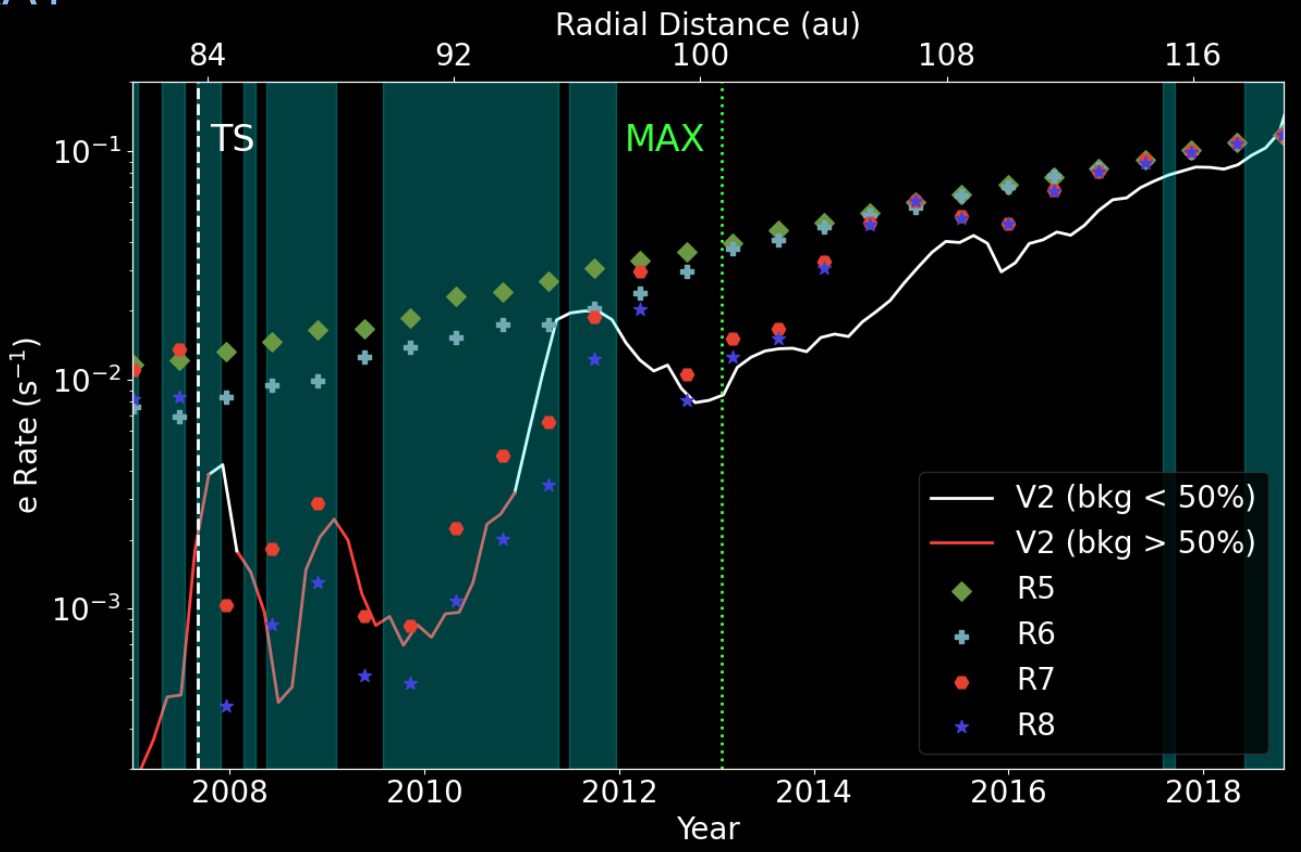
- Is the GCR behavior in the HS, as observed by V2, dominated by spatial or temporal effects?

Method:

- We used an analytic, time-dependent model of the heliosphere and solved the Parker transport equation for GCRs throughout a simulated V2 trajectory.

Results:

- The large-scale GCR depletions episodes in the HS are much easier to replicate appealing to transient modulation structures emanating from the Sun. This implies that **space weather effects are still relevant in the outer heliosphere**.



Observed (solid line) and simulated (symbols) GCR electron rate in the along the V2 trajectory in the HS. The white/red color on the measured rate denotes a signal-to-background ratio above/below 1. Results labeled R5 and R6 did not include the effects of transient modulation structured advected from the Sun, while the results labeled R7 and R8 did, and the latter match the observations much better. The vertical dashed lines mark the termination shock (white) and the solar cycle maximum (green).

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