

Pinching of ICME Flux Rope: Multipoint Observations of Internal Magnetic Reconnection during Gannon's Superstorm

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In collaboration with

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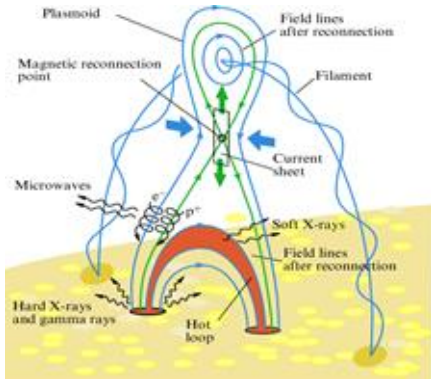
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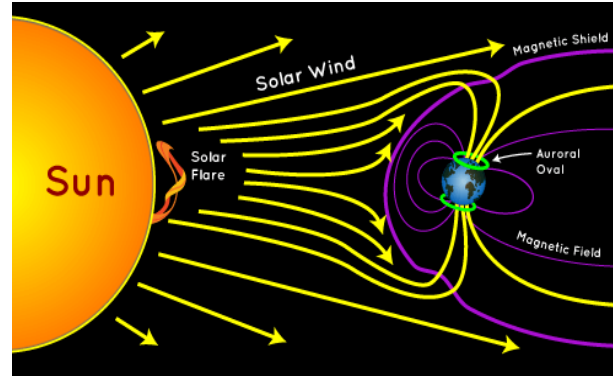
Magnetic Reconnection in Heliosphere

Solar Flares



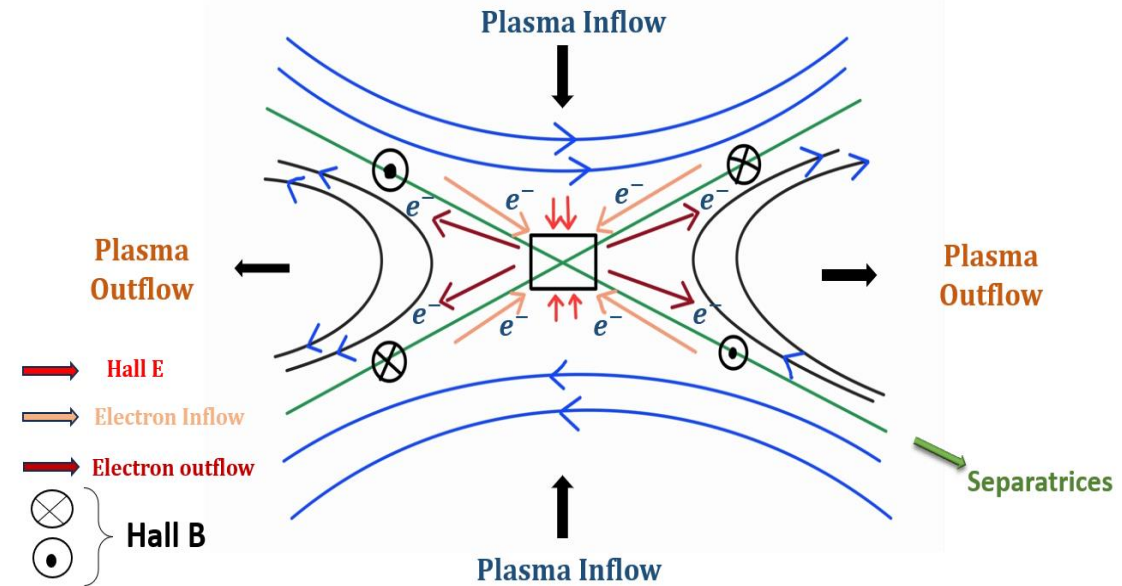
Source: Wikipedia

Planetary Magnetospheres

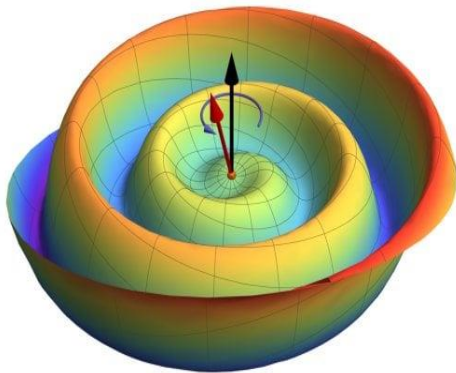


Source: NASA

Magnetic Reconnection Topology

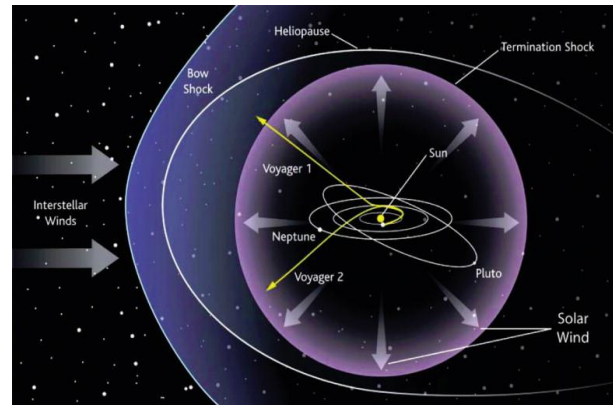


Heliospheric Current Sheet



Source: Orcinha+ 2019, Journal of Physics: Conference Series

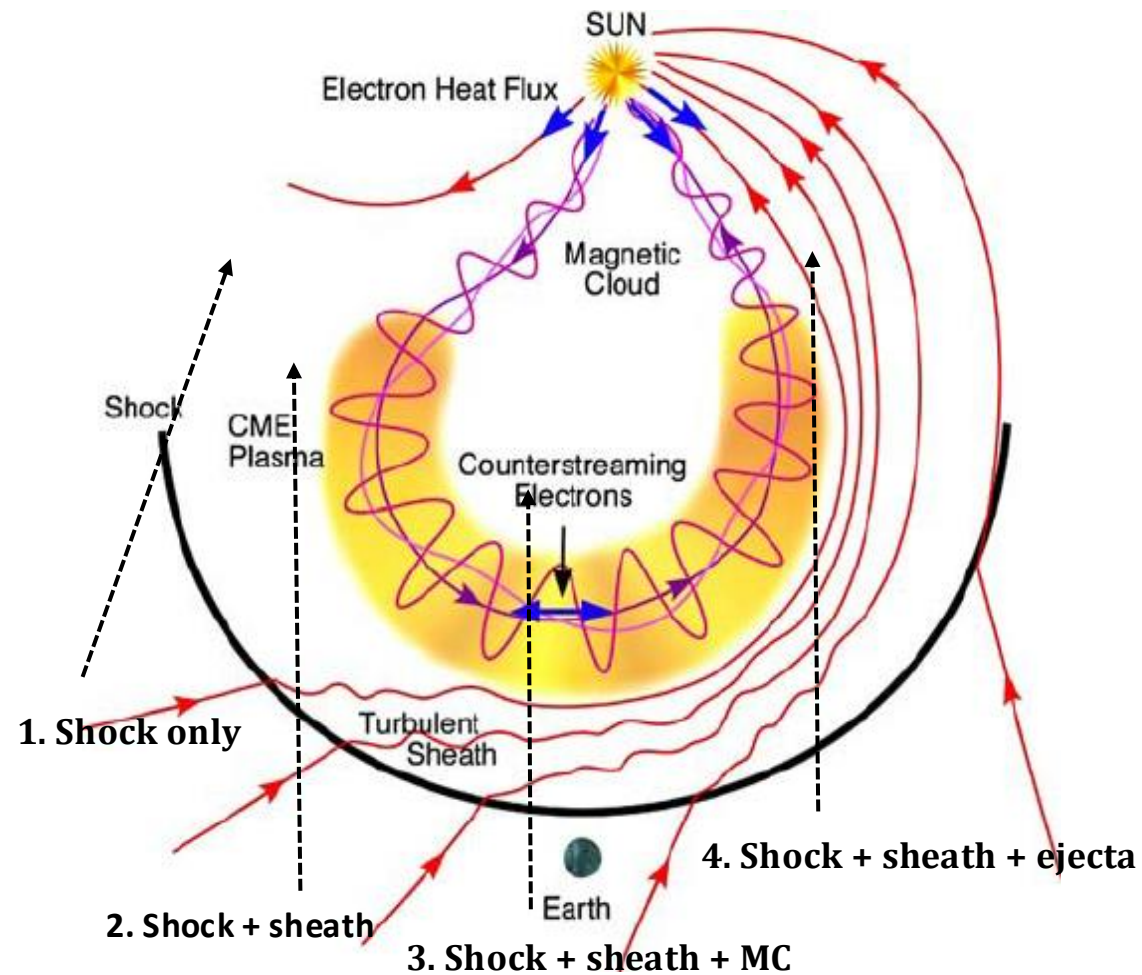
Heliopause



Source: ScienceDirect

Swisdak+ 2013, ApJL;
Drake+ 2010, ApJ

Interplanetary Coronal Mass Ejection (ICME)

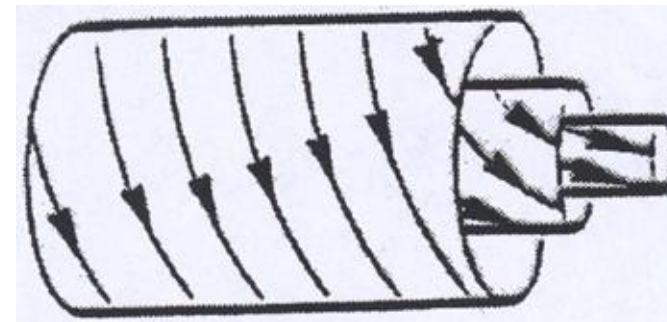


Source: Lysenko et al, X-ray and gamma-ray emission of solar flares. Physics-Uspokhi. 63. 10.3367/UFNe.2019.06.038757.

ICME- Morphology (in-situ Observation)

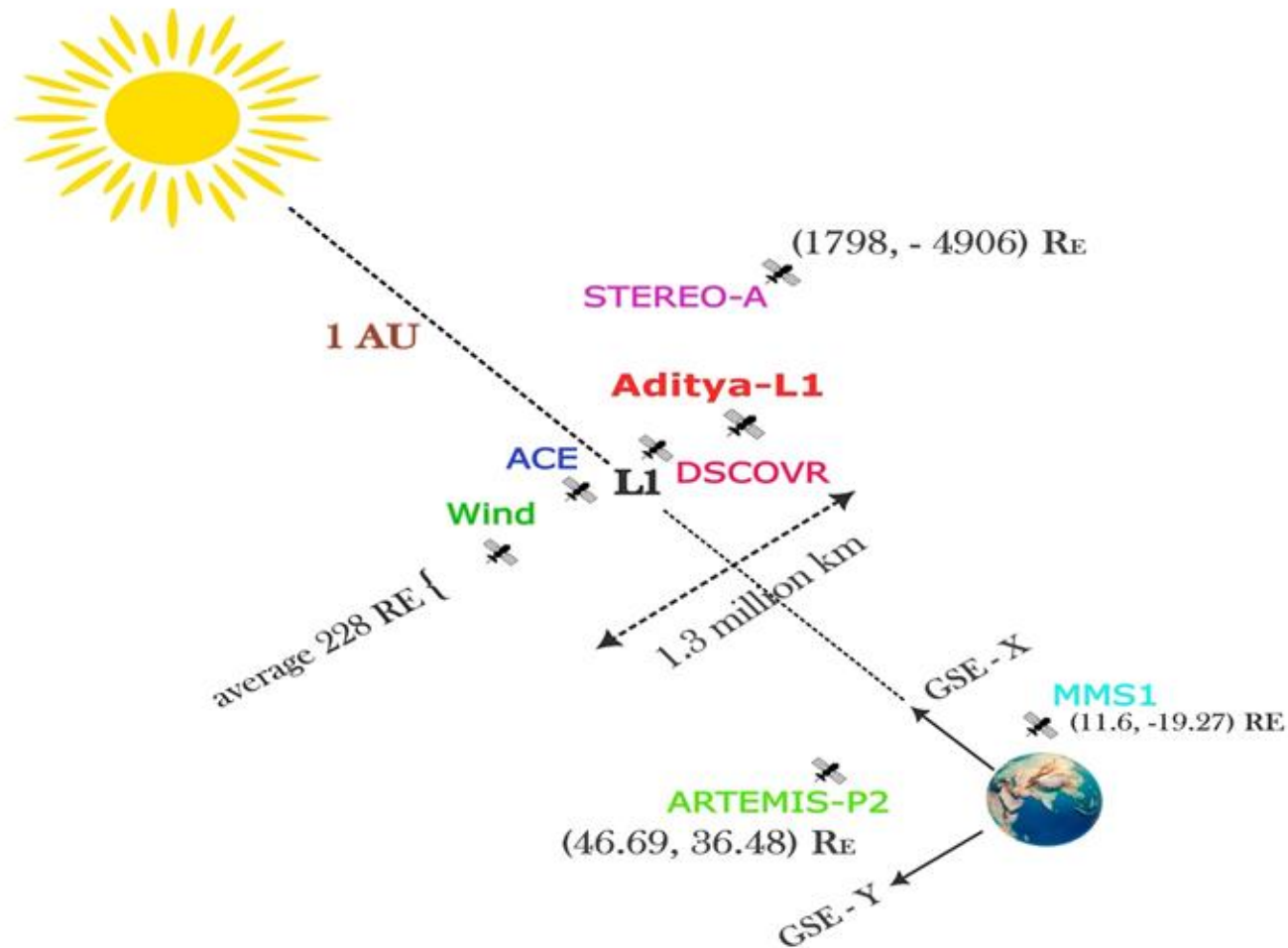
- Shock
- Compressed solar wind (sheath)
- Ejected Coronal mass (magnetic flux rope)

Magnetic flux rope (MFR)



Source: Kilpua et al., Annales Geophysicae. 23. 10.5194/angeo-23-625-2005.

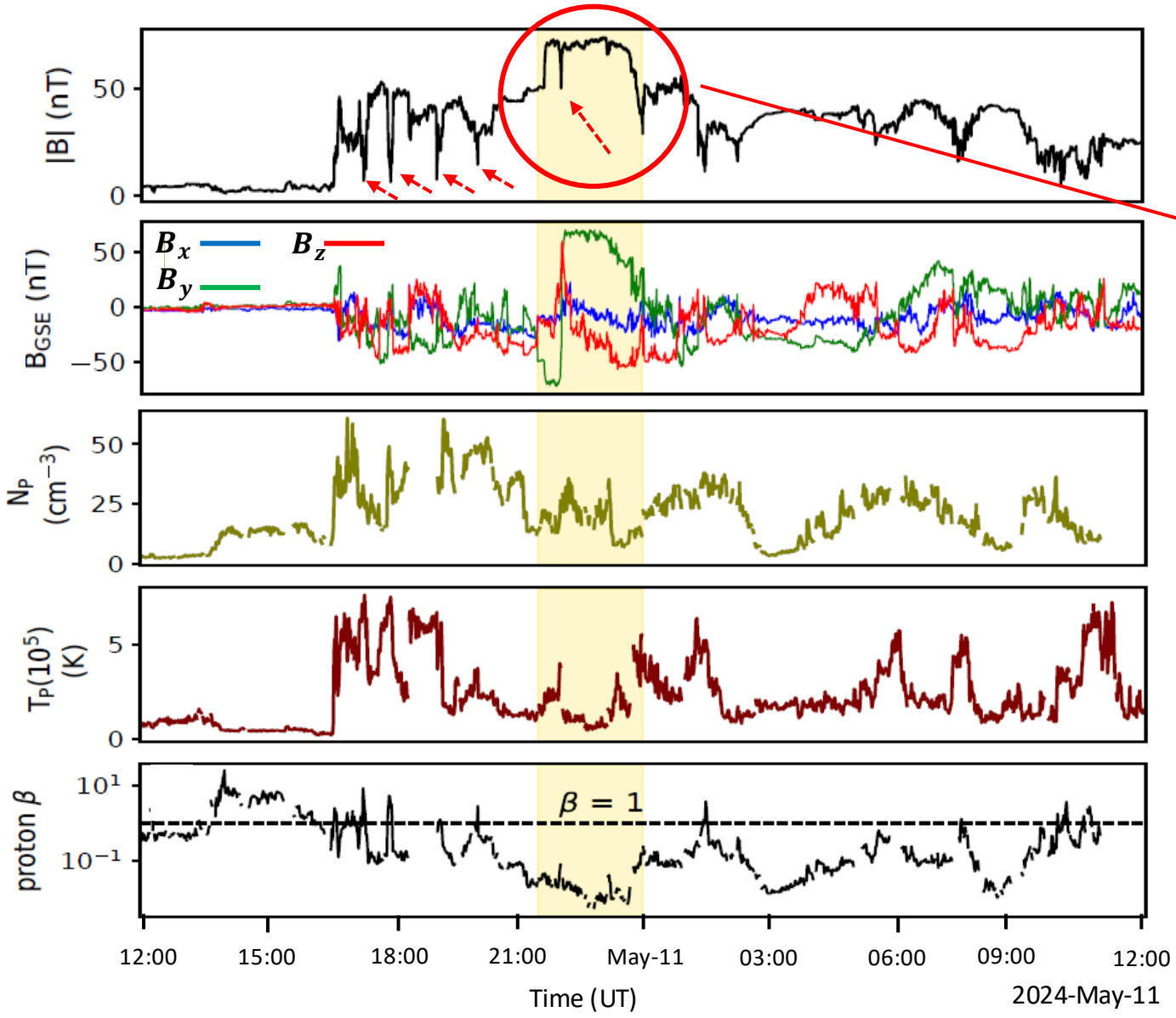
Multi spacecraft Observation



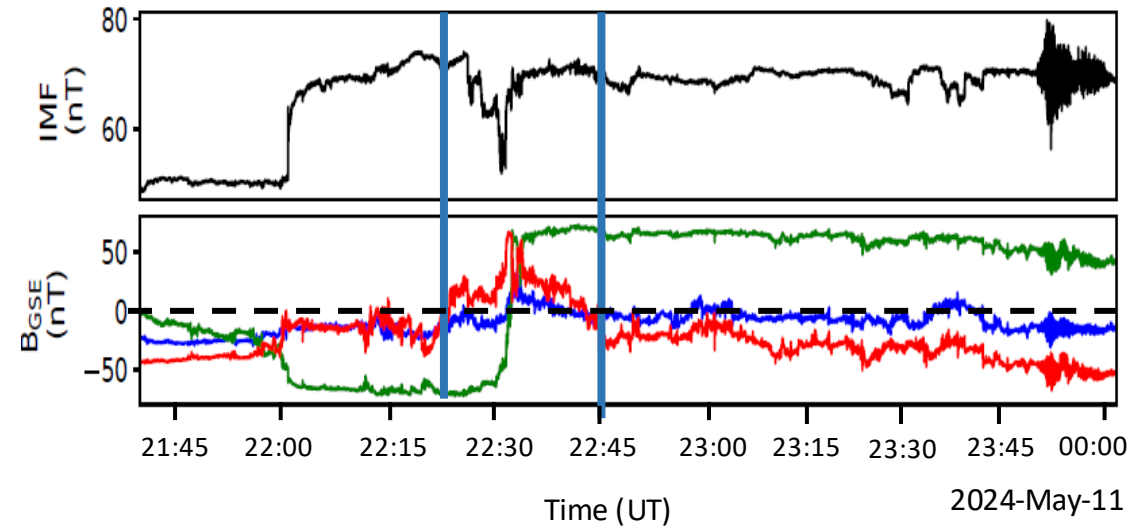
Radial and Azimuthal Coverage

- STEREO Ahead
- ACE (L1)
- Wind (L1)
- DSCOVR (L1)
- Aditya- L1
- MMS (magnetosphere)
- ARTEMIS-P2 (at Moon)

ACE (L1 point)



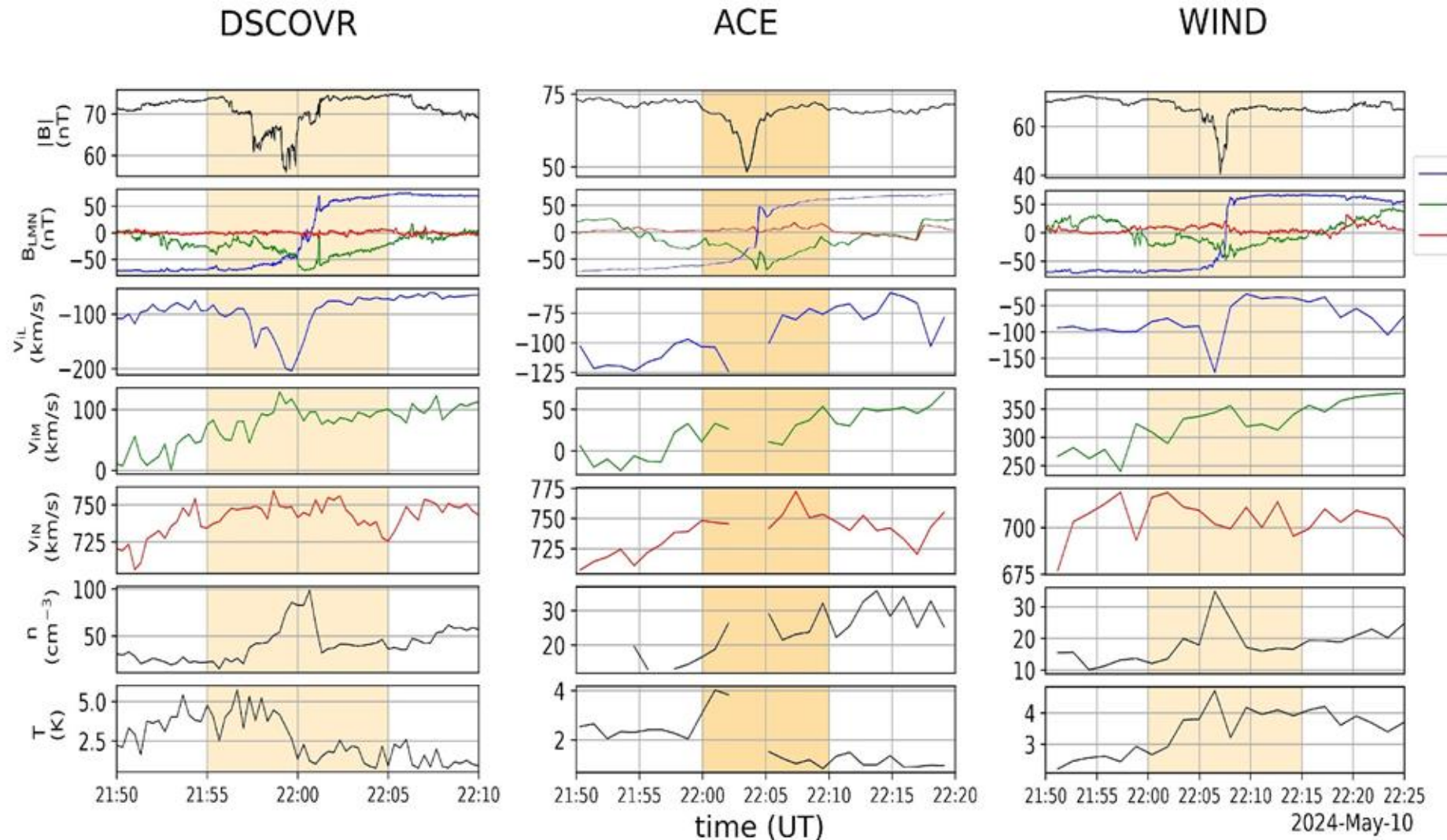
Highlighted ROI (Near Earth, MMS)



Our Objective
To Check for possible ICME Magnetic Reconnection events
and their Space Weather Impact

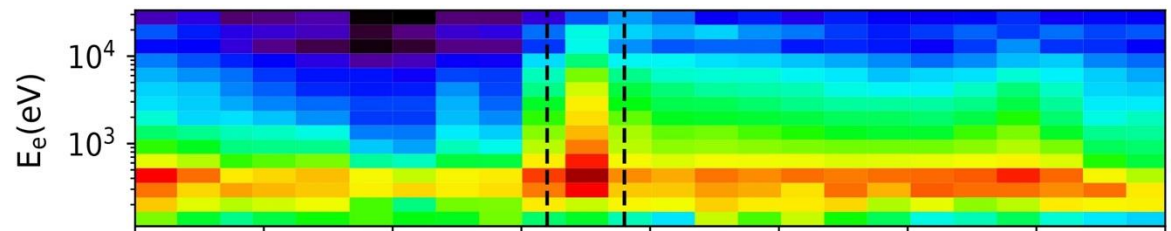
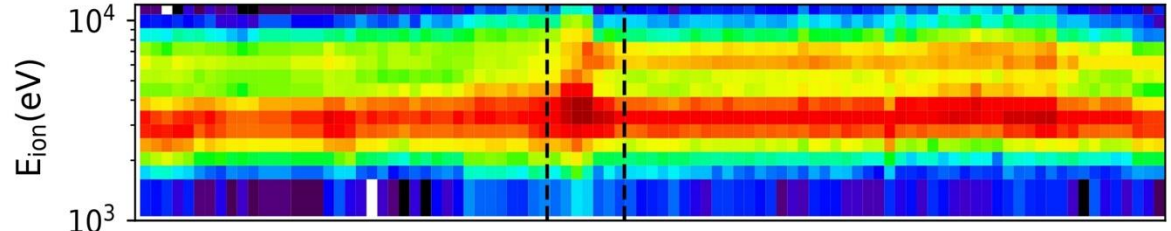
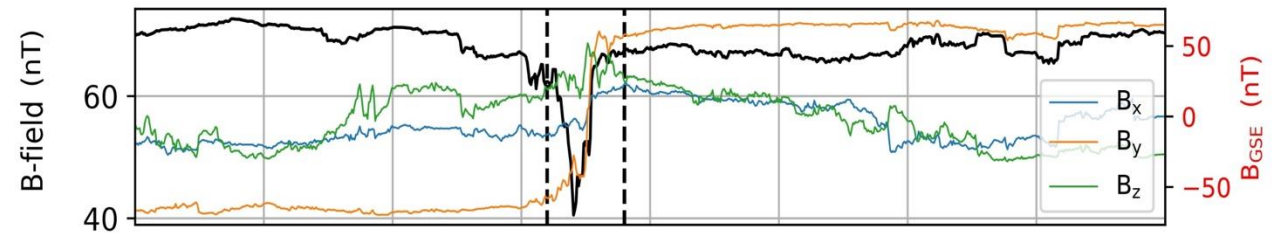
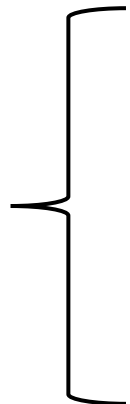
Magnetic field and plasma parameters at L1 in Boundary normal Coordinates (LMN)

- Sharp reversal of B_L at B_{total} drop
- Outflow along $-L$ (GSE-Y)
- Width of outflow decreasing from DSCOVR to Wind
- Proton temperature, density has local maxima

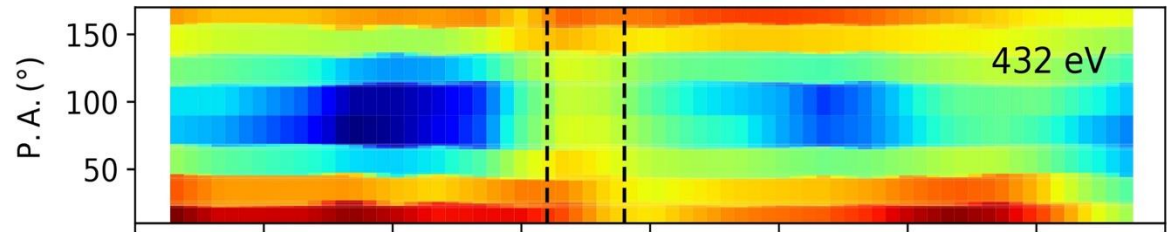
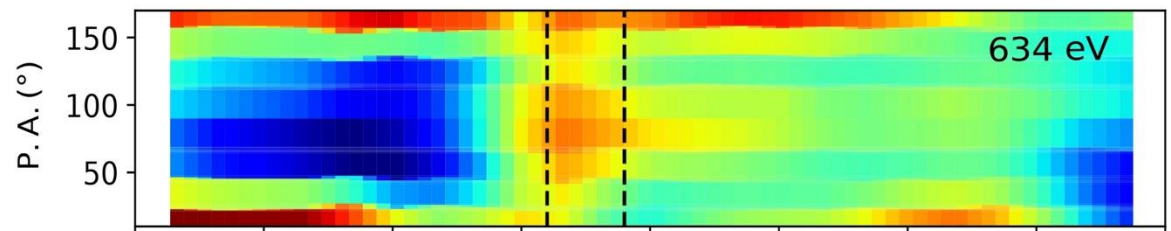
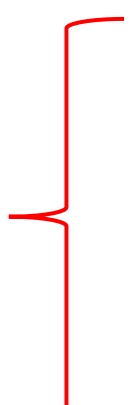


Wind 3DP instrument plasma data

Ion & Electron
Omnidirectional flux



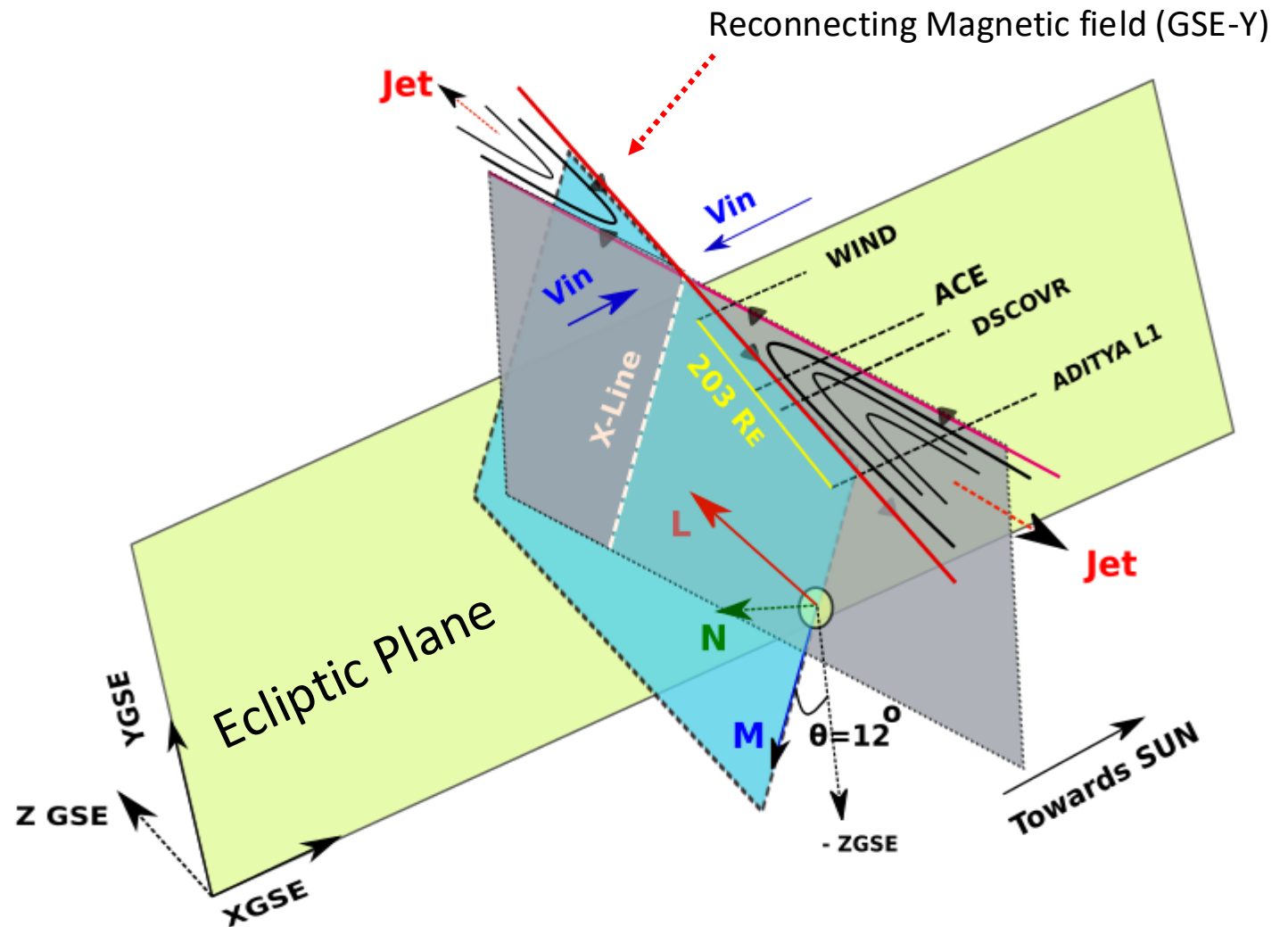
Supra-thermal electron
Pitch angle



time (UT) 2024-May-10

3D Visualisation of Reconnection topology

- Minimum Variance Analysis
- Boundary Normal Coordinate (LMN)
- Change of Reference frame from GSE to LMN
- Calculate reconnection diffusion region scales & plasma parameters



*Figure Conceptualized using Phan et al. 2006, Nature Letters

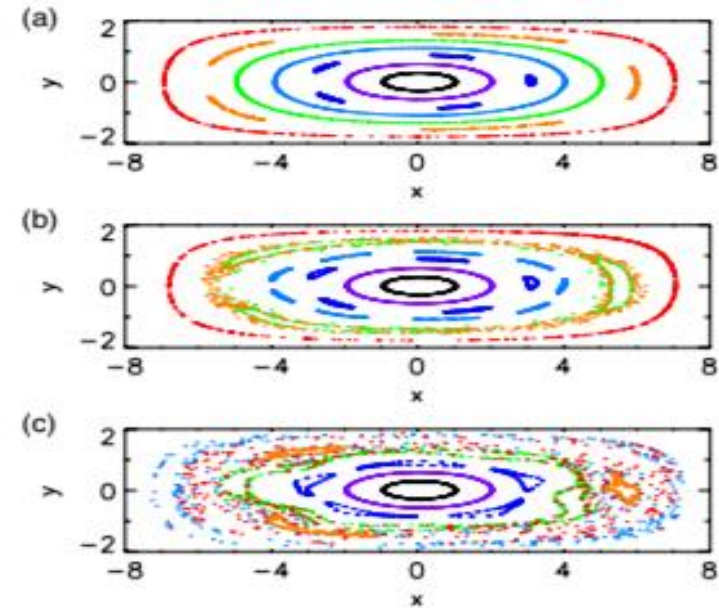
What is the possible mechanism of reconnection ?

**Internal Flux rope Disruption/pinching
Due to ICME-ICME interaction**

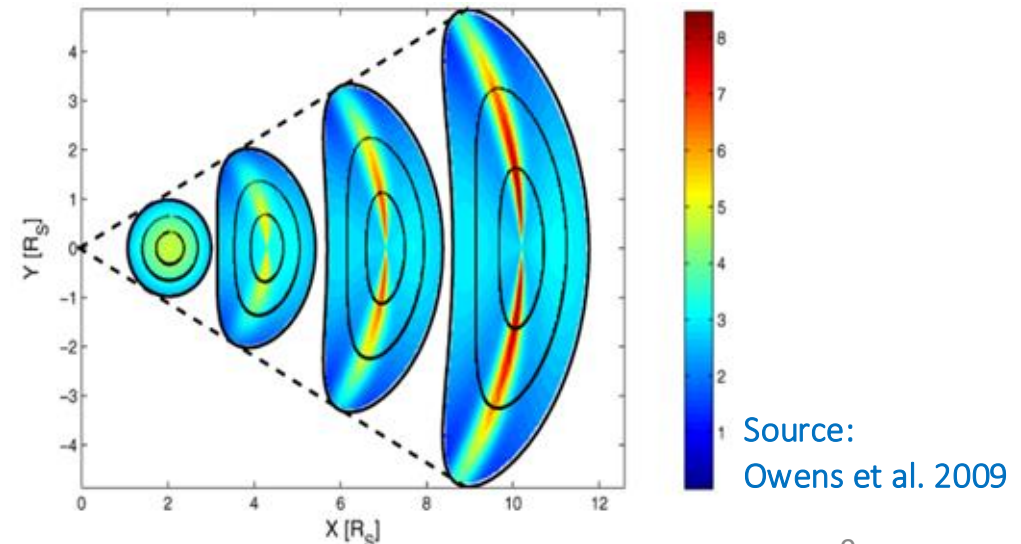
CME flux rope originate in force Free Equilibrium: $\nabla \times \vec{B} = \alpha \vec{B}$
Burlaga et al. 1981, Lepping et. al 1990
(but not always H. Xie at al. 2003)

**Fermo et al. 2014, PRL
(internal reconnection between concentric flux
rope surfaces)**

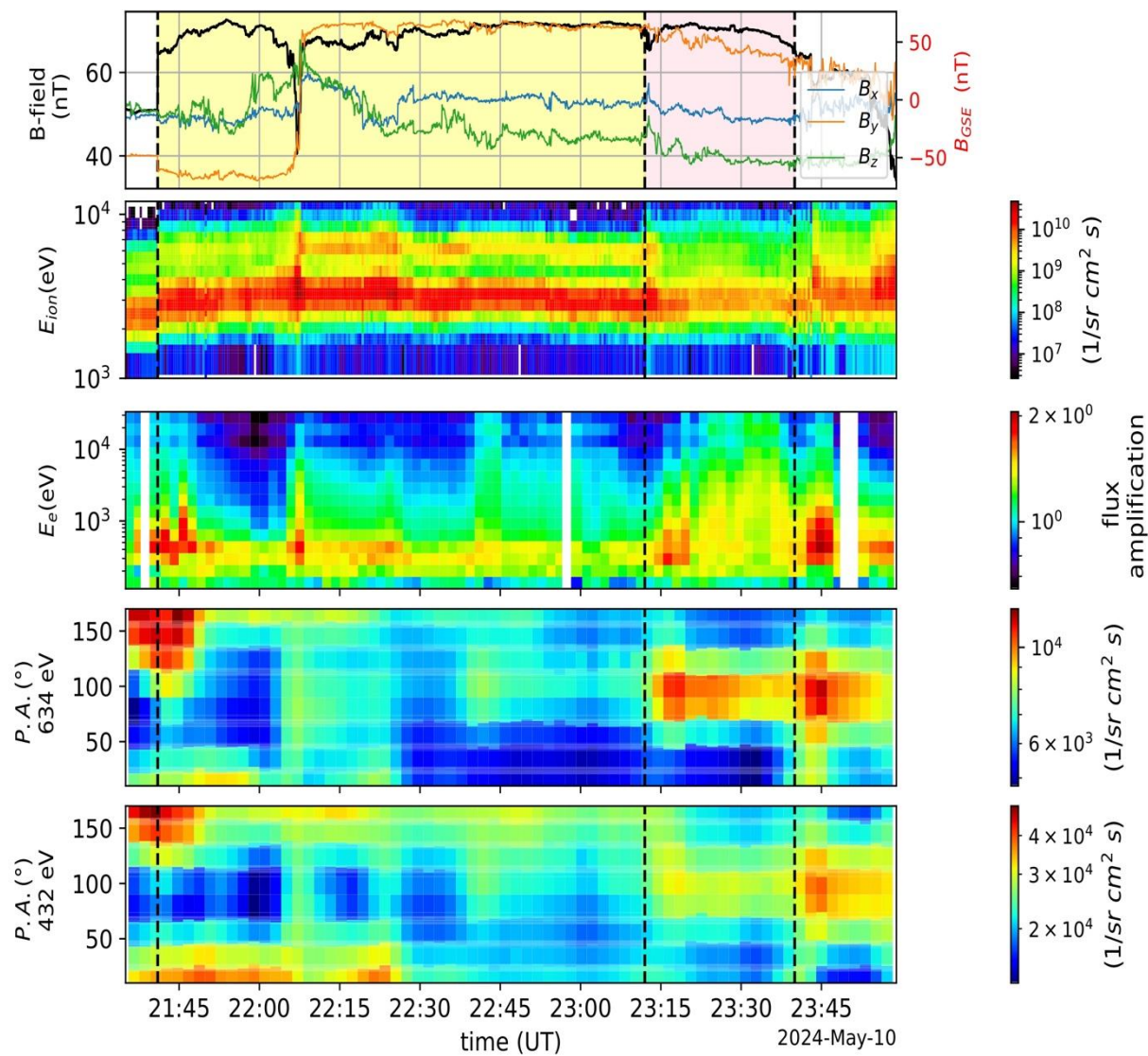
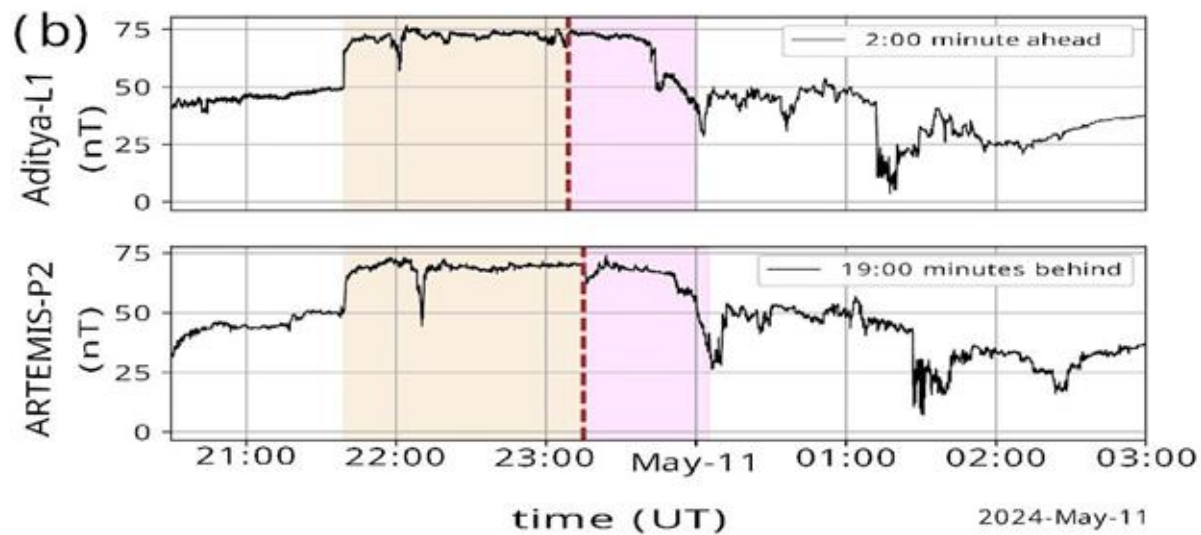
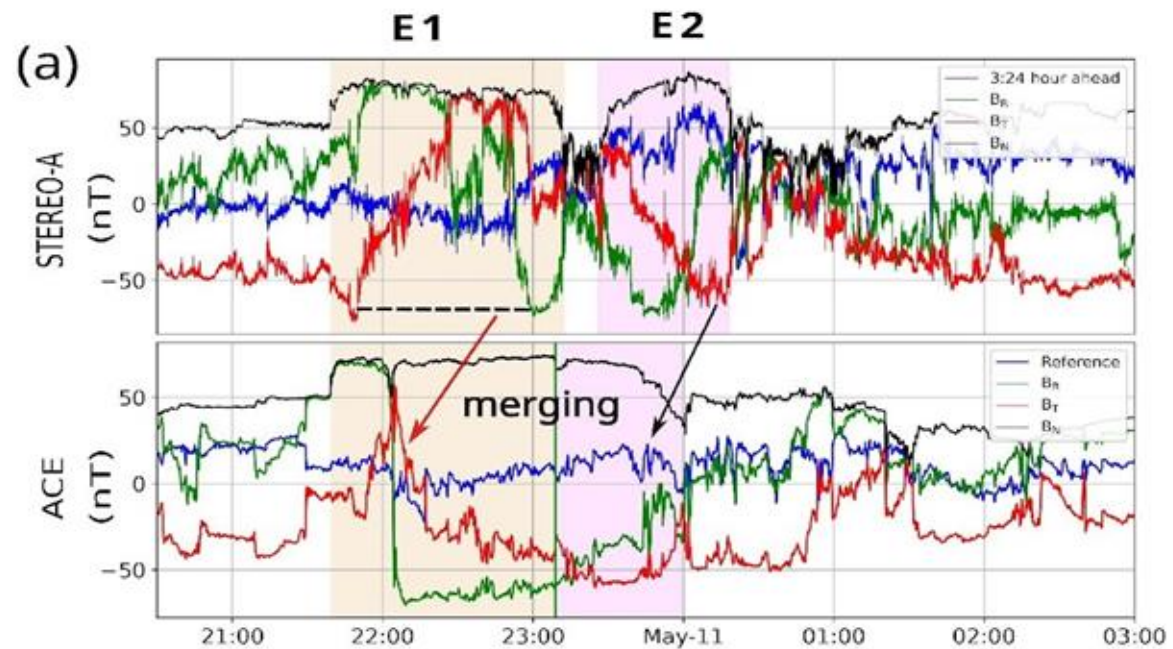
**Owens et al. 2009
(Due to kinematic propagation, current sheet develops
without any external forcing)**



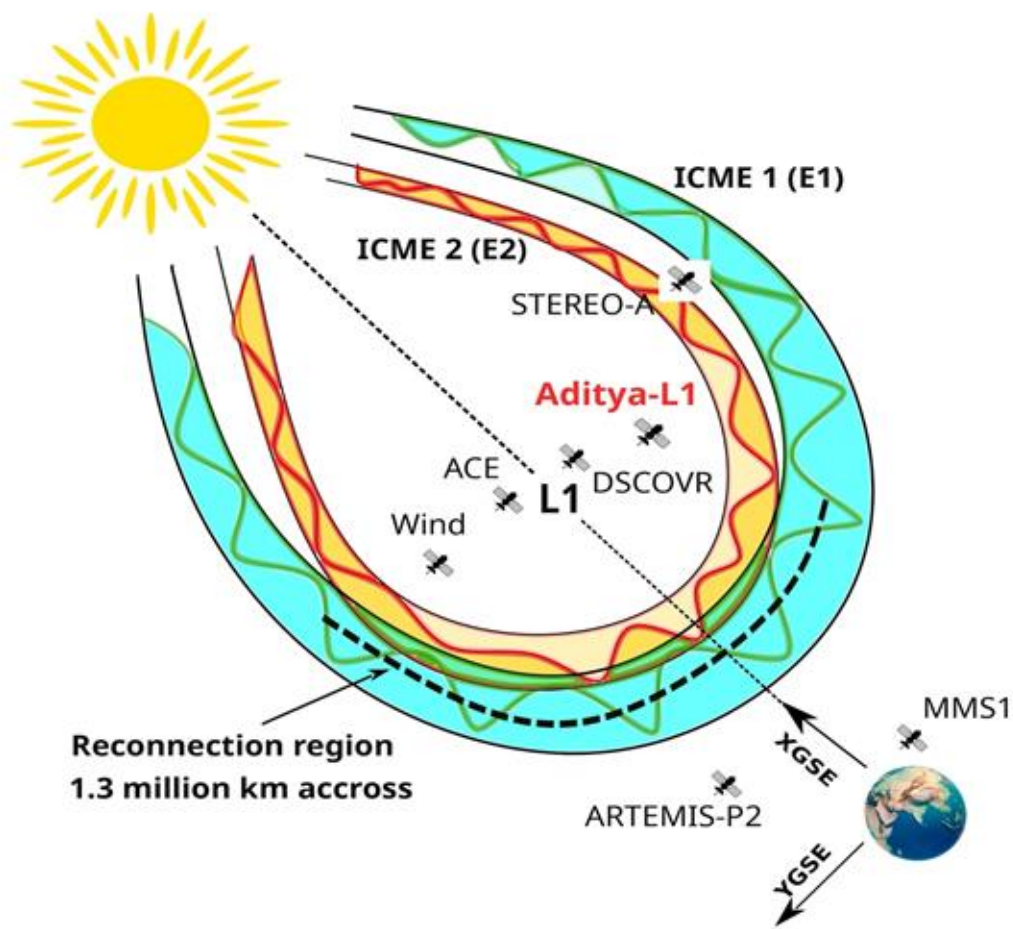
Source:
Fermo et al. 2014



Source:
Owens et al. 2009



Conclusion & Summary



- At STEREO-A E1 & E2 were structures with similar magnetic helicity
- At L1, E1 faced enhanced compression (and possibly merging) due to E2 & triggered internal magnetic reconnection within E1.
- Reconnection region spread across **1.3 million km (observationally)**
- It was **quasi-steady** for almost more than 30 minutes
- **Highlights the importance of Multi-spacecraft** analysis from L1 for space weather study and forecasting

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Authors  Figures  Tables  References 

Article information 

Abstract

The extreme solar storm of 2024 May 10, during the 25th solar cycle, which recorded a symmetric H component index (Sym-H) reaching -500 nT, was the strongest since the 2003 Halloween storm. This

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Abstract

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