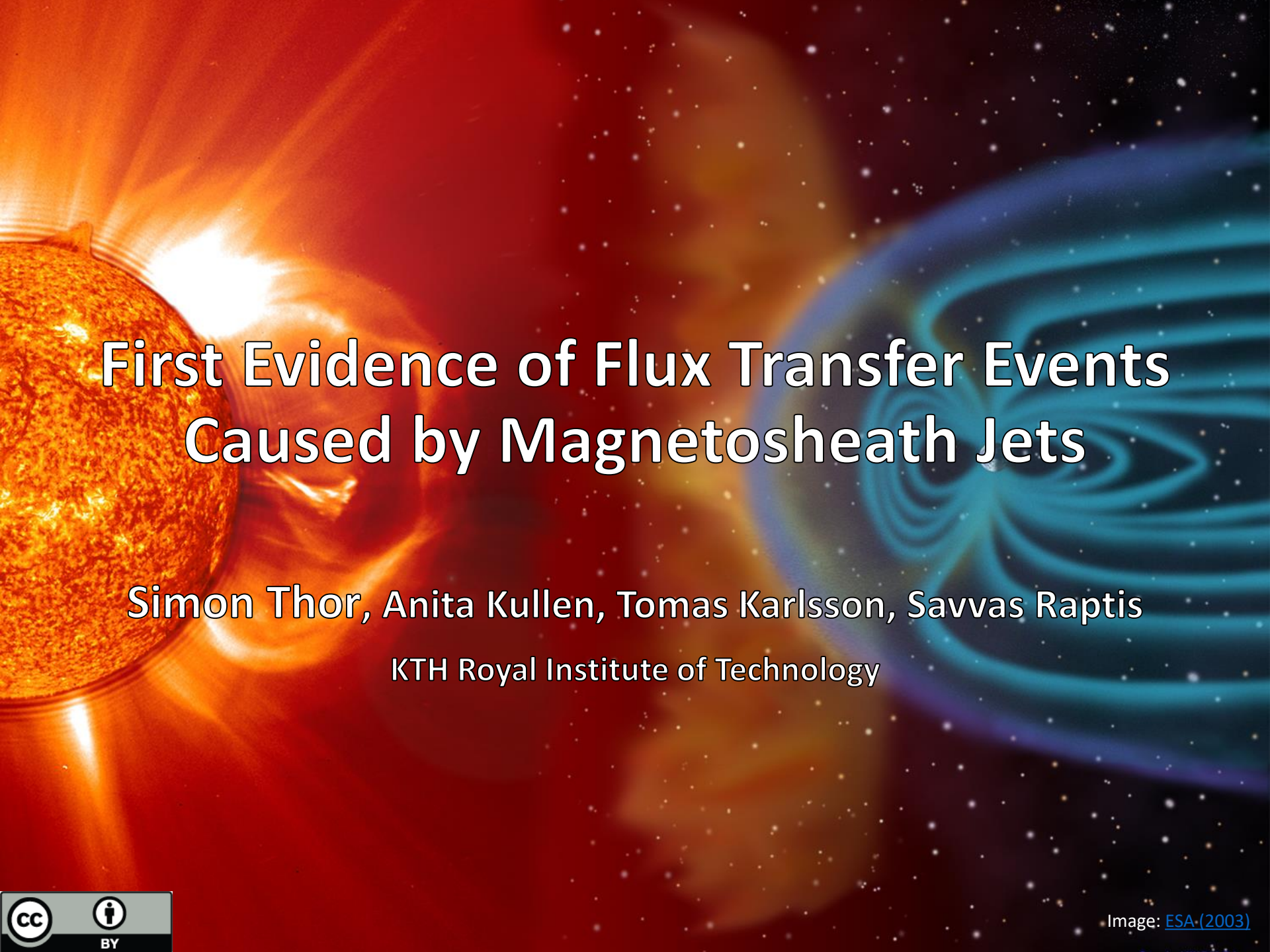

First Evidence of Flux Transfer Events Caused by Magnetosheath Jets

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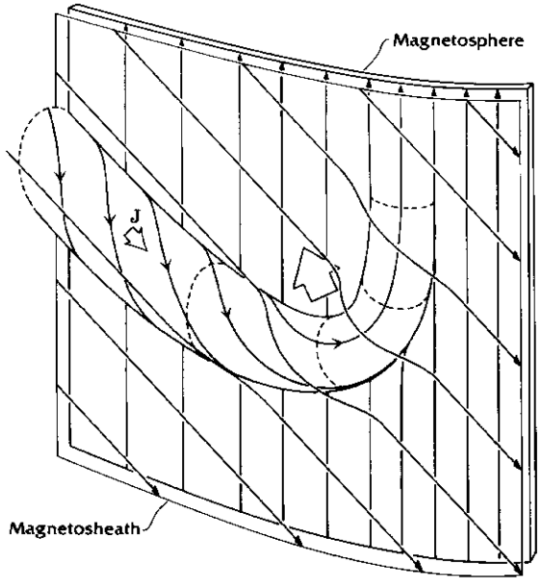
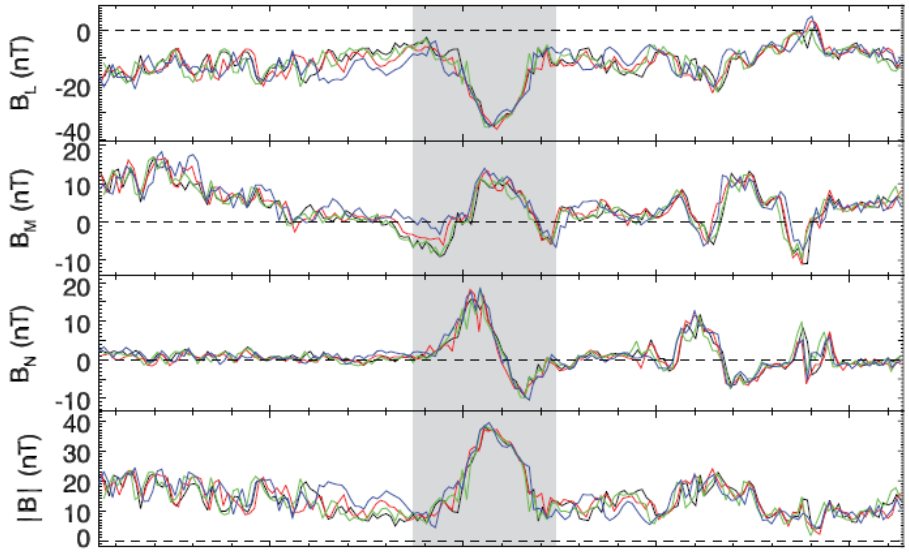
Image: ESA (2003)

Flux Transfer Events (FTEs)

- Localized magnetic field line reconnection
- Satellite passing through shows bipolar signature in B-field measurements
- Appear typically in cascades but can also appear as isolated events (Kullen, Thor & Karlsson, 2019)
- Origin of isolated events unknown



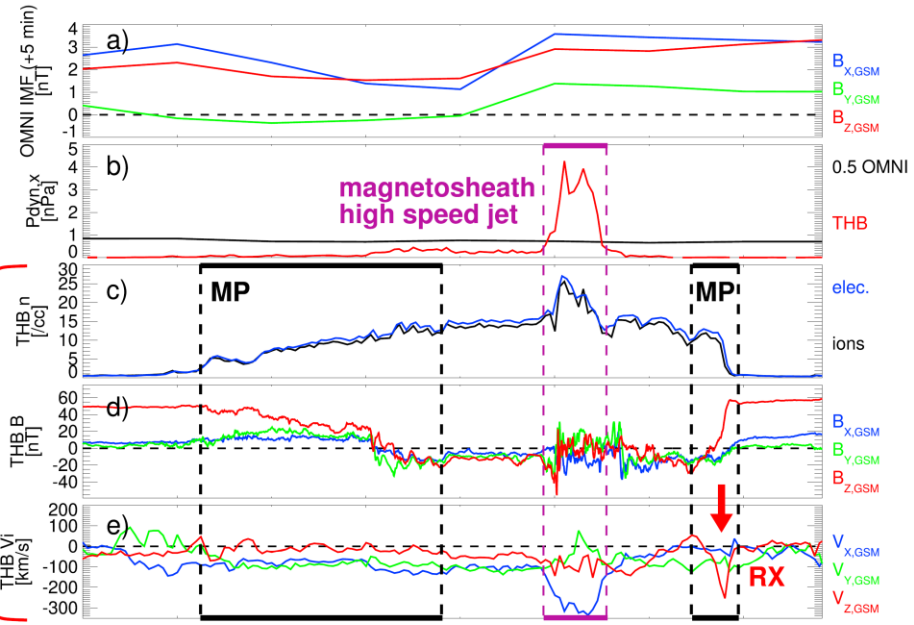
Geometry of a recently reconnected flux tube (Russell and Elphic, 1979, figure 2)



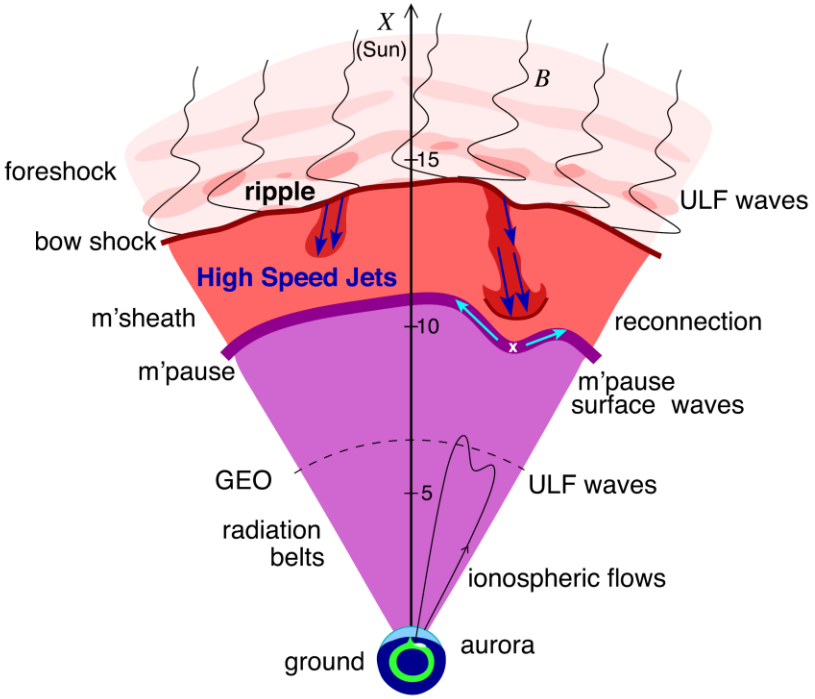
Magnetic field signature of FTE in LMN boundary-normal coordinate system (Wang et. al., 2005, figure 1)

Magnetosheath Jets

- Localized dynamic pressure enhancement in magnetosheath
  - Criteria: jet = 2x average dynamic pressure of magnetosheath over 20 min
- Caused by solar wind with dominant IMF B_X
- Can cause reconnection when colliding with magnetopause (Hietala et. al., 2018)
- Topic of present study: **Can jets cause FTEs?**



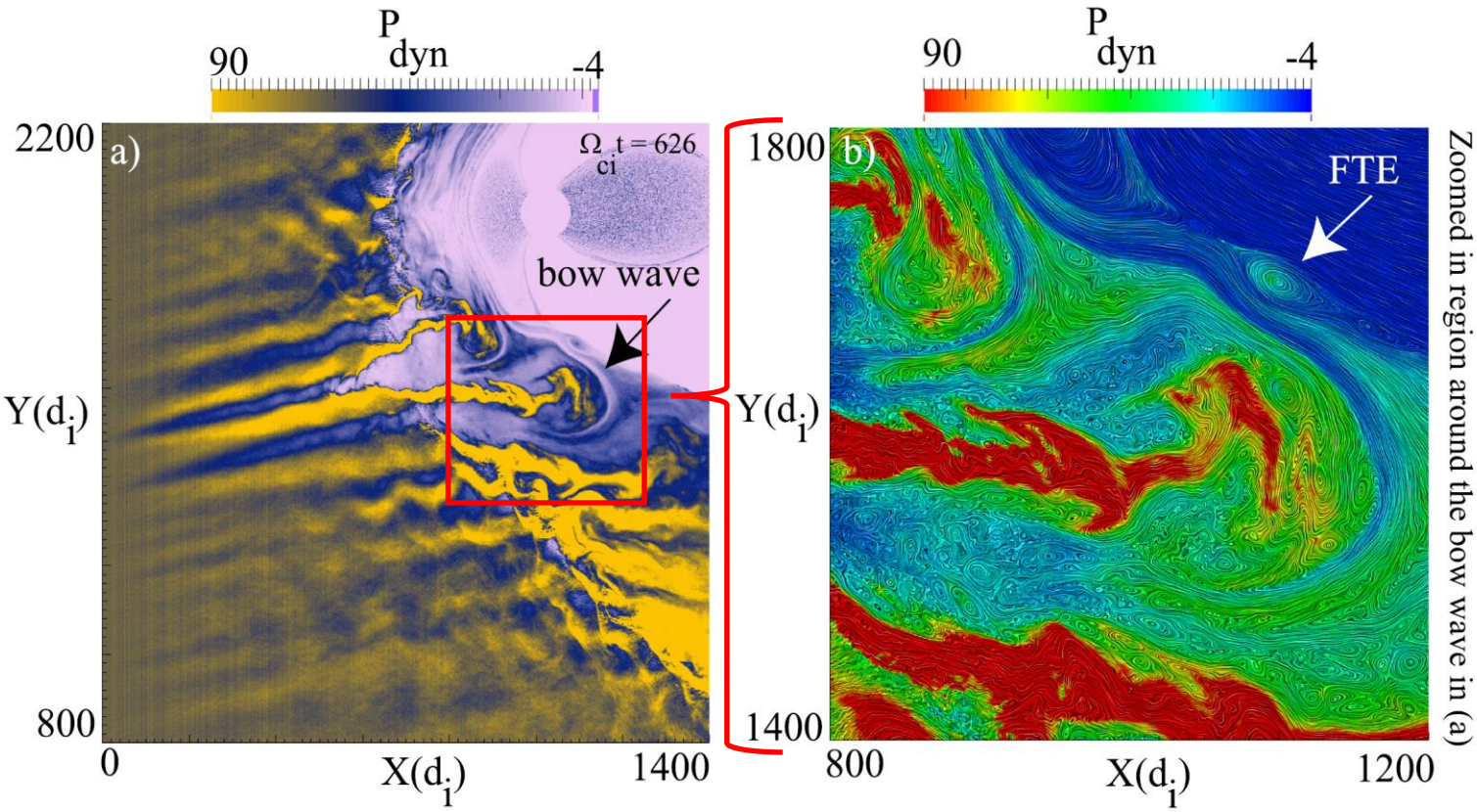
Signatures of magnetosheath jet (purple) causing local magnetopause reconnection (red arrow) in THEMIS data (Hietala et al., 2018, figure 1)



Schematic of magnetosheath jet causing local reconnection at magnetopause (Plaschke et al., 2018, figure 1)

FTEs and Jets – Previous Research

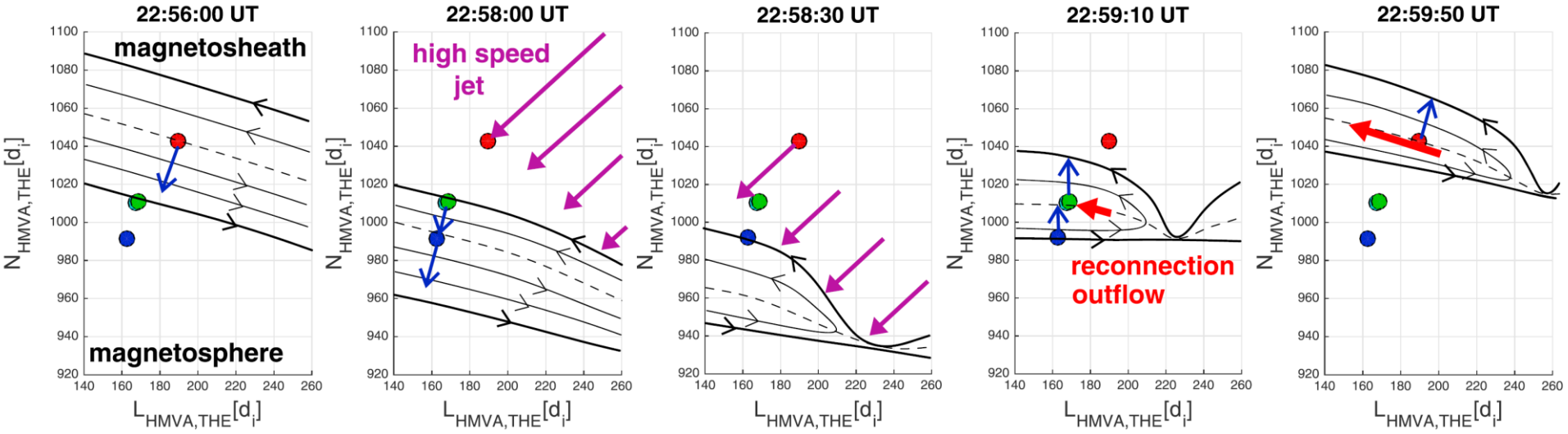
- Karimabadi et al. (2014):
  - MHD simulations of the geomagnetic field
  - Simulation shows magnetosheath jet colliding with geomagnetic field, creating an FTE
  - Simulation results indicate that FTEs caused by magnetosheath jets are possible



Simulation results in XY-plane showing magnetosheath jets colliding with magnetopause where FTEs appear (Karimabadi et al., 2014, figure 15)

FTEs and Jets – Previous Research

- Hietala et al. (2018):
  - In-situ study, based on data from all four THEMIS satellites
  - High speed jet compresses magnetopause (22:58:30)
  - Reconnection results in reconnection outflow (22:59:10)

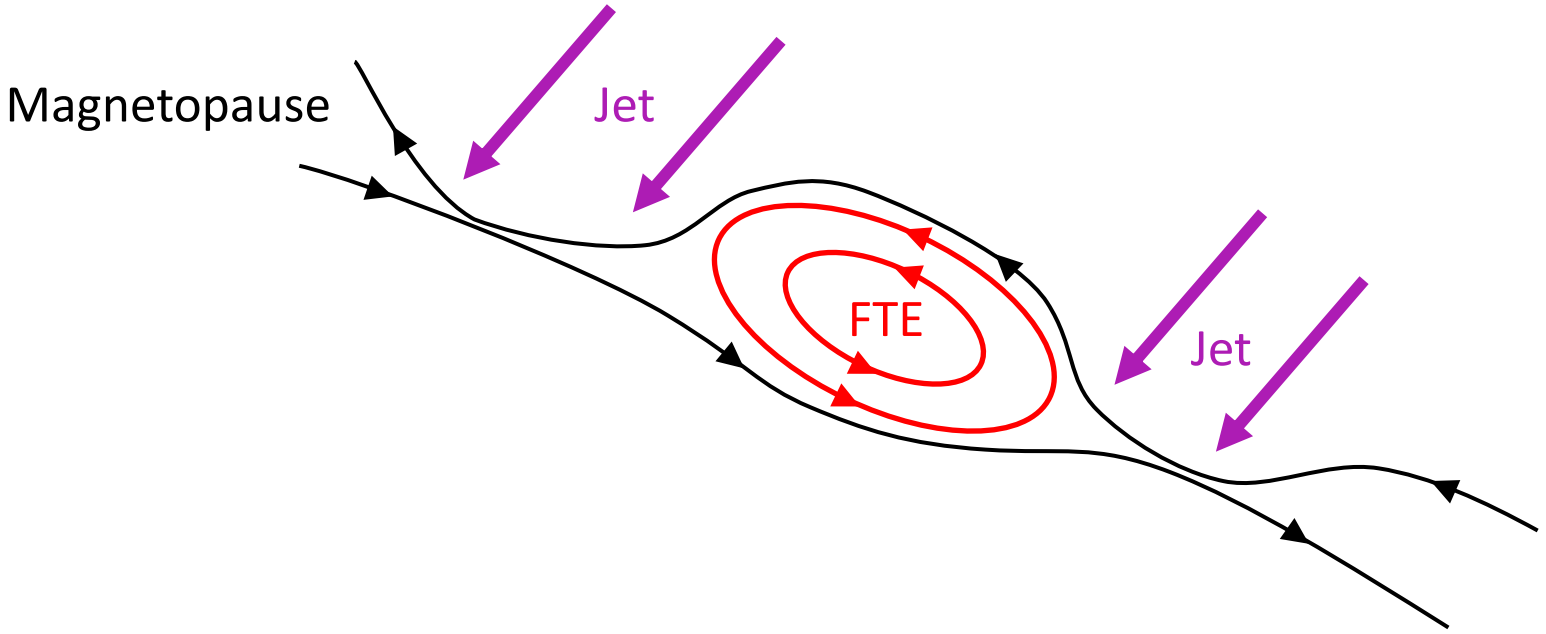


Schematic summarizing THEMIS measurements. Black lines indicate possible magnetopause geometry, colored dots indicate different THEMIS satellites. High speed jet is seen 22:58:00-22:58:30, while reconnection outflow seen 22:59:10-22:59:50 (Hietala et al., 2018, figure 4)

Creation Mechanism

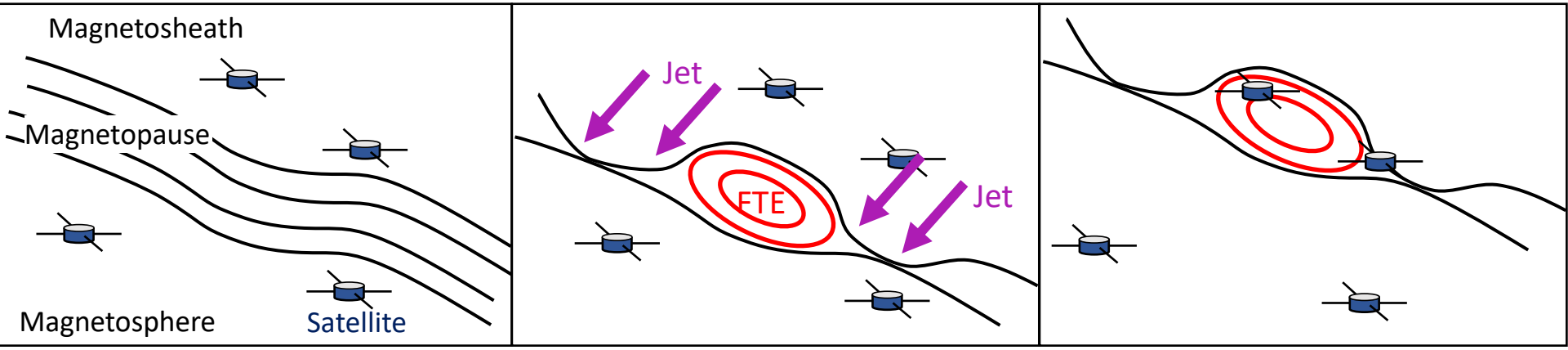
- Our hypothesis of FTE formation due to jets:
  - Jet(s) cause multiple reconnections
  - Flux tube magnetic field geometry forms between two local reconnection sites

- Jets causing FTEs would explain why some FTEs are isolated instead of cascades



Method of Study

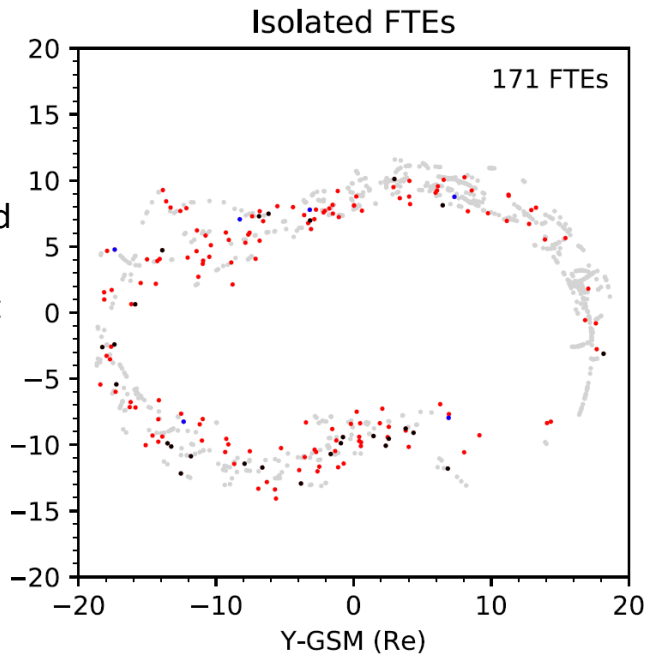
- Key question 1: How do jets cause FTEs?
  - Case study based on Cluster FTE dataset by Wang et al. (2005)
  - Identify all isolated FTEs (Selected by Kullen, Thor & Karlsson, 2019) in conjuction with magnetosheath jets.
    - Criteria: jet appears within [-20, +5] minute interval around FTE.
  - Create a 3D schematic of the situation. Example:



- Key question 2: How often do jets cause FTEs?
  - Statistically analyze how often FTEs appear close to jets
  - Compare to background
  - Analyze if there is a significant difference and if so, by how much

Preliminary Statistical Results

- Results from Kullen, Thor & Karlsson, 2019:
  - 17% (171 FTEs out of 973 total FTEs) of all FTEs are isolated
  - 16% of all isolated FTEs occur during dominant IMF B_X, i.e. cone angle < 30˚
  - Distribution of FTEs:

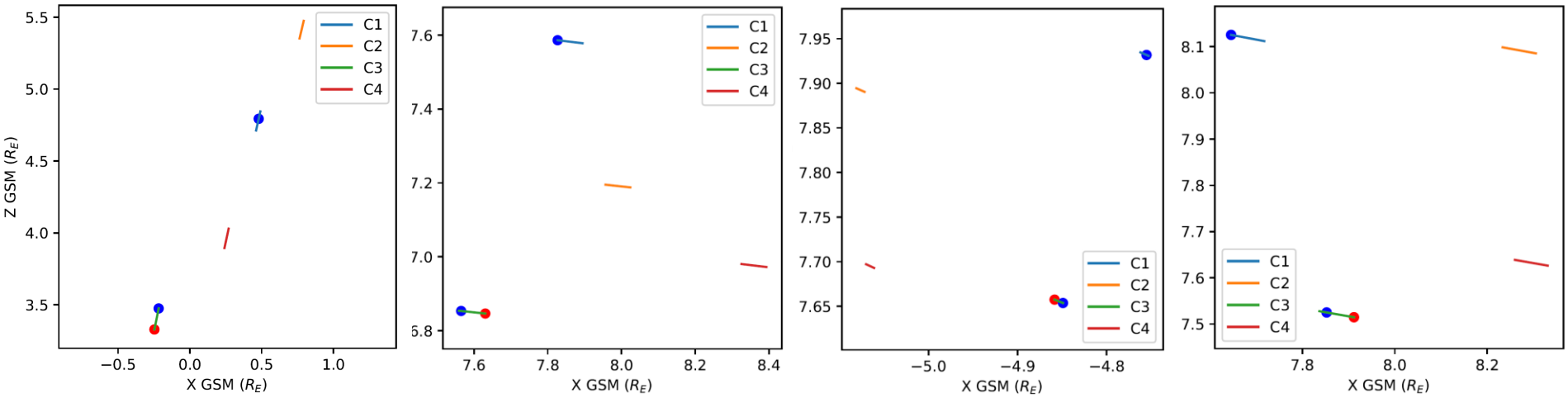


Distribution of all FTEs identified in Cluster dataset. Black dots mark all isolated FTEs with dominant Bx (cone angle < 30), red dots mark all isolated FTEs with high cone angle, blue dots mark isolated FTEs without IMF data, and grey dots mark all other FTEs from list by Wang et al. (2005). Note that Cluster only crosses magnetopause at dayside high latitudes and low-latitude flanks, hence no FTEs in equatorial plane (Kullen, Thor & Karlsson, 2019, figure 11).

- Results from present study:
  - 31 of 171 isolated FTEs appear in vicinity of magnetosheath jet
    - 21 of these have a clear magnetosheath jet signature
      - 4 of these events appear close to magnetopause
      - Ongoing case study on these 4 events

Preliminary Case Study Results

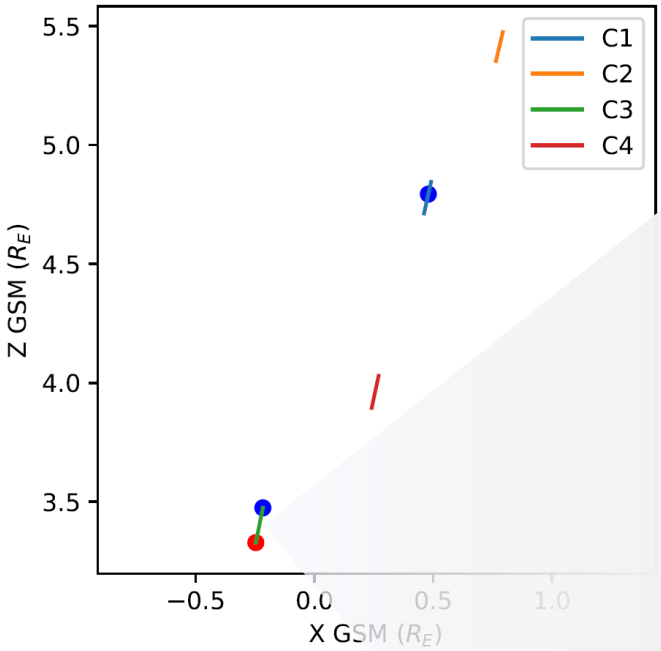
- Jet (blue dot) is seen close to FTE (red dot) and magnetopause
- Secondary jet observed in other satellite
  - Related?
- Jets cannot be detected by Cluster 2 and Cluster 4 (C2 and C4) due to broken instruments

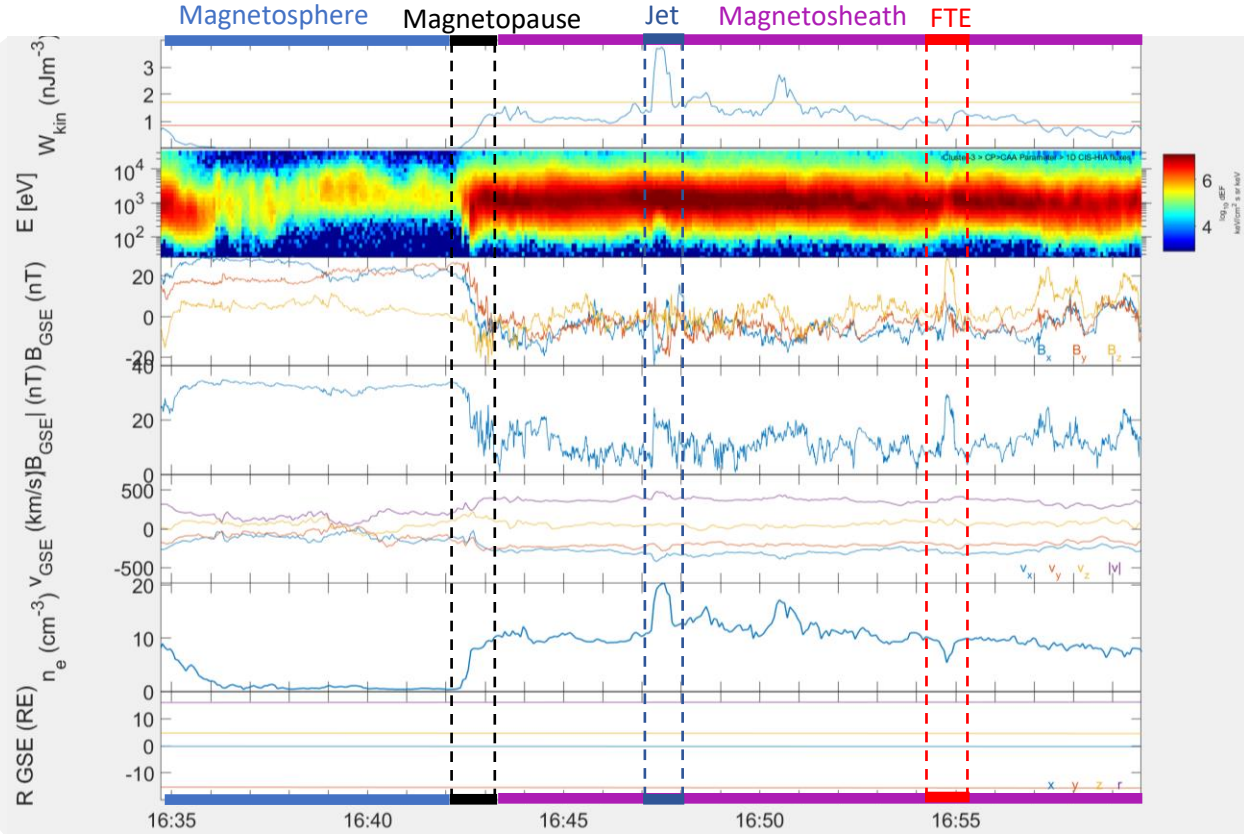


Visualization of the satellites' motion (lines) and when they detected an FTE (red dot) or a magnetosheath jet (blue dot). The different colors of the lines represent different Cluster satellites, as described by the legend. Each subplot shows one of the four FTEs that we are conducting case studies on.

Preliminary Case Study Results

- Closer look on one satellite:
  - Magnetopause can be seen, followed by jet, followed by FTE
  - Indicates that the jet collided with magnetopause, creating an FTE





Summary

- Previous work show that magnetosheath jets can cause reconnection and indicates that jets can cause FTEs

- This study investigates whether jets can cause FTEs using:
  - Case study
  - Statistical analyses

- Preliminary results:
  - 18% of all isolated FTEs appear close to magnetosheath jet
  - Case study indicates that FTEs can be caused by magnetosheath jets

- Further investigation is needed

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