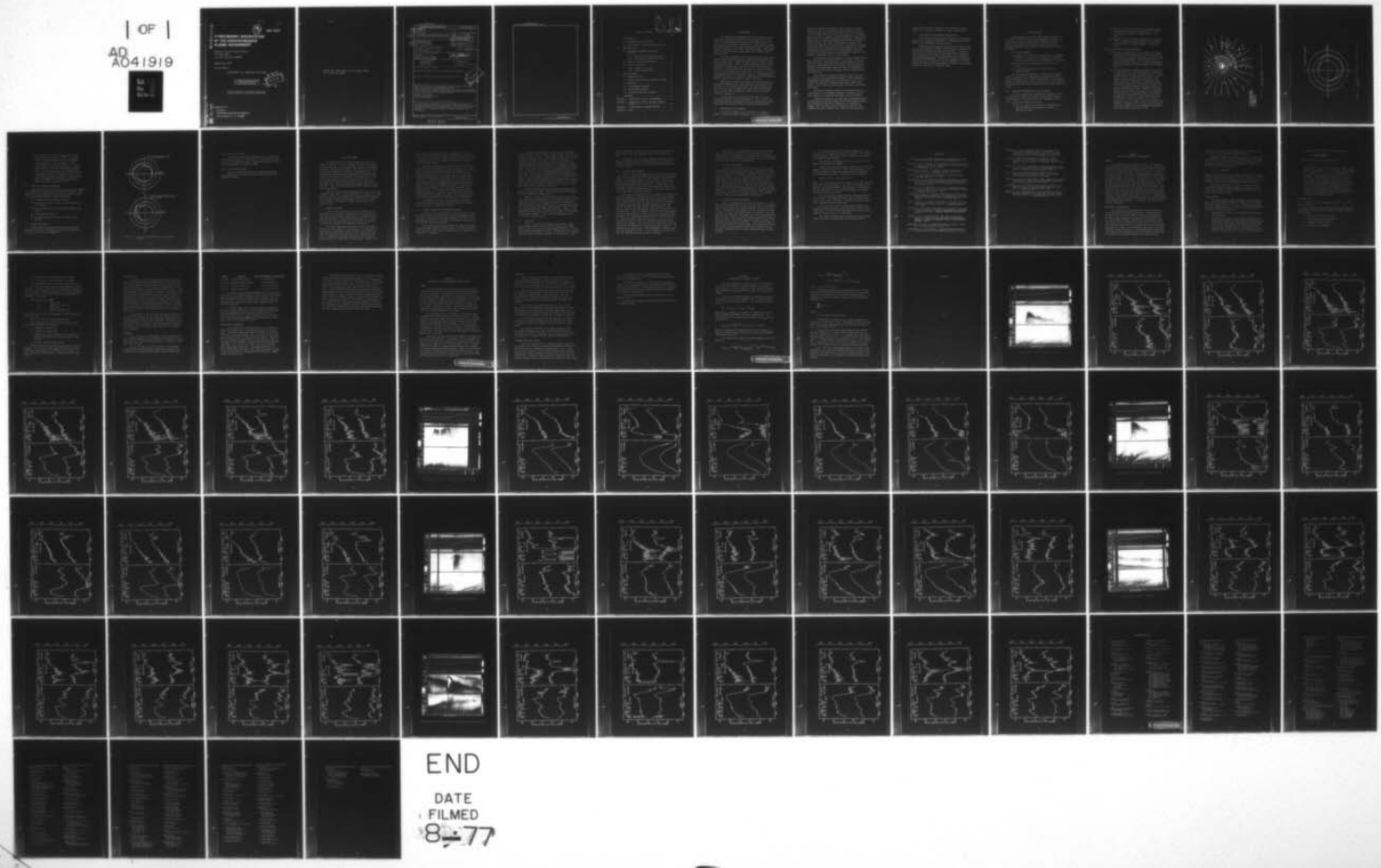
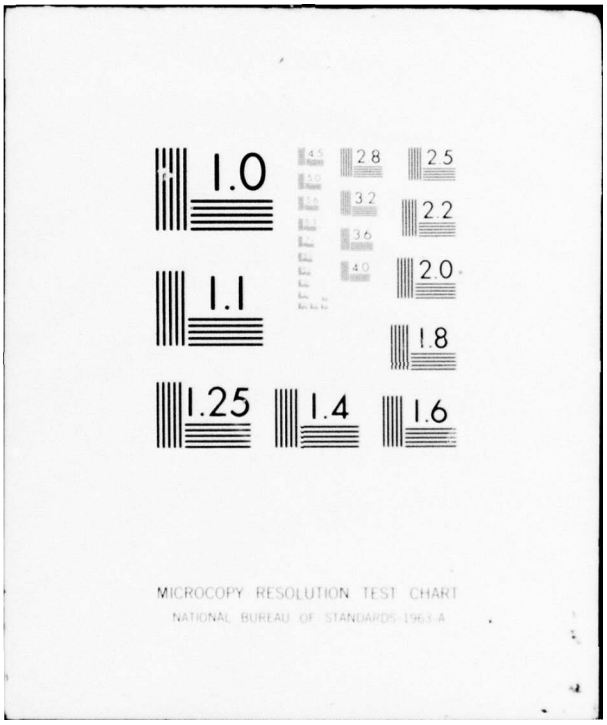
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A PRELIMINARY SPECIFICATION OF THE GEOSYNCHRONOUS PLASMA ENVIRONMENT

Systems, Science and Software
P.O. Box 1620
La Jolla, California 92038

September 1976

Topical Report

CONTRACT No. DNA 001-76-C-0121

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A preliminary specification of the plasma environment of geosynchronous satellites is provided. The plasma electron and ion density histories and temperatures are provided for a few selected days, including periods of substorm activity and eclipse.

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1. INTRODUCTION

The widespread acknowledgement of the hazards to normal spacecraft operation of electrostatic charging due to interaction of the spacecraft with the natural plasma has led to a need by several government agencies for a specification of the environment which can be used to make predictions of spacecraft behavior (DeForest, 1971, 1972; McPherson, et al., 1975; Rosen, 1975; Scarf and Fredricks, 1972; Shaw, 1974; Stevens, 1975; Whipple, 1976).

The work presented in this report grew out of the special needs of DNA to model spacecraft charging, particularly in unusual circumstances. This work covers only the plasma at the geosynchronous orbit (GSO). Similar studies have been funded by NASA's Lewis Research Center and the Air Force Geophysics Laboratory. Those studies are not targeted at DNA's needs and are on a longer schedule for completion. In particular, the work being funded by AFGL is expected to lead to a comprehensive environmental "Atlas" to be used by a wide variety of researchers. However, that report is still at least a year away.

Therefore, to satisfy the needs of current research programs being funded by DNA, this preliminary specification was created. It is accurate, but crude. The data presented here can be used as input to modeling programs with the assurance that it is the best available, but that a better model will eventually replace it.

To facilitate use of this and later models, we have closely coordinated the various efforts so that the final form of the environmental specification will be compatible with this preliminary specification without extensive re-programming.

1.1 DESCRIPTION OF THE PROBLEM

The natural plasma at GSO is difficult to describe simply. The various plasma parameters vary over orders of

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magnitude (DeForest and McIlwain, 1971) from hour to hour. The main source of this plasma is the geomagnetic substorm (Akasofu, 1968) which can release 10^{22} ergs into the magnetosphere in about 20 minutes. Many ground-based and spacecraft experiments have studied this problem (Chappell, 1970; Konradi, et al., 1975; Lezniak and Winckler, 1971; Mauk and McIlwain, 1974; McIlwain, 1972, 1974, 1975; Reasoner, et al., 1975; Vasyliunso, 1968) with limited success. Such basic parameters as where the particles originate, how the energy gets transferred from the solar wind to the magnetosphere, and what triggers the substorm are yet to be answered. Similarly, prediction of substorms is still in the future.

To make matters more difficult, only two spacecraft have been flown at GSO to provide data on the plasma. These are ATS-5 and ATS-6. Both spacecraft carried detectors that respond to a given energy per unit charge. For the negative channels this undoubtedly means that they are responding to electrons, but the positive channels could be either protons or heavier ions.

ATS-5 covered the energy range from 50 eV to 50 KeV with two pairs of body-mounted analyzers. ATS-6 represents a considerable improvement with an energy range of 0.1 eV to 80 KeV with two pairs of analyzers mounted in heads which rotate – one in the north-south plane; the other in the east-west plane.

ATS-6 has uncovered a wealth of new information, but unfortunately, it is extremely complex to analyze. Some of these effects are field-aligned fluxes, and cold plasmas.

Therefore we begin to see that the environmental specification must include such items as the local magnetic field, the distribution function of electrons as a function of energy, time, and pitch angle, the same for protons, and probably the same for heavy ions. Much of this information

simply does not exist. Moreover, the variability of parameters is too great to consider all cases of everything.

1.2 DEVELOPMENT OF PRELIMINARY SPECIFICATION

The solution of the problems presented in the previous section is to recognize that this is a preliminary study and that not all parameters can be presented.

Therefore we have limited our data base to ATS-5 only. This is much simpler to handle, and the analysis programs are much better developed than they are for ATS-6. We use the ATS-5 data to give the bulk of the plasma and in Appendix C give prescriptions for adding hypothetical cold plasmas and field-aligned components. Also in the appendix is reasonable ranges over which to vary the relevant parameters. This approach will get a preliminary model to potential users quickly without the expense of a complete study.

2. DATA SELECTION

Environmental data from the UCSD plasma instrument on board ATS-5 covering the period of September 1969 through the vernal equinox of 1971 (approximately 500 days) has been analyzed to provide input spectra for general modeling. Representative data from six days is presented in the following forms:

- 24 hr spectrogram
- Integrals, for electrons and protons, of the number densities and energy fluxes respectively based on 2.3 minute averages for the selected 24 hour periods
- Plots of six selected spectra for each 24 hour period
- Printouts and punched cards containing the selected spectra

The data has been selected to typify several broadly different categories of magnetospheric weather which occur at geosynchronous orbit. While representative of the magnetospheric conditions the data are not extensive. It is meant to provide useful input for the development of spacecraft charging codes.

2.1 BACKGROUND INFORMATION FOR DATA SELECTION

Previous studies provide background information which is useful in the selection of data for the study of spacecraft charging. Facts which should be considered include:

2.1.1 Spacecraft Performance Features

- Spin up anomalies on the DSCS-II spacecraft are well correlated with geomagnetic substorms (TRW SCA II, 1975)

- There is a strong association of unexplained satellite performance with the midnight to dawn sector of local time (McPherson, et al. (1975)). (See Figure 2.1.)
- The local time distribution of spacecraft charging events is found to maximize between local midnight and dawn (Reasoner, et al. (1975)). (See Figure 2.2.)

2.1.2 Magnetospheric Weather Features

- Equatorial observations by the geostationary satellite ATS-5 of charged particles on auroral lines of force reveal the frequent injection of plasma clouds into the magnetosphere. These intrusions of hot plasma are found to have a one to one correspondence with magnetospheric substorms (DeForest and McIlwain, 1971).
- The electromagnetic fields surrounding the earth act to separate the injected plasma clouds on the basis of both charge and energy (McIlwain, 1972). Electric fields attempt to bring about corotation of low energy electrons and protons as one moves inward toward the earth. Magnetic field gradients cause high energy electrons to drift toward the dawn side of the magnetosphere while high energy protons are caused to drift toward dusk. Effects of importance which follow are first, the spectra in the midnight to dawn sector are characterized by high electron energies and thus tend to induce spacecraft charging (DeForest, 1972), and second, field aligned fluxes are set up in order to maintain overall charge neutrality (McIlwain, 1975). These fluxes can make important contributions to differential charging of spacecraft surfaces (DeForest, 1973).

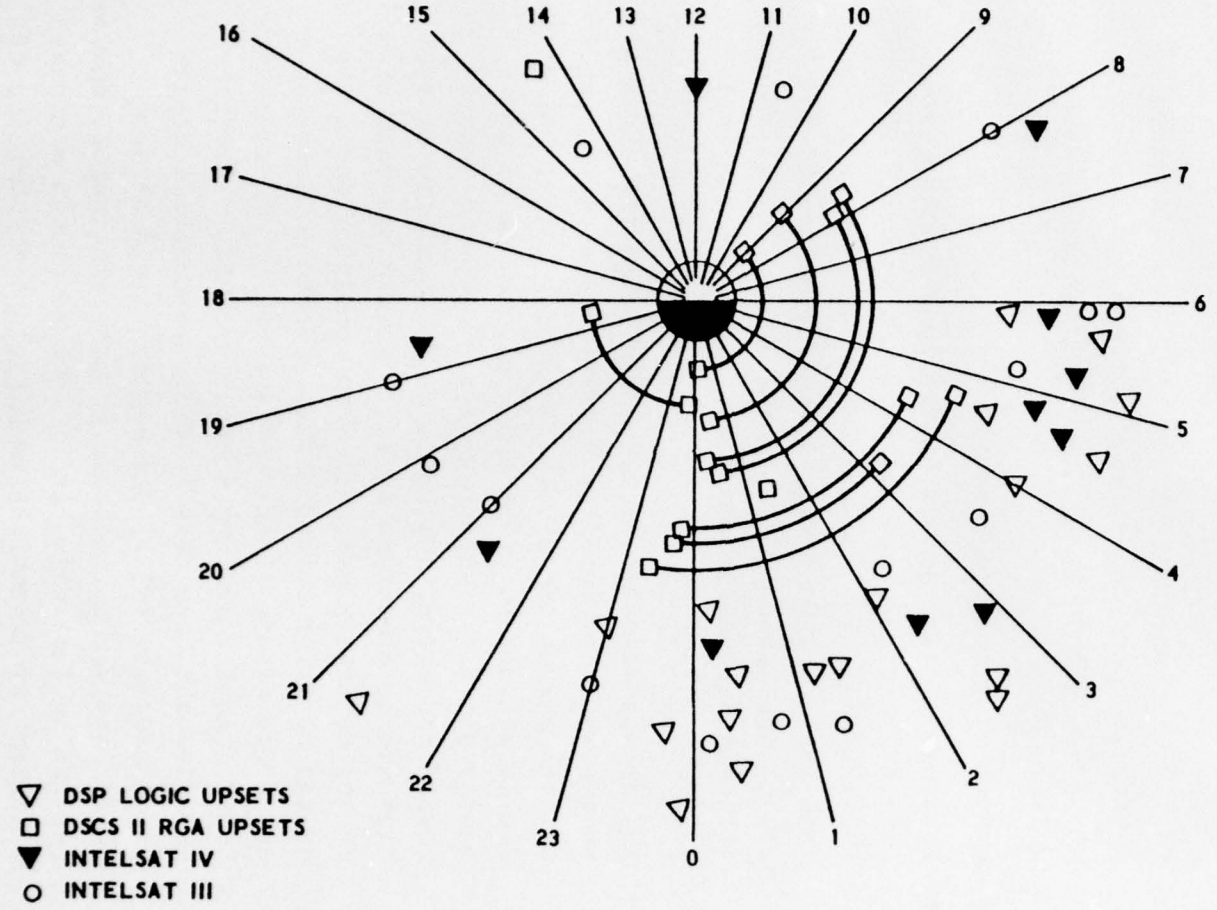


Figure 2.1. Unexplained satellite performance correlates with local time.

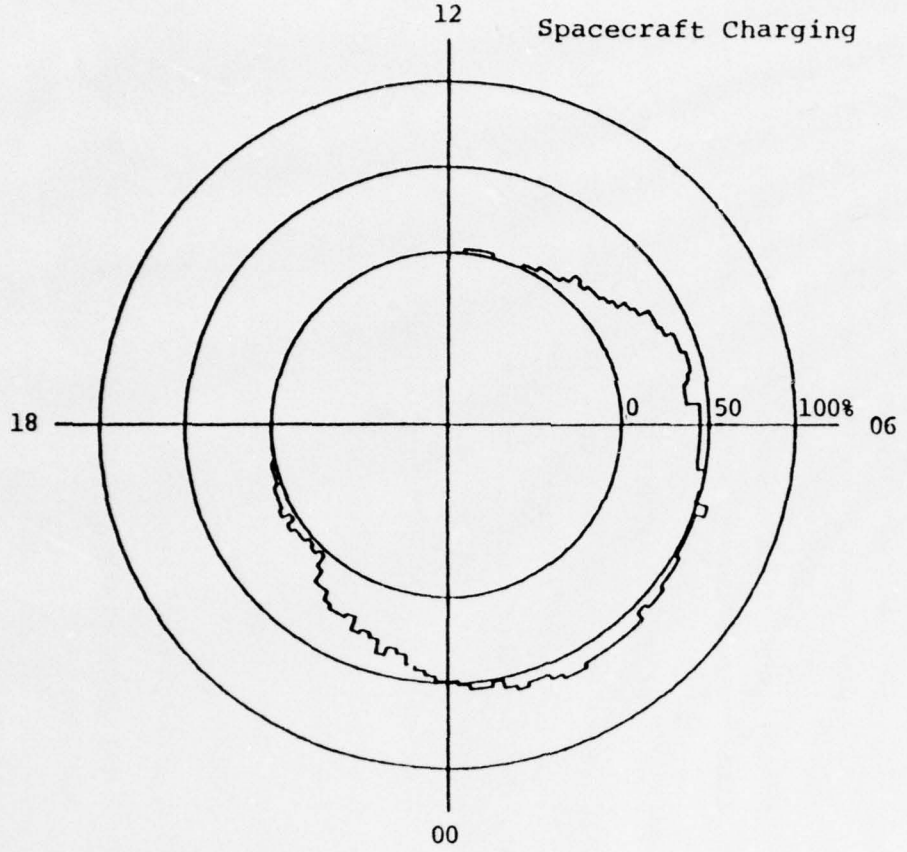


Figure 2.2 Local time distribution of spacecraft charging events.

- The plasmasphere shrinks during periods of high magnetic activity (Chappel, 1970). At geosynchronous orbit encounters with the plasmasphere are concentrated in the local noon to local evening section as shown in Figure 2.3. Plasmasphere encounters are anti-correlated with spacecraft charging. There are two reasons for this. First, the high density low energy plasma provides a grounding current to the spacecraft thus preventing large potential buildups. Second, plasmasphere encounters are more common during quiet times when substorm activity is low.

2.2 TYPICAL CONDITIONS REPRESENTED

With these facts in mind data from the year 1970 gathered by the UCSD plasma spectrometers on ATS-5 was analyzed. From these data the six representative days were chosen to typify the following magnetospheric weather conditions:

- A quiet day with no substorm activity
- A moderately active day with a single substorm of low intensity
- Two days with intense localized post midnight substorms
- A pre-midnight substorm
- A day when spacecraft charging occurred in the sunlight

2.3 SPECIAL CONDITIONS

Several special conditions can occur which we have designed into the total distribution functions which are to be used in this study (see Appendix C).

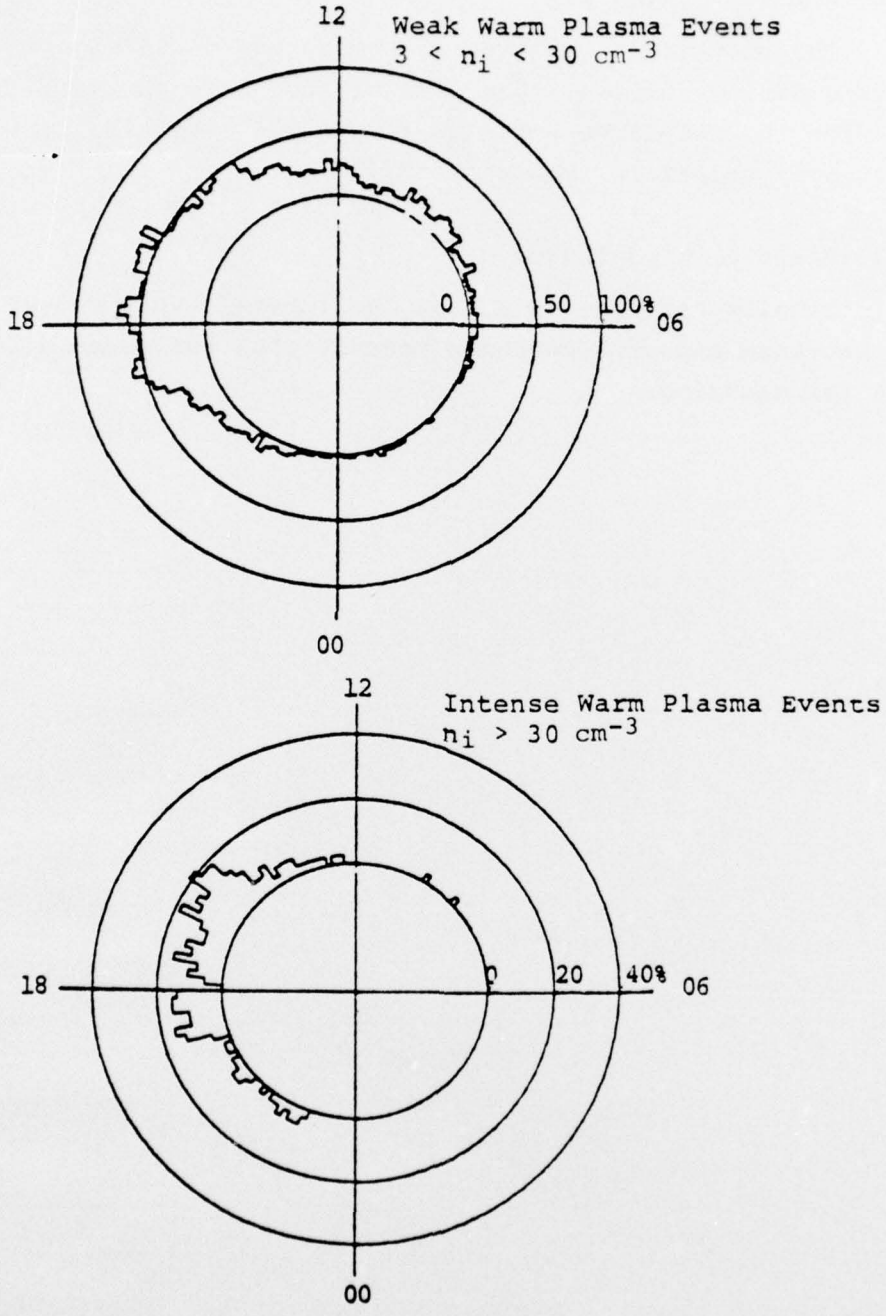


Figure 2.3 Local time distribution of warm plasma encounters.

2.3.1 Eclipse of the Sun

The spacecraft charging phenomena was first discovered on ATS-5 during eclipse. The loss of the large photoelectron flux from the satellite surfaces allows the satellite to float up to high potentials (DeForest, 1972).

2.3.2 Field Aligned Fluxes

Usually encountered during the intense early phases of a substorm and of importance because they can cause differential charging.

3. DATA AND FORMAT

The data presented in this section consists of four types in addition to sets of punched cards for easy computer use. For each day or event presented, a 24-hour spectrogram is used to establish the context. Following that, selected spectra are shown which illustrate significant events. Instruction for reading both the spectrograms and the average plots are provided in the appendix. The same data have been written on punched cards and are available for future use. The printouts of the detailed spectra are also available. Note that these detailed spectra are produced from 6.8 minute averages. This gives good statistics without smoothing rapid time fluctuations.

The final form of data presentation is a table of various integrals taken over 2.3 minute periods for the whole day. These might prove useful for studies where analytical approximations to the spectral shape is more useful than the actual spectra. The whole day is provided for possible future use in time-varying codes.

3.1 MODERATE ACTIVITY

2/1/70 – The activity on this day was limited to two early morning injections at approximately 0110 and 0500 UT. The effect was to bathe the spacecraft in a moderate flux of 3000 volt electrons. From previous experience, we can estimate that had the spacecraft gone into eclipse on this day, it would have charged to approximately 1000 volts.

The fluxes associated with this injection were insufficient to cause charging in the sunlight. (For purposes of this report a potential of less than about 50 volts will be neglected since the ATS-5 detectors do not sense lower energies). Furthermore, isolated substorms of this type have never been seen to charge ATS-5 significantly. However, from

ATS-6 data we can estimate that a potential of at least -5 volts occurred and that by simply renormalizing the total flux by a factor of 2-10 while keeping the same spectral shape, we can simulate the conditions under which daylight charging of -100 volts would happen.

Detailed spectra are provided for 0300 to see the pre-electron encounter conditions. The next spectra are at 0400 when the high-energy protons had been encountered, but not the associated electrons. The next three sets of spectra are taken at different points in the main part of the substorm. At 0530 ATS-5 experiences the greatest flux of high energy electrons. By 0630 the average energy of the electrons has fallen slightly due to gradient drifting while the average energy of the ions has increased slightly. At 0730 the ion chasm is well developed, and a notch has developed in the electron spectra. This feature is common and will persist for the entire day. A final set of spectra taken at 1200 is provided simply to complete the story. The spectra at 0530 and 0630 are probably the most hazardous to the spacecraft.

In summary, 2/1/70 is a good example of isolated, moderate activity which could be used to study the response of a spacecraft to a normal environment.

3.2 INTENSE LOCALIZED POST MIDNIGHT SUBSTORM

2/11/70 – On this day we were fortunate enough to find an intense substorm occurring right at the spacecraft location. This day is particularly valuable because of the lack of complicating activity at other times, and because no corrections for daylight charging are needed.

The injection took place at 0850 when ATS-5 was located in the hazardous midnight-to-dawn sector. The total fluxes at 0900 were quite close (within a fraction of 2) of charging the spacecraft in sunlight.

The first set of spectra are taken in the quiescent plasma at 0700. The next spectra taken at 0900 show the first encounter with this event. The low-energy spike seen in both electron detectors is not due, as might be suspected, to charging positively, but rather is most likely the locally produced secondaries being reflected from a suddenly enhanced plasma sheath about the spacecraft (see discussion by Whipple, 1976). This event could easily have produced charging in excess of 10,000 volts if the spacecraft had been eclipsed at this time. Such a sharp, localized event was probably responsible for the main power supply failing on a non-NASA spacecraft. (Note both ATS-5 and ATS-6 are research craft and are somewhat better built than ordinary operational craft. Therefore one is not surprised that they can sail through disturbances that would sink weaker vehicles.)

Spectra at 1000 and 1100 document the evolution of the event in the normal manner. The predominant spectral changes are again caused by gradient drifts.

Spectra at 1400 and 1700 show the complex spectra that can result from the combination of injected particles, particle losses (the chasm in the protons, and loss of high-energy electrons), and multiple encounters with the high-energy particles as they circle the earth. These spectra would be useful for studying spacecraft conditions near noon. However, a low-temperature plasma must be assumed to be present in both sets (see previous section). (See also the description of day 12/3/70 for a similar event.)

3.3 QUIET DAY

2/12/70 – This day was chosen to illustrate a quiet period partly because it is one of the longest quiet times normally seen, and because it fortunately followed the intense event already described on 2/11/70. Therefore we have a single two-day period of uncommon interest for this project. Note

that we have small data gaps at both the start and end of the day. These are of no consequence since the activity is so low.

The spectra for this day is simply spaced throughout to sample uniformly. Any use of these spectra must assume the presence of copious cold (or "warm") plasma with densities of at least 30 cm^{-3}.

3.4 POST-MIDNIGHT SUBSTORM

3/18/70 – The event shown on this day actually consists of two closely spaced injections occurring after a large quiet period. The activity starts at about 1040 UT. This is sufficiently past midnight that the plasma response is very different than the case shown for 2/11/70. In particular, the main body of protons do not reach the spacecraft until about 1330 after traveling around the world to the west. This situation could produce hazardous charging.

The first set of spectra taken at 0900 set the stage for the later injection. The next three sets are spaced somewhat closer than the nominal minimum of one hour followed in the rest of this report. This was necessary because of the rapid development and the desire to show all phases of the event. The set of 1000 shows some electron enhancement over the earlier spectra. The 1050 spectra shows the leading edge of the injection. (Note the apparent oscillations in the electron spectra in this and the following set are an unavoidable artifact due to the particular operating mode chosen that day and the relatively rapid changes taking place.) At 1112 we see significant changes in both the low-energy electrons and the shape of the protons. But at 1200 we see even hotter electrons instead of the effective cooling we would expect normally. The explanation is easily seen in the spectrogram: another injection has followed this first. This is common and does not affect the usefulness of this day for the report.

The final set of spectra follow the injection development. Only now we see that the electrons have experienced rapid depletion (by probably precipitating into the atmosphere) and the arrival of the protons from their trip around the world has given us a spike in the distribution.

3.5 PRE-MIDNIGHT SUBSTORM

12/3/70 – The main feature of this day is the surplus of high-energy protons early in the day. Although this condition is probably not hazardous to spacecraft from the point of view of charging, it is a common occurrence, and the vehicle's response should be studied. Spectra are provided for 0200, 0400, 0600, 0700, 0800, and 1200 LT. The first four are of prime interest for the study of the effect of high-energy protons. The 0800 spectra can be used in a way similar to those of 2/11/70 for intense localized substorms. The main difference between the two are the higher energies, but lower fluxes seen on 12/3/70. The last set of spectra (1200 LT) are provided simply to show the time development of the storm.

3.6 ECLIPSE AND SUNLIGHT CHARGING

3/14/71 – Although the intent of this report is to provide isolated examples of various types of events at synchronous altitude, we realize that for many purposes this is not sufficient. Therefore we also present an active day which has both charging in eclipse and a good example of charging in sunlight. As can be seen from the spectrogram, this day is very different from the other examples. Several distinct substorms follow one after the other. The plasma conditions change so quickly that obtaining good averages is difficult. The charging events are easily identified by the bright bands in the low energy protons. The eclipse is always centered about local midnight, and the sunlight charging on ATS-5 is always observed between midnight and dawn.

The first spectra taken at 0600 is pre-eclipse. The next two are at different phases of the eclipse. The 0800 set is post-eclipse. The last two sets of spectra are preceding and during sunlight charging.

The parallel electrons in the last two cases show the effects of differential charging.

Persons using this set of data might want to correct the fluxes to what they would be if there were no charging. The cookbook method for doing this assumes that the instrument is a differential detector. Then by Liouville's theorem,

$$J_p(E) = [E^2/(E - q\phi)^2]\ J_m(E - q\phi)$$

where J_p is the predicted flux at energy E, J_m is the measured flux, and ϕ is the potential. The sign of the charge, q, is positive for ions and negative for electrons. We emphasize that the only fluxes to be corrected by means of the above equation are those for 3/14/71.

For the sunlight charged cases the average potential ϕ is -80 volts. The spread throughout the event ranges from zero to -200 volts in sunlight. Therefore corrections above a few thousand volts are unnecessary.

As can be seen from the spectrogram on 3/14/71, the potential varies throughout the entire eclipse from zero to -2500 volts. For the eclipse case shown in p. 40 all channels should be corrected with ϕ = -1700 volts.

The lowest energy fluxes of electrons and the highest energy ions will be missing from the corrected spectra.

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APPENDIX A
DESCRIPTION OF ATS-5 SPECTROGRAMS

FORMAT

The spectrograms are produced in pairs: one showing the spectra from the perpendicular proton and the perpendicular electron analyzers and one showing the spectra from the parallel proton and electron analyzers. They are labeled by a large $\perp$ or $\parallel$ on the middle left side. The proton part is always below the electron part. The day of the year (January 1 equals day 1) and year is given at the bottom. The month, day in month, and year are also given at the left just above the $\perp$ or $\parallel$ label. The times at the beginnings and ends of the spectrograms can be arbitrarily set, and can cover any desired time span. Time scales covering as little as 10 minutes and as great as 4 days have been used. When more than one day is encompassed, either negative hours or hours greater than 24 are used to prevent any ambiguity. Grey scales are located at the right. Six different integrals are plotted in grey coded bands in the upper part along with magnetic field quantities. At the very top are two data quality indicators.

GREY SCALE INTERPRETATION

The primary value of spectrograms is their ability to reveal patterns in the energy-time plane. The determination of actual flux levels from them is of secondary importance. For this reason, and because of the loss in time resolution, the option which produces a coded pattern with which accurate flux values can be obtained is now rarely used. Color coding also permits accurate values to be obtained, but is more expensive than grey coding. In the present case, color is reserved for adding another dimension: by superimposing the perpendicular and parallel spectrograms with color filters limiting each to one-half of the visible spectrum, the energy and time

dependence of the pitch angle anisotropies are clearly displayed as patterns of different shades of color.

Should one desire to estimate the flux at a given point on a spectrogram, first locate the corresponding level on the grey scale at the lower right and determine the value of "G" on the scale marked 0 to 3. The differential energy flux in eV/cm^2 sec sr eV is then given by

$$(10^G - 1)\ 10^{b+4.367}$$

where b is given by "EL" in the lower left corner of the spectrogram for the electron fluxes or "PR" for the proton fluxes. The value of "ST" in the lower left corner gives the change in G between each of the 33 discrete grey levels available.

One option available is to let the grey scale recycle repeatedly instead of simply saturating. This option with a small value of "ST" is used to reveal small variations over a wide dynamic range of fluxes.

ENERGY SCALES

The computer program which generates the spectrograms can utilize any arbitrary function of energy for the energy scales for exhibiting all or any part of the measured spectra. The entire range from 50 eV to 50 keV is usually plotted with one of the two types of scales:

1. Logarithmic with 50 eV at the bottom for both protons and electrons.

2. Proportional to 1/(E + 3 keV) with the electron part inverted and sharing the same point with the protons at zero energy. The bias of 3 keV was arbitrarily chosen to give a good presentation of the 50 eV to 50 keV energy range. If the scale, S, is taken to be 0.0 at infinite proton energy, 1.0 at zero electron and proton

energy and 2.0 at infinite electron energy, then

$$S = \frac{E(1-q) + 3 \text{ keV}}{E + 3 \text{ keV}}$$

where E is the particle energy in keV,

$$q = \pm 1$$

depending on the sign of the particle's charge. Note that at low energies, $S \simeq 1 + qE/3$ keV. Time tic marks are located at S = 0, 1, and 2. The extrapolation of dispersion curves back to the time marks (at S = 0 or 2) yields the time infinite energy particles would have arrived, and therefore, the time of the event responsible for the dispersing particles. The slopes of the high energy parts of dispersion curves give a measure of the distance of the satellite from the regions in which the particles were perturbed, but it is apparently necessary to include electric field effects to obtain useful accuracy.

SUBSIDIARY DATA

A number of useful quantities are given in the lower left hand corner.

The analyzers in the "master" and "mate" channels are identified by numbers following "MASTR" and "MATE" according to the scheme:

1. perpendicular electron analyzer
2. perpendicular proton analyzer
3. parallel electron analyzer
4. parallel proton analyzer

TA = averaging time for the spectra in minutes

TS = time between spectral averages in minutes

TM = averaging time for the magnetic data in minutes

The seven bit command word is given immediately below "COMMAND". The first three bits give the channel assignments and are therefore redundant to the master and mate identifications given above. Bits 4 and 5 specify the operating mode according to the scheme:

bit	4	5	Mode
	0	0	track-scan
	0	1	single step scan only
	1	0	track only
	1	1	double step scan only

Bits 6 and 7 not set to zero correspond to other modes which are rarely used.

"ST", "EL", and "PR" are described above.

"PSNG" specifies the quantity being plotted in the spectrogram according to the scheme:

1. differential energy flux.
2. differential number flux.
3. ratios of the flux averaged over "TS" minutes to the flux averaged over the previous "TA" - "TS" minutes.
4. ratios of adjacent energy steps.

Options other than the first are used only in special studies. If the option to make the background black rather than white has been used, then "PSNG" will be negative. A black background is preferred for slides that are to be projected.

MAGNETIC FIELD

Data from the ATS-5 magnetometer have been kindly supplied by T. Skillman of the Goddard Space Flight Center and are plotted above the spectral data along with lines at 0, 50, 100, and 150 gammas. The data are not corrected for the effects of time changes in the spacecraft current systems. These perturbations can be as large as 15 gammas. The absolute value of the magnetic field component parallel and perpendicular to the spin axis is given by the darker and lighter points respectively (and usually the upper and lower respectively) with the spectrograms of the perpendicular analyzers. The perpendicular component is obtained using only the coarse (33 gamma step size) data and is thus uncertain by at least $\pm$ 10 gammas. Most of the scatter in this component is due to using only the coarse data.

The magnitude of the field and the angle of the field to the spin axis are given by the lighter and darker points respectively (and usually the upper and lower respectively) with the spectrograms of the parallel analyzers. The angle to the spin axis is given in degrees. Both the magnitude and angle are subject to the additional uncertainties in the perpendicular component.

INTEGRALS

Above and below the magnetometer data are six strips in which various quantities are logarithmically encoded in a grey scale such that a ratio of about 2000 to 1 is covered in going from black to white.

In the 1st, 2nd, 3rd, and 5th strips, the following integrals from the perpendicular and parallel analyzers are plotted with perpendicular and parallel spectra respectively:

Label	Quantity	Value at Midpoint of Grey Scale
PR N DEN	proton number density	1.0 proton/cm^3
EL N DEN	electron number density	1.0 electron/cm^3
E E FLX	electron energy flux	1.0 erg/cm^2 sec sr
PR E FLX	proton energy flux	1.0 erg/cm^2 sec sr

In the 4th strip labeled "PRESSURE", the total perpendicular electron plus proton pressure is plotted with the spectrogram of the perpendicular detectors with a midpoint value of 10^{-8} dynes/cm^2. In the 4th strip with the parallel data, the magnetic field pressure is plotted with a midpoint value of 2×10^{-8} dynes/cm^2.

In the 6th strip (near the top) labeled "PAR NFLX" the parallel electron number flux is plotted with the spectrogram of the perpendicular detectors with a midpoint value of 10^8 electron/cm^2 sec sr. In the top strip with the parallel data, the parallel proton number flux is plotted with a midpoint value of 10^7 protons/cm^2 sec sr.

DATA QUALITY INDICATORS

At the very top of the spectrogram is a line which increases in breadth with an increasing percentage of missing data. In the track-scan mode, about 73 percent of the potential data is usually "missing" since 75 percent of the time is spent tracking a peak in a narrow spectral region. When data are not available, previous data are used unless the time gap is greater than 30 minutes in which case the spectrograms are left blank. The top line, of course, goes to its maximum width during gaps in the data. The magnetometer data are not plotted during such gaps. Care must be exercised to avoid false interpretations of spectrograms containing data padded in from an earlier time.

Just below the missing data line is a line which becomes darker and thicker with increasing numbers of bad points. Often the quality of data transmission is such that over one percent of the data points are bad. Even the highest quality data being obtained are usually incorrect more than 0.1 percent of the time. This corresponds to over 800 bad data points per day of data. A data editing scheme has been devised which eliminates approximately 99 percent of the bad data and rarely removes data later judged to be good. Failure to remove bad points usually occurs when the false data happen to form a self-consistent context. This type of failure to edit properly is responsible for the two white areas in the lower right of Figure 4. The bad data indicating line reaches its maximum thickness when there are more than 10 bad points in the four spectra measured during the time covered between averages (equal to "TS").

APPENDIX B
DESCRIPTION OF ATS-5 SPECTRAL AVERAGE PLOTS

FORMAT

The spectra from the two electron and the two proton analyzers are plotted in adjoining log-log plots with borders at 30 eV and 100 keV. The range of the vertical scale is variable and depends upon whether the differential energy flux or the differential number flux is being plotted. The parallel electron spectrum is shifted down by a factor of 100 (i.e., x 0.01) and the perpendicular proton spectrum is shifted up by a factor of 100 (i.e., x 100). These shifts usually provide adequate separation and place the perpendicular spectra above the parallel spectra in each case.

The universal time at the midpoint of the data being averaged over is given twice at the top of the plots. On the left hand (electron) side, the time is given in hours, minutes, tenths of minute, month, day of month, and year, and is followed by the averaging time in minutes. On the right hand (proton) side, the time is given in hours (to the nearest one thousandth of an hour), day of year (January 1 equals day 1), and the year. The local time in hours and minutes is sometimes added on the left side.

Also given near the top are four different integrals over each of the four spectra. The integrals for the perpendicular data are given above the integrals for the parallel data. Following two of these sets of integrals will be found the words "MASTER" and "MATE" to indicate which analyzers are occupying the two non-subcommutated data channels. When in the track mode, the "master" analyzer controls the peak tracking system. The operating mode (for example, the scan only or track-scan modes) of the system is given on the right side.

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ERROR BARS

Vertical bars which encompass the middle 68.26 percent of the Poisson distribution are given at each data point. At high rates, they correspond to plus and minus one standard deviation. The approximation $N_{\pm} \approx N \pm \sqrt{N}\ (1.0 - 0.17/N)$ is used where N is the total number of counts accumulated at the point.

When in the track-scan mode, there are about four times the number of accumulations at the points near the energy of the peak being tracked than at other energies. Also the spectra from the "MASTER" and "MATE" channels will have about twice the accumulation time as the other two (subcommutated) spectra.

When in the single step scan only mode, every other data point in the subcommutated spectra will be missing. This under-sampling of the spectra can lead to substantial errors in the smooth line drawn through the data points since structure as sharp as the instruments' resolution is frequently observed.

If zero counts are obtained, then the error bar is replaced by a triangle pointing up to the line which is placed at one-half the flux corresponding to one count being accumulated.

If no data are available for a point during the time period being averaged over, then the flux obtained during a preceding time period is inserted. In this case, the error bar is replaced by a triangle pointing down to the data point.

INTEGRALS OVER THE SPECTRA

The four integrals given for each analyzer at the top of the plots are of course intrinsically directional quantities. The parallel cases correspond to pitch angles $\alpha \sim 0$ (α = the angle of the spin vector to the magnetic field vector) and the perpendicular cases correspond to averages over the pitch angle range of $90 \pm \alpha$ degrees. The integrals are taken only over the measured range of 50 eV to 50 keV and are, therefore, lower limits.

The number densities in particles/cm^3 are labeled "DEN" and correspond to 4 π times the directional number densities in particles/cm^3 sr.

The particle pressures in 10^{-9} dynes/cm^2 are labeled "PRES". They correspond to 8 $\pi/3$ times the directional energy densities in ergs/cm^3 sr. The multiplication by 8 $\pi/3$ simplifies computation of the total particle pressure perpendicular to the magnetic field vector.

The directional energy fluxes in ergs/cm^2 sec sr are labeled "E FLX".

The directional number fluxes in 10^6 particles/cm^2 sec sr are labeled "N FLX".

APPENDIX C
CONSTRUCTION OF COMPLETE SPECTRA

The data presented in the main report can be combined with experience gained in the ATS-6 program to construct a most probable set of total spectra. This consists of adding other components (estimated for ATS-6 data) to the measured fluxes.

Let dN_ℓ be the number density of particles of species ℓ with energies in the range between E and E + dE, and directions in the range between $\vec{\Omega}$ and $\vec{\Omega} + d\vec{\Omega}$. We represent dN_ℓ by the sum

$$dN_\ell = dN_{\ell,cold} + dN_{\ell,iso} + dN_{\ell,FA}$$

where $dN_{\ell,cold}$ and $dN_{\ell,FA}$ represent the unmeasured cold and field aligned components of the total distribution. The measured spectrum is isotropized to construct $dN_{\ell,iso}$, so that we may write

$$dN_{\ell,iso} = \sqrt{m_\ell/2}\ E^{-3/2}\ dj,\ 50\ eV \leq E \leq 50\ keV$$

where dj represents the measured energy flux for either the parallel or perpendicular detectors, or may be some weighted combination of the two.

The unknown cold and field aligned components are represented as

$$dN_{\ell,cold} = \frac{N_{\ell,cold}}{2} \left(\frac{1}{\pi kT_{\ell,cold}}\right)^{3/2} \sqrt{E}\ e^{-E/kT_{\ell,cold}}\ dEd\Omega$$

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$$dN_{\ell,FA} = \frac{N_{\ell,FA}}{2} \left(\frac{1}{\pi k T_{\ell,FA}} \right)^{3/2} \sqrt{E}$$

$$\cdot e^{-[(E-2\sqrt{EE_o}\cos\alpha + E_o)/kT_{\ell,FA}]} dE d\Omega$$

where α is the pitch angle.

The unknown quantities in these equations are the densities and the temperatures of the cold and field aligned components, and the energy E_o in the field aligned component. In choosing the unknown parameters, charge neutrality should be observed, i.e.,

$$\sum_{\ell} q_\ell N_\ell = 0$$

where

$$N_\ell = N_{\ell,cold} + N_{\ell,iso} + N_{\ell,FA} .$$

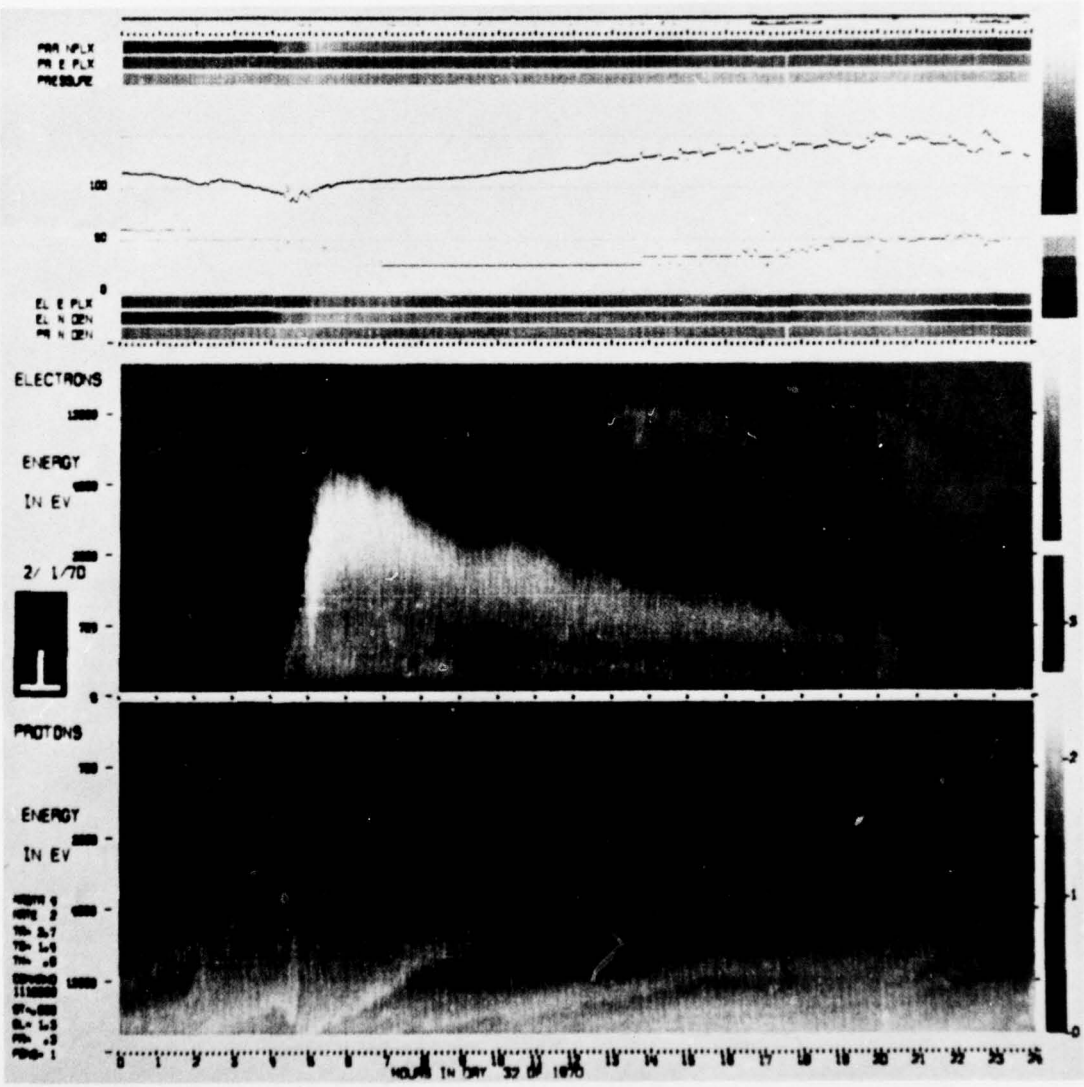
The temperature chosen for T_{cold} should probably be a few volts to a few tens of volts. The density of the cold component can be estimated from Reasoner's work (1975) and Figure 2.3 to be about $30/cm^3$.

The form for the field-aligned component was derived from the assumption of a displaced Maxwellian plasma falling through a potential well of ε_o. If we assume that these particles have their origins in the ionosphere, then we can estimate $100 < \varepsilon_o < 10{,}000$ electron volts and that kT_{FA} is a few electron volts. The density is more difficult to estimate, but a few percent of the ambient would be consistent with measurements.

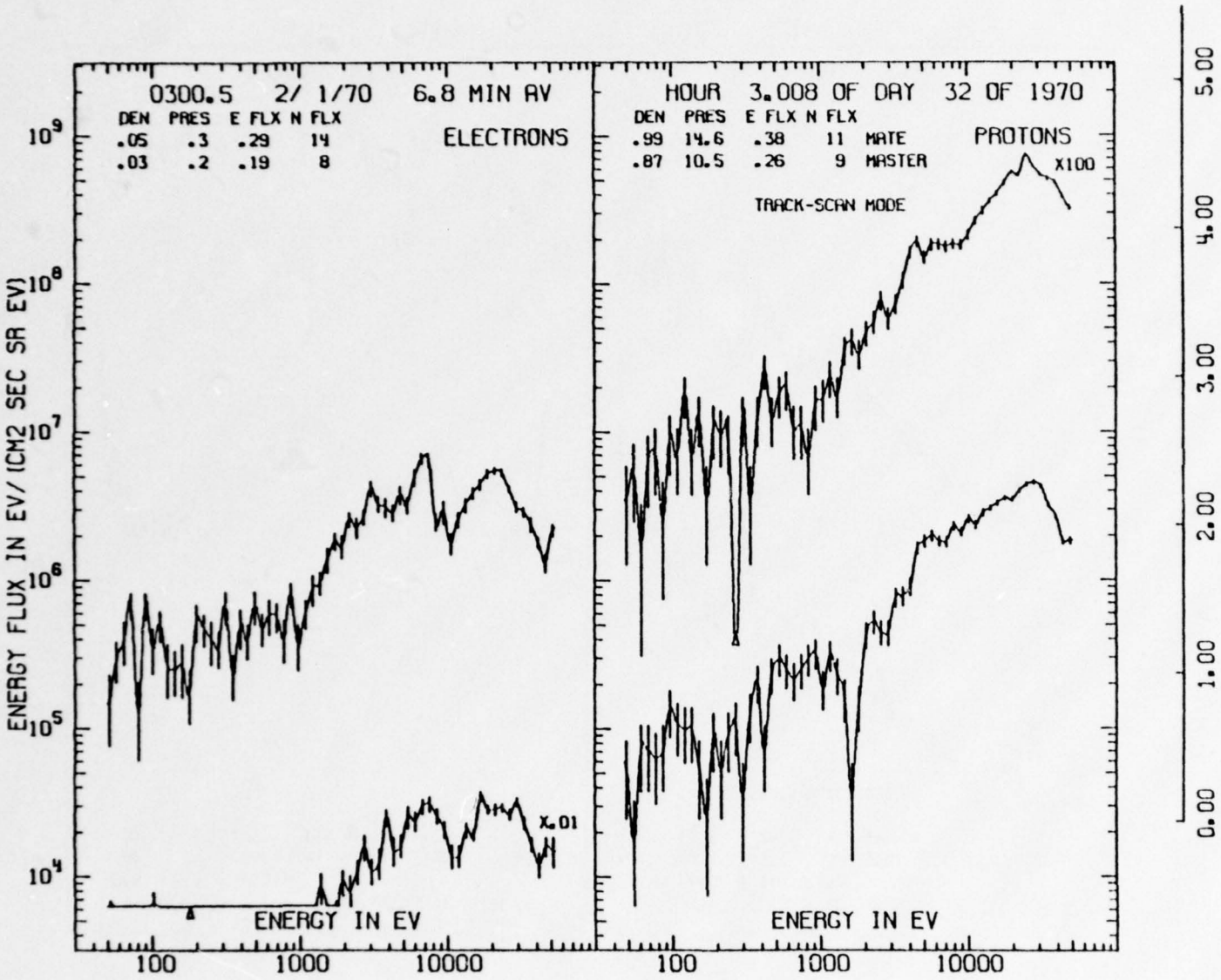
Note that the field-aligned component is probably only important for the study of differential charging since it only influences the charge state at locations where the bulk of the plasma is excluded (i.e., in properly oriented cavities on the vehicle).

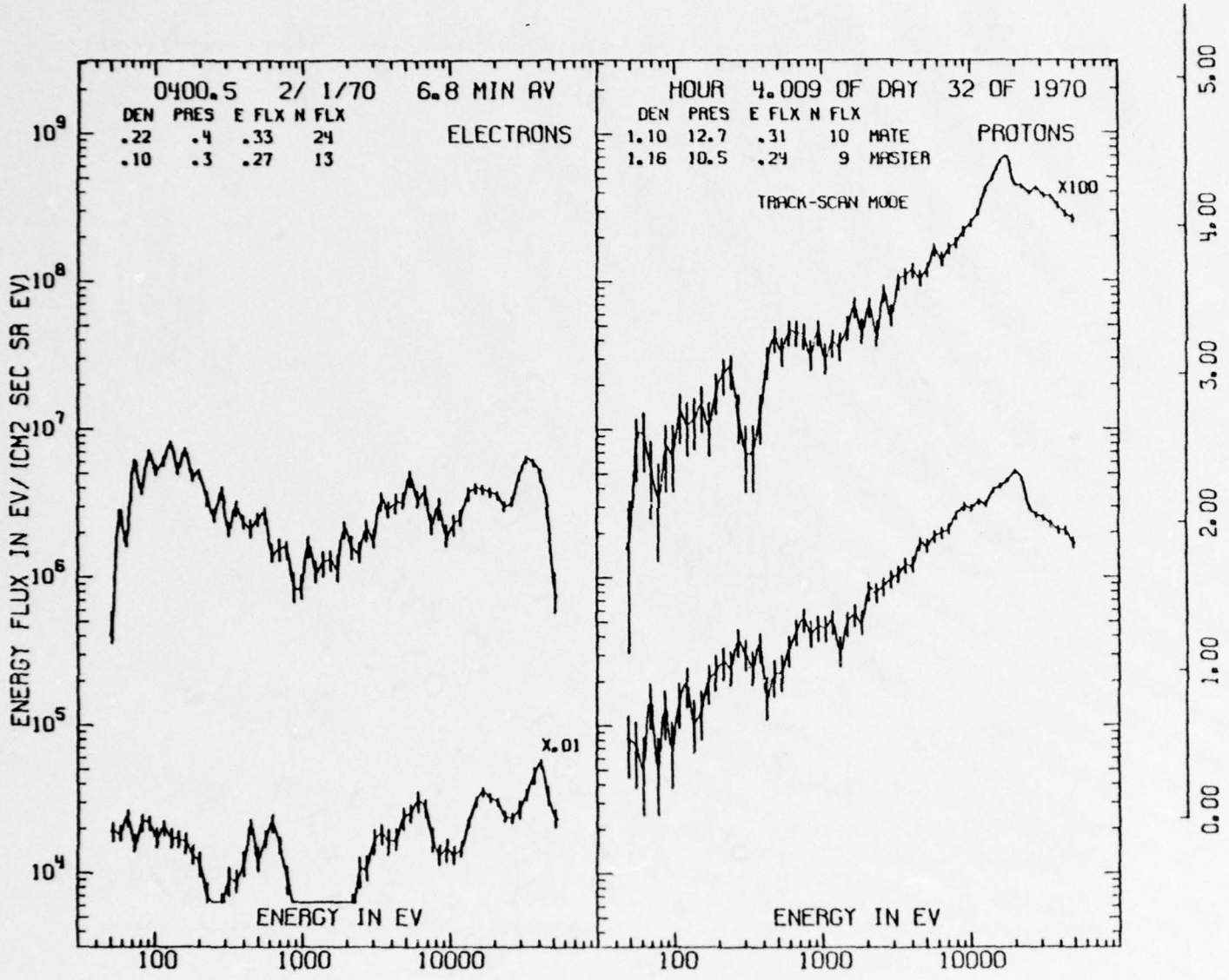
APPENDIX D

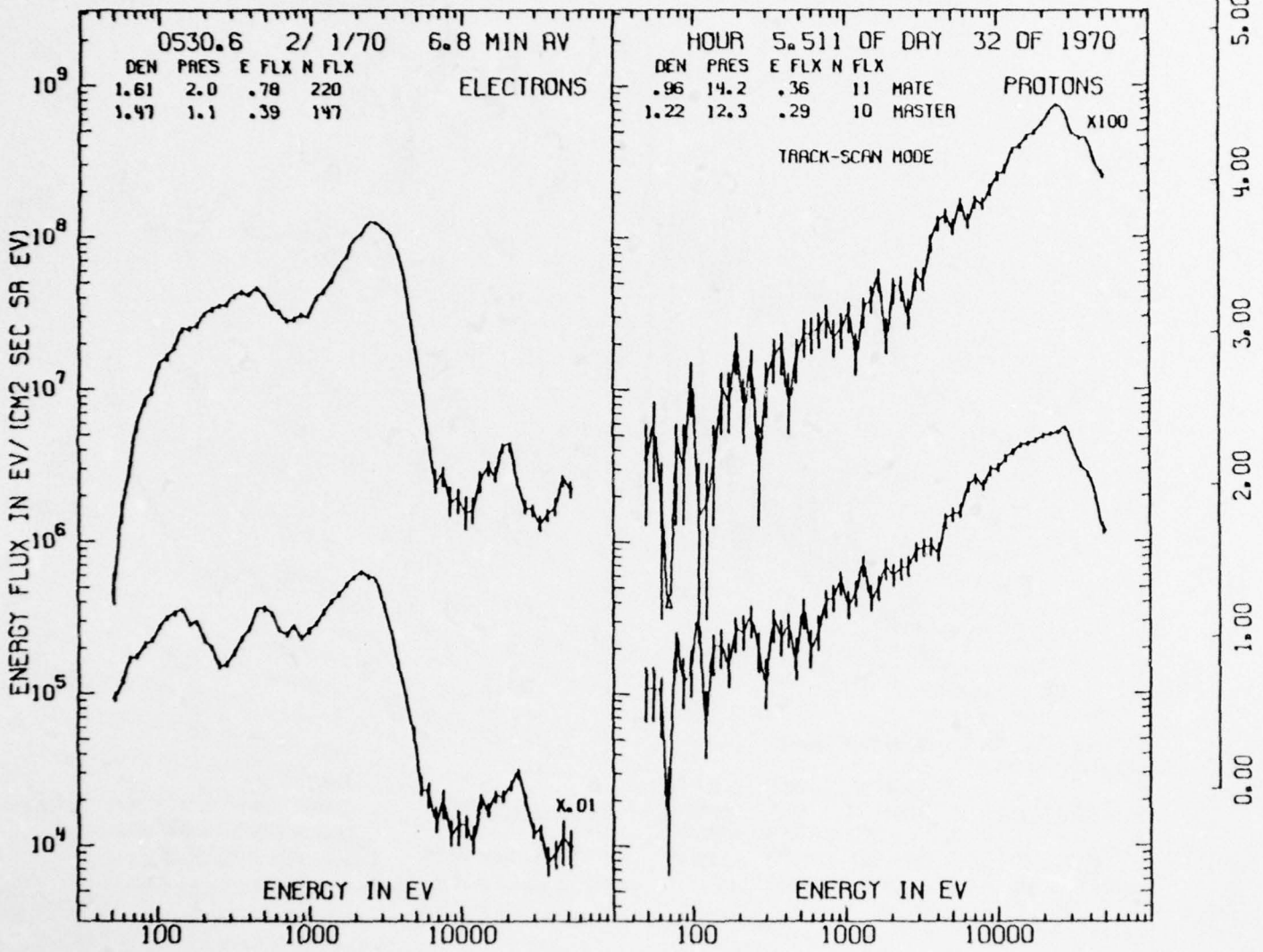
DATA

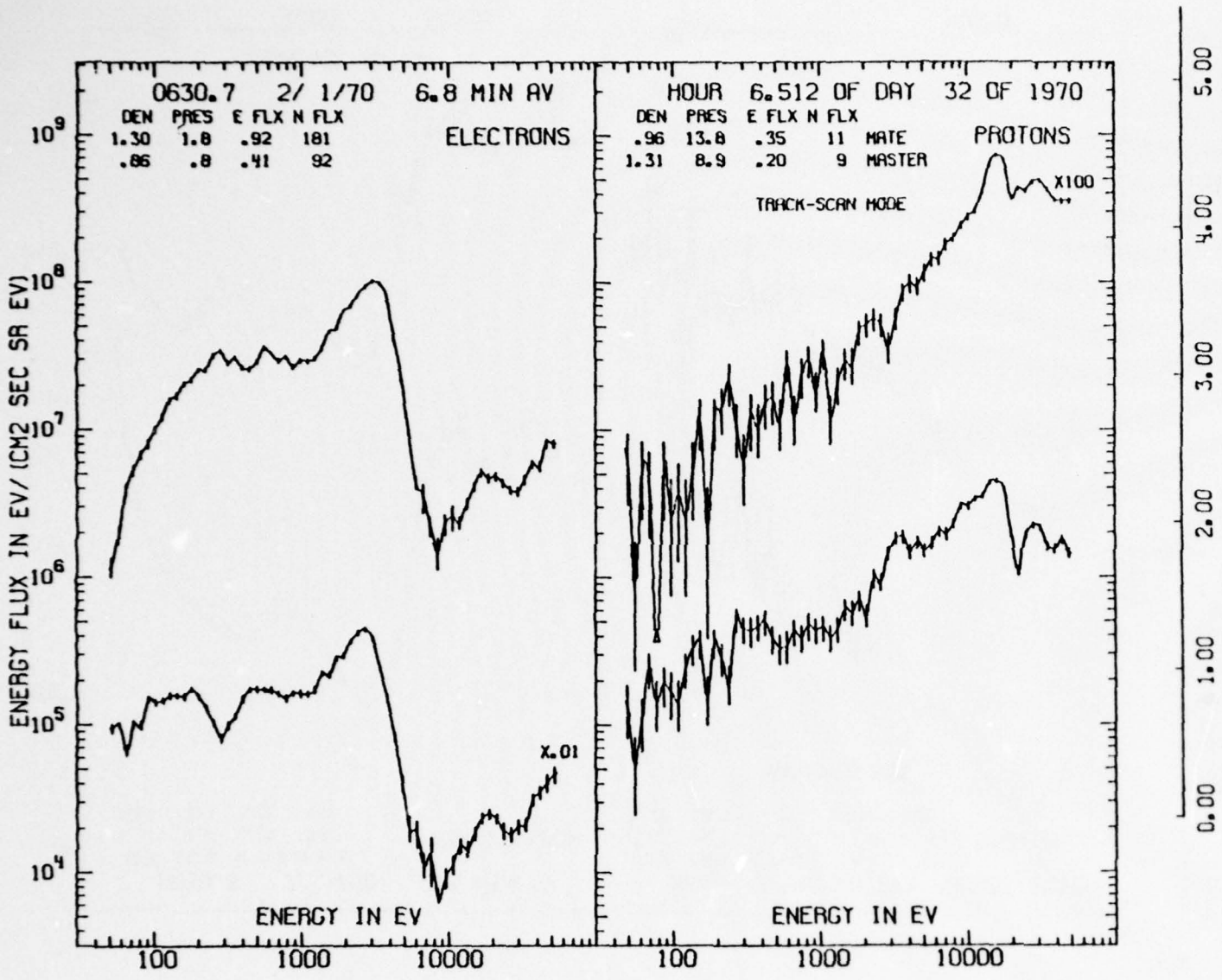


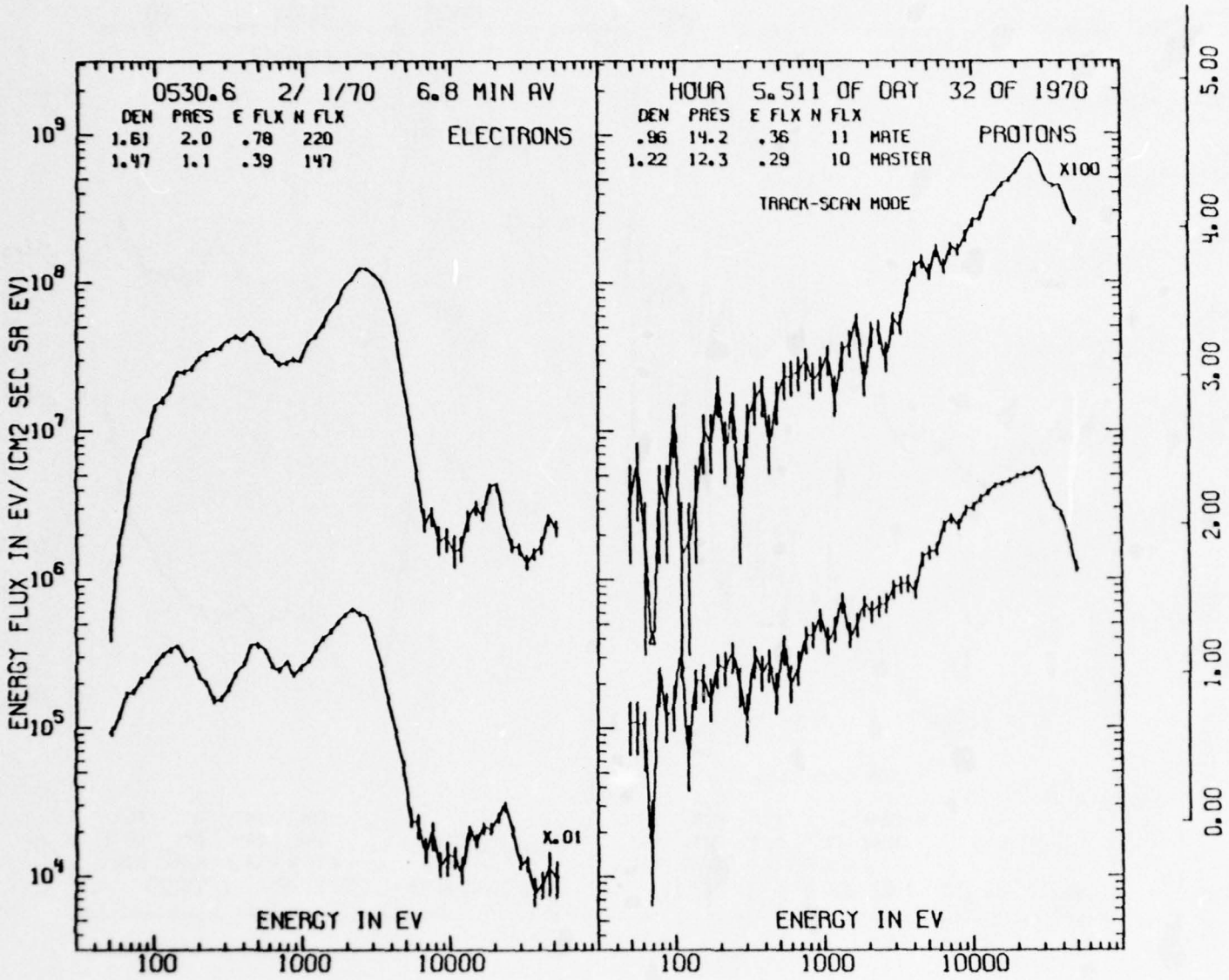
Spectrogram for 2/1/70 - Moderate activity.

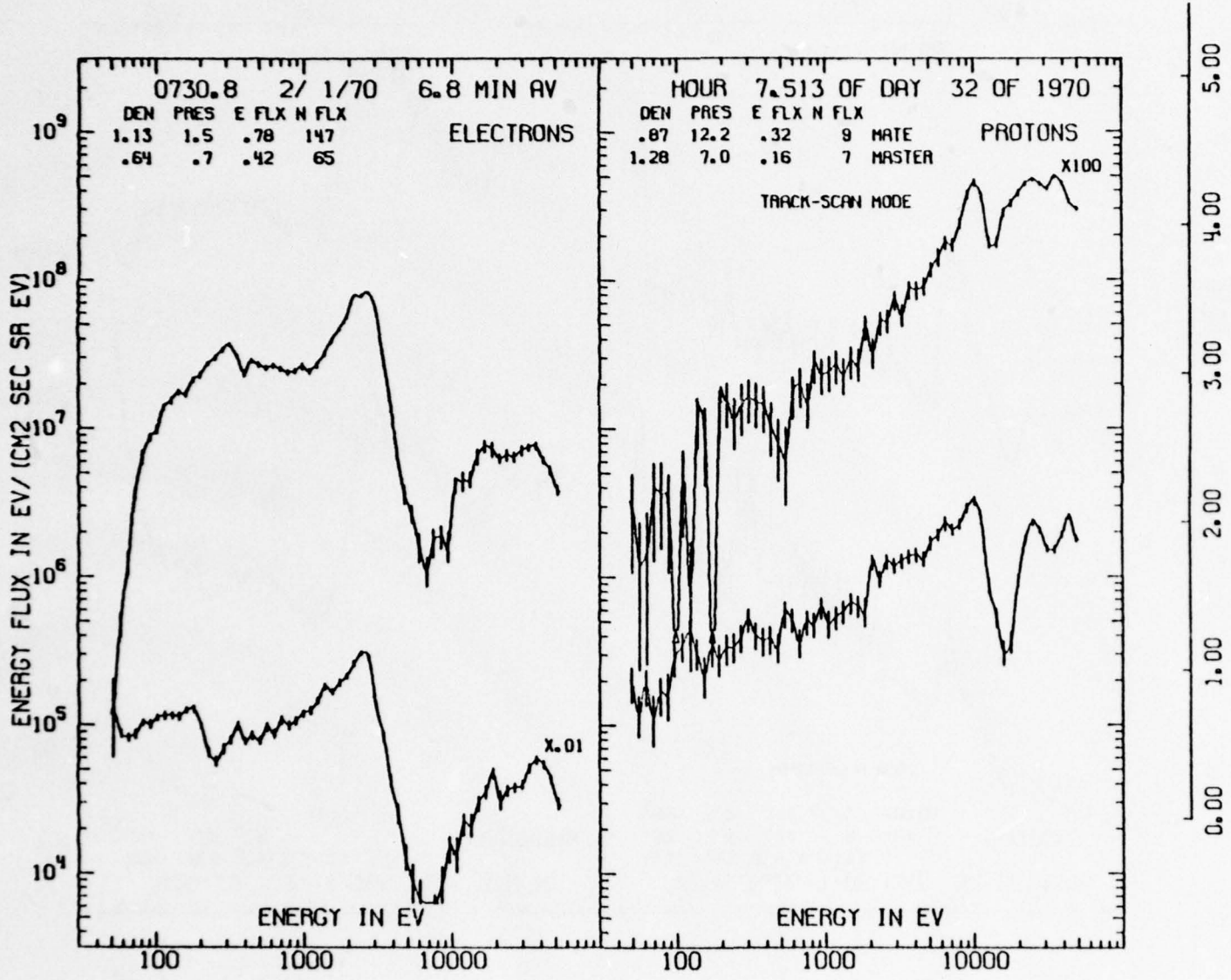

0300.5 2/ 1/70 6.8 MIN AV
DEN PRES E FLX N FLX
.05 .3 .29 14
.03 .2 .19 8
ELECTRONS
X.01
ENERGY IN EV
100
1000
10000
HOUR 3.008 OF DAY 32 OF 1970
DEN PRES E FLX N FLX
.99 14.6 .38 11 MATE
.87 10.5 .26 9 MASTER
PROTONS
X100
TRACK-SCAN MODE
ENERGY IN EV
100
1000
10000
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
0.00
1.00
2.00
3.00
4.00
5.00

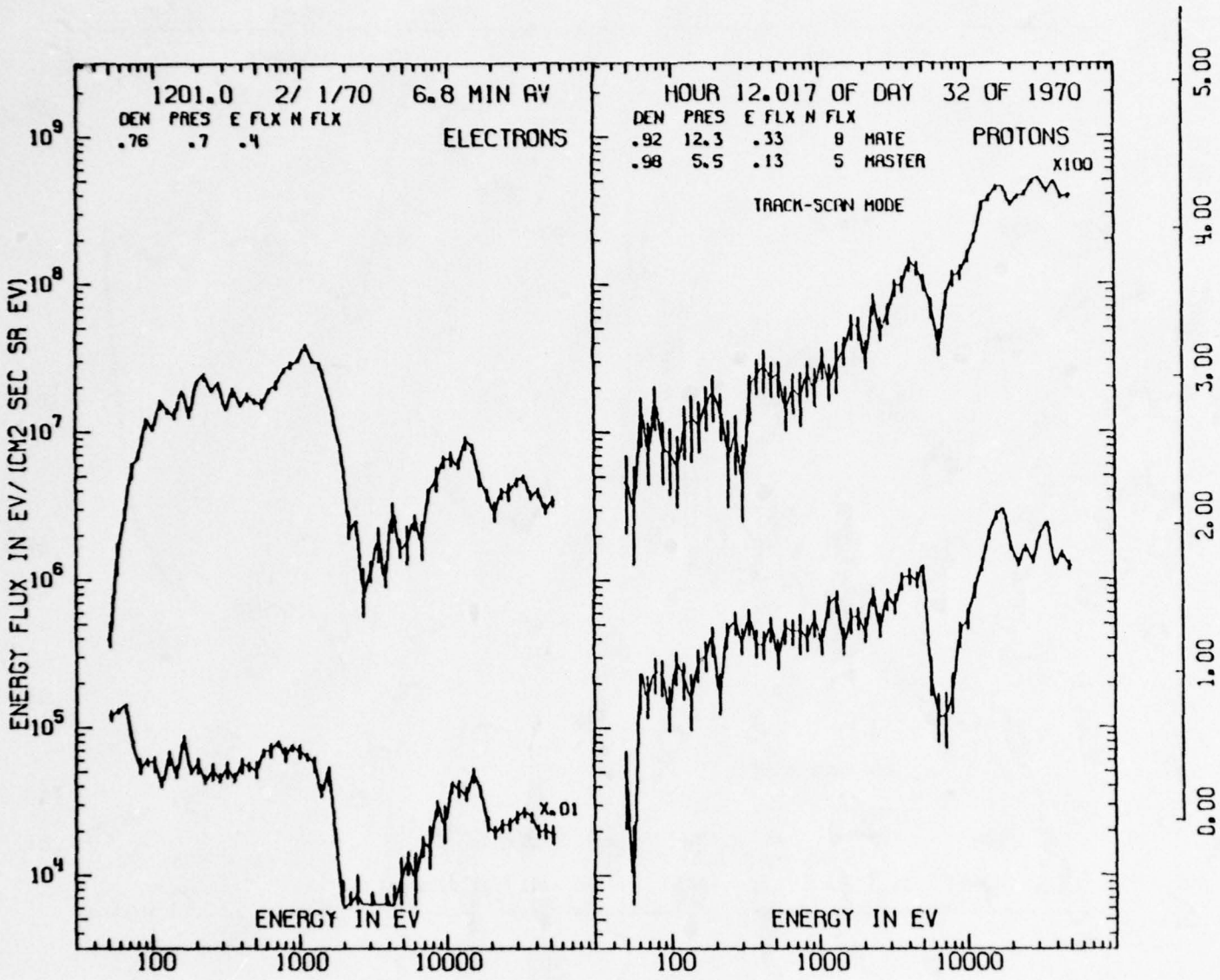

0400.5 2/ 1/70 6.8 MIN AV
DEN PRES E FLX N FLX
.22 .4 .33 24
.10 .3 .27 13
ELECTRONS
X.01
HOUR 4.009 OF DAY 32 OF 1970
DEN PRES E FLX N FLX
1.10 12.7 .31 10 MATE
1.16 10.5 .24 9 MASTER
PROTONS
TRACK-SCAN MODE
X100
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

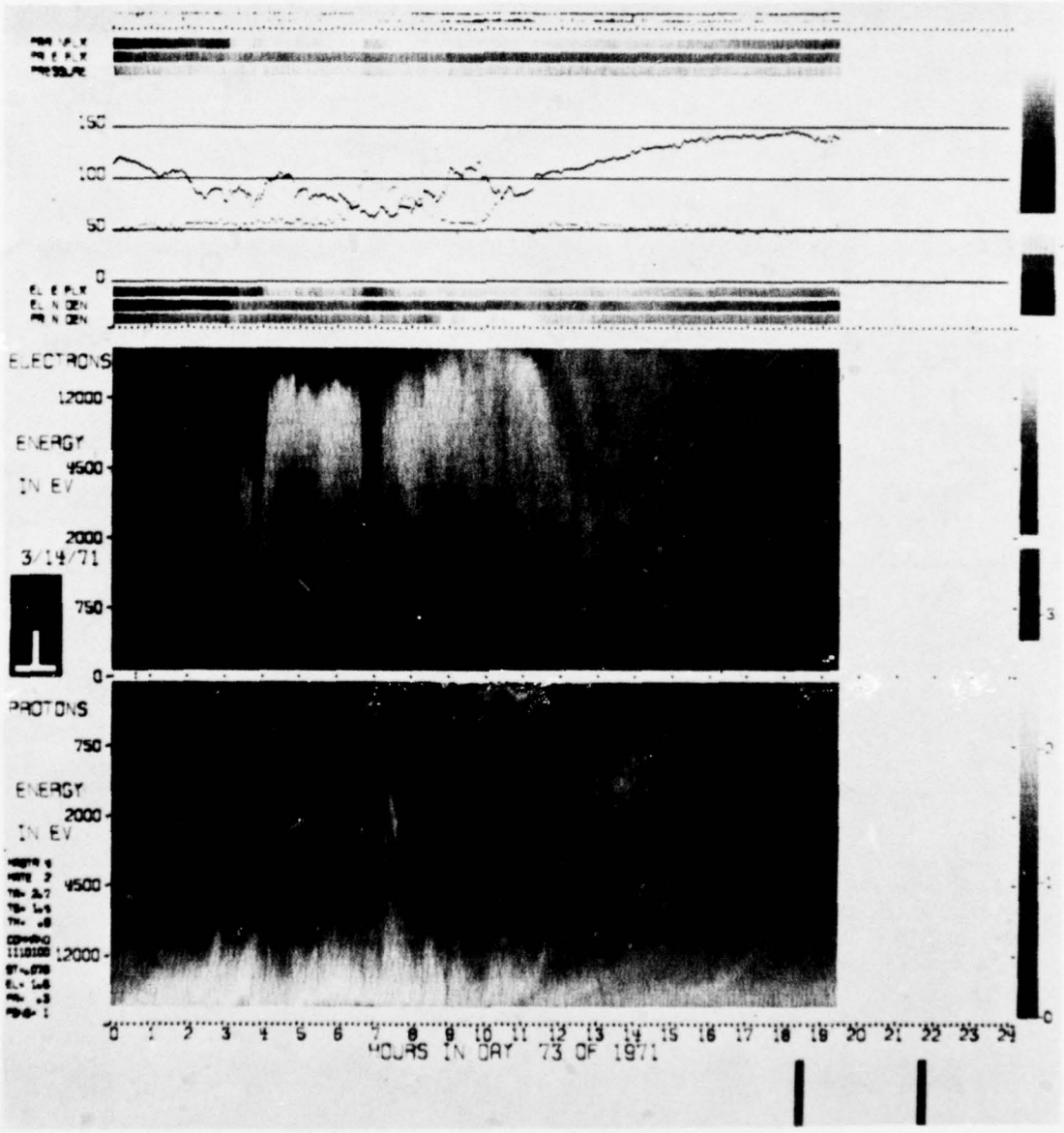

0530.6 2/ 1/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.61 2.0 .78 220
1.47 1.1 .39 147
ELECTRONS
HOUR 5.511 OF DAY 32 OF 1970
DEN PRES E FLX N FLX
.96 14.2 .36 11 MATE
1.22 12.3 .29 10 MASTER
PROTONS
X100
TRACK-SCAN MODE
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


0630.7 2/ 1/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.30 1.8 .92 181
.86 .8 .41 92
ELECTRONS
X.01
ENERGY IN EV
100
1000
10000
HOUR 6.512 OF DAY 32 OF 1970
DEN PRES E FLX N FLX
.96 13.8 .35 11 MATE
1.31 8.9 .20 9 MASTER
PROTONS
TRACK-SCAN MODE
X100
ENERGY IN EV
100
1000
10000
ENERGY FLUX IN EV/(CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
0.00
1.00
2.00
3.00
4.00
5.00

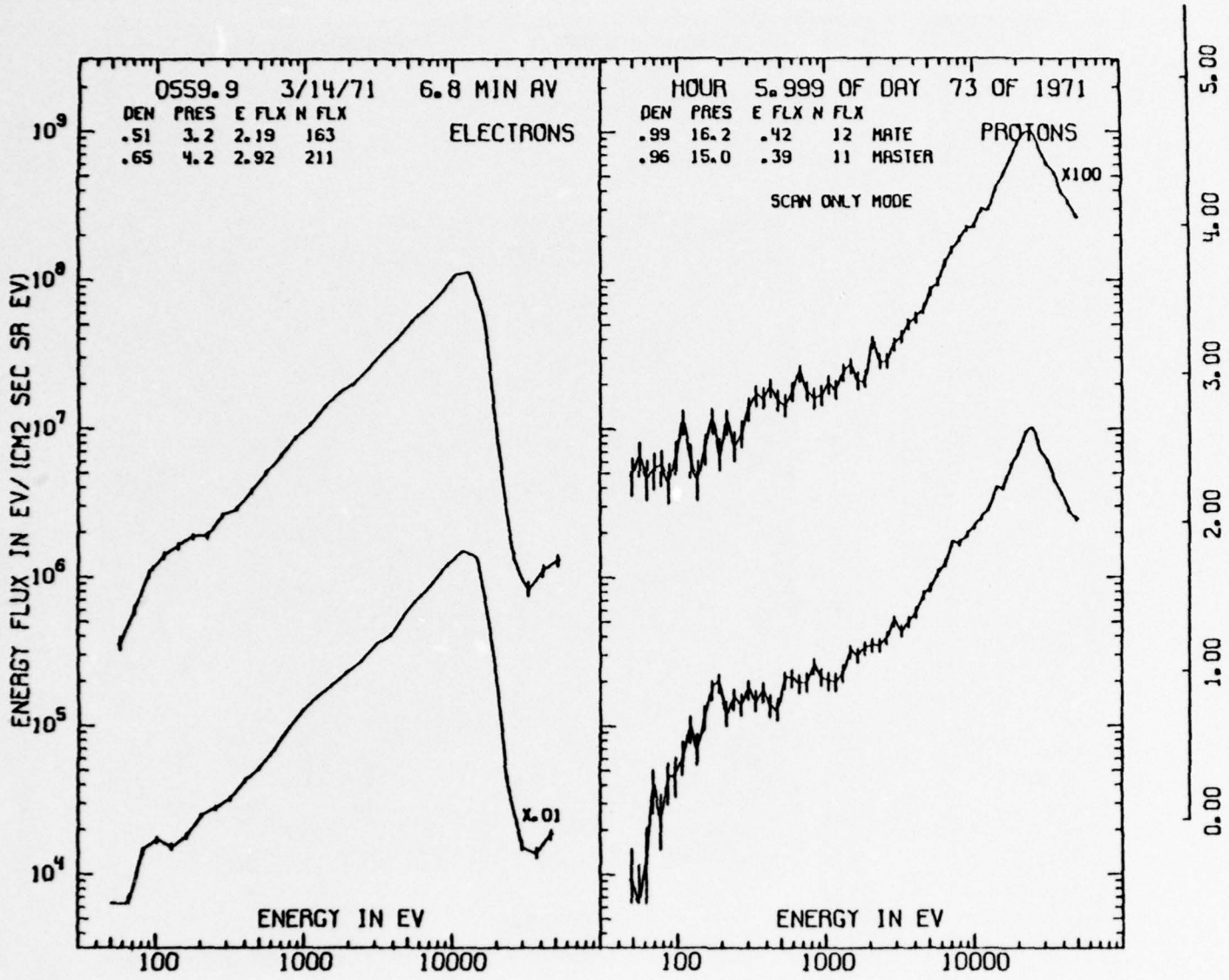

0530.6 2/ 1/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.61 2.0 .78 220
1.47 1.1 .39 147
ELECTRONS
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
100
1000
10000
HOUR 5.511 OF DAY 32 OF 1970
DEN PRES E FLX N FLX
.96 14.2 .36 11 MATE
1.22 12.3 .29 10 MASTER
PROTONS
X100
TRACK-SCAN MODE
ENERGY IN EV
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

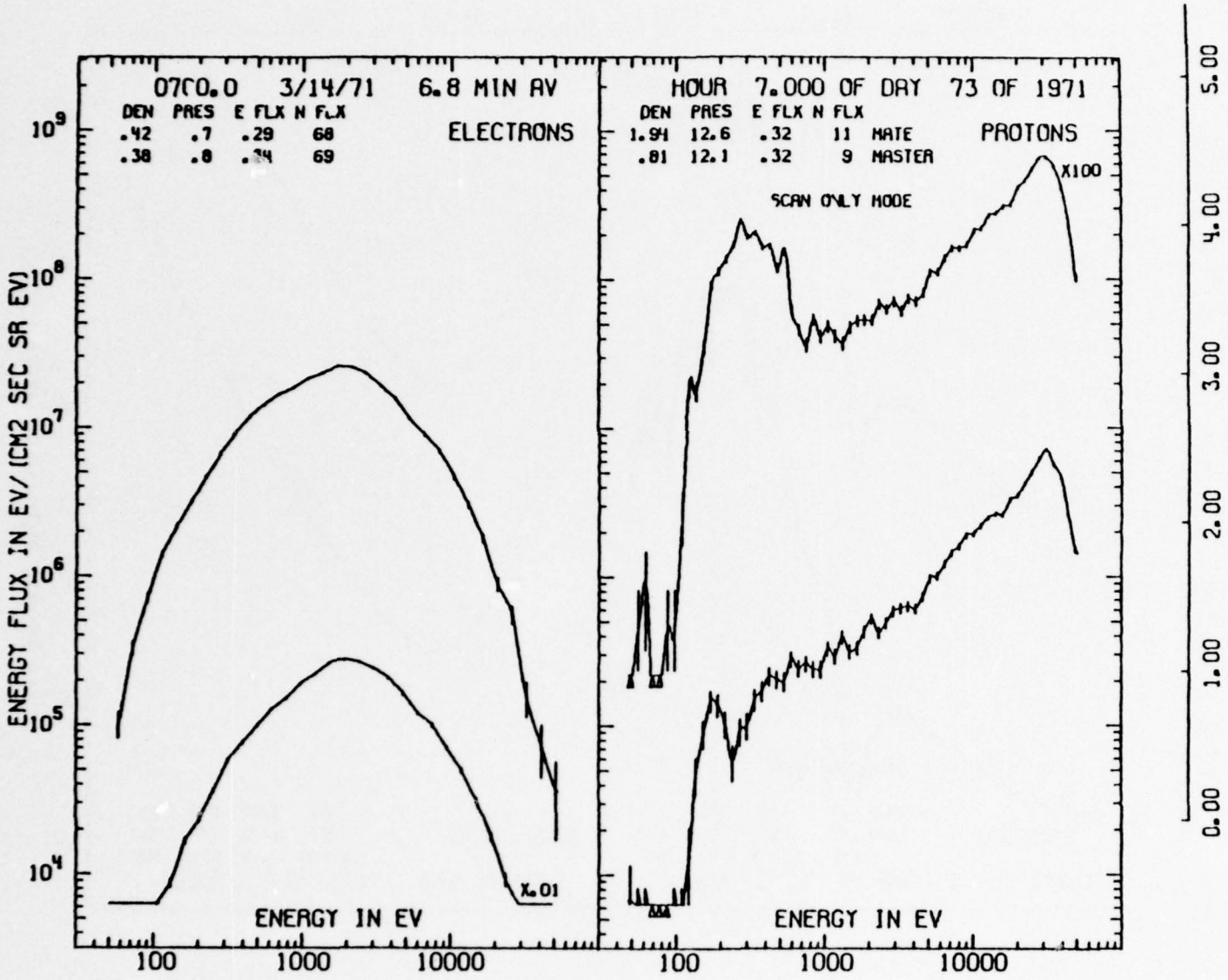

0730.8 2/ 1/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.13 1.5 .78 147
.64 .7 .42 65
ELECTRONS
X.01
ENERGY IN EV
100
1000
10000
HOUR 7.513 OF DAY 32 OF 1970
DEN PRES E FLX N FLX
.87 12.2 .32 9 MATE
1.28 7.0 .16 7 MASTER
PROTONS
X100
TRACK-SCAN MODE
ENERGY IN EV
100
1000
10000
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
0.00
1.00
2.00
3.00
4.00
5.00

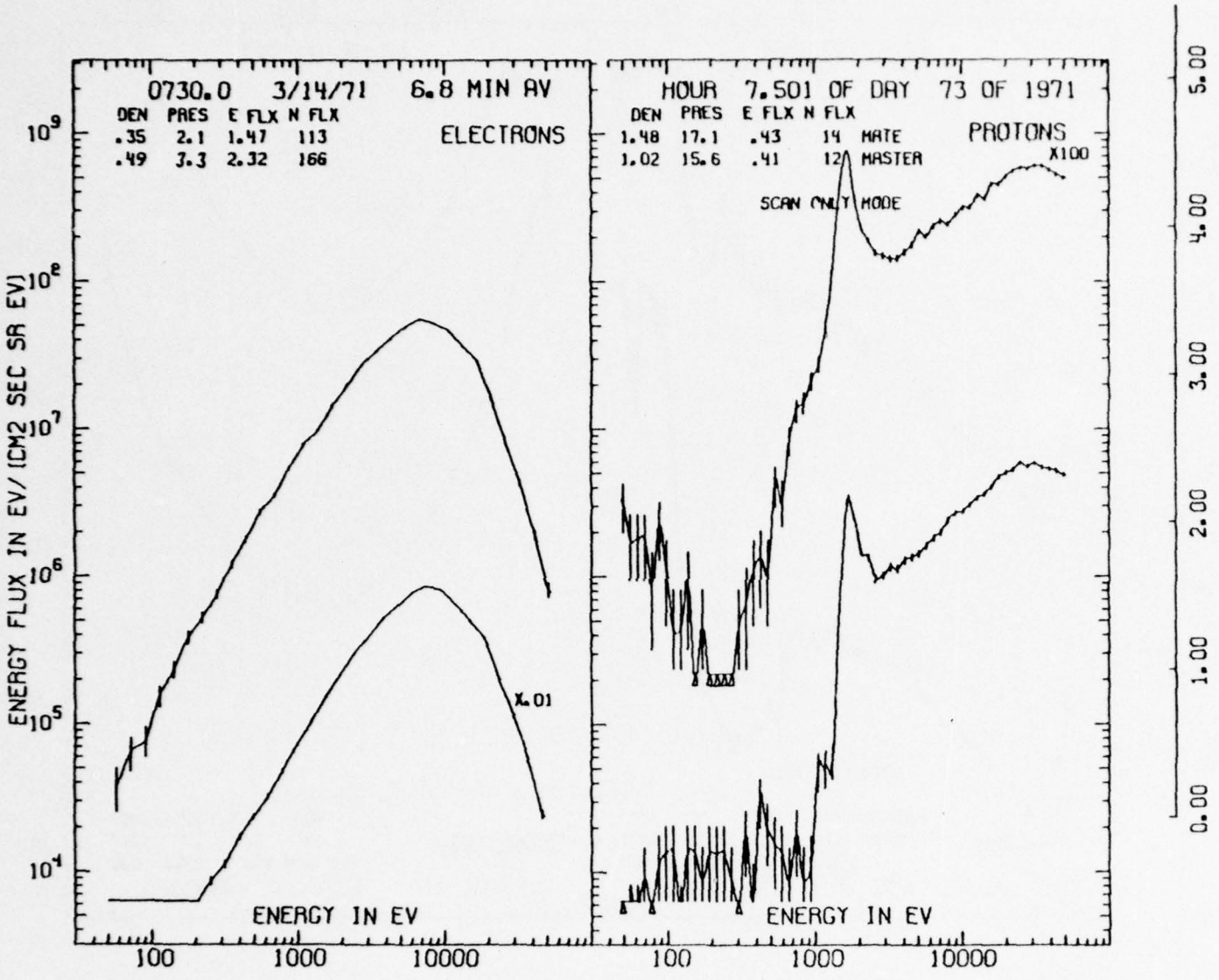

1201.0 2/ 1/70 6.8 MIN AV
DEN PRES E FLX N FLX
.76 .7 .4
ELECTRONS
HOUR 12.017 OF DAY 32 OF 1970
DEN PRES E FLX N FLX
.92 12.3 .33 8 MATE
.98 5.5 .13 5 MASTER
PROTONS
X100
TRACK-SCAN MODE
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
X.01
ENERGY IN EV
100
1000
10000
ENERGY IN EV
100
1000
10000
5.00
4.00
3.00
2.00
1.00
0.00

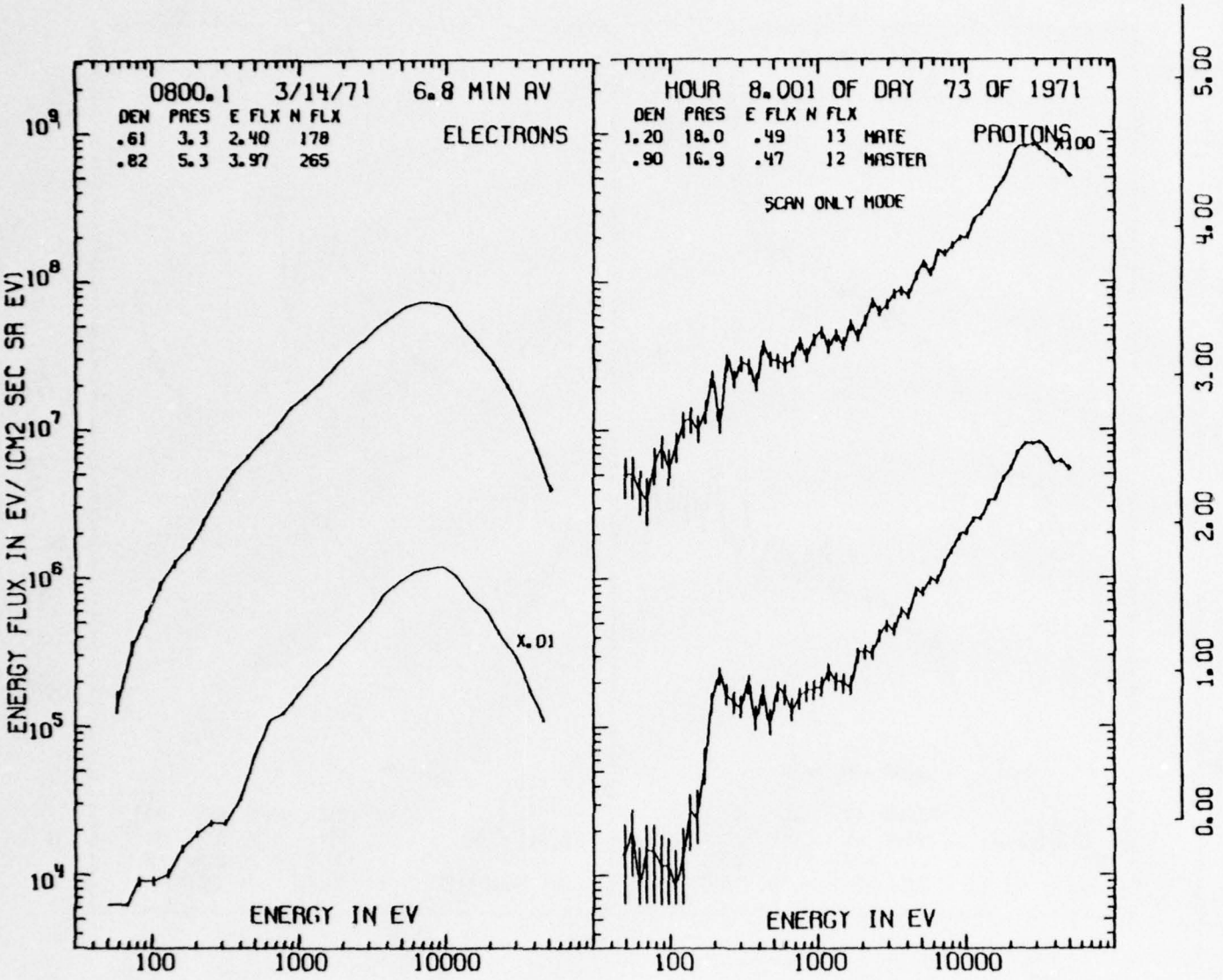


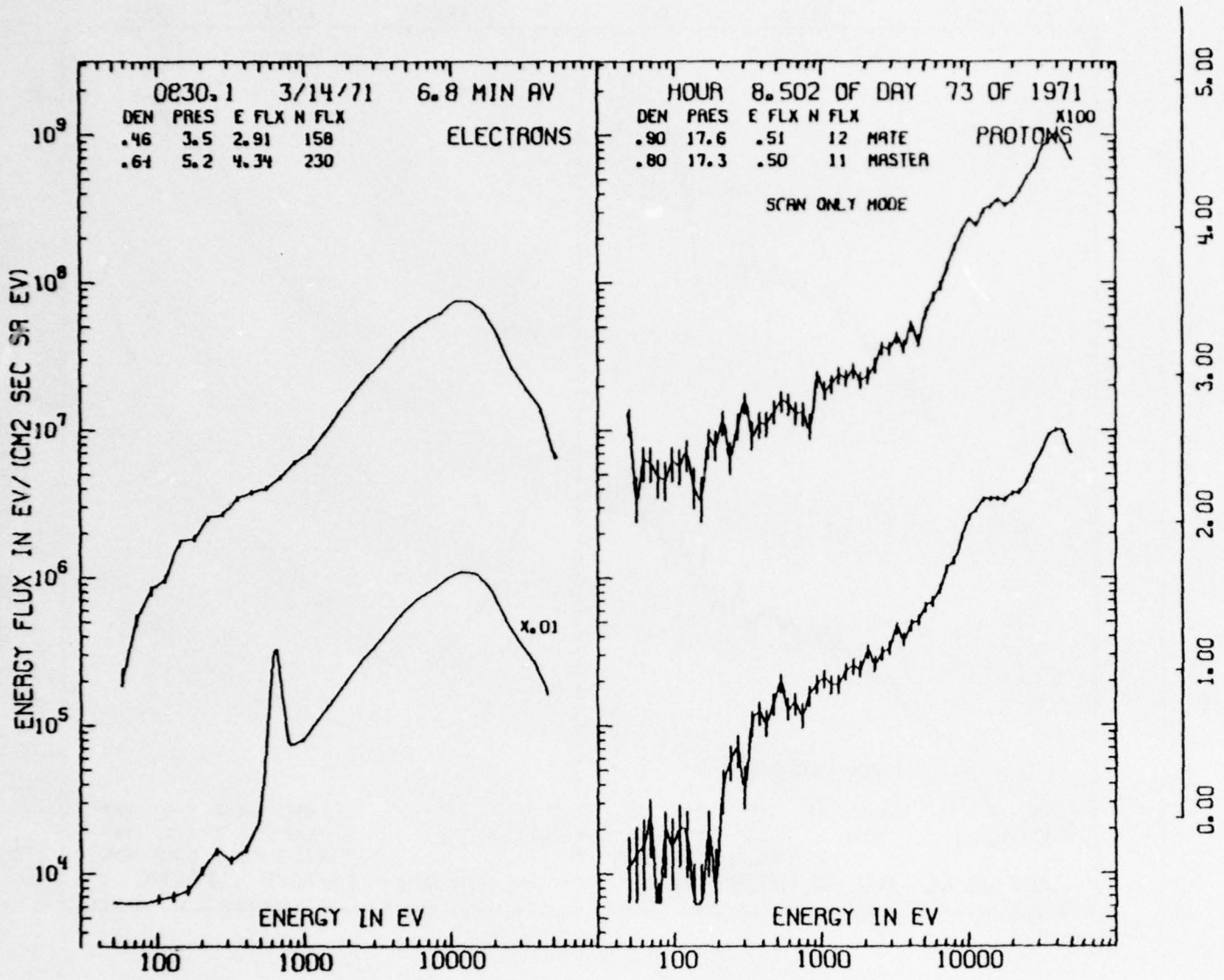
Spectrogram for 3/14/71 - Eclipse and sunlight charging.

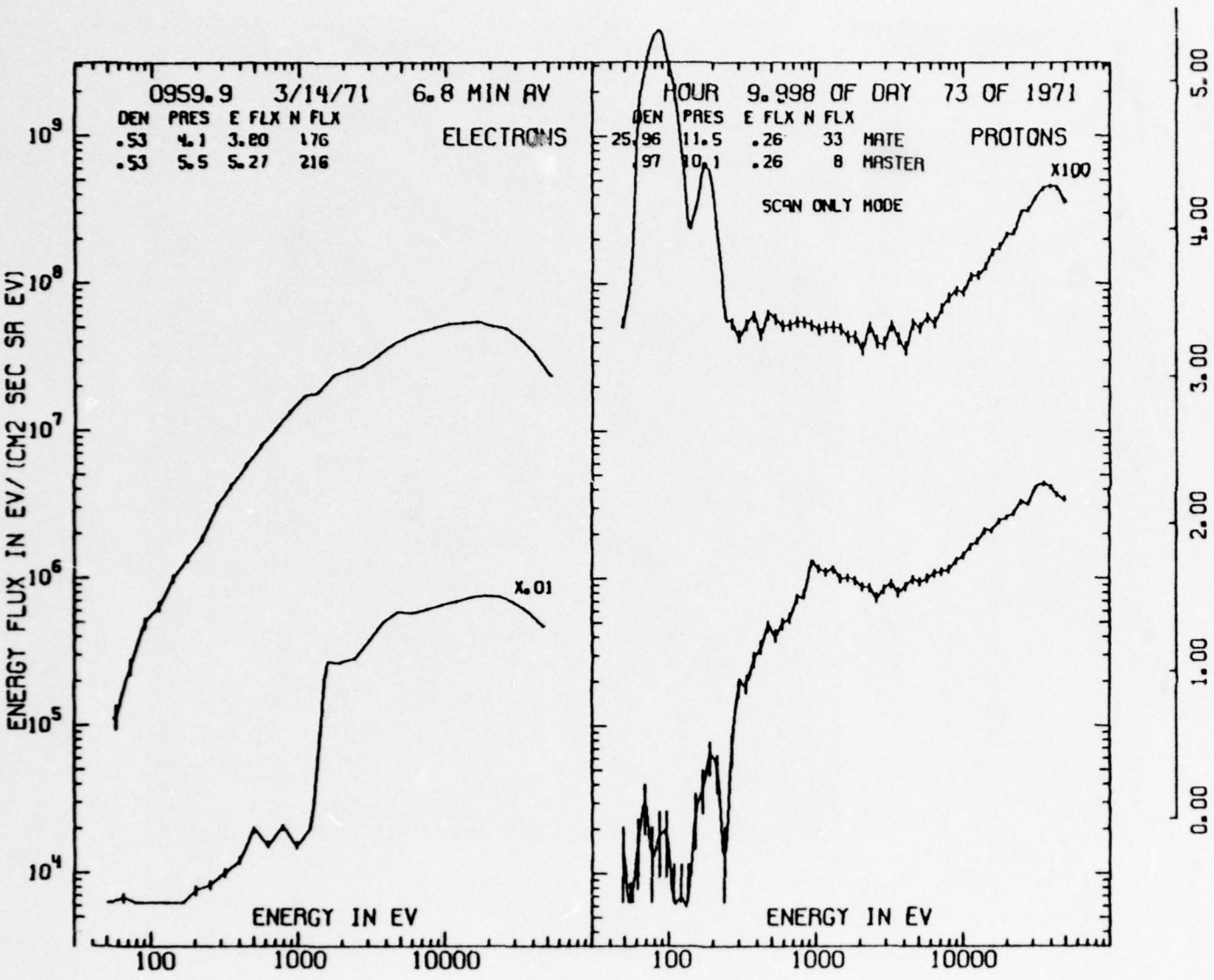

0559.9 3/14/71 6.8 MIN AV
DEN PRES E FLX N FLX
.51 3.2 2.19 163
.65 4.2 2.92 211
ELECTRONS
X.01
ENERGY IN EV
100
1000
10000
HOUR 5.999 OF DAY 73 OF 1971
DEN PRES E FLX N FLX
.99 16.2 .42 12 MATE
.96 15.0 .39 11 MASTER
PROTONS
X100
SCAN ONLY MODE
ENERGY IN EV
100
1000
10000
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
0.00
1.00
2.00
3.00
4.00
5.00

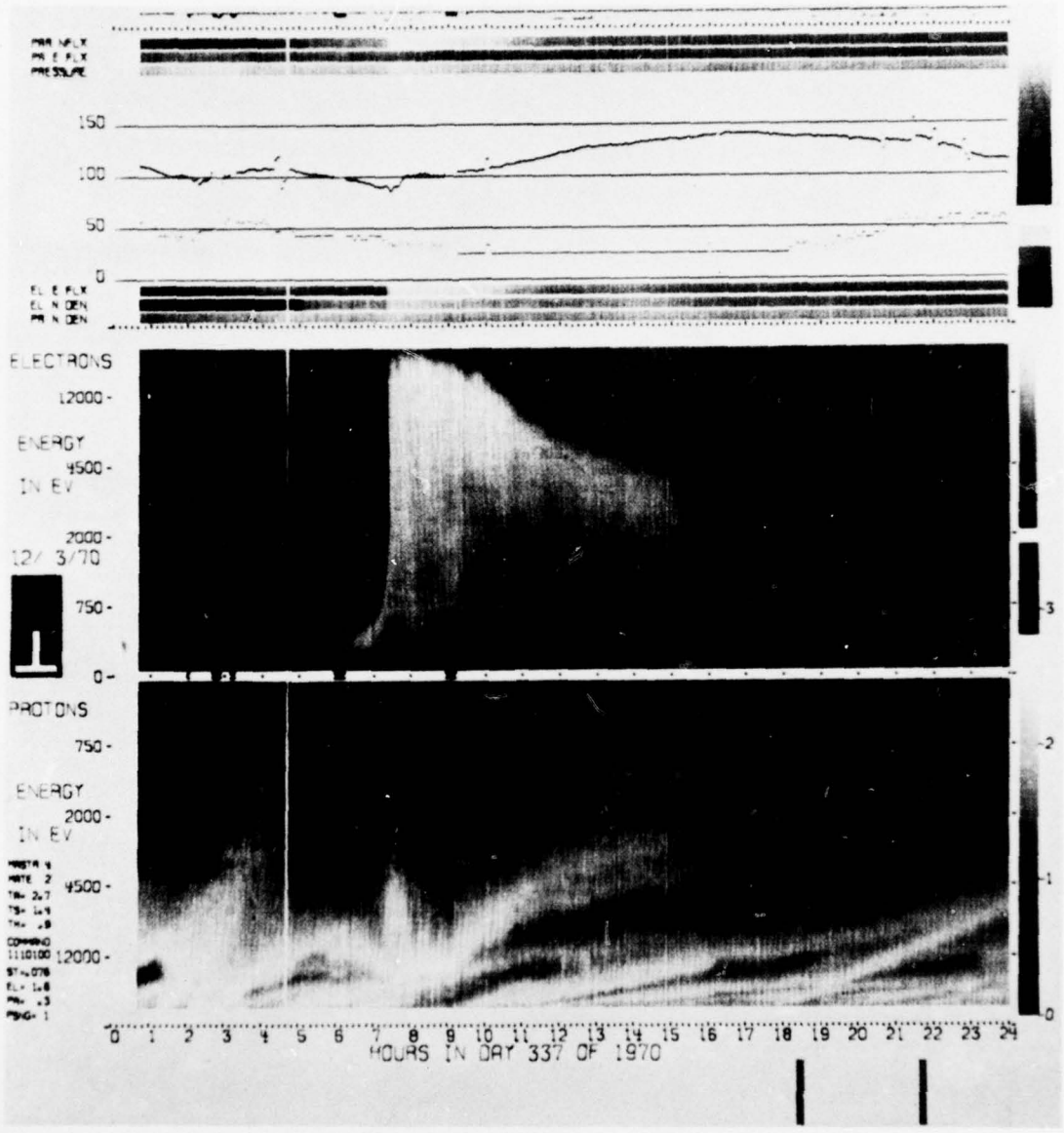

0700.0 3/14/71 6.8 MIN AV
DEN PRES E FLX N FLX
.42 .7 .29 68
.38 .8 .34 69
ELECTRONS
HOUR 7.000 OF DAY 73 OF 1971
DEN PRES E FLX N FLX
1.94 12.6 .32 11 MATE
.81 12.1 .32 9 MASTER
PROTONS
X100
SCAN ONLY MODE
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
X.01
ENERGY IN EV
100
1000
10000
ENERGY IN EV
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


0730.0 3/14/71 6.8 MIN AV
DEN PRES E FLX N FLX
.35 2.1 1.47 113
.49 3.3 2.32 166
ELECTRONS
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
100
1000
10000
HOUR 7.501 OF DAY 73 OF 1971
DEN PRES E FLX N FLX
1.48 17.1 .43 14 MATE
1.02 15.6 .41 12 MASTER
PROTONS
X100
SCAN ONLY MODE
ENERGY IN EV
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

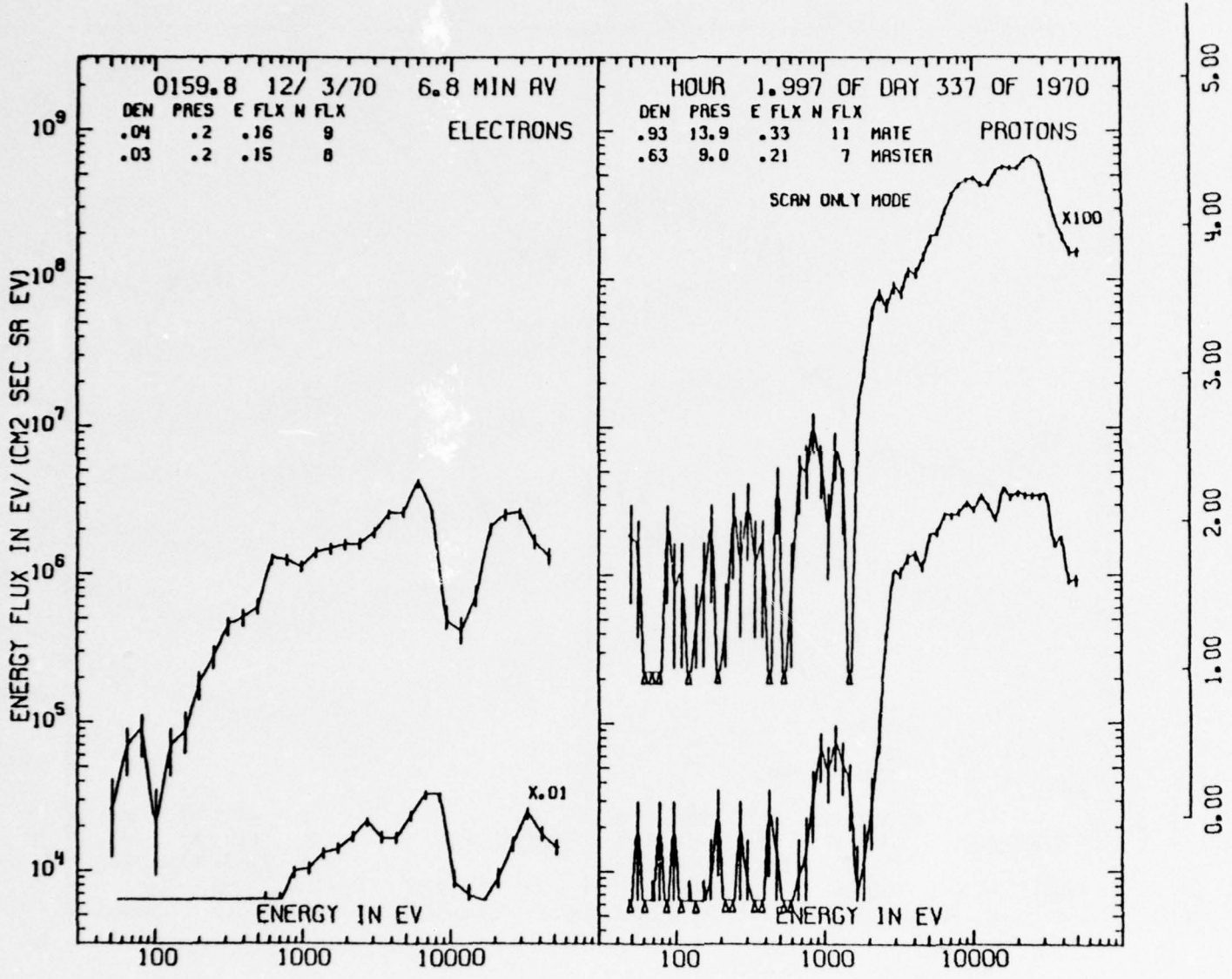

0800.1 3/14/71 6.8 MIN AV
DEN PRES E FLX N FLX
.61 3.3 2.40 178
.82 5.3 3.97 265
ELECTRONS
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
100
1000
10000
HOUR 8.001 OF DAY 73 OF 1971
DEN PRES E FLX N FLX
1.20 18.0 .49 13 MATE
.90 16.9 .47 12 MASTER
PROTONS
X100
SCAN ONLY MODE
ENERGY IN EV
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

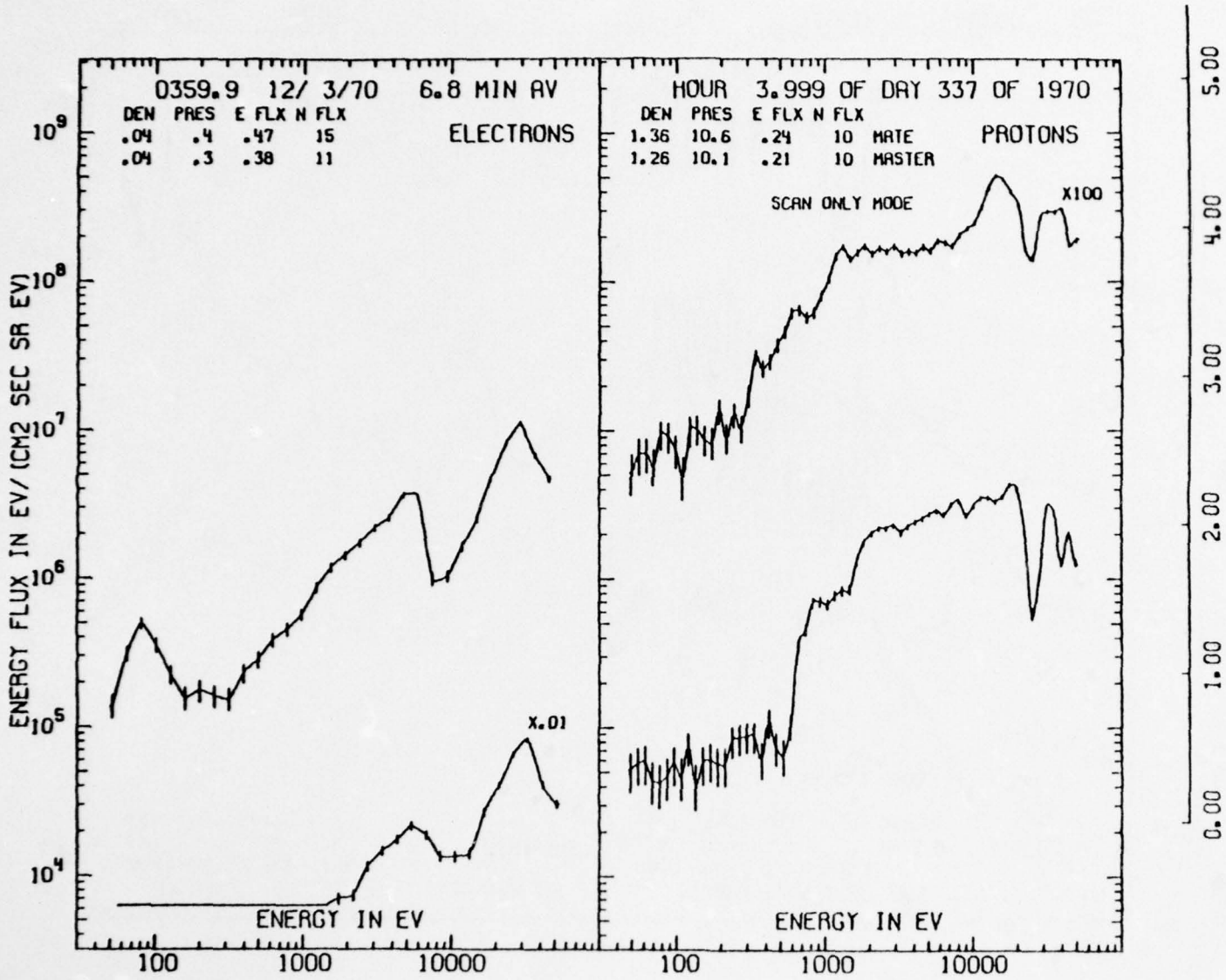

0830.1 3/14/71 6.8 MIN AV
DEN PRES E FLX N FLX
.46 3.5 2.91 158
.61 5.2 4.34 230
ELECTRONS
X.01
HOUR 8.502 OF DAY 73 OF 1971
DEN PRES E FLX N FLX
.90 17.6 .51 12 MATE
.80 17.3 .50 11 MASTER
SCAN ONLY MODE
PROTONS
X100
ENERGY FLUX IN EV/(CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

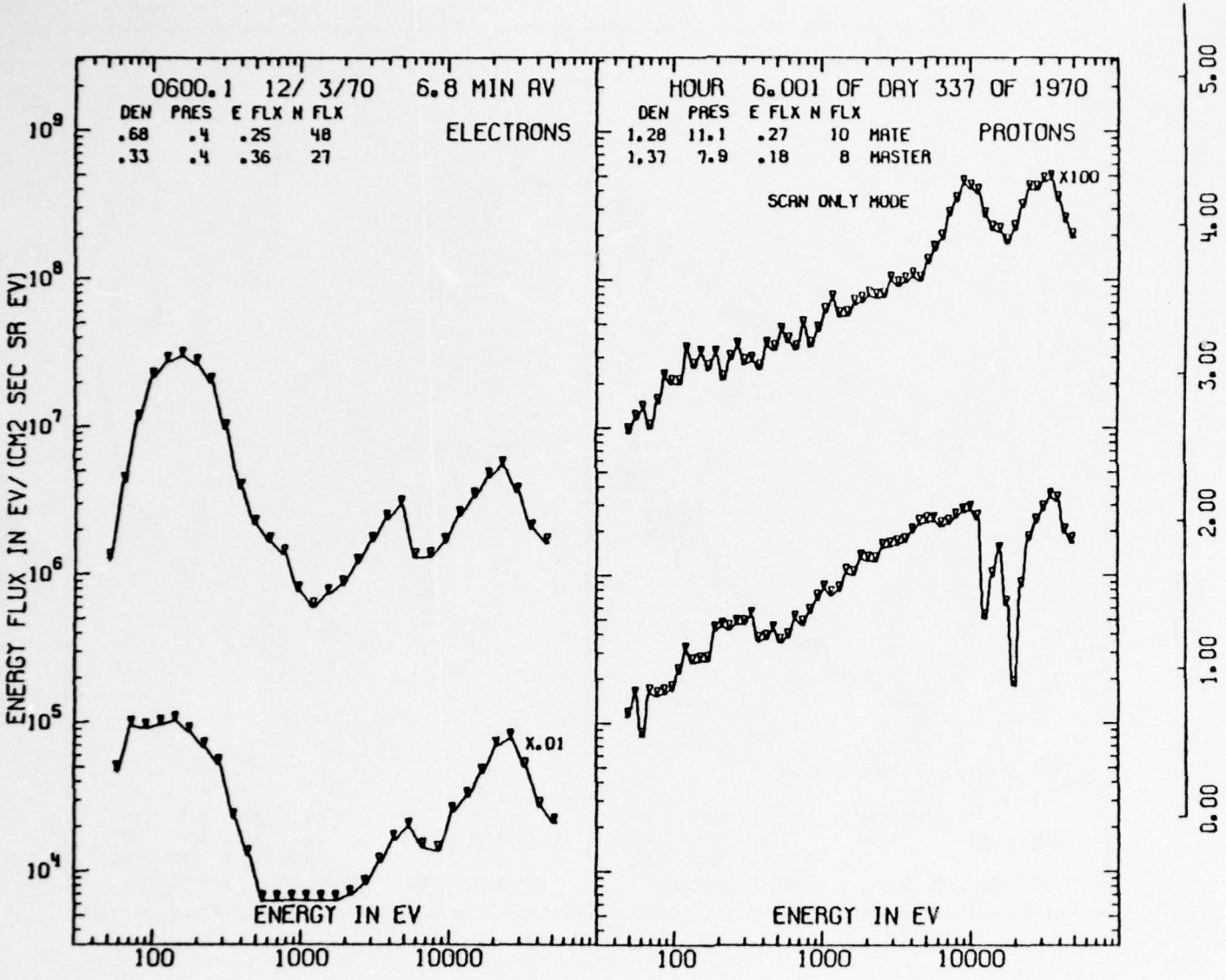

0959.9 3/14/71 6.8 MIN AV
DEN PRES E FLX N FLX
.53 4.1 3.80 176
.53 5.5 5.27 216
ELECTRONS
HOUR 9.998 OF DAY 73 OF 1971
DEN PRES E FLX N FLX
25.96 11.5 .26 33 MATE
.97 10.1 .26 8 MASTER
PROTONS
X100
SCAN ONLY MODE
X.01
ENERGY FLUX IN EV/(CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
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3.00
4.00
5.00

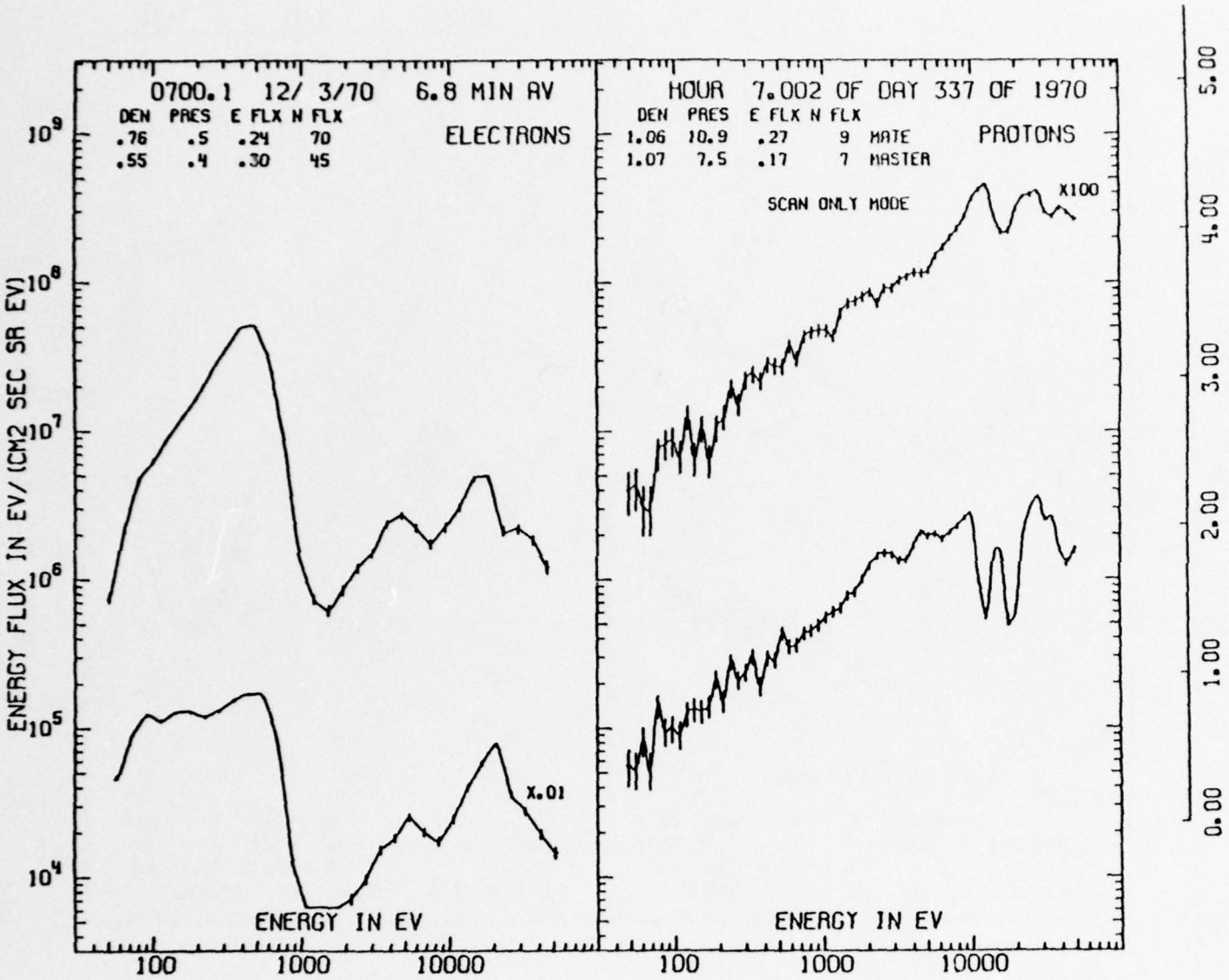


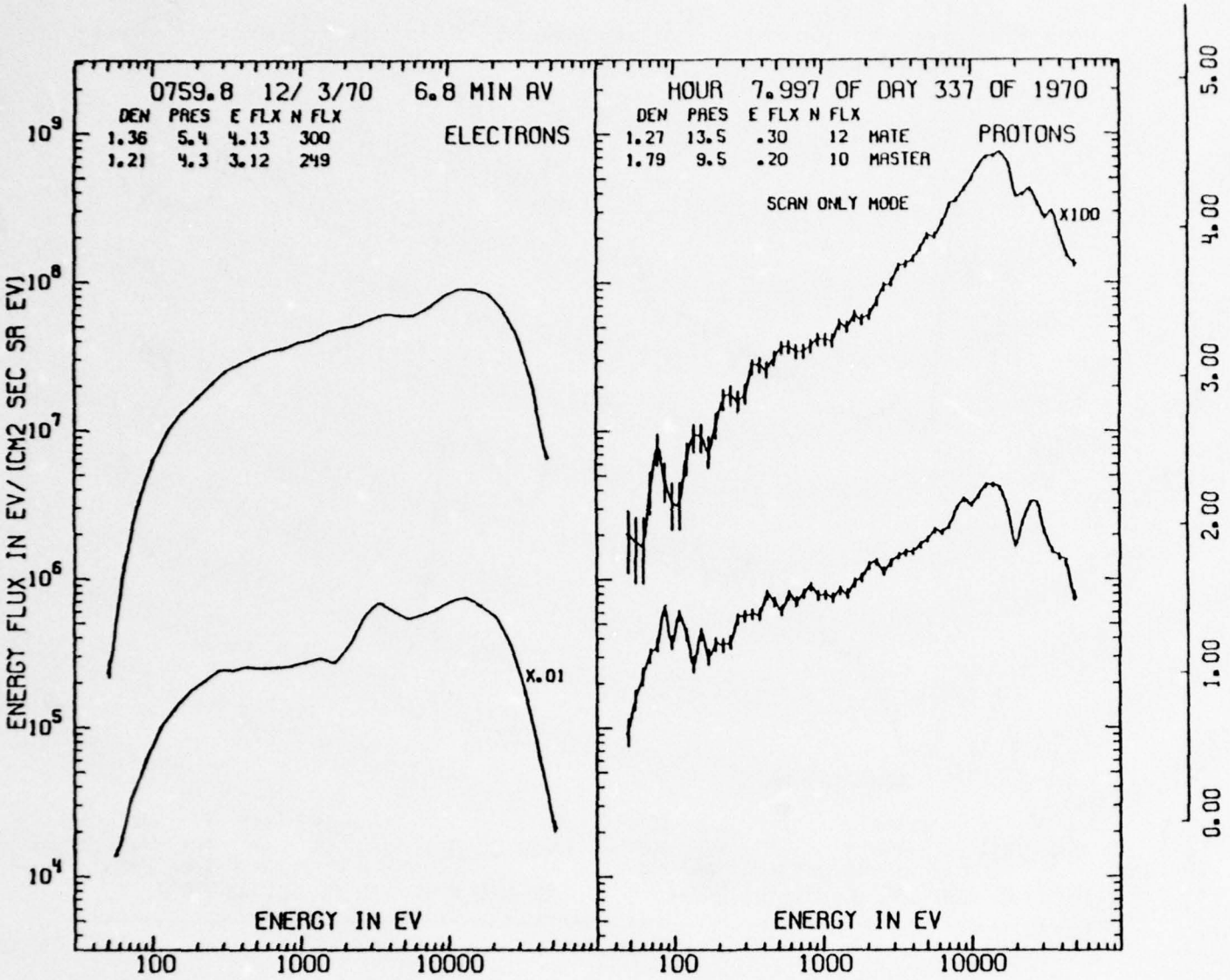
Spectrogram for 12/3/70 - Pre-midnight substorm.

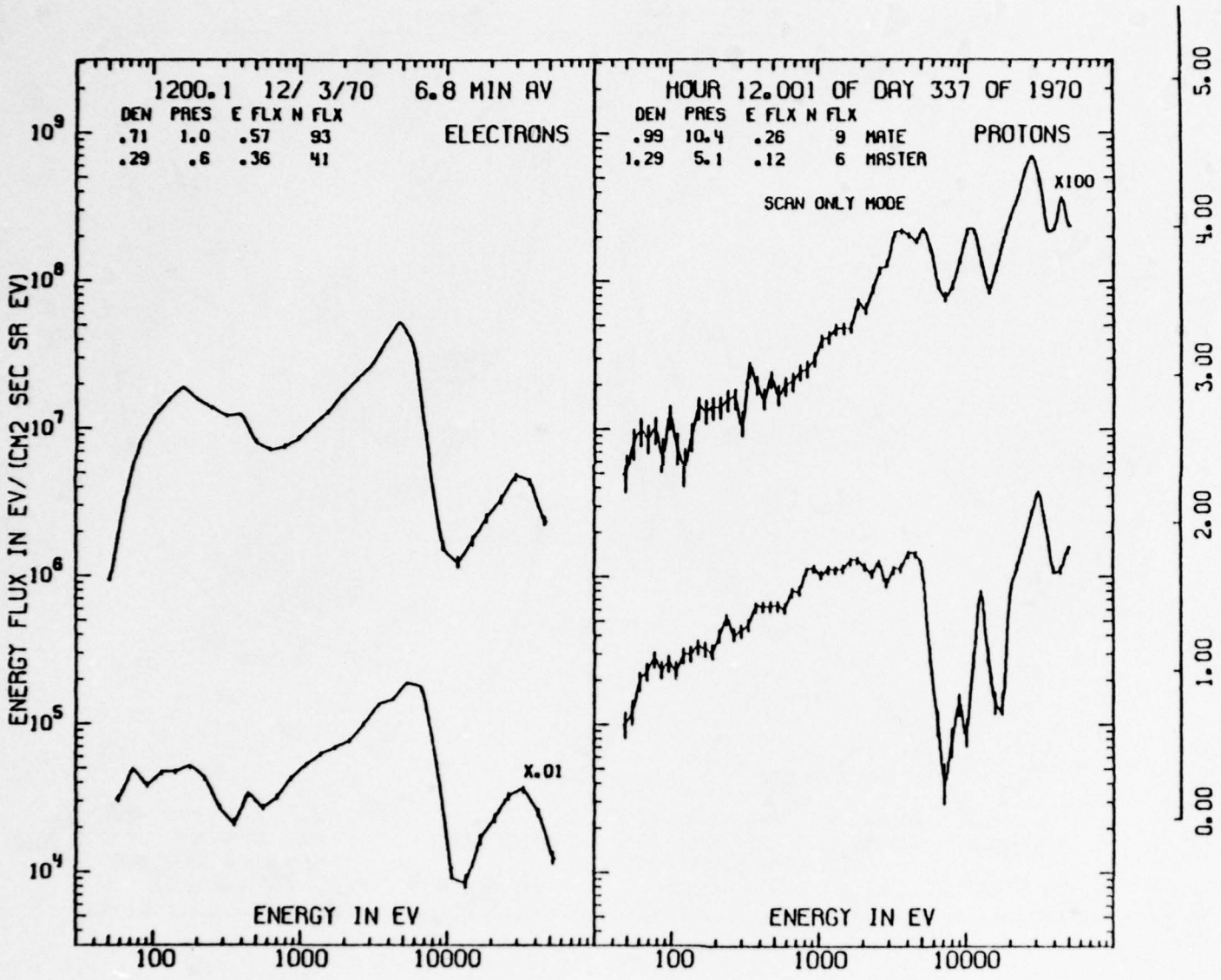

0159.8 12/ 3/70 6.8 MIN AV
DEN PRES E FLX N FLX
.04 .2 .16 9
.03 .2 .15 8
ELECTRONS
X.01
ENERGY IN EV
HOUR 1.997 OF DAY 337 OF 1970
DEN PRES E FLX N FLX
.93 13.9 .33 11 MATE
.63 9.0 .21 7 MASTER
PROTONS
SCAN ONLY MODE
X100
ENERGY IN EV
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

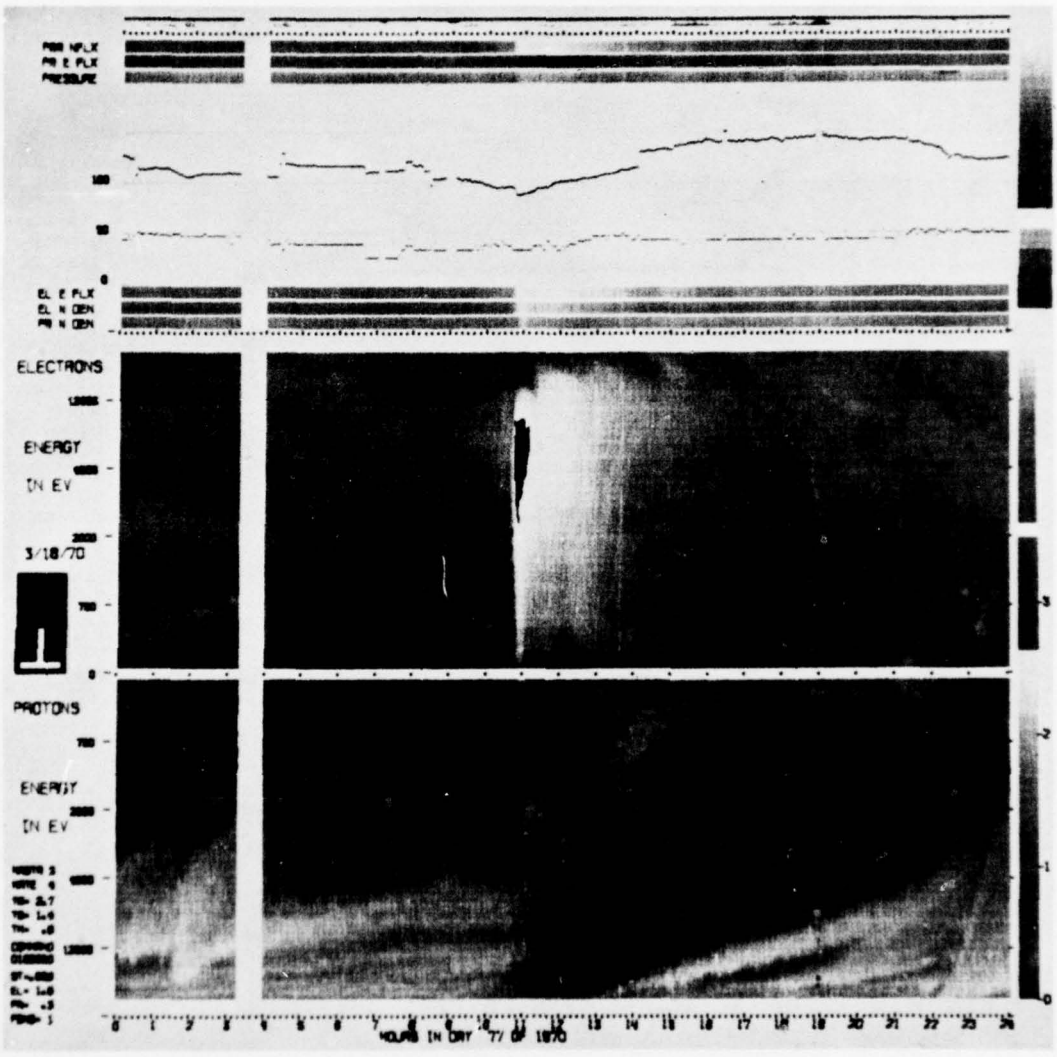

0359.9 12/ 3/70 6.8 MIN AV
DEN PRES E FLX N FLX
.04 .4 .47 15
.04 .3 .38 11
ELECTRONS
X.01
HOUR 3.999 OF DAY 337 OF 1970
DEN PRES E FLX N FLX
1.36 10.6 .24 10 MATE
1.26 10.1 .21 10 MASTER
PROTONS
SCAN ONLY MODE
X100
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


0600.1 12/ 3/70 6.8 MIN AV
DEN PRES E FLX N FLX
.68 .4 .25 48
.33 .4 .36 27
ELECTRONS
HOUR 6.001 OF DAY 337 OF 1970
DEN PRES E FLX N FLX
1.28 11.1 .27 10 MATE
1.37 7.9 .18 8 MASTER
PROTONS
SCAN ONLY MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

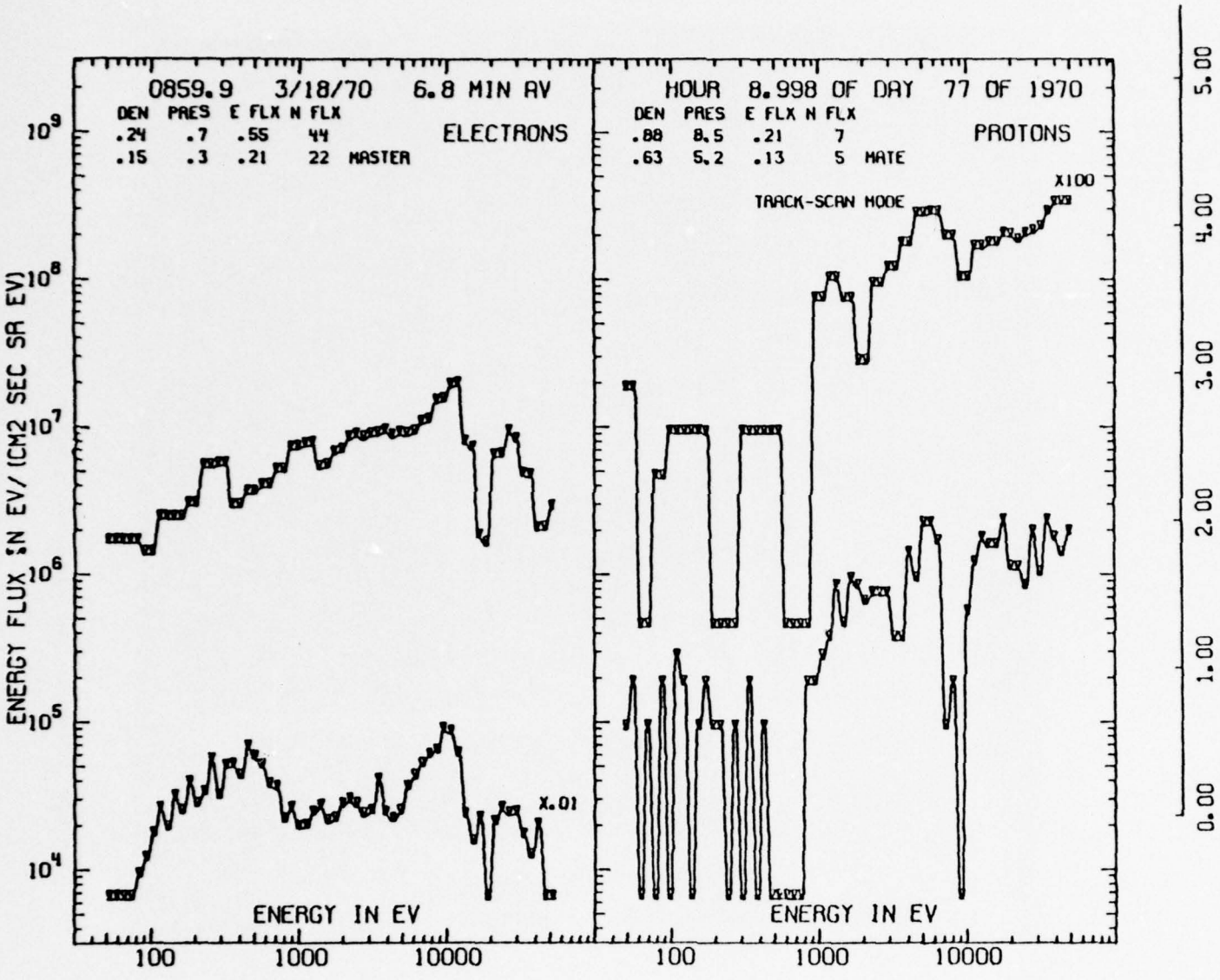

0700.1 12/ 3/70 6.8 MIN AV
DEN PRES E FLX N FLX
.76 .5 .24 70
.55 .4 .30 45
ELECTRONS
HOUR 7.002 OF DAY 337 OF 1970
DEN PRES E FLX N FLX
1.06 10.9 .27 9 MATE
1.07 7.5 .17 7 MASTER
PROTONS
SCAN ONLY MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

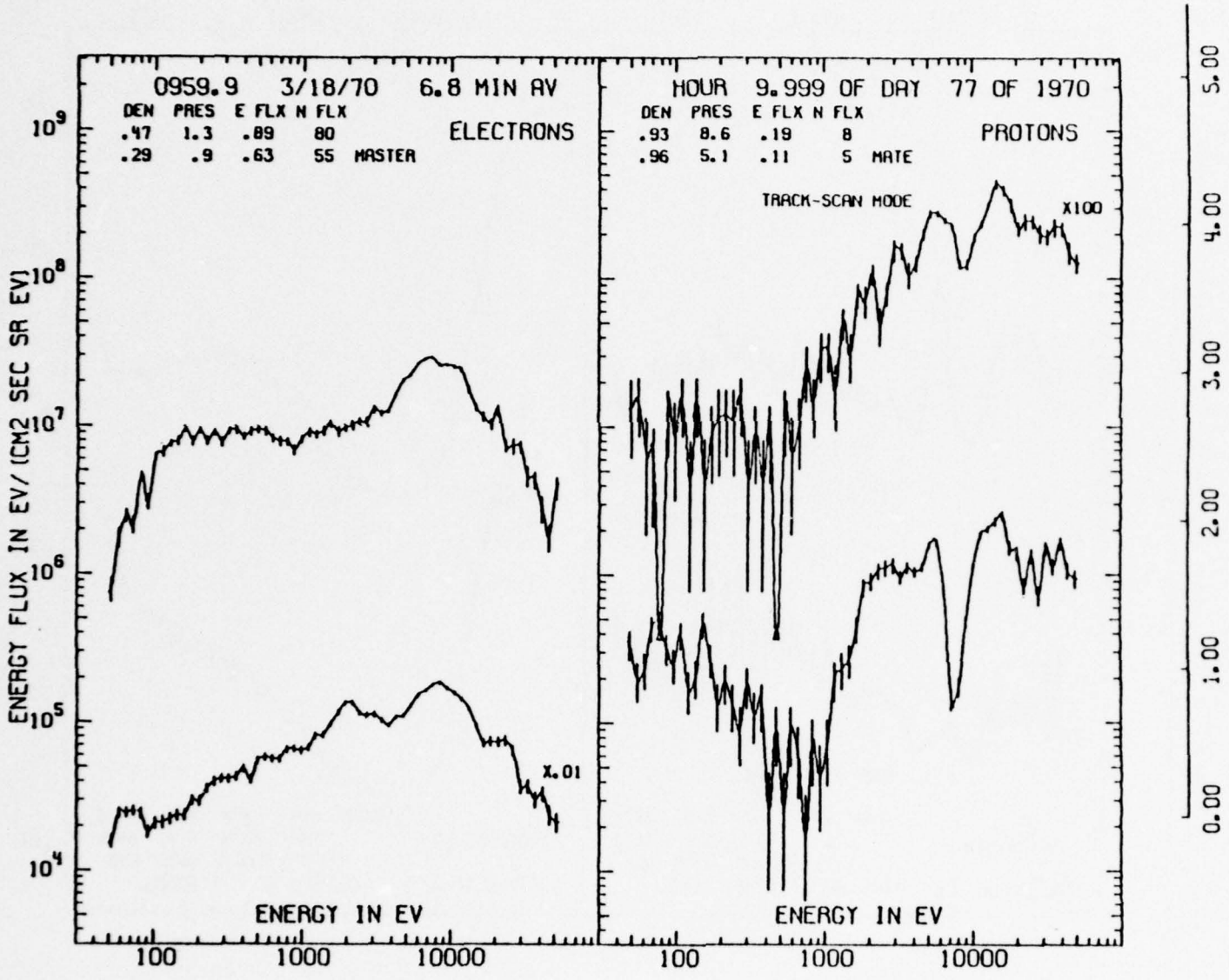

0759.8 12/ 3/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.36 5.4 4.13 300
1.21 4.3 3.12 249
ELECTRONS
X.01
ENERGY IN EV
100
1000
10000
HOUR 7.997 OF DAY 337 OF 1970
DEN PRES E FLX N FLX
1.27 13.5 .30 12 MATE
1.79 9.5 .20 10 MASTER
PROTONS
SCAN ONLY MODE
X100
ENERGY IN EV
100
1000
10000
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
0.00
1.00
2.00
3.00
4.00
5.00

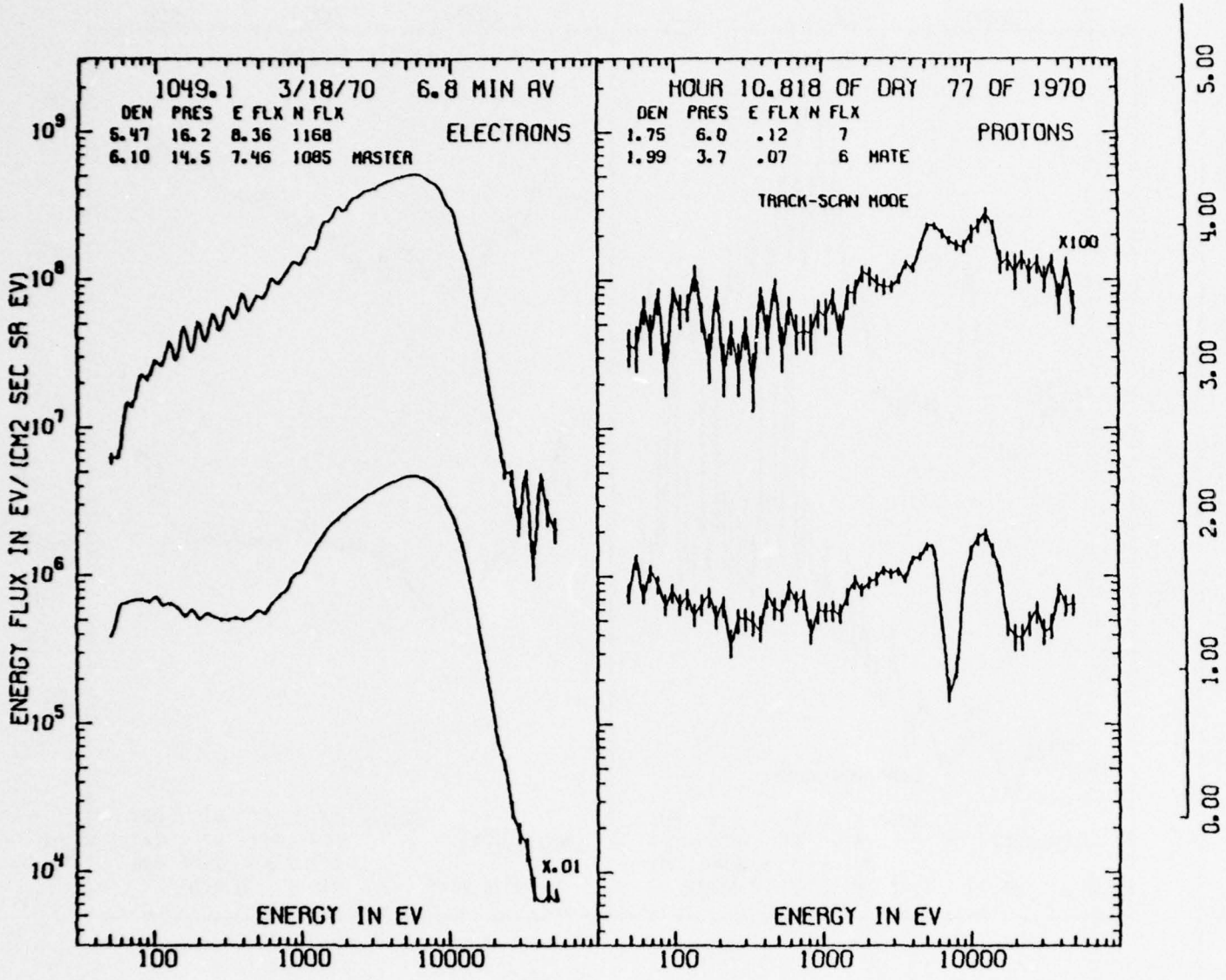

1200.1 12/ 3/70 6.8 MIN AV
DEN PRES E FLX N FLX
.71 1.0 .57 93
.29 .6 .36 41
ELECTRONS
X.01
HOUR 12.001 OF DAY 337 OF 1970
DEN PRES E FLX N FLX
.99 10.4 .26 9 MATE
1.29 5.1 .12 6 MASTER
PROTONS
SCAN ONLY MODE
X100
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

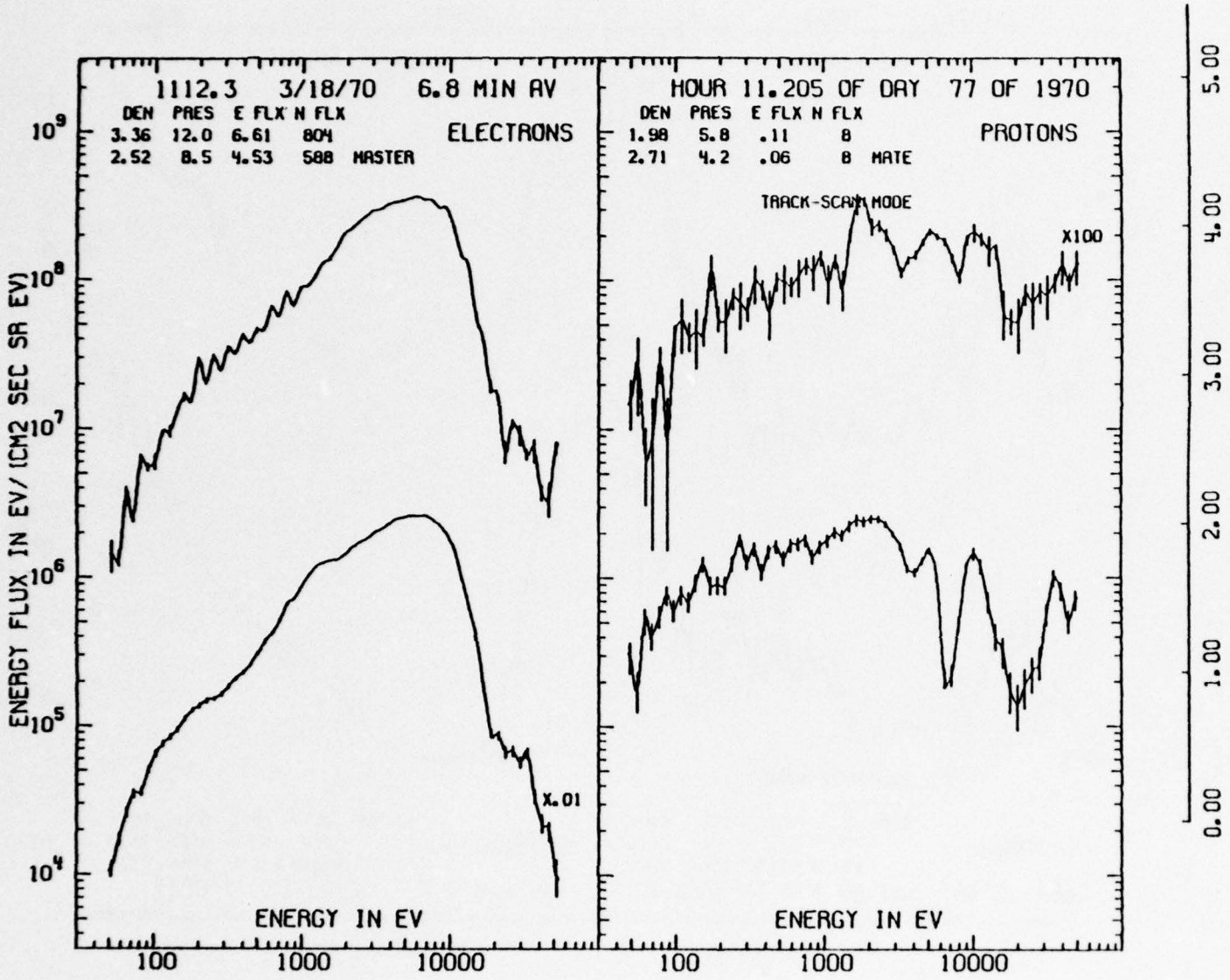


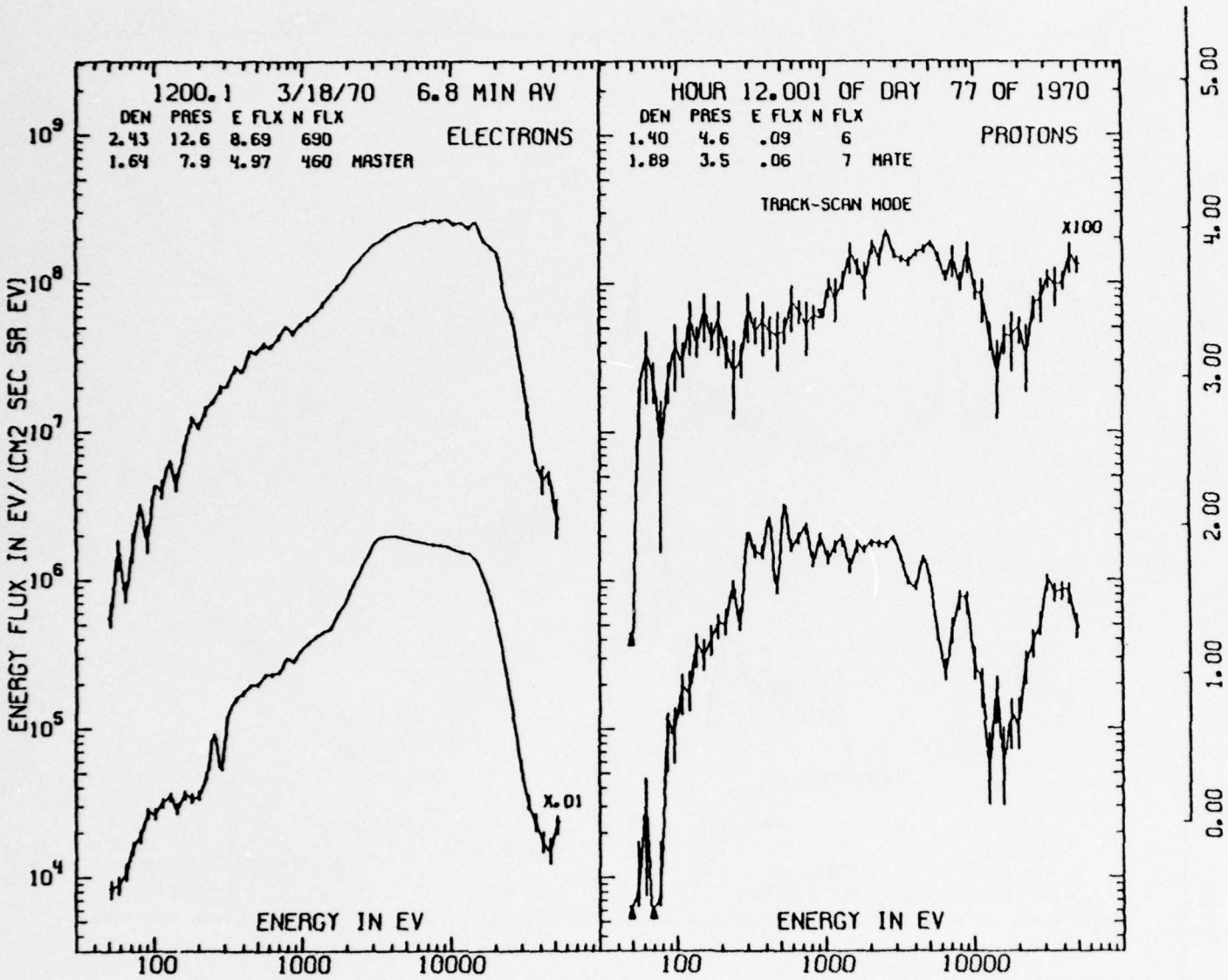
Spectrogram for 3/18/70 - Post-midnight substorm.

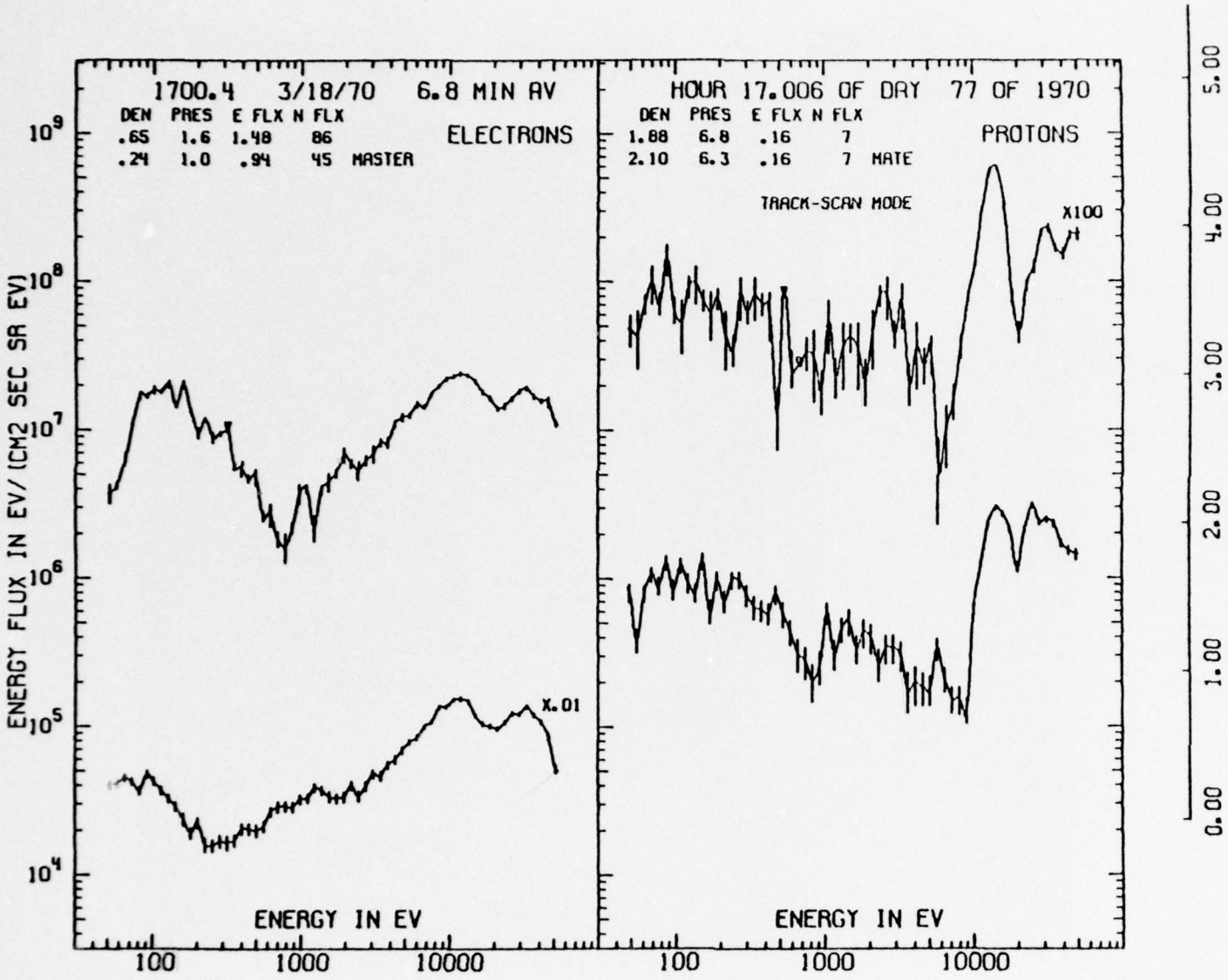

0859.9 3/18/70 6.8 MIN AV
DEN PRES E FLX N FLX
.24 .7 .55 44
.15 .3 .21 22 MASTER
ELECTRONS
X.01
ENERGY IN EV
100
1000
10000
HOUR 8.998 OF DAY 77 OF 1970
DEN PRES E FLX N FLX
.88 8.5 .21 7
.63 5.2 .13 5 MATE
PROTONS
TRACK-SCAN MODE
X100
ENERGY IN EV
100
1000
10000
ENERGY FLUX IN EV/(CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
0.00
1.00
2.00
3.00
4.00
5.00

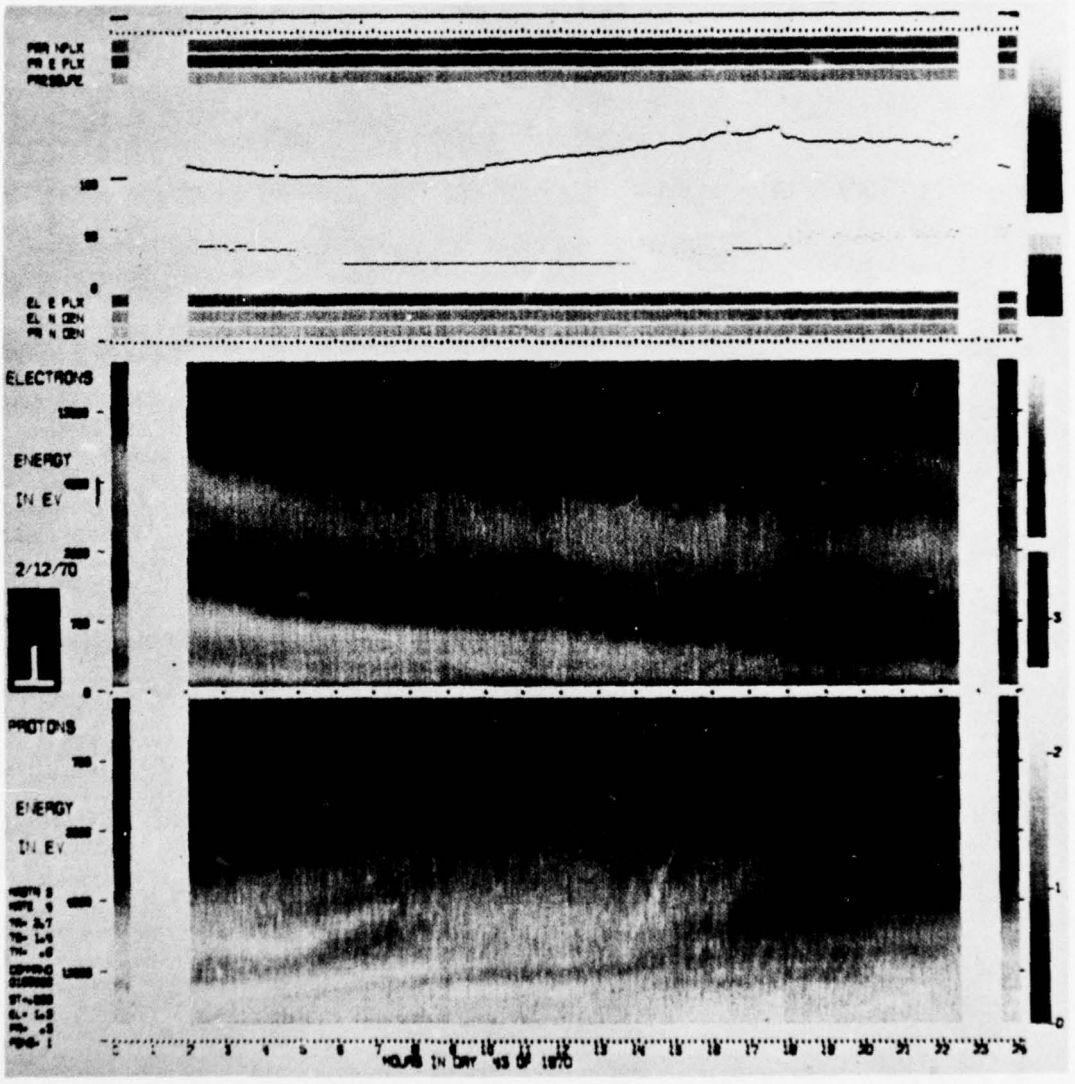

0959.9 3/18/70 6.8 MIN AV
DEN PRES E FLX N FLX
.47 1.3 .89 80
.29 .9 .63 55 MASTER
ELECTRONS
HOUR 9.999 OF DAY 77 OF 1970
DEN PRES E FLX N FLX
.93 8.6 .19 8
.96 5.1 .11 5 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


1049.1 3/18/70 6.8 MIN AV
DEN PRES E FLX N FLX
6.47 16.2 8.36 1168
6.10 14.5 7.46 1085 MASTER
ELECTRONS
HOUR 10.818 OF DAY 77 OF 1970
DEN PRES E FLX N FLX
1.75 6.0 .12 7
1.99 3.7 .07 6 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

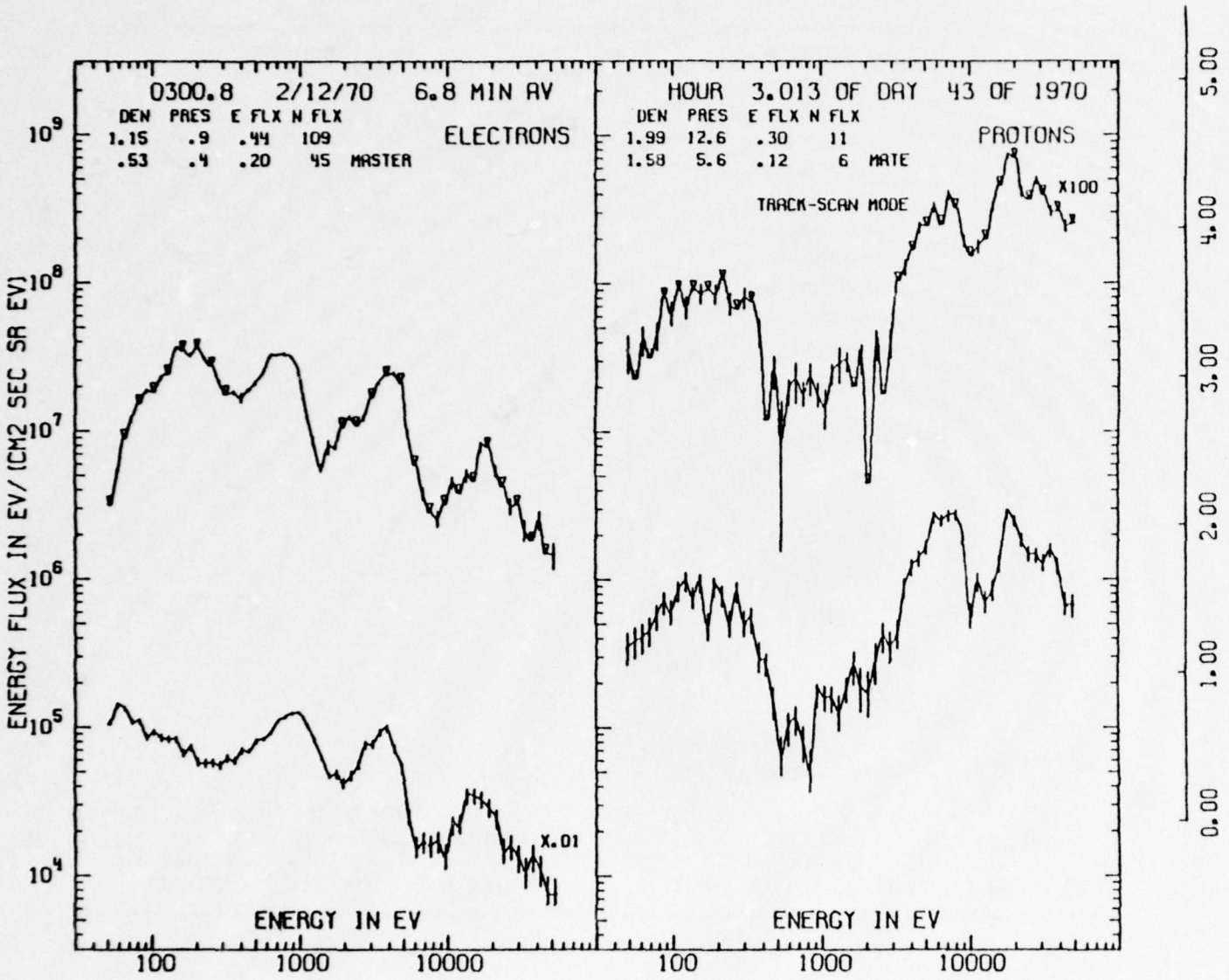

1112.3 3/18/70 6.8 MIN AV
DEN PRES E FLX N FLX
3.36 12.0 6.61 804
2.52 8.5 4.53 588 MASTER
ELECTRONS
HOUR 11.205 OF DAY 77 OF 1970
DEN PRES E FLX N FLX
1.98 5.8 .11 8
2.71 4.2 .06 8 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

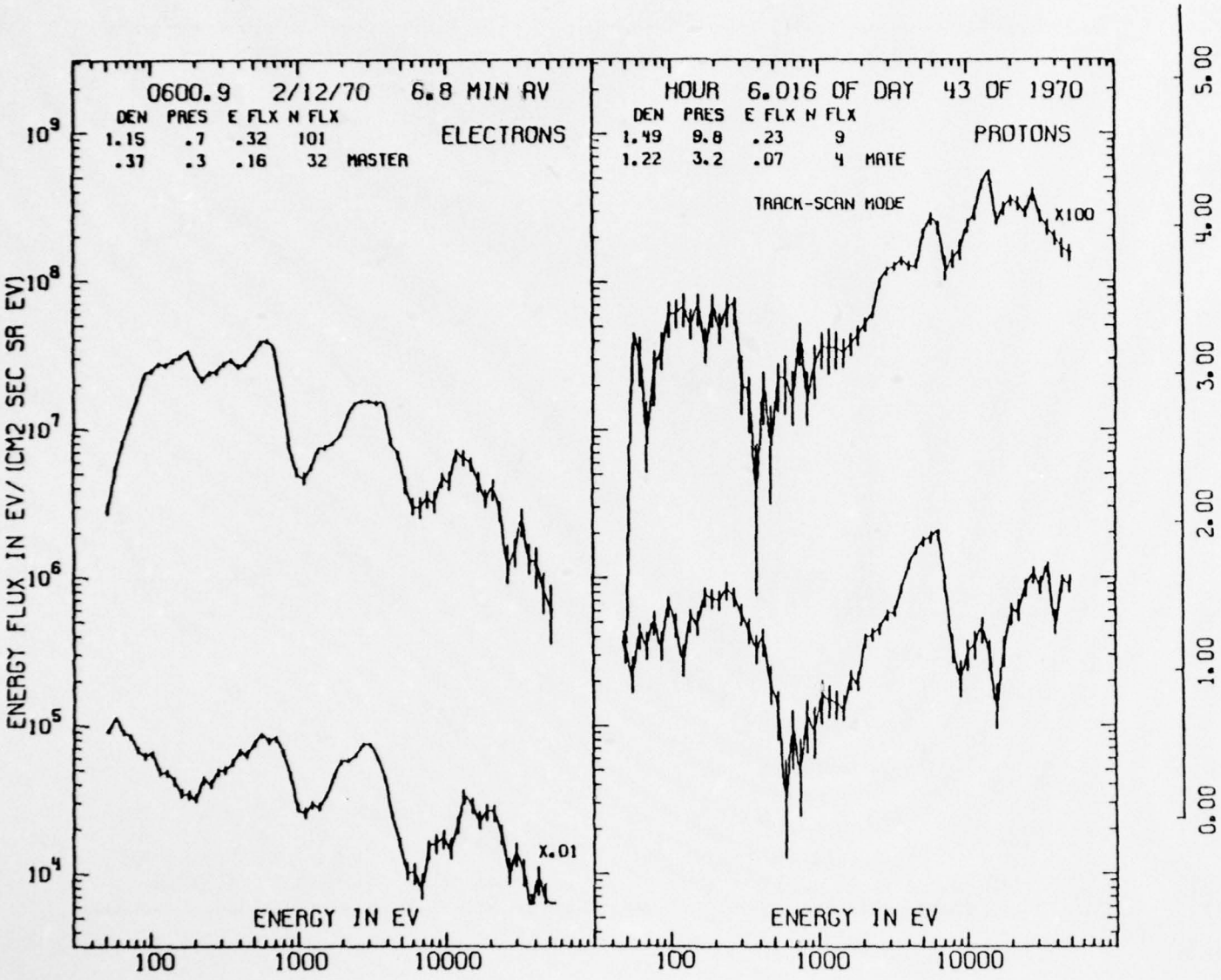

1200.1 3/18/70 6.8 MIN AV
DEN PRES E FLX N FLX
2.43 12.6 8.69 690
1.64 7.9 4.97 460 MASTER
ELECTRONS
HOUR 12.001 OF DAY 77 OF 1970
DEN PRES E FLX N FLX
1.40 4.6 .09 6
1.89 3.5 .06 7 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/(CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

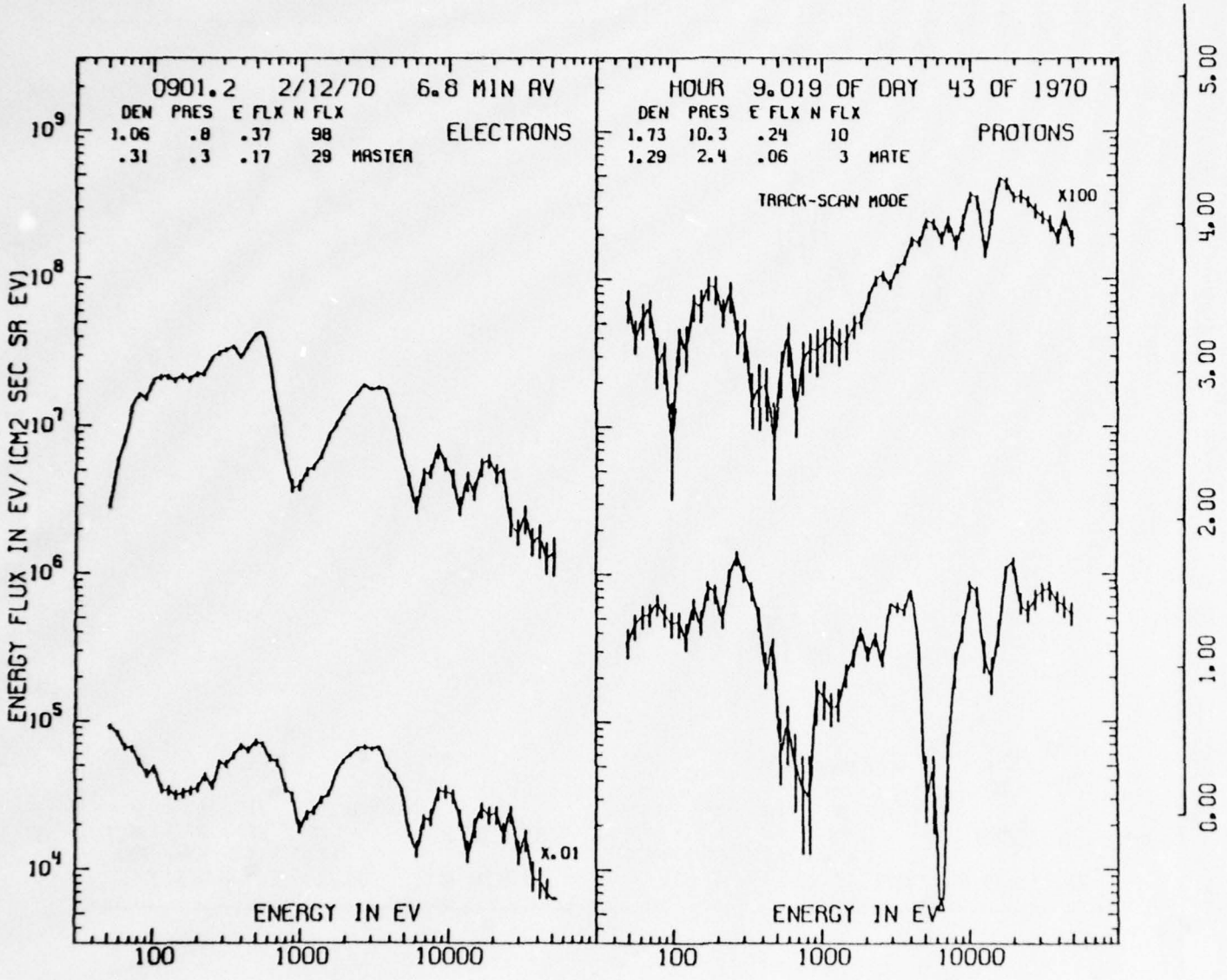

1700.4 3/18/70 6.8 MIN AV
DEN PRES E FLX N FLX
.65 1.6 1.48 86
.24 1.0 .94 45 MASTER
ELECTRONS
HOUR 17.006 OF DRY 77 OF 1970
DEN PRES E FLX N FLX
1.88 6.8 .16 7
2.10 6.3 .16 7 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

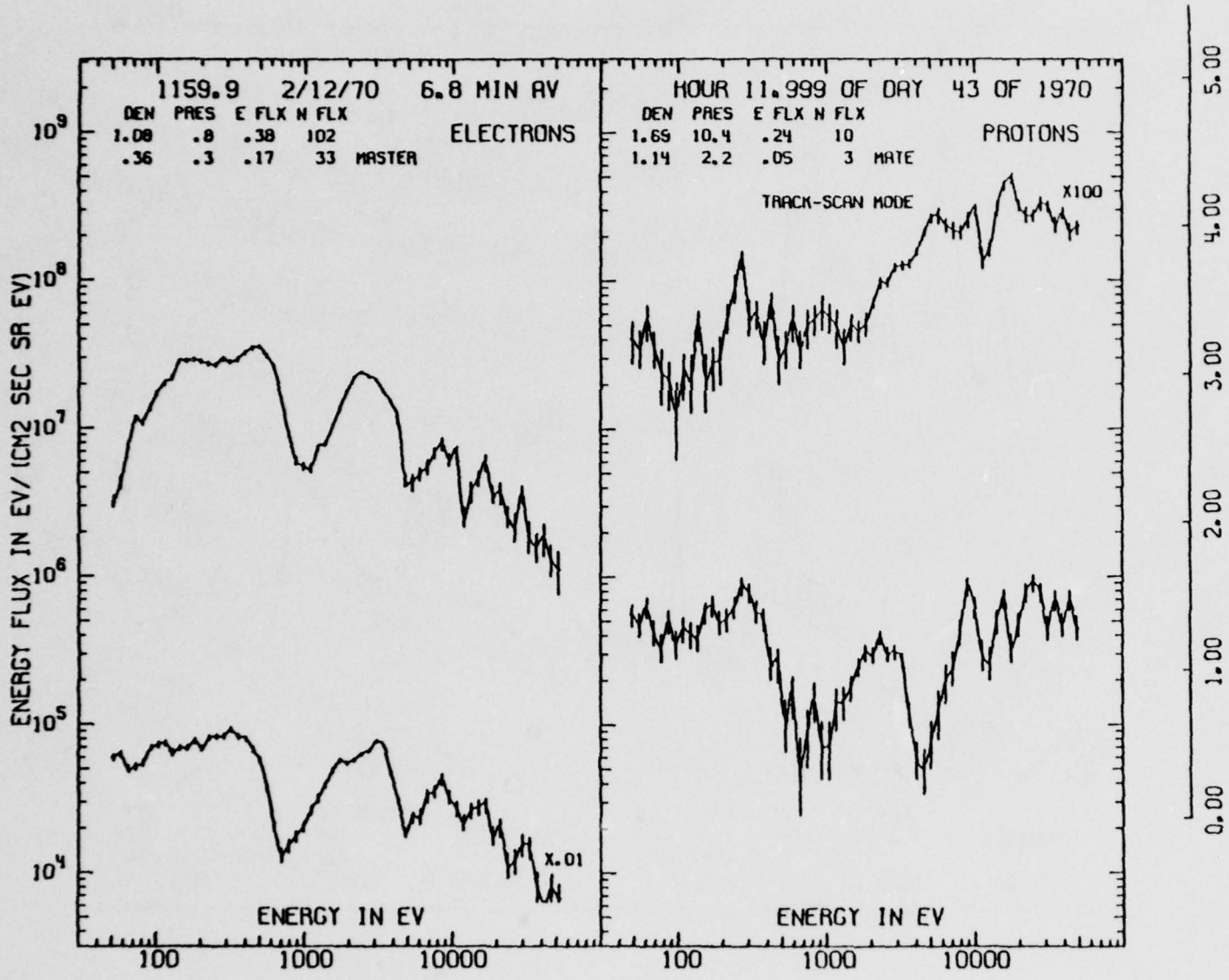


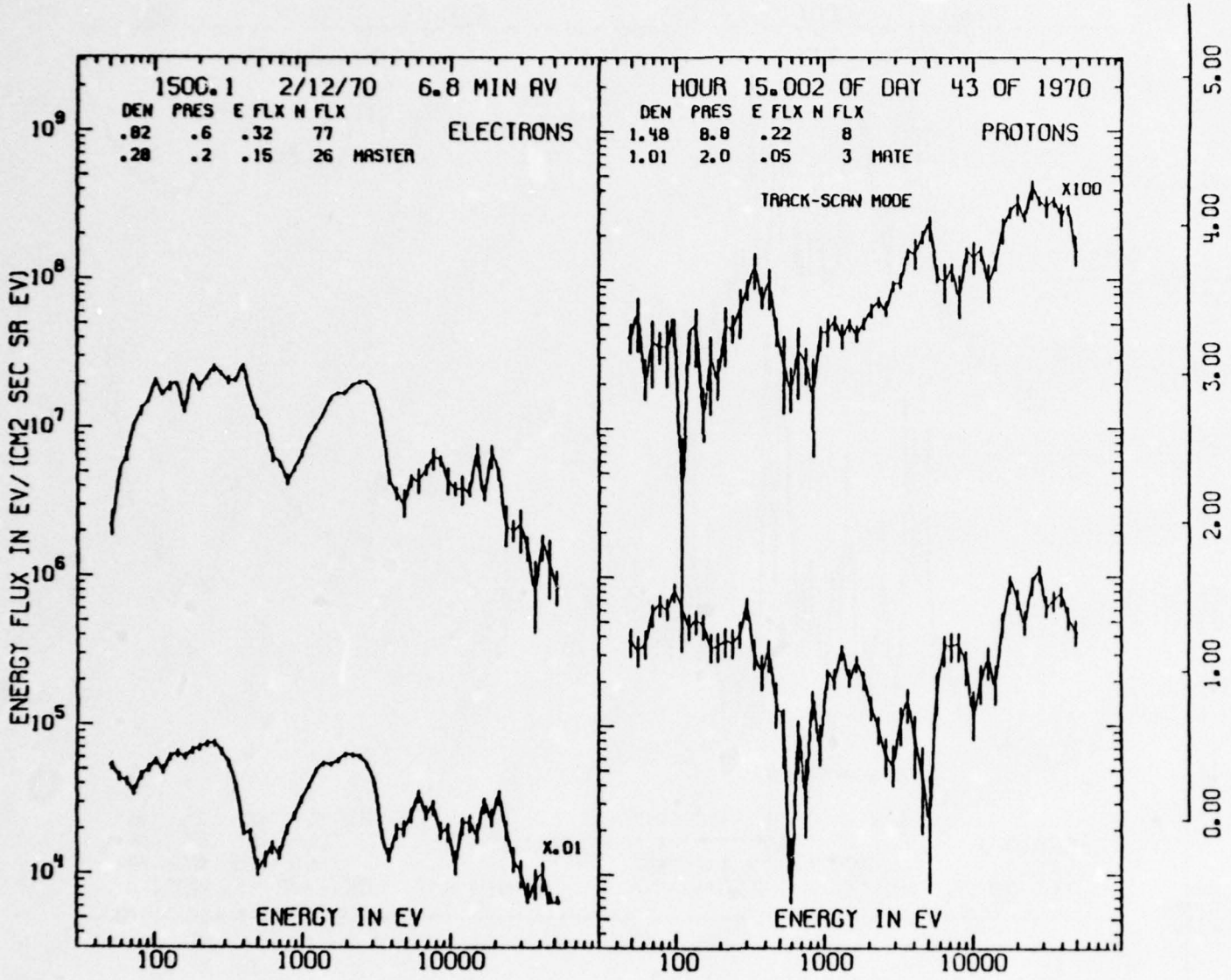
Spectrogram for 2/12/70 - Quiet day.

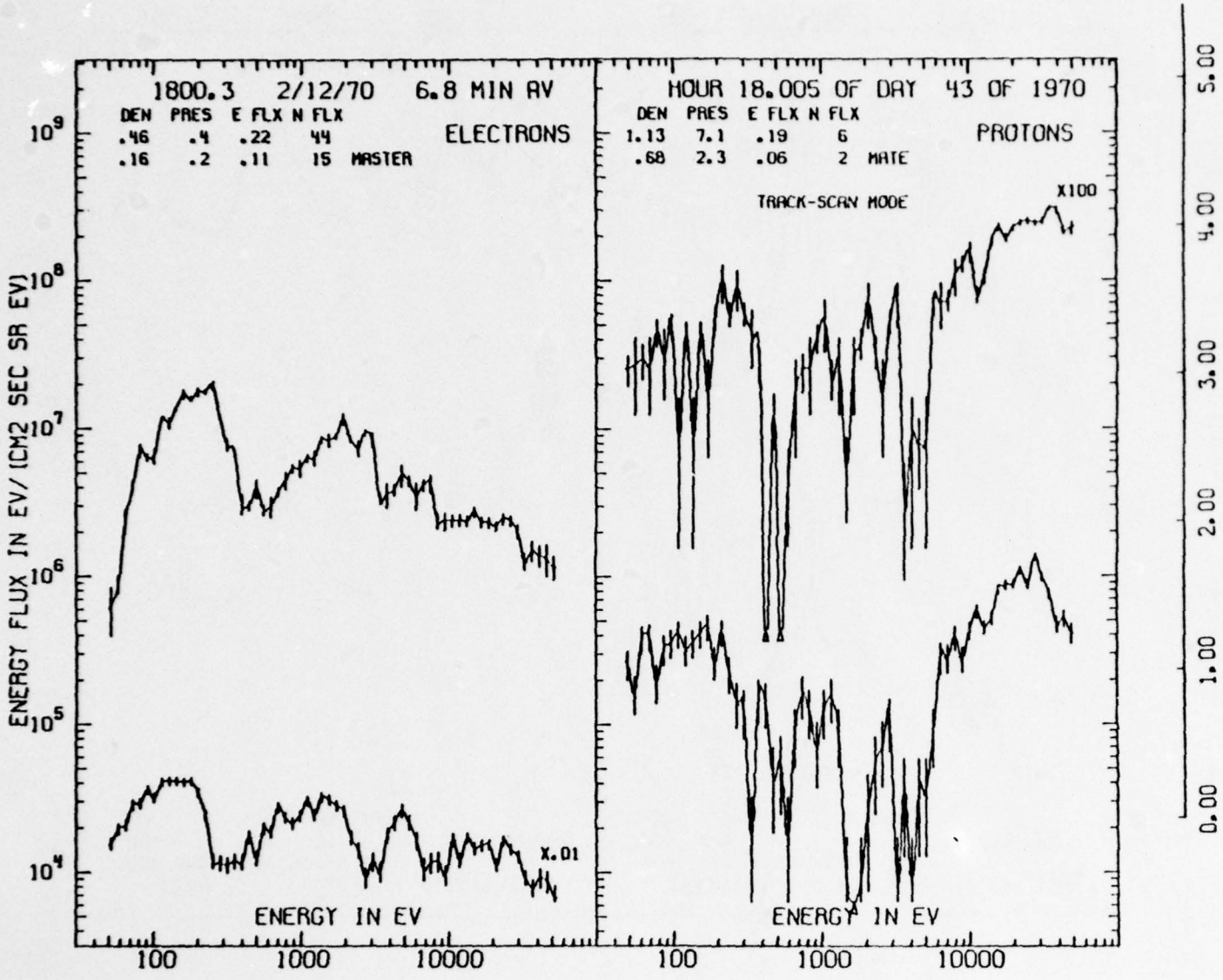

0300.8 2/12/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.15 .9 .44 109
.53 .4 .20 45 MASTER
ELECTRONS
HOUR 3.013 OF DAY 43 OF 1970
DEN PRES E FLX N FLX
1.99 12.6 .30 11
1.58 5.6 .12 6 MATE
PROTONS
X100
TRACK-SCAN MODE
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

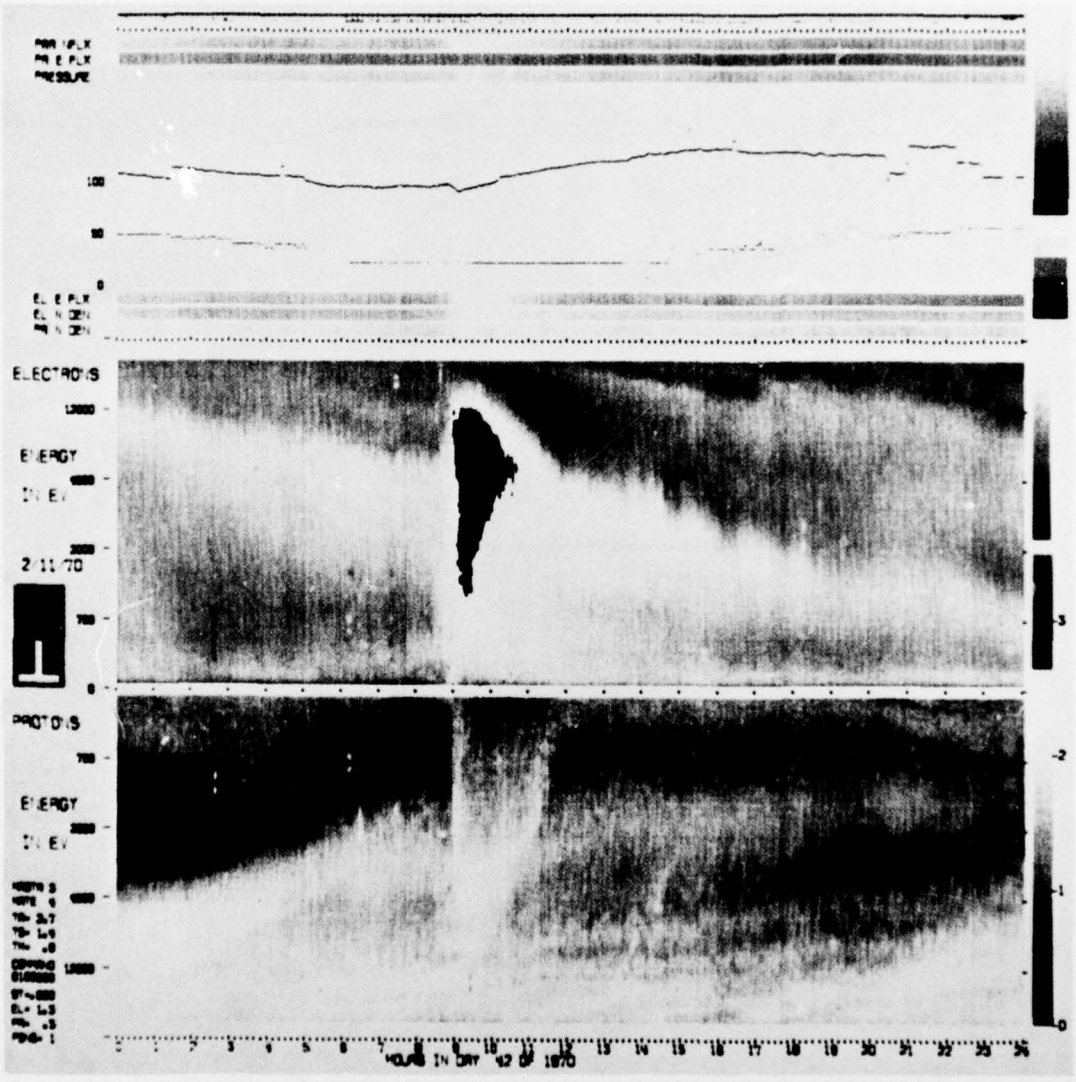

0600.9 2/12/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.15 .7 .32 101
.37 .3 .16 32 MASTER
ELECTRONS
HOUR 6.016 OF DAY 43 OF 1970
DEN PRES E FLX N FLX
1.49 9.8 .23 9
1.22 3.2 .07 4 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


0901.2 2/12/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.06 .8 .37 98
.31 .3 .17 29 MASTER
ELECTRONS
HOUR 9.019 OF DAY 43 OF 1970
DEN PRES E FLX N FLX
1.73 10.3 .24 10
1.29 2.4 .06 3 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

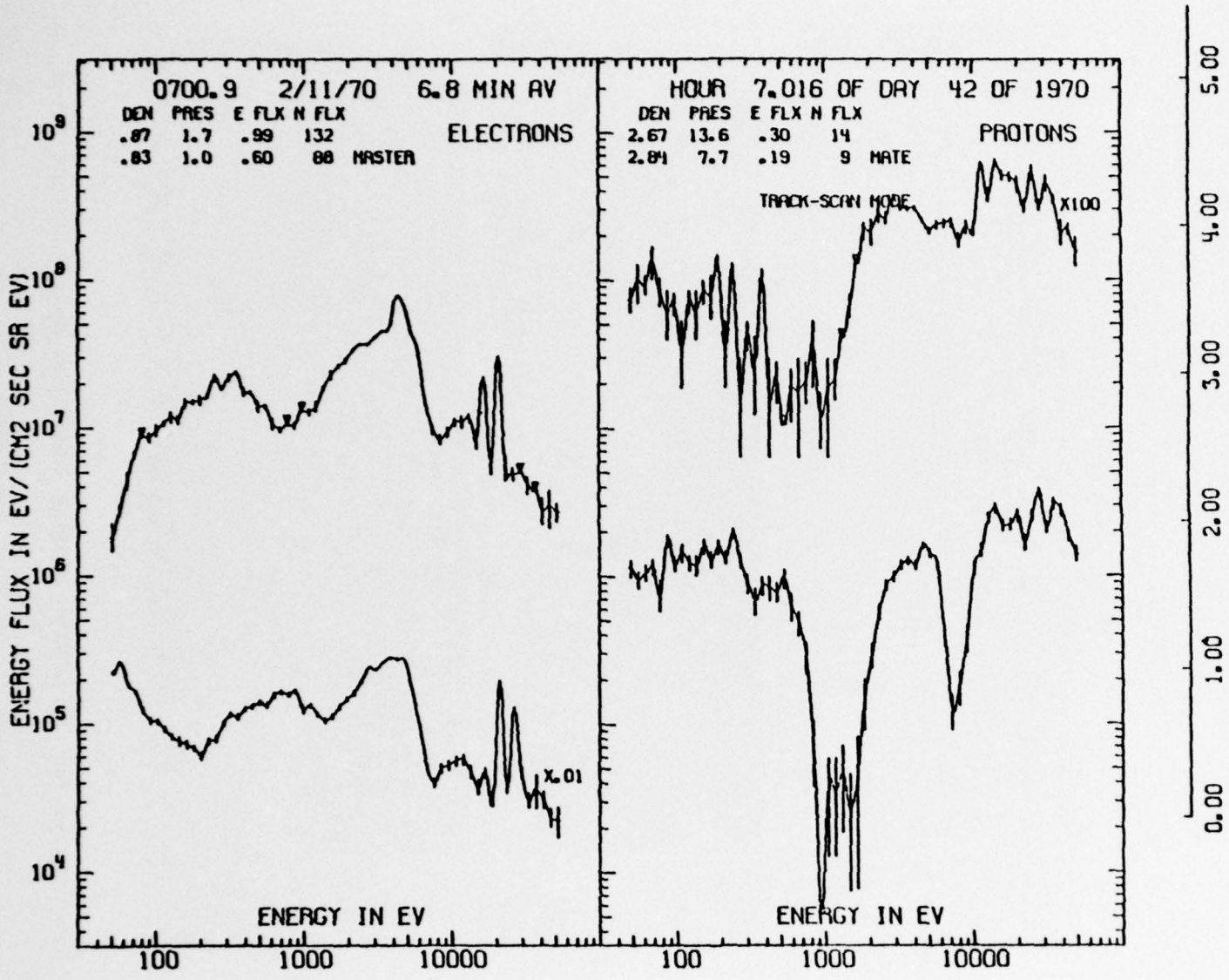

1159.9 2/12/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.08 .8 .38 102
.36 .3 .17 33 MASTER
ELECTRONS
HOUR 11.999 OF DAY 43 OF 1970
DEN PRES E FLX N FLX
1.69 10.4 .24 10
1.14 2.2 .05 3 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

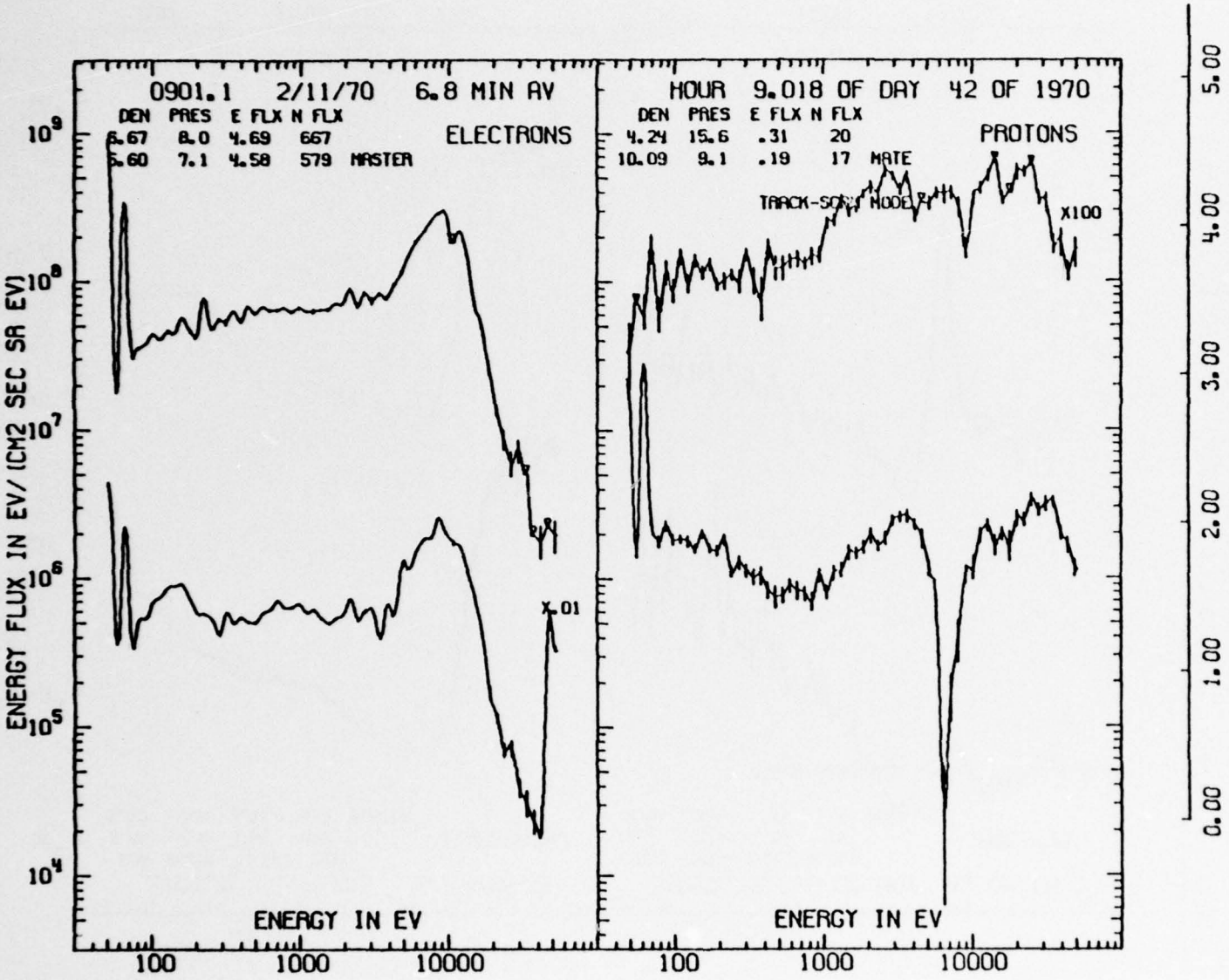

1500.1 2/12/70 6.8 MIN AV
DEN PRES E FLX N FLX
.82 .6 .32 77
.28 .2 .15 26 MASTER
ELECTRONS
HOUR 15.002 OF DAY 43 OF 1970
DEN PRES E FLX N FLX
1.48 8.8 .22 8
1.01 2.0 .05 3 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

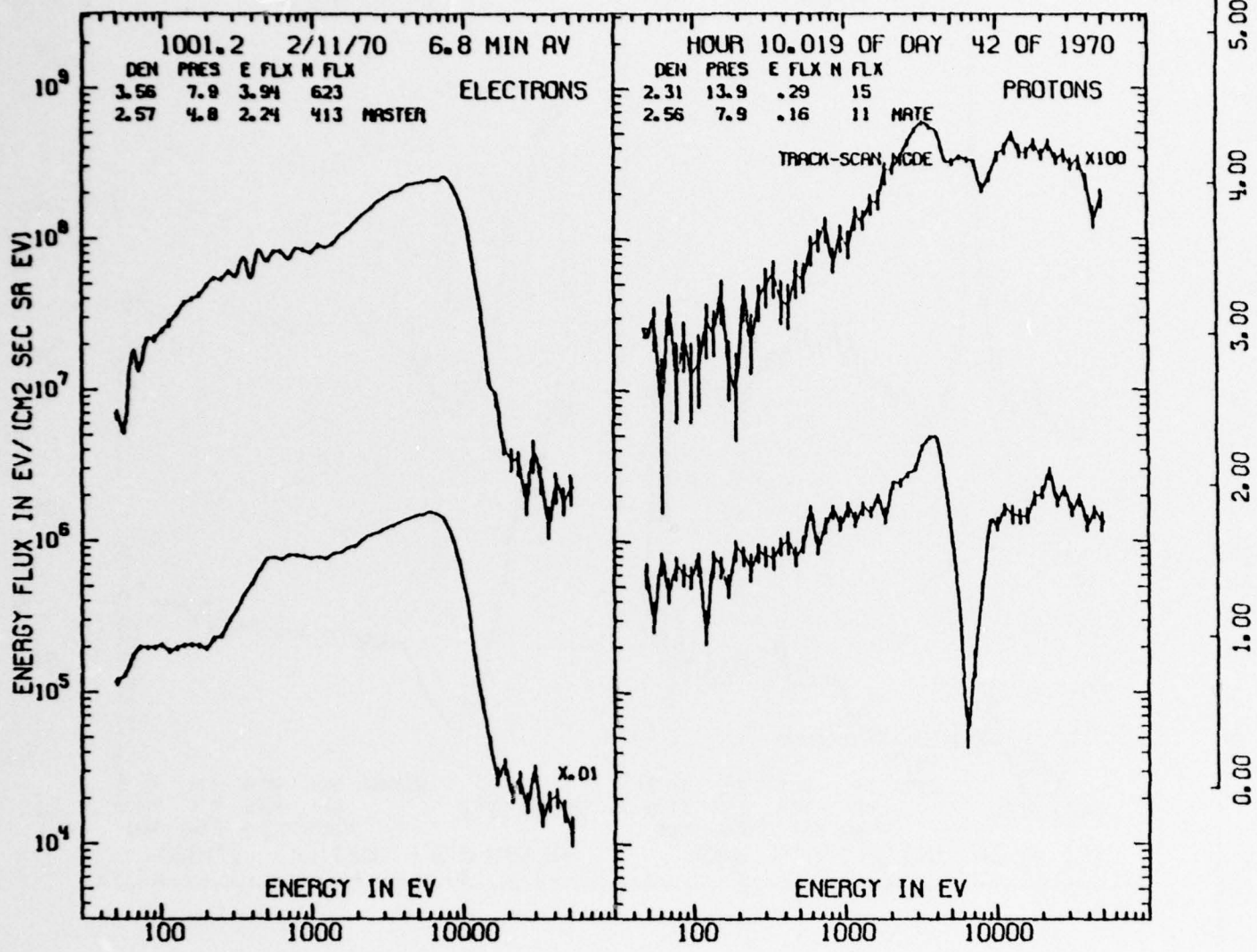

1800.3 2/12/70 6.8 MIN AV
DEN PRES E FLX N FLX
.46 .4 .22 44
.16 .2 .11 15 MASTER
ELECTRONS
HOUR 18.005 OF DAY 43 OF 1970
DEN PRES E FLX N FLX
1.13 7.1 .19 6
.68 2.3 .06 2 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/(CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

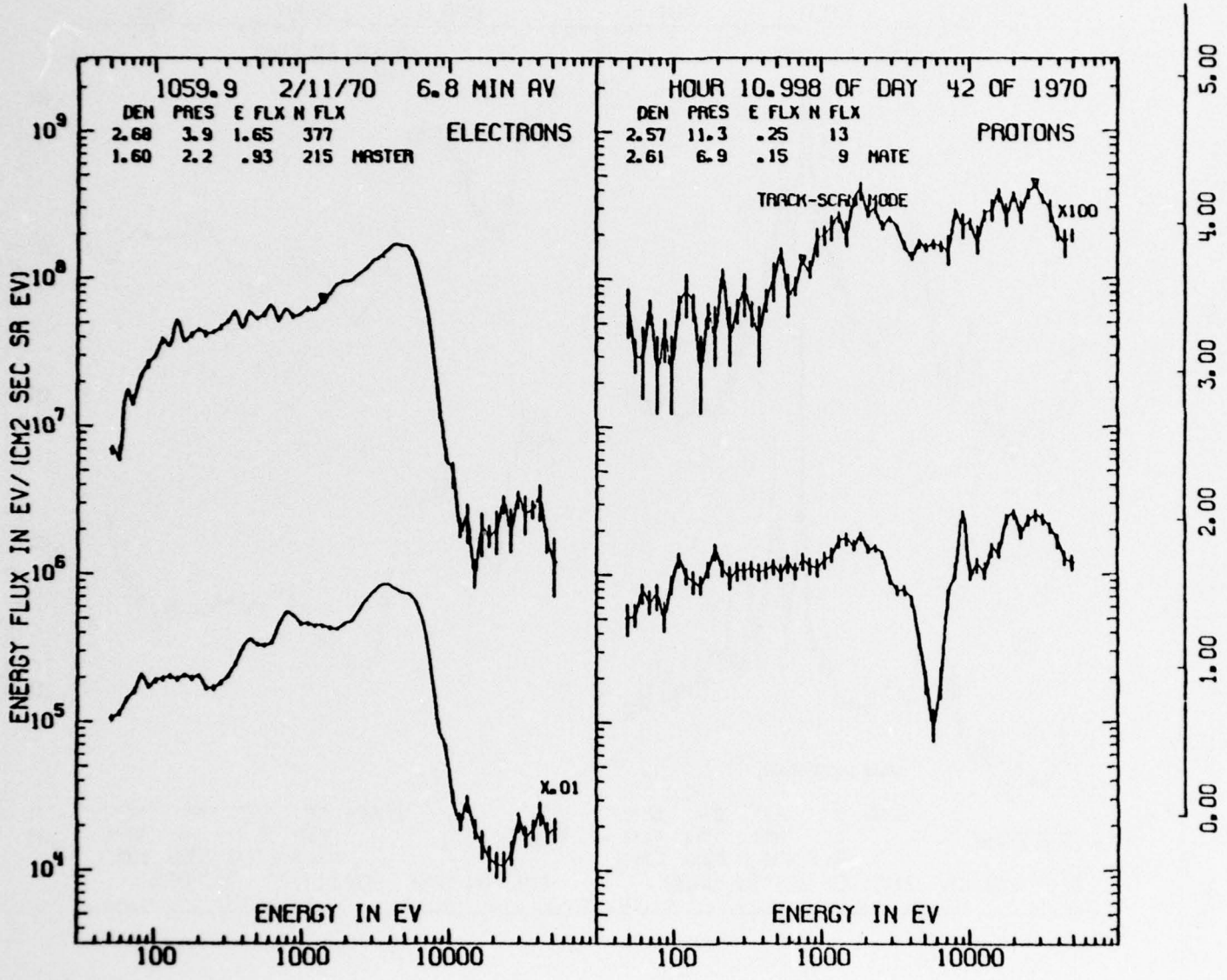


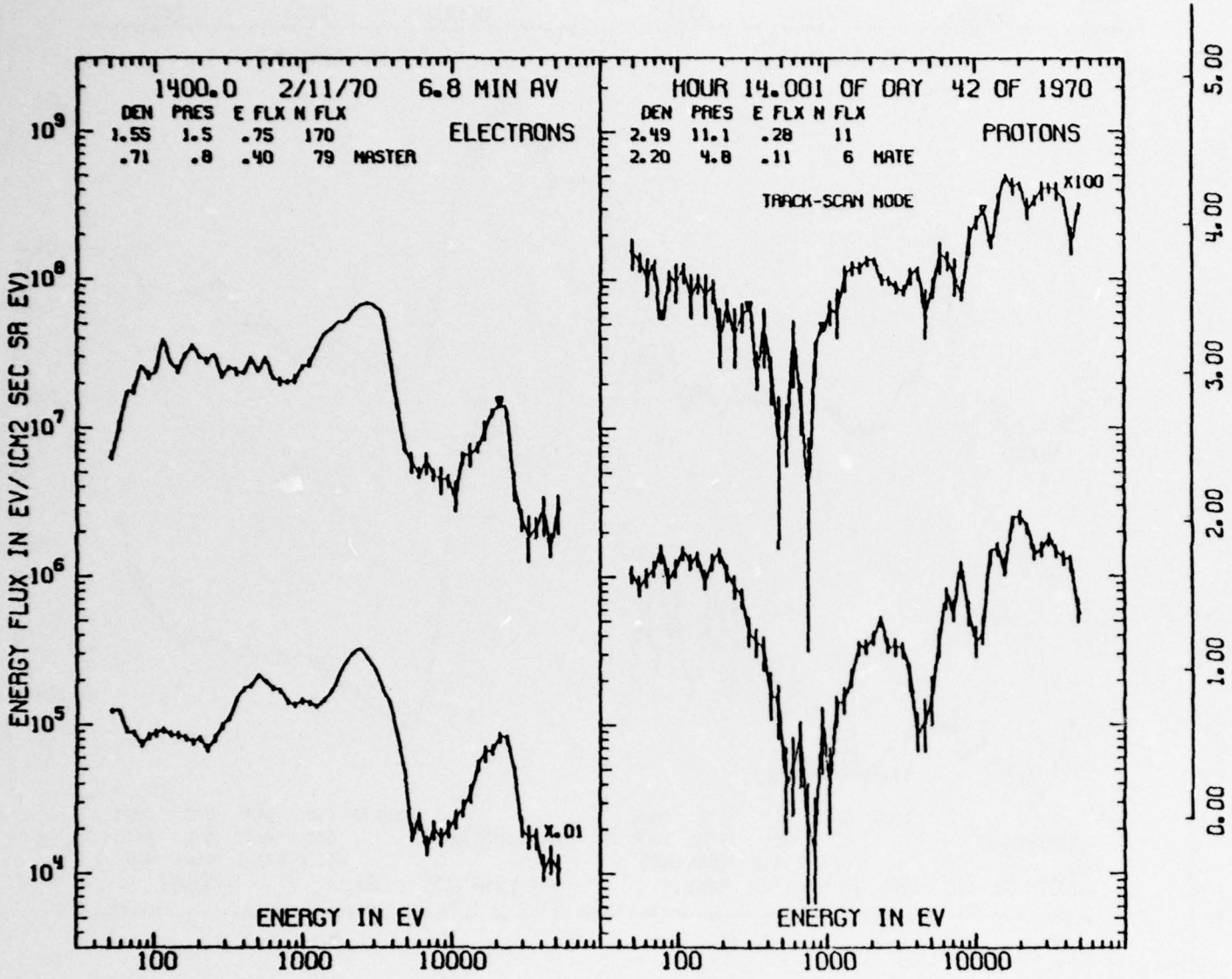
Spectrogram for 2/11/70 - Intense localized post midnight substorm.

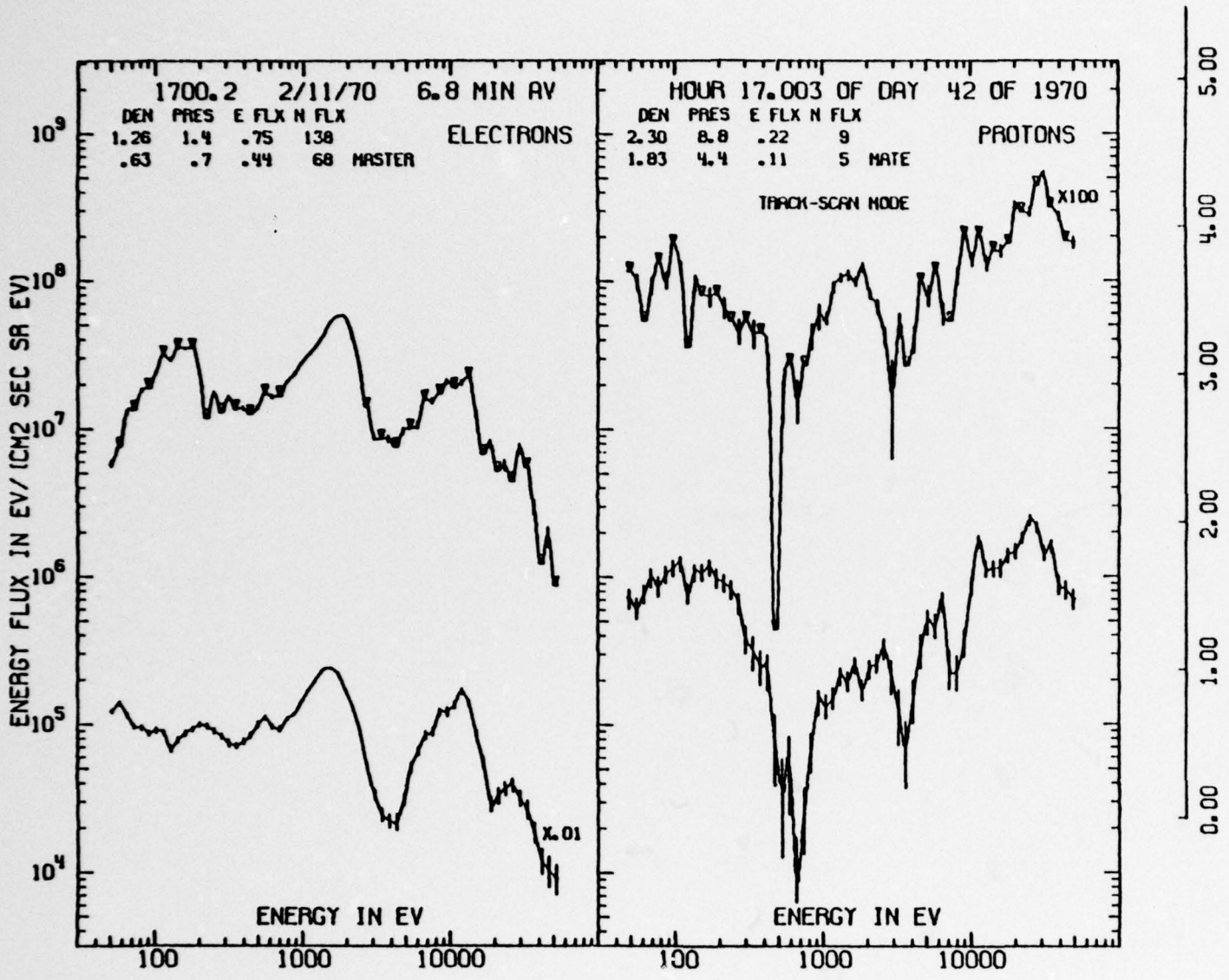

0700.9 2/11/70 6.8 MIN AV
DEN PRES E FLX N FLX
.87 1.7 .99 132
.83 1.0 .60 88 MASTER
ELECTRONS
HOUR 7.016 OF DAY 42 OF 1970
DEN PRES E FLX N FLX
2.67 13.6 .30 14
2.84 7.7 .19 9 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/(CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


0901.1 2/11/70 6.8 MIN AV
DEN PRES E FLX N FLX
6.67 8.0 4.69 667
5.60 7.1 4.58 579 MASTER
ELECTRONS
HOUR 9.018 OF DAY 42 OF 1970
DEN PRES E FLX N FLX
4.24 15.6 .31 20
10.09 9.1 .19 17 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


1001.2 2/11/70 6.8 MIN AV
DEN PRES E FLX N FLX
3.56 7.9 3.94 623
2.57 4.8 2.24 413 MASTER
ELECTRONS
X.01
ENERGY IN EV
100
1000
10000
HOUR 10.019 OF DAY 42 OF 1970
DEN PRES E FLX N FLX
2.31 13.9 .29 15
2.56 7.9 .16 11 MATE
PROTONS
TRACK-SCAN MODE
X100
ENERGY IN EV
100
1000
10000
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
10^9
10^8
10^7
10^6
10^5
10^4
0.00
1.00
2.00
3.00
4.00
5.00


1059.9 2/11/70 6.8 MIN AV
DEN PRES E FLX N FLX
2.68 3.9 1.65 377
1.60 2.2 .93 215 MASTER
ELECTRONS
HOUR 10.998 OF DAY 42 OF 1970
DEN PRES E FLX N FLX
2.57 11.3 .25 13
2.61 6.9 .15 9 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/(CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


1400.0 2/11/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.55 1.5 .75 170
.71 .8 .40 79 MASTER
ELECTRONS
HOUR 14.001 OF DAY 42 OF 1970
DEN PRES E FLX N FLX
2.49 11.1 .28 11
2.20 4.8 .11 6 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/(CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00


1700.2 2/11/70 6.8 MIN AV
DEN PRES E FLX N FLX
1.26 1.4 .75 138
.63 .7 .44 68 MASTER
ELECTRONS
HOUR 17.003 OF DAY 42 OF 1970
DEN PRES E FLX N FLX
2.30 8.8 .22 9
1.83 4.4 .11 5 MATE
PROTONS
TRACK-SCAN MODE
X100
X.01
ENERGY FLUX IN EV/ (CM2 SEC SR EV)
ENERGY IN EV
ENERGY IN EV
100
1000
10000
100
1000
10000
0.00
1.00
2.00
3.00
4.00
5.00

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