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ABSTRACT

During August 1972, Explorer 45 orbiting near the equatorial plane with an apogee of ∿5.2 R_e traversed magnetic field lines in close proximity to those simultaneously traversed by the topside ionospheric satellite ISIS 2 near dusk in the L range 2-5.4. The locations of the Explorer 45 plasmapause crossings (determined by the saturation of the d.c. electric field double probe) during this month were compared to the latitudinal decreases of the H^+ density observed on ISIS 2 (by the magnetic ion mass spectrometer) near the same magnetic field lines. The equatorially determined plasmapause field lines typically passed through or poleward of the minimum of the ionospheric light ion trough, with coincident satellite passes occurring for which the L separation between the plasmapause and trough field lines was between 1 and 2. Hence, the abruptly decreasing H^+ density on the low latitude side of the ionospheric trough is not a near earth signature of the equatorial plasmapause. Vertical flows of the H^+ ions in the light ion trough as detected by the magnetic ion mass spectrometer on ISIS were directed upward with velocities between 1 and 2 kilometers/sec near dusk on these passes. These velocities decreased to lower values on the low latitude side of the H^+ trough but did not show any noticeable change across the field lines corresponding to the magnetospheric plasmapause. The existence of upward accelerated H^+ flows to possibly supersonic speeds during the refilling of magnetic flux tubes in the outer plasmasphere could produce

an equatorial plasmapause whose field lines map into the ionosphere at latitudes which are poleward of the H^+ density decrease.

INTRODUCTION

An abrupt decrease in the equatorial thermal plasma density with increasing geocentric distance was originally detected in 1963 by ground based whistler observations (Carpenter, 1963) and by in-situ ion density measurements (Gringauz, 1963). This magnetospheric plasmapause is usually approximated by a discontinuous boundary since it sometimes corresponds to an order of magnitude density change within a distance 0.1 R_e (e.g., Angerami and Carpenter, 1966), although gradual or broadly extended irregular plasmapause transitions have been observed (e.g., Harris et al., 1970; Chappel, 1974). From the time of its original discovery until only recently this boundary to the densely populated plasmasphere was assumed to extend from the equatorial plane along magnetic field lines down to the F region of the ionosphere.

At ionospheric altitudes a deep trough in the latitudinal distribution of electron density is typically detected between 1400 and 0700 LT (Muldrew, 1965; Sharp, 1966; Tulunay and Sayers, 1971) in the expected vicinity of magnetic field lines which intersect the equatorial plane plasmapause (i.e., near 60° invariant latitude). Statistically the invariant latitude of this trough varies inversely with the magnetic index K_p in a manner quite similar to the average dependence of the equatorial plasmapause position (Thomas and Andrews, 1968; Tulunay and Sayers, 1971). This leads to the impression that the low latitude wall of the ionospheric trough would be the near earth field aligned extension of the plasmapause, i.e., the ionospheric "plasmapause". However, the statistical study of Thomas and Andrews (1968) showed a tendency for the low latitude side of the trough to be displaced from the expected plasmapause field lines. Indeed, a more recent study of coincident observations of the equatorial plane plasmapause and of the topside ionosphere electron density distributions in the vicinity of the same magnetic field lines (Grebowsky et al., 1977) gave evidence that, although the low latitude side of the nightside trough often straddles the plasmapause field lines, at times these field lines are located poleward of the trough. Hence, caution must be employed in using electron density trough positions as indicators of the plasmapause locations.

It is well established that the midlatitude electron density trough in the ionosphere wholly, or in part, corresponds to variations in the number density of the ion O^+, which is usually the major ion component within and poleward of the trough in the daytime and frequently at night at altitudes as high as 2000 kilometers (e.g., Brinton et al., 1971). On the other hand the equatorial plasmapause is a transition observed usually in the number density of the light ion H^+. The absence of a one-to-one correlation between equatorial and ionospheric plasma density depressions near the plasmapause field lines indicates that localized perturbations in the ionospheric O^+ distributions can occur which do not have a major effect on the high altitude H^+ distributions. Several sources exist for such perturbations: e.g., auroral precipitation, joule heating, photoionization, etc. It therefore seemed logical that only abrupt latitudinal decreases in the density of the light ion H^+ in the topside ionosphere, and not that of the electrons, would be the ionospheric counterpart of the equatorial plasmapause.

Figure 1 depicts schematically a simple view of the manner in which the equatorial plasmapause could be topologically coupled with the ionospheric ion density variations. Assuming a sharp plasmapause transition, the top of Figure 1 depicts a typical equatorial profile of the H^+ density variation (in terms of relative density units). The termination of the densely populated plasmasphere extends along the magnetic field lines from the equator towards the earth as shown in the middle of the figure. Near these field lines in the topside ionosphere, a polar orbiting satellite would tend to traverse O^+ and H^+ distributions of the type indicated in the bottom of the figure (e.g., Taylor, 1972). During the day photoproduction of ions dominates over localized depletion mechanisms so that O^+ is the dominant ion from the vicinity of F_{MAX} to altitudes above 1000 kilometers. (Park and Banks, 1975, have shown that in such regions plasmapause related troughs are not expected.) At night however, H^+ can be the dominant ion at the higher altitudes, particularly equatorward of the electron density trough, whereas O^+ is usually the major ion in or poleward of the ionospheric trough. During both the day and the night, the topside ionospheric latitudinal decrease of H^+ (which occurs even when O^+ is the major ion) is characteristic of a plasmapause transition. Indeed many authors (e.g., Taylor, 1972; Morgan et al., 1977) have reasoned that the region of decreasing H^+ density in the topside ionosphere, and not the electron density decrease, would be a better signature of the magnetic field lines passing through the equatorial plasmapause.

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In the above model, the depletion of magnetic flux tubes outside of the plasmasphere requires that the H^+ ions produced in the ionosphere (via charge exchange between O^+ and H) be redistributed by upward transport along the field lines. Hence, there will be an ionospheric depletion of H^+ ions associated with an equatorial depletion. Also carrying this simple model one step further it is to be expected that high speed upward directed H^+ flows would exist along the depleted flux tubes in the topside ionosphere. This is in contrast to the light ion flows within the plasmapshere which are directed upwards during the day and downward at night, corresponding to a diurnal ebb and flow of the light ions (e.g., Raitt and Dorling, 1976). Under such conditions, in the presence of a sharp plasmapause transition, a sharp change in the magnitude of the upward H^+ velocity in the ionosphere across the plasmapause field lines is to be expected.

This simple conception of a one-to-one correlation between the light ion density decrease in the topside ionosphere and the equatorial plasmapause has recently come under suspicion. Titheridge (1976), using a comparable ionospheric definition of the plasmapause, deduced statistically from Alouette 1 sounder observations that the dusk equatorial plasmapause did not lie on the same field line as the ionospheric plasmapause. Indeed a more recent study by Foster et al. (1977) comparing ground based whistler plasmapause observations with simultaneously observed ionospheric light ion density variations on ISIS 2 showed that for a week following a magnetic disturbance in June 1973 the invariant latitude of the equatorial plasmapause was typically a few degrees poleward of the low latitude wall of the ionospheric H^+ trough and of where the change in the upward H^+ flow velocity occurred. The present study will explore this further by considering an extensive set of equatorial plasmapause observations by Explorer 45 made simultaneously with ISIS 2 observations of ion density and H^+ flow variations throughout the month of August 1972 which encompasses an immense magnetic storm.

Measurements employed

The orbital configuration of the equatorial orbiting satellite Explorer 45 is elliptical with an apogee of ∿5.2 R_e as seen in Figure 2. A typical Explorer orbital trajectory from August, 1972, is plotted. During that month the topside ionosphere satellite ISIS 2 (polar orbiting at a fixed altitude of 1400 km) was in nearly a dawn to dusk orbital plane while the apogee of Explorer 45 occurred just before dusk. Hence as seen in Figure 2 (where the range of magnetic local times traversed by ISIS 2 in the course of a day is shown shaded) magnetic field lines traversed by Explorer 45 with L coordinates greater than 3 near dusk were also at times traversed by ISIS 2 in the topside ionosphere. Since the orbit of Explorer 45 processed towards noon during this time at a rate of 4/5 hr-LT/month compared to the precession of ISIS 2's orbital plane in the same direction at the rate of ∿2 hr-LT/month, an extended period of time existed when both satellites traversed similar magnetic field line region between L's of 3 and 5 (this L range is typical of the average plasmapause position). Since Explorer 45 spent a greater part of its orbital period near apogee and since ISIS 2 with a shorter orbital period of less than 2 hours traversed the same group of field lines in both hemispheres on the same orbit, many instances occur when both satellites cross the same field line region nearly simultaneously. Thus, the month of August, 1972, was an excellent period for comparing the location of the equatorial plasmapause (from the electric field double probe) with ion composition and upward H^+ flow variations observed near the same field lines in the ionosphere (using magnetic ion mass spectrometer observations).

The electric field double probe experiment on Explorer 45 goes into saturation when the ambient plasma density drops below a critical value (Maynard and Cauffman, 1973). Currently the best estimate of this saturation density is ~60 electrons/cm^3 (Morgan and Maynard, 1976). A density of this magnitude typically corresponds to a point on the sloping portion of the plasmapause transition although sometimes it occurs equatorward of the plasmapause (e.g., see the many OGO 5 observed density profiles in Chappell, 1972). Maynard and Grebowsky (1977) have shown that the sharper transitions into saturation favorably compare with the positions of the plasmapause deduced by whistler observations (Carpenter 1966), whereas for gradual transitions into saturation (or when no saturation occurs) the actual plasmapause will be at a higher altitude (or beyond apogee). In the present paper the saturation will be used as a locator of the plasmapause, keeping in mind that at times it can correspond to a lower L bound for it.

For comparison with the Explorer 45 plasmapause observations, ion composition measurements made by the magnetic ion mass spectrometer on ISIS 2 will be used. This spectrometer is particularly useful for protonospheric-ionospheric coupling studies because it can measure the upward flow velocities of the light ions, in addition to the ion number densities. The flow speeds are determined by measuring the phase shifts between the O^+ and H^+ roll modulation profiles (see Hoffman et al., 1974, for a complete discussion of this technique). Only the H^+ and O^+ distributions will be considered here as these ions are the most important ones in relating equatorial and ionospheric plasmapause signatures. Although the orbital configurations of Explorer and ISIS were synchronized enough to produce many intersections of the orbits in L-MLT space beyond August, 1972, a change in the spin configuration of ISIS precluded use of the ion data beyond that month. Hence only those observations made during August, 1972, will be considered.

OBSERVATIONS

A few of the latitudinal distributions of the O^+ and H^+ ion densities observed on ISIS 2 passes during August, 1972, near dusk are plotted in Figure 3. As seen in these profiles O^+ is the dominant ion with number density an order of magnitude or more greater than the corresponding H^+ density. This relationship between the two ions prevailed in the trough region for all of the dusk passes under consideration. The location of the innermost plasmapause (PP) crossing of Explorer 45 which occurred nearest in universal time and magnetic local time to each of the ISIS passes plotted is also indicated in the figure. The number listed above the notation PP is an index which describes approximately the sharpness of the equatorial plasmapause on a scale of 1 to 5, where 1 indicates the most rapid rate of saturation of the electric field experiment and 5 the most gradual transition (see Maynard and Grebowsky, 1977, for the quantitative definition of this code). From the comparison in Figure 3 it is apparent that a rough correlation exists between variations in the light ion density in the ionosphere and the plasmapause, but not between the electron density (as indicated by O^+) and the plasmapause on all orbits at 1400 km.

The ion composition distributions plotted in Figure 3 show the variety of H^+ distributions which occurred during the period under investigation. The H^+ profiles ranged from steep troughs such as that on the August 11 pass, more gradual latitudinal decreases as on the August 7 pass, to localized enhancements in the H^+ density (similar to equatorial detached plasmas -- Chappell, 1972) which lead to the formation of two light ion troughs on the August 1 pass. The sharp bite outs in the O^+ density distributions shown on two of the passes in Figure 3 occurred near midlatitudes on only a few of the August orbits, although many instances were found for which similar O^+ perturbations occurred far poleward of the expected plasmapause position (i.e., at or poleward of ∿70°Λ). In association with these O^+ density troughs similar decreases in the H^+ densities occur at the same time, which is to be expected since H^+ is the product of charge exchange between the neutral H and O^+. Hence, H^+ density perturbations unrelated to the position of the plasmapause take place if localized depletions of the heavy ion O^+ occur away from the plasmapause field lines. Such depletions can result from enhanced recombination rates resulting from enhanced vibrational excitation (Newton and Walker, 1975) or from localized increases in the plasma drift speed (Banks et al., 1974). Out of the scores of passes to be considered, however, such abrupt perturbations in the O^+ distributions in the vicinity of the plasmapause field lines were detected on only a few passes and did not play a major role in the analysis.

Although electron density distributions in the ionosphere are usually plotted in terms of the independent variable invariant latitude (as was done in Figure 3), such plots correspond to compressed L coordinate variations at midlatitudes and tend to overemphasize the steepness of trough walls in comparison to plasmapause transitions in the equatorial plane. Indeed sharp troughs seen in terms of invariant latitude are in many instances rather gradual compared to expected equatorial plasmapause gradients. Figure 4 depicts in terms of L the H^+ density variation on four selected ISIS 2 orbits showing that indeed the low latitude side of the H^+ density depressions seen on these dusk passes is not characteristic of sharp plasmapause transitions (the August 1 pass plotted is identical to that shown in the previous plot). Further in comparing the ionospheric variations to the nearly coincident equatorial plasmapause observation on these individual passes it is apparent that the plasmapause field lines do not traverse the trough wall.

To better determine the general relationship between the equatorial plasmapause position and ionospheric H^+ density gradients, a comparison of all the measured plasmapause and trough locations was made for the first 17 days of August (corresponding to the period when the greatest number of observations were made). The equatorial plasmapause crossings were chosen as the innermost transitions into saturation of the double probe on the inbound passes of Explorer 45 (the outbound portions of the passes were not considered since they corresponded to saturations which occurred near noon, far removed from the magnetic field lines traversed by ISIS 2.) The position characterizing the location of the ionospheric H^+ trough was chosen to be the high latitude termination of the low latitude wall -- i.e., the point in the trough where the latitudinal density gradient changes abruptly. Such a definition of the trough location typically corresponded to the low latitude edge of the trough minimum and in cases with multiple inflections, the lower L wall of the trough was singled out in order to be consistent with the choice of the inner equatorial saturation region on Explorer 45.

The plasmapause and trough locations determined for August 1-17 are plotted as functions of universal time in Figure 5. The magnetic local times corresponding to these locations were typically in the range between 16 and 18 MLT as seen at the top of the figure. In response to variations in magnetic activity (the K_p index is plotted at the bottom) both the trough and plasmapause L coordinates moved to lower L coordinates with enhancements in the magnetic activity and recovered toward prestorm values after the subsidence of the large magnetic storm which began on August 4. On the average the plasmapause and trough L positions vary similarly with time, but the equatorial plasmapause field lines tend to be shifted toward higher L values than the ionospheric H^+ troughs. Indeed, for all the events in Figure 5 where the trough L location was significantly greater than that of the nearest plasmapause sampled, there was either a few hours difference between the magnetic local times or between the universal times of the two locations. Considering that longitudinal gradients in the plasmapause position exist near dusk which are dependent upon present and previous magnetic conditions (e.g., Nishida, 1971), differences in plasmapause locations at widely separated times are not unexpected. Due to such behavior a critical evaluation of the equatorial-ionospheric boundary relationship requires that only those measurements made closely coincident in time and L space be considered.

From the entire set of data only those passes were considered as coincident for which the equatorial plasmapause crossing occurred within one hour magnetic local time and one hour universal time of the corresponding ISIS 2 pass through the same L coordinate in the topside ionosphere. This produced a limited set of 15 events, some of which already appeared in Figure 3. For this subset of passes the magnetic ion mass spectrometer data from ISIS was used to determine the vertical speeds of the thermal H^+ ions, in order to determine whether or not the magnitude of this flow, as well as the ionospheric H^+ number density, changed across the plasmapause field lines. Although a few of the passes of this data subset while in the same magnetic field line region traversed the plasmapause, the edge of the ionospheric H^+ trough, and a decrease in the upward H^+ velocity with decreasing latitude, the majority of the events detected the plasmapause field line to lie poleward of the trough and the velocity change in the ionosphere. Figures 6 through 8 depict three of the more prominent examples of this latter behavior. In these figures the O^+ density is seen to lack any trough structure in the vicinity of the plasmapause field line; while in agreement with the conclusion drawn from the complete plot of data in Figure 5, the most prominent low latitude side of the ionospheric H^+ depression is situated equatorward of the plasmasphere boundary. The H^+ flow is directed upwards in the depleted H^+ density region with velocities of the order of 1-2 km/sec as is to be expected if the depleted magnetic flux tubes are being refilled from the ionosphere. Such flows persist to the equatorward wall of the ionospheric depression and do not change abruptly across the plasmapause field lines (as was expected for the simple model depicted in the introduction).

The relationship between the plasmapause and light ion density variations in the ionosphere was not discernably dependent on magnetic activity conditions. Figures 6 through 8 correspond to measurements made under different magnetic conditions (the K_p indices from the time of the observation backwards in time to 15 hours before are listed on each plot). This is further seen in Figure 9 where the L difference between the plasmapause location and the H^+ trough location is plotted as a vertical bar on the same universal time plot of the K_p and D_{st} index which as an indicator of the ring current variation gives a rough indication of distortions in the magnetic field configuration. Since the separations of the ionospheric and magnetospheric signatures do not follow in phase with the D_{st} variations for the coincident observations, it is unlikely that the discrepancy is due to distortions of the magnetic field lines connecting the ionospheric and equatorial H^+ density variations. Indeed, L differences greater than 1 are far greater than any differences which could be attributable in most instances to field line distortions at the nominal altitudes of Explorer 45 (see the estimate of this effect during quiet periods given in Morgan and Maynard, 1976). Since a rather limited data set was considered which was extended over a period of a month, it was impossible to determine definitively, however, whether or not the spatial separation between the two detected signatures varied in response to changes in, rather than to the actual intensity of the magnetic activity at the time of the measurements.

DISCUSSION

The observation that the equatorial plasmapause field lines do not pass through a similar latitudinal decrease of the H^+ density in the topside ionosphere, but actually traverse a region at the minimum of, or poleward of the low latitude wall of, the H^+ ionospheric density depression is in agreement with the statistical analysis of Titheridge (1976) and the study of Foster et al. (1977). Indeed since the upward directed H^+ velocities were detected not only in the region of the H^+ trough minimum but also with undiminished magnitudes in a region equatorward of the near earth extension of the magnetospheric plasmapause field lines, Titheridge (1976) offered the explanation that the outward expansion of the magnetic flux tubes in the plasmapause bulge region near dusk would produce the high speed flows. Such a mechanism may be in part responsible for the observations near dusk, but it is not the complete solution because the plasmasphere bulge tends to be skewed to the nightside of dusk (Maynard and Grebowsky, 1977) on the average, whereas the present observations are located on the dayside of dusk, and a similar trough-plasmapause separation is seen at dawn (Foster et al., 1977).

Thus the displacement of the plasmapause field lines from the trough is seen even when outward expansions of magnetic flux tubes do not occur.

A mechanism is required which is operative both at dawn and at dusk and possibly at all local times, although studies of the noon and midnight behavior have yet to be made. This mechanism must produce enhanced H^+ densities near the equatorial plane via the observed upward transport of the light ions from the ionosphere and yet must let the ionospheric H^+ densities of the same field lines remain undisturbed. By such a process the equatorial plasmapause boundary can be formed at higher L coordinates in the equatorial plane than the corresponding boundary at lower altitudes in the ionosphere. Such a situation would prevail if the field aligned flows of H^+ were accelerated upwards to high velocities. As the upward H^+ number flux increases in magnitude, the low altitude H^+ density increases more slowly than the higher altitude densities (e.g., see the steady state flow solutions depicted in Figure 21.9 of Banks and Kockharts, 1973). Once the flow becomes supersonic at some point along the magnetic field line, the equatorial plasma density can increase with time without a change in the topside ionosphere light ion density. In such a case the ionospheric plasma medium will not respond to pressure buildups near the equator because information about changes in the high altitude distributions are carried downward by ion acoustic waves which, of course, in supersonic flows cannot propagate upstream. Such flows must persist on the outer field lines of the plasmasphere for at least one day following a storm depletion in order to account for a separation between the trough and plasmapause at all local times. Such times are consistent with model computations which assume that the supersonic flows dissipate through shock formations (Grebowsky, 1971); but, since those calculations did not include the important effects of thermalization of the streams via the two stream instability or coloumb collisions (see Schulz and Koons, 1972 for a discussion of these effects), the shock model times are at best upper limits. The observation of 1-2 km/sec field aligned H^+ flow velocities in the current study are consistent with the model studies of the polar wind velocities (e.g., Banks and Holzer, 1969) and with experimental deductions by Brinton et al. (1971) and direct observations by Hoffman (1970) which indicate that high speed supersonic flow occurs at higher altitudes.

For this mechanism, the L difference (ΔL) between the plasmapause and H^+ trough field lines would be determined by the length of time needed for the ambient plasma in the refilling flux tubes to build up to density levels corresponding to subsonic flows everywhere. Since the upward H^+ flows are(through charge exchange) related to the ionospheric O^+ densities, localized ionospheric sources or sinks of ionization (e.g., effects of energetic particle precipitation or enhanced $\vec{E}x\vec{B}$ drifts) will play a role in determining the variation of ΔL with time, as will temporal variations in the gross convection electric field which can lead to an irregular plasmasphere boundary such as that deduced by Bewersdorff and Sagalyn (1972). Hence, although the plasmapause field line can be expected to lie poleward of the light ion trough in the ionosphere, the separation between these plasma regions can vary irregularly.

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FIGURE CAPTIONS

Figure 1. Classical view of plasmapause-light ion trough relationship. Equatorial plasmapause (top) maps along magnetic field lines to the topside ionosphere (middle) where a latitudinal H^+ density decrease is expected (bottom). It has often been assumed that the region of abrupt H^+ density decrease in the ionosphere is the near earth signature of the plasmapause with the largest upward velocities of the H^+ flows occurring poleward of the plasmapause field lines.

Figure 2. Explorer 45-ISIS 2 overlap. A typical orbit of the equatorial satellite Explorer 45 is superimposed on an ISIS 2 trajectory in L-LT space near dusk for the same period. The magnetic local times traversed by ISIS in the course of a day are shown shaded. Coincident crossings of the same magnetic field lines by ISIS 2 and Explorer 45 were therefore found pre-dusk in the L range ∿2-5.

Figure 3. Examples of observations in August. O^+ and H^+ density profiles detected on 3 ISIS 2 passes show the characteristic depression in the light ion density commonly referred to as the light ion trough. The most coincident passage through the plasmapause by Explorer 45 is indicated by PP. This refers to the innermost saturation of the d.c. double probe. The number above PP refers to the sharpness of the plasmapause transition on a scale of 1 to 5 with 1 the sharpest, 5 the most gradual. Density depressions in the H^+ density occur near

the PP field line, but rapid H^+ density decrease in the ionosphere are seen separated from PP. The August 1, and 11 passes show that H^+ may vary in response to ionospheric O^+ depressions which can be produced away from the plasmapause.

Figure 4. ISIS 2 H^+ density profiles vs. L. Topside ionosphere profiles which appear rapidly varying in terms of invariant latitude are often gradual in L space. Comparison of the nearly simultaneously observed plasmapause and light ion trough variations shows that the prominent low latitude side of the trough lies equatorward of the plasmapause extension into the ionosphere.

Figure 5. Plasmapause-H^+ trough variations. The locations (L,MLT) of all the plasmapause and ionospheric H^+ trough passages near dusk during the first half of August 1972 are compared. Using the point of termination of the low latitude side of the trough as its position, the equatorial PP typically, as seen in this figure, is the same as that of the trough or greater. For the few instances where PP is at a smaller L than the nearest trough crossing, the trough and plasmapause were sampled at much different universal and/or local times. Hence these differences could be attributed to longitudinal or temporal changes. In response to the large storm beginning on the 4th the trough and plasmapause move to lower L to recover after the disturbance ends.

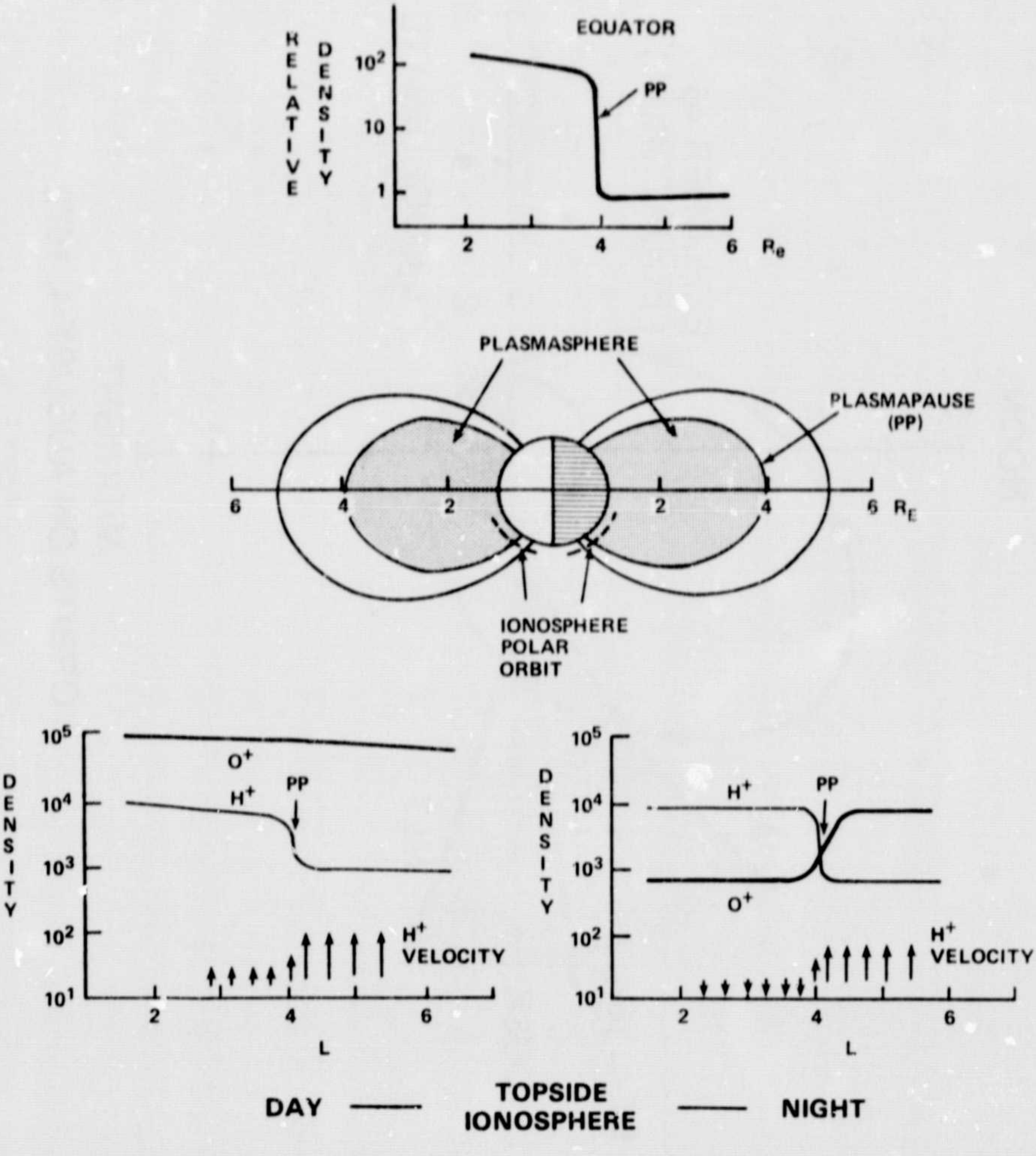
Figure 6. A coincident observation on August 8. The plasmapause crossing which occurred within one hour UT and MLT of the trough

crossing was at a higher L than the low latitude side of the trough. The vertical H^+ flow velocity did not decrease with decreasing L across the plasmapause field line. These observations were made as magnetic activity increased -- the K_p indices are listed backwards in time from that at the time of the observations.

Figure 7. A coincident observation on August 14. Again the plasmapause is traversed at an L coordinate significantly greater than the low latitude side of the H^+ depression and the field aligned flow shows no prominent change at the plasmapause. Magnetic activity was not very high at this time.

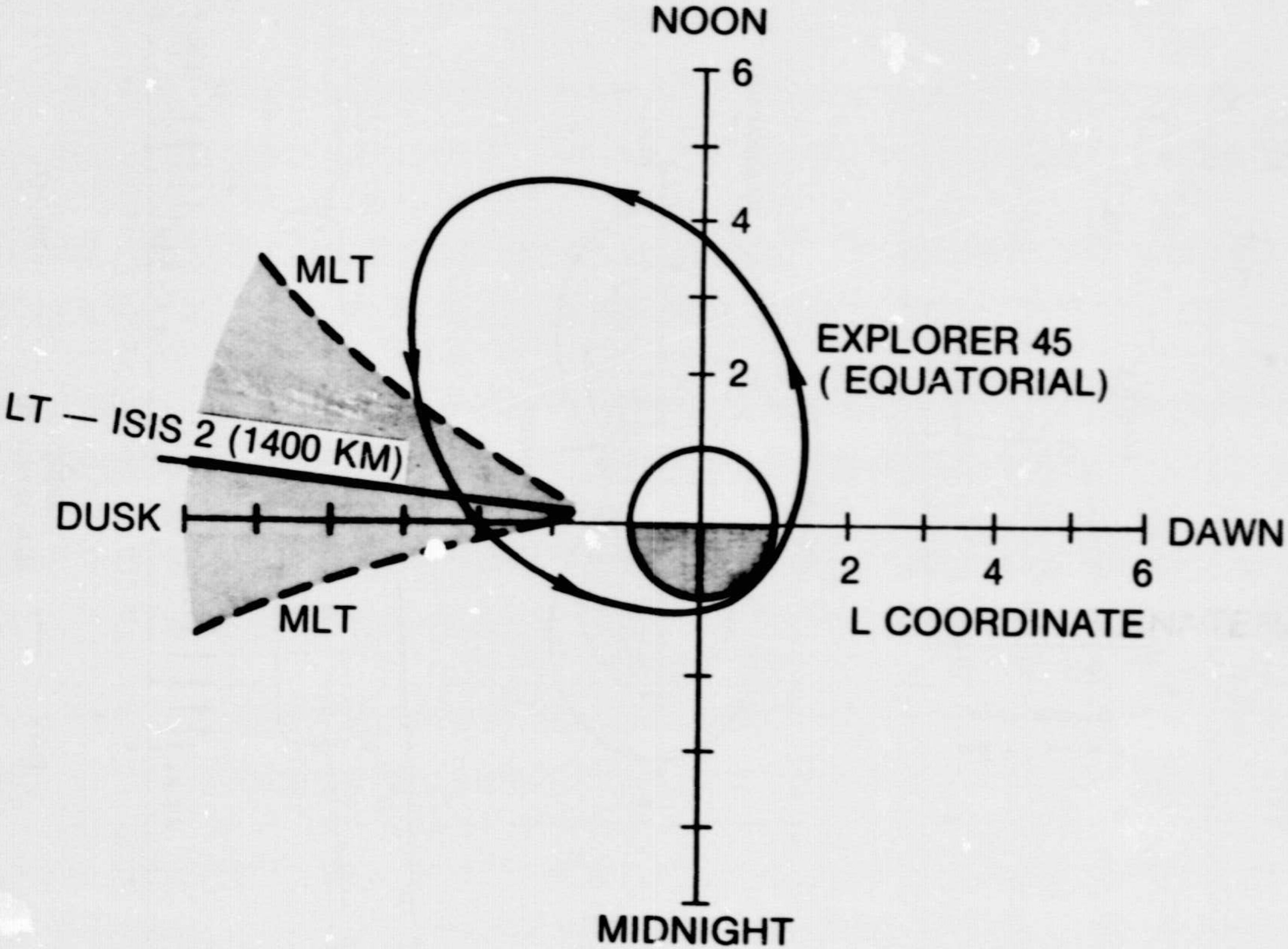
Figure 8. A coincident observation on August 6. These passes, which took place following a severe disturbance, show a similar behavior to that seen in the previous examples.

Figure 9. All trough-plasmapause separations. The differences between the trough and plasmapause L position on passes which occurred within one hour UT and one hour MLT are plotted as a bar graph throughout August 1972. The variations of D_{st} and K_p throughout the month show no obvious correlation with the differences.



EQUATOR
RELATIVE DENSITY
10²
10
1
PP
2
4
6
Re
PLASMASPHERE
PLASMAPAUSE (PP)
6
4
2
2
4
6
RE
IONOSPHERE POLAR ORBIT
10⁵
10⁴
10³
10²
10¹
DENSITY
O⁺
H⁺
PP
H⁺ VELOCITY
2
4
6
L
10⁵
10⁴
10³
10²
10¹
DENSITY
H⁺
PP
O⁺
H⁺ VELOCITY
2
4
6
L
DAY
TOPSIDE IONOSPHERE
NIGHT

Figure 1



ORBITS ON AUGUST 4, 1972

Figure 2

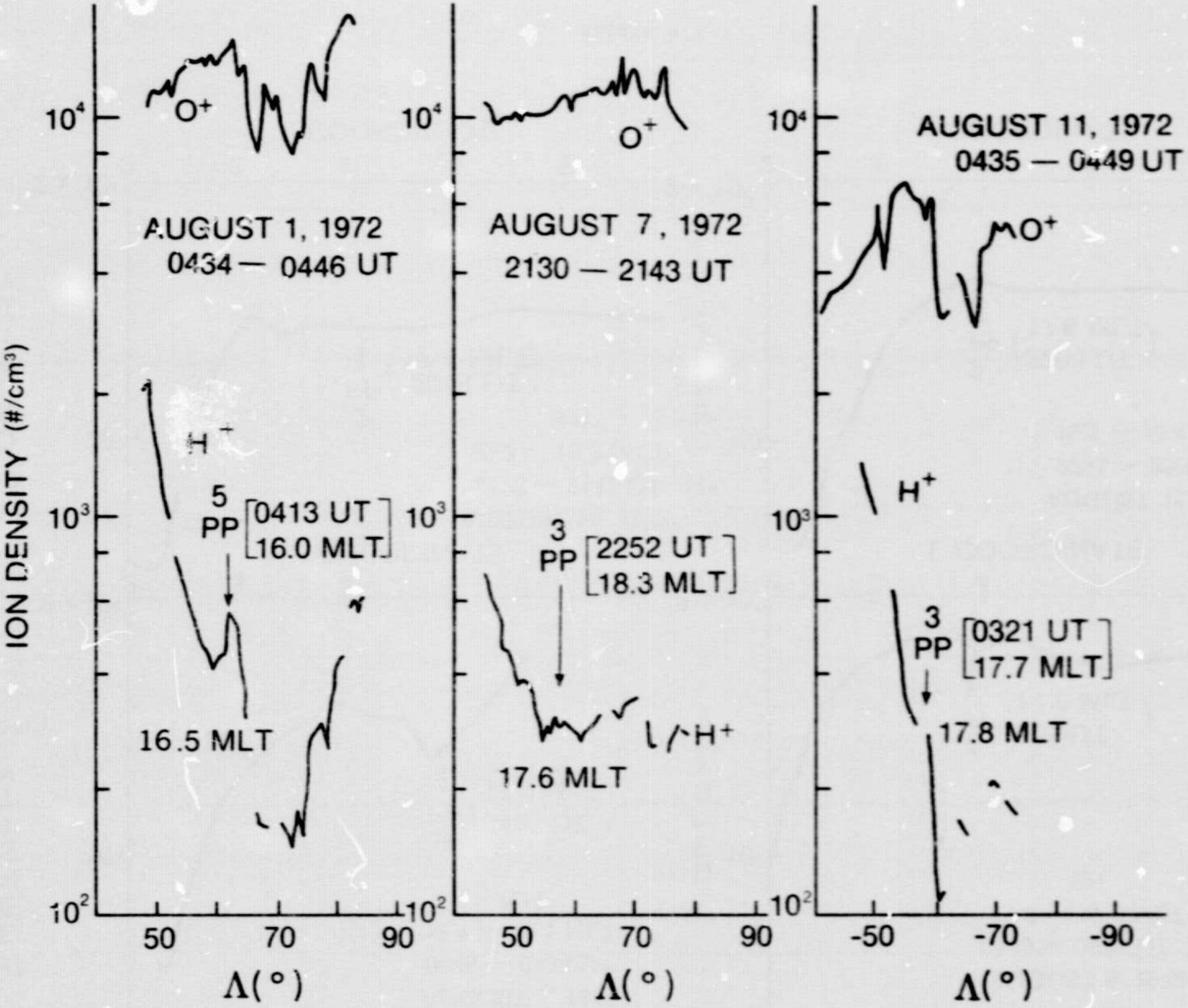
ION DENSITY (#/cm³)
10⁴
10³
10²
AUGUST 1, 1972
0434 — 0446 UT
O⁺
H⁺
5
PP [0413 UT 16.0 MLT]
16.5 MLT
50
70
90
Λ(°)
AUGUST 7, 1972
2130 — 2143 UT
O⁺
3
PP [2252 UT 18.3 MLT]
17.6 MLT
H⁺
AUGUST 11, 1972
0435 — 0449 UT
O⁺
H⁺
3
PP [0321 UT 17.7 MLT]
17.8 MLT
-50
-70
-90

Figure 3

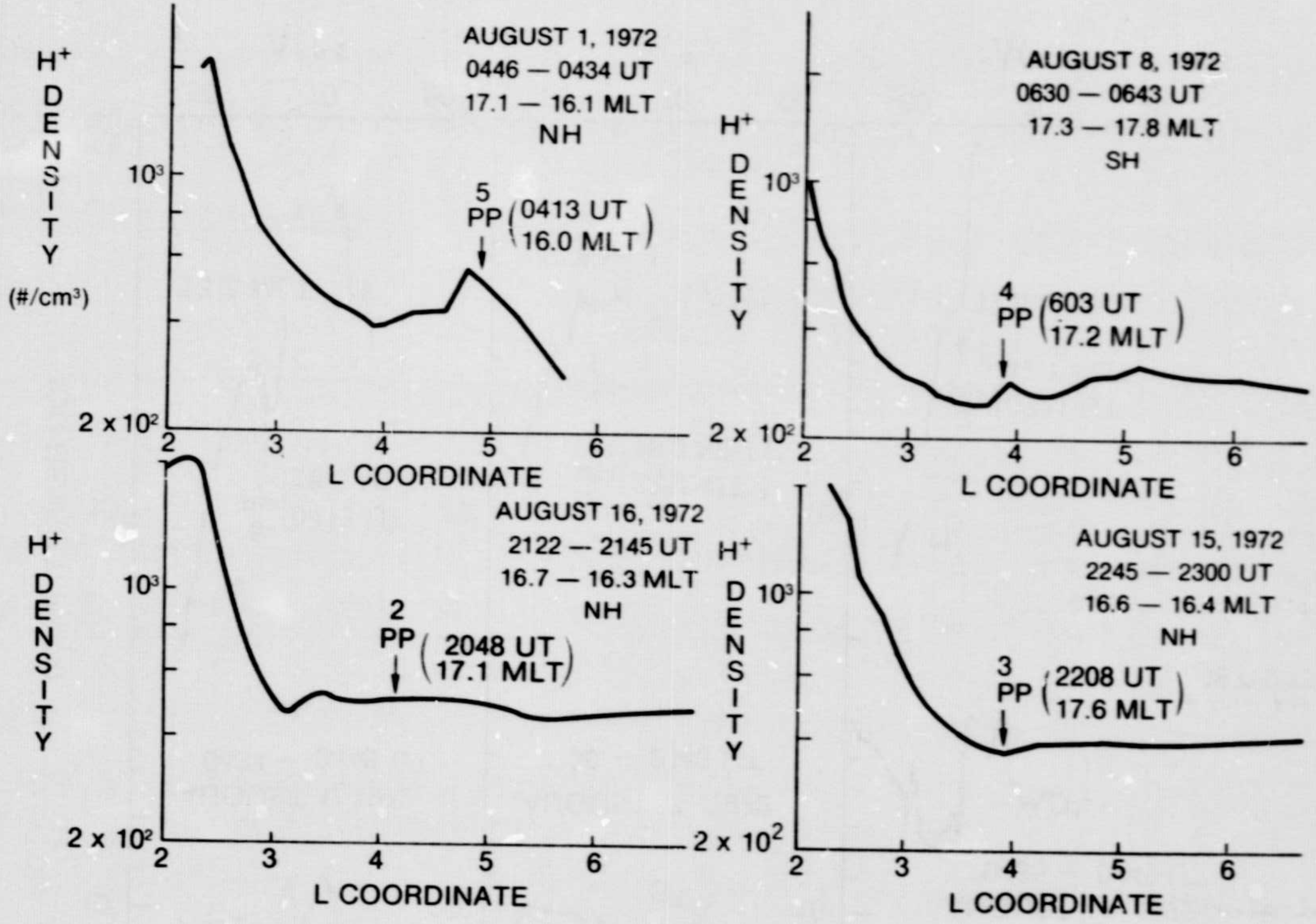

H+ DENSITY (#/cm³)
10³
2 x 10²
2
3
4
5
6
L COORDINATE
AUGUST 1, 1972
0446 — 0434 UT
17.1 — 16.1 MLT
NH
5
PP (0413 UT 16.0 MLT)
H+ DENSITY
10³
2 x 10²
2
3
4
5
6
L COORDINATE
AUGUST 8, 1972
0630 — 0643 UT
17.3 — 17.8 MLT
SH
4
PP (603 UT 17.2 MLT)
H+ DENSITY
10³
2 x 10²
2
3
4
5
6
L COORDINATE
AUGUST 16, 1972
2122 — 2145 UT
16.7 — 16.3 MLT
NH
2
PP (2048 UT 17.1 MLT)
H+ DENSITY
10³
2 x 10²
2
3
4
5
6
L COORDINATE
AUGUST 15, 1972
2245 — 2300 UT
16.6 — 16.4 MLT
NH
3
PP (2208 UT 17.6 MLT)

Figure 4

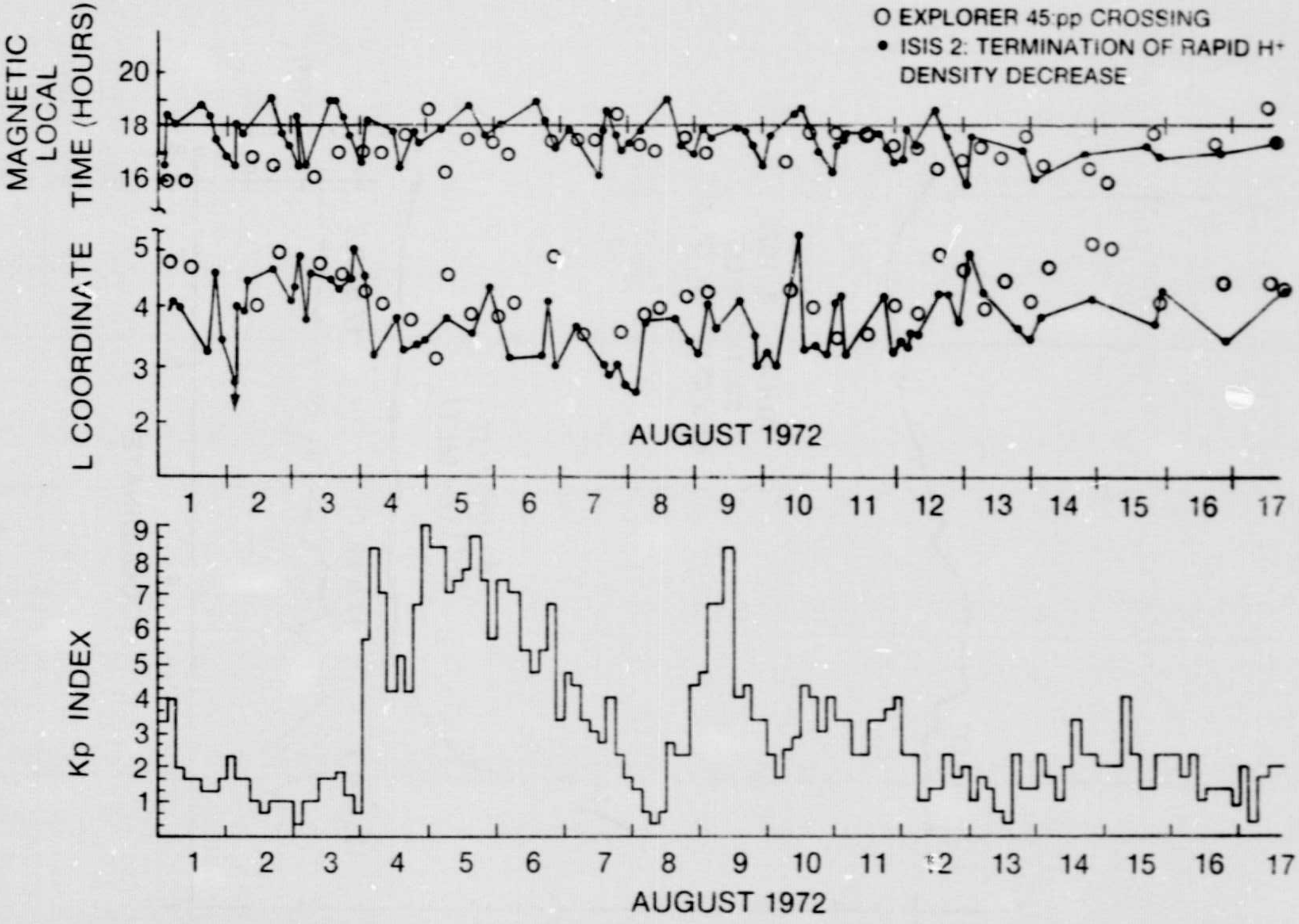

O EXPLORER 45:pp CROSSING
• ISIS 2: TERMINATION OF RAPID H+ DENSITY DECREASE
MAGNETIC LOCAL TIME (HOURS)
20
18
16
L COORDINATE
5
4
3
2
AUGUST 1972
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Kp INDEX
9
8
7
6
5
4
3
2
1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
AUGUST 1972

Figure 5

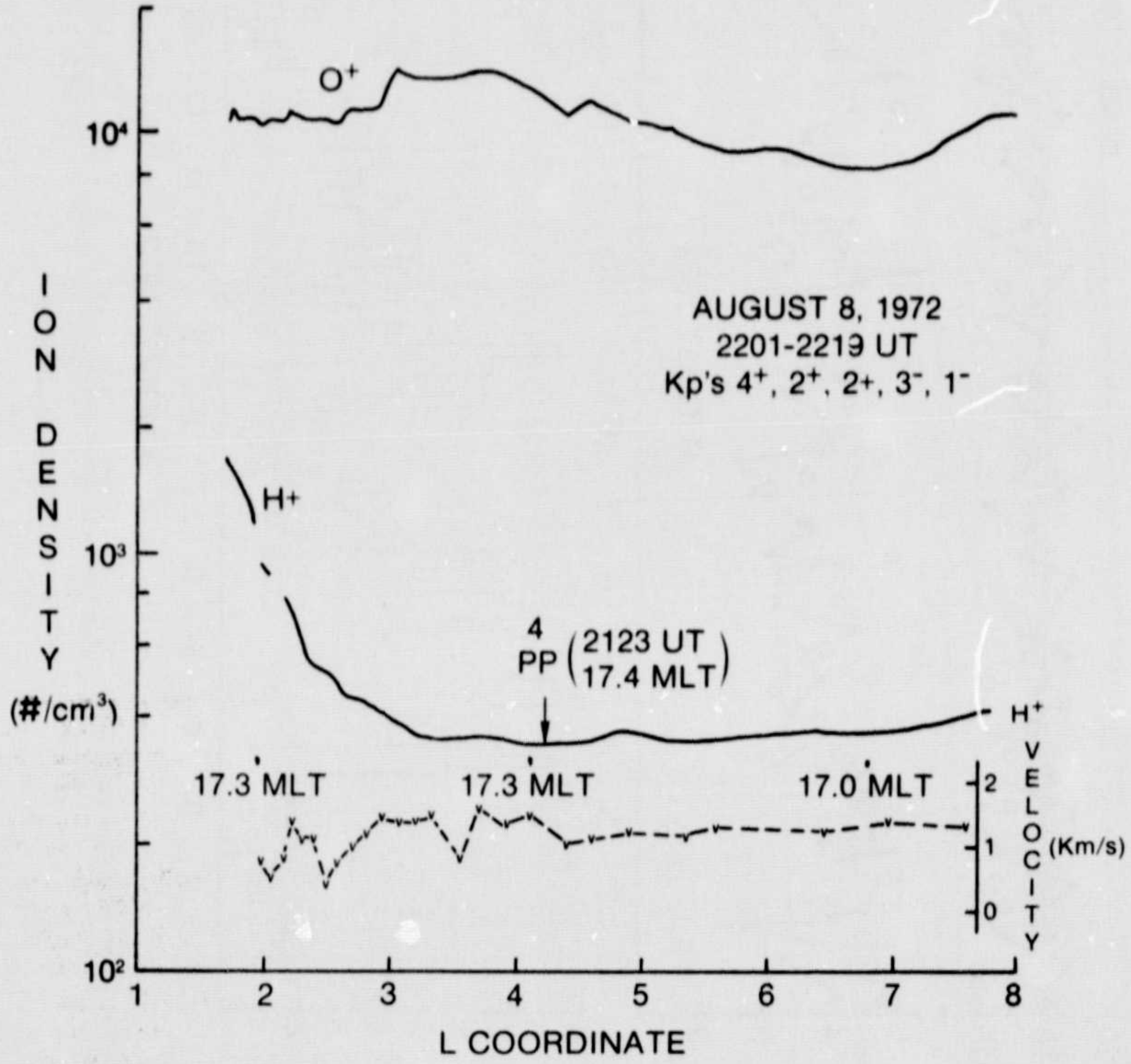

O⁺
H+
H⁺
AUGUST 8, 1972
2201-2219 UT
Kp's 4⁺, 2⁺, 2+, 3⁻, 1⁻
4
PP (2123 UT 17.4 MLT)
17.3 MLT
17.3 MLT
17.0 MLT
ION DENSITY (#/cm³)
10⁴
10³
10²
1
2
3
4
5
6
7
8
L COORDINATE
VELOCITY (Km/s)
2
1
0

Figure 6

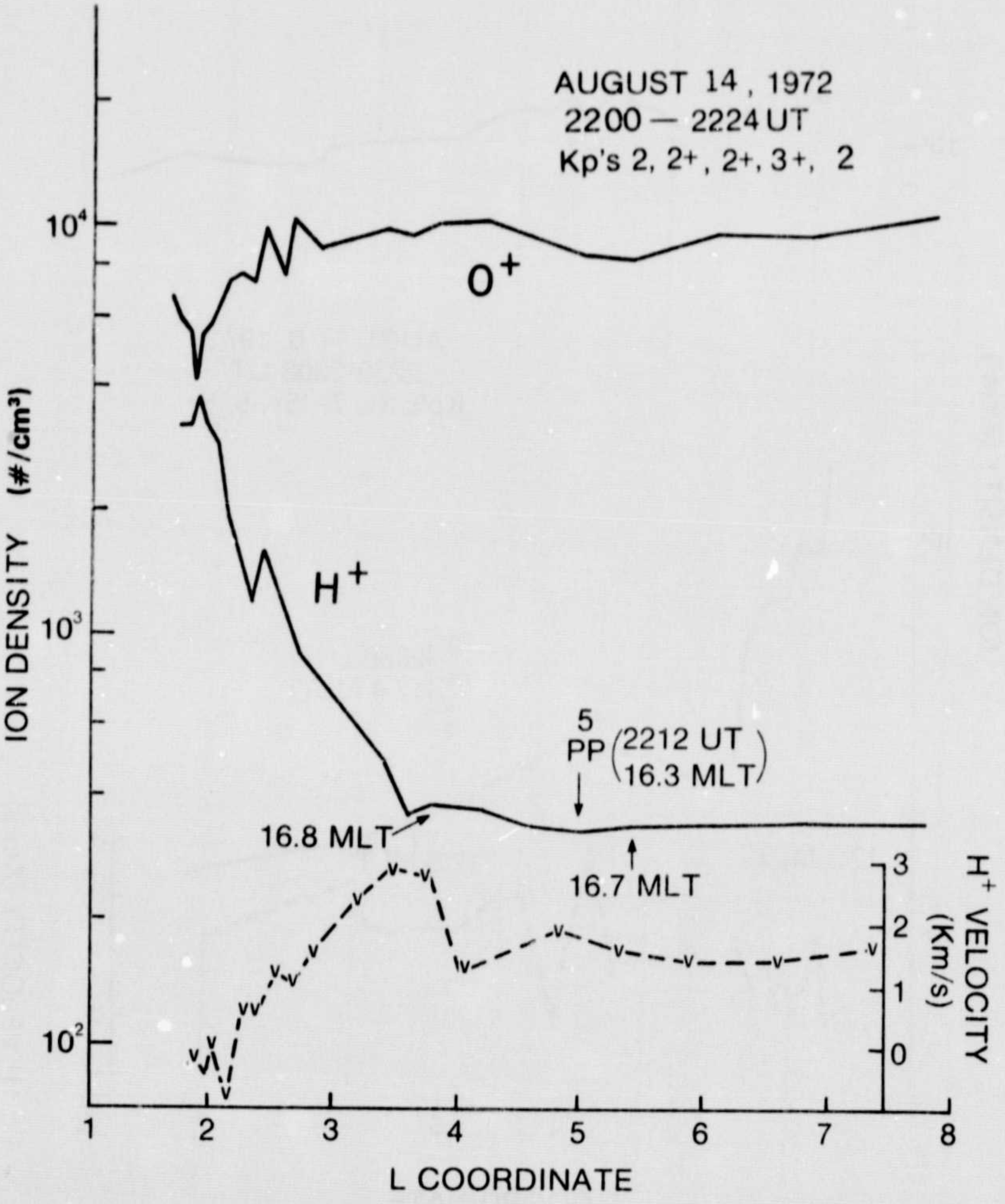
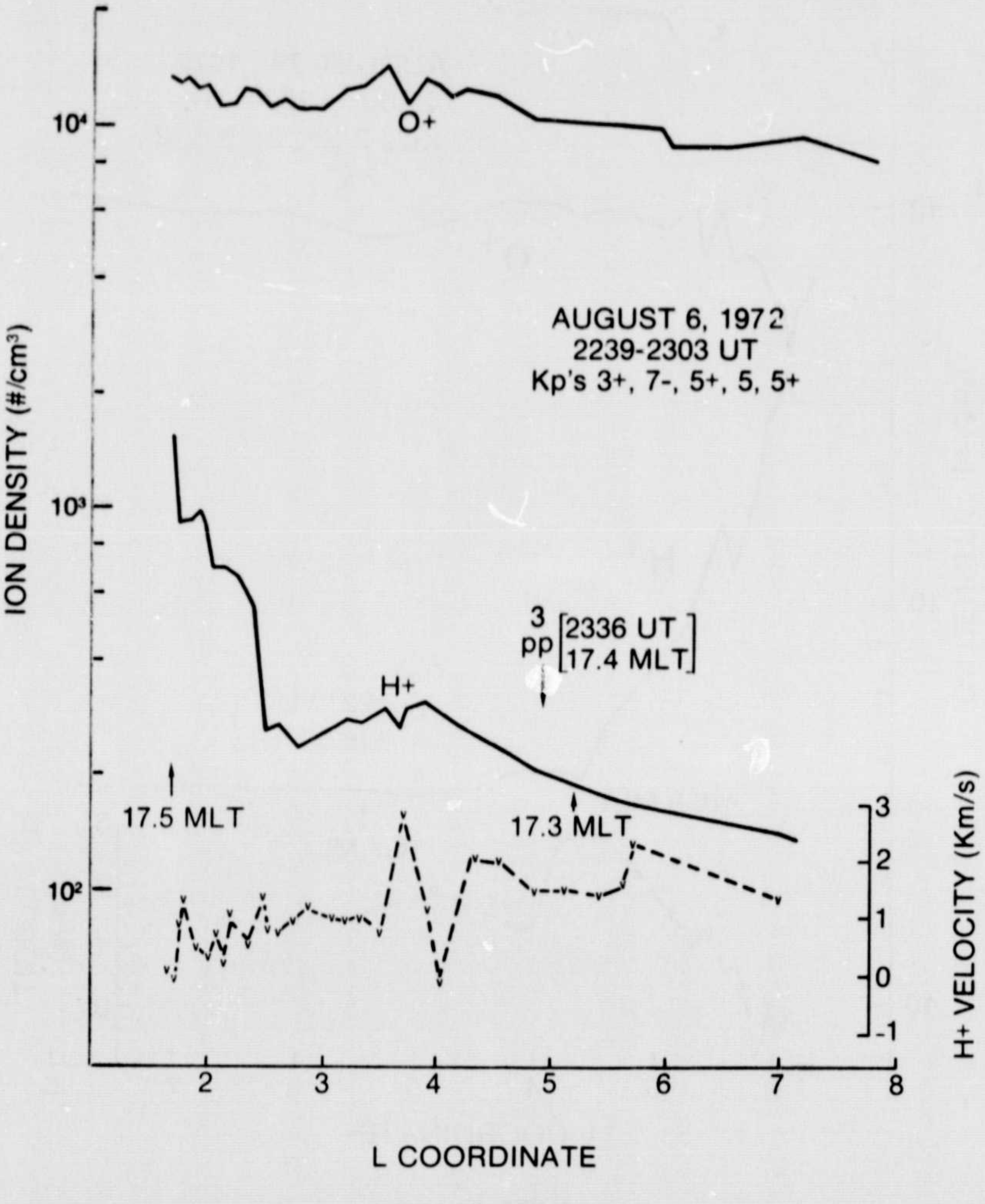

AUGUST 14, 1972
2200 — 2224 UT
Kp's 2, 2+, 2+, 3+, 2
10^4
10^3
10^2
ION DENSITY (#/cm³)
O^+
H^+
5
PP (2212 UT
16.3 MLT)
16.8 MLT
16.7 MLT
3
2
1
0
H^+ VELOCITY (Km/s)
1
2
3
4
5
6
7
8
L COORDINATE

Figure 7



ION DENSITY (#/cm³)
10⁴
10³
10²
O+
H+
AUGUST 6, 1972
2239-2303 UT
Kp's 3+, 7-, 5+, 5, 5+
3
pp [2336 UT 17.4 MLT]
17.5 MLT
17.3 MLT
H+ VELOCITY (Km/s)
3
2
1
0
-1
2
3
4
5
6
7
8
L COORDINATE

Figure 8

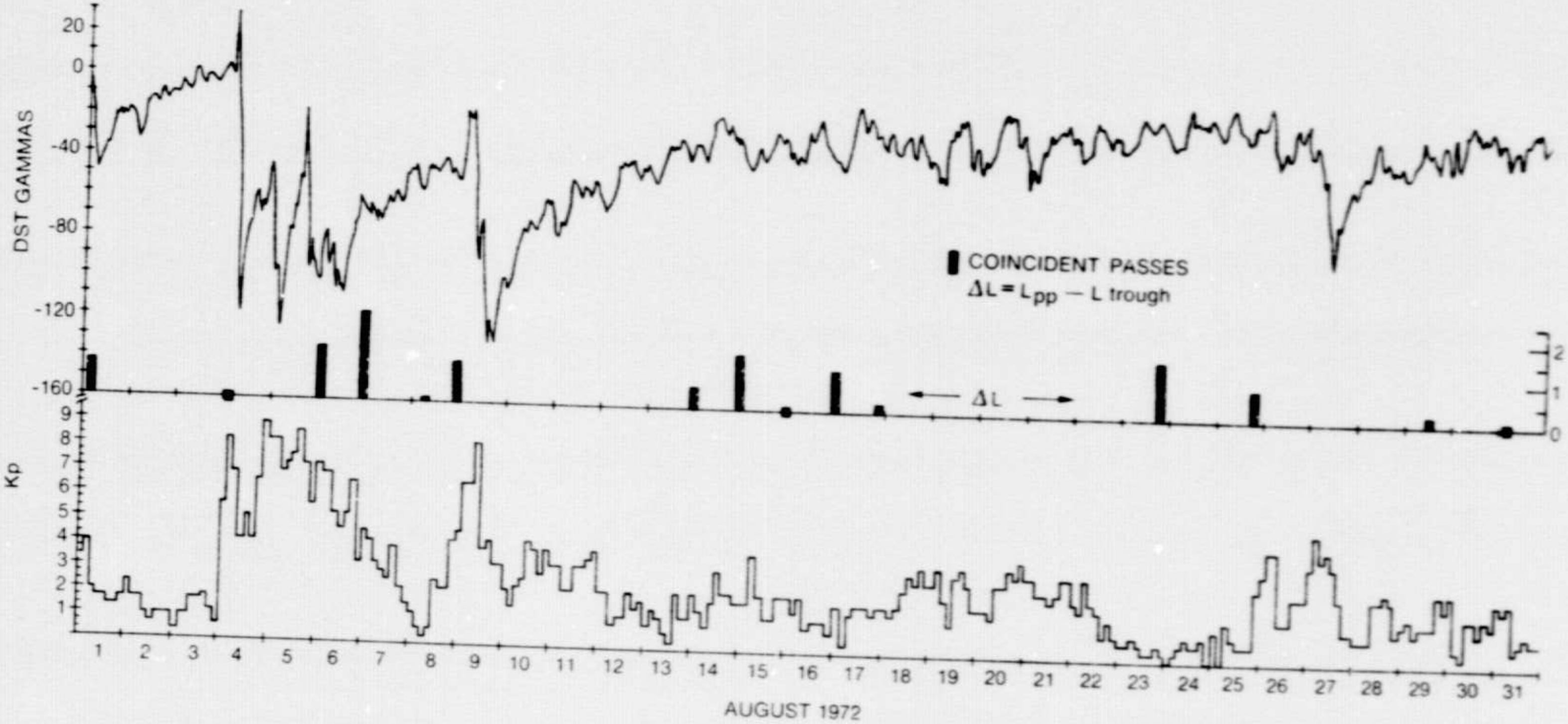

DST GAMMAS
20
0
-40
-80
-120
-160
COINCIDENT PASSES
$\Delta L = L_{pp} - L$ trough
← ΔL →
2
1
0
Kp
9
8
7
6
5
4
3
2
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AUGUST 1972

Figure 9