The role of low-energy ions in the microphysics of magnetic reconnection

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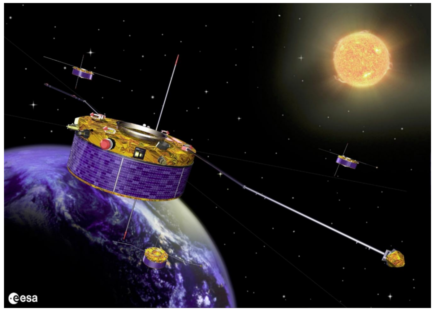

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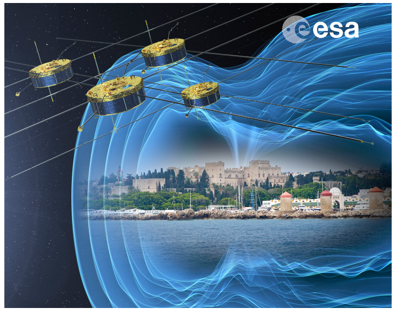


Initial hypothesis

Low-energy ions introduce a **new length-scale** in the magnetic reconnection process.

Procedure

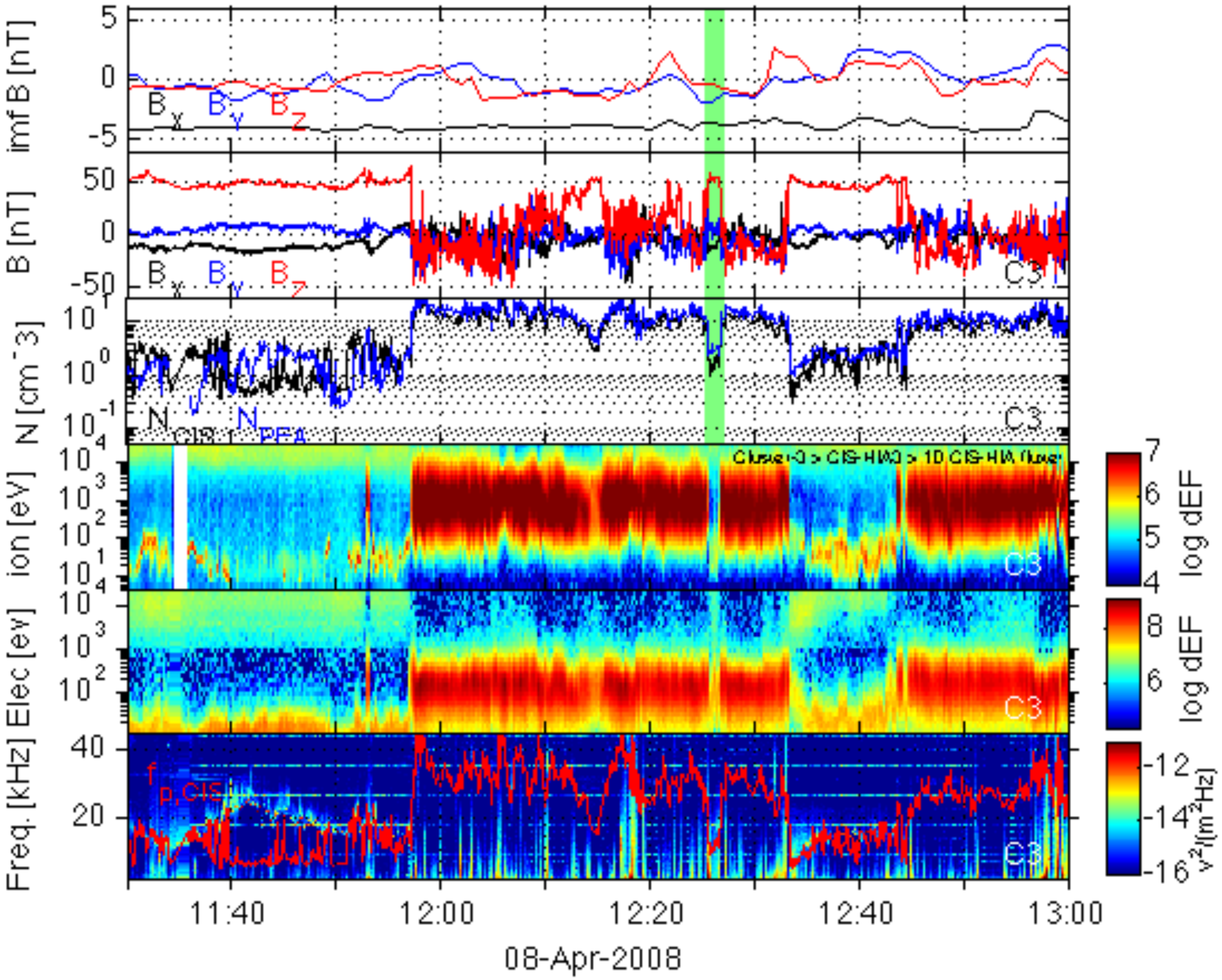
Cluster spacecraft to study **microphysics** at dayside magnetopause.

Data of Feb-Apr 2008: (1) **subsolar magnetopause** crossings, (2) distance C3-C4 **below ion inertial length** -> Hall currents from 2 spacecraft method.

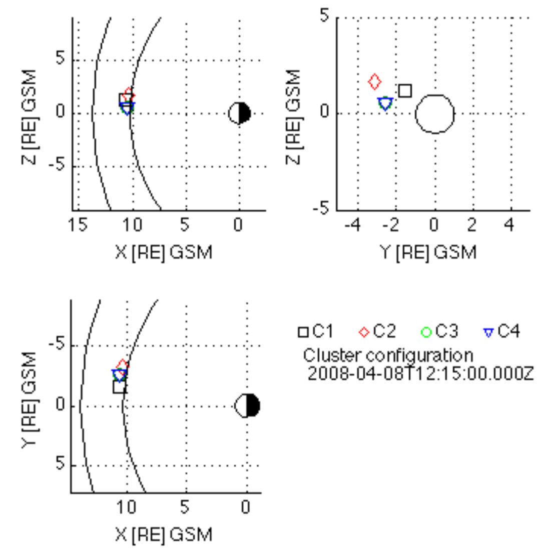
Determine the **presence of low-energy ions** near the boundary.

Quantify the **terms in the Ohm's law** equation to observe their contribution.

Magnetopause crossing overview

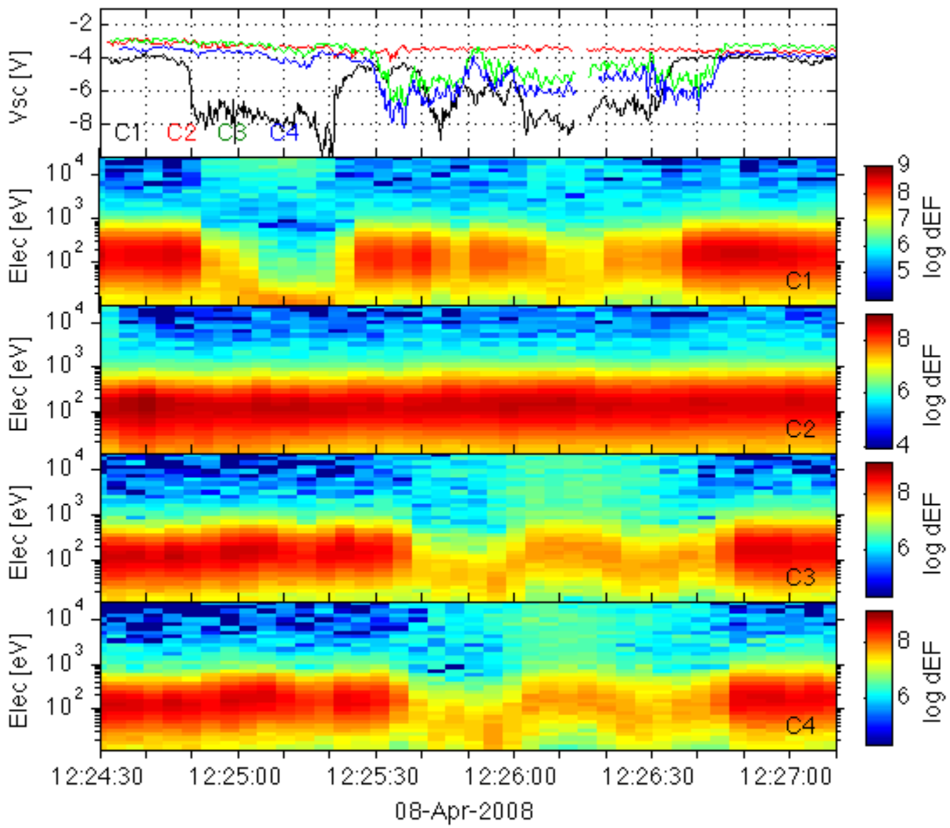


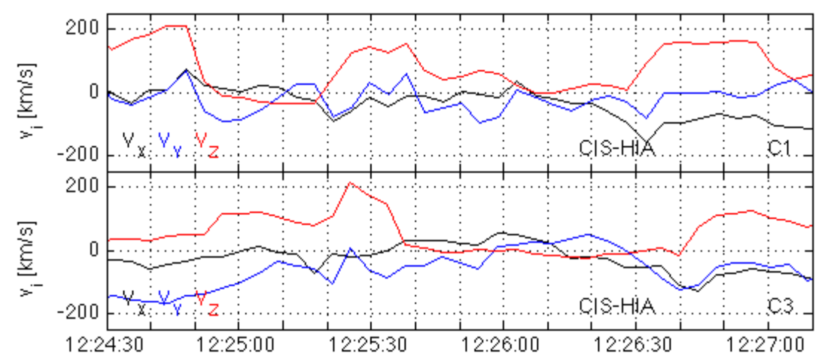
Overview of C3 multiple magnetopause crossings.
Green region is analyzed in detail.



Subsolar magnetopause.

Multi-spacecraft event overview

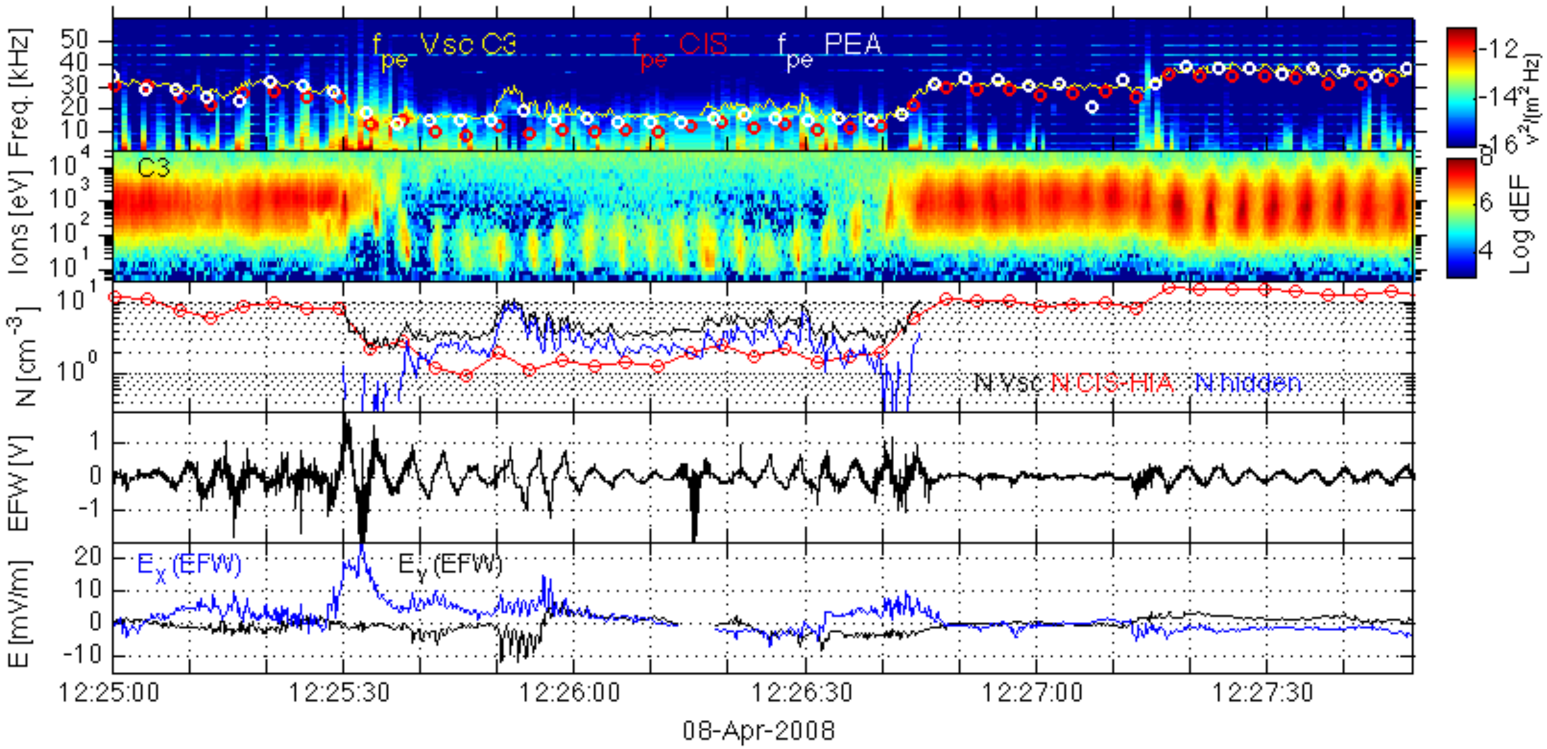




C3-C4 same signatures (short separation).
C1 modified signatures (distance ~1R_E).
C2 does not cross the boundary.

Outflow jets originated by reconection in the Z component.

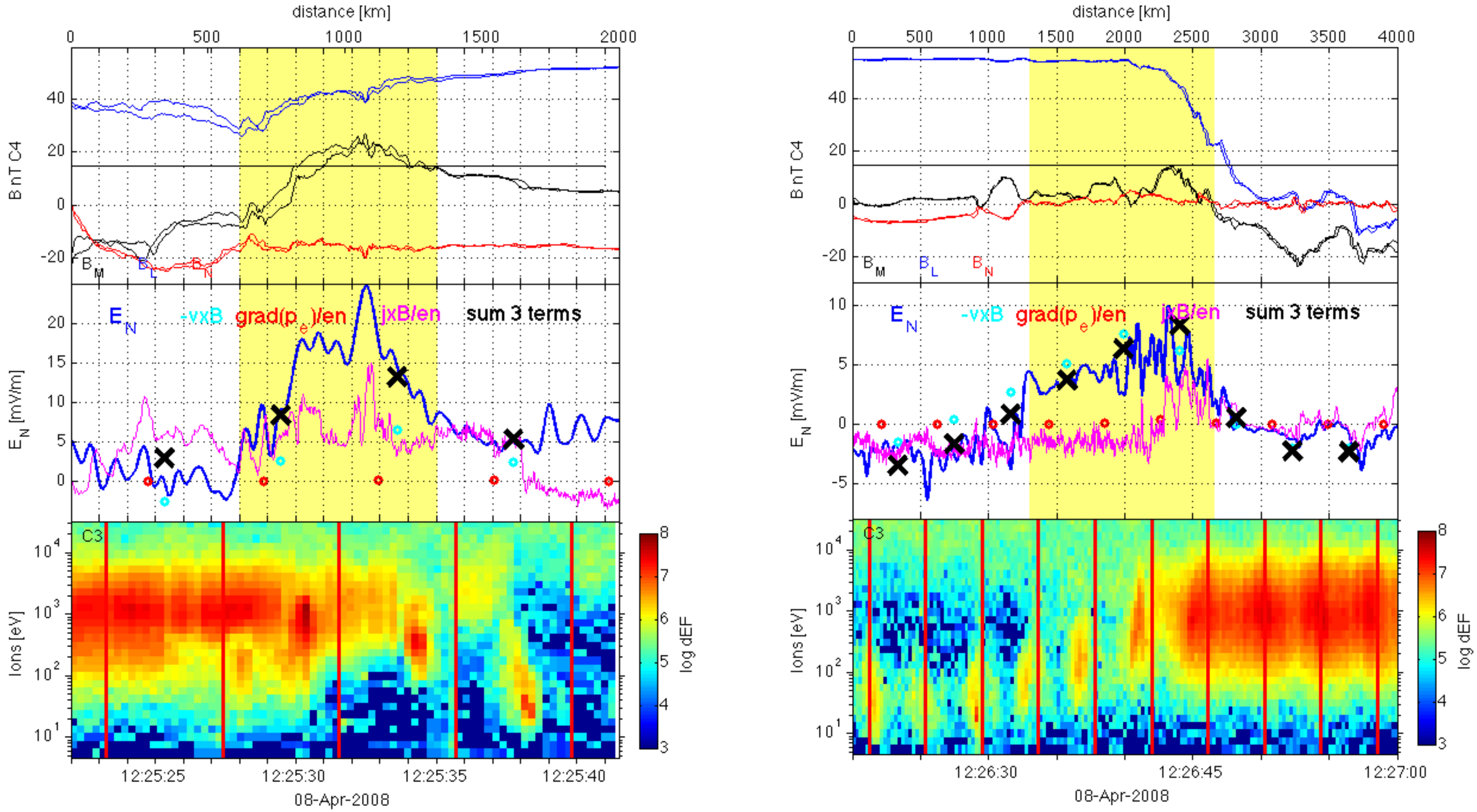
Presence of low-energy ions



- **Three instruments** indicate the **presence of low-energy ions**.

- Hidden ions to CIS are at least on the **same order of magnitude** as detected ions.

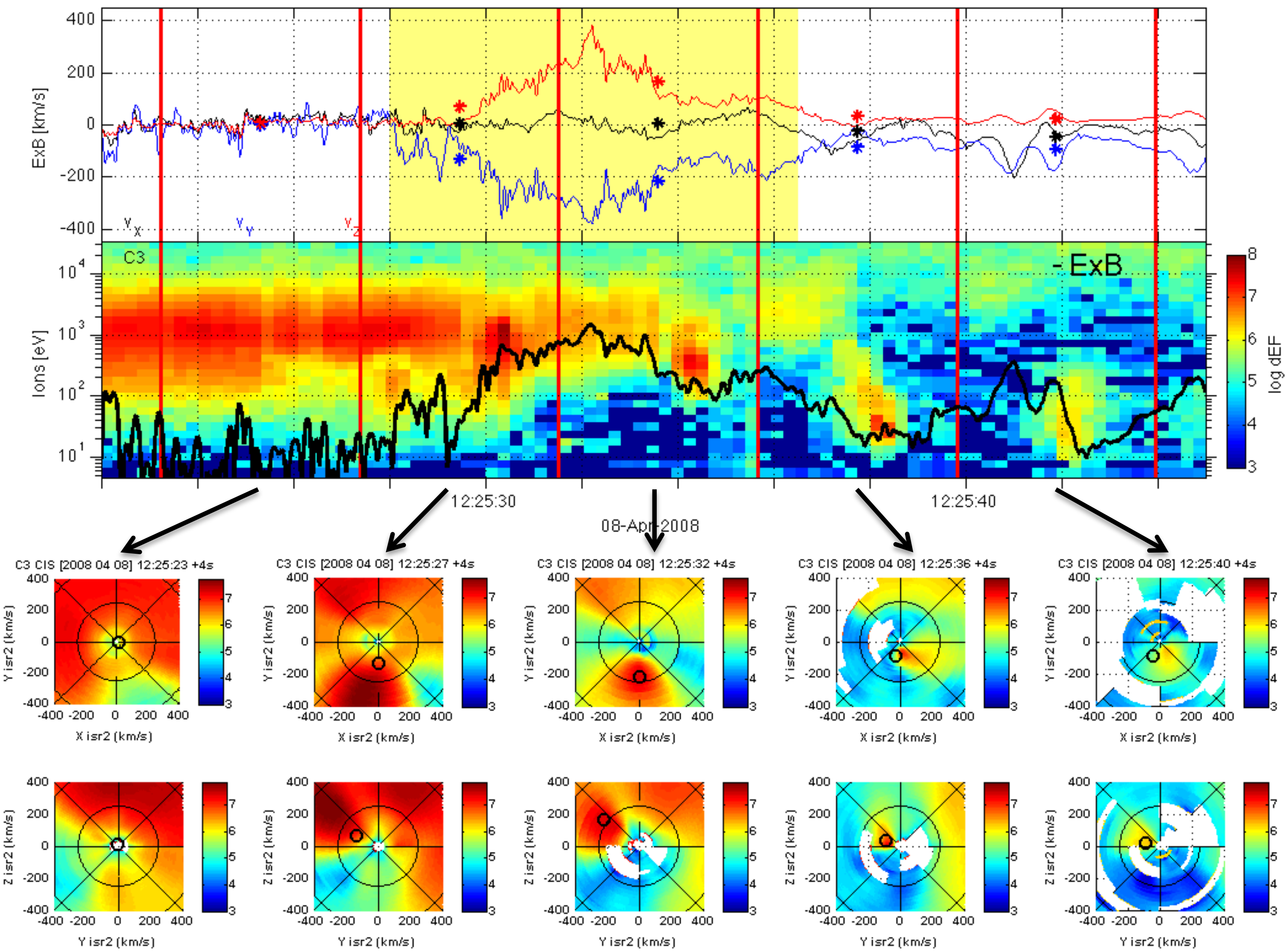
Terms in the Ohm's law



Estimation of terms in the **Ohm's law**. v_ixB term must be accounted for in order to balance the equation.

$$\mathbf{E} = -\mathbf{v}_i\times\mathbf{B} + \mathbf{j}\times\mathbf{B}/ne - \Delta p_e/ne$$

ExB drift in the thin layer

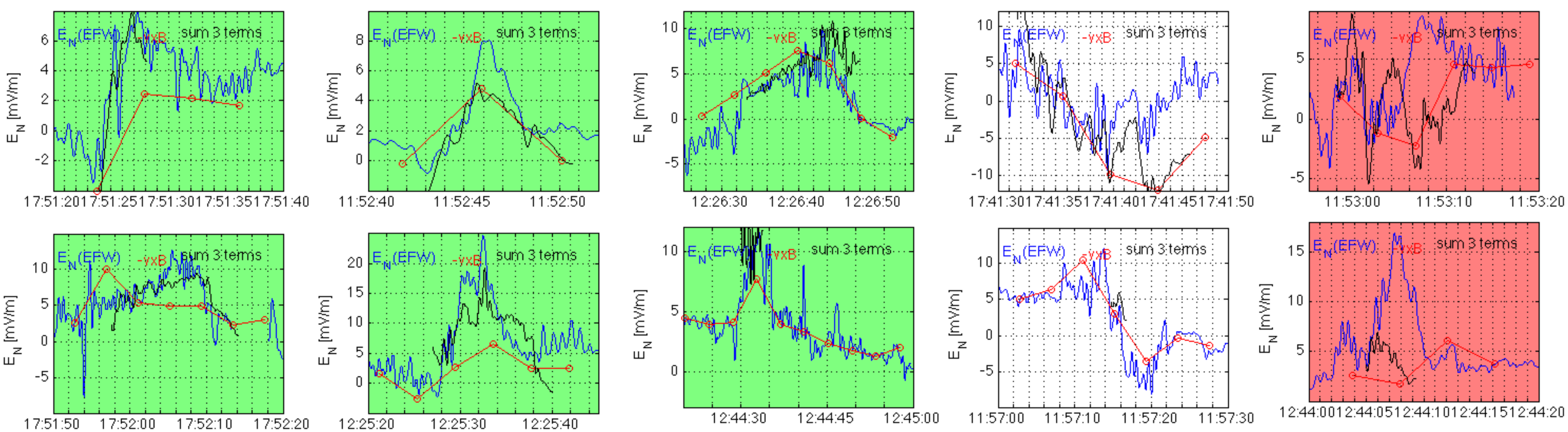


Other crossings

- Analysis could be applied to **10 crossings** from **2 orbits.**

- All the **10 crossings** show **signatures of low-energy ions**.

- In **6/10**, evidence of drifting low-energy ions contributing to balance Ohm's law in the narrow layer.
- In **2/10**, the estimations for the terms **do not balance** E_n. Atributed to error estimations in $\mathbf{v_i}$ (4s resolution) and **j** (1D magnetopause).
- In **2/10**, it is hard to give conclusions.



Conclusion

- **Low-energy ions** are **common** in the subsolar magnetopause.

- **Low-energy ions gyrate** inside **magnetic reconnection** structures, introducing a new **length-scale.**

- $\mathbf{v_i x B}$ can sometimes become the **dominant term** balancing $\mathbf{E_n}$, instead of jxB.

Estimation of Ohm's law terms

$$\mathbf{E} = -\mathbf{v}_i \times \mathbf{B} + \mathbf{j} \times \mathbf{B}/ne - \Delta p_e/ne$$

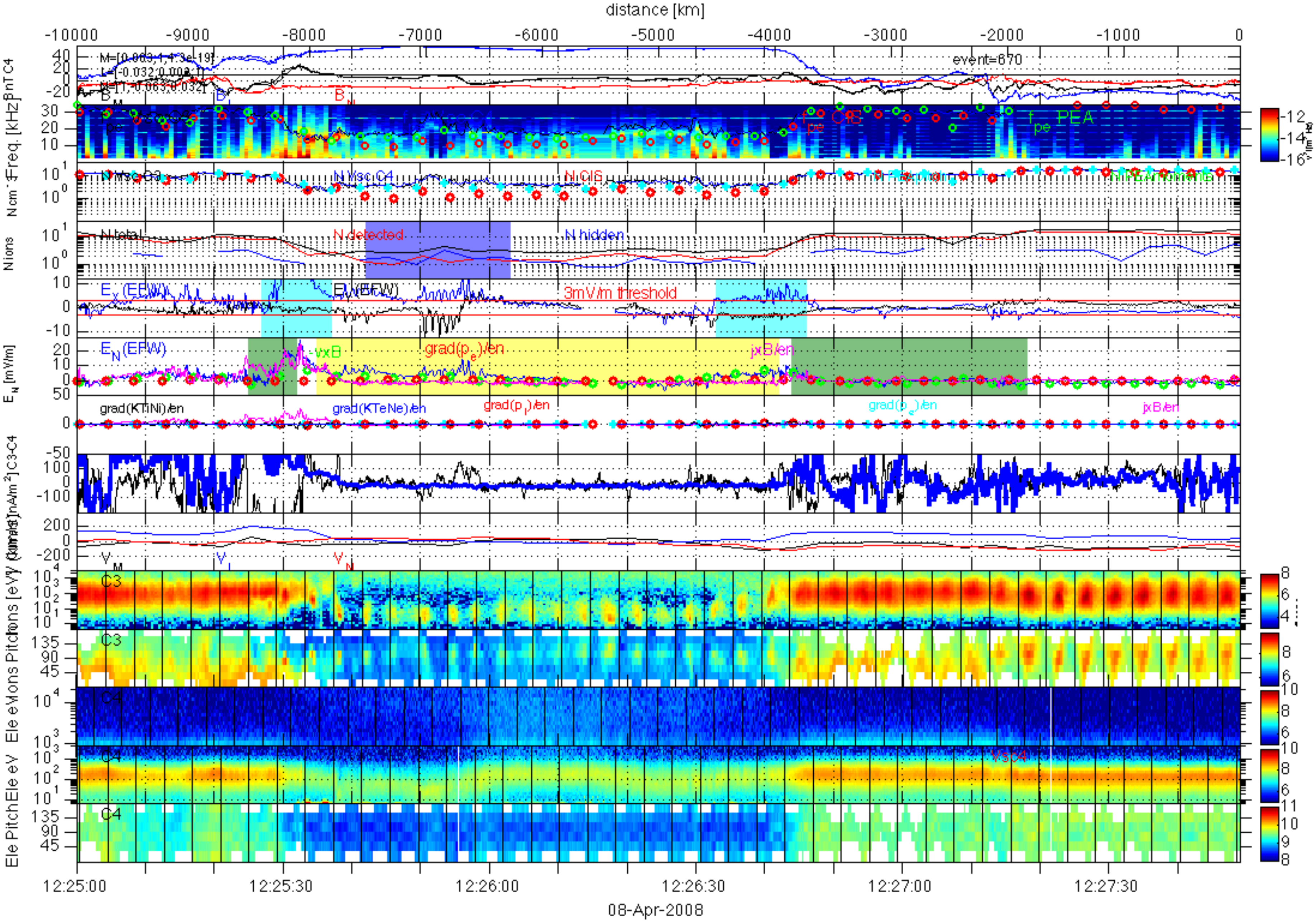
Assume **1D magnetopause** (2SC). Estimation only of **normal components.**

E_n measured by EFW.

jxB/en: B from FGM, j from c3-c4 + 1D MP.

v_ixB: B from FGM, v_i from CIS moments (4s resolution).

grad(p_e)/en: p_e from CIS 4s moments, assume constant V_{mp}.



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-8000
-7000
-6000
-5000
-4000
-3000
-2000
-1000
0
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B nT C4
Freq. [kHz]
f pe CIS
f pe PEA
N cm^-3
N Vsc C3
N Vsc C4
N CIS
N PEA moments
Nions
N total
N detected
N hidden
E_x (EFW)
E_y (EFW)
3mV/m threshold
E_N [mV/m]
E_N (EFW)
-vxB
grad(p_e)/en
jxB/en
grad(KTiNi)/en
grad(KTeNe)/en
grad(p_i)/en
grad(p_e)/en
jxB/en
C3-C4
V_M
V_L
V_N
C3
C4
Vsc4
Ions [eV]
Ions Pitch
Ele eV
Ele Pitch
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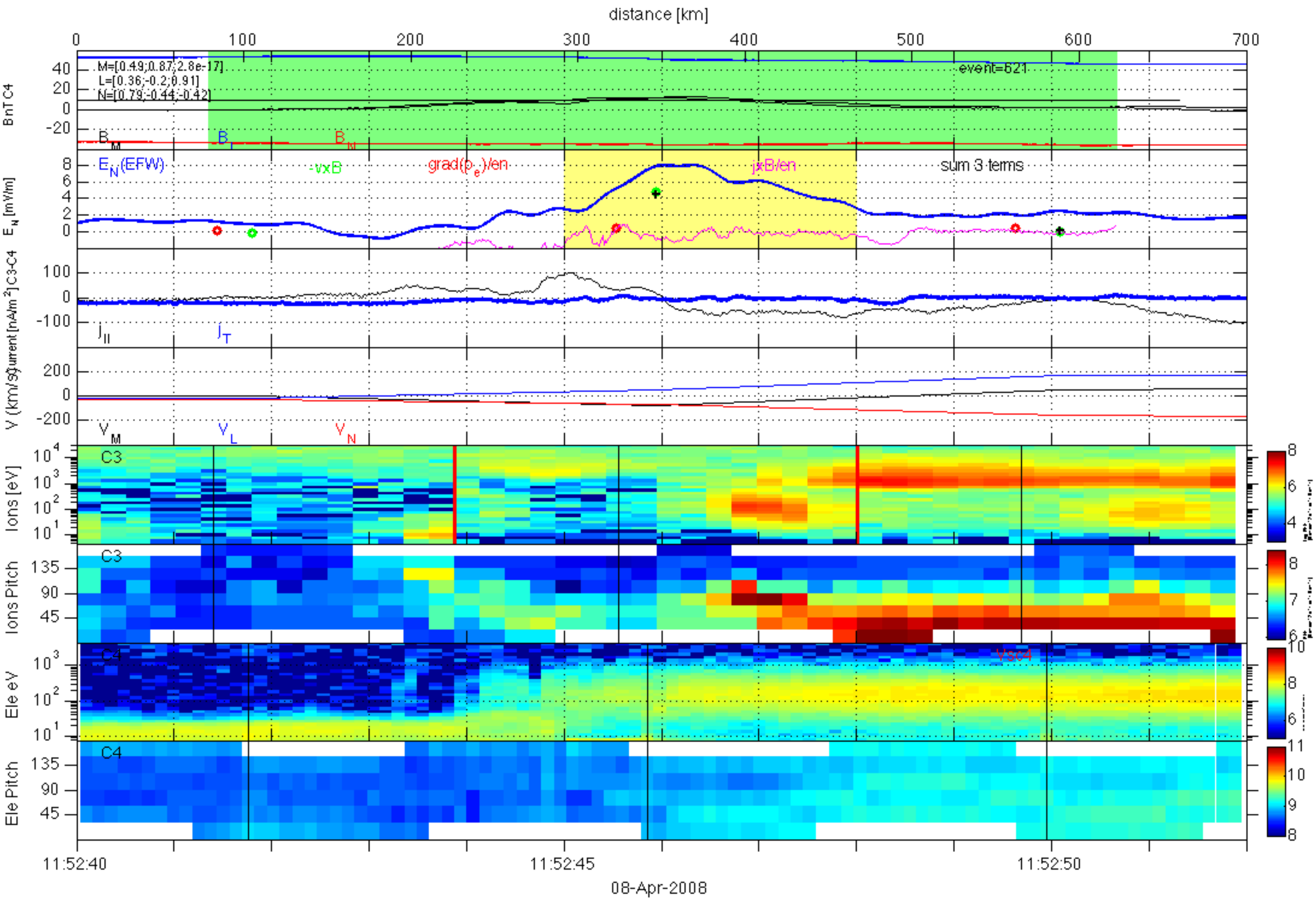
12:25:30
12:26:00
12:26:30
12:27:00
12:27:30
08-Apr-2008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700
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N=[0.79;-0.44;-0.42]
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B_L
B_N
E_N(EFW)
-vxB
grad(p_e)/en
jxB/en
sum 3 terms
E_N [mV/m]
current [nA/m^2] C3-C4
j_{II}
j_T
V (km/s)
V_M
V_L
V_N
C3
Ions [eV]
Ions Pitch
C4
Ele eV
Vsc4
Ele Pitch
11:52:40
11:52:45
11:52:50
08-Apr-2008