

INVESTIGATION OF THE EVOLUTION OF ENERGY CONVERSION PROCESSES AT AN EDR-ACCOMPANIED DIPOLARIZATION FRONT, USING POLYNOMIAL MAGNETIC FIELD RECONSTRUCTION TECHNIQUES

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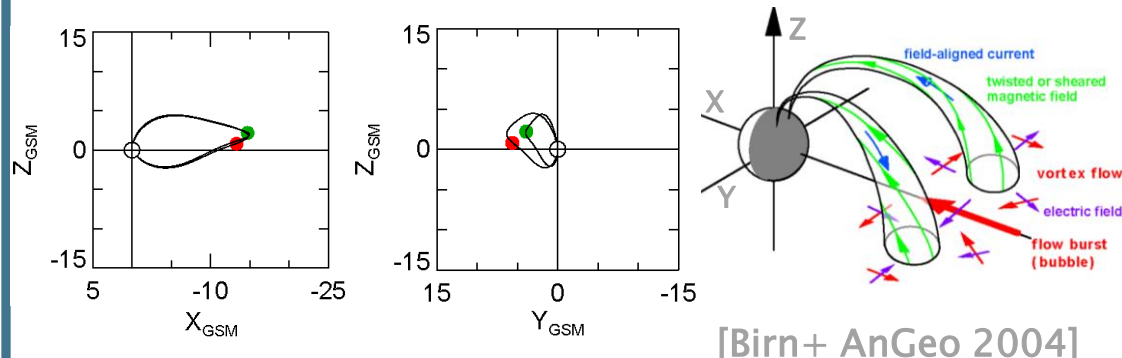
1 Motivation

Asymmetric reconnection within a Flux Rope-type DP Front, first reported by **Marshall+ JGR 2020** in the Earth's Magnetotail using **MMS** data. Recently, **Liu+ APJ 2022** identified this event as Jet Front/Dipolarization Front.

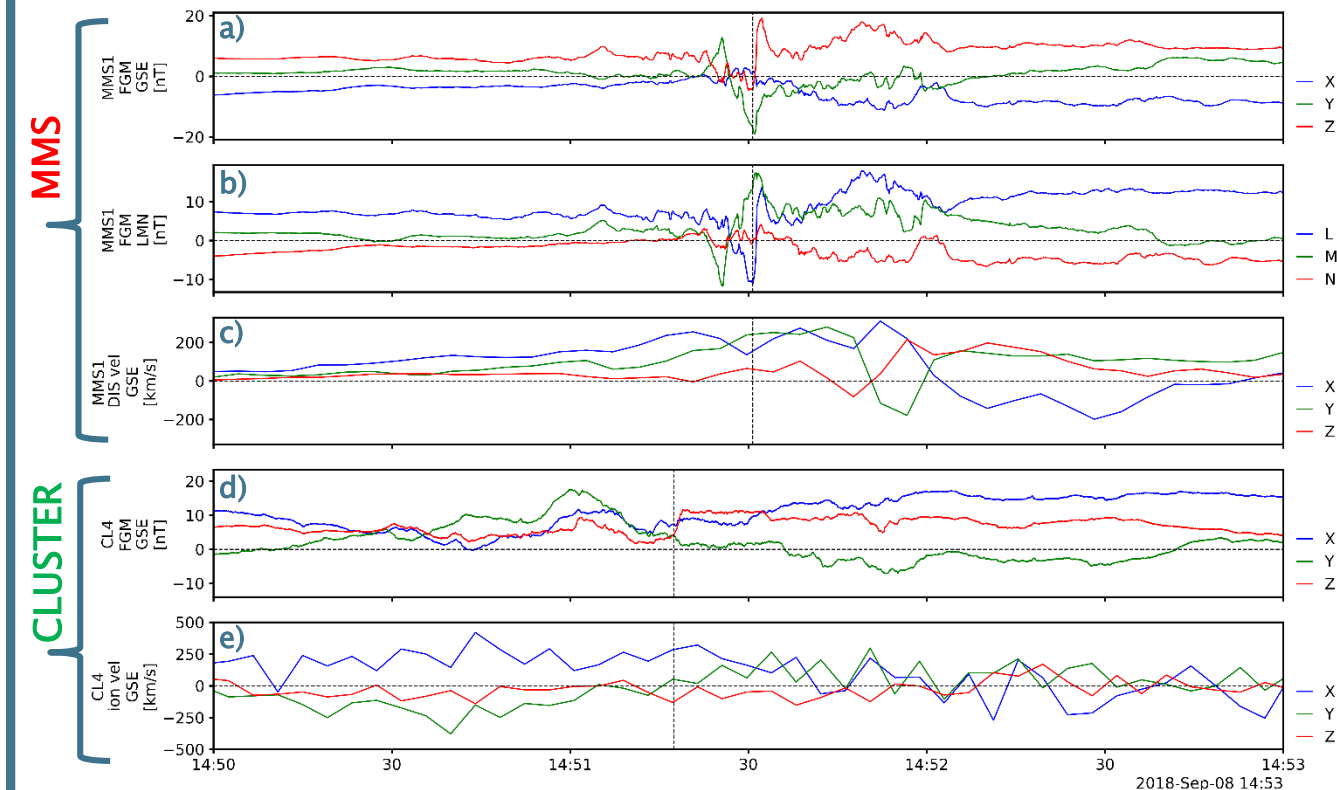
In this work: Identification and characterization of observed event, using a polynomial magnetic field reconstruction method by **Denton+ JGR 2020**, applied to MMS data.

2 Event Location Large-Scale Situation

Observed by the **MMS** and **CLUSTER** spacecraft at 2018-09-08/14:51 UT



3 Event Overview



$$\begin{aligned} L &= (-0.290, 0.411, 0.861) \sim Z \\ M &= (-0.103, -0.911, 0.398) \sim -Y \\ N &= (0.951, 0.026, 0.306) \sim X \end{aligned}$$

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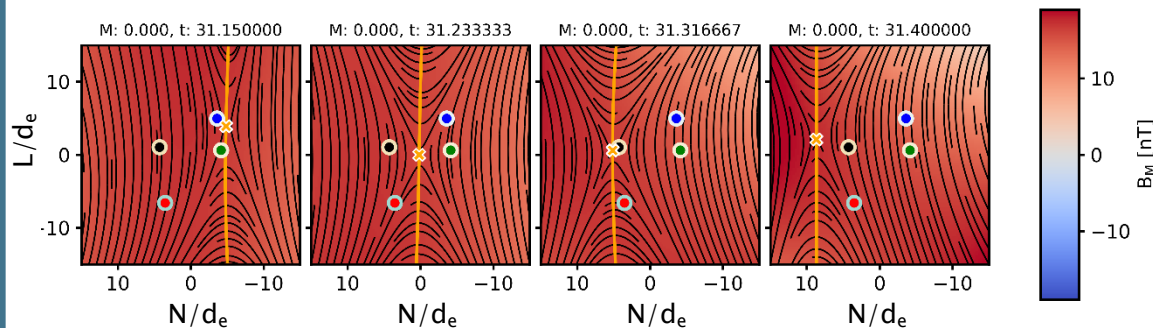
4 Current Sheet Determination

We apply the Reduced Quadratic Model of **Denton+ JGR 2020** to MMS data, which is a 2nd-order polynomial magnetic field and 1st-order current density reconstruction model.

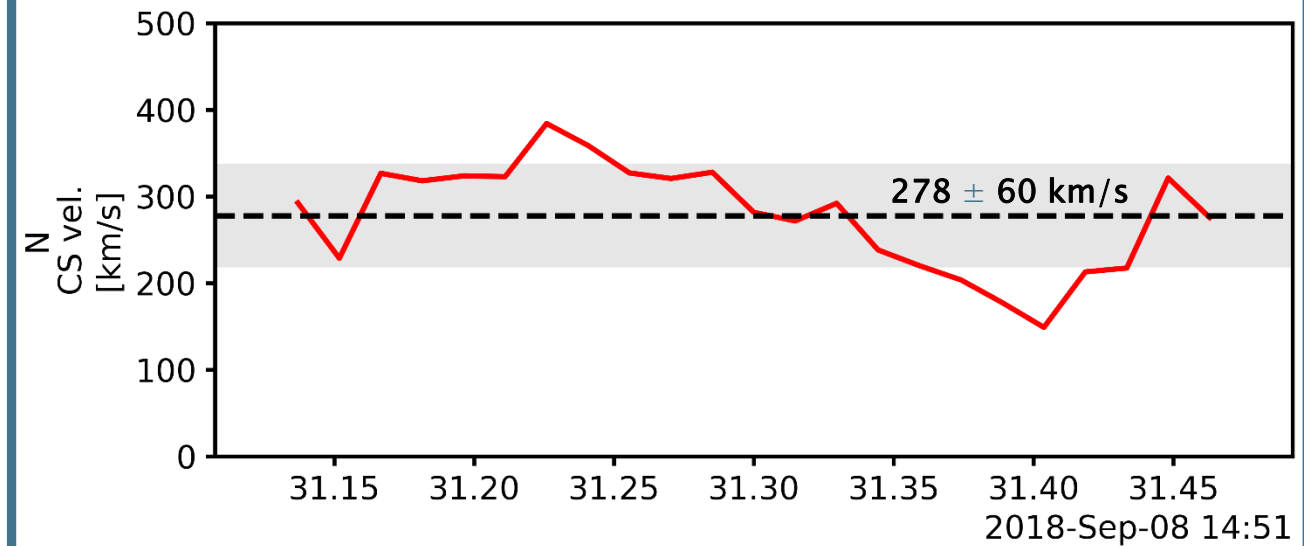
To identify Neutral Sheet, find the plane in N where B_L exhibits reversal (yellow line).

Start with LMN system from **Marshall+ JGR 2020** and rotate it 11° CCW such that current sheet is parallel to L direction.

Determine CS velocity from reconstructions at several time points



5 Current Sheet Propagation w.r.t. the S/C barycenter



6 Summary

- Reconstruction method confirms X-Line structure
- CS velocity in N direction: 278 ± 60 km/s (ion flow vel.)
- Velocity is consistent with Marshall+ JGR 2020

SUPPLEMENTARY INFORMATION

Polynomial Magnetic Field Reconstruction

3D magnetic field and current density reconstruction at any time point [Denton+ JGR 2020].

Four-point measurement of \mathbf{B} only provides linear variation of \mathbf{B} in space and constant current density \mathbf{j} .

With additional current density information from high-resolution plasma measurements: Representation of \mathbf{B} by 2nd-order Taylor Polynomial:

$$B_l = B_{l,0} + \left(\frac{\partial B_l}{\partial l} l + \frac{\partial B_l}{\partial m} m + \frac{\partial B_l}{\partial n} n \right) + \frac{1}{2} \left(\frac{\partial^2 B_l}{\partial l^2} l^2 + \frac{\partial^2 B_l}{\partial m^2} m^2 + \frac{\partial^2 B_l}{\partial n^2} n^2 \right) + \left(\frac{\partial^2 B_l}{\partial n l} nl + \frac{\partial^2 B_l}{\partial m l} ml + \frac{\partial^2 B_l}{\partial m n} mn \right)$$

Find parameters (here derivatives) of the polynomial by a set of equations:

$$\begin{aligned} B_{\text{mms}} &= B_{\text{model}} & 12 \text{ equations} \\ \mu_0 \mathbf{j}_{\text{mms}} &= \nabla \times B_{\text{model}} & 12 \text{ equations} \\ \nabla \cdot B_{\text{model}} &= 0 & 4 \text{ equations} \end{aligned}$$

but 30 unknowns. Also there is no FPI data from MMS4 for this event!

Solution: Neglect parameters that are likely small.

Reduced Quadratic Model and Finding the Solution

1. Neglect $\partial^2 / \partial m^2$ since changes in m direction are likely the smallest.
2. Due to thin current sheet at reconnection events, $\partial B_n / \partial n$ is expected to be small (but not exactly zero). It is balanced by (a small) $\partial B_l / \partial l$.

To ensure this, neglect 2nd-order terms in the Taylor Expansion of B_l and B_n , which are proportional to n and l , respectively.

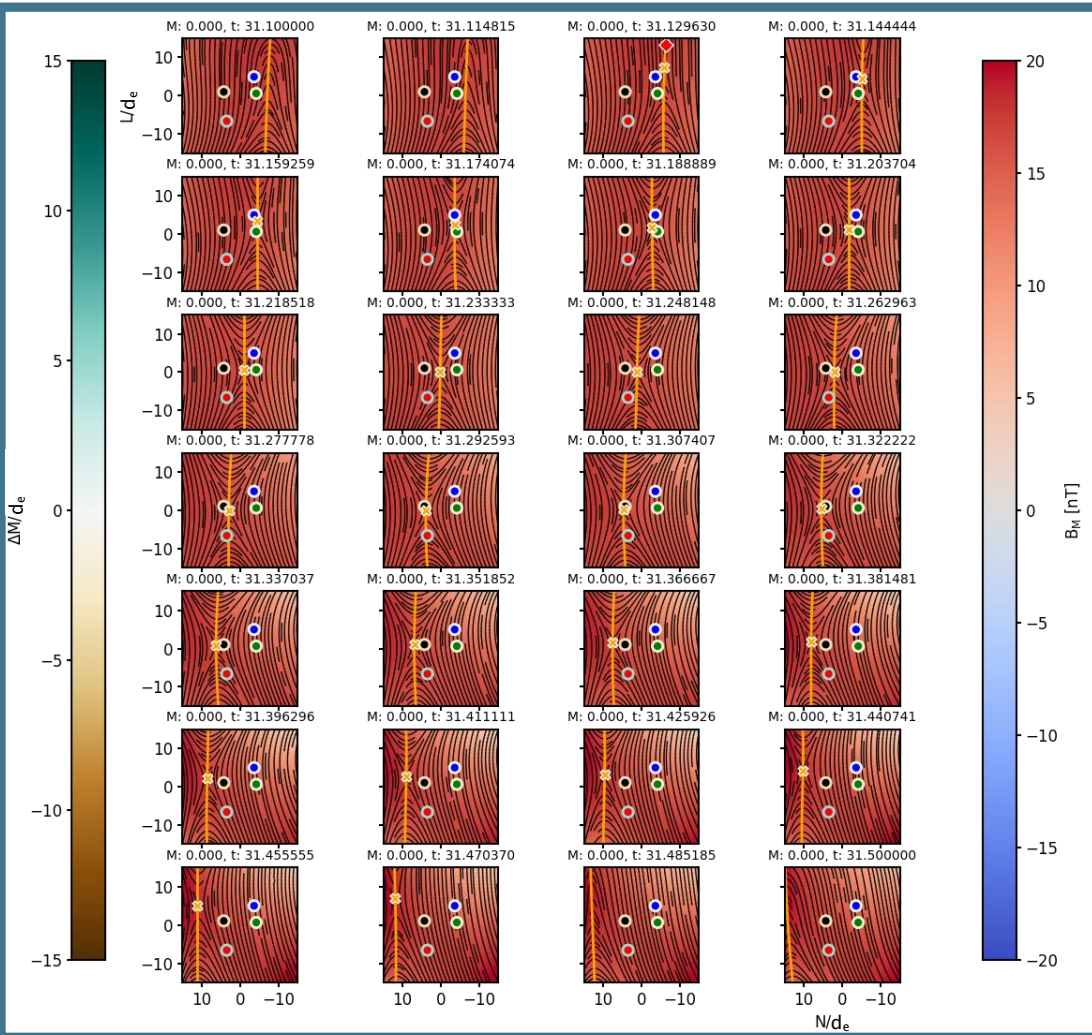
This yields 25 equations and 17 unknowns: Problem is overdetermined.

To find solution:

1. Determine lmn system at each time point, using MDD technique [Shi+ GRL 2005]
2. Determine parameters using a least-squares fit

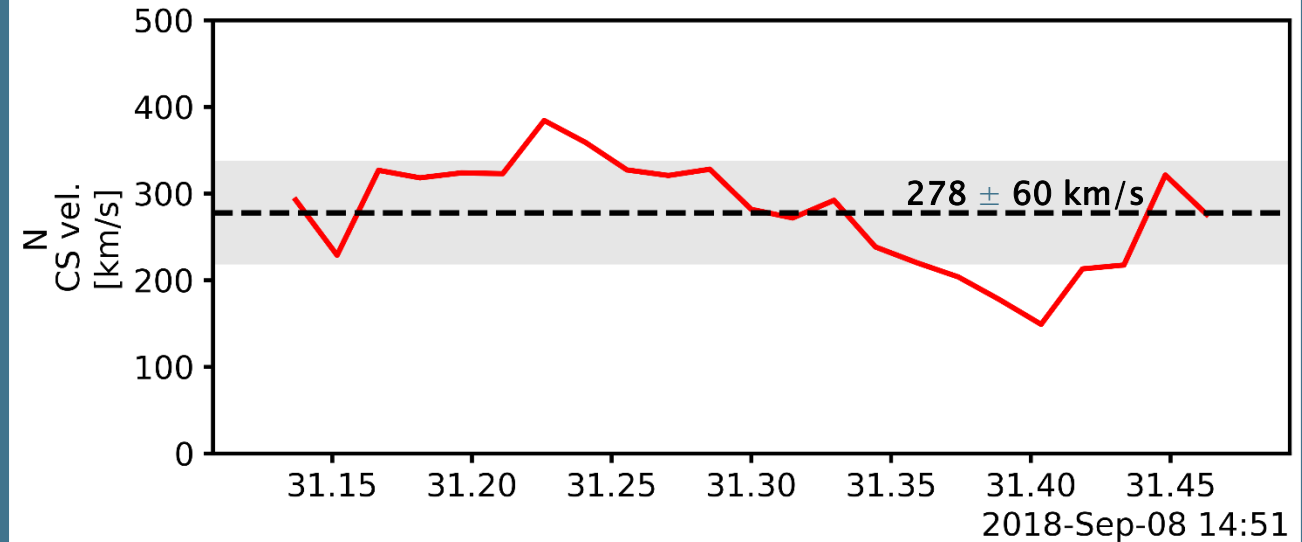
SUPPLEMENTARY INFORMATION

Detailed Time Series



Current Sheet Propagation

Find the plane of B_L reversal



Summary

- Reconstruction method confirms X-Line structure
- CS velocity in N direction: 278 ± 60 km/s
- Consistent with initial findings of Marshall+ JGR 2020