SRAMP

S-RAMP, Oct 2-6, 2000, Japan

Interplanetary Ram Pressure Increases/Decreases and Dayside Auroral Variations

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Solar wind ram pressure increases and decreases are shown to be a triggering of dayside auroral intensifications and dimming, respectively. The auroral intensifications last for ~ 10-15 min propagate towards nightside along both the dawn and dusk flanks. In this study, we analyze interplanetary pressure pulse events and dayside auroral events in 1997-1999 using WIND interplanetary magnetic field and solar wind plasma data and POLAR UVI data. The relationship between the intensity of interplanetary pressure pulses and the intensity and symmetry of dayside auroras will be shown statistically. The micro-mechanism(s) of the particle acceleration and the auroral propagation will be discussed.

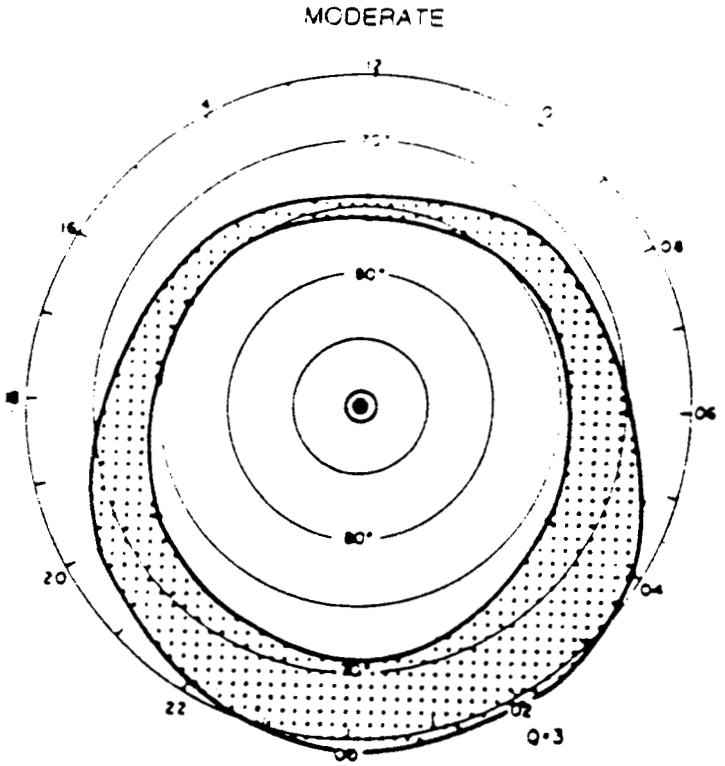
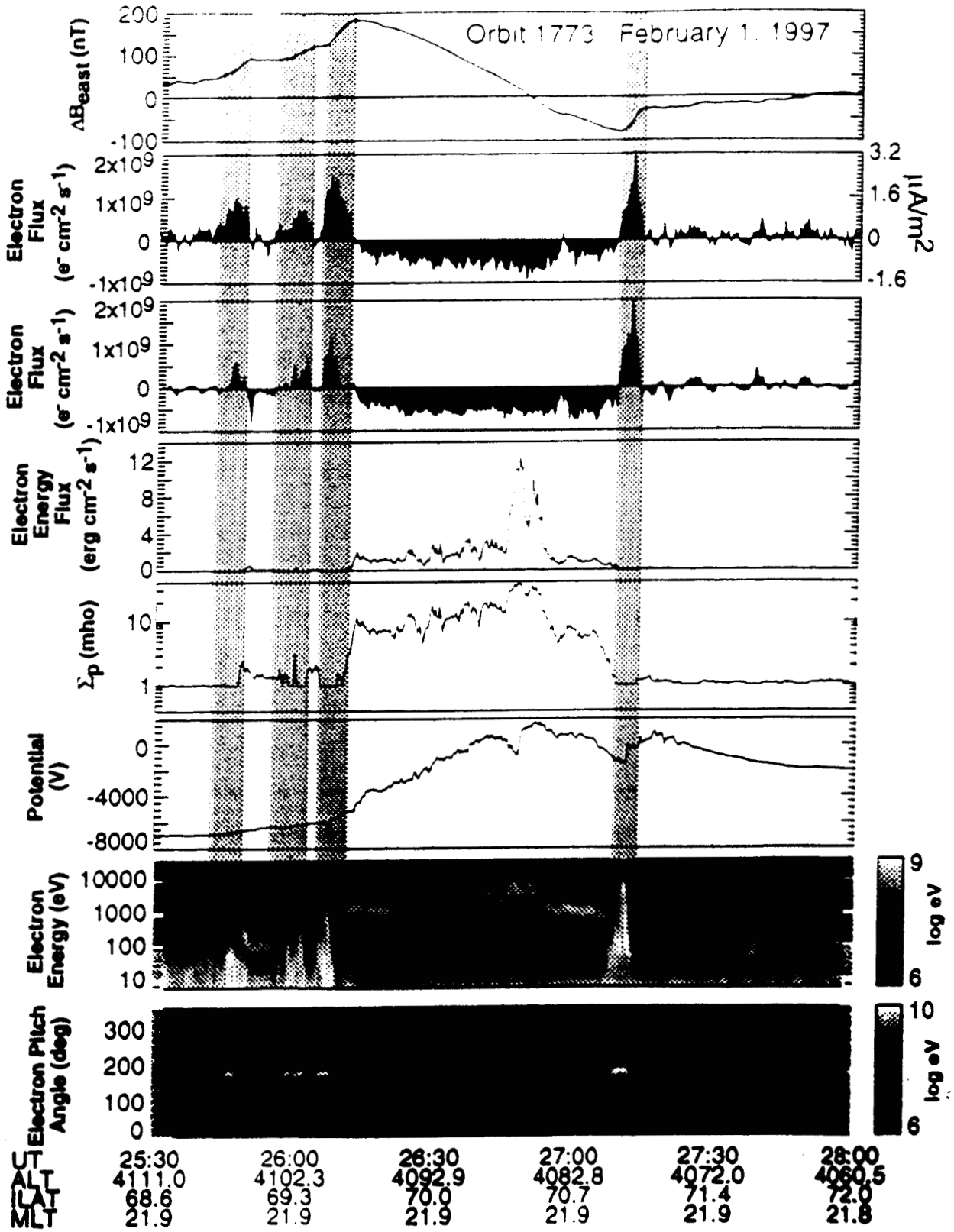
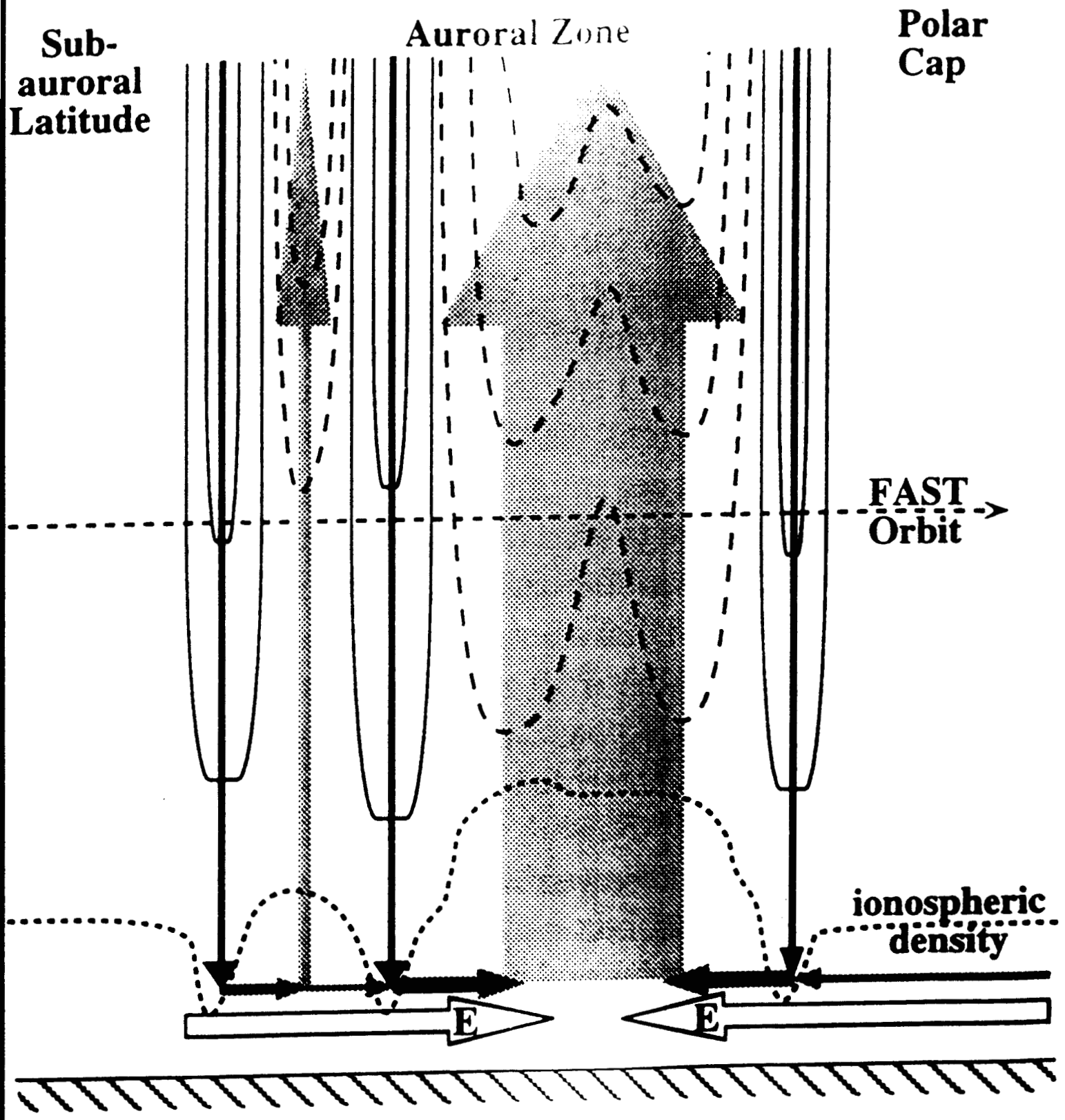
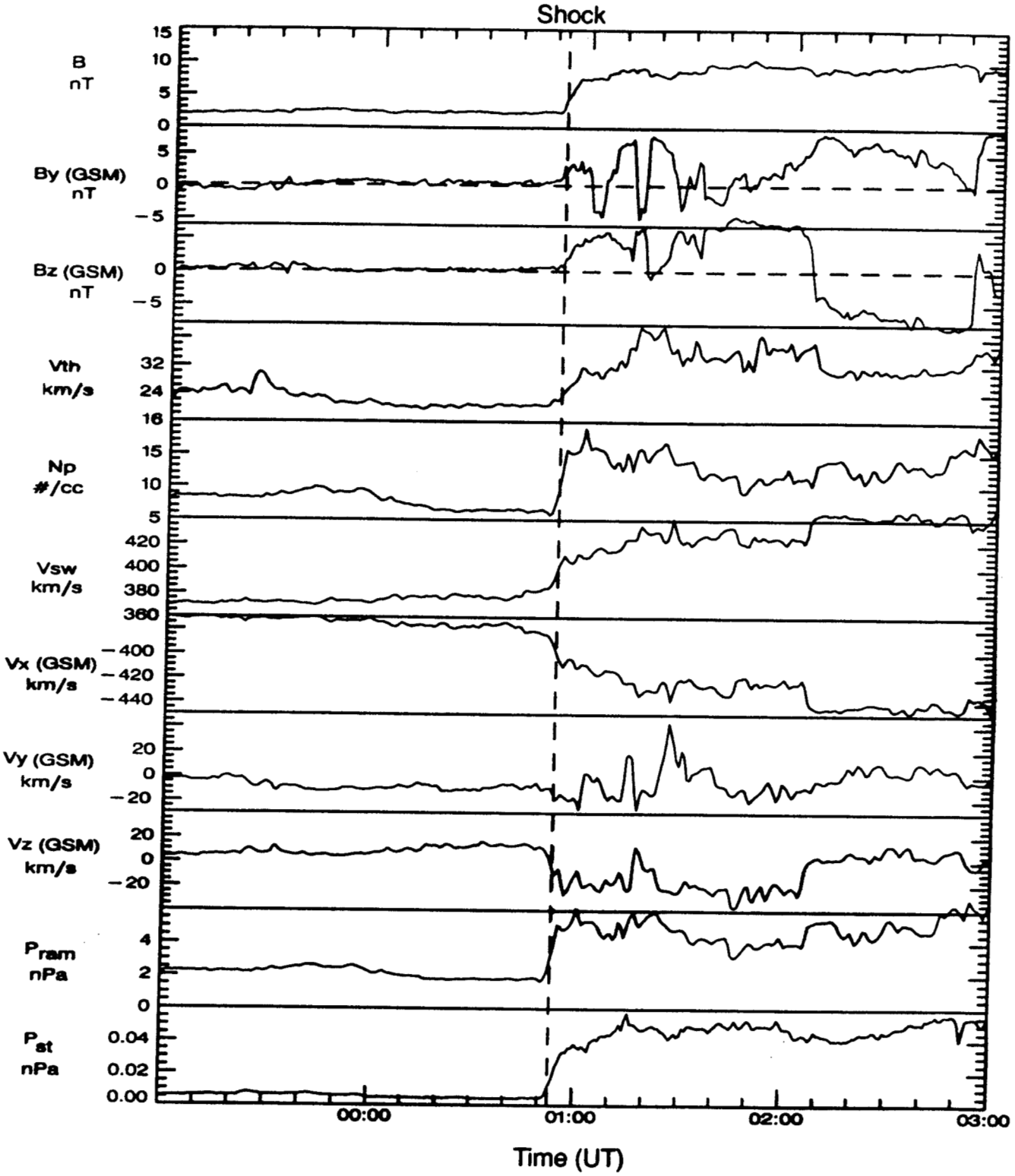


FIG. 14.8. Variation in the size of the auroral oval with activity. The shaded area represents the distribution of maximum auroral activity in the northern hemisphere. Coordinate system is corrected geomagnetic (CG) latitude and CG local time, and noon is at the top. (Adapted from Feldstein and Starkov, 1967.)

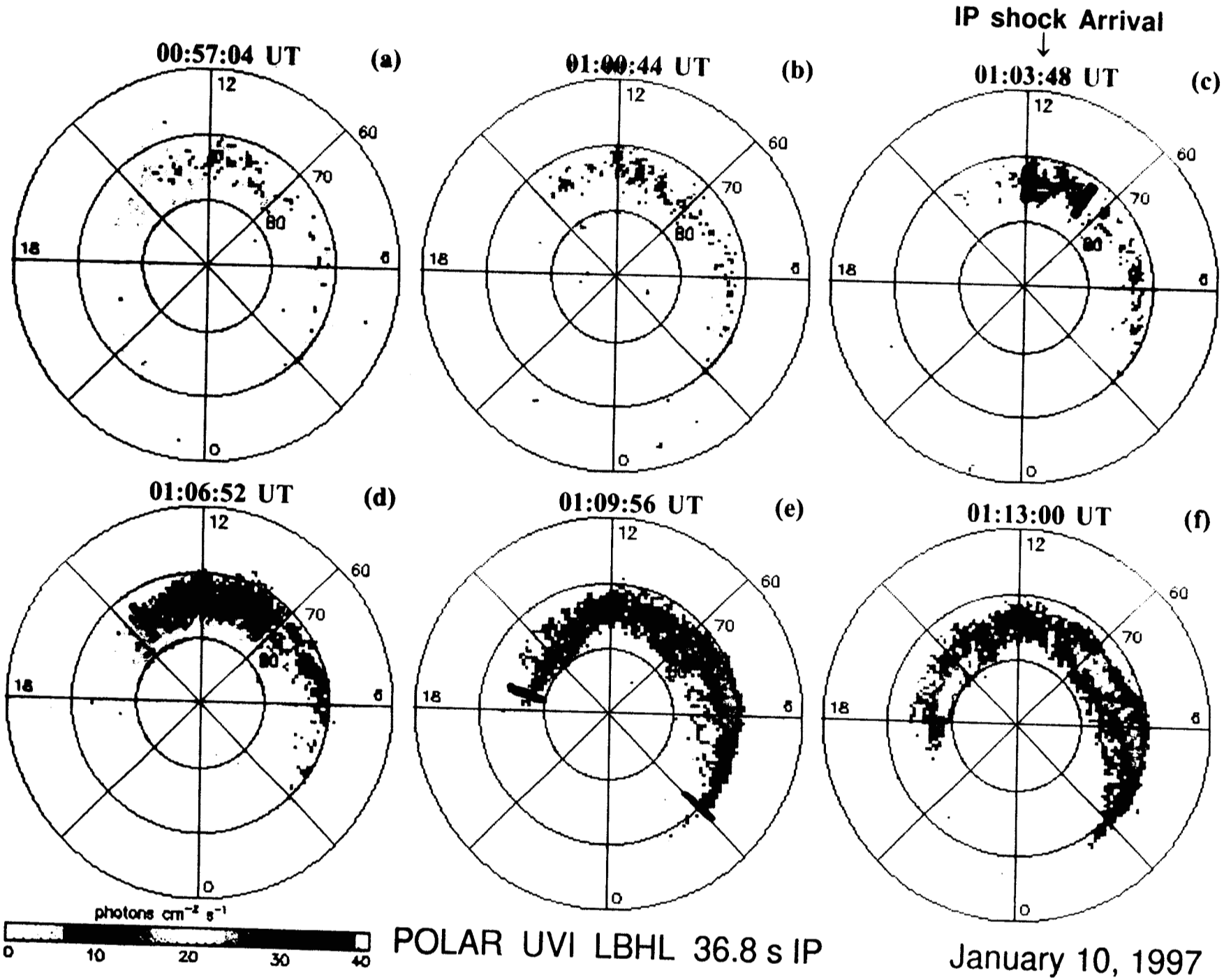

Orbit 1773 February 1, 1997
ΔB east (nT)
200
100
0
-100
Electron Flux (e⁻ cm⁻² s⁻¹)
2x10⁹
1x10⁹
0
-1x10⁹
Electron Flux (e⁻ cm⁻² s⁻¹)
2x10⁹
1x10⁹
0
-1x10⁹
Electron Energy Flux (erg cm⁻² s⁻¹)
12
8
4
0
Σp (mho)
10
1
Potential (V)
0
-4000
-8000
Electron Energy (eV)
10000
1000
100
10
Electron Pitch Angle (deg)
300
200
100
0
3.2
1.6
0
-1.6
μA/m²
9
6
log eV
10
6
log eV
UT 25:30 26:00 26:30 27:00 27:30 28:00
ALT 4111.0 4102.3 4092.9 4082.8 4072.0 4060.5
ILAT 68.6 69.3 70.0 70.7 71.4 72.0
MLT 21.9 21.9 21.9 21.9 21.9 21.8


Sub-
auroral
Latitude
Auroral Zone
Polar
Cap
FAST
Orbit
ionospheric
density
E
E

WIND – January 10, 1997



Xgsm (Re)	84.3	84.7	85.1	85.4	85.8
Ygsm (Re)	-54.9	-54.9	-55.2	-55.8	-56.6
Zgsm (Re)	-23.3	-23.1	-22.1	-20.4	-18.1



POLAR UVI LBHL 36.8 s IP

January 10, 1997

Table 1. "Auroral speed" in the ionosphere (& mapped into the solar wind/magnetosheath).

Event	Ionospheric V (km/s)	Calculated V* (km/s)	Observed $V_{sh/sw}$ (km/s)	Spacecraft Position (Re)	
Jan 10, 97	6 (dusk)	280	300	I-T (Sheath)	(-19, 19, 10)
Oct 1, 97	10 (dusk)	370	460	IMP-8 (SW)	(10, 32, -3)
Dec 10, 97	11 (dawn)	365	360	GT (SW)	(-4, -25, -0.5)

* Assuming a dipole field of L=10.

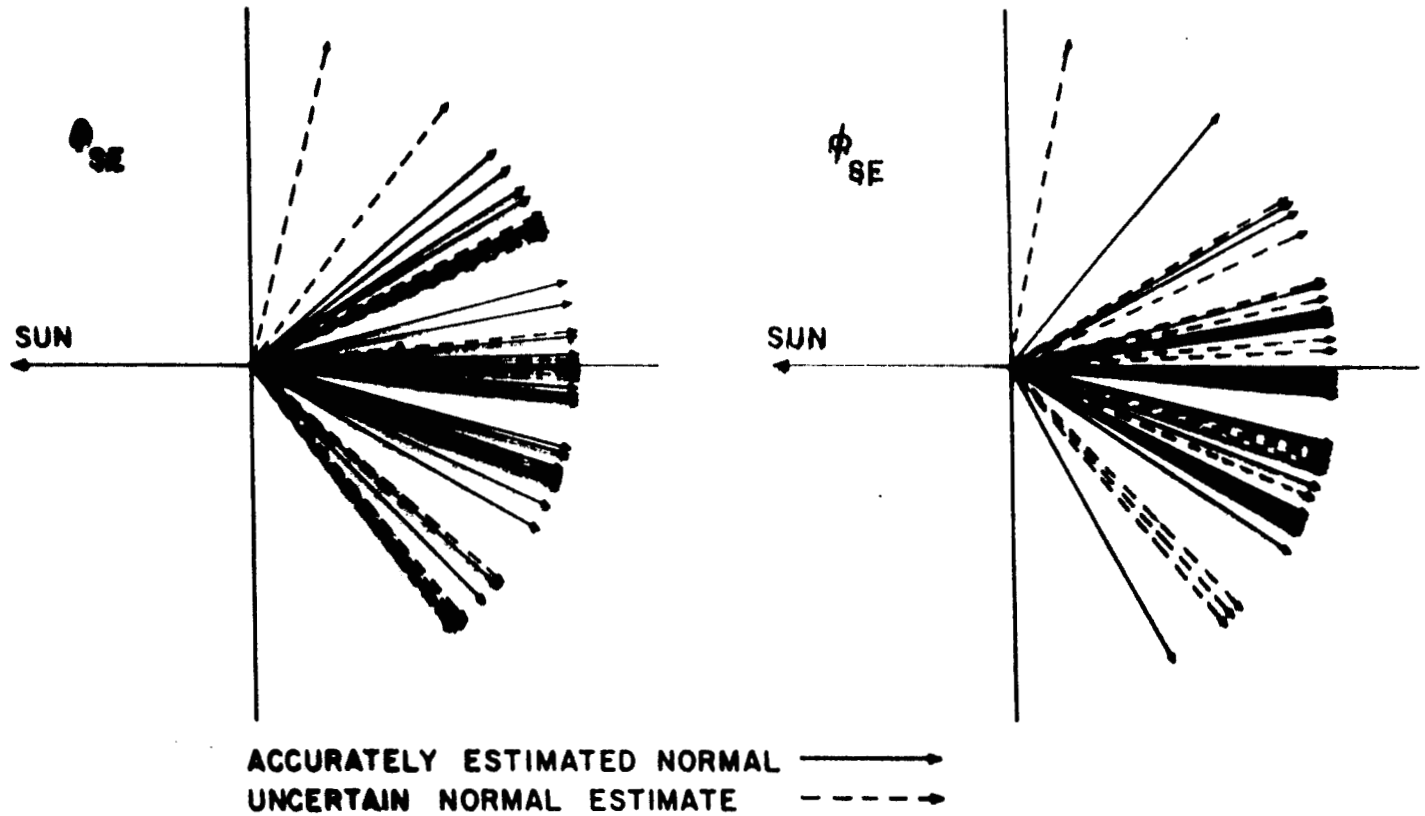
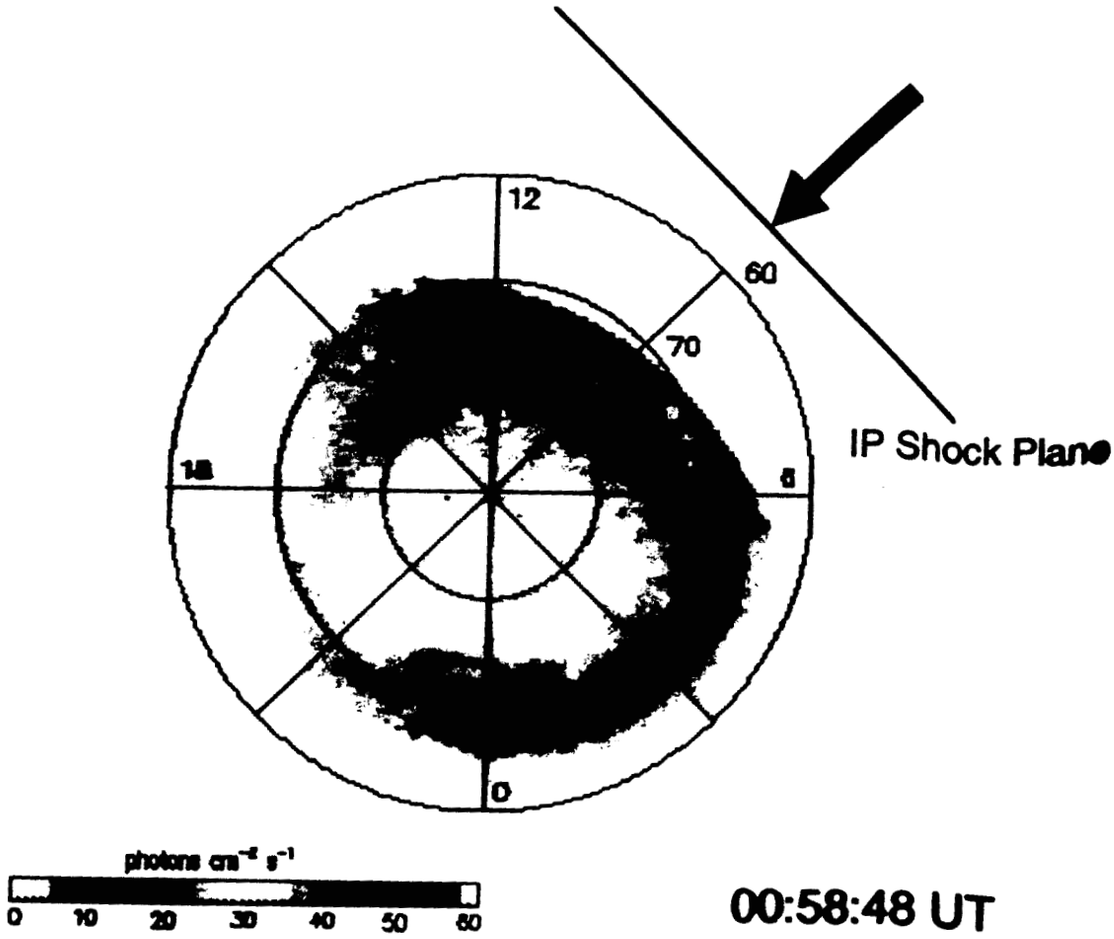


Fig. 2. Orientations of 38 shock normals. The angle θ_s is the solar ecliptic latitude and ϕ_s is the solar ecliptic longitude. The dashed arrows represent events with uncertainties larger than those represented by solid arrows (see text).

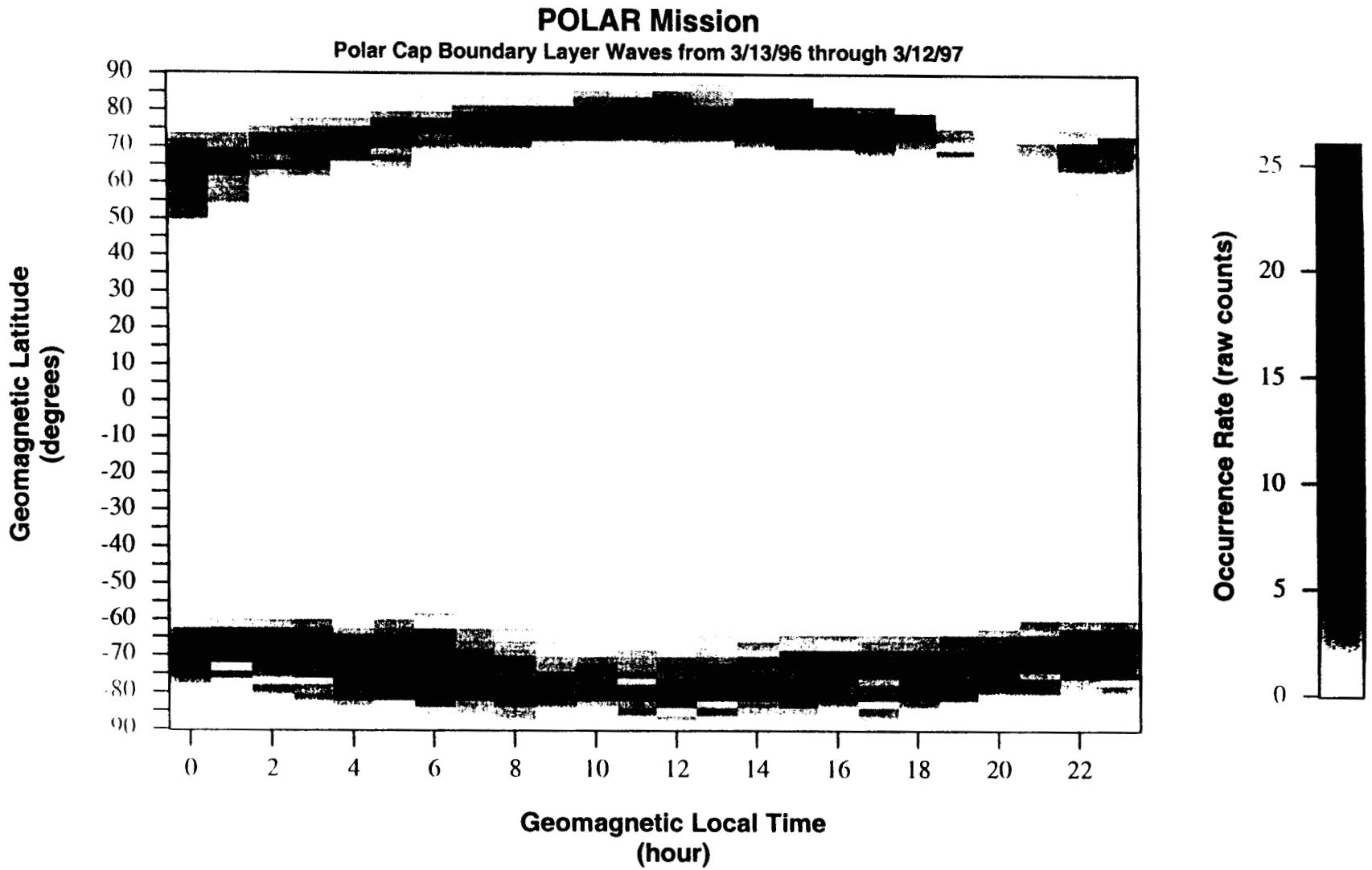
Shock normal= (-0.74, -0.3, -0.6) in GSM



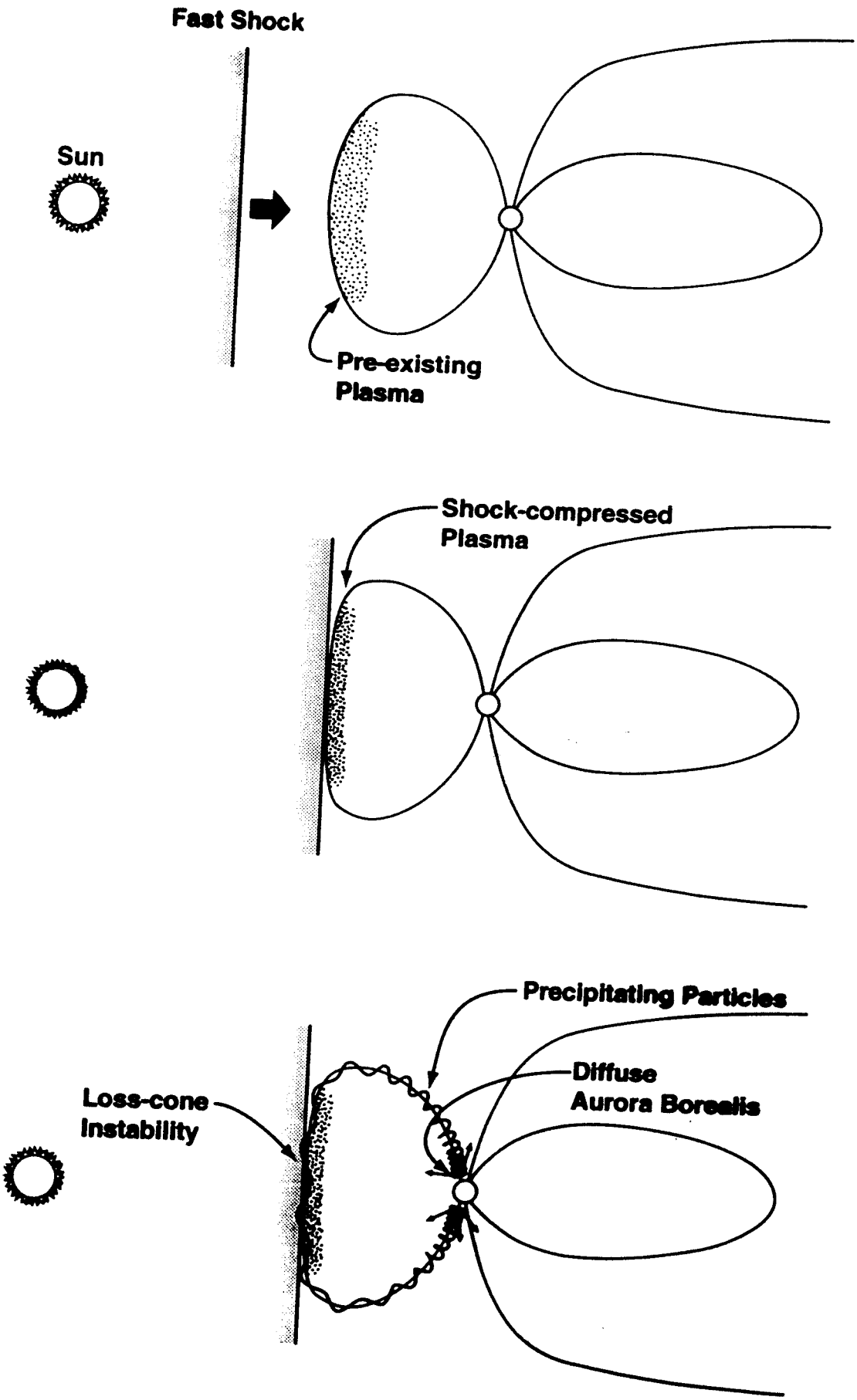
00:58:48 UT

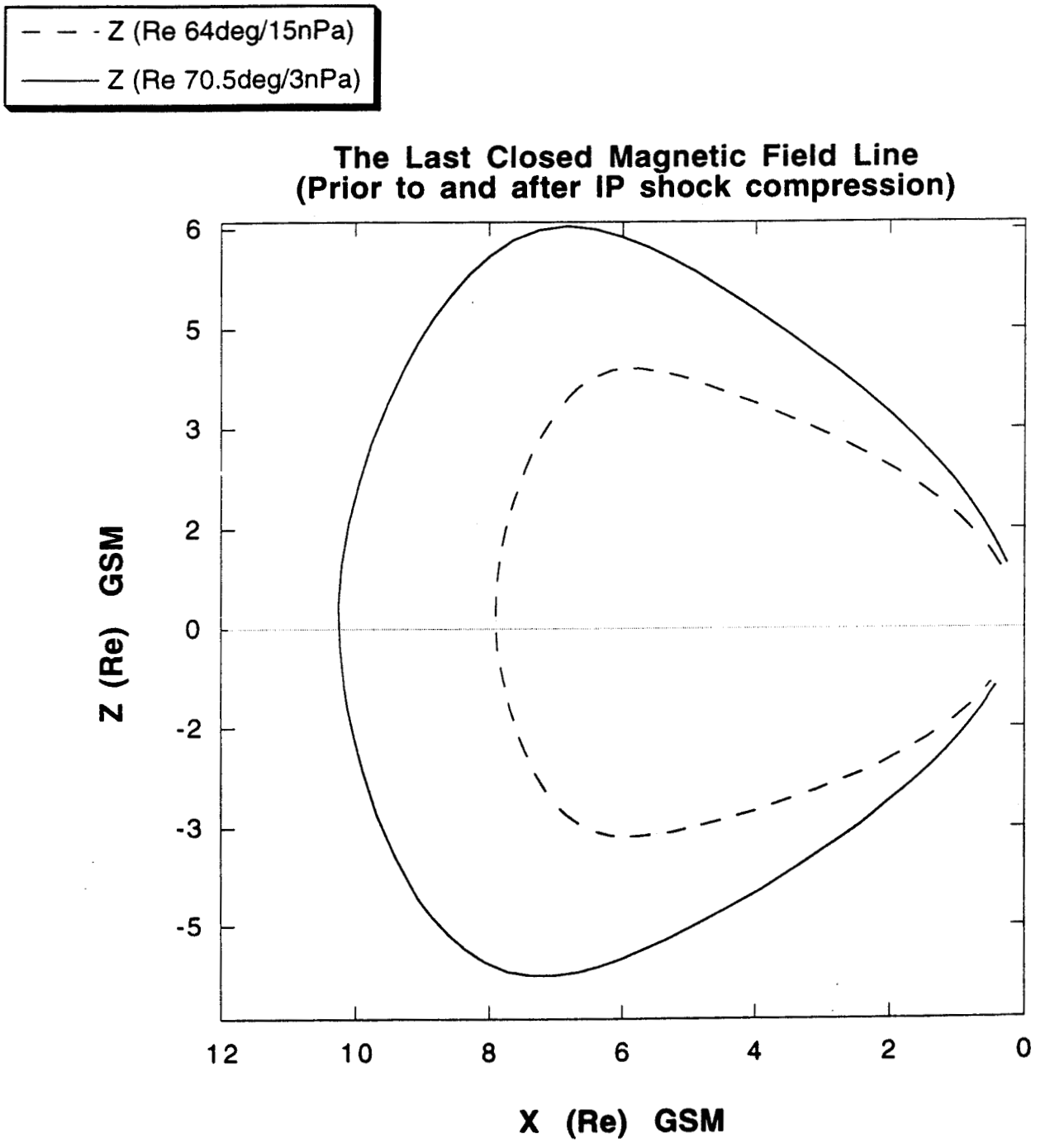
POLAR UVI LBHL

October 1, 1997


POLAR Mission
Polar Cap Boundary Layer Waves from 3/13/96 through 3/12/97
Geomagnetic Latitude (degrees)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
0
2
4
6
8
10
12
14
16
18
20
22
Geomagnetic Local Time (hour)
Occurrence Rate (raw counts)
25
20
15
10
5
0

5/25/98


Fast Shock
Sun
Pre-existing
Plasma
Shock-compressed
Plasma
Precipitating Particles
Diffuse
Aurora Borealis
Loss-cone
Instability


Z (Re 64deg/15nPa)
Z (Re 70.5deg/3nPa)
The Last Closed Magnetic Field Line
(Prior to and after IP shock compression)
6
5
3
2
0
-2
-3
-5
Z (Re) GSM
12
10
8
6
4
2
0
X (Re) GSM

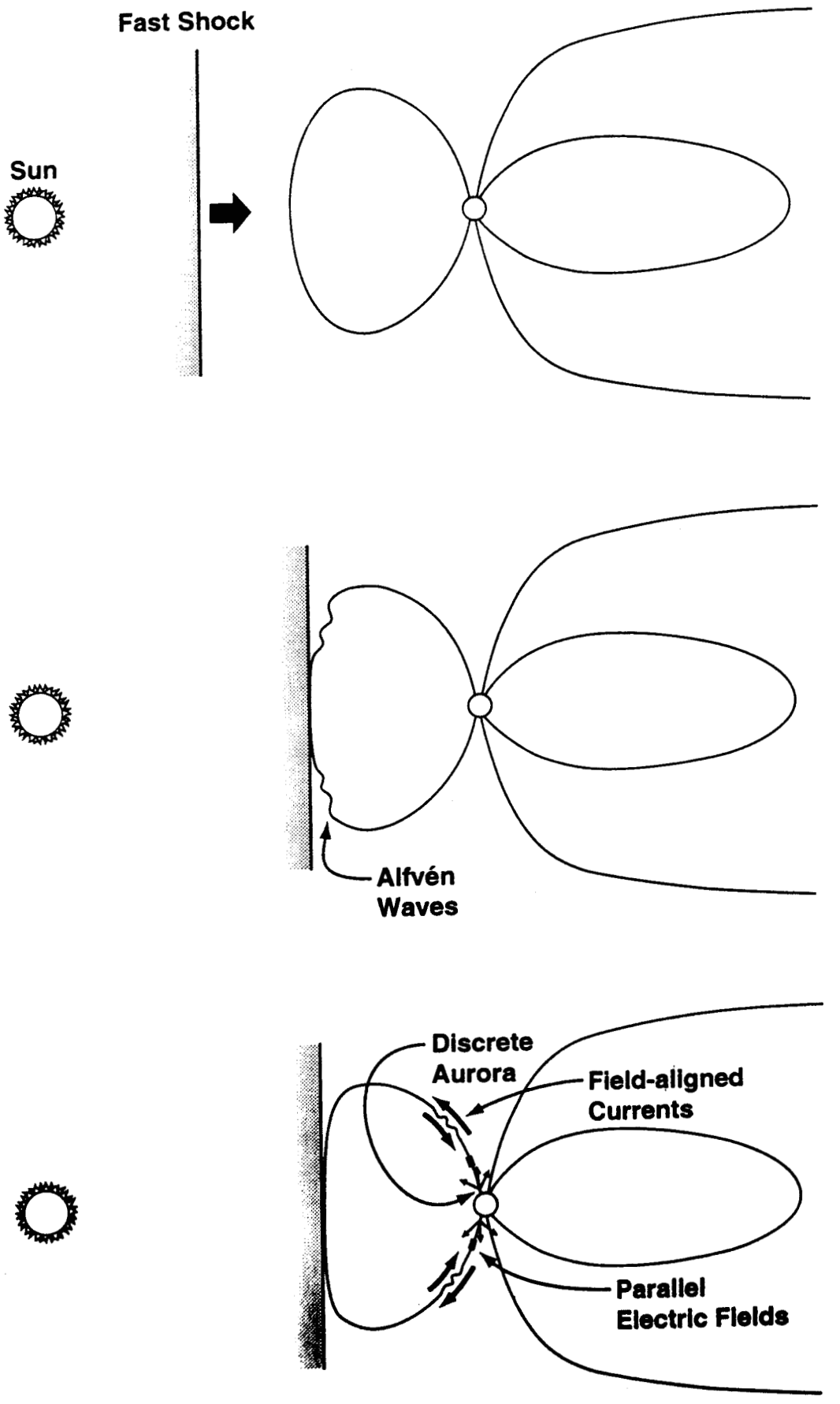
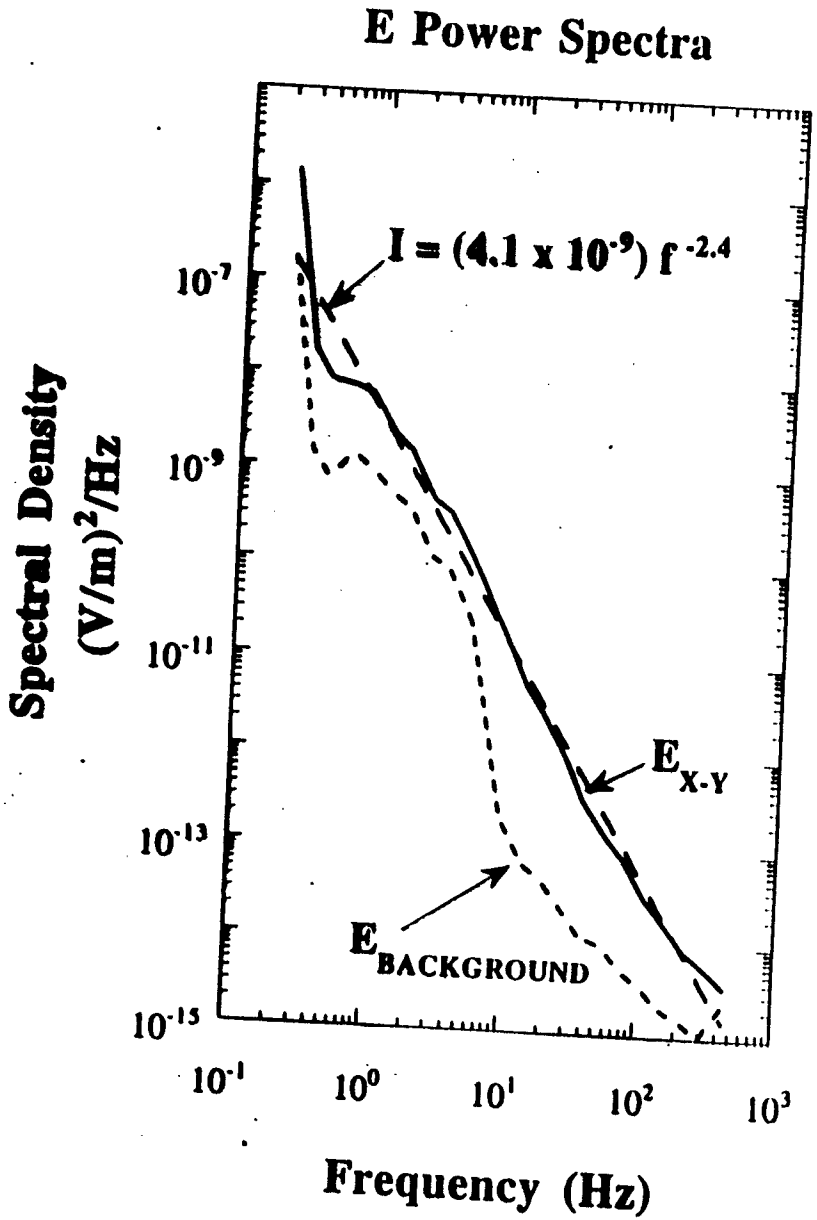

Fast Shock
Sun
Alfvén
Waves
Discrete
Aurora
Field-aligned
Currents
Parallel
Electric Fields

Table 1. The 14 BL crossings identified by *Phillips et al.* [1993]

			Entry			Exit		
Event	**Transition**	**Boundary**	**Date**	**Day of Year**	**Time, UT**	**Date**	**Day of Year**	**Time, UT**
1	Msh-BL-Msh	MP1	Feb. 2, 1992	033	2130	Feb. 2, 1992	033	2308
		MP2	Feb. 2, 1992	033	2222	Feb. 2, 1992	033	2308
2	Msp-BL-Msh	MP	Feb. 3, 1992	034	1655	Feb. 3, 1992	034	1720
3	Msh-BL-Msh	MP	Feb. 3, 1992	034	1945	Feb. 4, 1992	035	0025
4	Msh-BL-Msh	MP	Feb. 4, 1992	035	0100	Feb. 4, 1992	035	0125
5	Msh-BL-Msp	MP	Feb. 4, 1992	035	0250	Feb. 4, 1992	035	0400
6	Msp-BL-Msp		Feb. 12, 1992	043	0024	Feb. 12, 1992	043	0100
7	Msp-BL-Msp		Feb. 12, 1992	043	1058	Feb. 12, 1992	043	1226
8	Msp-BL-Msh	MP	Feb. 12, 1992	043	1337	Feb. 12, 1992	043	1357
9	Msh-BL-Msp	MP	Feb. 12, 1992	043	1700	Feb. 12, 1992	043	1740
10	Msp-BL-Msh	MP	Feb. 12, 1992	043	1820	Feb. 12, 1992	043	1910
11	Msh-BL-Msp	MP	Feb. 14, 1992	045	0933	Feb. 14, 1992	045	1030
12	Msp-BL-Msp		Feb. 14, 1992	045	1400	Feb. 14, 1992	045	1600
13	Msp-BL-Msp		Feb. 14, 1992	045	1815	Feb. 14, 1992	045	1825
14	Msp-BL-Msh	MP	Feb. 14, 1992	045	2045	Feb. 14, 1992	045	2140

Magnetosheath (Msh), boundary layer (BL), and magnetosphere (Msp), with identification of the boundary crossed, bow shock (BS) or magnetopause (MP). MP1 - based on magnetic field observations. MP2 - based on plasma observations. There are five crossings on the Ulysses inbound pass, days 33-35, 1992, and nine crossings on the outbound pass, days 43-45, 1992. The events have been numbered in chronological order for ease of description.

ULYSSES VHM - 2/14/1992 (Day 45)
BS
BS
Mah
SW
Mah
BL
Msp
BL
Msp
BL
Msp
BL
Mah
B' (nT)
B' (nT)
B'' (nT)
|B| (nT)
00:00
04:00
08:00
12:00
16:00
20:00
00:00
UT


E Power Spectra
I = (4.1 x 10^-9) f^-2.4
E X-Y
E BACKGROUND
Spectral Density
(V/m)^2/Hz
10^-7
10^-9
10^-11
10^-13
10^-15
10^-1
10^0
10^1
10^2
10^3
Frequency (Hz)

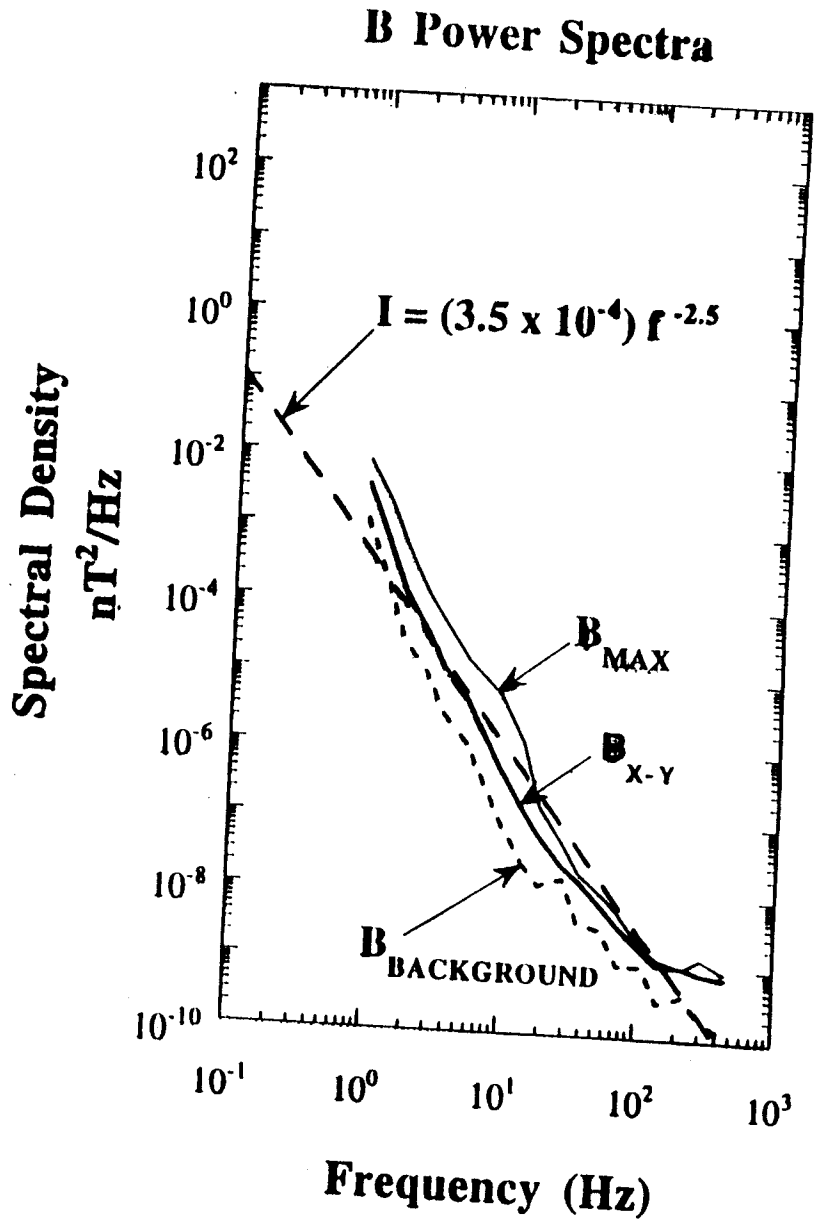
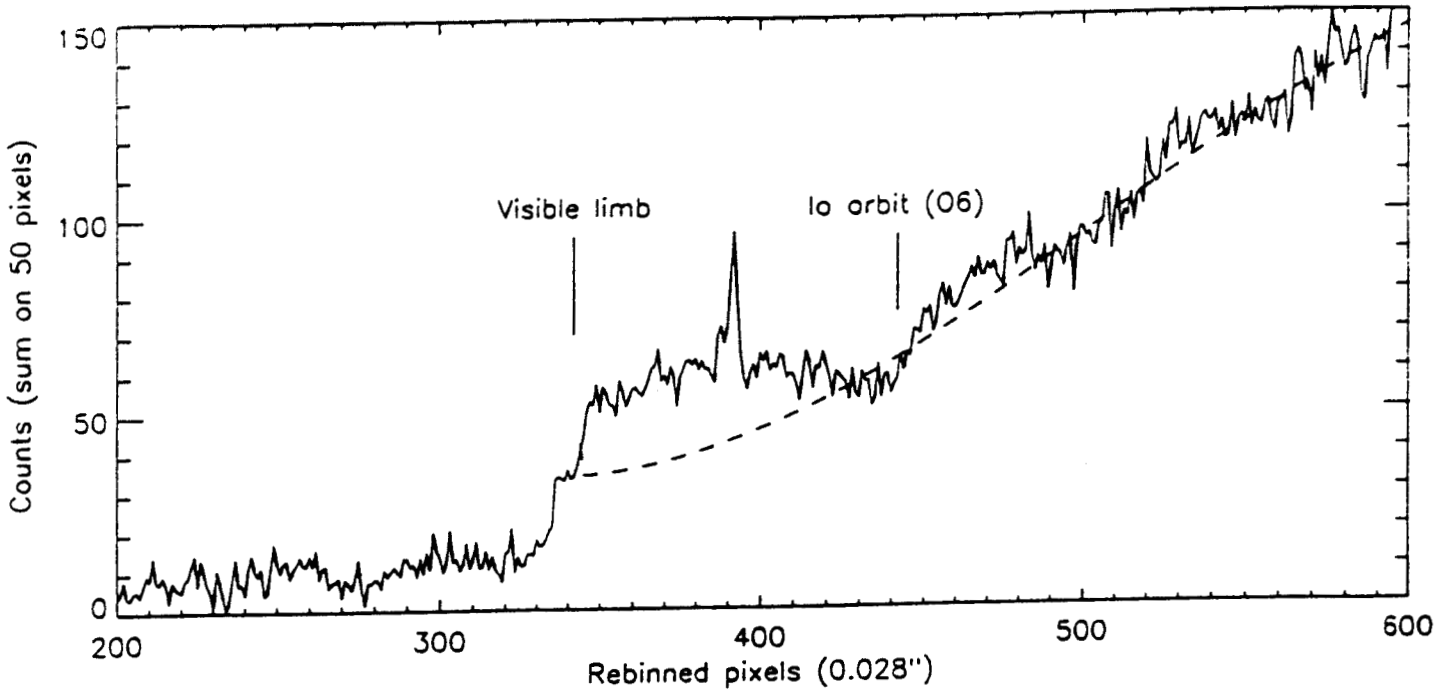
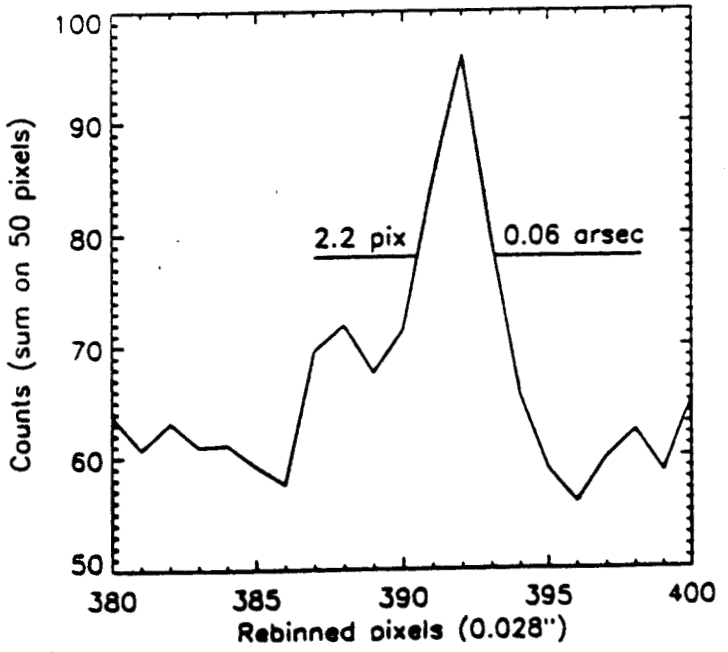

B Power Spectra
I = (3.5 x 10^-4) f^-2.5
B MAX
B X-Y
B BACKGROUND
Spectral Density
nT^2/Hz
10^2
10^0
10^-2
10^-4
10^-6
10^-8
10^-10
10^-1
10^0
10^1
10^2
10^3
Frequency (Hz)

Figure 5

Table 2. A comparison of the Jovian BL plasma wave spectra and the Earth's wave spectra

Spacecraft	Location	Date	B'	E'
ISEE 1[a]	Earth magnetopause	day 314, 1977	$\sim f^{-3.3}$	$\sim f^{-2.2}$
ISEE 1 and 2[b]	Earth magnetopause	1977	$(1 \times 10^{1}) f^{-3.9}$	$(3 \times 10^{-5}) f^{-2.8}$
ISEE 1 and 2[c]	Earth magnetopause	1977	$(7.9 \times 10^{-2}) f^{-2.9}$	$(6.3 \times 10^{-6}) f^{-2.2}$
GEOS 2[d]	Earth magnetopause	day 240, 1978	X: $(3.6 \times 10^{1}) f^{-2.6}$ Y: $(1.8 \times 10^{1}) f^{-2.4}$ Z: $(2.8 \times 10^{1}) f^{-2.7}$	$(1.2 \times 10^{-6}) f^{-2.6}$
ISEE 1[e]	Earth magnetopause	1977-79	$(3 \times 10^{-1}) f^{-3.3}$	$(6 \times 10^{-7}) f^{-2.1}$
Ulysses	Jupiter magnetopause	day 043, 1992	$(2 \times 10^{-4}) f^{-2.4}$	$(4 \times 10^{-9}) f^{-2.4}$


Visible limb
Io orbit (O6)
Counts (sum on 50 pixels)
Rebinned pixels (0.028")
0
50
100
150
200
300
400
500
600


2.2 pix
0.06 arsec
Counts (sum on 50 pixels)
Rebinned pixels (0.028")
50
60
70
80
90
100
380
385
390
395
400

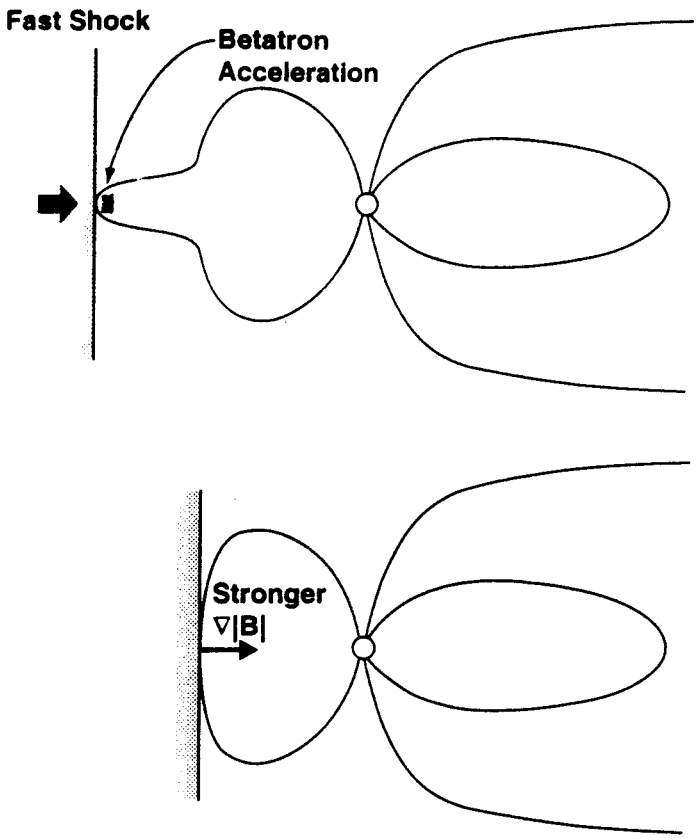
JOVIAN LLBL REGION AND AURORAL LATITUDINAL WIDTHS

- Mapping the Jovian BL to ionospheric heights give latitudinal widths of ~150-200 km.

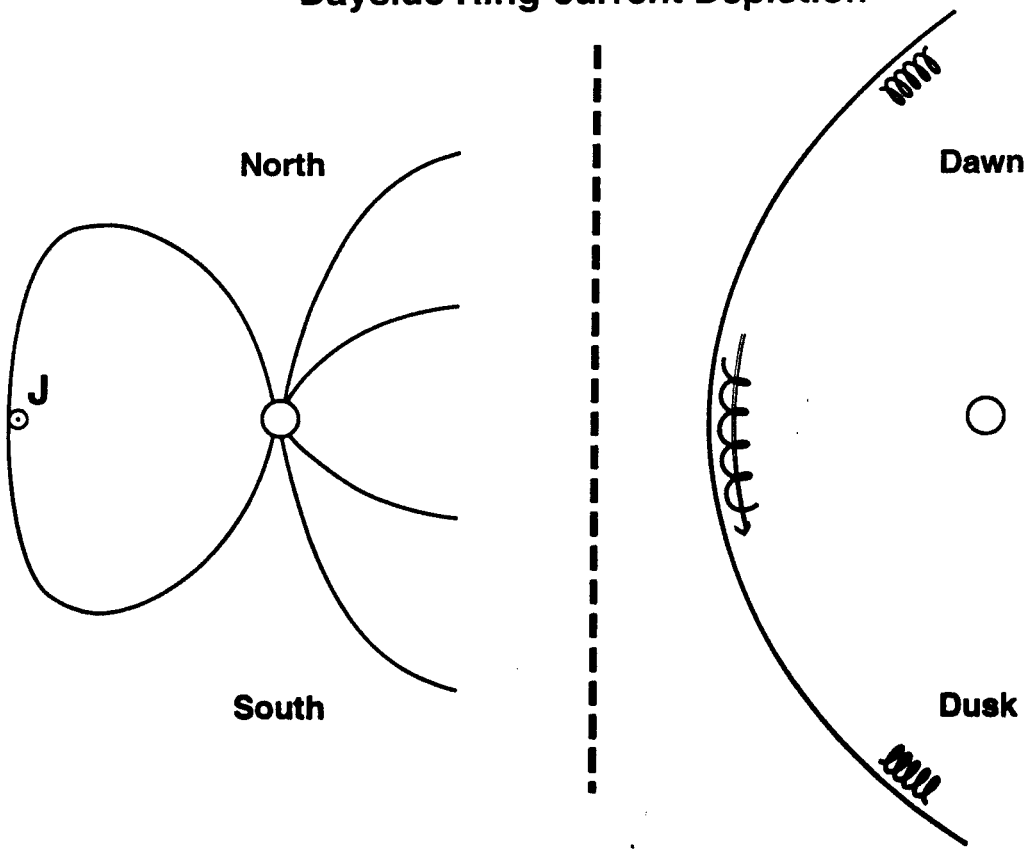
- The "main" Jovian ovals can be as narrow as 230 ± 100 km in width.

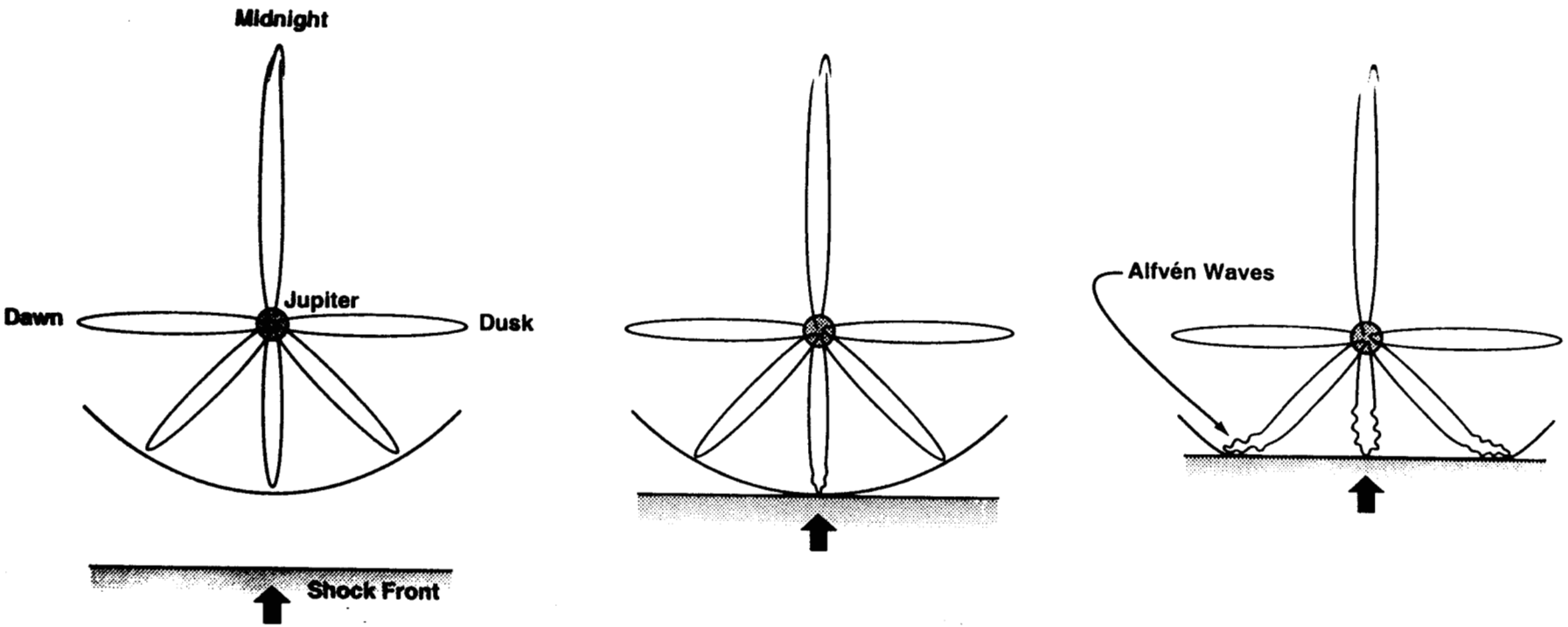
Do Pitch Angle Scattering of Electrons and Ions Have Insufficient Energies to Create Aurora?

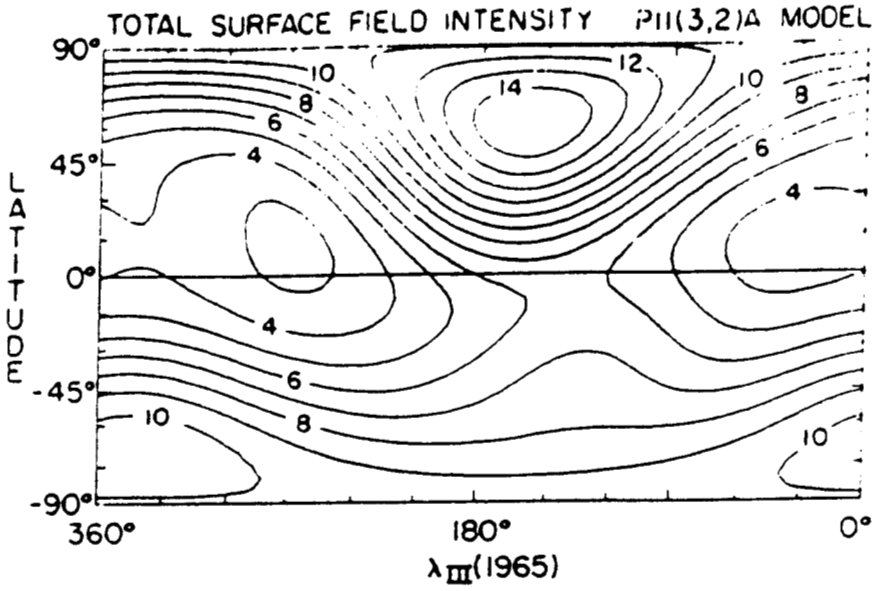
- 1-5 keV electrons and 1 keV – 1 MeV protons on strong pitch angle diffusion. But E_{TOTAL} = 0.1 erg $cm^{-2}s^{-1}$.

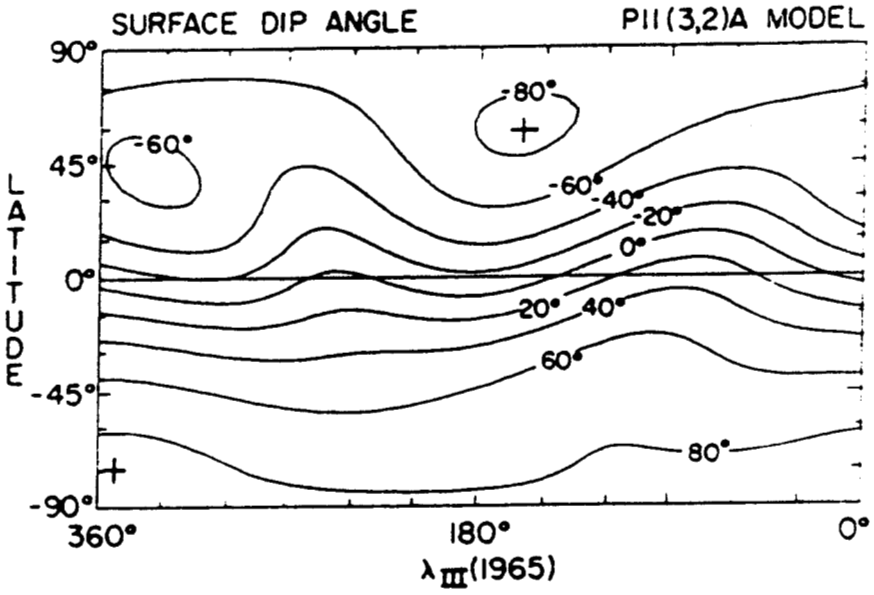


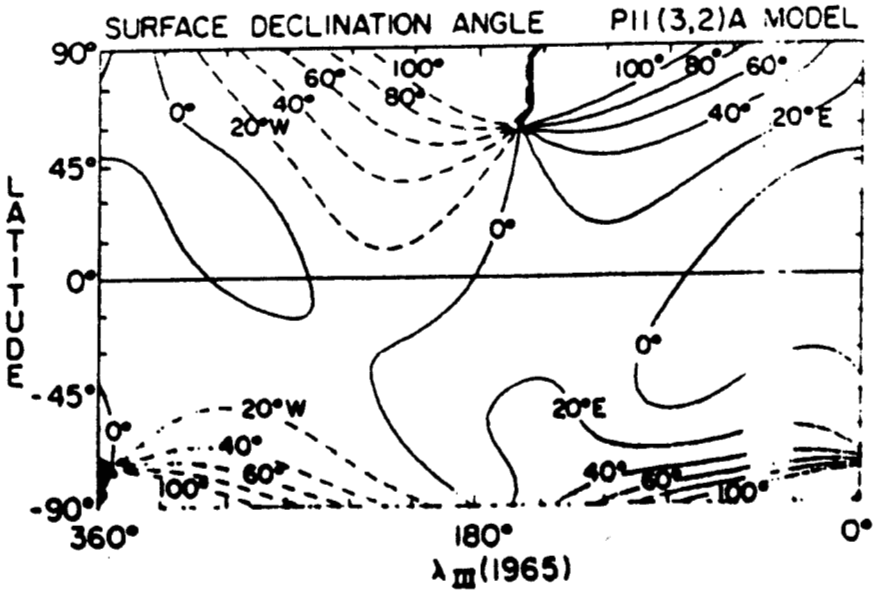
Dayside Ring-current Depletion




Midnight
Dawn
Jupiter
Dusk
Shock Front
Alfvén Waves


TOTAL SURFACE FIELD INTENSITY
PII(3,2)A MODEL
90°
45°
0°
-45°
-90°
LATITUDE
360°
180°
0°
λ III (1965)
10
8
6
4
12
14


SURFACE DIP ANGLE
PII(3,2)A MODEL
90°
45°
0°
-45°
-90°
LATITUDE
360°
180°
0°
λ III (1965)
-80°
-60°
-40°
-20°
0°
20°
40°
60°
80°


SURFACE DECLINATION ANGLE
PII(3,2)A MODEL
90°
45°
0°
-45°
-90°
LATITUDE
360°
180°
0°
λ III (1965)
0°
20°W
40°
60°
80°
100°
20°E

FIELD-ALIGNED POTENTIAL DROPS*

$j_{\parallel} = k \cdot \phi_{\parallel}$ where k^{-1} is the mirror impedance $= \dfrac{m_e C_{BL}}{e^2 n_{BL}}$

$$\phi_{\parallel} = j_{\parallel} k^{-1} = j_{\parallel_{BL}} \frac{B_c}{B_{BL}} k^{-1}$$

let: $B_{\perp} \approx B_{BL} \approx 5\text{nT}, \; B_o \approx 10\text{G},$

w = 7,000 km (Sonnerup et al., 1981), $n_{BL} = 0.1\ \text{cm}^{-3}$,

$C_{BL} = 10^4\ \text{km s}^{-1}$

$\phi_{\parallel} = 50$ kilo Volts

*following Haerendel, *Ap.J.Suppl. 90*, 765, 1994.

4/20/00

Galileo MAG Trajectory in Jupiter (December 1997 to March 2001)
GLL Prime Mission
GLL GEM
GLL Post GEM
DEC 2000
CASS
GLL
Sunward
Magnetopause
Bow Shock
Io
Europa
Ganymede
Callisto
X
Y
-300
-120
-100
-20
0
20
100
120
300

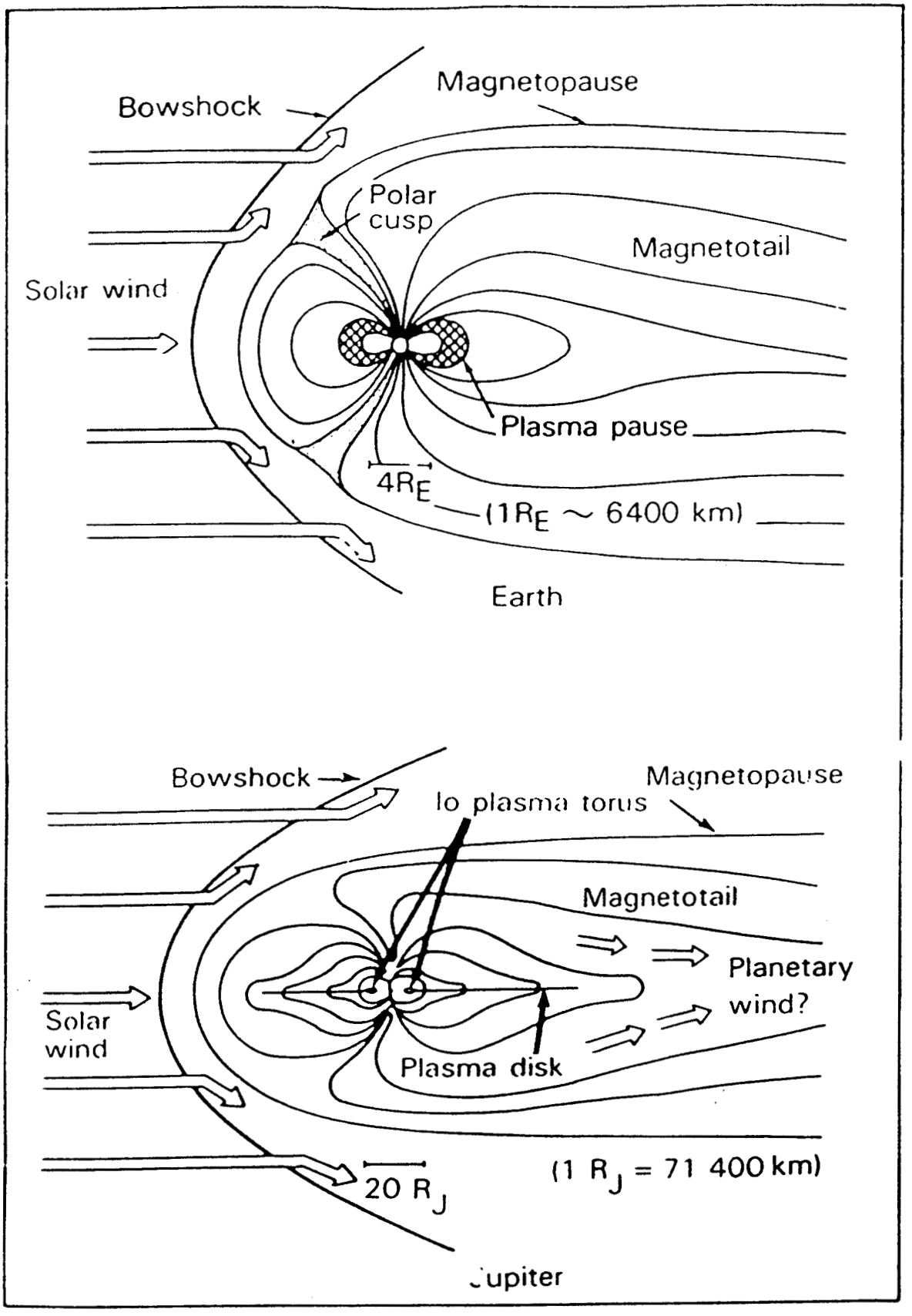
CONCLUSIONS

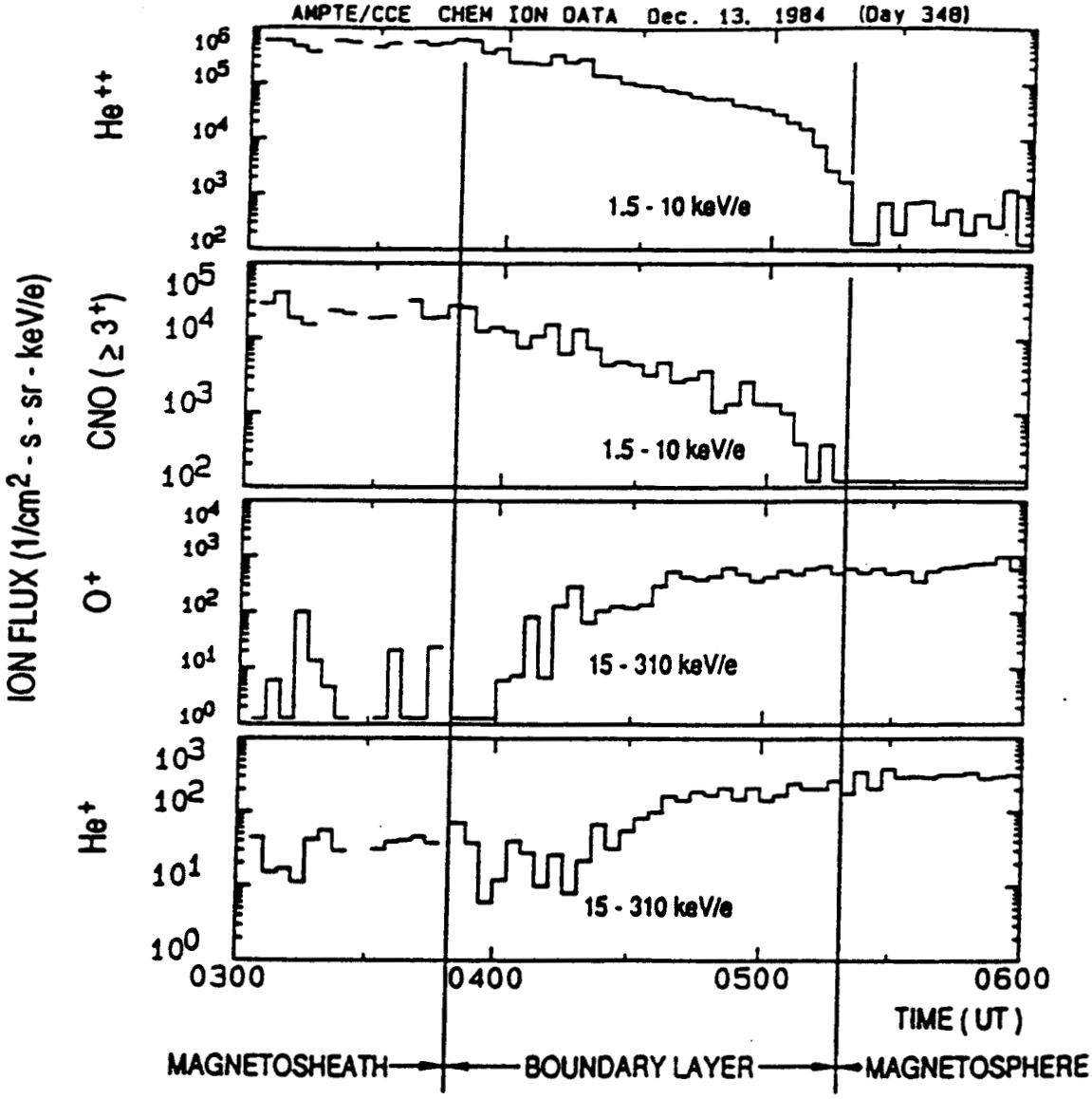
- "Magnetopause boundary layers" are on ***auroral zone field lines.***

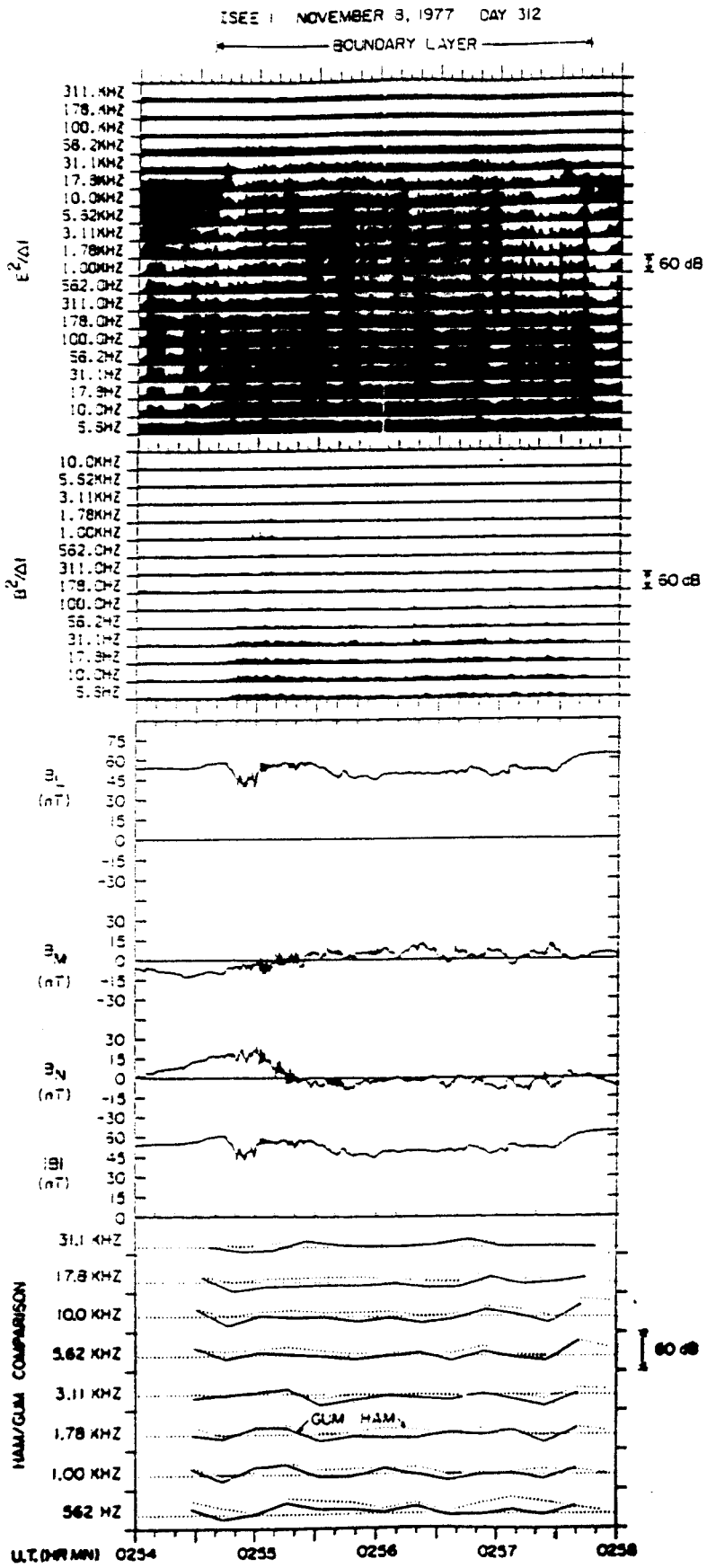
- The dynamics of boundary layers is perhaps controlled by near-ionospheric physics, rather than the other way around.

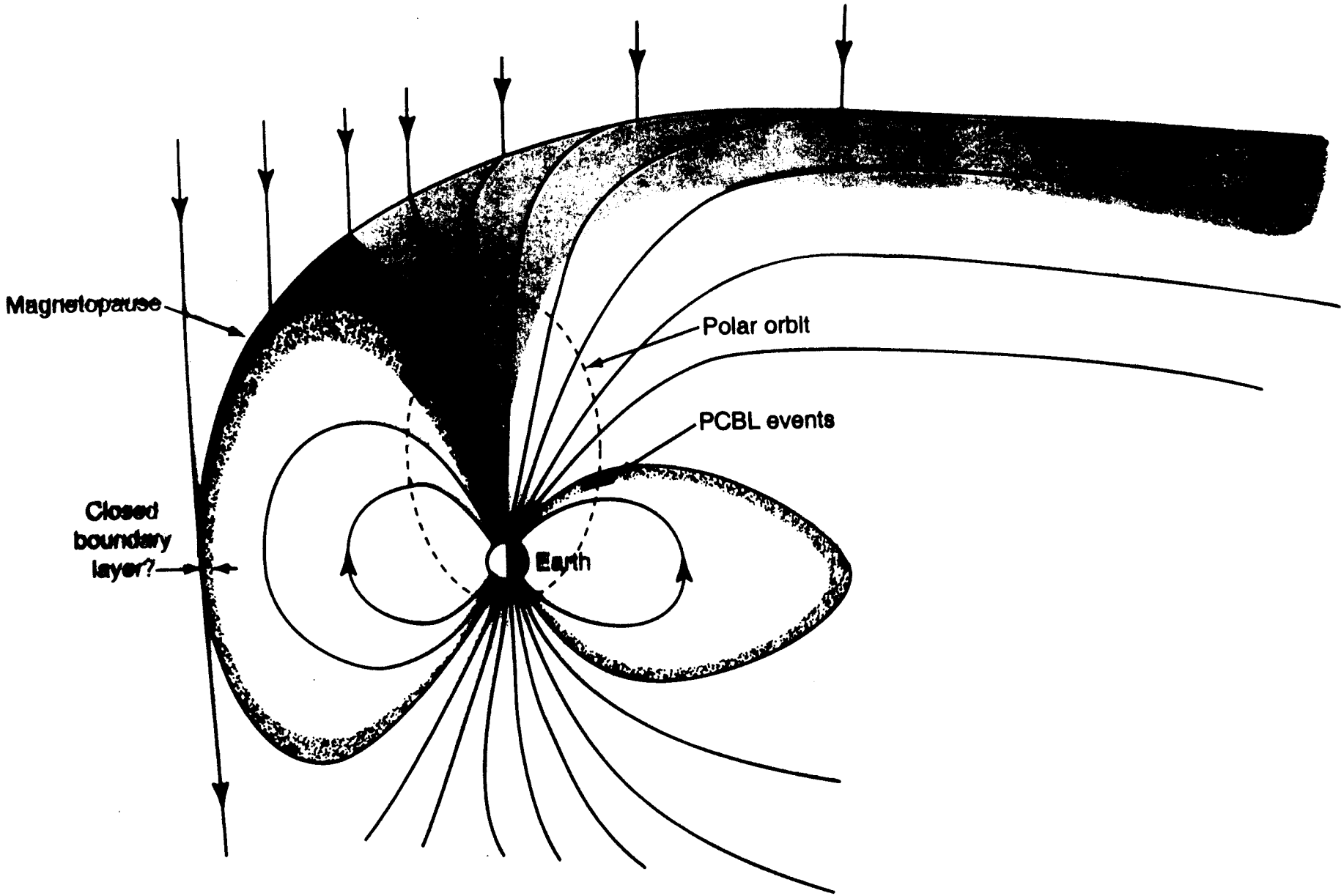
- The ionospheric parallel electric fields can easily be 10 - 100 k Volts.

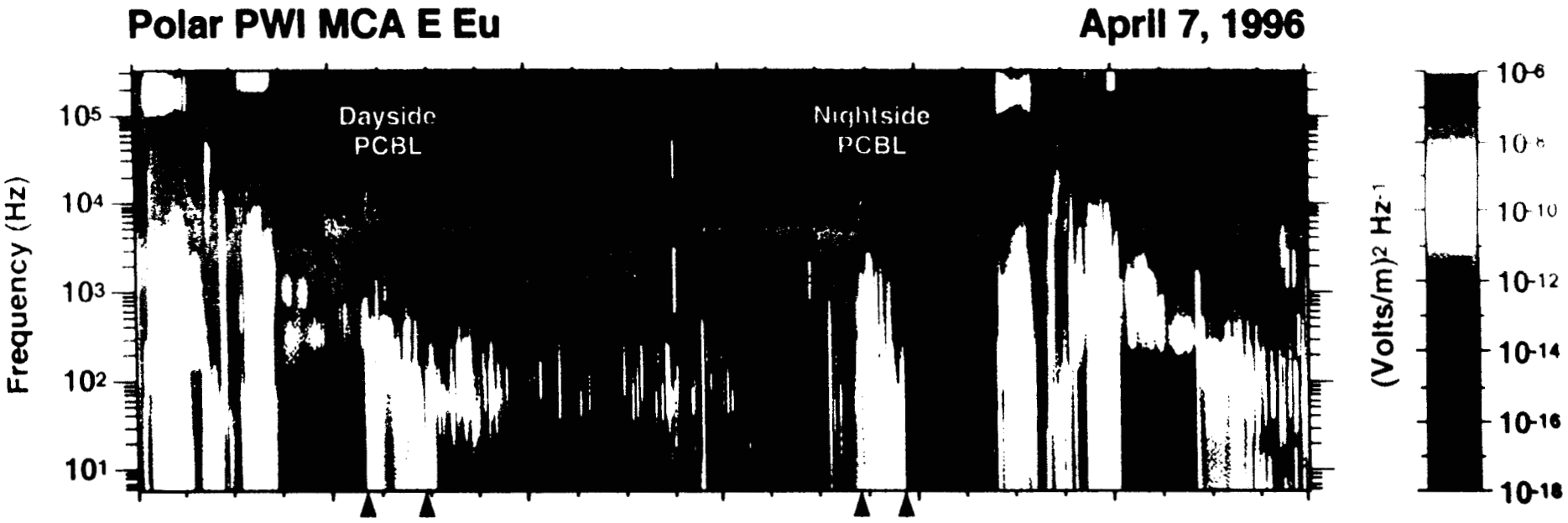
- Shock compression of the Jovian magnetosphere with simultaneous auroral observations can establish the magnetic field mapping from the equatorial plane to the ionosphere.


Bowshock
Magnetopause
Polar cusp
Magnetotail
Solar wind
Plasma pause
4R_E
(1R_E ~ 6400 km)
Earth
Bowshock
Magnetopause
Io plasma torus
Magnetotail
Planetary wind?
Solar wind
Plasma disk
20 R_J
(1 R_J = 71 400 km)
Jupiter

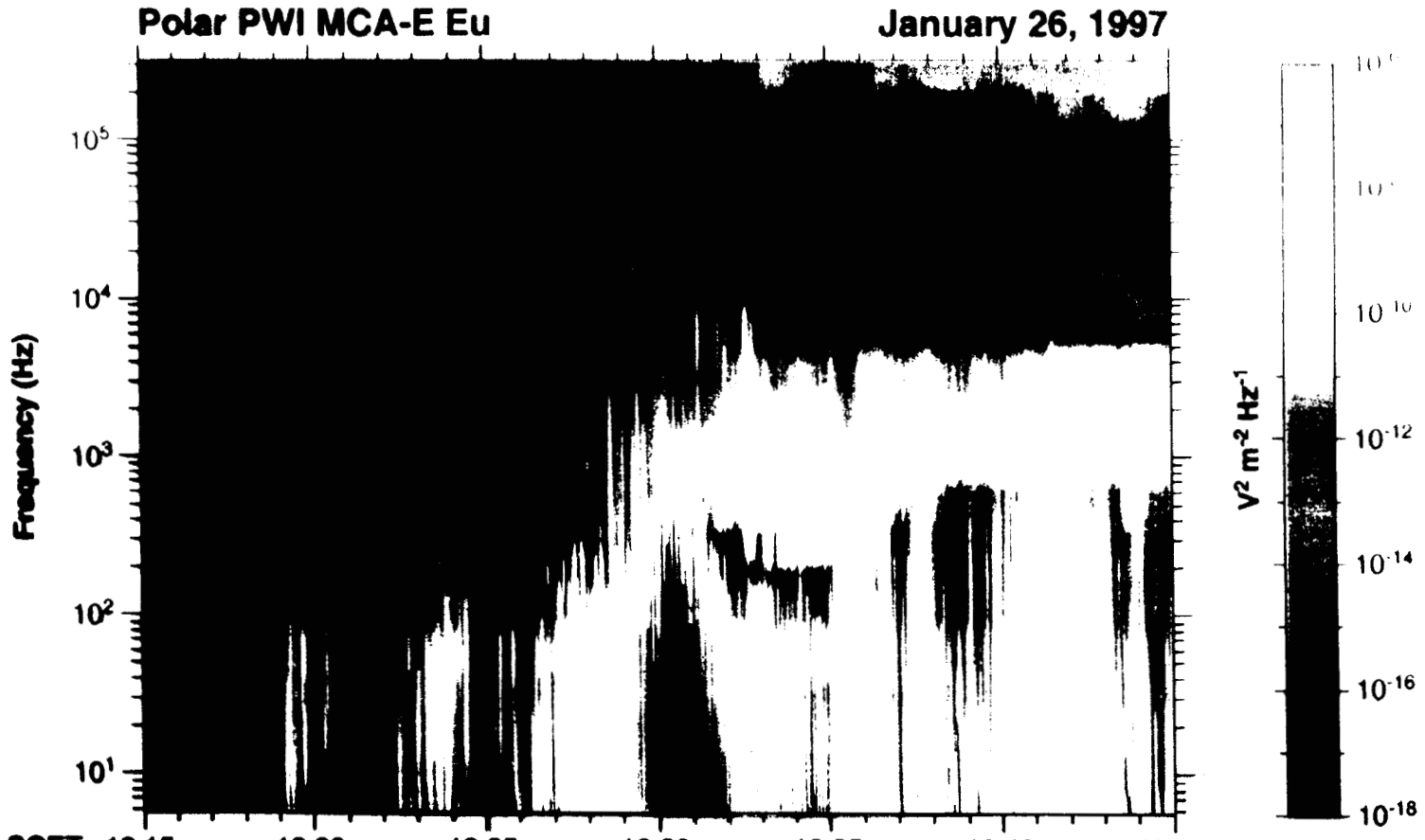

AMPTE/CCE CHEM ION DATA Dec. 13, 1984 (Day 348)
ION FLUX (1/cm2 - s - sr - keV/e)
He++
1.5 - 10 keV/e
CNO (≥ 3+)
1.5 - 10 keV/e
O+
15 - 310 keV/e
He+
15 - 310 keV/e
0300
0400
0500
0600
TIME (UT)
MAGNETOSHEATH
BOUNDARY LAYER
MAGNETOSPHERE


ISEE I NOVEMBER 8, 1977 DAY 312
BOUNDARY LAYER
311.4KHZ
178.4KHZ
100.4KHZ
56.2KHZ
31.1KHZ
17.8KHZ
10.0KHZ
5.62KHZ
3.11KHZ
1.78KHZ
1.00KHZ
562.0HZ
311.0HZ
178.0HZ
100.0HZ
56.2HZ
31.1HZ
17.8HZ
10.0HZ
5.6HZ
E²/Δf
60 dB
10.0KHZ
5.62KHZ
3.11KHZ
1.78KHZ
1.00KHZ
562.0HZ
311.0HZ
178.0HZ
100.0HZ
56.2HZ
31.1HZ
17.8HZ
10.0HZ
5.6HZ
B²/Δf
60 dB
B_L (nT)
B_M (nT)
B_N (nT)
|B| (nT)
31.1 KHZ
17.8 KHZ
10.0 KHZ
5.62 KHZ
3.11 KHZ
1.78 KHZ
1.00 KHZ
562 HZ
HAM/GUM COMPARISON
GUM
HAM
60 dB
U.T. (HR MN) 0254 0255 0256 0257 0258

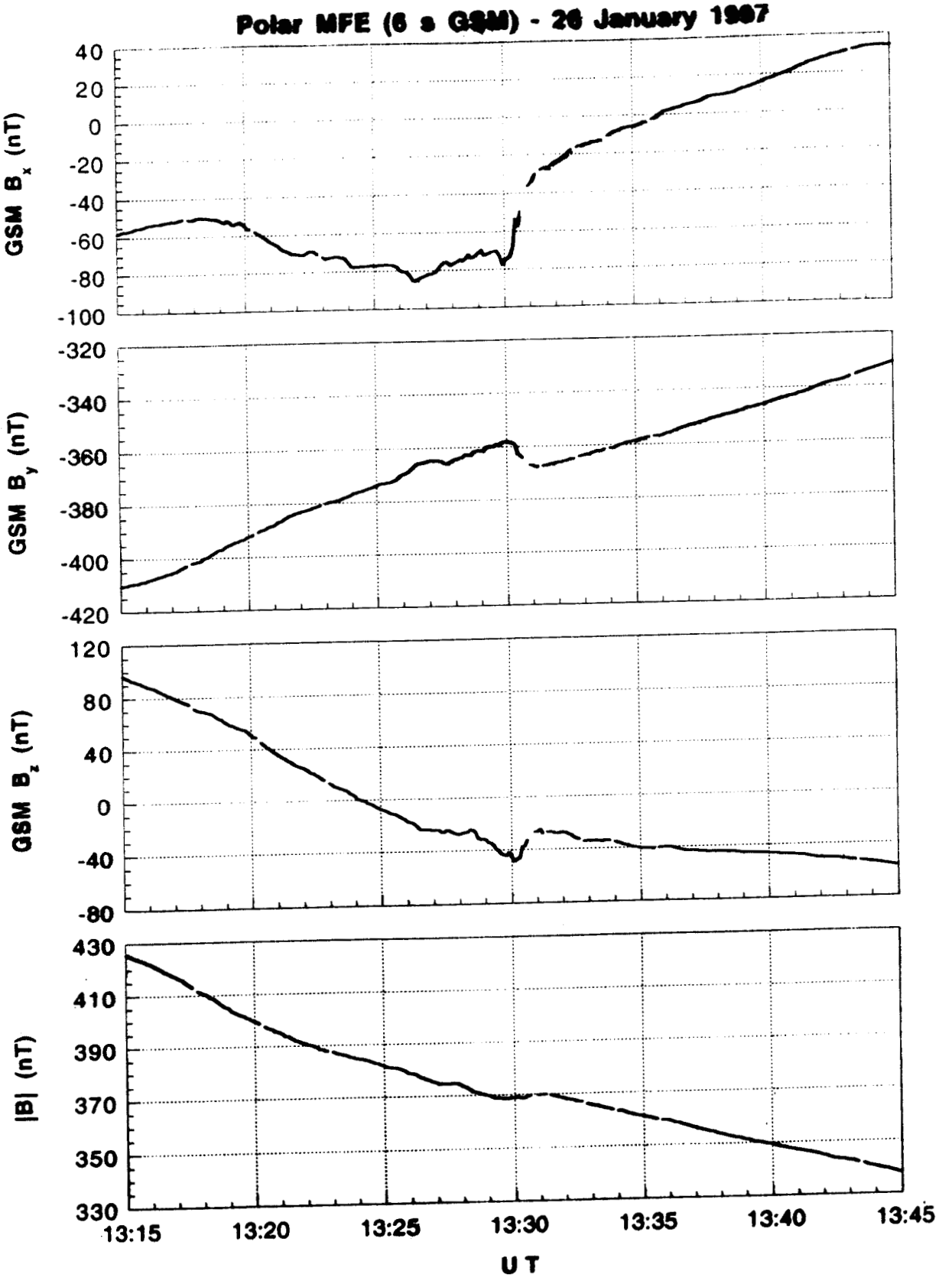

Magnetopause
Polar orbit
PCBL events
Closed boundary layer?
Earth

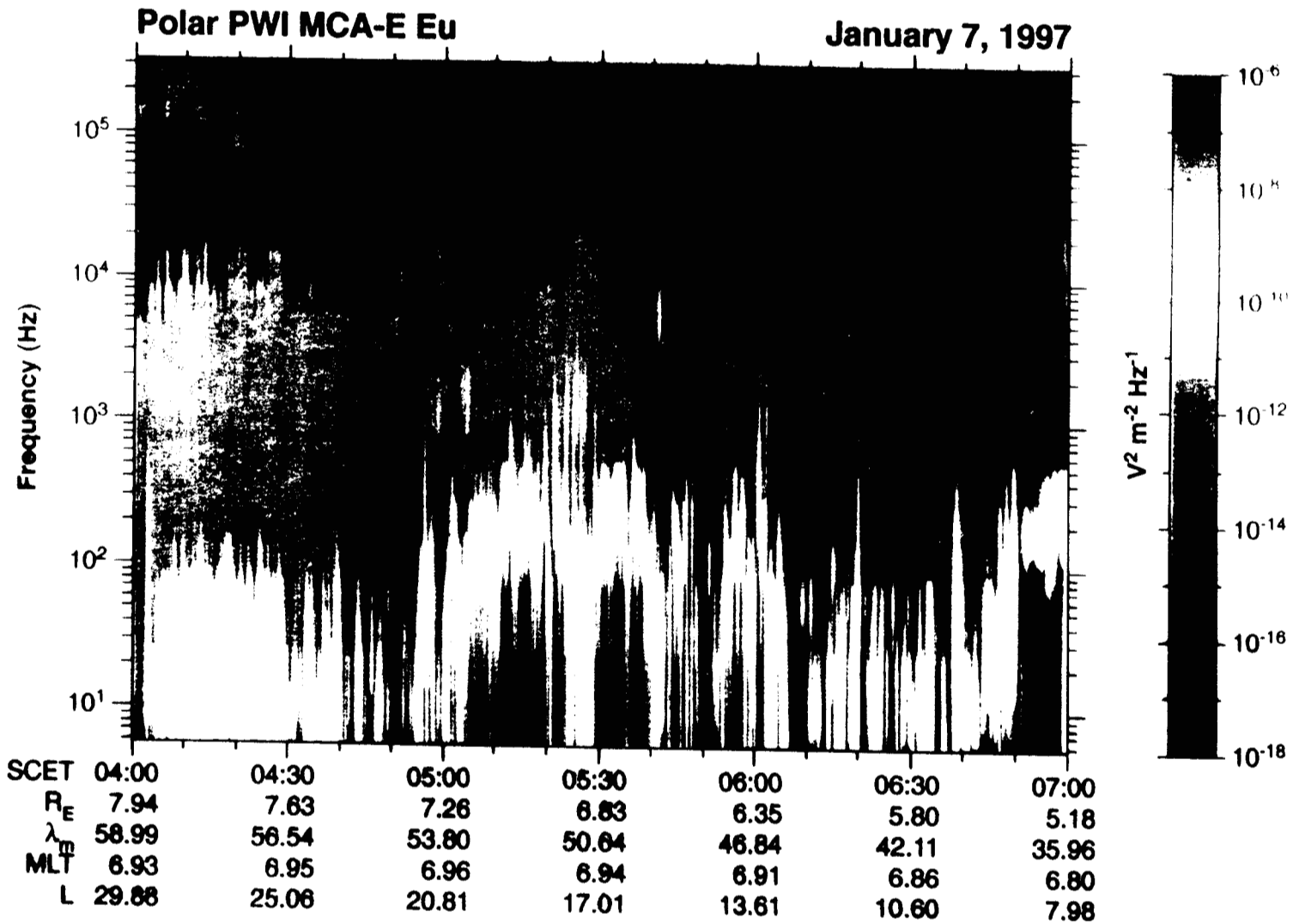


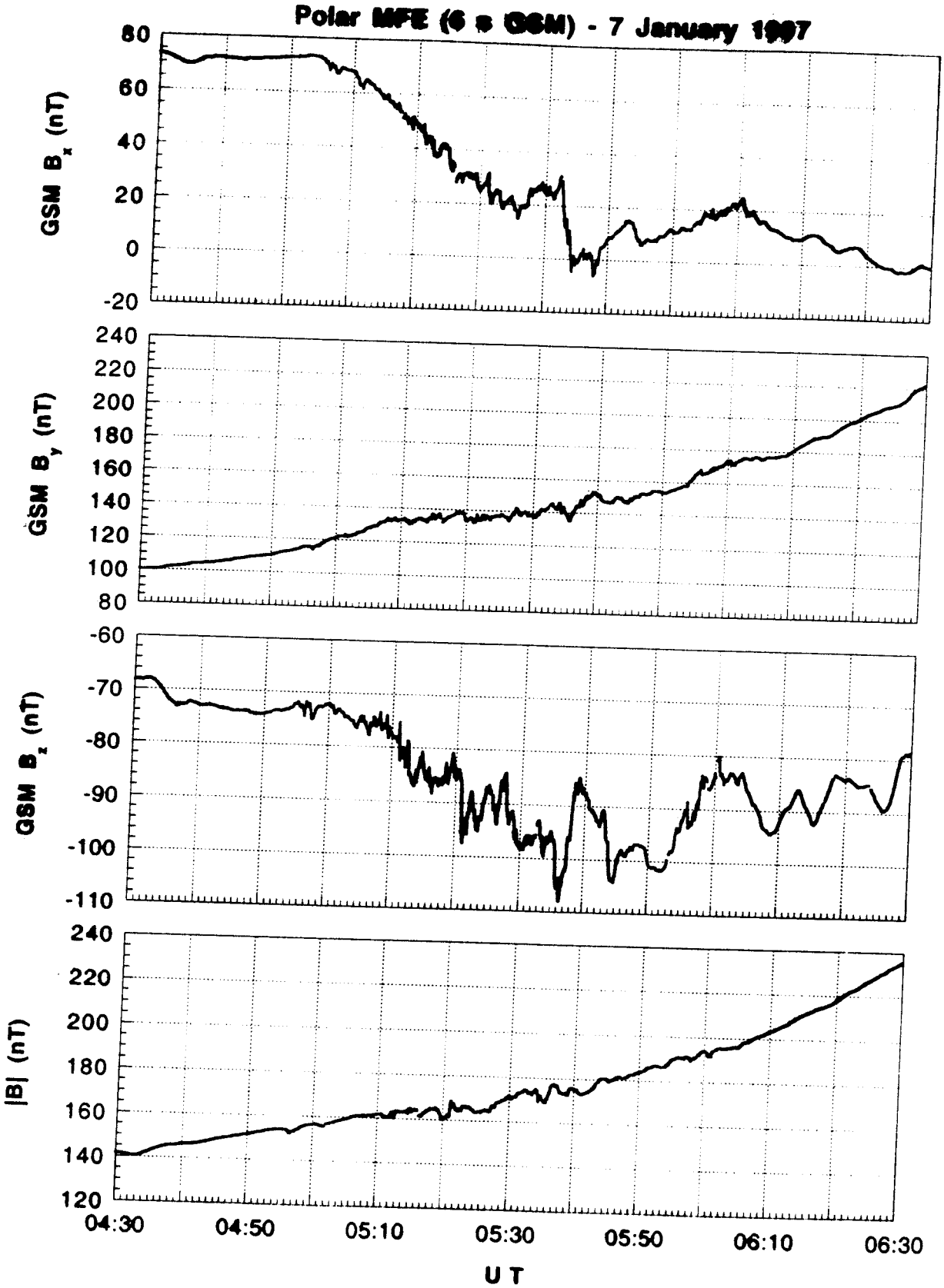
UT	00:00	04:00	08:00	12:00	16:00	20:00	00:00
R_E	4.302	4.980	8.398	8.755	6.257	2.568	7.521
λ_m	7.707	47.26	79.71	57.70	21.59	12.25	81.17
MLT	0.7827	12.71	17.56	23.02	0.3515	12.84	9.891
L	4.432	10.66	262.4	30.47	7.144	2.712	318.2

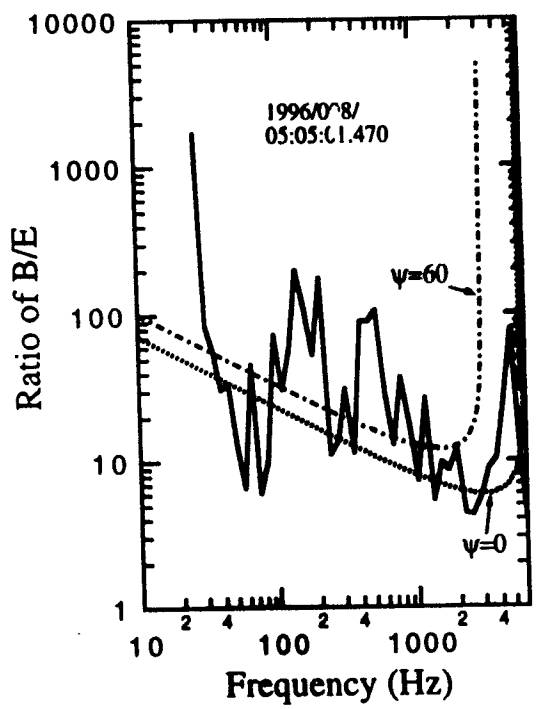


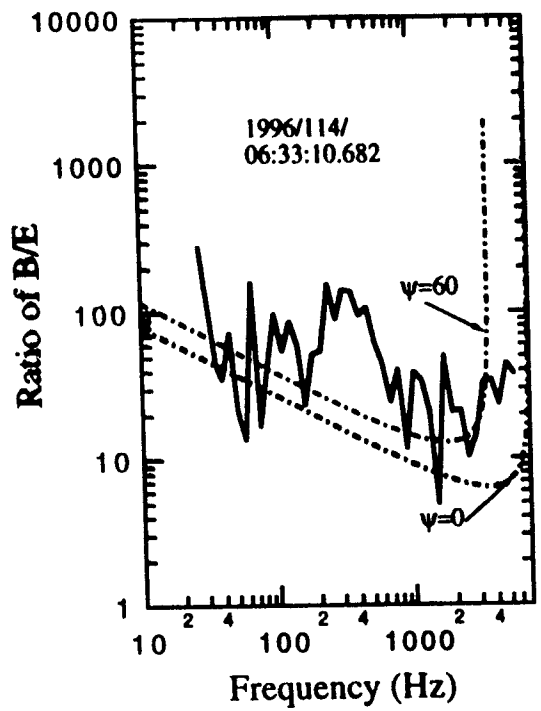
SCET	13:15	13:20	13:25	13:30	13:35	13:40	13:45
R_E	4.52	4.64	4.76	4.87	4.99	5.10	5.21
λ_m	26.36	28.26	30.08	31.82	33.48	35.07	36.60
MLT	17.52	17.55	17.59	17.62	17.66	17.69	17.73
L	5.60	5.95	6.32	6.72	7.14	7.58	8.05

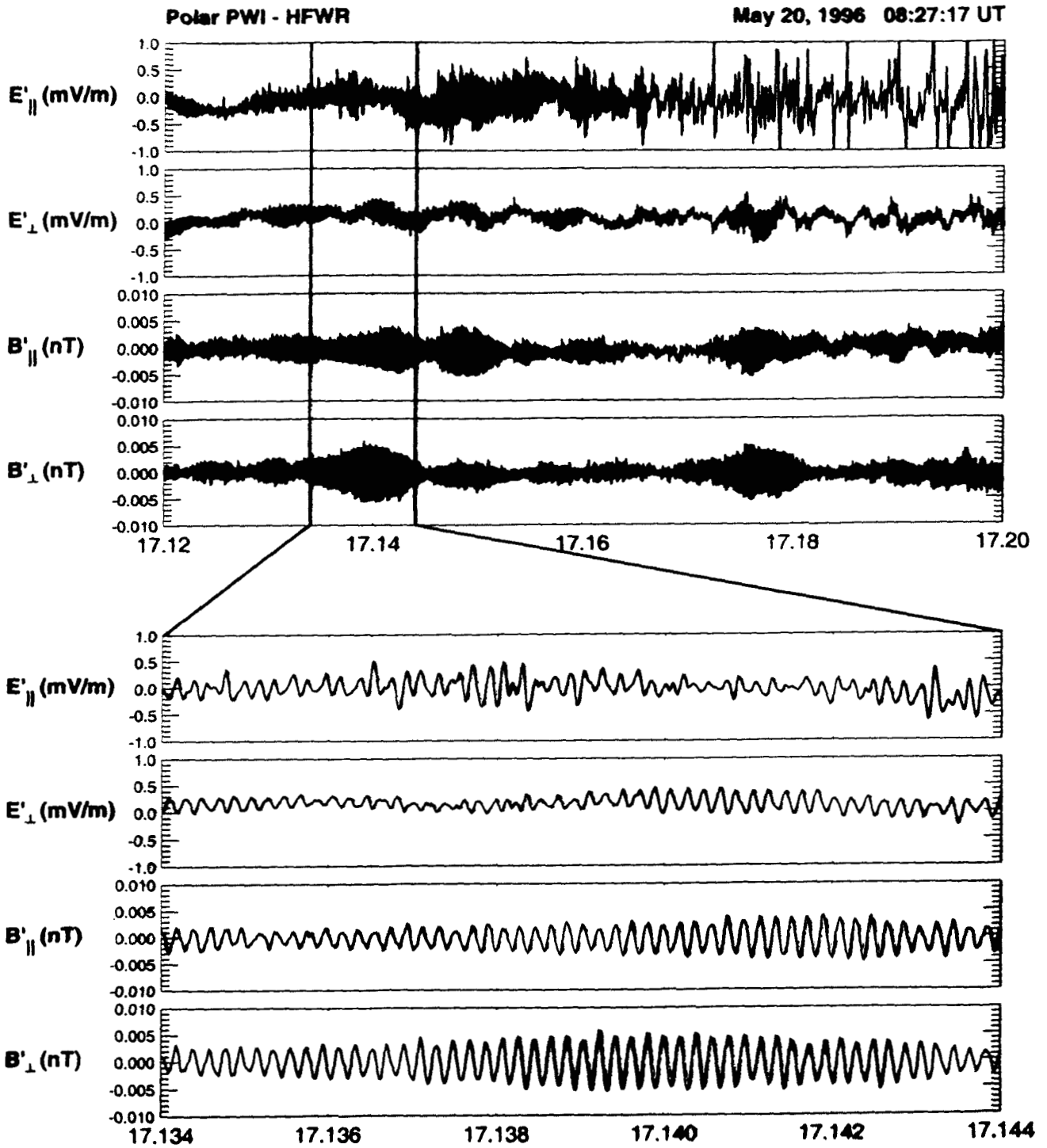

Polar MFE (6 s GSM) - 26 January 1997
GSM B_x (nT)
40
20
0
-20
-40
-60
-80
-100
GSM B_y (nT)
-320
-340
-360
-380
-400
-420
GSM B_z (nT)
120
80
40
0
-40
-80
|B| (nT)
430
410
390
370
350
330
13:15
13:20
13:25
13:30
13:35
13:40
13:45
U T

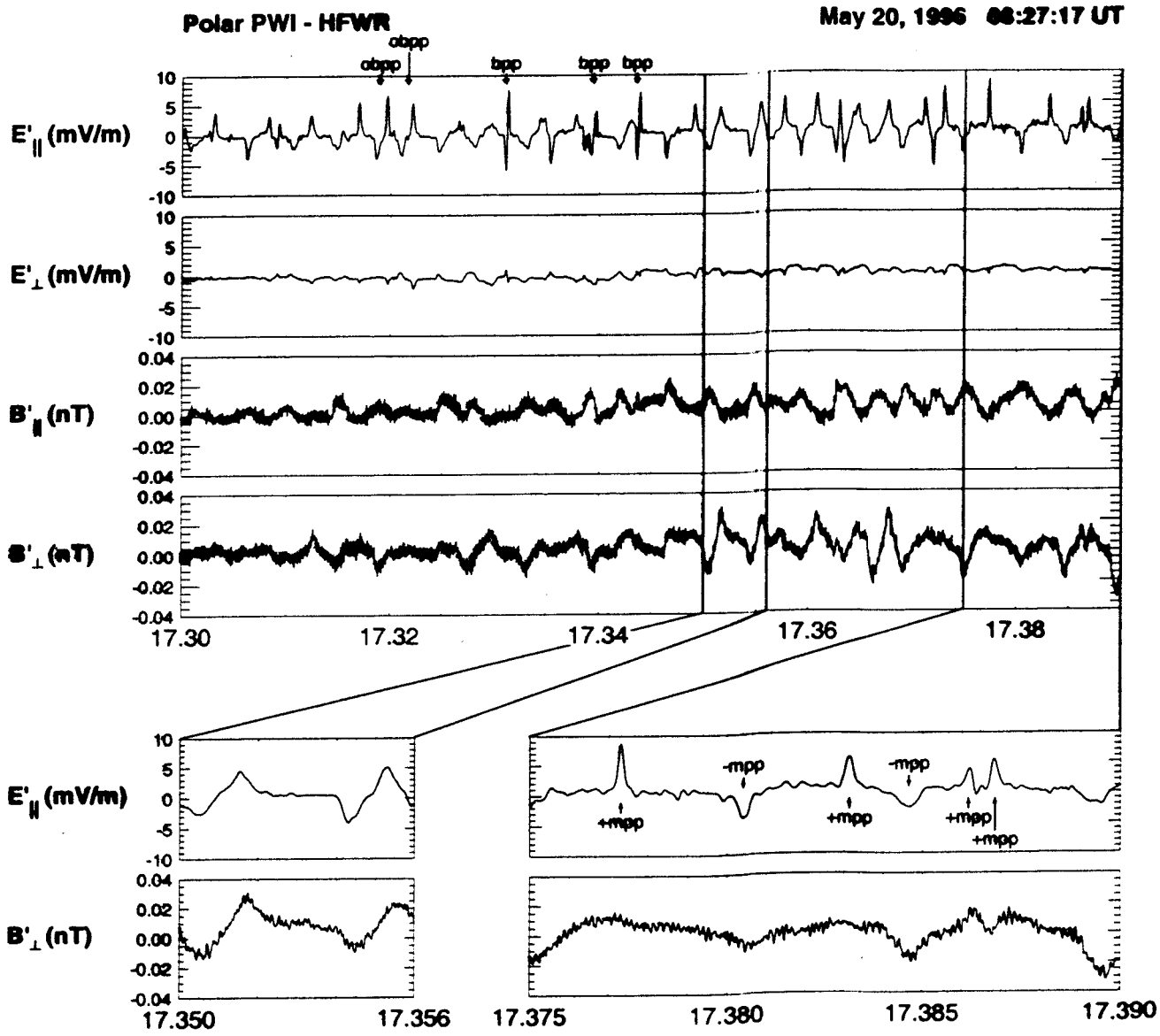

Polar PWI MCA-E Eu
January 7, 1997
Frequency (Hz)
10^5
10^4
10^3
10^2
10^1
$V^2\ m^{-2}\ Hz^{-1}$
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{-14}
10^{-16}
10^{-18}
SCET 04:00 04:30 05:00 05:30 06:00 06:30 07:00
R_E 7.94 7.63 7.26 6.83 6.35 5.80 5.18
λ_m 58.99 56.54 53.80 50.64 46.84 42.11 35.96
MLT 6.93 6.95 6.96 6.94 6.91 6.86 6.80
L 29.88 25.06 20.81 17.01 13.61 10.60 7.98

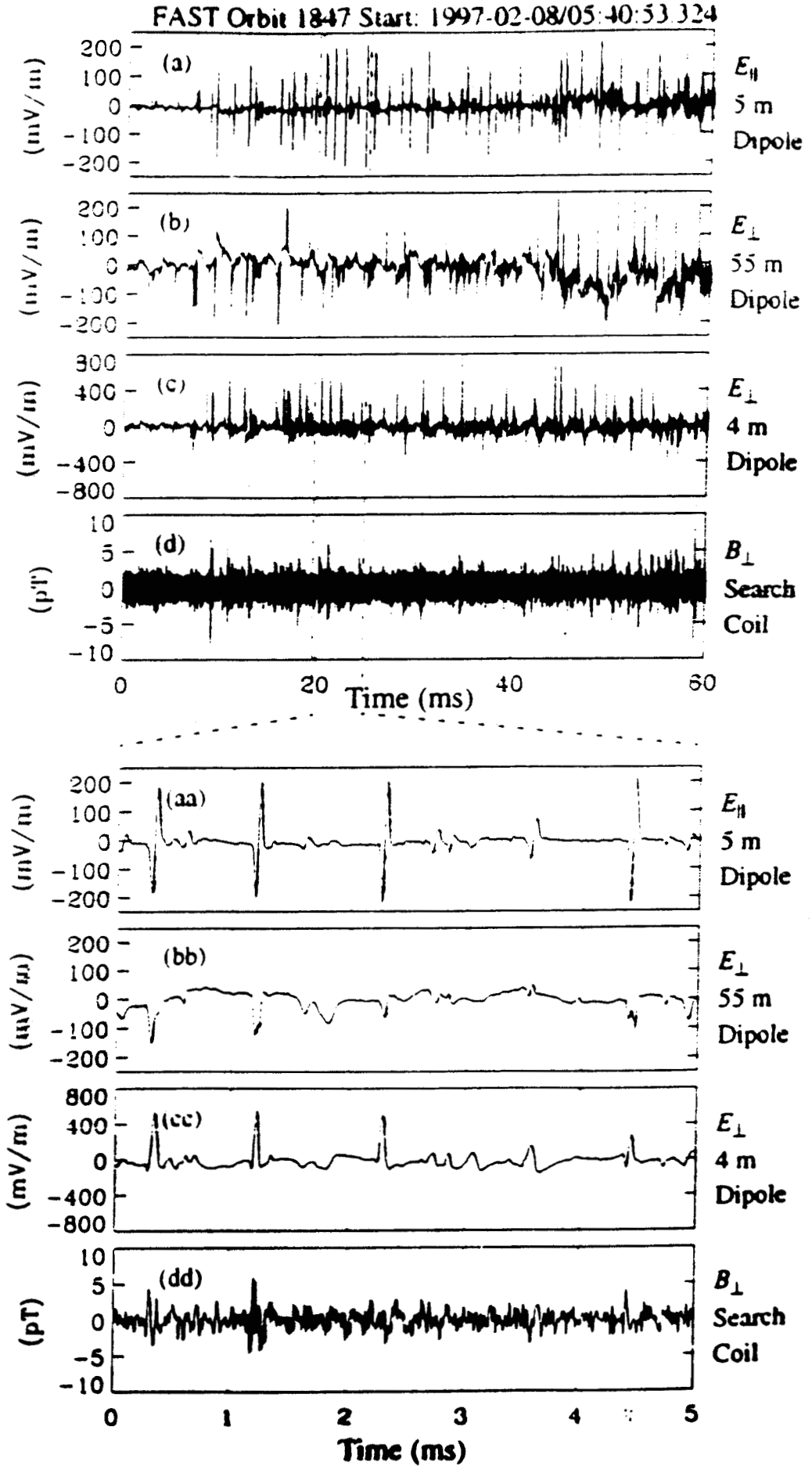

Polar MFE (6 s GSM) - 7 January 1997
GSM B_x (nT)
80
60
40
20
0
-20
GSM B_y (nT)
240
220
200
180
160
140
120
100
80
GSM B_z (nT)
-60
-70
-80
-90
-100
-110
|B| (nT)
240
220
200
180
160
140
120
04:30
04:50
05:10
05:30
05:50
06:10
06:30
U T

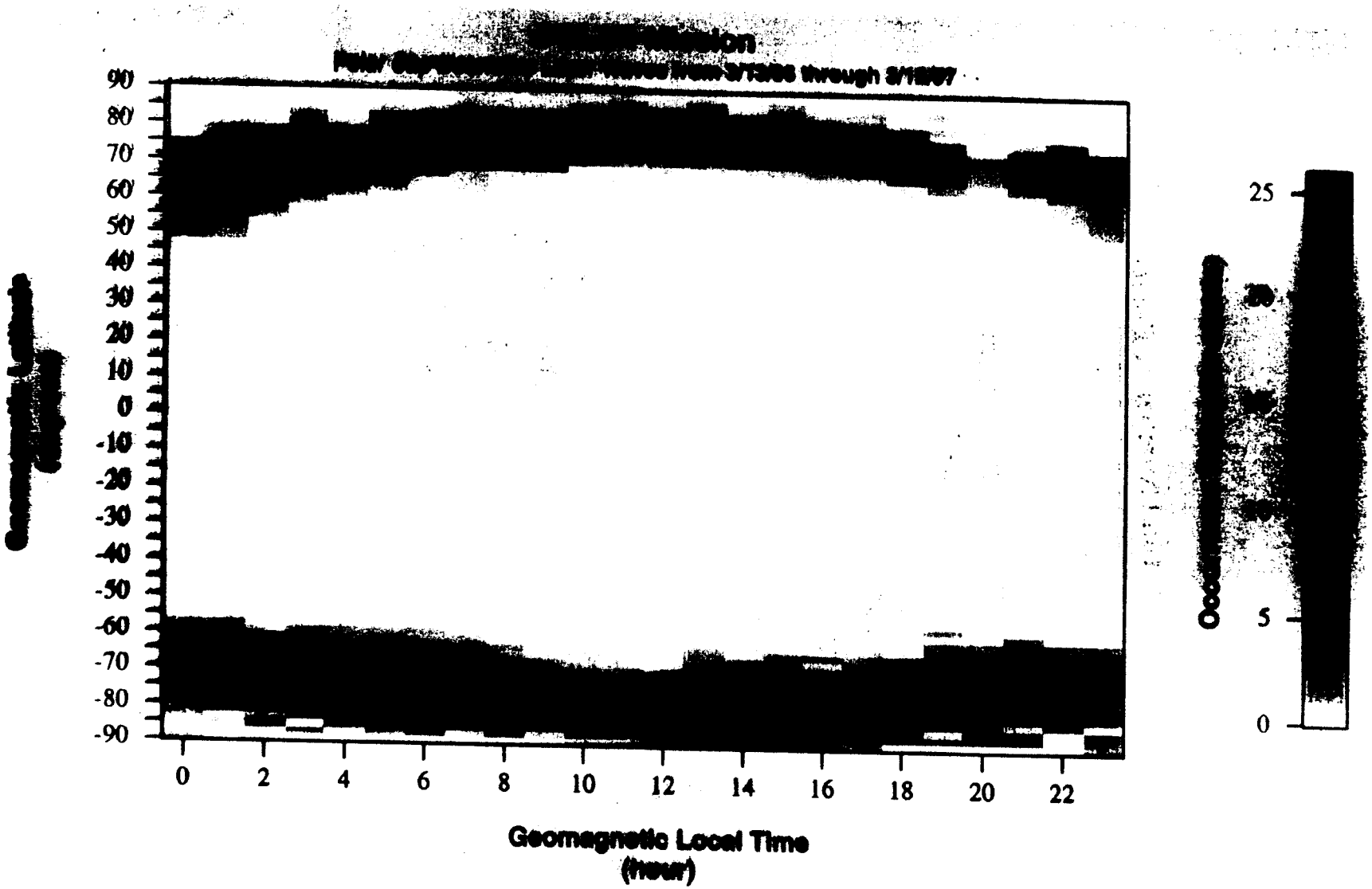

10000
1000
100
10
1
Ratio of B/E
1996/0^8/
05:05:01.470
ψ=60
ψ=0
10
100
1000
Frequency (Hz)


10000
1000
100
10
1
Ratio of B/E
1996/114/
06:33:10.682
ψ=60
ψ=0
10
100
1000
Frequency (Hz)


Polar PWI - HFWR
May 20, 1996 08:27:17 UT
E'∥ (mV/m)
E'⊥ (mV/m)
B'∥ (nT)
B'⊥ (nT)
1.0
0.5
0.0
-0.5
-1.0
0.010
0.005
0.000
-0.005
-0.010
17.12
17.14
17.16
17.18
17.20
17.134
17.136
17.138
17.140
17.142
17.144


Polar PWI - HFWR
May 20, 1996 08:27:17 UT
obpp
obpp
bpp
bpp
bpp
E'∥ (mV/m)
E'⊥ (mV/m)
B'∥ (nT)
B'⊥ (nT)
17.30
17.32
17.34
17.36
17.38
-mpp
+mpp
-mpp
+mpp
+mpp
+mpp
17.350
17.356
17.375
17.380
17.385
17.390


FAST Orbit 1847 Start: 1997-02-08/05:40:53.324
(a)
(b)
(c)
(d)
(aa)
(bb)
(cc)
(dd)
(mV/m)
(pT)
$E_{\parallel}$
5 m
Dipole
$E_{\perp}$
55 m
Dipole
$E_{\perp}$
4 m
Dipole
$B_{\perp}$
Search
Coil
Time (ms)


90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
0
2
4
6
8
10
12
14
16
18
20
22
Geomagnetic Local Time
(hour)
25
5
0