SRAHP

INTERPLANETARY SHOCK TRIGGERING OF SUBSTORMS

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We use WIND solar wind data and POLAR UV imaging data to study magnetospheric responses and substorm triggering mechanisms during and after interplanetary (IP) shock events. It is found that the solar wind precondition determines the causes of the different auroral responses, with a ~ 1.5 hr "precondition" (upstream of the IP shock) giving the best empirical results. The upstream IMF B_z is strongly southward prior to substorm triggerings (44% of all events), the IMF B_z is ~ 0 nT for PB triggerings (39% of all events), and the IMF is almost purely northward for quiescent events (17%). A magnetotail-compression substorm triggering model is developed and presented. This model uses dayside magnetic reconnection to load the near-Earth plasma sheet and a current disruption mechanism to unload the stored energy. We call this model a Dripping, Tilting Bucket (DTB) model.

INTERPLANETARY SHOCK TRIGGERING OF AURORAL SUBSTORM ACTIVITY: A MECHANISM

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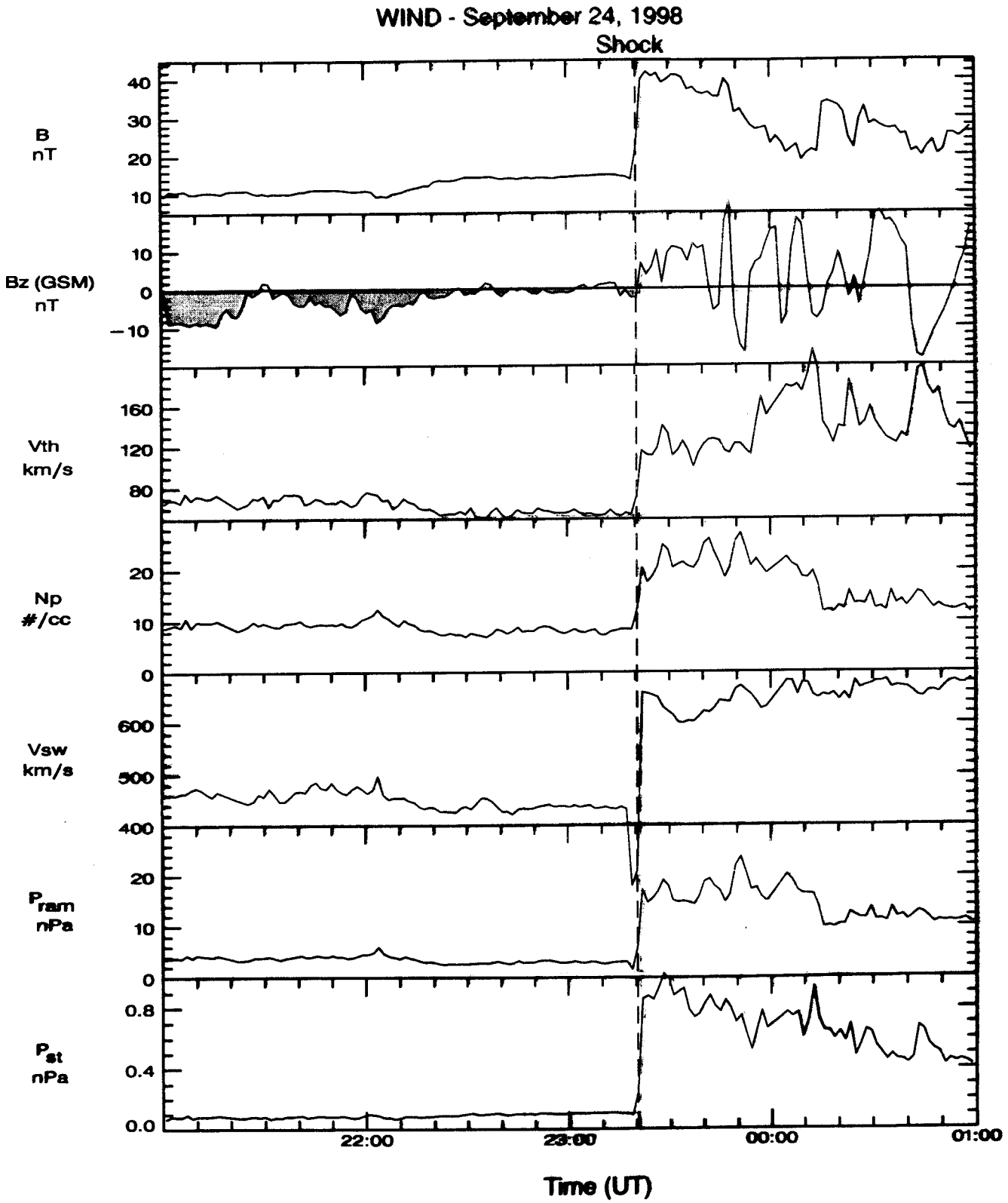
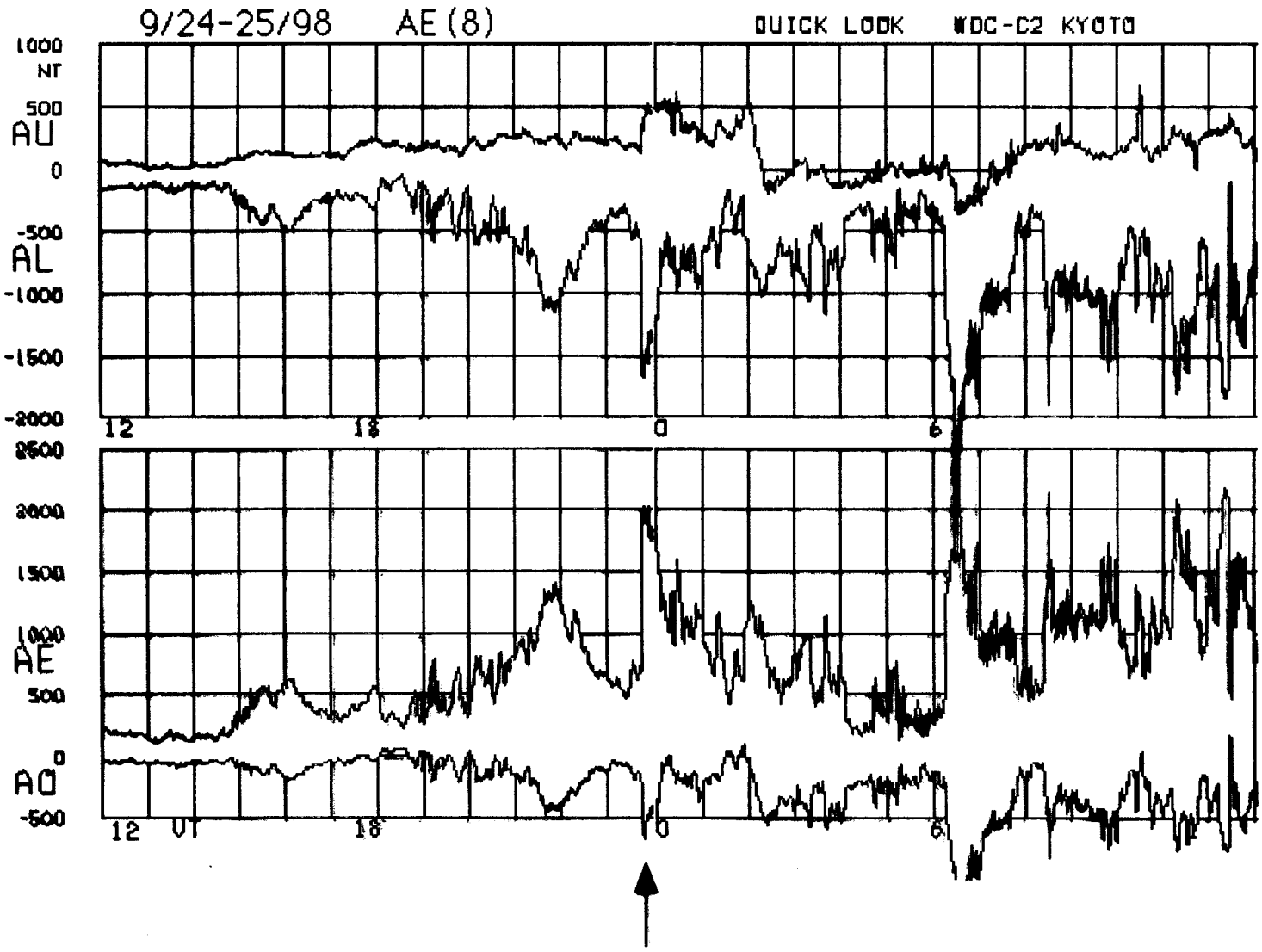
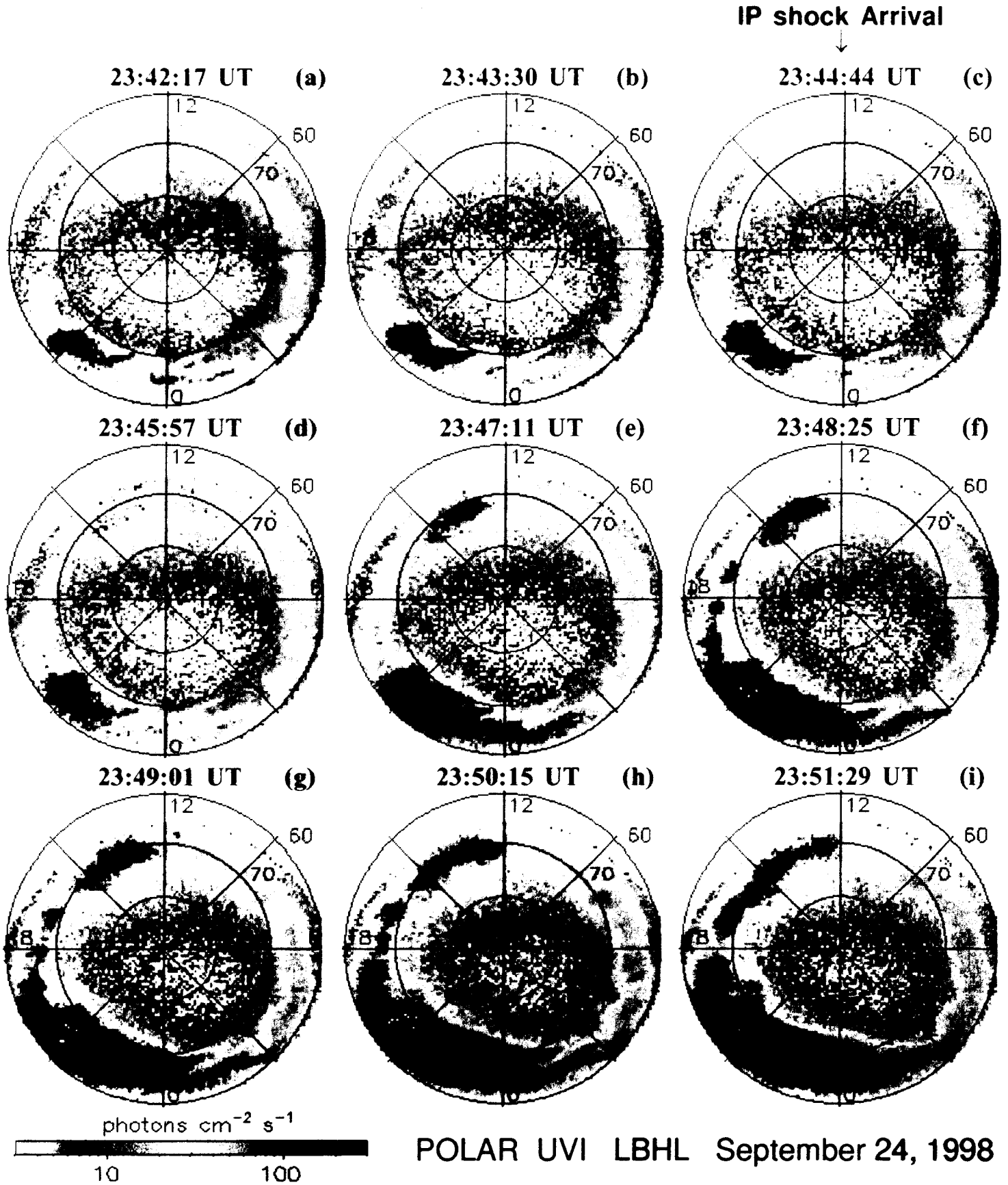
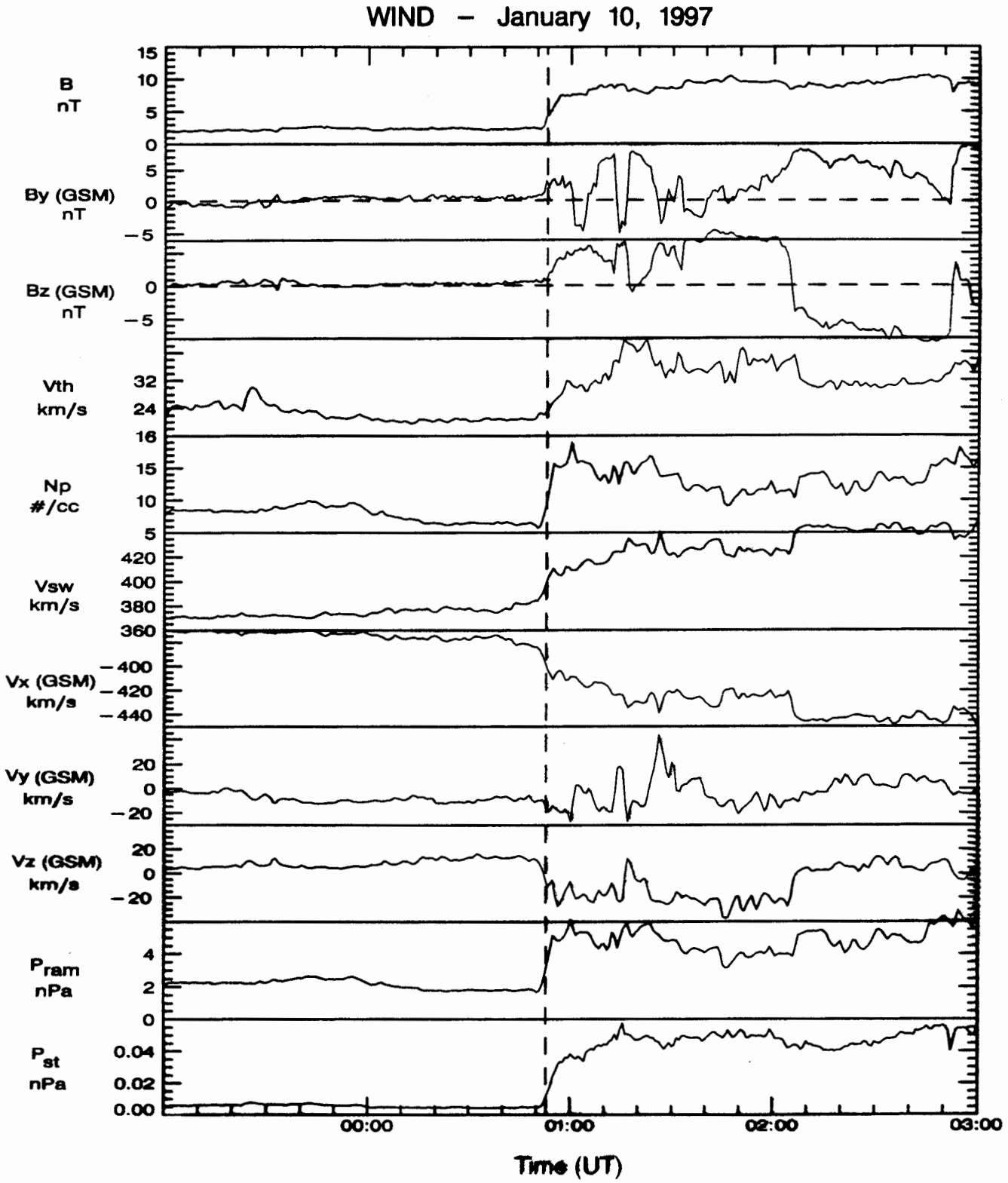

WIND - September 24, 1998
Shock
B
nT
40
30
20
10
Bz (GSM)
nT
10
0
−10
Vth
km/s
160
120
80
Np
#/cc
20
10
0
Vsw
km/s
600
500
400
Pram
nPa
20
10
0
Pst
nPa
0.8
0.4
0.0
22:00
23:00
00:00
01:00
Time (UT)



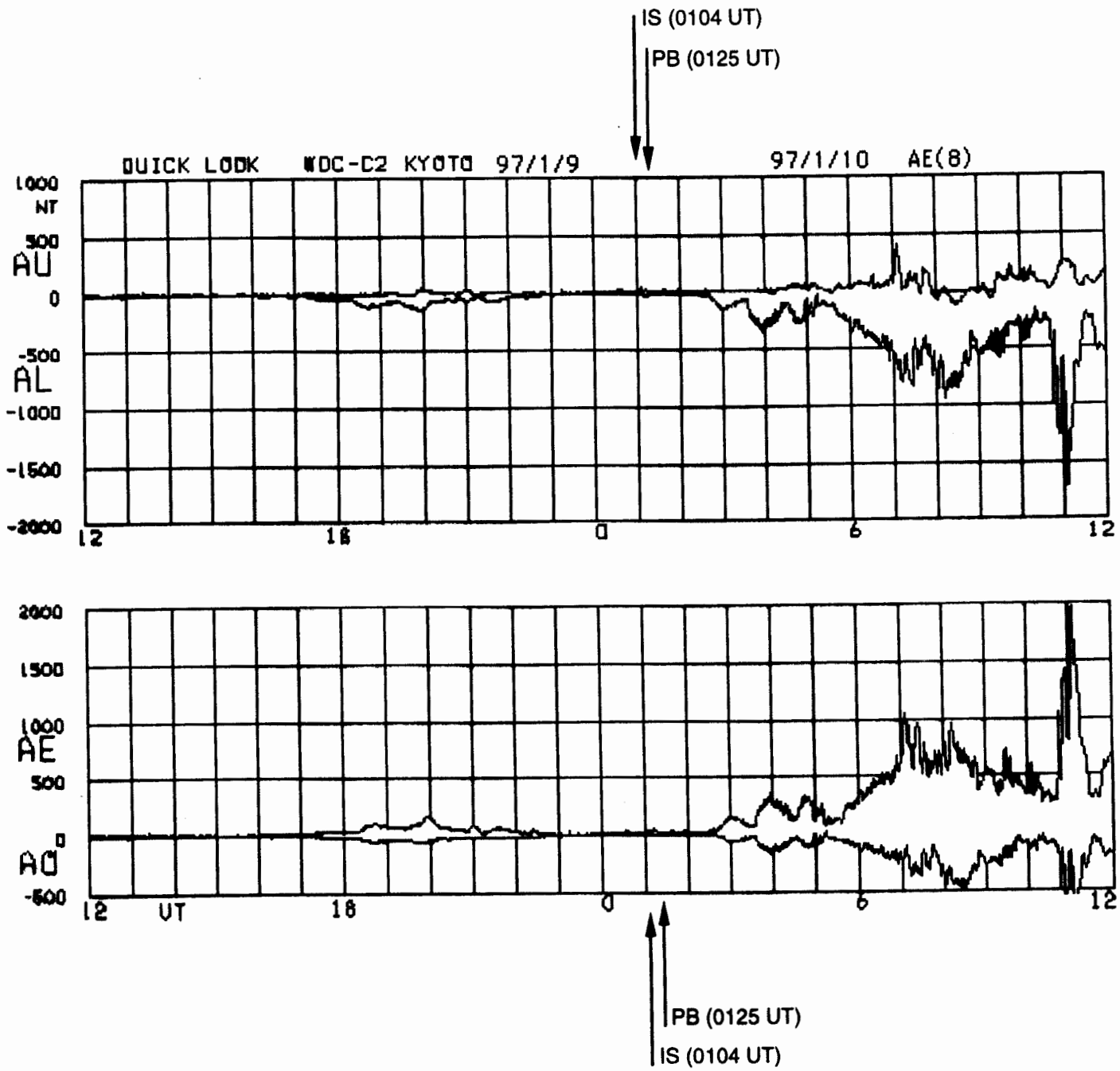
IP shock triggered
substorm intensification



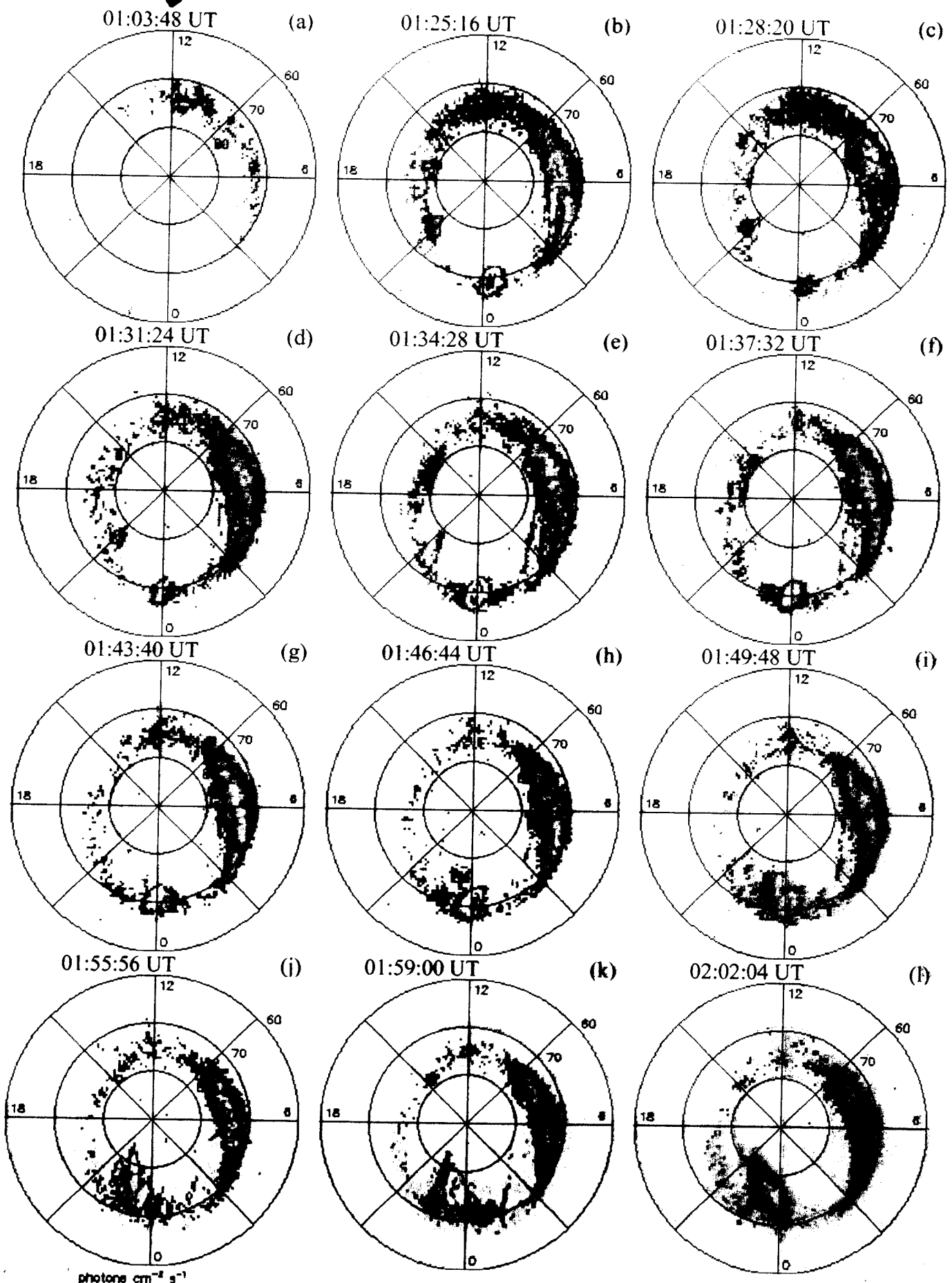
POLAR UVI LBHL September 24, 1998

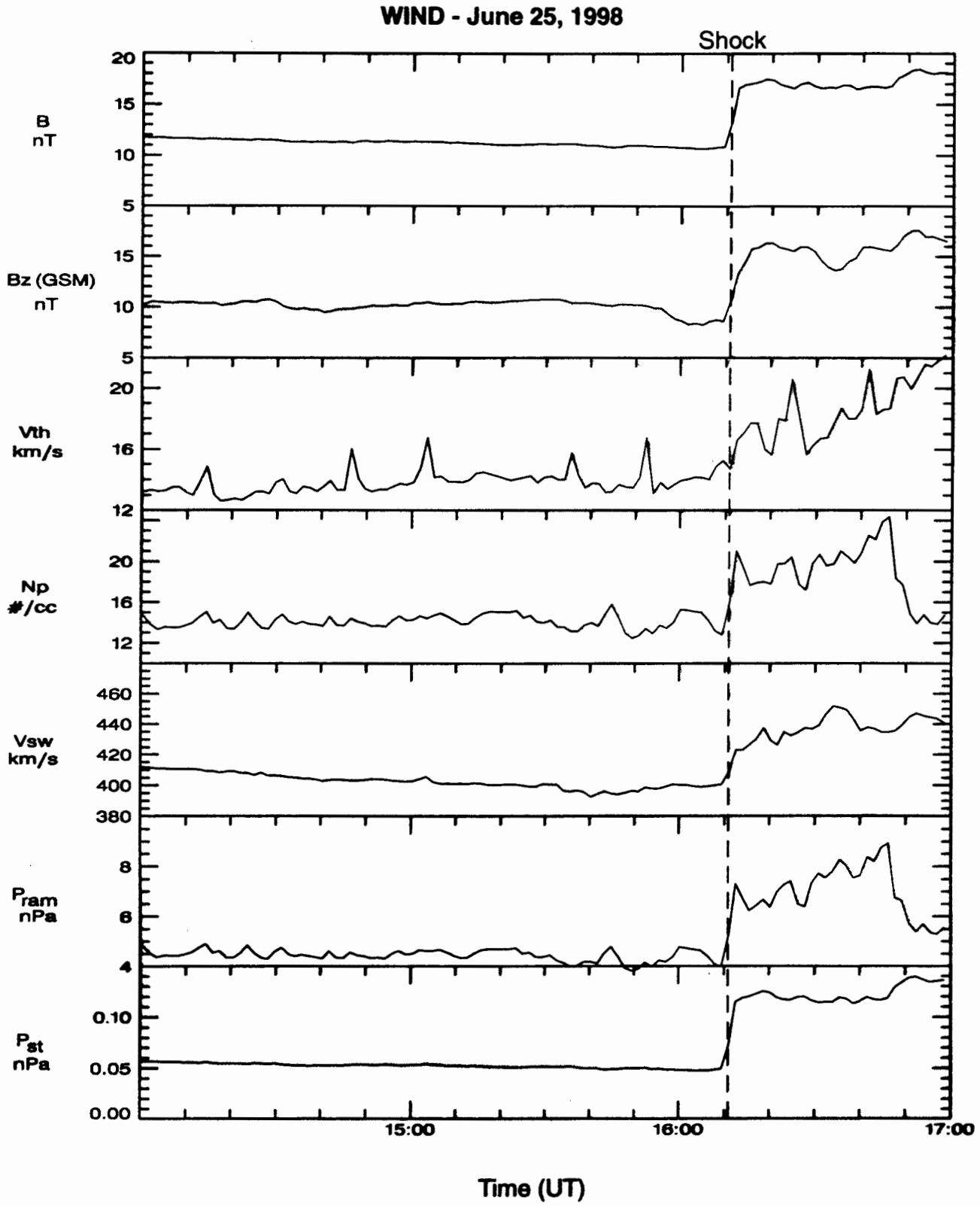


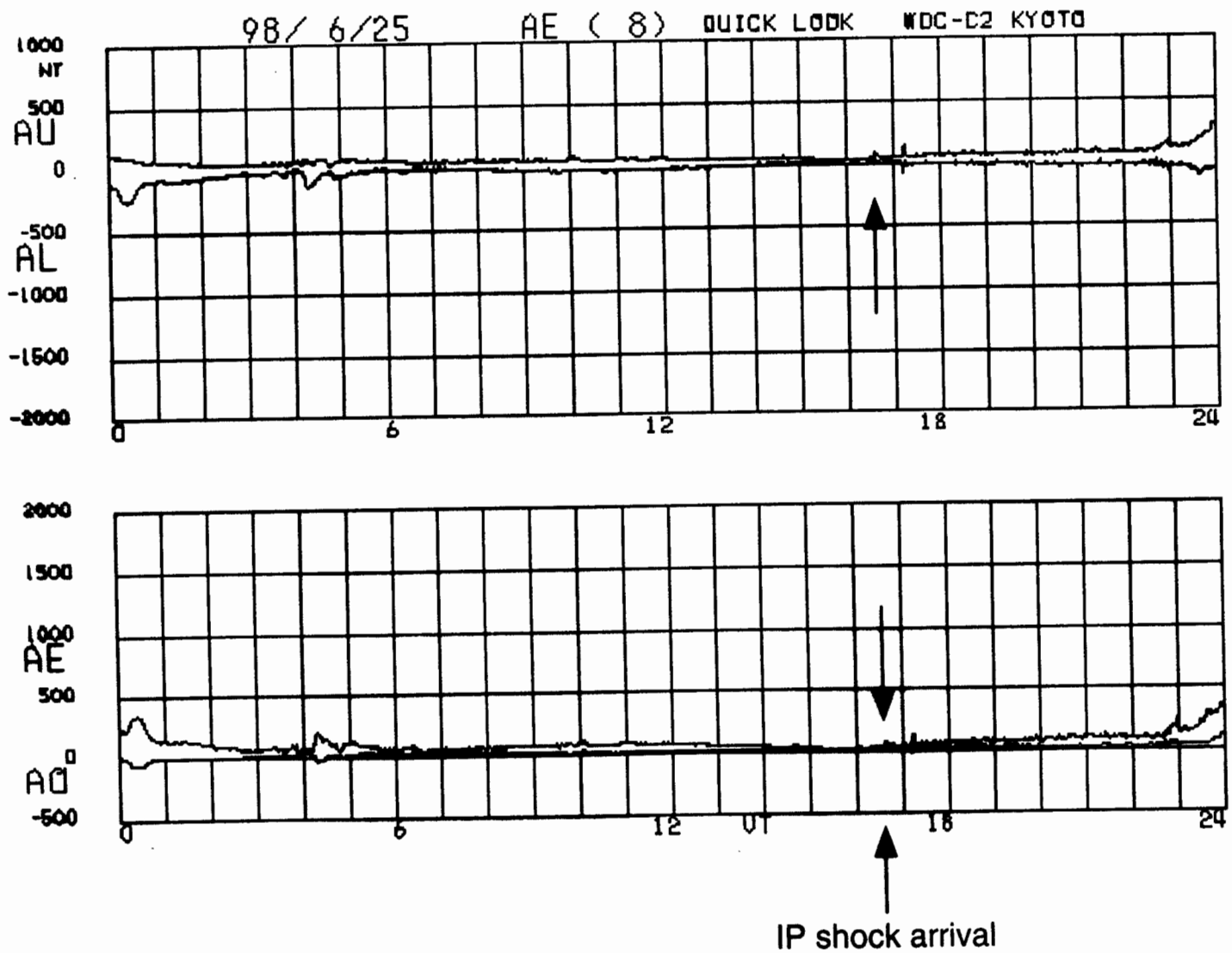
Xgsm (Re)	84.3	84.7	85.1	85.4	85.8
Ygsm (Re)	-54.9	-54.9	-55.2	-55.8	-56.6
Zgsm (Re)	-23.3	-23.1	-22.1	-20.4	-18.1

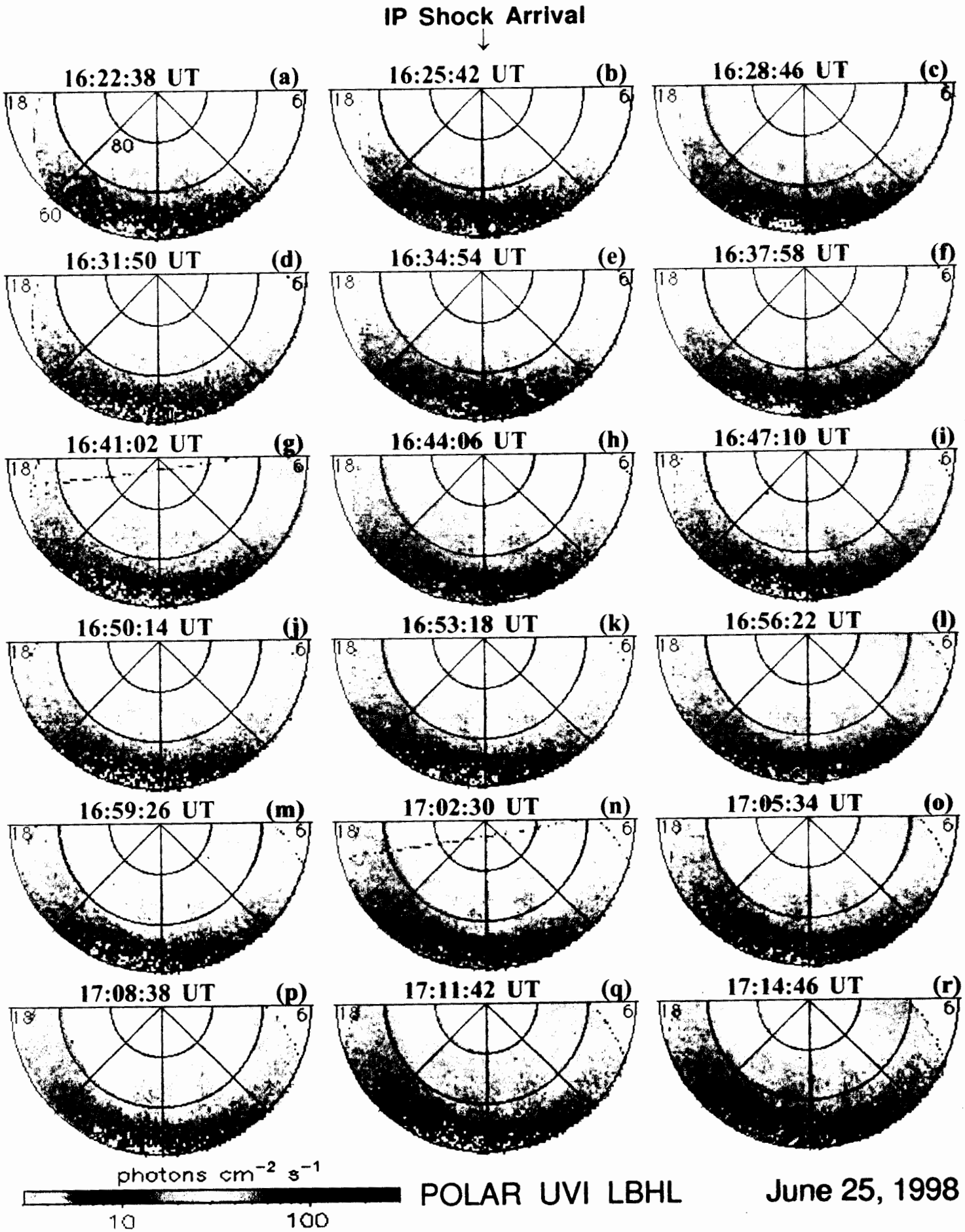

IS (0104 UT)
PB (0125 UT)
QUICK LOOK WDC-C2 KYOTO 97/1/9
97/1/10 AE(8)
1000
NT
500
AU
0
-500
AL
-1000
-1500
-2000
12
18
0
6
12
2000
1500
1000
AE
500
AO
0
-500
12
UT
18
0
6
12
PB (0125 UT)
IS (0104 UT)

IP Shock arrival




WIND - June 25, 1998
Shock
B
nT
20
15
10
5
Bz (GSM)
nT
15
10
5
Vth
km/s
20
16
12
Np
#/cc
20
16
12
Vsw
km/s
460
440
420
400
380
Pram
nPa
8
6
4
Pst
nPa
0.10
0.05
0.00
15:00
16:00
17:00
Time (UT)


98/ 6/25 AE (8) QUICK LOOK WDC-C2 KYOTO
1000
NT
500
AU
0
-500
AL
-1000
-1500
-2000
0
6
12
18
24
2000
1500
1000
AE
500
0
AO
-500
0
6
12
UT
18
24
IP shock arrival



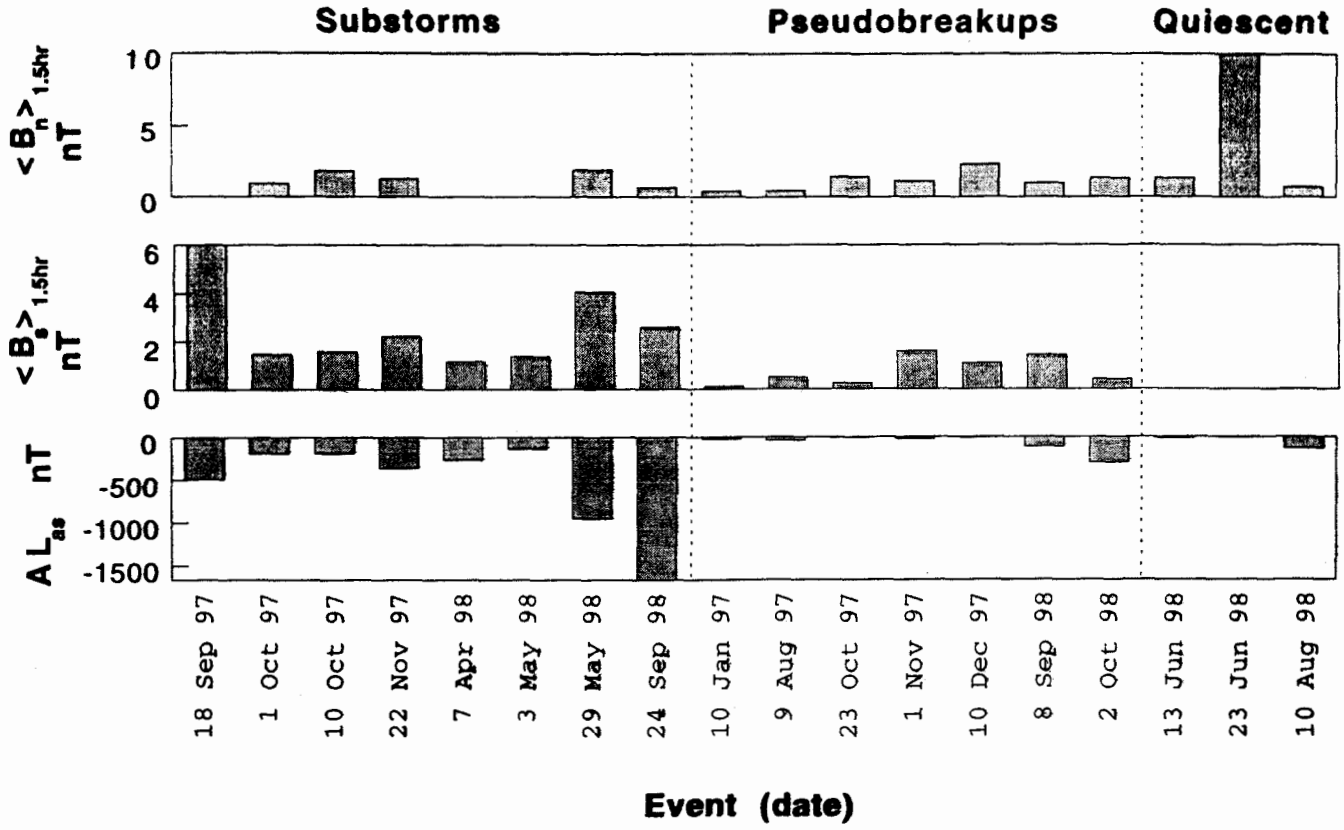
POLAR UVI LBHL

June 25, 1998

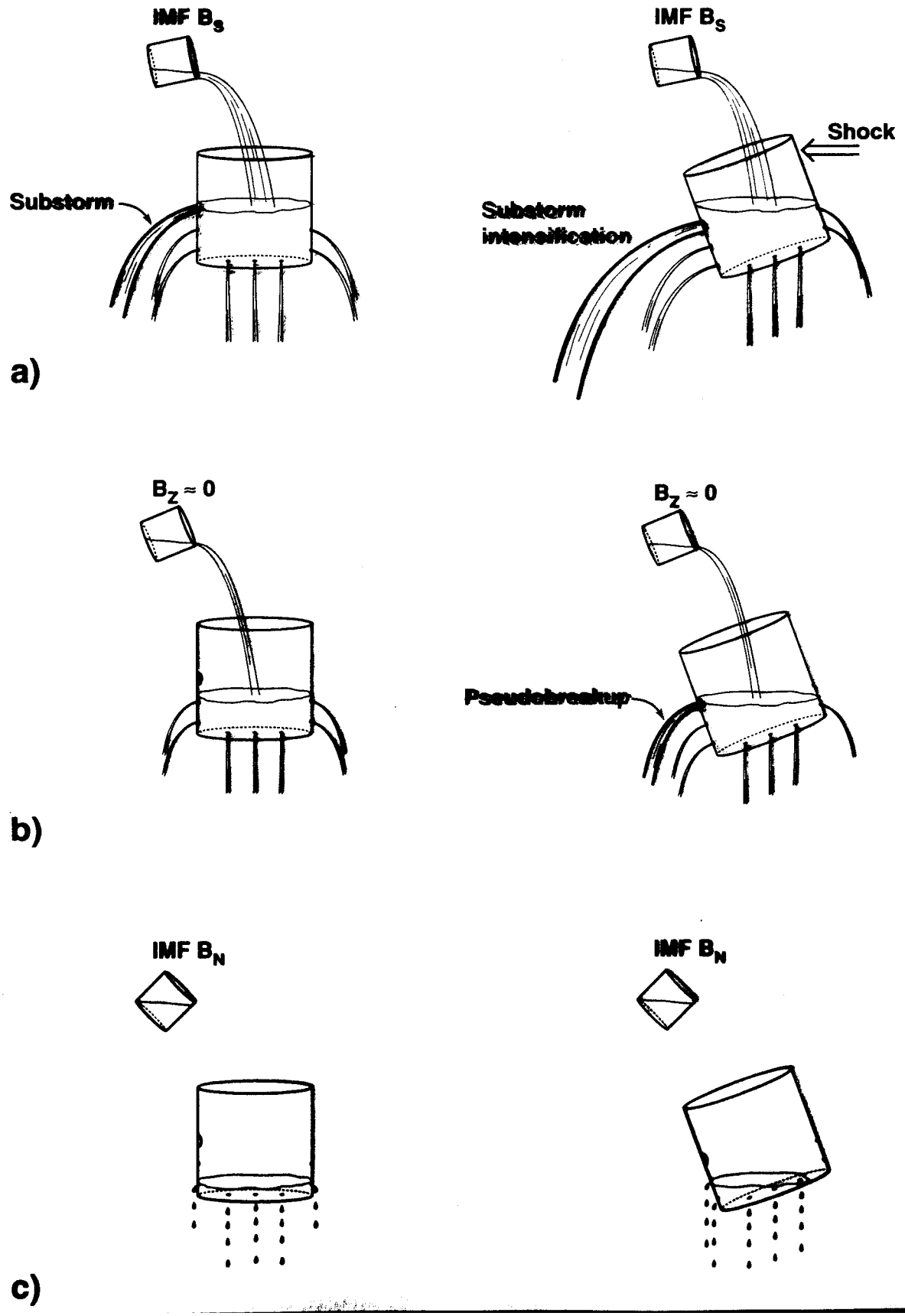
Associated IMF Bz turning events

(Within expected time ± 15 min)

Type	Date	IMF Bn (nT) Events	IMF Bs (nT) Events
	Sep 18, 1997	No	No
	Oct 1, 1997	No	No
	Oct 10, 1997	Yes	No
	Nov 22, 1997	No	No
SS	Apr 7, 1998	No	No
	May 3, 1998	No	No
	May 29, 1998	No	Yes
	Sep 24, 1998	Yes	No
	Jan 10, 1997	No	No
	Aug 9, 1997	Yes	No
	Oct 23, 1997	No	No
PB	Nov 1, 1997	No	No
	Dec 10, 1997	No	No
	Sep 8, 1998	No	Yes
	Oct 2, 1998	No	No


Substorms
Pseudobreakups
Quiescent
<B_n>_1.5hr nT
10
5
0
<B_s>_1.5hr nT
6
4
2
0
AL_as nT
0
-500
-1000
-1500
18 Sep 97
1 Oct 97
10 Oct 97
22 Nov 97
7 Apr 98
3 May 98
29 May 98
24 Sep 98
10 Jan 97
9 Aug 97
23 Oct 97
1 Nov 97
10 Dec 97
8 Sep 98
2 Oct 98
13 Jun 98
23 Jun 98
10 Aug 98
Event (date)

Dripping, Tilting Bucket Model



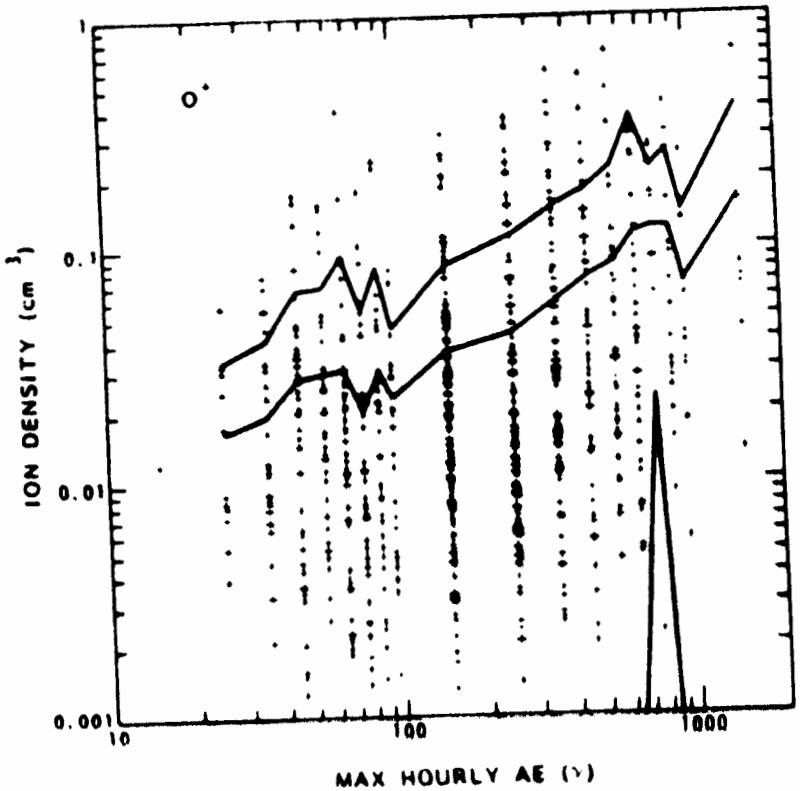


Fig. 6. A scatter plot of all the individual samples of the O^+ number density. The three lines show the average (middle line) and the average plus or minus one sample standard deviation (as opposed to a standard deviation of the average itself). The lowermost of these three is partly below scale.

Lennartsson & Shelly JGR. 1986

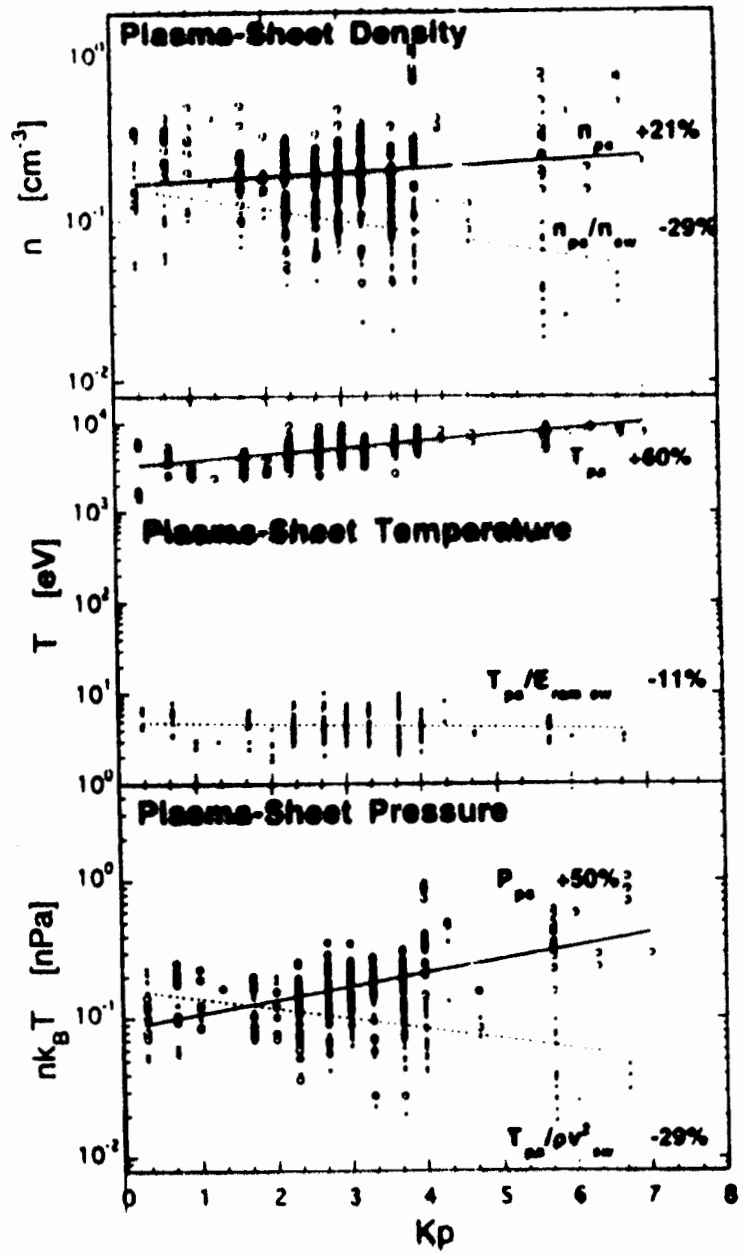
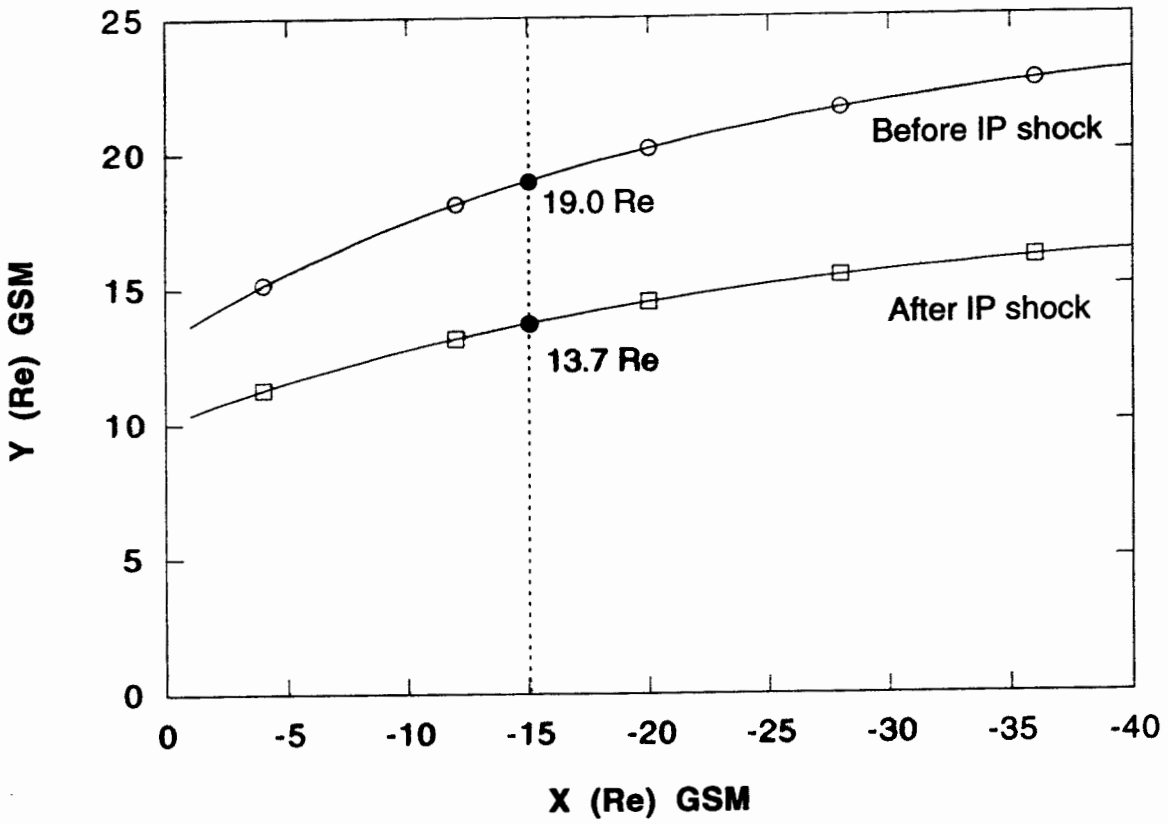


Figure 9. For neutral-sheet encounters between 17.5 and 22.5 R_E, the density, temperature, and particle pressure of the plasma sheet are plotted as functions of Kp and then normalised to instantaneous solar wind quantities and replotted.

Brambu et al JGR, 1986


25
20
15
10
5
0
Y (Re) GSM
0
-5
-10
-15
-20
-25
-30
-35
-40
X (Re) GSM
Before IP shock
After IP shock
19.0 Re
13.7 Re

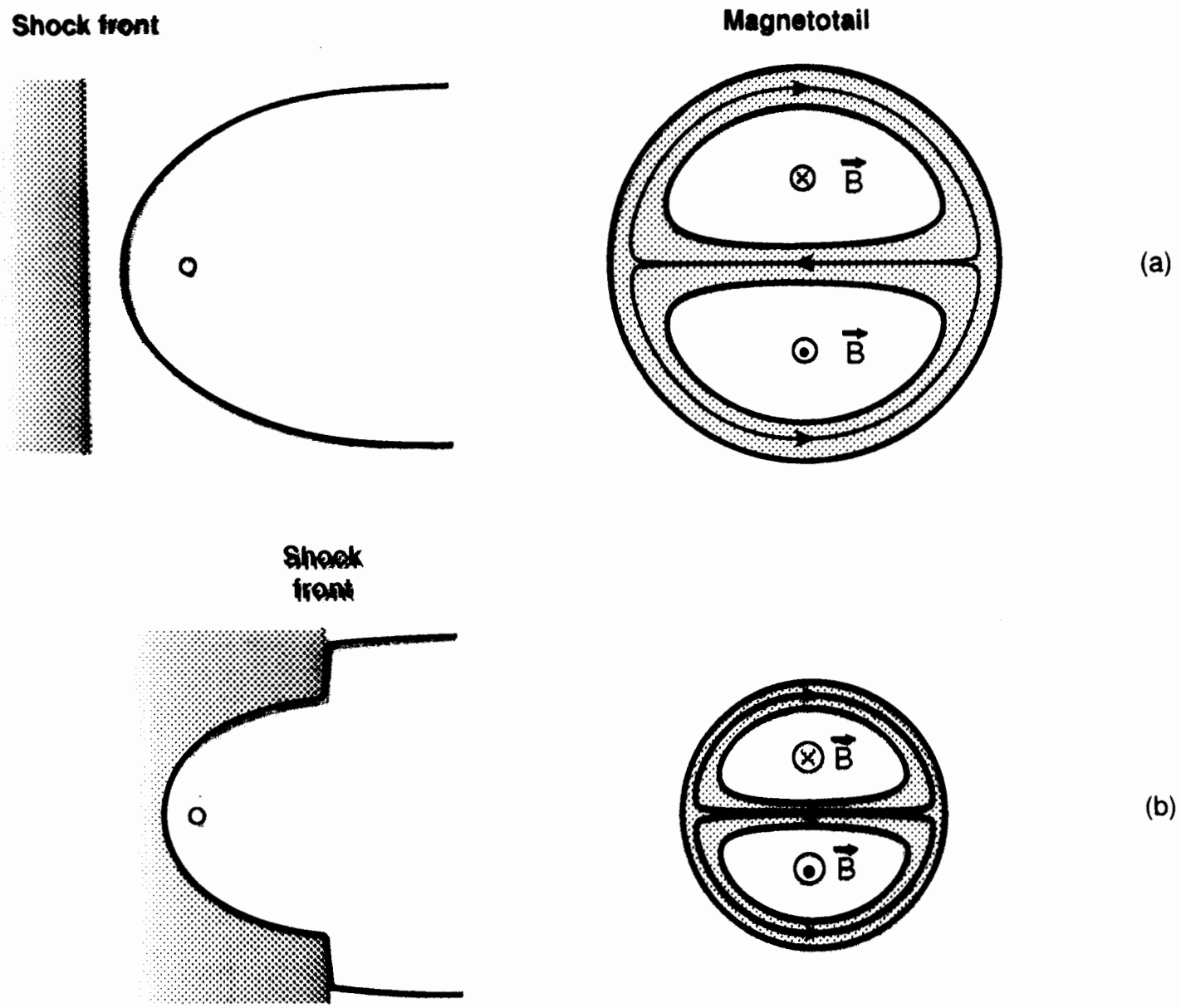
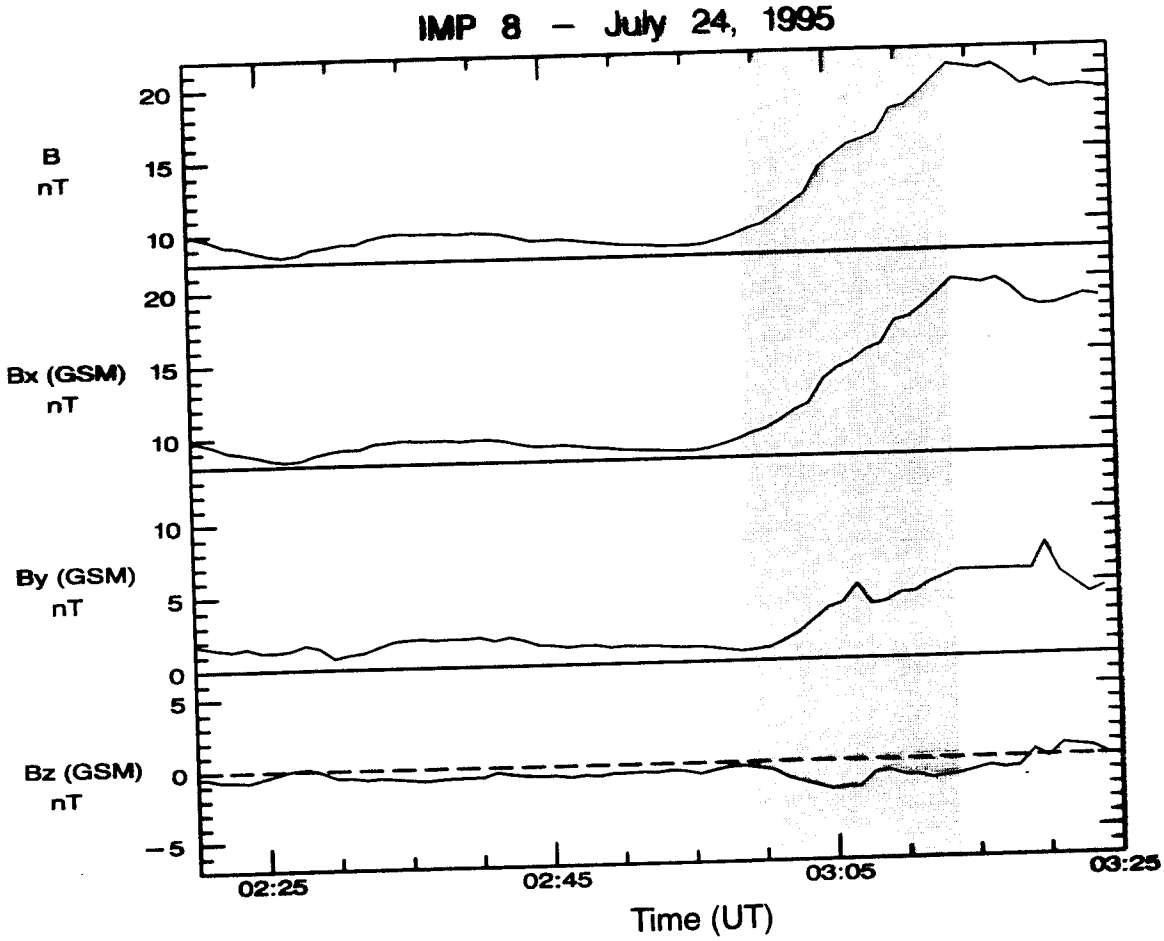


Figure 8



X (Re GSM)	-31.3	-31.2	-31.1	-31.1
Y (Re GSM)	-12.3	-12.4	-12.4	-12.4
Z (Re GSM)	8.5	8.9	9.3	9.6

TRIGGERING MECHANISMS

1. *Magnetic Reconnection* Precursor IMF B_s will lead to near-tail plasma sheet density (Lennartsson and Shelley, 1986) and thermal pressure (Borovsky et al., 1998) enhancements. Tail compression will cause cross-tail current sheet thinning and magnetic reconnection as discussed in Coroniti and Kennel (1972).

2. *Current Disruption* Decrease in tail diameter and also current sheet compression both lead to cross-tail current density enhancements. Plasma instabilities (Papadopoulos, 1979 and Chang et al., 1990) can lead to current sheet disruption (Lui et al., 1990).

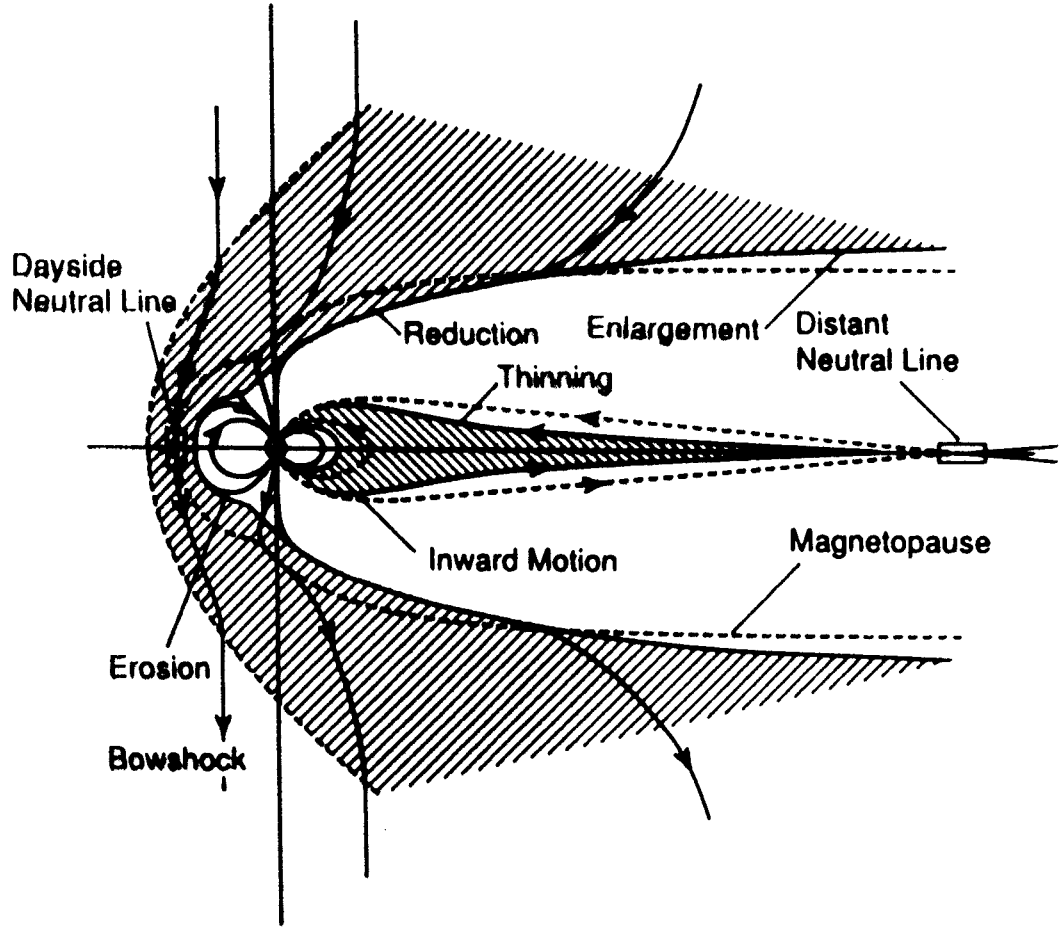
SUMMARY AND CONCLUSIONS

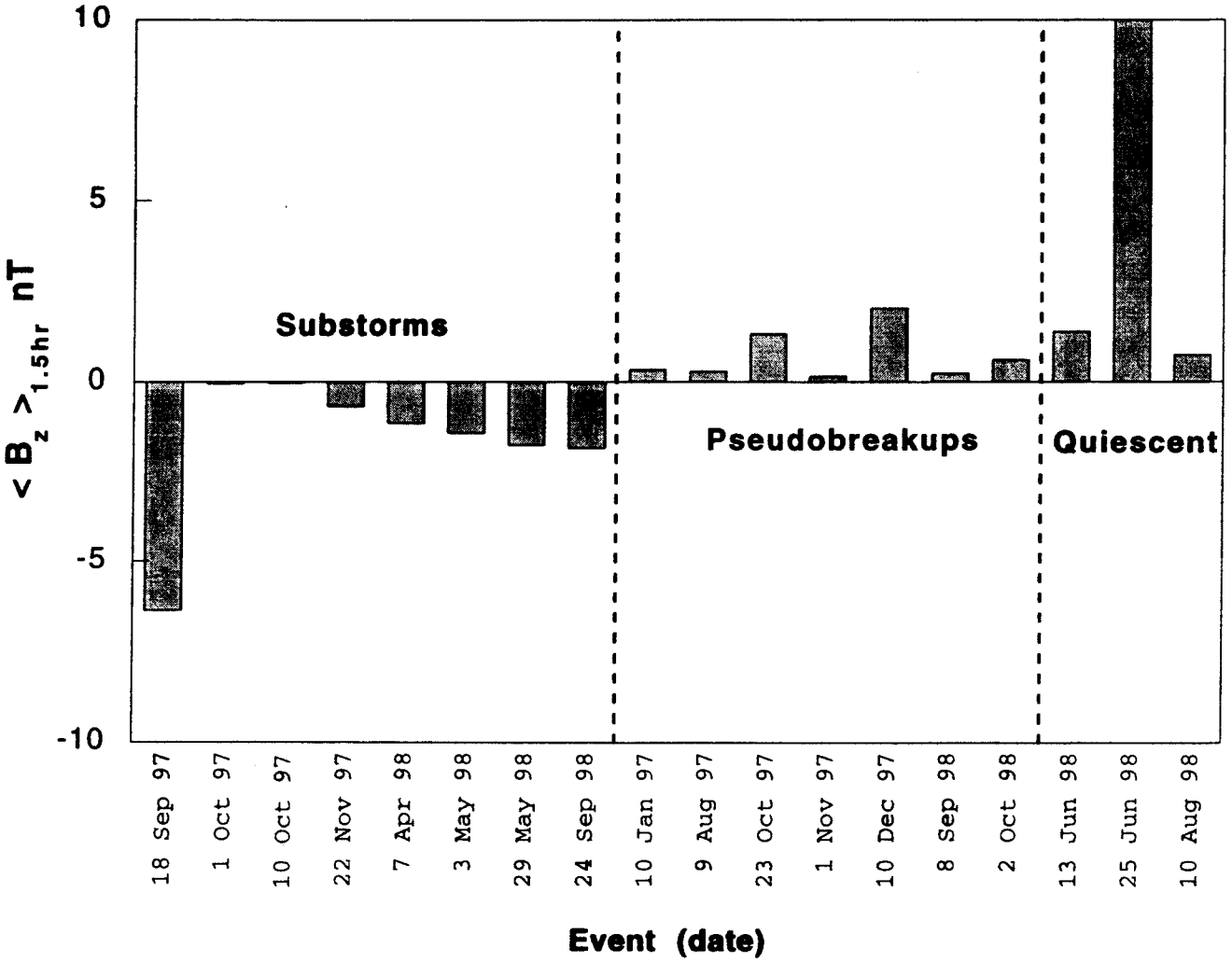
1. Substorm triggering mechanism can be studied using interplanetary shock events. Effects in the magnetotail are large, clear and have small time uncertainties.

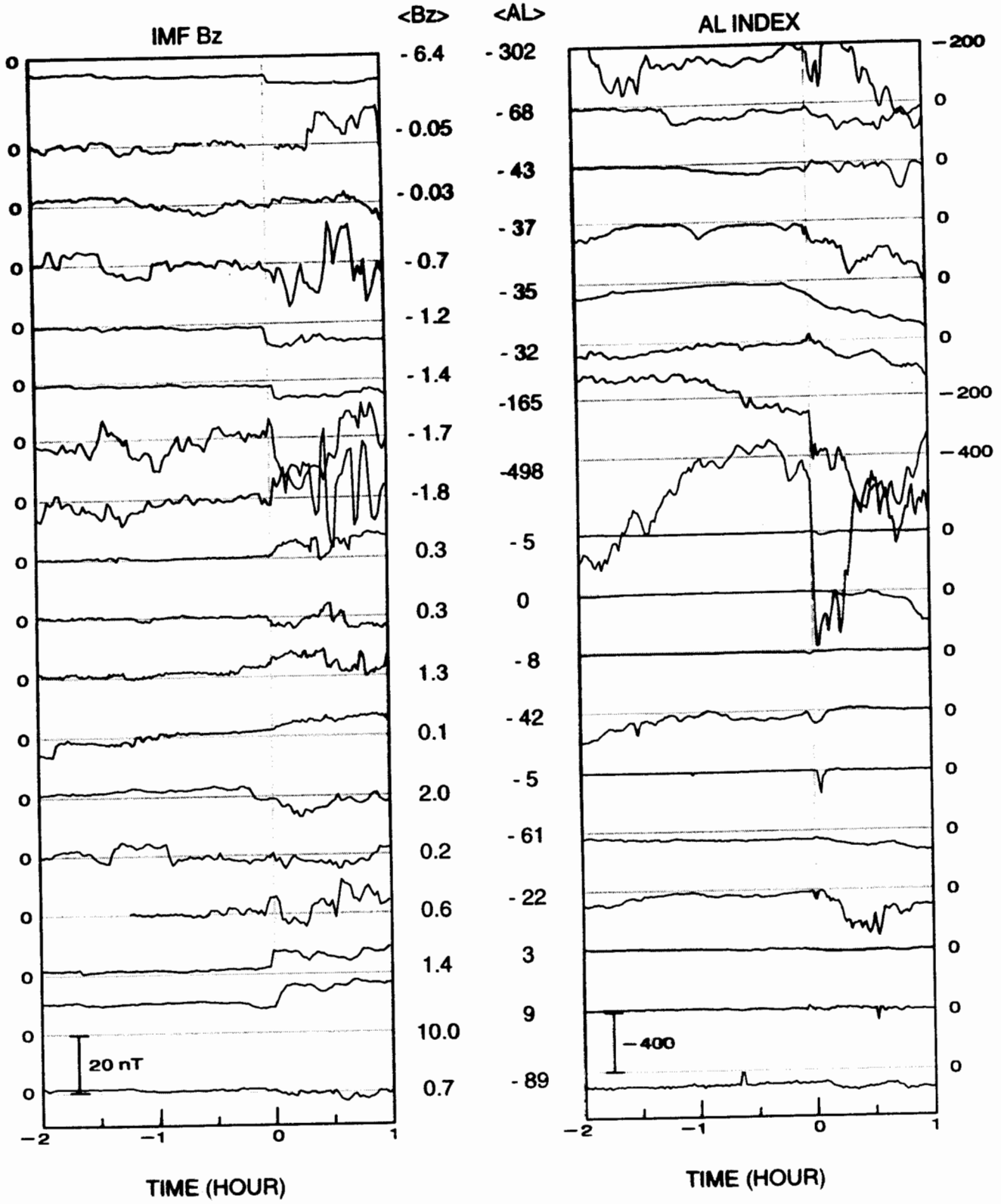
2. Interplanetary precursors play a major role in the triggering of substorms, pseudobreakups or nothing (quiescent events). Shock triggering geomagnetic activity can now be predicted?

3. Effects of magnetotail compression are well understood. Specific triggering mechanisms should be tested in this light.

FIG. 13.21. Schematic illustration of the changes in magnetic field and plasma sheet expected in the situation where the reconnection rate on the dayside exceeds that on the nightside. Increased magnetopause flaring, plasma-sheet thinning, and earthward motion of the tail current are the main effects.




10
5
0
-5
-10
< B_z >_1.5hr nT
Substorms
Pseudobreakups
Quiescent
18 Sep 97
1 Oct 97
10 Oct 97
22 Nov 97
7 Apr 98
3 May 98
29 May 98
24 Sep 98
10 Jan 97
9 Aug 97
23 Oct 97
1 Nov 97
10 Dec 97
8 Sep 98
2 Oct 98
13 Jun 98
25 Jun 98
10 Aug 98
Event (date)


IMF Bz
<Bz>
<AL>
AL INDEX
- 6.4
- 0.05
- 0.03
- 0.7
- 1.2
- 1.4
- 1.7
-1.8
0.3
0.3
1.3
0.1
2.0
0.2
0.6
1.4
10.0
0.7
- 302
- 68
- 43
- 37
- 35
- 32
-165
-498
- 5
0
- 8
- 42
- 5
- 61
- 22
3
9
- 89
20 nT
-200
-400
-2
-1
0
1
TIME (HOUR)

An IMF northward turning event is identified by:

1) the turning occurred after a period (≥ 30 min) of predominantly negative IMF B_z, at ≤ - 2 nT.

2) B_z remained elevated for at least 10 min with at least one point at least 2.5 nT higher than at the turning onset.

An IMF southward turning event is identified by:

1) The IMF $B_z \geq 2$ nT for more than 5 hr.

2) and then, the IMF $B_z \leq -1.5$ nT over next one hour.

The expected time T is:

$$T = T_o - \tau - T_C$$

where τ is the delay time between magnetopause contacting and the a substorm expansion onset. For Bn event it is ~ 9 min (Lyons et al., JGR, 1997), for Bs event it is ~ 1 hr (Iyemori, JGG, 1980). We examined IMF B_z turning events in a duration of $\Delta T = T \pm 15$ min.

September 24, 1998 event

R:	$19 \Rightarrow 13.3\ Re$	$(at\ X = -15\ Re)$	
	$B_L \Rightarrow 2.1\ B_L$	$I \Rightarrow 2.1\ I\ (mA/m)$	
	$P_L \Rightarrow 4.4\ P_L$	$h \Rightarrow h/1.7$	$(PV^{\gamma})_{CS} = const.$
	$Vy \Rightarrow const.$	$Ey \Rightarrow 1.43\ Ey$	