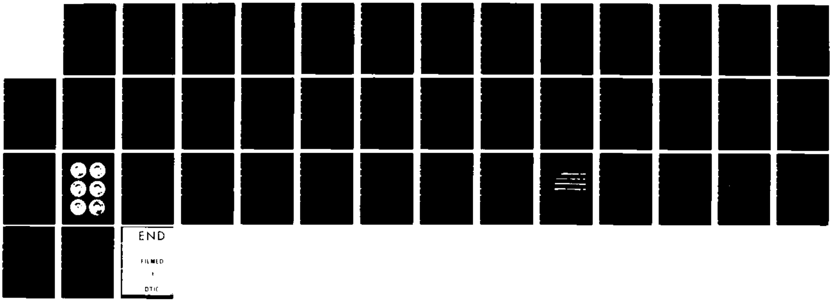
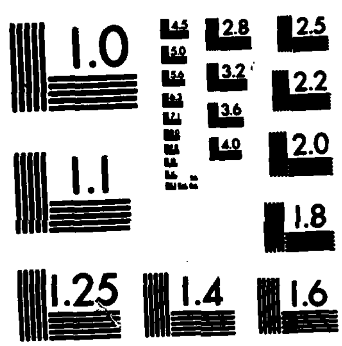
AD-A125 096 ENERGETICS AND INTERPLANETARY EFFECTS OF THE AUGUST 14 AND 18 1979 SOLAR..(U) CALIFORNIA UNIV BERKELEY SPACE SCIENCES LAB S R KANE ET AL. JAN 83 SCIENTIFIC-3 1/1

UNCLASSIFIED AFGL-TR-83-0023 F19628-80-C-0208 F/G 3/2 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(18)

AD A125096

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-83-0023	2. GOVT ACCESSION NO. AD-A125096	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ENERGETICS AND INTERPLANETARY EFFECTS OF THE AUGUST 14 AND 18, 1979 SOLAR FLARES		5. TYPE OF REPORT & PERIOD COVERED Scientific Report No. 3 (reprint)
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S.R. Kane et al		8. CONTRACT OR GRANT NUMBER(s) F19628-80-C-0208
9. PERFORMING ORGANIZATION NAME AND ADDRESS Space Sciences Laboratory University of California, Berkeley Berkeley, CA 94720		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F 2311G1AQ
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory Hanscom AFB, Massachusetts 01731 Monitor/Edward W. Cliver/PHG		12. REPORT DATE January 1983
		13. NUMBER OF PAGES 37
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

To be published in the Proceedings of the SCOSTEP/STIP Symposium on Solar/Interplanetary Intervals

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Sun
Flares
Energetic particles
Interplanetary disturbances

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

See reverse side for abstract

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) approximately

The STIP Event No. 1, which covered the time interval August 14 - 18, 1979, was characterized by two energetic flares: one on August 14 ($\sim$ 1243 UT) and the other on August 18 ($\sim$ 1400 UT). The hard X-ray, soft X-ray, optical, radio and energetic particle emissions from these flares and their interplanetary effects were observed with many instruments in space and on the ground. A summary of some of these observations is presented. The results of a preliminary analysis relevant to the acceleration of particles, coronal transients and evolution of shocks are as follows: (1) During the August 14 flare energetic particles were probably accelerated but could not escape the Sun in large numbers. On the other hand, during the August 18 flare the acceleration of high energy particles occurred relatively high in the corona, from whence they could easily escape into interplanetary space but could not penetrate down to the lower altitudes in the solar atmosphere in large numbers. (2) The kinetic energy of the coronal transient associated with the August 14 flare was much larger than the total energy of energetic electrons, indicating an additional energy source for the transient. (3) The shock associated with the August 18 flare extended to $\geq 2\pi$ steradians. The shock maintained its speed from the flare site to a distance of $\sim 35\ R_{\odot}$ and then decelerated to a distance of $\sim$ 1 AU as $\sim R^{-0.8}$.

(3.14)

greater than or equal to

to the minus 0.8 power

AFGL-TR-83-0023

SPACE SCIENCES LABORATORY

ENERGETICS AND INTERPLANETARY EFFECTS OF THE AUGUST 14 AND 18, 1979 SOLAR FLARES

Summary of observations made during the SMY/STIP Event No. 1: August 14-18, 1979

Authors: S. R. Kane, M. K. Bird, V. Domingo, G. Green, G. R. Gapper, A. Hewish, R. A. Howard, B. Iwers, B. V. Jackson, U. Koren, H. Kunow, R. Muller-Mellin, B. Rompolt, B. Sanahuja, H. S. Sawant, R. T. Stewart, G. Wibberenz, and P. Zlobec

Paper presented at the SCOSTEP/STIP Symposium on Solar/Interplanetary Intervals, Maynooth, Ireland, August 4-6, 1982. A condensed version of this paper will appear in the Proceedings of the Symposium.

UCB Space Sciences Laboratory
Preprint No. SSL-83-100MA

January, 1983

UNIVERSITY OF CALIFORNIA, BERKELEY

Energetics and Interplanetary Effects of the August 14 and 18, 1979 Solar Flares

Summary of observations made during the SMY/STIP Event No. 1:

August 14-18, 1979

S. R. Kane, M. K. Bird, V. Domingo,
G. Green, G. R. Gapper, A. Hewish, R. A. Howard,
B. Iwers, B. V. Jackson, U. Koren, H. Kunow,
R. Muller-Mellin, B. Rompolt, B. Sanahuja, H. S. Sawant,
R. T. Stewart, G. Wibberenz, and P. Zlobec

ABSTRACT

The STIP Event No. 1, which covered the time interval August 14 - 18, 1979, was characterized by two energetic flares: one on August 14 (~ 1243 UT) and the other on August 18 (~ 1400 UT). The hard X-ray, soft X-ray, optical, radio and energetic particle emissions from these flares and their interplanetary effects were observed with many instruments in space and on the ground. A summary of some of these observations is presented. The results of a preliminary analysis relevant to the acceleration of particles, coronal transients and evolution of shocks are as follows: (1) During the August 14 flare energetic particles were probably accelerated but could not escape the Sun in large numbers. On the other hand, during the August 18 flare the acceleration of high energy particles occurred relatively high in the corona, from whence they could easily escape into interplanetary space but could not penetrate down to the lower altitudes in the solar atmosphere in large numbers. (2) The kinetic energy of the coronal transient associated with the August 14 flare was much larger than the total energy of energetic electrons, indicating an additional energy source for the transient. (3) The shock associated with the August 18 flare extended to $\geq 2\pi$ steradians. The shock maintained its speed from the

flare site to a distance of $\sim 35\ R_\odot$ and then decelerated to a distance of ~ 1 AU as $\sim R^{-0.8}$.

I. Introduction

Energetic solar flares are known to produce a variety of electromagnetic emissions extending from gamma-ray energies to radio wavelengths. The flares also produce mass motions, shock waves and energetic particles detectable in interplanetary space. The terrestrial effects of such flares vary from short wave fadeout and polar cap absorption to increases in the neutron monitors located at high latitudes. The primary energy source for all these phenomena is believed to be the magnetic field (or equivalent electric currents) in the vicinity of the optical flare. The release of energy seems to occur in the form of the acceleration of particles and/or the heating of the ambient plasma.

Although the above general aspects of the flares have now been well observed, the relevant physical processes at the Sun, as well as in interplanetary space, are not well understood. For example, it is not clear whether the acceleration of particles occurs in one or more stages or what role the shocks play in the acceleration process. The distribution of energy dissipated in different processes such as energetic particles, heating of plasma, moss motions, shocks, etc. is also not known. The generation of shocks and their evolution as they propagate from the Sun is another aspect of the flare phenomenon which is very little understood.

The study of solar flares and their interplanetary effects is often made difficult by the absence of a well-coordinated, wide range of observations for individual flares. This difficulty was partially overcome during the SMY/STIP Event No. 1 when institutions and individuals in many different countries participated in a joint observational effort. This report presents a summary of those observations and the progress made so far in their analysis and interpretation. It is hoped that a detailed analysis of this STIP event will add considerably to our understanding of the acceleration and propagation of energetic particles, the formation and evolution of shocks, and other phenomena associated with large (energetic) solar flares.

II. General Characteristics of STIP Event No. 1

The period August 14 - 18, 1979, covered by STIP Event No. 1, was characterized by two energetic flares: one on August 14 (~ 1243 UT) and the other on August 18 (~ 1400 UT). Both flares produced large hard X-ray bursts and other energetic phenomena, such as energetic particles, coronal transients, and shock waves, although some phenomena may not have been observed because of the locations of the flares near the east limb of the Sun and/or data gaps in the observations. In the August 18, 1979, flare, the peak ~ 30 keV X-ray flux was as large as that from the well-known large flare on August 4, 1972. Although the peak ~ 30 keV X-ray flux in the August 14, 1979 flare was smaller than that in the August 4, 1972 flare by a factor of ~ 10, the hardness of the X-ray spectrum and characteristic features such as the magnitude and variation of the gradual hard X-ray emission were similar in the two flares. Thus STIP Event No. 1 consists of two energetic flares comparable in some respects to the very large August 4, 1972 flare.

In addition to the ground-based instruments and near-Earth spacecraft, a number of interplanetary spacecraft were also in operation during this period (cf. Figure 1; *Vette*, 1981). They provide a variety of observational information which is complementary/supplementary to that obtained with the near-Earth instruments. We present below the observations of the two August 1979 flares in some detail and then discuss briefly some of the implications of these observations.

III. 14 August 1979 Flare

The principal optical and radio characteristics of the 14 August 1979 flare are summarized in Table 1. The optical flare was of importance 1B and was located at S22,E73 in McMath Region 16224. The flare started at ~ 1240 UT and reached two successive maxima at ~ 1244 UT and ~ 1251 UT followed by a long decay during the next two or more hours.

Prior to the optical flare, a large and unusually bright eruptive prominence was observed in Hα by the Wroclaw Astronomical Observatory (Poland) at S32-E from 1140 to 1216 UT

[*Rompolt*, 1982]. The prominence developed into an expanding arch in the later phase of evolution. The Hα material was observed up to a height of 3×10^5 km above the limb. The velocity of eruption for the top part of the expanding arch varied from 120 km/sec to 285 km/sec during the observational period. The synoptic maps indicate that a twisted filament was present earlier in the place of the erupting prominence.

Figure 2 [*Vilmer et al.*, 1982] shows the flare-associated hard X-ray burst observed with the ISEE-3 spacecraft. The spectrum averaged over the whole event is shown in Figure 3. The impulsive and gradual hard X-ray emissions can be very clearly identified in this event. Spectra of both types of emissions are relatively hard. During the gradual phase all X-ray energies do not peak at the same time but exhibit an energy dependent delay, the higher energy X-rays reaching their maxima later. This behavior has been observed before in only three other large flares, viz., those on 4 August 1972, 7 August 1972, and 22 November 1977.

The microwave emission recorded at Sagamore Hill Observatory is shown in Figure 4 [*Sawant and Kane*, 1982]. The impulsive maximum was not well developed, as can be seen from the Ottawa measurements (Figure 5). The two gradual maxima are shown separately in Figure 4. The gradual emission extended to $\sim$ 35 GHz frequency and exhibited a frequency-dependent delay in the time of maximum, the highest frequency emission reaching the maximum earliest.

Intense decimetric and metric type IV bursts starting at $\sim$ 1243 UT have been recorded by the Dwingeloo and Weissenau radiospectrographs, respectively (Solar Geophysical Data). The observations of 237 - 505 MHz type IV emission made at the Trieste Astronomical Observatory [*Zlobec and Koren*, 1982] show an unusually dense and strong spike activity superimposed on the smoothly varying time profile. The continuum was unpolarized. However, unlike most type IV events, the polarization (right-handed) of spikes was evolving in time. No type II bursts in close association with the flare have been reported. A weak SA (shock-accelerated) event [*Cane et al.*, 1981] was observed by the ISEE-3, however, indicating the presence of a weak shock and acceleration of electrons [*Cane*, 1982].

There is no clear evidence for the release of a substantial number of energetic particles from this flare. Measurements of energetic particles are available from Helios-1 and -2 (Figure 6 and Figure 7; *Kunow et al.*, 1982) and IMP-8 and ISEE-3 spacecraft [*McGuire et al.*, 1982; *Lin*, 1982]. Low energy particle measurements are available from ISEE-3 (Figure 8; *Domingo and Sanahuja*, 1982). A few hours after the 14 August flare there was a small increase in the low energy proton flux. At that time (~ 2100 UT), the flux associated with the previous event was still quite large. The timing of these particles is compatible with near simultaneous injection of particles of all energies in the corona. Therefore it is plausible that they have been accelerated near the Sun by the shock produced by the flare.

On August 17, between 0925 and 1015 UT (data gap), a new particle flux increase started at all energies. The maximum was reached on August 17. The association of these particles with the August 14 flare is uncertain because of the occurrence of another 1B flare on August 16 at N18,E25.

The "Solwind" white light coronagraph aboard the P78-1 satellite recorded a coronal transient at ~ 1337 UT on August 14 1979 (Figure 9; *Poland et al.*, 1981). The transient was located on the SE limb (20°) and was one of the most massive ($\sim 2\times10^{16}$ g) and fastest ($\sim$900 km sec^{-1}) transients ever observed.

Interplanetary scintillation (IPS) observations have been made at the University of California, San Diego and in Cambridge, England following the 14 August flare (Figure 10, *Jackson*, 1982a; Figure 11, *Jackson, Hewish, and Gapper*, 1982). Sky maps of IPS made at Cambridge show a major enhancement during Aug. 15-22 of the kind usually associated with a corotating stream. The disturbance approached from the East and passed over the Earth on Aug. 19-20. This was probably caused by the fast solar wind stream which was observed on ISEE-3 during Aug. 20-21. No clear evidence was found for expanding spherical shells which might have been associated with either of the flares on Aug. 14 and 18. [*Hewish and Gapper*, 1982].

A composite of NRL, San Diego, and Cambridge data from *Jackson* [1982b] is given in Figure 12. Lines dashed and solid give elongations of two simple constant velocity models of the position of the outermost extent of the mass of the ejection. Neither model fits the data well. *Jackson* [1982a] proposes that the material of this mass ejection extends over a large range of longitude (>90°) as well as latitude throughout the interplanetary medium. The radial speed of the ejection is not uniform with solar longitude, however, and especially, is considerably slower (~400 km sec^{-1}) in the direction towards earth along the ecliptic plane.

Other sources of information regarding the solar wind plasma are the IMP-8 and Pioneer-12 instruments (Figure 13, and Figure 14; Solar Geophysical Data) and ISEE-3 Plasma Waves instrument [*Scarf,* 1981]. There appears to be no detection of the shock near the Earth or a geomagnetic sudden commencement following the 14 August 1979 flare.

IV. 18 August 1979 Flare

Figure 15 shows the hard X-ray emission observed with ISEE-3 during the 18 August 1979 flare [*Kane,* 1981]. This figure and Table 2 also present a summary of other emissions, such as Hα, soft X-rays (SMS-GOES) and radio, obtained from Solar Geophysical Data.

The optical flare (~ 1420 UT, -B, N08,E90) often associated with this event occurred later than the largest maximum in the hard X-ray burst. This flare is therefore not directly related to the main event. It appears that two relatively large flares occurred in the same active region considerably before this (~ 1420 UT) flare. Those two flares probably occurred somewhat behind the East limb and so could not be observed at optical wavelengths. The hard X-ray, soft X-ray, and microwave radio measurements are consistent with this inference.

The ~ 30 keV X-ray flux at the large maximum (~ 1420 UT) is the largest X-ray flux observed by ISEE-3 in the 1978-79 period and is comparable to the very large flare on 4 August 1972. The X-ray spectrum (Figure 16), however, is considerably softer in the 18 August 1979 flare. It is possible that part of the hard X-ray source was occulted from the line of sight of the ISEE-3 instrument.

The microwave emission from this flare, which was recorded at Ottawa, Boulder, and other observatories, had three pronounced maxima as in the hard X-ray emission (Figure 5;

Solar Geophysical Data). However, the peak flux (490 SFU at 2.8 GHz) is smaller than that in the 14 August 1979 flare (4030 SFU at 2.8 GHz) by a factor of ~ 8. Although this is consistent with the softer hard X-ray spectrum, it is surprising that an apparently energetic flare produced a very modest microwave flux. It is possible that part of the microwave source was occulted from the line of sight.

Decimetric (type IIIG-Int. 2) and metric (type IV-Int. 3) radio bursts have been reported by the Dwingeloo and Weissenau radiospectrographs, respectively. Measurements of the type IV emission made at the Trieste Astronomical Observatory [*Zlobec and Koren*, 1982] indicate rapid pulsations in the 237 MHz emission (left-handed channel). The intensity of the continuum decreased with increasing frequency and the polarization was 0%. A metric type II burst was recorded at Fort Davis from 1412 to 1433 UT [*Maxwell*, 1982]. A type II burst was also observed by ISEE-3 in the KHz frequency range (Figure 17; *Cane et al.*, 1982).

Energetic particles (electrons, protons and He nuclei) were observed by Helios-1 and -2 (Figures 6 and 7 *Kunow et al.*, 1982) and IMP-8 instruments (Figure 18; *McGuire et al.*, 1982). Protons with energy $\geq$ 50 MeV were detected on August 19. Faster rise time and larger peak flux recorded by Helios-2 compared with Helios-1 indicates that the former spacecraft was magnetically better connected with the flare site, and hence measured the "true magnitude" of the particle event. This is consistent with the locations of the two spacecraft relative to the Sun (Figure 19; based on *Kunow et al.*, 1982). The proton-to-alpha ratios are, however, comparable at the two spacecraft. The modulation of the particle flux during the decay is probably caused by interplanetary shocks. This is difficult to verify, however, since no plasma or magnetic data are presently available from either Helios spacecraft.

Low energy particle measurements from ISEE-3 are also available (Figure 8; *Domingo*, 1981). The relatively slowly rising flux is consistent with the location of the flare near the east limb of the Sun.

The flare produced a shock which was well observed near the east limb (1500 UT, 18 August) at a distance of $\sim 13\ R_\odot$ from the Sun (Figure 20; *Woo and Armstrong*, 1981) and also near the Earth (0550 UT, 20 August) at the ISEE-3 location (Figure 21; *Smith*, 1982; *Scarf*, 1981). A geomagnetic sudden commencement was recorded at ~0600 UT on August 20. Enhancement in the solar wind parameters was also recorded by IMP-8 (Figure 13; Solar Geophysical Data). Thus the shock seems to have extended to $\gtrsim 2\pi$ steradians. Using the ground-based scattering observations of the 2.3 and 8.4 GHz radio signals from the Voyager 1 spacecraft, Woo and Armstrong have derived the solar wind flow speed and characteristic parameters of the turbulence such as electron density fluctuations. They found a shock speed of 3500 km sec^{-1} at 13.1 $R_\odot$ and an average shock speed of 3509 km sec^{-1} from the Sun to 13.1 $R_\odot$. A more appropriate value for this average shock speed has been estimated to be ~ 2350 km sec^{-1} [*Maxwell and Dryer*, 1982; *Woo*, 1982]. The ISEE-3 measurementss [*Smith*, 1982] indicate an average shock speed of 1053 km sec^{-1} between the Sun and ~ 0.99 AU and a speed of 875 km sec^{-1} between ~ 0.99 AU and ~ 1 AU. *Cane et al.*, [1982] have examined the kilometric type II emission observed with the ISEE-3 spacecraft and other available data (Figure 22 and Figure 23). They have found that the shock speed was constant or possibly increased up to a distance of 35 $R_\odot$ and then decreased at larger distances from the Sun as $\sim R^{-0.8}$.

Observations of coronal transients are not available for this event.

V. Summary and Discussion

The STIP Event No. 1 has provided us two relatively large flares which are remarkable in many ways. We discuss below some of these distinctive features:

A. Acceleration of Particles at the Sun

The August 14 flare had all the characteristics of an energetic flare. Although the optical flare and soft X-ray burst were of medium magnitude, the hard X-ray, microwave, and metric type IV radio bursts were intense. Both impulsive and gradual components were present in the hard X-ray emission. The total energy of electrons $\gtrsim$ 25 keV deduced from the hard X-ray emission produced in a thick target chromospheric source was $\sim 3 \times 10^{30}$ ergs. The long duration and hard spectrum of the gradual hard X-ray component extending into MeV range is often considered as an indication of the second stage of particle acceleration. However, no metric type II burst has been reported. Also, no significant fluxes of energetic particles were detected in interplanetary space. This could be due to any or all of the following: (a) unfavorable location of the flare – E73, (b) relatively closed magnetic field structure near the site of the particle acceleration region, or (c) relatively low efficiency of the particle acceleration process during this flare. It seems very likely that particles were accelerated during the August 14 flare but could not escape the Sun in sufficiently large numbers.

On the other hand, the August 18 flare produced energetic electrons, protons and heavier nuclei, which were detected in interplanetary space. The type II radio burst and interplanetary shock were well observed. The metric type IV radio burst (intensity 3) and the soft X-ray burst (X 6) were also very intense. The hard X-ray emission had a large flux at ~ 30 keV, the total electron energy ≥ 25 keV being $\sim 4 \times 10^{32}$ ergs. However, the spectrum for the impulsive as well as the gradual hard X-ray components was rather steep. There was no detectable flux of X-rays ≥ 400 keV. The microwave emission was also relatively weak. Thus, in the hard X-ray and microwave emissions, there is no clear signature of the second stage of particle acceleration. It appears that, in this flare, the acceleration of high energy particles occurred relatively high in the corona, from whence they could escape easily into interplanetary space but could not penetrate down to the lower altitudes in the solar atmosphere in sufficiently large numbers.

(b) Coronal Transients

The massive coronal transient observed in association with the August 14 flare corresponds to a kinetic energy of $\geq 4 \times 10^{31}$ ergs if $\geq ½$ the mass of $\sim 2 \times 10^{16}$ g was moving at a speed of ~ 900 km sec^{-1}. This energy is at least ~ 10 times larger than the total energy ($\sim 3 \times 10^{30}$ ergs) in ≥ 25 keV electrons deduced from hard X-ray emission produced in a chromospheric thick target bremstrahlung source. This energy can be increased by a factor of ~ 2 if electrons down to ~ 10 keV are included. Also, if the X-ray source for the gradual hard X-ray emission is coronal rather than chromospheric, the total energy carried by the energetic electrons will be considerably higher. However, there is an indication here that the kinetic energy of the coronal transient was larger than that carried by energetic electrons, indicating an additional source of energy in the flare. This is consistent with the observations of coronal transients even in the absence of large solar flares [*Poland et al.*, 1981].

(c) Interplanetary Shock

The interplanetary shock associated with the August 18 flare seems to have extended over $\gtrsim 2\ \pi$ steradians. It appears to have maintained its speed or accelerated from the flare site up to a distance of $\sim 35\ R_{\odot}$ and then decelerated out to a distance of $\sim$ 1 AU as $\sim R^{-0.8}$. It has been suggested by *Cane et al.* [1982] that the shock was driven out to $\sim 35\ R_{\odot}$ and then was a blast wave out to a distance of $\gtrsim 1$ AU.

Acknowledgments

The preparation of this report by S. R. Kane was supported at Berkeley by the National Aeronautics and Space Administration under contract NAS5-25980 and by the U. S. Air Force Systems Command (Air Force Geophysics Laboratory) under contract F19628-80-C-0208.

References

Cane, H. V., 1982 (private communication).

Cane, H. V., Stone, R. G. and Woo, R., Velocity of shock generated by a large east limb flare on August 18, 1979, submitted to *Geophys. Res. Lett.*, 1982.

Domingo, V. and Sanahuja, 1982, Low frequeny protons (35-1600 keV) associated with the August 14-18, 1979 events (SMY/STIP Event No. 1), preprint, 1982.

Hewish, A., and Gapper, G. R., 1982 (private communication).

Jackson, B., 1982a (private communication).

Jackson, B., 1982b, paper presented at the SCOSTEP/STIP Symposium on Solar/Interplanetary Intervals, Maynooth, Ireland, Aug. 4 - 6.

Jackson, B., Hewish, A., and Gapper, G. R., 1982 (private communication).

Kane, S. R., 1982 (private communication).

Kunow, H., Wibberenz, G., Green, G., Iwers, B., and Muller-Mellin, R., 1982, private communication.

Lin, R. P., 1982 (private communication).

Maxwell, A., and Dryer, M., Measurements on a shock wave generaed by a solar flare, letter to *Nature*, in press, 1982.

McGuire, R. E., Reames, D. V., and van Rosenvinge, T. T., 1982 (private communication).

Poland, A. I., Howard, R. A., Koomen, M. J., Michels, D. J., and Sheeley, Jr., N. R., Coronal transients near sunspot maximum, *Solar Phys.*, *69*, 169, 1982.

Rompolt, B., 1982 (private communication).

Sawant, H. S., and Kane, S. R., 1981 (private communication).

Scarf, F. L., 1981 (private communication to M. Dryer).

Smith, E. J., 1982 (private communication).

Vette, J., 1981 (private communication to M. Dryer and M. A. Shea).

Vilmer, N., Kane, S. R., and Trottet, G., Impulsive and gradual hard X-ray surces in a solar flare, *Astron. and Astrophys.*, *108*, 306, 1982.

Woo, R., 1982 (private communication).

Woo, R., and Armstrong, J. W., Measurements of a solar flare-generated shock wave at 13.1 $R_\odot$, *Nature*, *292*, 608, 1981.

Zlobec, P., and Koren, V., 1982 (private communication).

Figure Captions

Figure 1. Locations of interplanetary spacecraft during STIP Event No. 1 [*Vette*, 1981].

Figure 2. Hard X-ray emission observed by ISEE-3 in association with the August 14, 1979 flare [*Vilmer et al.*, 1982]. Information about the optical flare, soft X-rays and radio bursts is also given.

Figure 3. ISEE-3 observations of the X-ray spectrum averaged over the entire hard X-ray burst associated with the 14 August 1979 flare [*Kane*, 1982].

Figure 4. 2.7 - 3.5 GHz microwave emission observed at Sagamore Hill at the time of the August 14, 1979 flare [*Sawant and Kane*, 1982].

Figure 5. 2.8 GHz emission observed at Ottawa during the August 14 and 18, 1979 flare [Solar Geophysical Data].

Figure 6. 0.3 - 0.8 MeV electrons observed by Helios-1 and -2 during the August 14 - 22, 1979 period [*Kunow et al.*, 1982].

Figure 7. Same as Figure 6 except for 12.6 - 22.5 MeV protons [*Kunow et al.*, 1982].

Figure 8. ISEE-3 observations of low energy protons during the August 14 - 22, 1979 period [*Domingo and Sanahuja*, 1982].

Figure 9. P78-1 observations of a massive coronal transient in association with the August 14 1979 flare [*Poland et al.*, 1981].

Figure 10. Velocity data from the San Diego multi-station IPS (Interplanetary Scintillation) equipment. Shown is an increase in velocity present at 3C 273 and not at 3C 298, indicating that the region of enhanced scintillation and velocity associated with the transient on the solar east limb had reached 3C 273 (elongation 43°) but not 3C 298 (elongation 68°) [*Jackson*, 1982a].

Figure 11. Position of the region of enhanced scintillation at ~ 1700 UT, 17 August 1979 from the 3.6 hectare IPS array in England. Depicted is the outermost extent of the IPS region of enhanced scintillation in polar coordinates centered on the Sun's position on 17 August 1979. Solar north is at the top, east is to the left. The region of "no information" is caused partially by interference. The general outline of the region of

enhanced scintillation changes from day to day. Shown is the elongation of the region and its latitudinal extent three days following the mass ejection at the solar surface [*Jackson, Hewish, and Gapper*, 1982].

Figure 12. The elongation of the IPS enhanced region shown versus time. Arrows indicate elongations of the sources 3C 273 (·) and 3C 298 (×) and whether the region of high velocity has passed that source at that time. The average outermost extent of the region of enhanced scintillation from the single station IPS array in England is shown (H). Lines dashed and solid give the respective elongations of the models of a 900 km/sec constant velocity spherical shell and outward moving material at the position of the flare normal [*Jackson*, 1982b]. Obviously, the data (and observations at earth) do not support either model.

Figure 13. Solar wind plasma observed by IMP-8 [Solar Geophysical Data].

Figure 14. Pioneer-XII observations of the solar wind parameters [Solar Geophysical Data].

Figure 15. ISEE-3 observations of the hard X-ray emission associated with the August 18, 1979 flare. Information about the Hα flare, soft X-rays and radio bursts and energetic particles is also given [*Kane*, 1982].

Figure 16. ISEE-3 observations of the X-ray spectrum averaged over the entire hard X-ray burst associated with the 18 August 1979 flare [*Kane*, 1982].

Figure 17. The ISEE-3 dynamic spectrum of the August 18 event. The intense fast-drift burst at ~1412 UT is an SA event. The dark band drifting from high to low frequencies is the type II burst. It is clearly visible from ~1700 UT on August 18 until ~1400 UT on August 19. The other band at the low frequency end of the spectrum is local thermal noise. The sudden jump in the background intensity at ~0600 UT on August 20 is caused by the passage of the shock at ISEE-3 [*Cane et al.*, 1982].

Figure 18. (a) Energetic protons observed by IMP-8 instrument during the period 13 - 22 August, 1979. (b) Maximum flux spectra of protons and alpha-particles for the 18 - 20 August period [*McGuire et al.*, 1982].

Figure 19. Locations of the Helios-1 and -2 spacecraft at the time of the August 18, 1979 flare (based on [*Kunow et al.*, 1982].

Figure 20. Characteristics of the shock wave at 13 $R_\odot$ associated with the August 18, 1979 flare. The deduced parameters are based on ground-based radio measurements [*Woo and Armstrong*, 1981].

Figure 21. ISEE-3 measurements of plasma waves associated with the August 18, 1979 flare [*Scarf*, 1981].

Figure 22. Height of the shock as a function of time using remote sensing of the shock and the drift rate of the type II burst [*Cane et al.*, [1982].

Figure 23. Velocity of the shock as a function of heliocentric distance. The distance is the mean between heliocentric distances of two detections of the shock. [*Cane et al.*, [1982].

Table 1.

Table 1. Characteristics of 14 August 1979 Flare

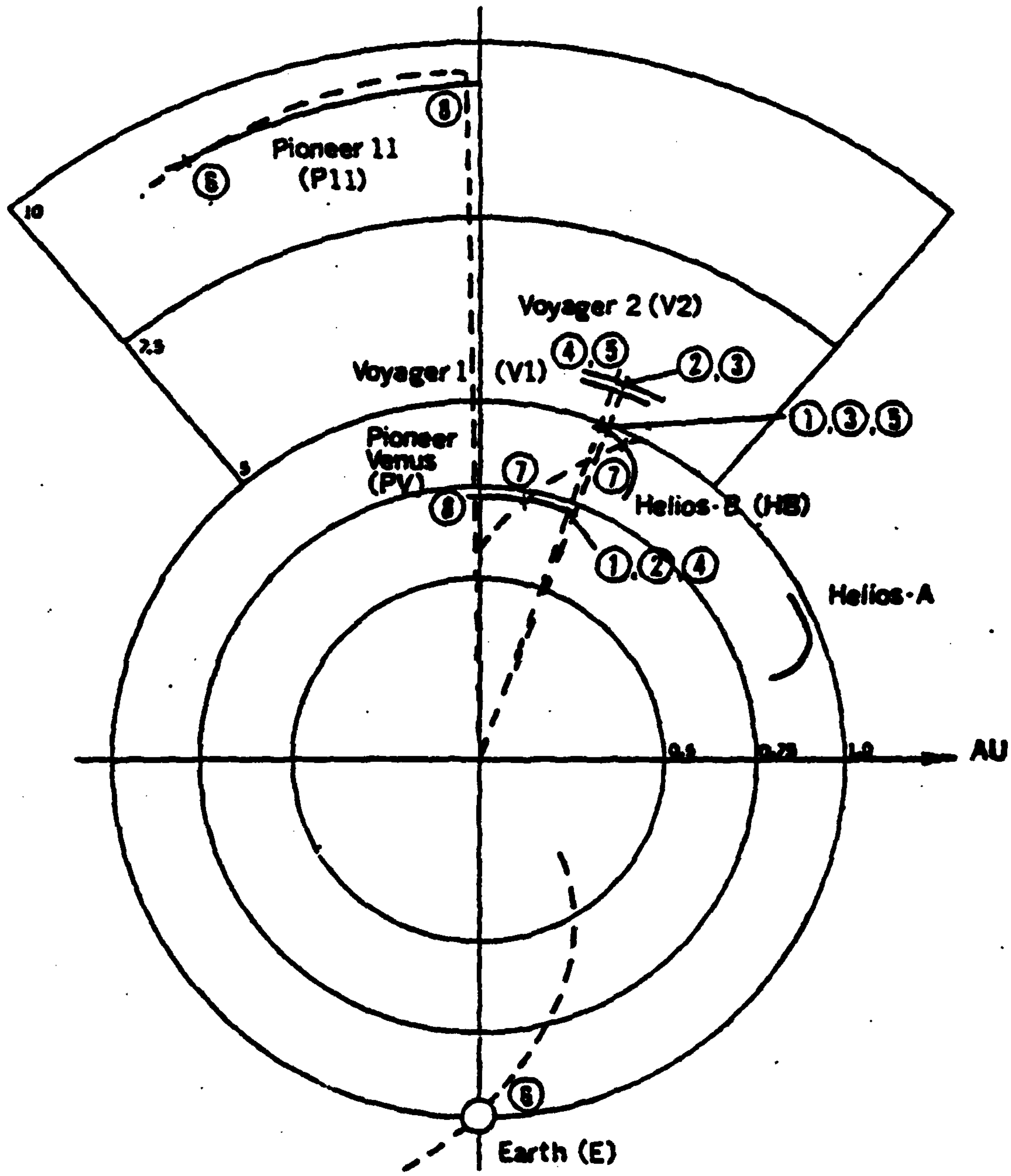
Hα			
Start (UT)			1243
Max (UT)			1244
End (UT)			~1451
Importance			1B
Location			S22, E73
McMath Region			16224
Microwave Radio			
Frequency (GHz)	2.8	9.4	15
Start (UT)	1242	1242.5	1242
Max (UT)	1251.8	1248.7	1248.3
End (UT)	1400	1326.8	–
Type	GB	C	GB
Peak Flux (sfu)	4030	12139	2000
Metric and Decimetric Radio			
Wavelength range	Metric	Decimetric	
Start (UT)	1242.7	1243	
End (UT)	1416	1318	
Intensity	3	3	
Type	IV	IV	
Hard X-rays (ISEE-3)			
Type	Impulsive	Gradual	
Time of max (UT)	1243.1	1248.1	
Peak Flux at ~30 keV (photons cm^{-2} sec^{-1} keV^{-1})	2	12	
Coronal Transient (P78-1)			
Time (UT)			1337
Mass (grams)			$\sim 10^{16}$
Speed (km sec^{-1})			900

Table 2.

Table 2. Characteristics of 18 August 1979 Flare

Hα		
Start-end (UT)	?	
Location	Behind east limb	
Importance	Large (?)	
Microwave Radio (2.8 GHz)		
Start (UT)	1345.5	
Max (UT)	1423.5	
End (UT)	1450	
Type	C	
Peak Flux (S.F.U.)	490	
Metric and Decimetric Radio		
Wavelength range	Metric	Decimetric
Start (UT)	1409.0	1401.0, 1410.2
End (UT)	1456.0	1403.0, 1411.9
Intensity	3	2, 2
Type	IV	IIIG, IIIG
Kilometric Radio (ISEE-3)		
Start (UT)	~1425	1700
End (UT)	–	1400
Type	III	II
Hard X-rays (ISEE-3)		
Time of max (UT)	1347.5	1412.3
Peak Flux at ~30 keV (photons cm^{-2} sec^{-1} keV^{-1})	35	140
Energetic Particles (Helios-2)		
Type	Electrons (0.3 - 0.8 MeV)	Protons (27 - 37 MeV)
Start (UT)	~1430	~1430
Max (UT)	~1800	~1800
Peak Flux	–	–
Interplanetary Shock		
Distance from Sun	13.1 $R_{\odot}$	~1 A.U.
Time (UT)	1500	0552 (20 August)
Speed (km sec^{-1})	3500	727
Geomagnetic Effects		
Sudden Commencement	~0600 UT (20 August)	

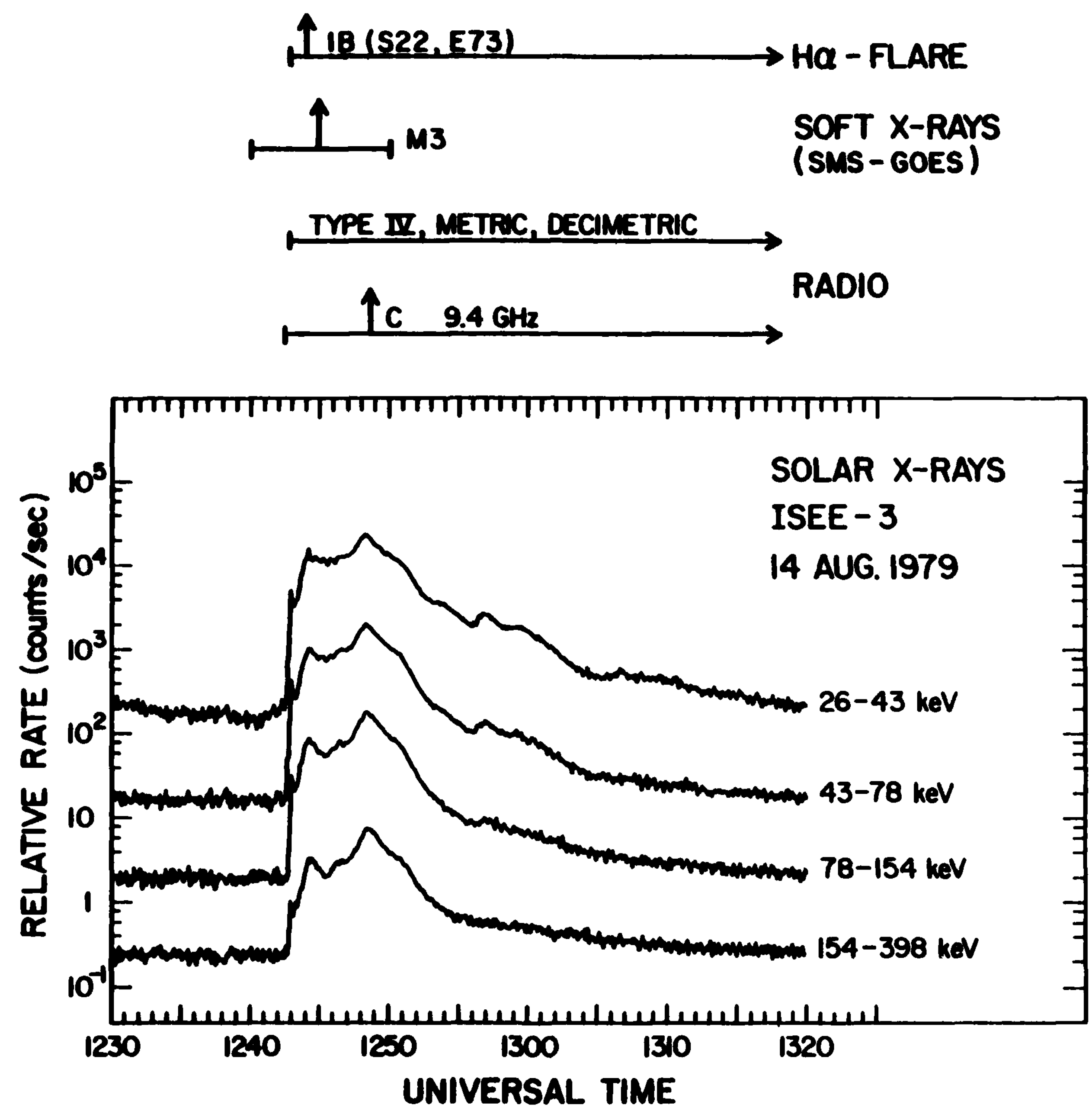
STIP INTERVAL VII
(Start of Solar Maximum Year)
1 AUGUST - 30 SEPTEMBER 1979

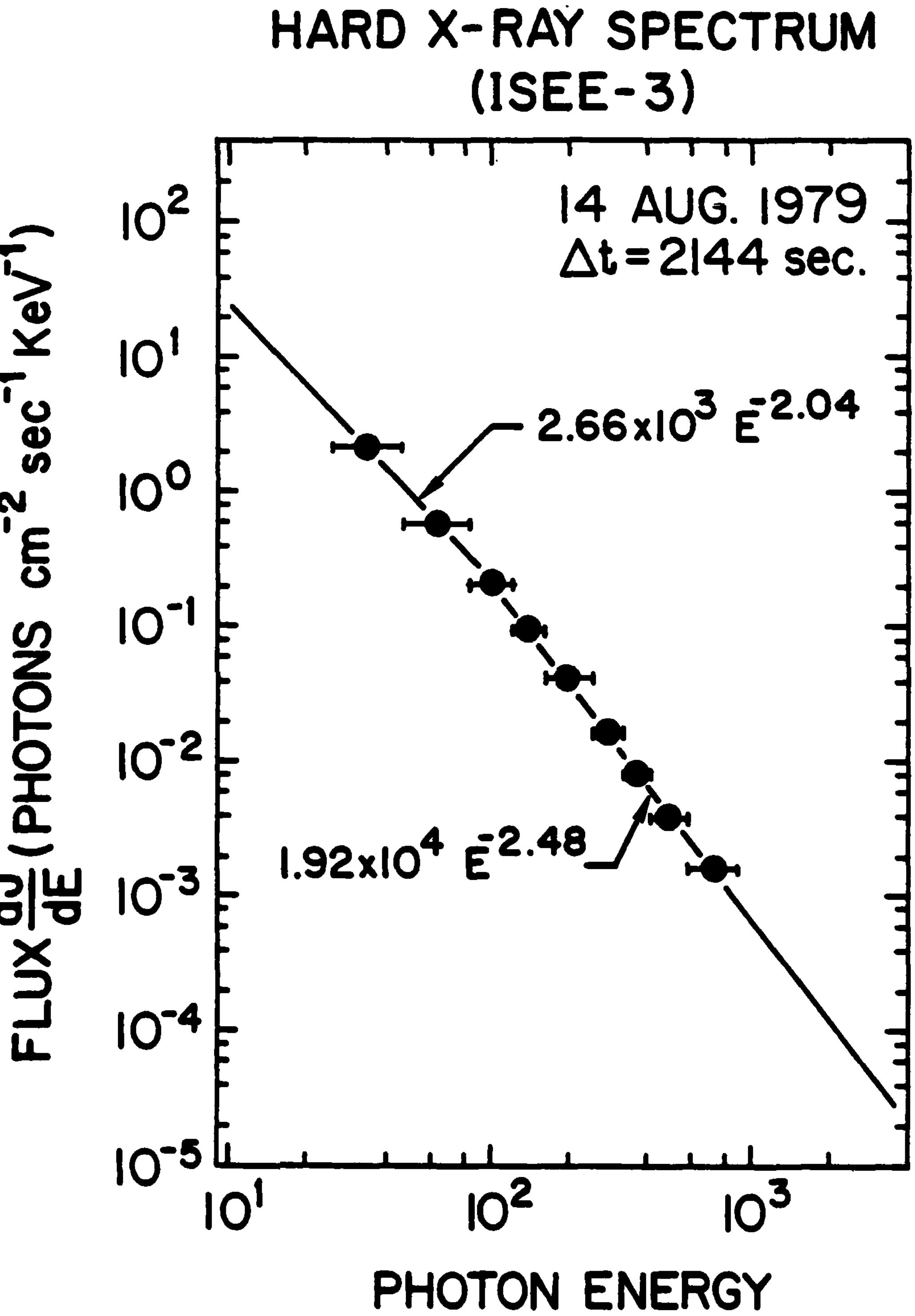


<u>Special Conjunctions</u>

1	PV & HB;	RA	8/06	2.0h		5	HB & V2;	RA	8/08	3.5h	
2	PV & V1;	RA	8/06	3.0h		6	E & P11;	IMF	8/13	18.0h	τ = 0.0d
3	HB & V1;	RA	8/06	4.0h		7	PV & HB;	IMF	8/22	15.0h	τ = 11.5d
4	PV & V2;	RA	8/07	0.0h		8	PV & P11;	RA	9/09	14.0h	

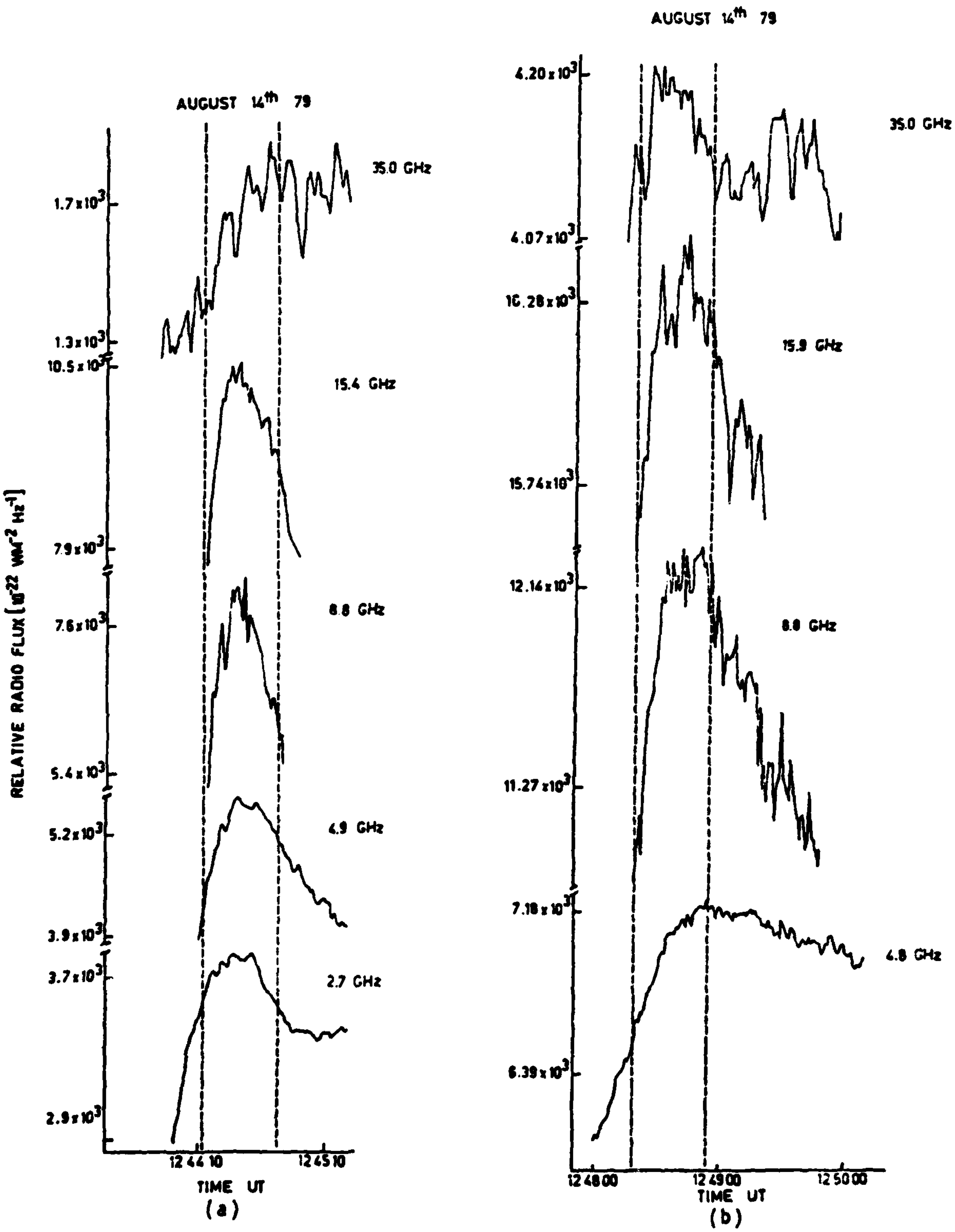
Fig. 1


1B (S22, E73)
Hα - FLARE
M3
SOFT X-RAYS
(SMS - GOES)
TYPE IV, METRIC, DECIMETRIC
RADIO
C
9.4 GHz
SOLAR X-RAYS
ISEE - 3
14 AUG. 1979
26-43 keV
43-78 keV
78-154 keV
154-398 keV
RELATIVE RATE (counts/sec)
UNIVERSAL TIME
1230
1240
1250
1300
1310
1320



HARD X-RAY SPECTRUM
(ISEE-3)
14 AUG. 1979
Δt = 2144 sec.
2.66x10^3 E^-2.04
1.92x10^4 E^-2.48
FLUX dJ/dE (PHOTONS cm^-2 sec^-1 KeV^-1)
PHOTON ENERGY

Fig. 3



AUGUST 14th 79
35.0 GHz
15.4 GHz
8.8 GHz
4.9 GHz
2.7 GHz
1.7x10³
1.3x10³
10.5x10³
7.9x10³
7.6x10³
5.4x10³
5.2x10³
3.9x10³
3.7x10³
2.9x10³
RELATIVE RADIO FLUX [10⁻²² Wm⁻² Hz⁻¹]
12 44 10
12 45 10
TIME UT
(a)
AUGUST 14th 79
35.0 GHz
15.9 GHz
8.8 GHz
4.8 GHz
4.20x10³
4.07x10³
16.28x10³
15.74x10³
12.14x10³
11.27x10³
7.18x10³
6.39x10³
12 48 00
12 49 00
12 50 00
TIME UT
(b)

Fig. 4

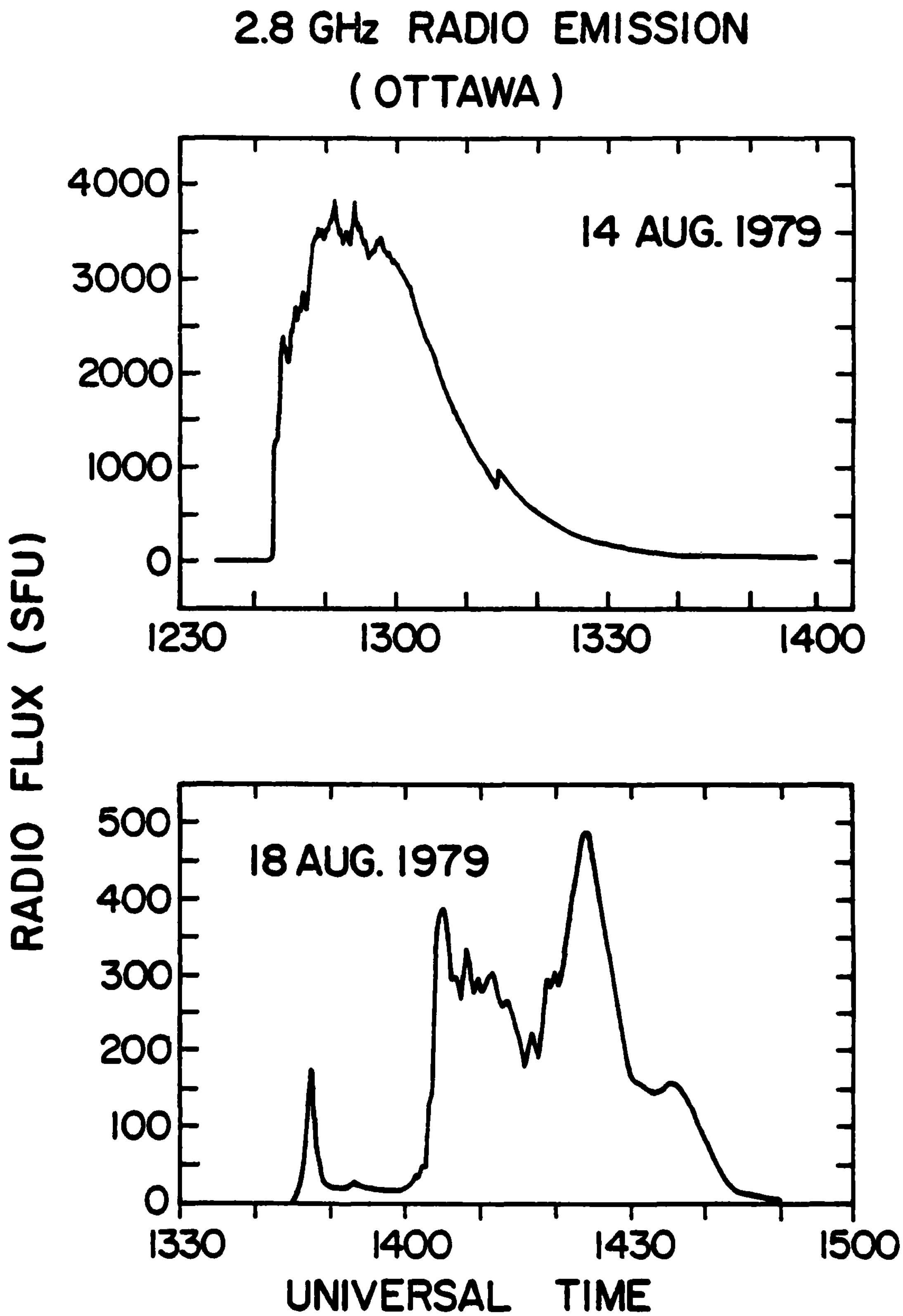
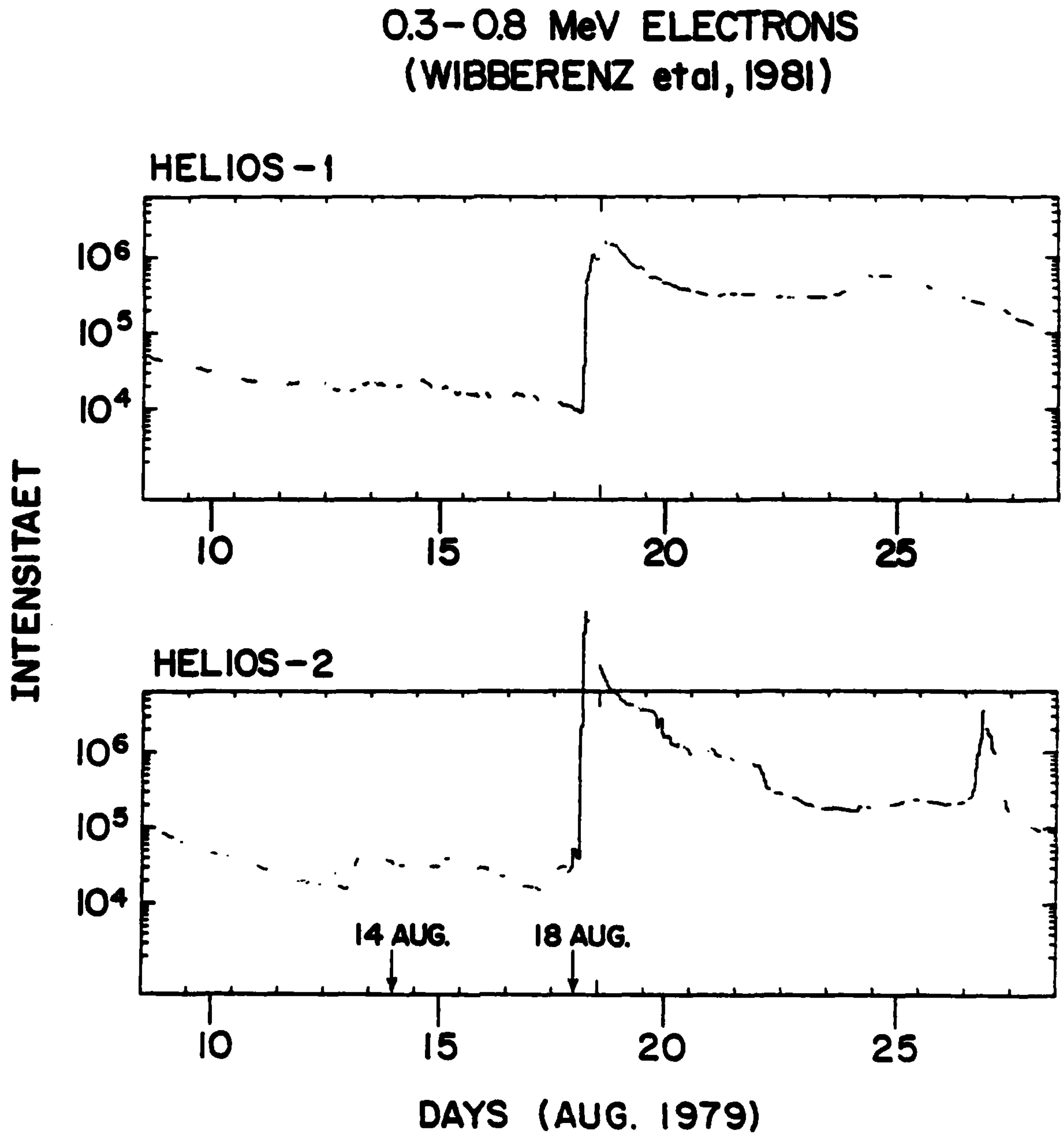

2.8 GHz RADIO EMISSION
(OTTAWA)
RADIO FLUX (SFU)
4000
3000
2000
1000
0
1230
1300
1330
1400
14 AUG. 1979
500
400
300
200
100
0
1330
1400
1430
1500
18 AUG. 1979
UNIVERSAL TIME

Fig. 5



0.3-0.8 MeV ELECTRONS
(WIBBERENZ etal, 1981)
HELIOS-1
HELIOS-2
INTENSITAET
10^6
10^5
10^4
14 AUG.
18 AUG.
10
15
20
25
DAYS (AUG. 1979)

Fig. 6

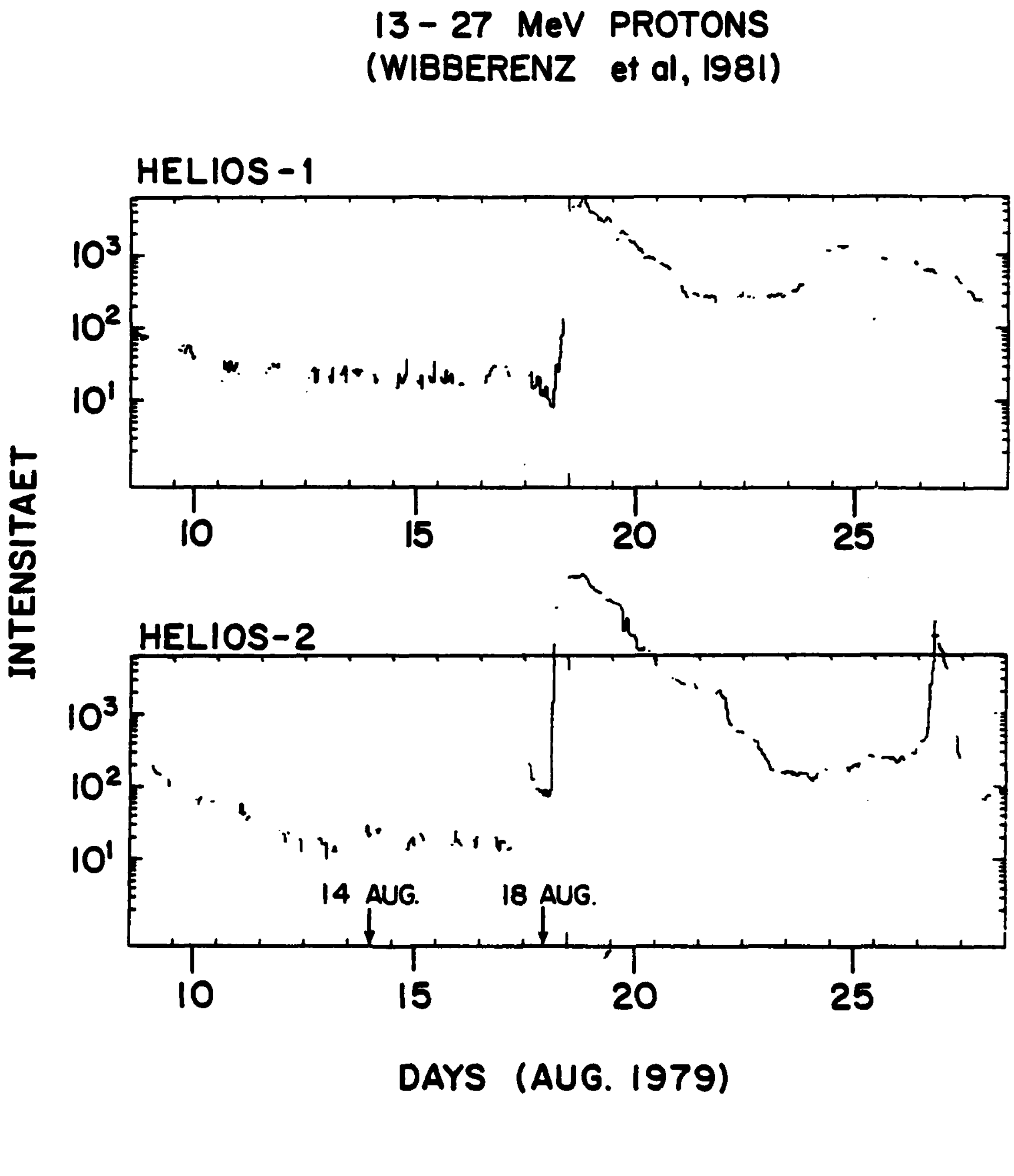
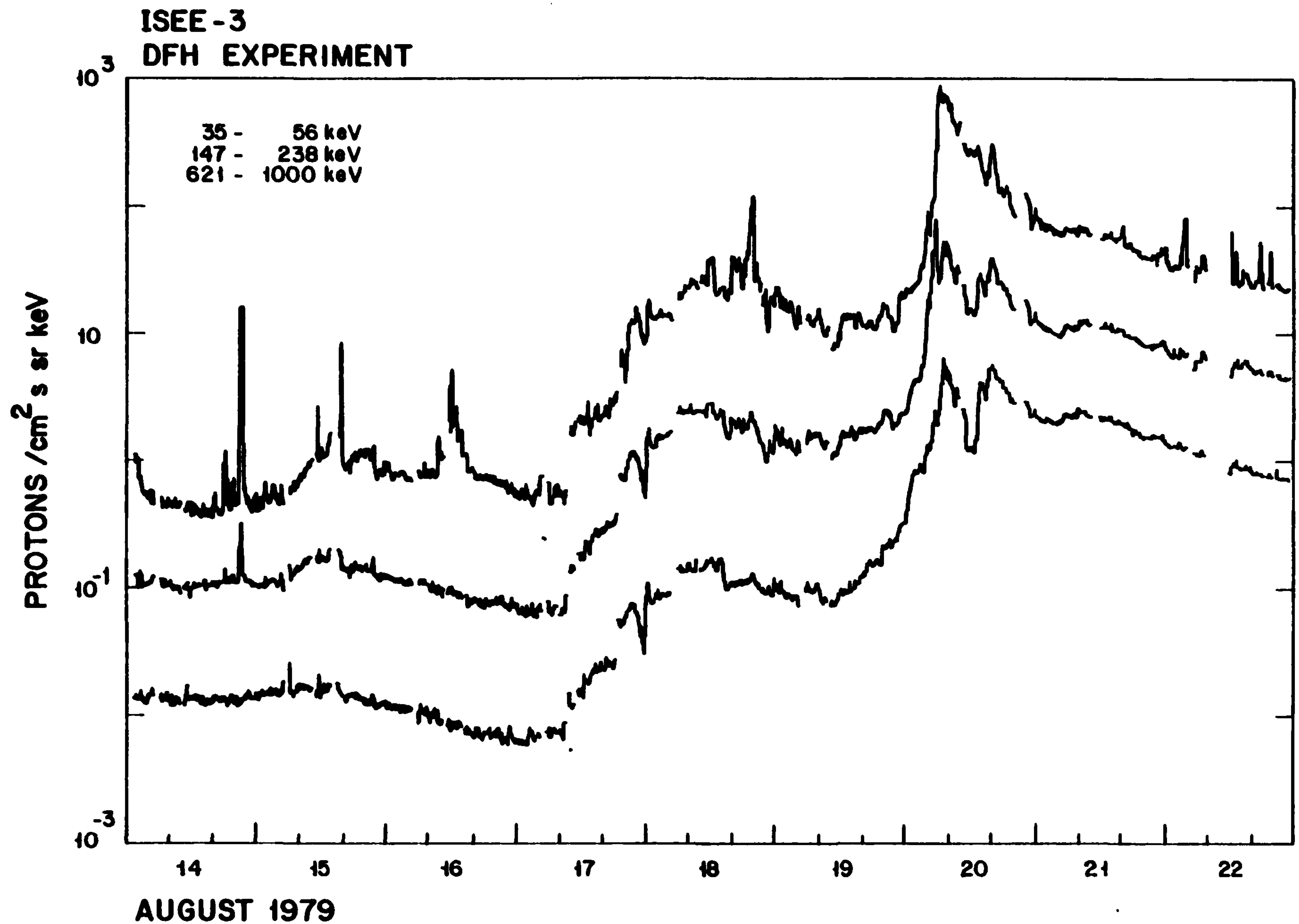
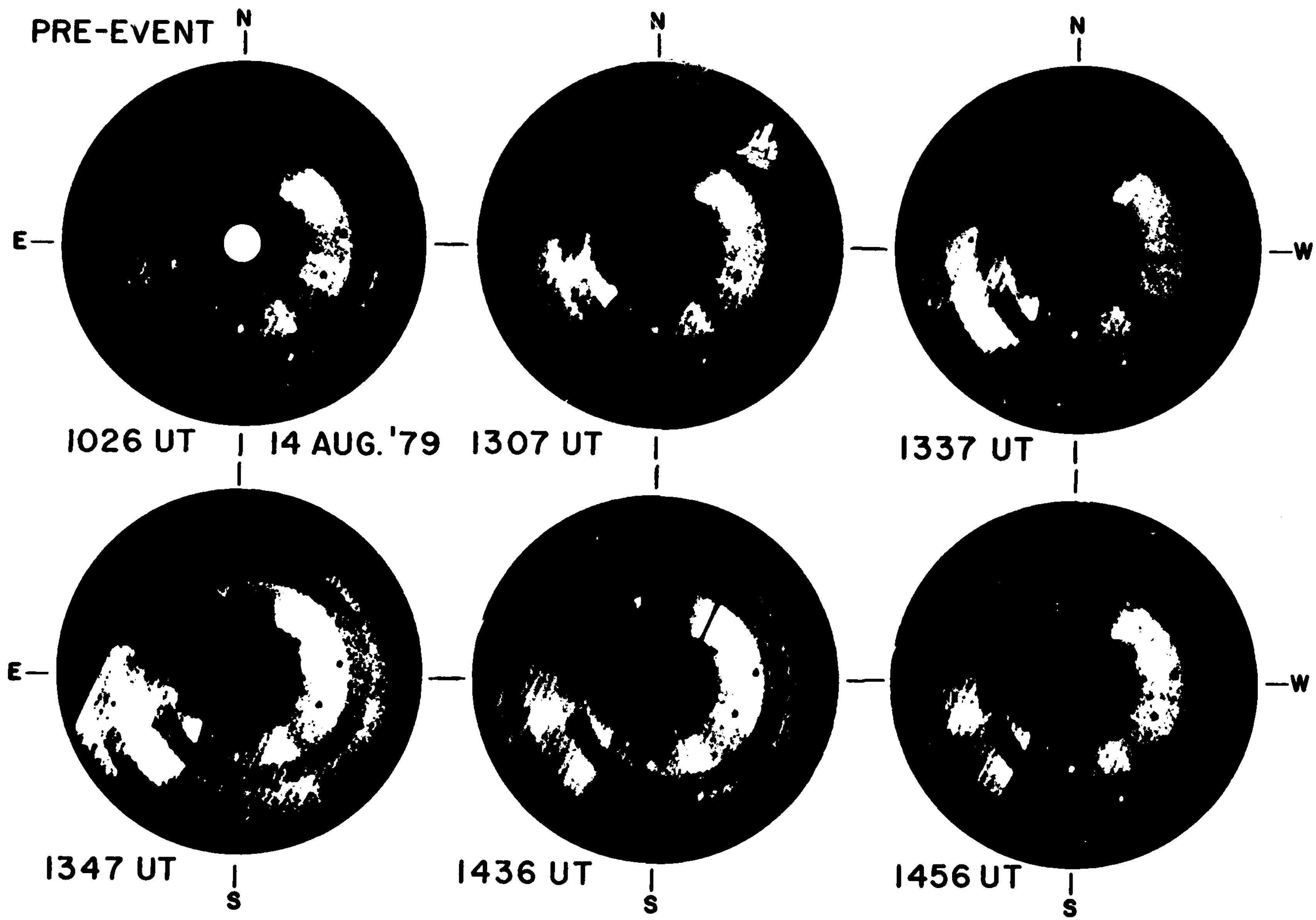

13 - 27 MeV PROTONS
(WIBBERENZ et al, 1981)
HELIOS - 1
HELIOS - 2
INTENSITAET
10³
10²
10¹
10
15
20
25
14 AUG.
18 AUG.
DAYS (AUG. 1979)

Fig. 7

3/11364/2

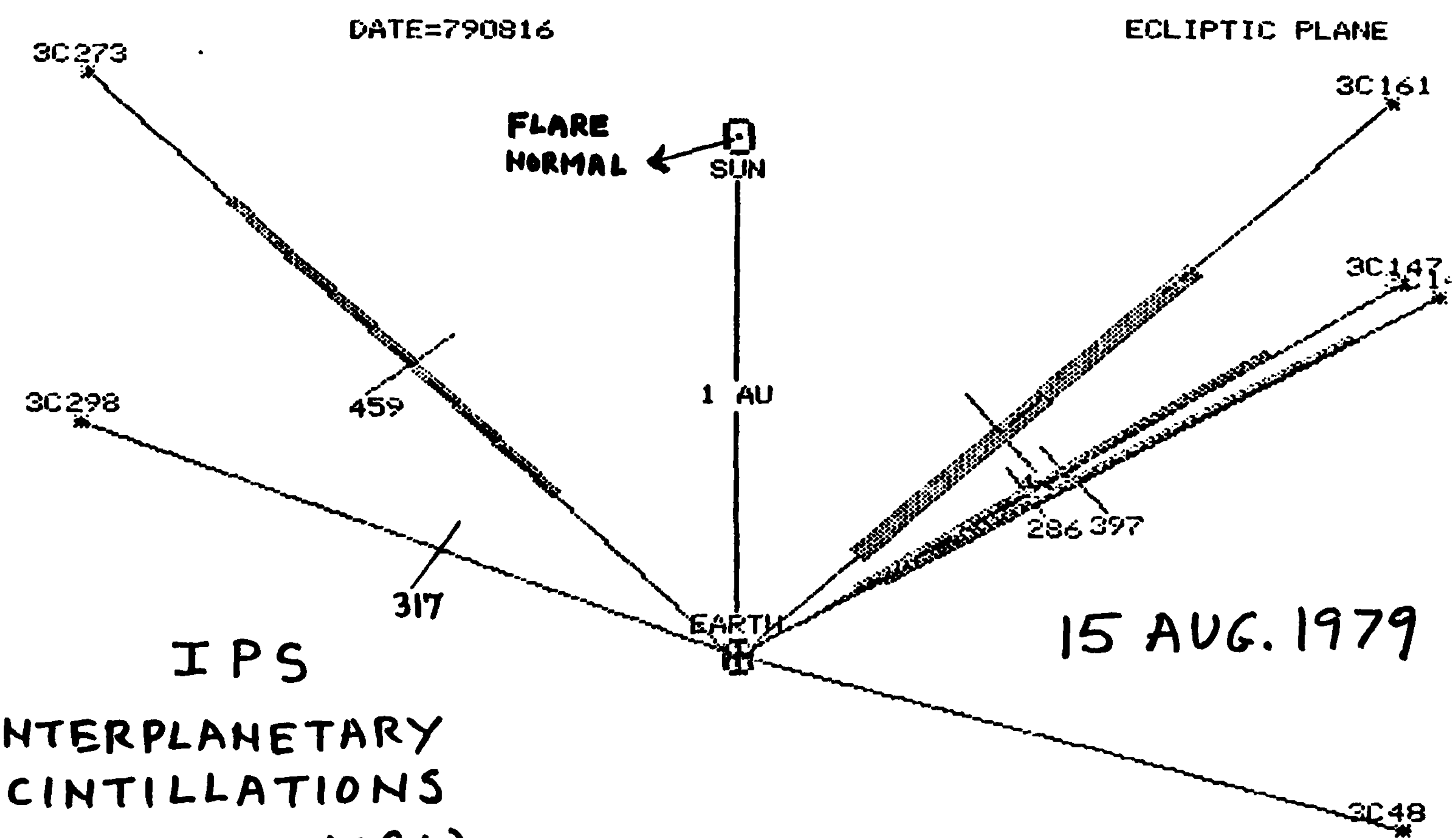


ISEE-3
DFH EXPERIMENT
35 - 56 keV
147 - 238 keV
621 - 1000 keV
PROTONS /cm^2 s sr keV
10^3
10
10^{-1}
10^{-3}
14
15
16
17
18
19
20
21
22
AUGUST 1979


PRE-EVENT
N
E
W
S
1026 UT
14 AUG. '79
1307 UT
1337 UT
1347 UT
1436 UT
1456 UT

		HR	KM/S		1-4		DEG	DEG	AU	DEG	DAY	NUMBER
790815	227	12	-		1	3C48	106	13				
	227	14	-		1	3C144-	59	6				
	227	15	286	15	2	3C147	60	22	0.87	28	1.22	1684.80
	227	16	397	37	2	3C144	58	6	0.85	32	1.68	1684.85
	227	17	447	31	3	3C161	52	-15	0.79	32	1.52	1684.88
	227	23	459	19	2	3C273	43	8	0.68	-47	-4.89	1685.12
790816	228	1	317		2	3C298	68	13				

DATE AND DOY ARE IN UT. VMID IS A MEAN VELOCITY IN THE IPS SCATTERING REGION. THIS REGION'S CENTROID IS SPECIFIED BY HELIOGRAPHIC COORDINATES LAT, DIST, DLON LAG (- TO EAST OF SUN) AND ROTATION NUMBER GIVE MAPPING TO EARTH AND SUN AT VMI



IPS
INTERPLANETARY
SCINTILLATIONS
(JACKSON, 1981)

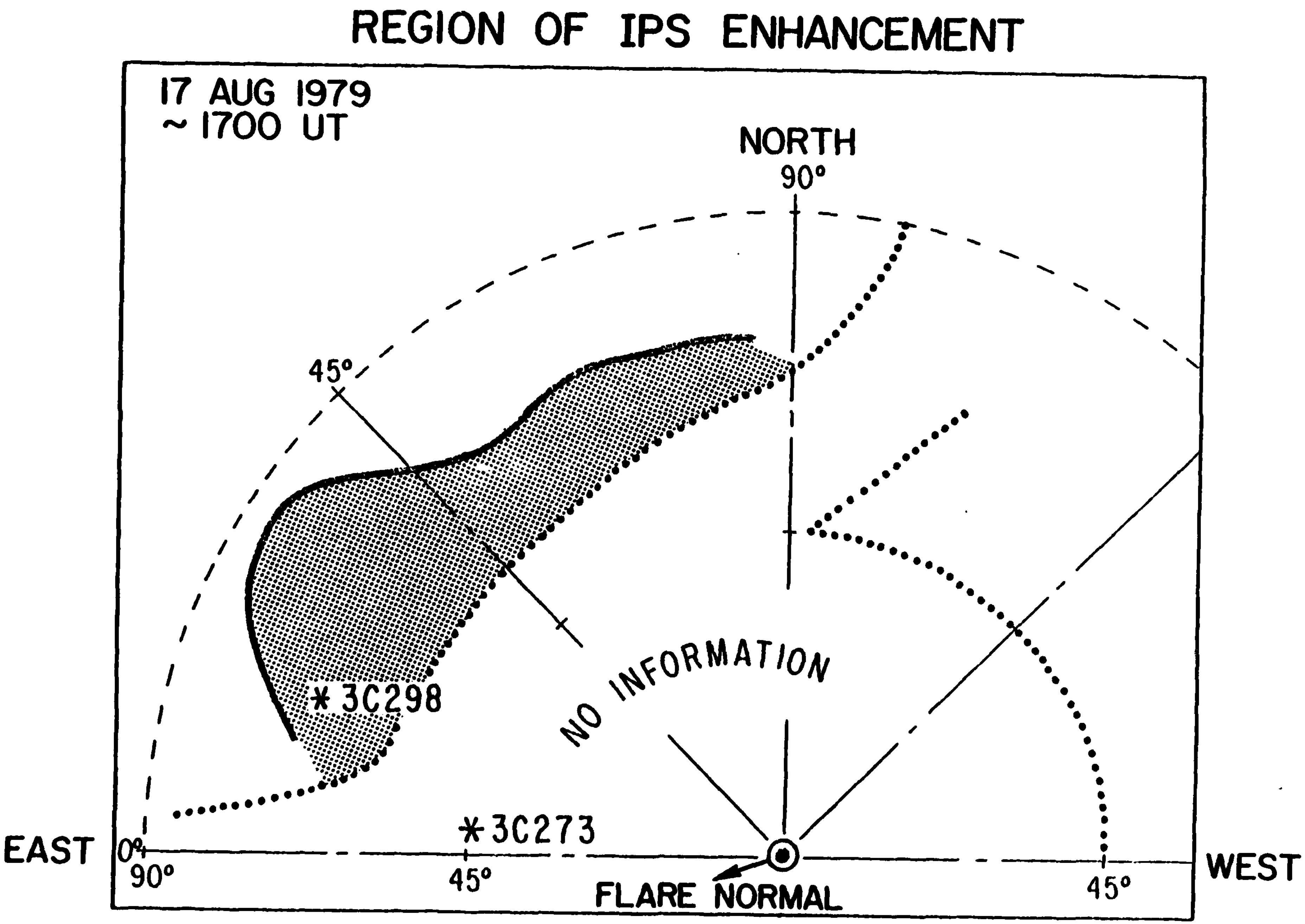

REGION OF IPS ENHANCEMENT
17 AUG 1979
~ 1700 UT
NORTH
90°
45°
* 3C298
NO INFORMATION
* 3C273
EAST
0°
90°
45°
FLARE NORMAL
45°
WEST

Fig. 11

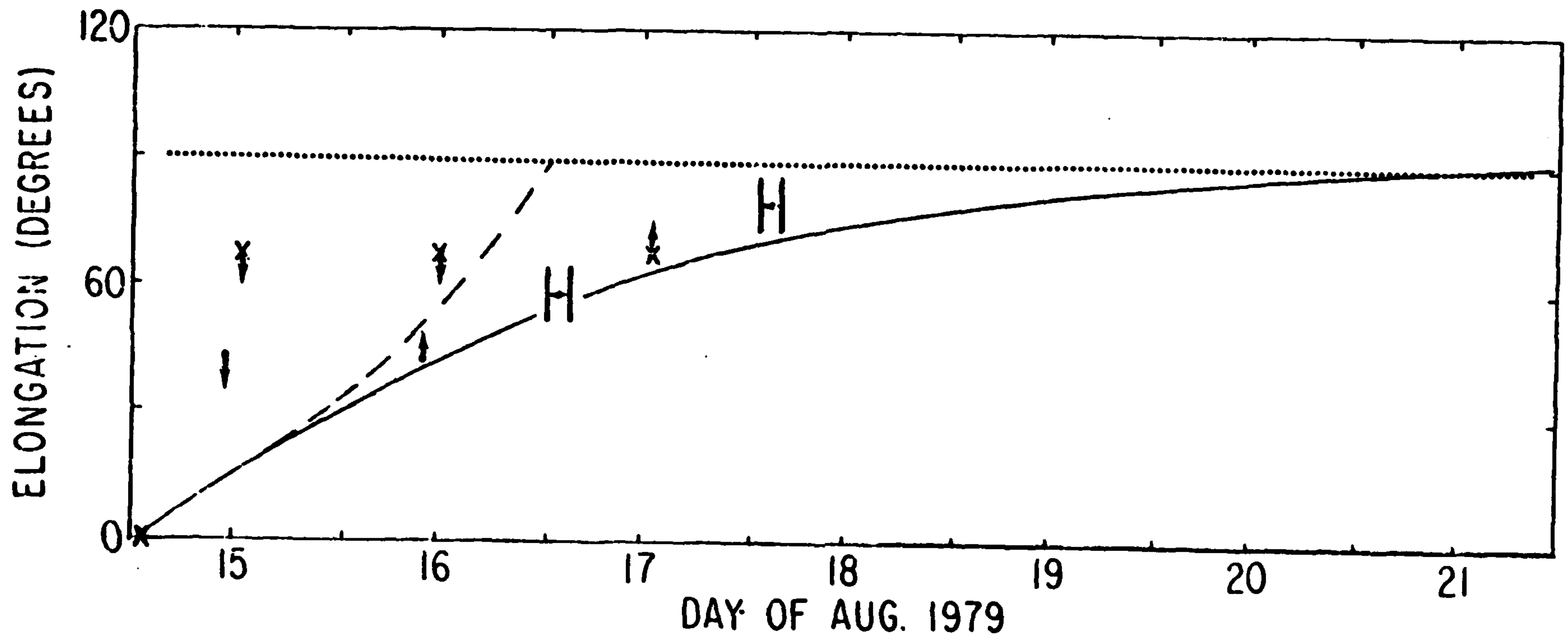


Fig. 12

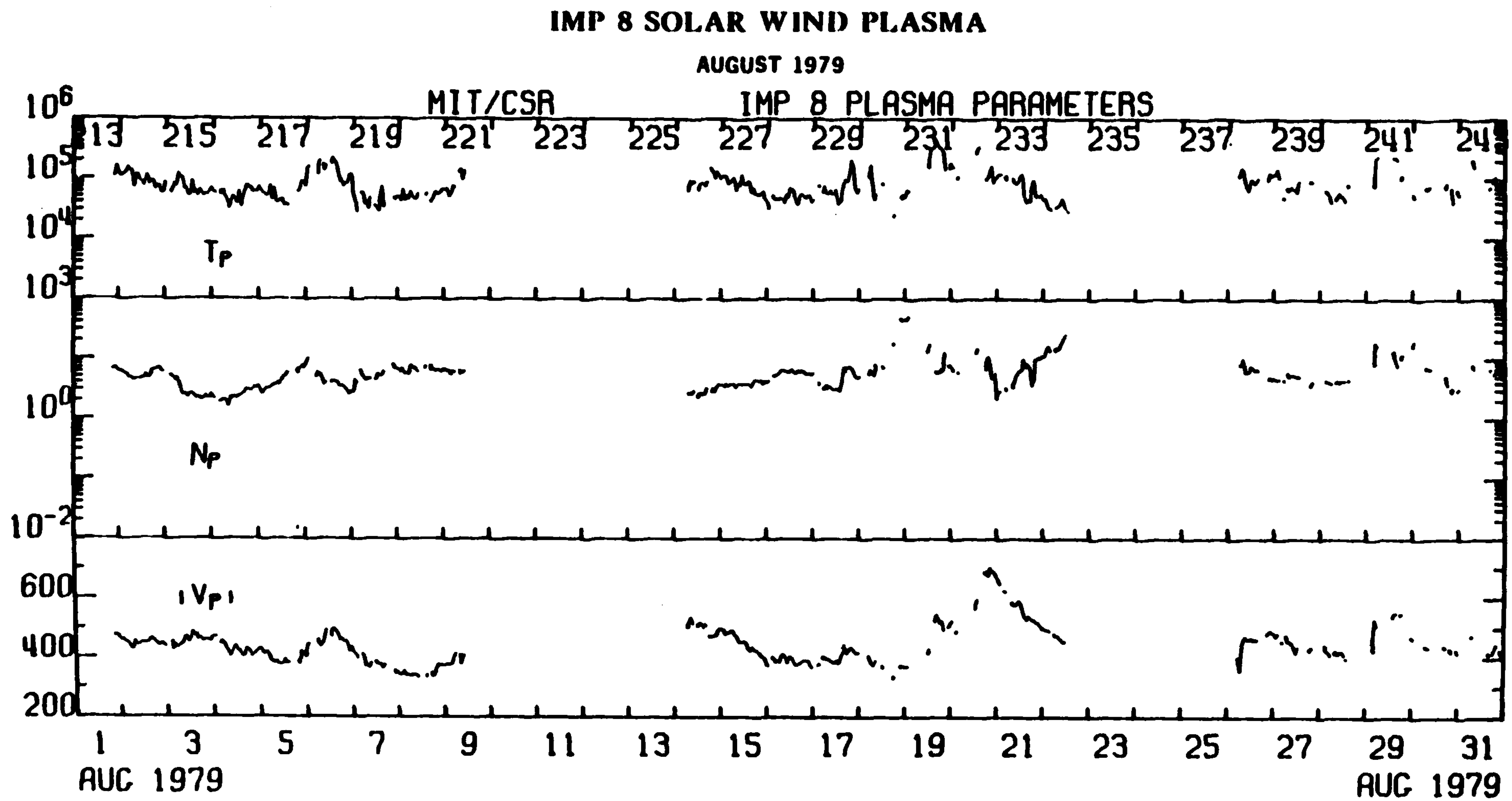


Fig. 13

23 Aug 79

PIONEER XII

AUGUST 1979

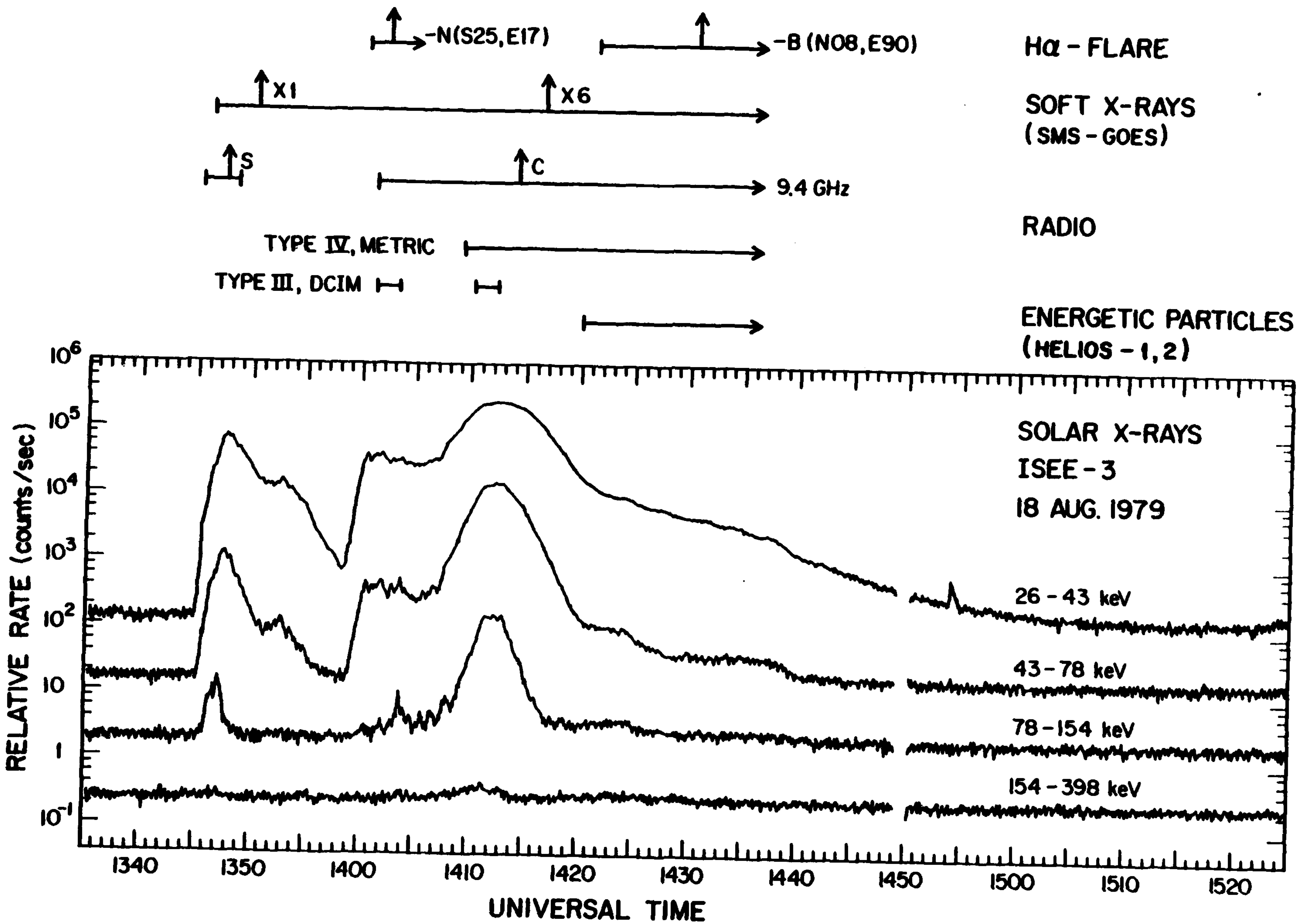
DATE Aug '79	TIME (UT)	ESV (°)	U_{H+} (Km/sec)	N_{H+} (H^+/CC)	T_{H^+} ($\times 10^6$ °K)
1	1147	164.	428.	22.3	0.203
2	1117		573.	5.3	.436
3	1212		473.	6.8	.13
4	1220		837.	26.3	.519
5	1310		618.	4.8	.282
6	0855		495.	5.4	.078
7	0521		419.	6.6	----
8	1524		323.	13.2	.032
9	1006		318.	26.1	.048
10	1022		313.	56.4	.047
11	1129		471.	41.9	.721
12	0653		562.	8.8	.117
13	0000		528.	12.9	.279
14	2207		597.	4.4	.102
15	2358	173.	459.	----	----
16	0007		----	10.8	----
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30		176.			
31					

NOTE: PN-12 data estimated suspended until approximately 9 Sep 79.

Venus undergoing superior conjunction. Communication link immersed in solar corona resulting in somewhat noisy and unsatisfactory data.

Additionally, PN-11 undergoing Saturn encounter thus reducing PN-12 Deep Space Net (DSN) priority.

Fig. 14



-N(S25, E17)
-B (N08, E90)
Hα - FLARE
X1
X6
SOFT X-RAYS
(SMS - GOES)
S
C
9.4 GHz
RADIO
TYPE IV, METRIC
TYPE III, DCIM
ENERGETIC PARTICLES
(HELIOS - 1, 2)
SOLAR X-RAYS
ISEE - 3
18 AUG. 1979
26 - 43 keV
43 - 78 keV
78 - 154 keV
154 - 398 keV
RELATIVE RATE (counts/sec)
10^6
10^5
10^4
10^3
10^2
10
1
10^-1
1340
1350
1400
1410
1420
1430
1440
1450
1500
1510
1520
UNIVERSAL TIME

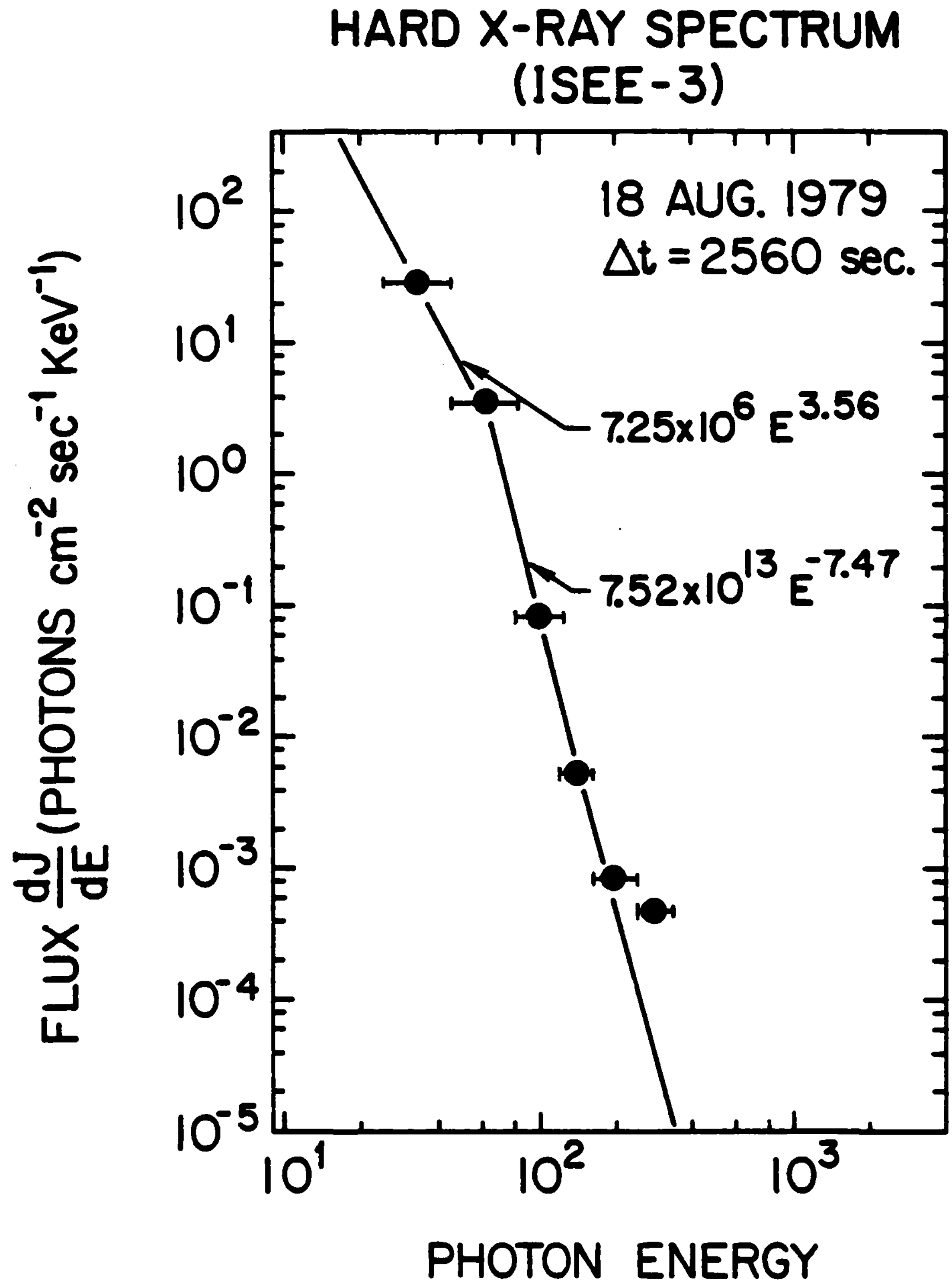
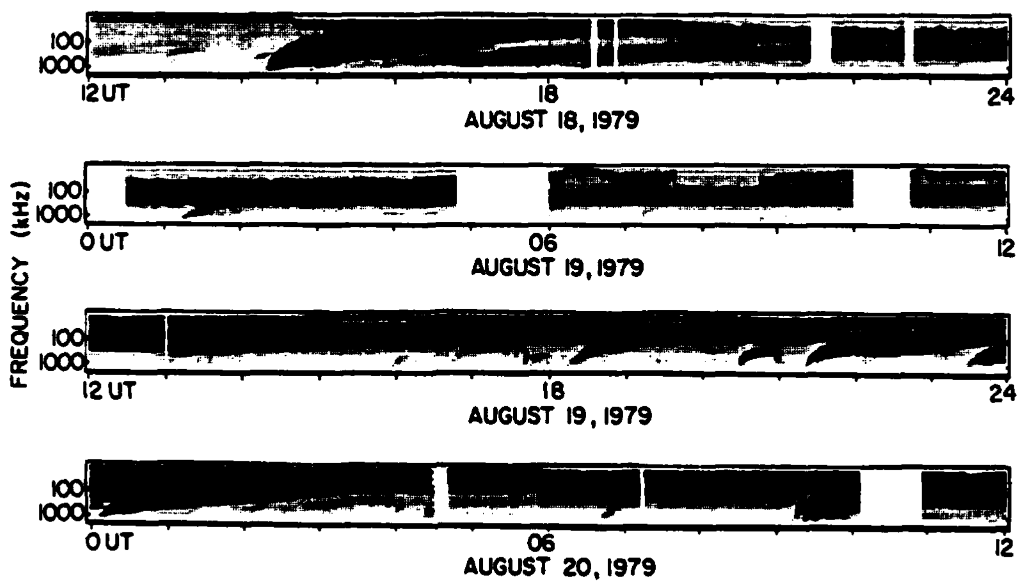
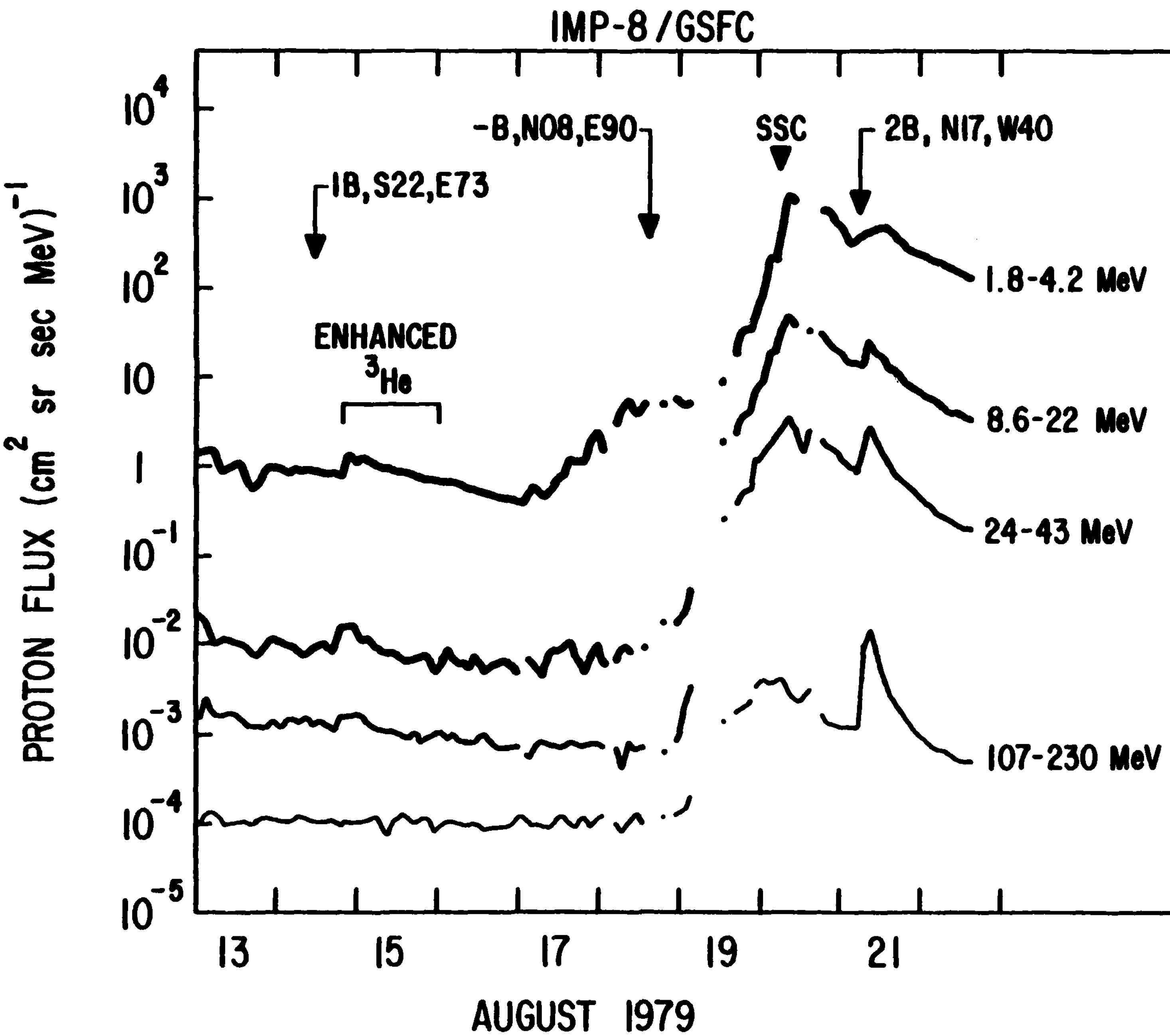

HARD X-RAY SPECTRUM
(ISEE-3)
18 AUG. 1979
$\Delta t = 2560$ sec.
$7.25 \times 10^{6}\ E^{3.56}$
$7.52 \times 10^{13}\ E^{-7.47}$
FLUX $\frac{dJ}{dE}$ (PHOTONS cm^{-2} sec^{-1} KeV^{-1})
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{1}
10^{2}
10^{3}
PHOTON ENERGY

Fig. 16

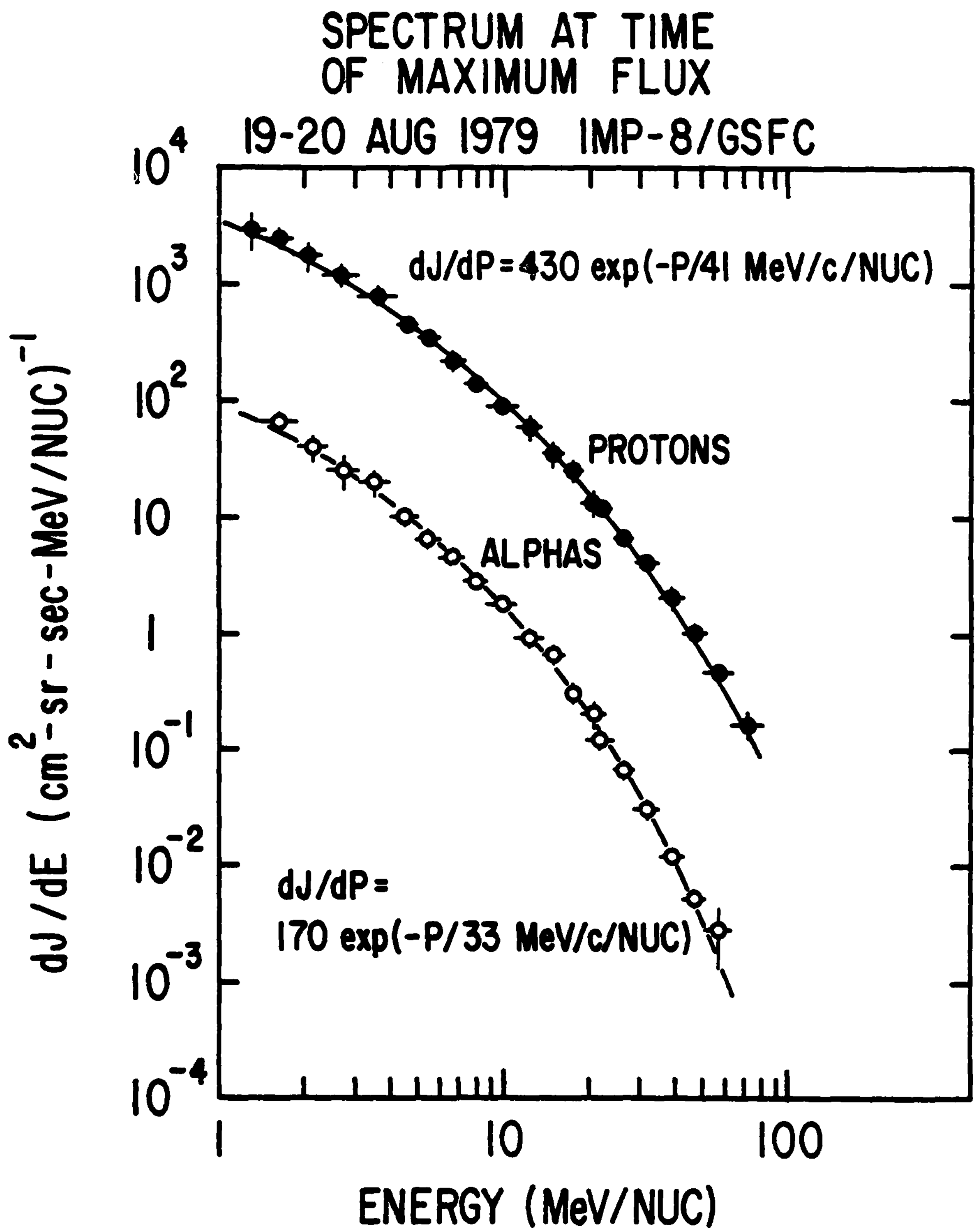


100
1000
12 UT
18
24
AUGUST 18, 1979
FREQUENCY (kHz)
100
1000
0 UT
06
12
AUGUST 19, 1979
100
1000
12 UT
18
24
AUGUST 19, 1979
100
1000
0 UT
06
12
AUGUST 20, 1979

Fig. 17



IMP-8 /GSFC
1B, S22, E73
-B, N08, E90
SSC
2B, N17, W40
ENHANCED ^3He
1.8-4.2 MeV
8.6-22 MeV
24-43 MeV
107-230 MeV
PROTON FLUX $(cm^2 \; sr \; sec \; MeV)^{-1}$
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
13
15
17
19
21
AUGUST 1979



SPECTRUM AT TIME
OF MAXIMUM FLUX
19-20 AUG 1979 IMP-8/GSFC
dJ/dP=430 exp(-P/41 MeV/c/NUC)
PROTONS
ALPHAS
dJ/dP=
170 exp(-P/33 MeV/c/NUC)
dJ/dE (cm²-sr-sec-MeV/NUC)⁻¹
ENERGY (MeV/NUC)

Fig. 18b

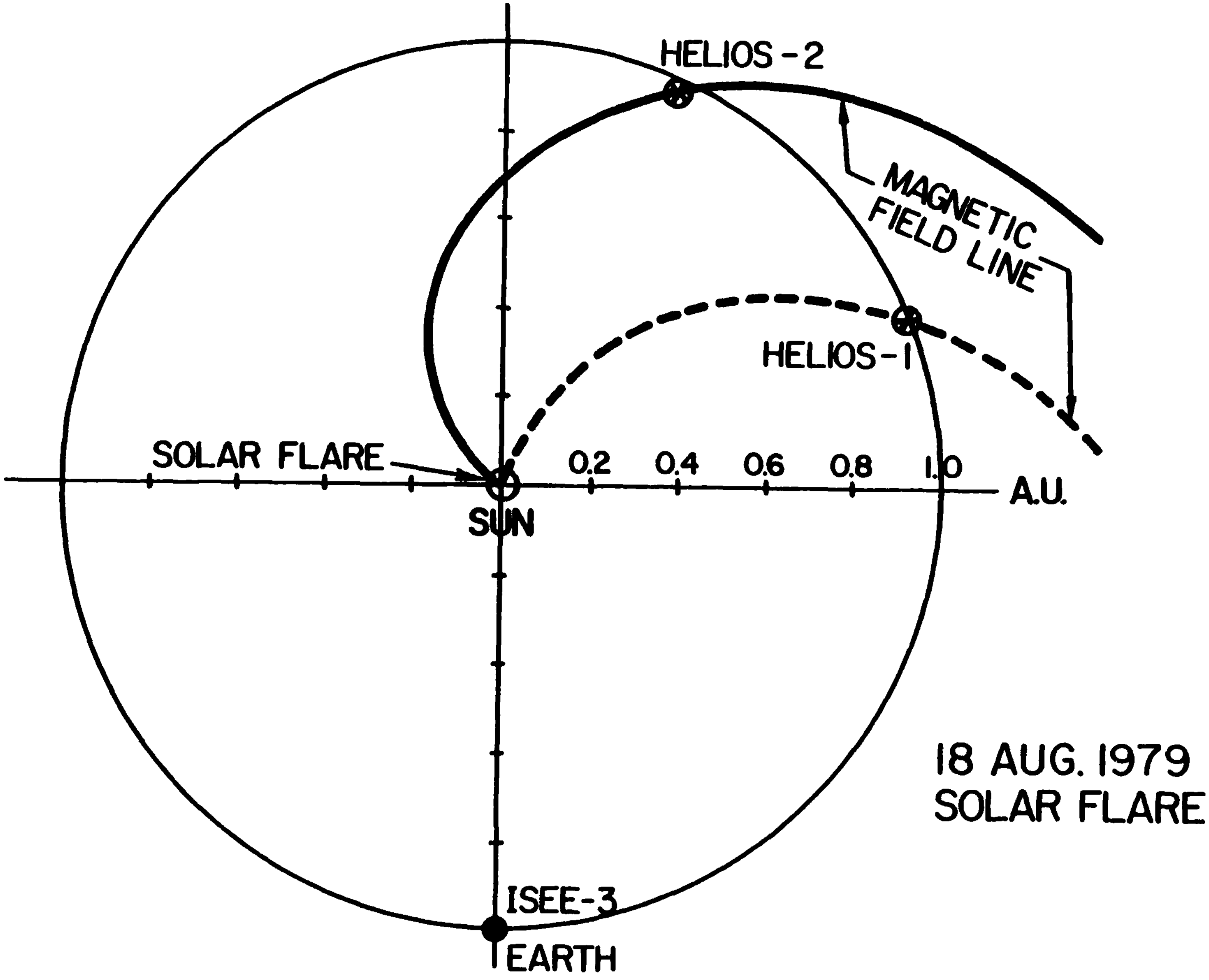

HELIOS - 2
MAGNETIC FIELD LINE
HELIOS - 1
SOLAR FLARE
0.2
0.4
0.6
0.8
1.0
A.U.
SUN
ISEE-3
EARTH
18 AUG. 1979
SOLAR FLARE

Fig. 19

SHOCK WAVE INFERRED FROM RADIO MEASUREMENTS

18 AUG. 1979 FLARE

(WOO & ARMSTRONG, 1981)

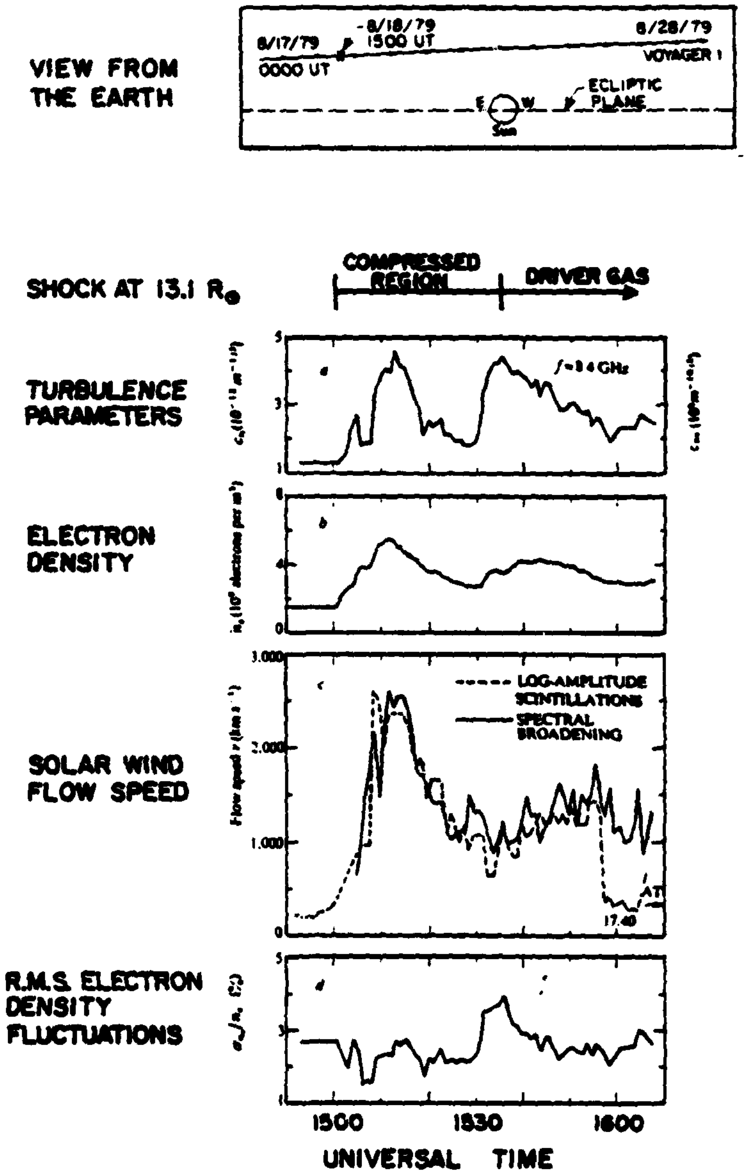
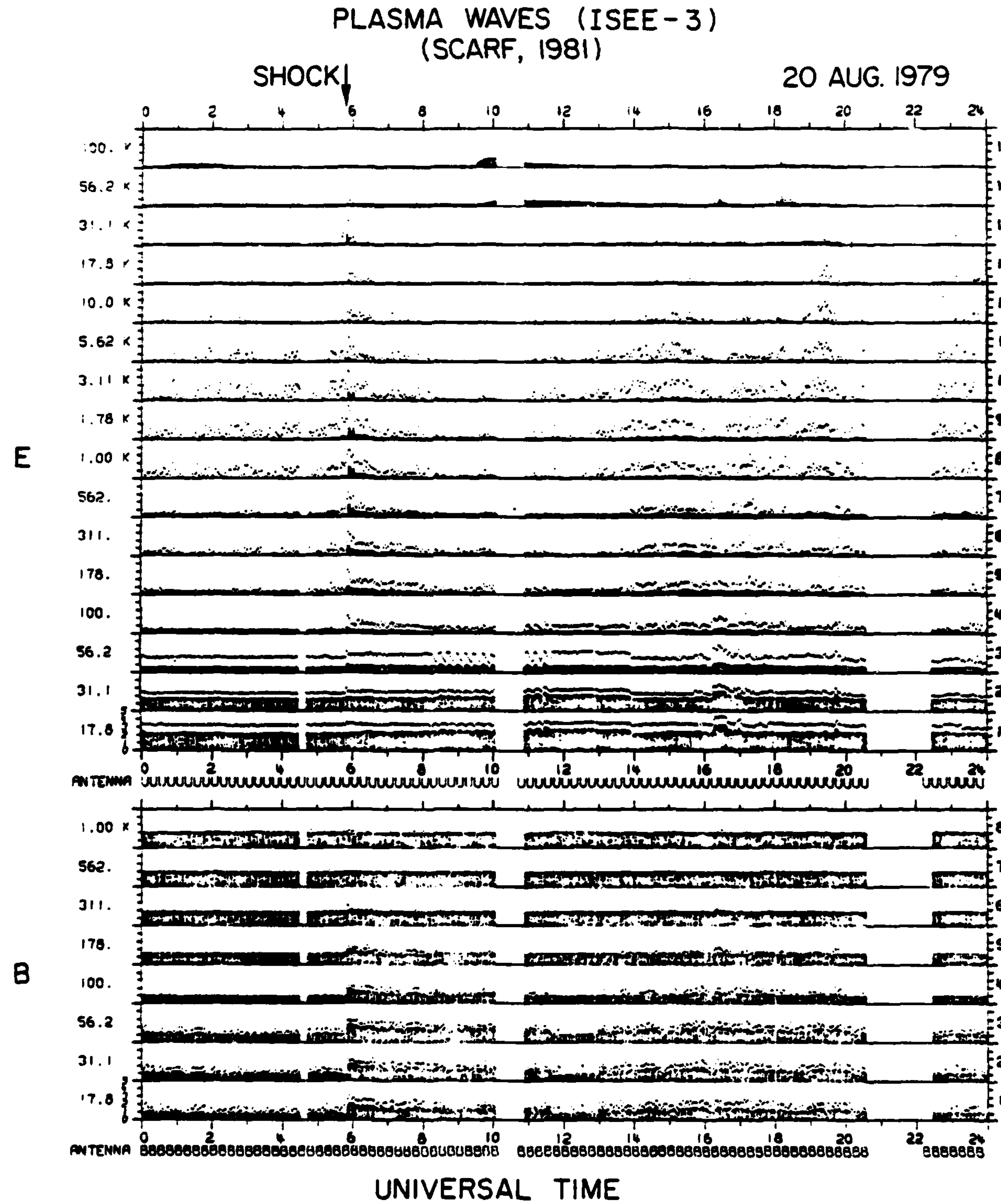
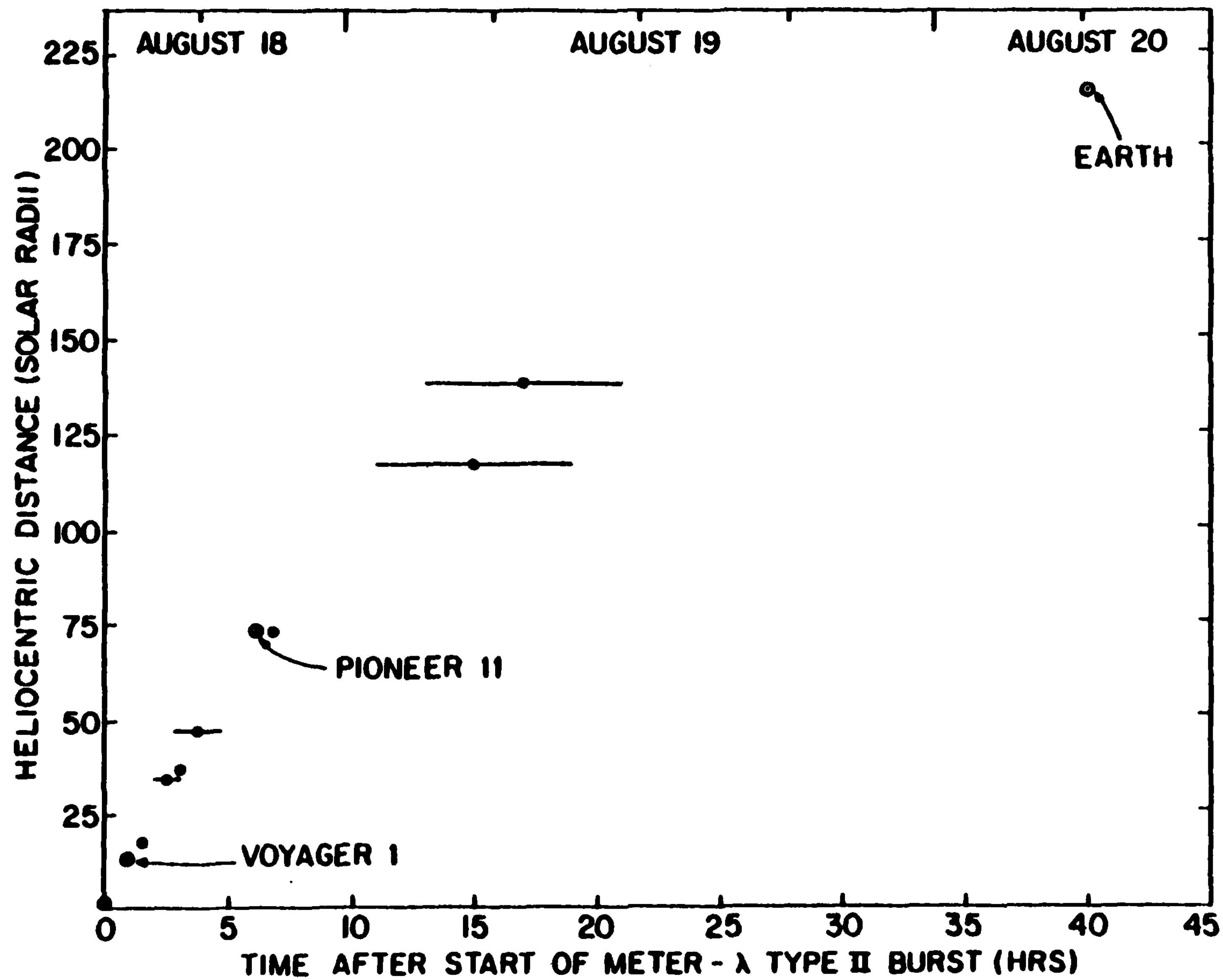


Fig. 20



PLASMA WAVES (ISEE-3)
(SCARF, 1981)
SHOCK
20 AUG. 1979
E
B
ANTENNA
UNIVERSAL TIME

Fig. 21


AUGUST 18
AUGUST 19
AUGUST 20
EARTH
PIONEER 11
VOYAGER 1
225
200
175
150
125
100
75
50
25
0
5
10
15
20
25
30
35
40
45
HELIOCENTRIC DISTANCE (SOLAR RADII)
TIME AFTER START OF METER - λ TYPE II BURST (HRS)

END

FILMED

3-83

DTIC