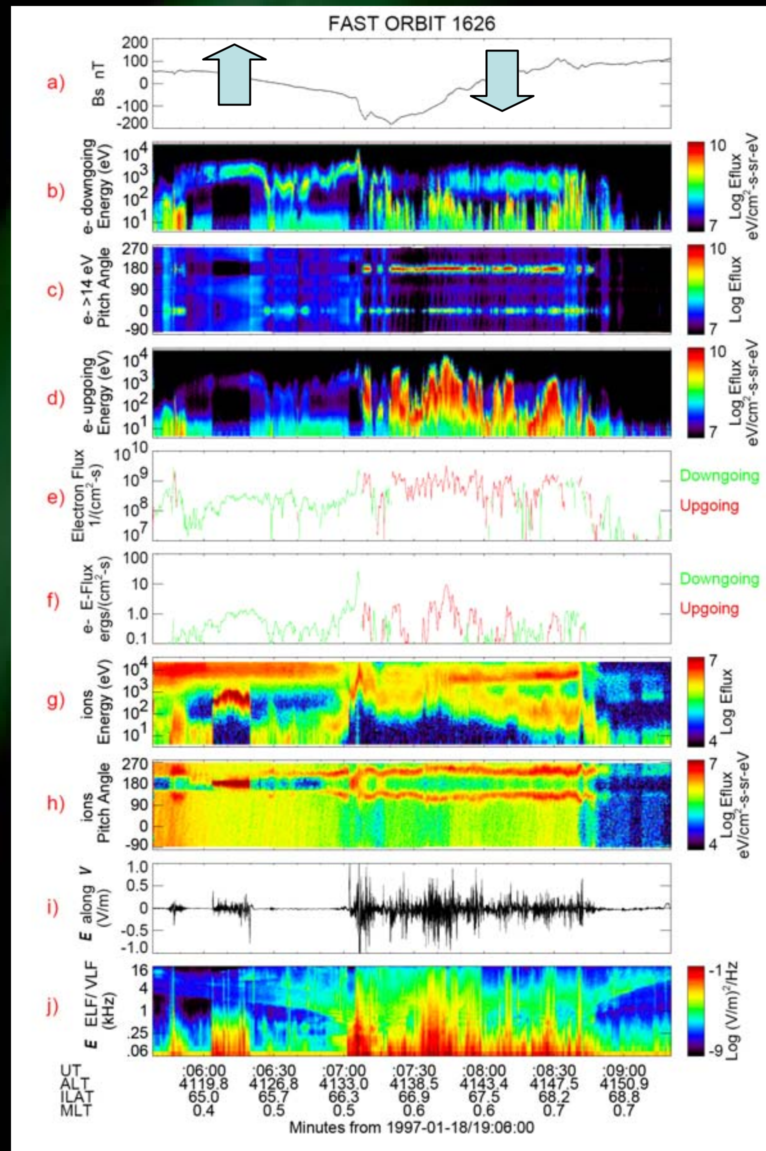
Downward current region

Upward current region

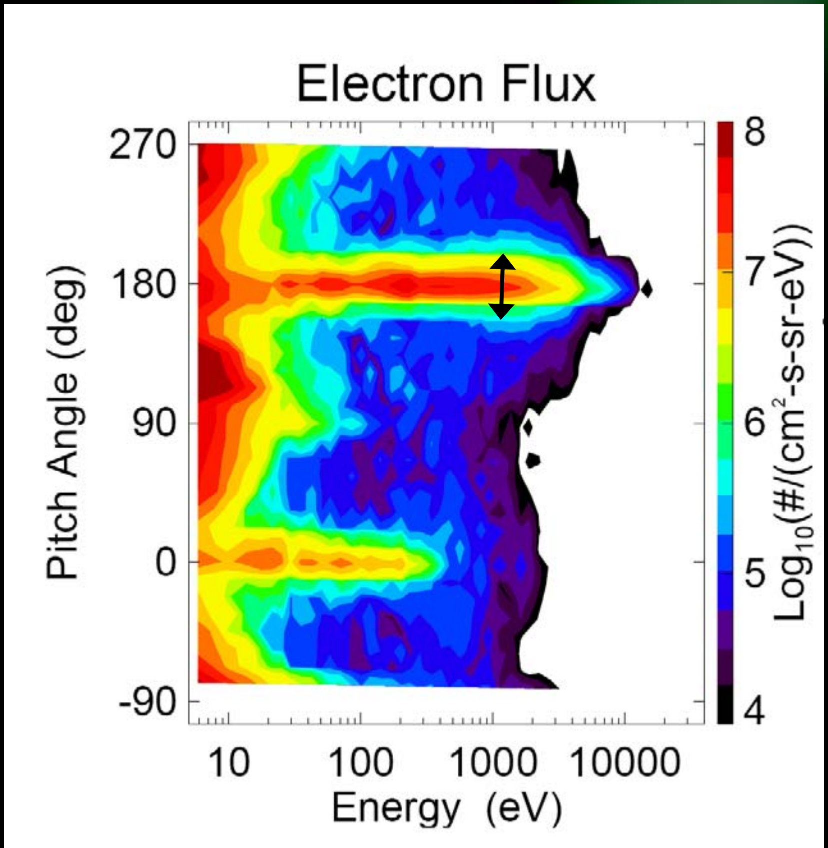
Downward electron beams: *Narrow in energy - broad in pitch-angle*

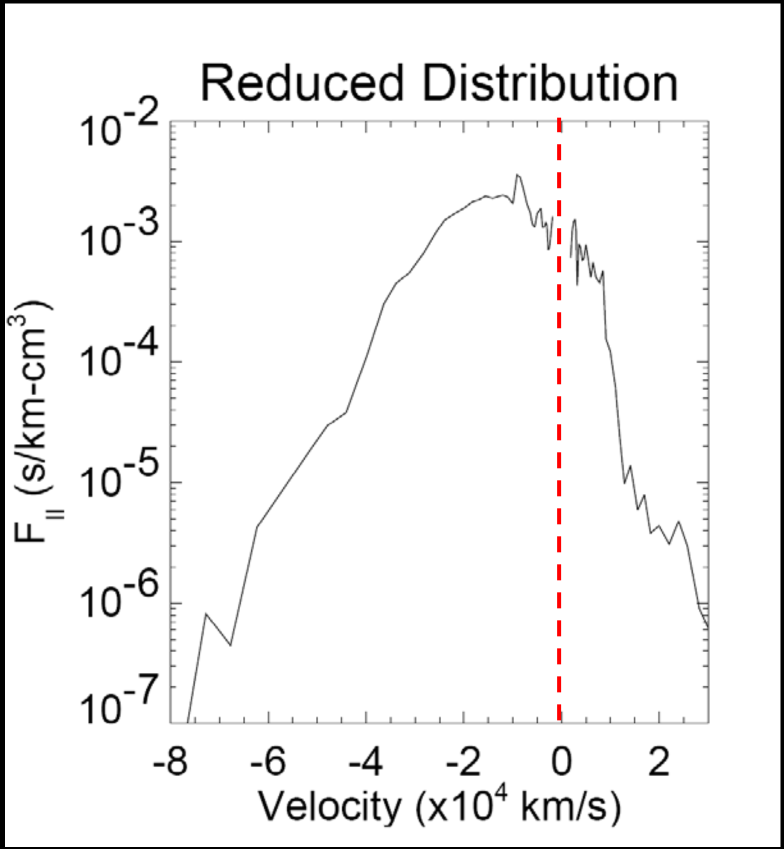


Downward current region

Upward electron beams: *Narrow in pitch angle - broad in energy*

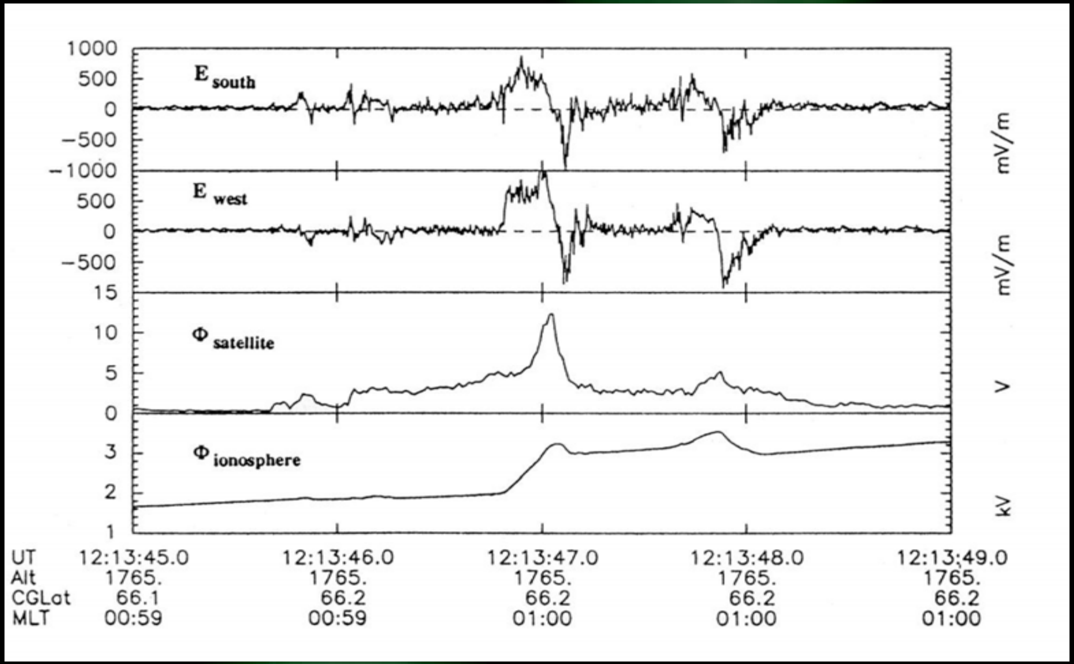
Upward electron beam

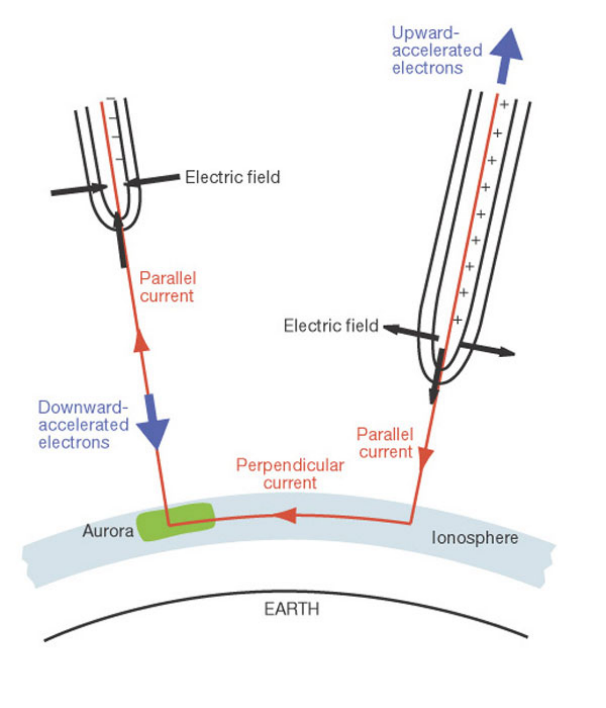




Seemingly also a downward beam?? But…

Potential structure in the downward current region

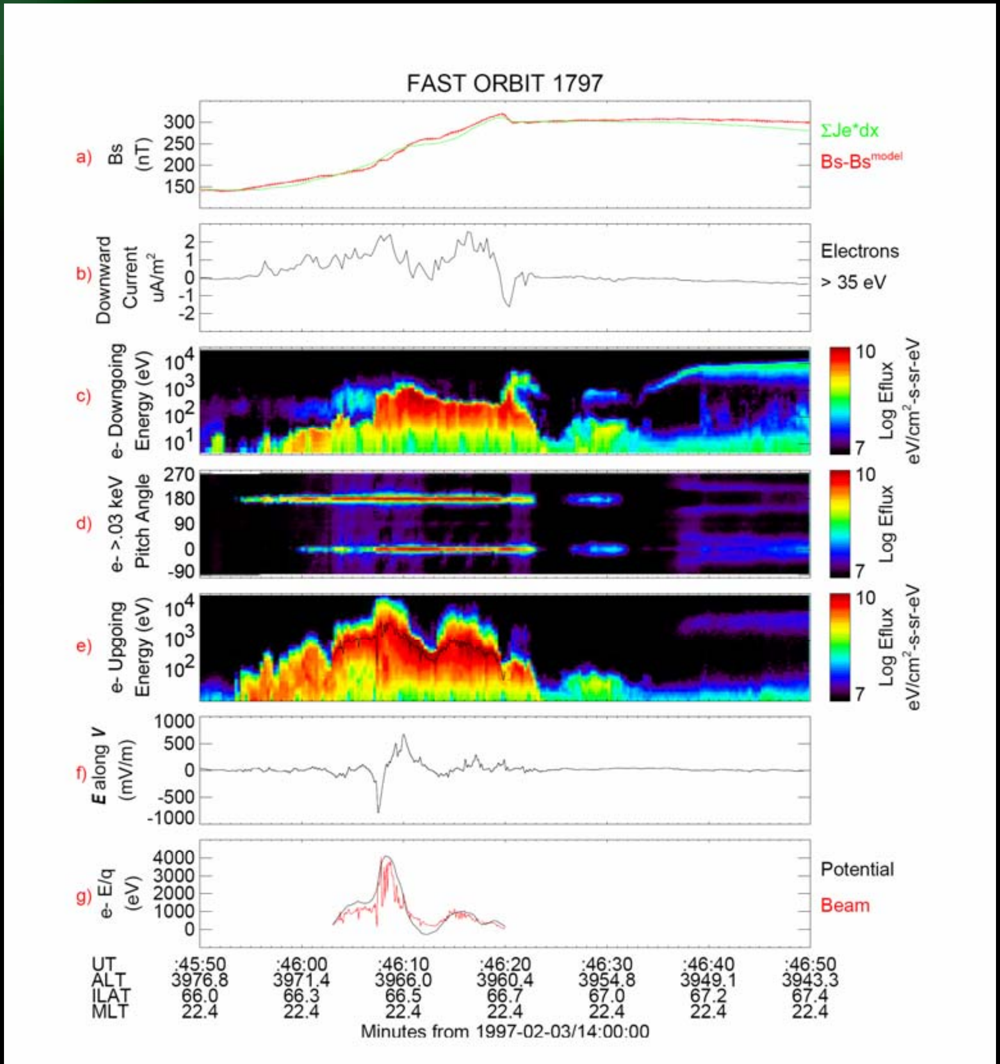




Freja electric field measurements, (Marklund et al., 1994)

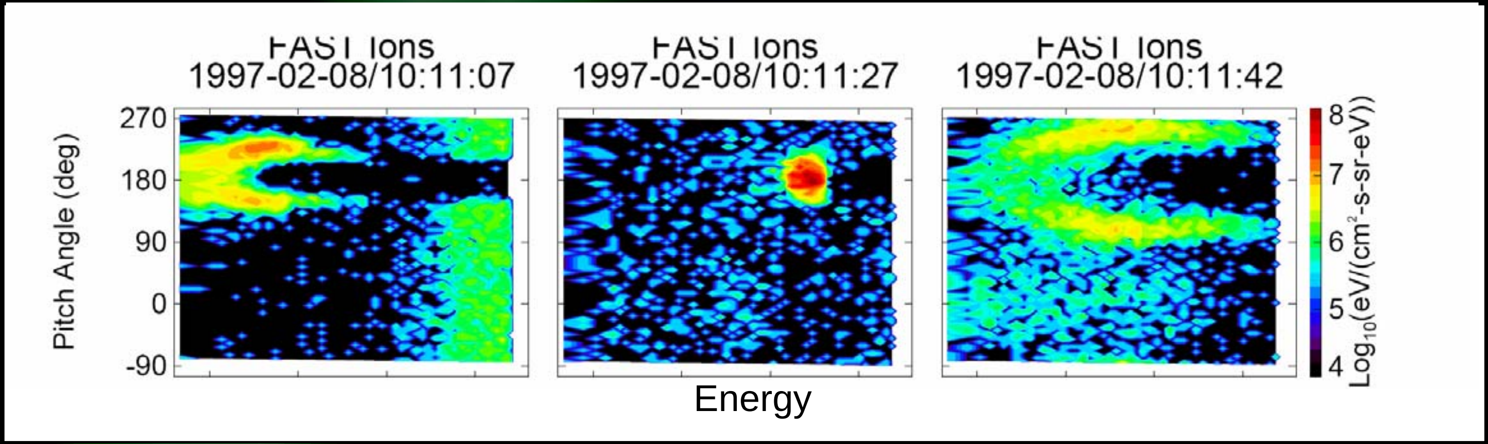
Upward electron beams

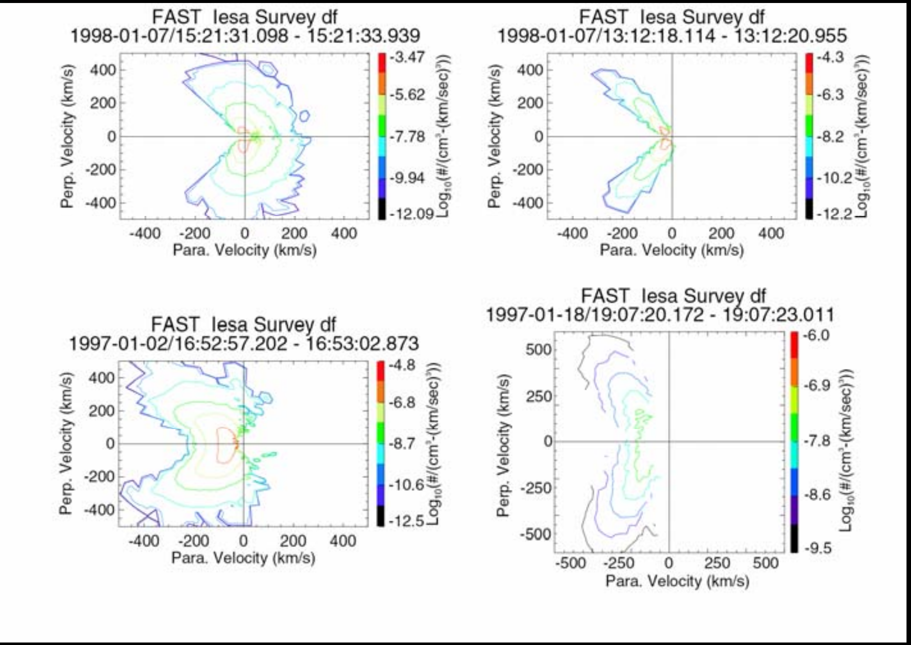
- Good agreement with integrated E-field
- Widening in energy is due to extensive wave-particle interaction.



Ion conics and beams

'Distribution functions'



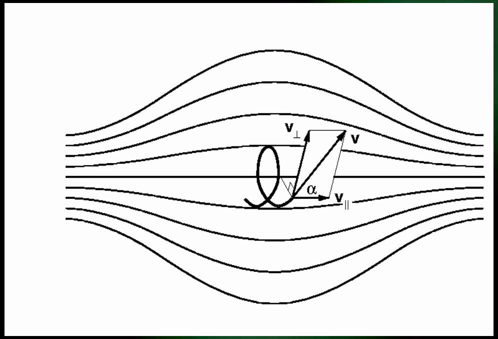


Ion conics – adiabatic motion

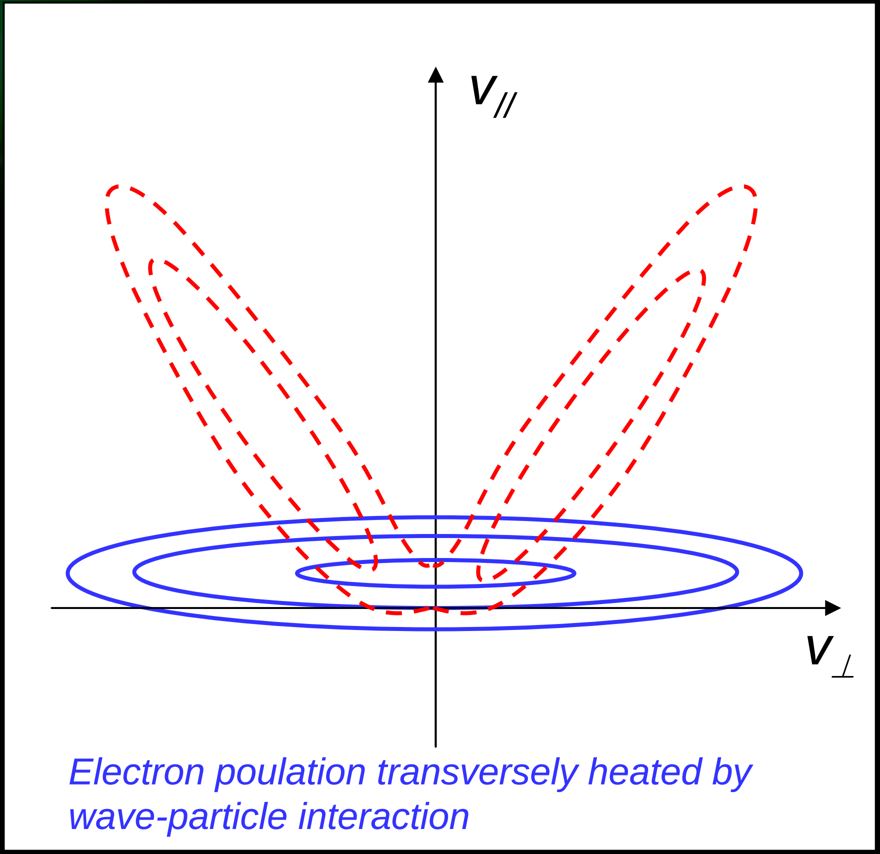
In a sense the opposite process to magnetic mirroring

$$\mu = \frac{mv_\perp^2}{2B} = \frac{mv^2 \sin^2 \alpha}{2B}$$

Magnetic moment conserved



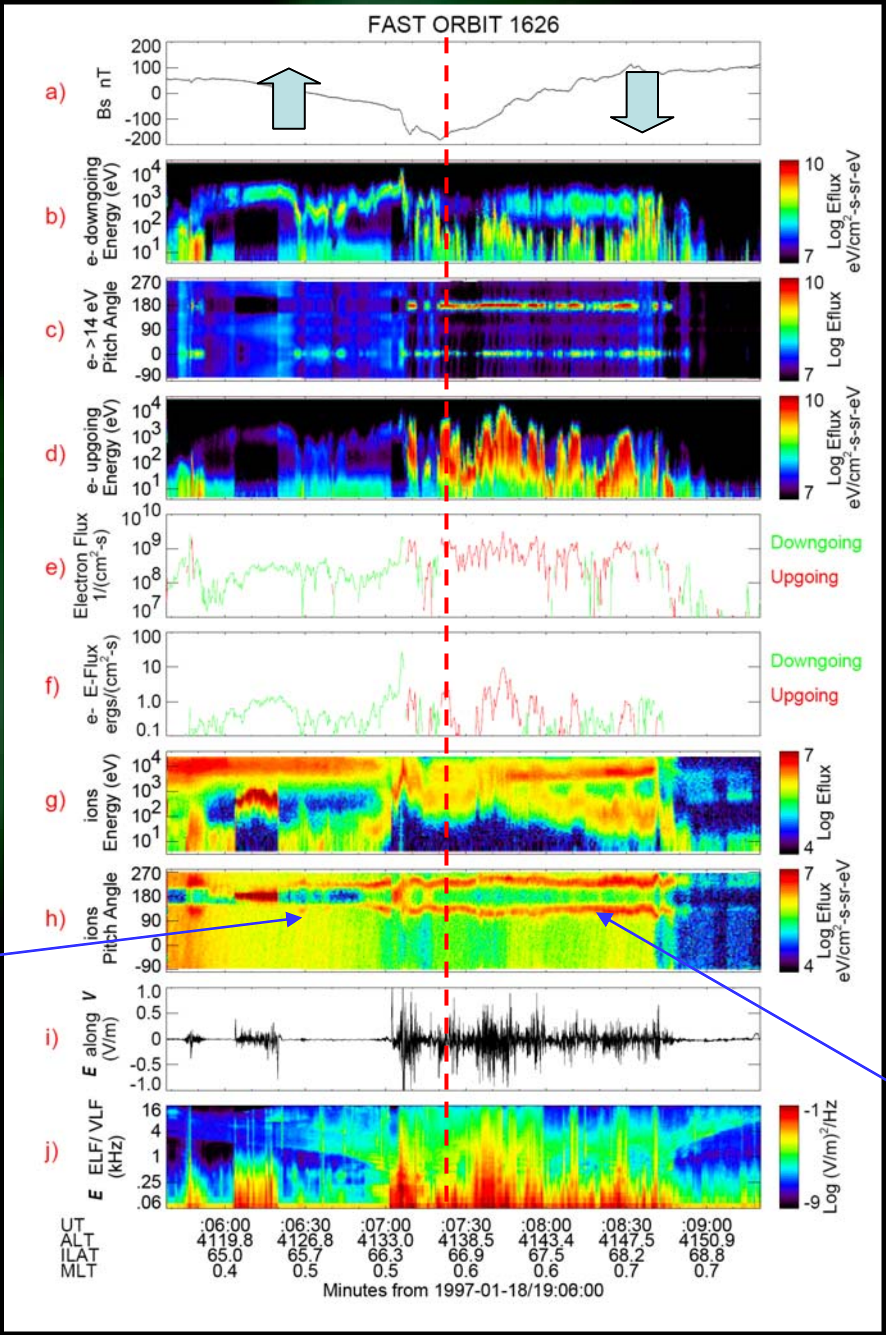
Weaker B means α decreases



An ion distribution originally heated in the direction perpendicular to B will fold up to a conic

$$\alpha = \sin^{-1}\sqrt{\frac{B}{B_0}}$$

Ion conics



FAST ORBIT 1626
a)
Bs nT
b)
e- downgoing Energy (eV)
Log Eflux eV/cm²-s-sr-eV
c)
e- >14 eV Pitch Angle
Log Eflux
d)
e- upgoing Energy (eV)
Log Eflux eV/cm²-s-sr-eV
e)
Electron Flux 1/(cm²-s)
Downgoing
Upgoing
f)
e- E-Flux ergs/(cm²-s)
Downgoing
Upgoing
g)
ions Energy (eV)
Log Eflux
h)
ions Pitch Angle
Log Eflux eV/cm²-s-sr-eV
i)
E along V (V/m)
j)
E ELF/VLF (kHz)
Log (V/m)²/Hz
UT
ALT
ILAT
MLT
:06:00 4119.8 65.0 0.4
:06:30 4126.8 65.7 0.5
:07:00 4133.0 66.3 0.5
:07:30 4138.5 66.9 0.6
:08:00 4143.4 67.5 0.6
:08:30 4147.5 68.2 0.7
:09:00 4150.9 68.8 0.7
Minutes from 1997-01-18/19:06:00

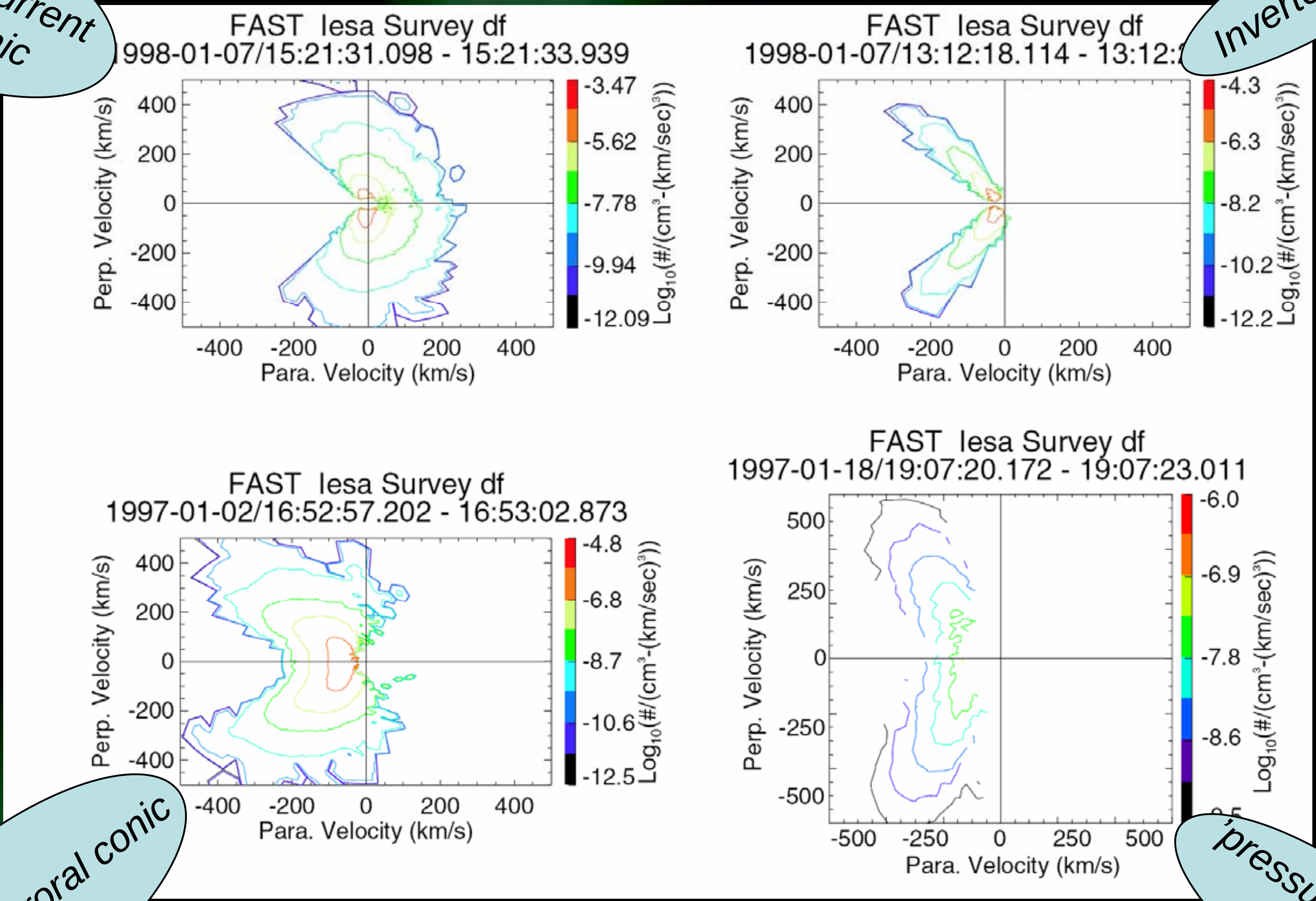
Ion conics – adiabatic motion

Downward current region conic

BBELF?

Inverted V conic

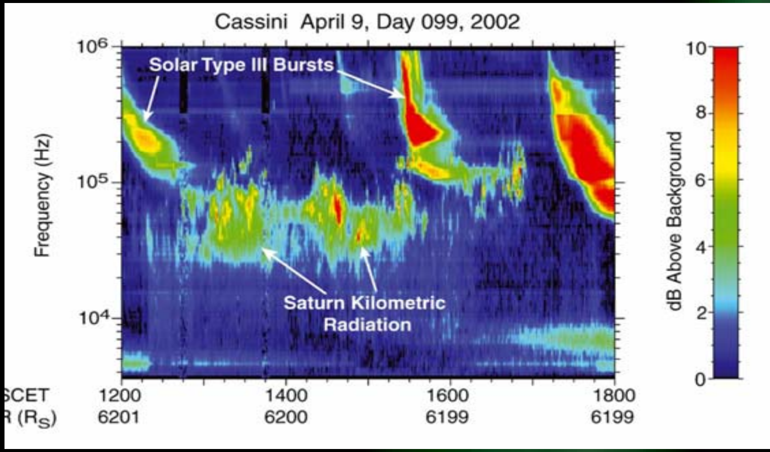
EMIC?



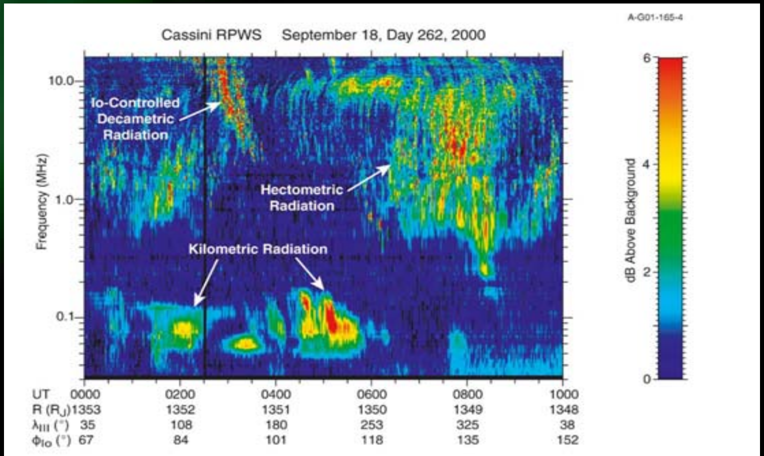
Alfvénic auroral conic

'pressure cooker' conic

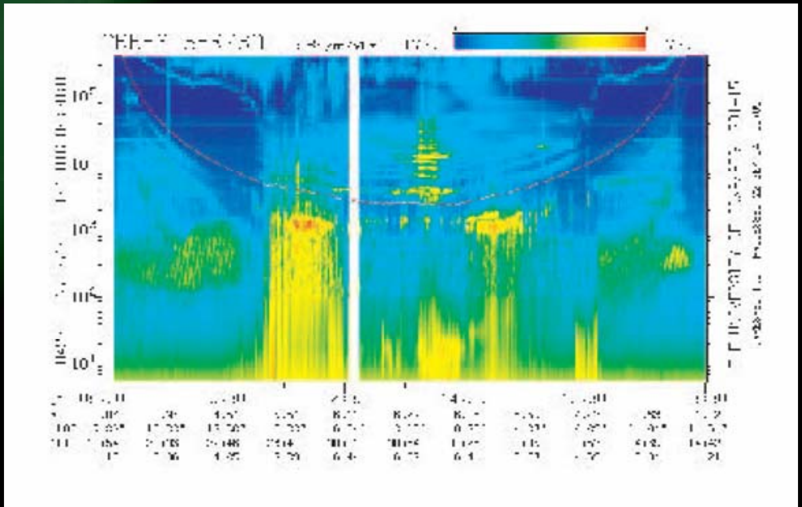
Waves in upward current region



Saturn kilometric radiation



Jupiter hectometric radiation

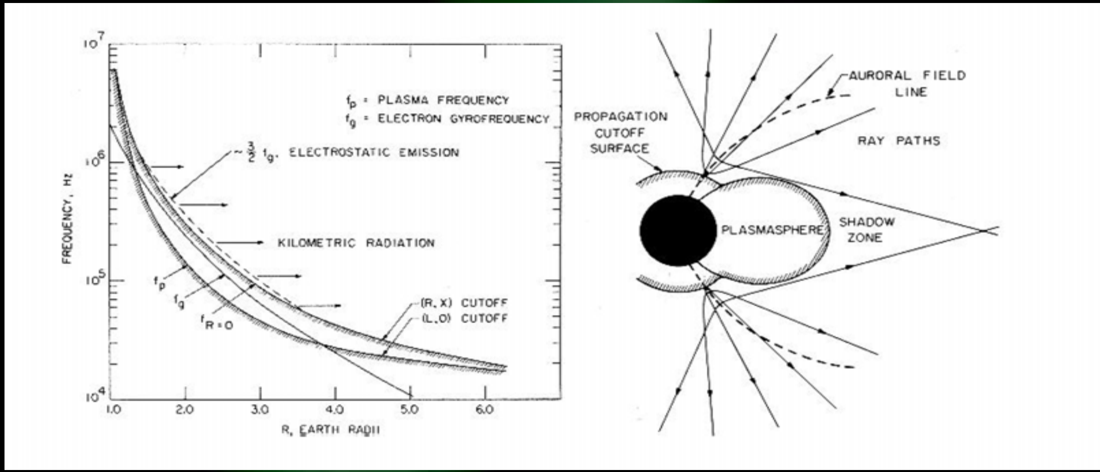


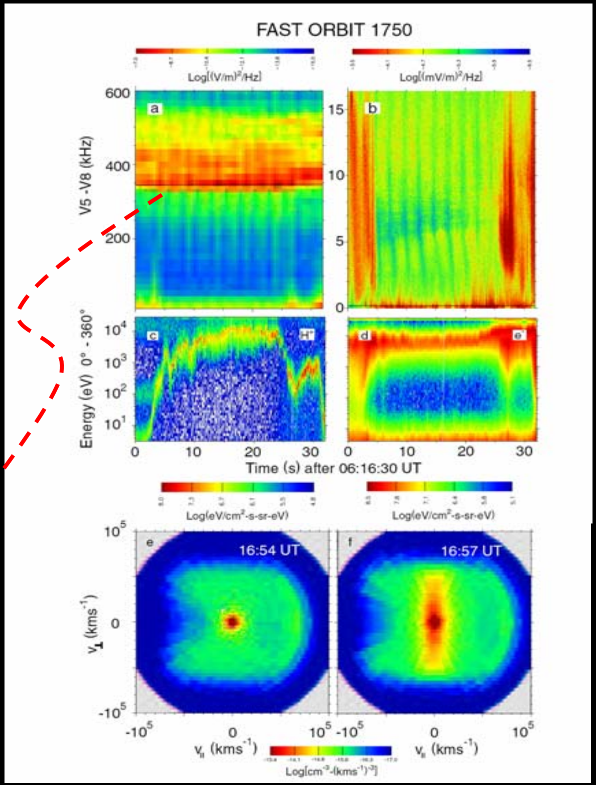
Auroral kilometric radiation

Auroral kilometric radiation

Dominating radiative feature of auroral zone

Generated by cyclotron-maser instability in auroral acceleration region



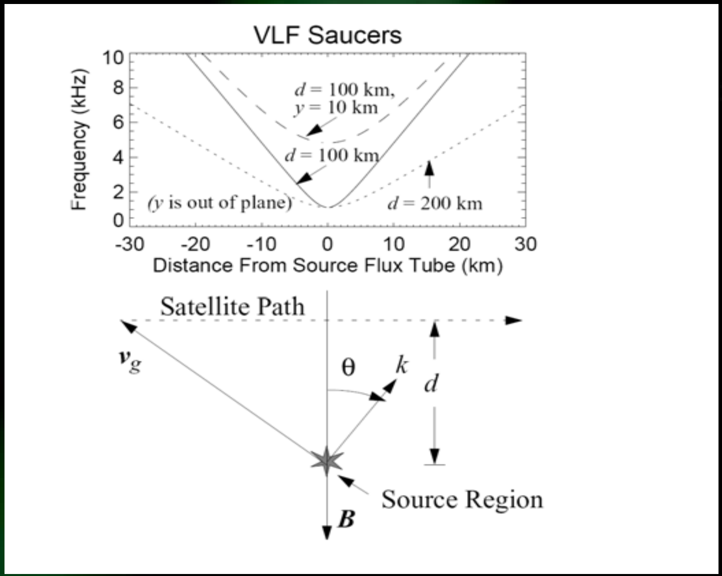


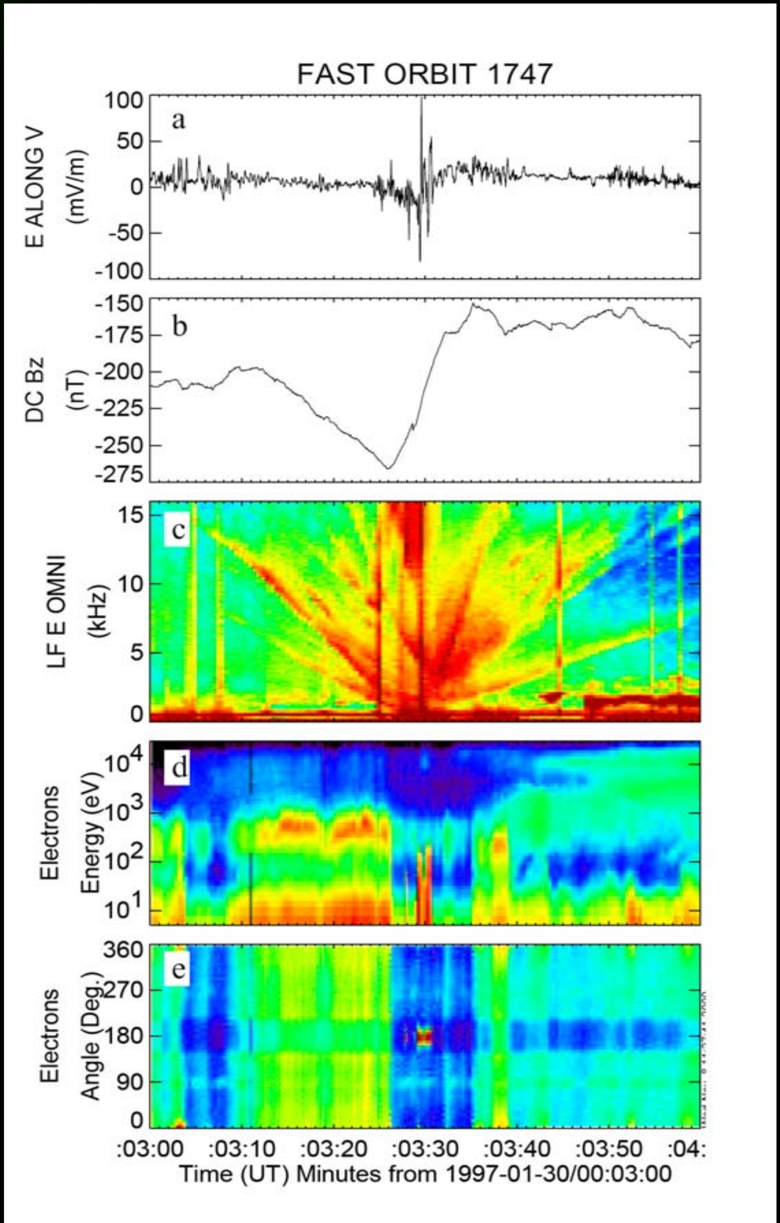
Lower cutoff at ω_{ce} of the *source region*.

Waves in downward current region

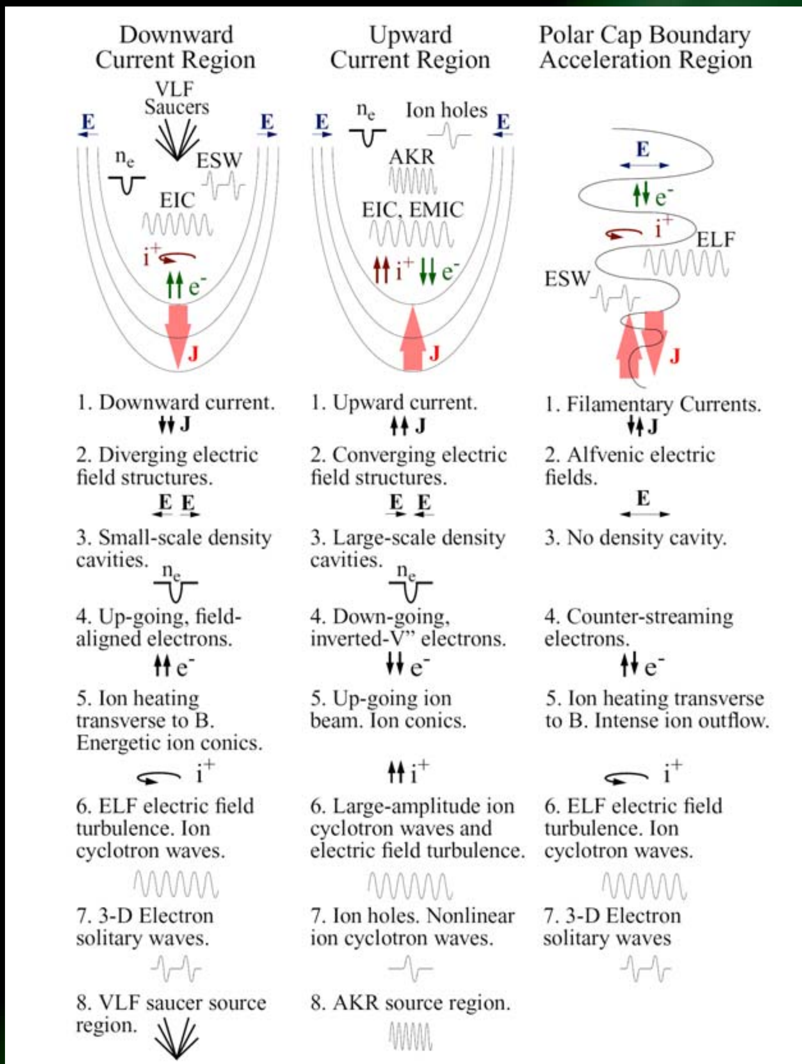
VLF saucers

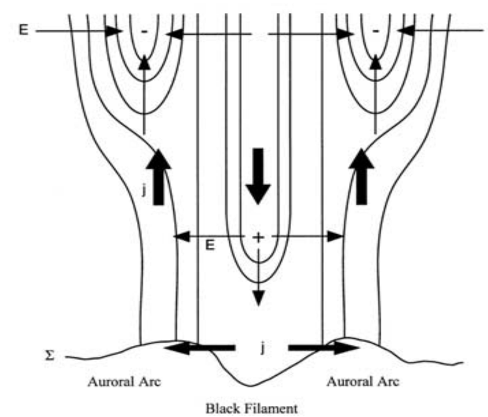
- Often most prominent wave feature of downward current region.
- ***k*** larger angle for higher frequencies
- Probably generated by upward ion beams





The symmetry between the upward and downward current regions

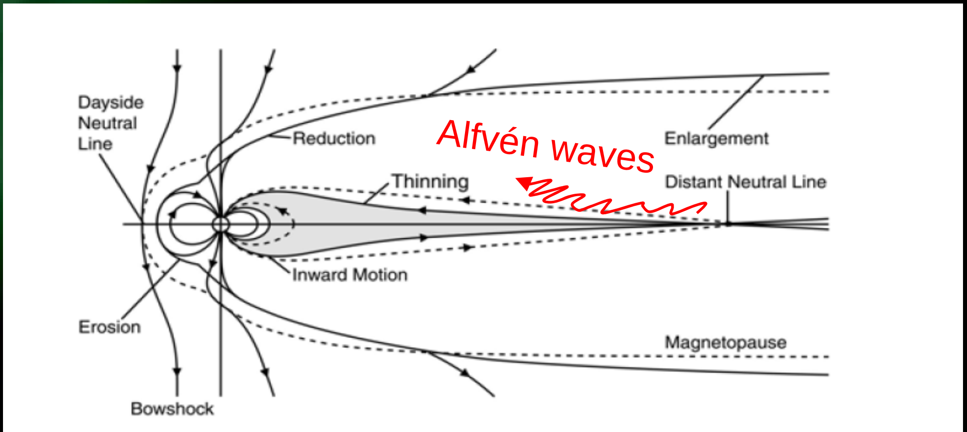




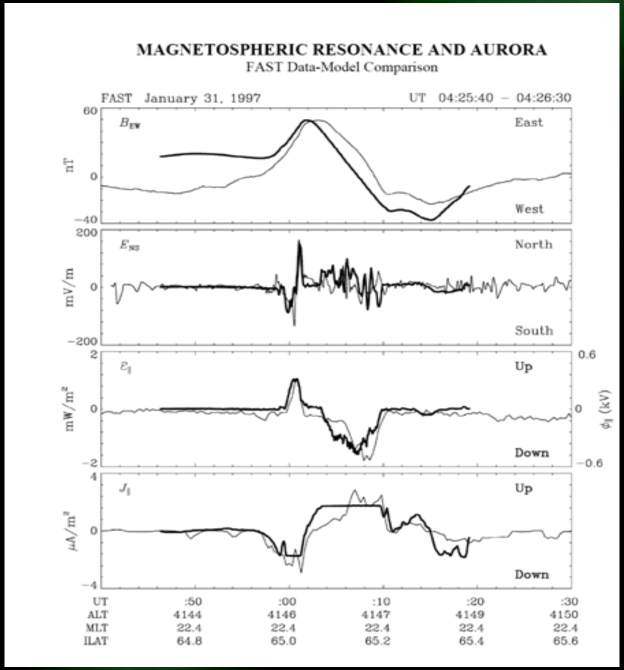
Dynamic MI-coupling

Alfvén wave driven aurora

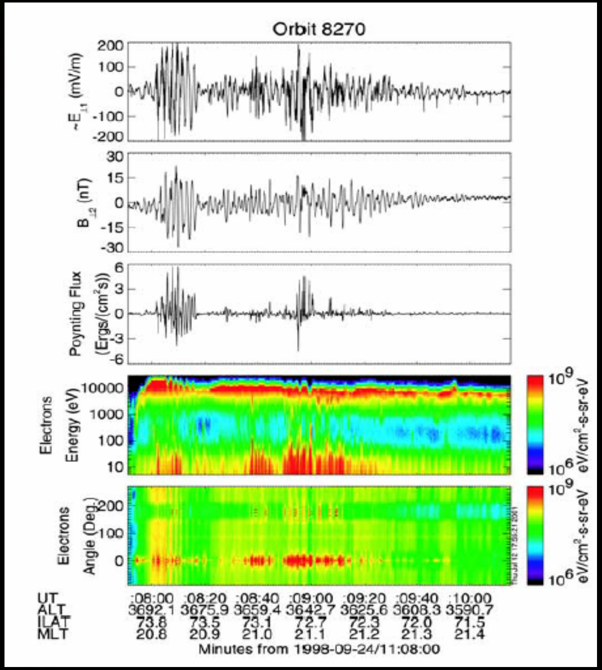
X-line aurora

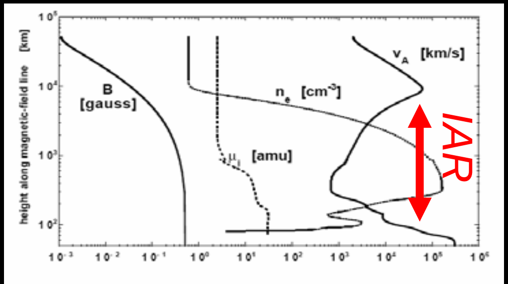


Field-line resonances



Ionospheric auroral resonator

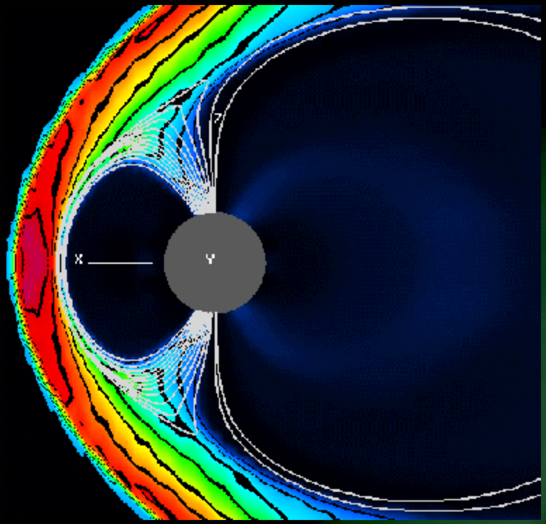




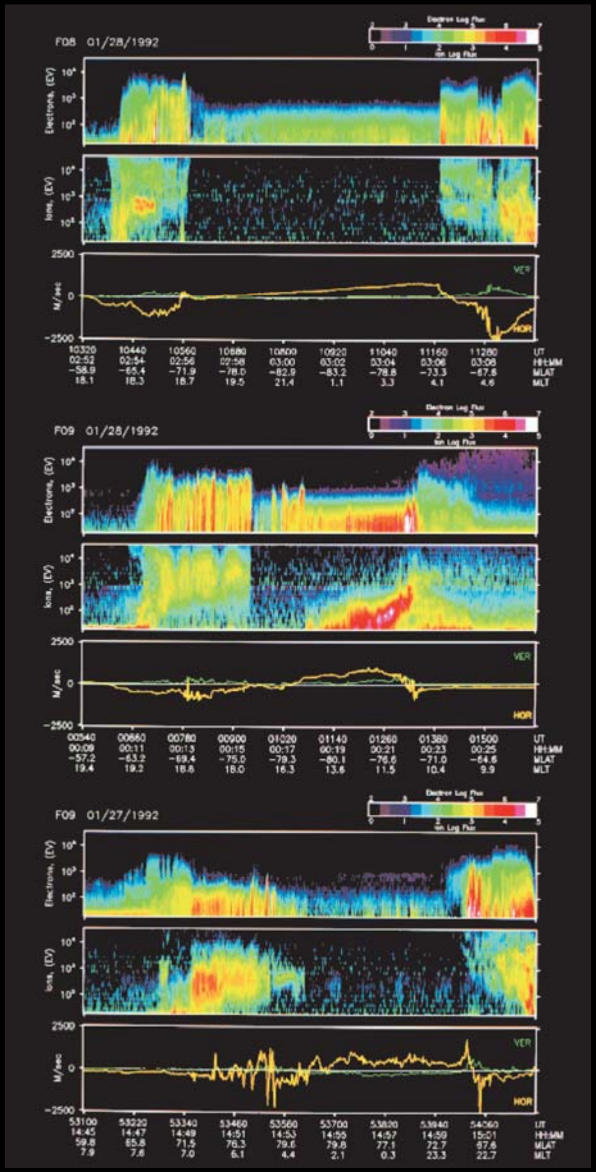
Lotko et al., 1998

Chaston et al., 1999

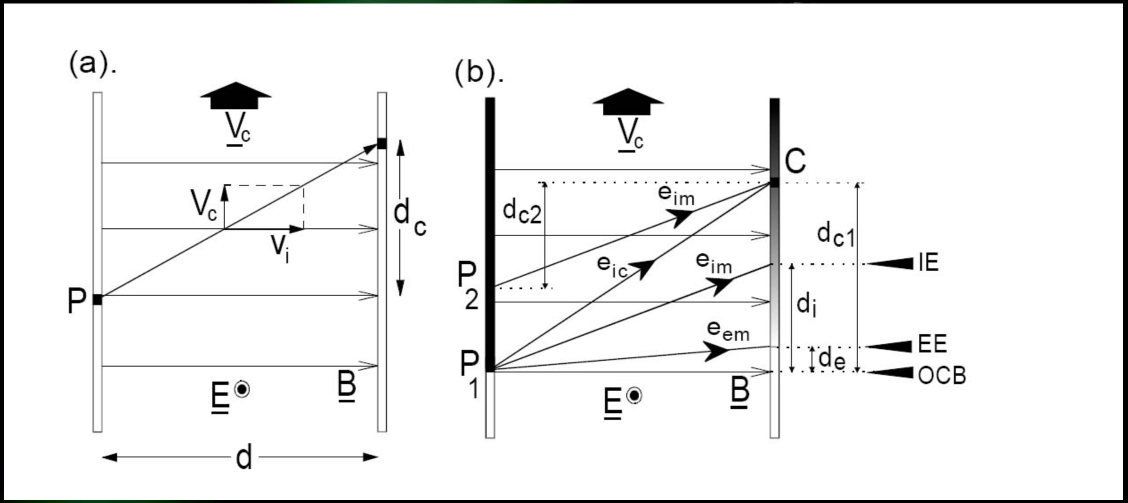
Cusp and dayside aurora



Direct entry of magnetosheath plasma
Fedder et al. (1997)



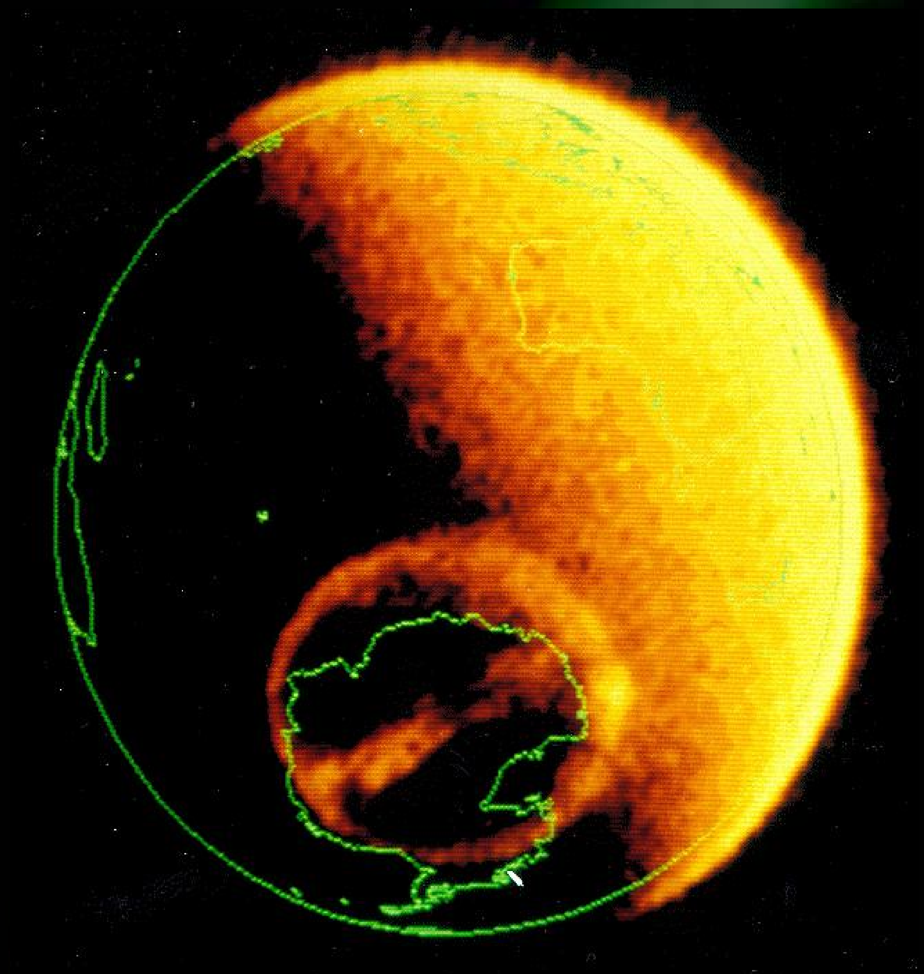
Velocity filter effect

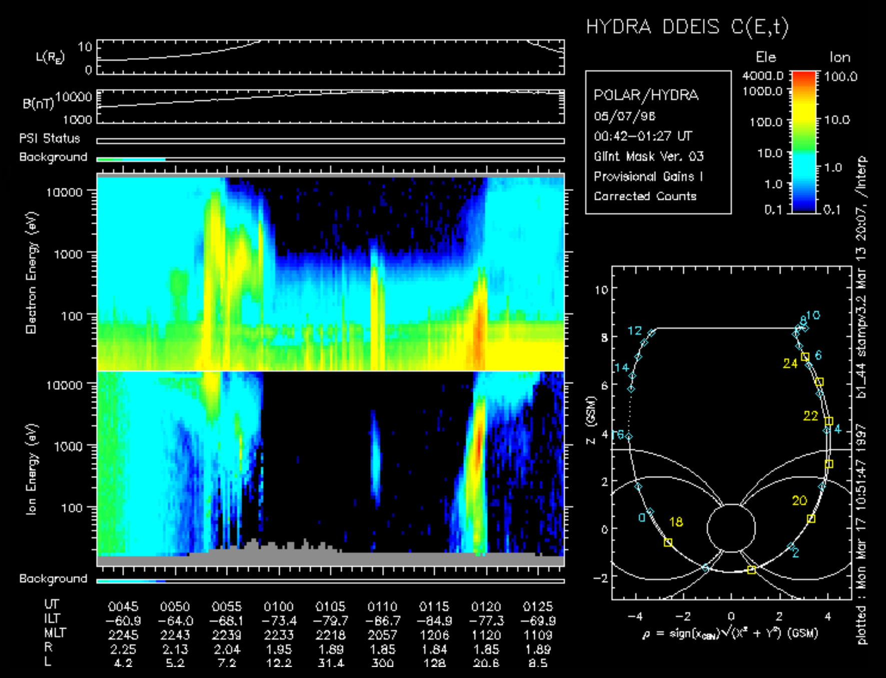


DMSP 9 data (Lyons et al., 1999)

Theta aurora

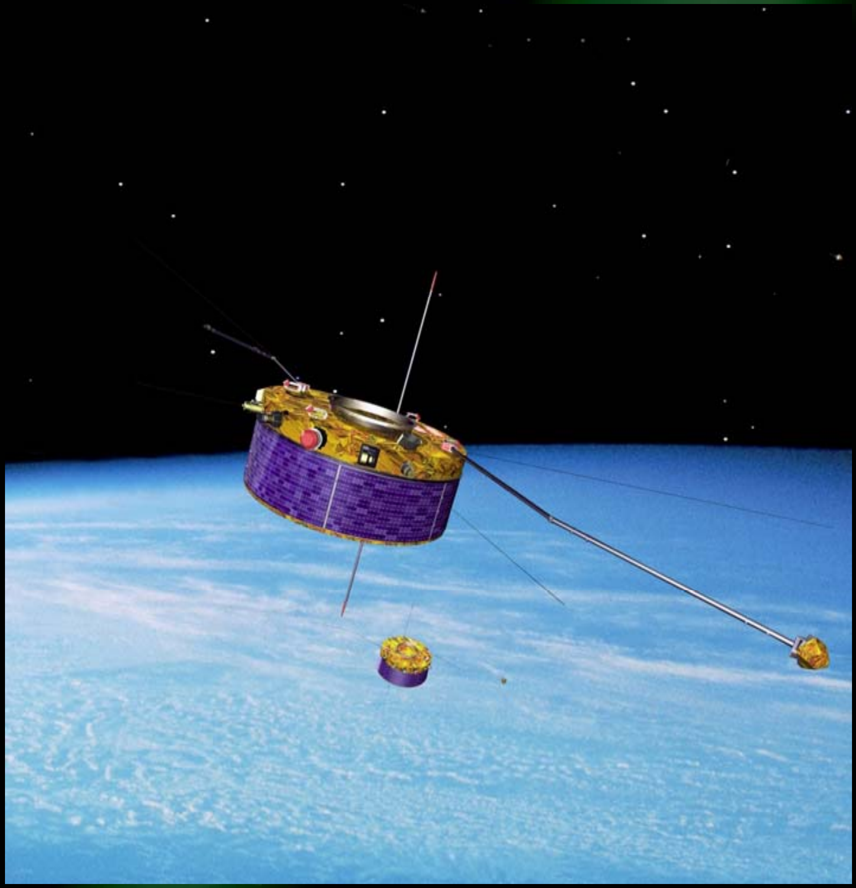
What are they???





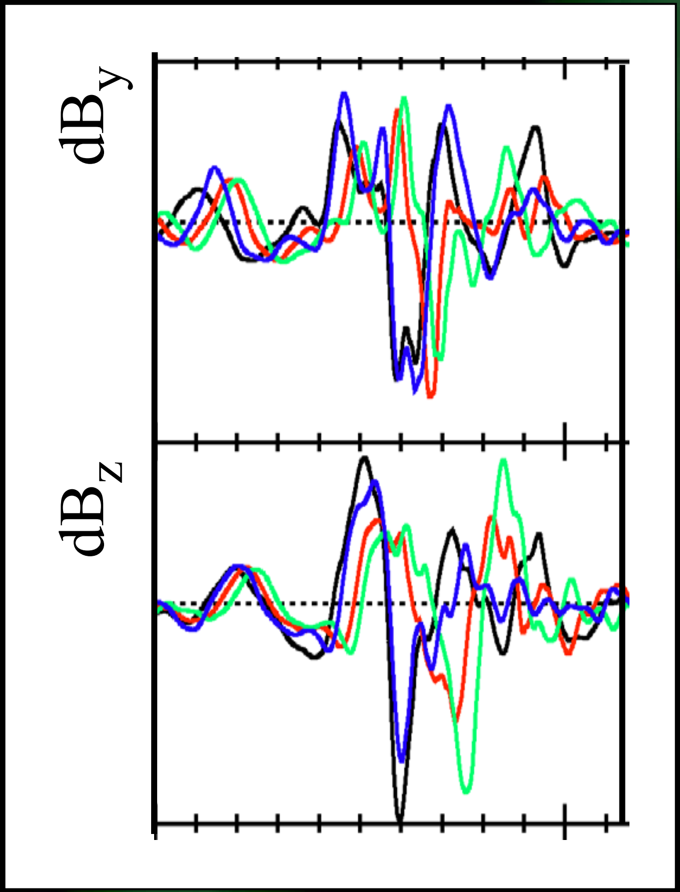
Cluster multi-point measurements

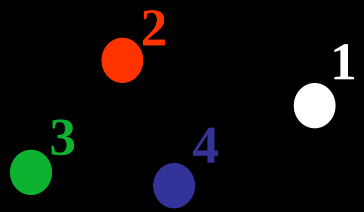
Seeing the temporal evolution



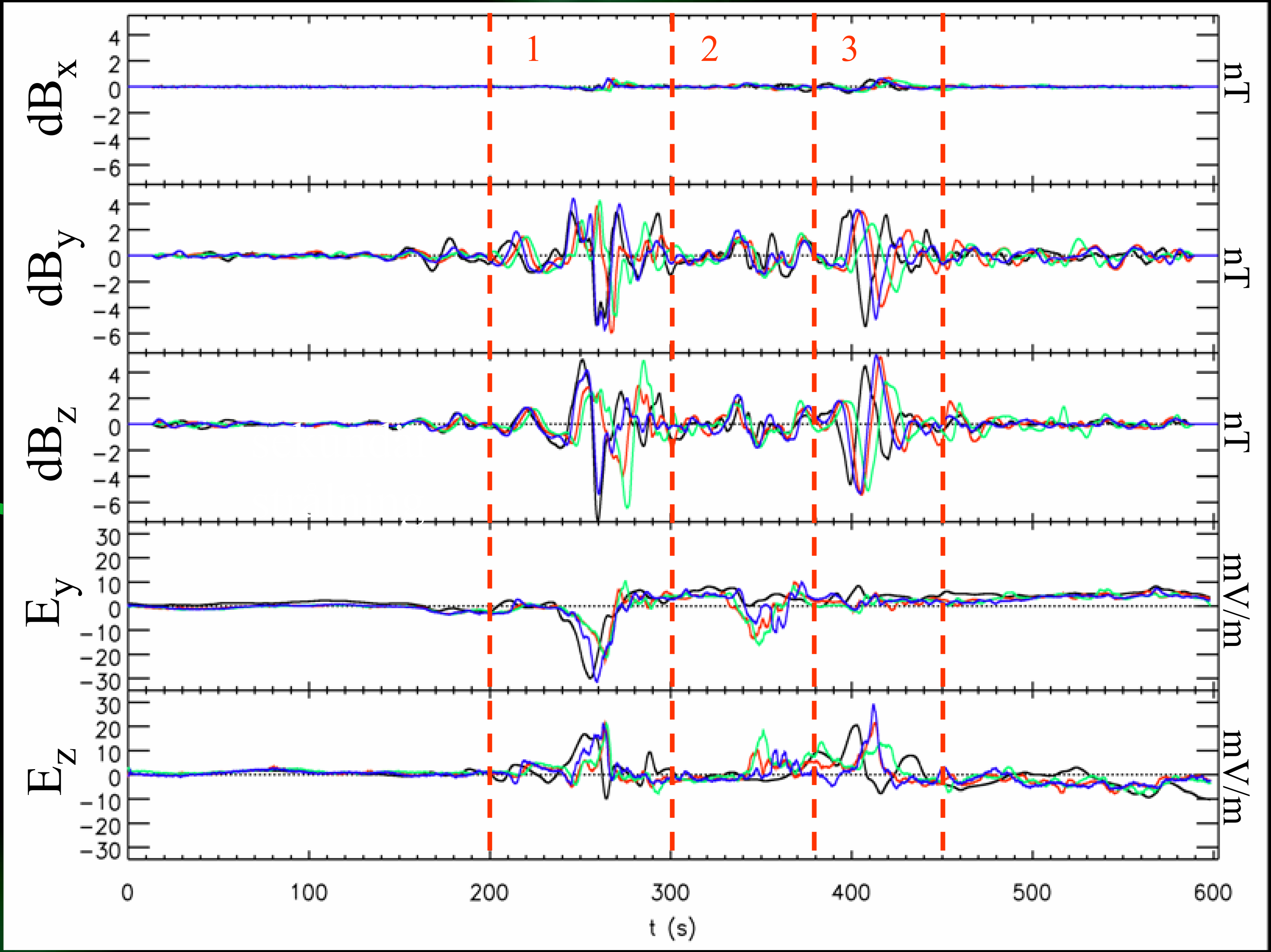
- Launched 2000
- Apogee: 20 R_E
- Perigee: 4 R_E
- Separations:
  200-10000 km

Interpreting Cluster multipoint measurements

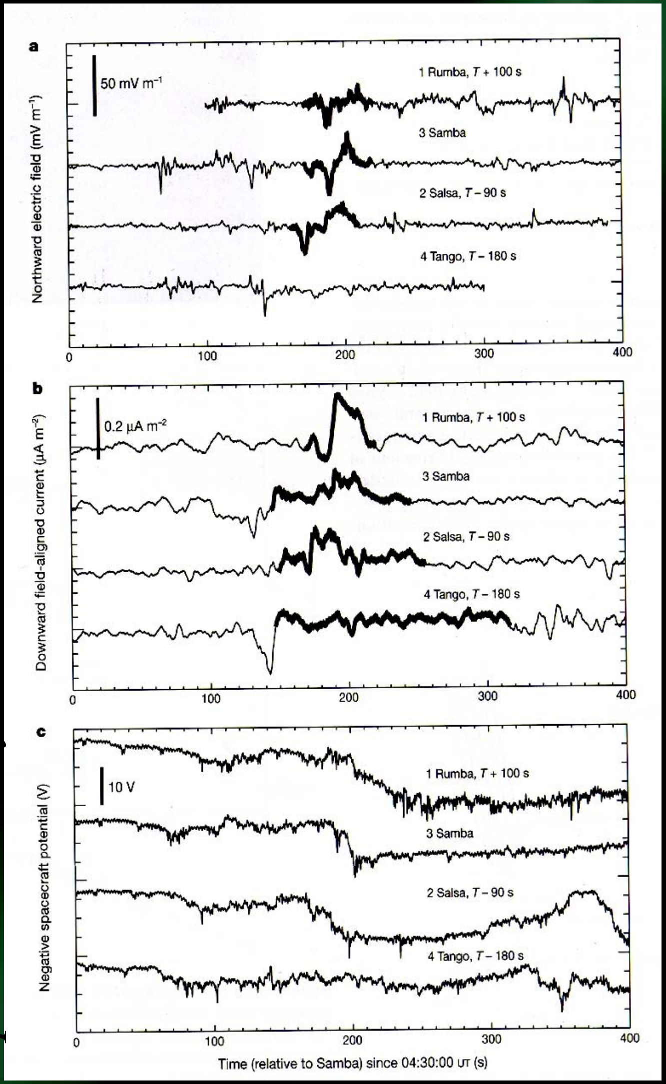


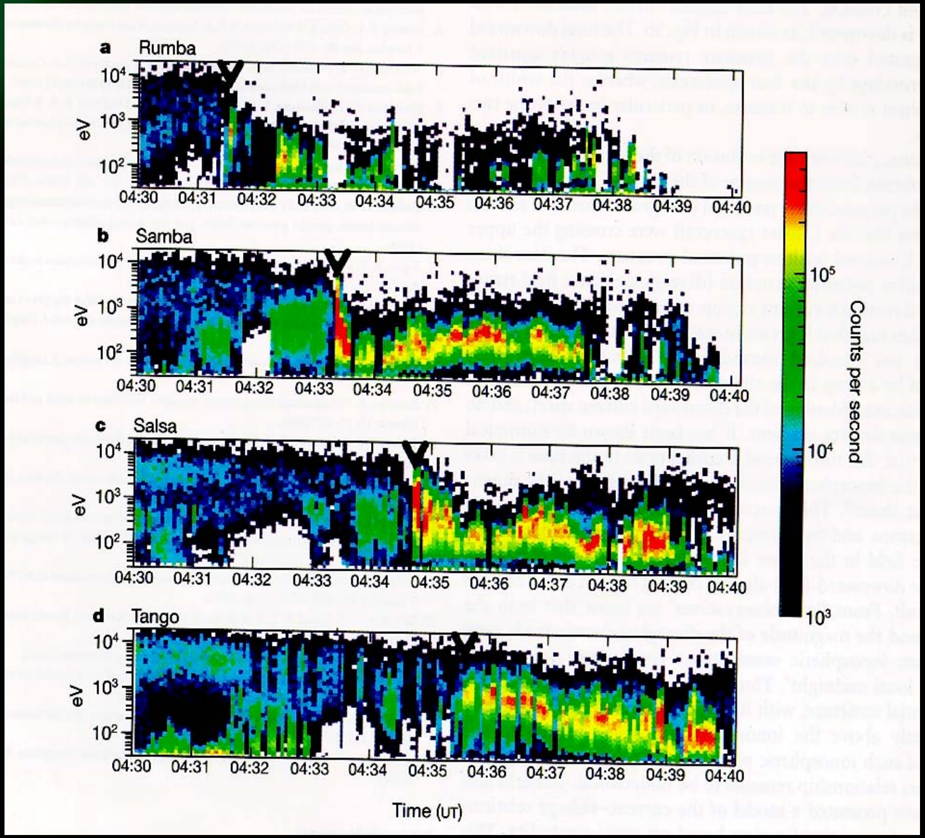


Cluster field data



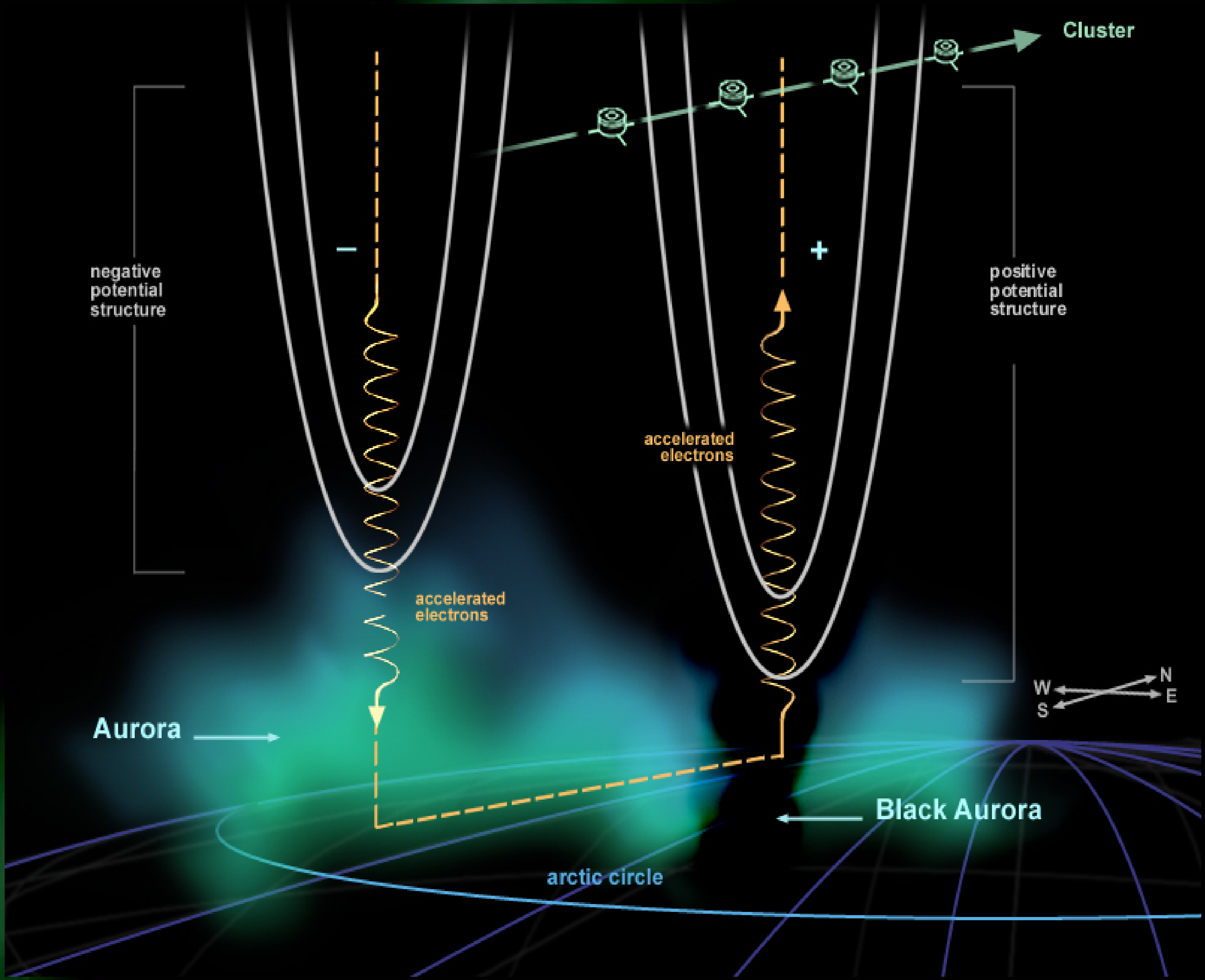
CLUSTER multipoint measurements (1)



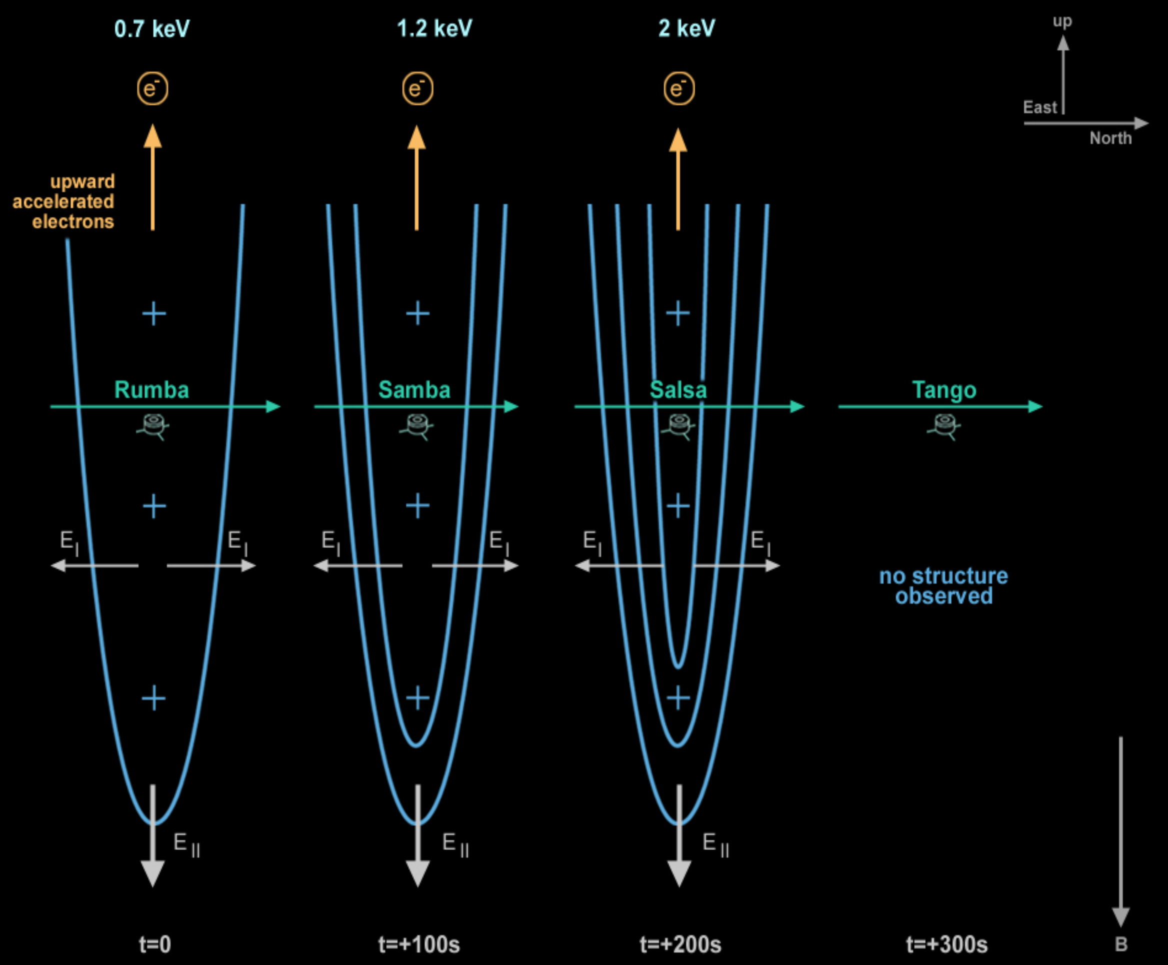


Marklund et al, 2001

Cluster passage through black aurora

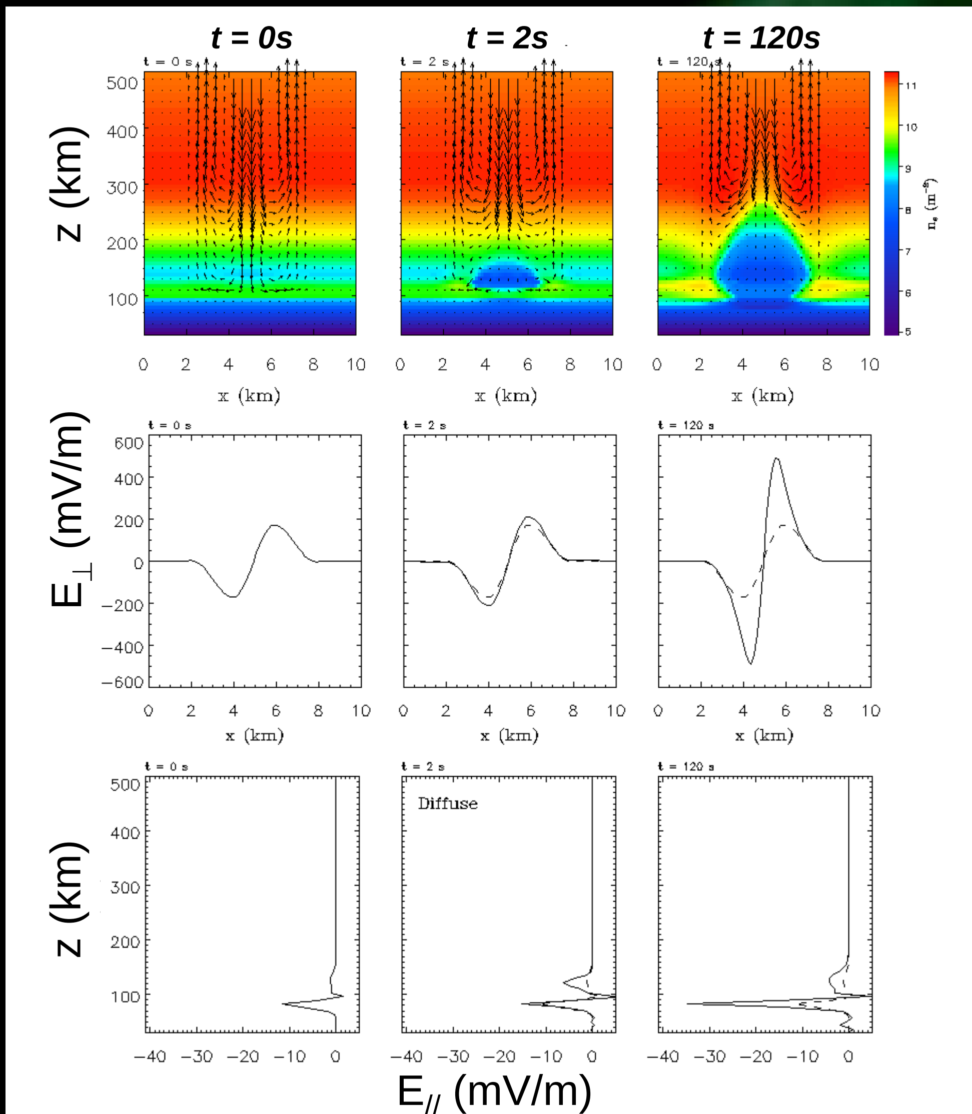


Temporal evolution of the acceleration potential above black aurora



The active role of the ionosphere

Density cavities



Simulations show deep density cavities formed by downward FAC and associated increased E-fields.

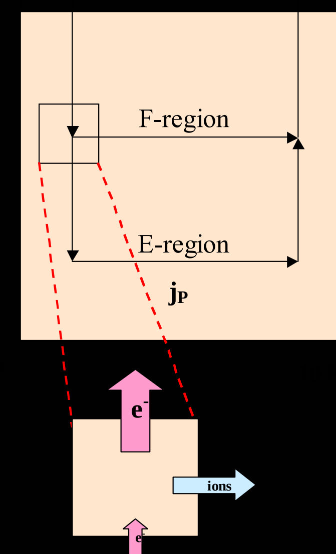
Important to take into consideration when mapping from high-altitude measurements.

Assumptions:

$j_{//}$ carried by e^-
j_P carried by ions

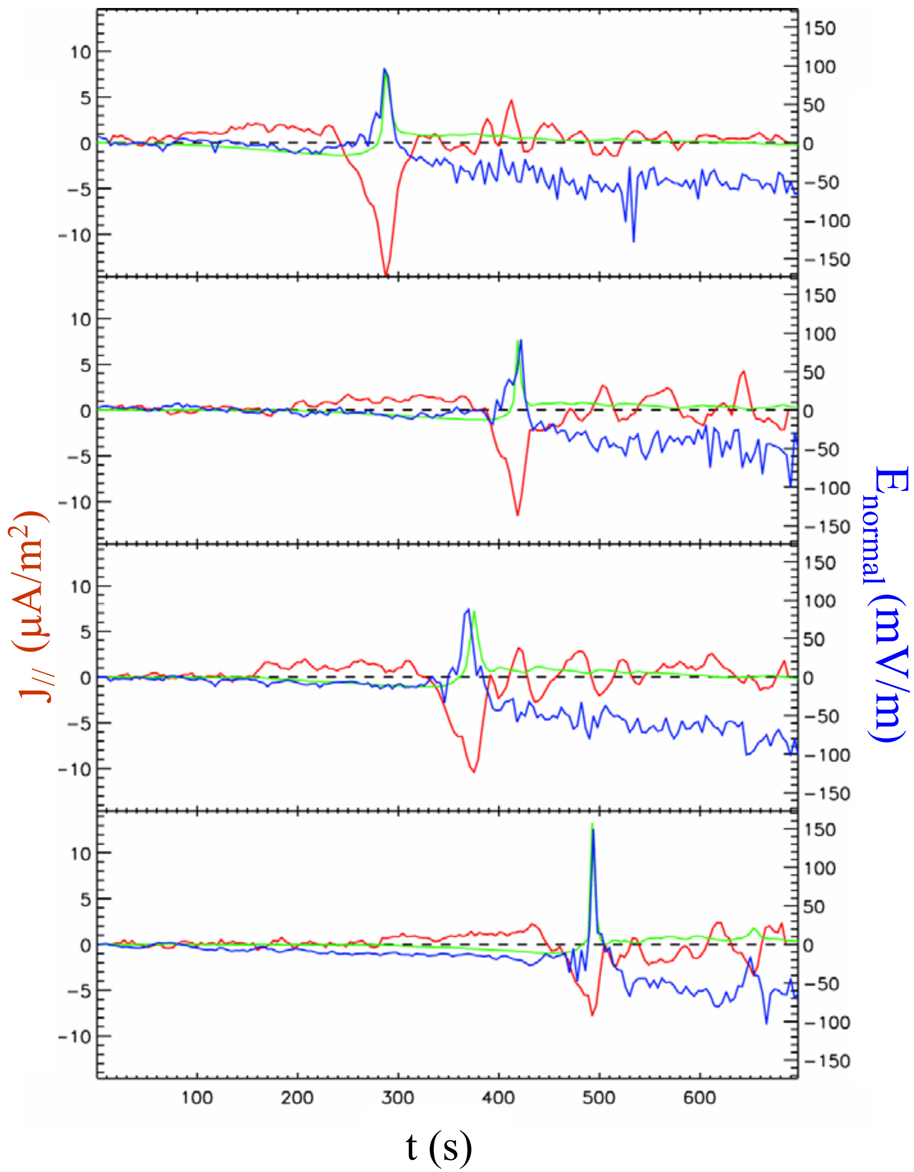
⇒

$$\frac{\partial n_e}{\partial t} = -\frac{1}{q}\frac{\partial j_{//}}{\partial z}$$



Karlsson, 1998

Cluster data, 2004-02-18, and model results



S/C 1-4
NH, MLT≈4, ILAT ≈~66

E_n = 1 mV/m
E_t = -3 mV/m
$\Sigma_{P,BG}$ = 5 S

$k_{down,1}$ = 0.31 $Sm^2/\mu A$
$k_{down,2}$ = 0.40 $Sm^2/\mu A$
$k_{down,3}$ = 0.42 $Sm^2/\mu A$
$k_{down,4}$ = 0.72 $Sm^2/\mu A$

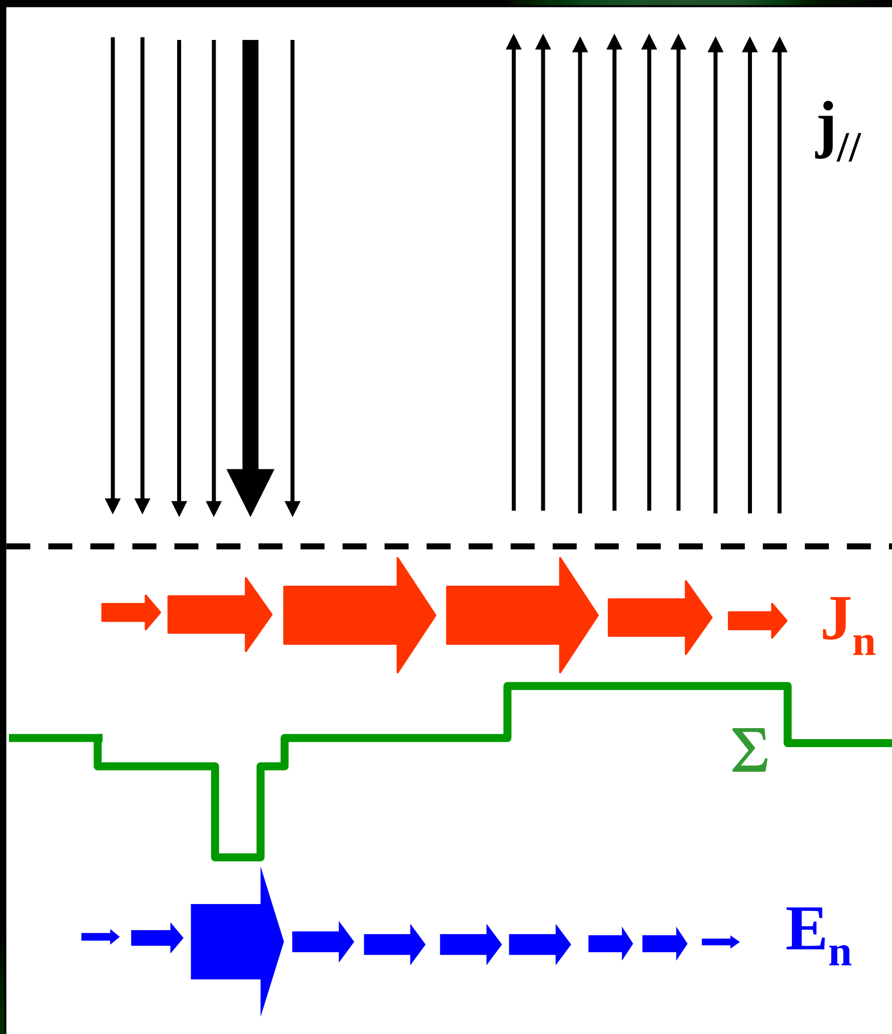
Karlsson, 2007

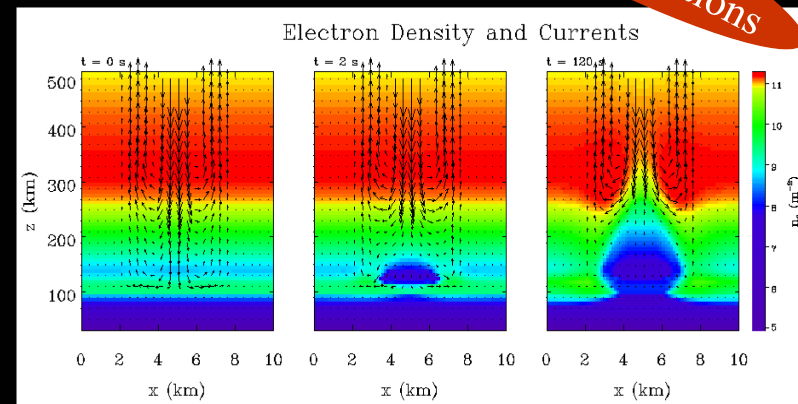
Model – inospheric modification by downward FAC

From earlier simulations

Magnetosphere

Ionosphere





$$J_n = \int j_{\|} dn + \Sigma_{P,0} E_{n,0} + \Sigma_{H,0} E_t$$

$$\Sigma_P = \Sigma_{P,0} + \begin{cases} k_{down} j_{//} & \text{downward } j_{//} \\ 0 & \text{upward } j_{//} \end{cases}$$

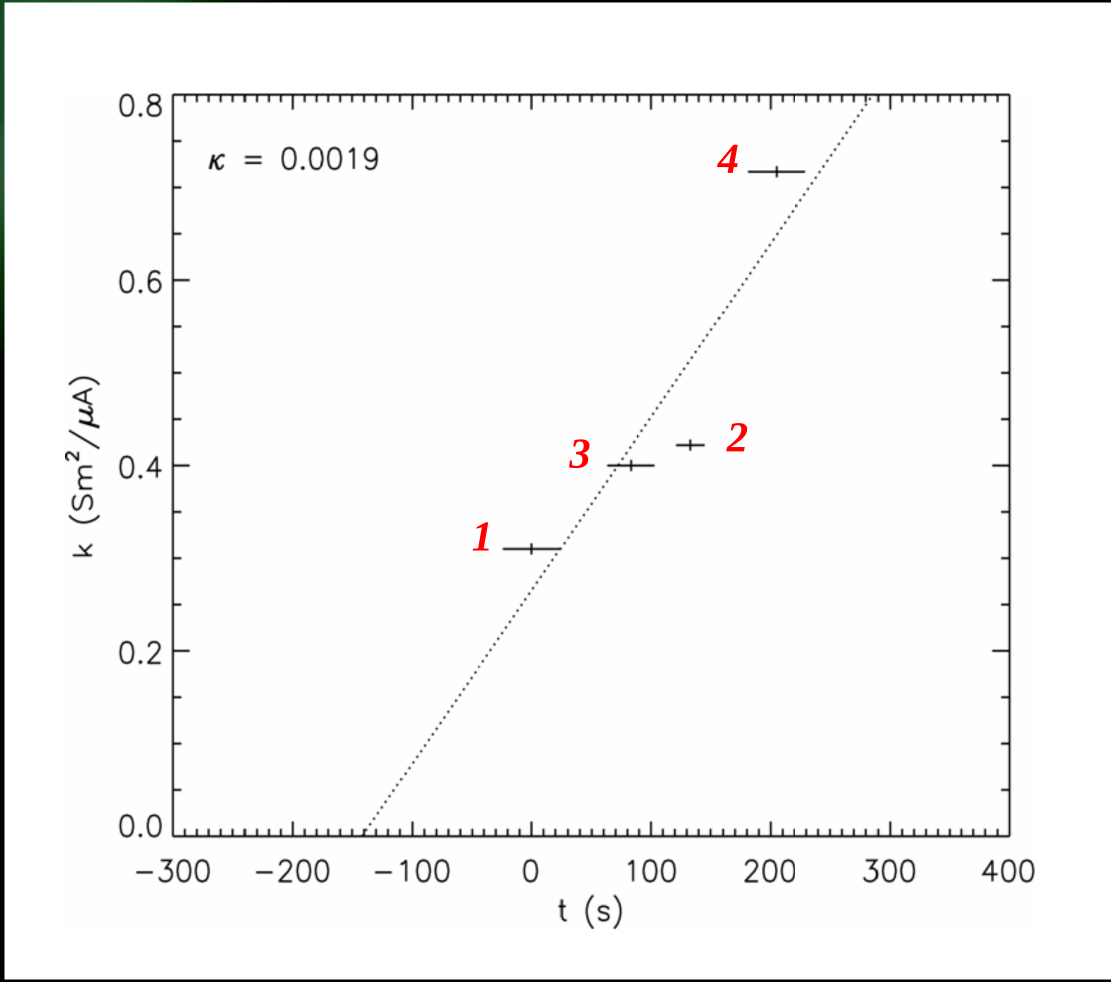
$$\Sigma_P \geq \Sigma_{P,min}, \quad \Sigma_H = 2\Sigma_P$$

$$E_n = \frac{\Sigma_{P,0} E_{n,0}}{\Sigma_P} + \frac{\left(\Sigma_H - \Sigma_{H,0}\right) E_t}{\Sigma_P} + \frac{1}{\Sigma_P} \int j_{\|} dn$$

2004-02-18
k as a function of time

Fit $k = \kappa t \Rightarrow$

$\kappa = 1.9 \cdot 10^{-3}$
$Sm^2/\mu As$



From simulations:

$1 \cdot 10^{-5} \leq \kappa \leq 2 \cdot 10^{-3}$
$Sm^2/\mu As$


Thank you for your attention!