Enclosure (1) to LMSC/699062

FIFTH QUARTERLY PROGRESS REPORT
FOR
LOCKHEED EXPERIMENT ON ATS-5

(1 September through 30 November 1970)

Contract No. NAS 5-10392

Goddard Space Flight Center

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ABSTRACT

The Lockheed experiment on ATS-5 is continuing in its successful operation. The results of a series of simultaneous coordinated measurements of the low energy electrons on both ATS-5 and the low altitude polar orbiting satellite OV1-18 indicate significant spectral differences between the two locations. A detailed examination of the quasi-periodic oscillations of the particle fluxes and magnetic field, as measured on ATS-5 during a Pc-5 micropulsation event has been performed. A comparison with rapid run magnetograms from both northern and southern hemisphere conjugate stations is illustrated.

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INTRODUCTION

The analysis of the data from the Lockheed auroral particles experiment on ATS-5 is continuing. Particular emphasis during this quarter has been placed in two areas: 1) The analysis of a set of coordinated observations performed with similar instruments on the ATS-5 and the low altitude polar satellite OV1-18; 2) The detailed examination of the ATS-5 data during a particularly interesting Pc-5 micropulsation event which happened to occur during the period when the longitudinally drifting ATS-5 was on a field line whose conjugate points were in the vicinity of two ground observatories from which rapid run magnetograms are available, Great Whale River in the northern hemisphere and Byrd Station in the southern hemisphere.

During this reporting period two oral presentations of the ATS-5 results were made at the National Fall Meeting of the American Geophysical Union, and an abstract was submitted to the National Symposium on Natural and Manmade Radiation in Space, Las Vegas, Nevada, March 1971, sponsored by NASA and the AEC. These abstracts are included in the Appendix. A paper entitled, "Preliminary Results of a Low Energy Particle Survey at Synchronous Altitude," by R. D. Sharp, E. G. Shelley and R. G. Johnson was published in the November 1 issue of the Journal of Geophysical Research.

DISCUSSION

Coordinated Measurements with the OV1-18 Satellite

As indicated in our last report we are examining a subgroup of the ATS-5 data acquired during periods of simultaneous coordinated measurements made with similar instrumentation on the low altitude, polar orbiting satellite OV1-18. The central focus of the present investigation is on the comparison of the intensity of the precipitated electrons to that of the trapped electrons and on the comparison of the electron energy spectra at the two locations in the magnetosphere. The principle uncertainties in such a comparison arise from our lack of knowledge of exactly how the magnetic field lines at the ATS-5 location map down into the polar ionosphere. In this work we did the field line tracing with a static model (GSFC 12-66 Epoch 1969.75) which does not take into account diurnal distortions or the effects of magnetic storms or substorms. We will attempt to find cases where the electron flux characteristics at low altitudes are varying sufficiently slowly with latitude so that we can draw some conclusions independent of some reasonable uncertainty in the exact location of the conjugate point to ATS-5.

Figure 1 shows the results of this field line tracing for five examples which are presently under investigation, days 293, 294, 308, 314, and 342 of 1969. The OV1-18 trajectories at approximately 500 km altitude, and the projected ATS-5 field line locations for each case are illustrated. Figure 2 shows some results for two of the five cases, i.e. days 293 and 308. The time (to) at which the OV1-18 crosses the ATS-5 L shell is indicated for each case. The electron number flux in the region $0.7 \leq E \leq 45$ keV, the average electron energy and the pitch angle of the electrons measured with the OV1-18 detector are plotted as a function of time from to. The corresponding spatial relationships can be seen with the use of the time scale on the left hand side of Figure 1. One sees in Figure 2 that the measured number fluxes are quite comparable in the two experiments while the average energies are about a factor of two higher from the ATS experiment. These results are seen to be independent of uncertainties in field line tracing of the order of a degree in latitude.

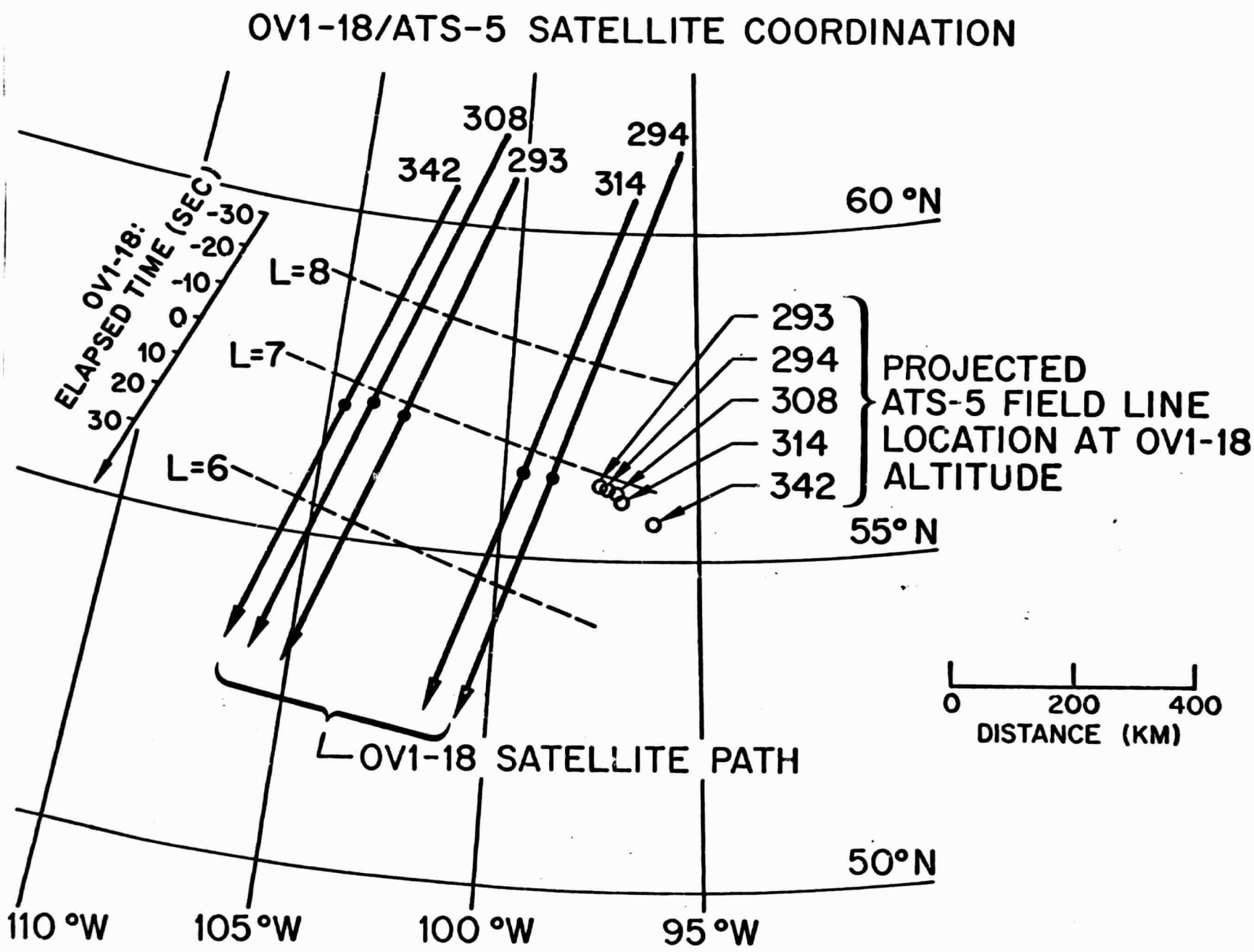

Figure 1. Geometry of Coordinated Observations

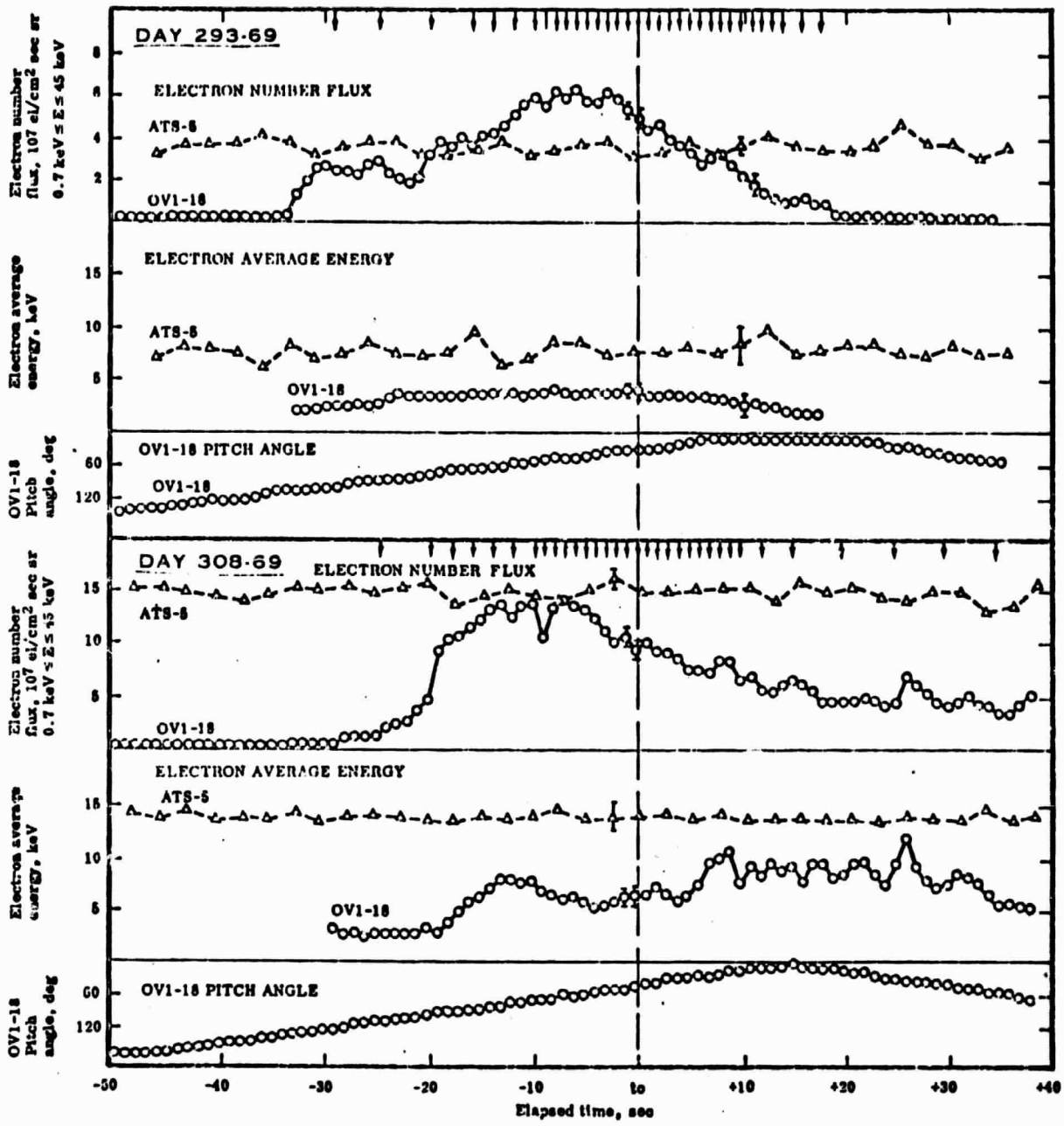

Figure 2. Electron fluxes and average energies measured simultaneously on OV1-18 and ATS-5.

Another interesting result is obtained by the comparison of the spectral shapes at the two locations. In order to make a representative intercomparison over the entire interval we show the spectrums from both experiments in Figures 3 and 4 at the times indicated by the arrows in Figure 2. One sees that over much of the period in question, the electron spectrums show a prominent peak in the OV1-18 data that is not evident in the ATS-5 measurements.

Quasi-Periodic Oscillations

Analysis of the quasi-periodic electron and proton flux modulations observed at synchronous altitude is continuing. The dominent frequency range of these modulations was found to be consistent with the frequency range of Pc-4 and Pc-5 micropulsations in the geomagnetic field which have been observed in the auroral zone. To investigate the possible connection between the two phenomena we have begun to analyze events in which flux modulations are found to occur in coincidence with micropulsations in the vicinity of the foot of the ATS-5 field line. Some of the results of the analysis of one event are shown in Figures 5 through 10. Rapid-run magnetograms from Great Whale River Observatory and Byrd station, near the northern and southern earth intercept of the ATS-5 field line respectively, have been digitized at approximately ten-second intervals. Spectral power densities were calculated for each electron energy channel and proton channel in which modulations were observable and these were compared with each other and with the spectral power densities of the magnetic field micropulsations which were calculated from the digitized magnetograms. The spectra are shown in Figures 6, 7 and 8. The phase relationship between the particle flux modulations and the field oscillations as well as the phase relationship between the field of the two magnetic observatories were determined by cross correlation analysis. The results of the cross correlation analyses are shown in Figures 9 and 10. The preliminary results of the analysis on this event suggest that it is consistent with an odd harmonic in the standing Alfven wave model for the micropulsations.

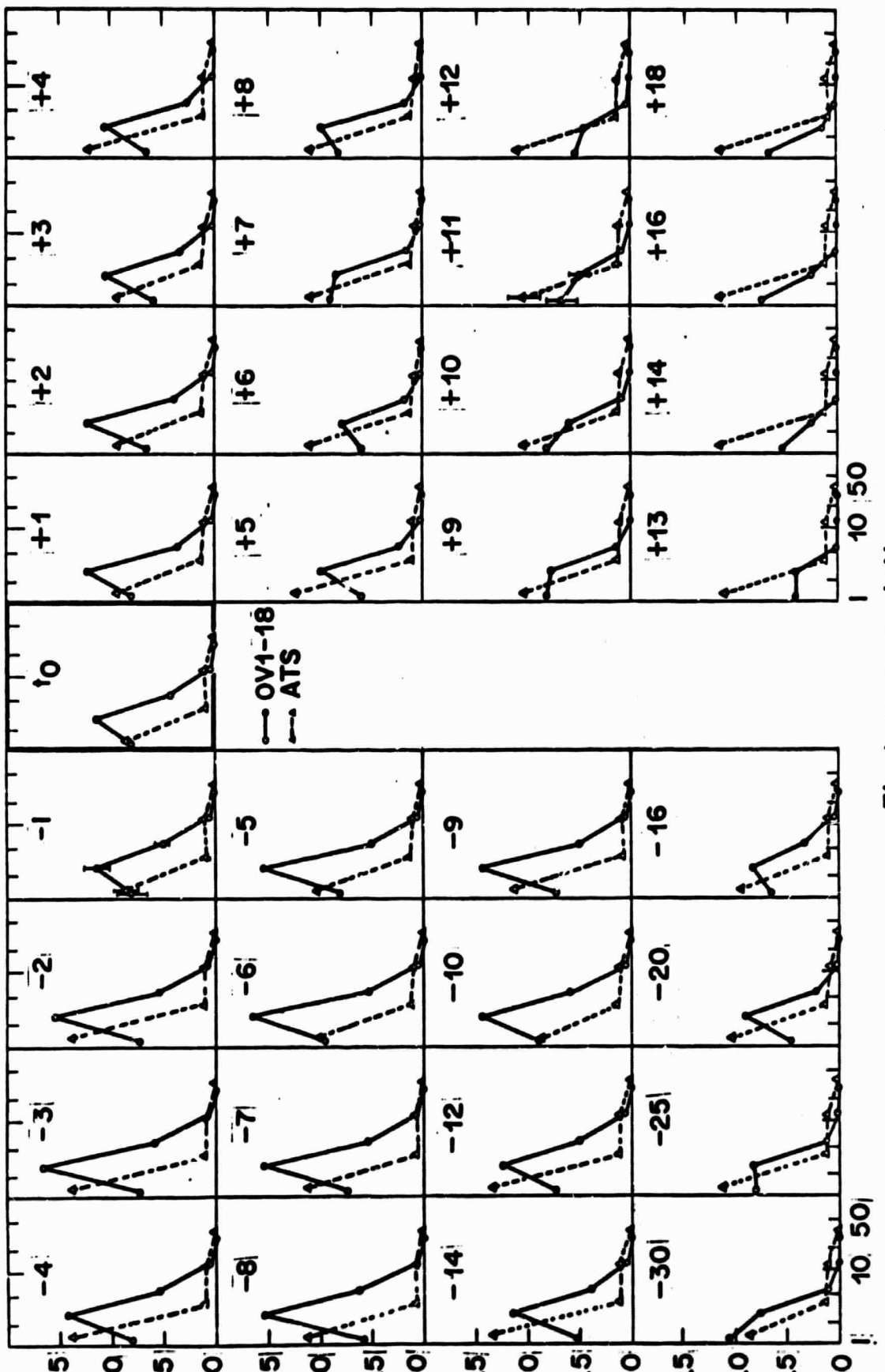

Figure 3. Electron spectrums measured simultaneously on the two satellites on Day 293.

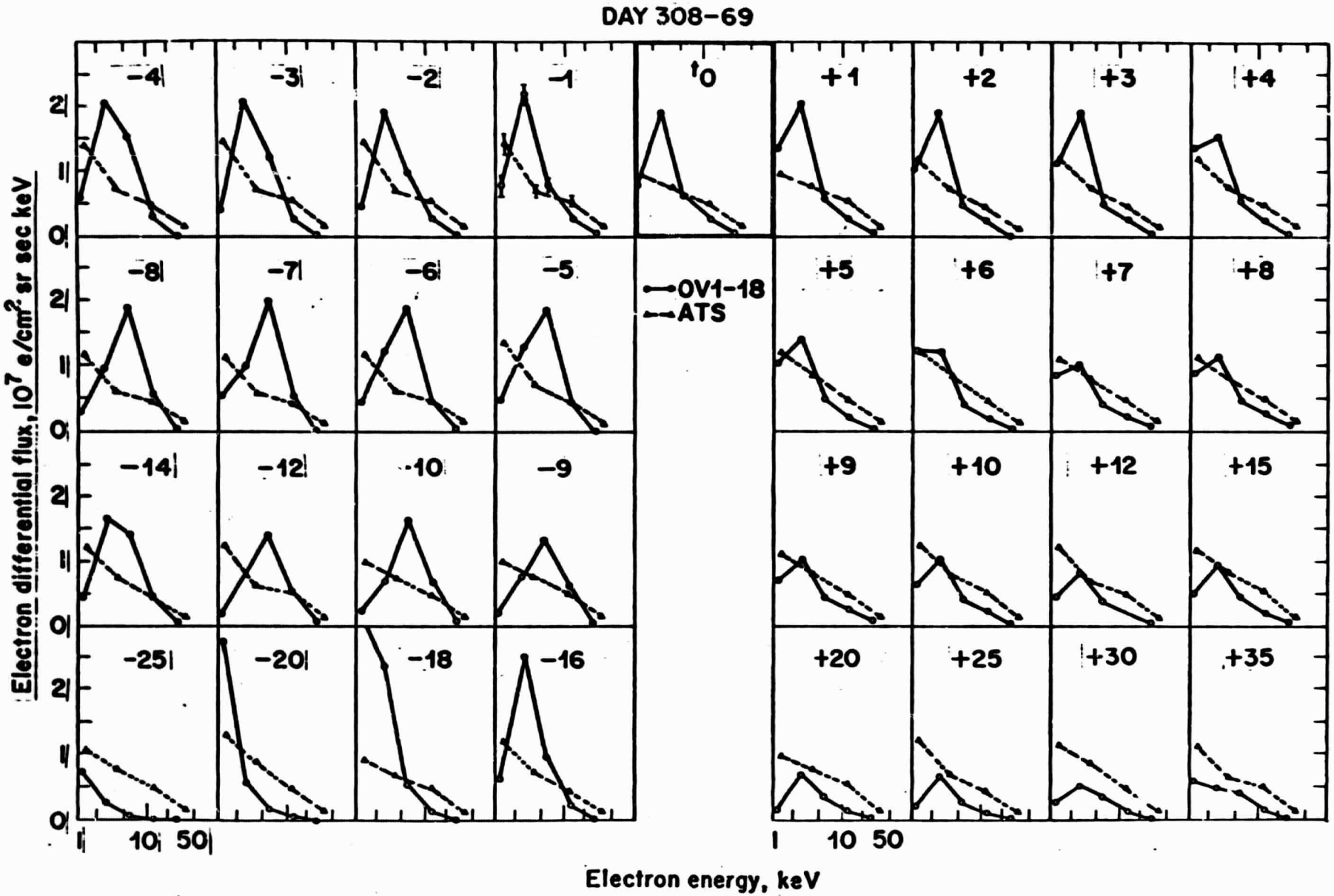

Figure 4. Electron spectrums measured simultansously on the two satellites on Day 308.

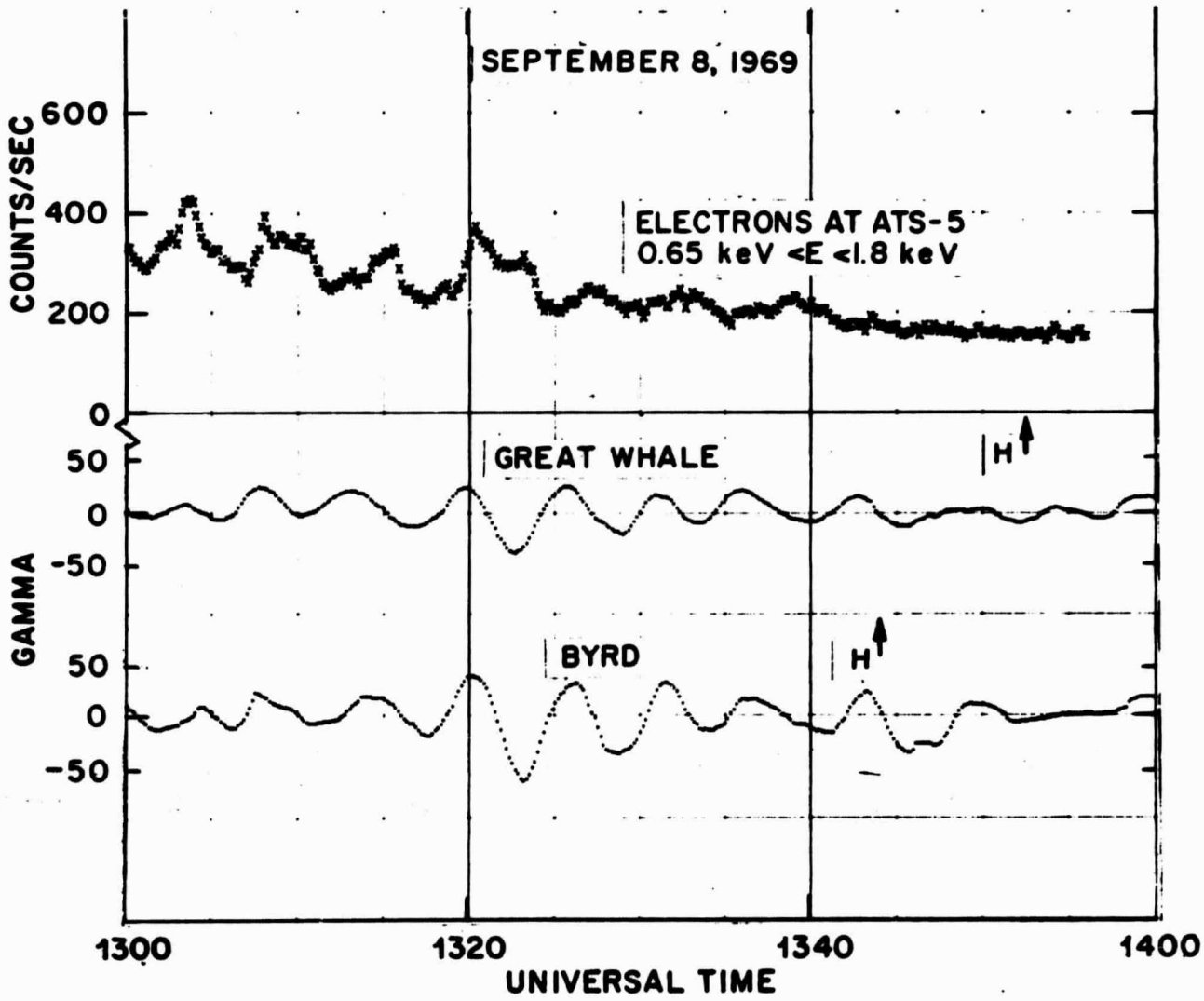

Figure 5. One-hour section of simultaneous measurements at ATS-5 and two observatories. The top curve is a 20-second running average of the CME-A output. The second and third curves are the H components at Great Whale and Byrd stations respectively with trends removed.

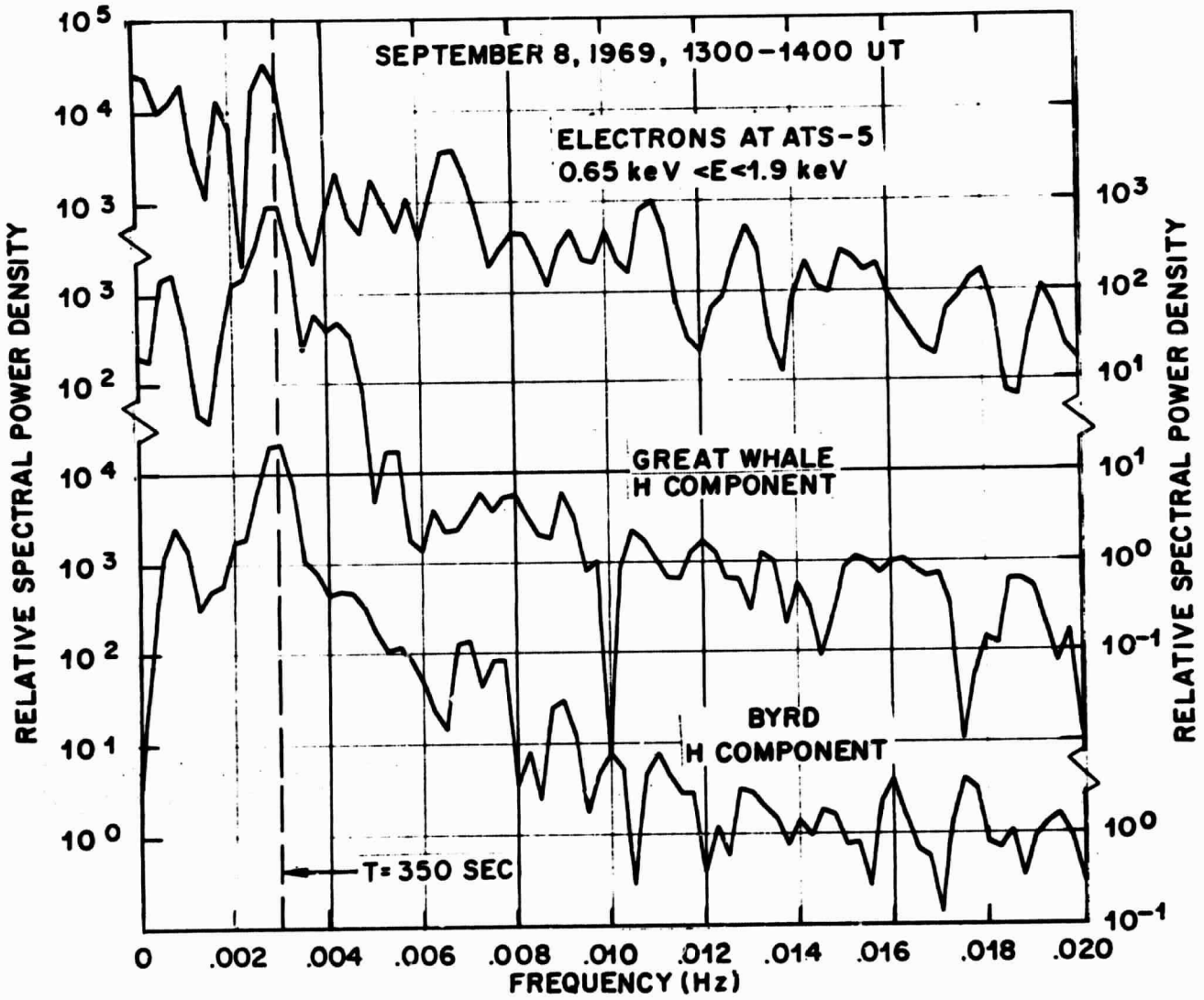

Figure 6. Relative spectral power densities for the three curves of Figure 5.

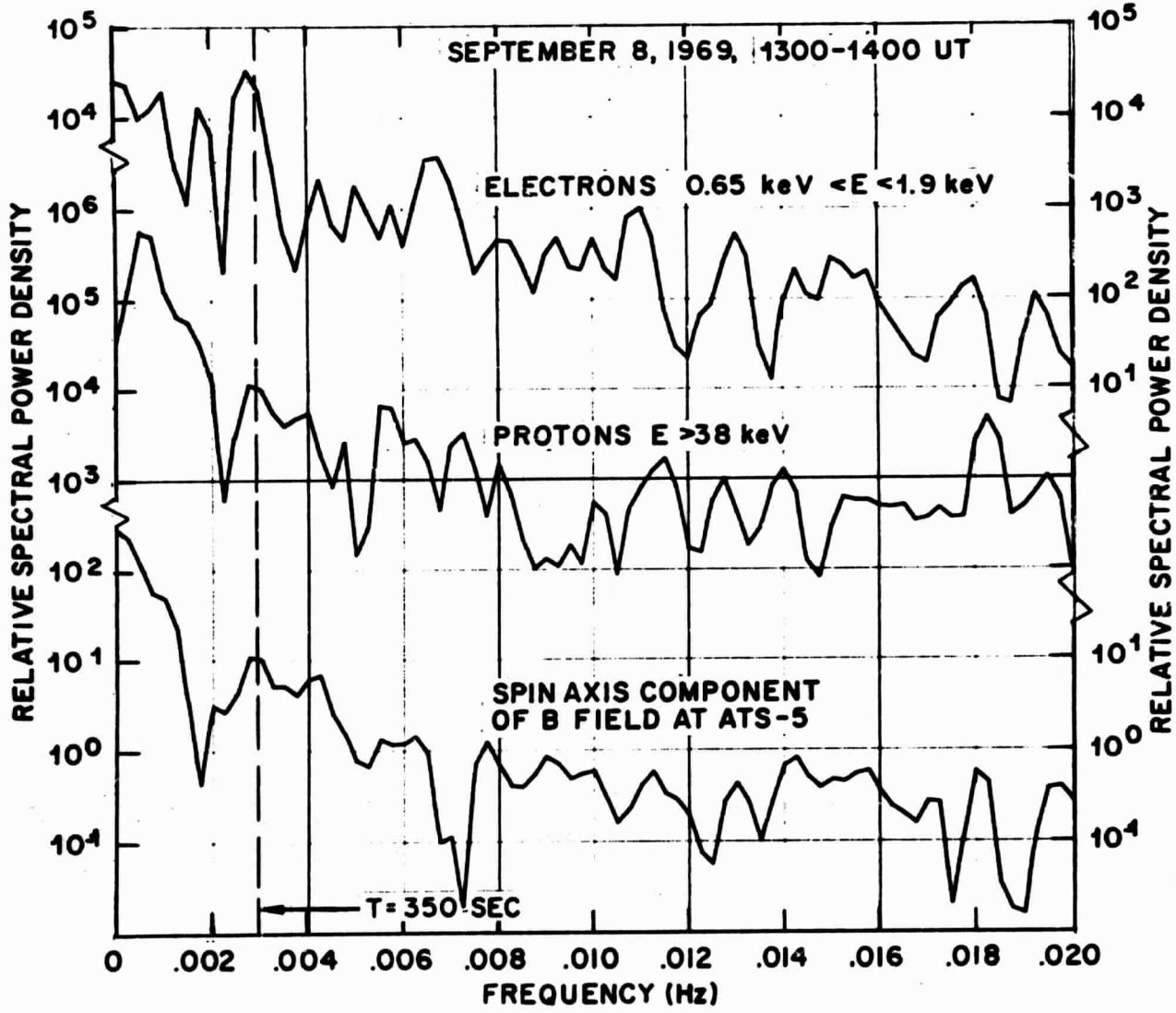

Figure 7. Relative spectral power densities of low-energy electrons, high-energy protons and B field at ATS-5.

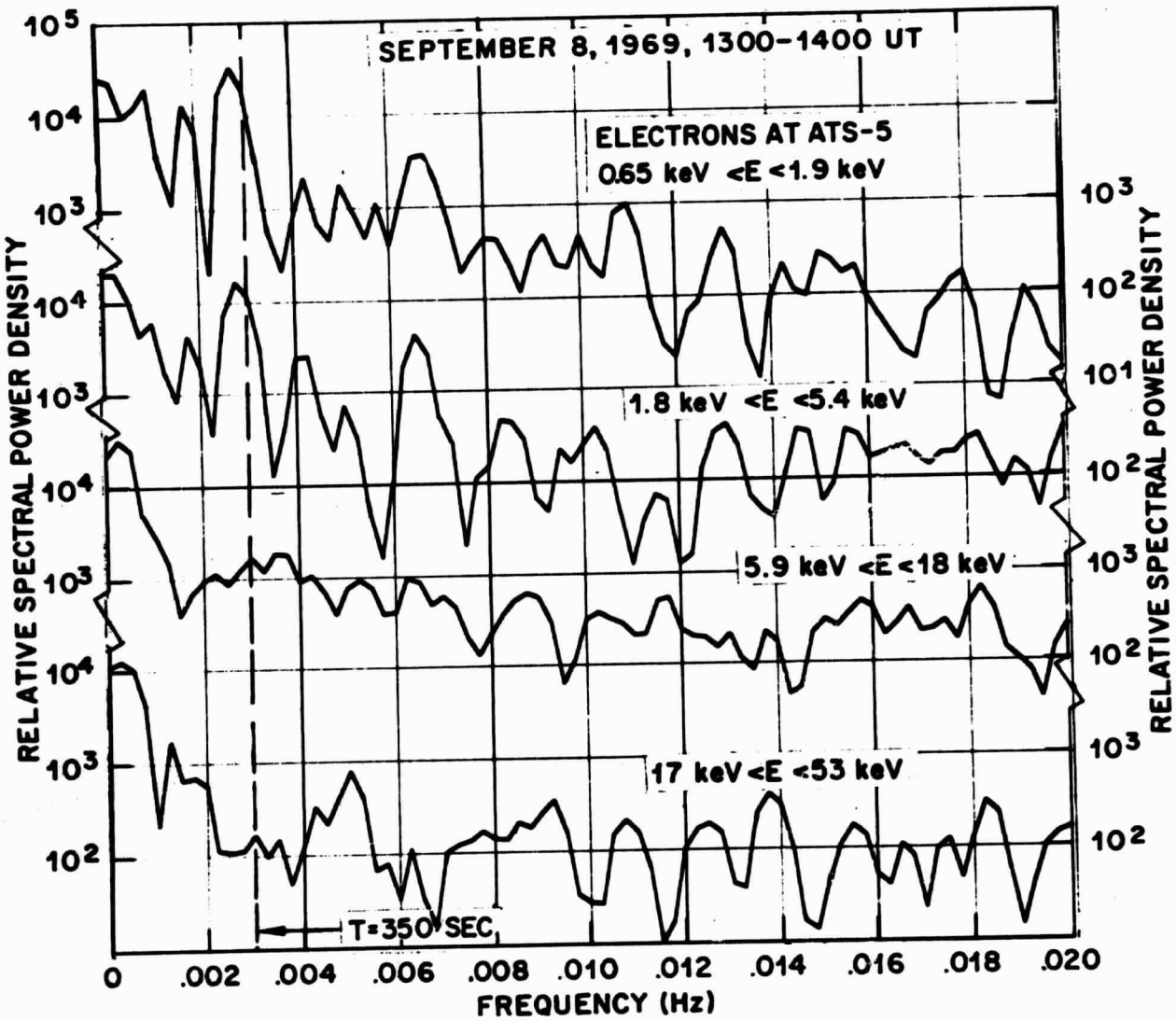

Figure 8. Relative spectral power densities of electron fluxes as a function of energy.

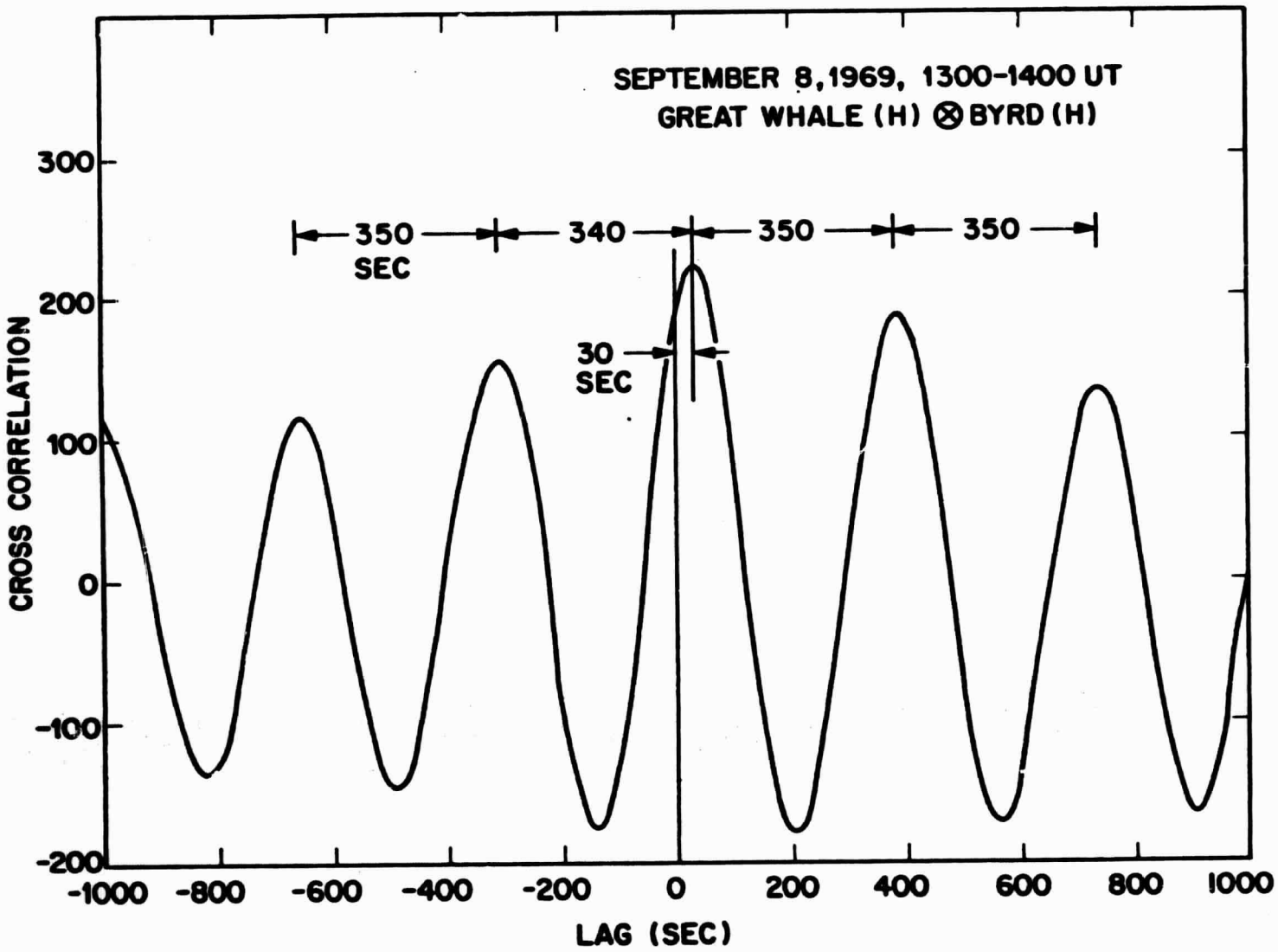

Figure 9. Cross correlation between Great Whale and Byrd H components.

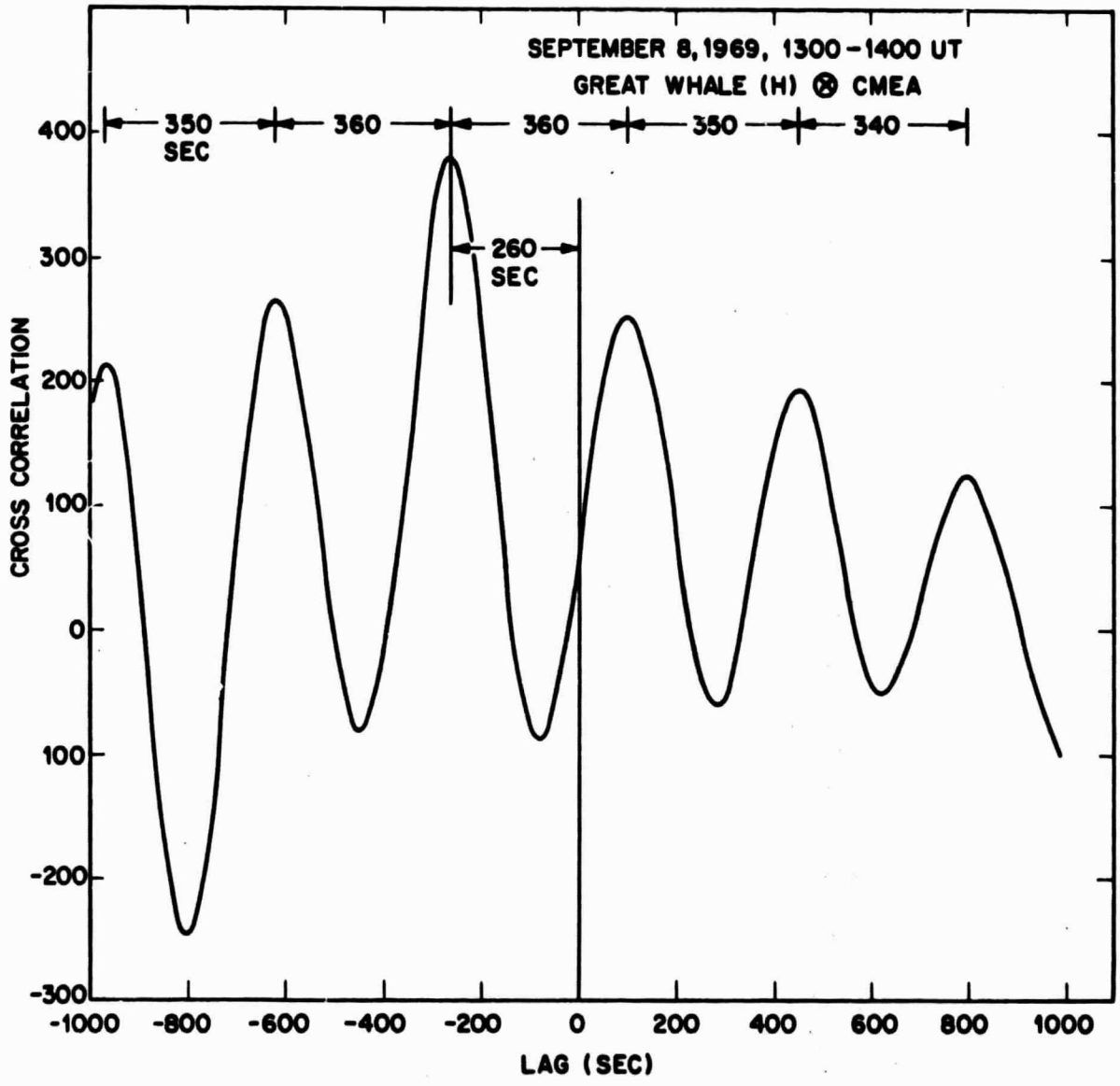

Figure 10. Cross correlation between Great Whale H component and CME-A electron fluxes.

PROGRAM FOR NEXT REPORTING INTERVAL

We will continue our analysis along the lines outlined in our post-launch data analysis plan as submitted on 15 October 1969.

CONCLUSIONS AND RECOMMENDATIONS

The experiment is continuing in its successful operation. The principal new results are in the study of micropulsation phenomena and in a series of coordinated measurements made between the ATS-5 and OV1-18 satellites.

A P P E N D I X

For presentation at the
December 1970 AGU Meeting
in San Francisco

COORDINATED AURORAL PARTICLE OBSERVATIONS WITH THE ATS-5 AND THE OV1-18 SATELLITES

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ABSTRACT

ATS-5 was launched on August 12, 1969, into a nearly synchronous orbit and has been maintained in the vicinity of 105° west longitude. The OV1-18 satellite was launched on March 18, 1969, into a 99° inclination orbit with apogee at 590 km and perigee at 469 km. Similar experiments by the Lockheed Palo Alto Research Laboratory on both spacecraft consist of auroral particle spectrometers using channel-multiplier sensors and either magnetic analysis or foil-threshold techniques to measure specific energy groups of protons and electrons. Primary emphasis was placed on the energy range between about one-half and 50 keV which contains most of the auroral particles. During selected intervals in 1969 an effort was made to program the OV1-18 satellite such that it would acquire data in the vicinity of the northern hemisphere conjugate point to ATS-5. Preliminary results from two cases indicate that the number fluxes of electrons are quite comparable at the two locations; that is, there is no evidence for equatorial angular distributions highly peaked in the loss cone. Significant spectral differences, however, are observed.

For presentation at the
December 1970 AGU Meeting
in San Francisco

QUASI-PERIODIC FLUX MODULATIONS AT SYNCHRONOUS ALTITUDE CORRELATED WITH MICROPULSATIONS

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ABSTRACT

The ATS-5 satellite was launched into a nearly synchronous orbit on August 12, 1969. The Lockheed Palo Alto Research Laboratory's experiment was designed to perform a survey of charged particle fluxes in the auroral energy range. It was previously reported that quasi-periodic flux modulations are frequently observed with periods in the range of one-half to several minutes. Several of these events have recently been analyzed for power spectra. Examples of the power spectral densities for these events will be shown together with similar power spectral densities for micropulsations of the Pc-4,5 type observed near the foot of the ATS-5 field line. The correlation between the satellite and ground-based measurements will be discussed.

10-30-70

LOW-ENERGY PARTICLE RADIATION ENVIRONMENT AT SYNCHRONOUS ALTITUDE

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ABSTRACT

Low-energy charged particles in the space environment are known to be important contributors to the degradation of thermal control surfaces on satellites and to structural effects in thin films such as cover materials used in connection with large flexible solar arrays. These particle-induced degradation effects are of particular importance in planning future satellite projects with projected lifetimes up to ten years. Some of these projects, such as communication satellites, are planned for synchronous altitude. Early measurements in the vicinity of synchronous altitude showed that intense and highly variable fluxes of protons and electrons with energies between one and 50 keV populate this region of space. The ATS-5 satellite, launched into synchronous orbit in August 1969, was the first synchronous satellite to include instrumentation for the investigation of the plasma properties of these low-energy charged particles. The Lockheed Palo Alto Research experiment on ATS-5, consisting of eleven individual sensors using continuous channel electron multipliers for particle detection, measured electron and proton fluxes in the energy range from approximately one-half to several hundred keV with primary emphasis on the region below 50 keV which contains most of the plasma energy. Energy analysis and particle identification was accomplished either by fixed field magnetic spectrometers or threshold foils. The experiment has been providing nearly continuous data on the particle environment for a period in excess of one year. Results from analysis of some of these data will be given.