



An Exploration of Small Flux Rope Boundary Identification Methods



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Introduction

- Small flux ropes (SFRs) are small (radius 0.01 to 0.05 au) magnetic structures with field lines wrapped around an axis.
- One open question is: What is the best way to identify the SFR boundaries?
- For example, Murphy+ 2026, Chen+ 2020, and Zhao+ 2020 include lists of SFRs observed during PSP's first encounter, but in the cases where they identify the same event, they disagree about the boundary locations (see Figure 1).
- In this work, we analyze the boundary markers used in each event and explore the hypothesis that including the presence of discontinuities and current sheets as ID criteria will lead to better results.

Methodology

- We use the encounter 1 event lists from Chen+ 2020 and Zhao+ 2020.
- We use data from the Parker Solar Probe (Fox+ 2016) spacecraft's FIELDs/MAG (Bale+ 2016) and SWEAP/SPC (Case+ 2020).
- We examine each event for the presence of current sheets and discontinuities within 10 minutes of each of the boundaries given.
- We then calculate the number of events that have a current sheet within 10 minutes of the starting boundary (but none near the end), the number of events that have a current sheet near the rear boundary (but none near the start), the number of events with a current sheet near each boundary, and the number of events with no significant current sheets near either boundary.

Example Events

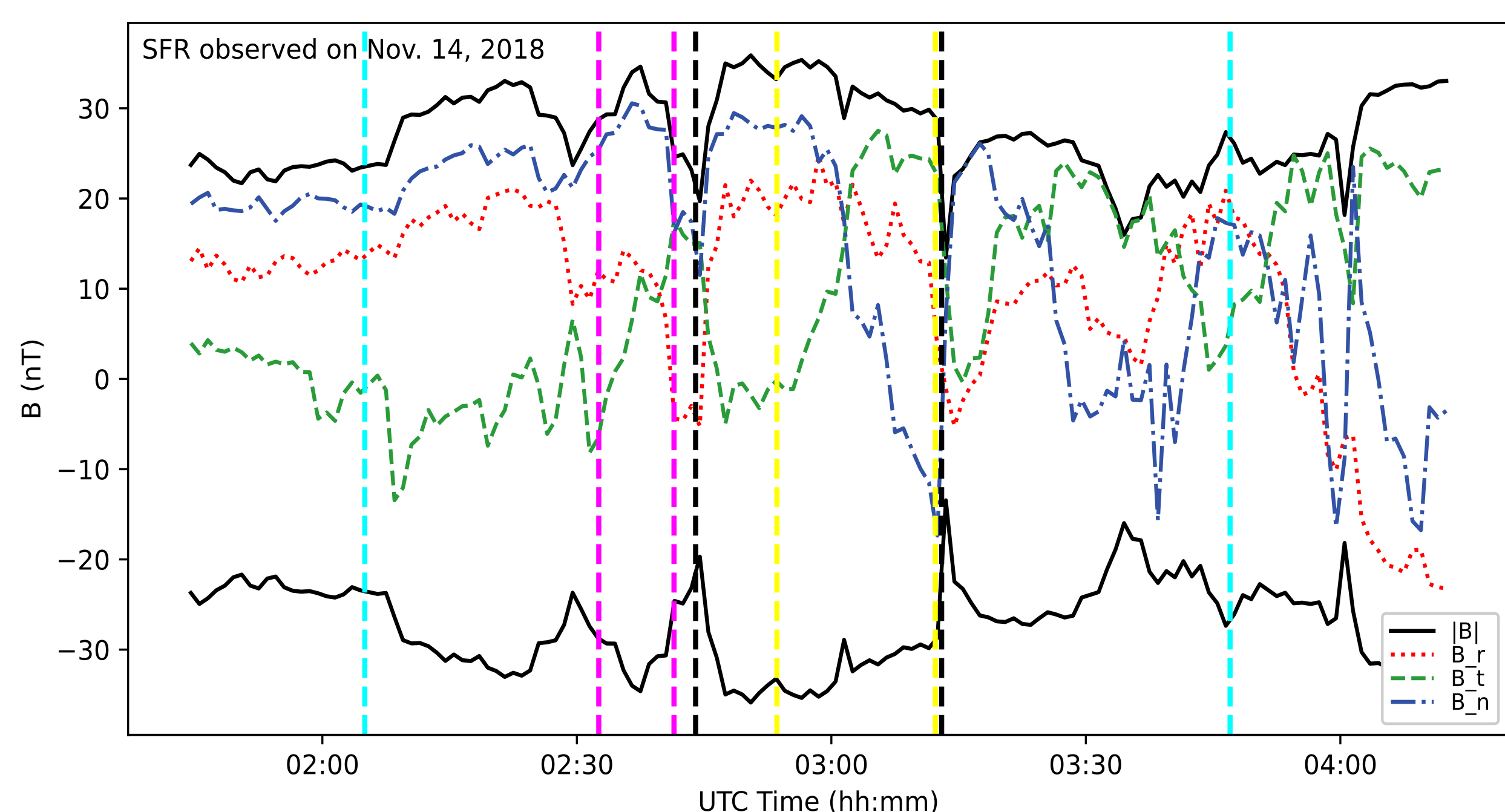


Figure 1: An SFR observed on 14 November 2018 that is on the Chen, Zhao, and Murphy+ 2026 lists. Black lines show the event boundaries from Murphy+ 2026, cyan lines the boundaries from Zhao+ 2020, and the magenta and yellow lines the boundaries from the two events identified in this interval by Chen+ 2020.

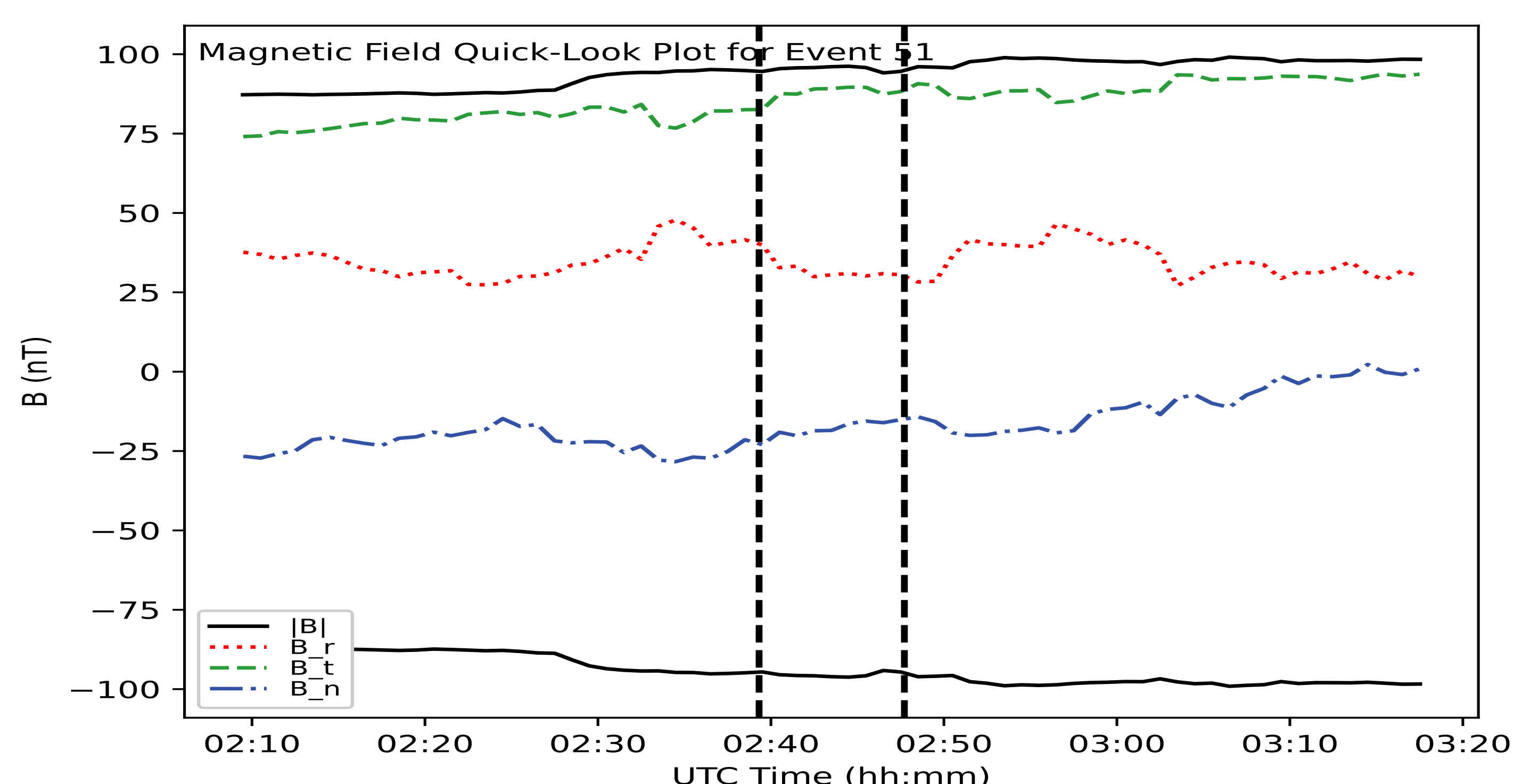


Figure 2: An SFR from the Chen+ 2020 list.

Number of Events with Current Sheets

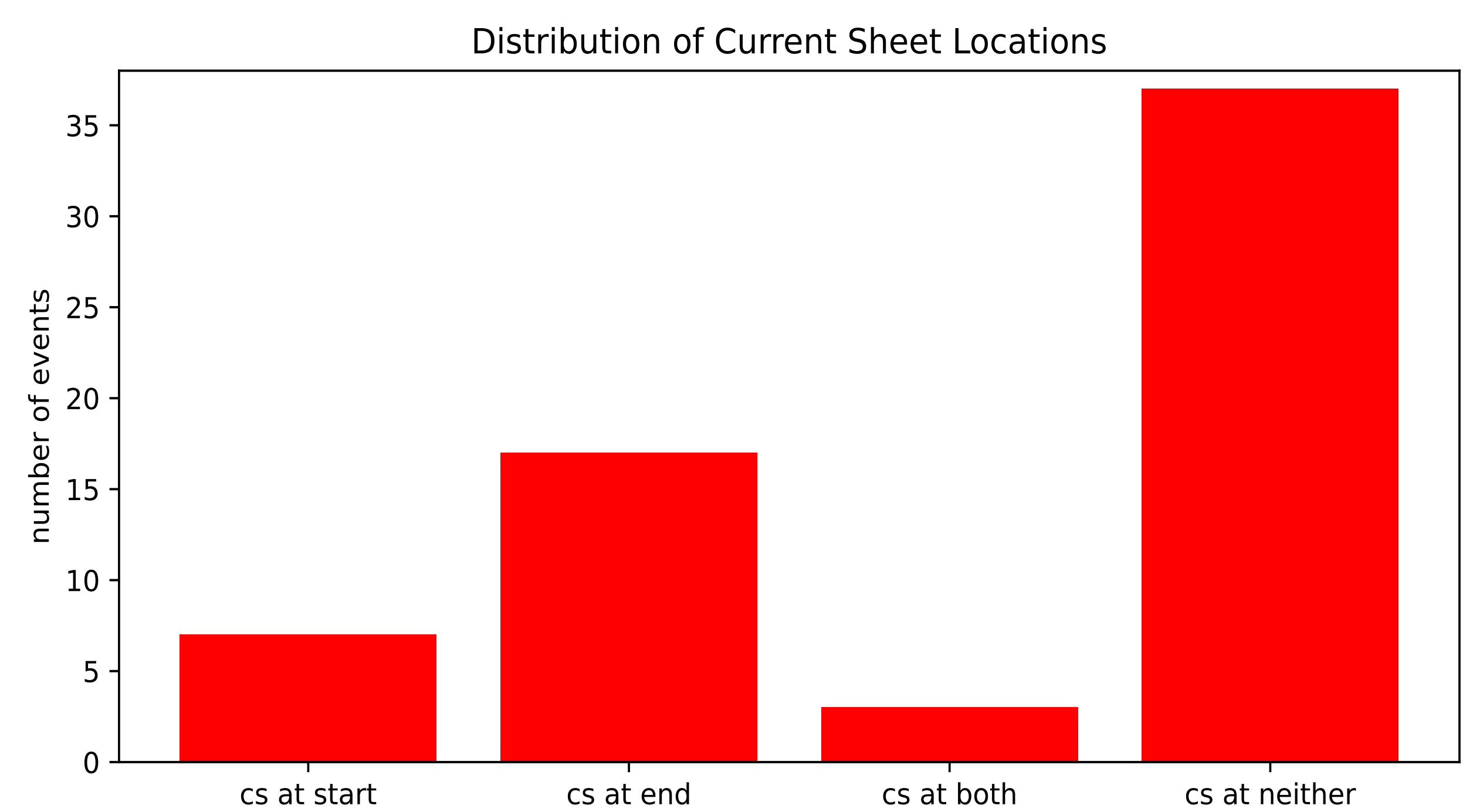


Figure 3: How many events have current sheets at the beginning, at the end, at both sides, or at neither side.

Number of Events with Discontinuities

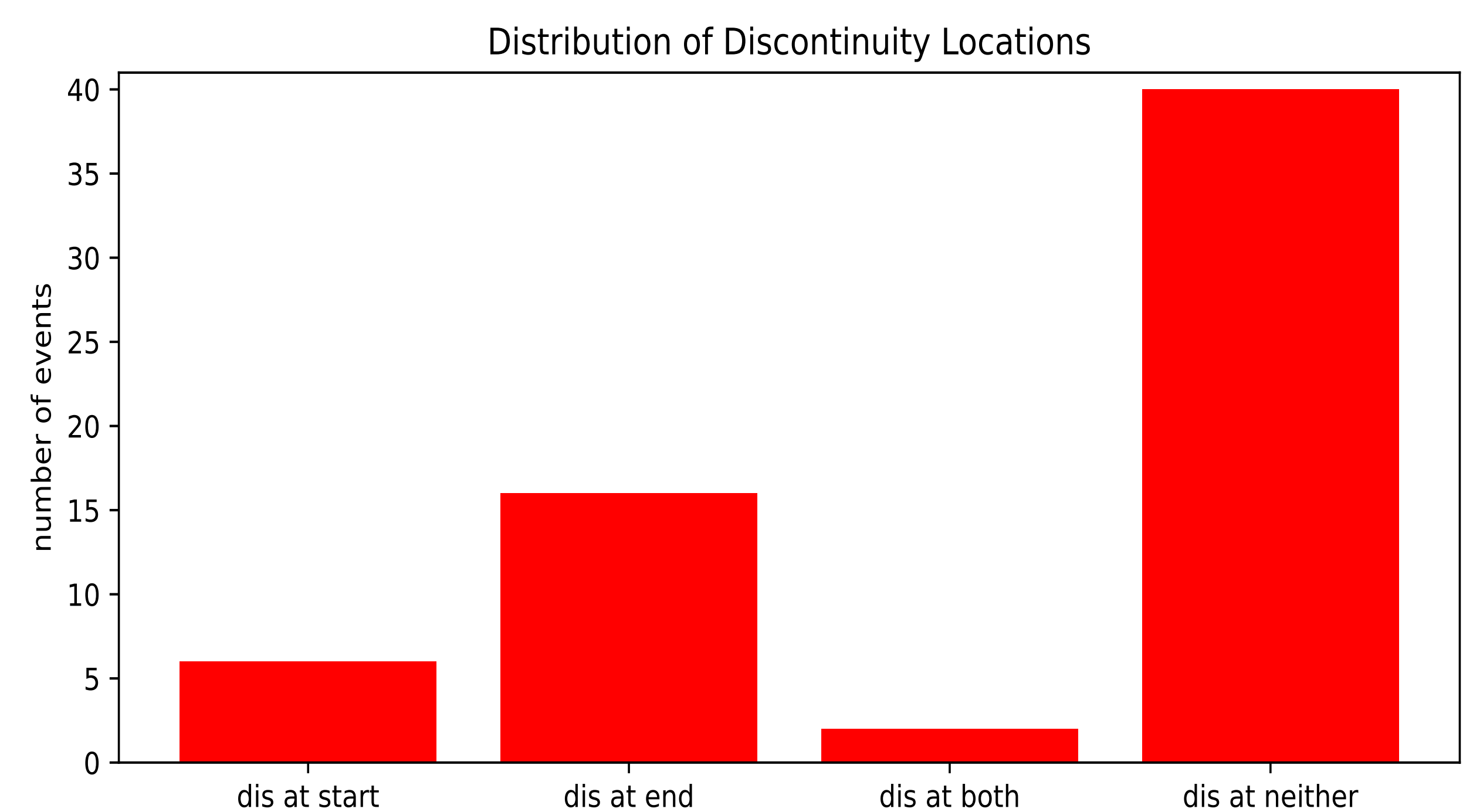


Figure 4: How many events have discontinuities at the beginning, at the end, at both sides, or at neither side.

Discussion

- While most of the events didn't have obvious current sheets or discontinuities within 10 minutes of the boundaries, many had current sheets and/or discontinuities farther away.
- There are more than twice as many events with current sheets and/or discontinuities near the end as near the beginning. This could be due to the interaction of the SFRs with the solar wind, or it could be an artifact of the identification methods.
- It was rare to find obvious current sheets and/or discontinuities at both sides of an SFR.
- Next steps: analyzing more events, looking for current sheets and discontinuities farther away from the boundaries, analyzing the relationships between current sheets and discontinuities and other boundary indicators such as the rotation start and end points, and using more quantitative approaches (such as PVI) to locate current sheets and discontinuities in the data.

References

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