

# **Suprathermal electron acceleration during reconnection onset in the magnetotail**

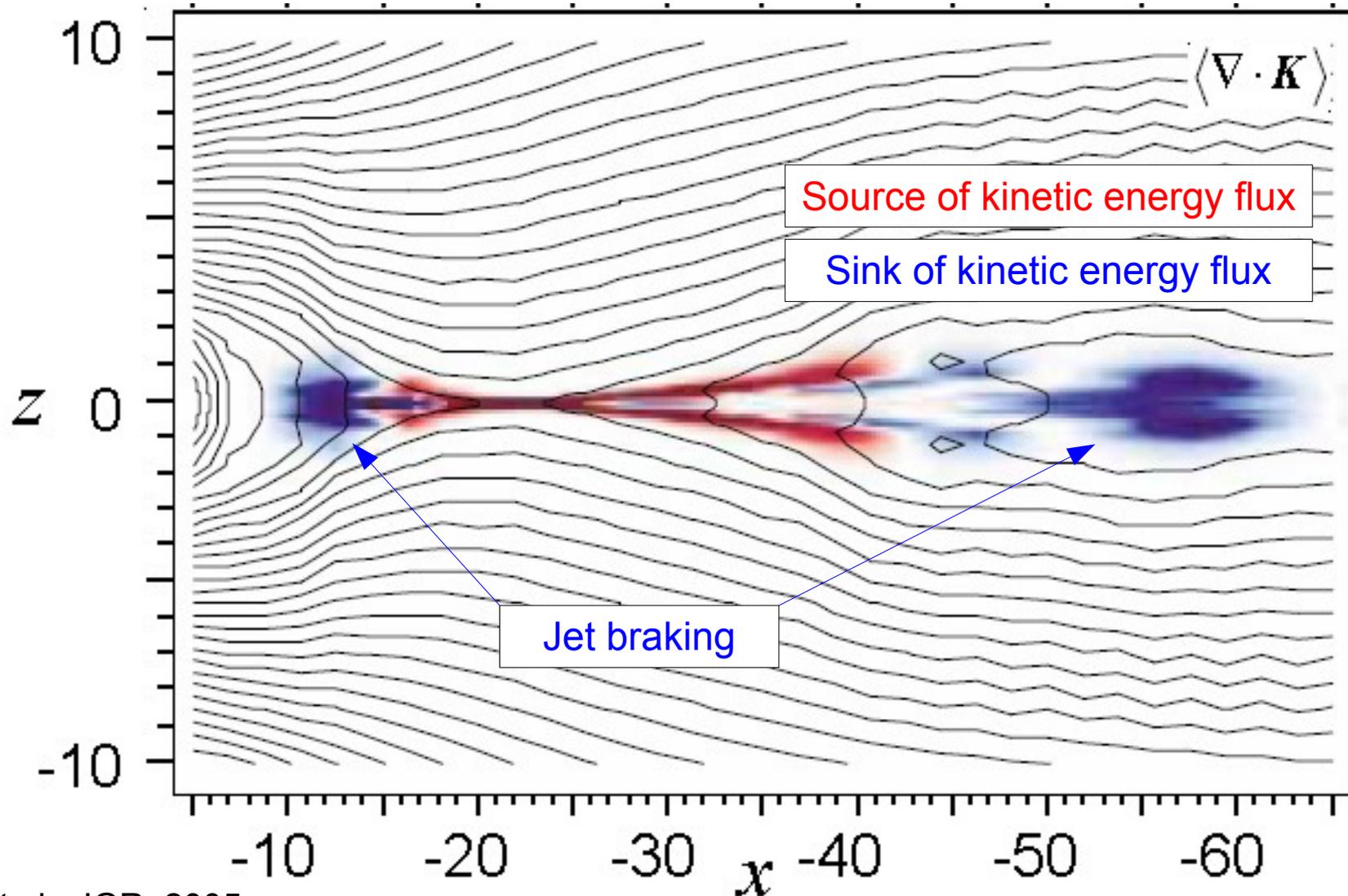
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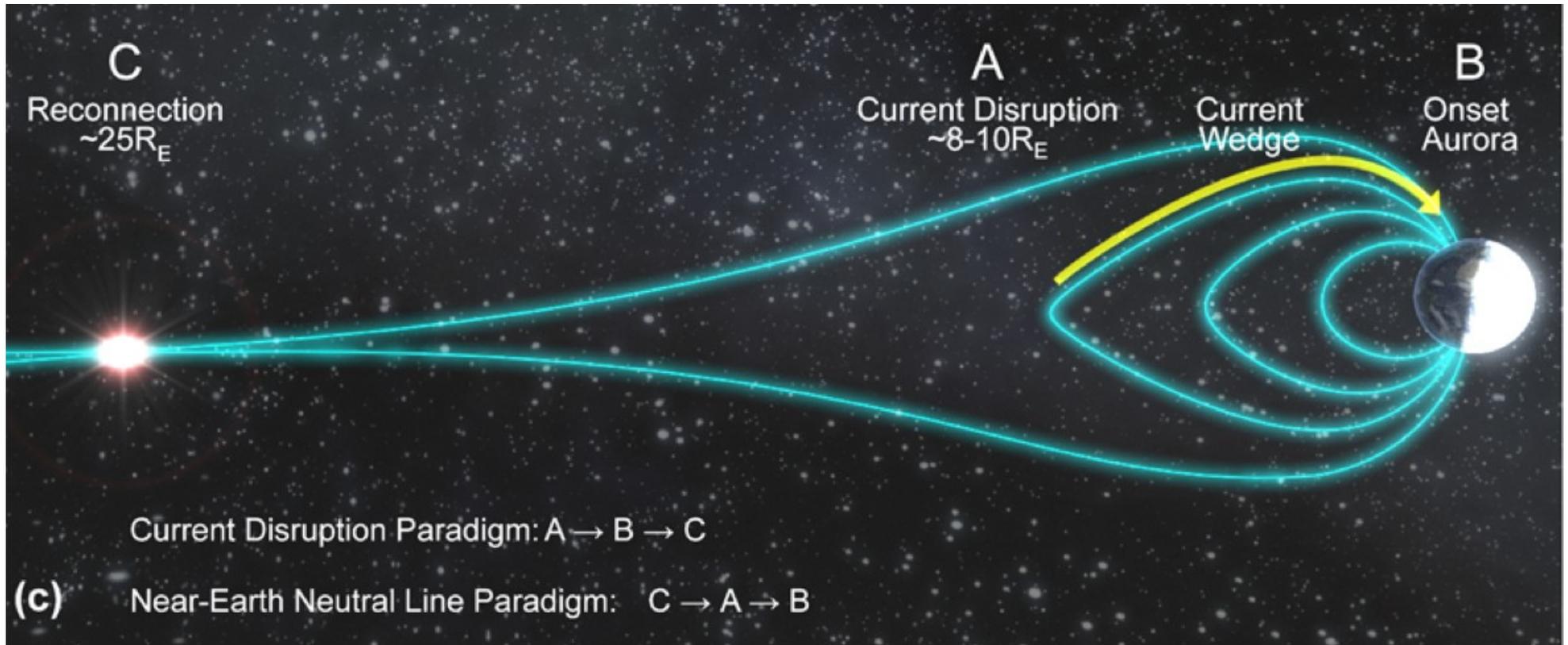
# Energetic electrons, jet braking, magnetic flux pile-up ( $B_z$ )



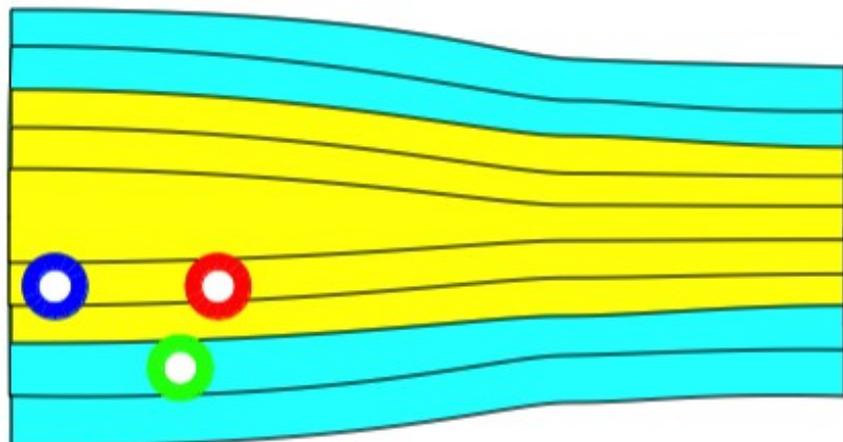
Birn et al., JGR, 2005

- ✓ Jet braking related to regions of magnetic flux pile-up ( $B_z$  increase, dipolarization)
- ✓ These are regions of most energetic electrons

# Substorm onset open question



A) 17:12 stretched tail



Preexisting plasma sheet

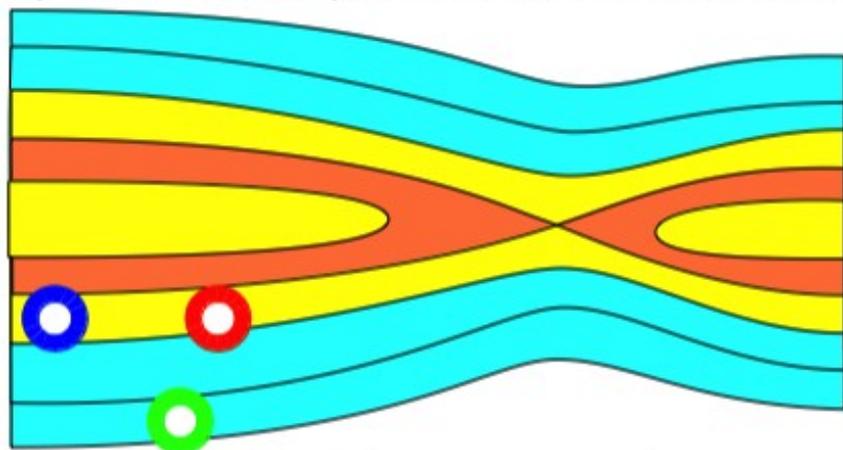
Reconnected lobe

Reconnected plasma sheet

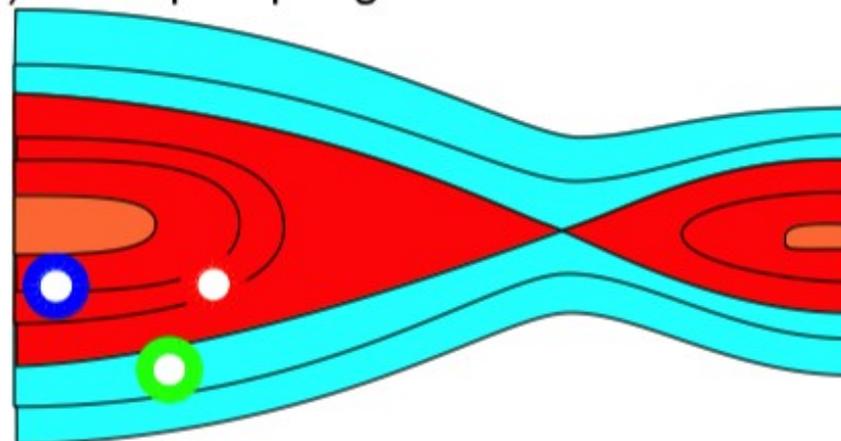
Lobe

Cluster 2,3,4

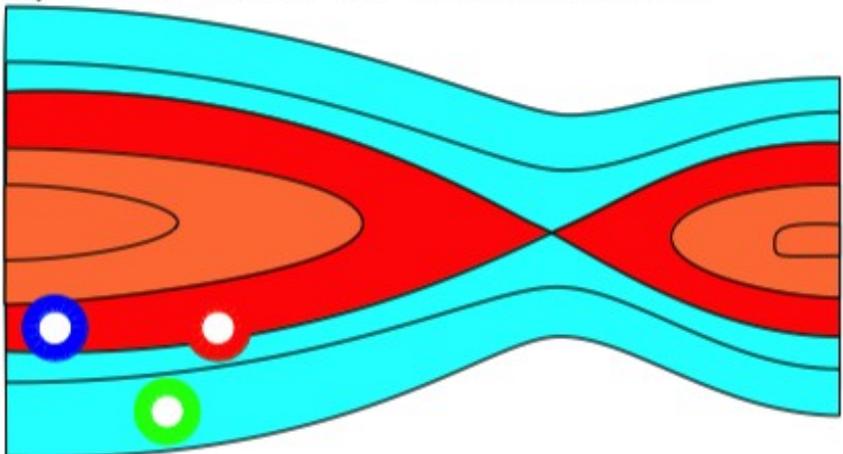
B) 17:15 starts plasma sheet reconnection



D) 17:21 pileup region hits C2/C4



C) 17:18 starts lobe reconnection



F) 17:25:30 more dipolar magnetosphere

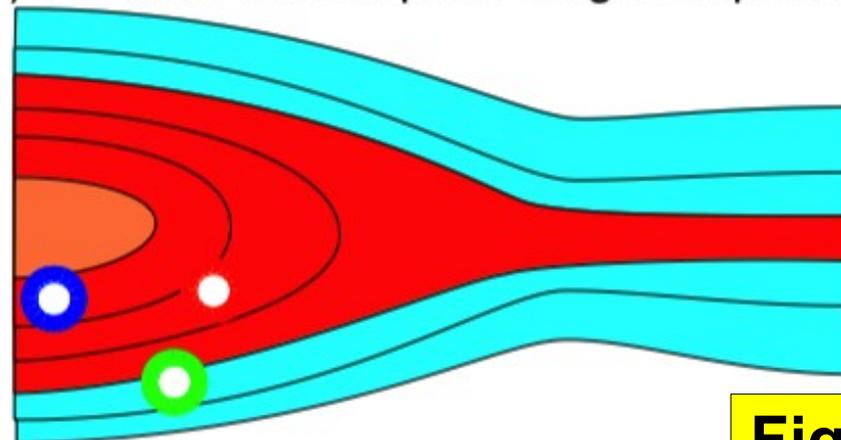
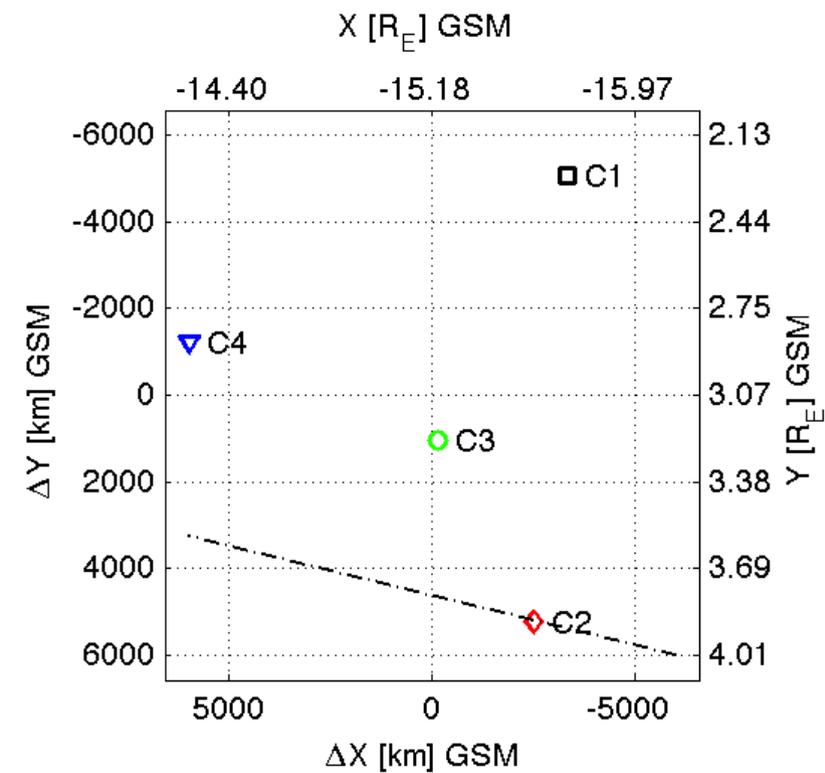
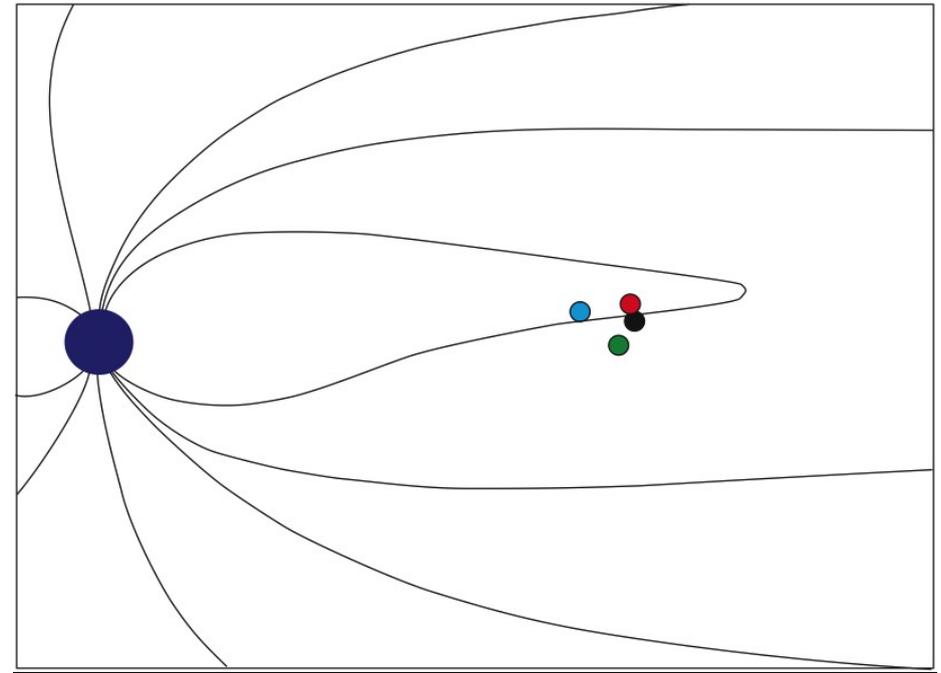
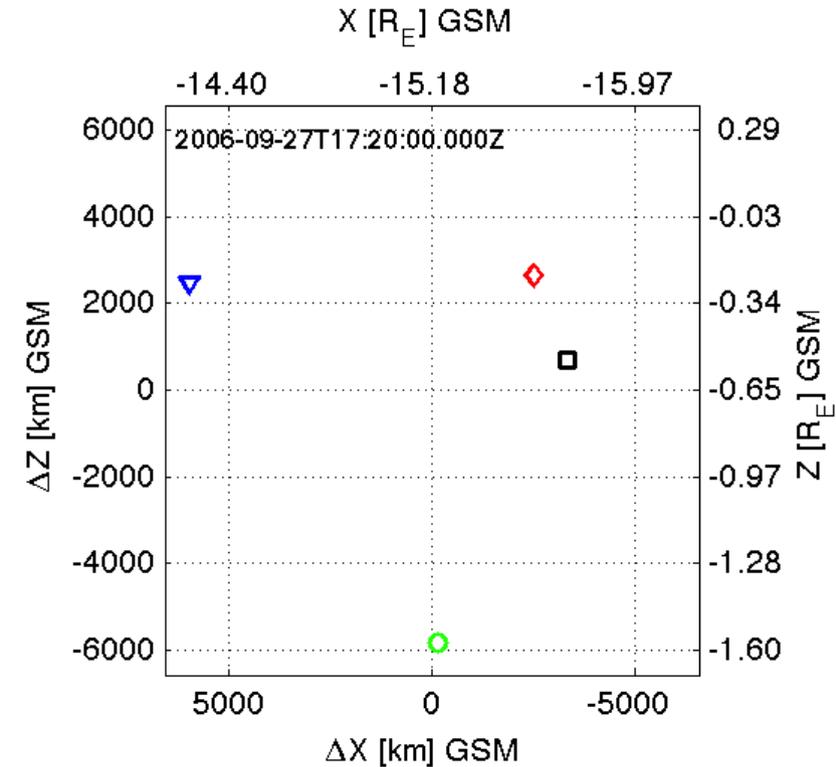
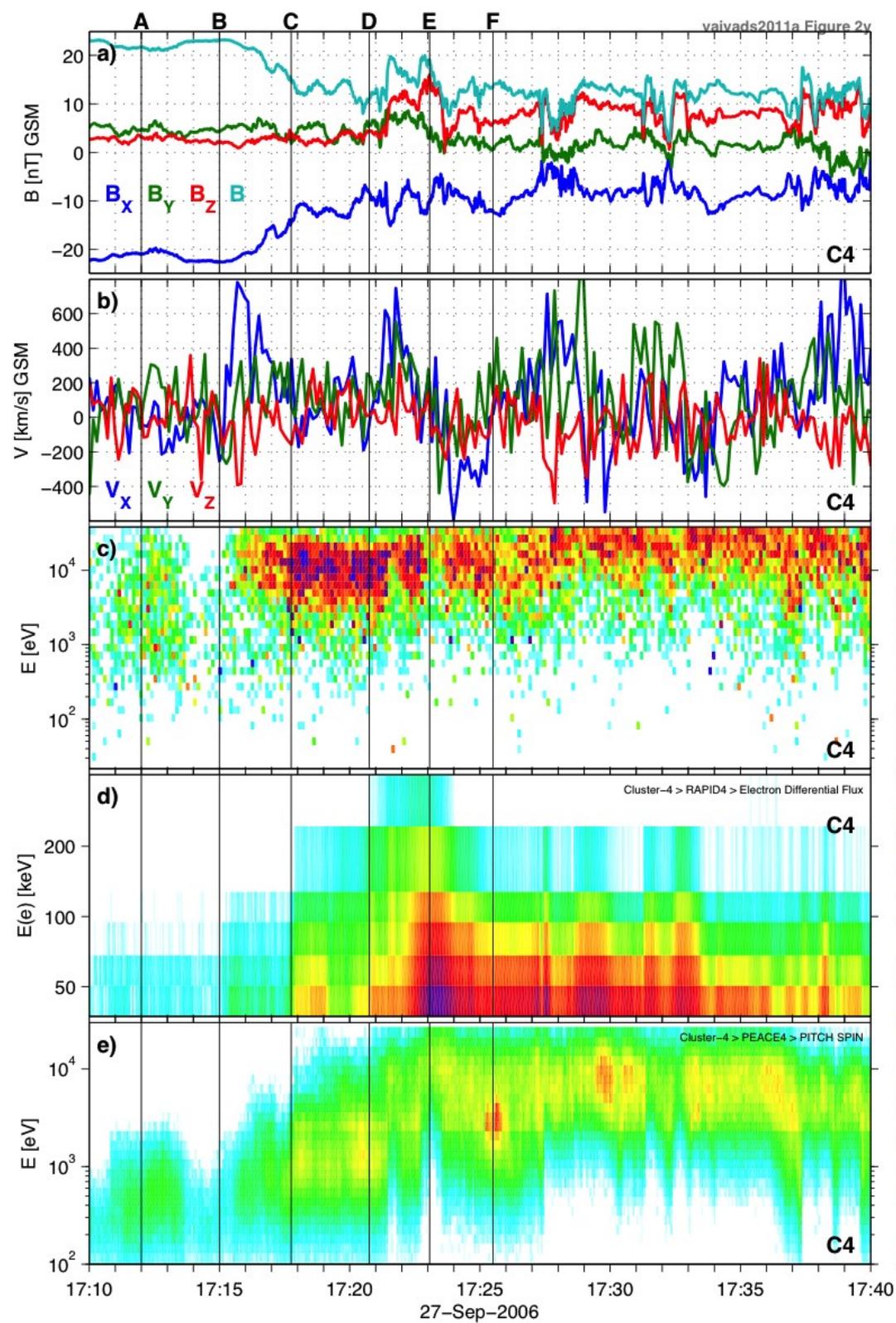


Figure 6



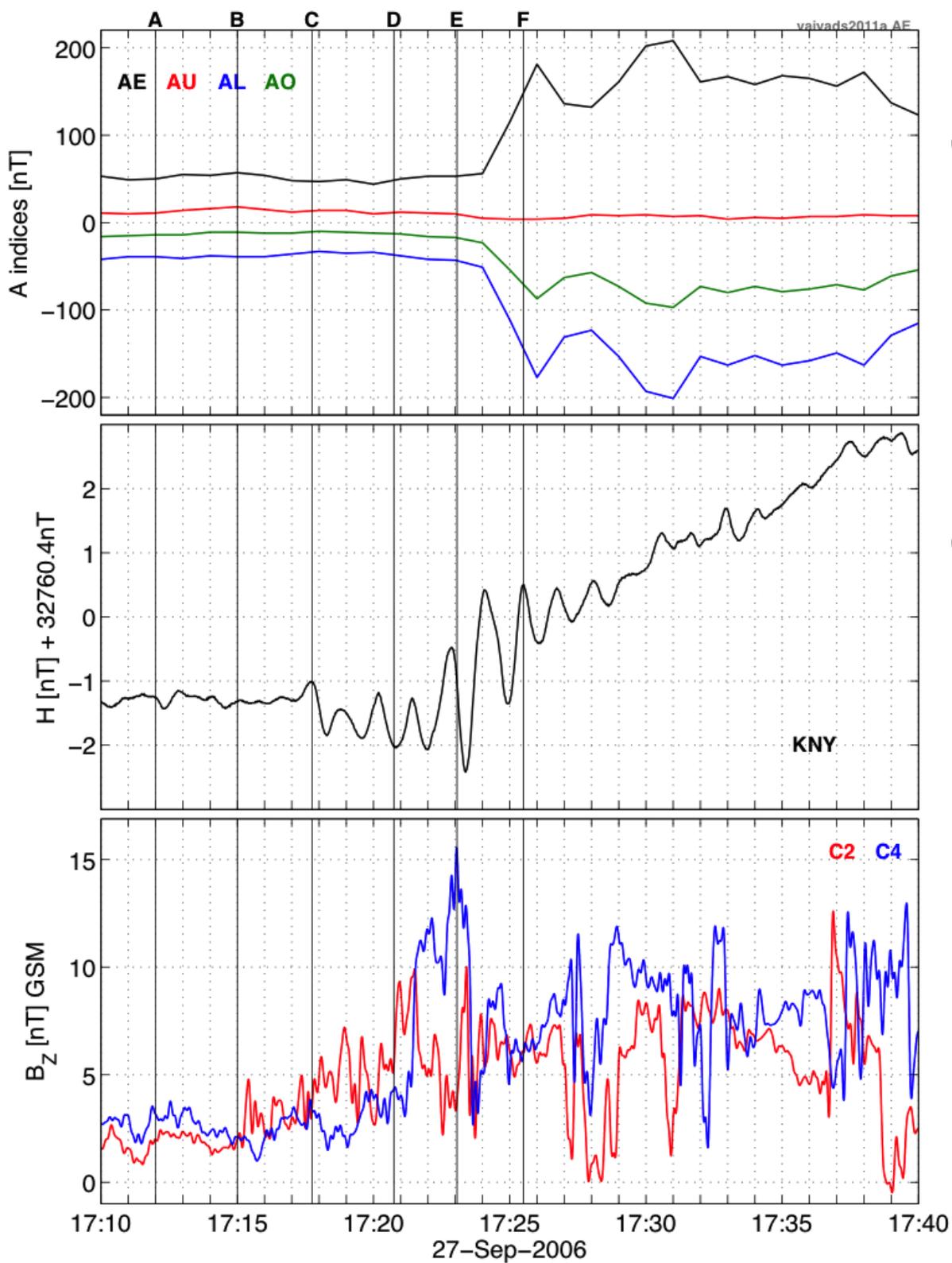
- ✓ Cluster located in the tail between the reconnection region in far tail and dipolar field lines closer to the Earth.
- ✓ Large separation, 10000km.
- ✓ C3 furthest from the current sheet.
- ✓ C4 closest to the Earth.

**Figure 1**



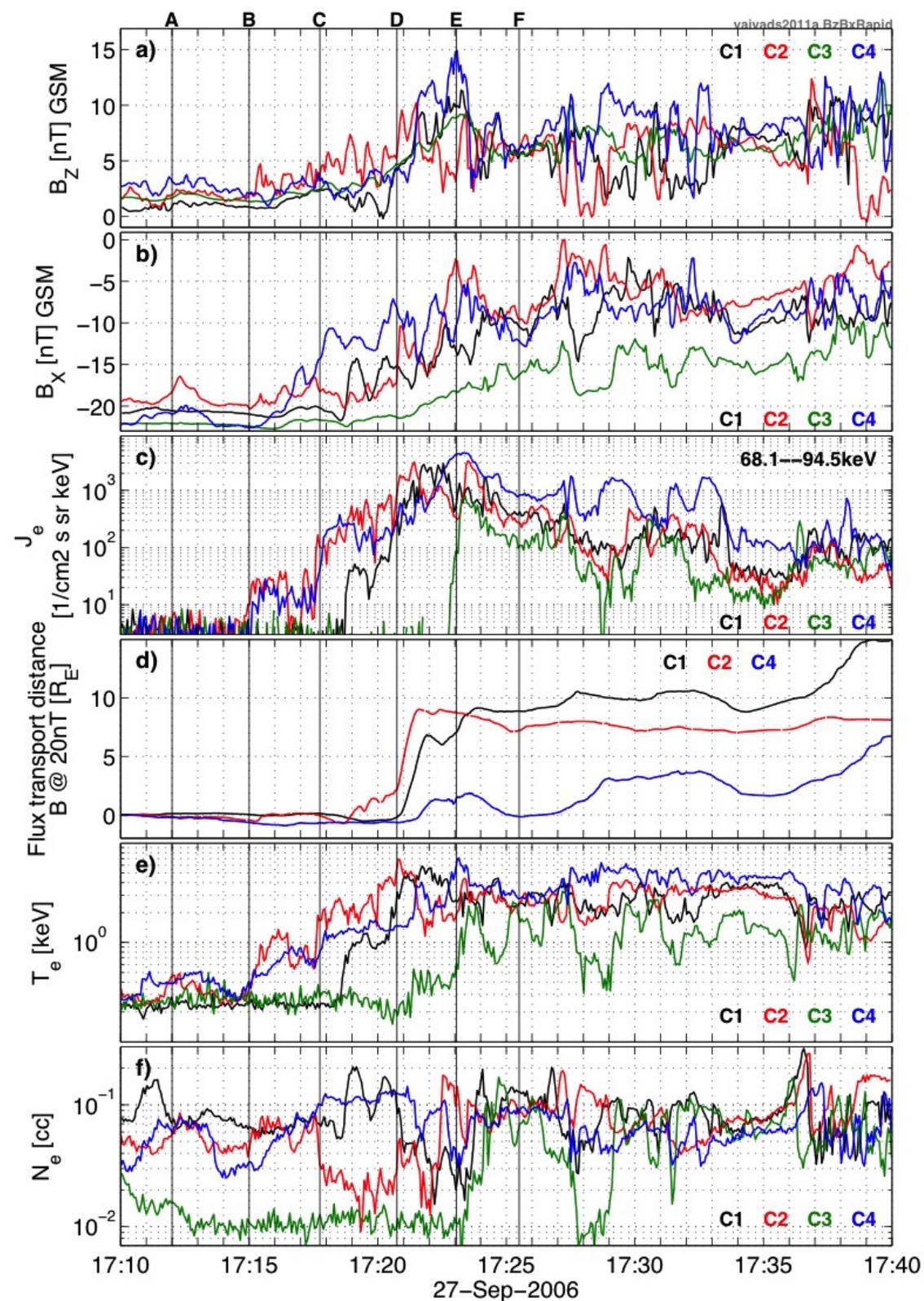
- ✓ **Dipolarization** – magnetic flux pile-up associated with the reconnection jets.
- ✓ Mainly earthward ion flows, reversal around E.
- ✓ Hot ions,  $T$  increases at the end of the interval.
- ✓ Suprathermal electrons, highest flux around E.
- ✓ Thermal electrons, temperature increase between C and F.

**Figure 2**



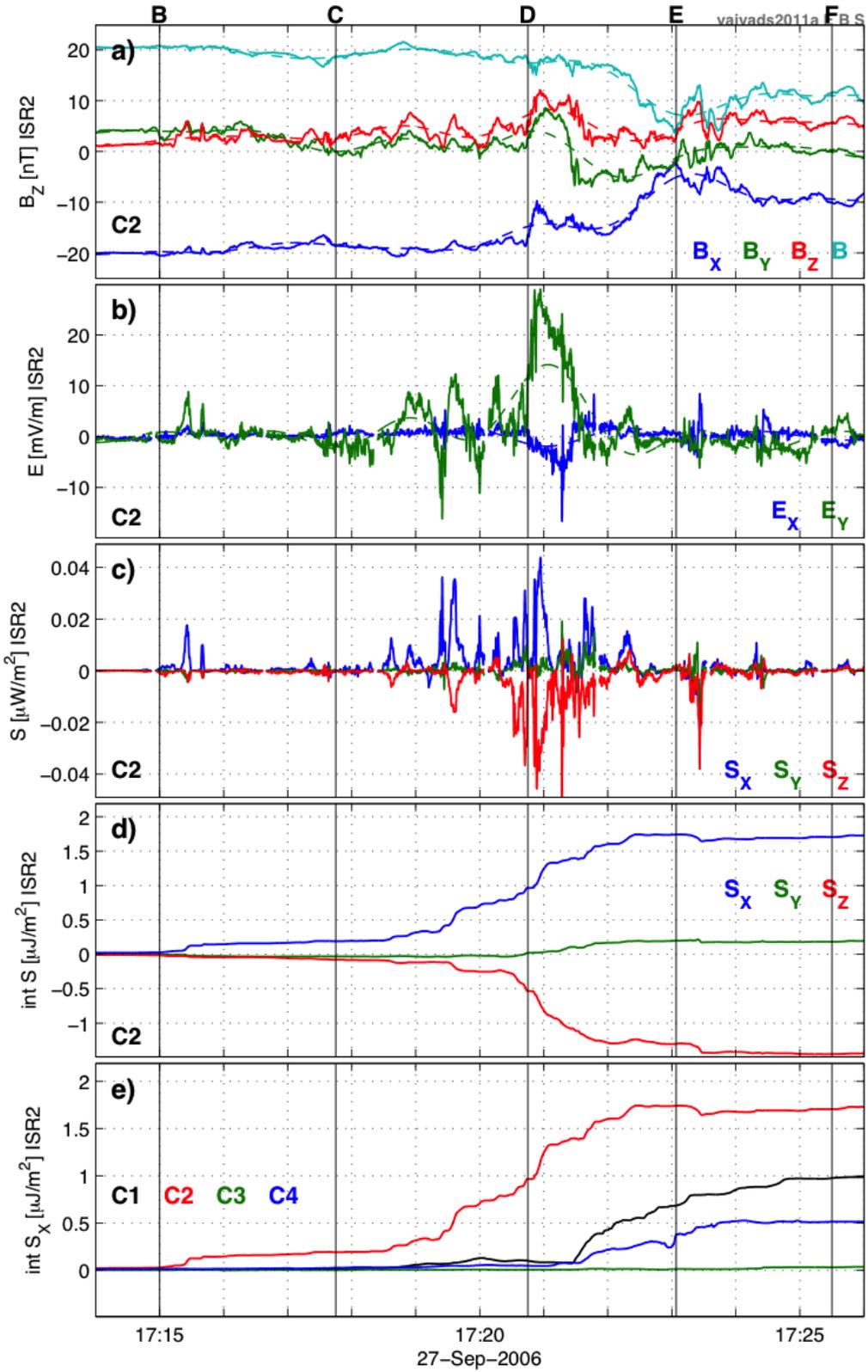
- ✓ **Small substorm onset**  
AE increase (E/F)  
~9min after tail reconnection onset (B) and a few min after full jet braking (E).
- ✓ Pi2 onset (C) ~2-3 min after reconnection onset, maximum Pi2 amplitude just after full jet braking.

**Figure 3**



- ✓  $B_z$ , all satellites observe magnetic flux pile-up. C4 strongest(E), C2 earliest(B).
- ✓  $B_x$ , proxy for distance to the current sheet. C3 furthest.
- ✓ Suprathermal electrons. C4 sees highest fluxes(E). Simult. increase C2,C4 (B,C)
- ✓ Flux transport across C1,C2. C4 observes return fluxes. Flux change at E.
- ✓ Thermal electrons show temperature increase on all spacecraft.
- ✓ Plasma density, as proxy for being in the current sheet.

**Figure 4**



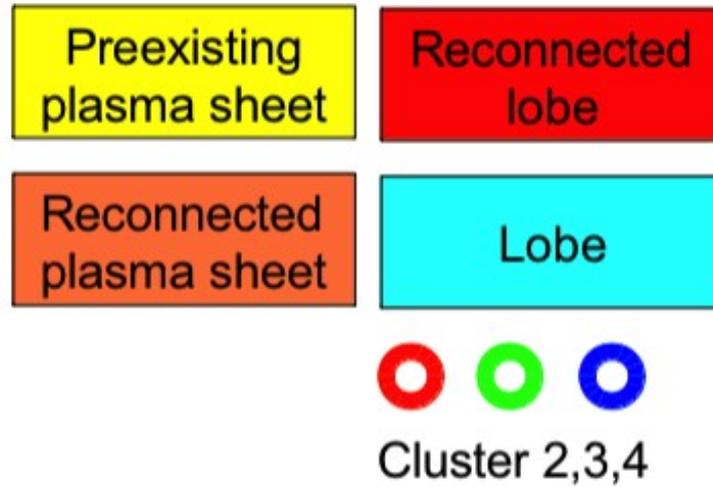
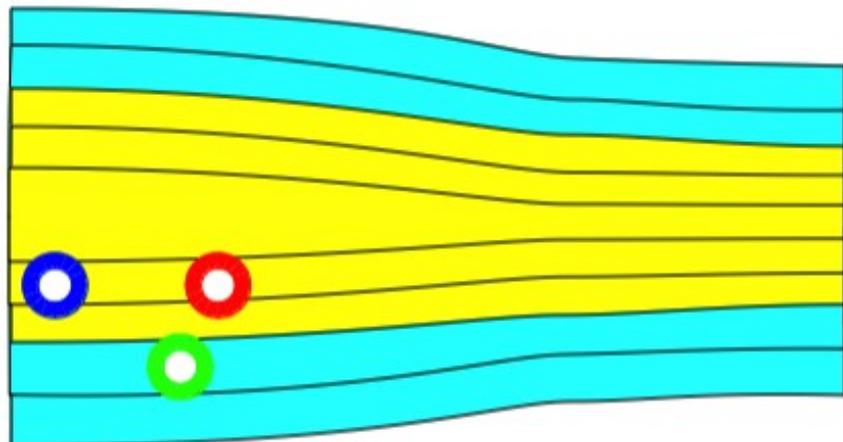
✓ Poynting flux.

✓ Integrated Poynting flux C2

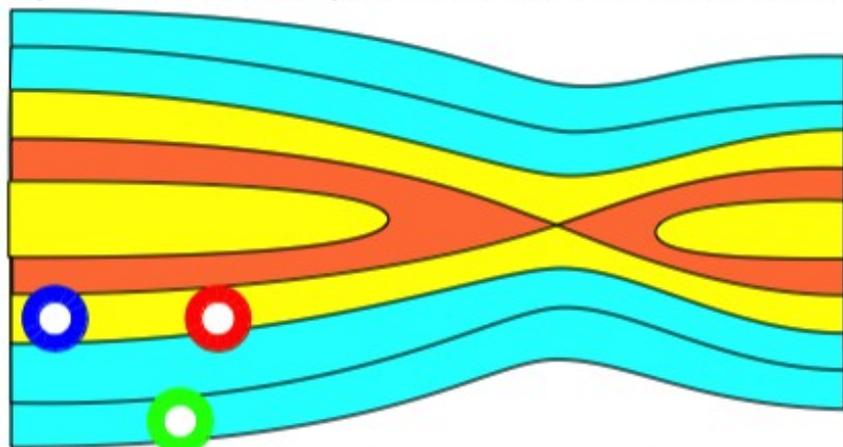
✓ Integrated Poynting flux all spacecraft. First increase at C2 around B.

**Figure 5**

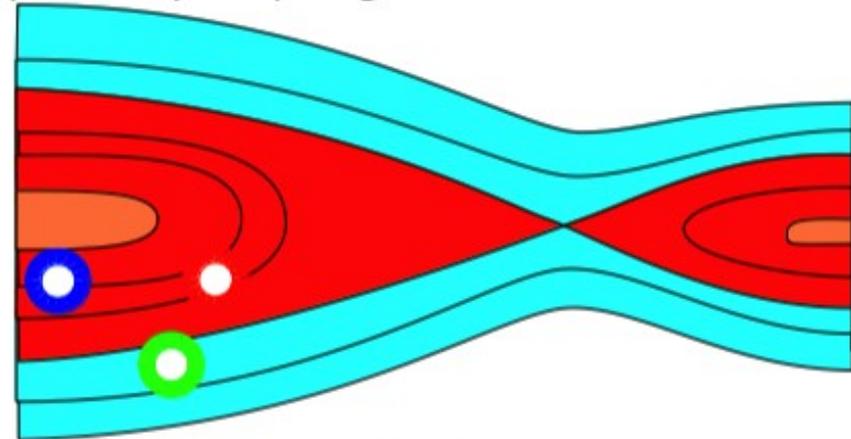
A) 17:12 stretched tail



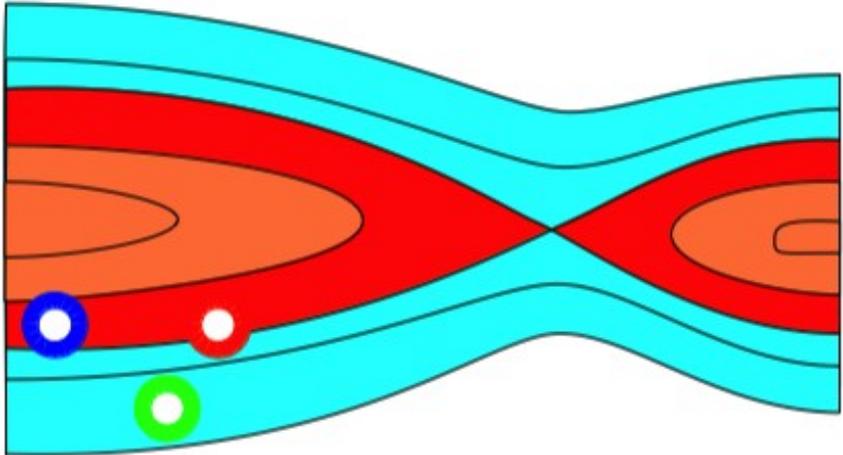
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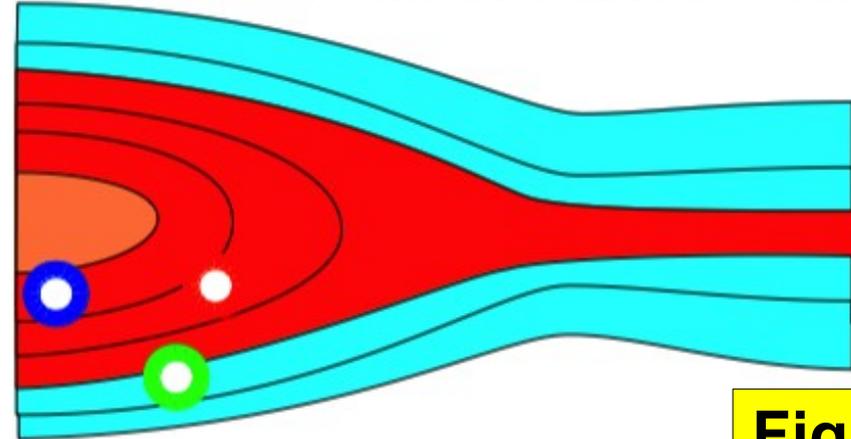
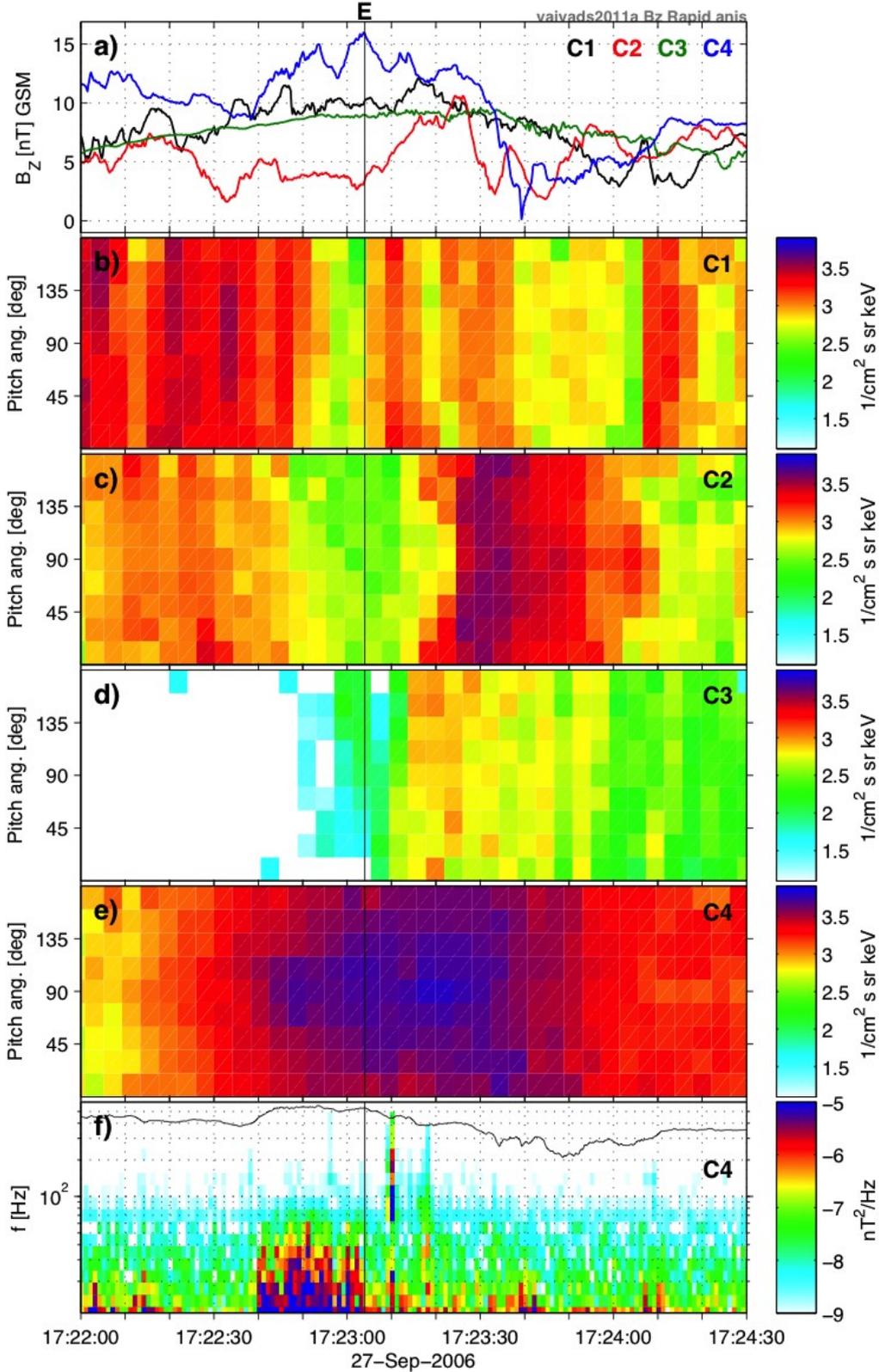


Figure 6



- ✓ Acceleration of suprathermal electrons is associated to magnetic flux pile-up regions but is not directly correlated with the peaks in the magnetic flux pile-up.
- ✓ Whistler emissions can be indicators of local regions of electron heating.  
*Khotyaintsev et al., 2011*
- ✓ For more discussion on acceleration mechanisms see also *Fu et al., 2011*.

**Figure 7**

# SUMMARY

- ✓ 10,000 km Cluster separation observations of tail reconnection/substorm onset.
- ✓ Reconnection proceeds in a few steps:
  - 1) reconnection of preexisting plasma sheet,
  - 2) reconnection of lobe plasma,
  - 3) formation of magnetic flux pile-up (dipolarization region).
- ✓ Pi2 generated after 1) step.
- ✓ AE index increase a few min after 3) step.
- ✓ Suprathermal electrons fluxes increase at each of the steps with highest fluxes at 3) step.
- ✓ Highest suprathermal electrons fluxes are not directly correlated to peaks in magnetic flux pile-up.