Supporting Information for "Solar wind - magnetosphere coupling during radial IMF conditions: simultaneous multi-point observations"

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Figures S1 - S6 show the Cluster 4 (dusk flank) and MMS1 (subsolar region) magnetopause crossings for events with ID 3, 5, 6, 8, 10 and 11 (see Table 1 of the main article). Panels a-e correspond to Cluster (C4) observations, and panels f-j correspond to MMS observations of the same variables, namely magnetic field, ion density, ion velocity, and ion spectrogram. All vectors are provided in local LMN coordinates, obtained from applying MVA to the **B** field in the yellow-shaded regions. The LMN coordinates are specified in panels a and f, for C4 and MMS1, respectively. The blue-shaded regions correspond to the reference time interval for inferring magnetosheath quantities, and the red-shaded regions correspond to the reference time interval for inferring magnetospheric quantities. Ion velocities estimated by CIS-CODIF on C4 are not reliable in the magnetosphere due to the low counts, and have been masked in panel c. We assume a negligible flank magnetosphere bulk velocity, compared to flank magnetosheath bulk velocity.

Table S1 complements Table 1 of the main article. It provides, for each spacecraft crossing, the local L and N directions of the magnetopause current sheet, the average B_L and n values in the magnetosphere and magnetosheath reference intervals, the hybrid Alfvén velocity (Cassak & Shay, 2007), the shear flow velocity in the L direction at the magnetopause, the variation of plasma β, and the **B** clock angle in the local LM plane.

References

Cassak, P. A., & Shay, M. A. (2007). Scaling of asymmetric magnetic reconnection: General theory and collisional simulations. *Physics of Plasmas*, *14*(10).

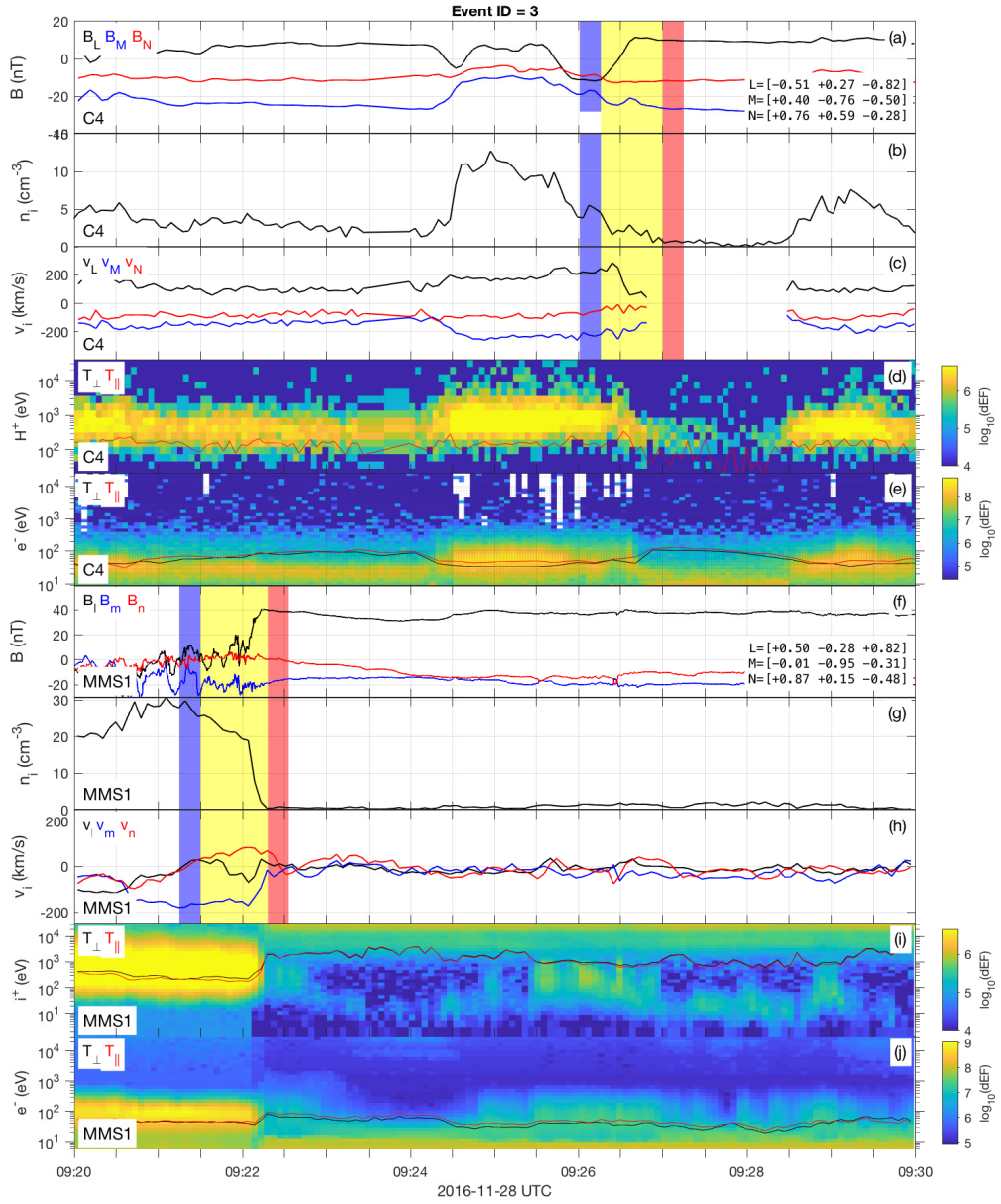

Figure S1. MMS and Cluster simultaneous observations of the magnetopause during event 3 (see Table 1). The yellow-shaded regions mark the time interval used to apply MVA to the current sheet crossing and obtain the LMN coordinate system for each spacecraft. Blue-shaded and red-shaded regions mark the intervals used as reference for the asymptotic conditions of the magnetosheath and the magnetosphere, respectively. (a) C4 magnetic field in LMN coordinates. (b) C4 ion number density. (c) C4 ion velocity in LMN coordinates. (d) (color) C4 CODIF proton spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular proton temperature, (red) parallel proton temperature. (e) (color) C4 PEACE electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature. (f) MMS1 magnetic field in LMN coordinates. (g) MMS1 ion number density. (h) MMS ion velocity in LMN coordinates. (i) (color) MMS1 FPI ion spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular ion temperature, (red) parallel ion temperature. (j) (color) MMS1 FPI electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature.

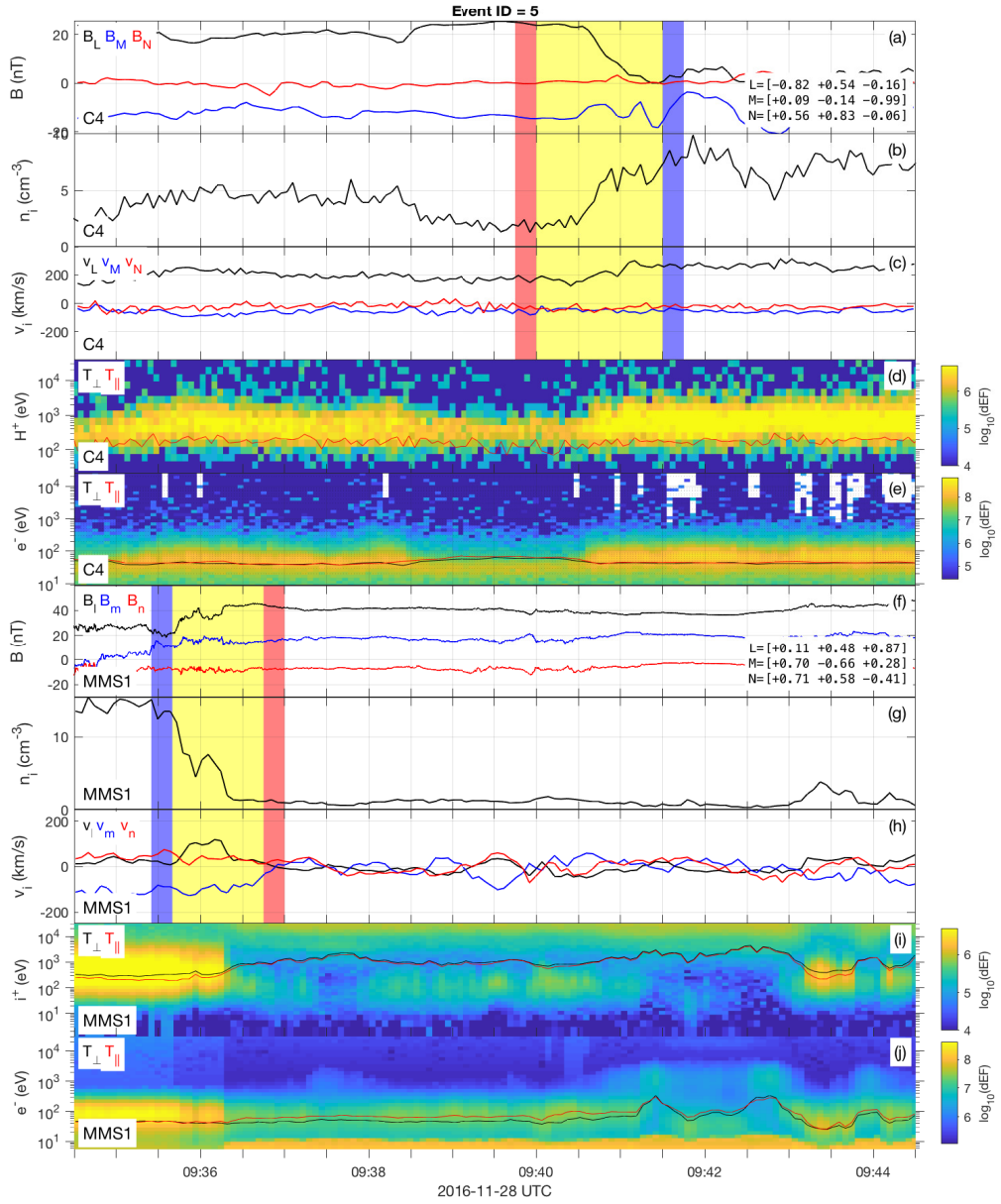

Figure S2. MMS and Cluster simultaneous observations of the magnetopause during event 5 (see Table 1). The yellow-shaded regions mark the time interval used to apply MVA to the current sheet crossing and obtain the LMN coordinate system for each spacecraft. Blue-shaded and red-shaded regions mark the intervals used as reference for the asymptotic conditions of the magnetosheath and the magnetosphere, respectively. (a) C4 magnetic field in LMN coordinates. (b) C4 ion number density. (c) C4 ion velocity in LMN coordinates. (d) (color) C4 CODIF proton spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular proton temperature, (red) parallel proton temperature. (e) (color) C4 PEACE electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature. (f) MMS1 magnetic field in LMN coordinates. (g) MMS1 ion number density. (h) MMS ion velocity in LMN coordinates. (i) (color) MMS1 FPI ion spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular ion temperature, (red) parallel ion temperature. (j) (color) MMS1 FPI electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature.

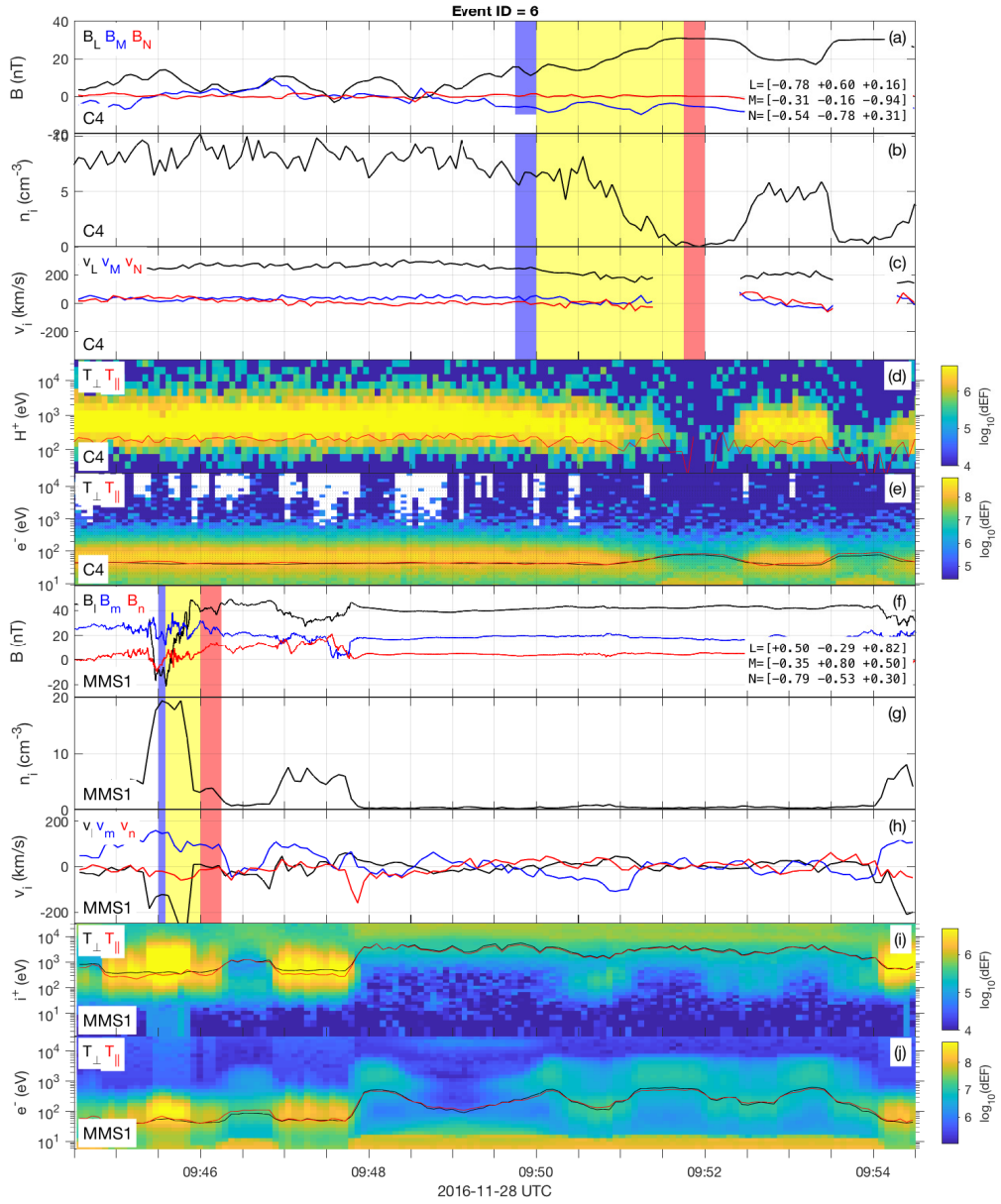

Figure S3. MMS and Cluster simultaneous observations of the magnetopause during event 6 (see Table 1). The yellow-shaded regions mark the time interval used to apply MVA to the current sheet crossing and obtain the LMN coordinate system for each spacecraft. Blue-shaded and red-shaded regions mark the intervals used as reference for the asymptotic conditions of the magnetosheath and the magnetosphere, respectively. (a) C4 magnetic field in LMN coordinates. (b) C4 ion number density. (c) C4 ion velocity in LMN coordinates. (d) (color) C4 CODIF proton spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular proton temperature, (red) parallel proton temperature. (e) (color) C4 PEACE electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature. (f) MMS1 magnetic field in LMN coordinates. (g) MMS1 ion number density. (h) MMS ion velocity in LMN coordinates. (i) (color) MMS1 FPI ion spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular ion temperature, (red) parallel ion temperature. (j) (color) MMS1 FPI electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature.

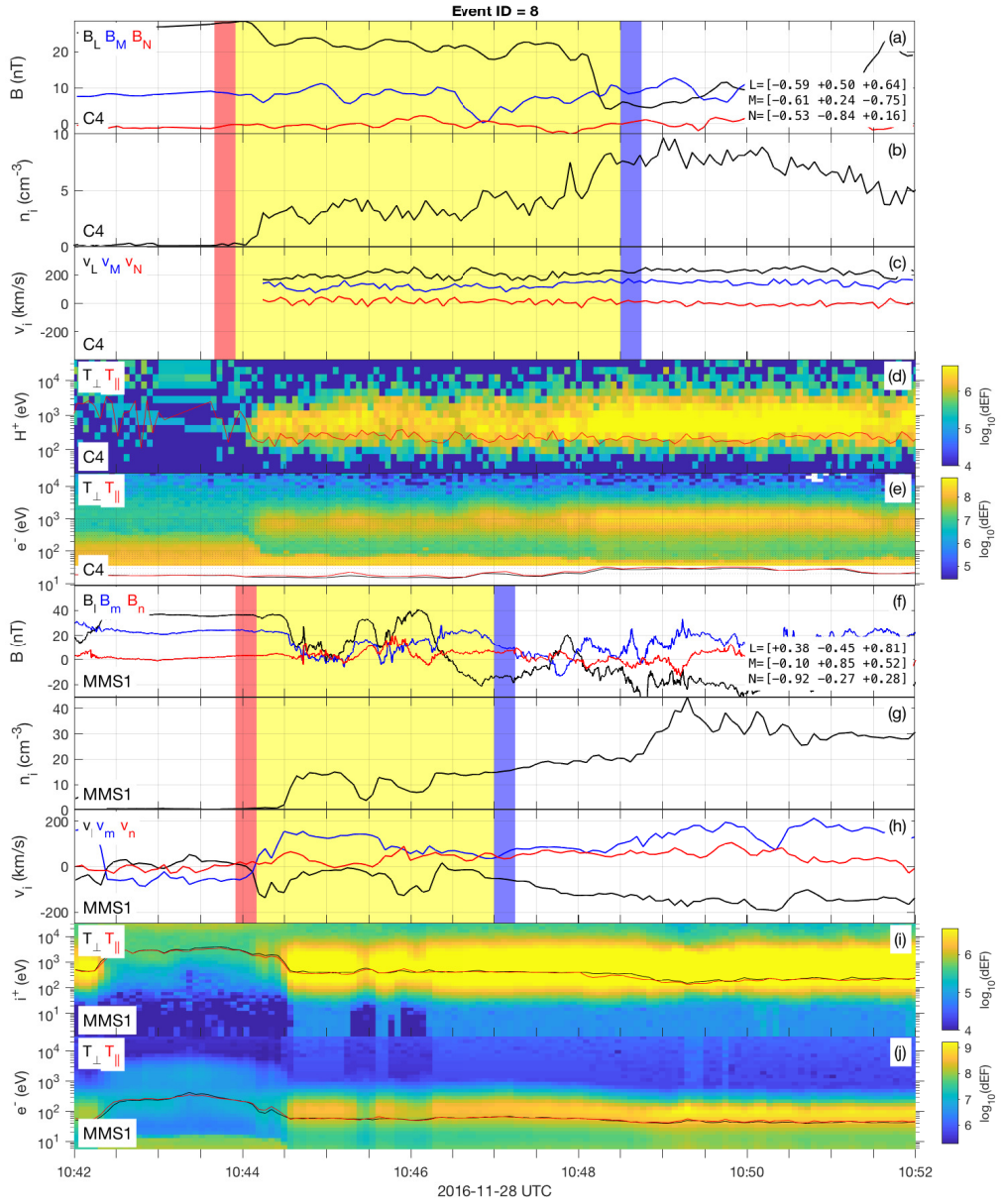

Figure S4. MMS and Cluster simultaneous observations of the magnetopause during event 8 (see Table 1). The yellow-shaded regions mark the time interval used to apply MVA to the current sheet crossing and obtain the LMN coordinate system for each spacecraft. Blue-shaded and red-shaded regions mark the intervals used as reference for the asymptotic conditions of the magnetosheath and the magnetosphere, respectively. (a) C4 magnetic field in LMN coordinates. (b) C4 ion number density. (c) C4 ion velocity in LMN coordinates. (d) (color) C4 CODIF proton spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular proton temperature, (red) parallel proton temperature. (e) (color) C4 PEACE electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature. (f) MMS1 magnetic field in LMN coordinates. (g) MMS1 ion number density. (h) MMS ion velocity in LMN coordinates. (i) (color) MMS1 FPI ion spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular ion temperature, (red) parallel ion temperature. (j) (color) MMS1 FPI electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature.

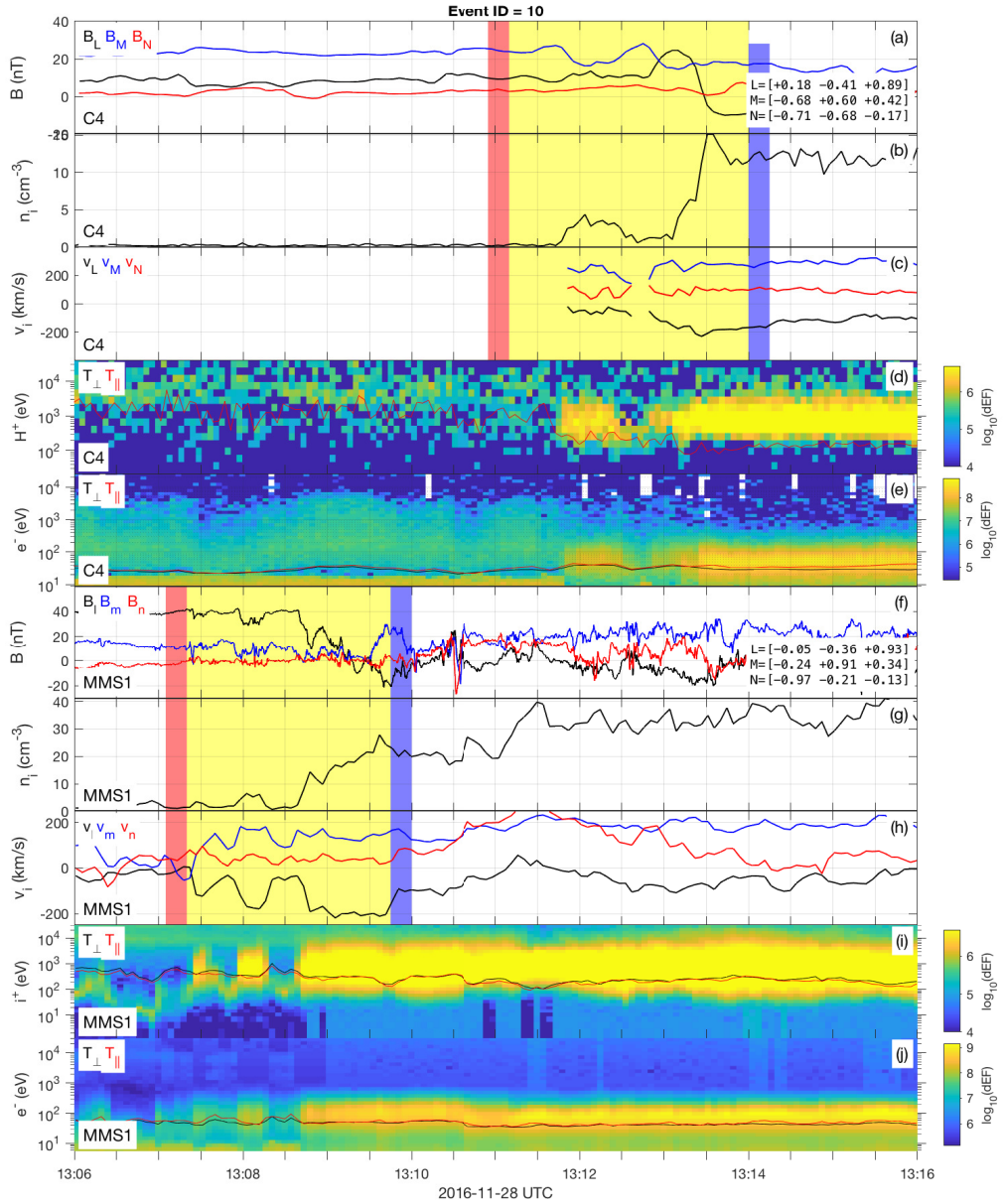

Figure S5. MMS and Cluster simultaneous observations of the magnetopause during event 8 (see Table 1). The yellow-shaded regions mark the time interval used to apply MVA to the current sheet crossing and obtain the LMN coordinate system for each spacecraft. Blue-shaded and red-shaded regions mark the intervals used as reference for the asymptotic conditions of the magnetosheath and the magnetosphere, respectively. (a) C4 magnetic field in LMN coordinates. (b) C4 ion number density. (c) C4 ion velocity in LMN coordinates. (d) (color) C4 CODIF proton spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular proton temperature, (red) parallel proton temperature. (e) (color) C4 PEACE electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature. (f) MMS1 magnetic field in LMN coordinates. (g) MMS1 ion number density. (h) MMS ion velocity in LMN coordinates. (i) (color) MMS1 FPI ion spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular ion temperature, (red) parallel ion temperature. (j) (color) MMS1 FPI electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature.

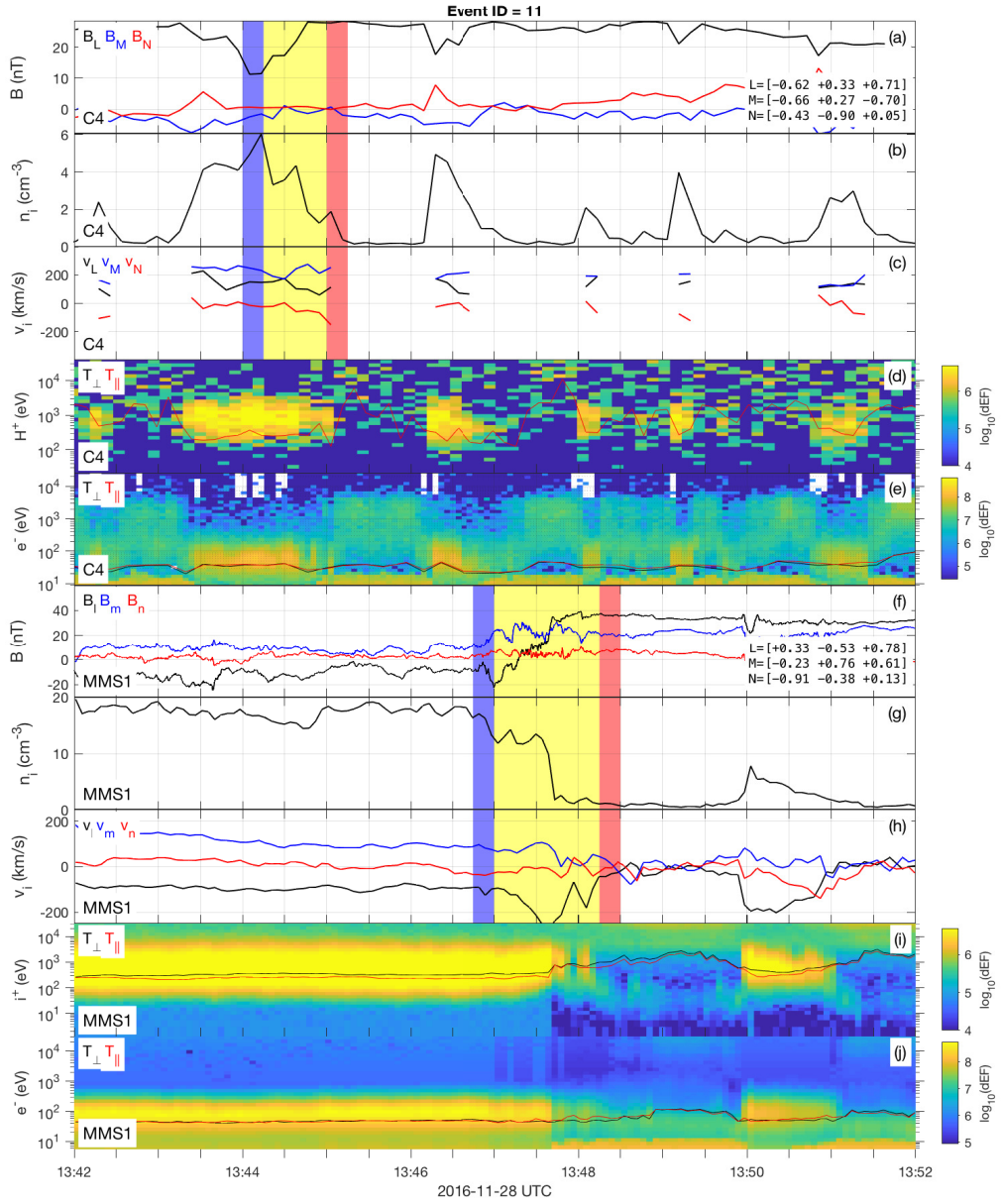

Figure S6. MMS and Cluster simultaneous observations of the magnetopause during event 8 (see Table 1). The yellow-shaded regions mark the time interval used to apply MVA to the current sheet crossing and obtain the LMN coordinate system for each spacecraft. Blue-shaded and red-shaded regions mark the intervals used as reference for the asymptotic conditions of the magnetosheath and the magnetosphere, respectively. (a) C4 magnetic field in LMN coordinates. (b) C4 ion number density. (c) C4 ion velocity in LMN coordinates. (d) (color) C4 CODIF proton spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular proton temperature, (red) parallel proton temperature. (e) (color) C4 PEACE electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature. (f) MMS1 magnetic field in LMN coordinates. (g) MMS1 ion number density. (h) MMS ion velocity in LMN coordinates. (i) (color) MMS1 FPI ion spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular ion temperature, (red) parallel ion temperature. (j) (color) MMS1 FPI electron spectrogram in differential Energy Flux units (dEF), keV/(cm^2 s sr keV), (black) perpendicular electron temperature, (red) parallel electron temperature.

Table S1. Asymptotic conditions at dusk flank (C4) and subsolar region (MMS1)

ID	SC	L (GSE)	N (GSE)	Magnetosphere[a] B_L (nT)	Magnetosphere[a] n (cm^{-3})	Magnetosheath[a] B_L (nT)	Magnetosheath[a] n (cm^{-3})	v_A^b (km/s)	$v_{s,L}^c$ (km/s)	$\Delta\beta$	B clock angle[d] (deg)
3	C4	-0.51 +0.27 -0.82	+0.76 +0.59 -0.28	10	0.6	-11	4.7	338	225	0.6	52
	MMS	+0.50 -0.28 +0.82	+0.87 +0.15 -0.48	39	0.8	6	27.6	124	16	9.8	45
5	C4	-0.82 +0.54 -0.16	+0.56 +0.83 -0.06	24	1.9	2	7.8	146	262	5.8	46
	MMS	+0.11 +0.48 +0.87	+0.71 +0.58 -0.41	43	1.2	21	13.6	249	15	2.1	9
6	C4	-0.78 +0.60 +0.16	-0.54 -0.78 +0.31	31	0.1	13	6.3	221	248	2.5	13
	MMS	+0.50 -0.29 +0.82	-0.79 -0.53 +0.30	41	3.4	-11[e]	19.3[e]	188	1	5.7	88
8	C4	-0.59 +0.50 +0.64	-0.53 -0.84 +0.16	28	0.2	5	7.6	159	223	7.2	41
	MMS	+0.38 -0.45 +0.81	-0.92 -0.27 +0.28	36	0.6	-14	15.3	187	51	7.3	112
10	C4	+0.18 -0.41 +0.89	-0.71 -0.68 -0.17	9	0.2	-8	12.3	187	163	1.4	44
	MMS	-0.05 -0.36 +0.93	-0.97 -0.21 -0.13	40	1.2	-10	21.3	169	100	4.4	102
11	C4	-0.62 +0.33 +0.71	-0.43 -0.90 +0.05	28	1.1	11	5.5	192	150	4.5	9
	MMS	+0.33 -0.53 +0.78	-0.91 -0.38 +0.13	36	1.1	-10	15.5	177	71	6.1	95
15	C4	+0.36 -0.55 +0.76	-0.48 -0.80 -0.35	15	0.2	-11	7.1	228	116	0.2	82
	MMS	+0.24 -0.34 +0.91	-0.64 -0.76 -0.12	43	0.6	-12	26.4	223	86	2.5	82

[a] Averaged values over 15 s adjacent to the magnetopause current sheet.
[b] Hybrid Alfvén velocity (Cassak & Shay, 2007).
[c] Shear flow speed parallel to the outflow (L) direction.
[d] Rotation angle in the LM plane.
[e] Averaged values over 5 s, see Figure S3.