ANALYSIS OF ENERGY CONVERSION PROCESSES AT KINETIC SCALES ASSOCIATED WITH A SERIES OF DIPOLARIZATION FRONTS OBSERVED BY MMS DURING A SUBSTORM

2020 EGU Sharing Geoscience Online

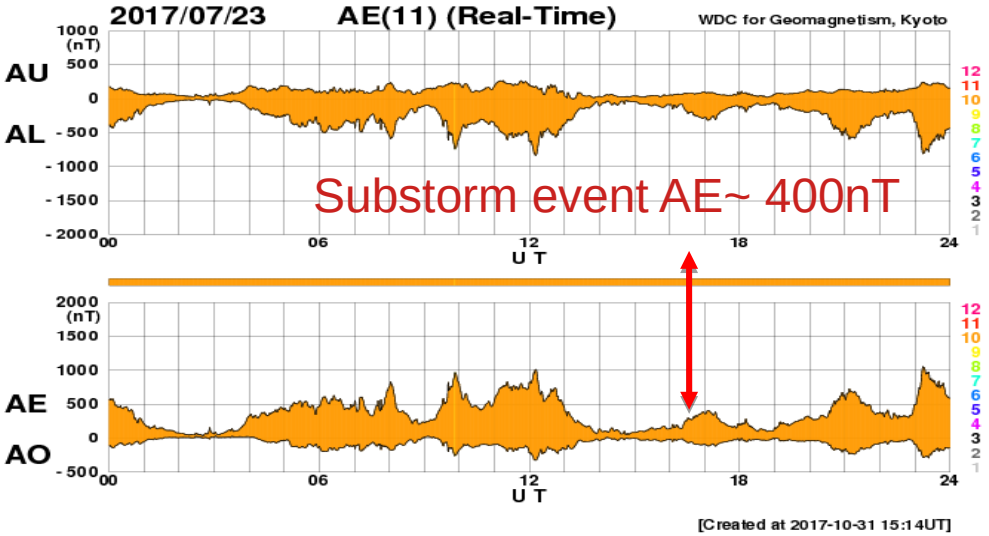
Laboratoire de Physique des Plasmas

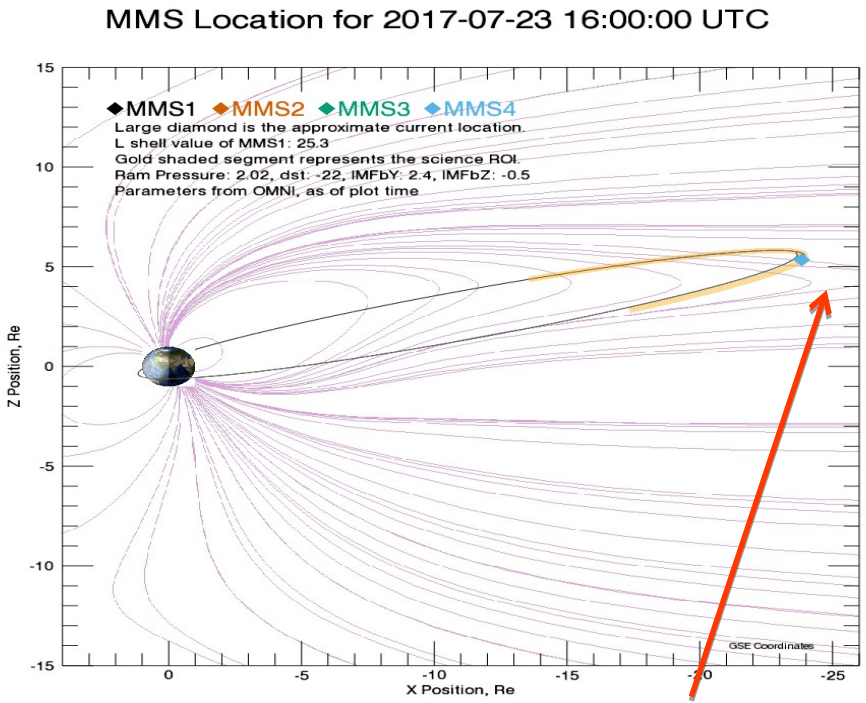
Soboh Alqeeq 1 , Olivier Le Contel 1 , Patrick Canu 1 , Alessandro Retino 1 , Thomas Chust 1 , Laurent Mirioni 1 ,Y. Khotyaintsev (2), R. Nakamura (3), F. D. Wilder (4), N. Ahmadi (4), H. Y. Wei (5), M. Argall (6), D. Fischer (3), D. J. Gershman (7), J. L. Burch (8), R. B. Torbert (6), B. L. Giles (7), S. A. Fuselier (8), R. E. Ergun (4), P.-A. Lindqvist (9), D. L. Turner (10), I. J. Cohen (11)

Email address:
soboh.al-qeeq@lpp.polytechnique.fr

PAUSE
Programme national d'Accueil en Urgence des Scientifiques en Exil

Substorm event on July 23rd , 2017 around 16:19 UT





MMS located in
pre-midnight sector near magnetic equator
X~-23.9RE, Y~5.8RE, Z~ 5.4 RE

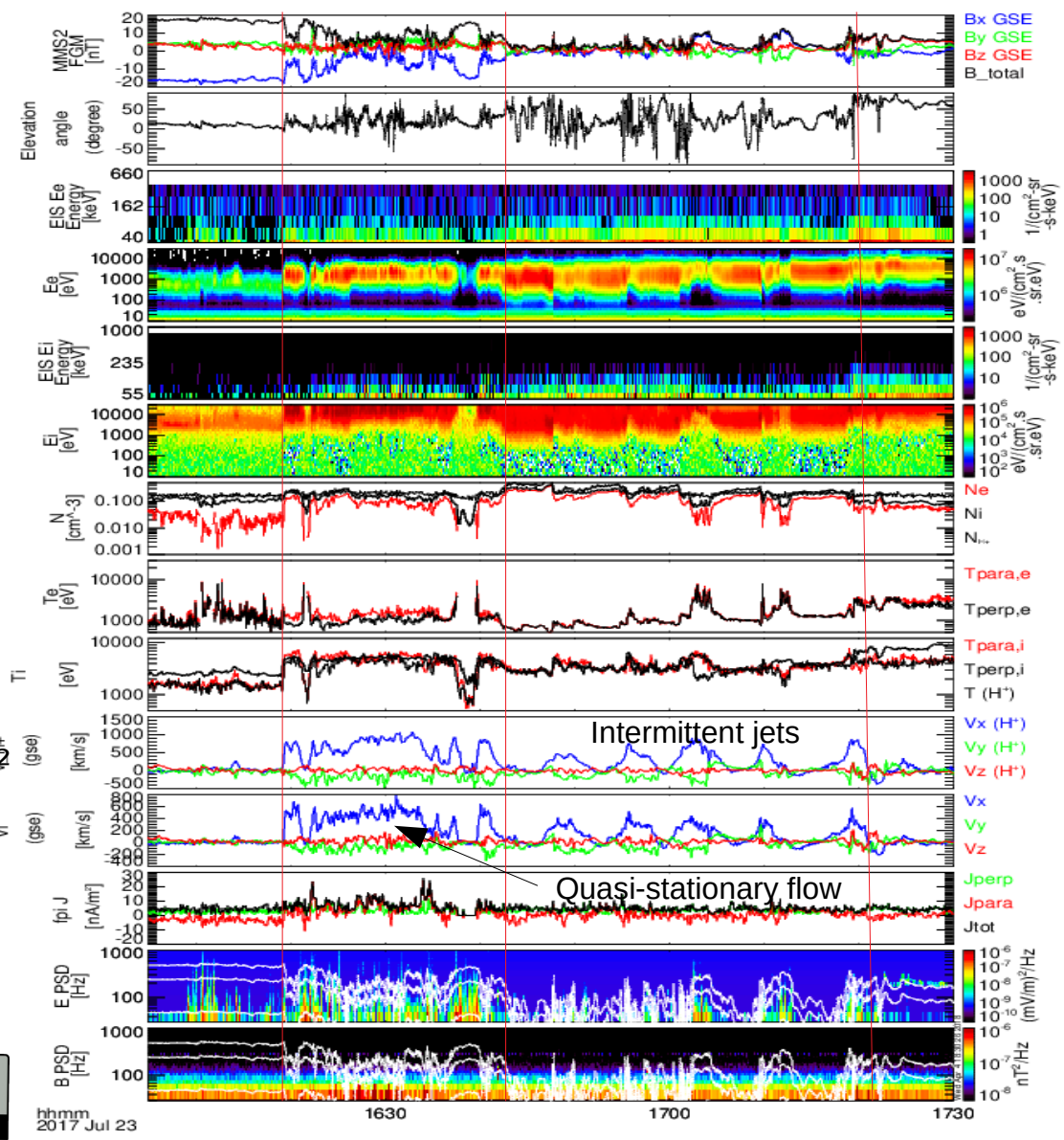
Substorm overview 16:05-17:30 UT

Small substorm AE~ 400 nT
Local onset ~ 1619 UT

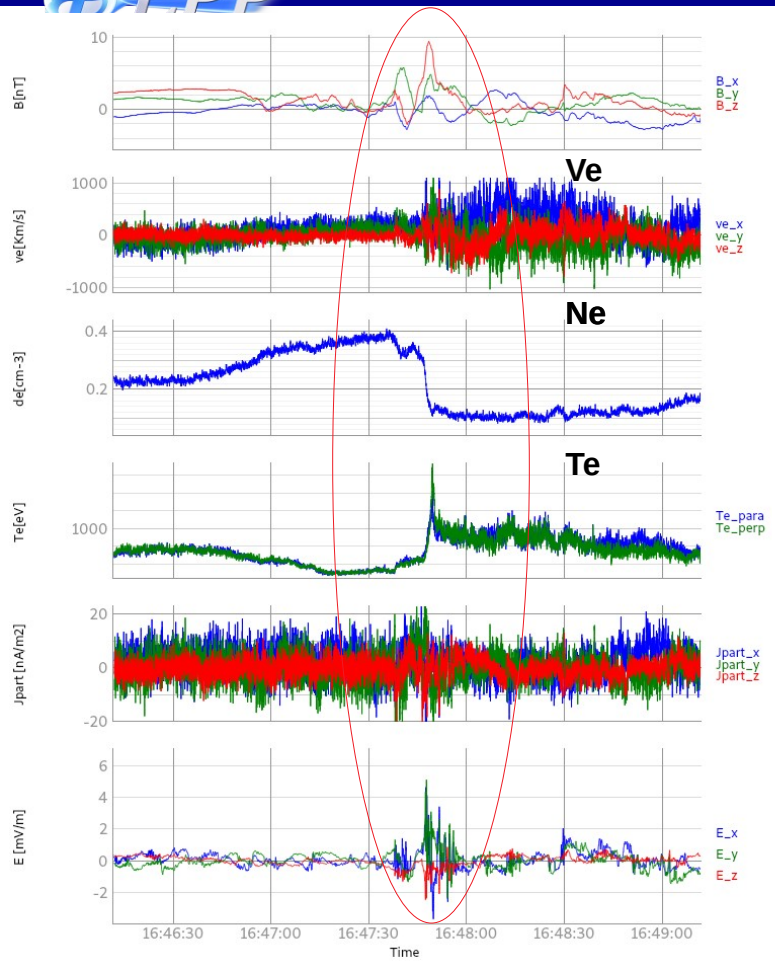
- **Quasi-stationary earthward flow**
  Vx(HPCA)~ 800 km/s > Vx(FPI),
  low density~0.1 p/cc and B<15 nT
  with current fluctuations |δj(fpi)|<30nA/m²
- **Intermittent earthward jets** with embedded DFs
- 0<Vx(HPCA)<800 km/s
  higher density and smaller B<10 nT
  with smaller current fluctuations <15nA/m²
- Electrostatic fluctuations
  up to Fce at the CS edge (Bx>15 nT)
  associated with electron heating

Two regimes of plasma transport?

- Flow reversal at the end of event :
  +800km/s to -400 km/s

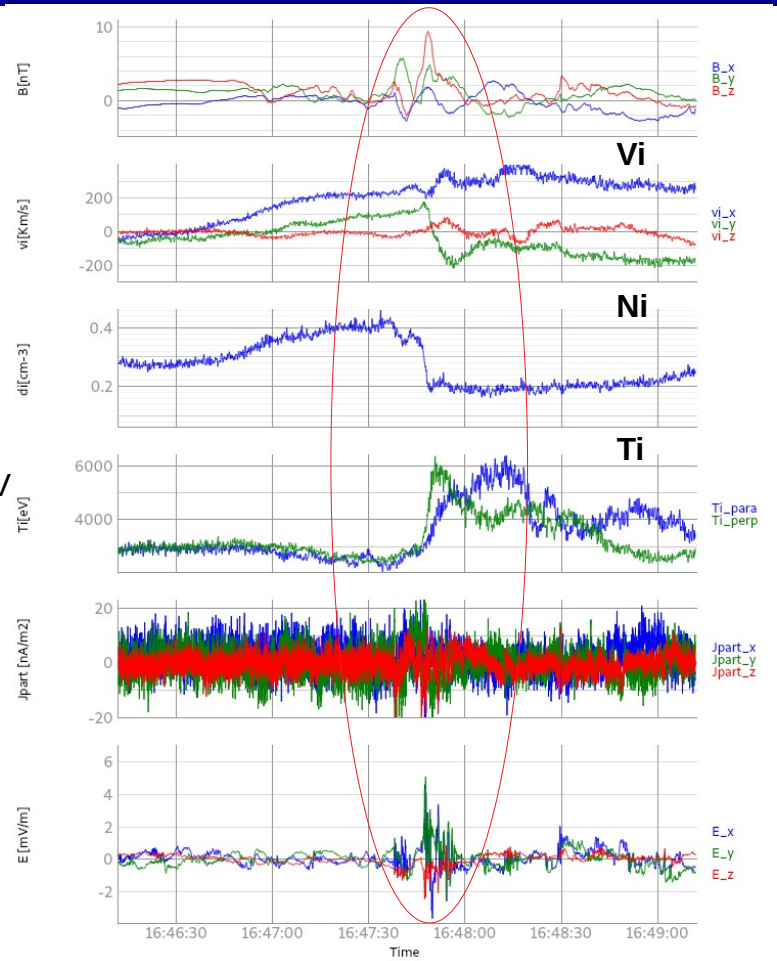


One MMS DF example 16:46:30-16:49:00 UT



DF/fast flow properties
[e.g. Runov et al., GRL 2009, Sergeev et al., GRL, 2009]]

- Transition between cold dense plasma at rest to hot tenuous fastly moving plasma
- Increase of Bz
- Increase of Ve,x&Vi,x
- Decrease of density
- Increase of Tpara,e~Tperp,e ~1 keV
- Increase of Tpara,i~Tperp,i~6 keV but not simultaneous
- Current density <20nAm2
- Ey field ~ 4 mV/m



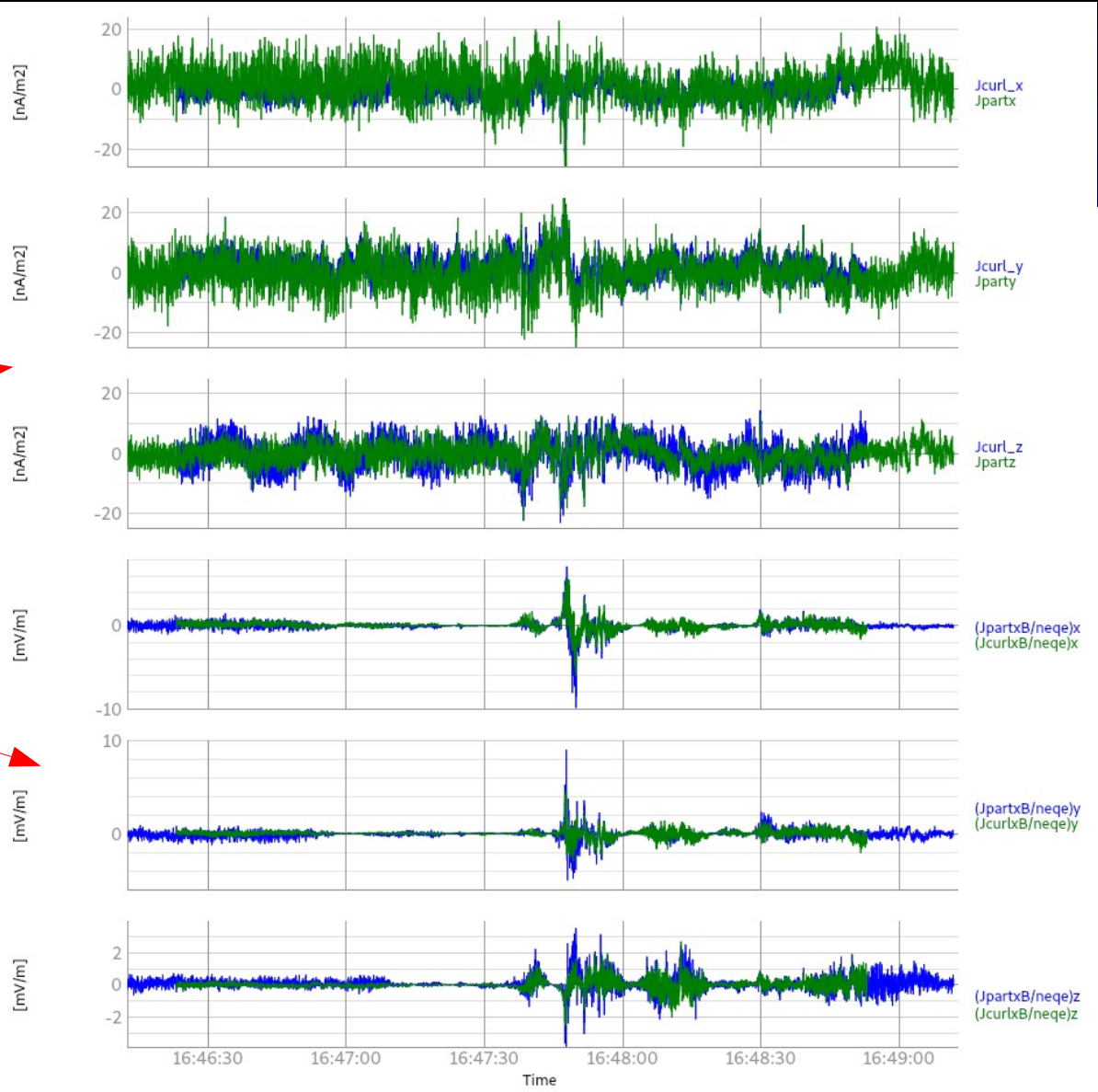
Current density comparisons

Current density comparison between
<Jpart> = e<n>(<vi>-<ve>)
<...> denotes 4 s/c averaging
& Jcurl = (CurlB/mu0)

Small values but good agreement within <10nA/m2

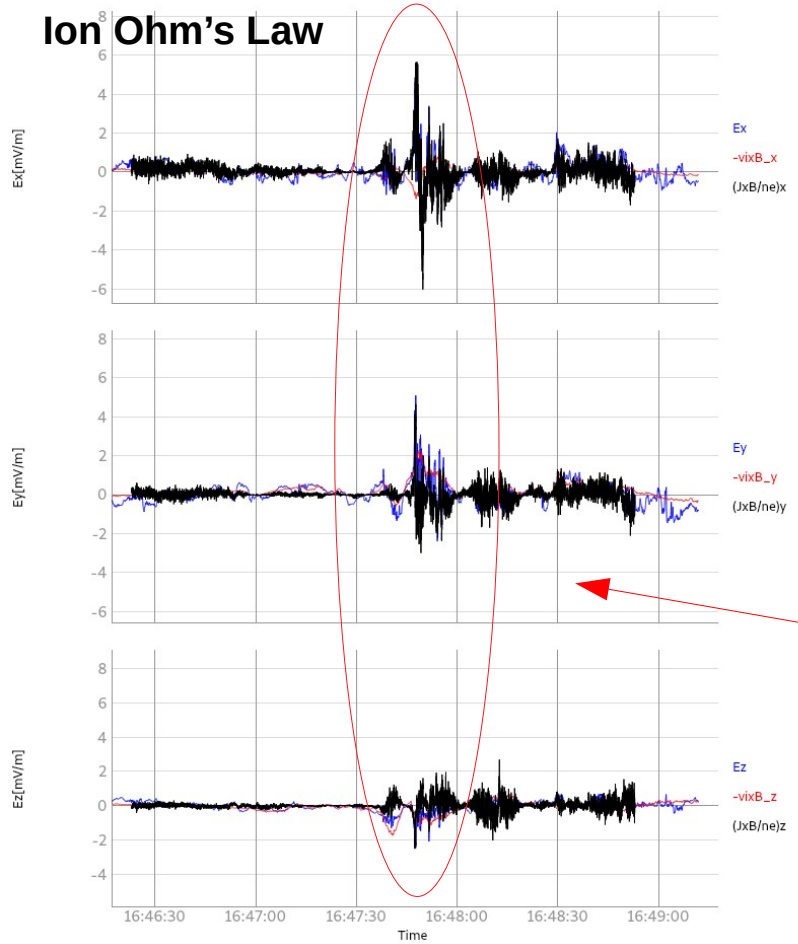
Hall field comparison between
<JpartxB/(nqe)>
& (JcurlxB/(nqe)

Good agreement within 1 mV/m



Ion Ohm’s Law & electron Ohm’s Law 1646:05-1649:00 UT

Ion Ohm’s Law



Ohm's Law

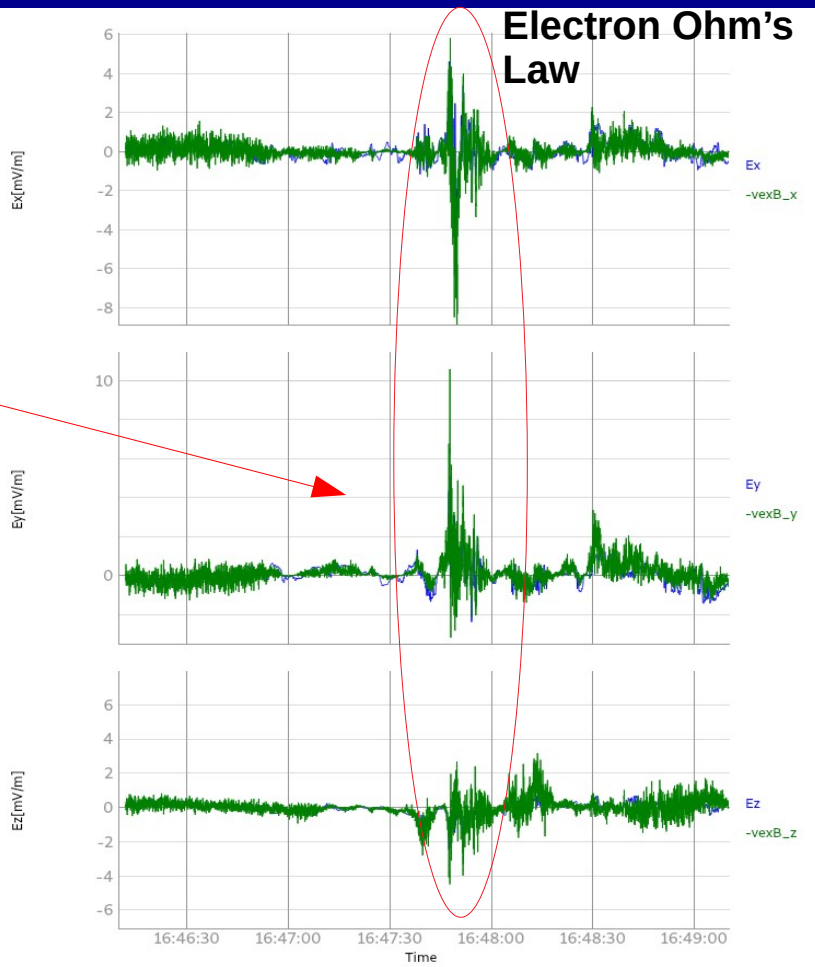
Electrons

- Good agreement E&(-vexB)~1mV/m
- Electrons mostly magnetized

Ions

- Good agreement
- E, (-vixB) and (JxB/ne)
- Ions can be decoupled from B due to large Hall fields at DF

Electron Ohm’s Law

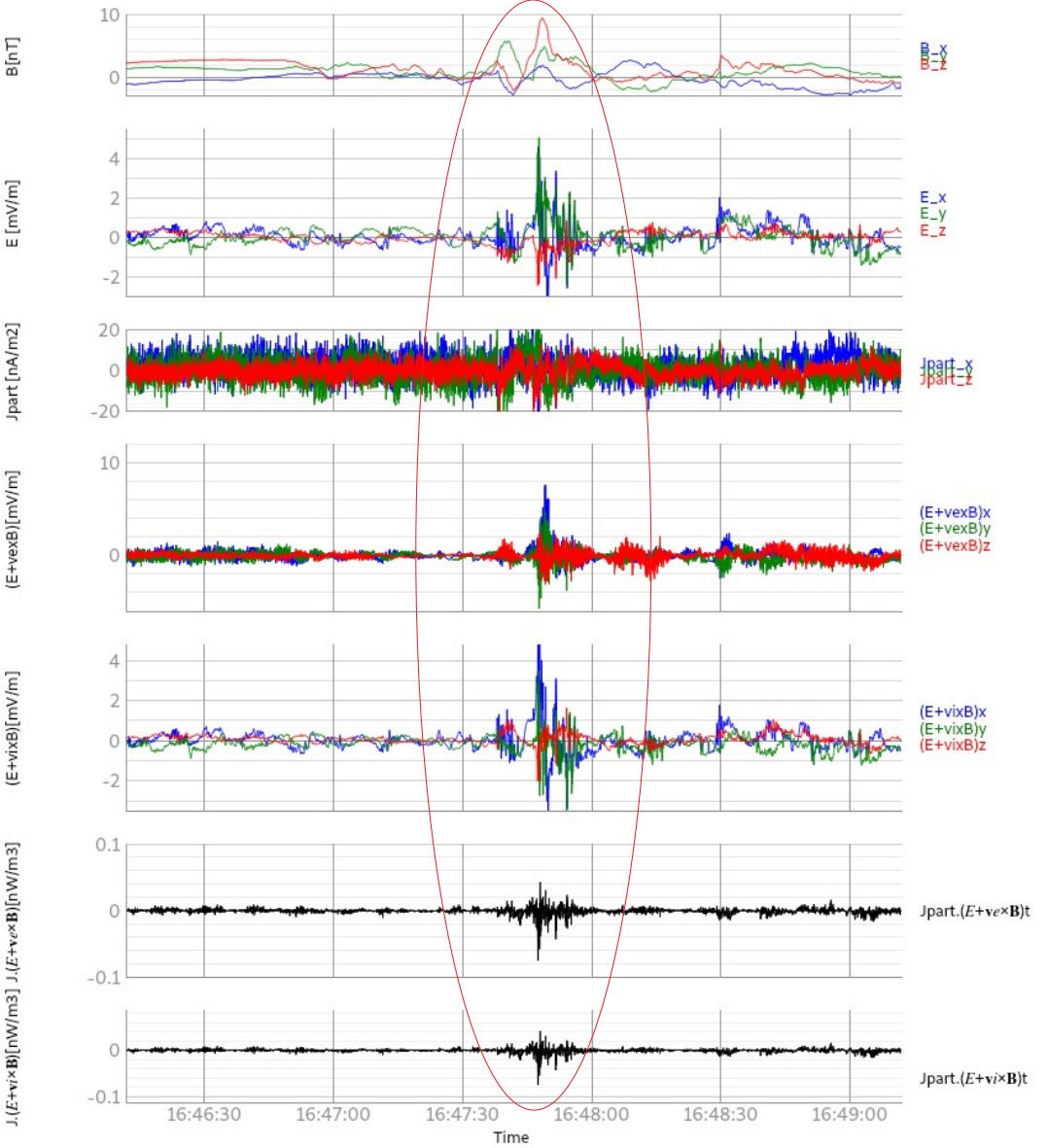


Energy conversion (I)

- **Jpart,y and E field maximums around 1647:45 UT**

  Max of Jpart,y ~ +23 nA/m²
  Max (E+vexB)x ~ +8.3 mV/m
  Max (E+vixB)x ~ +4.3 mV/m
  Max (E+vexB)y ~ 4 mV/m
  Max (E+vixB)y ~ 4.3 mV/m

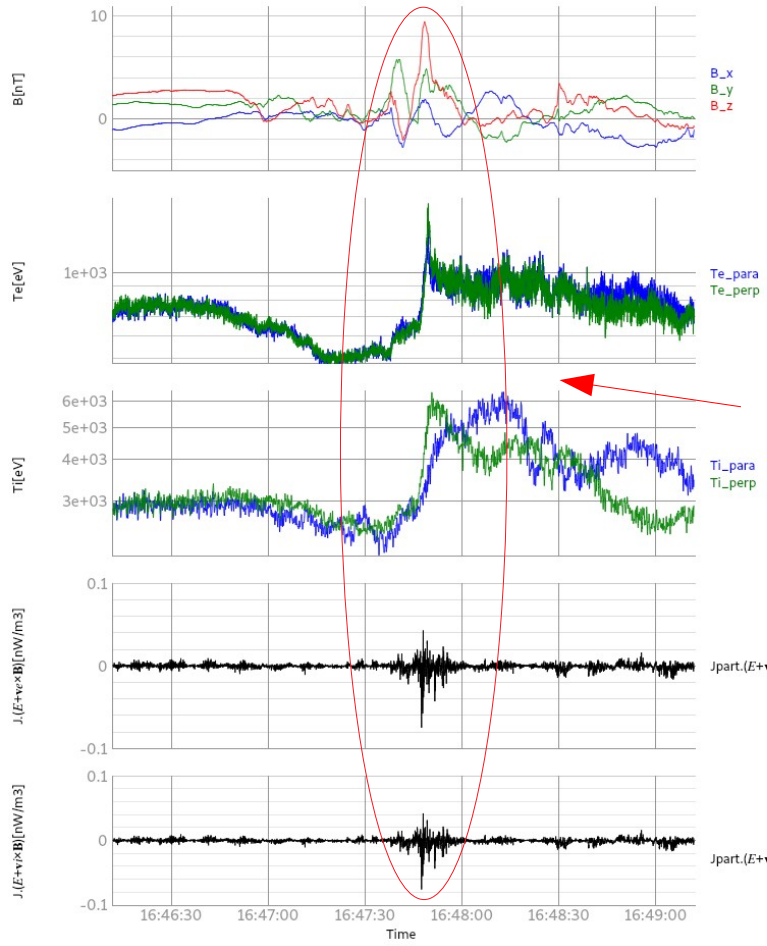
- Due to high frequency fluctuations energy conversion also appears to be very fluctuating at the DF yet this 4 s/c average suggests a negative value just at the beginning of the DF crossing (sharp increase of Bz).

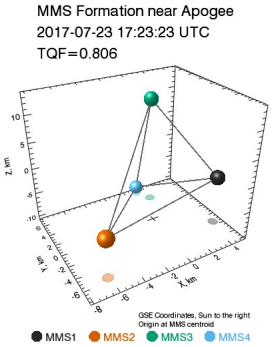


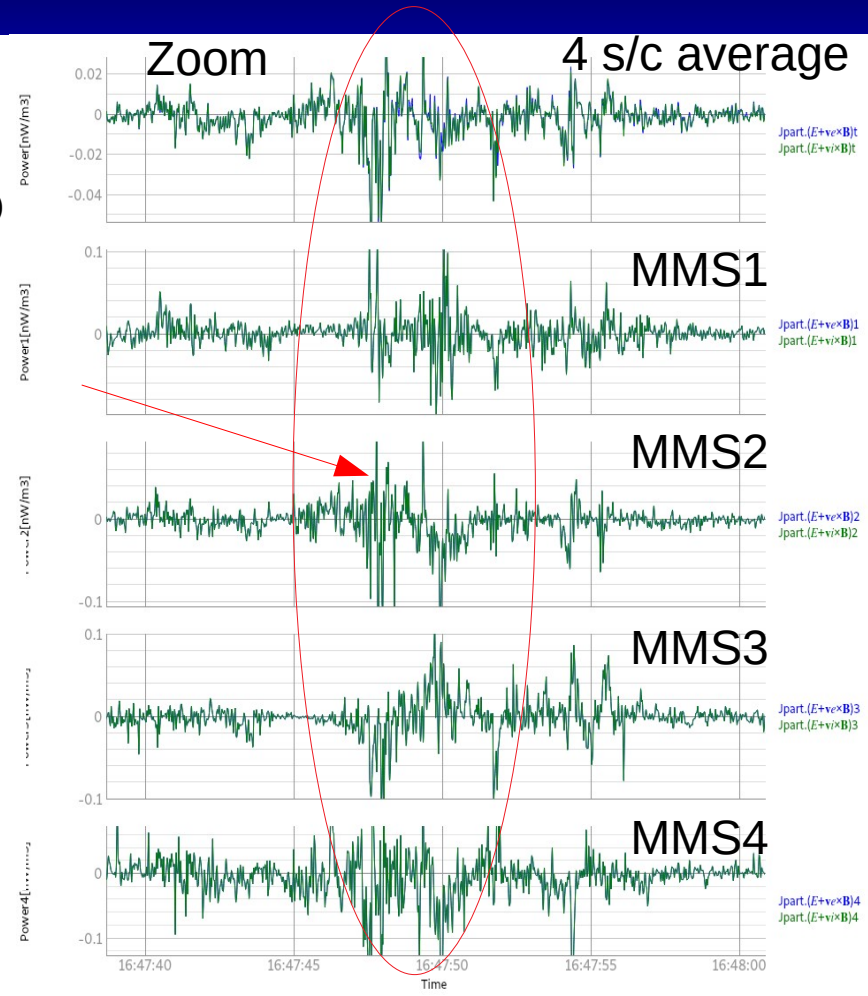
Energy conversion (II)

Energy conversion is not homogeneous at the scale of the tetrahedron :

1/ with regions of dissipation (>0) transfer from field to particles
Ex : MMS3
2/ regions of energy transfer from particles to field (<0)
Ex : MMS2
Yet the 4 s/c average is negative
Local electron & ion heating ?
Need further investigations







Summary

- We have shown a DF event detected by MMS during a subsorm event on July 23rd 2017 with classical signatures consistent with general properties of DF.
- We have found a good agreement between current densities calculated from particles and curl B.
- From Ohm's law, we have shown that electrons are almost always magnetized whereas ions can be decoupled from B due to Hall field.
- Energy conversion given by (J.(E+vexB) or (J.(E+vixB)) is not homogeneous at the scale of the tetrahedron :

  4 s/c average value indicates an energy transfer from particle to field at the beginning of the DF crossing (region of temperature and density gradients)
- Whereas individual s/c values can be positive or negative which require further investigations.

Acknowledgments: We thank the whole MMS team for providing data and the spedas software team in particular E. Grimes for pyspedas effort developments.