CURRENT SHEETS AND WAVES INSIDE MAGNETOSHEATH JETS

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MAGNETOSHEATH JETS

- **First reported by** Nemeček et al. (1998) - "Transient Flux Enhancements"
- **Other names**: **High Kinetic Energy Density Plasma Jets** (Savin et al., 2008), **High Kinetic energy Jets** (Amata et al., 2011), **Plasmoids** (Karlsson et al., 2012, 2015), **Supermagnetosonic Jets** (Hietala et al., 2012), **Dynamic Pressure Pulses** (Archer et al., 2012), **High Speed Jets** (Plaschke et al., 2013), etc.
- **We use** the name **magnetosheath jets** as in Plaschke et al. 2018 - (review paper).

FORMATION MECHANISMS

- Formation at the rippled quasi-parallel shocks (Figure 1, Hietala et al., 2009)
- Short, Large Amplitude Magnetic Structures (SLAMS) convected into the quasi-parallel magentosheath (Karlsson et al., 2012)
- SW plasmoids convected into the magnetosheath (Karlsson et al., 2012)

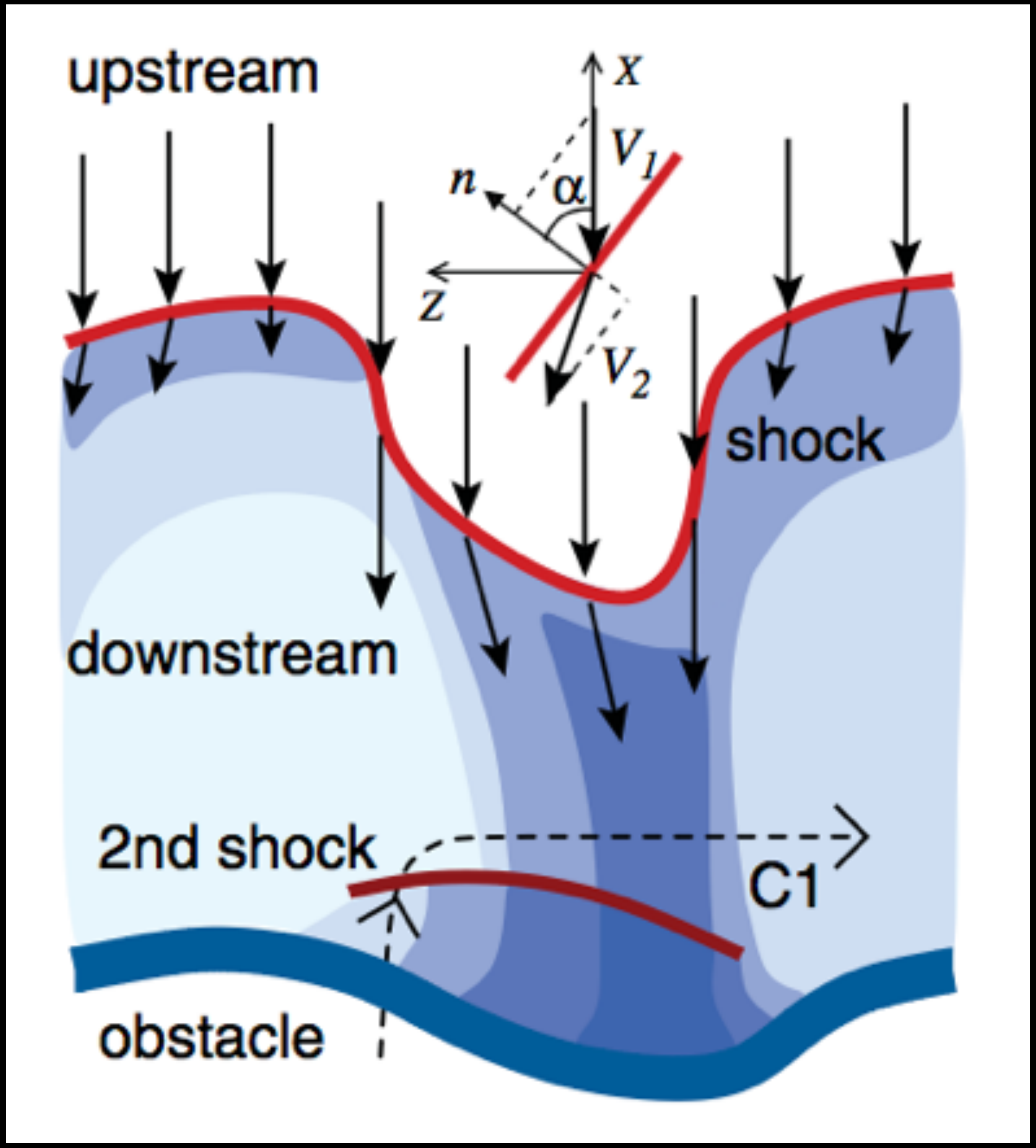
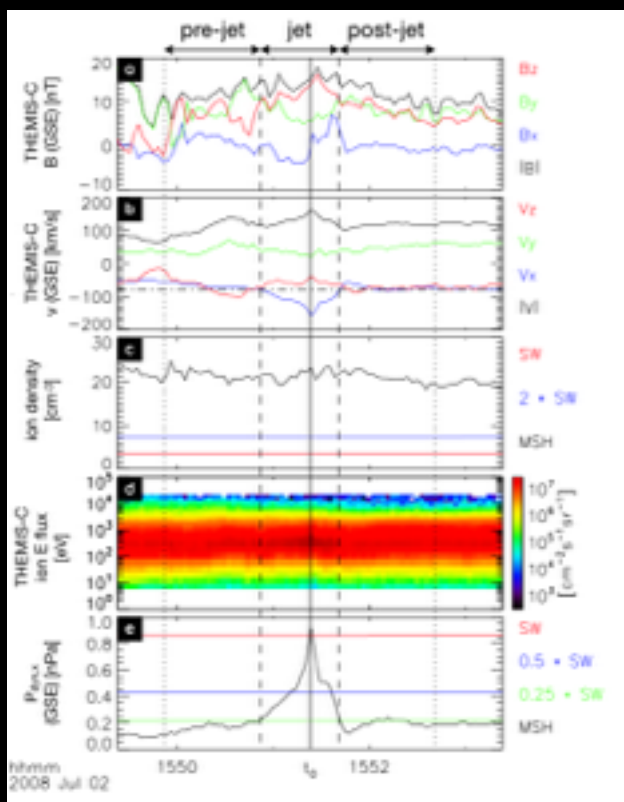
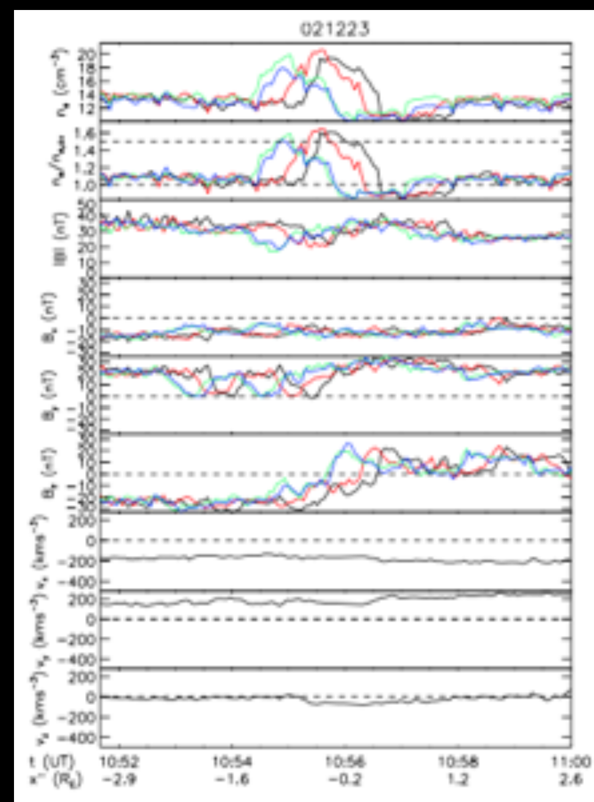


Figure 1: jet formation at rippled surfaces of quasi-parallel shocks.

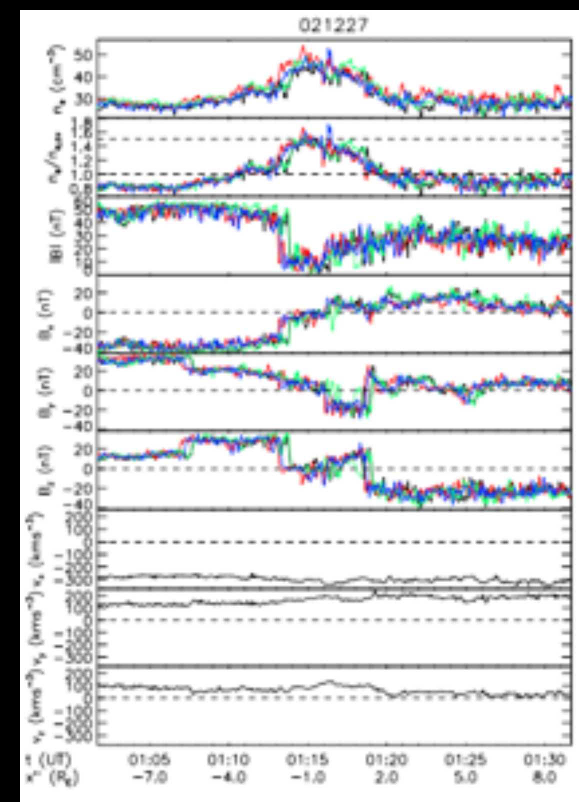
EXAMPLES FROM LITERATURE



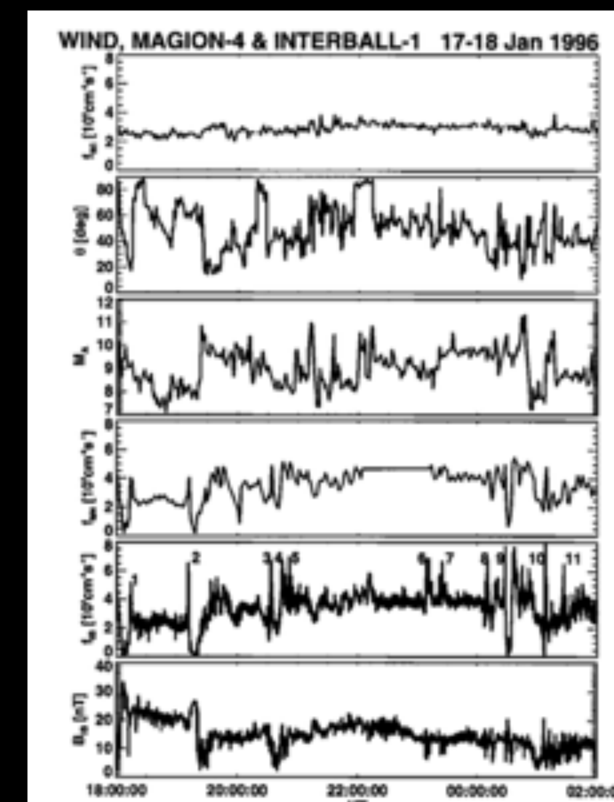
(a)



(b)



(c)



(d)

(a) Plaschke et al. (2013): increase in $P_{dyn,x}$ (calculated only with V_x). Threshold: $P_{dyn,x} \geq 1/2 P_{dyn,x,SW}$

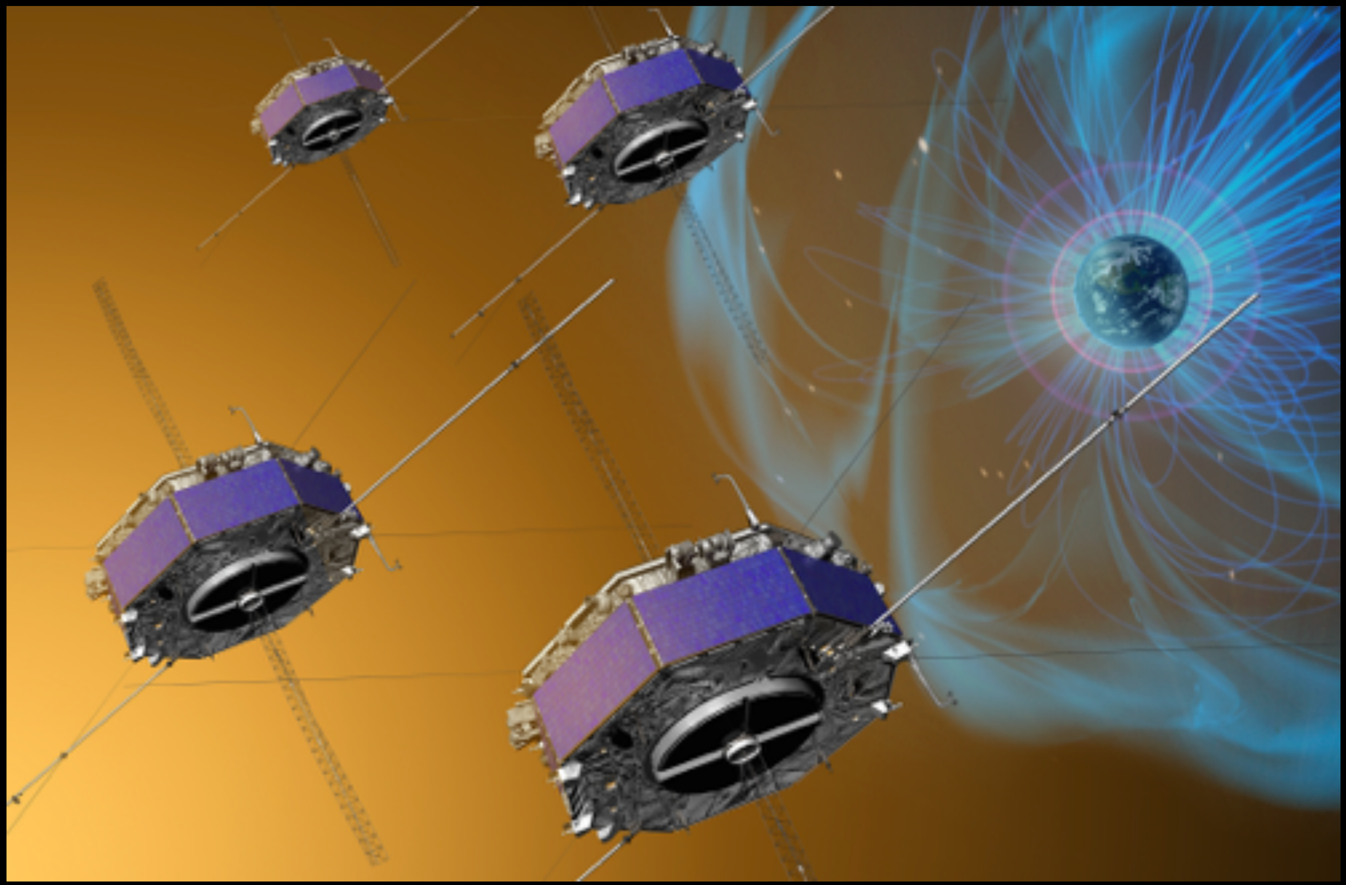
(b) Karlsson et al. (2012): increase of plasma density. Threshold: $\rho \geq 1.5 <\rho_{msh}>$. Correlated ρ and B (**paramagnetic** plasmoid).

(b) Karlsson et al. (2012): increase of plasma density. Threshold: $\rho > 1.5 <\rho_{msh}>$. Anticorrelated ρ and B (**diamagnetic** plasmoid).

(d) Nemeček et al. (1998): Increase of ion flux. Threshold $F \geq 1.5\ F_{msh}$.

OUR OBSERVATIONS

- We use observations performed by the Magnetospheric Multi Scale Mission (MMS) probes in survey and burst modes.
- Four case studies.
- Emphasis on B-field and E-field fluctuations, electric currents and
- posible magnetic reconnection signatures (velocity, energy dissipation, B-field rotations, high frequency waves).



CASE STUDY 1

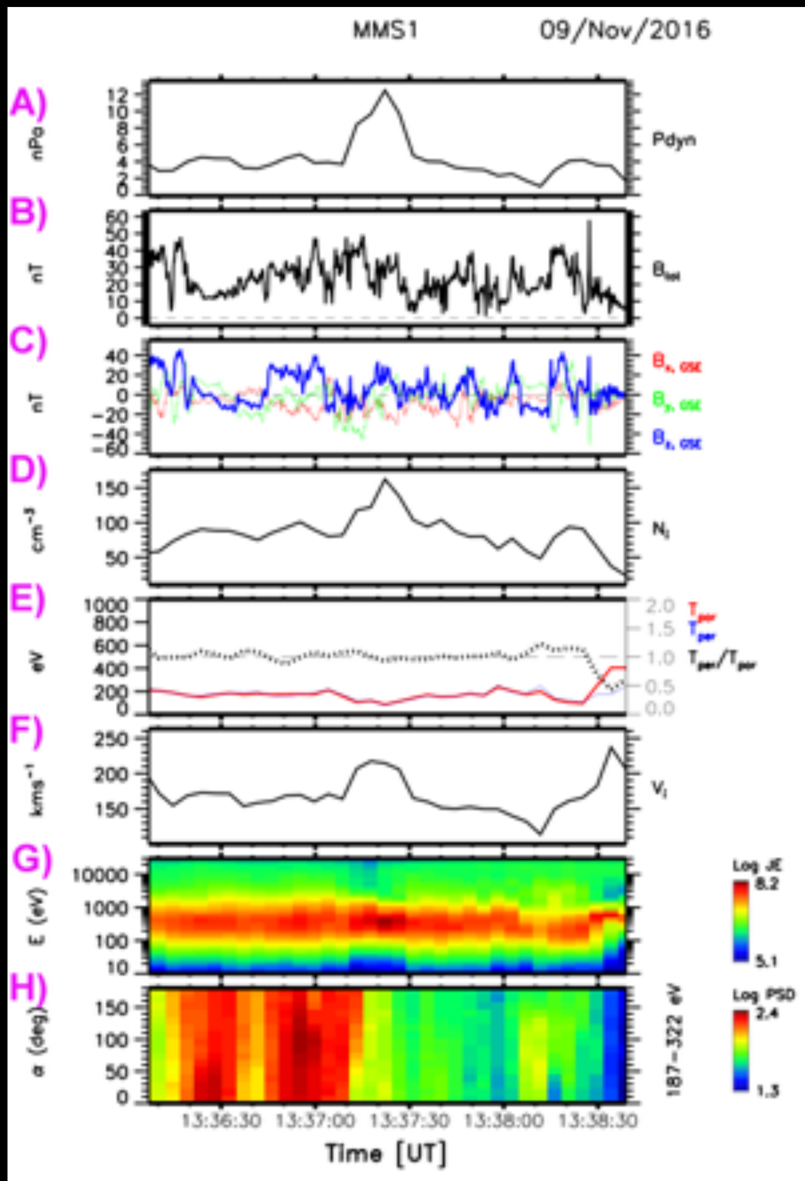


Figure 2

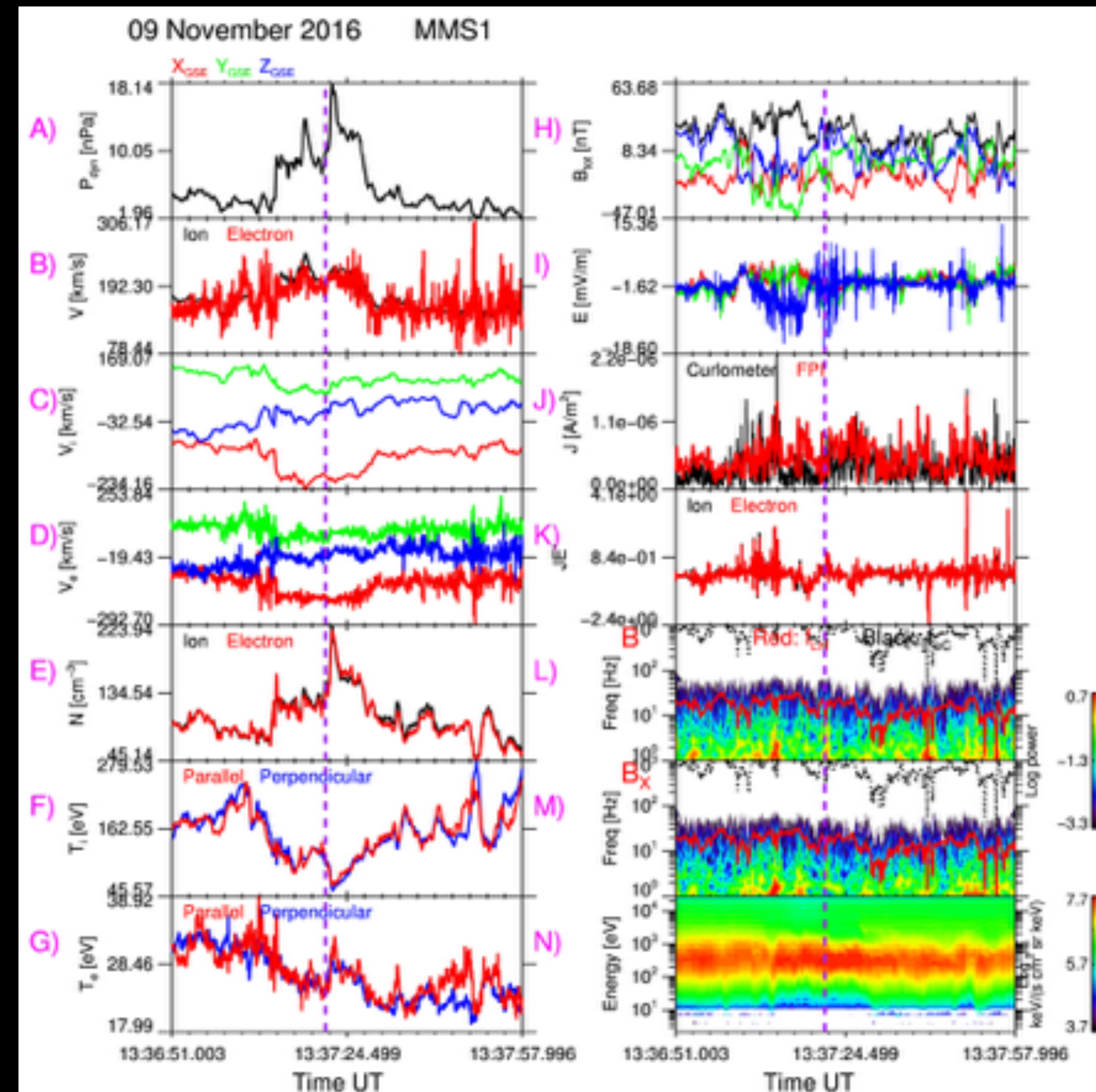


Figure 3

Figure 2: Magnetosheath jet observed by MMS1 (**survey mode**) featuring simple structure in plasma parameters without any heating.

Figure 3: Jet in **burst mode** data featuring complex, 2 peak structure in P_{dyn} **(A)**, a narrow peak in electron and ion density (N_i, **E**) and electron heating (T_e, **F**) adjacent to the highest peak in P_{dyn} (purple line). Large E-field fluctuations are present inside the jet **(I)**, especially around the peak. JE', where **E'** =**E** + **v**×**B**, **(J)** exhibits a small, positive peak adjacent to the purple line, indicating energy transfer from fields to particles.

CASE STUDY 2

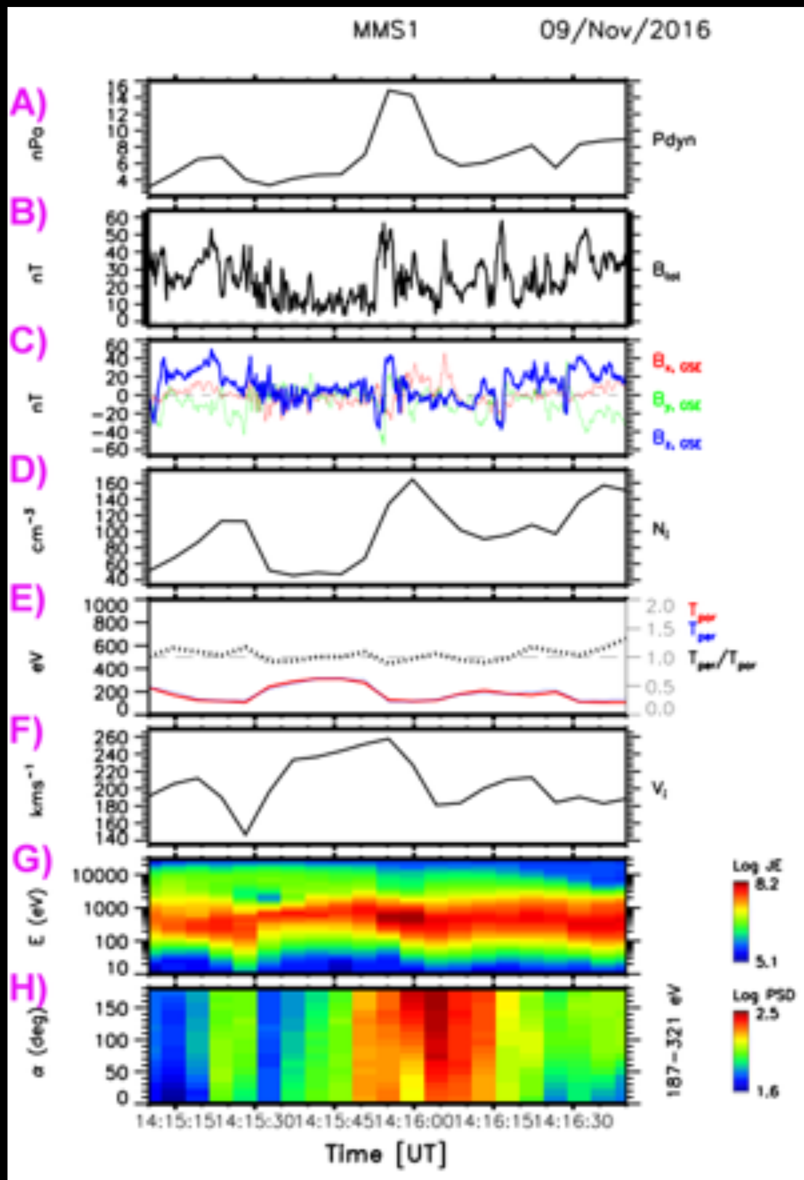


Figure 4

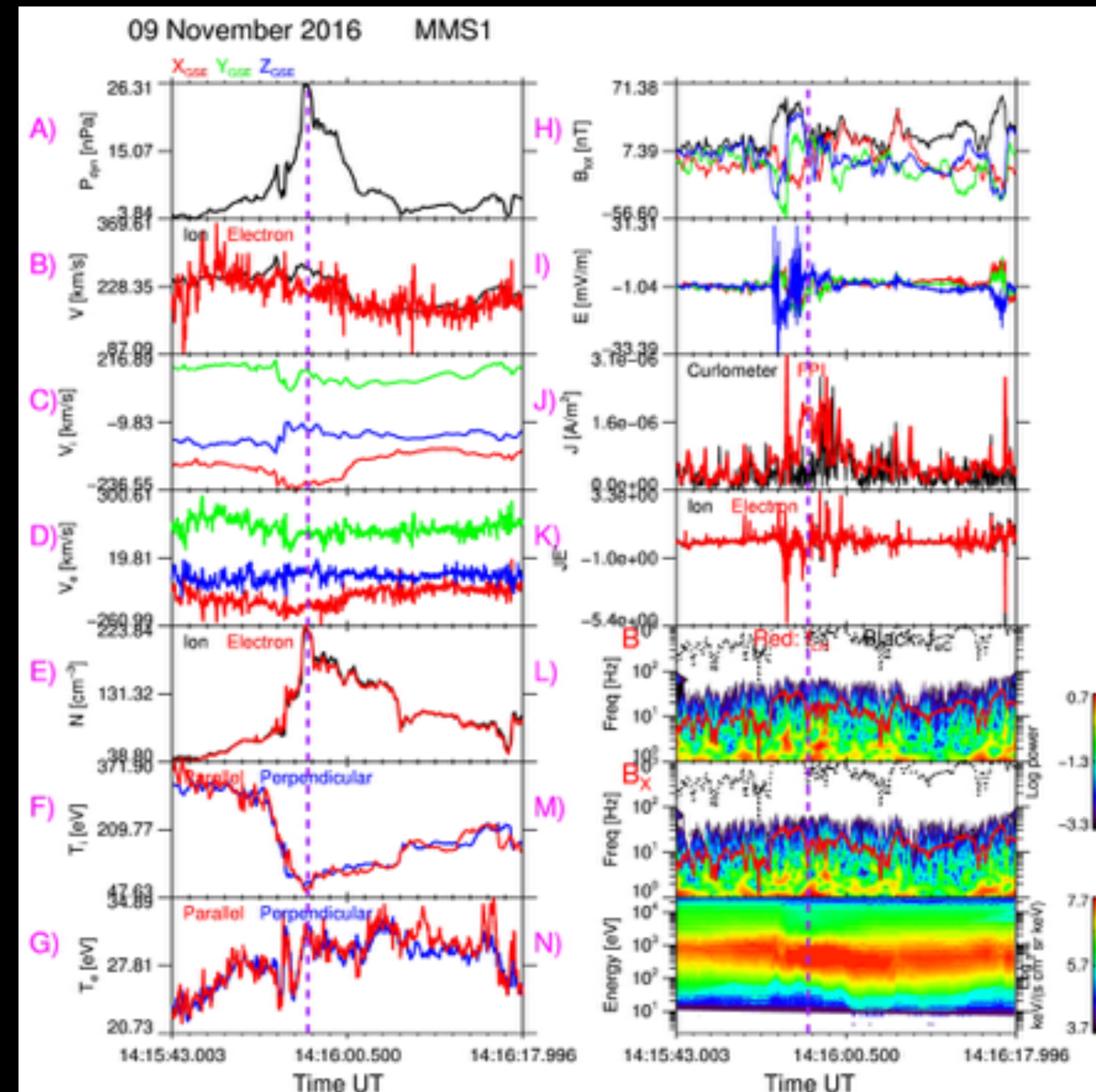


Figure 5

Magnetosheath jet as observed by MMS1 in **survey mode** (**Figure 4**) and **burst mode** (**Figure 5**) data. Again, the burst mode data exhibit a vey complex inner structure of the jet. A narrow peak in P_{dyn} **(A)**, marked with the vertical purple line, is due to the peak in N_i **(E)**. Some jet signatures are different in the region before and after the peak. Intense E-field fluctuations **(I)** occur only before the peak. In the same region there is a narrow peak in electric current, while the whole rear region is contains strong electric currents **(J)**. JE' exhibits two positive and one strongly negative peak in the front region, while many positive and only one negative peak can be observed in the rear region of the jet.

CASE STUDY 3

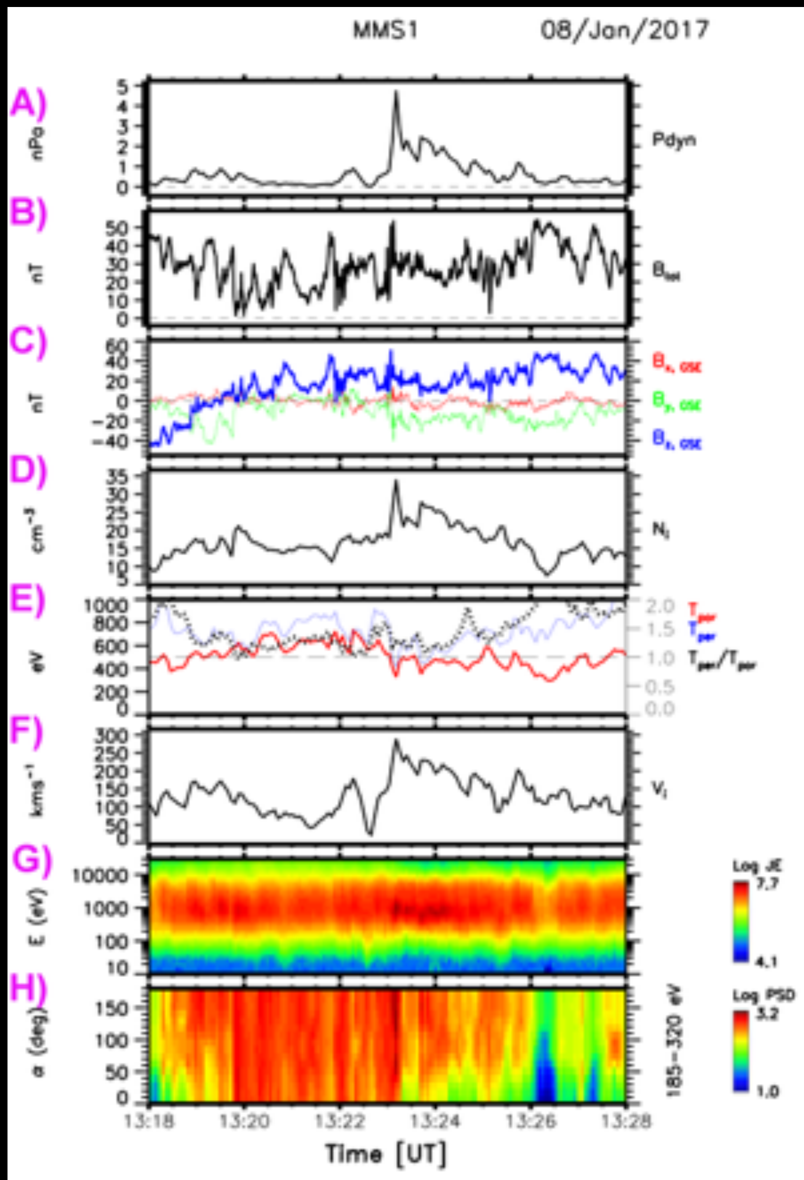


Figure 6

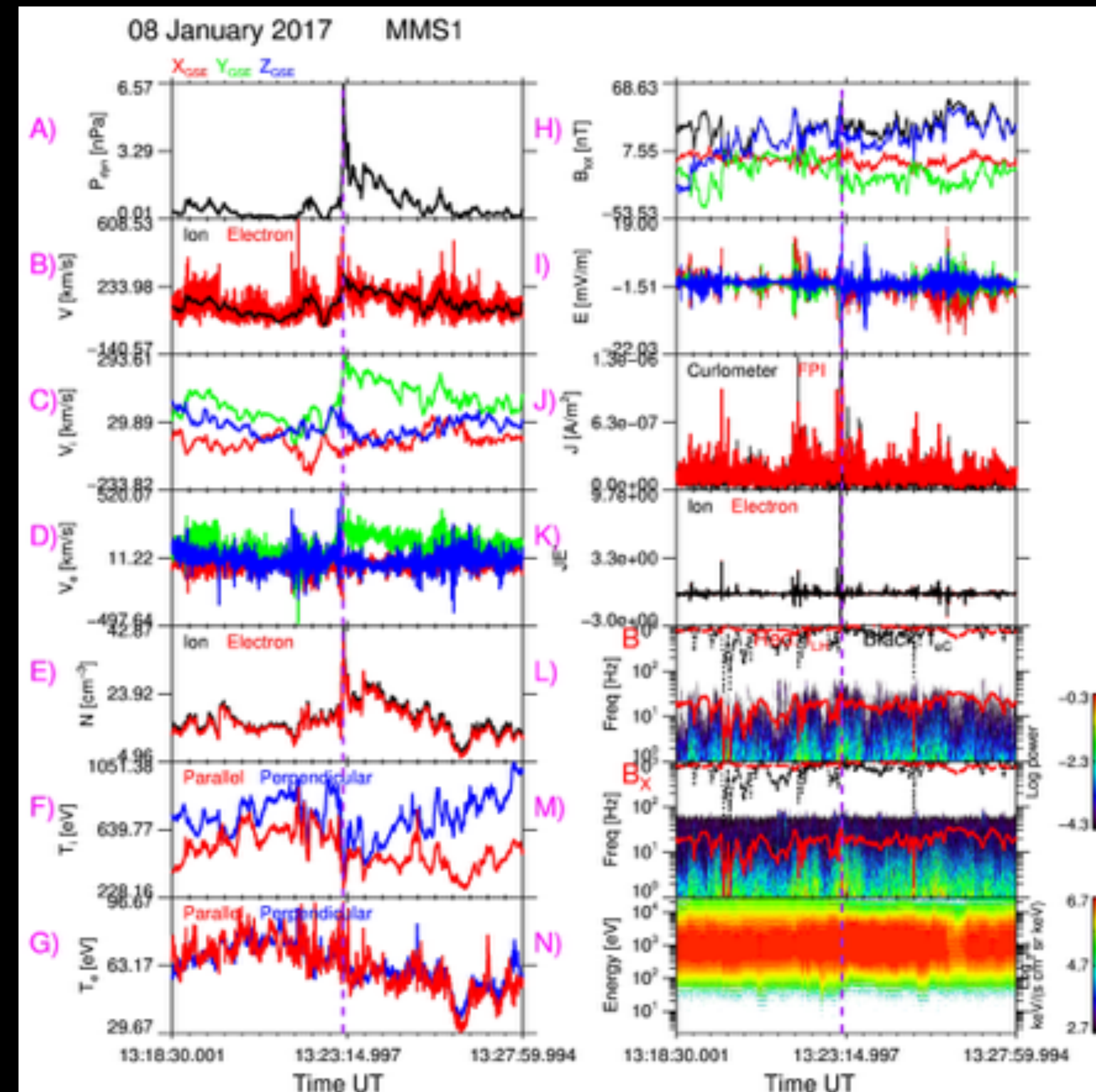


Figure 7

Magnetosheath jet observed by MMS1 in **survey mode** (**Figure 6**) and **burst mode** (**Figure 7**) data. The jet exhibits a very narrow peak which in survey mode data reached the values of less than 5 nPa, while in burst mode data it reaches 6.6 nPa **(7A)**. This peak is associated with a peak in N_i **(E)**, electron velocity V_e **(B, D)**, strong B-field rotation **(H)**, string electric current **(J)**, and positive peak in JE’ **(K)**. All this points to magnetic reconnection inside the jet.

CASE STUDY 4

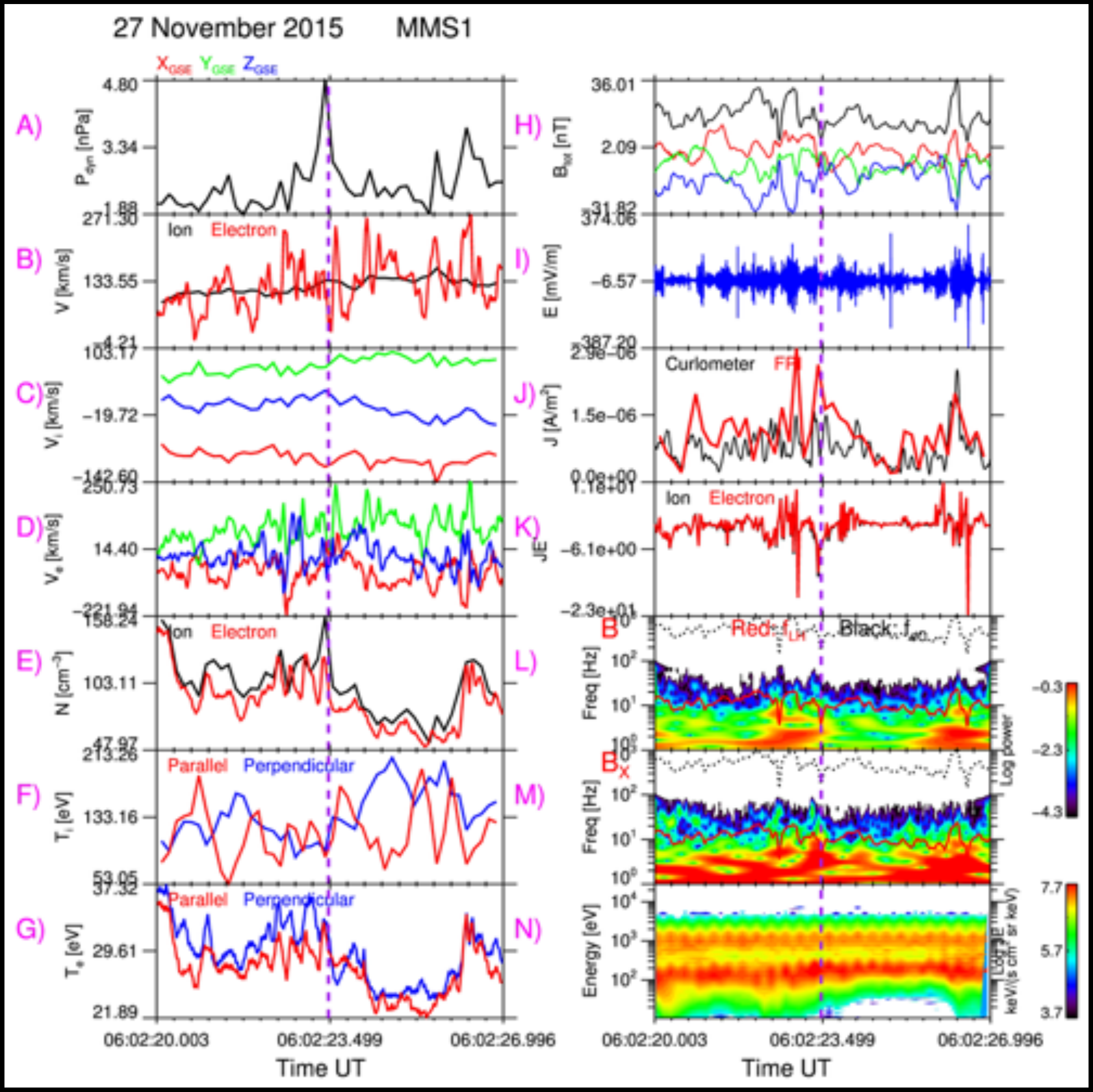


Figure 8

The last jet discussed here was not observed in the survey mode data due to its short duration. The peak in P_{dyn} **(A)** is due to a narrow peak in Ni **(E),** while the ion velocity exhibits no peak at all **(B)**. At the time of the peak, marked with a dashed vertical line, B-field magnitude shows a decrease **(H)**, while the electric current **(J)** exhibits a large peak. This is not only peak in the current though as an even stringer peak occurs moments earlier. At both peaks JE' exhibits negative peaks suggesting energy transfer from particles to electromagnetic fields. E-field **(I)** shows strong fluctuating throughout the interval.

CONCLUSIONS

We exhibit four magnetosheath jets observed by MMS1 probe. Survey and burst mode data are shown.

We show that:

1. Burst mode data reveal a very complex inner structure of magnetosheath jets.

2. Some jets exhibit more than one P_{dyn} peaks.

3. B-field rotations and E-field fluctuations are common inside the jets.

4. Magnetosheath jets commonly contain strong electric currents and current sheets.

5. JE' shows positive and negative peaks especially inside these current sheets pointing to energy exchange between electromagnetic fields and plasma particles.

6. Magnetosheath jets may occur on very short timescales (see case study 4). Many of them may have been missed by previous missions whose plasma data had a poorer time resolution.

7. Burst data show that the maximum values of P_{dyn} inside the jets may be very different depending on the data time resolution. This is the case in the case study 3 where the difference in maximum P_{dyn} in burst and survey modes is ~1.6 nPa. This particular jet exhibits several properties that suggests that the narrow peak is caused by magnetic reconnection inside the jet.