

# MMS-CLUSTER JOINT MEASUREMENTS NEAR PLASMA SHEET BOUNDARY LAYER CROSSINGS



Laboratoire de Physique des Plasmas

2020 MMS Fall SWT Oct. 6-8 hosted by SWRI

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# MMS/Cluster conjunction

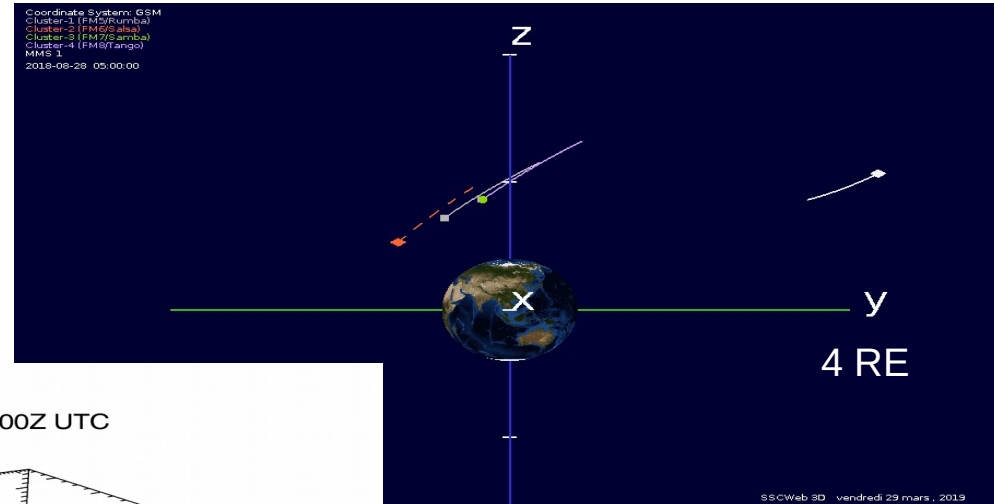
## on August 28th , 2018 5:00-7:00 UT



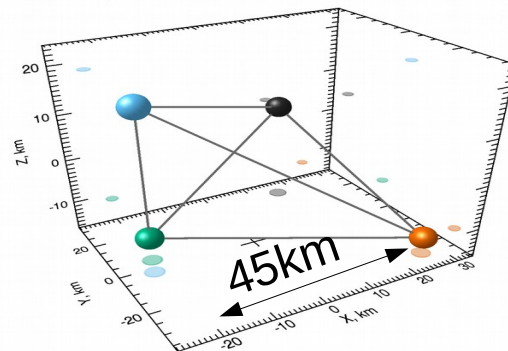
XZ GSE plane



YZ GSE plane



MMS Formation  
 2018-08-28T06:06:00Z UTC  
 TQF=0.782



GSE Coordinates, Sun to the right  
 Origin at MMS centroid

- MMS1
- MMS2
- MMS3
- MMS4

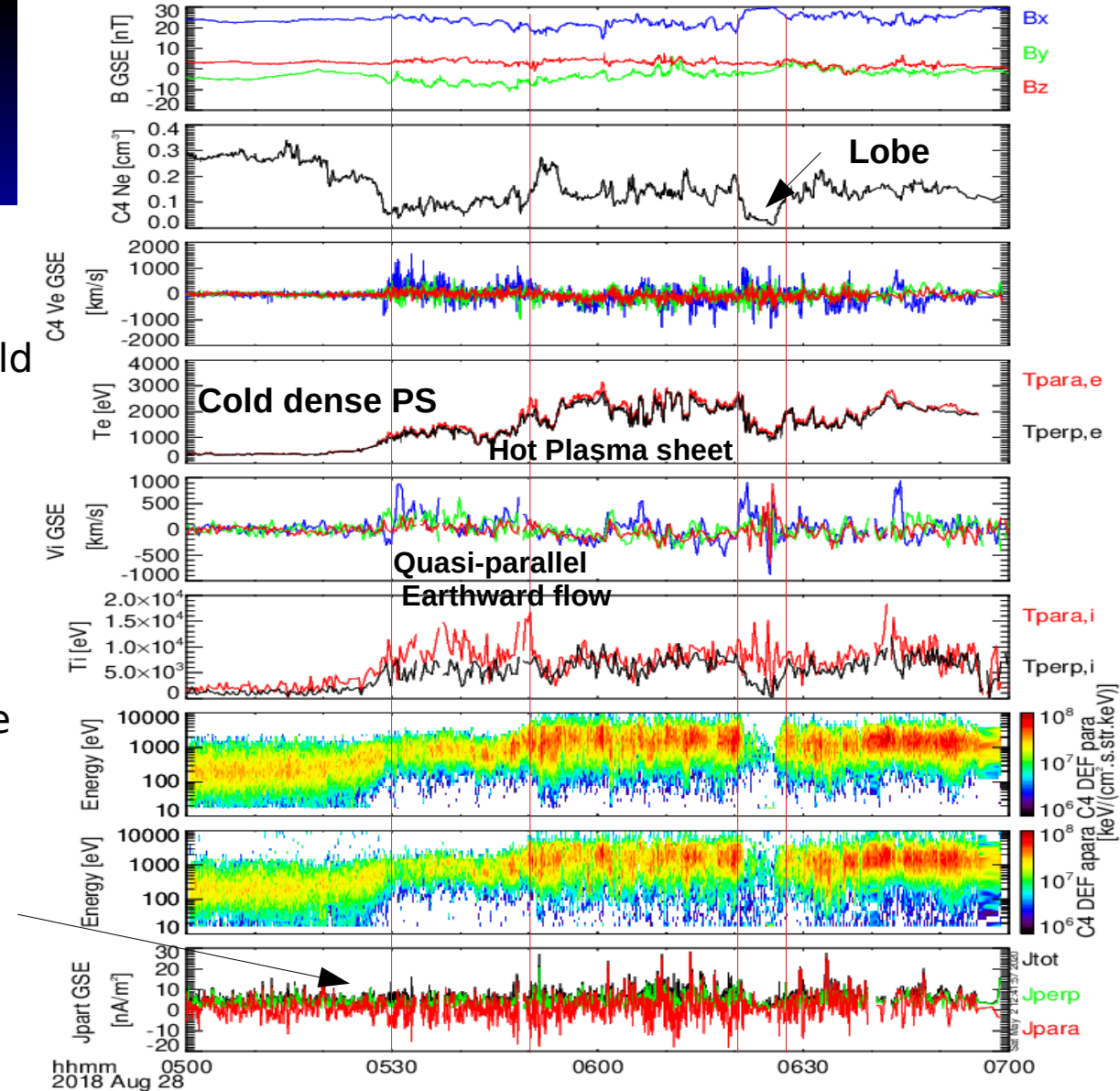


# Event overview (Cluster 4)



05:00-07:00 UT

- At 5:30 UT, Cluster 4 moved from a cold dense Plasma Sheet (CDPS) to a hot tenuous PS associated with a quasi-parallel earthward flow  $V_{x,i} \sim 500-1000$  km/s
- $T_{para,i} > T_{perp,i}$  while  $T_{para,e} \sim T_{perp,e}$
- Mostly anti-parallel (upward) current only short periods with  $J_{para} > 0$  even around the lobe region

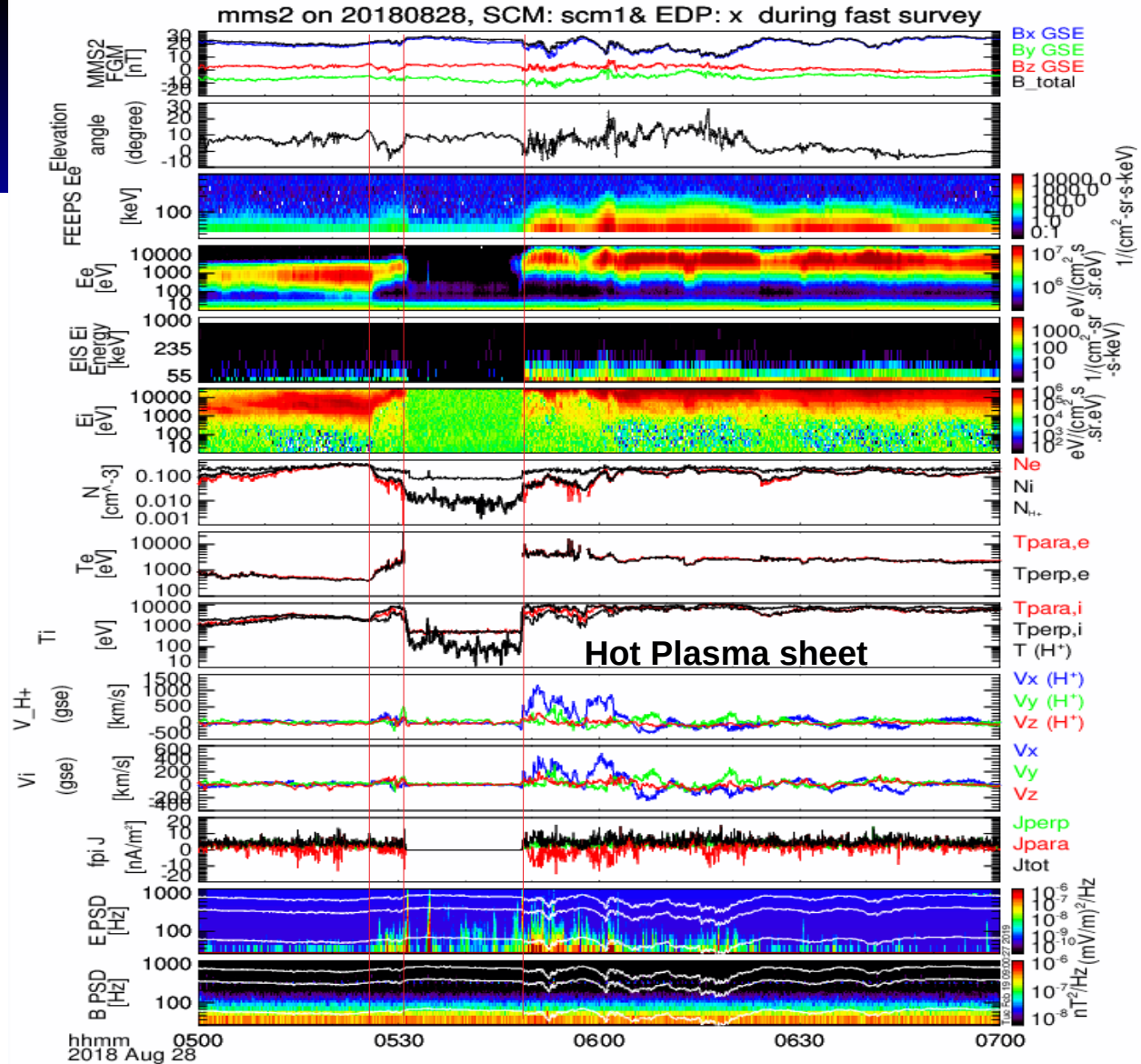


# Event overview (MMS2)



05:00 UT- 07:00 UT

- Elevation angle  $< 10^\circ$
- MMS moved from a cold dense PS to the lobe region  $\sim 05:30$  UT via a brief period of hot PS
- returned to a hot PS around 05:48 UT associated with a quasi-parallel earthward flow (18 min later than Cluster)  
 $V_x \sim 400$  km/s (FPI)  
 $\sim 800$  km/s (HPCA)
- Increasing of energetic ions and electrons
- Mostly anti-parallel (upward) currents as on Cluster [e. g. Nakamura et al., 2004]
- High-frequency electric fluctuations are detected near the PSBL crossings [ e.g. Onsager et al., 1993]



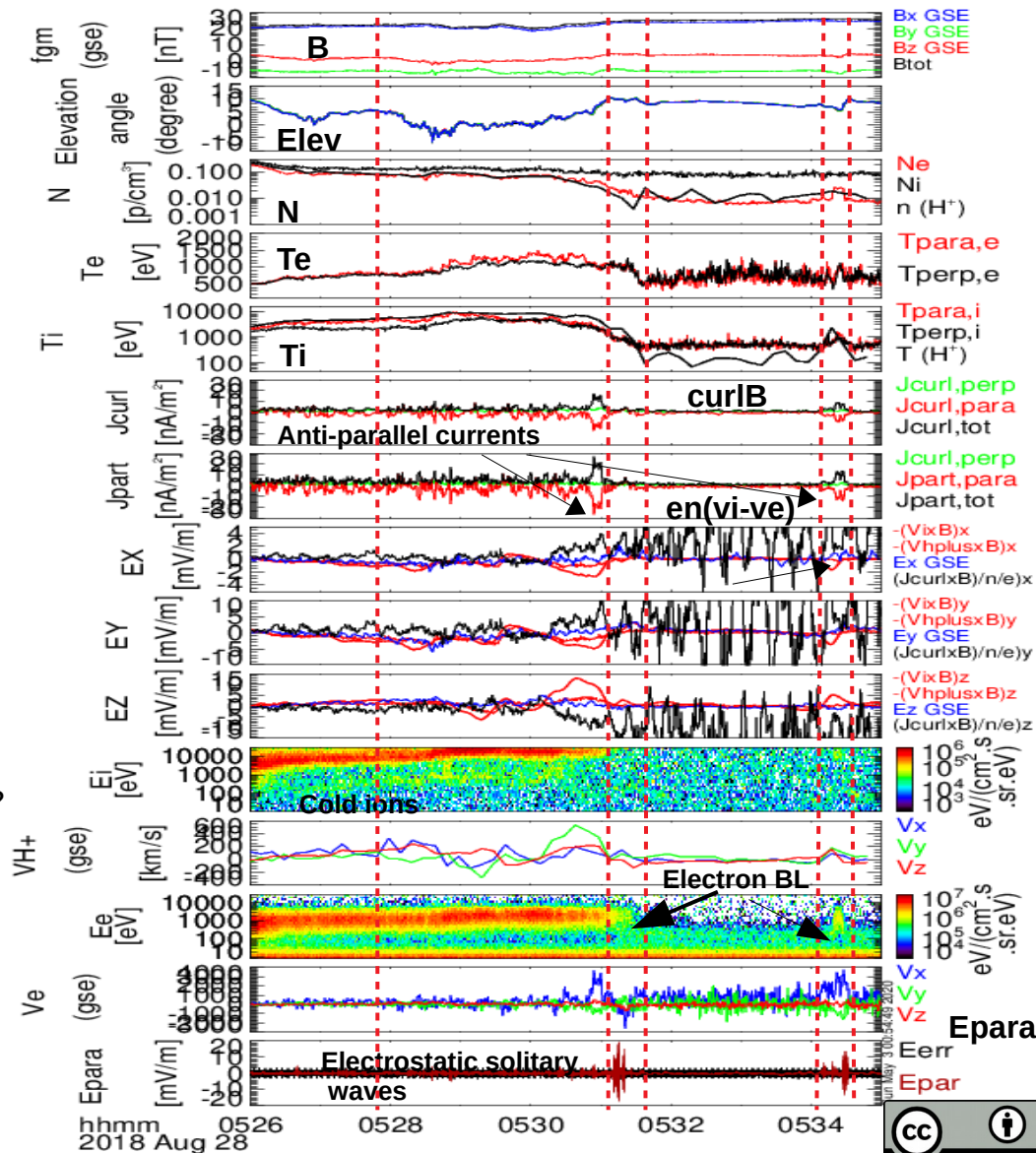


# MMS

## 1st PSBL Xing

0526-0535 UT (MMS2)

- Elevation angle increases from 0 to 10°
- Increase of Te and Ti just before Xing
- Anti-parallel (upward) current** signatures from **curlB** and from particles ( $en(\mathbf{V}_i - \mathbf{V}_e)$ )  
~ -20 nA/m<sup>2</sup> just before the Xing
- Despite small perpendicular currents, ions are decoupled from B due to Hall field ( $(\mathbf{j} \times \mathbf{B})/n/e$ ) just before PSBL Xing
- First Earthward flow (200 km/s) at 05:28 UT followed by a bipolar  $V_{y,i}$  -200/+600 km/s : ion vortex just before Xing ?
- Inside the electron BL**  
(no ions, see e.g. [Varsani et al, 2017])  
Electrostatic waves (ESW) are detected with parallel Efield signatures up to  $\pm 10$  mV/m consistent with Onsager et al., 1993 suggesting that **ESW are generated by plasma sheet electrons** and not by ion beams



# Summary



- MMS&Cluster PSBL crossings produced by large scale kink-like current sheet oscillations associated with fast earthward flow and possible waves induced by fire hose instability (not shown)
- Electrostatic waves (ESW) were detected inside the electron boundary layer [Onsager et al., JGR, 1993] but not always and also inside the plasma sheet (not shown)
- Fast electron holes moving tailward were detected in the electron boundary layer related to hot PS electrons.
- Slow ( $\sim 400$  km/s) electron holes ( $\sim 20\lambda_{De}$ ) moving tailward were also detected in the PS and possibly related to counter streaming beams (not shown).

To be continued.

