Waves associated with reconnection sites at the magnetopause

Yuri Khotyaintsev

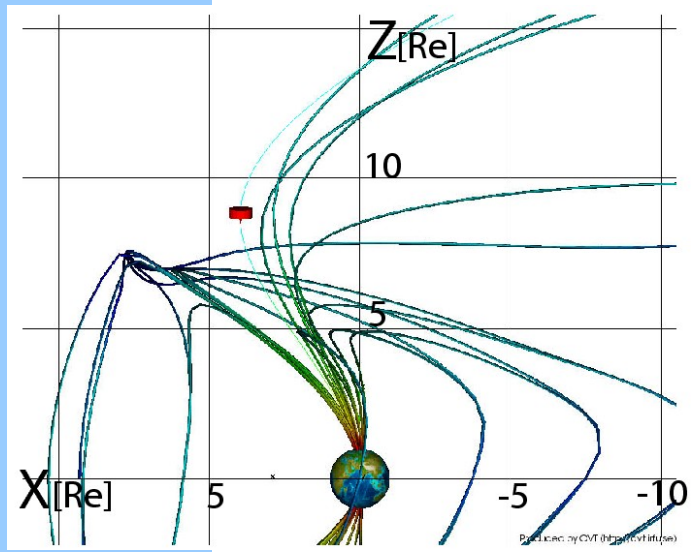
IRF, Uppsala, Sweden

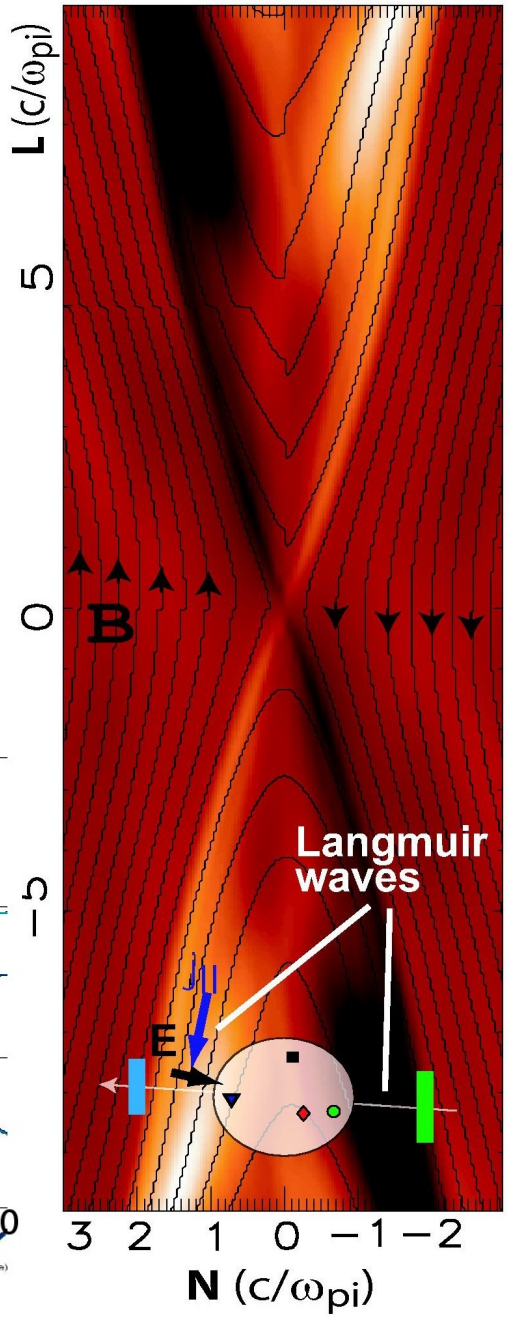
Outline

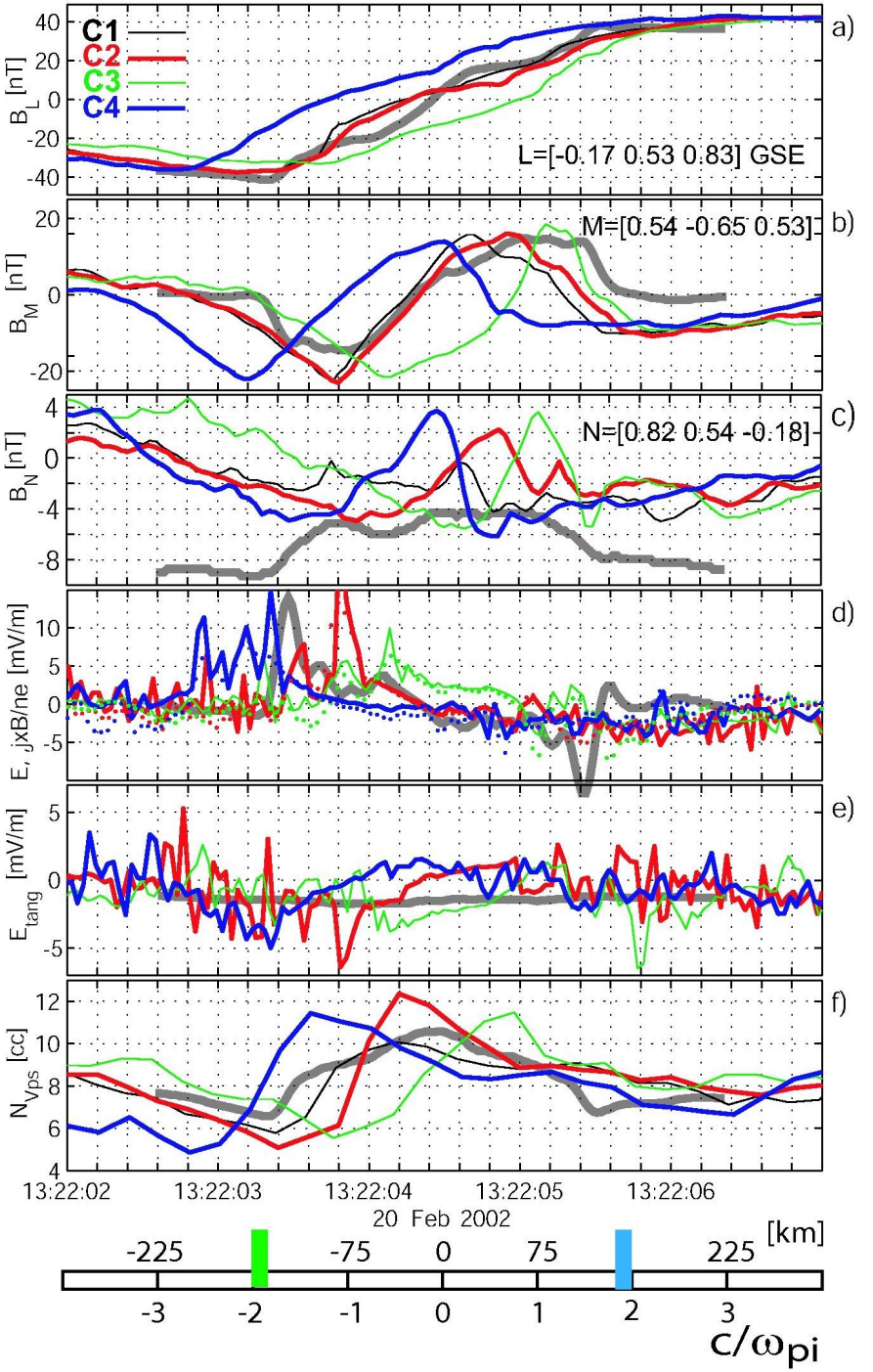
- Which waves are typically observed at the magnetopause in relation to reconnection, in which regions, and what is their role?
- Observations
  - Antiparallel reconnection ~6 λ_i from the reconnection site
    - Stable 2D structure, Hall dynamics (**E=jxB**), Langmuir waves and $\mathbf{j}_{||}$ at the separatrices
  - Component reconnection ~60 λ_i from the reconnection site
    - Separatrix region (LW, ESW,LHDW), jet, RD
  - Tangential magnetopause
    - Thin magnetopause <λ_i with strong LHDW, reconnection onset
  - High-β cusp
    - Langmuir and whistler waves
  - FTEs
    - Strong DC $\mathbf{E}_n$ in a density cavity at the boundary, potential jump

Cluster close to X-line (magnetopause)

- ✔ Structure is stable on observation scales
- ✔ Structure is 2D
- ✔ E = jxB

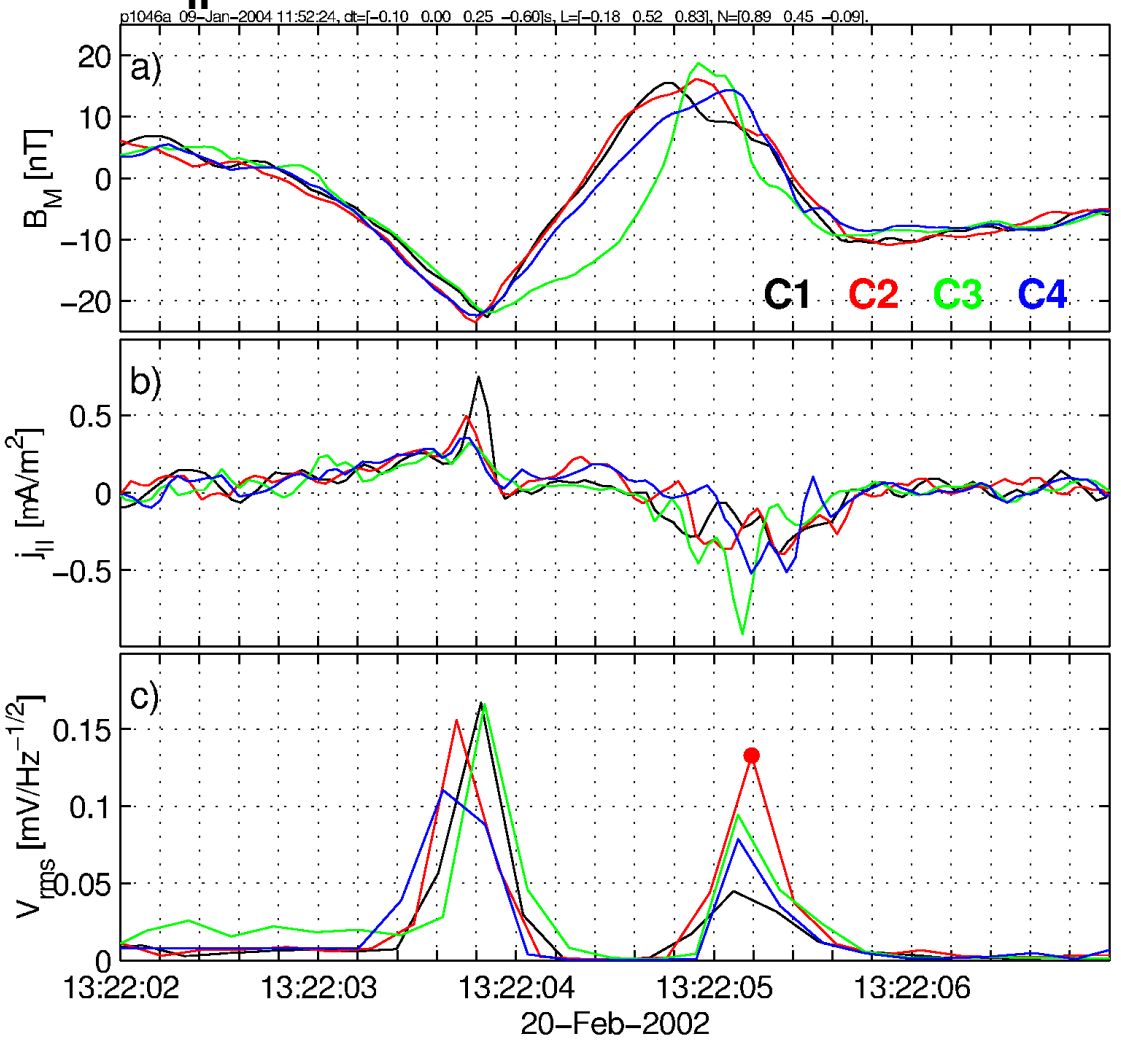




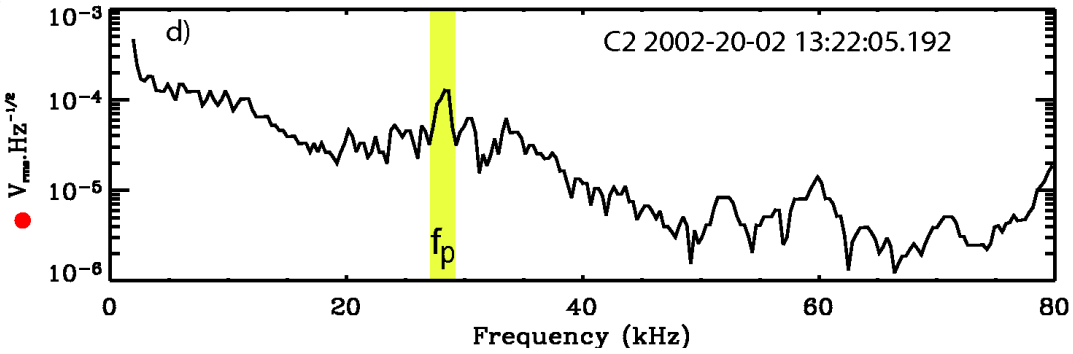


[Vaivads et al., 2004a]

Separatrices, $j_{||}$ and HF waves

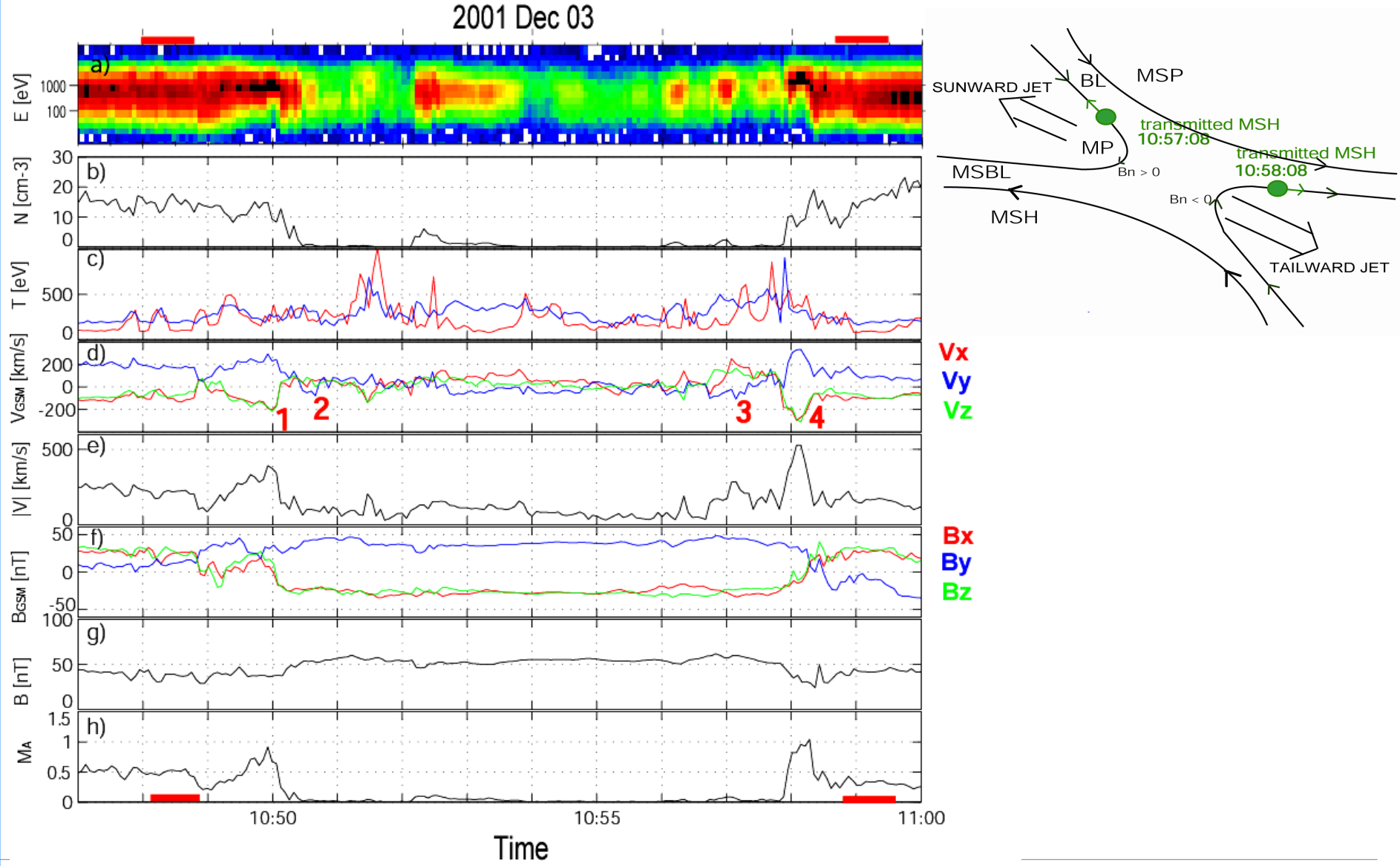


- ✔ Strong parallel currents
- ✔ Langmuir/upper hybrid emissions
- ✔ The role of waves? (anomalous resistivity, diffusion)



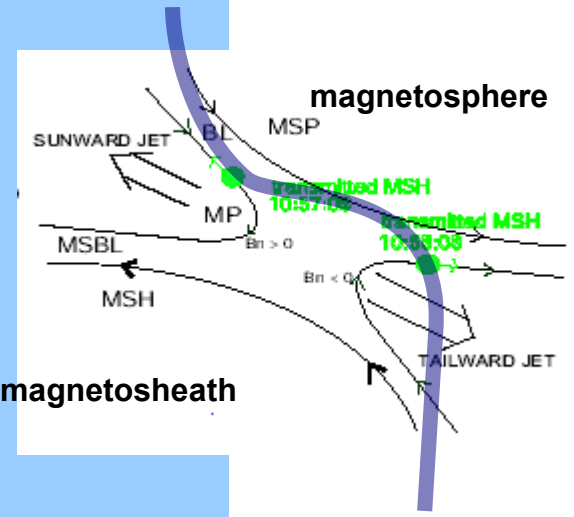
[Vaivads et al., 2004a]

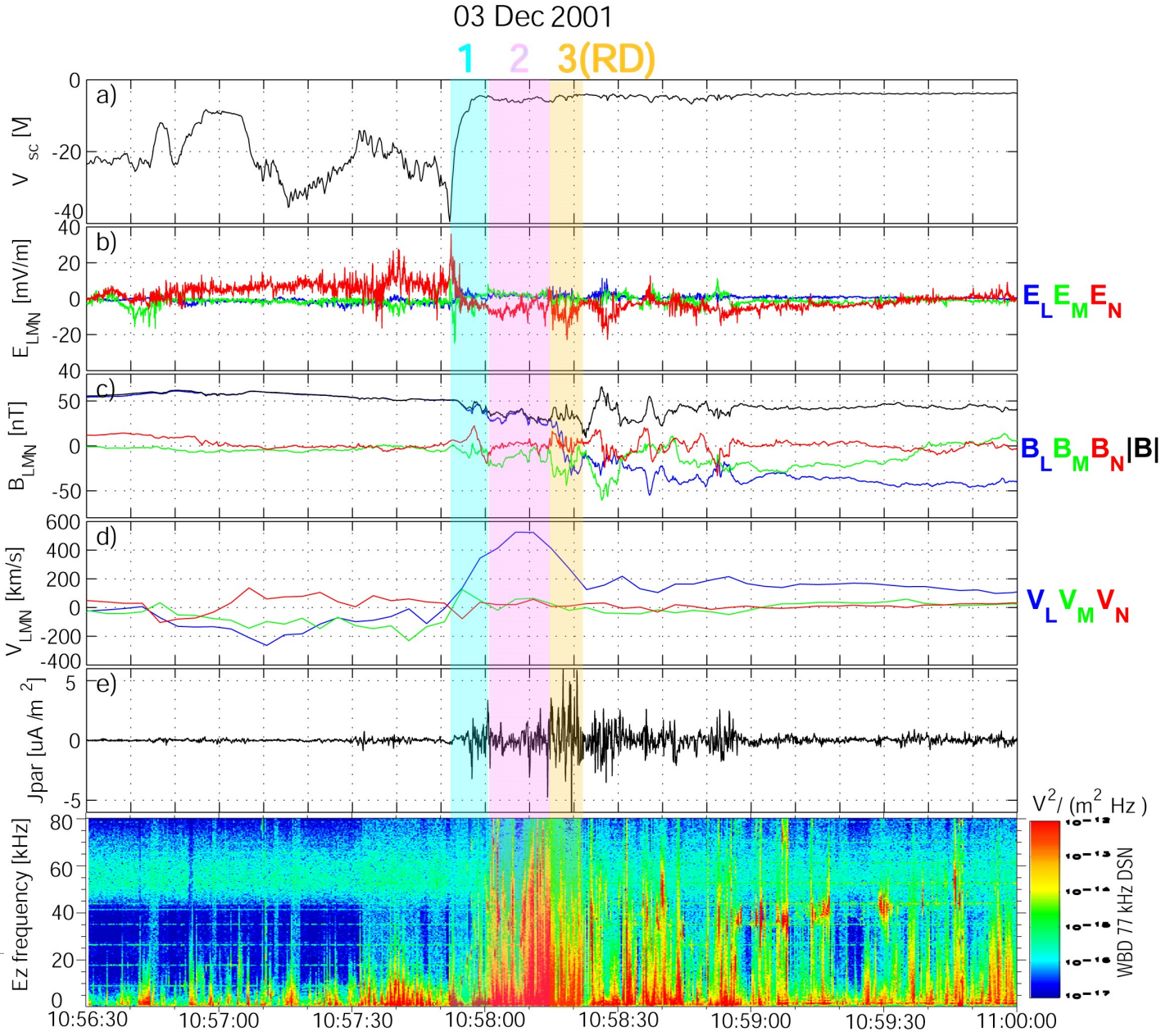
Component reconnection. Jet reversal.



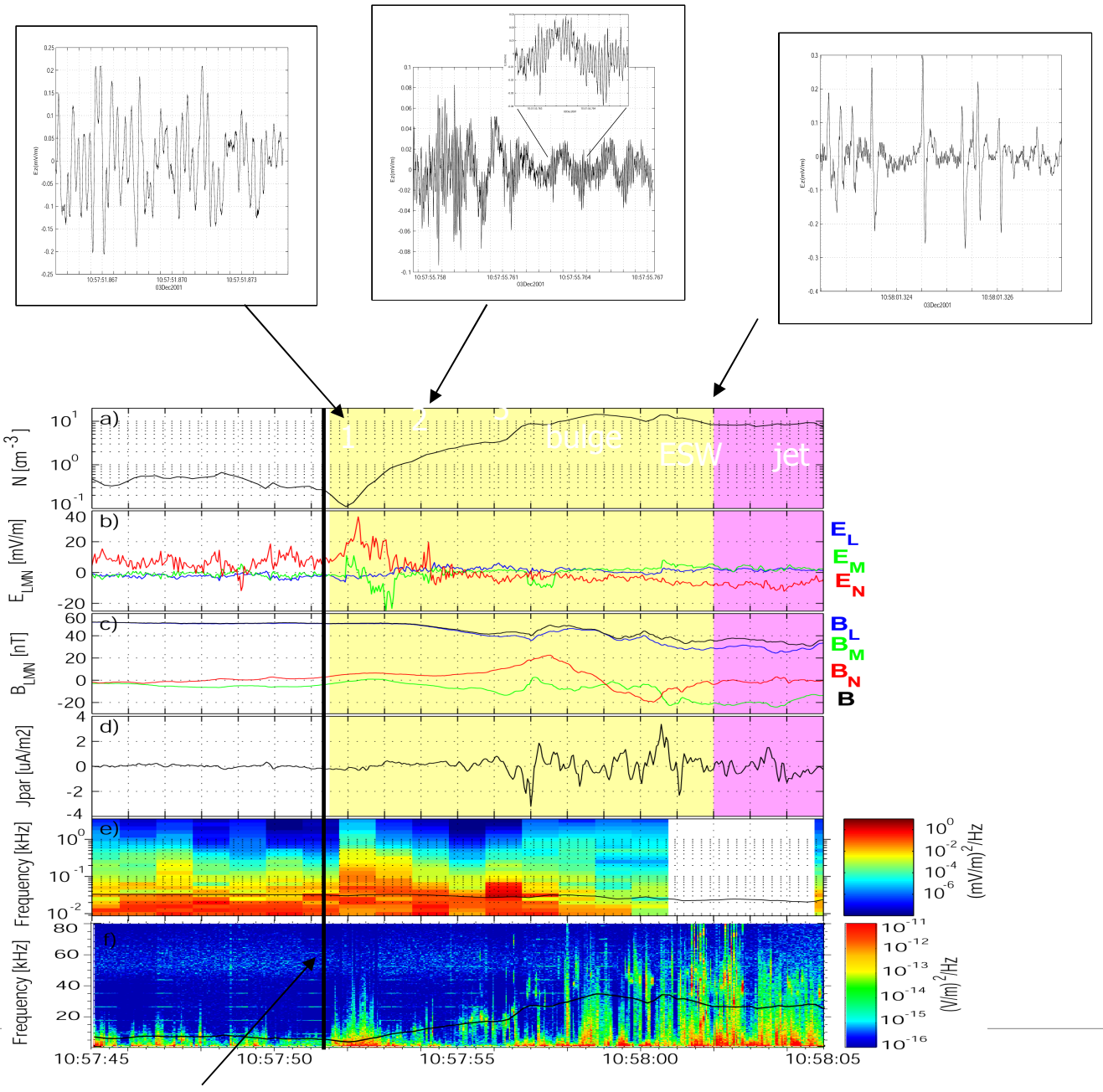
[Retino et al., 2004]

Reconnection site in details



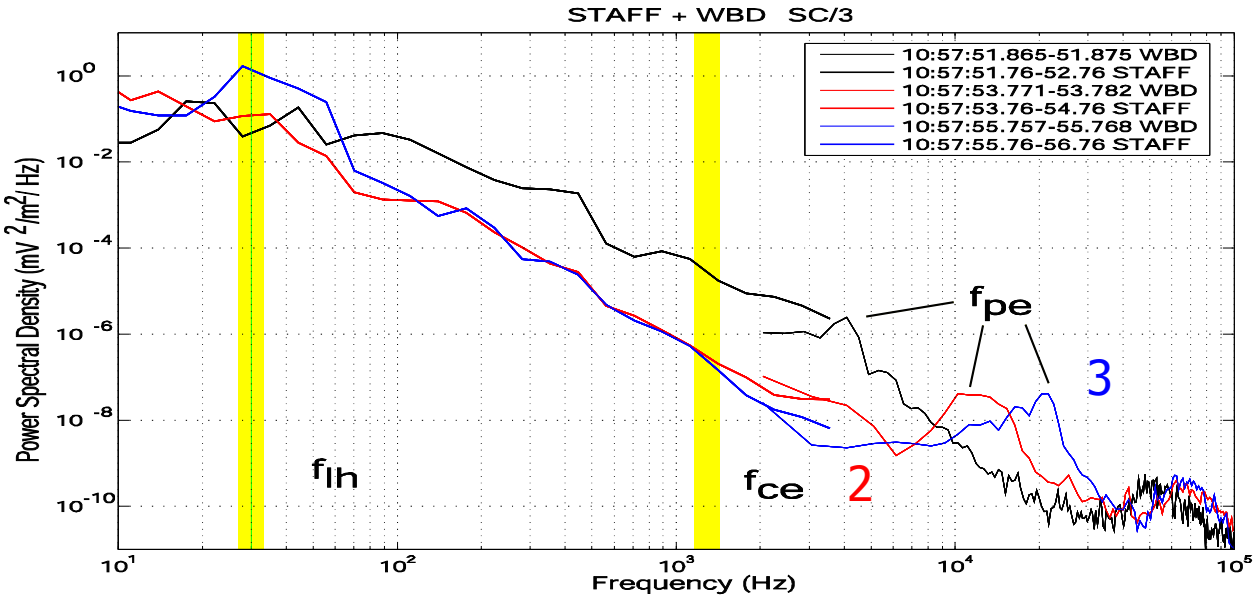


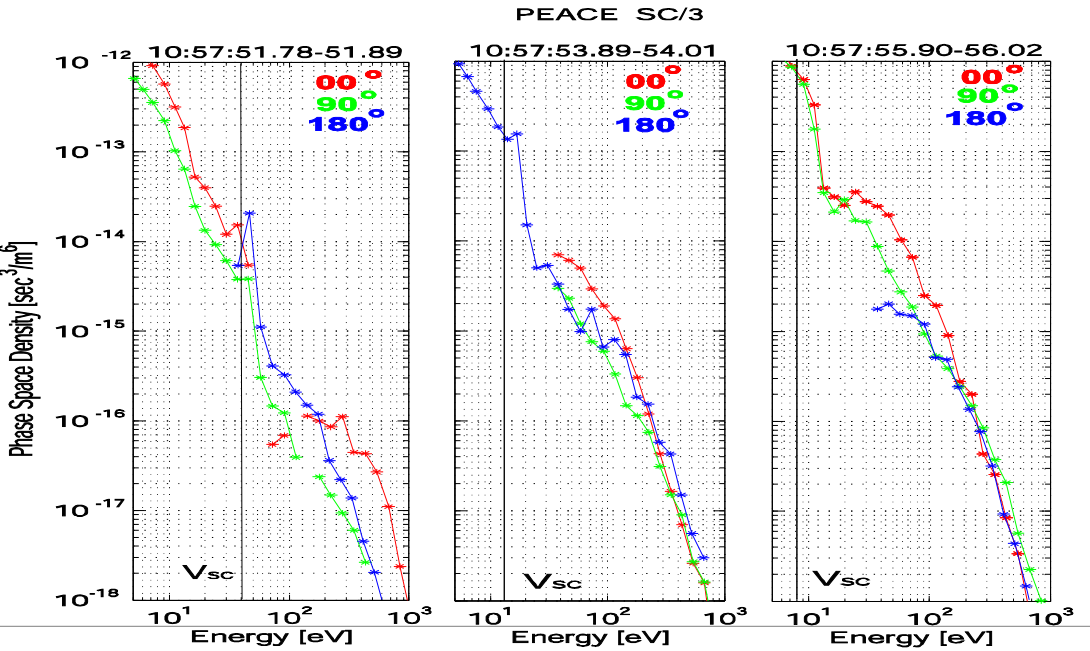
The separatrix region (SR)



[Retino et al., 2005]

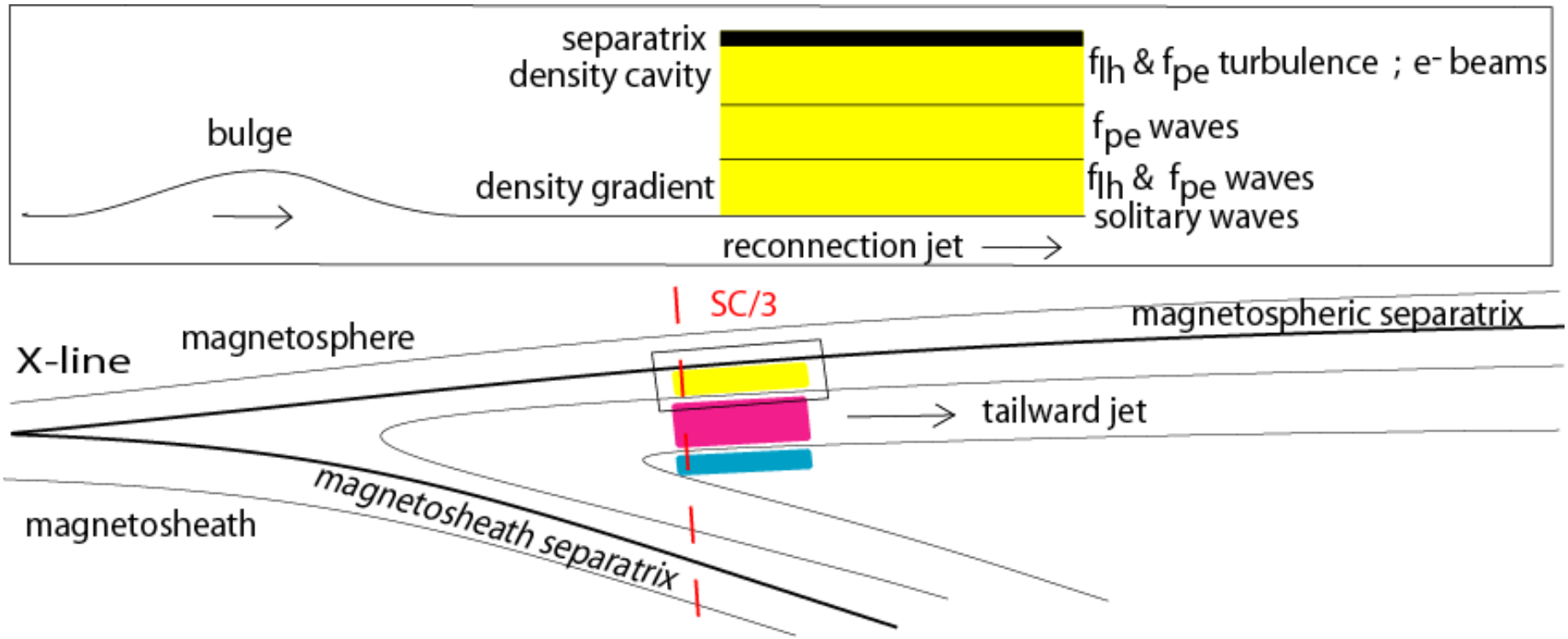
Wave-particle interaction inside the SR





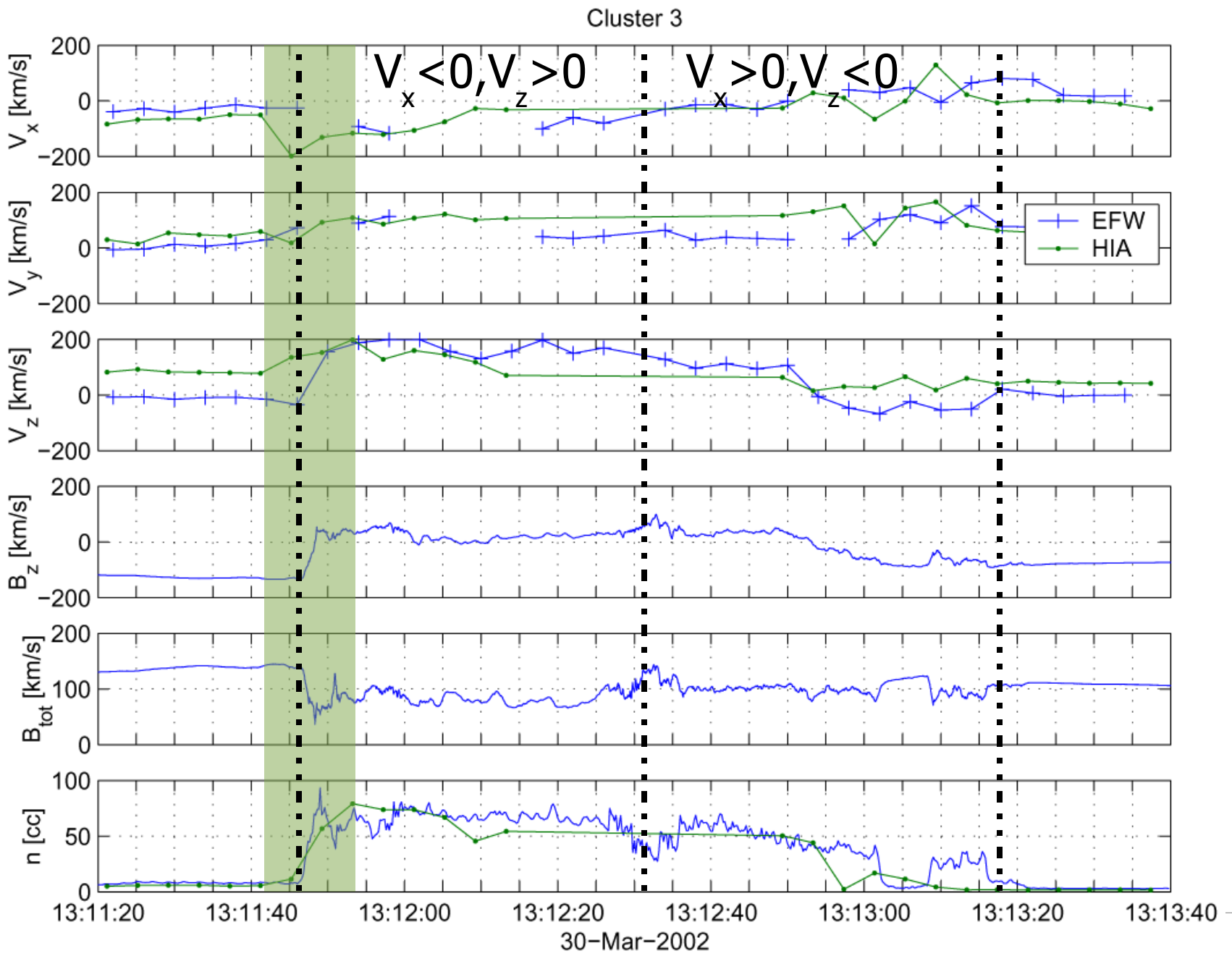
[Retino et al., 2005]

Schematic of the separatrix region

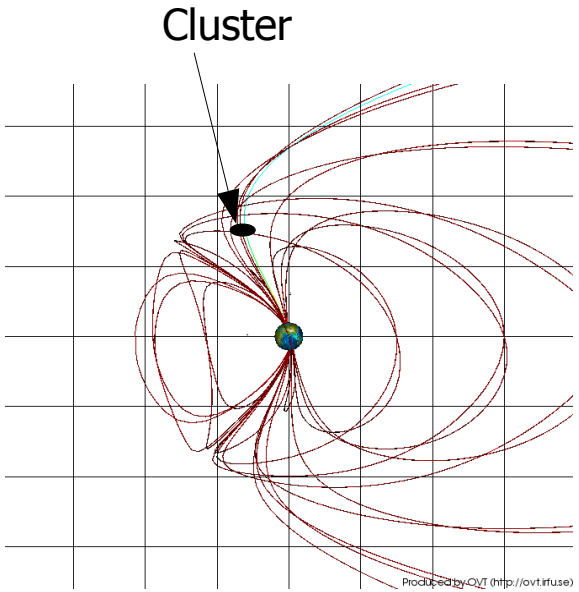


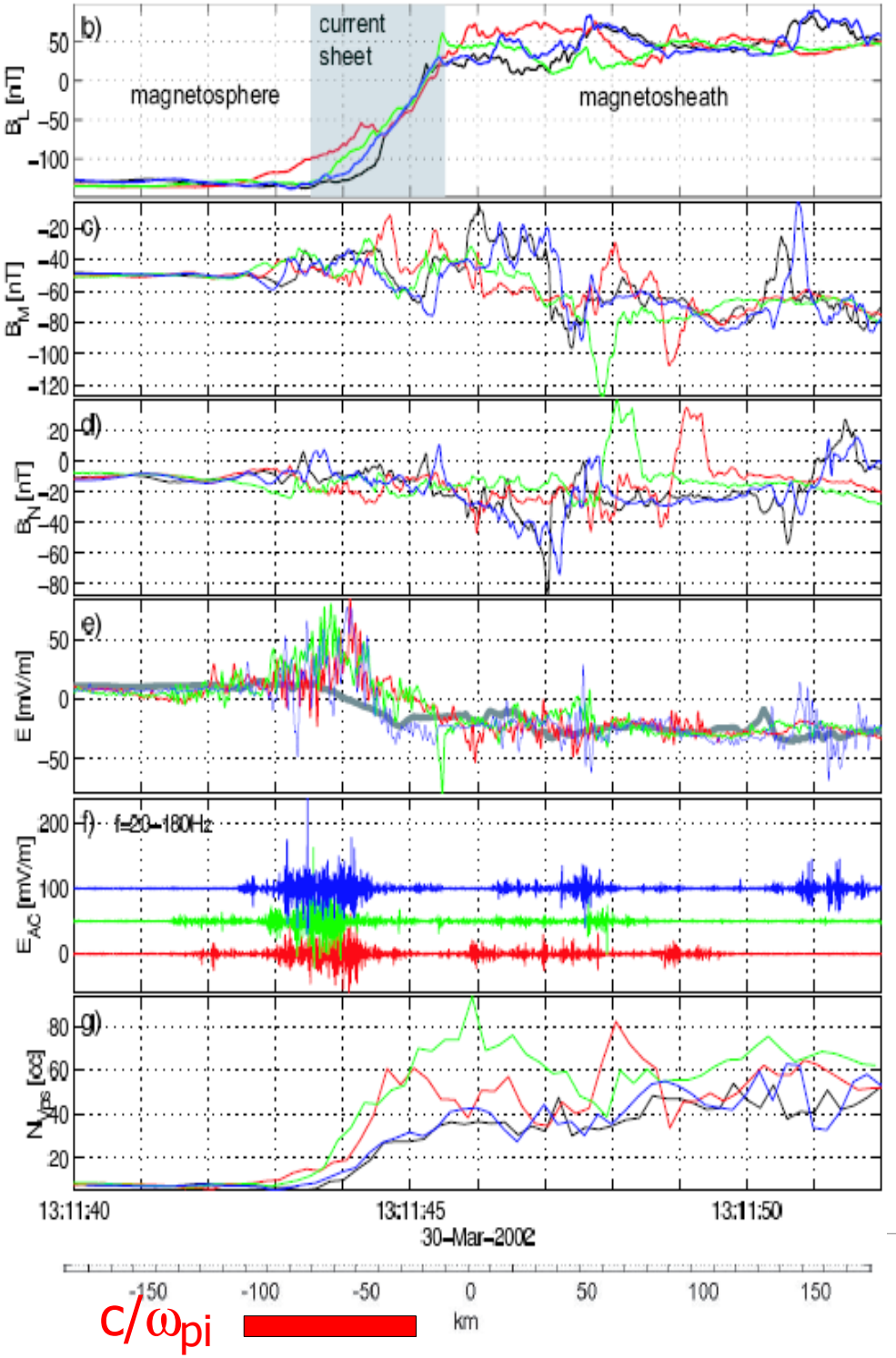
[Retino et al., 2005]

Reconnection onset



Magnetopause current layer



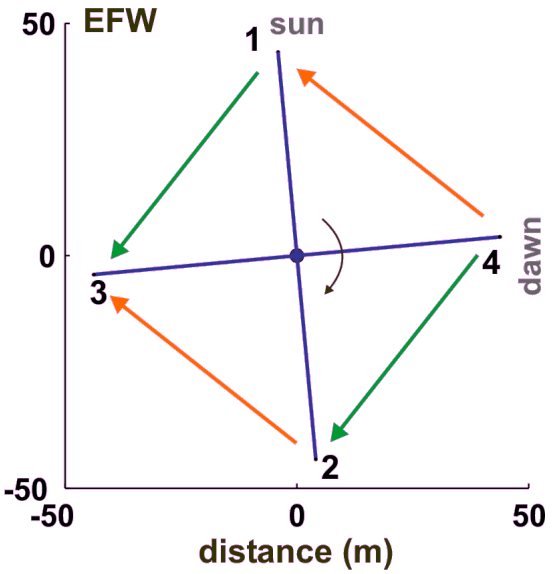


We can compute

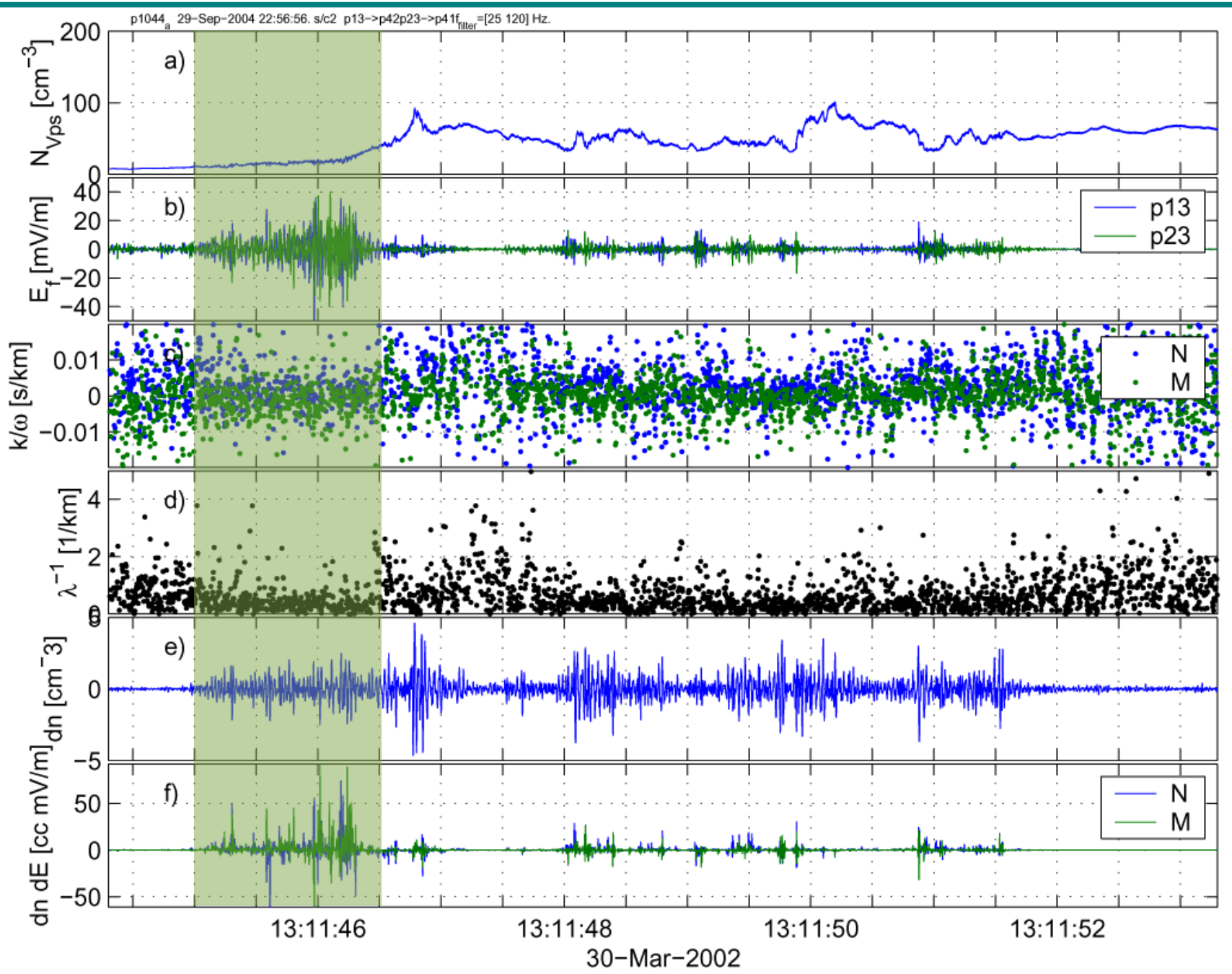
- Phase velocity, wavelength
- Anomalous resistivity $<\delta E\ \delta n>$:

$$(\partial/\partial t\ nmV)_{anom} = e <\delta E\ \delta n>$$

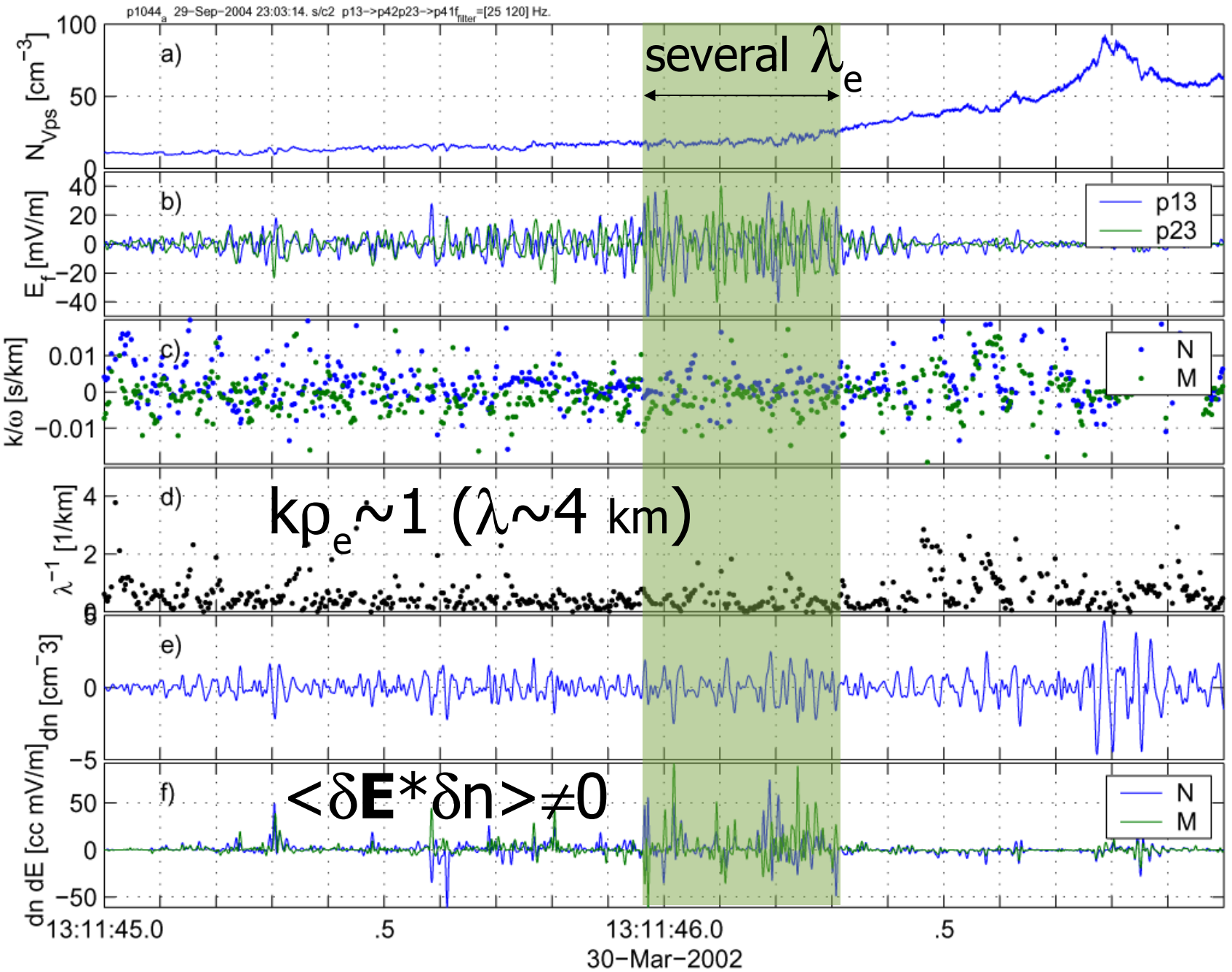
$$\nu_{eff} = (e/nmV) <\delta E\ \delta n>$$



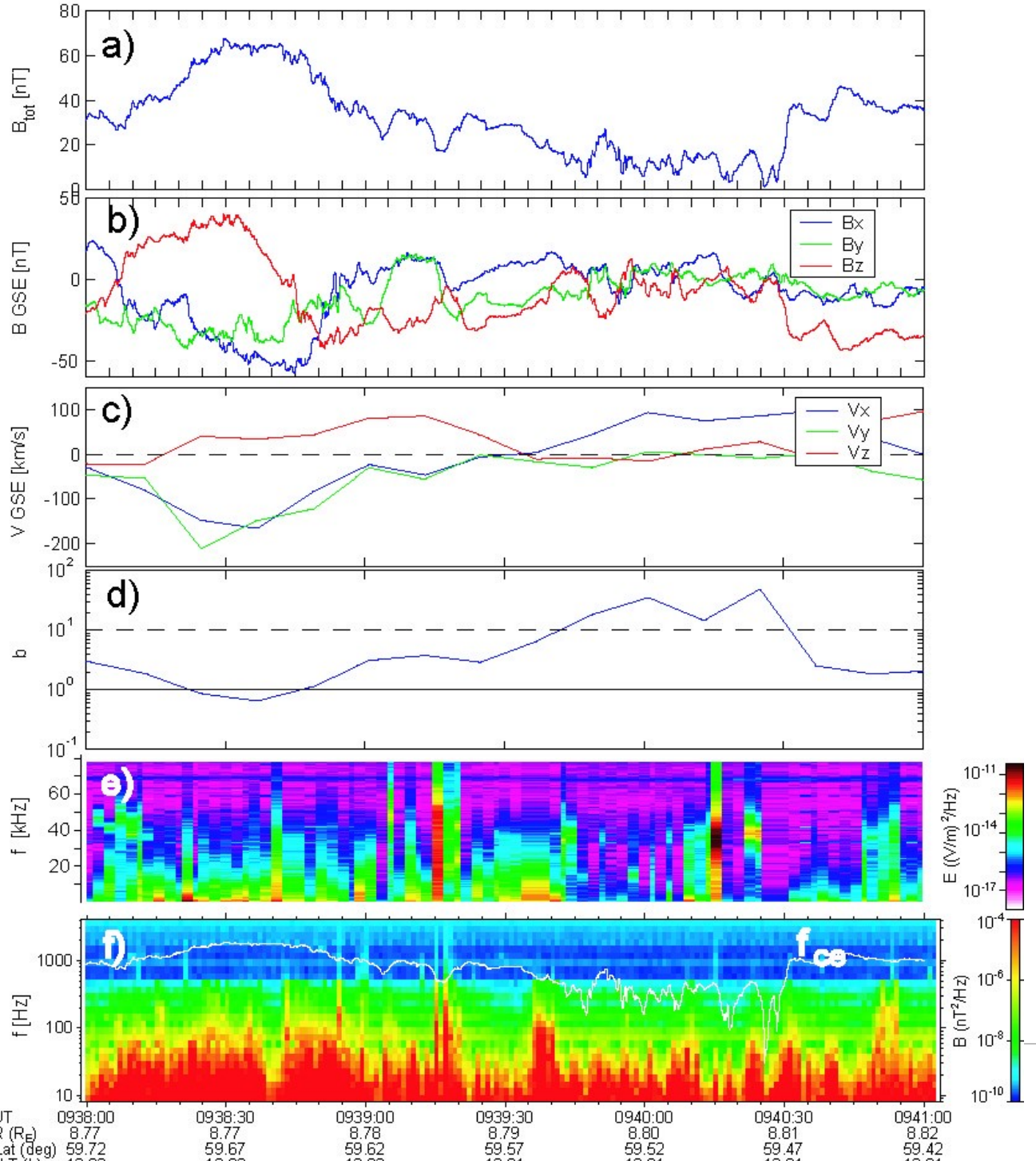
Interferometry



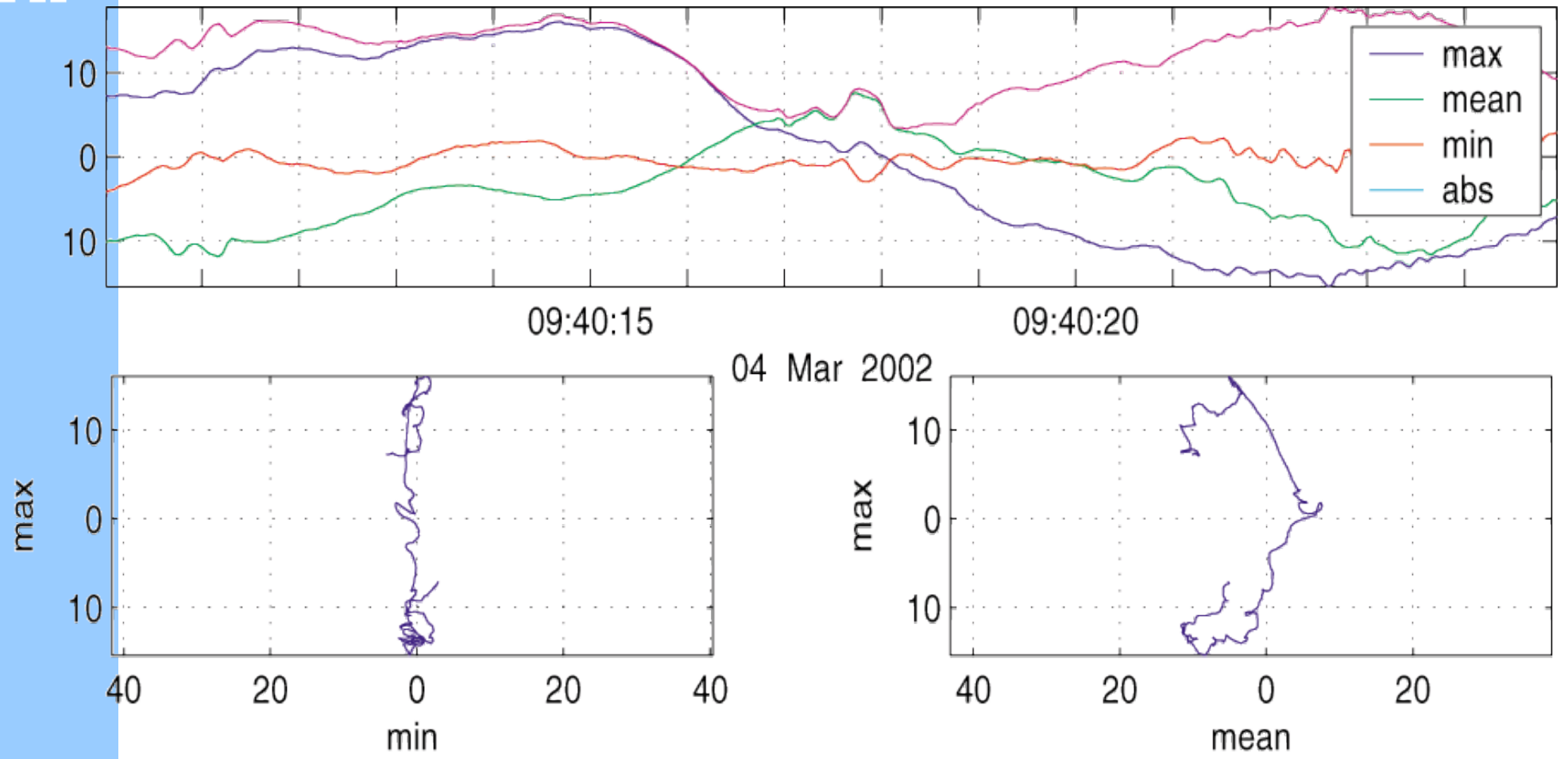
Thin layer


p1044a 29-Sep-2004 23:03:14. s/c2 p13->p42p23->p41f filter =[25 120] Hz.
a)
several λe
N Vps [cm-3]
b)
p13
p23
Ef [mV/m]
c)
N
M
k/ω [s/km]
d)
kρe~1 (λ~4 km)
λ-1 [1/km]
e)
dn [cm-3]
f)
<δE*δn>≠0
N
M
dn dE [cc mV/m]
13:11:45.0
.5
13:11:46.0
.5
30-Mar-2002

High-β cusp



Small scale current sheet



L1=121 L2=24.8 L3=1.56

L1/L2=4.9 L2/L3=16

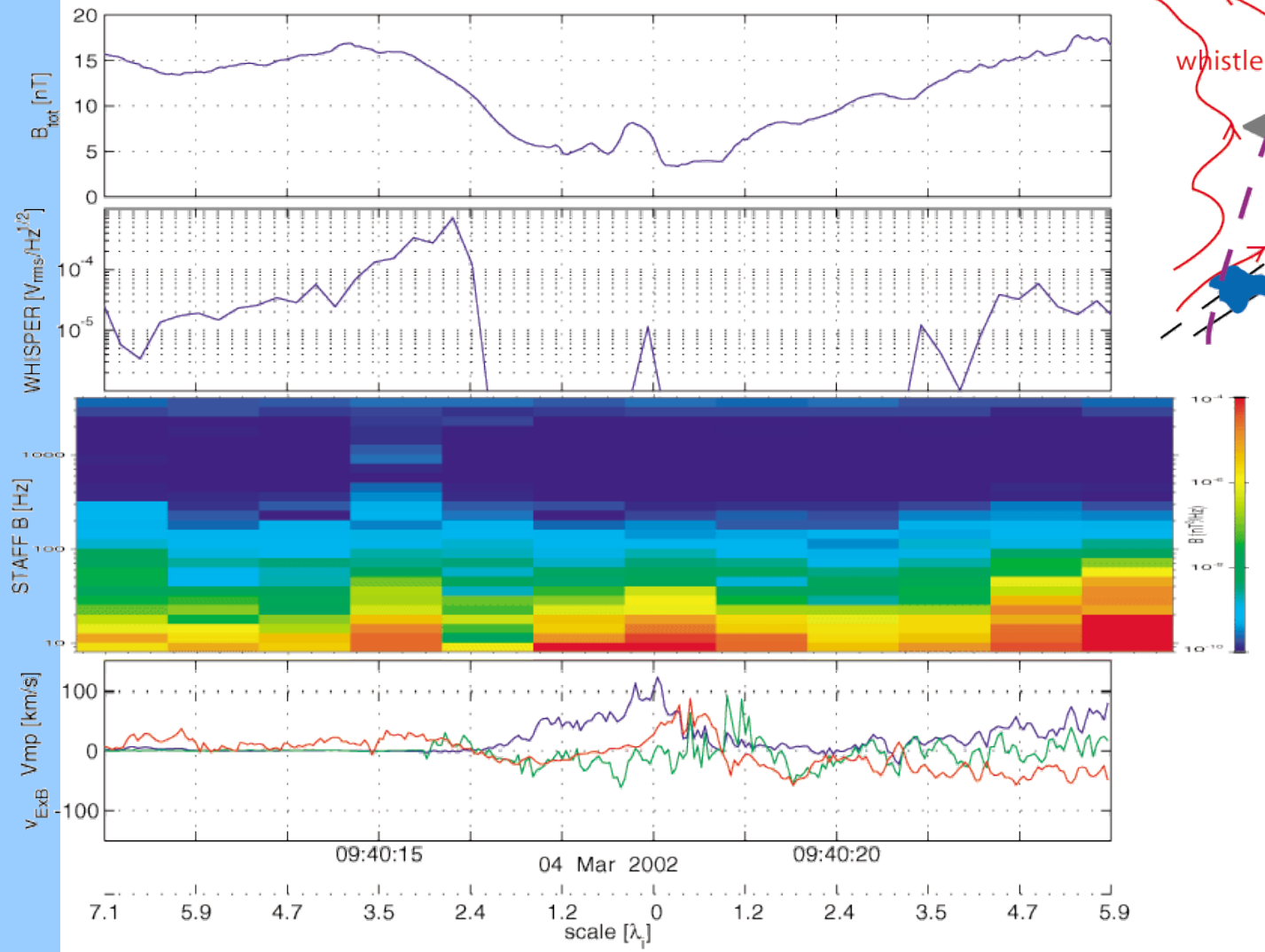
v1=[0.94 0.19 0.29]

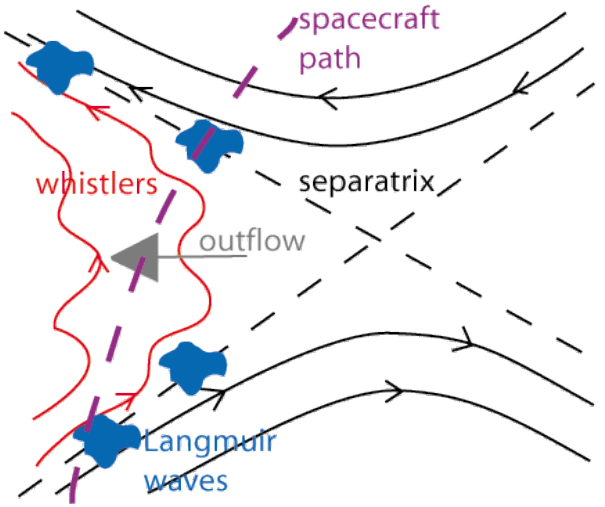
v2=[0.33 0.21 0.92]

v3=[0.12 0.96 0.26]

October 21, 2005

Details: Waves





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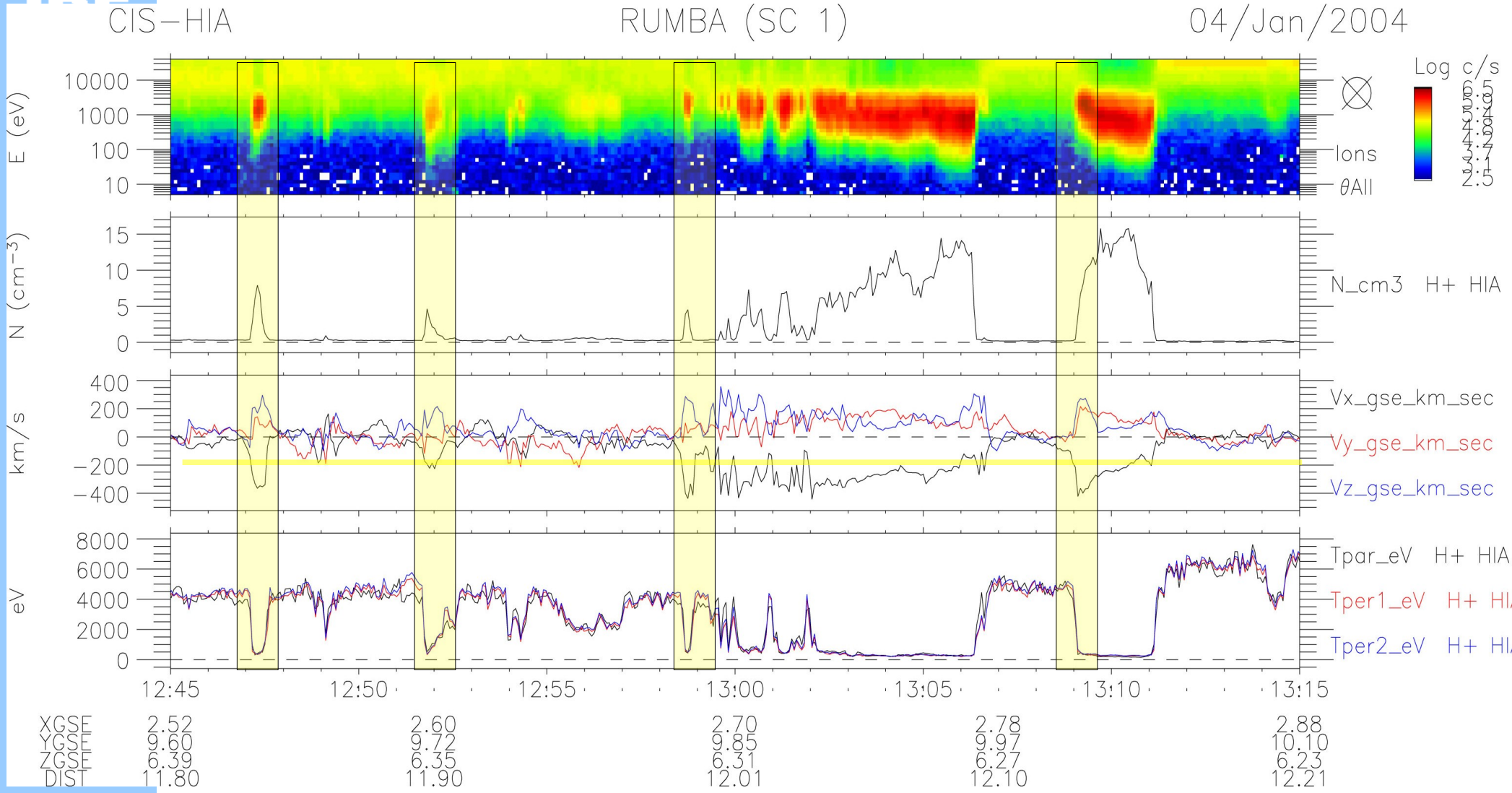
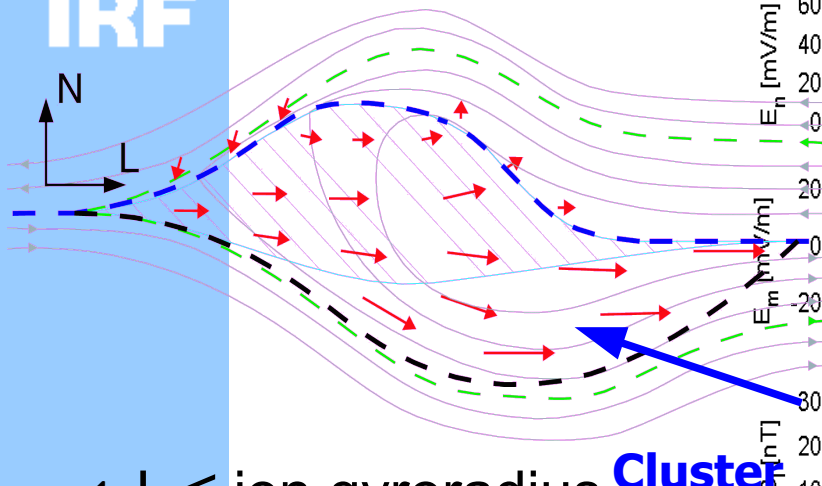
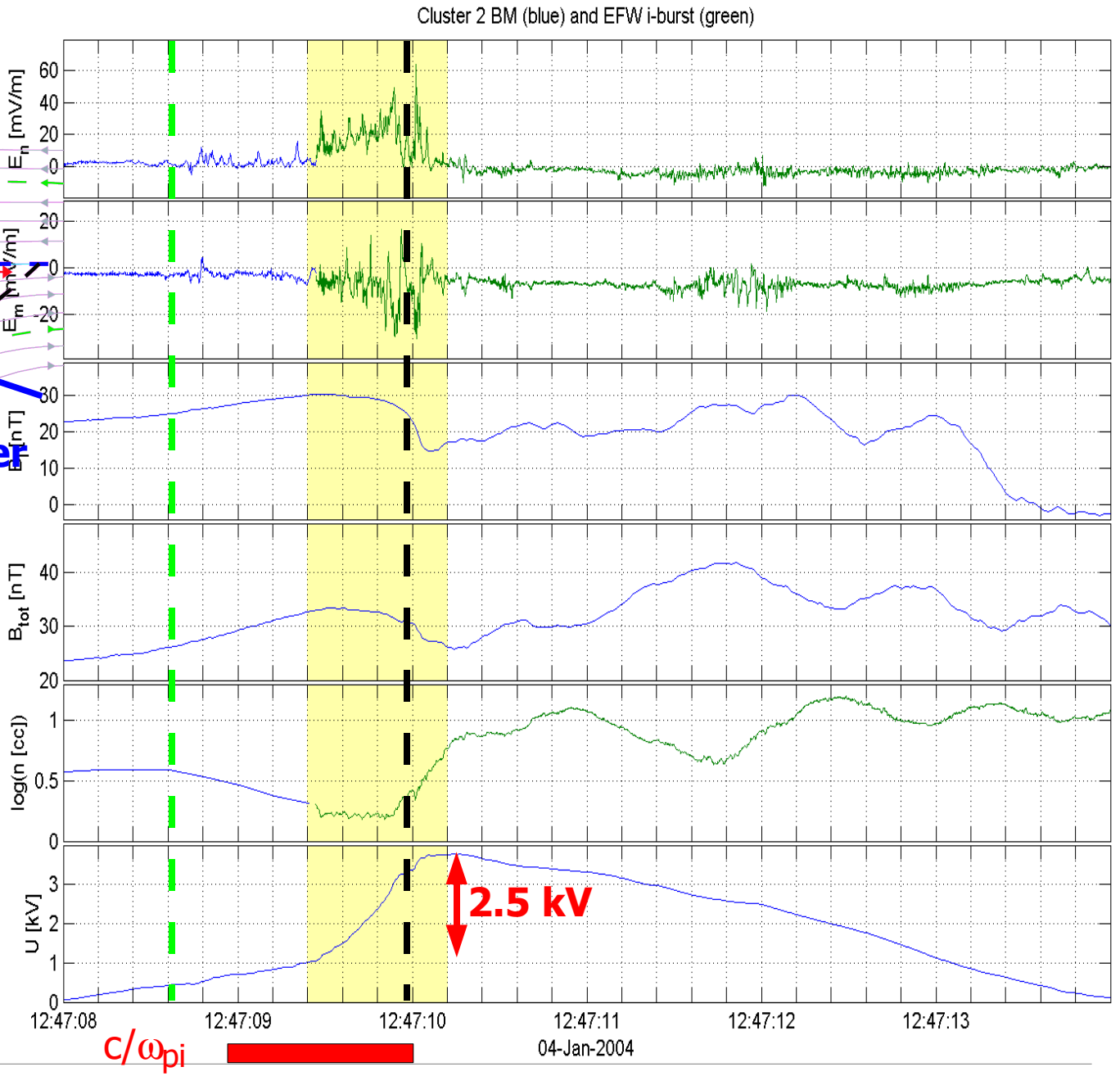
Flux Transfer events (FTEs)



FTE, E field structure



- ✔ L ≤ ion gyroradius
- ✔ Strong E. $E/B_0 \sim V_A$
- ✔ Strong $j_{||} \sim 0.3 \mu A/m^2$
- ✔ Density gradient
- ✔ Large potential jump
- ✔ dt < 1s



Chapman-Ferraro current