Investigation of the homogeneity of energy conversion processes in a flux rope observed in the Earth's magnetotail using MMS measurements

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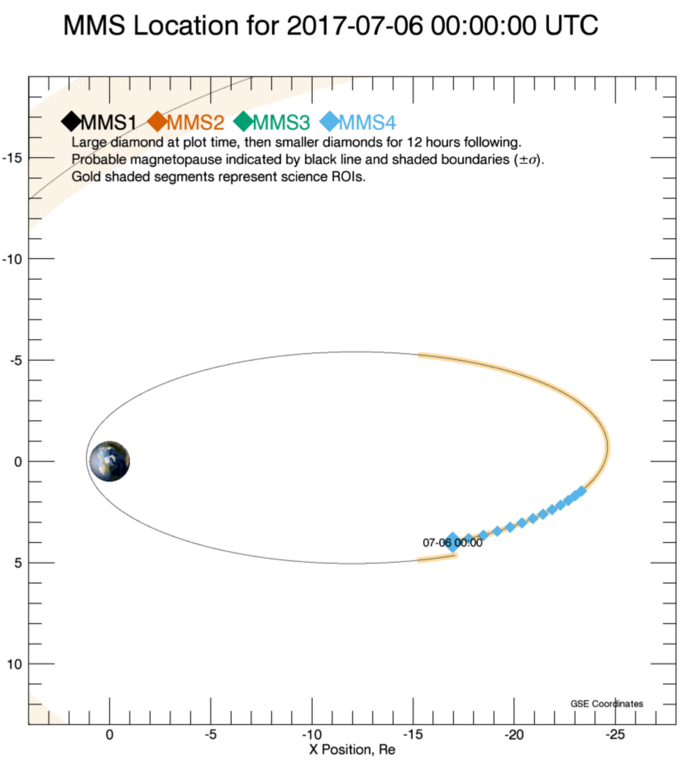
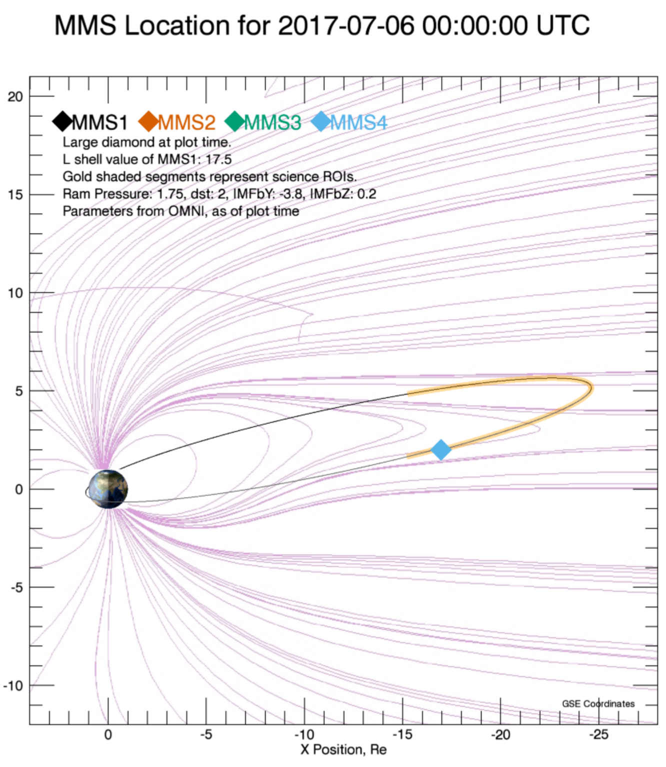
Motivations

- A better understanding of the energy transfers in the magnetotail during a flux rope event.
- Clarify the sources of the Earth's magnetotail energy conversion processes.
- Investigate the accompanying waves that effectively influence various energy conversion processes.

Questions

- What are the waves associated with a flux rope event?
- How do these waves affect the processes of energy conversion processes in the magnetotail?
- What is the role of Poynting vector calculations in energy transfers?
- Can the source of energy in the magnetotail be monitored and how does it affect its dynamics affected by the solar wind?





Observational Approach

Flux rope (FR)/fast flow properties [e.g. David G. Sibeck, GRL 1990] event detected by MMS on July 6th 2017 with classical signatures consistent with general properties of FR.

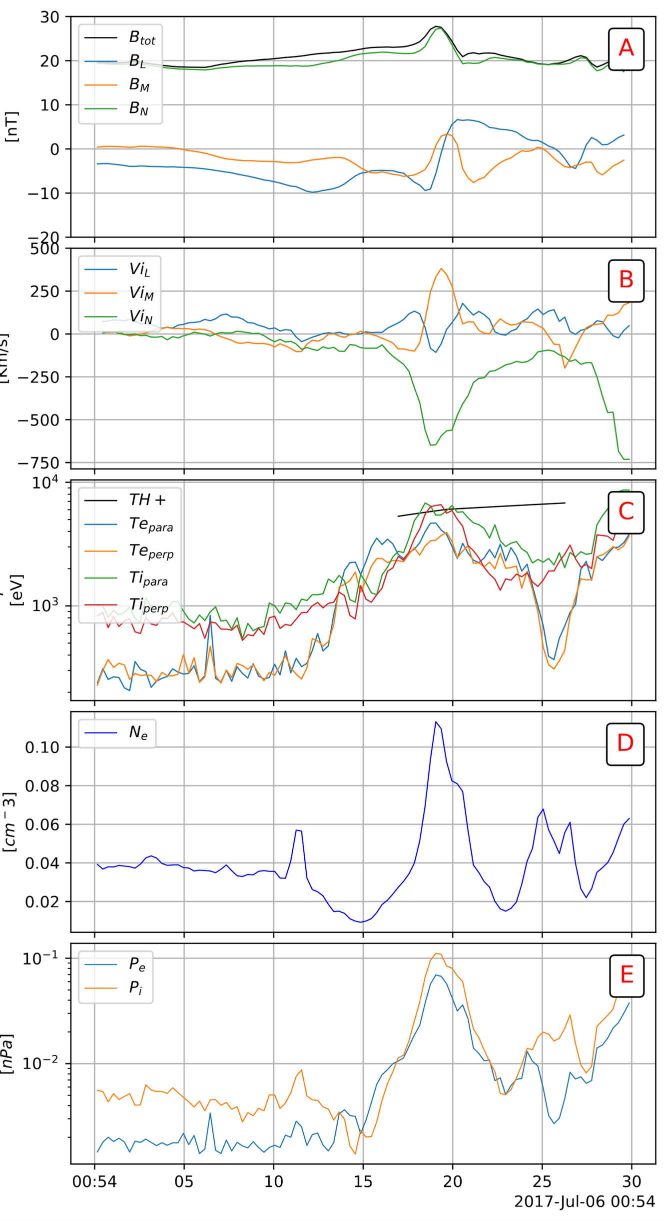
Increase of BN

Reversal of BL

Increase of Ve&Vi

Increase of density

Increase of:
Tpara,e~Tperp,e
Tpara,i~Tperp,i~10^4eV



Current density comparisons

Current density comparison between:

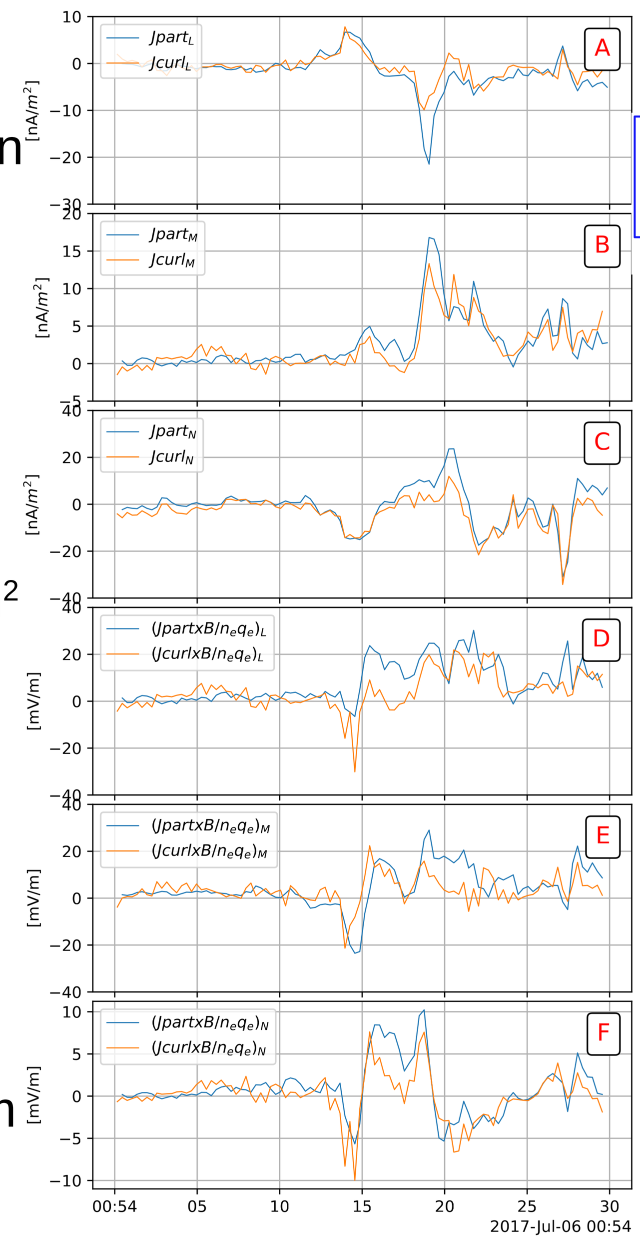
Jpart= en(vi - ve)
4 s/c averaging
&
Jcurl = (CurlB/mu$_0$)

Good agreement <40nA/m^2

Hall field comparison between:

JpartxB/(nqe)
&
JcurlxB/(nqe)

Good agreement~30 mV/m



Ohm's Law

$$\mathbf{E}+\mathbf{v}_i\times\mathbf{B}=\frac{\mathbf{J}\times\mathbf{B}}{en}-\frac{1}{en}\nabla\cdot\mathbf{P}_e-\frac{m_e}{e}\frac{d\mathbf{v}_e}{dt}$$

Ideal ion frozen-in; Hall electric field; Electron pressure gradient; Initial term

Large scale; Ion and electron scales

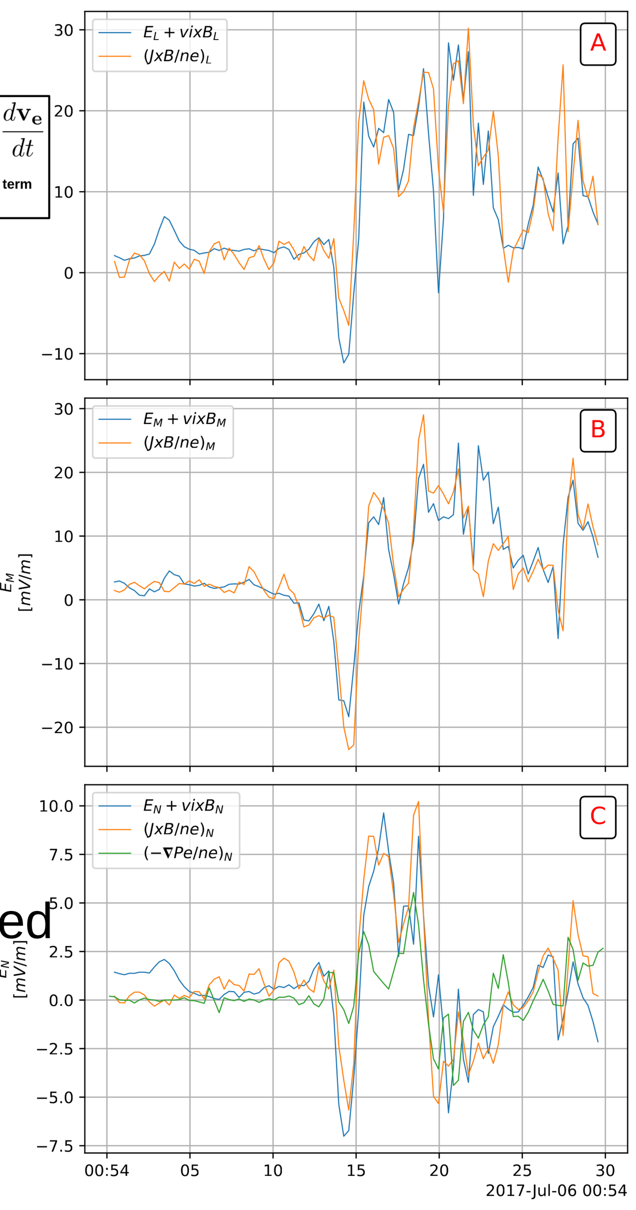
Good agreement:

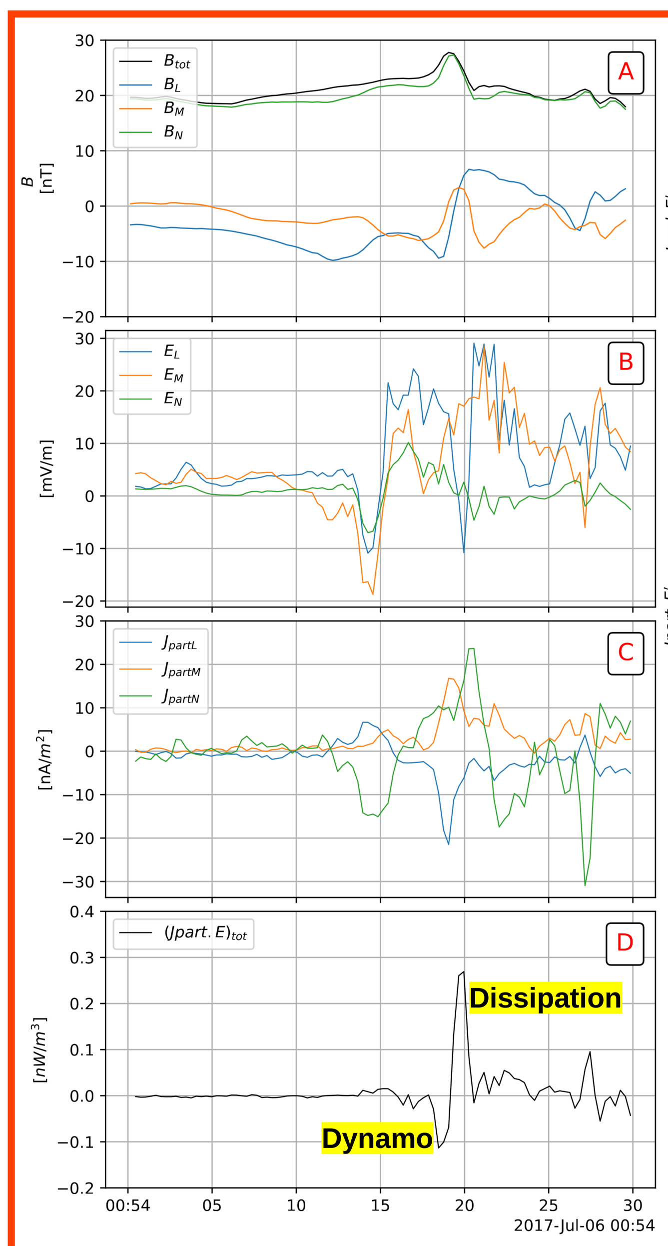
E&(-vexB)~30mV/m
Electrons mostly magnetized.

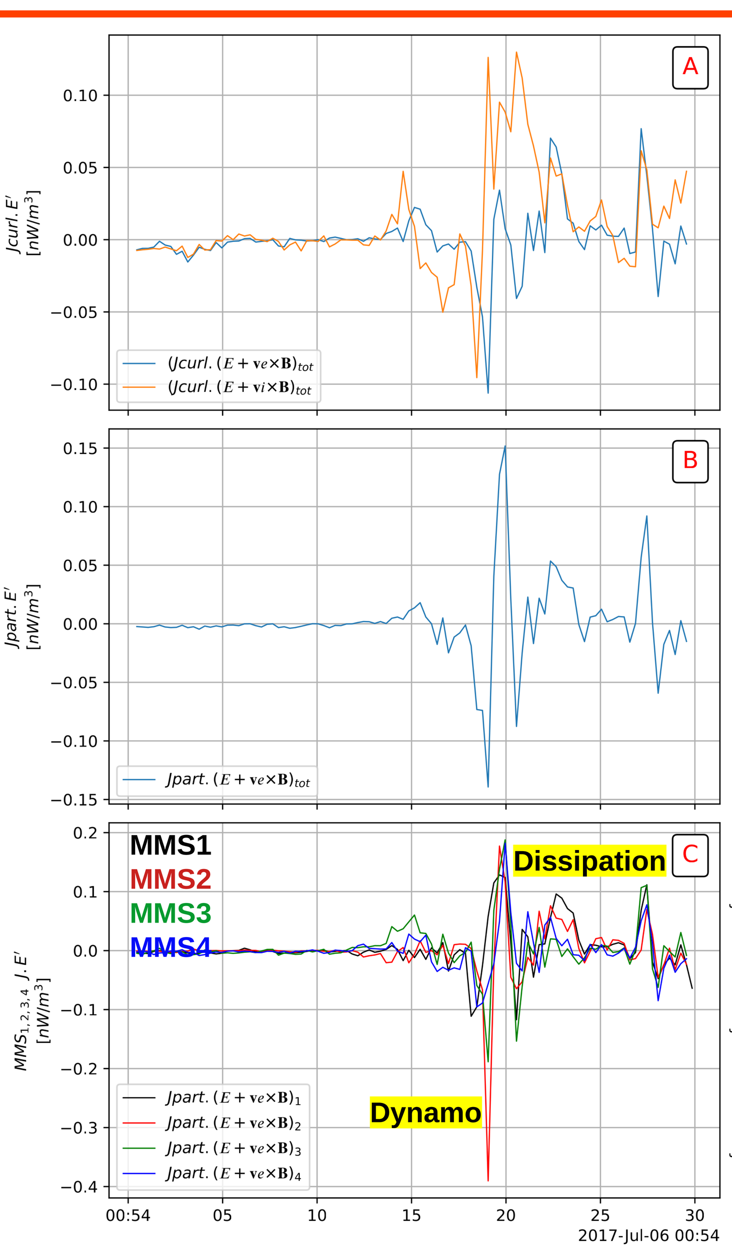
Good agreement:

(E & -vixB)
&
(JxB/ne)~30mV/m

Ions can be decoupled from B Due to large Hall fields at FR but also due to electron pressure gradient.







Compute the standard deviation (SD) **normalized** by its error bar:

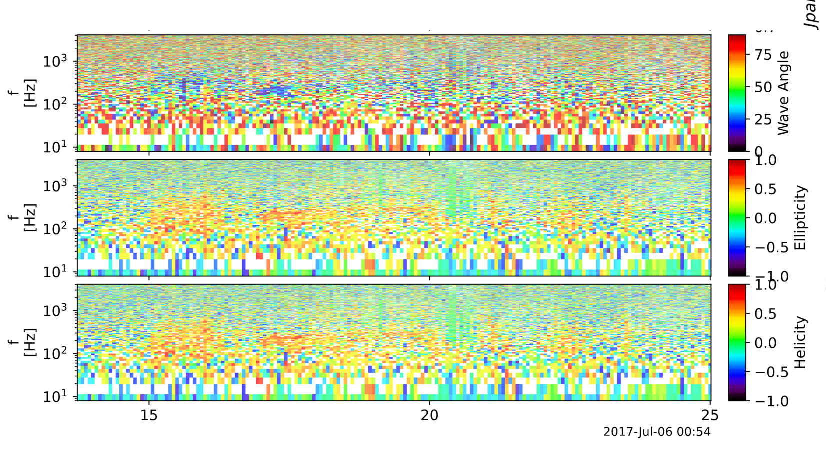
$$SD(X)/\Delta X=\sqrt{\Sigma_{i=1}^{4}(X_i-\langle X\rangle)^2/4}/\Delta X$$

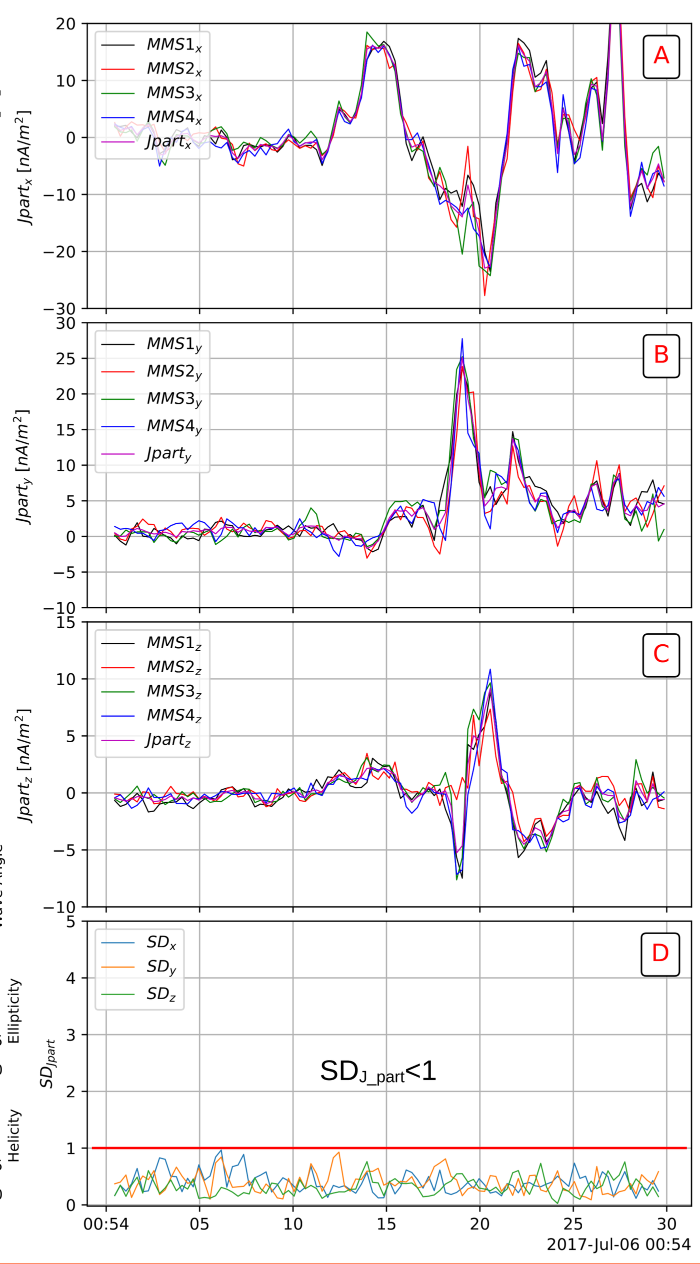
<X> : The four spacecraft average of the X component

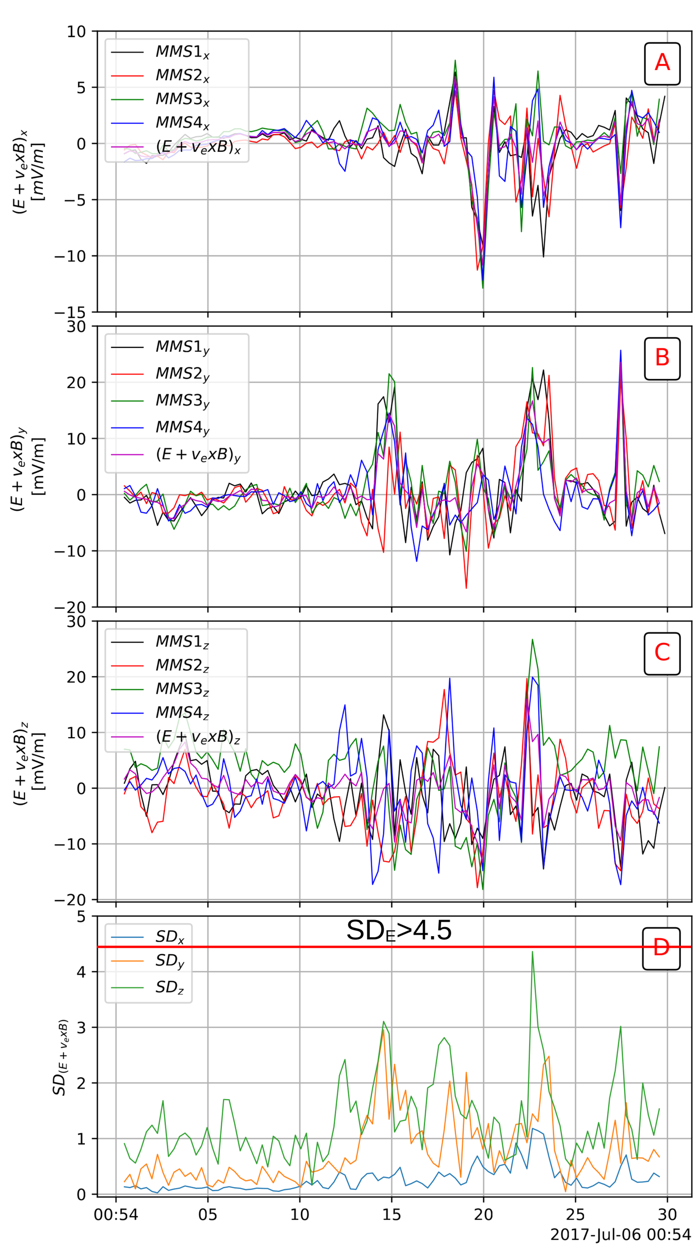
ΔX : Respective estimated error bar

Larger **normalized** SDs for E' field than for Jpart suggest that non homogeneity comes from the E field.

Whistler Waves







Conclusion

- **We have shown a flux rope (FR) event detected by MMS on July 6th 2017 with classical signatures consistent with general properties of FR.**
- **Good agreement between current densities calculated from particles and curl B.**
- **Ions are decoupled at DF mostly due to Hall field but also due to electron pressure gradient. Also electrons can be decoupled by electron pressure gradient.**
- **In the satellite frame, the energy is transferred (J.E<0, dynamo or generator region) ahead of the FR but dissipated (J.E>0, dissipation or load region) from the field to the plasma behind the front. Shows the same in the fluid frame (J.E').**
- **The energy conversion is not homogeneous at the electron scale (scale of the tetrahedron) mostly due to the E field fluctuations which are likely related to whistler waves.**
- **Possibly perform a statistical analyses of FR based on MMS database and/or 3D Hybrid simulations of FR with LPP code and comparison with MMS data.**