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Multi-Spacecraft Observations of the Evolution of ICMEs Between 0.3 and 2.2 AU: Conjunctions with Juno

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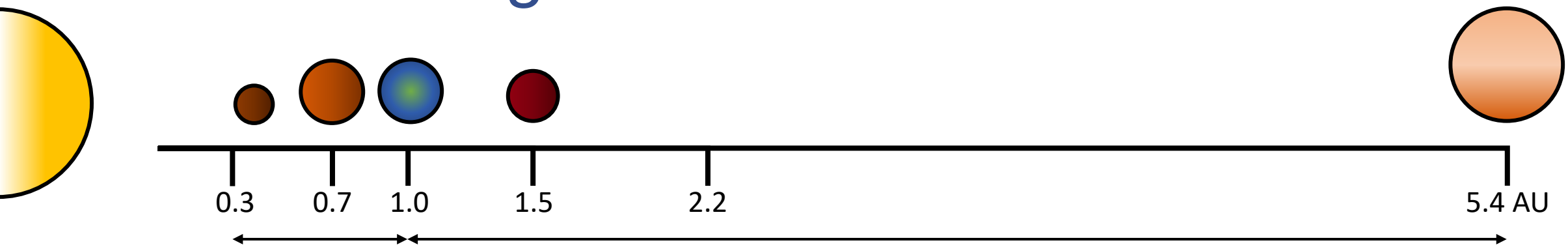
ICME Catalogues



Helios (0.3-1 AU)
e.g. Cane et al. 1997; Bothmer & Schwenn 1998

ACE/Wind and STEREO (1 AU)
e.g. Cane & Richardson 2003; Richardson & Cane 2010; Jian et al. 2018

Ulysses (1–5.4 AU)
e.g. Liu et al. 2005; Wang et al. 2005; Ebert et al. 2009; Du et al. 2010; Richardson 2014)

MESSENGER
(0.3–0.5 AU) Winslow et al. 2015, 2017
(0.3-1 AU) Good & Forsyth 2016

Juno
(1-5.4 AU) Davies et al. 2021

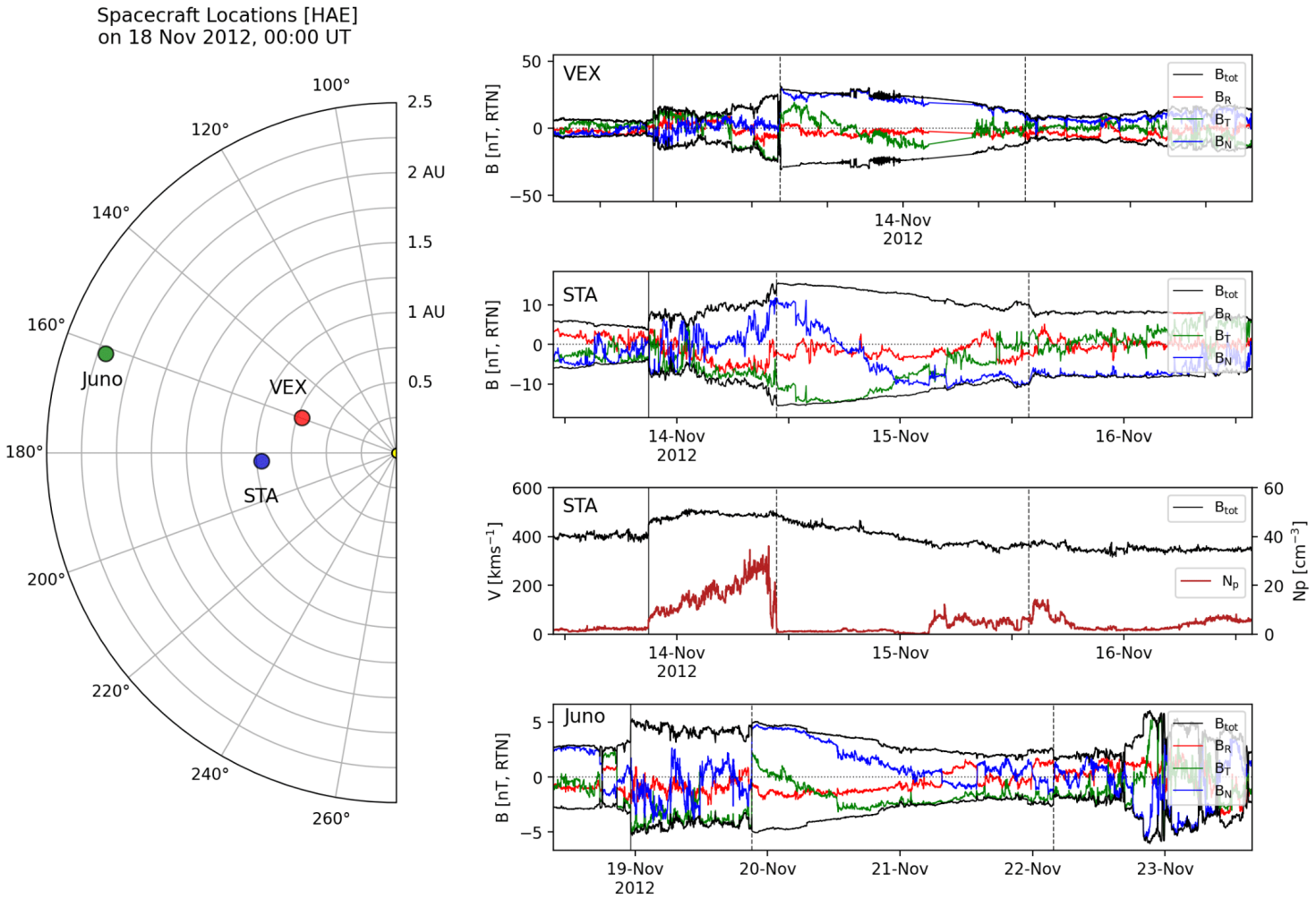
Venus Express
(0.7 AU) Good & Forsyth 2016

Davies et al. (Accepted in ApJ)

Good et al. 2019: 18 ICME events with clear magnetic flux rope structures
Salman et al. 2020: 47 ICMEs observed by two or more radially aligned spacecraft

Identification of Events

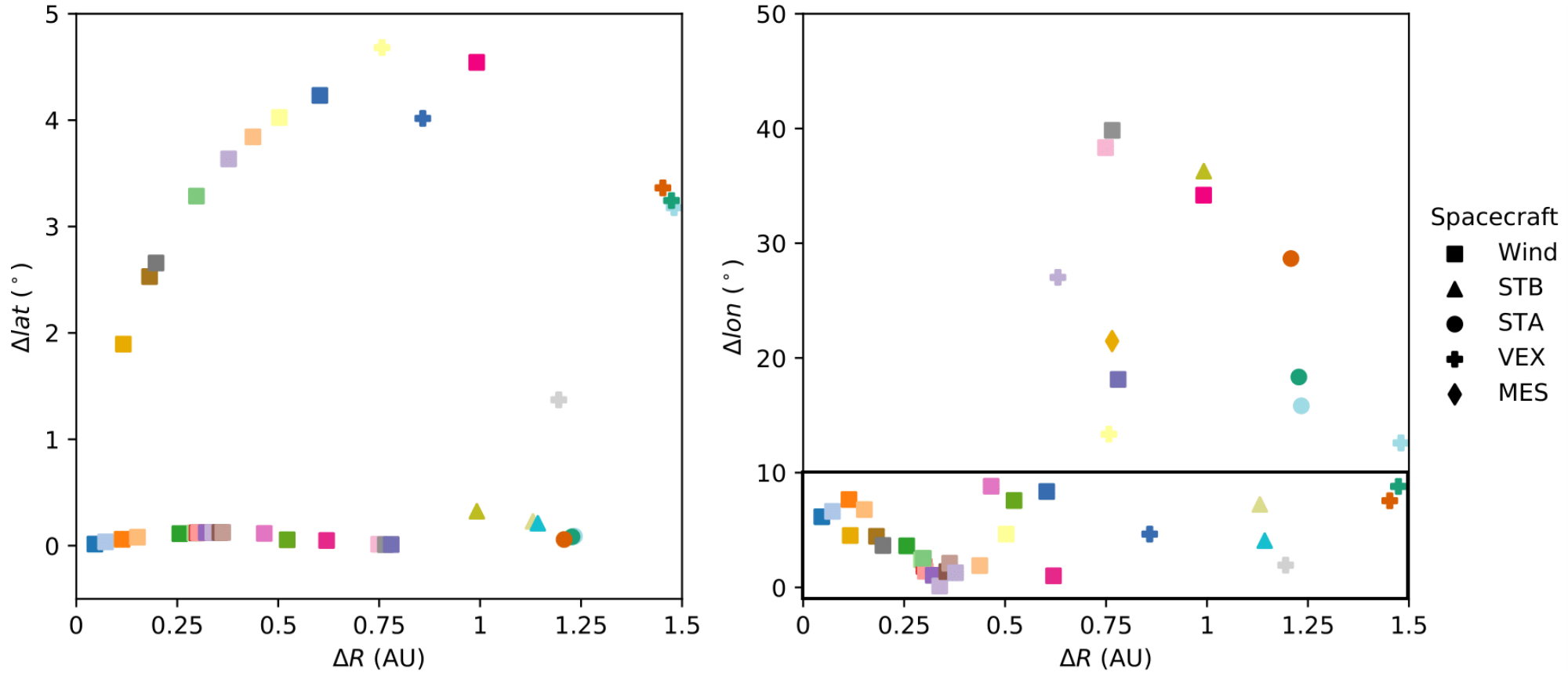
- Back-propagated events identified at Juno by Davies et al. 2021.
- With only magnetic field data available at Juno, we recognise that the Juno ICME catalogue may not be an exhaustive list.
- Worked forwards from previously catalogued events (Helio4cast, Salman et al. 2020, Richardson et al. 2010) to establish links with signatures in the Juno magnetic data that may not have been previously identified.



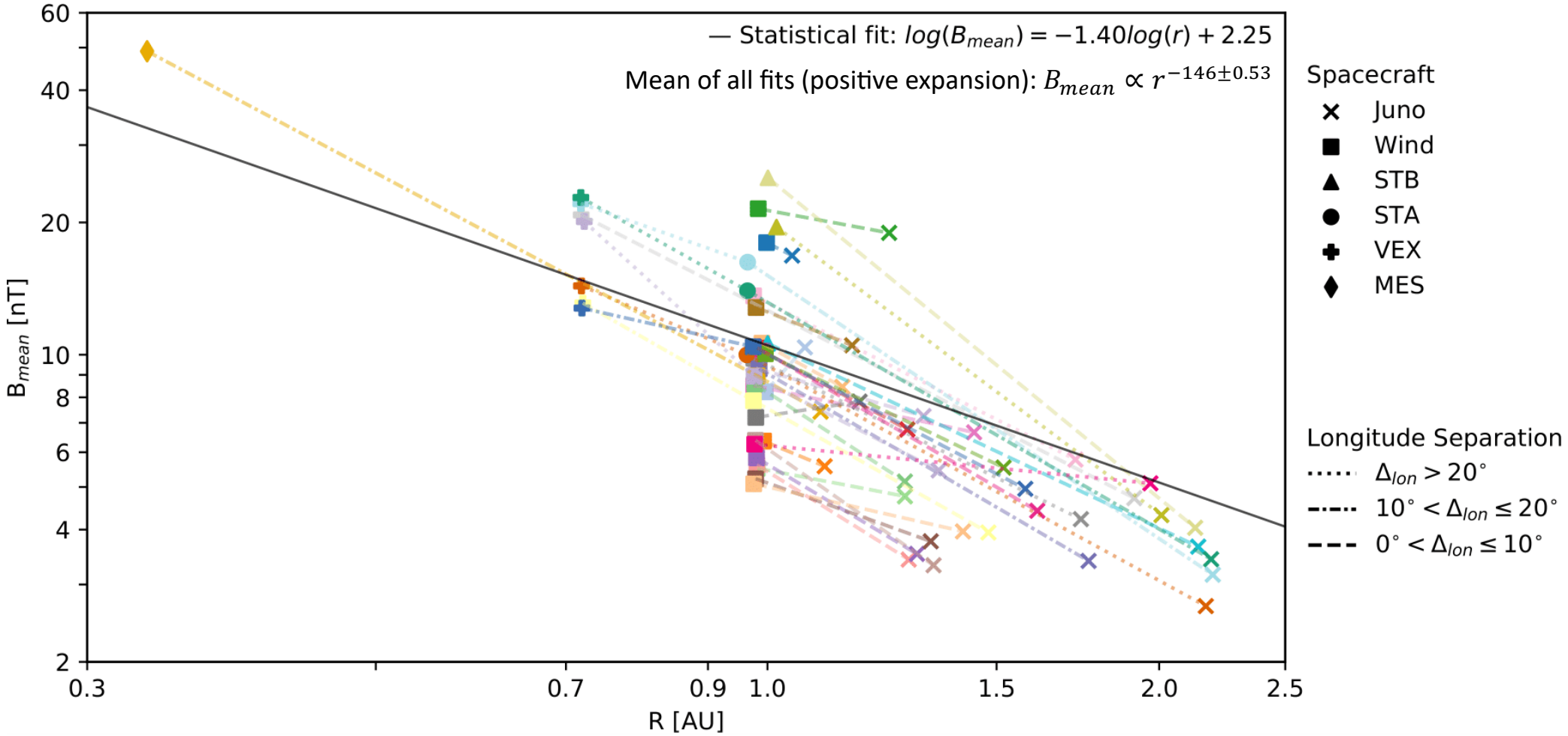
All underlined studies are hyperlinked!

Catalogue of Multi-Spacecraft ICMEs

- A total of 35 multi-spacecraft events were identified, 7 of which had not been identified in the Juno ICME catalogue.

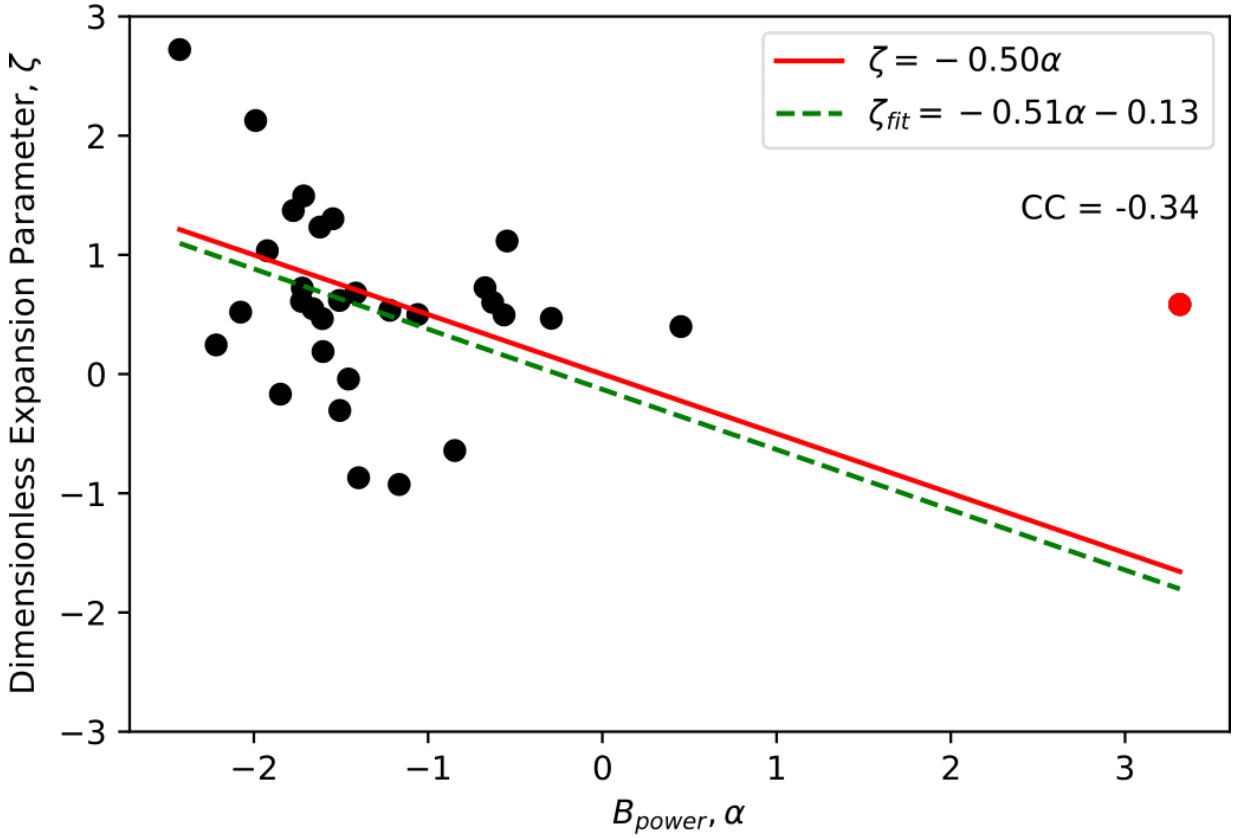


Variation of Event Properties with Heliocentric Distance



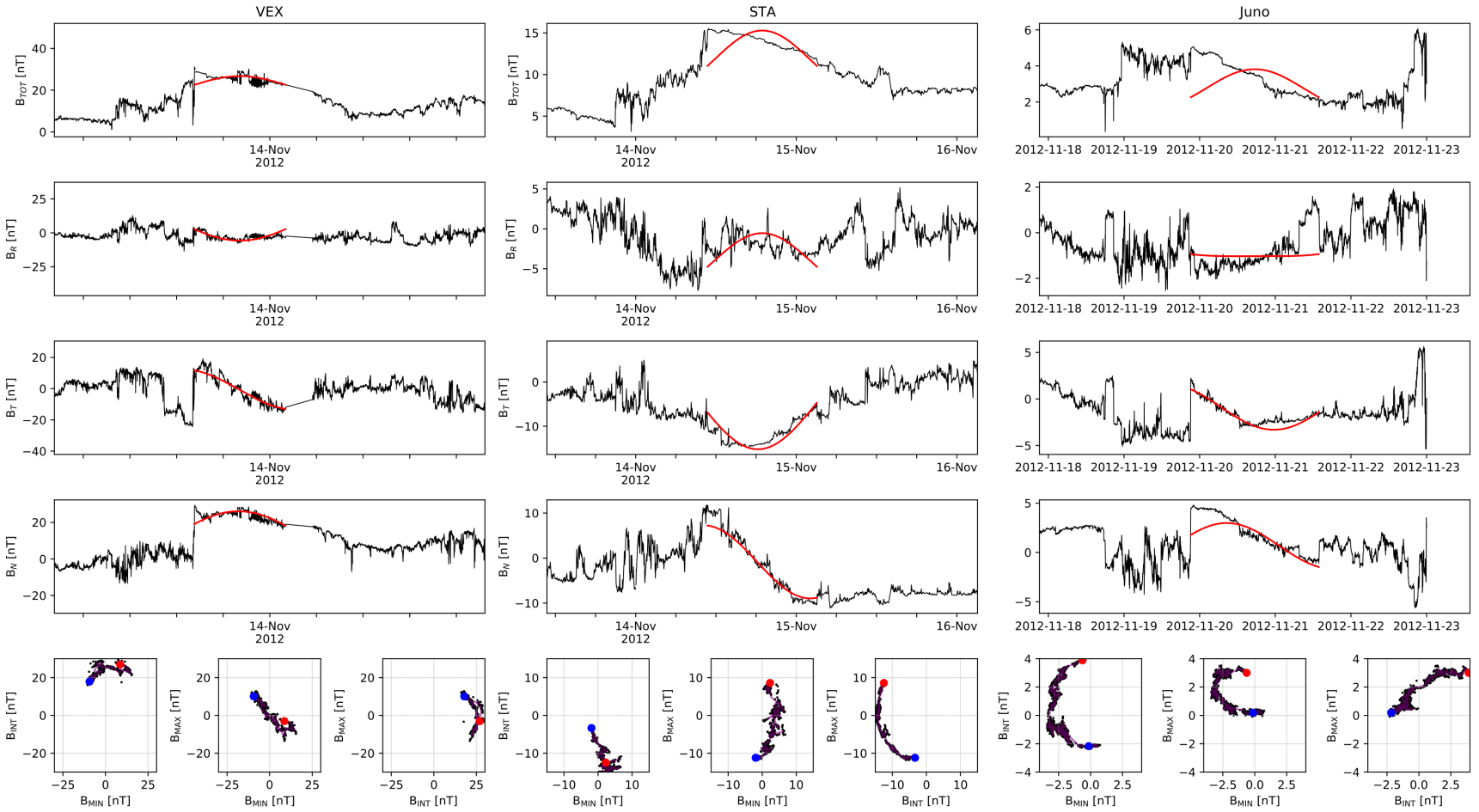
Comparing Local and Global Measures of Expansion

- The dimensionless expansion parameter provides a measure of the local expansion of an ICME: $\zeta = \frac{\Delta v}{\Delta t}\frac{r_H}{v_c^2}$
- ζ is independent of distance and found to be related to the global expansion as $r^{-2\zeta}$.
- Despite the best fit following the expected relationship between the two parameters, they are weakly correlated.



Evolution of Events with Magnetic Flux Ropes

- 10 events with magnetic flux ropes were identified and fit using a linear force-free model.
- 64% of events displayed a decrease in inclination with increasing heliocentric distance.
- The mean decrease in inclination across all events was found to be only 3°.



Summary

- We have identified 35 multi-spacecraft events, Most of events were observed by Juno and one other spacecraft at 1 AU (Wind, STEREO-A, or STEREO-B), 7 of which were observed by a third spacecraft (MESSENGER or Venus Express).
- Statistical relationships of the magnetic field strength with distance agree with those previously found. However, there is a large spread in radial dependencies calculated for individual events.
- We found that the local and global expansion parameters were weakly correlated with a correlation coefficient of -0.34, despite the best fit to the data being consistent with the expected relationship.
- 64% of events with clearly identifiable magnetic flux ropes were found to display a decrease in flux rope inclination with increasing heliocentric distance, suggesting that a very small change in flux rope inclination may continue to occur beyond 1 AU.

Juno ICME Catalogue:
Davies et al. 2021, ApJ
DOI: 10.3847/1538-4357/ac2ccb

Multi-Spacecraft Catalogue:
Davies et al. Accepted, ApJ
ArXiv DOI: 10.48550/arXiv.2205.09472